

## MS 4: Poster

Time: Tuesday 17:00–19:00

Location: Aula Foyer

MS 4.1 Tue 17:00 Aula Foyer

**The CSR-ReMi – a wide-range spectrometer for collision studies in the CSR** — ●CLAUS DIETER SCHRÖTER, FELIX HERMANN, WEIYU ZHANG, DAVID V. CHICHARRO, FLORIAN TROST, KLAUS BLAUM, MANFRED GRIESER, FLORIAN GRUSSIE, HOLGER KRECKEL, OLDŘICH NOVOTNÝ, ANDREAS WOLF, ALEXANDER DORN, ROBERT MOSHAMMER, and THOMAS PFEIFER — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Deutschland

Reaction microscopes (ReMi's) [1, 2] are combined electron and ion spectrometers for energy and angular resolved detection of fragments resulting from elementary collision processes. In order to use this powerful technique for collision studies with slow and cold molecular or cluster ions inside the cryogenic storage ring CSR [3], we have built a dedicated in-ring spectrometer, the CSR-ReMi. The CSR-ReMi is fully operational and first experiments have been performed just recently on electron transfer and collisional ionization reactions. Experiments on photo-detachment with atomic and molecular anions are envisaged for spring 2024. In the poster we will present an overview of the complex technical design of the machine and we will give insights into possible future scientific applications.

References:

- [1] J. Ullrich et al., Rep. Prog. Phys. 66, 1463-1545 (2003)
- [2] H. Schmidt-Böcking et al., Ann. d. Phys. 533, 2100134 (2021)
- [3] R. von Hahn et al., Rev. Sci. Instrum. 87, 063115 (2016)

MS 4.2 Tue 17:00 Aula Foyer

**Apparatus for deterministic ionization and loading of molecules** — ●RENÉ NARDI, BRANDON FUREY, STEFAN WALSER, ZHENLIN WU, MARIANO ISAZA MONSALVE, ELYAS MATTIVI, and PHILIPP SCHINDLER — Universität Innsbruck, Institut für Experimentalphysik, Innsbruck, Österreich

We study the complex rovibrational structure of trapped molecular ions and their potential applications in molecular quantum information processing. Our experiments are currently limited to investigating  $\text{CaOH}^+$ , which are created from chemical reactions of trapped  $\text{Ca}^+$  and free  $\text{H}_2\text{O}$ . In order to load other molecular species, we are building a test setup where a molecular gas is injected in a vacuum chamber, photoionized, and then guided into an ion trap. This test setup features a time-of-flight mass spectrometer to determine the ions created by photoionization of  $\text{N}_2^+$  and acetylene. Mass filters and ion optics can then be added to steer and focus the molecule of interest through a differential pumping region towards a linear Paul trap in a UHV chamber. Molecular ions can be injected into the trapping region through an aperture in the end-cap electrode for axial confinement in our linear ion trap.

MS 4.3 Tue 17:00 Aula Foyer

**Recent measurements and developments at ISOLTRAP** — ●CHRISTOPH SCHWEIGER for the ISOLTRAP-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

ISOLTRAP [1] is a multi ion-trap mass spectrometer located at ISOLDE/CERN dedicated to high-precision mass measurements of artificially produced, short-lived, exotic radionuclides far from stability. Experimentally, ISOLTRAP employs multi-reflection time-of-flight and Penning trap mass spectrometry for absolute and relative mass measurements. The measured masses can be connected to nuclear binding energies using Einsteins famous relation between mass and energy:  $E = mc^2$ . The nuclear binding energy reflects all underlying interactions in the nucleus and allows the study of nuclear structure and nuclear astrophysics, the weak interaction and further fundamental physics applications. The current status of the experimental setup and recent technical developments will be presented as well as the results of the most recent beamtime periods. This includes the neutron deficient  $^{97,98}\text{Cd}$  ground states in vicinity of the doubly-magic  $^{100}\text{Sn}$  and the  $^{97m}\text{Cd}$  isomeric state as well as the first mass measurements of the neutron rich  $^{209,210}\text{Hg}$ . A measurement of the  $^{79m}\text{Zn}$  isomer resolved the state ordering of the  $1/2^+$  and  $5/2^+$  states and solidifies previous evidence of shape coexistence [2].

