Solenoidal Spectrometer Workshop 2025

Tuesday, 9 December 2025 - Friday, 12 December 2025

IGFAE

Book of Abstracts

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Welcome

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Day 2 - Session 02 / 11

Track fitting in low-energy active target TPCs

Author: Adam Anthony[1]

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Accurate reconstruction of charged-particle tracks in active-target time projection chambers (AT-TPCs) is essential for extracting reaction kinematics. A common approach in high energy physics is the use of a Kalman Filter (KF); however, KFs developed for high energy experiments (e.g., GENFIT) typically treat the energy loss of particles as a Gaussian process noise term in the propagator. This assumption can break down at low energies. A new Unscented Kalman Filter (UKF) has been developed that explicitly incorporates both deterministic average energy loss and stochastic energy straggling into the particle propagator. In the UKF framework, different energy loss models can be easily incorporated allowing for the exploration of the effect of energy loss models on reconstructed kinematics. In contrast, when no magnetic field is present, such as in a 2020 fusion-fission experiment, one must rely on event geometry and energy loss information from recorded traces for this same task. For this case, a new Monte-Carlo based fitting method was developed, independent of the UKF framework. The MC method can determine the element number (Z) of fission fragments along with other observables such as the beam energy at the vertex point and, by extension, the excitation energy of the fissioning nucleus. The MC method can handle complex detector effects such as missing channels in the pad plane and electric field distortions due to space-charge buildup. We present validation of both techniques against simulated data using ATTPCROOT and show preliminary reconstructed Z distributions for 204At using the MC method.

Day 1 - Session 03 / 97

Commissioning the Solenoid Spectrometer for Nuclear Astrophysics and Decays

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The Solenoid Spectrometer for Nuclear Astrophysics and Decays (SSNAPD) is a new silicon-array solenoidal spectrometer system in development at the University of Notre Dame's Nuclear Science Lab (NSL). Using single nucleon transfer and charge exchange reactions in forward kinematics as a production mechanism, SSNAPD will provide sensitive measurements of charged particle partial widths for excited states in near-stability nuclei that exert significant influence on nucleosynthetic pathways in astrophysical explosions. The robust magnetic separation capabilities and high backwards-angle efficiencies of the solenoid spectrometer concept make measurements of the charged particle branching ratio, from which the partial width is determined, nearly background-free and

provides a significant improvement in sensitivity to the smallest partial widths that traditional techniques cannot probe. In this talk I will discuss the progress made in the commissioning of SSNAPD, and its integration into the NSL's TriSol facility, with a particular focus on recent off- and on-line experiments that have been performed to verify and optimize the capabilities of various components of the system. Plans for finalizing commissioning, transitioning into scientific measurements, and the future of SSNAPD at the NSL will also be reviewed.

Day 3 - Session 02 / 98

LHCb VELO upgrade phase II: a 4D silicon vertexing detector

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LHCb plans an Upgrade II detector for 2034 to operate at luminosities of 1.5x1034cm−2s−1, accumulating over 300 fb−1. This will result in about 42 interactions per crossing, producing approximately 2000 charged particles within acceptance. The higher luminosity requires a new VErtex LOcator (VELO) with enhanced capabilities to handle increased data rates, radiation levels, and occupancies. New techniques are needed to assign b hadrons to their primary vertices and perform real-time pattern recognition, involving a new 4D hybrid pixel detector with advanced rate and timing capabilities. Prototype front-end ASICs are under design in 28 nm technology, including large processing power and rapid analog response, which requires fast rise times and high power consumption, yet limited by vacuum operation and cooling constraints. The ASIC must handle extreme hit rates and added timing information. The sensor must provide time measurements with 35 ps resolution and resist to $2.5\text{x}10^{16}$ 1 MeV neq cm−2, while keeping the and spatial resolution below 9 µm. The mechanical design will minimize material and achieve an integrated module with thinned sensors and ASICs combined with lightweight cooling. This presentation will review the technologies for the HL-LHC upgrade, with a particular focus on achieving precision timing for vertexing in next-generation detectors. Special emphasis will be placed on the technological R&D in data acquisition and processing, which extends beyond the LHCb collaboration and is essential for handling data volumes generated by the VELO.

