

## Mass Spectrometry Division Fachverband Massenspektrometrie (MS)

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### Overview of Invited Talks and Sessions

(Lecture room f128; Poster Empore Lichthof)

#### Invited Talks

MS 1.1	Mon	11:00–11:30	f128	<b>Towards a nuclear clock: On the direct detection of the Thorium-229 isomer</b> — ●LARS VON DER WENSE, BENEDICT SEIFERLE, MUSTAPHA LAATIAOUI, PETER G. THIROLF
MS 2.1	Mon	14:30–15:00	f128	<b>High Precision Comparison of the Antiproton-to-Proton Charge-to-Mass Ratio</b> — ●STEFAN ULMER
MS 3.1	Mon	15:15–15:45	f128	<b>Mass-Spectroscopic Trace of Transient Reaction Kinetics of CO Oxidation Catalyzed by Uni-Sized Pt Clusters Directly Bound to Si Surface</b> — ●HISATO YASUMATSU
MS 4.1	Tue	14:30–15:00	f128	<b>Applications of ISOLTRAPs multi-reflection time-of-flight mass spectrometer</b> — ●FRANK WIENHOLTZ
MS 7.1	Thu	11:00–11:30	f128	<b>The ILIAS project - Isobar suppression in AMS by laser photodetachment</b> — ●MARTIN MARTSCHINI, PONTUS ANDERSSON, OLIVER FORSTNER, DAG HANSTORP, JOHANNES LACHNER, YUAN LIU, TOBIAS MOREAU, JOHANNA PITTERS, ALFRED PRILLER, PETER STEIER, ROBIN GOLSER
MS 9.1	Thu	14:30–15:00	f128	<b>Multi-actinide analysis with AMS for ultra-trace determination and small sample sizes: advantages and drawbacks</b> — ●FRANCESCA QUINTO, MARKUS LAGOS, MARKUS PLASCHKE, THORSTEN SCHÄFER, PETER STEIER, ROBIN GOLSER, HORST GECKEIS
MS 11.1	Fri	11:00–11:30	f128	<b>Accelerator Mass Spectrometry at AARAMS</b> — ●JESPER OLSEN

#### Invited talks of the joint symposium SYAD

See SYAD for the full program of the symposium.

SYAD 1.1	Tue	11:00–11:30	e415	<b>Artificial gauge fields and topology with ultracold atoms in optical lattices</b> — ●MONIKA AIDELSBURGER
SYAD 1.2	Tue	11:30–12:00	e415	<b>Many-body physics with impurities in ultracold quantum gases</b> — ●FABIAN GRUSDT
SYAD 1.3	Tue	12:00–12:30	e415	<b>How to determine the handedness of single molecules</b> — ●MARTIN PITZER
SYAD 1.4	Tue	12:30–13:00	e415	<b>Quantum systems under gravitational time dilation</b> — ●MAGDALENA ZYCH

#### Invited talks of the joint symposium SYML

See SYML for the full program of the symposium.

SYML 1.1	Wed	11:00–11:30	e415	<b>Laboratory studies of interstellar molecules: from the first molecules to complex organics in space</b> — ●HOLGER KRECKEL
SYML 1.2	Wed	11:30–12:00	e415	<b>Detecting astrophysically relevant ions in laboratory and space</b> — ●STEPHAN SCHLEMMER

SYML 1.3	Wed	12:00–12:30	e415	<b>Interstellar ice - a hot topic</b> — ●HAROLD LINNARTZ
SYML 1.4	Wed	12:30–13:00	e415	<b>Exoplanets: The Thorny Path to Habitable Conditions</b> — ●MANUEL GÜDEL
SYML 2.1	Wed	14:30–15:00	e415	<b>Physics with keV Ion Beams in the Cryogenic Storage Ring CSR</b> — ●ANDREAS WOLF
SYML 2.3	Wed	15:15–15:45	e415	<b>A generalized theory for rovibrational motion in cold, extremely floppy molecules</b> — ●HANNO SCHMIEDT, PER JENSEN, STEPHAN SCHLEMMER
SYML 2.6	Wed	16:15–16:45	e415	<b>Lead-cluster investigations at ClusterTrap</b> — STEPHAN KÖNIG, PAUL FISCHER, GERRIT MARX, ●LUTZ SCHWEIKHARD, MARKUS WOLFRAM, ALBERT VASS

## Sessions

MS 1.1–1.7	Mon	11:00–13:00	f128	<b>Precision Mass Spectrometry and Fundamental Applications I</b>
MS 2.1–2.2	Mon	14:30–15:15	f128	<b>Precision Mass Spectrometry and Fundamental Applications II</b>
MS 3.1–3.6	Mon	15:15–17:30	f128	<b>Ion Traps, Ion Storage Rings, Molecules, Clusters, Decays and Reactions</b>
MS 4.1–4.7	Tue	14:30–16:30	f128	<b>Resonance Ionization MS and others</b>
MS 5.1–5.6	Tue	16:30–19:00	Empore Lichthof	<b>Posters I</b>
MS 6.1–6.6	Wed	16:30–19:00	Empore Lichthof	<b>Posters II</b>
MS 7.1–7.6	Thu	11:00–12:45	f128	<b>Accelerator Mass Spectrometry and Applications I</b>
MS 8	Thu	12:45–13:15	f128	<b>Annual General Meeting of the Mass Spectrometry Division</b>
MS 9.1–9.6	Thu	14:30–16:15	f128	<b>Accelerator Mass Spectrometry and Applications II</b>
MS 10.1–10.5	Thu	16:30–19:00	Empore Lichthof	<b>Posters III</b>
MS 11.1–11.6	Fri	11:00–12:45	f128	<b>Accelerator Mass Spectrometry and Applications III</b>

## Annual General Meeting of the Mass Spectrometry Division

Thursday 12:45–13:15 f128

- Bericht
- Verschiedenes

## MS 1: Precision Mass Spectrometry and Fundamental Applications I

Time: Monday 11:00–13:00

Location: f128

## Invited Talk

MS 1.1 Mon 11:00 f128

**Towards a nuclear clock: On the direct detection of the Thorium-229 isomer** — ●LARS VON DER WENSE<sup>1</sup>, BENEDICT SEIFERLE<sup>1</sup>, MUSTAPHA LAATIAOUI<sup>2,3</sup>, and PETER G. THIROLF<sup>1</sup> — <sup>1</sup>Ludwig-Maximilians-Universität München, 85748 Garching — <sup>2</sup>Helmholtz Institut Mainz, 55099 Mainz — <sup>3</sup>GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt

In the whole landscape of atomic nuclei, <sup>229</sup>Th possesses the only known transition which by today could allow for the development of a nuclear frequency standard. The corresponding isomeric state has an energy of just 7.8 eV, which is even accessible by laser and frequency-comb technology. The isomer to ground-state transition, however, could not be directly detected within the past 40 years, despite significant efforts. In the presentation the first time unambiguous direct detection of the isomeric transition is described. This detection will allow for the determination of the decay parameters and in this way pave the way for the development of a nuclear clock.

This work was supported by DFG (Th956/3-1) and by Horizon 2020 grant agreement no 664732 "nuClock".

MS 1.2 Mon 11:30 f128

**High resolution MC-ICP-MS of ultra-trace amounts of silicon isotopes with lowest associated measurement uncertainty** — ●AXEL PRAMANN — Physikalisches-Technische Bundesanstalt (PTB), 38116 Braunschweig, Germany

The redefinition of the Si-unit of the mass - the kilogram - awaited for 2018 will be performed via the Planck constant and the Avogadro constant. (1) The Avogadro-Project (counting Si atoms in a Si sphere) seems to be the candidate resulting in lowest uncertainties for that purpose. PTB developed several complementary methods for the mass spectrometric determination of the isotopic distribution, the molar mass  $M$  of the silicon crystal material used for the preparation of the Avogadro silicon spheres with silicon highly enriched in <sup>28</sup>Si. (2) In order to reduce the uncertainties further, new silicon crystal material with extended enrichment in <sup>28</sup>Si was produced in a cooperation with external companies and institutes in Russia. This work presents the improved MS techniques and current results performed on new crystal material with  $x(^{28}\text{Si}) = 0.999995$  mol/mol accompanied with a comprehensive uncertainty analysis showing a reduction in  $u(\text{rel},M)$  by three orders of magnitude in ten years.

(1)Y. Azuma *et al.*, *Metrologia*, 52, 360 (2015). (2)O. Rienitz, A. Pramann, D. Schiel, *Int. J. Mass Spectrom.*, 289, 47 (2010). (3)A. Pramann, K.-S. Lee, J. Noordmann, O. Rienitz. *Metrologia*, 52, 800 (2015).

MS 1.3 Mon 11:45 f128

**High-precision mass measurements around  $N = 152$  at TRIGA-TRAP** — ●DENNIS RENISCH<sup>1</sup>, KLAUS BLAUM<sup>2</sup>, MICHAEL BLOCK<sup>1,3,4</sup>, CHRISTOPH DÜLLMANN<sup>1,3,4,5</sup>, KLAUS EBERHARDT<sup>1,4</sup>, JESSICA GRUND<sup>1,5</sup>, JACQUES VAN DE LAAR<sup>1,5</sup>, SZILARD NAGY<sup>2</sup>, FABIAN SCHNEIDER<sup>1,5,6</sup>, and KLAUS WENDT<sup>5,6</sup> — <sup>1</sup>Institut für Kernchemie, Johannes Gutenberg-Universität, Mainz — <sup>2</sup>Max-Planck-Institut für Kernphysik, Heidelberg — <sup>3</sup>GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — <sup>4</sup>Helmholtz-Institut Mainz, Mainz — <sup>5</sup>PRISMA Cluster of Excellence, Johannes Gutenberg-Universität, Mainz — <sup>6</sup>Institut für Physik, Johannes Gutenberg-Universität, Mainz

The heaviest nuclei owe their existence to stabilizing nuclear shell effects. The mapping of the strength of these shell effects in the heaviest elements and their extension in atomic number is possible e.g. by the measurement of neutron separation energies using high-precision mass spectrometry. The Penning-trap mass spectrometer TRIGA-TRAP, located at the TRIGA Mainz research reactor, is used to perform such measurements on long-lived transuranium isotopes that are still available in weighable quantities.

The ongoing measurement campaign comprises ten different nuclides from  $Z = 94$  (Pu) to  $Z = 98$  (Cf) in the vicinity of the deformed shell closure at  $N = 152$ . The masses of seven of the investigated nuclides are directly measured for the first time. In this contribution, the status of the measurements and selected results will be presented.

MS 1.4 Mon 12:00 f128

**Towards a mass ratio measurement of tritium and helium-3 at THE-Trap** — ●TOM SEGAL, MARTIN HÖCKER, JOCHEN KETTER, MARC SCHUH, SEBASTIAN STREUBEL, and KLAUS BLAUM — Max-Planck-Institut für Kernphysik Saupfercheckweg 1 69117 Heidelberg Germany

THE-Trap is a precision Penning-trap mass spectrometer [1] at the Max Planck Institute for Nuclear Physics (MPIK) in Heidelberg. It aims to measure the mass ratio of tritium to helium-3 with a relative uncertainty of a few tens parts per trillion (10ppt). This value will provide a systematic check for the KATRIN experiment, which seeks to measure the anti-electron neutrino's mass. In 2014, in order to determine the systematic shifts occurring in the mass measurements, we measured the mass ratio of the non-mass doublet carbon-12 to oxygen-16 [2]. This measurement is one of the most precise mass measurements in the world [2]. In January 2015 our superconducting magnet quenched. Additional problems with the cryostat forced us to start a maintenance phase which lasted ten months. In October 2015 the magnet was successfully charged and shimmed, and the experiment returned to a fully functioning state. In the talk we will present the current status of the experiment and ideas for future measurements.

MS 1.5 Mon 12:15 f128

**Image charge shift simulations for THE-Trap** — ●MARC SCHUH, MARTIN HÖCKER, JOCHEN KETTER, TOM SEGAL, SEBASTIAN STREUBEL, SVEN STURM, and KLAUS BLAUM — Max-Planck-Institut für Kernphysik, 69117 Heidelberg

Tritium-Helium-Trap (THE-Trap) is a precision Penning-trap mass spectrometer [1] at the Max-Planck-Institut für Kernphysik in Heidelberg. While the main goal is to measure the tritium/helium-3 mass ratio with a relative uncertainty of 10 parts per trillion (ppt), the experiment is not limited to the measurement of mass doublets.

In 2014 we reported a measurement of the mass ratio of carbon-12 to oxygen-16 with an uncertainty of 120 ppt, limited by uncertainties of systematic shifts [1]. A later measurement decreased this uncertainty significantly (to be published). One significant systematic shift for the measurements of non mass doublets is caused by image charges on the trap electrodes, which are created by the ion present in the trap. It is possible to simulate this effect reliably by extensive finite element simulations performed with Comsol Multiphysics. The results are in excellent agreement with experimental values [2]. The simulations have been extended to the Mainz  $g$ -factor Penning-trap [3], where, where an image charge shift measurement is in progress. In this talk the concept of the simulation and its results are presented.

