IUVSTA Workshop
109 APPEC Tech Forum
Vacuum & Cryogenics - Industry meets Academia

Report of Contributions

https://indico.cern.ch/e/1514758

Contribution ID: **4** Type: **Poster**

Monitoring and mitigation of gas accumulation on cryogenic mirror surfaces of ET

Monday 24 November 2025 18:00 (2 hours)

The Einstein Telescope (ET) will be a third generation gravitational wave detector consisting of a set of low frequency and a high frequency interferometers. In order to mitigate thermal noise, the mirrors for the low frequency interferometer are required to be cooled down to cryo temperatures. This leads to freezing of residual gas from the vacuum chamber onto the mirror surface. This will affect the required cooling power and the sensitivity of ET. Hence R&D measurements at cryogenic temperatures are being prepared, investigating the formation of ice layers on the mirror from different gases using ellipsometry and quartz micro balances (QMB) for monitoring the thickness of the layer. Further research will include the testing of different in-situ cleaning procedures of silicon surfaces with methods, such as argon plasma cleaning low-energy electrons or UV light. The poster will show the setup being prepared at KIT and describes methods developed together with several groups in the ET collaboration.

Author: SCHULZ-RITZ, Markus (KIT)

Presenter: SCHULZ-RITZ, Markus (KIT)

Session Classification: Poster session with snacks

Contribution ID: **5** Type: **Invited plenary talk**

Vacuum Technology Developments at Daresbury Laboratory for modern accelerators

Wednesday 26 November 2025 09:00 (30 minutes)

The Vacuum Solutions group at the STFC Daresbury Laboratory has a unique position in that it has the capability to operate and design the vacuum systems for new accelerators whilst maintaining a very active research laboratory looking at many new facets of vacuum design for accelerators. This gives the group the opportunity to develop ideas in the laboratory before implementing them on the accelerator. This paper will present some of the latest accelerator ideas and machines at Daresbury and provide an insight into how some of our laboratory developments are helping improve the vacuum design.
A range of topics will be covered such as:
1) Machine developments –CLARA, FEBE and the vacuum challenge of plasma-wakefield experiments
2) NEG coatings –our latest research
3) Thin films –SRF coating developments
4) Photocathode research –metal and semiconductor cathode developments
5) New cleaning solutions for UHV and XHV
6) In-Kind contributions to major projects, ESS, Hi-Lumi LHC and PIP-II

Authors: Dr BENJAMIN, Chris; Dr SEAL, Dan; Ms MARSHALL, Eleni; Mr CONLON, James; Mr SMITH, Liam; Dr MALYSHEV, Oleg; Mr POYNTON, Oliver; Ms LUFF, Rebekah; Dr VALIZADEH, Reza; Dr WILDE, Stuart

Presenter: MIDDLEMAN, Keith (STFC Daresbury Laboratory)

Session Classification: Session 8: Technology and ETpathfinder (Chair: Joachim Wolf)

Contribution ID: **6** Type: **Invited plenary talk**

Welcome and introduction

Monday 24 November 2025 12:30 (30 minutes)

Session Classification: Session 1: Neutrinos (Chair: Freek Molkenboer)

Contribution ID: **9** Type: **Invited plenary talk**

Low-Energy Neutrino Physics and Cryogenic Innovation with the NUCLEUS Experiment

Monday 24 November 2025 14:30 (30 minutes)

Coherent elastic neutrino–nucleus scattering (CEvNS) is a powerful probe of fundamental neutrino properties and a sensitive tool to search for physics beyond the Standard Model at low energies. The NUCLEUS experiment aims to observe CEvNS using $CaWO_4$ cryogenic calorimeters based on transition-edge sensors (TES) with nuclear-recoil energy thresholds in the few–10 eV regime. The complex cryogenic detector, together with its active and passive shielding systems, was successfully commissioned and characterized at the Technical University of Munich in 2024. The experiment is currently being relocated to its dedicated experimental site at the Chooz nuclear power plant in France, with first data expected in 2026. In this talk, I will present the current status of NUCLEUS and compare its approach with other complementary cryogenic CEvNS experiments, such as Ricochet and MINER.

On the cryogenic technology side, NUCLEUS has driven several innovations that enable the use of a dry dilution refrigerator for low-threshold and low-background operation of TES-based detectors. These include the development of a fully cryogenic 4π active veto system, a muon veto operating at cryogenic temperatures, and, in particular, a novel vibration decoupling system based on a cryogenic spring pendulum. This technology has led to a patent application and is now being pursued for potential commercialization with applications in both particle physics and quantum computing.

Author: STRAUSS, Raimund Johann (TUM)

Presenter: STRAUSS, Raimund Johann (TUM)

Session Classification: Session 2: Neutrinos (Chair: Thomas Thümmler)

Contribution ID: **13** Type: **Invited plenary talk**

Searching for Dark Matter and Rare Events with XENONnT

Tuesday 25 November 2025 09:00 (30 minutes)

The XENONnT experiment is aiming for the direct detection of dark matter in the form of weakly interacting massive particles (WIMPs) using a liquid xenon (LXe) time projection chamber. The detector, operated at Laboratori Nazionali del Gran Sasso (LNGS) in Italy, features a total LXe mass of 8.6 tonnes of which 5.9 tonnes are active.

In order to reach world-leading sensitivities for several physics channels, the target material xenon needs to be ultra-pure. Electronegative impurities such as oxygen can absorb or capture the photons and electrons created 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.

