Mass Spectrometry Division
Fachverband Massenspektrometrie (MS)

Robin Golser
Faculty of Physics
University of Vienna
Währinger Str. 17
1090 Vienna
robin.golser@univie.ac.at

Overview of Invited Talks and Sessions

(Lecture room R 1.020; Poster Redoutensaal and Wassersaal)

Invited Talks

MS 1.1	Mon	10:30–11:00	R 1.020	**An Improved Value of the Atomic Mass of the Proton** — •Florian Köhler-Langes
MS 2.1	Mon	14:00–14:30	R 1.020	**Production, Separation and Implantation of ^{163}Ho for Neutrino Mass Measurements** — •Tom Kieck, Holger Dorrer, Christoph E. Düllmann, Klaus Eberhardt, Lisa Gamer, Christian Enss, Loredana Gastaldo, Clemens Hassel, Ulli Köster, Christoph Mokry, Jörg Runke, Andreas Türler, Klaus Wendt
MS 3.1	Mon	16:15–16:45	R 1.020	**Direkte Massenmessungen der schwersten Elemente** — •Michael Block
MS 4.1	Tue	14:00–14:30	R 1.020	**First molecular beam cooled to its lowest quantum states at the Heidelberg Cryogenic Storage Ring** — •Christian Meyer, Arno Becker, Klaus Blaum, Christian Breitenfeldt, Sebastian George, Jürgen Göck, Manfred Grieser, Florian Grussie, Claude Krantz, Holger Kreckel, Preeti M. Mishra, Oldřich Novotný, Felix Nuesslein, Aodh P. O'Connor, Roland Repnow, Sunny Saurabh, Stefan Schippers, Lutz Schweikhard, Kaija Spruck, Stephen Vogel, Robert von Hahn, Patrick Wilhelm, Andreas Wolf
MS 5.1	Wed	14:00–14:30	R 1.020	**Nachweis von Beryllium-10 aus exotischen Zerfällen mit Hilfe von Beschleunigermassenspektrometrie (AMS)** — •Oliver Forstner, Silke Merchel, Johannes Lachner, IS541 Kollaboration
MS 6.1	Thu	10:30–11:00	R 1.020	**High precision radiocarbon analysis of annual tree-ring samples** — •Lukas Wacker, Stephanie Arnold, Silvia Bollhalder Lück, Marcus Christl, Hans-Arno Synal
MS 6.4	Thu	11:30–12:00	R 1.020	**A Gas Ion Source and its extension by Laser Ablation for Online Radiocarbon Analyses** — •Christiane Yeman, Lukas Wacker, Bodo Hattendorf, Marcus Christl, Caroline Welte, Hans-Arno Synal

Invited talks of the joint symposium SYPS

See SYPS for the full program of the symposium.

SYPS 1.1	Mon	14:00–14:30	RW HS	**Floquet engineering of interacting quantum gases in optical lattices** — •André Eckardt
SYPS 1.2	Mon	14:30–15:00	RW HS	**Experiments on driven quantum gas and surprises** — •Cheng Chin
SYPS 1.3	Mon	15:00–15:30	RW HS	**Exploring 4D Quantum Hall Physics with a 2D Topological Pumps** — •Oded Zilberberg, Michael Lohse, Christian Schweizer, Immanuel Bloch, Hannah Price, Yaacov Kraus, Sheng Huang, Mohan Wang, Kevin Chen, Jonathan Guglielmon, Mikael Rechtsman
SYPS 1.4	Mon	15:30–16:00	RW HS	**Floquet Discrete Time Crystals in a Trapped-Ion Quantum Simulator** — •Guido Pagano, Jiehang Zhang, Paul Hess, Antonis Kyprianidis, Patrick Becker, Jacob Smith, Aaron Lee, Norman Yao, Tobias Grass, Alessio Celi, Maciej Lewenstein, Christopher Monroe

Invited talks of the joint symposium SYAD

See SYAD for the full program of the symposium.

SYAD 1.1	Tue	10:30–11:00	RW HS	**Integrated photonic quantum walks in complex lattice structures** — •Markus Graefe
SYAD 1.2	Tue	11:00–11:30	RW HS	**Testing the Quantumness of Atom Trajectories** — •Carsten Robens
SYAD 1.3	Tue	11:30–12:00	RW HS	**Engineering and probing topological bands with ultracold atoms** — •Nick Fläschner
SYAD 1.4	Tue	12:00–12:30	RW HS	**Statistical signatures of many-particle interference** — •Mattia Walschaers

Sessions

MS 1.1–1.5	Mon	10:30–12:00	R 1.020	**Precision Mass Spectrometry 1**
MS 2.1–2.5	Mon	14:00–15:30	R 1.020	**Laser Assisted Mass Spectrometry**
MS 3.1–3.3	Mon	16:15–17:15	R 1.020	**Precision Mass Spectrometry 2**
MS 4.1–4.2	Tue	14:00–14:45	R 1.020	**New Developments**
MS 5.1–5.6	Wed	14:00–15:45	R 1.020	**Accelerator Mass Spectrometry 1**
MS 6.1–6.4	Thu	10:30–12:00	R 1.020	**Accelerator Mass Spectrometry 2**
MS 7	Thu	14:00–14:30	R 1.020	**Annual General Meeting of the Mass Spectrometry Division**
MS 8.1–8.4	Thu	14:30–15:30	R 1.020	**Accelerator Mass Spectrometry 3**
MS 9.1–9.5	Thu	16:15–18:15	Redoutensaal	**Poster 1**
MS 10.1–10.10	Thu	16:15–18:15	Orangerie	**Poster 2**

Annual General Meeting of the Mass Spectrometry Division

Thursday 14:00–14:30 R. 1.020

MS 1: Precision Mass Spectrometry 1

Time: Monday 10:30–12:00 Location: R 1.020

Invited Talk MS 1.1 Mon 10:30 R 1.020

An Improved Value of the Atomic Mass of the Proton — •Florian Köhler-Langes — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

In combination with the neutron and the electron, the proton is one of the basic building blocks of atomic matter. The precise knowledge of its properties, e.g. its mass, is of utmost importance for tests of fundamental physics and the clarification of 3 to 4 sigma discrepancies between high-precision mass measurements of various light atoms.

Therefore, a new cryogenic five-fold Penning trap setup was constructed. The measurement principle is based on a phase-sensitive comparison of the proton's cyclotron frequency to that of a bare carbon nucleus. In order to measure both frequencies in the same electric and magnetic field configuration, both single ions are transported alternately into an ultra-harmonic Penning trap, consisting of seven cylindrical electrodes. Exactly the same electric field configuration for both ions with different charge/mass ratio requires two separate, precisely tuned axial resonators for non-destructive frequency detection.

At this conference, the new experimental setup will be introduced and the latest result on the atomic mass of the proton will be presented. This new value is 3 times more precise than the current literature value and reveals a disagreement of about 3 standard deviations to it [1]. Aiming for relative precisions of a few parts per trillion the next upgrade will be discussed.

[1] F. Heiße et al., Phys. Rev. Lett. 119, 033001 (2017)

MS 1.2 Mon 11:00 R 1.020

Towards parts per trillion mass measurements on light nuclei — •Sascha Rau[1], Fabian Heisse[1,2], Florian Köhler-Langes[1], Wolfgang Quint[2], Günter Werth[3], Michael Jentschel[4], Sven Sturm[1], and Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany — [2]GSI-Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt, Germany — [3]Institut für Physik, Johannes Gutenberg-Universität Mainz, D-55099 Mainz, Germany — [4]Nuclear and Particle Physics Group, Institut Laue-Langevin, Grenoble, France

Light nuclei play a fundamental role in physics. The proton and the neutron, together with the electron make up all matter we encounter in our everyday life, making their properties highly interesting for metrology. Another application is the determination of the electron-antineutrino mass at KATRIN [1], where the mass difference of tritium and helium-3 is required.

We developed a cryogenic Penning-trap setup dedicated to mass measurements on light ions. With this setup we were recently able to measure the proton's atomic mass at a relative uncertainty of 3×10^{-11} by comparing the cyclotron frequencies of a proton and a $^{12}C^{6+}$-ion utilizing a phase-sensitive measurement technique [2].

In this talk I will present our progress to push relative mass uncertainties down to the 10^{-12}-regime and extend the measurement to other light ions.

[1] E. W. Otten & C. Weinheimer, Rep. Prog. Phys. 71, 086201 (2008)
[2] F. Heiße et al., Phys. Rev. Lett. 119, 033001 (2017)

MS 1.3 Mon 11:15 R 1.020

Precision Measurements of Neon Isotopes at THe-Trap — •Tom Segal, Martin Höcker, Jochen Ketter, Marc Schuh, Sebastian Streubel, and Klaus Blaum — Max-Planck-Institut für Kernphysik

THe-Trap is a precision Penning-trap mass spectrometer [1] at the Max-Planck-Institut für Kernphysik (MPIK) in Heidelberg. It aims to solve the 4-σ discrepancy in the mass measurements of helium-3 [2,3] by measuring its mass with a relative uncertainty of about 10^{-10}. Left unresolved, the discrepancy increases the uncertainties of the hydrogen and deuterium masses, as well as the values of physical constants such as h, k_B and N_A. A new gas injection system was developed in preparation for the helium measurement. To test it, neon gas was successfully injected into the traps region and ionized by a field emission point. The produced ions were trapped and their cyclotron frequency measured. The measurement process will be presented, as well as preliminary mass results for ^{20}Ne, ^{22}Ne and future plans.

