Mass Spectrometry Division
Fachverband Massenspektrometrie (MS)

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Overview of Invited Talks and Sessions

(Lecture hall F128; Poster Empore Lichthof)

Invited Talks

MS 1.1	Tue	11:00–11:30	F128	**Lasers against barium – Detection of ^{135}Cs in the environment by AMS** — •Alexander Wieser, Johannes Lachner, Silke Merchel, Martin Martschini, Anaëlle Magre, Judith Kobler Waldis, Oscar Marchhart, Robin Golser
MS 3.1	Wed	14:30–15:00	F128	**Durable, low-temperature and highly-selective catalysis in NO reduction and CO oxidation driven by uni-sized Pt clusters supported on Si and SiC substrates** — •Hisato Yasumatsu
MS 4.1	Thu	11:00–11:30	F128	**Observation of the radiative decay of the thorium-229 nuclear clock isomer** — •Sandro Kraemer
MS 4.2	Thu	11:30–12:00	F128	**Mass measurements of heavy and superheavy nuclides and isomers with SHIPTRAP** — •Manuel J. Gutiérrez
MS 8.1	Fri	11:00–11:30	F128	**Two color resonant laser SNMS for isotope micro imaging of nuclear fuel debris** — •Tetsuo Sakamoto
MS 9.1	Fri	14:30–15:00	F128	**Developments to improve antiproton and other mass measurements** — •Christian Smorra on behalf of the BASE collaboration

Invited Talks of the joint Symposium Precision Physics with Highly Charged Ions

See SYHC for the full program of the symposium.

SYHC 1.1	Mon	11:00–11:30	E415	**First experiments at CRYRING@ESR** — •Esther Babette Menz, Michael Lestinsky, Håkan Danared, Claude Krantz, Zoran Andelkovic, Carsten Brandau, Angela Bräuning-Demian, Svetlana Fedotova, Wolfgang Geithner, Frank Herfurth, Anton Kalinin, Ingrid Kraus, Uwe Spillmann, Gleb Vorobyev, Thomas Stöhlker
SYHC 1.2	Mon	11:30–12:00	E415	**Testing quantum electrodynamics in the simplest and heaviest multi-electronic atoms** — •Martino Trassinelli
SYHC 1.3	Mon	12:00–12:30	E415	**Indirect measurements of neutron-induced reaction cross-sections at heavy-ion storage rings** — •Beatriz Jurado
SYHC 1.4	Mon	12:30–13:00	E415	**Laboratory X-ray Astropohysics with Trapped Highly Charged Ions at Synchrotron Light Sources** — •Sonja Bernitt
SYHC 2.1	Mon	17:00–17:30	E415	**Observation of metastable electronic states in highly charged ions by Penning-trap mass spectrometry** — •Kathrin Kromer, Menno Door, Pavel Filianin, Zoltán Harman, Jost Herkenhoff, Paul Indelicato, Christoph H. Keitel, Daniel Lange, Chunhai Lyu, Yuri N. Novikov, Christoph Schweiger, Sergey Eliseev, Klaus Blaum
SYHC 2.2	Mon	17:30–18:00	E415	**Towards extreme-ultraviolet optical clocks** — •José R. Crespo López-Urrutia
SYHC 2.3	Mon	18:00–18:30	E415	**Coupling atomic and nuclear degrees of freedom in highly charged ions** — •Adriana Pálffy
SYHC 2.4	Mon	18:30–19:00	E415	**Laser Spectroscopy at the Storage Rings of GSI/FAIR** — •Wilfried Nörtershäuser

Invited Talks of the joint Symposium SAMOP Dissertation Prize 2023

See SYAD for the full program of the symposium.

SYAD 1.1	Mon	14:30–15:00	E415	**Quantum gas magnifier for sub-lattice resolved imaging of 3D quantum systems** — •Luca Asteria
SYAD 1.2	Mon	15:00–15:30	E415	**From femtoseconds to femtometers – controlling quantum dynamics in molecules with ultrafast lasers** — •Patrick Rupprecht
SYAD 1.3	Mon	15:30–16:00	E415	**Particle Delocalization in Many-Body Localized Phases** — •Maximilian Kiefer-Emmanouilidis
SYAD 1.4	Mon	16:00–16:30	E415	**Feshbach resonances in a hybrid atom-ion system** — •Pascal Weckesser

Prize Talks of the joint Awards Symposium

See SYAS for the full program of the symposium.

SYAS 1.1	Tue	14:35–15:05	E415	**The Reaction Microscope: A Bubble Chamber for AMOP** — •Joachim Ullrich
SYAS 1.2	Tue	15:05–15:35	E415	**Quantum Computation and Quantum Simulation with Strings of Trapped Ca+ Ions** — •Rainer Blatt
SYAS 1.3	Tue	15:35–16:05	E415	**Amplitude, Phase and Entanglement in Strong Field Ionization** — •Sebastian Eckart
SYAS 1.4	Tue	16:05–16:35	E415	**All-optical Nonlinear Noise Suppression in Mode-locked Lasers and Ultrafast Fiber Amplifiers** — •Marvin Edelmann

Invited Talks of the joint Symposium From Molecular Spectroscopy to Collision Control at the Quantum Limit

See SYCC for the full program of the symposium.

SYCC 1.1	Thu	11:00–11:30	E415	**The unity of physics: the beauty and power of spectroscopy** — •Paul Julienne
SYCC 1.2	Thu	11:30–12:00	E415	**Using high-resolution molecular spectroscopy to explore how chemical reactions work** — •Johannes Hecker Denschlag
SYCC 1.3	Thu	12:00–12:30	E415	**Monitoring ultracold collisions with laser light** — •Olivier Dulieu
SYCC 1.4	Thu	12:30–13:00	E415	**The birth of a degenerate Fermi gas of molecules** — •Jun Ye

Invited Talks of the joint PhD-Symposium – Many-body Physics in Ultracold Quantum Systems

See SYPD for the full program of the symposium.

SYPD 1.1	Thu	14:30–15:00	E415	**Entanglement and quantum metrology with microcavities** — •Jakob Reichel
SYPD 1.2	Thu	15:00–15:30	E415	**Many-body physics in dipolar quantum gases** — •Francesca Ferlaino
SYPD 1.3	Thu	15:30–16:00	E415	**Quantum Simulation: from Dipolar Quantum Gases to Frustrated Quantum Magnets** — •Markus Greiner
SYPD 1.4	Thu	16:00–16:30	E415	**Quantum gas in a box** — •Zoran Hadzibabic

Sessions

MS 1.1–1.7	Tue	11:00–13:00	F128	**Accelerator Mass Spectrometry I**
MS 2.1–2.5	Wed	11:00–12:15	F128	**Multi-Reflection Time-of-Flight Spectrometers**
MS 3.1–3.5	Wed	14:30–16:00	F128	**Mass Spectrometry Applications**
MS 4.1–4.6	Thu	11:00–13:00	F128	**Heavy and Superheavy Elements**
MS 5	Thu	13:00–13:30	F128	**Members' Assembly**
MS 6.1–6.8	Thu	14:30–16:30	F128	**Accelerator Mass Spectrometry II**
MS 7.1–7.13	Thu	16:30–19:00	Empore Lichthof	**Poster**
MS 8.1–8.6	Fri	11:00–12:45	F128	**Accelerator Mass Spectrometry III**
MS 9.1–9.7	Fri	14:30–16:30	F128	**Penning traps, highest precision, neutrino physics, storage rings, new facilities and approaches**

Members' Assembly of the Mass Spectrometry Division

Thursday 13:00–13:30 Raum F128

- Report
- Miscellaneous

MS 1: Accelerator Mass Spectrometry I

Time: Tuesday 11:00–13:00 Location: F128

Invited Talk MS 1.1 Tue 11:00 F128

Lasers against barium – Detection of ^{135}Cs in the environment by AMS — •Alexander Wieser[1], Johannes Lachner[1,2], Silke Merchel[1], Martin Martschini[1], Anaëlle Magre[3], Judith Kobler Waldis[4], Oscar Marchhart[1], and Robin Golser[1] — [1]University of Vienna, Isotope Physics, Vienna, Austria — [2]HZDR, Accelerator Mass Spectrometry and Isotope Research, Dresden, Germany — [3]Institut de Radioprotection et de Sûreté Nucléaire, Fontenay-aux-Roses, France — [4]Universität Basel, Departement Umweltwissenschaften, Basel, Schweiz

^{137}Cs ($T_{1/2} \approx 30$ yrs) is a high-yield product of nuclear fission and easily detectable via its gamma decay but ^{137}Cs alone without further information is not assignable to an anthropogenic source. The measurement of ^{135}Cs ($T_{1/2} \approx 2$ Myrs) can help identifying the origin of radiocesium. While it is impossible to measure ^{135}Cs radiometrically in the presence of ^{137}Cs, mass spectrometric methods need to suppress stable isobars ^{135,137}Ba and molecules of similar mass. The Ion-Laser Interaction Mass Spectrometry (ILIAMS) setup at the Vienna Environmental Research Accelerator (VERA) does exactly that. Overlapping a 10 W laser beam with the ion beam in a radiofrequency quadrupole, the interfering isobars ^{135,137}Ba are suppressed by seven orders of magnitude, realizing detection limits of $7 \cdot 10^6$ atoms, i.e. ≈ 5 mBq of ^{137}Cs per sample. We will present the progress of our ILIAMS measurements at VERA, with our struggles to reduce cross contamination in the ion source and a focus on Cs measurements of environmental sediment samples prepared from 100 g of soil.

MS 1.2 Tue 11:30 F128

Thickness measurement of thin foils using a Time of Flight spectrometer — •Elisa Chopan, Gereon Hackenberg, Markus Schiffer, Stefan Heinze, Martina Gwozdz, Timm-Florian Pabst, Carlo Baddeliyanage, Tom Sittig, Alfred Dewald, and Dennis Mücher — Institut für Kernphysik, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Deutschland

In many nuclear physics experiments, a target foil is shot at, whereby the precise thickness is often unknown. A Time of Flight setup at the AMS setup of the Cologne FN tandem accelerator (10 MV) was established, with which the thickness of thin target foils can be determined. The setup can use ions of different charges and energies to measure the ToF between a start and stop detector. The foil of interest is placed in front of the start and stop detector and hence induces an energy loss of the ions. Using known stopping powers then allows to determine the thickness of the foil. In this contribution, we present the setup consisting of multichannel plate (MCP) detectors and show the achieved accuracy for different combinations of foils and ions. We have found good agreement of our results with measurements using standard techniques.

