MS 4: New Methods, Technical Development

Time: Wednesday 14:30–16:30 Location: N 6

Invited Talk MS 4.1 Wed 14:30 N 6

Pushing the boundaries of laser spectroscopy at radioactive ion beam laboratories using mass spectrometry tools — •Agota Koszorus — KU Leuven, Belgium — SCK CEN, Belgium

The precise determination of atomic energy levels using laser spectroscopy has become an indispensable tool in radioactive ion beam laboratories. Ongoing experiments address scientific questions spanning atomic and nuclear structure, chemistry, and fundamental interactions. In this contribution, a summary of recent experimental highlights will be presented, with particular emphasis on the emerging limitations encountered when pushing the sensitivity and precision frontiers in studies of radioactive isotopes. Finally, current plans and developments will be outlined demonstrating how advances in mass spectrometry can be integrated to overcome these limitations and shape the future of laser spectroscopy of short-lived isotopes.

MS 4.2 Wed 15:00 N 6

Optimization of the isochronous mass spectrometry mode at the Cryogenic Storage Ring — •Tobias Orlemann[1], Manfred Grieser[1], Florian Grussie[1], Leonard Isberner[3,1], Holger Kreckel[1], Viviane Schmidt[2], Andreas Wolf[1], and Oldřich Novotný[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Universität Innsbruck — [3]Columbia University, New York

The Cryogenic Storage Ring (CSR) at the Max Planck Institute for Nuclear Physics is dedicated to the study of astrophysically relevant molecular ions. Due to its electrostatic ion optics, species of different masses can be stored simultaneously along with the primary beam. In the isochronous mode of the CSR, the relative revolution frequency depends only on the particle's mass-to-charge ratio. We use isochronous time-of-flight mass spectrometry (ISO-ToF) to analyze the storage of impurities in the primary beam, including molecular isobars, with a mass resolution down to $\Delta m/m < 10^{-5}$ [1]. Furthermore, improving the resolution requires the reduction of space charge effects by storing less intense ion beams, while increasing the detection efficiency through fast extraction and full beam detection. Here, we report on the first test of this method. We present detailed data on the evolution of the ion beam properties over several seconds of storage in isochronous mode.

[1] Grieser et al., Rev. Sci. Instrum. 93, 063302 (2022)

MS 4.3 Wed 15:15 N 6

Status of the cooler buncher for laser spectroscopy with JetRIS — •Maren Stahl[1], Michael Block[1,2,3], Alexandre Brizard[4], Premaditya Chhetri[2,3], Julia Even[5], Julian Hindermann[1,2,3], Raquel Ibáñez Campo[1], Tom Kieck[2,3], Nathalie Lecesne[4], Danny Münzberg[1,2,3], Sebastian Raeder[2,3], Daniel Rodríguez[6], Hervé Savajols[4], Domenik Studer[2,3], Tim van de Vendel[2,5], Klaus Wendt[1], and Jana Weyrich[1,2,3] — [1]JGU, Mainz, DE — [2]GSI, Darmstadt, DE — [3]Helmholtz Institut, Mainz, DE — [4]GANIL, FRA — [5]University of Groningen, NLD — [6]Universität de Granada, ESP

The research on the properties of nuclei is major for improving nuclear models. Laser spectroscopy enables studies of nuclear deformation and moments by measuring isotope shifts and hyperfine structures.

The Jet Resonance Ionization Spectroscopy (JetRIS) setup at GSI extends measurements to previously inaccessible nuclides ($Z > 100$). The ionization in a hypersonic gas jet allows the measurement of atomic transitions of the nuclei. Detecting nuclides via α-decay limits the accessible nuclides. A decay-independent detection scheme will expand this number. For this purpose, JetRIS will be combined with a multiple-reflection time-of-flight mass spectrometer (MR-ToF MS), which will also enhance detection efficiency. A radiofrequency quadrupole cooler buncher is used for the conversion of the continuous ion beam of JetRIS into ion bunches required for the MR-ToF MS.

This contribution will present results from the characterization and optimization of the buncher system.

MS 4.4 Wed 15:30 N 6

A recoil ion source for the SHIPTRAP experiment — •Briain Drew Hartigan[1,2,3], Michael Block[1,2,4], Julia Even[3], Francesca Giacoppo[2,4], Manuel J. Gutiérrez[5], and Jaykumar Patel[2,4,6] — [1]JGU University Mainz, Germany — [2]GSI Darmstadt, Germany — [3]University of Groningen, The Netherlands — [4]HIM Mainz, Germany — [5]University of Greifswald, Germany — [6]TU Darmstadt, Germany

The Penning trap mass spectrometers SHIPTRAP has measured the masses of transuranic nuclides, despite low production rates, at a part-per-billion precision. To complement previous measurements at SHIPTRAP, mass measurements of long-lived isotopes in the Cm-Fm region can contribute to asses the size of the deformed neutron shell gap at N=152 as a function of the proton number; these actinides can be bred in sufficient amounts at nuclear reactors. Production of ions via laser-ablation limits sample sizes to 10^{14}, however with a recoil ion source one could push this limit much lower.

