BOOK of ABSTRACTS

MARC XIII

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METHODS AND APPLICATIONS OF RADIOANALYTICAL CHEMISTRY
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The organizers of the Thirteenth International Conference on Methods and Applications of Radioanalytical Chemistry (MARC XIII) conference are pleased to provide the following summary of abstracts for reference by attendees of the conference. These materials are a supplement to the actual Program, which provides complete details of the conference and sequence of presentations. MARC XIII is expected to be a very successful MARC conference with over 550 abstracts submitted.

The following document is over 270 pages containing the abstracts submitted for presentation at the MARC XII conference as of January 20, 2025. The list will only be provided electronically and only a small number of hard copy abstract summary books will be available for reference at the conference at the desk. Individual copies will not be provided.

A special thanks to Prof. George Steinhauser for his assistance with editing this document! It was greatly appreciated.

If you have any questions, please contact the program chair, Sam Glover (sam.glover@uc.edu). Please visit the MARC website for additional details at www.marcconference.org.

Log 110. THE WORLD'S FIRST REACTOR-PRODUCED PLUTONIUM AND THE UNTOLD STORY OF CAPTAIN JANE.

Steinhauser, G.(1,2, P); Macsik, Z.(2); Hudston, L.A.(2); Boswell, M.(1); Fisher, W.S. (2); Inglis, J.D.(2); Meinl, T.(3); Steiner, R.E.(2); LaMont, S.P.(2). (1) TU Wien. (2) Los Alamos National Laboratory. (3) Stanford University. (P) Presenting Author.

The Manhattan Project, ultimately leading to the design of two functioning types of nuclear weapons in 1945, after only 27 months of research, undoubtedly represents one of the most spectacular scientific undertakings in history. Crucial investigations of the properties of plutonium were conducted since spring 1944 in the Los Alamos laboratory, NM, USA, on gram-amounts of the world's first reactor-produced plutonium that was produced in the X-10 Graphite Reactor at the Clinton Engineer Works, Oak Ridge, TN, USA. In September 2021, a number of historical artifacts were uncovered from a former underground waste disposal pit on the former Technical Area 21 (TA-21) area at Los Alamos. Using gamma spectrometry, it was found that two of the artifacts (a stack of approximately stamp-sized newsprint snippets and a filter paper) were contaminated with plutonium. This isotopic signature of this contamination, as determined by gamma spectrometry and thermal ionization mass spectrometry, revealed extremely low-burn plutonium, which was consistent with X-10 plutonium. After a laborious search for the date and background of the contamination, it is now possible to conclude that not only was the material X-10 plutonium, but likely even the first batch of plutonium to arrive at the Los Alamos laboratory in spring 1944.

Log 111. FOR THE AGES: RADIOCHRONOMETRY SIGNATURES OF URANIUM MATERIALS.

Gaffney, A.M. (1, P) (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Radiochronometry is a powerful analytical tool that relies upon the predictable nature of radioactive decay to understand the history of nuclear materials and production processes. This method has a wide range of applications in areas including nuclear forensics and safeguards. Analytical advancements over the past decade have focused on developing fit for purpose reference materials and robust mass spectrometry analysis methods to support a mature capability for accurate and precise measurement of parent-progeny isotope ratios. Interpreting measured isotope ratios as a predictive signature of a material's processing history and timelines requires making a fundamental assumption that the material was completely purified of decay products at the time it was processed. Our current work focuses on evaluating this assumption by performing ground-truth radiochronometry analyses on a broad range of fuel cycle materials with a known and well-constrained provenance. For some materials, we are able to validate the assumption that the material was completely purified of decay progeny at the time of production, and therefore that the radiochronometric age of the material represents the time of material production. In cases where this assumption does not hold true, we are developing analytical approaches to independently evaluate this assumption, and meaningfully interpret analytical results in the face of invalid assumptions. Prepared by LLNL under Contract DE-AC52-07NA27344, LLNL-ABS-20001518

Log 121. IMPACT OF ORGANIC AND BIOGENIC CHELATORS ON THE MIGRATION OF ACTINIDES. Deblonde, G. J.-P. (1, P); Morrison, K. (1); Wasserman N. (1); Balboni E. (1); Kersting A. (1); Zavarin M. (1). (1) Lawrence Livemore National Laboratory. (P) Presenting Author.

Anthropogenic radionuclides have been released in significant quantities in the environment due to civilian and military activities and will be present in various ecosystems for thousands of years. Understanding the biogeochemistry of radionuclides is essential for developing effective means of isolation for future nuclear waste repositories and managing currently contaminated sites. In particular, actinide elements (e.g., U, Pu, Np, Am, Cm) are major contributors to the long-term radiotoxicity of nuclear waste. In this context, it is important to decipher the interplay between actinide ions, soluble inorganic ligands, minerals, and also the wide variety of water-soluble organic molecules that can be present in the environment. Our studies focus on the solution complexation and sorption behavior of actinides in organic-rich systems. We study emerging organic chelators such as actinide-binding proteins and also prospective geological sites for nuclear waste storage that are unusually rich in organic matte. The results presented will show that under certain environmentaly-relevant conditions, specific biogenic ligands can significantly impact the overall mobility of actinides, and even reverse solubility trends traditionally observed amongst actinide ions. The results will be put in context of the selection of future nuclear waste repository sites and the survey of potential biogenic chelators.

Log 122. PLUTONIUM-240 ABUNDANCE IN REFRACTORY FALLOUT IN ENGLAND AND THE CHERNOBYL NUCLEAR EXPLOSION HYPOTHESIS. Joyce, M. J. (1, P); Boxall, C. (1); Christl, M. (2); Collins-Price, P. (1); Gaca, P. (3); Gautschi, P. (2); Livens, F. (4); Madina, A. (1); Semple, K. T. (1); Warwick, P. (3); Wilbraham, R. (1). (1) Lancaster University. (2) ETH Zurich. (3) University of Southampton. (4) University of Manchester. (P) Presenting Author.

Reports of a blue flash, seismic records and isotopic xenon signatures have been interpreted as evidence that an uncontrolled nuclear excursion contributed to the destruction Unit 4 at Chernobyl, but the high temperatures necessary have not been confirmed. Here, we report isotopic ratios in soil samples from the English Lake District prepared to isolate the volatile and refractory components in fallout based on hydrochloric/nitric (HCl/HNO3) acid and hydrofluoric (HF) acid dissolutions, respectively. The corresponding plutonium-244/plutonium-239 ratios are observed to be consistent with accepted measurements of the corresponding global average, with a slight increase observed for the HF preparation consistent with there being a refractory component present which is not penetrated by the HCl/HNO3 preparation. Conversely, whilst the plutonium-240/plutonium-239 ratio is observed to be consistent with the global average for the HCl/HNO3 preparation, the ratio obtained for samples prepared via the more vigorous HF preparation is observed to be inconsistent with both the global average and with what is known for nearby sources, i.e., the Windscale fire and discharges from Sellafield. However, it is consistent with measurements of the volatile component of fuel debris fallout measured close to the site of the Chernobyl accident. This suggests the existence of a long-range and therefore sub-micron component to Chernobyl fallout, but in refractory phase formed at high temperatures and injected at high altitude, consistent with the aforementioned uncontrolled nuclear excursion.

Log 123. MODELING POTENTIAL IMPACTS OF NEW MEDICAL ISOTOPE FACILITIES ON GLOBAL XENON MONITORING. Johnson, C.M. (1,P); Lowrey, J.D. (1); Eslinger, P. (1); Inman, J. (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

The anticipated rise of novel medical isotope production facilities (MIPFs) in the United States and around the world underscores the need to assess their potential impacts on the International Monitoring System (IMS) noble gas monitoring regime. This study focuses on two proposed MIPFs by Niowave, Inc. and SHINE Medical Technologies, LLC, and their potential IMS impact for three proposed locations. By integrating publicly available data into a suite of software models, we simulated the release, decay, transport, and detection of noble gases from these facilities to IMS stations and assessed their potential impacts. Here we demonstrate the simulation development process and how this method could be extended to other facility types, as well as the predicted results of these facilities on the IMS.

Log 124. NBL PROGRAM OFFICE NUCLEAR REFERENCE MATERIAL PROGRAM: CURRENT STATUS AND NEAR-TERM PLANS. Essex, R.M. (1,P) (1) Department of Energy, National Nuclear Security Administration, NBL Program Office. (P) Presenting Author

NBL Program Office (NBLPO) is fulfilling its mission to support national security, nonproliferation, and research and development efforts by producing and certifying nuclear reference materials. The NBL PO has continued to provide reference materials for chemical assay and isotope analysis of U, Pu, and Th materials to US Department of Energy (DOE) customers as well as commercial, academic, and international users. The program office has continued to work with its DOE laboratory partners and other National Nuclear Security Administration offices to maintain stocks of existing reference material and to develop new materials that meet ongoing and future needs. Recently completed projects include the development of dedicated infrastructure for UF6 material handling, a new 19.6% U-235 enriched isotope ratio reference material, and 2 new U radiochronometric reference materials. Current projects include production and certification of new Pu isotope ratio (CRMs 136-A, 137A, and 138-A) and Pu metal (CRM 126-B) reference materials. A Np reference material for chemical assay and a new DU metal reference material (C115-A) are also in production. Major near-term activities in the planning stages include the maintenance and enhancement of the NBL PO Quality Assurance program, development of new UF6 reference materials (HALEU), recertification and U series isotope reference materials, and expansion of the nuclear material measurements evaluation program.

Log 125. ADVANCING ATOM TRAP TRACE ANALYSIS (ATTA) FOR RADIOXENON DETECTION: ENHANCING NUCLEAR TREATY VERIFICATION AND FORENSICS. Hartig, K.C. (1, P); Scoville, J.A. (2); Anderson, M. (2); Knize, R.J. (2). (1) Unviersity of Florida (2) United States Air Force Academy. (P) Presenting Author.

The detection of radioxenon isotopes, particularly Xe-133, Xe-135, Xe-131m, and Xe-133m, is critical for nuclear treaty monitoring and verification. Atom Trap Trace Analysis (ATTA), a laser-based technology, enables isotopic selectivity at ultra-trace levels, achieving unparalleled sensitivity for detecting noble gas isotopes. This work focuses on advancing ATTA for radioxenon measurement to enhance radionuclide noble gas detection capabilities, with applications in non-cooperative verification, and exploring ATTA's potential for future verification missions. The project leverages a multidisciplinary collaboration, including the US Air Force Academy, Argonne National Laboratory, Air Force Institute of Technology, and University of Florida, contributing novel methodologies for treaty verification and environmental monitoring. This presentation highlights the measurement of the radioxenon isotope Xe-133 using ATTA, a critical milestone for developing a technique for nuclear treaty verification. It will also detail the progress in refining ATTA to enhance its sensitivity and applicability for both verification and nuclear forensics, expanding its utility in monitoring proliferation activities. USAFA-DF-2024-804

Log 126. APPLICATIONS OF MICROCALORIMETRIC GAMMA COUNTING TO NUCLEAR FORENSICS RESEARCH. Pierson, B.D. (1, P); Batie, G. (1); Archambault, B.C. (1); Good, E.C. (1); Carpenter, M.H. (2); Schreiber, K.A. (2); Croce, M.P. (2); Becker, D. (3); Keller M. (3); Gard, J. (3). (1) Pacific Northwest National Laboratory. (2) Los Alamos National Laboratory. (3) National Institute of Technology & Standards. (P) Presenting Author.

Microcalorimetric gamma counting techniques are an emerging technology that provides nearly an order of magnitude better energy resolution for gamma spectroscopy over the current state-of-the-art germanium-based detection systems. This technology is on the cusp of revolutionizing non-destructive radiometric analysis not unlike the advent of the germanium detector in 1963. The High Efficiency and Resolution Microcalorimeter Spectrometer-700 (HERMES-700) was recently commissioned at Pacific Northwest National Laboratory in late-2024 to support post-irradiated material characterization, specifically the analysis of short-lived fission and activation products. Measurement and quantification of 147Nd, 153Sm and 144Ce in the presence of short-lived fission products with germanium-based detection systems are often biased and unreliable without the aid of radiochemical separations; such separations are time-consuming, difficult, and expensive. Leveraging the superior resolution of microcalorimetry, these isotopes have been observed as well separated signatures without the aid of radiochemistry as early as one-week post-irradiation. Measurements of a highly-enriched uranium target irradiated under 10B4C at the WSU TRIGA reactor 24-hrs post irradiation using the microcalorimeter will be presented along with methods for quantification that leverage high-purity germanium counting in tandem to overcome limitations of this emerging technology.

Log 127. FIT FOR PURPOSE PROFICIENCY TEST MATERIALS. Jassin, L. E. (1, P). (1) Eckert & Ziegler Analytics. (P) Presenting Author.

Laboratories supporting all facets of the nuclear industry depend on proficiency test (PT) materials/samples that are fit for the work they currently do and in support of their ISO 17025 accreditation. This poster will outline key considerations in acquiring traceable PT materials/samples that cover a broad range of matrices and isotopes. Examples will be given of new materials which support everything from incident response to decommissioning and NORM. These are available to both individual laboratories/facilities and in collaboration with governmental laboratories for their own distribution and administration.

Log 128. ACCELERATING DATA-DRIVEN PREDICTIVE CAPABILITIES IN RADIOCHEMISTRY THROUGH HIGH-PERFORMANCE COMPUTING. Penchoff, D.A.(1,P); Peterson, C.C.(2); Valeev, E.F.(3); Harrison, R.J.(4). (1) University of Central Florida. (2) University of California, Los Angeles. (3) Virginia Tech. (4) Stony Brook University. (P) Presenting Author.

This presentation examines how High Performance Computing (HPC), Artificial Intelligence (AI), and advanced molecular modeling techniques can address fundamental challenges in radiochemistry. Radiochemical processes, from selective radionuclide separations to designing environments that selectively bind f-block elements, rely on understanding complex electronic structures and reaction pathways. HPC-enabled electronic structure simulations facilitate descriptions of the interplays of electronic and environmental factors shaping chemical behavior. When combined with AI-driven analytics, these simulations can be rapidly sifted to identify correlations, predict ideal conditions, and guide experimental strategies. We will discuss how HPC resources accelerate the chemical characterization of molecular systems, enabling a more complete description of electronic structures and enhancing our ability to model complex species. Emphasis will be placed on quantum chemistry calculations specific to f-element containing systems, where subtle relativistic effects and intricate electronic configurations pose unique challenges. Additionally, we will highlight the REACKT (Rare Earth Actinides Constants and logK Thermodynamics) initiative, illustrating its applications in nuclear forensics. The integration of HPC, AI, and molecular modeling methods enables knowledge-based design of radiochemical separations and supports fundamental inquiries into electronic structure theory. By streamlining data analysis and simulation workflows, these approaches reduce experimental trial-and-error, promote efficient utilization of resources, and ultimately accelerate advancements in nuclear forensics.

Log 129. CONSORTIUM FOR NUCLEAR FORENSICS INTERNATIONAL EFFORTS IN RADIOCHEMISTRY EDUCATION AND TRAINING . Czerwinski, K.R. (1,P); Schwantes, J. (2). (1) Radiochemistry Program, University of Nevada, Las Vegas. (2) Penn State. (P) Presenting Author.

The National Nuclear Security Administration supports university-based nuclear forensics research and education through the Consortium for Nuclear Forensics (CNF). This brings together 16 universities and 7 U.S. national laboratories to conduct innovative research and foster development of a skilled workforce. The CNF adopts a global perspective, actively engaging with the international nuclear forensics community to enhance research and education. A key collaboration is with the UK's Nuclear Threat Reduction Network (NTR-Net), a consortium of universities supported by the Atomic Weapons Establishment. Together, the CNF and NTR-Net are advancing nuclear forensics and nuclear security through innovative collaborative programs. These initiatives aim to address the global decline in radiochemical expertise while preparing students to meet international regulatory, security, and scientific challenges. By exposing students to diverse perspectives and fostering international partnerships, the CNF is developing a comprehensive training pipeline that equips graduates with the skills needed to excel in nuclear forensics. This presentation will highlight CNF's achievements in building global collaborations, advancing research, and addressing workforce challenges in radiochemistry and nuclear forensics. These efforts have also impacted undergraduate efforts at partner universities.

Log 130. RADIOCHEMICAL METHODOLOGY USED TO CHARACTERIZE SAVANNAH RIVER SITE HEU SOLUTIONS FOR HALEU FEEDSTOCK. DiPrete, D. (1,P). (1) SRNL. (P) Presenting Author.

The Savannah River Site's H-Canyon has been re-processing spent nuclear HEU fuel since the early 1950's using the PUREX process. In addition to SRS reactor fuel, the Canyon re-processed aluminum-clad HEU reactor fuel supplied by the US Department of Energy to research reactors around the world. After the SRS reactors were turned off in the 1980's, H-Canyon continued to reprocess the spent nuclear fuel stored in the Site reactor basins as well as DOE fuel returns. In the early 2000's , the reprocessed HEU was blended down, supplying LEU feed for the TVA reactors. After a period, the price of commercial reactor fuel fell to the point the blend-down processes weren't economically competitive, so the purified HEU solutions were stored in H-Canyon tanks rather then used for LEU blend-down. In 2022, the Site put the H Canyon PUREX processes in an inactive state. H-Canyon transitioned to the Accelerated Basin De-inventory (ABD) process, dissolving and discarded the spent nuclear fuel assemblies currently stored in SRS's L-Basin repository into the SRS Liquid Waste Operations process streams. The Canyon still maintains storage tanks containing hundreds of thousands of liters of purified HEU solutions from the earlier PUREX processes. The need for HALEU for next generation nuclear reactors have driven interest in the suitability of these stored, reprocessed HEU solutions for feed for blend-down processes for HALEU. Various interested parties required purity analyses of the available SRS HEU solutions to ensure the material would meet specifications for HALEU feed. SRNL was requested to conducted analyses for ~ 100 radiological and non-radiological analytes on an expedited analysis request on these HEU . The various radiochemistry processes used to characterize both radiological and non-radiological analytes will be discussed.

Log 131. FALLOUT FROM TACTICAL NUCLEAR WEAPON DETONATIONS: IMPROVING MODELLING CAPABILITIES AND DECISION-MAKING PROCESSES IN NORWAY.

Lind, O.C.(1,P); Berge, E.(2); Brown, J.E.(3); Hosseini, A. (3); Klein, H. (2); Oughton, D.H. (1). (1) Norwegian University of Life Sciences. (2) Norwegian Meteorological Institute. (3) The Norwegian Radiation and Nuclear Safety Authority. (P) Presenting Author.

The present risk assessment and risk management knowledge of civilian emergency planning organisations concerning radiological consequences of fallout from nuclear detonations is still limited, while the threat of tactical nuclear weapons to be used appears to have increased. The currently ongoing EU PIANOFORTE funded project PREDICT aims at filling in significant gaps and improving upon current radiological assessment and decision-aiding technological capabilities with focus on the fallout zone, where urgent protective actions could significantly help reduce health impacts. This work aims to give an overview of the Norwegian contribution to the project, which focuses on enabling the decision support systems ARGOS and nationally used atmospheric dispersion and transport codes (SNAP) and follow-on radionuclide transfer foodchain models (Terrestrial Food chain and Dose Module, FDMT) to simulate and predict consequences due to the fallout of a nuclear detonation. A key aspect will be the source term characterization including radioactive particle properties. Using a range of source terms and weather conditions based on publicly available Nevada test site data, our results will be compared with those from different PREDICT partner assessment models allowing a better understanding of uncertainties and paving the way to improve dose modelling and computing run times. Furthermore, risk assessment and risk management following a nuclear detonation event at the European level will be enhanced by adapting existing advice on response to nuclear power plant accidents, reviewing public protection strategies and further developing ways of communicating these to the public.

Log 132. THE POTENTIAL OF SOL-GEL CHEMISTRY TO TAILOR FUEL CANDIDATES FOR INTENTIONAL FORENSICS.

Finkeldei, S. C. (1, P); Granger-Jones (1); Proctor, J. (1); Lori, O. (1). (1) The Unviersity of California, Irvine. (P) Presenting Author.

An overview about sol-gel chemistry at UC Irvine dedicated to the development of materials relevant to nuclear energy will be presented. Advances in tuning the synthesis method to fabricate tailored materials e.g. doped UO2 as advanced nuclear fuels, materials for radioisotope power systems, as well as fusion breeder blanket material candidates will be discussed. The effect of dopant uptake towards the microstructural properties and thermal conductivity of advanced fuel systems has been evaluated. Finally, the highly versatile internal gelation method allows for homogeneous uptake of dopants into microspheres which holds tremendous potential for nuclear forensics by e.g. implementing taggants for intentional forensics.

Log 133. COUNTERFOIL BLUE AND OTHER HOT PURSUITS: CURRENT STRATEGIES FOR NUCLEAR FORENSICS-BY-DESIGN. Chamberlin, R.M.(1,P); Marks, N.(2); Wellons, M.(3); Shields, A.(4); Condon, N.(5); Brown, D.(6); Green, G.(3), Osborn, J.(7). (1) Los Alamos National Laboratory. (2) Lawrence Livermore National Laboratory. (3) Savannah River National Laboratory. (4) Oak Ridge National Laboratory. (5) Argonne National Laboratory. (6) Brookhaven National Laboratory. (7) Sandia National Laboratories. (P) Presenting Author.

Nuclear forensics is a key element of nuclear security and traditionally has leveraged known relationships between material characteristics and process history to establish material provenance. A major goal in recent years has been to increase confidence in these relationships. Intentional Forensics is the concept of deliberately introducing benign and persistent material signatures into nuclear fuels during fabrication, in order to reduce the lag time between recovery of a material outside of regulatory control and identification of its original provenance. An integrated, multi-laboratory project is developing the scientific and technical basis to enable adoption of this forward-looking approach. Research is focused on developing options for intentionally tagging various nuclear materials, designing taggants that provide the desired forensics outcomes while also remaining benign during reactor irradiation, and recovering taggant signatures rapidly with high confidence. Since the project was initiated, considerable progress has been made in several areas including nuclear data development, taggant formulation and incorporation, and modeling of taggant transmutation behavior. An integrated experiment, dubbed Counterfoil Blue, is underway to provide initial information on safety of tagged fuels and retrievability of the tags pre- and post-irradiation. This presentation will give an overview and roadmap of our multi-lab work that evaluates the probative value, manufacturability, safety, and persistence within the fuel cycle of various taggants.

Log 134. CHEMICAL ANALYSIS IN PROMPT GAMMA ACTIVATION ANALYSIS USING THE IMPROVED SPECTROSCOPY DATABASE. Révay, Zs. (1), Maróti, B. (2,P), (1) Forschungs-Neutronenquelle Heinz Maier-Leibnitz (FRM II). (2) HUN-REN Centre for Energy Research. (P) Presenting Author.

At BNC and FRM II, the ProSpeRo program is used for the determination of sample composition in Prompt Gamma Activation Analysis (PGAA). The program's input is a peaklist file containing the peak energies and their fitted areas together with their uncertainties, as determined by HYPERMET PC or HyperLab software. The full revision of the database is based on more than 400 new library measurements performed dominantly in FRM2's strong cold beam. The improved statistics made possible the detection of lower intensity peaks that were not visible in previous measurements. At the same time, the uncertainties of the partial gamma-ray production cross section (i.e. sigma-gamma) values of the already known peaks could be reduced thanks to the larger peak areas. The derived data (peak energies and sigma-gamma values) are compared with the previous PGAA database.

Log 135. UNVEILING THE ARCANA OF NUCLEAR MATERIALS: DISCOVERING NUCLEAR FORENSIC SIGNATURES USING "BIG" DATA. Marks, N.E.(1,P); Simons-Rondona, J-P.(1); Hansen, S. (1); Genetti, V.(1); Chen, C.Y. (1); Robel, M.R.(1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

The National Nuclear Material Archive (NNMA) program characterizes and preserves nuclear materials of US origin to support attribution of materials discovered out of regulatory control. The program includes a physical archive of materials; a robust materials characterization program; a data management structure and data repository; and a fundamental science R&D process focused on nuclear forensics signature discovery. The NNMA sample characterization work produces a large quantity of analytical data which must be captured and stored in a way that is secure, accessible to stakeholders, and available for use in identifying novel nuclear forensic signatures in archive materials. In support of this goal, we have developed Arcana, a bespoke relational database specifically designed for efficient upload, storage, retrieval, and queries of NNMA data. The database structure is implemented in SQL through the Oracle APEX development environment, enabling rapid development of web-browser interfaces for database uploads, queries, and data visualization. The flexible structure can accommodate detailed processing and signature information about each sample, as well as associations between samples representing similar processes. The data in Arcana has been used to enable a deeper understanding of the processes by which signatures are created, modified, and replaced throughout the fuel cycle. The NNMA is managed by the Office of Nuclear Forensics, Counterterrorism and Counterproliferation Office of the National Nuclear Security Administration.

Log 136. VR INTEGRATION FOR MATERIAL ACCOUNTANCY AND MODELING. Cole, S. (1,P); Erickson, A.(1). (1) Georgia Institute of Technology. (P) Presenting Author.

Material accountancy is critical when working with any radioactive materials, this can become even more important when these radioactive materials are submersed in a liquid. Modeling of experiments can help determine where build up can occur and optimal radiation detector placement to monitor these conditions. Virtual Reality (VR) is an emerging technology that can help visualize these models and assist in monitoring. This research aims to integrate radiation modeling software (Geant 4) with VR using Unity to achieve robust visualization that can be applied in the lab space. In addition this work strives for real time integration of radiation detectors with VR for monitoring of abnormal or unsafe conditions.

Log 137. EXTRACTION OF HEXAVALENT URANIUM, NEPTUNIUM, AND PLUTONIUM BY HEH[EHP] AND T2EHDGA. Smith, L.A.(1, P); Gelis, A.V. (1). (1) University of Nevada, Las Vegas. (P) Presenting Author.

This work is an investigation of the extraction of hexavalent uranium, neptunium, and plutonium from nitric acid media by mono-2-ethylhexyl (2-ethylhexyl)phosphonate (HEH[EHP]) and N,N,N′,N′-tetra-2-ethylhexyl diglycolamide (T2EHDGA) individually and in combination. These ligands have previously been employed together in the Actinide-Lanthanide SEParation process (ALSEP), a mixed-ligand solvent extraction process for the separation of trivalent minor actinides from lanthanides and fission products. As part of a wider effort at UNLV to expand the scope of this process, the extraction behaviors of major actinides are being investigated. We report distribution coefficients for U(VI), Np(VI) and Pu(VI) across a range of nitric acid and ligand concentrations, stoichiometries of the extracted complexes, thermodynamics of the extractions, kinetics of Np(VI) and Pu(VI) reduction in the organic phase, and visible-NIR spectra from 450-1350nm of the loaded organic phases.

Log 138. ESTABLISHING METHODS FOR QUANTIFYING ANTIMONY FISSION PRODUCTS.

Weberg, A. B. (1,P); May I. (1); Hanson, S. K. (1); Selby, H. D. (1); Boswell, M.(1). (1) Chemistry, Nuclear and Radiochemistry (C-NR), Los Alamos National Laboratory. (P) Presenting Author.

Technical nuclear forensics (TNF) is a cornerstone of nuclear deterrence, with application in preventing nuclear terrorism. Rapid analysis of post-detonation nuclear debris for key radioisotopes provides information into the sources/types of materials involved in a nuclear detonation or accident, leading to attribution, and thus supporting international accountability. Specifically, the presence of short-lived radioactive fission products is a direct indication of a nuclear event. Antimony (Sb) is an element that uniquely contains at least six fission product radioisotopes that vary with neutron energy and actinide fuel. Developing methods for accurately quantifying radioisotopes of Sb could therefore potentially improve technical flexibility for samples of differing type and/or age. Technical aspects of these goals and their associated challenges will be discussed. (LA-UR-24-33338)

Log 139. PRODUCTION OF Am-240. Glennon, K.J.(1); Parsons-Davis, T.(1); Shusterman, J.A.(1); Wilkinson, J.T.(1); Gharibyan, N. (1,P). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

The production of the short-lived americium isotope (Am-240 with a half-life of just 2.12 days) has historically posed significant challenges, limiting its use in various national security applications. We have developed a method for the production and recovery of Am-240 through the Np-237(a,n) reaction. Our initial studies focused on measuring cross sections using thin targets of Np-237 plated on beryllium substrates. Based on the results of these studies, we scaled-up the production using mixed neptunium oxide-aluminum pressed targets. Irradiation experiments were conducted at the Center for Accelerator Mass Spectrometry (CAMS) utilizing its tandem Van de Graaff accelerator. This presentation will detail the experimental procedures for target preparation and radiochemical separations, as well as present the results of (a,xn) and (a,f) cross-section measurements.

Log 140. NEUTRON ACTIVATION ANALYSIS AS A REFERENCE METHOD FOR GRAPHENE CHARACTERIZATION.

Capucin, V.L. (1,P); Fernandes, E.A.N. (1); Zamunér Filho, A.N. (1); Bacchi, M.A. (1) Nuclear Energy Center for Agriculture, University of São Paulo (CENA/USP). (P) Presenting Author.

Graphene-based materials have attracted increasing interest due to their technological applications in catalysis, construction reinforcement, and agricultural biostimulants. The exfoliation of graphite to obtain graphene can be a viable alternative for scaling up the production of this material. However, the wider use of this innovative material depends on the adequated standardization of techniques for characterizing its morphology and chemical composition, as well as the establishment of reference materials. The ISO/DTS 23359 Nanotechnologies - Chemical characterization of graphene-related two-dimensional materials from powders and liquid dispersions, still under development, aims to standardize techniques for determining the chemical composition of 2D graphitic materials and suggests inductively coupled plasma mass spectrometry (ICP-MS) for trace element analysis. Challenges in sample digestion may lead to inconsistent results, on the other hand, neutron activation analysis (NAA), a primary method of measurement, offers the possibility of identifying metallic impurities with high metrological accuracy with minimal sample preparation. Graphene samples were analyzed using NAA, ICP-TQ-MS, and SEM-EDX for chemical composition and morphological characterization. The results suggest that NAA should be integrated into reference techniques for determining the chemical composition of graphene-based materials.

Log 141. ADVANCES IN CHARACTERIZATION OF COLLOIDAL SILICA: INSIGHTS FROM NEUTRON ACTIVATION ANALYSIS.

Capucin, V.L. (1,P); Fernandes, E.A.N. (1); Lima, R.C. (1); Zamunér Filho, A.(1) N.; Bacchi, M.A. (1) Nuclear Energy Center for Agriculture, University of São Paulo (CENA/USP). (P) Presenting Author.

Colloidal silica (SiCol) is a porous material steadily applied in medicine, agro-environment, telecommunications, food and catalysis sectors, with properties highly sensitive to the presence of dopants and contaminants. Colloidal silica can be produced from various silicate-rich materials. Sustainable mining in Brazil is expanding with a focus on "green minerals", aiming to reduce CO_2 emissions, recycle water and strengthen the circular economy, in line with SDGs 2030. Basalt, one of the most abundant magmatic rocks on the planet, containing 45-55% of silica (SiO_2), emerges as an alternative silicate source for SiCol production. Advances in the synthesis and characterization of colloidal materials require metrological tools to accurately determine their elemental composition, establish quality standards and ensure safe application. Basalt samples from Uberlândia, Minas Gerais, Brazil, with different granulometries were used for the production of SiCol via the precipitation method after sodium silicate extraction. Neutron activation analysis (NAA), a primary method of measurement, was used to determine the elemental composition of the raw materials and SiCol. Optical properties were measured by UV-Vis spectroscopy. The elemental profile (As, Ba, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, La, Mo, Na, Rb, Sc, Sm, Sr, Ta, Tb, Yb and Zn) were correlated with Band Gap variations. Sc ($p<10\%$) and Zn ($p<5\%$) showed significant relationships with Band Gap reduction, thus leading to a more conductive material, critical for optoelectronic applications.

Log 142. MODELING HPGe DETECTOR RESPONSE: ACHIEVING HIGH-FIDELITY GAMMA SPECTRA.

Burggraf, J. (1, P) ; Chichester, D. (1); Holschuh, T. (1); (1) Idaho National Laboratory.

Modern Monte Carlo codes are capable of achieving remarkable accuracy in simulating high-resolution gamma spectra using high-purity germanium (HPGe) detectors. In this work, we employ MCNP to achieve simulated accuracies within 1% for full-energy peak areas for gamma energies below 2 MeV. Furthermore, the Compton continuum above 150 keV is predicted to within a few percent. These results enable the determination of detector efficiency solely using models, a particularly useful capability in cases of complex source geometries. Discrepancies seen in the Compton continuum below 150 keV are observed and discussed. Additionally, the sensitivity of the results to the inclusion of various detector and environmental components in the model is examined.

Log 143. CHRONOMETRY MEASUREMENTS OF URANIUM PARTICLES BY LG-SIMS.

Williamson, T.L. (1, P); Groopman, E.E. (1); Pope, T.R. (2). (1) National Institute of Standards and Technology. (2) Pacific Northwest National Laboratory. (P) Presenting Author.

Large geometry secondary ion mass spectrometry (LG-SIMS) has been widely used for isotopic measurements of uranium particles for many years. In recent years, it has been demonstrated it is possible to perform chronometry (a.k.a. age-dating) measurements of single uranium-containing, micrometer-sized particles using LG-SIMS. For these chronometry measurements, the isotopes measured are the 234U – 230Th mother-daughter chronometry pair. This initial measurement protocol was developed using the single, mono-collector electron multiplier (EM) configuration on a LG-SIMS instrument with the preponderance of the counting time of an analysis cycle being on the 230Th to maximize measurement precision. In addition to the 234U – 230Th pair, the 235U – 231Pa chronometer pair has frequently been measured as a secondary chronometer for uranium-based materials in several scientific fields. Most LG-SIMS instruments have a multi-collector system configured with five EM detectors, which allows for simultaneous measurement of up to five isotopes, typically improving measurement precision and detection limits over single, mono-collector protocols. The multi-collector configuration allows the simultaneous counting of both 230Th and 234U, with the added advantage of allowing the collection of 231Pa, 232Th, and 235U isotopes, too. We will present results on the development of our multi-collector system protocol for dual measurements. Data presented will focus on results from commonly available U-series Certified Reference Materials (CRM) and from synthetic working reference materials created by a hydrothermal synthesis method. We will also discuss how increased background from peak tailing – often referred to as abundance sensitivity – and detector noise can negatively impact detection limits for the multi-collector configuration.

Log 144. ENHANCING NUCLEAR FORENSICS IN THE SOUTH CAUCASUS THROUGH KNOWLEDGE TRANSFER AND INTERNATIONAL COLLABORATION. Dallas, L. (1); Belyaeva, O. (2, P); Movsisyan, N. (2); Pyuskyulyan, K. (3); LaMont, S. (4); Hudston, L. (4); Harris, M. N. (4); Mayer, K. (5). (1) National Nuclear Security Administration DOE, USA. (2) Center for Ecological-Noosphere Studies of NAS RA. (3) National Academy of Sciences of Armenia. (4) Los Alamos National Laboratory. (5) Joint Research Centre, European Commission, Karlsruhe, Germany. (P) Presenting Author.

The partnership between the U.S. Department of Energy's National Nuclear Security Administration (DOE/NNSA/GMS) and the European Commission's Joint Research Centre (EC-JRC) has played an important role in advancing nuclear security worldwide. In September 2021, a collaborative project was initiated within the framework of the International Science and Technology Center (ISTC) with substantial input from the Los Alamos National Laboratory. The project's objective is twofold: firstly, to enhance capabilities in the field of nuclear forensics and secondly, to reinforce regional collaboration in the South Caucasus region. Over the three years of the project, several short training sessions were conducted, each contributing to the professional development of participants. Among these, the most significant was a training focused on capacity building in alpha spectrometry and radiochronometry conducted by the team of LANL. This brief training was held at the Armenian Nuclear Forensics Library and included participation from project members representing both Georgia and Armenia. Furthermore, key stakeholders from national authorities were involved, underscoring the importance of this training for strengthening regional expertise in NF.

Log 145. MACHINE LEARNING-ENABLED TRIPLE PARTICLE DISCRIMINATION. Duce, M. (1, P); Walk, C. (1); Hill, A. C. (1); Erickson, A. (1). (1) Georgia Institute of Technology. (P) Prestenting Author.

Advanced reactor technologies beget advanced detection tools for fuel cycle monitoring and ensuring nuclear safeguards. Organic scintillators doped with thermal-neutron sensitive material are particularily well-suited to this application space given their additional sensitivity to fast neutrons and gamma rays. However, untangling the contributions of each particle in the detector response can be challenging as their features often overlap. Given the complexity of the overlap and the large data required for analysis, machine learning may thrive here. By establishing a framework for untangling particle contributions, detection scenarios that feature complex radiation fields can be decyphered with a single detector. This work presents a survey of both unsupervised and supervised machine learning tools to address this problem. Models are tested on real, experimental data from boron-10 doped polysiloxane scintillators and from commercially available Eljen 254B-5 boron-doped plastic scintillators. Results indicate that for data with singificant feature overlap, supervised learning outperforms unsupervised learning. However, unsupervised learning with Gaussian Mixture Models may be suitable in more separated cases.

Log 146. ANGULAR CORRELATIONS OF GAMMA-RAYS FROM FISSION PRODUCT SOLUTION. Holschuh, T. (1,P); Quist, T. (1); Johnson, J. (1); Diaz, J. (2); Chichester, D. (1). (1) Idaho National Laboratory, (2) Northern Arizona University. (P) Presenting Author.

Fission products from photon-induced fission are routinely used at Idaho National Laboratory as part of nuclear forensics activities. Typically, the focus is on fission products with relatively large fission yields (Ba-140, Mo-99, etc.). The nuclear data associated with the well-known isotopes have small uncertainties, and many have well-known angular correlations between emitted gamma-rays, if applicable. However, for isotopes with smaller fission yields or less intense gamma-ray emission intensities, the nuclear decay schemes and gamma-ray emission intensities may be less well-known. The Germanium Rotational Measurements for Angular Correlation (GeRMAC) system was designed to use two high-purity germanium (HPGe) detectors in a coincidence counting set-up but allows one of the HPGe detectors to rotate at a constant distance from a radioactive source, changing the relative angle between the two HPGe detectors. Angular correlations can then be determined from the relative photopeak areas between two gamma-rays emitted as part of the same nuclear decay. By recording the HPGe spectra in list mode, the angular correlations of gamma-rays emitted from complex sources, consisting of multiple isotopes, can be measured simultaneously and the individual isotope emissions can be isolated. Using the GeRMAC system, a multi-isotope fission product source, produced with photon-induced fission of U-238, was measured using a single rotational arc (180 degrees) to obtain the angular correlation between gamma rays emitted by the large number of fission products contained in the solution.

Log 147. 236U/238U IN URANIUM ORE CONCENTRATES. Dorais, C. (1, P); Marks, N.E. (1); Brennecka, G.A. (1); Tumey, S.J. (1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Uranium ore concentrate (UOC), the refined uranium product that is subsequently enriched for use in reactors and weapons, is one of the nuclear materials most frequently targeted for theft and trafficking. When UOC outside of regulatory control is recovered, nuclear forensic analyses are conducted to assist in provenance assessment. Isotope ratios of the major and minor U isotopes (234U, 235U, and 238U) are commonly measured in UOC samples; however, 236U is not often measured because of its low abundance. Accelerator Mass Spectrometry (AMS) is a highly sensitive technique that allows for the measurement of ultra-trace isotopes, such as naturally occurring 236U. The natural range of 236U/238U has been shown to span several orders of magnitude (10- 14 to 10-10). This wide natural variation is thought to be controlled by factors that affect neutron production or moderation in the ore body, such as ore grade, deposit age, the abundance of neutron moderators or scavengers, and water content. In an effort to better understand the production of 236U in U ore bodies, UOCs from a variety of deposit types were analyzed for 236U/238U. Results will be presented here, along with the measurement setup used at LLNL's Center for Accelerator Mass Spectrometry. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344 and was supported by the LLNL-LDRD Program under Project No. 21-ERD-030.

Log 148. COMPARISON OF LINEAR ENERGY TRANSER SPECTRA OF THE NEUTRON GENERATOR AND THE SPACE RADIATION ENVIROMENT . Mukhopadhyay,S. (1, P); Arnold ,L. (1); Mercado, A. (1); Aranda, R. (1); Hertel, N. (1); Brittingham, J. (1); Pooser, E. (1); Dewji, S. (1). (1) Georgia Institut of Technology. (P) Presenting Author.

Galactic cosmic radiation (GCR) originates from outside the solar system and poses a health concern for exposed individuals, such as astronauts. To systematically study relevant space radiation environments and select potential medical countermeasures, the linear energy transfer (LET) spectrum of GCR needs to be replicated. While recreating the environment can be accomplished with accelerator-based ion beams, using Georgia Tech's neutron generator in combination with available gamma sources offers significant cost and schedule advantages. To ensure the neutron generator can adequately replicate the LET spectrum, the properties of the emitted neutrons need to be quantified. By combining measurement data from Bonner Spheres (BS), CLLBC:Ce (Cs6LiLaBrCl) scintillator, and Advacam TPX3 sensor with MCNP6.2 simulations, one can determine the energy and direction of the generated neutrons with the aim of reproducing the GCR's LET spectrum and developing countermeasures to protect astronauts from GCR's harmful effects. Preliminary measurements with the CLLBC scintillator show that 5-7 cm of HDPE is required to achieve maximum thermal neutron flux from the DD neutron generator at 100 kV. The counts per second have been normalized to the generator output current. Using the results from the CLLBC experiment, the response of the ADVACAM Timepix 3, 1000 µm Si sensor coated with 6LiF, was examined in a well-defined thermal neutron field from the DD neutron generator using 3 inches of HDPE. Pattern recognition analysis of the single particle tracks to resolve particle-event type in terms of particle type, energy loss, and direction is ongoing.

Log 149. AUTOMATED RADIOISOTOPE PURIFICATION USING HIGH PRESSURE ION CHROMATOGRAPHY: A LOOK TO THE FUTURE OF ISOTOPE PRODUCTION AT OAK RIDGE NATIONAL LABORATORY. Roach, B.D. (1,P); Gaddis, K.A. (1); Keever, T.J. (1); Thakur, P. (1); Davern, S.M. (1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

The production and purification of radioisotopes are critical to applications in medicine, industry, and national security. The demand for isotopes with high specific activities and high purity, such as those used in imaging, therapeutic devices, and energy storage, has driven advancements in separation and analytical techniques. Despite these advancements, the isolation of certain isotopes remains challenging because of their chemical similarities to neighboring elements, low natural abundance, and high activity levels in feedstocks. Promethium-147 serves as a case study for tackling these challenges. The High-Pressure Automated Recovery and Optimized Separation of Promethium-147 (PHAROS) project employs high-performance ion chromatography (HPIC) combined with inductively coupled plasma mass spectrometry (ICP-MS) to develop an efficient, scalable, and automated process for radioisotope purification. HPIC-ICP-MS offers high sensitivity, real-time analysis, and robust process control, making it a powerful tool for optimizing complex separations. Specifically, PHAROS aims to integrate custom high-capacity HPIC columns and hot-cell-ready automated sample introduction and fraction collection systems with the goal to isolate milligram quantities of promethium-147 from lanthanide-rich fission product streams. This innovative approach not only enhances the scalability and reproducibility of promethium-147 separation but also demonstrates broader applicability to other isotopes.

Log 150. INTEGRATED ONLINE GAMMA SPECTROSCOPY AND ALPHA COUNTING TOOLS FOR ENHANCED RADIOCHEMICAL SEPARATION AND RADIOISOTOPE PRODUCTION. Taylor, N.R. (1,P); Parker, C.J. (1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Online spectroscopy enables researchers to receive real-time information on their experiments and processes but often introduces unique challenges for seamless integration with radiochemical operations. Radiochemical separations and isotope research is one field that currently relies on time- and cost-consuming analytical sampling. Alpha particle and gamma ray detection has the advantage over other spectroscopic techniques such that the energies are unique to each isotope and are independent of chemical form and solution chemistry. An online alpha detector has been used for aiding separations of heavy actinides and we are designing a simple gamma spectroscopy tool for online monitoring of separation processes by enabling isotope identification and tracking with collimation and robotics. The tool uses a cadmium zinc telluride (CZT) detector with shielding and collimation coupled with a stepper motor to monitor gravity-fed columns by tracking the elution of gamma-emitting isotopes during and after separation processes. The shielding and collimation design is being optimized through modeling and simulation using MCNP and ISOCS of the detector and column configuration with various isotopes of interest for isotope production and radiotracer R&D efforts. A packaged graphical user interface (GUI) is also being designed to integrate the motor, controls and detector such that the user can easily monitor the elution profile and scan the length of the column for remaining isotopes. The system is being designed to be customizable and easily adaptable for usage within fume hoods, gloveboxes and for various gamma-emitting isotopes of interest.

Log 151. SETUP AND CALIBRATION OF A NEW HIGH-COUNT-RATE GAMMA-RAY DETECTOR AND A LOW-ENERGY LOW-LEVEL GAMMA-RAY DETECTOR. Veit, M.(1, P); Hammermann, M.(1); Hainz, D.(1); Musilek, A.(1); Steinhauser, G.(1). (1) TU Wien. (P) Presenting Author.

A large number of gamma detectors are used at the TRIGA Center Atominstitut. Yet, the recent strong increase in activities in the field of radiochemistry has led to a shortage of detector capacities and made it necessary to expand the detector park. A new high count rate detector was installed for activated samples, which is also suitable for low gamma ray energies thanks to its beryllium window. In addition, a new low-level detector for extremely low-energy gamma rays was installed. On this poster we present first results of the performance evaluation and calibration of the two detectors.

Log 152. INTERNATIONAL COOPERATION OF THE NNC RK IN THE CONTEXT OF DEVELOPMENT OF COMPETENCIES IN THE FIELD OF NUCLEAR FORENSICS AND CREATING THE NNFL IN KAZAKHSTAN. Syssaletin, A (1, P), Batyrbekov (1), E., Baklanova (1), Yu., Yermakov, V. (1), Marks, N. (2), Kips, R., Dallas, L. (3), Tompson, A. (2). (1) National Nuclear Center of the Republic of Kazakhstan, (2) Lawrence Livermore National Laboratory, (3) Oak Ridge National Laboratory

In 2021, a joint project of the United States Department of Energy's National Nuclear Security Administration, Lawrence Livermore National Laboratory, and the National Nuclear Center (NNC) of the Republic of Kazakhstan dedicated to nuclear forensics was launched. Two main objectives are considered within the project: (1) the development of the NNC competencies in laboratory research for the purposes of nuclear forensics; solving research issues to determine various characteristics of nuclear materials (signatures), and (2) research and applied tasks to create a prototype information concept of a National Nuclear Forensics Library (NNFL) for the Republic of Kazakhstan. Conditions have been created for performing a wide range of studies of various materials of nuclear energy in the NNC laboratories such as fuel elements and others. Various types of radiation materials science techniques have been mastered: a study of neutron-physical characteristics of materials, spectrometry, and many other types of research. Based on the obtained laboratory data, analytical portraits of materials (signatures) are determined and the basic data structure for NNFL is formed. In cooperation with international partners, the task of creating a prototype of the NNFL in the Republic of Kazakhstan is being successfully solved. The concept and structure of the database are being developed. NNC has developed a methodology for NNFL search algorithms which shows good relevance of the results of searching for material in databases. The NNFL concept, implemented as a systematized database and knowledge, has been repeatedly presented for discussion at various authoritative international venues. Prepared, in part, by LLNL under Contract DE-AC52-07NA27344. LLNL-ABS-2002070.

Log 153. CHARACTERIZATION OF NOBLE GAS ADSORPTION AND DIFFUSION IN SUBSURFACE GEOLOGIC MATERIALS. Wang, G.(1,P), Denis, E.(1), and Carman, A.(1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Noble gas transport through geologic materials has important applications in the verification and characterization of underground nuclear explosions. Transport of those gases to the surface is a complex process relying on the adsorption and diffusive processes in the subsurface at different temperatures and pressures, where adsorption/diffusion coefficients are the key physicochemical parameters used for modeling subsurface gas transport. However, the adsorption measurements for noble gas on geologic sediments could be practically challenging due to their low sorption capacity. In this study, a modified continuous column method was developed to measure trace noble gas element adsorption to geologic materials in the presence of a background gas that could potentially compete for surface adsorption sites. Adsorption of four noble gas elements (Ne, Ar, Kr, and Xe) at variable concentrations in helium and nitrogen were measured on a sample of crushed tuff (a volcanic zeolitic material) at 0 – 45 °C (Cantrell et al. 2022, https://doi.org/10.1016/j.jenvrad.2021.106809). Another study was conducted to better understand the diffusion process in relevant porous geologic materials, especially noble gas diffusion from rock fractures to the surrounding rock matrix. A modified time-lag method by using a chromatographic column based on Fick's law was developed and used to measure krypton and xenon diffusion through crushed tuff in the presence of a background gas (N_2) under different temperatures (0 – 60°C) and pressures (10 – 50 psi). The results in this study could improve model predictions on gas fractionation and transport in the subsurface by using the determined temperature/pressure-dependent adsorption/diffusion parameter values.

Log 154. UNDERSTANDING FISSION PRODUCT BEHAVIOR OF MOLTEN SALT REACTORS WITH RADIOCHEMICAL TRANSPORT ANALYSIS. Shahbazi, S. (1, P), Rollins, N. (1), Lund, A. (1), Seifert, L. (1), Martinson, S. (1), Beauvais, Z. (1), Romano, P. (1), Fei, T. (1). (1) Argonne National Laboratory.

The unique nature of flowing fuel in molten salt reactors (MSR) brings with it challenges as well as opportunities in developing reactor monitoring approaches spanning various applications in safety, security, and safeguards. Among other sensor types, gamma spectroscopic detectors integrated into the reactor system have been discussed as a method of remote monitoring. This is primarily motivated by the high technology readiness of gamma detectors as well as its use during the Molten Salt Reactor Experiment (MSRE). To this end, gamma detector response simulations of MSRE using GADRAS-DRF were performed to investigate fission product radiochemical behavior. The source terms for these simulations were developed with radiochemical transport analyses and nuclear fuel depletion modeling. Experimentally measured salt and gas samples from MSRE are used to infer elemental removal rates for use with these source term modeling tools. Uncertainty quantification and sensitivity analyses are also performed to assess the effects of chemical removal rates on inventories, representing effects such as that from fuel processing systems or unintentional actinide precipitation. These modeling studies are meant to investigate compositional changes that arise due to chemical removal and ex-core residence times in addition to nuclear reactions, ultimately informing analysts on the radiochemical transport behavior of radionuclides in MSRs.

Log 201. GAMMA-RAY EMITTING RADIONUCLIDES IN WATER SAMPLES: 30 YEARS OF SUCCESSFUL PARTICIPATION IN THE IRD/CNEN NATIONAL INTERCOMPARISON PROGRAM. Gonzaga, C.L.(1,P); Bacchi, M.A.(1); Fernandes, E.A.N.(1). (1) Nuclear Energy Center for Agriculture, University of São Paulo. (P) Presenting Author.

Brazil is a major exporter of agricultural commodities, which significantly contribute to the country's economy. The Chernobyl nuclear accident in 1986 impacted global trade, prompting the need for measuring artificial radionuclides in foods. Following the Goiânia radioactive accident involving 137Cs, in 1987, many countries began requiring certificates of analysis for Brazilian agricultural products, specifically for the measurement of 134Cs and 137Cs. Since then, the Radioisotopes Laboratory (LRi) of CENA/USP has conducted radiometric analyses for exporters, comprising a diversity of matrices such as sugar, meat, soybean, maize, coffee, and others, helping Brazil to overcome technical trade barriers. LRi has operated according to ISO/IEC 17025 standard [1], performing gamma-ray spectrometry for both the determination of chemical elements by neutron activation analysis and the determination of natural and artificial radionuclides in agriculture and environmental samples. As a requirement of the quality system, several actions were implemented to ensure the quality of the results produced, including frequent participation in laboratory comparisons and proficiency tests. In this context, since 1993, LRi has participated in the National Intercomparison Program (PNI) coordinated by the Institute of Radioprotection and Dosimetry, Brazilian Nuclear Energy Commission (IRD/CNEN), which is the designated national laboratory for ionizing radiation metrology. The main objective of PNI is to evaluate the analytical performance of Brazilian laboratories for measuring low-level activity radionuclides in environmental samples. Along such 30-years period, LRi participated in 64 runs of the intercomparison on determination of gamma-emitting radionuclides (60Co, 65Zn, 106Ru, 133Ba, 134Cs and 137Cs) in water. A normalized deviation (D) from the reference value was used for assessing the performance and, according to the evaluation provided by IRD/CNEN, 90% of the results reported by LRi showed good accuracy and precision, with |D| £ 1. Moreover, only 1 value out of 384 was outside the limits of acceptable results (|D| £ 3). Considering the long-time frame of the intercomparison and the determination of six radionuclides emitting gamma-rays over a relatively wide energy range (assessed between 276 keV and 1332 keV), data have demonstrated the competence of LRi-CENA/USP for measuring low level activities of radionuclides by high resolution gamma-ray spectrometry in water samples. Due to the minimal matrix effect in gamma-ray spectrometry, such demonstration can be extended to agriculture and environmental samples in general.

Log 202. CHARACTERIZATION OF QUALITY CONTROL MATERIAL FOR FORENSIC TIMBER IDENTIFICATION. Moreira, G.R.(1,P); Fernandes, E.A.N.(1); Bacchi, M.A.(1); Gonzaga, C.L.(1). (1) Nuclear Energy Center for Agriculture, University of São Paulo. (P) Presenting Author.

The Amazon rainforest covers 8.4 million km² and is the largest tropical rainforest in the world. The rapid expansion of human activities has resulted in unprecedented forest degradation. Handroanthus spp (Ipê) is the most illegally exploited tree, with 96% of exports coming from Brazil. Through fraudulent actions, part of this wood is marketed as if it originated from legal areas. Chemical and isotopic wood patterns are becoming valuable tools in forensic analysis to trace the origin of timber. To ensure the reliability of the results, reference materials for quality control purposes should be used in the analysis. Here, an in-house quality control material of tropical wood had been prepared and characterized by NAA and ICP-MS, following ISO Guide 80:2014, in support of this analytical measurements. The wood had been pulverized in a knife mill, passed through a nylon sieve of 250 µm, homogenized and packaged in 185 plastic bottles containing 20 g each. Approximately 250 mg of samples were analyzed by instrumental neutron activation analysis (INAA) and triple quadrupole inductively coupled plasma mass spectrometry (TQ-ICP-MS). The mass fractions of twenty-eight elements - B, Ba, Br, Ca, Cd, Ce, Co, Cr, Cu, Eu, Fe, Gd, K, La, Mg, Mn, Mo, Na, Ni, P, Rb, Sb, Sc, Sm, Sr, Tb, W and Zn were quantified. This wide range of chemical elements determined will allow possible tracers of the geographical origin of wood to be determined with assurance of the repeatability, intermediate precision and reproducibility of the measurement result.

Log 203. RADIOECOLOGY AFTER FUKUSHIMA: LESSONS LEARNED AND CHALLENGES FOR THE FUTURE. Konoplev, A.V.(1, P); Wakiyama Y.(1); Golosov, V.N.(2); Nanba, K.(1). (1) Fukushima Unviersity. (2) Moscow State University. (P) Presenting Author.

Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident in March 2011 led to extensive environmental contamination by several radionuclides, particularly Cs-134 and Cs-137. This has rekindled the interest in the behavior of radionuclides in the environment, particularly given the geoclimatic conditions of Japan. The studies after the Fukushima accident have clearly demonstrated that behaviour of accidentally released radionuclides in the environment is governed by radionuclide speciation in fallout and site-specific environmental characteristics. The Fukushima-derived radiocesium is found to be strongly bound to soil and sediment particles, which reduces the potential bioavailability of this radionuclide. Up to 80% of the deposited Cs-137 on the soil of the contaminated area were reported to be incorporated in hot glassy particles insoluble in water. These particles decompose in the environment very slowly, and long-term radiocesium leaching from these particles is a challenge for future studies. In Fukushima contaminated areas the high annual precipitation and steep slopes are conducive to significant erosion and intensive radiocesium wash-off especially during devastating typhoons. Understanding mechanisms and prediction of radiocesium remobilization from river-transported sediments at the interface between freshwater and marine water in estuaries is important challenge for contemporary radioecology. Another acute issue, which requires our research study, is the ongoing discharge of decontaminated wastewaters containing tritium from FDNPP site to the Ocean.

Log 204. QUANTIFYING HOT-PARTICLE ACTIVITY BY GAMMA SPECTROMETRY. Semkow, T.M.(1,3,P); Chu L.T.(1,2); Burn A.G.(1,2). (1) New York State Department of Health. (2) State University of New York at Albany. (3) Retired. (P) Presenting Author.

In gamma spectrometry of voluminous samples, inhomogeneous distribution of radioactivity caused by the presence of refractory hot particles, such as from Chernobyl and Fukushima, can cause significant bias in the results of activity determinations when homogeneous detector calibration is used. Remixing of the sample only repositions the hot particles. We investigated this effect using numerical modeling. We explored the fact that the peak-to-total (PT) and peak-to-peak (PP) ratios are sensitive to the distribution of hot particles in the samples. We derived new calibration models of gamma peak efficiency as a function of PT or PP ratio. The PT model is applicable to samples containing a single radionuclide, either single- or multi-gamma. When several multi-gamma radionuclides are present in the sample, the PP model has to be applied. Subsequently, we numerically tested the PT model for Cs-137, while the PP model for Eu-152, by simulating random distribution of individual and grouped hot particles within a soil matrix in 0.6-L and 1-L sample containers positioned on top of a 48% HPGe gamma detector. When measuring inhomogeneous samples containing hot particles, both the PT and PP calibration models were shown to reduce the bias range and standard deviation of the activity determinations by several times as compared with the homogeneous calibration. Using these new calibration methods requires only a single measurement of a sample, while the knowledge of the number and distribution of hot particles is not necessary.

Log 205. DETECTION CAPABILITY OF ENVIRONMENTAL ALPHA SPECTROMETRY. Semkow, T.M.(1,3,P); Faye S.A.(1,2); Burn A.G.(1,2); Torres M.A.(1); Haines D.K.(1). (1) New York State Department of Health. (2) State University of New York at Albany. (3) Retired. (P) Presenting Author.

A comprehensive study was performed to assess the detection capability of alpha spectrometry on environmental samples. Eleven water samples were spiked with Pu-239 and 16 with U-nat (U-234, U-235, U-238) isotopes at activities below 100 mBq. Isotope dilution with Pu-236 and U-232 tracers and radiochemical separations preceded alpha spectrometry using silicon detectors. The results were subjected to a variety of quantitative criteria and statistical significance tests to evaluate precision and accuracy. We used a 5% 2-sided significance (95% confidence level) for the tests. In terms of precision, the average variation coefficients were between 4 and 5% for most radionuclides, except it was about 18% for U-235 due to its low activity. The Grubbs test did not reveal any outliers, and the variance chi-squared test showed that the uncertainties were calculated properly. In terms of accuracy, the average biases were: 2.46% for Pu-239, -0.44% for U-234, 2.48% for U-235, and -0.11% for U-238. The respective average En-scores were 0.23, -0.05, 0.04, and -0.03. The location z-test and t-test with respect to constant reference values passed for all radionuclides, except for Pu-239. Including uncertainty of the reference value of Pu-239 resulted in passing the Welch test. State-of-the-art alpha spectrometry emerged as a robust and reliable radioanalytical technique for Pu and U determinations at environmental levels.

Log 206. REDOX CHEMISTRY OF ACTINIDES AT METAL OXIDE ELECTRODES. Dares, C. J. (1,P); McLachlan, J. R. (1,2); Sheridan, M. V. (1,3); Grimes, T. S.(4). (1) Florida International University. (2) The University of California, Berkeley. (3) The University of Nevada, Las Vegas. (4) Idaho National Laboratory. (P) Presenting Author.

The early actinides (U, Np, Pu, and Am) feature rich redox chemistry, where they can be generated in oxidation states ranging from +3 to +7. Oxidation state stability depends upon conditions including pH, coordination environment, and radiation environment. The array of possible oxidation states for actinides can complicate used fuel reprocessing but can also present new research opportunities and applications. Many actinide separations processes, including PUREX (Plutonium Uranium Reduction Extraction), heavily rely on actinide oxidation state control. This reliance continues to be a mainstay of processes that mitigate proliferation concerns. This talk will focus on our work on transparent conductive oxide electrodes which may be surface functionalized with ligands to electrochemically or photoelectrochemically adjust the oxidation state of uranium and transuranic elements. This has included electrodes capable of quantitatively oxidizing Am(III) to Am(VI) in nitric acid solutions electrochemically at potentials as low as 1.9 V, and electrodes that operate photoelectrochemically using UV-LEDs and a potential of 1.45 V (~1 V below the Am(IV/III) potential). This platform can be exploited by others to develop new separations schemes or to prepare actinides in unusual oxidation states to study their electronic structure and binding properties.

Log 208. IDENTIFICATION OF URANIUM AND PLUTONIUM ISOTOPIC COMPOSITION IN ENVIRONMENTAL SAMPLES WORLDWIDE. Corcho Alvarado J.A. (1, P); Röllin S. (1); Sahli H. (1). (1) Spiez Laboratory, Switzerland. (P) Presenting Author.

We present our radiochemical methods for the determination of major and minor uranium and plutonium radionuclides in different types of environmental matrices using ICP-MS techniques (sector field and multi-collector). Data from the following study sites are presented and discussed: 1) Soil cores from the Marshall Islands and Switzerland; 2) Surface ice samples from the Gauli and Aletsch glaciers, in Switzerland; 3) Sediment cores from freshwater systems in Switzerland, Russia, Uruguay, Bolivia/Peru, Argentina, Kerguelen Islands, South-Africa and Ethiopia; 4) Marine sediment cores from the Gulf of Mexico and the Caribbean Sea. U and Pu fingerprints are used to identify potential sources of radioactive contamination at each site. For example, the impact of the French atmospheric nuclear tests is evidenced in most of the investigated sites from the southern hemisphere. We provide a summary of U and Pu isotope ratios (e.g., 236U/239Pu, 236U/233U, 240Pu/239Pu, 242Pu/239Pu, 244Pu/239Pu) relevant to important contamination sources (e.g., nuclear weapon tests, releases from NPP, nuclear reprocessing plants, etc.) at each studied site.

Log 209. ASSESSMENT OF LONG-LIVED CONTAMINANTS IN Zr-89 LABELED MONOCLONAL ANTIBODIES. Metzger, R.L.(1,P); Lasche, P (2). (1) Radiation Safety Engineering. (2) Snakedance Scientific. (P) Presenting Author.

A method has been developed to rapidly assess the long-lived contaminants in 89Zr labeled monoclonal antibodies using high resolution gamma spectroscopy. 89Zr decays by electron capture with a half-life of 78.41 hours, which makes it well suited for Positron Emitted Tomography (PET) studies with monoclonal antibodies(mAb). As compared to other PET imaging ligands, monoclonal antibodies exhibit slow kinetics in vivo, and require an isotope with a slightly longer half-life than other common PET isotopes (e.g. 18F T1/2 109.8m, 68Ga T1/2 67.7 m) to allow the mAbs to accumulate in the tissues of interest before imaging. 89Zr is most often produced by proton irradiation of solid target of 89Y in a medical cyclotron. The list of possible contaminating isotopes drawn from the literature and measurements of produced product include:88Y, 88Zr, 89mZr, 65Zn, 48V, 56Co, 156Tb, & 175Hf. The 89mZr (T1/2 4.161 m), is normally allowed to decay away prior to the retrieval of the target. The 89Zr activity is determined at the End of Synthesis (EOS) using a medical dose calibrator, and the activity at expiration is done by calculation. The possible contaminants are measured by high resolution gamma spectroscopy after the 89Zr product has decayed for several half-lives and are reported as contaminant activity per MBq 89Zr at EOS, and at expiration. The total contaminant load must not exceed 0.5% of the 89Zr activity (99.5% pure) at EOS and at expiration under US Pharmacopeial (USP) requirements.

Log 210. FEASIBILITY OF A PORTABLE X-RAY TUBE BASED KXRF SYSTEM TO MEASURE LEAD IN BONE.

Grier, T. R. (1); Weisskopf, M. G. (2); Taylor, K. M. (3); Specht, A. J. (1, P). (1) Purdue University. (2) Harvard T.H. Chan School of Public Health. (3) United States Army Research Institute of Environmental Medicine. (P) Presenting Author.

X-ray Fluorescence (XRF) is commonly used to measure cumulative exposure to lead. For many years, a method called K-shell X-ray fluorescence (KXRF) had been utilized to detect the adverse effects of metal exposure on human health. Although the equipment had undergone numerous advancements, it still has some limits. Due to its bulkiness, liquid nitrogen cooled germanium detectors, and radioisotope use it is not very portable. A handheld L-shell XRF (pXRF) has been utilized recently as a replacement, but this system cannot measure trabecular bone and has uncertainty linked to skin thickness. In this study, we developed a new portable K-shell XRF for bone lead measurement utilizing either the traditional Cd-109 source or a 140 kV X-ray tube with two different CdTe detector setups each using a ten-minute measurement time. We measured lead concentrated standard bone phantoms, cadaver bones, and goat bones to test the limitations of the system. Using two CdTe detectors with 1cm3 active area and the 140 kV X-ray tube source gave a limit of detection (LOD) of 10 ug/g bone mineral, whereas using a 23cm3 CdZnTe detector with a Cd-109 radioisotope source gave a detection limit of 2 ug/g. This can be compared to the LOD for previous KXRF and pXRF at 2-3 ug/g and 2-10 ug/g respectively. Thus, our new measurement system can detect bone lead at similar rates using a non-liquid nitrogen cooled detector, but the X-ray tube source significantly increases the detection limit. Future work with this device will focus on reduction of the detection limit with X-ray tube sources and further applications of CdZnTe detectors.

Log 211. FROM SYNERGIC SOLVENT EXTRACTION TO EXTRACTION CHROMATOGRAPHIC RESINS FOR GADOLINIUM AND TERBIUM SEPARATIONS.

Holiski, C.K. (1,2, P); Hoekstra, L. (3); Becker, N. (1); Hennkens, H.M. (4,5); Embree, M.F (5); Wang, M-J. (1); Sjoden, G.E. (1); Mastren, T. (1). (1) University of Utah. (2) LLNL. (3) Texas A&M University. (4) University of Missouri. (5) University of Missouri Research Reactor Center (MURR). (P) Presenting Author.

Terbium-161, a rare earth element (REE) radionuclide of growing interest in nuclear medicine, can be produced in nuclear reactors via an indirect neutron capture reaction with enriched gadolinium-160 targets. One of the main challenges in using terbium-161, and other new REE radionuclides, in radiopharmaceuticals is efficiently separating the product from the target material to achieve high specific activity. Extraction chromatography (EXC) has proven effective for these separations, though there is room for improvement in its performance. Traditionally, EXC has used single-extractant resins, but this study explores the use of synergic ligand combinations to enhance the extraction and separation of Gd(III) and Tb(III). This research focused on converting synergic solvent extraction (SX) systems into novel EXC resins for the separation of gadolinium and terbium. The ligands dibutyl N,N-diethylcarbamylmethylenephosphonate (DBDECMP) and 2-thenoyltrifluoroacetone (HTTA) were sorbed onto a macroporous support at different ratios using rotary evaporation, and their uptake behavior for Gd(III) and Tb(III) was characterized. The resulting EXC resins showed excellent metal retention in column studies, successfully separating Gd(III) from Tb(III), with 96.6% recovery of terbium-161 and less than 5% of the original Gd(III) mass remaining. Kinetic studies revealed rapid uptake, while thermodynamic analysis showed that the adsorption process was endothermic, with increased uptake and decreasing Gibbs free energy (ΔG) at higher temperatures. The evaluation of separation behavior across the lanthanide series suggests potential applications for other adjacent REE separations. Overall, this study successfully demonstrated the conversion of synergic SX systems into novel synergic EXC resins for adjacent REE separations.

Log 212. MODELLING SELENIUM SORPTION IN SOIL. Kogiomtzidis, A.(1,P); Sassenberg, N.(1); Elgert, D.(1); Schmalz, T.(1); Walther, C.(1). (1) Leibniz University Hannover. (P) Presenting

As a long-lived and relatively mobile fission product, Se-79 is a critical radionuclide for environmental impact assessments. Selenium exhibits a pronounced redox sensitivity, resulting in highly variable environmental behavior. Therefore, increased research efforts are required to understand selenium transport in the environment. An important aspect in this context is transport in soil, which is primarily influenced by sorption described by the solid-liquid distribution coefficient Kd. Hormann (2021) proposed the UNiSeCs model to estimate Kd values of various radionuclides with respect to different soil properties and chemical conditions while at the same time requiring only a minimum number of soil parameters that are typically included in standard soil analysis protocols. The PHREEQC-based model was successfully tested for selenium against batch experiments on multiple agricultural soils. However, the utilized study did not provide soil phosphate contents or redox potential, both of which significantly affect selenium sorption. Consequently, disregarding these parameters can conceal potential systematic errors and is thus highly problematic in terms of model validation. To address this issue, further batch experiments were conducted with four German reference soils in combination with varying phosphate and selenium concentrations. Soil characteristics, chemical parameters and Kd values were measured and results were compared with the predictions of the UNiSeCs model to gain deeper insight into selenium sorption behavior and provide a more profound model validation.

Log 213. SEPARATION OF U FROM SOLID SOLUTIONS OF Ce AND Pu DOPED URANIUM OXIDES BY CHLORIDE VOLATILITY. Victor, J. (1,P); Czerwinski, K. (1). (1) University of Nevada, Las Vegas. Radiochemistry Program. (P) Presenting Author.

Uranium was separated from solid solutions of PuxU1-xO2 (0.5, 0.8, 0.88, 1.02, 20 % by mass) and of CexU1-xO2 (X=0.09, 10, 20, 40, 70 % by atom fraction) using aluminum trichloride (AlCl3). The separations occurred via chemical vapor transport of the more volatile U compound (UCl4). Additional syntheses of plutonium halides using aluminum halides (AlX3, PuX3, X=Cl, Br, I) were performed and tested for the ability to undergo chemical vapor transport. This method allowed for separations of U from Pu and avoided harsh oxidizing agents (Cl2(g)) and large assemblies for the separation to occur. The synthesized powders and efficiency of this separation technique were evaluated via powder x-ray diffraction (PXRD), thermogravimetric analysis/ differential scanning calorimetry (TGA/DSC), scanning electron microscopy/energy-dispersive x-ray spectroscopy (SEM/EDS), and alpha spectroscopy.

Log 214. RADIOCHEMICAL SEPARATIONS AND TARGET DEVELOPMENT FOR CROSS SECTION MEASUREMENTS AT THE NATIONAL IGNITION FACILITY. Labb, S.A.(1,P); Despotopulos, J.D.(1); Kmak, K.N.(1); Shaughnessy, D.A.(1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

The high neutron yields and short burn time achieved at the National Ignition Facility (NIF) create a stellar-like plasma and thermonuclear environment suitable for cross section measurements on small amounts of radioactive target material. The measurement of nuclear reactions in this environment is integral for nuclear science areas including stockpile stewardship and nuclear astrophysics and can be carried out by doping small amounts of radionuclides onto the inner surface of NIF capsule targets. While isotopic purity is the main concern when carrying out these measurements in traditional accelerator facilities, the capsules feature a 10-micrometer fill hole that even nanograms of salt will plug requiring clean chemistry. We have developed tedious chemistry and two automated capsule doping systems to meet the requirements for NIF capsule preparation. This talk will cover the radiochemical separations, capsule doping process, and recent results for the first (n,2n) cross section measurements in a high energy density plasma.

Log 215. GROUP HEXAVALENT ACTINIDE SEPARATION FROM LANTHANIDES USING SODIUM BISMUTHATE CHROMATOGRAPHY. Labb, S.A.(1,2,P); Kmak, K.N.(1); Despotopulos, J.D.(1); Kerlin, W.M.(1); Sudowe, R.(2). (1) Lawrence Livermore National Laboratory. (2) Colorado State University. (P) Presenting Author.

Advanced used nuclear fuel (UNF) reprocessing strategies are limited by the complex radiochemical separations and engineering required to achieve the separation of actinides (An) from neutron scavenging lanthanides (Ln). The accessibility of the hexavalent oxidation state for the actinides (U – Am) provides a pathway to achieving a group An(VI) separation from the Ln(III) and Cm(III). The solid oxidant and ion exchanger, sodium bismuthate, has been demonstrated to quantitatively oxidize and separate Am(VI) from Cm(III) in a column chromatographic system. This work expands the use of sodium bismuthate chromatography to characterize the adsorption, kinetic, and elution behavior or U, Pu, and Eu. Separation factors over 200 were achieved with rapid and sustained kinetics at dilute nitric acid concentrations with a complete An/Ln separation achieved in under an hour. The adsorption and chromatographic behavior of key fission products present in various reprocessing raffinates was characterized which demonstrated potential application of a sodium bismuthate-based separation following a TRUEX process.

Log 216. APPLICATION OF LABORATORY-BASED PHOTOELECTRON SPECTROSCOPY WITH HARD AND SOFT X-RAYS TO NUCLEAR FORENSICS CHARACTERIZATION OF URANIUM DIOXIDE FUEL.. Dunn S.(1,2, P), Roussel P.(2), Wood A.(3), Spencer B.(3,4), Harrision R.(3), Kaye P.(2), Higginson M.(2), Flavell W.(5,6). (1) Nuclear Futures Institutes, Bangor University. (3) Department of Materials, School of Natural Sciences University of Manchester. (4) Henry Royce Institute, University of Manchester. (5) Photon Science Institute, University of Manchester. (6) Department of Physics and Astronomy, University of Manchester. (P) Presenting Author.

Nuclear Forensic investigations rely on the analysis of the chemical and physical properties to determine the provenance of nuclear materials, found out of regulatory control. X-ray photoelectron spectroscopy (XPS) has been shown to be a powerful tool in supporting material assessment by analysis of the surface. With the onset of laboratory-based hard X-ray photoelectron spectroscopy (HAXPES) instrumentation, this provides the opportunity to probe deeper into the bulk. Furthermore, HAXPES spectra of high Z elements will have multiple core level peaks occurring over a range of different kinetic energies / sampling depths and analysis of these can offer a unique non-destructive depth profile. The work presented in this study demonstrates the utility of a combined XPS and HAXPES analysis to isolate forensic signatures on the surface and into the bulk of uranium dioxide. Survey quantification shows the changing stoichiometry, utilising a 9.25 KeV excitation range of HAXPES, from different average depths within the sample matrix. Peak fitting of high-resolution spectra allows identification of oxidation states as well inspection of secondary features, which provide insight into the material characteristics. Combined with XPS analysis, this shows different chemical and elemental states at the surface into the bulk sample, highlighting the usefulness of this approach. Inelastic background analysis was performed to determine the in-depth distribution of atoms, developing a consistent model to describe the surface overlayer, correlated to the chemical and stoichiometric differences over the excitation range. Finally, the MNN X-ray excited Auger electron spectra are acquired from uranium dioxide for the first time.

Log 217. DEVELOPMENT OF REFERENCE MATERIALS FOR THE DETERMINATION OF Fe-55 AND Ni-59 IN CONCRETE.

Jung, Y.(1, P), Lee, M.J. (1), Lee, S.H. (1). (1) Korea Research Institute Standards & Science. (P) Presenting Author.

The decommissioning of nuclear power plants generates radioactive waste, including isotopes of 55Fe and 59Ni. Neutrons produced during plant operation interact with materials like concrete, where they can activate stable iron and nickel isotopes, leading to the formation of radioactive 55Fe and 59Ni. These activated isotopes decay, emitting radiation and contributing to concrete waste during decommissioning. As such, these nuclides must be prioritized in radioactive waste disposal considerations. Accurate analysis of these isotopes is critical for environmental protection, waste management, and radiation safety assessments. The use of reference materials (RMs) and the establishment of quality assurance and quality control (QA/QC) procedures are essential for obtaining reliable data and ensuring the integrity of the analysis process. At the Korea Research Institute of Standards and Science (KRISS), 55Fe and 59Ni were selected for the development of new concrete RMs. The radioactivity concentrations of these isotopes in the RMs ranged from 200-10000 Bq/kg-dry, with an expanded uncertainty of less than 10% (k = 2). These RMs will support accurate and consistent measurements of 55Fe and 59Ni in concrete waste, facilitating improved management and disposal of radioactive materials.

Log 218. TRANSFER EFFICIENCIES OF SURFACE-TO-SURFACE TRANSPORT OF MICRON-SIZED ACTINIDE SURROGATE PARTICLES.

Powell, A.R.(1,P); Bickley, A.A.(1). (1) Air Force Institute of Technology. (P) Presenting Author.

Particle effluent of varying sizes is released during laboratory activities and comes into contact with surfaces. This effluent can vary in size, but particles of micron size or smaller can be especially pervasive and transfer between surfaces in series. This leads to the potential for progressive contamination and is a concern in laboratories handling actinide materials. Understanding the transport dynamics of small particles will help inform facility personnel of the possibility of trace contamination by materials of interest. Studies in the field of adhesion science do not sufficiently quantify the transport dynamics of trace quantities of micron sized particles to substrates in series considering the transport mechanism of gloved hands. In this research the transfer efficiency of trace levels of particles is measured for multiple materials. The transfer efficiency is measured by quantifying fluorescent particles of Europium-doped Gadolinium Oxysulfide with a 3D microscope under blacklight illumination. In each microscope image the number of illuminated pixels are counted computationally. This experiment examines three types of materials (glass, cotton, and steel), two particle sizes (25 and 2.5 microns) and three contact durations (1, 10, and 60 seconds). A reproducible methodology and algorithm have been developed that will allow expanded tests using different material substrates and actinide oxide surrogate compounds. Preliminary results suggest material roughness could impact results; thus, the 3D microscope will be used to quantify material substrate roughness.

Log 219. ULTRA-SENSITIVE RADIONUCLIDE DETECTION WITH ION-LASER INTERACTION MASS SPECTROMETRY.

Martschini, M.(1,P); Merchel, S.(1); Hain, K.(1); Frost, L.(2); Gaertner, A.(3); Marchhart, O.(1); Steier, P.(1); Wieser, A.(1,4); Wiederin, A.(1); Winkler, S.(4); Golser, R.(1). (1) Unviersity of Vienna, Austria. (2) Juelicher Entsorgungsgesellschaft fuer Nuklearanlagen mbH, Germany. (3) Senckenberg Natural History Collections Dresden, Germany. (4) Helmholtz-Zentrum Dresden-Rossendorf, Germany. (P) Presenting Author.

Interferences from isobars typically restrict the applicability of Accelerator Mass Spectrometry (AMS) to selected long-lived radionuclides. The novel Ion-Laser InterAction Mass Spectrometry (ILIAMS) technique can overcome this limitation in many cases by highly-efficient isobar removal at eV-energies. ILIAMS-assisted AMS enables the detection of 26Al and 41Ca directly from crushed stony meteorites containing intrinsic ~1% Al and Ca, respectively, for fast provenance checks for extraterrestrial origin. Measurements of 41Ca in chemically untreated concrete from nuclear decommissioning underline the huge potential of this technique also for nuclear clearance. The presence of isobars originating from the natively abundant elements (26Mg, 41K) does not cause any analysis problems making radiochemical separation redundant. The laser-induced suppression of U during measurements of Np constitutes the first non-chemical isobar discrimination in AMS in the actinide region. For 90Sr, ILIAMS enables a detection limit of <0.016 mBq in a sample of mg of stable Sr – at least a factor 100 better than other techniques. Recently, we have successfully determined the 90Sr/Sr ratio in 1 g contemporary coral aragonite and seawater samples of less than 500 ml, and analyzed the 90Sr concentration in small samples of soils, snails, antlers and reactor concrete after adding Sr carrier. This project has received funding from the European Union (ChETEC-INFRA, No. 101008324, and RADIATE, No. 824096), and from the Austrian Science Fund: grant I4803-N.

Log 220. IMPROVEMENT TO IN-VIVO COUNTING PROGRAMS USING WHOLE BODY COUNTERS AT NUCLEAR POWER PLANTS.

Kong, T.Y.(1, P). (1) Chosun Unviersity. (P) Presenting Author.

A whole body counter is used in nuclear power plants to identify radionuclides and measure radioactivity in the human body. Several experiments have been conducted to determine the optimal and practical methods for improving the accuracy of in vivo counting with whole body counters at nuclear power plants. The results indicate that comparing counts from the front and back of the body can effectively differentiate between internal and external radioactive contamination. Specifically, the ratio of detected radioactivity levels between the front and back counts was more than double for cases of external contamination.

Log 221. STATISTICAL ANALYSIS OF JAPANESE FUKUSHIMA RADIOACTIVE FOODSTUFF CRM VERIFICATION BY INTERNATIONAL COMPARISON STUDY. Paul, M.J.(1,2); Byers, M.F.(1); Haas, D.A.(1, P); Biegalski, S.R.(3); De Luna, B.A.(1);Barth, B.S.(1). (1) The University of Texas at Austin. (2) Sandia NationalLaboratories. (3) Georgia Institute of Technology. (P) Presenting Author.

Following the Japan Fukushima incident, they needed radioactive foodstuff CRMs. Brown Rice, Dried Fish Meal, and Fish Bone Ash containing Cs-134, Cs-137, K-40 and Sr-90 were manufactured and certified by 16 experienced Japanese radiochemistry laboratories. Following the certification of massic activities of the selected radionuclides in their natural matrix CRMs, they invited a group of 10 radiometrology NMI, environmental, and health and safety laboratories to verify their certified values. The process of comparing the CRM certified values to those from the International Comparison Study required selected statistical tools. The questions posed and the results are as follows: 1]Do the participating international laboratories have consistent location, i.e. no significant bias? The normal probability plots indicate that the laboratory means are not inconsistent with a normal distribution and none of the laboratory means is identified as an outlier based on Grubbs test. The percent difference plots show the degree of difference in the laboratory means. An ANOVA indicated that there was not a statistically significant laboratory effect at the 95% confidence level except for the Fishbone Ash Sr-90 case. 2] Do the participating international laboratories have consistent variation, i.e., no significant difference in uncertainty determinations? The uncertainty determinations for ICS measurements were behaved and in the range of expectations. However, we were not able to perform tests for the equality of the uncertainties because of unknown, and perhaps large, Type B uncertainty effects. 3] Are the Japanese CRM certified values consistent with those from the ICS? The one- and two-sample t-test indicated a statistical difference at the 95% confidence level for Cs-134 for all three matrices. Furthermore, the one sample chi-square test and two sample F test indicate a statistically significant difference between the Japanese and ICS uncertainty values for the Cs-134 Brown Rice case at the 95% confidence level.

Log 222. COMPLEXATION OF RADIUM SURROGATES. Valley, B.J.(1, P); Bai, Z.(1); Beck, N.B.(1); Brannon, J.P.(1); Castilow, V.(1); McKinnon, N.C.(1); Sperling, J.M.(1); Wineinger, H.B.(1); Albrecht, T.E.(1). (1) The Colorado School of Mines. (P) Presenting Author.

The use of Radium-226 as a target in the generation of Actinium-227 for the radiopharmaceutical Xofigo(Registered) combined with the use of the short-lived, alpha-emitting isotopes Radium-223 and Radium-224 in cancer treatment drugs has sparked a resurgence in radium research. Thanks to the success of these radiopharmaceuticals, the development of a more robust radium supply chain is now necessary. This need can be met while simultaneously addressing another historically studied area of radium chemistry: its sequestration from the environment. Prior research has explored obtaining radium through salt, acid, and base leaches as well as by various chelators. Unfortunately, due to the radiotoxicity and scarcity of radium, as well as its radon daughter, minimal work has been done to study its fundamental structural properties. Coordination chemistry can provide valuable insight towards conducting radiopharmaceutical research and utilizing chelators to sequester metals for environmental applications. To further these endeavors, the radium proxies barium and strontium were used to investigate the encapsulation of radium by multidentate ligands as elucidated by single crystal X-ray diffraction. This investigation led to the formation of several complexes: [Sr(4,4′(5′)-di-tertbutylcyclohexano-18-crown-6)(ClO4)2], [Ba(4,4′(5′)-di-tertbutylcyclohexano-18-crown-6)(ClO4)2], and [Ba(4,4′(5′)-di-tertbutylcyclohexano-18-crown-6)(ClO3)2]. Herein, the coordination environments of the barium and strontium crown complexes are described.

Log 223. COMPARISON OF METHODS FOR FLUORIDE DETERMINATION IN A HIGH ACTINIDE MATRIX.

Warne, M. (1); Couch, J. (1); Partridge, J. (1); Delmau, L. (1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Legacy Neptunium Oxide material from Savannah River National Laboratory dating from 1986 is used in the assembly of aluminum clad Neptunium-237 target rods at the Radiochemical Engineering Development Center for use in the Pu-238 program at Oak Ridge National Laboratory. After examination of the analysis report performed on the original material in 1986, it was discovered that it contained approximately 80 ug/g of fluoride. The possibility that the fluoride present in the oxide has been concentrated in the waste and dissolution tanks is a potential problem in that in a highly acidified environment, the fluoride would be converted into hydrofluoric acid, which will likely cause corrosion to any containment vessel not specifically designed to resist it. Different avenues were and are being explored to definitively quantify this potential fluoride content, considering the challenges associated with solutions of very high activity and acid molarity.

Log 224. HUMIDITY EFFECTS ON HF GENERATION FROM FLUORIDE MOLTEN SALT SPILLS IN FHR ACCIDENT SCENARIOS.

Pryor, N. (1,P); Clegg, M. (1); Simpson, M. (1); University of Utah. (P) Presenting Author.

Development of new reactor designs, particularly Fluoride Salt-Cooled High-Temperature Reactors (FHR), necessitates comprehensive investigation of potential spill scenarios under operational conditions. However, the scarcity of data on molten salt spills impedes the creation of accurate scenario models. This study addresses this gap by examining hydrogen fluoride (HF) generation from a surrogate fluoride molten salt under varying humidity conditions, simulating potential FHR spill scenarios. Experiments used a 1-gram sample of FLiNaZr eutectic salt mixture (LiF-NaF-ZrF, 26.0-37.0-37.0 mol%) with surrogate fission products and uranium fuel. The sample was heated to 625°C in a glassy carbon boat within a pure Ni-201 tube furnace. Air with varying relative humidity was flowed through the reaction tube at a constant rate. Effluent gas analysis was performed using Quadrupole Mass Spectrometry (QMS) and auto titration. Post-experiment recovered salt samples underwent ICP-MS analysis to assess the extent of fluoride hydrolysis. Results demonstrated a direct and predictable correlation between relative humidity and HF generation. These findings contribute crucial data for molten salt reactor risk mitigation and accident model development, advancing the implementation of new reactor designs.

Log 225. HARNESSING THE STRUCTURAL AND SPECTROSCOPIC CHARACTERIZATION OF CALIFORNIUM(II) USING LANTHANIDE(II) ANALGOUES. Wineinger, H.B.(1,P); Sperling, J.M.(1); Albrecht, T.E.(1). (1) Colorado School of Mines. (P) Presenting Author.

Exploiting the wide range of actinide oxidation states may present an answer to the separations challenge of partitioning adjacent actinides with near-identical chemistries. Unfortunately, little structural information is available on high- and low-valent actinides. The study of actinide structural composition has long been precluded by a lack of available technology to analyze small amounts of solid-state material prior to their radiolytic decomposition. This, combined with the innate difficulties in actinide synthesis, has long prevented the study of less favorable oxidation states, particularly those of divalent actinides. The recent developments in non-destructive techniques that can fully analyze one single crystal within hours of its synthesis (single crystal X-ray diffraction, Raman microscopy, and solid-state UV-vis-NIR measurements) has achieved characterization of previously inaccessible actinide chemistry, including the first structurally characterized californium(II) complex. To study the fundamental chemistry of californium(II) and other divalent actinides, small scale reactions of lanthanide analogues samarium(II), ytterbium(II), and europium(II) with crowns ranging in size from 12-crown-4 to dibenzo-24-crown-8 have been analyzed. Both the structural and spectroscopic properties are discussed in context of preparation for californium(II) reactions, with emphasis on the fit between the lanthanide(II) cation and the crown cavity. The successful formation of different complexes from varying only the metal center from samarium(II) to the smaller ytterbium(II) cation provides a unique opportunity for understanding the size and behavior of californium(II).

Log 226. 4D ISOTOPE TRACKING WITH THE N4DP INSTRUMENT AT MLZ. Neagu, R. (1,P); Gernhäuser, R. (2); Golenev, S. (2); Märkisch, B. (2); Stieghorst, C. (1); Gilles, R. (1); Revay, Z. (1). (1) Heinz Maier-Leibnitz Zentrum, Technical University of Munich. (2) TUM School of Natural Sciences, Technical University of Munich (P) Presenting Author.

NDP is a non-destructive, element-specific, high-resolution nuclear analytical technique commonly used to study concentration profiles of several light elements, such as lithium. Operating systems with light elements require intensive monitoring studies to understand morphological interface effects. For example, in the operation of thin-film batteries, it is of great interest to follow the movement of the Li cloud during the (dis-)charging with high precision. However, there is a lack of detectors with high detection efficiency and temporal resolution. We have developed a detector system based on double-sided silicon strip detectors with extremely thin and homogeneous entrance windows to provide laterally resolved NDP measurement types for the N4DP instrument. Together with integrated, self-triggering electronics for vacuum operation, the system has been successfully tested and evaluated at the Research Reactor in Delft, achieving a spatial resolution down to ~100µm x 200µm, and a lower integration time limit in the order of seconds to collect sufficient statistics to monitor variations of Li concentrations. This project is supported by the BMBF, contract No. 05K16WO1, 05K19WO8.

Log 227. TESTING REFERENCE ELECTRODES IN FLINAZR MOLTEN SALT ENVIROMENT FOR NUCLEAR APPLICATIONS. Krishnakumar, P. (1,P); Simpson, M. (1); Steppan, J. (1); Meaders, T. (1); Millet, B. (1). (1) University of Utah. (P) Presenting Author.

Building stable thermodynamic reference electrodes compatible with molten fluoride salts has long been an unsolved problem. Fluoride salts chemically react with ceramic/glass membranes that are commonly used for reference electrodes in molten chloride salts. An experimental fluoride salt reference electrode developed by HiFunda LLC, that features a proprietary metallic membrane was tested for its stability in molten FLiNaZr (LiF-NaF-ZrF4) at temperatures ranging from 550-750°C. This Ni/NiF2 based high temperature reference electrode (HTRE) was tested with continuous immersion in the salt for 7 days connected to an electrochemical cell. Electrochemical analysis methods included open circuit potentiometry (OCP), electrochemical impedance spectroscopy (EIS), linear polarization resistance (LPR) and cyclic voltammetry (CV). Salt samples were taken to measure corrosion product concentration using inductively coupled plasma mass spectroscopy (ICP-MS). Tests were run with and without zirconium (Zr) metal immersed in the salt as a redox buffer.

Log 228. NON-DESTRUCTIVE DETERMINATION OF THE ISOTOPIC DISTRIBUTION OF ACTINIDE MATERIALS. Adelman, S. L.(1, P); Carver, N. R.(1); Cava, A. J.(1); Jump, R. K. (1); Matonic, J. H.(1); Muscarella, K. B.(1). (1) Los Alamos National Laboratory. (P) Presenting Author.

The “gold-standard” for analyzing the isotopic distribution of actinide materials is typically a destructive analysis technique. While these techniques are incredibly powerful, they also result in the loss of valuable samples and tend to require high levels of instrument and facility upkeep. A well-established complimentary technique is non-destructive analysis via gamma-ray spectrometry. One obstacle to implementing gamma-ray spectrometry to characterize the isotopic composition of actinide materials is the spectral complexity and overlapping features typical of samples that contain mixtures of actinides and fission products. To overcome this hurdle, the excellent energy resolution of modern high purity germanium (HPGe) gamma-ray detectors can be coupled with an isotopic analysis software (Fixed-energy Response function Analysis with Multiple efficiency, or FRAM) to accurately determine the isotopic composition of actinide samples. This work demonstrates that the isotopic ratios determined with this non-destructive approach for a variety of Pu-238 samples can achieve results that agree extremely well with those obtained through destructive analysis techniques. The accurate and reliable isotopic information obtained from HPGe gamma-ray spectrometry and subsequent FRAM analysis allows for increased sample throughput, retention of a valuable radioisotope, and a safer worker environment.

Log 229. AN IMPROVEMENT OF A LABORATORY COURSE: A DESIGN-BASED RESEARCH APPROACH.

Fischer, C.(1,2, P); Friege, G.(2); Hanemann, P.(1); Walther, C.(1). (1) University of Hannover, Institute of Radioecology and Radiation Protection. (2) University of Hannover, Institute for Didactics of Mathematics and Physics. (P) Presenting Author.

Practical laboratory courses are a key aspect of physics education, bridging theoretical knowledge with practical application. This is why the University of Hannover offers a practical course on radioactivity and dosimetry. This course has remained largely unchanged for decades and will be revised and enhanced as part of a PhD project. The challenges and needs of tutors and students in this laboratory course are explored with the aim of better enabling students to apply their knowledge and manage experiments and analyze results. The Design-Based Research (DBR) approach, characterized by its practice-oriented nature, is employed to develop a learning environment aligned with student needs and course requirements. The process comprises a series of iterative cycles, during which the learning environment is examined for potential issues. Based on this analysis, solutions to identified problems are designed, implemented, and reflected. The close cooperation between researchers, tutors, and students ensures that the developed solutions can be integrated into practice in a sustainable way. The first cycle of the DBR included interviews with the laboratory tutors. Based on the aforementioned results and course materials, an online examination was devised for students to complete prior to the laboratory course to ascertain that students possess the requisite prior knowledge. Additionally, the necessity for revising the script was identified through the interviews. Therefore, in addition to interviews with students, the creation of a digital script will be one of the next steps.

Log 230. INVESTIGATIONS OF ACTINIDE RADIONUCLIDE COUPLES FOR TARGETED ALPHA THERAPY .

Martelles, M. (1, P), Celis-Barros, C. (2), Albrecht, T. (1). (1) Colorado School of Mines. (2) Oak Ridge National Lab. (P) Presenting Author.

Targeted alpha therapy (TAT) has shown promising results for treating late-stage tumor cancers. This is due to alpha particles increased linear energy transfer compared to beta and gamma particles. Radioisotopes such as 225Ac, 213Bi, and 226Th, have been shown to exhibit desired properties such as fast kinetics and highly stable thermodynamics for TAT when chelated to various known ligands for heavy elements. Even with TAT growing in popularity for cancer treatment, a fundamental understanding of the bonding in these radionuclides remains unknown. This research is focused on investigations utilizing energy decomposition analysis (EDA) and thermodynamic calculations for enhanced insight into the bonding properties of the radionuclide and chelator to better understand the thermodynamics of these systems. Four metals, AcIII, BiIII, LaIII, and ThIV, were coupled with five different known targeted therapy chelators, DOTA, DEPA, Macropa, PyPA, and DTPA, some of which are currently used in clinical studies of TAT, to determine the trends and fundamental bonding differences between these 20 radionuclide chelator couples. The EDA results demonstrated that the electrostatic energy component in these complexes is dependent on the ligand. The orbital component, often expressed as the covalent interaction, is mainly dependent on the metal in the complex, not the ligand. Interestingly, when correlating the EDA and thermodynamic results, it was found that the thermodynamic stability of the complex better parallels the orbital energy component than the electrostatic interaction. Previously, time intensive thermodynamic calculations such as complexation free energy have not been graphed against more convenient EDA calculations.

Log 231. THIN-LAYER ELECTROCHEMICAL SENSOR DEVELOPMENT FOR PYROPROCESSING UNITS.

Williams, T. (1,P); Mercado, E. (1); Rappleye, D. (1). (1) Brigham Young University. (P) Presenting Author

Pyroprocessing units, such as the Mark-IV electrorefiner at INL, operate for decades with high analyte (e.g. uranium) concentrations, and growing concentrations of lanthanides and actinides. These conditions suggest the need for a sensor with (1) the ability to analyze solutions containing multiple species, (2) a broad range of measurable concentrations, and (3) quick measurement times. Thin-layer electrochemical sensors are a promising class of sensors that can fulfill each of these three requirements. Thin-layer electrochemical sensors isolate a miniscule volume of solution from the bulk solution and hold it in a very thin layer (<100 micrometers) next to an electrode. Voltametric peaks from such a sensor are much thinner than those for a typical macroelectrode, which naturally leads to a greater ability to analyze peaks from different analytes occurring at similar reduction potentials. Because bulk coulometry of the solution is available within seconds, these sensors are also able to measure both low and high concentrations of analyte with quick measurement times. While commercially available options for room temperature thin-layer electrochemical sensors are available, no such sensor for molten salt application is available. Here, efforts to produce a molten salt thin-layer electrochemical sensor are presented, and the sensor’s ability to accurately measure concentrations of uranium in fluoride and chloride salts is evaluated.

Log 232. DEVELOPMENT OF STABLE AND BUFFERED REFERENCE ELECTRODES FOR PLUTONIUM ELECTROREFINING IN BINARY MOLTEN CHLORIDE SALTS.

Mejia, C. (1, P); Rappleye, D. (1). (1) Brigham Young University. (P) Presenting Author.

The development of stable and buffered reference electrodes (REs) is crucial for molten salt electrochemistry, particularly in pyrochemical processing, such as electrorefining. These REs must maintain a stable potential to ensure precise control over electrorefining processes by preventing unwanted shifts in the potential that could lead to impurity deposition. This work evaluated metal chlorides and metal oxides as potential candidates for REs, with their stability assessed via electrochemical methods, including electrochemical impedance spec-troscopy (EIS), chronopotentiometry (CP), open circuit potential (OCP), and cyclic voltam-metry (CV), over extended durations in molten NaCl-KCl. While metal chloride-based REs exhibited stable potential behavior over time, their response followed the Nernst equation, leading to potential shifts with varying concentrations of oxidized species. Metal oxide-based REs were explored to address the need for both stability and concentration-independent potential. These REs demonstrated the ability to maintain a constant potential regardless of concentration changes. The concentration of metal oxide-based REs were based on the O2− ions, which was later confirmed through analytical measurements, such as back titration. The introduction of this metal oxide-based RE presents a promising ad-vancement for use in binary chloride molten salts, offering robust, stable performance in plutonium electrorefining and other applications within NaCl-KCl molten salt systems.

Log 233. RADIOANALYTICAL CHEMISTRY AND THE ANTHROPOCENE. Cundy, A.B.(1,P); (1) GAU-Radioanalytical, University of Southampton, and the Anthropocene Working Group. (P) Presenting Author.

The Anthropocene is the proposed geological epoch in which humans have become the dominant force on the planet, transforming our land, seas, air and climate and taking the Earth System into a new planetary trajectory and state. In the Anthropocene Working Group's 2023 proposal to recognise the Anthropocene as part of the geological timescale radioanalytical chemistry played a central part, with the base of the Anthropocene (co-incident with the beginning of the so-called "Great Acceleration" in human activity and global impact) being defined in a range of geological and biological materials (sediments, ice, corals etc.) on the basis of the marked increase in plutonium fallout activities following the Ivy Mike thermonuclear test in 1952, at the onset of the above-ground high-yield thermonuclear weapons testing programmes of the 1950s and 1960s. This presentation discusses the work undertaken by the Anthropocene Working Group in defining the base of the Anthropocene via finely-resolved Pu fallout chronologies at a range of sites around the globe, and, following rejection of the proposal to establish a GSSP (a Global Boundary Stratotype Section and Point) for a new formal geological Anthropocene epoch at Crawford Lake (Canada), examines "where next?" for the Anthropocene as a concept.

Log 234. Monitoring plutonium concentration in process solutions through UV-Vis spectrophotometry and multivariate analysis. Pellerin-Lefebvre, A.(1); Bailly, G.(1); Geoffray, G.(1); Clement, A.(1, P). (1) CEA, DAM, Valduc. (P) Presenting Author.

Reliable analyte quantifications are necessary for process control applications such as nuclear fuel recycling. Standard determination of plutonium concentration in nitric acid solutions, performed through UV-Vis spectrophotometry, requires chemical preparation such as complete oxidation to Pu(VI), reduction to Pu(III) or pH control before analysis, as the UV-Vis spectral response of Pu(IV) not only depends on Pu concentration but also on HNO3 concentration and the presence of interfering species. In order to limit chemical preparation, contaminated waste and operators' exposure, chemometrics provides a statistical approach to overcome the complexity of this whole system through multivariate analysis. This study applies a partial least square regression (PLS) model on various calibration sets including either labproduced solutions of set [Pu] and [HNO3] concentrations, process solutions or both, to get the best prediction on a validation set composed of a large range of process solutions. Model parameters are adapted in order to decrease errors and get the best fit between offline measurements and model predictions. The results show that the PLS model can get a reliable estimation of plutonium concentrations at the different process checkpoints, and identify outliers, provided that the solutions used to build the model are representative of process solutions in terms of [Pu], [HNO3] and fluoride concentrations. It confirms the potential of UV-Vis spectrophotometry coupled to multivariate analysis to be implemented for on-line measurements.

Log 235. THE FEASIBILITY OF HELIUM AS ADDITIONAL RADIOCHRONOMETRIC TECHNIQUE.
Shilling A. (1, P); Puxley, C (1); Harker, R. (1); Higginson, M. (1); Gilligan, C. (1); Dawkins B. (1); Kaye, P. (1). (1) AWE Nuclear Security Technologies. (P) Presenting Author.

Historically radiochronometry has focused on traditional radiochemical wet techniques to analyse parent-daughter pairs and provide a model age for actinide materials. The radiogenic ingrowth and evolution of helium with processing in actinide material could provide additional information about the date of last heat treatment or oxidation, adding a further tool to the radio-chronometric tool kit [1]. This talk will specifically focus on the Pu-He parent daughter pair, in both plutonium metal and plutonium dioxide samples. We will present recent analytical work applying the helium chronometer to materials of known provenance including certified reference material, to determine the feasibility of using this technique in specific areas of the fuel cycle and add context to the nuclear forensic toolkit. References: [1] M. Higginson, C. Gilligan, B. Dawkins, and P. Kaye, in Environmental Radiochemical Analysis VII, ed. N. Evans, Royal Society of Chemistry, London, 2023 ch. 4, pp. 43-49.

Log 236. RIMS ANALYSIS OF TAGGED URANIUM WITH APPLICATION TO INTENTIONAL FORENSICS. Shulaker, D.Z.(1, P); Raiwa, M.(1); Savina, M.(1); Isselhardt, B.(1); Marks, N.(1) (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Traditional nuclear forensics approaches leverage isotopic measurements for characterizing nuclear forensics signatures in fuel cycle materials. Recent research and development activities focus on adding isotopically perturbed transition metal taggants to fuel cycle materials to aid in provenance assessment. However, widely used isotope dilution mass spectrometry methods, such as thermal ionization mass spectrometry (TIMS) and multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS), require completely dissolving material and time-intensive chemical separation prior to analyses. Resonance Ionization Mass Spectrometry (RIMS) is a powerful analytical technique that has several advantages over other mass spectrometric techniques, such as TIMS or MC-ICP-MS. Firstly, RIMS has high spatial resolution and sensitivity. Secondly, RIMS discriminates against isobaric interferences by selectively ionizing only the elements of interest, eliminating the need for chemical separation of samples. Also, samples can be analyzed as solids or dried-down solutions. Here we present a case study for measuring uranium oxides that were tagged with isotopically perturbed Mo and W at different concentrations by RIMS. Micrometer-sized single particles were analyzed by RIMS at the laser ionization of neutrals (LION) laboratory at Lawrence Livermore National Laboratory. Approximately 5% uncertainties (at 2σ) were obtained for Mo, W, and U after ~7-minutes, ~20-minutes, and ~10 minutes, respectively. All Mo, W, and U isotopes were collected from each particle, with the entire particle remaining post-analysis. Ultimately, this method allows for accurately and precisely measuring taggant compositions in tagged uranium, enabling rapid and robust assessment of material provenance. LLNL-ABS-2001023

Log 237. REAL-TIME NEUTRON SOURCE LOCALIZATION USING THE NOMAD He-3 DETECTOR. Cannon, N.L. (1,2,P); Thompson, N.W. (2); Hutchinson, J.D. (2); Biegalski, S.R. (1); Erickson, A. (1); Nelson, M.A. (2). (1) Georgia Institute of Technology. (2) Los Alamos National Laboratory. (P) Presenting Author.

