



Study on low energy events in liquid argon for dark matter searches

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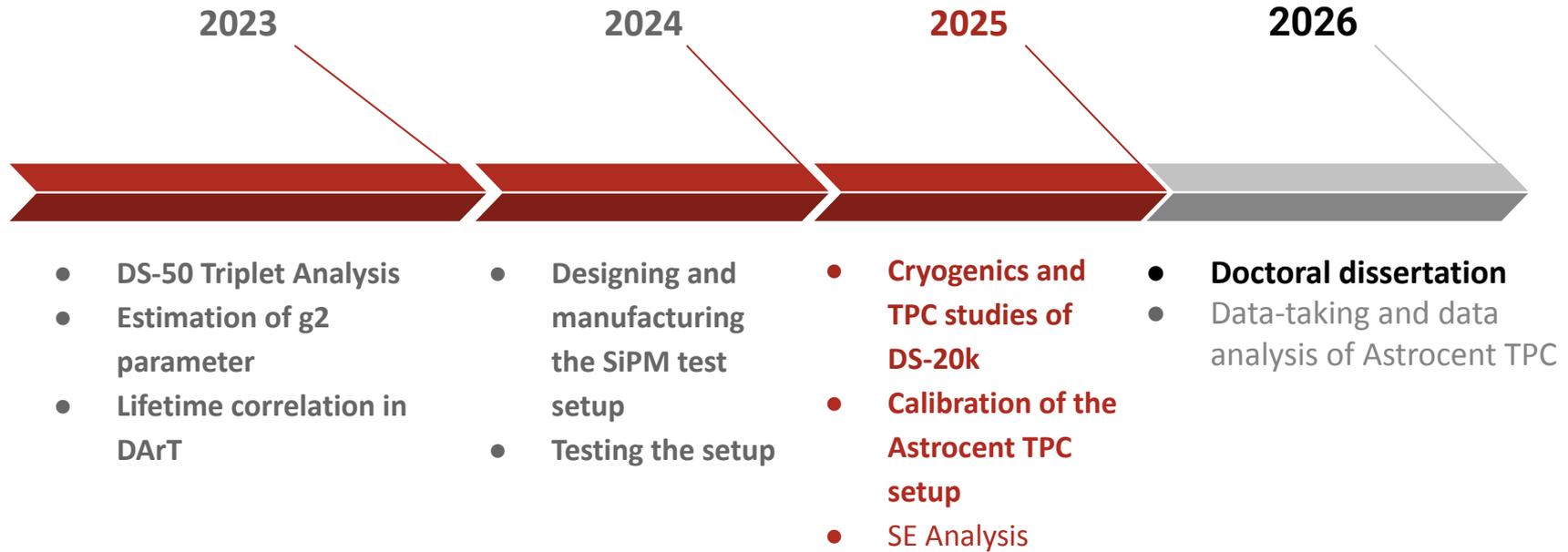
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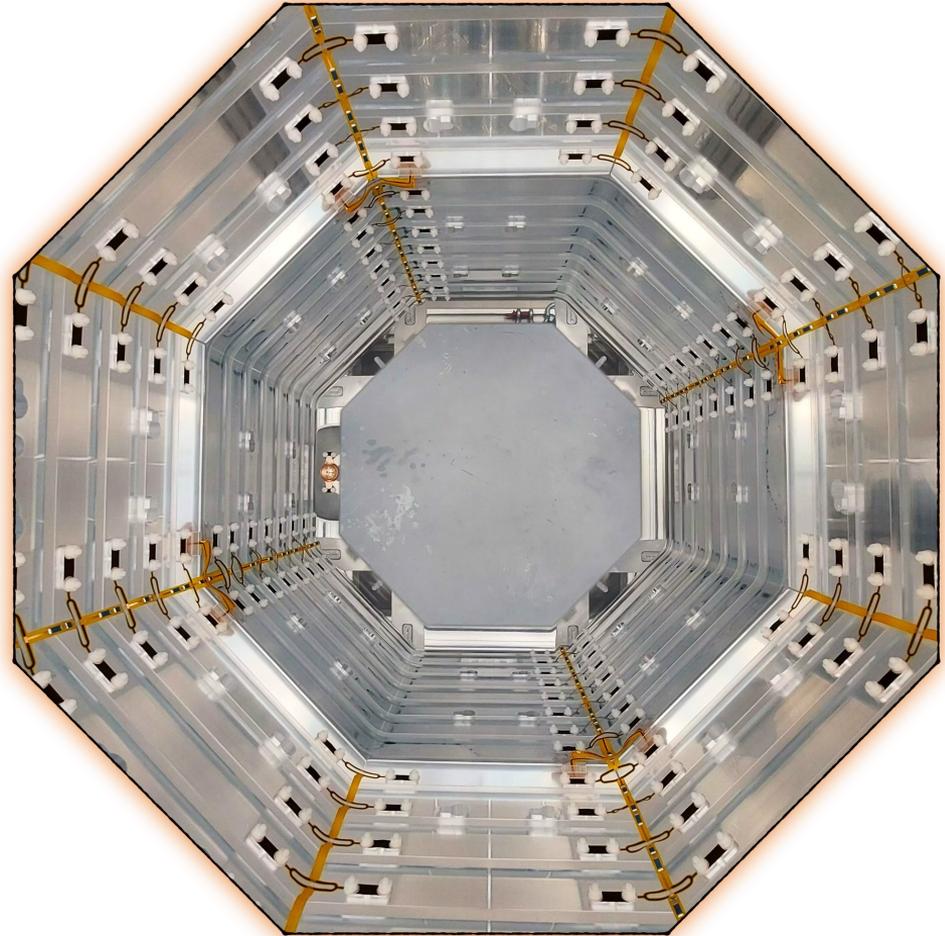
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Ph.D. journey so far...