MS 1.3 Tue 11:45 F128

Status of the advanced radiofrequency quadrupole for AMS - first results from the test bench setup of VERA — •Oscar Marchhart[1,2], Markus Schiffer[3], Alfred Priller[1], Susan Herb[3], Peter Steier[1], Gereon Hackenberg[3], Martin Martschini[1], Dennis Mücher[3], Alfred Dewald[3], and Robin Golser[1] — [1]University of Vienna, Faculty of Physics, Isotope Physics, Vienna, Austria — [2]University of Vienna, Vienna Doctoral School in Physics, Vienna, Austria — [3]University of Cologne, Institute for Nuclear Physics, Cologne, Germany

Accelerator Mass Spectrometry (AMS) is the most sensitive method for the detection of trace amounts of long-lived radionuclides. The Ion-Laser InterAction Mass Spectrometry (ILIAMS) setup at the Environmental Research Accelerator (VERA) has demonstrated great isobar suppression capabilities using laser photodetachment in a gas-filled radiofrequency quadrupole (RFQ). With the ILIAMS technique, new AMS isotopes for research on environmental radioactivity (^{90}Sr, ^{135}Cs) and astrophysics (^{182}Hf) become accessible.
An advanced RFQ ion cooler based on ILIAMS has been developed and built. Its performance is currently being studied at the test bench setup of VERA. The new design consists of elliptically shaped injection and extraction electrodes and a new guiding field structure that uses hybrid-electrodes. These changes intend to solve the technical challenges of decelerating and trapping ion beams with high emittance which typically arise when using fluoride anions like SrF_3^- and result in significant transmission losses up to 90%.

MS 1.4 Tue 12:00 F128

Towards ^{41}Ca AMS measurements at low energies with laser-based isobar suppression — •Carlos Vivo-Vilches[1], Martin Martschini[2], Silke Merchel[2], Johannes Lachner[1], and Anton Wallner[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Accelerator Mass Spectrometry and Isotope Research, Germany — [2]University of Vienna, Faculty of Physics, Isotope Physics, Austria

In 2023, a new 1 MV AMS facility including laser-based isobar suppression capabilities, HAMSTER, will be installed at HZDR. Because of the successful use of this suppression technique to ^{41}Ca AMS measurements at VERA (Vienna, Austria), preliminary tests were performed there at a terminal voltage of 1.2 MV.

The transmission through the He gas stripper for charge states 1+, 2+ and 3+ at different stripping energies was studied. A transmission of 38% for the 2+ state at 1.2 MV was measured. While molecular ions survive the interaction with the buffer gas and the 355 nm laser, these can be totally discriminated by the gas ionization chamber, even for the 2+ state (2.9 MeV). Hence, a higher stripper pressure to suppress these molecular ions is not required.

After collision- and photo-induced KF_3^- dissociation, the final ^{41}K/^{40}Ca interference was $(2.0 \pm 1.0) \times 10^{-13}$. Looking for suppression based on electron photodetachment, the stability of CaF^- and KF^- ions interacting with laser light of different wavelengths might be worth to be studied in the future.

MS 1.5 Tue 12:15 F128

Improving the ^{10}Be detection efficiency with DREAMS — •Johannes Lachner, Carlos Vivo Vilches, Dominik Koll, Georg Rugel, Konstanze Stübner, and Anton Wallner — Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Accelerator Mass Spectrometry & Isotope Research

^{10}Be measurements presently take up the largest fraction of the DREAMS (DREsden AMS) beamtimes at the 6 MV accelerator of HZDR. We investigated the advantages of increasing the accelerator terminal voltage in order to improve the ^{10}Be counting efficiency. Stripping of the BeO^- ions extracted from the ion source to Be^{2+} is done using Ar stripper gas at a gas density below the level required for an equilibrium charge state distribution. The positive ions are directed towards a 1 μm thin silicon nitride foil that helps to suppress the ^{10}B interference by differential energy loss and separation in the following electrostatic analyser. After passage through the absorber foil the mean charge state of Be ions is increased and the 4+ charge state is selected and transported to the detector. Because of the higher ion energy, the yield for this charge state gets higher and the efficiency of ^{10}Be measurements is improved with higher terminal voltage.

At 5.8 MV terminal voltage ca. 32.5% of the ^{10}Be extracted from the ion source are transported to the detector compared to 23% at the previous setting of 4.5 MV. We furthermore present data of samples with known B concentration and give values for the ^{10}B suppression related to the different effects of separation, via the energy loss and via the gas ionization chamber.

MS 1.6 Tue 12:30 F128

The Anion Laser Isobar Separator - ALIS — •Markus Schiffer[1], Oscar Marchhart[2,3], Gereon Hackenberg[1], Peter Steier[2], Alfred Priller[2], Susan Herb[1], Timm-Florian Pabst[1], Elisa Chopan[1], Carlo Baddeliyanage[1], Martin Martschini[2], Robin Golser[2], Alfred Dewald[1], and Dennis Mücher[1] — [1]University of Cologne, Institute of Nuclear Physics, Cologne, Germany — [2]University of Vienna, Faculty of Physics, Isotope Physics, Vienna, Austria — [3]University of Vienna, Vienna Doctoral School in Physics, Vienna, Austria

Low energy isobar suppression has taken on increasing importance and has demonstrated a new access to environmental (^{90}Sr, ^{135}Cs), and cosmogenic isotopes (^{26}Al, ^{41}Ca). For this purpose, a new injector for the Cologne 6 MV AMS-System was developed. This "Anion Laser Isobar Separator" (ALIS) uses an advanced gas-filled radio frequency quadrupole (RFQ) ion cooler to suppress isobars by use of laser photodetachment in combination with gas reactions.

ALIS will use a 134 sample MC-SNICS ion source and a double focusing magnet for the ion cooler injection. The system is designed to separate the ion beam by slits before it is focused into the deceleration section of the RFQ. The ion cooler extraction section is designed to couple the ion beam to the ion optics of the AMS-System, or alternatively to a diagnose setup for stand-alone operation. For the element selective isobar suppression by laser photodetachment a 532 nm continuous wave laser with 18 W will be used.

MS 1.7 Tue 12:45 F128

Implementation of an EA-IRMS-GIS system to CologneAMS — •Martina Gwozdz, Stefan Heinze, Markus Schiffer, Alexander Stolz, Carlo Baddeliyanage, Elisa Chopan, Gereon Hackenberg, Devin Hymers, Timm-Florian Pabst, Tom Sittig, Alfred Dewald, and Dennis Mücher — Universität zu Köln, Germany

As part of the CRC1211 project "Earth - Evolution at the dry limit"

^{14}C dating analysis is asked for soil samples from the Atacama desert, resulting in ultra-small samples with a carbon content of 2-20μg. The ultra-small-scale AMS ^{14}C analysis will be used for the determination of ages of organic compounds isolated from the desert soils.

For this reason a new elemental analyser (EA) and an isotope ratio mass spectrometer (IRMS) have been coupled to the 6MV AMS system of CologneAMS. The EA oxidises solid samples and measures the nitrogen and carbon content. For the measurement of δ^{13}C and δ^{15}N the sample is transported to the IRMS.

The EA-IRMS has been set up with a direct connection to the existing gas injection system (GIS) and has been implemented into the software which is controlling the measurements. In this way it is possible to measure quasi-simultaneously the ^{14}C concentration with the 6MV AMS system and the δ^{13}C value with the IRMS.

We will investigate whether this new set-up will enable improved fractionation correction which are used in the ^{14}C data evaluation. This will increase the measurement accuracy and therefore will contribute to solve dating problems in different archives of the desert.

MS 2: Multi-Reflection Time-of-Flight Spectrometers

Time: Wednesday 11:00–12:15 Location: F128

MS 2.1 Wed 11:00 F128

Disentangling poly-cationic fullerenes with multi-reflection time-of-flight MS — •Paul Fischer and Lutz Schweikhard — Institut für Physik, Universität Greifswald, 17487 Greifswald, Germany

Large carbon-cluster cations of size-to-charge ratios $n/z \approx 40$ to ≈ 600 are observed after laser ablation of a glassy carbon target without additional aggregation gas. Their size distribution is well described by a log-normal function, implying an underlying coalescent growth mechanic. Resolving isotopologues via multi-reflection time-of-flight mass spectrometry (MR-ToF MS) confirms the clusters to be fullerenes as well as the presence of doubly- and triply-charged species. Comparing size- and charge-state-resolved abundances with results from a statistical simulation suggests charge aggregation through ion-ion collisions during the coalescent fusion processes. This is contrary to the assumption that poly-cations are formed primarily by subsequent photoionization under these conditions.

MS 2.2 Wed 11:15 F128

A setup for the study of clusters from a magnetron sputter source by MR-ToF mass spectrometry — •Paul Florian Giesel, Paul Fischer, and Lutz Schweikhard — Institut für Physik, Universität Greifswald, 17487 Greifswald, Germany

The Greifswald multi-reflection time-of-flight (MR-ToF) mass-spectrometer experiment investigates the properties of atomic clusters. So far, a pulsed laser-ablation source has been used to produce cluster ions with sizes up to about ten atoms from a solid target without the use of aggregation gas. The setup has now been expanded by a magnetron sputter source capable of producing considerably larger clusters. In order to incorporate this new source, a linear Paul trap has been installed to accumulate and bunch the continuous ion beam for injection into the MR-ToF analyzer. First measurements to characterize the new components as well as the system's capability to handle large clusters with masses up to 40,000 u have been performed.

MS 2.3 Wed 11:30 F128

Ion beam purification with the PUMA multi-reflection time-of-flight mass spectrometer — •Moritz Schlaich[1], Alexandre Obertelli[1], Frank Wienholtz[1], and Clara Klink[1,2] — [1]Institut für Kernphysik, TU Darmstadt, Darmstadt, Deutschland — [2]CERN, Genf, Schweiz

Using low-energy antiprotons provided by the Extra Low Energy Antiproton ring (ELENA) at CERN, the antiProton Unstable Matter Annihilation (PUMA) experiment aims to probe the isospin composition in the density tail of radioactive nuclei. For this purpose, PUMA intends to trap one billion antiprotons at ELENA in a portable Penning trap and transport them to the Isotope mass Separator On-Line DEvice (ISOLDE) at CERN. By analyzing the annihilation reactions of antiprotons with radioactive nuclei, the experiment plans to study neutron skin formation of neutron-rich nuclei and halo nuclei.

Reference measurements and the investigation of the neutron skin evolution along isotopic chains of stable nuclei (e.g. Ca, Sn or Xe) preceding the application to radioactive nuclei require a versatile offline ion source setup. In addition to a linear Paul trap used for ion cooling and accumulation, it includes a multi-reflection time-of-flight mass spectrometer (MR-ToF MS) for ion beam purification. By using electrostatic fields only, the MR-ToF MS can prolong the ion flight path by up to three orders of magnitude. This allows ion ejection with a mass resolving power up to 10^5, thus separating only the mass-over-charge value of interest. The talk will provide an overview of the experimental setup as well as first results of ion beam purification experiments.