[1] S. Streubel *et al.*, Applied Physics B: Lasers and Optics (2014), 114(1-2), 137-145
[2] R.S. Van Dyck *et al.*, Metrologia (2015), Volume 52, Number 2
[3] E.G. Meyers *et al.*, Phys. Rev. Lett (2015), 144,013003

MS 1.4 Mon 11:30 R 1.020

Current status of the high-precision Penning-trap mass spectrometer Pentatrap — •M. Door[1], J. R. Crespo López-Urrutia[1], S. Eliseev[1], P. Filianin[1], Y. Novikov[2], A. Rischka[1], R. X. Schüssler[1], Ch. Schweiger[1], S. Sturm[1], S. Ulmer[3], and K. Blaum[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Peterburg Nuclear Physics Institute, 188300 Gatchina, Russia — [3]RIKEN, Ulmer Fundamental Symmetries Laboratory, Wako, Saitama 351-0198, Japan

The high-precision Penning-trap mass spectrometer Pentatrap [1] is being commissioned at the Max-Planck-Institut für Kernphysik in Heidelberg. We are aiming at mass ratio measurements of stable and long-lived highly charged ions with relative uncertainties of 10^{-11}. This allows, among others, contributions to neutrino physics research, i.e. the mass difference of the mother and daughter nuclide of the electron capture decay of ^{163}Ho to ^{163}Dy or a direct test of special relativity [2], i.e. via the mass difference of the mother and daughter nuclide of the neutron capture in ^{35}Cl to ^{36}Cl. After a revision of the cryogenic setup and the ion transfer beamline we have recently trapped the first single ion in our trap system, demonstrated transport between traps and showed full control over the three eigenmotions by means of resonant dipolar and quadrupolar radiofrequency excitations.

This contribution will report on the experimental setup and current to near future measurements at Pentatrap.

[1] Repp, J. et al., Appl. Phys. B 107, 983 (2012)
[2] Rainville, S. et al., Nature 438, 1096, (2005)

MS 1.5 Mon 11:45 R 1.020

SHIPTRAP upgrades for mass measurements beyond Z=103 — •M. Eibach[1,2], K. Blaum[3], M. Block[2,4,5], S. Chenmarev[3], P. Chhetri[6], S. Eliseev[3], P. Filianin[3,7], F. Giacoppo[2,4], S. Götz[2,4,5], Yu. Gusev[7], F.-P. Hessberger[2,4], O. Kaleja[3,5], M. Laatiaoui[8], S. Lohse[4,5], E. Minaya Ramirez[9], A. K. Mistry[2,4], T. Murböck[2,4], Yu. Novikov[7,10], S. Raeder[2,4], D. Rodriguez[11], F. Schneider[2,4], L. Schweikhard[1], and P. Thirolf[12] — [1]Universität Greifswald — [2]GSI Darmstadt — [3]MPIK Heidelberg — [4]Helmholtz Institut Mainz — [5]Universität Mainz — [6]TU Darmstadt — [7]PNPI KI Gatchina — [8]KU Leuven — [9]IPN Orsay — [10]SPbSU St.Petersburg — [11]Universidad de Granada — [12]LMU München

With the goal of locating the island of stability, it is essential to study the predictive power of nuclear mass models. This for example is carried out with precise mass measurements of the heaviest nuclei which provide anchor points for nuclear masses. In previous experiments, the masses of several $_{102}$No and $_{103}$Lr isotopes have been measured directly for the first time with the Penning-trap mass spectrometer SHIPTRAP. Further extending mass spectrometry towards the superheavy elements required accommodating the low production rates through major modifications. The Penning-trap system was moved to a new location in order to integrate a cryogenic buffer-gas cell for a more efficient thermalization of the fusion-evaporation products of interest.

An overview of the technical developments and the latest high-precision off-line measurements in the context of neutrino and nuclear astrophysics will be presented in this contribution.

MS 2: Laser Assisted Mass Spectrometry

Time: Monday 14:00–15:30 Location: R 1.020

Invited Talk MS 2.1 Mon 14:00 R 1.020

Production, Separation and Implantation of ^{163}Ho for Neutrino Mass Measurements — •Tom Kieck[1], Holger Dorrer[1], Christoph E. Düllmann[1,2], Klaus Eberhardt[1], Lisa Gamer[3], Christian Enss[3], Loredana Gastaldo[3], Clemens Hassel[3], Ulli Köster[4], Christoph Mokry[1], Jörg Runke[1,2], Andreas Türler[5], and Klaus Wendt[1] — [1]JGU, Mainz, Germany — [2]GSI, Darmstadt, Germany — [3]Heidelberg University, Heidelberg, Germany — [4]ILL, Grenoble, France — [5]PSI, Villigen and University of Bern, Bern, Switzerland

The ECHo collaboration aims at measuring the electron neutrino mass by recording the spectrum following electron capture of ^{163}Ho using metallic magnetic calorimeters (MMCs). The radioisotope ^{163}Ho is produced from enriched ^{162}Er in the ILL high flux nuclear reactor, chemically and mass spectrometrically separated and purified and is fully embedded into the 180x180 μm^2 Au-absorber of the ECHo MMCs. Resonance ionization at the RISIKO mass separator guarantees elemental and isotopic selectivity for ultra-pure ^{163}Ho ion implantation with a sub millimeter beam spot size. The performance of the laser ion source and the implantation process was improved to minimize sample losses. On-line in-situ deposition of Au using pulsed laser deposition (PLD) ensures homogeneous ^{163}Ho/Au layer formation in the implantation area. To verify the purity of the ECHo source material from production up to implantation and data taking a varity of different analytical techniques is applied, including γ-ray spectrometry, NAA, ICP-MS and RIMS.

MS 2.2 Mon 14:30 R 1.020

Single-ion Penning-trap mass measurements using a laser-cooled ^{40}Ca$^+$ ion as sensor — •Manuel J. Gutiérrez[1], Jesús J. Del Pozo[1], Francisco Domínguez[1], Raúl A. Rica[1,2], Michael Block[3,4,5], and Daniel Rodríguez[1,2] — [1]Departamento de Física Atómica, Molecular y Nuclear, Universidad de Granada, 18071 Granada, Spain — [2]Centro de Investigación en Tecnologías de la Información y las Comunicaciones, Universidad de Granada, 18071 Granada, Spain — [3]Institut für Kernchemie, Johannes Gutenberg-Universität, 55128 Mainz, Germany — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany — [5]Helmholtz-Institut Mainz, 55099 Mainz, Germany

Mass measurements on superheavy elements demand a technique that is single-ion capable and fast, while maintaining the level of precision required for nuclear physics studies. Our proposed technique arises from an existing Paul-trap experiment, where a laser-cooled ^{40}Ca$^+$ (sensor) ion is used as motional energy detector, but now implemented in a Penning-traps beamline. First, the axial motion of the sensor ion is characterized. The target ion is then loaded into the trap, where it forms a two ion crystal, together with the sensor ion, along the axial direction. By measuring the modified axial frequencies through the fluorescence photons emitted by the sensor ion, the target mass is calculated. This contribution will focus on the cooling of the target and sensor ions in 7 Tesla and the analysis method, presenting also the developments carried out for the implementation of the technique.

MS 2.3 Mon 14:45 R 1.020

Progress in spatially resolved ultra-trace analysis on plutonium containing particles by rL-SNMS — •Hauke Bosco[1], Martin Weiss[1], Manuel Raiwa[1], Klaus Wendt[2], and Clemens Walther[1] — [1]Institute for Radioecology and Radiation Protection, Leibniz Universität Hannover, Germany — [2]Institute of Physics, Johannes-Gutenberg Universität Mainz, Germany

The resonant laser secondary neutral mass spectrometry (rL-SNMS) system at the IRS in Hanover has been previously tested for its sensitivity to plutonium, uranium and other elements on synthetic and mineral samples. After these first test measurements, hot particles from the Chernobyl exclusion zone have been measured and influences of insulating sample materials instead of conductive bulk samples have been investigated. As a result, the omnipresent background of the measurement process could be lowered to a minimum, so that the signal to noise ratio has been increased. Furthermore, significant progress in suppression of isobars could be achieved, for example non-resonantly ionized uranium 238 as interfering signal for plutonium 238. In addition, further elements like fission products and transuranium elements have been tested. Results of the progression and improvements will be presented.

