

DEAP, DarkSide, and ARGO

Sean Daugherty and Christopher Jillings

SNOLAB SEF, July 29, 2025

Outline

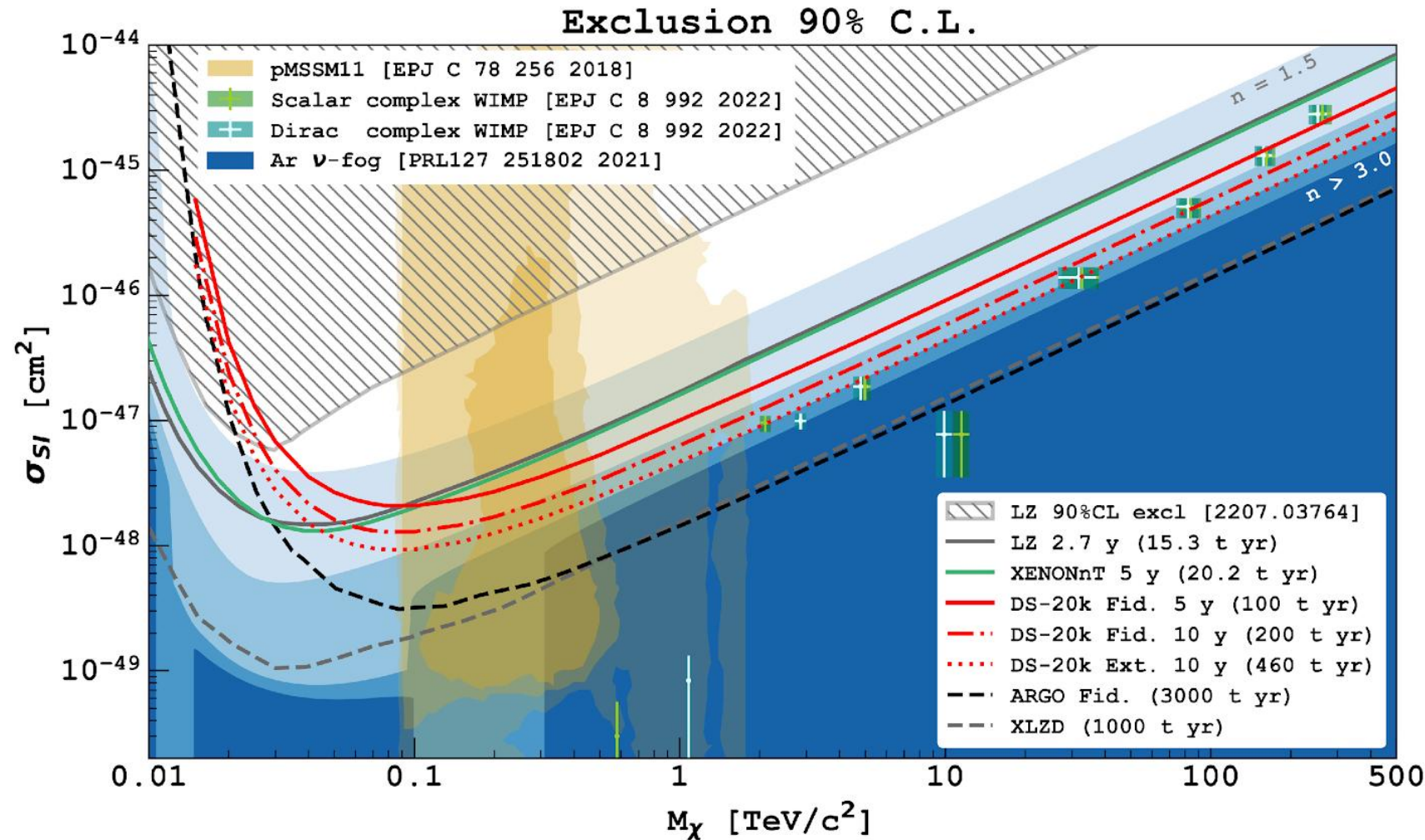
- Overview of the program
- Recent Science
- Collaboration Health
- Experiment Status – The Fill!
- Schedule, Impacts, Milestones
- Challenges
- Conclusions

The Global Argon Dark Matter Collaboration

ArDM, DarkSide, DEAP, and MiniCLEAN joined forces in 2017

High Mass WIMPS

- Complete run and analysis of DEAP-3600 at SNOLAB
- Build, operate, and analyze DarkSide-20k at LNGS
- Build, operate, and analyze data from ARGO, a multi-hundred tonne detector with SNOLAB the preferred site.