This work presents ongoing efforts to develop a real-time program for detecting the direction and general location of a neutron source using the NoMad detector, a 15-tube He-3 array. This program is part of a larger proof-of-concept system focused on real-time neutron multiplicity monitoring, with potential applications during fuel debris removal at Fukushima Daiichi units 1, 2, and 3. The approach employs a random forest regression model, which predicts neutron source locations by learning the relationship between neutron count rates from the NoMad detector and the corresponding source positions. For real-time implementation, the system is designed to continuously collect neutron count data across all 15 tubes of the NoMad detector, feeding this data into the trained model to estimate the neutron source's location. To manage transient variations in count rates, a sliding time window approach will be applied, while optimization efforts aim for low-latency computation to support on-the-fly source localization. The random forest algorithm’s capacity to manage the non-linear relationship between neutron count rates and spatial positions is expected to address challenges from fluctuating neutron backgrounds and noise in high-radiation settings. Results for source location accuracy, latency, and resilience to background radiation fluctuations will be presented. Beyond Fukushima Daiichi, this system will have applications in nuclear nonproliferation and accident response, where its ability to provide real-time source location information will aid in critical decision-making.

Log 238. RAPID QUANTIFICATION OF Pu IN SOLUTION: A NITRIC ACID ASSAY . Muscarella, K.B.(1,P); Adelman, S. L.(1); Carver, N. R.(1); Cava, A. J. (1); Jump, R. K.(1); Matonic, J. H.(1). (1) Los Alamos National Laboratory. (P) Presenting Author.

Assays that determine the purity of actinide materials are foundational to radioanalytical chemistry. Increasing the ease-of-use and reliability of current assay methodology has the potential to greatly reduce processing time while also increasing sample throughput. One current method for the analysis of Pu purity relies on the quantification of Pu3+ in aqueous hydrochloric acid (HCl) solutions using UV-Vis spectroscopy. While this assay method is reliable and rapid, HCl is highly reactive and corrosive, destroying containment vessels and the interior of stainless-steel gloveboxes. In addition, there is the potential for Pu colloid formation, which adds several cumbersome recovery steps. Our team sought to demonstrate an alternative method for Pu quantification that avoids these pitfalls. In this study, we will demonstrate the benefits of using nitric acid (HNO3) for dissolution and subsequent Pu quantification. Using this method, Pu is oxidized and held in a +6 oxidation state using a chemical oxidant, allowing for straightforward analysis with UV-Vis spectroscopy. Additionally, we will define the accuracy and precision of this Pu quantification method using HNO3. Finally, we will determine the stability of Pu under these conditions over the span of several months. Overall, the potential benefits of changing the matrix of this Pu assay method are decreased corrosion to work environments, increased stability of samples and standards, and better compatibility with other radioanalytical techniques.

Log 239. LEVERAGING SOLID-STATE TRACE ELEMENT ANALYSIS FOR PLUTONIUM-238.

Cava, A.J.(1,P); Matonic, J.H.(1); Jump, R.K.(1). (1) Los Alamos National Laboratory. (P) Presenting Author.

The identification and quantification of trace elements is vital to the many processes that involve actinide materials. This analysis is typically preceded by sample dissolution and cumbersome pre-analysis separations but is still further limited by the safety requirements to work with these materials. Direct Current Arc Atomic Emission Spectroscopy (DC Arc AES) allows for this assay to be performed on a solid-state analyte, addressing the previous obstacles and also introducing the capability for sample recovery. This work will lay out an overview of the methodologies and advantages that DC Arc AES provides for Plutonium 238 analysis. By tracing from the past into the future, DC Arc is an established and robust analytical technique capable of providing single digit ppm detection limits for common contaminants found in actinide materials while remaining a fast and accessible assay method. LA-UR-24-32112.

Log 240. DETECTION AND CHARACTERIZATION OF NUCLEAR MATERIAL PARTICLES USING LARGE GEOMETRY-SECONDARY ION MASS SPECTROMETRY .

Fauré, A.-L. (1,P); Cornaton, M. (1); Pointurier, P. (1) (1) CEA, DAM, DIF F-91297 Arpajon, France. (P) Presenting Author.

In the framework of nuclear safeguards, IAEA inspects nuclear facilities to check compliance with declared activities and possibly detect clandestine ones. Despite the strict precautions to confine nuclear materials inside a nuclear facility, some micrometre-sized fragments, so-called particles, coming from the processed nuclear material itself, are released and eventually settle onto surfaces. Those particles, that can be easily collected by IAEA inspectors, are considered as fingerprints of the nuclear material because of their isotopic and elementary compositions. Thus, particle analysis, which mainly consists in accurately determining the nuclear material isotopic composition at the particle scale, is a powerful technique for detecting clandestine nuclear activity without having direct access to the nuclear material itself. Thanks to its imaging capabilities, high sensitivity and lateral resolution, large geometry secondary ion mass spectrometry is perfectly suited to the detection and the characterization of these micrometer sized objects. The implemented methodology consists in two successive steps: nuclear material particles are first detected among all the other particulate matter, then individual particle analysis enables to determine their isotopic composition. Initially focused on uranium bearing particle characterization, appropriate hydride correction enables now to analyze plutonium bearing particles. This presentation emphasizes the capabilities of the automated particle measurement software, so-called APM, to detect and discriminate different types of nuclear particles. Then, we present the results of the isotopic measurements carried out on uranium particles, weapon grade plutonium particles, which contain a low 240Pu abundance, and mixed uranium plutonium oxide particles, with contain a low plutonium content.

Log 241. DETECTION AND CHARACTERIZATION OF PLUTONIUM BEARING PARTICLES USING LARGE GEOMETRY-SECONDARY ION MASS SPECTROMETRY AN ADDITIONAL TOOL FOR NUCLEAR SAFEGUARDS. Fauré, A.-L. (1,P); Cornaton, M. (1); Pointurier, P. (1) (1) CEA, DAM, DIF F-91297 Arpajon, France. (P) Presenting Author.

Particle analysis is considered as a powerful tool for detecting clandestine nuclear activity without having direct access to the nuclear material itself. It involves characterizing the nuclear material contained in the particulate matter collected by IAEA inspectors within nuclear facilities in the frame of the non proliferation treaty. Those particles are considered as fingerprints of the nuclear material because of their isotopic and elementary compositions. Thanks to its imaging capabilities, high sensitivity, lateral resolution and multi-collection device, large geometry secondary ion mass spectrometry is perfectly suited to the detection and the characterization of these micrometer sized objects. Initially, SIMS measurements were focused on uranium bearing particles. Due to the formation of hydride ions within the instrument during the ionization process, isobaric interferences, like 239PuH+ on 240Pu+, limit the accuracy of isotopic measurements of plutonium bearing particles. These limitations can be overcome by using appropriate hydride corrections. This presentation describes the methodology developed at CEA, which is based on the measurement of the hydride rate on uranium particles and its time dependant interpolation. This methodology was successfully applied for the accurate measurement of the 240Pu/239Pu isotopic ratio on weapon grade plutonium particles, which contain low amount of the 240Pu isotope, and on mixed uranium plutonium oxide (MOX) particles, with contain low amount of plutonium. Moreover, for MOX particles, we demonstrate the capabilities for measuring simultaneously the uranium and plutonium isotopic compositions and the 239Pu/238U ratio.

Log 242. DETECTING PERCENT LEVEL Pu IN U-BEARING PARTICLES BY SEM-EDS FOR NUCLEAR SAFEGUARDS APPLICATIONS. Wurth, K. (1, P); Tenner, T. (1); Naes, B. (1); LaMont, S.P. (1). (1) Los Alamos National Laboratory: C-NR. (P) Presenting Author.

For nuclear safeguards, several DOE supported programs rely on environmental sampling programs where particulate materials are analyzed for treaty compliance. A desired capability for environmental material characterization is detecting Pu intermixed in a predominantly uranium matrix at the particle level. Several methods exist to measure low abundances of Pu within uranium particles, mainly involving mass spectrometry. For such techniques however, several challenges exist including Pu heterogeneity at the particle level, isobaric signal interferences that overlap with U and Pu, complex sample preparation, and overall cost and timeliness of characterization. Previously, we demonstrated the ability to use scanning electron microscopy combined with energy dispersive spectroscopy to rapidly and nondestructively analyze single micron sized particles and to detect and quantify percent level abundances of Pu within particles consisting of uranium oxide using the relationship between Pu abundance and U M beta peak intensity, the ratio of 3.34keV peak intensity to 3.17keV intensity. This method overcomes the critical issue of spectral peak overlap between U M beta and Pu M alpha. We used this relationship in combination with mixed U, Pu test materials with known Pu abundances produced by Savanna River National Laboratory to develop a calibration curve for estimating percent level Pu level abundances within unknown U bearing particle samples. Here, we expand upon our initial work to reduce analysis time and error with a new and significantly upgraded SEM EDS system. With additional materials from SRNL, we enhance the initial calibration curve and compare our results to peak deconvolution methods. LAUR2432385.

Log 243. ASTM STANDARD PRACTICE C1845 USE AND MODIFICATION FOR RADIOCHEMICAL ASSAY OF HIGH BURNUP URANIUM FUEL.

Keever, T. J.(P); Roach, B. D.; Delashmitt, J. S.; Procop, G.; Zirakparvar, N.; Rogers, K. T.; Grant, C. B.; Hexel C.R.; Bevard, B. B; Giaquinto, J. M. Oak Ridge National Laboratory. (P) Presenting Author.

The separation of lanthanide elements from uranium matrices using high-pressure ion chromatography has proven to be a useful and efficient tool for the assay of high burn up spent reactor fuels when coupled with inductively coupled plasma mass spectrometry and isotope dilution mass spectrometry techniques. ASTM Standard Practice C1845 was issued as a practical guideline for on-line rapid separations of lanthanide elements using buffered alpha-HIBA and cation exchange columns. The effective separation and purification of the lanthanide and actinide series from uranium matrices further benefited from a modified elution scheme from the original standard practice, which resulted in better separation performance, greater resolution between peaks, and more stable retention times. The modified elution scheme also enabled plutonium assay from uranium and the ability to push uranium off to waste stream if desired. This change was particularly useful for purification in which elemental fractions were collected and analyzed using multi-collector ICP-MS (MC-ICPMS) or gamma spectroscopy. The Nuclear Analytical Chemistry Section at Oak Ridge National Laboratory received 16 of the 25 available “Sibling Rods” from LWR fuel as part of the High Burnup Spent Fuel Data Project with joint support from DOE-NE and the NRC. These spent fuels were digested, and high-precision radiochemical assay (HP-RCA) was performed. Several of the fuels examined had estimated burnups of 60-65 GWd/MTU. Chemical burnup determinations were assisted using the modified ASTM Standard Practice C1845. Modifications to this standard practice will be outlined for considerations for publication to ASTM subcommittee C26.05.

Log 244. DEVELOPMENTS IN THE USE OF GLOVE BAGS FOR CONVENTIONAL AND NUCLEAR FORENSIC ANALYSIS IN ACTIVE GLOVEBOXES.

Attwood, S. (1, P); Dunn, S. (1). (1) AWE Nuclear Security Technologies. (P) Presenting Author.

AWE possesses bulk actinide handling facilities to aid law enforcement in nuclear forensic investigations. The actinides analysis facility is responsible for the chemical analysis of bulk actinide samples in support of all key programmes at AWE and its therefore important to ensure the integrity of all samples is maintained. Current processes for this involve the segregation of work areas, samples, and exhibits, in addition to thorough cleaning and decontamination before and after analysis. To improve the workflow in a forensics investigation the introduction of glove bag technologies for exhibit handling within gloveboxes and fume cupboards has been developed. The addition of this would expand the capability and allow additional work areas and improve exhibit processing efficiencies, while maintaining the integrity of forensic samples and exhibits. This work focuses on the introduction of glove bag technologies to the actinides analysis facility and the recent developments to enhance the capability. Glove bags were initially introduced for basic sample and exhibit unpacking, however this has since been expanded to include further processing and maintaining sample integrity, through tasks such as size reduction, sample preparation for Non-Destructive Analysis, and dissolution for Destructive Analysis. More recently, development work has been carried out to integrate conventional and nuclear forensics on the most challenging samples. Conducting basic conventional forensic analysis techniques within the glove bags, mostly focussed on exhibit and fingerprint photography. Future work will continue in this area to look at additional fingerprint recovery options and enhanced photography.

Log 245. THE IMPACT OF ALPHA AND GAMMA IRRADIATIONS ON THE REDOX DISTRIBUTION OF PLUTONIUM IN ACIDIC MEDIA. Grimes, T.S.(1, P); Kynman, A.E.(1), Mezyk, S.P.(2); Holmbeck, G.P.(1). (1) Idaho National Laboratory. (2) California State University Long Beach. (P) Presenting Author.

Managing plutonium continues to play a critical role in the development of sustainable nuclear fuel cycles. However, fundamental understanding of plutonium's radiation-induced redox chemistry and associated impacts on nuclear fuel cycle recycling processes is limited. Radiolytically driven processes, which are unavoidable under fuel cycle conditions due to ionizing radiation from plutonium decay and various other radioisotopes generated by nuclear fission and neutron-capture processes, can lead to oxidation state changes which influence plutonium speciation and complicate the desired transport of plutonium in recovery schemes. For efficient and cost-effective plutonium management, oxidation state control is essential since the separation and recovery is typically achieved by the selective formation, maintenance, and complexation of specific oxidation states. Therefore, mechanistically understanding the response of plutonium's multiple oxidation states to multi-component ionizing radiation fields is essential for predicting the behavior of this critical element under used nuclear fuel reprocessing conditions. In this study, in situ alpha and ex situ cobalt-60 gamma irradiations are applied to plutonium in various oxidation states under acidic conditions to facilitate further development of an experimentally verified predictive multiscale computer model, to both advance understanding of radiation-induced plutonium redox chemistry and to improve plutonium management strategies in the future.

Log 246. NEUTRON AND X-RAY COMPUTED TOMOGRAPHY OF A NATURAL URANIUM TRISTRUCTURAL ISOTROPIC (TRISO) FUEL COMPACT. Chuirazzi, W.C. (1,P); Zhang, Y. (2); Morankar, S.K. (1). (1) Idaho National Laboratory. (2) Oak Ridge National Laboratory. (P) Presenting Author.

Tristructural isotropic (TRISO) fuel consists of sub-millimeter diameter uranium-bearing fuel kernels encapsulated in layers of carbon and ceramic materials. A fuel compact consists of thousands of these individual microspheres dispersed within a carbon or ceramic matrix. During the post-irradiation examination process to assess materials' performance in harsh environments of nuclear reactors, X-ray computed tomography (XCT) has been employed to volumetrically image unirradiated and irradiated TRISO particles and compacts nondestructively. Computed tomography of fuel compacts can provide quantitative data, such as particle sphericity and location in the matrix, which can aid fuel design and evaluation by providing inputs for models or informing traditional destructive examinations. In XCT the fuel kernels within compacts create imaging artifacts due to uranium's high attenuation of X-rays. These artifacts can obscure features in the compact's matrix, such as cracks. Neutron computed tomography (nCT) was performed on a compact containing natural uranium particles at the MARS (CG-1D) beamline at Oak Ridge National Laboratory's High Flux Isotope Reactor (HFIR). A proof-of-principle study was conducted to observe if nCT could provide more detailed information on the compact's matrix since uranium does not attenuate neutrons in a manner that introduces artifacts as in XCT. Both XCT and nCT were performed on the same unirradiated compact and compared to determine which techniques were most suitable for emphasizing different features as correlating data from both techniques provides more comprehensive data on the compact. Lastly, a discussion on future work of applying neutron imaging techniques to irradiated compacts and materials is included.

Log 247. LASER-INDUCED BREAKDOWN SPECTROSCOPY FOR REAL-TIME ELEMENTAL AND ISOTOPIC ANALYTICAL MEASUREMENTS FOR MOLTEN SALT REACTORS.

Andrews, H.B. (1,P); Kitzhaber, Z.B. (1); Orea, D. (1); McFarlane, J. (1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Online monitoring is a key challenge for the continued development of molten salt reactor (MSR) technology. Laser-induced breakdown spectroscopy (LIBS) has previously been demonstrated to be a viable tool for monitoring aerosolized species and noble gases in real-time, but the ability to discern varying isotopes in these streams has not yet been investigated for MSR applications. Tritium will form in MSRs from ternary fission and from (n,α) reactions occurring in lithium-containing salts. This work presents LIBS used to monitor the elemental composition of a molten salt and corresponding hydrogen isotopic shifts in real time. Initial experiments used a nitrate salt saturated with protium and deuterium gases, then the effluent aerosol stream formed using an argon sparging vessel was monitored with LIBS. This modular LIBS system permitted several spectrometers to be used simultaneously to capture high-resolution isotopic shifts and provide broadband elemental coverage. The results exhibit how LIBS can be used to understand salt–gas chemical and physical interactions such as diffusion. Furthermore, LIBS' broad elemental coverage can provide greater insight into the chemical reactions within the salt vessel, such as the formation of water vapor by monitoring hydrogen and oxygen signatures simultaneously. Ultimately, this study demonstrates the analytical possibilities of LIBS for real-time monitoring of isotopes and elemental composition in molten salt systems.

Log 248. ELECRTHERMAL VAPORIZATION AS A NEW METHOD FOR PRE-INSPECTION CHECK SAMPLES.

Hexel, C.R. (1,P); Manard, B.T. (1); Thompson, C. (1); Zirakparvar, N.A. (1); Metzger, S.C. (1); Adkisson, M.L. (1); Dunlap, D.R. (1); Parihk, J.H. (1); Springer, K.W. (1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Electrothermal vaporization (ETV) presents a promising yet underutilized technology for nuclear safeguards and pre-inspection check (PIC) sample analysis, particularly suited for low-level isotopic quantification due to its high analyte transport efficiency. This study introduces an automated, commercial off-the-shelf (COTS) ETV system for PIC safeguard analysis, demonstrating its capability for rapid and sensitive isotopic detection. The ETV method effectively integrates with mass spectrometry platforms, enabling simultaneous determination of uranium assays and major isotopic ratios for both uranium and plutonium. This approach exhibits exceptional sensitivity, with a detection limit (LOD) as low as 250 fg of uranium and a limit of quantification (LOQ) down to 2.5 pg. The application of isotope dilution techniques has further enhanced reproducibility, allowing accurate quantification of uranium at levels of 50 pg. The ETV-MC-ICP-MS method demonstrates reliable detection of uranium isotopes, including 235U and 238U, at femtogram quantities, with effective performance across a wide mass range from 2.5 pg to 4.5 µg. The method achieved precise 235U/238U isotope ratio measurements with an average deviation of less than 2% across replicates. This novel ETV-based methodology offers a versatile and efficient analytical option for nuclear safeguards, combining high sensitivity, rapid analysis, and broader isotopic detection capabilities.

Log 249. MOBILE SYSTEMS FOR NEUTRON GAMMA ANALYSIS OF SOIL ELEMENTAL CONTENT. Yakubova, G. (1,P), Kavetskiy, A. (1), Gautam, S.S. (1), Prior, S.A. (1), Torbert, H.A. (1). (1) USDA-ARS National Soil Dynamics Laboratory (P) Presenting Author.

Two main types of neutron-gamma analysis systems are currently being developed for determining soil elemental content in the field: Pulsed Fast/Thermal Neutron Analysis (PFTNA) and the Tagged Neutron Method (TNM). Both the PFTNA and TNM mobile systems were constructed and are now used for routine field measurements. The PFTNA system includes a pulsed portable MP320 neutron generator, three NaI gamma detectors (total volume of 7.5 dm3), Vega board split electronics for powering gamma detectors and separately acquiring inelastic neutron scattering (INS) and thermal neutron capture (TNC) gamma spectra, a neutron detector, biological shielding, a power system, and an operational laptop. The TNM system uses an API 120 neutron generator with a built-in alpha detector (YAP scintillator and PMT), a LaBr gamma detector (diameter of 89x203 mm), a 4-channel digital pulse Pixie-Net processor in desktop format with an integrated Linux operating system for detecting radiation in the coincidence mode, a neutron detector, biological shielding, a power system, and an operational laptop. Both systems were constructed on mobile platforms with a GPS module and are suitable for both laboratory and field measurements in static and scanning modes. The design of both systems, their geometrical and electrical schemes, working diagrams, examples of measured gamma and timing spectra, and measurements results (i.e., soil elemental distribution maps for the PFTNA system, soil spectra deconvolution of elemental components for the TNM system, and comparison of measurement results to other methods) will be presented in a poster for detailed discussions.

Log 250. IN-SITU NEUTRON GAMMA ANALYSIS OF SOIL. Kavetskiy, A. (1,P), Yakubova, G.(1), Gautam, S.(1), Prior, S.A.(1), Torbert, H.A.(1). (1) USDA-ARS National Soil Dynamics Laboratory. (P) Presenting Author.

Neutron gamma analysis can serve as a good alternative to the labor-intensive and time-consuming soil chemical analysis approach. Neutron gamma analysis is a non-destructive, in-situ, relatively fast, and radiation-safe method. This method is based on extracting soil elemental content from measured neutron-stimulated gamma spectra. Two main approaches were currently developed for determining soil elemental content: Pulsed Fast/Thermal Neutron Analysis (PFTNA) and the Tagged Neutron Method (TNM). Due to the use of pulsed neutron flux in PFTNA, the simultaneous and separate measurement of inelastic neutron scattering (INS) and thermal neutron capture (TNC) gamma spectra allows for measuring gamma peaks attributed exclusively to soil elements such as carbon, silicon, iron, and hydrogen. Soil elemental content is defined using calibration dependencies. In the TNM method, gamma spectra are measured in the alpha-gamma coincidence mode. The deconvolution of these spectra (based on using reference sample spectra) provides the mass fraction content of primary soil oxides (e.g., SiO_2, Al_2O_3, Fe_2O_3, and CaO) along with carbon and water. Both the PFTNA and TNM mobile systems were developed and constructed for current routine field measurements. The PFTNA system's capability of determining and mapping soil carbon content has made it a valuable tool in the emerging carbon credit market. The TNM system can be used for the determining both soil elemental content and soil texture in basic soil science research and modern agricultural practice assessments. Details of PFTNA and TNM and their applications will be reported and discussed in this presentation.

Log 251. PROCESSING SIGNATURES OF URANIUM ORE CONCENTRATE PRECIPITATIONS.

Daniel E. Felton (1,P), Keith L. Ringley (1), Andrew J. Miskowiec (1), Tyler L. Spano (1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Uranium ore concentrates (UOCs) are uranium phases formed from mining, milling, leaching, and precipitation in the front end of the nuclear fuel cycle. The predominant UOCs produced in industrial settings are uranyl peroxide, ammonium uranyl carbonate, and ammonium diuranate. Although these processes are well established and have been employed for decades, some of the underlying chemistry behind the precipitations is not well understood. Additionally, recent work on ammonium diuranate has shown that long held structural assumptions are not true, highlighting a need for a better understanding of the material. This work is a dual effort to study the kinetics of UOC precipitations as well as to determine how changes in the processing parameters may produce forensic signatures. This work focuses on the differences in spectroscopic and crystallographic signatures caused by changes in temperature, stir rate, and strike direction of the precipitation reaction. Sample heterogeneity is also examined using a variety of spatially resolved analytical techniques. Additionally, changes in trace elemental composition and uranium isotope ratios of the samples are discussed. The kinetics of the solution are reported based on in situ Raman and near-infrared spectroscopy measurements of the solutions.

Log 252. MOLTEN SALT ELECTRODEPOSITION OF METALLIC ZIRCONIUM COATINGS ON URANIUM NITRIDE.

Chamberlain, J. (1,P); Patenaude, H. (1); Terricabras, A. (1); Batrice, R (1); Coons, T. (1); Monreal, M. (1). (1) Los Alamos National Laboratory, (P) Presenting Author.

This work presents a method for electrodepositing a homogenous protective zirconium coating onto a uranium nitride (UN) substrate using molten salt electrodeposition. Uranium nitride is a strong candidate fuel for nuclear reactors and nuclear thermal rockets. These UN fuels are subjected to multiple cycles of high-temperature operation. To improve their stability and containment during operation, a protective zirconium coating can be deposited onto the UN. Electrodeposition was conducted in a molten fluoride salt system with the UN oriented as the working electrode the crucible oriented as the counter electrode. A controlled current program was applied to reduce the precursor to metallic zirconium onto the UN. Post-electrodeposition characterization of the UN and coating included Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS) and X-ray Computed Tomography (XCT). This characterization suite was used to characterize the adhesion of the coating substrate interface and estimate the thickness of the coating. The electrochemical cell setup, electrical parameters and mechanism of deposition are all evaluated to optimize the zirconium coating.

Log 253. RADIOIODINE SPECIATION IN PYROPROCESSING RESEARCH AND DEVELOPMENT.

Brookhart J. (1,P), Fredrickson G.(1), Holschuh II T.(1), Snow M. (1). (1) Idaho National Laboratory. (P) Presenting Author.

Pyroprocessing is an ideal approach for reprocessing metallic nuclear fuels from fast breeder reactors. INL has engaged in pyroprocessing research since the 1980's as a potential method to prepare legacy spent fuel for long term geological storage. Despite decades of research and operations in several pilot scale pyroprocessing facilities around the world, including the Fuel Cycle Facility (FCF) at Idaho National Laboratory, numerous scientific questions remain regarding the fundamental mechanisms of actinide and fission product dissolution, diffusion, electrodeposition, and chemical speciation. Regulatory frameworks for the commercial licensing of these facilities necessitate a thorough understanding of off-gas chemical speciation. Recent environmental modeling efforts indicate that the decontamination factors required for facility licensing are species-dependent, particularly for radioiodine. Mass balance data for electrorefiner eutectic salt fission product concentrations at FCF suggest quantitative retention of radioiodine in the electrolyte; however, the measurement uncertainties of that previous work exceed the decontamination factors required if iodine reporting to the gaseous waste stream is primarily particulate-bound. This research aims to address the question of pyroprocessing off-gas iodine speciation through the evaluation of FCF hot-cell HEPA filter and electrorefiner salt samples, alongside direct headspace measurements in INL's molten salt electrorefiner testbed. Tests will include cold surrogates and simulated fast neutron fuel through photofission of depleted uranium. In these experiments, carrier argon is measured directly by TQ-ICP-MS and gas-phase Fourier-transform infrared spectroscopy (FIR). This setup is intended to directly correlate voltametric measurements with elemental identification and limited optical spectroscopy to identify general off-gas constituents and their speciation.

Log 254. NEW INNOVATIVE DEVELOPMENT AT PENN STATE BREAZEALE REACTOR: COLD NEUTRONS SOURCE INSTALLATIONS AND UTILIZATIONS.

Unlu, K. (1, P), Beck, D. (1). (1) Penn State Nuclear Engineering, Radiation Science & Engineering Center. (P) Presenting Author.

A third generation mesitylene moderated cold neutron source called PSU-CNS has been designed, installed and tested at the Breazeale Nuclear Reactor (PSBR) at the Radiation Science and Engineering Center at Penn State. The PSU-CNS is positioned within one of the newly installed beam ports at the PSBR. The main components of the PSU-CNS are a cold source cryocooler and neutron guide system. Components of the cold source cryocooler system are a vacuum system, helium circulating and buffer system, compressor system, and mesitylene moderator. Circulating helium lines are attached to a cryocooler used to cool and maintain cold temperature of the mesitylene moderator using the method of forced flow helium gas circulated between the refrigeration unit. A helium loop cools and maintains a cold neutron mesitylene moderating material at about 20 K in a 10 cm diameter aluminum chamber located inside the D2O tank of the PSBR. The cold neutrons coming from the mesitylene chamber are transported out of the biological shield of the reactor with three supermirror neutron guides. The three in-pile guides extend to out-of-pile guides with several different neutron guide sections with straight guides, beam benders, and parabolic focusing guides with different surface coatings. The cold neutron beams will be utilized for a small angle neutron scattering, conventional and TOF neutron depth profiling, and a prompt gamma activation analysis facility. Some of the design, installation, and testing features of the PSU-CNS and intended utilizations of the three cold neutron beams will be discussed

Log 255. HIGH PURITY U-233 PRESERVATION UPDATE 2025. Partridge, J.(1,P); Couch, J.(1); Delashmitt, J.S.(1); Wightman, C.(1); Warne, M.(1); Meadows, H.(1); Skidmore, B.(2). (1) Chemical Sciences Division Oak Ridge National Laboratory. (2) Radioisotope Science and Technology Division Oak Ridge National Laboratory. (P) Presenting Author.

Nuclear Analytical Chemistry and Isotopics Laboratory (NACIL) at Oak Ridge National Laboratory has provided many different radioanalytical services. A few of these services were for environmental, medical isotope, nuclear fuels characterization, isotopic production analysis, and batch processing of U-233. The preservation of U-233 by converting materials of a similar isotopic purity has been important for several different applications. Isotopically the U-233 material ranges from 99.5-99.996% which has been important for accurately characterizing uranium when used as a certified reference material (CRM), and the Th-229 recovered from U-233 has been used as an operational Th/Ac generator where Ac-225 has been used in targeted alpha therapy. Since 2010, several batches of U-233 with similar isotopic purity have been converted into a stable oxide to preserve the material for future use. After a four-year hiatus, the processing of U-233 has resumed. The latest U-233 batch includes the return of previously preserved material to milk the Th-229 for the creation a new Th/Ac generator.

Log 256. SINGLE-CRYSTAL CHEMICAL VAPOR DEPOSITION (SCVD) DIAMOND RESPONSE TO FAST-ENERGY NEUTRONS. Nowicki, S. (1, P); Wender, S. (1); Perello Izaguirre; J. (1) Los Alamos National Laboratory. (P) Presenting Author.

There are several challenges to designing a neutron detector for space due to the harsh environment of space such as extreme vacuum and temperatures as well as radiation exposure due to lack of atmosphere. Galactic cosmic rays (GCR - mostly high-energy protons, as well as heavy ions), and solar energetic particle (SEP – primarily protons) constitute the primary natural deep space radiation environment. In addition, in Low Earth Orbit (LEO), there is trapped radiation (protons and electrons) and on the surface of the Moon or Mars, high energy charged particles interact with the soil due to thin atmosphere and undergo nuclear reactions which produce secondary particles such as neutrons and gamma rays. Single-crystal chemical vapor deposition (SCVD) diamond detector material has gained interest in nuclear fusion technology such as d-d and d-t plasma reactors, and nuclear reactor technology due to excellent thermal and mechanical robustness, high radiation hardness, high efficiency, and excellent spectroscopic properties. Due to the harsh nature of the space environment, SCVD diamond has also gained our attention. Recently, we have been evaluating the response of a commercial-off-the-shelf (COTS) SCVD diamond detector to fast neutrons and we present our results here.

Log 257. CHARACTERIZATION OF SALTS, CRUCIBLES, AND METALS WITH GAMMA AND NEUTRON METHODS. Egozi, C.(1, P); Wenz, T. R.(1); Akin, A. C.(1); Tandon, L.(1). (1) Los Alamos National Laboratory. (P) Presenting Author.

Within the Plutonium Facility (PF-4) at LANL, various materials containing special nuclear materials, including Plutonium Metal Anodes (PMAs), and Electrorefining (ER) and Molten Salt Extraction (MSE) salts and crucibles need to be quantified. Nuclear material accountability requires certain accuracy and precision on data, so for the first time in decades, a campaign of measurements was done on these materials to determine the optimal measurement technique. Each method (Thermal Neutron Counter (TNC), Passive/Active Neutron coincidence counter (PAN1), neutron multiplicity, far-field gamma) was compared to calorimetry – considered to be the most accurate nondestructive assay method. However, this requires 12 hours for data acquisition and a gamma measurement, which necessitates an attenuation correction factor. Far-field gamma involved performing a 1200 second measurement with an HPGe detector. One of the benefits of neutron measurements is that unlike gamma rays, neutrons are unaffected by attenuation. TNC results were compared to calorimetry, as well as a separate multiplicity detector, and PAN1. Long count times were required for good statistics on salts, due to their (α,n) reactions complicating results. Completing the measurement campaign was a time-consuming process, including waiting for items to be taken out of line for calorimetry measurements, as well as waiting for the production of enough items within the desired mass range. The ultimate intent of this campaign was to determine the feasibility of measuring all items on the in-line TNC. All items were confirmed to fall within accuracy and precision requirements; therefore, in-line TNC measurements are feasible. LA-UR-24-32457

Log 258. DEVELOPMENT OF NOVEL CHEMISTRY TECHNICS AND DOPING METHODS FOR ADDITION OF RADIONUCLIDES TO NIF CAPSULES. Huynh, T.L. (1, P); Despotopulos, J.D. (1); Kmak, K.N. (1); Reynolds, R. (1); Braun, T. (1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

The National Ignition Facility (NIF) at Lawrence Livermore National Laboratory is a leading research center for Inertial Confinement Fusion (ICF). In ICF shots, a high-density carbon (HDC) capsule filled with deuterium and tritium (DT) is subjected to extreme densities and temperatures from 192 high-energy laser beams. The resulting DT fusion generates alpha particles and a substantial yield (currently up to 1e18) of 14.1 MeV neutrons in a short pulse (~100 ps). Material on the inside of the HDC capsule sees large neutron fluxes (ranging from 1e28 to 1e34 n/s/cm^2), allowing precise cross-section measurements with minimal target material (~1e13 atoms). This unique environment allows for study of nuclear reactions difficult to investigate in conventional nuclear reactors or particle accelerators. To utilize NIF's capabilities for cross-section measurements, target materials are doped to the inner surface of the 2-mm diameter HDC capsules via the tiny 10 µm fill hole used for DT fuel injection. Dopants must be ultrapure and small in volume; total capsule volume is approximately 3 µL, and contaminants (e.g. salts) can obstruct the fill hole. Two doping systems were developed: the Automated Robotic Injection System for Targets (ANDARIST), which microinjects materials, and the Vacuum Optimized Radionuclide-to-Capsule Administer for NIF (VORCAN), which uses a vacuum to draw liquid into the capsule. New radiochemical techniques have been developed to meet the purity requirements for capsule doping and ensure precise quantification of the dopants as required for post-shot analysis.

Log 259. CHALLENGES IN PRE-DETONATION NUCLEAR FORENSIC ANALYSIS. DiBlasi, N.A.(1); Hampton, S. (2, P); Worsham, E. (3); Galyean, A. (1) (1) Los Alamos National Laboratory. (2) National Nuclear Security Administration. (3) Lawrence Livermore National Laboratory. (P) Presenting Author.

The U.S. Department of Energy (DOE) National Nuclear Security Administration (NNSA) is the lead organization for a multi-lab capability whose responsibility is to provide analytical chemistry investigations of special nuclear material found outside of regulatory control, also known as pre-detonation technical nuclear forensics. Central to the development and success of pre-detonation nuclear forensics' functions is the ability to identify, characterize, evaluate, and relate nuclear material origins and processes to material samples. This mission is achieved through the efforts and tasks implemented by a specific program where a large suite of forensically valuable nuclear materials produced and located at all DOE/NNSA sites are identified, recorded, preserved, and analyzed. Through this program, pre-detonation nuclear forensics capabilities have encountered, grappled with, and overcome many analytical challenges unique to the pre-detonation nuclear forensics realm. This presentation will discuss many of these challenges, including avenues identified for solutions, current research thrust areas, and challenges that remain open questions for the future.

Log 260. DEVELOPMENT AND USE OF HIGH PRECISION HOT CELL FUEL DISSOLUTION PROTOCOL. Canaan, D. (1); Couch, J.(1, P), Delashmitt, J. (1); Guy, J. (1); Meadows, H. (1); Parker, B. (1); Partridge, J. (1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

The Nuclear Analytical Chemistry (NAC) Section of the Oak Ridge National Laboratory has built a reputation as a leading organization for performing high precision characterization of spent nuclear fuels. These projects include ORNL's Post Irradiation Examination (PIE) Plan for Full Length Mixed-Oxide (MOX) Fuel Rod Examination, ORNL's re-evaluation of Spent Nuclear Fuel Assay Data for the Three Mile Island 1 Reactor, and most recently ORNL's Sister Rod Destructive Analysis Plan. These characterizations provide a better understanding of nuclear safety, waste processing, computational modeling, and validation of burnup calculations (Roach, et.al. 2022). The NAC's Transuranium Analytical Laboratory (TAL) Group contributes to these projects by completing the first step in this process, the hot cell dissolutions. This analytical process involves the quantitative dissolution of designated fuel segments in a shielded hot cell for high precision measurements of select fission products and actinide isotopes employing isotope dilution mass spectrometry (IDMS) among other analyses. Over the past decade, the TAL has developed a robust dissolution apparatus capable of withstanding the high radiation generated by spent nuclear fuels while also minimizing cross contamination in a hot cell or glovebox environment. The design of the dissolution apparatus and analytical protocol used to ensure complete recovery of all isotopes quantified for these projects will be discussed.

Log 261. MELT CRYSTALIZATION TOWARDS THE SEPARATION OF FISSION PRODUCT CESIUM FROM ALKALI SALTS. Tolman, K. (1, P); del Rocio Rodriguez Laguna, M. (1). (1) Idaho National Laboratory. (P) Presenting Author.

High-temperature molten salt processes containing nuclear materials will contain fission products with high halide affinity. This work focuses on recovering Cs+, a high-yield fission product, from two different salt matrices (CsCl-LiCl-NaCl-KCl and CsF-LiF-NaF-KF). The separation and recovery of cesium can benefit waste-stream minimization because Cs-137—a strong gamma-ray emitter (661.66 keV)—is a potential source of environmental contamination. A laboratory-scale crystallization apparatus was used to fractionally melt samples, allowing the collection of a liquid fraction for analysis and determined that cesium can be concentrated in the liquid phase during melt-crystallization. Results were obtained from high-temperature X-ray diffraction, inductively coupled plasma mass spectrometry, differential scanning calorimetry, and thermodynamic modeling. The high temperature X-ray diffraction revealed that the addition of 10 weight percent Cs-salt crystallized as a CsLiX2 compound, consistent with the predictions of the thermodynamic calculations. All results demonstrated that Cs+ in the system concentrates in the liquid phase and confirmed the viability of recovering purified salt through thermally controlled solid-liquid separation. This investigation highlights how chloride-based salts and fluoride-based salts have the potential of employing melt-crystallization to effectively separate cesium from alkali salt matrices.

Log 262. DETERMINATION OF CHELATING AGENT CONCENTRATION FOR MINIMIZING RADIONUCLIDE MIGRATION IN RADIOACTIVE WASTE DISPOSAL FACILITIES. Cha, G.Y.(1, P); Shin, H.(1); Son, J.(1); Yun, J.W.(1). (1) Korea Radioactive Waste Agency. (P) Presenting Author.

Chelating agents are primarily used in nuclear decontamination because they form selective and strong complexes with numerous radionuclides. Disposal of environmentally persistent chelating waste without pre-treatment to remove the chelating agents increases the rate of radionuclide migration from the waste disposal site. Korea Radioactive Waste Agency(KORAD), which is a quasi-governmental agency that dedicated nation operator for the safe and stable operation of low-and-intermediate level radioactive waste(LILW) management facilities, limits the chelating agent content in radioactive waste considering the radionuclides inventory and geochemical disposal environment. Especially, the most common aminopolycarboxylic acid chelating agents, EDTA(ethylenediaminetetraacetate), NTA(nitrilotriacetate), and citrate, binds to radionuclides and alter the adsorption and dissolution characteristics of engineered and natural barriers, while cellulose (e.g. paper, cotton, wood) also decompose into isosaccharinate under the strong alkaline hydrolytic conditions of cement disposal facility, promoting the migration of radionuclides. Here, we present chelating agent content criteria based on the evaluation of the radionuclide adsorption reduction index, and analysis methods such as UV-Vis spectroscopy and chromatography, and utilize the analytical results to introduce recent advances in modeling and statistical methodologies for unanalyzed radioactive waste to demonstrate that the chelating agent concentration in the field meets the criteria for minimizing the adsorption reduction effect.

Log 263. INELASTIC NEUTRON SCATTERING TO PROBE WATER ENVIRONMENTS OF U(IV) AND Th(IV) OXALATE HYDRATES. Barth B.S. (1, 2, P), Daemen L. (1), Peruski K.M. (1), Hunt R. (1), Chen S.A. (1), Burns P.C. (2), Miskowiec A. (1), Spano T.L. (1). (1) Oak Ridge National Laboratory. (2) The University of Notre Dame. (P) Presenting Author.

Tetravalent actinide oxalates are common intermediates in the nuclear fuel cycle, often produced via precipitation from solution en route to production of actinide oxide or metal. Despite their commercial significance and relevance to the nuclear fuel cycle, much about these compounds remains unexplored. For example, the crystal structures of Th(IV) and Pu(IV) oxalate hexahydrates were first reported in 2023 along with reevaluations of the previously published structures of the isostructural U(IV) and Np(IV) oxalate hexahydrates. However, the locations of hydrogen atoms of the water molecules were not resolved because of the large electron density differences between the actinides and H atoms. Because these actinide oxalate compounds exhibit a change in the coordination geometry of the oxalate ligand corresponding to their dehydration, understanding the role of coordinated and interstitial waters in these structures is important. Inelastic neutron scattering is useful for probing the H bonding and vibrational modes of water molecules in these hydrated structures because it is highly sensitive to hydrogen and not constrained by selection rules like Raman and infrared spectroscopy. We performed inelastic neutron scattering on a series of U(IV) and Th(IV) oxalates of varying hydration states and present the full vibrational spectra of these compounds along with comparisons of this experimental data with modeled inelastic neutron scattering spectra. Using a combination of experimental and theoretical methods, we provide new insight into the structure of tetravalent actinide oxalates and their spectroscopic features.

Log 264. SELECTIVE SEPARATION OF Es-254 FROM OTHER ACTINIDES AND IMPURITIES. Du, M. (1, P). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Oak Ridge National Laboratory's 252Cf program produces hundreds of milligrams of 252Cf (t1/2 = 2.65 years), tens of milligrams of 249Bk (t1/2 = 330 days), micrograms of 254Es (t1/2 = 276 days), and picograms of 257Fm (t1/2 = 100 days) every 2 years. In the past 55 years, the heavy actinide production route at Oak Ridge National Laboratory involved irradiation of the heavy Cm target for 6 months, target cooling for 3 months, primary chemical separation in the hot cells for 7 months that involves cation exchange columns containing a water-soluble α-hydroxyisobutyric acid (CX-AHIB process), and then final separation/purification of specific heavy actinides in respective glove boxes for nearly 3 months using small CX-AHIB columns. Since 2018, efforts have been made to improve the final separation/purification of specific heavy actinides in glove boxes by replacing the current CX-AHIB process with simpler but more-efficient methods to obtain individual heavy actinide products of higher purity. First success was for 249Bk (presented in MARC XII) and recently a new procedure for 254Es purification has been developed and used in the Campaign 80 (2023), achieving a historic high recovery of purified 254Es in a shorter processing period. This presentation will compare the new method with the original CX-AHIB process. The required operational conditions and controlling parameters toward a better 254Es separation/purification will be discussed.

Log 265. DEVELOPMENT, CLINICAL APPLICATION OF AN IN VIVO NEUTRON ACTIVATION ANALYSIS SYSTEM FOR Na STORAGE AND HYPERTENSION STUDY. Yue, S. (1, P); Nie, L.H. (1). (1) Purdue Univeristy, West Lafayette. (P) Presenting Author.

Our lab developed a novel in vivo neutron activation analysis (IVNAA) system using a DD neutron generator for sodium (Na) measurement in bone and soft tissue, which are considered more important compartments for Na storage, and to investigate their association with blood pressure and dietary Na intake. A new moderator design was introduced to enhance thermal neutron flux, hence improve system sensitivity. It was predicted by Monte Carlo simulations and verified experimentally. Na dietary intervention experiments were conducted using two pigs. A compartmental model based on the internal dosimetry theorem was developed to determine bone and soft tissue Na concentrations and biokinetics. Human experiments were then conducted at the University of California, San Diego. Simulations predicted a 68% increase in thermal neutron flux for the same neutron dose, further improved to 85% with a 4% increase in neutron dose. Neutron experiments showed higher gamma counts with reduced neutron and photon doses. Animal studies revealed significantly higher soft tissue Na concentrations in pigs on a high-Na diet (1057.08 ± 43.62 ppm vs. 704.46 ± 45.60 ppm; $p = 0.007$), while bone Na concentrations remained unchanged. Similar trends were observed in humans. The IVNAA system shows great potential for in vivo studies of human Na biophysics, offering valuable insights into the relationship between Na intake, storage, and hypertension.

Log 266. A NUCLEAR FORENSIC ANALYSIS OF A HISTORICAL Ra-226 PIGMENT SAMPLE. Garcia, J.R. (1,2,3,P); Bond, E.M. (3); Folden III, C.M. (1,2). (1) Department of Chemistry at Texas A&M University. (2) Cyclotron Institute at Texas A&M University. (3) C-NR at Los Alamos National Laboratory. (P) Presenting Author.

226Ra was identified as a threat in nuclear terrorism events by the IAEA in 2008 for potential usage in RDDs. In the field of nuclear forensics, literature regarding 226Ra radiological samples is nonexistent; thus, this work aims to perform a radiochronometric analysis of a historical 226Ra pigment sample, a popular product from the watch dial industry. As part of this analysis, the pigment sample age will be determined by measuring absolute quantities of 226Ra and daughters 210Pb and 210Po. Chemical procedures were developed from the ground up, given the nature of the understudied 226Ra pigment matrix from historical recipes. Preliminary results of developed procedures and analyses will be discussed. This presentation will discuss using a 224Ra mock pigment sample for all preparatory work to analyze the historical 226Ra pigment sample. Thus far, the mock sample was created containing 224Ra, 212Pb, 209Po, 207Bi, 133Ba, and 65Zn radiotracers and has been successfully dissolved in solutions containing phosphonium and ammonium salts. Furthermore, column chromatographic separations using Chelex-100 resin have successfully separated radiotracers from complicated matrices. Additionally, the auto-deposition properties of trace amounts of Po on Ni foil were advantageous when recovering and assaying 209Po. These developed methods were used to validate the known age of the mock 224Ra pigment sample. Furthermore, these analysis methods were used to date a historical 226Ra pigment sample with an unknown production history. These results aim to pioneer future nuclear forensic analyses for 226Ra radiological samples.

Log 267. ACTINIDE ELEMENTAL RATIOS OF SPENT NUCLEAR FUEL SAMPLES BY RESONANCE IONIZATION MASS SPECTROMETRY. Isselhardt, B.H. (1,P); Raiwa, M. (1); Savina, M.R. (1); Roberts, A.G. (1); Shulaker, D.Z. (1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Resonance Ionization Mass Spectrometry (RIMS) has demonstrated utility in measuring isotopic compositions of elements in complex matrices without the need for chemical separations to remove isobaric interferences but has had limited application in measuring elemental compositions. Particularly in spent nuclear fuel analysis, in which elemental compositions are important in determining reactor histories and whose chemical separation presents a radiological hazard, the ability to determine elemental compositions via an in situ method such as RIMS would be a valuable asset. Because each element is ionized by its own set of lasers, elementally quantitative RIMS requires special considerations. We present the first comprehensive study of elemental ratios from spent nuclear fuel samples by RIMS and discuss trends in the observed actinide concentrations radially from the center to the edge of a fuel pellet that are not readily accessible by bulk measurements.

Log 268. UPGRADED FISSION GAS MONITORING SYSTEM FOR POST IRRADIATION EXAMINATION HEATING TESTS OF TRISO PARTICLES FOR HIGH-TEMPERATURE GAS COOLED REACTORS. Reber, E.L.(P); Fronk, R.G.; Walker, K.V.; Stempien, J.D. Idaho National Laboratory. (P) Presenting Author.

At Idaho National Laboratory (INL), the Fission Gas Monitoring System (FGMS-I), which facilitates real-time monitoring of fission gas released during nuclear fuel heat tests, has been enhanced with the FGMS-III. Both versions of the FGMS are compatible with the new Screen Neutron-Irradiated Fuel for Failure (SNIFF) furnace and the Fuel Accident Condition Simulator (FACS) at the Hot Fuels Examination Facility (HFEF) within the Materials and Fuels Complex (MFC) on the INL campus. The SNIFF furnace was specifically designed to evaluate Advanced Gas Reactor (AGR) Tri-isotropic (TRISO) fuel compacts from the AGR5/6/7 experiment. It operates in conjunction with the new Removable Assembly Providing TRISO Reirradiations (RAPTOR) assembly, which holds twelve TRISO compacts from AGR5/6/7. The Neutron Radiography Reactor (NRAD) will be used to re-irradiate the loaded RAPTOR assembly. The RAPTOR will then be inserted into the SNIFF furnace to be heated to determine if there are failed TRISO particles due to the original irradiation during the AGR5/6/7 experiment. Both FGMS I & III use High Purity Germanium (HPGe) detectors with liquid-nitrogen-cooled cold traps to measure the release of fission products, such as krypton and xenon isotopes, from the heating of the compacts to determine the number of failed TRISO particles contained in the compacts. INL developed software continuously monitors the accumulated fission products and provides near real-time data reporting. This presentation outlines the design of FGMS I & III, the associated acquisition software, and status.

Log 269. COMPARATIVE ANALYSIS OF STRONTIUM-90 AND CESIUM-137 IN FRESHWATER FISH NEAR THE FUKUSHIMA DAIICHI NUCLEAR POWER PLANT. Stephenson, W.(1, P); Tazoe, H.(2); Akata, N.(2); Anderson, D.(2); Sudowe, R.(1). (1) Colorado State University. (2) Institute of Radiation Emergency Medicine, Hirosaki University, Japan. (P) Presenting Author.

Following the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident in Japan, food products from Fukushima Prefecture have come under increased scrutiny by the public due to concerns about potential radionuclide bioconcentration. The fish harvested from both fresh and saltwater sources are among such products of interest. The main isotopes of concern in fish are strontium-90 (Sr-90) and cesium-137 (Cs-137). These are radioisotopes that have been found to substitute stable calcium and potassium in bone and muscle tissue, respectively. This research explores the concentration of Sr-90 and Cs-137 in freshwater fish sampled near the FDNPP to determine if they are safe for consumption. This assessment is important in assuaging the fears of the public regarding the safety of products exported from the Fukushima region, allowing for commerce to flourish once again in the Fukushima Prefecture. Fish were sampled from the Ukedo River, located northwest of the FDNPP. Tissue and bone samples were separated, dried, and then divided into aliquots. These aliquots were divided between Colorado State University and Hirosaki University for a comparison study using the same dissolution and separation method. Tissue samples were dissolved in 8 M HNO3 and measured via HPGe. Bone samples were ashed and dissolved in 8 M HNO3 for separation of Sr-90 and yttrium-90 (Y-90) via Eichrom DGA resin. Analysis and determination of Sr-90 was completed using a gas flow proportional counter at Colorado State University and utilizing an inductively coupled plasma mass spectrometer at Hirosaki University.

Log 270. IRRADIATION INDUCED CHANGES IN MIXEC (Th, U)OXIDE THIN FILMS. Cabanas, N.(1, P); Manukyan, K. (2); Aprahamian, A. (1,2). (1) Department of Chemistry and Biochemistry University of Notre Dame. (2) Notre Dame Nuclear Science Laboratory. (P) Presenting Author.

We have shown success in synthesizing thin film targets using electrospray or spin coating coupled with solution combustion synthesis to produce actinide targets such as ThO2, UO2, and Th1-xUxO2. To achieve this, we have benefitted from techniques developed in material science. We have continued to expand our approaches and methods toward the synthesis of mixed oxide films using a novel ethanol-based combustion reaction. We synthesized thin films (ThO2, Th0.15U0.85O2, Th0.5U0.5O2) with a thickness of ~200 nm and then irradiated them using a Kr beam at the 5U single ended accelerator at the University of Notre Dame Nuclear Science Laboratory. Three films of each composition were produced to allow for irradiation across a range of doses. We will then characterize the irradiation induced changes and potential trends associated with them. This presentation will detail the synthesis and preliminary characterization of thin film targets pre and post irradiation using electron microscopy. Funding for this work was provided by: U.S. Department of Energy (DOE) National Nuclear Security Administration Grant #NA0004093 and National Science Foundation Grant #NSF-PHY-2310059.

Log 271. URANIUM CHEMICAL COMPOUND CLASSIFICATION USING SUB-IMAGES AND STATISTICAL MACHINE LEARNING FOR NUCLEAR FORENSICS . Lambert, L.C. (1), Borghetti, B.J. (1), Bickley, A.A. (1, P). (1) The Air Force Institute of Technology. (P) Presenting Author.

Uranium particle analysis from Scanning Electron Microscope (SEM) imagery is a crucial tool in nuclear forensics. The particle morphology lexicon proposed by Tamasi et al follows a standardized, manual identification process to identify particle morphology features [1]. The present work seeks to mirror this methodology using computer feature selection from the scikit-image Python library rather than human classification. The methodology introduced splits a particle image into sub-images and then uses statistical machine learning techniques to predict the chemical compound present in the sub-image. These sub-images use a majority rules voting mechanism to classify the chemical compound and calcination temperature of the original whole particle. Images analyzed were from particles of pure compounds, however, because sub-particle-size patches are analyzed, such an approach opens the door for future impure or mixed compound particle analysis. Creating many small images from the original larger image allows a low-quantity image dataset to be analyzed via machine learning models that require large quantities of data. The dataset utilized contained 1906 SEM images where each image was one of 13 uranium chemical classifications, each containing a different number of images. Using a random forest classifier, a 56% overall uranium true positive classification accuracy (a 39.6% balanced classification accuracy) was achieved on a test set outperforming a naïve (chance) model by 48%.

Log 272. PORTABLE X-RAY FLUORESCENCE (XRF) TO MEASURE LEAD (Pb) AND STRONTIUM (Sr) IN HUMAN BONE. Nie, L. (1, P). (1) Purdue Univeristy, West Lafayette. (P) Presenting Author.

Metal concentrations in bone serve as a reliable biomarker for cumulative exposure to multiple metals. In this project, we present a portable x-ray fluorescence (XRF) technology designed for convenient measurement of bone metal concentrations both in vivo and ex vivo. This technology is adapted from a commercially available portable XRF device, with voltage, current, and filters optimized for detecting lead (Pb) and strontium (Sr) in bone. The system was calibrated and used to measure Pb and Sr concentrations in the mid-tibia bones of 71 individuals recruited from northwestern Indiana. The average bone Pb concentration was 12.3 ± 16.7 µg Pb/g dry bone, while the average bone Sr concentration was 75.6 ± 44.8 µg Sr/g dry bone. Additionally, Pb concentrations were measured in post-mortem bones from 80 participants of the Memory and Aging Project (MAP) study cohort at the Rush Alzheimer's Disease Center. The study explored the relationships between bone Pb concentrations, neuropathological brain status, and clinical diagnoses of Alzheimer's disease (AD). It also assessed the influence of APOE phenotypes on bone Pb levels and these associations. The results indicate that cumulative lead exposure is significantly associated with various forms of ADRD neuropathology, with the APOE phenotype playing a mediating role in these relationships.

Log 273. USING NEUTRON ACTIVATION TO STUDY HEAVY METALS IN WATER SAMPLES OF LAKE MEAD.

Hunter, D., (1), Tran, T. (1, P); Nangeelil, K. (1), Yang F. (2), Dickenson, E. (3), Kelly, C. (4), Sun, Z. (1).(1) University of Nevada Las Vegas. (2) University of Nevada Reno. (3) Southern Nevada Water Authority. (4) Nevada Radon Education Program. (P) Presenting Author.

Water resource management is critical for Southern Nevada, where rapid population growth and climatic changes place significant pressure on water supplies. This poster highlights preliminary results from a winter 2023 study analyzing water samples from Lake Mead, Las Vegas Wash, and Lake Tahoe using Instrumental Neutron Activation Analysis (INAA). Elevated concentrations of selenium, sodium, and magnesium were observed in Las Vegas Wash. In contrast, Lake Mead showed slightly elevated levels of magnesium and barium, the latter exceeding regulatory limits. Lake Tahoe presented higher tellurium levels, potentially linked to distinct anthropogenic or environmental influences. Principal Component Analysis (PCA) of the Lake Mead dataset identified aluminum, magnesium, manganese, and zinc as the primary contributors to water quality variance, collectively accounting for 85% of the variation. This study underscores the importance of monitoring water quality in these systems, which provide vital resources for domestic and agricultural use in downstream communities, to mitigate potential health risks.

Log 274. EVALUATING COSMIC-RAY BACKGROUNDS IN A HPGE SYSTEM: EXPERIMENTAL OBSERVATIONS AND GEANT4 SIMULATIONS.

Nangeelil K. (1); Tran, T. (1,P); Pak S. (2); Sun Z. (1). (1) University of Nevada Las Vegas. (2) Princeton University. (P) Presenting Author.

This study demonstrates the efficacy of employing the GEANT4 simulation toolkit for investigating the background spectra of high-purity Germanium (HPGe) gamma spectrometer systems induced by atmospheric cosmic rays. By accurately replicating the experimental setup, detector geometry, and the surface-level cosmic-ray particles for the given terrain, GEANT4 allows for a thorough analysis of the impact of cosmic rays on the system's background radiation. Various techniques, such as the use of low-activity lead and oxygen-free copper as shielding materials, along with an external plastic scintillator to veto cosmic rays from the atmosphere, are employed to improve the signal-to-background ratio of High Purity Germanium (HPGe) detector gamma spectrometry systems. In the experimental spectra, peaks due to 40K, 60Co, and the daughter radionuclides of 232Th and 238U natural decay series were observed. The integral count rates of the experimental and simulated background spectrum in the 20 - 2000 keV energy range were 1.92 ± 0.06 s-1 and 1.84 ± 0.14 s-1, respectively. The experimental and simulated background spectra match well, both qualitatively and quantitatively, indicating that GEANT 4 is an effective simulation tool for these types of detectors.

Log 275. MEMBRANE ADSORBERS AS A NEXT-GENERATION TECHNOLOGY FOR Ac-225 PURIFICATION.

Radhakrishnan, S.K.(1, P); Venturina, L.A.(1); Lai, G.(1); Sibley, M.M.(1); Duval, C.E.(1). (1) Case Western Reserve University. (P) Presenting Author.

Ac-225 is an alpha-emitting radioisotope with a short half-life of 9.9 days and significant potential for Targeted Alpha Therapy (TAT). Despite increasing demand, Ac-225 faces a widespread shortage due to limited production. The current method for separating Ac-225 from spallation products relies on extractive chromatography using diglycolamide (DGA)-based resins. While effective, this method faces challenges such as slow processing and large elution volumes, leading to Ac-225 loss to radioactive decay. Membrane adsorbers may offer faster separation and smaller bed volumes. In this study, DGA-functionalized membranes were synthesized by electrospinning poly(chloromethyl styrene) and grafting DGA ligands on its surfaces and pores. Adsorption studies using lanthanum, a non-radioactive surrogate for Ac-225, in 4 M nitric acid showed a notable difference in capacities, with resins achieving 130 ± 6 mmol/mg and membranes 3.0 ± 0.4 mmol/mg, but a similarity in affinities (57.6 ± 12.6 L/mmol for resins and 38.4 ± 17.6 L/mmol for membranes). Dynamic resin experiments at varying flow rates confirmed diffusion-limited transport, with breakthrough at 90 mL (180 min) for 0.5 mL/min and 25 mL (5 min) for 5 mL/min. Membrane results are pending, but convection-driven transport is expected to maintain similar capacities across different flow rates. This study highlights membranes' potential to replace conventional methods for Ac-225 purification.

Log 276. DEVELOPMENT OF VARIOUS REFERENCE MATERIALS FOR QA/QC OF RADIONUCLIDE ANALYSIS IN NUCLEAR WASTE..

Lee, S.-H (1,P); Lee, M.-J (1); Jung, Y.-H (1). (1) Korea Research Institute of Standards and Science. (P) Presenting Author.

Substantial amounts of radioactive waste, including concrete, soil, liquid, and metal, are generated during facility decontamination, dismantling, and demolition. Accurate and precise radioactive waste measurement can play a crucial role in ensuring the safety, environmental protection, regulatory compliance and resource management. Currently, using concrete, soil and metal, the Korea Research Institute of Standards and Science (KRISS) has developed various of new reference material (RM) for the measurement of gamma-emitting radionuclides (Cs-134, Cs-137, Zn-65, Am-241, Eu-152, Eu-154 and Co-60), alpha-emitting radionuclide (Pu isotopes and uranium isotopes) and beta-emitting radionuclide (Sr-90, Ni-59 and Fe-55) to improve and maintain the QA/QC of the radioactivity measurement in radioactive waste generated during the decommissioning of nuclear power plants. Homogeneity and stability tests, conducted according to ISO guidelines [1], confirmed the suitability of the concrete RM for QA/QC purposes. The developed RM holds potential as proficiency test material and for validating and verifying analytical methods in radioactive waste analysis[2]. [1] ISO-33405, ISO 33405, Reference materials – Approaches for characterization and assessment of homogeneity and stability, 1st Ed. Geneva, Switzerland (2024) [2] ISO/IEC 17034, General requirements for the competence of reference material producer, 1st Ed. Geneva, Switzerland (2016).

Log 277. ANALYSIS OF TECHNETIUM-99 IN RADIOACTIVEWASTE USING ICP-MS. Choi, J.W.(1, P); Jung. K.(1); Yoo. J.(1). (1) Korea Atomic Energy Research Institue. (P) Presenting Author.

According to the Korean Radioactive Waste Disposal Regulations, Tc-99 is one of the 14 radionuclides that must be identified for low- and intermediate-level radioactive waste disposal, and the Korea Atomic Energy Research Institute(KAERI) is currently measuring it using a gas proportional counter (GPC). Recently, studies have been conducted to analyze ultra-low-level radionuclides with long half-lives using an Inductively Coupled Plasma-Mass Spectrometer (ICP-MS), and Tc-99 with a half-life of 211,000 years may be included among them. In the measurement using GPC, TPAC (tetraphenyl arsonium chloride), a hazardous substance, is used, and since it is analyzed by the gravimetric method, an additional analysis process is required. Therefore, in this study, we investigated the recovery rate and validity of analyzing Tc-99 using ICP-MS, investigated the influence of interfering nuclides, and discussed whether it can be practically applied. As a result of the experiment, the economic feasibility was secured by reducing the amount of Rehnium(Re) used as a carrier, and the applicability was confirmed by deriving excellent resolution through KED mode.

Log 278. EVALUATING RADIOLOGICAL IMPACTS OF TIN MINING IN THE JOS PLATEAU, NIGERIA: INNOVATIVE METHODOLOGY AND HEALTH RISK ASSESSMENTS. Blenke, T. (1,P); Rohkamm, H. (1), Ademola, J. (2); Vahlbruch, C.(1); Walther, C. (1); (1) Institut of Radiecology and Radiation Protection - Leibniz University Hannover. (2) University of Ibadan. (P) Presenting Author.

Mining activities can significantly affect the surrounding environment. This study aims to analyze the radiological impact of tin mining in the Jos Plateau, Nigeria, on both the environment and local populations. In 2023, various samples, including soil, water, and agricultural products, were collected from the region for analysis. The soil samples, being high-volume, were measured using Marinelli geometry. In contrast, low-volume samples such as food and tailing materials were analyzed using an innovative and simple approach, the Top-Down method. This method involves measuring a sealed paper with a known activity level, matching the petri dish (sample) size. Measurements are conducted in two configurations: once with the paper placed above (Top) and once below (Down) the sample. Based on these measurements, the efficiency is calculated which also takes into account sample-specific properties such as density. The measured activities for U-238 in soil and tailing materials ranged from 55 Bq/kg to 2210 Bq/kg, while Th-232 levels varied between 60 Bq/kg and 3250 Bq/kg. For agricultural products, the activities of U-238 ranged from 8 Bq/kg to 21 Bq/kg, and those of Th-232 were between 13 Bq/kg and 20 Bq/kg. These activity levels were subsequently used to calculate the excess lifetime cancer risk, revealing an overall increased risk for the local population (>1.5 mSv/a per person). Additionally, the study established a mathematical framework for the Top-Down method, providing a deeper understanding of its application and accuracy in comparison to standard material.

Log 279. AN R SHINY GRAPHICAL USER INTERFACE FOR HIGH-PRECISION MASS SPECTROMETRIC DATA ANALYSIS.

LaBone, E.D.(1,P); Samperton, K.M.(1); Bowden, S.(1); Riche, A.T.(1). (1) Savannah River National Laboratory. (P) Presenting Author.

We have developed an R package centered on a graphical user interface (GUI) for analyzing high-precision mass spectrometric data. There is currently a lack of advanced, generalized software for the complete analysis of raw data produced by modern isotope ratio mass spectrometers, including multicollector—inductively coupled plasma—mass spectrometry (MC-ICP-MS) and thermal ionization mass spectrometry (TIMS). This work aims to fill this gap with a GUI accessible to those without programming experience, written in the open source and multi-platform programming language R. The “point-and-click” GUI was written using the Shiny GUI development package and Golem framework for production-grade Shiny applications, the latter of which includes the testing and documentation standards for R packages. The GUI will guide a user with no programming experience through the process of uploading and analyzing their data in a statistically rigorous and standardized method. The software is compatible with raw data file types and structures generated by different MS platforms (TIMS and MC-ICP-MS) and different instrument manufacturers (Nu Instruments, Thermo Scientific, Isotopx). Analyses include calculating isotope ratios; calibrating data based on standard analyses; uncertainty propagation and evaluation; and isotope dilution. A major thrust of the work is accommodating both metrologically-traceable compositional quantities and relative compositions depending on the use case, including both actinide and (non)traditional stable isotope systems. Once the user completes their data analysis, publication-quality graphics and tables can be output and saved from the GUI framework.

Log 280. BAYESIAN STATISTICAL ANALYSIS FOR MASS SPECTROMETRIC DATA PROCESSING.

McLarty, E.C.(1, 2, P); LaBone, E.D.(1); Samperton, K.M.(1); Bowden, S.(1); Riche, A.T.(1). (1) Savannah River National Laboratory. (2) Clemson University School of Mathematical and Statistical Sciences (P) Presenting Author.

Analytical techniques such as thermal ionization mass spectrometry (TIMS) are routinely employed to determine the precise isotopic composition of diverse natural and anthropogenic materials. In mass spectrometric data analysis, frequentist statistics are typically utilized. As the accessibility and performance of statistical computing mature, there is an opportunity to explore alternative, complementary data processing methods. The use of Bayesian inference, a data-driven statistical process which sequentially updates quantities-of-interest when available, may offer value in mass spectrometric metrology. We suggest the implementation of Markov chain Monte Carlo (MCMC) and other sampling algorithms to better standardize and quantify the distribution of traceable isotope ratios in support of high precision mass spectrometry data processing and related challenges in instrument calibration and sample analysis. In doing so, we aim to emphasize how practitioners can seamlessly implement Bayesian analysis into their own research.

Log 281. AGE DATING INDIVIDUAL PARTICLES WITH 230Th-234U AND 231Pa-235U CHRONOMETERS USING LG-SIMS. Wood, R.S. (1, P); Cunningham, H.S. (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

The high mass resolving power and transmission of large-geometry secondary ion mass spectrometry (SIMS) allow precise 230Th-234U and 231Pa-235U chronometer ages to be obtained from individual, microscopic (< 10 um) particulate. The presented methods and results are pertinent to nuclear forensics and the dating of anthropogenic materials where complete isotopic separation/purification can be assumed. Here, we present SIMS 230Th-234U and 231Pa-235U chronometer ages obtained from New Brunswick Laboratory (NBL) U850, U500 and U030a reference materials. The assessed materials have nominal ages between 42 – 68 years, and individual particles frequently produce fewer than 100 measurable daughter ions. Despite the scarcity of daughter isotopes (230Th, 231Pa), the calculated particle ages are highly reproducible and consistent with known purification dates. The 95% confidence intervals for particle ages are calculated via Feldman-Cousins and often span 2 – 7 years; particle age uncertainties vary systematically between chronometers (230Th uncertainty < 231Pa), reference material age, and 235U enrichment level. In total, over 200 NBL particles were assessed with a Cameca SIMS 1280-HR, and 230Th-234U and 231Pa-235U measurements were performed in both mono- and multi-collector configurations.

Log 282. USING RADIOACTIVE MATERIAL TO EVALUATE DECONTAMINATION OF CONTAMINATED ELECTRONICS. Heiden, Z. M. (1,P)); Kazi, Z. (2); Cree, W. (2); Mann, N.(3); Hines, C.C.(1); Green, A. (2); Vincent, C. (4). (1) Washington State University. (2) Defence Resaerch and Development Canada. (3) Idaho National Laboratory. (4) Irregular Warfare Technical Support Directorate. (P) Presenting Author.

Electronic materials are used everywhere and can get easily contaminated by their use in the field/laboratory. With electronic devices getting smaller and smaller, electronic devices become harder to clean when they become contaminated. The goal of this project was use radioactive material to track the effectiveness of cleaning procedure for contaminated electronics. Radioactive potassium bromide (KBr) was used as a model contaminant in four contamination scenarios to gauge the effectiveness of decontamination of contaminated electronic devices. This talk will discuss the contamination scenarios, the decontamination technique, and effectiveness of the decontamination procedure.

Log 283. QUANTIFICATION OF Fe-55 IN MIXED RADIONUCLIDE SAMPLES. Goodell, J.J. (1,P); Kolos, K. (1); Thomas, K. (1); Weiss, M.A. (1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Iron-55 is a high-value activation product for neutron spectral index characterization due to multiple production pathways with different threshold energies. It is also an important nuclide in site decommissioning waste characterization. However, it is a difficult to measure radionuclide due to its low energy X-rays, 2.744 yr half-life, and lack of strong alpha, beta, or gamma emissions. Most measurement techniques for Fe-55 require a radiopure sample, using chemical separations and allowing other radionuclides to decay away, sometimes a period of years, in order to remove interferences. Liquid scintillation counting is often the preferred method, but is indiscriminate and suffers from multiple complicating factors, especially if Fe-59 is also present. Other methods use low energy photon spectrometry with specialized Ge detectors, but those detectors have limited resolution in the low-keV range and can have high backgrounds caused by other radionuclides, which can complicate analysis and reduce signal. In this work, we use a silicon drift diode (SDD) detector to explore the challenges of quantifying Fe-55 in mixed radionuclide samples at early times post-irradiation. The SDD is a low-energy X-ray detector with superior resolution in the few keV range and is also transparent to gamma rays. This enables us to forego the usual separations and waiting times since other radionuclide emissions will not be seen by the detector. However, this system does have a lower counting efficiency, interferences from other neighboring X-rays, and sample self-shielding factors can vary based on sample characteristics. LLNL-ABS-871421. Prepared by LLNL under Contract DE-AC52-07NA27344.

Log 284. INTEGRATING STEREOLITHOGRAPHY WITH POLYMER-ASSISTED DEPOSITION FOR TUNABLE ACTINIDE OXIDE TARGET PRODUCTION. Hastings, A.M.(1,P); Maxwell, K.J.(1); Boro, J.R.(1); Griffiths, J.(1); Parsons-Davis, T.(1); Shusterman, J.A.(1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Stereolithography is an established 3-D printing method that can readily incorporate ceramic powders into a photocurable resin. The traditional vat-style scale, however, is not appropriate for higher activity radioactive materials or transuranic elements. By combining the stereolithography resin matrix with the existing thin film coating method of polymer-assisted deposition (PAD), we have developed a moderately efficient consolidation approach to produce thick (>1 mg/cm2) metal oxide films. Layer homogeneity is achieved with the use of spherical nano- to sub-micron particles in the resin mixture. Method variables, such as particle-resin formulation and spin coating conditions will be discussed. Target homogeneity, composition, and thickness are evaluated with optical and scanning electron microscopy, powder X-ray diffraction, Raman spectroscopy, and profilometry. The particle-PAD method presents an opportunity for composite target production and is amenable to radioactive materials.

Log 285. MICRON MATTERS: SMALL IMPURITIES, BIG TIME IN ISOCHRON RADIOCHRONOMETRY. Chan, C.F.(1, P); Boro, J.R.(1); Gaffney, A.M.(1); Marks, N.E.(1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Impurities in uranium ore concentrates (UOCs) provide a diagnostic forensic signature for identifying sample provenance. Assessing the degree of heterogeneity in impure UOCs is essential for accurately interpreting bulk elemental and isotopic characterization and applying model age radiochronometry, which relies on the assumption of homogeneity. However, we can leverage an isochron approach that enables us to quantify the initial decay progeny isotope present at the time of formation. Our research has two primary objectives: (1) to quantify the scale of heterogeneity using microanalytical techniques (e.g., SEM and EPMA) on individual UOC particles, and (2) to develop a protocol for identifying and isolating distinct UOC particle populations with varying U/Th ratios for isochron dating. Our particle analysis reveals that compositional heterogeneity is discernable on the sub-particle scale, distinct populations of uranium particles can be identified by textural context and brightness in backscattered electron imaging, and spatially resolved analytical techniques can uncover the presence of multiple phases that are not detectable through bulk analytical approaches (i.e. XRD and MC-ICPMS). This textural and compositional data are then used to identify optimal locations for micro-sampling, which will facilitate the application of isochron radiochronometry using isotope dilution mass spectrometry. Prepared by LLNL under Contract DE-AC52-07NA27344.

Log 286. PRECISE CHARACTERIZATION OF PLUTONIUM TRANSITION PROBABILITIES. Medici, E.(1,P), Hartig, K.C.(1). (1) Nuclear Engineering Program, University of Florida (P) Presenting Author.

Accurate modeling of optical spectra with absolute radiometric intensities is essential for nuclear forensics and characterizing prompt optical signals from nuclear detonations. This requires precise knowledge of the individual transition probabilities, known as Einstein A-coefficients, for each spectral line. However, obtaining these coefficients theoretically or experimentally is often impractical because of the complex electronic structures and vast number of transitions involved. In this study, we explore the use of machine learning to predict Einstein A-coefficients for atomic transitions. We evaluated models such as neural networks, stacked ensembles, and decision trees, and found that gradient boosting algorithms performed best, achieving 87% precision on transitions from 36 elements. We extended it to heavier elements, estimating unknown Einstein A-coefficients for uranium, plutonium, and other actinides relevant to nuclear forensics. This work represents the first publication of accurate transition probabilities for plutonium, filling a critical gap in the atomic data necessary for the precise spectral modeling and characterization of plutonium plumes. Enhancing these transition probability predictions improves the accuracy of the modeling of optical spectra, which is critical for interpreting prompt optical signals from nuclear detonations. This advancement enables more effective characterization and rapid analysis of such events, contributing to national security by aiding the detection and understanding of nuclear detonations and proliferation activities. Finally, initial work will be presented using a similar architecture for the prediction of thermochemistry and fluid dynamics parameters of actinides necessary for improving nuclear detonation modeling for nuclear forensic applications, such as prompt characterization and fallout forecasting.

Log 287. IMPLEMENTATION OF STACKED ENSEMBLE MACHINE LEARNING FOR DETECTION OF PLUTONIUM SURROGATE CONTAIMINATION IN SOIL.

Anderson, P.(1,P); Braun, J.I.(2); Borrero-Negron, J.(1); Rao, A. (3); Hartig, K.C.(1). (1) Nuclear Engineering Program, University of Florida; (2) Department of Chemical and Materials Engineering, New Mexico State University; (3) Space Vehicles Directorate, Air Force Research Laboratory, Kirtland AFB, NM. (P) Presenting Author.

This study implements laser induced breakdown spectroscopy (LIBS) for the identification of plutonium surrogate material (Cerium oxide) in soil matrices by training supervised machine learning methods on the recorded spectral data. A bagged ensemble using Random Forest yields the highest sensitivity predictions with a detection limit of 0.015 wt%. However, high precision in Ce content prediction required the use of a stacked ensemble regression which provided the superlative Ce quantification model with error 0.107% and a detection limit of 0.022 wt%. This underscores the utility in applying tiered machine learning methods like stacking to solve complex spectral analysis problems.

Log 288. SMALL-SCALE Pu ANION EXCHANGE CONTACT STUDIES FOR MODEL DEVELOPMENT.

Tardiff, E. (1,P); Kohlgruber, T. (1); Di Pietro, S. (1); Simpson, S. (1); Ferrier, M. (1); Childs, B. (1); Narain, S. (1); Scher, J. (1); Saito, H. (1); Banks, L. (1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Lawrence Livermore National Laboratory's (LLNL) plutonium (Pu) facility has successfully produced the overall lifecycle of Pu processing. Aqueous chemistry of Pu is a critical step in Pu recovery, and anion exchange (AX) represents a critical step in Pu purification during aqueous processing where impurities such as americium are removed. As part of the Nonproliferation Stewardship Program (NSP) project Simulating Processing of Actinides and Developing Expertise (SPADE), we look to optimize Lawrence Livermore National Laboratory's AX process by building a model on which we can apply machine learning to simulate multiple process variables. Overall recovery efficiency depends on variables such as Reillex HPQ® resin column properties, Pu concentration, and contact time kinetics. To measure these data points quickly and efficiently, we employ small-scale contact studies between the liquid and solid phases to generate dynamic models that can predict the large-scale column effluent concentration profiles. Solution concentration data for these contact studies are measured using ultraviolet-visible-near infrared (UV-vis-NIR) spectroscopy. This talk will go into the results of the contact studies including loading, washing, and eluting profiles of Pu with Reillex HPQ® anion exchange resin.

Log 289. A FIELD INSTRUMENT FOR DETECTION OF TRACE ATMOSPHERIC GASES USING TWO-COLOR CAVITY RING-DOWN SPECTROSCOPY.

Robben, K.C.(1,P); Mccartt, A.D.(1); Jiang, J.(1); Ognibene, T.J.(1); (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Methods for detection of trace atmospheric gases at ppt-ppq levels are typically limited to delayed post-collection analysis techniques, such as Accelerator Mass Spectrometry (AMS). There exists a technological gap for field-deployable instruments capable of providing real-time detection with ppq sensitivity. Here we present a newly developed field instrument aimed at filling this gap. This instrument utilizes Two-Color Cavity Ring-Down Spectroscopy (2C-CRDS), which combines the high sensitivity of cavity ring-down spectroscopy with the high selectivity of two-color excitation. We review the technique in greater detail, discuss the challenges overcome in building the first 2C-CRDS field instrument, present results from a recent deployment, and discuss future directions. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Log 290. IN-SITU DENSITY MEASUREMENT FOR ENHANCED ELECTROREFINING MATERIAL ACCOUNTANCY.

Mercado, E.(1,P); Fuller, R.(1); Rappleye, D.(1). (1) Brigham Young University. (P) Presenting Author.

To further enhance the proliferation resistance of electrorefining (ER) processes, precise and reliable analytical methods are essential for determining the inventory of fissile material. This can be achieved by electrochemically measuring the salt concentration and converting it to mass using its density. However, the density within the refiner is not fixed, and small variations in salt composition can significantly impact its thermophysical properties. While an ideal mixing model provides reasonable density estimates (with errors up to 2-3%), such errors are unacceptable when precise material accountancy of fissile material is crucial. This study developed a methodology to measure density in situ without relying on crucible calibration curves, enabling simultaneous density and electrochemical measurements when the density of the salt cannot be accurately modeled. This approach utilizes a precision-machined crucible, a single tungsten electrode, and a multimeter to measure the open circuit potential for direct density calculation. This methodology has been validated in a pure LiCl-KCl eutectic salt with a relative error of 0.3% compared to literature values. Future work will focus on measuring the density of varying concentrations of synthesized UCl3 to determine the concentration of uranium dissolved in the salt. Additionally, the diffusion coefficient and standard potential of the U(0/III) redox couple in the molar standard reference state can be measured with high precision. The aim of this project will benefit the ER process due to its simplicity and ability to provide accurate concentrations in a molar reference state, thus improving the reliability of diffusion coefficients and standard potentials.

Log 291. MICROEXTRACTION – INDUCTIVELY COUPLED PLASMA – MASS SPECTROMETRY FOR THE DIRECT ANALYSIS OF ENVIRONMENTAL SAMPLES.

Stanberry, J.S. (1,P); Szakas, S.E. (1); Andrews, H.B. (2); Thompson, C.V. (1); Ticknor, B.W. (1); Zirakparvar, N.A. (1); Manard, B.T. (1). (1) Chemical Sciences Division, Oak Ridge National Laboratory, USA; (2) Radioisotope Science and Technology Division, Oak Ridge National Laboratory, USA

The International Atomic Energy Agency (IAEA) collects environmental samples from nuclear facilities around the world to detect undeclared nuclear materials. The environmental samples are then distributed to the Network of Analytical Laboratories (NWAL) where they undergo particle and/or bulk digestion analysis. Both avenues of analysis currently require extensive sample preparation often leading to long sample turnaround time. For example, methods generally require cotton swipes (a common environmental sample) to be ashed and then digested before actinides can be quantified via multi-collector (MC) ICP-MS or thermal ionization mass spectrometry (TIMS). Here we present the use of a microextraction (ME) system to directly sample analyte from a swipe surface and deliver it to an inductively coupled plasma – mass spectrometer, bypassing much of the length sample preparation typically required for the analysis of environmental samples. Thus far, we have used ME-ICP-MS to directly quantify uranium and plutonium on cotton and cellulous materials, to extract particles from a solid surface. The work presented here will focus on these efforts and exploring the extraction of different particle types and substrates for isotopic characterization.

Log 292. ANALYZING SIDEROPHORE-DRIVEN SORPTION MECHANISMS OF ACTINIDES ONTO MANGANESE OXIDES. Hunley, L.(1); Moe, S.(1); Rodriguez, W.(1); Anagnostopoulos, V.(1, P). (1) University of Central Florida. (P) Presenting Author.

This work investigates the fate and transport of actinides in the presence of natural ligands to address challenges associated with the long-term management of anthropogenic sources, such as weapons testing and nuclear facility releases, to actinide contamination. Measurements with ICP-MS assessed actinide migration in complex geochemical environments, revealing sorption mechanisms influenced by pH and mineral content. Actinide mobility is discussed for uranium(VI) and thorium(IV) with siderophores in manganese oxide systems. Results reveal that uranium complexed with the metal chelator, desferrioxamine B (DFOB), exhibits increased sorption to acid birnessite, while the sorption of DFOB to the mineral surface decreases in the presence of uranium. Sorption percentages also vary among actinides, as thorium shows a higher affinity for acid birnessite. A key mechanism is identified when the charged terminal amine is acetylated and neutralized, as in DFOD which shows a 23% difference in sorption. Inner-sphere coordination involving hydroxamate and secondary amine groups was identified as a key mechanism. These findings emphasize the complexity of radionuclide-siderophore-mineral interactions which are governed by electrostatic and coordination mechanisms. Such insights are critical for improving predictive modeling of radionuclide transport and developing effective remediation strategies for actinide-contaminated environments.

Log 293. URANIUM MINERALS FOR NUCLEAR FORENSIC SIGNATURE DISCOVERY AND CURIES: THE COMPENDIUM OF URANIUM RAMAN AND INFRARED EXPERIMENTAL SPECTRA.. Spano, T.L. (P,1); Olds, T.A. (2); McDonnell, M.T. (1); Smith R.W. (1); Miskowiec A. (1); Felton, D.E. (1); Sweet, T.F.M. (1); Barth, B.S. (1); Niedziela, J.L. (1); Shields, A.E. (1). (1) Oak Ridge National Laboratory. (2) Carnegie Museum of Natural History. (P) Presenting Author.

Optical vibrational spectra can be powerful indicators of solid-phase U(VI) coordination chemistry, and, as such, techniques like Raman spectroscopy are becoming an important tool in nuclear forensic research and development. Although significant progress has been made in recent years detailing the optical vibrational spectra of nuclear fuel cycle materials, a deeper understanding of structure-property relationships is needed to fully characterize intermediate phases, poorly crystalline materials, and/or to identify materials that have not been reported in the literature. Luckily, U(VI) minerals exhibit extreme chemical and structural diversity as artifacts of geochemical processes, and we have exploited the variability of U minerals to understand the origins of spectroscopic features observed for inorganic U materials found in the nuclear fuel cycle. The Compendium of Uranium Raman and Infrared Experimental Spectra (CURIES), a first-of-its-kind database, has been developed via an exhaustive survey of peer-reviewed literature and databases, and new spectral dataset collection. In addition to spectra from the literature and new datasets collected for mineral species, mineral analog samples and uranium oxides and oxysalts that appear in the nuclear fuel cycle were synthesized at Oak Ridge National Laboratory for inclusion in CURIES. Continuous addition to CURIES has resulted in significant improvements in spectroscopic signatures. Computational methods, including electronic structure calculations via density functional theory, and machine learning in tandem with neutron scattering experiments are employed to fully elucidate the structural origins of spectroscopic signatures and provide a holistic view of structure-property relationships that can be applied to nuclear forensic science research and development.

Log 294. OPTICAL SPECTROSCOPY FOR ANALYTICAL MEASUREMENTS AND REAL-TIME MONITORING IN SUPPORT OF THE Cf-252 PROGRAM. Sadergaski, L. R. (1,P); Andrews, H. B. (1); Cary, S. K.(1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Online optical spectroscopy is useful for process control in many nuclear fuel cycle applications. Light can be transmitted in and out of glove box and hot cell facilities to obtain analytical data in situ with fiber-optic cables. Laser-induced fluorescence spectroscopy (LIFS) is useful for trace analysis, complexation and speciation studies, and probing f-electron behavior. LIFS requires minimal sample quantity, little to no chemical preparation, atmospheric pressure, no sample contact, and rapid analysis time (seconds). Laser-induced breakdown spectroscopy (LIBS) is a form of optical spectroscopy capable of rapidly providing an element fingerprint of a sample regardless of form (i.e., solid, liquid, gas, or aerosol). LIBS offers an in situ, near–real-time complementary—or alternative—technique to grab samples being sent to an analytical laboratory, providing savings in cost and time. This presentation will discuss the results from a series of studies envisioned to establish ultraviolet–visible absorption spectroscopy, LIFS, LIBS, and multivariate chemometric techniques for monitoring impurities and lanthanide [e.g., Sm(III)] and actinide [e.g., Cm(III)] species in systems relevant to 252Cf Program processing streams.

Log 295. THE NUCLEAR ANALYTICAL CHEMISTRY SECTION'S SUPPORT TO PRODUCE THE NEXT GENERATION OF ACTINIDE REFERENCE MATERIALS. Grant, C.E.(1, P); Giaquinto, J.M.(1); Ticknor, B.W.(1); Rogers, K.T.(1); Dyke, T.(1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

The Nuclear Analytical Chemistry (NAC) Section at ORNL supports the New Brunswick Laboratory Program Office’s (NBLPO) mission to produce, certify, and distribute actinide reference standards for the nuclear analytical community. Through a span of several years, NAC has made significant investments to prepare new laboratory infrastructure, improve measurement capabilities, and train staff in this effort. This includes obtaining ISO 17025 accreditation of key analytical methodologies, which are used for the assignment of the certified attributes of new materials and in recertification campaigns. An overview of the work NAC has completed to standup the new laboratory capabilities and current projects being executed in support of the NBLPO nuclear reference materials mission will be given. These include the production of a ten-gram batch of Np-237 and a low-enriched uranium nitrate solution with low-uncertainty U-235/U-238 isotope-amount ratios, both of which are candidates to become certified reference materials.

Log 296. PRELIMINARY ANALYSIS OF CHLORINATION AND REDUCTION INTEGRATED SINGLE PROCESS APPARATUS CAPABILITIES.

Vann, C (1, P); Klvacek, S (1); Larsen, M (1); Torrie, M (1); Mejia, C (1); Rappleye, D (1). (1) Brigham Young University. (P) Presenting Author.

Chloride volatility separations have been proposed to separate and purify used nuclear fuel and rare earth elements. To address the hazards associated with storing and handling chlorine gas required for this process, we developed a method that integrates chlorine gas generation through bulk electrolysis in molten chloride salts with the electroreduction of chloride products from volatility separation. The Chlorination and Reduction Integrated Single Process (CRISP) has been implemented in an apparatus capable of processing hundreds of grams of material per run, with cerium selected as the material for this process evaluation. The process performance was assessed using various analytical techniques to guide future design improvements, support industrial implementation, and provide near-real-time feedback. The process operates under constant current, with the electrode potential difference monitored for any deviation from expected values. The gas produced in CRISP is analyzed for relative chlorine content and purity using a quadrupole mass spectrometer (QMS). Additionally, the purity and yield of the reduced metal and chlorinated feed materials are evaluated using X-ray fluorescence (XRF). Inductively coupled plasma mass spectrometry (ICP-MS) is also used to quantify the chloride product's purity and yield, with the results compared to those from XRF. These results demonstrate the feasibility and effectiveness of CRISP as a safer and integrated approach for chloride volatility separations and reduction to metal, providing valuable insights for developing process monitoring and optimization for CRISP and advancing toward industrial application.

Log 297. SOL-GEL SYNTHESIS FOR NUCLEAR FORENSIC APPLICATIONS: INVESTIGATING METAL INCORPORATION AND ANNEALING EFFECTS.

Burns, A.D.(1,P); Rivera Rodriguez, W.I.(1); Anagnostopoulos, V.A.(1).(1) The University of Central Florida. (P) Presenting Author.

Synthesis of forensic materials resembling the color, size, shape, morphology, elemental composition, and radionuclide content of real nuclear debris is critical for advancing nuclear forensic techniques. The characteristics of nuclear debris are highly dependent on factors such as the type of device used, the height of detonation, and the local environment. The variations expected in real nuclear debris samples highlight the need for a wide range of sample matrices to simulate varying forensic scenarios. Sol-gel synthesis has emerged as a promising method for replicating the size, elemental composition, and radionuclide content of real nuclear debris. This research focuses on optimizing sol-gel synthesis techniques by systematically analyzing the effects of annealing temperature and heating rates on the structural properties of sol-gel particles. By varying these parameters, the optimal conditions for reincorporating metals such as iron and aluminum into the sol-gel matrix are being investigated. Characterization techniques, including SEM-EDS, FT-IR, and XRD, are utilized to study structural changes and metal incorporation mechanisms. The collected data will be integrated with machine learning models to predict how different metals interact with sol-gel silica networks under varying annealing and loading conditions. This research aims to provide insights into the mechanisms responsible for metal reincorporation and the influence of annealing on the glass structure of sol-gel particles, ultimately contributing to the development of improved nuclear forensic methodologies.

Log 298. DEVELOPMENT OF A SYSTEM TO MEASURE FISSION-PRODUCT RELEASE RATES DURING HEATING OF IRRADIATED TRISO FUELS UNDER AIR/MOISTURE-INGRESS CONDITIONS.

Fronk, R.G. (1, P); Scates, D.M. (1); Scates, W.W. (1); Walker, K.V. (1); Reber, E.L.(1); Stempien, J.D. (1). Idaho National Laboratory. (P) Presenting Author.

Two gamma-ray detection systems are being developed to perform the real-time quantification of fission product release rates during fuel heating in an oxidizing atmosphere. Fuels testing will be performed using the Air Moisture Ingress eXperiment (AMIX) by heating irradiated tristructural isotropic (TRISO)-coated fuels from the U.S. Advanced Gas Reactor fuel-development program. The systems for detecting fission products will consist of two stages of measurement. First, the In-Cell GAmma Monitoring System (IC-GAMS), consisting of five shielded LaBr3 detectors, will sit inside the open-air hot cell at the Fuel Conditioning Facility (FCF) in the Materials and Fuels Complex at Idaho National Laboratory (INL). The IC-GAMS will be responsible for monitoring condensable fission products, (e.g., Cs, Eu) by directly measuring products deposited along the thermal gradient tube, outside of the AMIX furnace. Second, the Fission Gas Monitoring System for AMIX (FGMS-AMIX), consisting of two high-purity germanium detectors and two electrically cooled cryogenic gas traps, will monitor the release of non-condensable fission products. The FGMS-AMIX is outside the FCF hot cell and will trap and measure Kr and Xe fission gases. The two systems will be used to quantify fission product release as a function of test temperature, atmospheric conditions, and time. INL-developed software will be used to monitor the released fission products and will report data in near real time. This paper describes the design considerations, assembly, and testing of the FGMS and IC-GAMS systems.

Log 299. ADVANCING TRACE-LEVEL ANALYSIS OF REDOX-SENSITIVE FISSION PRODUCTS: A NOVEL IC-ICP-MS APPROACH FOR IODINE AND SELENIUM IN ENVIRONMENTAL CONTAMINANTS.

Szlamkowicz, I.; Ballerini, G.; Carroll, A.; Anagnostopoulos, V. (P) University of Central Florida

Inadequate waste management practices have introduced fission products into the environment, alongside those from nuclear testing and fallout. These contaminants, including radioiodine, are typically found at trace levels, often below the detection limits of standard techniques like ion chromatography or UV-vis spectroscopy. This has led to studies being conducted at artificially elevated concentrations. A novel method using tandem ion chromatography-inductively coupled plasma-mass spectroscopy (IC-ICP-MS) allows for the one-step analysis of redox-sensitive fission products at trace levels. IC separates analytes from the sample matrix, and the sample is then detected by ICP-MS, enhancing sensitivity. This study focuses on iodine and selenium, both of which pose environmental and health risks. Iodine is biologically active, has a half-life of 16 million years, and is carcinogenic. Its presence in the environment has increased significantly due to anthropogenic sources. Selenium, with a half-life of 6,500 years, is a toxin but also an essential micronutrient. Both elements exist primarily in aqueous forms, with their mobility depending on their redox states. Reduced forms are highly mobile, while oxidized forms are less mobile and more sorptive. Manganese oxide minerals, particularly birnessite, are environmental geochemical regulators. Their strong oxidative capabilities, influenced by the Mn(III/IV) ratio, impact the speciation and mobility of iodine and selenium. This study aims to better understand iodine and selenium's environmental behavior under realistic concentrations.

Log 300. A NOVEL PROTEIN-BASED APPROACH FOR TRACE ACTINIDE EXTRACTION FROM ENVIRONMENTAL MATRICES. Wasserman, N.L. (1, P); Deblonde, G. J-P. (1); Baransky, E.J. (1); Balboni, E. (3); Park, D. M. (1) Lawrence Livermore National Laboratory.

Current laboratory protocols for trace actinide measurements by state-of-the-art techniques, including multicollector inductively coupled plasma mass spectrometry (MC-ICP-MS), can be lengthy and costly due to the low efficiency and limited flexibility of the chemical systems (e.g. ion-exchange resin) required for scavenging sub-parts per billion levels of actinides from complex sample matrices. This project will develop a disruptive technology for faster recovery and analysis of trace actinides in environmental matrices by leveraging the unique properties of the newly discovered metal-binding protein, lanmodulin. Evidence from previous studies at LLNL show that this protein is highly selective for trivalent actinides even at low concentrations. In addition, the lanmodulin-actinide complex is stable under a wide range of pH, and in the presence of high concentrations of environmentally relevant anions, transition metals, and mineral surfaces. However, these studies utilized chemical and mineral standards that do not fully encompass the complexity of real environmental samples. In addition, there is only limited data on the complexation of lanmodulin to tetravalent actinides, like Pu(IV) and Np(IV), which are useful signatures of proliferation detection. We plan to address these gaps in our effort to apply lanmodulin extraction to trace-level trivalent and tetravalent actinides from natural soils and waters. Here, we present our recent results on the characterization of lanmodulin complexation to Pu(III) and Pu(IV) and experiments coupling the lanmodulin-extraction approach to actinide isotope analysis by MC-ICP-MS. Prepared by LLNL under Contract DE-AC52-07NA27344.

Log 301. AUTONOMOUS ELECTROREFINING PROCESS AND CHARACTERIZATION OF TIN AS A PLUTONIUM SURROGATE. Ankrah, G. (1, P); Johnson, B. (1); Fuller, A. (1); Rodriguez, R. (1); Rappleye, D. (1). (1) Department of Chemical Engineering, Brigham Young University. (P) Presenting Author.

Electrorefining (ER) is an effective method for metal purification but often is the limiting step in many processes, including the production of refined plutonium. Automating this process can significantly reduce operational time and minimize supervision. Studies are being conducted using surrogate materials to optimize parameters and develop a methodology for autonomous, current-controlled ER. Tin with nickel impurity was selected as a surrogate. Zhang et al. presented a method for ER control using a calibration curve obtained from a current linear sweep during ER operations [1]. Using Ohm's law to approximate ideal ER operations, deviations in linear sweep data from linearity indicate the oxidation of nobler impurities at the anode. Parameters, including operating current and sweep limit were investigated to determine optimal operating conditions and facilitate automatic run termination upon completion. The refined product and the residual anode of the ER runs were analyzed using Scanning Electron Microscopy (SEM) with Energy-Dispersive X-ray Spectroscopy (EDX) and Focused Ion Beam (FIB). These analyses provided insights into the factors affecting the quality of the refined material and nature of the residual anode. This study demonstrates the potential for significant improvements in the ER process through parameter optimization and the application of advanced analytical techniques. [1] C. Zhang, A. M. Parkes, K. S. Holliday, Journal of Nuclear Materials 577, 154327 (2023)

Log 302. POLYMER-ASSISTED DEPOSITION WITH A TWIST: USING NANOPARTICLE FEEDSTOCKS FOR TARGET PRODUCTION. Maxwell, K.J. (1, P); Hastings A.M. (1); Parsons-Davis T. (1); Shusterman J.A. (1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Traditional polymer-assisted deposition (PAD) has been shown to produce highly uniform thin films of metal oxides, including actinide oxides. While producing thicker films for nuclear targets is possible through repeated application, we were interested in evaluating if using nanoparticles (NPs) in lieu of individual metal ions would increase individual layer thickness. In this work, cerium dioxide NPs suspended in a polyethyleneimine (PEI) matrix were spin coated onto circular titanium foils. Calcining the deposit removes the solvent and polymer, leaving behind a CeO2 film. Incorporation of various custom-designed components into the spin-coating apparatus improved radial homogeneity and eased recovery of excess NP-polymer material. Concurrently, the relative PEI and NP concentrations and spin-coating speed were varied until a homogeneous deposit with maximal areal density was achieved. Optical and scanning electron microscopy, profilometry, powder X-ray diffraction, and Raman spectroscopy were conducted on the targets to evaluate their composition, microstructure, thickness, and homogeneity. NP-PAD presents a spin on a classic thin film deposition technique that can be adapted to various target compositions and requirements. Process optimization on this basic particle-polymer system has paved the way for safe and effective spin coating practices with radioactive materials. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. Release Number: LLNL-ABS-2001261

Log 303. DEVELOPMENT OF MACHINE LEARNING POTENTIALS TO MODEL ACID-BASE DISSOCIATION IN NITRIC ACID AND THE OSMOTIC AND ACTIVITY COEFFICIENTS.. Dinpajooh M. (1,P), LaCount M.D. (1), Muller S.E. (1), Henson N.J. (1), Mundy C.J. (1), Ritzmann A.M. (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Nitric acid is the most commonly used supporting electrolyte in the reprocessing of used nuclear fuel. It is employed in a wide range of concentrations, from relatively dilute solutions (approximately 0.1 mol L^{-1}) to highly concentrated solutions (around 10 mol L^{-1}). In this work, we develop ab initio-based machine learning (ML) potentials and perform molecular dynamics (MD) simulations to investigate the structural, thermodynamical, and transport properties of nitric acid at different state points as a benchmark system. We show that the MD simulation results provide an accurate assessment of the degree of associations for nitric acid. We also explore predicting osmotic and activity coefficients over a wide range of concentrations. Acknowledgements: The research described in this presentation is part of the National Security Directorate Mission Seed Initiative at Pacific Northwest National Laboratory. It was conducted under the Laboratory Directed Research and Development Program at PNNL, a multiprogram national laboratory operated by Battelle for the U.S. Department of Energy. The research was performed using resources available through Research Computing at Pacific Northwest National Laboratory (PNNL).

Log 304. SMALL-SCALE RADIOCHEMISTRY AND ANALYSIS PLATFORM FOR POST-DETONATION NUCLEAR FORENSICS . Shusterman, J.A. (1,P); Glennon, K.J (1); Valdovinos, H. (1); Bence, J. A. (1); Wimpenny, J. (1); Cicchetti, N. (2); Parsons-Davis, T. (1); Gharibyan, N. (1). (1) Lawrence Livermore National Laboratory (2) University of Nevada, Las Vegas. (P) Presenting Author.

To reduce analytical timelines in support of post-detonation nuclear forensic analysis, research has been performed to develop a supported-liquid membrane (SLM)-based microfluidic platform. The small-scale modular design and selective chemistry can be adapted to a variety of analytes and detectors. With minimal sample volume, the platform can drastically reduce in lab analytical timelines as well as offer potential for field applications. The SLM system based on a tributyl phosphate-saturated membrane has been used for U and Pu separations from fission products, other actinides, and environmental matrix elements. The platform has been integrated with a custom alpha spectrometer to measure Pu activity ratios, as well as UV-Visible spectrophotometry and gamma spectrometry to measure U-237/total U ratio. While this integrated system has been designed with an outlook towards field utility, efforts coupling the SLM chemistry to ICP-MS detection for rapid lab-based analyses will also be discussed.

Log 305. MICROFLUIDIC SEPARATION OF BULK RARE EARTH ELEMENTS FROM FISSION PRODUCTS . Bence, J. (1, P); Glennon, K. (1); Valdovinos, H. (1); Cicchetti, N. (2); Parsons-Davis, T. (1); Gharibyan, N. (1); Shusterman, J. (1). (1) Lawrence Livermore National Laboratory. (2) University of Nevada, Las Vegas. (P) Presenting Author.

In support of post-detonation nuclear forensics, research into rapid and fieldable chemical separation methods of fission products has been ongoing. A 3D-printed module was designed for carrying out microfluidic separations of target analytes using a flat-sheet, supported liquid membrane (SLM) at LLNL. Some fission products of interest in post-detonation nuclear forensics include those of the rare-earth elements (REEs). Utilizing the TODGA extractant, REE fission products were recovered and analyzed with a total separation time of less than 30 minutes. These results work towards implementing a bulk REE separation from other fission products using the microfluidic extraction system, including early results for REE quantification.

Log 306. ON THE STABILITY CONSTANTS OF METAL-NITRATE COMPLEXES IN AQUEOUS SOLUTIONS.

Dinpajooh, M. (1,P); Hightower, G. L. (1,2); Curtis, K. (1); Overstreet, R. E. (1); Metz, L. A. (1); Henson, N. J. (1); Govind, N. (1); Ritzmann, A. M. (1); Uhnak, N. E. (1). (1) Pacific Northwest NationalLaboratory. (2) University of Hartford. (P) Presenting Author.

Stability constants are very useful for chemists to understand, predict, and control the behavior of chemical species in complex systems. Stability constants of simple reactions involving addition of the NO3- ion to hydrated metal complexes, [M(H2O)x]n+ are calculated with a computational workflow developed using cloud computing resources. The computational workflow performs conformational searches for metal complexes at both low and high levels of theories in conjunction with a continuum solvation model (CSM). The low-level theory is mainly used for the initial conformational searches, which are complemented with high-level density functional theory conformational searches in the CSM framework. The lowest energy conformations are then found to obtain the reaction free energies for the addition of one NO3- to [M(H2O)x]n+ complexes, where M represents a sample of earth alkaline, transition, post-transition, and actinide metals and the whole lanthanide series. We discuss predictions of the computational workflow and address whether NO3- coordinates metals in a monodentate or bidentate fashions. When the systematic errors in the calculations are accounted for using linear free energy approaches, good agreements are obtained between the calculated stability constants and the available experimental data. Acknowledgements: The research described herein was funded by the Generative AI for Science, Energy, and Security Science & Technology Investment under the Laboratory Directed Research and Development Program at Pacific Northwest National Laboratory (PNNL), a multiprogram national laboratory operated by Battelle for the U.S. Department of Energy. This work was also supported by the Center for AI and Center for Cloud Computing at PNNL.

Log 307. EFFECT OF TEMPERATURE AND REDOX POTENTIAL ON EQUILIBRIUM CONCENTRATION OF SELECT METALS IN SIMULATED MOLTEN SALT CHLORIDE FAST REACTOR FUEL SALT.

Rood, N.(1,P); Harward, A.(2); Johnson, A.(1); Feistel, D.(1); Cernyar, M.(1); Unger, A.(s); Chatterjee,D.(2); Simpson, M.(1). (1) University of Utah. (2) TerraPower, LLC. (P) Presenting Author.

