

Nuclear Structure 2026



Abstracts: Talks

Contribution ID: **165**

EDI in Physics Collaborations

Monday, 27 July 2026 09:10 (30 minutes)

Equity, Diversity, and Inclusion have become increasingly important topics discussed in society. Physics collaborations are unique organizations that can play an important role in advancing these ideas. Host laboratories can also play a role with the policies they have for collaborations building and operating experiments on their sites. In this talk, I will discuss the current situation in terms of equity, diversity, and inclusion in nuclear and astroparticle physics, highlighting progress and challenges. I will present some of the work that has been done in physics collaborations and laboratories to advance these ideals.

Author: Dr CADEN, Erica (SNOLAB)**Presenter:** Dr CADEN, Erica (SNOLAB)**Session Classification:** EDI & Theory

Contribution ID: 35

Nuclear Shell Model on Current and Future Quantum Computers

Monday, 27 July 2026 09:40 (25 minutes)

Quantum computers hold the promise of being a transformational in application to many spheres of human endeavour. In particular, the simulation of many-body quantum systems, such as nuclei, is naturally amenable to quantum computation. This is due, in part, to the exponential scaling of Hilbert space size as the number of quantum bits (qubits) grows linearly. This mirrors the exponential growth of Hilbert space size as the number of particles or orbitals in a nuclear problem grows linearly.

Real quantum computers now exist. They have some drawbacks, including short coherence times limiting their ability to deliver the hoped-for breakthroughs, yet first results show promise and algorithmic developments are underway to prepare for future “fault-tolerant” quantum computers which are on the road map of the quantum hardware companies.

In this contribution we present our current results for nuclear shell model developments in simulation 1, along with calculations on real quantum hardware 2 - with nuclei up to ^{210}Pb calculated on 29 qubits on the IBM_pittsburgh machine. We then go on to show preparatory work for future hardware, in which we use tensor network methods to produce states with >50% overlap with exact solutions on 76-qubit systems, equivalent to a shell model calculation with matrix dimension $\sim 10^{11}$ in ^{143}Ce . We use tensor network to quantum circuit compilation techniques to prepare algorithms ready to go on near-future fault-tolerant machines 3.

Work in collaboration with B. Bhoy, C. Sarma, and J. Gibbs at the University of Surrey

1 B. Bhoy and P. D. Stevenson, New. J. Phys. 26, 075001 (2024)

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3 J. Gibbs, L. Cinzio, C. Sarma, Z. Holmes, and P. Stevenson, arXiv:2603.11156 (2026)

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Session Classification: EDI & Theory

Contribution ID: 45

Halo Nuclei from Ab Initio Nuclear Theory

Monday, 27 July 2026 10:05 (25 minutes)

A realistic description of halo nuclei, characterized by low-lying breakup thresholds, requires a proper treatment of continuum effects. We have developed an ab initio approach, the no-core shell model with continuum (NCSMC), capable of describing both bound and unbound states in light nuclei in a unified way. With chiral two- and three-nucleon interactions as the only input, we can predict structure and dynamics of halo and other light nuclei and, by comparing to available experimental data, test the quality of chiral nuclear forces. We review NCSMC calculations of weakly bound states and resonances of exotic halo nuclei ^6He , ^8B , ^{11}Be , and ^{15}C . For the latter, we discuss its production in the capture reaction $^{14}\text{C}(n,\gamma)^{15}\text{C}$. We highlight challenges of a description of ^6He as a Borromean n - n - ^4He system. Finally, we present calculations of excited states in ^{10}Be exhibiting a one-neutron halo structure and a large scale no-core shell model investigation of ^{11}Li as a precursor of a full n - n - ^9Li NCSMC study.

Author: NAVRATIL, Petr (TRIUMF)**Co-authors:** QUAGLIONI, Sofia (LLNL); HUPIN, Guillaume (CNRS/IJCLab); GENNARI, Michael (JGU-Mainz); KRAVVARIS, Konstantinos (Lawrence Livermore National Laboratory)**Presenter:** NAVRATIL, Petr (TRIUMF)**Session Classification:** EDI & Theory

Contribution ID: 54

The Standard Model and Beyond from a Nuclear Structure Perspective

Monday, 27 July 2026 11:00 (30 minutes)

At the heart of particle physics lies the the Standard Model, one of the most (if not the most) successful theories of all of science, which describes the fundamental building blocks of the Universe and how they interact with each other. However, even with all the successes of this theory, mounting evidence tells us that it is at best incomplete. Nonetheless, after years of searches at particle accelerators, direct observation of any process Beyond the Standard Model still eludes us. In this talk, I will present how developments in nuclear theory can allow another, less expensive, avenue to become competitive in those searches: the high-precision measurement of low-energy processes inside the atomic nucleus. I will focus of recent developments that have allowed the rigorous quantification of uncertainty of nuclear structure properties required to interpret these searches.

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Session Classification: Nuclear Structure in Standard Model Physics

Contribution ID: 101

Measuring Electroweak Nuclear Properties with Single Molecular Ions in a Penning Trap

Monday, 27 July 2026 11:30 (20 minutes)

The NEPTUNE collaboration is developing a new Penning ion trap aimed at precision spectroscopy of symmetry-violating electroweak effects using single trapped molecular ions 1. The inherent strong magnetic field for ion confinement can be used to Zeeman-shift two opposite-parity molecular states into near degeneracy, increasing sensitivity to parity-violating nuclear properties by more than 11 orders of magnitude 2. This approach is therefore expected to enable extremely sensitive measurements of symmetry-violating nuclear properties, such as anapole moments, across a wide range of nuclei. This contribution will summarize the current status of the cryogenic Penning trap for measurements in SiO^+ and outline future prospects for the technique.

1 J. Karthein, S. Udrescu, S. Moroch et al. Phys. Rev. Lett. 133, 033003 (2024)

2 Altuntas, E. et al. Phys. Rev. Lett. 120, 142501 (2018)

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Session Classification: Nuclear Structure in Standard Model Physics

Contribution ID: 25

Exploring the origin of the reactor antineutrino anomaly: high-resolution β -decay study of ^{92}Rb

Monday, 27 July 2026 11:50 (20 minutes)

The β decay of neutron-rich nuclei produced via fission processes from nuclear reactors have played a crucial role in developing our understanding of neutrinos within the standard model of particle physics. Reactor antineutrino experiments are unique in providing intense fluxes of with pure electron flavour ($\bar{\nu}_e$) within an MeV-scale energy range which are exploited to perform three-neutrino-flavour oscillation experiments 1 and the search for a fourth-flavour sterile neutrino leading to new physics beyond the standard model. The Reactor Antineutrino Anomaly (RAA) refers to an $\sim 6\%$ deficit in antineutrino measured detection rates 2 and an excess of antineutrinos at 5-7 MeV known as the ‘shoulder’ when compared to state-of-the-art Huber-Muller model predictions [3,4]. This anomaly has prompted a flurry of activity from both theory and experiment over the past 15 years to resolve this disagreement and significant progress has been achieved. These antineutrinos are produced via the β decay of fission fragments and therefore, the origin of the RAA lies in the details of the β -decay processes. Despite their importance, much of the existing β -decay data is unsatisfactory, and improvements are essential to the future of reactor antineutrino experiments.

The β decay of ^{92}Rb is one of the main contributors to the reactor high-energy antineutrino spectrum and consequently an important contributor to the RAA. Recent studies of this decay using Total Absorption Spectroscopy (TAS) [5,6] reveal significant discrepancies with significant additional feeding to high-lying levels when compared with previous work utilising High-Resolution Spectroscopy (HRS) performed in the 1970s. This discrepancy can be attributed to the Pandemonium effect leading to incorrect β feeding measurements in the HRS data which in turn lead to incorrect predictions of the antineutrino flux produced. While the TAS method is excellent at obtaining reliable β feeding measurements, it is a limited probe of nuclear structure and exploiting both methods is essential to obtain a comprehensive understanding of this decay.

We have thus revisited the β decay of ^{92}Rb ($J^\pi = 0^-, Q_\beta = 8.1$ MeV) with the GRIFFIN spectrometer at TRIUMF that consists of up to 16 Compton-suppressed HPGe clover detectors. Due to the high intensity of radioactive beam of ^{92}Rb and the high efficiency of GRIFFIN for detecting γ rays, we have obtained an unparalleled picture of ^{92}Sr with over 180 levels populated and over 850 γ -ray transitions placed within the level scheme up to and beyond the neutron separation energy of ^{92}Sr . The β feeding of ^{92}Sr measured in this work compare very well with the most recent TAS study demonstrating a significant suppression of this Pandemonium effect.

This work reveals the β decay of ^{92}Rb populated numerous high-lying levels in ^{92}Sr . These levels are situated in the energy region of the Pygmy Dipole Resonance (PDR) that manifests as an enhancement of electric dipole strength at the low-energy tail of the Giant Dipole Resonance (GDR) near the neutron separation energy of ^{92}Sr . The PDR is interpreted as an out-of-phase oscillation between the neutron skin and an isospin saturation core; however, this remains a matter of debate. The new information of nuclear levels in ^{92}Sr from our study demonstrate the possibility in exploiting β decay to investigate the PDR in nuclei and provide a complementary approach to existing techniques.

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Session Classification: Nuclear Structure in Standard Model Physics

Contribution ID: 118

Nuclear structure from higher-order multipole moments

Monday, 27 July 2026 12:10 (20 minutes)

Electromagnetic transition rates and multipole moments are crucial observables for understanding and interpreting nuclear structure. While $E2$ transitions tend to be dominant among the low-excitation states of broad ranges of nuclei, particularly as collectivity emerges, and the magnetic moment is sensitive to the structure of an individual state, giving a measure of how the nucleus is carrying its angular momentum, higher-order moments are also important despite data being relatively rare. One example is the unique $E6$ transition in ^{53}Fe 1 where it was found that the effective charges appropriate for higher-multipolarity $E4$ and $E6$ transitions differ from those applicable to $E2$. It can be said that the higher-multipolarity electric (magnetic) transitions help reveal the physics hidden in the effective charges (g factors).

The data on magnetic octupole moments, which are fairly rare, have been compiled recently by Bofos and Mertzimekis 2. It will be shown that the $M3$ magnetic octupole moment, in most of the cases that have been measured, can be estimated with considerable accuracy from the measured magnetic dipole ($M1$) moment. The level of agreement is a surprise, given that the core-polarization mechanism associated with the effective g factors in the $M1$ operator is not expected to be applicable for the $M3$ operator.

Implications and possible explanations, along with some strategies for further investigation, will be discussed. For example, high-precision laser spectroscopy could add to the $M3$ moment data base [3,4] and it can be anticipated that a renaissance in muonic-atom x-ray spectroscopy [5] will yield new data on higher-order nuclear moments.

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Session Classification: Nuclear Structure in Standard Model Physics

Contribution ID: 63

Recent Results with the FDSi at FRIB and the new GROVER Detector

Monday, 27 July 2026 14:00 (30 minutes)

A brief overview of recent results from the FRIB Decay Station initiator (FDSi) will be presented. An emphasis will be placed on new gamma-decaying isomers. These isomers provide highly constrained structure possibilities for each region and important landmarks for future exotic beam studies. Finally, a brief overview of the new DEGA-FDS prototype, GROVER, will be presented. The new detector houses four p-type point-contact HPGe crystals in a single cryostat, combining design elements from both LEGEND and GRETA.

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Session Classification: Gamma Spectroscopy following Beta Decay I

Contribution ID: 79

Two Neutrons, Three Discoveries: Using Two-Neutron Energy Correlations to Probe Nuclear Structure from ^{134}In Decay

Monday, 27 July 2026 14:30 (20 minutes)

Exotic, neutron-rich nuclei are a testing ground for the evolution of nuclear structure away from stability [1]. As radioactive beam facilities extend isotope production toward the neutron dripline [2-3], it is paramount that experimental efforts follow into this less-explored region of the nuclear chart to fully exploit its discovery potential. In these nuclei, beta-delayed single- and multi-neutron emission often dominates decay paths toward stability [1]. Neutron spectroscopy combined with gamma-ray measurements is necessary to uncover the full picture. Nuclei such as those southeast of ^{132}Sn in the chart of nuclides are less affected by the typical experimental challenges of neutron detection; studying the decays of near-doubly magic nuclei simplifies the analysis, as they populate nuclei with low nuclear level densities and strong single-particle character. In this regard, I will present results from the beta-delayed neutron spectroscopy of ^{134}In performed at the ISOLDE Decay Station at CERN [4], using the Neutron dEtector with multi-neutron (Xn) Tracking (NEXT) array [5-6]. For the first time, energy correlations in two-neutron emission were exploited as a probe for nuclear structure. In the two-neutron emission channel from ^{134}Sn , the population of the long-sought $i13/2$ neutron single-particle state was observed as an intermediate step, thereby pinning down the energy of the final elementary excitation in ^{133}Sn between the $N = 82$ and 126 shell closures [7-10]. Furthermore, we find a significant discrepancy between the experimental neutron-branching ratios to this state and the predictions of the Hauser-Feshbach statistical model for spherical neutron emitters [11-12]. This result indicates that the Bohr assumption of the immediate formation of a compound nucleus following beta decay is not valid in this case and should be revisited, with important implications for future experimental studies.

