

Mass Spectrometry Division Fachverband Massenspektrometrie (MS)

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Overview of Invited Talks and Sessions

(Lecture room: DO24 1.205)

Invited Talks

| | | | | |
|---------|-----|-------------|------------|---|
| MS 1.1 | Mon | 10:30–11:00 | DO24 1.205 | Mass spectrometry in planetary sciences — ●INGO LEYA |
| MS 2.1 | Mon | 14:00–14:30 | DO24 1.205 | A Phase-Imaging Ion-Cyclotron-Resonance Technique for Mass Measurements of short-lived Nuclides — ●SERGEY ELISEEV |
| MS 3.1 | Mon | 16:30–17:00 | DO24 1.205 | Precision Measurements with the Multi-Reflection Time-of-Flight Mass Spectrometer of ISOLTRAP at ISOLDE/CERN — ●FRANK WIENHOLTZ |
| MS 4.1 | Tue | 14:00–14:30 | DO24 1.205 | The Cryogenic Storage Ring Project — ●ROBERT VON HAHN |
| MS 5.1 | Tue | 16:30–17:00 | DO24 1.205 | Quantitative Elemental and Molecular Mass Spectrometry for Biological Application — ●MICHAEL LINSCHIED |
| MS 7.1 | Wed | 16:30–17:00 | DO24 1.205 | Mass spectrometry of exotic nuclear species for the study of neutron stars — ●DAVID LUNNEY |
| MS 7.2 | Wed | 17:00–17:30 | DO24 1.205 | High-resolution spectroscopy of (deuterated) molecular ions — ●OSKAR ASVANY |
| MS 8.1 | Thu | 10:30–11:00 | DO24 1.205 | Komponenten-spezifische Radiokohlenstoffanalysen: Technische Aspekte und geowissenschaftliche Anwendungen — ●JANET RETHEMEYER |
| MS 9.1 | Thu | 14:00–14:30 | DO24 1.205 | Progress at DREsden AMS — ●GEORG RUGEL |
| MS 10.1 | Thu | 16:30–17:00 | DO24 1.205 | Towards a compact multi isotope AMS system - status and applications — ●MARCUS CHRISTL |
| MS 11.1 | Fri | 10:30–11:00 | DO24 1.205 | Environmental sample analysis by SIMS in the search for undeclared nuclear activities — ●MAGNUS HEDBERG |

Invited talks of the joint symposium SYAD

See SYAD for the full program of the symposium.

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|----------|-----|-------------|---------|--|
| SYAD 1.1 | Tue | 10:30–11:00 | Audimax | Rotationally resolved fluorescence spectroscopy - from neurotransmitter to conical intersection — ●CHRISTIAN BRAND |
| SYAD 1.2 | Tue | 11:00–11:30 | Audimax | Quantum simulations with ultracold atoms: Beyond standard optical lattices — ●PHILIPP HAUKE |
| SYAD 1.3 | Tue | 11:30–12:00 | Audimax | Degenerate quantum gases of alkaline-earth atoms — ●SIMON STELLMER |
| SYAD 1.4 | Tue | 12:00–12:30 | Audimax | One step beyond entanglement: general quantum correlations and their role in quantum information theory — ●ALEXANDER STRELTSOV |

Invited talks of the joint symposium SYSE

See SYSE for the full program of the symposium.

| | | | | |
|----------|-----|-------------|---------|---|
| SYSE 1.1 | Wed | 14:00–14:30 | Audimax | Addressing open questions of stellar evolution with laboratory experiments — ●ALMUDENA ARCONES |
| SYSE 1.2 | Wed | 14:30–15:00 | Audimax | Methods and problems of the modern theory of stellar evolution — ●ACHIM WEISS |
| SYSE 1.3 | Wed | 15:00–15:30 | Audimax | Photoabsorption and opacity in the X-ray region: The role of highly charged ions — ●JOSÉ R. CRESPO LÓPEZ-URRUTIA |
| SYSE 1.4 | Wed | 15:30–16:00 | Audimax | Neutron-rich matter: From cold atoms to neutron stars — ●ACHIM SCHWENK |

Invited talks of the joint symposium SYPS

See SYPS for the full program of the symposium.

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|----------|-----|-------------|---------|--|
| SYPS 1.1 | Thu | 14:10–14:40 | Audimax | Oxygen and imaging, a perfect match — ●DAVID PARKER |
| SYPS 1.2 | Thu | 14:40–15:10 | Audimax | Attosecond imaging — ●MARC VRACKING |
| SYPS 1.4 | Thu | 15:25–15:55 | Audimax | Applications of the fast imaging Pixel Imaging Mass Spectrometry camera — ●MARK BROUARD |
| SYPS 2.1 | Thu | 16:30–17:00 | Audimax | Unraveling the dynamics of state- and conformer selected molecules fixed in space with the VMI — ●JOCHEN KÜPPER |
| SYPS 2.3 | Thu | 17:15–17:45 | Audimax | Velocity map imaging: from molecules to clusters, nanoparticles and aerosols — ●MICHAL FARNIK, VIKTORIYA POTERYA, JOZEF LENGYEL, ANDRIY PYSANENKO, PAVLA SVRCKOVA, JAROSLAV KOCISEK |
| SYPS 2.5 | Thu | 18:00–18:30 | Audimax | Velocity map imaging studies of quantum state resolved scattering at gas-solid and gas-SAMs surfaces — ●DAVID J. NESBITT, MONIKA GRUETTER, J. ROBERT ROSCIOLI, CARL HOFFMAN, DANIEL J. NELSON |

Invited talks of the joint symposium SYQS

See SYQS for the full program of the symposium.

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|----------|-----|-------------|---------|--|
| SYQS 1.1 | Fri | 10:30–11:15 | Audimax | Tutorial Complex Systems: From Classical to Quantum, from Single to Many Particle Problems — ●KLAUS RICHTER |
| SYQS 1.2 | Fri | 11:30–12:00 | Audimax | Multiphoton random walks: Experimental Boson Sampling on a photonic chip — ●IAN WALMSLEY, JUSTIN SPRING, BEN METCALF, PETER HUMPHREYS, STEVE KOLTHAMMER, XIANMIN JIN, ANIMESH DATTA, JAMES GATES, PETER SMITH |
| SYQS 2.1 | Fri | 14:00–14:30 | Audimax | Charge transfer and quantum coherence in solar cells and artificial light harvesting systems — ●CHRISTOPH LIENAU |
| SYQS 2.6 | Fri | 15:30–16:00 | Audimax | Feedback control: from Maxwell's demon to quantum phase transitions — ●TOBIAS BRANDES |
| SYQS 3.4 | Fri | 17:15–17:45 | Audimax | Multi-photon dynamics in complex integrated structures — ●FABIO SCIARRINO |
| SYQS 3.5 | Fri | 17:45–18:15 | Audimax | Complexity and many-boson coherence — ●MALTE TICHY |

Sessions

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|--------------|-----|-------------|------------|--|
| MS 1.1–1.7 | Mon | 10:30–12:30 | DO24 1.205 | New Mass Spectrometric Methods and Technical Developments |
| MS 2.1–2.5 | Mon | 14:00–15:30 | DO24 1.205 | Precision Mass Spectrometry 1/ RIMS |
| MS 3.1–3.4 | Mon | 16:30–17:45 | DO24 1.205 | Precision Mass Spectrometry 2 |
| MS 4.1–4.4 | Tue | 14:00–15:15 | DO24 1.205 | Ion Storage Rings |
| MS 5.1–5.4 | Tue | 16:30–17:45 | DO24 1.205 | Molecules, Clusters, Decay and Reactions |
| MS 6.1–6.18 | Wed | 14:00–14:00 | DO24 Foyer | Poster |
| MS 7.1–7.5 | Wed | 16:30–18:15 | DO24 1.205 | Fathoming Stellar Evolution (Part 2) |
| MS 8.1–8.7 | Thu | 10:30–12:30 | DO24 1.205 | Accelerator Mass Spectrometry and Applications 1 |
| MS 9.1–9.7 | Thu | 14:00–16:00 | DO24 1.205 | Accelerator Mass Spectrometry and Applications 2 |
| MS 10.1–10.7 | Thu | 16:30–18:30 | DO24 1.205 | Accelerator Mass Spectrometry and Applications 3 |
| MS 11.1–11.7 | Fri | 10:30–12:30 | DO24 1.205 | SIMS / Accelerator Mass Spectrometry and Applications 4 |

Annual General Meeting of the Mass Spectrometry Division

Dienstag 15:30–16:00 DO24 1.205

- Begrüßung
- Bericht des MS Vorsitzenden
- Vorschläge für Symposien
- Verschiedenes

MS 1: New Mass Spectrometric Methods and Technical Developments

Time: Monday 10:30–12:30

Location: DO24 1.205

Invited Talk

MS 1.1 Mon 10:30 DO24 1.205

Mass spectrometry in planetary sciences — ●INGO LEYA — Physical Institute, University of Bern, Switzerland

Thanks to recent improvements in mass spectrometry, there is actually a significant progress in our understanding of planet formation and evolution. By way of example, studying meteorites and especially early solar system condensates found in meteorites with secondary ion mass spectrometry, thermal ionization mass spectrometry and/or inductively plasma mass spectrometry a consistent and reliable chronology of the first few million years of the solar system can be obtained. Some of the new results significantly changed our understanding of planetary accretion, differentiation, and evolution. In addition, very important results can be obtained by studying noble gases in planetary bodies and their constituents. Since noble gases are not affected by chemical reactions, their abundances directly trace back to the physical conditions at the beginning of the solar system. Noble gases are depleted in planetary bodies by up to 10 orders of magnitude, therefore small changes and small contributions are relatively easy to detect. By way of example, noble gases are a major tool to detect and study presolar grains, i.e., grains that have been formed in supernova explosions and/or red giant stars earlier and outside of the solar system. However, studying noble gases comes with a price; we need very sophisticated and efficient mass spectrometers and extraction techniques, which very often results in self-made systems and instruments dedicated for special tasks.

MS 1.2 Mon 11:00 DO24 1.205

MC-ICP-MS vs. IRMS: Advantages and Limits in Case of Isotopic Enriched Silicon — ●AXEL PRAMANN¹, JANINE NOORDMANN¹, OLAF RIENITZ¹, HELMUT BECKERS², and HELGE WILLNER² — ¹Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany — ²Bergische Universität Wuppertal, Gausstr. 20, 42097 Wuppertal, Germany

The scheduled redefinition of the Si unit kilogram is connected to the determination of the Avogadro constant with smallest associated uncertainty.[1] Mass Spectrometry on the highest metrological level is used to measure the molar mass of a silicon material enriched in ²⁸Si.[2] We report on the advantages and improvements using high resolution multicollector-ICP-MS to measure that material. A new advancement of an analytical approach of mass bias correction in isotope ratio measurement, resulted in a strong reduction of the uncertainty associated with M down to a relative uncertainty of 6.1×10^{-9} . The uncertainty budget and main features of the new theory for correction (K) factor determination are given. For calibration purposes of an isotope ratio gas mass spectrometer (IRMS) this Si material was converted into silicon tetrafluoride and further investigated with respect to the isotopic composition of silicon. The limits and improvements compared to the complementary MC-ICP-MS method are presented.

[1] B. Andreas et al., *Metrologia*, 48, S1 (2011).

[2] A. Pramann, O. Rienitz, D. Schiel, J. Schlote, B. Güttler, and S. Valkiers, *Metrologia* 48, S20 (2011).

MS 1.3 Mon 11:15 DO24 1.205

Performance Results of a Mobile High-Resolution MR-TOF Mass Spectrometer for in-situ Analytical Mass Spectrometry — ●WAYNE LIPPERT¹, JOHANNES LANG¹, SAMUEL AYET SAN ANDRÉS², TIMO DICKEL^{1,2}, HANS GEISSEL^{1,2}, WOLFGANG PLASS^{1,2}, CHRISTOPH SCHEIDENBERGER^{1,2}, and MIKHAIL YAVOR³ — ¹Justus-Liebig-Universität Gießen — ²GSI, Darmstadt — ³RAS St. Petersburg

A mobile multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS) has been developed which provides a mass resolving power exceeding 250,000 and sub-ppm mass accuracy in a transportable format. Thus it allows resolving isobars and enables accurate determination of the composition and structure of biomolecules. Furthermore the device offers high mass resolving MS/MS capability via selective ion re-trapping and collisional-induced dissociation (CID). An atmospheric pressure interface (API) provides for routine measurements with various atmospheric ion sources. All supply electronics, DAQ and control system are mounted with the spectrometer into a single frame with a total volume of only 0.8m³. With the current system many applications like waste water monitoring at hot spots, mass-based classifica-

tion of biomolecules and breath analysis are possible. In addition the mass spectrometer is readily scalable and can be adopted and simplified for even more specific use like in space science for instance. A characterization and first performance results will be shown and the implementation of MS/MS in combination with CID will be discussed.

MS 1.4 Mon 11:30 DO24 1.205

Ion Sources for systematic Gas Cell studies — ●ANN-KATHRIN RINK¹, SAMUEL AYET², TIMO DICKEL^{1,2}, JENS EBER¹, HANS GEISSEL^{1,2}, FLORIAN GREINER¹, EMMA HAETTNER², IVAN MISKUN³, WOLFGANG R. PLASS^{1,2}, SIVAJI PURUSHOTHAMAN², MORITZ PASCAL REITER¹, and CHRISTOPH SCHEIDENBERGER^{1,2} — ¹Justus-Liebig Universität Gießen — ²GSI Helmholtzzentrum für Schwerionenforschung — ³Tomsk Polytechnic University

The FRS Ion Catcher, a test facility for the low energy branch (LEB) of the Super-FRS, has been commissioned and successfully tested. The current setup consists of a gas filled cryogenic stopping cell (CSC) to thermalise exotic nuclei, a diagnostic unit to monitor and transport the stopped and extracted ion beam into the multiple-reflection time-of-flight mass-spectrometer (MR-TOF-MS), where they are identified by precision mass measurements. The MR-TOF-MS can also be used to provide isobarically clean beams for experiments further downstream.

To investigate ion transport and extraction processes of the CSC three different ion sources are in use inside the CSC. A movable radioactively ion source is mounted to test the ion transport depending on the initial ion position. A multiple target laser ablation ion source is mounted to test the mass and time dependency of the ion transport and extraction. It also provides calibration ions for the MR-TOF-MS. For investigating intensity limitations due to space charge and plasma effects and the cleanliness of the CSC an electrical discharge ion source is installed.

MS 1.5 Mon 11:45 DO24 1.205

RF-Quadrupol-Strahlweiche des MR-TOF-Isobarenseparators für das TITAN-Experiment — ●FLORIAN GREINER¹, DEVIN SHORT^{1,3}, CHRISTIAN JESCH¹, TIMO DICKEL^{1,2}, WOLFGANG PLASS^{1,2}, SAMUEL AYET SAN ANDRÉS², ALEXANDER BUERS¹, HANS GEISSEL^{1,2}, JOHANNES LANG¹, WAYNE LIPPERT¹, CHRISTOPH SCHEIDENBERGER^{1,2} and MIKHAIL YAVOR⁴ — ¹JLU Gießen — ²GSI, Darmstadt — ³TRIUMF, Vancouver, Kanada — ⁴Inst. for Analytical Instrum., Russian Academy of Sci., St. Petersburg, Russland

Eine Möglichkeit zur Erzeugung exotischer Nuklide ist die ISOL-Methode. Neben einer hohen Anzahl an gewünschten, werden aber auch viele unerwünschte Nuklide erzeugt. Daher wird eine effiziente Separationsmethode benötigt. Typischerweise wird ein magnetischer Separator verwendet, welcher jedoch keine Isobarenseparation ermöglicht. Da die TITAN-Anlage an TRIUMF (Vancouver) stark von isobarenreinen Strahlen profitieren wird, wurde ein spezieller Isobarenseparator auf Basis eines MR-TOF-MS entwickelt. Dieser weist ein wesentlich höheres Massenaufklärungsvermögen als Magnetseparatoren auf. Um den Isobarenseparator in die Strahlführung bei TITAN einzubinden, ist eine spezielle Strahlweiche nötig. Wichtige Anforderungen sind das schnelle Umschalten ($\sim 100\mu\text{s}$) zwischen verschiedenen Ein- und Ausgängen und die Möglichkeit sie direkt in ein gasgefülltes System einzubinden. Es konnte erstmals eine solche Strahlweiche erfolgreich getestet werden. Mit ihr ist es ebenfalls möglich Ionen aus mehreren Quellen zu unterschiedlichen Detektoren zu leiten. Die Strahlweiche ist an jeder Niederenergie-Strahlführung universell einsetzbar.