Day 3 - Session 02 / 99

Solenoidal Spectrometers: Progress and Possibilities

Author: Benjamin Kay[1]

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The solenoidal-spectrometer technique was developed at Argonne over 15 years ago and realized in the form of HELIOS; successful programs have since been established at ISOLDE with the ISS and at FRIB with SOLARIS. I will highlight a few recent developments and results, as well as possible future directions for this technique. An overarching output of the solenoidal-spectrometer programs at Argonne, CERN, and FRIB has been the determination of single-particle energies in weakly bound nuclei across the chart of nuclides, revealing an emerging picture of how structure evolves towards the particle threshold. 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

Day 1 - Session 02 / 100

Search for Rotational Bands at High Excitations in 8Be using the ISOLDE Solenoidal Spectrometer

Author: Moshe Gai[1]

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The d(7Be, p)8Be* reaction was measured using 5x10ˆ6 p/s, 11 MeV/u, 7Be beam extracted from the HIE-ISOLDE. The ISOLDE Solenoidal Spectrometer (ISS) was used to detect the backward angle emitted protons from high lying states in 8Be. A rich rotational band structure is predicted above 16 MeV in 8Be, by an extension to conjectured particle-hole states of the Cluster Shell Model (CSM) of Della Rocca, Bijker and Iachello. We will review the CSM as well as preliminary analyses and extracted proton excitation spectra of 8Be.

Day 3 - Session 01 / 101

Low-lying spectroscopy of 20O and 19O with ACTAR TPC

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Neutron-rich oxygen isotopes provide a unique probe to test state-of-the-art shell-model interactions such as SFO-tls [1] and YSOX [2]. In particular, 19O and 20O isotopes can be further employed to constrain shell evolution near the drip-lines, a crucial step towards a universal interaction. In this regard, single-nucleon transfer reactions are suitable tools to study the single-particle nature of the populated states, enabling the extraction of valuable model inputs, such as spectroscopic factors and excitation energies. To this end, neutron pick-up reactions 20O(p, d) and 20O(d, t) were performed at a beam energy of 35 AMeV at GANIL. The experimental setup featured the active target ACTAR TPC [3, 4], serving both as a thick gaseous target and as a detection medium for particle tracking, resulting in an overall enhancement of the experimental resolution compared to a conventional thick-target experiment. Additional silicon detectors surrounding the active volume measured the residual energy of the light reaction products, enabling unambiguous particle identification (PID) [5]. This talk will present preliminary results on the low-lying spectroscopy of 19O, along with a comparison to theoretical shell-model calculations and an analysis of the N = 8 shell gap behaviour. Additionally, the inelastic scattering 20O(d, d′) data have been analyzed, and early results on the inelastic excitations will also be discussed.

Day 2 - Session 01 / 102

Unraveling the Structure of Be and the Disappearance of the N=8 Magic Number

Author: Jie Chen[1]

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Be isotopes provide a great testing ground for investigating the novel effects incorporated in modern theories. Understanding the low-lying states of 12Be is crucial for explaining the disappearance of the N=8 magic number in the nearby region. We conducted a series of measurements for the 12Be nucleus, including the one-neutron adding 11Be(d,p)12Be, one-neutron removal 12Be(p, d) and 12Be(p, p') inelastic scattering reactions using either the ISS or the AT-TPC coupling to HELIOS.

The high-resolution and high-statistics data enabled us to overcome previous experimental ambiguities. Our findings suggest that a combination of core deformation, weak-binding effects and cluster structure is responsible for the exotic phenomena observed in Be isotopes.

Day 2 - Session 03 / 103

Improved Method for Excitation Energy and Angle Reconstruction for Solenoidal Spectrometer

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We present a new calibration and reconstruction method for solenoidal spectrometers like HELIOS. By calibrating detector response with known states and applying an analytical inverse transformation based on relativistic kinematics, the method directly extracts excitation energies and scattering angles from measured data. This approach overcomes limitations of traditional projection methods at forward angles and enables real-time, accurate spectra and angular distributions. Its effectiveness is demonstrated with the 25Mg(d,p) reaction, showing improved precision and efficiency for nuclear reaction studies.