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

[2] R.S. Van Dyck Jr., *International journal of mass spectrometry* (2006), DOI:10.1016/j.ijms.2006.01.038

[3] S. Sturm *et al.*, *Phys. Rev. A* 87, DOI:10.1103/PhysRevA.87.030501

MS 1.6 Mon 12:30 f128

**Status of the on-line coupling of the TRIGA-SPEC experiment to the research reactor TRIGA Mainz** — ●JESSICA GRUND<sup>1,2</sup>, KLAUS BLAUM<sup>3</sup>, MICHAEL BLOCK<sup>1,4,5</sup>, CHRISTOPH DÜLLMANN<sup>1,2,4,5</sup>, KLAUS EBERHARDT<sup>1,5</sup>, CHRISTOPHER GEPPERT<sup>1</sup>, CHRISTIAN GORGES<sup>6</sup>, SIMON KAUFMANN<sup>1,6</sup>, JACQUES VAN DE LAAR<sup>1,2</sup>, SZILARD NAGY<sup>3</sup>, PASCAL NAUBEREIT<sup>7</sup>, WILFRIED NÖRTERSHÄUSER<sup>1,6</sup>, DENNIS RENISCH<sup>1</sup>, FABIAN SCHNEIDER<sup>1,2,7</sup>, and KLAUS WENDT<sup>2,7</sup> — <sup>1</sup>Institut für Kernchemie, Johannes Gutenberg-Universität, Mainz — <sup>2</sup>PRISMA Cluster of Excellence, Johannes Gutenberg-Universität, Mainz — <sup>3</sup>Max-Planck-Institut für Kernphysik, Heidelberg — <sup>4</sup>GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — <sup>5</sup>Helmholtz-Institut Mainz, Mainz — <sup>6</sup>Institut für Kernphysik, Darmstadt — <sup>7</sup>Institut für Physik, Johannes Gutenberg-Universität, Mainz

The TRIGA-SPEC experiment - comprising the collinear laser spectroscopy setup TRIGA-LASER and the double Penning-trap mass spectrometer TRIGA-TRAP - allows determining ground-state properties of exotic nuclei. On-line coupling to the research reactor TRIGA Mainz offers the possibility to perform high-precision measurements on short-lived nuclides produced by neutron-induced fission of U-235. Fission products are extracted by an aerosol-based gas-jet system, collimated by an aerodynamic lens and guided through a skimmer system to a high-temperature surface ion source. To improve the ionization

efficiency, a new ion source is being built in collaboration with JAEA Tokai, Japan. An overview of the current status will be given.

MS 1.7 Mon 12:45 f128

**On-line commissioning of the cryogenic buffer-gas stopping cell at SHIPTRAP** — ●OLIVER KALEJA<sup>1</sup>, KLAUS BLAUM<sup>2</sup>, MICHAEL BLOCK<sup>3,4,5</sup>, PREMADITYA CHHETRI<sup>1</sup>, SERGEY ELISEEV<sup>2</sup>, FRANCESCA GIACOPPO<sup>5</sup>, FRITZ-PETER HESSBERGER<sup>5</sup>, MUSTAPHA LAATIAOUI<sup>5</sup>, FELIX LAUTENSCHLÄGER<sup>1</sup>, ENRIQUE MINAYA RAMIREZ<sup>6</sup>, ANDREW MISTRY<sup>5</sup>, SEBASTIAN RAEDER<sup>5</sup>, LUTZ SCHWEIKHARD<sup>7</sup>, and PETER THIROLF<sup>8</sup> — <sup>1</sup>TU Darmstadt — <sup>2</sup>MPIK Heidelberg — <sup>3</sup>Helmholtz-Institut Mainz — <sup>4</sup>Universität Mainz — <sup>5</sup>GSi Darmstadt — <sup>6</sup>IPN Orsay — <sup>7</sup>Universität Greifswald — <sup>8</sup>LMU München

In previous experiments the masses of <sup>252–255</sup>No ( $Z=102$ ) and

<sup>255,256</sup>Lr ( $Z=103$ ) were measured directly for the first time with the Penning-trap mass spectrometer SHIPTRAP [1,2]. In order to proceed to even heavier elements with  $Z \geq 104$  the overall efficiency of the setup, currently dominated by the combined stopping and extraction efficiency from the gas stopping cell, has to be increased. Therefore, a new cryogenic buffer-gas stopping cell with a larger stopping volume has been developed [3]. Its combined stopping and extraction efficiency was recently measured for the first time under on-line conditions using fusion-evaporation reaction products from SHIP. In this talk, results from the on-line commissioning of the new cell will be presented.

[1] M. Block et al., Nature 463 (2010) 785

[2] E. Minaya Ramirez et al., Science 337 (2012) 1207

[3] C. Droese et al., Nucl. Instr. Meth. Sec. B 338 (2014) 126

## MS 2: Precision Mass Spectrometry and Fundamental Applications II

Time: Monday 14:30–15:15

Location: f128

### Invited Talk

MS 2.1 Mon 14:30 f128

**High Precision Comparison of the Antiproton-to-Proton Charge-to-Mass Ratio** — ●STEFAN ULMER — RIKEN, Wako, Saitama 351-0198, Japan — on behalf of the BASE collaboration

Invariance under the charge, parity, time-reversal (CPT) transformation is one of the fundamental symmetries of the standard model of particle physics. This CPT invariance implies that the fundamental properties of antiparticles and their matter-conjugates are identical, apart from signs. There is a deep link between CPT invariance and Lorentz symmetry, although model dependent. A number of high-precision CPT and Lorentz invariance tests have been performed, but only a few direct high-precision tests that compare the fundamental properties of matter and antimatter are available. The BASE collaboration at the antiproton decelerator of CERN aims at such tests by comparing the fundamental properties of protons and antiprotons with ultra-high precision. Very recently we measured the proton-to-antiproton charge-to-mass ratio with a fractional precision of 69 parts in a trillion. The measurement relies on fast comparisons of the cyclotron-frequencies of a single antiproton and a negatively charged hydrogen ion using an advanced Penning trap system. With an upgraded apparatus we demonstrated the feasibility to overcome our 69 ppt result by another factor of 10. In the talk I will summarize the results described above.

MS 2.2 Mon 15:00 f128

**A high-precision experiment for the determination of the proton mass** — ●FABIAN HEISSE<sup>1,2</sup>, JIAMIN HOU<sup>1</sup>, FLORIAN KÖHLER-LANGES<sup>1</sup>, ANDREAS MOOSER<sup>3</sup>, WOLFGANG QUINT<sup>2</sup>, GÜNTER WERTH<sup>4</sup>, KLAUS BLAUM<sup>1</sup>, STEFAN ULMER<sup>3</sup>, and SVEN STURM<sup>1</sup> — <sup>1</sup>Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany — <sup>2</sup>GSi-Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt, Germany — <sup>3</sup>RIKEN Ulmer Initiative Research Unit, Hirosawa, Wako, Saitama 351-0198, Japan — <sup>4</sup>Institut für Physik, Johannes Gutenberg-Universität Mainz, D-55099 Mainz, Germany

The proton, together with the electron and the neutron, form the central building blocks of the visible universe. The precise knowledge of its properties, among others its atomic mass, is of great interest for high-precision tests as well as for metrology.

Therefore, a new experiment consisting of a cryogenic fivefold Penning-trap setup is built up in our group for the determination of the proton mass with improved accuracy. The measurement principle is based on a simultaneous phase-sensitive comparison of the proton's cyclotron frequency to that of a bare carbon (<sup>12</sup>C<sup>6+</sup>) nucleus. With this new setup it is planned to pin down the atomic mass of the proton with a relative uncertainty as low as 10<sup>-11</sup> or better. The status of the experiment and the experimental setup will be presented.

## MS 3: Ion Traps, Ion Storage Rings, Molecules, Clusters, Decays and Reactions

Time: Monday 15:15–17:30

Location: f128

### Invited Talk

MS 3.1 Mon 15:15 f128

**Mass-Spectroscopic Trace of Transient Reaction Kinetics of CO Oxidation Catalyzed by Uni-Sized Pt Clusters Directly Bound to Si Surface** — ●HISATO YASUMATSU — Cluster Research Laboratory, Toyota Technological Institute: in East Tokyo Laboratory, Genesis Research Institute, Inc. 717-86 Futamata, Ichikawa, Chiba 272-0001, Japan

I will present mass-spectroscopic studies on low-temperature and anti-poisoning catalytic activity driven by uni-sized Pt clusters directly bound to a Si substrate surface, Pt<sub>N</sub>/Si ( $N=10-71$ ). A tandem Quadrupole mass spectrometer was employed; the first one (16000 Da) selects the cluster size,  $N$ , so that uni-sized Pt<sub>N</sub><sup>+</sup> are impacted onto a Si(111) surface for their fixation on the surface, and the second one (500 Da with high transmittance) analyzes catalysis products. The highly selective, sensitive and reproducible detection of the products allows tracing their intensity transients after changing the partial pressures of reactants. In CO oxidation as an example, the transient measurements in combination with numerical simulation led to reaction rate constants of the four elemental steps; CO adsorption/desorption, O<sub>2</sub> dissociative adsorption and Langmuir-Hinshelwood reaction for the CO<sub>2</sub> production. It was found that Pt<sub>60</sub>/Si and Pt<sub>30</sub>/Si possess the catalytic activity 40-K lower than the Pt(111) single-crystal surface. This result was interpreted as the CO anti-poisoning nature of the monatomic-layered Pt<sub>N</sub>/Si due to efficient activation of oxygen by

electrons accumulated in a Schottky barrier junction at the sub-nano interface between Pt<sub>N</sub> and the Si surface.

MS 3.2 Mon 15:45 f128

**A 4k-pixel molecule camera for position and energy resolving detection of neutral molecular fragments** — ●DENNIS SCHULZ<sup>1</sup>, ANDREAS FLEISCHMANN<sup>1</sup>, LISA GAMER<sup>1</sup>, LOREDANA GASTALDO<sup>1</sup>, SEBASTIAN KEMPF<sup>1</sup>, CLAUDE KRANTZ<sup>2</sup>, OLDŘICH NOVOTNÝ<sup>2</sup>, ANDREAS WOLF<sup>2</sup>, and CHRISTIAN ENSS<sup>1</sup> — <sup>1</sup>Kirchhoff Institute for Physics, Heidelberg — <sup>2</sup>Max Planck Institute for Nuclear Physics, Heidelberg

Stored beams of molecular ions at kinetic energies of some tens or hundreds of keV are widely used in molecular collision physics, and a mass spectroscopic identification of fragmentation products is often a key requirement for unambiguous data interpretation. For the reconstruction of the kinematics of electron-ion collisions at the Cryogenic Storage Ring (CSR, MPIK Heidelberg) we developed MOCCA, a new large-area 4096-pixel detector based on magnetic micro-calorimeters. Here, the kinetic energy deposited by a fragmented reaction product in one of the pixels is a measure of its mass, as all fragments have roughly the speed of the initial molecular ion. This calorimetric approach allows for identification of all fragments, in particular including neutrals. MOCCA has an active area of 45mm x 45mm, which is segmented into 64 x 64 absorbers, each 700μm x 700μm in size.

We discuss design considerations and present micro-fabricated detec-

tors. We discuss the results of first tests with x-ray photons, including the uniformity of the detector response, cross-talk, multi-hit capability and the energy resolution for photons and for the massive particles. Including all effects, we expect MOCCA to easily resolve mass differences down to  $1u$  for molecules with a few hundred mass units at CSR.

MS 3.3 Mon 16:00 f128

**Production and storage of new poly-anionic metal clusters at ClusterTrap** — ●MARKUS WOLFRAM, PAUL FISCHER, STEPHAN KÖNIG, GERRIT MARX, LUTZ SCHWEIKHARD und ALBERT VASS — Felix-Hausdorffstraße 6, Institut für Physik, Greifswald, Deutschland

The properties of metal clusters depend on their cluster size  $n$  but also on their charge state  $z$ . The number of electrons which can be attached to a cluster depends on its size but also on the particular metal. While not many nano-systems have yet been investigated with respect to electron attachment, they may well reveal interesting properties and behavior. The aim of the present investigation is to produce new poly-anionic metal clusters by electron attachment to mono-anionic precursors. The mono-anionic clusters are delivered from a laser-ablation/He-gas condensation source and stored in a Penning Trap \* simultaneously with electrons. With this so-called electron-bath technique it is possible to charge the clusters up to higher (negative) charge states. The method is currently applied to further metals, including vanadium, iron, cobalt, zinc, zirconium, niobium, tin, tantalum, titanium and lead. The measurements will provide a basis for future investigations of, e.g., the electron binding energies as a function of charge state. The project is supported by a Collaborative Research Center 652 of the DFG.

MS 3.4 Mon 16:15 f128

**A Novel Laser Ablation Ion Source for Multiple-Reflection Time-of-Flight Mass Spectrometry** — ●FLORIAN GREINER<sup>1</sup>, CHRISTINE HORNING<sup>1</sup>, SAMUEL AYET SAN ANDRÉS<sup>1,2</sup>, TIMO DICKEL<sup>1,2</sup>, JENS EBERT<sup>1</sup>, HANS GEISSEL<sup>1,2</sup>, EMMA HAETTNER<sup>2</sup>, IVAN MISKUN<sup>1</sup>, WOLFGANG PLASS<sup>1,2</sup>, MORITZ PASCAL REITER<sup>1</sup>, ANN-KATHRIN RINK<sup>1</sup>, and CHRISTOPH SCHEIDENBERGER<sup>1,2</sup> — <sup>1</sup>JLU Giessen, Germany — <sup>2</sup>GSI, Darmstadt, Germany

At the FRS Ion Catcher, projectile and fission fragments are produced at relativistic energies, separated in the fragment separator FRS, thermalized in a gas-filled cryogenic stopping cell, extracted and transported to a multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS). The MR-TOF-MS can be used for high precision mass measurements, isobar and isomer separation and for diagnostics purposes. For the calibration and for systematic studies of the MR-TOF-MS a novel laser ablation carbon cluster ion source (LACCI) has been designed, built and commissioned. This source produces ions over a broad mass range as well as isobaric calibrants. It can be operated at a repetition frequency of 100 Hz in order to be compatible with the high repetition rate of the MR-TOF-MS, and . Due to an x-y-movable table the source can run stably for a long time ( $\sim$  days) and targets can be changed without opening the system. The LACCI setup also contains a thermal alkali ion source, a channeltron detector and an RFQ mass filter. It will be coupled to the FRS Ion Catcher beamline via an electrically switchable RFQ switchyard.

