MS 3: New Mass Spectrometric Methods and Technical Developments

Time: Monday 17:00–19:00 Location: PH/HS2

MS 3.1 Mon 17:00 PH/HS2

Anreicherung und Implantation von ^{163}Ho im RISIKO Massenseparator für das ECHo Projekt — •Tom Kieck für die ECHo-Kollaboration — Institut für Physik, Johannes-Gutenberg-Universität Mainz

Die ECHo-Kollaboration nutzt zur Untersuchung der Masse des Elektron-Neutrinos den Elektroneneinfangsprozess von ^{163}Ho. Dabei wird das Zerfallsspektrum in einem metallisch-magnetischen Kalorimeter bestimmt. Die Produktion dieses Isotops bringt eine möglicherweise signifikante Verunreinigung mit anderen Radio- wie auch stabilen Isotopen mit sich, welche nur begrenzt chemisch abgetrennt werden können.

Der RISIKO Massenseparator der LARISSA Arbeitsgruppe bietet über den Einsatz vollständig elementselektiver und effizienter resonanter Laserionisation und nachfolgender Isotopenselektion in einem Sektorfeld-Magneten optimale Voraussetzungen für die Auswahl und Anreicherung des Isotops. Die Beschleunigung der Ionen auf 30 keV ermöglicht eine optimale Strahlformung zur direkten Implantation des reinen ^{163}Ho Strahls in die kleinflächigen Kalorimeter mit Kantenlängen von 160 μm.

Die entsprechenden Modifikationen des RISIKO Massenseparators für diesen Einsatzzweck sowie Messungen zu Effizienz, Strahlfleckgröße und Isotopenverhältnissen der ^{163}Ho Produktionen werden vorgestellt.

MS 3.2 Mon 17:15 PH/HS2

Multi-purpose RFQ Beamline for ion cooling, transport, identification, separation, beam mixing and bunching at the FRS Ion Catcher — •Ann-Kathrin Rink for the FRS Ion Catcher-Collaboration — Justus-Liebig Universität Gießen

Conventional low-energy beam lines use a structures of electrostatic or magnetic fields for transporting and guiding ions. However, those beam lines require low vacuum pressures for efficient transport; in the vicinity of buffer gas stopping cells low vacuum pressures cannot be provided. At pressures of about 10^{-2} mbar radio-frequency quadruples (RFQ) can provide an efficient, reliable ion transport. Such a transport system based on RFQs also enables identification, mass separation (RFQ operated as mass filter), cooling, bunching and beam mixing (merging ions of interest with calibration ions) in a compact setup. It is coupled easily to identification detectors using alpha or beta spectroscopy and accurate mass spectrometers. For these reasons the low-energy beam line of the FRS Ion Catcher is designed as RFQ beam line.

A novel component in the RFQ beam line of the FRS Ion Catcher is an RFQ switch yard that allows to guide or split a beam into five directions, as well as to merge five beams. The RFQ beam line was commissioned offline and online and was essential for performing efficient experiments at the FRS Ion Catcher.

MS 3.3 Mon 17:30 PH/HS2

Multiple-Reflection Time-of-Flight Mass Spectrometer as Isomer Separator — •Jens Ebert for the FRS Ion Catcher-Collaboration — Justus-Liebig-Universität Gießen

Recently multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS) have been established as important tools for isobar separation at several facilities for research on exotic nuclei. They combine short measurement cycles with high efficiencies and very high mass resolving power.

Through technical improvements of mass resolving power and stability, the MR-TOF-MS for the FRS Ion Catcher at GSI and the Low-Energy Branch of the Super-FRS at FAIR is now also capable to separate isomers in time and space. The spatial separation can provide isomeric clean beams for further experiments. This has been successfully demonstrated in a beamtime of the FRS Ion Catcher in October 2014. Isomers have been produced via projectile fragmentation and fission, thermalized in a cryogenic stopping cell and transported to the MR-TOF-MS, where mass measurements and spatial separation with a Bradbury-Nielsen-Gate have been performed on them. After the separation the decay of α-emitting isomers was measured with a silicon detector to verify the identity of the separated nuclides.

MS 3.4 Mon 17:45 PH/HS2

Status of the MR-TOF-MS for the TITAN facility — •Timo Dickel[1,2], Christian Jesch[1], Wolfgang R. Plass[1,2], Devin Short[3], Samuel Ayet San Andrés[1,2], Jens Dilling[4], Hans Geissel[1,2], Florian Greiner[1], Johannes Lang[1], Kyle G. Leach[3,4], Wayne Lippert[1], Christoph Scheidenberger[1,2], and Mikhail I. Yavor[5] — [1]JLU, Giessen — [2]GSI, Darmstadt — [3]Simon Frasier University, Vancouver, Canada — [4]TRIUMF, Vancouver, Canada — [5]Inst. for anal. instr. RAS, St. Petersburg, Russia

At TRIUMF's Ion Trap for Atomic and Nuclear Science (TITAN) the MR-TOF will extend TITAN's capabilities and facilitate mass measurements and in-trap decay spectroscopy of exotic nuclei that so far have not been possible due to strong isobaric contaminations. The MR-TOF-MS will also enable mass measurements of very short-lived nuclei ($T_{1/2} > 5$ ms) that are produced in very low quantities (a few detected ions overall).

In order to allow the installation of an MR-TOF-MS in the restricted space on the TITAN platform, novel mass spectrometric methods have been developed. Ion transport into and out of the device is performed using an RFQ-based switchyard. In addition the exotic ions can be merged with ions from several offline ion sources. Mass selection is performed using a dynamic retrapping technique after time-of-flight analysis. The isobarically clean beam can be provided for the EBIT, Penning trap or in the future to the laser spectroscopy setup.