Cryogenics and TPC (Time Projection Chamber) studies of DS-20k (Mockup) Experiment



DS-20K TPC Mockup field-cage

DarkSide-20k TPC Mockup

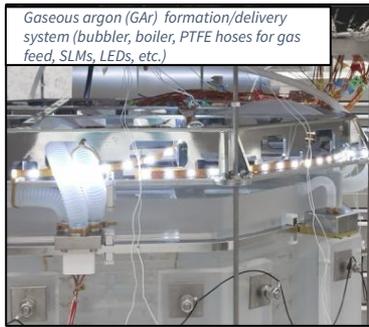
- DS-20k TPC Mockup: Small-scale prototype, setup to perform several tests to confirm the functionality of DS-20k TPC
 - Total (active) mass of AAr: 760 kg (160 kg)
- Visited LNGS for 1 month to assist the Mockup team with the
 - assembly of the detector (Nov 2024-Feb 2025)
 - transfer to the underground lab (Feb-Mar 2025)

Aligning the base plates for TPC assembly



Stacking up the TPC panels one-by-one on the base plate

Gaseous argon (GAR) formation/delivery system (bubbler, boiler, PTFE hoses for gas feed, SLMs, LEDs, etc.)



Transferring to the UG lab



TPC insertion to the cryostat



Setting up heaters onto the TPC



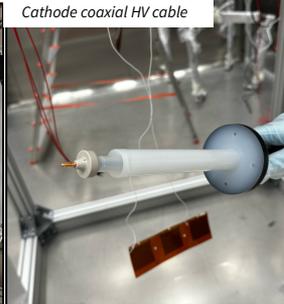
DS-Mockup inside the cryostat all ready for the running phase



Kapton-Copper Resistor Chains



Cathode + Kneewall



Cathode coaxial HV cable



Camera setup

Performance results from TPC Mockup

- Remote shifts (~8 hr/day) for 3 months for the performance run (March-May 2025)
- Mockup campaign: Slow cool-down, thermal cycling of PMMA TPC, high-voltage operation, gas pocket generation, slow warm-up
- Temperature evolution of TPC panels monitored by 44 PT-100 sensors
 - Estimated temporal gradient $\rightarrow -0.5$ K/h
 - Could achieve a spatial gradient below 2 K/cm (Fig. 1)
- Gas pocket formation and maintenance require far more power than expected (Fig. 2)
- HV stability test in dual phase:
 - Cathode at **-75 kV** \rightarrow General stability achieved for over ~60 hrs (Fig. 3)
 - Some glitches were observed on grid wires

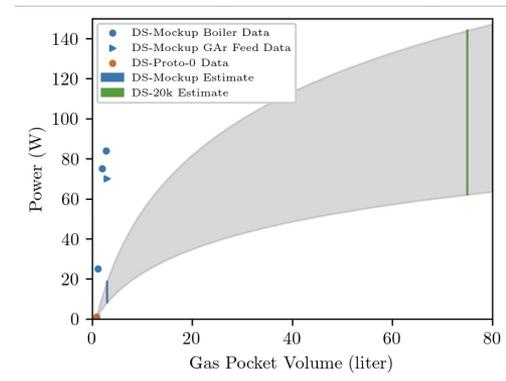


Fig.2: Relation between gas pocket volume and power needed for generation. The extrapolated power values are also shown for DS-20k