MS 2.4 Mon 15:00 R 1.020

ISOLDE's Highly Selective Laser Ion Source LIST - Upgrades and Development — •Reinhard Heinke[1], Katerina Chrysalidis[2], Dominik Studer[1], Valentin Fedosseev[2], Tom Kieck[1], Bruce Marsh[2], Sebastian Raeder[3], Sebastian Rothe[2], Marcel Trümper[1], and Klaus Wendt[1] — [1]Institut für Physik, JGU Mainz — [2]EN Department, CERN — [3]Helmholtz-Institut Mainz

Laser ion sources based on resonance ionization techniques today are well-established core techniques at all leading radioactive ion beam facilities worldwide. Ensuring both, highly efficient and element-selective ion beam production for on-line experiments on low-yield isotopes, these devices in addition allow for direct laser spectroscopic investigations on exotic nuclides. The Laser Ion Source and Trap (LIST) approach comprises preeminent suppression of contaminations from competing non-selective ionization mechanisms by spatially separating the hot atomization cavity from a clean laser - atom interaction volume, permitting access to nuclides previously inaccessible.

For this year's measurement campaign, a "next generation" LIST has been derived from operation experience and systematic studies: Revised repelling electrode and geometrical design yield further improvements in selectivity and efficiency.

On top, recent developments comprise a fast and robust cavity heating current switch to allow for both laser repetition rate synchronized heating and quick in-situ polarity switching to select between additional suppression and ion guiding operation.

MS 2.5 Mon 15:15 R 1.020

Isotopentrennung von Mangan mittels Resonanzionisations-Massenspektrometrie - Charakterisierung von Effizienz und Selektivität — •Nina Kneip, Reinhard Heinke, Tom Kieck, Pascal Naubereit, Dominik Studer und Klaus Wendt — Institut für Physik, Johannes Gutenberg-Universität Mainz

Das Paul Scherrer Institut in der Schweiz beschäftigt sich im Rahmen des MeaNCoRN-Projekts mit Nachweismethoden zur zeitlichen Einordnung von Supernovae im näheren Umfeld unseres Sonnensystems. Für die Experimente werden isotopenreine Targets mit $5 \cdot 10^{17}$ implantierten ^{53}Mn-Atomen benötigt. Bei der Implantation von ^{53}Mn in das Target am RISIKO-Massenseparator in Mainz müssen die im Probenmaterial im hohen Überschuss vorliegende Isotope ^{54}Mn und ^{55}Mn separiert werden und gleichzeitig das wertvolle ^{53}Mn mit hoher Effizienz transmittiert werden. Dazu wird eine hocheffiziente und selektive Resonanzionisations-Laserionenquelle verwendet. Für Mangan wurde mittels zweier frequenzverdoppelter konventioneller Ti:Saphir-Laser und eines weitabstimmbaren gittergestützten Ti:Saphir-Lasers dezidiertes Anregungsschema am stabilen Isotop ^{55}Mn entwickelt. Durchgeführt wurden damit Effizienzmessungen an unterschiedlichen Probengrößen und mit Ionenströmen bis zu 1 μA, um das neue Verfahren zu charakterisieren. Dabei konnten in Proben mit 10^{14} Atomen durchschnittliche Effizienzen von 23 % erreicht werden, die bei sehr hohen Ionenströmen deutlich abfallen.

MS 3: Precision Mass Spectrometry 2

Time: Monday 16:15–17:15 Location: R 1.020

Invited Talk MS 3.1 Mon 16:15 R 1.020

Direkte Massenmessungen der schwersten Elemente — •Michael Block — GSI Helmholtzzentrum für Schwerionenforschung Darmstadt — Helmholtz Institut Mainz — Johannes Gutenberg-Universität

Hochpräzise Massenmessungen von Radionukliden mit Penningfallen liefern Informationen über deren Kernstruktur durch die Bestimmung der Bindungsenergie. Bestimmte magische Anzahlen von Protonen und Neutronen stabilisieren Kerne besonders stark. Die schwersten Elemente im Periodensystem verdanken ihre Stabilität solchen nuklearen Schaleneffekten, die sie gegen die starke Coulombabstossung stabilisieren, die ansonsten zur spontanen Kernspaltung führen würde. Kerne mit etwa Z=114 und N=184 sollen sogar eine Insel der Stabilität bilden. Solche Kerne können zurzeit noch nicht experimentell hergestellt werden. Daher sind Experimente mit leichteren Kernen in der Region um Nobelium-254 von Interesse, mit denen theoretische Modelle getestet werden können, die eine bessere Vorhersage der Insel der Stabilität erlauben. Solche Messungen können mit der Penningfalle SHIPTRAP durchgeführt werden. Der aktuelle Status sowie zukünftige Perspektiven werden präsentiert.

MS 3.2 Mon 16:45 R 1.020

Status and Recent Results of the FRS Ion Catcher — •Sönke Beck[1,2] and the FRS Ion Catcher Collaboration[2] — [1]Justus-Liebig-Universität, Gießen — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

The Fragment Separator at GSI produces and separates exotic nuclei in-flight at relativistic energies. The ions are then slowed down and thermalized in a cryogenic stopping cell (CSC), extracted and transferred to a Multiple-Reflection Time-of-Flight Mass-Spectrometer (MR-TOF-MS) for high precision mass measurements or isobar and isomer separation.

The current setup is a prototype for the future Ion Catcher at the low energy branch of the Super-FRS at FAIR and provides scientific results now. More than 40 short-lived isotopes and 15 isomers have been measured. Among these measurements is a systematic study of isomer-to-ground state ratios and excitation energies of neutron-deficient odd indium isotopes.

In the upcoming GSI beamtime period (2018/19), several experiments with the FRS Ion Catcher will be performed. These experiments cover a wide range of topics, including new isotope searches and measurements of unknown masses. Investigations of beta-delayed neutron emission probabilities and studies of multi-nucleon transfer reactions have also been approved.

MS 3.3 Mon 17:00 R 1.020

Production of Highly Charged ^{163}Ho Ions in a Room Temperature Electron Beam Ion Trap — •Rima X. Schüssler[1], Christoph Schweiger[1], Alexander Rischka[1], Peter Micke[1,2], José R. Crespo López-Urrutia[1], Pavel Filianin[1], Sergey Eliseev[1], Yuri Novikov[1], and Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]QUEST Institute for Experimental Quantum Metrology, Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

The ECHo experiment [1] aims to investigate the value of the electron neutrino mass in the sub-eV range by analysing the de-excitation spectrum of ^{163}Dy following the electron capture process in ^{163}Ho. In order to reduce systematic uncertainties in the analysis of the endpoint region, the Q-value of this process will be directly measured as the mass difference of ^{163}Ho and ^{163}Dy with the high-precision Penning-trap mass spectrometer PENTATRAP [2]. The aim is to achieve a relative mass uncertainty of 10^{-11}. At this level of precision the use of highly charged ions is required, which will be produced in an electron beam ion trap (EBIT). Due to the small sample size of ^{163}Ho of less than 10^{13} atoms, the wire probe technique [3] will be applied for the precise injection of the sample into the trapping volume of a Heidelberg compact EBIT.

[1] Gastaldo, L. et al.. J. Low Temp. Phys. 176, 876 (2014)
[2] Repp, J. et al., Appl. Phys. B 107, 983 (2012)
[3] Elliott, S.R. et al., Nucl. Instr. and Meth. B 100, 523 (1995)

MS 4: New Developments

Time: Tuesday 14:00–14:45 Location: R 1.020

Invited Talk MS 4.1 Tue 14:00 R 1.020

First molecular beam cooled to its lowest quantum states at the Heidelberg Cryogenic Storage Ring — •Christian Meyer[1], Arno Becker[1], Klaus Blaum[1], Christian Breitenfeldt[1,2], Sebastian George[1], Jürgen Göck[1], Manfred Grieser[1], Florian Grussie[1], Claude Krantz[1], Holger Kreckel[1], Preeti M. Mishra[1], Oldřich Novotný[1], Felix Nuesslein[1], Aodh P. O'Connor[1], Roland Repnow[1], Sunny Saurabh[1], Stefan Schippers[3], Lutz Schweikhard[2], Kaija Spruck[1,3], Stephen Vogel[1], Robert von Hahn[1], Patrick Wilhelm[1], and Andreas Wolf[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Institut für Physik, Ernst-Moritz-Arndt Universität Greifswald, 17487 Greifswald, Germany — [3]Justus-Liebig-Universität Gießen, 35392 Gießen, Germany

The Heidelberg Cryogenic Storage Ring (CSR) [1] is a fully cryogenic, electrostatic ring with a circumference of 35 m. By cooling the experimental chambers down to 6 K, a residual gas density below 140 cm^{-3} can be reached. Thus ion beams can be stored up to several hours. Under such conditions infrared-active molecules can radiatively cool down to their rovibrational ground state. The excitation of OH^- was probed in a 60 keV ion beam by near-threshold photodetachment revealing radiative lifetimes of the lowest rotational states (∼190 s for $J = 1$) and an effective molecular temperature of 15 K [2]. Hence we are ready to study molecular ions in collisions with neutral atoms, electrons and photons under truely interstellar conditions. The experimental approach and results will be discussed.