The xenon needs to be constantly purified for both, electronegative impurities and radioactive contaminants, resulting in specific demands for the cryogenic systems. This talk will discuss the concepts behind the various XENONnT cryogenic systems such as the novel liquid phase purification and show the recent science results achieved with the purest xenon on Earth leading to the lowest background in an operating LXe TPC.

Author: ALTHÜSER, Lutz (University Münster)

Presenter: ALTHÜSER, Lutz (University Münster)

Session Classification: Session 4: Dark Matter with Xe (Chair: Julien Masbou)

Contribution ID: **16** Type: **Invited plenary talk**

Applications of mK technologies in astroparticle physics: from resolution to exposure frontiers

Monday 24 November 2025 17:30 (30 minutes)

In recent years, millikelvin (mK) technologies have undergone remarkable progress, driven both by scientific applications and by rapid developments in quantum-computing industries. Rare-event searches - such as the hunt for the dark-matter content of the universe and investigations into the Majorana nature of the neutrino - continue to push the performance of cryogenic instrumentation to new levels.
The CUORE experiment has established the era of tonne-scale cryogenic detectors, achieving for the first time the operation of an active mass of about 740 kg at a base temperature of 10 mK. Its successor, CUPID, is designed to further enhance the performance and sensitivity of this large cryogenic infrastructure. In parallel, the CRESST experiment, based on TES technology, has dramatically advanced energy-resolution and threshold capabilities, reaching thresholds at the level of 10 eV with detectors operated at approximately 15 mK.
These technological achievements pave the way for unprecedented opportunities in particle and astroparticle physics and open new paths toward a broad range of future applications.

Author: Dr GORLA, Paolo (Laboratori Nazionali del Gran Sasso (INFN) (IT))

Presenter: Dr GORLA, Paolo (Laboratori Nazionali del Gran Sasso (INFN) (IT))

Session Classification: Session 3: Neutrinos & Dark Matter (Chair: Carlos P. Garay)

Contribution ID: **24** Type: **Invited plenary talk**

ET tower (vac & cryo)

Tuesday 25 November 2025 15:00 (30 minutes)

Author: RICCI, Fulvio (Sapienza Universita e INFN, Roma I (IT))

Presenter: RICCI, Fulvio (Sapienza Universita e INFN, Roma I (IT))

Session Classification: Session 6: Gravitational Waves (Chair: Achim Stahl)

Contribution ID: **26** Type: **Invited plenary talk**

Panel discussion: Cryogenic Technology

Tuesday 25 November 2025 16:30 (1 hour)

Session Classification: Session 7: Panel Discussions (Chair: Fulvio Ricci)

Contribution ID: **28** Type: **Invited plenary talk**

ET-Pathfinder

Wednesday 26 November 2025 09:30 (30 minutes)

Author: BULTEN, Henk Jan

Presenter: BULTEN, Henk Jan

Session Classification: Session 8: Technology and ETpathfinder (Chair: Joachim Wolf)

Contribution ID: **30** Type: **Invited plenary talk**

Panel discussion: Vacuum Technology

Wednesday 26 November 2025 11:00 (1 hour)

Session Classification: Session 9: Panel Discussion (Chair: Martin Wüest)

Contribution ID: **31** Type: **Invited plenary talk**

Wrap-up

Wednesday 26 November 2025 12:00 (20 minutes)

Session Classification: Session 9: Panel Discussion (Chair: Martin Wüest)

Contribution ID: **32** Type: **Invited plenary talk**

Vacuum and cryogenics technologies in Xenon Purification

Tuesday 25 November 2025 09:30 (30 minutes)

With the installation of rare event search experiments in underground laboratories, passive and active shielding measures, careful material selection and surface treatments, radioactive isotopes in the xenon of xenon-based detectors have become the most important background source in the search for rare events besides solar and atmospheric neutrinos. Particularly important are radioactive noble gases, especially Rn-222 because of its gamma and beta-emitting progenies Pb-214, Bi-214 and Pb-210. In this talk, various methods for the continuous active removal of radon from xenon, in particular cryogenic distillation, will be presented. To reach the ultra-low concentrations of radioactive contaminants ultrahigh-vacuum technology is not only necessary for cryogenic insulation but also to avoid emanation or release of impurities into the purification systems.
New records in the purity of Ar-39, Kr-85 and Rn-222 have been achieved with cryogenic "online distillation"in the dark matter experiment XENONnT.
This presentation also provides an outlook on how these methods can be further developed to achieve the required purity of radioactive noble gases with a target concentration of 1 radon atom per 160 moles of xenon (or 0.1 μBq/kg) for the next generation of experiments such as XLZD, nEXO or NEXT.
In particular, developments within our ERC AdG project LowRad (No. 101055063) also aim to combine these methods with the purification from electronegative impurities and the required highly sensitive online diagnostic methods.

Author: WEINHEIMER, Christian Philipp (Universität Münster (DE))

Presenter: WEINHEIMER, Christian Philipp (Universität Münster (DE))

Session Classification: Session 4: Dark Matter with Xe (Chair: Julien Masbou)

Contribution ID: **33** Type: **Poster**

Development of a platform dedicated to the measurement of material properties at cryogenic temperatures : CryoMat

Monday 24 November 2025 18:00 (2 hours)

The CryoMat project aims to answer a demand in the field of astrophysics, where instruments need to work at cryogenic temperatures to get high sensitivity. A wealth of data on the properties of metallic and plastic materials is now available for temperatures down to 1K. However, there is still a significant lack of data on thermal, electrical and mechanical properties, particularly for anisotropic materials, and especially composites, across the entire temperature range, and below 1K for metallic and plastic materials.