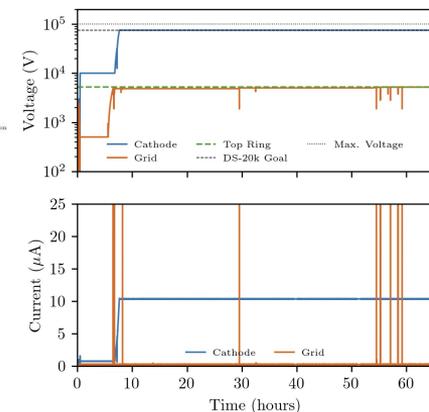


Fig.3: Dual-phase HV test at nominal DS-20k voltages

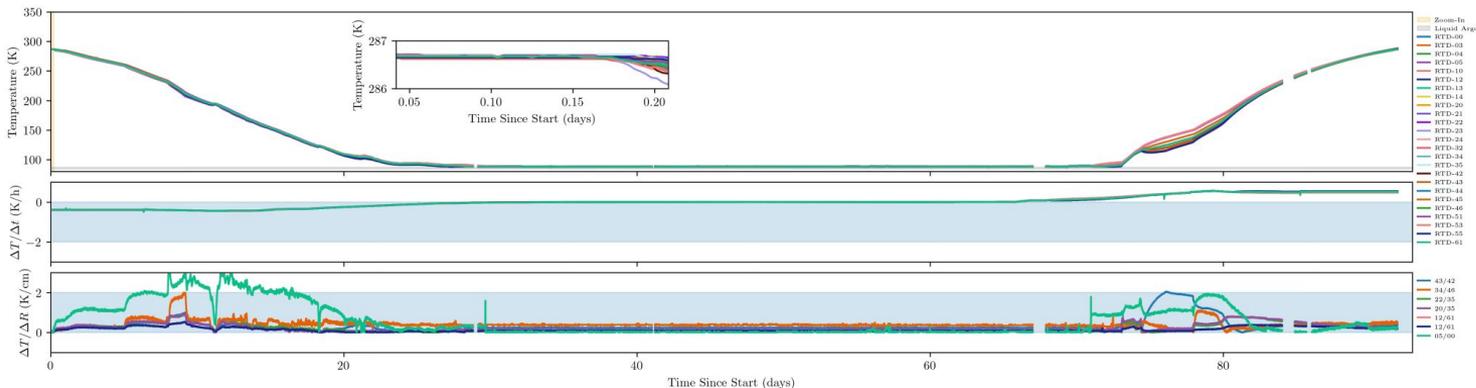
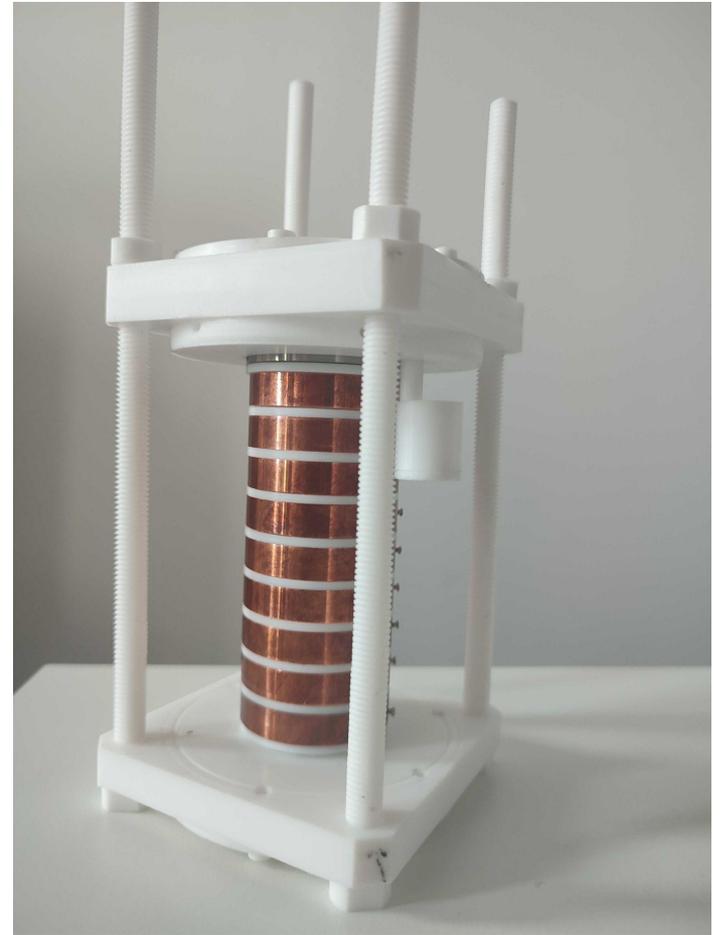