[1] R. von Hahn et *al.*, Rev. Sci. Instrum. 87, 063115 (2016)
[2] C. Meyer et *al.*, Phys. Rev. Lett. 119, 023202 (2017)

MS 4.2 Tue 14:30 R 1.020

High-resolution mass separation by transversal contaminant-ion ejection from a multi-reflection time-of-flight device — •Paul Fischer, Stefan Knauer, Gerrit Marx, and Lutz Schweikhard — Institut für Physik, Universität Greifswald, 17489 Greifswald, Germany

Synchronized transversal ejection of unwanted species in an electrostatic ion-beam trap (EIBT) or multi-reflection time-of-flight (MR-ToF) device [1,2,3] has been studied in detail at a new setup at the University of Greifswald [4]. As this separation is performed within the trap, there is no need for additional devices such as ion gates or further traps for either pre- or postselection of ions of interest. Contaminant ions are kicked out by appropriate deflector pulses.

The parameters affecting selection effectivity and resolving power are illustrated with tin-cluster isotopologues. Deflection voltages of 10 V were found to be sufficient for the transversal ejection with as few as three deflection pulses. The duty cycle, i.e. the pulse duration with respect to the period of ion revolution, has been optimized with respect to separation resolving powers, leading to values of up to several tens of thousands.

[1] M. Dahan et al., Rev. Sci. Instrum., 69:76-83(1998).
[2] W. H. Benner, Anal. Chem. 69:4162(1997).
[3] H. Wollnik et al., Int. J. Mass. Spectrom., 96:267-274(1990).
[4] S. Knauer et al., Int. J. Mass. Spectrom., online: https://doi.org/10.1016/j.ijms.2017.10.007(2017).

MS 5: Accelerator Mass Spectrometry 1

Time: Wednesday 14:00–15:45 Location: R 1.020

Invited Talk MS 5.1 Wed 14:00 R 1.020

Nachweis von Beryllium-10 aus exotischen Zerfällen mit Hilfe von Beschleunigermassenspektrometrie (AMS) — •Oliver Forstner[1,2], Silke Merchel[3], Johannes Lachner[4] und IS541 Kollaboration[5] — [1]FSU Jena — [2]HI Jena — [3]HZDR — [4]Universität Wien — [5]ISOLDE/CERN, Genf

Der Ein-Neutronen Halokern ^{11}Be geht über einen Beta-Minus-Zerfall in ^{11}B über ($t_{1/2} = 13,76$ s). In seltenen Fällen jedoch erfolgt über eine anschließende Emission eines Protons die Umwandlung zu ^{10}Be. Ziel dieser Studie ist es, das nach theoretischen Vorhersagen bei unter 10^{-7} liegende Verzweigungsverhältnis dieses raren Zerfallskanals zu messen. Mit Hilfe der Möglichkeiten der AMS zur Messung extrem niedriger Isotopenverhältnisse ist dies erstmalig experimentell gelungen und wurde zu $8,3(0,9) \times 10^{-6}$ bestimmt [1].

Zur Bestimmung dieser Rate wurde an ISOLDE / CERN ein Strahl radioaktiver ^{11}Be Ionen produziert und in Kupfer-Targets implantiert. Daraus wurde chemisch Beryllium extrahiert und mittels AMS das Verhältnis ^{10}Be/^{9}Be bestimmt sowie die Menge des implantierten ^{10}Be berechnet. Aufgrund des niedrigen Verzweigungsverhältnisses und der daraus resultierenden niedrigen Zahl von entstehenden ^{10}Be-Atomen ist eine möglichst hohe Effizienz und niedriger Untergrund im ^{9}Be-Trägermaterial [2] essentiell. Für die Datenanalyse wurde besonderes Augenmerk auf die Methodik der Produktion gelegt, um mögliche systematische Fehler ausschließen zu können.

[1] K. Riisager, et al., Phys. Lett. B 732 (2014) 305
[2] S. Merchel, et al., Nucl. Instr. and Meth. B 266 (2008) 4291

MS 5.2 Wed 14:30 R 1.020

Beryllium-7 at DREAMS — •Georg Rugel[1], Silke Merchel[1], Andreas Scharf[1], Rebecca Querfeld[2], Georg Steinhauser[2], and Collin Tiessen[1,3] — [1]HZDR, Dresden, Germany — [2]IRS Hannover, Germany — [3]AEL AMS Laboratory, Canada

Half-lives of routine AMS nuclides range from thousands to millions of years. We measured short-lived ^{7}Be ($T_{1/2} = 53.2$ d) at the DREsden AMS-facility (DREAMS) [2] as low as 90 mBq, which can be challenging for rapid γ-counting. Simultaneous determination of ^{7}Be and ^{10}Be ($T_{1/2} = 1.387$ Ma) via AMS is advantageous for improved understanding of production, transport, and deposition of atmospherically produced ^{7,9,10}Be [2].

Data was normalized to a ^{7}Be sample produced via ^{7}Li(p,n)^{7}Be, measured by γ-counting and chemically processed to BeO (^{7}Be/^{9}Be $\approx 10^{-12}$). The isobar ^{7}Li is completely eliminated by chemistry and the degrader foil technique (^{7}Be^{4+}, 10.2 MeV). The blank ratio of 5×10^{-16} ^{7}Be/^{9}Be (0.8 mBq) and simple and fast chemistry allows for the measurement of rainwater samples, collected in Germany, as small as 10 ml corresponding to a few times 10^{-14} ^{7}Be/^{9}Be [3,4].

Thanks to D. Bemmerer (HZDR) and G. György (ATOMKI, Hungary) for help with the ^{7}Be normalization material.

Ref.: [1] G. Rugel et al., *NIMB* 370 (2016) 94. [2] A.M. Smith et al., *NIMB* 294 (2013) 59. [3] R. Querfeld et al., *JRNC* 314 (2017)521. [4] C. Tiessen et al. *JRNC* (submitted).

MS 5.3 Wed 14:45 R 1.020

The Flux of Interplanetary Dust on Earth: Status. — •David Krieg[1], Christoph Busser[1], Thomas Faestermann[1], Leticia Fimiani[1], J. M. Gomez-Guzman[1], Angelina Kinast[1], Dominik Koll[1], Gunther Korschinek[1], Manuel Lebert[1], Silke Merchel[2], Jan Welch[3], and Sepp Kipfstuhl[4] — [1]Technische Universität München, Garching, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [3]Atominstitut of the Technischen Universität Wien, Vienna, Austria — [4]Alfred-Wegener-Institut, Bremerhaven, Germany

Earth's accumulation rate of Interplanetary Dust Particles (IDPs) is a matter of discussion, ranging from 5 (middle atmosphere measurements) up to 300 (space borne dust detection) tons per day.
A new approach for a more precise measurement of this accumulation rate is made by extracting manganese from 500 kg of Antarctic snow collected near the Kohnen station, and measuring the concentration of ^{53}Mn with AMS at the MLL in Munich.
This ^{53}Mn ($t_{1/2} = 3,7\ Ma$) is mostly produced by nuclear reactions of cosmic rays on the iron of the IDPs. Relating the amount of ^{53}Mn to the precipitation rate, a meridional transport and deposition model based on ^{10}Be measurements, and to a chemical model of meteoritic ablation will help to reduce the uncertainty of the IDP input on Earth. The method of our measurement and the status of this study will be discussed.

MS 5.4 Wed 15:00 R 1.020

Search for Recent ^{60}Fe Deposition in Antarctic Snow via AMS — •Dominik Koll[1], Christoph Busser[1], Thomas Faestermann[1], Leticia Fimiani[1], J. M. Gomez-Guzman[1], Angelina Kinast[1], Gunther Korschinek[1], David Krieg[1], Manuel Lebert[1], Silke Merchel[2], Johannes Sterba[3], Jan Welch[3], and Sepp Kipfstuhl[4] — [1]Physik Department, Technische Universität München, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [3]Atominstitut, Technische Universität Wien, Austria — [4]Alfred-Wegener-Institut, Germany

^{60}Fe with a half-life of 2.6 Myr [1] is produced in stellar environments and ejected into space mainly by core-collapse supernovae. Due to its long half-life, traces of ^{60}Fe were deposited and incorporated on Earth and on the Moon and have been detected there [2,3,4,5].

Here, a new possible reservoir will be presented: Antarctic snow. This time, in contrast to former investigations, any signal detected would be recent material which might origin from the local interstellar cloud. 500 kg of Antarctic snow were chemically processed and are going to be analyzed by AMS in Munich at the 14 MV tandem. First results for ^{60}Fe measurements will be presented as well as chemical extraction methods applied.

[1] Rugel et. al. ; Phys. Rev. Lett. 103, 072502 (2009)
[2] Knie et. al. ; Phys. Rev. Lett. 93, 171103 (2004)
[3] Ludwig et. al. ; PNAS 113 (33), 9232-9237 (2016)
[4] Wallner et. al. ; Nature 532, 69-72 (2016)
[5] Fimiani et. al. ; Phys. Rev. Lett. 116, 151104 (2016)

MS 5.5 Wed 15:15 R 1.020

The first (^{53}Mn/^{55}Mn) isotopic ratio measurements at the Cologne FN-Tandem Accelerator — •Markus Schiffer, Richard Altenkirch, Claus Müller-Gatermann, Susan Herb, Claus Feuerstein, Stefan Heinze, Alexander Stolz, and Alfred Dewald — Institute for Nuclear Physics, University of Cologne, Germany

The new AMS system at the Cologne 10 MV FN accelerator is finalized in its first stage. The system has been designed for the measurement of medium mass isotopes, especially for ^{53}Mn and ^{60}Fe. It provides the opportunity to use several detector systems in different combinations: degrader foils with an electrostatic analyzer, a 4m time-of-flight system, a 135° gas filled magnet and different gas ionization detectors.