- [1] Lunney, D. et al., *J. Phys. G: Nucl. Part. Phys.* **44**, 064008 (2017)
- [2] Nies, L. et al., arXiv:2310.16915v1 (2023)

MS 4.4 Tue 17:00 Aula Foyer

**Simulating space charge effects in the ILIAMS ion cooler @ VERA** — ●DANIEL BAUMGARTNER, MARTIN MARTSCHINI, and ROBIN GOLSER — University of Vienna, Faculty of Physics, Austria

Ion Laser InterAction Mass Spectrometry (ILIAMS) at the Vienna Environmental Research Accelerator (VERA) is a novel approach to Accelerator Mass Spectrometry (AMS) enabling the measurement of nuclides otherwise inaccessible to low- and medium-energy AMS facilities and improving the detection limit for several other isotopes by orders of magnitude. Undesired isobaric components of an anion beam are neutralized through photodetachment via a collinearly overlapped laser of suitable energy inside a buffer-gas-filled, RF-Quadrupole ion cooler. The selected nuclear species of interest with higher detachment energy remain unaffected and propagate along a constant electric gradient. The system is optimized for long ion residence times of several milliseconds to ensure sufficient interaction time with the laser. However, measurements show that residence time decreases for increasing nA beam currents. At  $\mu\text{A}$  ion currents, even the transmission starts to decrease. To provide insights and potential explanations for these indeterminate effects, this poster highlights results of recent particle simulations with COMSOL Multiphysics<sup>®</sup> accounting for fully dynamic space charge. In addition to a strong influence on particle trajectories, charge effects can also cause an increase in a) phase space volume, b) average particle energy and c) velocity of propagation.

MS 4.5 Tue 17:00 Aula Foyer

**Complementary Actinide Markers for the Anthropocene in Coral Cores** — ●ALINE ZOUFAL<sup>1</sup>, KATEŘINA FENCLOVÁ<sup>2</sup>, JENS ZINKE<sup>3</sup>, SIMON TURNER<sup>4</sup>, ANDREW CUNDY<sup>5</sup>, and KARIN HAIN<sup>1</sup> — <sup>1</sup>University of Vienna, Faculty of Physics, Austria — <sup>2</sup>Czech Technical University in Prague, Czech Republic — <sup>3</sup>University of Leicester, England — <sup>4</sup>University College London, England — <sup>5</sup>University of Southampton, England

This study investigates the presence of anthropogenic actinides ( $^{236}\text{U}$ ,  $^{237}\text{Np}$ ,  $^{239,240}\text{Pu}$ ) in the marine environment, originating from intense nuclear weapons testing in the 1960s, resulting in global fallout of radioactive isotopes. Corals, chosen for their ability to incorporate trace elements from surrounding seawater into their skeletons, serve as archives of past environmental conditions. Their growth bands offer a precise annual chronological record of actinide concentrations, potential proxies for ocean circulation changes in (sub)tropical oceans. Our project examines actinide concentrations in corals from Flinders Reef, Coral Sea, Australia in the context of discussions of the newly proposed Anthropocene epoch. This study presents the first profile of  $^{237}\text{Np}$  in coral cores, positioning it as a promising oceanographic tracer. Preliminary results indicate a conservative behaviour in ocean water, similar to  $^{236}\text{U}$ . The high sensitivity and selectivity of Accelerator Mass Spectrometry (AMS) allow for small sample sizes and eliminate the need for chemical separation of the elements. Consequently, a simplified sample preparation procedure can be applied which precipitates all actinides together with a carrier and a  $^{242}\text{Pu}$  spike.

MS 4.6 Tue 17:00 Aula Foyer

**Development and improvement of radiochemical separation schemes for actinide determination using AMS** — ●JANIS WOLF, DOMINIK KOLL, SEBASTIAN ZWICKEL, and SEBASTIAN FICHTER — Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Dresden, Germany

The determination of minute amounts of actinides in a huge variety of sample matrices is a challenging task. The current capabilities of state-of-the-art accelerator mass spectrometers enable detection limits close to a few hundred atoms per sample. However, proper sample preparation is inevitable to separate the element of interest from the overwhelming majority of the sample mass. Here, we present some of our current activities regarding the optimization of work-up procedures for different actinides (i.e. Pa, Np, Pu, Am, Cm) from environmental samples like water, soil, deep sea ferromanganese crusts and lunar regolith.

