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Book of Abstracts

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Updates on the Scintillating Bubble Chamber Experiment

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The Scintillating Bubble Chamber (SBC) collaboration combines historic bubble chamber technologies with the scintillation properties of liquid nobles to create a detector uniquely suited to low threshold rare event searches. The collaboration has built two nearly identical assemblies; SBC-LAr10 is being used for calibration studies at Fermilab and planned future coherent elastic neutrino-nucleus scattering research, and SBC-SNOLAB is bound for a low background dark matter search. SBC uses a superheated xenon-doped liquid argon active volume, allowing for event by event scintillation-based energy discrimination, electron-recoil insensitivity, and a projected 100 eV threshold. The cryogenic nature of the detector presents motivation for an investigation into the low temperature properties of both the argon active volume and CF₄ hydraulic fluid at the 30 PSI operating pressures of the detector. This investigation is being conducted with a novel combination of bulk fluid and molecular dynamics simulation approaches. This presentation will update on the current status of both SBC-LAr10 and SBC-SNOLAB, as well as briefly discussing the potential for calculating cryogenic physical and thermal properties of the detector constituents.

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Poster session / 6

Current Status and Prospects of the DEAP-3600 Dark Matter Search

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DEAP-3600 is a single-phase liquid argon (LAr) dark matter detector located 2 km underground at SNOLAB in Sudbury, Canada, searching for nuclear recoils from dark matter scattering in a 3.3-tonne LAr target. In 2019, the collaboration published a leading limit on the WIMP-nucleon spin-independent cross section, based on 231 exposure days. A new profile likelihood ratio analysis extends the exposure to 790.8 days, with unblinding in progress; it is expected to set the most stringent argon-based exclusion limit for WIMPs, ahead of next-generation experiments such as DarkSide-20k and Argo. Since the second-fill run ended in 2020, the detector has undergone upgrades to reduce shadowed-alpha and dust-related backgrounds, two dominant contributors in the WIMP region of interest. Refilling began in early 2025, followed by vacuum, gas-argon, and LAr datasets, with full data taking continuing into 2026. With these improvements, DEAP-3600 aims for background-free sensitivity at the 10^{-46} cm^2 level, advancing background modeling and detector performance for future LAr dark-matter searches.

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Nuclear Physics / 7

Lifetime of a muon bound to a light nucleus

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A muon bound in the 1S state of a hydrogen-like ion can decay into an electron and a pair of neutrinos. For small nuclear charge Z, Überall (1960) predicted a suppression of the total rate relative to the free-muon width, 1−Γ/Γ0⊠(αZ)^2/2, α⊠1/137. The first all-orders numerical calculation in αZ (Watanabe et al., 1993) reported for oxygen (Z=8) Γ/Γ0=0.994, in tension with Überall's analytic expectation ≈0.998. This 4×10^−3 discrepancy is too large to be explained by the next term O((αZ)^3), which is ~2×10^−4.
In this work we revisit the calculation and trace the discrepancy to slow convergence of the partial-wave sum. Truncation at κ=31 underestimates the rate; extending the sum to κ=59 and controlling the tail yields Γ/Γ0=0.9976 for Z=8, now consistent with Überall's prediction within expected O((αZ)^3) effects. Our result resolves the long-standing conflict and clarifies the numerical requirements for reliable bound-state QED calculations.It also supports analogous expansion methods used in heavy-quark physics.

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Poster session / 10

Search for Two-Proton Decay from the 6.15 MeV Resonance in 18Ne with ACTAR TPC

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Type I X-ray bursts are among the most frequent thermonuclear explosions we can observe, and can reveal important properties of accreting neutron star systems. Understanding their light curves requires detailed knowledge of the nuclear reactions that enable the transition from the hot CNO cycle towards explosive burning and the rp process. One such key breakout reaction is the 14O(α,p)17F reaction, which at typical burst temperatures proceeds predominantly through a 6.15 MeV resonant state in 18Ne. Although the energy and spin of this resonance are well established, its decay scheme remains uncertain. In particular, previous studies have reported inconsistent results for a possible two-proton decay branch, spanning several orders of magnitude, which could significantly affect the resonance's astrophysical contribution.

To resolve this discrepancy, we recently performed a resonant scattering experiment at TRIUMF using the Active Target and Time Projection Chamber (ACTAR TPC), a gaseous active target that enables precise reconstruction of charged-particle tracks and reaction vertices. A 5.5 MeV/u 17F beam was delivered into ACTAR TPC that was filled with pure hydrogen (95%) mixed with isobutane (5%) gas, serving as a proton target. This measurement provides the first direct search for the two-proton decay of the 6.15MeV resonance in 18Ne and aims to determine the branching ratios between the 2p, p, and α decay channels.

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Determination of point proton radii of neutron-rich nitrogen isotopes

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Exploring neutron-rich nuclei near the drip line with significant neutron/proton asymmetry exposes exotic phenomena like the existence of a neutron halo or skin and (dis)appearance of existing magic numbers. Nuclear halos result from the spatial distribution of outermost neutrons, causing a low-density extende. A systematic study of the point proton radii (root mean square radii of the density distribution of protons treated as point particles, referred to as point proton radii) along an isotopic chain reveals insights into the impact of the extended neutron wavefunction on the protons. This work presents the first determination of the point-proton radius for ^{23}N, as well as the radius of ^{21}N. The systematic study of $^{21-23}$N radii will be performed.

The RI beams of $^{21-23}$N are produced via projectile fragmentation reaction after the primary beam of ^{48}Ca (345A MeV) interacts with the rotating ^{9}Be target at the BigRIPS facility at RIKEN Nishina Center in Japan. The charge-changing cross section (σ_{cc}) was measured with a carbon target placed at the final focal plane using the transmission technique. The ratio of the number of particles transmitted through the target without any loss of protons to the number of incoming particles provides the desired cross-section. The proton radii are extracted from the measured σ_{cc} using the finite-range Glauber model framework.

The proton radii derived from this study, combined with the previously reported significantly large matter radius of ^{23}N, as well as the proton radii measurements of $^{17-22}$N, offer valuable insights into the structural features of the neutron-rich isotope ^{23}N. Furthermore, a σ_{cc} measurement of ^{21}N at two different energies (i.e., at approximately 230A MeV and 900A MeV) further provides the groundwork for the necessity of a scaling factor.

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Electroweak Physics / 12

Radiation Shielding Design for the MOLLER Spectrometer Coils at Jefferson Lab

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The MOLLER experiment at Jefferson Lab will measure the weak mixing angle with unprecedented precision via parity-violating Møller scattering. A major engineering challenge is mitigating radiation damage to the spectrometer coils and their S2-glass/CTD-403 insulation.

The upstream and downstream regions receive radiation levels beyond acceptable limits, necessitating the implementation of protective shielding. High-statistics, GEANT4-based simulations were performed to iteratively design and optimize shielding geometries within mechanical constraints. These studies achieved significant dose reduction and included analyses of symmetric versus asymmetric magnetic configurations, dominant radiation pathways called as hotspots, and the sensitivity of the design to small coil misalignments.

This work presents the resulting shielding strategy for the MOLLER upstream torus.

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Fundamental Physics with Ultracold Neutrons at TRIUMF

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Ultracold neutrons enable some of the most precise measurements of neutron properties. With energies in the nano-electronvolt range, these neutrons can be trapped in material or magnetic bottles and observed for extended periods. These long observation times allow for highly accurate determinations of fundamental quantities, including the electric dipole moment of the neutron, the neutron lifetime, the interaction of neutrons with gravity, beta-decay parameters, and potential decay channels beyond the Standard Model. Each of these measurements serves as a crucial test of fundamental physics, contributing to our understanding of the early universe, symmetries, as well as the search for new physics.

At TRIUMF, Canada's national particle accelerator centre in Vancouver, the TUCAN collaboration is commissioning a next-generation ultracold neutron source. By utilizing superfluid helium, this new source aims to significantly increase ultracold neutron production, thereby improving the statistical precision of neutron property measurements, including the search for the neutron electric dipole moment at TRIUMF.

This talk will provide an introduction to ultracold neutrons, review recent progress within the TUCAN collaboration, including the first ultracold neutron production with the new ultracold neutron source, and discuss the experimental challenges in achieving high-precision measurements. It will also highlight Canada's role in advancing the global effort to determine the fundamental properties of the neutron.

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Inverse kinematics measurement of the 18O(α, γ)22Ne reaction with DRAGON

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Have you ever wondered how all the elements we find here on Earth and in the universe were created? Nearly all naturally occurring elements are produced via nuclear reactions in the interiors of the stars. Half of the elements heavier than iron are synthesized in the slow neutron capture process (s-process), which occurs mainly in two astrophysical sites: asymptotic giant branch (AGB) stars (main s-process) and massive stars during core helium burning and shell carbon burning (weak s-process). The ^{18}O(α, γ)^{22}Ne reaction is a key link in determining the availability of ^{22}Ne in the stellar environment, which affects the amount of neutrons available for the s-process through the ^{22}Ne(α, n)^{25}Mg reaction. The ^{18}O(α, γ)^{22}Ne reaction was measured in inverse kinematics for the first-time using the DRAGON recoil separator at TRIUMF, Canada's particle accelerator centre. In this talk, I will present the scientific motivation for studying this reaction, the experimental setup, and progress on the analysis so far. I will also discuss potential future plans for additional measurements of the ^{18}O(α, γ)^{22}Ne reaction with DRAGON.

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Electroweak Physics / 15

Semileptonic B meson Tagging with Missing Energy: Performance of Full Event Interpretation Algorithm at Belle II

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At Belle II, B mesons are produced in pairs nearly at rest. The Full Event Interpretation (FEI), a machine-learning based background-suppression method, reconstructs one of the B mesons in a well-known decay mode (the tag side). The remaining particles in the event are then used to reconstruct the signal B meson.