MS 1.6 Mon 12:00 DO24 1.205

Optimierungen und Anwendungen des kompakten Lasermassenspektrometers LAMPAS 3 zur Charakterisierung von Aerosolpartikeln — ●KLAUS-PETER HINZ, ALOIS FENDT and BERNHARD SPENGLER — Institut für Anorganische und Analytische Chemie, Universität Giessen, Schubertstrasse 60, 35392 Giessen

Die schnelle und detaillierte Analyse von Aerosolpartikeln der Umgebungsluft ist von zentraler Bedeutung bei der Beurteilung von Umwelt- und Gesundheitsrisiken. Mit dem kompakten, on-line Lasermassenspektrometer LAMPAS 3 [1] steht ein Messsystem zur Verfügung, das eine schnelle und aussagekräftige vor-Ort-Analyse einzelner Partikel ermöglicht. Die Partikel werden dazu ohne störende Beeinflussung direkt in die Ionenquelle eines Flugzeitmassenspektrometers eingelassen.

Nach der Partikeldetektion und der Bestimmung der Partikelgröße erfolgt die zeitlich abgestimmte Laserdesorption/Ionisation (LDI) der Partikel mittels eines UV-Laserpulses. Die simultane Detektion der erzeugten positiv und negativ geladenen Ionen ermöglicht die umfassende chemische Charakterisierung der Einzelpartikel. Die Ergebnisse der instrumentellen Optimierung des LAMPAS 3-Systems und seine Leistungsfähigkeit werden anhand verschiedener Labor- und Feldmessungen vorgestellt. [1] K.-P. Hinz, E. Gelhausen, K.-C. Schäfer, Z. Takats, B. Spengler. *Anal. Bioanal. Chem.* (2011) 401:3165-3172.

MS 1.7 Mon 12:15 DO24 1.205

Unexpected Ions in the ICPMS: Abundance and Impact of Doubly Charged Molecular Argide (MAr^{2+}) Ions — ●BODO HATTENDORF, BIANCA GUSMINI, LADINA DORTA, MARKUS REIHER, and DETLEF GÜNTHER — ETH Zurich, Laboratory of Inorganic Chemistry, Wolfgang Pauli Str. 10, 8093 Zurich, Switzerland

Doubly charged molecular ions containing argon in mass spectra from an inductively coupled plasma mass spectrometer were recently detected using a highly sensitive sector field instrument (NU Plasma

HR). Their presence was previously unexpected as only molecular ions with high binding energies were suspected to survive the high temperature, high density atmospheric ICP ion source. Quantum mechanical calculations indicate that such species can be formed via association of a doubly charged elemental ion to a neutral argon atom and their bond energy can reach values of up to 0.3 eV. Doubly charged atomic ions are present in the ICP at varying degree for elements with low 2nd ionization energy as alkaline earth or rare earth elements amongst others. Due to the fact that formation rates are in the 10^{-5} range, relative to the corresponding elemental ions, their influence on quantification should remain small. Significant impact can, however, occur in isotope ratio analyses, when aiming at accuracy in the 10 ppm range. Critical contributions may be observed for Sr isotope ratios, where $^{86}\text{Sr}^+$, $^{87}\text{Sr}^+$ and $^{88}\text{Sr}^+$ cannot be resolved from $^{132}\text{Ba}^{40}\text{Ar}^{2+}$, $^{134}\text{Ba}^{40}\text{Ar}^{2+}$ and $^{136}\text{Ba}^{40}\text{Ar}^{2+}$ respectively or S isotopes where $^{32}\text{S}^+$ and $^{33}\text{S}^+$ cannot be distinguished from $^{24}\text{Mg}^{40}\text{Ar}^{2+}$ and $^{26}\text{Mg}^{40}\text{Ar}^{2+}$. Additionally interesting was the fact that the corresponding singly charged molecular ions are by about 10 times less abundant, despite the more than 10 times higher concentration of the atomic ions within the ICP source.

MS 2: Precision Mass Spectrometry 1/ RIMS

Time: Monday 14:00–15:30

Location: DO24 1.205

Invited Talk

MS 2.1 Mon 14:00 DO24 1.205

A Phase-Imaging Ion-Cyclotron-Resonance Technique for Mass Measurements of short-lived Nuclides — ●SERGEY ELISEEV¹, KLAUS BLAUM¹, MICHAEL BLOCK², STANISLAV CHENMAREV³, ANDREAS DOERR¹, CHRISTIAN DROESE⁴, TOMMI ERONEN¹, PAVEL FILJANIN³, MIKHAIL GONCHAROV¹, MARTIN HOECKER¹, JOCHEN KETTER¹, ENRIQUE MINAYA RAMIREZ¹, DMITRIY NESTERENKO³, YURI NOVIKOV³, LUTZ SCHWEIKHARD⁴, and VANESSA SIMON¹ — ¹Max-Planck Institute for Nuclear Physics, Germany — ²GSi Helmholtzzentrum fuer Schwerionenforschung GmbH, Germany — ³Petersburg Nuclear Physics Institute, Russia — ⁴Institute for Physics, Ernst-Moritz-Arndt-University, Germany

A novel approach to mass measurements on the sub-ppb level even for short-lived nuclides with half-lives well below one second is presented. It is based on the projection of the radial ion motion in a Penning trap onto a position sensitive detector. Compared to the presently employed time-of-flight ion-cyclotron-resonance technique, the novel approach is 25-times faster and provides a 40-fold gain in resolving power. With the new technique low-lying isomeric states with excitation energy on the 10-keV level can be separated from the ground state. Moreover, the new technique possesses a substantially higher sensitivity since just two ions are sufficient to determine the ion cyclotron frequency. A measurement of the mass difference of singly charged ions of ^{132}Xe and ^{131}Xe with an uncertainty of 25 eV has demonstrated the great potential of the new approach.

MS 2.2 Mon 14:30 DO24 1.205

Progress with the PENTATRAP mass spectrometer — HENDRIK BEKKER¹, ●CHRISTINE BÖHM^{1,2}, JOSÉ CRESPO LÓPEZ-URRUTIA¹, ANDREAS DÖRR¹, SERGEY ELISEEV¹, MIKHAIL GONCHAROV¹, YURI NOVIKOV³, JULIA REPP¹, ALEXANDER RISCHKA¹, CHRISTIAN ROUX¹, SVEN STURM¹, and KLAUS BLAUM¹ — ¹Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — ²Extreme Matter Institute EMMI, Helmholtz Gemeinschaft, 64291 Darmstadt, Germany — ³PNPI, Gatchina, 188300 St. Petersburg, Russia

The five-trap mass spectrometer PENTATRAP has been constructed and is currently being characterized at the Max-Planck-Institut für Kernphysik, Heidelberg. It aims for high-precision mass ratio measurements with a relative mass uncertainty of a few 10^{-12} . Long-lived and stable, highly charged nuclides with masses up to uranium will be addressed to perform e.g. stringent tests of quantum electrodynamics and neutrino oriented mass measurements. The main part of the experiment is a stack of five cylindrical cryogenic Penning traps. An ultra-stable voltage source is required to supply the Penning trap electrodes with appropriate and stable potentials. Therefore, an elaborated source was developed and built at MPIK. Recently, first ions have been successfully trapped. Details about the progress of the installation, especially the status of the voltage source and first ion signals will be presented in the talk.

MS 2.3 Mon 14:45 DO24 1.205

High-precision mass measurements of transuranium nuclides at TRIGA-TRAP — ●M. EIBACH^{1,2,3}, T. BEYER^{2,3}, K. BLAUM³, M. BLOCK⁴, CH. E. DÜLLMANN^{1,4,5}, K. EBERHARDT^{1,5}, J. GRUND¹, SZ. NAGY^{3,4}, W. NÖRTERSCHÄUSER^{1,4,6}, D. RENISCH^{1,5}, F. SCHNEIDER¹, and C. SMORRA^{3,7} — ¹Johannes Gutenberg-Universität, Mainz — ²Ruprecht-Karls-Universität, Heidelberg — ³Max-Planck-Institut für Kernphysik, Heidelberg — ⁴GSi Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — ⁵Helmholtz-Institut Mainz, Mainz — ⁶Technische Universität Darmstadt, Darmstadt — ⁷RIKEN Advanced Science Institute, Wako, Japan

Reflecting the sum of all interactions inside a nucleus, its mass is an important characterizing property. Precisely known nuclear masses are used to benchmark and improve nuclear mass models and to probe the nuclear structure. Penning-trap mass spectrometers such as TRIGA-TRAP are well-suited to provide such data with highest precision. At TRIGA-TRAP, the nuclides of interest are either produced by thermal neutron-induced fission of, e.g., ^{235}U at the research reactor TRIGA Mainz or ionized off-line by a non-resonant laser ablation ion source. The latter was recently upgraded with a miniature radio-frequency quadrupole device resulting in an efficiency gain of more than an order of magnitude enabling for the first time direct mass measurements of long-lived transuranium nuclides. In this contribution the mass measurement results on $^{241,243}\text{Am}$, ^{244}Pu , and ^{249}Cf will be presented. Their impact on nuclear structure studies as well as their implementation into the Atomic-Mass Evaluation will be discussed.

MS 2.4 Mon 15:00 DO24 1.205

Die hochselektive Ionenquelle LIST und darüber hinaus — ●SVEN RICHTER¹, KLAUS BLAUM², DANIEL FINK³, SEBASTIAN ROTHE³, BRUCE MARSH³, VALENTIN FEDOSSEEV³ und KLAUS WENDT¹ — ¹Institut für Physik, Universität Mainz — ²MPI für Kernphysik, Heidelberg — ³CERN, Genève

Für Grundlagenforschung und wichtige Präzisionsmessungen an exotischen Nukliden, wie sie nur an modernen On-line Isotopengeneratoren wie ISOLDE am CERN durchgeführt werden können, sind hochselektive Ionenquellen eine der entscheidenden Voraussetzungen. Da ein Isotopenseparator prinzipiell keine isobaren Kontaminationen eliminieren kann, wurde als Verfeinerung der nur weitgehend elementselektiven Laserresonanzionisation die Laserionenquelle Ion Source & Trap (LIST) entwickelt und erfolgreich in den on-line Betrieb aufgenommen. Sie gewährleistet vollständige Isobarenunterdrückung, wodurch Messungen an Poloniumisotopen möglich wurden, die bisher durch isobares Francium verhindert wurden.

Spezielle Effekte, die während des on-line Betriebs aufgetreten sind, wie eine eingeschränkte Isobarenunterdrückung für einige wenige Isotope, sowie andererseits der unerwartete Nachweis von extrem kurzlebigen Nukliden, wurden beobachtet. Der Vortrag schildert hier die Ursachenforschung und macht Ansätze das System besser kontrollierbar zu machen. Der aktuelle Stand daraus abgeleiteter weiterer Entwick-

lungen zur Selektivitäts- und Effizienzsteigerung der Laserionisation wird vorgestellt.

MS 2.5 Mon 15:15 DO24 1.205

Difference-frequency generation with pulsed Titanium:sapphire lasers and sodium spectroscopy — ●JULIA MARÍN SÁEZ, PASCAL NAUBEREIT, AMIN HAKIMI, TOBIAS KRON, FABIAN SCHNEIDER, and KLAUS WENDT — Institut für Physik, Universität Mainz

Tunable laser emission with wavelengths in the green to yellow spectral range of 550 to 600 nm is easily achieved with conventional dye lasers, while it is a challenge for state-of-the-art solid-state Titanium:sapphire lasers emitting in the range of 680 to 1000 nm. In the workgroup Larissa at Mainz University narrow bandwidth, high-repetition rate

pulsed Ti:sapphire lasers are developed and used for atomic spectroscopy, ultra trace analysis and application at on-line radioisotope production plants like ISOLDE/CERN. For enhancing the universality of these laser systems the expansion to this wavelength range is aimed for. Therefor frequency mixing of the radiation from a Ti:sapphire laser, operating in the fundamental infrared range, and from a frequency doubled Ti:sapphire in the blue range was carried out by means of difference-frequency generation in a non-linear crystal, obtaining the green-yellow-orange visible spectral range. To demonstrate its performance two- and three-step resonant ionization was tested on atomic sodium. The excitation schemes have the well-known 589 nm sodium doublet as first transition. Step-wise resonance ionization up to excitation of Rydberg states with even and/or odd parity are studied and presented.

MS 3: Precision Mass Spectrometry 2

Time: Monday 16:30–17:45

Location: DO24 1.205

Invited Talk MS 3.1 Mon 16:30 DO24 1.205

Precision Measurements with the Multi-Reflection Time-of-Flight Mass Spectrometer of ISOLTRAP at ISOLDE/CERN

— DINKO ATANASOV¹, PAULINE ASCHER¹, DIETRICH BECK², CHRISTOPHER BORGMANN¹, MARTIN BREITENFELDT³, CHRISTINE BÖHM¹, BURCU CAKIRLI⁴, THOMAS ELIAS COCOLIOS⁵, SERGEY ELISEEV¹, TOMMI ERONEN¹, SEBASTIAN GEORGE¹, FRANK HERFURTH², ALEXANDER JOSEF HERLERT⁶, DMITRY KISLER¹, MAGDALENA KOWALSKA⁷, SUSANNE KREIM^{1,7}, YURI LITVINOV², DAVID LUNNEY⁸, VLADIMIR MANEA⁸, ENRIQUE MINAYA RAMIREZ², SARAH NAIMI¹, DENNIS NEIDHERR², MARCO ROSENBUSCH⁹, LUTZ SCHWEIKHARD⁹, JULIANE STANJA¹⁰, ●FRANK WIENHOLTZ⁹, ROBERT WOLF⁹, and KAI ZUBER¹⁰ — ¹Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — ²GSi Helmholtzzentrum für Schwerionenforschung GmbH, Planckstr. 1, 64291 Darmstadt, Germany — ³Instituut voor Kern- en Stralingsfysica, Celestijnenlaan 200d - bus 2418, 3001 Heverlee, Belgium — ⁴University of Istanbul, Department of Physics, 34134 Istanbul, Turkey — ⁵University of Manchester, Manchester, United Kingdom — ⁶FAIR GmbH, Planckstr. 1, D-64291 Darmstadt, Germany — ⁷CERN, Geneva 23, 1211 Geneva Switzerland; — ⁸CSNSM-IN2P3-CNRS, 91405 Orsay Campus, bât. 104, 108, France — ⁹Ernst-Moritz-Arndt-Universität, Institut für Physik, Felix-Hausdorff-Str. 6, 17487 Greifswald, Germany — ¹⁰Institut für Kern- und Teilchenphysik, Technische Universität Dresden, Zellescher Weg 19, 01069 Dresden, Germany

The masses of exotic nuclides are among the most important input parameters for modern nuclear theory and astrophysical models. At the high-precision Penning-trap mass spectrometer ISOLTRAP at ISOLDE/CERN, a multi-reflection time-of-flight mass spectrometer (MR-ToF-MS) in combination with a Bradbury-Nielsen gate (BNG) can be used to achieve high-resolution isobar purification with mass-resolving powers of 105 in a few tens of milliseconds [1, 2]. Furthermore, the MR-ToF device can be used as a spectrometer to determine the masses of nuclides with very low yields and short half-lives, where a Penning-trap mass measurement becomes impractical due to the lower transport efficiency and decay losses during the purification and measurement cycles. Recent cross-check experiments show that the MR-ToF MS allows mass measurements with uncertainties in the sub-ppm range. In a first application the mass measurements of the nuclides ^{53,54}Ca was performed [3], delivered with production rates as low as 10/s and half-lives of only 90(6) ms [4]. The nuclides serve as important benchmarks for testing modern chiral effective theory with realistic 3-body forces.

The contribution will present the on-line mass spectrometer ISOLTRAP focusing on the new applications, which became possible after the implementation of the MR-ToF MS into the current setup. In particular, the mass measurements of the neutron-rich calcium isotopes up to A=54 will be discussed. In addition, measurements of the isotonic potassium isotopes will be reported.

