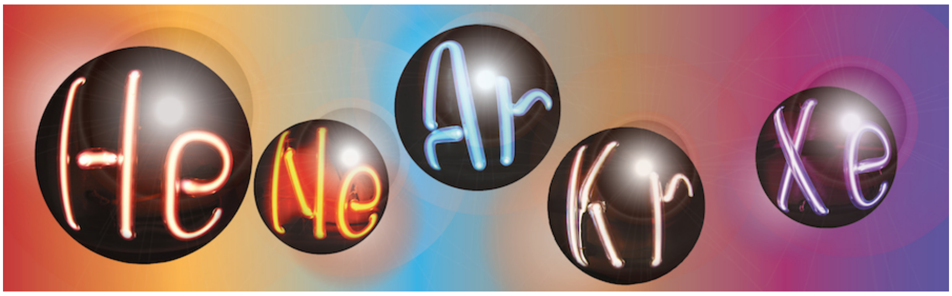
LIDINE 2026: LIght Detection In Noble Elements



Report of Contributions

https://indico.nikhef.nl/e/7584

Contribution ID: **6** Type: **Talk**

Design and Characterization of a Readout System for Large-Area SiPM Arrays in the DarkSide-20k Neutron Veto

DarkSide-20k is a global direct dark matter search experiment in the construction phase at LNGS (Italy). The core of the detector is a dual-phase Time Projection Chamber (TPC) filled with 50 tonnes of low-radioactivity liquid argon. The entire TPC wall is surrounded by polymethylmethacrylate (PMMA), which acts as a neutron veto, immersed in a second low-radioactivity liquid argon bath enclosed in a stainless-steel vessel. The TPC and the neutron veto are enclosed within the cryostat volume, which is filled with 650 tonnes of atmospheric argon comprising the outer veto volume. DarkSide-20k aims to reach a world-leading high WIMP mass 7.4 x 10-48 cm2 for a 1 TeV/c2 WIMP in a background-free instrumental background in 200 tonne x years. A key role is played by the neutron veto, which is instrumented with large-area light detectors utilising a custom Silicon Photo-Multiplier (SiPM) technology optimised for high optical photon detection efficiency and low noise at liquid argon temperatures. SiPMs are arranged in a compact design meant to minimise the material (and hence the radioactive budget) used for the active electronics, cables and connectors: the veto PhotoDetection Units (vPDUs). A vPDU comprises 16 "Tiles", each containing 24 SIPMs, together with front-end electronics, and a motherboard (which distributes voltage and control signals, sums Tiles channels, and drives the electrical signal transmission), providing a single readout area of 10x10 cm2.
This talk presents the characterisation of the vPDUs operated in cryogenic conditions using liquid nitrogen, with measurements conducted across international laboratories in the UK and Poland. The study includes tests of the readout performance, stability, and noise behaviour, together with radiopurity-driven material selection and background modelling to assess the impact of the veto readout system on the overall background budget of the DarkSide-20k experiment.

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Contribution ID: **7** Type: **Talk**

Production and characterization of Photosensors for the DarkSide-20k Dark Matter Experimen

The DarkSide-20k is a next-generation dark matter experiment aiming at a direct detection of Weakly Interacting Massive Particles (WIMPs) via nuclear recoils in liquid argon. The detector, currently under construction at the Gran Sasso National Laboratory (LNGS), Italy, will benefit from the natural shielding against cosmic rays provided by the lab's underground location. It will employ a dual-phase time projection chamber (TPC) with a 50-tonne of underground-sourced argon acting as an active volume. DarkSide-20k is designed to operate in an "instrumental background-free" regime over a planned exposure of 200 tonne-years.
A key element in reaching this goal is the photon detection system based on custom-developed cryogenic Silicon Photomultiplier (SiPM) arrays, designed to provide high photon detection efficiency, low noise, and stable operation in liquid argon conditions. These photosensors instrument both the active veto detectors and the top and bottom planes of the TPC, covering a total active optical surface of about 28 m^2.
The TPC photosensors are currently being produced, assembled, and characterized by the DarkSide collaboration at Nuova Officina Assergy in LNGS and at the Photodetector Test Facility (PTF) in Naples. This contribution will present the strategy adopted for the large-scale production and validation of the SiPM arrays, including testing procedures, quality control protocols, and performance characterization at cryogenic temperature.

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Contribution ID: **8** Type: **Talk**

Amorphous Selenium as a Scalable Path to Integrated Charge-and-Light Readout in Noble-Element Detectors

Efficient detection of vacuum-ultraviolet scintillation light remains a central challenge for liquid noble detectors, particularly as future experiments move toward highly segmented, pixelated readout architectures. Amorphous selenium (a-Se) offers an appealing path toward scalable, cryogenic photon detection because it combines low dark current, thin-film manufacturability, broad spectral sensitivity, and compatibility with direct VUV-to-charge conversion. We present recent progress on the testing and characterization of a-Se-based photon detectors for liquid noble applications, spanning material studies, device fabrication, and cryogenic detector response. Prototype sensors have been characterized as a function of temperature and electric field, with measurements targeting low-photon-yield response and operating regimes relevant to liquid argon and liquid xenon TPCs. We also describe progress toward transparent graphene top electrodes, including transfer methods optimized to avoid crystallization or delamination of the underlying a-Se. In parallel, EXAFS measurements of a-Se and Se/Te alloys provide element-specific information on short-range structural evolution at cryogenic temperatures and under optical illumination. These combined studies connect microscopic material behavior to device-level performance, advancing a-Se photodetectors toward use in integrated charge-and-light sensing for future noble-element experiments.

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Contribution ID: **9** Type: **Talk**

Characterization of candidate wavelength-shifting reflectors for the LEGEND-1000 liquid argon instrumentation

Located at LNGS, LEGEND (Large Enriched Germanium Experiment for Neutrinoless ββ Decay) aims to probe the Majorana nature of the neutrino by observing the neutrinoless double beta decay in high-purity germanium crystals enriched in 76Ge and immersed in an ultrapure instrumented liquid argon (LAr) volume. The first phase, LEGEND-200, has collected data since spring 2023, while the second phase, LEGEND-1000, currently in the technical design phase, is expected to reach a discovery sensitivity to the decay half-life of 10ˆ28 years over a 10-year data-taking period starting around 2030. The LAr instrumentation is pivotal in background rejection, by collecting the scintillation light generated by background interactions in the LAr. Wavelength-shifting reflective (WLSR) materials are employed to enhance the light collection efficiency.

A common choice of WLSR for particle physics experiments employing LAr is the reflective Tetratex® (expanded polytetrafluoroethylene, ePTFE) coupled to the wavelength-shifting tetraphenyl butadiene (TPB). Within this R&D effort, we are studying and characterizing novel WLSR materials for LEGEND-1000 that can better meet the experiment requirements in terms of light collection efficiency, radiopurity, stability and scalability. Candidate materials include crystallized polyethylene naphthalate, which acts as both wavelength-shifter and reflector, thin reflective films based on sintered PTFE, polyethylene terephthalate, and high-density polyethylene, which are candidate scattering substrates to possibly be coupled to wavelength-shifting molecules.

In this talk, we compare the relative VUV response, visible reflectance, emission spectra, and cryogenic stability of candidate materials, assessed with the Liquid Argon Setup (LArS) at the University of Zurich, against the TPB-coated Tetratex® reference used in LEGEND-200. We also present the recent upgrades performed on LArS to improve its measurement capabilities.

This work is supported by the US DOE and NSF; the LANL, ORNL and LBNL LDRD programs; the European ERC and Horizon programs; the German DFG, BMFTR, and MPG; the Italian INFN; the Polish NCN and MNiSW; the Czech MEYS; the Slovak APVV; the Swiss SNF; the UK STFC; the Canadian NSERC; the Chinese (Taiwan) MOE and NSTC; and the LNGS and SURF facilities.

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Contribution ID: **10** Type: **Talk**

Gaseous wavelength shifting in CF_4-based mixtures: from microscopic modelling to scintillation observables

Gaseous wavelength shifting in CF_4-based mixtures: from microscopic modelling to scintillation observables
Gaseous wavelength shifting (GWS) plays a key role in the optical readout of modern micropattern gaseous detectors (MPGDs). It is closely analogous to Penning transfer, but involves excitation transfer rather than ionization transfer. In principle, GWS enables trace additive concentrations to tailor both the spectrum and intensity of gas scintillation.
Indirect, mostly qualitative, evidence suggests that GWS is present in CF_4-based mixtures under conditions relevant to gaseous detectors. Here we show that a joint description of primary X-ray-induced and secondary avalanche-induced scintillation in Ar–CF_4 and He–CF_4 mixtures provides a stringent test of this hypothesis. We develop a simple kinetic model based on the atomic and molecular states populated during electron transport, as estimated using state-of-the-art Degrad/Garfield++ cross sections. The model reproduces scintillation yields and emission spectra for both primary and secondary processes using the same input parameters.
We argue that the combination of Degrad/Garfield++ electron transport with the proposed kinetic model provides a practical and internally consistent framework for predicting primary and secondary scintillation in the technologically relevant wavelength range, from 400 to 800 nm, over pressures from 50 mbar to 10 bar and arbitrary CF_4 concentrations. The data indicate a strong wavelength-shifting capability in Ar-based mixtures, driven by transfer from Ar excited p-states to CF_3 Rydberg-like p-states, followed by p⟶s and p⟶p radiative branches contributing to the visible and UV regions, respectively. Unquenched Ar excited p-states emit intensely in the red/near-infrared region. No comparable enhancement of either the visible component or the red/near-infrared emission is observed in He-based mixtures, resulting in lower scintillation yields per electron.
We conclude by presenting state-of-the-art theoretical predictions, including DFT and coupled-cluster calculations, to describe the main spectral observations qualitatively. Finally, we place this work in the broader context of Ar/N_2 and Ar/Xe systems, whose study is also at an advanced stage.

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Contribution ID: **11** Type: **Talk**

Latest LEGEND-200 results for germanium-based neutrinoless double beta decay searches

The LEGEND experiment is designed to search for neutrinoless double beta decay of Ge-76. This decay, if observed, would establish the Majorana nature of neutrinos and demonstrate lepton number non-conservation. The first stage of the program, LEGEND-200, is currently taking physics data at the INFN Laboratori Nazionali del Gran Sasso and can accommodate up to about 200 kg of enriched high-purity germanium detectors.

This contribution presents the latest LEGEND-200 results, with emphasis on the performance of the germanium detector array, energy reconstruction, detector stability, and background levels in the region of interest. Recent hardware upgrades of LEGEND-200 are also discussed, including the optimization of components with lower background. The impact of these improvements on detector operation, data quality, and background reduction is presented. The contribution concludes with the ongoing LEGEND-200 program, including continued data taking, further detector deployment, and the path toward reaching the experiment design exposure and sensitivity.

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Presenter: D'ANDREA, Valerio (INFN Laboratori Nazionali del Gran Sasso)

Contribution ID: **12** Type: **Talk**

The Light Readout System of the DUNE 2x2 Demonstrator

The Deep Underground Neutrino Experiment (DUNE) is a long-baseline neutrino oscillation experiment currently under construction at the Sanford Underground Research Facility, with a near detector planned for installation at Fermi National Accelerator Laboratory (Fermilab). The 2x2 Demonstrator, a DUNE Near Detector prototype currently operating at Fermilab, recorded ˜30,000 neutrino interactions in 2024, took data with a series of radioactive sources in 2025, and is scheduled to collect several additional months of neutrino beam data in 2026.

Composed of four integrated, single-phase, 600 kg liquid argon modules, the 2x2 Demonstrator prototypes the modular design of the DUNE Liquid Argon Near Detector in beamline conditions. Designed to optimize performance in an unprecedented, high-pileup, neutrino beam environment, the 2x2's four modules are bisected into eight optically isolated time projection chambers (TPCs), each of which contains a pixelated charge readout and 16 wavelength-shifting light traps. The 2x2 Demonstrator uses two distinct light trap designs coupled to a total of 384 Hamamatsu silicon photomultipliers, which collectively provide O(ns) timing with pileup separation on the order of ˜200 ns, as well as spatial reconstruction. This talk will provide an overview of the 2x2 Demonstrator's light readout system: its design, its calibration techniques, its performance at high and low energies, and fledgling efforts to incorporate pulse shape analysis tools for applications in the neutrino beam.