MS 2.4 Wed 11:45 F128

A laser ablation carbon cluster ion source for the MR-TOF-MS of the FRS Ion Catcher — •Jiajun Yu[1,3], Christine Hornung[1,2], Timo Dickel[1,2], Zhuang Ge[1], Hans Geissel[1,2], Gabriella Kripko-Koncz[2], Meetika Narang[2], Wolfgang Plass[1,2], Christoph Scheidenberger[1,2], and FRS Ion Catcher Collaboration[1,2,3] — [1]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — [2]Justus-Liebig-Universität Gießen, Gießen — [3]Jinan University, Guangzhou, China

A laser ablation carbon cluster ion source (LACCI) has been built and commissioned. It is capable of providing closely-spaced calibrant ions in the mass range up to ∼300 u for highly accurate mass measurements of exotic nuclei (δm/m $\sim 10^{-8}$) and systematic studies of the mass uncertainties with the MR-TOF-MS of the FRS Ion Catcher at GSI Darmstadt, Germany. The LACCI contains newly developed advanced techniques, including a special ion optics design and a 2D movable target table to ensure stable long-term (weeks) operation, a laser-spot/target monitoring system, and a dedicated re-capture unit, which will be reported. A study of the laser energy, repetition rates and long-term measurements, has been carried out with carbon targets (Sigradur, Fullerene) and metallic targets (Ag, W, Au, Cu, Pt). The commissioning results of LACCI coupled via a radio frequency switchyard to merge ions from different sides and transport them through a quadrupole mass filter into an MR-TOF-MS will be reported in this contribution.

MS 2.5 Wed 12:00 F128

Mass measurements of neutron-rich nuclides at the N=126 shell with the FRS Ion Catcher — •Kriti Mahajan[1], Daler Amanbayev[1], Alison Bruce[3], Timo Dickel[1,2], Tuomas Grahn[4], Gabriella Kripko-Koncz[1], Ali Akbar Mehmandoost-Khajeh-Dad[5], Stephane Pietri[2], Wolfgang Plass[1,2], and Christoph Scheidenberger[1,2] — [1]JLU Gießen — [2]GSI Darmstadt — [3]University of Brighton, UK — [4]University of Jyvaskyla, Finland — [5]University of Sistan and Baluchestan, Zahedan, Iran

At GSI, experiments with exotic nuclides can be performed, including direct mass measurements. For such mass measurements, the nuclei can be produced at relativistic velocities by projectile fragmentation, separated, range-focused and slowed down in the fragment separator FRS and precise mass measurements are done with the FRS Ion Catcher. The beam from the FRS is injected into the cryogenic stop-

ping cell (CSC), thermalized and transmitted to the multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS). The MR-TOF-MS features a high resolving power of up to 1,000,000, short cycle times of a few ten milliseconds, and mass accuracies down to a few 1E-8.

Mass measurements were performed in the region "south" of the doubly magic nucleus ^{208}Pb close to the N=126 line, which is of key importance for the study of nuclear structure and nuclear astrophysics and can help us to better understand the r-process, in particular the third abundance peak. The preliminary results of these mass measurements will be presented along with comparisons with different mass models, including the first mass measurements of ^{204}Au and ^{205}Au.

MS 3: Mass Spectrometry Applications

Time: Wednesday 14:30–16:00 Location: F128

Invited Talk MS 3.1 Wed 14:30 F128

Durable, low-temperature and highly-selective catalysis in NO reduction and CO oxidation driven by uni-sized Pt clusters supported on Si and SiC substrates — •Hisato Yasumatsu — Toyota Technological Institute, Ichikawa, Chiba, Japan

It has been found that Pt clusters are fixed to a Si substrate as Pt cluster disks by impact of Pt cluster ions onto the substrate. Electrons accumulated at the sub-nano interface between the Pt cluster and the Si substrate surface enable catalytic NO reduction and CO oxidation at low temperatures with high selectivity.

When the substrate is changed to silicon carbide, SiC, which is well known to possess high chemical and thermal stability, one can obtain durable catalysis as high as 1200 K with maintaining the low-temperature and highly-selective catalytic performance. This study shows a way to utilize this unique and high-performance catalysis driven by the electron accumulation as practical catalysts of electron donation including the gas treatment, and further extension to water-splitting hydrogen production and fuel-cell oxygen reduction reaction (ORR) as well.

Size-selected clusters by passing through a mass filter and cooled through a He collision cell were allowed to collide onto the substrate. Geometry and electron distribution were studied by means of scanning-tunneling microscopy. Electronic structures were obtained through X-ray photoelectron spectroscopy. Catalytic activity was measured with surface-chemistry techniques and fixed-bed gas-flow reaction analysis in combination of mass spectroscopy.

MS 3.2 Wed 15:00 F128

Multi-element isotopic analysis of hot particles from Chornobyl — •Darcy van Eerten[1], Manuel Raiwa[1], Paul Hanemann[1], Laura Leifermann[1], Tobias Weissenborn[1], Wolfgang Schulz[1], Martin Weiss[1], Danielle Ziva Shulaker[2], Peter Boone[2], David Willingham[2], Keenan Thomas[2], Brian Sammis[2], Brett Isselhardt[2], Mike Savina[2], and Clemens Walther[1] — [1]Institut für Radioökologie und Strahlenschutz, Leibniz Universität Hannover, Herrenhäuser Str. 2, 30419 Hannover, Germany. — [2]Chemical and Isotopic Signatures Group, Lawrence Livermore National Laboratory, Livermore, USA.

Nuclear materials that contaminate the environment present an ongoing challenge to characterize due to their small size and diverse morphology. The analysis of isotope ratios in actinides and fission products can provide determination of origin, age and environmental weathering of these materials. Resonance ionisation mass spectrometry (RIMS) utilizes selective laser ionization to target single elements and suppress the isobaric interferences typically found in mass spectrometry. Two specialized instruments were used to analyse single hot particles from Chornobyl: rL-SNMS at the IRS in Hannover, Germany, and LION at LLNL in Livermore, USA. Results from multiple particles are presented with interpretations of isotope ratios in U, Pu, Cs, Rb, Sr and Ba.

MS 3.3 Wed 15:15 F128

Mass spectrometric determination of the speciation of radium in the human digestive tract using ESI-MS — •Linus Holtmann, Ahmadabdurahman Shamoun, Beate Riebe, and Clemens Walther — Institut für Radioökologie und Strahlenschutz, Leibniz Universität Hannover, Hannover, Germany

Radionuclides pose a potential radio- and chemotoxic hazard to humans when ingested. Knowledge of radionuclide interaction in the digestive tract at the molecular and cellular level is necessary for risk assessment and to contribute to an element-specific decontamination strategy.

Synthetic biofluids prepared according to the UBM protocol (BARGE) are used to investigate the speciation of radium in the human digestive tract. The biofluids are analyzed in the presence and absence of Ra(II)/Ba(II) by mass spectrometry using electrospray ionization (ESI-MS). In our experiments, an Orbitrap mass spectrometer allows the measurement of the speciation without any chemical separation. The identification of barium-containing species takes place via specific isotope pattern signatures. Algorithms specifically tailored to the evaluation of complex mass spectra are used.

In addition, the influence of different decorporation and complexing agents on the speciation of Ra(II)/Ba(II) in the simulated digestive process is studied. This way, element-specific decorporation strategies are investigated for their potential efficacy after oral ingestion of radium.

MS 3.4 Wed 15:30 F128

ALPINAC - A non-target screening algorithm for high-resolution mass spectra and its application to the detection of halogenated greenhouse gases. — •Katharina Höveler, Lionel Constantin, Myriam Guillevic, Paul Schlauri, Martin K. Vollmer, and Stefan Reimann — Swiss Federal Laboratories for Materials Science and Technology (Empa), Dübendorf, Schweiz

Efficient and automated screening of gaseous or liquid samples to detect novel compounds based on their mass spectral fingerprints (non-target screening) is an ongoing computational challenge that goes beyond standard library-based approaches. We present a novel algorithm that uses combinatorial and directed graph methods, taking into account chemical rules, to automatically assign high-resolution mass spectral peaks from gas-chromatography-separated time-of-flight mass-spectroscopy (GC-TOF MS) measurements to possible chemical formulas by considering possible fragmentation pathways. In a further step, this information is used to reconstruct the chemical formula of likely molecular parent ions. We show how this technique can be used to detect unknown contaminants in pre-concentrated air samples and how the algorithm can be extended to reconstruct not only the molecular formula but also the chemical structure of the parent ion.

MS 3.5 Wed 15:45 F128

Analysis of the cutting edge of individual 'hot particles' from the Chernobyl Exclusion Zone — •Laura Leifermann[1], Martina Klinkenberg[2], Felix Brandt[2], Paul Hanemann[1], Tobias Weissenborn[1], Sandra Reinhard[1], Manuel Raiwa[3], Wolfgang Schulz[1], and Clemens Walther[1] — [1]IRS, Hannover, Deutschland — [2]FZJ IEK-6, Jülich, Deutschland — [3]LLNL, Livermore, USA

During the Chernobyl reactor accident on April 26, 1986, radioactivity was in part released in the form of nuclear fuel particles. These so-called 'hot particles' have various structures that belong to specific oxidation states of uranium. These oxidation states behave differently in the environment. We obtain individual particles by density separation with a poly tungsten solution. Via radiometric scanning with a Geiger counter we locate the particles. The extraction is performed on tungsten needles with a micromanipulator in a scanning electron microscope (SEM). The particle surface was analyzed by different non-destructive methods such as SIMS, rL-SNMS and EDX. Gamma measurements and optical analyses in SEM were also performed. Micrometer sized particles glued to needles are cut in half with a focused ion beam. We can thus extend our mass spectrometric analysis to the cutting edge and study the particle cross section. Since the particles have been exposed to the environment for over 30 years, weathering effects from outside to inside can be investigated. In addition, it is possible to test to what extent the elemental and isotopic composition of the particles is homogeneous.

MS 4: Heavy and Superheavy Elements

Time: Thursday 11:00–13:00 Location: F128

Invited Talk MS 4.1 Thu 11:00 F128

Observation of the radiative decay of the thorium-229 nuclear clock isomer — •Sandro Kraemer for the ISOLDE-IS658-Collaboration — Instituut voor Kern- en Stralingsfysica, KU Leuven, Belgium — Fakultät f. Physik, LMU München, Germany

A unique feature of thorium-229 is its isomeric first excited state with an exceptionally low excitation energy, proposed as a candidate for future nuclear optical clocks. The development of such an optical clock requires, however, knowledge of the excitation energy by at least an order of magnitude more precise. Additionally, spectroscopic experiments searching for a direct signature of the radiative decay have so far been unsuccessful.

In this work, an alternative approach using the beta decay of actinium-229 is studied as a novel method to populate the isomer with high efficiency and in low background conditions. Produced online at the ISOLDE facility at CERN, actinium is laser-ionized and implanted into a large-bandgap crystal.

A vacuum-ultraviolet spectroscopic study of implanted mass 229 beams at the ISOLDE facility will be presented. From the results obtained during a first measuring campaign it can be concluded that the radiative decay of the thorium-229 isomer has been observed for the first time, the excitation energy of the isomer has been determined with a factor of 5 improved uncertainty and the ionic lifetime in a crystalline environment was constrained.

Invited Talk MS 4.2 Thu 11:30 F128

Mass measurements of heavy and superheavy nuclides and isomers with SHIPTRAP — •Manuel J. Gutiérrez for the SHIPTRAP-Collaboration — GSI Darmstadt, Germany — HIM Mainz, Germany

The existence of superheavy elements is due to quantum shell effects, which stabilize them against spontaneous fission. Several theoretical models exist to describe these very complex nuclear systems. By providing nuclear binding energies, direct mass measurements can benchmark these models.

