MS 6: New Methods, AMS II, Applications, Actinides

Time: Wednesday 17:00–19:00 Location: HS 3042

Invited Talk MS 6.1 Wed 17:00 HS 3042

Can we tame neutrons with a storage ring? — •Iris Dillmann — TRIUMF Vancouver, Canada — University of Victoria, Canada

Neutrons play a crucial role in the synthesis of elements heavier than iron in stars and stellar explosions via the slow (s), intermediate (i), and rapid (r) neutron capture processes.

Due to the location of these processes on the chart of nuclei, the availability of experimental data greatly differs. While masses and beta-decay half-lives are well measured for the majority of the presently known ~3300 nuclei, neutron capture reactions have only measured at and close to stability in the past 50 years [1]. However, the direct measurement of neutron cross sections with shorter half-lives (half-live <1 year) requires the use of radioactive beams in inverse kinematics and the development of new methods.

For the measurement of neutron capture cross sections of shorter-lived nuclei so far only indirect methods have been used. I will describe a path towards a pioneering facility consisting of a heavy-ion storage ring connected to our ISAC radioactive beam facility at TRIUMF where some of these reactions could be measured directly, with a moderated neutron target [1].

[1] I. Dillmann, O. Kester, et al., Eur. Phys. J. A59 (2023) 105

MS 6.2 Wed 17:30 HS 3042

Assessment of anthropogenic actinide background levels on HZDR's research campus — •Sebastian Fichter[1], Karin Hain[2], Peter Steier[2], Michael Hotchkis[3], and Anton Wallner[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Dresden, Germany — [2]University of Vienna, Faculty of Physics, Isotope Physics, Vienna, Austria — [3]Australian Nuclear Science and Technology Organisation, Lucas Heights, Australia

The new multi-purpose 1-MV AMS facility HAMSTER (*Helmholtz Accelerator Mass Spectrometer for Tracing Environmental Radionuclides*) in Dresden-Rossendorf will commence operation in 2024. The new machine is dedicated to the analysis of ultra-trace levels of actinides in environmental samples. Thus, the aim of this study is to assess the actinide background on HZDR's research campus to rule out any potential contamination caused by the former research reactor on-site. Hence, several soil samples close to the construction site of the new accelerator building and former radioisotope production facilities have been analyzed. The samples have been processed in the existing chemistry labs of HZDR's 6-MV DREAMS facility and the newly established HAMSTER labs showing comparable low background levels. The measured Pu concentrations and isotopic ratios are in agreement with global fallout signature. However, in some samples increased ^{236}U concentrations and relatively low ^{233}U/^{236}U atomic ratios have been detected pointing to an additional reactor source of ^{236}U. Additional sample analysis will be performed with HAMSTER in 2024.

MS 6.3 Wed 17:45 HS 3042

Where do we lose Protactinium in Environmental Sample Preparation for Accelerator Mass Spectrometry? — •Janis Wolf[1,2], Astrid Barkleit[2], Leonie Ebenberger[1,3], Sebastian Fichter[1], Robin Steudtner[2], and Anton Wallner[1] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf — [2]Institute of Resource Ecology, Helmholtz-Zentrum Dresden-Rossendorf — [3]University of Vienna, Austria

Protactinium-231 (Pa-231) is a long lived ($t_{1/2} = 3.28 \cdot 10^4$ a), naturally occurring radionuclide, produced in the natural decay series of uranium-235 (U-235). A measurement of Pa-231 at environmental concentrations would enable the investigation of the migration pattern of Pa-231 in the environment and thus improve the radiological risk assessment of the U-235 decay chain.

Pa-231 is not yet routinely measured by Accelerator Mass Spectrometry (AMS) but procedures for the chemical sample preparation for AMS measurements of Pa-231 are currently being developed. The biggest challenge in establishing a Pa-231 measurement procedure is the lack of knowledge on the chemical behavior of Pa. High losses of Pa in the sample preparation pose the biggest issue in the development of a reliable and reproducable chemical sample preparation procedure.

Using the short-lived isotope, Pa-233 ($t_{1/2}$ = 27 days), we tested the AMS sample preparation procedure for different environmental samples. By conducting gamma activity measurements of Pa-233 after every sample preparation step, a comprehensive overview of the biggest Pa sinks is established.

MS 6.4 Wed 18:00 HS 3042

Residence time measurements of Cl^- ions inside the ILIAMS cooler in equilibrium — •Felix Albrecht, Martin Martschini, Michael Kern, Peter Steier, and Robin Golser — University of Vienna, Faculty of Physics, Austria

The ILIAMS (Ion-Laser InterAction Mass Spectrometry) ion cooler, developed at VERA (Vienna Environmental Research Accelerator), plays a pivotal role in providing isobar separation for isotopes that are typically inaccessible to mid-energy accelerator mass spectrometry systems. By combining a gas-filled RFQ ion guide with high-powered lasers, ILIAMS suppresses unwanted isobaric anions via laser photodetachment. The suppression efficiency is limited by the ion residence time inside the cooler, which can be varied mainly through the buffer gas pressure and the guiding field strength.