CryoMat aims to fill this gap by developing a platform dedicated to the characterisation of materials at cryogenic temperatures, down to sub-Kelvin. This development is being carried out as part of the DIM Origines programme, over a period of five years (2022-2027). This platform, based on the Grands Moulins campus of Paris Cité University (Paris, France), will be accessible to scientific laboratories and industries. The physical data of the measured properties will be shared via an open database. CryoMat will cover three families of physical properties installed in cryostats dedicated to electrical, thermal and mechanical properties.

Author: DENIEL, Gwendal

Co-authors: THERMEAU, Jean-Pierre (Laboratoire APC - CNRS/IN2P3 - Université Paris Cité); Mr N'SOUGAN, Marie-Reine (APC, CNRS / IN2P3); Mr PIAT, Michel (APC, UPC); Mr GRANDSIRE, Laurent (APC, CNRS / IN2P3); Mr ILIONI, Alin (APC, CNRS / IN2P3); Mr CHAILAN, Christophe (APC, CNRS / IN2P3); Mr GIVAUDAN, Alain (APC, CNRS / IN2P3); Mr CHAPRON, Claude (APC, CNRS / IN2P3); Mr BIERNACKI, Kevin (APC, CNRS / IN2P3); Mr DHEILLY, Stéphane (APC, CNRS / IN2P3); Mr DUTHIL, Patxi (IJCLab, CNRS / IN2P3); Mr THOER, Rémy (IJCLab, CNRS / IN2P3); Mr BLIVET, Sébastien (IJCLab, CNRS / IN2P3); Mr GALET, François (IJCLab, CNRS / IN2P3)

Presenter: DENIEL, Gwendal

Session Classification: Poster session with snacks

Contribution ID: **34** Type: **Invited plenary talk**

Vacuum and Cryogenic Technologies in large Axion Detectors

Tuesday 25 November 2025 11:00 (30 minutes)

The large axion experiments ALPS II, (Baby)IAXO and MADMAX are either already in operation or planned for installation at DESY. This type of experiment requires the use of vertical fields, which are typically created using superconducting dipole magnets. In addition, all of these experiments have specific requirements for the experimental setups used in cryogenic and vacuum environments. This talk will provide an overview of the experiments and their subcomponents, some of which are already operational, while others are still in the planning or testing phase.

Author: SCHAFFRAN, Joern (Deutsches Elektronen-Synchrotron (DE))

Presenter: SCHAFFRAN, Joern (Deutsches Elektronen-Synchrotron (DE))

Session Classification: Session 5: Axions and CMB (Chair: Christian Weinheimer)

Contribution ID: **35** Type: **Poster**

Sterile neutrino search at the KATRIN experiment

Monday 24 November 2025 18:00 (2 hours)

The Karlsruhe Tritium Neutrino (KATRIN) experiment was designed to measure the absolute neutrino mass scale based on a high-precision measurement of the tritium β-decay spectrum, close to its endpoint.
Its unprecedented tritium source luminosity and spectroscopic quality makes it a unique instrument to also search for physics beyond the Standard Model (BSM). Most notably, a keV-scale sterile neutrino
would manifest with a characteristic signature several keV away from the endpoint. This poster summarizes the physics potential of such a search, the technical challenges to optimize the beamline for it
and the status of the advanced preparations to start in 2026.

Author: HINZ, Dominic (KIT - Institute for Astroparticle Physics (IAP))

Presenter: HINZ, Dominic (KIT - Institute for Astroparticle Physics (IAP))

Session Classification: Poster session with snacks

Contribution ID: **36** Type: **Invited plenary talk**

The QUBIC Instrument: Design and Implementation of a Bolometric Interferometer for CMB Polarization

Tuesday 25 November 2025 11:30 (30 minutes)

The QUBIC instrument (Q&U Bolometric Interferometer for Cosmology) is a novel experiment dedicated to measuring the polarization of the Cosmic Microwave Background (CMB) and, in particular, the elusive B-modes that would provide evidence of primordial gravitational waves. Detecting such faint signals requires highly sensitive cryogenic detectors operating at sub-Kelvin temperatures and an extremely stable low-background environment.

QUBIC introduces a unique approach—bolometric interferometry—combining the sensitivity of bolometric detectors with the systematic control of interferometric techniques. The instrument integrates a complex cryogenic system hosting an array of transition-edge sensor (TES) bolometers cooled to 300 mK, within a large vacuum vessel that accommodates not only the detector array and cold electronics, but also the telescope and optical components of the instrument.

This presentation will review the scientific motivation driving the design choices of QUBIC, outline the main features of its cryogenic and vacuum systems, and discuss some of the technical challenges encountered during integration and commissioning. I will present the current status of the instrument, now in its commissioning phase in Argentina, and the perspectives for future observations and upgrades.