Metal compatibility and corrosion in molten salt systems is critical for the development of safe future reactors. Some possible fuel salt eutectic mixtures for molten chloride fast reactors are NaCl-UCl3 and KCl-NaCl-UCl3. In this work the equilibrium concentration of Fe, Ni, Cr, Ag, W, and Mo between the solid metals and their chloride forms in the eutectic melt were studied as functions of temperature and redox potential of the system. The NaCl-UCl3 eutectic was studied at temperatures between 873 - 1023 K while the KCl-NaCl-UCl3 was studied between 823 - 923 K. The redox potential of the salt was first stabilized by submerging a uranium-zirconium rod in the melt. This showed to be an effective method of removing any metal chloride contaminants which are reduced to their metallic form and precipitated out of the melt due to the reduction potential of uranium being lower than any of the monitored components. After stabilization of the redox potential, the uranium rod was replaced with a bundle containing pure forms of each metal component. The redox potential of the salt was then allowed to restabilize, and samples were taken to analyze the equilibrium metal concentration change in the salt. The equilibrium concentrations of the metals were observed to generally follow the reduction potentials of each metal with Cr and Fe equilibrating in the highest concentration and Mo and W being the lowest across the temperature range studied.

Log 308. MACHINE LEARNING-ENHANCED SPECTRAL ANALYSIS OF Pu OXALATE SURROGATE. Borrero Negrón, J.I. (1,P); Braun, J.I. (2); Anderson, P.E. (1); Emrick, P.J.(3); Villa-Aleman, E.(4); Rao, A.P.(5); Hartig, K.C. (1) (1) Nuclear Engineering Program, University of Florida. (2) Department of Chemical and Materials Engineering, New Mexico State University. (3) COSMIAC at the University of New Mexico. (4) Global Security Directorate, Savannah River National Laboratory. (5) Space Vehicles Directorate, Air Force Research Laboratory. (P) Presenting Author.

For nuclear forensics applications, qualitative and quantitative analyses of interdicted nuclear materials include identification of major and trace elements via enhanced characterization methods. In pre-detonation scenarios, the PUREX process involves the production of Pu oxalates [Pu(OXA)], which exist in two oxidation states: Pu(III) and Pu(IV) oxalate. Despite significant advancements in the characterization of interdicted PuO_2 samples, little is known on the impact of oxidation states on optical signatures. Owing to the hazardous nature of sample preparation, Laser-Induced Breakdown Spectroscopy (LIBS) has emerged as an attractive method for standoff detection of radiological materials by assessing their optical emission signatures to identify their chemical composition. Here, we aimed to showcase the enhancement of LIBS spectral discrimination and identification capabilities of Fe(II,III) oxalates as surrogates for preprocessed Pu(III) and Pu(IV) oxalate samples by implementing spectral feature selection using ML algorithms. Hence, we report how matrix effects affect the use of clustering analysis and supervised regression techniques to discriminate the spectral signatures of Fe II and III (OXA) for the chemometric analysis of mixed Fe(OXA) samples. By advancing our understanding of how the underlying algorithmic functions of ML techniques can be applied to challenging spectral LIBS data imposed by optical signatures of chemically homogenous samples, we can strengthen nonproliferation efforts and forensic capabilities essential for national and global security.

Log 309. MACHINE LEARNING WITHIN RADIOCHEMISTRY DECONFLICTION OF GAMMA PEAKS. Wroe-Brown, J.(1,2,P); Lee-Brewin, L.(2); Shenton-Taylor, C.(2). (1) AWE Nuclear Security Technologies. (2) University of Surrey. (P) Presenting Author.

The application of machine learning to gamma spectroscopy has previously been attempted successfully using synthetic data with a limited, predetermined list of possible radionuclide detections. In the field of nuclear forensics such limitations are insufficient for making a determination of the content of a radioactive sample as a practical system would require training with real data to ensure consistency and ability to discern a wide and evolving array of radionuclides. This work presents an alternative approach to implementing a neural network as part of a gamma spectra analysis process by training a feedforward neural network to resolve individual conflicts based on comparison between spectral peaks and a nuclear library. In this way identifications can be made without prior knowledge of the nuclides being deconflicted thus removing the limitations of previous implementations. This work is the subject of a PhD in its second year that has already produced a prototype. Recent focus has been placed on validating the successful initial tests of this approach to ensure that the prototype neural network is making correct classifications independently. Due to the use of real data, it is possible that unconscious predispositions caused by manual analysis have introduced inconsistencies into the dataset that are limiting the neural networks accuracy. To combat this, a range of techniques including input reduction and dataset refinement have been used to expose any possible systematic biases being introduced into the neural network to ensure the calculated accuracy is valid. (UK Ministry of Defence Crown owned copyright 2024/AWE)

Log 310. ANALYTICAL CHEMISTRY OF TRITIUM: IMPURITIES AND ISOTOPE SEPARATION.

Kelly, J.T. (1), Guin, T. (1), Angelette, L. (1), Beaumont, P. (1), Larsen, G. K. (1), Colon-Mercado, H. (1), Klein J. (1). (1) Savannah River National Laboratory. (P) Presenting Author.

The United States government relies on the Department of Energy’s national laboratory system for tritium production starting with tritium-producing burnable absorber rods (TPBARs) testing and evaluation and ending with extraction, purification, and storage. The research performed at the Savannah River Site focuses on understanding the behavior of hydrogen isotopes – specifically their absorption, decomposition, and recombination. While there are many analytical solutions for the evaluation of irradiated materials, process upsets, impurity removal, and isotopes separation, the results and data presented here focuses on process monitoring by optical spectroscopy. Spectroscopic signatures and molecular fingerprinting is used to study the isotopic exchange and impacts on the materials currently used for processes in tritium production, extraction, purification, and separation. The nature of producing tritium requires impurity removal and isotopes separation and these areas are currently being developed and demonstrated at Savannah River National Laboratory. Spectroscopic techniques provide insight to the ammonia cracking process for tritium recovery and recycling in addition to hydrogen isotopes separation by thermal cycling absorption process (TCAP).

Log 311. CALCULATION OF THE DETECTION LIMIT FOR THE MEASURAND-RELATED CONTINUOUS BACKGROUND.

Petrovic, T. (1, P); Korun, M. (1); Vodenik, B. (1); Zorko, B. (1). (1) Jozef Stefan Institute. (P) Presenting Author.

The calculation of the detection limit (DL), as outlined in the standards, assumes that the background value, where the gamma-ray peak used to determine the measurand is located, is independent of the observed value of the measurand, though its uncertainty is not, because it depends on the peak area uncertainty. This assumption becomes invalid when the peak used for calculation lies on the Compton plateau of a peak associated with the measurand, or in activation analysis cases where decay products of the analyte affect the continuous background. The presented method explicitly highlights that the correlated background is linked to the indication, while the intensities of both, the correlated and uncorrelated continuous background, remain unknown. However, the shape of the correlated background is assumed to be known. To determine the detection limit (DL), the spectrometer's responses to the analyte are measured at various ratios of the indication and the correlated background. These measurements are used to reconstruct the spectrometer's response during analyte measurement. The appropriate response is derived using correlation coefficients between the channel contents of the uncorrelated background and the measured responses. A near-zero correlation coefficient indicates a suitable ratio of the indication to the correlated background's height, enabling the calculation of the desired response. The results of the DL calculation are presented and analyzed for cases where the shapes of the correlated and uncorrelated backgrounds differ.

Log 312. A RAPID MICROFLUIDIC NEPTUNIUM EXTRACTION USING A SUPPORTED LIQUID MEMBRANE MODULE . Cicchetti, N. (1, 2, P); Glennon, K.J. (2); Parsons-Davis, T. (2); Shusterman, J.A. (2); Gelis, A.V. (1). (1) University of Nevada, Las Vegas (2) Lawrence Livermore National Laboratory. (P) Presenting Author.

Efficient extraction of neptunium is essential in radioanalytical applications like nuclear forensics R&D and environmental monitoring, but its complex redox behavior can lead to variable extraction yields. This presentation details the development of a microfluidic extraction technique that implements chemical redox to control the Np oxidation state and impart more predictable behavior. Our results demonstrate a fast, effective extraction with yields up to 90% within 10 minutes for 100 µL samples, and over 97% yield at steady-state after 20 minutes. The system uses a supported liquid membrane module to perform forward- and back-extraction steps simultaneously, using a solution of 30 vol% tributyl phosphate in n-dodecane as the organic phase. Neptunium in the feed is oxidized to the hexavalent state to improve its extractability and is then reduced during back-extraction. Batch extraction studies were used to study oxidation and extraction kinetics and optimize the process. Based on these studies, bromate was chosen as the optimal oxidant due to its compatibility with the organic phase, achieving complete oxidation in less than 30 seconds, while ascorbic acid and hydrogen peroxide were both effective as reductants with slight variations in their ideal concentrations. When implemented in an SLM module, this method achieves high extraction yields from submilliliter samples across a range of neptunium concentrations (pM to µM), offering a promising approach for future separations of complex samples. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344, and was supported by the Department of Energy, National Nuclear Security Administration, Office of Defense Nuclear Nonproliferation Research and Development at LLNL.

Log 313. EXTRACTION AND SEPARATION OF RARE EARTH ELEMENTS USING SOFT DONOR LIGANDS IN CONJUNCTION WITH IONIC LIQUID AND 1-OCTANOL. Harris, B.K.(1, P); Ball, R.D.(1). (1) Idaho National Laboratory. (P) Presenting Author.

The extraction of lanthanides from acidic aqueous solutions using the ionic liquid 1-Butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (BMIM TFSI) and 1-octanol has been evaluated with the soft donor ligands N,N,N′,N′-tetrakis(2-pyridylmethyl)ethylenediamine (TPEN) and N,N,N′,N′-tetracyclohexyl-3-oxapentanediamide (ETH-129). The extractions using BMIM TFSI were compared to those using the traditional solvent 1-octanol, and the effects of the diluents and possible mechanisms involved were discussed. ETH-129 proved to be effective across all acid ranges and in both diluents, whereas TPEN was only effective in BMIM TFSI at low acidities. For applications in energy resource recovery and the nuclear industry, both ETH-129 and TPEN adhere to the desirable CHON principle, allowing the ligand or its degradation products to be completely incinerated at the end of their useful life, thereby avoiding secondary waste generation.

Log 314. ENHANCING URANIUM CHLORIDE DIGESTION AND PREPARATION FOR RELIABLE ICP-MS MEASUREMENTS OF CHLORIDE VOLATILITY PRODUCTS. Torrie, J.M (1,P); Wright, J. (1); Rappleye, D. (1). (1) Brigham Young University. (P) Presenting Author.

With the advent of generation IV nuclear reactors, new nuclear fuel types are under development. These new fuel types create opportunities for innovative reprocessing strategies. One option for reprocessing several of these new fuel types is a chloride volatility scheme. The two-step chloride volatility process selectively separates and collects uranium chlorides and other transuranics from simulated spent nuclear fuel by controlling the valence state of uranium using various gaseous chlorinating agents. This process leverages the fact that the volatility of uranium chlorides increases as the uranium valence state increases. However, the solubility of higher-valence uranium chlorides in aqueous solutions is very low. This poses an analytical challenge for quantifying uranium amounts, determining the valence state, and calculating separation coefficients using an inductively coupled plasma mass spectrometer (ICP-MS), which typically requires aqueous samples for data collection. Although the literature states that higher-valence uranium chlorides are insoluble in aqueous solutions, we have found that mixtures of UClx (x>3) dissolve readily in deoxygenated nitric acid. This solvent enables accurate quantification of uranium at different stages in the chloride volatility separation process. Furthermore, by quantifying other cations present in the salt and measuring the total chloride content via ICP-MS, we can derive reasonable averages for the uranium valence state.

Log 315. WHO WILL WATCH THE WATCHMEN (IN ORDER TO OPTIMIZE THEIR WATCHING)? Bakker, C. (1, P); Irvahn, J. (1); Mills, J.A. (1); Pulliam, R.M. (1); Willis, J.C. (1); Brigantic, R.T. (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

A treaty Monitoring and Verification (M&V) system consists of a set of data streams generated by M&V technologies and/or processes. Different M&V systems can be realized with different combinations of data streams from different combinations of M&V technologies and processes. In this paper, we characterize M&V systems as a Bayesian updating problem with intermediate (unobserved) and observed variables, and we prove that this characterization guarantees certain desirable properties of an M&V system; for example, under most circumstances, adding a data stream increases the difference between prior and posterior estimates of the likelihood of treaty compliance. We also quantify the expected false-positive rate, expected false-negative rate, and expected information gain from different candidate M&V systems. This allows us to formulate M&V system design as a multi-objective optimization problem. Furthermore, the party being monitored may have incentives to manipulate the system to avoid detection of non-compliance. A strategic approach to such manipulation could involve the monitored party identifying a) which data streams could most easily be manipulated and b) how to manipulate those vulnerable data streams to increase the likelihood that the M&V system indicates treaty compliance under non-compliant conditions. We define this deception problem as an optimization for the monitored party. Solving this optimization enables us to identify the “weakest links” in each M&V system and to quantify the susceptibility of the M&V system as a whole to falsified data streams.

Log 316. A STRAIGHTFORWARD METHOD FOR CALCULATING EFFECTIVE CUMULATIVE FISSION YIELDS.

Barker, B. J. (P,1); Charboneau, J. A.(1); Carney, K. P.(1); Coleman, M. E.(1); Erfurth, N. H.(1); Hobbs, I. M.(1); Pincock, C. M.(1). (1) Idaho National Laboratory. (P) Presenting Author.

Here a novel method was developed for calculating the effective cumulative fission yields for fission products in uranium-based fuels. Calculation of effective fission yields is often not a straightforward task and this can cause systematic errors to occur in burn-up determinations. The calculation uses the experimentally determined concentrations of a host of fission products and an iterative approach to calculate the total number of fissions. While the method is simple (it assumes that U-235 and Pu-239 are the only fissioning species) it was found to give robust results for a large selection of fission products. This enables the reliable use of burn-up monitors in the calculation of atom percent burn-up with significantly different U-235 and Pu-239 fission yields. The major advantage of this method is that it depends only on end-of-life measurements and requires only minimal knowledge of reactor history or beginning-of-life fuel composition. When compared to the standard practice of using only Nd-148 as a burn-up monitor, it results in significantly lower uncertainty in the atom percent burn-up. To validate the method a sample of BR3 PWR fuel was analyzed for a selection of fission products (Sr, Rb, Ba, La, Nd) using a MC-ICP-MS and high precision isotope dilution mass spectrometry (IDMS). The IDMS method is time consuming, and the method was further tested using much faster but less precise Q-ICP-MS measurements. Lastly, the values from the method were used to predict the beginning-of-life enrichment of the fuel and found to agree with the known values within experimental uncertainty.
INL/CON-24-82197

Log 317. OXYGEN ANALYSIS OF CHLORIDE SALTS - METHOD DEVELOPMENT AND STATISTICAL EVALUATION.

Charboneau, J.A.(1,P); Tolman, K.R.(1); (1) Idaho National Laboratory. (P) Presenting Author.

The evaluation of oxygen content in molten salt systems is an important topic for many nuclear technologies. The impact oxygen can have on the chemistries and materials of construction is significant and an upfront determination of oxygen in the salts is often needed. While some work has been done for high oxygen content salt systems, there is little published information on low level oxygen determination methodologies. Even less information is available for these methods being applied to chloride salt systems. This work focuses on oxygen analysis using existing inert gas fusion instrumentation and presents the validation process for a method used to determine oxygen concentrations of less than 0.1 weight percent in a eutectic neodymium-sodium chloride system. Uncertainty propagation of replicate analysis showed good precision and illuminated the need for further development in oxygen spiking processes for solid materials.

Log 318. REVERSE QUANTIFICATION OF UCl3 MOLTEN SALT SYSTEMS USING ARTIFICIAL INTELLIGENCE WITH ELECTROCHEMICAL METHODS. Smith, J.T. (1,P); Phongikaroon, S. (1); (1) Virginia Commonwealth University. (P) Presenting Author.

A large dataset of UCl3 electrochemical measurements from Dr. Dalsung Yoon's dissertation research was utilized to train, validate and test an artificial neural network to predict molten salt system properties [1]. Cyclic voltammetry (CV), open current potential (OCP) and electrochemical impedance spectroscopy (EIS) data of UCl3 with a weight percent ranging from 0.5% to 4% in an LiCl-KCl molten salt were used with a novel deep learning neural network to train and validate a long and short-term memory (LSTM) network. Hold-out test sets were then utilized to evaluate the performance of the model on unseen data and also to calculate the simulated kinetic, transport, and thermodynamic properties along with the estimated concentration of uranium. The two hold-out test sets were one and four weight percent UCl3 in a LiCl-KCl molten salt at 475 oC and 525 oC, respectively. Preliminary studies show the RMSE between the generated and true current for the 1% weight test set of around 1.8-3.2 whereas the 4% by weight showed much larger RMSE of around 18.3-24.2 indicating that generalization is harder to achieve at higher concentrations of UCl3. OCP and EIS reverse quantifications are still currently underdevelopment and only preliminary work has been done. More data is to be obtained soon along with an optimized deployment of the CV LSTM network. Furthermore, the generated spectras will be utilized to calculate key system parameters and then compared against the true system parameters. Results will be reported after all networks have been finalized.

Log 319. DENSITY CHARACTERIZATION OF TRITIUM PRODUCING $LiAlO_2$ PELLETS THROUGH SCANNING ELECTRON MICROSCOPY (SEM) AND HE PYCNOMETRY. Robb, A. (P, 1, 2); Bhakta, K. (1); Yao, J. (1); Harper, A. (1); Campbell, E. (1); Burgeson, I. (1); Buck, E. (1); Biegalski, S. (2); Luscher, W. (1). (1) Pacific Northwest National Laboratory. (2) Georgia Institute of Technology. (P) Presenting Author.

Large scale tritium (H-3, T) production within the United States leverages the Watts Bar commercial light-water power reactors to irradiate annular lithium aluminate (LiAlO2) pellets of the high temperature gamma phase allotrope to support mission needs. Density changes within the LiAlO2 material are expected due to radiative swelling, fission of Li, loss of tritium as both diatomic and tritiated water, and buildup of lithium pentaluminate (LiAl5O8). As part of a research campaign to evaluate tritium release and speciation in these lithium aluminate materials, eight pellets were irradiated in a test train at Idaho National Laboratory's (INL) Advanced Test Reactor (ATR). Four different types of lithium aluminate microstructures, characterized as standard, large grain, small pore, and large pore, were irradiated to two different Li burnups. This allows for (1) comparison of microstructural effects and (2) radiation effects within the same pellet type. This study explores three methods of density determination post-irradiation via metrology, Helium Pycnometry, and Scanning Electron Microscopy (SEM). The metrology method provided a 1.79% decrease in density between pre- and post-irradiation, across the varying pellet types versus the He pycnometry, generally viewed as a more accurate technique, with a 7.70% decrease. SEM imaging on select pellets show an increase of pore quantity and size accompanied by increased LiAl5O8 compared to the pre-irradiation samples. Analysis at the microstructural level provides insight on how lithium burnup impacts retention and pellet integrity.

Log 320. IMPACT OF ANIONS ON THE CHEMICAL ACTIVITY OF TANK WASTE APPLIED TO SUPERNATE CESIUM REMOVAL. Robb, A.(1,2,P); Campbell, E. (1), Bachman, A. (1), Bhakta, K. (1); Murray, K.(1); Ortega, A.Z. (1); Westesen, A.(1); Biegalski, S.(2); Peterson, R. (1). (1) Pacific Northwest National Laboratory. (2) Georgia Institute of Technology. (P) Presenting Author.

Crystalline silicotitanate (CST) is an ion exchanger currently being used at the Hanford Site for the removal of cesium-137 from the supernate component of tank waste prior to disposal. Treatment of 56 million gallons of tank waste is one of the federal government's largest obligations for the foreseeable future. Radioactivity in the supernate is dominated by the Cs-137 radionuclide. To make handling of the supernate easier, removal of 99.9% of the Cs-137 before vitrification into low-level waste is desirable. While it is shown that period 1 cations (Na and K) significantly impact the capacity of the CST for Cs, the anion composition of the supernate can also substantially affect the Cs capacity, and thus alter the expected quantity of CST needed for processing. To better understand and predict TSCR (Tank Side Cesium Removal) system performance, batch contacts were performed with a typical Na concentration by varying the anions in the Na containing compounds, both with and without K present. Results demonstrated that anion composition can double CST's ability to remove Cs from solution. Specifically, activity coefficients decreased with higher potassium/sodium nitrate concentrations, versus sodium hydroxide, nitrite, and carbonate increasing the activity coefficients at higher concentrations. In addition, a method adapted from Marcos-Arroyo was used to estimate Cs activity coefficients to develop a method to interpolate between anion compositions. The results from this work will allow better understanding of current and future TSCR operation at Hanford.

Log 321. ANALYTICAL METHODS TO INVESTIGATE KEY RADIONUCLIDES AND HAZARDOUS CONTAMINANTS IN CEMENTITIOUS WASTE FORMS. Reiser, J.T. (1,P); Asmussen, R.M. (1); Saslow, S.A. (1), Smith, G.L. (1). (1) Pacific Northwest National Laboratory. (P) Presenting author.

Cementitious materials play a crucial role internationally in the mission to immobilize and dispose of nuclear and hazardous wastes. A wide range of waste streams and radionuclides have been or are targeted for inclusion in cementitious waste forms. To ensure adequate predictions of long-term performance of these materials in disposal settings to maintain environmental safety compliance, a fundamental understanding of the interactions between cementitious matrices and radionuclides is required. However, in many cases these radionuclides (or hazardous contaminants) are present at low, but regulatory significant, concentrations. To study their properties (local bonding, speciation, oxidation state, migratory behavior) within a cementitious matrix over time, a suite of analytical techniques is required. This presentation will provide an overview of analyses carried out to date to investigate the behavior of key radionuclides (e.g., Tc-99, I-129) in candidate cementitious waste forms at the US Department of Energy Hanford site. Analysis techniques include synchrotron analyses, mass spectroscopy, NMR/EPR, TOFSIMs, digital autoradiography, atomistic modeling and election microscopy to probe the interactions with the cementitious matrix.

Log 322. EFFECT OF ZIRCONIUM TETRACHLORIDE TO STRUCTURAL MATERIAL CORROSION IN MOLTEN SALT REACTOR. Kyeongtae Park K.(1,P); Jaeyeong Park J.(1)
(1) Ulsan National Institute of Science and Technology

Molten salt reactor, one of the 4th generation reactors applies molten salt as heat exchanging media. It's widely being developed by high thermal efficiency and safety. Even with the advantages, the aggressively corrosive property of salt structural material degrades with many factors of moisture, radiation and impurities. However, fission product effects were not widely clarified yet for material degradation. In this study, one of the fission products in chloride MSR, $ZrCl_4$ was investigated through electrochemical approaches and corrosion tests. Whole process of experiments were done in argon glovebox with less than 0.1 ppm of oxygen and moisture. Cyclic voltammetry was done for NaCl, KCl eutectic salt base with 1 weight percent $ZrCl_4$ for various scan rate and scan range, in 700 degree celsius. Two oxidation and redcution peak was collected, containing reduction peak near chromium oxidation potential. Disproportionation was checked by reducing Zr^{4+} to Zr^{2+} and it was observed to leave pure zirconium. Inconel 600 was applied for immersion corrosion test during 7 days with and without $ZrCl_4$. More mass loss was observed in specimen with $ZrCl_4$ and its surface and cross section SEM, EDS result showed aggressive corrosion through grain boundary and inside the grain. In blank salt, corrosion only occured through grain boundary. Pure zirconium also found on $ZrCl_4$ added corrosion test salt, reclaiming disproportionation of $ZrCl_4$. These results show that $ZrCl_4$ accelerate corrosion in MSR material by accelerating chromium dissolution, leaving pure zirconium particle impurity.

Log 323. REAL-TIME PARTICLE DISCRIMINATION IN DIGITAL AUTORADIOGRAPHY FOR NUCLEAR FORENSICS. Patz, H. (1, 2, P), Baciak, J.E. (1), Hartig, K.C. (1), McDonald, B. (2), Zalavadia, M. (2). (1) University of Florida. (2) Pacific Northwest National Laboratory. (P) Presenting Author.

Post detonation samples may have a high inherent background causing complications when performing measurements within a timely manner. High-resolution spatial mapping of alpha and beta/gamma emissions may provide forensically useful data, and guide selection of regions of interest for further analysis steps. The ionizing radiation quantum imaging detector (iQID) is a scintillation-based detector that operates as a real-time, single particle digital autoradiography system. It can measure spatial and temporal locations of the ionizing radiation interactions along with energy and activity estimations. The system relies on a scintillator in contact with an image intensifier, which is lens-coupled to a complementary metal-oxide semiconductor (CMOS) imaging sensor. The iQID can detect multiple types of radiation, operating in either an alpha-only (nearly blind to betas/gammas) or in a mode sensitive to all three particles. This is achieved via choice of scintillation material, gain settings, and post processing list mode data. A new effort aims to leverage the choice of scintillation material and frame parsing methods to achieve multi-particle imaging and greater discrimination between particles. The latter is being investigated based on intensities and shapes of the scintillation light clusters. The knowledge of beta/gamma and alpha location and activity may help target regions of interest and reduce measurement times. PNNL-SA-206219

Log 324. ACTIVATION ANALYSIS OF MINIATURIZED NEUTRON DOSIMETER FILMS IN THE HIGH FLUX ISOTOPE REACTOR. Mulligan, P.L. (1,P); Glasgow, D.C. (1); La Riviere, B.A. (2). (1) Oak Ridge National Laboratory. (2) Sandia National Laboratories. (P) Presenting Author.

Neutron dosimeters are a critical component of nuclear experiments to determine neutron flux, fluence, and energy spectrum conditions. These dosimeters are often made from thin foils or wires of high purity material to minimize flux perturbation, neutron self-shielding, and gamma self-attenuation. This work presents a new method of preparing miniaturized neutron dosimeter films using standard semiconductor fabrication processes. High purity films (10 – 200 nm thick) of Ni, Ti, Al, Cu, Mn, and Au were deposited on Si substrates using electron beam evaporation. The geometry of the films was controlled using photolithography and metal-liftoff processes, creating square and circular shapes of several different sizes as well as QR-codes. Si wafers were cut into 5 x 5 mm die sizes creating 250 devices per wafer, each with unique serial numbers and films of each dosimeter material. Devices were irradiated the pneumatic tube facility in the Neutron Activation Analysis laboratory of the High Flux Isotope Reactor. Gamma counting of irradiated devices showed 0% detector deadtime and nearly identical radioisotope quantities between devices with the same metal geometries. A linear regression analysis of 40 devices irradiated showed strong linearity between Au-198 activity and Au film mass, indicating the fabrication process was well controlled and repeatable. Flux measurements using these devices were also within 3% of measurements made with conventional Au and Mn dosimeter foils.

Log 325. PRODUCTION OF TAILORED ACTINIDE IONS FOR FUNDAMENTAL PHYSICS. Stricker, J. (1, 2, P); Arndt, L. (1); Duellmann, Ch. E. (1, 2, 3); Renisch, D. (1,2); Velten, J. (1); TACTICa Collaboration (1, 2, 3). (1) Johannes Gutenberg-University Mainz, Germany. (2) Helmholtz Institute Mainz, Germany. (3) GSI Helmholtzzentrum für Schwerionenforschung GmbH, Germany. (P) Presenting Author.

Trapped atomic and molecular actinide ions are considered to be ideal for a variety of fundamental physics experiments designed to explore physics beyond the standard model (1). Deformed actinide nuclei appear promising for use as quantum sensors, which could interact with dark matter or strange particles (2). Laser ablation is one of the most common ion-production methods. We report on the production of ions of thorium- and uranium-containing species, in a modified commercial ion gun in an electron-impact supported laser ablation process. The produced ions are extracted and analyzed by an ultra-high vacuum time-of-flight mass spectrometer. The ion source will be coupled to a Paul trap, where actinide ions of interest will be cooled sympathetically in a laser-cooled calcium cation crystal, thus allowing trapped-ion spectroscopy to study signatures hinting at novel physics. We investigated the dependence of the generated ion species, including atomic and di-atomic actinide ions, depending on different chemical actinide compounds used as laser ablation target material. We show that this allows selective production of tailored actinide ion species. As a first step, we demonstrated the ablation of metallic thorium and thorium fluoride crystals to produce thorium fluoride ions in different charge states (ThF^(n+), where n = 1 – 3) (3). (1) G. Arrowsmith-Kron Rep. Prog. Phys. 2024, 87, 084301. (2) V. V. Flambaum et al., Phys. Rev. C. 2019, 99, 035501. (3) J. Stricker et al., to be submitted.

Log 327. EXPLORATION OF STRUCTURE-PROPERTY RELATIONSHIPS WITHIN A SERIES OF LOW-DIMENSIONAL HYBRID RUTHENIUM HALIDES.

Guthrie, H.D.(1,P); Schofield, M.H.(1) Cahill, C.L.(1). (1) The George Washington University. (P) Presenting Author.

Hybrid perovskites have shown exceptional use for the detection of x-rays, y-rays and neutrons over recent years. These materials show promise due to desirable properties such as: tunable bandgaps, defect tolerance, strong x-ray absorption, and near-unity photoluminescent quantum yields. In particular, tunable bandgaps allow for tailored detection of specific radiation types by adjusting the range of photons the materials are capable of absorbing. This study reports on the synthesis and characterization of a novel family of hybrid metal halides consisting of haloruthenium octahedra (X = Cl, Br) charge balanced with halopyridinium (XPy; X= H, Cl, Br, I) organic cations. Exploration of the photophysical and electronic properties of these materials was achieved by systematically varying the composition. Using diffuse reflectance spectroscopy, it was found that compounds containing isolated RuBr62- octahedra displayed a lower bandgap (1.06 eV < x > 1.13 eV) compared to compounds with isolated RuCl62- octahedra (1.49 eV < x > 1.55 eV). Additionally, computational density functional theory (DFT) based natural bonding orbital (NBO) analysis, Quantum ESPRESSO and density of states (DOS) methods were used to characterize second-sphere non-covalent interaction strengths, investigate band structure, and elucidate molecular orbitals of the metal octahedra. This study signifies the potential for using second-sphere interactions to probe the relationship between photophysical properties and structure to inform the development of small bandgap, low dimensional hybrid perovskites.

Log 328. A NON-DESTRUCTIVE WAY TO MEASURE U-235 ENRICHMENT USING MÖSSBAUER SPECTROSCOPY.

de Morais, M.R.(1, P); Schwantes, J.M.(1). (1) The Pennsylvania State University. (P) Presenting Author.

This research is focused in modeling Mössbauer spectroscopy simulations to measure uranium-235 enrichment levels using plutonium isotopes, Pu-238 and varying concentrations of Pu-242, as gamma-ray sources. The process begins by selecting the concentration of Pu-242 relative to Pu-238 activity to ensure an appropriate balance for the simulation. Gaussian distributions are employed to simulate the energy profiles of low-energy gamma rays emitted during the alpha decay of plutonium isotopes to U-234 and U-238 in excited states, which subsequently decay to their ground states. The emitted gamma rays, with energies of 43.5 keV and 44.9 keV, interact with absorbers composed of U-234 and U-238 in the sample, enabling the Mössbauer effect to be detected. The low-energy band is defined at 43.5 keV and the high-energy band at 44.9 keV, with the count ratio between these bands used to correlate and quantify the enrichment levels of U-234 and U-238 in the sample. By correlating the low-band and high-band count ratio with U-235 enrichment data, the model identifies acceptable levels of enrichment measurable by this technique. Accurate uncertainty calculations are incorporated to ensure reliable confidence levels in determining enrichment. This approach demonstrates an effective method for simultaneously measuring uranium isotopes and quantifying enrichment, contributing to advancements in nuclear material analysis and addressing proliferation challenges.

Log 329. RADIOLOGICAL CONTROL OF THE TERRITORY THROUGH PERIODIC MEASUREMENTS OF WASTE WATER SEWAGE SLUDGE.

Cantaluppi, C.(1,P);Morelli, B. (1). (1) ICMATE-CNR Italy. (P) Presenting Author.

This paper concerns the study of the radionuclides content of urban sewage sludge produced in wastewater treatment plants (WWTP). In fact, sludge produced in wastewater treatment processes represents a receptacle for everything that flows into the sewerage network and its composition depends on the geographical and geological provenience. Gamma spectrometry analyses, conducted with an hyperpure germanium gamma detector, for at least 7200 seconds, were conducted on sludges collected monthly from 2012 to 2023 in some treatment plants in the Veneto region (North-East of Italy). A large database of sludge samples (more than 700) was collected in the monitoring programme and so it was possible to analyse the trend of natural and non-natural radionuclides over time, their evolution and their possible relationship with external factors. The evolution over time of the concentration of 137Cs in the sludge was studied by analysing the historical series for each treatment plant and comparing them with the expected decrease for radioactive decay.7Be was detected in almost all the samples analysed, present almost ubiquitously in the geographical area considered and the same for 40K. The gamma-emitting radionuclides of the 238U and 232Th decay chains were also analysed. The determination of 210Pb made it possible to verify the presence of its supported and atmospheric components. This work therefore demonstrates that the statistical analysis of the concentrations of radionuclides in the sludge of each treatment plant and their temporal succession allows us to obtain important information on environmental dynamics and any ongoing anomalies.

Log 330. MONTE CARLO MODELLING OF ELECTROREFINING SALT MEASUREMENTS.

McKay, K. (1,2); Winkler, R. (1); Landsberger, S. (2); Charlton, W. S. (2). (1) Los Alamos National Laboratory. (2) The University of Texas at Austin: (P) Presenting Author.

Nuclear material control and accountability (NMCA) is vital to safeguarding special nuclear materials (SNM) against theft and diversion. Nondestructive assay (NDA) via gamma-ray spectrometry is one of the most common methods employed by NMCA programs to determine the amount or composition of SNM. However, accurate gamma-ray NDA of SNM can be difficult in certain scenarios due to the complex distributions and compositions samples can exhibit. Monte Carlo models of a high-purity germanium (HPGe) gamma-ray detector used for assaying plutonium were developed and benchmarked to simulate a difficult measurement scenario often faced at Los Alamos National Laboratory (LANL): electrorefining salt (ER) residues. For the ER salts, NDA is hindered by samples' complex compositions which arise from the fresh separation of elemental components and the possible presence of heterogeneities. Gamma-ray measurements of both homogenous and heterogenous samples were modelled with varying amounts of plutonium present. The simulation results from these Monte Carlo models were then used to determine the minimum detectable amount (MDA) of 235U for different plutonium masses and to develop two improved FRAM parameter files used for determining the isotopic compositions of the salts. (LA-UR-32439)

Log 331. FINDING THE NEEDLE IN THE HAYSTACK: PINPOINT AND CHARACTERISING RADIOACTIVE NANO- AND MICROPARTICLES IN THE ENVIROMENT VIA ADVANVED SINGLE PARTICLE TECHNIQUES. Clases, D. (1, P); Lockwood, T. (8); Elinkmann, M. (1); Paton L. (1); Schlatt L. (2); Simic, M. (3, 4, 5, 6); Neuper, C. (3, 4); Hill, C. (3,7); Gonzalez de Vega, R. (1); Bohleber, P. (9); (1) Institute of Chemistry, University of Graz, Austria, (2) Nu Instruments, Wrexham, UK, (3) Brave Analytics GmbH, Austria, (4) Gottfried Schatz Research Center, (5) Medical Physics and of Biophysics, Medical University of Graz, Austria, (6) Institute of Physics, University of Graz, Austria, (7) Graz Centre for Electron Microscopy, Graz, Austria, (8) University of Technology Sydney, Ultimo, Australia, (9) Alfred Wegner Insitute, Germany. (P) Presenting Author.

Nano- and microparticles are ubiquitous and are known to be involved in various processes affecting geology and life. Despite their first scientific mention some 160 years ago, we are still struggling to find and understand them. This is particularly true for rare particualte entities, which comprise of rare elements including radioactive ones. Studying the size, abundance and composition of these particles is interesting to understand their environmental mobility and fate. Unfortunately, these rare particles are surrounded by a vast number of inconspicuous particles and finding relevant particualte species can resemble the search for the needle in the haystack. Only when employing single particles techniques with capabilities to pinpoint and characterise particles from distinct perspectives, it becomes possible to investigate and understand them. Inductively coupled plasma – mass spectrometry (ICP-MS) and its associated techniques initiated a paradigm shift for the investigation of micro- and nanostructures. In its single particle (SP) mode, it is capable to count individual particles rapidly whilst estimating critical particle features in a bottom-up fashion. This presentation will point out relevant facets of ICP-MS and set a focus on the analysis of rare particulates in an environmental context. Samples of different origin will be discussed regarding rare radioactive nano- and microparticles whilst pointing out new opportunities and technologies for their in-depth characterisation.

Log 332. USING ICP-MS/MS TO MEASURE Sr-90 IN MILK AND DRINKING WATER. Östman, M. (1, P); Lagerkvist, P. (1); Grange, M. (2); Mortensen, M. (2); Tovedal, A. (1); Dario, M. (3); Carlsson, M. (3); Liu, Y. (3); Eriksson, M. (3). (1) Swedish Defence Research Agency. (2) The Swedish Food Agency. (3) Linköping University. (P) Presenting Author.

A fast analysis method for Sr-90, intended for emergency preparedness, was developed using ICP-MS/MS and applied to milk and drinking water. In situation of a radiological emergency (involving fission of U or Pu), two important nuclides that might contribute to the radiation dose through food and water are Sr-89 and Sr-90. Sr-isotopes have their own limits in Euratom directive 2016/52 and the maximum levels of Sr-isotopes in water and liquid foodstuff should not exceed 125 Bg/kg. Sr-90 is traditionally analysed using liquid scintillation counting (LSC) since it is a pure beta emitter. This technique has several advantages, but as it is time consuming its usefulness is limited in situations where high sample throughput is necessary. In order to increase the measurement capabilities of Sr-90 in Sweden, a method using ICP-MS/MS was developed, validated and implemented in three Swedish laboratories. In short, the method digests 8 ml of milk with nitric acid. The sample is further separated and pre-concentrated using Sr-specific resin before analysis on ICP-MS/MS. Acidified drinking water can be analysed directly without any sample pre-treatment for screening purpose to maximise sample throughput and shorten turn-around times. Water samples can also be purified and pre-concentrated using Sr specific resin, which lower the limit of quantification (LOQ). The LOQ of the new method is below 30 Bq/kg.

Log 333. QUANTIFYING ACTINIDE UPTAKE THROUGH HUMAN SKIN WITH LA-ICP-MS. Jun, B.H.(1, P); Hull, G.A.(1); Harris, J.F. (1). (1) Los Alamos National Laboratory. (P) Presenting Author.

This study aims to quantify actinide excretion through the human skin surface using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) and Laser Induced Breakdown Spectroscopy (LIBS). Currently, monitoring of internal radiation exposure at nuclear facilities relies heavily on urinalysis, a resource-intensive and time-consuming process. Although the skin is typically regarded as a barrier to external threats, it also plays a vital role in excreting heavy metals that are ingested or inhaled. Adopting a skin-based dosimetry approach could expedite uptake determination and enhance the monitoring program effectiveness. Full-thickness human skin samples were obtained 24 hours post-excision, cut to a diameter of 12 millimeters, and cultured in a transwell plate under an air-to-liquid interface. The growth media was spiked with varying concentrations of uranium (U) up to 50 micrograms per milliliter, and the samples were incubated for 10 days to simulate internal actinide exposure. LA-ICP-MS analysis revealed U-238 signals three orders of magnitude higher than those from samples grown in non-spiked media. The LIBS emissions of sodium, calcium, and potassium were used to normalize the LA-ICP-MS signal and account for differences in ablation efficiency caused by the inhomogeneous skin surface. Future work will involve calibrating the raw signals using U-spiked gelatin standards and continuing data collection to map the 3D biodistribution of U through skin layers with depth profiling.

Log 334. U(VI) COORDINATION BY POLYDENTATE N,O-DONOR LIGANDS. Gutorova, S. V. (1,P); Matveev, P.I. (1). (1) Lomonosov Moscow State University. (P) Presenting Author.

N,O-donor ligands are promising for group separation of actinides. Previously it has been shown that such ligands efficiently extract U(VI) and Th(IV) at low concentrations, in ligand excess over metal, to form complexes with stoichiometry metal to ligand 1 to 1. However, the composition and structure of complexes during extraction from highly concentrated industrial solutions in metal excess over ligand have not been studied in thorough detail for these extractants. In an effort to fill this gap, we investigated the extraction of macroquantities of uranium by tri- and tetra-dentate ligands in F3 solvent. First of all an isotherm for the extraction of uranyl nitrates was constructed. Phenanthroline- based ligands demonstrated a high U(VI) capacity providing a uranium to ligand ratio in the organic phase up to 2 to 1. Using combination of spectroscopic techniques (UV-vis and EXAFS) and theoretical methods we showed that uranyl forms complexes with the structure of tight ion pars with tetradentate phenanthroline-based ligands. While, with tridentate pyridine-based ligands U(VI) forms a mixture of complexes with different stoichiometry. Moreover, both ligands show high loading capacity, being promising for industrial use as U(VI) extractants.

Log 335. THE DESIGN AND DEMONSTRATION OF A SIMULATION SURROGACY METHOD FOR THE STUDY OF MSR LIFECYCLE CHEMISTRY. Clayton, B.(1, P); Duong, L.(1); Gatenby-Latham, N.(1); Pope, S.(1); Xacur, J.(1); Chvala, O.(1); Clarno, K.(1). (1) The University of Texas at Austin. (P) Presenting Author.

Molten Salt Reactors (MSRs) promise significant advantages over traditional light water reactors, including enhanced safety and improved fuel efficiency. Among MSR designs, those using fueled fluoride salts have the most extensive operational history and are the focus of this study. In these systems, understanding and controlling salt chemistry is essential to reactor safety and performance. Challenges include preventing the release of volatile uranium species, avoiding unintended metallic uranium deposition, and managing fission product speciation as burnup progresses. These issues impact heat exchanger fouling, component corrosion, and potential criticality fluctuations, which define operational limits. Given the complexity of operating MSR's chemical and isotopic inventory, accurate simulation is challenging, particularly with limited experimental data. This work introduces a simulation surrogacy methodology to simplify the reactor system by grouping chemically similar species based on available data, balancing computational efficiency with fidelity. The approach integrates SCALE reactor physics framework for modeling fuel salt depletion and fission product generation with the Molten Salt Thermochemical Database-Thermochemical (MSTDB-TC) and Thermochimica for Gibbs energy minimization to predict species behavior. The methodology is demonstrated for a simple MSR design at key points in its lifetime, addressing operational challenges and safety concerns. Key data gaps, including radiological, neutronic, and quantitative limitations, are identified. Although focused on fueled fluoride salts, this methodology is adaptable to other reactor designs, providing a versatile framework for advancing MSR chemistry simulations.

Log 336. A SCOPING STUDY FOR THE DEVELOPMENT OF A CORROSION CHEMISTRY DIGITAL TWIN SUPPORTING THE OPERATION OF MOLTEN FLUORIDE SALT SYSTEMS . Clayton, B.(1, P); Xacur, J.(1); Pope, S.(1); Gentry, C.(1); Clarno, K.(1). (1) The University of Texas at Austin. (P) Presenting Author.

The global push for clean, reliable energy has renewed interest in nuclear technologies, with the United States aiming to triple nuclear energy production by 2050. Advanced Nuclear Reactor systems, particularly Molten Salt Reactors (MSRs), offer significant advantages in this pursuit, including enhanced safety and efficiency. However, the licensing of novel reactor concepts remains a major bottleneck due to the complexity and cost of regulatory processes. Digital twins—virtual replicas of physical systems—present a promising avenue for streamlining reactor licensing by enabling predictive simulations of system behavior. While digital twins for water-, liquid metal-, and gas-cooled reactors primarily rely on thermal hydraulics and neutronics, MSRs introduce an additional critical challenge: modeling the dynamic chemistry of molten salts. This study conducts a comprehensive review of existing salt chemistry models relevant to digital twin development for MSRs. Key gaps in research and development are identified, including limitations in current simulation tools and the scarcity of integrated experimental data. The interplay between salt chemistry and other reactor physics, such as thermal and radiological effects, is analyzed to highlight areas where further research is essential. The findings of this study provide a roadmap for advancing salt chemistry modeling, emphasizing the need for robust experimental validation and improved simulation frameworks. By addressing these challenges, this work aims to accelerate the adoption of digital twins in MSR licensing, paving the way for faster and more cost-effective deployment of next-generation nuclear reactors.

Log 337. EXPLORING ACTINIDE FLUORIDE PRODUCTION: IONOTHERMAL TREATMENT AND SPECTROSCOPIC AND MACROSCOPIC SIGNATURES OF UF_4 THERMAL DEGRADATION.

Ciprian, E. (1, P); Foley, B. J. (2); Spano, T. L. (3); Miskowiec, A. (3) Shehee, T. (2); Hixon, A. E. (1). (1) University of Notre Dame, Notre Dame. (2) Savannah River National Laboratory, Aiken. (3) Oak Ridge National Laboratory. (P) Presenting Author.

The pivotal role of uranium and plutonium fluorides in the nuclear fuel cycle, particularly in the pyrochemical reduction process, is well recognized. Traditionally, the fluorination of uranium and plutonium materials relies on the use of highly toxic and corrosive gases (e.g., HF(g), F2(g)). In this presentation, we introduce an alternative method that utilizes ionic liquids and a mild fluorinating acid as the primary fluorinating agents for f-element oxalates M2III(C2 O4)3·9H2 O(s)(MIII = Ce, Pu) and MIV(C2 O4)2·6H2 O(s) (MIV = Th, U). Our findings demonstrate that [Bmim][PF6] and HPF6 enable the ionothermal fluorination of f-element oxalates, resulting in the formation of anhydrous CeF3(s), ThF4(s), and UF4(s). This method also facilitates the partial fluorination of plutonium-III oxalate, yielding a mixture of PuF3(s) and an unidentified phase. Overall, the ionothermal treatment approach offers a safer and more efficient means of producing anhydrous f-element fluorides than conventional methods involving hazardous gases. Additionally, we detail the morphology and spectroscopic characteristics of UF_4 materials as influenced by production methods and thermal degradation, highlighting morphological features that could serve as indicators in nuclear forensic investigations.

Log 338. EVALUATION OF Cl-36 AND H-3 DIFFUSION IN DEEP GEOLOGICAL REPOSITORIES USING LSC AND AMS.

Baur, S. (1,P); Vockenhuber, C. (2); Christl, M. (2); Mäder U. (3); Martin, L. (4); Kiczka, M. (5); Heule, M.; Harzmann, S. (1); Mayer, S.(1). (1) Paul Scherrer Institute, Department of Radiation Safety and Security, Radioanalytics Group, Villigen PSI, Switzerland. (2) ETH Zurich, Laboratory of Ion Beam Physics, Switzerland. (3) Rock-Water Consulting, Boll, Switzerland. (4) Nagra, Wettingen, Switzerland. (5) University of Bern, Institute of Geological Sciences, Rock-Water Interaction (RWI), Switzerland. (P) Presenting Author.

Designs for deep geological repositories for radioactive waste use cementitious materials for structural elements, backfilling, or waste fixation. Chemical interactions at interfaces, e.g. between the host rock and cement, can influence properties such as permeability, swelling pressure and retention of radionuclides. The cement-clay interaction experiment at the Mont Terri Rock Laboratory in Switzerland aimed to reduce uncertainties about cement-clay interfaces by analyzing the diffusive transport of Cl-36 and H-3 over time under realistic conditions. In 2019, a small circulation system was installed to inject artificial cement pore water with the radionuclide cocktail and allow them to diffuse across the concrete-claystone interface into the Opalinus Clay in the 12-year-old concrete section. The diffusion was monitored over 4.5 years by liquid scintillation counting (LSC). Afterward, an overcoring sample was collected and about 250 concrete and claystone samples were analyzed for activity gradients. Accelerator mass spectrometry (AMS) was used to detect Cl-36, revealing detailed diffusion profiles. Both techniques complement each other in their ability to provide accurate radioanalytical data, with LSC being suitable for routine measurements of H-3 and Cl-36 and AMS offering unmatched precision for Cl-36 analysis of trace amounts. Together, they are essential tools in research regarding the detection of radionuclides e.g. in diffusion transport experiments at low concentration levels.

Log 339. ACTINIDES UNDER PRESSURE. Albrecht, T.E.(1). (1) Colorado School of Mines (P) Presenting Author.

This talk will focused on changes in structure, spectroscopy, and bonding in transuranium and lanthanide coordination complexes as a function of pressure. Data will be presented that provide evidence that at moderately high pressures, compression of An-L bonds results in increased hybridization of metal frontier orbtials with ligands orbitals, and that even though this increase is small that it results in large changes in spectroscopic features.

Log 340. THE SURRI PROJECT: DEVELOPING NEW METHODS FOR RISK MANAGEMENT AND CRITICAL ELEMENT RECOVERY AT LEGACY URANIUM PRODUCTION SITES. Cernik, M.(1); Burrell, F.(2); Sevcu, A.(1); Palusak, M.(1); Silvestri, D.(1); Hlavackova, V.(1); Nguyen, N.H.A.(1); Povedano Priego, C.(3); Merroun, M.(3); Petrangeli Papini, M.(4); Gomez-Gonzalez, M.(5); Cundy, A.B.(2,P). (1) Technical University of Liberec, Liberec, Czech Republic. (2) GAU-Radioanalytical, University of Southampton, UK. (3) Universidad de Granada, Granada, Spain. (4) Sapienza Universita di Roma, Rome, Italy. (5) Diamond Light Source Ltd., Didcot, Oxfordshire, UK. (P) Presenting Author.

Legacy uranium mining and production facilities present complex remediation and rehabilitation challenges, due to the presence of elevated radioactivity, potentially toxic metals, and/or sulphide minerals (which may promote acid mine drainage). This, and the often-large spatial coverage of tailings and other wastes (and their susceptibility to leaching, erosion or collapse) means that sizeable areas of land are made unfit for other uses and require risk management or rehabilitation. SURRI is a Horizon Europe Twinning project aimed at developing new integrated (and more sustainable) risk management methods for legacy uranium production sites (and other sites with uraniferous, thoriated or radioactive wastes) in Eastern Europe. Led by the Technical University of Liberec in the Czech Republic, the project draws on expertise from partners in Italy, Spain and the UK to develop new electrochemical and biological remediation processes to manage risk in legacy wastes, while also promoting element recovery from waste solids and leachates / drainage waters. This presentation examines the risk management, rehabilitation and radioanalytical challenges posed by the SURRI target sites and materials, evaluates the efficiency and likely scalability of the integrated electrochemical and bioremediation approaches developed in the project, and discusses synchrotron- and TOF-MS based work used to assess (radio)element speciation and transfer/uptake processes during element recovery.

Log 341. DEVELOPMENT OF GRADUATE CERTIFICATE IN RADIOCHEMISTRY AT THE UNIVERSITY OF IOWA. Forbes, T.Z. (1)(P); May, D. (1,2); Carter, K. P. (1); Celik, E (1). (1) The University of Iowa, (2) University of Iowa State Hygienic Laboratory. (P) Presenting Author.

Developing educational programs in radiochemistry is crucial for meeting the international workforce needs in public health, security, and energy sectors. However, trends in higher education make it difficult to create sustainable programs that can provide the hands-on experience necessary for these fields and reach students who need the foundational knowledge to advance in their careers. To meet this critical need, the University of Iowa Department of Chemistry and State Hygienics Laboratory have partnered with the Association of Public Health Laboratories to develop a unique program to support continuing education of the current workforce. The University of Iowa Radiochemistry Graduate Certificate Program is designed to provide post-baccalaureate science majors with the fundamentals of radiochemistry to enhance their technical capabilities in the laboratory. The accredited program consists of 12 semesters hours of coursework that combines both asynchronous online lectures with a two-week intensive hands-on laboratory. This presentation will discuss the design and use of best practices in online education to create novel programs that can meet the needs of the radiochemistry workforce. In addition, it will discuss current challenges and potential next steps in the expansion of these efforts across a range of sectors.

Log 342. TOWARD OPTIMIZED LIGAND SELECTION: A REVIEW FOR NUCLEAR FUEL REPROCESSING.

Alonzo, J.T. (1,2,P); Abergel, R.J. (1,2). (1) University of California - Berkeley (2) Lawrence Berkeley National Laboratory (P) Presenting Author.

Aqueous reprocessing of used nuclear fuel (UNF) is essential for reducing its long-term radiotoxicity and enhancing the safety and public perception of nuclear energy. Traditional aqueous reprocessing R&D involves testing the extraction efficiency of proposed ligand scaffolds with iterative ligand design and system condition changes. However, this laborious approach, coupled with the iterative nature of ligand development, significantly limits progress in nuclear separation technologies. Traditional approaches to ligand design often rely on incremental modifications of familiar molecular families, overlooking key factors like radiolytic resistance and process scalability, which are pivotal for industrial applications. Our literature review aims to evaluate critical data and process parameters essential for selecting ligands in the nuclear fuel cycle, with the goal of identifying strategies to enhance separation processes for lanthanides, actinides, and other valuable elements. The ligand selection criteria is categorized into three groups: chemical, process, and physical parameters, ranked by importance, to streamline their prioritization in ligand design pipelines. The potential for innovative ligand design to address critical challenges in nuclear waste management, such as improving efficiency, reducing process stages, and enhancing long-term sustainability, is highlighted in this review. Our research advances ligand discovery insights, providing a framework to expedite cutting-edge reprocessing technologies and foster innovation in nuclear waste management.

Log 343. AUTOMATED SAMPLE INTRODUCTION AND CHROMATOGRAPHIC SEPARATIONS FOR IMPROVED MASS SPECTROMETRIC DETECTION OF TARGETED ELEMENTS AT ULTRA-TRACE LEVELS.

Quarles Jr, C.D. (1, P); Horstmann, M. (2); Clases, D. (3); Karst, U. (2); Sullivan, P. (1) Elemental Scientific, Inc. (2) University of Muenster (3) University of Graz (P) Presenting Author.

Radioisotopes play an important role in nuclear energy, space exploration, military applications, and for medical imaging. The ability to detect and quantitatively measure these isotopes in environmental samples helps to gain a general understanding on mobility, impact and fate of radioisotopes and is critical to limit or control exposure events. However, determining radioisotopes in the environment poses several severe challenges which are linked to extremely low concentrations and complex matrices. In the past, these challenges prevented the analysis of 99Tc, which is a popular radioisotope used in nuclear medicine and little is known about its environmental discharge due to medical applications. This work describes an advanced analytical platform for the analysis of Tc integrating extraction and ion chromatography into an inline-ICP-MS workflow while automating preconcentration, clean-up as well as calibration steps entirely. This platform brings trace analysis to the next level and combines high robustness with minimal manual preparation. The platform offers flexibility to target specific species as well as other nuclides and elements. Besides the speciation analysis of medical Tc, further examples are shown for Gd contrasting agents as well as for U and Am in environmental samples.

Log 344. EXPLORING THE USE OF ELECTRON PARAMAGNETIC RESONANCE SPECTROSCOPY FOR NUCLEAR FORENSICS APPLICATIONS.. S. K. Scherrer (P); Forbes, T.Z. (1). (1) The University of Iowa. (P) Presenting Author.

Uranyl peroxides have been the focus of nuclear forensics studies due to their importance as a precursor for uranium oxide solids. Recent studies have focused on morphological changes upon thermal degradation or evaluation of trace elemental impurities by mass spectrometry techniques to provide new forensic handles to evaluate origin and processing history. Electron Paramagnetic Resonance (EPR) Spectroscopy is a technique that evaluates the presence of unpaired electrons in a solid material and is widely used within inorganic chemistry and biochemistry to understand oxidation states of metals and presence of radical species, such as superoxide (O2-•). Normally this technique would not be effective for evaluating U(VI) peroxide phases; however, during the formation of these solids, the peroxide can degrade and generate radical oxygen species (ROS) that can be detected using this spectroscopic method. In the current presentation, we evaluate the use of EPR spectroscopy as a tool in nuclear forensics for U(VI) peroxide materials, including the importance of specific activity and age of the material in the overall analysis. In addition, we explore how radiation fields can change the overall chemical signatures of the initial peroxide material and enhance the formation of ROS within these materials.

Log 345. RESULTS FROM THE FIFITH GALAXY SERPENT TABLETOP EXERCISE. Borgardt, J. (1,P); Marks, N. (2); LaMont, S. (3). (1) Juniata College, Huntingdon, PA. (2) Los Alamos National Laboratory. (3) Lawrence Livermore National Laboratory (P) Presenting Author.

Galaxy Serpent is an ongoing series of virtual, web-based international tabletop exercises designed to advance the application of National Nuclear Forensics Libraries (NNFLs) in investigations involving radioactive or other nuclear material found out of regulatory control (MORC). In its fifth iteration, the exercise expanded upon previous versions by emphasizing mock interactions between scientific teams and investigative entities. Approximately 30 teams, comprising 300 participants globally, were provided with synthetic NNFL data and a realistic scenario of recovered material, progressing through tiered stages of inquiry. These stages featured data, and storyline injects simulating an actual investigation, beginning with site detection and initial field measurements, followed by detailed laboratory analyses. Participants utilized their NNFLs to assess material consistency with provided holdings, provide confidence levels, and identify key characteristics relevant to investigative queries. This iteration underscored the NNFL’s integral role in supporting nuclear security investigations and showcased enhanced methodologies for integrating scientific expertise with investigative processes. The exercise highlighted both challenges encountered, and lessons learned, and advanced best practices in nuclear forensics.

Log 346. 234U/230Th RADIOCHRONOMETRY FOR URANIUM MATERIALS BY ALPHA SPECTROMETRY FOR NUCLEAR FORENSICS ANALYSIS. Macsik, Z.(1,P); LaMont, S.P.(1,2); Wende, A.M.(1); Flanagan, D.C.(1); Steiner R.E.(1). (1) Los Alamos National Laboratory. (2) University of New Mexico. (P) Presenting Author.

The mission of nuclear forensics is to identify the origin and history of nuclear materials found outside of regulatory control through the examination of confiscated materials using various analytical techniques. Radiochronometry of nuclear materials, is an important forensic examination technique that provides information about the production or last purification date of the material. Radiochronometry systems often used to determine model ages include - 234U/230Th, 235U/231Pa, and 241Pu/241Am. In our study, we have developed a method for 234U/230Th radiochronometry for uranium materials by alpha spectrometry including radiochemical separation of uranium and thorium, calibration of the 232U tracer, optimization of the amount of total uranium and 230Th in the analyzed aliquots and the alpha spectrometry measurement. The method was tested by analyzing a certified reference material, CRM 125-A uranium oxide pellet assay, isotopic, and radiochronometric standard. The results were compared to those of obtained by our routine 234U/230Th radiochronometry using multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS).

Log 347. INVESTIGATING PARTICLE FORMATION IN NUCLEAR FIREBALLS. Vasu, S.S.(1, P); Koroglu, B. (2); Urso, J. (1); Dennis, C. (1); Loye, T. (1); Ambarish, A. (1). (1) University of Central Florida. (2) LLNL. (P) Presenting Author.

Understanding post-detonative conditions in the wake of a nuclear event is essential for national response plans. Post-detonative conditions and debris fields are predicted using state-of-the-art fallout models, which require chemical kinetic inputs, ultimately dictating nuclear debris's morphology, size, and spread. Factors like humidity, salt, soil, and soot content can affect key nucleation, condensation, and coagulation processes, leading to more uncertainty in urbanized environments that have not been tested. Soot particle formation at the fireball interface influences chemistry, microphysics, and turbulence models. This work aims to experimentally understand how untested environmental conditions affect post-detonation particle formation. Experiments conducted at LLNL flow reactors allowed for investigations into nuclear debris formation at relevant temperatures (10,000K), while work done with impulse facilities (multiple shock and detonation tubes) at UCF allowed us to replicate shockwave and detonation wave phenomena. Coupling these facilities with advanced diagnostics tools enables in-situ measurements that support a first principles approach to model development. The water vapor concentration measured from LLNL provides a source of hydrogen and oxygen influencing UOx and UHx reaction pathways. In-situ, time-resolved water vapor measurements provide critical information into the (U, O, H) chemical kinetic system and test/refine model accuracy. Soot Volume Faction measurements from UCF offer valuable data for chemical kinetic mechanism development.

Log 348. CHARACTERIZATION OF CONCRETE SAMPLES USING THE UPGRADED CCD CAMERA NEUTRON IMAGING SYSTEM AT UFTR. Sarceno, A.N. (1, P); Nimmagadda, J.K. (1); Mueller, T.K. (1); Ferraro, C. (1); Baciak, J.E. (1). (1) University of Florida; (P) Presenting Author.

The University of Florida Training Reactor (UFTR) recently upgraded its thermal neutron imaging system with a new CCD neutron camera. The UFTR can operate at adjustable power levels of up to 100 kW thermal. Neutron imaging is conducted using the thermal column beam port, with collimation added as needed based on sample size. A SCINTACOR 6LiF/ZnS screen with an aluminum window, measuring 250 x 200 mm and 0.4 mm thick, was acquired to provide a larger imaging area compared to previous setups. The neutron camera was characterized to assess the maximum resolution of the updated imaging system, with the modulation transfer function evaluated using concrete test objects. This enhanced neutron imaging capability significantly improves the University of Florida's non-destructive examination capabilities for characterization of various concrete samples.

Log 349. MEASUREMENT OF GROSS ALPHA AND GROSS BETA ACTIVITIES AT LOW ALPHA-TO-BETA ACTIVITY RATIOS- A METHOD FOR EMERGENCY PREPAREDNESS. Norlin, K. (1, P); Rameбäck, H. (1); Tovedal, A. (1). (1) Swedish Defence Research Agency. (P) Presenting Author.

A method for the measurement of gross alpha and gross beta activities at low alpha-to-beta activity ratios is presented. Measurement of the gross alpha activity would still be important from an internal dose perspective when the gross beta activity is dominating, since a significant dose contribution may come from alpha emitting radionuclides. The method is intended for screening of drinking water after a radiological emergency when many samples would be valuable to be measured during a short period of time. The work shows that, in contrast to the often used radionuclides Am-241 and Sr-90/Y-90 for calibration, several radionuclides is prominent to use to determine the measurement efficiency and misclassification factors for an unknown sample. Furthermore, the method was adapted to be able to measure low alpha-to-beta activity ratios (0.001-10) with acceptable measurement uncertainties for samples with moderate quench.

Log 350. A NEW HALEU ISOTOPIC CERTIFIED REFERENCE MATERIAL. Rogers, K.T.(1, P); Grant, C.E.(1); Hexel, C.R.(1); Parikh, J.R.(1); Ticknor, B.W.(1) Springer, K.W.(1); Essex, R.M.(2). (1) Oak Ridge National Laboratory (2) NBL Program Office. (P) Presenting Author.

Isotopic reference material CRM U196 was prepared by gravimetrically mixing and dissolving NBL Program Office CRM 112-A (natural uranium metal) and CRM 116-A (high enriched 93.2% U-235) to achieve a high assay low enriched uranium (HALEU) isotopic abundance. CRM U196 will be certified for the 234U/238U, 235U/238U and 236U/238U ratios. Gravimetrically determined uranium isotope-amount ratios and values derived from the isotope data were calculated from the buoyancy corrected mass data and from certified values for the metal CRMs used to create the solution. The U-235 isotope-amount fraction (•100) and expanded uncertainty is 19.5846 ± 0.0028. For attribute verification, Total Evaporation (TE) and Modified Total Evaporation (MTE) isotope ratio measurements were performed at ORNL along with a single Davies and Gray uranium assay titration. The uncertainty budget showed the major contributors to the final combined uncertainty of the isotopic abundance were from the certified assays and isotopic abundances of the starting materials, with negligible contributions from the mass measurements. The solution was dispensed to create final units containing 5 mg uranium dried to a uranyl nitrate. Isotopic ratio verification by TE was repeated for two randomly selected units.

Log 351. CONTROLLED REACTION DYNAMICS OF BINARY HEXAFLUORIDES TO EXPLORE NEW CHEMICAL SIGNATURES.

Dorris, A.L. (1,P), McNamara, L.E. (1), Kelly, J.T. (1), Waldron, A.M. (1). 1 Savannah River National Laboratory. (P) Presenting Author.

Uranium hexafluoride (UF6) is an important feedstock material for the enrichment of nuclear power and weapons grade uranium. When exposed to air, UF6 spontaneously reacts with water vapor to generate hydrofluoric acid and uranyl fluoride (UO2F2). Despite decades of experimental and theoretical investigations attempting to uncover the reaction pathway, the identity of intermediates is still debated. In this study, we cryogenically trap the reaction intermediates using a custom-built vacuum chamber equipped with a cold finger capable of reaching temperatures below the activation barrier of the UF6 + H2O reaction. Fourier-transform infrared spectroscopy (FTIR) is used to interrogate the vibrational signatures of the system at various points along the reaction coordinate. Beyond UF6, a host of other binary hexafluorides are investigated using the same methodology to yield a deeper understanding of the complex spectra acquired as the reaction is underway. For each of the binary hexafluorides used in this study, the complete conversion from reactants to products is observed as well as spectral evidence of relatively long-lived intermediates. For some of these reactions, intermediates are trapped by lowering the temperature of the cold finger and secondary reactants were then introduced. By comparing the products in these experiments to those of the standard hydrolysis controls, we can suggest possible structures of the intermediates with a higher degree of confidence and develop a proposal for the hydrolysis pathways. Quantum chemical modeling of the reaction pathways at Sandia National Labs is being performed to help inform assignments of experimental peaks as well.

Log 352. ISOTOPE RATIO MASS SPECTROMETRY WITHOUT CHROMATOGRAPHY USING A MICROPLASMA/ORBITRAP COMBINATION.

Goodwin, J.V.(1); Shresthra, S.(1); Manard, B.T.(2); Marcus, R.K. (1,P). (1) Clemson University. (2) Oak Ridge National Laboratory. (P) Presenting Author.

Virtually all isotope ratio determinations of NP/NF/safeguards relevance require some form of chemical separations prior to the analytical determination due to the presence of isobaric (same mass) interferences. Isobars may be in the form of interatomic overlaps or the presence of polyatomic ions at the same nominal mass. The use of sector-field mass analyzers in thermal ionization and multi-collector ICP-MS can provide mass resolution of the order of 10,000, but that affords much freedom from many interferences, but in most instance of relevance here, some form of chemical separation is still required. As such, sacrifices in terms of sample turnaround times and absolute sensitivity are inevitable. We demonstrate the ultrahigh mass resolution achieved in the coupling of the liquid sampling-atmospheric pressure glow discharge (LS-APGD) microplasma to an Orbitrap mass spectrometer to overcome some of the most notorious of isobaric interferences. Known as the gold standards in “organic” mass spectrometry, this unique coupling provides the ability to perform elemental/isotopic analysis with mass resolution approaching 1,000,000! Examples of the utility of the method will include the direct mass resolution of the 87Rb:87 Sr pair and all of the Nd:Sm isotopic overlaps. Additionally, freedom from common ICP-MS interferences by high concentration Pt and Pb for U IR measurements will be demonstrated. Beyond the ability to do interference-free determinations, the system provides femtogram sensitivities and isotope ratio performance that meets IAEA targets.

Log 353. MOVING TOWARDS SINGLE-PARTICLE, ULTRAHIGH RESOLUTION ISOTOPE RATIO MEASUREMENTS USING A MICROPLASMA/ORBITRAP COMBINATION.

Shresthra, S.(1); Goodwin, J.V.(1); Manard, B.T.(2); Marcus, R.K. (1,P). (1) Clemson University. (2) Oak Ridge National Laboratory. (P) Presenting Author.

In the analytical chemistry of relevance to NP/NF/safeguards/environmental applications, granularity of information, rather than a homogeneous picture, is invaluable. Single particle analysis via microprobe methods (SEM/EDX or SIMS) places a premium on actually “hitting” a particle of interest across a much larger “background” population. As such, methods which provide high throughput, sequential analysis over thousands of particles is a priority. To this end, single particle (SP) ICP-MS performed on commercial MS platforms leads the way. The primary MS decision lies in whether comprehensive elemental/isotopic monitoring is needed (ToF platforms) or if high precision IR information is needed (MC platforms). A key consideration in this choice involves the projected spectral complexity, with MC instruments providing ~10X greater resolution, though insufficient for many applications. This laboratory is working towards single particle, ultrahigh resolution elemental/isotopic analysis by coupling a liquid sampling-atmospheric pressure glow discharge (LS-APGD) microplasma to an Orbitrap mass spectrometer. Here, resolution of >500,000 is obtained, with sensitivities on the fg level. Recent efforts have involved the analysis of 100 nm diameter Nd particles, suggesting that the plasma has energy for effective vaporization/ionization and very acceptable IR statistics on a few thousand particles. We describe studies of plasma/ MS sampling strategies towards the single particle level, where Orbitrap platform provides ultrahigh mass resolution and broad spectral coverage.

Log 354. A ROBUST ASSESSMENT OF HIGH-PRECISION PLUTONIUM ISOTOPIC ANALYSIS BY THERMAL IONIZATION MASS SPECTROMETRY.

Riche, A.T. (1,P); Samperton, K.M.(1); Norris, N.(1); Perez, S.(1); Morales-Arteaga, M.(1); Bonilla, H.(1); McNamara, L.(1). (1) Savannah River National Laboratory. (P) Presenting Author.

Thermal ionization mass spectrometry (TIMS) is a “gold standard” technique for actinide isotope ratio and assay measurements in support of nuclear nonproliferation, safeguards, and forensics. Savannah River National Laboratory (SRNL) is actively establishing state-of-the-art, high precision mass spectrometric capabilities to support multiple Department of Energy (DOE) programs and mission spaces. A new TIMS instrument was installed in SRNL’s Category II Nuclear Facility in February 2024, allowing for handling, preparation, purification, and analysis of high-level radiological materials within a single location. Here, we highlight SRNL’s efforts to qualify and optimize the instrument for Pu Total Evaporation (TE) isotopic analysis. Raw TE data were processed and explored using the open-source R statistical programming environment and Shiny Graphic User Interface (GUI) development package. Data processing tools included both conventional statistical methods and probabilistic approaches using Markov Chain Monte Carlo algorithms. This programming environment allows integration of online-collected metadata (e.g., filament current/ramp rate, ion source extraction lens settings, etc.) with signal intensities and reconstructed ionization profiles. This approach enables assessment of potential correlations between such variables to inform development of an objective basis for quantifying TIMS run performance. The framework presented here will be adapted to support development of additional actinide and stable isotopic measurement capabilities at SRNL.

Log 355. CHALLENGES IN ANALYZING UNUSUAL PLUTONIUM MATERIALS: PuF_4. Colletti, L.P. (1, P); DiBlassi, N. A. (1). (1) Los Alamos National Laboratory. (P) Presenting Author.

Since the founding of Los Alamos National Laboratory and the subsequent development of the Department of Energy (DOE) complex as a whole, the United States has had a wide range of nuclear materials over the decades supporting many different programs that range from nuclear power plant fuels, reprocessing, safeguards, and weapons testing and production. At LANL the Actinide Analytical Chemistry (AAC) group is one of the oldest analysis groups within the DOE complex that can trace it’s history back to the original chemists of the Manhattan Project. As a result, AAC has worked with most of the different types of nuclear materials over the years and developed a deep bench of “corporate knowledge” on how to handle, dissolve and analyze these materials. In 2024 LANL was asked to help figure out a way to completely dissolve PuF4 salts as they are historically very resistant to dissolution. This talk will go over the factors controlling full dissolution of PuF4 dissolutions, issues that you can run into during dissolution, and the impact of matrix choices on subsequent analyses.

Log 356. AN UPDATED ULTRAVIOLET-VISIBLE-NEAR INFRARED ABSORPTION SPECTRUM OF HEPTAVALENT NEPTUNIUM IN PERCHLORIC ACID MEDIA. Cicchetti, N. (1, P); Gelis, A.V. (1). (1) University of Nevada, Las Vegas. (P) Presenting Author.

Neptunium is known for its complex oxidation state chemistry, with five different valences available in aqueous solution, from (III) to (VII). Of these states, Np(VII) is the least well-studied. Heptavalent neptunium is stable in alkali but is a strong oxidizer under acidic conditions and is quickly reduced by water. This property makes Np(VII) difficult to characterize in acidic media, where its structure, reactivity, and chemical behavior are still poorly understood. Neptunium oxidation state is commonly quantified by UV-Vis-NIR spectrophotometry, but high quality data on the absorbance spectrum of Np(VII) in acidic media are not available. The most recent available spectra are more than fifty years old, are limited in resolution and range, and are drawn by hand. Quantitative information on the molar absorptivity of Np(VII) is also scarce. In this presentation we present an updated, quantitative absorbance spectrum for Np(VII) in 0.1 M perchloric acid, with a wavelength range of 200 - 1100 nm. Maxima are observed at 360 and 420 nm, which agrees with previously published results. Extinction coefficients are reported at these wavelengths. Kinetic data on the reduction of Np(VII) by water are also discussed.

Log 357. PRECISION GAMMA SCANNER: GAMMA RAY MEASUREMENT CAPABILITY FOR HIGHLY RADIOACTIVE MATERIAL. Walker, K.W.(1, P); Fronk, R.G.(1); Reber, E.L.(1); Stempien, J.D.(1); Hawkins, K.(1). (1) Idaho National Laboratory. (P) Presenting Author.

The Precision Gamma Scanner (PGS) at Idaho National Laboratory (INL) is a specialized detection system housed in the Hot Fuel Examination Facility (HFEF). It enables researchers to measure highly radioactive materials using a high-purity germanium (HPGe) detector for isotopic analysis and to identify fission and activation products. PGS is comprised of an HPGe detector, an 8-foot collimator, lead shielding, a digital signal processing spectrometer, and a Compton suppression system. Due to the high radioactivity of the specimens, they must remain inside the hot cell where the collimator is located. The collimator directs the gamma rays toward the HPGe detector situated just outside of the hot cell. The complex geometry and setup of the PGS measurement system require more complicated efficiency calculations to determine the activity of each isotope. This work will explain the efficiency calculation and analysis process used to determine isotopes present in the material of interest, as well as the design and setup of the current PGS system.

Log 358. NEXT GENERATION PARTICLE MAPPING FOR ISOTOPIC CHEMICAL AND ELEMENTAL ANALYSIS (MICE).

Ticknor, B.W.(1, P); Manard, B.T.(1); Szakas, S. (1); Stanberry, J.(1); Andrews, H. (1); Spano, T.(1); Beiswenger, T (1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Over the past few years, ORNL has developed new analytical tools and workflows for imaging, mapping, and analyzing materials of relevance to the nuclear fuel cycle, especially particles in complex matrices. The Mapping of Isotopic, Chemical, and Elemental (MICE) project combines micro-Raman spectroscopy, scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDS), and simultaneous laser induced breakdown spectroscopy / laser ablation – inductively coupled plasma – mass spectrometry (LIBS/LA-ICP-MS) to image particles or other materials of interest. The novel workflows developed offer the ability to combine techniques and to choose a combination of chemical (micro-Raman), elemental (SEM-EDS), and/or tandem elemental and isotopic (LIBS/LA-ICP-MS) analyses on the same sample region or particle population. Materials as varied as TRISO fuel pellets, inclusions in naturally occurring minerals, nuclear fuel cycle relevant particles, and particles collected via active air samplers have been studied with these tools. Ultimately the ability to provide high throughput particle characterization, particularly in the presence of complex matrices, while capitalizing on the flexibility offered by the various combinations of analytical techniques, represents a major step forward in the area of material analysis for nuclear nonproliferation.

Log 359. GLOBAL LESSONS: A COMPARATIVE ANALYSIS OF NUCLEAR GAMIFICATION'S IMPACT IN AMERICAN AND UK SCHOOLS.

Lu, S.E. (1, P); Hemming, S.D. (2); LaMont, S.P. (1). (1) Los Alamos National Laboratory. (2) University of Southampton. (P) Presenting Author.

This research explores the use of gamification in nuclear science education through the interactive card game RAD Ratings, focusing on its implementation in American schools and comparing outcomes with results from UK classrooms. This study assesses the impact of RAD Ratings on student engagement and comprehension of nuclear science concepts among U.S. students aged 11 to 18, while comparing these results with those from the UK. As the demand for skilled professionals in the nuclear industry continues to rise, there is an increasing focus on improving educational approaches that engage students, particularly in radiochemistry. The research examines how RAD Ratings enhances student engagement and supports teacher-led instruction in nuclear science classrooms in both the U.S. and UK. Data collection will involve pre- and post-intervention assessments to measure changes in student knowledge, alongside surveys and Likert-scale questions for both students and teachers. A key focus of the study is the comparison of outcomes from schools located near nuclear sites in both the U.S. and UK. This will provide insights into how students in these communities, who may have more direct exposure to the nuclear industry, respond to gamified learning approaches in comparison to students in other regions. This research aims to demonstrate how gamification can improve student engagement, comprehension, and interest in nuclear science. It will also offer recommendations for integrating gamified learning into U.S. curricula to strengthen the development of skilled professionals in the nuclear sector. LA-UR-24-32715

Log 360. ACCELERATING DISSOLUTION RATE EXPERIMENTS OF PLUTONIUM OXIDE IN SIMULATED LUNG FLUID USING IN SILICO MODELS. Lu S.E.(1,P), Klumpp J.(1), Anderson K.D.(1), Macsik Z.(1), Inglis J.(1), Harris J.(1), Steiner R.E.(1), LaMont S.P.(1). (1) Los Alamos National Laboratory. (P) Presenting Author.

We have developed a in silico model to study the dissolution behaviour of plutonium oxide, thorium dioxide, and uranium oxides in simulated lung fluid. The model examines the influence of surface roughness and permeability resulting from nuclear recoil tracks due to alpha decay on the flux of particles and dissolution rates. It integrates a mathematical relationship between surface roughness and material age, offering insights into the long-term behaviour of these actinide oxides in biological systems and their dissolution rates. Understanding the dissolution behaviour of actinide oxides in lung environments is critical for accurately assessing health risks associated with inhalation exposure to radioactive materials. By simulating these conditions, our model can evaluate the potential toxicity, bioavailability, and clearance of plutonium, thorium, and uranium compounds, improving post-exposure treatment plans, bioassay techniques, and dosimetry assessments. Our findings have the potential to advance regulatory standards for radioactive materials by providing a more sophisticated framework for managing radioactive exposure. Given the variability in the dissolution behaviour of actinide materials, this research has the potential to provide greater understanding of these dynamics following inhalation moving beyond the limitations of conventional in vitro and animal studies. By integrating in silico models with experimental in vitro studies, we can reduce the time delays, secondary exposure and enhance safety protocols and treatment strategies for individuals exposed to actinides. This is especially critical as the nuclear workforce continues to expand, increasing the number of individuals handling radioactive materials. LA-UR-24-32589

Log 361. INFLUENCE OF NICKEL AND COPPER ON THE ELECTROCHEMICAL BEHAVIOR OF TIN TO GUIDE THE AUTOMATION OF PLUTONIUM SURROGATE ELECTROREFINING. Johnson, B. (1,P); Ankrah G. (1); Fuller, A. (1); Rodriguez, R. (1); Rappleye, D. (1). (1) Department of Chemical Engineering, Brigham Young University. (P) Presenting Author.

Potential surrogate materials for plutonium are beneficial due to their cost-effectiveness in optimizing parameters and developing a methodology for autonomous, current-controlled electrorefining (ER). Current methodologies for incorporating an autonomous ER process involve optimizing the applied current, as deviations from a current linear sweep can introduce impurities and affect the performance of the ER run. However, challenges remain, such as determining the threshold cell potential. This potential is critical to avoid reducing impurities in the electrorefined metal, which can be addressed by incorporating a stable reference electrode (RE) in the cell. This study approached the problem by first understanding the electrochemistry of potential surrogate metal chlorides, such as SnCl2, in a eutectic LiCl-KCl-CaCl2 molten salt system using a silver-silver chloride (Ag/AgCl) RE. Electrochemical properties, including reduction potentials and diffusion coefficients, were obtained using different electrochemical techniques. The effects of impurities, such as CuCl and NiCl2, were also investigated to better understand their impact on the electrochemical properties of Sn in the eutectic molten salt system. This understanding can enable better control of potentials in an ER cell. The results of this study can provide a pathway to optimize the ER process by understanding the reduction potentials of Sn when an Ag/AgCl RE is used. This includes determining the operating and sweep limits to shorten the ER process while minimizing impurities in the electrorefined metal.

Log 362. DEEP LEVEL TRANSIENT SPECTROSCOPY OF SILICON CARBIDE PASSIVE THERMOMETRY. Mulligan, P.L. (1,P); Glasgow, D.C. (1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Silicon carbide is frequently used as a passive temperature monitor in uninstrumented irradiation experiments. SiC temperature monitors are particularly useful for this application because they can be fabricated into compact geometries, do not require instrumentation leads, and provide a continuous indication of peak temperature between approximately 200 – 1,000°C. The primary mechanism of this monitoring technique relies on lattice dilations in the material formed by neutron bombardment during irradiation. These dilations produce changes in the thermophysical properties of the material – such as swelling, thermal diffusivity, and electrical resistivity – which can be measured after irradiation to determine the experiment temperature. In single crystal SiC material, lattice dilations and point defects can also produce electrically active trapping states within the bandgap which can be measured using Deep Level Transient Spectroscopy (DLTS). This work will present DLTS measurements of N-Type 4H-SiC passive temperature monitors irradiated to four different neutron fluences in the pneumatic tube facility of the High Flux Isotope Reactor. Measurements of these samples were compared to similar SiC temperature monitors analyzed using conventional continuous dilatometry methods. A description of the DLTS instrument design, construction, and control software developed for this purpose will also be included.

Log 363. REMOVAL OF METAL BYPRODUCT FROM IN-SITU GENERATION OF ZIRCONIUM TETRACHLORIDE IN MOLTEN EUTECTIC LiCl-KCl. Eckley, C.A. (1,P); Camunez, A. (1); Fredrickson, G. (2); Yoo, T. (2); Simpson, M.F. (1). (1) The University of Utah, Department of Materials Science & Engineering. (2) Idaho National Laboratory. (P) Presenting Author.

It was first reported by Sakamura et. al. that spent uranium oxide fuel can be chlorinated via reaction with ZrCl4 and dissolved in molten LiCl-KCl, which provides a gateway into pyrochemical separations. Due to its high volatility, however, ZrCl4 is difficult to dissolve in LiCl-KCl. A workaround is to generate ZrCl4 in situ in molten LiCl-KCl via reaction of Zr metal with a reactive metal chloride such as NiCl2 or FeCl2. None of these reactants are volatile, and chlorination of Zr is spontaneous and fast. To recover the nickel or iron metal byproduct from the salt, galvanic reduction was tested. The zirconium metal used to generate the $ZrCl_4$ acts as the anode, and the metal byproducts were plated on stainless steel or nickel cathodes. Zirconium concentrations reached 2.2 wt% with $NiCl_2$ as the chlorinating agent and 1.6 wt% with $FeCl_2$. Zr solubility at 500oC is estimated to be 2.2 wt% based on extrapolation of reported data. In addition to providing a means to separate the by-product from the salt, this method yields real time process monitoring data in the form of cathode potential and galvanic current. This process monitoring data can be used to inform the operator when the reaction has gone to completion and when the by-product can be removed.

Log 364. INVESTIGATION OF URANIUM AND IRON CONDENSATION FROM HIGH TEMPERATURE PLASMA CONDITIONS. Weerakkody E. N. (1, P); Dai, Z. (1); Rodriguez, K. E. (1); Knight, K. B. (1); Koroglu, B (1); Balboni, E. (1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

The plasma flow reactor (PFR) was used to generate synthetic fallout nanoparticles containing uranium and iron oxides. In this study, two mixtures of aqueous U and Fe nitrates were prepared with 1:1 and 1:2 U:Fe atom ratios. These mixtures were injected into the PFR under two different flow conditions, and resulting particulate from the four conditions were analyzed using transmission electron microscopy and compared to prior results with singular analytes (U, Ce, Fe, etc.), increasing the complexity of systems studied. Results show that varied iron or oxygen content and flow rates affected formation of oxides, particle sizing, and spatial distribution in condensation products. Higher iron content promoted larger particulate formation. Increasing the plasma-generating argon gas flow led to more homogeneous mixtures of U and Fe products with uranium-rich regions encasing iron-rich regions, indicating that the iron oxides may have condensed first. From selected area diffraction patterns, the cases with 1:1 U:Fe preferentially formed different U oxides based on flow rate, possibly due to increased mixing from the increased flow rate, and oxygen sequestration by Fe, whereas additional Fe drove an even distribution of U and Fe oxides, indicating competing effects from mixing, iron sequestration, and oxygen availability. UFeO4 was also detected under extended acquisition time. This suggests that fallout models should account for chemical speciation among different metals in addition to condensation of singular metal oxides. These data will contribute to a model of particle condensation processes from the vapor phase and improve understanding of nuclear fireball phenomena. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DEAC52-07NA27344. LLNL-ABS-871454.

Log 365. METAL ALLOY MICROPARTICLE TAGGING OF UO2 FUEL PELLETS FOR NUCLEAR FORENSICS. Weerakkody, E. (1,P); Boro, J. (1); Amon, A. (1); Swift, A.J. (1); Long, O. (1); Kerlin, M. (1); Baker, A. (1); Marks, N.E. (1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

A tagging strategy for UO2 fuel pellets will be discussed which involves the creation of alloyed ternary microparticles that can be tuned to create a barcode that would indicate the provenance of the pellets. These alloy barcodes would contain high temperature resistant materials, such as Ti, Cr, and V, in small quantities (ideally 100-500 ppm) such that they do not interfere with the performance of the pellets. The Amazemet rePowder system was used to manufacture these pellets, which were incorporated into UO2 aliquots in concentrations of 500-1000 ppm. A process was established for pressing and sintering the pellets in house, and the resulting doped pellets were then imaged using scanning electron microscopy (SEM) and Electron Probe Microanalysis (EPMA) to determine if the barcode particles could be readily identified using these techniques. Details on how the particles were manufactured and characterized using techniques like EPMA will be discussed, as well as preliminary results from their incorporation into test pellets. Next steps will involve the scale up of this technique using more conventional pellet manufacturing methods as well as the implementation of more realistic barcode alloys. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DEAC52-07NA27344. LLNL-ABS-871590.

Log 366. PUSHING THE LIMITS OF ACTINIDE ISOTOPE ENRICHMENT FOR ISOTOPE DILUTION AND NUCLEAR DATA MEASUREMENTS.

Liezers, M. (1, P); Jeffries, B.D.(1); Pierson, B.D.(1); Hilton, C.D.(1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Barriers to the availability of single isotopes with ultra-high purity, greater than 99.99% for actinide analysis and research are longstanding. The primary isotope enrichment methods, such as centrifuge or Calutron type Electro-Magnetic Isotope Separators EMIS, have historically been capable of enriching material on the gram or even kilogram scale. However, these methods have rarely been applied to produce isotopes of ultra-high purity, and generally unavailable for research applications. Nevertheless, there currently exists a broad range of analytical measurements in which smaller quantities of ultra-high purity isotopes maybe adequate for addressing research needs. Thanks to advances in mass spectrometry, the ability to isolate almost any single actinide isotope to a purity of 99.99-99.99999% on the nanogram to microgram scale is now possible. Enrichment gains of 100,000 or more can be achieved using commercially available mass spectrometry. An added benefit of this approach is the ability to handle small quantities of source material which can be introduced directly from aqueous solution. This greatly simplifies material requirements and mitigates the radiological hazards encountered when handling actinides in a solid or gaseous form. Product recovery also involves minimal steps, resulting in a material that is both elementally and isotopically pure. Details of the novel production process and recent work leveraging it to produce ultra-high purity U238 and Pu244 will be described.

Log 367. MICROSAMPLE IDENTIFICATION WITH ADVANCED DIGITAL AUTORADIOGRAPHY METHODS.

McDonald B.(1,P), Hossbach T.(1), Zalavadia M.(1), Pagani L.(1), Patz H.(1,2), Wood R.S.(1), Miller M.(1), Cunningham H.(1), Fehringer B.(1). (1) Pacific Northwest National Laboratory (2) The University of Florida (P) Presenting Author.

Advanced, real-time digital autoradiography systems may provide rapid and selective identification of regions of interest on post-detonation samples. Data from these systems could aid in the creation of microsamples, enabling faster and more robust techniques for sample analysis. One challenge is the high radioactivity of such samples, which can overwhelm many systems. Further, alpha emissions from actinides, of forensics interest, are overshadowed by colossal fission and activation products emitting beta and gamma-rays. Finding and sampling regions of interest that emit both betas and alphas may enable lower backgrounds than if an entire sample is dissolved. In this paper, we will present an assessment of two advanced digital autoradiography methods for measuring such samples, and discuss steps taken to make these systems compatible with the expected counting rates. The two systems are the ionizing-radiation Quantum Imaging Detector (iQID), a real-time scintillation-light intensified camera, and large area Charge-Coupled Devices (CCDs) developed for dark matter detection. These systems offer complementary features for identifying regions and particles of interest on a sample. Initial results include tests with high-activity alpha sources, different scintillator screens, and using gating to mitigate high counting rates. Concepts for measuring large (>17” diameter) samples with an iQID will also be presented. PNNL-SA-206169.

Log 368. SMART SPECTRAL MATCHING: MACHINE LEARNING NEW SPECTRAL SIGNATURES IN URANIUM MATERIALS. Smith, R. W. (1); Spano; T. L. (1); McDonnell, M. (1); Miskowiec, A. (1); Niedziela, J. L. (1); Shields, A. E. (1, P) (1) Oak Ridge National Laboratory. (P) Presenting Author.

Here, we present interpretable machine learning models that can classify uranium minerals by secondary oxyanion chemistry and other physicochemical properties based solely on Raman spectra. This machine learning method, implemented within our Smart Spectral Matching scientific analysis framework, produces a mineral profile of physical and chemical properties for an unknown sample and can rapidly classify or identify unknown minerals from Raman data without the need for an exact pattern match in a spectral library. Training models are validated by (1) strong correlation of high-confidence model regions with published spectroscopic assignments and (2) correct classification of a mineral not present in training data. Physically meaningful classifier models can rapidly identify key structural and chemical information about unknown uranium minerals, and the overall methodology is broadly applicable for mineral phases. We will discuss extension of these models to technogenic uranium materials and the ability to add additional categories of metadata classifiers to the open-source Smart Spectral Matching framework and associated ontology.

Log 369. APPLICATION OF MICROANALYTICAL TECHNIQUES (SEM/EDX/RAMAN) TO THE CHARACTERIZATION OF POST-EXPLOSION PARTICLES. Martinez, M.(1, P); Totland, M.(1); Chaudhuri, A.(1); Cota-Sanchez, G.(1); Garcia-Alonso, J.(1); Gruntz, T.(1); Ayyagari, A.(1); Afolabi, O.(1). (1) Canadian Nuclear Laboratories. (P) Presenting Author.

A Radiological Dispersal Device (RDD) is a device which intends to spread radioactive material over an area to contaminate air, soil, water, or food with the intent to cause damage or injury to the public. The development of methodologies for characterizing these types of devices and the post-explosion particles they produce is key to connect people, places and events for law enforcement and security purposes. Microanalytical techniques such as SEM, EDX, and Raman spectroscopy are suitable techniques to determine the RDD device characteristic signatures and its original components. CNL conducted two experiments at the Canadian Explosives Research Laboratory (CERL). These experiments used pipe-bomb-style simulated RDD devices with different assembling configurations: a) CsCl as surrogate for Caesium-137, inside stainless-steel capsules to emulate a gamma-ray emitting tool, but with no direct contact to the explosive material (ammonium nitrate/fuel oil, ANFO), and b) CsCl powder physically mixed with ANFO. In parallel, we have also developed a method using an electric arc to generate RDD particles using laboratory-controlled explosion conditions in a plasma reactor.Post-explosion debris and particles from the experimental detonations and the laboratory-generated particles were collected and analyzed using a benchtop SEM/EDX/Raman system.Results from the size, morphology, elemental, and spectroscopic analyses of these particles will be discussed.The feasibility assessment of using the electric arc method to produce reference particles for RDD forensics will also be analyzed.

Log 370. RADIOCHRONOMETRY SIGNATURES ENGENDERED DURING LARGE-SCALE VACUUM INDUCTION MELTING CASTING OF A DEPLETED URANIUM METAL LOG.

Rice, N.T. (1, P); Wende, A.M. (1); Luitjohan, K.E. (1); Edwards, M.A. (1); LaMont, S.P. (1); Sanborn, M.E. (1); Torrano, Z.A. (1); Urso, V. J. (1); Denton, J.S. (1). (1) Los Alamos National Laboratory. (P) Presenter.

Radiochronometry provides the model age of a material, which is an integral signature in pre-detonation nuclear forensics. Model ages calculated for uranium materials using the 230Th/234U and 231Pa/235U chronometer systems are frequently employed to understand when a material was produced and aid provenance determination. When the Th and Pa model ages calculated for a sample are concordant this increases confidence that progeny were completely removed during the most recent purification of the material and that the model ages reflect the timing of this purification. However, material processing steps can alternatively fractionate decay progeny such that radiochronometry model ages are discordant, a phenomenon frequently observed in uranium metals. Though discordance is somewhat difficult to interpret, the nuclear forensics community is beginning to address this challenge by investigating how specific processes may result in discordance. Metal casting is a production step that has been observed to engender discordance, but few studies have been performed to understand in depth how these radiochronometry signatures relate to casting under controlled conditions. To remedy this, we investigated radiochronometry signatures engendered by large-scale vacuum induction melting (VIM) casting of a depleted uranium metal hollow log, first using a well-characterized feedstock, then by re-casting the same material into a second log. Protactinium model ages were largely preserved from the feedstock to the cast metal. Thorium concentration varied between the volume and surfaces of the casting but was mostly purified from the uranium during the casting process resulting in younger model thorium ages than those for the protactinium chronometer.

Log 371. ADAPTATIONS TO THE INTERNAL GELATION SOL-GEL PROCESS TO SUPPORT NUCLEAR FORENSICS APPLICATIONS.

Granger-Jones, J. (1, P); Keel, N. (1); Finkeldei, S. (1, 2, 3). (1) University of California, Irvine, Department of Chemistry. (2) University of California, Irvine, Department of Chemical and Biomolecular Engineering. (3) University of California, Irvine, Department of Materials Science and Engineering. (P) Presenting Author.

A summary of recent progress in research and development of process modifications to internal gelation (IG) to facilitate fine tuning of dopant incorporation. IG is a dust-free sol-gel synthesis technique that utilizes a pH change to form a gel network and can be used to fabricate homogeneously doped samples. The current work explores the application of this technique to mixed-metal systems containing neodymium and lithium, which hydrolyze and precipitate at a pH higher than what is achieved in the typical IG process. For neodymium, this work explores the use of different organic acids as complexing agents to alter the reaction pathway, allowing neodymium to incorporate into the gel structure alongside other metals (e.g., Zr and Mg) that form gel networks following the typical hydrolysis pathway. For lithium incorporation into an aluminum gel network, our recent work revealed that a layered double hydroxide intermediate limits the lithium content of the final product. Furthering this work, infiltering is investigated as an alternative method of lithium incorporation, attempting to alter the reaction pathway and avoid the stoichiometry-limiting intermediate. In addition to tuning the gel chemistry, this work explores considerations, such as the wash liquid (e.g., ammonium hydroxide, isopropanol), that must be taken to avoid dissolution of the gel and leaching of the metals into the wash liquid. This work broadens the range of metals that can be gelled, opening opportunities for the incorporation of various taggants for nuclear forensics purposes using this technique.

Log 372. ACTIONABLE UNCERTAINTY QUANTIFICATION METHODS FOR REAL APPLICATIONS OF NEURAL NETWORKS. Phathanapirom, B. (1); Hatton, C. (1, P); Dayman, K. (1); Stomps, J. (1). (1) Oak Ridge National Lab. (P) Presenting Author.

Although novel data analytic methods such as deep leanring offer cutting-edge predictive power, techniques for quantifying uncertainty with these methods are less developed and understood. Due to the high-consequence nature of forensics-related work, a dichotomous situation arises: the forensics community requires high precision and accuracy in its analytic capabilities while simultaneously requiring an understanding of the associated uncertainties to establish trustworthiness in the analytics. To this end, Gal and Ghahramani demonstrated that dropout training in deep neural networks results in approximate Bayesian inference in deep Gaussian processes, allowing uncertainty to be decomposed into its aleatoric and epistemic components. Generally, aleatoric uncertainty may be considered the irreducible component of uncertainty, whereas epistemic uncertainty may be considered the reducible component. This work applies dropout training to both regression tasks and classification tasks, as well as in both traditional feed-forward neural networks and in more novel transformer networks, where the original dropout for uncertainty quantification mechanics is adapted to the attention heads that drive transformer models. Methods for calibrating uncertainties in this paradigm are presented, and the degree to which these uncertainty values aid in the decision making process is discussed. Additionally, this work considers scenarios in which the decomposition of uncertainty may be advantageous in the concept of operations and experiment design.

Log 373. TOWARD UNDERSTANDING AND OVERCOMING DOMAIN SHIFT. Phathanapirom, B. (1, P); Dayman, K. (1); Stomps, J. (1). (1) Oak Ridge National Lab. (P) Presenting Author.

Domain shift, also known as distribution shift, is a phenomenon that occurs when the underlying data generating distribution changes for an event of interest due to a variety of factors that may include shifts in seasonal or temporal patterns, aging effects or sensor poisoning, or entirely new, emerging subclasses that fit within an event of interest. Domain shift can degrade model performance, resulting in misinterpreted events of interest during a system's deployment. Under the Multi-Informatics for Nuclear Operating Scenarios venture, domain shift was observed to degrade the performance of an acoustic vehicle detector over several months, likely due to changes in the background operating environment. A self-supervised learning paradigm was demonstrated to adapt to the shift in the data generating distribution by iteratively updating a classifier with pseudo-labeled data from the previous day's collected data. In this talk, we will overview other possible causes of domain shift that are relevant in the nonproliferation mission space, and we discuss methods (e.g., entropy minimization) beyond the iterative self-supervised learning procedure previously used for overcoming domain shift. Our primary goal in this talk is to facilitate discourse surrounding the issue of domain shift in the community and draw on subject matter expertise.

Log 374. CHARACTERIZATION OF 4H-SILICON CARBIDE SCHOTTKY BARRIER DIODES FOR HIGH TEMPERATURE APPLICATIONS. Giglio, D (1,P); Remy, J(1); Takahiro M. (2); Cao, L.R. (1). (1) The Ohio State University, Mechanical and Aerospace Engineering Department, Nuclear Engineering Program. (2) National Institute of Quantum Science and Technology, Japan. (P) Presenting Author.

The nuclear fuel cycle monitoring and advanced reactors require sensors capable of operating in extreme environments, such as high-radiation fields and high temperatures. Current silicon-based detectors are unable to provide reliable data in such harsh conditions. Wide band-gap semiconductor radiation detectors offer a robust alternative. The 4H silicon carbide (SiC), a wide band-gap semiconductor with a band-gap energy of 3.27 eV, possesses characteristics that make it an excellent candidate for extreme environment sensing. These include high breakdown voltage, low leakage current, high radiation tolerance, and stable operation across variable temperatures. This study focuses on evaluating and characterizing 4H-SiC Schottky barrier diodes at elevated temperatures (up to 600ºC) through voltage characteristic analysis and alpha spectroscopy using a vacuum-heater setup. The goal is to gain a deeper understanding of 4H-SiC behavior under high-temperature conditions for its implementation in next-generation nuclear fuel cycle and reactor technologies.

Log 375. A COMPARISON BETWEEN REAL TIME RADIOXENON(Xe-127) AND GAS GRAB SAMPLE STABLE XENON(Xe-126) MEASUREMENTS FROM THE PE1-A EXPERIMENT.. Liezers, M.(1, P); Alexander, T.R.(1); Carman, A.J.(1); Johnson, C.M.(1); Bodmer, M.A.(2); Foxe, M.P.(1); Fritz, B.G.(2); Roberts, B.(2); Tofaya, J.(2); Wright, A.A.(2); PE1 Experiment Team. (1) Pacific Northwest National Laboratory. (2) Sandia National Laboratory. (P) Presenting Author.

On the 18th of October 2023 an underground chemical explosive experiment PE1-A was peformed at the Nevada National Security Site. A small amount ~1 Ci of Xe127 (half-life 36.345 days) was emplaced in the sealed explosion chamber as a tracer. This radioisotope was prepared by irradiating 1 L of highly enriched (99.936%) stable Xe126, which normally displays the lowest natural abundance (0.089%) of all the Xe isotopes in air. As the radioxenon conversion efficiency was very low (<0.001%), most of the Xe gas released was stable Xe126, when this is combined with the low concentration of natural Xe in air (86 ppb) it presents a unique opportunity to study explosively driven stable and radioxenon geological migration in the same setting. There is 1 L of Xe126 in 12.7 million cubic meters of air, that would equate to the volume of a spherical chamber with a diameter of 290 meters. Radioxenon measurements were performed as real-time field measurements at multiple locations by gamma spectrometry. Stable Xe126 laboratory measurements were performed subsequently, on preserved gas samples also collected from multiple locations at different times over the course of the experiment using lab based Noble Gas Mass Spectrometry (NG-MS). Experimental details of the Xe analysis will be presented along with the first comparison between stable Xe and radioxenon measurements.

Log 376. OXIDATION STATE FAVORABILITY DUE TO CATION RADII IN MOLTEN SALT REACTOR FUEL SYSTEMS.

Patenaude, H.K.(1,P); Chamberlain, J.L.(1); Hatfield, C.A.J.(1); Parker, S.S.(1); Monreal, M.J.(1). (1) Los Alamos National Laboratory. (P) Presenting Author.

The extreme conditions of Molten Salt Reactors (MSRs) make even fundamental chemistry challenging for simple salts. However, an operating MSR comprises fission products, corrosion products, and actinides at various concentrations that have yet to be fully described in the literature. The primary objective of this work is to study complex molten salt systems while expanding the evidence for the impacts of solvent salt cation radii on coordination and oxidation state stabilization of species relevant to MSR fuel systems in a range of eutectic solvent salts with varying hardness. Cyclic voltammetry was performed in four solvent salt eutectics (LiCl-KCl, MgCl2-NaCl, CaCl2-MgCl2, and UCl3-NaCl) using lanthanide benchmarks as surrogates to inform future Pu experiments. An essential element in ensuring consistency and precision during such measurements is a novel, custom boron-doped diamond electrode for electrochemistry extreme environments. Diamond is known for low background capacitance, rapid electron transfer kinetics, wide potential windows, and resilience in chloride and fluoride molten salts. The present study used BDD to describe Eu3+/2+ and Ce4+/3+ via formal potentials, electron transfer kinetics, diffusion, and thermodynamics (ΔG, ΔH, and ΔS) in the various solvent systems. The success of these measurements informs fundamental chemistry by expanding our understanding of ion interactions in molten salts while characterizing systems applicable to an operating MSR. Additionally, it proves that BDD is an ideal electrochemical sensor for continued measurements in chloride and fluoride molten salts to support the safe, secure deployment of MSRs.

Log 377. MICROFLUIDIC DETERMINATION OF MOLYBDENUM(VI) SOLVENT EXTRACTION KINETICS.

Williams, B. (1), Gelis, A. (1), Brown, M.A. (2), (1) University of Nevada, Las Vegas (2) Argonne National Laboratories. (P) Presenting Author.

Efficient separation and purification of molybdenum-99 for medical isotope production requires understanding the kinetic regime. Extraction of molybdenum (Mo) from a nitric acid medium with bis-2-ethylhexyl phosphoric acid (HDEHP), bis(2,4,4-trimethylpentyl)-phosphinic acid (Cyanex 272), and 2-ethylhexyl phosphonic acid (HEHEHP) in dodecane is performed with a droplet-based microfluidic device. Rate constants and other parameters are determined by modifying the total flow rate, extractant concentration, and extraction channel size. Droplet-based microfluidics provides a unique method for determining several parameters with minimal time and set-up cost.

Log 378. PRODUCTION OF TWO NEW URANIUM RADIOCHRONOMETRY CERTIFIED REFERENCE MATERIALS. Gaffney, A.M. (1); Worsham, E.A. (1, P); Essex, R.M. (2, 3); Tarng, C. (1); Cocciadiferro, A.N. (1); Woods, L.M. (1); Mason, P. (2). (1) Lawrence Livermore National Laboratory. (2) NBL Program Office. (3) National Institute of Standards and Technology. (P) Presenting Author.