30 min. break

## MS 4: Resonance Ionization MS and others

Time: Tuesday 14:30–16:30

Location: f128

### Invited Talk

MS 4.1 Tue 14:30 f128

**Applications of ISOLTRAPs multi-reflection time-of-flight mass spectrometer** — ●FRANK WIENHOLTZ — Ernst-Moritz-Arndt-Universität, Institut für Physik, Greifswald, Germany

For the ISOLTRAP collaboration <https://isoltrap.web.cern.ch/isoltrap/>

Mass spectrometers (MS) and more specific high-resolving multi-reflection time-of-flight (MR-ToF) devices have provided a fast way to separate the different components of ion beams. Thus, they are applicable to many fields of physics and beyond. This contribution will give an overview on how ISOLTRAPs MR-ToF MS at ISOLDE/CERN was already used, not only to support Penning-trap mass spectrometry and for mass measurements on its own, but also as a highly-selective detector for target and ion-source developments as well as for in-source laser spectroscopy. Furthermore, it has been a valuable tool as a highly sen-

MS 3.5 Mon 17:00 f128

**MAc, a software package for hardware control, data acquisition and online analysis for multiple-reflection time-of-flight mass spectrometers (MR-TOF-MS)** — ●JULIAN BERGMANN<sup>1</sup>, ALEXANDER PIKHTELEV<sup>2</sup>, TIMO DICKEL<sup>1,3</sup>, HANS GEISSEL<sup>1,3</sup>, WOLFGANG PLASS<sup>1,3</sup>, CHRISTOPH SCHEIDENBERGER<sup>1,3</sup>, SAMUEL AYET SAN ANDRÉS<sup>1,3</sup>, JENS EBERT<sup>1</sup>, CHRISTINE HORNING<sup>1</sup>, CHRISTIAN JESCH<sup>1</sup>, WAYNE LIPPERT<sup>1</sup>, CHRISTIAN LOTZE<sup>1</sup>, MORITZ PASCAL REITER<sup>1</sup>, and ANN-KATHRIN RINK<sup>1</sup> — <sup>1</sup>JLU Giessen, Deutschland — <sup>2</sup>Institute of Energy Problems of Chemical Physics, RAS, Moscow, Russia — <sup>3</sup>GSI Darmstadt, Deutschland

MAc (Mass Acquisition) is a software package designed for half-automated hardware control, data acquisition and online data analysis for MR-TOF-MS. It offers multi-dimensional automatic hardware parameter optimization e.g. electrode voltage optimization regarding transport efficiency or mass resolving power. Mass resolving powers in excess of 400.000 have been reached. MAc provides support for multiple data acquisition hardware (TDCs and ADCs), online filter features (peak detection, data smoothing etc.) and long-term measurements (days). Automated methods for peak detection and chemical compound identification are provided. Furthermore methods have been developed to visualize long-term signal stability and to correct flight time deviations due to electric field drifts by time-resolved calibration. Applications of MAc's main features for on- and offline data analysis will be presented.

MS 3.6 Mon 17:15 f128

**Conceptual Design of the Cryogenic Stopping Cell for the Super-FRS at FAIR.** — ●IVAN MISKUN<sup>1</sup>, SAMUEL AYET SAN ANDRÉS<sup>1,2</sup>, TIMO DICKEL<sup>1,2</sup>, HANS GEISSEL<sup>1,2</sup>, FABIAN HEISSE<sup>1,2</sup>, WOLFGANG R. PLASS<sup>1,2</sup>, SIVAJI PURUSHOTHAMAN<sup>2</sup>, MORITZ P. REITER<sup>1</sup>, ANN-KATHRIN RINK<sup>1</sup>, and CHRISTOPH SCHEIDENBERGER<sup>1,2</sup> — <sup>1</sup>II. Physikalisches Institut, Justus-Liebig-Universität Gießen, Gießen, Germany — <sup>2</sup>GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

Gas-filled stopping cells are powerful tools used to convert high-energy ion beams to ion beams with kinetic energies of few eV. At the Low-Energy Branch of the Super-FRS at FAIR a cryogenic stopping cell (CSC) filled with ultrapure helium gas at temperature of  $\sim$  70 K will be used to stop, thermalize and transfer exotic nuclei to high precision trap-based experiments and laser spectroscopy. The prototype of this CSC was recently successfully commissioned as the part of FRS Ion Catcher experiment at GSI. An areal density of  $\sim$  6.3 mg/cm<sup>2</sup> was reached while providing short extraction times ( $\sim$  25 ms).

To meet the challenging requirements of the Super-FRS even higher areal densities are needed. Therefore, the design of a next-generation CSC has been developed based on the experience of advanced stopping cell techniques. The novel concept of CSC will provide 5 times higher areal densities increasing the stopping efficiency close to unity and increasing the rate capability by three orders of magnitude. At the same time the extraction time will be decreased down to 5 ms. Results of dedicated simulations and experiments will be presented.

sitive and selective ion-beam monitor supporting gamma spectroscopy measurements, isotope accumulations for solid state physics and collections for medical applications. With their advantageous combination of high measurement speed and high resolving power it can be expected that further fields of application for MR-ToF devices are just around the corner. The development of the ISOLTRAP MR-ToF MS is supported by the BMBF (contract numbers 05P12HGCI1 and 05P15HGCI1A).

MS 4.2 Tue 15:00 f128

**Integration of the compact Photoionization Spectroscopy Apparatus (PISA) to ISOLDE-RILIS** — ●K. CHRYSALIDIS<sup>1,2</sup>, B. CREPIEUX<sup>1</sup>, T. DAY GODACRE<sup>1,3</sup>, V. FEDOSSEEV<sup>1</sup>, P. GACH<sup>1,4</sup>, T. KRON<sup>2</sup>, B.A. MARSH<sup>1</sup>, R.E. ROSSEL<sup>5</sup>, S. ROTHE<sup>1,3</sup>, C. SEIFFERT<sup>1</sup>, and K. WENDT<sup>2</sup> — <sup>1</sup>CERN, Geneva, Switzerland — <sup>2</sup>Johannes-

Gutenberg Universität, Mainz, Germany — <sup>3</sup>The University of Manchester, UK — <sup>4</sup>Cracow University of Technology, Poland — <sup>5</sup>Hochschule RheinMain, Wiesbaden, Germany

The Resonance Ionization Laser Ion Source (RILIS) is the principal ionization technique for radioactive ion beam production at the CERN-ISOLDE on-line isotope separator facility. We introduce the photoionization spectroscopy apparatus (PISA), a compact atomic beam unit for RILIS ionization scheme development. Samples of the element to be investigated can be evaporated from an oven and ionized using the RILIS lasers. Other additional applications of PISA are envisaged: During setup it provides the means to optimize some laser parameters prior to the availability of an ion beam from the target; During operation it could serve as an additional observable for the RILIS performance monitoring; PISA can be used as a reference while performing in-source laser spectroscopy.

We will present the current status of integration into the RILIS setup and results from first applications of PISA to scheme development and in-source laser spectroscopy. We conclude with an outlook on future upgrades of PISA towards mass selectivity and faster sample switching.

MS 4.3 Tue 15:15 f128

**Separation and Implantation of the Rare Isotope <sup>163</sup>Ho for the ECHO Project** — ●TOM KIECK<sup>1</sup>, KATERINA CHRYSALIDIS<sup>1</sup>, HOLGER DORRER<sup>1</sup>, CHRISTOPH DÜLLMANN<sup>1,2</sup>, LISA GAMER<sup>3</sup>, LOREDANA GASTALDO<sup>3</sup>, STEFAN KORMANNSHAUS<sup>1</sup>, SEBASTIAN SCHMIDT<sup>1</sup>, FABIAN SCHNEIDER<sup>1</sup>, and KLAUS WENDT<sup>1</sup> — <sup>1</sup>JGU Mainz — <sup>2</sup>GSi Darmstadt — <sup>3</sup>Universität Heidelberg

The ECHO collaboration aims at measuring the electron neutrino mass by recording the spectrum following electron capture of <sup>163</sup>Ho. To reach a sub-eV sensitivity, a large number of individual microcalorimeters is needed, into which the isotope must be implanted in a well-controlled manner. The necessary amount of <sup>163</sup>Ho is produced by neutron irradiation of enriched <sup>162</sup>Er in the ILL high flux reactor. This introduces significant contaminations of other radioisotopes, which have to be quantitatively removed both, by chemical and mass spectrometric separation. The application of resonance ionization at the RISIKO mass separator guarantees the required isotope selectivity for purification and suitable energy for ion implantation. The efficiency and stability of the laser ion source was improved by Finite-Element Analysis of the thermal processes. For optimum implantation into the detector pixels (170 × 170 μm<sup>2</sup>) with minimum losses a small ion beam spot at the implantation site is needed. For this purpose, post focusing ion optics were installed. Simulations were performed in order to optimize the homogeneous distribution of the implanted ions. The necessity to alternate implantation phases with deposition of a thin metallic layer for <sup>163</sup>Ho activities larger than 10 Bq is being discussed.

MS 4.4 Tue 15:30 f128

**Enhanced Isobaric Suppression in the Laser Ion Source & Trap (LIST)** — ●MARCEL TRÜMPER<sup>1</sup>, VALENTIN FEDOSSEEV<sup>4</sup>, REINHARD HEINKE<sup>1</sup>, TOBIAS KRON<sup>1</sup>, BRUCE MARSH<sup>4</sup>, SEBASTIAN RAEDER<sup>2</sup>, TOBIAS REICH<sup>3</sup>, SVEN RICHTER<sup>1</sup>, SEBASTIAN ROTHE<sup>4</sup>, PASCAL SCHÖNBERG<sup>3</sup>, CARSTEN WEICHOLD<sup>1</sup>, and KLAUS WENDT<sup>1</sup> — <sup>1</sup>Institute of Physics, Mainz University — <sup>2</sup>GSi Helmholtzzentrum für Schwerionenforschung, Darmstadt — <sup>3</sup>Institute of Nuclear Chemistry, Mainz University — <sup>4</sup>CERN, Switzerland

Highly selective and efficient ion sources using laser resonance ionization are needed in order to provide isotopically pure ion beams of rare exotic nuclei at on-line facilities like ISOLDE/CERN. To gain access to isotopes with vanishingly low production rates, for which isobaric contaminations may completely overwhelm the isotope of interest, even more advanced isotope selective approaches are required. The laser ion source and trap LIST combines the high elemental selectivity of laser resonance ionization with electrostatic ion manipulation to suppress any remaining isobaric contaminations from surface ionization.

During final characterization of the LIST in recent off-line studies at the Mainz RISIKO mass separator, electron impact ionization was identified as another interfering ionization process generating isobaric contaminants. In order to address this aspect, the LIST was enhanced by adding an additional electron-repelling electrode. Performance, advantages and constraints of this enhancement of the LIST will be discussed in this talk.

MS 4.5 Tue 15:45 f128

**Laser Ionization of Lanthanides in Preparation of the CERN MEDICIS-PROMED project** — ●VADIM GADELISHIN<sup>1,2</sup>, THOMAS

COCOLIOS<sup>3</sup>, PIET VAN DUPPEN<sup>3</sup>, BRUCE MARSH<sup>4</sup>, YISEL MARTINEZ PALENZUELA<sup>3,4</sup>, SEBASTIAN ROTHE<sup>4</sup>, THIERRY STORA<sup>4</sup>, DOMINIK STUDER<sup>1</sup>, and KLAUS WENDT<sup>1</sup> — <sup>1</sup>Institut für Physik, University of Mainz — <sup>2</sup>Ural Federal University, Yekaterinburg — <sup>3</sup>IKS, KU Leuven — <sup>4</sup>EN Department, CERN

The MEDICIS-PROMED Project is an Innovative Training Network (ITN) under the EU Marie Skłodowska-Curie Actions within EU H2020. In the framework of the CERN knowledge transfer program "Physics for Health Initiatives" it aims to develop a scientific network, exchange and active cooperation between physicists and physicians from European universities and medical institutions with CERN in the field of personalized cancer treatments by providing and testing novel radioisotopes for diagnostics and treatment. The project will apply a dedicated off-line mass separator at CERN's ISOLDE facility for selection of the innovative radiopharmaceuticals, and aims to involve a resonance ionization laser ion source (RILIS) for ensuring highest efficiency and purity of the radioactive ion beams. At Johannes Gutenberg-Universität Mainz the optical ionization processes for the primarily envisaged lanthanide elements are investigated and preparations for the development of a specialized, highly automated laser system are ongoing. A future transfer towards application at compact hospital-based medical cyclotrons and accelerators for enhancement of specific radioisotope production efficiency and purity is envisaged.

MS 4.6 Tue 16:00 f128

**Resonance Laser-SNMS on actinides for spatially resolved ultra-trace analysis** — ●MICHAEL FRANZMANN<sup>1,2</sup>, HAUKE BOSCO<sup>1</sup>, LINDA HAMANN<sup>1</sup>, CLEMENS WALTHER<sup>1</sup>, and KLAUS WENDT<sup>2</sup> — <sup>1</sup>Institut für Radioökologie und Strahlenschutz, Leibniz Universität Hannover — <sup>2</sup>Institut für Physik, Johannes Gutenberg Universität Mainz

The transport mechanisms and geochemical behavior of actinides in natural systems is of major importance to evaluate their distribution in geological formations at contaminated areas and storage sites. The composition analysis of hot particles, sorption on mineral surfaces and migration of trace concentrations of radionuclides requires an excellent suppression of organic background and isobaric contamination in combination with high spatial resolution while maintaining the natural structure of the sample. The new resonant Laser-SNMS system at the IRS Hannover was developed to cover those specifications by combining the high element selectivity of resonance ionization with the non-destructive spatially resolved analysis of a static TOF-SIMS. After the setup of a Ti:Sa laser system and the adaption of an IONTOF TOF.SIMS 5 for laser post-ionization we achieved a platform for a broad range of radioecological measurements. This talk presents the results of characterization and simulation based optimization of the system as well as latest measurements on artificial and environmental samples containing uranium, plutonium and other radionuclides.