The Penning-trap mass spectrometer SHIPTRAP is devoted to performing mass measurements of heavy and superheavy nuclei produced via fusion-evaporation reactions with minute yields. Mass resolving powers in the 10^7 range, which are achieved with the Phase-Imaging Ion-Cyclotron-Resonance technique, enable the study of low-lying, long-lived isomeric states. Within the FAIR Phase-0 campaign, the latest measurements focused on several nuclides with such isomeric states, ranging from ^{241}Cf to ^{258}Db. Additionally, measurements were carried out on the ^{206}Fr–^{202}At–^{198}Bi chain, aiming to pin down the absolute excitation energies of two known isomers for the first time.

In this contribution, selected results from the analysis of the 2021 beamtime data will be presented, with emphasis on the studies of isomeric states.

MS 4.3 Thu 12:00 F128

Progress of the Laser Resonance Chromatography — •Eunkang Kim[1,2], Michael Block[1,2,3], Biswajit Jana[1,2], Sebastian Raeder[2,3], Harry Ramanantoanina[1], Elisabeth Rickert[1,2,3], Elisa Romero Romero[1,2,3], and Mustapha Laatiaoui[1,2] — [1]Department Chemie, Johannes Gutenberg-Universität, Fritz-Strassmann Weg 2, 55128 Mainz, Germany — [2]2Helmholtz-Institut Mainz, Staudingerweg 18, 55128 Mainz, Germany — [3]3GSI, Planckstraße 1, 64291 Darmstadt, Germany

Optical spectroscopy of superheavy elements is experimentally challenging as their production yields are low, half-lives are very short, and their atomic structure is barely known. Conventional spectroscopy techniques such as fluorescence spectroscopy are no longer suitable since they lack the sensitivity required in the superheavy element research. A new technique called Laser Resonance Chromatography (LRC) could provide sufficient sensitivity to study superheavy ions and overcome difficulties associated with other methods. In this contribution, I will introduce the LRC technique and report the progress and the results from the first LRC test experiments. This work is supported by the European Research Council (ERC) (Grant Agreement No. 819957).

MS 4.4 Thu 12:15 F128

Status of the gas-jet apparatus for laser spectroscopy of the heaviest elements — •Matou Stemmler for the JetRIS-Collaboration — Institute of Physics, Johannes Gutenberg University Mainz, Germany

Laser spectroscopy measurements can provide information about fundamental properties of both atomic and nuclear structure. Such measurements are of particular importance for the heaviest actinides and superheavy elements, where data is sparse. In recent resonance-ionization-spectroscopy experiments on nobelium isotopes at GSI, Darmstadt, Germany, have been carried out with the in-gas-cell technique RADRIS [1,2]. However its limited spectral resolution hampers the precision, and occasionally renders the precise determination of nuclear moments and spins impossible. Furthermore, the inherent collection and measurement cycle precludes studies of isotopes with half-lives below ≈ 1 s. To overcome these limitations, a new JetRIS apparatus has been built to perform laser spectroscopy on atoms in a hypersonic jet [3].
This presentation will give an update on the JetRIS apparatus and discuss results from the 2022 beam time.

1 M. Laatiaoui, et al., Nature 538, 495-498 (2016)
2 S. Raeder, et al., Phys. Rev. Lett. 120, 232503 (2018)
3 S. Raeder, et al., Nucl. Instrum. Meth. Res. B, 463, 272-276 (2020)

MS 4.5 Thu 12:30 F128

Status of Development of MR-ToF MS for JetRIS for laser spectroscopy of the heavy actinides at GSI/HIM — •Danny Münzberg[1,2,3], Michael Block[1,2,3], Arno Claessens[4], Piet van Duppen[4], Rafael Ferrer[4], Jeremy Lantis[3], Mustapha Laatiaoui[3], Steven Nothhelfer[1,2,3], Sebastian Raeder[1,2], Moritz Schlaich[5], Lutz Schweikhard[6], Matou Stemmler[3], Thomas Walther[5], and Klaus Wendt[3] — [1]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, DE — [2]Helmholtz-Institut, Mainz, DE — [3]Department Chemie, Johannes Gutenberg-Universität, Mainz, DE — [4]Institut voor Kern- en Stralingsfysica, KU Leuven, Leuven, Belgium — [5]Technische Universität Darmstadt, DE — [6]Universität Greifswald, DE

At GSI-Darmstadt we use the in gas-Jet Resonant Ionization Spectroscopy (JetRIS) apparatus to perform laser spectroscopy of elements in the heavy actinide region to determine their nuclear and atomic properties. JetRIS utilizes α-decay detection to maximize sensitivity while minimizing the background from unwanted ions. However, for long-lived nuclides ($t_{\frac{1}{2}} > 10$ h) a decay-based detection will not be practical. Thus, a multi-reflection time-of-flight mass seperator (MR-ToF MS) is being developed for the JetRIS apparatus, allowing a separation of ions according to their mass to charge ratios with a high mass-resolving power, opening the possibility of direct ion detection. This will allow measuring β-decaying species and long-lived isotopes. An overview of the MR-ToF MS design and its integrations into the system will be given. Prospects for measurements will be discussed.

MS 4.6 Thu 12:45 F128

Relativistic calculation of binding energies of highly charged ions for precision mass spectroscopy — •Zoltán Harman, Chunhai Lyu, Vincent Debierre, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics, Heidelberg

Penning-trap mass spectrometry has recently enabled a novel determination of electron binding energies through the comparison of ionic masses. The collaboration of experiment and our multiconfiguration Dirac-Hartree-Fock theory has enabled the discovery of ultra-narrow ionic transitions, suitable for constructing future atomic clocks: in the Re 29+ ion, a long-lived electronic state with an excitation energy of 202 eV was observed via the mass difference of excited and ground-state ions [1]. A further application of such investigations is the determination of the Q value of the beta decay of various atomic isotopes, relevant for the determination of the neutrino mass [2]: experimentally, the masses of Re and Os ions could be determined to high precision, and our calculations have delivered the accurate binding energies of the electrons missing from the neutral atoms. Finally, mass spectrometry has largely contributed to a comparison of the magnetic moments of two isotopically different neon ions, allowing to set upper bounds on the coupling strength of new scalar bosons that might mediate a

hypothetical interaction between electrons and nucleons [3]. – [1] R. X. Schüssler, et al., Nature 581, 42 (2020); [2] P. E. Filianin, et al., Phys. Rev. Lett. 127, 072502 (2021); [3] T. Sailer et al., Nature 606, 479 (2022).

MS 5: Members' Assembly

Time: Thursday 13:00–13:30 Location: F128

All members of the Mass Spectrometry Division are invited to participate.

MS 6: Accelerator Mass Spectrometry II

Time: Thursday 14:30–16:30 Location: F128

MS 6.1 Thu 14:30 F128

Status and development of Sr-90 measurements at CologneAMS — •Gereon Hackenberg[1], Markus Schiffer[1], Susan Herb[1], Dominik Elchine[2], Stefan Heinze[1], Carlo Baddeliyanage[1], Elisa Chopan[1], Devin Hymers[1], Martina Gwozdz[1], Tom Sittig[1], Erik Strub[2], Alfred Dewald[1], and Dennis Mücher[1] — [1]Institute for Nuclear Physics, University of Cologne — [2]Division of Nuclear Chemistry, University of Cologne

^{90}Sr is produced by nuclear fission and is a prominent nuclide in nuclear waste and fallout. Since the decay of ^{90}Sr produces no γ rays, but only low energy β rays, the detection mainly depends on the β decay of the daughter nucleus ^{90}Y. This demands a complex chemical treatment, because a probe has to be free of other beta emitters.

Using accelerator mass spectrometry ^{90}Sr can be measured directly. Here main efforts are a high sputter efficiency and the suppression of the stable isobar ^{90}Zr.

Measurements have been performed at the 10MV tandem accelerator in Cologne using standards produced at the department of nuclear chemistry. At 9MV a full separation of ^{90}Sr and ^{90}Zr was achieved. This contribution will present charge state distributions behind the stripper, transmission measurements, dE/dx-measurements with our multi anode gas ionization detector and sensitivity limits of the current setup for multiple energies.

This technique will be applied to characterize soil samples from the AVR Jülich.

MS 6.2 Thu 14:45 F128

Slow ions for heavy nuclei: The quest to find interstellar ^{182}Hf on Earth — •Michael Kern[1,2], Martin Martschini[1], Silke Merchel[1], Peter Steier[1], Anton Wallner[3], and Robin Golser[1] — [1]University of Vienna, Faculty of Physics, Isotope Physics, Austria — [2]Vienna Doctoral School in Physics, University of Vienna, Austria — [3]Helmholtz-Zentrum Dresden-Rossendorf, Germany

A decade-long search to pin down nucleosynthesis events in our stellar neighborhood could be propelled by measuring the abundance patterns of live ^{182}Hf ($T_{1/2} = 8.9$ Myr) together with ^{60}Fe and ^{244}Pu, which were incorporated in terrestrial archives.

At the Vienna Environmental Research Accelerator (VERA), we developed an ion-laser interaction mass spectrometry (ILIAMS) setup to suppress challenging medium-mass isobars. It uses a radio-frequency quadrupole ion-guide filled with a reactive buffer-gas (He and O_2), where an intense laser beam overlaps with the ion beam. Less-strongly bound unwanted isobar species ($^{182}WF_5^-$) are removed, while wanted species ($^{182}HfF_5^-$) remain unaffected.

Ion optical simulations on injection and transport through the ILIAMS setup resulted in a new ion-guide design. It will allow acceptance of large emittance ion beams and will feature a UV-laser to destroy and/or neutralize WF_5^-. Additional challenges for ^{182}Hf detection are (a) the chemical preparation of HfF_4 AMS targets from large amounts of deep-sea MnFe crusts and (b) fabrication of reliable low-level ($^{182}Hf/Hf \simeq 10^{-13}$) reference materials.

MS 6.3 Thu 15:00 F128

Measurement of Interstellar Radionuclides as Fingerprints of Recent r-Process Events — •Sebastian Zwickel[1,2], Sebastian Fichter[1], Dominik Koll[1], Johannes Lachner[1], Georg Rugel[1], Konstanze Stuebner[1], Carlos Vivo Vilches[1], Stephan Winkler[1], and Anton Wallner[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Technical University Dresden, Dresden, Germany

Interstellar radionuclides deposited in our solar system can give information about recent nucleosynthesis events in the solar neighbourhood. The detection of ^{60}Fe with Accelerator Mass Spectrometry (AMS) in various geological and lunar samples yields evidence for two nearby supernovae (SNe) in the last 10 My. Measuring pure r-process ^{244}Pu in the same samples can relate SN nucleosynthesis with r-process signatures; either as a concomitant production or deposition. Its first detection in a deep sea manganese crust demonstrates the recent deposition of interstellar r-process nuclides in terrestrial archives, but is suffering from poor time resolution due to the rarity of ^{244}Pu.