MS 4.7 Tue 17:00 Aula Foyer

**Preparing the implantation of  $^{55}\text{Fe}$  for radioactive activity standardisation at RISIKO using RIMS** — ●DANIEL MOWITZ<sup>1</sup>, SEBASTIAN BERNDT<sup>1</sup>, HOLGER DORRER<sup>1</sup>, CHRISTOPH

E. DÜLLMANN<sup>1,2,3</sup>, RAPHAEL HASSE<sup>1</sup>, SEBASTIAN KEMPF<sup>5</sup>, TOM KIECK<sup>2,3</sup>, NINA KNEIP<sup>4</sup>, MICHAEL MÜLLER<sup>5</sup>, OLE J. NÄHLE<sup>6</sup>, THORBEN NIEMEYER<sup>1</sup>, DENNIS RENISCH<sup>1,3</sup>, and KLAUS WENDT<sup>1</sup> — <sup>1</sup>Johannes Gutenberg-Universität, Mainz — <sup>2</sup>GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — <sup>3</sup>Helmholtz-Institut, Mainz — <sup>4</sup>Leibniz Universität, Hannover — <sup>5</sup>Institut für Mikro- und Nanoelektronische Systeme, Karlsruhe — <sup>6</sup>Physikalisch-Technische Bundesanstalt, Braunschweig

In the frame of the EU PrimA-LTD project, injection of 5 Bq of the radioisotope <sup>55</sup>Fe into gold absorbers of metallic magnetic calorimeter (MMC) detectors with a size of 0.14 x 0.14 mm<sup>2</sup> is in progress at the RISIKO mass separator at JGU Mainz. Within PrimA-LTD, new activity standardisation techniques for radionuclide metrology are developed to increase the resolution of energy measurements on electron-capture decay considerably. Resonance ionisation mass spectrometry with a recently developed two-step ionisation scheme for iron is employed using the JGU Ti:Sa laser systems, to ensure outstanding element selectivity and efficiency. In order to attain maximum ion beam quality, i.e. yield and purity in respect to the ubiquitous stable iron isotopes <sup>54,56,57,58</sup>Fe, several components of the laser ion source unit were optimized. Mass spectra and further implantation tests show the feasibility of our approach and will be discussed at the conference.

MS 4.8 Tue 17:00 Aula Foyer

**Photodissociation of mono-, di-, and trianionic tin clusters** — ●MORITZ GRUNWALD-DELITZ, PAUL FISCHER, ALEXANDER JANKOWSKI, and LUTZ SCHWEIKHARD — Inst. of Physics, Univ. of Greifswald, 17487 Greifswald

(Poly-)anionic tin clusters (Sn<sub>n</sub>z<sup>-</sup> of sizes  $n < 70$  with charge states  $z = 1, 2, 3$ ) were studied at the ClusterTrap setup [F. Martinez et al., IJMS **266** (2014) 365] with regard to their fragmentation patterns upon photoexcitation. While monoanionic tin clusters have shown a shift in their fragmentation behavior from break-off of neutral Sn<sub>7</sub> and Sn<sub>10</sub> clusters (for  $n < 45$ ) to sequential monomer evaporation (for  $n > 45$ ) [M. Wolfram et al., EPJD **74** (2020) 135], the investigations have now been extended to larger clusters, also including charge state  $z = 3$ . To this end, the tin cluster ensemble, produced by laser ablation, is stored in a Penning trap. After isolation of a single mono-anionic cluster species, it is exposed to an electron bath for electron attachment, i.e. the population of higher charge states [S. König et al., EPJD **72** (2018) 153]. The separated cluster species is then irradiated with a nanosecond-laser pulse, resulting in delayed photodissociation. Break-off of neutral Sn<sub>3</sub>, Sn<sub>5</sub> and Sn<sub>9</sub> is observed for all three charge states. In addition, the trianionic cluster shows fission into Sn<sub>n-10</sub><sup>2-</sup> + Sn<sub>10</sub><sup>-</sup> in analogy to the decay of dianions, where Sn<sub>10</sub><sup>-</sup> is also identified as a fission product.

MS 4.9 Tue 17:00 Aula Foyer

**Progress Update on the ELISE Project at FSU Jena: Optimizing Negative Ion Suppression for AMS through Laser Techniques** — ●SHIVA PRASAD PULIPATI<sup>1</sup>, OLIVER FORSTNER<sup>1</sup>, KLAUS WENDT<sup>2</sup>, and THORBEN NIEMEYER<sup>2</sup> — <sup>1</sup>Friedrich-Schiller-Universität Jena — <sup>2</sup>Gutenbergs-Universität Mainz