The whole system was tested with measurements of stable ion beams and isotopic ratios. During the test measurements of (^{41}Ca/^{40}Ca) isotopic ratios without passive absorbers a detection limit lower 5.3×10^{-13} was reached. A high ^{53}Cr suppression in the (^{53}Mn/^{55}Mn) isotopic ratio measurement with the electrostatic analyzer was reached by using the optimal silicon nitride degrader foil thickness.

We will present the first (^{53}Mn/^{55}Mn) ratio measurements in a range from 10^{-9} to 10^{-10}, and background spectra measured with blank sample material. Transmission tests show an overall efficiency of 0.0033%, including sputter efficiency, charge state yield, transmissions and software gates.

MS 5.6 Wed 15:30 R 1.020

Ultra-trace analysis of Tc-99 with AMS in environmental samples — •Francesca Quinto[1], Christoph Busser[2], Thomas Faestermann[2], Horst Geckeis[1], José-Manuel Gomez-Guzman[2], Karin Hain[3], Dominik Koll[2], Gunther Korschinek[2], Peter Ludwig[2], Markus Plaschke[1], and Thorsten Schäfer[1] — [1]Institute for Nuclear Waste Disposal, Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]Physics Department, Technical University of Munich, Garching, Germany — [3]Isotope Research and Nuclear Physics, University of Vienna, Vienna, Austria

Tc-99 originating from global fallout, accidents and activities related to nuclear energy production shows environmental levels down to 1E+7 atoms/g (ca. 1.6 fg/g). The analytical capability of determining Tc-99 at such ultra-trace levels offers the possibility to investigate its behavior in a variety of environmental systems. The main limitation to the sen-

sitivity of the mass spectrometric analysis of Tc-99 is the background of its stable isobar Ru-99. For ultra-trace analysis, in addition to a chemical separation of Tc from Ru, the Gas-Filled Analyzing Magnet System (GAMS) at the 14 MV Tandem AMS facility of the Technical University of Munich is greatly effective in suppressing the interference from Ru-99. In the frame of studies on the safe management of nuclear waste, we present our recent results in the analysis of Tc-99 in natural samples and reference materials using AMS.

MS 6: Accelerator Mass Spectrometry 2

Time: Thursday 10:30–12:00 Location: R 1.020

Invited Talk MS 6.1 Thu 10:30 R 1.020

High precision radiocarbon analysis of annual tree-ring samples — •Lukas Wacker, Stephanie Arnold, Silvia Bollhalder Lück, Marcus Christl, and Hans-Arno Synal — LIP, Otto-Stern-Weg 5, CH-8093 Zürich

Trees catalogued by dendrochronology are the most valuable source for radiocarbon calibration throughout the Holocene, as trees rings preserve atmospheric radiocarbon concentrations from the time they were formed. The longest continuous European tree ring chronology reaches back to 12 300 BP. However, the majority of the tree-ring based international radiocarbon calibration curve (IntCal13) is presently based on measurements with decadal resolution. We will show that highest precision radiocarbon analysis on annual tree-ring samples are now possible on a routine basis with compact AMS systems, which require less material than for previous measurements performed with decay counting. The newly acquired data will not only improve the next iteration of IntCal, but also carries new, high fidelity information about past solar activity and therefore will allow for synchronization with other not-so-well dated environmental archives.

MS 6.2 Thu 11:00 R 1.020

Design of a new Gas Interface for biomedical ^{14}C analyses — •Daniele De Maria[1], Simon Fahrni[2], Lukas Wacker[1], and Hans-Arno Synal[1] — [1]Laboratory of Ion Beam Physics, ETH Zurich, Switzerland — [2]Ionplus AG, Dietikon, Switzerland

Radiocarbon analyses by accelerator mass spectrometry (AMS) have a great potential for biomedical applications, in particular in pharmacokinetic studies using ^{14}C as a microtracer. Thus, the AMS approach for this research field was investigated in a validation study conducted in collaboration with Novartis (Basel, Switzerland) to evaluate the performance of the MICADAS. Since these studies require the measurement of a large number of samples in a short period of time, a key problem of AMS technology is its low sample throughput. Therefore, our aim is to develop a new gas handling system to achieve a faster measurement process for applications where low precision but higher throughput is required. The design of the new interface will be presented, focusing in particular on the strategies to overcome the time consuming cleaning procedure required after each sample to avoid cross-contamination.

MS 6.3 Thu 11:15 R 1.020

Optimierung von $^{14}CO_2$-Gasmessungen am CologneAMS — •A. Stolz[1], A. Dewald[1], S. Heinze[1], G. Zitzer[1], R. Altenkirch[1], M. Schiffer[1], S. Herb[1], C. Müller-Gatermann[1], A. Wotte[2], J. Rethemeyer[2] und T. Dunai[2] — [1]Institut für Kernphysik, Universität zu Köln — [2]Institut für Geologie und Mineralogie, Universität zu Köln

Zur Messung von $^{14}CO_2$-Gasproben wurde eine zweite HVEE SO-110B Sputterquelle mit einem Gasführungssystem von Ionplus AG am Kölner 6 MV Tandetron Beschleuniger installiert und weitere Optimierungen in Hinblick auf die Steigerung der Sputtereffizienz, Reproduzierbarkeit, und Betriebssicherheit durchgeführt. Darüber hinaus wurde ein EuroVektor EA3000 an das Gassystem angeschlossen und das Magazin des Gassystems von 8 auf 16 Proben erweitert. Zur Einbindung neuer Hardware und der Erweiterung des Funktionsumfangs wurde eine eigene Steuersoftware entwickelt. Unbeaufsichtigte Übernachtmessungen mit dieser Software wurden mit EA-Proben und Ampullen erfolgreich durchgeführt. Der Blankwert von Proben aus Glasampullen liegt bei $2...3{\cdot}10^{-15}$. Die Reproduzierbarkeit von typischerweise 0.5...1.5 % liegt im Rahmen der Zählstatistik. Zur Erhöhung der Betriebsstabilität wurde die Temperatur des Cs-Reservoirs von 130 °C auf 116 °C verringert. Die Sputtereffizienz beträgt mit den neuen Einstellungen 4...5 %. Ergebnisse zu Reproduzierbarkeit und Blankwerten für verschiedene Probengrößen und zu ersten Tests mit dem EA werden vorgestellt.

Das Projekt wurde teilweise aus Mitteln des ULDETIS Projekts der Universität zu Köln im Rahmen der DFG Exzellenzinitiative finanziert.

Invited Talk MS 6.4 Thu 11:30 R 1.020

A Gas Ion Source and its extension by Laser Ablation for Online Radiocarbon Analyses — •Christiane Yeman[1], Lukas Wacker[1], Bodo Hattendorf[2], Marcus Christl[1], Caroline Welte[1], and Hans-Arno Synal[1] — [1]Laboratory of Ion Beam Physics, ETH Zurich, Switzerland — [2]Laboratory of Inorganic Chemistry, ETH Zurich

In 2017, 5000 gaseous samples were analysed for radiocarbon with a versatile gas interface at the gas ion source of the MICADAS (MIniCArbonDAtingSystem) at ETH Zurich. It is a fast way for radiocarbon analysis, for many applications favored over graphitization due to higher sample throughput and the smaller sample sizes that are required.

Even faster radiocarbon analyses can be achieved by using the novel laser ablation (LA) interface coupled to the AMS. A full radiocarbon record can be collected in a single measurement. The sample surface is scanned with a focused pulsed laser beam of UV light producing a gas mixture of CO, CO_2 and O_2, which is directly and continuously introduced into the gas ion source of the MICADAS.

The pros and cons of the continuous online measurements of laser ablation are compared in detail with the routine sequential gas measurements using the versatile gas interface.