ARGO Details

ARGO is being designed to use 400 tonnes of LAr with leading sensitivity for dark matter particles deep into the neutrino fog.

It is the ultimate detector within the phased GADMC approach.

The experiment, with a target mass similar to SNO's, will also enable new measurements of low and intermediate-energy solar neutrinos,

- has the ability to resolve the solar metallicity problem
- provides substantial new sensitivity to neutrinos from supernovae.

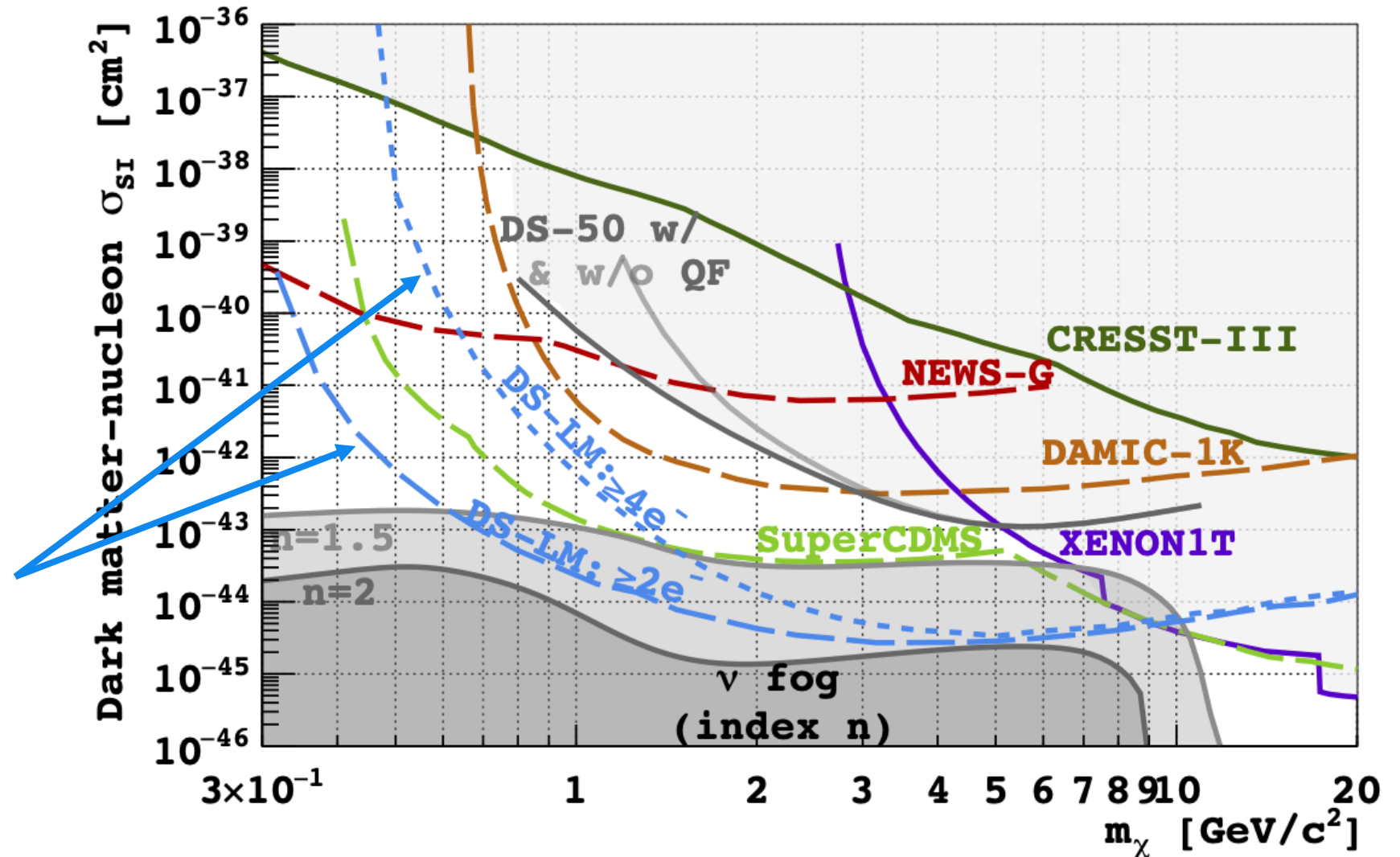
The Global Argon Dark Matter Collaboration