Fig.1: GAr cool-down progression in the PMMA panels

Progress report on the development of Astrocent TPC



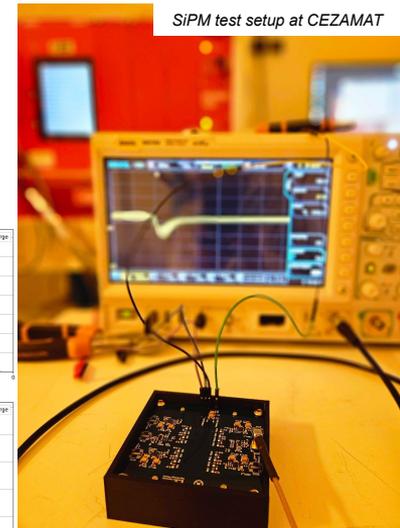
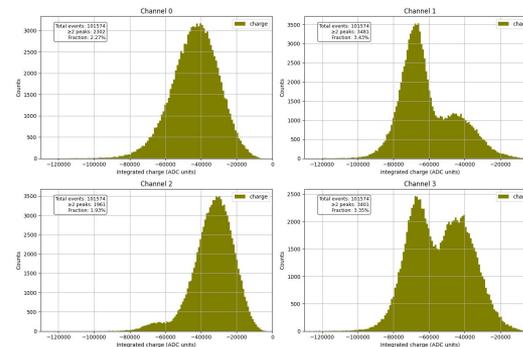
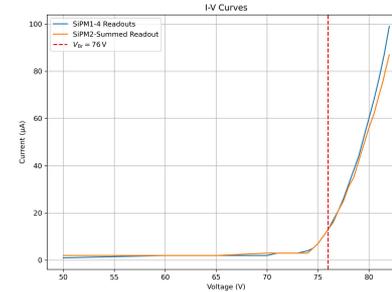
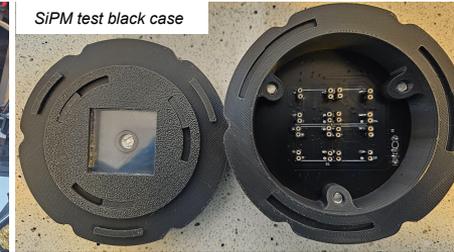
Astrocent TPC: Setup, Monitoring, and Testing

➤ Current status of the TPC:

- Procurement is ongoing
- Awaiting availability of installation space
- Assembly will begin once both are secured

➤ Activities done for Astrocent TPC setup:

- **Slow Monitoring Setup:** Gained hands-on experience with Grafana and InfluxDB for familiarization
- **PCB Testing:** Conducted tests on Printed Circuit Board (PCB) for X-ArT project
- **Setting up SiPM test casings:** Designing and 3D-printing the black cases used for SiPM (Silicon Photomultiplier) testing
- **SiPM Testing:** Tested two SiPM-mounted PCBs for their performance
- **Data Analysis:** Performed detailed analysis on SiPM test data



SiPM test analysis results

DS-50 sensitivity study at APC, Paris

- One-week visit to AstroParticule & Cosmologie (APC) in Paris, Dec 2025): Collaboration with Dr. Davide Franco and his team on spurious electron (SE) analysis and DS-50 sensitivity studies
- Goal → Improve DS-50 sensitivity to below $1.2 \text{ GeV}/c^2$, with an updated background model (Fig. 1)
- SE events limit sensitivity to lower WIMP mass range
 - Model SE in the background to avoid misinterpreting it as WIMP signals
- **SE model update:** Introduced one-primary-SE hypothesis and the Vinogradov fn. to model overlapping SE contributions from the photoelectric effect (Fig. 2)
- Currently working on the final results