MS 4.7 Tue 16:15 f128

**ToF-SIMS and Laser-SNMS Investigations of Different Polymer Systems** — ●ANDREAS PELSTER<sup>1</sup>, MARTIN KÖRSGEN<sup>1</sup>, RAINER KASSENBOHMER<sup>1</sup>, HIROMI MORITA<sup>2</sup>, and HEINRICH F. ARLINGHAUS<sup>1</sup> — <sup>1</sup>University of Münster, Physikalisches Institut, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany — <sup>2</sup>Panasonic Corporation, Device Research Laboratory, Advanced Research Division, 3-1-1 Yagumonaka-machi, Moriguchi City, Osaka 570-8501, Japan

Polymer systems become more and more important for the technical or medical industries. For characterizing and improving of thin organic film systems, it is very important to determine the 3D chemical composition of such systems. For this, two powerful methods are time-of-flight secondary ion mass spectrometry (ToF-SIMS) and laser post-ionization secondary neutral mass spectrometry (Laser-SNMS). Both techniques are based on the detection of sputtered particles from the surface produced by ion bombardment. In the case of ToF-SIMS the sputtered secondary ions can be directly detected while in the case of Laser-SNMS the sputtered neutrals have to be post-ionized with a pulsed laser beam prior detection. In this study we investigated the yields of different polymer systems and films using both ToF-SIMS and Laser-SNMS. It was found that with 157 nm laser post-ionization the molecular yield for several polymer signals could be enhanced by more than one order of magnitude compared to the corresponding molecular yields obtained with ToF-SIMS. High-resolution sub-micrometer images showed that for some polymer samples only Laser-SNMS could distinguish between specific polymers in a structured mixture.

## MS 5: Posters I

Time: Tuesday 16:30–19:00

Location: Empore Lichthof

MS 5.1 Tue 16:30 Empore Lichthof

**Isobar-free High Resolution On-Line Spectroscopy: New Features for the Laser Ion Source & Trap (LIST) at ISOLDE/CERN** — ●CARSTEN WEICHHOLD<sup>1</sup>, VALENTIN FEDOSSEEV<sup>4</sup>, REINHARD HEINKE<sup>1</sup>, TOBIAS KRON<sup>1</sup>, BRUCE MARSH<sup>4</sup>, SEBASTIAN RAEDER<sup>2</sup>, TOBIAS REICH<sup>3</sup>, SVEN RICHTER<sup>1</sup>, SEBASTIAN ROTHE<sup>4</sup>, PASCAL SCHÖNBERG<sup>3</sup>, MARCEL TRÜMPER<sup>1</sup>, and KLAUS WENDT<sup>1</sup> — <sup>1</sup>Institute of Physics, Mainz University — <sup>2</sup>GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — <sup>3</sup>Institute of Nuclear Chemistry, Mainz University — <sup>4</sup>CERN, Switzerland

Highly selective and efficient ion sources are of fundamental importance in the research field of nuclear properties at the edges of the chart of nuclei, where production yields at isotope generators such as ISOLDE at CERN are low and any background is overwhelming. To address this, the LIST combines the highly element-selective laser resonance ionization technique with suppression of isobaric contaminants inside a radiofrequency quadrupole structure. Today, the LIST is integrated as a routine-operational ion source at ISOLDE and has allowed investigations of previously not accessible isotopes.

In order to achieve higher resolution and to pave the way for isomer-selective ionization, a crossed laser/atom beam geometry inside the LIST quadrupole structure has been developed, reducing the spectral linewidth from a few GHz down to around 100 MHz. First off-line tests at the Mainz RISIKO mass separator, advantages, constraints as well as required refinements of this new PI(Perpendicular Illuminated)-LIST design are presented.

MS 5.2 Tue 16:30 Empore Lichthof

**Design of a grating Ti:Sapphire laser with computer controlled wavelength tuning and intra-cavity second harmonic generation for resonant ionization** — VINCENT DEGNER<sup>1,2</sup>, ●PASCAL NAUBEREIT<sup>2</sup>, DAIKI MATSUI<sup>1</sup>, TAKAHIDE TAKAMATSU<sup>1</sup>, ATSUSHI NAKAMURA<sup>1</sup>, KOUSUKE SAITO<sup>1</sup>, RYOHEI OHTAKE<sup>1</sup>, VOLKER SONNENSCHNEIN<sup>1</sup>, TOMITA HIDEKI<sup>1</sup>, TETSUO IGUCHI<sup>1</sup>, and KLAUS WENDT<sup>2</sup> — <sup>1</sup>Department of Quantum Engineering, Nagoya University, Japan — <sup>2</sup>Institut für Physik, University of Mainz, Germany

Tunable lasers with spectrally well controlled, high power output are desirable for inducing a variety of resonant atom-photon interactions. A specific technique serving a broad range of applications is multi-step Resonance Ionization Mass Spectrometry (RIMS). In this field, pulsed high repetition rate Ti:Sapphire (Ti:Sa) lasers are used due to their reliable long term operation and large tuning range from 680 to 1000 nm. Conventional wavelength selection based on birefringent filters and etalons does not allow for wide range mode-hop free tuning as needed for atomic spectroscopy. Therefore, a motorized grating Ti:Sa laser with computer controlled wavelength tuning and synchronized tracking of intra-cavity second harmonic generation (ic-SHG) is currently being developed. Merits of ic-SHG are wide coverage of the blue spectral range and high conversion efficiency combined with a compact setup. Application of this laser design in RIMS will simplify the search for new ionization schemes and enable fast exchange between different ionization schemes for multi-elemental analysis. Both the development and the first characterization of this laser system is discussed.

MS 5.3 Tue 16:30 Empore Lichthof

**Spectroscopy and Laser-SNMS on stable and radioactive Strontium** — ●HAUKE BOSCO<sup>1</sup>, MICHAEL FRANZMANN<sup>1,2</sup>, TOBIAS KRON<sup>2</sup>, CLEMENS WALTHER<sup>1</sup>, and KLAUS WENDT<sup>2</sup> — <sup>1</sup>Institut für Radioökologie und Strahlenschutz, Leibniz Universität Hannover — <sup>2</sup>Institut für Physik, Johannes Gutenberg Universität Mainz

Nuclear accidents as experienced e.g. in Chernobyl or Fukushima and nuclear weapon tests released considerable activity levels and a variety of medium to long-lived radionuclides into the environment. Strontium-90 appears as a significant share of the fission products in spent nuclear fuel and correspondingly in any possible release. Due to its chemical properties it is subject to long range transport through the environment and can cause considerable dose to man when entering the food chain. Correspondingly, the investigation of speciation and migration channels is of major relevance. A radioanalytical approach is severely hampered by the low beta energy of the strontium-90 decay and the need to separate strontium-90 from the secular equilibrated daughter yttrium-90. Hence, application of a mass spectromet-

ric method without chemical separation of the elements is a promising alternative for low-level investigation of strontium-90. Application of the new Laser-SNMS system at IRS Hannover could well suit those needs. It applies three Ti:Sa lasers for resonant ionization of neutral atoms produced by primary ion sputtering in a SIMS together with a time-of-flight mass analysis which provides high spatial resolution. The analytical measurements are preceded by spectroscopic studies on the level structure of strontium to develop a most efficient ionization scheme.

MS 5.4 Tue 16:30 Empore Lichthof

**Ein Multireflektions-Flugzeitmassenspektrometer zur Untersuchung von atomaren Clustern** — PAUL FISCHER<sup>1</sup>, GERIT MARX<sup>1</sup>, MADLEN MÜLLER<sup>1</sup>, MARCO ROSEBUSCH<sup>1</sup>, ●BIRGIT SCHABINGER<sup>1</sup>, LUTZ SCHWEIKHARD<sup>1</sup> und ROBERT WOLF<sup>2</sup> — <sup>1</sup>Institut für Physik, Universität Greifswald, Felix-Hausdorff-Str. 6, 17489 Greifswald — <sup>2</sup>Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Ein Greifswalder Multireflektions-Flugzeitmassenspektrometer (MR-ToF MS) wird seit ein paar Jahren erfolgreich bei ISOLTRAP zur Massenseparation und -spektrometrie exotischer Radionuklide in der experimentellen Kernphysik angewendet [1–4]. Darauf aufbauend wurde kürzlich ein weiteres MR-ToF-Gerät konstruiert, das zur Untersuchung von atomaren Clustern zum Einsatz kommen soll. Aufgrund des hohen Massenaufklärungsvermögens kann die Zusammensetzung auch großer Cluster bestimmt werden. Für Experimente zu Cluster-Laser-Wechselwirkungen, wie der Photofragmentation oder der Photoelektronenspektroskopie, sollen einzelne Clustergrößen mit dem MR-ToF isoliert werden. Erste Ergebnisse werden vorgestellt.

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

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

[3] M. Rosenbusch et. al, Phys. Rev. Lett. 114 (2015) 202501

[4] D. Atanasov et al., Phys. Rev. Lett., in print

MS 5.5 Tue 16:30 Empore Lichthof

**Ion source area of the Cryogenic Storage Ring** — ●JONAS KARTHEIN<sup>1</sup>, KLAUS BLAUM<sup>1</sup>, CHRISTIAN BREITENFELDT<sup>1,2</sup>, SEBASTIAN GEORGE<sup>1</sup>, JÜRGEN GÖCK<sup>1</sup>, MANFRED GRIESER<sup>1</sup>, THOMAS KOLLING<sup>3</sup>, HOLGER KRECKEL<sup>1</sup>, CHRISTIAN MEYER<sup>1</sup>, PREETI MANJARI MISHRA<sup>1</sup>, JENNIFER MOHRBACH<sup>3</sup>, GEREON NIEDNER-SCHATTEBURG<sup>3</sup>, ROLAND REPNOW<sup>1</sup>, LUTZ SCHWEIKHARD<sup>2</sup>, SUNIL KUMAR SUDHAKARAN<sup>1</sup>, ROBERT VON HAHN<sup>1</sup>, and ANDREAS WOLF<sup>1</sup> — <sup>1</sup>Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — <sup>2</sup>Institut für Physik, Ernst-Moritz-Arndt Universität, Felix-Hausdorff-Str. 6, 17487 Greifswald, Germany — <sup>3</sup>Fachbereich Chemie, Universität Kaiserslautern, 67663 Kaiserslautern, Germany

The new electrostatic Cryogenic Storage Ring at the Max-Planck-Institut für Kernphysik in Heidelberg - operated at cryogenic temperatures below 10K and thus at background pressures of below  $10^{-13}$  mbar room temperature equivalent - is designed to perform background-free laser spectroscopy and collision experiments on cold molecular and cluster ions. Ion beam storage times of hours have been demonstrated. Thus, it is ideally suited for studies in astro-, molecular- and cluster physics. To cover this wide range of applications many different ionic systems have to be produced at nA to  $\mu$ A currents. A 5 m  $\times$  5 m high-voltage platform of up to 300 kV is available for the ion sources, which include a cesium sputter ion source, an electro-spray ion source and a buffer-gas cooled laser-vaporization ion source in combination with a radio-frequency quadrupole ion trap for cooling and accumulation. The layout of the area as well as first ion source tests will be presented.

MS 5.6 Tue 16:30 Empore Lichthof

**Laser-induced delayed electron emission of small copper cluster anions** — ●CHRISTIAN BREITENFELDT<sup>1,2</sup>, KLAUS BLAUM<sup>2</sup>, SEBASTIAN GEORGE<sup>2</sup>, JÜRGEN GÖCK<sup>2</sup>, JONAS KARTHEIN<sup>2</sup>, MICHAEL LANGE<sup>2</sup>, SEBASTIAN MENK<sup>2</sup>, CHRISTIAN MEYER<sup>2</sup>, LUTZ SCHWEIKHARD<sup>1</sup>, and ANDREAS WOLF<sup>2</sup> — <sup>1</sup>Institut für Physik, Ernst-Moritz-Arndt Universität, Felix-Hausdorff-Str. 6, 17487 Greifswald, Germany — <sup>2</sup>Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The Cryogenic Trap for Fast ion beams (CTF) is an electrostatic ion beam trap located at the Max-Planck-Institute for nuclear physics in Heidelberg and designed to investigate fundamental properties of charged particles in the gas phase. Here it is employed to study thermionic and laser-induced electron emission of cluster anions with complex multi-body structure. In recent measurements the cooling of small copper cluster anions was investigated both at room tempera-

ture as well as under cryogenic conditions of about 15 K. The cluster ions were produced in a caesium sputter ion source, known to produce poly-atomic ions in highly excited ro-vibrational states. For probing the evolution of the internal energy as a function of the storage time the clusters have been irradiated with nanosecond laser pulses at 1064 nm, and the delayed electron emission has been recorded. Results for copper clusters with cluster sizes ranging from 4 to 7 will be presented.