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Session Classification: Gamma Spectroscopy following Beta Decay I

Contribution ID: 157

Erosion of the N=40 Subshell Closure: New Insights from ^{68}Fe

Monday, 27 July 2026 14:50 (20 minutes)

Although the shell model is fundamental to our understanding of nuclear structure, the breakdown of traditional magic numbers far from stability provides insight into the nature of the underlying nuclear interactions and acts as a tool to test existing models. Islands of inversion (IoI) in the nuclear landscape are characterized by the presence of deformed multi-particle multi-hole ($n\nu pnh$) ground states instead of the ($0p0h$) configurations predicted by spherical mean-field calculations. This is typically driven by the strong nuclear quadrupole-quadrupole interaction that induces shape transitions, wherein these highly correlated “intruder” states become more bound than spherical ones.

In the $N=40$ region, the relatively large energy gap separating the pf shell from the $\nu g_{9/2}$ orbital points towards a strong sub shell closure at $N=40$ which has been supported by the observation of a high-lying 2^+ state and low $B(E2)$ value in ^{68}Ni ($Z=28$) [1]. However, systematics of $E(2^+)$ and $B(E2)$ values have indicated a sudden increase in collectivity below $Z=28$ when approaching $N=40$, seen especially in the rapid drop of $E(2^+)$ in Fe ($Z=26$) and Cr ($Z=24$) isotopes [2,3]. This is attributed to the neutron occupation of intruder states from a higher shell, similar to the IoI around $N=20$ [4, 5]. Shape coexistence also manifests in nuclei at the boundaries of IoIs [6]. In the $N=40$ region, low-lying 0^+ excited states, which are traditional indicators of shape coexistence have been identified up to $A=66$ [7, 8]. In ^{68}Fe , a state at 2035 keV is tentatively assigned as 0^+ or 2^+ and the confirmation of this spin would indicate whether this trend extends past $N=40$.

To explore these phenomena, an experiment was performed at TRIUMF-ISAC using the GRIF-FIN spectrometer that utilized the β^- and βn decay of ^{68}Mn to populate excited states in $^{67,68}\text{Fe}$, $^{67,68}\text{Co}$ and $^{67,68}\text{Ni}$. This experiment produced the highest-statistics data set to date for these isotopes. Consequently, we have greatly expanded the level scheme of ^{68}Fe and measured key spectroscopic quantities. Angular correlation analysis performed using the 64 HPGe crystals of GRIFFIN has provided new information on the spin assignment of the proposed 0_2^+ state, resulting in a reinterpretation of shape coexistence in this nucleus. Furthermore, the first direct measurement of the lifetime of the 2_1^+ level in ^{68}Fe was performed using $\beta\gamma\gamma$ fast-timing analysis, and $B(E2; 2_1^+ \rightarrow 0_1^+)$ was subsequently calculated. The associated nuclear structure implications and other results from the analysis will be presented and discussed.

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Session Classification: Gamma Spectroscopy following Beta Decay I

Contribution ID: 106

First β -Decay Spectroscopy Measurements of ^{31}F and ^{37}Na Using FDSi

Monday, 27 July 2026 15:10 (20 minutes)

The study of nuclear structure in regions of extreme neutron excess provides stringent tests of shell-model predictions. Experiments at the Facility for Rare Isotope Beams (FRIB) continue to explore nuclei at the limits of stability. On the neutron-rich side, crossing from $N = 20$ toward the $N = 28$ island of inversion, the isotopes ^{31}F and ^{37}Na lie at or very near the neutron drip line in this region. In this work, we report the first β -decay half-life measurements of ^{31}F and ^{37}Na , utilizing the state-of-the-art experimental setup of the FRIB Decay Station Initiator (FDSi).

The reported results represent the shortest β -decay half-lives measured to date and serve as sensitive benchmarks for theoretical shell-model calculations in the $N = 20$ – 28 region. Comparisons with calculations using the *sdpf-m* 1 and *SDPFSDG-MU* 2 interactions show overall good agreement within uncertainties associated with the effective interactions and adopted Q_β values. However, further investigations are ongoing to understand differences between interactions and localized discrepancies with experiment, particularly in relation to the role of cross-shell excitations and intruder configurations.

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Acknowledgment

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Session Classification: Gamma Spectroscopy following Beta Decay I

Contribution ID: 107

Beta-decay spectroscopy with laser-polarized beams at CERN ISOLDE

Monday, 27 July 2026 16:00 (30 minutes)

Nuclear spin orientation provides access to an additional observable in beta-decay experiments – the anisotropy of radiation emission, which reflects the parity-nonconserving nature of the weak interaction [1]. The resulting directional distribution of the radiation depends on the asymmetry parameter, which is sensitive to the angular momentum change, as well as on the polarization of the parent nuclei. Higher beam polarization leads to more pronounced anisotropy, which can be used to determine the asymmetry parameter and thereby assign the spins and parities of excited states. Such assignments are particularly straightforward for states involved in allowed Gamow–Teller transitions, as demonstrated in experiments at RIKEN [2, 3] and TRIUMF [4, 5], where beta-decay spectroscopy with polarized nuclei was pioneered.

In this contribution, the CERN ISOLDE's first beta-decay spectroscopy experiment with laser-polarized beams is presented. A dedicated station has been designed and integrated into the VITO beamline [6]. Full compatibility of the new setup was demonstrated in commissioning campaigns with polarized atoms of $^{47,49,51}\text{K}$. The new station at VITO opens opportunities to advance beta-decay studies at ISOLDE and to provide new insights into the decay mechanisms of strong beta-delayed neutron emitters [7, 8].

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Session Classification: Gamma Spectroscopy following Beta Decay II

Contribution ID: 27

Nuclear structure of ^{114}Sn via β decay of ^{114}Sb with GRIFFIN

Monday, 27 July 2026 16:30 (20 minutes)

The semi-magic Sn ($Z = 50$) isotopes with neutron numbers extending from $N = 50$ to beyond the $N = 82$ shell, provide an important testing ground for studying the evolution of nucleon–nucleon interactions across the chain. Although ground states of Sn isotopes are predominantly spherical, mid-shell isotopes ($A = 112\text{--}122$) display shape coexistence associated with proton $2p\text{--}2h$ intruder configurations, leading to deformed rotational bands built upon excited 0^+ states 1. Recent studies have suggested different bandheads for these intruder structures, namely 0_2^+ state in ^{118}Sn and the 0_3^+ state in ^{116}Sn [2,3]. This motivates a detailed spectroscopic investigation of the neighboring nucleus ^{114}Sn to clarify the bandhead of the shape-coexisting structure and to search for possible bands built upon the 0_3^+ state. Furthermore, recent theoretical and experimental studies have proposed the presence of pygmy quadrupole resonance (PQR) in $^{112,114,124}\text{Sn}$, although its existence is yet to be firmly established [4,5].

We report on a comprehensive γ -ray spectroscopy study of ^{114}Sn following the β decay of ^{114}Sb , produced at the TRIUMF-ISAC facility. The resulting γ rays were detected using the GRIFFIN spectrometer, consisting of 15 Compton-suppressed HPGe clover detectors with a total of 60 crystals, facilitating angular correlation measurements. Ancillary detectors included the Zero Degree Scintillator (ZDS) for β tagging and the PACES array of five Si(Li) detectors for conversion-electron spectroscopy. In addition, eight $\text{LaBr}_3(\text{Ce})$ detectors were employed for lifetime measurements using fast-timing techniques.

In this work, more than 600 new γ -ray transitions and over 100 new excited states have been established in ^{114}Sn . The results confirm the 0_2^+ state as the bandhead of deformed $2p\text{--}2h$ band, in contrast to ^{116}Sn . The implications for the evolution of shape-coexisting structures near the neutron mid-shell and low-lying quadrupole strength in this region will be discussed at the conference.

1 P. Garrett et al., Prog. Part. Nucl. Phys. 124, 103931 (2022).

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[5] N. Tsoneva et al., Nucl. Phys. A 990, 183–198 (2019).

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Co-author: COLLABORATION, GRIFFIN

Presenter: MADHU, Madhu (Simon Fraser University)

Session Classification: Gamma Spectroscopy following Beta Decay II

Contribution ID: 104

Exploring the structure of nuclei with $A \approx 100$ via β decay

Monday, 27 July 2026 16:50 (20 minutes)

A sudden ground-state shape transition is known to occur sharply at $N = 60$ for several nuclei in the $A \approx 100$ region [1]. Dramatic changes are observed in the energy spectra of Sr and Zr, including an appearance of low-energy 0^+ states that are associated to competing configurations characterized by different nuclear shapes. In contrast, in Mo isotopes the ground state shape evolution appears to be more gradual, in accordance with the moderate change in $E_x(2_1^+)$ across $N = 60$ [2], proposed to be the result of emerging triaxiality [3].

Recent state-of-the-art Monte Carlo Shell Model (MCSM) calculations [3] reproduced the ground-state band properties throughout the Zr isotopic chain and suggested the appearance of multiple shape coexistence in ^{100}Zr . In addition, it was proposed that the abrupt shape transition at $N = 60$ is caused by an inversion of a spherical and prolate-deformed configurations, corresponding to the ground states of ^{98}Zr and ^{100}Zr , respectively, appearing with small to no mixing between them due to type-II shell evolution [3].

To test the MCSM predictions and investigate in detail this fascinating region, a β -decay study of $A = 100$ isotopes was carried out at the TRIUMF-ISAC facility. A radioactive ion beam mixture of ^{100}Rb and ^{100}Sr was used and population of excited states in isotopes ranging from ^{100}Sr to ^{100}Mo was observed. The powerful GRIFFIN array [4] coupled to a tape station allowed to explore the level structure of several nuclei with a main focus on ^{100}Zr ($N = 60$). In addition, ^{100}Mo ($N = 58$) was studied with the aim of observing low-intensity γ -ray transitions and establishing spins of excited states that have remained undetermined to date. While a low-energy Coulomb-excitation study [5] revealed that the triaxial ground state of ^{100}Mo coexists with a prolate-deformed 0_2^+ level, little is known for the higher-lying 0^+ states.

Selected results will be highlighted, including the identification of new 0^+ states in ^{100}Zr via γ - γ angular correlations and candidates for 2^+ states built on them. The mixing of coexisting configurations will be addressed relying on high-precision branching and mixing ratios obtained in this work. In addition, a comparison between Zr isotopes with $N = 58, 60$ will be presented, reporting on recent key findings from our group in ^{98}Zr [6]. Finally, for the first time results concerning newly discovered structures in ^{100}Mo will be presented and a possible multiple-shape coexistence scenario will be discussed.

[1] P.E. Garrett et al., Prog. Part. Nucl. Phys. 124 (2022) 103931.

[2] R. Rodriguez-Guzman et al., Phys. Lett. B 691, 202 (2010).

[3] T. Togashi et al., Phys. Rev. Lett. 117 (2016) 172502.

[4] A.B. Garnsworthy et al., Nucl. Instrum. Methods Phys. Res., Sect. A, 918 (2019).

[5] K. Wrzosek-Lipska et al., Phys. Rev. C 86, 064305 (2012).

[6] K. Mashtakov et al., in preparation.

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Session Classification: Gamma Spectroscopy following Beta Decay II

Contribution ID: 31

Electrons for Neutrinos: from MAMI to MESA

Monday, 27 July 2026 17:10 (20 minutes)

Next-generation long-baseline neutrino experiments aim to measure neutrino oscillation parameters with percent-level precision and to determine the CP-violating phase in the lepton sector of the Standard Model. Achieving these ambitious goals requires a significantly improved understanding of neutrino–nucleus interaction cross sections, which currently constitute one of the dominant sources of systematic uncertainty. Electron-scattering experiments can provide essential constraints on nuclear response functions through high-statistics and high-precision measurements, since electrons probe the same vector current component involved in neutrino interactions. Such measurements therefore offer a powerful and complementary approach to reducing nuclear-model uncertainties.

In this contribution, recent results from electron-nucleus scattering experiments performed at MAMI will be presented, together with prospects for future studies at the upcoming MESA energy-recovery accelerator facility.

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Presenter: DORIA, Luca (Johannes Gutenberg University Mainz)

Session Classification: Gamma Spectroscopy following Beta Decay II

Contribution ID: 103

Nuclear structure for X-ray burst models via beta decay at FRIB

Tuesday, 28 July 2026 09:00 (30 minutes)

Type I X-ray bursts are frequent transient events observed in the Milky Way using space-based X-ray telescopes. Each burst results from a thermonuclear explosion on the surface of an accreting neutron star in a close binary system. Along with various astrophysical parameters, X-ray burst models are sensitive to nuclear uncertainties. Among the most significant nuclear uncertainties identified are the thermonuclear rates of the $^{15}\text{O}(\alpha,\gamma)^{19}\text{Ne}$, $^{59}\text{Cu}(\text{p},\gamma)^{60}\text{Zn}$, and $^{59}\text{Cu}(\text{p},\alpha)^{56}\text{Ni}$ reactions. To address these uncertainties, an experimental campaign was recently completed at FRIB using the beta decays of ^{20}Mg and ^{60}Ga and the Gaseous Detector with Germanium Tagging II (GADGET II) system. The goals are to measure the alpha-particle branching ratio of the key ^{19}Ne resonance, and to discover and characterize resonances in ^{60}Zn by their energies, spins/parities, and branching ratios. Preliminary analysis of these data sets will be presented, along with plans to follow up by measuring ^{60}Zn resonance lifetimes using ^{60}Ga decay and the new Lifetimes and Branching Ratios Apparatus (LIBRA) system, also at FRIB.