The Semileptonic FEI uses a hierarchical decay-chain reconstruction in which intermediate particle candidates are ranked with gradient-boosted decision trees, allowing reconstruction of tag-side Semileptonic decays such as $B \to D^*\ell\nu$. In this study, we extend the scope of the tag-side reconstruction by adopting tagging modes that tolerate missing soft photons and slow pions from $D^* \to D\,\pi/\gamma$ decays. The performance of this extended SL tag is evaluated using Monte Carlo simulation and $365\ \mathrm{fb}^{-1}$ of Belle II data, with the well-known benchmark decays $B \to D^{(*)}\ell\nu$ used for comparison. This work reports a sensitivity estimate of the extended Semileptonic tagging algorithm and provides a comparison to the conventional FEI tag at Belle II.

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CEDAR Conversion Electron Detection ARray

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A new array of Si(Li) detectors is under development for conversion electron spectroscopy in combination with the GRIFFIN decay spectrometer at TRIUMF-ISAC. Internal conversion coefficients play a crucial role in studying electromagnetic transitions in nuclei as they assist in the assignment of spin and parity of excited nuclear states. In addition, the direct observation of L=0, E0, transitions is made possible as these are forbidden for gamma-ray emission. E0 transitions between 0+ states are of particular interest as an indicator of shape changes and as direct evidence of shape coexistence. The current detector array PACES (Pentagonal Array of Conversion Electron Spectrometers) is not optimized for the GRIFFIN geometry and often limits the maximum beam rate. GEANT4 simulations of the new CEDAR detector demonstrated significantly improved performance; including enhanced GRIFFIN and LaBr3 efficiencies, higher beam-rate tolerance, and greater angular coverage. The detector arrangement shows great promise for studying gamma-conversion electron directional angular correlations. Additionally, the incorporation of a new mechanical cooling system has demonstrated a great reduction in detector cooling time while also allowing accommodation of all sixteen GRIFFIN clovers.

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0νββ and antimatter / 17

Towards Demonstrating Magnetic Trapping of Hydrogen in the HAICU Experiment

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If matter and antimatter were created equally at the Big Bang, then why did they not annihilate each other, leaving behind a barren universe? That our universe is dominated by matter with little antimatter is a mystery of modern physics. At CERN, the ALPHA (Antihydrogen Laser Physics

Apparatus) collaboration is studying antihydrogen, investigating its atomic energy levels in a magnetic trap. I am part of the ALPHA Canada collaboration and am working on HAICU (Hydrogen Antihydrogen Infrastructure for Canadian Universities), an experiment aiming to raise our precision to cutting-edge levels. With HAICU, the goal is to develop and build the technologies that would enable us to use state-of-the-art quantum techniques such as Raman interferometry and Ramsey spectroscopy on antihydrogen—building the first-of-its-kind antiatom fountain!

In this presentation, I shall describe HAICU and talk about my progress simulating the trapping of hydrogen in our apparatus.

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Poster session / 19

Kaon Structure at Low Photon Virtuality

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One of the long standing questions in the standard model of particle physics is the origin of nucleon mass, spin, and the charge and density spatial distributions within. In the theory of the strong interaction, the structure of the nucleon is described by form factors which can be accessed through hard exclusive meson production. The main focus of this study is to measure the form factor of one of the lightest mesons and simplest bound state of a quark and antiquark, the kaon. The kaon form factor is measured indirectly from the scattering of a high-intensity electron beam on a proton target producing a kaon along with the Λ and Σ baryons. The data analyzed here were taken at a photon virtuality of $Q^2 = 0.5$ GeV^2 using the high precision Hall C spectrometers of the Jefferson Lab. We will be presenting preliminary results on Λ and Σ production cross sections, separated according to the polarizations of the exchanged virtual photon.

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Poster session / 20

Structure beyond the neutron threshold in N = 50 nuclei using neutron detection techniques at ALTO

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As nuclei get richer in neutrons, the Q-value for beta-decay gets larger while the neutron separation energy decreases. Consequently, for large enough N/Z ratios, the daughter nucleus can decay by emitting one to several neutrons. Directly studying states above the neutron separation energy is an experimental challenge as it requires neutron detectors that have a good energy resolution while maintaining a good efficiency. This has lead to a lack of knowledge of these states, and several properties linked to the beta-delayed neutron emission are therefore not well understood or predicted. This has a significant impact on the modeling of the astrophysical "r-process" in which this decay highly occurs. The study of these states and their structure is part of a physics program based at the ALTO facility in Orsay, France. The beta-delayed two-neutron emission of Gallium 84 has been investigated using the Helium 3 neutron counter TETRA, and for the first time, a fully microscopic semi-quantitative approach based on "doorway-states" has been used to describe the beta-delayed neutron emission two-step process. Additionally, the response function of the detector TETRA has been thoroughly studied using Monte-Carlo simulations, and new methods have been developed allowing to use this detector to obtain gross information on the neutron energy spectra even though it was not initially designed for this purpose.

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Forward Correction for Real-Time Processing of ATLAS Liquid Argon Calorimeter Signals

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The ATLAS detector relies on its liquid-argon (LAr) calorimeter to measure the energies of electrons and photons produced in proton–proton collisions at the LHC. After the high-luminosity upgrade of the LHC, the calorimeter will face substantially increased background activity from many overlapping signals produced in nearby bunch crossings, complicating real-time energy reconstruction. To prepare for these conditions, new readout electronics built around modern FPGA processors will process digitized samples using updated digital signal processing techniques. A new causal technique, forward correction, is being developed as an extension of the traditionally employed optimal filter: using the calibrated pulse shape and the current energy estimate, it predicts and subtracts the expected pulse tail to mitigate overlap in subsequent samples. The forward-correction algorithm is implemented within the the standard LAr reconstruction chain and validated using simulations that include realistic electronics, noise, and high pile-up conditions. By comparing the reconstructed cluster energies, shower-shape variables, and dielectron invariant-mass distributions in pp->Z->e+e- events, the study demonstrates that forward correction significantly reduces biases, improves energy linearity at high pile-up, and yields a measurable improvement in both resolution and event-to-event stability relative to the current optimal filtering approach.

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Beta-Delayed Charged-Particle Emmission From 20Mg

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One of the most important nuclear reactions in astrophysics is the 15O(α,γ)19Ne(p,γ)20Na reaction, which provides a possible breakout pathway from the hot CNO cycle in stars. Studying this reaction directly in the laboratory is challenging, instead, an indirect study using β-decay proton and α decays of 20Mg was recently performed at TRIUMF. The experiment used the Gamma-Ray Infrastructure for Fundamental Investigations of Nuclei (GRIFFIN) gamma-ray spectrometer and, for the first time, the Regina Cube for Multiple Particles (RCMP), a newly developed silicon detector array designed to detect low-energy protons and alpha particles. This setup enables the most sensitive search to date for rare decay branches and gamma-ray transitions from astrophysically important states. My thesis focuses on calibrating the RCMP array and analyzing this new high-statistics dataset to constrain the properties of resonances that play a key role in stellar nucleosynthesis.

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Nuclear Physics / 24

Development of next generation ultra cold neutron detectors to measure electric dipole moment of neutrons by TUCAN

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This presentation will show ongoing R&D of the new ultra cold neutron detectors. These detectors, filled with He3 at 15 mbar and CF4 to atmospheric pressure, detects neutrons via capture on He3. The resulting proton and triton deposit energy in the CF4, producing scintillation light. These detectors will be used to measure the neutron electric dipole moment (nEDM) by TRIUMF Ultracold Advanced Neutron (TUCAN) Collaboration to measure nEDM with a target sensitivity of up to 10^{−27} e.cm, an order of magnitude better than the current best limit. Measurement of nEDM higher than predicted by standard model will indicate another source of charge-parity violation in the universe and may improve our understanding of why the universe is matter dominated.
This presentation will detail the detector's construction, the working mechanism of the detector and the data acquisition methods. To calibrate the detector before its first commissioning test, it was used to measure the background rate of the TUCAN experimental hall at TRIUMF. The data was taken in different filling configurations vacuum, CF4 and CF4 + He3. The detector was also calibrated with gamma (Cs-137) and neutron (CF-252, AmBe-241) sources and the neutron background in TRIUMF Neutron Irradiation Facility (NIF). Results will be presented for measured
timing resolution, the efficiency of the detector to distinguish neutrons from background, and the characteristics of the neutrons signals detected.

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A Coincidence Algebra Bundle for Decay Quivers: An Algebraic Approach to Gamma-ray Spectroscopy.

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Motivated by the need for a more comprehensive algebraic structure to calculate coincidence probabilities of a general decay scheme for gamma ray spectroscopy, we model the decay scheme, rather naturally, as a quiver through which we define a decay quiver. The path algebra of quivers is the underlying, more general, algebra for transition matrices that is typically used in modeling decay schemes. The path algebra allows for concatenation of transitions which affords the calculation of cascade probabilities. We extend the path algebra to allow for the multiplication of non-composable paths, i.e., transition that don't directly share a level connecting them. We define the coincidence algebra as the algebra that allows for such an extension and realize it as the fibres for a coincidence algebra bundle, the base space of which is the path algebra where decay schemes live. Detection maps are defined as linear maps on the base space that map transition probabilities to detected probabilities.

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QCD / 26

GPD Factorization in Pion Electroproduction: PionLT Luminosity Studies

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Generalized Parton Distributions (GPDs) are a huge advancement in our understanding of hadronic structure and non-perturbative QCD. To study GPDs, one may use the Deep Exclusive Meson Production (DEMP) reaction. The PionLT experiment in Jefferson Lab Hall C measures the DEMP reaction, but to access GPD information we must perform a LT separation on the data. An LT separation divides the cross-section into components based on the virtual-photon polarization. But to do this, first one must understand the rate dependence of the data. This is because to do a single LT separation requires high precision knowledge of the cross-sections at atleast two values of photon virtuality, epsilon, for fixed Q^2 and W, which means directly comparing settings at different beam energies with different rates. In addition, to obtain full azimuthal coverage in Hall C one must take data at three angles in the SHMS spectrometer, meaning a total of 6 settings that must be directly compared. This talk reports finalized luminosity studies for the PionLT experiment which determines the rate dependence precisely.