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Presenter: WHITE, Angela (University of Chicago)

Contribution ID: **13** Type: **Talk**

The DarkSide 20k experiment: construction and goals

The DarkSide 20k experiment is the next generation Liquid Argon-based, direct Dark Matter search experiment, focusing on extending the present sensitivity limits on the search for WIMP-like particles. It is a dual-phase LAr-TPC equipped with custom-developed arrays of SiPMs, assembled at LNGS, for light readout. The project draws from the successful experiences of DS50 and DEAP, to which it adds the use of a DUNE-like membrane cryostat, that will hold the main detector vessel in a bath of atmospheric argon (AAr). The actual detector will sit in a leak-tight stainless-steel vessel, hanging from the cryostat and filled with underground argon (UAr), depleted in 39Ar, specially extracted from the Urania plant in Colorado.
The cryostat and AAr cryogenics plant are completed at LNGS; the production of detector components is ongoing, with the photosensors being produced in LNGS and tested in Naples, whereas TPC parts will undergo test assembly and preparation in the University of Alberta in the second half of 2026.
This contribution aims at giving an overview of the DarkSide detector and goals, along with its rich prototypes program. As well, status of construction will be described in detail, focusing on the cryostat and cryogenics plants, and the production and test of photodetectors.

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Presenter: ZANI, Andrea (INFN Milano)

Contribution ID: **14** Type: **Poster**

Neutrino magnetic moment constraint based on DarkSide-50 results

This work investigates the feasibility and sensitivity of constraining the neutrino magnetic moment with liquid-argon detectors using DarkSide-50 data corresponding to an exposure of approximately $12\ \mathrm{ton}\cdot\mathrm{d}$.
To describe solar neutrino scattering in liquid argon, a neutrino–electron elastic scattering model including both weak and electromagnetic interactions is constructed. The analysis is performed using a Profile Likelihood method, with the uncertainties in the solar neutrino flux and background normalizations treated as nuisance parameters. Using the observed DarkSide-50 data, an upper limit on the neutrino magnetic moment of $\mu_\nu < 1.57\times10^{-11}\mu_B$ is obtained at 90% C.L.
In addition, Asimov datasets are used to study the impact of exposure and different background components on the projected sensitivity. The results indicate that the $^{39}\mathrm{Ar}$ and PMT backgrounds are the main factors limiting further improvements in sensitivity. For example, at an exposure of $12\ \mathrm{ton}\cdot\mathrm{d}$, assuming effective suppression of the $^{85}\mathrm{Kr}$ background and a 90\% reduction of the $^{39}\mathrm{Ar}$ background, a projected upper limit of $\mu_\nu < 1.05\times10^{-11}\mu_B$ can be achieved at 90% C.L.

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Presenter: CHEN, Yiming (IHEP-CAS)

Contribution ID: **15** Type: **Talk**

Projection of purification performance in LXeTPC for the RELICS experiment

The RELICS (REactor neutrino LIquid xenon Coherent elastic Scattering) experiment employs a dual-phase liquid xenon time projection chamber to search for Coherent Elastic Neutrino-Nucleus Scattering (CEνNS) induced by reactor neutrinos. To detect these sub-keV nuclear recoils and minimize signal attenuation, it is critical to maintain a sufficiently low impurity concentration in the detector. To this end, we have developed a comprehensive purity evolution model that describes impurity migration inside the detector, taking into account the outgassing of electronegative impurities from materials and incorporating non-uniform transport mechanisms of impurities, including circulation, vaporization, and condensation. The model is validated using data from a dedicated prototype detector. Based on this validated model, projections for the purification performance of the upcoming RELICS detectors are provided. We also expect this model to be applicable to other similar experiments that require strict purity control.

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Presenter: YU, Jiachen (University of Science and Technology of China)

Contribution ID: **16** Type: **Talk**

Understanding infrared scintillation light in xenon

Thanks to its excellent properties, xenon is widely used as a target material in dark matter and rare-event search experiments. Ultraviolet scintillation has long been recognized as the primary signal channel in xenon-based detectors and its properties have been well studied. However, xenon also scintillates infrared light, a component which has received very little attention so far. Taking advantage of this additional signal could enhance the performance of future xenon detectors.
This contribution reports recent progress on the characterization of infrared scintillation in both gaseous and liquid xenon, with particular emphasis on its pulse-shape behavior. Furthermore, new wavelength-resolved measurements of the infrared emission are presented, providing enhanced insight into its spectral structure and the mechanisms underlying its production.

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Presenter: MARRODAN UNDAGOITIA, Teresa (Max-Planck-Institut für Kernphysik, Heidelberg)

Contribution ID: **17** Type: **Talk**

Xenon Doping in ProtoDUNE-VD

The Deep Underground Neutrino Experiment (DUNE) employs large Liquid Argon Time Projection Chambers (LArTPCs) to address key questions in neutrino physics and astroparticle physics. Doping Liquid Argon (LAr) with xenon is proposed to improve light-collection uniformity and efficiency, thereby improving timing, triggering, and low-energy physics capabilities. This work details xenon-doping studies performed in the ProtoDUNE Vertical Drift (VD) detector at CERN in 2026. The standard DUNE photon detection system recorded the time profile of xenon-doped LAr over seven xenon injections, from approximately 10 parts per billion to 10 parts per million (ppm). Over the 12 detectors studied, one featured a quartz window to suppress the detection of scintillation light from pure LAr. This setup facilitated a systematic study of the light, employing a global fit across all detectors with a strong constraint on the xenon component of the light. A cosmic ray tagger, operated in two configurations, allowed for the study of charge and light from crossing muons. This xenon doping campaign achieved stable and improved operation of a large-scale LArTPC doped with 10 ppm of xenon, representing a significant milestone for the DUNE Collaboration.

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Presenter: VIEIRA DE SOUZA, Henrique (INFN - Milano Bicocca)

Contribution ID: **18** Type: **Poster**

Optimization of dual-phase doped argon TPCs for dark matter WIMP detection

Dual-phase argon Time Projection Chambers (TPCs) are a leading technology for rare-event searches including dark matter WIMP and neutrino interactions. Searching for dark matter candidates at lower masses requires detectors with lower energy thresholds than those of current noble liquid TPCs. Our research focuses on optimizing detector materials for very low energy deposition events, such as those expected from a WIMP-argon nuclear recoil. We will build a modular mini-TPC and use it to study the effect of doping LAr with Xe or photosensitive dopants to lower the ionization energy which can increase yield and lower the energy threshold, extending sensitivity to lower masses. While photosensitive dopants can increase the ionization yield, UV electroluminescence photons that enter the liquid phase can reionize the dopants and initiate a positive feedback loop. Our solution is to optically decouple the gas and liquid portions by constructing a barrier that is transparent to electrons and opaque to photons in place of the traditional wire mesh. We are also conducting tests on materials to improve electric field shaping such as the carbon-loaded Kapton DR-9 and a through-glass ground connection in the anode using cryogenic epoxy. Together, these studies aim to inform the development of a new generation of low-threshold dual-phase argon TPCs optimized for rare-event detection.

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Presenter: RAMOS, Leticia (University of California, Riverside)

Contribution ID: **19** Type: **Poster**

Development of Cryogenic Silicon Photomultipliers Based on FBK Technology for the DUNE Experiment and Light Detection in Liquid Argon

The Deep Underground Neutrino Experiment (DUNE) is a next-generation neutrino experiment designed to investigate neutrino oscillations, determine the neutrino mass ordering, and search for possible CP violation in the lepton sector. The experiment comprises a Near Detector and a Far Detector located 1300 km apart. The Far Detector will consist of four liquid argon time projection chambers (LArTPCs), which detect particles through the collection of ionization charge and scintillation light produced in the active medium. The Photon Detection System (PDS) is based on X-ARAPUCA light collectors coupled to silicon photomultipliers (SiPMs).

For this application, FBK has developed the NUV-HD-Cryo SiPM technology, specifically optimized for operation at cryogenic temperatures. These devices exhibit extremely low dark count rates, of the order of a few mHz/mm^2, enabled by a low peak electric field, reduced afterpulsing probability, and a limited temperature dependence of the quenching resistance. Within the framework of the DUNE collaboration, the technology has been further tailored to meet the experiment requirements obtain a device with high gain and limited crosstalk by increasing the number of Deep Trench Isolation (DTI) structures, with the goal of achieving a better signal-to-noise ratio.

For the Vertical Drift detector module, a new SiPM architecture, named FLEXI, has been developed. Compared to the previous design adopted for the first DUNE module, FLEXI introduces several improvements. All SiPMs are operated at the same bias voltage, ensuring uniform gain and photon detection efficiency across the device. Moreover, the reduced total capacitance results in lower electronic noise and faster signal response, producing narrower and cleaner pulses. In addition, the differential signal readout enhances the signal-to-noise ratio by suppressing common-mode noise through the measurement of the voltage difference between two signal lines.

To support the large-scale production of FLEXI devices, FBK has developed a dedicated setup for their characterization and validation. This contribution presents the FLEXI architecture and its main features, together with the experimental setup implemented for quality control and the characterization results obtained during the validation phase.

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Contribution ID: **20** Type: **Poster**

High-Voltage Delivery and Breakdown Studies in Liquid Xenon for Next-Generation TPCs

Next-generation liquid xenon (LXe) time projection chambers (TPCs) aim to push direct dark matter searches to the neutrino fog and support a broader rare-event physics program, including neutrinoless double-beta decay.

Building on these advancements, the next-generation XLZD observatory would scale this technology to an LXe-TPC with a height and inner diameter of nearly $3\,\mathrm{m}$, containing about $60\,\mathrm{tonnes}$ of LXe in its first stage. Scaling to this size requires increasing the voltage delivered to the cathode to maintain the required drift field. This makes it important to understand both how to deliver this voltage reliably and what limits the maximum usable voltage before high-voltage (HV) breakdown occurs.

However, although LXe is predicted to sustain bulk fields of approximately $1\,\mathrm{MV/cm}$, experimental observations consistently show breakdown at lower fields, closer to detector operating fields, around $100\,\mathrm{kV/cm}$. This issue becomes particularly important as LXe-TPCs are scaled up.

To address these challenges, the MOTION detector, a $70\,\mathrm{kg}$ LXe setup at the Karlsruhe Institute of Technology, serves as a dedicated testing platform for HV delivery and breakdown studies in LXe. It aims to systematically study factors affecting the breakdown voltage, including conductor surface quality, xenon purity, and other relevant variables.

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Presenter: SONIUS, Tom (Karlsruhe Institute of Technology)

Contribution ID: **21** Type: **Talk**

Optical characterization of detector materials using VULCAN

Vacuum ultraviolet (VUV) scintillation light is central to noble-liquid detectors used in neutrino and dark matter experiments. Understanding the optical response of detector materials under VUV excitation is therefore important for detector design, performance optimization, and background mitigation.

The Vacuum Ultraviolet Light Characterization At Nikhef (VULCAN) setup is a tabletop experiment combining VUV excitation with single-photon-sensitive optical measurements. VULCAN enables studies of material reflectance, fluorescence spectra, fluorescence timing, and wavelength-shifting performance. Recent measurements include reflectance studies of materials relevant for the DUNE cryostat, investigations of photoluminescence from detector materials and components, and studies of fluorescence induced by solder-flux residues, which have been identified as a potential source of nuisance optical signals in noble-liquid detectors. We also discuss the characterization of wavelength-shifting materials such as polyethylene naphthalate (PEN) and their application in light-collection systems for future experiments.

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Presenter: VAN NULAND-TROOST, Marjolein (Nikhef)

Contribution ID: **22** Type: **Poster**

Study of Xenon-Doped Liquid Argon Scintillation Light Properties in ProtoDUNE Vertical Drift Using Cosmic Ray Tagger Data

Doping liquid argon (LAr) with a few parts per million (ppm) mass of xenon (Xe) is a known technique to modify the scintillation light properties. The energy deposited by charged particles crossing the detector is transferred from argon excimers to xenon excimers, through the process Ar2->ArXe->Xe2*, which emits photons with a longer wavelength. These effects are expected to affect the light yield, the light transport, and timing performance in large-scale detectors such as the Deep Underground Neutrino Experiment (DUNE). In this work, we use ProtoDUNE Vertical Drift (VD) cosmic-ray-tagger (CRT) data to study the properties and spatial dependence of photon detector responses in Xe-doped liquid argon, and to investigate their impact on photon detection performance.