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Presenter: WREDE, Christopher (Michigan State University and Facility for Rare Isotope Beams)

Session Classification: Nuclear Structure in Astrophysics

Contribution ID: 21

Probing explosive nucleosynthesis with radioactive beams

Tuesday, 28 July 2026 09:30 (20 minutes)

Explosive astrophysical environments, such as X-ray bursts, novae and supernovae govern nucleosynthesis on the proton-rich side of the valley of stability. In these sites, nucleosynthesis proceeds mainly through p- and α - induced reactions, as well as photodisintegration reactions that push the nuclear flux away from the valley of stability. Modeling these environments requires detailed knowledge of nuclear properties and reaction rates for the nuclei involved. To address this need, direct measurements in the astrophysically relevant energy region with radioactive beams are essential. In this talk, I will present two radioactive beam experiments for explosive nucleosynthesis.

In the lighter-mass region, I will discuss one of the main breakout pathways from the hotCNO cycle towards explosive burning and the rp process, the $^{14}\text{O}(\alpha, p)^{17}\text{F}$ reaction. At typical burst temperatures, this reaction proceeds predominantly through a 6.15 MeV resonant state in ^{18}Ne , that can decay through p, α or possibly 2p emission. Using the Active Target and Time Projection Chamber (ACTAR TPC) at TRIUMF, the 6.15 MeV resonance was populated through inelastic proton scattering on a radioactive ^{17}F beam. This measurement aims to provide branching ratios between the 2p, p, and α decay channels by observing all particles in the final state.

Moving on towards the heavy elements and the astrophysical γ process, I will present the first measurement of the $^{73}\text{As}(p, \gamma)^{74}\text{Se}$ reaction, one of the main destruction mechanisms of the lightest p nucleus ^{74}Se . The measurement was performed using a radioactive ^{73}As beam with the Summing NaI (SuN) detector at the Facility for Rare Isotope Beams. Along with the total cross-section measurement, the impact of the extracted reaction rate in the production of ^{74}Se in Type II supernovae will be presented.

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Presenter: TSANTIRI, Artemis (University of Regina)

Session Classification: Nuclear Structure in Astrophysics

Contribution ID: 116

Direct Neutron Capture Measurements with a Storage Ring

Tuesday, 28 July 2026 09:50 (20 minutes)

Neutron capture reactions are fundamental to understanding the synthesis of elements heavier than iron in stellar environments, occurring through the slow (s), intermediate (i), and rapid (r) neutron-capture processes. While neutron-capture cross sections along the valley of stability—particularly for stable or long-lived isotopes—have been extensively studied, direct measurements on short-lived nuclides ($T_{1/2} \ll 1$ year) remain inaccessible with current techniques.

Heavy-ion storage rings coupled to radioactive-beam facilities provide a powerful platform for advancing such studies. Over the past decade, the ESR and CRYRING at GSI Darmstadt have enabled inverse-kinematics measurements of astrophysically relevant reaction rates, though to date only for charged-particle reactions. With the NRING project at CRYRING 1, we propose the first facility capable of performing direct neutron-capture measurements on shorter-lived isotopes.

In this contribution, I will outline the NRING concept and discuss its expected capabilities and limitations. Ultimately, fully harnessing this new approach will require the development of a dedicated future “neutron-capture storage ring” integrated with an ISOL facility—an advancement that could enable hundreds of direct neutron-capture measurements on short-lived nuclei down to half-lives of seconds in the coming decade. One possibility for such a new dedicated facility could be the TRIUMF Storage Ring (TRISR) 2 at the TRIUMF-ISAC facility.

1 Ariel Tarifeño-Saldivia, César Domingo-Pardo, Iris Dillmann, Yuri A. Litvinov, “Direct Neutron Reactions in Storage Rings Utilizing a Supercompact Cyclotron Neutron Target”, [<https://arxiv.org/abs/2508.15465>], subm. to Phys. Rev. Acc. and Beams (2026)

2 I. Dillmann, O. Kester, et al., Eur. Phys. J. A59 (2023) 105.

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Session Classification: Nuclear Structure in Astrophysics

Contribution ID: 155

ORRUBA: two decades of discovery

Tuesday, 28 July 2026 10:10 (20 minutes)

ORRUBA (the Oak Ridge Rutgers University Barrel Array) comprises the largest suite of highly-segmented silicon detectors for radioactive beam physics in the US. It was initially conceived as a standalone ~300-channel detector array for measuring (d,p) reactions on fission fragments around the Coulomb barrier. Initial experiments were performed in 2006, including the first measurement of the $^{132}\text{Sn}(d,p)^{133}\text{Sn}$ reaction.

Over the following two decades, ORRUBA has been further developed and expanded (now 1200 channels), with various auxiliary detectors. It has been deployed at numerous facilities (ATLAS, NSCL, FRIB, HIgS, ...) for measurements of direct and compound nuclear reactions spanning a wide range of beam energies and masses, to inform nuclear structure, reactions, astrophysics and applications. Particular mileage has been gained from coupling to other instruments, including the GODDESS coupling to large HPGe arrays (Gammasphere and GRETINA), and coupling to the S800 spectrometer and the JENSA gas-jet target. An overview of some of these experiments, upgrades and results will be presented, with a focus on recent experiments (including the first at FRIB), and a look toward future plans for operation with the SECAR recoil separator and GRETA at FRIB and ATLAS.

Work supported in part by the US DOE Office of Science (NP) under Contracts DE-AC05-00OR22725 (ORNL), DE-AC52-07NA27344 (LLNL), DE-FG02-96ER40963 (UTK), DE-AC02-05CH11231 (LBL), under (NNSA) Contract no. DE-NA0003897 (Rutgers), and the National Science Foundation.

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Presenter: JONES, Kate (University of Tennessee)

Session Classification: Nuclear Structure in Astrophysics

Contribution ID: 166

Coulomb Breakup and soft E1 excitation of Halo Nuclei

Tuesday, 28 July 2026 11:00 (30 minutes)

Soft E1 excitation, characterized by enhanced electric dipole strength at low excitation energies, is a distinctive feature of neutron halo nuclei, and has been extensively studied via Coulomb breakup reactions [1,2]. It serves as a powerful spectroscopic probe for both one-neutron and two-neutron halo nuclei. In this talk, we present recent Coulomb breakup studies of the one-neutron halo nucleus ^{31}Ne , and the two-neutron halo nuclei, ^{19}B 3, and ^{22}C , performed with the SAMURAI spectrometer at RIBF, RIKEN. We discuss new insights into the soft E1 excitation, particularly in two-neutron halo nuclei. We also discuss future perspectives for Coulomb breakup studies of halo nuclei.

1 T. Nakamura, Coulomb breakup and soft E1 excitation of neutron halo nuclei, in Handbook of Nuclear Physics, edited by I. Tanihata, H. Toki, and T. Kajino (Springer Nature Singapore, Singapore, 2020) pp. 1-37

2 T. Aumann and T. Nakamura, The electric dipole response of exotic nuclei, Physica Scripta 2013, T152, 014012 (2013).

3 K.J. Cook et al., Phys. Rev. Lett. 124, 212503 (2020).

Author: Prof. NAKAMURA, Takashi (Institute of Science Tokyo)

Presenter: Prof. NAKAMURA, Takashi (Institute of Science Tokyo)

Session Classification: Halo Nuclei

Contribution ID: 19

First spectroscopic study with direct reactions at RAON

Tuesday, 28 July 2026 11:30 (20 minutes)

The Rare isotope Accelerator complex for ON-line experiments (RAON) is the first Radioactive Isotope (RI) beam facility in Korea. After the commissioning of the Super-Conducting Linac (SCL3) and the first commissioning experiments carried out in summer 2024, 2025 was marked for the first spectroscopic campaign at RAON, with stable and unstable beams. For this purpose, a large amount of effort was devoted at the Center for Exotic Nuclear Studies (CENS) to develop nuclear detection instruments especially intended for experiments with direct reactions in inverse kinematics: these include ASGARD array of HPGe detectors and STARK Jr silicon barrel array that were the major workhorses of the aforementioned experimental campaign.

This contribution will report on the first spectroscopic study using direct reactions performed at RAON, discussing the physics motivation of these studies, the detailed experimental setup: its current status and the achieved performance, including in-beam commissioning results; and the preliminary outcome of this work. Ongoing development efforts and future experimental plans will also be discussed.

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Session Classification: Halo Nuclei

Contribution ID: 141

Study of the structure of neutron-rich isotopes $^{23, 24}\text{F}$ in inverse kinematics with the R3B experimental setup at GSI/FAIR

Tuesday, 28 July 2026 11:50 (20 minutes)

Understanding the structure of nuclei far from stability remains one of the major challenges in nuclear physics. In particular, many-body correlations can lead to nuclear systems whose properties deviate significantly from those expected from a simple independent-particle picture. A striking example is the drastic extension of the neutron drip line for $Z = 9$ isotopes compared with $Z = 8$ nuclei¹. The neutron drip line marks the limit of nuclear binding beyond which additional neutrons cannot be bound to the nucleus and are immediately emitted. Investigating the structure of $Z = 8$ and $Z = 9$ isotopes through one-nucleon removal reactions is therefore essential for understanding this phenomenon.

In this work, we study the reaction $^{25}\text{F}(p,2p)^{24}\text{O}$ in inverse kinematics in order to characterize the final states of the residual ^{24}O nucleus. This measurement builds upon previous studies^{2,3}, but benefits from the higher resolution, statistics, and acceptance provided by the R³B (Reactions with Relativistic Radioactive Beams) experimental setup at GSI/FAIR.

In the experiment, a cocktail beam containing ^{25}F beam at 650 MeV/nucleon impinges on a 5 cm long LH₂ target. The outgoing oxygen fragments ($^{22,23,24}\text{O}$) produced in the (p,2p) reaction are measured in coincidence with the reaction products, providing information on the populated ground and excited states of ^{24}O . Since ^{23}O and ^{24}O do not exhibit bound excited states, their de-excitation proceeds through the emission of one or two neutrons. These neutrons are detected with high resolution in the NeuLAND 3 neutron detector, allowing the reconstruction of unbound states in ^{24}O and ^{23}O . In addition, bound states of ^{22}O are studied using the CALIFA calorimeter [4].

The measured cross sections for the population of individual final states, together with the reconstructed momentum distributions of the decaying ^{24}O system, will provide valuable information on the configuration of the ^{24}O core in ^{25}F . Moreover, since our cocktail beam also contains $^{23, 24}\text{F}$, an extension of this study towards $^{22, 23}\text{O}$ will allow a complete spectroscopic characterization of both bound and unbound states of $^{22, 23, 24}\text{O}$.

1 D. S. Ahn et al., Phys. Rev. Lett 123, 212501 (2019). DOI: 10.1103/PhysRevLett.123.212501.

2 T. L. Tang et al., Phys. Rev. Lett 124, 212502 (2020). DOI: 10.1103/PhysRevLett.124.212502.

3 K. Boretzky et al., Nuclear Instrum. Methods Phys. Res. A 1014, 165701 (2021). DOI: 10.1016/j.nima.2021.165701.

[4] H. Alvarez-Pol et al., Nuclear Instrum. Methods Phys. Res. A 767, 453 (2014). DOI: 10.1016/j.nima.2014.09.018.

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Session Classification: Halo Nuclei

Contribution ID: 96

Probing Halo Structure in the $1/2^+$ Excited State of ^{17}C via Interaction Cross Section Measurements

Tuesday, 28 July 2026 12:10 (20 minutes)

Halo nuclei have served as benchmarks for understanding weakly-bound and continuum effects on the evolution of single-particle energies and particle correlations at and beyond the dripline. However, direct evidence of halo structures in nuclear excited states has remained elusive due to experimental challenges, thus limiting the number of cases available for investigating halo formation near the threshold.

A new technique, based on a combination of gamma-ray spectroscopy and the transmission method, has been developed to probe the presence or absence of halos in excited states. This novel approach, termed the Gamma-decay Transmission Method, quantifies gamma-ray yields with and without a reaction target to extract the interaction cross section of excited states.

The $1/2^+$ excited state of ^{17}C , characterized by a small one-neutron separation energy of 0.5 MeV and a significant s-wave component, is a strong halo candidate and therefore well suited to demonstrate the new method. An experimental study using this technique was performed at FRIB utilizing GRETINA, the S800 spectrograph, and a dedicated target assembly to produce ^{17}C . This talk will describe the new methodology and provide an overview of preliminary results.