MS 7: Annual General Meeting of the Mass Spectrometry Division

Time: Thursday 14:00–14:30 Location: R 1.020

-

MS 8: Accelerator Mass Spectrometry 3

Time: Thursday 14:30–15:30 Location: R 1.020

MS 8.1 Thu 14:30 R 1.020

Recent applications and developments of actinide detection at VERA — •Karin Hain[1], Peter Steier[1], Robin Golser[1], Jixin Qiao[2], Gabrielle Wallner[3], Stephan Winkler[4], and Philipp Zima[3] — [1]Faculty of Physics, University of Vienna, Austria — [2]Technical University of Denmark, Denmark — [3]Faculty of Chemistry, University of Vienna, Austria — [4]iThemba LABS, Johannesburg, South Africa

Long-lived actinides like ^{239,240}Pu, ^{241}Am and in particular ^{236}U are routinely analyzed in environmental samples at the Vienna Environmental Research Accelerator (VERA). The aim is to understand the migration of these elements by studying their distribution in the environment and also biosphere, and their emission sources. In this con-

text, for example, depth profiles of these nuclides and ^{237}Np in the Pacific Ocean and the ^{236}U concentration in human lungs ashes were studied. Most recently our portfolio was extended by anthropogenic ^{233}U which can be found in global fallout at around 1 % of ^{236}U on the Northern Hemisphere where it seems to offer the opportunity to discriminate between U releases from thermonuclear weapons and civil nuclear industry. First measurements on corals and snow from Antarctica, however, indicate a considerably lower ^{233}U/^{236}U ratio on the Southern Hemisphere. Current developments mainly focus on the increase of the negative ion yield of actinides from the sputter ion source by using fluoride based targets and to simplify sample preparation by detecting ^{236}U directly from the soil matrix. The results of the mentioned applications and developments will be discussed in this talk.

MS 8.2 Thu 14:45 R 1.020

Developments towards AMS of ^{182}Hf with ILIAMS — •Martin Martschini[1], Xiaohe Zhang[1], Dag Hanstorp[2], Johannes Lachner[1], Alfred Priller[1], Peter Steier[1], Paul Wasserburger[1], and Robin Golser[1] — [1]VERA Laboratory, University of Vienna - Faculty of Physics, Austria — [2]Department of Physics, University of Gothenburg, Sweden

The Ion Laser InterAction Mass Spectrometry (ILIAMS) technique is currently developed at the Vienna Environmental Research Accelerator (VERA). It provides suppression of isobar contaminants in negative ion beams for AMS via selective laser photodetachment in a gas-filled radio frequency quadrupole (RFQ). Measurement of the longlived trace isotope ^{182}Hf ($T_{1/2} = 8.9$ Ma) is one of the main objectives of this project. ^{182}Hf is of high astrophysical interest, however, despite substantial efforts, could not be measured at its natural abundance level with conventional AMS so far due to strong isobaric interference from stable ^{182}W.

With He-O mixtures as buffer gas in the RFQ, suppression of $^{182}WF_5^-$ vs $^{180}HfF_5^-$ by up to 10^6 has recently been achieved with W-spiked targets. Mass analysis of the ejected anion beam identified the formation of oxyfluorides as an important reaction channel. Furthermore, first tests with ^{182}Hf reference materials have been conducted. In this contribution, we will give details on these measurements including the overall detection efficiency and the present sensitivity limit. In addition, we will report on a survey of several sputter materials for highest negative ion yields of HfF_5^-.

MS 8.3 Thu 15:00 R 1.020

Progress in detection of Cs isotopes with ILIAMS at VERA — •Johannes Lachner, Martin Martschini, Alfred Priller, Peter Steier, Xiaohe Zhang, and Robin Golser — VERA Laboratory, University of Vienna, Faculty of Physics, Austria

The development of Ion Laser InterAction Mass Spectrometry (ILIAMS) establishes new prospects for sensitive Accelerator Mass Spectrometry analyses of isotopic systems. The reliability of the new method was proven with measurements of ^{36}Cl and ^{26}Al. Inside a radiofrequency quadrupole filled with ≈0.2 mbar He buffer gas the isobars ^{36}S and ^{26}Mg could be suppressed by up to 10 orders of magnitude via laser photodetachment using 532 nm photons from a 18 W cw laser.

Further application of the technique is expected by studying isotopic systems that are new to AMS: Here, one focus is on the detection of the trace isotopes ^{135,137}Cs as the measurement of these two Cs isotopes has widespread applications in the environmental sciences for dating or source apportionment. In this case a suppression of the isobars ^{135}Ba and ^{137}Ba is required.

I will present the benefits of the use of either Cs^- or CsF_2^- as primary extracted negative ion and their performance in the ion source and transmission through the ion cooler. By generating the di-fluoride anions CsF_2^- and BaF_2^- a suppression of the ^{135,137}Ba isobars can be accomplished using 532 nm photons in the photodetachment process. The suppression furthermore profits from an additional chemical effect inside the ion cooler, which is enhanced by an admixture of O_2 to the He buffer gas.

MS 8.4 Thu 15:15 R 1.020

AMS measurement of Cl-36 with Gas-Filled Magnet at 6 MV — •Christof Vockenhuber — Laboratory of Ion Beam Physics, ETH Zurich, Otto-Stern-Weg 5, 8093 Zürich

Cl-36 is one of the AMS nuclides that still requires high ion energy to suppress the interfering isobar S-36 and is often used to justify a (relatively) large tandem accelerator with a terminal voltage of 5-6 MV. Over the past decades several methods have been developed by the different AMS laboratories to solve the S-36 problem, each with its own advantages and disadvantages. At ETH we recently switched to the method of the gas-filled magent (GFM) for routine Cl-36 measurements. Traditionally the GFM method has been only employed by even larger accelerators at higher ion energies. In this talk I will discuss the setup of the GFM at the 6 MV tandem accelerator at ETH Zurich and the performance of Cl-36 under routine measurement conditions. Additionally the question of how low in energy one can go with the GFM will be addressed.

MS 9: Poster 1

Time: Thursday 16:15–18:15 Location: Redoutensaal

MS 9.1 Thu 16:15 Redoutensaal

^{36}Cl, a Tool to Determine Atmospheric Neutrons in Aircrafts. — •Manuel Lebert, Christoph Busser, Thomas Faestermann, J. M. Gomez-Guzman, Angelina Kinast, Dominik Koll, Gunther Korschinek, and David Krieg — Technische Universität München, Garching, Germany

For ultra-sensitive AMS measurements, the initial radioisotope concentration must not be altered by transportation or storage.
To investigate if transportation by aircrafts leads to alteration, NaCl was transported by plane for around 90 hours and afterwards the ^{36}Cl ($t_{1/2} = 3 \cdot 10^5$ a) concentration, produced by ^{35}Cl(n,γ)^{36}Cl reactions, was measured with AMS at the MLL in Munich. We found that these atmospheric neutrons had no effect on the samples.
In addition to that, the small concentration of $^{36}Cl/Cl$ of few 10^{-16} which we found in the samples will be studied further. The effect of high energy muons formed in the atmosphere and the emission of neutrons by spontaneous fission of uranium in the salt stock beside others will be considered. Further measurements of unprocessed NaCl from the same salt mine are going to be performed.

MS 9.2 Thu 16:15 Redoutensaal

Optimierter Gasionisatioinsdetektor zum Nachweis von ^{26}Al am 6MV Tandetron am CologneAMS — •Gereon Hackenberg, Richard Altenkirch, Alexander Stolz, Markus Schiffer, Susan Herb, Claus Müller-Gatermann, Stefan Heinze und Alfred Dewald — Institut für Kernphysik, Universität zu Köln

Um am CologneAMS bei ^{26}Al-Messungen den statistischen Fehler zu reduzieren, ist geplant neben elementarem Al auch AlO für Standardmessungen zu nutzen, da dies zu einem höheren Quellenoutput führt. Zur Unterdrückung des dabei auftretenden Isobars ^{26}Mg wurde ein neuer Gasionisationsdetektor entworfen und direkt hinter dem Gas gefüllten Magneten installiert.

Dabei musste beachtet werden, dass der Detektor leicht aus dem Strahlgang entfernbar ist, um den dahinter liegenden Aufbau für Be-Messungen unverändert nutzen zu können.

Der neue Detektor verfügt über 5 Anoden, von denen 2 diagonal gesplittet sind. Hierdurch wird es möglich gestreute Strahlen in der dispersiven Ebene zu trennen. Zusätzlich wurden X-Schlitze in die Detektorkammer integriert. Außerdem verfügt der Detektor über eine große Akzeptanz auf Grund seines $4cm^2$ großen SiN-Eintrittfensters.

Neben dem Aufbau und den Detektoreigenschaften werden erste Messungen und Ergebnisse vorgestellt.

MS 9.3 Thu 16:15 Redoutensaal

Improving the accuracy in the analysis of 99Tc using AMS — •Christoph Busser[1], Thomas Faestermann[1], José Manuel Gómez-Guzmán[1], Karin Hain[2], Angelina Kinast[1], Dominik Koll[1], Gunther Korschinek[1], Florian Kortmann[3], David Krieg[1], Manuel Lebert[1], Christoph Lierse v. Gostomski[3], Peter Ludwig[1], and Francesca Quinto[4] — [1]Physics Department, Technical University of Munich, Garching — [2]Isotope Research and Nuclear Physics, University of Vienna, Vienna — [3]Radio Chemistry Munich, Technical University of Munich, Garching — [4]Institute for

Nuclear Waste Disposal, Karlsruhe Institute of Technology, Karlsruhe

Significant amounts of Tc-97 are released in to the environment by nuclear bomb tests, nuclear reprocessing plants, nuclear accidents and nuclear medicine. Further, as a fission product, Tc-99 is a concern for the storage of spent nuclear fuel concerning the high mobility of the pertechnetate ion. Hence quantitative ultra trace analysis of it is of great importance. However the lack of stable Tc isotopes hampers the measurements by AMS. Our approach to overcome this obstacle is to utilize the long lived isotope Tc-97. Therefore we have produced Tc-97 in two ways, by Ru-96(n,γ)Ru-97 -> Tc-97 in our research reactor FRMII and by the nuclear reaction of Li-7 with Nb-93 at our tandem accelerator. An important issue is the proceeding sample chemistry to suppress Mo-97 and Ru-99 to achieve low backgrounds for the AMS measurements. In this presentation we will report on the nuclide production, our sample chemistry and details of the first AMS measurement.