## MS 6: Posters II

Time: Wednesday 16:30–19:00

Location: Empore Lichthof

MS 6.1 Wed 16:30 Empore Lichthof

**Entwicklung eines Gasionisationsdetektors** — ●GEREON HACKENBERG, ALFRED DEWALD, CLAUS MÜLLER-GATERMANN, MARKUS SCHIFFER, CLAUS FEUERSTEIN, GREGOR ZITZER, ALEXANDER STOLZ, STEFAN HEINZE und RICHARD ALTENKIRCH — Universität zu Köln, Institut für Kernphysik, Deutschland

Zur Spektrometrie kosmogener Nuklide wie  $^{10}\text{Be}$ ,  $^{14}\text{C}$  und  $^{26}\text{Al}$ , als auch Actinoide wurde ein kleiner Gasionisationsdetektor entwickelt, der zunächst bei Pu-Messungen am 6MV Tandetronbeschleuniger eingesetzt wurde. Das Detektordesign ist stark an den Ionisationsdetektor der ETH Zürich angelehnt [1]. Zur Bestimmung der elektrischen Felder innerhalb des Detektors wurden mit dem Programm SIMION detaillierte Simulationsrechnungen durchgeführt. Da zunächst keine kontinuierliche Gaszirkulation vorgesehen ist, wurde beim Bau speziell darauf geachtet, dass Verunreinigungen des Zählergases (Isobutan) durch Auswahl geeigneter Materialien möglichst klein gehalten werden, um die Standzeiten des Detektors zu maximieren. Die verwendeten Vorverstärker wurden am IKP der Universität zu Köln selbst entwickelt und gebaut. Die Detektoreigenschaften wurden mit verschiedenen Ionen wie  $^{12}\text{C}$  bei 26MeV,  $^{37}\text{Cl}$  bei 33MeV und  $^{238}\text{U}$  bei 12MeV getestet. Auflösung und Resultate einer ersten Pu-Messung werden vorgestellt.

[1] A.M. Müller et al., Performance of the ETH gas ionization chamber at low energy, Nucl. Inst. Meth. B 287 (2012) 94.

MS 6.2 Wed 16:30 Empore Lichthof

**Atmospheric picosecond IR laser desorption by impulsive vibrational excitation mass spectrometry (PIRL-DIVE-MS)** — ●YINFEI LU<sup>1</sup>, CORNELIUS L. PIETERSE<sup>1</sup>, WESLEY D. ROBERTSON<sup>1</sup>, and R. J. DWAYNE MILLER<sup>1,2</sup> — <sup>1</sup>Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany — <sup>2</sup>University of Toronto, Toronto, Canada

Desorption by impulsive vibrational excitation (DIVE), using a recently developed picosecond infrared laser (PIRL), has been shown to be an efficient and ultra-soft laser ablation method for the extraction of biomolecules from tissue and solution free of thermal and acoustic damage. DIVE ablation has been shown to efficiently extract intact and even functional proteins, protein complexes and viruses. Here we apply DIVE ablation for the development of a new extraction and ionization technique for mass spectrometry. We demonstrate the efficient production of gas phase ions of small molecules, peptides and large proteins from bulk water for ultra-high sensitivity (femto-mole) mass spectrometry using DIVE in combination with a novel mass spectrometry interface. No further ionization or nebulization methods are employed. The system is directly compared to standard electrospray ionization (ESI). Further, a nanofabricated, dynamically wetted, pico-liter chip array system for aqueous DIVE-MS is demonstrated by utilizing custom image processing base fiducial registration software for sample loading and sampling. The method represents an efficient method for ultra-high sensitivity extraction and MS detection of analytes directly from lab on chip constructions.

MS 6.3 Wed 16:30 Empore Lichthof

**The Heidelberg ATTA setup for  $^{39}\text{Ar}$  dating** — ●ZHONGYI FENG<sup>1</sup>, SVEN EBSER<sup>1</sup>, ANIKA FRÖLIAN<sup>1</sup>, MAURUS HANS<sup>1</sup>, LISA RINGENA<sup>1</sup>, FLORIAN RITTERBUSCH<sup>1,2</sup>, WERNER AESCHBACH<sup>2</sup>, and MARKUS K. OBERTHALER<sup>1</sup> — <sup>1</sup>Kirchhoff-Institute for Physics, Heidelberg, Germany — <sup>2</sup>Institute of Environmental Physics, Heidelberg, Germany

The half-life of  $^{39}\text{Ar}$  covers a dating range from 50 to 1000 years before present and is ideal for ocean water and ice samples, but a challenge arises due to the low abundance  $^{39}\text{Ar}/\text{Ar} = 8.23 \cdot 10^{-16}$  and the small probe volumes in the order of few liters. Atom Trap Trace Analysis

(ATTA) is an ultra-sensitive counting method based on the high selectivity of many photon scattering processes in a Magneto-Optical Trap (MOT) to distinguish the rare isotope from the abundant ones. With this poster we will give a summary of the current status of the experiment and the prospects for dating water samples on a routine basis. We will specifically discuss the possible improvement of the metastable argon source performance utilizing optical pumping inferred from spectroscopic results in a cell. An improved laser setup allowing robust and reliable measurements over many hours as well as alternative cooling schemes will be presented. The smallest possible sample size is currently limited due to a contamination with  $^{39}\text{Ar}$  enriched samples. We will present the results of our detailed studies and will discuss measurement strategies which make the dating of water samples in the order of 10 liter possible.

MS 6.4 Wed 16:30 Empore Lichthof

**Implementation of a position-sensitive detector at TRIGA-TRAP for a phase-sensitive ion cyclotron resonance measurement** — ●JACQUES J. W. VAN DE LAAR<sup>1,5</sup>, KLAUS BLAUM<sup>2</sup>, MICHAEL BLOCK<sup>1,3,4</sup>, CHRISTOPH E. DÜLLMANN<sup>1,3,4,5</sup>, KLAUS EBERHARDT<sup>1,4</sup>, JESSICA GRUND<sup>1,5</sup>, SZILARD NAGY<sup>2</sup>, DENNIS RENISCH<sup>1</sup>, FABIAN SCHNEIDER<sup>1,6</sup>, and KLAUS WENDT<sup>5,6</sup> — <sup>1</sup>Institut für Kernchemie, Johannes Gutenberg-Universität, Mainz, DE — <sup>2</sup>Max-Planck-Institut für Kernphysik, Heidelberg, DE — <sup>3</sup>GSII Helmholtzzentrum für Schwerionenforschung, Darmstadt, DE — <sup>4</sup>Helmholtz-Institut Mainz, DE — <sup>5</sup>PRISMA Cluster of Excellence, Johannes Gutenberg-Universität, Mainz, DE — <sup>6</sup>Institut für Physik, Johannes Gutenberg-Universität, Mainz, DE

Experimental data of ground-state properties of exotic nuclei are important for nuclear structure studies and can test the reliability of nuclear mass models. The TRIGA-TRAP experiment is a double Penning-trap mass spectrometer to perform high-precision measurements on long-lived transuranium isotopes and neutron-rich radionuclides at the research reactor TRIGA Mainz. A novel phase-sensitive detection technique[1] based on the projection of the radial ion motion in the Penning trap onto a position-sensitive detector, the Phase-Imaging Ion-Cyclotron-Resonance (PI-ICR) technique, will be implemented at TRIGA-TRAP. This technique provides a gain of a factor of 40 in resolving power compared to the currently used method. The current status and first results will be presented. [1] S. Eliseev et al., Appl. Phys. B 114 (2014), 107-128

MS 6.5 Wed 16:30 Empore Lichthof

**High-Precision Mass Measurements with PENTATRAP** — ●RIMA X. SCHÜSSLER<sup>1,2</sup>, HENDRIK BEKKER<sup>1</sup>, JOSÉ R. CRESPO LÓPEZ-URRUTIA<sup>1</sup>, SERGEY ELISEEV<sup>1</sup>, PAVEL FILIANIN<sup>1</sup>, MIKHAIL GONCHAROV<sup>1</sup>, YURI NOVIKOV<sup>3</sup>, ALEXANDER RISCHKA<sup>1</sup>, SVEN STURM<sup>1</sup>, STEFAN ULMER<sup>4</sup>, and KLAUS BLAUM<sup>1</sup> — <sup>1</sup>Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — <sup>2</sup>Universität Heidelberg, Fakultät für Physik und Astronomie, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — <sup>3</sup>Petersburg Nuclear Physics Institute, 188300 Gatchina, Russia — <sup>4</sup>RIKEN, Ulmer Initiative Research Unit, Wako, Saitama 351-0198, Japan

The high-precision Penning-trap mass spectrometer PENTATRAP is currently being commissioned at the Max-Planck-Institut für Kernphysik, Heidelberg. PENTATRAP aims at mass-ratio measurements of single stable and long lived highly charged ions with a relative uncertainty of a few  $10^{-12}$ . At this precision level, PENTATRAP will, for instance, contribute to electron-neutrino mass related measurements within the ECHO collaboration, which determines the de-excitation spectrum following the electron capture in  $^{163}\text{Ho}$ . PENTATRAP will determine the mass ratios of the desired ion species through measurements of their respective cyclotron frequencies in the strong magnetic



field of a Penning trap. The experimental setup consists of five Penning traps, making simultaneous storage of several ion species possible. This allows for in situ calibration and reference measurements. The current status and outlook of the experiment will be presented in the poster.

MS 6.6 Wed 16:30 Empore Lichthof

**Fabrication of the 4k-Pixel Molecule Camera MOCCA and its Integration into the Cryogenic Storage Ring CSR** — ●L. GAMER<sup>1</sup>, C. ENNS<sup>1</sup>, A. FLEISCHMANN<sup>1</sup>, L. GASTALDO<sup>1</sup>, S. KEMPF<sup>1</sup>, C. KRANTZ<sup>2</sup>, O. NOVOTNÝ<sup>2</sup>, D. SCHULZ<sup>1</sup>, and A. WOLF<sup>2</sup> — <sup>1</sup>Heidelberg University — <sup>2</sup>MPIK Heidelberg

The Cryogenic Storage Ring at the Max Planck Institute for Nuclear

Physics in Heidelberg is able to store heavy molecular ions in their rotational and vibrational ground states. In a near future electron-ion-interactions, such as the dissociative recombination, will be investigated in laboratory environment at conditions that are close to those in cold interstellar plasmas. To reconstruct the full kinematics of these processes, a position and energy sensitive coincident detection of multiple reaction products is necessary. We recently designed and fabricated MOCCA, a 4k-pixel molecule camera based on magnetic calorimeters with a detection area of 45 mm × 45 mm segmented into 64 × 64 absorbers. We present the detector design and microfabrication as well as the plans for integrating MOCCA and its <sup>3</sup>He/<sup>4</sup>He dilution refrigerator into CSR.

## MS 7: Accelerator Mass Spectrometry and Applications I

Time: Thursday 11:00–12:45

Location: f128

### Invited Talk

MS 7.1 Thu 11:00 f128

**The ILIAS project - Isobar suppression in AMS by laser photodetachment** — ●MARTIN MARTSCHINI<sup>1</sup>, PONTUS ANDERSSON<sup>2</sup>, OLIVER FORSTNER<sup>3</sup>, DAG HANSTORP<sup>4</sup>, JOHANNES LACHNER<sup>1</sup>, YUAN LIU<sup>5</sup>, TOBIAS MOREAU<sup>1</sup>, JOHANNA PITTERS<sup>1,6</sup>, ALFRED PRILLER<sup>1</sup>, PETER STEIER<sup>1</sup>, and ROBIN GOLSER<sup>1</sup> — <sup>1</sup>VERA Laboratory, University of Vienna, Faculty of Physics, Austria — <sup>2</sup>Earth and Space Sciences Department, Chalmers Technical University, Gothenburg, Sweden — <sup>3</sup>Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universität, Jena, Germany — <sup>4</sup>Department of Physics, University of Gothenburg, Sweden — <sup>5</sup>Oak Ridge National Laboratory, Oak Ridge, USA — <sup>6</sup>Beams Department, CERN

The ILIAS-project at the University of Vienna was initiated in 2010 to explore isobar suppression by selective laser photodetachment for future AMS purpose. A gas-filled radio frequency quadrupole is used to decelerate negative atomic and molecular ion beams from a cesium sputter source and thereby extend the ion laser interaction time. Following successful development and characterization of the RFQ cooler at a purpose-built test bench, the ILIAS cooler is currently moved to a new injector beamline at VERA. This will allow first applications of this novel technique at a state-of-the-art AMS facility.

Besides an overview of the project, the talk will highlight experimental results on the performance of the RFQ ion cooler. This includes the suppression of a <sup>63</sup>Cu<sup>-</sup> test beam by more than 99.999% with a 532nm laser, optical filtering of MgO<sup>-</sup> and AlO<sup>-</sup> and comprehensive measurements of the ion residence time inside the RFQ ion cooler.

MS 7.2 Thu 11:30 f128

**Status of the 300 kV multi isotope AMS project** — ●SASCHA MAXEINER, HANS-ARNO SYNAL, MARCUS CHRISTL, MARTIN SUTER, ARNOLD MÜLLER, and CHRISTOF VOCKENHUBER — Laboratory for Ion Beam Physics (LIP), ETH Zurich, Switzerland

The goal of the presented 300 kV multi isotope project is the development of a compact AMS system capable of measuring a wide range of isotopes including <sup>10</sup>Be, <sup>14</sup>C, <sup>26</sup>Al, <sup>41</sup>Ca, <sup>129</sup>I and the actinides. The high voltage platform for tandem acceleration is housed in a vacuum insulated chamber and fed by a commercial power supply. Helium stripper gas feeding from ground, compactness, good vacuum but sufficient areal stripper gas density are key features of the accelerator. Some of the latest technical improvements to achieve stable operation conditions will be discussed and results of AMS measurements with a prototype setup are presented.