To prepare these recoil ions for mass measurement, a new recoil-ion source branch for SHIPTRAP, dedicated to the offline study of long-lived isotopes is currently being constructed. It consists of a compact gas cell that uses nonlinear electric fields to stop and transport recoil ions, coupled to a cooler-buncher RFQ to provide cooled ions for Penning trap mass spectrometry. In this work, the results of testing the gas cell will be given. Additionally, the design and simulation of the RFQ cooler-buncher will be presented.

MS 4.5 Wed 15:45 N 6

A Multi-Reflection Time-of-Flight Mass Spectrometer for PENTATRAP — •Finn Mehlhorn[1], Sergey Eliseev[1], Pavel Filianin[1], Julius Franke[1], Jan Nägele[1], Moritz Schlaich[2], Christoph Schweiger[1], Frank Wienholtz[2], and Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Technische Universität Darmstadt, Institut für Kernphysik, Darmstadt, Germany

PENTATRAP is presently the most precise Penning-trap mass spectrometer, achieving routinely relative mass uncertainties of down to a few 10^{-12} for stable and long-lived nuclides. Precision measurements at this level contribute to investigations of fundamental and beyond Standard Model physics [1,2]. The Highly-Charged Ions (HCI) are created inside an Electron Beam Ion Trap and separated using a Bradbury-Nielsen gate, according to their q/m ratios, before reaching the main apparatus. The limited path length towards the gate only allows for resolving powers of $R \approx 100$. Thus, contaminants with nearby q/m values of the ion of interest appear in the traps [1].

This talk will present the development of a Multi-Reflection Time-of-Flight Mass Separator using HCI for PENTATRAP, to complement the current system. The design targets a resolving power of $R \geq 10000$ for separation of contaminants. The device is optimized towards a high acceptance for the ion source and the wide application range of PENTATRAP. The current status and simulations will be presented.

[1] Door, et al., Phys. Rev. Lett. 134, 063002 (2025)
[2] Schweiger, et al., Nature Physics 20, 921-927 (2024)

MS 4.6 Wed 16:00 N 6

Numerical study and mitigation strategies of radiation damage of the Super-FRS Ion Catcher setup — •Tommaso Piazza[1,3], Daler Amanbayev[2,3], Davide Bortot[1], Timo Dickel[2,3], Wolfgang Plass[2,3], Ekaterina Kozlova[2], and Alexey Sokolov[2] — [1]Politecnico di Milano, Italy — [2]GSI Darmstadt — [3]JLU Giessen

At the Super-FRS, experiments with exotic nuclei produced by the projectile fragmentation or fission of a high energy (up to 1.5 GeV/u) primary beam will be performed. The interaction between the secondary beam and the components along the beamline, such as the degrader and the collimators, produces a complex secondary radiation field. Irradiation represents a challenging condition, by means of both physical damage and degradation of the electrical performance, for the supply and controllers' electronics of the Super-FRS Ion Catcher.

The present research firstly addresses the main interaction mechanisms between radiation and electronics. The most relevant quantities to evaluate are the absorbed dose and the fast neutron fluence, which is connected to structural damage. Secondly, simulations are performed with FLUKA software reproducing a simplified geometry of the beamline, to assess the composition of the radiation field and the physical quantities of interest. The results are compared with relevant literature data to establish the risk of damage. The possible risk reduction solutions range from the relocation of the components to low radiation level areas to the design of a shielding device.

MS 4.7 Wed 16:15 N 6

UniCell - A new fast buffer-gas stopping cell for superheavy elements — •Felix Sprunk[1,2], Christoph E. Düllmann[1,2,3], Jochen Ballof[2], Alexander Yakushev[2], Marco Biljan[2], Meyhar Dudeja[2], Jörg Krier[2], Jan Kulawik[4], Sven Löchner[2], Yeqiang Wei[2,3], and Frederik Zielke[2] — [1]JGU Mainz, Germany — [2]GSI Darmstadt, Germany — [3]HI Mainz, Germany — [4]Łukasiewicz - IMiF Cracow, Poland

A new universal fast buffer gas stopping cell (UniCell) has been built at GSI Darmstadt. It is optimized for the fast thermalization and efficient transfer of single atoms of these elements after their separation in the TASCA separator. It is designed to overcome the limitations of existing setups used for chemical studies of elements up to moscovium (element 115). The existing setup allows extracting separated and thermalized radioisotopes within a few hundred milliseconds, which is too slow, given that no isotopes with half-lives >60 ms are known for the heavier elements. UniCell will stop ions in helium at atmospheric pressure and extract them through a funnel using a DC gradient supported by an RF field, enabling fast and efficient ion extraction. Simulations yielded extraction times as short as 2 ms at nearly 100% efficiency. A prototype has been built and is now being commissioned. The current status of UniCell will be presented. Commissioning UniCell is a crucial step toward forthcoming investigations of the chemical behavior of livermorium and heavier elements.