This talk discusses the motivation and chemical sample preparation towards the search for ^{244}Pu as well as other radionuclides in lunar soil. The absence of geological activity allows for a longer search into the past than is possible with terrestrial material.

MS 6.4 Thu 15:15 F128

Improved ^{60}Fe measurements at CologneAMS — Susan Herb, Gereon Hackenberg, Markus Schiffer, Timm Pabst, Elisa Chopan, Alfred Dewald, and •Dennis Mücher — Institut für Kernphysik, Universität zu Köln

Since the first indication of Supernovae (SN) deposited signals in terrestrial reservoirs, the key isotope ^{60}Fe became an appealing isotope for astrophysical applications. Furthermore, ^{60}Fe produced in iron meteorites by galactic cosmic rays via spallation on ^{62}Ni and ^{64}Ni gives pivotal insight into the structure and history of our solar system. AMS is by far the most sensitive method to detect ^{60}Fe, with currently only a single laboratory offering ^{60}Fe AMS measurements, worldwide. This is partly due to the high beam energies required to suppress and separate the highly abundant isobar ^{60}Ni. In this work we present recent improvements of the 10MV AMS system at the University of Cologne which have significantly improved the efficiency and stability of the ^{60}Fe measurements using a gas-filled magnet. The fully digital setup now allows to tune the system and conduct the ^{60}Fe measurements fully automatically, further improving the overall efficiency of the AMS measurements. The currently achieved background level of $^{60}Fe/Fe$ of about $5 \cdot 10^{-15}$ allows for a routine measurement of iron meterotites. Future ideas to further improve the detection limit and efficiency of the setup will be discussed.

MS 6.5 Thu 15:30 F128

Cosmogenic ^{10}Be Dating of a Ferromanganese Crust Into the Early Miocene — •Dominik Koll[1,2], Anton Wallner[1], Johannes Lachner[1], Sebastian Fichter[1], Georg Rugel[1], Konstanze Stuebner[1], Carlos Vivo-Vilches[1], Stephan Winkler[1], Rene Ziegenruecker[1], and Sebastian Zwickel[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]The Australian National University, Canberra, Australia

Deep-sea ferromanganese crusts are slow-growing geological archives on seamounts without sediment coverage and are found in all major oceans. Their growth by precipitation with growth-rates of 1-10 mm/Myr records the oceanic inventory of radionuclides over several million years. The dating of ferromanganese crusts is typically achieved by following the decrease of cosmogenic ^{10}Be concentration in a depth-profile as a result of its radioactive decay.

In preparation for the search for the interstellar radionuclides ^{60}Fe and ^{244}Pu, the ferromanganese crust VA13/2-237KD was analyzed by optical and X-ray scans, stable element analysis and accelerator mass spectrometry for cosmogenic ^{10}Be until the end of the early Miocene. In this contribution, the characterization of the crust is presented with results from the cosmogenic ^{10}Be dating at the DREAMS facility of HZDR including an unexpected anomaly during the late Miocene.

MS 6.6 Thu 15:45 F128

Lowering the background levels of ^{14}C AMS measurements at CologneAMS — •Tom Sittig, Martina Gwozdz, Stefan Heinze, Markus Schiffer, Elisa Chopan, Gereon Hackenberg, Timm Pabst, and Dennis Mücher — Institute for Nuclear Physics, University of Cologne, Germany

AMS CO_2 gas measurements are useful as they allow for ultra small sample sizes to be analysed. A low background is important to achieve reliable and reproducible $^{14}C/^{12}C$ ratios. Because previously these background levels were higher than expected at CologneAMS when performing blank measurements, a source of contamination was investigated. As the result a new preparation routine has been implemented at the 6MV AMS system of CologneAMS.

By including the target holders alongside the CO_2-targets during heating for an extended period of time, followed by cooling both to room temperature under an argon atmosphere, we were able to decrease the background level by 60%. The new blank ratios are consistent with the machine blank level at $3.7 \cdot 10^{-15} \pm 18\%$. The stability of background levels is also improved and consistent with statistical expectations.

This increased stability allows us to investigate the sources of memory effects observed in cases where samples with low ^{14}C contents were preceded by samples with high ^{14}C content, optimising our setup even further in the future.

MS 6.7 Thu 16:00 F128

Exploring analysis of ^{99}Tc at environmental levels — •Stephanie Adler[1], Karin Hain[1], Fadime Gülce[1], Martin Martschini[1], Stefan Pavetich[2], Stephen G. Tims[2], L. Keith Fifield[2], and Robin Golser[1] — [1]University of Vienna, Faculty of Physics - Isotope Physics, Vienna, Austria — [2]Australian National University, Canberra, Australia

Determination of absolute concentrations of the anthropogenic radionuclide ^{99}Tc ($t_{1/2}$=2.1×10^5 yr) in environmental samples by AMS requires suppression of the stable isobaric background of ^{99}Ru and a reliable normalization method. At the Vienna Environmental Research Accaelerator (VERA) it was shown that RuF_5^- can be suppressed by a factor of up to 10^5 using a laser, making extraction of $^{99}TcF_5^-$ a viable option for Ion Laser InterAction MS (ILIAMS). However, none of the methods for the extraction of TcF_5^- provided a reproducibility better than 50%. Without ILIAMS, the separation of ^{99}Ru from ^{99}Tc is currently only possible at the AMS facility at the Australian National University (ANU), using a 14 MV tandem accelerator. There, ^{99}Ru and ^{99}Tc are separated in an 8-anode ionization chamber owing to minute differences in their energy loss characteristics, observable only at high ion energies. Experiments at the meanwhile shut-down Munich AMS-facility using TcO^- and normalization to the ^{93}Nb-current extracted from the sputter matrix showed a precision of 30%. Using this approach at the ANU, a ^{99}Tc dilution series of 10^{10}-10^7 at/sample was measured in preparation for the measurement of environmental samples, achieving R^2=0.993 and a blank level of ∼2×10^6 at/sample.

MS 6.8 Thu 16:15 F128

Sample preparation for accelerator mass spectrometry (AMS) – Approach to identify potential ^{10}Be contamination sources — •Silke Merchel[1,2], Johannes Lachner[1,2], Oscar Marchhart[1], Georg Rugel[2], and Alexander Wieser[1] — [1]University of Vienna, Faculty of Physics, Isotope Physics, Austria — [2]Helmholtz-Zentrum Dresden-Rossendorf, Germany

In the last decades, AMS has largely improved in the direction of lower detection limits, especially for applications of $^{10}Be/^9Be$ in Earth and environmental sciences. However, potential sources of ^{10}Be contamination while chemical sample preparation are often known but rarely identified in detail and quantified, which would be the first step to reduce these unwanted contributions. Thus, we have aimed at investigating ^{10}Be in (a) deionised/subboiled water, (b) commercial ^{27}Al carrier solutions, (c) ^{9}Be minerals and (d) cation exchange materials differently precleaned before first use. For better quantification, we have e.g., varied ^{27}Al amounts and used ^{27}Al carriers from different companies. Though, it was partially hard to distinguish in-between "single" ^{10}Be sources and between other sources like laboratory "dust" and cross-contamination (in lab and ion source) at the <4x10^{-15} level. To conclude, our general recommendation is to minimize the amounts of water, ion exchange materials and ^{27}Al carrier. For ultra-low-level $^{10}Be/^{26}Al$ dating, subboiled water and customised Al carriers from minerals might be advantageous. The good news, cross-contamination in an AMS chemistry lab in use for >12 years – for samples orders of magnitude different in $^{10}Be/^9Be$ – is negligible.

MS 7: Poster

Time: Thursday 16:30–19:00 Location: Empore Lichthof

MS 7.1 Thu 16:30 Empore Lichthof

Doppler- and sympathetic cooling for the investigation of short-lived radionuclides — •Franziska Maria Maier[1,2] and Simon Sels[1] — [1]ISOLDE/CERN — [2]Universität Greifswald

For the MIRACLS collaboration.

Ever since its introduction in the mid 1970s, laser cooling has become a fundamental technique to prepare and control ions and atoms for a wide range of precision experiments. Nevertheless, because of its simplicity and element-universality, buffer-gas cooling in a linear, room-temperature Paul trap is more commonly used at contemporary radioactive ion beam (RIB) facilities. Recent advances in experimental RIB techniques, especially in laser spectroscopy and mass spectrometry, would however strongly benefit from ion beams at much lower beam temperature as in principle attainable by laser cooling.

Within the MIRACLS low-energy apparatus, we demonstrate that laser cooling is compatible with the timescale imposed by short-lived radionuclides as well as with existing instrumentation at RIB facilities[1]. Despite an initial kinetic energy of the externally-produced hot ions of several eV at the trap's entrance, temporal widths of the extracted ion bunches corresponding to an ion-beam temperature of around 6 K are obtained within a cooling time of 200 ms.

I will present the experimental results of our laser cooling studies, including the improvement of mass resolving power of an MR-ToF device (electrostatic ion beam trap), and give an outlook to future opportunities for high-precision measurements at RIB facilities.

[1] S. Sels, F.M.Maier et al, Phys.Rev.Res. 4, 033229 (2022).

MS 7.2 Thu 16:30 Empore Lichthof

Atomic Vapor Laser Isotope Separation of ^{48}Ca — •Dominik Studer[1,2,3], Tom Kieck[1,2], Sebastian Raeder[1,2], Michael Block[1,2,4], Christoph E. Düllmann[1,2,4], and Klaus Wendt[3] — [1]Helmholtz-Institut Mainz — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — [3]Institut für Physik, JGU Mainz — [4]Department Chemie - Standort TRIGA, JGU Mainz

Due to its high neutron excess, ^{48}Ca is a highly favorable nuclide for accelerator-based production of superheavy elements (SHE) in fusion-evaporation reactions. Elements with atomic numbers >113 can exclusively be produced with this projectile. Consequently, the SHE programme at, e.g., GSI Darmstadt depends critically on the availability of gram amounts of this isotope. Since ^{48}Ca has a low abundance of 0.187% in natural calcium, an isotope enrichment process is mandatory. In order to assess local production capabilities, a tabletop Atomic Vapor Laser Isotope Separation (AVLIS) setup is being tested at JGU Mainz. A highly collimated atomic beam of calcium is produced from an array of heated microcapillaries and ^{48}Ca is selectively ionized in a three-step photoionization process by pulsed laser radiation. Ions are separated by an electric field and collected on a metal plate. The efficiency, selectivity and scalability of this setup is studied. The present status is presented in this contribution.