The Extended Laser Isobar Separator (ELISE)@IBC project, is currently in the construction phase at FSU Jena. Our current work focuses on constructing a negative ion source test setup for ELISE and emphasizes the process of negative ion suppression through laser-assisted techniques. Our goal is to significantly improve the isotopic measurements concerning abundance sensitivity by highly selective AMS (accelerator mass spectrometer) techniques by further orders of magnitude without altering the state-of-the-art Cs sputter ion sources. This contribution provides a progress update on our ongoing investigations on the intricate relationship between laser radiation and negative ions at the low energy side of an AMS. Our primary objective is to leverage laser technology for the selective enhancement or suppression of specific negative ion species already during or immediately after production in the ion source, thereby enhancing the sensitivity of isotopic measurements considerably. Our efforts include the meticulous characterization of laser parameters influencing ion suppression and the testing of an ion cooler system designed to slow down negative ions to thermal energies, ensuring long-term overlap with a laser beam. Careful tuning of laser frequency and power for the photodetachment process will allow for optimum suppression of elemental and molecular contaminations.

MS 4.10 Tue 17:00 Aula Foyer

**A new ion cooler for HAMSTER** — ●ALEXANDER WIESER<sup>1,2</sup>,

JOHANNES LACHNER<sup>1</sup>, STEFAN FINDEISEN<sup>1</sup>, MARTIN MARTSCHINI<sup>2</sup>, TORALF DÖRING<sup>1</sup>, TONI WALLNER<sup>1</sup>, and ROBIN GOLSER<sup>2</sup> — <sup>1</sup>HZDR - Accelerator Mass Spectrometry and Isotope Research — <sup>2</sup>University of Vienna - Faculty of Physics, Isotope Physics

Using laser photodetachment for isobar separation in Accelerator Mass Spectrometry (AMS) was successfully established with the Ion-Laser Interaction Mass Spectrometry (ILIAMS) system at the Vienna Environmental Research Accelerator, enlarging the repertoire of long-lived radioisotopes measurable by AMS. The ion beam is overlapped with a laser beam of suitable photon energy, neutralizing interfering isobars, while leaving the isotope of interest unaffected. To maximize interaction time between laser beam and ion beam, the 30 keV ions are decelerated and cooled in a gas-filled radiofrequency quadrupole to near-thermal energies. A similar setup called ILTIS (Ion Linear Trap for Isobar Suppression) was designed at HZDR in cooperation with the University of Vienna and will be incorporated in the new 1 MV-accelerator facility HAMSTER. With a powerful 532 nm cw-laser, this ion cooler will enable HAMSTER to measure <sup>36</sup>Cl, <sup>26</sup>AlO, <sup>90</sup>Sr and <sup>135,137</sup>Cs at environmental abundances. This poster will give an overview on design and first ion beam tests of the new ion cooler.

MS 4.11 Tue 17:00 Aula Foyer

**Characterization of ion transmission in an electrospray ionization-mass spectrometry interface equipped with an S-lens** — ●YIHUI YAN, KEVIN LI, and JOZEF LENGYEL — Chair of Physical Chemistry, TUM School of Natural Sciences, Technical University of Munich, Garching, Germany

We present the design and performance of an in-house-built electrospray ionization-mass spectrometry (ESI-MS) interface equipped with an S-lens ion guide. The ion source was designed specifically for our ion beam experiments to investigate the particle nucleation and chemical reactivity of the clusters and nanoparticles. This interface consists of standard ESI-MS components, including: ion transfer capillary, the S-lens, quadrupole, and hexapole ion guides. A custom design enables systematic optimization of all relevant factors influencing transfer through the interface. Each of these ion guides was characterized over a wide range of RF frequencies and amplitudes. To track the ion transmission properties, we monitored both ion current and ion signals recorded by TOF mass spectrometer. The maximum transmission efficiency of the ESI-MS interface ranged from 10% to 30%, depending on whether the analyte was a molecular ion or a fragile cluster. Herein, we will describe the factors influencing ion transmission and analyze the observed trends.

MS 4.12 Tue 17:00 Aula Foyer

**MOCCA: a 4k-pixel molecule camera for the position and energy resolved detection of neutral molecule fragments** — ●ABDULLAH ÖZKARA<sup>1</sup>, CHRISTIAN ENSS<sup>1</sup>, ANDREAS FLEISCHMANN<sup>1</sup>, LISA GAMER<sup>2</sup>, LOREDANA GASTALDO<sup>1</sup>, DANIEL HENGSTLER<sup>1</sup>, CHRISTOPHER JAKOB<sup>2</sup>, DANIEL KREUZBERGER<sup>1</sup>, ANSGAR LOWACK<sup>1</sup>, OLDŘICH NOVOTNY<sup>2</sup>, ANDREAS REIFENBERGER<sup>1</sup>, DENNIS SCHULZ<sup>1</sup>, and ANDREAS WOLF<sup>2</sup> — <sup>1</sup>Heidelberg University — <sup>2</sup>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 the molecule fragments incident on the detector, even with multiple particles hitting the detector simultaneously. We present an improved read-out scheme which uses a logarithmic decay time spacing. This makes it possible to use only 32 SQUID channels for the read-out of 4094 pixels of the detector. In addition, we compare the simulations of this read-out scheme to previous measurements.