MS 9.4 Thu 16:15 Redoutensaal

Concept of the automatic measurement using AMS setup at the Cologne FN Tandem Accelerator — •Susan Herb, Nima Saed-Samii, Claus Feuerstein, Markus Schiffer, Richard Altenkirch, Mario Cappellazzo, Stefan Heinze, Claus Müller-Gatermann, Gereon Hackenberg, and Alfred Dewald — Institut für Kernphysik, Universität zu Köln

The parameters of the hardware components of the AMS setup at the FN Tandem Accelerator are controlled by the in-house developed control software (phoenix software). In a first test phase AMS measurements at the FN Accelerator were performed manually using a standard amperemeter and the rare isotope data were processed by the commercial analog MPA3-system from FAST ComTec. In this contribution, we describe the concept and realization of an automated AMS-measurement. The timing for the sequential isotope injection is handled by an Arduino micro-controller which provides logical signals used to control the bouncer unit and as trigger for the acquisition. The detection signals are processed via a new in-house programmed digital DAQ-system based on CAEN digitizers. The phoenix software and the data acquisition are coupled over an Ethernet interface. Therefore the complete AMS data analysis is provided by the phoenix software.

MS 9.5 Thu 16:15 Redoutensaal

Development of an efficient high-current ion source for Accelerator Mass Spectrometry — Felipe Lipp Bregolin[1], •Hans Hofsäss[1], Georg Rugel[2], Shavkat Akhmadaliev[2], Silke Merchel[2], and Jenny Feige[3] — [1]Georg-August-Universität Göttingen — [2]Helmholtz-Zentrum Dresden-Rossendorf — [3]Technische Universität Berlin

A new high-current negative ion source for Accelerator Mass Spectrometry (AMS) is being built to quantify the ratios of long-lived cosmogenic radionuclides in micrometeorites, which are of great astrophysical interest. Measuring these extremely small ratios is at the technological limits of present AMS systems. The new source is designed specifically to provide a higher AMS detection sensitivity by having an optimal ion-optics design, incorporating new concepts for the construction and operation of the Cs ionizer, optimized Cs ion beam currents and Cs vapor transport. The operation with higher cathode, extraction and pre-acceleration voltages than usual is possible. Moreover, its design is modular providing ease of access and simplifying maintenance while having better mechanical stability at the same time. Several operational parameters can be controlled and measured during operation to achieve a higher ion source performance. Detailed ion-optics simulations of the ion source are compared with test measurements, and the design optimized based on its results. The authors would like to thank the Federal Ministry of Education and Research of Germany for its financial support (project 05K2016), and the HZDR's Ion Beam Center for its essential contribution to the realization of this project.

MS 10: Poster 2

Time: Thursday 16:15–18:15 Location: Orangerie

MS 10.1 Thu 16:15 Orangerie

Resonant Laser Ionization Spectroscopy for Highly Selective Extraction of Specific Lanthanides — •Felix Weber, Vadim Gadelshin, Dominik Studer, Pascal Naubereit, and Klaus Wendt — Johannes Gutenberg-Universität, Mainz

Resonance ionization spectroscopy is a versatile technique for efficient and selective ionization as well as to study the energy levels of exotic species. Due to the unique energy level structure a multi-step ionization scheme is selective for a specific element. The combination of resonance ionization with techniques from mass spectrometry allows the selection of a single isotope of interest. The LARISSA group in Mainz uses a high-repetition rate pulsed Ti:sapphire laser system with tunability from about 680 to 1000 nm for spectroscopy, which can be extended using frequency doubling, tripling and quadrupling. All lanthanide elements can be ionized by a two stage excitation using SHG for both steps. An automatized tunable grating laser with intra-cavity frequency doubling provides high output power over a wide wavelength range. In order to combine high ionization efficiency and selectivity with the ability to rapidly switch between different lanthanides, dedicated ionization schemes are developed at Johannes Gutenberg University Mainz. These will be used within the CERN-MEDICIS project which aims to produce lanthanide isotopes for medical applications and in addition serve as preparation for few-element detection of minor actinides by laser based ultratrace determination techniques.

MS 10.2 Thu 16:15 Orangerie

Laserablations unterstützte RIMS refraktärer Elemente — •Felix Julian Wieschер, Reinhard Heinke, Dominik Studer und Klaus Wendt — Johannes Gutenberg Universität, Mainz, Deutschland

Optische Spektren refraktärer Elemente wurden bisher nur eingeschränkt untersucht, da diese aufgrund ihres hohen Schmelzpunktes und hoher Reaktivität für die meisten Experimente an neutralen Atomen nur schwer zugänglich sind. An der Mainzer Atomstrahlapparatur MABU wurde daher die ursprüngliche Quellenregion, eine resistiv geheizte Kavität, durch eine kompakte Quadrupolfallenkonstruktion, den sogenannten Mini-RFQ [1], ersetzt. Dieser beinhaltet ein rotierendes Laserablationstarget an dessen einem Ende. Unter Einsatz hochrepetierender Titan:Saphir-Laser Mainzer Bauart (Pulslänge ca. 50 ns, Pulsenenergie ca. 0.4 mJ) werden Atome aus dem rotierendem Target ablatiert und erzeugte Neutrale in mehreren Anregungsschritten selektiv resonant ionisiert. Das Durchstimmen der einzelnen Anregungsschritte erlaubt die Messung der Spektrallinien, wodurch fundamentale atomphysikalische Größen wie Energielagen hochangeregter Zustände und z.B. das Ionisationspotential präzise ermittelt werden können. [1] - F. Schneider et al., Eur.Phys. J. A (2015)

MS 10.3 Thu 16:15 Orangerie

An improved value of the proton's atomic mass — •Fabian Heisse[1,2], Florian Köhler-Langes[1], Sascha Rau[1], Jiamin Hou[1], Sven Junck[3], Anke Kracke[1], Andreas Mooser[4], Wolfgang Quint[2], Stefan Ulmer[4], Günter Werth[3], Klaus Blaum[1], and Sven Sturm[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt, Germany — [3]Institut für Physik, Johannes Gutenberg-Universität Mainz, D-55099 Mainz, Germany — [4]RIKEN, Ulmer Fundamental Symmetries Laboratory, Wako, Saitama 351-0198, Japan

The proton is a central building block of the visible universe. The precise knowledge of its properties is of great interest for tests of fundamental physics and metrology.

To measure the proton's mass in natural units, a new cryogenic fivefold Penning-trap setup was constructed. The measurement principle is based on a phase-sensitive comparison of the proton's cyclotron frequency to that of a bare carbon nucleus ($^{12}C^{6+}$) in a highly harmonic and purpose-built Penning trap.

The setup as well as the proton's atomic mass will be presented. The result improves the current literature value by a factor of 3 and reveals a disagreement of about 3 standard deviations to it [1].

[1] F. Heiße et al., Phys. Rev. Lett. 119, 033001 (2017)

MS 10.4 Thu 16:15 Orangerie

High-precision mass measurements with Pentatrap — •Ch. Schweiger[1], R. X. Schüssler[1], A. Rischka[1], M. Door[1], P. Filianin[1], Y. Novikov[1], S. Sturm[1], S. Ulmer[2], S. Eliseev[1], and K. Blaum[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [2]RIKEN, Ulmer Initiative Research Unit, Saitama, Japan

The high-precision Penning-trap mass spectrometer Pentatrap [1] is currently being commissioned at the Max-Planck-Institut für Kernphysik in Heidelberg. It aims at mass-ratio measurements of stable and long-lived highly-charged ions with a relative uncertainty below 10^{-11} through measurements of their respective cyclotron frequencies in the strong magnetic field of a Penning trap.
Mass data at this level of precision have numerous applications, especially for tests of fundamental interactions and their symmetries, among others in neutrino physics research or a direct test of the theory of special relativity (SR). For a determination of the electron neutrino mass on the sub-eV level within the ECHo collaboration [2] Pentatrap contributes with an independent measurement of the Q-value of the electron capture transition of ^{163}Ho to ^{163}Dy. In collaboration with the Institut-Laue-Langevin (ILL) a direct test of SR by conversion of a mass to electromagnetic radiation as e.g. in the neutron capture process of ^{35}Cl is planned. The mass ratio of ^{35}Cl/^{36}Cl will be precisely measured at Pentatrap whereas the photon wavelength is measured by means of crystal Bragg spectroscopy at the ILL.
[1] Repp, J. et al., Appl. Phys. B 107, 983 (2012)
[2] Gastaldo, L. et al., Eur. Phys. J. ST 226, 1623 (2017)