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Poster session / **27**

Inverse kinematics measurements of key resonances in 15N(a,g)19F with DRAGON

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The origin of the only stable fluorine isotope, ^{19}F, has remained a longstanding question in nuclear astrophysics due to persistent discrepancies between observations and model-predicted abundances constrained by laboratory reaction rates and nuclear physics input. Recent work by Cristallo *et al.* highlighted that the reaction rate of $^{15}N(a,g)^{19}F$ –one of the key production channels –may carry significantly larger uncertainties than previously assumed. By exploring reaction-rate variations beyond the standard error estimates, they demonstrated improved agreement between predicted and observed ^{19}F abundances, thereby suggesting that unaccounted nuclear physics uncertainties could reconcile this mismatch. This result has motivated new experimental efforts to measure the rate-determining resonances of the $^{15}N(a,g)^{19}F$ reaction, aiming to refine fluorine nucleosynthesis models and resolve the ^{19}F abundance puzzle.
The $^{15}N(a,g)^{19}F$ reaction rate at relevant temperatures is determined by a number of narrow resonances, together with the direct-capture component and the tails of the two broad resonances at E_{cm} = 1323 and 1487 keV. Discrepancies in the results of recent measurements regarding the exact

energies and strengths of the resonances at $E_{cm} = 1323$ and 1487 keV have triggered a new measurement at the DRAGON recoil separator at TRIUMF. The former is of particular note because of its use as a reference resonance for measurements of other rate-determining resonances.
Using the inverse kinematics method at the DRAGON facility, we directly measured the resonance energies and strengths of the two broad resonances. In my presentation, I will outline the scientific motivation for studying this reaction rate, the analysis method used, and I will discuss the results in relation to the literature.

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QCD / 28

A New Angle into the Proton: u-Channel Meson Electroproduction

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Due to the dramatic running of the QCD coupling constant α_S, hadronic structure varies drastically with measurement scale. Therefore, combining complementary measurements of many unique observables is key to completing our picture of the proton. The KaonLT experiment at Jefferson Laboratory probes hadron structure through measurements of Deep Exclusive Meson Production (DEMP) reactions. My research is to analyze a subset of these reactions known as the u-channel, in which the meson is produced at a backward angle. These reactions offer unique access to the $qqqq\bar{q}$ (valence quark plus meson) part of the nucleon wave function. Backward-angle DEMP is also anticipated to measure the distribution of baryon number within the proton. This talk will describe the u-channel analysis of the KaonLT data, focusing on event selection for cross-section measurements. Mostly unexplored, the u-channel offers unique physics opportunities, complementary to previous measurements, bringing us one step closer to a complete understanding of the nucleon.

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Nuclear Physics / 29

Probing the s-process via Indirect Measurement of $^{22}Ne(\alpha,\gamma)^{26}Mg$ Reaction

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The slow neutron capture process (s-process) creates almost half of the elements heavier than iron in the universe. One of the most important neutron sources for the s-process is the $^{22}Ne(\alpha,n)^{25}Mg$ reaction, which competes with the $^{22}Ne(\alpha,\gamma)^{26}Mg$ reaction. The current nuclear data for these reactions show great discrepancies. Thus, in order to understand the synthesis of heavy elements, it is crucial to study the ratio between these two reactions.

Using the EMMA mass spectrometer and TIGRESS γ-ray spectrometer at TRIUMF, we are able to indirectly measure the $^{22}Ne(\alpha,\gamma)^{26}Mg$ reaction. The indirect measurement involves bombarding a LiF target with a $3MeV/u$ ^{22}Ne beam. A silicon detector is used to detect light ejectiles, the TIGRESS array is used to detect the γ-rays from the reactions, and the EMMA spectrometer to select the ^{26}Mg recoils. Using different coincidence measurements between the three detectors allows us to measure the α particle spectroscopic factors for ^{26}Mg states above the neutron threshold. Preliminary results from the measurements will be discussed in this talk.

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Neutrino Physics / 30

Pion Photoproduction Analysis in the Water Test Cherenkov Experiment (WCTE)

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The Water Cherenkov Test Experiment (WCTE) at CERN was designed to provide controlled measurements of processes central to large-scale water Cherenkov detectors such as Hyper-Kamiokande. Using a water target together with a high-precision tagged-photon beam, WCTE recorded detailed data on charged-pion hadronic scattering, secondary neutron production, and Cherenkov-light emission from secondary charged particles. With data-taking now complete, analysis efforts are underway across simulation, reconstruction, and event characterization.

My PhD research focuses on the simulation and analysis of pion photoproduction events in WCTE. The goal is to develop a framework capable of identifying both inclusive and exclusive pion-production channels and comparing observed distributions with theoretical models and Monte Carlo simulations. The resulting constraints will improve neutrino–nucleus interaction modelling and strengthen the precision of oscillation measurements in water Cherenkov detectors.

Pion photoproduction provides a sensitive probe of nucleon and nuclear structure in the non-perturbative regime of QCD and plays a central role in modelling neutrino interactions and backgrounds, particularly neutral-pion signatures that mimic electron-like Cherenkov rings. A detailed understanding of its kinematics, cross-sections, and final-state topologies is therefore essential for hadronic and neutrino-physics applications.

In this presentation, I will show initial studies using WCTE Monte Carlo samples and preliminary visualizations of photon-tagged data, including early event displays. I will outline the planned reconstruction strategy—such as first attempts using an existing likelihood fitter and describe the broader analysis roadmap toward isolating pion-photoproduction channels and extracting physics results from the full dataset.

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Poster session / 31

Effective Field Theory Interpretation of Same-Sign WW Vector Boson Scattering with the ATLAS Experiment

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While the Standard Model (SM) of particle physics has been successful in describing known fundamental particles and interactions, it is incomplete. The amount of charge-parity (CP) violation predicted within the SM is insufficient to explain the observed matter-antimatter asymmetry in the Universe. Additionally, possible deviations in the self-interactions of electroweak bosons motivate the exploration of theoretical frameworks that extend the SM. Effective Field Theories (EFTs) provide model-independent approaches to capture effects of new physics by adding higher-dimensional operators to the SM Lagrangian. This talk will explore using data collected at Run 3 of the Large Hadron Collider at a centre-of-mass energy of 13.6 TeV to explore observables sensitive to effects

of CP-odd EFT operators and study potential deviations from SM predictions using same-sign WW vector boson scattering.

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0νββ and antimatter / **32**

Ab Initio Nuclear Theory for Neutrinoless Double-Beta Decay

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The search for neutrinoless double-beta decay ($0\nu\beta\beta$) stands among the most promising avenues for uncovering new physics. An observation would confirm Majorana neutrinos, establish lepton-number violation, and potentially reveal the absolute neutrino mass scale. As next-generation experiments propose to push half-life sensitivities up to two orders of magnitude beyond previous efforts, reliable nuclear matrix elements (NMEs) are essential, since extracting neutrino masses or distinguishing decay mechanisms is impossible without them. Because $0\nu\beta\beta$ is an inherently beyond-Standard-Model (BSM) process, multiple mechanisms may contribute to the decay. While the standard light-neutrino channel has been extensively studied, short-range contributions such as heavy-neutrino exchange remain far less explored within nuclear theory. Heavy sterile Majorana neutrinos are strongly motivated in many BSM frameworks, e.g. seesaw models, where they may play a significant or even dominant role in $0\nu\beta\beta$ decay.

We present the first ab initio calculations of heavy-neutrino-exchange NMEs for four major experimental isotopes. Starting from internucleon forces derived from chiral effective field theory, we use the in-medium similarity renormalization group to obtain effective valence-space Hamiltonians and consistently transformed decay operators. Because heavy-neutrino exchange is short-range, the associated operators show strong sensitivity to the renormalization procedure. Using different chiral interactions and operator-renormalization choices, we obtain NME ranges that are consistent with—but generally smaller than—those from phenomenological methods. Combining our ab initio NMEs with current experimental limits yields a minimum lower bound of 2.51×10^8 GeV for the effective heavy-neutrino mass, assuming heavy-neutrino exchange dominates the decay.

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Dark Matter / 33

Pushing Boundaries of WIMP Detection with DarkSide-20k

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The Global Argon Dark Matter Collaboration (GADMC), formed to unite liquid argon–based dark matter experiments, is currently constructing its next-generation experiment DarkSide-20k. Located at the Laboratori Nazionali del Gran Sasso (LNGS), DarkSide-20k builds upon the success of previous argon experiments, including its predecessor, DarkSide-50, to continue the search for weakly interacting massive particles (WIMPs). The experiment introduces several new technologies and design improvements to reduce backgrounds and enhance sensitivity.
DarkSide-20k features a three-chamber design: a central dual-phase time projection chamber (TPC), an inner veto, and an outer veto. The TPC contains 50 tonnes of low-radioactivity underground argon (UAr). Surrounding the TPC, the inner veto, filled with 32 tonnes of UAr, provides efficient neutron tagging, while the outer veto, containing 650 tonnes of atmospheric argon (AAr), shields against cosmogenic backgrounds. The detectors are instrumented with novel photodetectors called silicon photomultiplier (SiPMs), small pixel-like detectors that can work under cryogenic temperatures. This design will allow the experiment to run nearly background free with a 200 tonne-year exposure.
With its large target mass and advanced instrumentation, DarkSide-20k is expected to probe WIMP–nucleon cross sections below $1\times10^{-42}\ cm^2$ for WIMP masses above 800 MeV. As its name implies, DarkSide-20k will look into unknown areas that have never been explored in search of dark matter, pushing closer to boundaries such as the neutrino floor than any experiment ever has.

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Nuclear structure / 34

Evidence for shape coexistence in ^{120}Sn from the first 0_3^+ lifetime measurement

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The intruder bands in the mid-shell Sn isotopes, built on the proton 2p-2h excitation across the $Z = 50$ shell gap, are well-known examples of shape coexistence, where more than one shapes appear within the same nucleus. Spectroscopic signatures for shape coexistence include enhanced $E0$ transitions between the 0^+ band heads. However, until now, lifetime information for the 0^+ states in ^{120}Sn has been incomplete. The first measurement of the 0_3^+ lifetime in ^{120}Sn using the fast-timing technique following thermal-neutron capture will be presented in this talk. The first $\rho^2(E0; 0_3^+ \to 0_2^+)$ value obtained from this experiment, which is sensitive to the deformation and mixing between the 0^+ states, will be discussed.

