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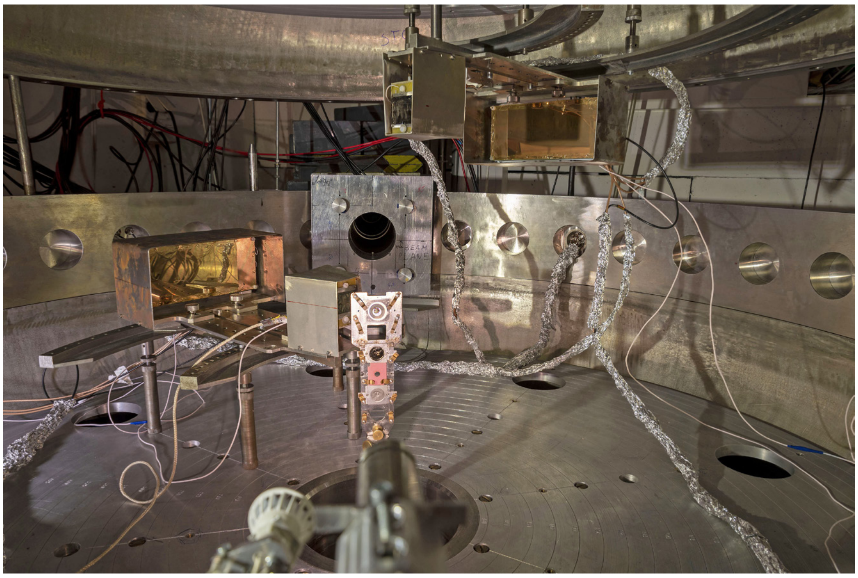
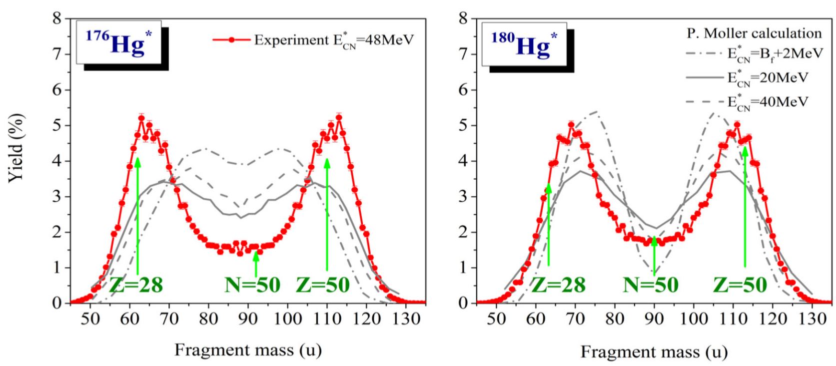
JYFL Accelerator News

– Accelerator Laboratory, Department of Physics University of Jyväskylä, Finland –

Influence of nuclear shells on fission of excited Hg and Sg nuclei



CORSET setup in the LSC during the August 2019 experiment



Preliminary fragment mass distributions of fission of ^{176,180}Hg formed in the reactions ^{64,68}Zn+^{112}Sn (red points)) in comparison with the predictions of P.Möller [1] (grey lines).

A successful two-week experimental session was completed this summer in the modernized Large Scattering Chamber at JYFL Accelerator Laboratory. The goal of the run was to improve our knowledge of the fission process in the regions of transactinide nuclei (superheavy nuclei) and confirm the recently observed asymmetric mass distribution for beta-delayed fission of ^{180}Hg. This observation has provoked intensive studies of the fission properties of nuclei with Z≤82. The fission of trans-actinide nuclei is of special interest for the study of the fission process connected with the investigation of influence of nuclear shells on the fission process of superheavy nuclei. Are they the same as for actinide nuclei? What is the influence of shell structure on the formation of fission fragments?