MS 10.5 Thu 16:15 Orangerie

Commissioning and First Experiments with TITAN's Multiple-Reflection Time-of-Flight Isobar Separator and Mass Spectrometer — •S. Beck[1,4], C. Hornung[1], S. Ayet[1,4], M.P. Reiter[1,2], J. Bergmann[1], T. Dickel[1,4], J. Dilling[2,3], A. Finlay[2,3], H. Geissel[1,4], F. Greiner[1], C. Jesch[1], A.A. Kwiatkowski[2], E. Leistenschneider[2,3], W.R. Plass[1,4], C. Scheidenberger[1,4], D. Short[2], C. Will[1], M. Yavor[5], and the TITAN collaboration[2] — [1]Justus-Liebig-Universität, Gießen — [2]TRIUMF, Vancouver — [3]University of British Columbia, Vancouver — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — [5]Russian Academy of Sciences, St. Petersburg

Exotic nuclei can be produced with very high rates at the ISOL facility ISAC at TRIUMF (Vancouver, Canada). TRIUMF's Ion Trap for Atomic and Nuclear Science (TITAN) is a multiple ion-trap system for high-precision mass measurements and in-trap decay spectroscopy. Recently a Multi-Reflection Time-of-Flight Mass Separator and Spectrometer (MR-TOF-MS) has been installed and commissioned at TITAN. It is based on an established concept tested at the FRS Ion-Catcher at GSI. The ion of interest can be spatially separated from isobaric contaminations with mass-selective dynamic re-trapping. Furthermore, the device is well suited to perform high precision mass measurements, particularly for short-lived isotopes produced at low rate.

High-precision mass measurements of neutron-rich titanium isotopes were performed by the MR-TOF-MS to probe the existence of the N=32 sub-shell closure above calcium.

MS 10.6 Thu 16:15 Orangerie

MOCCA: A 4k-pixel molecule camera for the position and energy resolving detection of neutral molecule fragments at the Cryogenic Storage Ring CSR — •Dennis Schulz[1], Steffen Allgeier[1], Christian Enss[1], Andreas Fleischmann[1], Lisa Gamer[1], Loredana Gastaldo[1], Sebastian Kempf[1], Oldřich Novotný[2], and Andreas Wolf[2] — [1]Kirchhoff-Institute for Physics, Heidelberg — [2]Max Planck Institute for Nuclear Physics, Heidelberg

The Cryogenic Storage Ring CSR at the Max Planck Institute for Nuclear Physics in Heidelberg can be used to prepare and store molecular ions in their rotational and vibrational ground states, enabling state-resolved studies on electron-ion interactions. The use of Metallic Magnetic Calorimeters for particle detection allows for identifying all neutral reaction products, using the deposited energy of incident particles into MMC absorbers as a measure of the particle mass. To resolve the complete reaction kinematics, a position sensitive coincident detection of multiple reaction products is necessary.

For those measurements we designed MOCCA, a 4k-pixel molecule camera based on MMCs with a detection area of 45 mm×45 mm, which is segmented into 64×64 absorbers and read out using only 32 SQUIDs. We discuss the detector design, multi-hit capability, cross-talk and the integration of its ^{3}He/^{4}He dilution refrigerator into the setup of the CSR. We show first measurements and the expected energy resolution.

MS 10.7 Thu 16:15 Orangerie

Multi-reflection time-of-flight mass spectrometry with combined in-trap lift capture and mirror-switch ejection — •Paul Fischer[1], Stefan Knauer[1], Gerrit Marx[1], Birgit Schabinger[1], Lutz Schweikhard[1], and Robert N. Wolf[2] — [1]Institut für Physik, Universität Greifswald, 17489 Greifswald, Germany — [2]ARC Centre of Excellence for Engineered Quantum Systems, School ofPhysics, The University of Sydney, NSW 2006 Australia

Multi-reflection time-of-flight (MR-ToF) devices are mass separators and analyzers with high resolving powers and fast processing times. For ion injection and ejection, either the electrostatic ion-mirrors or an in-trap lift electrode [1] can be switched. Both methods result in advantages as well as drawbacks. We show the results of a combination of the two, i.e. in-trap lift switching is employed for ion capture with increased mirror-potential stability and exit-side mirror switching for increased ejection mass band width.

Measurements with small lead clusters illustrate the individual techniques as well as the gain from their combination [2].

[1] R. N. Wolf et al., Int. J. Mass Spectrom. 313:8-14(2012)
[2] S. Knauer et al., Int. J. Mass. Spectrom., online: https://doi.org/10.1016/j.ijms.2017.10.007(2017).

MS 10.8 Thu 16:15 Orangerie

A laser ablation ion source for the MR-TOF-MS at the FRS Ion Catcher — •Lizzy Gröf[1], Daler Amanbayev[1], Samuel Ayet[1,2], Julian Bergmann[1], Timo Dickel[1,2], Hans Geissel[1,2], Florian Greiner[1], Christine Hornung[1], Wolfgang Plass[1,2], Ann-Kathrin Rink[1], and Christoph Scheidenberger[1,2] — [1]Justus-Liebig Universität Gießen, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

High resolution mass spectrometry of exotic nuclei is an important tool to provide information about nuclear structure. Multiple reflection time-of-flight mass spectrometers (MR-TOF-MS) proved to be the perfect devices in particular for short-lived (≈ms) isotopes. For MR-TOF-MS it is necessary to have calibrant ions over a broad mass range and a high repetition rate(≈100 Hz). These requirements can be full-filled by the laser ablation carbon cluster ion source (LACCI), which is a part of the new diagnostics unit for the FRS Ion Catcher. The new diagnostics unit consists in addition of an RFQ based beam transport and distribution system, differential pumping sections and an RF Quadrupole mass filter. It will be integrated in 2018 in the beam line of the FRS Ion Catcher, which consists of a cryogenic stopping cell, a RFQ based beamline and a MR-TOF-MS. With LACCI a stable (10 hours) and high repetition rate (100Hz) ion production from different target materials is possible due to a 2D movable target table. The capabilities of the new diagnostics unit and first long term measurements with LACCI will be presented.

MS 10.9 Thu 16:15 Orangerie

Analysis of isobaric interferences in the analysis of Tc-99 with SF-ICPMS — •Markus Plaschke, Francesca Quinto, Frank Geyer, and Horst Geckeis — Institute for Nuclear Waste Disposal, Karlsruhe Institute of Technology, Karlsruhe, Germany

Tc-99 is, due to its long half-life and high mobility in the environment, a fission product of concern for the safe management of nuclear waste. SF-ICPMS constitutes a powerful tool for the analysis of Tc-99 in samples from nuclear decommissioning activities or experiments on the geochemical behavior of Tc. Isobaric background in the determination of Tc-99 with SF-ICPMS arise from the molecular species Mo-98H and from the stable nuclide Ru-99. Chemical separation of Tc from Mo and Ru is effective in removing a relevant part of the interfering nuclides. However, for some applications the direct measurement of Tc-99 in water samples without previous chemical separation is required. It is of great interest to verify which levels of Tc-99 can be reliably determined in presence of variable concentrations of Mo and Ru. We present a systematic investigation of the influence of Mo and Ru at various orders of magnitude on the background for the determination of Tc-99 in samples with different matrices.

MS 10.10 Thu 16:15 Orangerie

Lab Intercomparison for the Establishment of a New Multi-Isotope Plutonium Standard — Björn Dittmann[1,2], Raffaele Buompane[3], Elena Chamizo[4], Marcus Christl[5], Alfred Dewald[6], Tibor Dunai[2], Claus Feuerstein[6], Kieth Fifield[7], Fabio Marzaioli[3], Carsten Münker[2], Antonio Petraglia[3], Erik Strub[1], Carmina Sirignano[3], Hans-Arno Synal[5], Michael Fröhlich[7], •Stefan Heinze[6], Filippo Terrasi[3], Stephen Tims[7]

und Anton Wallner[7] — [1]Division of Chemistry, University of Cologne — [2]Institute of Geology and Mineralogy, University of Cologne — [3]VanCentre for Isotopic Research on the Cultural and Environmental Heritage, University Luigi Vanvitelli — [4]Centro Nacional de Aceleradores, Universidad de Sevilla — [5]Laboratory of Ion Beam Physics, ETH Zurich — [6]Institute of Nuclear Physics, University of Cologne — [7]Department of Nuclear Physics, Research School of Physics & Engineering, Australian National University

A new multi-isotopic plutonium standard for isotopic ratio measurements with AMS was created by mixing different single-isotope IRMM standards (Pu-239, Pu-240, Pu-242, Pu-244). This standard material has been measured at the AMS facilities at Canberra (Australia), Cologne (Germany), Caserta (Italy), Sevilla (Spain) and Zurich (Switzerland). Aditionally, the material was characterized using a Neptune MC-ICPMS (multi-collector inductively coupled plasma mass spectrometry) at the joint Cologne-Bonn facility and with RIMS (resonant ionisation mass spectrometry) at the University of Mainz (Germany). Consensus values for the standard material will be proposed.