The radiochronometric model age of nuclear material is an important parameter for evaluating the accuracy and completeness of a safeguards declaration and a powerful signature for forensic evaluation of unknown material. In both applications, quality assurance of material analysis relies upon metrologically traceable reference materials (RMs) that are fit for purpose, with ages and isotopic compositions that are similar to the questioned samples. However, existing uranium radiochronometry RMs are limited in production age and isotopic composition and do not reflect the young ages of interest for some applications. To address the analytical needs of the safeguards and nuclear forensics communities, we have produced two new fit-for-purpose uranium radiochronometry certified reference materials (CRMs) for isotope dilution mass spectrometry analysis. The new materials, candidates CRM 150 and CRM 151, contain 19 and 90 percent U-235, respectively, have model dates in 2019, and are certified for Th-230/U-234 and Pa-231/U-235 radiochronometers. The CRMs were produced from metrologically traceable base materials provided by NBL Program Office and National Institute of Standards and Technology. The bulk uranium materials were quantitatively purified of all Th and Pa, and then known amounts of Th-230 and Pa-231 were gravimetrically added to achieve the target model ages. The certified standard values are derived from gravimetric preparation of the CRMs and were verified through interlaboratory comparison.

Log 379. NOVEL SPENT FUEL REPROCESSING METHOD UTILIZING SOLID STATE ACTINIDE FLUORIDIZATION AND ANTISOLVENT RECRYSTALLIZATION. Gibbs, T.M. (1,P), Chemey, A.T. (1) Oregon State University. (P) Presenting Author.

Nuclear power is the most economical and sustainable method to meet the growing global energy demand and near-term decarbonization initiatives employed in much of the developed world. Although nuclear power is not inherently renewable, it is recyclable, offering a pathway for sustainable energy production. While some countries have adopted closed-cycle technologies, such as the PUREX process, the United States has yet to implement these systems. However, aqueous reprocessing techniques like PUREX generate substantial quantities of highly acidic radioactive waste and raise significant concerns about nuclear proliferation, which have prevented their widespread adoption in the U.S. This study proposes a novel approach to bulk actinide separation through a gas-mediated solid-state reaction of spent nuclear fuel, aimed at producing actinide fluoride salts. This method leverages differences in solubility between targeted actinide fluoride salts and fission products in a saturated ammonium fluoride solution, followed by anti-solvent-induced crystallization of actinide fluorides. We hypothesize that this innovative technique will offer a proliferation-resistant, efficient means of recycling spent nuclear fuel. Furthermore, the final products of this purification cycle serve as stable precursors for the synthesis of actinide-bearing fuels, such as mixed oxide (MOX) fuels used in modern reactors, as well as advanced reactor fuel types. Notably, this process does not rely on the use of hazardous high-temperature gaseous hydrogen fluoride or strong acids, making it both safer and more environmentally friendly. Additionally, it can be completed within a practical timeframe, offering a promising alternative for future nuclear fuel recycling.

Log 380. INVESTIGATION OF SPECTRAL EMULATION FOR HPGE GAMMA-RAY RESPONSE GENERATION.

Bauyrzhan, A.B.(1, P); Hawari, A.I.(1). (1) North Carolina State University. (P) Presenting Author.

Applications such as advanced reactor on-line monitoring, nuclear fuel assay, and nuclear safeguards, require accurate measurement and analysis techniques for determination of variables such as isotopic content, burn-up, and enrichment. For these applications, high count rate conditions may emerge that exhibit considerable complexity and require advanced tools for real-time analysis. In this work, high count rate dependent gamma-ray spectra are generated using spectral emulation hardware that is designed for spectral reproduction. The performance of the emulator was assessed using gamma-spectra of progressive complexity including Cs-137, Co-60, and multi-line Eu-154 sources as count rates increased. The experimental spectra were recorded using an HPGe detector. Data collection was performed using a digital multi-channel analyzer (MCA) and the associated spectroscopy software. The experimentally measured spectra were employed as input data for the emulator, which was then utilized to regenerate the corresponding spectra. The experimental spectra and their corresponding emulated spectra from the three sources were compared. It was verified that the characteristics of the measured spectra, including the Compton continuum, peak-to-Compton ratio, full-energy peak, FWHM, and additional parameters, were maintained within acceptable uncertainties. Thus, it was concluded that the emulator is capable of generating accurate HPGe detector responses for increasing count rates. Investigation is underway to produce difficult to observe spectra using the emulation approach.

Log 381. ADVANCING DETECTION: ENHANCING SENSITIVITY FOR TRACE RADIUM MEASUREMENT IN DIVERSE MATRICES USING INNOVATIVE TOOLS.

Lariviere, D. (1,P) (1) Radioecology laboratory, Chemistry department, Laval Univeristy. (P) Presenting Author.

The detection of trace amounts of radium in various environmental and biological matrices remains a critical challenge due to its low concentration and the need for accurate monitoring of radioactive contaminants. This study explores the development and application of advanced analytical tools aimed at improving the sensitivity and precision of radium detection. By leveraging cutting-edge technologies, tandem mass spectrometry, and emerging sample preparation techniques, we demonstrate the ability to identify and quantify radium at increasingly lower concentrations. These approaches significantly enhance detection limits, enabling the analysis of complex matrices such as soil, water, and biological tissues with higher reliability and reduced detection time. These advancements hold significant promise for environmental monitoring, health diagnostics, and nuclear safety applications, providing a more effective means to address the challenges posed by radium contamination. This work underscores the importance of continued innovation in analytical instrumentation to meet the evolving needs of radiological research and public safety.

Log 382. SINGLE ALIQUOT NUCLEAR FORENSICS. Engel, J.R. (1,P); Rice, N. T. (1); Knapp, J.G. (1) Buettner, J.E. (1); Wende, A.M. (1); Sanborn, M.E. (1). (1) Los Alamos National Laboratory. (P) Presenting Author.

Nuclear forensics analyses often generate assay data of U and other trace actinides, such as Th, Pa, Np, Pu, and Am, to help determine an interdicted material's intended use, provenance, and ultimately to aid in source attribution. Destructive analysis via isotope dilution mass spectrometry (IDMS), wherein a U material is dissolved and aliquots of this solution are traced with a corresponding isotopic spike, can provide some of the highest precision isotopic assay data available. Current best practices for IDMS take separate aliquots for each trace actinide of interest and purify them from the bulk U matrix using bespoke chromatography methods. As a potential means to expedite sample throughput and analysis timelines, here we present work on a "single-aliquot" nuclear forensics approach, where a single aliquot of the U solution is taken, all relevant isotopic spikes are added, and then purified fractions of Th, Pa, Np, Pu, and Am are sequentially generated. We employ a stacked TEVA-DGA column scheme to sorb Th, Pa, Np, and Pu to the TEVA resin; sorb Am to the DGA resin; and elute the bulk U matrix as waste. We discuss the current yields and U separation factors for each element in this scheme, as well as data indicating the compatibility of our isotopic spikes to the single-aliquot approach.

Log 383. EXPERIMENT SERIES WITH PRESSURE DRIVEN SUBSURFACE NOBLE GAS TRANSPORT AND ATMOSPHERIC RELEASES. Foxe, M.(1,P); The PE1 Experiment Team(5). (1) Pacific Northwest National Laboratory. (2) https://doi.org/10.2172/2345984 . (P) Presenting Author.

The transport of radioxenon through the subsurface is important for understanding the fractional release into the atmosphere and the availability of radioxenon as a nuclear explosion monitoring signature. On October 18th, 2023 we executed a 13.58 T CompB chemical explosive experiment with stable, radioxenon, and tritium tracers to understand pressure-driven transport through the subsurface. The chemical explosion and subsequent gas migration were monitored with a network of seismic, infrasound, EM, radionuclide, and stable gas sensors. The material sensors included real-time radioxenon, tritium, and high explosive by-product sensors, as well as a series of samples that collected gas and water for laboratory measurement. This experiment was followed by venting tunnel gases into the atmosphere for local transport and detection. Additionally, we have also implemented other stand-alone atmospheric release experiments. In this presentation, we outline the experimental conditions and highlight the primary detection mechanisms and results. Subsequent presentations will cover specific aspects of the experiment such as tracer production/emplacement and measurements of the tracer gases.

Log 384. TRANSPORT VARIABILITY OF XENON AND TRITIUM FOLLOWING AN UNDERGROUND EXPLOSIVELY DRIVEN RELEASE. Foxe, M.(1,P); Liezers, M.(1); Alexander, T.(1); Boukhalfa, H.(2); Rahn, T.(2); Couture, A.(1); Rocco, N.(1); Lyons, S.(1); Rush, L.(1); Abbott, G.(3); Jenkins, A.(3); Goodwin, M.(3); Galvin, G.(3); Archambault, B.(1); Auld, G.(3); Beck, K.(1); Bertschinger, K.(1); Britt, C.(1); Fritz, B.(1); Glasgow, B.(1); Johnson, C.(1); Keillor, M.(1); Knox, J.(1); Moore, M.(1); Perea, R.(1); Roberts, B.(4); Sharma, M.(1); Slack, J.(1); Tafoya, J.(4); Taguba, C.(1); Terry, B.(4); Van Morris, A.(1); Whitehill, A.(1); Wright, A.(4); The PE1 Experiment Team(5). (1) Pacific Northwest National Laboratory. (2) Los Alamos National Laboratory. (3) Atomic Weapons Establishment. (4) Sandia National Laboratories. (5) https://doi.org/10.2172/2345984 . (P) Presenting Author.

The detection of radionuclides plays an important role in confirming if an explosion is nuclear or chemical. As radioactive gases are transported through the subsurface environment, there is potential for fractionation between the species. The fractionation between species is important for understanding the source term for isotopes detectors. During a recent field experiment, radioactive tracers were released along with a high explosive source. The experiment was aimed at understanding the pressure driven transport of materials. Two tracers of interest for this study were 127Xe and tritium gas. The transport of these gases is expected to vary as a function of geologic media, gas sizes, and gas chemistry. Real-time measurements were made for 127Xe in gas sampling boreholes and within the tunnel, while tritium real-time measurements were performed throughout the tunnel. In addition to the real-time measurements, grab sample measurements from select gas boreholes and tunnel locations were performed on 126Xe, tritium gas, and tritiated water (HTO) to help understand the fractionation. In this presentation, we compare the transport of xenon with tritium (gas and water) through a series of measurements from both real-time field and laboratory systems.

Log 385. REVISION TO THE "ALTERNATE ACTINIDE CALIBRATION" MASS RANGE IN ASTM C1590, ALTERNATE ACTINIDE CALIBRATION FOR INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY. Giaquinto, J. M.(P); Keever, T. J.; Khaing, H.; Roach, B.D.; Wightman, C. Oak Ridge National Laboratory, Oak Ridge, TN. (P) Presenting Author.

The Nuclear Analytical Chemistry (NAC) Section at Oak Ridge National Laboratory routinely uses single detector ICPMS instrumentation to measure isotopes of the heavy elements in unirradiated and irradiated nuclear materials. Many such isotopes are unique for which certified calibration standards are not available. Originally, starting in the 1990's, the isotopes measured were limited to the elements thorium, uranium, and plutonium (mass range 232 – 244.) Today, with the growth of isotope programs at ORNL, the practice has been expanded to include isotopes of elements ranging from radium to californium (mass range 223 – 252). To quantify these heavy isotopes by ICPMS, NAC chemists optimize the mass spectrometer to affect a plateau across the high mass range. This linear response in this range enables the use of certified reference standards of thorium, uranium, or plutonium to create the alternate calibration. This practice utilizes comparisons of the ICPMS results to other analytical methods such as gamma-spectroscopy. Presented will be an overview of the nuclear projects supported using this methodology and the isotopes measured for each. Comparisons between ICPMS and gamma and alpha spectroscopy measurements will be presented. These data sets will be used for a proposed revision to ASTM C1590 standard practice for extending the alternate calibration mass range.

Log 386. Advancing Nuclear Forensics Education and Research through the Consortium for Nuclear Forensics (CNF). Hartig, K.C. (1,P); Palmer, C. (2); Penchoff, D. (3); Baciak, J. (1); 1. Nuclear Engineering Program, University of Florida; 2. School of Nuclear Science and Engineering, Oregon State University; 3. Department of Chemistry, University of Central Florida; P. Presenting Author.

The U.S. Department of Energy's National Nuclear Security Administration (DOE/NNSA) has established the Consortium for Nuclear Forensics (CNF) to enhance nuclear forensics education and research. Bringing together sixteen universities and seven U.S. National Laboratories, CNF advances scientific discoveries and technological innovations in nuclear forensics. Collaborators' expertise spans radiochemistry, nuclear physics, materials science, and data science. Central to CNF's mission is developing skilled professionals through interdisciplinary training and hands-on research, ensuring a robust pipeline of experts in nuclear forensics. The consortium's research is organized into five Thrust Areas: (1) Rapid Turnaround Forensics, (2) Advanced Analytical Methods, (3) Ultrasensitive Measurements, (4) Signature Discovery, and (5) Prompt Effects and Measurements. Complementing these areas is a cross-cutting initiative leveraging high-performance computing and artificial intelligence. This presentation will overview each thrust area, highlighting how CNF's integrated education and research efforts strengthen the national nuclear forensics mission.

Log 387. AN EXPLORATION OF DATA FUSION TECHNIQUES APPLIED TO NUCLEAR FORENSICS TASKS. Johnson, J. (1, P); McDonald, L. (2); Tasdizen, T. (1). (1) University of Utah, Scientific Computing and Imaging Institute (SCI). (2) University of Utah, Department of Civil and Environmental Engineering. (P) Presenting Author.

Increasing the fidelity of analyses of nuclear material is an important goal of technical nuclear forensics R&D. Many well-proven and mature analysis tools exist; some give visual representations of materials, while others offer clues to the chemical composition. We use a new dataset of paired Scanning Electron Microscope (SEM) images and X-Ray Diffraction (XRD) patterns, with data collected from the same material sample. We use this dataset to present a framework for fusing these very distinct modalities -- themselves well-studied tools of nuclear forensics -- to increase their specificity together. We show that allowing the model to use correlations between sources of information through early model fusion can significantly improve accuracy over any single model alone and even over baseline methods that incorporate ground-truth information about the resulting uranium ore concentrate (UOC) from the processing route. If XRD data is limited, we show that generating synthetic patterns using crystallographic information is a viable method for increasing the available data. Comparing models trained on real and synthetic XRD data, we conclude that our early fusion method trained on real XRD data is able to utilize processing route information previously hidden in the XRD pattern, outperforming late fusion methods and models trained on synthetic data alone. We hope this work will prompt additional efforts to build multi-modal datasets to further develop data fusion techniques.

Log 388. MORPHOLOGICAL SIGNATURES OF U-OXIDES PRODUCED FROM THE HIGH-TEMPERATURE FIRING OF U-METALS. . Gibb, L.D. (1,P); Chung, B.W. (2); McDonald, L.W., IV (3); Simpson, M.F. (1). (1) The University of Utah. (2) Lawerence Livermore National Lab. (3) Oregon State University. (P) Presenting Author.

In the past decade, the morphological signatures of uranium oxides have been extensively studied to quantify their processing history. These studies have focused primarily on U3O8 and UO2 produced from precipitation and subsequent calcination and reduction reactions. Nonetheless, U-oxides can also be made from the high-temperature firing of U-metals. This study quantitively compares how U-oxides produced from U-metals compare to U-oxides produced from traditional synthetic routes. Eighteen U-metal samples were fired in a controlled atmosphere box furnace at the University of Utah. Half of the samples were fired in dry atmospheres with the temperature varying from 500 to 900C; while the other half of the samples were fired at the same temperature but with steam added to the furnace. The resulting U-oxides were characterized using powder X-ray diffractometry to quantify the crystalline phase and scanning electron microscopy (SEM) to document the morphology. Image segmentation was performed using the morphological analysis of materials (MAMA). In addition, machine learning based on convolutional neural networks was used to compare these U-oxides to those previously produced from traditional means.

Log 389. U-METAL MORPHOLOGICAL SIGNATURES DURING LABORATORY STORAGE. Gibb, L.D. (1,P); Varszegi, A.J. (1); Chung, B.W. (2); McDonald, L.W., IV (3); Simpson, M.F. (1). (1) The University of Utah. (2) Lawerence Livermore National Lab. (3) Oregon State University. (P) Presenting Author.

U-metals are an essential component of the nuclear fuel cycle and are gaining popularity in advanced reactor designs. There is interest in understanding the storage histories of these materials as a signature for nuclear forensics. Morphology can potentially reveal the storage history, but fundamental laboratory experiments are needed to know why and how U-metals' morphology evolves. This analytical study aims to determine how the metals oxidize and hydrolyze under laboratory conditions. To do this, uniform samples were mounted in epoxy with the surface polished and exposed to three storage environments. The first atmosphere was based on the natural conditions in our laboratory at the University of Utah in Salt Lake City, UT, which holds relatively constant at 20C temperature and 20% humidity. The second atmosphere was a humidity chamber held a constant high temperature of 35C and high humidity of 75%. The final atmosphere was a diel cycle humidity chamber, which fluctuated from 10C temp and 20% humidity to 35C temp and 75% humidity. Samples were aged for identical times in these different environments and then analyzed using X-ray diffraction (XRD) and scanning electron microscopy (SEM). Rietveld refinement was performed on the diffraction patterns to determine the sample's chemical composition. The samples stored in standard laboratory conditions had the least change in chemical composition and morphology, while the samples stored in the high temperature/high humidity chamber and the diel chamber showed extensive oxidation to studtite or metastudtite.

Log 390. NuTIMS NX - UPDATED MULTI-IC SYSTEM. Roberts, D.J. (1,P). (1) Nu Instruments. (P) Presenting Author.

To address the increasing demand for full-size secondary electron multipliers (SEMs) within the NuTIMS instrument, a new and enhanced design has been developed. This updated configuration includes improved standard vacuum pumping capabilities, with optional enhancements for further optimization. Additionally, a newly integrated zoom lens system enables precise alignment, facilitating the measurement of masses ranging from 232 to 246 within a single analytical routine. Furthermore, the instrument incorporates additional filters designed to mitigate tailing effects, ensuring improved analytical performance and data fidelity.

Log 391. ROTATING PACKED BEDS FOR LANTHANIDE RECOVERY FROM USED NUCLEAR FUEL. Kent, K.M. (1,P); Wang, I.(1); Lai, G.(1); Dean-Kersten, W.R.(2); Servis, A.G.(2); Duval, C.E.(1). (1) Case Western Reserve University. (2) Argonne National Laboratory. (P) Presenting Author.

A major limitation to implementing reprocessed used nuclear fuel (UNF) in the U.S. is the high cost of reprocessed uranium compared to mined uranium. Recovering high-value products such as lanthanides can improve the economic viability of UNF reprocessing by increasing the profitability of reprocessing facilities thus lowering the cost of reprocessed uranium. Resin packed columns are traditionally used for metal recovery from aqueous streams; however, their large size requires large amounts of concrete and rebar for radiation shielding which increases capital costs. Thus, smaller process equipment is necessary to implement lanthanide recovery from UNF. Rotating packed beds (RPBs) are a type of process intensification tool used to drastically decrease the size of reprocessing equipment. RPBs distribute a liquid stream onto a continuously rotating bed of packing, where an applied centrifugal force shears the liquid into thin films thereby improving mass transport. In this work, a bench-scale RPB packed with tetraoctyldiglycolamide resin was fabricated using additive manufacturing in a Form 4 printer. Simulated UREX raffinate was used as the inlet liquid feed to the system. The impact of feed flowrates and rotational speeds on lanthanide recovery and purity in the RPB was investigated. At the optimal condition, lanthanide capacity was shown to double in an RPB when compared to that in a stationary packed column while maintaining high neodymium purity. This work demonstrates the use of new, process intensified equipment for enhancing the economic argument for UNF reprocessing.

Log 392. FUNDAMENTAL DATA SUPPORTING NOVEL RADIOCHEMICAL SEPARATIONS. Olney, K.A.(1, P); Snow, M.S.(1); Fanner, A.J.(1); Cooper, J.T.(1). (1) Idaho National Laboratory.

Rapid chemical separation of actinide, lanthanide, and other radioactive elements is an important pursuit in the field of radioanalytical and nuclear chemistry. Vital to the development of advanced systems to achieve such separations is the determination of elements’ distribution coefficients (Kd values) for chromatographic resins. In this study, batch contacts of 68 elements were performed with various commercially available resins, and the resulting distribution coefficients were determined by Inductively Coupled Plasma – Mass Spectrometry Analysis (ICP-MS). An evaluation of the resulting Kd data for elements on the resins was performed. Finally, this work presents prototype flowsheets for streamlined separation of radioisotopes from a variety of complex matrices.

Log 393. LONG-TERM ANNUAL PROFICIENCY TESTING IN FUKUSHIMA FOR QUALITY CONTROL OF ACTIVITY MEASUREMENT USING GAMMA RAY SPECTROMETRY. Furukawa, R. (1, P); Miura, T. (1); Hachinohe, M. (2); Matsuzaki, S. (3); Murakoshi, M. (3); Yuki, M. (3); Hamamatsu, S. (4); Tokonami, S. (5); Harano, H. (1). (1) National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST). (2) National Agriculture and Food Research Organization (NARO). (3) Fukushima Prefectural Centre for Environmental Creation (CEC). (4) Tokyo Metropolitan Agriculture Forestry Research Center. (5) Institute of Radiation Emergency Medicine (IREM), Hirosaki University. (P) Presenting Author.

After the accident at TEPCO the Fukushima Daiichi Nuclear Power Plant, the number of institutes in Japan engaged in activity measurement of environmental samples has increased. Such institutes often have limited experience, their entry into the activity measurement raised concerns about the reliability of the activity measurements. Then, for ensuring the reliability of their inspections, evaluating measurement competences of such institutions is crucial. In addition, continuous support, such as technical guidance, can further improve their measurement capability. Therefore, the prefectural government, the CEC, has been conducting annual proficiency testing for institutes using HPGe semiconductor detectors in Fukushima Prefecture since 2015. The target nuclide is Cs-137, with Cs-134 also included until 2020. Unspiked brown rice harvested domestically was used as the sample. Sample preparation was performed by the NARO. The activity reference value was set by the NMIJ, to ensure traceability to the national standard. Considering that many of the participants were not experienced in uncertainty evaluation, each institute reported the standard uncertainty associated with the counting statistics, while other components were provisionally estimated by the CEC. The D percent, the z prime score, and the special En value were used to evaluate the results from each institute. In addition, feedback was provided at each proficiency testing. This presentation covers the results of the proficiency testing from the first year, 2015, to the late year, 2023.

Log 394. Assessing Uranium Compositions in Debris Post-Radiological Incident. Sahin, D. (1,P), H. Heather Chen-Mayer (1), Bryan Remley (1), Osman S. Celikten (1), Anil Gurgen (1). (1) National Institute of Standards and Technology. (P) Presenting Author.

On February 3, 2021, the National Bureau of Standards Reactor (NBSR) experienced a radiological accident. The current cleanup effort aims to remove remaining uranium within the core region by vacuuming or deploying remote tools. This work investigates quantitative methodologies to analyze the composition of recovered fission products and burnup levels in fuel elements. The situation involving unclad and unidentified fissile material calls into question the traditional use of Cs-134 and Cs-137 isotopes in determining fissile compositions. Utilizing the MCNP model of the NBSR and high-resolution gamma spectroscopy, we present a modified methodology for quantifying U-235 in debris samples. The method has been applied to an 85 mg debris piece retrieved from the NBSR reactor core. The study found that an average of 12.5 mg of U-235 was consistently derived from the measured activities of Zr-95, Ru-106, Sb-135, and Ce-144, whereas Cs-134 and Cs-137 activities correspond to only about 30% and 60% of the U-235 mass, respectively. Underprediction via Cs isotopes suggests that Cs release occurred in unclad fuel. Moreover, MCNP calculated Cs-134/Cs-137 activity ratio was about 0.12, whereas the measured Cs-134/Cs-137 activity ratio was approximately 0.07, implying that Cs-134 and Cs-137 were not released uniformly. Therefore, Cs-134 and Cs-137 cannot be used alongside the other isotopes in future assessments. New sample measurements will be completed in January 2025 and included later. Although the proposed method has inherent uncertainties, it offers an initial roadmap for quantifying fissile material in collected samples and evaluating the effectiveness of reactor cleaning procedures.

Log 395. MEASURING THE THERMAL NEUTRON CROSS SECTION FOR THE 40Ca(n,a)37Ar REACTION.

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Argon-37 is a signature of interest for nuclear explosion monitoring because its longer half-life compared to radioxenon isotopes provides a longer detection window and it is produced in underground nuclear explosions (UNEs) with high eneough activity to be detected using current detection systems. 37Ar is formed via the (n,a) reaction with 40Ca, the dominant isotope in natural Ca, which is found in most common rock types. The thermal neutron cross section for the 40Ca(n,a)37Ar reaction is poorly characterized, with the Evaluated Nuclear Data File (ENDF) and the Japanese Evaluated Nuclear Data Library (JENDL) disagreeing on what occurs at low energies. We designed and conducted an experiment to measure the 40Ca(n,a)37Ar thermal neutron cross section. Prompt alpha spectroscopy was conducted by placing a cylindrical vacuum chamber in a thermal neutron beam with a thin Ca foil and an alpha detector inside. A high purity germanium detector was placed on the side of the chamber to measure the prompt gammas coming off the sample.

Log 396. RAPID MEASUREMENT OF DYNAMIC SOLVENT EXTRACTION DISTRIBUTION COEFFICIENTS THROUGH ONLINE MONITORING.

Fanner, A.J.(1,P); Cooper, J.T(1); Barnes, A.L.(1). (1) Idaho National Laboratory. (P) Presenting Author.

Nuclear fuel reprocessing is a necessary step in closing the nuclear fuel cycle. The reprocessing of used nuclear fuel (UNF) allows for separation of potentially reusable fissile material from fission products in UNF. It also could allow for extraction of elements that could be useful in other industries such as radiopharmaceuticals. The most viable method of reprocessing UNF is solvent extraction (SX), which entails the mixing of an aqueous solution containing UNF with an organic solvent to extract desired elements. The dispersal of an analyte between organic and aqueous phases is characterized by the distribution ratio, which is a fundamental parameter for modeling the SX process and the development of future reprocessing flow sheets. The distribution ratio, however, is dynamic and is a function of various parameters such as acid concentration, organic-aqueous ratio, extractant concentration, etc. Gathering data on distribution ratios through a range of conditions is necessary for robust model development. In this work, we demonstrate a measurement system for the dynamic distribution ratio, in real-time, by monitoring analyte concentration in each phase during a single-stage contactor SX process using in situ ultraviolet-visible spectroscopy. Cerium(IV) was used as a surrogate for uranium(VI) and plutonium(IV) in a simulated PUREX extraction. Distribution coefficients were measured as parameters were changed, such as the organic-aqueous ratio, acid concentration, and flow rates. This method will be used to generate dynamic distribution ratio data to feed novel SX models.

Log 397. 239+240Pu AND 137Cs IN SOUTHERN HEMISPHERE SOILS: DISTRIBUTION, SOURCES, APPLICATIONS, AND OUTLOOK. Dicen, G. (P,1,2), Guillevic, F.(1), Gupta, S.(1), Kobler, J. (1), Chaboche, P.-A.(3), Meusburger, K.(4), Sabatier, P.(5), Evrard, O.(3), and Alewell, C(1). (1) University of Basel, Switzerland. (2) Department of Science and Technology-Philippine Nuclear Research Institute (DOST-PNRI),Philippines. (3)Laboratoire des Sciences du Climat et de l'Environnement (LSCE/IPSL) France. (4) Swiss Federal Institute for Forest Snow and Landscape Research WSL, Switzerland (5) Université Savoie Mont-Blanc, France. (P) Presenting Author.

The fallout radionuclides (FRNs) 239+240Pu and 137Cs from past nuclear weapons testing (NWT) and nuclear powerplant accidents (NPP) have been of particular interest to the Earth Science community. Despite the potential health risks associated with them, these fallout radionuclides provide the privileged markers (golden spikes) of the Anthropocene stratigraphic layers. Their deposition in the 1950s coincided with the Great Acceleration, which makes these FRNs as important tools in studying critical Earth surface processes. Among the FRNs deposited globally, 137Cs has been the most commonly used in assessing soil erosion and/or the chronology of sediment deposition, but 239+240Pu is an emerging soil erosion tracer and chronological marker. Here, we compiled 137Cs and 239+240Pu data published from undisturbed (so called "reference") soils in the Southern Hemisphere regions to build a database under the AVATAR Project or A reVised dATing framework for quantifying geomorphological processes during the Anthropocene. Using this database, named the AVATAR-Soils Database, we determine the distribution of 137Cs and 239+240Pu inventories in the Southern Hemisphere, along with the relative contributions of different fallout sources (i.e., global, French, and British NWTs) using their isotopic ratios. We also demonstrate how our synthesized knowledge of the distribution and sources of FRNs can be used to improve their applications in research. Finally, we present the activities of the AVATAR Project and the research questions that we are currently engaged in answering in the project.

Log 398. QUANTIFYING UNCERTAINTY IN URANIUM CONCENTRATION MEASUREMENTS VIA K-EDGE DENSITOMETRY. Henning, A.N.(1,2,P); Swinney, M.W.(2); Chirayath, S.S.(2); Hogue, K.K.(2); Sobel, P.W.(2); Biegalski, S.R.(1). (1) Georgia Institute of Technology. (2) Oak Ridge National Laboratory.

This study is part of an ongoing project to design a novel system to monitor fresh, unirradiated fuel salt entering a molten salt reactor system for nuclear safeguards purposes. Specifically, this study evaluates the application of K-edge densitometry for quantifying uranium in molten fluoride salts flowing through steel pipes. Sensitivity to changes in uranium concentration, pipe material, and salt composition was analyzed using Monte Carlo N-Particle (MCNP) transport code simulations with uncertainty quantification. Simulation results indicate that as either photon beam displacement or beam size are increased, the predicted concentrations become progressively more inaccurate for a fixed number of particles. This suggests a potential correlation between source positioning and measurement fidelity. To address these findings, we propose implementing a correction factor that accounts for the volume of the sample intersected by the beam or extending measurement times to enhance result reliability.

Log 399. DRIVERS FOR THERMAL AND RADIOLYTIC DEGRADATION OF PLUTONIUM OXALATES.

Kersey, W.A. (1, P); Darvin, J.R. (2); Villa-Aleman, E. (2); Dick, D.D. (2); Steehee, T.C. (2); Foley, B.J. (2); Hartig, K.C. (1). (1) Nuclear Engineering Program, Unviersity of Florida; (2) Savannah River National Laboratory; (P) Presenting Author.

PuO2, a material used in nuclear reactor fuel, is primarily produced via the thermal degradation of plutonium oxalates. During the thermal degradation process, Pu(III) and Pu(IV) oxalates are heated to form dehydrated oxalates and carbonate species, followed by conversion to PuOCO3 and finally to PuO2. In contrast to the thermal decomposition, the radiolytic degradation process is not well understood. The radiolytic degradation of Pu(III) oxalate and Pu(IV) oxalate was analyzed using diffuse reflectance spectroscopy (DRS), Fourier transform infrared spectroscopy (FTIR), and Raman spectroscopy. Radiolytic degradation is the molecular damage of a material caused by the emission of ionizing radiation, in this case alpha particles. This degradation, combined with the natural aging of plutonium oxalates, produces intermediate products with unique spectroscopic signatures that are yet to be studied. This experiment presents a collection of weekly or close to weekly spectroscopic data of samples within double-walled containment cells containing solid-state 240Pu(III), 240Pu(IV), or 242Pu(IV). These data show the radiolytic degradation differences between 240Pu and 242Pu and provide spectroscopic insights into the production of intermediate products. These intermediates provide useful information regarding the aging and molecular development of nuclear materials, which could be useful in nuclear fuel cycles and nuclear forensic studies.

Log 400. ENCAPSULATION OF METAL IONS USING FUNCTIONALIZED SOLID PHASE.

Peterman, D.R. (1,P);Pilgrim, C.D.(1); Anderson, K.R. (1); Rehbein, S.M. (1); Holmbeck, G.P. (1). (1) Radiochemical Separations and Radiation Science, Idaho National Laboratory. (P) Presenting Author.

The nuclear industry is currently undergoing a paradigm shift towards advanced reactor concepts with higher levels of uranium enrichment to meet present and future societal energy demands. Historically the economics of reprocessing irradiated fuels for civilian fuel cycles has been disfavorable in the United States. However, as advanced reactor concepts pursue demonstrations with high assay low enriched uranium (HALEU), uranium enriched above 5% but below 20%, the need for advanced technologies to simplify and accelerate fuel cycle options becomes critical for the management and recovery of this precious resource. The goal of this work is to simplify waste management at the back-end of the nuclear fuel cycle by utilizing solid phase extractants to achieve recovery of actinide species from nuclear fuel cycle raffinates. Specifically, our work focuses on the application of both commercially available and in-house synthesized silica-grafted chelators to achieve this separation, while also providing a waste form that can be easily incorporated into existing vitrification recipes to help mitigate the large volumes of high-level waste that come from typical liquid-liquid extraction processes.

Log 401. TINY SAMPLES FOR NEUTRON TRANSMISSION EXPERIMENTS WITH THE DICER INSTRUMENT AT LANSCE. Stamatopoulos A.(1,P), Koehler P.(1), Bond E.(2), Chasapoglou S.(1), Couture A.(1), DiGiovine B.(2), Essenmacher S.(1), Marenco A.(3), Mocko V.(4), Rusev G.(2), Ullmann J.(1), Vermeulen C.(2). (1) Physics Division, Los Alamos National Laboratory, USA. (2) Weapon Stockpile Modernization Division, Los Alamos National Laboratory, USA. (3) Actinide Material Processing & Power Division, Los Alamos National Laboratory, USA. (4) Chemistry Division, Los Alamos National Laboratory, USA. (P) Presenting Author.

Radiative neutron capture data targeted to nuclear security applications are essential, however, challenging to acquire for short-lived radionuclides. A technique has been recently developed at the Los Alamos Neutron Science CEnter (LANSCE), that can provide accurate data on a plethora of radionuclides relevant to nuclear criticality safety, radiochemical diagnostics, astrophysics, nuclear forensics and nuclear security, by performing neutron transmission measurements. The Device for Indirect Neutron Capture Experiments on Radionuclides (DICER) is a capability that was developed to address the aforementioned challenge. DICER performed its first measurement on a radioactive sample recently, by irradiating liquid 88Zr samples that were produced in collaboration with the Isotope Production Facility (IPF) at LANSCE. This measurement resulted in the discovery of a nuclear level near the neutron separation energy. Other efforts include the measurements of 239Pu and 88Y. Performing new measurements requires the development of fabrication techniques which are not straightforward. A description of the new apparatus, preliminary data on a few stable and radio-isotopes as well as as sample requirements will be presented.

Log 402. DEMONSTRATION OF ULTRAVIOLET SENSITIVE 4H-SIC AVALANCHE PHOTODIODES. Remy, J.L. (1,P); Cao, L.R. (1). (1) The Ohio State University. (P) Presenting Author.

The deployment of silicon-based photomultipliers (SIPMs) and photo-avalanche diodes (SPADs) along the advancing nuclear fuel cycle has been limited by the increased dark current above room temperature, reduced photodetection efficiency for sub 300 nm light, and poor survivability to radiation exposure. Wide bandgap semiconductor, 4H-silicon carbide (SiC), is being investigated to address each these limitations. A graded, (P+)PN-, doping profile was formed in high purity, low defect, n-type 4H-SiC epitaxial layers by means of ion implantation. P-N diodes were realized by depositing temperature resistant nickel contacts by electron beam evaporation. The active contact pattern was achieved using photolithographic techniques and lift-off. Electronic characteristics were determined by current-voltage (IV) and capacitance-voltage (CV) profiling. Characteristics resulting from IV and CV profiling include dark current, breakdown voltage, depletion width, built-in voltage, and ideality factor. The photo response of chosen samples was determined using a collimated 255 nm ultraviolet LED. The amplification factor was determined for varying applied biases. Additionally, an initial characterization of temperature dependence was performed using a heated stage capable of heating to 600 °C. Finally, a resistive passive quenching circuit was designed and optimized for quick quenching and reset times.

Log 403. PRACTICAL BOUNDS ON SUBSURFACE GAS TRANSPORT MODELS FOR NUCLEAR EXPLOSION MONITORING. Seifert, C.E. (1, P); Johnson, C.M. (1); Simo, J.M. (1); Eslinger, P.W (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Subsurface gas transport models are used in nuclear explosion monitoring to predict timing, quantity, and isotopic composition of gases that escape an underground nuclear explosion. These models are increasingly complex, incorporating explosively driven transport through crushed or damaged rock zones, models of naturally occurring heterogeneities in geologic media, chemistry at interfacial surfaces, and both porous media and fracture driven flow. In this work, we examine the practical bounds on such transport models for radioxenon using known detection limits for two scenarios: a high-efficiency atmospheric sampler located near the test location, and collection and later laboratory measurement of a soil gas sample taken from surface ground zero. In each of these cases, there is a minimum concentration of xenon required to exist just below the surface for the xenon to be emitted or collected at detectable concentrations. This implies that practical bounds can be placed on the transport models themselves, and phenomena that do not result in sufficient xenon concentrations in the appropriate time frame can be excluded from NEM subsurface transport models. We explore these bounds as a function of emplacement conditions (geology, depth of burial) for a nominal 1 kT explosion.

Log 404. ORGANOMETALLIC FUNCTIONALIZED CLAYS FOR TECHNETIUM IMMOBILIZATION. Maulden, E. (1); Gager, E. (1); Ta, A.T. (1); Wood, R. (1, P); Boglaienko, D. (2); Nino. J.C. (1); Pearce, C.I. (2); Phillpot, S.R. (1); Szecsody, J.E. (2); Wall, N. (1). (1) Unviersity of Florida. (2) Pacific Northwest National Laboratory. (P) Presenting Author.

Nuclear waste repositories use backfill materials to contain long-lived radionuclides, such as technetium-99 (99Tc). The Tc isotope is present as pertechnetate (TcO4-) under oxic environmental conditions and is mobile in the environment with high aqueous solubility. Bentonite, primarily composed of montmorillonite, has been proposed as a barrier in nuclear waste repositories to limit radionuclide transport after the degradation of waste canisters and water intrusion. However, the isomorphous cation substitutions in montmorillonite are not conducive to anionic TcO4– sorption. Improved TcO4– sorption onto montmorillonite is observed when the clay is functionalized with inorganic or organic moieties. The work presents TcO4– sorption onto clays functionalized with organic, inorganic, and dual organic/inorganic moieties. TcO4– sorption depends on the order of functionalization of the organometallic clays, where adding metal to the organoclay exhibited higher sorption of TcO4– compared to the reverse order. Furthermore, the TcO4– sorption to the organometallic clays is consistent with either chemisorption or cooperative sorption, with a multi-step mechanism determining the kinetics of sorption.

Log 405. RADIOMETRIC AGING OF EASTERN BERING SEA SNOW CRABS. Wood, Rachel (1, P); Fedewa, Erin (2); Wall, Donald (1); Wall, Nathalie (1). (1) Unviersity of Florida. (2) Resource Assessment and Conservation Engineering Division – Shellfish Assessment Program (RACE-SAP), National Oceanic and Atmospheric Association (NOAA). (P) Presenting Author.

Bering Sea snow crabs (Chionoecetes opilio) constitute most of the commercial crab species that support high-value fisheries in Alaska. However, the decreasing biomass trend of mature male snow crabs raises concern for commercial fisheries. Significant data gaps in snow crab growth, longevity, and mortality hinder the accuracy of assessment models. The aging of snow crabs can be quantified through radiometric analysis of radium incorporated with calcium in the exoskeleton. While the crab's molting processes challenge traditional aging methods, the decay of radium through the crab's shell creates a chronometric clock that can be used to determine the age of the crab at the time of terminal molt. Radiometric measurement using gamma spectroscopy improves the speed of analysis by decreasing sample preparation time compared to previously used techniques such as digestion followed by alpha spectroscopy. This work aims to date Bering Sea snow crabs using gamma spectroscopy and short-lived 228Th and 228Ra decay products. Special care was given to minimize the HPGe detector background counts, as most peaks of interest are in the low-energy region. This work closes the data gap for the maximum age and natural mortality estimates in snow crab stock assessments.

Log 406. TODGA EXTRACTION OF COBALT (II) FROM AQUOEUS CHLORIDE MEDIA. Wood, R. (1, P); Monte, P. (2); Salcedo, R. (2); Burton-Pye, B. (3); Francesconi, L. (2); Penchoff, D. (4); Wall, N. (1). (1) Unviersity of Florida. (2) Hunter College of the City University of New York. (3) Lehman College of the City University of New York. (4) University of Central Florida (P) Presenting Author.

Nuclear forensic analysis will support law enforcement inquiries by analyzing evidence tainted with radioactive substances. Separation techniques may be used to identify and quantify actinides, fission products, and activation products in post-detonation debris. Transition metals, also present in post-detonation residues, have been observed to impact critical isotope extractions. For example, cobalt, ubiquitous in urban environments, particularly in corrosion-resistant alloys, paint drying agents, dyes, and pigments, can impact the separation of important actinides and fission products. This work aims to understand the chemistry governing cobalt extraction by tetraoctyl diglycolamide (TODGA), the ligand hosted by the commercial chromatographic resin DGA that is often used for actinide separations. We quantified the extraction kinetics, the effect of reactant concentrations, and the temperature of solvent extraction systems in which cobalt is extracted by TODGA from HCl solutions. Furthermore, potentiometric titrations allowed for quantifying the number of protons exchanged, and dual isotope experiments provided information on the number of chlorides extracted. These data enable the quantification of the extraction system thermodynamic parameters (ΔH, ΔS, ΔG) and the stoichiometry of the extracted complex. Computational modeling driven by electronic structure theory calculations and artificial intelligence tools allows for deriving binding preferences and coordination environments. Spectroscopic techniques such as XANES, EXAFS, and FTIR provide the cobalt-TODGA coordination environment of the extracted complex.

Log 407. EVALUATION OF ADDITIVE MANUFACTURING SIDE CHANNELS FOR NUCLEAR NONPROLIFERATION APPLICTIONS. Biegalski, S.R.(1,P); Le, K.(1). (1) Georgia Institute of Technology. (P) Presenting Author.

The nuclear industry is continuing to grow and adopt new technologies to manufacture components. One of the technologies under consideration is additive manufacturing (AM). AM could make production of components at lower cost and could lessen lead times significantly. However, AM could be prone to proliferation risks. AM machines give off signatures during the manufacturing process, and these signatures offer an alternative means of observing the component. Correlations between these signatures and the geometry being manufactured could be developed; enabling proliferators as they could take advantage of these correlations to steal AM manufacturing instructions relating to nuclear technology. This work pertains to preliminary work exploring the feasibility of tapping into AM side channels to predict geometries being manufactured on AM machines. The feasibility of utilizing vibration to draw geometric correlations will be assessed on an Ultimaker 2+ thermoplastic 3D printer.

Log 408. REVISITING TRADITIONAL RADIOCHEMICAL SEPARATION TECHNIQUES: A DETAILED STUDY OF IRON HYDROXIDE AND NEODYMIUM OXALATE COPRECIPITATIONS . Price, A.P.(1,P); Hinrichs, K.A.(1); Cook, D.L.(2); Hrkach, S.M.(1); Christensen, K.L.(1); Gurganus, D.W.(1); Nunn, A.J.(1); Amato, R.S.(1). (1) Los Alamos National Laboratory. (2) Pacific Northwest National Laboratory. (P) Presenting Author.

The aim of this work was to obtain greater insight into two methods commonly applied to environmental collections for the separation and preconcentration of uranium (U) and plutonium (Pu): iron hydroxide and neodymium oxalate coprecipitations. Some of the oldest and most common methods for the separation, purification, and preconcentration of trace elements and radionuclides in analytical chemistry include coprecipitation techniques. However, highly detailed studies of coprecipitation methods, including the partition coefficients of trace elements and actinides into the resulting supernatant and precipitate, are scarce. To this end, we performed these coprecipitations on purified U and Pu tracers as well as environmental standard reference materials and subsequently analyzed the resulting supernatant and corresponding precipitate for trace element composition by quadrupole inductively coupled plasma mass spectrometry (q-ICP-MS) or for high-precision U or Pu isotopic composition and concentration by isotope dilution thermal ionization mass spectrometry (ID-TIMS). Here we report the results of these comprehensive tests, which provide an improved understanding of the effectiveness of these coprecipitations. This includes how environmentally available major and trace elements, as well as U, and Pu partition into the supernatant and precipitate, as well as decontamination factors of U from Pu. These data provide a basis for tailoring preconcentration methods based on prior knowledge of a sample’s matrix and/or initial sample screening.

Log 409. FROM FALLOUT TO FLAVOR: Cs-137 AND Sr-90 ASSESSMENT OF FUKUSHIMA'S WINE. Coupannec M. (1,P), Sudowe R.(1). (1) Department of Environmental and Radiological Health Sciences, Colorado State University. (P) Presenting Author.

The Fukushima Daiichi nuclear accident led to the deposition of various radionuclides in the surrounding area. Among these, Cs-137 and Sr-90 remain of significant concern due to their long half-lives (30.04 and 28.74 years, respectively) and bioavailability. Despite extensive land remediation efforts and Japan's highly restrictive limit for radioactive cesium in food (100 Bq/kg, compared to 1,200 Bq/kg in the US), businesses in Fukushima continue to suffer reputational damage. Products from the region still sell at prices approximately 10% lower than the national average. To combat prejudices against Fukushima-grown produce, local farmers' cooperatives have begun diversifying by processing their produce, including winemaking. A radiological assessment was conducted on locally produced wine from the Fukushima prefecture to measure Cs-137 and Sr-90 levels. Results revealed that radionuclide activities were orders of magnitude below regulatory limits, with the highest Cs-137 activity measured at 2.23 Bq/L.

Log 410. RADIUM WITH A GRAIN OF SALT: Ra EXTRACTION AND PRECONCENTRATION FROM OIL AND GAS LIQUID WASTE. Coupannec, M. (1, P), Sudowe, R. (1). (1) Department of Environmental and Radiological Health Sciences, Colorado State University. (P) Presenting Author.

Radium analysis in hydraulic fracturing waste effluent is essential to mitigate environmental risks and ensure appropriate waste management practices. Traditional methods, such as gamma spectroscopy and radon emanation have slow turnaround times due to the need for radium to reach secular equilibrium and extended counting times. Alternatively, radium can be analyzed via alpha spectrometry (Ra-226) or ICP-MS following separation and purification. One of the primary challenges encountered when performing chemical analyses of Ra in produced fluids is the presence of high and widely varying levels of total dissolved solids, and chemical analogues. Extraction chromatographic resins developed by TrisKem International (Bruz, France) were evaluated to isolate and purify Ra from its chemical analogues. This separation is crucial, as interference from chemical analogs could cause mass attenuation in alpha spectrometry or polyatomic interference. The TK101 resin showed promise, achieving rapid preconcentration and effective separation, with an 87 percent recovery of radium in 2 M HNO3 and minimal barium breakthrough. While these results are promising, the influence of interfering salts on the separation was investigated to evaluate the robustness of the separation in complex matrices like processed fluids. It was found that alkali metals such as sodium and potassium significantly affect the partitioning. Various preconcentration steps, including cation exchange and precipitation methods, were explored to refine the analytical protocol.

Log 411. LANTHANIDE TETRAFLUORTEREPHTHALATE MOFS FOR USE IN OPTICAL DETECTION OF RADIONUCLIDES.

Decoteau, E.A. (1,P); Belatti, C.T.(1); Jacobsohn, L.G.(2); Cahill, C.L. (1). (1) The George Washington University (2) Clemson University. (P) Presenting Author.

Metal organic frameworks (MOFs) are porous materials comprised of metal cations and organic linkers that form 3-dimensional architectures on the molecular scale. These materials have garnered interest among many scientific disciplines for use in gas storage, separations, chemical detection, and optical sensing. With an interest in nuclear forensics, we sought to synthesize a MOF that could trap and detect the presence of radioisotopes via scintillation. Lanthanides were candidates for the metal centers in these materials owing to their characteristic optical properties. We also employed a dual-ligand synthetic approach in an attempt to maximize porosity. Presented herein are two structure types with the compositions, [Ln2(TFTA)3(2,2'-bpy)2(H2O)2] (1, Ln = Sm-Lu) and [Ln2(TFTA)3(1,10-phen)2(H2O)2] (2, Ln = Nd-Yb) which consist of lanthanide metal cations bound to tetrafluoroterephthalate linkers and N-donor capping ligands to form 3-dimensional frameworks. The structures of these materials were determined using single-crystal X-ray diffraction and their purity was confirmed via powder X-ray diffraction. Initial void space calculations via PLATON show that these materials contain solvent accessible voids, indicating a potential for uptake capabilities. However, adsorption isotherm data collected under N2 at 77 K indicate very little gas uptake of both materials with a surface area of 8-9 m2/g for 1 with Eu3+. Despite a lack of porosity, the materials featuring Eu3+ and Tb3+ metal centers produce bright red and green emission, respectively, upon irradiation with X-ray sources and are therefore solid-state scintillators. Radioluminescence measurements with a tungsten target were collected on both 1 and 2 with Sm3+, Eu3+, and Tb3+ metal centers. The emission profiles indicate that both structure types featuring Tb3+ are brighter than those with Eu3+ or Sm3+ metal centers. Notably, compound 1 with Tb3+ is the brightest scintillator with a relative luminosity of 1.7x that of bismuth germanate (BGO).

Log 412. ELECTROCHEMICAL TRANSIENT TECHNIQUE FOR THE MEASUREMENT OF HIGH CONCENTRATION OF METAL IONS IN HIGH TEMPERATURE MOLTEN SALTS.

Bae, S.-E.(1, P); Jung, C(1); Cha, H,-L(1). (1) Korea Atomic Energy Research Institute. (P) Presenting Author.

A real-time monitoring technique for nuclear materials in pyroprocessing and molten salt reactors is proposed using an electrochemical transient method, designed for high-temperature molten salts. The transient technique was tested in LiCl-KCl melts containing various metal ions, such as uranium trichloride, magnesium dichloride, and lanthanum trichloride, as well as in NaCl-KCl-UCl3 melts. In the multi-component systems, the current response and charge passed during electrodeposition and dissolution reactions were monitored as a function of the metal ion concentrations. The results demonstrated that both the current and the passed charge increased linearly with the concentration of metal ions in the LiCl-KCl melt, with concentrations up to ~10 wt%. The transient technique was also tested to determine the concentrations of uranium ions in NaCl-KCl-UCl3 melts, which are expected to be used as coolants in molten salt reactors. These results suggest that this electrochemical transient technique is a promising candidate for real-time monitoring of metal ion concentrations in pyroprocessing and molten salt reactors.

Log 413. NUCLEAR FORENSICS TRANSFORMATIONAL INNOVATION AT PACIFIC NORTHWEST NATIONAL LABORATORY.

Douglas, M.(1, P); Metz, L.M.(1); Friese, J.I.(1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

To address the pressing need for an accelerated nuclear forensics analysis capability, Pacific Northwest National Laboratory (PNNL) has embarked on a five-year internal research and development investment. The Nuclear Forensics Transformational Innovation (NFTI) Initiative aims to demonstrate the science basis for a new material characterization and analysis process. Our approach focuses on advancements in microanalysis, the development of models for real-time process optimization, and the application of AI/ML technologies to assist analysts with instrumental data processing and multimodal analysis. By identifying microsamples concentrated in nuclear debris within bulk environmental collections, unwanted background material is reduced, and characterization can proceed more rapidly. For subsequent processing steps, we are exploring microfluidic separation technologies combined with modeled chemistry to enable tailored separations based on sample characteristics and analyte priorities. Moreover, we are integrating data science advances to aid the analyst with time consuming and repetitive tasks. This integration will allow the analyst the opportunity to review intermediate results to ensure tasks are being performed correctly. This presentation will introduce the NFTI Initiative at PNNL, detailing its objectives across pre- and post-detonation nuclear forensics, and initial approaches to achieving more timely characterization of nuclear materials and debris.

Log 414. PREPARATION AND CHARACTERIZATION OF Pu-239 AND Pu-240 RECOIL ION SOURCES FOR U-235M and U-236 STUDIES..

Reed, L. E. (1, P); Raggio, A. (2); Renisch, D. (1, 3); Block, M. (1, 3, 4); Düllmann, Ch.E. (1, 3, 4); Julin, J. (2); Kivekäs, M. (2); Laitinen, M. (2); Mokry, C. (1, 3); Moore, I. D. (2); Pohjalainen, I. (4); Runke, J. (1, 4); Sajavaara, T. (2); Warbinek, J. (1, 4). (1) Johannes Gutenberg University Mainz, Germany. (2) University of Jyväskylä, Finland. (3) Helmholtz-Institut Mainz, Germany. (4) GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany. (P) Presenting Author.

Alpha-decaying radioisotopes can serve as recoil sources for their daughters, offering free ions of rare isotopes. One such daughter is U-235m (26 min), the second-lowest known nuclear isomeric state (76.7 eV), which deexcites via internal conversion electron (CE) emission. At Univ. Jyväskylä, Finland, the U-235m hyperfine structure is under study by collinear laser spectroscopy. For these studies, recoil ion sources of Pu-239 emitting U-235m (99.8% isomer population) and of Pu-240 providing U-236 for reference, were prepared via molecular plating (MP) [1]. The sources vary in activity, dimension, substrate, and drying procedure, and exhibit striking color diversity. Characterization methods include radiographic imaging, alpha spectroscopy, scanning electron microscopy and Rutherford backscattering spectrometry. To determine recoil efficiencies as a function of MP parameters, the rate of recoiling daughter nuclei must be measured. While alpha-spectrometry of U-235 (7.10E8 a) is insensitive, detecting CEs from U-235m deexcitation offers sensitive measurements. The Detection of Internal Conversion Electrons (DICE) setup facilitates this, allowing determination of recoil efficiencies and U-235m half-life [2]. At MARC XIII, we will discuss the preparation, characterization, and performance of Pu recoil sources and U-235m half-life determination using DICE. Funded by the EU Horizon 2020 Research and Innovation Programme (Grant No. 861198, ‘LISA’ MSC ITN). References: [1] W. Parker & R. Falk, Nucl. Instr. Meth. 1962, 16, 355; [2] L.E. Reed et al., EPJ Web Conf. 2023, 285, 01002.

Log 415. APPLICATION OF CHEMOMETRIC ANALYSIS FOR COMPLEX MOLTEN SALT CHEMISTRY .

Branch, S.D.(1, P); Rakos, J.M.(1); Choi, S.(1); Felmy, H.M.(1); Schafer Medina, A.(1); Bryan, S.A.(1); Lines, A.M.(1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Molten salt reactors represent a key opportunity to efficiently meet present and future energy needs. MSRs by design present many benefits (high heat transfer capacity and ability to operate at atmospheric pressure) that allow for significant advances in safe and energy efficient operations. There are many MSR designs being considered, each with their own benefits and challenges for operation. To better support these reactors as they transition to market and seek to meet energy needs, it is imperative to build monitoring tools for the purpose of process control and material accounting. Several robust analytical techniques, including spectroscopy, provide powerful and non-destructive tools to gain a fundamental insight into complex reactor chemical systems and conditions without placing undue burden on the reactor and its operators. Optical techniques such as UV-vis and Raman can be used to elucidate key information (inventory, oxidation state, speciation, etc.) for species of interest such as fuel, fission, and corrosion products within a liquid salt. Other techniques, such as gamma spectroscopy, can provide similar information where knowledge of isotopic inventory is necessary. Spectral data for both optical and gamma spectroscopy are used to build spectral libraries which then serve as models for chemometric analysis of a given chemical system. Optical-based chemometric analysis is demonstrated on industry relevant molten salt systems through small-scale, high temperature spectroscopic systems that allow for rapid, cost-effective, and safe experimentation of target species. Gamma-based chemometric analysis is demonstrated on archived fission samples.

Log 416. ISSUES AND METHOD IMPROVEMENTS TO THE AUTOMATED MODIFIED DAVIES AND GRAY METHOD FOR URANIUM ASSAY.

Ingman, L. (1, P); Attwood, S. (1); Firkin, S.J. (1); Shaw, T. (1). (1) AWE Nuclear Security Technologies. (P) Presenting Author.

The modified Davies and Gray method is used at AWE for the uranium assay of metal, oxide, and alloy samples. The titration process was resulting in the formation of a cerium phosphate precipitate on the anti-diffusion tip of the concentrated cerium solution. This issue was causing an increased variation in data and a downward trend and was only resolved once the anti-diffusion tip for the cerium solutions was replaced. Owing to the precise nature of this analytical technique and the requirements to generate uranium assay data an investigation to identify the cause of the precipitate was instigated. Multiple trials were conducted to eliminate the generation of this precipitate, including altering dosing rate, stirrer speed, molarity of the solution, and changing rinsing volumes and times. The investigation of this method issue, the data generated, the resolution, and the method improvements identified to resolve the precipitate are fully documented.

Log 417. RECENT ADVANCES IN THE DEVELOPMENT OF NANO-POROUS ION EMITTERS (NANO-PIES) FOR LOW LEVEL ACTINIDE ANALYSES BY TIMS .

McHugh, K.C. (1,P); Barpaga, B. (1); Seo, J-H. (1); Kumar, A. (1); Makovsky, K. (1); Wu, Y. (1); Sinnwell, M.A. (2); Krogstad, E.J. (1). (1) Pacific Northwest National Laboratories. (2) IUniversity of Iowa. (P) Presenting Author.

The isotopic analysis of trace-level actinides is essential for the International Atomic Energy Agency (IAEA) for verifying nuclear safeguards. This research explores integrating thermal ionization mass spectrometry (TIMS) with metal-organic frameworks (MOFs) to develop nanoporous ion emitters (nano-PIEs). The extensive use of TIMS has been limited by labor-intensive sample preparation needed to achieve high sample utilization efficiencies (SUEs). MOFs, with their synthetic versatility, porosity, and absorption affinities, offer a potential solution. This project demonstrated that nano-PIEs could enhance uranium SUE up to 20 times compared to a bare filament, with the highest SUE of 1.0% on a nano-Zn-MOF-74 and an average SUE of 0.7% ± 0.3% (n = 4). Unlike previous TIMS emitters, the heat of vaporization rather than the work function or first ionization energy correlates with SUE. The parent MOF composition appears to control the redox state of the analyte, although no molecular species formation was observed. Changes in pore size did not significantly impact SUE, but structural variations (3D vs. 2D) did influence performance. Additionally, tuning MOF crystal size and modifying current ramp rates during analysis can further modify SUE. While uranium was the primary focus for most of the work, limited tests with plutonium showed an approximate 2x increase in SUE. This research highlights the potential of nano-PIEs to significantly improve actinide analysis by TIMS, offering promising advancements in nuclear safeguards verification.

Log 418. A SYSTEMATIC EXPLORATION OF URANIUM TRIOXIDE HYDROLYSIS PRODUCTS AND THEIR OPTICAL VIBRATIONAL SPECTRA.

Kaitschuck, N.M.(1); Barth, B.S.(2); Hutter, T.(1); Landsberger, S.(1); Miskowiec, A.(2); Spano, T.L.(2). (1) The University of Texas at Austin. (2) Oak Ridge National Laboratory

Study of the uranium trioxide (UO3)-water system is complex with inconclusive results and limited details in the literature. The UO3 system is home to at least 7 structural polymorphs and an amorphous phase. The proposed hydrolysis products of UO3 are just as numerous, yet investigations of these alteration products are sporadic and generally antiquated, thus requiring systematic investigations. Recent developments in the understanding of UO3 phase space, aided by improvements in analytical and computational techniques, necessitate more modern investigations into the uranyl hydroxide family and their naturally occurring mineral counterparts. We present findings from a systematic investigation of the products formed via hydrothermal reactions of common UO3 polymorphs and discuss how the equatorial coordination of the uranyl/uranyl-like ions within the UO3 precursors leads to differences in the optical vibrational spectra of the resulting hydrolysis products. The hypo-stochiometric nature of alpha-UO2(OH)2 leads to the formation of multiple unique uranyl sites and a distortion of the unit cell to a lower symmetry. This study provides, for the first time, an analysis of beta-UO2(OH)2 using modern techniques and instrumentation (Raman/infrared spectroscopy and powder x-ray diffraction) and lays a foundation for future time-dependent investigations into the structural dependence of the hydrolysis kinetics of the UO3 phases. Given the prevalence of UO3 at both ends of the nuclear fuel cycle, an understanding of its behavior with water has applications ranging from nuclear forensics to waste management and environmental transport.

Log 419. VALIDATION OF ^{236}U CORRECTION FOR ^{237}Np ASSAY ANALYSIS IN URANIUM MATRICES—A CROSS PLATFORM APPROACH . Fisher, W.S.(1,P); Miller, H. B. D.(1); Sandborn, M.E. (1); Rice, N.T. (1); Macsik, Z. (1); Inglis, J. D. (1); Steiner, R. (1). (1) Los Alamos National Laboratory. (P) Presenting Author.

Neptunium (Np) is produced in high-neutron fluence environments and therefore can be found in large quantities in spent nuclear fuel, high-level nuclear waste, as well as trace amounts in the biosphere, making it an important element for nuclear forensics. Np is commonly measured at LANL using isotope dilution mass spectrometry (IDMS), with an in-house 236Np tracer. This employs TIMS or MC-ICP-MS, both of which, in principle, can deliver highly precise assay values. One issue with 236Np IDMS is potential isobaric interreference from 236U. In samples that have been imperfectly purified of U, any detectable 236U will decrease the measured 237-sampleNp/236-tracerNp, resulting in low neptunium assays results. This is problematic in the analysis of trace amounts of Np in previously irradiated uranium materials. Efforts to improve U-Np chemical purification in uranium metals to produce high U-Np separation factors, have not yet proven successful. An alternative approach to this problem utilizes an isobaric mass correction for the contribution of 236U on the 236 mass. Here we show that the 236U isobaric bias can be calculated by combining within run uranium isotope analyses during the Np analysis, with the previously determined isotope composition of the U metal. This study proposes a new validation for handling a 236U isobar: using the 236U/235U and 236U/238U ratios to correct the mass-236 signal in known reference materials NBL CRM U005A and NFRM U-1. In this study, the correction is tested against known refence values to validate the method on both TIMS and MC-ICP-MS. (LA-UR-24-32831)

Log 420. IODOMETHANE INTERACTIONS WITH SOLID SORBENT. Roenfeldt, R.(1,P); MacLaughlin, E.(1); Snow, M.(1); Lyon,K.(1); Welty,A.(1); Watrous, W.(1). (1) Idaho National Laboratory. (P) Presenting Author.

Organoiodine is released into the off-gas stream during the aqueous reprocessing of fuel and must be captured with high efficiency for environmental and safety reasons. Silver containing sorbent and organoiodine interactions of iodomethane have been researched in literature. Iodomethane, upon interacting with the sorbent, is converted into elemental iodine that is then trapped on the sorbent. Byproducts of this interaction include dimethyl ether, methanol, and other organics. The concentration of these byproducts are unknown and the mass balance is incomplete. This research aims to quantify the byproducts of the interaction of iodomethane with silver containing sorbent by flowing iodomethane through a column containing the sorbent and characterizing the gas at the end of the column. Quantifying the concentrations of the byproducts will help understand the sorbent capacity for the byproducts informing vital environmental impact questions. This work will help inform future research into iodobutane and iododecane interactions with the sorbent.

Log 421. RAPID SINGLE-PARTICLE ANALYSIS OF URANIUM SAMPLES WITH FEMTO-SECOND LASER ABLATION INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY (LA-ICPMS) AND LASER-INDUCED BREAKDOWN SPECTROSCOPY (LIBS). Hull, G.A. (1, P); Inglis, J.D. (1); Sanborn, M.E. (1). (1) Los Alamos National Laboratory. (P) Presenting Author.

Laser-based analytical techniques provide rapid spatially resolved isotopic and elemental information. The micron-scale laser focal spot offers the ability to map large surfaces or analyze single particles to inform on sample homogeneity. The rapid analysis time (on the order of seconds to minutes) has the potential to provide vital information at an early stage of a forensics investigation. Additionally, utilizing a femto-second laser causes minimal sample damage and almost no ablation-shockwave, which allows multiple analysis shots of individual particles to improve precision. Here, we present ongoing research utilizing femto-second LA-ICPMS and LIBS on several different powdered uranium materials. Analytical campaigns for both uranium isotopics and trace elements have been completed with certified reference materials and 'real-world' samples. LA-ICPMS was used to study uranium isotopics of four uranium-containing powders. These samples had vastly different morphologies and particle sizes, ranging from <5 µm to >750 µm, which presented interesting ablation challenges to ensure consistent reporting. We also present LIBS results for trace element analysis of certified reference material CRM-124. In this study, we were able to correctly identify the sample's processing methods by analyzing three trace elements on a single-particle basis. Additionally, we created bi-modal mixtures of sample particles and were able to differentiate them from single-sample particle populations using LA-ICPMS analysis of fourteen different trace elements. LA-UR-24-32823

Log 422. DEVELOPMENT AND IRRADIATION OF A Xe-136 TARGET FOR THE PRODUCTION OF Cs-136. Glennon, K.J.(1,P); Gharibyan, N.(1); Wilkinson, J.T.(2); Velsko, C.A.(1); Tumey, S.J.(1). (1) Lawrence Livermore National Lab. (P) Presenting Author.

As a shielded fission product, the fission yield of 136Cs is particularly sensitive to the compound nucleus of the fissioning system. When coupled with its short half-life (13 days) and ease of radiometric analysis, it proves a suitable analyte for evaluating systems which have undergone fission. However, producing an isotopically pure 136Cs source for closer study is particularly challenging, as it's co-produced at much lower rates than its longer-lived isotope 137Cs from fission. In this work, a target system has been developed for use at the Center for Accelerator Mass Spectrometry facility to make the first attempts at producing 136Cs from a proton irradiation of a gas target: enriched 136Xe. Design features and challenges of preparing the gas target will be discussed, and measured production rates will be compared to predicted rates using evaluated cross sections.

Log 423. METHODS FOR PREPARATION OF LOW MASS CHLORINE SAMPLES FOR PLANETARY, SPACE, AND NUCLEAR FORENSIC APPLICATIONS. Anderson, T.S.(1,P); Hidy, A.J.(1); Walker A.(1); Boyce, J.W.(2); (1) Lawrence Livermore National Laboratory (2) NASA Johnson Space Center (P) Presenting Author.

The volatile element Cl can be lost during high temperature events like those occurring during planetary formation and evolution, causing fractionation of its two stable isotopes 35Cl and 37Cl. Chlorine isotope variations (reported as d37Cl, in per mil, relative to Standard Mean Ocean Chloride) can serve as an important tracer of these events, but the loss of Cl leads to small remaining masses. Commonly used techniques for stable chlorine isotope analysis, secondary ion mass spectrometry (SIMS) and isotope ratio mass spectrometry (IRMS), require at least 20 micrograms, but more often > 100 micrograms of Cl. We present methods for preparation of micrograms of Cl to be used with our recently developed accelerator mass spectrometry (AMS)-based technique for determining stable Cl isotope ratios, which has also been used to improve 36Cl analyses. More complete collection and reduction of Cl loss is achieved through co-precipitation of Cl with Br as Ag(Cl+Br) followed by re-dissolution and separation with ion chromatography. This technique can be coupled with our AMS-based technique to enable analyses of 1 microgram of Cl accurate to ~1 per mil, with precision of ~3-4 per mil, similar to SIMS results and capable of resolving large variations in astromaterials. Initial experiments outlining the details of the method and impacts on the final sample will be presented and discussed along with initial tests to further reduce minimum sample masses and potential applications in planetary science, space science, and nuclear forensics. Prepared by LLNL under Contract DE-AC52-07NA27344.

Log 424. LEVERAGING HERMES-700 FOR PASSIVE GAMMA SPECTROSCOPY MEASUREMENTS OF U-233 FOR ENHANCED THORIUM FUEL CYCLE SAFEGUARDS. Batie, G. (1, P), Good, E.C. (1), Becker, D. (3), Keller, M. (3), Gard, J. (3), Carpenter, M.H. (2), Schreiber, K.A. (2), Croce, M.P. (2), Pierson, B.D. (1), Archambault, B. C. (1). (1) Pacific Northwest National Laboratory. (2) Los Alamos National Laboratory. (3) National Institute of Technology & Standards. (P) Presenting Author.

Molten salt systems (e.g. electrochemical recycling and Molten Salt Reactors (MSRs)) utilizing the thorium fuel cycle present unique challenges in nuclear safeguards and online process monitoring. These challenges are particularly pronounced in passive gamma spectroscopy methods involving U-233 bearing materials because the low probability gamma emissions from U-233 are often obscured by the more intense emissions from U-232 decay products. This research explores the use of a new instrument at Pacific Northwest National Laboratory (PNNL), the High Efficiency and Resolution Microcalorimeter Spectrometer (HERMES-700). This system offers exceptional energy resolution, on the order of 85 eV (FWHM), enabling enhanced passive measurements of U-233 in the presence of an obscuring source background. Two freshly irradiated 3.5 g samples of U-233 oxide, consisting of 98 wt% U-233 and 0.05 wt% U-232, were evaluated based on U-233 gamma emissions at 42.5 keV, 54.7 keV, and 97.13 keV. Initial findings indicate that this method may advance previous efforts, which were constrained by peak interferences and insufficient energy resolution, thereby hindering accurate identification and quantification. Future research will focus on leveraging further advancements in microcalorimetry to improve its timing resolution for potential use in coincidence detection methods.

Log 425. A MINORITY SERVING INSTITUTION CONSORTIUM FOR ISOTOPE R&D AND PRODUCTION EDUCATION. Goddard, B. (1, P); Rojas, J. (1); Phangikaroon, S. (1); Ndip, G. (2); Kalantarians, N. (3), Queern, S. (4); Phelps, C. (4). (1) Virginia Commonwealth University. (2) Virginia State University. (3) Virginia Union University. (4) Oak Ridge National Laboratory. (P) Presenting Author.

Three Minority Serving Institutions in the Richmond, Virginia, area formed a consortium with the relatively close-distanced Oak Ridge National Laboratory (ORNL) to train undergraduate and graduate students in all aspects related to isotope R&D and production, including computational and experimental techniques. The universities in the Minority Serving Institutions for Manufacturing Sustainable Isotopes and Mainstreaming Scientific Inclusion (MSI3) consist of the Department of Mechanical and Nuclear Engineering at Virginia Commonwealth University (VCU), the Department of Chemistry at Virginia State University (VSU), and the Department of Natural Sciences (physics) at Virginia Union University (VUU). The initial 5-year expected outcome of MSI3 is to support/create 63 B.S., 6 M.S., and 1 Ph.D. degreed students from VCU, VSU, and VUU with the knowledge and hands-on experience in isotope R&D and production. The new coursework developed, equipment acquired, and connections generated between the universities and ORNL will strengthen the group’s ability to sustain the MSI3 program and perform future isotope R&D and production research. All research conducted by MSI3 will be connected to a central theme of improving the efficiency of isotope production with each student having their own research topic.

Log 426. DEVELOPMENT OF FISSION FRAGMENT DETECTION SIMULATION. Shire, J. (1, P), Walker, L. (1), Olinger, J. (1), Jaffe, J. (1), Chemey, A. (1). (1) Oregon State University. (P) Presenting Author.

An analysis code “JANGOFETT: A New Geant4-Operated Fission Event Tracking Tool” has been developed to correlate fission observables within the Geant4 simulation framework. Geant4 generates individual particles, and does not handle the covariant observables well. JANGOFETT is intended to track simulated fission events by sampling particle lists produced by other codes for detection. To address Geant4’s independent particle timeline limitation, a "universal time" adjustment is applied, randomly sampling time differences for realistic fission rates and enabling delayed decay backgrounds. It results in high-fidelity data on energy depositions and time-correlated interactions, enabling simulations of independent fission yields, total kinetic energy, and total excitation energy. CGMF is used as the fission model code to generate lists of fission product momentum vectors. Highly excited ions are initialized in Geant4 for transport simulations with virtual detector volumes. These simulations support the development of algorithms for experimental fission correlations. This poster will include results from simulated fission events and analyses correlating these parameters. This tool enables experimenters to generate synthetic nuclear data for comparison to experiment that can inform applications in nuclear security, nonproliferation, reactor design, and forensics. By offering a unified, event-based perspective on fission, JANGOFETT enhances the applicability of simulated nuclear data.

Log 427. INVESTIGATING URANIUM HEXAFLUORIDE HYDROLYSIS IN SUPERSONIC JETS.

Waldron, A.M. (1,P); McNamara, L.E. (1); Dorris, A. (1); Kelly, J.T. (1). (1) Savannah River National Laboratory. (P) Presenting Author.

Depleted uranium hexafluoride (UF6) is a stockpiled byproduct of the nuclear fuel cycle. UF6 will react readily with atmospheric water to form chemically toxic and radioactive reaction products, uranyl fluoride (UO2F2) — a soluble solid — and HF gas. However, the mechanism by which this reaction proceeds is poorly understood, as previous experimental and computational methods show different pathways and intermediates for the reaction. Studying the gas-phase reaction of UF6 hydrolysis is limited by a given method's ability to either trap intermediates when they form or monitor reaction progress over short time scales. Recent advances in Quantum Cascade Laser have resulted in the development of new mid-InfraRed absorption spectrometers capable of both very high spectral resolution and microsecond temporal resolution. Combined with methods to super cool samples, such as supersonic expansion, these instruments have demonstrated the ability to capture spectra of gas samples with doppler limited peak widths while simultaneously observing rapid changes in the gas dynamics. By capitalizing on these recent advances in QCL spectrometer technology, a new method is being developed to experimentally monitor the generation of gas dynamics at high resolution and microsecond time scales. Studies will be done to examine the change in reaction pathways as the relative ratios of the starting materials are adjusted to limited UF6 or H2O.

Log 428. DEVELOPMENT OF SOLUTION COMBUSTION SYNTHESIS CAPABILITIES FOR INTENTIONAL NUCLEAR FORENSICS RESEARCH.

Roach, J.M. (1, P); Shields, A.E. (1); Miskowiec, A.(1); Spano, T.L. (1) (1) Oak Ridge National Laboratory. (P) Presenting Author.

Solution combustion synthesis (SCS) is a unique method that offers a simple, rapid, and energy-efficient means to produce nanoscale oxide materials. Taking advantage of highly exothermic oxidation-reduction reactions between metal nitrates and organic reductants, SCS has been used in the study of rapid oxide synthesis across the periodic table. In the past decade, research has pushed the field further into the realm of actinide materials, opening the door for unique opportunities within the field of nuclear nonproliferation. Recently, we have developed bench-scale reaction capabilities for the continued study and innovation of actinide oxide combustion syntheses with applications for intentional nuclear forensics research. Here we present initial results pertaining to the incorporation of Ni taggants into uranium oxides via traditional SCS as well as through solid-phase combustion synthesis of pre-tagged uranyl nitrate. Additionally, we provide results on the combustion synthesis of uranium oxides under different reaction atmospheres to evaluate the effects of oxidative and reductive gasses.

Log 429. THE FUTURE LOOKS BRIGHT: WHAT WE'VE LEARNED SO FAR FROM THE INTENTIONAL FORENSICS VENTURE. Marks, N.E.(1,P); Chamberlin, R.M (2); Shields, A.E. (3); Wellons, M (4). (1) Lawrence Livermore National Laboratory (2) Los Alamos National Laboratory. (3) Oak Ridge National Laboratory. (4) Savannah River National Laboratory. (P) Presenting Author.

Several US National Laboratories have engaged in a Multilab Venture to develop and test intentional taggant approaches for nuclear fuels. Approaches have included surface tagging of cladding using ALD, incorporation of photoluminescent compounds into fuel-plate welds, and incorporation of multielement microparticles. One of the most promising approaches has been the incorporation of perturbed isotopic taggants into uranium oxide fuel forms. We have evaluated several isotopic systems with introduced isotopic perturbations including Ni, Mo, Fe, Cr and W. Characterization of more than 30 commercially produced LEU fuel pellets revealed that Mo and W both had significant isotopic perturbation relative to natural abundance; Ni, Fe, and Cr isotopic are not isotopically perturbed; which would be predicted given that they do not form volatile fluorides. We propose that a taggant concentration of at least 250 ppm will be sufficient to overcome the baseline concentrations and overcome any intrinsic perturbation for UOx fuels, however current analytical capabilities can detect perturbed isotopic taggants at concentrations less than 1 ppm. We have also synthesized a series of isotopically-perturbed compounds of Mo, Ni, and W which were incorporated into UO2 MiniFuels in 100 and 1000 ppm concentrations for irradiation studies. These tagged samples were irradiated in ORNL's High-Flux Isotope Reactor and at levels representative of uranium oxide lifetimes in a power reactor, providing the first glimpse into the safety and feasibility of this approach.

Log 430. ASSESSING A NEW CAPABILITY FOR THE ANALYSIS OF TAGGED URANIUM OXIDE PELLETS: A BENCHTOP LALI-TOF MS INSTRUMENT. Erickson, K. (1); Schappert, M. (1, P). (1) Los Alamos National Laboratory. (P) Presenting Author.

LANL has been investigating a new capability, a commercially available benchtop LALI-TOF (Laser Ablation-Laser Ionization-Time of Flight) Mass Spectrometer, for Intentional Forensics sample workflows. The instrument requires little-to-no sample preparation and provides elemental and preliminary isotopic data within minutes. Therefore, there is a potential role for this instrument in “day one” forensic analyses that inform down-stream analysis with “gold standard” methods. The LALI-TOF MS has been used to analyze mock fuel pellets consisting of natural uranium oxide doped with the taggants molybdenum, tungsten, and nickel that are isotopically perturbed from natural abundance. Early investigations include identifying signals from these taggants in mock pellets doped at 1000 ppm and 100 ppm and correlating the signals to the parent isotopically perturbed mixtures. Unexpectedly, processing signatures unique to the samples were also observed in this study, so the technique could become a potential tool in provenance assessments in a nuclear forensics investigation.

Log 431. ANALYTICAL WORKFLOW DEPENDENCE OF EXPERIMENTAL OBSERVABLES FOR URANIUM CHEMISTRIES. Beiswenger, T.N. (1,P); Manns, R.G. (2); Spano, T.L. (1); Niedziela, J.L. (1). (1) Nuclear Nonproliferation Division, Oak Ridge National Laboratory. (2) University of Nevada, Las Vegas. (P) Presenting Author.

Understanding the influence of analytical tools on material observables is a complex and important precursor to robust forensic investigations. Here we document the influence of Raman spectroscopy and scanning electron microscopy on observables from uranium compounds relevant to forensic application as a function of analytical technique order and sample size. Specifically, we investigate the order of analytical tool application on the observables for particles of uranium dioxide (UO2), triuranium octoxide (U3O8), studtite (UO2O2·4H2O), and beta uranium trioxide (β-UO3). The findings indicate that uranium chemistries are affected by the order of analytical techniques, with Raman spectral response being significantly degraded by prior exposure to the high-resolution SEM imaging. The degree of loss of spectral integrity is based on particle chemistry and size. These findings warrant further investigation to determine beam duration thresholds to better understand how to implement operating procedures for unknown samples for improved forensic characterization. This work presents results of a study conducted with a Nuclear Science and Security Consortium summer student from University of Nevada, Las Vegas.

Log 432. DEVELOPING A REMOTE MONITORING AND CONTROL SYSTEM FOR A LOW-BACKGROUND LABORATORY. Soenke, D.R.(1,2,P); Boswell, M.(2); Lamont, S. (1,2). (1) The University of New Mexico. (2) Los Alamos National Laboratory. (P) Presenting Author.

I will primarily focus on our new low-background laboratory being constructed in a historic Manhattan-project era tunnel in the Los Alamos canyon. The tunnel at TA-41 was built between June 1948 until May of 1949. The tunnel is lined with concrete and extends approximately 250 feet into the north side of Los Alamos Canyon, providing roughly 300 ft of rock overburden. Such a facility is a prime location for a low-background laboratory, and currently home to 3 PGe detectors, with a plan to expand that to include 7 more detectors along with several low-background beta chambers. Operating so many detectors in a remote location requires extensive monitoring and control software, in additional to autonomous data acquisition systems. My poster will primarily focus on the development of these monitoring and control systems and how we plan to interface with them, given the infrastructure challenges that come with operating in an historic remote facility.

Log 433. Isotope Production Capabilities and Gold Radiotracer Development at CAMS . Wilkinson, J.T. (1, P); Tumey, S.J. (1); Moody, K.J. (2); Brown, T.A. (1); Gharibyan, N. (2). (1) Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory. (2) Nuclear and Chemical Sciences Division, Lawrence Livermore National Laboratory. (P) Presenting Author.

An overview of isotope production capabilities at LLNL's Center for Accelerator Mass Spectrometry (CAMS) will be presented. Experimentally measured cross sections from light-ion irradiations of platinum for production of carrier-free gold radiotracers will be discussed. Several novel cumulative and independent cross sections, like 190Au, 191Au, and 199Pt were determined and are compared to TENDL-2023. Upcoming facility developments will also be presented.

Log 434. MULTI FISSION PRODUCT SEPARATION AND ANALYSIS IN LIGHT WATER REACTOR FUEL .

Speetjens, S.(1, P); Bubas, M.(1); Conte, E.R.(1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

This study aims to improve understanding physicochemical phenomena of ruthenium (Ru) behavior in irradiated fuel process environments. The complexity of Ru's behavior, attributed to its volatility, chemical properties, and the formation of semi-volatile compounds, like RuO_4, complicate containment and safety. Despite the abundance of Ru in irradiated fuel, its behavior in fuel cycle processes continues to be problematic for material balance and accountancy due to its complex chemistry. Building on established isotopic techniques from the geological sciences, we adapted these methods to handle the complex chemical matrices of dissolved of spent fuel. We developed chromatographic separation techniques coupled with multicollector mass spectrometry to measure stable Ru isotopes (^{101}Ru, ^{102}Ru, ^{104}Ru). These methods are applicable to actual spent light water reactor (LWR) fuel—an uncommon but important step—enabling study of Ru partitioning across liquid, solid, and gas phases during dissolution. Furthermore, we employed electrospray ionization tandem mass spectrometry (ESI-MS/MS) to elucidate Ru speciation in nitric acid, a key medium in reprocessing. This study provides new, detailed insights into Ru mass balance, containment, and loss mechanisms during spent fuel reprocessing, building on prior research in the nuclear field. By combining innovative methods with real-world application, this research enhances our ability to control and monitor nuclear materials, strengthens environmental stewardship, and supports global nonproliferation efforts.

Log 435. USING LUMINESCENT TRACERS TO UNDERSTAND NUCLEAR MATERIAL FATE AND TRANSPORT.

Carman, A.J.(1, P); Casella, A.J.(1); Nicholas, A.D.(1); Williams, A.N.(1); Hubbard, L.R.(1); Buck, E.C.(1); Muller, S.E.(1); Henson, N.J.(1); Alcantar-Anguiano, S.(1); Barnett, D.S.(1); Cunningham, H.S.(1); Bautista A.(1); DeSmet, M.M.(1); Kremer, E.(1); Davis, D.(1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Characterization of particles is critical for detecting signatures of proliferation activities that may result in the production of nuclear weapons. Analyzing individual particles reveals elemental and isotopic signatures that provide information about activities that may be ongoing in a facility. The information obtained from particle analysis highlights the importance of not only good particle selection by microscopists but also at the swipe stage when obtaining particle samples from areas most likely to contain particles of interest. Our work examined Pu particle source material characteristics, which fed into the design of synthesized luminescent tracers with the preferred size, density, and physical morphology. We developed computational models of particle transfer systems to inform glovebox experiments that examined the contained transport of calcined PuO2 powder mixed with tracers. We also assessed the high-temperature stability and luminosity retention of the tracers, preparing them for more complex activities at the Radiochemical Processing Laboratory (RPL) such as spent fuel reprocessing, plutonium purification, and Pu metal conversion. This work generated a robust dataset for comparing the movements of luminescent tracers and PuO2 particles, as well as evaluating computational modeling predictions. This presentation will offer insight into how particles move in complex radiological environments.

Log 436. Pu AGE DATING ON TRACE AMOUNT OF NUCLEAR MATERIAL. Hubert, A. (1, P); Varga, Z. (2); Burban, S. (1). (1) CEA, DAM, DIF, F-91297 Arpajon, France. (2) European Commission, Joint Research Centre, Karlsruhe, Germany. (P) Presenting Author.

When investigating nuclear material, several question have to be answered. Where is it from? What is it use for? When has it been produced? Isotopic measurements are a powerful tool to answer some of these questions. The age of a material is obtained by measuring the ratio between a daughter nuclide and its parent. In the case of Pu age dating several radiochronometers can be used: 234U/238Pu, 235U/239Pu, 236U/240Pu, 241Am/241Pu and 238U/242Pu. In this study, we developed a chemical separation and purification of U, Am and Pu with extraction chromatography for low amounts of Pu (below 50 ng). The method was validated thanks to two Pu reference materials (CRM137 and a “freshly” separated CRM136 purified at the Joint Research Centre Karlsruhe). The quantification of the radionucleides was performed by isotope dilution mass spectrometry using multiple collector inductively coupled plasma mass spectrometry. Amount of Pu was minimized to avoid any contamination of instruments and workplaces. Effects of this low amount on the accuracy of the method and on the uncertainty budget was evaluated and will be discussed.

Log 437. MULTIMODAL APPROACH TO UNDERSTANDING URANIUM OXIDES. Miskowiec, A. J. (P, 1); Spano, T. (1), Shields, A. (1); Niedziela, J. (1); Isbill, S. (1); Hunt, R. (1); Barth, B. (1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Uranium oxides are ubiquitous in the nuclear fuel cycle. Their importance ranges from their use in nuclear fuels to environmental chemistry and waste product handling. At the same time, uranium oxides often appear as open f shell systems and thus their electronic properties are fundamentally interesting. In this discussion, we will explore the combined use of experimental and computational methods to study the physical properties of uranium trioxides and triuranium octoxide, with a specific interest in magnetic and lattice excitations. We will show how the combined use of inelastic light and neutron spectroscopy with density functional theory can provide synergistic information, providing more scientific insight together than their independent contributions.

Log 438. Single-Particle Multi-Collector Inductively Coupled Plasma Mass Spectrometry for Analysis and Characterization of Isotopic Ratios. Szakas, S.E. (1, P), Manard, B. (1), Ticknor, B. (1), Stanberry, J. (1), Andrews, H. (1), Zirakparvar, A. (1), Darnell, M. (1), Dunlap, D. (1), Shultz-Johnson, L.R. (2), Barrett, C.A. (2), (1) Oak Ridge National Laboratory (2) Savannah River National Laboratory (P) Presenting Author.

Single particle ICP-MS (sp-ICP-MS) is an established technique that allows for the detection and quantification of inorganic species within nano- and micro- particles (spherical diameter ranging from ~0.02 to 2 microns). Within a few minutes, thousands of particles can be detected from a sample volume of just tens of microliters. These detected particles can then quantified, with limits of detection in the tens to hundreds of attograms for many elements. The high-throughput nature of sp-ICP-MS makes it ideal for both screening and confirmation techniques. Typically, both quadrupole and time-of-flight mass analyzers have been characterized and employed to study particle populations. Besides information on elemental composition and particle number concentrations, isotope ratios within particles are obtainable when using time-of-flight. However, precision is limited by instrument noise, sensitivity, and particle size. Generally, multi-collector ICP-MS offers greater ratio precision and accuracy but the validation of isotope ratios within particles is not yet widely researched or reported. This study presents the use of sp-MC-ICP-MS to determine the isotopic composition of cerium, in 1 micron CeO2 particles. These particles were developed using a lanthanide as a surrogate for other actinides, with the intention to eventually create particulate reference materials. These particles were detected using using various integration times and detector configurations. This study, while used to validate sp-MC-ICP-MS, also highlights the need for a rapid and reliable method to characterize particle standards for environmental and nuclear safeguard applications.

Log 439. CHARACTERIZATION OF BROAD MACHINE LEARNING APPROACHES FOR GENERAL USE, QUANTITATIVE MORPHOLOGICAL ANALYSIS. Ly, C. (1, P); Johnson, J. (1,2); Yaros, J.L. (1); Nizinski, C.A. (1); Tasdizen, T. (2); Hagen, A.R. (1); (1) Pacific Northwest National Laboratory. (2) University of Utah, Scientific Computing and Imaging Institute (SCI). (P) Presenting Author.

A succession of publications has shown the utility of morphological analysis for material characterization, and more recent results illustrate the utility of quantitative (as compared to qualitative) morphology. While techniques utilizing strongly supervised neural networks have achieved extremely high performance on specific and highly constrained tasks, un- or weakly-supervised techniques have shown to obtain competitive performance to their supervised counterparts, and the embeddings obtained from a unsupervised model can be used for diverse set of downstream tasks once trained. We find this flexibility especially useful for agile, short timeline analyses of materials and for “open” problems where relevant materials may not have been characterized a priori. Recent work preliminarily indicated that the size of data (i.e., millions of images) used to train unsupervised models is the single largest predictor of encoding performance, even more so than domain relevance of such data. This study presents the culmination of our initial designed experiments; it includes models trained with contrastive learning through relevant text and image pairing to include domain relevant information in the training process. The results of this study will provide more evidence as to whether domain relevant data can be leveraged, even at relatively small data size. The results from this study can further guide dataset development, future model training, and provide a baseline “best” morphology model that can be used for nuclear material characterization.

Log 440. EFFECT OF PRECIPITATION BATCH SIZE ON THE MORPHOLOGICAL PROPERTIES OF VARIOUS ACTINIDE OXALATES. Nizinski, C.A. (1, P); Chalifoux, A.M. (1); Warzecha, E.J. (1); Hagen, A.R. (1); Hanson, A.B. (2); Mathies, K. (2); Sentz, K. (2); Heller, F.D. (1); Clark, R.C. (1); Meier, D.E. (1); Lumetta, G.J. (1); Tingey, J.M. (1) (1) Pacific Northwest National Laboratory. (2) Los Alamos National Laboratory. (P) Presenting Author.

The effect of process scale on the morphological properties of nuclear materials remains a pertinent question for developing signatures for material provenance. Uranyl oxalate precipitation was carried out at three process scales (1 g, 20 g, 400 g). Plutonium(III) oxalate and plutonium(IV) oxalate were each precipitated at the 10 g and 200 g scale. The parameters of the chemical synthesis were the same across precipitation scales, though the process equipment varied across scales. Particle size and shape features of the resulting calcined oxides were measured by dynamic image analysis (PSA-DIA). A particle extraction pipeline segmented and quantified particles from the SEM images. Unsupervised machine learning (ML) encoders were used to get embeddings for the extracted particles, which enabled statistical comparison of textural morphological features using a high-dimensional test statistic, d-dimensional Kolmogorov Smirnov (ddKS). Findings from the morphological comparisons across several precipitation scales for uranyl oxalate, Pu(III) oxalate, and Pu(IV) oxalate chemistries will be presented. Preliminary results show that precipitation scale has a smaller effect on the resulting particle morphology than the chemical synthesis parameters.

Log 441. RECOVERY OF Ni, Mo, and W ISOTOPIC TAGGANTS FROM URANIUM OXIDE FUEL PELLETS. Rolison, J.M.(1,P); Render, J.(1); Shollenberger, Q.R.(1); Marks, N.(1); (1) Nuclear and Chemical Sciences Division, Lawrence Livermore National Laboratory, USA. (P) Presenting Author.

The intentional addition of isotopic taggants to nuclear material is being investigated as an R&D method for rapidly and confidently identifying the origin of nuclear material found outside of regulatory control in a nuclear forensics' investigation. Demonstrating the reliable recovery and identification of isotopic taggants from various nuclear material types with various process histories is crucial for implementing the use of isotopic taggants in the real world. Here, we demonstrate the successful recovery of Ni, Mo and W isotopic taggants from doped uranium oxide (UO2) fuel pellets produced at Oak Ridge National Laboratory and shipped to Lawrence Livermore National Laboratory for analysis. Prior to high-precision isotope ratio analysis via multi-collector inductively coupled plasma mass spectrometry, a portion of each UO2 fuel pellet was dissolved and the Ni, Mo and W isotopic taggants were purified via ion exchange chromatography. The measured isotopic compositions of the recovered Ni, Mo and W isotopic taggants agree with the isotopic compositions of the pure taggants determined prior to doping, albeit there is evidence of isotopic mixing between the taggants and the background Ni, Mo and W inherent to the UO2 matrix. This simple scenario demonstrates that the successful recovery of an isotopic taggant relies on accurately predicting the two-endmember mixing regime between the taggant and the inherent background. Thus, accurately characterizing the isotopic compositions of both the taggant and the matrix which is to be tagged is a perquisite for successfully recovering an isotopic taggant. LLNL-ABS-2001413

Log 442. INVESTIGATION OF THE MIGRATION BEHAVIOUR OF I-125 USING A LABORATORY LYSIMETER WITH GERMAN REFERENCE SOIL. Sassenberg, N. (1, P); Schmalz, T. (1); Riebe, B. (1); Walther, C. (1). (1) Leibniz University Hannover. (P) Presenting Author.

In many countries the storage of radioactive waste in deep geological formations is planned for final disposal. Release of long-lived radionuclides (e.g. I-129), can lead to a potential radiation exposure. For the assessment of long-term safety, processes such as the migration and accumulation of radionuclides in the far field around the repository, and thus in the surface soil layers of the geosphere, must be considered. However, upwards transport of radionuclides in the vadose zone currently is not yet part of models for assessing deep geological repositories. To get more detailed knowledge on the migration behavior of I-129 in soil, long-term lysimeter experiments with in-situ measurement of pH and redox potential have been performed twice over a period of more than two years each. The reference soil chosen is a dystric cambisol (RefeSol 01-A, provided by IME, Schmallenberg/DE), mainly consisting of sand (approx. 73 %) with low content of organic Carbon, representing one typical soil in Germany. I-125 as a substitute tracer for I-129, has been added to the system, and its upward migration driven by evaporation was studied performing gamma-measurements of both pore water and soil layers. The lysimeter experiment showed a considerable migration from the saturated zone to upper soil layers, with a maximum at a depth around 10 cm below surface. Sections with higher redox potential and thus oxidation of Fe(II) to Fe(III), revealed a higher amount of sorbed I-125. Also, sequential extractions will be performed, to get an insight into existing binding conditions.

Log 443. TECHNETIUM IN SOIL: THE ROLE OF PLANT ROOTS AND WATER DYNAMICS .

Schmalz, T.(1,P); Sassenberg, N.(1); Riebe, B.(1); Walther C.(1). (1) Leibniz University Hannover. (P) Presenting Author.

Studies on the mobility of radionuclides in the soil-plant system are of great relevance, for instance for risk analysis in the final disposal of radioactive waste or phytoremediation approaches. However, data on radionuclide soil migration over long time scales are difficult to obtain. In this work, a laboratory lysimeter was utilized, which made it possible to investigate the geochemical migration of Tc-99 in a German reference soil over an extended time period of several years. Furthermore, this setup allowed a controlled change in the water level to investigate the translocation of technetium within the soil profile. Analysis of the pore water and two soil cores showed that even after several years, technetium is still weakly sorbed to the soil, which indicates that hydrology plays an important role in technetium migration. However, using sequential extraction it was shown that a part of the technetium is immobilized, which was particularly evident in deeper soil layers under more reductive conditions. Ongoing experiments additionally will give an insight into the plant availability of technetium by the cultivation of model plants on top of the lysimeter. Thus, possible remobilization of the technetium by root exudates will also be examined.

Log 444. MORPHOLOGICAL COMPARISON OF URANYL OXALATE PRECIPITATES PRODUCED BY BATCH VERSUS CONTINUOUS PROCESSES.

Warzecha, E.J. (1, P); Chalifoux, A.M. (1); Tingey, J.M. (1); Hagen, A.R. (1); Nizinski, C.A. (1); (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Continuous precipitation processes represent another way nuclear material production can be scaled rather than simply having larger precipitation batches. A continuous precipitation apparatus was developed to investigate how the morphological properties of materials synthesized by continuous precipitation processes might vary from those from batch processes. This apparatus was used to precipitate uranyl oxalate (UO2C2O4) in a continuous manner; the material thus formed was compared to material prepared in a batch mode. Parameters such as reagent concentrations, reaction temperatures, agitation speeds, and vessel geometry were held constant between the batch and continuous processes. The continuous precipitation was operated with simultaneous addition of the uranyl nitrate and oxalic acid; the resulting product was recovered for analysis at different time steps so that properties could be studied separately from process start-up to steady state. Process scale for the continuous precipitation was 660 g of uranium. Batch precipitations were carried out at the 20 g scale in the direct strike direction (oxalic acid added to the uranyl nitrate) and reverse strike direction. The microstructural properties of the materials from each precipitation were analyzed by X-ray diffraction (XRD) and Raman spectroscopy. Qualitative particle analysis for size and shape measurements was performed by two methods: dynamic image analysis (PSA-DIA) and segmentation from scanning electron microscopy (SEM) images. High-dimensional test statistics on unsupervised machine learning embeddings are used to provide a statistical comparison of the particle features holistically, i.e., including textural features captured in SEM images.

Log 445. A SOFTWARE FOR CALCULATING THE RETENTION OF CR(TMHD)3. Muckenhuber H. (1,P), Welch J. M. (1), Pichler V. (1), Sterba J. H. (1). (1) Center for Labelling and Isotope Production, TRIGA Center Atominstitut, TU Wien. (P) Presenting Author.

After the discovery of Szilard and Chalmers that atoms in a molecule, upon capturing a thermal neutron and undergoing a de-excitation process, gain sufficient recoil energy to break the chemical bond and become chemically separable [1], much effort was put into this field to investigate this effect. Retention, or the percentage of finding the radioisotope in the original chemical form, was studied for many compounds and lately, an experimental method was developed for tris(2,2,6,6-tetramethyl-3,5-heptandionato)chromium(III), or Cr(tmhd)3 [2]. In this study, we present an investigation into retention calculations utilizing a self-developed software tool designed to calculate recoil energies based on experimental data from the International Atomic Energy Agency (IAEA). Considering every excited nuclear state from the binding energy of a neutron down to the ground state and calculating the recoil exerted, a value for retention was calculated. The obtained retention for Cr(tmhd)3 is in agreement with the experimentally observed value, which amounts to 6.8% and 7-8%, respectively. Even for metallocenes the calculated retention fits well, although not comparable to experimental data due to lack of in-depth investigations of retention. Although this software seems to yield fitting results for some compounds, a more detailed description of the process is necessary to get a glimpse of this highly dynamic picture that puts the models of physics and chemistry to the test. [1] Szilard L, Chalmers T A 1934 Nature 134 462. [2] Pichler V et al 2022 J Radioanal Nucl Chem 331 5067-5079

Log 446. ISOTOPIC COMPOSITIONS OF TITANIUM, IRON, AND NICKEL IN COMMERCIAL FUEL PELLETS – PROMISING CANDIDATE ELEMENTS FOR STABLE ISOTOPE TAGGING. Render, J. (1, P); Shollenberger, Q.R. (1); Rolison, J. (1); Marks, N. (1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

The implementation of stable isotope taggants would constitute unique identifiers for early nuclear fuel cycle materials, expediting timelines in nuclear forensic investigations and allowing for high confidence conclusions. Here, we present high-precision isotope data for titanium (Ti), iron (Fe), and nickel (Ni) in a set of 13 commercial fuel pellets to assess if these transition metals are suitable candidate elements for tagging purposes. Our investigations reveal that all 13 fuel pellets show broadly uniform isotopic compositions in all three elements that are comparable to the ranges of mass-dependent isotope fractionations previously reported for terrestrial rocks. These observations contrast with previous investigations of Mo and W isotopes in the same set of fuel pellets, for which significant isotope variations had been reported. Collectively, these observations are best explained by the readiness of Mo and W to form volatile hexafluoride compounds during U refinement and enrichment processes, whereas Ti, Fe, and Ni do not. In practice, tagged nuclear materials would fall along mixing lines, since background levels of taggant elements would dilute the isotopically perturbed compositions towards natural isotope ratios. The observation that Ti, Fe, and Ni isotopic compositions in the fuel pellets are close to or indistinguishable from estimates for the Bulk Silicate Earth demonstrates that a two end-member mixing assumption would be valid for these transition metals, indicating that all three are promising candidate elements to be used for stable isotope tagging.

Log 447. HIGH SENSITIVITY MEASUREMENTS AT LANL IN SUPPORT OF IAEA'S INTERLABORATORY COMPARISONS OF ALPS-TREATED WATER FROM FUKUSHIMA DAIICHI.

Hinrichs, K.A. (1, P); Price, A.A. (1); Goldstein, S.J. (1); Christensen, K.L. (1); Gurganus, D.W. (1); Nunn, A.J. (1); Hrkach, S.M. (1); Amato, R.S. (1); Hudston, L.A. (1); Boswell, M. (1); Wende, A.M. (1); James, M.R.(1); LaMont, S.P. (1). (1) Los Alamos National Laboratory. (P) Presenting Author.

Ultra-trace actinide measurements by mass spectrometry and radiometric measurements by gamma spectroscopy and liquid scintillation counting (LSC) were employed at Los Alamos National Laboratory (LANL) in support of the International Atomic Energy Agency’s (IAEA’s) Interlaboratory Comparisons (ILCs) of treated water that has been stored at the Fukushima Daiichi Nuclear Power Station (FDNPS) since the 2011 accident. The water has been treated through the Advanced Liquid Processing System (ALPS), which removes radiological constituents, with the intent to discharge it to the ocean. LANL has participated in two source monitoring ILCs, the 1st ILC (1st ALPS batch) with samples taken from tank K4-B in March 2022, and the 3rd ILC (8th ALPS batch) with samples taken from tank K4-C in June 2024. LANL measured isotopes of plutonium, uranium, and neptunium by thermal ionization mass spectrometry (TIMS), americium and thorium by multi-collector inductively-coupled plasma mass spectrometry (MC-ICP-MS), several fission products by gamma spectroscopy, and tritium by LSC. Results for the first ILC showed good agreement with other participating laboratories. All radionuclides measured except for tritium (average, 1.45E+05 Bq/L) were well below regulatory compliance discharge limits. Results for plutonium concentrations indicated some heterogeneity in the tanks, possibly due to association with particulate matter, but plutonium ratios were consistent both between samples (indicating a common source term) and with typical ocean sediment values for the region. Results for uranium indicated very trace amounts of uranium-236 with a slightly enriched uranium-238/uranium-235 ratio (average, 136.65). A comparison of new results from the 3rd ILC will be discussed.

Log 448. EXPLORING THE SENSITIVITY OF URANIUM ISOTOPE RATIO MEASUREMENTS BY TIMS.

Reinhard, A.A.(1, P); Inglis, J.D.(1); Kara, A.S.(1); Cook, D.(1); Hinrichs, K.A.(1); LaMont, S.P.(1); Steiner, R.E.(1) (1) Los Alamos National Laboratory, Nuclear and Radiochemistry group. (P) Presenting Author.

Uranium isotopic composition is a powerful signature of a materials provenance and processing history and therefore measurement of uranium isotopic composition is frequently requested for treaty monitoring, safeguards, and nuclear forensic investigations. The broad utility of this signature has created a consistent push to develop mass spectrometry methods that can measure smaller amounts of uranium and/or measure minor isotopes at extremely low levels. Established thermal ionization mass spectrometry techniques have typically measured the most abundant isotopes (235U, 238U) on Faraday cups paired with amplifying resistors and the minor isotopes (234U, 236U) on ion counting detectors. The development of the ATONA amplification system (IsotopX) which utilizes capacitance-based amplifier technology allows for the measurement of the major and minor isotopes on Faraday cups. Using a Faraday cups to measure all isotopes of uranium using a total evaporation technique yields a rapid and simple measurement routine that doesn’t require time consuming gain calibrations like multi-ion counting techniques or lengthy analysis times like peak-hopping routines. Data will be presented that demonstrate the ability of the paired Faraday cup-ATONA system to precisely measure ion-beam intensities orders of magnitude smaller than what is possible with conventional resistance-based amplifiers. Experiments were performed to empirically determine the limits of quantification for both Faraday-ATONA and secondary electron multiplier detectors. Analysis of NIST 4350B which were chemically separated and analyzed to determine measurement accuracy and reproducibility on uranium separated from a complex matrix will be presented as an example application of this TIMS method. LA-UR-24-32448

Log 449. URANIUM SCIENCE AND TECHNOLOGY CENTER. Ngelale, R. (1,P); Kapsimalis, R. (1); Hobby, J. (1); Dayman, K. (1); Birdwell, J.F. (2); Braatz, A.D. (2). (1) Oak Ridge National Laboratory; (2) Y-12 National Security Complex. (P) Presenting Author.