For the first time, measurements of the ion residence time at equilibrium conditions were performed using a new, custom-built multi-beam switcher. Through sequential injection of the stable isotopes $^{35}Cl^-$ and $^{37}Cl^-$, followed by mass separation by a Wien filter, the buildup- and washout functions of both ion species were observed. The about 3-times higher-current $^{35}Cl^-$ beam pushed the previously injected, lower-current $^{37}Cl^-$ ions through the cooler, yielding a peak in the washout function. This allowed for a direct observation of space charge effects inside the ILIAMS cooler.

Similarly, by pulsed injection of $^{37}Cl^-$ into a $^{35}Cl^-$-filled cooler, residence time distributions of the former were directly measured.

MS 6.5 Wed 18:15 HS 3042

Development of an Ion Mobility Spectrometer towards studies of Lanthanides and Actinides — •Biswajit Jana[1,2], Aayush Arya[1,2], Eunkang Kim[1,2], Elisabeth Rickert[1,2,3], Elisa Romero Romero[1,2], Harry Ramanantoanina[1,2], Sebastian Raeder[2,3], Michael Block[1,2,3], and Mustapha Laatiaoui[1,2,3] — [1]Department Chemie, Johannes Gutenberg Universität, Fritz-Strassmann-Weg 2, 55128 Mainz, Germany — [2]Helmholtz-Institut Mainz, Staudingerweg 18, 55128 Mainz, Germany — [3]GSI Helmholtzzentrum für Schwerionenforschung, Planckstraße 1, 64291 Darmstadt, Germany.

Relativistic effects significantly alter the electronic configuration of the heaviest elements and strongly influence their chemical and physical properties. Ion mobility within a noble gas environment is sensitive to the ions' electronic configuration due to ion-neutral gas interactions, unveiling the impact of relativistic effects on their structure. An ion mobility spectrometer was developed to precisely measure the reduced ion mobility of heavy lanthanides and actinides by conducting parametric studies under varying electric fields, buffer-gas pressures, and temperatures. Ions from a specific element are generated through laser ablation. Following extraction, cooling, and bunching via an RF buncher, these ions traverse the drift tube and are separated by mass using a quadrupole mass spectrometer prior to detection. Here I report systematic ion mobility measurements of Lu+ ions drifting in helium gas for reduced electric fields, spanning from 1 to 30 Td.

MS 6.6 Wed 18:30 HS 3042

A compact single ion detector system for radioactive isotopes with α-decay energy discrimination — •Tom Kieck[1,2], Sebastian Raeder[1], and Michael Block[1,2,3] — [1]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — [2]Helmholtz-Institut Mainz — [3]Johannes Gutenberg-Universität, Mainz

The detection of single ions is usually done by secondary electron multiplication. When detecting isotopes originating as daughters from a radioactive decay and accelerator-produced radionuclides they need to be discriminated from unwanted stable and radioactive ions created in the beam-preparation processes. The detection of specific α-decay energies in a silicon detector provides a versatile solution. It can be a less complex and more compact alternative to mass spectrometric methods. The implementation and challenges of such a detector system in a cost-effective and "open" way will be presented together with application examples from off-line measurements and on-line laser spectroscopy of actinides.

MS 6.7 Wed 18:45 HS 3042

Production and characterisation of synthetic homogenous multi-element actinides samples via sol-gel as standards for mass spectrometry — •Aaron Lehnert, Paul Hanemann, Darcy van Eerten, Sandra Reinhard, Tim Schmalz, and Clemens Walther — Institute of Radioecology and Radiation Protection, Leibniz University Hannover, Herrenhäuser Straße 2, 30419 Hannover, Germany

MetroPOEM[1] is committed to developing SI-traceable mixed element reference materials for the calibration of mass spectrometric devices. In nuclear forensics, elemental selectivity and precise spatially resolved mass spectrometry is essential for ultra-trace analysis of environmental samples. Resonant laser secondary neutral mass spectrometry (rL-SNMS) combines both element selective isotope ratio measurements and spatial resolution on the micrometre scale. Multi-element reference materials are needed to investigate different ionisation efficiencies for the elements important for environmental analytics.

In this work we present a production method of mixed actinide samples such as U, Pu and Am via sol-gel. These samples consist exclusively of the respective metal and fulfil the conditions for homogeneity confirmed by EDX and SIMS. The spatially resolved element distribution was determined using rL-SNMS. ICP-MS is also used to determine the element composition.

[1]MetroPOEM is a collaboration of 22 partners from 13 countries throughout Europe funded by EURAMET under grant number 21GRD09 https://www.npl.co.uk/euramet/metropoem