XeSAT2024 - International Workshop on Application of Noble Gas Xenon to Science and Technology

Report of Contributions

Contribution ID: **1** Type: **not specified**

How to produce the purest xenon on Earth for rare event searches with XENONnT

Monday, 27 May 2024 11:00 (40 minutes)

The dark matter experiment XENONnT utilizes about 8.6 tonnes of liquid
xenon for the direct search of Weakly Interacting Massive Particles (WIMPS) and other rare event searches, employing a dual-phase Time Projection Chamber (LXe TPC).

In order to reach world-leading senstivities for the several physics channels, the target material xenon needs to be ultra-pure. Electrogentive impurities such as oxygen can absorb or capture the created photons and electrons after a particle interaction inside the detector, diminishing the potential dark matter signals. Additionally, radioactive contaminants such as Kr-85 and Rn-222 can mimic signal events and are the main source of background in XENONnT.

This talk will present the different purification techniques developed for XENONnT to produce the purest xenon on Earth leading to the lowest background in an operating LXe TPC.

Primary author: Dr MURRA, Michael (Columbia University in the City of New York)

Presenter: Dr MURRA, Michael (Columbia University in the City of New York)

Session Classification: Detector R&D

Contribution ID: **2** Type: **not specified**

Validation of the VUV-reflective coating for next-generation liquid xenon detectors

Sunday, 26 May 2024 10:00 (30 minutes)

Coating detector materials with films highly reflective in the vacuum ultraviolet (VUV) region improves sensitivity of the next-generation rare-event detectors that use liquid xenon (LXe). In particular, nEXO requires its Cu field-shaping rings and cathode to be coated by films that are 80% reflective at 175 nm, the mean wavelength of LXe scintillation. Other experiments, like DARWIN, could also benefit from such films. Al-MgF_2 coatings are known to be highly reflective in VUV, but depositing Al directly on Cu leads to alloying, decreasing VUV reflectance. Additionally, it was not clear how thin-film coatings would perform on realistic detector components, which are unpolished and passivated. This talk describes dedicated measurements in LXe and gaseous nitrogen of thin-film coatings that were designed to address these issues.

Primary author: OSTROVSKIY, Igor (University of Alabama)

Presenter: OSTROVSKIY, Igor (University of Alabama)

Session Classification: Double Beta Decay

Contribution ID: **3** Type: **not specified**

XENONnT Data Analysis

Saturday, 25 May 2024 10:30 (30 minutes)

The XENONnT experiment is a multi-ton-scale liquid-xenon detector operated by the XENON Collaboration in search of dark matter and other beyond the standard model phenomena. The dual-phase time projection chamber (TPC) design enables simultaneous measurement of scintillation and ionization signals produced by interactions within the target volume, which can be utilized to reconstruct the energy, position, and type of the interaction for each event. Then by performing event selection, detector response characterization via calibration, and determination of signal and background model, the XENONnT experiment has set world-leading limits on models on WIMP nucleon interaction, solar axions, enhanced neutrino magnetic moment, and bosonic dark matter. This talk will cover the analysis work that goes into arriving at these limits.

Primary authors: MURRA, Michael (Columbia University in the City of New York); LIN, Ying-Ting (Max-Planck-Institut für Kernphysik)

Presenter: LIN, Ying-Ting (Max-Planck-Institut für Kernphysik)

Session Classification: Dark Matter Direct Detection

Contribution ID: **4** Type: **not specified**

GanESS: Gaseous Detectors for neutrino Physics at the ESS

Monday, 27 May 2024 10:00 (30 minutes)

The recent detection of the coherent elastic neutrino-nucleus scattering (CEνNS) opens the possibility to detect neutrinos with small-size detectors and with different techniques, opening a new window to explore possible BSM physics.
The CEνNS process generates signals at the few-keV level, requiring sensitive detection technologies for its observation. The European Spallation Source (ESS) has been identified as the best possible site for the exploration this CEνNS process.
GanESS will use of a high-pressure noble gas time projection chamber to measure CEνNS at ESS in gaseous Xe, Ar and Kr. Such technique appears extraordinarily promising for detecting the process albeit characterization of the response to few-keV nuclear recoils will be necessary.
With this goal, we are currently comissioning GaP, a small prototype capable of operating up to 50 bar. GaP will serve to fully evaluate the low energy response of the technique, with a strong focus on measuring the quenching factor for the different noble gases that will later be used at GanESS.
I will give an overview of GanESS with a focus on the status of GaP and its short-term plans.