In 2020, the US Department of Energy's National Nuclear Security Administration established the Nonproliferation Stewardship Program to ensure the US government maintains the foundational technical capabilities and workforce needed to meet nuclear nonproliferation objectives. The Uranium Science & Technology Center (USTC) is one such initiative and is charged with developing and sustaining DOE’s expertise in uranium chemical processing, upstream and downstream of enrichment. Despite nearly 80 years of fuel cycle operations, the US’s national proficiency in uranium chemical processing has atrophied over the past several decades, and knowledge gaps remain in specific chemical processes of fuel cycle operations. USTC seeks to grow and sustain workforce knowledge thorough the advanced characterization of uranium processing by developing and operating a state of the art uranium processing and analysis center. USTC seeks to address science gaps that exist in front-end uranium fuel cycle processing by, (1) quantifying process effects on the physical and chemical properties of uranium products, (2) characterizing processing effects through the parametric studies of unit operations in various flowsheets, and (3) identifying chemical species and chemical kinetics of processes. The focus of this talk will be on establishing the laboratory-scale unit operations to support workforce development and the methods currently being developed to capture ex situ and in situ chemical characterization of processing effects to better understand the fundamental chemistry of uranium processes.

Log 450. RECOVERY OF ISOTOPIC TAGGANTS ALONG THE PRODUCTION PATHWAY OF URANIUM DIOXIDE. Shollenberger, Q.R (1,P); Render, J. (1); Chalifoux, A. (2); Cisneros, M. (1); Marks, N. (1).McDonald, L. (3); Rolison, J.M. (1); (1) Lawrence Livermore National Laboratory. (2) Pacific Northwest National Laboratory. (3) Oregon State University. (P) Presenting Author.

Stable isotope taggants introduced into nuclear fuel pellets could potentially be diagnostic signatures in front-end nuclear fuel cycle material analysis. However, the behavior of isotopic taggants during nuclear fuel cycle processing is presently not well constrained. Furthermore, the optimal amount of taggant to be added to nuclear material and still be successfully recoverable is not currently quantified. To understand how isotopic taggants behave during production of UO2, we added our in-house Mo and W isotope spikes at parts per billion (ppb) concentrations to starting materials used to synthesize UO2. Subsequently, we sampled five stages along the synthesis pathway, including the starting compound (uranyl nitrate hexahydrate), a filtrate solution, intermediate studtite, U3O8, and the final UO2 product to test if taggants are recoverable and measurable after some processing. These five sample types were processed through various chemical procedures to isolate and purify the Mo and W prior to high precision isotopic measurements using multi-collector inductively coupled plasma mass spectrometry. The results demonstrate that the addition of isotopic taggants to UO2 at the ppb level is sufficient for successful taggant recovery. LLNL-ABS-2001352.

Log 451. DENSITY FUNCTIONAL THEORY INVESTIGATIONS OF Ni- AND Fe-TAGGED UO2.
Isbill, S.B.(1,P); Shields, A.S.(1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Intentionally adding transition metal taggants to nuclear fuels is being investigated as a way to identify materials for nuclear forensics purposes. However, it is crucial to understand how the taggants influence the chemical and physical properties of the fuel to ensure in-pile safety and performance are not compromised. Additionally, determining the atomic-level structure of taggant incorporation is valuable for rationalizing experimental observables and developing improved sintering models to build experimental and predictive capabilities that ensure a comprehensive understanding of the taggant impacts on fuel properties. To this end, we have investigated the electronic and vibrational properties of iron and nickel taggant incorporation in UO2 using density functional theory. We considered several defect structures and report the structural, electronic, and vibrational property changes induced by the taggants. Although some complex defect structures are found to be dynamically stable, several commonly investigated defect structures had dynamic instabilities, underscoring the value of density functional theory as a foundation for building macroscopic models. We connect these observations to recent experimental measurements of tagged UO2 lattice constants and Raman spectra to provide additional insights into the microstructural origins of the measured property changes.

Log 452. ZIRCONIUM MOLYBDATE LEACHING IN NITRIC ACID. Duckworth, A.(1, P); Gogolski, J.(2); Rudisill, T.(2); Fara, R.(2); Wall, N.(1). (1) The University of Florida. (2) Savannah River National Lab. (P) Presenting Author.

Understanding the interaction between actinides and zirconium molybdate offers valuable insights for material accountability and treaty verification efforts. Zirconium molybdates are precipitates that form when used nuclear fuel is dissolved in nitric acid. These precipitates sequester actinides and fission products present in the solution. Actinides interact with zirconium molybdate in two distinct manners: tetravalent actinides may be incorporated into the crystal structure, substituting in for the zirconium, while non-tetravalent actinides are sorbed onto the surface of the solid, both of which contribute to their removal from the nitric acid solution. While it is important to understand the mechanisms that lead to the incorporation of actinides in these solids, it is equally imperative to quantify their leaching during fuel dissolution. In the present study, we quantified the leaching of thorium from thorium-doped zirconium molybdate solids. Zirconium molybdate precipitates were synthesized in the presence of varying concentrations of thorium, a tetravalent actinide often used as an analog for Pu(IV) and U(IV). The solids were added to nitric acid solutions of different concentrations, and the leached thorium concentration was quantified over time using inductively coupled plasma inductively optical emission spectroscopy. Kinetics models were applied to elucidate the mechanisms of thorium retention. Results show faster thorium leaching and higher concentrations of thorium in increased nitric acid concentrations.

Log 453. ZIRCONIUM MOLYBDATE INTERACTIONS WITH ACTINIDES. Duckworth, A.(1, P); Gogolski, J.(2); Rudisill, T.(2); Fara, R.(2); Wall, N.(1). (1) The University of Florida. (2) Savannah River National Lab. (P) Presenting Author.

The characterization of the interaction between actinides and zirconium molybdate can provide crucial data for material accountability and treaty verification. Zirconium (a fission product and from the cladding) and molybdenum (a fission product) form precipitates during the dissolution of used nuclear fuel in nitric acid. Zirconium molybdate can sequester actinides during the dissolution process. Actinides interact with zirconium molybdate in two ways: tetravalent actinides may substitute zirconium in the precipitate crystal structure and non-tetravalent actinides may sorb onto the solid surface. This work investigates the formation of zirconium molybdate precipitates in the presence of a tetravalent actinide. Zirconium molybdate solids were synthesized with various thorium concentrations. Thorium was used because it is a typical analog for plutonium. The solids were characterized using inductively coupled plasma optical emission spectroscopy and X-ray diffraction. X-ray diffraction showed that thorium was substituted into the crystal structure and that this substitution resulted in a less crystalline solid. Inductively coupled plasma optical emission spectroscopy was used to quantify the solid ratio Zr:Mo:Th.

Log 454. ACTINIDE SEPARATION BY COLUMN METHOD USING POLYVINYL-POLYPYRROLIDONE. Wada, K. (1, 2, P), Kazama, H. (3), Abe, C. (4), Ohnishi, T. (5), Yamamoto, M. (2), Taguchi, S. (2), Kuno, T. (2), Maeda, K. (5), Idemitsu, K. (4), Suzuki, T. (1). (1) Department of Nuclear Technology, Nagaoka University of Technology. (2) TRP Decommissioning Center, Japan Atomic Energy Agency. (3) Graduate School of Science, Osaka University. (4) Institute of Material Science, Tohoku University. (5) Fast Reactor Cycle Research and Development Center, Japan Atomic Energy Agency. (P) Presenting Author.

Elemental analysis and isotope ratio analysis of actinides in spent fuel and fuel debris generated in a severe accident can provide valuable information such as burnup. For such analyses, mass spectrometry such as ICP-MS and TIMS are one of the powerful tools. The mass spectrometry requires mutual separation of actinides for the removal of isobaric interferences. In the present study, we developed an actinide separation using polyvinylpolypyrrolidone as a pretreatment for mass spectrometry. The adsorption behavior of actinides was confirmed by batch experiments, and mutual separation were conducted by column method. As results, we confirmed that tetravalent and hexavalent actinides adsorb on polyvinylpolypyrrolidone, but trivalent actinides does not adsorb. We confiremed that trivalent/tetravalent/hexavalent actinides can be separated.

Log 455. INVESTIGATION OF THE EFFECTIVENESS OF OPTICAL COLOR MEASUREMENT FOR SCREENING UOC SAMPLES IN NUCLEAR FORENSICS ANALYSIS. Kimura, Y.(1, P); Shollenberger, Q.R.(2); Matsumoto, T.(1); Lindvall, R.(2); Hoffman, D.(2); Yamaguchi, T.(1). (1) Japan Atomic Energy Agency. (2) Lawrence Livermore National Laboratory. (P) Presenting Author.

Uranium ores and uranium ore concentrates (UOCs) serve as front-end materials in the nuclear fuel cycle and exhibit distinct material characteristics, known as nuclear forensic signatures, which can assist in determining their origins such as the provenance and deposits. The interpretation of these signatures is often challenging due to the diversity of mining techniques and the complex nature of natural minerals. As part of a joint research collaboration between the Japan Atomic Energy Agency (JAEA) and the Nuclear Smuggling Detection and Deterrence (NSDD) program of NNSA/US DOE, we investigated nuclear forensic signatures and methodologies for tracing the origins of uranium-bearing materials, including ores and UOCs. This study focuses on the optical color measurement of UOCs as a potential screening method for identifying their chemical compounds. UOCs are known to exhibit a variety of colors, influenced by the oxidation states of uranium compounds and the presence of trace elements. Optical colors of seven UOC samples provided by JAEA were analyzed using different approaches by LLNL and JAEA. We will discuss the relationship between the optical colors of UOCs and their major uranium compounds as well as trace elements. The findings highlight the potential of optical color measurements as a screening tool to support nuclear forensic analysis and provide insights into the chemical diversity of UOCs.

Log 456. 3D VOLUME ANALYSIS OF MULTI-DIMENSIONAL FIB-SIMS DATASETS. Kracica, M (1,P); Davis, J (1); Oldfield, D (1). (1) Australian Nuclear Science and Technology Organisation (P) Presenting Author.

We describe the elemental and isotopic analyses of enriched uranium oxide and ceramic nuclear waste form materials using Focused Ion Beam- Scanning Electron Microscopy (FIB-SEM) and Time of Flight-Secondary Ion Mass Spectroscopy (ToF-SIMS) methods, and the computational programs developed using Python to process large multi-dimensional FIB-SIMS datasets. As part of the data processing workflow, 3D- plots are constructed to allow for the precise mapping of U-isotope intensities and detection of trace elements within very small (microns) volumes. Of particular interest is the ability to detect and map concentrations of boron, which is often challenging with Electron Diffraction Spectroscopy (EDS) techniques. The importance of charging compensation during FIB-ToF-SIMS experiments is also discussed to highlight ways of increasing signal intensities. Experiments were conducted using a Xe plasma TESCAN FERA FIB-SEM equipped with EDS and a TOFWERK ToF-SIMS detector. Continued progress has been made to optimise this fully integrated microanalysis system and refine data processing techniques for rapid and accurate characterisation of diverse samples for materials science, nuclear forensics, and safeguards applications. The talk will present our current efforts at improving analytical workflows to broaden the scope of our research.

Log 457. INAA AND ICP-MS METHODS TO QUANTIFY TRACE ELEMENTS LEVELS IN LIMITED QUANTITY BIOPSY TISSUE .

Wiles, M.W.C.(1P); Diamond, A.M.(2); Brockman, J. D.(1,3); (1) University of Missouri. (2) University of Illinois Chicago. (3) University of Missouri Research Reactor. (P) Presenting Author.

Prostate cancer affects approximately 1 in 8 men over the course of their lifetime. Dysregulation of trace elements has been proposed as a potential risk factor for prostate cancer development. This study used instrumental neutron activation analysis methods to quantify total selenium, bromine and zinc levels in limited quantity prostate biopsy samples. Following radioactive decay, the prostate tissue samples were subjected to destructive analysis for calcium, iron, magnesium, zinc, cadmium, and lead using inductively coupled plasma mass spectrometry (ICP-MS). A comparative analysis of INAA and ICP-MS results for zinc was conducted to assess the reliability of each method. The INAA results were comparable to ICP-MS, however sensitivity decreased with longer decay times during the batch INAA analysis. The concentration ranges of the analyzed elements in biopsy samples from 145 prostate cancer patients are reported and the results are compared to reported values in the literature.

Log 458. COMPARISON OF MEASURED AND SIMULATED RADIOTRACER TRANSPORT THROUGH COMPLEX TERRAIN.

Stave, S.C.(1,P); Bertschinger, K.L.(1); Emmons, S.B.(1); Fast, J.D.(1); Siciliano, E.R.(1); Gowardhan, A.A.(2); and the PE1 REACT Team. (1) Pacific Northwest National Laboratory. (2) Lawrence Livermore National Laboratory. (P) Presenting Author.

Xe-127 radiotracer was released at the Nevada National Security Site in a series of measurements designed to improve modeling fidelity in complex terrain. Twenty-two xenon sensors were deployed in a region measuring approximately 10 square kilometers. The sensors reported the measured gamma-ray spectrum every twenty seconds. The results were processed and compared with two meteorological models: Aeolus, a computational fluid dynamics model designed for efficient and accurate simulations of local terrain and small feature effects; and FLEXPART-WRF, a coupled Large Eddy Simulation and Lagrangian particle dispersal modelling system that uses full physics to treat small-scale atmospheric processes. Large volume MCNP simulations were used to generate the simulated detector response to the model predictions for the calculated distributions of the radiotracer. The results were compared at the twenty second time resolution to preserve the ability to observe finer details. Previous comparisons had used a five-minute running average to maximize detection probability. The new, finer time comparisons are in good general agreement for appropriately chosen weather conditions. Several measurements had sufficient statistics to make a spectral comparison between simulation and measurement possible. Both the time dependence and spectral information can provide additional insight into how well the models are agreeing with the measured data and potentially indicate pathways to improve the models. Details on the analysis, results, and comparison to predictions will be presented. This is PNNL document number PNNL-SA-206559.

Log 459. SINGLE ISOTOPE VERSUS MULTIPLE ISOTOPE SOURCE-LOCATION MODELS.
Eslinger, P.W.(1,P); Sarathi, R.S.(1); Schrom, B.T.(1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Many releases of radioactive materials to the atmosphere include multiple isotopes. Such events include routine releases from nuclear power plants and medical isotope production as well as nuclear explosions. Algorithms that determine the location and magnitude of the releasing event from samples that provide concentration of isotopes in the air usually operate on a single isotope. A large synthetic data set was developed for 384 release events with varying levels of Xe-131m, Xe-133m, Xe-133, and Xe-135 from simulated nuclear explosions at 8 locations over 4 different time periods. These data are used to compare and contrast three Bayesian source-location algorithms: a single-isotope algorithm (Eslinger and Schrom 2016), a multiple isotope model with strong assumption on the ratios between the isotope concentrations at the time of the release (Eslinger et al. 2020), and a multiple isotope model (Eslinger and Milbrath 2024) with no release ratio assumptions.

Log 460. RADIONUCLIDE SIGNATURES FROM COMPLEX RELEASES OF FISSION PRODUCTS.
Adhikari, P. (1, P); Gordon, E.M. (1); Lapka, J.L. (1); Haas, D.A.(1). (1) The University of Texas at Austin. (P) Presenting Author.

Following an underground nuclear explosion, fission products may be vented to the surface and transported through the atmosphere. Initial systems built for nuclear explosion monitoring were based on requirements assuming a simple release of these fission products. A more rigorous evaluation of the inventory releases will provide better requirements for measurement systems and improve analysis of detections. This work compares isotopic signatures reaching monitoring stations under complex venting scenarios. The release of fission products to the surface was modeled in two components - prompt and delayed releases - and were varied to produce 63 total scenarios (example: 0.1 percent gas vent prompt release and no delayed release). The transport of these radionuclides was modeled using HYSPLIT, an atmospheric transport modeling software. Various scripts were developed to automate the writing of the initialization files for a set of HYSPLIT simulation runs for a period of 366 days and to automate the execution of these simulations. This computationally intensive modeling was performed on machines at the Texas Advanced Computing Center (TACC). Dilution factors for the resulting plume reaching IMS monitoring stations and detection frequencies are presented for a select number of fission products at a subset of IMS monitoring stations, corresponding to specific release scenarios.

Log 461. DETECTING Xe-127 AS AN ATMOSPHERIC TRACER. Eslinger, P.W. (1, P); Goodwin, M.A. (2); Sarathi, R.S. (1); Warren, G.A. (1); Schrom, B. T. (1); Foxe, M. P. (1); Chester, D. (2); Galvin, G. (2); Turley, L. (3); Hardy, D. (3); PE-1 Experiment Team (4). (1) Pacific Northwest National Laboratory. (2) Atomic Weapons Establishment (AWE), UK. (3) Nevada National Security Sites. (4) doi:10.2172/2345984. (P) Presenting Author.

The Xcounts algorithm for calculating air concentrations of radioactive xenon isotopes (Eslinger et al. 2023) has been extended to estimate Xe-127 in addition to Xe-131m, Xe-133m, Xe-133, and Xe-135. The algorithm was applied to 119 samples collected with a SAUNA QB system (Ringbom et al. 2023) during a two-month period bracketing the release of the Xe-127 tracer as part of the PE-1A experiment. Two consecutive samples bracketing the atmospheric venting time had estimated Xe-127 counts above the MDC and no false detections of Xe-127 were observed in the other samples. The concentration values from Xcounts are within about 9% of the values calculated using an adaptation of the standard net-counts algorithm for other xenon isotopes, while the Xcounts method has a lower MDC (1.41 mBq/m3) than the net-counts method (2.72 mBq/m3).

Log 462. URANIUM PARTICLE ANALYSIS BY SINGLE PARTICLE-ICP-MS. Manard, BT (1,P), Stanberry, J (1), Szakas, S (1), Ticknor, BW (1), Andrews, H (1), Dunlap, D (1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Within the realm of nuclear forensics, safeguards, and nonproliferation, the ability to determine actinide (e.g., U and Pu) content and the respective isotopic abundances (e.g., 235U/238U, 234U/238U) in various sample matrices is critical. The detection of such target analytes, in low abundance, within a complex matrix, is the typical “needle in a haystack” problem. Regarding elemental / isotopic analysis, a traditional bulk analysis approach will ultimately homogenize the results leading to possibly a misinterpretation of respective processes. Being able to directly characterize the sample, for particles, can provide a more comprehensive understating of such sample. Here, recent develops in the realm of single particle analysis, which a focus on the nuclear analytical chemistry space, will be discussed. More specifically, the ability to introduce single particles (in a solution / suspension phase) into the ICP-MS. An emphasis will be placed on the exploration of multiple ICP-MS platforms including TOF-Quadrupole-, and multi-collector-based measurements.

Log 463. APPLICATION OF TOTAL REFLECTION X-RAY SPECTROMETRY IN ELEMENTAL ANALYSIS OF HUMAN CELLS AND TISSUES. Pejovic-Milic, A.(1) (1) Department of Physics, Toronto Metropolitan University, Toronto. (P) Presenting Author.

Analytical capabilities of total reflection X-ray spectrometry (TXRF) have been extended to medicine and biology, where accurate quantification of analytes has important implications for human health. The availability of bench-top, low-power TXRF spectrometers in the last decade presented this powerful technique as an ideal analytical instrument comparable, if not superior, to other analytical spectrometers, such as ICP, used in medicine. Besides the simplicity of sample preparation, the TXRF technique requires a very small amount of sample, which is typically the case in medicine, as only a few micrograms or microliters are required for the analysis. The low detection limits are attainable with careful sample preparation to achieve total reflection conditions. The matrix matching between the sample and calibrator is eliminated due to the use of internal calibration. A rapid analysis time and simultaneous detection of many elements are additional threats to this technique. The analysis power is an important requirement of modern medicine, while the detection of many elements (from boron to uranium) in one measurement opens up new insights on the multi-elemental effects on human health, a new area of research significantly undermined at present. This presentation provides an overview of TXRF applications in the elemental analysis of human cells, fluids and tissues. It starts by describing TXRF measurements of gold nanoparticles in cancer cells due to a combo cancer therapy. Furthermore, it describes TXF measurement of bodily fluids and concludes with a prediction for the future use of TXRF in medicine.

Log 464. ADVANCING RADIOCHRONOMETRY: EXPLORING NORMAL AND INVERSE U-Th ISOCHRON ANALYSES OF URANIUM METALS.

Inglis, J. (1,P); Pollington, A. (1); Rice, N. (1); Wende, A. (1); LaMont, S.P (1); Steiner, R.E. (1). (1) Los Alamos National Laboratory. (P) Presenting Author.

Determining the age of nuclear materials is a critical goal in nuclear forensic investigations. Chronometry techniques estimate material age by exploiting the decay of a radioactive isotope into its daughter product, yielding a model age. Typically, model ages are interpreted as the time since the last chemical purification, relying on two assumptions: (1) the material has remained a closed system for parent and daughter isotopes, and (2) all decay products were removed during purification. Incomplete purification challenges these assumptions, leading to excess daughter products and overestimated model ages. Recent studies using the widely employed 230Th/234U chronometer for uranium metals reveal variable purification levels, raising concerns about the reliability of 230Th/234U model ages for tracing processing histories. A promising alternative is the isochron method, which eliminates the need to assume the initial daughter isotope concentration. This study explores the feasibility of applying both normal and inverse U-Th isochron approaches to uranium materials. We outline the theoretical basis for isochrons, emphasize their relevance to nuclear forensics, and detail the conditions necessary for constructing meaningful isochrons. Using examples from prior uranium characterizations, we show how isochron plots improve understanding of initial thorium isotope composition and can enhance the interpretation of chronometry data. LA-UR-24-32786

Log 465. CROSS-SECTIONS MEASUREMENTS OF ALPHA PARTICLES INDUCED REACTIONS ON NATURAL EUROPIUM TARGET FOR THE PRODUCTION OF THERANOSTIC TERBIUM RADIONUCLIDES.

Colucci, M. (1); E. Nigron, E. (2); Haddad, F. (2,3); Manenti, S. (1); Groppi, F. (1). (1) LASA laboratory, Physics Department of University of Milan and INFN – Milan, Milan, Italy; (2) GIP Arronax, Saint-Herblain, France; (3) Laboratoire Subatech, IN2P3-CNRS, IMT Atlantique, Nantes Universite´, Nantes, France. (P) Presenting Author.

This study explores novel production methodologies for terbium isotopes, which are crucial for theranostic applications in nuclear medicine due to their unique diagnostic and therapeutic capabilities. The cross-sections of the reactions induced by alpha particles on natural europium targets over an energy range of 20-65 MeV were measured for the very first time, with the aim to investigate a different production route for 149Tb, 152Tb, 155Tb in order to address the current limitations in scalable production techniques. Irradiation and short-term measurements were conducted at GIP ARRONAX, followed by a 30-month post-irradiation study at the LASA laboratory, enabling a comprehensive cross-section analysis. Results demonstrated good alignment with data from enriched 151Eu targets, especially for producing isotopes 149Tb and 152Tb, which hold significant clinical relevance. Theoretical modeling using TALYS 1.96 underscored the need for model refinement to improve the accuracy of predictive outcomes for these reactions. Importantly, a promising production pathway was identified for theranostic 155Tb through irradiation of enriched 153Eu targets with medium-energy alpha particles, achieving a yield of 300 MBq/uA over a 5-day irradiation with high radionuclidic purity, with 156gTb as the main contaminant. Further cross-section measurements for 153Eu(a, x) reactions are recommended to validate this method as a robust source for high-purity 155Tb.

Log 466. IMPROVING THE DECAY DATA FOR LONG-LIVED FISSION PRODUCTS. Scielzo, N.D.(1,P); Kolos, K.(1); Iacob, V.(2); Hoff, D.E.(1); Hernandez, I.(3); Neupane, S.(1); Bencomo, M.(1); Champine, B.(1); Clark, J.A.(4); Gharibyan, N.(1); Hardy, J.C.(2); Hennessy, A.M.(5); Melconian, D.(2); Norman, E.B.(3); Orford, R.(6); Park, H.-I.(2); Ray, D.(7); Sammis, B.N.(1); Santiago-Gonzalez, D.(4); Savard, G.(4); Shusterman, J.(1); Stoyer, M.A.(1); Thomas, K.J.(1); Tonchev, A.P.(1); Valverde, A.(4); (1) Lawrence Livermore National Laboratory. (2) Texas A & M University. (3) University of California at Berkeley. (4) Argonne National Laboratory. (5) University of California Irvine. (6) Lawrence Berkeley National Laboratory. (7) University of Manitoba. (P) Presenting Author.

We have been carrying out a campaign of measurements to significantly improve the nuclear data for the gamma-ray intensities following the beta decay of long-lived fission products. For national-security applications, such as stockpile stewardship and nuclear forensics, the emitted gamma rays from a sample can provide valuable information about the quantity and distribution of fission products present. The focus of this talk is on our team's recent measurements that improve the nuclear-decay data for several fission products, including 95Zr, 111Ag, 144Ce, 147Nd, and 156Eu. These measurements involved implanting fission-product samples into a thin carbon foil using low-energy mass-separated ion beams from the CARIBU facility and then performing beta counting using a custom-made 4-pi gas proportional counter in coincidence with gamma-ray spectroscopy using the precisely-calibrated HPGe detector at Texas A&M University. Our results will be presented, and recent measurements on 161Tb and 115mCd with samples produced by way of reactor irradiation that are measured with a newly setup LLNL beta-gamma counting system will be discussed. This work was supported under Contract DE-AC52-07NA27344 (LLNL), Office of Nuclear Physics Contract DE-AC02-06CH11357 (ANL), and DE-FG03-93ER40773 (Texas A&M).

Log 467. PERSPECTIVE ON RADIONUCLIDE MEASUREMENTS AT CEA/DAM FOR NUCLEAR EXPLOSION DETECTION. Topin, S. (1,2,P); Paradis, H. (1); Gross, P.(1); Morin, M. (1); Mano, C.-P.(1); Lenouvel, H.-D.(1); Couchaux, G. (1). (1) CEA DAM Ile de France. (2) CNAM Paris, EPN7. (P) Presenting Author.

The CEA/DAM is the French organization specifically responsible for technical developments in the field of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). Regarding the radionuclide component, the CEA/DAM serves as a system developer, station operator, certified laboratory, and National Data Center (NDC). Significant and continuous efforts are made in research and development for all these components. The purpose of this presentation is to provide an overview of ongoing developments at CEA/DAM in this field.
In terms of system development, the CEA/DAM designed the SPALAX and SPALAX-New Generation systems for radioxenon measurement several years ago. The CEA/DAM is currently working on the development of xenon adsorbent materials to significantly reduce the size of these systems.
Concerning the certified laboratory FRL08, which specializes in aerosol and radioxenon measurements, the main focus is on advanced detection technologies, such as βγ and γγ coincidence, as well as evolution of gas processing technologies. A substantial effort is also being made in data processing. In particular, the French NDC is working on advanced spectral analysis methods, including artificial intelligence (AI), machine learning (ML), and global analysis techniques, to enable deeper and more efficient analysis of spectra from the CTBT's International Monitoring System.

Log 468. DETERMINATION OF THE MOST EFFICIENT VOLUME OF DETECTION FOR VOLUMINOUS GAMMA-RAY SOURCES.

Kang, M.Y.(1,P); Kim, G.H.(1); Im, J.H.(1); Hwang, D.S.(1); Lee, J.H.(1); Kim, T.H.(1). (1) Korea Atomic Energy Research Institute (P) Presenting Author.

At a research reactor decommissioning site in Seoul (KRR1 & KRR2), radioactive waste drum disposal work is in progress. It is essential to provide a safe working environment for radiation workers. Before performing radiation work, it is necessary to determine the radioactivity of the waste drum to ensure safety. In this reason, we conducted a study to determine the detection efficiency of waste drums using the EXVol code. For the various types of gamma-ray sources considering the geometrical effect and attenuation, determination of the full energy absorption peak efficiency (detection efficiency) is one of the important processes of the gamma-ray activation analysis. In this study, we extended and verified the performance of the EXVol (Efficiency calculator for eXtended Voluminous source) code, which is a detection efficiency calculation code using the effective solid angle method. EXVol can calculate coaxial and asymmetric structure. In addition, the introduction of a collimator made it possible to reduce the radiation intensity of a high radiation source. And it is possible to determine the precise detection efficiency according to the energy of a gamma ray at a specific position of the volume source. To verify the performance of the EXVol, a high resolution gamma spectroscopy system was constructed. Measurements were performed on coaxial, asymmetric and collimated structures with standard point source, standard 1 L liquid volume source and HPGe detector. The measured results were compared with the calculation results of EXVol. The relative deviation of the measurement and calculation was 10%~ 20%.

Log 469. ONLINE ALPHA MONITORING OF MIXED ALPHA/BETA SOURCES WITH TENSIONED METASTABLE FLUID DETECTORS.

Boyle, N.M. (1,P); DiPrete, D.P. (1); Whiteside, T. (1); Taleyarkhan, R.P. (2); Ozerov, S. (2); (1) Savannah River National Lab. (2) Purdue University. (P) Presenting Author.

Hanford and the Savannah River Site maintain millions of gallons of caustic supernate and salt high level waste in their waste tank farms. These salt wastes are high in Cs-137 and low in actinides due to the relative solubilities in these high salt, highly caustic matrices. These unique characteristics lead to significant technical challenges in making rapid gross alpha measurements in the presence of these overwhelming beta, gamma, as well as dissolved sodium salt matrices. A gamma/beta blind, spectroscopic alpha measurement system “Tensioned Metastable Fluid Detectors (TMFDs)” was identified as a potential solution for performing gross alpha measurements in these high gamma/beta environments. Measurements using the Indirect Drive Acoustically Tensioned Metastable Fluid Detectors were performed with an alpha emitting radionuclide. Successful determination of gross alpha activity was observed, indicating a potential pathway for online-alpha monitoring.

Log 470. A SENSITIVITY STUDY FOR A DIRECT IMAGING APPROACH FOR GRATINGS-BASED PHASE CONTRAST X-RAY IMAGING (GBX) AT HIGH ENERGIES.

Sarceno, A.N. (1, 2, P); Kasparek, D.M. (1); Miller, E.A. (1). (1) Pacific Northwest National Laboratory, (2) University of Florida, (P) Presenting Author.

Gratings-based phase contrast x-ray imaging (GBX) provides three different materials signatures: an attenuation image, a differential phase image highlighting object edges, and a dark-field or scatter image sensitive to material microstructure below the imaging resolution. For use in field radiography, an approach is needed to work at high energy (100-450 kVp) with a large format detector, but with as little mechanical complexity as possible. Here we explore direct imaging of a patterning grid, which we have used successfully with high resolution detectors, with a large format detector and higher energies. A parameter study was carried out looking at the effects of x-ray energy spectrum, filtration, and grid tilt on scatter signal and noise. We find that the beam modulation of the gratings decreased with increasing energy, and discuss the approach to separating scattering effects from spectral changes. PNNL-SA-206751

Log 471. METHOD DEVELOPMENT: MEASUREMENT OF LABILE IRON AS AN OXIDATIVE STRESS MARKER FOR URANIUM IN RAT SAMPLES.

Sadi B., Imperial K.(P), Gadani K., Pirapakaran A., Ebadi Z., Jiang J. (P) Presenting Author.

Iron is an essential component for the survival of cells as it fulfills many different roles. It is an electron carrier, catalyst for oxygenation and hydroxylation and a requirement for cellular growth and proliferation. A major fraction of biologically available iron are protein bound while the rest remains as labile iron which is chelatable and redox-active. Oxidative stress and the resulting production of reactive oxygen species can affect the folding patterns of these proteins releasing the bound iron and increasing the labile iron pool. This provides an opportunity to quantify oxidative stress caused by stressors such as uranium through the change in the labile iron pool. Various attempts have been made to analyze the levels of labile iron pools following uranium exposure. The goal is to develop a convenient and economical benchtop assay that can quantitively measure labile iron in varying complexity. Rat samples used were kidney, whole blood and serum. Different methods have been explored such as colorimetric methods using ferene and fluorometric method such as calcein.

Log 472. DATING PLUTONIUM DIOXIDE MICROPARTICLES BY MICRO-RAMAN SPECTROMETRY.

Fabien Pointurier (1, P). (1) CEA/DAM. (P) Presenting Author.

The Raman spectrum of PuO2 contains numerous peaks. The most intense corresponds to the symmetrical elongation vibration of the PuO2 molecule at 480 cm-1 (T2g band). Some authors have shown that alpha self-irradiation modifies the Raman spectrum, notably bringing out minor peaks associated with crystalline defects (around 580 and 630 cm-1). Villa-Aleman et al. have shown, using PuO2 particles a few tens of µm in size, that the ratio of the intensity of these defect peaks to the T2g band increases with time, thus providing a means of dating PuO2, provided the isotopic composition of Pu, and consequently the flux of alpha-particles, is known. The aim of this study is to assess the feasibility of this concept for very small particles, less than one µm in size, likely to be found in “environmental samples” analyzed as part of IAEA safeguards support. Another study by Villa-Aleman et al. [4] also shows that it is possible to “reset” the crystalline chronometer by heating the particle to a very high temperature with one of the lasers of the micro-Raman spectrometer, so that the PuO2 recrystallizes erasing the crystalline defects (annealing). Ten sub-micrometric PuO2 particles of known isotopic composition were “purified” at the crystalline level, and the changes in their Raman spectra, in particular the intensity ratios of the defect peaks to the T2g band, were monitored for almost a year and a half, using a micro-Raman spectrometer. The results and current conclusions of the study are presented in this communication.

Log 473. UNIQUE & CHALLENGING ASPECTS OF PLUTONIUM METAL STANDARDS EXCHANGE PROGRAM FOR ACTINIDE MEASUREMENTS.

Tandon L.(1,P); Kuhn K.(1); Dorn M.F.(1); Nachtsheim A.(1); Murph A.(1); Olson A.(1); Andrade S.(1). (1) Los Alamos National Laboratory. (P) Presenting Author.

Plutonium metal exchange programs operated by the Rocky Flats Plant were conducted from 1956-1989 to ensure quality of analytical data and to compare measurements in a plutonium metal matrix. The Los Alamos National Laboratory (LANL) re-established the program in 2001 to assess the quality of analytical chemistry capabilities that support special nuclear material characterization. It is the only program of it’s kind for the preparation and distribution of plutonium standards materials with a range of impurity contents to multiple laboratories for destructive measurements of elemental concentration, isotopic abundance, and both metallic and non-metallic impurity levels. This program provides independent verification of analytical measurement capabilities for each of the participating laboratories and allows any technical problems with analytical measurements to be identified and addressed. This presentation will focus on unique aspects of the program that include specialized statistical tools that were implemented to evaluate the data in a meaningful manner. Challenges include how to evaluate a data set when 1) a large fraction of the values are minimum detection limits (MDL), 2) there is a lack of independent methods available at a participating laboratory, 3) some analytical methods result in analytical data with large variability, 4) data are not normally distributed, and 5) potential outliers must be identified with limited information on the true spread of the data. A summary of analytical methods that are, or have been, used to determine trace metal impurities in plutonium materials will be discussed.

Log 474. POSTIRRADIATION EXAMINATION OF INTENTIONALLY TAGGED URANIUM DIOXIDE FUEL. Ulrich, T. (1, P); Harp, J. (1); Jones, M. (1); Wilson, B. (1); Shields, A. (1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Nuclear fuel produced with trace amounts of transition metal additives, or taggants, is of interest for intentional nuclear forensics research. Recently, a series of irradiations has been completed at Oak Ridge National Laboratory's High Flux Isotope Reactor as part of a larger effort to investigate effects of perturbed isotopic Ni, Mo, and W taggants on UO2 fuel. This presentation will capture the initial postirradiation examination results for the set tagged samples irradiated for approximately 15 MWd/kgU, including the results of fission gas release measurements. In initial measurements of 85Kr activity, we found low levels of fission gas release for samples doped at the 100 and 1,000 ppm levels. The influence of taggant additives on key fuel performance and safety parameters will be discussed, as well as our upcoming postirradiation examination plans for the irradiated tagged samples. This work was supported by the U.S. Department of Energy, National Nuclear Security Administration, Office of Defense Nuclear Nonproliferation R&D.

Log 475. PRODUCTION OF NBL PLUTONIUM ISOTOPIC STANDARDS CRM136A, CRM137A, AND CRM138A. Parsons-Davis, T.(1, P); Wimpenny, J.(1); Tarng, C.(1); King, C.(1); Henderson, R.(1); Holliday, K.(1); Roberts, D.(1); Williams, R.(1); Mason, P.(2); Toureville, A.(2); Santisi, C.(2); Holland, M. (2); Watters, R.(2); Essex, R(2). (1) Lawrence Livermore National Laboratory. (2) New Brunswick Laboratory Program Office. (P) Presenting Author.

Lawrence Livermore National Laboratory (LLNL) and the NBL Program Office (NBL PO) are collaborating on production of purified units of the aging plutonium isotopic certified reference materials (CRM) CRM 136, 137, and 138, formerly called NBS 936, 937 and 938. The purified units will be distributed as certified reference materials CRM 136A, CRM 137A, and CRM 138A, respectively. This presentation will describe the production of the CRMs at LLNL. An original unit of each CRM was purified in a new glovebox at LLNL via two-stage anion exchange chromatography to significantly reduce the quantities of U, Am, and Np in the source materials. The purified plutonium was dispensed in nitric acid into individual units containing 1 mg Pu in 30 mL FEP bottles. Solutions were gently evaporated to dryness and the units were packaged for distribution. The concentrations of Pu, U isotopes, 241Am, and 237Np in three analytical units of each CRM were measured at LLNL to provide informational values via isotope dilution mass spectrometry (IDMS). High-precision measurements of the Pu isotopic composition have been made at LLNL using multicollector–inductively coupled plasma–mass spectrometry (MC-ICP-MS). CRM units have also been shipped to four other DOE laboratories for independent isotopic characterization. The NBL PO evaluation of isotopic abundance data will be used to issue certificates for CRMs 136A, 137A, and 138A, as well as new certificates for the source materials. Prepared by LLNL under Contract DE-AC52-07NA27344. LLNL-ABS-2001447

Log 476. EXPLORING ACTINIDE MOLTEN SALTS WITH ATOMISTIC MODELING AND MACHINE LEARNING.

Nguyen, M.-T. (1,P). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Actinide-containing molten salts are used as liquid fuels in next-generation nuclear reactors. Yet, studying these materials is very challenging for both experimentalists and modelers. I will present our recent efforts in understanding their fundamental properties at the atomistic level by using electronic structure theory, statistical mechanics and machine learning. I will first discuss our development of pseudopotentials and basis sets for the actinide series that allow for large scale ab initio molecular dynamics (AIMD) simulations. I will then talk about our AIMD studies and machine learning -based analyses of the coordination structure of single actinide ions in host molten salts. I will finally talk about how we used machine learning interatomic potential molecular dynamics to accelerate simulations of the materials and graph theory to learn about the clustering of actinide ions and a structure-transport relationship.

Log 477. COMBINED STRONTIUM AND LEAD ISOTOPIC SIGNAURES IN ORE SAMPLES AS A NUCLEAR FORENSIC SIGNATURE: A PARTNERSHIP BETWEEN THE UNITED STATES AND SOUTH AFRICA.

Kupi, T. (1, P), Mathuthu, M. (1), Brennecka, G.A. (2) Inglis, J. (3) (1) Center for Applied Radiation Science and Technology (CARST), North-West University, Republic of South Africa.(2) Lawrence Livermore National Laboratory, USA. (3) Los Alamos National Laboratory, USA. (P) Presenting Author.

It is not uncommon for material at the front end of the nuclear fuel cycle to be found outside regulatory control. As such, it is important for countries around the world to have the capability to trace the origin of such materials. In order to expand this capability, we report on a joint project between Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and the Centre for Applied Radiation Science and Technology (CARST) at North-West University in the Republic of South Africa. In this project, each laboratory will measure the strontium (Sr) and lead (Pb) isotopic compositions of uranium ore sourced from South Africa. Variations in Sr and Pb isotopic compositions can be used for geolocation, and this joint sample analysis represents the continued development of these isotopic tools to bolster nuclear forensic efforts worldwide.

Log 478. ANALYZING EXPLOSIVELY GENERATED ROCK DAMAGE IMPACTS ON SUBSURFACE RADON AT BLUE CANYON DOME.

Johnson, C.M. (1,P); Lowrey, J.D. (1); Luo, X (1); Linneman, C.C. (1); Rockhold, M.L. (1); Knox, H.A. (1,2); Knox, J.M. (1,2); Roberts, B. (1); Shah, K. (1); Strickland, C. (1); Linneman, D. (1); Sprinkle, D.P. (1); St. Clair, J. (1); Johnson, T.C. (1); Sirota, D (1); Feldman, J.D. (1,2). (1) Pacific Northwest National Laboratory. (2) Sandia National Laboratories. (P) Presenting Author.

Understanding the immediate impact of underground nuclear explosion-generated rock damage on the mobility of radioactive materials is essential for improving predictive models of such events. Subsurface rock damage profoundly influences the flow and transport properties of the geology by creating and altering fractures and changing the local permeability and porosity. As part of an investigation into the subsurface rock damage from different explosions Pacific Northwest National Laboratory and Sandia National Laboratories have executed a series of chemical explosive experiments at Blue Canyon Dome in Socorro, New Mexico, utilizing both traditional and innovative measurement and sensing methods. The experimental setup features a central borehole for detonations, surrounded by eight monitoring wells equipped with gas sampling zones and a range of sensors. Pre- and post-explosion measurements of natural radon levels were analyzed alongside other site characterization techniques such as electrical resistivity tomography, which provided visualizations of rock damage and gas flow under experimental conditions. Here we introduce a new dataset that includes the final set of radon gas measurements collected after the third explosion, expanding our analysis to incorporate the third chemical explosive experiment at the site. This dataset enriches our understanding of the radon gas evolution and provides a more comprehensive analysis of the spatial distribution of rock damage and gas flow patterns.

Log 479. RADIOCHRONOMETRY OF A YOUNG PLUTONIUM STANDARD: AN INTERLABORATORY COMPARISON.

Scheiderich, K. (1, P); Worsham, E.(1); Gaffney, A.M. (1); Edwards, M.A.(2); Macsik, Z. (2); Wende, A.M. (2); Steiner, R.E. (2) Sanborn, M.E., (2); Fisher, W.S. (2); Nicholl, A. (3); Varga, Z. (3); Wallenius, M. (3); Mayer, K. (3). (1) Lawrence Livermore National Lab (2) Los Alamos National Lab (3) Joint Research Center Karlsruhe (P) Presenting Author.

Radiochronometry measurements of recently purified plutonium materials can be challenging due to the small amounts of ingrown decay products expected to be present. As part of a collaborative effort to demonstrate and validate relevant analytical methods, LLNL, LANL, and JRC-Karlsruhe, performed a Pu radiochronometry interlaboratory comparison of NBL CRM 136 Pu purified by JRC-Karlsruhe in 2015 for use as a Pu radiochronometry standard. JRC-Karlsruhe provided several aliquots to each laboratory, containing variable quantities and forms of Pu. Plutonium, Am, U, and Np were separated from the solutions for concentration and isotopic composition measurements. Analyses were completed on multi-collector ICP-MS or TIMS instruments, together with alpha spectrometry for Pu-238 quantification. Each lab produced dates for each aliquot, for 234U-238Pu, 235U-239Pu, 236U-240Pu, and 241Am-241Pu daughter-parent pairs and for the 241Pu-241Am-237Np granddaughter decay chain. The model dates for the parent-daughter chronometers are in excellent agreement with the known production date. Granddaughter radiochronometry (237Np-241Pu and 237Np-241Am) proved more challenging; dates were less precise and may have unaccounted-for sources of bias, such as incomplete processing, that make interpretation more difficult. This effort strengthens confidence in Pu radiochronometry for recently purified material but suggests that improved process knowledge would help interpretation of Pu radiochronometry signatures for samples with unknown purification history.

Log 480. LLNL'S PARTICIPATION IN GALAXY SERPENT V. Scheiderich, K. (1, P); (1); Willingham, D. (1); Robel, M. (1); Said, M. (1); Jacobsen, B. (1); Hansen, S. (1) Cameron, D. (1); Boone, P. (1); Rolison, J. (1); Lindvall, R. (1); Truax, K. (1). (1) Lawrence Livermore National Lab (P) Presenting Author.

A team of 11 LLNL scientists participated in Galaxy Serpent V, sponsored by ITWG. The team's expertise spans the nuclear forensics portfolio, from microanalytical techniques to isotope chemistry. The LLNL team received the first inject in February 2023 and completed the exercise in December 2023. There were seven injects, divided into three "A" and "B" pairs and a lone final inject, each introducing new materials and data from the scenario's investigation, with associated investigative questions. "A" injects generally consisted of lower-precision isotopic data, usually gamma spectrometry, while the "B" consisted of higher-precision isotopic data and additional information such as trace elements, chemical form, and blanks. The team did rigorous analyses such as spider plots and PCA analysis of the investigation data against materials in the library provided with the exercise. Using the guided decision framework, we were able to determine whether the materials collected at each stage of the investigation were consistent or inconsistent with one another, and assign a degree of confidence in that assessment. The LLNL team proposed early on—with Inject 2A—that material mixing might be occurring. We finalized this assessment with the 3B inject, where we created 3-isotope mixing plots to show that mixing of depleted uranium and HEU found in the investigation could reproduce the isotopic composition of the queried swipe.

Log 481. TRACER TRANSPORT DYNAMICS IN SUBSURFACE ENVIRONMENTS: INSIGHTS FROM THE PE1-A TRACER EXPERIMENT. Johnson, C.M. (1,P); Lowrey, J.D. (1), Burghardt, J.A. (1); Feldman, J.D. (1); PE1-A Experiment Team (2). (1) Pacific Northwest National Laboratory. (2) See Authorship list on Experiment Report LLNL-TR-864107. (P) Presenting Author.

Understanding gas transport in the environment is critical for analyzing radioxenon and other material signatures from underground nuclear explosions. In October 2023, the Physics Experiment 1-A (PE1-A) was conducted as part of a larger nonproliferation experiment series at the P-Tunnel facility of the Nevada National Security Site. This study involved the release of 127Xe as a radioxenon tracer, driven by a chemical explosion. The tracers, along with various stable gases produced by the chemical explosive, were then measured in the surrounding geology, tunnel air, and the facility's air exhaust. The collected data has been analyzed to provide qualitative insights into gas movement and has been compared to subsurface transport models that explore material flow in geology and tunnels. This presentation will offer an overview of the tracer transport component of the PE1-A experiment, detail the sensor suite used for instrumentation, and highlight key findings from the experimental data and the models used for its analysis.

Log 482. COLLISION-INDUCED DISSOCIATION MASS SPECTROMETRY FOR SMALL QUANTITY ACTINIDE-LIGAND INTERACTION STUDIES. Zarzana, C. A.(1,P); Kim, J. (1); Martelles, M. (2); Pilgrim, C. D.(1); Celis-Barros, C. (3); Albrecht, T. (2); Hodges, B. D. M. (1). (1) Idaho National Laboratory. (2) Colorado School of Mines. (3) Oak Ridge National Laboratory. (P) Presenting Author.

Differences in the covalency of metal-ligand bonds in lanthanide- and actinide-containing complexes are a key lever in the development of new f-element separation processes. We have explored the behavior of An- and Ln-containing complexes with nitrate and (N,N-diisobutylcarbamoylmethyl)phenyloctylphosphine oxide (CMPO) when they are collided with gas molecules in vacuum using new capability at Idaho National Laboratory for studying gas-phase transuranic chemistry. This allows us to probe the interaction strength between the metal and ligand free from interference from solvent, utilizing only nanograms of actinide material. Collision-induced dissociation of a complex containing 243-americium, two CMPO molecules, and two nitrate molecules results in either the loss of a neutral CMPO, loss of nitric acid, or fragmentation of CMPO. The CMPO fragmentation mechanism involves cleavage of the phosphorous-methylene carbon bond, eliminating a neutral octyl-phenyl phosphine oxide. The loss of the phosphine oxide-containing fragment is unusual, as it is expected that the phosphine oxide side of CMPO binds to americium more strongly than the amide side. Density functional theory calculations indicate that the shifts in electron density as the phosphorous-methylene carbon bond cleaves strengthens the amide oxygen-americium bond and simultaneously weakens the phosphine-oxide-americium bond, resulting in elimination of the phosphine-oxide-containing fragment. Curiously, this fragmentation mechanism does not exist for analogous neodymium-containing complexes.

Log 483. USE of Xe-127 IN A TRACER EXPERIMENT FOR MODEL VALIDATION. Ely, J. (1, P); Abromeit, B. (1); Hallen, T. (1); Harper, W. (1); Hayes, J. (1); Sharma, M. (1); Suarez, R. (1); PE-1 Experiment Team (2). (1) Pacific Northwest National Laboratory. (2) doi:10.2172/2345984. (P) Presenting Author.

A Release Experiment (REACT) using smoke and Xe-127 as tracers was conducted in October 2022 at the Nevada National Security Site to validate and improve atmospheric transport modeling for nuclear explosion monitoring applications. The experiment was well instrumented with meteorological sensors, real-time xenon sensors and air samplers to collect dilute xenon-127 samples (20-30 liters air) for off-line measurements. This talk will focus on the laboratory analysis of the air samples, which was measured in two different approaches: one a direct measurement of the xenon-127 signature through the container in a highly sensitive gamma detector system and the other using chemical separation and subsequent measurement of the xenon in a detector. The experiment and sample analysis will be presented as well as the advantages and challenges associated with Xe-127 as tracer including the sample collection and measurement approaches.

Log 484. U238 FISSION PRODUCT STUDIES USING THE MAUI D-T SOURCE USING LAPAKI-KOHANA. Harke, J.T.(1,P); Garcia-Duarte, J. (1), Tamashiro, A.S.(1); Cameron, R.C.(1), Wright, D.M.(1); Harward, N.(1); (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

The accurate understanding of fission product yields is key for nuclear reactor fuel cycles, reactor decay heat, and nuclear waste inventory. We have performed gamma-ray spectroscopy on fission fragments produced from a 14 MeV fission neutron spectrum irradiation using the Maui high flux D-T neutron generator. During this experiment, U238 samples were irradiated using the D-T head to produce equilibrium conditions for several short-lived FPYs. Within 1 minute of the end of the irradiation, gamma-ray spectroscopy was commenced, and event-by-event list mode data was collected for up to 2 days post-irradiation. The performance of Maui as a neutron source and the Lapaki-Kohana HPGe gamma-ray spectrometer array will be presented along with latest results on U238 short lived fission products.

Log 485. RADIOCHRONOMETRIC DATING OF PARTICLES. Savina, M.R.(P) Lawrence Livermore National Laboratory. (P) Presenting Author.

Radiochronometry is a staple of nuclear forensic science. The ability to pinpoint production or purification dates adds important information to forensic or nonproliferation investigations. Dating individual particles can add additional information by, e.g., revealing whether a batch of material derives from a single event or many, or it may be necessary when only a few small particles are available. Particle analysis faces unique challenges compared to bulk. The small number of decay product atoms quickly becomes the limiting factor in the precision of a model age when the sample size shrinks to the particle level. In addition, inhomogeneity due to differential parent/daughter mobility at the micron scale can be an issue, particularly in irradiated material such as spent nuclear fuel. Traditional dissolution and chemical separation methods have been developed for relatively large particles, however these can be impractical for small particles. This talk will focus on recent advances in in situ analytical methods such as LG-SIMS and RIMS applied to traditional radiochronometric pairs such as Th-230 / U-234 and Am-241 / Pu-241 to address these challenges. In addition, new chronometers based on Sr-90 and Kr-85 that show promise for dating irradiated materials such as spent nuclear fuel in nonproliferation applications will be discussed. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. This work was supported by the National Nuclear Security Agency Office of Defense Nuclear Nonproliferation Research and Development. LLNL-ABS-2001581

Log 486. EXAMINATION OF CUMULATIVE FISSION YIELDS FOR ACTINIDES IRRADIATED IN ENRICHED BORON CARBIDE SHIELDING FOR NUCLEAR FORENSICS. Uhnak, NE(1); May, I(2) Pierson, B(1); Bredeweg, T(2) Zimmer, M(1) 1. Pacific Northwest National Laboratory 2. Las Alamos National Laboratory. (P) Presenting Author.

A deeper understanding of the fission process is needed for nuclear forensics research and development. However the quality of the foundational nuclear data can be suspect. High uncertainties, incorrect fission yields, or poor understandings of the nuclear decay properties can affect the interpretation of fission or activation products in these investigations. The bulk of the fundamental nuclear data, particularly for fission from neutron energies greater than thermal neutron energy, were collected during the 1960s to the 1980s from the National Laboratory system. These measurements relied on the state of the science at the time. Since then, modern technologies and analysis methods have greatly improved the capabilities for radioanalytical measurements. In this work we present the results from a campaign to determine and compare cumulative fission yields (CFY) of actinides. Targets of 235U, 238U, 237Np, and 239Pu were irradiated in a custom enriched boron carbide shield in a 1 MW TRIGA reactor. The irradiated samples were then processed and analyzed radiochemically. We present the cumulative fission yields of fission products from each actinide target and compare them with historical CFY data, highlighting a number of improved uncertainties.

Log 487. NEW OPPORTUNITIES FOR PLUTONIUM SCIENCE AND TECHNOLOGY (S&T) AT LOS ALAMOS NATIONAL LABORATORY: HARMONIA, THE PLUTONIUM SCIENCE LABORATORY (PLUS LAB). Erickson, K. (1,P) (1) Los Alamos National Laboratory. (P) Presenting Author.

The Harmonia Plutonium Science Laboratory (PluS Lab) at Los Alamos National Laboratory is a new venue for fundamental plutonium science and technology (S&T) that is outside of existing production facilities within the national security complex. The PluS Lab is sponsored by the NA-22 Nonproliferation Stewardship Program, which seeks to buoy US nonproliferation capabilities in infrastructure, workforce, and S&T. The newly renovated PluS Lab comprises of three interconnected laboratories equipped with fume hoods, double gloveboxes, and the equipment and analytical instrumentation needed to support molten salt science, aqueous systems studies, and molecular chemistry and materials science. The PluS Lab provides opportunities for collaborations throughout the radioanalytical and nonproliferation communities, with a strong focus on workforce development. Towards the goal of inspiring new collaborations, current and future PluS Lab projects will be discussed, demonstrating how these capabilities support plutonium S&T.

Log 488. DETERMINATION OF TRACE ACTINIDE ABUNDANCES IN PLUTONIUM REFERENCE MATERIALS. Wimpenny, J. B. (1, P); Tarng, C. (1); Williams, R. (1); Parsons-Davis, T. (1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Lawrence Livermore National Laboratory was tasked with production of new plutonium isotopic reference materials via purification and sub-aliquoting units of the certified reference materials (CRMs) NBL C136, C137 and C138. These were originally produced in the 1960s and 1970s and have certified plutonium isotope ratios that are imprecise by the standards of modern mass spectrometry. The production efforts at LLNL involved performing a bulk separation of each plutonium material from its ingrown daughter isotopes prior to dispensing individual 1 mg units for distribution. Here, we detail efforts to characterize the effectiveness of the bulk separation procedure and determine the residual concentrations of uranium, americium and neptunium at the time of separation. The progeny concentration measurements are not part of the certification process for the new isotopic standards but will be provided as informational values along with the certificates. For each CRM, three production aliquots were dispensed equating to 1mg of plutonium and daughter isotopes were separated from plutonium by ion exchange chromatography. Total masses of daughter isotopes were determined by isotope dilution mass spectrometry, using high purity isotopic tracers. Results indicate that all three CRMs contained small amounts of residual neptunium and uranium after bulk separation, whereas the bulk separation of americium from plutonium was fully quantitative. Prepared by LLNL under Contract DE-AC52-07NA27344. LLNL-ABS-2001481

Log 489. COLLINEAR, MULTI-PULSE LASER ABLATION FOR PASSIVATION INDUCTION AND SURFACE UNIFORMITY ON PYRPROCESSING MATERIALS.. Phongikaroon, S. (1); Milota, P. (1, 2,P); Andrews, H. (2); Breeden, W. (1). (1) Virginia Commonwealth University. (2) Oak Ridge National Laboratory. (P) Presenting Author.

Advanced reactor development requires progression in molten salt corrosion studies, as in-line processing of used nuclear fuel increases inherent system corrosion and more probable pyroprocessing byproduct reuse requires better control of corrosion products and ultimately cathode impurities. By utilizing the natural passivation properties of structural materials and advancing work in pre-passivation treatments, dense alpha-phase alumina layers can allow more readily available materials to match both structural and corrosion mitigation requirements of these systems. When treated with laser ablation as a means of pre-passivation, however, care must be taken to ensure a smooth oxide layer is formed to prevent UCl3 leaching and fuel material loss. The use of an Applied Spectra J200 LIBS system, set up for multi-pass/multi-pulse surface rastering, under an oxygen-containing cover gas, is proposed to minimize material removal and topography roughness while maximizing plasma temperature thin film growth. A grid of power percentage, spot size and overlap will be compared. These treated alloy coupons will then be tested in a eutectic LiCl-KCl- UCl3 salt at 773 K to simulate a pyroprocessing environment. Data sets will be collected to allow electrochemical corrosion analysis – rounds of open circuit voltage, electrochemical impedance spectroscopy, and linear sweep voltammetry to quantify passivation layer formation and deterioration while in the chlorides. Additionally, once removed from the salt bath, coupon surfaces will be cleaned and tested for UCl3 residue, verifying the

Log 490. DEVELOPMENT OF A FIELD PORTABLE COINCIDENCE SYSTEM AND TECHNIQUES FOR NUCLEAR FORENSICS. (P) Garland, H.I. (1); Archambault , B.C. (1); Pierson, B.D. (1); Good, E.D. (1); Cheng, S. (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Portable gamma-ray spectrometers are used for on-site sample screening to characterize nuclear material pertinent to nuclear safeguards, forensics, and consequence management. However, data originating from complex radionuclide mixtures, akin to what would be present in post-detonation nuclear debris, taken with portable high purity germanium (HPGe) spectrometers are often incapable of assessing the complete inventory of fission products and activated materials. Coincidence detection methods have already been demonstrated as a means of providing a more complete solution to the radio-assay inventory of irradiated materials. The FATES (Feature Assessment of Time-synced Emissions Spectrometer), consisting of two PHDS Germanium Gamma-ray Imager (GeGI) HPGe portable detectors and two Photomultiplier Tubes (PMT), is the first prototype of a field-capable gamma-ray charged particle coincidence spectrometer. The FATES detector system runs in tandem with TListSpectrum, a custom machine learning toolset for gamma-ray analysis within the CERN ROOT framework, to expedite analysis of coincidence data. Preliminary results from the first measurements of fissionable material taken with the FATES will be presented alongside a brief introduction to updates made by the author to the TListSpectrum ROOT package regarding binary processing and offline analysis of FATES data.

Log 491. EFFECT OF MOISTURE ON CORROSION OF 316 STAINLESS STEEL IN MOLTEN NaCl-MgCl2.

Park, T.(1, P); Yang, W.(1), Foster, R.I.(1), Choi, S.(1). (1) Seoul National University. (P) Presenting Author.

Structural materials in molten salt reactors are exposed to not only high temperature and excess irradiation, but also the corrosiveness of halide ions in the liquid state. Furthermore, moisture present in molten salts is widely recognized as having detrimental impacts on the integrity of structural materials by producing corrosive impurities at high temperatures, thereby accelerating the metallic corrosion process. However, few reports are found on quantitative examination of the effect of moisture in molten salts, particularly in chlorides such as NaCl and MgCl2. In this work, the influence of moisture on the corrosion characteristics of 316 stainless steel (316 SS) in a molten NaCl-MgCl2 eutectic mixture at 700 ℃ was investigated. The amount of moisture in the salt mixture was strictly controlled by adding hydrated salts, specifically MgCl2·6H2O, to purified base salts. To prevent undesired moisture absorption, all preparation steps and corrosion tests were conducted in a glovebox filled with argon gas. A conventional three-electrode system, including 316 SS working electrodes, was employed to determine the corrosion potential and corrosion rates of 316 SS immersed in the salt melt. Subsequent to electrochemical analysis, the effect of H2O content on corrosion was quantified through mass loss measurements, SEM-EDS, and ICP-OES analysis. This research was supported by the Nano & Material Technology Development Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science and ICT (RS-2023-00229215).

Log 493. CURRENT PROGRESS OF NDP AND PGAA SYSTEMS USING COLD NEUTRONS AT KAERI.

KIM, JH.(1,P); Sun, G.M.(1). (1) The Korea Atomic Energy Research Institute. (P) Presenting Author.

At the Korea Atomic Energy Research Institute, we are advancing the development of Neutron Depth Profiling (NDP) and Prompt Gamma Activation Analysis (PGAA) systems utilizing cold neutrons. The NDP system focuses on analyzing LLZTO materials in lithium-ion batteries to understand depth distributions of light elements like lithium. Additionally, an operando NDP system is being constructed to enable real-time measurements under operating conditions. The PGAA system is undergoing enhancements, including improved shielding and the integration of an anti-coincidence system to reduce background noise and enhance sensitivity. These developments are critical for precise, non-destructive elemental analysis, providing high sensitivity and depth resolution. Both systems are expected to contribute significantly to advanced material characterization and broaden the applications of neutron-based techniques in energy and materials science research.

Log 494. USING PLUTONIUM ISOTOPES TO IDENTIFY FRENCH NUCLEAR TEST FALLOUT PERIOD (1966-1974): AN ADDITIONAL TIME-MARKER FOR SOUTH AMERICA.

Guillevic, F.(1,P); Gastineau, R.(2); Evrard, O.(3); Sabatier, P.(2); Chaboche, P.A.(3); Foucher, A.(3); Bardelle, A.(3); Achaga, R.(4); Ruiz-Fernandez, A.C.(5); Sanchez-Cabeza, J.A.(5); Tassano, M.(6); Cabrera, M.(6); Chalar, G.(7); Quincke, J.A.(8); Moreno-Allende, V.(9); Moernaut, J.(9); Corcho Alvarado J.A.(10); Röllin, S.(10); Sahli, H.(10); Kobler, J.(1); Dicen, G.(1); Alewell, C.(1). (1) University of Basel, Switzerland. (2) EDYTEM, Université Savoie Mont-Blanc, CNRS, France. (3) Laboratoire des Sciences du Climat et de l'Environnement (LSCE/IPSL), Université Paris-Saclay, France. (4) CIFICEN, Universidad Nacional Del Centro de La Pcia. de Bs. As. (UNCPBA), Argentina. (5) Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Mexico. (6) Centro de Investigaciones Nucleares, Facultad de Ciencias, Universidad de la República, Uruguay. (7) Sección Limnología, Facultad de Ciencias, Instituto de Ecología y Ciencias Ambientales, Facultad de Ciencias, Universidad de la República, Montevideo, Uruguay. (8) Instituto Nacional de Investigación Agropecuaria, Uruguay. (9) Institute of Geology, University of Innsbruck, Innsbruck, Austria. (10) Spiez Laboratory, Federal Office for Civil Protection, Switzerland. (P) Presenting Author.

In regions where rapid environmental changes have occurred, particularly in South America, with widespread changes in agricultural practices leading to major ecosystem changes, it is essential to have reliable time markers to date recent sediments and further quantify such disturbances. The occurrence of fallout associated with French atmospheric nuclear tests, conducted between 1966 and 1974 at the Mururoa and Fangataufa atolls (French Polynesia) was recently confirmed in South American soils and sediments through the analysis of 239Pu and 240Pu isotopes. Here, we present several continuous records of 240Pu/239Pu isotopes ratios in lake sediments along a west-east transect located between 32º and 42º south latitude: Lake Natri (Chile), Lakes Barrancosa and Melincué (Argentina), the Rincon del Bonete reservoir, and La Estanzuela pond (Uruguay). Most records archive information covering the period since the beginning of the nuclear weapon testing. During the atmospheric nuclear weapon test period (1945-1980), lakes exhibited a similar pattern in Pu isotope ratios: (i) an initial phase dominated by the U.S. nuclear weapon test signature (240Pu/239Pu > 0.20), followed by (ii) a phase of increasing Pu activity characterized by a Pu isotope signature consistent with global fallout (240Pu/239Pu = 0.18), and finally (iii) a period of maximum Pu activity marked by fallout from the French nuclear tests (0.03 <240Pu/239Pu < 0.08). These results may contribute to refine the dating of environmental archives in South America, which has experienced significant land-use changes over the past several decades.

Log 495. PRECISE QUANTIFICATION OF RADIOISOTOPES BY COINCIDENT GAMMA-GAMMA HPGE SPECTROMETRY. Archambault, BC (1, P), Pierson, BD (1), Good, EC (1), (1) Pacific Northwest National Laboratory. (P) Presenting Author.

No automated commercial software resource exists for the analysis of data from coincident gamma detection systems (e.g. gamma-gamma, alpha/beta-gamma, alpha/beta-gamma-gamma). Coincident radiation spectroscopy techniques have already demonstrated potential towards expediting the technical nuclear forensics process, particularly in analyzing debris from nuclear explosions. Traditionally, this analysis involves chemical separations, radiometric counting, and mass spectrometry, which are precise but time-consuming and require skilled personnel. Delays can increase uncertainties due to radioactive decay, especially for isotopes with short half-lives. This work presents the R&D of a novel approach to the identification and quantification of radioisotopes present in mixed fission products using a synergistic fusion of conventional analysis methods and physics-informed machine learning techniques to automate the analysis of coincidence radiation spectra. An open-source toolset, named TListSpectrum, developed within CERN’s ROOT framework, was developed for the manipulation, visualization, and analysis of data-streams from coincident spectroscopic systems. Accurate quantification is aided by employing the G4ARES (Geant4 Advanced Radio-Emission Simulations) application to calculate and quantify the required angular and cascade summing corrections necessary for radio-isotopic quantification. End-to-end validation and verification of these techniques was performed and will be presented for certified gamma standards measured with a new 8 HPGe crystal coincidence multi-particle spectrometer named SXGABRIEL. Finally, comparisons of results with a complex mixed fission product sample derived utilizing these tools will be made to traditional “gold” standard assay employing radiochemical separations, traditional radiometric counting and mass spectrometry.

Log 496. QUATITATIVE ANALYSIS IN PROMPT GAMMA ACTIVATION ANALYSIS. Zs. Révay (1, P); B. Maróti (2), (1) Technical University Munich, FRM II, Garching, Germany, (2)Center for Energy Research, Budapest Neutron Center, Budapest, Hungary. (P) Presenting Author.

Prompt Gamma Activation Analysis (PGAA) is based on the detection and analysis of gamma rays induced by neutron capture. This versatile nuclear analytical technique started propagating after the 1990s not just because of the difficulties of the spectrum evaluation, but also due to the lack of the proper analytical database. The first comprehensive spectroscopy database with the ambition of reliably supporting chemical analysis for all naturally occurring elements was published in 2004—2007 based on the measurements performed at Budapest. It is available e.g. in the Handbook of Prompt Gamma Activation Analysis (Kluwer, Dordrecht, 2004) or the PGAA as well as the EGAF databases of the IAEA Nuclear Data Services. It contains energy and partial gamma-ray production cross section data for all stable elements for 25-100 strongest lines derived from spectra of pure elements, calibrated using stoichiometric compounds and special mixtures. Using this database, an analytical method was also developed to determine the composition from the PGAA spectra. This method is based on the comparison of statistical quantities of different possible fits of elements, in the end deriving the element masses averaged from several characteristic lines. The method has been successfully used in BNC at Budapest, FRM II Garching, tested at NIST and Texas University. After 20 years of minor upgrades in both the database and the analytical method, the database is now fully revised based on the new measurements in FRM2’s strong cold beam with improved statistic.

Log 497. STATISTICAL REVIEW OF THE PERFORMANCE OF A LARGE SET OF DETECTOR MODELS USED FOR EFFICIENCY CALIBRATION IN GAMMA SPECTROMETRY. Persson, H. (1,P); Phillips, K.E. (1); Sullivan, D. (1) Mirion Technologies (Canberra), Inc. (P) Presenting Author.

Developed initially as a solution to create accurate efficiency calibrations for in-situ gamma spectroscopy measurements in the late 1990's, the ISOCS (In-Situ Object Counting System) technology is used today in In-Situ, In-Vivo, Laboratory, and NDA applications. The core of the methodology is a high-quality Monte-Carlo model used for detector efficiency characterization of typically a high-purity germanium detector, which is performed by the detector manufacturer in a rigorous process. The spectroscopist user then combines this characterization with sample-specific geometry definition, which is used by the ISOCS application software and its ray tracing algorithms to generate a full energy peak efficiency calibration for the specific measurement. Today, Mirion has created over 5,000 Monte-Carlo models and detector characterizations for gamma spectroscopy systems worldwide. In this presentation, we will detail the technical development of the Monte-Carlo model and the ISOCS characterization. The discussion will continue with a description of the stated uncertainties of the characterization. The main focus of this presentation will be a statistical review of comparisons between full energy peak efficiencies from physical calibration source measurements to modeled full energy peak efficiencies of hundreds of recent detector models (from 2016 to 2022).

Log 498. MEDDLING WITH METAL MEDLEYS. Luitjohan, K. E. (1, P); Thrun, M. M.(1); (1) Los Alamos National Laboratory. (P) Presenting Author.

One strategy to provide a unique taggant signature in bulk metal uranium includes adding natural isotopes of various elements during casting, one of the first processing steps. After a previous study demonstrated this was possible in metallic uranium, scope was expanded to investigate the tagging of metallic fuel, specifically uranium – 10 wt% molybdenum (U-10Mo). Five taggant elements were chosen for the first generation of tagged alloys including Ni, Ti, Sn, Zr, and Ce. After mixed results, two of those taggants, Ti and Ni, were down selected for the second generation. After casting three alloys with different ratios of Ti and Ni, the tagged alloys were heat treated and rolled to analyze the impact of taggants on downstream processing. Microscopy and chemical assessment techniques were utilized to track effects of the taggant species. Chemical taggant detection was generally good while microscopy revealed the second phases did not always contain the expected tagging elements.

Log 499. CHARACTERISATION OF INDIVIDUAL MICRON SIZED NUCLEAR WEAPONS FRAGMENTS FROM THE THULE AREA BY RL-SNMS.

Hanemann, P.(1,P); Weissenborn, T.(1); Lehnert, A.(1); Qiao, J. (2); Nilsen, S.(2); Walther, C. (1). Leibniz University Hannover, IRS. (2) Technical University of Denmark. (P) Presenting Author

In 1968 a B-52 bomber carrying four Mark 28 thermonuclear bombs crashed near the Thule Airbase in Greenland. A conventional explosion following the crash lead to a release of radioactive material to the close environment. Dahlgaard et al. [1] detected weapons grade plutonium in sediments from the environment. Resonant Laser-ionisation Secondary Neutral Mass Spectrometry (rL-SNMS), which combines elemental selectivity with quasi non-destructive spatially resolved mass spectrometry has been used in previous work [2-4] to characterize individual nuclear fuel fragments from the Chornobyl Exclusion Zone. In this work we applied this method to soil samples from the Thule area. Individual hot particles were isolated from soil samples using an SEM with an installed micro manipulator. rL-SNMS measurements were performed successfully on multiple particles, isotope ratios for uranium and plutonium were obtained. The particles contain both weapons grade plutonium (mass ratio 240Pu/239Pu > 0.05) as well as highly enriched uranium (mass ratio 235U/238U > 1.0) which clearly shows that these environmental particles are fragments of a nuclear weapon. Gamma spectrometry showed, that the hot particles contain similar amounts of uranium and plutonium. Results for different hot particles will be presented and discussed from a nuclear forensics standpoint. References: 1: DOI: 10.1016/S1569-4860(01)80004-8; 2: DOI: 10.1126/sciadv.abj1175; 3: DOI: 10.1016/j.sab.2022.106377; 4: DOI: 10.1016/j.jhazmat.2023.131338

Log 500. DETAILS OF THE VERTICAL NEUTRON RADIOGRAPHY DEVICE FOR THIN LIQUIDS.

Schillinger, B (1,P), Craft, A (2), Sponar, S (3), Tkacz,P (1), Trunner,C (3) (1) Heinz Maier-Lebnitz Zentrum (FRM II), Technical University of Munich, Germany. (2) Idaho National Lab, USA. (3) TU Wien, Austria. (P) Presenting Author.

We describe a vertical neutron beam setup using pyrolithical graphite crystals to deflect a neutron beam into the vertical, in parallel to the gravity vector, for the examination of thin liquids and two-phase flows. First successful experiments have been conducted at the reactors of Atominstitut Vienna, Austria, and the Institut Laue-Langevin (ILL) in Grenoble, France on water-air bubble two phase flows as well as heterogenous liquids like glass beads or fat drops on water. Movies could be recorded with 50 ms frame resolution that still showed the air bubbles. These experiments suffered from the mosaicity of the graphite crystals that destroys the parallelity of the incoming beam and delivers unsharp images if the sample is not placed in immediate contact with the neutron imaging detector. We show images of different collimation from crystals of different mosaicity. The crystals act as secondary source with Diamater D and teh distance L to sample and detector which define the new beam collimation. We show more details about the effective beam mgeometry, in addition to the talk. One possible application is watching crystal melts, but we hope to find more applications at the MARC XIII conference.

Log 501. A VERTICAL NEUTRON RADIOGRAPHY DEVICE FOR THIN LIQUIDS. Schillinger, B (1,P), Craft, A (2), Sponar, S (3), Tkacz,P (1), Trunner,C (3) (1) Heinz Maier-Lebnitz Zentrum (FRM II), Technical University of Munich, Germany. (2) Idaho National Lab, USA. (3) TU Wien, Austria. (P) Presenting Author.

We describe a vertical neutron beam setup using pyrolithical graphite crystals to deflect a neutron beam into the vertical, in parallel to the gravity vector, for the examination of thin liquids and two-phase flows. First successful experiments have been conducted at the reactors of Atominstitut Vienna, Austria, and the Institut Laue-Langevin (ILL) in Grenoble, France on water-air bubble two phase flows as well as heterogenous liquids like glass beads or fat drops on water. Movies could be recorded with 50 ms frame resolution that still showed the air bubbles. These experiments suffered from the mosaicity of the graphite crystals that destroys the parallelity of the incoming beam and delivers unsharp images if the sample is not placed in immediate contact with the neutron imaging detector. We show images of different collimation from crystals of different mosaicity. A future experiment uses a multi-channel plate made of borated glass to post-collimate the reflected beam, either before or after the sample, increasing the beam collimation roughly from L/D=17 to L/D=100. Measurements at ATI Vienna failed for lack of intensity, new experiments at ILL can only be conducted after the conferrence. New installations are planned at ILL for crystal melts, but we hope to find more applications at the MARC XIII conference.

Log 502. TRACING FRENCH NUCLEAR FALLOUT IN LAKE SEDIMENTS: A WEST-EAST TRANSECT FROM SOUTH AFRICA TO NEW ZEALAND. Kobler, J.(1, P); Guillevic, F.(1); Gatineau, R.(2); Dicen, G.(1); Evrard, O.(3) ; Sabatier, P.(2); Corcho Alvarado, J.A.(4); Röllin, S.(4); Sahli, H.(4); Arnaud, F.(1); Paris, R.(5); Howarth, J.D.(6); Haberzettl, T.(7); Alewell, C.(1). (1) University of Basel, Switzerland. (2) EDYTEM, Université Savoie Mont-Blanc, CNRS, France. (3) Laboratoire des Sciences du Climat et de l'Environnement (LSCE/IPSL), Université Paris-Saclay, France. (4) Spiez Laboratory, Federal Office for Civil Protection, Switzerland. (5) Laboratoire Magmas et Volcans, OPGC, IRD, CNRS, Université Clermont Auvergne, France. (6) School of Geography, Environment and Earth Sciences, Victoria University of Wellington, New Zealand. (7) Geomorphology and Polar Research (GEOPOLAR), Institute of Geography, University of Bremen, Germany. (P) Presenting Author.

The worldwide deposition of artificial radionuclide fallout (e.g., 137Cs, 239Pu and 240Pu) since the 1950s has been used for several decades to support dating of recent sedimentary archives. It has also been used to reconstruct geomorphological processes such as soil erosion and the remobilization and transfer of sediment to fresh water systems. The spatial and temporal distributions of fallout radionuclides, used as markers of modern archives, are nonetheless less known in the Southern Hemisphere than in the Northern Hemisphere.To improve our understanding of the spatial and temporal distribution of Pu isotopes in the Southern Hemisphere, we measured 239+240Pu activity and 240Pu/239Pu isotope ratio in lake sediment cores from Southern Africa and in Oceania. For this study, we selected three lakes in South Africa (Lake Verlorenvlei, Lake Mzingazi, Lake Bolangvlei), one lake on the Kerguelen Islands (Lake Aphrodite), one lake in New Zealand (Lake Waihau), and one lake in Vanuatu Archipelago (Lake Anatom), based on their 210Pb and 137Cs vertical profiles. Additionally, uranium isotopes (235U, 233U, 236U, 238U) were measured in one of the South African lakes to allow comparison with Pu isotopes and to investigate their use as source fingerprints. This study aims to determine (i) whether Pu chronologies vary depending on the nuclear weapon testing periods in the Southern Hemisphere (e.g., British tests in Australia and French Polynesian tests) and (ii) the potential use of Pu isotope ratios to get insights into soil erosion dynamics and histories in catchments with Pu-bearing soil particles.

Log 503. NUCLEAR NONPROLIFERATION WORKFORCE: KEEPING PACE IN A CHANGING WORLD. Ladd-Lively, J. L. (1, P). (1) Oak Ridge National Laboratory. (P) Presenting Author.

The Nuclear Nonproliferation community has a need for a sustained technical workforce across numerous domain expertise to continue to support its mission. In order to sustain this workforce, we must get new people in the pipeline as well as senior experts that can transfer knowledge prior to retirement. With the current growth in the nuclear industry and the rapidly emerging technologies, it is difficult to get people into the nuclear field and to keep them there. I will discuss Oak Ridge National Laboratory's efforts within this topic.

Log 504. TAG, YOU'RE IT: DEVELOPING A METHOD TO ISOLATE CHROMIUM FROM URANIUM-RICH MATERIALS AND IMPLICATIONS FOR CHROMIUM AS AN ISOTOPIC TAGGANT. Baransky, E.J. (1, P); Render, J. (1); Rolison, J.M. (1). (1) Nuclear and Chemical Sciences Division, Lawrence Livermore National Laboratory, USA. (P) Presenting Author.

Stable isotopic taggants could provide unique nuclear material identifiers and thus could possibly help expedite the identification of nuclear materials discovered outside of regulatory control. However, optimal element candidates for isotopic tagging are still being identified. Chromium (Cr) is of particular interest as a taggant because it has four stable isotopes, thereby enabling the use of the double-spike technique. Furthermore, Cr is present at the parts per million level in typical nuclear fuel materials which alleviates some of the uncertainty around how trace additions of Cr would impact fuel performance and safety. However, the extent to which Cr isotopes fractionate during nuclear fuel processing is unknown, leading to uncertainty in the suitability of Cr as an isotopic taggant. Extreme isotopic fractionations, as previously reported for molybdenum and tungsten in enriched uranium materials, would potentially prevent identification of a Cr isotope taggant. Considering that Cr is in the same elemental group as molybdenum and tungsten, it is conceivable that Cr isotope ratios may also fractionate during nuclear material production processes. To constrain the Cr isotope ratios of nuclear materials, we must first develop a robust method to separate Cr from uranium-rich matrices. In this study, we examine purification protocols to optimize isolation of Cr from nuclear materials for high-precision isotope ratio measurements. This research will aid in directing efforts to identify suitable isotopic taggants.

Log 505. REAL-TIME GROSS ACTINIDE MONITORING IN EXTREME (1e6:1) BETA-GAMMA BACKGROUND FLUID STREAMS USING MINI-ATMFDs. Ozerov, S. (1,P); Boyle, N. (1), DiPrete, D. (1); Taleyarkhan, R. (1). (1) Purdue University. (P) Presenting Author.

Gross alpha activity monitoring in near real-time is a well-known challenge in environmental radiochemistry and radiation measurements. The challenge involves fission product-rich streams bearing beta-gamma emitting isotopes, which create a challenging detection environment because of the extreme 1E6x higher beta-to-alpha activity background. Tensioned metastable fluid detectors (TMFDs) have been proven to remain 100% blind in intense (10,000+ R/h) photon and also beta fields. An experimental technique was developed and tested at Purdue University (using dissolved Rn-Po alpha emitters), and validated (with dissolved Pu actinide) at Savannah River National Laboratory to permit real-time monitoring of alpha activity in the 100 -10,000 dpm/mL range using a novel miniaturized acoustically tensioned metastable fluid detector (mini-ATMFD) monitoring system. This presentation will present salient aspects of the mini-ATMFD design and the results of assessments to date.

Log 506. PRODUCTION AND INITIAL CHARACTERIZATION OF A NEW PLUTONIUM METAL STANDARD, CRM126B.

Olson, A.(1,P); Tandon, L.(1); Fox, D.(1); Getha, G.(1); Gilbert, T.(1); Kalin, T.(1); Eiroa-Lledo, C.(1); Peach, W.(1); Risdon, D.(1); Essex, R.(2); Mason, P.(2). (1) Los Alamos National Laboratory. (2) New Brunswick Laboratory Program Office. (P) Presenting Author.

A series of nine plutonium (Pu) metal certified reference materials (CRMs) have been produced in the Unites States since the 1960s, beginning with the National Bureau of Standards (NBS) Standard Reference Material SRM 949 and most recently concluding with CRM126A (C126A) in 2004. Plutonium metal standard C126A resulted from a joint effort between Los Alamos National Laboratory (LANL) and the New Brunswick Laboratory (NBL). The production of a new Pu metal standard, CRM126B (C126B), has been undertaken in a continued partnership between LANL and the NBL Program Office. The newly produced C126B material will be used for the calibration and quality control of measurement systems performing Pu mass fraction (assay) and Pu isotopic composition determinations. Attaining high-purity, homogeneous, and stable material is of critical importance. In addition, the production of an actinide standard that meets the requirements for a Certified Reference Material of the highest metrological quality brings unique technical challenges. This presentation will describe the C126B material production, analytical tools that have been deployed to monitor the material processing, as well as initial characterization results collected throughout the production sequence. Finally, perspective on LANL's work with the certifying organization (i.e. NBL Program Office) to devise an analytical plan for material certification will be provided. LA-UR-24-33126

Log 507. PRODUCTION OF GASEOUS RADIOTRACERS WITH A CRYOGENIC IRRADIATION FACILITY.

Hudson, C.C.(1, P); Slack, J.L.(2); Johnson, C.M.(2); Seifert, C.E.(2); Haas, D.A.(1). (1) The University of Texas at Austin. (2) Pacific Northwest National Laboratories. (P) Presenting Author.

Radiotracers are an important tool in nuclear explosion monitoring. Tracers allow researchers to test detection equipment and simulate underground nuclear explosions. Tracers in TRIGA type reactors are typically produced using invasive in-core irradiation procedures that take up time, are expensive, restrict research access, and leave equipment contaminated and unable to be used. One solution is a beam port-based irradiation system, which is less intrusive on reactor operations, but has a lower neutron flux than in-core systems. To compensate for this, a cryogenic irradiation facility was developed to produce gaseous radiotracers at the University of Texas at Austin. A helium compressor placed inside the beam port freezes gaseous isotopes and increases the reaction rate to comparable levels with the in-core irradiation. In addition to radiotracer activation, this design is also planned to be used for testing off-gas retention for molten-salt reactors as a cryotrap, in support of a digital-twin reactor system. Initial tests for this facility were promising, but equipment failure towards the end of the experiment resulted in only 0.043 Ci of Xe-127 being produced after approximately one month despite a production target of 2 Ci. Issues with gas leaks and pump failures were the expected culprit, and repairs to remedy these issues were completed. A second slate of activation experiments using argon and xenon have been performed to verify the cryogenic irradiation facility's efficacy. A review of the facility's design, activation rates, and planned future use are discussed.

Log 508. APPLICATION OF FLOW ELECTROLYSIS TO MASS SPECTROMETRY OF TETRAVALENT ACTINIDES. K. Yanagisawa(1,P); M. Matsueda(1); T.Oka(1); Y. Kitatsuji(1). (1) Japan Atomic Energy Agency. (P) Presenting Author.

Neptunium-237 (Np-237) is a highly radiotoxic actinide with a long half-life (2.14x10^6 years). Driven by ageing nuclear reactors and increasing of radioactive waste, its analytical methods are of great interest in fields such as decommissioning, radioactive waste management, and environmental monitoring. To meet the growing global demand, time-efficient and high-throughput analytical methods are essential. While mass spectrometry is widely used for determination of Np-237, removal of interferences (e.g., U-238 peak tailing at m/z 237) is required by chemical separation with solid-phase extraction followed by valency adjustment, as Np exists in aqueous solutions in valence states ranging from trivalent to hexavalent. Manual addition of reducing agents, such as potassium disulfite, has been conventional approach, but this approach risks causing polyatomic interferences (e.g., 205Tl32S+) and human error. In this study, we propose a sequential pretreatment process to simplify valency adjustment and chemical separation for determination of Np-237 by mass spectrometry. By using flow electrolysis in a flow cell, 94±5% of pentavalent Np was successfully reduced to tetravalent at an optimized sample flow rate without the addition of reducing agents. We demonstrated the analytical performance of the proposed method, which combines flow electrolysis with a PEEK column filled with TEVA resin, using inductively coupled plasma-mass spectrometry.

Log 509. EDUCATION PROJECTS AT ITALIAN NATIONAL INSTITUTE OF NUCLEAR PHYSICS - INFN ABOUT NATURAL AND ARTIFICIAL RADIOACTIVITY . Groppi, F. (1,2); Cagnetta, M.F. (2); Persico, E. (2); Manenti, S. (1,2); Colucci, M. (1,2). (1) LASA Laboratory, Physics Department of University of Milano, Milan, Italy; (2) LASA Laboratory, National Institute of Nuclear Physics - INFN, Milan, Italy.

Educational initiatives have emerged as crucial tools for disseminating knowledge and fostering awareness among students and the public about lack of information that can result in unwanted fears and distorted perceptions of everyday risks in relation of ionizing radiations and all "nuclear" related topics. Italian National Institute of Nuclear Physics – INFN, with a focus on the initiatives conducted at the Milan section, promotes activities designed to engage students and the broader community in exploring the complexities and implications of IR. We will present: 1. the RadioLab project and its extension ISOradioLAb, devoted specifically to minor Italian islands such as Lampedusa/Linosa and Pantelleria, educating young people and the wider population about natural radioactivity, its presence in the environment, and its impact on human health; 2. activity proposed to bachelor students in STEM disciplines, related to measurements in food and its derivate to monitor the radioactivity in these matrices and to address the importance of food safety and risk assessment following nuclear incidents; 3. EyeRAD (Environmental RADioactivty monitoring network) project, focused on monitoring the concentration of radionuclides present in atmospheric particulates to promptly identify any releases of radioactivity in air due to anomalous events; 4. the International Particle Therapy Masterclass (PTMC) introduces high school students to the intersection of particle physics and medical science. All these initiatives are conducted as citizen science projects.

Log 510. GammaEDU EDUCATION KIT TO MEASURE RADIOACTIVITY: THE LAMPEDUSA CASE. Colucci, M. (1,2); La Verde G. (3); Pugliese M. (3); Cagnetta, M.F. (2); Persico, E. (2); Manenti, S. (1,2); Groppi, F. (1,2). (1) LASA laboratory, Physics Department of University of Milano, Milan, Italy; (2) LASA laboratory, INFN-MI, Milan, Italy; (3) Physics Department of University of Naples Federico II and INFN-NA, Naples, Italy

The public imagination often associates a negative feeling to the phenomenon of radioactivity. We want to introduce students to topics related to natural and artificial radioactivity. A way to increase the familiarity with these topics is to make measurements of environmental radioactivity to understand that is all around us. For this purpose we develop educational project that involves many schools on Italian territory and also in the small Italian islands Lampedusa and Pantelleria in which the students are involved in many laboratory activities starting from radon-222 measurements. We introduce also the use of a portable detection backpack GammaEDU of the CAEN Company that includes a high efficiency gamma-ray scintillation detector to reveal the presence of radioactive materials in the environment. With the GammaEDU Android application the students can acquire and analyze in real time a gamma-ray spectrum to get the K, U and Th abundances, keep note of the surrounding environment, take the GPS coordinates and shoot a picture of the on-going measurement. We will present the results obtained for the mapping of all Lampedusa Island territory as an example of this educational activity.

Log 511. DEVELOPMENT OF AN INERT GAS FUSION ANALYTICAL METHOD FOR OXYGEN QUANTIFICATION IN CHLORIDE AND FLUORIDE SALTS. Gonzalez, M.(1,P); Simpson, M.F. (1). (1) The University of Utah. (P) Presenting Author.

A method was developed and demonstrated for oxygen (O) quantification in chloride (LiCl) and fluoride-based (FLiNaK) salts using an ELTRA ONH-p 2 inert gas fusion (IGF) analyzer, a copper certified reference material (CRM), and a custom heating profile. Oxygen quantification relies on oxygen liberation from samples through reaction with graphite to form CO or CO2. Early analyses of LiCl-Li2O showed that salt samples volatilize before oxygen liberation can occur when using traditional methods which use steel CRMs. For LiCl-Li2O, the use of a copper CRM, tin capsules for sample containment, and lower method temperatures resulted in oxygen measurements within 0.25% of those determined using titration and a standard deviation of 0.014 for triplicate samples. FLiNaK salt samples were analyzed using this new method and the results were compared to those of a LECO procedure, which used a steel CRM. Both the new ELTRA method and LECO produced repeatable results for quadruplet samples. However, the ELTRA procedure reported an oxygen concentration (0.15 wt% O) up to 120% greater than that of LECO. The new procedure resulted in a standard deviation of 0.0295 and was independent of sample size. Samples were prepared in glove boxes. This means it should only be possible to underreport oxygen content in a sample. Thus, this newly developed IGF method is promising for oxygen quantification in chloride and fluoride salts.

Log 512. DEVELOPMENT OF COMBUSTION ION CHROMATOGRAPHY METHOD FOR FLUORIDE AND CHLORIDE CHARACTERIZATION USING A MITSUBISHI AQF-2100H SYSTEM.

Brown, A. N. (1, P); Nolan, J. R. (1); Williams, S. N. (1); Martinez, P. T. (1); Tandon, L. (2); Olson, A. C. (1). (1) Los Alamos National Laboratory, Actinide Analytical Chemistry Group. (2) Los Alamos National Laboratory, Metal Production Group. (P) Presenting Author.

Pyrohydrolysis – high-temperature combustion using oxygen, steam and argon – is widely considered the optimal extraction method for fluoride and chloride from actinide materials. When joined with quantitative instrumentation like ion chromatography (IC), the technique is known as combustion ion chromatography (CIC). In use since the 1950s, this method followed by IC is still considered state-of-the-art in the analytical actinide community. Quantification of fluoride and chloride is important for many actinide programs, but this technique has recently faced challenges regarding high-temperature safety restrictions at nuclear facilities worldwide. This and the complexities of sample analyses performed in highly radioactive environments have traditionally forced most pyrohydrolysis systems to be highly customized and hands-on in nature, de-coupled from IC, and not intended for high-throughput analyses. Coupled CIC systems developed for the coal industry have drawn interest from the actinide community for their potential to characterize several halides, particularly fluoride and chloride. Currently, CIC is used by the Actinide Analytical Chemistry Group at Los Alamos National Laboratory at two separate facilities. At the older facility, the traditional, customized system de-coupled from IC is currently in use. At the second facility, a Mitsubishi AQF-2100H CIC system is undergoing process development. Challenges, advancements and lessons-learned while developing the AQF-2100H CIC method are discussed, performance analyzed, and recovery data compared between these two systems. LA-UR-24-33211

Log 513. ASSESSMENT OF THE HALF-LIFE AND GAMMA-RAY BRANCHING RATIO OF 91-Y USING TRADITIONAL AND MULTI-MODAL COINCIDENCE MEASUREMENT TECHNIQUES.

Good, E.C. (1, P); Pierson,B.D. (1); Archambault, B.A. (1); Haney, M.M. (1); Herman, S. (1); Friese, J. (1); Douglas, M. (1); Metz, L. (1); Warzecha E. (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Applications such as nuclear medicine, toxicology studies, and nuclear forensics require half-lives and gamma-ray intensities to accurately quantify isotopes in samples. 91Y is an important longer-lived isotope that was last evaluated [1] over a decade ago and uses one published measurement for the half-life and disparate measurements for the branching ratio evaluation. The only 91Y measurement taken in the last 50 years was a branching ratio published by Gilligan et al. [2] that did not use an isotopically pure sample. Here we present analysis of two different samples and measurement campaigns of the 91Y beta-decay half-life and 1204-keV gamma-ray branching ratio taken with the Gamma Alpha Beta Radio-Isotope EvaLuator (GABRIEL) detector [3,4]. GABRIEL is a multi-particle coincident spectrometer that uses two PMTs and two HPGes to measure gammas, alphas, and betas time-synchronously for multi-modal coincident analysis using list-mode data post-processing. The chemically-separated, isotopically-pure fractions of 91Y were verified to be contamination-free using gamma-gamma and beta-gamma-gamma coincidences. The half-life and gamma-ray branching ratio are determined using time-dependent beta, gamma, and beta-gamma coincident spectroscopy employing traditional LSC and singles gamma counting as well as the GABRIEL detection system. [1] C. Baglin, Nucl. Data Sheets 114 (2013) 1293–1495. [2] C. Gilligan et al. Appl. Radiat. Isot. 205 (2024) 111172. [3] B.D. Pierson et al. J Radioanal Nucl Chem 331 (2022) 5453–5467. [4] S.M. Collins et al. Appl. Radiat. Isot. 182 (2022) 110140.

Log 514. CHEMICAL ANALYSIS PLANS FOR ACU'S MOLTEN SALT RESEARCH REACTOR; THE NATURA RESOURCES MSR-1. Pamplin, K.L.(1,P); for the NEXT Lab Collaboration. (1) Abilene Christian University. (P) Presenting Author.

As the demand for energy increases, advanced nuclear power emerges as a safe, clean, sustainable, and reliable alternative to other options. Among advanced nuclear possibilities, liquid-fueled molten salt reactors (MSRs) offer some compelling advantages. The long-term operation of MSRs requires operators to control and/or respond to a variety of parameters within the salt, including fuel, fission products, corrosion products, and trace components like oxygen. Researchers at the Nuclear Energy eXperimental Testing Laboratory (NEXT Lab) at Abilene Christian University are building the Multi-instrument AnalyTical ArRAY (MANTA RAY) to capture a comprehensive collection of chemical compositions from the Molten Salt Research Reactor (MSRR), the Natura Resources MSR-1. MSRR data will inform future reactor designs by documenting the chemistry of the reactor. For example, the distribution of iodine-131 in the salt and cover gas during operation and in a potential release and after a spill is critical to assessing the maximum hypothetical accident and therefore the necessary planning for such an event. Research described here presents an update on the development of several real-time online measurements of the molten fuel salt and its cover gas and complementary offline measurements of quenched salt samples. Efforts to monitor the salt purification process and corrosion progress during the life of the reactor will be described. Measurement capabilities include electrochemistry, mass spectrometry, OES, Raman spectroscopy, gamma spectroscopy, oxygen analysis, DSC, SEM, EDS, and XRD.

Log 516. TOWARD A NOBLE GAS SYSTEM FOR NEAR-FIELD MONITORING. Humble, P.H.(1,P); Bottenus, D.R.(1); Serkowski, J.(1); Salalila, M.(1); Ely, J.H.(1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Air separations are a necessary part of high sensitivity measurement systems used for detecting and measuring radioactive noble gases such as radio-xenon for nuclear explosion monitoring. Locating a detection system closer to the radioactive gas source or suspected nuclear event provides unique advantages. Closer proximity minimizes dilution, allowing for smaller gas samples and/or higher sensitivity. The shorter transport distances and transport time allows access to short-lived noble gas isotopes providing more information about the event. We are focused on decreasing the size, weight, and power (SWaP) of the measurement system to enable implementation at local distances. Process intensification concepts are used to accomplish this, including leveraging the scaling rules for heat and mass transport to optimize separation performance and heat recuperation. We have successfully demonstrated a microchannel distillation process that enables miniaturizing the collection and concentration of high molecular weight radioactive gasses such as radioxenon. The process uses microchannel heat exchangers and a high efficiency stirling cooler to minimize the required energy. We are also developing a rapid cycle temperature swing adsorption process that decreases system size and energy use by applying high efficiency heat transfer structures with thermal recuperation. These processes can be used to create a small noble gas detection system suitable for near-field monitoring.

Log 517. U.S.-U.K. INTERLABORATORY COMPARISON CONFIRMS RADIOCHRONOMETRIC DISCORDANCE AS A SIGNATURE OF VACUUM INDUCTION MELTING IN CAST URANIUM METALS.

Chen, C.Y. (1, P); Higginson, M.A. (2, P); Edwards, M.A. (3); Ainge, A. (2); Cocciadiferro, A. (1); Cross, S. (2); Denton, J. (3); Dunne, J. (2); Engel, J. (3); Gaffney, A.M. (1); Gilligan, C. (2); Johnson, A. (1) Lamont, S.P. (3); Luitjohan, K.E. (3); Oldman, C. (2); Page, S. (2); Puxley, C. (2); Rice, N.T. (3); Sanborn, M.E. (2); Shilling, A. (3); Steiner, R.E. (3); Stow, M. (2); Wende, A.M. (3); Woods, L.M. (1); Worsham, E.A. (1). (1) Lawrence Livermore National Laboratory, USA. (2) Atomic Weapons Establishment, UK. (3) Los Alamos National Laboratory, USA.

We present two studies marking the successful reproduction of a discordance pattern between the 230Th-234U and 231Pa-235U chronometers in cast uranium metal, an achievement resulting from collaborative work between the Atomic Weapons Establishment in the UK, and Lawrence Livermore and Los Alamos National Laboratories in the US. In the first study, radiochronometric analysis was applied to subsamples of a feedstock and cast item produced by AWE. Here, we observed that while 230Th-234U model ages more closely reflected the timing of the last casting event, the 231Pa-235U model ages of both the feedstock and cast item preserved the timing of initial uranium metallization. In the second study, subsamples were taken from a depleted uranium rod, cast under controlled conditions using vacuum induction melting at LANL's Sigma Facility in early 2024. By taking subsamples radially along four cross sections of the cast rod and distributing them randomly among the laboratories, 230Th-234U and 231Pa-235U model ages determined by all three laboratories produced a map of the internal spatial distribution of 230Th and 231Pa within the rod. This spatial relationship between sample location and model ages offers valuable insights for the interpretation of radiochronometry results in nuclear forensic investigations. Overall, these results highlight the importance of interlaboratory comparisons in cross-validating laboratory findings and reproducing patterns, providing a framework for future efforts to identify and confirm other signatures of uranium production processes. Prepared by LLNL under Contract DE-AC52-07NA27344. LLNL-ABS-871597.

Log 518. REACTIVITY PENALTY OF INCORPORATING TAGGANT ELEMENTS INTO FUEL.

Ayaz-Maierhafer, B.(1, P); Osborn, J.M.(1). (1) Sandia National Laboratories. (P) Presenting Author.

The Intentional Forensics Venture (IFV) is a multi-lab project researching the capability to identify and demonstrate deliberate taggant strategies to enable the introduction of unique signatures into nuclear fuel to potentially improve the timeliness and accuracy of material provenance forensics. There are several aspects of the IFV work that must be considered, but paramount of them is minimizing the effects of an intentionally added material on the reactor performance. The initial reactivity penalty due to taggant incorporation was calculated for three selected reactor archetypes, 36 selected taggant elements and their naturally occurring isotopes, and various taggant concentrations at ppm level. The radiation transport code, MCNP, was utilized to develop 3D infinite-lattice fuel assembly models of the reactors of interest to perform criticality simulations to calculate the reactivity penalty due to the taggant incorporation. By assessing individual isotopes, we may convolve reactivity data with perturbed isotopic taggants. These perturbed isotopes can selectively avoid isotopes of an element having a significant neutron capture cross-section or enable the incorporation of double spike taggants. The reactivity worth and ingrowth data generated provides insight into neutronics economy behavior of potential taggant isotopes and will be input into a venture-level model integration software tool.

Log 519. COMPARISON OF COMMERICALLY AVAILABLE ANION EXCHANGE RESINS FOR PLUTONIUM PURIFICATION. Arbova, D.L.(1,P); Reinhart, E.D.(1); Perry, A.N.(1); Corbey, J.F.(1); Lumetta; G.J.(1); Seiner, B.N.(1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Reillex HPQ is the gold-standard anion exchange resin for the purification of plutonium in nitric acid. HPQ is a methyl-quaternized poly(4-vinylpyridine) resin, crosslinked with 25% divinylbenzene, which uptakes Pu(IV) with high capacity, rapid kinetics, and radiological hardness. Reillex HPQ is no longer commercially available in research quantities. Therefore, there is a potential impetus to find a commercial-off-the-shelf alternative to Reillex HPQ. Four commercially available resins, Bio Rad AG MP-1, Lewatit MP 500, Reillex 425, and Reillex HP were examined alongside Reillex HPQ for their ability to uptake Pu(IV). For the first round of experiments, batch Pu(IV) distribution ratios for these five resins were measured in 0.35 M, 3.0 M, and 8.0 M HNO3 after a 24 h contact period. Resins with good uptake at 8.0 M HNO3 and low to no uptake at 0.35 M HNO3 were used in a second round of experiments in which distribution ratios in 8.0 M HNO3 were determined after 1 h of contact to investigate Pu(IV) uptake kinetics. Aliquots of the contacted solution were measured via ICP-MS to minimize the quantity of Pu-242 used. In this study, the Pu(IV) distribution ratios for the commercially available Reillex 425 and Reillex HP, the unquaternized versions of HPQ, will be published in the literature for the first time and under identical experiment conditions to Reillex HPQ.

Log 520. MODEL PREDICTIONS OF TAGGED FUEL TRANSMUTATIONS. Lutz, E.C.(1, P); Salazar III, A. (1); Osborn, J.M.(1); Wilson, B.(2). (1) Sandia National Laboratories. (2) Oak Ridge National Laboratory. (P) Presenting Author.

The Intentional Forensics Venture (IFV) is a multi-lab project researching the capability to identify and demonstrate deliberate taggant strategies to enable the introduction of unique signatures into nuclear fuel to potentially improve the timeliness and accuracy of material provenance forensics. Initial efforts identified three metals (Mo, Ni, W) to isotopically perturb to generate six unique taggants. Each taggant was enriched in two isotopes to create the double spike taggants that were used to tag UnatO2 minifuel samples at both 100 PPM and 1000 PPM concentrations. The samples were irradiated in the High Flux Isotope Reactor (HFIR) for either three, five, or six full cycles to consider the effects of the taggant at various burnups. This experiment was taken as an opportunity to test the ability of Monte Carlo N-Particle (MCNP) to calculate the burnup and transmutation of the taggants. An existing MCNP model of HFIR cycle 400 was modified to add the sample basket, target, sample holder, and minifuel samples using the measured dimensions and compositions. The HFIR control elements were placed and held at their cycle average positions and the fuel was burned to the corresponding time in the cycle. The burn capability of MCNP was used to track the burnup and transmutation of all 18 samples through all six HFIR cycles. The actual HFIR cycle lengths and downtime for each of the six cycles was used for the calculations. Results from the simulations will be compared to post irradiation measurements of the samples for validation purposes.

Log 521. TAGGANT INVENTORY UNCERTAINTY ANALYSIS WITH CINDER FOR POST IRRADIATION EXAMINATION AT HIGH FLUX ISOTOPE REACTOR. Salazar III, A. (1, P); Lutz, E.C.(1); Osborn, J.M.(1). (1) Sandia National Laboratories. (P) Presenting Author.

Evaluating the isotopic compositions of taggant samples irradiated at the High Flux Isotope Reactor (HFIR) involves uncertainty in both the reference nuclear data sets and several key parameters used in modeling. Inventory results are expected to vary when using the latest Evaluated Nuclear Data File release (ENDF/B-VIII.1) and earlier evaluations. Additionally, the concentration of the element of interest in the natural UO2 matrix may vary for each taggant, and within the element, there is uncertainty in the isotopic compositions (including the enriched components). Finally, the expected neutron environment at the sample location at HFIR may vary over time depending on operating conditions, so varying neutron spectra and power levels may need to be incorporated. Given these considerations, an uncertainty quantification analysis is performed by sampling the uncertain parameters, creating model inputs, and driving several iterations of the transmutation analysis for each taggant of interest with a fixed nuclear data set. The point depletion code CINDER was used to model taggant inventories over time given the HFIR irradiation schedule, which is assumed to be fixed. Representative neutron environments at the sample locations are obtained through MCNP 6.3. Python is used to drive the CINDER iterations, perform statistics on the ensemble, and generate uncertainty bands for the time-dependent taggant delta values. These uncertainty bands are then compared between ENDF/B-VIII.1 and ENDF/B-VIII.0, and implications on the mass spectroscopy measurements for the post irradiation examination are discussed.