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QCD / 35

Investigation of the Eta1 exotic meson at GlueX

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Hadronic physics aims to understand the contribution and dynamics of quarks and gluons in the formation of hadrons. Quantum Chromodynamics predicts a number of states, including those having gluonic degrees of freedom called hybrids, but only a few have been established experimentally. The GlueX experiment at Jefferson Lab, USA, utilizes a linearly polarized photon beam of 8-9 GeV and a large solid angle particle detector system for hadron spectroscopy. Among the physics goals are the study of the hybrid meson spectrum and the search for mesons with exotic quantum numbers.

Recently, the signature of a predicted exotic isoscalar, η_1 has been reported by the BESIII collaboration in the radiative decay of $J/\psi \to \eta_1\gamma \to \eta\eta'\gamma$. The production of a two pseudoscalar system, $\eta\eta'$ is also allowed in the photon-induced interaction $\gamma p \to \eta\eta' p$, and can be reconstructed with the GlueX spectrometer, giving us an excellent opportunity to search for the signature of the η_1. An initial analysis of this two meson system, based on GlueX Phase-I data set (2017-2018), did not provide a conclusive result because of limited statistics. An increase in statistics, by a factor of 2-3 is expected from the GlueX Phase-II data set, that is currently being recorded. This should allow us to perform a precise study and yield better results. Preliminary Monte Carlo simulation studies for this channel will be presented and discussed.

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QCD / 36

Investigating scattering rates in Thermal Field Theory beyond the leading log

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Relativistic heavy-ion collisions are reaching temperatures where the quarks and gluons, fundamental constituents of the nucleus, become deconfined and enter a state called the Quark-Gluon plasma (QGP). Its properties are a window into the underlying nature of the strong force under extreme conditions of temperature and pressure, which can be inferred from experimental measurement. Like proton-proton collisions, heavy-ion collisions produce a collimated spray of energetic particles known as a jet. Our understanding of jets in the vacuum setting –such as that in proton-proton collisions –makes them a calibrated probe to study the QGP. Through their exchange of energy and momentum with the QGP, jets probe the microscopic physics describing the QGP itself. Constraining jet-medium transport coefficients, such as their transverse-momentum broadening in the QGP, is a key objective of jet quenching studies in heavy-ion collisions. The transverse-momentum broadening is a moment of the jet-medium scattering rate that will be discussed in this presentation. The jet-medium scattering rate will first be presented using the eikonal forward scattering approximation, followed by the full tree-level scattering rate in thermal field theory. The transverse-momentum broadening coefficient is then computed as a moment of scattering rate. We find significant deviations away from the eikonal result, both in the scattering rate and the transverse-momentum broadening transport coefficient. As these eikonal results have been employed in recent Bayesian constraints on the transverse-momentum broadening of jets in the QGP, we will explore how our results can be used to improve current Bayesian analysis of jet-medium transport coefficients.

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Nuclear structure / 37

Investigating Space-Charge Effects in TITAN's Multi-Reflection Time of Flight Mass Spectrometer

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Nuclear masses are a fundamental observable that give insight into nuclear structure, fundamental interactions, and astrophysics. Multi-Reflection Time of Flight (MR-TOF) mass spectrometers provide high mass separation power in a short amount of time by bouncing ions between electrostatic mirrors. This increases the flight path of trapped ions allowing ions with the same energies but different masses to separate. The high mass resolving powers and short storage times have contributed to MR-TOF devices becoming common for beam purification and mass spectrometry in rare-isotope-beam (RIB) and accelerator facilities around the world. However, Coulomb interactions among ions within the trapping volume can cause deviations from the desired MR-TOF performance. These space-charge effects limit the ion flux that MR-TOF devices can separate. Two well-known effects, self-bunching and peak coalescence, have been observed at the TRIUMF Ion Trap for Atomic and Nuclear Science (TITAN) MR-TOF mass spectrometer and elsewhere. These effects occur when enough space charge in the trap prevents the ion bunches from temporally separating from one another. Since typically the RIB is a cocktail of masses, the injected ion bunch either stays the same width or becomes narrower with increasing time in the trap. Peak coalescence is a similar effect that causes bunches of different ion species to merge with each other, making mass separation impossible. We have simulated detector deadtime as a function of ion flux, enabling estimations of individual ion pulse widths and heights. These simulations and the data analysis will be presented and used to estimate the impact on the MR-TOF performance.

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Dark Matter / 38

Nuclear Physics in Liquid Argon with DEAP-3600

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With the technical complexity required by ongoing dark matter direct detection experiments, as well as requiring more refined background rejection techniques, some direct detection experiments have the ability to investigate neutrinos as well. One such detector in recent years involves the liquid argon based DEAP-3600 experiment. The detector assembly allows for nearly 3600 kg of liquid argon scintillator to be used for direct detection experiments in the low-background environment 2 km underground at SNOLAB in Sudbury, Canada.

This talk will go over a brief history of the DEAP experiment, discuss basic technical details on the current experimental design, and the data analysis techniques being used for ongoing search efforts utilizing the large detector mass (3.3 tonnes) of DEAP. This will inform a discussion on the most recent results regarding precision measurements of the radioactive properties of ^{39}Ar –a measured specific activity of $(0.964{\pm}0.001_{stat}{\pm}0.024_{sys})$ Bq/(kg·atmAr) and a half-life of $(302{\pm}8_{stat}{\pm}6_{sys})$ years. Additionally, the scintillation quenching factor of α-particles in liquid argon will be covered, namely the extrapolation of the quenching factor down to the low energy region of 10 keV. This will be followed by a discussion of the ongoing efforts towards the neutrinoless double electron capture search via ^{36}Ar using the DEAP experiment and how these efforts allow for the investigation into the nature of neutrinos.

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Neutrino Physics / 39

Creating accurate optical module models in IceTray for the Pacific Ocean Neutrino Experiment

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The detection of high-energy cosmic neutrinos by the IceCube and KM3NeT collaborations has raised questions of what astrophysical processes are creating these particles. In order to answer this question, additional large volume neutrino detectors must be constructed to offer full sky sensitivity to neutrino flux. The Pacific Ocean Neutrino Experiment (P-ONE) is a future underwater neutrino observatory located off the coast of Vancouver Island. With the first detectors expected to be in place next year, the simulation and analysis pipeline is being finalized. The Monte Carlo (MC) simulations and analysis for P-ONE are done using the IceTray framework, initially created for the IceCube Observatory. This framework requires geometry files which need to accurately represent the physical detector. The optical modules (OMs) that contain photomultiplier tubes (PMTs) are a pair of hemispheres mounted on either side of a titanium ring. The previous OM models used for the MC simulations were a single sphere with minimal detector information. Different shapes and configurations of OM models available within IceTray were created and tested, with the final design closely resembling the physical detectors. The updated model contains correct PMT orientations, along with accurate separation between the two hemispheres. This also allows for the visualization of events to show the directionality of the detected photons. While further tests and optimization of this model are needed as lab measurements from collaborators are collected, this model provides a significantly more accurate detector geometry for our simulations.

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Neutrino Physics / 40

Combining PYTHIA and Geant4 for High-Energy Event Simulation in Neutrino Telescopes

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Neutrino telescopes are large volume detectors ($\sim 1\ km^3$) embedded in optically transparent media that observe the secondary particles produced when neutrinos —ranging in energy from GeV to TeV —interact in the medium. These experiments rely on detailed Monte Carlo simulations to interpret their data, yet events at TeV energies and above produce extensive hadronic and electromagnetic particle cascades whose full modeling would involve propagating millions of secondary particles, creating a substantial computational challenge. Effective simulations must therefore balance physical accuracy with computational cost.
In this talk, I will present a new simulation pipeline for neutrino telescope experiments that is intended to deliver more accurate results than standard simulation approaches, while still remaining practically applicable. This framework combines PYTHIA for generating the primary neutrino interaction with Geant4 for particle transport and secondary production. Preliminary performance results will be shown.

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Poster session / 41

Development of an accelerator-driven Ba-ion source to optimize Barium tagging techniques for a nEXO upgrade

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Neutrinoless double-beta decay ($0\nu\beta\beta$) offers a way to probe for physics beyond the Standard Model. Observation of $0\nu\beta\beta$ will validate the Majorana nature of neutrinos, demonstrate violation of lepton number leading to an explanation of the observed baryon asymmetry in the universe, and probe new mass generation mechanisms up to the GUT scale. The planned nEXO experiment will search for $0\nu\beta\beta$ decay in ^{136}Xe with a projected half-life sensitivity exceeding 10^{28} years at the 90% confidence level over 10 years of livetime, using a tonne-scale liquid xenon (LXe) time projection chamber (TPC). In parallel, research is ongoing for future upgrades to nEXO to suppress background and further increase this sensitivity. One such approach is the extraction and identification of the $\beta\beta$-decay daughter Ba ion, also known as Ba tagging, which will ensure classification of an event as a $\beta\beta$ event irrefutably. Barium tagging would help next-generation, tonne-scale Xe TPC experiments like nEXO and NEXT reach sensitivities $\sim 10^{28}$ years. An accelerator-driven ion source is currently being developed at TRIUMF, where radioactive ions will be implanted inside an LXe volume for subsequent ion extraction and identification using methods under development by other groups within the nEXO

collaboration. For the commissioning phase of the ion source, radioactive ions will be extracted electrostatically from LXe and identified via γ spectroscopy. The background for the project, the apparatus, and recent updates will be presented along with planned measurements.