MS 7.3 Thu 16:30 Empore Lichthof

Towards deterministic ionization and loading of molecules for quantum logic spectroscopy — •René Nardi, Stefan Walser, Brandon Furey, Zhenlin Wu, Guanqun Mu, and Philipp Schindler — Institut für Experimentalphysik, Universität Innsbruck

Our group studies the complex rovibrational structure of trapped molecular ions. These states are inaccessible to standard quantum information readout methods, but can be explored by co-trapping them with an atomic ion for which a convenient cooling and qubit level

scheme exists. The molecular states can then be coupled to an electronic state of the atomic ion via quantum logic spectroscopy. To prepare and load arbitrary molecular species, we are developing a system where a molecular gas is leaked in, photoionized, and then accelerated towards a linear Paul ion trap. Ion optics are then used to steer the molecules through a differentially pumped region and into our UHV chamber. Molecules can be injected into the trapping region by adjusting the accelerating voltage and aligning the molecular beam through an aperture in the trap end cap. Here they can interact with an atomic ion crystal, cooling the molecules and resulting in their entrapment. We are building a setup to test this approach and we use time-of-flight mass spectrometry to map out the molecular ion species produced from photoionization of various gasses.

MS 7.4 Thu 16:30 Empore Lichthof

A Faraday cup for absolute ion beam current determination at the RISIKO mass separator — •Raphael Hasse[1], Sebastian Berndt[1], Vadim Gadelshin[1], Christoph E. Düllmann[1,2,3], Tom Kieck[2,3], Nina Kneip[4], and Klaus Wendt[1] — [1]Johannes Gutenberg-Universität Mainz — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [3]Helmholtz-Institut Mainz — [4]Leibniz Universität Hannover

Faraday cups are commonly used for ion beam current measurements. They provide an easy and robust way to quantitatively determine ion currents for different applications in mass spectrometry, accelerator operation and others. Based on comparative measurements using γ spectroscopy, which indicated a systematic underestimation of the ion beam current in earlier measurements, a new Faraday cup was developed and characterized at the RISIKO mass separator of the Johannes Gutenberg-University Mainz. During this work several target shapes and repeller configurations were investigated in simulations, optimized to compensate and minimize errors due to the loss of charged secondary particles, i. e., secondary electrons and sputtered secondary ions. Calibration measurements with ^{165}Ho using resonance ionization mass spectrometry confirm an absolute quantification of ion beams in the range of 100 pA to 100 nA with a precision of better than 5%.

MS 7.5 Thu 16:30 Empore Lichthof

Fe-55 ion implantation by resonance ionization mass spectrometry for the PrimA-LTD project — •Thorben Niemeyer[1], Sebastian Berndt[1], Holger Dorrer[1], Nina Kneip[2], Dennis Renisch[1,3], Dominik Studer[1,3,4], Christoph E. Düllmann[1,3,4], and Klaus Wendt[1] — [1]Johannes Gutenberg Universität Mainz, 55099 Mainz — [2]Leibniz Universität Hannover, 30060 Hannover — [3]Helmholtz-Institut Mainz, 55090 Mainz — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt

New activity standardisation techniques for radionuclide metrology are developed within the scope of the the PrimA-LTD project. Low temperature micro calorimeters will be implanted with 100 Bq Fe-55 to measure its fractional electron-capture probabilities in the K-, L- and M-shell with high precision. This will allow experimental assessment of high-precision theoretical calculations.

The implantation of Fe-55 into the absorbers of the microcalorimeters is underway at the RISIKO mass separator at Mainz University. The resonance ionisation mass spectrometry method will be used due to its outstanding element selectivity and efficiency. Fully-automated pulsed Ti:Sa lasers are used to probe the atomic spectrum below and above the ionization potential. Measurements of Rydberg series allow the verification of the known ionization potential while strong autoionizing states will be used for the identification of a new element-selective two-step ionization scheme later to be used for the implantation. Laser spectroscopy and efficiency measurements of RISIKO are performed with stable Fe-56.

MS 7.6 Thu 16:30 Empore Lichthof

MOCCA: a 4k-pixel molecule camera for the position and energy resolved detection of neutral molecule fragments — •Daniel Kreuzberger[1], Christian Enss[1], Andreas Fleischmann[1], Lisa Gamer[2], Loredana Gastaldo[1], Christopher Jakob[2], Ansgar Lowack[1], Oldřich Novotný[2], Andreas Reifenberger[1], Dennis Schulz[1], and Andreas Wolf[2] — [1]Heidelberg University — [2]Max Planck Institute for Nuclear Physics, Heidelberg

The MOCCA detector is a 4k-pixel high-resolution molecule camera based on metallic magnetic calorimeters and read out with SQUIDs that is able to detect neutral molecule fragments with keV kinetic energies. It will be deployed at the Cryogenic Storage Ring CSR at the Max Planck Institute for Nuclear Physics in Heidelberg, a storage ring built to prepare and store molecular ions in their rotational and vibrational ground states, enabling studies on electron-ion interactions. To reconstruct the reaction kinematics, MOCCA measures the energy and position of incident particles on the detector, even with multiple particles hitting the detector simultaneously.

We present a new read-out scheme which uses only 32 SQUID channels for the 4096 pixels of the detector as well as some new fabrication details including copper-filled through-wafer vias to heat-sink the detector to the wafer backside. In addition we present the results of first characterization measurements.

MS 7.7 Thu 16:30 Empore Lichthof

Novel use of Actinide Resin® for multi-actinide analysis with AMS — •Thomas Roth[1], Francesca Quinto[1], Markus Plaschke[1], Karin Hain[2], Peter Steier[2], and Horst Geckeis[1] — [1]Institute for Nuclear Waste Disposal (INE), Karlsruhe Institute of Technology (KIT), Germany — [2]Faculty of Physics, University of Vienna, Austria

$Fe(OH)_3$ co-precipitation and conversion to an Fe_2O_3 specimen is an effective procedure for group separation (without subsequent column separation) and concurrent determination of actinides in aqueous environmental samples using AMS. However, matrix elements like Al and Si can also be precipitated in the process and thus increase the AMS specimen′s mass. As previously observed, the overall detection efficiency of the actinides decreases with increasing matrix content of the AMS specimen, partly due to a dilution effect. A novel procedure employing Actinide Resin® has been tested and compared to the $Fe(OH)_3$ co-precipitation for preparation of two sets of six Rhine River water samples (each 2 L volume) collected near the French Fessenheim NPP. Preliminary results for separation efficiency indicate that the use of Actinide Resin® reduces the Al and Si content of the AMS specimen by ca. 80%. Such a result is supported by a similar reduction of the specimen mass. The results obtained with the two preparation methods were consistent with each other, indicating global fallout as origin with concentrations of ca. 10^7 atoms/L for ^{237}Np, ca. 10^7 atoms/L for ^{236}U and Pu at background level.

MS 7.8 Thu 16:30 Empore Lichthof

Super-SIMS - from the idea to first measurements — •René Ziegenrücker[1], Georg Rugel[1], Dominik Koll[1], Johannes Lachner[1], Axel D. Renno[1], Carlos Vivo Vilches[1], Anton Wallner[1], and Michael Wiedenbeck[2] — [1]Helmholtz- Zentrum Dresden-Rossendorf, Dresden — [2]Deutsches GeoForschungsZentrum GFZ, Potsdam

The Dresden Super-SIMS is a combination of the DREAMS facility and a CAMECA IMS7f-auto as the ion source, and combines the advantages of both worlds: on one hand the suppression of molecular isobaric background with a 6 MV tandem accelerator and on the other the special and depth resolved information about the origin of the measured signals in the sample. This is possible without the samples undergoing any chemical treatment, and a polished surface ($<$ a few nm) is sufficient for the measurement. While former attempts were intended to analyse semiconductor samples, the primary aim of Super-SIMS is the measurement of geological samples.

Nevertheless, first experiments were done with silicon to characterise the system and compare it with former attempts. Several samples with known content of phosphorus, including the blank, from the former URI-Project (Ultra clean injector) at the Technical University of Munich were measured. The sample with highest P content was used as internal reference material and the measurements showed a good agreement between measured concentrations by Super-SIMS and URI.

MS 7.9 Thu 16:30 Empore Lichthof

ISOLTRAP's new Mini-RFQ buncher for beam purification — •Daniel Lange on behalf of the ISOLTRAP collaboration — Max-Planck-Institute for Nuclear Physics, Heidelberg, Germany

High-precision mass measurements of radioactive ions are used to determine nuclear binding energies, which reflect all forces in the nucleus and are used to study among others nuclear structure, nuclear astrophysics and weak interaction. Far away from stability, production cross-sections drop and beams are contaminated with isobars and molecules, impeding precision measurements.

For this, the ISOLTRAP mass spectrometer at ISOLDE/CERN [1] uses various ion traps, including a tandem Penning-trap system and multi-reflection time-of-flight mass spectrometer (MR-ToF MS). The latter is suitable of both mass separation and fast, precise mass mea-

surements. These two different modes of operation can be used in succession to enable measurements of extremely contaminated beams when a re-trapping system is used [2].
The new Mini-RFQ behind the MR-ToF MS should not only recapture the ions of interest, but also re-bunch them. Additionally, a cryogenic approach is pursued to further improve the precision of the mass measurement with the MR-ToF MS. The current setup of the ISOLTRAP experiment is presented together with the future re-bunching design. For this purpose, the experimental test-setup with initial simulations will be outlined in more detail.
[1] Lunney D. et al., J. Phys. G: Nucl. Part. Phys. 44 (2017) 064008
[2] Dickel T. et al., J. Am. Soc. Mass Spectrom., 28 (6) (2017)

MS 7.10 Thu 16:30 Empore Lichthof

Design of a tandem mass spectrometer with ion trap to study particle nucleation under multicollisional conditions. — •Anastasiya Khramchenkova, Yihui Yan, and Jozef Lengyel — TUM School of Natural Sciences, Technical University of Munich, Garching, Germany

The goal of our research is to describe the essential molecular factors of one of the most critical atmospheric processes - the first steps of new particle formation. During aerosol formation, small clusters can grow and dissociate at any time, but only few reach the critical size at which further growth of the particle becomes spontaneous. However, the size and chemical composition of such critical nuclei have yet to be characterized, as there is currently no suitable analytical method. To this end, we are developing a tandem mass spectrometer for investigating particle nucleation at close to ambient pressures, combining precise control over cluster size with in situ real-time monitoring of complex kinetic analysis. The hydrated particles are generated by electrospray ionization, mass selected in a quadrupole mass filter, subsequently stored and exposed to precursor molecules in a ring electrode ion trap. After a variable storage time, an ion packet is extracted and focused into a perpendicularly mounted TOF MS, where the spectra are recorded with an MCP detector. Herein, we will discuss the instrumentation - design and implementation of each component. We will describe the characteristics of different RF ion guides, including stacked ring ion guides and multipoles, supplemented by ion trajectory simulations probed by the software package SIMION.