Author: GONZALEZ, Manuel

Presenter: GONZALEZ, Manuel

Session Classification: Session 5: Axions and CMB (Chair: Christian Weinheimer)

Contribution ID: **37** Type: **Invited plenary talk**

ET @ CERN (beam line)

Tuesday 25 November 2025 14:30 (30 minutes)

Building upon the success of the LIGO and Virgo experiments in gravitational wave (GW) detection, the GW community is now setting its sights on new laser interferometers capable of detecting GWs from cosmological events spanning a much larger volume of the universe and occurring in its early phases. In pursuit of this objective, the European community has proposed the construction of the Einstein Telescope (ET), a complex comprising six interferometers arranged within a triangular tunnel spanning 10 km on each side. To mitigate noise stemming from statistical pressure fluctuations, the laser beams necessitate Ultra-High Vacuum (UHV) conditions within a 1 meter diameter beamtube, extending across a total vacuum length of 120 km. However, the projected cost of the ET vacuum system, based on previous-generation GW detectors, is notably high, second only to that of the civil engineering. To address this challenge, CERN, in collaboration with other institutes, has launched a study to explore alternative and more cost-effective technological solutions. This investigation includes assessing the UHV compatibility of various steels, potentially eliminating high-temperature degassing treatments, optimising bakeout temperatures, designing and implementing thin-walled pipes, and optimising vacuum layouts and tunnel integration logistics. To validate these optimisations, a 36-meter-long pilot sector is under construction at CERN.

Author: Dr SCARCIA, Carlo (CERN)

Presenter: Dr SCARCIA, Carlo (CERN)

Session Classification: Session 6: Gravitational Waves (Chair: Achim Stahl)

Contribution ID: **38** Type: **Invited plenary talk**

The Virgo Vacuum System and Next-Phase Upgrades

Tuesday 25 November 2025 14:00 (30 minutes)

Virgo is currently operating in the O4b data-taking phase, ongoing for over one year and regularly detecting gravitational-wave signals. In parallel, several hardware upgrades are being prepared to enhance the detector sensitivity for the next data-taking phase O5. Among these, significant upgrades are planned for the vacuum system. Here we give a quick overview of the overall vacuum system and we detail the new components under design,including vacuum chambers, pumping systems, and contamination-control equipment. These developments are now at their final design stage, with the corresponding industrial tenders expected to be launched in the near to mid term.

Author: PASQUALETTI, Antonio (European Gravitational Observatory)

Presenter: PASQUALETTI, Antonio (European Gravitational Observatory)

Session Classification: Session 6: Gravitational Waves (Chair: Achim Stahl)

Contribution ID: **39** Type: **Poster**

Manufacturing Opportunities for the FCC-ee Vacuum System

Monday 24 November 2025 18:00 (2 hours)

The FCC-ee or Future Circular Collider for electrons and positrons is a key study in CERN's long-term programme, aiming to advance precision physics through unprecedented energies and luminosities. Achieving these goals requires an ultra-high vacuum system maintaining pressures below 10^{-10} bar along a 90km ring. Two vacuum chambers (VCs) form a 180km long system, that must combine performance, reliability, cost efficiency, beam stability and long service life under intense synchrotron radiation with minimal maintenance.

Design, material selection, and manufacturing are therefore critical. The vacuum chamber must offer mechanical robustness, low desorption, and compatibility with coatings such as the non-evaporable getter (NEG) coating and thermally sprayed coatings. Cu-OFS (silver-doped copper) has been chosen for the chamber. Synchrotron Radiation Absorbers (SRAs), exposed to high photon and thermal loads, are being developed using laser powder bed fusion (L-PBF) of CuCrZr, enabling optimised cooling channels and intercepting surfaces. Cold-Spray Additive Manufacturing followed by CNC-machining is envisioned to produce leak-tight sockets for the Beam-Positioning Monitors (BPM) directly on the chamber profile.

The bake-out system (BOS) is vital to activate the NEG by heating to around 230℃. It demands a radiation-hard, reproducible, and efficient multilayer metallic-ceramic coating applied via thermal spraying. The beampipe, assembled from segments whose length is defined by magnet layout, uses copper-alloy flanges joined to the VC by friction-stir welding. Numerous laser-welded and brazed connections attach cooling lines and auxiliary components to the VC.

This poster summarises the main challenges and R&D activities focused on material optimisation, coating technologies, and manufacturing, combining conventional and additive methods to enable reliable, scalable solutions for the FCC-ee vacuum system.

Author: BAMMER, Martin (Technische Universitaet Wien (AT))

Co-author: GARION, Cedric (CERN)

Presenter: BAMMER, Martin (Technische Universitaet Wien (AT))

Session Classification: Poster session with snacks

Contribution ID: **40** Type: **Invited plenary talk**

Technological Challenges in the Design and Operation of Tritium-Based Experiments: A Case Study on Atomic Tritium Production

Monday 24 November 2025 13:30 (30 minutes)

The Tritium Laboratory Karlsruhe (TLK) was established in the early 1990s as a technical research facility and today operates under a licence to handle up to 40 g of tritium. With its unique infrastructure, TLK supports a broad range of experiments relevant to both the fusion fuel cycle and precision particle physics, most notably the Karlsruhe Tritium Neutrino (KATRIN) experiment.
Transitioning from hydrogen or deuterium to tritium introduces a number of technological challenges arising from the isotope's radiological properties, higher reactivity, and strong interaction with materials. These factors influence nearly every aspect of an experimental design —from process engineering and analytics to safe operation and confinement.
To illustrate these aspects, this contribution presents the initial steps toward a next-generation - atomic - tritium source, currently being established at TLK as a feasibility demonstration. The experiment aims to produce and detect atomic tritium generated from molecular gas, serving as a technological testbed for future neutrino mass measurements.
The presentation highlights key design decisions related to tritium compatibility, identifies critical technological interfaces, and outlines how these findings contribute to the broader goal of having off-the-shelf tritium-compatible systems for both scientific and fusion-technology applications.