Primary author: ZHU, Kaixin (Colorado State University)

Presenter: ZHU, Kaixin (Colorado State University)

Contribution ID: **23** Type: **Talk**

Surface treatments to improve the detection efficiency of VUV-SiPMs

The high-efficiency detection of the VUV scintillation light of liquid Xenon (LXe) and Argon (LAr) is a key driver of science reach for detectors employing these media. Silicon photomultipliers (SiPMs) are becoming the photon detector of choice for a number of current and planned experiments, but photon detection efficiency (PDE) at VUV wavelengths remains limited. Current VUV SiPMs demonstrate PDE of ˜15% and 20-25% at 128nm (LAr) and 175nm (LXe) respectively - by comparison, the state-of-the-art VUV PMT achieves a PDE of 33% at 178nm and ˜30% at 128nm. PMTs therefore remain the baseline solution for large-scale LXe experiments, including XLZD, but replacement with SiPMs would significantly reduce radiogenic backgrounds and would improve sensitivity to neutrinoless double beta decay in Xe-136. Additionally, current-generation LAr detectors employ SiPMs combined with wavelength shifters to convert VUV photons to visible light. However, these also contribute to radiogenic backgrounds, and increase complexity due to the isotropic re-emission of the shifted light. An improved PDE at 128nm, permitting direct detection of LAr scintillation by SiPMs, could remove the need for wavelength shifting - this would represent a transformative reduction in cost and complexity for future large-scale LAr detectors.

We present recent work at TRIUMF to apply two technologies for improved VUV sensitivity to SiPMs: delta-doping and 'black silicon'. Various performance metrics of delta-doped digital SPAD array structures, produced by the University of Sherbrooke, have been studied, including PDE at wavelengths down to 140nm. This is the first demonstration of a delta-doped SPAD structure and of VUV responsivity in a digital SPAD array. We will also show results extending the measured quantum efficiency of black silicon photodiodes down to 115nm, investigating the suitability of this technology for deployment in LAr detectors. Additionally, we will present optical simulation work of the XLZD detector architecture. We demonstrate that, even with current technology, overall photon collection efficiency can be maintained or improved over an all-PMT baseline by incorporating SiPMs into the light readout system.

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Presenter: LEWIS, Harry (TRIUMF)

Contribution ID: **24** Type: **Talk**

Calibrating the scintillation and ionization responses of LZ for 8B neutrino and low-mass WIMP searches.

Detecting low-energy xenon recoils from dark matter or neutrino interactions requires a nuanced understanding of near-threshold signal yields in liquid xenon. This necessitates specialized neutron calibration. In this presentation, I will discuss recent measurements of scintillation and ionization yields in liquid xenon in the LUX-ZEPLIN (LZ) detector using a deuterium-deuterium neutron generator. Using a high-statistics analysis of single-scatter events produced by 2.45 MeV neutrons, we constrained critical xenon microphysics parameters, including electron-ion recombination and scintillation fluctuations. Our findings highlight significant discrepancies with previous xenon response models, emphasizing the need to update signal models for dual-phase xenon time projection chambers. These insights have refined our understanding of the near-threshold region of the LZ detector and were crucial for recent results on the coherent elastic neutrino nucleus scattering of the ^{8}B solar neutrinos and light WIMP searches.

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Presenter: GHOSH, Sayan (SLAC National Accelerator Laboratory)

Contribution ID: **25** Type: **Poster**

Muon spallation on xenon in the KamLAND-Zen search for 0νββ

Searches for neutrinoless double beta decay (0νββ) require extremely low backgrounds, especially as detectors move toward larger isotope masses and longer exposures. A potentially limiting background is muon-induced spallation of the isotope used for the search, especially at moderate underground depths such as Kamioka, where xenon spallation is currently the dominant background in KamLAND-Zen. Muon interactions with xenon can produce many long-lived radioactive isotopes, with lifetimes from hours to days, making simple time-based vetoes impractical. In this poster, I present an improved KamLAND-Zen tagging strategy for muon-induced xenon spallation. I will discuss the limitations of the existing tagger, new correlations with neutron captures and other shower products, and a machine-learning transformer model that shows improved background rejection on simulated data. Understanding and tagging this background is important for future xenon-based rare-event detectors, where spallation can influence sensitivity projections, background budgets, and decisions on detector location and underground depth.

Primary author: WEERMAN, Kelly

Presenter: WEERMAN, Kelly

Contribution ID: **26** Type: **Talk**

Particle Identification in ProtoDUNE Detectors Using Scintillation Light

Characterized by prime 3D imaging precision, low energy thresholds, and robust particle identification tracking, Liquid Argon Time-Projection Chambers (LArTPCs) stand at the forefront of modern neutrino and dark matter detection. These capabilities — fundamental for reconstructing final-state interactions and conducting precise physics measurements — are currently being demonstrated at CERN's ProtoDUNE facilities through a combination of beam tests and cosmic ray atmospheric data for comprehensive performance verification. While LArTPCs collect both ionization charge and scintillation light that provide complementary information, standard interaction reconstruction relies primarily on charge data, utilizing the scintillation photon signal chiefly to determine the interaction time of non-beam particles. This work demonstrates how the scintillation light signal can be further exploited. Specifically, we present how the photon detection systems in the latest iterations of the ProtoDUNE detectors — ProtoDUNE Horizontal Drift and Vertical Drift — can successfully identify some primary beam particles. Notably, this approach enables, independently of the ionization charge data, the differentiation between muons and pions with good efficiency and purity, a task where traditional beam instrumentation, combining Time-of-Flight and Cherenkov detectors, falls short.

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Presenter: PAULUCCI, Laura (ITA)

Contribution ID: **27** Type: **Poster**

Cryogenic Charge Readout Electronics for LArTPCs in DUNE

The Deep Underground Neutrino Experiment (DUNE) will employ liquid argon time projection chambers (LArTPCs) at unprecedented scales for its far detectors and under unprecedented neutrino beam intensities in its near detector. To meet their performance requirements for ionization electron readout, these LArTPCs require custom electronics capable of operating in cryogenic conditions. This has resulted in a 3-ASIC solution for wire/strip readout in DUNE's far detectors, and in the LArPix ASIC for pixelated readout in DUNE's near detector. This talk will present the design of these electronics, along with their performance results from recent prototypes.

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Presenter: HUANG, Roger (Lawrence Berkeley National Laboratory)

Contribution ID: **28** Type: **Talk**

Validation of the Measurement System for Mass Characterization of SiPMs in the Photon Detection System of the DUNE Far Detector VD

Currently under construction in the United States, the Deep Underground Neutrino Experiment (DUNE) is a next-generation international experiment focused on neutrino oscillation studies. The DUNE Far Detector will consist of four 17-kton Liquid Argon Time Projection Chamber (LArTPC) modules, two with established geometries and technologies in Phase I, while the remaining two are under discussion for Phase II. Phase I will consist of one Vertical Drift (VD) detector and one Horizontal Drift (HD) detector. Both LArTPCs will employ a Photon Detection System based on X-ARAPUCA devices instrumented with Silicon Photomultipliers (SiPMs).

This contribution presents the validation of a custom measurement system developed for the characterization of SiPMs for the VD module. The experimental setup is designed to ensure accurate and reliable I-V measurements at both room and cryogenic temperatures, supporting the large-scale automated testing required for more than 100,000 light sensors.
It presents a comprehensive analysis of the measurement chain (including biasing and current-readout stages) to evaluate metrological performance, stability, repeatability, and breakdown voltage extraction through normalized-derivative methods coupled with second-order polynomial fitting.
Experimental results demonstrate the suitability of the system to serve as the baseline for the CACTUS-VD (Cryogenic Apparatus for Continuous Tests Upon SiPMs for Vertical Drift) facility, enabling robust qualification of SiPMs in large batches for long-term neutrino experiments.

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Contribution ID: **29** Type: **Talk**

NEXT R&D Path towards the Ton-Scale

The NEXT experiment aims to detect neutrinoless double-beta decay using a high-pressure xenon gas time projection chamber with electroluminescence. To successfully reject background, the detector relies on excellent energy resolution and high-performance tracking capabilities.

Scaling traditional photomultiplier tube (PMT) technology for the future ton-scale phase of the experiment presents significant challenges. Consequently, the collaboration is actively developing an alternative system: optical wavelength-shifting fibers surrounding the detector barrel, read out by Silicon Photomultipliers (SiPMs). This new design aims to match or exceed the light collection efficiency of the current NEXT-100 configuration. Additionally, a dedicated ASIC is under development to handle the growing channel count and provide a highly scalable readout architecture. Furthermore, to move toward a zero-background regime, the collaboration is developing a barium tagging system to identify the specific ^{136}Xe daughter ion produced in double-beta decay.

In this presentation, we will review the technical challenges of realizing the ton-scale experiment and explain how the wavelength-shifting fiber barrel addresses them. We will present the development of the first fiber barrel prototype along with its measured light collection efficiency. Next, we will discuss the construction and preliminary performance of the 5 kg demonstrator (NEXT-HD-DEMO) instrumented with 18 fiber panels around the barrel read out by 36 SiPMs. Finally, we will outline the roadmap for integrating this fiber technology into both the NEXT-100 detector (NEXT-100U) and the future ton-scale detector (NEXT-HD) alongside with a description of the ASIC and the barium tagging system, for which we'll show the sensitivity achievable under the Ba tagging hypothesis.

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Presenter: TORELLI, Samuele (Donostia International Physics Center)

Contribution ID: **30** Type: **Talk**

Study of hole-geometry impact in the light yield using thick electroluminescence-based MPGDs

In this work we report a recently developed simulation framework to model the full detection process from radiation/particle primary interaction with a given gas medium to charge transport (drift and diffusion), light production (primary and secondary photon emission), conversion (wavelength-shifting) and propagation and detection in a suitable photosensor. This simulation framework was developed with the ultimate goal of performing studies on MPGD-based optical amplification structures of potential interest to rare-event searches.

To validate the simulation framework, a systematic characterization of light production and energy resolution in novel MPGD-based optical amplification structures with and without wavelength-shifting capabilities (FAT-GEMs) and focused on different hole geometries, was performed. The preliminary results on the performance of these structures in Xe-doped Ar will be presented, including the effect of conical holes (and different geometric configurations) on light production and the fraction of converted light reaching the photosensors, used to validate this tool.

The validated simulation framework will enable future studies on the impact of different materials (electrodes, bulk media, wavelength shifters) and geometric parameters (hole pattern, pitch, size, and shape) in the performance of optical amplification structures This tool will be an invaluable component in the R&D of novel optical amplification concepts and detector designs.

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Presenter: Dr COSTA E SILVA, Pedro (Astrocent)

Contribution ID: **31** Type: **Poster**

Simulation Framework for the APEX Advanced Photon Detection System in Liquid Argon Test Apparatus

The Deep Underground Neutrino Experiment aims to explore fundamental neutrino properties and probe for physics beyond the Standard Model. DUNE's deployment involves constructing four large liquid argon time projection chambers, each utilizing a scintillation photon detection system for interaction timing, astrophysical triggering, and calorimetry. For modules 3 and 4, a detailed simulation is underway for a two-ton liquid argon test apparatus dedicated to evaluating "APEX"—an advanced PDS concept. To study several aspects associated with the unique operating conditions of the scintillation sensing devices under development, we implemented a comprehensive Monte Carlo simulation detailing the setup's geometry, optical properties, and particle interactions. The simulation records the essential physical data required for electronic readout digitization. This work presents findings on the apparatus's capability to determine signal-to-noise ratio, single photo-electron pulse shapes, and timing characteristics (rise and decay times). Finally, we discuss the platform's utility for evaluating detection efficiency, optimizing electronic dynamic range, and assessing how various parameter choices impact device performance.

Primary author: Prof. MARINHO, Franciole (ITA)

Presenter: Prof. MARINHO, Franciole (ITA)

Contribution ID: **32** Type: **Talk**

Optical, structural and aging study of P-Terphenyl thin films

Scintillation light is a powerful tool in liquid argon (LAr) based detectors for rare events searches, since it can be used for timing, calorimetric and particle discrimination purposes. Photons are emitted in the Vacuum Ultra Violet, in a ten nm band centered around 128 nm where most of the commercially available photosensors are not sensitive. p-Terphenyl (PTP) thin films are a common choice of wavelength shifter used in combination with LAr, that converts VUV light into the near-visible range (350-400 nm). This work investigates the optical, structural, and aging properties of PTP thin films as a function of thickness and wavelength. Measurements of relative conversion efficiencies were performed with a vacuum monochromator and a deuterium lamp at the Leptons Lab (Universidade Estadual de Campinas, Brazil). Preliminary results show that, within the investigated interval, there exists an optimal film thickness that maximizes the conversion factor in the VUV region. In addition, an aging setup developed to expose 2.5 cm × 2.5 cm films to continuous, constant-intensity LED irradiation at four distinct wavelengths. The mass and relative conversion efficiency of these films were periodically monitored against a reference sample to track degradation. This study is still in progress, with long-term degradation data being accumulated.