Low Mass WIMPs

Exploring a detector at
SNOLAB

S2-only signal in a
dual-phase TPC

Sensitivity depends on
threshold



Recent Science

Alpha Quenching Model

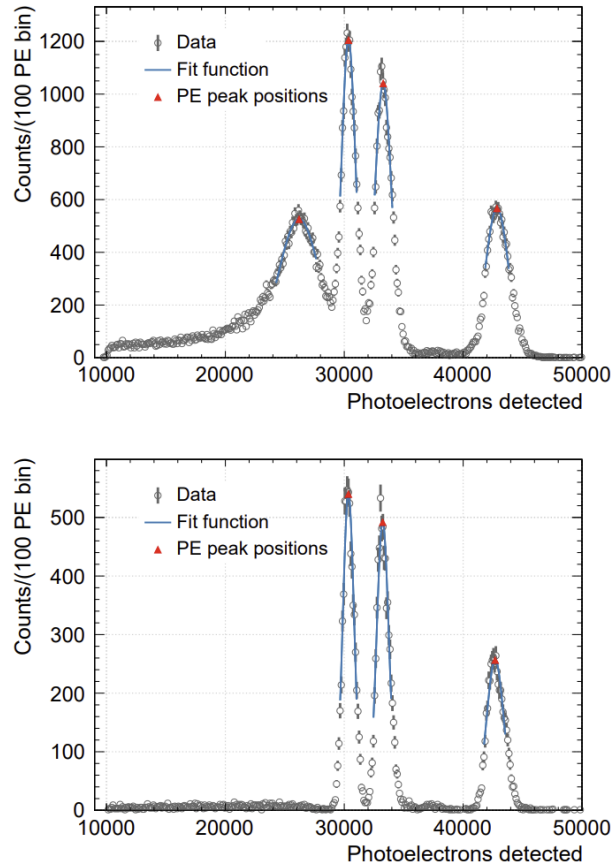


Fig. 1 Distribution of the number of PE detected from α -decay events the position of which is reconstructed within radius 0–850 mm (top histogram) and 0–600 mm (bottom histogram) from the origin of the detector. From left to right, the peaks are from the decay of the ^{210}Po , ^{222}Rn , ^{218}Po and ^{214}Po isotopes. Each peak is fitted by a Gaussian distribution (blue line). Red solid points are the detected peak PE positions from each Gaussian fit.

Have developed a data-driven quenching model for alpha events, which are significant contributors to our background model.

Relevant for future experiments.