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Presenter: DOUGLAS, Andrew (FRIB/Michigan State University)

Session Classification: Halo Nuclei

Contribution ID: 168

A universal fate for spin-orbit partners in the weak-binding regime?

Tuesday, 28 July 2026 14:00 (30 minutes)

The solenoidal-spectrometer technique was pioneered at Argonne just over 15 years ago with the HELIOS spectrometer. Its success has been emulated in Europe at CERN's HIE-ISOLDE facility with the ISOLDE Solenoidal Spectrometer and at DOE's Facility for Rare Isotope Beams with SOLARIS. Solenoidal spectrometers are highly versatile tools, perhaps more so than originally imagined, for studying direct reactions in inverse kinematics (mainly with radioactive ion beams) with good resolution. From the solenoidal spectrometer programs at ATLAS, CERN, and FRIB, key insights have emerged: the behavior of single-particle energies in weakly bound nuclei suggests a seemingly ubiquitous way nuclear structure evolves towards the limits of stability. I will present physics highlights from recent measurements that reflect this. This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under Contract Number DE-AC02-06CH11357.

Author: Dr KAY, Benjamin (Argonne National Laboratory)

Presenter: Dr KAY, Benjamin (Argonne National Laboratory)

Session Classification: Single Particle Structure

Contribution ID: 61

Abrupt structural transition in exotic molybdenum isotopes unveils an isospin-symmetric island of inversion

Tuesday, 28 July 2026 14:30 (20 minutes)

Protons and neutrons in nuclei are arranged in orbitals that follow a shell structure, with energy gaps at specific magic numbers. Experiments using radioactive beams have shown that these magic numbers vanish in some neutron-rich isotopes. This results in unusual arrangements, where configurations with nucleons scattered to higher energy orbitals are the most bound, forming what has been called “Islands of Inversion”.

We have measured the lifetimes of 2^+ states in ^{84}Mo and ^{86}Mo isotopes, discovering a dramatic structural change. This has been understood as the boundary of a “Isospin-Symmetric Island of Inversion”¹, where both proton and neutron excitations play an equal role and evolution of collectivity is governed by three-nucleon forces.

¹ J. Ha, F. Recchia et al. Abrupt structural transition in exotic molybdenum isotopes unveils an isospin-symmetric island of inversion. Nat Commun 16, 10631 (2025).

<https://doi.org/10.1038/s41467-025-65621-2>

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Session Classification: Single Particle Structure

Contribution ID: 123

Direct Observation of Superalloyed Alpha Decay of ^{104}Te

Tuesday, 28 July 2026 14:50 (20 minutes)

Historically, the simplest α decay is that of ^{212}Po , which is conceptualized as a doubly magic ^{208}Pb core with a valence α particle. For decades, this well-measured isotope has stood as the baseline for α -decay models and comparison among other α -emitting nuclei. However, a lighter region of α radioactivity was found in neutron-deficient tellurium and xenon isotopes resulting from the $Z=50$ and $N=50$ shell closures. Discovered by Macfarlane and Siivola, these decays are enhanced relative to ^{212}Po , allowing the authors to coin the term “superalloyed” α decay for the nuclei 1. The self-conjugate decay of ^{104}Te to ^{100}Sn was then postulated to be the most enhanced α decay due to an increase in proton-neutron correlations. Two events of ^{104}Te were measured by Auranen et al. Despite limited statistics, the authors placed an upper limit on the half-life via the decay chain of ^{108}Xe 2. This work reports an experiment at RIKEN RIBF using the fragmentation of ^{124}Xe to produce the decay chain of ^{108}Xe to ^{104}Te to ^{100}Sn 3. In preparation for the short lifetime, a fast-response charged particle detector was utilized [4]. The half-life of ^{104}Te was measured for the first time and is found to be the fastest ground-state α -emitting nucleus known to date. Additionally, the deduced preformation demonstrates that the enhancement is greater for ^{104}Te than for any other α -decaying nucleus 3. This presentation will compare the results with previous results from Auranen et al and numerous theoretical models.

1 R. Macfarlane and A. Siivola, Phys. Rev. Lett. 14, 144 (1965)

2 K. Auranen, et al. Phys. Rev. Lett. 121, 182501 (2018)

3 I. Cox, et al. Nature, in Press (2026) <https://doi.org/10.21203/rs.3.rs-7991707/v1>

[4] Y. Xiao, et al. Phys. Rev. C 100, 034315 (2019)

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Presenter: COX, Ian (Argonne National Laboratory)

Session Classification: Single Particle Structure

Contribution ID: 66

Fast-Beam One-Neutron Pickup Reactions: A Selective Probe of High- ℓ States

Tuesday, 28 July 2026 15:10 (20 minutes)

High- ℓ single-particle configurations provide critical information on nuclear structure and place important constraints on theoretical models but are typically difficult to access experimentally due to their weak population in commonly used experimental methods such as low-energy transfer and knockout reactions. Intermediate-energy one-neutron pickup reactions in inverse kinematics are uniquely suited to this problem as due to poor angular momentum matching the population of high- ℓ ($\ell \geq 3$) states are drastically enhanced whilst also suppressing low- ℓ transfer [1,2]. When applied to nuclei with high-lying high- ℓ orbitals these reactions provide selective access to states that have remained unobserved in previous γ -ray spectroscopy studies, even in otherwise well-studied systems.

Here, one-neutron pickup reaction experiments performed at the former NSCL will be discussed. Beams delivered by the Coupled Cyclotron Facility were impinged on a ^{12}C target to induce one-neutron pickup reactions. Prompt γ rays were detected with the Gamma-Ray Energy in-beam Nuclear Array (GRETINA), while reaction residues were subsequently identified in the S800 magnetic spectrometer. These measurements build on earlier one-neutron pickup studies performed at the NSCL which first demonstrated the strong selectivity of one-neutron pickup reactions [3,4]. Results from the $^{12}\text{C}(^{46}\text{Ca}, ^{47}\text{Ca} + \gamma)\text{X}$ reaction will be discussed, which provided new insight into the placement and strength of the $\nu(0f_{5/2})$ and $\nu(0g_{9/2})$ orbitals in ^{47}Ca [5], including the population of states not previously observed in γ -ray spectroscopy. In addition, preliminary results from the ongoing analysis of the $^{12}\text{C}(^{44}\text{Ar}, ^{45}\text{Ar} + \gamma)\text{X}$ reaction will be presented, further demonstrating the strong selectivity of one-neutron pickup reactions and their potential to probe high- ℓ structure in neutron-rich nuclei.

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Presenter: PARRY, Thomas (Facility for Rare Isotope Beams)

Session Classification: Single Particle Structure

Contribution ID: 47

The Gamma Ray Energy Tracking Array - GRETA

Tuesday, 28 July 2026 16:00 (30 minutes)

The Gamma-Ray Energy Tracking Array (GRETA) Project started in 2017, following nearly a decade of successful science with the predecessor GRETINA array. Led by LBNL, with a team including partner institutions ANL, ORNL and FRIB, GRETA marked the completion of construction and initial commissioning of all technical systems (mechanical, electronics and computing) with a subset of Quad Detector modules in late summer of 2025. It is currently being installed at the Facility for Rare Isotope Beams (FRIB), with a full array of 30 Quad modules for the first time covering 80% of the 4π solid angle. First PAC-approved science measurements are expected in early 2027. I will discuss physics highlights from the decade of GRETINA operations, and review the GRETA project, both scientific and technical aspects, and the progression toward anticipated first science at FRIB.

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Session Classification: Instrumentation and Facilities I

Contribution ID: 5

Recent results on the double-gamma decay

Tuesday, 28 July 2026 16:30 (20 minutes)

The nuclear two-photon or double-gamma (2γ) decay is a second-order electromagnetic decay process whereby a nucleus in an excited state emits two gamma rays simultaneously. Compared to first-order decay pathways, such as single photon emission or internal electron conversion, the two-photon decay rate is very small. Ideal cases for this search are $0^+ \rightarrow 0^+$ transition where single photon emission is prohibited. However, the only cases where the 2γ decay from a first-excited 0^+ state was successfully observed using γ -ray spectroscopy are ^{16}O , ^{40}Ca and ^{90}Zr [1, 2], where the high energy of the transitions is favorable for the 2γ branch. More recently, also the competitive 2γ decay was observed from the long-lived $11/2^-$ isomer in ^{137}Ba 3.

For lower decay energies the 2γ branch becomes prohibitively small to be observed in γ -ray spectroscopy ($<10^{-6}$). We have therefore combined the isochronous mode of the Experimental Storage Ring (ESR) at GSI with Schottky resonant cavities. This newly developed Schottky plus Isochronous Mass Spectrometry (S+IMS) allows to study exotic decays of short-lived nuclear states. The obtained mass resolving power enables experiments on nuclear isomers with excitation energies down to ~ 100 keV and half-lives as short as a few ms. The first measurement of the partial half-life for the isolated 2γ decay of the 0^+ isomer in ^{72}Ge turned out to be surprisingly short [4]. Recent results for the 2γ decay of the 0^+ isomers in ^{98}Zr and ^{98}Mo will be presented as well as first steps to measure the weak 2γ branch in ^{72}Ge by direct γ -ray spectroscopy.

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The main results are based on the experiments E143 and G22-00018, which were performed at the GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt (Germany) in the context of FAIR Phase-0. This work was supported by the Slovenian Research and Innovation Agency under Grants No. I0-E005 and No. P1-0102, by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (ERC-AdG NECTAR, grant agreement No 884715; ERC-CoG ASTRUM, grant agreement No 68284), by the State of Hesse (Germany) within the Research Cluster ELEMENTS (Project ID 500/10.006), by the STFC (UK), by the NSF grant PHY-2110365, by the BMBF under grant NuSTAR.DA 05P19RDFN1, by the JSPS KAKENHI Grant Number T23KK0055. Work at ANL is supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under contract No. DE-AC02-06CH11357.

Author: WEINERT, Michael

Presenter: WEINERT, Michael

Session Classification: Instrumentation and Facilities I

Contribution ID: 117

Neutron spectroscopy at the FRIB Decay Station Initiator

Tuesday, 28 July 2026 16:50 (20 minutes)

The FRIB Decay Station Initiator [All25] was designed for comprehensive decay studies, including the ability to perform beta-delayed neutron emission studies. The bn-precursors investigated so far with FDSi range from doubly magic ^{24}O to deformed ^{111}Nb . The analysis of three cases was recently completed at the University of Tennessee. The measurement of ^{24}O reveals the role of continuum coupling in neutron emission [Neu26] by directly measuring the widths of nuclear resonances populated in beta decay. The decay of deformed ^{44}S revealed an unexpected suppression of the $L=0$ neutron emission channel, and we are investigating the nature of this process using microscopic models [Bra26]. Finally, the decay of ^{54}K to doubly magic ^{54}Ca demonstrated a role of two-body currents [Gys18] in very neutron-rich nuclei [Xu26]. These experimental results show that beta-delayed neutron emission is an effective tool for studying very neutron-rich nuclei and provide new insights into these exotic nuclei.

This research was sponsored by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics under DE-FG02-96ER40983, and by the Stewardship Science Academic Alliances program through DOE Award No. DE-NA0003899.

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[Xu26] Z. Xu et al. submitted

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Presenter: GRZYWACZ, Robert (University of Tennessee)

Session Classification: Instrumentation and Facilities I

Contribution ID: 34

Study of shape coexistence and triaxial deformation in ^{56}Cr using AGATA spectrometer: The puzzling $B(E2)$ values

Tuesday, 28 July 2026 17:10 (20 minutes)

The Cr isotopes with $N \geq 28$ are a good testing ground for rapid shape evolution from a spherical to a well deformed region close to $N=40$ 1. Among the Cr isotopic chain, the ^{56}Cr ($N=32$) shows a very particular interest. The appearance of a subshell closure in this nucleus is indicated by high excitation energy of the 2_1^+ state and reduced $B(E2: 2_1^+ \rightarrow 0_1^+)$ values 2 compared to neighbouring Cr isotopes, same as in ^{52}Ca and ^{54}Ti 3 nuclei. Shell-model calculations, using various interactions and/or effective charges, are able to reproduce well the trend of the energy of the 2_1^+ state along the Cr isotopic chain but fail to reproduce the staggering of the $B(E2: 2_1^+ \rightarrow 0_1^+)$ values with a minimum at ^{56}Cr ($N=32$) 1. Beyond mean-field calculations using Gogny interaction reproduce the experimental zigzag behaviour in the Ti isotopes without any need to invoke effective charges but again this is not the case for the Cr isotopes [4]. Calculations performed with the AMD+HFB framework [5] aiming to investigate the triaxial deformation of the states and shape coexistence in this region reproduce the staggering of $B(E2)$ values at $N=32$ but the theoretical values of $B(E2)$ remain much higher than the experimental ones [6].