MS 7.3 Thu 11:45 f128

**Carrier free <sup>10</sup>Be/<sup>9</sup>Be measurement with AMS** — ●JOHANNES LACHNER<sup>1</sup>, MARCO PLONER<sup>1</sup>, AYA SAKAGUCHI<sup>2</sup>, PETER STEIER<sup>1</sup>, and ROBIN GOLSER<sup>1</sup> — <sup>1</sup>Faculty of Physics, University of Vienna, Austria — <sup>2</sup>Faculty of Pure and Applied Sciences, University of Tsukuba, Japan

Measuring <sup>10</sup>Be/<sup>9</sup>Be ratios is a powerful tool to date marine deposits in the range of million years if it succeeds to determine minute amounts of the long-lived <sup>10</sup>Be and the stable <sup>9</sup>Be. The low abundance of Be in natural samples poses challenges to the preparation of samples and to very sensitive measurements of both <sup>10</sup>Be and <sup>9</sup>Be. The high efficiency of BeO<sup>-</sup> extraction from the Fe<sub>2</sub>O<sub>3</sub> target matrix in combination with a good transmission from the low energy side into the detector enables

us to measure 0.1% of the total material during the first hour of sputtering a target. Ion source cross-contamination from intense standards and traces of Be taken up during the preparation of the targets currently limit the background to levels of 0.06 counts per second (<sup>10</sup>Be) and 15 pA (<sup>9</sup>Be<sup>2+</sup>). We present the establishment of the carrier-free Be method at the VERA laboratory and show results of Fe-Mn crusts from the Pacific Ocean dated back to 17 Myr.

MS 7.4 Thu 12:00 f128

**Improved <sup>26</sup>Al measurements with absorber setup at low energies** — ●KLAUS-ULRICH MILTENBERGER, MARCUS CHRISTL, ARNOLD MILENKO MÜLLER, HANS-ARNO SYNAL, and CHRISTOF VOCKENHUBER — Laboratory of Ion Beam Physics, ETH Zurich, Otto-Stern-Weg 5, 8093 Zurich, Switzerland

At the ETH 500 kV AMS facility (Tandy) transmission of more than 50% is achieved for aluminium ions in charge state 2+, enabled by the use of helium as a stripper gas in the accelerator. However, to utilize the high transmission for sensitive AMS measurements of <sup>26</sup>Al, the intense interference caused by <sup>13</sup>C<sup>1+</sup> entering the detector has to be suppressed. To achieve this, a new absorber setup for low energy <sup>26</sup>Al<sup>2+</sup> measurements was developed and tested.

Using the new absorber-detector configuration, several standards, blanks, and real samples were measured. Compared to earlier measurements conducted at the ETH 6 MV accelerator, the statistical measurement errors could be reduced significantly due to better counting statistics and more stable measurement conditions. The <sup>26</sup>Al/<sup>27</sup>Al ratios measured for different standards (ZAL94N, Nishiizumi) correspond very well with their nominal ratios ranging from  $5 \cdot 10^{-13}$  to  $5 \cdot 10^{-10}$ . Blank ratios are currently in the range of  $1 - 3 \cdot 10^{-14}$  and limited by <sup>26</sup>Al cross-contamination in the SNICS ion source caused by the high ratio  $((480 \pm 18) \cdot 10^{-12})$  of the ZAL94N standard. To minimize cross-contamination the new ETH Zurich standard ZAL02 with a nominal <sup>26</sup>Al/<sup>27</sup>Al ratio of  $(46.5 \pm 0.1) \cdot 10^{-12}$  was introduced.

MS 7.5 Thu 12:15 f128

**Online coupling of thermal-optical and 14C AMS analysis in atmospheric aerosols source apportionment** — ●SÖNKE SZIDAT, KONSTANTINOS AGRIOS, and GARY SALAZAR — Universität Bern, Departement für Chemie und Biochemie & Oeschger-Zentrum für Klima- und Klimafolgenforschung, Bern, Schweiz

Radiocarbon (<sup>14</sup>C) is a powerful tool that allows the distinction of fossil and non-fossil sources of atmospheric carbonaceous aerosols. The total carbon fraction and its sub-fractions organic carbon (OC) and elemental carbon (EC) comprise a significant portion of the atmospheric fine air particulate matter, influencing the global climate and human health. The separation of OC and EC for <sup>14</sup>C measurement is performed with a commercial thermo-optical aerosol analyzer that transforms thermal degradation products into gaseous carbon dioxide. Currently, these gas fractions are then analyzed for <sup>14</sup>C with the accelerator mass spectrometry (AMS) system MICADAS either offline (i.e. by sealing of ampules) or by trapping with a zeolite molecular sieve and direct transfer. Although these techniques have been frequently applied with success, they suffer from a loss of information by mixing, as both fractions, OC and EC, comprise many individual chemical compounds. Therefore, we present here the development of a continuous-flow AMS analytical hyphenation. This approach allows for real-time <sup>14</sup>C AMS analysis of carbonaceous aerosol samples, as they

evolve sequentially from the thermo-optical aerosol analyzer according to their volatility and refractivity.

MS 7.6 Thu 12:30 f128

**Speed Dating: A Rapid Way to Determine the Radiocarbon Age of Wood by EA-AMS** — ●ADAM SOOKDEO<sup>1</sup>, LUKAS WACKER<sup>1</sup>, SIMON FAHRNI<sup>1</sup>, CAMERON P. MCINTYRE<sup>1</sup>, MICHAEL FREDRICH<sup>2,3</sup>, FREDERICK REINIG<sup>4</sup>, BERND KROMER<sup>2</sup>, and ULF BÜNTGEN<sup>4</sup> — <sup>1</sup>Laboratory of Ion beam physics, ETH-Zürich, Zürich Switzerland — <sup>2</sup>Institute of environmental physics, Heidelberg University, Heidelberg, Germany — <sup>3</sup>Institute of Botany, Hohenheim University, Stuttgart, Germany — <sup>4</sup>Swiss Federal Research Institute, WSL, Birmensdorf, Switzerland

Trees ranging from modern to 14000BP and older are discovered in construction sites, rivers and lake sediments, these trees contain information about past atmospheric 14C concentration that is used to create 14C calibration curve. When new trees are found the scientific value remains unclear until they are dated, this can be expensive and time consuming using conventional techniques. At the Laboratory of Ion beam Physics (LIP), we developed a new application called Speed Dating to quickly establish 14C dates for wood samples using an Elemental Analyzer (EA) coupled to an Accelerator Mass Spectrometer (AMS). For Speed Dating we do not chemically treat the wood samples but rather directly combust wood using an EA and the CO<sub>2</sub>(g) is measured by an AMS. This results in measurements times that are five times quicker than conventional 14C dating and are cheaper.

## MS 8: Annual General Meeting of the Mass Spectrometry Division

Time: Thursday 12:45–13:15

Location: f128

Annual General Meeting of the Mass Spectrometry Division

## MS 9: Accelerator Mass Spectrometry and Applications II

Time: Thursday 14:30–16:15

Location: f128

### Invited Talk

MS 9.1 Thu 14:30 f128

**Multi-actinide analysis with AMS for ultra-trace determination and small sample sizes: advantages and drawbacks** — ●FRANCESCA QUINTO<sup>1</sup>, MARKUS LAGOS<sup>1</sup>, MARKUS PLASCHKE<sup>1</sup>, THORSTEN SCHÄFER<sup>1</sup>, PETER STEIER<sup>2</sup>, ROBIN GOLSER<sup>2</sup>, and HORST GECKEIS<sup>1</sup> — <sup>1</sup>Institute for Nuclear Waste Disposal, Karlsruhe Institute of Technology, Germany — <sup>2</sup>VERA Laboratory, Faculty of Physics, University of Vienna, Austria

With the abundance sensitivities of AMS for U-236, Np-237 and Pu-239 relative to U-238 at levels lower than 1E-15, a simultaneous determination of several actinides without previous chemical separation from each other is possible. The actinides are extracted from the matrix elements via an iron hydroxide co-precipitation and the nuclides sequentially measured from the same sputter target. This simplified method allows for the use of non-isotopic tracers and consequently the determination of Np-237 and Am-243 for which isotopic tracers with the degree of purity required by ultra-trace mass-spectrometric analysis are not available. With detection limits of circa 1E+4 atoms in a sample, 1E+8 atoms are determined with circa 1 % relative uncertainty due to counting statistics. This allows for an unprecedented reduction of the sample size down to 100 ml of natural water. However, the use of non-isotopic tracers introduces a dominating uncertainty of up to 30 % related to the reproducibility of the results. The advantages and drawbacks of the novel method will be presented with the aid of recent results from the CFM Project at the Grimsel Test Site and from the investigation of global fallout in environmental samples.

MS 9.2 Thu 15:00 f128

**Detection of Pu in Pacific Ocean water with AMS related to the Fukushima accident** — ●KARIN HAIN<sup>1</sup>, THOMAS FAESTERMANN<sup>1</sup>, LETICIA FIMIANI<sup>1</sup>, ROBIN GOLSER<sup>2</sup>, JOSÉ MANUEL GUZMÁN<sup>1</sup>, GUNTHER KORSCHINEK<sup>1</sup>, FLORIAN KORTMANN<sup>1</sup>, CHRISTOPH LIERSE V. GOSTOMSKI<sup>1</sup>, PETER LUDWIG<sup>1</sup>, PETER STEIER<sup>2</sup>, and MASATOSHI YAMADA<sup>3</sup> — <sup>1</sup>TUM, Germany — <sup>2</sup>Universität Wien, Austria — <sup>3</sup>Hirosaki University, Japan

The concentration of plutonium (Pu) and its isotopic ratios were determined by accelerator mass spectrometry (AMS) in Pacific Ocean water samples. The isotopic ratios <sup>240</sup>Pu/<sup>239</sup>Pu and <sup>241</sup>Pu/<sup>239</sup>Pu can be used to identify a possible release of Pu into the ocean by the Fukushima accident. <sup>241</sup>Pu from fallout of nuclear weapon testings has already significantly decayed. <sup>241</sup>Am, the daughter nuclide of <sup>241</sup>Pu, causes isobaric background on <sup>241</sup>Pu in mass-spectrometric measurements. Therefore, Am and Pu had to be separated chemically using extraction chromatography. The method was verified by analyzing certified reference material. 12 sea water samples, collected at different depths, were prepared at the Radiochemie München. The concentration of Pu was measured with AMS at the Maier-Leibnitz-Laboratory in Munich and the Vienna Environmental Research Laboratory (VERA). After a short motivation related to the Fukushima accident, the chemical separation method will be presented. Prelimi-

nary results of the distribution of Pu in ocean water will be discussed. This work was funded by the Studienstiftung des deutschen Volkes. We would like to acknowledge the valuable support of T. Shinonaga.

MS 9.3 Thu 15:15 f128

**I-129 in Böden der nördlichen Ukraine und die retrospektive Dosimetrie der I-131-Exposition nach dem Reaktorunfall von Tschernobyl** — ●ABDELOUAHED DARAOU<sup>1</sup>, ROLF MICHEL<sup>1</sup>, MONIKA GORNY<sup>1</sup>, DIETER JAKOB<sup>1</sup>, RÜDIGER SACHSE<sup>1</sup>, CLEMENS WALTHER<sup>1</sup>, VASSILI ALFIMOV<sup>2</sup> und HANS-ARNO SYNAL<sup>2</sup> — <sup>1</sup>Institut für Radioökologie und Strahlenschutz, Leibniz Universität Hannover, Deutschland — <sup>2</sup>Labor für Ionenstrahlphysik, ETH Zürich, Schweiz

Nach dem Unfall von Tschernobyl stiegen in der Ukraine, Weißrussland und Russland die Fälle von Schilddrüsenkrebs bei Jugendlichen aufgrund der I-131 Strahlenexpositionen dramatisch an. Aufgrund von zu wenigen direkten Messungen der Schilddrüsenaktivitäten ist die Dosimetrie der I-131 Expositionen nicht befriedigend. Mit Hilfe des langlebigen I-129 kann retrospektiv der Fallout von I-131 nach dem Unfall von Tschernobyl bestimmt. Dafür wurden 300 Bodenproben aus 60 Siedlungen aus der nördlichen Ukraine aus Kontaminationszone II und III im Zeitraum zwischen 2004 und 2007 untersucht. Mit Hilfe von AMS für I-129 werden die Bodenproben analysiert. Die Ergebnisse zeigen, dass noch immer mehr als 90 % der I-129-Konzentration in den oberen 40 cm der Bodenprofilen zu lokalisieren sind. Die I-129-Inventare sind mit den Cs-137-Inventaren in den hoch kontaminierten Gebieten korreliert. Allerdings ist die Variabilität der I-129/Cs-137 Verhältnisse groß, sodass für die retrospektive Dosimetrie auf die I-129-Daten zurückzugreifen ist. Aus den I-129 Inventaren wurden über aggregierte Dosisfaktoren die I-131 Schilddrüsendosen berechnet. Die Ergebnisse werden mit direkten Messungen der Schilddrüsenaktivität verglichen.

MS 9.4 Thu 15:30 f128

**Development of high-sensitivity AMS for <sup>93</sup>Zr** — BOYANA DENEVA<sup>1</sup>, THOMAS FAESTERMANN<sup>1</sup>, LETICIA FIMIANI<sup>1</sup>, JOSÉ MANUEL GÓMEZ-GUZMÁN<sup>1</sup>, KARIN HAIN<sup>1</sup>, GUNTHER KORSCHINEK<sup>1</sup>, ●PETER LUDWIG<sup>1</sup>, VICTORIA SERGEYEVA<sup>2</sup>, NICOLAS THIOLLAY<sup>2</sup>, and OLIVIER VIGNEAU<sup>2</sup> — <sup>1</sup>Physik Department TUM, Garching — <sup>2</sup>Centre CEA, Cadarache, France

The radioisotope <sup>93</sup>Zr ( $T_{1/2} = 1.5$  Ma) represents a very challenging background situation for AMS. Its two stable neighbouring isotopes <sup>92</sup>Zr and <sup>94</sup>Zr only differ in mass by ~1%, making them difficult to separate. Additionally, the stable isobar <sup>93</sup>Nb with only one unit difference in proton number, needs to be suppressed in order to achieve high sensitivity. In recent studies at the Maier-Leibnitz-Laboratory in Garching, different experimental approaches have been explored: Firstly, by using stacked passive absorber (SiN) foils, exploiting the energy loss difference of <sup>93</sup>Zr and <sup>93</sup>Nb, in combination with a time-of-flight measurement and isotopic suppression of the neighbouring isotopes by a Wien-filter. And secondly, using the gas-filled magnet system GAMS providing isobaric suppression, in combination with an

ionization chamber with a five-fold segmented anode. Both techniques have shown excellent preliminary results with sensitivities for the atom ratio of  $^{93}\text{Zr}/\text{Zr} \approx 2 \cdot 10^{-10}$ . This opens the door towards applications in the fields of nuclear materials, fuel behaviour, and waste management, but also nuclear astrophysics, where  $^{93}\text{Zr}$  represents a weak branching point in the s-process.