The measurements were done with a new version of the double-arm time-of-flight spectrometer CORSET (Photo) allowing the mass distributions of fission fragments to be measured with accuracy of ±1.5u and to reliably separate fission from other competing binary processes taking place in these reactions. The compound nuclei of ^{176,180}Hg (Z=80) and ^{264}Sg (Z=106) were formed in the reactions ^{64,68}Zn+^{112}Sn and ^{32}S+^{232}Th. Each beam/target combination was measured at several excitation energies. The data analysis is ongoing but the first, preliminary results are shown in the figure. It is evident that the fragment mass distributions of fission of ^{176,180}Hg are asymmetric even at the excitation energy of about 48 MeV. That observation agrees qualitatively with P. Möller's predictions [1] for these nuclei. However, contrary to the theoretical prediction, the mass distribution for ^{176}Hg is more asymmetric, in terms of peak-to-valley ratio, than ^{180}Hg.

We are very grateful to the JYFL cyclotron, ion source, and target lab teams. This work would not be possible without their commitment, support and flexibility.

[1]. P. Möller, J. Randrup and A. J. Sierk, Phys.Rev. C 85 024306 (2012).

NEWS

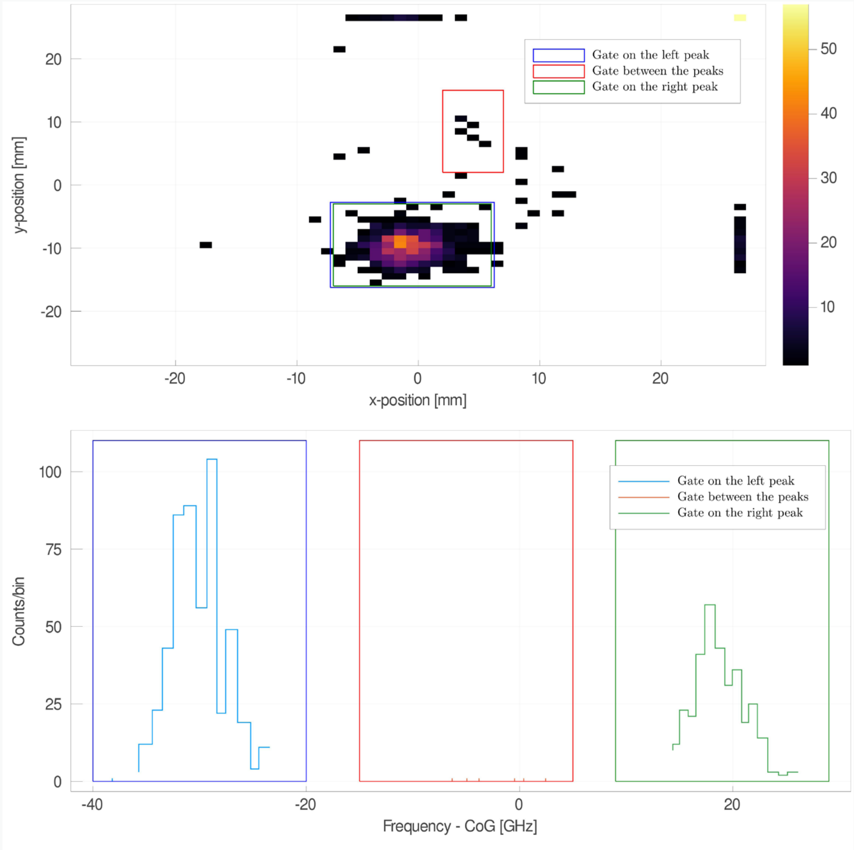
Next Call for Proposals Deadline: September 15, 2019

READ MORE

In-source laser spectroscopy crosses the *N*=50 shell closure in silver

The neutron-deficient silver isotopes around the *N*=*Z* line remain an attractive goal for many facilities worldwide, including the future S^3 facility at SPIRAL-2, the Ion Catcher collaboration at the FRS, GSI, and the future MARA-LEB facility, JYFL. The IGISOL team has recently achieved an important milestone in the production and study of these isotopes. Selective and efficient resonance laser ionization of radioactive silver isotopes produced, stopped and extracted from a radiofrequency (rf) inductively-heated graphite catcher, has been combined with the mass purification capabilities of the JYFLTRAP Penning trap and the detection of ions using the Phase-Imaging Ion-Cyclotron-Resonance (PI-ICR) technique.