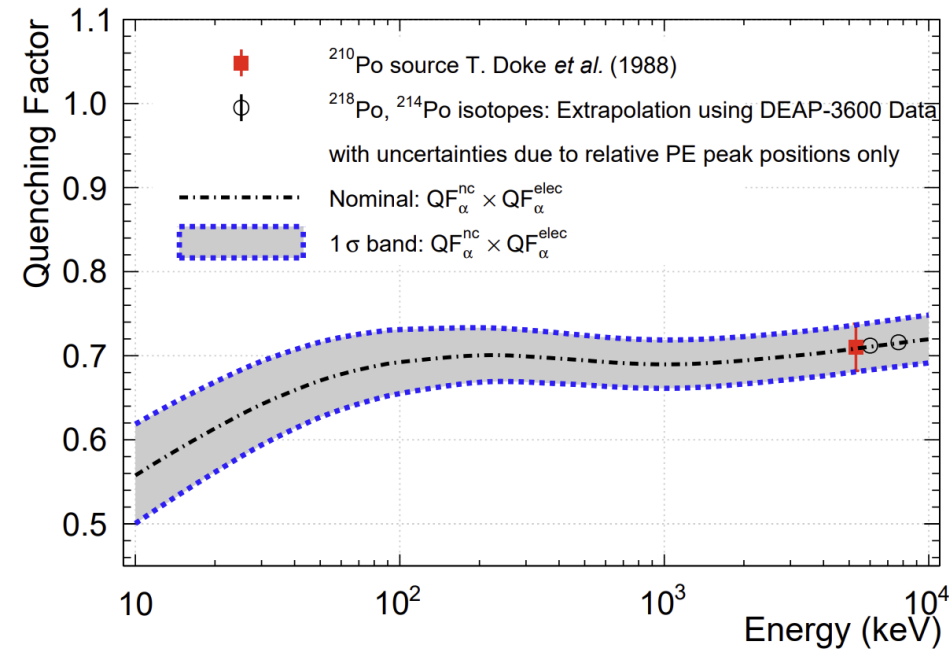


Fig. 6 Energy-dependent scintillation QF curve for α -particles within LAr, as a function of their energy on a logarithmic scale. The nominal and $\pm 1\sigma$ QF curves are the product of the electronic QF (see Fig. 5) with the nuclear QF from TRIM (see Fig. 2).