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Presenter: LONGHITANO PAGLIUSO, Lucca (Universidade Estadual de Campinas)

Contribution ID: **33** Type: **Talk**

X-ARAPUCA Characterization and Large-Scale Assembly for DUNE

The Deep Underground Neutrino Experiment (DUNE) is a next-generation long-baseline experiment exploiting the liquid argon TPC technology. DUNE will employ a photon detection system based on X-ARAPUCA devices. These detectors capture incoming vacuum ultraviolet (VUV) photons via internal reflection within a wavelength-shifting light guide, enabling their detection by silicon photomultiplier (SiPM) arrays sensitive to visible light. The photon detection efficiency of the X-ARAPUCAs has been measured for several configurations in liquid argon at CIEMAT. These studies, carried out as part of an R&D optimization campaign, demonstrate significant improvements in detector performance for both the Vertical and Horizontal Drift designs for the DUNE Far Detector, ultimately leading to a baseline design without dichroic filters. The next step involves the large-scale assembly and characterization of 350 X-ARAPUCA devices at CIEMAT, which will be installed on the cryostat walls of the DUNE Far Detector Vertical Drift module.

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Presenter: CUESTA, Clara (CIEMAT)

Contribution ID: **34** Type: **Talk**

The NEXT-100 detector: performance and first low-background results for the 0nubetabeta search

The NEXT Collaboration searches for neutrinoless double beta decay ($0\nu\beta\beta$) in ^{136}Xe using high-pressure xenon gas electroluminescent time projection chambers. This technology offers excellent energy resolution and powerful background rejection via three-dimensional event topology reconstruction.

The NEXT-100 detector, which can accommodate approximately $100\,\mathrm{kg}$ of xenon at a pressure of $15\,\mathrm{bar}$, began operation at the Laboratorio Subterr\'aneo de Canfranc in 2024. Its main objectives are to demonstrate the scalability of the NEXT technology and to deliver the first competitive $0\nu\beta\beta$ results of the collaboration. Following a successful commissioning campaign, the detector was calibrated with the low-energy $^{83\mathrm{m}}$Kr and high-energy ^{228}Th sources. These measurements yielded an energy resolution below 1% FWHM at the $Q_{\beta\beta}$ value of $2.46\,\mathrm{MeV}$, meeting the experimental design goal. A first low-background run with xenon depleted in ^{136}Xe was subsequently carried out to measure and characterize the different sources of background. The contribution from internally produced radon was found to be negligible, with a background index of approximately $0.4\times10^{-4}\,\mathrm{counts\,keV^{-1}\,kg^{-1}\,yr^{-1}}$.
In addition, the radon abatement system at the LSC allows NEXT-100 to operate in an effectively radon-free environment. I will also describe the next phase of the NEXT-100 programme, in which high-pressure data for the $0\nu\beta\beta$ search will be collected with both depleted and enriched xenon.
%I will also describe the next phase of the NEXT-100 programme, focused on high-pressure operation under conditions approaching those foreseen for the $0\nu\beta\beta$ search.
With an expected total background index below $10^{-3}\,\mathrm{counts\,keV^{-1}\,kg^{-1}\,yr^{-1}}$, NEXT-100 is projected to reach a $0\nu\beta\beta$ half-life sensitivity of $6\times10^{25}\,\mathrm{yr}$ at 90% C.L. after three years of data taking with xenon enriched in ^{136}Xe.

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Presenter: LOPEZ MARCH, Neus (IFIC (CSIC-UV))

Contribution ID: **35** Type: **Talk**

A vacuum-insulated liquid argon purifier for removing nitrogen, oxygen, and water featuring a novel Li-FAU molecular sieve

LEGEND is searching for neutrinoless double-beta ($0\nu\beta\beta$) decay of ^{76}Ge using isotopically enriched high-purity germanium detectors operated bare in liquid argon (LAr), which serves as coolant, shielding, and active detector. Achieving and maintaining excellent LAr purity is essential, as oxygen, water, and nitrogen impurities degrade scintillation and optical properties and thus deteriorate background rejection. [1]
Molecular sieves and copper catalysts are routinely used to remove water and oxygen from noble gases [2], whereas removing nitrogen has historically been more challenging. A recently identified Li-FAU molecular sieve effectively removes nitrogen from liquid argon. We developed, commissioned, and operated a liquid argon purification system for the 1-tonne LAr test stand SCARF at the Technical University of Munich, combining a Li-FAU molecular sieve and a copper catalyst. The system operates in batch and loop mode, is actively cooled and vacuum-insulated to minimize heat influx.
The LAr quality is monitored in-situ with the triggered SiPM array LLAMA [3], which measures scintillation light yield, triplet lifetime, and attenuation length. Following commissioning, an initial purification run validated system performance and guided optimization. A subsequent long, continuous purification campaign recovered the effective triplet lifetime of air-contaminated liquid argon from 0.61 ± 0.01 µs to 1.35 ± 0.01 µs. Here, we present the system design, commissioning, and purification performance results providing operational input for future LEGEND applications.

[1] M. Harańczyk et al., Procurement and Purification of Liquid Argon for the LEGEND-200 Experiment, arXiv:2605.20507

[2] C. Vogl et al., A liquid-phase loop-mode argon purification system, 2024 JINST 19 C03030

[3] M. Schwarz et al., Liquid Argon Instrumentation and Monitoring in LEGEND-200, EPJ Web Conf. 253 (2021) 11014.

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Presenter: PAVLIDAKI, Georgia (Technical University Munich)

Contribution ID: **36** Type: **Talk**

The COLINA experiment

The COLINA project is developing a novel frustum-shaped time projection chamber (TPC) for the detection of Coherent Elastic Neutrino–Nucleus Scattering (CEvNS) in liquid noble media at the European Spallation Source.
The detector concept employs a conical TPC geometry in which ionization electrons released in the active volume are focused into a small region, where they are amplified through electroluminescence (EL) directly in the liquid phase. With this design, the EL region is kept small, mitigating the scalability problems related to EL production in liquid phase, while maintaining a large target volume.

COLINA includes an extensive R&D program to evaluate and optimize the detector design, including the electric field configuration, charge transport and focusing, the EL amplification structure and the active medium.

In this contribution, we will present the COLINA project with a strong focus on the planned R&D activities supporting the development of the experiment.

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Presenter: MARTINEZ LEMA, Gonzalo (IFIC, CSIC-UV)

Contribution ID: **37** Type: **Talk**

XLZD – the next generation of dark matter search

Liquid xenon based dark matter experiments have rapidly increased in size and sensitivity in recent years. They are at the forefront of the search for dark matter interactions with nuclei for dark matter masses above a few GeV/c^2. Achieving this objective requires maintaining an ultra-low background level while scaling up the active target mass by about a factor of 10 compared to current-generation detectors. XLZD represents a unique collaboration that brings together the XENON, LUX-ZEPLIN, and DARWIN collaborations, joining their complementary expertise and technologies. This definitive experiment is designed to achieve unmatched sensitivity, probing the accessible WIMP parameter space above the neutrino fog. In addition, XLZD will perform a competitive search for neutrinoless double-beta decay and will be sensitive to a wide variety of other science targets. I will discuss the scientific goals of XLZD, as well as ongoing R&D efforts undertaken for the experiment design.

Primary author: BIONDI, Yanina (KIT)

Presenter: BIONDI, Yanina (KIT)

Contribution ID: **38** Type: **Talk**

A digital SiPM in liquid xenon

The currently most competitive direct dark matter detection experiments are liquid xenon time projection chambers (LXe TPCs) usually instrumented with PMTs. In the search for alternatives to those PMTs, a digital SiPM sensor has been developed, where the digitization happens directly on the chip. Digital SiPMs show dark count rates comparable to that of PMTs, with the added benefit of not needing analog to digital converters and greatly reduced data rates.
For the first time, one digital SiPM has been immersed and operated in cryogenic LXe. We present the results of this test, which allowed to measure some of the characteristics of this prototype, such as its dark count rate at different temperatures and its photon detection efficiency. The test shows the potential of such sensor for future liquid xenon experiments.

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Presenter: LUCE, Tiffany (Freiburg Universität)

Contribution ID: **39** Type: **Talk**

From Materials to Readout: Advances in VUV Photodetection

Efficient detection of vacuum ultraviolet (VUV) scintillation light is essential to fully exploit the physics potential of next-generation neutrino and dark matter experiments. We are pursuing a broad R&D programme aimed at improving VUV photodetection through innovations in both sensor materials and readout architectures. On the sensor side, we investigate novel concepts including amorphous selenium photodetectors and graphene-based surface engineering for enhanced VUV sensitivity and cryogenic operation. In parallel, we explore Photon-to-Digital Converters (PDCs), or digital SiPMs, which integrate photon detection and digitization at the SPAD level, offering improved timing, dynamic range, and noise suppression. We present recent developments and discuss how the combination of advanced materials and digital readout technologies can enable the next generation of scalable, high-performance photosensors for particle physics applications.

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Presenter: GARCIA PERIS, Miguel Angel (University of Manchester)

Contribution ID: **40** Type: **Talk**

DarkSide Proto-0: Recent Insights from the DarkSide-20k Prototype Programme

DarkSide-20k, currently under construction at LNGS, is a next-generation dual-phase liquid argon Time Projection Chamber designed for the direct search of WIMP dark matter. Within the DarkSide-20k program, Proto-0 is a dedicated prototype developed to validate key detector technologies, study signal formation, and support the development and commissioning of detector subsystems for the final experiment. Following the completion of its first physics data-taking campaign, Proto-0 has provided a unique platform for the characterization of novel technologies foreseen for DarkSide-20k, including cryogenic SiPM-based Photon Detection Units, acrylic detector components, and transparent conductive polymer coatings for electric-field generation. The detector also features a configurable extraction and electroluminescence region, enabling dedicated studies of proportional scintillation in gaseous argon under varying geometrical and operating conditions. In this contribution, we present an update on the Proto-0 program, including the status of the analysis of the first physics dataset, long-term detector operation and stability studies, recent developments from the ongoing experimental campaign, and the implications of these activities for the commissioning of DarkSide-20k.

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Presenter: MATTEUCCI, Giuseppe (INFN Sezione di Napoli)

Contribution ID: **41** Type: **Talk**

The GRAMS Experiment: A LAr TPC for Astrophysical Gamma-Ray and Antimatter Detection

The Gamma-Ray and AntiMatter Survey (GRAMS) is a balloon-borne experiment that will use a liquid argon time projection chamber (LAr TPC) to detect both MeV gamma rays and cosmic ray antiparticles. GRAMS exploits the excellent energy and spatial resolution of LAr TPCs to act as a Compton telescope, providing unprecedented sensitivity to gamma rays in the historically under-explored energy regime known as the MeV Gap. At the same time, the LAr TPC will serve as a 3D tracking detector for charged particles, allowing GRAMS to perform a background-free search for low-energy antinuclei, a possible signature of dark matter annihilation. These complementary capabilities will enable GRAMS to probe a wide range of interesting phenomena, from high-energy astronomical objects to physics beyond the Standard Model. The GRAMS detection concept is potentially expandable to a future satellite mission due to the low-cost, scalable nature of the LAr TPC technology. A prototype balloon flight, pGRAMS, has been funded by NASA and is slated to launch from Tucson, Arizona in the summer of 2026. This talk will present an overview of the GRAMS experiment and describe the current status of the project.

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Presenter: AMES, Drew (Northeastern University)

Contribution ID: **42** Type: **Poster**

X-ARAPUCA Photon Detectors in SBND

The Short-Baseline Near Detector (SBND) is a liquid argon time projection chamber for detecting neutrinos from Fermilab's Booster Neutrino Beam. Located 110 m downstream of the beam target, SBND collects both ionization electrons and scintillation photons from particle interactions within the detector volume. The photon detection system (PDS) consists of both PMTs and X-ARAPUCAs, a novel technology featuring large area cost-effective coverage with single photo-electron resolution
at cryogenic temperatures. SBND utilizes two types of X-ARAPUCAs: one sensitive to the vacuum ultra-violet (VUV) scintillation light produced in liquid argon and one sensitive to the visible light generated by the reflection of VUV light off the TPB-coated reflective foils at the cathode. SBND is the only experiment currently testing the X-ARAPUCA technology in a neutrino beam and will provide critical information for deployment in future detectors like DUNE. This poster will cover the
calibration and early performance of X-ARAPUCAs in SBND.

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Presenter: ROMEO, Jorge (CIEMAT)

Contribution ID: **43** Type: **Poster**

Integral equation study for nuclear fano factor determination in noble liquids

It is known that for noble liquids, experimental data on the Fano factor for nuclear recoils remain sparse; consequently, many experiments fix this factor to unity, assuming binomial statistics. In this work, we present a formal theory, based on the Lindhard integral equation, to compute the statistical variance arising from nuclear recoil energy depositions. The model is based on the solution to a new second-order, non-homogeneous integro-differential equation for the atomic motion variance, Ω_ν^2. Furthermore, we demonstrate that at second order and for low energies, the probability distribution energy governing nuclear recoil fluctuations is determined by a Beta function. Finally, we discuss the implications of incorporating this variance into dark matter searches.