To get an insight into the structure ^{56}Cr , shape coexistence and triaxial deformation were studied in a recent experiment via lifetime measurements of the 0_1^2 and 2_1^2 states employing the RDDS and the DSAM technique. The states of interest were populated using a two-neutron transfer reaction: $^{54}\text{Cr}(^{18}\text{O}, ^{16}\text{O})^{56}\text{Cr}$. Gamma rays were measured using the state of the art of gamma-ray spectroscopy, the AGATA array [7], coupled with the SPIDER silicon detector [8] to reach the needed channel selectivity. Experimental results will be discussed and compared to theoretical calculations.

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Session Classification: Instrumentation and Facilities I

Contribution ID: 100

Shaking up the Periodic Table with Superheavy Element Molecules

Wednesday, 29 July 2026 09:00 (30 minutes)

The Periodic Table is a cornerstone of chemistry, but its validity is challenged by the extreme properties of superheavy elements (SHEs, $Z \geq 104$) and actinides ($Z > 88$). Relativistic effects, stemming from their large nuclear masses, significantly alter their chemical behaviors, potentially limiting the predictive power of the Periodic Table. Recent breakthroughs have provided insights into the chemistry of these elements, including the direct identification of molecular species formed by actinium (Ac, $Z = 89$) and nobelium (No, $Z = 102$) ions. Using a cutting-edge, atom-at-a-time technique at the 88-Inch Cyclotron Facility at Lawrence Berkeley National Laboratory, we have synthesized and characterized molecular species produced by these ions in reactions with H_2O and N_2 . Our findings underscore the importance of direct identification of molecules in SHE chemistry experiments and offer new perspectives on the chemical properties of these enigmatic elements. This presentation will explore the current state of superheavy element chemistry research, highlighting recent advances and future directions for unraveling the mysteries of SHE chemistry. By pushing the boundaries of our understanding, we aim to shed light on the chemical behaviors of these extraordinary elements and challenge our current understanding of the Periodic Table.

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Presenter: PORE, Jennifer (Lawrence Berkeley National Laboratory)

Session Classification: Structure of Superheavy Nuclei

Contribution ID: 46

Hyperfine spectroscopy of the $K = 8^-$ isomer in ^{254}No with JetRIS resolving a 20-year-old debate

Wednesday, 29 July 2026 09:30 (20 minutes)

Modern nuclear structure studies in the heavy-element region combine state-of-the-art experimental techniques with advanced theoretical models [1,2]. This interplay between experiment and theory not only enhances the interpretation of experimental data but also drives the refinement of theoretical approaches, underscoring the importance of benchmarking models against independent experimental observables.

The $K^\pi = 8^-$ state in ^{254}No has been investigated extensively over the past two decades [3-5], yet its configuration remained unresolved. Owing to the production mechanisms employed in previous studies, which do not populate the rotational band built on the isomer, in-beam and decay spectroscopy measurements have not been sufficient to determine its g -factor, precluding a definitive configuration assignment. Consequently, both neutron-neutron [4] and proton-proton [3,5] two-quasiparticle configurations have been proposed based on indirect evidence, such as decay patterns and comparisons between measured excitation energies and theoretical predictions.

In this work, we resolve this ambiguity by presenting nuclear model-independent measurements of the electromagnetic multipole moments of the $K^\pi = 8^-$ state in ^{254}No . Using the in-gas-jet laser ionisation spectroscopy setup JetRIS [6,7], we have recorded the hyperfine spectrum of the short-lived isomer ($T_{1/2} = 259(7) \text{ ms}$ [5]), enabling the extraction of its g -factor. In addition, we provide information on the quadrupole deformation of the isomer and on the change in mean-square charge radius between the ground and excited states of ^{254}No .

Previous studies in the $N = 150$ region have identified and characterised $K^\pi = 8^-$ states in ^{244}Pu , ^{246}Cm , ^{250}Fm , and ^{252}No , all consistently assigned a neutron-neutron two-quasiparticle configuration [8,9]. Our results for ^{254}No demonstrate that this structure persists across the $N = 152$ sub-shell gap, challenging the predictions of most theoretical models.

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Presenter: IVANDIKOV, Fedor (KU Leuven)

Session Classification: Structure of Superheavy Nuclei

Contribution ID: 149

Laser spectroscopy of heavy actinides

Wednesday, 29 July 2026 09:50 (20 minutes)

The heaviest elements are of interest to nuclear and atomic physicists due to their peculiar properties. While nuclear shell structure effects are responsible for their very existence stabilizing them against spontaneous disintegration, the structure of their electronic shells is affected by strong relativistic effects leading to different atomic and chemical properties compared to their lighter homologs. The atomic structure can be probed by laser spectroscopy. This is a powerful tool to unveil fundamental atomic and, by detecting subtle changes in atomic transitions, nuclear properties. The scarcity in atomic information on the heavy element of interest, the limited availability, and the rather short half-lives make experimental investigations challenging and demand very sensitive experimental techniques.

Here, laser spectroscopic studies of accelerator produced heavy nuclei were performed using the RADRIS (Radiation Detected Resonance Ionization Spectroscopy) setup for laser spectroscopy inside a buffer gas cell. This sensitive technique enabled laser spectroscopy measurements on isotopes of nobelium (No, $Z = 102$), fermium (Fm, $Z = 100$) and californium (Cf, $Z = 98$), which were produced with atom-at-a-time quantities in fusion-evaporation reactions at the velocity filter SHIP at GSI, Darmstadt.

Complementary hot-cavity laser spectroscopy on radio-chemically purified samples allowed for off-line investigation of long-lived, reactor-bred isotopes of the heavy actinides curium (Cm, $Z = 96$), californium, einsteinium (Es, $Z = 99$), and fermium. This experimental work is accompanied by improvements of theoretical atomic calculations enabling the determination of nuclear ground state properties from the extracted atomic observables of isotope shifts and hyperfine structure parameters. This provides insight to the peculiar nuclear nature and, in particular, the deformation of the heaviest elements. The obtained results will be discussed in view of nuclear theory predictions together with perspectives for laser spectroscopic investigations in even heavier elements.

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Presenter: RAEDER, Sebastian

Session Classification: Structure of Superheavy Nuclei

Contribution ID: 129

In-beam γ -ray spectroscopy of $^{249,251}\text{Md}$

Wednesday, 29 July 2026 10:10 (20 minutes)

In-beam γ -ray spectroscopy experiments on the heavy odd-Z nuclei ^{249}Md and ^{251}Md were performed at the ATLAS accelerator facility of Argonne National Laboratory using the $^{203}\text{Tl}(^{48}\text{Ca}, 2n)$ and $^{205}\text{Tl}(^{48}\text{Ca}, 2n)$ fusion evaporation reactions, respectively. In both experiments the Argonne Gas-Filled Analyzer (AGFA) was used to separate recoils of interest, while Gammasphere detected prompt γ -rays emitted from excited states and the X-array provided sensitivity to isomeric states and decays. Recoil- and recoil-decay tagging techniques were utilised to identify new rotational bands in ^{249}Md based on one-proton quasiparticle states. One observed set of states forms a pair of strongly coupled bands with relatively strong E2 transitions, and another sequence of γ -ray transitions is indicative of a decoupled band of E2 transitions. These bands are respectively assigned as based on the Nilsson level configurations $7/2^- [514]$ and $1/2^- [521]$, corresponding to the ground and first excited state of ^{249}Md . The presence of at least one high- K multi-quasiparticle isomer was also confirmed in ^{249}Md . This talk presents the results of the ^{249}Md experiment, and a discussion of preliminary findings from the experiment on ^{251}Md .

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Presenter: APPLETON, Corrigan (LBNL)

Session Classification: Structure of Superheavy Nuclei

Contribution ID: 64

ACTAR TPC Studies of Direct and Resonant Reactions: Insights from the TRIUMF campaign

Wednesday, 29 July 2026 11:00 (30 minutes)

The ACtive TARget and Time Projection Chamber (ACTAR TPC), is a versatile detector designed to address a wide range of nuclear physics topics near the drip-lines. In this contribution, previous results obtained with ACTAR TPC in transfer reaction studies with a 200 beam will be reviewed, demonstrating its capabilities for precise measurements in inverse kinematics. Particular emphasis will be placed on preliminary results from an experimental campaign carried out at TRIUMF in 2025. Nuclear structure studies of neutron-rich Li isotopes and proton-rich exotic nuclei will be presented. These results underline the potential of ACTAR TPC as a powerful tool for studying direct and resonant reactions with rare isotope beams.

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Session Classification: Instrumentation and Facilities II

Contribution ID: 70

Determination of the electromagnetic nature of the Low Energy Enhancement in the γ -ray strength function of ^{70}Zn

Wednesday, 29 July 2026 11:30 (20 minutes)

The γ -ray strength function (γSF) is a statistical nuclear property that describes the likelihood of γ -ray emission as a function of γ -ray energy. Investigations into the γSF have identified prominent features in its shape, such as the giant dipole resonance, pygmy dipole resonance, scissors mode, and low energy enhancement (LEE). The LEE is a fundamental property of atomic nuclei, and it has been shown to have significant impact on astrophysical reaction rates ¹. The electromagnetic nature of the LEE has puzzled the nuclear physics community since it was first discovered in $^{56,57}\text{Fe}$ ², and despite two decades of theoretical and experimental efforts, it remains unclear if the LEE is due to electric dipole or magnetic dipole transitions ³. Here, we present the results from an experiment conducted at the Facility for Rare Isotope Beams (FRIB) at Michigan State University, where we use a novel combination of experimental and analytical techniques to probe the electromagnetic nature of the LEE in the nucleus ^{70}Zn . At FRIB, beams of the ground and second isomeric states of ^{70}Cu ($J=6^-$ and $J=1^+$, respectively) were isolated with the Low Energy Beam and Ion Trap (LEBIT) Penning trap mass spectrometer [4] and delivered to the upgraded Summing NaI(Tl) Total Absorption Spectrometer [5]. These two β -decaying states populate different levels in ^{70}Zn , with the 6^- ground state favoring $E1+M1$ transitions and the 1^+ isomeric state favoring $M1$ transitions. In this contribution, we present the comparison of the ^{70}Zn γSF extracted from both β -decaying states of ^{70}Cu with the β -Oslo [6] and Shape [7] methods. From these results we are able to make a conclusive determination about the electromagnetic nature of the LEE in ^{70}Zn .

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Session Classification: Instrumentation and Facilities II

Contribution ID: 74

Charge Radii of $^{52,53}\text{Ni}$ from Precision Laser Spectroscopy

Wednesday, 29 July 2026 11:50 (20 minutes)

The evolution of nuclear structure in the magic nickel chain provides stringent tests of nuclear theory with the presence of three doubly magic nuclei ($^{48,56,78}\text{Ni}$) and a prominent subshell closure at ^{64}Ni . In this work, precision laser spectroscopy measurements on $^{52,53}\text{Ni}$ will be presented, which extend the known Ni charge-radii chain beyond doubly magic ^{56}Ni towards the proton drip line at ^{48}Ni . The nuclear magnetic-dipole and electric-quadrupole moments of ^{53}Ni will also be reported. From the difference in the ^{52}Ni - ^{52}Cr mirror pair charge-radii, a constraint on the slope parameter (L) in the symmetry energy of the nuclear equation of state will be deduced, analogous to the previously measured ^{54}Ni - ^{54}Fe mirror pair 1. Details of the measurement technique and results will be discussed.

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Presenter: DOCKERY, Adam (Michigan State University / Facility for Rare Isotope Beams)

Session Classification: Instrumentation and Facilities II

Contribution ID: 29

Support for multiple shape coexistence: the first lifetime measurements of the 0_3^+ states in ^{118}Sn and ^{120}Sn

Wednesday, 29 July 2026 12:10 (20 minutes)

The semi-magic Sn nuclei, extending beyond the $N = 50$ and $N = 82$ shell closures, present one of the most-studied isotopic chains on the nuclear chart. $^{118}\text{Sn}_{68}$ and $^{120}\text{Sn}_{70}$ lie in the neutron mid-shell, where shape coexistence was proposed with the signature of deformed excited 0^+ states intruding into the seniority-like spherical yrast bands. However, transition strengths studies were hindered because only limits were available in the literature on the lifetimes of the excited 0_3^+ states. Notably, the lack of electric monopole strengths between the 0_3^+ and 0_2^+ states, $\rho^2(E0; 0_3^+ \rightarrow 0_2^+)$, obscured the shape difference and mixing amplitudes between the excited 0^+ states.

These 0_3^+ lifetimes were recently measured for the first time in a thermal-neutron capture experiment at the Institut Laue-Langevin. The world's highest-flux thermal neutron beam of 10^8 neutrons/cm²/s was delivered onto enriched ^{117}Sn and ^{119}Sn targets, respectively. Low-spin states in $^{118,120}\text{Sn}$ were populated up to the ≈ 9 -MeV neutron separation energies, and the decaying gamma-ray cascades were detected with the Fission Product Prompt Gamma-ray Spectrometer (FIPPS) comprised of eight Compton-suppressed HPGe clovers coupled to an array of 15 LaBr₃ fast scintillation detectors.

In total, $\approx 4 \times 10^9$ counts were recorded in the $\gamma\gamma\gamma$ cube for each isotope, where two LaBr₃ events were in coincidence with one HPGe.