The frequency of the ground state 328.2-nm atomic transition was scanned as part of a three-step resonant laser ionization scheme while recording the mass-purified ions using a position-sensitive detector. By this means, background-free laser spectroscopy measurements were performed on $^{104\text{-}96}$Ag. An example of a frequency scan for ^{99}Ag, shown in the figure, reveals clear evidence of the production of the high-spin ground state from the heavy-ion fusion reaction between a nitrogen beam and a molybdenum target. The optical data will allow for the extraction of changes in mean-square charge radii across the *N*=50 shell closure below ^{100}Sn for the first time, as well as nuclear structure information from the magnetic dipole moments. In parallel, JYFLTRAP was used to measure the mass of the high-spin ground state of ^{97}Ag with high precision.



In-source laser spectroscopy of 99Ag using JYFLTRAP as a mass purifier and the PI-ICR method for ion detection. Bottom: gates have been set on the two groups of hyperfine peaks (blue, green) as well as in between (red) and then projected onto the position-sensitive detector (top). A low-spin isomer is expected, with a hyperfine structure in the middle (red) gate, however appears to be only very weakly produced if at all.

Later in the year, a further experiment will be performed using a calcium beam on a nickel target, a reaction which is optimized for the production of the most exotic cases, $^{96\text{-}94}$Ag.

NEWS

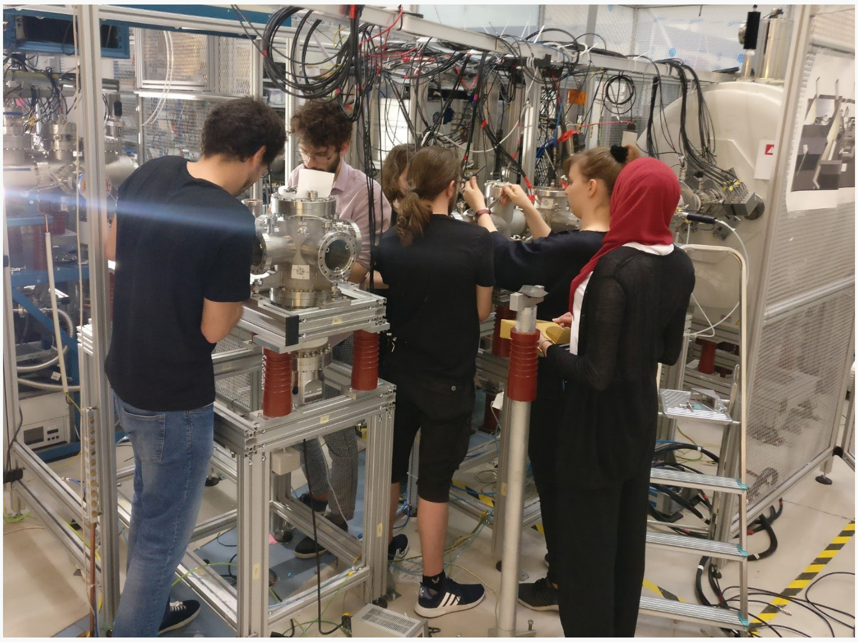
Sakari Juutinen reaches retirement

University Lecturer Sakari Juutinen, a pioneer of in-beam gamma-ray spectroscopy at JYFL, retired on 1st of September 2019 after a career spanning over 30 years. Following the development of large germanium detector arrays and heavy-ion beams, Sakari became an expert of high-spin physics of rotational nuclei. During his PhD in 1985-1987 in the University of Knoxville and at Oak Ridge National Laboratory, he was one of the first to combine gamma-ray and particle detection from heavy-ion transfer reactions. Sakari worked as a post-doctoral researcher in the Nordic Nordball project at NBI Risö creating contacts with the European gamma-ray spectroscopy community, which later were vital for the decisions to place the UK Tessa- array to the new JYFL Accelerator Laboratory in 1994. Sakari was also a key person both during the installation and in running the first experiments with large arrays of detectors at the new JYFL Laboratory. Sakari's expertise in nuclear structure physics, especially in that of rotational nuclei, has been invaluable for the JYFL spectroscopy group. Therefore, we are pleased to hear that in spite of retirement, he will remain as a member of the group.