MS 7.11 Thu 16:30 Empore Lichthof

Spatially resolved trace analysis of radionuclides with laser ionization mass spectrometry — •Paul Hanemann[1], Tobias Weissenborn[1], Nina Kneip[1], Laura Leifermann[1], Darcy van Eerten[1], Manuel Raiwa[1], Felix Berg[2], and Clemens Walther[1] — [1]Institute of Radioecology and Radiation Protection, Leibniz University Hannover — [2]Institute of Nuclear Chemistry, University Mainz

Resonant laser secondary neutral mass spectrometry (rL-SNMS) combines the high spatial resolution of traditional time of flight secondary ion mass spectrometry (ToF-SIMS) with the advantage of element selectivity. Multiple grating-tuned Ti:Sa lasers allow access to a range of resonant ionization schemes. Combined with mass spectrometry, the method can detect actinides in single radioactive particles from the environment, down to 10^7 atoms of a single isotope [1]. In micrometer-sized particles from the Chornobyl exclusion zone, the relative ^{238}Pu content can be determined by suppressing the dominant ^{238}U in spent fuel. This is achieved quasi non-destructively without chemical preparation of the sample. The current capabilities of the rL-SNMS system are presented in this poster, with an outlook on further developments of the method and application to ultra-trace analysis.[1] DOI:10.1126/sciabv.abj1175

MS 7.12 Thu 16:30 Empore Lichthof

Assessment of anthropogenic actinide background levels on the ground of the new 1-MV compact AMS system HAMSTER at HZDR — •Sebastian Fichter[1], Anton Wallner[1], Karin Hain[2], and Michael Hotchkis[3] — [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*) is built within the HZDR research campus in Dresden-Rossendorf starting in 2022. The new machine is especially dedicated to the analysis of ultra-trace levels of actinides in environmental samples. Therefore, eventual contamination of the site where the new accelerator building is being constructed should be avoided and clarified. Hence, several soil samples close to the construction site of the new accelerator building have been analyzed to assess the content and isotopic ratios of the actinides U, Np and Pu. The samples have been processed in the existing chemistry labs of HZDR's 6-MV DREAMS facility showing low background levels. Overall, the samples show expected signatures of global fallout in Pu concentrations and ^{A}Pu/^{239}Pu ratios. However, in some samples increased ^{236}U concentrations and relatively low ^{233}U/^{236}U atomic ratios have been detected pointing to an additional source of ^{236}U. Additional analysis is currently ongoing.

MS 7.13 Thu 16:30 Empore Lichthof

Preparation of a Pa-233 tracer for accelerator mass spectrometry of Pa-231 in environmental samples — •Janis Wolf, Astrid Barkleit, Sebastian Fichter, Robin Steudtner, and Anton Wallner — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

The measurement of Pa-231 ($t_{1/2} = 3.28 \cdot 10^4$ a) by accelerator mass spectrometry (AMS) has many applications including nuclear forensics, U/Pa dating and radiological risk assessment of the U-235 decay chain. The measurement requires the addition of an isotopic spike and as Pa-231 is the only long-lived Pa isotope, the short-lived isotope Pa-233 ($t_{1/2} = 26.98$ days) is used. This enables the measurement of the isotopic ratio Pa-231/Pa-233 and monitoring of the efficiency of the sample preparation and measurement procedure.

The Pa-233 spike is typically separated from a solution of its long-lived mother nuclide Np-237 using an ion-exchange resin. Due to the tendency of Pa to attach to surfaces, different procedures for this separation are tested with the aim to find a procedure with high Pa-233 yields that can be performed quickly and without additional safety precautions during AMS sample preparation.

MS 8: Accelerator Mass Spectrometry III

Time: Friday 11:00–12:45 Location: F128

Invited Talk MS 8.1 Fri 11:00 F128

Two color resonant laser SNMS for isotope micro imaging of nuclear fuel debris — •Tetsuo Sakamoto — Kogakuin University, Tokyo, Japan

Tetsuo Sakamoto

Great East Japan Earthquake occurred in 2011. Effect of the earthquake was very large. Fukushima Daiichi (1F) nuclear accident is one of the serious disasters. The decommissioning of 1F is now in progress. There are many problems to be solved. One of those is the method for taking out nuclear fuel debris safely. For that reason, there is a strong need for analysis methods of debris precisely. The most important thing in the debris analysis is isotope ratio of a certain elements, because the ratio is closely related to both the accident progress and the state of debris. Secondary ion mass spectrometry (SIMS) is a candidate for the analysis. However, isobaric interferences often make it difficult to analyze precise isotope ratio analysis.

The author has been developed a resonance ionization sputtered neutral mass spectrometer (R-SNMS) for element-selective ionization and detection by using a set of newly developed tunable Ti:Sapphire lasers. It consists of two lasers independently tunable at a repetition rate of 10 kHz.

MS 8.2 Fri 11:30 F128

Isobar separation in the actinide range with ILIAMS — •Andreas Wiederin[1,2], Karin Hain[1], Martin Martschini[1], Aya Sakaguchi[3], Peter Steier[1], and Robin Golser[1] — [1]University of Vienna, Faculty of Physics - Isotope Physics, Austria — [2]University of Vienna, Vienna Doctoral School in Physics, Austria — [3]University of Tsukuba, Faculty of Pure and Applied Science, Japan

Isobaric background is among the main obstacles to the development of new AMS applications. By combining ILIAMS (Ion Laser InterAction

Mass Spectrometry) with the actinide beamline of VERA (Vienna Environmental Research Accelerator), instrumental isobar separation in the mass range of the actinides has become available for the first time in AMS. ILIAMS combines an RFQ ion guide with high-powered lasers or reactive gases for isobar separation of anions at thermal energies.

The first application for ILIAMS in this mass range is the characterization of a recently produced ^{236}Np spike material intended for normalizing environmental ^{237}Np measurements. ILIAMS is used to monitor potential isobaric interference from ^{236}U or ^{236}Pu co-produced alongside the desired ^{236}Np and even suppresses ^{236}U by several orders of magnitude.

The isotopic ratios ^{238}Pu/^{239}Pu, ^{241}Pu/^{241}Pu, and ^{238}Pu/^{241}Pu are used as fingerprints for nuclear emission sources but partially require extensive chemical separation procedures and tedious radiochemical analysis. First results indicate that ILIAMS will also enable unambiguous mass-spectrometric access to ^{238,241}Pu usually superimposed by isobaric background from ^{238}U and ^{241}Am, respectively.

MS 8.3 Fri 11:45 F128

A new setup to characterise the tritium content of reactor graphite at Cologne-AMS — •Timm-Florian Pabst, Markus Schiffer, Gereon Hackenberg, Stefan Heinze, Martina Gwozdz, Alfred Dewald, and Dennis Mücher — Institute for Nuclear Physics, University of Cologne, Germany

There is approximately one kiloton of activated reactor graphite in Germany, mainly originating from research reactors and waiting for characterization and disposal. For storage in repositories like the mine Konrad, activity limits have to be considered. Reactor graphite has a complex radio nuclide vector with ^{3}H and ^{14}C as its main components. We are aiming for a small AMS system dedicated for ^{3}H measurement, by which gas is extracted from the reactor graphite and directly injected into a sputter ion source. Such a set-up is well suited for automated measurements and a high sample throughput. As a first step we expanded our ion source test bench at Cologne-AMS by a 100 kV tandem accelerator with a carbon stripper foil and a 90° analysing magnet followed by a multi-Faraday cup unit. The gas analyte is provided by heating the reactor graphite to approximately 1000°C, enhancing the diffusion of ^{3}H. Isobar molecules are suppressed by the tandem accelerator stage. A dedicated control system based on Siemens S7 programmable logic controllers and a LabVIEW based control software allows complete remote operation of all components of the setup.
In this contribution we will present the system layout as well as results of first test measurements with an H-beam regarding sample preparation, system transmission and molecular dissociation.

MS 8.4 Fri 12:00 F128

Anthropogenic Actinides as Potential Markers for the Anthropocene — •Janis Wolf[1,2], Andreas Maier[3], Maria Meszar[4], Michael Strasser[5], Michael Wagreich[4], and Karin Hain[2] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]University of Vienna, Faculty of Physics, Vienna, Austria — [3]University of Vienna, Department of Geography and Regional Research, Vienna, Austria — [4]University of Vienna, Department of Geology, Vienna, Austria — [5]University of Innsbruck, Department of Geology, Innsbruck, Austria

To establish the Anthropocene as a new geological epoch, a reference point for the base of this epoch has to be defined using stratigraphic markers. Long-lived anthropogenic actinides released by atmospheric nuclear weapons testing may be suitable markers.

Thus, anthropogenic actinides U-233,236, Np-237 and Pu-239,240,241 were analyzed in a peat bog core taken from the Pürgschachen mire, using Accelerator Mass Spectrometry (AMS). The distribution of the actinides in the peat bog is compared to their distribution in other environmental reservoirs including a lake sediment core and urban sediments. This presentation will discuss the measurement results and interpret the isotope ratios in terms of emission source identification and their suitability as geological markers for the Anthropocene.

MS 8.5 Fri 12:15 F128

Characterisation of Reactor Graphite with AMS Ion Beam Techniques — Martina Gwozdz[1], Markus Schiffer[1], •Stefan Heinze[1], Klaus Eberhardt[2], Gereon Hackenberg[1], Susan Herb[1], Timm- Florian Pabst[1], Max Stefan[1], Alexander Stolz[1], Erik Strub[3], Alfred Dewald[1], and Dennis Mücher[1] — [1]Institut für Kernphysik, Universität zu Köln — [2]Institut für Kernchemie, Johannes Gutenberg Universität, Mainz — [3]Institut für Kernchemie, Universität zu Köln

Activated graphite, e.g. from graphite moderated reactors contains several radioactive isotopes like ^{14}C, ^{36}Cl, or ^{3}H. For the final disposal of such material a quantitative characterization is demanded. We are aiming for a system which enables automated measurements using the AMS technique with gaseous samples for the above mentioned isotopes. The aimed system should provide a high sample throughput as well as the possibility of sample dilution in cases of high activity. At CologneAMS, a new gas-interface was built and tested for ^{14}C measurements which uses a syringe for the transport of the sample gas into the ion source and a separate reservoir which can be used for high dilution. An advantage over the already established procedure using Liquid Scintillation Counting (LSC) is that the setup at the CologenAMS does not need elaborate chemical sample preparation and has a sensitivity down to $3 \cdot 10^{-9}$Bq/g. In this contribution we will present the layout of our systems as well as the stage of realisation. Supported by BMBF under contract number 15S9410B.

MS 8.6 Fri 12:30 F128

Super-SIMS at HZDR: Status and Future — •Georg Rugel[1], René Ziegenrücker[1], Axel D. Renno[1], Dominik Koll[1], Johannes Lachner[1], Pavol Noga[2], Carlos Vivo-Vilches[1], Anton Wallner[1], and Michael Wiedenbeck[3] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Slovak University of Technology in Bratislava, Trnava, Slovakia — [3]Deutsches GeoForschungsZentrum GFZ, Potsdam, Germany

The status and the future setup of the Super-SIMS at HZDR, Dresden will be outlined. The instrument is the combination of a commercial **S**econdary **I**on **M**ass **S**pectrometry instrument (CAMECA IMS 7f-auto) with DREAMS (DREsden AMS). While the SIMS provides micron-scale lateral resolution, AMS ensures high selectivity through highly effective molecule suppression by the stripping process. High transmission for major element ions including silicon, fluorine and iodine has been demonstrated in initial tests (see ref. [1]). The high energies from our 6-MV tandem were not actually required for our background suppression needs. Our new compact 1-MV AMS system will be used in the future for Super-SIMS.