Day 4 - Session 01 / 104

Fast and common data acquisition system in Japan and its applicability to the solenoidal spectrometers

Author: Shinsuke Ota[1]

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A worldwide and common issue in the data acquisition and processing is an increase in the data flow and data amount, although the human and budgetary resources are quite limited. In Japan, to overcome this situation, we are organizing the development platform SPADI Alliance, where more than 170 researchers and students are registered. The first package was released this year, and it has reached a throughput of 10 Gbps in total, thanks to the combination of the streaming readout front-end circuit AMANEQ TDCs and the streaming readout software NestDAQ. Some online filters in NestDAQ are also developed for the reduction of the data amount. Corrected data is monitored by the data analysis and monitoring software ARTEMIS. The data acquisition system is implemented in RCNP, J-PARC, RARiS and some small test experiments. Some other front-end electronics are under development: RAYRAW for the MPPC readout, SAMIDARE for the TPC readout, MIRA for the semiconductor readout, and the STAG for the gas chamber readout. In this paper, the details and an implementation of the system are introduced and its applicability to the solenoidal spectrometer will be discussed.

Day 1 - Session 02 / 105

Transfer-induced fission at the ISOLDE Solenoidal Spectrometer

Author: Maria Vittoria Managlia[1]

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The study of nuclear fission remains a critical area of research, not only for understanding fundamental nuclear properties but also for its implications in the production of heavy elements in astrophysical environments. In r-process nucleosynthesis, fission plays a crucial role as it ultimately limits the mass of nuclei that can be produced. Currently, very limited data on fission barriers of neutron-rich nuclei are available. Moreover, studying fission barriers is essential for investigating the influence of nuclear structure on fission dynamics. The ISOLDE Solenoidal Spectrometer (ISS) offers a new approach to investigate fission probabilities of neutron-rich actinides via (d,pF) reactions using Radioactive Ion Beams. This approach utilises a novel setup designed to enhance the detection efficiency for fission fragments in coincidence with transfer-like protons in a solenoidal field. This optimised method provides access to the fission probability as a function of the excitation energy. Additionally, complementary γ-ray measurements offer insight into the total energy and multiplicity of γ-rays emitted during the fission process. In this context, the measurement of the fission barrier of 233U has been performed, as a first step to establish this new approach. This data might be also relevant for the thorium fuel cycle. In this contribution, the experimental setup will be presented, and preliminary results of the experiment will be discussed, highlighting its potential for advancing our understanding of nuclear fission. Beyond this study, this method has the potential to be extended to investigate even more exotic nuclei farther from the valley of stability, opening new opportunities to explore fission in regions of the nuclear chart that have so far remained experimentally inaccessible.

Day 1 - Session 03 / 106

Spin-State Teleportation at MeV Energies via Entanglement Generation and Manipulation Between Protons

Author: Dong Bai[None]

Quantum teleportation enables the transfer of an unknown quantum state between distant qubits via entanglement. While it has been demonstrated in systems such as photons and superconducting circuits, it remains largely unexplored in nuclear physics at MeV energies. We propose new teleportation protocols based on Bell-state projection and transition operators that are naturally realized in low- and intermediate-energy proton–proton scattering. When two protons are in a spin-singlet state with low or intermediate center-of-mass energy, an appropriately chosen elastic scattering between one of them and a third, state-carrying proton projects their spin state onto a Bell state, thereby achieving spin-state teleportation. Our work establishes a foundation for spin teleportation in nuclear reactions and opens a pathway for quantum information applications in MeV-scale hadronic systems.

Day 4 - Session 02 / 107

Study of the full electric dipole strength of the double halo nucleus 11Li using proton inelastic scattering