Log 522. INCORPORATING MICROSCOPY IMAGES INTO A NUCLEAR FORENSICS LIBRARY. Dimayuga, I.(P); Echlin, M.; Chin, T.; Totland, M.; Pruszkowski, B.; Martinez, M. (P) Presenting Author.

Canadian Nuclear Laboratories (CNL) has a long history of examining a variety of nuclear fuels, particularly experimental and CANDU fuels, and has been compiling fuel fabrication, power history, irradiation parameters and post irradiation examination information in an Irradiated Fuels System (IFS). The IFS comprises a database and user interface and was originally focused on fuel performance and safety issues. The suitability of the IFS for nuclear forensic applications was investigated by CNL, and a number of modifications have been implemented to the IFS to enable search of NF-significant parameters. Functionality was added to enable search of isotopic abundance and isotope ratio data for U and Pu. The current work looked to expand the search criteria to also include such things as fuel type, burnup, and noble gas volume and their isotope ratios. Additional data are being added to the IFS to increase the diversity of materials, including a wide variety of research reactor fuels. Morphology has the potential to provide important information related to processing of nuclear materials, and thus may inform a nuclear forensics investigation. Inclusion of images in the IFS is under development. An overview of the development work to incorporate microscopy images into the IFS will be presented with examples of images of real-world nuclear materials. Strategies on how to retrieve information will be discussed. Important developments being achieved in the project will be highlighted, and future direction of our R&D effort will be provided.

Log 523. CONCENTRATION MEASUREMENTS IN SOLVENT EXTRACTION USING COTS COLOR SENSORS. Cardenas, E. S.(1, P); Greenhalgh, M.(1); Hix, J.(1); Ocampo Giraldo, L.(1); Daw, M.(1). (1) Idaho National Laboratory. (P) Presenting Author.

Solvent extraction separates compounds based on their solubility in two immiscible liquids. Samples taken during the extraction process are traditionally analyzed in a laboratory post-process, with concentration being a key indicator of extraction success. This post-process analysis creates a delay in fully validating the extraction, leading to potential investment losses and delays in inventory accountability. More timely measurements enable process operators to adjust process parameters on-the-fly, saving both time and money. This presentation focuses on using low-cost commercial off-the-shelf color sensors to measure metal concentrations inline. Preliminary research results from laboratory tabletop experiments show promising outcomes when using solutions within the sensor's color sensitivity range. These results indicate the potential of using color sensors for inline extraction monitoring and quick evaluation at key process stages.

Log 524. STABLE RUTHENIUM ISOTOPE RATIOS IN NUCLEAR REACTOR FUEL SAMPLES.

Patton, G.M. (1, P), Torrano, Z.A. (1), Salazar, A. (1), Miller, J. (1), Sanborn, M.E. (1), Hanson, S.K. (1). (1) Nuclear and Radiochemistry Group, Chemistry Division, Los Alamos National Laboratory. (P) Presenting Author.

Ruthenium fission product isotopes have captured increasing attention as potential signatures for nuclear verification and non-proliferation monitoring; they can be volatile and are known to be released in certain types of nuclear accidents. Previous work suggests that ruthenium isotopic signatures could provide information about the nuclear reactor type responsible for a release. Despite the growing theoretical interest in ruthenium, there are few experimental measurements of ruthenium isotopes in nuclear source terms. Here we present ruthenium (Ru), uranium (U), and plutonium (Pu) isotope ratios and concentrations in six samples taken along a single nuclear fuel rod from the BR3 pressurized water reactor (PWR). Ruthenium isotope ratios comprise inputs from nuclear capture reactions and fission and are correlated with the amount of burnup indicated by U and Pu isotope ratios. These results support the idea that ruthenium isotopes could be a powerful tool for understanding the origin of a radioactive release and the operating history of a reactor (LA-UR-24-33242).

Log 525. CHEMICAL SEPARATION AND MEASUREMENT OF PLATINUM ACTIVATION PRODUCTS .

Melinda S. Wren (1,P), Iain May (1), Elena Guardincerri (1), Melissa S. Boswell (1), Staci M. Herman (2), Evan J. Warzecha (2), Morgan M. Haney(2), Nikolaos Fotiades (1), Gregory E. Dale (1), Amanda A. Salazar (1), Alexander B. Weberg (1), Susan K. Hanson (1). (1) Los Alamos National Laboratory, Los Alamos, NM. (2) Pacific Northwest National Laboratory, Richland, WA. (P) Presenting Author.

The rapid detection and analysis of key activation products provide important signatures following a nuclear accident or event. Our laboratory has developed a new radiochemical separation procedure to purify and measure platinum radioisotopes from fission products and environmental matrix. This method outlines a rapid carrier based decontamination scheme using a combination of precipitation and both cation and anion exchange resin purification steps. Several different experiments were performed to evaluate the effectiveness of the procedure. The results of these experiments and their implications for nuclear forensic analysis will be discussed. This work was funded by a LANL DOE grant H7UQ. LA-UR-24-33244.

Log 526. RADIOCHRONOMETRIC DISCORDANCE IN HIGHLY ENRICHED CAST URANIUM METAL. Chen, C.Y. (1, P); Engel, J.R. (2); Gaffney, A.M. (1); Denton, J.S. (2); Kayzar-Boggs, T.M. (2); Rice, N.T. (2); Sharp, M. (1); Wende, A.M. (2). (1) Lawrence Livermore National Laboratory, USA. (2) Los Alamos National Laboratory, USA. (P) Presenting Author.

This study applies 230Th-234U and 231Pa-235U radiochronometry to highly enriched uranium (HEU) metal materials to understand the behavior of uranium progeny isotopes during metal casting in the United States. The materials were sampled from two HEU logs and analyzed by Lawrence Livermore National Laboratory (LLNL) and Los Alamos National Laboratory (LANL). The two logs formed a feedstock-cast pair with known casting dates, offering an opportunity to examine the impact of casting on the 230Th-234U and 231Pa-235U chronometers. The results consistently demonstrated that the 230Th-234U radiochronometer produced younger model ages than the 231Pa-235U radiochronometer, suggesting inefficiencies in the separation of protactinium during uranium processing. Additionally, the 230Th-234U model ages were consistently older than the casting dates. Based on the feedstock-cast relationship of the logs, these findings suggest that 231Pa-235U model ages may retain historical information about prior metallization events. This research enhances our understanding of isotope mobility during casting for U.S. materials, aiding nuclear forensic laboratories in interpreting model age data and assessing the process history of uranium metal samples. Prepared by LLNL under Contract DE-AC52-07NA27344. LLNL-ABS-871762.

Log 527. QUANTIFICATION OF SILICON IN PLUTONIUM METALS - METHOD COMPARISONS AND CHALLENGES. Nolan, J.R.(1,P); Colletti, L.P.(1); Bartlett, J.H.(1); Walker, L.F.(1); Lujan, E.J.W.(1); Tandon, L.(1); Olson, A.C. This is an example. Paul, M.J.(1,2); Byers, M.F.(1); Haas, D.A.(1, P); Biegalski, S.R.(3); De Luna, B.A.(1);Barth, B.S.(1). (1) Los Alamos National Laboratory (P) Presenting Author.

Silicon (Si) is an important element to quantify in plutonium (Pu) because of its potential significant impacts on Pu physical properties such as phase transitions and overall stability. The characterization of Si in Pu is known to have inherent challenges. The Actinide Analytical Chemistry group (C-AAC) at LANL currently utilizes two methods to quantify Si; a method by ICP-OES and a method developed by LANL in 2004 using UV-VIS spectrophotometry. A summary of the differences between the two methodologies will be provided, including method detection limits and uncertainties, as well as comparisons of recent sample results collected for the Pu Metal Standards Exchange Program to those collected from other participating laboratories. Twenty years later, we discuss the challenges C-AAC has experienced to maintain capabilities and detail our investigations of potential instabilities observed during the revival of the UV-VIS spectrophotometry method. LA-UR-24-33240

Log 528. IMPACT OF UNDESIRABLE OXIDE FORMATION ON VISCOSITY AND DENSITY OF CL-BASED MOLTEN SALTS. Sujeong Lee (1,2,P); Taehoon Park (2); Wonseok Yang (3); Richard I. Foster (3); Sungyeol Choi (2). (1) Seoul National University Electric Power Research Institute (SEPRI), Seoul National University (2) Department of Nuclear Engineering, Seoul National University (3) Nuclear Research Institute for Future Technology and Policy, Seoul National University (P) Presenting Author.

During the operation of molten salt reactors (MSRs), undesirable impurities such as fission, activation, and corrosion products continuously affect the composition of fuel salts. Maintaining oxygen concentration within the designed level is challenging, increasing the potential of undesirable oxide formation. These oxides significantly impact the change of viscosity and density of molten salts, which are key parameters for hydraulic analysis and the operation of MSRs. However, their effects on the physical properties of Cl-based molten salts remain insufficiently studied. In this study, the effects of SrO as undesirable oxides on the viscosity and density of the eutectic 50.6NaCl-49.4KCl composition were measured with varying concentrations of SrO at 700-800 ℃ under an argon atmosphere using a rheometer. Strontium, a heat-generating and non-volatile fission product, existed as SrO under elevated oxygen levels in Cl-based MSRs. SrO has a lower Gibbs free energy than Na_2O, K_2O, and UO_2 in the Ellingham diagram, suggesting its potential formation under operating conditions. The results provide critical insights into how undesirable oxides affect the physical properties of molten salts, contributing to improved hydraulic behavior modeling, operational condition optimization, and the development of purification methods and drain tank designs for MSRs. ACKNOWLEDGEMENT This study was supported by the National Research Foundation of Korea (NRF-2022M2D4A1052797) and Korea Hydro & Nuclear Power (RS-2024-00408520) granted by the Ministry of Science and ICT of the Republic of Korea.

Log 529. OXIDE ION SPECIFIC YSZ ELECTRODE FOR DETECTING OXYGEN IN MOLTEN SALT. Felling, F.M.(1, 2, P); Unger, A. (2); Chatterjee, D. (2); Zhang, C. (2); (1) The University of Utah. (2) TerraPower LLC. (P) Presenting Author.

Yttria Stabilized Zirconia (YSZ) exhibits selective oxide ion conductivity. This selective conductivity presents an opportunity for developing a robust and reliable method for oxide ion detection in molten salt systems, using YSZ-based electrodes. This study aimed to develop an oxide sensing electrode for use in open circuit potential (OCP) measurements for passive oxide detection. The OCPs were measured with a Ag/AgCl reference electrode (RE) against a tungsten working electrode control, and a YSZ based W/WO3 oxide sensing electrode (OSE). Results showed good agreement between the measured WE vs. RE potentials and calculated values from JANAF Thermochemical tables and stable OSE vs. RE signal. Once electrode signals are stable, oxide concentration was incrementally increased to correlate concentration and potential data via the Nernst equation.

Log 530. COMPREHENSIVE ELEMENTAL CHARACTERIZATION OF CEMENT REFERENCE MATERIALS USING INTERNAL MONO-STANDARD NAA. Kishore B. Dasari(1,2), Seongpyo Hong(1,3), Boyoung Han(1,3), Jaegi Lee (1,3), Gwang-Min Sun(1,3,P), (1)KAERI-KRISS Joint Research Center for Reference Materials using Research Reactor, KAERI, Republic of Korea, (2) The Research Institute of Natural Science, Gyeongsang National University, Jinju, Republic of Korea, (3) 3HANARO Utilization Division, Korea Atomic Energy Research Institute (KAERI), Daejeon, Republic of Korea. (P) Presenting Author.

Cement is used to construct a bio-shield around the nuclear reactor cores, protecting against radiation. However, during reactor operation, neutron exposure can activate the elements within bio-shield, forming long-lived radionuclides such as Co-60, Cs-137, Eu-152, and Eu-154. To minimize radioactive waste and environmental impact, it's essential to use cement materials with low concentrations of these trace elements. Additionally, the cement industry significantly contributes to air pollution and soil contamination, with cement dust adversely affecting vegetation, human and animal health, and ecosystems. Accurate quantification of trace elements in cement is crucial for environmental monitoring and ensuring the suitability of materials used in sensitive applications like nuclear reactors. Certified reference materials (CRMs) for cement are important for analyzing the elements in cement. While several cement CRMs are available, many are certified only for major elemental compositions, lacking specified values for trace elements. This gap poses challenges for laboratories aiming to achieve precise trace element analysis in cement matrices. In the present study, multiple cement samples of local and seven Portland cements, two calcium aluminate cements, and one silica fume from NIST SRM 634a, 635a, seven 1880 series, and 2896 were analyzed using the k0-based Internal Mono-Standard Instrumental Neutron Activation Analysis (k0-IM-NAA) method. This method was established at the KAERI NAA laboratory using a highly thermalized neutron flux at the HANARO reactor (f > 1000). The high f irradiation position is optimal for IM-NAA because it minimizes epithermal and fast neutron energy nuclear reactions, ensuring accurate trace element measurements. This method is particularly advantageous as it doesn't require external standards, streamlining the analytical process. In addition to trace elements, WD-XRF also applied for major elemental composition. This approach enabled the quantification of both major and trace elements, providing valuable data to support the development of CRMs with certified trace element concentrations.Acknowledgments: This work was supported by the Korea government (MSIT) (1711078081).

Log 531. URANIUM ISOTOPIC RESULTS AFFECTED BY THERMAL IONIZATION MASS SPECTROMETRY METHOD CHANGES. Maassen, J (P)(1); Butterfield N (1); Ottenfeld, C (1); Levesque, S (1); Kuhn, K (1); Tandon, L (1) Olson, A (1); (1) Los Alamos National Laboratory. (P) Presenting Author.

Uranium ingrowth in plutonium occurs at a constant rate from radioactive decay. Uranium concentration and isotopic composition in plutonium samples can be quantified to provide material property information. The Plutonium Metal Standards Exchange Program submits plutonium metals for analysis each year. One of the metals recently submitted for analysis was characterized with a gallium concentration greater than 1 weight percent. The mass spectrometry analysis technique at LANL used for the uranium fraction changed from a single filament, peak-hopping method for the first characterization effort to using total evaporation (TE) by a double or triple filament configuration for the most recent measurement effort. The changes in mass spectrometry techniques and instrumentation including the challenges it offered will be discussed as well as effects on the analytical measurement and data. The approach to address these effects on the data will be presented. Also, the data from these analytes will be compared against peer methods and laboratories. LA-UR-24-33127

Log 532. IMPACT OF PRODUCTION SCALE EXTREMES ON URANIUM ORE CONCENTRATE PARTICLE MORPHOLOGY.

Ditcham, T (1,P), Keegan, E (1), Pont, C (1), Hagen, A (2), Gibb, L (3), Meigs, N (3), Sentz, K (4), Hanson, A (4), Matties, K (4), McDonald IV, LW (3) (1) Australian Nuclear Science and Technology Organisation (2) Pacific Northwest National Laboratory (3) The University of Utah (4) Los Alamos National Laboratory. (P) Presenting Author.

Morphological analysis of uranium ore concentrates (UOCs) has garnered considerable interest within nuclear forensics due to the realization that morphology of UOC particles is influenced by several chemical and environmental factors present during and following their production. One factor that has not been investigated is the impact of production scale extremes on the morphology of laboratory-synthesised samples (gram-scale) versus industrial-scale samples (tonnage-scale) produced at a uranium mine of UOC produced through the same, or similar, production processes. This paper compares quantitative particle morphological data from nine industrial-scale UOC samples produced by three Australian uranium mines through ammonium diuranate (ADU) and uranyl peroxide (UO4) production routes against their laboratory-scale counterparts synthesized at the University of Utah. The quantitative morphological data of the industrial-scale UOCs was generated through scanning electron microscopy (SEM) imaging at ANSTO, with particle segmentation and quantification performed using the Morphological Analysis of Materials (MAMA) software package by researchers at ANSTO, the University of Utah, and Los Alamos National Laboratory. Furthermore, this paper investigates the classification accuracy obtained from these industrial-scale UOCs against a neural network developed by Pacific Northwest National Laboratory using SEM images obtained from five different laboratory-synthesized UOC types (ADU, UO4, ammonium uranyl carbonate, magnesium diuranate and sodium diuranate) produced at the University of Utah. An understanding of the impact of production scale extremes on quantitative particle morphology and laboratory-synthesized sample trained neural networks will advance these approaches as valuable capabilities for nuclear forensics.

Log 533. IMPACT OF SAMPLE PREPARATION METHODOLOGIES ON QUANTITATIVE PARTICLE MORPHOLOGY ANALYSIS.

Ditcham, T (1,P), Keegan, E (1), Holland, J (1), McDonald IV, LW (2) (1) Australian Nuclear Science and Technology Organisation (2) Oregon State University. (P) Presenting Author.

The development of image analysis software to extract quantitative data from scanning electron microscopy (SEM) images has significantly furthered nuclear forensics' understanding of what chemical and environmental factors present during the production of a uranium ore concentrate (UOC) influence a UOC particle's morphology. This body of quantitative particle morphology research has utilised various SEM imaging parameters and sample preparation methods; however, the impact of these varying approaches is unknown. The research presented here aims to investigate several different 'dry' and 'wet' SEM sample preparation methodologies found within the literature to examine whether these approaches bias the quantitative particle morphological data extracted from SEM images. Three different 'dry' sample preparation methods (dusting, needling and reverse dusting) and the influence of three other variables involved in 'wet' sample preparation methodologies (solvent, suspension volume, and stirring method) will be evaluated by preparing two UOCs from two different Australian uranium mines for SEM imaging. SEM images will be collected at four magnifications (10,000x, 25,000x, 50,000x, and 100,000x) and segmented and quantified using the 'Morphological Analysis of Materials' (MAMA) software package. By comparing data collected at each magnification, the impact of magnification on the quantitative particle morphological data can also be investigated. Together, this developed understanding of both the impact of sample preparation and SEM image magnification on quantitative particle morphological analysis will contribute towards a standardised protocol for preparing and imaging UOCs and potentially other relevant powders as part of nuclear forensics research and investigations.

Log 534. GEOCHEMICAL CHARACTERIZATION OF NORTHEAST ASIAN OBSIDIANS USING XRF AND NEUTRON ACTIVATION ANALYSIS. Mi-Eun Jin(1); Gwang-Min Sun(1); Kishore Babu Dasari(2); Yong-Joo Jwa(2); Seongpyo Hong(1); Sung Hyo Lee(1). (1) HANARO Utilization Division, Korea Atomic Energy Research Institute. (2) Department of Geology, Gyeongsang National University. (P) Mi-Eun Jin: (P) Presenting Author.

Obsidian serves as a pivotal role in geological research to understanding volcanic activity and magmatic processes. This study aims to analyzed the geochemical characteristics of obsidians from Northeast Asia (Baekdusan of Korea, Kyushu and Hokkaido of Japan) to understand its formation processes and tectonic settings. In addition, it seeks to provide a robust geochemical database to support archaeological provenance studies and geological research. X-ray fluorescence (XRF) analysis and Neutron Activation Analysis (NAA) were employed as complementary techniques to investigate the petrological characteristics of obsidians. By integrating these methods, the major and trace elements of the obsidians were analyzed, allowing for the identification of petrological characteristics specific to each region. The analysis was conducted using a HANARO research reactor at the Korea Atomic Energy Research Institute, and the accuracy and precision of the analysis were verified using geostandards. The results showed that among the obsidians had significant differences in geochemical composition, which reflecting differences in the composition of the magma, cooling rate, and the tectonic settings. Morever, the geochemical "fingerprinting" of obsidians offers valuable insights into tracing the provenance of archaeological artifacts. The combined analysis method of XRF and NAA for obsidians will be useful for future studies of geological characterization and provenance interpretation

Log 535. CHARACTERIZATION OF OPTICAL DETECTED MAGNETIC RESONANCE OF NITROGEN-VACANCY ENSEMBLES IN DIAMOND. Shoen, L.(1, P); Remy, J.(1); Cao, L.R. (1). (1) The Ohio State University. (P) Presenting Author.

Localized centers of electron-spins in solid, crystalline lattice structures allow for applications in quantum sensing, defect detection, magnetometry, and quantum computing. Optically Detected Magnetic Resonance (ODMR) leverages the spin-dependent photoluminescence of Nitrogen-Vacancy (NV) centers in diamond to detect spin states. Through optical excitation, typically a visible-spectrum laser, the NV center emits fluorescence, of which the intensity is dependent on spin state alignment under a weak external magnetic field. Microwave radiation induces a resonance condition between the sublevels of spin states, allowing for high-resolution measurement of magnetic fields at nanoscale. The customized ODMR system at OSU connects with a home-built confocal microscopy setup. This study explores the use of Silicon Carbide (SiC) in radiation and high temperature sensing found in nuclear fuel cycle and nuclear non-proliferation, leveraging ODMR for the identification and spatial mapping of color centers to determine defect distributions in SiC devices.

Log 536. EVALUATION OF AREAL HALEU FUEL ENRICHMENT VARIATION USING RASTER GAMMA SCANNING. Maier, A. (1,P); Yankevich, T. (1); Herminghuysen, K. (1); Kauffman, A. (1); Kandlakunta, P. (1); Catalan, M. (2); Cao, L.R. (1). (1) The Ohio State University. (2) Pacific Northwest National Laboratory. (P) Presenting Author.

A method to non-destructively evaluate areal uranium enrichment in commercially fabricated HALEU fuel samples using gamma and X-ray spectrometry is being developed at The Ohio State University. The U-10Mo monolithic high-density HALEU fuel being developed for the United States High Performance Reactor conversion program must have an areal enrichment variation no more than +/- 5% within a 0.2" diameter area. The system in development at Ohio State employs gamma-ray and X-ray raster scanning using HPGe and silicon drift detectors to oversample each 0.2" area of interest on a sample fuel plate. Peak evaluation methods like enrichment meter, and software tools including MGAU and FRAM are used to verify areal enrichment variation from acquired gamma and X-ray spectra. Maintaining the areal 235-U enrichment in these fuels to within +/- 5% is critical to prevent the formation of hotspots which may cause these fuels to prematurely age and fail during operation. Non-destructive methods of fuel evaluation will allow for enrichment verification of finished monolithic alloy fuels that will be used in reactors without having to evaluate samples using destructive methods like ICP-MS.

Log 537. LANTHANIDES QUANTIFICATION IN LIQUID LiCl-KCl EUTECTIC USING LASER-INDUCED PLASMA AND ACOUSTIC SIGNALS. Lee Y.(1); Kim H.(2); Park J.(2); Yang W.(3); Choi S.(2,3,4,P). (1) Device Solutions, Samsung Electronics, Republic of Korea. (2) Department of Nuclear Engineering, Seoul National University, Republic of Korea.(3) Nuclear Research Institute for Future Technology and Policy, Seoul National University, Republic of Korea.(4) Institute of Engineering Research, Seoul National University, Republic of Korea. (P) Presenting Author.

In high-temperature molten salts, traditional laser-induced breakdown spectroscopy (LIBS) often relies on analyzing solidified samples or off-gas, avoiding direct liquid-state measurements. Liquid sample analysis using LIBS faces challenges, including high relative standard deviation in spectra, as splashed molten salts solidify and obstruct the optical path. Additionally, fluctuations and vibrations cause changes in molten salt levels. This study demonstrates the successful application of in situ data fusion using laser-induced acoustic (LIA) and LIBS signals to directly measure rare earth elements such as Ce, Eu, Er, and Pr in molten LiCl-KCl salts at 500°C in a glovebox. A gas protective layer was employed for year-long operation to shield optical components from splashing of molten salts at high temperatures. LIA signals, distinguishable from mechanical noise, were simultaneously collected with LIBS spectra using a compact electret condenser sensor. The LIA signals also corrected shot-to-shot variance and lens-to-sample distance. This correction improved the limit of detection (LOD) for Ce from an uncorrected range of 425–513 ppm to an acoustic-corrected range of 360–397 ppm. By integrating acoustic and optical signals through partial least-squares regression, the methodology significantly enhanced predictive accuracy. Compared to LIBS-only data, the fused data reduced root-mean-square errors of prediction (RMSEP) by 18–40%. These results underscore the effectiveness of fusing LIBS and LIA data in improving the accuracy of rare earth element monitoring in molten salts.

Log 538. PROVENANCE ANALYSIS OF KOREAN CELADON AND WHITE PORCELEIN USING NEUTRON ACTIVATION ANALYSIS : IDENTIFYING TRACE ELEMENT INDICATORS AND OPTIMIZING QUANTITATIVE METHODS. Jang, S.E. (1,2,P); Sun G.M. (1); Dasari, K.B. (1); Hong S.P. (1); Lee S.H. (1); Kim G.H.(2). (1) HANARO Utilization Division, Korea Atomic Energy Research Institute. (2) Department of Cultural Heritage Conservation Science, Kongju National University. (P) Presenting Author.

Trace elements in ceramics act as chemical fingerprints in provenance studies, as they remain stable during production. Neutron Activation Analysis (NAA) is advantageous in such studies due to its high accuracy and sensitivity for detecting trace elements. This study aims to: 1. Identify classification characteristics and provenance indicators by analyzing NAA results of celadon and white porcelain excavated from kilns. 2. Establish appropriate quantitative methods and analytical conditions for ceramics by analyzing standards and reviewing prior research. The samples include 178 celadons from kilns in Gangjin, Haenam, Buan, and Gochang, and 50 white porcelains from kilns in Jinhae, Hadong, and Sacheon. Findings indicate that celadons could not be classified by region, likely because secondary clay, their main raw material, results in similar properties across regions. However, they could be classified by specific kiln sites, suggesting that different manufacturing techniques were employed with the same materials. In contrast, white porcelain, made from primary clay, could be clearly classified by region and kiln site. Provenance indicators include chromium and rare earth elements for celadon, and potassium, cobalt, thorium, and rare earth elements for white porcelain. The internal mono-standard method is deemed the most suitable quantitative approach, with recommended analytical conditions involving subdivided cooling and measurement processes, along with extended measurement times.

Log 539. EXPERIMENTAL APPROACH TO DETERMINE NATURALLY OCCURING RADIONUCLIDE FATE IN BIOHEAP LEACH MINING . Vettese, G.F. (1P); Law, G.T.W. (1). (1) Radiochemistry Unit, The University of Helsinki. (P) Presenting Author.

Bioheap leaching is a major mining process in Nordic counties, permitting efficient extraction of metals from lower grade ores. Here, ore excavated from open pit mining is crushed, agglomerated, and then put into bioleaching stacks. The stacks are kept aerated and are constantly irrigated through recirculation of acidic production solutions. Indigenous chemoautotrophic bacteria leach metals from the ore under these conditions. The metals are then recovered from the leachates for further processing. The ores also often contain trace amounts (<20 mg/kg) of natural U, Th, and their progeny. Understanding the environmental behavior and mobility of these radionuclides in the bio-heap leaching process is critical for ensuring the purity of the produced commodities, and for assessing the long-term safety and environmental impact of the mining process. Here, we present a novel laboratory-based methodology that permits small-scale replication of the mining process over long time-periods, together with isolation and quantification of U/Th and their progeny. Our method provides radionuclide leaching data under naturally maintained acidic conditions, microbiology, and mineralogy. Our experiments shed light on key biogeochemical processes influencing NOR fractionation in the mining process, and details the subsequent mobility and partitioning of the radionuclides under site-specific conditions. The data offers valuable insights for environmental monitoring, risk assessment of mining operations, and waste management for technologically enhanced NORM derived from bio-heap leaching.

Log 540. CHEMISTRY OF INDIVIDUAL MICROMETER-SIZED "HOT-PARTICLES": HOW TO CHARACTERIZE ENVIRONMENTAL BEHAVIOUR. Weissenborn, T. (P, 1); Leifermann, L. (1); Hanemann P. (1); Reinhard, S. (1); Schulz, W. (1); van Eerten, D. (1); Walther, C. (1). (1) University of Hanover, Institute of Radioecology and Radioprotection. (P) Presenting Author.

Hot particles (microscopic nuclear fuel fragments) pose a risk through incorporation, and over time, weathering can release radionuclides, which may enter the food chain. Because hot particles vary in morphology, composition and stability [1], they require investigation on a particle-by-particle basis instead of previously used bulk analysis. This is enabled via separation from environmental samples using a SEM equipped with a micro-manipulator [2]. Fixed to a tungsten needle, experiments with individual particles can be conducted. Now isolated, radioactive isotopes are identified via γ-spectrometry, while elemental composition and isotopic ratios are assessed through EDX, SIMS, and RIMS [3] for each particle. These methods are low-invasive and leave particles available for further beamline-based characterization and chemical experiments like sequential leaching based on Kashparov et al. [4] and the UBM protocol [5]. Initial leaching showed that only small amounts of radionuclides were released under mild conditions, indicating lower bioavailability. Early results of leaching experiments with synthetic biofluids indicated no dissolution in the digestive tract. Measurements and experiments combined make it possible to categorize the particles and allow predictions about their environmental behavior. [1] Salbu et al. doi.org/10.1016/j.jenvrad.2017.09.001[2] Leifermann et al. doi.org/10.1039/9781837670758-00001 [3] Bosco et al. doi.org/10.1126/sciadv.abj1175 [4] Kashparov et al. doi.org/10.1016/j.jenvrad.2019.106025 [5] Wragg et al. doi.org/10.1016/j.scitotenv.2011.05.019

Log 541. ICPMS/MS: AN EXCELLENT METHOD FOR LOW-LEVEL ANALYSIS FOR ENVIRONMENTAL MONITORING . Carrier, C. (1, P), Habibi, A. (1), Jaegler, H. (1), Varela, D.D. (1), Baconet, I. (1), Haloche, D. (1), Laconici, C. (1). (1) Nuclear safety and radioprotection authority (ASNR), SAME, LERCA, 781160 Le Vésinet. (P) Presenting Author.

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) is an analytical method based on the separation, identification and quantification of isotopes of a sample according to mass/charge ratio. Since its first commercialization in the 1980s, ICP-MS has been adopted for the simultaneous analysis of trace and ultra-trace elements (< 10-6 g/g) and for accurate isotope ratios determination in biological and environmental samples. Indeed, depending in the expected performances, this technique allows the analysis of 20 to 30 different isotopes in about ten minutes. During the last decade, triple quadrupole ICP-MS devices (ICP-MS/MS), containing a collision reaction cell between two mass filters, has extended the applicability of this technique and improved the performance of instruments including sensitivity, abundance sensitivity, instrumental background and accuracy on isotope ratios. These improvements have made this new technology an essential piece of equipment in the field of radionuclides measurement in environmental samples. This measurement technique became then an alternative to radiametric measurement techniques such as alpha spectrometry and some less accessible mass spectrometry methods such as Accelerator Mass Spectrometer (AMS). The objective of the work carried out during the last decade by ASNR is to develop new analytical methods based on ICP-MS/MS measurement. Thanks to ICP-MS/MS, ASNR can answer questions in the context of quantifying radionuclides (e.g. 129I, 226Ra, 236U, 237Np, 239Pu…) in environmental matrices (e.g. water, air filters, mineral and biological), with excellent performances (e.g. detection limit, precision and turnaround time) both in routine situations and in the context of emergency, control, monitoring, expertise and research programs.

Log 542. ULTRA SENSITIVE MEASUREMENTS OF AIRBOURNE NUCLEAR DEBRIS – PROGRESS.

Britton R.(1,P), Davies A.(1), Hermanspahn N.(1). (1) Preparatory Commission for the CTBTO. (P) Presenting Author.

The Comprehensive Nuclear Test-Ban Treaty (CTBT) International Monitoring System (IMS) is designed to provide a network of 80 Radionuclide detection systems, strategically positioned around the globe to detect particulate radionuclide emissions from nuclear explosions. This paper describes progress on the implementation of ultra-sensitive monitoring systems to the IMS, including the incorporation of gamma coincidence measurements into routine operations, an efficient and automated data collection/processing chain, and analysis methodologies to maximise the value of the data collected. The importance of these advances, which include significantly improved detection limits, reliability and redundancy of the Treaty measurement, and the potential for an improved (shortened) collection/measurement cycle, are also discussed.

Log 543. URANINITE DISSOLUTION POST INHALATION LEADS TO CREATION OF SUB-MICRON NEEDLE-LIKE U-P CRYSTALLITES.

Khng, Y. (1); Psyrillou, A. (1); Sarparanta, M. (1); Utsunomiya, S. (2); Vettese, G.F. (1); Parker, J. (3); Morris, K (4); Law, G.T.W. (1P). (1) Radiochemistry Unit, The University of Helsinki, Finland. (2) Department of Chemistry, Kyushu University, Japan. (3) Diamond Light Source, UK; (4) University of Manchester, UK. (P) Presenting Author.

Uranium contamination poses a significant threat to global health and the environment, originating from mining activities, weapons testing, and nuclear industry discharges. While the toxicity of soluble uranium compounds is well-studied, limited research addresses particulate uranium phases, whose chemical and physical properties may influence their lung retention and toxicity. This is particularly relevant for particles smaller than 5 microns (<PM5), which can penetrate the alveoli and interact with local lung macrophages. Our study focuses on the dissolution, chemical alteration, and toxicity of uraninite in simulated lung fluid (SLF), which mimics interstitial lung fluids. Uraninite particles were exposed to SLF for 180 days, revealing poor solubility under these conditions. Post-reaction characterization using transmission electron microscopy and nano-focused synchrotron spectroscopies showed significant surface disruption of uraninite crystals. A secondary uranyl phosphate phase, featuring sub-micron crystallites with needle-like morphology, had formed on the particle surfaces. The chemistry, size, and shape of this newly formed phase suggest potential impacts on the residence time, toxicity, and translocation behavior of U particles in the lungs that have not yet been properly considered. This highlights the need for further investigation to assess the health risks associated with inhalation of uranium particulates, including assessment of U particle solubility in fluids representative of the body’s immune system responses.

Log 544. MASS TRANSPORT IN ENERGY DEVICES BY NEUTRON IMAGING. Nikolic, M. (1,2); Cesarini, A. (1); Billeter, E. (3); Weyand, F. (1); Kiefer, F. (1); Trtik, P. (4), Strobl, M. (4); Borgschulte, A. (1,2,P); (1) Chemical Energy Carriers and Vehicle Systems Laboratory, Empa, Switzerland. (2) Department of Chemistry, University of Zürich, Switzerland. (3) Department of Physics, DTU - Technical University of Denmark, Denmark. (4) Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institut, Switzerland. (P) Presenting Author.

The technical implementation of fundamental scientific results into a real working device is a challenging long-term journey. Operando neutron imaging allows the visualization of chemical processes inside running devices, such as batteries, and chemical reactors, even on large scale. I will showcase examples where neutron imaging gave scientific insights helping to improve the devices. Power-to-X is a potential technology to bridge the gap between renewable energy production and consumption. A key process is the CO2 methanation reaction taking place in large chemical reactors. Operando neutron imaging is used to map the distribution of hydrogen containing compounds in the reactor, laying the foundation of a rational reactor design. Neutron tomography of Ni-MH batteries visualizes the mobility of hydrogen during charging, i.e., the hydrogen exchange between the electrodes as well as hydrogen generated by side reactions. I will present the underlying concepts and discuss the potential for a future chemical neutron imaging beamline focused on the domain of renewable energy research.

Log 545. AN INNOVATIVE METHOD FOR RADIUM 226 QUANTIFICATION IN ENVIROMENTAL SAMPLES. Azza Habibi (P), Danièle Dias Varela. Nuclear safety and radioprotection autority (ASNR). (P) Presenting Author.

At the nuclear safety and radioprotection authority (ASNR), the analysis of radium 226, alpha and gamma emitter, at the lowest levels is necessary as part of the environmental monitoring, to better understand its biogeochemical dynamics or to study its transfer mechanisms. Radium 226 can be quantified by direct gamma spectrometry or by the emanometry method via the measurement of its descendant, radon 222. Although these methods have many advantages, practicality and performances they achieve in terms of detection limit and accuracy are not always sufficient. The proposed alternative is a more efficient method and unique for all environmental matrices (e.g., liquid and solid). This new method is based on the alkaline fusion dissolution of solid samples, the extraction of radium using the EMPORE™ radium RAD disks followed by ICP-MS measurement. The use of this selective extraction method improves the existing procedures due to the decrease of the turnaround time, a more efficient elimination of polyatomic interferences and an improved detection limit. Moreover, this new method proposes a quantification of radium 226 by the isotopic dilution technic using radium 228, purified from a natural thorium standard, as a tracer. Performances with the proposed method are characterized by an optimized turnaround time (< 0.5 day), excellent yields (> 80%) and low detection limits for water and solid samples (e.g., 0.01 Bq.L-1 and 2.8 Bq.kg-1). Furthermore, radium 226 quantified activities are consistent with reference activities in different kind of environmental samples.

Log 546. OPTIMIZATION OF POLONIUM SPONTANEOUS DEPOSITION.

Herman, S. (1, P), Cunningham, L. (1), Allen, C. (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Polonium has both anthropogenic and naturally occurring radioisotopes. Therefore, the quantification of Po is important in human health, consequence management, and nuclear forensics areas. Quantification of Po is best achieved via alpha spectroscopy. To prepare samples for alpha spectroscopy, Po can be spontaneously deposited onto an Ag disc for counting. However, the efficiency of the deposition can be dictated by multiple factors including, solution volume, pH, temperature, and substrate cleaning. This works aims to determine the optimum conditions for Po spontaneous deposition on an Ag disk and how the recovery of Po deposition compares to contemporary microprecipitation techniques.

Log 547. SEPARATIO OF SELECT ACTINIDES, FISSION, AND ACTIVATION PRODUCTS FROM A SINGLE SAMPLE WITH A MULTI EXTRACTION CHROMATOGRAPHY COLUMN.

Herman, S. (1, P); Arnold, E. (1); Lawler, B. (1); Beck, C. (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Important analytes for nuclear forensics evaluations fall into the general classes of actinides, fission products, and activation products. Each class provides a piece to the forensics puzzle, making it advantageous to gain as much information as possible from a single sample to gain a complete view of the forensics puzzle. However, due to incompatible chemistry between these analytes, multiple separations and schemes are required. This works aims to separate key actinides (Am, Cm, Np, Pu, and U), fission (Cd, lanthanides, Mo, and Zn), and activation products (Au, Fe, Ga, Pd, Pt, Ta, and W) from a single sample using a single column with multiple extraction resins. The resins investigated for this separation and stacked in series are SR, UTEVA, TEVA, TRU, and DGA.

Log 548. INDIRECT DETERMINATION OF NEUTRON-CAPTURE CROSS-SECTIONS FOR REACTOR PHYSICS.

Lyons, S.M.(1,P), Bleuel, D.L.(2), Liddick, S.N.(3,4), Richard, A.L.(5), Spyrou, A.(3,4), Sweet, A.(2), Wiedeking, M.(6). (1) Pacific Northwest National Laboratory. (2) Lawrence Livermore National Laboratory (3) Facility for Rare Isotope Beams. (4) Michigan State University, (5) Ohio University. (6) Lawrence Berkeley National Laboratory. (P) Presenting Author.

The highest priority nuclear data discrepancy for the nuclear reactor community is to resolve the neutron-capture cross-section discrepancy for the unstable fission fragment and reactor poison, Xe-135, for neutron energies greater than 1 keV. Current nuclear data evaluations (ENDF, JEFF, JENDL, etc.) contain up to 2 orders of magnitude variation in the reaction cross section, with a discontinuity at 19 keV. The uncertainty and discontinuity are known to produce inconsistent predictions in neutronics codes, particularly in attempts to model the next generation of reactors which operate in higher energy regimes than traditional thermal reactors. Furthermore, reactions on a long-lived isomer of Xe-135m are almost ignored in evaluations and absent from experimental measurements. Using the indirect neutron-capture measurement method, the beta-Oslo technique, we will constrain this cross section. The planned measurement will take place at the nuCARIBU facility at Argonne National Laboratory using Te-136 and I-136 beams to isolate high and low-spin contributions to the cross-section to 1) provide experimentally validated constraints to the Xe-135 cross section, and 2) inform the spin-selectivity limitations of the beta-Oslo method and validity of the Brink-Axel hypothesis.

Log 549. UTILIZING MULTIPLE NEUTRON DOSIMETERS AS NUCLEAR FORENSIC SIGNATURES IN URANIUM ORE CONCENTRATES.

Brennecka, G.A. (1, P); Shollenberger, Q.R. (1); Render, J.H. (1); Herbst, A.K. (1, 2) (1) Lawrence Livermore National Laboratory. (2) Arizona State University. (P) Presenting Author.

The existence of early nuclear fuel cycle material, such as uranium ore concentrates, outside regulatory control is a concern for law enforcement worldwide. Consequently, novel nuclear forensic signatures are needed to confidently determine the provenance of nuclear materials. Here we investigate isotopic signatures created by the capture of thermal neutrons in uranium-rich ore bodies through the examination of uranium ore concentrates. Prior work has shown neutron capture can be quantified in some uranium-rich ore bodies by measuring the transmutation of Sm-149 into Sm-150. However, having multiple monitors for neutron capture is highly desired and other neutron dosimeters include the gadolinium isotopic system (specifically, transmutation of Gd-157 to Gd-158) and the uranium isotopic system (specifically, the capture of a neutron by U-235 to produce U-236). Here, we report an improved chemical separation technique and mass spectrometry method to utilize the gadolinium isotopic system to quantify neutron capture in uranium ore concentrates previously investigated for their Sm isotopic compositions. We demonstrate that the capture of thermal neutrons can also be recognized by the isotopic pair of Gd-157 and Gd-158 and that the Sm and Gd neutron capture effects are correlated. Future work will include measurement of Gd isotopics and U-236 in the same samples, providing multiple neutron capture proxies for early fuel cycle materials.

Log 550. EVIDENCE FOR BIOACCUMULATION OF PLUTONIUM AND NEPTUNIUM RADIONUCLIDES IN TURTLES, TORTOISES, AND SEA TURTLES FROM NUCLEAR TEST SITES.

Brown, A.N.(1,2,P); Price, A.A.(1); Inglis, J.D.(1); Fisher, W.S.(1); Conrad, C.(3). (1) Nuclear and Radiochemistry (C-NR) – Los Alamos National Laboratory. (2) University of South Carolina-School of Earth, Ocean and Environment. (3) Pacific Northwest National Laboratory. (P) Presenting Author.

The bioaccumulation of actinides (e.g., uranium (U), plutonium (Pu), and neptunium (Np)) derived from natural or anthropogenic sources have been documented within certain animal or plant species (Conrad et al., 2023). Species from the Chelonia and Gopherus taxonomic genera (sea turtles, turtles, and tortoises) living near nuclear test sites were subjected to resulting radionuclides, potentially enabling bioaccumulation of actinides within shell scute keratin from the local environment. Our previous work has assessed the bioaccumulation of anthropogenic uranium within scute keratin at several nuclear test sites in the United States and Pacific Islands (Conrad et al., 2023). Here we investigated whether the genus living in areas with legacy contamination have accumulated measurable amounts of Pu and Np. Bulk analyzes of Pu were completed for chelonians from the Trinity Test Site, Pacific islands, and southwestern Utah. However, only samples originating from the Trinity Test Site and southwestern Utah had quantifiable 239Pu and 240Pu concentrations. The total Pu concentrations obtained from Trinity and southwestern Utah samples are not correlated to the amount of scute digested for analysis. Additional scutes from southwestern Utah sample were separated into growth rings to assess shifts in Pu and Np concentration and composition through time. The innermost ring of one scute, containing neonatal scute, has lower concentrations of Pu and Np relative to the subsequent rings, with the outermost ring displaying the highest concentration of Pu and Np. Future work includes analyzing scute material from a control location for Pu and Np.

Log 551. EXPERIMENTAL CHARACTERIZATION OF AN IN-CORE FAST NEUTRON IRRADIATION FACILITY AT A TRIGA REACTOR. Castro, S.T.(1, P); De Luna, B.A.(2); Lapka, J.L.(1); Haas, D.A.(1). (1) The Unviersity of Texas at Austin. (2) Sandia NationalLaboratories. (P) Presenting Author.

A novel in-core fast neutron irradiation facility was designed and tested for pneumatic transfer capability, installed in a TRIGA Mark II research reactor, and experimentally characterized for safety and research purposes. Engineering challenges to sample transfer sensing and repeatability are addressed and iterated for improved consistency. Experimental evaluation of the facility is conducted to verify modeling conclusions that the facility is both compatible with operation at full reactor power (nominally 900 kW) and capable of approximating a Watt fission neutron energy spectrum with a total flux of 4.01x1012 n/cm2s. The facility will ultimately be used for cyclic irradiation and gamma-gamma coincidence measurement of nuclear fuel samples. Data collected will be used to reduce uncertainties for short-lived fission and activation product yields for nuclear forensics and reactor applications.

Log 552. COMPARISON OF CATION EXCHANGE RESINS FOR CONCENTRATION OF Pu USING Sm AS A SURROGATE. Rocco, N.D. (1, P); Beck, C.L. (1); Heathman, C.R. (1); Corbey, J.F. (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Ion exchange purification methods are used in a variety of scientific and industrial applications. In hydrometallurgy, ion exchange materials serve industrial needs to sequester target analytes from process streams and achieve necessary conditions for downstream processes. For concentrating analytes, ion exchange is often chosen due to its low-cost operation relative to historical processes such as evaporation, distillation/condensation, or precipitation. In irradiated nuclear fuel reprocessing environments, ion exchange techniques are often used to purify or concentrate dilute process streams to facilitate waste minimization and process economics. This work aims at evaluating commercially available cation exchange materials to elicit physiochemical differences and their implications to ion exchange processes post solvent extraction. Historically, DOWEX 50W X12 50-100 mesh was used at Savannah River Site to concentrate dilute Pu product from PUREX, but this mesh size cation exchange resin with 12% cross-linking is no longer commercially available. The purpose of this study is to survey and identify modern, competitive cation exchange resins with comparable function. Here, three, presumably chemically equivalent, cation exchange resins from different manufacturers (Dowex 50W X8 50-100 (H), Amberchrom 50W X8 50-100 (H), and AG 50W X8 50-100 (H)) were compared for their capacity, kinetics, and concentration factors, using Sm as a surrogate for Pu. While the capacity and kinetics were indistinguishable between the three resins, Amberchrom had a slightly more effective elution profile and concentration factor. Details of this study and future plans with Pu for comparison with historic DOWEX 50W X12 will be presented.

Log 553. CHANGES IN RISK PERCPTION THROUGH HANDS-ON EXPERIMENTS IN SCHOOLS..

Schulz, W.(1,P); Schmidt-Mueller, N.(1); Seidl, R.(1); Walther, C.(1); (1) Leibniz University Hannover (P) Presenting Author.

The risk perception of an individual regarding radioactivity, develops - likewise to other risks - throughout his or her life and is based on personal experiences. While most individuals are practically not confronted with issues of radioactivity in their daily lives (or seem not to be), the topic often plays a prominent and largely very negative role in the media, contributing to a heightened risk perception of radioactivity within society. Using a pre-post design questionnaire, we surveyed 227 high school students from Germany to assess their personal risk perception before and after independently conducting a series of radioactivity measurements. The samples measured by the students ranged from objects from everyday life to environmental samples. While some of the samples contained expectable levels of radioactivity, others were surprisingly low (e.g. sand from the Bravo crater) or surprisingly high (e.g. TENORM) in radioactivity. Based on the analysis of the surveys we could demonstrate a significant decrease in the risk perception of our experimental group before and after conducting their measurements. By independently verifying (and falsifying) their preconceptions about radioactivity in everyday and environmental samples, the students gained confidence in the handling of natural levels of radioactivity, leading to a reevaluation of the perceived risk. The results stress the importance of education and hands-on training in radioactivity on the high school level for the overall understanding and perception of radioactivity in society.

Log 554. ANALYZING XENON ISOTOPIC VARIABILITY DURING OPERATIONAL TRANSITIONS AT ANSTO's NUCLEAR MEDICINE FACILITY.

Friese, J.I.(1,P); Gedz, A.(2); Corry, M.(2); Metz, L.A.(1), Doll, C.(1); Bowyer, T.W.(1). (1) Pacific Northwest National Laboratory. (2) Australian Nuclear Science and Technology Organisation. (P) Presenting Author

We present an analysis of xenon isotopics during the operational shutdown and startup periods at the Australian Nuclear Science and Technology Organisation (ANSTO) facility, a leading global supplier of the medical isotope Molybdenum-99 (99Mo) through its ANSTO Nuclear Medicine (ANM) division. ANSTO has been actively participating in the Source Term Analysis of Xenon (STAX) project since 2018, which involves continuous measurement of xenon concentrations and isotopics every 15 minutes. During the scheduled maintenance period from March to October, when the OPAL reactor and subsequently the ANM facility were offline, the STAX detector system documented the decay of xenon isotopes within ANM. Upon resumption of operations, further data captured the isotopic shifts observed during the startup phase. Notably, these observations revealed distinct xenon isotopic ratios during both the shutdown and startup phases compared to steady-state operations. This presentation will delve into the detailed data and insights gathered, shedding light on the isotopic behavior of xenon under varying operational conditions.

Log 555. MODELING FLUORINATED SPENT NUCLEAR FUEL IN A MOLTEN SALT REACTOR.

Gladden, Bradley J.(1,P); Haas, Derek A.(1); (1) The University of Texas at Austin. (P) Presenting Author.

This research explores the potential for reusing spent nuclear fuel in a molten salt reactor without the need for reprocessing. Fluoride fuel salt compositions are developed from BWR and PWR spent nuclear fuel. These compositions reflect the results of a fluorination experiment that avoids actinide separation and has a lower proliferation risk. The resulting fuel salt is modeled in SCALE to determine the effects of spent nuclear fuel on reactivity in a molten salt reactor and the necessary removal or addition of certain nuclides to maintain criticality.

Log 556. VALIDATION OF AEOLUS LARGE EDDY SIMULATION MODEL USING REACT22 FIELD DATA.

Gowardhan, A.A. (1,P); Stave, S.C. (1) Lawrence Livermore National Laboratory. (2) Pacific Northwest NationalLaboratories. (3). (P) Presenting Author.

The Aeolus large eddy simulation (LES) was conducted using a uniform grid configuration, specifically designed to capture the intricate atmospheric dynamics in the vicinity of the P-tunnel apron region. A high-resolution grid was essential for accurately modeling the turbulent flow and dispersion patterns associated with the REACT 22 experiments, which aimed to investigate the atmospheric transport of contaminants released during the tests. Initial conditions for the simulation were based on real-time data from meteorological tower MT03, located 10 meters above ground near the release site, with a wind speed of 6.3 m/s and a direction of 6 degrees. However, the model's performance was initially suboptimal compared to actual test data. To improve accuracy, we reviewed data from various monitoring towers and identified tower MT01, situated on a mesa top and less influenced by surrounding terrain, as a better initialization point. This location provided more representative atmospheric conditions, free from localized effects like turbulence and wind shadowing. After incorporating data from MT01 into the simulation, we observed significant improvements in accuracy, aligning results more closely with REACT 22 observations. This underscores the importance of selecting appropriate meteorological data sources for model initialization, as the quality of inflow conditions greatly affects simulation reliability. Future studies should focus on identifying suitable meteorological locations to enhance the accuracy of atmospheric transport models.

Log 557. DEVELOPMENT OF THE HARDWARE IMPROVEMENT AND SIGNAL PROCESSING TECHNOLOGY FOR LIQUID SCINTILLATOR COUNTER.

Jang, M.(1, P); Kim, H. C.(1); Lim, J.M.(1) (1) Environmental Radioactivity Assessment Team, Nuclear Emergency & Environmental Protection Division, Korea Atomic Energy Research Institute, Daejeon, Republic of Korea. (P) Presenting Author.

Variety model of Liquid Scitintillator Counter system are provided for alpha/beta analysis. Among these, Quantulus 1220 made by PerkinElmer's is a famous Liquid Scintillator Counter for low-level radioactivity analysis and has high shielding performance. In Korea, many Quantulus 1220 units are already in operation, and KAERI also operates four units. However, with the release of the GCT 6220 model, Quantulus 1220 was discontinued, making maintenance difficult. Accoridingly, hardware improvement and signal processing technology were developed for continuous use of KAERI's unit. For hardware, we improved the sample transport device(X, Y, Z axis), cooling device, ionization device for static electricity removal, external souce supply device to evaluate the degree of extinction, hardwere control unit and power supply device. For signal processing, we improved the electronic board. The electronic board of the existing equipment consisted of complex circuit. However, with the advancement of technology, the improvement of the circuits integration and the digitalization of logic led to the new signal processing unit including function in 5~6 sheets of electronic board. The develped technology will be applied to Qunatulus1220 through an optimization stage, and is expected to enable continuous use while utilizing the shielding abillty of existing equipemnt.

Log 558. FEASIBILITY STUDY OF SCINTILLATOR-BASED DETECTION SYSTEM FOR Ni-59 MEASUREMENT. Seo, J.H.(1); Jang, M.(1, P); Kim, Y.H.(1); Lee, M.S.(1); Lim, J.M.(1). (1) Environmental Radioactivity Assessment Team, Nuclear Emergency & Environmental Protection Division, Korea Atomic Energy Research Institute, Daejeon, Republic of Korea. (P) Presenting Author.

The accurate measurement of Ni-59 in radioactive waste is essential due to its long half-life and its classification as a regulated radionuclide for radioactive waste disposal in certain regions. Ni-59 primarily emits 5.8–7.7 keV electrons and 6.9–7.7 keV X-rays. However, when nickel is chemically separated, Ni-63 emits higher-energy beta particles and is over 100 times more abundant than Ni-59, making beta counting with Liquid Scintillation Counters ineffective. As a result, gamma-ray spectroscopy becomes necessary for Ni-59 quantification. Low-Energy Germanium (LEGe) detectors, a type of high-purity germanium detector optimized for low-energy gamma detection, are typically used. However, their high cost and the need for cooling-related maintenance make them less practical for radioactive waste analysis. To address these challenges, we developed a scintillator-based detection system for Ni-59 measurement. The system consists of a YAP:Ce scintillator, photomultiplier tube, high-voltage power supply, multichannel analyzer, and amplifier, surrounded by a lead shield to reduce background radiation. To evaluate system performance, 2.2 ml liquid Ni-59 samples with activities of 25, 50, 100, and 200 Bq were measured. The system achieved a detection efficiency of 5%, which is higher than the 2% efficiency of LEGe detectors. The proposed system offers higher efficiency, reduced operational costs, and simplified maintenance compared to LEGe systems. With further development, it could enable practical and cost-effective analysis of large volumes of Ni-59 in radioactive waste.

Log 559. EVALUATION OF RADIOCARBON IN AIR AND GROUNDWATER ON-SITE AT A RADIOACTIVE WASTE DISPOSAL FACILITY. Ji, S.J.(1, P), Min,H.Y(1), Park,E.S(1), Beak,B.S(2);(1) Korea Radioactive Waste Agency,(2)Soosan Industries CO,.Ltd. (P) Presenting Author.

Radiocarbon (14C) is naturally produced by cosmic rays and is artificially generated in nuclear power plants (NPPs). The 14C concentrations were monitored at the Wolsong Low- and Intermediate-Level Radioactive Waste Disposal Center (WLDC), located at the northwest of the Wolsong and Shin-Wolsong NPPs, to assess its environmental impacts. This study evaluated 14C concentrations in air and groundwater over five years, along with precipitation and wind data. Air 14C levels showed seasonal variation, peaking in June (0.721±0.020 Bq/g-carbon) and July (0.693±0.018 Bq/g-carbon) and declining from August. The highest levels of 14C resulted from the Wolsong and Shin-Wolsong NPPs. Its lowest concentrations were observed in winter (0.273±0.014–0.322±0.013 Bq/g-carbon). The decrease seems to be caused by increased precipitation from July to September and the change of wind direction from the WLDC to the NPPs. In contrast, the 14C concentrations in groundwater remained stable (approximately 0.249±0.01 Bq/g-carbon), unaffected by external factors, indicating the buffer effects of aquifer. In conclusion, this study recognizes that 14C concentrations in air at the WLDC were influenced by seasonal wind and precipitation patterns.

Log 560. DESIGNING AN INTEGRAL Cl-35(n,p) CROSS SECTION MEASUREMENT. Mathis, K.D. (1, P); Castro S. (1), Lapka, J.L. (1), Haas, D.A. (1). (1) The University of Texas at Austin. (P) Presenting Author.

The growing interest in molten salt reactors drives improved cross section measurements and their associated uncertainties. One common element of molten salt is chlorine, which is composed of 35Cl and 37Cl. The fast neutron cross section for the 35Cl(n,p)35S reaction has a large uncertainty that subsequently drives up the uncertainty in reactivity calculations for the Molten Chloride Research Experiment (MCRE) and other fast reactors using a chloride-based salt. Recent efforts by the Los Alamos Neutron Science Center (LANSCE) have attempted to characterize this cross section, but there is still a need to measure the integral cross section for a fast neutron spectrum. An experiment was designed at The University of Texas at Austin to measure the integral fast neutron cross section. The cross-section measurement requires a fast neutron, high-flux facility, a method to count the beta particles from the 35S decay, and a sample that does not contain strong neutron absorbers. An in-core fast 3-element (f3EL) facility was recently installed at UT and can be used to irradiate the 35Cl. The 35S will be dissolved into a liquid scintillation cocktail and counted to measure the activity. The experiment was modeled using Monte Carlo N-Particle Code and SCALE to determine the activation rates of various samples at various power levels and times. Modeling results and experiment plans will be presented.

Log 561. QUANTIFICATION OF Cu-64 IN NUCLEAR DEBRIS SAMPLES. Wren, M.S. (1), Weberg, A.B. (1), Salazar, A.A. (1, P), Klosterman, M.R. (1), Eaton, S.J. (1), Goehring, T.L. (1), Herman, S.M. (2), Pierson, B.D. (2), Warzecha, E.J. (2), Dale, G.E. (3), Fotiadis, N. (3), May, I. (1), Hanson, S.K. (1). (1) Nuclear and Radiochemistry (C-NR), Los Alamos National Laboratory, Los Alamos, NM. (2) Pacific Northwest National Laboratory, Richland, WA. (3) Accelerator Operations and Technology (AOT-DO), Los Alamos National Laboratory, Los Alamos, NM. (P) Presenting Author.

Copper 64 is an activation product that could be produced in a nuclear accident, reactor or nuclear detonation. The quantification of this radioisotope can provide important information in the field of post-detonation nuclear forensics. However, 64Cu can be very challenging to measure due to its short half-life (12.701 h), the weak gamma emissions associated with decay, and the presence of interfering fission product isotopes in a sample. Multiple tests have been conducted with mixed fission products and different environmental matrices to develop a validated method for separation and quantification of 64Cu that has overcome these challenges. The method enables quantification by beta decay counting, which improves the detection limit of 64Cu by more than two orders of magnitude as compared to gamma-ray spectrometry. The development and evolution of this method will be discussed. The work was funded by the Office of Defense Nuclear Nonproliferation Research and Development within the U.S. Department of Energy’s National Nuclear Security Administration. LA-UR-24-33195

Log 562. US-JAPAN NUCLEAR FORENSICS ANALYSIS TO IDENTIFY THE ORIGINS AND PROCESS HISTORY OF UOCS.

Shollenberger, Q.R(1,P); Kimura, Y.(2); Inglis, J.(3); Lindvall, R.(1); Nishiwaki, H. (2); Yamanaka, R. (2); Umino, Y. (2); Hosoi, M. (2); Marks, N (1); Kips, R. (1); Yamaguchi, T. (2); Sanborn, M. (3); Steiner, R. (3). (1) Lawrence Livermore National Laboratory. (2) Japan Atomic Energy Agency. (3) Los Alamos National Laboratory. (P) Presenting Author.

Uranium ore concentrate (UOC) is a precursor material for nuclear fuel and is formed when uranium ore has been mined and milled (chemically processed). UOC is a commercially and internationally traded product, and several cases have been reported where UOC was found outside regulatory control or interdicted as part of a law enforcement investigation. Consequently, we need to advance our understanding of nuclear forensic signatures to identify the origins and process history of UOCs. However, the interpretation of these nuclear forensic signatures can be difficult due to various types of uranium mining techniques, as well as the processing of U ores to UOCs. Therefore, multiple nuclear forensics signatures are necessary to determine material origin with high confidence. Through the United States' Department of Energy (DOE)'s National Nuclear Security Administration (NNSA)'s Office of Nuclear Smuggling Detection and Deterrence, we present the analysis of seven UOCs provided by the Japan Atomic Energy Agency (JAEA). This study will focus on the signatures of uranium concentration, trace elements, and U and Sr isotopic compositions. We will discuss the results from the different laboratories and evaluate the importance of these signatures in the context of nuclear forensics. LLNL-ABS-2001377. A subsidy from the Japanese government, MEXT (Ministry of Education, Culture, Sports, Science, and Technology), supports the activity of the Japan Atomic Energy Agency (JAEA) for the "promotion of strengthening nuclear security or the like."

Log 563. A COMPARATIVE NEURAL NETWORK BENCHMARK STUDY ON REVERSE QUANTIFYING ZIRCONIUM CONCENTRATION AND WEIGHT PERCENT IN A LiCl-KCl MOLTEN SALT.

Smith, J.T. (1,P); Phongikaroon, S. (1); (1) Virginia Commonwealth University. (P) Presenting Author.

Three neural network models–a feed-forward neural network (FFNN), a gated recurrent unit network (GRU-NN), and a long short-term memory network (LSTM-NN)–were evaluated for their effectiveness in analyzing cyclic voltammetry measurements of zirconium in LiCl-KCl molten salt. The analysis focused on concentration measurements, with data filtered to include current values below -0.001 A and potential values between 0 and -2.6 V, corresponding to the anodic current. The filtered dataset comprised four features and one target, containing 37,287 unique data points per feature. For testing, a separate hold-out set of 8,863 data points was used, covering scan rates from 200 mV/s to 500 mV/s in 50 mV/s increments. The test sample's concentration was determined using the Randles-Sevcik equation and peak currents corresponding to each scan rate. Each model underwent training and validation using progressively smaller datasets, starting at 100% of available data and decreasing to 10% in 10% increments. The performance evaluation showed the FFNN achieved the lowest root mean squared error (RMSE), with the LSTM-NN following closely behind. In contrast, the GRU-NN demonstrated notably weaker performance. Regarding computational efficiency, the LSTM-NN proved to be the fastest in training, validation, and testing phases, while the FFNN ranked second in speed. The GRU-NN required significantly more training time. Based on these findings, both the FFNN and LSTM-NN emerge as viable options for reverse concentration quantification in novel electrochemical systems.

Log 564. FROM RESEARCH TO PRODUCTION: SCALING UP ISOTOPE ACTIVITIES AND LESSONS LEARNED. Tipping, T.N.(1,P); Nolting, D.D.(1); Lapka, J.L.(1); Haas, D.A.(1). (1) The Unviersity of Texas at Austin. (P) Presenting Author.

The production and radiological considerations associated with research quantities of radioactive materials are typically well-characterized. However, as research progresses and demonstrates success, there is often a need for larger quantities to evaluate scalability to full production levels. This paper outlines the lessons learned as our facility transitioned from producing and utilizing research quantities of radioactive materials to managing full production quantities.

Log 565. COMPARING MC-ICP-MS AND ALPHA SPECTROMETRY 234U-230Th RADIOCHRONOMETRY UNCERTAINTY BUDGETS. Wende, A.M. (1,P); Macsik, Z. (1); Flanagan, D.C. (1); Lamont, S.P. (1); Steiner, R.E. (1). (1) Los Alamos National Laboratory. (P) Presenting Author.

Radiochronometry is an important tool in nuclear forensics investigations as model ages can be used to constrain when a material was produced or last purified. For uranium materials, 234U-230Th is a commonly used chronometer. In this work, we compare 234U-230Th model ages of certified reference material (CRM) 125-A measured by multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS) and alpha spectrometry. In particular, alpha spectrometry methods were modified for radiochronometry to broadly include a radiochemical separation procedure for U and Th, calibration of the 232U tracer, and optimized alpha spectrometry measurement parameters. Replicate (n=3) results from both measurement techniques produce 234U-230Th model dates that agree within uncertainty of the CRM 125-A certificate value (August 18, 1994 +/- 116 days). Model dates measured by MC-ICP-MS range from March 13 to June 5, 1994 with expanded uncertainties of 53 to 57 days. The largest sources of MC-ICP-MS uncertainty are contributed from measurement of the 234U/238U ratio (85%), followed by the 229Th tracer concentration (7.6%), and the 234U decay constant (4.4%). Alpha spectrometry model dates range from September 16 to November 24, 1994 with expanded uncertainties of 146 to 147 days. Here, the uncertainty is dominated by calibration of the 232U tracer (79%) with lesser contributions from counting statistics on 229Th (6.0%) and 230Th (5.7%). While less precise than MC-ICP-MS, alpha spectrometry is more widely available and able to determine model ages with meaningful resolution. LA-UR-24-33002.

Log 566. CHARACTERIZATION OF REACTOR GRAPHITE COMPONENTS FOR NUCLEAR WASTE REPOSITORY CONSIDERATIONS. Boya, D.(1, P); Wickham, A.(2); Steinmetz, H.-J. (3); Langegger, E. (1,4); Steinhauser, G. (1). (1) TU Wien. (2) retired. (3) FH Aachen. (4) DMT. (P) Presenting Author.

Graphite is often used in nuclear reactor components, e.g the neutron reflector. Its key advantages are high moderation efficiency, low neutron absorption, and commercial availability. During its lifetime, irradiation with neutrons causes carbon atoms of the graphite to be displaced in the crystalline structure, which causes the creation of crystallographic defects that store potential energy, also called Wigner energy. The sudden release of this energy as heat poses a safety risk, which becomes especially relevant in the course of decomissioning nuclear reactors and the disposal of reactor graphite components. Characterization of neutron irradiated reactor graphite is key for improving the long-term disposal concept of nuclear waste. For this, samples of graphite from the research reactor FRJ-2 are examined. Production of a reference material of reactor graphite and differential scanning calorimetry for derivation of the rate of energy released per unit of temperature is used for the quantification of the Wigner energy stored in the reactor graphite. Additionally, thermogravimetrical examinations of the reactor graphite are conducted to determine the release of material and its activity upon heating.

Log 567. PLUTONIUM PROCESSING SIGNATURE RESEARCH AND DEVELOPMENT FOR NUCLEAR FORENSICS APPLICATIONS. Clark, R.A. (1, P); Hagen, A.R.(1); Heller, R.D. (1); Lumetta, G.J.(2); Meier, D.E.(1); Muller, S.E.(1); Nizinski, C.A.(1); Sweet, L.E.(1); Tingey, J.M.(1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Understanding nuclear material processing and the fundamental chemistry that underlies it is essential across the nuclear security missions. While it is well known that different flowsheets for processing of plutonium results in differences in the material properties, it is not well understood how flowsheet variations result in those property variations. Pacific Northwest National Laboratory (PNNL) has established flexible plutonium processing capabilities which have been used to perform nuclear forensics research and development from dissolution to metal production. The capability can follow and monitor a variety of flowsheets, steps along the process, and alter parameters within the steps. A large effort has been focused on the signature rich step of nitrate to oxide conversion which has followed several precipitation methods such as the Pu(III) oxalate, Pu(IV) oxalate, and peroxide precipitations. Different parameters have been changed within these flowsheets including the precipitation temperature, reagent concentrations, reagent addition direction, agitation speed, digestion time, and calcination temperatures. A comprehensive suite of analytical capabilities is used to characterize the variations in the final oxide product. Various modeling techniques have been applied to understand the correlation between the physical properties (including morphologies) and the various processes for potential nuclear forensics applications. In addition, physics-based models are being developed to fundamentally understand the effect of processing parameters on PuO2 morphology. An update on the work conducted and modelling status will be presented.

Log 568. ENVIRONMENTAL RADIOCHEMISTRY AT AWE, OUR CURRENT DISSOLUTION PROCESS, CHALLENGES AND FUTURE DEVELOPMENTS. Hackett, R.W (1, P). (1) AWE Nuclear Security Technologies.

Environmental Monitoring and Bulk Waste Analysis at AWE requires a total result for specific actinides in various solid matrices. The radiochemistry involved in the dissolution of solid samples, separation chemistry and alpha or beta spectrometry for these nuclides provides unique challenges. For solids the lab currently employs a traditional hydrofluoric acid based leaching technique, which is only reliable in removing surface contamination, and thus has limited success in the dissolution of matrices with a high concentration of NORM and / or interfering salts. Results received from proficiency testing exercises also indicate the fact that acid leaching techniques are unsuitable for certain types of uranium contamination, therefore a stronger dissolution process is required for a more accurate analysis. AWE is exploring more efficient, reliable and greener methodologies, with a focus on automated fusion and associated work up. The introduction of these technologies over acid leaching or microwave digestion add their own challenges to sample dissolution and the subsequent separation chemistry. The aim is to tune the variables of temperature, flux material and removal of interferences for an optimised and concise method for multiple key sample types within the lab, including air particulate, soil, sediment and contaminated building material samples. UK Ministry of Defence © Crown Owned Copyright 2024/AWE

Log 569. ENVIRONMENTAL AND RELEASE MONITORING AT TU WIEN'S TRIGA MK II REACTOR IN AN URBAN AREA. Hainz, D. (1,P), Veit, M. (1), Musilek, A. (1). (1) TU Wien. (P) Presenting Author.

TU Wien university operates a 250 kW TRIGA Mk II research reactor in Vienna, Austria. In order to fulfil recent demands by the licensing authority and the national regulations, the environmental impact of reactor operation has to be reconsidered. The urbanization in the facility’s vicinity has greatly increased since the reactor's first criticality in 1962, when the surroundings were only allotments gardens with the nearest residential building in a distance of more than 300 meter. Today, the institute is surrounded by small living homes and newly built apartment towers. A holistic view of all radiological emissions and their impact on the nearby population is presented to show the safety status of a small research reactor in an urban environment.

Log 570. OPTIMIZATION OF ANALYTICAL PROCEDURE FOR THE RADIONUCLIDES OF ION EXCHANGE RESINS SAMPLES . Kam, D.Y. (1, P), Kim, H.R. (1, 2), Lim, J.M (1). (1) Korea Atomic Energy Research Institute (2) Chung-Nam National University. (P) Presenting Author.

The radioactive solid waste from the nuclear facilities consists of soft waste, disassembled equipment, and laboratory supplies used during the operation, filters and ion exchange resins used in the purification of gas and liquid effluents, and other various types of combustible materials. In this study, analytical procedures for the radiological characterization of radionuclides including Fe-55, Ni-59, Ni-63, Sr-90, and Tc-99 were developed and optimized for the sample of ion exchange resins used in the purification of liquid effluents from the nuclear facilities. Since the recovery of target nuclides in ion exchange resin samples can significantly fluctuate depending on the method of functional group removal, optimization of the analytical procedure is essentially required. The resin samples were subjected to acid digestion using aqua regia after dry ashing, and Sr-90, Fe-55, Ni-63, and Tc-99 were separated and purified using Sr resin, DIBK-coated prefilter, Ni resin, and TEVA resin. Finally, the results of the method optimization, including the accuracy and precision of the method, were evaluated by measuring the recovery of spiked radionucles. The validation results using standard spiked samples revealed that the methods can be applied for rapidly and satisfactorily recovering the specific target nuclides from samples with a high degree of accuracy and precision.

Log 571. COMPARISON OF TAGGANT FORMFACTOR IMPACT ON FUEL PELLET PROPERTIES.

Shultz-Johnson, L. (1); Koh, K. (1, P); Bowden, S. (1); Fitzgerald, C. (1); Wellons, M. (1); Barrett, C. (1); Gage, G. (1). (1) Savannah River National Laboratory. (P) Presenting Author.

Identification of the origin of illicitly trafficked nuclear material remains a key focus for the nuclear forensics community. To advance this mission, the concept of deliberately incorporating tracers, or taggants, into nuclear fuels has been developed. One such taggant is an isotopically perturbed dopant which can be produced using a double spike method that involves introducing two enriched stable isotopic feedstocks into a natural abundance feedstock. Savannah River National Laboratory (SRNL) synthesized several isotopic taggants in the form of bulk metal-oxide powder and/or engineered microparticles, including Ni, Mo, W, Ti, and Fe-based oxides. The main difference between bulk powder and engineered microparticles is the means of production; the bulk powder taggants are produced by thermal oxidation in a muffle furnace, while engineered microparticles are prepared through a droplet-to-aerosol calcination via in-line heating technique. While the bulk powder form is currently being used for fuel irradiation studies as a part of the Intentional Forensics Venture's Counterfoil Blue campaign, a rigorous comparison between the bulk powder and engineered microparticle formfactors had not yet been explored. The objective of this study was to characterize and compare the two taggant form factors, particularly in regards to particle geometry and size, resulting material effects on the matrix material, and the detectability under inductive couple plasma mass spectroscopy analysis. Using Ni as the taggant element, bulk powder and microparticle samples were separately analyzed, and then incorporated into cerium oxide (a surrogate material for uranium oxide fuel meat); the tagged ceria was then pelletized and heat-treated up to 1500 degrees Celsius. The impact of the taggant formfactor on the pellet's morphology, grain size, porosity, and detectability through mass spectrometry was elucidated.

Log 572. SINGLE ATOM COUNTING OF TECHNETIUM-99 AT THE AUSTRALIAN NATIONAL UNIVERSITY.

Pavetich, S.(1,P); Adler, S.(2); Burge, P.D.(1); Fifield, L.K.(1); Froehlich, M.B.(1); Gülce, F.(2); Hain, K.(2); Martschini, M.(1); Rothery, C.N.(1) Tims, S.G.(1). (1) Department of Nuclear Physics and Accelerator Applications, The Australian National University, Australia. (2) University of Vienna, Faculty of Physics, Isotope Physics, Vienna, Austria. (P) Presenting Author.

The Heavy Ion Accelerator Facility (HIAF) at the Australian National University (ANU) is home to a diverse accelerator mass spectrometry (AMS) program for more than thirty years. AMS is an ultrasensitive technique for the detection of radioisotopes with half-lives in the order of years to 100 million years. Concentrations of rare radionuclides from Be-10 to Am-243 in various sample materials are quantified at HIAF. Applications covered range across astrophysics and cosmochemistry, environmental and geological research, nuclear safeguards, and nuclear data. Here we focus on the radionuclide Tc-99, a high-yield fission product with a half-life of 211 ka. It was generated and distributed in the environment by atmospheric nuclear weapons tests and nowadays is produced in large quantities in nuclear power plants and released into the environment by reprocessing plants and by reactor accidents. Technetium-99 is a potential ocean current tracer and owing to its long half-life and high mobility, it is an important isotope for long-term dose-assessment and radiotoxicity. The high achievable particle energies (200 MeV) at HIAF are uniquely suited to tackle the challenging separation of Tc-99 from its stable isobar Ru-99. First AMS measurements of Tc-99 at HIAF were performed in the early 2000s. In collaboration with the University of Vienna, we are currently refining AMS methods for its detection, enabling quantitative and reproducible measurements of environmental samples containing less than 10 million Tc-99 atoms, which corresponds to e.g. global fallout amounts in grams of soil.

Log 573. NEUTRON FLUX DENSITY MEASUREMENTS OF TU WIEN'S TRIGA MK II REACTOR AFTER CONVERSION TO LOW ENRICHED URANIUM FUEL. Petz, T.(1, P); Trunner, C.(1); Stummer, T.(1); Villa, M.(1); Steinhauser, G. (1). (1) TU Wien. (P) Presenting Author.

During its long history dating back to its first criticality in 1962, the TRIGA Mk II research reactor of the TRIGA Center Atominstitut (TU Wien) has undergone several changes and updates. It has been converted to exclusively LEU fuel more than 10 years ago, and fresh fuel has been added constantly every since. In preparation for several new projects in radiochemistry and neutron physics, a complete set of neutron flux density measurements has been performed. In order to avoid uncertainties due to scale-up from low power levels to higher levels, measurements were conducted at all relevant positions at both low (10 W) and full (250 kW) power. The differential measurement technique employing cadmium shielding of the gold foils was used to gain spectral information of the reactor's neutron energy spectrum.

Log 574. USE OF BOVINE BONES AS A BIOMONITOR FOR THE RELEASE OF RADIONUCLIDES INTO THE ENVIRONMENT. Sahovic, N.(1, P); Shozugawa, K.(2); Steinhauser, G.(1). (1) TU Wien. (2) The University of Tokyo. (P) Presenting Author.

Releases of radionuclides into the environment often require a forensic approach for the fundamental understanding of the circumstances of these releases. In the course of the Fukushima Daiichi nuclear accident (2011), large activities of radionuclides were released. While some prominent radionuclides (e.g., Cs-134, Cs-137, I-131, etc.) are not only volatile (hence emitted in large quantities) but also allow straightforward detection and quantification, Sr-90 has been emitted in lower quantities, and is notorious for its laborious sample preparation. Data on Sr-90 from Fukushima are, therefore, scarce by comparison. With its chemical similarity to calcium and its relatively long half-life of 29 years, it poses a potential threat to human and environmental health. Due to its chemical properties, radiostrontium is known to accumulate in bone tissue. Previous studies have shown that, if any, increased environmental levels of Sr-90 are to be found in close vicinity to the Fukushima Daiichi reactors. An interesting research opportunity arose when bones from a deceased cow that had lived approximately two kilometers from the reactor and was roaming freely for around one year after the accident were obtained. Here, we present the results of the radiochemical analyses of major fission products (Cs-134, Cs-137, and Sr-90) in bovine bone samples as potential biomonitors following nuclear releases.

Log 575. ISOTOPICALLY PERTURBED TAGGANT SYNTHESIS AS A NUCLEAR FORENSICS TOOL. Shultz-Johnson, L. (1, P); Koh, K. (1); Bowden, S. (1); Harrell, M. (1); Reamer, K. (1); Bronikowski, M. (1); Fitzgerald, C (1); Barrett, C. (1); Wellons, M. (1); Gage, G. (1). (1) Savannah River National Laboratory. (P) Presenting Author.

To assist in identifying the origin of trafficked nuclear material, deliberate introduction of benign and persistent material signatures into nuclear fuel has become an area of focus. Adding isotopically enriched taggants to the fuel meat as a chemical barcode, detectable by mass spectroscopy, is one avenue of interest. These additives would be implemented at an impurity level, and ideal taggant candidates would have precursor commercial availability, be compatible with the fuel fabrication process, result in no adverse effects on reactor performance, and be probative and measurable. Savannah River National Lab (SRNL) has been exploring incorporation of isotopic taggants in both microparticle and bulk metal oxide formfactors with the hypothesis that taggant formfactor could alter material properties of the fuel pellet. Here, we report on the Fe isotopic taggant, produced through a double spike method whereby two enriched feedstocks (same element, different isotopes) are blended into a natural feedstock. Blending these at different ratios provides two variations, Fe-alpha and Fe-beta. Engineered microparticle Fe taggants are then synthesized through a droplet-to-aerosol calcination via in-line heating technique. The bulk particles are prepared through drying down the feedstock mixture and oxidizing via thermal treatment. In order to study the limit of detectability of these taggants, five different dilutions are synthesized, whereby Fe-alpha and Fe-beta are diluted with natural Fe at 1:1 to 1:10,000 ratios. Successful incorporation of these taggants into nuclear fuel requires that these taggants be distinguishable from natural abundance. In this, we report on the successful synthesis of both bulk and microparticle Fe taggants, confirm their physical and chemical properties including isotopic profiles, and determine the lowest distinguishable dilution.

Log 576. IMPROVING THE SUSTAINABILITY OF ENVIRONMENTAL MONITORING AND SAMPLING. Wilson, G. (1, P) (1) AWE Nuclear Security Technologies. (P) Presenting Author.

With the increasing need for environmental sampling on sites, whether related to permits or current and potential future legislation or treaties, there is a need to consider sustainable sampling practices and analysis campaigns. AWE Nuclear Security Technologies currently undertake an environmental monitoring programme as part of requirements under the UK Environmental Permitting Regulations (2016) [1]. AWE have also recently launched a new and ambitious environmental sustainability strategy. With UK regulators currently updating relevant guidance such as Environmental Radiological Monitoring [2] to include an aspect on sustainability, it is becoming more important than ever to consider sustainability alongside any sampling campaigns. The main outcome of any sampling campaign is to provide reassurance/verification that there is no impact from site activities on the surrounding area thus protecting sensitive habitats, biodiversity and ensuring environmental sustainability. However, sustainability should also be considered within the context of monitoring programmes themselves at all different stages of the process: sampling strategy, sample collection, delivery of samples, quality of samples, analysis, reporting and sample waste. This presentation outlines the challenges of ensuring a sustainable environmental monitoring programme versus the overriding need to ensure sample integrity and minimisation of cross contamination. It considers the different areas of a sampling campaign that can be reviewed and outlines what considerations should be included when setting up a sampling campaign for future nuclear sites, treaties, or regulatory compliance. [1] Environmental Permitting Regulations (England and Wales) (2016). [2] Scottish Environment Protection Agency, Food Standards Agency, Environment Agency (2010). Radiological Monitoring Technical Guidance Note 2, Environmental Radiological Monitoring, Version 1 UK Ministry of Defence © Crown Owned Copyright 2024/AWE

Log 577. CONSTRAINING SOURCE COMPOSITIONS FROM ANALYSES OF MIXTURES.

Caseres, J.R. (1, P); Fitzgerald, M.A. (1); Sun, Y. (1); Kim, K.K. (1); Norris, G.A.(2). (1) Lawrence Livermore National Laboratory (2) Environmental Protection Agency. (P) Presenting Author.

Analyses of mixtures often yields an inverse problem – we would like to extract the original source compositions (or “endmembers”) without knowledge of how much each endmember contributed to each analysis. We are developing approaches to unmixing for nuclear forensics and environmental datasets. Unmixing algorithms are an active area of research in a variety of fields, but the small sample sizes and analytical noise in nuclear forensics and environmental datasets present additional challenges. We are adapting an approach from chemometrics to generate the entire range of possible source compositions (“feasible sets”) and incorporating prior knowledge to decrease the solution space. We also apply a Python-based environmental source apportionment tool, UnmixPy, which uses constrained optimization to estimate the source compositions. These approaches will be tested on a NanoSIMS image dataset at varying spatial resolutions to resolve three endmembers within a UO2 fuel pellet, and on a groundwater contaminant dataset with two endmembers. We anticipate that these tools will be broadly applicable to analyses of mixtures in many areas, including major and trace element analyses, spectroscopy, and atmospheric data. Prepared by LLNL under Department of Energy’s (DOE) National Nuclear Security Administration (NNSA) contracts Contract DE-AC52-07NA27344. LLNL-ABS-871475.

Log 578. CHLORINE MASS FRACTION IN CONCRETE – COMPARISON OF RESULTS FROM INAA AND PGAA.

Chen-Mayer, H.H. (1,P), Maria Vega Martinez (1), László Szentmiklósi (2). 1. National Institute of Standards and Technology, USA. 2. HUN-REN Centre for Energy Research, Hungary. (P) Presenting Author.

Chlorides diffusion in concrete structures is known to promote corrosion of metal reinforcement within. To facilitate non-destructive measurement of bulk concrete using portable neutron generator-based prompt gamma activation analysis (PGAA), gram sized amounts of concrete were sub-sampled from bulk concrete cast with 5 levels concentrations of chloride (< 2% by mass). The samples were analyzed by reactor-based instrumental activation analysis (INAA) and reactor-based PGAA, independently, at two different reactor facilities. The INAA analysis was performed by ratio to standard of known mass fractions, and the PGAA was performed by using nuclear cross section data and detector efficiency calibration, which then reported absolute mass in the irradiated volume. The comparison was made by mass fractions in concrete. Among all the measured elements by both methods, the mass fractions of Cl, Ca, and Fe agreed between the two methods by a Z-score of within +/- 3. These results provided useful information for neutron generator-based PGAA of larger concrete. Spectral analysis methods using whole-spectrum fitting and individual peak fitting were also compared.

Log 579. NUCLEAR FORENSICS ON SWIPE SAMPLES COLLECTED AT THE SALASPILS RESEARCH REACTOR IN LATVIA.

Swider, J.R. (1); Barons, E. (2,P); Murnieks (2); Kips, R. (1); Jacobsen, B. (1). (1) Lawrence Livermore National Laboratory. (2) Latvian Environment, Geology and Meteorology Center.

The analysis of swipe samples for nuclear forensics can yield valuable insights into the sampling environment and the material history of the sampled locations. Unlike traditional bulk analysis, swipe analysis allows for direct examination with minimal sample destruction. This study emphasizes the application of non-destructive analysis (NDA) methods at LLNL as a preliminary approach to evaluate swipe samples. Here we present NDA results of swipes from the now non-operational “Salaspils research reactor” (SRR) located 18 km southeast of Riga in the town of Salaspils. The swipe samples were taken in three different locations where nuclear material would potentially be expected: 1) a primary hot cell for fuel rods; 2) a fresh fuel storage area; 3) a room that experienced an accident involving Eu-152. Prior to shipping the swipe samples to LLNL for further analyses, gamma spectrometry measurements were performed at the LEGMC Laboratory. At LLNL, whole swipes were analyzed in their as-received state for radioisotopes using gamma spectrometry, alongside autoradiography to assess the distribution of radioactivity. These initial findings guide the selection of targeted areas on each swipe for further investigation. Light microscopy and scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDS) are used to investigate the removed material. The results demonstrate that a substantial amount of information can be rapidly and non-destructively gathered from swipe samples, highlighting the potential of these initial findings to inform and guide subsequent analyses.

Log 580. 239−241,244Pu AND 236U FALLOUT ISOTOPE RECORDS IN THE SOUTHERN HEMISPHERE – INTERPRETATION OF RELEASE AND ENVIRONMENTAL DISTRIBUTION.

Child, D. (1, P), Hotchkis, M. (1), Marx, S. (2), Saunders, K (1). Woodward, C. (1). (1) Australian Nuclear Science and Technology Organisation. (2) GeoQuest Research Centre, School of Earth, Atmospheric and Life Sciences, University of Wollongong. (P) Presenting Author.

Nuclear fallout has been widely dispersed across the Earth’s surface since the commencement of atmospheric weapon testing in the 1940’s. This fallout, and its pattern of dispersal and accumulation in environmental archives, has been successfully utilised for many years as a geomorphological chronometer to complement other radio-chronological techniques such as 210Pb dating [1]. Much data exists on the temporal sequestration of 137Cs, and more recently the long-lived and high yield plutonium isotopes 239Pu and 240Pu. The use of high sensitivity mass spectrometry techniques such as the VEGA Accelerator Mass Spectrometry system at ANSTO is enabling the detection of a broader range of rare higher actinides such as 241Pu and 244Pu as well as 236U [2]. This has allowed studies to be undertaken in environments with lower fallout accumulation such as alpine and sub-alpine regions of the Southern Hemisphere. Several detailed profiles have been measured in the Southern Hemisphere, including, alpine and sub-alpine Australia and New Zealand, which show distinct variations in the temporal isotopic ratio profiles. Records indicate a distinct shift in regional influence from Pacific Proving Ground (PPG) dominated fallout in the 1950’s to Artic dominated fallout in the mid-1960’s, as well as an anticorrelation between 236U and Pu isotopic fallout ratios. [1] P.G. Appleby, Three decades of dating recent sediments by fallout radionuclides: a review, The Holocene 18 (2008) 1. [2] S.K. Marx et al., Examining the response of an eastern Australian mangrove forest to changes in hydroperiod over the last century, Estuarine, Coastal and Shelf Science 241 (2020) 106813.

Log 581. USE OF NEUTRON IMAGING FOR ELEMENTAL COMPOSITION MAPPING IN METAL MATERIALS PRINTED BY ADDITIVE MANUFACTURING. A.S. Tremsin(1,P), E. Eimer(2), S. Ganguly(2), T. Shinohara(3), K. Oikawa(3), W. Kockelmann(4), (1)University of California at Berkeley, Berkeley, CA 94720, USA; (2)Cranfield University, Cranfield, Bedfordshire MK43 0AL, England; (3)Japan Atomic Energy Agency, Naka-gun Ibaraki 319-1195, Japan; (4)STFC-Rutherford Appleton Laboratory, ISIS Facility, Harwell, OX11 0QX, UK. (P) Presenting Author.

Neutron imaging techniques provide a unique possibility to map the bulk elemental composition in various materials, which are opaque to other conventional methods. Neutron can penetrate relatively thick metal samples and probe the interior composition of centimetre-scale samples (up to several cm of steel, 10 cm in case of Al, for example). The presence of sharp resonance absorption features in neutron transmission spectra – that is what can be used for the elemental composition mapping, which can be done presently to sub-mm resolution. These measurements are to be performed at bright pulsed neutron beams, such as facilities at several spallation neutron sources. In this paper we present the results of experiments where distribution of Ag and Cu additives was reconstructed within Al alloy samples, which were produced by wire-arc additive manufacturing (AM) technique. The diffusion of Ag and Cu during printing is quantified in these measurements demonstrating the strengths of this technique. This non-destructive method can be applied for mapping of various elements, which have sufficiently large resonance absorption cross sections. In addition, the same measurement can provide information on the bulk microstructure within these samples (distribution of strain, uniformity of texture, presence of large grains, etc.) and thus can be very attractive alternative where other techniques fail due to sample opacity.

Log 582. MOLTEN SALT VISCOSITY (PLEASE UPDATE - THIS WAS BLANK). M. C.F. Karlsson (1, P); T. Karlsson (1), M. E. Tano (1) (1) Idaho National Laboratory. (P) Presenting Author.

Molten salts possess desirable characteristics such as resistance to radiation damage, low vapor pressures, low viscosities, high heat capacities, and high temperature stability, making them suitable for various energy applications, including molten salt reactors (MSRs) and pyrochemical reprocessing. However, their use presents engineering challenges, notably in MSRs, due to their hygroscopic nature and the formation of insoluble oxides, oxyhalides, and complexes that alter salt chemistry. These salts are also corrosive, causing vessel and container materials to leach into the molten salt, further complicating the system's chemistry. This study focuses on the viscosity of a molten eutectic NaCl-$MgCl_2$ salt, comparing a clean system with one containing solid particulate impurities formed from hydrated salts. Viscosity measurements were conducted over a range of temperatures (500°C to 750°C) and shear rates. The presence of particulate impurities introduced significant shear-thinning behavior, deviating from the Newtonian behavior typically expected of pure molten salts. This behavior was influenced by factors such as particle size, shape, concentration, and temperature. The findings highlight the complexity of accurately measuring and modeling the viscosity of molten salts with particulate contamination. The rheological behavior observed underscores the importance of considering particulate impurities when designing and optimizing equipment for nuclear reactor technologies.

Log 583. ADVANCEMENTS IN SINGLE PARTICLE MASS SPECTROMETRY (SPMS) ANALYSIS FOR NUCLEAR FORENSICS. Omana, M.A. (1, P); Wiemann, D.K. (1); Settecerri, T. (1); Hammond, A.L. (1). (1) Sandia National Laboratories. (P) Presenting Author.

This poster highlights the advancements made in generating and analyzing challenge aerosols for Single Particle Mass Spectrometry (SPMS) systems, setting the stage for future nuclear forensics research and development. Under a previous effort, a spray-dry calcination system was developed to produce test aerosols with a variety of inorganics, including lanthanides. This system allows for tuning of particle size and composition, enabling the generation of metals, metal oxides, and novel chemistries such as fluorine bonds and metal alloys. Future work will expand this capability to include actinides, further enhancing nuclear forensics relevancy. Preliminary benchmarking was conducted using a Livermore Instruments SPAMS 3.0 instrument to identify performance limits. Test aerosols included common metals like aluminum, as well as more challenging materials such as tantalum and gallium. Lanthanides, specifically europium and dysprosium, were also tested. Key findings demonstrate the SPAMS 3.0's ability to detect all particle types with relative ease, distinguishing between metals and metal oxides. Notably, the system successfully identified fluorine in the aerosols and showed promising results in observing isotopic fractionation of lanthanide particles, with mass spectrometry peak intensities reflecting the natural abundances of the isotopes. These initial results underscore the potential of SPMS systems in nuclear forensics. The ability to generate and analyze complex aerosols with high throughput and near real-time will significantly enhance capabilities in rapid and accurate characterization of nuclear debris, ultimately supporting event characterization and attribution efforts. SNL is managed and operated by NTESS under DOE NNSA contract DE-NA0003525

Log 584. NAUTILUS AT THE UNIVERSITY OF NOTRE DAME. Hixon, A.E.(1,P); Collon, P. (1); Bailey, T. (1); Robertson, D. (1); Stech, E. (1). (1) University of Notre Dame. (P) Presenting Author.

The NAUTILUS instrument combines secondary ion mass spectrometry (SIMS) with a single-stage accelerator mass spectrometer (SSAMS) to produce a unique capability for spatially-resolved trace-element and isotope analysis. The instrument was designed and built by the US Naval Research Laboratory, but transferred to the University of Notre Dame in August 2023. At Notre Dame, NAUTILUS will be operated jointly by the Institute for Nuclear Astrophysics (ISNAP) and College of Engineering (CoE) to support research programs ranging from actinide research to anthropology. This poster will describe the reassembly and future operation of NAUTILUS at Notre Dame, including a specific use-case in the area of nuclear forensics.

Log 585. LEAD ISOTOPIC RATIOS AS A NUCLEAR FORENSIC SIGNATURE: A PARTNERSHIP BETWEEN THE UNITED STATES AND SOUTH AFRICA.

Mathuthu (1,P); Kupi, T. (1); Brennecka, G.A. (2); Inglis, J. (3). (1) Center for Applied Radiation Science and Technology (CARST), North-West University (Mafikeng campus), Mmabatho, 2735, Republic of South Africa. Tel: +27 76 507 3327. (2) Lawrence Livermore National Laboratory, USA. (3) Los Alamos National Laboratory, USA. (P) Presenting Author.

South Africa has four uranium “ore provinces”, and largely based on the ages of the provinces, they have distinct nuclear forensics signatures. The International Atomic Energy Agency has mandated all its Member States to develop National Nuclear Forensics Libraries in response to the nuclear security threat posed by nuclear material trafficking. South Africa and the USA are thus enhancing their capabilities to interdict and attribute any nuclear material out of regulatory control within their borders, by undertaking this joint project to document the origin of uranium ore materials. To achieve this objective, we will discuss results from a joint project between Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and the Centre for Applied Radiation Science and Technology (CARST) at North-West University in the Republic of South Africa. In this project, each laboratory will determine lead (Pb) isotopic ratios of uranium ore sourced from South Africa and evaluate isotopic differences between the sources. Variations in the Pb isotopic ratios of different geologic deposits provides a unique nuclear forensic signature between different locations, which will be a new nuclear security tool for South Africa.

Log 586. DETECTION OF REACTIVE OXYGEN SPECIES IN URANYL PEROXIDE MATERIALS USING ELECTRON PARAMAGNETIC RESONANCE AND VIBRATIONAL SPECTROSCOPIES.

Lottes, B. (1, P), Benjamin Stein (2), Samuel Michael Greer (2), Cassandra Gates (2), Korey P. Carter (1) University of Iowa Department of Chemistry. (1) Los Alamos National Laboratory (2). (P) Presenting Author.

Hydrogen peroxide (H2O2) possesses a unique affinity for the uranyl (UO22+) cation and is also known to spontaneously generate reactive oxygen species such as O22-, •OH, and O2•- in aqueous solution upon homolysis. Understanding uranyl chemistry with reactive oxygen species is relevant in multiple radiochemistry research areas including spent fuel processing and nuclear forensics, and O22- and O2•- are known to directly coordinate to UO22+ during the formation of uranyl coordination compounds or larger three dimensional structures such as uranyl peroxide clusters (UPCs). Herein we describe the synthesis and characterization of two free radical containing UPCs, Rb@U60Ox30 and Gd@U24 and a uranyl superoxide monomer, Na2[UO2(O2)2(ONH2)2]. Structural analysis was done using single crystal X-ray diffraction (SCXRD) that identified shortened O – O bond distances of ~ 1.4 Å, indicative of O2•- coordination. Spectroscopic analysis verified the presence of free radicals wherein electron paramagnetic resonance spectra for the uranyl monomer was determined through simulation to contain hyperfine interactions with Na+ cations, while EPR of both UPCs contained a single isotropic signal at g = 2.003. Moreover, Raman spectra collected of the UPCs identified the UO22+ v1 and O22- v1 stretching modes, whereas no O2•- v1 stretches were observed, which suggests the free radical character noted from SCXRD results may be not be representative of the bulk material. However, signal enhancement from resonance Raman studies was able to identify the O2•- v1 mode in Rb@U60Ox30.

Log 587. APPLICATION OF INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY IN THE ANALYSIS OF PLUTONIUM CONTENT OF FAST CRITICAL ASSEMBLY FUEL DISPOSITION.

Bonilla HJ (1,P), Wyeth NG (1), Jones MA (1), Morales MA (1). (1) Savannah River National Laboratory. (P) Presenting Author.

In 2014 the United States Department of Energy (DOE) and the Japan Atomic Energy Agency (JAEA) reached an agreement to have all plutonium and highly enriched uranium removed from Japan's Fast Critical Assembly (FCA) reactor at Tokai. Dissolution of the material successfully began in early 2024 at the Savannah River Site, a DOE facility in South Carolina, and process monitoring is supported through a collaboration with the Savannah River National Laboratory (SRNL) to provide analytical characterization of the dissolved material. In an effort to meet the project's accelerated timeline for process support and DOE Nuclear Material Control and Accountability (NMC&A) requirements, SRNL analytical personnel developed methods to accurately measure plutonium isotopic composition and concentration using a quadrupole inductively coupled plasma mass spectrometer (Q-ICP-MS). High precision plutonium measurements are typically performed using multicollector instruments, such as multicollector ICP-MS or thermal ionization mass spectrometry; however, these methods can be labor-intensive, and expensive. SRNL utilizes an unmodified Agilent 8900 QQQ-ICP-MS to perform precision plutonium measurements at a more affordable cost to the facility and customer, in addition to minimizing turnaround times. This work will also expand on the overall sample analysis process at SRNL in support of this mission.

Log 588. UNVEILING UNKNOWN TAGGANTS IN NUCLEAR FUELS: MACHINE LEARNING-ASSISTED DETECTION USING EDS AND EPMA.

Boro, J.B. (1); Marks, N.E. (1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Research and development on tagging nuclear materials for forensic applications has shown promise, allowing us to detect tags as trace elements or isotopic perturbations. But what if we don't know what we're supposed to look for? How effective could routine non-destructive analysis (NDA) techniques be at finding unknown taggants in nuclear fuels? Here we present a blind study on three nuclear fuels with well-characterized trace elements re-analyzed using Energy Dispersive Spectroscopy (EDS) and Electron Probe Micro-Analysis (EPMA), as well as blank fuels with no tagged additions. Using EDS and Wavelength Dispersive Spectroscopy (WDS) spectrum analyses, we apply unsupervised machine learning techniques/statistical methods—including Principal Component Analysis (PCA) and anomaly detection algorithms such as Isolation Forest—to identify subtle outliers in the characteristic X-ray data. Our approach demonstrates the potential for routine NDA methods to detect unknown taggants without prior knowledge, potentially enabling more effective forensic analysis of nuclear materials. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Log 589. A GLOWING STUDY: SURFACE TAGGING CLADDINGS USING PHOTOLUMINESCENT PARTICLES. Hawk, C.L. (1,P); O'Brien, L.B. (1); Bloom, R.A. (1); Gandara, N.J. (1); Musico, B.L. (1); Fetrow, T.V. (1); Smith, J.P.(1); Thrun, M.M.(1); Strohmeyer, M.J. (1); Condon, N.J. (2); Abdel-Rahman, M.(2); Roach, J. (3). (1) Los Alamos National Laboratory. (2) Argonne National Laboratory. (3) Oak Ridge National Laboratory (P) Presenting Author.

Surface tagging of nuclear fuels is of interest to introduce benign and persistent signature to store information about the material provenance while being difficult to observe with the naked eye. Photoluminescence is a promising method for surface tagging because it is benign under normal lighting conditions, visible under specific lighting conditions, and requires knowledge on material to cause excitation of the photoluminescent particles. Welding is a viable option to introduce photoluminescent particles into the cladding as it is part of the manufacturing process of normal fuel production, and it can be gentle enough to not detrimentally affect the cladding. This works explores various oxides that luminesce at various wavelengths and the effects of various manufacturing processes such as welding and rolling on the photoluminescence of the taggant.

Log 590. MCNP DETERMINATION OF OPTIMIZED COMPTON SUPPRESSED GEOMETRY FOR QUANTIFICATION OF PLUTONIUM IN SOLUTION. Egozi, C.(1, P); Winkler, R.(1); Charlton, W. S.(2); Landsberger, S.(1). (1) Los Alamos National Laboratory; (2) The University of Texas at Austin. (P) Presenting Author.

The Solution Assay Instrument (SAI) is an in-line quantification system designed for measurements of solutions in gloveboxes. It is comprised of a lead shielded HPGe detector below the glovebox facing up, as well as a tungsten and lead shielded sample chamber inside the glovebox. The source is contained in a cylindrical plastic vial. This is effective for high concentration samples, however, the Compton background is high, limiting quantification capabilities for low concentrations and therefore raising the detection limits. MCNP (Monte Carlo N-Particle) was employed to determine the effectiveness of adding Compton suppression to reduce detection limits. A mixed 239Pu and 241Am surface source mimicked the instrument surface contamination, and high energy neutron interaction gamma rays were added to this source. Once the value of adding suppression was verified and quantified, further optimizations were performed by modification of the source and glovebox geometry. This was done to determine the minimum achievable detection limit within design constraints. These modifications included altering the source from a cylinder to a box with variable thickness (thickness is defined along the HPGe axis). An optimal thickness for this new geometry was determined, and the reduction of the continuum with Compton suppression for this setup was 34.6%, allowing for a lower detection limit. With alterations to the source geometry and the inclusion of Compton suppression, it was determined that the peak counts at the 239Pu 129 keV peak were 43.34 times larger than the original unsuppressed counts, resulting in an SAI with far better detection limits. LA-UR-24-33319

Log 591. RADIOACTIVE TARGET FABRICATION EFFORTS AT LANL. Essenmacher, S.D.(1,P); Lee, H.Y.(1); Mocko, V.(1); Stamatopoulos, A.(1); Kuvin, S.A.(1). (1) Los Alamos National Laboratory. (P) Presenting Author.

Many nuclear applications, ranging from models of astrophysical processes to validations for nuclear reactors and defense applications, require high fidelity nuclear data. Such data has been obtained for primarily stable nuclei, but not radionuclides. Two radionuclides that currently lack highly accurate nuclear data are aluminum-26 and yttrium-88. The Low Energy (n,Z) (LENZ) instrument at the Los Alamos National Laboratory (LANL) was developed to allow for accurate measurements of neutron-induced charged particle reactions, and has the potential to clarify the observed discrepancies in neutron-induced charged particle reaction data for aluminum-26. While the Device for Indirect Capture Experiments on Radionuclides (DICER) could be used to perform neutron transmission measurements on yttrium-88 using the time-of-flight technique for the first time. To perform these measurements, efforts were undertaken to fabricate an aluminum-26 target via molecular plating and a yttrium-88 target by a new target manufacturing technique called microjet printing. This presentation will cover these efforts and the future outlook for radioactive target fabrication for neutron-induced reaction studies at LANL.

Log 592. TRACE ELEMENTAL AND ISOTOPIC ANALYSIS OF ACTINIDE MATERIALS WITH AN AUTOMATED MICROFLUIDIC SYSTEM. Han, S.Y.(1, P); Treves Brown, B.(1); Higginson, M.A.(2); Kaye, P.(2); Sharrad, C.A.(1); Heath, S.(1). (1) The University of Manchester. (2) AWE. (P) Presenting Author.