MS 9.5 Thu 15:45 f128

**Accretion rate of IDPs onto the Earth by means of  $^{53}\text{Mn}$  and  $^{41}\text{Ca}$  AMS measurement in Antarctic snow** — ●JOSE MANUEL GOMEZ GUZMAN<sup>1</sup>, SHAWN BISHOP<sup>1</sup>, THOMAS FAESTERMANN<sup>1</sup>, JENNY FEIGE<sup>2</sup>, LETICIA FIMIANI<sup>1</sup>, KARIN HAIN<sup>1</sup>, SEPP KIPFSTUHL<sup>3</sup>, GUNTHER KORSCHINEK<sup>1</sup>, PETER LUDWIG<sup>1</sup>, SILKE MERCHEL<sup>4</sup>, DARIO RODRIGUES<sup>5</sup>, JOHANNES STERBA<sup>6</sup>, JAN WELCH<sup>6</sup>, and ROLF WELLER<sup>3</sup> — <sup>1</sup>Technische Universität München, Fakultät für Physik, Garching (Germany) — <sup>2</sup>Zentrum für Astronomie und Astrophysik TU Berlin, Berlin (Germany) — <sup>3</sup>Helmholtz-Zentrum Alfred-Wegener-Institut, Bremerhaven (Germany) — <sup>4</sup>Helmholtz-Zentrum Dresden-Rossendorf (Germany) — <sup>5</sup>Laboratorio TANDAR, Comisión Nacional de Energía Atómica (Argentina) — <sup>6</sup>Atominstut der Technische Universität Wien (Austria)

Interplanetary Dust Particles (IDPs) are small grains, a few hundred micrometers in size and mainly originated in the Asteroid Belt. During their flight to the Earth they are irradiated by GCR and SCR and  $^{41}\text{Ca}$  ( $T_{1/2} = 1.03 \times 10^5 \text{yr}$ ) and  $^{53}\text{Mn}$  ( $T_{1/2} = 3.68 \times 10^6 \text{yr}$ ) are formed. Since there are no significant terrestrial sources for those radionuclides they can be used as a key tracer to determine the accretion rate of IDPs onto the Earth. For this project, 550 kg of snow have been collected at the Antarctic German station Kohnen to be processed to extract  $^{41}\text{Ca}$  and  $^{53}\text{Mn}$ . Also the filter used will be processed to check the existence

of IDPs surviving evaporation during their entry in the atmosphere. The AMS measurements will be made at the MLL in Garching, a facility with sensitivity down to  $10^{-16}$  for  $^{41}\text{Ca}$  and  $10^{-14}$  for  $^{53}\text{Mn}$ .

MS 9.6 Thu 16:00 f128

**Dating with Atom Trap Trace Analysis of  $^{39}\text{Ar}$**  — ●SVEN EBSER<sup>1</sup>, ZHONGYI FENG<sup>1</sup>, LISA RINGENA<sup>1</sup>, FLORIAN RITTERBUSCH<sup>1,2</sup>, ARNE KERSTING<sup>2</sup>, STEFAN BEYERSDORFER<sup>2</sup>, EME-LINE MATHOUCHANH<sup>2</sup>, WERNER AESCHBACH<sup>2</sup>, and MARKUS K. OBERTHALER<sup>1</sup> — <sup>1</sup>Kirchhoff-Institute for Physics, Heidelberg, Germany — <sup>2</sup>Institute of Environmental Physics, Heidelberg, Germany

Atom Trap Trace Analysis (ATTA) is an ultra-sensitive counting method for rare and long-lived isotopes. It is based on the high selectivity of resonant photon scattering during laser cooling and trapping in order to distinguish the rare isotope from the abundant ones. We have focused on the rare argon isotope  $^{39}\text{Ar}$  and developed an ATTA-setup. As an inert noble gas and with a half-life of 269 years it is the perfect tracer to fill the dating gap for ice and water samples between 50 and 1000 years before present, for which time period no other tracers exist. The experimental challenge lies in the low atmospheric abundance of  $^{39}\text{Ar}$  ( $^{39}\text{Ar}/\text{Ar} = 8.23 \cdot 10^{-16}$ ) which requires a stable and reproducible performance of all components of the apparatus leading to a robust  $^{39}\text{Ar}$  detection efficiency. Our first results from groundwater samples reveal the potential of this table top experiment to routinely measure small samples down to 10 mL STP of argon. Furthermore, we will present current developments such as more efficient cooling techniques and optical pumping to enhance the flux of metastable argon atoms with the aim to increase the count rate. Shorter measurement times and smaller sample sizes together with a reduction of statistical uncertainties will thus become possible.

## MS 10: Posters III

Time: Thursday 16:30–19:00

Location: Empore Lichthof

MS 10.1 Thu 16:30 Empore Lichthof

**Supernova-produced  $^{60}\text{Fe}$  in Earth's microfossil record** — ●PETER LUDWIG<sup>1</sup>, SHAWN BISHOP<sup>1</sup>, RAMON EGLI<sup>2</sup>, VALENTYNA CHERNENKO<sup>1</sup>, BOYANA DENEVA<sup>1</sup>, THOMAS FAESTERMANN<sup>1</sup>, LETICIA FIMIANI<sup>1</sup>, JOSÉ MANUEL GÓMEZ-GUZMÁN<sup>1</sup>, KARIN HAIN<sup>1</sup>, GUNTHER KORSCHINEK<sup>1</sup>, MARIANNE HANZLIK<sup>3</sup>, SILKE MERCHEL<sup>4</sup>, and GEORG RUGEL<sup>4</sup> — <sup>1</sup>Physik Department TUM, Garching — <sup>2</sup>ZAMG, Wien — <sup>3</sup>Chemie Department TUM, Garching — <sup>4</sup>HZDR, Dresden

It is possible for a nearby supernova (SN) explosion to deposit a fraction of its ejecta on Earth. Due to the lack of significant anthropogenic and cosmogenic background,  $^{60}\text{Fe}$  ( $T_{1/2} = 2.6 \text{Ma}$ ) is perfectly suited to serve as a radioactive tracer of recent SN events. The ratio of  $^{60}\text{Fe}/\text{Fe}$  was measured in over 100 samples extracted from two sediment cores from the Eastern Equatorial Pacific. The AMS samples were produced using a carefully tuned chemical leaching technique that specifically targets fine-grained iron-oxides, such as magnetofossils. Magnetofossils are the remains of magnetosome chains, built up by magnetotactic bacteria, which are abundantly present in our sediment, as shown by magnetic analysis and electron microscopy. The AMS samples were measured at the GAMS setup at the Maier-Leibnitz-Laboratory in Garching, where the use of a gas-filled magnet for isobaric suppression provides a sensitivity of  $^{60}\text{Fe}/\text{Fe} \approx 5 \cdot 10^{-17}$ . Our results reveal a  $^{60}\text{Fe}$  signature over a time-range of about 1.7-2.7 Ma, which is attributed to the deposition of SN debris.

MS 10.2 Thu 16:30 Empore Lichthof

**Iodine-129 and iodine-129 in natural waters from Fuhrberger Feld catchment near Hannover, Germany** — ●ALFATIH OSMAN<sup>1</sup>, STEFAN BISTER<sup>1</sup>, ABDELOUAHED DARAOU<sup>1</sup>, ALEX HOELZER<sup>1</sup>, BEATE RIEBE<sup>1</sup>, CLEMENS WALTHER<sup>1</sup>, CHRISTOF VOCKENHUBER<sup>2</sup>, and HANS-ARNO SYNAL<sup>2</sup> — <sup>1</sup>Institute for Radioecology and Radiation Protection (IRS), Leibniz University of Hannover, Germany — <sup>2</sup>Laboratory of Ion Beam Physics, ETH Zurich, Switzerland

Environmental input of anthropogenic iodine-129 has been increased due to various nuclear applications. Such releases lead to a diffuse pollution of large scale reservoirs. In the framework of the TransAqua project, funded by BMBF, we are aiming at assessing the sensitivity of the drinking water reservoir in Fuhrberger Feld catchment near Hannover with regard to introduction and accumulation of iodine-129. For

that purpose, surface- and groundwaters were analyzed for I-127 and I-129 using ICP-MS and AMS. I-129/I-127 isotopic ratios in all samples are significantly higher than the pre-nuclear isotopic ratio ( $1.5 \cdot 10^{-12}$ ). Concentrations of I-129 of the investigated waters were compared to other environmental compartments in the same region (Lower Saxony). The investigated groundwater revealed comparable I-129 concentration and I-129/I-127 isotopic ratio as in surface waters from the same area, but higher values in contrast to other aquifers in the same region. This means that the water reservoir in Fuhrberger Feld has already been slightly affected by atmospheric input of anthropogenic I-129, which is most likely originating from the European reprocessing plants.

MS 10.3 Thu 16:30 Empore Lichthof

**Actinide AMS at DREAMS** — ●NASRIN B. KHOJASTEH<sup>1</sup>, SILKE MERCHEL<sup>1</sup>, STEFAN PAVETICH<sup>1,2</sup>, GEORG RUGEL<sup>1</sup>, ANDREAS SCHARF<sup>1</sup>, and RENÉ ZIEGENRÜCKER<sup>1</sup> — <sup>1</sup>HZDR, Dresden, Germany — <sup>2</sup>ANU, Canberra, Australia

Radionuclides such as  $^{236}\text{U}$  and  $^{239}\text{Pu}$  were introduced into the environment by atmospheric nuclear weapon tests, reactor accidents (Chernobyl, Fukushima), releases from nuclear reprocessing facilities (Sellafield, La Hague), radioactive waste disposal, and accidents with nuclear devices (Palomares, Thule) [1]. Accelerator Mass Spectrometry (AMS) is the most sensitive method to measure these actinides.

The DREsdn AMS (DREAMS) facility is located at a 6 MV accelerator, which is shared with ion beam analytics and implantation users, preventing major modifications of the accelerator and magnetic analyzers. DREAMS was originally designed for  $^{10}\text{Be}$ ,  $^{26}\text{Al}$ ,  $^{36}\text{Cl}$ ,  $^{41}\text{Ca}$ , and  $^{129}\text{I}$  [2,3]. To modify the system for actinide AMS, a Time-of-Flight (TOF) beamline at the high-energy side has been installed and performance tests are on-going. Ion beam and detector simulations are carried out to design a moveable ionization chamber. Especially, the detector window and anode dimensions have to be optimized. This ionization chamber will act as an energy detector of the system and its installation is planned as closely as possible to the stop detector of the TOF beamline for highest detection efficiency. [1] Srncik et al., J. Environ. Radioact. 132 (2014) 108. [2] Akhmadaliev et al., Nucl. Instr. Meth. B. 294 (2013) 5. [3] Rugel et al., Nucl. Instr. Meth. B. in review.

MS 10.4 Thu 16:30 Empore Lichthof  
**AMS measurements of  $^{10}\text{Be}$ ,  $^{26}\text{Al}$  and  $^{41}\text{Ca}$  at DREAMS** — ●ANDREAS SCHARF<sup>1</sup>, SHAVKAT AKHMADALIEV<sup>1</sup>, MAURICE ARNOLD<sup>2</sup>, PASCAL BOHLEBER<sup>3</sup>, INGO LEYA<sup>4</sup>, SILKE MERCHEL<sup>1</sup>, GEORG RUGEL<sup>1</sup>, THOMAS SMITH<sup>4</sup>, RENÉ ZIEGENRÜCKER<sup>1</sup>, and LARS ZIPP<sup>3</sup> — <sup>1</sup>HZDR, Dresden, Germany — <sup>2</sup>CEREGE, Aix-en-Provence, France — <sup>3</sup>Universität Heidelberg, Germany — <sup>4</sup>University of Bern, Switzerland

DREAMS, the DREsdn AMS-facility, is performing routine accelerator mass spectrometry for the isotopes  $^{10}\text{Be}$ ,  $^{26}\text{Al}$ ,  $^{36}\text{Cl}$ ,  $^{41}\text{Ca}$  and  $^{129}\text{I}$ . Sample ratios of  $^{10}\text{Be}/^9\text{Be}$  as low as  $8 \times 10^{-15}$  (background-corrected) have been measured and an exposure age of about 330 years of a boulder of 3000 t in Nepal could be determined [1]. We could demonstrate that a by-product of ice core drilling, so-called drilling chips, are also suitable for  $^{10}\text{Be}$  analysis of ice cores, instead of using valuable ice core samples. A set of several in-house  $^{26}\text{Al}$  and  $^{41}\text{Ca}$  standards has been made traceable to primary standards by cross-calibration [2]. Numerous  $^{26}\text{Al}$  and  $^{41}\text{Ca}$  concentrations of meteorites could be determined, but for marine sediments there is still a need for a low-level ( $10^{-13}$ )  $^{26}\text{Al}$  standard. ICP-MS measurements have shown that the steel pins used to fix the  $\text{CaF}_2$  sample material in the cathodes have high K-concentrations of  $(44.6 \pm 2.2) \mu\text{g/g}$ . By replacing the steel pins with copper pins the  $^{41}\text{K}$  background during  $^{41}\text{Ca}$  measurements could be lowered by a factor of three.