MS 3.2 Mon 17:00 DO24 1.205

Recent Developments of the MR-TOF-MS for the LEB of the Super-FRS — ●SAMUEL AYET SAN ANDRES¹, JULIAN BERGMANN², TIMO DICKEL^{1,2}, JENS EBERT², HANS GEISSEL^{1,2}, CHRISTINE HORNUNG², CHRISTIAN JESCH², JOHANNES LANG², CHRISTIAN LOTZE², WOLFGANG PLASS^{1,2}, PASCAL REITER², ANN-KATRIN

RINK², CHRISTOPH SCHEIDENBERGER^{1,2}, JOHAN SIEBRING³, ALEXANDER PIKHTOLEV⁴, MATTI WERNER¹, and MIKHAIL YAVOR⁵ — ¹GSi Darmstadt — ²JLU Gießen — ³KVI - University of Groningen — ⁴IPCP RAS Chernogolovka — ⁵IAI RAS St. Petersburg

A multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS) is being currently tested and improved at the FRS Ion Catcher facility. This MR-TOF-MS will be used at the LEB of the Super-FRS facility to provide a low energy isobarically clean beam to other experiments, as a diagnostic tool for the cryogenic stopping cell of the Low-Energy Branch (LEB) and as a mass spectrometer for the most short-lived nuclides. Understanding the influence of many parameters in such a complex system, as well as getting new instrumental developments in order to maximize the performance of the system is an important and continuous task. Most recent improvements of the system are: increase of the kinetic energy of the ions in the analysis path, optimization of ion optics and an upgrade in the electronics. Also, a dedicated data acquisition software for high quality online analysis and a full remote control software of the system were developed. The current status of the system, the latest developments of the system and a systematic characterization of the device will be presented.

MS 3.3 Mon 17:15 DO24 1.205

Status Report of the FRS Ion Catcher — ●TIMO DICKEL^{1,2} and THE FRS ION CATCHER COLLABORATION¹ — ¹GSi Darmstadt — ²Justus-Liebig-Universität

The FRS Ion Catcher facility is a prototype for the LEB of the Super-FRS. It is used to thermalize relativistic exotic nuclides in a cryogenic helium-filled stopping cell (CSC) and provides, with the help of a multi-reflection time-of-flight mass spectrometer (MR-TOF-MS), an isobarically clean beam to experiments further downstream. The MR-TOF-MS can also be used for mass measurements of short-lived nuclei with half-lives down to 10ms. The MR-TOF-MS is also an indispensable diagnostic device for operation of the stopping cell.

The CSC and MR-TOF-MS are central elements of the LEB and were successfully commissioned on-line in recent beamtimes at the FRS Ion Catcher at GSI. For the first time, a stopping cell for exotic nuclei was operated on-line at cryogenic temperatures. Various projectile fragments were thermalized and extracted with high efficiencies and short extraction times. Moreover, direct mass measurements of short-lived nuclei were performed with an MR-TOF-MS, among them the nuclide ²¹³Rn with a half-life of only 19.5 ms. Current status and upgrades of the facility will be presented.

MS 3.4 Mon 17:30 DO24 1.205

Progress at The-Trap — ●MARTIN HÖCKER¹, TOMMI ERONEN¹, JOCHEN KETTER¹, MARC SCHUH¹, SEBASTIAN STREUBEL¹, ROBERT S. VAN DYCK JR.², and KLAUS BLAUM¹ — ¹Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — ²Department of Physics, University of Washington, Seattle, WA 98195-1560

The-Trap is a Penning-trap mass spectrometry experiment that is currently being set up to measure the atomic mass ratio of tritium and helium-3 with a relative uncertainty of 10⁻¹¹. In 2013, the experiment's first high-precision mass ratio measurement was performed on the ions ¹²C⁴⁺ and ¹⁶O⁵⁺. The carbon-12/oxygen-16 mass ratio is one of the most precisely determined mass ratios [1] and serves as a

benchmark for the experiment. This measurement reached a statistical uncertainty of $6.3 \cdot 10^{-11}$ [2] and was limited by systematic frequency shifts [3] due to too high motional amplitudes.

In the following service cycle, the experiment was modified to address the shortcomings that were discovered in the 2013 ratio measurements. This talk summarizes the results of the 2013 measurements and

introduces the upgrades to the experiment, including a new amplifier, a modified ion source, and an improved vacuum system.

[1] R. S. Van Dyck Jr. *et al.*, *Int. J. Mass Spectrom.* (2006) 251:231–242

[2] S. Streubel *et al.*, *Appl. Phys. B*, DOI:10.1007/s00340-013-5669-x

[3] J. Ketter *et al.*, *Int. J. Mass Spectrom.*, DOI:10.1016/j.ijms.2013.10.005

MS 4: Ion Storage Rings

Time: Tuesday 14:00–15:15

Location: DO24 1.205

Invited Talk

MS 4.1 Tue 14:00 DO24 1.205

The Cryogenic Storage Ring Project — ●ROBERT VON HAHN¹, KLAUS BLAUM¹, ARNO BECKER¹, FLORIAN FELLENERGER¹, SEBASTIAN GEORGE¹, MANFRED GRIESER¹, FLORIAN GRUSSI¹, PHILIPP HERWIG¹, CLAUDE KRANTZ¹, HOLGER KRECKEL¹, MICHAEL LANGE¹, SEBASTIAN MENK¹, ROLAND REPNOW¹, KAIJA SPRUCK², STEPHEN VOGEL¹, and ANDREAS WOLF¹ — ¹Max-Planck-Institut für Kernphysik, Heidelberg, Germany — ²Justus-Liebig-Universität, Giessen, Germany

At MPIK the electrostatic cryogenic storage ring CSR is nearing completion. At beam energies of 20 to 300 keV per charge unit and 35 m circumference the CSR will allow experiments in a cryogenic environment providing conditions of extremely low vacuum and heat radiation. By using liquid helium at 2 K for cryopumping, the projected vacuum (confirmed at a prototype) lies at $1E-13$ mbar or below, ensuring long storage times for slow singly charged and highly charged ions, molecules and clusters. Moreover, phase space cooling by electrons will be implemented. The internal quantum states of molecular and cluster ions can be cooled to low temperature, yielding well defined vibrational and for smaller systems also rotational structures. In the CSR construction, the cryogenic ion beam vacuum system has been set up. Extensive tests confirming the criteria on heat flow, alignment and high-voltage stability were successfully completed on the first quadrant. In addition beam diagnostic units for electric pickup signals and spatial profiles, detectors for neutral and charged fragments, the injection beam line, and an electron cooling device are under construction.

MS 4.2 Tue 14:30 DO24 1.205

A New Data Evaluation Approach for Mass Measurements of Exotic Nuclei performed with Isochronous Mass Spectrometry — ●M. DIWISCH¹, R. KNÖBEL^{1,2}, H. GEISSEL^{1,2}, Z. PATYK³, W.R. PLASS^{1,2}, C. SCHEIDENBERGER^{1,2}, H. WEICK², K. BECKERT², F. BOSCH², D. BOUTIN^{1,2}, C. BRANDAU^{1,2}, L. CHEN^{1,2}, I.J. CULLEN⁴, C. DIMOPOULOU², A. DOLINSKI², B. FABIAN¹, M. HAUSMANN⁵, O. KLEPPER², C. KOZHUHAROV², J. KURCEWICZ², N. KUZMINCHUK¹, S.A. LITVINOV², YU.A. LITVINOV², Z. LIU⁴, M. MAZZOCCO², F. MONTES⁵, G. MÜNZENBERG², A. MUSUMARRA⁷, S. NAKAJIMA⁸, C. NOCIFORO², F. NOLDEN², T. OHTSUBO⁹, A. OZAWA¹⁰, M. STECK², B. SUN^{2,11}, T. SUZUKI⁸, P.M. WALKER⁴, N. WINCKLER⁶, M. WINKLER², and T. YAMAGUCHI⁸ — ¹Justus Liebig University Gießen — ²GSI, Darmstadt — ³Soltan Institute for Nuclear Studies, Warszawa, Poland — ⁴University of Surrey, Guildford, United Kingdom — ⁵Michigan State University, East Lansing, U.S.A. — ⁶Max Planck Institut für Kernphysik, Heidelberg — ⁷Laboratori Nazionali del Sud, INFN Catania, Italy — ⁸Saitama University, Saitama, Japan — ⁹Niigata University, Niigata, Japan — ¹⁰University of Tsukuba, Tsukuba, Japan — ¹¹School of Physics, Peking University, Beijing, China

The Isochronous Mass Spectrometry (IMS) and Schottky Mass Spectrometry (SMS) are powerful tools to measure masses of rare exotic nuclei in a storage ring. While the SMS method provides very high accuracies it does not give access to rare isotopes with lifetimes in the sub second range because beam cooling has to be performed for a few seconds before the measurements start. As a complementary method IMS can be used without beam cooling to reach isotopes with lifetimes of only a few $10\mu s$. As a drawback of the IMS method one cannot achieve the high mass accuracy of the SMS method until now.

For the data evaluation of the SMS data a correlation matrix method has been successfully applied in the past. In order to improve the accuracy of the IMS measurements the same method will now be used, which will allow to combine and to correlate data from different IMS measurements with each other. Applying this method to the analysis of previous experiments with uranium fission fragments at the FRS-ESR facility at GSI and to future experiments, will increase the accuracy of the IMS method and may lead to new mass values with reasonable accuracies for very rare and important nuclei for nuclear astrophysics such as ^{130}Cd , which were not accessible before.

MS 4.3 Tue 14:45 DO24 1.205

The low-energy electron cooler for the Cryogenic Storage Ring — ●STEPHEN VOGEL, KLAUS BLAUM, CLAUDE KRANTZ, and ANDREAS WOLF — Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany

The Cryogenic Storage Ring (CSR) at the Max Planck Institute for Nuclear Physics in Heidelberg, Germany, is being commissioned. CSR will be an ideal tool for preparing and studying cold atomic and molecular ions using ion beams of 20–300 keV kinetic energy (per ion charge unit). As a first important upgrade CSR will be equipped with an electron cooler. Latter is designed for cooling beams with a charge-to-mass ratio q/m of 1 to $1/160$ e/amu. This corresponds to an electron beam energy range of 1 to 163 eV. The beam will be produced by a cryogenic photocathode and electron temperatures in the co-moving frame reach down to 10 K. The cooler can also be used as an electron target by detuning the electrons' kinetic energy. This allows precision experiments on low-energy collisions between cold electrons and stored atomic and molecular ions using counting and imaging detectors. The design and the status of the setup will be presented.

MS 4.4 Tue 15:00 DO24 1.205

Cryogenic microcalorimeter energy resolution measurements for multi-keV atoms and molecules. — ●OLDŘICH NOVOTNÝ¹, STEFFEN ALLGEIER³, LISA GAMER³, DANIEL HENGSTLER³, SEBASTIAN KEMPF³, CLAUDE KRANTZ², ANDREAS PABINGER³, CHRISTIAN PIES³, DANIEL W. SAVIN¹, DIRK SCHWALM^{2,4}, CHRISTIAN ENSS³, ANDREAS FLEISCHMANN³, and ANDREAS WOLF² — ¹Columbia Astrophysics Laboratory, New York, USA — ²Max Planck Institute for Nuclear Physics, Heidelberg, Germany — ³Kirchhoff Institute for Physics, Heidelberg, Germany — ⁴Weizmann Institute of Science, Rehovot, Israel

We have experimentally investigated the kinetic energy resolution of an ~ 10 mK magnetic microcalorimeter (MMC) detector for 12-150 keV atomic and molecular ion beams. The ion masses were varied from 1 amu (H^+) to 58 amu ($\text{C}_3\text{H}_6\text{O}^+$). The resulting FWHM energy resolutions were $\lesssim 0.5$ keV for atomic ions and $\lesssim 1$ keV for molecular ions. The measured energy resolutions were similar for the neutral particles of the corresponding ions. The high resolving power in energy, the charge independence, and the optional position sensitivity all demonstrate the expected versatility of the MMC detectors for use in various mass spectrometry techniques. As a next step we will implement the MMC detector for mass and position resolved fragment counting in the Cryogenic Storage Ring (CSR) at the Max Planck Institute for Nuclear Physics in Heidelberg. The storage energies of ~ 300 keV will allow 1 amu mass resolution for stored ions of up to ~ 150 amu (assuming a separation of 2 FWHMs between peaks).

MS 5: Molecules, Clusters, Decay and Reactions

Time: Tuesday 16:30–17:45

Location: DO24 1.205

Invited Talk

MS 5.1 Tue 16:30 DO24 1.205

Quantitative Elemental and Molecular Mass Spectrometry for Biological Application — SEBASTIAN BECK, GUNNAR SCHWARZ, RENEE BECKER, DAVID BENDA, VIOLETTE FROCHAUX, KATHLEEN SCHWARZ, KATRIN BRÜCKNER, and MICHAEL LINSCHIED — Humboldt-Universität zu Berlin, Dept. of Chemistry

When chromatographic techniques such as high pressure chromatography (HPLC) and electrophoresis were coupled directly to ICP-MS, elemental MS began to attract attention in biological research, since particularly heavy metals play an important role in biology and ICPS MS is one of the most precise methods in quantitative mass spectrometry. Thus, the analysis of metals and synthetic metal tags came into focus. Recently, we introduced metal tags carrying lanthanoids ("MeCAT") to quantify biopolymers using ICP-MS. Then, we investigated the fragmentation of MeCAT labeled peptide molecular ions and found characteristic fragments, which are formed upon infrared multiphoton dissociation. Hence, it should be possible to screen for MeCAT peptides in mixtures and distinguish between the different metals without the need for an element specific mass spectrometer. Most recently we extended the application range of the tagging technique to DNA oligomers allowing the detection and quantification of specific DNA sequences at very low levels. In this presentation the design of the techniques and the required instrumentation will be discussed. Then, strategies for application in biological mass spectrometry will be presented. Finally, the scope and limitations of this approach will be discussed in the light of most recent developments.

MS 5.2 Tue 17:00 DO24 1.205

Desorption and evaporation sources with photoionizable organic molecules beyond 24 kDa for their suitability for matter wave interferometers — UGUR SEZER¹, LUKAS FELIX², PHILIPP SCHMID¹, MARCEL MAYOR^{2,3}, and MARKUS ARNDT¹ — ¹University of Vienna, Faculty of Physics, QuNaBioS, VCQ Vienna, Austria — ²Department of Chemistry, University of Basel, Basel, Switzerland — ³Karlsruhe Institute of Technology (KIT), Institute of Nanotechnology, Karlsruhe, Germany

With new matter-wave interferometers substantial progress has been made in testing the quantum superposition in a domain of higher complexity. In order to push the limits of matter wave interferometry towards even higher masses, the production of a neutral and slow molecular beam of complex and massive molecules is essential. In this work we present a series of experiments characterizing different laser desorption sources in combination with photoionization (157 and 266 nm). A major result of these studies is the intact volatilization and successful single-photon ionization of organic molecules beyond 24 kDa. Using organic molecules between 7 and 13 kDa we investigate the mass dependence of the photoionization efficiency and of the desorption process. We present mass spectra, velocity distributions, photoionization efficiencies and fragmentation rates of large tailor-made perfluoroalkyl-functionalized molecules as well as more thermolabile biomolecules and

we discuss the suitability of each of the desorption/evaporation sources for matter wave interferometry.

MS 5.3 Tue 17:15 DO24 1.205

Wie invasiv ist der Electro Spray-Ionisationsprozess? — ANDREAS HARTMANN¹, MELJIE CHENG^{1,2}, MICHAEL STEPPERT¹ und CLEMENS WALTHER¹ — ¹Leibniz Universität Hannover, Institut für Radioökologie und Strahlenschutz, Herrenhäuser Str. 2, 30419 Hannover — ²Karlsruher Institut für Technologie, Institut für Nukleare Entsorgung, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen

Die nano-Electrospray-Ionisations Flugzeit Massenspektrometrie kann zum direkten Nachweis in Lösung vorkommender Spezies eingesetzt werden. Mit dieser sanften Ionisationsmethode lassen sich dabei die relativen Anteile geladener Spezies in Lösung abbilden. Dazu wird mit Hilfe einer Spraykapillare, welche sich auf einem hohen positiven Potential befindet, aus einer Lösung ein so genanntes Electro Spray erzeugt, in dessen Tröpfchen sich positiv geladene Ionen befinden. Diese werden ins Vakuum überführt und massenspektrometrisch untersucht. Aufgrund der großen positiven Spannung, herrschen in der Kapillare oxidierende Bedingungen. In kürzlich erfolgten Messungen an Mischungen aus Molybdän und Eisen, wurden beide Metalle trotz der oxidierenden Bedingungen zum Teil in ihren reduzierten Formen detektiert (Mo(V) bzw. Fe(II)). Um einen Einfluss der Methode auf den Oxidationszustand der in Lösung vorkommenden Ionen auszuschließen, werden Eisenlösungen mit definierten Fe(II)/Fe(III)-Verhältnissen im stark sauren Bereich bei verschiedenen Säurestärken untersucht.