Author: RÖLLIG, Marco (Karlsruhe Institute für Technologie)

Presenter: RÖLLIG, Marco (Karlsruhe Institute für Technologie)

Session Classification: Session 1: Neutrinos (Chair: Freek Molkenboer)

Contribution ID: **41** Type: **Invited plenary talk**

The LiteBIRD Space Mission cryogenic detection chain

Tuesday 25 November 2025 12:00 (30 minutes)

LiteBIRD (Lite satellite for the study of B-mode polarisation and Inflation from cosmic background Radiation Detection) is a JAXA Space Mission that aims to detect faint polarised signatures in the Cosmic Microwave Background radiation, the so-called primordial B-modes, whose discovery would represent a milestone in Cosmology. To achieve this goal, LiteBIRD will observe the full sky for 3 years from the Lagrangian point L2, delivering a unique set of deep all-sky maps from 40 to 402 GHz. In order to meet sensitivity requirements, the Instrument relies on Transition Edge Sensor (TES) superconducting microwave polarimeters that are operated around 100 mK, in a thermally stable environment, at the focal plane of a cryogenic telescope. Besides the telescope, all the optical components are operated at cryogenic temperatures, so as to minimise the photon loading from the instrument itself, in order to approach the sky photon noise. For these reasons, the thermal design and the overall cryogenic architecture are fundamental ingredients of LiteBIRD. In this communication we outline the LiteBIRD instrument architecture (including the cooling chain) with particular emphasis on detectors and cold readout electronics.

Author: TARTARI, Andrea (INFN Pisa)

Presenter: TARTARI, Andrea (INFN Pisa)

Session Classification: Session 5: Axions and CMB (Chair: Christian Weinheimer)

Contribution ID: **42** Type: **Invited plenary talk**

INFICON

Wednesday 26 November 2025 10:00 (8 minutes)

INFICON stands ready to advance Astrophysics, Cosmology and Fundamental Physics by delivering cutting-edge technologies in vacuum sensing and control, ultra-sensitive leak detection, residual gas analysis, and sub-nanometer surface engineering via Atomic Layer Deposition.
With a long-standing history of providing high-end measurement instruments to a broad spectrum of Research applications such as Particle Accelerators, Fusion, Space Simulation and Material Science, INFICON's solutions are shaped by decades of expertise in vacuum measurement and a pioneering spirit for innovation.
The comprehensive active vacuum measurement portfolio offers versatile sensing capabilities, while the passive range of gauges and controllers is engineered to perform reliably under extreme conditions including Ultra-High Vacuum (UHV), high bake-out temperatures, harsh ionizing radiation, and strong magnetic fields with minimal stray interference. INFICON's leak detectors identify even the smallest leaks in large volumes, and its residual gas analysers enable accurate identification and quantification of gas species within vacuum systems.
Whether through proven instruments or tailored and innovative solutions, INFICON meets the evolving needs of the Big Science community and remains the trusted partner in cutting-edge scientific research.

Author: Dr SALEMME, Roberto

Presenter: Dr SALEMME, Roberto

Session Classification: Session 8: Technology and ETpathfinder (Chair: Joachim Wolf)

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

Innovative On-Site Continuous Production and Welding of the Einstein Telescope Vacuum Pipes

Monday 24 November 2025 18:00 (2 hours)

The Einstein Telescope will be the first gravitational wave detector of the third generation. It will consist of 120 km of vacuum pipes with a diameter of 1 m to achieve the required design sensitivity. The BeamPipes4ET project introduces an innovative production concept for these vacuum pipes by manufacturing them on-site in the tunnels through a continuous process using coils of sheet metal. This minimizes the transportation needs - forming the key concept of this project. Additionally, the project investigates the use of seamless flanges for ultra-high vacuum applications and explores laser beam welding under mobile vacuum. These approaches enhance reliability while reducing labor costs, welding efforts, and finishing work. This poster presents the current status and ongoing activities of the BeamPipes4ET project.

Author: BENNING, Charlotte

Co-authors: STAHL, Achim (Rheinisch Westfaelische Tech. Hoch. (DE)); POOTH, Oliver (RWTH Aachen University)

Presenter: BENNING, Charlotte

Session Classification: Poster session with snacks

Contribution ID: **44** Type: **Poster**

R&D activities at LNF-INFN on cryogenic vacuum issues in future cryogenic gravitational wave detectors

Monday 24 November 2025 18:00 (2 hours)

In the upcoming third generation of gravitational wave (GW) detectors, a frost layer may develop on cryogenically cooled mirrors. Also, the mirrors can suffer from electrostatic charging formation. Both phenomena may represent two potentially critical showstoppers for GW detection. We already proposed a possible mitigation solution for both such issues, relying on irradiation with low energy electrons (from few eV to less than hundred eV) of the optical elements. Low energy electrons are known to interact only with the very top layers (some nm) of any irradiated surface, are known to be very efficient in inducing gas desorption and, by properly tuning their energy, they can neutralize both positive and negative charges on surfaces. Therefore, low energy irradiation of mirrors'surfaces seems ideal to induce frost desorption and neutralize charge.
Here we present the experimental activity carried out at LNF-INFN and the necessary R&D activity aiming to pass from a valid and demonstrated concept to the possible integration of the method in the complex low frequency tower design.