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Nuclear Physics / **42**

Status update on the next-generation Penning-trap mass spectrometry at TITAN

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Mass spectrometry plays an important role in many fields of physics research such as nuclear astrophysics, nuclear structure, and fundamental symmetries. Precise knowledge of masses is critical to these studies. For example, a relative mass precision of ≤10^-8 is required to probe the Standard Model and beyond. This level of precision with radioactive species has been achieved only with Penning trap mass spectrometry. Penning trap mass spectrometry relies on measuring the cyclotron frequency of an ion in a homogeneous magnetic field. Coupling the Penning trap to a charge breeder allows for further improvement in precision by boosting the charge state of the ions. In order to extend storage time of these highly charged ions, the TITAN Penning trap system has been upgraded recently to cool the trap to cryogenic temperatures using cryoabsorption and cryocondensation, attaining a vacuum of ~10^-11 mbar. Consequently, a complete characterization of the cryogenic trap, including a study of its error budget and a verification of its accuracy, are being performed. In parallel, a phase-based technique to determine the frequency is being implemented which will allow the TITAN Penning trap mass spectrometer to achieve relative precisions <10^-9. The characterization of the cryogenic trap and the upgrade towards phase-based frequency determinations will be presented.

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QCD / 43

Probing Hadron Structure with Exclusive Pion Production Reaction at Jefferson Lab

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One of the central challenges in modern physics is to unravel hadronic structure, as the strongly coupled, non-perturbative nature of QCD at low energies makes it difficult to derive the observed properties of hadrons from their underlying quarks and gluons. The pion (π-meson) is the lightest quark system, and its properties are deeply linked to our understanding of how quarks are confined in hadronic matter. The pion form factor (F_π) is a key observable that can be accessed through the exclusive pion electro-production reaction $p(e, e'\pi^+)n$. The Pion-LT experiment was conducted to measure F_π to high Q^2 across a broad kinematic range at the Thomas Jefferson National Accelerator Facility (JLab) in Newport News, Virginia, USA. This experiment aims to measure the separated longitudinal (σ_L) and transverse (σ_T) cross-sections using the unique Rosenbluth LT-separation technique to extract F_π with high precision. In this talk, I will present preliminary results for LT-separated cross-sections at $Q^2 = 3.85$ GeV measured using the Rosenbluth technique, on behalf of the PionLT Collaboration.

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Dark Matter / 45

Dark Matter Search Results from DEAP-3600

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The latest results from the DEAP-3600 experiment in the search for dark matter will be presented. DEAP-3600 is a direct detection experiment that uses 3.3 tonnes of liquid argon as its target material. Located over 2 km underground at SNOLAB in Sudbury, Canada, the detector is designed to observe scintillation light from nuclear recoils induced by dark matter interactions. Pulse-shape discrimination is employed to suppress the dominant background from beta decays of argon-39. Additional backgrounds include alpha decays from the inner surface of the detector and from dust within the liquid argon, radiogenic neutrons from detector components, and Cherenkov radiation. This talk will present the latest dark matter search results from the DEAP-3600 collaboration, which uses a profile likelihood ratio analysis and increased livetime to improve our results.

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Electroweak Physics / 46

Enhanced Background Modelling and Signal Extraction for Electroweak Zjj Measurements with ATLAS

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Electroweak production of a Z boson in association with two jets (EW Zjj) provides a clean way of probing vector boson fusion (VBF) and serves as a sensitive test of electroweak couplings within the Standard Model at high energies. Using the ATLAS detector at the Large Hadron Collider, this analysis aims to measure differential cross-sections of key observables in the dilepton channel and to investigate the distinct VBF topology characterized by two forward, high-pT jets with large invariant mass (m_{jj}) and rapidity separation (Δy_{jj}). The study uses the full Run 2 dataset at √s = 13 TeV (139 fb^{-1}) and most of the available Run 3 dataset at √s = 13.6 TeV (164 fb^{-1}), enabling independent measurements with increased sensitivity in the high-m_{jj} and high-Δy_{jj} regions where EW contributions dominate. A central challenge of the EW Zjj measurement is suppressing and precisely modelling the dominant QCD-induced Z+jets background, which mimics the signal topology but lacks colour-singlet exchange. This work develops an improved background-estimation strategy using control-region constraints in an optimized phase space, combined with a custom multi-bin likelihood fit. The analysis benefits from both datasets being reprocessed with the latest ATLAS calibration and reconstruction algorithms, providing improved object performance and enabling a more robust background-subtraction and signal-extraction procedure compared with previous EW Vjj measurements. Preliminary studies show enhanced discrimination power in the VBF-like phase space. While the datasets cannot be statistically combined due to their different centre-of-mass energies, they allow for a direct comparison of sensitivities and highlight the increased statistical and

kinematic reach provided by Run 3 data. The resulting measurements are expected to provide a valuable benchmark for future Effective Field Theory (EFT) interpretations.

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Neutrino Physics / 47

Scintillator Phase Deployment of the 'Laserball' Optical Calibration Source in SNO+

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The SNO+ experiment is a multi-phase, kilotonne-scale neutrino detector located 2km underground at SNOLAB in Sudbury, Ontario. SNO+ has an extensive physics program, where the primary objective is a search for neutrinoless double beta decay ($0\nu\beta\beta$) in ^{130}Te. To achieve the physics goals, it is essential to have a thorough understanding and calibration of the detector response and optics. The 12m diameter acrylic vessel (AV) is currently filled with 780 tonnes of liquid scintillator, linear alkylbenzene (LAB), doped with the fluor 2,5-diphenyloxazole (PPO). The detector is viewed by approximately 9400 photomultiplier tubes (PMTs) and surrounded by a shielding volume of ultra-pure water (UPW). In SNO+, a photon from a physics event is subjected to optical processes on its trajectory from the interaction vertex to the PMTs. These optical processes include scattering, absorption, and re-emission from the scintillator, acrylic, and external water; and reflection and refraction at media boundaries. Both the optical processes and PMT response are position, energy and wavelength dependent. An ideal optical calibration source, the Laserball, was developed, which produces quasi-isotropic light at well-defined wavelengths, and can be deployed throughout the detector.
The SNO+ scintillator Laserball, constructed from compatible materials, improves on predecessor designs. The earlier, SNO+ water phase Laserball measured the acrylic and external water attenuation lengths as well as the PMT angular response. Building from this, the scintillator Laserball measures the scintillator attenuation length and the PMT angular response. This talk presents the first deployment of the SNO+ Laserball in the scintillator phase, highlighting the hardware, scintillator optics and a contributing analysis.

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Nuclear Physics / 48

Systematics and Calibration for the KDK+ experiment

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KDK and KDK+ research is focused on measuring the rare decays of Potassium-40 (40K). The KDK experiment recently recorded the first experimental measurement of 40K electron capture decay directly to the ground state of 40Ar. KDK+ will follow this with an experiment aimed at obtaining a refined experimental decay constant for the β+ decay in 40K as the currently accepted value is in tension with modern theoretical predictions. The initial measurement will be performed using a liquid scintillator due to a high counting efficiency for β+ decays, and they can be loaded with a variety of chemicals for calibration purposes. This liquid scintillator will be contained in a 300 mL vessel with PMTs placed on either end and placed in the centre bore of an annulus with four Sodium Iodide crystals surrounding it measured by PMTs. This apparatus requires systematic calibration of the NaI crystals, the liquid scintillator, and the PMTs measuring them. Work has been done to calibrate the liquid scintillator vessel, as well as an extensive investigation into the methodology for loading potassium into a liquid scintillator. The liquid scintillator has also been tested extensively for stability as a loss in light yield has been observed over long periods and this must be understood over a long-term experiment.

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Neutrino Physics / 49

Energy Calibration Studies for the Reactor Antineutrino Search at SNO+

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The SNO+ experiment is a kilo tonne-scale liquid scintillator neutrino detector located 2 km underground at SNOLAB in Sudbury, Ontario. Within its broad physics program, SNO+ detects anti-neutrinos through an inverse beta decay (IBD) reaction, producing a characteristic delayed-coincidence signal that can be easily separated from most backgrounds. This allows SNO+ to make two key measurements: the determination of a subset of neutrino mixing parameters from reactor anti-neutrino oscillations, and the flux of geo-neutrinos emitted from the decay of unstable elements in the Earth. The SNO+ collaboration has recently released improved measurements for both.

An important component of the improved anti-neutrino analysis was the use of a deployed ^{241}Am-^{9}Be neutron calibration source, which produces a delayed-coincidence signal similar to IBD interactions. The calibration campaign was used to validate our understanding of the detector response to this type of event. This, in turn, enabled the first-time use of a novel analysis technique to distinguish IBD events from a class of background delayed-coincidence events caused by neutrons produced by (α, n) reactions within the detector. This talk will summarize these recent results and highlight the role of the calibration campaign in enabling this improved analysis.

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0νββ and antimatter / 50

Antihydrogen detection with the radial time projection chamber in the ALPHA-g antimatter gravity experiment

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The ALPHA-g experiment at CERN aims to precisely measure the effect of Earth's gravitational field on antihydrogen atoms, providing a unique test of the weak equivalence principle with antimatter. A key component of the ALPHA-g apparatus is the radial time projection chamber (rTPC), which is designed to detect the annihilation of antihydrogen atoms when they come into contact with matter. The accurate detection and reconstruction of these events is crucial for determining the gravitational behavior of antihydrogen. This presentation will discuss a study of the rTPC's performance, with a focus on position- and rate-dependent efficiencies and potential asymmetries that are relevant for future precision gravity measurements.

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Neutrino Physics / 51

Design and construction of the first P-ONE detector line

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Astrophysical neutrinos at the TeV scale would open a new observational window into currently obscured and inaccessible extreme environments, such as the centre of other galaxies. Detecting them poses significant challenges due to their low rate and weak interactions with matter. The Pacific Ocean Neutrino Experiment (P-ONE) addresses this problem by instrumenting a large volume of water at a depth of 2.6 km in the Northeast Pacific Ocean, profiting of a large oceanographic infrastructure maintained by Ocean Networks Canada. The ocean water will be used as a detection medium for the Cherenkov light emitted by the charged secondary particles produced by a neutrino interaction at TeV and above. This is done using an array of photomultiplier tubes encapsulated in glass hemispheres. A total of 20 hemispheres are mounted on a kilometer-high mooring line and read out by a newly designed data acquisition system that ensures sub-nanosecond timing, which is critical for correlating and reconstructing signals across the detector array. This talk will provide an overview of the design and current status of the first mooring line, focusing on its construction, operation and the measurements taken to ensure proper functionality of all its subsystems.