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Presenter: SARKIS, Youssef (Instituto de Ciencias Nucleares UNAM)

Contribution ID: **44** Type: **Talk**

Development of Poly(ethylene naphthalate) Components for Next-Generation Liquid Noble Gas Detectors

Liquid noble gas detectors for neutrino and rare-event searches rely on efficient detection of vacuum-ultraviolet (VUV) scintillation light while minimizing radioactive backgrounds from nearby materials. To improve the detection of VUV photons, wavelength shifters are required to convert scintillation light into the visible range. At the scale of next-generation experiments such as DUNE, DarkSide-20k, and LEGEND-1000, replacing components with optically active materials that contribute directly to light conversion or scintillation becomes necessary. Among these, poly(ethylene naphthalate) (PEN) is a particularly promising candidate due to its intrinsic wavelength-shifting and scintillation properties, mechanical robustness, and long-term stability at cryogenic temperatures such as liquid argon.

In addition to components injection-molded from commercial PEN granulate, successfully implemented in LEGEND-200, custom-synthesized PEN offers a route to improved material performance for next-generation detectors. We report on the latest efforts to synthesize PEN using pre-purified reagents.

Further, commercial PEN thin films are explored for their use in low-background environments. We present the achieved levels of radio-impurities and optical performance after extensive cleaning. Finally, new developments in 3D printing of optically active components using PEN filament and their potential for on-demand part production are presented.

This work is supported by the U.S. DOE, and the NSF, the LANL, ORNL and LBNL LDRD programs; the European ERC and Horizon programs; the German DFG, BMBF, and MPG; the Italian INFN; the Polish NCN and MNiSW; the Czech MEYS; the Slovak RDA; the Swiss SNF; the UK STFC; the Canadian NSERC and CFI; the LNGS and SURF facilities.

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Presenter: LEONHARDT, Andreas (Technical University of Munich (TUM))

Contribution ID: **45** Type: **Talk**

Beam Event Light Yield Measurment with the Photon Detection System in the ProtoDUNE-VD Detector at CERN

ProtoDUNE-VD is the first large-scale prototype for the Vertical Drift configuration of the Deep Underground Neutrino Experiment (DUNE) far detector, installed at CERN's Neutrino Platform. During the summer of 2025, both calibration and test beam data were collected. The H2 Very Low Energy (H2-VLE) beamline at the CERN Neutrino Platform can deliver particles (electrons, protons, pions, muons, and kaons) with momenta ranging from sub-GeV/c to a few GeV/c. A series of beamline instruments provides particle identification via Cherenkov response and time-of-flight measurements.

Precise particle identification and background rejection are crucial for a light yield measurement with the PDS system. In this work, we focus primarily on beam electrons delivered by the H2-VLE beamline in the momentum range of 1.0-8.0 GeV/c. By applying a spectral method to isolate beam electrons, we are able to discriminate them from background contamination and improve event selection in cases where beam instrumentation is insufficient. Finally, by applying geometrical corrections to the photon count from selected beam electrons, we provide a preliminary light yield measurement using beam electrons.

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Presenter: BOZA, Jacob (Colorado State University)

Contribution ID: **46** Type: **Talk**

Design and performance optimizations of the Outer Veto and light detection facilities for the LEGEND-1000 Experiment

The LEGEND-1000 experiment aims to search for neutrinoless double-beta decay with an unprecedented background goal of 10-5 cts/(keV·kg·yr). A critical requirement for reaching this sensitivity is the suppression of cosmogenic backgrounds, specifically muon-induced neutrons that produce 77mGe, to below 10-6 cts/(keV·kg·yr). To achieve this, the experiment utilizes an Outer Liquid Argon (LAr) instrumentation system optimized to detect argon scintillation light within the large-volume atmospheric LAr shield.
The baseline design combines a passive, radiopure PMMA neutron moderator with an active light detection system consisting of Light guiding and Detecting Modules (LDM). These LDMs utilize wavelength-shifting (WLS) doped PMMA light guides wrapped in PEN foil or coated with TPB/PTP to shift 128 nm (or 178 nm in Xe-doped LAr) scintillation light for detection by high-density Silicon Photomultiplier (SiPM) arrays. This contribution details the integrated R&D and performance optimizations conducted across different specialized facilities.
Initial prototype characterization is performed at INFN-LNGS using a cryogenic test stand dedicated to assessing the mechanical stability and optical performance of individual LDM designs.
Development of low-radioactivity SiPM flex PCBs and evaluation of photon detection efficiencies across various module geometries and wavelength-shifting configurations are conducted at INFN-Milano Bicocca setup.
Benchmarking of the complete readout chain, including the SiPMs, optimized front-end electronics, and data acquisition systems, is carried out at the facility at INFN-Roma Tre. Complementing these studies, a setup at INFN-Naples focuses on characterizing Xe-doped liquid argon, exploring how varied xenon concentrations modify scintillation decay time constants, increase the Rayleigh scattering length, and enhance light yield while preserving pulse shape discrimination capabilities.
Finally, the upcoming LEGENDArY facility at INFN-LNGS, currently in its design phase, will scale these efforts as a comprehensive, large-scale cryogenic platform for the mass characterization and testing of the approximately 500 LDMs required for the experiment.
Together, these integrated R&D efforts establish the technical foundation for imminent full-scale prototype testing and the ultimate implementation of an optimized, high-reliability outer veto system for LEGEND-1000 experiment.

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Presenter: CANCI, Nicola (INFN)

Contribution ID: **47** Type: **Talk**

Initial characterization of fully processed NUV Backside-Illuminated SiPMs developed by FBK in the framework of IBIS and IBIS_NEXT projects

Silicon Photomultipliers (SiPMs) are compact, high gain photon detectors widely used in particle physics and medical imaging. In conventional front side–illuminated (FSI) devices, light enters through the same surface that hosts metal routings and quenching resistors, limiting the fill factor and the photon detection efficiency. By adopting a backside illuminated (BSI) architecture, photons enter through a dedicated window on the side opposite the metallization, thereby enabling an almost 100% fill factor and allowing the implementation of a thin, uniform entrance window that could be designed to enhance photon detection efficiency down to the VUV range. In this work, we present the initial characterization of the first batch of next generation NUV BSI (Near UV Back Side Illuminated) SiPM technology devices currently being developed by FBK in collaboration with INFN within the framework of the IBIS and IBIS_NEXT projects.

The development of this new technology requires modifications to the microcell architecture with respect to standard FBK technology. The high field region is reduced and separated from the bottom surface and the charge is collected through a focusing mechanism. Deep Trench Isolation (DTI) does not reach the bottom surface in order to have a uniform surface after substrate thinning to implement the novel entrance window. The backside fabrication sequence comprises wafer thinning down to ~10 µm, followed by plasma doping, laser annealing and the deposition of an anti reflective coating. Collectively, these steps yield a newly engineered entrance window optimized for NUV photon detection.

Preliminary measurements on both FSI only and fully BSI processed devices confirmed the correct operation of the newly implemented device architecture. FSI wafers exhibit the expected reduction in gain and recharge time associated with the small cell pitch and charge focusing design, together with controlled DCR levels and correlated noise behavior consistent with the presence of non metal filled DTIs. Fully BSI processed devices show an increase in both primary and correlated noise, with a strong dependence on the applied annealing fluence, yet they retain promising PDE and timing characteristics. PDE measurements on SPAD structures reach approximately 65% at 550 nm and 40% at 400 nm, with a pronounced sensitivity to backside window optimization. SPTR values are around 200 ps FWHM for 35 µm cells, whereas 15 µm cells display diffusion induced tails indicative of residual neutral regions. A preliminary characterization in liquid nitrogen is also reported.

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Contribution ID: **48** Type: **Poster**

Investigation of the Temperature-Dependent Optical Properties of Wavelength Shifters Used in High-Energy Physics Experiments

Wavelength shifters (WLS) are widely employed in high-energy physics experiments to con-vert ultraviolet (UV) and vacuum ultraviolet (VUV) radiation into wavelengths compatible with the spectral sensitivity of photodetectors. Among the materials investigated in this work are p-terphenyl (PTP), tetraphenyl butadiene (TPB), and polyethylene naphthalate (PEN), which are commonly used in scintillation detectors, cryogenic systems, and optical readout devices based on silicon pho-tomultipliers (SiPMs). The optical properties of these WLS materials are studied through tempera-ture-dependent absorption and photoluminescence measurements performed over a temperature range extending from liquid argon conditions to room temperature. In addition, structural and topo-graphical analyses are conducted to investigate the influence of morphological and crystalline cha-racteristics on their optical response. The main objective is to evaluate the impact of temperature on spectral conversion efficiency, emission behavior, and optical stability. The observed temperature dependence is discussed in terms of the interplay between radiative and non-radiative relaxation processes. As temperature increases, thermally activated non-radiative pathways become more sig-nificant, enhancing thermal quenching mechanisms and consequently reducing the photolumines-cence quantum yield. Furthermore, stronger electron–phonon coupling promotes spectral broadening and possible peak shifts, reflecting the increased contribution of vibrational modes to the excited-state dynamics. Temperature-induced structural effects, including thermal expansion, confor-mational rearrangements, and variations in crystallinity, may further modify the local electronic en-vironment of the emitting centers, affecting both absorption and emission spectra. Understanding these effects is essential for establishing correlations between optical performance and material structure. The results provide valuable insights into the optimization of wavelength-shifting mate-rials for photon detection systems operating under a wide range of thermal conditions, particularly in cryogenic environments employed by modern high-energy physics experiments.

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Presenter: AGUIAR DE MENDONÇA, Ana Paula (Universidade Estadual de Campinas)

Contribution ID: **49** Type: **Talk**

Investigating SiPM PDE change from high VUV photon exposure in LXe detectors

Silicon photomultipliers (SiPMs) are the photosensors of choice for many future liquid xenon (LXe) scintillation detectors, yet their long-term stability under intense vacuum-ultraviolet (VUV) exposure remains poorly characterized. During data taking, the MEG II experiment observed a degradation of the SiPM photon detection efficiency (PDE) for the ˜175 nm LXe scintillation channel, with a much less significant degradation in the response to visible calibration light. This effect has so far not been reproduced in dedicated laboratory measurements, motivating a controlled in-beam study. Of particular importance, as next-generation LXe experiments will instrument thousands of sensors for several years of run-time. To isolate the underlying mechanism, we will deploy spare MEG-production SiPMs, FBK HD3 devices, and new generation Hamamatsu SiPMs which feature smaller SPADs and surface treatments developed to suppress degradation. These measurements will take place in the πM1 beam at PSI in November 2026. The delivered VUV dose will be constrained through detailed optical simulations, and absolute VUV and visible PDE, correlated noise, and light emission will be measured before and after exposure, using the testing facilities at TRIUMF Lab. This presentation will outline the effect, the measurement program, and preliminary testing results.

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Contribution ID: **50** Type: **Talk**

Physics at the Edge: Fast, Accurate, and Low Power Consuming AI for Particle Physics

AI has had a transformative effect on particle physics, including visual pattern recognition in liquid argon time-projection chamber (LArTPC) experiments. To solve complex topological problems both at trigger level and in offline reconstruction, algorithms are currently deployed on CPUs or GPUs. The former are unspecialised chips with low speed, whilst the latter offer high speed but at the cost of very high power consumption. In this talk, we will go through the work we have been doing on new paradigms for fast, accurate, and low-power-consuming AI in LArTPC experiments using edge AI devices. In our first publication, we conducted a benchmark of different quantisation techniques and speed, accuracy, and power consumption of convolutional neural networks (CNNs) used for neutrino event recognition on CPU, GPU, and edge TPU. We showed that with the edge TPU, made by Google Coral, we obtained accuracy and latency comparable to a powerful GPU, but with two orders of magnitude less power consumption. In our current work, we are testing advanced transformer models to separate at a hit-based level track and shower-like topologies in LArTPCs. We will show that these models can be successfully quantised and deployed on state-of-the-art edge devices, with competitive speed and accuracy, but a fraction of the energy required by CPUs and GPUs. The power consumption and costs of GPUs represent a bottleneck to future AI-enabled LAr experiments, in addition to serious concerns for the environment. With this work, we aim to present a possible solution without sacrificing latency or accuracy.

