Development of the Most Sensitive Dark Matter Detector with Liquid Argon

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ASTROCENT/CAMK PAN
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CAMK PAN
ASTROCENT
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Current Status: DarkSide-20k Mockup Assembly at LNGS

Location: Gran Sasso National Laboratory (LNGS), Italy

Key Activities:

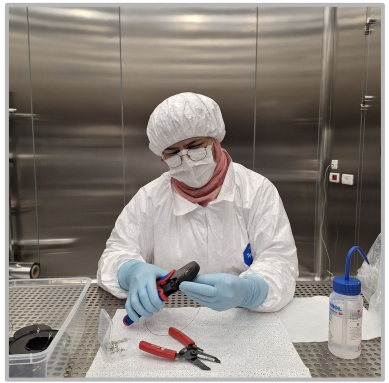
Participation in the assembly of the DarkSide-20k mockup, a crucial step in detector development.

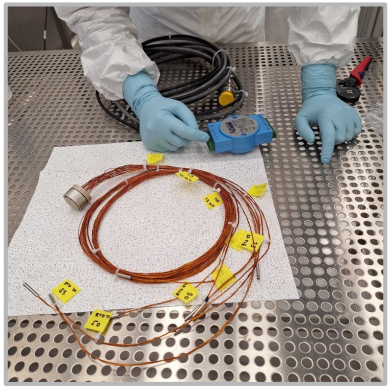
Daily work involves:

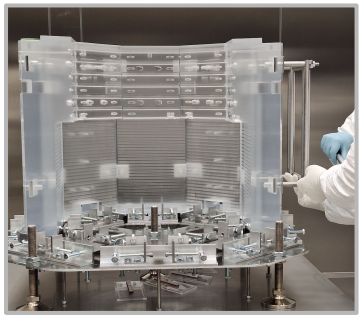
Precise assembly and integration of components.

Conducting functionality tests to ensure operational readiness.

Next Steps: Preparing for the cooldown phase and eventual operation.







Goal of Research

Measurement of Delayed Electron Emission Due to Chemical Impurities in Liquid Argon

Challenge

Electronegative impurities (O_2, N_2) at low concentrations (0.1 ppm – 10 ppm) capture and re-emit ionized electrons, leading to background noise in low-energy events.

Our Approach:

Introducing controlled O_2 and N_2 concentrations into LAr.

Measuring impurity levels via:

- Triplet lifetime of S1 scintillation light.
- Mass spectrometry verification.

Investigating impurity removal using a cold charcoal trap at 87K, previously applied in DarkSide-50.

Reducing Backgrounds from Photoelectronics

Challenge

In DarkSide-50, PMTs were the second-largest background source.

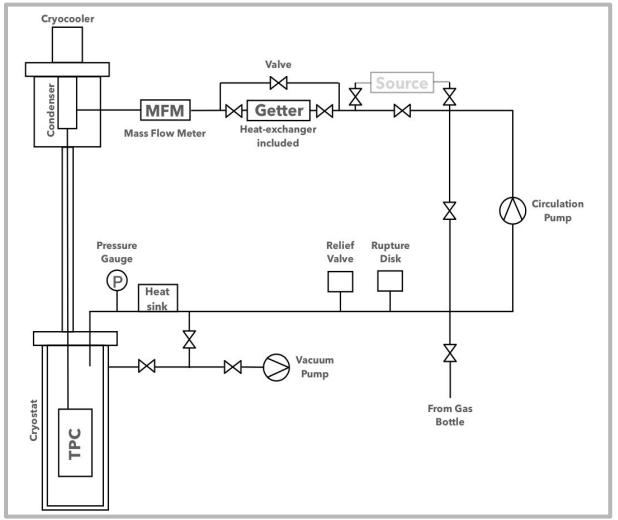
In DarkSide-20k, this will become the primary background after reducing ^{40}Ar contributions.

Our Approach:

Transitioning from PMTs to SiPM-based photodetector modules (SiPDM):

10x lower radioactivity compared to PMTs.

Improving photodetection efficiency and timing resolution.



LAr TPC schematic

Progress Overview: Hardware and Software Development

Hardware Development:

Researching, selecting, and procuring the optimal components for the TPC LAr.

Ensuring that all technical specifications align with project requirements and grant policies.

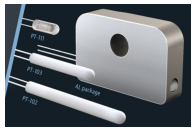
Software Development (utilizing existing components**)**

Implementing a real-time monitoring system using **InfluxDB and Grafana**, providing:

Continuous system monitoring.
Performance tracking and parameter control.
Early detection of potential issues.

Temperature Controller


PCB components


Temperature Sensors


MPPC(Multi-Pixel Photon Counter


Raspberry Pi 5

Mass Flow Meter

Progress Overview: 3DPi PET Project

3DPi PET project

- Paper submitted to *Physics in Medicine & Biology* and responded to reviewer comments.
- Submitted two research grants:
    - **First Team**, FNP (first improvement in terms of formal comments)
    - **SONATA 20**, NCN (Under eligibility check)

Academic Engagement And Plane for 2025

Grant Evaluation:

- Evaluated a grant proposal submitted to the Swiss National Science Foundation (SNSF).

Paper Reviews:

- Reviewed several research papers for academic journals.

Contributions to the Iranian Scientific Community

Role: Corresponding author for both publications, collaborating with Iranian PhD students.

- Monte Carlo study of high-energy light ions for minibeam radiation therapy approach, The European Physical Journal Plus, Volume 139, 1024, Published: 25 November 2024
- Dosimetric evaluation of light ion beams for spatially fractionated radiation therapy: a Geant4 Monte Carlo study, The European Physical Journal Plus, Volume 139, 365, Published: 29 April 2024

Plan for 2025

Development of the Most Sensitive Dark Matter Detector with Liquid Argon

- Measurement of delayed electron emission due to chemical impurities in liquid argon.
- Reducing backgrounds from photoelectronics

3DPi PET Project

- Transitioning from simulation to experimental phase (contingent on grant approval).

Thank you

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