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QCD / 52

BEAM ASYMMETRY FOR THE γp → η Δ+ REACTION AT GLUEX*

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The principal goal of the GlueX experiment at the Thomas Jefferson National Accelerator Facility is to search for
non-q ¯q mesons, a construction not allowed by the simple quark model but predicted by Quantum Chromodynamics.
Specifically, hybrid mesons, which result from the addition of a gluonic field with exotic states and are pictured as a q¯qg
state, will be accessed using a 8.2-8.8 GeV linearly polarized photon beam. Conventional and exotic meson states will
be mapped as a function of their quantum numbers using partial wave analysis (PWA). Utilizing linear polarization,
we can learn more about the photoproduction process, which is needed as an ingredient for PWA. Specifically, the
beam asymmetry will be extracted by exploiting azimuthal-angle distributions, which informs the photo production
mechanism. This asymmetry will be extracted as a function of four-momentum transfer (−t) for the reaction γp →
ηΔ+. Results from the full GlueX-I data set (2017-2018) over a wide range of −t will be shown and will test whether
the production mechanism is dominated by natural (ρ and ω) exchange processes. The results will be compared to
complimentary analyses for the reactions γp → ηp and γp → η′p.

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Nuclear structure / 53

Determination of matter radii and neutron skin thickness of neutron-rich isotopes ^{51,52}Ca

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The unexpectedly large charge radius of the doubly magic nucleus ^{52}Ca, with the new neutron magic number $N = 32$, has puzzled theoretical studies, as this trend differs from a decrease in charge radius observed for closed-shell isotopes ^{40,48}Ca. Only the Hartree-Fock-Bogolyubov calculation with the Fayans energy density function was able to reproduce this experimental result. On the other hand, a rapid growth in the point matter radius was observed for $^{49-51}$Ca isotopes, which could only be explained by considering the swelling of the ^{48}Ca core. In order to understand the abrupt increase in charge radius of ^{52}Ca, it is necessary to determine the extent of its matter distribution to study the effect of neutrons. This also leads to the determination of the neutron skin thickness, which is correlated with the density derivative of the symmetry energy in the equation of state of asymmetric nuclear matter. Therefore, to address this issue, the reaction cross-section of $^{48-52}$Ca was measured at RIBF, RIKEN, using the BigRIPS and ZeroDegree Spectrometer. The cross-section was measured on carbon and polyethylene targets at an energy of approximately 230 MeV/u. The point matter radius of isotopes will be extracted from the measured cross-sections using the Glauber model. The results will determine the structure of neutron-rich calcium isotopes. By determining the neutron skin thickness of two doubly magic calcium isotopes, ^{48}Ca and ^{52}Ca, this measurement will constrain the density derivative of symmetry energy in the equation of state.

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Neutrino Physics / 54

βNMR Spectroscopy of Ta films for the BeEST Sterile Neutrino Search

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The BeEST experiment (Beryllium Electron-capture in Superconducting Tunnel-junctions (STJs)) is a world-leading search for beyond the standard model (or "new") neutrino physics and investigating quantum properties of weak decay using radioactive beryllium atoms embedded into thin-film superconducting quantum sensors. These sensors provide a unique tool for eV-scale measurements of the recoiling atom that accompany the emitted neutrino. The nuclear recoils are encoded with the fundamental quantum information of the decay process and carry unique signatures of new physics, if they exist! One puzzling observation in the ^{7}Li recoil spectra is the fact that the peaks widths are significantly broader than the ~2eV width of the laser peaks set by the energy resolution of the STJ's. This isn't currently understood, thus is a limitation to the progression of the BeEST experimentation through the sensitivity, which is crucial for the observation of small sterile neutrino masses which are especially interesting for warm dark matter candidates. A possible investigation to provide clarity in where this broadening could have come from, involves looking deeper into the material properties of STJ's themselves, especially in the low temperature range. While tantalum has been used for a long time in the fabrication of STJ's, its material behaviours in this environment remain unresearched. With this in consideration, beta-NMR was utilised to analyse the material effects of Ta foils. This experiment consisted of the film being implanted with a ^{8}Li probe, used for its similar properties to the recoil daughter nucleus from the BeEST experiment. This technique allows the ability to infer the probes landing site in the Ta lattice after implantation at 25keV. This presentation will discuss the results from these experiments and indicate probable implantation sites combining experimental data and density functional theory analysis.

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Nuclear structure / 55

Study of Multiple Shape Coexistence in 110Cd

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Cd isotopes, particularly ^{110,112}Cd, have long been considered the best examples of nuclei with vibrational behaviour. However, recent studies challenge this interpretation, suggesting that Cd isotopes possess characteristics of multiple shape coexistence. To further investigate this issue, a series of β-decay experiments were conducted to improve the spectroscopic information on ^{110,112}Cd. The obtained results will be crucial for the complementary Coulomb-excitation studies that aim to determine the intrinsic shapes of low-lying 0^+ states.

The current work examines the nuclear structure of ^{110}Cd through the $\beta-$ decay of ^{110}Ag and the $\beta+$/EC decay of ^{110}In conducted at the TRIUMF-ISAC facility. The radioactive-ion beams of ^{110}Ag and ^{110}In were delivered to a mylar tape located at the centre of the GRIFFIN spectrometer, which consisted of 15 HPGe clover detectors with BGO Compton-suppression shields.

The obtained γ-γ coincidence data was used to construct a level scheme of ^{110}Cd, to confirm previously observed in-band transitions, and to seek evidence for rotational bands in ^{110}Cd. In this presentation, selected preliminary results and key findings will be discussed.

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Poster session / 56

R&D and Status of the LED System for Hyper-K's LED-mPMT Module

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The Hyper-Kamiokande (Hyper-K) main detector is under construction and is planned to begin operation in 2027. The detector will consist of a cylindrical water tank measuring 68 metres in diameter and 72 metres in height, instrumented with 20,000 inward-facing 50-cm photomultiplier tubes (PMTs). To enhance calibration capabilities, 800 of the conventional PMTs will be replaced by multi-PMT (mPMT) modules: 600 regular mPMTs, each equipped with 19 8-cm fast PMTs, and 200 LED-mPMT modules, each equipped with 14 8-cm fast PMTs and five UV-light sources pointing in different directions. Each LED system in the LED-mPMT modules includes three diffuse and four collimated UV-light sources at different wavelengths. The combination of these UV-light sources with the fast timing resolution of the mPMTs will allow us to address two critical calibration needs for Hyper-K: (1) calibrating the diffused light source at the opposite wall to improve understanding of the angular response of the 50-cm PMTs and water-attenuation effects, and (2) calibrating the collimated light source to measure water quality in the tank by analyzing light transmission, including position-dependent scattering effects such as those caused by bacteria. In this presentation, I will talk about the research and development of the LED system for the LED-mPMT module and give an update on its production status. I will then describe the development of experimental test stands to measure both collimated and diffuse light output and to assert the quality and consistency of the devices. Together, these efforts ensure readiness for Hyper-K's start of operation and support its goal of achieving unprecedented precision in neutrino measurements and related physics analyses.

Keywords: Neutrino, calibration, R&D, Hyper-Kamiokande, mPMT, LED-mPMT.

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Poster session / 57

Spectroscopy of A=100 nuclei with GRIFFIN

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A sudden ground-state shape transition is known to occur sharply at $N = 60$, accompanied by equally dramatic changes in the low-energy spectra of the nuclei with A≈100. Detailed spectroscopic data on the γ decay of ^{100}Zr are essential for understanding this phase transition and the emergence of shape coexistence, predicted by recent Monte Carlo Shell Model (MCSM) calculations.

Studying ^{100}Zr via γ-ray spectroscopy following β decay presents an experimental challenge due to the refractory nature of ^{100}Y, which prevents its direct extraction at Isotope Separator On-Line (ISOL) facilities. To overcome this, a beam mixture of ^{100}Rb and ^{100}Sr was delivered to a tape in the center of the powerful Gamma Ray Infrastructure For Fundamental Investigations of Nuclei (GRIFFIN) spectrometer at the TRIUMF facility.

The use of a tape station facilitated the selective separation of short-lived activity, permitting the disentanglement of the complex γ-ray spectra. The collected $\gamma - \gamma$ coincidence data allowed for vastly extending the previously known level scheme of ^{100}Zr and to unambiguously assign the spins of key states via $\gamma - \gamma$ angular correlations.

Selected results will be presented, including evidence for the recently found 0_4^+ state in ^{100}Zr, which was predicted by MCSM to possess a spherical shape. Candidates for a spin-2 member of a band presumably built on the 0_4^+ state will be discussed. Branching and mixing ratios will be used to test the existing structural interpretations.

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Poster session / 58

Insight on shape coexistence in ^{100}Zr through lifetime measurements at GRIFFIN

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The sudden onset of deformation in $A \approx 100$ nuclei at $N = 60$ has been described as a ground-state shape transition that has raised a lot of interest over the years from an experimental and theoretical point of view. This transition is most pronounced in the Zr and Sr isotopic chains where the low-energy excited-state structure shows significant signs of deformation developing at $N = 60$, as opposed to the spherical-like structure observed at $N \leq 58$.

At present, the two most promising theoretical interpretations of this phenomenon are given by the Monte Carlo Shell Model (MCSM) and the Interacting Boson Model with Configuration Mixing (IBM-CM). The MCSM calculations interpret the structure of ^{100}Zr within a multiple-shape-coexistence scenario with several distinct deformed shapes predicted for the lowest 0^+ states, with rotational bands built on top of them. In contrast, the IBM-CM calculations predict a weakly-deformed ‘’intruder” ground-state configuration in ^{100}Zr, with corresponding β and γ bands, and a low-lying spherical ‘’normal” configuration.

In order to test these theoretical models an experiment was performed at Canada’s national particle accelerator centre TRIUMF to investigate the structure of ^{100}Zr following the β decay of ^{100}Y by utilizing the γ-ray spectrometer GRIFFIN (Gamma Ray Infrastructure For Fundamental Investigations of Nuclei). The 15 hyper-pure Ge clover detectors of GRIFFIN were coupled with seven lanthanum bromide detectors for fast-timing lifetime measurements using the Generalized Centroid Difference method.