Monopole transition strengths from the lifetime measurements for the 0_3^+ states in $^{118,120}\text{Sn}$ will be presented along with theoretical interpretations employing MR-CDFT calculations without adjustable parameters.

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Session Classification: Instrumentation and Facilities II

Contribution ID: 171

Shape coexistence studied with Coulomb excitation and AGATA

Thursday, 30 July 2026 09:00 (30 minutes)

The history of Coulomb-excitation measurements with the new-generation European γ -ray spectrometer AGATA dates back to the very first physics experiment with this array, which took place in April 2010 and aimed at investigation of a highly-deformed structure in ^{42}Ca 1. The shape parameters obtained from this study confirm that the excited structure in ^{42}Ca possesses a strikingly large elongation, similar to that established for superdeformed bands in this mass region, and a slightly non-axial character. In contrast, those for the ground state are consistent with large fluctuations about a spherical shape.

During the AGATA campaign at GANIL (2014-2021) Coulomb-excitation data were collected as a by-product of experiments performed at near-barrier beam energies. Notably, the analysis of slightly "unsafe" Coulomb-excitation data on ^{106}Cd , collected during an experiment aiming at lifetime measurements in $^{106,108}\text{Sn}$ 2, provides information on the collectivity of the presumably oblate structure built on the 0^+3 state, as well as on the role of octupole correlations in this nucleus [3, 4].

Coulomb-excitation experiments to study nuclear shapes constitute one of the pillars of the on-going AGATA campaign at LNL (2022-2028). Their main focus is on multiparticle-multihole excitations across the $Z = 50$ shell gap in Cd, Pd, and Te nuclei, although the structure of nuclei as light as ^8Li and as heavy as ^{232}Th has also been probed using this method. Another area of interest has been the region of light $A \approx 70$ nuclei known for prolate-oblate shape coexistence.

I will discuss the highlights from Coulomb-excitation studies with AGATA, as well as preliminary results of selected experiments from the current campaign.

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Session Classification: Shape Coexistence

Contribution ID: 23

Search for Shape Coexistence Signatures in ^{100}Ru using Thermal Neutron Capture Reaction.

Thursday, 30 July 2026 09:30 (20 minutes)

At the forefront of nuclear structure research is the topic of shape coexistence, which occurs when states within the same nucleus at similar energies possess distinct shapes. Studies of nuclei in the Zr ($Z=40$) - Sn ($Z=50$) region have shown evidence for shape coexistence with deformed rotational-like bands coexisting with spherical or weakly deformed ground state configurations. In the Ru ($Z=44$) isotopes, strong evidence has emerged for shape coexistence within ^{102}Ru and ^{104}Ru from Coulomb excitation [1,2], and it was suggested to be present in ^{98}Ru and ^{100}Ru as well [3]. In order to explore shape coexistence in ^{100}Ru , and also probe possible vibrational motion, key mixing ratios and the observation of low-energy, and hence often very weak intensity, transitions between non-yrast states are required. The study of ^{100}Ru presented in this work aims to extract precise transition multipolarity mixing ratios, unobserved weak g-ray transitions, and transition probabilities to resolve its structural nature. We used the thermal neutron capture reaction, $^{99}\text{Ru}(n,g)^{100}\text{Ru}$, carried out at the Institut Laue-Langevin in Grenoble, France [4]. The g-ray transitions depopulating the excited states in ^{100}Ru were detected by the FIPPS array consisting of two sets of eight clover-type hyper pure Germanium detectors. FIPPS provides high efficiency and the ability to perform detailed gamma-gamma angular correlations due to its high granularity. Results from the current analysis will be presented with an emphasis on the structural implications of the results.

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Session Classification: Shape Coexistence

Contribution ID: 20

Shape transitions of the 2+ states in 106,108,110Sn from Coulomb excitation

Thursday, 30 July 2026 09:50 (20 minutes)

The experimental $B(E2; 2_1^+ \rightarrow 0_1^+)$ values in neutron-deficient, even-even Sn isotopes are found to be enhanced compared to calculations, a discrepancy which has eluded a satisfactory solution for over a decade. A Monte Carlo Shell Model (MCSM) 1 attributed this phenomenon to significant proton excitations across the $Z = 50$ shell in neutron-deficient Sn isotopes, and predicted a shape transition from a prolate to an oblate quadrupole deformation of the 2_1^+ states from ^{106}Sn to ^{110}Sn .

A safe-energy Coulomb excitation campaign of $^{106,108,110}\text{Sn}$ was conducted at HIE-ISOLDE, CERN. The radioactive Sn beams were accelerated to 4.4-4.5 MeV per nucleon and Coulomb excited on ^{206}Pb targets. Gamma rays from the beam and the target nuclei were detected with the Miniball HPGe spectrometer 2. In all three nuclei, record γ -ray counts were obtained from Coulomb excitation experiments 3.

Through excitation probability analysis in GOSIA [4,5], The $B(E2; 2_1^+ \rightarrow 0_1^+)$ value of ^{110}Sn was determined with the best precision to date as $451(22) \text{ e}^2\text{fm}^4$, and the $B(E2; 4_1^+ \rightarrow 2_1^+)$ and $B(E2; 4_2^+ \rightarrow 2_1^+)$ values were also determined for the first time [6]. Furthermore, the spectroscopic quadrupole moment (Q_s) of the 2_1^+ state of ^{110}Sn was newly determined as $+0.20(8) \text{ eb}$. Both the sign and the magnitude of $Q_s(2_1^+)$ are in agreement with the MCSM prediction of an oblate shape for the 2_1^+ state in ^{110}Sn 1. Preliminary results suggest a negative $Q_s(2_1^+)$ for ^{106}Sn and $Q_s(2_1^+) \sim 0$ for ^{108}Sn , which are also consistent with MCSM. The shape transition in the light Sn isotopes will be discussed, as well as a more detailed view on the role of protons above the $Z = 50$ shell.

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Session Classification: Shape Coexistence

Contribution ID: 138

Investigating the deformation of intruder states in ^{79}Zn via Coulomb excitation

Thursday, 30 July 2026 10:10 (20 minutes)

In the region of $N \sim 50$ several pieces of evidence supporting shape coexistence close to ^{78}Ni have been found [1-3]. In particular, the ~ 940 -keV $1/2^+$ isomeric state in ^{79}Zn , first observed in a (d,p) transfer measurement [4], has been interpreted as an intruder state, related to neutron excitations across $N=50$. Laser-spectroscopy measurements found a large isomeric shift for this state with respect to the ^{79}Zn $9/2^+$ ground state indicating a significantly larger mean squared charge radius 2. With the assumption of an axial quadrupole shape, this suggests a deformation of $\beta=0.22$, considerably larger than $\beta=0.15$ of the ground state. Indeed, the intruder structure in ^{79}Zn has been attributed to a $K=1/2$ rotational band 3.

To probe the quadrupole collectivity of the ^{79}Zn intruder states, we performed a Coulomb-excitation measurement with a post-accelerated ^{79}Zn beam from HIE-ISOLDE that consisted of a mixture of nuclei in the $9/2^+$ ground state and the $1/2^+$ isomeric state, to populate excited states built on these two different configurations. In the experiment, γ rays were detected by the Mini-ball array [5], while scattered projectiles and beam recoils by an annular DSSD detector placed at forward angles.

The extracted quadrupole strengths from the Coulomb-excited transitions in the level scheme will be presented and compared with state-of-the-art shell model calculations. The implications of the results in the context of the shape coexistence around ^{78}Ni will be discussed.

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Session Classification: Shape Coexistence

Contribution ID: 78

Investigations of the unbound states in ^{20}C

Thursday, 30 July 2026 11:00 (30 minutes)

The carbon isotopes, with $Z=6$ being the first spin-orbit shell gap originating from the splitting of the $1p_{1/2}$ – $1p_{3/2}$ orbitals, provide an excellent ground to study changes in proton spin-orbit splitting from stability to the dripline. Neutron-rich carbon isotopes have been intensively investigated over the last decade. Transition probabilities, $B(E2; 2^+ \rightarrow 0^+)$, have been measured up to ^{20}C [1,2], revealing an increase from ^{16}C to ^{20}C . These $B(E2)$ values have been interpreted in terms of the mixing of unperturbed neutron and proton 2^+ excitations, with the observed increase in collectivity explained by an enhanced contribution of proton excitations. This enhancement is likely due to a reduction of the proton $1p_{1/2}$ – $1p_{3/2}$ spin-orbit splitting toward the dripline [3].

In a more recent experiment [4], neutron-rich carbon isotopes $^{16,18,20}\text{C}$ were studied via proton removal reactions from nitrogen isotopes. Cross sections populating the ground and 2^+_1 states were measured in each case. The results showed an increase in the proton component of the 2^+_1 state, supporting a moderate reduction of the proton $1p_{1/2}$ – $1p_{3/2}$ splitting towards the neutron dripline [4]. This study, as well as [3], further suggested that a mixed-symmetry 2^+ state with an excitation energy around 7 MeV should be strongly populated in proton removal reactions from nitrogen isotopes. This state, lying above the neutron separation energy and therefore unbound, likely decays via neutron emission. Investigating this unbound 2^+ state in carbon isotopes will provide critical experimental data to shed light on the evolution of the $Z=6$ spin-orbit splitting and benchmark theoretical models.

We present the investigation of the unbound states in ^{20}C , populated via proton removal from ^{21}N . The radioactive ^{21}N beam was produced by the BigRIPS separator at RIBF and induced a proton removal reaction on a carbon target. The unbound states in ^{20}C were analyzed using the SAMURAI spectrometer via invariant mass spectroscopy. In this report, the experimental setup, the data analysis as well as the preliminary results will be presented.

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Session Classification: Shell Evolution

Contribution ID: 145

Neutron knockout from titanium isotopes near the new magic numbers $N=32,34$

Thursday, 30 July 2026 11:30 (20 minutes)

The nuclear shell model is extremely effective in describing the behaviour of stable magic nuclei. Modern radioactive ion beam facilities have facilitated tests of the shell model along chains of magic isotopes stretching far from the valley of stability. With increased isospin asymmetry, the energies of proton and neutron orbitals can shift, in some cases moving far enough that magic numbers vanish or appear. Double-magicity of calcium isotopes has been established at conventionally non-magic $N = 32, 34$ on the basis of mass, radius, $E(2^+)$ and $B(E2)$. In the neighbouring elements, however, clear evidence for the persistence of these magic neutron numbers remains elusive, and more detailed spectroscopy is needed to understand how the neutron orbitals depend on the occupancy of the proton orbitals.

The $N = 32, 34$ shell gaps in ^{52}Ca are thought to appear due to the $\pi f_{5/2}$ orbital sitting well above the $\pi p_{1/2}$ orbital to leave gaps on either side. One explanation for the disappearance of the $N = 34$ magic number at larger Z is that when the $\pi f_{7/2}$ orbital starts filling, the tensor force coupling between the $\pi f_{7/2}$ protons and $\pi f_{5/2}$ neutrons reduces the energy of the $\pi f_{5/2}$ orbital. To experimentally probe this phenomenon we study titanium isotopes, two protons above calcium. We present results from in-beam gamma-ray spectroscopy of one-neutron knockout from $^{56,58}\text{Ti}$ with the HiCARI gamma array and the BigRIPS and ZeroDegree spectrometers. Using the parallel momentum distribution of the outgoing ions, we can determine the angular momentum of the orbital from which the neutron is removed. Combined with the spectroscopic analysis, we aim to determine the relative position of the $\pi f_{5/2}$ with two protons in the $\pi f_{7/2}$ orbital, and identify whether it has already dropped below the $\pi p_{1/2}$ orbital.

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Contribution ID: 40

Rare decay branches of $A \sim 90$ isomers studied with GRIFFIN using local source production

Thursday, 30 July 2026 11:50 (20 minute)

Modern HPGe detector arrays such as GRIFFIN and TIGRESS at TRIUMF/ISAC allow for extremely high precision γ -ray branching ratio measurements - as low as 10^{-7} depending on counting rate and measurement time - allowing for examination of rare decay branches. A promising avenue for pursuing these high precision measurements at TRIUMF is local production of high activity sources using the TR13 medical cyclotron, located within walking distance of both ISAC halls. We have initiated a series of experiments to study the rare decays of ^{93m}Mo ($t_{1/2} = 6.85$ hr) and ^{92m}Nb ($t_{1/2} = 10.15$ d) using MBq activity sources produced on the TR13 via proton bombardment of niobium foils.

For ^{93m}Mo , our goal is to measure the rare $21/2_1^+ \rightarrow 9/2_1^+$ $E6$ (electric hexacontatetrapole) IT decay branch. Only one $E6$ decay branch has been previously observed, from ^{53m}Fe decay [1,2]. Despite the presence of significant summing and time-random background, there is some preliminary evidence of this extremely rare decay branch in our data. Additional data will be collected throughout 2026, to improve statistics and evaluate systematic uncertainties.