MS 5.4 Tue 17:30 DO24 1.205

Novel setup for the investigation of metal-cluster-ligand complexes in the gas phase — DANIEL NEUWIRTH, KATHRIN LANGE, JAN ECKHARD, BRADLEY VISSER, MARTIN TSCHURL, ULRICH BOESL, and UELI HEIZ — Lehrstuhl für Physikalische Chemie & Catalysis Research Center, Chemistry Department, Technische Universität München, Lichtenbergstraße 4, 85748 Garching bei München, Germany

Many properties, like reactivity, of metal clusters are different from those of the bulk material. While gold is noble under most circumstances the reactivity of gold clusters depends highly upon charge and size. Furthermore noble metal clusters can catalyze various reactions. Our goal is to study metal clusters with organic ligands acting as tracer molecules in the gas phase.

Therefore, a state of the art cluster source was combined with a pulsed gas inlet. The formed cluster-ligand complexes can then be characterized by time-of-flight mass spectrometry or further investigated by different spectroscopic methods.

In a second part of the experiment it is planned to store cluster-ligand complexes within an ion trap. The trapped complexes can then interact with reactant gases present in the trap. Therefore a ring electrode trap is currently added to the experiment.

MS 6: Poster

Time: Wednesday 14:00–14:00

Location: DO24 Foyer

MS 6.1 Wed 14:00 DO24 Foyer

Search for Supernova debris on the Moon — LETICIA FIMIANI¹, THOMAS FAESTERMANN¹, JOSE MANUEL GOMEZ GUZMAN¹, KARIN HAIN¹, GREGORY HERZOG², GUNTHER KORSCHINEK¹, BRET LIGON², PETER LUDWIG¹, JISUN PARK², and GEORG RUGEL³ — ¹Physics Department, Technische Universität München, Garching, Germany — ²Department of Chemistry and Chemical Biology, Rutgers University, Piscataway, NJ, United States — ³Forschungszentrum Dresden Rossendorf, Dresden, Germany

The enhanced deposition of ⁶⁰Fe in a deep ocean ferro-manganese crust about (2.1±0.4) Myr ago (Knie *et al.*, PRL 93, 171103 (2004), Fitoussi *et al.*, PRL 101, 121101 (2008)) indicate that one or more supernova (SN) explosions occurred in the vicinity of the Solar System. That observation was only possible with the ultrasensitive Accelerator Mass Spectrometry (AMS) technique at the Maier-Leibnitz-

Laboratory, which is able to measure concentrations of ⁶⁰Fe/Fe down to a level of 10⁻¹⁶ and even below. Due to its lack of atmosphere and its negligible sedimentation rate, the Lunar surface is an excellent quantitative reservoir for SN debris. We searched for live ⁶⁰Fe (T_{1/2} = 2.62 × 10⁶ yr) and ⁵³Mn (T_{1/2} = 3.7 × 10⁶ yr) in different samples from 3 Apollo missions. ⁵³Mn is, similar as ²⁶Al and ⁶⁰Fe, a tool to trace nucleosynthesis activities. It is formed primarily during the explosive silicon-burning of the inner shells of SNe via ⁵³Fe which β-decays to ⁵³Mn. Samples where we found an enhanced ⁶⁰Fe concentration showed also an enhancement of ⁵³Mn. This could be the first detection of live ⁵³Mn originating from recent nucleosynthesis.

MS 6.2 Wed 14:00 DO24 Foyer

AMS of actinides in groundwater: development of a new procedure for trace analysis of Np, Pu, Am and Cm

isotopes — ●FRANCESCA QUINTO¹, MARKUS LAGOS¹, MARKUS PLASCHKE¹, THORSTEN SCHÄFER¹, PETER STEIER², and HORST GECKEIS¹ — ¹Karlsruhe Institute of Technology, Institute for Nuclear Waste Disposal (KIT-INE), Hermann-von-Helmholtz-Platz 1, D-76344 Eggenstein-Leopoldshafen, Germany — ²VERA Laboratory, Faculty of Physics, University of Vienna, Währinger Straße 17, A-1090 Vienna, Austria

In order to assess the actinides contamination in groundwater, their geochemistry is intensely studied in field and laboratory experiments focusing on speciation and ways of transport through the aquifers. A challenge lies in the analysis of actinides below ppq levels. We present a new analytical protocol suited to the measurement by accelerator mass spectrometry of Np, Pu, Am and Cm isotopes without previous chemical separation from each other. The actinides are quantitatively co-precipitated with Fe-hydroxide from the groundwater specimens. This procedure allows the pre-concentration of the actinides from the bulk elements and their incorporation into a sample matrix suited to the AMS measurements. The chemical yield of the co-precipitation is estimated measuring samples with suitable spikes by HR ICP-MS. At the AMS system: a) the ionization yield of Np, Pu, Am and Cm in the given sample matrix, b) the maximum number of nuclides per sample allowing detection limits below 0.01 ppq, and c) the influence of the laboratory background on the results, are determined.

MS 6.3 Wed 14:00 DO24 Foyer

Large-area detector for position and energy resolving detection of molecular fragments — ●L. GAMER¹, S. ALLGEIER¹, D. HENGSTLER¹, S. KEMPF¹, C. KRANTZ², O. NOVOTNY³, A. PABINGER¹, C. PIES¹, A. WOLF², L. GASTALDO¹, A. FLEISCHMANN¹, and C. ENSS¹ — ¹KIP Heidelberg University. — ²MPI-K Heidelberg. — ³Columbia Astrophysics Laboratory, New York, USA.

To study reactions like the dissociative recombination in laboratory environment, the MPI-K Heidelberg is building a cryogenic storage ring to prepare molecular ions in their rotational groundstate. The kinematics of these processes can be resolved by a position and energy sensitive detection of the produced molecule fragments. Previously, we described a magnetic calorimeter for position and energy sensitive detection of massive particles. The detector encompasses 16 large-area absorbers, the temperature of each is monitored by a paramagnetic sensor located at a short edge of the absorber. Due to the finite thermal diffusivity in the absorber material, the rise-time of the detector depends on the impact location of the particle. Now, we compare the expected energy resolution and position sensitivity of this detector to experimental results where energy was deposited at different positions. We investigate the impact of backscattering, sputtering and lattice damage effects on the instrumental linewidth by means of Monte Carlo simulations and measurements performed with a similar detector that was irradiated with ions and small molecules. We find that the degradation of energy resolution is less than predicted and show that molecular fragments differing by only 1 mass unit can clearly be resolved.

MS 6.4 Wed 14:00 DO24 Foyer

Einsatz eines Allisonscanners zur Untersuchung der Strahlmittanz einer Sputter - (Caesium)- Ionenquelle — ●ALEXANDER STUHL, WOLFGANG KRETSCHMER, ANDREAS SCHARF, MATTHIAS SCHINDLER und KARIN KRITZLER — Universität Erlangen-Nürnberg, Physikalisches Institut Abt. IV, Erwin-Rommel-Str.1, 91058 Erlangen

Am Tandembeschleuniger der Universität Erlangen werden routinemäßig Altersbestimmungen kohlenstoffhaltiger Proben mittels Radiokarbondatierung durchgeführt. Ein Teil der Forschung besteht darin, die Messgenauigkeit zu verbessern und die Messzeit zu verkürzen. Zur Optimierung des Quellenstroms und der Emittanz der Erlanger AMS-Anlage werden derzeit Computersimulationen der Ionenquelle mittels der Programme CPO und Lorentz 2d durchgeführt. Im Mittelpunkt der Untersuchung steht die Variation der Elektrodengeometrie und der Betriebsparameter, wie Beschleunigungsspannungen oder Heizleistung des Ionisierers bzw. des Caesiumreservoirs. Dadurch soll eine Maximierung des Sputtervorgangs erreicht, sowie die Wechselwirkung des Primär- mit dem Sekundärstrahl und der Teilchentransport aus der Quelle optimiert werden. Zur Überprüfung der Simulationsergebnisse ist die exakte Bestimmung der Strahlmittanz von zentraler Bedeutung. Zu diesem Zweck wurde ein Allisonscanner entwickelt. Dies ist ein Präzisionsmessgerät, bestehend aus planparallelen Ein- und Austrittsspalten, welches durch die Ablenkung des Teilchenstrahls mittels eines Plattenkondensators die Geometrie des Strahls vermisst. In diesem Beitrag wird die Funktionsweise, sowie der mechanische und elek-

trische Aufbau des Scanners und erste Testmessungen präsentiert.

MS 6.5 Wed 14:00 DO24 Foyer

Klassische Berechnung relativistischer Frequenzverschiebungen in einer idealen Penningfalle — ●JOCHEN KETTER, TOMMI ERONEN, MARTIN HÖCKER, MARC SCHUH, SEBASTIAN STREUBEL und KLAUS BLAUM — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Die ideale Penningfalle besteht aus einem homogenen Magnetfeld und einem elektrostatischen Quadrupolpotential. Klassisch betrachtet hängen die charakteristischen Frequenzen der drei Eigenmoden eines geladenen Teilchens nicht von seinen Bewegungsamplituden ab. Die spezielle Relativitätstheorie hebt diese Unabhängigkeit auf. Für eine erste Abschätzung wird die Amplitudenabhängigkeit der Frequenzen meist als relativistische Massenzunahme verstanden, was allerdings drei der neun Abhängigkeiten nicht korrekt erklärt. Bislang erfolgte die vollständige störungstheoretische Behandlung relativistischer Effekte in einer Penningfalle über einen quantenmechanischen Operatorformalismus [1]. Ausgehend von der Methode zur klassischen Berechnung der Frequenzverschiebung durch rotationssymmetrische Feldfehler [2] bestätigen wir durch eine entsprechende Näherung der relativistischen Bewegungsgleichungen [3] das klassische Limit der quantenmechanischen Vorhersage. Das Verständnis solcher Systematiken spielt eine wichtige Rolle für das Penningfallenexperiment THE-Trap [4].

[1] L. S. Brown and G. Gabrielse, *Rev. Mod. Phys.* 58, 233–311 (1986)

[2] J. Ketter *et al.*, *IJMS*, DOI:10.1016/j.ijms.2013.10.005

[3] J. Ketter *et al.*, arXiv:1310.4463

[4] S. Streubel *et al.*, *Appl. Phys. B*, DOI:10.1007/s00340-013-5669-x

MS 6.6 Wed 14:00 DO24 Foyer

Ion bunch stacking in a Penning trap after purification in an electrostatic ion-beam trap — ●M. ROSENBUSCH¹, D. ATANASOV², K. BLAUM³, CH. BORGMANN³, S. KREIM^{2,3}, D. LUNNEY⁴, V. MANEA⁴, L. SCHWEIKHARD¹, F. WIENHOLTZ¹, and R. WOLF¹ — ¹Uni Greifswald — ²CERN, CH-1211 Geneva, Switzerland — ³Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — ⁴CSNSM-IN2P3-CNRS, Université Paris-Sud, 91406 Orsay, France

Measurements in analytical mass spectrometry as well as in precision mass determinations for atomic and nuclear physics are often handicapped when the ion sources deliver contaminations, i.e., unwanted ions of masses similar to those of the ions of interest. In particular, in ion-trapping devices, large amounts of contaminant ions result in significant systematic errors. At the Penning-trap mass spectrometer ISOLTRAP (ISOLDE/CERN), ions are purified in a multi-reflection time-of-flight mass separator (MR-ToF MS), which reaches a mass resolving power in excess of 10^5 in only tens of milliseconds [1,2]. However, the subsequent Penning-trap mass measurements require durations in the order of a second. If only a certain maximum amount of ions can be processed simultaneously and the major parts are contaminants, the number of purified ions per mass-measurement cycle is limited. An improvement for such situations has been developed and realized recently [3]. The fast separation procedure of the MR-ToF MS is repeated several times while the purified ions are accumulated in a preparation Penning trap. In this contribution the method is described and proof-of-principle measurements are presented.

[1] R. N. Wolf *et al.*, *Nucl. Instrum. Meth. A* 686, 82 (2012)

[2] R. N. Wolf *et al.*, *Int. J. Mass Spectrom.* 349-350, 123 (2013)

[3] M. Rosenbusch *et al.*, *Appl. Phys. B*, accepted (2013), <http://dx.doi.org/10.1007/s00340-013-5702-0>

MS 6.7 Wed 14:00 DO24 Foyer

Probing the shell closure at $N = 32$ by mass measurements of neutron-rich potassium isotopes — ●M. ROSENBUSCH¹, D. BECK², K. BLAUM³, CH. BORGMANN³, M. BREITENFELD⁴, R. B. ÇAKIRLI^{3,5}, S. GEORGE¹, F. HERFURTH², M. KOWALSKA⁶, S. KREIM^{3,6}, D. LUNNEY⁷, V. MANEA⁷, D. NEIDHERR^{2,3}, L. SCHWEIKHARD¹, J. STANJA⁸, F. WIENHOLTZ¹, R. WOLF¹, and K. ZUBER⁸ — ¹Ernst-Moritz-Arndt-Universität, Institut für Physik, 17487 Greifswald — ²GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt — ³Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — ⁴Katholieke Universiteit, 3000 Leuven, Belgium — ⁵University of Istanbul, 334452 Istanbul, Turkey — ⁶CERN, CH-1211 Geneva, Switzerland — ⁷CSNSM-IN2P3-CNRS, Université Paris-Sud, 91406 Orsay, France — ⁸Technische Universität Dresden, 01069 Dresden

The Penning-trap mass spectrometer ISOLTRAP at the on-line isotope separator ISOLDE/CERN has been set up for precision mass measure-

ments of short-lived nuclides and has been continuously improved for accessing more exotic nuclides. A crucial step forward has been made with the installation of a multi-reflection time-of-flight mass separator (MR-ToF MS), which enables high-resolution mass separation of contaminated ions, resulting, e.g., in the measurement of the nuclide ^{82}Zn [1]. More recently, nuclear mass measurements have been performed directly in the MR-ToF MS instead of using a Penning trap. This paved the way for the determination of the masses of $^{53,54}\text{Ca}$ [2], which would not have succeeded in ISOLTRAP's Penning traps. The obtained two-neutron separation energies (S_{2n}) unambiguously confirm a shell closure at $N = 32$, which has been indicated earlier by measurements of the excitation energies of the first 2^+ state in ^{52}Ca [3]. In addition, with the MR-ToF MS at ISOLTRAP the masses of ^{52}K and ^{53}K have been determined for the first time. With a half-life of only 30 ms, ^{53}K is the shortest-lived nuclide ever investigated at ISOLTRAP. The data are currently under evaluation. In this contribution, the new S_{2n} values will be presented and the crossing of the neutron shell closure at $N = 32$ for potassium will be discussed.

[1] R. N. Wolf *et al.*, Phys. Rev. Lett. 110, 041101 (2013)

[2] F. Wienholtz *et al.*, Nature 498, 346-349 (2013)

[3] A. Huck *et al.*, Phys. Rev. C 31, 2226 (1985)

MS 6.8 Wed 14:00 DO24 Foyer

FRS Ion Catcher: Ion Survival Efficiency of Radioactive Ions — ●TIMO DICKEL^{1,2}, EMMA HAETNER¹, FABIAN HEISSE³, SIVAJI PURUSHOTHAMAN¹, MORITZ PASCAL REITER², and THE FRS ION CATCHER COLLABORATION¹ — ¹GSI Darmstadt — ²Justus-Liebig-Universität — ³TU Dresden

At the MATS and LaSpec experiments of the LEB of the Super-FRS, high precision experiments will be done with low-energy exotic nuclei. To reach out to the most exotic nuclei, high efficiencies in the thermalization and beam preparation (e.g., separation and identification) are of utmost importance. Therefore, these parameters are optimized and tested online with the of the FRS Ion Catcher facility and in a separate off-line experiment. An in depth study of ion survival efficiencies has been performed to characterize the cryogenic stopping cell, to understand the slowing down process and to optimize the overall efficiency of the FRS Ion Catcher. Alpha-decay recoil ions from a ^{223}Ra source are used to determine the ion survival and transport efficiencies, which reflect the charge-exchange and stripping cross-sections during the slowing down process of the ions. These investigations as well as other efficiency optimizations of the FRS Ion Catcher will be presented.