Advancement in analytical device miniaturisation through microfluidic technology offers an alternative approach towards radiochemical analysis. Compared to traditional macroscale analytical processes, microfluidics devices manipulate and process fluid samples typically in the microlitre range, which provides benefits in terms of more efficient mixing and precise conditions control that are not feasible in macroscopic systems while reducing waste generation. Microfluidic extraction devices are fabricated using poly (methyl methacrylate). Recovery and separation of uranium and plutonium from trace elements relevant to the nuclear fuel cycle are demonstrated using extraction chromatographic resins packed within the microdevice in concentrated mineral acids. Enabling analysis of nuclear materials with a drastic volume reduction to less than 2 ml per analysis in total. A novel online analytical system was also developed in parallel. Where flows from the microfluidic separation system are redirected towards a coupled ICP MS and MC ICP MS systems, enabling online analysis of trace elements and precise analysis of actinide isotopic ratios as it is separated within the microdevice with minimal operator-sample interaction. Such an online microdevice Mass spectrometry system enables automated separation-detection of radioactive samples within 2 hours of sample uptake while generating less radioactive waste, satisfying the As Low As Reasonably Achievable (ALARA) principle.

Log 594. RECENT ADVANCES IN MORPHOLOGICAL ANALYSES AS A NUCLEAR FORENSICS SIGNATURE AT LOS ALAMOS NATIONAL LABORATORY.

Hanson, A.B.(1, P); Matthies, K.S.(1); Parkes, A.M.(2); Gilbert, M.R.(2); Cohn, J.D.(1); Skurikhin, A.N.(1); Valencia, M.D.(1); Sentz, K. (1) Los Alamos National Laboratory, Los Alamos, NM, USA. (2) AWE Nuclear Security Technologies, Aldermaston, Berkshire, England. (P) Presenting Author.

Los Alamos National Laboratory is involved in a collaborative, cross-institutional project aimed at advancing the R&D of morphological analysis of scanning electron microscopy (SEM) imagery as a reliable nuclear forensics signature. This presentation provides an overview of the LANL team's ongoing efforts to refine and apply morphology as a potential tool for forensics investigations using an integrated approach of experimental research and data science. Key initiatives include: (1) Advancing morphological experimental and analytical methodologies while strengthening international partnerships. A technical exchange was conducted with AWE Nuclear Security Technologies to develop experimental collaborations for the morphological characterization of UF4 using the ammonium bifluoride (ABF) synthetic route. By investigating potential morphological signatures from a range of precursor materials and experimental scales, this work will leverage the unique capabilities and expertise of each institution and bridge gaps in the existing literature. (2) Addressing the time-consuming nature of manual particle segmentation that has been traditionally used for nuclear forensics morphology studies. Efforts in unsupervised neural networks for automated particle segmentation have recently focused on the use of masked autoencoders, which can leverage a large unlabeled dataset and combine it with smaller labeled training sets to capture rich contextual information important for segmentation. (3) Preparing the general release of the next generation Morphological Analysis of MAterials (MAMA) software. The goal is to enable plug-ins for new image segmentation algorithms and utilize the benefits of the MAMA interactive user interface to modify segmentations as needed and quantify results for downstream comparison.

Log 595. ANALYTICAL DATA MANAGEMENT SYSTEM FOR THE ENVIRONMENTAL RADIOACTIVITY MONITORING PROGRAM AROUND RESEARCH REACTOR IN KOREA.

Lim, J.M (1, P), Kim, W.Y. (1), Yoon, J.Y. (1), Gam, D.Y. (1), Jang, M. (1), (1) Korea Atomic Energy Research Institute. (P) Presenting Author.

Environmental radioactivity monitoring at the Daedeok nuclear facility, which includes research reactors, fuel production facilities, radioactive waste storage facilities, and related research facilities, is critical for the safety and preservation of the surrounding population and environment. Environmental radioactivity monitoring for the KAERI site, gamma radionuclides, H-3, C-14, U isotopes, gross alpha-beta, and Sr-90 in the various sample media has been analyzed routinely. Thus, an information system has been established for the compilation, management, and efficient use of environmental monitoring data. The system consists of the control of various internal and external measurement equipment, calculation and evaluation of radioactivity analysis results, dose assessment, all databases, weather and diffusion assessment data, and the radiation dose assessment system to be used in the event of an actual accident. It also includes a geo-information-based webpage where all data is available to the public. Analytical Data Management System for Environmental Radioactivity was built for the production and evaluation of environmental radioactivity analysis data. ADAMS-ER can input all data from sampling, pretreatment, and instrumentation. And analysts can produce and report analytical results including concentration, uncertainty, and MDA by simply uploading raw data files from the instrument. In addition, anomalies in the analytical results are evaluated through statistical analysis. Using this web-based system, we are able to efficiently produce, manage, and report on environmental monitoring data.

Log 596. METHOD VALIDATION OF SEQUENTIAL ANALYSIS FOR Fe-55, Ni-63, Tc-99 IN THE GROUNDWATER SAMPLE. Kim, H.R. (1,2), Gam, D.Y.(1), Yang, J.H.(2), Lim, J.M (1, P), (1) Korea Atomic Energy Research Institute, (2)Chung-Nam National University, (P) Presenting Author.

Fe-55, Ni-63, and Tc-99 radionuclides are pure beta nuclides and emit relatively low energy, but due to their relatively long half-lives and high mobility in the environment, they are considered important radionuclides in media samples such as groundwater and soil around decommissioning waste and radioactive waste disposal sites. In addition, monitoring Fe-55, Ni-63, and Tc-99 in environmental samples requires a complex process such as chemical pretreatment, separation, and purification of each nuclide from the sample, followed by measurement using a liquid scintillation counter. Therefore, a method that can rapidly analyze the three nuclides in a sequential process is essential. In this study, we aimed to develop and optimize a method for the sequential analysis of Fe-55, Ni-63, and Tc-99 in groundwater from a radioactive waste disposal site. The optimized method was developed to handle a sample volume of more than 2 L for the purpose of environmental radioactivity monitoring. Quality factors such as accuracy, precision, and uncertainty were evaluated to validate the method, and the final developed method was applied to groundwater samples to confirm its applicability.

Log 597. A PORTABLE, LOW-POWER ELECTROSTATIC PRECIPITION-BASED AEROSOL MONITOR FOR NUCLEAR EXPLOSION MONITORING. Keillor, M.E.(1); Beck, K.A.(1); Emmons, S.B.(1); Johnson, J.C.(1); Moore, M.E.(1,P); Kasparek, D.M.(1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

A low-power aerosol collector with on-board measurement for gamma-emitting radionuclides is currently being developed at PNNL. An electrostatic precipitator with low airflow restriction is central to the design. The device uses a 3" wide roll of collection media, which can be advanced at a continuous rate, or in a stop-and-go approach to collection followed by measurement. Radiation measurement is accomplished with two radiation detectors, providing for the potential application of coincidence techniques. Detectors currently in-hand for testing in the system include Mirion sodium iodide (NaI(Tl)) and cerium bromide (CeBr) scintillators, and an H3D cadmium zinc telluride (CZT) detector module. The status of this development will be presented. The potential for valuable contribution to explosion monitoring with portable aerosol monitors processing lower air volumes at distances of less than ~1000 km from the source will also be considered.

Log 598. INTERLABORATORY COMPARISON OF SECONDARY ION MASS SPECTROMETRY ANALYSES OF NUCLEAR FORENSIC SAMPLES FROM THE 7TH COLLABORATIVE MATERIAL EXERCISE. Lorincik, J.(1, P); Swider, J.(2); Kips, R.(2); Liu, M.-Ch.(2); Tenner, T.J.(3); Elantyev, I.(1). (P) Presenting Author.

Review and interlaboratory comparison of the Secondary Ion mass Spectrometry (SIMS) data obtained by laboratories participating in the 7th Collaborative Material Exercise has been conducted. The analyzed materials were two uranium compounds in powder form and two pieces of uranium metal. The instruments used in this comparison were a small geometry SIMS, CAMECA IMS 7f from the Research Centre Rez, and a large-geometry (LG) SIMS, CAMECA IMS 1280 from the Los Alamos National Laboratory. Despite the differences in instruments and analytical procedures, e.g., sample preparation, SIMS setups, and data post-processing, there was good agreement for the 234U/238U, 235U/238U, and 236U/238U ratios in the analyzed materials. The main difference was in the precision, which was, as expected, higher for the LG-SIMS. In addition, the comparison between the laboratories was also made for the image processing algorithms applied to raw data acquired in automated particle measurement (APM) mode. The result of this comparison has led to identification of best practice for setting up parameters of the APM software.

Log 599. OPTIMIZING THE SCALING PROCESS FOR URANIUM RECOVERY FROM IONIC LIQUIDS. Olney, R. (1, P), Schröder, F. (2), Bryden, T. (2), Czerwinski, K. (1), Hatchett, D. (1). (1) The University of Nevada - Las Vegas. (2) URENCO. (P) Presenting Author.

Over 700,000 metric tons of depleted uranium hexafluoride (UF6) are currently being stored in the United States. Storage of this nuclear material is not only costly, but also poses a large risk, as the material has a high vapor pressure and is exceedingly corrosive. The conventional method of UF6 deconversion is to react the compound with water, generating hydrogen fluoride gas (HF) and uranyl fluoride (UO2F2). Recent studies have demonstrated that UF6 may be dissolved in the room temperature ionic liquid (IL), 1-methyl-1-propylpiperidinium bis(trifluoromethanesulfonyl)imide, chemically stabilizing the uranium through a redox reaction. This treatment method may convert UF6 to UF4 by addition of water. The presented work investigates the effects of water on the IL solution, the precipitation process of UF4 from the solution, and reproduction of the experiment at larger scales. The upscaling of the uranium recovery may be dependent on the surface area of water to the immiscible IL. Additionally, the effect of temperature on the reaction rate and final product was also examined. The uranium speciation was determined by UV-vis-NIR spectroscopy. Thermogravimetric analysis and powder x-ray diffraction were performed to characterize the precipitation product as UF4. Inductively coupled plasma atomic emission spectroscopy was used to quantify the amount of uranium remaining in each liquid phase. As an alternative deconversion method for depleted UF6 stocks, extraction of UF4 from RTIL appears to provide a promising and more efficient approach for deconversion and storage of this nuclear material.

Log 600. ULTRA-HIGH-RESOLUTION MICROCALORIMETER X-RAY SPECTROMETER FOR NUCLEAR FORENSICS CHEMICAL AND ELEMENTAL ANALYSIS IN THE SCANNING ELECTRON MICROSCOPE. Carpenter, M.H. (1, P), Croce, M.P. (1), McNeel, D.G. (1), Schrieber, K.A. (1), Stark, E.N. (1), Dede, S. (1), Hansen, H. (1), Jackson, D.E. (1), Godt, C.J. (1), Ullom, J. (2), Bennett, D. (2), Mates, J.A.B. (2), Schmidt, D. (2), Weber, J. (2), Gard, J. (3), Becker, D. (3), Morgan, K. (3). (1) Los Alamos National Laboratory. (2) National Institute of Standards and Technology, Boulder. (3) University of Colorado, Boulder. (P) Presenting Author.

Hyperspectral X-ray Imaging (HXI), consisting of ultra-high resolution microcalorimeter X-ray emission spectroscopy in the scanning electron microscope (SEM), has made significant advancements in spatially-resolved microanalysis of nuclear materials. This instrument combines desirable features of energy-dispersive spectroscopy (EDS) like broad energy range and high efficiency with ultra-high energy resolution typically reserved for wavelength-dispersive spectroscopy (WDS), enabling new approaches to microanalysis. With 6-12 eV full-width at half-maximum (FWHM) energy resolution (versus 100-150 eV FWHM typical for EDS), HXI can resolve emission lines (peaks) within 10 eV of one another, lowering the detection threshold for many elements and compounds and improving measurement uncertainty. Additionally, this energy resolution enables analysis of the shape of emission line complexes that demonstrate chemical sensitivity, yielding information about oxidation state and bound ligand species in certain cases. This presentation covers the fundamentals of this detector technology including recent developments in high-resolution mapping and presents several application scenarios relevant to nuclear forensics and particle analysis. LA-UR-24-33272.

Log 601. QUANTIFYING MAXIMUM POTENTIAL IMPURITY RATIO IN RADIOPHARMACUITICAL APPLICATIONS. Persson, H. (1,P); Phillips, K.E. (1) Mirion Technologies (Canberra), Inc.

Radiopharmaceuticals are an important and growing application of radionuclides. Radionuclides for pharmaceuticals can be produced by numerous methods, including neutron irradiation, cyclotron production or extraction from existing long-lived radionuclides, and often includes chemical separation to ensure the product is as pure as possible. Quality assurance measurements are performed to evaluate the sample for the presence of radionuclidic impurities. In this application, the critical metric for impurity evaluation is the ratio of the activity of the radionuclidic impurity to the target radionuclide activity of the sample. To distribute product in the FDA or similar regulated industry, producers must demonstrate that the impurity ratio is below a maximum value. When the impurity is below detectable levels, it is common to use the minimum detectable activity (MDA) divided by the primary radionuclide activity to report the impurity ratio. However, this use is not ideal for several reasons. In this paper, Mirion proposes an alternate analysis algorithm that calculates an upper limit, or maximum potential percent impurity (MPPI) of the ratio of a radionuclidic impurity activity to the target radionuclide activity using Bayesian statistics and taking uncertainties of both radionuclide activities into account. The method works when the signal is not present, is weak, and when the signal is large without the need to change metric. The MPPI can be used to conclude with a specified confidence that the ratio of the activities of the two radionuclides are below a defined limit.

Log 602. VALIDATION OF A NEW TRUE COINCIDENCE SUMMING CORRECTION ALGORITHM FOR GENIE TO MONTE-CARLO SIMULATIONS AND MEASUREMENTS. Persson, H. (1); Archambault, B.C. (2); Greenwood, L.R. (2); Phillips, K.E. (1); Pierson, B.D.(2), (1) Mirion Technologies (Canberra), Inc. (2) Pacific Northwest National Laboratory

True coincidence summing (TCS) occurs when a detector detects more than one gamma or X-ray from a single decay of a radionuclide. This changes the probability to register a count in the full energy peak from a gamma emission. If not corrected for, it can lead to incorrect activity determination. The effect is largest for high efficiency geometries that offer the best detection sensitivity and shortest feasible measurement times. Automated utilities that provide reliable and accurate TCS corrections is a necessity to offer timely and accurate results from radiometric sample analysis. Mirion has developed a new algorithm to calculate TCS correction factors. The new algorithm improves the accuracy of the correction factors for radionuclides that decay by electron capture and positron emission, has excited states with half-lives longer than 1 microsecond, and radionuclides with complex decays. New features include estimation of uncertainties, correction factors for k X-rays and summing out from L X-rays. The algorithm uses ISOCS/LabSOCS for calculating peak and total efficiencies and has a library of decay data for over 500 radionuclides. In this presentation we will compare the correction factors calculated by the algorithm to measurements performed at PNNL of radionuclides that are of interest to instrument calibration for fundamental nuclear data studies and Monte-Carlo simulations using Geant4 and MCNP-CP.

Log 603. SPECTROELECTROCHEMISTRY OF MOLTEN SALT SYSTEMS: A GLOBAL ANALYSIS OF RESEARCH PROGRESS AND TRENDS. Phongikaroon, S. (1, P) (1) Virginia Commonwealth University (P) Presenting Author.

Recent advances in spectroelectrochemistry studies of molten salt systems have shown significant progress across leading nations. Our analysis focuses on key developments in molten salt chemistry, which has expanded beyond its traditional metallurgical roots to find new applications in energy technology. By examining open-source data and scientific databases, we present a comprehensive overview of three critical research areas: speciation studies, corrosion investigations, and thermophysical property measurements. The analysis highlights collaborative work between universities and national laboratories, particularly in the United States, and compares these findings with research from France, South Korea, Japan, Russia, and China. Spectroelectrochemistry, which combines spectroscopic and electrochemical techniques, has become essential for understanding molten salt behavior at the molecular level. The work compiles statistics on research output and methodological advances across different regions, revealing how various nations approach molten salt chemistry challenges. Our findings show how different countries contribute to the field, with each bringing unique perspectives to molten salt research. The comparative analysis not only presents the current state of research but also identifies emerging trends and potential areas for future investigation. The results demonstrate the importance of international collaboration in advancing our understanding of molten salt systems and their applications in modern technology.

Log 604. ADVANCES IN SINGLE-PARTICLE ICP-MS FOR ACTINIDE DETECTION WITH NUCLEAR FORENSICS APPLICATIONS. VanGundy, R.A. (1,P); Duffin, A.M. (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Obtaining accurate actinide isotope ratios is one of the most critical components of nuclear forensics. Isotope ratio information from particulate material reveals additional information with respect to a homogenized or bulk analysis, but particle methods are traditionally time and labor intensive. However, developments in single-particle mass spectrometry do allow for the identification of distinct particle populations within a larger and complex sample and allow direct and rapid analysis of sample materials. Using multicollector inductively coupled plasma mass spectrometry (MC-ICPMS) and the transient analysis detection method developed at PNNL, we will present recent advances in detection of actinide particle populations directly from complex sample matrices. We have demonstrated the ability to identify particles of interest by directly aerosolizing dust into the MC-ICPMS without any preprocessing. Additionally, we show that our single-particle technique coupled with laser ablation can robustly identify distinct uranium enrichments on filter material when these populations are at roughly equal concentration or when one enrichment is present in trace quantities.

Log 605. DETERMINATION OF Zn AND Ga ISOTOPES IN FISSION PRODUCT MIXTURES. White, J. M. (1, P); Wren, M. S. (1); May, I. (1); Weberg, A. B. (1); Hanson, S. K. (1). (1) Los Alamos National Laboratory. (P) Presenting Author.

The isotope 72Ga can form from neutron activation reactions on stable gallium and can indicate the presence of gallium in a sample. However, in samples containing fission products, interpretation of this measurement is complicated by the presence of the fission product isotope 72Zn, which is formed in low cumulative yield and decays to form 72Ga. Through measurement of both 72Zn and 72Ga, it is possible to determine if excess 72Ga is present in a sample from activation of stable Ga. Work has focused on optimization and validation of the gallium and zinc chemistries by making use of the irradiations each time examining various parts of the procedure. In addition, it was shown that Zn can be successfully isolated and electroplated in good yields even in the presence of matrix elements (rock, soil, or entrained environment, as would be found in an environmental sample). During this talk, further discussion on chemistry development on both Ga and Zn will be examined. LA-UR-24-33198

Log 606. MICROELECTRODE AND HYDRODYNAMIC VOLTAMETRIC ANALYSIS OF SAMARIUM IONS IN LiCl -KCl EUTECTIC MOLTEN SALT. Yang; W. (1,P); Choi, S. (2); Lee, N. (2); Jung, C. (2); Park, T.-H. (3,4); Choi, S. (1, 5, 6); Bae, S.-E. (2, 4). (1)Nuclear Research Institute for Future Technology and Policy, Seoul National University. (2)Nuclear Chemistry Technology Division, Korea Atomic Energy Research Institute. (3)Radioactive Waste Chemical Analysis Center, Korea Atomic Energy Research Institute. (4)Department of Nuclear Science and Technology, University of Science and Technology. (5)Department of Nuclear Engineering, Seoul National University. (6)Institute of Engineering Research, Seoul National University. (P) Presenting Author.

The electrochemical properties of Sm(III)/Sm(II) redox reaction in LiCl-KCl eutectic molten salt is critical for optimizing pyroprocessing, a sustainable approach to recycling spent nuclear fuel. This study employed microelectrode and rotating disk electrode (RDE) techniques to overcome the limitations of conventional macro electrodes, such as low sensitivity to convection and iR distortion. The microelectrode enabled precise measurements of kinetic parameters by enhancing mass transport through radial diffusion, while the RDE provided controlled hydrodynamic conditions, minimizing the effects of natural convection. These advanced methodologies offer reliability for determining kinetic properties, supporting the development of efficient separation processes in molten salt systems.

Log 607. MEASURING UCl3 CONCENTRATION VIA PHASE TRANSITION VARIATION. Yang W.(1,P), Kim T.(2), Jung C.(3), Cha H.L.(3), Kim J.(4), Jung I.H.(2,5), Bae S.E.(3, 6), Sungyeol Choi S.(1,4,7). (1) Nuclear Research Institute for Future Technology and Policy, Seoul National University. (2) Department of Materials Science and Engineering, Seoul National University. (3) Nuclear Chemistry Technology Division, Korea Atomic Energy Research Institute. (4) Institute of Engineering Research, Seoul National University. (5) Research Institute of Advanced Materials, Seoul National University. (6) Department of Nuclear Science and Technology, University of Science and Technology. (7) Department of Nuclear Engineering, Seoul National University. (P) Presenting Author.

Accurate measurement of UCl3 concentration in molten salts is vital for the safe operation of molten salt reactors (MSRs) and plays a critical role in international safeguards and non-proliferation efforts. Traditional methods, including electrochemical and spectroscopic techniques, face limitations in high-concentration environments due to cost, maintenance challenges, and measurement uncertainties. To address these issues, we propose a novel method to monitor UCl_3 concentration with a temperature sensor, which has a high technical readiness level, in a potential fuel salt (KCl-UCl3) by determining phase transition temperatures. By analyzing liquidus and solidus temperatures during cooling, we established clear correlations between phase transition behavior and UCl_3 concentration in the molten salt. Our experimental work on the KCl-UCl_3 binary system, conducted under an argon atmosphere to prevent oxidation, demonstrated shifts in phase transition temperatures with varying UCl_3 concentrations (0.4 < UCl3 mole fraction < 0.7). This innovative approach provides a cost-effective solution for real-time monitoring of fuel salt composition. It holds significant potential for integration into automated reactor control systems, offering improved safety and efficiency for MSRs. Moreover, the method supports non-proliferation goals by enabling accurate, continuous monitoring of nuclear materials. *This work was supported through the National Research Foundation of Korea (NRF) funded by the Ministry of Science and ICT directly (grant numbers: RS-2023-00229215 and NRF-2022M2D4A1052797).*

Log 608. ACCELERATING THE OPTIMIZATION OF *f*-ELEMENT SEPARATIONS VIA HIGH-THROUGHPUT EXPERIMENTATION AND MACHINE-LEARNING. Augustine, L.J.(1,P); Wang, Y.(1); Lee, J.(1); Adelman, S.L.(1); Batista, E.R.(1); Kozimor, S.A.(1); Taylor, M.G.(1); Schrier, J.(2); Perez, D.(1); Yang, P.(1). (1) Los Alamos National Laboratory. (2) Fordham University. (P) Presenting Author.

The development of efficient, high-yielding separations of the f-elements is a challenging task due to their complex chemistry. Achieving optimal separations requires a comprehensive understanding of how various experimental variables influence the reaction process. Therefore, navigating this complicated, multi-dimensional experimental space efficiently is extremely important. Advances in high-throughput experimentation platforms help expand the accessible experimental domain while improving the robustness of data acquisition. However, due to their high radiotoxicity, limited material availability, and overall costs associated with the f-elements, traditional grid-based sampling approaches for these systems are inefficient and impractical. Therefore, merging high-throughput experimentation with machine-learning decision-making processes can drastically reduce the time and effort required to optimize f-element separations. In this study, we demonstrate this approach by integrating the LANL Super Separator with Bayesian Optimization for liquid-liquid extraction experiments. Using this technique, we optimized the extraction of thorium with the N,N-dialkyl monoamide, DEHBA; showing the need to sample only ~25% of an experimental space composed of over 400 possible experimental combinations. Additionally, we highlight the use of multi-objective optimization for elemental selectivity experiments, and lastly, discuss how incorporating multi-fidelity modeling with kinetic reaction network models can accelerate the optimization process even further.

Log 609. EXPLORING THE DIAGNOSTIC VALUE OF THE STABLE OXYGEN ISOTOPIC SIGNATURE IN NUCLEAR FORENSICS. . Baranowska, P.(1,2, P); Lacey, J.(2); Jones, M.(1); O'Donnel, E.(1); Dunne, J.(3);Dunn, S.(3); Sanders, S. (3) The Unviersity of Nottingham, UK. (1) British Geological Survey, Keyworth, Nottingham, UK. (2) AWE, Aldermaston, Reading, UK. (P) Presenting Author.

Forensic signatures are crucial in determining the origin and production history of materials that have come out of regulatory control, informing law enforcement for further investigation. This research presents a novel, interdisciplinary approach integrating stable isotope geochemistry, surface science chemistry, and material behaviour to develop a robust method for analysing oxygen isotopes ($\delta^{18}O$) in heavy metal oxides including uranium and plutonium bearing materials. The study leverages the interaction between the hydrological and nuclear fuel cycles to design $\delta^{18}O$ as a nuclear forensic tracer. By investigating $\delta^{18}O$ variations in surrogate materials like molybdenum oxides, chosen for their structural similarity to uranium oxides, manageable reactivity, and well-characterized corrosion behaviour, this work offers a safer, scalable alternative for laboratory studies. The development of a novel Elemental Analyser Isotope Ratio Mass Spectrometry (EA-IRMS) method tailored for heavy metal oxides minimizes reliance on hazardous reagents associated with traditional fluorination techniques. Microfluorination, combined with surface science techniques such as Scanning Electron Microscopy (SEM), X-ray Photoelectron Spectroscopy (XPS), and X-ray Diffraction (XRD), is vital to understanding oxygen exchange processes influenced by corrosion and environmental conditions. These insights enhance the forensic utility of $\delta^{18}O$ by linking isotopic variations to the hydrological cycle and environmental exposure. This approach aims to establish $\delta^{18}O$ as a reliable forensic marker for nuclear materials, providing safer, more efficient tools for isotope analysis. Future work will involve inter-laboratory validation and method refinement to evaluate the full potential of $\delta^{18}O$ in tracing nuclear materials.

Log 610. A HIGH-FLUX TRANSIENT NEUTRON BEAM FOR HIGH-SPEED NEUTRON RADIOGRAPHY UP TO 10,000 FRAMES PER SECOND.

Craft, A.E.(1,P); Pinho, A.d.S.S.(1); Gross, B.J.(1). (1) Idaho National Laboratory. (P) Presenting Author.

The Transient Reactor Test (TREAT) Facility is a reactor located at the Idaho National Laboratory which is used for transient testing of materials and experiments with customized power profiles tailored for each experiment. TREAT can provide a peak reactor power of 19,000 MW thermal. The TREAT neutron radiography facility allows for low resolution radiography of experiments between reactor transients with the reactor operating at a steady state power of 80 kW. However, recent efforts have pursued using the neutron radiography facility's neutron beam during a high-power reactor transient to produce a very high flux neutron beam for visualization of highly dynamic processes such as two-phase flow. The TREAT neutron radiography station and beamline collimation have been modified to produce a neutron beam suitable for use with a high-speed digital neutron imaging system. This presentation describes modifications to the radiography system, the high-speed neutron imaging system, and most recent measurements. This developing capability was able to capture dynamic neutron radiography at 10,000 frames per second during a 9,800 MW peak transient.

Log 611. RADIUM-228 TARGET FABRICATION AFTER SEPARATION FROM THORIUM-232 BY POLYVINYLPOLYPYRROLIDONE FOR RADIOPHARMACEUTICAL ACTINIUM-225 PRODUCTION.

Yin, F.(1, P); Yamamura, T.(2); Suzuki, T.(1). (1) Nagaoka University of Technology. (2) Kyoto University. (P) Presenting Author.

The production of actinium-225 using radium-228 based on magnesium oxide targets has been studied. The advantages of this approach include a single neutron capture process, resulting in a higher yield of thorium -229 and fewer radioactive by-products, with short-lived intermediate isotopes. Since radium-228 is a decay product of thorium-232, it is essential to isolate radium-228 from thorium-232. In this study, we successfully separated radium-228 from thorium-232 using crosslinked polyvinylpyrrolidone (PVPP) and employed a co-precipitation methode to obtain magnesium-radium carbonate precipitate. Through subsequent heating, the magnesium-radium carbonate precipitate powder was successfully converted to magnesium oxide with radium carbonate, providing a viable target material for actinium-225 production.

Log 612. EXAMINATION OF URANIUM SORPTION, LOCALIZATION, AND PHYSIOLOGICAL RESPONSE IN MARINE MICROALGAE, ISOCHRYSIS GALBANA. A.K. Gonzales(1,P); E.R. Fix(1); D. A. Montgomery(1); S.E. Donaher(2); P. van den Hurk(3); N.E. Martinez(1). (1) Department of Environmental Engineering and Earth Sciences, Clemson University. (2) Department of Civil and Environmental Engineering, University of Tennessee. (3) Department of Biological Sciences, Clemson University. (P) Presenting Author.

Understanding radionuclide migration and transfer in marine environments is important for developing robust computational geochemical models; however, data describing the influence of ecological processes on the fate and transport of radionuclides in marine systems are limited. In conjunction with geochemical processes, characterization and quantification of ecological processes through examination of biological effects could further develop our knowledge on how biological responses influence transport (e.g., uptake). This presentation describes a selection of laboratory-scale studies that explored the sorption, bioaccumulation, and biological effects in the marine microalgae species, Isochrysis galbana exposed to environmentally relevant levels of radioactivity. I. galbana stock was cultivated in autoclaved F/2 nutrient media with continuous aeration, then transferred to experimental vessels and exposed to 0, 20, and 200 ppm uranium (U) over the course of its exponential growth phase (3 days). To understand the interaction of U with I. galbana, biological endpoints such as biomass, lipid peroxidation, and chlorophyll content were quantified. To characterize U sorption, scanning and transmission electron microscopy techniques provided visualization of radionuclide complexation to the cell membrane and intracellular localization respectively. Preliminary results at higher concentrations (30 and 300 ppm U) suggest no statistically significant difference in chlorophyll content in U treated algae relative to control algae. The aqueous speciation was examined via geochemical modeling, which suggested that the formation of uranyl carbonate complexes may limit the bioavailability of U in solution. Future work will consider plutonium uptake by freshwater algae in a laboratory setting for comparison, building on the work with I. galbana.

Log 613. NOVEL APPROACH TO ELUCIDATING MAGNESIUM-POTASSIUM CHLORIDE VOLATILITY. Harris, M.S. (1, P); Makovsky, K.A. (1); Seo, J. (1); Detrick, K.P. (1). (1) Pacific Northwest National Laboratory (P) Presenting Author.

Thermophysical properties play a critical role for the thermal hydraulic design of a molten salt reactor (MSR). Each property (e.g., density, specific heat capacity, vapor pressure, and volatility) serves an individual role in the behavior of the salt, which in turn affects the function of the reactor. Volatility may have a significant impact on all thermophysical properties necessary for a successful demonstration. In this work the aim was to evaluate the congruity of vaporization, as incongruent vaporization would lead to changes in the residue chemistry which may have significant impacts to reactor design and operation. At the Pacific Northwest National Laboratory (PNNL), a capability to elucidate the volatility of the potassium-magnesium chloride system has been developed. In this technique, an inert furnace is coupled with a conductively cooled condenser rod. Salt is loaded onto a high-purity platinum foil and placed into the furnace. At the target temperature, the salt vaporizes and condenses onto the rod. Three eutectic compositions of KCl-MgCl2 were tested- 43, 65, and 69 mol % KCl at 850 °C for 120 minutes. The condensed salts and residues were characterized by laser induced breakdown spectroscopy (LIBS), scanning electron microscopy energy dispersive x-ray spectroscopy (SEM-EDS), and x-ray diffraction (XRD). Preliminary results suggest the KCl-MgCl2 system does not volatilize congruently, with mass balance calculations showing an enrichment of KCl in the condensate fraction as high as 10%.

Log 614. HIGH-GRADIENT MAGNETIC FILTRATION OF UO2 FROM WATER STREAMS. Hunter, B.W.(1, P); Manard, B.(1); McFarlane, J.(1); Stanberry, J.(1); Szakas, S.(1); Tsouris, C.(1); Vick, M. (1); Wiechert, A.(1); Weber, C.F.(1). (1) Oak Ridge National Laboratory. (P) Presenting Author.

Characterization of actinide particles is a major tool used by the International Atomic Energy Agency to ensure facilities operate according to their declarations. Often, actinides are mixed with innocuous materials that make them difficult or expensive to analyze, and so it is expedient to develop a procedure to separate out the actinide particles. High-gradient magnetic filtration (HGMF) is a non-destructive separation technique that captures magnetic constituents from a matrix containing other non-magnetic species. One characteristic that actinide metals share across much of the group is that they are paramagnetic. This means that they exhibit weak magnetic attraction when placed within a magnetic field. By using HGMF to separate paramagnetic actinide species from standard dust materials, we have shown that we are capable of effectively separating intact UO2 particles from undesirable metal species. This work created a novel HGMF device for magnetic capture that proves effective in the separation of UO2 particles from silica (SiO2) or Arizona road dust (ARD) in suspension. Aqueous suspensions of 10 mg/L UO2 and 100 mg/L SiO2 or ARD were used for these tests. The effectiveness with which UO2 was separated from the other dust species in suspension was determined through characterization of the intact UO2 particles by single particle time-of-flight inductively coupled plasma mass-spectroscopy. Further efforts to refine the capture and elution processes for UO2, and to prove the robustness of this separation technique are currently underway. This work is funded by NA-22’s Research and Development Program.

Log 615. PERFORMANCE OF BORON BASED NEUTRON SCINTILLATOR SCREENS FOR NEUTRON IMAGING. Craft, A.E.(1); Kilby,S.M.(1,P); Chuirazzi, W.C.(1); Schillinger, B.(2); Trunner, C.(3). (1) Idaho National Laboratory; (2) Heinz Maier-Leibnitz Zentrum (FRM II); (3) TU Wien. (P) Presenting Author.

Neutron imaging is one of the first examinations for assessing nuclear fuels and materials after irradiation, which produce high gamma radiation fields that degrade the achievable signal to noise ratios for the resulting neutron radiographs. Recent efforts to develop digital neutron imaging capabilities for such samples include an initiative to create screens with higher neutron capture efficiency that potentially yield improved signal to noise ratios. Recent research has explored development of boron-based neutron scintillator screens, which potentially offer improved spatial resolution and detection efficiency compared to traditionally employed lithium-based screens. This work builds upon previous efforts to improve boron-based neutron scintillators by assessing a newer generation of boron-based scintillator screens fabricated using different combinations and approaches compared to previous generations of screens. This presentation described the current state of screen development, recent measurements of the most recent generation of screens, and future activities.

Log 616. SEPARATION OF I-132 FROM FISSION PRODUCTS BY SOLVENT EXTRACTION FOR GAMMA RAY BRANCHING RATIO DETERMINATION. Lapka, J. L (1, P); Fuller, R. (1); Haas, D. A. (1). (1) The Unviersity of Texas at Austin. (P) Presenting Author.

Iodine-132 is an important isotope of interest for nuclear forensics. Currently there are large uncertainties associated with the gamma-ray branching ratios of I-132 which complicate forensic analyses. Previous separation methods focused on directly separating the Te-132 parent from fissioned uranium or separating iodine using organic solvents such as benzene or carbon tetrachloride. In this work, the extraction and stripping of iodine from nitric acid solutions with n dodecane was studied. By chemically controlling the oxidation state to ensure that iodine is quantitatively converted to I2, up to 94% extraction of iodine with cold carrier was achieved, followed by chemical reduction to strip I- back into the aqueous phase. Utilizing this procedure, I-132 was successfully and selectively extracted from the bulk fission products to allow for radiometric counting and gamma decay branching ratio determination. The separation of I-132 from fissioned uranium and its impact on nuclear data measurements is discussed.

Log 617. SEPARATION OF Zr-88 AND Y-88 FOR THE PREPARATION OF Zr-88 TARGETS IN NUCLEAR DATA MEASUREMENTS. Lapka, J. L. (1, P); Nolting, D. D. (1); Charlton, W. (1); Moldenhauer, J. (2) Flanagan, W. H. (1, 2). (1) The Unviersity of Texas at Austin. (2) University of Dallas. (P) Presenting Author.

Zr-88 has recently been shown to have the second largest known thermal neutron capture cross section. Measurements performed since 2019 have indicated a cross section on the order of 800,000 barns for thermal neutrons; however, there are significant discrepancies in the estimated resonance integral. Multiple new irradiation experiments were planned to investigate the discrepancy utilizing the n_TOF facility at CERN and the UT Austin TRIGA reactor as neutron sources. For these experiments, several Zr-88 targets were prepared for irradiation from an accelerator produced solution of Zr-88. Due to the age of the Zr-88 sample, the activity of the decay product Y-88 presented radiological handling and gamma counting issues that necessitated separation from the Zr-88. 2-diethylhexyl phosphoric acid (HDEHP) was used to extract Zr-88, leaving any of the original Y-89 target and Y-88 decay product in the aqueous phase. Zr-88 was then stripped from the organic using oxalic acid. Oxalic acid was then decomposed by the addition of nitric acid and hydrogen peroxide under heating. The Zr-88 residue was redissolved and dried onto a Kapton tape target to be used for each nuclear data measurement. This separation resulted in 98% removal of the total Y content while significantly reducing the sample dose rate.

Log 618. ENHANCING NEUTRON IMAGING CAPABILITIES AT LANSCE WITH TIMEPIX TECHNOLOGY: KEY INSIGHTS, ACHIEVEMENTS, AND FUTURE OUTLOOK. Long, A.M.(1,P); Losko, A.S.(2); Hirsh, T.Y.(3); Wolfertz, A.(2); Jaeger, T.T(4); Vogel, S.C.(1). (1) Los Alamos National Laboratory, Los Alamos, NM 87545, USA. (2) Forschungs Neutronenquelle Heinz Maier Leibnitz, Garching, 85748, Germany. (3) Soreq Nuclear Research Center, Yavne, 81800, Israel. (4) Technical University Darmstadt, Darmstadt, 64289, Germany. (P) Presenting Author

Timepix based imaging sensors coupled with neutron-sensitive scintillators have demonstrated significant potential to advance neutron imaging capabilities, offering many advantages over other systems. These sensors feature a data-driven readout that allows researchers to identify and group pixel activations or photon distributions into discrete scintillation events. Events can be classified as neutron or background, with precise timing and position information readily determined. This capability enables the generation of neutron images with minimal background and exceptional timing accuracy, making these systems a valuable tool for advanced neutron imaging. Furthermore, the optical-based nature of the system offers a high degree of configurability, allowing it to be tailored to diverse experimental setups. This flexibility supports various neutron-sensitive scintillators, detector geometries, and configurations, making it a versatile tool for numerous imaging applications. At the Los Alamos Neutron Science Center (LANSCE), neutron imaging capabilities span several beamlines, covering nearly 10 orders of magnitude in neutron energies. Integrating these systems into the available beamlines has opened new opportunities in neutron imaging, including improved neutron resonance imaging, simultaneous Bragg-edge imaging and diffraction, and reaction product tracking in fast neutron imaging. In this presentation, I will discuss lessons learned in integrating these systems into our many beamlines, provide an overview of current capabilities, and outline potential future directions for advancing neutron imaging at LANSCE.

Log 619. PROMPT GAMMA ACTIVATION ANALYSIS OF BRONZE AGE ARTIFACTS. Maróti, B. (1,P), Révay, Zs. (2), Tarbay J.G. (3), Bíró, Cs. (4). (1) HUN-REN Centre for Energy Research. (2) Forschungs-Neutronenquelle Heinz Maier-Leibnitz (FRM II). (3) HNM Public Collection Centre. (4) Tűzvarázs Művészeti Műhely (bronze casting workshop). (P) Presenting Author.

In the literature, the composition of archaeological bronzes is determined typically by XRF, PIXE, and SEM-EDX methods. In the recent years, PGAA has become more widespread in the analysis of bronzes and other archaeological alloy types, as it provides the average composition of several tens of cubic mm volume, which is at least an order of magnitude larger than in case of X-ray based methods. Comparison of these data often requires attention, as non-destructive XRF and PIXE are surface analytical methods, while SEM-EDX analysis is invasive and is usually performed on a clean and polished alloy surface. The aim of this study was to determine the bulk alloy composition of small sub-samples taken out from original Bronze Age and replica bronzes and to compare them with the SEM-EDX results, as well as previous PGAA concentration data obtained at different parts of the intact objects. Some important alloy components (e.g. Sn, Sb, Pb) and impurities (Sb, As) are difficult or time consuming to determine in copper matrix using PGAA. We also observed discrepancies while comparing the previously measured bulk concentrations with those determined with surface and / or invasive methods. The uncertainties of Sb and As concentrations with PGAA were in the range of 10%. To overcome this, we combined PGAA and in-beam activation analysis to measure the alloying components and the impurities with high accuracy and precision. The PGAA evaluations were repeated using the fully revised PGAA database based on new measurements performed in FRM2's high intensity cold neutron beam.

Log 620. HPGE PROBES: INNOVATIVE, ADAPTABLE CHARACTERIZATION TOOLS FOR USE IN CHALLENGING OPERATING CONDITIONS. Masseron, J. (1, P); Ilie, G. (2); Ginsz, M. (1); Ralet, D. (1); Altermatt, G. (1). (1) Mirion Technologies (Canberra) SAS - Lingolsheim, France ; (2) Mirion Technologies Inc. - Meriden, CT, USA. (P) Presenting Author.

Invented in the 1970s, High-Purity Germanium (HPGe) detection technology is still today the benchmark for gamma spectrometry thanks to its detection features, particularly its excellent energy resolution performance. However, HPGe detectors remain complex to implement (cryogenic cooling, advanced vacuum levels required, fragility, vibration sensitivity, etc.), encouraging them to be used under controlled conditions, such as in laboratories. Despite this, Mirion has made major advances in electrical cooling and thermal design and managed to develop HPGe detectors suited for challenging use conditions, such as the all-in-one spectrometer AEGIS. But, in some cases, the AEGIS spectrometer cannot cope with all the requirements and constraints. In response, Mirion has developed Specialty HPGe probes, innovative and adaptable tools that combine proven technological blocks. Numerous adaptation possibilities are possible to meet every need: HPGe crystal type and size selection to optimize detection features, adapted electrical cooler in terms of power and dimensions to meet any footprint constraints, and so on. An overview of recent developments will be presented, listing the challenging needs and encountered constraints, and how we have responded to them. Concrete technical results will also be presented. Finally, usable as all-in-one solutions, these HPGe detection solutions can also be considered as components and integrated into more global systems, making them very agile and opening the way to new and valuable applications for which HPGe detectors will surely be beneficial.

Log 621. P-TYPE SINGLE-ELEMENT DETECTORS: COMBINING P-TYPE BETTER ENERGY RESOLUTION AND X-RAY DETECTORS HIGHER COUNT RATES CAPABILITY. Masseron, J. (1, P); Ginsz, M. (1); Ilie, G. (2); Legras, J.-B. (1); Ralet, D. (1). (1) Mirion Technologies (Canberra) SAS - Lingolsheim, France; (2) Mirion Technologies Inc. - Meriden, CT, USA. (P) Presenting Author.

The Mirion BEGe Broad Energy Ge Detector uniquely covers an energy range from 3 keV to 3 MeV. The resolution at low energies is equivalent to that of our Low Energy Ge (LEGe) Detector and the resolution at high energy is comparable to that of coaxial (SEGe) detectors. The BEGe detectors are widely recognized for their exceptional performance, offering a combination of high detection efficiency and excellent energy resolution. To advance radiation detection technologies and improve the count rate obtain with the detector, we recently developed a single element p-type HPGe detector, close to a BEGe detector, but equipped with a transistor reset preamplifier, thus combining the excellent energy resolution performance and larger energy range covered by BEGe detectors with LEGe detectors' higher count rates capability. This presentation will provide an overview of this newly designed technology, emphasizing the performance measurements achieved with the new detector, particularly its enhanced energy resolution, high counting rates capabilities, and good detection efficiency up to 1.5 MeV. The new p-type detector development in conjunction with a Mirion Lynx II MCA provides an excellent gamma spectroscopy performance across an energy range up to few MeV. This detector technology offers a potentially optimized solution for applications demanding exceptional energy resolution at high count rates, delivering superior performance compared to existing detectors in areas such as radiochemistry, medical radionuclide production, and nuclear fuel manufacturing.

Log 622. NEW IN-LINE MONITOR OF URANIUM OR PLUTONIUM IN NUCLEAR FUEL FACILITY PROCESS STREAMS. McKisson, J.E.(1,P); McKisson, J (1); Ratner, R.T.(2). (1) McKisson Integrated Systems, LLC. (2) Nuclear Fuel Services, Inc. (P) Presenting Author.

Nuclear fuel production typically requires in-line process monitoring to quantify uranium or plutonium in material flow streams. For this process monitoring, gamma radiation emanating from U-235 or Pu-239 is used to quantify the respective uranium and plutonium concentration within solutions. The monitoring is an essential process to manufacturing operations, material accountability, and nuclear criticality safety. When production feed materials transitioned to more recycled content, monitoring requirements exceeded the capabilities of traditional Single Channel Analyzer (SCA) monitors. Therefore, a spectroscopy-based In-Line Monitor System (ILMS) was developed in the early 2000's to respond to the more challenging monitoring requirements of material flow streams. Additional ILMS improvements included enhanced fault detection and fail-safe performance. A new, third-generation ILMS (or ILMS3) has been developed in the last several years to modernize the original electronics and to provide additional capabilities and design features. For uranium applications, the ILMS3 monitors the U-235 concentration in a flow stream by gathering gamma energy spectra and calculating 185-kiloelectron volt (keV) peak activity in the possible presence of other radioactive impurities. One or more sodium iodide scintillators provide input to a multichannel analyzer (MCA), which accumulates spectra over short time periods. Each gamma spectrum is analyzed to quantify several parameters. A central parameter test determines if the U-235 concentration in the processing line exceeds a predetermined limit. Although the ILMS3 has been primarily tested for U-235 materials, the instrument could also be used to monitor the 414-keV gamma from Pu-239. The ILMS3 base design offers fail-safe performance with redundant monitoring of systems and interfaces, so that any component failure results in closure of associated valves, consequently providing a safe condition of the uranium or plutonium materials. The features, design, testing, and performance of the ILMS3 are described.

Log 623. DETERMINATION OF RESIDUAL STRESS BY X-RAY DIFFRACTION. Newell, B.S. (1,P); Chuirazzi, W.C. (1). (1) Idaho National Laboratory. (P) Presenting Author.

As the demand of the world's energy needs continue to increase, the attractiveness of nuclear power as an energy-dense, carbon-free power source is clear. To be licensed for commercial use, however, new nuclear designs must by thoroughly developed, tested, and studied. To aide in the development and commercialization of novel nuclear concepts, Idaho National Laboratory (INL) is at the center of US Department of Energy's mission for nuclear research. Part of this mission involves the pre- and post-irradiation examination (PIE) of nuclear materials to assess their performance in the harsh environments of nuclear reactors. The Irradiated Materials Characterization Laboratory (IMCL) at INL exists for the purpose of performing PIE on these materials to assist in the determination of their operation in reactor conditions. Presented are XRD results used to determine the residual stress in directed energy deposition (DED) stainless steel 316L (SS316L) for the Advanced Materials and Manufacturing Technologies (AMMT) program. Advanced manufacturing (AM) can help produce nonstandard parts for nuclear reactors that cannot be manufactured via traditional means. It also provides a route to thwarting the supply chain which can reduce lead times that are historically long. This is particularly useful when considering the potential use of AM SS316L for producing structural components of nuclear reactors.

Log 624. STRUCTRUAL DETERMINATION AND CHARACTERIZATION OF A NOVEL URANYL TETRANUCLEAR CLUSTER.

Russell, I.A.(1,P); Emory Z.C.(1); Sockwell, A.K.(1); and Hixon, A.E.(1). (1) University of Notre Dame. (P) Presenting Author.

We report here the structure of a novel tetranuclear uranyl cluster with the formula (UO2)4O2Cl4(H2O)6·2H2O. This cluster crystallizes in the space group C2/c with unit cell parameters a = 14.0516(2) Å, b = 10.29170(10) Å, c = 16.7314(2) Å, and β = 116.692(2)˚. The cluster fits within a class of polynuclear uranyl complexes capped by waters and chlorides and bridged by oxo, chloride, and hydroxy groups. Uniquely, this cluster contains four μ2 chloride bridges and is completely capped with waters, maintaining a neutral charge. It takes a nearly planar geometry with two unique uranium sites that make up a tetramer of edge sharing pentagonal bipyramids. A previously reported binuclear cluster, (UO2)2(OH)2Cl2(H2O)6, also formed during synthesis. Both the tetranuclear and binuclear complexes are characterized here with ss-UV-Vis, IR, and Raman spectroscopy. These clusters may exist stably in solution, having implications for uranium speciation in high chloride environments such as long-term geological repositories.

Log 625. DECONTAMINATION POTENTIAL OF RADIOACTIVELY CONTAMINATED WOUNDS WITH PURIFIED CLINOPTILOLITE-TUFF.

Welch, J. (1); Foster, M. (1); Sterba, J.H. (1, P); Nagl, D. (2); Tschegg, C. (2). (1) Center For Labelling and Isotopte Production, TRIGA Center Atominstitut, TU Wien, Vienna, Austria; (2) GLOCK Health, Science and Research GmbH; Deutsch-Wagram, Austria

Zeolites are well known for their large and often specific ion-exchange capacities and natural clinoptilolite-rich zeolite-tuffs have shown good selectivity and large capacities for cesium and strontium. By purification of a specific zeloite-tuff, the material was made useable for health applications, including benefits for wound repair and regeneration. Combining the ion-exchange capacities and the health applications, the purified clinoptilolite-tuff (PCT) was suggested for its application in a PCT-doped wound dressing in a radiolytically contaminated environment. To this end, initial quantitative studies of the capacity of the specially prepared clinoptilolite for SrCl2 utilizing Sr-85 radiotracered material and CsCl utilizing Cs-134 radiotacered material in both aqueous (AQ) and physiological (artificial wound fluid exudate; AWFE) media were performed. Additionally, preliminary qualitative information relating to the selectivity of the material studied for Sr2+ and Cs+ vs Ca2+ on the basis of radiotracer studies will also presented. Finally, proof of concept experiments comparing uptake of radio-Cs and radio-Sr by state of the art wound dressings and PCT-doped wound dressings will also be presented.

Log 626. FORWARD MODELLING OF ANALYTICAL OUTCOMES FOR INTENTIONALLY TAGGED NUCLEAR FUELS. Wellons, M. (1,P); Gamble, S. (1); Samperton, K. (1); Green, G. (1); Hoar, E. (1); Fitzgerald, C. (1); Scott, S. (1); Osborn, J. (2); Lutz, E. (2); Shields, A. (3); Wilson, B. (3); Marks, N. (4); Chamberlin, R. (5). (1) Savannah River National Laboratory. (2) Sandia National Laboratory. (3) Oak Ridge National Laboratory. (4) Lawerence Livermore National Laboratory. (5) Los Alamos National Laboratory. (P) Presenting Author.

A multi-lab project, the Intentional Forensics Venture (IFV), has been focused on the deliberate introduction of benign and persistent material signatures into nuclear fuel fabrication and processing. Isotopically enriched dopants, or taggants, aim to positively mark fuels, pre-irradiation, and post-irradiation, as a potential nuclear forensics tool. There are numerous taggant incorporation and use scenarios including specific targeted taggant endmember isotope ratios, their concentration within nuclear fuel, and use in various nuclear reactor operations. Three metals (Ni, Mo, and W) were selected for physical experimentation as taggants incorporated into UO2 Minifuel and then irradiation at the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory. The selected taggants contain a double spike of two stable isotopes that can be readily distinguished from any elemental impurity of natural isotopic distribution. Prior venture efforts have focused on synthesis and high-fidelity mass spectrometry bulk analysis characterization of these compositions. More recently, HFIR reactor simulations where preformed to model taggant transmutation in preparation for post irradiation Minifuel examination activities. The simulated post-irradiation values for taggant isotopic ratio and elemental composition were incorporated into a forward analytical model capable of simulating mass spectrometry characterization results. Planning considerations, initial modelling of taggant nuclear transmutation, and forwarded modelled mass spectrometry results will be presented.

Log 627. RADIOISOTOPE DATING OF NUCLEAR MATERIALS USING CRYOGENIC DECAY ENERGY SPECTROMETRY . Wood R.(1, P); Kim G.B.(2); Jovanovic I.(1). (1) University of Michigan. (2) Lawrence Livermore National Laboratory. (P) Presenting Author.

Nuclear dating is a key component of nuclear forensics, providing information on sample ages and their production histories. Various nuclear dating techniques can determine the time since nuclear material purification, differing in accuracy, efficiency, and turnaround time. Mass spectrometry provides high accuracy but is hindered by isobaric interferences and turnaround times that can extend to weeks. Semiconductor-based spectroscopy offers rapid turnaround times but is limited in accuracy due to its strong dependence on branching ratios and can also be constrained by energy resolution. Decay Energy Spectrometry (DES) is a promising alternative to complement existing nuclear dating techniques. DES utilizes cryogenic microcalorimeters to measure radionuclide decays with a 4π-detection geometry, enabling precise measurement of the absolute activities of each radioisotope. This allows for direct comparison of parent and daughter isotope quantities within a few days without requiring chemical separations. A DES experiment was conducted using a magnetic microcalorimeter (MMC) to determine the age of a surrogate nuclear forensic sample. A sensitivity study of DES to various radiochronometers, including 235U-231Pa, 238U-234U, 241Pu-241Am, 240Pu-236U, and 238Pu-234U, was performed. Digital signal processing techniques were also studied to reduce pulse pile-up and improve the counting speed of DES, enhancing sensitivity to chronometers with longer half-lives.

Log 628. A NOVEL METHOD FOR MEASURING PARTIAL VAPOR PRESSURES OF A MOLTEN SALT MIXTURE VIA COMBINED HORIZONTAL TRANSPIRATION AND TGA/DSC ANALYSIS.

Yankey, J.A. (1, P); Cernyar, M. (1); Leavitt, C. (1); Monreal M. (2); Jackson, M. (2); Holland, J. (3); Fitzhugh, R. (3); Simpson, M. (1). (1) The University of Utah. (2) Los Alamos National Laboratory. (3) Oak Ridge National Laboratory. (P) Presenting Author.

A novel method combining thermogravimetric analysis (TGA) and horizontal transpiration coupled with elemental analysis allows for the calculation of partial pressures of molten salts in mixture. The technique uses TGA to measure constant rate of total mass loss and horizontal transpiration to generate condensate for elemental analysis to determine vapor phase composition. Two chloride salts (NaCl-MgCl2 eutectic and NaCl-MgCl2 + UCl3 (4.89 wt.%)) and one mixed halide salt (LiCl-LiF + Li2O (1.98 wt.%)) were tested using this method at 750 and 550oC (for the chloride and mixed halide salts, respectively). Argon carrier gas flow during TGA ranged from 5 to 100 cc/min to achieve saturation. For the chloride mixtures, inductively coupled plasma mass spectrometry measured relative concentrations of cations evaporated from the salt. For the mixed halide salt, ion chromatography measured relative concentrations of anion evaporated from the salt. Vapor pressures for NaCl, MgCl2, and UCl3 were calculated at 750oC to be 2.19-2.42 x 10^-4, 2.29-2.48 x 10^-5, and 1.32 x 10^-7 atm, respectively. Vapor pressures for LiCl and LiF were calculated at 550oC to be 1.53 x 10^-6 and 6.32 x 10^-6 atm, respectively. Additionally, samples of unary LiCl and LiF were tested at 650 and 875oC (with argon flow rates from 10 to 80 cc/min), respectively, to validate the method against known values and establish confidence.

Log 629. EXPERIENCES IN METHOD DEVELOPMENT OF ULTRA-TRACE Np-237 MEASUREMENTS BY MASS SPECTROMETRY IN ABSENCE OF A Np-236 TRACER.

Dunne, J.A.(1, P); Jiang, J.(1); Page, S.(1); Stow, M.(1); Stokes, T.(1); Horgan G.(1). (1) AWE. (P) Presenting Author.

Measurement of neptunium is required for environmental monitoring, waste characterisation, and nuclear forensics. Isotope dilution mass spectrometry is an established measurement method the Radiochemistry community is reliant on for assay of analytes present in trace quantities. The technique requires the sample of interest and an isotopic spike of known molality to be weighed with a high degree of precision. As identified previously, there are no commercially available isotope dilution tracers of suitable purity and traceability for measurement of 237Np. This is a chronic issue for the Radioanalytical Chemistry community. This presentation outlines alternative approaches and corresponding recommendations for measurement of 237Np where a suitable 236Np tracer is not available. Specifically, production and calibration of 239Np for chemical yielding, chemical yielding measurements by gamma spectrometry, separation of 237Np from sample matrix, comparison of mass spectrometry methods. Validation data using NIST Standard Reference Material 4341a and NPL Neptunium-237 Standard Solution R210420200204371 A200005, are presented that demonstrate accuracy at the sub-picogram level with estimated relative uncertainties on the order three percent at one sigma. Finally, application of these measurements are discussed in the context of recently published work from our laboratory on plutonium radiochronometry, lower level environmental samples (Standard Reference Material NIST 4350B, Columbia River Sediment), and a recent blind laboratory intercomparison exercise.

Log 630. NOVEL TOOLS FOR INTERPRETATION OF URANIUM DISEQUILIBRIUM IN COMPLEX FUEL CYCLE MATERIALS. Dunne, J.A.(1, P); Higginson, M.A.(1); Gilligan, C.R.D.(1); Cross, S.(1). (1) AWE. (P) Presenting Author.

Over the last 10 years, radiochronometry has become an important nuclear forensic signature for assessing the process history of unknown nuclear material. Together, multiple chronometric pairs may be used to obtain a model production date of a material with confidence. Modern analytical techniques can measure these atom ratios to high accuracy and precision. However, recent work demonstrates that measurement uncertainties can underestimate the variability of this signature. This issue is exacerbated where nuclear industry processes chemically fractionate uranium decay progeny to yield discordant model ages. A phenomenon that is common to the nuclear fuel cycle. The current paradigm amongst the Nuclear Forensics community assumes a discordant model age limits the utility of this signature to being comparative rather than predictive. Currently there is limited information in the open literature that details tools for interpretation of a discordant model age. There is no consensus amongst the Nuclear Forensics community regarding an accepted approach for interpretation of discordant model ages. Furthermore, the challenge of interpretation is increased when heterogeneity is considered. This presentation proposes tools and approaches for interpretation of discordant radiochronometric signatures that have recently been established and applied to complex fuel cycle materials. This initial work aims to steer the community towards establishing more robust tools and an agreed approach for interpretation of discordant signatures.

Log 631. MIXED U-Pu MICROPARTICLE METROLOGY USING LG-SIMS. Groopman, E.E. (1, P), Williamson, T.L. (1, P), Foley, B. (2), Bronikowski, M. (2), Scott, S.M. (2,3), Wellons, M. (2), King, G. (2), Samperton, K. (2). (1) National Institute of Standards and Technology. (2) Savannah River National Laboratory. (3) DOE/NNSA Office of International Nuclear Safeguards. (P) Presenting Author.

We present on the metrology of large-geometry secondary ion mass spectrometry (LG-SIMS) measurements of mixed uranium-plutonium microparticles. Mixed actinide analysis in microparticles is typically challenged by the presence of molecular isobaric interferences (such as 238U1H on 239Pu) and surface chemical effects that can introduce analytical artifacts. At the National Institute of Standards and Technology (NIST), we developed a new LG-SIMS multicollector protocol for simultaneous U and Pu isotopic and assay analysis. We investigated hydride correction algorithms and demonstrated that using O3- primary ions to consume most of each particle yielded highly reproducible isotopic and assay results (< 1% variance relative). We discuss several ways that apparent analytical artifacts can introduce variance into particle measurement results. There currently exist few, if any, certified mixed U-Pu microparticle reference materials that are widely available. The U-Pu particles measured here were produced and characterized in bulk by Savannah River National Laboratory (SRNL). Here, the use of highly homogeneous particles aided in the development of new analytical methods and the identification of measurement artifacts. Further development and characterization of microparticle reference materials coupled with advances in metrology will have a positive impact on the international nuclear materials analysis community.

Log 632. RADIOCHEMICAL METHODS IN PRODUCTION OF RADIONUCLIDES AT A CYCLOTRON. Bernd Neumaier, Syed M. Qaim.

Radiochemical methods play an important role at various stages of development of production methodologies of novel radionuclides, namely nuclear data measurement, high-current targetry, chemical processing of the irradiated material and quality control of the prepared products. Our work at the Forschungszentrum Jülich (Germany) is broad-based, involving all those areas of investigations, utilizing mainly the newly installed Cyclone 30XP (IBA, Belgium). The major emphasis is, on one hand, on production of non-standard positron emitters like 45Ti, 64Cu, 72As, 86Y, 124I, etc. using low-energy nuclear reactions like (p,n) and (d,2n), mostly on highly-enriched targets and, on the other, on therapeutic radionuclides like 67Cu, 77Br and 193mPt, also using enriched targets. A host of radioanalytical techniques like ion-exchange, solvent extraction, dry distillation and thermochromatography are used to prepare the desired radionuclide in a pure form. A few typical examples will be presented. Very recently we have intensified our efforts regarding the use of the 30 MeV alpha-particle beam to produce special radionuclides, with particular reference to 193mPt for Auger therapy and 211At for alpha-targeted therapy. A collaborative network of cyclotron laboratories, with the available apha-particle beam, is being built in Europe to produce 211At for broader use.

Log 633. EVALUATION OF MACHINE LEARNING ALGORITHMS FOR NUCLEAR MONITORING APPLICTIONS. Pace, J.(1); Biegalski, S.R.(1,P) (P) Presenting Author.

Measuring radioactive signatures from decaying elements is crucial for international nuclear safety and monitoring. For instance, sparse amounts of radioactive xenon detected within the atmosphere serve as evidence of nuclear fission reactions. 131m Xe, 133 Xe, 133m Xe and 135 Xe are key xenon gaseous isotopes which international monitors use to recognize and categorize nuclear events. When these gaseous elements decay, unique beta-gamma energy spectra are produced; however, the different spectra from these elements can overlap. The work of the present study is to use machine learning methods, in particular the kmeans clustering algorithm, to classify and differentiate various radioactive spectra. Several methods of data organizing are implemented to investigate the algorithm’s precision in identifying and grouping distinct energy spectra. Overall, this investigation shows machine learning can be used to categorize distinct energy spectra and provide accurate isotope identification.

Log 634. DEVELOPING A COST-EFFECTIVE MULTISPECTRAL IMAGING SYSTEM FOR REAL-TIME NUCLEAR FUEL PELLET INSPECTION. Dunphy, R. D. (1, P); Bandala, M. (2); Boxall, C. (2); Chard, P. (3); Cockbain, N. (4); Eaves, D. (5); Edwards, P. R. (1); Goddard, D. (4); Hutchinson, D. (5); Ma, X. (2); Marshall, S. (1); Martin, R. W. (1); Murray, P. (1); Parker, A. J. (2); Stirzaker, P. (5); Taylor, C. J. (2); Wilbraham, R. (2); Zabalza, J. (1); Joyce, M. J. (2). (1) University of Strathclyde, Glasgow, G1 1XW, UK. (2) School of Engineering, Lancaster University, Bailrigg, Lancashire, LA1 4YR, UK. (3) Mirion Technologies, Warrington, UK. (4) National Nuclear Laboratory, Workington, UK. (5) Westinghouse Springfields Fuels Ltd., Salwick, Preston, PR4 0XJ, UK. (P) Presenting Author.

The production of sintered uranium dioxide (UO2) nuclear fuel pellets is a crucial process in the nuclear power industry. Given the intended use of these pellets - to provide fuel in nuclear reactors - ensuring the integrity and quality of UO2 pellets during- and post- manufacture is paramount. Currently, quality assurance (QA) methodologies tend to rely upon sampling and time-consuming offline lab analysis as well as subjective human visual inspection on the production line. In this work, we propose that QA for nuclear fuel manufacturing can be improved by Hyperspectral imaging (HSI) - a powerful technique which can be used to image a scene to capture combined spatial and spectral data simultaneously. In recent work, we have shown that HSI has been successfully used to characterise UO2 pellets and we have identified useful spectral regions in the short-wave infrared (SWIR) range [1000 nm – 2500 nm]. In particular, we have identified prominent absorption bands at around 1100 nm and 2300 nm, as well as a series of smaller spectral features between 1300 nm and 1750 nm. A key challenge for deploying HSI on the production line is associated with the cost of the HSI system itself. To address this, we have designed, built and tested a relatively low-cost multispectral imaging (MSI) sensor (10 wavelengths rather than 100s) to perform QA of UO2 fuel pellets during manufacture. In this paper, we compare the results of our novel MSI sensor against the full HSI sensor to determine its utility in practice.

Log 635. DIAMOND DETECTOR WITH NOVEL CONTACTS FOR NEUTRON SPECTROSCOPY. Young, G.J.(1,P); Ison, A.H.(1); Romero-Romero, E.(1). (1) Nucleon Power, Inc. (P) Presenter

A single crystal CVD diamond detector was developed to explore its potential for high-resolution neutron spectroscopy of a D-T fusion source. In contrast to previous efforts, the challenge of achieving high-quality ohmic or Schottky contacts was addressed through a straightforward cleaning procedure and the use of pressure-adhered indium foil. The detector was coupled with an ultra-low-noise preamplifier compatible with both warm and cryogenic FETs. When exposed to high-energy neutron sources, including 241Am-Be and D-T fusion, the contacts successfully collected charge from both the 12C(n,n') and 12C(n,α) reactions, achieving spectroscopic quality at room temperature and under cryogenic conditions. The detector, paired with the preamplifier, provided high-resolution neutron spectra across multiple temperature cycles and varying neutron flux conditions, demonstrating the viability of this approach for precise high-energy neutron spectroscopy.

Log 636. REFINED DETERMINATION OF k0 AND Q0 FACTORS FOR KEY SHORT-LIVED RADIONUCLIDES IN k0-NEUTRON ACTIVATION ANALYSIS. Truong, T.S. (1); Ho, M.D. (2); Ho, V.D. (2); Tran, Q.T. (3); Hoang, S.M.T. (4,P). (1) HCMC University of Education. (2) Center for Nuclear Technologies. (3) Dalat Nuclear Research Institute. (4) Thu Dau Mot University. (P) Presenting Author.

The present study meticulously re-determined the k0 and Q0 factors, which are pivotal for the k0-neutron activation analysis (k0-NAA) method, for three short-lived radionuclides: 116m2_In, 165m_Dy, and 183m_W. The experiments were conducted at Vietnam's 500 kW Dalat Research Reactor (DRR). The k0 factors, ascertained using the "Bare monitor" method at the Thermal Column (TC) where f is approximately 200, displayed excellent agreement with established literature values. In contrast, the Q0 factors obtained via the "Cd-ratio" method at Channel 13-2 showed significant deviations, suggesting the need for potential methodological refinements or further investigation into unexplored discrepancies. This highlights the inherent challenges in accurately determining Q0 factors for short-lived radionuclides and underscores the importance of continuous validation against established benchmarks. The results of this study contribute valuable data to the nuclear database for k0-NAA, emphasizing the necessity for ongoing examination and potential re-evaluation of existing values as new data and advancements emerge.

Log 637. EFFECTIVE TREATMENT OF COLORED WASTEWATER USING ELECTRON BEAM IRRADIATION: A SUSTAINABLE SOLUTION FOR THE TEXTILE INDUSTRY. Hoang, S.M.T. (1,P). (1) Thu Dau Mot University. (P) Presenting Author.

Colored wastewater, primarily originating from the textile industry, presents a significant environmental challenge, particularly in countries with expanding textile sectors such as Vietnam. This investigation examines the treatment of colored wastewater using electron beam (EB) irradiation at an energy level of 10 MeV. The study's findings indicate a systematic decrease in various wastewater parameters as the irradiation dose was escalated up to 30 kGy. Specifically, at this dose, there was an observed reduction in pH by 18%, a decrease in chemical oxygen demand (COD) by 75%, a diminution in biological oxygen demand (BOD) by 70%, and a significant decrease in color intensity by 95%. The combination of EB irradiation with 3.8 mM hydrogen peroxide (H2O2) proved synergistic, effectively lowering the necessary irradiation dose while simultaneously increasing the degradation efficiency of color, COD, BOD, and pH in the wastewater. This approach leverages the chemical changes induced by ionizing radiation, which includes the generation of reactive species that facilitate the degradation of organic pollutants.These results highlight the potential of electron beam irradiation as a viable and scalable method for the treatment of colored wastewater in industrial applications. The technique capitalizes on the radiation-induced chemical transformations to address environmental pollutants, thereby supporting sustainable and dependable wastewater management strategies in the textile industry.

Log 638. COMPREHENSIVE DETERMINATION OF THE ELEMENTAL COMPOSITION OF COMMON ELECTRONIC WASTE COMPONENTS USING NEUTRON-BASED METHODS. Buczkó, N.A.(1,2); Maróti, B.(1); Gméling, K.(1, P); Szentmiklósi, L.(1). (1) HUN-REN Centre for Energy Research, Budapest Neutron Centre. (2) ELTE Eötvös Loránd University, Hevesy György PhD School of Chemistry. (P) Presenting Author.

Nowadays, the presence of waste electrical and electronic equipment (e-waste or WEEE) has become one of the most important environmental problems. Their recycling could significantly reduce their impact on the environment and in addition they could become a valuable secondary source of raw materials. The development of efficient, economical, safe, and environmentally friendly recycling methods requires knowledge of their elemental composition, which is frequently unknown. In our work, we have investigated the applicability of different neutron-based analytical methods such as INAA, PGAA and in-beam NAA for the determination of the elemental composition of two common types of e-waste, printed circuit boards and integrated circuits. These methods have several advantages that make them suitable for the analysis of WEEE, such as multi-element techniques that enable the direct analysis of solid samples without dissolution. Furthermore, matrix effects are typically negligible or easily correctable, providing a major advantage in the analysis of WEEE, which often have highly complex compositions. We identified the advantages and limitations of each method, as well as the elements measurable by the different methods and the achievable detection limits. Each method was capable of determining only a subset of the important elements; however, the combination of methods made it possible to measure most of the valuable, critical and hazardous elements. The concentrations measured with the different methods were in good agreement with each other.

Log 639. DETERMINATION OF NEUTRON ABSORPTION SELF-SHIELDING FACTORS FOR THREE LANTHANIDE ELEMENTS DURING NEUTRON ACTIVATION ANALYSIS. Ross, W., (1,P) Landsberger, S. (1), Kennedy, G. (2). (1)The University of Texas at Austin, (2) Ecole Polytechnique, Montreal: (P) Presenting Author.

Neutron Activation Analysis (NAA) is a non-destructive method of analyzing the elemental composition of a sample with detection limits that can reach parts per billion for some isotopes. When conducting NAA, materials with high absorption cross-sections reduce the overall neutron flux within the sample by absorbing incident neutrons. This effect is known as neutron self-shielding. The implementation of correction factors that can account for these effects are important in increasing the accuracy of NAA.The objective of this research was to determine neutron self-shielding factors for gadolinium, european and samarium for a range of elemental concentrations which are the major rare-earths that lead to neutron self-shielding.

Log 640. SOURCE TERM ANALYSIS OF 127Xe FROM SURFACE AND SUBSURFACE TRACER TRANSPORT EXPERIMENTS OF THE PE1 SERIES. Slack, J.L.(1); Emmons, S.B.(1); Johnson, C.M.(1,P); Britt, C.G.(1); Keillor, M.E.(1); Knox, J.M.(1); Moore, M.E.(1); Morris, A.V.(1); Taguba, C.T.(1); PE1 Experiment Team(2). (1) Pacific Northwest National Laboratory. (2) See Authorship list on Experiment Report LLNL-TR-864107. (P) Presenting Author.

The development and validation of noble gas transport models through field collected data is critical in the improvement of nuclear explosion monitoring techniques. Complex surface terrain in the area of release can drastically impact the transport of the resulting plume and the subsurface geology can alter material flow to the surface resulting in large discrepancies in release times. To better understand these effects and provide validation data for modeling, 127Xe was utilized as a radiotracer in multiple large-scale, multi-physics field experiments of the Low Yield Nuclear Explosion Monitoring (LYNM) Physics Experiment 1 (PE1) series. Aliquots were collected from both a metrological surface release experiment (REACT) and a subsurface chemical explosive experiment (PE1-A). Release systems deployed in both experiments captured gas from the source container before experiment execution and were shipped to PNNL for post-analysis. Both surface and subsurface systems collected telemetry data related to pressures, temperatures, and flow rates of the radioxenon during release operations. Through a combination of telemetry data, laboratory spectroscopy of the aliquots, and xenon concentration measurements, the total inventory in both atmospheric and subsurface releases was calculated.

Log 641. INTEGRATING A COLLABORATIVE ROBOT INTO COUNTING FACILITY OPERATIONS. Weiss, M. A. (1, P), Thomas, K. J. (1), Hunter, S. (1), Goodell, J. (1), Frandson, T. (1), McConkie, J. (1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Gamma spectrometry is a fundamental analysis technique used in a variety of applications, including in support of samples for post-detonation nuclear material analysis. In applications such as these, the variety of radioisotopes and sample quantity increases substantially following radiochemical separations, straining the capacity of radiological counting laboratories. This requires gamma spectroscopists to balance a variety of factors (number of samples and detectors, half-lives of nuclides, impact of interferences, count times, etc.) to ensure high-quality data are collected. An engineering design approach for enhancing these processes in a radiological counting facility has been established by (1) implementing a modern off-the-shelf collaborative robot for sample rotations across existing instrumentation; and (2) applying an algorithm to automate the process of dynamic, scenario-based prioritization in the queuing of samples. Many new programs and workflow improvements were developed to accommodate for utilizing a collaborative robot in conjunction with the standard work of the gamma spectroscopists. Details from the development of this system including component design, robot training, prioritization and queue management, and workflow design will be presented. LLNL-ABS-871609. Prepared by LLNL under Contract DE-AC52-07NA27344.

Log 642. Ru-103 RADIOLABELING OF ETHYLENE-PROPYLENE-DIENE (EPDM) ELASTOMER.

Muckenhuber, H. (1); Sahovic, N. (2); Welch, J. M. (1, P); Sterba, J. H. (1). (1) Center for Labelling and Isotope Production, TRIGA Center Atominstitut, TU Wien. (2) TU Wien. (P) Presenting Author.

Mechanical degradation of rubber significantly affects its performance and lifetime, making it a key focus of research in the field of industrial applications [1]. Ethylene-propylene-diene terpolymer (EPDM) rubber is widely used in automotive parts and industrial seals due to its chemical resistance and flexibility. However, it is susceptible to degradation, so tracking this process is crucial. Radiolabeling EPDM with radioactive isotopes offers a powerful analytical method to trace and monitor the degradation, as small substance amounts enable easy and precise detection [2]. In this study, Ru-103 was selected based on its suitable half-live and gamma emission properties. The radiolabeling process was conducted by incorporating gaseous ruthenium(VIII) oxide into the EPDM matrix. Gamma spectrometry and autoradiographic methods were employed to confirm the successful incorporation. The findings affirm that EPDM can be effectively radiolabeled, and the amount of radioactivity within the rubber can be controlled by several different parameters. To ensure that the radioactivity was not confined to surface deposition, solvent treatments using ultrasonic baths were performed, and the spatial distribution of the activity inside the rubber was visualized. Our preliminary results demonstrate a viable technique for radiolabelling EPDM, however, further research is needed to understand the diffusion mechanisms of radionuclides within the crosslinked rubber matrix at the molecular level. [1] Zellhofer M et al 2022 Tribol Lett 70 55. [2] Sterba J 2018 J Radioanal Nucl Chem 316 753-759.

Log 643. QUANTITATIVE MATERIAL MORPHOLOGY ANALYSIS OF URANIUM POWDER SAMPLES.

Matthies, K.S. (1,P); Hanson, A.B. (1); Sentz, K. (1); Dimayuga, I. (2); Ayyagari, A. (2); Cluff, D. (2); Osmond, R. (2); Szlachta, V. (2); Totland, M. (2). (1) Los Alamos National Laboratory. (2) Canadian Nuclear Laboratories. (P) Presenting Author.

The characterization of material morphology in scanning electron microscopy (SEM) is an emergent tool for indicating the provenance of nuclear materials with decades of prior research demonstrating how synthetic and environmental factors influence morphological characteristics [McDonald et al (2023)]. In this international exercise led by Canadian Nuclear Laboratories (CNL), eight nuclear forensics laboratories analyzed five uranium powder samples of varying compositions and processing histories, including U3O8, ADU, UO2, U3Si, and U-Mo. Each institution employed different methodologies and analysis tools on SEM images to quantify particle size and shape for each sample. This poster highlights Los Alamos National Laboratory's analysis, where SEM images of each powder were segmented using the LANL-developed Morphological Analysis of Materials (MAMA) software. Of the 101 SEM images originally provided, 54 images were segmented to avoid segmenting the same particles in multiple images, leading to a total of over 3,000 individual particles segmented across the five different materials. Size and shape attributes calculated by the MAMA software were used to quantitatively compare results across each of the five different powder samples to determine the statistical significance of morphological changes resulting from composition and processing conditions. A high-level overview of the overall statistical findings is presented.

Log 644. DESIGN, EXECUTION, AND RESULTS OF CRITICALITY VALIDATION EXPERIMENTS.

Hutchinson, J. (1, P); Brain, P. (1); Bredeweg, T. (1); Cutler, T. (1); Goda, J. (1); Gooden, M. (1); Grosskopf, M. (1); Kleedtke, N. (1); Neudecker, D. (1); Little, R. (1); McKenzie, G. (1); Rising, M. (1); Thompson, N. (1); Weldon, R. (1); Whitman, N. (1). (1) Los Alamos National Laboratory. (P) Presenting Author.

Accurate nuclear data are required for useful predictive simulations. Criticality experiments (also referred to as integral experiments or validation experiments) are an important part of validating that nuclear data are accurate. These experiments are simultaneously sensitive to multiple nuclides/reactions/energies (unlike differential experiments), but are particularly useful within the nuclear data pipeline due to the small measurement uncertainties present when determining delayed critical. This work will discuss the design of modern criticality experiments to ensure that experiments are optimally sensitive to validate the desired nuclear data. In addition, specific recent validation examples from the National Criticality Experiments Research Center (NCERC) will be discussed. NCERC contains four critical assembly machines which can be used to perform criticality experiments with a wide variety of Special Nuclear Material (SNM). Comparisons between experimental and simulated data with various nuclear data libraries will be shown. Also, the use of various experiment responses (such as neutron leakage spectra, reaction rate ratios, etc.) for nuclear data adjustment will be discussed. Last future experiments will be presented.

Log 645. ACTINIDE ACCELERATOR MASS SPECTROMETRY MEASUREMENT DEVELOPMENTS AT THE AUSTRALIAN NATIONAL UNIVERSITY.

Tims, S. (1,P); Fifield, L.K. (1); Pavetich, S. (1); Froehlich, M. (1); Medley, P. (1,2,3). (1) Australian National University. (2) Environmental Research Institute of the Supervising Scientist. (3) Queensland Health. (P) Presenting Author.

Capabilities for trace-level measurement of actinide species with the accelerator mass spectrometry (AMS) system on the 14UD accelerator at the Australian National University are under development. The isotopes of interest are measured relative to an artificially added spike isotope of the same element. Trials using an automated semi-fast cycling system with custom ionization detectors and a 6 m long time-of-flight detector arrangement, used to suppress interference from ubiquitous neighboring mass isotopes present in far greater abundance, are underway. In these trials, the AMS system is set for the desired elemental species, with all magnets in the system held fixed. The different isotopes are then transmitted in turn to the detector by switching the energy of the ions from the ion source, the terminal voltage of the accelerator, and a velocity (Wien) filter. The limit on the switching time is imposed by the terminal voltage, which takes less than 1.5 seconds for the small changes needed for actinide isotopes. Spike isotopes are measured for 5 or 6 seconds, with rare isotope measurement times of 10 to 30 seconds set to reflect the expected isotope abundance in the samples. Cycle times for measuring the desired suite of isotopes typically range between 25 to 35 seconds, of which the switching 'dead time' is less than 13%. The switching control is integrated with the data acquisition system and takes into consideration the special requirements for our unique detector arrangements. Experience with automated measurements of isotopes of Pa, U, Pu and Am will be discussed.

Log 646. RADIOPURITY STUDIES OF MATERIALS DESIGNED FOR UNDERGROUND EXPERIMENTS. Povinec, P.P.(1, P); Benedik, L.(2); Bujdoš, M.(1); Hou, X.(3,4,5); Ješkovský, M.(1); Kaizer, J.(1); Kontuľ, I.(1); Kučera, J.(6); Larivière, D.(7); Laubenstein, M.(8); Nisi, S.(8); Pham, M.K.(9); Perrot, F.(10); Sýkora, I.(1); Terrasi, F.(11); Wang, Y.(4); Warot, G.(12); Zeman, J.(1). (1) Comenius University, Bratislava, Slovakia. (2) Jožef Stefan Institute, Ljubljana, Slovenia. (3) Technical University of Denmark, Risø Campus, Roskilde, Denmark. (4) Institute of Earth Environment of the China Academy of Sciences, Xi'an, China. (5) Lanzhou University, Lanzhou, China (present address). (6) Czech Academy of Sciences, Nuclear Physics Institute, Husinec-Řež, Czech Republic. (7) Université Laval, Quebec City, Canada. (8) Laboratori Nazionali del Gran Sasso, Istituto Nazionale Di Fisica Nucleare, Assergi, Italy; (9) International Atomic Energy Agency, Marine Environment Laboratories, Monaco, Principality of Monaco. (10) Université de Bordeaux, CNRS/IN2P3, LP2i Bordeaux, Gradignan, France. (11) University of Campania Luigi Vanvitelli, Caserta, Italy. (12) Laboratoire Souterrain de Modane, Modane, France. (P) Presenting Author.

Natural radionuclides present in various construction materials used in detectors searching for neutrinoless double beta decays and for dark matter particles in underground laboratories present limiting factors for new discoveries in these exciting scientific fields. Recent developments in high-sensitivity gamma-spectrometry, inductively coupled plasma mass spectrometry (ICPMS) and accelerator mass spectrometry (AMS) will be reviewed, with focus on determinations of U-238 and Th-232 (and their decay products) in various materials. Special interest will be devoted to glass and copper samples which served for interlaboratory comparisons.

Log 647. ELEMENTAL COMPOSITION OF SAND AND ITS HEAVY MINERALS THAT INFLUENCE ACTIVATION SUSCEPTIBILITY. Gmeling, K.(1,P); Szilagyi, V.(1); Harsanyi, I.(2); Szentmiklosi, L.(3); Revay, Zs.(4). (1) HUN-REN Centre for Energy Research, Budapest Neutron Centre. (2) HUN-REN Wigner Research Centre for Physics. (3) Varian Medical Systems Hungary Ltd. (4) TUM, FRM-II. (P) Presenting Author.

Construction of nuclear power plants must comply mandatory regulations for decommissioning. The objective is to design radiation shielding concrete with the lowest possible residual activity, thus selecting materials with low activation susceptibility. Concrete is a composite of cement, water and aggregates (sand and gravel). The sand supply of Hungary (16 mines from 4 different regions) was systematically sampled, to estimate suitable raw material for local radiation shielding, and explore differences in various sources and parallel elemental composition with heavy mineral (HM) distribution. HM content of sand influencing the mass fraction of isotopes with high-neutron-capture-cross-section, gamma emission probability and long half-lives. Elemental compositions were examined with PGAA, NAA, and in-beam NAA at the Budapest Neutron Centre, and at the FRM-II. The conclusion pointed towards trace elements with rather long-lived radionuclides e.g. Ce, Hf, Fe, Sb, Tb, Sc, Ta, Co, and Eu which enriched in HMs (e.g. ilmenite, magnetite, amphibole, rutile, pyroxene, zircon). Correlations between elemental distributions and mineralogical properties were identified, provided insights into provenance. The analytical data of sand supplied the basic input for numerical modelling program, calculating time dependent multi-factor process of activation susceptibility, which depends on the level of activation reached by neutron radiation of a given intensity and energy, and the decay time needed to fall below clearance level.

Log 648. NEUTRON IMAGING FOR PLANT REHYDRATION. Gracheva M.(1,2); Maróti B.(1,P); Kis Z.(1); Müller B.(2); Solti A.(2). (1) Budapest Neutron Centre, HUN-REN Centre for Energy Research. (2) Department of Plant Physiology and Molecular Plant Biology, Institute of Biology, ELTE Eötvös Loránd University. (P) Presenting Author.

The increasing frequency and severity of droughts due to climate change and global warming present significant challenges for agriculture. Understanding how certain plants survive extreme desiccation could lead to breakthroughs in improving drought tolerance in crops through biotechnological approaches. Orpheus flower (Haberlea rhodopensis) is a resurrection species capable of surviving near-total dehydration and recovering upon rehydration. It thrives in diverse habitats, from shady areas to sun-exposed rocky environments. Although the rehydration process is rapid upon watering, the exact mechanisms of water uptake through roots and leaves remain unclear. Due to neutron interaction with atomic nuclei, neutron activation-based methods – unlike X-rays – sensitive to light atoms, enables time-scale neutron imaging as perfect non-destructive method to visualize water dynamics in real time and in a non-invasive way. Desiccated H. rhodopensis plants were placed in aluminium containers that also served as water reservoirs. Plants were positioned in two orientations, either the foliage or the roots merged into water, to compare their contribution to whole plant rehydration. Data indicate the significant contribution of foliage to water uptake. Work was supported by the grant K-146865 of NKFIH, by the bilateral grant NKM2023-57 between the Bulgarian and Hungarian Academies of Science. Á.S. was supported by the János Bolyai Scholarship of HAS under grant number BO-00113-23-8.

Log 649. GAMMA-RAY SELF ATTENUATION IN URANIUM ORE. Martin, C. (1,2,P); Landsberger, S. (1). (1) University of Texas at Austin. (2) Los Alamos National Laboratory. (P) Presenting Author.

Gamma ray sellf-attenuation can severely affect the accuracy of determining radioactive isotopes in environmental samples. This attenuation can be caused by both the sample size as well as the presence of high-Z elements as well as the energy used. For instance, the 46.1 keV gamma-ray of Pb-210 can be attenuated significantly. In our laboratory we have been using direct gamma-ray spectroscopy to ascertain the amount uranium in Texas or samples using both decay lines from U-238 without the need the need to wait for secular equilibrium as well as U-235. Because a representative sample is needed several grams of the uranium is needed thus yielding a significant attenuation of the low energy gamma rays of 143.8, 163.4 and 205.4 keV belonging to U-235 and less of an attenuation of the 1001.3 keV gamma-ray belonging to Pa-234m, the second daughter product of U-238. A comparison of the uranium content in the ore is given using both isotopes.

Log 650. HEAVY METAL LEVELS IN URBAN DOMESTIC WATER: AN INAA STUDY REVEALS LOW CONCENTRATIONS BUT HIGHLIGHT CHALLENGES IN CONTAMINATION ASSESSMENT. Hoang, S.M.T. (1,P). (1) Thu Dau Mot University. (P) Presenting Author.

This study assessed heavy metal contamination in domestic water sources in Thu Dau Mot City (Binh Duong, Vietnam) using advanced analytical techniques, including electrochemical methods, molecular absorption spectroscopy (UV-VIS), atomic emission spectroscopy (AES), atomic absorption spectroscopy (AAS), and particularly Instrumental Neutron Activation Analysis (INAA). INAA results revealed average concentrations of As (0.008 mg/L), Mn (0.15 mg/L), Fe (0.22 mg/L), and Zn (0.05 mg/L). Most metal concentrations were below health standards. However, the study also highlighted challenges related to background noise from Na and Cl, affecting the accuracy of Cu measurements (approximately 15% error). Prolonged irradiation analysis revealed some metals, like Cr (0.06 mg/L), exceeding standards, potentially due to water contamination or buried metal artifacts. Although As levels measured by AAS (0.005 mg/L) were lower than INAA, they remained within safe limits. This research emphasizes the role of INAA in tracing the origin of domestic water and proposes the application of Blockchain technology for enhanced water resource management.

Log 651. MANAGING RADIOXENON MONITORING NETWORKS. M. Luchkov(1); A. Wehrhahn(1); B. Flierl(1); V. Thorén (1, P). (1) Scienta Envinet. (P) Presenting Author.

Monitoring of atmospheric radioxenon is a powerful tool that enables the remote detection and classification of nuclear activities. It has been used for many years as part of the CTBTO international monitoring system to provide a smoking gun signal to reveal nuclear weapons tests, but could also be used as a means of monitoring the operation of nuclear power plants. Traditionally, radioxenon instruments have been complex and expensive. The SAUNA QUBE, developed by the Swedish Defence Research Agency (FOI) and manufactured by Scienta Envinet, changes that. Based on a new platform, the QUBE offers high performance at a lower cost, thus enabling the construction of dense monitoring arrays. These open a new paradigm in terms of sensitivity, data availability and for precision in determining the source location. To follow this hardware development, Scienta Envinet is now devoting significant energy to developing advanced analysis tools that can make efficient use of the new data. A particular focus is given to atmospheric transport modelling and algorithms for robustly tracking emission sources as part of the routine operation of monitoring networks. This talk intends to give an overview of how such a network is constructed and managed in practice, including how data is handled in the central monitoring software NMC, and to provide some first results from the source tracking algorithm applied to real-world cases.

Log 652. DEVELOPMENT OF MIXED ELEMENT RADIOACTIVE REFERENCE MATERIALS FOR MASS SPECTROMETRY MEASUREMENTS OF ENVIRONMENTAL POLLUTANTS IN EUROPE. Lehnert, A.(1, P); Hanemann, P.(1); van Eerten, D.(1); Leifermann, L.(1); Weissenborn, T(1); Reinhard, S.(1); Schmalz, T.(1); Wendt, K.(2); Lourenço, V.(3); Chambon, L.(3); Russel, B.(4); Simon, J.(5); Arnold, D.(6); Walther, C.(1). (1) Leibniz University Hannover, IRS. (2) Johannes Gutenberg-Universität in Mainz. (3) Université Paris-Saclay, CEA in Paris. (4) National Physical Laboratory in Teddington. (5) Norwegian University of Life Sciences. (6) Physikalisch-Technische Bundesanstalt in Brunswick. (P) Presenting Author.

In nuclear forensics, high-precision measuring instruments that can determine samples isotope-specifically are employed. It is imperative that the efficiency of such devices be subjected to constant calibration and examination. Resonant laser secondary neutral mass spectrometry (rL-SNMS) combines quasi non-destructive isotope and element-resolved mass spectrometry of solid samples, providing spatial resolution [1]. For calibration purposes, this technique requires micrometre-sized, homogeneous reference particles, which are not readily available [2]. The European project MetroPOEM is committed to develop SI-traceable mixed element reference materials (RM) for the calibration of several mass spectrometry devices. The new RMs developed in this project will meet the ongoing need for the production of suitable and relevant RMs, which can be used to validate measurement capabilities. The project results can be applied in various fields, including routine real-time monitoring, emergency measures, geological dating, climate change studies, and other activities, such as nuclear forensics and the decommissioning of non-nuclear industries. In this work, we present the production of solid mixed actinide particle samples, especially uranium and plutonium via sol-gel. These samples consist exclusively of the respective metal and do not contain a carrier element. The new production method of homogeneous RMs is to be extended to all elements relevant for environmental mass spectrometry measurements. 1: https://doi.org/10.1126/sciadv.abj1175 2: https://doi.org/10.1007/s10967-022-08600-x

Log 653. NOVEL SAMPLE PREPARATION FOR ACTINIDE ANALYSIS USING FIB-SEM. Wood, A. (1,P); Harrison, R. (1); Higginson, M. (2); Dunn, S. (2); Kaye, P. (2). (1) University of Manchester. (2) AWE Aldermaston. (P) Presenting Author.

Actinide analysis is a core component of the nuclear industry, but poses radiological hazards to workers in both standard and accident conditions. A reduction in sample size and, consequently, activity through a more precise preparation technique offers the potential to minimise these hazards. Further benefits could include reduced waste generation, improved spatial resolution of sample information, and an increase in the analysis capacity of a limited stock. We will report on the use of a Focussed Ion Beam – Scanning Electron Microscope (FIB-SEM) to produce nano-to-microgram actinide analysis samples: developing methods for measuring key material parameters and evaluating utility by their comparison against conventional wet chemistry. SEM was used to map prepared uranium oxide fuel pellets, then guide FIB sample extraction from their surface. Samples were analysed using a range of mass spectrometry, radiochemical, and surface spectroscopy techniques. Properties of interest were isotopic profiles, elemental impurities, chemical form, and surface science. Once acquired, these parameters were related back to the sample extraction site, allowing the heterogeneity of the material to be probed. Conventional wet chemistry on bulk material provides a reference baseline for the sample measurements: individual accuracies can be quantified as well as the extent to which the sample matrix represents the bulk material. We have demonstrated methods through which nanogram samples can produce similar isotopic and elemental concentrations to bulk wet chemistry, maintaining tolerable accuracies and precisions.

Log 654. FRICTIONLESS KNOWLEDGE INJECTION FOR FEW-SHOT LEARNING. Stomps, J. (1); Dayman, K. (1,P); Randolph, C. (1); Hite, J. (1); Phathanapirom, B. (1). (P) Presenting Author.

Cutting-edge data science solutions require large volumes of carefully curated training data. However, the ubiquity of rare events embedded in massive datasets limits the applicability of these solutions to many national security problems. Consequently, the data are often analyzed manually by subject-matter experts to incorporate mission knowledge. Although these approaches initially seem incompatible, we present a method for incorporating potentially abstract knowledge into models tailored for sparse data with only a few samples of interest. A subject-matter expert defines salient, human-interpretable concepts and provides positive and negative examples of the concepts. These examples are encoded in the embedding space of the model, and a concept activation vector that corresponds to the desired concept in the embedding space is derived. Concept activation vectors were originally proposed for improving model explainability and understanding model performance in terms of human-readable features. We repurpose these vectors to enable knowledge injection. Although our formulation is data and model agnostic and therefore could be used for a variety of target applications, we demonstrate our analyses on nonproliferation-relevant data modalities, including microscopy images and Raman spectra. This method will allow non–data science experts to incorporate their subject-matter expertise into few-shot models to yield effective models that use very limited attributed data across the nonproliferation mission space.

Log 655. RADIONUCLIDE SEQUENTIAL SAMPLING OF SPRING 1974 AND 1977 THUNDERSTORMS. Inn, K.G.W. (1, 2 Retd., 3, P); Kuroda, P.K. (3); Gavini, M. (3); Holloway, R. (3); Raines, W. (3); Flanders, M. (3); Harris, C. (3). (1) K&E Inn Ovations, Inc. (2) National Institute of Standards and Technology. (3) Formerly University of Arkansas. (P) Presenting Author.

Strontium-89, Sr-90, Y-91, Cs-137, Ce-141, Ce-144, Pb-210, Bi-210, Po-210, Pb-212 concentrations and Bi-210/Pb-210 and Po-210/Pb-210 residence times were determined from sequential samples of three thunderstorms in Feb 1974, April 1974 and Mar 1977 during Spring Peak after the Chinese 15th 3 Mt and 21st 4 Mt atmospheric nuclear tests. The general results for radionuclide concentrations were 1] fallout nuclides were correlated for all three thunderstorms, although some small deviations could indicate smaller secondary effects, 2] shorter lived radionuclides were very strongly correlated with each other, 3] fallout radionuclides were moderately correlated with rainfall rates for the moderately strong Feb 1974 thunderstorm, no correlation for the strong April 1974 storm, and negatively correlated for the very strong March 1977 storm, 4] indicator RaEF radionuclides were sometimes correlated with the fallout radionuclides, and 5] indicator Pb-212 concentrations were sometimes correlated with Po-210 and/or Bi-210.

Log 656. RAPID ANALYSIS Cs-137 IN SEAWATER USING LSC.. Kim, Y. H. (1, 2, P); Kim, H. C. (1, 2). (1) Korea Atomic Energy Research Institute. (2) University of Science and Technology. (P) Presenting Author.

In the analysis of Cs-137 in the marine environment, current method is AMP coprecipitation that requires 2-3 days for sample preparation. Previous research aimed to reduced this time to under a day by using AMP-PAN. We studied a method for analyzing Cs-137 in seawater using LSC. LSC has higher detection efficiency and automatic sample replacement, unlike the less detection efficiency HPGe that requires manual handling. Initially, 4 columns filled with 2 mL of AMP-PAN was used to concenctrate Cs from 40 L of seawater. Interfering nuclides, such as K and Rb, were removed using ammonium nitrate solution. Cs adsorbed on AMP-PAN was then eluted with 1 M NaOH solution. The elute passed through cation exchange resin to further purification of Cs using nitric acid of various concentration. Finally, the sample concentration process using AMP-PAN and the rinsing with ammonium nitrate were performed. 10 mL of the eluate was then mixed with cocktail for measurement using LSC. Results show that there was no difference in the counting rate compared to the BLK sample when K in the final sample was less than 0.01 mg and Rb was less than 0.001 mg. If new method is used for Cs-137 analysis in seawater, the same MDA as before can be obtained with a smaller sample volume and a shorter measurement time. in addition, since the sample is automatically replaced during the measurement, labor is reduced. It seems that efficient analysis in terms of time and equipment use is possible.

Log 657. LABORATORY REMEASUREMENTS OF RADIOXENON TO SUPPORT NUCLEAR EXPLOSION MONITORING. Goodwin, M.A.(1,P); (1) AWE Aldermaston. (P) Presenting Author.

Isotopes of Radioxenon are measured on the International Monitoring System (IMS) as part of the verification measures of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). Civil nuclear facilities such as nuclear power reactors, nuclear research reactors and medical isotope production facilities emit significant quantities of radioxenon to the atmosphere, resulting in many detections on the IMS which are not related to a nuclear explosion. Arguably the most effective method for discriminating between the type of source is to utilise isotopic activity ratios. The current state-of-the-art spectroscopic measurement technique uses beta-gamma coincidence spectrometry to detect and measure the relevant isotopes of radioxenon: Xe-133, Xe-135, Xe-133m and Xe-131m; however there are some overlapping coincidence signals between these isotopes, meaning there is a functional dependence of the detection limit of the long-lived metastable isomers Xe-133m and Xe-131m on the activity of the ground state isotopes Xe-133 and Xe-135. Previous works highlighted the significance of improved photon energy resolution in making measurements of radioxenon, providing separation of the X-rays from ground state isotopes and metastable isomers, which in turn reduces the dependency of the latter on the former. This work overviews previous work in testing and developing systems for laboratory measurements and sets out plans for future laboratory systems at the UK CTBT Radionuclide Laboratory, GBL15. The impact of such developments on the ability to determine the source type is explored, and the detection sensitivity benefits of the noble gas radionuclide laboratory network are established.

Log 658. A GAMMA-GAMMA COINCIDENCE SPECTROMETRY DETECTOR SYSTEM IN THE BOULBY UNDERGROUND LABORATORY. Goodwin, M.A.(1,P); Galvin, G.,(1); Toth, C.(2); Davies, A.V.(3); Britton, R.(3); Paling, S.(2); Scovell, P.(2); Shoemark-Banks(2); Meehan, E.(2). (1) AWE Aldermaston. (2) STFC Boulby Underground Laboratory. (3) Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO). (P) Presenting Author.

An underground nuclear explosion can prevent the release of many of the radionuclides produced during a nuclear explosion, so there is a drive to push the sensitivity of measurement systems to the limit. One of the limits to gamma-spectroscopy is the background signal associated with cosmic ray-induced radiation, which increases the spectral count-rate and decreases the sensitivity of air filter measurements. Underground laboratories, such as that at Boulby Mine in the UK, operate with ~1E6 times lower radiation than on the surface, meaning a drastic reduction in the background count-rate so that detectors can achieve much lower (improved) detection limits. Another source of background noise is Compton scattering of γ-rays in the detectors, which mean that one radionuclide can negatively impact the sensitivity of many others. One solution to this is to use coincidence-based spectroscopy, which is far more selective, and can be more sensitive than singles measurements. Here we provide a first look at a new detector system installed in the Boulby Underground Laboratory (Yorkshire, UK), with 1.1 km overburden. The dual high-purity germanium (HPGe) detector system within a low-background lead shield has been custom-designed to be entirely enclosed within a shield and provide a multi-contact signal output to the multi-channel analyser (MCA). The system performance is described, along with the impact of such a system on the ability to verify the Comprehensive Nuclear-Test-Ban Treaty (CTBT) through enhanced laboratory capabilities.

Log 659. ANALYSIS OF Xe-127 TRACER MEASUREMENTS DURING A FIELD EXERCISE USING A NET COUNTS METHOD. Goodwin, M.A.(1,P); Chester, D.L.(1); Galvin, G.,(1); Foxe, M.(2); Ely, J.(2); Eslinger, P.W.(2); Turley, R.S.(3); PE-1 Experimentation Team(4). (1) AWE Aldermaston. (2) Pacific Northwest National Laboratory. (3) Nevada National Security Sites (NNSS). (4) A multi-Physics Experiment for Low-Yield Nuclear Explosion Monitoring, LLNL-TR-864107. (P) Presenting Author.

A suite of measurement systems were deployed as part of the Physical Experiment 1 series of experiments, which involved detonating chemical explosives along with radionuclide tracers in an underground cavity, at the Nevada National Security Site (NNSS) in the United States. One of the radionuclide tracers, Xe-127 was released from the containment following the explosion and detected on a SAUNA QB sampler situated approximately 3.5 km away. The system uses a beta-gamma coincidence detector system to measure fission product radioisotopes of xenon relevant to nuclear explosion monitoring. In this work we use the coincidence measurement data to analyse and interpret the results from the SAUNA QB system, to calculate the measured Xe-127 activity concentration(s).

Log 660. DETERMINATION OF PLUTONIUM ASSAY VIA ICP-MS FOR NUCLEAR MATERIALS ACCOUNTABILITY.

Ripplinger, L.S. (1, P); Stanley, F.E. (2); Tardiff, E.R. (1); Harris, S.L. (1); Schaeffer-Cuellar, C.A. (1); Roehling, T.T. (1); Roberts, D.J. (1); Meeker, J.F. (1). (1) Lawrence Livermore National Laboratory. (2) Savannah River Nuclear Solutions. (P) Presenting Author.

The accurate measurement of plutonium (Pu) in aqueous media is critical for nuclear materials control and accountability. Traditionally, Pu samples are measured via non-destructive techniques like calorimetry, gamma spectroscopy, and neutron multiplicity counting, but current pitfalls with those techniques are their limited ability to accurately measure samples that are not solids or powders. Lawerence Livermore National Laboratory's (LLNL) new aqueous recovery laboratory within the Pu processing facility is refining its processes for Pu recovery work, and aqueous sample accountability will be necessary due to the large volumes (>50 L) required for processing runs. Therefore, getting Pu into a solid form, like Pu oxide, while meeting nuclear materials inventory requirements poses a unique challenge. There are instances when Pu is in solution when accountability measurements need to occur. This work describes the process of using an Inductively Coupled Plasma-Mass Spectrometer (ICP-MS) to determine Pu Assay values in those solutions specifically for accountability measurements. Representative Pu samples were collected from a storage tank in the aqueous lab, sent for destructive analysis, and compared to similar processes in non-destructive accounting. The samples were prepared in triplicate using a well-characterized plutonium sample for an external calibration curve and Certified Reference Material C126A for quality control. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-ABS-871810

Log 661. COMPARISON OF INTERSPEC AND FRAM FOR THE ANALYSIS OF URANIUM ENRICHEMENT.

Nikolov, J. (1, P); Murineks, R. (1); Vranicar, A.(1); Ansone, A. (1). (1) University of Novi Sad, Faculty of Sciences, Department of physics, Nuclear Physics Group. (P) Presenting Author.

Gamma spectrometry is a valuable non-destructive method for the characterization of nuclear materials that is particularly used in the first 24 hours of criminal investigation if there is a material out of regulatory control (MORC) found. It is very important do develop method and test capabilities in determination of isotopic ratio of uranium in nuclear material that can help in estimating the risk and proper radiation protection measures at the radiological crime scene. Well known gamma spectrometry equipment producers – Ortec and Cannberra – have their own software for spectra analysis, but they place the limitation when the specific needs for the nuclear forensics analysis must be met. Different commercial software (FRAM, MGA++ and MGAU packages) that are especially dedicated to the fast analysis of gamma spectra of nuclear materials are available and very commonly used. They present very convenient and easy-to-use alternatives because the entire isotopic analysis of uranium and plutonium is reduced to just a few steps. FRAM software allows users to tailor the analysis to the specific requirements of a given measurement. This is achieved by a different selection or by creating a completely new set of parameters that defines the type of detector as well as the suitable energy region for analysis, then the shape (type) of the efficiency function, the selection of photopeaks used for energy, shape and efficiency calibrations as well as many other options within the software itself. On the other side there are laboratories that do not have any of the mentioned commercial software for the analysis of gamma spectra of nuclear materials. This paper focuses on the potential use of InterSpec that is a native or web application with the aim to assist in the analysis of nuclear radiation spectra using the peak-based methodology. The set of different gamma spectra was used for testing the applicability of InterSpec in the isotopic ratio determination for uranium containing samples and the optimal peak selection for the InterSpec were found. The obtained results from FRAM software and InterSpec show good agreement although with FRAM more precise values of isotopic ratios are determined. It can be concluded that InterSpec can be efficiently used for the rough estimation of enrichment and serve as a good screening tool for initial characterization of the MORC.