Primary author: MONRABAL CAPILLA, Francesc (Donostia International Physics Center)

Presenter: MONRABAL CAPILLA, Francesc (Donostia International Physics Center)

Session Classification: Dark Matter Direct Detection

Contribution ID: **5** Type: **not specified**

Fluorescent Indicators for Barium Tagging in Double Beta Decay Reactions of Xe-136

Saturday, 25 May 2024 14:30 (30 minutes)

In this communication, recent advances on the design, development and experimental validation of fluorescent indicators for barium tagging in double beta decay reactions of Xe-136 to yield one Ba(2+)-136 cation plus two electrons will be presented. These developments include mono- and bicolor indicators. The components of the fluorescent sensors include a Barium catcher and a fluorophore, together with a spacer-linker unit to anchor covalently the sensor to a suitable material in order to generate a functionalized surface able to detect Ba2(+) with low background and high selectivity. The photophysics of these sensors in solid-gas (Xe-136) interfaces will be also discussed.

Primary author: COSSÍO, Fernando P. (University of the Basque Country (UPV/EHU))

Presenter: COSSÍO, Fernando P. (University of the Basque Country (UPV/EHU))

Session Classification: Double Beta Decay

Contribution ID: **6** Type: **not specified**

nEXO, search for 0νββ beyond 10^28 years

Sunday, 26 May 2024 09:30 (30 minutes)

The pursuit of neutrinoless double beta decay (0νββ) detection stands at the forefront of particle physics research, promising profound insights into fundamental physics beyond the Standard Model. nEXO, a cutting-edge experiment, endeavors to explore this phenomenon utilizing a 5-tonne liquid xenon (LXe) time projection chamber (TPC), enriched to 90% in Xe136, poised to achieve a half-life sensitivity exceeding 10ˆ28 years after a decade of operation. The potential observation of 0νββ decay heralds transformative implications, suggesting novel physics characterized by lepton number non-conservation and substantiating the Majorana nature of neutrinos. Leveraging ionization and scintillation light to gauge energy, nEXO aims for energy resolutions below 1% at the Qββ endpoint, bolstered by meticulous design enhancements to mitigate background noise, including the utilization of electroformed copper and a careful selection of low-activity materials. Situated at SNOLAB, nEXO employs advanced detector configurations, featuring segmented anodes and a large-area SiPM array, to capture ionization electrons and scintillation photons, thus facilitating precise event reconstruction. Recent advancements in detector design and data analysis, including the adoption of deep neural network architectures, underscore nEXO's pursuit of enhancing signal-to-background discrimination. nEXO reaches a sensitivity to 0νββ half-life of 1.35×10ˆ28 years over a decade-long observational span.

Primary author: MASBOU, Julien (Subatech - Nantes Université)

Presenter: MASBOU, Julien (Subatech - Nantes Université)

Session Classification: Double Beta Decay

Contribution ID: **7** Type: **not specified**

Dual-Phased Xenon Time Projection Chamber Prototype for the RELICS Neutrino Experiment

Saturday, 25 May 2024 17:20 (20 minutes)

The RELICS experiment is dedicated to the search for the Coherent Elastic ν-Nucleus Scattering (CEvNS) process between neutrinos of approximately MeV energy and xenon nuclei, to be conducted at the Sanmen nuclear power plant using a ~ 30-kilogram dual-phased xenon detector. We have developed a dual-phased Xenon Time Projection Chamber prototype, the RELICS prototype, containing ~0.6 kg of xenon in the sensitive volume to verify the functionality of the RELICS detector. This prototype aims to maximize the efficiency of single-electron detection, which is the key to CEvNS measurement. It is also used to test the cryogenic, purification, storage, slow control and data acquisition systems to be employed by the RELICS experiment. In this talk, we summarize the design, construction, and operation of the RELICS prototype. Specific focus is given to the single electron detection and calibrations with internal Kr83m and Ar37 sources, demonstrating the energy threshold for the RELICS experiment. Through these advancements, the RELICS project aims to pioneer the detection of neutrino signals on the ground, detecting the high neutrino flux from the Sanmen reactor.

Primary author: XIE, Lingfeng (Tsinghua University)

Presenter: XIE, Lingfeng (Tsinghua University)

Session Classification: Leptons and Neutrinos

Contribution ID: **8** Type: **not specified**

RELICS: Search for Coherent Elastic Neutrino-Nucleus Scattering from reactor neutrinos using LXeTPC

Saturday, 25 May 2024 17:00 (20 minutes)

The precise measurement of the Coherent Elastic Neutrino-Nucleus Scattering (CEνNS) cross-section is of significant importance to understanding the properties of neutrinos and constraining new physics beyond the Standard Model. However, due to the background noise in the low energy region, the detection of CEνNS signals from reactor neutrino is quite challenging. The Liquid Xenon Time Projection Chamber (LXeTPC), which demonstrates good performance in dark matter detection and shows great potential in detecting events with nuclear recoil energy lower than 1keV, is a promising technology for detecting CEνNS signals. Reactor neutrino Liquid xenon Coherent Scattering experiment (RELICS) looks forward to employing this technology to detect CEνNS caused by ˜MeV neutrinos from the reactors. This presentation will introduce the latest developments of the RELICS experiment.