Authors: SPALLINO, Luisa; Dr ANGELUCCI, Marco (INFN-LNF); CIMINO, Roberto

Presenter: SPALLINO, Luisa

Session Classification: Poster session with snacks

Contribution ID: **45** Type: **Poster**

The Cryogenic System of Darkside Proto-0: Design and Long-Term Performance

Monday 24 November 2025 18:00 (2 hours)

Detectors for direct dark matter searches based on noble liquids require highly stable cryogenic systems capable of liquefying, purifying, and continuously recirculating the target medium. The Proto-0 setup, developed within the DarkSide experiment, is a compact dual-phase liquid argon TPC aimed at studying the spatial distribution of scintillation and ionization signals with large SiPM arrays.

The detector is integrated with a dedicated cryogenic system designed to ensure efficient argon liquefaction, ultra-high purity levels, and long-term operational stability. The system consists of a double-walled cryostat housing the TPC, a high-efficiency purification stage capable of reducing impurities below the part-per-billion level, a condenser for argon liquefaction, and a custom-designed gas recirculation panel equipped with a specially developed pump.

Since October 2021, the cryogenic system has been successfully operated at the INFN Laboratory in Naples, demonstrating excellent thermal stability and robust performance during extended runs. This contribution presents the design, main features, and performance of the cryogenic system, emphasizing its long-term stability, thermodynamic control, and reliability in support of high-sensitivity liquid argon detectors for dark matter searches.

Author: Mr GRAUSO, Gianfrancesco (INFN)

Presenter: Mr GRAUSO, Gianfrancesco (INFN)

Session Classification: Poster session with snacks

Contribution ID: **46** Type: **Poster**

3Dpi: PET Scanner with Xenon-doped Liquid Argon and SiPM

Monday 24 November 2025 18:00 (2 hours)

The 3Dpi scanner is a Total-Body, Time of Flight, Positron Emission Tomography (PET) imaging device with silicon photomultiplier (SiPM) and a xenon-doped Liquid Argon (LAr) scintillator with the aim of ultra-low-dose imaging for pediatric and pregnant patients. The scanner has an axial field-of-view of 200 cm and consists of nine double-sided concentric rings of SiPM panels. The xenon doping to the LAr scintillator has a few advantages: 1) fast scintillation, 2) suppression of the long tail of the LAr scintillation light, and 3) wavelength shifting to xenon scintillation. These advantages, in turn, improve the time resolution and detection efficiency of positron-electron annihilation signals. Moreover, lowering the operating temperature of the SiPMs to the LAr temperature significantly reduces the dark count rate of the SiPMs.

The 3Dpi scanner project is a medical imaging application of the ongoing research and development efforts of the DarkSide collaboration, which is focused on dark matter direct detection experiments using LAr targets. The 3Dpi Monte Carlo simulation package has been derived from the DarkSide simulation package based on the Geant4 toolkit.

I will present the results that we recently published on the performance of the 3Dpi scanner using established NEMA NU 2–2018 standards for spatial resolution, sensitivity, image quality, count rate performance, and timing resolution. I will also discuss the future plan of the 3Dpi project.

Author: Dr WADA, Masayuki (AstroCent: Nicolaus Copernicus Astronomical Centre, PAN, Poland)

Presenter: Dr WADA, Masayuki (AstroCent: Nicolaus Copernicus Astronomical Centre, PAN, Poland)

Session Classification: Poster session with snacks

Contribution ID: **47** Type: **Poster**

Low radon and low internal radioactivity (LowRad) for next generation liquid xenon experiments

Monday 24 November 2025 18:00 (2 hours)

Next generation liquid nobel gas detectors for the search of weakly interacting massive particles (WIMPs), such as XLZD, aim to increase their sensitivity down to the neutrino fog. This ambitious goal can only be achieved by further reducing the detector backgrounds dominated by LXe intrinsic isotopes of 85Kr and 222Rn to a factor ten below the unshieldable solar and atmospheric neutrino background. Already the XENONnT experiment achieved world leading low background levels for 85Kr (56 ppq) and 222Rn (0.9 μBq/kg) through their removal via cryogenic distillation, paired with stringent material selections and specialized detector design.

In the ERC Advanced Grand project LowRad the technical foundations for the next generation cryogenic krypton and radon removal systems are developed. This includes among other things a krypton concentrator and a cryogenic heat pump. The concentrator aims to reduce the krypton enriched xenon off-gas losses during cryogenic distillation by another factor 1000 (6 g/day) making a continuous online distillation during regular detector operation feasible. The cryogenic heat pump is needed to address the 60 kW heating and 60 kW cooling power demands (equivalent to 200 kW electrical power) of future radon removal systems (XLZD-sized, 1600 kg/h), which is required to reduce the 222Rn background to less than 0.1 μBq/kg, or less than 1 atom in 100 mol xenon. The heat pump demonstrator operates on a left-turning Clausius-Rankine cycle, utilizing xenon as phase-changing working medium.

On this poster we focus on the status of these two systems and report about first measurements.

Acknowledging the support of the ERC AdG project “LowRad” (101055063).