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Contribution ID: **51** Type: **Talk**

Identifying neutron induced scintillation in liquid argon for neutrino oscillation experiments in SArIT

Accelerator-based neutrino oscillation experiment expected sensitivity relies on precise understanding of neutrino-nucleus interaction. Insufficient knowledge of the energy carried by undetected particles, particularly neutrons, produced in neutrino-nucleus interactions can distort the reconstructed neutrino energy spectrum and introduces bias in the determination of oscillation parameters, and in searches for new physics. The characteristics of the scintillation produced by neutrons resulting from these interactions with the leading detector material in neutrino oscillation experiments remains poorly understood, especially in the tens-of-MeV energy range where experimental data are limited. We present a new local setup, SArIT, to measure scintillation in LAr induced by neutrons up to 40 MeV in kinetic energy. We aim to measure the scintillation light temporal pulse shape induced by neutrons and utilise Pulse Shape Discrimination (PSD), with and without the presence of an electric field, to improve the light modelling in neutrino interactions, enhanced neutron detection, thereby improving the neutrino energy reconstruction methods.

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Contribution ID: **52** Type: **Talk**

Recent results and current status of the XENONnT Dark Matter experiment

The XENONnT experiment is designed for the direct detection of dark matter through elastic WIMP-nucleus scattering, employing a 5.9-tonne liquid xenon target in a dual-phase time projection chamber. Located at the Laboratori Nazionali del Gran Sasso in Italy, XENONnT has collected a total of more than 600 live-days of data during its first three science runs.
Thanks to its high discrimination power, low energy threshold, and record-low background rate and impurity levels, XENONnT achieves world-leading sensitivity to low-energy dark matter interactions, as well as other rare processes such as neutrino scattering.
In this talk, I will present the latest results from physics searches in XENONnT, including the most recent WIMP dark matter search results over a broad mass range (few GeV/c^2 to TeV/c^2), and the measurement of coherent elastic neutrino–nucleus scattering (CEvNS) from solar 8-B neutrinos.
I will also provide an overview of the XENONnT detector upgrade carried out in summer 2025 and present the status and first results of the subsequent commissioning campaign.

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Presenter: HÖTZSCH, Luisa (Universität Zürich)

Contribution ID: **53** Type: **Talk**

Latest results from LUX-ZEPLIN

The LUX-ZEPLIN experiment is a liquid-gas dual phase time projection chamber that utilizes 7 active tonnes of liquid xenon as a target for dark matter searches and observatory for neutrino-less double beta and other rare nuclear processes. It has been collecting science data near-continuously since 2021. In this time we have published the world leading limits on WIMP dark matter, reported the first statistically significant observation of solar ^{8}B neutrino coherent nuclear scattering, observed and studied the second rarest decay of a nuclear isotope, ^{124} Xe, and probed non-WIMP dark matter interactions in our electronic recoil data. This talk will focus on the challenges and novel aspects of the WIMP search results with a brief update on LZ's capabilities in neutrino-less double beta decay.

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Presenter: GREEN, Joshua (University College Lodnon)

Contribution ID: **55** Type: **Poster**

Characterisation of the R8520-506 PMT and Its Long-Term Performance in Liquid Argon

The Hamamatsu R8520-506 PMT is an alternative photosensor candidate for small-scale liquid argon detector. A systematic characterization of seven Hamamatsu R8520-506 1-inch PMTs will be presented in this report, comparing their key performance parameters at room temperature and in the liquid argon environment, with a particular focus on their long-term operational stability through a two-week continuous test. As a result, the PMT gains at cryogenic temperatures are found to be approximately 20%-40% higher than those at room temperature, and the gain enhancement is accompanied by improved peak-to-valley ratios, better single photoelectron resolution and lower afterpulse rates. In contrast, the dark count rates exhibited non-uniform variation trends, with some PMTs showing increases while others showed decreases. Besides, The afterpulse time spectrum is also analyzed, in which three potential characteristic peaks attributed to He+, CH4+ and Ar+ ions of residual gas are roughly identified. Overall, the R8520-506 PMT demonstrates stable and reliable performance at cryogenic temperatures, indicating its suitability for use in liquid argon detectors.

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Contribution ID: **56** Type: **Poster**

Feasibility studies of Migdal Effect detection in gases relevant for low-mass dark matter searches

The Migdal effect has recently emerged as a relevant phenomena of potential interest to dark matter searches enabling to extend the sensitivity of direct searches to sub-GeV mass scales. In such cases, the detection of ejecting electrons from accelerating recoiling atoms, the Migdal effect, provides a critical enhancement in signal yield and opens a new detection channel for light dark matter interactions. Its exploitation is particularly relevant for dual-phase and gas-based time projection chambers (TPCs), where high-resolution (spatial and energy) light/charge readout can significantly improve event reconstruction at the keV and sub-keV regime.

In this work, we present feasibility studies of the Migdal effect in argon-based gas mixtures within the context of the DarkSide programme. We investigate a hybrid gas-phase TPC concept instrumented with a high-granularity charge readout based on the Timepix4 bare-ASIC. This approach aims to combine the scalability of noble gas targets with the spatial resolution required to identify low-energy electron signals induced by Migdal processes.

To optimize the detector performance, we have carried out a comprehensive experimental characterization of charge transport properties in candidate argon mixtures, including drift velocity, longitudinal and transverse diffusion, electron extraction efficiency, and charge gain. These measurements provide essential input parameters for detector modeling and are critical for assessing the achievable sensitivity to Migdal-induced signals in future low-mass dark matter searches with Argon.

In addition, these measurements will be complemented with the study of the optical properties of these mixtures. Together, these results will be fed into a dedicated simulation framework designed to optimize detector configuration and performance, enabling a robust evaluation of the potential of argon-based gas TPCs for next-generation light dark matter searches.

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Presenter: Dr HAVERSON, Kristian (Astrocent)

Contribution ID: **57** Type: **Talk**

Optical properties of materials under Liquid Xenon VUV scintillation light

Efficient detection of 178 nm VUV scintillation light is a staple of xenon-based detectors for rare-event searches, including next-generation experiments to search for neutrinoless double beta ($0\nu\beta\beta$) decay like nEXO. nEXO is a 5-tonne liquid xenon (LXe) time-projection chamber enriched to 90% Xe-136 designed to search for $0\nu\beta\beta$ decay with a projected half-life sensitivity of 1.35*10ˆ28 years over a 10-year lifespan. Achieving this sensitivity requires excellent collection of scintillation light and accurate modeling of the detector VUV optics, motivating a rigorous characterization of light sensors, including silicon photomultipliers (SiPMs), and of the optical properties of detector materials. We present selected results from a small, optically simple cryogenic cell at UMass Amherst to study light collection in LXe. The setup is equipped with a Fondazione Bruno Kessler HD3 VUV SiPM and an 241Am alpha source. Results from optical measurements of silicon and aluminum-coated surfaces will be presented.

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Contribution ID: **58** Type: **Poster**

Optical and quenching models for low energy nuclear recoil detection in liquid neon

Neon is a light element, making it well-suited for the detection of low-energy nuclear recoils from dark matter and neutrinos. In particular, reactor antineutrinos are difficult to detect via coherent elastic neutrino-nucleus scattering (CEνNS) due to the characteristically low-energy recoils they produce. The COHERENT Collaboration is planning to redeploy the CENNS-10 detector hardware as a new subsystem called MicroCLEAR, using liquid neon instead of liquid argon as a target. Prior to pursuing a CEνNS cross section measurement, MicroCLEAR will be recommissioned at the Triangle Universities Nuclear Laboratory to re-evaluate the energy dependence of the quenching factor. Previously, a single measurement was produced by members of the DEAP/CLEAN Collaboration in 2012 using the MicroCLEAN detector. Moreover, recent theoretical work by Sarkis et al. has improved the behaviour of quenching at low energies to account for physical effects in this limit. In this contribution, we apply this new recipe to neon and find reasonable agreement with existing calculations by Mei et al. Additionally, we have calculated optical model properties of liquid neon to enable a more robust modelling of the detector response.

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Contribution ID: **59** Type: **Talk**

Solar neutrino absorption in DEAP-3600: A new chapter for argon dark matter detectors

The Dark matter Experiment using Argon Pulseshape discrimination (DEAP-3600) is a leading single-phase liquid argon experiment located 2 km underground at SNOLAB. The experiment was designed and optimized for sensitivity to nuclear recoils produced by WIMP dark matter through careful material screening, immense overburden, passive shielding, and careful analysis methods. Many of these properties also make DEAP-3600 well-suited to detect MeV-scale charged-current interactions from ^{8}B solar neutrinos. To that end, DEAP-3600 has recently produced the first measurement of low-energy charged-current interactions on ^{40}Ar, which have eluded detection since 1986. In an exposure of (7.29 $\pm$ 0.05) tonne-years, 6 events in the signal region of interest were observed against an expectation of 2.3 signal events and 0.48 background events. The energy-averaged cross section was measured as $(4.0\,^{+2.0}_{-1.6}\,(\mathrm{stat})\,^{+0.8}_{-0.7}\,(\mathrm{sys}))\times 10^{-41}\,\mathrm{cm}^2$, which is larger than the most recent data-driven predictions.

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Contribution ID: **60** Type: **Poster**

DEAP-3600 Hardware Upgrades and Study of Effect of Pyrene-Doped Polystyrene Wavelength Shifting

Located 2 km underground at SNOLAB in Sudbury, Canada, the DEAP-3600 experiment uses a 3.3-tonne single-phase liquid argon (LAr) target to detect nuclear recoils from dark matter interactions. Following the conclusion of its second fill run in 2020, the detector underwent major upgrades to mitigate shadowed-alpha and dust-related backgrounds, the two primary noise sources in the WIMP search region. Refilling commenced in early 2025, with subsequent vacuum, gaseous argon, and liquid argon data runs scheduled before full-scale operations resume through 2026. These enhancements, including a slow-time-constant pyrene-based wavelength shifter coating to mitigate shadowed alphas from the detector inlet, are expected to enable background-free sensitivity at the 10ˆ-46 cm2 cross-section level, significantly refining background models and boosting detector performance for next-generation LAr dark matter experiments.

Analysis of the populations of events in the detector data which are affected by pyrene doped polystyrene scintillation and wavelength shifting will be presented, alongside comparisons with the updated Monte
Carlo simulation model.

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Contribution ID: **61** Type: **Poster**

The commissioning and fist results from the LEGENDArYno setup.

LEGENDArYno is a newly constructed liquid argon (LAr) R&D setup located at LNGS. Its primary purpose is to provide suitable, realistic conditions for testing prototype Light Detection Modules (LDMs) envisioned for the Outer LAr volume instrumentation of the future LEGEND-1000 detector. The experimental setup is housed in a 140-cm-tall, 40-cm-diameter cryostat equipped with liquid nitrogen cooling, a LAr purification system, LAr purity monitoring, and a movable 241Am alpha source. This configuration allows for the optical characterization of geometries up to 1 m long and 35 cm wide. The LDM prototypes are based on doped PMMA and a wavelength-shifting (WLS) layer coupled to a SiPM-based light readout. We present a first report on the successful commissioning of LEGENDArYno and the results of LDM prototypes tests performed this year.

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Contribution ID: **62** Type: **Poster**

Search for BSM Astroparticles in DUNE Far Detectors

Despite the gravitational evidence supporting the existence of Dark Matter (DM), its composition remains unknown. As new approaches were demanded, a well-motivated class of models beyond the minimal WIMP scenario was proposed in the last decade. In this context, the Deep Underground Neutrino Experiment (DUNE) presents an excellent opportunity to search for BSM particles with its massive, underground far detector based on the technology of liquid-argon time-projection chambers (LArTPCs).

In this work, we present sensitivity studies of cosmogenic BSM particle searches in DUNE. In the first, we search for boosted dark matter (BDM), a small fraction of relativistic DM particles generated through the annihilation of the cold and dominant dark matter component in concentrated regions of mass, specifically the Sun in our study. We look for BDM through nucleus scattering via hadronic interactions in DUNE with complete simulated and reconstructed samples, along with an initial evaluation for systematic uncertainties. Secondly, we present an early-stage study for the search for Cosmogenic Axions via Inverse Primakoff interaction in the detector, producing quasi-monoenergetic photons. In these searches, the main background consists of atmospheric neutrinos.

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Contribution ID: **63** Type: **Talk**

Gamma Ray Detection in Liquid Argon Time Projection Chambers

The future Deep Underground Neutrino Experiment (DUNE) experiment will require unprecedented levels of precision to reach its physics goals. To this end, efficient reconstruction of photons produced in neutrino-nucleus scattering will be essential. This talk will present a new Compton scattering gamma-ray reconstruction tool that can associate blip-like energy depositions with a primary interaction vertex. This would improve the reconstruction of both accelerator and supernova neutrino interactions.