Log 662. BENEFITS FROM THE LATEST ADVANCEMENT ON MIRION CLOVER DETECTORS.

Ilie, G. (1, P);Masseron, J. (2);Ginsz, M. (2); Ralet, D. (2). (1) Mirion Technologies Inc. - Meriden, CT, USA; (2) Mirion Technologies (Canberra) SAS - Lingolsheim, France. (P) Presenting Author.

As a global leader in radiation measurements, Mirion has been supplying sophisticated HPGe detectors and instrumentation which are used in cutting-edge materials analysis, fundamental nuclear physics research, and space studies to world's leading research institutes. The Clover detector is one of Mirion unique product, recognized as an advanced gamma-ray detection system widely used in nuclear physics experiments. Clover detectors consist of four high-purity germanium (HPGe) crystals, arranged in a compact cloverleaf-like configuration within a single cryostat. This unique geometry enhances its efficiency, enabling precise gamma-ray detection and energy resolution. The detectors design minimizes dead space, improving sensitivity to weak signals and increasing the likelihood of coincident gamma-ray detection for advanced spectroscopic studies. The Clover detectors versatility is augmented by its segmented configuration, which allows for effective background suppression and Doppler shift correction, making it invaluable for nuclear physics experiments and high-energy gamma-rays. Recent advancements in signal processing and digital electronics have further enhanced the performance of Clover detectors which continue to be a cornerstone in gamma-ray spectroscopy due to its high efficiency, excellent energy resolution, and timing. This presentation will provide an overview of various building block technologies for Mirion Clover detectors, highlighting the benefits of recent advancements like electrical cooling, an expanded energy dynamic range, and more.

Log 663. ROTATING PACKED BEDS FOR LIQUID-LIQUID TRIVALENT LANTHANIDE AND ACTINIDE SEPARATIONS.

Dean-Kersten, W.(1, P); Kent, K. (2); Wang, I. (2); Lai, G. (2); Duval, C. (2); Servis, A. (1) (1) Argonne National Laboratory (2) Case Western Reserve University (P) Presenting Author.

Rotating packed beds (RPBs) are a type of processing equipment that leverage centrifugal force for process intensification, enabling significant reductions in equipment volume—a critical advantage for nuclear applications. RPBs enhance mixing and mass transfer in liquid-liquid separation processes, making them well-suited for rate-limited separations like the actinide-lanthanide separation (ALSEP) process. The ALSEP process is used for the group separation of trivalent lanthanides and actinides. In this study, a bench-scale RPB was fabricated using additive manufacturing and filled with inert packing material to increase surface area during liquid-liquid extraction. A simulated raffinate stream containing major non-radioactive fission product elements was used to demonstrate an ALSEP-like separation. Feed flow rates and rotational speeds were systematically varied to optimize both recovery and purity. These results demonstrate the potential of RPBs to significantly enhance the efficiency and compactness of liquid-liquid separations, offering a promising solution for separations at the back end of the nuclear fuel cycle and critical material recovery.

Log 664. ACTINIDE ELECTROCHEMISTRY AND TRANSPORT PROPERTIES IN DEEP EUTECTIC SOLVENTS. Dean-Kersten, W.(1, P); Servis, A. (1) (1) Argonne National Laboratory (P) Presenting Author.

Deep eutectic solvents (DESs) are an attractive new class of tunable solvents used for electrochemical and separation applications. While many different separations have been investigated in DESs, they have received only limited consideration for radiochemistry applications. In this work, we are studying the electrochemistry of f-element actinide surrogates (lanthanides) to observe how the varying bonding environments of different DESs, with diverse functionalities and polarities, impact solvation and redox behavior. We have demonstrated the use of microliter-scale voltammetry employing both macro- and microelectrodes in small-volume electrochemical cells fabricated using 3D printing. This approach conserves valuable materials and significantly reduces waste generation, specifically concerning radiochemistry with actinides. Utilizing steady-state microelectrode measurements will enable the determination of diffusion coefficients for small amounts of actinides in DESs. This work sheds light on the potential utility of DESs in actinide electrochemistry and yields valuable insights that can be leveraged for broader research efforts in the nuclear fuel cycle, with implications extending to f-element separations.

Log 665. ABSOLUTE INTEGRAL FISSION PRODUCT YIELDS AT NCERC. Gooden, M.E.(1,P), Bredeweg, T.A.(1), Goda, J.M.(1), Hanson, S.(1), May, I.(1). (1) Los Alamos National Laboratory. (P) Presenting Author.

Utilizing the critical assemblies at the National Criticality Experiments Research Center (NCERC) at the Nevada National Security Site (NNSS), we have undertaken a program to measure absolute fission product yields. Supporting nuclear forensics missions to provide improved and modern nuclear data, we have developed specially designed fission chambers to operate within the harsh environments of the critical assemblies at NCERC. We will present recent measurements using 239Pu irradiated in the Godiva critical assembly using these new fission chambers to determine absolute integral fission products yields. The fission chamber allows for an absolute normalization on a per fission basis of the fission yields which are determined by dissolution and chemical seperation of the irradiated sample at Los Alamos National Laboratory (LANL) followed by beta and gamma-ray spectroscopy.

Log 668. SIMULTANEOUS INTERELEMENT ACTINIDE ANALYSES USING GAS PHASE REACTIONS ON THE NEOMA MS/MS MC-ICP-MS. Scott, S.R. (1, P); Hobbs, K.P. (1); Arnquist, I. J. (1); Schlieder, T.D. (1); Sullivan, D.L. (1); French, A.D. (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Recent developments in MC-ICP-MS include the addition of collision reaction cells to the typical double focusing geometry of previous generation instruments. Collision reaction cells use gas phase chemistry to reduce or eliminate isobaric interferences. In addition, pre-cell mass filtering capabilities, such as the Double Wien filter, are equipped on the Thermo Neoma MS/MS. One novel application for these newly designed mass spectrometers is the ability to simultaneously measure isotopic compositions and inter-element ratios. For example, in-situ measurements of Rb-Sr and Lu-Hf have been recently reported. We have explored the use of this technology to measure isotopic compositions and inter-element ratios of the actinides. Specifically, we have developed a method to simultaneously measure Pu and U isotopic compositions using CO2 gas to measure U isotopes as oxides on faraday cups while Pu is measured "on-mass" on the multi-ion counting nuclear array. The method has been evaluated using mixtures of U and Pu reference materials and sample standard bracketing mass bias corrections. Limitations include extraction of spectral interferences when gas is present in the cell and an in depth understanding of the relative reactivities of the actinides. Results show promise for exploring new applications in simultaneous inter-element isotopic ratio measurements.

Log 670. EXTRACTION OF NEUTRON-GAMMA IRRADIATED DIFFUSION PUMP OILS. Tillman, C.L. (1,P); McDonald, K.D. (2); Guin, T. (2); Folkert, J. (2); Bliznyuk, V.N. (1); DeVol, T.A. (1); Larsen, G.K. (2). (1) Clemson University (2) Savannah River National Laboratory (P) Presenting Author.

This work successfully demonstrates solvent extraction methods for separation of oil from the by-products produced during intense irradiations. Nuclear fusion power at a commercial scale has accelerated the need for cost-effective radiation resistant vacuum technology, such as oil-based diffusion pumps. Two commercially available vacuum pump oils, a polyphenyl ether and an aromatic silicone oil, received absorbed doses up to 5+ MGy from neutron and gamma-ray radiation at the Rhode Island Nuclear Science Center (RINSC). Solvent extractions were performed using hexane and isopropanol to characterize the oil extraction as a function of total absorbed dose. The by-products of irradiation, herein referred to as residue, tended to be less soluble in the solvent thus allowing for separation from the bulk oil. The extraction procedure used on the polyphenyl ether oil outperformed that used for the siloxane oil with greater than 60% of the oil extracted after receiving mixed gamma-neutron absorbed doses exceeding 5 MGy. Neutron activation of a chlorine impurity allowed for quantification and tracking of radioactive components. The specific activity of the neutron irradiated oils was measured using liquid scintillation counting and served as an internal flux monitor.

Log 671. STUDIES OF HYDROGELS FOR UPTAKE OF URANIUM ENVIRONMENTAL SAMPLES. Tillman, C.L. (1,P); Bliznyuk, V.N. (1); DeVol, T.A. (1). (1) Clemson University (P) Presenting Author.

This study demonstrates the rapid extractive ability of polyacrylamide-co-polyacrylic acid (PAAM/PAA) hydrogels for uranium at environmental levels in aqueous media including DI water and artificial seawater samples. Adsorption and kinetic behavior for a broad range of experimental conditions were performed; pH ranges from 2 to 8 and concentrations as low as 1 ppb and as high as 100 ppm. A capacity of 0.65 grams uranium per gram hydrogel, which represents 90% of the maximum capacity, is reached after 6 hours. This study additionally investigated the incorporation of self-polymerizing, uranium-selective monomers, such as dopamine into the hydrogel to observe the effects on extractive ability. Inclusion of a uranium selective polymer was found to improve selectivity, while only sacrificing 20% of the maximum loading capacity compared to the unloaded gel. Further considerations for designing and performing these experiments, such as approaching the solubility limit of uranium and surface adsorption, were compared to thermodynamic equilibrium and speciation modelling using PHREEQC.

Log 672. IMPROVING PLUTONIUM ISOTOPE RATIO MEASUREMENTS BY TIMS USING POLYMER FIBERS. Folkes, K.A.(1,P); Bliznyuk, V.N.(2); Powell, B.A.(2); Husson, S.M.(1)(1) Department of Chemical and Biomolecular Engineering, Clemson University, Clemson, SC, USA (2) Department of Environmental Engineering and Earth Science, Clemson University, Clemson, SC, USA. (P) Presenting Author.

Accurate measurement of Pu isotope ratios in environmental samples is critical for nuclear forensics, environmental risk assessments, and emergency action plans. This study aims to improve the sensitivity, precision, and accuracy of Pu isotope ratio measurements by thermal ionization mass spectrometry (TIMS). It was inspired by findings from a prior study, in which we demonstrated that polymer fibers provide a more robust, reliable, and sensitive method for producing high-quality TIMS sources than the standard bead loading method. While fibers improve thermal ionization efficiencies for Pu, the underlying mechanism is poorly understood. Additionally, the impact of polymer fiber properties, such as Pu binding energy and elemental composition, on ionization efficiency is lacking. In this presentation, we will describe how we are filling this knowledge gap by investigating the effects of fiber chemistry on ionization efficiencies measured using a custom-built ionization chamber emulating the TIMS environment. We will present findings from a systematic study using a series of lightly crosslinked amine- and phosphonate-functionalized polymer fibers, where we attempt to correlate Pu ionization efficiencies with Pu distribution coefficients and fiber chemistry. This research holds great promise for gaining a deeper understanding of how fiber properties affect ionization efficiency. Armed with this knowledge, fibers may be designed rationally to improve TIMS measurement sensitivity, precision, and accuracy, which would reduce the required sample size from environmental samples.

Log 673. QUANTIFICATION OF HYDROGEN ISOTOPE EXCHANGE ON SELECT DIFFUSION PUMP OILS. Allen, C.G.(1); Bliznyuk V.N. (1,2); Guin, T (3); Larsen G.K. (3); DeVol T.A. (1,2,P). (1) Clemson University, (2) Center for Nuclear Environmental Engineering Sciences & Radioactive Waste Management, (3) Savannah River National Laboratory. (P) Presenting Author.

Isotopic exchange for three chemically diverse diffusion pump oils across ten different treatment scenarios was conducted. The three oils are representative of different classes of hydrocarbon oil — mineral, silicone, and polyphenyl ether — which together encompass the majority of commonly used diffusion pump oils. Nine of the treatments consisted of conducting exchange experiments at 170°C, 200°C, or 225°C, for 3, 7 or 14 days. For these nine treatments HTO was contacted with the oil in flame-sealed glass ampoules in an argon atmosphere. The tenth treatment consisted of contacting the oils with T2 at room temperature for 7 days. From the HTO experiments, the specific activity of the oil ranged from 0 Bq/g for the 3-day at 170°C treatment with the silicone and polyphenyl ether oils to 7,300 Bq/g for the 14-day at 225°C for the silicone oil. For the T2 experiments, the specific activity following the treatment tended to be significantly lower, less than 3 Bq/g. Isotopic exchange of deuterium and tritium with protium atoms along with neutron activation and radiation damage to hydrocarbon pump oil are important considerations for diffusion pump applications at tritium facilities. Reliable, cost-effective vacuum pump technology is considered one of the top challenges for fusion electrical energy production

Log 674. SEPARATIONS FOR POST-DETONTATION NUCLEAR FORENSICS: EFFECTS OF MAJOR METALS FOUND IN ASPHALT ON ACTINIDE DETERMINATION. Chunko, R.N. (1, P); Sudowe, R. (1). (1) Colorado State University. (P) Presenting Author.

In case of a nuclear incident, standardized radioanalytical techniques must be available to analyze radionuclides in unusual matrices. Radiochemical analysis of sample matrices such as soil, water, and air are well established; however, less research has been conducted on the effect of urban matrices such as asphalt on available methods. In the event of a detonation of an improvised nuclear device (IND) in an urban environment, the existing separation techniques used for the determination of plutonium in asphalt samples originating from roadways and roofing shingles must be rigorously tested to provide useful insight on the characteristics of the special nuclear material. Batch studies were used to determine the changes in uptake of plutonium and americium on commercially available extraction chromatography resins in the presence of major metal components found in asphalt including aluminum, iron, manganese, potassium, and magnesium. Column studies were conducted to translate trends observed in batch studies to a separation scheme. In these studies, cations with a strong ionic behavior exhibited a positive effect on the uptake of plutonium on extraction chromatography resins leading to an increased retention of plutonium on columns and a slight reduction in recovery of plutonium. Extraction chromatography resins can be used to isolate plutonium from asphalt-like matrices with large quantities of contaminants with excellent recoveries. The methods tested have potential to separate plutonium from asphalt samples rapidly and accurately to support investigations in a state of emergency following the detonation of an IND in an urban environment.

Log 675. OPTIMIZATION OF TRITIUM ANALYSIS FOR BIOASSAY SAMPLES AT LANL. Chunko, R.N. (1, 2, P); Gooden, M.E. (1); Flanagan, D.C. (1); Sudowe, R. (2). (1) Los Alamos National Laboratory. (2) Colorado State University. (P) Presenting Author.

Providing timely and accurate results for enrolled workers is the primary function of the tritium bioassayprogram at Los Alamos National Laboratory (LANL). Improving the accuracy while simultaneouslymodernizing the program is therefore of utmost importance to reduce uncertainty of measurement as well as lower the likelihood of generating false negative or positive results. A NIST traceable tritiated water solution was used to test the accuracy of instrument response based on a combination of variables including vial type, cocktail selection, instrumental settings, and quench curve parameters. Differences inthe vial and cocktail choice used for quench measurements and samples were shown to drastically affect the accuracy of the tritium activity measured. Additionally, a urine-based quench curve was developed for use to most closely match the sample matrices analyzed. Its performance was compared to commercially available quench standards. Additional quench standards were prepared to compare different cocktail bases and vial types. Further testing with quench standards showed high accuracy can be achieved under any conditions as long as the tritium quench standards match the sample’s vial type and cocktail choice.

Log 676. LIPOPHILIC SULFONAMIDOPHENOL EXTRACTANTS & SENSORS FOR ALKALINE HIGH-LEVEL WASTE (HLW). Ruddock, L.D. (1); Mudgal, M.M. (1); DeSimone, A.D. (1); Panzer, R. (1); Adedoyin, O.W. (1); Morozov, A. N. (1); Mebel, A. M. (1); Lehman-Andino, I. (2); DiPrete D.P, (2); Kavallieratos, K. (1,P). (1) Florida International University. (2) Savannah River National Laboratory. (P) Presenting Author.

HLW processing at Savannah River Site (SRS) is comprised of the Actinide Removal Process (ARP) for sorption of Sr-90 and Actinides (An) with monosodium titanate followed by the Next-Generation Caustic Side Solvent Extraction (NG-CSSX) for extraction of Cs-137. This can be improved by incorporation of An chelators during extraction that can reduce the amount and need for extensive contact time with the titanate sorbent. Furthermore, fluorescence and optical sensing offer potential for monitoring extraction, and optimize processing. We identified sulfonamidophenols as f-element extractants and sensors from HLW, due to electron rich O- and N- coordination sites. Previously, we demonstrated up to 90% Sm(III) single-cycle recovery from alkaline solutions. Several sulfonamidophenol derivatives have now been tested showing up to 30% Sm(III) and 15% Cs(I) recovery in the NG-CSSX solvent at 2.0 M NaOH. These also showed extraction of Am and Eu under CSSX-HLW conditions under irradiation, with Cs extraction maintained. Two new bis-sulfonamidophenol derivatives were also synthesized. Spectroscopic studies of the above as well as analogs that contain the dansyl or dabsyl fluorophores with Ln(III) and extraction and sensing studies under alkaline conditions in the presence of potentially competing ions will be presented. The binding and sensing properties of the synthesized ligands were studied by UV-Vis and fluorescence titrations. Non-linear regression analysis of the binding data and Job plots provided insight into Ln(III) binding affinities and complexation stoichiometry.

Log 677. DEVELOPMENT OF A NEW ULTRA HIGH ENERGY RESOLUTION MICROCALORIMETER GAMMA SPECTROMETER. Schreiber, K.A. (1,P); Keller, M.W. (3); Wessels, A.L. (2); McNeel, D.G (1); Croce, M.P. (1); Carpenter, M.H. (1); Dede, S. (1); Stark, E.N. (1); Schoenemann, R.U. (1); Becker, D.T. (4); Bennett, D. A. (3); Gard, J.D. (4) Mates, J.A.B. (3); Swetz, D. (3); Schmidt, D. (3); Ullom, J.N. (3,4); Pierson, B. (5); Archambault, B. (5); Batie, G. (5); Arrigo, L. (5); Good, E. (5). (1) Los Alamos National Laboratory, (2) HRL Laboratories, (3) National Institute of Standards and Technology, Boulder, CO, (4) University of Colorado Boulder, Boulder, CO, (5) Pacific Northwest National Laboratory (P) Presenting Author.

Microcalorimeters are highly sensitive gamma ray detectors. They operate at temperatures below 0.1 Kelvin, and obtain energy spectra with energy resolution an order of magnitude better than high purity germanium detectors. A gamma ray peak at 100 keV measured by a microcalorimeter gamma-ray detector typically has a full-width half maximum of 90 eV and can be as low as 60 eV. The High Efficiency and Resolution Microcalorimeter Spectrometer, 700 pixels (HERMES-700) has been developed to obtain high statistics gamma-ray spectra with very high energy resolution and high efficiency. Currently the HERMES-700 operates with 400 microcalorimeter pixels, making it one of the largest detector area gamma-ray microcalorimeter systems ever built. Here, we describe the development of the instrument, which was deployed at Pacific Northwest National Laboratory in 2024. Improvements over previous microcalorimeter gamma-ray spectrometers will be described, including enhanced vibration isolation and shielding from magnetic fields, which enhances performance. Applications of the instrument for ultra-high energy resolution characterization of nuclear material will be discussed. LA-UR-24-32529

Log 678. PHYSICS-AWARE DATA ANALYTICS EFFECTIVELY TREAT SPARSE SENSOR DATA.

Stomps, J. (1); Dayman, K. (1); Phathanapirom, B. (1,P); (1) Oak Ridge National Laboratory; (P) Presenting Author

Semi-supervised machine learning methods are a promising approach to nuclear nonproliferation applications for which attributed calibration data are either limited or entirely unavailable. Many semi- or self-supervised training routines use data augmentations to increase the efficiency and utilization of the limited available measured data. Such methods have traditionally been applied to imagery data, where augmentations include intuitive transforms such as rotations, shifts, and flips. Using semi-supervised methods to analyze sensor data common in nonproliferation applications requires data augmentations that respect physical phenomena specific to each measurement data modality. Prior work has demonstrated that methods such as contrastive learning are able to learn informative data encodings, thereby enabling performant downstream analyses. However, the physics-informed data augmentations developed for these analyses may be sufficient to develop effective supervised models that would otherwise be ineffective under the constraint of sparse calibration data. To test this possibility, this study used a small dataset of labeled gamma-ray spectra spanning several classes of shielded radiological material transfers collected at a real multiuse nuclear facility. For each labeled spectrum, one of a collection of physics-informed, label-invariant data augmentations designed for gamma-ray spectra was used to alter the measured data. Supervised models were then trained and their performance compared. If trained with augmented data, relatively low-capacity supervised models can achieve benchmark test performance with severely limited initial attributed data. Although data augmentations are well studied for images, this work in analyzing gamma-ray data could motivate additional work to develop comparable physics-informed data augmentations for other measurement modalities relevant to the nuclear nonproliferation mission.

Log 679. ADDRESSING CHALLENGES OF NONPROLIFERATION WITH DISCIPLINED MACHINE LEARNING.

Dayman, K. (1,P); Phathanapirom, B. (1); Stomps, J. (1). (1) Oak Ridge National Laboratoryl. (P) Presenting Author.

Modern data science has the potential to significantly advance capabilities across the nuclear nonproliferation landscape, including laboratory and in-field research as well as operational systems. Although data science has been transformative in image analysis and natural language processing for commercial applications, the unique challenges of nonproliferation have limited data science’s impact in the community. These diverse challenges may be understood as stemming from the high-consequence nature of data interpretation and associated conclusions in the nonproliferation community and the difficulty in obtaining or generating high-quality data with sufficient granularity, fidelity, and contextual information. To address these challenges, we adopt a framework called disciplined machine learning, whereby the data generation process, data geometry, model behavior, deployment scenario, and science questions or mission needs are considered and aligned. To illustrate the approach to developing effective and impactful data-driven solutions, we present four use cases from our research. Solutions include developing a novel method for flexibly incorporating subject matter expertise into models in the form of potentially abstract concepts, a permutation-invariant analysis to respect the nonordinal geometry of particulate data, an iterative self-supervision paradigm enabling a model to adapt to a continuously shifting data domain and adapt to new scenarios or deployments, and several approaches to data without attribution or ground truth.

Log 680. AFRRI MIXED FIELD EXPOSURE ROOM SPECTRA CHARACTERIZATION AND SIMULATION FOR DEVELOPMENT OF MACHINE LEARNING BASED REACTOR CONFIGURATION RECOMMENDATION SYSTEM. Makinde O.(1,2,P); Kulesza J.A.(4); Jain R.(2); Dr. Reichenberger M.A.(3); Dr. Holschuh II T.V.(3);Dr. Diaz-Elsayed N.(2); Dr. Gallant N.(2). (1) United States Army Student Detachment. (2) University of South Florida, Mechanical Engineering Department. (3) Idaho National Laboratory. (4) Los Alamos National Laboratory. (P) Presenting Author.

The Armed Forces Radiobiological Research Institute (AFRRI) operates a 1Mw TRIGA nuclear reactor to provide a source for experiments in support of the United States Department of Defense combat in a radiological or nuclear battle space. This research aims to build a reactor configuration recommendation system based on converting a KCODE Monte Carlo simulation to an SRDF simulation for generating machine learning input data. The AFRRI reactor was designed to move in a pool of water between two exposure rooms. The large exposure room measures approximately 20 x 20 x10 ft, and multiple neutron activations were conducted in statistically relevant configurations within the exposure room. Configurations varied core position, sample position, and shielding. The measurements are decomposed into fluxes and both flux and activities are compared with the results generated from the MCNP 6.1 input file to determine agreement between simulated and measured results. 16 samples containing indium, gold, iron, cadmium-covered gold, and cadmium-covered indium wires were irradiated in the AFRRI ER 1, with activated radiation counted in a high-purity germanium detector. The activity of the samples is then calculated based on the net count and detector efficiency. The same sample setup is geometrically modeled in the MCNP 6 code for a flux tally and simulated activity. artificial intelligence implementations are explored to develop a recommendation system that predicts the best configuration for the AFRRI reactor to be placed in to produce a specific spectrum

Log 682. ONE-POT NEUTRON IMAGING OF TWO PHASE SYSTEMS: A METHODOLOGICAL STUDY. Sercl, J (1, P), Lee, J. (2), Melcak, M. (1), Heyda, J. (1), Vopicka, O. (1), Trtik, P. (2). (1) Department of Physical Chemistry and Technology, Prague, (2) PSI Center for Neutron and Muon Sciences.

Neutron imaging of liquid-gas systems in pressurized metal cells enables the simultaneous measurement of multiple properties within a single experiment. In this study, we present advancements in the one-pot neutron imaging methodology, focusing on hardware and image processing improvements to enhance measurement precision and accuracy. Modifications in the cell design, including optimized dimensions and material selection, have reduced uncertainties in surface energy calculations. Improved apparatus alignment—addressing gravitational effects and beam orientation—has minimized distortions in radiographic data. Advancements in image processing significantly improved meniscus detection and interface characterization, leading to enhanced surface tension measurements under vacuum and pressurized conditions. Additionally, the neutron imaging results provide valuable input for molecular dynamics simulations, offering insights into interfacial behavior at the molecular scale. This work showcases the robustness and versatility of one-pot neutron imaging as a comprehensive tool for analyzing complex liquid-gas systems, with broad implications for applications in energy, chemical engineering, and material science. (Authors acknowledge GACR-SNSF project 23-04741K)

Log 683. MULTICAMERA DETECTOR SYSTEM FOR HIGH RESOLUTION NEUTRON IMAGING. Wissink, M.L. (1,P). (1) Phoenix LLC. (P) Presenting Author.

Nondestructive testing of aerospace components such as turbine blades and pyrotechnic devices has been a long-standing application of neutron radiography. This work continues to be done almost entirely on radiographic film due to its ability to achieve simultaneously high spatial resolution (~ 15 – 30 μm) and large field of view (432 mm × 356 mm), allowing many components to be imaged in parallel so that high throughput can be realized. Duplicating this performance with a digital detector would require a sensing area with >250 megapixels (MP), which is not currently available with any single sensor package. However, the last few years have shown significant development with back-illuminated CMOS sensors offering high resolution (>60 MP), small pixels (<4 μm), high quantum efficiency (>80%), and very low dark current in a full frame format that allows the use of a wide range of commercially available lenses. The price per pixel of these new CMOS sensors has dropped substantially compared to previous generations, and they have seen wide application spanning photography, scientific imaging, and astronomical imaging. This also makes mosaic imaging, which has mainly been used in security and astronomical applications, economically practical for neutron imaging. This presentation will detail the design, development, and first results from a 6-camera mosaic neutron imaging system offering a 432 mm × 432 mm field of view at 25 μm pixel pitch for a total effective pixel resolution of 298 MP, making this the highest known pixel count for any neutron imaging system to date.

Log 684. MICROCALORIMETER MEASUREMENTS OF NUCLEAR FUEL SAMPLES AT IDAHO NATIONAL LABORATORY. Abel, E.P. (1,P), Williams, A.N. (1), Ullom, J.N. (2), Schreiber, K.A. (3), Keller, M.W. (2), Bucher, B.M. (1), Seabury, E.H. (1), Swetz, D.S. (2), Becker, D. (2,4), Croce, M.P. (3). (1) Idaho National Laboratory, (2) National Institute of Standards and Technology, (3) Los Alamos National Laboratory, (4) University of Colorodo, Boulder. (P) Presenting Author.

The High Efficiency and Resolution Microcalorimeter Spectrometer (HERMES) is a gamma ray spectrometer that utilizes recent advances in readout, cryogenic, and detector technology to produce high precision and resolution isotopic composition measurements. This instrument is the result of a multi-institutional effort between Los Alamos National Laboratory (LANL), the National Institute of Standards and Technology, and the University of Colorado to develop a detector system using a microcalorimeter array for nuclear fuel cycle measurements. The microcalorimeter has been installed in the Analytical Research Laboratory (ARL) at Idaho National Laboratory (INL) where radioanalytical measurements are performed on nuclear fuel and related samples. Representative samples of different nuclear fuel types and from key stages within the nuclear fuel cycle will be used to demonstrate the performance and applicability of a microcalorimeter, especially to improve measurement precision and sample throughput. Recently, two samples, a Byron reactor fuel sample and an irradiated Advanced Gas Reactor TRISO particle, were counted on HERMES at INL. The results of these measurements will be discussed and compared to those produced by current measurement techniques used for these sample types at the ARL.

Log 685. EFFORTS TOWARDS HIGH SPECIFIC ACTIVITY PRODUCTION OF AUGER ELECTRON EMITTERS WITH GERMANIUM-71.

Abel, E.P. (1,P), Jaussi, M. (2, 3), Erfurth, N. (1). (1) Idaho National Laboratory, (2) Idaho Accelerator Center, (3) Idaho State University. (P) Presenting Author.

Targeted internal radiotherapy is a treatment technique for metastatic cancers that utilizes ionizing radiation such as alpha, beta, and Auger electron (AE) emissions to damage cancer cells. Recently, AE-emitting radionuclides have gained attention for their potential as effective therapeutic agents with minimal side effects compared to other radiotherapies. However, typical production methods like neutron irradiation or photonuclear reactions often result in low-specific-activity products for AE emitting radionuclides. To produce a high-specific-activity product, a physical separation method is required to separate the product from the stable target material. A new method of in-line separation using nuclear recoil and ultra-thin target foils has been tested to produce high specific activity germanium-71 (Ge-71) from a natural germanium target via a photonuclear neutron emission. Following the absorption of a photon and subsequent neutron emission, the product nucleus is imparted with a small amount of kinetic energy resulting in a “nuclear recoil”. With 8 μm thick target foils, the product nucleus can receive enough energy to escape from the foil a small fraction of the time. Predictions of the effectiveness of this technique have been investigated with Monte Carlo simulations and nuclear recoil models and have guided an irradiation at the Idaho Accelerator Center. Subsequent radioanalytical measurements have been performed to measure the total production yield of Ge-71 and the efficiency of nuclear recoil separation in 8 μm thick Ge foils. Evidence of nuclear recoil separation in the production of Ge-71 has been observed, and the feasibility of this production route will be discussed.

Log 686. DETERMINATION OF 4, 6 DINITROPHENOL IN SIMULATED RADIOACTIVE WASTE BY HIGH PERFORMANCE LIQUID CHROMOTOGRAPHY.

Dekarske, J.R.(1), White, T.L.(1); Johnson, S.A. (1) Savannah River National Laboratory (SRNL). (P) Presenting Author.

The River Protection Project (RPP) at Hanford is evaluting an alternative treatment method for low activity tank waste (LAW) disposition. Specifically, grout solidification/immobilization for LAW needs to demonstrate adequate treatment for Land Disposal Restricted (LDR) Organic chemicals. LDR organic chemical pretreatment, such as evaporations testing and oxidation decomposition, are under assessment to reduce the LDR organic chemicals concentration in the LDR waste. 4,6-dinitrophenol was spiked into LAW simulated waste and monitored in these studies using High Performance Liquid Chromatography (HPLC). The development and implementation of this HPLC method is discussed in this presentation.

Log 687. FLOURIDE ANALYSIS BY ION CHROMATOGRAPHY IN SUPPORT OF FAST CRITICAL ASSEMBLY (FCA) SPENT NUCLEAR FUEL PROCESSING .

White, T.L.(1); Carter, L.M.(1). (1) Savannah River National Laboratory (SRNL). (P) Presenting Author.

The Savannah River Site (SRS) is currently processing Fast Critical Assembly (FCA) fuel received from the Japan Atomic Energy Agency (JAEA) for disposition. Stainless steel-clad plate and rods in stianless steel containers are dissolved using electrolysis with a solution mixture of nitric acid (HNO3), potassium fluoride (KF), and gadolinium (Gd). An ion chromatography (IC) was developed and vetted to monitor fluoride at various sampling points of the process. To finalize the method, FCA test solution was analyzed to qualify the analytical method followed by real FCA process solution analysis using two different analytical columns. This presentation summarizes the development and vetting of the IC method.

Log 688. NEUTRON ACTIVATION ANALYSIS IN C3-CAM PHOTOSYNTHESIS TRANSITION STUDIES.

Mróz, T(1,P); Kornas, A(2); Brudecki, K (1); Rusin, G(3) (1)The Henryk Niewodniczanski Institute of Nuclear Physics PAS. (2)University of The National Education Commission. (3)The University Hospital in Kraków. (P) Presenting Author.

The transition from C3 to CAM photosynthesis in Mesembryanthemum crystallinum represents a vital adaptation to environmental stress, yet its chemical basis remains insufficiently explored. This study employs neutron activation analysis (NAA) to investigate the elemental composition of the plant during different growth phases associated with this metabolic shift. NAA, a highly sensitive and non-destructive analytical technique, allows for precise quantification of trace elements, which play a pivotal role in photosynthetic function, enzyme activity, and stress responses. Application of NAA in this area of research, highlighting its potential to uncover novel insights into the physiological and biochemical basis of photosynthetic plasticity. Elemental concentrations of key nutrients, rare earth elements and trace metals were measured in samples collected from juvenile (C3-dominated), transitional, and mature (CAM-dominated) phases. These data provide a deeper understanding of the dynamic changes in nutrient allocation and metabolic regulation during this photosynthetic transition. Our findings shows the importance of NAA in biological sciences, particularly for plant physiological studies requiring high sensitivity and specificity. This innovative application sets a precedent for future research into the elemental dynamics of photosynthesis and stress tolerance in plants, contributing to broader advancements in plant science and sustainable agriculture.

Log 689. IMPROVEMENTS IN TANDEM MASS SPECTROMETRY RADIONUCLIDE MEASUREMENTS FOR NUCLEAR FORENSICS.

Hobbs, K.P. (1,P); French, A.D.(1); Schlieder, T.S. (1); Scott, S.R. (1); Arnquist, I.J. (1); Beck, C.L. (1); Herman, S.M. (1). (1) Pacific Nortwest National Laboratory. (P) Presenting Author.

The analyses of many radionuclides typically require chemical processing and purification of samples prior to analysis to remove spectral and matrix interferences for radiometric counting and mass spectrometry methods. This is due to analytes of interest present at low concentration or activity relative to matrix constituents. The additional processing steps increase the time to analysis and potentially introduce an avenue for contamination to the sample. Recent advancements in gas phase separation methods have increased the number of radionuclides possible for practical measurements on inductively coupled plasma tandem mass spectrometry. The addition of a collision reaction cell between two quadrupole mass filters provides separation of many analyte interferent pairs during analysis, allowing for direct radionuclides determination in bulk sample solutions. Previous work has laid the groundwork for identifying reaction gases that can achieve the separation efficiencies and sensitivities needed for such measurements. We have developed multiple analysis and data processing methods to measure radionuclides, including actinides and activation products, down to the ppq level. Results show that tandem mass spectrometry is capable of making practical measurements at levels needed to assess nuclear accidents and events without resource intensive procedures.

Log 690. STABLE GAS MEASUREMENTS FOR UNDERSTANDING RADIOLOGICAL RELEASES IN UNDERGROUND NUCLEAR EXPLOSIONS. Whitehill, A.M.(1,P); Couture, A.H.(1); Fritz, B.G.(1); Alexander, T.R.(1); PE1-A Experiment Team. (1) Pacific Northwest National Lab. (P) Presenting Author.

On October 18th, 2023, Physics Experiment 1-A (PE1-A) was executed at the Nevada Nuclear Security Site as part of a larger nonproliferation experiment series. Chemical explosives with an equivalent yield of 16.3 tons TNT were detonated, releasing various radiological and stable tracers that had been collocated with the explosives. One of the many primary diagnostics employed were stable high explosive byproduct gas and radon concentration measurements in the tunnel and its exhaust, which supplemented tracer measurements such as those made on released radioxenon. These stable gas measurements were made with the Tunnel Environment and Vent Stack systems which effectively detected carbon monoxide, carbon dioxide, and methane at all sampling locations. A first look at the data suggests that it is valuable for qualitative observations of differing gas permeation through the geology as well as providing a deeper understanding of tunnel flow dynamics and predicting gas releases in the event of an underground nuclear explosion. A comparison with radioxenon concentration measurements shows that carbon monoxide release rates and pathways were similar to those of xenon in the day following the execution of the shot.

Log 691. CHARACTERIZING NATURAL MATRICIES TO DEVELOP REFERENCE MATERIALS FOR EVIRONMENTAL AND NORM MEAUREMENTS. Jassin, L. E. (1, P); Taskaev, E. (1); Hexcel, C.R. (2); Rogers, K.T. (2). 1. Eckert & Ziegler Analytics. 2. Oak Ridge National Laboratory. (P) Presenting Author.

This presentation will describe the characterization work and present results for olivine and pitchblende. Olivine is a low background matrix material consisting of magnesium and iron nesosilicate or orthosilicate and is a primary component of the Earth's upper mantle. As a base for developing useful environmental and NORM measurement reference materials and PT's, Olivine's naturally low radioactive background allows for spiking analytes of interest without the uncertainly typical of other natural materials such as soils at lower activity levels. Eckert & Ziegler and collaborators characterized Olivine using radiometric and mass spectrometric methods. The results included U-238 present in Olivine at 0.3 +/-0.25 mBq/g, k=2 versus a common soil used by Eckert & Ziegler at 15.91 mBq/g, k=2. Already US federal agencies are finding Olivine useful as a base in standards used in the development of alpha beta methods with lower uncertainty and better matrix matching than alternatives available previously. Pitchblende is generally considered to have uranium and its daughters in secular equilibrium making it an interesting reference material. In a collaboration with Oak Ridge National Laboratory, Eckert & Ziegler provided ORNL pitchblende samples for analysis by a variety of techniques to confirm the concentration of the uranium isotopes present, daughters and impurities. Techniques included uranium assay by Davies and Gray titration, Uranium isotopic abundance by TIMS and trace elemental analysis. Analytical laboratories may benefit from characterized pitchblende to confirm their gamma spectrometry assumptions for Ra-226 which has a nearly identical energy line as U-235 at approximately 186keV.

Log 692. PERIODIC TRENDS INCLUDING ACTINIDE REACTIVITY WITH NOVEL REACTION GASES USING ICP-MS/MS. French, A.D. (1, P), Hobbs K.P. (1), Arnquist I.J. (1), Cox R.M (1), Scott S.R. (1) 1) Pacific Northwest National Laboratory. (P) Presenting Author.

Tandem mass spectrometry employs two mass filters with a collision/reaction cell positioned in between. This technique uses gas phase reactions to separate polyatomic and isobaric interferences through dissociative collisions, charge transfer reaction, and/or selective gas phase product ion formation that result in a mass shift between the interfering ions and the analyte. These separations occur in-line during the measurement, resulting in a faster and more effective analysis. Inductively coupled plasma (ICP) tandem mass spectrometry can be used in tandem with, or as an alternative to, chemical separations for elemental analyses, making it useful for a wide variety of applications. General reactivity for ions over much of the periodic table has been assessed with various reaction gases (e.g., NO, O2, CO2, N2O, NH3, H2, CH3F, N2O, and H2S) using commercial ICP-MS/MS. Using the Agilent 8900 ICP-MS/MS we have continued to explore product ion formation with additional gases to assess fundamental reactions, obtain thermodynamic information (where not previously available), and inform potential in-line separation schemes for quantitative analyses. Recent work has shown immense value in the use of ICP-MS/MS for nuclear forensics, especially for rapid actinide analyses. The focus of this research is to utilize ICP-MS/MS to explore reactivity trends that may prove useful for sample analysis and for which there is limited literature available using the latest advances.

Log 693. CHARACTERIZING URANIUM PARTICLES IN-SITU USING SYNCHROTRON X-RAYS. Krzysko, A.J.(1, P); Ilavsky, J.(1, 2); Steeb, J(1); McLain, D(1). (1) Argonne National Laboratory. (2) Advanced Photon Source. (P) Presenting Author.

Accurately assessing the processing history of uranium oxide samples can aid in determining the origin or intended use of unknown materials. Particle size and morphology have been used as signatures to link uranium oxide particles to the temperature they were produced at. Size and shape analysis is typically done using imaging techniques (e.g., scanning electron microscopy). However, these methods can be time intensive and make time-resolved experiments difficult to perform. In contrast, ultra-small-angle X-ray scattering (USAXS) measurements are fast (under 90 s), representative of the bulk sample, non-destructive, and can be performed during the heating treatment. Moreover, combining USAXS, small-angle X-ray scattering (SAXS), and wide-angle X-ray scattering (WAXS) provides size and shape information ranging from 6 angstroms to 10 micrometers. Uranium oxide particle phase transformations, size distributions, and morphology changes were quantified by the analysis of in-situ USAXS, SAXS, and WAXS measurements at various temperatures up to 800 degrees Celsius. The results of this analysis were compared to traditional imaging studies and used to investigate phase transformation mechanisms. Other on-going nuclear forensic work at Argonne National Laboratory using synchrotron produced X-rays will also be discussed.

Log 694. SAMPLE ENVIRONMENTS FOR USING HARD X-RAYS TO STUDY NUCLEAR FUEL CYCLE PROCESSES. Krzysko, A.J.(1, P); Servis, A(1); Lantis, J(1); Servis, M(1); McLain, D(1). (1) Argonne National Laboratory. (P) Presenting Author.

High-risk, high-reward science relies on our ability to conduct hazardous experiments safely at state-of-the-art facilities. However, opportunities to better understand reactions important to nuclear fuel cycle research are missing because of limitations in our ability to safely access Department of Energy (DOE) user facilities, which have understandably stringent safety protocols in place to accommodate the wide variety of samples being run and to ensure continuity of synchrotron operations. This ultimately inhibits nuclear forensic signature discovery and model development since fundamental research that looks to holistically understand different chemical processes implicitly reveals mechanism differences that drive the measurable properties targeted by forensic researchers. This proposed research seeks to bridge this gap by prototyping sample cells, reaction platforms, and workflows for radiochemical systems that comply with facility safety requirements to facilitate access to state-of-the-art techniques. Future research looking to generate novel signatures or answer challenging science questions using hard X-rays will have a clearer path forward by partnering with Argonne to use the research produced by this project.

Log 695. XENON RADIOISOTOPE PRODUCTION USING CARIBU. Krzysko, A.J.(1, P); Lantis, J(1); O'Connor, T(1); Steeb, J(1); Mueller, P(1). (1) Argonne National Laboratory. (P) Presenting Author.

Atmospheric radioxenon monitoring is a central component of the Comprehensive Test Ban Treaty International Monitoring System (CTBT IMS) network. Calibration and validation of instrumentation used to quantify radioxenon isotopes requires ready access to radioxenon samples with well-defined isotopic composition and activity concentrations. The Californium Rare Isotope Breeder Upgrade (CARIBU) at the Argonne Tandem Linear Accelerator System (ATLAS) facility was recognized as a potential single source for generating Xe-131m, Xe-133, Xe-133m, and Xe-135. This research successfully designed, constructed, and implemented a 3-step xenon production process. Production runs have successfully generated radiopure xenon-135 samples with relative efficiencies consistently over 90 percent of the collected activity from CARIBU. On-going production optimization and adaptation for the CARIBU upgrade will also be discussed.

Log 696. PLUTONIUM-ORGANIC MATTER COMPLEXATION COUPLED WITH IRON REDOX FACILITATED COPRECIPITATION: LABORATORY INSIGHT INTO PLUTONIUM CYCLING IN A SEASONALLY STRATIFIED POND. Montgomery, D.A. (1, P); Powell, B.A. (1). (1) Clemson University. (P) Presenting Author.

This work is aimed at supporting field studies of a radioactively contaminated pond examining, in part, the cyclical redistribution of Pu associated with seasonal thermal stratification and the resultant redox, iron, and organic matter (OM) cycling processes that occur. As Pu-OM complexation is thought to be a major factor influencing Pu distribution in this (and similar) environmental systems, Pu complexation with several International Humic Substance Society (IHSS) organic matter (OM) solutions and subsequent Fe(II)/(III) redox facilitated coprecipitation of Pu was investigated in this laboratory-based work. To gain some mechanistic insight into the molecular size fraction of the OM for which Pu may strongly or preferentially complex with, 20 kDa MWCO Float-A-Lyzer® dialysis devices were utilized in the initial Pu-OM complexation process to facilitate a general size discrimination threshold for the Pu-OM complexes. After equilibrium conditions were established between the size-discriminated and bulk solutions (inside and outside the dialysis cells), aliquots of both Pu-OM fractions were added to an anaerobically prepared iron (II) chloride solution and mixed under atmospheric conditions to quantify the effects of the Fe(II)/Fe(III) redox facilitated coprecipitation of the Pu. Analysis of the Pu-OM and Pu-Fe-OM solutions showed that while 30-40 wt% of the OM can pass through the dialysis membrane, only 0.3% - 2.3% of Pu-OM complexes could pass through, indicating that the Pu preferentially complexes with the larger molecular weight constituents of the OM. Additionally, the Fe(II)/Fe(III) redox facilitated coprecipitation treatment resulted in >98% Pu removal from the aqueous phase.

Log 697. LANL SPECIALIZED FACILITY FOR NONDESTRUCTIVE ASSAY OF LOW-LEVEL URANIUM AND PLUTONIUM SAMPLES. Boswell, M.; S.P. LaMont, E. Guardincerri, D. Soenke, and J. Williams (1) Los Alamos National Laboratory.

The Nuclear and Radiochemisty Group Counting Facility supports a comprehensive set of nuclear security missions, that require the radiometric analysis of a wide variety of operational and exercise samples. For decades we have performed thousands of gamma-ray spectrometry measurements samples in support of treaty monitoring, weapons radiochemistry, and nuclear forensics. More recently, our sample load of U and Pu nuclear forensic samples has increased, and we have recognized the need for improving our non-destructive analysis (NDA) capabilities to characterize everything from trace to bulk samples of U and Pu in a wide range of geometries. In this talk, I will present details of our new facility for specialized applications like measuring very small activities of U and Pu. I will focus on our new low-background laboratory being constructed in a historic Manhattan-project era tunnel in the Los Alamos canyon. This talk will describe the specialized detectors that are in use in the laboratory, our custom analysis software, and the highly specialized measurements that we are capable of making in this unique space.

Log 698. THE NATIONAL CRITICALITY EXPERIMENTS RESEARCH CENTER COUNTING LABORATORY: CURRENT CAPABILITIES AND RECENT RESEARCH. Whitman, N.H. (1,P); Weldon, R.A. (1); Gooden, M.E. (1); Bredeweg, T.A. (1); Hutchinson, J.; (1) Los Alamos National Laboratory. (P) Presenting Author.

The National Criticality Experiments Research Center (NCERC), sited in the Device Assembly Facility at the Nevada National Security Site in the United States, is the only general-purpose criticality experiments research facility in the United States. NCERC uses a vast and varied inventory of special nuclear material (SNM) to accomplish critical and subcritical experiments using highly-enriched uranium and plutonium. Due to investments from sponsors in nuclear forensics, the NCERC Counting Laboratory (NCERC-CL) is a recently revitalized reactor dosimetry capability with several high-purity germanium (HPGe) detector systems and unique SNM target materials to provide the critical assemblies Godiva IV, Flattop, Planet, and Comet with passive neutron activation diagnostics which provide benchmark parameters in addition to reactor kinetics parameters such as k_eff and the reactor period . The HPGe detector systems at NCERC-CL include an automated sample changer with a mechanically cooled HPGe detector, two low-background Kolga shielded HPGe detectors on continually recycled liquid nitrogen cooling, as well as multiple mechanically cooled and shielded mobile Aegis HPGe units. Some examples of the additional diagnostics commonly measured are activation foil reaction rate ratios, reaction rates, specific activities, and neutron energy spectra. This work will present the current capabilities and recent research highlights of NCERC-CL focusing on material irradiation campaigns and activation foil measurements.

Log 699. ALANINE X RAY DIFFRACTION FOR MIXED FIELD RADIATION DETECTION. LTC Omololu Makinde (1,2,P); Urvi Jain(2); Dr. Michael A. Reichenberger(3); Dr. Thomas V. Holschuh II (3);Dr. Nancy Diaz-Elsayed (2); Dr. Nathan Gallant (2). (1) United States Army Student Detachment. (2) University of South Florida, Mechanical Engineering Department. (3) Idaho National Laboratory. (P) Presenting Author.

Response to a nuclear incident requires knowledge of the characteristics of the radiation field created. Radiation fields comprising of both neutrons and gamma rays require dosimeters that can measure contributions from each particle type in a mixed field. Alanine-based Electron Paramagnetic Resonance (EPR) dosimetry has become a standard method to measure gamma doses. This work investigated the use of alanine in a mixed field as a singular detector for both gamma and neutrons using an X-ray diffractometer (XRD) alone or in conjunction with EPR. Changes in the X-ray diffraction angle characteristics of polycrystalline alanine were detected via XRD analysis when mixed field irradiation was applied to alanine, whereas no such effect was observed with pure gamma fields. Thirty alanine samples from the same batch were scanned pre-irradiation in a mixed field which resulted in an average of 24 ± 0.6 measured diffraction angles at 95% confidence. Post-irradiation, with a range of mixed field doses, the same samples had an average of 38 ± 1.3 diffraction angles, indicating an altered crystal structure. However, XRD scans of samples after pure gamma irradiation revealed a total number of diffraction angles not significantly different than the pre-irradiated measurements. The contrast in alanine’s behavior under neutron or gamma-ray exposure is exploited to develop a machine learning based technique to measure the relative dose due to each particle type in a mixed field from a single alanine dosimeter.

Log 700. 233Pa ISOTOPIC DILUTION SPIKE PREPARATION FOR USE IN 231Pa / 235U CHRONOMETRY APPLICATIONS. O'Hara, M. J. (1, P); Speetjens, S. E. (1); Shen, S. D. (1); Krogstad, E. J. (1); Paudel, W.; Springfels, D. C. (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Important uranium chronometers include determination of 230Th / 234U ratios, as well as 231Pa / 235U ratios. Both the 230Th and 231Pa concentrations in a sample can be determined by isotopic dilution mass spectrometry (IDMS). While a National Institute of Standards & Technology (NIST)-traceable isotopic dilution standard is available for 230Th – 229Th (t1/2 = 7825 a) – there is no such standard available for 231Pa. The 231Pa nuclide (t1/2 = 3.274E+04 a) bears the longest half-life of Pa by far; the next longest-lived nuclide is 233Pa, with a half-life of only 26.975 d. Due to the lack of a long-lived Pa nuclide that would be useful as an IDMS standard, 233Pa must be isolated from its parent 237Np (t1/2 = 2.144E+06 a) and standardized in-house for use as a viable 231Pa yield tracer in IDMS applications. Given the enormous half-life differentials between these two radionuclides, it requires ~30 mg of 237Np to produce ~1 ng of 233Pa. Herein, we will describe the process in which 233Pa is isolated and purified from 237Np stocks and standardized as a 231Pa IDMS spiking standard for use in 235U chronometry applications. Protactinium-233 processing times, chemical yields, and its decontamination factor from 237Np will also be presented.

Log 701. CHARACTERIZATION OF DUAL-MODE ELPASOLITE SCINTILLATORS IN MIXED RADIATION FIELDS. Franco, D.(1,P); Barzilov, A.(1). (1) University of Nevada, Las Vegas. (P) Presenting Author.

Solid-state inorganic CLYC and CLLBC elpasolites allow radiation measurements at ambient temperature. These bright scintillators are capable of providing photon energy resolution of less than 4% in full width at a half maximum (FWHM) at 662 keV. They can be used for thermal neutron counting via 6Li(n,α)t reaction and fast neutron measurements via 35Cl(n,p)35S reaction. The difference in decay times of photon-induced and neutron-induced scintillation events in elpasolites enables pulse shape discrimination (PSD) for neutrons and gamma rays. The lithium isotopic content of a CLYC scintillator can be varied in the crystal growth. Simultaneous registration of photons and neutrons by dual-mode elpasolite scintillators was modeled using MCNP6.2 code. Detectors were characterized in mixed radiation fields. Computational results will be compared to experimental measurements using gamma and neutron sources. The results of experiments will be discussed including the neutron-gamma PSD figure of merit. Coincidence measurements using two dual-mode detectors will be presented.

Log 702. THE USE OF IONIC LIQUIDS IN LSC MEASUREMENTS. Jovana Nikolov, J. (1, P); Stojkovic, I. (1); Todorovic, N. (1); Vranes, M. (1). (1) University of Novi Sad. (P) Presenting Author.

An overview of investigations of different performance of newly synthesized ionic liquids in enhancing the detection efficiency of Cherenkov radiation will be presented. So far the effect of different ionic liquids on the analyses has been performed for 210Pb/210Bi, 137Cs and 90Sr/90Y in water measurements with direct methods by using the Liquid Scintillation Counter, Quantulus 1220. It is proven that ionic liquids can act as wavelength shifters, significantly improving detection efficiency and detection limits. Experiments revealed that 1-butyl-3-methylimidazolium salicylate outperforms previously tested ionic liquids, reducing the detection limit for 210Pb and increasing detection efficiency by up to 30% for 137Cs in direct measurements. Additionally, the potential application of 3-methylpiridinium salicylate (3-MPS) was explored, showing significant influences on various radionuclide spectra due to both wavelength-shifting and scintillating effects. The simultaneous screening of 137Cs and 90Sr/90Y in colored water samples was improved using 1-butyl-3-methylimidazolium salicylate, achieving efficient detection within 2 hours, essential for nuclear emergency responses. These findings highlight the promising role of ionic liquids in enhancing LSC measurements.

Log 703. IN SITU MONITORING OF LANTHANIDE REACTIONS WITH OXIDE SPECIES VIA COMBINED ABSORPTION SPECTROSCOPY AND ELECTROCHEMICAL METHODs. LeCroy, G.S. (1, P); Yang, Q. (1); Cao, Guoping (1); Gakhar, R. (1). (1) Idaho National Laboratory (P) Presenting Author.

Molten salts for engineering scale applications of spent nuclear fuel pyrochemical processing will inevitably have some level of oxygen impurities which can form insoluble oxide and oxychloride species with fission products. This work demonstrates real-time concentration monitoring of two lanthanide (Ln3+) fission products, Nd3+ and Pr3+, and their reactions with oxygen (O2-) impurities to form insoluble products in LiCl-NaCl-KCl eutectic salt. Combined absorption spectroscopy and electrochemical testing were used to track lanthanide concentrations. O2- impurity levels were controlled by adding Li2O to lanthanide-salt solutions. After the introduction of O2- impurities, Ln3+ concentrations were monitored via time-resolved absorption spectroscopy. Concentrations of both Ln3+ species in solution decreased with time as insoluble products formed. The initial impurity concentration controlled whether insoluble products were predominantly oxychlorides or mixtures of oxychlorides and oxides. However, absorption spectroscopy is limited for weakly absorbing species, such as Pr3+, and under conditions of high impurity concentrations where solutions can be turbid. To circumvent this limitation, the concentrations of Pr3+ were monitored with square wave voltammetry (SWV). Reaction rates and extent of Pr3+ removal from solution as monitored by SWV agreed closely with results found from spectroscopic monitoring. This demonstrates that simultaneous electrochemical testing complements the capabilities of absorption spectroscopy to monitor reactions of fission products in molten salts.

Log 704. DEVELOPMENT OF CPB AND CBI PEROVSKITE RADIATION DETECTORS. Barzilov, A.(1, P); Han, C.(1); Rivera, M.(1); Tonkinson, S.(2); Ragsdale, A.(2); Kutty, M.N.(2); Martinez, J.(2); Dibert, A.(2); Balakrishnan, G.(2); Hecht, A.(2). (1) University of Nevada Las Vegas. (2) University of New Mexico. (P) Presenting Author.

Development of room temperature gamma detectors is important for field applications and in industry. Inorganic perovskites such as CsPbBr3 (CPB) and Cs3Bi2I9 (CBI) are promising materials due to a large gap between valence and conduction bands and survivability in various crystal growth conditions. The absence of Van der Waals gaps enables good electrical and mechanical properties of CPB and CBI: high mobility-lifetime product, low defect density, and long-term stability for detecting photons and charged particles. The CPB and CBI crystals were grown from their own melt by Bridgman method. Perovskite powder synthesis, ingot processing, semiconductor wafer fabrication, surface treatment, and the semiconductor detector design will be discussed. The detector materials were characterized using cryogenic and room temperature photoluminescence, optical and scanning electron microscopy, and x-ray diffraction.

Log 705. Cs ISOTOPE DETERMINATION IN ENVIRONMENTAL SAMPLES BY TIMS. Turner, G.L.(1, P); Berry, C.K.(1); Anderson, I.R(1); Gartman, B.N.(1); Gajos, N.A. (1). (1) Pacific Northwest National Laboratory.

Release of Cs fission products, 135Cs and 137Cs, into the environment has been documented throughout the nuclear fuel cycle. The 135Cs/137Cs isotopic ratio can be used to provide insight on various Cs source terms, including nuclear fuel reprocessing, nuclear accidents, and nuclear fallout. We present new 135Cs/137Cs ratio and concentration thermal ionization mass spectrometry (TIMS) data on three standard reference materials: IRMM-426 Wild Berries, SRM 4350b River Sediment, and SRM 4354 Freshwater Lake Sediment. The sample set ranges from low 135Cs/137Cs values observed in nuclear accidents (Chernobyl and Fukushima) to high 135Cs/ 137Cs values measured in nuclear fallout (Russell et al., 2015). 10-1000 mg soil aliquots of each reference material were used for 135Cs/137Cs determination. Cs in the sample was chemically separated using a custom AMP-PAN and Eichrom Sr Resin based method based on Dunne et al. (2007) and Snow et al. (2015). TIMS analyses of SRM 4354 and SRM 4350b fractions yielded 135Cs/137Cs ratio values of 3.56 ± 0.46 2SD and 1.94 ± 0.17 2SD, respectively (1/1/2015 reference date). An aliquot of IRMM-426 was spiked with 134Cs tracer for 137Cs concentration determination. PNNL TIMS data, 735 ± 15 2SD Bq/kg, shows good agreement with the certificate value, 780 ± 70 137Cs Bq/kg (1/1/2009 reference date). A large 135Cs impurity in our 134Cs tracer inhibited accurate analysis of the 135Cs/137Cs ratio in IRRM-426. Future analyses of unspiked IRMM-426 aliquots will provide a more accurate 135Cs/137Cs value.

Log 706. DEVELOPMENT OF A CYCLOIDAL MASS ANALYZER FOR APLLICATIONS IN NONPROLIFERATION AND NUCLEAR FORENSICS. Mannion, J. (1, P); Mannion, D. (1); Greer, R. (1); Fitzgerald, C. (1); Samperton, K. (1); LaBone, E. (1); Amsden, J. (2); Serpa, R.B. (2); Denton, M.B. (3); Keogh, J. (3); Zarzana, C. (4); Andrus, J. (4). (1) Savannah River National Laboratory. (2) Duke University. (3) University of Arizona. (4) Idaho National Laboratory. (P) Presenting Author.

Recent advances in array detectors have made the development of cycloidal mass analyzers (CMAs) viable for applications requiring high precision and sensitivity. Although first described in 1938, limited detector technology led to the practical abandonment of CMAs by the research community in the proceeding decades. Capacitive transimpedance amplifier (CTIA) array detectors, capable of operating within the magnetic field of the CMA, enable simultaneous ion detection and exhibit sensitivity approaching that of a multichannel plate (~5 ion detection limit) and the linear dynamic range of a Faraday cup (1011). This presentation describes the design, construction, and initial evaluation of a second-generation CMA tailored for single particle uranium isotope ratio and elemental analysis utilizing the CTIA technology. This instrument has demonstrated detection limits in the range of 60 – 100 fg with a resolving power exceeding 1750 up to m/z = 238 in a compact package (<1 m3). Ionization sources under development for the system include direct laser ionization, thermal ionization, and electron impact ionization.

Log 707. COMBINING SEAWATER ACTIVATION WITH PHOTOFISSION TOWARD PRODUCTION OF SURROGATE MARITIME NUCLEAR EXPLOSIVE DEBRIS. Cooper, J.C.(1)(P); Snow, M.S.(1); (1) Idaho National Laboratory (P) Presenting Author.

Post-detonation nuclear forensics employs the detection and analysis of forensic signatures entrained within the nuclear explosion debris generated following a nuclear detonation. Nuclear debris varies in shape, color, composition and radionuclide content. Producing surrogates of nuclear explosive debris is important for benchmarking nuclear forensic methods and training nuclear first responders. The major component of nuclear debris tends to be the predominant environmental matrix found at the location of the blast, such as the silica based debris found in historical nuclear testing in at the Neveda National Security Site. Production of surrogate nuclear debris has thus focused on silica as the base matrix for the debris produced. However, nuclear detonations occurring in a maritime environment would likely produce debris of a substantially different matrix composition with debris likely including the residue of evaporated seawater (salt crystals), which in turn would contain the forensic information being sought by nuclear first responders. In this work, we describe the production of surrogate maritime nuclear explosive debris. Salt particles of varying size were produced from a saturated salt solution using an advanced manufacturing printing method. The inclusion of radiological content was explored by neutron activation of a sample of evaporated seawater which formed the basis of the salt crystals produced. Furthermore, the ability to produce surrogate maritime debris with a targeted fission product content was also explored by combing the neutron activated salt with a fission product solution produced from photofission of a U target.

Log 710. BILATERAL COOPERATION BETWEEN THE U.S.A. AND TAJIKISTAN ON THE NUCLEAR FORENSICS ANALYSIS OF INTERDICTED NUCLEAR FUEL PELLETS. Rolison, J.M.(1,P); Barotov, B.(2,P); Mirsaidzoda, I.(2); (1) Nuclear and Chemical Sciences Division, Lawrence Livermore National Laboratory, USA.; (2) Chemical, Biological, Radiological and Nuclear Safety and Security Agency, Dushanbe, Republic of Tajikistan. (P) Presenting Author.

In 2021, the Chemical Biological, Radiological and Nuclear Safety and Security Agency (CBRN SSA) in Tajikistan was tasked with conducting a nuclear forensics analysis of a cache of suspected nuclear fuel pellets seized during a law enforcement operation within Dushanbe, Tajikistan. Non-destructive gamma spectrometry indicated an 235U enrichment level of 3 to 3.5%. The enrichment and physical dimensions of the pellets combined with additional law enforcement information allowed for the government of Tajikistan to exclude Tajikistan facilities as the source of the confiscated pellets. In 2022, the United States Government began coordinating an effort to support the Government of Tajikistan to preform additional nuclear forensic analyses on a subset of the fuel pellets. Ultimately, CBRN SSA shipped ten fuel pellets to Lawrence Livermore National Laboratory (LLNL) in 2023 where they were subjected to an array of non-destructive and destructive analytical techniques. The analytical results obtained at LLNL confirm the analytical results obtained at CBRN SSA and provide further details about the chemical and isotopic composition of the fuel pellets. Select analytical results will be presented along with discussion highlighting the successes and challenges this collaboration has produced. In addition to support from the Government of Tajikistan and CBRN SSA, this collaboration was supported by numerous U.S. Government agencies including the National Nuclear Security Administration’s Office of Nuclear Smuggling Detection and Deterrence (NSDD), the Department of Energy’s National Nuclear Forensics Library and the Department of State. LLNL-ABS-2001414

Log 711. USE OF ULTRAFAST GHZ-BURST FS LASER ABLATION FOR NUCLEAR FORENSICS APPLICATIONS. Bradley, VC (1); Zorba, V (1) 1; Lawrence Berkeley National Laboratory. (P) Presenting Author.

Laser ablation sampling of solids is a promising technique for sampling solid nuclear material without the need for lengthy dissolution procedures. It has a number of advantages, including improved detection limits, and spatial resolution, but it is not currently used for routine analyses as it generally leads to lower reproducibility and a larger mass bias compared to solution aspiration. One of the major causes in the high uncertainty found in laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) measurements stems from the wide particle size distribution in the plume of ablated material. Some large particles and agglomerates are formed, which causes signal spikes when these particles reach the detector. A new laser technology allows for ultrafast bursts of femtosecond laser pulses which form a sustained plasma at the surface of a sample, without the melting caused by longer nanosecond pulsed lasers. A burst of 50 or 200 pulses, with approximately 1 ns separating each pulse, creates an ablation crater with 10x more volume than a single fs pulse of the same total energy. The time between laser pulses gives the sample more time to cool, which creates less melting at the sample surface and leads to more even particle size distribution. This improvement in particle size could make it a useful sample introduction technique when high precision measurements are needed, like for uranium and plutonium isotope ratios in environmental samples.

Log 712. AUTOMATED SPECTRUM ANALYSIS AND RADIONUCLIDE IDENTIFICATION FOR ROBOT-BASED GAMMA PROBES. Barzilov, A.(1, P); Alila, K.(1). (1) University of Nevada Las Vegas. (P) Presenting Author.

The use of robotic platforms for wide area environmental radiation monitoring enables measurements in hazardous and hard-to-reach environments reducing health risks for workers. The method of automated spectral analysis and isotope identification for robot-based gamma detectors was developed. The algorithm enables smoothing of the energy histograms, peak search based on Mariscotti method, and isotope identification. Ambient temperature semiconductor and scintillation detectors (CZT and NaI) were integrated with the platforms (unmanned aerial systems and unmanned ground vehicles) using Robot Operating System (ROS). A robust algorithm to analyze measured radiation data in real time fusing it with the GPS and timestamps was programmed as a ROS function. It was deployed on a Linux microcomputer of a robot enabling transmission of the measured data to an operator. The results of experiments using different gamma sources will be discussed.

Log 713. UNCERTAINTY IMPROVEMENT OF 22Na-BASED RADIOACTIVE TRACER DILUTION FOR DETERMINING TOTAL MASS OF PYROPROCESSING MOLTEN SALT SYSTEMS BY 154EU REMOVAL .

Guoping Cao (1, P), Magen E. Coleman (1), Brian Storms (1), Shelly Li (1). (P) Presenting Author. (1) Idaho National Laboratory. (P) Presenting Author.

For safeguards purposes, it is necessary to accurately know the amount of special nuclear materials in the molten salt systems for pyroprocessing spent nuclear fuels, which contain various fission products and are highly radioactive. Both the concentration of each special nuclear material and total mass of the molten salt system are needed to be known. The concentration is usually determined by inductively coupled plasma mass spectrometry, but it is challenging to determine the total mass. In recent years, a 22Na-based radioactive tracer dilution (RTD) technique was developed for total mass determination of molten salts. One challenge is that the presence of the 154Eu in the salt significantly affected the uncertainty of total mass measurements, because one of its energy peaks and that of 22Na almost coincide at 1274.5keV. This study investigated the feasibility and benefits removing 154Eu isotope--by using DGA resin--in the salt samples taken from a salt system for electrorefining (ER). It was found that after the 154Eu was removed, the uncertainty (standard deviation) of 22Na radioactivity in the ER salt samples was significantly improved, from 13% to 2%. The success of this study solved a main hurdle for applying 22Na-based RTD for application to highly radioactive molten salt systems for pyroprocessing spent nuclear fuels.

Log 714. DIRECT MEASUREMENT OF Y-90 FOR THE DETERMINATION OF Sr-90 IN ENVIRONMENTAL SAMPLES FROM THE MARSHALL ISLANDS.

Ahrens, N.L.(1,P); Hamilton, T.F.(1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

A method has been developed for the direct determination of strontium-90 in secular equilibrium with yttrium-90 from complex matrices. For environmental samples which exceed the strontium capacity of Sr resin, a novel system was investigated utilizing the selective precipitation of yttrium followed by purification from matrix interferents with LN resin. This method was tailored for compatibility with existing methods used for the determination of plutonium and uranium for monitoring purposes. The addition of in-house strontium measurements to the monitoring program is expected to provide a more accurate basis to assess long-term health or ecological impacts of legacy contamination in the Marshall Islands and the local marine environment.

Log 715. FEASIBILITY AND CHALLENGES OF Na-22-BASED RADIOACTIVE TRACER DILUTION FOR DETERMINING TOTAL MASS OF HIGHLY RADIOACTIVE MOLTEN SALT FOR PYROPROCESSING SPENT OXIDE NUCLEAR FUELS. Cao, G. (1, P); Coleman, M. E. (1); Storms, B. (1); Williams, A. (1); Herrmann, S. (1); Li, S. (1); Cao, R. L. (2). (1) Idaho National Laboratory. (2) Ohio State University. (P) Presenting Author.

In recent years, a 22Na-based radioactive tracer dilution (RTD) technique was developed for total mass determination of molten salts, and it appears promising, based on laboratory scale experiments, for application to molten salt systems for pyroprocessing spent nuclear fuels. To evaluate the 22Na-based RTD for engineering scale, highly radioactive molten salt systems, a 60-kg scale LiCl-1wt%Li2O salt system for electrochemically reducing the spent oxide fuels (also called oxide reduction) was used. This salt for oxide reduction features very high gamma radioactivity (around 10000 µCi/g), mainly due to 137Cs. In this study, the feasibility and challenges of using 22Na-based RTD for total mass determination were studied. It was found that the traditional gamma spectroscopy that typically employed diluted salt samples for monitoring the total radioactivity was not a suitable way for analyzing the RTD samples which contained very low level of 22Na radioactivity. By increasing the detector-sample distance during gamma spectroscopy, from typically 20 cm to 40 cm, the 22Na radioactivity levels as low as 0.12 µCi/g were detected. The total mass determined by RTD is consistent with estimated actual value, with a difference between the two being less than 3%. Thus, the 22Na-based RTD technique for total mass determination of the 60-kg scale molten salt system can be considered feasible, though some challenges need to be addressed. Based on the successful results, some recommendations were made on using 22Na-based RTD for determining the total mass of a highly radioactive molten salt system with unknown total salt mass.

Log 716. MICROCHEMISTRY ANALYSES FOR POST-DETONATION NUCLEAR FORENSICS. Scott, S.R. (1, P); Pratt, S. (1); Melby, K. (1); Sullivan, D.L. (1); Noyes, K.L. (1); Douglas, M (1); Metz, L (1). (1) Pacific Northwest National Laboratory. (P) Presentig Author.

Bulk material analysis provides nuclear forensic information on the general composition of a sample but does not provide any information on heterogeneity within a sample. High precision data aquired from bulk sample analysis can potentially miss relevant information that can only be investigated by exploring sample heterogeneity at smaller scale. This project aims to exploit heterogeneities within a bulk sample by developing techniques to sample at "micro" scales and measure the same products typically measured in the bulk sample (e.g., fission products, actinides). Multiple methods for chemical separation are being investigated, including minitiarized versions of extraction chromatography using Eichrom resins or anion and cation exchange chromatography with the end-goal of rapid, automated separations from multiple samples simultaneously. Measurements of eluted fractions directly from columns without further processing have been accomplished in acidic matrices, including analyses of Pu, Np, and U. Results indicate that microchemical separations are a viable path forward, with ultimate sample size being limited by analyte inventories and instrumental sensitivities.

Log 717. FISSION PRODUCT YIELD MEASUREMENTS OF Pu-239 IRRADIATED AT THE GEOLOGICAL SURVEY TRIGA REACTOR. Linero, V.(1, P); Gooden, M.E.(2); Jackson, J.A.G.(1); Shafer, J.C.(1). (1) Colorado School of Mines. (2) Los Alamos National Laboratory. (P) Presenting Author.

Fission product yields are among the nuclear observables used to correlate fission pathways with respect to increasing neutron energies. The collective effort among the nuclear data community to fully understand the behavior of a fissioning nucleus is an iterative process, and additional measurements are required to further improve our predictive capabilities. For this work, two separate Pu-239 irradiations were completed under distinct neutron environments at the Geological Survey TRIGA Reactor (GSTR) located in Denver, CO. These integral measurements were designed to quantify Pu-239's path towards symmetric fission while approaching a hardened neutron spectrum. These measurements involved dissolving each irradiated Pu-239 target and radiochemically isolating select fission products for beta and gamma analysis. In this talk, I will highlight the major experimental and radiochemical steps taken to calculate the yields of those fission products recovered from byproduct material. The measured yields and corresponding uncertainties will also be compared to the reported literature values.

Log 718. FLUORINATION OF CERIUM MICROSPHERES FOR ACTINIDE TRANSPOSITION. Haynes, R. B. (1, P); Poineau, F. (2). (1) Rutherford Appleton LaboratoryUniversity of Manchester. (2) University of Nevada, Las Vegas. (P) Presenting Author.

Actinide microstructures serve a variety of purposes in nuclear forensics. Synthesis of Cerium microspheres is key for actinide transposition due to its redox potential and similar ionic radii to plutonium. The development of porous microstructures will allow for the use of gaseous reactants for the halogenation of these materials whilst maintaining morphology. As a result, development of porous cerium fluoride microspheres will serve as a key precursor to development of plutonium fluoride microspheres. These materials can be utilized as reference materials in nuclear forensics.

Log 719. RAPID SAMPLE PREP AND AMS ANALYSIS OF Be-10 IN FRESHLY IRRADIATED HEU. Hidy, A. J. (1, P); Dorais, C. (1); Wilkinson, J. T. (1); Walker, A. (1); Tumey, S. J. (1); Anderson, T. S. (1), Gharibyan, N. (1). (1) Lawrence Livermore National Laboratory. (P) Presenting Author.

Rapid and precise 10Be analyses may provide useful diagnostic information in the event of nuclear detonation. Accelerator Mass Spectrometry (AMS) is the preferred method for measurement of 10Be but typically involves significant sample preparation that leads to long analytical turnaround times. An additional challenge for analyzing highly radioactive samples via AMS is that doing so presents an undesirable dispersible radiological hazard in the Cs sputter sources used for ion beam generation. Hence, ion sources at the Center for Accelerator Mass Spectrometry (CAMS) are constrained to total activity limits of <1 nCi/AMS target. There is thus a need for a sample preparation method that is both rapid and capable of almost complete removal of the diverse and evolving suite of short-lived isotopes present in freshly irradiated material. Here, we present a rapid 10Be sample preparation protocol that was tested on samples of freshly irradiated HEU. We prepared and analyzed samples containing ~10e12 fissions that were received ~5 days after end of bombardment. This protocol produced viable 10Be AMS targets, successfully reduced total activity to <1nCi/target, and can return analytical results within a day of sample receipt. Furthermore, this protocol simultaneously prepares samples for measurement of 7Be and 26Al, such that all three isotopes can be analyzed rapidly with AMS. Prepared by LLNL under Contract DE-AC52-07NA27344. This is LLNL-ABS-2001705.

Log 720. PREDICTING, OPTIMIZING, AND ASSESSING PRECISION AND ACCURACY OF ISOTOPIC MASS SPECTROMETRIC SYSTEMS.. Bowden, S.(1,P); Samperton, K.M.(1); (1) Savannah River National Laboratory. (P) Presenting Author.

Ultimate performance in isotopic mass spectrometry is often limited by the chosen calibration method, reference materials, and measurement parameters (e.g., signal integration time, number of cycles, etc.). To ensure reliable, repeatable measurements and defensible uncertainty estimates, the mass spectrometry community has traditionally employed several "best practices" in metrology (e.g., intensity matching standards and samples). However, a robust, generalized, and quantitative exploration into theoretically achievable precision and the direct effects of different measurement practices for various analyses is lacking. We utilize synthetic and measured data from both multicollector- and single collector inductively coupled plasma—mass spectrometry (ICP-MS) to address outstanding first-order questions in measurement and calibration optimization. Data on analytes from across the periodic table are used to investigate the effects on precision, bias, and accuracy from practices such as 1) employing equal-atom calibration standards to maximize the signal on each detector vs. intensity matching standards and samples; 2) calibrating using “near-mass” elements in an effort to decrease instrument backgrounds on analytes-of-interest; 3) utilizing various calibration methods in correcting mass spectrometric data (e.g., calibration curves, standard-sample bracketing, double-spiking, secondary standard-based correction factors, internal normalization); and 4) the practical advantage in precision obtained by optimizing integration and cycle number parameters. This effort integrates forward modeling of synthetic with empirical data in providing a holistic approach to robustly predicting, optimizing, and assessing the precision and accuracy of an isotopic mass spectrometric system.

Log 721. ACCURATE QUANTIFICATION OF SHORT-LIVED RADIONUCLIDES IN INAA USING THE HANARO PNEUMATIC TRANSFER SYSTEM. Soengpyo Hong(1), Kishore B. Dasari(1,2,3), Bo-Young Han(1), Gwang-Min Sun(1,P), Jong-Hwa Moon(1), Sung Hyo Lee(1), Hana Cho(2), (1) HANARO Utilization Division, Korea Atomic Energy Research Institute. (2) Division of Chemical and Material Metrology, Korea Research Institute of Standards and Science (KRISS). (3)The Research Institute of Natural Science, Gyeongsang National University. (P) Presenting Author.

Instrumental neutron activation analysis (INAA) is a highly sensitive and precise method used to determine the elemental composition of a sample based on the process of neutron activation, which involves shooting neutrons at the atomic nuclei of a sample, causing some of the atomic nuclei to become radioactive. It is non-destructive and can analyze up to 70 different elements simultaneously, making it versatile for multi-element detection. The half-life of the radionuclides produced in these neutron irradiation analyses is very important for sample analysis, as nuclides with too short a half-life are difficult to analyze because they all disappear during the cooling time after neutron irradiation and spectra cannot be obtained. Representative nuclides with short half-lives include Mg, Ti, Al, F, Cl, and Na, with half-lives of 9.462 m, 5.76 m, 2.2414 m, 11 s, 0.715 s, and 0.0202 s, respectively. In this study, we conducted experiments utilizing srm and crm for INAA for Al, V, Ti, Dy, Mg, Mn, Na, K, and Cl with half-lives of a few minutes, and tried to derive the optimal analytical conditions for each element. The results of this study will be used as the basis for future improvements to INAA's analytical precision.

Log 722. CREATION AND CHARACTERIZAATION OF A LOW-LEVEL TRITIATED METHANE STANDARD BY ABSOLUTE GAS COUNTING.

T.R. Alexander (P,1), C.E. Aalseth (1), R.A Bunker (1), E.R. Edwards (1), B.G. Fulsom (1), S.M. Lyons (1), E.K. Mace (1), K.S. Thommasson (1), N.D. Rocco (1), A.M. Whitehill (1), M.A. Bodmer (2), M.P. Foxe (1), B.G. Fritz (1), B. Roberts (2), J. Tofaya (2), A.A. Wright (2). (P) Presenting Author (1) Pacific Northwest National Laboratory (2) Sandia National Laboratory

Measurement of radioactive gases with a proportional counter typically requires a well-known reference gas to first measure the detector-dependent efficiency for the radioisotope of interest. Ultra-sensitive measurements require precisely-known low-level reference gases that are also free of other radioisotopes like radiocarbon. It was therefore necessary to generate low-radioactivity methane containing a known amount of tritium while being free of other radioactivity for use in PNNL Ultra-Low-Background Proportional Counters (ULBPCs). A commercially-available HTO standard was diluted with tritium-free water to generate a low-level HTO sample. Tritiated methane was then generated from this HTO by heating the water over aluminum carbide. Most of the methane was mixed with argon to produce a standard P10 count gas, with a fraction of the pure methane being stored for later mixing as necessary. The specific activity was measured using the PNNL Absolute Gas Counting capability, a set of unequal length proportional counters filled to five different pressures and measured in PNNL’s Shallow Underground Laboratory, thereby characterizing the efficiency of PNNL's ULBPCs for tritium detection.

Log 723. MEASUREMENT OF OXIDE AND MOLECULAR TRITIUM IN PE1-A GAS GRAB SAMPLES.

T.R. Alexander (P), C.E. Aalseth (1), K.A. Beck (1), S.M. Lyons (1), E.K. Mace (1), K.S. Thommasson (1), N.D. Rocco (1), A.M. Whitehill (1), M.A. Bodmer (2), M.P. Foxe (1), B.G. Fritz (1), B. Roberts (2), J. Tofaya (2), A.A. Wright (2), and the PE1-A Experiment Team. (P) Presenting Author (1) Pacific Northwest National Laboratory (2) Sandia National Laboratory. (P) Presenting Author.

As a part of PE1-A’s gas transport experiment, one Curie of molecular tritium (a mixture of HT and T2) was included as a tracer to investigate how tritium transforms and migrates through the soil. While a fraction of the tracer remained molecular tritium in the aftermath of the explosion, a significant quantity was converted into other chemical forms such as tritiated water and tritiated hydrocarbons. During the 28-day gas experiment, 32x 2.7L air samples were collected from each of four boreholes and two tunnel sampling locations to be sent back for measurement after-the-fact. The grab samples were carefully split to allow for several analyses to be performed, including the measurement of tritium. The concentrations of HTO and HT present in the sample were quantified, then captured in a flame sealed glass bulb where it was heated to 300 °C and converted to a methane. The methane was quantified, filled into an Ultra-Low-Background Proportional Counter, and measured in PNNL’s Shallow Underground Laboratory to characterize both the transport and transmutation of the tritium tracer. This talk will discuss the methods used to extract, quantify, and measure both the molecular tritium and tritiated water signals from the gas grab samples, and discuss the results of the measurement of the samples and the speciation observed.

Log 724. URANIUM TRANSPORT IN A CONTAMINATED WETLAND STREAM: IMPACT OF FLOW RATE AND SUSPENDED SOLIDS COMPOSITION.

Kaplan, D.I.(1, P), Greene, K.M.(1), Xing, W.(1), Montgomery, D.(2), Powell, B.A.(2), Lin, P.(1). (1) University of Georgia. (2) Clemson University. (P) Presenting Author.

During the 1960s, the Tims Branch wetland, located on the Savannah River Site in South Carolina, USA received 43,500 kg of U released during the production of nuclear materials. More than 50 years later, 94% of the released U remains concentrated in five multi-hectare hotspots. The objective of this study was to quantify the impact of stream flow rate on U transport from the contaminated wetland. Hourly stream sampling was conducted during six rain events, including a hurricane. Some storm events, especially those after long periods of drought and low total rainfall, indicated an initial high release of U into the stream, coinciding with high concentrations of suspended solids that were comprised primarily of iron-oxyhydroxide flocs. These flocs were formed when dissolved Fe(II) from the contaminated wetland sediment encountered the oxygenated stream and precipitated as an Fe(III)-oxyhydroxide enriched in natural organic matter. The resulting flocs coprecipitated or otherwise bound the U at concentrations as high as 600 mg/kg U. Later during the storm events, when the flow rate and suspended solids load were typically much greater, the suspended solids were comprised primarily of the minerals found in the sandy stream bed (dominated by quartz), which tended to have appreciably lower U concentrations (<100 mg/kg U). Stream flow rates (m3/s) were inversely correlated to U solids concentrations (mg/kg U), and particulate organic C concentrations (mg/L C), and directly correlated to mean particle diameter (nm). This study demonstrates that the risk associated with contaminant transport from wetland streams may involve more than the physics associated with the hydrodynamic resuspension of contaminated particles, and that consideration of the suspended solids composition may also play an important role.

Log 725. DISTRIBUTION OF RADIOACTIVE STRONTIUM-90 IN SKULL BONE OF WILD SMALL ANIMALS DETERMINED BY THERMAL IONIZATION MASS SPECTROMETRY.

Goto, M.(1, P); Ishiniwa, H.(2); Takagai, Y.(1, 2). (1) Fukushima University. (2) IER, Fukushima University. (P) Presenting Author.

Sr-90 is a radioactive nuclide with a 28-year half-life, produced as a fission product of uranium. Due to its chemical similarity to calcium as an alkaline earth metal, Sr-90 accumulates in bones and teeth of animals that ingest contaminated food. It has assumed that Sr-90 concentrations in bone tissue were uniformly distributed. This study challenges that assumption by focusing on small wild animals such mice and moles. Conventional methods for detecting Sr-90 require large sample sizes; therefore, it is difficult to analyze small animals. A recent technique employing isotope dilution (ID) and a quadrupole mass filter (RPQ) in thermal ionization mass spectrometry (ID-RPQ-TIMS) enables quantification of ultra-trace levels of Sr-90 in milligram-sized samples [1, 2]. Using this method, the study revealed nonuniform distributions of Sr-90 in the skull bones of small animals. The patterns observed are similar to those of stable Sr, and this suggests a similar mechanism of incorporation. The distribution trends varied between species; however, since only a single measurement of each species was conducted, the specific trends could not be revealed. It is considered the nonuniform distribution of Sr-90 reflects its incorporation during the growth of bone tissue. This study emphasizes the importance of understanding localized Sr accumulation in assessing the environmental impact of radioactive contamination on wildlife. [1] Aoki, et al, Anal. Chem., 2023, 95, 4932 [2] Aoki, et al, JAAS, 2024, 39, 408

Log 726. I WONDER IF IN THE FUTURE..... Inn, K.G.W. (1, 2, P); Biegalski, S. (3); Bronson, F. (4); Burns, D. (5); Burns, J. (6); Cao, R. (7); DiPrete, D. (8); Fern, M. (9); Haas, D. (10); Klug, C. (11); Kurosaki, H. (12); Penchoff, D. (13); Porterfield, D. (14); Sudowe, R. (15); Taylor, B. (16); Van Cleef, D. (17). (1) K&E Inn Ovations, Inc. (2) NIST, Retd. (3) Georgia Institute of Technology. (4) Merion Technologies. (5) USAF. (6) USEPA, NAREL. (7) Ohio State U. (8) SRNL. (9) Eichrom Technologies. (10) U of Texas. (11) [Eckert & Ziegler Analytics, Inc. (12) ORNL. (13) U of Central Florida. (14) LANL. (15) Colorado State U. (16) Washington State Dept of Health. (17) ORNL. (P) Presenting Author.

By 2085 the world human population could double to 15 billion people. Potentially, combined with dramatic climate changes, there could be need for life basics - drinking water, food, shelter, health/medical, security and power [including robotics, machine learning and artificial intelligence]. Radioanalytical chemistry could be an important contributor for solutions to these problems. However, it takes time to build the education, science and infrastructure to make a meaningful impact. Now is the time to begin developing a long-term vision and plan. Initial workshops at MARC XII and RRMC 2023 began the conversation, and their results are summarized.

Log 727. TITANIUM PHOSPHATES FOR ION EXCHANGE STUDIES. Ramirez, P.I.(1,P); Czerwinski, K.R.(1). (1) University of Nevada, Las Vegas. (P) Presenting Author.

Phosphate-modified titanium dioxide was synthesized using different starting compounds, preparation methods, and procedures. The material was characterized using X-ray diffraction, scanning electron microscopy, thermogravimetric analysis, differential scanning calorimetry, and Fourier-transform infrared spectroscopy. X-ray diffraction patterns indicated that different titanium phosphate phases could be obtained by changing synthesis conditions, such as acid concentration. After synthesizing and characterizing these inorganic ion exchangers, batch experiments and column studies were performed on the behavior of Th, Ra, and Ac. Studies were conducted with nitric acid concentrations ranging from 0.1 M to 1.0 M and thorium concentrations ranging from 8.8E-4 to 8.8E-3 M. Variations in flow rates were also evaluated for the column studies. The Th concentration was evaluated by inductively coupled plasma atomic emission spectroscopy, while Ra and Ac concentrations were determined through gamma spectroscopy of 228Ac. The material was used to assess the behavior of Th and its Ra and Ac progeny. These experiments identified the optimal conditions for the titanium phosphate synthesis that provided the maximum Th sorption capacity for the material. The data obtained was used to determine dissociation constants and Th sorption kinetics to the titanium phosphate material. The results provide suitable conditions for the retention and separation of Th from its progeny.

Log 728. A SHIELDED SAMPLE HOLDER ENABLING EXAMINATION OF IRRADIATED SAMPLES IN LOW-DOSE RATE ENVIRONMENTS. Brian Gross (1); William Chuirazzi (1); Swapnil Morankar (1); Aaron Craft (1); Scott Moore (1). (1) Idaho National Laboratory. (P) Presenting Author.

The high radiation dose rates emitted from irradiated nuclear fuels and materials, often preclude their examination in instruments that require lower dose rates to handle. This presentation describes a shielded sample holder that enables handling of high-dose rate samples in low dose environments with remotely operated access to the irradiated sample. To date, the highest dose rate sample examined using this approach is 120 rem/hr, which was safely hand positioned into the X-ray microscope instrument. Variants of this sample holder are also being developed for neutron beam examinations.

Log 729. DEVELOPMENTS IN NEUTRON ACTIVATION ANALYSIS USING A MEDICAL ISOTOPE CYCLOTRON.

Duke, M.J.M. (1P). (P) Presenting Author.

Over the past 30 years a trend which has had a negative impact on the discipline of neutron activation analysis (NAA) is the global decline in operational research reactors due to their decommissioning or permanent shutdown. This has resulted in a loss of NAA and reactor-based radionuclide production capabilities and diminished opportunities for NAA-based research, teaching, training, and outreach. In contrast, during the past two decades there has been a surge in the commissioning of medical cyclotrons worldwide, particularly those which operate in the 10-25 MeV energy range. As an example, the University of Alberta (UofA) commissioned a TR-24 medical cyclotron in 2013 and decommissioned its SLOWPOKE nuclear reactor in 2017. The primary function of the UofA TR-24, like most medical cyclotrons, is the production of radionuclides via (p,xn) nuclear reactions for use in nuclear medicine. Such radionuclides are used to diagnose, treat and monitor certain diseases, especially various cancers. During radionuclide production medical cyclotrons generate neutrons as a by-product and these neutrons may be used advantageously for NAA and small-scale radionuclide production. At the MARC XII conference I presented preliminary work utilizing the UofA TR-24 as a neutron source for NAA. Based on 2-3 years of additional experience in cyclotron-based NAA I will showcase the benefits, and the limitations, of using a medical cyclotron such as the TR-24 for NAA-related research, using examples from a variety of fields (e.g., geology, archaeology, soil science, environmental science, and analytical chemistry) as well as for teaching and training purposes.

Log 730. EFFECTS OF ALKALINE EARTH METAL SALTS ON LITHIUM ISOTOPE EXCHANGE REACTIONS.

Tachibana, Y.(1, P); Kalak, T.(2); Abe, T.(3); Nogami, M.(4); Suzuki, T.(5); Tanaka, M.(6). (1) Kyushu University. (2) Poznań University of Economics and Business. (3) National Institute of Technology, Tsuruoka College. (4) Kindai University. (5) Nagaoka University of Technology. (6) National Institute for Fusion Science. (P) Presenting Author.

To operate a nuclear fusion reactor using the D(deuterium)-T(tritium) reaction, the enrichment of Li-6 from a raw Li material is surely required. In lithium isotope exchange reactions using chromatography, an isotope separation coefficient per unit mass (ε/Δm), which indicates the degree of isotope separation behavior, depends on the hydrophobicity and the surface roughness of cation exchange resins (Yu Tachibana et al., Sep. Sci. Technol., 55(12), 2183–2192(2020), J. Ion Exchange, 29(3), 41–47(2018), Tatsuya Suzuki et al., Journal of Plasma and Fusion Research SERIES, 11, 45–48(2015)). However, it is unclear how the difference in the valences of the used eluents affects this coefficient. Hence, in this study, lithium isotope enrichment experiments were carried out by cation exchange chromatography using three kinds of eluents, and the lithium isotope exchange mechanisms were examined. Potassium acetate, magnesium acetate, and calcium acetate were chosen as eluents. The ε/Δm values of lithium (Li(I)) for three kinds of eluents were calculated from the curves of Li(I) isotope discrimination. The ε/Δm values for potassium acetate system, for magnesium acetate system, for calcium acetate system, were εf-K = 0.00193 (front boundary), εr-K = 0.00191 (rear boundary), εf-Mg = 0.00155, εr-Mg = 0.00554, εf-Ca = 0.00269, εr-Ca = 0.00250, respectively. The difference of the ratio of the cation exchange reaction of Li(I) and K(I), Mg(II), or Ca(II) is cited as a reason for the difference in these ε/Δm values.

Log 731. DEVELOPMENT OF SMALL-SCALE SEPARATION METHODS FOR THE RAPID ANALYSIS OF POST-DETONATION NUCLEAR DEBRIS. Baltes, Anastasia (1, P); Gelis, Art (1). (1) University of Nevada, Las Vegas; (P) Presenting Author

Analyzing nuclear debris is vital for identifying forensic signatures in a post-detonation environment. While established methods exist for obtaining signatures from debris, ongoing efforts in nuclear forensics aim to shorten the analysis timeline. This project explores innovative approaches by integrating materials chemistry with radionuclide separation techniques to deliver actionable signatures more quickly than traditional methods. By leveraging the phase distribution of radionuclides in debris, we develop targeted dissolution methods combined with a microfluidic system, effectively reducing analytical timelines. Phases of uranium/plutonium-based debris collected from the Trinity test site were evaluated to identify novel dissolution and small-scale separation methods that can be implemented in the field. Synthesized surrogate debris is also leveraged within the project, as well as the ability to incorporate actinides and treat the debris with fast neutrons. After separating the mineral phases based on selective dissolution and sequential extraction methods, the correlation of radionuclides with specific mineral phases and the constituents impacting the performance of radioanalytical procedures is ascertained. Then, a microfluidic system that manipulates small amounts of fluids is utilized to perform multiple solvent extraction steps and purify the radionuclides of interest. The system's known interfacial areas and rapidly mixed regime allow for the measurement of kinetic rate constants for interfacial mass transfer during extraction. Entire separation protocols are performed inside a glass microfluidic cartridge, confining radiation, reducing exposure, and making radioactive waste disposal safer/simpler. Speciation data obtained from these studies will offer new methods for the specific and rapid separation of radionuclides, addressing a key challenge in ongoing forensic research. This advancement will facilitate the development of analytical techniques that eliminate the need for complete sample digestion and reduce the time required for isotopic ratio determination by solution methods. Our findings are directly applicable to real-world nuclear forensic scenarios, providing practical solutions for improving analysis efficiency.

Log 732. SPATIAL RADIOCHRONOMETRY MODEL AGE IN CAST DEPLETED URANIUM. Robertson, B.N.(1,2, P); Athon, M.A. (1); Shen, S.D.(1); Kroontje, F. K.(1); Krogstad, E.J.(1) Nims, M.K.(1) Kant, L.B.(1). (1) Pacific Northwest National Laboratory (2) Oregon State University. (P) Presenting Author.

Uranium radiochronometry seeks to determine temporal history of uranium bearing materials by measuring the long lived decay product content and correlating with material age, also referred to as model age. This model age is generally considered to be the time since most recent chemical purification of the uranium, presuming (1) the chemical process completely removed any in-grown decay product; (2) no uranium or decay product is added to or removed from the material during the aging period; and (3) the decay product grows in homogeneously throughout the volume of the material. Two chronometric pairs used to determine model age of uranium materials include 230Th/234U and 231Pa/235U, as both 230Th and 231Pa, though radioactive, have sufficiently long half lives that they accumulate roughly linearly in uranium materials over time for several decades. This project examines whether the uranium age dating assumptions hold true during physical transition of melting and re-solidifying aged uranium metal using a set of 50+ year old depleted uranium metal. Uranium age dating using both the 230Th/234U and 231Pa/235U chronometers is performed on aged feedstock materials then compared to melted and recast material examining subsamples from the interior and exterior of the recast samples.

Log 733. PYROCHEMICAL PROCESS IN-SITU MONITORING USING CZT ARRAY GAMMA-RAY DETECTOR SYSTEM. Rim, J.H. (1, P); Akin, A.C. (1); Winkler, R. (1); Tandon, L (1); Robbins N.D. (1). (1) Los Alamos National Laboratory. (P) Presenting Author.

This presentation will discuss use of a cadmium zinc telluride (CZT) array gamma-ray detector system as an in-situ monitoring tool during pyrochemical processes. The pyrochemical processes melt metal feeds to either combine and form them into a desired shape or to remove impurities from the Pu metal. CZT detectors have been strategically installed under gloveboxes around pyro-furnace wells to measure gamma-ray emissions of molten Pu and quantify the internal movement of molten metal and impurity elements during pyrochemical processes. A CZT system is an ideal system to perform real-time monitoring. Other gamma and X-ray detectors may provide better resolution or efficiency. However, CZT detectors are room temperature operating systems that can be designed into a small package size

Log 734. USE OF ADVANCED UO2 FUEL IN INTENTIONAL FORENSICS. Cluff, D. (1,P); Spencer, M. (1); Battersby, J. (1); Young, D. (1); Dimayuga, I (1); Totland, M. (1); 1 - Canadian Nuclear Laboratories. (P) Presenting Author.

Adding taggants to nuclear fuel would simplify and speed up provenance assessment for material out of regulatory compliance. It is important however, to ensure that the added material does not have deleterious effects on reactor operation and safety nor pose increased difficulties during fuel fabrication. Interestingly enough, outside the nuclear forensics circle, nuclear fuel manufacturers are looking to use advanced UO2 fuel (doped UO2 fuel with additive amounts around 1000 ppm) to help improve fuel safety and performance. This openness to adopt advanced fuels in power reactors opens the door for easier acceptance of taggants by the industry. In the present study, the fabrication of MnO-Al2O3 doped UO2 pellets was investigated. MnO and Al2O3 were added to the starting UO2 powder using 3 different MnO:Al2O3 ratios while maintaining a constant ratio of additive to uranium ((Mn+Al)/U) of 750 ppm. The persistence of Mn and Al throughout the fabrication process was monitored using ICP-MS during different stages of the fabrication process. The impacts of the additives on sintered density and grain size was examined and the distribution of Mn and Al in the U matrix was assessed using EDS mapping. The impact of including taggant materials on the fuel fabrication process and the opportunities and challenges associated with characterization will be discussed.

Log 735. OPTICALLY ACTIVE INVISIBLE SURFACE TAGS FOR NUCLEAR FORENSICS. Abdel-Rahman, M.K. (1, P); Mouche, P.A. (1, P); Jamison, L. (1); Yacout, A.M.(1); Condon, N.J. (1). (1) Argonne National Laboratory. (P) Presenting Author.

A hidden easily accessible and readable signature on nuclear fuel is of interest for intentional nuclear forensics. To achieve this, the tag must be sufficiently thin to be invisible under ambient lighting conditions and composed of a material that strongly interacts with ultraviolet (UV) light. ZnO is a promising candidate as tag material because it absorbs light with wavelengths below 375 nm and can be deposited in thin films (less than 50 nm) by atomic layer deposition (ALD). Tuning the film thickness with ALD provides films that are too thin to interact with visible light, yet the electronic properties of ZnO allow the film to be identified under ultraviolet irradiation. A series of ZnO films were grown on a 6061 aluminum substrate and investigated by scanning electron microscopy, UV reflection imaging, and X-ray photoelectron spectroscopy to determine the optical properties of the film as well as its resistance to aqueous corrosion. Initial corrosion tests indicate that the ZnO film spalls from the substrate in deionized water; therefore, alumina and titania were assessed as potential protective layers to inhibit ZnO spallation. To assess the film’s resistance to physical wear, the samples were investigated using nanoindentation. Readable patterns have been successfully applied with development ongoing to increase their robustness.

Log 736. MODELS OF Ar-39 AS A LONG-TERM INDICATOR OF UNDERGROUND NUCLEAR EXPLOSIONS. Lowrey, Justin (1); Johnson, Christine (1, P); Luo, Xiao (1); White, Signe (1); Rockhold, Mark (1). (1) Pacific Northwest National Laboratory. (P) Presenting Author.

Measurements were first made by Pacific Northwest National Laboratory in 2016 of legacy Ar-39 gas from the decades-old Barnwell underground nuclear explosion site within the Nevada National Security Site. The question of how ubiquitous the radionuclide Ar-39 can be expected to be for underground nuclear explosions in general locations has motivated a closer look at long term radionuclide signals following these events. In the years since, multiple gas sampling campaigns have confirmed the presence of Ar-39 underground at nearly every legacy explosion site studied. Subsurface transport modeling of gas evolution over years and decades is shown here to reinforce the idea that Ar-39 is a reliable long-term indicator of past underground nuclear explosions, and simulations demonstrate how such a gas can remain contained in subsurface environment. This modeling work also considers the sensitivity of this signal persistence to explosion depth of burial as well as native bulk rock permeability, porosity and water saturation.

Log 737. DIRECT NEUTRON CAPTURE MEASUREMENT OF ZIRCONIUM-88 AT CERN n_TOF. Flanagan, W. (1,2, P); Alpar, G. (1); Bacak, M. (3,4); Moldenhauer, J.(1); Balibrea-Correa J. (5); Lerendegui-Marco J.(5); Garcia-Infantes F. (3,6); Maugeri E.A. (7); CERN n_TOF Collaboration. (1) The University of Dallas. (2) The Unviersity of Texas at Austin. (3) CERN. (4) TU Wien. (5) CSIC - Universidad de Valencia. (6) University of Granada. (7) Paul Scherrer Institut. (P) Presenting Author.

We report the first direct measurement of zirconium-88 neutron capture cross section from 0.015 eV to 0.75 eV at the CERN n_TOF experiment. Zirconium-88 was measured in 2019 to have the second largest thermal neutron cross section of any isotope and orders of magnitude above expectation. The DICER experiment recently published a transmission-based cross section and evidence of a sub-eV resonance. This work confirms a sub-eV resonance at an energy of 0.17 eV, in agreement with DICER, and provides a Single-Level Breit-Wigner best fit.

Log 738. MEASUREMENT OF THE ISOMERIC YIELD RATIO OF ZIRCONIUM-89m FROM ZIRCONIUM-88 THERMAL NEUTRON ABSORPTION. Kelly I. (1); Flanagan W. (1,2,P); Moldenhauer J. (1); Charlton W. (2); Lapka J. (2); Nolting D (2). (1) The University of Dallas. (2) The Unviersity of Texas at Austin. (P) Presenting Author.

In light of the recently observed 800,000 barn thermal neutron absorption cross section of zirconium-88, this work investigates the rate (isomeric yield ratio) of metastable zirconium-89 production and resulting implications for ongoing measurements around zirconium-88 neutron absorption. The metastable state of zirconium-89 resides at 588 keV above the ground state with a half life of 4.2 minutes. A 5 micro-Curie zirconium-88 sample was irradiated for 10 minutes in the core of a TRIGA Mark II nuclear research reactor and measured with a high purity germanium detector starting 3 minutes after irradiation. The isomeric yield ratio was measured to be 74.9+-0.6%.

Log 739. ADVANCING GLOBAL COMPETENCE IN DIAGNOSTIC AND THERAPEUTIC RADIOISTOPES AND RADIOPHARMACEUTICALS THROUGH E-LEARNING COLLABORATION.

Dickman, P.T. (1,P); Qaim,S.M (1,2); Decristoforo, C (3);Park, C.T., (1) Horack, C.I (4); Ko, H.S. (5), Kim, H.J., (5). (1) World Council on Isotopes. (2) Forschungszentrum Jülich, Germany. (3) Medical University Innsbruck, Austria. (4) International Atomic Energy Agency. (5) Korean Atomic Energy Research Agency. (P) Presenting Author.

For several years the World Council on Isotopes (WCI), in partnership with the International Atomic Energy Agency (IAEA) and the Korea Atomic Energy Research Institute (KAERI), organized training for radioisotope professionals and related experts from countries with limited training resources in peaceful uses of radioisotopes. WCI recently conducted a highly successful e-learning program titled “Diagnostic and Therapeutic Radioisotopes and Radiopharmaceuticals Application with Foundational-Level Regulation.” This innovative educational initiative aimed to enhance global expertise in the use of radiopharmaceuticals for diagnostic and therapeutic applications while promoting foundational regulatory knowledge. The course was conducted in two parts. Part 1 offered flexible, self-paced online modules on critical topics such as Good Manufacturing Practices (GMP), quality control, and regulatory processes. Part 2 focused on the clinical and therapeutic applications of radioisotopes. Across the two sessions, a total of 169 participants from 29 nations engaged in this program, demonstrating the global reach and accessibility of the initiative. Key topics covered included radiopharmaceutical production techniques (reactor- and cyclotron-based), basic and advanced radiochemistry, regulatory landscapes in various regions, and guidance for establishing optimal radiopharmaceutical regulations. The program emphasized interactive learning through Google Classroom, with live Q&A sessions, expert-led discussions, and graded assignments to reinforce understanding. This program highlights the capacity of international cooperation to break down geographical and logistical barriers, ensuring equitable access to specialized knowledge. This initiative underscores the transformative potential of e-learning in building global technical competencies and fostering international collaboration aimed at building global capacity in the radiopharmaceutical sector.

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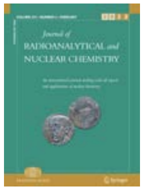
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METHODS AND APPLICATIONS OF RADIOANALYTICAL CHEMISTRY

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