Author: ALTHÜSER, Lutz (University of Münster)

Co-authors: HUHMANN, Christian; WEINHEIMER, Christian; WENZ, Daniel; KOKE, David; UNKHOFF, Patrick Alexander; SCHULTE, Philipp; BRAUN, Robert; HANNEN, Volker; LIN, Ying-Ting

Presenter: ALTHÜSER, Lutz (University of Münster)

Session Classification: Poster session with snacks

Contribution ID: **48** Type: **Invited plenary talk**

Next generation tritium-based direct neutrino mass searches: From KATRIN++ to Project 8, QTNM, and Ptolemy

Monday 24 November 2025 13:00 (30 minutes)

The neutrino mass is one of the missing ingredients in modern physics. At the intersection of particle physics, astroparticle physics, and cosmology the neutrino mass influences fundamental physics models and the evolution of the universe. The Karlsruhe Tritium Neutrino Experiment (KATRIN) investigates the endpoint spectrum of tritium beta decay to determine the neutrino mass. KATRIN is world leading in sensitivity and recently finished the first phase of its neutrino mass search after five years of operation.
For KATRIN the technological boundaries have been expanded successfully based on close collaboration with industry and external institutions. Especially industrial partnerships facilitate improvements of existing and innovations towards new equipment and methods. Preparations for the next phases of KATRIN have already been started, pushing for even higher sensitivity and expanding the physics program.
Common to all upcoming projects is the transition from molecular to atomic tritium, which puts high demands on vacuum equipment and gas handling. Leveraging the potential of KATRIN, new technologies and source concepts will be investigated within KATRIN++. Project 8 pioneered Cyclotron Radiation Emission Spectroscopy (CRES) as new method of beta spectroscopy. The Quantum Technologies for Neutrino Mass (QTNM) initiative cooperates with Project 8 to combine CRES with their quantum detectors. In Ptolemy all of the aforementioned methods are combined to not only measure their mass, but to detect relic neutrinos. All these projects require years of R&D and reliable vacuum equipment, magnetic field compatible, qualified for tritium operation, and they require clean vacuum conditions at the lowest pressures in large volumes, sometimes combined with cryogenic interfaces.
In my talk I want to outline these projects and point out technologies that will be beneficial for both parties in a fruitful science and industry cooperation with knowledge transfer and innovation.

Author: THÜMMLER, Thomas

Presenter: THÜMMLER, Thomas

Session Classification: Session 1: Neutrinos (Chair: Freek Molkenboer)

Contribution ID: **49** Type: **Invited plenary talk**

LARGE SIZE NOBLE LIQUID DETECTORS: DUNE AND PROTODUNE

Monday 24 November 2025 15:00 (30 minutes)

The Deep Underground Neutrino Experiment (DUNE) foreseen to be installed at the Sanford Underground Research Facility (SURF) in Lead, SD, USA, involves Time Projection Chambers housed in four liquid argon cryostats with a total liquid argon volume of about 50,000 m3, installed in underground caverns at about 1.5 km below the surface.
Largest of its kind, DUNE involves several challenges for the development of the cryostats and the cryogenic system among which the safety, the argon bath stability and the purity.
An extensive prototyping programme paved the way towards the design and construction of the DUNE first cryostat and associated cryogenic system due to start operation in 2029.

Author: FABRE, Caroline (CERN)

Presenter: FABRE, Caroline (CERN)

Session Classification: Session 2: Neutrinos (Chair: Thomas Thümmler)

Contribution ID: **50** Type: **Invited plenary talk**

LEGEND-1000 cryostat and cryogenic system

Monday 24 November 2025 16:30 (30 minutes)

LEGEND-1000 searches for the neutrinoless double beta decay of Ge-76 by operating germanium detectors in a liquid argon cryostat. The argon surrounding the detectors is from an underground gas source extracted by a method developed by the DarkSide experiment. The talk discusses special features of the cryostat design and the cryogenic infrastructure.

Author: SCHWINGENHEUER, Bernhard (MPI Kernphysik)

Presenter: SCHWINGENHEUER, Bernhard (MPI Kernphysik)

Session Classification: Session 3: Neutrinos & Dark Matter (Chair: Carlos P. Garay)

Contribution ID: **51** Type: **Poster**

‘1500W Cryostat’as a Testbed for ET Studies

Monday 24 November 2025 18:00 (2 hours)

The ET cryogenic tower will operate at 10–20 K, featuring exceptionally low vacuum level and implementing ultra-low noise technologies. Beyond cryostat development, a number of elements and GW instrumentation remain to be adapted or validated. Here we present an existing cryostat located at Virgo site, known as the ‘*1500W*’*facility*, recently refurbished and operated with cryocoolers providing a combined cooling power up to ˜2 W at 4 K. The facility is now open for studies within the ET Collaboration.

Authors: ERBANNI, Angelo (European Gravitational Observatory); PASQUALETTI, Antonio (European Gravitational Observatory); PIFFRE, Baptiste (Ecole d’ingénieurs du Centre National des Arts et Métiers (Paris)); GARGIULO, Julien (European Gravitational Observatory); FRANCESCON, Luca (European Gravitational Observatory)

Presenter: PASQUALETTI, Antonio (European Gravitational Observatory)

Session Classification: Poster session with snacks

Contribution ID: **52** Type: **Invited plenary talk**

DarkSide-20k cryogenics

Monday 24 November 2025 17:00 (30 minutes)

DarkSide-20k is a next-generation detector for the direct search for dark matter, currently under construction at the Gran Sasso National Laboratory (Italy). The experiment employs a dual-phase liquid-argon time projection chamber (TPC) and relies on two distinct types of liquid argon: atmospheric argon, used as a thermal bath and for the muon veto, and ultra-pure underground argon, which serves as the active target for dark-matter interactions. To ensure complete isolation between these media and to avoid any cross-contamination, DarkSide-20k is equipped with two independent cryogenic systems.
This talk will present the design and operation of both cryogenic systems, with a particular focus on the custom-made infrastructure developed for the underground argon. Emphasis will be placed on the dedicated performance tests, validation procedures, and technical challenges addressed during the development.