The lifetimes of several key excited states in ^{100}Zr, extracted for the first time in this study, will be compared to the MCSM and IBM-CM theoretical predictions. Evidence supporting the shape-coexistence scenario in ^{100}Zr will be presented, together with the notable structural similarities between ^{100}Zr and ^{98}Sr.

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Neutrino Physics / 60

Time-Charge HEALPix Direction Reconstruction Fitter for Supernova Neutrinos in Super-Kamiokande

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Supernova (SN) localization from water-Cherenkov neutrino detectors is critical for capturing early optical observations of the next galactic SN, as neutrinos are the earliest observables arriving well before shock breakout. SN neutrino bursts detected by Super-Kamiokande (SK) produce thousands of PMT time-charge (TQ) signals which contain directional information. Our current direction reconstruction pipelines at SK rely on first reconstructing the vertex, energy, and directions of all events. This enables highly resolved, but computationally costly, real-time SN localization that increases the alert latency when sending notices to the General Coordinates Network (GCN). We are developing a new reconstruction fitter that maps individual PMT hit TQ data onto a HEALPix sphere to directly extract directional information, bypassing individual event reconstruction. In this presentation, we describe the characteristics of the hit map and the methods of directional analysis. Preliminary results indicate direction reconstruction is done in $\mathcal{O}$(1 sec) compared to $\mathcal{O}$(90 sec) with our current reconstruction fitters, but consistent directional accuracy needs further development. This approach shows promise for improving rapid SN pointing and burst detection in future early-warning systems.

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0νββ and antimatter / 61

Vacuum Ultraviolet Stability Measurements of Silicon Photomultipliers at Liquid Xenon Temperatures.

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Silicon photomultipliers (SiPMs) are single-photon-sensitive devices under consideration for light sensing in noble liquid detectors. One of the experiments considering SiPMs is the neutrinoless double beta decay experiment nEXO. nEXO plans to search for this decay with 5 tonnes of liquid xenon enriched in the isotope Xe-136 over a lifetime of 10 years. SiPMs will be placed inside the liquid xenon volume to detect scintillation light. This long operating time necessitates the characterization of the response of nEXO's SiPM candidates, either VUV4 HPK (Hamamatsu) or FBK HD3, under conditions similar to those of the experiment. While non-ionising radiation (bulk) damage on SiPMs has been well studied, ionising radiation (surface) damage in the top SiO2 layer of SiPMs, which

causes surface currents, has not yet been investigated extensively. In this work, we present the study of VUV4 HPK SiPM performance at 165K (liquid xenon temperature) for different Vacuum UltraViolet (VUV) light exposure periods. Specifically, we investigate variations in dark count rates as a result of non-ionizing radiation damage, and leakage current variations caused by both ionizing and non-ionizing radiation damage of SiPMs. Latest results will be presented.

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Electroweak Physics / 62

The MOLLER Experiment: Probing Electroweak Dynamics via Parity-Violating Electron Scattering

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The MOLLER experiment aims to constrain fundamental parameters in the Standard Model by measuring the parity-violating asymmetry A_{PV} induced by the interference between electromagnetic and weak neutral current amplitudes. MOLLER will utilize polarized Møller scattering at Jefferson Lab to measure a highly precise 0.8 part per billion (ppb) uncertainty on the predicted 33 ppb A_{PV}. This precision will yield a 2.4% determination of the electron's weak charge and ultimately determine the weak mixing angle to 0.1% fractional uncertainty. As the most precise measurement of the weak mixing angle at low momentum transfer, the results will provide a unique probe into new, parity-violating physics at both MeV and multi-TeV scales. MOLLER has been designed to reach its precision through meticulous planning and the innovative design of its experimental apparatus—including the highest-power liquid hydrogen target to date, a toroidal spectrometer, and several detector systems capable of operating in tracking and integrating modes. This talk will outline the physics objectives, experimental design, and current status of construction efforts.

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0νββ and antimatter / 63

Dory: An Optical Monitoring and Calibration Module for the nEXO Outer Detector

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Neutrinoless double beta decay ($0\nu\beta\beta$) is a hypothetical nuclear process in which two neutrons in a nucleus transform into two protons and two electrons without emitting electron antineutrinos. Its observation would demonstrate lepton number violation in weak processes and confirm that neutrinos are Majorana particles. Next-generation $0\nu\beta\beta$ searches using candidate isotopes aim to reach half-life sensitivities beyond 10^{28} years. nEXO is a proposed experiment targeting this regime using ^{136}Xe in a liquid xenon (LXe) time projection chamber (TPC). The LXe TPC is housed within a vacuum insulated cryostat and shielded by a 12.3 m diameter, 12.8 m high tank containing 1.5 kilotonnes of ultra-pure water, instrumented with 125 photomultiplier tubes (PMTs). The water tank and the PMT array form the nEXO water Cherenkov muon veto system, also known as the Outer Detector (OD).

To ensure the long-term stability and performance of OD, a monitoring and calibration system is under development. In this system laser light is delivered via optical fibers to optical modules, called Dory, deployed inside the water tank. Each Dory module consists of a PTFE plug and sphere that together form the diffuser. The diffuser is housed inside a pressure enclosure composed of a glass dome window and inner and outer flanges. The Dory modules emit light isotropically, enabling water quality monitoring and PMT timing calibration.

We are preparing a setup for Dory prototype to verify its isotropic emission profile. The system uses a two-axis rotary stage on which the Dory module is mounted, allowing 4π angular coverage. A fixed PMT records the light intensity at each orientation of the module, producing a map of its emission profile.

In this talk, I will present the design and current development status of Dory, discuss the required upgrades identified during prototyping, describe the Dory test setup, and show first measurements of its light emission profiles.

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Poster session / 64

Light Sterile Neutrino Contributions to Neutrinoless Double-beta Decay

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Sterile neutrinos appear in various extensions of the Standard Model and can help explain the origin of the observed active neutrino masses. Light sterile neutrinos in particular can contribute to the neutrinoless double-beta ($0\nu\beta\beta$) decay amplitude, providing an additional avenue to probe new physics, in addition to the established sensitivity of the process to the Majorana nature of the neutrino, lepton-number violation, and the absolute neutrino-mass scale. In this talk, we present the first ab initio nuclear theory determination of nuclear matrix elements (NMEs) crucial in describing light sterile neutrino contributions to $0\nu\beta\beta$ decay. In contrast to previous phenomenological calculations, we use the Valence-Space In-Medium Similarity Renormalization Group (VS-IMSRG) method, which enables rigorous quantification of theoretical uncertainties. Results are presented for key isotopes of experimental interest, alongside constraints on sterile neutrino mixing from current and next-generation experimental searches.

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Nuclear Physics / 65

Toward APNC measurements in Fr: recent progress and ongoing developments at TRIUMF

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The FrPNC collaboration is working toward a campaign of atomic parity non-conservation (APNC) measurements in francium to study the weak nuclear force. Weak interactions between atomic electrons and nucleons make it possible for electric dipole (E1) transitions to occur between atomic S states. As the heaviest alkali atom, Fr has a higher sensitivity to APNC because the effect scales with nuclear charge roughly as Z^3. We plan to measure the $E1_{pnc}$ transition amplitude on the 7S→8S transition in Fr. These measurements will be carried out at the Francium Trapping Facility (FTF) located at TRIUMF. At the FTF, our group regularly uses AMO techniques to confine Fr and Rb atoms in a magneto-optical trap and investigates highly forbidden optical transitions in these atoms with precision laser spectroscopy. In this talk I will describe these techniques with a particular focus on the most recent experiment from January 2026 to measure the DC Stark shift of the 7S→8S transition in Fr and I will provide preliminary observations. I will also motivate and discuss the ongoing development of optical pumping to spin-polarize cold atom samples for APNC measurements.
This work is supported by the Natural Sciences and Engineering Research Council of Canada (NSERC), TRIUMF through the National Research Council of Canada (NRC), and the University of Manitoba.

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Nuclear structure / 66

DLC-coated guides for the TUCAN EDM experiment

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The neutron electric dipole moment (nEDM) is an important property that can reveal additional breaking of fundamental symmetries, such as charge-parity symmetry, which may help explain why the universe is dominated by matter. The TUCAN collaboration is commissioning a next-generation ultracold neutron (UCN) source to deliver higher UCN density to experiments, aiming to improve the

statistical precision of future nEDM measurements to a sensitivity of 10^{-27} e·cm. Ultracold neutrons, with energies in the nano-electronvolt range, can be stored for long periods, enabling precise studies of neutron properties.

Reaching these scientific goals requires transporting UCNs from the source to the experiment with minimal losses, which places strict demands on the surface quality of the UCN guides. To meet this need, a dedicated coating facility has been established at the University of Winnipeg to produce diamond-like carbon (DLC) coatings for the aluminum guides used in the TUCAN nEDM experiment. The system uses a high-power excimer laser and a custom vacuum-deposition chamber to apply low-loss, stable DLC films to the inner surfaces of the guide tubes. This talk will highlight the progress in facility setup, coating procedures, and preliminary surface science results, showing how DLC-coated guides contribute to improving UCN transport and enabling precise nEDM measurements.

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Electroweak Physics / 67

Mass Sensitivity Study of Boosted b-jet Reconstruction with Muon-in-Jet Corrections and Regressed Models

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The Higgs self-coupling, as related to the shape of the Higgs potential, is central to several fundamental questions, such as the dynamics of the early universe, its expansion and cooling, and the origin of baryon asymmetry. By analyzing di-higgs events that occur during proton-proton collisions in the ATLAS experiment, observed bounds have been placed on this self-coupling value, but remain insufficient to probe BSM modifications to the Higgs potential relevant for scenarios of early-universe dynamics. To improve these bounds, sensitivity at every step in the calculation must be improved, including sensitivity of reconstructed jet kinematics. For the di-higgs analysis isolating boosted 4b final states, improvements have been introduced for large radius b-jet reconstruction, including reintroducing energy from muons and muon neutrinos that had not been considered previously, and implementing machine learning regression models to reconstruct jet variables. This project quantifies these improvements considering sensitivity of reconstructed jet mass. The mass sensitivity can be improved by as much as 30% when comparing baseline reconstructed values to ones found with ML regression techniques for transverse momentum above 0.6 TeV. Techniques and limitations will be discussed.