MS 6.9 Wed 14:00 DO24 Foyer

Poly-Anion Production in Penning and RFQ Ion Traps — ●STEFFI BANDELOW, FRANKLIN MARTINEZ, GERRIT MARX, and LUTZ SCHWEIKHARD — Institute for Physics, Ernst-Moritz-Arndt University, 17487 Greifswald, Germany

The poly-anion production is being investigated in Penning and linear radio-frequency quadrupole (RFQ) traps at the ClusterTrap setup. The range of anionic charge states produced with the electron-bath technique in a Penning trap is restricted by the upper mass limit of this trap. By installation of a cylindrical Penning trap with a 12-Tesla superconducting magnet, the mass and thus cluster-size range is enhanced by a factor of 20 compared to the previously used hyperbolic 5-Tesla Penning trap. For first experimental tests with the 12-Tesla cylindrical Penning trap, gold cluster mono-anions Au_n^- , $n = 330 - 350$, have been exposed to an electron bath. As a result, higher negative charge states up to hexa-anionic clusters have been observed for the first time [1]. In a parallel effort, di- and tri-anionic gold clusters have been produced in an RFQ-trap [2]. To this end, an electron beam is guided through the RFQ-trap, which is operated by 2- or 3-state digital driving voltages [3,4]. In addition, both polyanion-production techniques have been combined by pre-charging clusters in the RFQ-trap, transferring the resulting dianions into the Penning trap and applying the electron-bath technique to produce higher charge states.

[1] Martinez *et al.*, *subm. to IJMS* (2013). [2] Martinez *et al.*, AIP Conf. Proc. 1521 (2013) 230. [3] Bandelow *et al.*, IJMS 336 (2013) 47. [4] Bandelow *et al.*, IJMS 353 (2013) 49.

MS 6.10 Wed 14:00 DO24 Foyer

Analysing Destruction Channels of interstellar Hydrocarbon Anions with a 22pol Ion-Trap — ●ERIC ENDRES, OLGA LAKHMAN-SKAYA, THORSTEN BEST, DANIEL HAUSER, SUNIL KUMAR, and ROLAND WESTER — Universität Innsbruck, Institut für Ionenphysik und Angewandte Physik, Österreich

In the interstellar medium (ISM), ion-molecule reactions are considered to play a key role in the formation of complex molecules. The detection of the first interstellar anions [1,2], which happen to be carbon chain anions, has raised new interest in the quantitative composition of the ISM and the underlying reaction network. To understand the observed abundance of these carbon chain anions, a detailed analysis of the possible destruction channels is indispensable.

A cryogenic 22-pol radio frequency ion trap is an ideal tool to observe reactions that take place slowly, such as carbon chain anions with molecular hydrogen [3]. Furthermore, measurements over a large temperature scale are feasible. Longitudinal optical access to the trap also provides the possibility to make precise photodetachment measurements.[4]

Temperature dependent measurements of the reaction rates for the reaction between hydrocarbon chain anions and H_2 will be presented.

[1] McCarthy *et al.* Ap.J. 652:L141 (2006); [2] Cernicharo *et al.* A&A 467, p. L37-L40; [3] Eichelberger *et al.* Ap.J. 667:1283 (2007);

[4] Best *et al.* Ap.J. 742:63 (2011)

MS 6.11 Wed 14:00 DO24 Foyer

New setup for studying correlation effects in poly-anionic metal clusters by photoelectron spectroscopy — ●MADLEN MÜLLER¹, GERRIT MARX¹, PATRICE OELSSNER², JOSEF TIGGESBÄUMKER², ROBERT WOLF³, KARL-HEINZ MEIWES-BROER², and LUTZ SCHWEIKHARD² — ¹Ernst-Moritz-Arndt-Universität, Greifswald, Deutschland — ²Universität Rostock, Deutschland — ³Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland

Photoelectron spectroscopy (PES) experiments open insight into the electronic structure of atomic clusters. In the case of multiply negatively charged clusters, electron affinities and Coulomb barriers of these species can be probed by varying the wavelength of the photo-detachment laser[1]. In addition, poly-anionic metal clusters serve as model systems for electron-correlation phenomena[2]. A setup is presented, which combines a Paul trap, used for cluster-size selection and poly-anion production by sequential electron attachment[3], with a magnetic-bottle time-of-flight electron spectrometer[1]. As a first test PES on mono- and di-anion fullerenes with ultraviolet nanosecond laser pulses has been performed. In the future the measurements will be extended to poly-anionic metal clusters in order to explore their electronic properties. The project is part of the Collaborative Research Center (SFB) 652.

[1] L.-S.Wang *et al.*, J. Phys. Chem. A 104, 1978 (2000).

[2] A. Herlert *et al.*, New J. Phys. 14, 055015 (2012).

[3] F. Martinez *et al.*, Eur. Phys. J. D 67, 39 (2013); AIP Conf. Proc. 1521, 230 (2013).

MS 6.12 Wed 14:00 DO24 Foyer

Status and Perspective of a New Time-Of-Flight Detector for the Isochronous Mass Spectrometry in the Collector Ring at FAIR — ●MARCEL DIWISCH¹, NATALIA KUZMINCHUK-FEUERSTEIN^{1,2}, HANS GEISSEL^{1,2}, RONJA KNÖBEL^{1,2}, TIMO DICKEL^{1,2}, WOLFGANG PLASS^{1,2}, CHRISTOPH SCHEIDENBERGER^{1,2}, and HELMUT WEICK² — ¹Justus-Liebig-University Gießen — ²GSI, Darmstadt

The masses of exotic nuclei can be measured directly in ion storage rings by measuring their revolution time in the ring. In the presently used FRS-ESR facility one method to do this is the so called Isochronous Mass Spectrometry (IMS). With the IMS method mass values of exotic nuclei with lifetimes as short as a few $10\mu\text{s}$ are accessible. To determine the masses the revolution time of the ions in the ring is measured by a Time-Of-Flight (TOF) detector.

The future Collector Ring (CR) will be different compared to the current ESR not only in circumference but also in terms of beam dimensions and intensities. In order to use an advanced version of the IMS in the CR a new double detector system, which improves the mass resolution of the IMS method and fulfills the requirements of the new beam dimensions will be shown.

Improvements of almost a factor 2 for the timing accuracy with at least 95% detection efficiency is expected compared to the current design, even though the detector dimensions had to be increased by a factor of 2 to adapt to the new beam dimensions.

MS 6.13 Wed 14:00 DO24 Foyer

Spatially resolved ultra-trace analysis of plutonium and technetium with resonant Laser-SNMS — ●MICHAEL FRANZMANN^{1,2}, SVEN KAYSER³, KLAUS WENDT², and CLEMENS WALTHER¹ — ¹Institut

für Radioökologie und Strahlenschutz, Leibniz Universität Hannover — ²Institut für Physik, Universität Mainz — ³ION-TOF GmbH, Münster

The geochemical behaviour of plutonium is of major concern for the safety analysis of contaminated sites. It is necessary to analyze the sorption on minerals and nanoparticles to elucidate the interactions in the environment and predict future migration and transport mechanisms. Therefore a system for resonant Laser-SNMS is currently being developed at the IRS Hannover. This system combines a commercial TOF-SIMS (IONTOF) with a Ti:sapphire laser system, which will be set up and tested by the Institute of Physics at University of Mainz. Identical laser systems are used there for resonance ionization of stable and radioisotopes for many years. Due to the high spatial resolution of the TOF-SIMS ion gun, the good mass resolution of the time-of-flight mass spectrometer and the excellent element selectivity of resonant ionization this laser mass spectrometric approach is seen as most promising system for ultra-trace analysis on actinides and fission products. For definition and design of the analytical system precise simulations on ion optics and mass spectrometer lay out are programmed to ensure highest efficiency together with suitable mass resolution. This simulation program optimizes the path of the ionized particle cloud through the ion optical structure of the mass spectrometer.

MS 6.14 Wed 14:00 DO24 Foyer

A Laser Ablation Carbon Cluster Ion Source for the FRS Ion Catcher — ●ANN-KATHRIN RINK¹, CHRISTINE HORNING¹, TIMO DICKEL^{1,2}, JENS EBERT¹, HANS GEISSEL^{1,2}, WOLFGANG R. PLASS^{1,2}, and CHRISTOPH SCHEIDENBERGER^{1,2} — ¹Jusuts-Liebig Universität Gießen — ²GSF Helmholtzzentrum für Schwerionenforschung

The FRS Ion Catcher, a test branch for the Super-FRS at FAIR, is commissioned and successfully tested. Consisting of a Cryogenic Stopping Cell (CSC), a diagnostic unit (DU) and a Multi-Reflection Time-of-Flight Mass-Spectrometer (MR-TOF-MS) to stop, identify and measure projectile and fission fragments produced by the FRS.

To do systematic studies of the MR-TOF-MS calibrants over a broad mass range are essential. To fulfil this task a laser ablation carbon cluster ion source has been designed, commissioned and tested in an external setup. Advantages of this source is a broadband mass range of calibrants (clusters), generation calibrants at every mass unit (C-13 enriched fullerenes), a high repetition rate (100Hz) and long term stable operation (x-y-table). Due to that it is a perfect tool to complete the current setup of the MR-TOF-MS. First tests and results will be presented.

MS 6.15 Wed 14:00 DO24 Foyer

Nd:YAG-Laserpuls-induzierte Ionenerzeugung an hochreinen Festkörperproben zur massenspektrometrischen Spurenelementanalyse — ●BERNHARD WIEDEMANN¹, MICHAEL DEVEAUX¹, MICHAEL PETRI¹ und KARL-HEINZ WIEDEMANN² — ¹Institut für Kernphysik, Max-von-Laue-Str. 1, D-60438 Frankfurt am Main — ²Heraeus, D-63450 Hanau, Heraeusstr. 12-14

Es wird eine Ultrahochvakuum-kompatible, laserinduzierte Ionenquelle für die Erzeugung eines matrixreinen Ionenstroms für die massenspektrometrische Spurenelementanalyse an elektrisch leitenden und nichtleitenden Festkörpermateriale beschrieben. Um Praxis-tauglichkeit zu erreichen wurden entscheidende technische Verbesserungen vorgenommen: (1) Die Leistung des Lasers wurde erhöht und seine Betriebsparameter auf die Aufgabenstellung angepasst (Wellenlänge 532nm, Puls-wiederholfrequenz 30Hz, Pulsdauer 4ns, Strahldivergenz <0,5mrad, Pulsenergie von 3 bis 5mJ für Siliciumdioxid im Fokus einer Plankonvexlinse mit der Brennweite 200mm und dem Durchmesser 24,4mm). (2) Es wurde eine nahezu optisch dichte, vakuumtechnisch offene Abschirmung der Ionenquelle entwickelt, die auf hohem elektrischen Potential Ionen beinahe vollständig zum Sensor lenkt und gleichzeitig durch Raumwinkelbegrenzung das Eintrittsfenster des Lasers vor neutralisierter Teilchenbelegung schützt, und dadurch die Konstanz der Laserinduktion in die Probe für die Dauer der Spurenelementanalyse gewährleistet. (3) Ein automatischer Manipulator erlaubt Probenwechsel und -bewegung relativ zum Laserstrahl. Hierdurch können Proben (insbesondere auch in Schichten) orts aufgelöst analysiert werden.

MS 6.16 Wed 14:00 DO24 Foyer

A time-of-flight mass spectrometer with laser ionization for sensitive product molecule detection for heterogeneous model reactions — ●MARTIN TSCHURL, ANDREAS WINBAUER, SEBASTIAN KOLLMANNBERGER, JOSEF KIERMAIER, ULRICH BOESL, and UELI HEIZ — Lehrstuhl für Physikalische Chemie & Catalysis Research Center, Chemistry Department, Technische Universität München, Lichtenbergstraße 4, 85748 Garching bei München, Germany

Investigations of model catalysts are very often performed in ultra-high vacuum for ensuring very well-defined systems. Usually, product molecule detection is performed by electron impact (EI) ionization in a quadrupole mass spectrometer. While this method offers the possibilities of continuous measurements and high sensitivity, it features the drawback that a mass scan has to be performed to detect the masses of all reaction products. In addition, the discrimination between isobars is difficult to achieve because of the unselective properties of EI ionization. In this work we present a time-of-flight MS in combination with laser ionization. Due to the setup, this system allows for a very sensitive detection of isobaric species. In this poster the detection principle is illustrated and first proof-of-principle measurements are shown.

MS 6.17 Wed 14:00 DO24 Foyer

Status of the future SPIRAL2 Resonance Ionization Laser Ion Source GISELE — ●FABIAN SCHNEIDER¹, JOSE LUIS HENARES², TOBIAS KRON¹, NATHALIE LECESNE², RENAN LEROY², BENOIT OSMOND², MARICA SJÖDIN², and KLAUS WENDT¹ — ¹Institut für Physik, Universität Mainz — ²GANIL, Caen, France

Resonance Ionization Spectroscopy is a most powerful tool for efficient and selective production of ion beams in particular useful at on-line isotope breeders. For this purpose the future upgrade S³ (Super Separator Spectrometer) of the SPIRAL2 accelerator at GANIL (Caen, France) includes a gas cell at its fission target. Therein high resolution RIS on short lived isotopes will be performed, addressing either the in-cell or in-jet technology. The corresponding Resonance Ionization Laser Ion Source project GISELE is furthermore designed to produce strong and pure radioisotope beams for experiments at the future hot cavity unit of SPIRAL2. Its laser system will combine sets of tunable high-repetition rate pulsed dye as well as titanium:sapphire lasers.

Currently, off-line preparation studies are performed with the titanium:sapphire lasers for the day 1 requested beams of Zinc and Tin. A suitable excitation scheme was developed for Zinc and the ionization efficiency was determined. For Tin three known ionization schemes, a 3-step and two widely identical 2-step schemes, were tested and compared with published results from other facilities.

MS 6.18 Wed 14:00 DO24 Foyer

Titan:Saphir-Laser mit Gitterresonator in Littman-Geometrie — ●PASCAL NAUBEREIT, TOBIAS KRON, FABIAN SCHNEIDER und KLAUS WENDT — Institut für Physik, Johannes Gutenberg-Universität Mainz, Germany

Hochrepetierend gepulste Titan:Saphir-Laser mit weitem Abstimm-bereich und geringer spektraler Breite sind wichtige Werkzeuge für moderne Spektroskopieansätze, z. B. beim hochauflösenden Studium von Ionisationsschemata und speziell Hyperfeinstruktur und Isotopieverschiebung an radioaktiven Isotopen. In der Mainzer Arbeitsgruppe LARISSA werden entsprechende Lasersysteme entwickelt und eingesetzt, wobei ein Reflexionsgitter in Littrow-Anordnung als frequenzselektives Element verwendet wird. Der existierende Aufbau bietet Verbesserungsansätze hinsichtlich Konversionseffizienz, Schmalbandigkeit, Strahlprofil und Benutzerfreundlichkeit. Aktuelle Ansätze tendieren zu einem Resonator in Littman-Geometrie, bei dem die Frequenzselektion über ein feststehendes Gitter stattfindet. Die 1. Beugungsordnung wird mit einem Drehspiegel an geeignet positioniertem Pivotpunkt zurückreflektiert. Die Laserstrahlung wird direkt über die 0. Beugungsordnung ausgekoppelt. Ein solcher Laseraufbau ohne Strahlauflaufweiter und Auskoppelspiegel und mit feststehendem Reflexionsgitter besticht durch seine Einfachheit. Zusätzlich soll eine Frequenzverdopplung etabliert werden, bei der die Phasenanpassung des Verdopplungskristalls automatisch in Abhängigkeit der Wellenlänge erfolgt. Somit wird der Abstimmbereich des Lasers um den Bereich der zweiten Harmonischen des Titan:Saphir-Lasers erweitert.

MS 7: Fathoming Stellar Evolution (Part 2)

Time: Wednesday 16:30–18:15

Location: DO24 1.205

Invited Talk

MS 7.1 Wed 16:30 DO24 1.205

Mass spectrometry of exotic nuclear species for the study of neutron stars — ●DAVID LUNNEY — CSNSM/IN2P3 – Université de Paris Sud, Orsay

A large fraction of stars end their lives in dramatic explosions forming ultra-compact objects with a density exceeding that of the atomic nucleus. These resulting neutron stars have a complex composition that requires a wide range of physics to model. Of particular interest is the neutron-star crust, which may contain exotic nuclear species that can be detected by astronomers.

The recent observation of a “kilonova” (an explosion larger than a nova but smaller than a supernova) has been associated with gravitational mergers involving neutron stars and hints at tantalizing evidence for the production of heavy elements from the rapid capture of abundant neutrons (the r process). Modeling the neutron star and its composition, as well as an associated r process, requires the knowledge of nuclear binding energies. These quantities are obtained by precision mass spectrometry at radioactive beam facilities.