To this end, efficient reconstruction of photons produced in inelastic neutrino-argon interactions in excess of 250 keV will be essential. This new reconstruction was tested with data collected by placing various gamma-emitting isotopes, Cobalt-60, Sodium-22, and Fluorine-18, in proximity to the 2x2 Demonstrator and the Full Scale Demonstrator. These prototype detectors are pixelated liquid argon time projection chambers designed to demonstrate the capabilities of the DUNE Liquid Argon Near Detector (ND-LAr). These tests showed the ability to reconstruct the direction of MeV photons within a 10 percent error, and provided strong support for applying this method to neutrino-nucleus interactions. Additionally, it provided a simple accurate method for measuring various detector performance metrics which will become increasingly useful for Module Assembly of the DUNE ND-LAr.

We aim to utilize this method to associate each blip-like energy deposit to its interaction vertex, which would improve reconstructed energy resolution in the DUNE Near Detector. Using this work, we have also developed a design for a liquid argon-based Positron Emission Tomography (PET) scanner. PET scanners detect gamma rays emitted by a tracer chemical like fluorine-18 to help screen for diseases like cancer.

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Contribution ID: **64** Type: **Poster**

Comparison of Oxygen Adsorbents for Large-Scale Liquid Argon Purification Using a Physics-Based Adsorption Model

The next generation of liquid argon time projection chambers, such as those employed in the Deep Underground Neutrino Experiment (DUNE), requires ultra-high purity liquid argon to ensure long electron lifetimes and optimal detector performance. Oxygen is one of the most critical electronegative contaminants, and its efficient removal during cryostat filling is essential to reduce detector commissioning time. In this work, a physics-based adsorption model is employed to compare the large-scale purification performance of the commercial BASF Cu-0226 oxygen adsorbent and an innovative reduced layered double hydroxide (R-LDH) adsorbent.

The model describes oxygen transport through the purification system by accounting for external film resistance, intraparticle pore diffusion, and Langmuir adsorption equilibrium, coupled with a transient mass balance for the cryostat. Adsorption and mass transfer parameters for both adsorbents were determined by nonlinear regression of experimental data obtained in the Liquid Argon Purification Cryostat (PuLArC) at IFGW–UNICAMP under cryogenic conditions. The calibrated models were subsequently applied to simulate the filling stage of the ProtoDUNE cryostat at CERN, enabling a direct comparison of the two materials under realistic operating conditions.

Simulation results show that, for the same adsorbent bed volume, the R-LDH material provides purification performance comparable to that of the commercial BASF adsorbent despite its significantly lower bulk density (approximately 950 kg m^{-3} compared with 2000 kg m^{-3}). Consequently, similar oxygen removal can be achieved using less than half the adsorbent mass, demonstrating the superior efficiency of the R-LDH material. Furthermore, when equal adsorbent masses are considered, the lower density of the R-LDH enables a larger adsorption bed, thereby increasing the total oxygen-capture capacity and substantially reducing the time required to achieve detector-grade liquid argon purity during cryostat filling.

These results demonstrate that experimentally calibrated adsorption models provide a robust framework for evaluating emerging purification materials at the detector scale. The superior mass efficiency of the R-LDH adsorbent highlights its potential to reduce purification costs or shorten commissioning time for future large liquid argon detectors, making it an attractive alternative to conventional commercial oxygen-getter materials.

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Contribution ID: **65** Type: **Poster**

Application of Pixelated Liquid Argon Time Projection Chambers to Nuclear Medicine

Single Photon Emission Computed Tomography (SPECT) scanners detect gamma rays resulting from tracer chemicals like fluorine-18. These gamma rays have been detected in a pixelated Liquid Argon Time Projection Chamber (LArTPC) optimized for neutrino physics studies. These tests have in part motivated the optimization and design of a LArTPC for application in SPECT. This talk will present simulations of and designs for the SPECT Acquisition Using Liquid Argon (SPECTAcULAr) test stand at Fermi National Accelerator Laboratory.

Simulation studies have been performed in order to optimize parameters relevant to medical imaging. This talk will discuss the details of those simulation studies and how the results have motivated the design and construction of nuclear imaging scanners that use liquid argon technology. In addition to the simulation, this talk will provide an overview of the hardware efforts and plans for the SPECTAcULAr test stand at Fermilab.

If these tests are successful, they will demonstrate an ability to perform bio-medical scans with liquid argon time projection chambers. The simulations suggest this technology could provide enhanced spatial resolution over traditional technology. If true, this could have clinical implications such as lowering scan time, radiation dosage, or increasing image quality which would ultimately diagnostic capabilities and improve patient outcome.

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Contribution ID: **66** Type: **Talk**

LowRad & HERETIX: Low background for Dark Matter and neutrinoless double beta decay searches with XLZD

Next-generation liquid xenon (LXe) observatories such as XLZD aim to push the search for both Weakly Interacting Massive Particles (WIMPs) and neutrinoless double beta decay ($0\nu\beta\beta$) to unprecedented sensitivities. This requires an aggressive reduction of intrinsic backgrounds, dominated by the LXe-intrinsic isotopes of Kr and Rn, to a factor of ten below the unshieldable solar and atmospheric neutrino background. For XENONnT it could be shown that cryogenic distillation is a suitable method for reducing these backgrounds, but XLZD will require an approximately 20-times higher radon purification flow, necessitating new technologies for the associated cooling and heating power. Within the ERC Advanced Grant project LowRad, the technical foundations for the next-generation cryogenic krypton and radon removal systems are developed, including a krypton concentrator and a radon removal system with a cryogenic xenon heat pump. The concentrator aims to reduce krypton-enriched off-gas losses by another factor of 1000 (to 6 g/day), enabling continuous online distillation, while the heat pump addresses the heating and cooling power demands of 60 kW each (XLZD-sized, 1600 kg/h) required to reduce the Rn background below 0.1 μBq/kg.

Beyond background reduction, the HERETIX (Hermetic, Enriched, Rare-Event Time Projection Chamber in Xenon; arXiv: 2606.26876) concept explores a unified detector architecture serving both physics programs simultaneously, exploiting the large technological overlap between $0\nu\beta\beta$ and WIMP searches. We present a dual-phase, dual-chamber TPC, whereby an inner hermetic sapphire vessel holds about 5 tonnes of ^{136}Xe-enriched active LXe for $0\nu\beta\beta$ searches, embedded within a larger depleted active volume of about 60 tonnes optimised for WIMP searches. Monte Carlo studies indicate that material-induced backgrounds can be effectively eliminated, yielding a projected $0\nu\beta\beta$ half-life sensitivity of 3.2×10^{28} years at 90% confidence level after a 10-year exposure.

This talk presents the working principles, design choices, and status of the LowRad systems developed in Münster, together with the projected sensitivities and practical challenges of the HERETIX dual-volume approach, outlining the prospects towards the final XLZD observatory.

The LowRad project is financed through the ERC AdG "LowRad", project number 101055063, and supported by the Pazy foundation, ISF grant 1859/22.

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Contribution ID: **67** Type: **Talk**

Status and Prospects of the Scintillating Bubble Chamber Liquid Argon 10 kg (SBC-LAr10) Detector

The Scintillating Bubble Chamber (SBC) collaboration is developing liquid noble bubble chambers as a technology for the detection of low energy (sub-keV) nuclear recoils. Identifying recoils at this energy would enable searches for light dark matter (˜GeV mass), as well as the observation of coherent elastic neutrino nucleus scattering (CEvNS) at low neutrino energy (˜MeV, such as from a reactor source). The SBC-LAr10 detector at Fermilab, in the MINOS underground facility, has taken data to demonstrate the operation and characterize the performance of the detector. In this talk, I will show some of the first results from this operation, demonstrating the capability of the detector to observe bubble-nucleating events through multiple coincident channels. I will also discuss the future prospects for the program. A twin chamber will soon be deployed at SNOLAB in Canada to enable a sensitive, low-background search for dark matter. Furthermore, a future deployment of the detector at a reactor neutrino source would enable novel measurements through the CEvNS process.

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Contribution ID: **68** Type: **Poster**

Electric-Field Dependence of Liquid Argon Scintillation in ProtoDUNE

The Deep Underground Neutrino Experiment (DUNE) is a next-generation neutrino experiment designed to perform high-precision measurements of neutrino oscillation parameters, investigate leptonic CP violation, determine the neutrino mass ordering, detect neutrinos from core-collapse supernovae, and search for physics beyond the Standard Model. Its far detector modules will be based on liquid argon time projection chambers (LArTPCs), which detect both the ionization charge and the scintillation light produced by charged particles in liquid argon. The Photon Detection System (PDS) is a key component of this detection strategy. It collects scintillation light and provides precise event timing, enabling drift-coordinate reconstruction, contributing to triggering and background rejection, improving calorimetric energy reconstruction, and playing a crucial role in the detection of supernova neutrino signals. Two LArTPC technologies are currently being developed for DUNE: the horizontal-drift and vertical-drift designs, tested at CERN through the ProtoDUNE-HD and ProtoDUNE-VD prototypes. These prototypes provide a unique opportunity to study the response of liquid argon scintillation under different electric-field conditions. In this work, scintillation observables, including the light yield, are measured as a function of the electric field, varied from 0 to 0.5 kV/cm, using a selected sample of cosmic-muon events.

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Contribution ID: **69** Type: **Poster**

Optimization of CuO-Layered Double Hydroxide Pellets for Oxygen Capture in Liquid Argon

Ultrapure liquid Argon (LAr) is a heavily used target for neutrino detection. Recently, an innovative adsorbent R-LDH based on layered double hydroxides has shown higher performance for oxygen capture in liquid argon than other materials frequently used 1. This work aimed to develop a new pelletization methodology for the R-LDH materials containing highly dispersed CuO that can allow the scale up of this metals for oxygen capturing in LAr. For this purpose, different concentrations of HNO3 were used as a binder in the preparation of R-LDH pellets. Subsequently, the influence of HNO3 concentration on the structural, textural, and mechanical properties of the pellets was investigated, as well its effect on activation and performance during reduction-oxidation cycles, in order to correlate these properties with oxygen capture efficiency in LAr. The results showed that the pellets prepared with HNO3 preserved the structure derived from the layered double hydroxide and the high dispersion of CuO species, exhibiting good mechanical strength. Among the prepared materials, the material with the highest mechanical strength was submitted for activation and reduction-oxidation cycles. After activation, the R-LDH material was found to exhibit superior oxygen capture performance compared to the commercial copper oxide-based material BASF Cu-0226S typically used in LAr cryostat. These results demonstrate that the developed methodology constitutes a promising strategy for the preparation of large amounts of R-LDH pellets, enabling excellent oxygen capture performance from LAr in massive cryostats. We thank FAPESP-SP and FINEP-Br for financial support.

1 A. M. Caffer et al, 2025, JINST, 20, C03043.

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Contribution ID: **70** Type: **Poster**

Hardware and electronic setup for aging study on P-Terphenyl thin films

Prolonged exposure of p-terphenyl (PTP) to environmental factors such as light, temperature, and humidity can induce aging processes that degrade their optical performance, potentially compromising the long-term stability and reliability of detector systems. A systematic investigation of these degradation mechanisms is therefore essential for qualifying WLS coatings in experiments, such as liquid argon time projection chambers (LAr-TPCs), that require stable operation over extended periods.

This work presents the development of a dedicated experimental setup to investigate the aging of PTP thin films under controlled environmental conditions. The system combines modular, custom-designed 3D-printed hardware with electronic instrumentation based on an Arduino microcontroller to precisely regulate and continuously monitor illumination, temperature, and relative humidity during long-term exposure tests. Environmental parameters are recorded in real time and wirelessly transmitted via Bluetooth to a database, ensuring traceability, reproducibility, and fully automated operation throughout the experiments.

The setup accommodates eight PTP thin-film samples (2.5×2.5 cm), arranged in pairs and exposed to red, yellow, green, and ultraviolet LEDs to investigate wavelength-dependent aging effects. At regular intervals, the samples are characterized by measuring their mass and relative wavelength-shifting conversion efficiency using a spectrophotometer available at the Leptons Laboratory (Universidade Estadual de Campinas, Brazil). The resulting long-term dataset will enable correlations between environmental exposure conditions and optical degradation, providing valuable information for improving the durability and performance of WLS coatings in photodetection systems.

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Contribution ID: **71** Type: **Talk**

Proof of concept of the PoWER concept

A proof-of-concept test of the PoWER (Polymer Wavelength Shifter and Enhanced Reflection) photon detection system was carried out at the Leptons Laboratory of UNICAMP. PoWER is an innovative photon detection concept for large liquid argon (LAr) detectors, designed to achieve an exceptionally high light yield—potentially reaching several hundred photoelectrons per MeV—while providing an active veto for interactions occurring outside the fiducial volume. The concept is based on polyethylene naphthalate (PEN) foils acting as wavelength shifters and on a hybrid array of visible- and VUV-sensitive silicon photomultipliers (SiPMs), which enables the active veto functionality.