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Over the years there have been many efforts put in trying to understand the electric dipole (E1) strength of atomic nuclei. It is known that the nuclear E1 response is mostly dominated by the IsoVector electric Giant Dipole Resonance (IVGDR), which can be understood as a collective harmonic motion of protons against neutrons. In neutron-rich nuclei, part of the E1 strength is redistributed around the neutron separation energy, producing a concentration of low-energy dipole excitations known as a Pygmy Dipole Resonance (PDR), which instead consists in an oscillation of a neutron skin against an isospin-symmetric core. The closer we are to the neutron drip-line, the more complex the PDR becomes, heavily affecting its properties. This study focuses on the double neutron halo nucleus 11Li. The PDR in 11Li is significantly different from a regular PDR due to the very low neutron separation energy of 11Li, which produces a large imbalance of neutrons in the neutron skin with pairing energy playing an important role in it. Although the PDR for 11Li was initially observed, this observation only accounts for a small part of the total E1 response in 11Li. Recent theoretical studies have predicted the presence of an IVGDR in 11Li that was not observed before, which accounts for most of its E1 strength. In order to experimentally study the complete E1 strength of 11Li, an inelastic scattering experiment in inverse kinematics was performed at the Facility for Rare Isotope Beams (FRIB) in July 2024. A 53.4 MeV/u 11Li beam was sent into the Active Target Time Projection Chamber (AT-TPC), which acted as the proton active target as well as the tracking detector for the scattered protons from the reaction. Additionally, the S800 spectrometer was used at the end of the beam line in order to study the decay products of the excited 11Li. Although the PDR in 11Li was already observed previously, the results from this experiment provide a preliminary measurement of an IVGDR in 11Li, which to our knowledge is a first for double halo nuclei. These results are of importance to fully understand the E1 response of 11Li and may provide useful insight into the E1 properties of halo nuclei in general.

Day 1 - Session 01 / 108

Study of alpha-cluster structures in 14C with the AT-TPC

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Well-bound spherical nuclei can be considered as closed quantum systems that can be described by state-of-the-art versions of the shell model, where nucleons occupy well-localized single-particle states. However, when we move towards the drip line or inject enough excitation energy into the system, the coupling to the continuum and reaction channels becomes more important, forcing the nucleus to behave like a many-body open quantum system. This complex interplay between reaction and structure leads to intriguing phenomena, where weakly bound or unbound systems exhibit features such as halos, particle emission near decay thresholds, and alpha clustering. Inferring the relevant observables to investigate such phenomena requires the use of efficient detection systems for experiments in inverse kinematics. Solenoidal spectrometers are precisely engineered to effectively analyze various reactions resulting in the formation of clustered states. SOLARIS, a next-generation solenoidal spectrometer, offers versatile functionality with its two distinct modes of operation: Si-array and Active Target mode. In this talk, we will discuss the cluster structure of 14C, as explored through an experiment conducted using SOLARIS in Active Target mode with the Active Target Time Projection Chamber (AT-TPC). Some of the states within the two rotational bands (π-bond and σ-bond) of the linear-chain cluster state (LCCS) remain unresolved. We have used resonant scattering of 10Be + 4He as the reaction to explore this nucleus. We present the cross sections, the angular distributions and the spin-parity of several 14C resonances, including states belonging to the rotational bands.

Day 1 - Session 03 / 110

Probing pairing correlations in nuclei with (t,p) reactions

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The existence of a superconducting phase associated with the breaking of particle number conservation was first identified in metals in the context of the BCS theory. It was realized very soon that the underlying mechanism, connected with pairing correlations at work in the formation of Cooper pairs, bore great generality and was expected to be relevant for a large variety of fermionic systems. More specifically, its importance in nuclear structure was recognized just a few months after the seminal papers of Bardeen, Cooper, and Schrieffer. Since that moment, the study of nuclear pairing has attracted much theoretical and experimental interest. Within this context, 2-neutron transfer reactions have been the experimental method of choice for the quantitative probe of pairing correlations in nuclei. We want to address in this talk our theoretical understanding of 2-neutron transfer reactions, with a special emphasis on new perspectives associated with the current availability of high-intensity exotic beams.