This presentation will explain the neutron-star model and describe the ISOLTRAP spectrometer at CERN-ISOLDE that produces the mass data necessary for the neutron-star composition and r -process modeling, along with some results.

Invited Talk

MS 7.2 Wed 17:00 DO24 1.205

High-resolution spectroscopy of (deuterated) molecular ions — ●OSKAR ASVANY, SANDRA BRÜNKEN, SABRINA GÄRTNER, PAVOL JUSKO, LARS KLUGE, ALEXANDER STOFFELS, and STEPHAN SCHLEMMER — I. Physikalisches Institut, Universität zu Köln, Köln, Germany

One phenomenon in the initial phases of star formation is the deuteration of molecules and ions observed in many different environments. Since several decades there is a vivid interplay between astronomical detections and laboratory measurements in this field, recent examples being the tentative observation of CH_2D^+ towards Orion IRC2 and the firm detection of para- H_2D^+ towards I16293 in Ophiuchus using the GREAT receiver on the SOFIA airplane.

This talk concentrates on the laboratory methods to obtain rotational and rovibrational spectra of mass-selected molecular ions of astronomical interest. High-resolution is achieved by cooling and trapping a few thousand ions in a multipolar trap, while using narrow-band IR or mm-wave sources for their excitation. This excitation is detected by action spectroscopy, laser induced reactions (LIR) being the main workhorse in our laboratory.

Recently, the arsenal of action spectroscopy methods has been enriched by the newly developed method of Laser Induced Inhibition of Cluster Growth (LIICG), in which attachment of He atoms to ionic species below 10 K is hindered by resonant excitation. Advantages of LIICG are operation at 4 K, its apparent applicability to any ion, and response to any sort of excitation (rotational/vibrational/electronic), as will be shown on selected examples (CD_2H^+ , H_3^+ , CO^+).

MS 7.3 Wed 17:30 DO24 1.205

Entwicklung von zwei-, drei- und vierstufigen Anregungsschemata für höchste Ionisationseffizienz am Palladium — ●TOBIAS KRON¹, SUSANNE KREIM^{2,3}, FABIAN SCHNEIDER¹, SVEN RICHTER¹ und KLAUS WENDT¹ — ¹Institut für Physik, Johannes Gutenberg-Universität Mainz — ²Max-Planck-Institut für Kernphysik, Heidelberg — ³CERN, Genf, Schweiz

Untersuchungen der Eigenschaften des Atomkerns entlang der Palladium-Isotopenkette, sowie hochpräzise Massenmessungen im Bereich des N=82-Schalenabschlusses sollen wertvolle Informationen zur noch immer nicht vollständig geklärten astrophysikalischen Nukleosyn-

these der Elemente schwerer als Eisen liefern und ermöglichen damit wichtige Tests verschiedener Theoriemodelle.

Zur Produktion isobarenreiner Ionenstrahlen dieser kurzlebigen Isotope an Online-Ionenquellen, wie ISOLDE (CERN), wird die resonante Laserionisation genutzt. Die Effizienz dieses hochselektiven Ionisationsprozesses hängt dabei vorrangig von der genutzten Leiter optischer Dipolübergänge zwischen den elementspezifischen Energieniveaus ab. Am Offline-Massenseparator RISIKO wurden Schemata mit zwei bis vier Anregungsschritten weiterentwickelt und hinsichtlich ihrer Ionisationseffizienz verglichen. Die Spektroskopie mehrerer Rydbergserien oberhalb des ersten Ionisationspotenzials ermöglichte die Wahl des optimalen finalen Ionisationsübergangs, was die Ionisationseffizienz deutlich erhöht. Die anschließenden Messungen der Effizienz mittels kalibrierter Proben geben Aufschluss über die zu erwartende Teilchenrate bei der zukünftigen Online-Anwendung.

MS 7.4 Wed 17:45 DO24 1.205

Detecting Supernova Dust on the Earth's Sea Floor with AMS — ●JENNY FEIGE¹, ANTON WALLNER², DIETER BREITSCHWERDT³, L. KEITH FIFIELD², GUNTHER KORSCHINEK⁴, SILKE MERCHEL⁵, GEORG RUGEL⁵, PETER STEIER¹, STEVE TIMS², STEPHAN R. WINKLER¹, and ROBIN GOLSER¹ — ¹University of Vienna, Austria — ²ANU Canberra, Australia — ³TU Berlin, Germany — ⁴TUM, Germany — ⁵HZDR, Germany

An ^{60}Fe anomaly was detected with accelerator mass spectrometry (AMS) - a very sensitive method to measure extremely low isotopic ratios - in a 2 Myr old layer of a ferromanganese crust (Knie et al., 2004). This signal is assumed to be of supernova origin and might be linked to the observation of our solar system being located in a region of thin, hot interstellar medium. This region, called the Local Bubble, was presumably formed by multiple supernova explosions starting ~14 Myr ago. Calculations suggest that at least one of these supernovae occurred close enough to the solar system to leave a detectable ^{60}Fe trace on Earth.

New AMS measurements are performed in deep-sea sediments from the Pacific Ocean. An international collaboration of different AMS facilities searches for signatures of the long-lived radionuclides ^{26}Al , ^{53}Mn , and ^{60}Fe in a time range from 1.7 to 3.1 Myr. Magnetostratigraphic dating of the samples is confirmed by measurements of the cosmogenic radionuclide ^{10}Be . All ^{10}Be and ^{26}Al measurements are finished, ^{53}Mn and ^{60}Fe is in progress. First results will be presented and discussed.

MS 7.5 Wed 18:00 DO24 1.205

Tracing back the Local Bubble's formation from isotopic anomalies in the deep ocean crust — ●MICHAEL SCHULREICH and DIETER BREITSCHWERDT — Zentrum für Astronomie und Astrophysik, TU Berlin, Berlin, Germany

Supernova explosions responsible for the creation of the Local Bubble (LB) and its associated HI cavity should have caused geological isotope anomalies via deposition of debris on Earth. The discovery of a highly significant increase of ^{60}Fe (a radionuclide which is exclusively produced in explosive nucleosynthesis) in layers of a deep sea ferromanganese crust, corresponding to a time of 2.2 Myr before present, appears very promising in this context. We report on our latest results in relating these measurements to the formation of the LB by means of 3D hydrodynamical adaptive mesh refinement simulations of the interstellar medium in the solar neighborhood. These calculations are based on a sophisticated selection procedure for the LB's progenitor stars and take advantage of passive scalars for modeling the turbulent chemical mixing process.

MS 8: Accelerator Mass Spectrometry and Applications 1

Time: Thursday 10:30–12:30

Location: DO24 1.205

Invited Talk

MS 8.1 Thu 10:30 DO24 1.205

Komponenten-spezifische Radiokohlenstoffanalysen: Technische Aspekte und geowissenschaftliche Anwendungen — ●JANET RETHEMEYER — Institut für Geologie und Mineralogie, Uni-

versität Köln

Radiokohlenstoffanalysen sind eine wichtige Methode zur Altersbestimmung bzw. zur Erstellung von Sedimentchronologien. Diese Methodik ist zudem nützlich bei der Aufklärung von Umsetzungspro-

zessen innerhalb bzw. Austauschprozessen zwischen den Reservoiren des Kohlenstoffkreislaufs. Neue Möglichkeiten haben sich durch die Entwicklung komponenten-spezifischer Radiokohlenstoffanalysen, d.h. Analysen einzelner organischer Verbindungen, ergeben. Diese in den 90er Jahren etablierte Methodik wird aufgrund ihrer analytischen Komplexität bisher nur wenig angewendet. Um sie effektiver einsetzbar zu machen, besteht Bedarf an methodisch-technischen Weiterentwicklungen. In diesem Vortrag werden die wesentlichen Aspekte der Isolierung organischer Verbindungen mit präparativer Gas- und Flüssigkeitschromatographie dargestellt. Die damit verbundenen Probleme, wie z.B. eine gewünschte hohe chromatographische Auflösung versus damit einhergehender niedriger Probenmengen sowie Kontaminationsprobleme werden vorgestellt. Außerdem werden aktuelle Anwendungen in arktischen Permafrostböden präsentiert, deren Ziel die Verfolgung von Veränderungen der Kohlenstoffdynamik aufgrund des Klimawandels ist.

MS 8.2 Thu 11:00 DO24 1.205

Die ersten drei Jahre von CologneAMS — STEFAN HEINZE, ALFRED DEWALD, TIBOR DUNAI, STEVE BINNIE und •JANET RETHEMEYER — Universität zu Köln

Wir präsentieren zusammenfassend die Performance des Kölner Beschleunigermassenspektrometers. Es werden Daten der ersten drei Betriebsjahre sowie einige statistische Eigenschaften dieser Daten gezeigt und es werden Auswirkungen der für die Datenanalyse wichtigen Korrekturen diskutiert. Insbesondere wird auf eine Korrelation des Ionenstroms mit den gemessenen Isotopenverhältnissen eingegangen. Mit der Kenntnis dieser Korrelation kann eine entsprechende Stromkorrektur durchgeführt werden. Durch diese Vorgehensweise verringert sich die Streuung der Isotopenverhältnisse erheblich. Wir führen solche Korrekturen bei Kohlenstoff- und Beryllium-Messungen durch.

Eine Stärke des Kölner Spektrometers ist ein sehr niedriger Maschinenblank. Entsprechende Daten werden gezeigt.

MS 8.3 Thu 11:15 DO24 1.205

Aufbau und Inbetriebnahme des Phoenix-Injektors am Kölner FN-Tandembeschleuniger — •RICHARD ALTENKIRCH, MARKUS SCHIFFER, CLAUS FEUERSTEIN, ALFRED DEWALD und ALEXANDER STOLZ — Kernphysik, Universität Köln

Aus den Komponenten der ehemaligen AMS-Anlage der Universität Utrecht wurde am Kölner FN-Beschleuniger des Instituts für Kernphysik ein neuer AMS-Injektor "Phoenix" aufgebaut und in Betrieb genommen. Dieser besteht aus einer NEC Ionenquelle (MC-SNICS) einem 90° ESA ($r_{ESA} = 435\text{ mm}$) und einem 90° Ablenkmagneten ($r_{Mag} = 435\text{ mm}$). Der Injektor wurde auf einer Hochspannungsplattform mit einem maximalen Potential von 80 kV installiert. Die Steuerung des Injektors erfolgt über eine SIMATIC S7-200. Wir berichten über die ersten Testergebnisse und über die Ankopplung an das existierende Strahlführungssystem des FN-Tandembeschleunigers.

MS 8.4 Thu 11:30 DO24 1.205

Verbesserung der Sensitivität für die Konzentrationsbestimmung stabiler Elemente durch die Kombination von Neutronenaktivierung und AMS — •MARTIN MARTSCHINI, OLIVER FORSTNER, STEPHAN WINKLER, ROSMARIE EIGL und ROBIN GOLSER — VERA-Labor, Fakultät für Physik, Universität Wien, Österreich

Die Bestimmung der Konzentration stabiler Elemente in Werkstoffen im ppb-Bereich stellt in vielen Fällen eine messtechnische Herausforderung dar. Die Nachweisgrenze mit Neutronenaktivierung hängt stark vom Gamma-Untergrund durch das Bulkmaterial ab, massenspektrometrische Methoden sind hingegen meist durch Kontamination bei der Probenaufbereitung und der Ionenquelle limitiert.

Durch Verwendung von Neutronenaktivierung zur Umwandlung der stabilen Elemente in langlebige Radionuklide und anschließender nahezu untergrundfreier Detektion mit Beschleuniger-Massenspektrometrie kann die Sensitivität deutlich verbessert werden. Die Möglichkeiten

und Grenzen dieser Methode werden anhand erster Messergebnisse des Chlor-Gehalts von Stahlproben diskutiert.

MS 8.5 Thu 11:45 DO24 1.205

Laserablation-AMS: zeitsparende online- ^{14}C -Analysen von Karbonaten — •CAROLINE MÜNSTERER^{1,2}, LUKAS WACKER¹, BODO HATTENDORF², JOACHIM KOCH², MARCUS CHRISTL¹, ROLF DIETIKER², DETLEF GÜNTHER² und HANS-ARNO SYNAL¹ — ¹Laboratory of Ion Beam Physics, ETHZ, Schafmattstr. 20, HPK, 8093 Zurich, Switzerland — ²Laboratory of Inorganic Chemistry, D-CHAB, ETHZ, Wolfgang-Pauli-Str. 10, 8093 Zurich, Switzerland

Mittels eines fokussierten und gepulsten Lasers können kleinste Probenmengen von einem Festkörper abgetragen und analysiert werden. Dies ist ein zeitsparendes Probengewinnungsverfahren, wobei eine hohe Ortsauflösung ($100\ \mu\text{m}$) erreicht werden kann. Bei dem Laserabtrag (LA) von Karbonaten entsteht ein hoher Anteil von CO_2 , das in AMS-Anlagen, die mit einer Gasionenquelle ausgestattet sind, direkt gemessen werden kann. Das neu entwickelte LA-System für online ^{14}C -Messungen besteht aus einem 193 nm ArF-Excimer Laser, einer optimierten Probenzelle, einer Beobachtungsoptik sowie einem Gastransport-System. Die genaue Charakterisierung der LA-AMS-Anlage ist zentraler Bestandteil der aktuellen Arbeiten. Dazu gehören u.a. die Bestimmung der CO_2 -Produktionsrate in Abhängigkeit von Laserfrequenz und Laserenergie. Marmor, gepresstes Karbonat Pulver und natürliche Karbonate werden auf ihre Eignung für Analysen mittels LA-AMS untersucht. Anhand eines Stalagmiten mit einem ausgeprägtem Bomben-Peak und bekannter ^{14}C -Signatur wird die Eignung dieses Aufbaus für online- ^{14}C -Analysen von Karbonaten mittels LA gezeigt.

MS 8.6 Thu 12:00 DO24 1.205

Besonderheiten der Vorbereitung von chromatographisch aufgetrennten Proben in der AMS — •ALEXANDER TSCHEK-LINSKIJ, MATTHIAS SCHINDLER, WOLFGANG KRETSCHMER, ANDREAS SCHARF, KARIN KRITZLER, and ALEXANDER STUHL — Uni Erlangen, Physikalisches Institut Abt. IV, Erwin-Rommel-Str. 1, 91058 Erlangen

Der Vortrag soll einen Überblick über die Besonderheiten von chromatographisch aufgereinigten Proben in der AMS geben. Hierbei sollen die möglichen Kontaminationsquellen aufgezeigt werden und die Weiterbehandlung von instabilen Proben besprochen werden.

MS 8.7 Thu 12:15 DO24 1.205

Optimierung eines Ionenoptik-Programms — •ALEXANDER STOLZ, STEFAN HEINZE, RICHARD ALTENKIRCH, MARKUS SCHIFFER, CLAUS MÜLLER-GATERMANN, CLAUS FEUERSTEIN und ALFRED DEWALD — Institut für Kernphysik, Universität zu Köln

Das am Institut für Kernphysik der Universität zu Köln entwickelte und auf einem Matrixformalismus basierende Ionenoptik-Programm LIMIOPTIC wurde mit einer Benutzeroberfläche versehen, die eine interaktive Eingabe von Parametern und eine direkte Darstellung des Strahlverlaufs ermöglicht. Dies wurde durch Optimierungen der Geschwindigkeit des Programmcodes realisiert. Allen Parametern, wie Linsenstärke, Beschleunigungsspannung oder Energiestragglung, können Schieberegler zugewiesen werden, wodurch die Untersuchung ionenoptischer Systeme wesentlich vereinfacht wird. Es ist auch möglich beliebige Parameterwerte automatisch unter Vorgabe ausgewählter Randbedingungen zu optimieren. Darüber hinaus wurden die Abbildungseigenschaften einiger ionenoptischer Elemente (Quadrupole, Einzellinsen, Magnete, Vorbeschleunigung) des 6 MV -Tandem-Beschleunigers von CologneAMS und des FN-Tandembeschleunigers untersucht und entsprechende Funktionen in LIMIOPTIC eingebaut. Hierfür wurden bekannte Näherungsformeln verwendet, jedoch war es notwendig bestimmte Korrekturfaktoren anzupassen, um zu realistischen Beschreibungen zu gelangen. Beispiele hierfür werden vorgestellt.