Author: Ms BOTTINO, Bianca

Presenter: Ms BOTTINO, Bianca

Session Classification: Session 3: Neutrinos & Dark Matter (Chair: Carlos P. Garay)

Contribution ID: **53** Type: **Poster**

Large-volume CRES detectors for the Project 8 neutrino mass measurement

Monday 24 November 2025 18:00 (2 hours)

Project 8 is a next-generation experiment aiming to directly measure the neutrino mass using the tritium endpoint method with a targeted sensitivity of 40 meV. The development of new technology and methods are required to reach this unprecedented sensitivity. Having established a new measuring technique, Cyclotron Radiation Emission Spectroscopy (CRES), we are now focusing on the scaling of CRES to large volumes and the development of an atomic source for a pilot-scale CRES experiment with atomic tritium. Our cubic-meter scale microwave cavity detector brings the challenges of cryogenic operation, RF quality, tritium tightness, ultra-high vacuum, low magnetic permeability, calibration capability, and demanding dimensional tolerances.

Author: STACHURSKA, Juliana

Presenter: STACHURSKA, Juliana

Session Classification: Poster session with snacks

Contribution ID: **54** Type: **Invited plenary talk**

Sumitomo (SHI) Cryogenics

Tuesday 25 November 2025 10:20 (8 minutes)

Author: ANYUM, Ummara (Sumitomo)

Presenter: ANYUM, Ummara (Sumitomo)

Session Classification: Session 4: Dark Matter with Xe (Chair: Julien Masbou)

Contribution ID: **55** Type: **Invited plenary talk**

RI Research Instruments GmbH

Tuesday 25 November 2025 16:10 (8 minutes)

Author: QUITMANN, Christoph (Research-Instruments)

Presenter: QUITMANN, Christoph (Research-Instruments)

Session Classification: Session 7: Panel Discussions (Chair: Fulvio Ricci)

Contribution ID: **56** Type: **Invited plenary talk**

Demcon Kryoz

Tuesday 25 November 2025 16:20 (8 minutes)

Author: VISSER, Adrie (Demcon Kryoz)

Presenter: VISSER, Adrie (Demcon Kryoz)

Session Classification: Session 7: Panel Discussions (Chair: Fulvio Ricci)

Contribution ID: **57** Type: **not specified**

Vernooy Vacuum Engineering B.V.

Wednesday 26 November 2025 10:10 (8 minutes)

Presenter: KRONENBERG, Freek (Vernooy Vacuum Engineering B.V.)

Session Classification: Session 8: Technology and ETpathfinder (Chair: Joachim Wolf)

Contribution ID: **58** Type: **not specified**

SAES - NEG solutions in large vacuum system: from material design to Integrated Engineering Solutions

Wednesday 26 November 2025 10:20 (8 minutes)

Author: MACHALLINI, Enrico (SAES Getter SpA)

Presenter: MACHALLINI, Enrico (SAES Getter SpA)

Session Classification: Session 8: Technology and ETpathfinder (Chair: Joachim Wolf)

Contribution ID: **59** Type: **Invited plenary talk**

Leybold Nederland B.V.

Monday 24 November 2025 15:30 (8 minutes)

Presenter: BENNINGHOVEN, Johannes (Leybold)

Session Classification: Session 2: Neutrinos (Chair: Thomas Thümmler)

Contribution ID: **60** Type: **Invited plenary talk**

Busch - Pfeiffer Vacuum

Monday 24 November 2025 15:40 (8 minutes)

Author: POLANCO, Ehider (Busch - Pfeiffer Vacuum)

Presenter: POLANCO, Ehider (Busch - Pfeiffer Vacuum)

Session Classification: Session 2: Neutrinos (Chair: Thomas Thümmler)

Contribution ID: **61** Type: **Invited plenary talk**

Hositrad Vacuum Technology

Monday 24 November 2025 15:50 (8 minutes)

Author: VAN ROOSMALEN, Frans (Hositrad Vacuum Technology)

Presenter: VAN ROOSMALEN, Frans (Hositrad Vacuum Technology)

Session Classification: Session 2: Neutrinos (Chair: Thomas Thümmler)

Contribution ID: **62** Type: **Invited plenary talk**

VACOM

Tuesday 25 November 2025 10:00 (8 minutes)

Author: GRAY, Christopher (Vacom B.V.)

Presenter: GRAY, Christopher (Vacom B.V.)

Session Classification: Session 4: Dark Matter with Xe (Chair: Julien Masbou)

Contribution ID: **63** Type: **Invited plenary talk**

Allectra GmbH

Tuesday 25 November 2025 10:10 (8 minutes)

Author: HOLMES, Benjamin (Allectra GmbH)

Presenter: HOLMES, Benjamin (Allectra GmbH)

Session Classification: Session 4: Dark Matter with Xe (Chair: Julien Masbou)

Contribution ID: **64** Type: **Invited plenary talk**

REUTER TECHNOLOGIE GmbH

Tuesday 25 November 2025 16:00 (8 minutes)

Author: LÖSCHINGER, Mike (Reuter Technology GmbH)

Presenter: LÖSCHINGER, Mike (Reuter Technology GmbH)

Session Classification: Session 7: Panel Discussions (Chair: Fulvio Ricci)