Primary author: CAI, Chang

Presenter: CAI, Chang

Session Classification: Leptons and Neutrinos

Contribution ID: **9** Type: **not specified**

MEG II experiment and the liquid xenon detecotr

Saturday, 25 May 2024 16:00 (30 minutes)

The MEG II experiment aims to discover the charged lepton flavor violation decay, μ+⟶e+γ, using high intensity continuous muon beam in the PSI. The MEG II began physics run since 2021 and we published first result with the an upper limit on the branching ratio of B(μ+ ⟶ e+γ) < 7.5 × 10^{−13} (90 % C.L.). We continue to take physics run also in 2022 and 2023, and will continue by 2026. Currently the analysis of 2022 data is ongoing and we aim to publish next result soon.
The liquid xenon calorimeter measures the energy, timing and position of signal gamma-ray. Approximately 800 L of liquid xenon is filled in a cryostat and generates scintillation lights by incident gamma-ray. The scintillation photons are detected by photo sensors attached on the cryostat wall and surrounding the liquid xenon. On the incident face of
gamma-ray, 4092 VUV-sensitive SiPMs are used and 668 VUV-sensitive PMTs are used for the other faces. The detector stability during beam time was regularly monitored using LED, alpha-ray, cosmic-ray, and mono-peak (9 MeV and 17.6 MeV) gamma-ray sources. Detector responses such as position dependence, energy resolution, and timing resolution were also studied using gamma-ray from charge exchange reaction between charged pion and hydrogen (55 MeV, 80 MeV). In the presentation, these detector performance evaluated by these calibration run are reported.
Photon Detection Efficiency (PDE) decrease of SiPMs during beam time was observed probably caused by radiation damage. We tried to recover the PDE decrease by annealing during beam-off period. This recovery process and result are also presented.

Primary author: BAN, Sei (The University of Tokyo, ICEPP)

Co-authors: OYA, Atsushi (The University of Tokyo); MATSUSHITA, Ayaka (The University of Tokyo); YAMAMOTO, Kensuke (The University of Tokyo); MORI, Toshinori (The University of Tokyo); IWAMOTO, Toshiyuki (The University of Tokyo); OOTANI, Wataru (The University of Tokyo); UCHIYAMA, Yusuke (KEK)

Presenter: BAN, Sei (The University of Tokyo, ICEPP)

Session Classification: Leptons and Neutrinos

Contribution ID: **10** Type: **not specified**

Dark matter search with crystalline xenon

Monday, 27 May 2024 09:30 (30 minutes)

Direct dark matter search experiments aim to detect rare events when a candidate dark matter particle scatters off a target. Ultra-low background is essential for such an effort. State-of-the-art liquid xenon time projection chambers (TPC) employ various effective methods to suppress and discriminate against background signals. The dominant background remaining is the Pb beta decay from the Rn chain, which limits our discovery sensitivity. A crystalline xenon TPC is a promising novel technology for next-generation dark matter search, as it could exclude and tag radon-chain backgrounds while maintaining the instrumental benefits of liquid xenon TPC. This talk will discuss instrumental performance as well as recent results to demonstrate the radon exclusion power of crystalline xenon with respect to liquid xenon.

Primary authors: Dr SORENSEN, Peter (Lawrence Berkeley National Laboratory); Dr XIA, Qing (Lawrence Berkeley National Laboratory); GIBBONS, Ryan (Lawrence Berkeley National Laboratory); Dr HASELSCHWARDT, Scott (Lawrence Berkeley National Laboratory); Dr KRAVITZ, Scott (The University of Texas at Austin); 昊, 陈 (复旦大学-现代物理研究所)

Presenter: 昊, 陈 (复旦大学-现代物理研究所)

Session Classification: Dark Matter Direct Detection

Contribution ID: **11** Type: **not specified**

Status of the LUX-ZEPLIN dark matter experiment

Saturday, 25 May 2024 11:00 (30 minutes)

LUX-ZEPLIN (LZ) is a dark matter direct detection experiment located at the Sanford Underground Research Facility in Lead, South Dakota. At the heart of the detector is a dual-phase time projection chamber containing 7 tonnes of active liquid xenon. During its 1000-day science run, LZ aims to achieve unprecedented sensitivity to Weakly Interacting Massive Particles (WIMPs) down to a WIMP-nucleon spin-independent cross section of about 1.4×10^{-48}cm^2 for a 40GeV c^2 mass WIMP. In this talk, I will give an overview of the LZ experiment, discuss its status and report on recent results.