Day 4 - Session 01 / 111

Probing Near-Threshold Narrow Resonances in ^{11}B Using the HELIOS Spectrometer

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The unusually large branching ratio observed in the β-delayed proton emission of ^{11}Be has been attributed to the existence of a narrow, near-threshold proton-emitting resonance in ^{11}B. However, direct measurements of this process have generated significant debate concerning the properties of this resonance and the unexpectedly high β-decay feeding. Multiple subsequent experiments have reported evidence for this elusive state, and while both theoretical and experimental studies broadly agree on its existence, its underlying nature remains unclear. A key difficulty arises from the complex structure of ^{11}B and its coupling to the continuum, involving four particle-emission thresholds within approximately 2 MeV of excitation energy. The characteristics of states near these thresholds—critical for understanding the nuclear structure of ^{11}B—are either poorly known or insufficiently constrained. To address these challenges, we performed an experiment to investigate the high-lying structure of ^{11}B via the ^{10}B(d,p) reaction in inverse kinematics using the HELIOS spectrometer. Detection of protons in coincidence with heavy recoils enabled precise determination of low-probability branching ratios and state widths near the particle-emission thresholds. The high-quality recoil identification achieved in this measurement allowed us to observe the long-debated near-proton-threshold resonance at 11.4 MeV, providing new insight into its structure and decay properties. This research was supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357. It utilized resources from the Argonne National Laboratory ATLAS facility and the Facility for Rare Isotope Beams (FRIB), both DOE Office of Science User Facilities. Additional support was provided by the Xunta de Galicia (CIGUS Network of Research Centers) and the Spanish Ministerio de Economía y Competitividad through the "Ramón y Cajal"program.

Day 2 - Session 01 / 112

Transfer Reactions with 16C as a Probe of Neutron-Rich Carbon Structure

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Carbon isotopes provide a rich testing ground for the evolution of shell structure and halo phenomena in light neutron-rich nuclei. In particular, 15C is a well-known one-neutron halo candidate, with the valence neutron weakly bound (Sn ≈ 1.2 MeV) in a 2s1/2 orbital. Its first excited state at 0.74 MeV has a dominant single-particle configuration with a neutron in the 1d5/2 orbital and a half-life of 2.61 ns. The transition between these states is expected to involve weak core polarization due to the inert 14C core, which may be further reduced by the spatial decoupling of the halo neutron. Understanding how the halo in 15C impacts core polarization is directly relevant for constraining the quadrupole moments of 16C. To address these questions, we studied the one-neutron transfer 16C(p, d)15C and the two-neutron transfer 16C(p, t)14C. These complementary reactions provide sensitivity to single-particle and pairing correlations in neutron-rich carbon isotopes and serve as benchmarks for theoretical models of transfer reactions with exotic beams. The experiment was performed in 2023 at the Argonne Tandem Linac Accelerator System (ATLAS) using the Active Target Time Projection Chamber (AT-TPC) and HELIOS solenoidal spectrometer. A primary 18O beam with an energy of 222.72±0.43 MeV was degraded to produce a 16C secondary beam, which was subsequently used to study these transfer channels. This work has received financial support from the Xunta de Galicia (CIGUS Network of Research Centres) and the European Union.

Day 2 - Session 02 / 113

Development of novel PID detector concepts for nuclear physics with rare isotope beams at FRIB

Author: Marco Cortesi[1]

[1] *Facility for Rare Isotope Beams*

Since their introduction in the 1930s, particle accelerator science has led to major discoveries and advancements in high-energy physics, nuclear physics, and other fields. In this context, Rare Isotope (RI) beam facilities represent a crucial resource for modern nuclear physics. The Facility for Rare Isotope Beams (FRIB), located on the campus of Michigan State University, is one of the world-leading user facilities for the study of RIs, produced by the in-flight fragmentation method. The unprecedented potential discovery of a modern rare isotope beam facility, such as FRIB, can only be realized by implementing state-of-the-art experimental equipment capable of studying these isotopes at a high beam rate and high performance. In this talk, I report on the development of a few innovative detector concepts for tracking and particle identification (PID) of heavy ions for applications in modern spectrographs. I will describe the development of new micro-pattern gaseous detector (MPGD) structures capable of stable, high-gain operation at low pressure, applied as either a position-sensitive readout for Time-Projection-Chamber in active-target mode (AT-TPC), or for drift chambers at the focal plane of a large-acceptance spectrometer. In addition, I will present progress on the design and construction of advanced, innovative instrumentation for highly accurate and efficient identification of the atomic number (Z) of nuclei transmitted to the focal plane of high-resolution spectrographs. This includes a novel detector concept based on event-by-event energy-loss measurement in a multi-segmented optical scintillator system (ELOSS), by recording the scintillation light released by a charged particle along its track. We discuss the optimization of the optical readout configuration based on DUV-sensitive Photo-Multiplier Tubes (PMTs), the expected performance of the novel detector concept, and the overall impact on radiation detection physics and technology applied to experimental nuclear physics with rare-isotope beams. Acknowledgment: This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics and user resources of the Facility for Rare Isotope Beams (FRIB) Operations, which is a DOE Office of Science User Facility under Award Number DE-SC0023633.