Multi-reflection time-of-flight mass separator installed at IGISOL

The long-awaited multi-reflection time-of-flight (MR-TOF) mass separator was characterized off-line in Spring prior to final installation in the IGISOL beamline in June. The first radioactive beam was sent through it in mid-July, though it was used only in a "shoot-through" mode. The MR-TOF will be mainly used as a mass separator for the JYFLTRAP Penning traps, complementing the purification (mass separation) Penning trap by offering an order of magnitude faster (down to a few ms) purification cycle.

In the offline characterization studies, a mass resolving power (M/ΔM) of $2x10^5$ was reached with about 5 ms separation time. This result is in line with simulations and comparable to what the purification Penning trap can reach in about 100 ms. For these characterization studies, a continuous ion beam consisting of Rb, Cs and K ions was chopped with a Bradbury-Nielsen ion gate to mimic the bunched beam required by the MR-TOF. Characterizations with actual bunched beam from the radiofrequency cooler-buncher will commence in September.



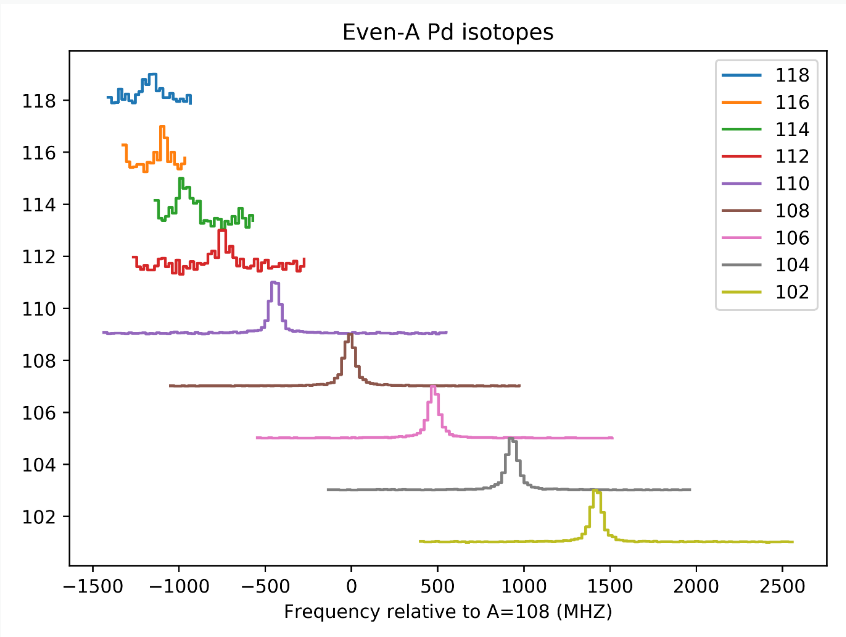
The MR-TOF installation work started in early June.

NEWS

Optical spectroscopy enters the transitional region

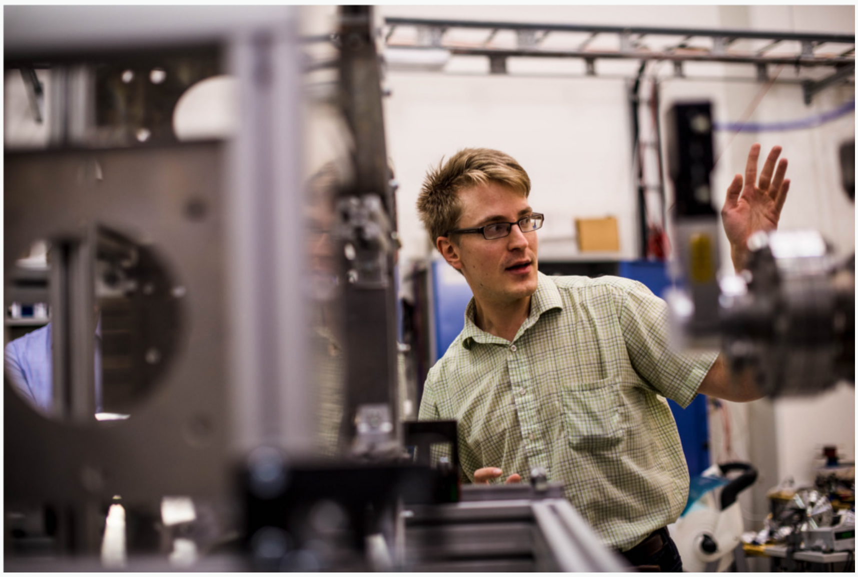
Between the region of nuclear structure associated with atomic number Z~40 and mass *A*~100, famous for sudden changes of nuclear shape, and the more smoothly evolving behaviour in the Sn, In, Cd and Ag nuclei, lie elements whose radioactive isotopes have yet to be probed via laser spectroscopy. The elements Tc, Ru, Rh and Pd are difficult to produce for conventional ISOL facilities and have complex atomic structure, contributing to challenges for optical measurements.