Ref.: [1] W. Schwanghart et al., Science (2015), DOI:10.1126/science.aac9865. [2] G. Rugel et al., Nucl. Instr. Meth.B (2015), in review.

MS 10.5 Thu 16:30 Empore Lichthof  
 **$^{36}\text{Cl}$  and  $^{129}\text{I}$  at ASTER and DREAMS** — ●GEORG RUGEL<sup>1</sup>, ASTER TEAM<sup>2</sup>, RÉGIS BRAUCHER<sup>2</sup>, SILKE MERCHEL<sup>1</sup>, STEFAN PAVETICH<sup>1,3</sup>, ANDREAS SCHARF<sup>1</sup>, and RENÉ ZIEGENRÜCKER<sup>1</sup> — <sup>1</sup>HZDR, Dresden, Germany — <sup>2</sup>CEREGE, Aix-en-Provence, France — <sup>3</sup>ANU, Canberra, Australia

At ASTER (Accélérateur pour les Sciences de la Terre, Environnement, Risques) and DREAMS (DREsdn Accelerator Mass Spectrometry) sophisticated ion sources are used for  $^{36}\text{Cl}$  and  $^{129}\text{I}$ . Both facilities have dedicated  $^{36}\text{Cl}$  chemistry labs. At DREAMS it is also used for storage and pressing of  $\text{AgCl}$  in sample holders (SHs). Most  $^{36}\text{Cl}$ -AMS labs, reduce the isobar  $^{36}\text{S}$  from the SH by a labor-intensive  $\text{AgBr}$ -backing. Though, at ASTER and DREAMS only ultrapure Ni and Cu is used, respectively. To find out the pros and cons of the two materials, we have (a) exposed  $\text{AgCl}$  pressed in Ni and Cu to air (in the dark). After 2 h only, cauliflower-type  $\text{NiCl}_2$  (analysed by EDX) has been formed from  $\text{AgCl}$  and Ni preventing any later AMS, whereas  $\text{AgCl}$  in Cu after 3 days looks unweathered and is still measurable. (b) compared S-decline in  $\text{AgCl}$  pressed in Ni and Cu (ASTER SHs). After  $\sim 5$  min S decreases by a factor of  $\sim 5$  for both reaching the same low S-rate after 20 min. However, S is higher at 5-20 min in Cu showing that Cu is contaminated at the surface. High S is not seen at all at DREAMS for DREAMS Cu SHs. Thus, chemical etching and controlled storage of Cu SHs might be a cheaper and better alternative for  $^{36}\text{Cl}$ -AMS. For  $^{129}\text{I}$  AMS a sophisticated tuning strategy is minimising sputtering of any iodine containing material at DREAMS.

## MS 11: Accelerator Mass Spectrometry and Applications III

Time: Friday 11:00–12:45

Location: f128

### Invited Talk

MS 11.1 Fri 11:00 f128

**Accelerator Mass Spectrometry at AARAMS** — ●JESPER OLSEN — Department of Physics and Astronomy, Aarhus University, Aarhus, Denmark

The new multi-element AMS system installed at the Aarhus University AMS Centre, Department of Physics and Astronomy has now been extensively tested, especially for  $^{14}\text{C}$ ,  $^{10}\text{Be}$ , and  $^{26}\text{Al}$ .

The system is the latest extended compact design manufactured by High Voltage Engineering Europa B.V. and based on a 1 MV Tandron accelerator with a dual gas system (Ar and He) for the terminal stripper to investigate possible increased charge exchange efficiency for e.g. actinides. The injector is equipped with two independently operating ion sources and a 120 deg. bouncer magnet with high resolution and a bending power of 340 amu at 35 keV, supporting the measurements of actinides. The high-energy (HE) spectrometer features a degrader foil for isobar suppression and a second HE magnet for suppression of ions scattered in the HE ESA. The control system supports different methods for isotope switching: \*traditional\* fast bouncing, adjusting the Hall-probe controlled magnet fields (for e.g.  $^3\text{H}$ ) or changing the complete set of operation parameters (e.g. for actinides).

During the on-site acceptance tests, the following background levels were measured:  $< 10^{-16}$  for tritium,  $< 10^{-15}$  for  $^{14}\text{C}$ ,  $< 10^{-15}$  for  $^{10}\text{Be}$  (down to  $< 10^{-16}$  in a later 3 hour run),  $2 \cdot 10^{-15}$  for  $^{26}\text{Al}$ ,  $2 \cdot 10^{-13}$  for  $^{129}\text{I}$  and  $9 \cdot 10^{-12}$  for  $^{41}\text{Ca}$  and for  $^{239}\text{Pu}$  ( $^{240}\text{Pu}$ ) a  $1.5 (0.5) \text{ pg per mg iron}$ , which demonstrates the multi-element capability of the system.

MS 11.2 Fri 11:30 f128

**$^{10}\text{Be}$ -Messungen am Trondheim 1 MV AMS** — ●MARTIN SEILER, JOHANNA ANJAR, EINAR VAERNES und MARIE-JOSÉE NADEAU — National Laboratory of Age Determination, NTNU, Trondheim

Das 1 MV AMS-System in Trondheim wird regelmässig zur Radiokarbon-Datierung verwendet und bietet stabile Messbedingungen für zuverlässige Resultate. Obwohl das System auch für  $^{10}\text{Be}$  und  $^{26}\text{Al}$  ausgelegt ist, wurden diese Elemente nach den anfänglichen Abnahmetests nicht mehr gemessen. Um die Möglichkeiten des National Laboratory of Age Determination an der NTNU zu erweitern, planen wir, unserem Repertoire  $^{10}\text{Be}$ -Messungen für Oberflächenexpositionsdatierungen hinzuzufügen. Dafür wurden erste Test mit Be-Proben durchgeführt. Wir extrahieren  $\text{BeO}^-$ -Ionen aus dem Probenmaterial und verwenden nach dem Beschleuniger eine  $\text{SiN}$ -Folie, um die  $^{10}\text{B}$ -Zählrate im Detektor zu reduzieren. Um die Betriebsbedingungen

zu optimieren, wurden verschiedene Ladungszustände untersucht. Die Nachweifeffizienz für  $^{10}\text{Be}$  sowie der Untergrund in verschiedenen Ladungszuständen werden gezeigt, um die besten Messbedingungen abzuleiten. Die Ergebnisse werden mit ähnlichen Messungen in anderen Labors verglichen und durch die AMS-Messung verursachte Einschränkungen für Anwendungen werden aufgezeigt.

MS 11.3 Fri 11:45 f128

**Inbetriebnahme einer neuen Ionenquelle für  $^{14}\text{CO}_2$  Gasproben am AMS-System der Universität zu Köln** — ●ALEXANDER STOLZ<sup>1</sup>, ALFRED DEWALD<sup>1</sup>, STEFAN HEINZE<sup>1</sup>, RICHARD ALTENKIRCH<sup>1</sup>, MARKUS SCHIFFER<sup>1</sup>, CLAUD FEUERSTEIN<sup>1</sup>, CLAUD MÜLLER-GATERMANN<sup>1</sup>, JANET RETHEMEYER<sup>2</sup> und TIBOR DUNAI<sup>2</sup> — <sup>1</sup>Institut für Kernphysik, Universität zu Köln — <sup>2</sup>Institut für Geologie, Universität zu Köln

Am CologneAMS-Beschleuniger der Universität zu Köln wurde eine neue Sputterquelle vom Typ HVE-SO110 aufgebaut. Die Quelle kann komplementär zur ersten Quelle betrieben werden. Die Gasinjektion erfolgt durch ein an die Sputterquelle angepasstes Gassystem der Firma Ionplus AG. Zunächst wurden die Sputtereffizienzen des neuen Quellaufbaus für unterschiedliche Quelleneinstellungen und Gasströme bestimmt. Daraufhin wurden ionenoptische Simulationen der Quelle und ähnlicher Systeme mit dem Programm SIMION durchgeführt. Aufgrund der Berechnungen wurde eine geänderte Immersionslinse entworfen und verbaut. Diese soll neben der Fokussierung des zu extrahierenden Strahls auch die Formung des Cs-Strahls beeinflussen um eine bessere Ausleuchtung der Targetoberfläche zu ermöglichen. Um eventuelle Memory-Effekte zu reduzieren, wurde zusätzlich eine Turbomolekularpumpe an das Probenradgehäuse angebaut. Die Resultate einer ersten  $^{14}\text{C}$ -Messung mit Gasproben werden vorgestellt.

Das Projekt wurde teilweise aus Mitteln des Deutschen GeoForschungszentrum GFZ, Helmholtz-Zentrum Potsdam finanziert.

MS 11.4 Fri 12:00 f128

**A dedicated AMS setup for  $^{53}\text{Mn}$  and  $^{60}\text{Fe}$  at the Cologne FN Tandem Accelerator** — ●MARKUS SCHIFFER, ALFRED DEWALD, RICHARD ALTENKIRCH, CLAUD FEUERSTEIN, CLAUD MÜLLER-GATERMANN, STEFAN HEINZE, PRACHANDA BHANDARI, GEREON HACKENBERG, ALEXANDER STOLZ, and GREGOR ZITZER — University of Cologne, Institute for Nuclear Physics, Germany

Following demands for AMS measurements of medium mass isotopes, especially for  $^{53}\text{Mn}$  and  $^{60}\text{Fe}$ , we started to build a dedicated AMS

setup at the Cologne FN Tandem accelerator. This accelerator with a maximum terminal voltage of 10 MV can be reliably operated at a terminal voltage of 9.5 MV which corresponds to energies of 95-100 MeV for  $^{60}\text{Fe}$  or  $^{53}\text{Mn}$  beams using the  $9^+$  or  $10^+$  charge state. These charge states can be obtained by foil stripping with efficiencies of 30% and 20%, respectively. With second foil stripping we can increase the energy to 130 MeV.

The suppression of the stable isobars  $^{60}\text{Ni}$  and  $^{53}\text{Cr}$  will be done by (dE/dx) techniques using combinations of energy degrader foils and dispersive elements like an electrostatic analyzer and a time of flight (TOF) system in combination with a gas filled magnet and a focal plane detector.

In this contribution we will report on details of the setup and the expected features of the new AMS system. Especially the first results of efficiency, transmission and background will be presented.

Supported by the DFG and the Excellence Initiative of the University Cologne, Emerging Group ULDETIS.

MS 11.5 Fri 12:15 f128

**Untersuchungen zu Methoden der Isobarenscheidung und erste  $^{41}\text{Ca}$  Messungen am CologneAMS** — ●CLAUS FEUERSTEIN<sup>1</sup>, ALFRED DEWALD<sup>1</sup>, STEFAN HEINZE<sup>1</sup>, MARKUS SCHIFFER<sup>1</sup>, CLAUS MÜLLER-GATERMANN<sup>1</sup>, TIBOR DUNAI<sup>2</sup>, BJÖRN DITTMANN<sup>2</sup>, STEVEN BINNIE<sup>2</sup>, RICHARD ALTENKIRCH<sup>1</sup> und ALEXANDER STOLZ<sup>1</sup> — <sup>1</sup>Institut für Kernphysik, Universität zu Köln — <sup>2</sup>Institut für Geologie und Mineralogie, Universität zu Köln

Die Unterdrückung von Isobaren bei AMS Messungen für mittelschwere Ionen wird mit zunehmender Masse immer schwieriger. Um die Messmöglichkeiten von CologneAMS zu erweitern und zukünftige Auf-

bauten zu planen, ist ein quantitatives Verständnis der Separationsmethoden notwendig. Die Beamprofiling Möglichkeit des Flugzeitspektrometers konnte zur Bestimmung des Winkelstragglings verschiedener Ionen beim Durchgang von Siliziumnitridfolien verwendet werden. Zudem werden erste Tests vorgestellt den 120-Grad Magnet in gasgefüllter Version zu nutzen. Außerdem wird über Arbeiten zur Entwicklung eines optimierten Routinebetriebs für  $^{41}\text{Ca}$  am CologneAMS berichtet.

Gefördert im Rahmen des Sonderforschungsbereichs 806, Our Way to Europe.

MS 11.6 Fri 12:30 f128

**$^{41}\text{Ca}$  measurements at 500 kV** — ●CHRISTOF VOCKENHUBER — Laboratory of Ion Beam Physics, ETH Zurich, Switzerland

$^{41}\text{Ca}$  is an AMS isotope particularly interesting for biomedical applications. We have improved the performance of  $^{41}\text{Ca}$  measurements using low-energy AMS at the 500 kV AMS system TANDY at ETH Zurich for reliable measurements and high sample throughput. In order to simplify sample preparation  $\text{CaF}_3^-$  ions from  $\text{CaF}_2$  material are used to suppress the interfering stable isobar  $^{41}\text{K}$  in the ion source by a large amount. The transmission for  $\text{Ca}^{2+}$  ions through the tandem accelerator at 500 kV is  $> 50\%$  with He stripping. However, at this low energy  $^{41}\text{Ca}$  and  $^{41}\text{K}$  cannot be separated in the gas ionization detector. Instead the beam switching system is utilized to correct measured  $^{41}\text{Ca}$  rates for the  $^{41}\text{K}$  contribution. For this purpose,  $^{41}\text{Ca}^{2+}$  and  $^{39}\text{K}^{2+}$  ions are sequentially injected and counted in the detector. Assuming a natural  $^{41}\text{K}/^{39}\text{K}$  ratio the measured  $^{41}\text{Ca}/^{40}\text{Ca}$  ratios can be corrected for the K content and allows measurements down to  $10^{-12}$  range. The measurement procedure and some applications are discussed.