MS 9: Accelerator Mass Spectrometry and Applications 2

Time: Thursday 14:00–16:00

Location: DO24 1.205

Invited Talk

MS 9.1 Thu 14:00 DO24 1.205

Progress at DREsden AMS — ●GEORG RUGEL, SHAVKAT AKHMADALIEV, SILKE MERCHEL, STEFAN PAVETICH, AXEL RENNO, and RENÉ ZIEGENRÜCKER — Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstr. 400, 01328 Dresden, Germany

The combination of a mass spectrometer with an accelerator allows very sensitive detection limits for many applications. At the Helmholtz-Zentrum Dresden-Rossendorf an AMS (accelerator mass spectrometry) facility, DREsden AMS (DREAMS), with a 6-MV tandem accelerator has been successfully installed [1]. DREAMS has its applications in many scientific fields by determining ^{10}Be , ^{26}Al , ^{36}Cl and ^{41}Ca . We made progress to develop a negative ion source for volatile elements like chlorine or iodine by reducing the memory effect [2]. The range of isotopes is broadened to higher masses by the first experiments with actinides. A time-of-flight beam line will enable the measurement at higher count rates and of additional isotopes. Another focus is the combination of a commercial SIMS (CAMECA 7f Auto) with the accelerator. For this so called Super-SIMS the CAMECA 7f is utilized as ion source and low energy mass spectrometer. By complete destruction of molecules in the stripping process at the terminal of the accelerator detection limits some orders of magnitude better than for traditional dynamic SIMS are expected, i.e. $\sim 10^{-9}$ – 10^{-12} , see e.g. [3]. The focus of applications will be geological samples in the framework of resource technology research. Ref.: [1] S. Akhmadaliev et al., *NIMB* 294 (2013) 5. [2] S. Pavetich et al., this conference. [3] C. Maden, *Dissertation* ETH Zürich 2003.

MS 9.2 Thu 14:30 DO24 1.205

Performance of the modified DREAMS ion source for ^{36}Cl applications — ●STEFAN PAVETICH, SHAVKAT AKHMADALIEV, SILKE MERCHEL, GEORG RUGEL, and RENÉ ZIEGENRÜCKER — Helmholtz-Zentrum Dresden-Rossendorf

First analyses of real ^{36}Cl -AMS samples were performed with the newly developed low memory-effect ion source at the DREsden Accelerator Mass Spectrometry (DREAMS) facility [1, 2]. Considerable improvements have been reached with respect to the overall ion source performance. Especially, parameters like current output, ion source fractionation effects, normalization factors, blank values and sulphur suppression factors have been investigated to enhance accuracy of ^{36}Cl -data.

Applications cover a wide spectrum, which implies also highly variable $^{36}\text{Cl}/^{35+37}\text{Cl}$ -ratios ranging from nearly background level of $\sim 10^{-15}$ up to 10^{-10} . Samples from aquifers in arid regions for groundwater dating and modelling were analysed. Meteorite samples were measured to investigate the constancy of the galactic cosmic radiation, production rates from sulphur, and reconstruction of exposure histories of individual meteorites.

Acknowledgements: C. Wilske, B. Merkel (TUBAF), T. Müller (UFZ), U. Ott (MPI Mainz), T. Smith (U Bern), G. Domènech i Surinyach (U Barcelona), DREAMS-Operators.

[1] S. Pavetich et al., *NIMB*, submitted.[2] Sh. Akhmadaliev et al., *NIMB* 294 (2013) 5.

MS 9.3 Thu 14:45 DO24 1.205

Search for supernova-produced ^{60}Fe in the microfossil record — ●PETER LUDWIG¹, SHAWN BISHOP¹, RAMON EGLI², VALENTYNA CHERNENKO¹, THOMAS FAESTERMANN¹, NICOLAI FAMULOK¹, LETICIA FIMIANI¹, THOMAS FREDERICH³, JOSE GOMEZ¹, KARIN HAIN¹, MARIANNE HANZLIK⁴, GUNTHER KORSCHINEK¹, SILKE MERCHEL⁵, and GEORG RUGEL⁵ — ¹TU München, Physik Department — ²ZAMG, Wien — ³Universität Bremen, Geowissenschaften — ⁴TU München, Fakultät für Chemie — ⁵HZDR, Dresden

Material distributed into the interstellar medium by supernova explosions can be incorporated into terrestrial archives. After the discovery of live ^{60}Fe atoms in 2-3 Myr old layers of a Pacific Ocean ferromanganese crust (Knie et al., *PRL* 93, 171103 (2004)), a confirmation of this signal, as well as a mapping of the signal with high time-resolution is desirable. Another reservoir in which the ^{60}Fe signature should have been incorporated are the fossils of magnetotactic bacteria in ocean sediment. To this end, two sediment cores from the Eastern Equatorial Pacific were obtained, iron was chemically extracted with high selectivity towards biogenic magnetite, and the extraction procedure

was characterized using novel magnetic measurements. The $^{60}\text{Fe}/\text{Fe}$ concentration in the samples was then measured with accelerator mass spectrometry at the GAMS setup in Garching. Preliminary results for both sediment cores will be reported.

MS 9.4 Thu 15:00 DO24 1.205

Production of $^{41}\text{CaH}_2$ samples for AMS measurements. Application to Interplanetary Dust Particles — ●JOSE MANUEL GOMEZ GUZMAN, SHAWN BISHOP, THOMAS FAESTERMANN, NICOLAI FAMULOK, LETICIA FIMIANI, KARIN HAIN, STEPHAN JAHN, GUNTHER KORSCHINEK, and PETER LUDWIG — TU Muenchen, Physik Department

Interplanetary Dust Particles (IDP) are small grains, generally less than a few hundred micrometers in size orbiting around the Sun. The most important source of IDP is the Asteroid Belt located at approximately 3 AU between Mars and Jupiter. During their flight from the Asteroid Belt to the Earth they are irradiated by SCR and GCR (solar and galactic cosmic rays) and ^{41}Ca is formed. ^{41}Ca ($T_{1/2}=1.03 \times 10^5$ y) can be used as a unique tracer to determine the accretion rate of IDP on Earth because there are no significant terrestrial sources for this radionuclide.

The chemical production of ^{41}Ca samples for AMS measurements can be made in two different ways: as fluoride or hydride, depending on the expected $^{41}\text{Ca}/^{40}\text{Ca}$ ratio in the samples. Since the very low expected $^{41}\text{Ca}/^{40}\text{Ca}$ ratios in IDP samples (in the order of 10^{-15}), the chemical procedure to get $^{41}\text{CaH}_2$ samples has been optimized at the Maier Leibnitz Laboratorium, presently the only AMS facility with sensitivity down to 10^{-16} for this radionuclide. First blank and standard measurements will be shown and the status of the AMS facility at MLL for the measurement of ^{41}Ca will be presented.

MS 9.5 Thu 15:15 DO24 1.205

Untersuchung des Laschamp-Events im Vansee mittels ^{10}Be — ●JOHANNES LACHNER^{1,2}, JÜRIG BEER¹, MARCUS CHRISTL³ und MONA STOCKHECKE¹ — ¹EAWAG, Dübendorf — ²Isotopenforschung und Kernphysik, Universität Wien — ³Labor für Ionenstrahlphysik, ETH Zürich

Im Rahmen des PALEOVAN (ICDP) Projektes wurden Sedimentbohrkerne des Vansees in der Türkei entnommen. Mit einer teilweise jährlichen Auflösung bietet der Vansee ein hervorragendes Sedimentarchiv zur Rekonstruktion der quartären Klimageschichte, das bis zu 600.000 Jahre in die Vergangenheit zurückreicht. Die Eignung dieses terrestrischen Archivs für hochaufgelöste ^{10}Be -Untersuchungen wurde anhand einer Studie zur Laschamp-Exkursion des Erdmagnetfelds getestet. Die Messungen wurden an der kompakten AMS Anlage Tandy durchgeführt. Experimente zur chemischen Extraktion von ^{10}Be aus dem Sediment zeigen, dass zwar eine Berücksichtigung der verschiedenen Sedimentfraktionen nötig ist, unterschiedliche Lithologien das Signal jedoch nicht deutlich beeinflussen. Die hochaufgelösten ^{10}Be Werte werden verglichen mit bekannten Daten aus Eisbohrkernen.

MS 9.6 Thu 15:30 DO24 1.205

Quantifizierung glazialer Erosion mit kosmogenen Nukliden — ●CHRISTIAN WIRSIG¹, SUSAN IVY-OCHS¹, MARCUS CHRISTL¹, CHRISTOF VOCKENHUBER¹, JÜRIGEN REITNER², MATTHIAS BICHLER³, MARTIN REINDL³, CHRISTIAN SCHLÜCHTER⁴ und HANS-ARNO SYNAL¹ — ¹Labor für Ionenstrahlphysik, ETH Zürich, Schweiz — ²Geologische Bundesanstalt, Wien, Österreich — ³Department of Environmental Geosciences, Universität Wien, Österreich — ⁴Institut für Geologie, Universität Bern, Schweiz

Kosmogene Nuklide bilden sich in situ in Gestein, das kosmischer Strahlung ausgesetzt ist. Durch Neutronen-induzierte Spallation gebildete Nuklide entstehen grösstenteils in den obersten 2-3 m der ausgesetzten Gesteinsoberfläche. Muonen hingegen dringen tiefer in Materie ein und bewirken auch dort die Entstehung von kosmogenen Nukliden.

Unter der Annahme, dass Nuklidbestände aus vorhergehenden Expositionen beseitigt wurden, ermöglichen AMS Messungen von ^{10}Be oder ^{26}Al so die Datierung der Freilegung von Oberflächen, etwa seit dem Rückzug einer Eismasse, die das Gestein zuvor abgedeckt hatte. Ist das Expositionsalter der Gesteinsoberfläche hingegen bekannt, ermöglicht die Messung der Nuklidkonzentration eine Analyse der subglazialen Erosion während des letzten Gletschervorstosses. Wir

präsentieren erste Ergebnisse einer derartigen Studie am Goldbergkees im Nationalpark Hohe Tauern, Österreich.

MS 9.7 Thu 15:45 DO24 1.205

Deep-Sea Astronomy with Accelerator Mass Spectrometry — ●JENNY FEIGE¹, ANTON WALLNER², L. KEITH FIFIELD², GUNTHER KORSCHINEK³, SILKE MERCHEL⁴, GEORG RUGEL⁴, PETER STEIER¹, STEVE TIMS², STEPHAN R. WINKLER¹, and ROBIN GOLSER¹ — ¹University of Vienna, Austria — ²ANU Canberra, Australia — ³TUM, Germany — ⁴HZDR, Germany

Accelerator Mass Spectrometry (AMS) is a highly sensitive method to measure extremely low isotopic ratios of long-lived radionuclides relative to its stable isotope. Inspired by findings of an excess of ⁶⁰Fe

in a ferromanganese crust approximately 2 Myr ago, which was interpreted to be of supernova-origin, we use this method to determine concentrations of a variety of radionuclides in deep-sea sediment samples covering a time range from 1.7 to 3.2 Myr.

An international collaboration of different AMS facilities is utilized to search for signatures of ²⁶Al, ⁵³Mn, and ⁶⁰Fe above terrestrial background production and extraterrestrial influx. In addition, the cosmogenic radionuclide ¹⁰Be is measured to confirm existing magnetostratigraphic dating of the samples and for comparison with atmospheric production ratios of ²⁶Al/¹⁰Be. All ¹⁰Be and ²⁶Al measurements are finished, ⁵³Mn and ⁶⁰Fe is in progress. Measurement results and the influence of different background sources on a potential supernova signature will be presented and discussed.

MS 10: Accelerator Mass Spectrometry and Applications 3

Time: Thursday 16:30–18:30

Location: DO24 1.205

Invited Talk MS 10.1 Thu 16:30 DO24 1.205

Towards a compact multi isotope AMS system - status and applications — ●MARCUS CHRISTL, SASCHA MAXEINER, JOHANNES LACHNER, CHRISTOF VOCKENHUBER, ARNOLD MÜLLER, NURIA CASACUBERTA, and HANS-ARNO SYNAL — Laboratory of Ion Beam Physics, ETH Zurich, Otto-Stern-Weg 5, 8093 Zurich, Switzerland

During recent years, significant progress has been made towards more efficient detection of light and heavy ions at low energies. The application of He gas in the stripping process, where negative ions are transformed into positive, provides high yields for comparably low charge states. Additionally, scattering losses of the ion beam are minimized due to the low nuclear charge of He. The combination of these effects generally allows the construction of a compact multi-isotope system operating at 300 kV that is capable of ultra-trace analyses of heavy ions. This presentation will give an overview about the status of all nuclides currently measured at the 0.5 MV ETH AMS system Tandy and discuss the potential of a compact multi-isotope AMS system operated by a conventional 300 kV power supply. Recent projects will be highlighted from different fields of applications including Pu samples from Fukushima, ¹²⁹I, ²³⁶U, and Pu isotopes in the North Atlantic Ocean, and the higher actinides in human urine samples.

MS 10.2 Thu 17:00 DO24 1.205

Messstabilität an der myCADAS Anlage — ●MARTIN SEILER, SASCHA MAXEINER und HANS-ARNO SYNAL — Labor für Ionenstrahlphysik, ETH Zürich, Schweiz

Die myCADAS Anlage ist eine experimentelle Plattform für den massenspektrometrischen Nachweis von ¹⁴C. Das Untergrundniveau erlaubt das Messen von Proben mit einem Alter von bis zu 40'000 Jahren. Bisherige Optimierungen zielten darauf ab den Untergrund zu reduzieren und die Effizienz zu steigern. Ein wesentlicher Punkt ist jedoch auch die Stabilität der Messbedingungen, um eine hohe Präzision zu erreichen. Ein Hauptproblem dabei ist der Phasenraum des Ionenstrahls, der bei Energien von etwa 45 keV wesentlich grösser ist, als bei anderen AMS-Systemen. Der Phasenraum der Ionenquelle wurde vermessen, um die Verluste zu minimieren. Limitierend ist dabei in erster Linie der Stripper, dessen Dimensionen jedoch auch durch den Gasfluss eingeschränkt werden. Einerseits muss die Flächendichte des Gases ausreichend sein, um eine Zerstörung von Molekülen zu gewährleisten, andererseits führt ein zu hoher Druck in den Filterelementen des Spektrometers zu zusätzlichen Verlusten und erhöhtem Untergrund. Die Anpassungen am Stripperrohr und der differentiellen Pumpstufe werden im Vortrag erklärt und ihre Auswirkungen auf die Stabilität der Messung aufgezeigt.

MS 10.3 Thu 17:15 DO24 1.205

Siliziumnitridfolien für die Trennung von Isobaren in der AMS - einige grundsätzliche Überlegungen — ●MARTIN SUTER — Labor für Ionenstrahlphysik, ETH Zürich

Siliziumnitridfolien werden in der AMS für die Isobarentrennung verwendet. Isobare verlieren beim Durchgang nicht gleich viel Energie und können somit mit einem weiteren Analyse System getrennt werden. Siliziumnitrid-Folien eignen speziell dafür, weil sie sehr homogen und robust gegen Strahlenschäden sind. Wie optimiert man diese Methode für ein bestimmtes Isobarenpaar um möglichst hohe Transmission und andererseits gute Trennung zu erhalten? Zu dieser Frage werden

ein paar grundlegende Faktoren diskutiert wie Verluste durch Winkel und Energie-Aufstreuung, sowie Ladungshäufigkeiten hinter der Folie. Die Unterdrückungsfaktoren hängen vom Unterschied des Bremsvermögens und Energieaufstreuung ab. Ebenso spielt die Auflösung des Instruments eine Rolle. Anhand von Modellrechnungen wird das Potenzial der Methode für verschiedene Isobaren-Systeme (¹⁰Be-¹⁰B, ²⁶Al-²⁶Mg, ³²Si-³²S, ³⁶Cl-³⁶S, ⁵³Mn-⁵³Cr, ⁶⁰Fe-⁶⁰Ni) aufgezeigt und mit Daten von Experimenten verglichen.

MS 10.4 Thu 17:30 DO24 1.205

Untersuchung des Energiestraggling in Si₃N₄ mit Hilfe eines Flugzeitmassenspektrometers — ●CLAUS FEUERSTEIN, STEFAN HEINZE, ALFRED DEWALD, CLAUS MÜLLER-GATERMANN und ALEXANDER STOLZ — Institut für Kernphysik, Universität zu Köln

Fast alle Verfahren zur Isobarentrennung bei AMS-Messungen nutzen die Z-Abhängigkeit des Energieverlustes (dE/dx)(Z) aus. Während der Energieverlust und das Winkelstraggling von gängigen Programmen (SRIM, LISE++, ...) für viele Anwendungen ausreichend gut berechnet werden können, sind die theoretischen Vorhersagen zum Energiestraggling eher unzureichend. Aus diesem Grund haben wir für unterschiedlich schwere Ionen das Energiestraggling im Energiebereich von 20 MeV bis 50 MeV in Si₃N₄-Folien verschiedener Dicken gemessen. Hierfür wurde das Flugzeitpektrometer von CologneAMS verwendet. Wir präsentieren unsere Messergebnisse und vergleichen sie mit gängigen Modellrechnungen. Darüber hinaus diskutieren wir Konsequenzen für zukünftige Messaufbauten am CologneAMS.