Day 2 - Session 03 / 114

Reaction studies with the Active Target Time Projection Chamber

Author: Daniel Bazin[1]

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The Active Target Time Projection Chamber (AT-TPC) has been used in experiments aimed at the exploration of structural effects in radioactive nuclei using various reactions such as transfer or elastic and inelastic scattering. When used as a solenoidal spectrometer by placing it inside a magnetic field, the AT-TPC allows performing this type of measurement in inverse kinematics with much reduced beam intensities, down to 100 particles per second, while preserving a good resolution and a wide range of angular coverage. This presentation will showcase the performance of this detector, based on results obtained on nuclei in the beryllium to carbon region using pure proton, deuterium and alpha targets. This research used resources of Argonne National Laboratory's ATLAS facility, which is a DOE Office of Science User Facility under Contract No. DE-AC02-06CH11357, and the Facility for Rare Isotope Beams (FRIB), which is a DOE Office of Science User Facility under Award Number DE-SC0023633.

Day 1 - Session 01 / 115

What can we learn from transfer, and how is best to do it? The good, the bad and the ugly

Author: Juan Lois-Fuentes[1]

[1] *IGFAE - USC*

This talk will explore how single-nucleon transfer reactions are carried out with radioactive beams in inverse kinematics, focusing primarily on experimental aspects. The scientific motivation and theoretical tools used to interpret these reactions will be briefly outlined, but the main emphasis is on the techniques employed and the observables that can be extracted. Particular attention will be given to reaction characteristics that influence experimental design. Several experimental strategies will be discussed, including configurations based on silicon-stripped detectors, time-projection chambers (TPCs), and solenoidal spectrometers. For each approach, the reasoning behind the setup will be examined in terms of feasibility, resolution, and physics reach. Recent transfer-reaction results with light nuclei will be presented to illustrate the capabilities of these methods, focusing on their strong points, fundamental limitations, and where subtle experimental details can complicate the interpretation and analysis of the data.

Day 3 - Session 01 / 117

Spectroscopy of neutron-rich Li isotopes with ACTAR TPC

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Neutron-rich lithium nuclei are ideal systems for studying the interplay between many-body correlations and the properties of the particle continuum. For example, ^{11}Li and ^{12}Li have a large neutron-to-proton imbalance and a very low neutron-separation energy, and their structure is expected to be influenced by coupling to the continuum. Only a few theoretical models implement the continuum, as the Gamow Shell Model. The structure study of ^{12}Li was measured through a one-neutron transfer reaction using an active target ACTAR-TPC, serving both as a thick gaseous target and as a detection medium for particle tracking, resulting in an overall enhancement of the experimental resolution compared to a conventional thick-target experiment. The goal of the experiment is to measure the location of the first p- and d-wave resonances and to deduce the nature of the low-energy states in ^{12}Li. The measured states will provide crucial information on the relative positions of the 0p1/2, 0d5/2, and 1s1/2 orbitals at N=9, as well as an important test of three-nucleon forces. This was the first experiment to measure the particles stopped inside the active volume of the detector with ACTAR-TPC. This talk will present preliminary results on the spectroscopy of ^{8}Li, a stable beam that was available during a maintenance in the experiment. This will work as a benchmark for the future analysis on the ^{11}Li beam.

Day 4 - Session 01 / 118

2 Neutron transfer reactions: present and future

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We present results of the experiment performed to measure the 10Be(t,p)12Be reaction with SOLARIS and results for the experiment performed to measure the 14C, in particular, the inelastic and (p,t) reaction channels with AT-TPC. These two solenoidal spectrometers present both great capabilities and benefits for direct-reaction measurements, but there is room for improvement. We propose simulations to study improvements with AT-TPC that will allow the use of new targets, such as tritium, better granularity read-out to obtain greater resolution or higher magnetic fields. To validate simulations, we analyze the same reactions under the new conditions.