Primary author: FRUTH, Theresa (University of Sydney)

Presenter: FRUTH, Theresa (University of Sydney)

Session Classification: Dark Matter Direct Detection

Contribution ID: **12** Type: **not specified**

The progress of ALETHEIA, a project hunting for low-mass dark matter with LHe TPCs

Sunday, 26 May 2024 11:00 (30 minutes)

DM direct detection aims to test the cross-section between galactic DM particles and an underground detector's nucleons. Although Weakly Interacting Massive Particles (WIMPs) is the most discussed DM candidate, the null-WIMPs conclusion has been consistently addressed by the most convincing experiments in the field. The low-mass WIMPs region (100s MeV/cˆ2 - 10 GeV/cˆ2), however, has not been fully exploited compared to high-mass WIMPs (10 GeV/ˆ2 - 1 TeV/ˆ2). The ALETHEIA (A Liquid hElium Time projection cHambEr In dArk matter) experiment aims to hunt for low-mass WIMPs with liquid helium-filled time projection chambers (TPCs). The project was officially launched in 2020 and has made significant progress ever since. So far, we have verificed all of the key technoligies to build a single-phase LHe TPC; the R&D on a dual-phase detector is still underway. I will introduce the progress we have made in the past four years.

Primary author: Dr LIAO, Junhui (Brown / CIAE)

Presenter: Dr LIAO, Junhui (Brown / CIAE)

Session Classification: Industry and Application

Contribution ID: **13** Type: **not specified**

LXe calorimeter for the PIONEER Experiment

Saturday, 25 May 2024 16:30 (30 minutes)

PIONEER aims to measure the charged-pion branching ratio to electrons versus muons (R) with about 15 times better precision in its first phase and the pion beta decay, $^{+}\rightarrow^{0}e+()$, with 3 to 10-fold improvement in sensitivity in the next step. The PIONEER detector is designe1d to measure these reactions with great precision by employing a 5D active target and a high-resolution calorimeter. One of the calorimeter designs is based on liquid xenon technology with scintillation light readout. We present the PIONEER LXe calorimeter R&D status as well as its design.

Primary author: MIHARA, Satoshi (KEK)

Presenter: MIHARA, Satoshi (KEK)

Session Classification: Leptons and Neutrinos

Contribution ID: **14** Type: **not specified**

Tritium Background for Direct Dark Matter Search

Monday, 27 May 2024 12:10 (30 minutes)

Direct dark matter searches require an ultra-low background, which is essential to improving sensitivity. Many efforts have been made to reduce and understand these techniques.
XENON1T observed an event excess at 1-7 keV in 2020, but not in XENONnT, which is thought to be background due to tritium. Quantitatively assessing this background is useful for future experiments.
In this talk, I will present measurements of atmospheric tritium by sampling HTO and HT and discuss an impact on the direct dark matter experiments with LXe.

Primary author: YAMASHITA, Masaki (Kavli IPMU, the University of Tokyo)

Presenter: YAMASHITA, Masaki (Kavli IPMU, the University of Tokyo)

Session Classification: Detector R&D

Contribution ID: **15** Type: **not specified**

Welcome Remarks

Saturday, 25 May 2024 09:00 (10 minutes)

Presenter: Prof. GIBONI, Karl (Shanghai Jiao Tong University)

Session Classification: Opening and Overview

Contribution ID: **16** Type: **not specified**

Logistics

Saturday, 25 May 2024 09:10 (5 minutes)

Presenter: HAN, Ke (SJTU)

Session Classification: Opening and Overview

Contribution ID: **17** Type: **not specified**

Status and prospects of PandaX

Saturday, 25 May 2024 09:15 (40 minutes)

Presenter: LIU, Jianglai (Shanghai Jiao Tong University)

Session Classification: Opening and Overview

Contribution ID: **18** Type: **not specified**

NEXT

Saturday, 25 May 2024 14:00 (30 minutes)

Presenter: MONRABAL CAPILLA, Francesc (Donostia International Physics Center)

Session Classification: Double Beta Decay

Contribution ID: **19** Type: **not specified**

PandaX Neutrino Program

Sunday, 26 May 2024 09:00 (30 minutes)

Presenter: WANG, Qiuhong (Fudan University)