We report on the commissioning of the system in Giessen and carried out tests and plans for TRIUMF.

MS 3.5 Mon 18:00 PH/HS2

Delayed bunching of ions in multi-reflection time-of-flight mass separators — •M. Rosenbusch[1], S. Kemnitz[2], P. Luksch[2], G. Marx[1], R. Schneider[1], L. Schweikhard[1], and N. R. Wolf[1] — [1]Institut für Physik, Ernst-Moritz-Arndt-Universität, 17487 Greifswald — [2]Institut für Informatik, Universität Rostock, 18095 Rostock

Multi-reflection time-of-flight mass separators (MR-ToF MS) consist of two electrostatic mirrors facing one another, which enable back-and-forth reflections of ions and thus provide a long flight path. In that way, mass resolving powers $m/\delta m$ exceeding 10^5 can be reached in only tens of milliseconds [1]. However, in case of contaminating ions in large quantities from the ion source, the mass separation is often hindered due to the dominance of coulomb interactions [2]. In this contribution a technique is discussed, that allows to decrease the ion density during the major part of the trapping period in the MR-ToF MS, while later on still enabling a high-resolution mass separation. To this end, an ion bunch with a purposely broad time-of-flight (ToF) distribution is injected into the MR ToF MS and trapped isochronously (no ToF energy dispersion) for a duration of choice. Then, the ToF-energy dispersion of the system is modified by a fast switching of the electrostatic-mirror voltages for strong focusing during the next few reflections. Proof-of-principle experiments with isobaric ions will be reported.

[1] R. N. Wolf *et al.*, Int. J. Mass Spectrom. 349-350, 123-133 (2013)
[2] M. Rosenbusch *et al.*, AIP Conf. Proc. 1521, 53 (2013)

MS 3.6 Mon 18:15 PH/HS2

Improvements on the MR-TOF-MS for the LEB of the Super-FRS and its application for high-accuracy mass measurements — •Samuel Ayet San Andrés for the FRS Ion Catcher-Collaboration — GSI Darmstadt — JLU Gießen

At the FRS Ion Catcher facility, in-flight separated exotic nuclei produced by Uranium beam fragmentation and fission in a Beryllium target are thermalized through gas collisions in a cryogenic stopping cell (CSC), transported through a diagnostic unit (DU) to a multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS) where mass measurements of the stopped ions are performed. The FRS Ion Catcher is a test bench for the low energy branch (LEB) at the Super-FRS at FAIR. Recently several improvements of the MR-TOF-MS were developed and tested online during a beam time in October 2014. The increase of kinetic energy from 750 eV to 1300 eV and improved stability of the system and power supplies in the MR-TOF-MS lead to a mass resolving power exceeding 400.000 FWHM in less than 16ms of total time-of-flight. With these performance characteristics, direct mass measurements of uranium projectile and fission fragments were performed.

MS 3.7 Mon 18:30 PH/HS2

Ultra-High Resolution Tandem Mass Spectrometry in a Mobile MR-TOF Mass Spectrometer — •Wayne Lippert[1], Johannes Lang[1], Samuel Ayet San Andrés[2], Julian Bergmann[1], Timo Dickel[1,2], Hans Geissel[1,2], Christian Jesch[1], Alexander Pikhtelev[3], Wolfgang Plass[1,2], Christoph Scheidenberger[1,2], and Mikhail Yavor[4] — [1]Justus-Liebig-Universität Gießen — [2]GSI Darmstadt — [3]RAS Moscow — [4]RAS St. Petersburg

The mobile multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS) provides a mass resolving power exceeding 400,000 and sub-ppm mass accuracy in a transportable format. It comprises an atmospheric pressure interface (API) that enables coupling with various atmospheric ion sources, an RFQ beam preparation system and a high resolution time-of-flight mass analyzer with MCP detector.

In addition to highly resolved and accurate mass measurements, the device offers unique MS/MS capability via selective ion re-trapping with ultra-high mass separation power (R ≈ 50,000) and collisional-induced dissociation (CID) as intermediate fragmentation method. By analyzing the molecule fragments in the time-of-flight analyzer after ion re-trapping and CID, structural information and unambiguous identification are provided.

The instrument is ideally suited for the identification of species in biological or environmental samples and can be applied for in-situ operation at various measurement sites.

MS 3.8 Mon 18:45 PH/HS2

Determination of krypton concentration in xenon gas with a quadrupole mass spectrometer following a cold-trap at a temporarily reduced pumping speed — •Alexander Fieguth, Ethan Brown, Gianmarco Bruno, Michael Murra, Sergej Schneider, and Christian Weinheimer — Institut für Kernphysik, WWU, Münster

The removal of trace impurities in xenon gas, as for example the radioactive isotope ^{85}Kr, is of viable importance for achieving new sensitivities in particle physics experiments, especially in the field of dark matter search. While the removal of this isotope can be performed by cryogenic distillation down to the sub-ppb level, the detection at this low concentrations is not trivial. A recently improved method (E.Brown et al. JINST 8 (2013) P02011) uses a commercial quadrupole mass spectrometer supported by an auxiliary structure based on a cold trap to achieve sub-ppb sensitivity in measurements on the minute scale and with consumption of only a few milliliters of expensive xenon gas. Additional sensitivity gain is provided by a self-made butterfly valve in front of the pumping system to allow for dynamically manipulate the pumping speed. This method can be used for the characterization of the working performance of the crygonenic distillation column build for the upcoming XENON1T experiment. This work is funded by DFG.