Day 1 - Session 04 / 119

Getting the Most from Your Solenoidal Spectrometer: Advanced Targetry

Author: Kelly Chipps[1]

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In any measurement, three components contribute to the quality of the final result: the detector system, the beam, and the target. In the case of Solenoidal Spectrometers, which improve the experimental resolution of an inverse kinematics measurement by effectively countering kinematic compression, the other components—beam and target—play a critical role. In-flight beams reduce the achievable resolution through the introduction of uncertainties in the reaction location; cocktail beams introduce uncertainty in the form of background reactions. Similarly, the choice of target can make or break a measurement. Thick targets, targets with stoichiometric contaminants, or targets with windows or backing materials, can all negatively impact the experimental resolution. In this talk, I will discuss advanced targetry techniques, such as frozen or gas jet targets, and their use in reaction measurements with Solenoidal Spectrometers.

Day 2 - Session 03 / 120

Status of FRIB DAQ Systems and Future Directions

Author: Jin-Hee Chang[1]

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Since the beginning of the FRIB scientific experimental program, upgrades of the existing devices (S800, Sweeper) and new projects (HRS) have directed the adoption of new solutions for DAQ to be able to sustain high data rates, minimize dead times, and possibly be the standard for the next decade. This presentation covers some of the projects that have been developed and deployed and highlights of what is to come.

Day 2 - Session 01 / 121

Super-radiance and two-neutron transfer reactions

Author: Augusto Macchiavelli[None]

Day 3 - Session 01 / 122

Multi-Purpose Machine Learning Models for TPCs

Author: Michelle Kuchera[1]

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This work centers on providing a multi-purpose deep learning model for time projection chamber detector systems that can be tuned for various tasks such as event identification, particle or track identification, and regression tasks. Foundation models such as the GPT models, BERT, and DALL-E have shown impressive performance in text and image domains. Such models are built through large-scale training on self-supervised tasks. In this talk, I will summarize results from various approaches to build a foundation model for TPCs. To build our initial models, we used data from the Active-Target Time Projection Chamber (AT-TPC) and the GADGET II detector, both at the Facility for Rare Isotope Beams at Michigan State University.

We tuned these models on a suite of downstream tasks such as of counting the number of reaction products for events in the ^{22}Mg $+\alpha$ experiment, also using the AT-TPC at FRIB. For this task, we show that we can achieve an F1 score of .91 with only 250 labeled training events using our pretrained model, compared to an F1 score of .45 using 250 labeled training events for a model trained from randomly initialized weights. Similarly, we find that more than 2000 labeled events are needed to surpass an F1 score of .9 when training a model from scratch. We discuss current efforts in incorporating more data into our pretrained model and our efforts that build towards our future plans of incorporating data from other TPCs.

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Day 4 - Session 02 / 123

Closing

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Day 2 - Session 04 / 124

Design and Optimization of a Nested and Tilted Superconducting Solenoid with Multifunction Quadrupole/Dipole for the ISOLDE Superconducting Recoil Separator

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The CERN HIE-ISOLDE facility accelerates a unique worldwide variety of radioactive ions up to collision energies close to 10 MeV/A. The physics program encompasses a broad range of nuclear structure studies, from shell evolution to nuclear astrophysics. To fully profit from the new facility, our collaboration has proposed the construction of the "Superconducting Recoil Separator"ISRS will extend the HIE-ISOLDE physics program by in-beam and focal-plane particle-gamma correlation studies. The design of ISRS is based on an array of superconducting multifunction magnets (Canted Cosine Theta, CCT), integrated into a compact FFAG particle storage ring. A/Q analysis of reaction fragments is achieved by combining cyclotron frequency and RF extraction with ToF and PID at the focal plane

One of the key elements of the ISRS spectrometer is the prototype of the magnet "MAGDEM"(MAGnet DEMonstrator), the basic building block of the ISRS particle storage ring. MAGDEM
is an extremely compact, helium-free Nb-Ti CCT superconducting magnet cooled by a single GM cryocooler that incorporates the nested quadrupole and dipole functions. The cryostat features a 200 mm clear aperture for the circulation of the heavy ion fragments, and it is only ~600 mm long. The innovative design incorporates a dipole coil (2.3 T) inside a quadrupole coil (10 T/m), providing the 36-degree bend needed for ion analysis/storage in the ISRS ring

In the talk, I'll review the design and characteristics of the ISRS ring, the ion optics, and the expected performance of the ring.