We have also obtained high statistics $^{92m}\text{Nb} \rightarrow ^{92}\text{Zr}$ decay data, allowing measurement of the $B(E2; 2_2^+ \rightarrow 0_2^+)$ value in ^{92}Zr for the first time, as well as improved limits for other weak transitions. These are important indicators as to whether ^{92}Zr exhibits shape coexistence similar to ^{94}Zr and other neutron rich zirconiums. We are also searching for direct population of 0^+ states in ^{92}Zr in order to definitively assign the spin of the ^{92m}Nb parent, which may be relevant to the survival of ^{92}Nb in astrophysical scenarios. The current status of our data analysis and future prospects for local source production experiments at TRIUMF will be discussed.

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Session Classification: Poster Session

Contribution ID: 68

Beyond Sphericity in a Semi-Magic Nucleus: Multiple Shape Coexistence in ^{116}Sn

Thursday, 30 July 2026 12:10 (20 minutes)

The evolution of nuclear shapes and the phenomenon of shape coexistence lie at the heart of our understanding of nuclear structure and the effective nuclear interaction. While dramatic examples of shape coexistence have long been established near closed shells, semi-magic nuclei have traditionally been regarded as structurally simple systems, dominated by pairing correlations and spherical mean fields. In this context, the tin isotopic chain, anchored by the robust $Z = 50$ shell closure, has served for decades as the textbook paradigm of sphericity and seniority-driven structure.

This contribution will present compelling experimental evidence that fundamentally challenges this long-standing picture. Using a high-precision Coulomb-excitation experiment on ^{116}Sn , located at the midpoint of the neutron mid-shell, an extensive and internally consistent set of electromagnetic matrix elements has been extracted. These data enable, for the first time in this nucleus, a fully model-independent determination of intrinsic quadrupole deformations for the ground and excited 0^+ states, as well as spectroscopic quadrupole moments for multiple low-lying 2^+ states.

The results reveal a remarkably rich and unexpected structural landscape. Rather than a spherical ground state weakly perturbed by a single intruder configuration, ^{116}Sn exhibits multiple coexisting shapes at low excitation energy. The ground state itself is shown to possess a small but finite oblate deformation, incompatible with spherical symmetry and characterized by limited shape fluctuations. In addition, two excited 0^+ states display distinct intrinsic deformations, providing unambiguous evidence for multiple-shape coexistence - a phenomenon observed in only a handful of nuclei across the entire nuclear chart.

These findings are discussed in the context of the experiment-driven Three-Band Mixing (3BM) model developed specifically for this work, as well as the Projected Generator Coordinate Method (PGCM) framework. Together, these approaches reveal strongly fragmented wave functions for the 0^+ states, in stark contrast to the largely unperturbed nature of the 2^+ states, and provide a coherent explanation of longstanding anomalies observed in nucleon-transfer reactions.

These results demonstrate that even semi-magic nuclei can host complex collective dynamics and multiple competing shapes. The case of ^{116}Sn thus emerges not as an exception, but as a key benchmark for testing modern nuclear structure theories beyond the traditional limits of shell closures.

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Presenter: SICILIANO, Marco (Argonne National Laboratory)

Session Classification: Shell Evolution

Contribution ID: 161

Recent developments of ab initio calculations in light nuclei

Thursday, 30 July 2026 14:00 (30 minutes)

The past decade has witnessed tremendous progress in theoretical and computational approaches to describing the atomic nucleus as a system of interacting protons and neutrons. In particular, ab initio calculations based on interactions and currents derived from chiral effective field theory have achieved an accurate description of key experimental quantities. In this talk, I will focus on selected electroweak observables in light nuclei and show that the level of accuracy now reached opens the possibility of using nuclear theory to address open questions in other areas of physics, such as neutrino physics.

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Presenter: Prof. BACCA, Sonia (Johannes Gutenberg University)

Session Classification: Structure of Light Nuclei

Contribution ID: 36

Approaching the N=20 Island of Inversion with the $^{29}\text{Mg}(\text{d},\text{p})^{30}\text{Mg}$ reaction

Thursday, 30 July 2026 14:30 (20 minutes)

We have studied the $^{29}\text{Mg}(\text{d},\text{p})^{30}\text{Mg}$ reaction in inverse kinematics, with the first use of a reaccelerated rare-isotope beam from FRIB delivered to the SOLARIS solenoidal spectrometer. The N=20 Island of Inversion (IoI) at ^{32}Mg is well known, arising from a diminished gap between the *sd* and *fp* neutron shells. Evidence for this modification comes from a variety of studies including mass measurements [1], neutron knockout [2], Coulomb excitation [3] and proton scattering [4]. A pioneering study of the two-neutron transfer reaction $^{30}\text{Mg}(\text{t},\text{p})^{32}\text{Mg}$ [5] and theoretical analyses [6] of those data suggested that the ^{32}Mg ground state is strongly deformed with significant contributions of 2p-2h and 4p-4h neutron excitations out of the *sd* shell. Differing interpretations of the approach to N=20 in the Mg isotopes exist, however. Coulomb-excitation work from the MINIBALL experiment suggest that ^{30}Mg is a spherical nucleus residing fully outside of the IoI [7], while other Coulex measurements [8] indicate that ^{30}Mg is deformed, and knockout data [9] identify non-negligible *fp*-shell strength in ^{30}Mg that is approximately 30% of that seen in ^{32}Mg . The question of whether the transition to N=20 IoI is sudden, or occurs more gradually, with particle-hole excitations already playing a role in the structure of low-lying states in ^{30}Mg , can also be addressed by studying neutron transfer to the low-lying 0^+ states in ^{30}Mg with the $^{29}\text{Mg}(\text{d},\text{p})^{30}\text{Mg}$ reaction. Furthermore, little information exists about the negative-parity states in ^{30}Mg , which inform us about the *fp*-shell single-particle energies. Shell-model calculations yield different predictions about the energies of negative-parity excitations, and single-neutron transfer strongly populates such states. We studied the $^{29}\text{Mg}(\text{d},\text{p})^{30}\text{Mg}$ reaction in inverse kinematics using a reaccelerated ^{29}Mg beam produced by the ReA6 facility at FRIB. The ^{29}Mg beam, with an intensity of approximately 40000 particles per second and energy of 8.46 AMeV, bombarded a 200 $\mu\text{g}/\text{cm}^2$ CD_2 target. Protons and recoiling ^{30}Mg nuclei were detected with SOLARIS, providing high-resolution measurements for final states in ^{30}Mg . The data suggest significant mixing between the ground and first-excited 0^+ states, clear evidence for several negative-parity excitations, and one new previously unobserved state. We will present these results, and discuss comparisons of the experimental observations with predictions from shell-model calculations.

This material is based upon work supported by the U. S. Department of Energy, Office of Science, Office of Nuclear Physics, under Contract Numbers DE-SC0014552 (UConn) and DE-AC02-6CH11357 (ANL) and used resources of the Facility for Rare Isotope Beams (FRIB) Operations, which is a DOE Office of Science User Facility under Award Number DE-SC0023633. SOLARIS is funded by the DOE Office of Science under the FRIB Cooperative Agreement DE-SC0000661.

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Session Classification: Structure of Light Nuclei

Contribution ID: 150

Experimental Study of Electromagnetic Transitions in Neutron-rich ^{22}F

Thursday, 30 July 2026 14:50 (20 minutes)

The evolution of nuclear shell structure at the interface between the p and sd shells remains a central problem in nuclear physics, where cross-shell excitations and proton–neutron correlations drive changes in nuclear structure. The odd–odd nucleus ^{22}F lies just above the $Z=8$ shell closure and is particularly sensitive to excitations across the p – sd shell gap, making it an ideal system for probing this transition region.

Excited states in ^{22}F were populated via the $^9\text{Be}(^{18}\text{O}, \alpha p)^{22}\text{F}$ fusion–evaporation reaction using a 55 MeV beam delivered by the ATLAS facility at Argonne National Laboratory. Prompt γ rays were detected with the GRETINA array in coincidence with recoils identified by the Fragment Mass Analyzer. Doppler-corrected γ – γ coincidence measurements enabled the construction of an expanded level scheme.

Several previously unobserved γ -ray transitions and new excited states were identified, significantly extending the known spectroscopy of ^{22}F . Spin and parity assignments were constrained through angular distribution and linear polarization measurements, providing new insight into the structure of this odd–odd system.

The results are compared with *ab initio* calculations based on chiral effective field theory and place new constraints on the description of proton–neutron correlations and shell evolution at the p – sd boundary.

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Session Classification: Structure of Light Nuclei

Contribution ID: 43

Exploring Configurations in Neutron-Rich Si Isotopes

Thursday, 30 July 2026 15:10 (20 minutes)

Understanding the evolution of nuclear shells with increasing nucleon number provides insight into how the fundamental interactions governing nuclear properties manifest at the scale of nuclear observables. One such region where this is particularly apparent is the $N = 20$ island of inversion, where the nominally higher-lying $\nu(f_{7/2})$ shell falls below the $\nu(d_{3/2})$ and dominates the ground state configuration of ^{32}Mg . Neutron rich Si isotopes lying at the northwestern boundary of the island of inversion have been of significant interest recently, as they represent a region where the evolution between the “normal” and “intruder” configurations are dominant. Specifically, the ground state of ^{32}Si is predicted to have a pure sd -shell configuration with little-to-no fp -shell contributions to the low-energy states, while ^{34}Si has been described as a “transitional” nucleus with dominant sd -shell ground state but significant fp -shell contributions in low-energy states. In this talk I will discuss the results of neutron-adding $^{31}\text{Si}(d, p)^{32}\text{Si}$ experiments recently performed using the HELIOS solenoidal spectrometer at ATLAS, as well as planned future experiments for the analogous $^{33}\text{Si}(d, p)^{34}\text{Si}$ reaction using SOLARIS at FRIB. The results and implications of these measurements will be addressed.

This work is supported in part by the U.S. Department of Energy Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357 and with resources of ANL’s ATLAS facility, a Department of Energy, Office of Science User Facility.

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Session Classification: Structure of Light Nuclei

Contribution ID: 169

Recent Results on Nuclear Structure from the University of Jyväskylä Accelerator Laboratory

Thursday, 30 July 2026 16:00 (30 minutes)

The nuclear spectroscopy program at the Accelerator Laboratory of the University of Jyväskylä has for decades relied on combining a germanium-detector array with a recoil separator, enabling the use of the highly sensitive recoil-gating and recoil-decay tagging techniques. Since 2019, the JUROGAM 3 spectrometer has been operated together with the vacuum-mode MARA and gas-filled RITU separators in numerous experiments addressing a broad range of nuclear structure questions. The success of this experimental program is reflected in recent results on nuclei near the $N=Z$ line, as well as in the heavier mass region. This presentation will discuss these recent results and outline ongoing and future nuclear structure studies of neutron-deficient nuclei in the $A=30$ -50 mass region.

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Session Classification: Special Topics

Contribution ID: 60

Excited-State Lifetime Measurements in Neutron-Rich Ca, Ar Isotopes at INFN LNL

Thursday, 30 July 2026 16:30 (20 minutes)

The isotopic mass region defined by the convergence of the $Z = 20$ and $N = 28$ magic numbers sits atop multiple areas of active study, offering a unique opportunity to constrain various distinct structural effects in a singular experiment. Working out towards the neutron-rich exotic Ca isotopes from the last stable isotope at ^{48}Ca , closures of the $N = 32$ and $N = 34$ neutron sub-shells are expected to emerge based on the recent mass measurements 1 and high 2_1^+ energies, while a monotonic increase in the nuclear radii from ^{48}Ca to ^{52}Ca suggests otherwise [2,3]. Looking proton deficient of this region, the evolution of $B(E2)$ values can be used to understand deformation and core breaking across the $N = 28$ shell gap [4], approaching the 2nd island of inversion surrounding the collective ^{44}Si [5]. Lifetime measurements of low-lying states in the yrast bands of $^{50,51,52}\text{Ca}$ and $^{46,47,48}\text{Ar}$ provides a mechanism of probing the largely unconstrained $B(E2)$ values for these states, providing a stringent test for the shell-model interactions in this region.

In 2024 at INFN LNL, a 305 MeV beam of ^{48}Ca beam was delivered to a ^{238}U target at the combined AGATA/PRISMA experimental station, populating $^{50,51,52}\text{Ca}$ and $^{46,47,48}\text{Ar}$ among other nearby isotopes in a multi-nucleon transfer reaction. Surrounding the ^{238}U target, the high-purity germanium Advanced GAMMA Tracking Array (AGATA) [6,7] was used to measure high-resolution γ -ray lineshapes from the states in the excited isotopes. These emitted recoil isotopes were then collected in the PRISMA large acceptance magnetic spectrometer [8], providing event-by-event resolution of the mass and atomic number. Two target configurations were used to study two distinct lifetime ranges using the Doppler-shift attenuation method (DSAM) and recoil distance Doppler-shift (RDDS) technique, utilizing a ^{238}U target with a thick ^{93}Nb backing and a ^{238}U target separated from a ^{93}Nb degrader in the Cologne Compact Plunger [9], respectively.

In this contribution, we will discuss the lifetime analysis of states in the Ca and Ar isotopes beyond $N = 28$, using shell-model calculations to provide further context to these observations.