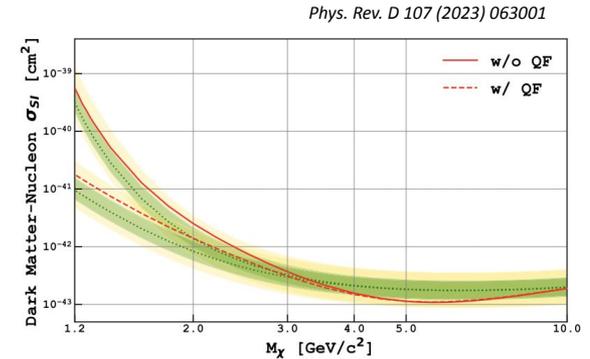


Fig.1: Observed upper limits on WIMP-nucleon cross sections from DS-50 in the range above $1.2 \text{ GeV}/c^2$ for both QF and NQ

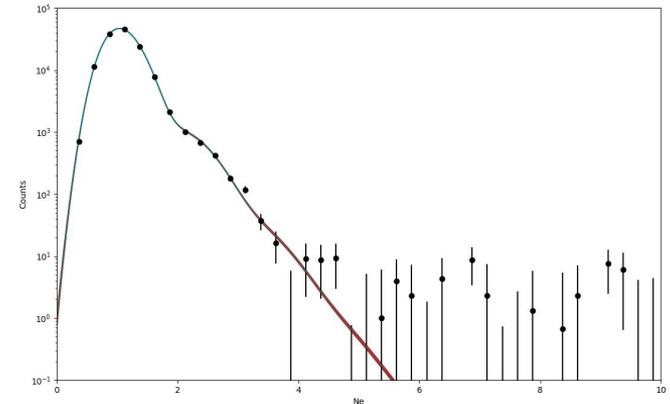


Fig.2: SE fit with the hypothesis model

Summary

- DS-20k Mockup:
 - Assembled the Mockup detector, and participated in the remote shifts during its run
- Astrocent TPC:
 - Procurement is ongoing
 - Tested PCB, SiPMs, and obtained hands-on training with the equipment and DAQ tools
- DS-50 sensitivity analysis:
 - Working on improving the sensitivity of DS-50 data by updating the SE model
- **2026: *Doctoral dissertation***

Extra-curricular activities and Publications

- **Workshop:** DarkSide Young Academy 2025, Cagliari, Italy, 3-7 March 2025
 - Presented a talk on the “ReD experiment: The g_2 parameter”
- **International Conference:** TeV Particle Astrophysics (TeVPA), Valencia, Spain, 3–7 November 2025
 - Attended and presented a talk on “DS-20k TPC Mockup”
- **Upcoming Public Outreach:** International Women in Science Day, *online, 13 February 2026*
 - Upcoming talk: “*Dark Matter 101: what we know and how I got into it*”
- Submitted research proposal for **PRELUDIUM 2024 grant**
- **Publications 2025:**
 - P. Agnes, et al. (DarkSide-50 collaboration), Characterization of spurious-electron signals in the double-phase argon TPC of the DarkSide-50 experiment, [arXiv:2507.23003](https://arxiv.org/abs/2507.23003) (2025)
 - P. Agnes, et al., Characterization of the ionization response of argon to nuclear recoils at the keV scale with the ReD experiment, [arXiv:2510.16404](https://arxiv.org/abs/2510.16404) (2025)
 - F. Acerbi, et al., Sensitivity to low-mass WIMPs with an improved liquid argon ionization response model within the DarkSide programme, [arXiv:2511.13629](https://arxiv.org/abs/2511.13629) (2025)
 - F. Acerbi, et al. (DarkSide-20k Collaboration), Production, quality assurance and quality control of the SiPM Tiles for the DarkSide-20k Time Projection Chamber, [Eur. Phys. J. C 85, 1334](https://doi.org/10.1088/1361-6470/ada934) (2025)
 - M. Ave, et al., Characterization of low energy argon recoils with ReD and ReD+, [JINST 20 C06062](https://arxiv.org/abs/2502.06062) (2025)
 - F. Acerbi, et al., Flow and thermal modelling of the argon volume in the DarkSide-20k TPC, [JINST 20 P06046](https://arxiv.org/abs/2502.06046) (2025)
 - F. Acerbi, et al., Quality assurance and quality control of the 26 m² SiPM production for the DarkSide-20k dark matter experiment, [Eur. Phys. J. C 85, 534](https://doi.org/10.1088/1361-6470/ada934) (2025)
 - F. Acerbi, et al., Benchmarking the design of the cryogenics system for the underground argon in DarkSide-20k, [JINST 20 P02016](https://arxiv.org/abs/2502.02016) 2025

Stay Safe
Thank
you!
The Future is Dark