MS 4.13 Tue 17:00 Aula Foyer

**Optimizing AMS parameters for actinide fluoride measurements** — ●SOPHIE SCHOBBERLEITNER, KARIN HAIN, MARTIN MARTSCHINI, ANDREAS WIEDERIN, and PETER STEIER — University of Vienna, Faculty of Physics, Austria

For anions with low ionization efficiencies by caesium sputtering, isotopic abundance ratios below 10<sup>-12</sup> pose a significant challenge even

for the sensitive method of Accelerator Mass Spectrometry (AMS), suppressing the total detection efficiency. Possibilities for improving actinide fluoride measurements at the Vienna Environmental Research Accelerator (VERA) regarding detection efficiency and reproducibility have been examined, and measurement procedures for detection efficiencies of  $^{236}\text{U}$ ,  $^{237}\text{Np}$ ,  $^{242}\text{Pu}$  and  $^{243}\text{Am}$ , extracted as various (oxy-)fluoride molecules, have been developed. Moreover, an in-depth investigation of the effect of various potential alternative sample holder materials (Ni, C, Fe) on the ionization efficiency of  $^{238}\text{UF}_5^-$  has been carried out. The potential of the fluorine-rich  $\text{NdF}_3$  sample matrix optimizing the formation of  $^{237}\text{Np}/^{242}\text{Pu}$  (oxy-)fluoride molecules, as well as the influence of injection energy and the use of shorting rods on sections of the tandem accelerator on the ion beam transmission, have been explored. The comparison of hydride suppression for  $^{238}\text{UF}_5^-$  and  $^{238}\text{UO}^-$  molecular systems as a function of stripper gas pressure indicates that measurements using the fluoride system can run at lower pressure, and thus, increase the ion optical transmission.

MS 4.14 Tue 17:00 Aula Foyer

**IRPD Study of  $[\text{Cu}(\text{OAc})\text{H}_2\text{O}]^{+1}$  and  $[\text{Cu}_2(\text{OAc})_3]^{+1}$**  —  
•SHABNAM HAQUE — Universität Leipzig, Wilhelm-Ostwald-Institut

für Physikalische und Theoretische Chemie, Linnéstr. 2, 04103 Leipzig, Germany

Porous materials like MOFs and zeolites containing under-coordinated Cu centres play an important role in dihydrogen adsorption as well as the efficient isotope separation of  $\text{H}_2/\text{D}_2$ . In the present study, our focus lies on the spectroscopic characterization of Secondary Building Units (SBU) of MOFs and understand the  $\text{H}_2/\text{D}_2$  adsorption and binding behaviour. The infrared photodissociation spectra of  $[\text{Cu}(\text{OAc})(\text{H}_2\text{O})-\text{D}_2]^{+1}$  and  $[\text{Cu}_2(\text{OAc})_3-2\text{D}_2]^{+1}$  are measured at 14 K for both far-IR (1000-1900  $\text{cm}^{-1}$ ) and mid-IR regions (2400-4400  $\text{cm}^{-1}$ ). On comparison with harmonic calculations (B3LYP-TZVPP),  $[\text{Cu}(\text{OAc})(\text{H}_2\text{O})-\text{D}_2]^{+1}$  is found to have a trigonal structure whereas the cation with two  $\text{Cu}^{2+}$  centres assumes a paddle-wheel motif. The  $\nu_{DD}$  stretch vibrations, appearing at 2802  $\text{cm}^{-1}$  for  $[\text{Cu}(\text{OAc})(\text{H}_2\text{O})-\text{D}_2]^{+1}$  and at 2889  $\text{cm}^{-1}$  for  $[\text{Cu}_2(\text{OAc})_3-2\text{D}_2]^{+1}$  indicate a stronger bonding. Furthermore, temperature dependent measurements performed in cryogenically cooled ring-electrode trap give an insight into the  $\text{D}_2$  adduct yield.  $\text{D}_2$  binding is found to be more efficient for  $[\text{Cu}_2(\text{OAc})_3]^{+1}$  compared to  $[\text{Cu}(\text{OAc})(\text{H}_2\text{O})]^{+1}$ , indicating a higher stability of the paddle-wheel complex.