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Poster session / 68

Status and Prospects of the RadioActive isotope Measurement Program at SNOLAB (RAMPS)

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The RadioActive isotope Measurement Program at SNOLAB (RAMPS) is designed to perform first direct measurement of long-lived nuclear decay processes. The pilot project focuses on performing the first direct measurement of the excited-state electron capture decay of Lutetium-176, a theoretically predicted yet experimentally unobserved nuclear transition. Understanding this highly suppressed transition can provide insight into electroweak interactions which in turn can inform the prediction for the neutrinoless double beta decay searches and advancing theoretical frameworks describing long-lived nuclear processes.

Beyond its fundamental physics objectives, a precise measurement of the excited-state branching ratio will refine the total decay constant of the Lu-176 to Hf-176 system. This will help geochronological applications in dating ancient terrestrial and meteoritic samples. Additionally, improved characterization of this decay channel informs astrophysical models of slow neutron capture (s-process) nucleosynthesis, improving our understanding of heavy element production in giant stars.

RAMPS's experimental setup is deployed 2 kilometre underground at SNOLAB's clean-room facility, providing low background environment. RAMPS employs a triple-coincidence detection method to identify the characteristic excited-state electron capture decay event signature. The system utilizes two high-purity germanium (HPGe) detectors, which provide superior energy resolution for detecting gamma rays from nuclear de-excitation. A silicon photomultiplier (SiPM) coupled with a LuAG crystal scintillator detects the characteristic X-rays produced during atomic de-excitation following electron capture.

In this talk, I will provide an overview of the RAMPS program objectives and the current status of the project, including detector system configuration and characterization as well as analysis methods for identifying rare triple-coincidence events and upcoming data collection timeline.

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Poster session / 69

Improving SNOLAB Radon counting sensitivity with low-background ZnS

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Rn-222 progeny produce unwanted background events in underground rare-event searches including those for dark matter and neutrinoless double beta decay. ZnS(Ag)-coated Lucas cells were used during the SNO experiment to evaluate Radon emanation into light water and continue to be used for ex-situ measurements of Radon concentration in SNO+ and at SNOLAB for materials assays. Support for current and future experiments housed at SNOLAB motivates the development of new Lucas cells to further improve SNOLAB's capabilities for characterizing materials radio-purity with greater precision and sensitivity.
In this presentation, Radon assays are introduced and developments for next-generation Lucas cells will be discussed. Topics include background characterization for Lucas cell components, fabrication methods, and development of ZnS synthesis and doping techniques. Future prospects and current investigations will be shared, including studies into elimination of U-238 chain impurities.

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Electroweak Physics / 71

Background Systematics in $HH \to b\bar{b}b\bar{b}$ gluon-gluon fusion

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The Standard Model (SM) predicts pair production of the Higgs boson, but it has not yet been observed. The physics involved in the creation of Higgs pairs can address numerous open questions in the SM.

There are several searches for Higgs pairs at the ATLAS detector, where they are formed primarily through gluon-gluon fusion (ggF), and the largest decay channel is to b-quark jets. Thus, analysis of $gg \to HH \to b\bar{b}b\bar{b}$ benefits from having the most data of any Higgs pair search. However, it also has the largest background, as there are many processes in the ATLAS detector with similar multijet signatures. The main goal of this analysis is to measure the Higgs self-coupling (κ_λ) and the observed signal strength (μ) relative to the SM expectations.

Monte Carlo simulation of this process is not sufficiently accurate, and the computing cost is very high, so the background must be derived through data-driven methods. Uncertainties in the background have been the largest in the analysis and have hindered its sensitivity. In this talk I will demonstrate a new approach to the background uncertainties, where the variance and bias systematics are measured using auxiliary datasets. This method allows for a more accurate determination of the uncertainty and could elevate the sensitivity of the analysis.

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Neutrino Physics / 72

Understanding neutrinos with accelerator beams and liquid argon time-projection chambers: ICARUS and DUNE

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A global program of experiments has worked towards characterizing neutrino oscillation over the past few decades. However, important parameters remain to be measured, and mysteries remain

to be elucidated. Current and upcoming experiments are targeting the open questions and probing the consistency of the neutrino oscillation paradigm. Likewise, the liquid argon (LAr) time-projection chamber (TPC) has emerged as a sensitive particle detection technology for neutrino experiments.

A current generation of LAr TPC detectors are being used to study neutrinos while also gaining important experience in operating and analyzing with this technology. SBND, MicroBooNE, and ICARUS have collected or are collecting data from beams at Fermilab (near Chicago) to explore the possibility of a sterile neutrino and/or other beyond Standard Model (BSM) physics. SBND and ICARUS will be used to conduct a two-detector analysis as part of the Short Baseline Neutrino (SBN) Program. Additionally, these detectors are enabling important neutrino interaction studies necessary to prepare for the next generation of oscillation experiments.

One such oscillation experiment that will come online over the next years is the Deep Underground Neutrino Experiment (DUNE), which will install multiple 10 kiloton LAr TPCs underground in South Dakota (south of Saskatchewan) to conduct oscillation measurements with neutrinos originating in a beamline at Fermilab. A detector complex will be installed at Fermilab as well, to study the beam before the expected flavour oscillations. This "near detector"will also employ a LAr TPC, with a segmented and pixel-based design, as well as other technologies to constrain uncertainties in the oscillation measurement by characterizing the beam and neutrino interactions.

This talk will discuss the ICARUS and DUNE experiments, the LAr TPC detector technology, and the efforts to realize and leverage these experiments to better understand the properties of neutrinos.

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Electroweak Physics / 73

HEP for AI and AI for HEP

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AI is everywhere, but a theoretical understanding of AI behaviour is still lacking. In this talk I will show how high-energy physics, in particular our well-understood data structures, can help open the black box of AI. Closing the circle, a better understanding of AI will help us use AI to better understand the physics of our universe.

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Nuclear Physics / 74

Neutron-rich nuclei and neutron-rich stars: a trapped ion's perspective of the two infinities

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Now famous as quantum computers, ion traps were already recognized (with the 1989 Nobel Prize) as superior instruments for precision measurements, made possible by long-term observation of their stored quarry.

The use of ion traps for measuring nuclear binding energies at on-line radioactive beam facilities (first CERN-ISOLDE, later TRIUMF-ISAC) has now brought improved topographical knowledge of the nuclear chart, revealing a richness of emergent nuclear structure - yet to be explained by the quarks and gluons of quantum chromodynamics.

Defining the energy available for reactions, the nuclear binding energy plays a key role in the stellar process of rapid neutron-capture nucleosynthesis that created the heavy elements, forming the basis of ourselves and our daily life. This *r* process was recently observed thanks to a "heads up"detection of gravitational waves from neutron-star merger GW170817 that has ushered in the present era of multi-messenger astronomy.

Understanding neutron stars and their associated gravitational wave signal requires deriving a nuclear equation of state –which can also be achieved from the same binding-energy data. Using an equation of state, with the help of the Tolman-Oppenheimer-Volkoff equations derived from General Relativity, we can perform the interesting thought experiment of drilling into the crust of a neutron star to mine these same heavy elements!

Optional reading:
"The origin of the elements and other implications of gravitational wave detection for nuclear physics,"
4Open Science 3, 14 (2020)
https://doi.org/10.1051/fopen/2020014

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Nuclear Physics / 76

How nuclear physics experiments shape our understanding of supernova γ-ray signatures

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The long-lived γ-ray isotopes observed in core-collapse supernovae remnants are direct signatures of the nucleosynthesis processes that occurred during the explosion. However, interpreting these signatures to understand the explosion dynamics requires precise nuclear physics input. Recent sensitivity studies have identified the $^{13}N(\alpha,p)^{16}O$ reaction as a major nuclear uncertainty affecting the production of observable isotopes like ^{44}Ti, ^{56}Ni, and neutron-rich iron-group elements [1,2]. However, the reaction remains poorly constrained, with existing estimates relying on statistical models or indirect measurements and only one direct measurement at relatively high energies [3,4]. To directly address this uncertainty, we performed a new measurement of the $^{13}N(\alpha,p)^{16}O$ reaction cross section. Using the thick-target inverse kinematics technique with a high-intensity radioactive ^{13}N beam at the CRIB facility (RIKEN), we probed the astrophysically relevant energy range ($E \approx 1.2$–5.0 MeV). This talk will present our experimental approach and the preliminary results from this campaign. This work shows how targeted nuclear physics experiments provide critical data needed to interpret astrophysical observations. By constraining this key reaction rate, we will directly refine nucleosynthesis models, improve the interpretation of current γ-ray data from supernova remnants, and enable more accurate predictions for next-generation space-based observatories.

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Dark Matter / 77

Expanding the Reach of Argon-Based Dark Matter Searches

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Liquid argon has proven to be a powerful medium for detecting GeV-scale dark matter, as demonstrated by the DEAP-3600 and DarkSide-50 experiments. Building on these successes, DarkSide-20k is now under construction at LNGS as the first flagship detector of the Global Argon Dark Matter Collaboration. With a 50-tonne ultra-pure argon target and exceptionally low backgrounds, DarkSide-20k, in about 10 years of data-taking, will scan for any WIMP interaction in argon above the neutrino fog for WIMP masses above a few GeV and up to 10^5 GeV.

To push noble liquid experiments sensitivity **below the GeV scale**, new detection strategies are required. At Queen's University, we are investigating the use of **molecular dopants**—introduced at part-per-million concentrations into liquid argon—**to enhance ionization yield and lower the effective energy threshold**. Identifying the optimal dopant mixture would enable a next-generation experiment proposed for SNOLAB within the coming decade. Such an experiment could exclude, or potentially discover, sub-GeV dark matter interacting as faintly as solar neutrinos within roughly one year of data-taking, **opening a new observational window on the fundamental composition of the Universe**.

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Neutrino Physics / 78

EDI in Physics