Day 1 - Session 04 / 125

Reactions with radioactive ion beams at the ISOLDE Solenoidal Spectrometer

Author: Liam Gaffney[1]

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The ISOLDE Solenoidal Spectrometer (ISS) at CERN was commissioned fully in 2021, following the second long shutdown at CERN, to take advantage of the exotic beams delivered from the HIE-ISOLDE facility at energies up to 10 MeV/u. It is designed to study direct reactions based on the solenoidal spectrometer concept developed in the HELIOS spectrometer at Argonne National Laboratory [1,2]. The on-axis position-sensitive silicon array at the heart of the spectrometer was constructed at the University of Liverpool and uses 24 DSSSD wafers arranged into a hexagonal structure. The readout of 1800 individual detector channels is performed with the use of on-board ASICs. It is coupled to a series of ancillary systems for recoil detection, beam diagnostics and monitoring.

This talk will present a technical overview of the setup followed by a selection of physics experiments from the past 4 successful years as we enter the third long shutdown at CERN and a hiatus from radioactive beams. New developments, such as those to study fission, are also being presented elsewhere in this workshop. Finally, I will summarise future ideas under consideration for the return of ISS in 2028 and welcome further discussion for new possibilities.

[1] A. H. Wuosmaa et al. Nucl. Instrum. Methods Phys. Res., Sect. A 580, 1290 (2007).
[2] J. C. Lighthall et al. Nucl. Instrum. Methods Phys. Res., Sect. A 622, 97 (2010).

Day 2 - Session 04 / 126

HYPER: when antimatter meets strangeness

Author: Alexandre Obertelli[None]

Observable hadronic matter is mostly composed of u, d quarks. The strangeness degree of freedom is expected to play an important role in dense nuclear matter in the form of hyperons, baryons with at least one valence strange quark. Hyperons can form bound nuclear systems with nucleons and create short-lived hypernuclei which decay on the time-scale of the weak interaction (typically 200 ps). Our knowledge of nuclear matter is so far restricted to precision nucleon scattering and nuclear data while a generalisation to other quark flavours lacks precision data.

HYPER is a new project pioneering a new production mechanism of hypernuclei from antimatter. HYPER will explore the strange nuclear landscape of single-lambda hypernuclei with unprecedented capabilities.

The measured precision ground-state properties and spectroscopy of single-lambda hypernuclei along isotopic chains, from neutron deficient to neutron rich, will give access to the isospin properties of the many-body interactions involving lambda hyperons, and thus to the role of strangeness in the nuclear equation of state and in neutron stars.

The core of HYPER is the development of a new multi-purpose detector inside a 4T solenoid with high sensitivity, energy and timing resolutions to be used at the Antimatter Factory of CERN.

Day 4 - Session 02 / 127

PUMA: Probing the Surface of Atomic Nuclei with Low-Energy Antiprotons

Author: Rico Holz[1]

[1] *TU Darmstadt*

The antiProton Unstable Matter Annihilation (PUMA) experiment at CERN studies the distribution of protons and neutrons in the nuclear density tail using low-energy antiprotons. By studying stable and short-lived nuclei, PUMA investigates surface phenomena such as nuclear halos and neutron skins. The experiment leverages the sensitivity of antiprotons to both neutrons and protons, with the neutron-to-proton annihilation ratio serving as the key observable. The antiproton-nucleon annihilation process conserves the electrical charge. PUMA uses this feature to disentangle the annihilation on neutrons and protons by measuring the charges of pions emitted from the annihilation with a time projection chamber located in a 4T magnetic field.
This contribution provides an overview of the PUMA experiment, covering its operation principle and the current status of the different components of the project. Particular attention is given to recent developments in the PUMA time projection chamber.

Day 3 - Excursion photos / 128

Group photos