Session Classification: Double Beta Decay

Contribution ID: **20** Type: **not specified**

AXEL

Saturday, 25 May 2024 15:00 (30 minutes)

Presenter: ICHIKAWA, Atsuko (Tohoku university)

Session Classification: Double Beta Decay

Contribution ID: **21** Type: **not specified**

Radiopure 2in PMT for liquid xenon detectors

Monday, 27 May 2024 11:40 (30 minutes)

Presenter: MENG, Yue (Shanghai Jiao Tong University)

Session Classification: Detector R&D

Contribution ID: **22** Type: **not specified**

DarkSide

Saturday, 25 May 2024 11:30 (30 minutes)

Presenter: WANG, Yi (IHEP)

Session Classification: Dark Matter Direct Detection

Contribution ID: **23** Type: **not specified**

Detector development for medical imaging and opportunities for Noble gas detectors

Presenter: LIU, Zheng (SIAT, CAS)

Session Classification: Industry and Application

Contribution ID: **24** Type: **not specified**

Enrichment of Xe-136 and other isotopes

Presenter: DOU, Dandan (Tianjin)

Session Classification: Industry and Application

Contribution ID: **25** Type: **not specified**

Xenon and Xenon Supply Chain in China

Sunday, 26 May 2024 12:20 (20 minutes)

Presenter: HUANG, Changwei

Session Classification: Industry and Application

Contribution ID: **26** Type: **not specified**

DARWIN

Saturday, 25 May 2024 12:00 (30 minutes)

Presenter: MASBOU, Julien (Subatech - Nantes Université)

Session Classification: Dark Matter Direct Detection

Contribution ID: **27** Type: **not specified**

Dark Matter with PandaX

Monday, 27 May 2024 09:00 (30 minutes)

Presenter: TAO, Yi (Shanghai Jiao Tong University)

Session Classification: Dark Matter Direct Detection

Contribution ID: **28** Type: **not specified**

Group Photo

Saturday, 25 May 2024 09:55 (5 minutes)

Session Classification: Opening and Overview

Contribution ID: **29** Type: **not specified**

Summary

Monday, 27 May 2024 12:40 (10 minutes)

Presenter: LIU, Jianglai (Shanghai Jiao Tong University)

Session Classification: Detector R&D

Contribution ID: **30** Type: **not specified**

Detector development for medical imaging and opportunities for Noble gas detectors

Sunday, 26 May 2024 11:30 (30 minutes)

Positron emission tomography (PET) is a highly sensitive molecular imaging technique capable of measuring biochemical and metabolic processes in living organisms. It plays an important role in the early diagnosis and efficacy evaluation of diseases, especially tumors, cardiovascular diseases and neurological diseases. In view of the urgent needs of drug development and neuroscience for the high resolution and efficiency of PET in small animals and the urgent need for high-definition images of PET in clinical practice, this report mainly discusses the methods of improving the performance of PET system from the aspects of PET detector resolution improvement method and TOF technology. The development of detectors for medical imaging is a dynamic and evolving field. Noble gas detectors, in particular, offer a range of unique properties that can be harnessed to enhance the capabilities of medical imaging systems. The utilization of noble gases in detectors is opening new avenues for the early and precise diagnosis of various medical conditions, including cancer, neurological disorders, and cardiovascular diseases.

Primary author: LIU, Zheng

Presenter: LIU, Zheng

Session Classification: Industry and Application

Contribution ID: **31** Type: **not specified**

Enrichment of Xe-136 and Other Isotopes

Sunday, 26 May 2024 12:00 (20 minutes)

Stable isotopes are used in more and more fields, among which neutrinoless double beta decay is one of the important application fields. At present, the Research Institute of physical and chemical Engineering of nuclear industry has mastered the preparation technology of Xenon, Germanium, Molybdenum and Selenium, and is developing the preparation technology of Tellurium. Among them, Xenon-134 and Xenon-136 can be used to detect neutrinoless double beta decay experiment, and have important application value in rare case detection. This paper mainly focuses on Xenon isotope enrichment technology. It studies and establishes high abundance xenon isotope enrichment process with natural xenon as raw material. Through technical breakthroughs such as single-unit development, cascade design and isotope enrichment, key problems such as abundance enhancement, scale production and purity enhancement were solved, and xenon-134 and xenon-136 samples with abundance and purity meeting the requirements were obtained.

Primary authors: DOU, DANDAN (核工业理化工程研究院); Dr XIE, QUANXIN (核工业理化工程研究院)

Presenter: DOU, DANDAN (核工业理化工程研究院)

Session Classification: Industry and Application