MS 10.5 Thu 17:45 DO24 1.205

Simulationen zur Bestimmung von Gasverteilung und Projektilstreuung im Gasstripper — ●SASCHA MAXEINER, MARTIN SUTER, MARCUS CHRISTL und HANS-ARNO SYNAL — Labor für Ionenstrahlphysik, ETH Zürich

Das Grundprinzip der Tandem AMS beruht auf der Umladung von negativen Ionen zu positiven im sogenannten Stripper. Durch Verwendung von leichtem Strippergas He werden für leichte wie schwere Ionen höhere Ladungsausbeuten, sowie geringere Verluste durch Winkelstreuung erreicht, als mit Gasen wie z.B. N₂ oder Ar. Um die Streuverluste zu quantifizieren, wurde ein Monte Carlo Programm entwickelt, welches unter Berücksichtigung der räumlichen Dichte-Verteilung des Strippergases die elastische Streuung an den Kernen der Strippergasatome simuliert. Die Simulation erklärt die experimentell gemessenen Transmissionswerte gut. Für Energien um 300 keV und für schwere Projektile wie z.B. den Aktiniden, ist der Energieverlust durch Wechselwirkung mit den Elektronenhüllen der He-Atome nahezu vernachlässigbar. Die Simulation vermag daher die experimentell gemessenen Strahlprofile nach dem Hochenergiemagneten gut zu erklären.

Mit Hilfe des neu entwickelten Simulationsalgorithmus kann nun die Geometrie eines Gastrippers auf maximale Transmission optimiert werden. Gleichzeitig ist es möglich, den Gasfluss in die Region des Strahltransports zu simulieren und damit den durch Wechselwirkung mit residualen Gasatomen verursachten Untergrund zu minimieren. Die Funktionsweise des Algorithmus wird anhand einfacher Beispiele erläutert.

MS 10.6 Thu 18:00 DO24 1.205

First photodetachment experiments at ILIAS and their relevance for AMS — ●MARTIN MARTSCHINI¹, PONTUS ANDERSSON²,

ROBIN GOLSER¹, DAG HANSTORP³, JOHANNES LAHNER¹, ALFRED PRILLER¹, and OLIVER FORSTNER¹ — ¹VERA Laboratory, Faculty of Physics, University of Vienna, Austria — ²Earth and Space Sciences Department, Chalmers Technical University, Gothenburg, Sweden — ³Department of Physics, University of Gothenburg, Sweden

The Ion Laser Interaction Setup ILIAS is a facility at the VERA Laboratory of the University of Vienna to study selective isobar suppression by laser photodetachment of negative ions. It provides mass-separated beams of negative atomic or molecular ions with energies up to 30 keV from a Middleton type cesium sputter ion source. In the final setup, a gas-filled radio frequency quadrupole cooler is used to overlap the ion beam with a strong continuous wave laser beam. This ion cooler is currently in the commissioning phase. With a recently built neutral particle detector and two electrostatic beam benders however, first photodetachment experiments with atomic and molecular ions were conducted in a crossed beam setup. Results of these measurements as well as first test results for the performance of the ion cooler will be presented and their relevance for AMS will be discussed.

MS 10.7 Thu 18:15 DO24 1.205

Status of the ILIAS project for selective isobar suppression by Laser photodetachment — ●OLIVER FORSTNER^{1,2}, PONTUS

ANDERSSON³, ROBIN GOLSER¹, DAG HANSTORP⁴, JOHANNES LAHNER¹, MARTIN MARTSCHINI¹, ALFRED PRILLER¹, and PETER STEIER¹ — ¹VERA Laboratory, Faculty of Physics, University of Vienna, Austria — ²Stefan-Meyer-Institut, Austrian Academy of Sciences, Vienna, Austria — ³Department of Earth and Space Sciences, Chalmers University of Technology, Sweden — ⁴Department of Physics, University of Gothenburg, Sweden

The ILIAS setup (Ion Laser InterAction Setup) at the University of Vienna provides mass separated beams of negative ions with energies up to 30 keV. It was constructed to study Laser photodetachment of negative ions and evaluate its applicability for selective isobar suppression in mass spectrometry. The negative ions are produced in a Middleton type cesium sputter ion source, mass selected and stopped in a gas-filled radio frequency quadrupole cooler where they can be overlapped with a strong continuous wave Laser beam. By careful selection of the photon energy only unwanted isobars are neutralized while the isobar of interest remain as ions.

After a description of the setup first photodetachment experiments of atomic and molecular ions with the RFQ cooler are presented. Furthermore, a possible scheme for application of this new method to a 3 MV AMS facility will be described.

MS 11: SIMS / Accelerator Mass Spectrometry and Applications 4

Time: Friday 10:30–12:30

Location: DO24 1.205

Invited Talk MS 11.1 Fri 10:30 DO24 1.205
Environmental sample analysis by SIMS in the search for undeclared nuclear activities — ●MAGNUS HEDBERG — European Commission, Joint Research Centre (JRC), Institute for Transuranium Elements, P.O. Box 2340, D-76125 Karlsruhe, Germany

When uranium is processed in industrial quantities, it is very difficult to avoid the release of micron to submicron-sized aerosol particles containing the isotopic signature of the handled materials to the immediate environment. This allows nuclear safeguards authorities to monitor the used nuclear materials by analysing dust samples from the facilities. Until recently, particle analyses have predominantly been performed by SIMS using the small geometry CAMECA IMS 3F-7F instruments. The performance of these instruments is however limited for these samples by the occurrence of isobaric interferences that cannot be resolved without compromising the transmission. A recent breakthrough to solve this problem has been the implementation of Large Geometry (LG)-SIMS, mainly by the CAMECA IMS 1280HR. These instruments are like the small geometry SIMS, based on a double focusing mass spectrometer, but with the implementation of a large-radius magnetic sector and improved secondary ion optics. In short, the LG-SIMS today provides isotopic data on particle analysis in safeguards applications that are at a state of the art level in a timely way. The latter is important for the safeguards application, where timely analysis can be critical. A short introduction to nuclear safeguards and forensics analysis are given together with a presentation of how LG-SIMS is used for safeguards analysis.

MS 11.2 Fri 11:00 DO24 1.205

AMS measurements of global fallout U-236 and Pu in an ombrotrophic peat profile: evidence for their post depositional migration — ●FRANCESCA QUINTO¹, ERICH HRNECEK¹, MICHAEL KRACHLER¹, WILLIAM SHOTYK², PETER STEIER³, STEPHAN WINKLER³, and ROBIN GOLSER³ — ¹European Commission Joint Research Centre, Institute for Transuranium Elements, P.O. Box 2340, 76125 Karlsruhe, Germany — ²Department of Renewable Resources, University of Alberta, 839 General Services Building, Edmonton, AB, Canada T6G 2H1 — ³VERA Laboratory, Faculty of Physics, University of Vienna, Währinger Straße 17, A-1090 Vienna, Austria

U-236, Pu-239, Pu-240, Pu-241 and Pu-242 were analysed in an ombrotrophic peat core representing the last 80 years of atmospheric deposition. The determination of these isotopes at femtogram and atogram levels was possible by using ultra-clean laboratory procedures and accelerator mass spectrometry. Since the Pu isotopic composition characteristic for global fallout, as well as anthropogenic U-236, were identified in peat samples pre-dating the period of atmospheric atom bomb testing, migration of Pu and U within the peat profile is clearly indicated. The vertical profile of the U-236/U-238 isotopic ratio rep-

resents the first observation of the U-236 bomb peak in a terrestrial environment. Comparing the abundances of the global fallout derived U-236 and Pu-239 along the peat core, the post depositional migration of plutonium exceeds that of uranium. These results highlight, for the first time, the mobility of Pu and U in a peat bog with implications for their migration in other acidic, organic rich environments.

MS 11.3 Fri 11:15 DO24 1.205

AMS of I-129: cross contamination and its correction — ●CHRISTOF VOCKENHUBER — ETH Zurich, Labor für Ionenstrahlphysik, Zürich, Schweiz

Low-energy AMS is well suited for measurements of the long-lived nuclide ¹²⁹I because the interfering stable isobar ¹²⁹Xe does not form negative ions, thus high ion energies are not required for discrimination in the final detector. Furthermore, low-energy AMS has the advantage that in combination with helium stripping the most probable charge state can be selected; in our case at the TANDY running at 300 kV we select charge state 2+ with a transmission of > 50%. With a proper spectrometer at the high-energy side interferences of the stable isotope ¹²⁷I can be completely eliminated.

Contrary to many AMS nuclides ¹²⁹I readily forms negative ions and the overall efficiency is high. The challenges lie more in the ion source where cross contamination can be quite severe due to the volatile nature of iodine. This is particularly of importance when analyzing samples that are influenced from anthropogenic sources because the isotopic ratios can span several orders of magnitude. On the other hand special care must be taken when analyzing samples with low isotopic ratios (¹²⁹I/¹²⁷I < 10⁻¹³) or samples with very low iodine content (carrier free samples) due to the very same reason.

This talk will discuss the advantages and challenges of low-energy AMS of I-129 with the focus on the issues with cross contamination and its correction.

MS 11.4 Fri 11:30 DO24 1.205

Anwendung von AMS zur Bestimmung von Iod-129 in Bodenprofilen in der Nord- und Südhalbkugel — ●ABDELOUAHED DARAOU¹, MAREIKE SCHWINGER¹, BEATE RIEBE¹, CHRISTOF VOCKENHUBER², HANS-ARNO SYNAL² und CLEMENS WALTHER¹ — ¹Institut für Radioökologie und Stahlschutz, Uni Hannover, Deutschland — ²Labor für Ionenstrahlphysik, Zürich, Schweiz

Die Ausbreitung von I-129 in der Umwelt ist in den letzten Jahrzehnten verstärkt in den Fokus der Wissenschaft gerückt. Das Gleichgewicht zwischen dem stabilen I-127 und dem I-129 ist aufgrund der kontinuierlichen Freisetzung von I-129 durch die Wiederaufarbeitungsanlagen (Sellafield und La Hague), aber auch durch in der Vergangenheit durchgeführte Atomwaffentests sowie durch nukleare Unfälle (Chernobyl und Fukushima) stark verändert. Der Iod-Gehalt im Boden ist das Ergebnis des Eintrags von Iod aus der Atmosphäre über nasse und trockene

Deposition. Das Migrationsverhalten von I-129 im Boden wird unter anderem durch seine Wechselwirkung mit Metalloxiden sowie organischen Bestandteilen bestimmt. AMS ist eine sensitive Methode für die Bestimmung von I-129. Die Nachweisgrenze für das I-129/I-127 liegt im Bereich von $1\text{E-}14$. Damit ist die AMS für die Untersuchung von I-129 sowohl in prä-nuklearen wie auch in kontaminierten Umweltproben geeignet. In dieser Arbeit berichten wir über die Untersuchung der Deposition und des Migrationsverhaltens von I-127 und I-129 in Böden der Nordhalbkugel (Deutschland, Ukraine) und der Südhalbkugel (Japan, Chile). Auf diese Weise ist es möglich, Rückschlüsse bezüglich der jeweiligen Kontaminationsquellen zu ziehen.

MS 11.5 Fri 11:45 DO24 1.205

^{236}U and ^{129}I as tracers of water masses in the Arctic Ocean — •NÚRIA CASACUBERTA¹, MARCUS CHRISTL¹, CHRISTOF VOCKENHUBER¹, CLEMENS WALTHER², MICHIEL VAN-DER-LOEFF³, PERE MASQUÉ⁴, and HANS-ARNO SYNAL¹ — ¹Laboratory of Ion Beam Physics, ETH-Zurich, Switzerland — ²Institut für Radioökologie und Strahlenschutz, Leibniz Universität Hannover, Germany — ³AWI-Geochemistry, Alfred Wegener Institut Für Polar und Meeresforschung, Bremerhaven, Germany. — ⁴Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, Bellaterra, Spain

Recently ^{236}U attested to be a new transient oceanographic tracer: it is conservative in seawater and far from having reached steady state in the oceans. Its main sources in the North Atlantic are global fallout and European reprocessing plants. In this study, concentrations of ^{236}U and ^{129}I of eight deep profiles in the Arctic Ocean collected in 2011-2012 were determined with a compact ETH Zurich AMS system (TANDY). Results on $^{236}\text{U}/^{238}\text{U}$ show a steep gradient, from the lowest ever-reported $^{236}\text{U}/^{238}\text{U}$ atomic ratio in open ocean water (5 ± 5) $\times 10^{-12}$ up to $(3700\pm 80) \times 10^{-12}$. Whereas the very low ratios are indicative for deep old waters, high ratios in shallow and surface waters show a clear signature of Atlantic Waters (AW) penetrating to the Arctic Ocean. The combination of ^{236}U with ^{129}I , both being released by the nuclear reprocessing plants of Sellafield and La Hague, with a distinct temporal input function, is used to estimate transit time of AW distributions in the Arctic Ocean.

MS 11.6 Fri 12:00 DO24 1.205

Analysis of Primordial Nuclides in High Purity Copper with Accelerator Mass Spectrometry — NICOLAI FAMULOK, •KARIN HAIN, THOMAS FAESTERMANN, LETICIA FIMIANI, JOSÉ GOMEZ GUZMAN, PETER LUDWIG, GUNTHER KORSCHINEK, and STEFAN SCHÖNERT — Technische Universität München, Physik Department, Garching

The sensitivity of experiments in rare event physics like neutrino or direct dark matter detection crucially depends on the background level. Therefore, all material surrounding the detectors requires low contamination of radionuclides to not create additional background. A significant contribution originates from the primordial actinides thorium and uranium and the progenies of their decay chains.

At the Maier Leibnitz Laboratorium in Munich the applicability of ultra-sensitive Accelerator Mass Spectrometry (AMS) for the direct detection of thorium and uranium impurities in a copper matrix was tested for the first time. For this special purpose, Th and U were extracted from the ion source as a copper compound. Two different samples of copper and one sample of a copper alloy were investigated. The lowest concentrations achieved with these first AMS measurements were $(1.4\pm 0.6)\cdot 10^{-11}$ g/g for thorium and $(7\pm 4)\cdot 10^{-14}$ g/g for uranium which correspond to (56 ± 16) $\mu\text{Bq/kg}$ and (0.9 ± 0.5) $\mu\text{Bq/kg}$, respectively.

The particular requirements on the AMS technique and the developed measurement procedure will be presented, followed by a discussion of the results of the first measurements.

MS 11.7 Fri 12:15 DO24 1.205

The upgrade of VERA for natural ^{236}U - first results on detection efficiency and background — •PETER STEIER, JOANNES LACHNER, ALFRED PRILLER, STEPHAN WINKLER, and ROBIN GOLSER — Universität Wien, Fakultät für Physik, VERA Labor, Währingerstraße 17, 1090 Wien, Österreich

Interest in the long-lived radioisotope ^{236}U ($t_{1/2}=23.4$ million years) has significantly increased recently, due to the emergence of environmental and earth science applications. Of the AMS instruments suited, none could achieve the sensitivity to address the expected typical natural isotopic ratios on the order $^{236}\text{U}:^{238}\text{U} = 10^{-13}$. One major limitation is the relatively low total detection efficiency. Stripping with helium was shown to be advantageous at lower energies [1]. We have implemented this capability at VERA, which improved the yield by a factor of four. The second instrumental limitation is background caused by ^{235}U hydrides. With our recently installed additional 90° magnet, we can suppress this background by several orders of magnitude. Our first measurements indicate a new instrumental limit below $^{236}\text{U}:^{238}\text{U} = 10^{-14}$, however, improved chemical procedures are still under development to extract such pure uranium from geological samples. Measurements of anthropogenic ^{236}U and other actinides profit from the higher sensitivity allowing for smaller samples.

[1] Vockenhuber, C., et al., The potential of He stripping in heavy ion AMS. Nucl. Instr. and Meth. in Phys. Res. B 294 (2013) 382-386.