The prototype consists of two concentric cubes: an outer $10 \times 10 \times 10\ \mathrm{cm}^3$ Teflon enclosure and an inner $8 \times 8 \times 8\ \mathrm{cm}^3$ acrylic cube that defines the active volume. The inner surfaces of the Teflon cube are lined with Vikuiti reflective foil and instrumented with four Hamamatsu S14160-6050HS SiPMs, including two standard devices and two coated with TPB to provide VUV sensitivity. The acrylic cube is internally covered with PEN foils. Three radioactive sources were employed to characterize the detector performance: a natural uranium alpha source placed inside the active volume, a ^{241}Am alpha source located in the veto region, and an external ^{22}Na gamma source. The detector was operated in liquid argon produced by \textit{in situ} liquefaction of high-purity argon gas. Preliminary results on the detector light yield and the performance of the active veto are presented.

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Contribution ID: **72** Type: **Poster**

Investigating Materials and Contaminants as Sources of Delayed Photon and Electron Backgrounds in Liquid Xenon TPCs

Delayed photon and electron signals in dual-phase xenon time projection chambers (TPCs) are a significant source of instrumental background in searches for sub-GeV dark matter candidate particles and solar neutrinos. Possible origins of delayed signals include detector materials, contaminants on detector surfaces, and impurities in the bulk of xenon.

In order to investigate the origins of delayed signals, we perform a series of lab measurements on samples collected from, or representative of, the XENONnT TPC. The composition of particulate samples is studied using elemental composition techniques, including EDX (energy-dispersive X-ray spectroscopy) and LIBS (laser-induced breakdown spectroscopy). In addition, through measurements under VUV excitation in the 120 nm – 190 nm range, we demonstrate the presence of nuisance photoluminescence (PL) emission from detector-relevant materials. We also perform temperature-dependent and time-resolved measurements of nuisance PL. These results are then compared with detector data and TPC behaviour to identify the underlying physical origins of the delayed signals.

Our studies motivate systematic material screening, improved cleaning procedures, and the incorporation of nuisance photoluminescence and photoionization mechanisms into background models for future liquid-xenon TPCs.

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Contribution ID: **73** Type: **Talk**

Status of the PandaX-20T Liquid Xenon Detector

PandaX (Particle and Astrophysical Xenon experiment), a large-scale liquid xenon dark matter detection project located at the China Jinping Underground Laboratory, has provided a high-sensitivity experimental platform for dark matter and neutrino searches through the iterative development of three generations of detectors since its launch in 2009. As a core leading institution of the collaboration, the Tsung-Dao Lee Institute (TDLI) of Shanghai Jiao Tong University hosts a full-chain detector operation and R&D platform featuring a 2-tonne liquid xenon prototype detector, supporting the stable data taking, performance calibration and low-background technology development of the PandaX program.

To further enhance the sensitivity to these rare signals, the PandaX collaboration has proposed the next-generation detector PandaX-20T, scheduled to come online in 2027. Over 20 tonnes of xenon will be utilized, with a time projection chamber measuring ˜2 m in diameter and ˜2.5 m in height. New R12699 photomultiplier tubes with significantly lower radioactivity will be employed for photon detection. The TDLI prototype platform also supports the pre-research of key technologies for PandaX-20T.

This talk will give an overview of the PandaX detector operation status, the latest R&D progress of PandaX-20T.

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Contribution ID: **74** Type: **Poster**

Integration of DAPHNE as the warm readout electronics for DUNE ND-LAr

The DUNE Near Detector Liquid Argon Time Projection Chamber (ND-LAr)
employs a light readout system (LRS) to provide precise event timing, pile-up separation, and complementary information for event reconstruction in the high-rate neutrino environment of the Long-Baseline Neutrino Facility (LBNF). The light readout system is composed of large area light trap units, read by an arrays of six silicon photomultipliers (SiPMs), cold pre-amplification and signal shaping, warm waveform digitization, and real-time data processing integrated into the Near Detector Data Acquisition (DAQ) infrastructure.
This contribution presents the architecture and initial quality performance of the proposed ND-LAr light readout chain based on the DAPHNE digitization scheme. DAPHNE performs low-noise waveform acquisition, online signal processing and self-triggering, while providing an interface to the DUNE DAQ system through high-bandwidth network links. Results from test bench and a small scale TPC operation in LAr are presented, including baseline noise assessment, signal to noise ratio, data rate measurements and operational stability.

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Contribution ID: **75** Type: **Poster**

Monte Carlo Simulation of the PoWER: Proof of Concept

The PoWER system is a novel, cost-effective photon detection proposal designed for large-scale Liquid Argon Time Projection Chambers (LArTPCs). A proof-of-concept prototype was developed at Unicamp to validate its light yield and veto capabilities, consisting of two concentric volumes: an outer Teflon cube internally lined with Vikuiti and an inner acrylic cube coated with PEN foils. Detection is handled by four SiPM arrays (two VUV-sensitive and two visible-light-only sensitive). Experimental tests utilized two alpha sources, an internal U-Al source and an intermediate Am source, alongside an external gamma source to evaluate detection performance and veto capabilities.

This work presents a Geant4-based Monte Carlo (MC) simulation of the proof of concept for the PoWER system, encompassing geometry and optical modeling. By analyzing event discrimination between different regions and calculating light yields for both alpha and gamma sources, the simulation results were validated against the experimental data.
The developed MC model demonstrates agreement with the experimental results, confirming both the event discrimination and the high light yield capabilities of the PoWER system. Furthermore, this agreement validates the accurate modeling and thorough understanding of the system's optical properties.

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Contribution ID: **76** Type: **Talk**

Early Performance and Calibration of the SBND Photon Detection System

The Short-Baseline Near Detector (SBND) is a liquid-argon time-projection chamber (LArTPC) for detecting neutrinos from Fermilab's Booster Neutrino Beam. Located 110 m downstream of the beam target, SBND collects both ionization electrons and scintillation photons from particle interactions within the detector volume. With an active mass of 112 tons, it enables high-precision studies of neutrino-argon interactions. The detector has been collecting data since 2024. The primary photon detection system (PDS) consists of PMTs, which serve as the neutrino interaction trigger source within the LArTPC. The PDS of SBND is expanding with the addition of X-ARAPUCA modules located next to the PMTs and reflective wavelength-shifting panels in front of the PMTs and X-ARAPUCAs. Combined, these components enhance light collection, especially in regions furthest from the PDS, and provide high light yield, more uniform detection efficiency, excellent timing resolution, and scintillation-light-only 3D position reconstruction. This talk will cover the calibrated PMT system, including measurements of the light yield and timing resolution.

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Contribution ID: **77** Type: **Poster**

Update and Progress of the X-ARAPUCAs in SBND

The Short-Baseline Near Detector (SBND) is a liquid-argon time-projection chamber (LArTPC) for detecting neutrinos from Fermilab's Booster Neutrino Beam. Located 110 m downstream of the beam target, SBND collects both ionization electrons and scintillation photons from particle interactions within the detector volume. The photon detection system (PDS) consists of both PMTs and X-ARAPUCAs, with the latter a novel technology that provides large-area, cost-effective coverage with single-photoelectron resolution at cryogenic temperatures. SBND utilizes two types of X-ARAPUCAs: one sensitive to vacuum ultraviolet (VUV) scintillation light and one sensitive to visible light from light reflected off TPB-coated reflective foils. SBND is the only experiment currently testing the X-ARAPUCA technology in a neutrino beam over several years and will provide critical information for deployment in future detectors such as DUNE. This talk will cover the calibration and early performance of X-ARAPUCAs in SBND.

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Contribution ID: **79** Type: **Talk**

Performance of the MainzTPC2

The MainzTPC is a dual-phase xenon time projection chamber (TPC) containing roughly 300 g of liquid xenon (LXe) and is dedicated to the study of scintillation and ionization processes in LXe for low-energy electronic and nuclear recoils. It has been designed to be the primary target in Compton and neutron scattering experiments to measure recoil energies in LXe down to 1 keV. To improve position resolution in x and y, the detector was redesigned to accommodate an array of 36 individually read-out, VUV-sensitive Hamamatsu silicon photomultipliers (SiPMs), replacing its monolithic top photomultiplier tube (PMT) and eight avalanche photodiodes. A primary goal of this upgrade is to enable measurements of low-energy nuclear recoils in LXe, with a focus on improving sensitivity to the Migdal effect. For this purpose, a cryogenic amplifier board housing the SiPM array was developed and installed. To address known instabilities in the liquid level, we rebuilt the liquid-level monitoring and control system based on camera observations of the liquid–gas interface. In this talk, we present the performance of the upgraded MainzTPC, with particular emphasis on the SiPM array and Compton scattering measurements performed with gamma-ray sources.

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Contribution ID: **80** Type: **Talk**

Recent results and future plans of Xenoscope TPC

Despite compelling astrophysical evidence for dark matter, a definitive detection in a terrestrial experiment has yet to be made. Dual-phase liquid xenon time projection chambers have achieved world-leading sensitivities to interactions between dark matter particles and ordinary matter. Although current detectors operate with LXe target masses of about ten tonnes and at unprecedented low background levels, their searches have so-far returned null results.

The XLZD collaboration aims to fully exploit this technology by constructing a detector containing 60-80 tonnes of liquid xenon. Several technical challenges remain, one of which is being addressed by the large-scale vertical demonstrator - Xenoscope - at the University of Zürich. The facility contains 360 kg of LXe and was recently upgraded to accommodate a 2.6 m long dual-phase TPC. A primary objective of Xenoscope is to study long-distance electron drift in liquid xenon. Initial results demonstrate successful electron drift over distances exceeding 2 m using ionization electrons produced by atmospheric muons. Ongoing and future studies include refined measurements of light and charge transport in LXe, as well as investigations of a novel surface-coating approach for radon mitigation.

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Contribution ID: **81** Type: **Talk**

Data driven Photon Detection Efficiency measurements in DUNE's Near Detector Demonstrators

The Deep Underground Neutrino Experiment (DUNE) Near Detector will be exposed to an extremely intense neutrino flux (over 100 beam-related interactions per spill). To cope with the very high event pile-up, the Near Detector uses a modular array of Liquid Argon time projection chambers (ND-LAr), which incorporates several innovations. Most importantly, a pixelated charge readout system with native 3D reconstruction, a high-coverage Light Readout System (LRS), and a segmented design. The latter is what enables the correct matching between charge and light signals, allowing energy depositions to be properly associated with their interactions.
The LRS employs Wavelength Shifter (WLS) based light traps, which absorb the VUV photons produced by LAr scintillation, shift them into visible wavelengths and guide them to Silicon Photomultipliers (SiPM). The Photon Detection Efficiency (PDE) quantifies how efficiently the light traps convert the absorbed scintillation photons into a detectable SiPM signal. A higher PDE improves the detected light yield, timing reconstruction, charge-light matching and generally improves the LRS performance across all key metrics. Therefore, an accurate determination of the PDE is essential not only for reconstruction, but also for QA/QC and detector performance validation. This contribution outlines a data-driven approach to determine the PDE of the light traps in the 2×2 and Full-Scale Demonstrator (FSD) using muon-track data.

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Contribution ID: **82** Type: **Talk**

Performance Comparison of PEN Foil and TPB Coating for LArTPC Light traps

Liquid Argon Time Projection Chambers (LArTPCs) rely on large-area photon detectors to detect liquid argon scintillation light necessary for precise event timing, triggering and complementary calorimetry alongside the charge readout.
Liquid argon emits scintillation light predominantly at 128 nm in the vacuum ultraviolet (VUV) region. As this wavelength cannot be efficiently detected by commonly used photon detectors, wavelength shifting techniques are required to convert the scintillation light into the visible region.
In a typical light trap architecture, incident VUV photons undergo a primary wavelength-shifting stage before being trapped within a secondary WLS component, where they propagate via total internal reflection toward silicon photomultipliers (SiPMs).
Traditional designs employ a Tetraphenyl Butadiene (TPB) coating for the initial wavelength-shifting stage. An alternative approach replaces this coating with a Polyethylene Naphthalate (PEN) foil, which similarly shifts the liquid argon scintillation light into the blue region. Compared to evaporative TPB coatings, PEN foil offers superior mechanical handling and scalability, presenting a promising pathway to simplify the fabrication of future large-scale light readout systems.

This contribution presents results from in situ measurements of cosmic-ray events in a small liquid argon TPC using two light trap tiles: one fabricated with a conventional TPB coating and the other with a PEN foil. Their performance is directly compared to evaluate the viability and efficiency of PEN foil as a scalable alternative wavelength shifter for future LArTPC detectors.

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