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Session Classification: Special Topics

Contribution ID: 30

Low-Energy Coulomb Excitation of Neutron Deficient $^{106,108}\text{Sn}$

Thursday, 30 July 2026 16:50 (20 minutes)

A low-energy Coulomb excitation experiment which employed $^{106,108}\text{Sn}$ radioactive ion beams was recently performed at the ReA6 facility of FRIB. The experiment utilized the SeGA-JANUS setup for coincident particle and gamma ray detection. The measurement, its motivation, and the experimental results will be presented. In particular, results on $B(E2)$ transition strengths and previously-unknown Q_s spectroscopic quadrupole moments will be shown. These results advance our understanding of shape and collectivity in an area of the nuclear chart very close to doubly-magic ^{100}Sn .

This work was performed under the auspices of the US Department of Energy by Lawrence Livermore National Laboratory under Contract No. DE-AC 52-07NA27344.

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Session Classification: Special Topics

Contribution ID: 135

Results from Commissioning Nuclear Structure Experiments at RAON and the CENS Experimental Program

Friday, 31 July 2026 09:00 (30 minutes)

The RAON accelerator facility in Korea has recently commenced operations with its low-energy superconducting linear accelerator (SCL3) and ISOL system, providing new opportunities for nuclear structure studies with both stable and RI beams. The Center for Exotic Nuclear Studies (CENS) leads a broad experimental program at RAON, focusing on nuclear shell evolution, collective excitations, and the structure of exotic nuclei. To support these scientific goals, CENS has developed a large-scale gamma-ray detection system, ASGARD, consisting of up to 16 clover-type HPGe detectors, optimized for in-beam spectroscopy experiments. Several commissioning experiments employing ASGARD were conducted at the KoBRA spectrometer at RAON in Fall 2025. In this presentation, we will report on the early results from these commissioning experiments and provide an overview of ongoing and future nuclear structure programs lead by CENS.

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Session Classification: Masses and Nuclear Structure

Contribution ID: 38

Mass measurements of neutron-rich barium isotopes for the r-process and probing the evolution of nuclear structure

Friday, 31 July 2026 09:30 (20 minutes)

High-precision mass measurements of radioactive isotopes play a key role in advancing our understanding of nuclear structure and nuclear astrophysics. Nuclear masses provide direct access to binding energies and are essential inputs for testing nuclear models and studying shell evolution far from stability 1. One area of interest is the rare-earth abundance peak around $A = 165$, which hints at a sub-shell closure or a change in nuclear structure 2.

The IGISOL (Ion Guide Isotope Separator On-Line) facility 3 in Jyväskylä provides a versatile approach to produce exotic nuclei. Reaction products from fusion, fission, or multi-nucleon transfer reactions are stopped in a gas cell, extracted, bunched and delivered to various experimental setups. The JYFLTRAP double Penning-trap mass spectrometer [4], located downstream of IGISOL, is dedicated to high-precision mass measurements. It combines a purification trap for isobaric cleaning with a precision trap where cyclotron frequencies are measured using time-of-flight ion-cyclotron-resonance [5] and phase-imaging techniques [6].

In this contribution, I present recent developments of the IGISOL facility and results of the JYFLTRAP setup at IGISOL, such as the mass measurement of neutron-rich barium isotopes with $A = 146 - 151$. Theoretical models predict strong structural changes including quadrupolar and octupolar deformation in this region [7]. The results of these measurements will be employed to investigate the effects of these deformations on the binding energies, benchmark nuclear models and constrain r-process simulations.

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Session Classification: Masses and Nuclear Structure

Contribution ID: 77

Precision Mass Measurements of $N \approx Z$ Nuclei Near the Proton Dripline around $A \approx 80$

Friday, 31 July 2026 09:50 (20 minutes)

Understanding the mechanisms that cause nuclei in the ground or excited state to stabilize at certain shapes is pivotal to explaining structured evolution, especially far from closed shells. Rich systems for shape studies are found in the neutron-deficient $A \approx 80$ region, around the $N = Z$ nuclei ^{76}Sr , ^{78}Y , ^{80}Zr , and ^{82}Nb . Evidence from spectroscopic signatures indicates that the ground states of nuclei in this region are highly deformed. As such, there are opportunities to study deformation as well as contributions from the Wigner energy and pairing along the $N = Z$ line. In this region, we used the Low Energy Beam and Ion Trap (LEBIT) Facility to measure the masses of $^{77,78,79}\text{Y}$, $^{79,80}\text{Zr}$ and ^{82}Nb to uncertainties <10 keV/c. This includes the first mass measurements of $^{77,78}\text{Y}$, ^{79}Zr , and ^{82}Nb as well as the first Penning trap measurements of $^{78m,79}\text{Y}$, which improve their precision by an order of magnitude. Additionally, the mass of ^{80}Zr deviates from the previous LEBIT value 1, resulting in a major update to the surrounding region's structure. These mass results and their implications will be presented.

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Session Classification: Masses and Nuclear Structure

Contribution ID: 158

Nuclear structure studies of neutron-rich lanthanides using precision mass spectrometry at TITAN, TRIUMF

Friday, 31 July 2026 10:10 (20 minutes)

Mass spectrometry plays an important role in different branches of physics including nuclear structure. Precise masses can help identify trends in nucleon separation energies, offering insight into shell closures and nuclear deformation. The TITAN (TRIUMF's Ion Trap for Atomic and Nuclear science) facility is dedicated to conducting high-precision and fast mass measurements by utilizing a state-of-the-art Multi-Reflection Time-of-flight Mass Spectrometer (MR-TOF-MS), and a Penning trap. In recent experimental campaigns, masses of several neutron-rich nuclides have been measured using the MR-TOF-MS, including that of many previously-unmeasured isotopes of lanthanides Eu, Tm and Yb. The measured masses were used to investigate nuclear structure effects in the rare-earth region, mainly in the hole-hole quadrant below the doubly magic ^{208}Pb , such as subshell closures around $N \sim 104$, strong proton-neutron interaction in ^{186}Hf and the potential onset of a prolate-to-oblate shape transition around $N \sim 116$, opening the door to investigating the effects of the strong force in a previously inaccessible region. These recent results along with an outlook of planned measurements in the region will be presented in this contribution.

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Presenter: RAY, Dwaipayan**Session Classification:** Masses and Nuclear Structure

Contribution ID: 92

New frontiers in collinear laser spectroscopy at COLLAPS: Shell structure in exotic Ca isotopes

Friday, 31 July 2026 11:00 (30 minutes)

Collinear laser spectroscopy provides high-precision access to nuclear spins, electromagnetic moments, and changes in mean-square charge radii of atomic nuclei. In this contribution, I will present an overview of recent progress at COLLAPS during CERN Run 3, with emphasis on spectroscopy of the neutron-rich calcium isotopes $^{53,54}\text{Ca}$ and on major instrumental developments aimed at pushing the sensitivity frontier. Measurements on $^{53,54}\text{Ca}$ address the debated emergence of a shell closure at $N=32$, reaching production yields down to a few ions per second. I will also discuss the new LIAF setup, which opens new opportunities for charge-radius measurements in light nuclei such as fluorine and oxygen through improved background suppression and novel detection concepts. Together, these developments establish the basis for future studies of very exotic species at radioactive facilities.

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Session Classification: Nuclear Structure from Atomic Structure

Contribution ID: 94

Charge Radii and Magnetic Moments of Neutron-Rich Silicon Isotopes

Friday, 31 July 2026 11:30 (20 minutes)

This contribution will present the first laser spectroscopy measurements of neutron-rich silicon isotopes from stable ^{28}Si up to ^{38}Si , performed using the Resonance Ionization Spectroscopy Experiment (RISE) at the BEam COoling LAser spectroscopy (BECOLA) facility, located at the Facility for Rare Isotope Beams (FRIB). From the measured isotope shifts and hyperfine structure, we extracted the nuclear magnetic dipole moments of odd- N silicon isotopes and differential mean-square nuclear charge radii of $^{28-36,38}\text{Si}$.

The silicon isotopic chain, having a proton sub-shell closure at $Z=14$, serves as an important probe of nuclear structure [1,2], especially in the vicinity of the suggested doubly magic ^{34}Si at $N=20$, for which recent studies suggest the presence of a central depletion or bubble-like structure in ^{34}Si [3-7]. These results provide a comprehensive study of the evolution of nuclear shell structure and collectivity across $N=20$, offering an important guide for the development of nuclear theory.

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Session Classification: Nuclear Structure from Atomic Structure

Contribution ID: 65

Laser-radio-frequency double-resonance spectroscopy of ^{209}Bi for the extraction of its nuclear magnetic octupole moment

Friday, 31 July 2026 11:50 (20 minutes)

Nuclear electromagnetic moments provide sensitive probes of the distribution of charge and magnetization inside the nucleus, yet higher-order moments remain largely unexplored. Current high-resolution laser spectroscopy techniques allow to achieve precisions of the order of 1 MHz ¹, giving access to magnetic dipole and electric quadrupole moments. However, as the multipole order increases, the magnitude of the shift in the atomic energy levels decreases rapidly, from ~ GHz for the dipole to hundreds of MHz for the quadrupole and only hundreds of kHz for the octupole, with even smaller shifts expected for higher orders, leaving the octupole and beyond out of reach of standard spectroscopic techniques. The magnetic octupole moment is nevertheless of particular interest, as it offers a rare window on subtle aspects of the nuclear magnetization distribution and thus provides a stringent test for nuclear-structure models.

In this work, we target the magnetic octupole moment of stable ^{209}Bi through a precision measurement of the hyperfine structure of its atomic ground state $^4S_{3/2}$. With one valence proton outside the doubly magic ^{208}Pb core, ^{209}Bi is a benchmark near-single-particle system in which experimental results can be confronted directly with modern nuclear-structure calculations.

To enable this measurement, we have developed at KU Leuven an atomic beam apparatus for laser-radio-frequency double-resonance spectroscopy ². Beyond the specific case of ^{209}Bi , this effort is motivated by the longer-term goal of extending the method to radioactive isotopes, where precision measurements of higher-order moments could provide new structural information far from stability. The setup and analysis procedure were first developed and validated using potassium, allowing the dominant sources of systematic uncertainty to be identified and controlled before moving to bismuth.

We will present the performance of the apparatus, results from the potassium commissioning measurements, and highest-precision hyperfine-structure data to date on ^{209}Bi . Combined with state-of-the-art atomic structure calculations, these measurements will enable the extraction of a precise magnetic octupole moment for ^{209}Bi and provide a new benchmark for the description of magnetization properties in heavy nuclei.

¹ P. Campbell, I.D. Moore, and M.R. Pearson, 'Laser spectroscopy for nuclear structure physics', Progress in Particle and Nuclear Physics, vol. 86, pp. 127-180, 2016.

² W.J. Childs, 'Overview of laser-radiofrequency double-resonance studies of atomic, molecular, and ionic beams', Physics Reports, vol. 211.3, pp. 113-165, 1992.

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Collinear Laser Spectroscopy far from stability: Mg and Cd

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In recent years, significant progress in nuclear structure theory has been driven by the availability of precise experimental data on short-lived nuclei with neutron-to-proton ratios far from those at the valley of stability in the nuclear chart. Collinear Laser Spectroscopy (CLS) is a powerful technique for obtaining nuclear ground-state properties such as spins, electromagnetic moments, and charge radii.

To access exotic radionuclides with very low production yields, the Multi Ion Reflection Apparatus for Collinear Laser Spectroscopy (MIRACLS) was conceived to enhance the sensitivity of fluorescence-based CLS. It is based on a unique high-energy (>10 keV) multi-reflection time-of-flight (MR-ToF) device, which utilizes two electrostatic mirrors to reflect ions back and forth for several thousands of revolutions. Hence, at MIRACLS, ion bunches are probed by the spectroscopy laser many times per measurement cycle to obtain higher measurement statistics compared to conventional, single-passage CLS. The resulting improvement in sensitivity allows the probing of isotopes with yields as low as 5 ions per second. In this way, radionuclides that would have been impossible to probe with conventional CLS techniques due to their low production yield and short half-lives now become accessible with the MIRACLS approach.

With MIRACLS, previous measurements have recently been extended to uncharted magnesium ($^{33,34}\text{Mg}$) and cadmium ($^{98,99}\text{Cd}$) isotopes. The determination of charge radii of neutron-rich Mg isotopes allows us to probe the structure of nuclei in the $N = 20$ island of inversion, an area of the nuclear chart where conventional shell closures disappear. Previously measured magnesium isotopes show a steady increase in charge radii up to ^{32}Mg 1, with no indication of the shell closure, and our latest results on $^{33,34}\text{Mg}$ will provide valuable insight into the trend beyond $N = 20$, acting as a stringent benchmark for new ab initio calculations motivated by our measurements.

In this oral contribution, the MIRACLS technique will be introduced and results from recent laser spectroscopy experiments on the aforementioned magnesium and cadmium isotopes will be presented.

References

1 D. T. Yordanov et al., PRL, 108:042504 (2012)

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