[1] Rugel et al. NIMB 532 (2022) 52-57.

MS 9: Penning traps, highest precision, neutrino physics, storage rings, new facilities and approaches

Time: Friday 14:30–16:30 Location: F128

Invited Talk MS 9.1 Fri 14:30 F128

Developments to improve antiproton and other mass measurements — •Christian Smorra on behalf of the BASE collaboration — Johannes Gutenberg Universität Mainz — RIKEN Fundamental Symmetries Laboratory — Max-Planck Insititute for Nuclear Physics

Precision mass measurements in Penning traps have been performed on a wide variety of charged particles, and provide important input parameters for testing the fundamental interactions. For example, the most recent precision comparison of the proton and antiproton masses with 16 parts per trillion uncertainty provides the most stringent test of CPT invariance in the baryon sector and an antiparticle test of the weak equivalence principle with unprecedented resolution.

Common limitations to all mass measurements are uncertainties imposed by magnetic field fluctuations and finite particle temperatures. I will present the current efforts by the BASE collaboration to improve on these limitations for the antiproton mass measurements. This comprises the development of the transportable antiproton trap BASE-STEP that provides the possibility to relocate measurements of accelerator-produced particles away from the magnetic noise environ-

ment at the production site. Further, I will present the sympathetic cooling method for a single proton in a two-trap system using a cloud of laser-cooled beryllium ions. Here, we exchange energy by image currents between the traps in a coupled oscillator system. Presently, we cool the proton to a fraction of 1 K and plan to extend the cooling range down to the temperature of laser-cooled ions.

MS 9.2 Fri 15:00 F128

Preparations for ^{163}Ho implantation into 3-inch wafers for ECHo — •Sebastian Berndt[1], Nikolas Bittner[1], Holger Dorrer[1], Christoph E. Düllmann[1,2,3], Raphael Hasse[1], Tom Kieck[2,3], Nina Kneip[4], and Klaus Wendt[1] for the ECHo-Collaboration — [1]Johannes Gutenberg University Mainz — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [3]Helmholtz Institute Mainz — [4]Leibniz University Hannover

The "Electron Capture in ^{163}Ho" (ECHo) experiment aims at measuring the electron neutrino mass in the sub-eV range by the analysis of the calorimetrically measured energy spectrum following the electron capture process of ^{163}Ho. The radioisotope ^{163}Ho is produced from enriched ^{162}Er in the high-flux nuclear reactor at Institut Laue-Langevin (ILL) Grenoble in France. This production process is followed by chemical separation to remove all elements other than Ho and by mass spectrometric separation for removal of remaining trace amounts of ^{166m}Ho. The ^{163}Ho is finally implanted into the absorbers of the ECHo Metallic Magnetic Calorimeters with high purity. Mass separation and implantation is performed in a single step at the RISIKO mass separator at University Mainz. For the scalability of the ^{163}Ho implantation from a single ECHo-100k chip with 64 absorbers to a 3-inch wafer with 40 ECHo-100k chips, the implantation region at RISIKO had to be adapted. A x-y stage and a Mapping Aperture Detector (MAD) were installed in the implantation chamber. The MAD is a wire detector with 8 wires that are read out individually to constantly monitor the size and position of the ion beam.

MS 9.3 Fri 15:15 F128

Towards a Parts-per-trillion Atomic Mass Measurement of the ^{3}He Nucleus — •Olesia Bezrodnova[1], Sangeetha Sasidharan[1,2], Sascha Rau[1], Wolfgang Quint[2], Sven Sturm[1], and Klaus Blaum[1] — [1]Max Planck Institute for Nuclear Physics, Heidelberg, Germany — [2]GSI Helmholtzzentrum, Darmstadt, Germany

Masses of light nuclei provide a network of essential parameters used for the fundamental nature description. For example, the mass difference of T and ^{3}He is used as a consistency check for the model of systematics in the KATRIN experiment, aiming to set a limit on the $\bar{\nu}_e$ mass [1].

The most precise mass measurements of the lightest nuclei, including ^{3}He, revealed considerable inconsistencies between the values reported by different experiments [2]. In order to provide an independent cross-check, the multi-Penning-trap mass spectrometer LIONTRAP has obtained the masses of the proton [3], the deuteron and the HD^+ molecular ion [4].

Present activities of the experiment are directed at the atomic mass measurement of the ^{3}He nucleus with a relative uncertainty lower than 10 ppt. This contribution presents the status of the ongoing measurement campaign.

[1] M. Aker *et al.*, Nat. Phys. **18**, 160-166 (2022)
[2] S. Hamzeloui *et al.*, Phys. Rev. A **96**, 060501(R) (2017)
[3] F. Heiße *et al.*, Phys. Rev. A **100**, 022518 (2019)
[4] S. Rau *et al.*, Nature **585**, 43-47 (2020)

MS 9.4 Fri 15:30 F128

A novel transportable PI-ICR Penning-trap mass spectrometer — •Daniel Lange, Menno Door, Sergey Eliseev, Pavel Filianin, Jost Herkenhoff, Kathrin Kromer, Alexander Rischka, Chistoph Schweiger, and Klaus Blaum — Max-Planck-Institute for Nuclear Physics, Heidelberg, Germany

The new, transportable PILOT (Phase-Imaging Located in One Transportable) - trap experiment aims to measure masses of short-lived nuclides with low production rates and half-lives down to 100 ms with relative uncertainties of about 10^{-8}. This should be realised with a Penning-trap based modified buffer-gas cooling and PI-ICR technique [1]. In order to deal with the low production rates of some isotopes a modified dynamic buffer-gas cooling technique is used in only a single measurement trap. Therefore a fast piezo valve has been developed, which enables a fast and precisely timed helium injection into the Penning-trap, followed by a fast helium release to be directly able to measure in the same trap. This increases the overall efficiency by also avoiding the transport of ions between the traps. The setup is situated in the warm bore of a 6 T superconducting coldhead-cooled magnet which ensures transportability to different radioactive beam facilities. Here, mass measurements of e.g. rare superheavy nuclides become possible contributing to nuclear physics and the search for the island of stability, see e.g. [2]. The current status as well as the developed dynamic cooling method of this experiment are presented.

[1] Eliseev, S. et al., Phys. Rev. Lett. 110, 082501 (2013).
[2] Block, M. et al., Nature 463, 785-788 (2010).

MS 9.5 Fri 15:45 F128

MOCCA - A 4k-pixel microcalorimeter detector for the Cryogenic Storage Ring CSR — •Christopher Alexander Jakob[1], Lisa Gamer[1], Klaus Blaum[1], Christian Enss[2], Andreas Fleischmann[2], Oded Heber[3], Daniel Kreuzberger[2], Ansgar Lowack[2], Michael Rappaport[3], Andreas Reifenberger[2], Dennis Schulz[2], Abhishek Shahi[3], Yoni Toker[4], Andreas Wolf[1], and Oldřich Novotný[1] — [1]MPIK Heidelberg — [2]KIP Heidelberg University — [3]Weizmann Institute of Science, Rehovot, Israel — [4]Bar-Ilan University, Ramat Gan, Israel

The low temperatures and low gas densities in cold interstellar clouds allow the present molecules to relax into their vibrational and rotational ground states. At the Max Planck Institute for Nuclear Physics in Heidelberg, these conditions can be reproduced in the Cryogenic Storage Ring CSR, where heavy molecular ions can cool down while stored for thousands of seconds and electron-ion recombination can be investigated. To reconstruct the full kinematics of these processes, position- and energy-sensitive coincident detection of multiple neutral reaction products is required. For this purpose, MOCCA, a 4k-pixel molecule camera based on metallic magnetic calorimeters with a detection area of 45 mm×45 mm, was developed at the Kirchhoff Institute for Physics in Heidelberg. We present the detector readout scheme, characterization measurements, and the implementation of MOCCA into the CSR-independent MOCCA standalone setup, that will be used to study photon- and collision-induced ion fragmentation processes before MOCCA will be integrated into CSR.

MS 9.6 Fri 16:00 F128

Nuclear two-photon decay of ^{72m}Ge with an isochronous heavy-ion storage ring — •David Freire-Fernández for the E143-Collaboration — MPIK, Heidelberg, Germany — Heidelberg University, Heidelberg, Germany

The nuclear two-photon (2γ) decay is a rare decay mode in atomic nuclei whereby a nucleus in an excited state emits two gamma rays simultaneously. First order processes usually dominate the decay, however two-photon emission may become significant when first order processes are forbidden or strongly suppressed, which can be achieved at the experimental storage ring ESR (GSI/FAIR).
Within this work we will present the implemented methodology and the obtained results of a beam time performed in 2021, when for the first time the isochronous mode of the ESR alongside two non-destructive Schottky detectors were operated for the study of short-lived isomers. We investigated specifically the isotope ^{72}Ge, as it is the most easily accessible nucleus having a first excited 0^+ state below the pair creation threshold paramount for the study of 2γ decay without competition of first order decays.
Preliminary results point out that its half-life is considerably shorter than expected from the extrapolation of previously studied $0^+ \rightarrow 0^+$ transitions. Therefore, new theoretical investigations are required which, in combination with our experimental measurements, will allow us to determine the transition nuclear polarizabilities. In addition, the most precise mass measurements obtained by isochronous mass spectrometry will be presented.

MS 9.7 Fri 16:15 F128

Plan of collinear fast beam laser spectroscopy on neutron rich La isotopes to explore the onset and evolution of triaxiality in nuclear ground states using RAON CLS system — •Jung-Bog Kim[1], Jens Lassen[2], Rouhong Ki[2], Hans A. Schuessler[3], SeongGi Jo[4], Sinbee Choi[1], Sung Jong Park[4], A Takamine[5], M Wada[5], H Limura[6], and Duck-Hee Kwon[7] — [1]Korea National University of Education, Cheongju, Rep. Korea — [2]TRIUMF Canada Particle Accelerator Laboratory, Vancouver BC, V6T2A3, Canada — [3]Dept. of Physics & Astronomy, Texas A&M University, College Station TX, 77843-4242, USA — [4]Institute of Basic Science, RISP, Daeheon, Rep. Korea — [5]Atomic Physics Laboratory, RIKEN, 2-1 Hi-

rosawa, Wako, Saitama 351-0198, Japan — [6]Japan Atomic Energy Agency, Tokai-mura, Naka-gun, Ibaraki 319-1195, Japan — [7]Korea Atomic Energy Research Institute, Daejeon, Rep. Korea

The RAON radioactive ion beam facility with resonant ionization laser ion source and a dedicated collinear fast beam laser spectroscopy facility will be the ideal place to carry out challenging, state-of-the-art experiments. One such experiment is to investigate nuclear structure beyond quadrupolar deformation. The neutron-deficient La isotopes are in the mass region where an axially asymmetric shape of nuclei is predicted theoretically. To clarify the deformation of 129La and even more neutron-deficient La isotopes, we are now planning to extend the laser spectroscopy to these nuclides.