In a collaboration involving researchers from JYFL, Liverpool, Manchester, GANIL, ISOLDE-CERN and TU Darmstadt, collinear laser spectroscopy of neutron-rich fission fragments of Pd has been performed for the first time. Four different optical transitions, accessible to the new Ti:sapphire laser system, were tested on stable isotopes of Pd for efficiency and sensitivity to atomic parameters prior to the main experiment. In July, optical spectra were then obtained on a series of even-*A* radioactive isotopes (^{112,114,116,118}Pd) as well as preliminary data on the odd-*A* isotopes of ^{113,115}Pd. The figure highlights the shift observed in the optical transition for stable and radioactive even-*A* isotopes. Conventional nuclear spectroscopy indicates a change of deformation in the Pd isotopes however the origin and character of such evolution remains an open question. With support from nuclear theory, the new data aims to clarify the situation.



Optical resonance fluorescence spectra of even-A isotopes of Pd.

Jari Partanen 1988-2019



It is with great sorrow that we report the passing of our young and highly talented Laboratory Engineer Jari Partanen, who was killed in a road traffic accident on June 19th 2019 at the age of 31. Jari joined the Accelerator Laboratory around a decade ago as a summer student working in the Nuclear Spectroscopy group. Following this, he worked on his MSc thesis under the supervision of Juha Uusitalo and continued as a doctoral student playing a key role in the development of the new MARA separator. Jari's contribution to the smooth start-up, commissioning and experimental campaigns of MARA cannot be understated. In 2015, a permanent position as a Laboratory Engineer supporting the Nuclear Spectroscopy and IGISOL groups became available and Jari was selected for the position. Jari's expertise in designing electronics and control systems and his dedication to work were invaluable for the whole of the Accelerator Laboratory. Jari will be remembered for his sharp wit, unique sense of humour and strong Savo accent by all the staff of the Accelerator Laboratory who miss him greatly.

NEWS

Next Call for Proposals – Deadline: September 15, 2019

The next deadline for submission of proposals and letters of intent is September 15, 2019. **Proposals should include an abstract/summary.** A justification of the beam time requested, based on cross-sections, detector efficiencies, etc. should be given. If a proposal is the continuation of an existing experimental program at the JYFL Accelerator Laboratory, a summary of the status of the project should be included. Proposals and letters of intent should be sent (preferably as a postscript or pdf file) to the Program Advisory Committee secretary Mikael Sandzelius (address: see below) and include the Proposal Summary Sheet which is available from the JYFL WWW-pages (https://www.jyu.fi/science/en/physics/research/infrastructures/accelerator-laboratory/access/apply-for-beamtime). You are encouraged to contact anyone in the Contact List at the end of this Newsletter for more information.

From 1st March 2016, the JYFL Accelerator Laboratory is one of the HORIZON2020 ENSAR2-Infrastructures offering a certain amount of supported access to the users from the EU and associated countries. Requests for such support (travel and living expenses during experiments) should be attached to the scientific proposal. All publications resulting from work done at the Accelerator Laboratory should also contain the following acknowledgement:

This work has been supported by the EU HORIZON2020 programme "Infrastructures", project number: 654002 (ENSAR2). ❋

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