ArXiv: 2406.18597

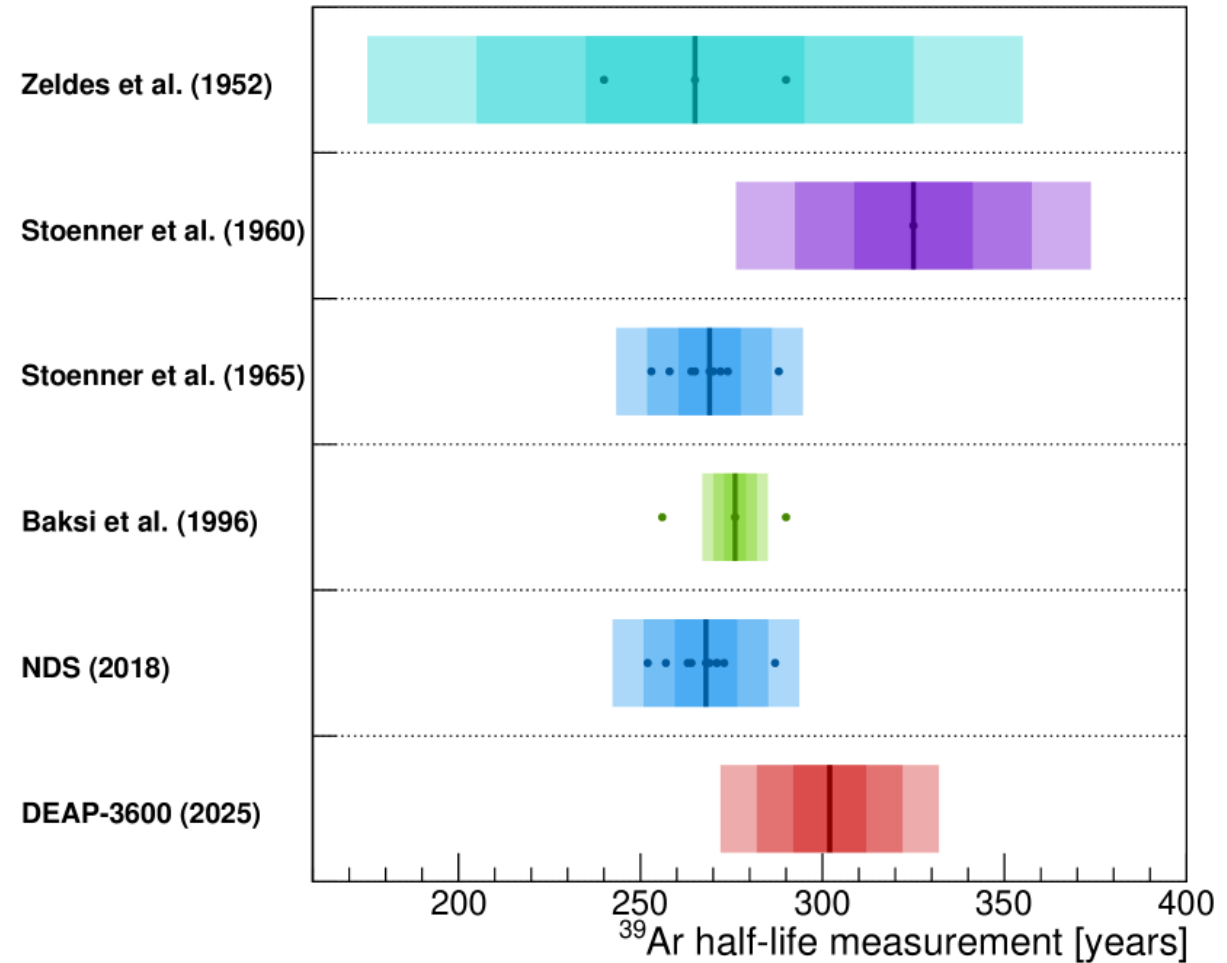
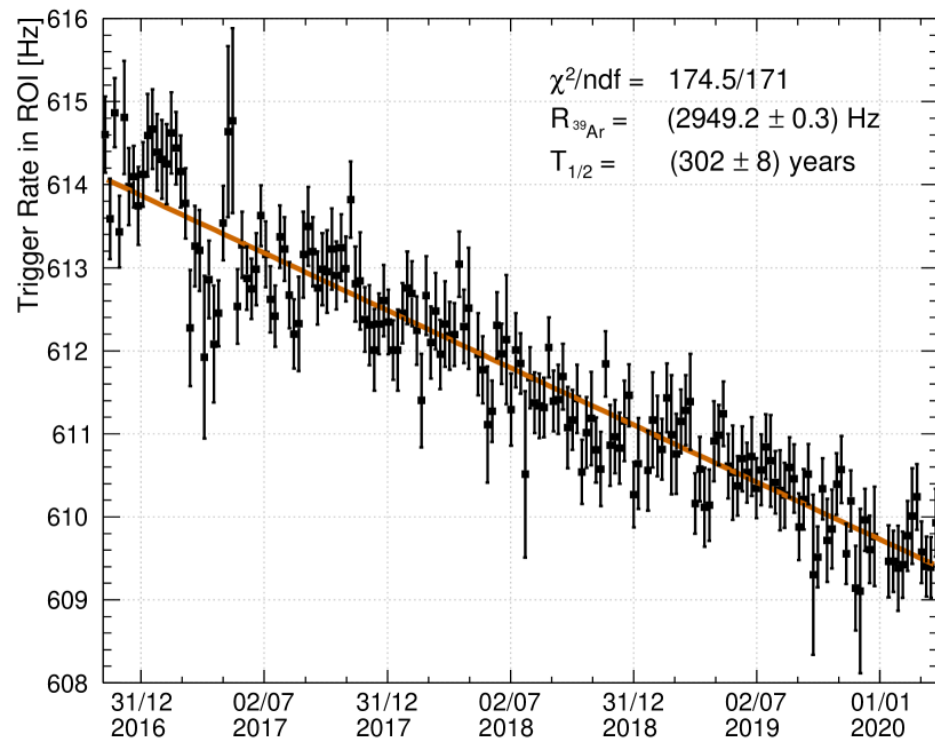
Eur. Phys. J. C **85**,
87 (2025)

<https://doi.org/10.1140/epjc/s10052-024-13518-7>

Argon-39 Half Life

Direct measurement of decay rate.

We have already received communication from a group doing Ar-Ar dating in ice cores.



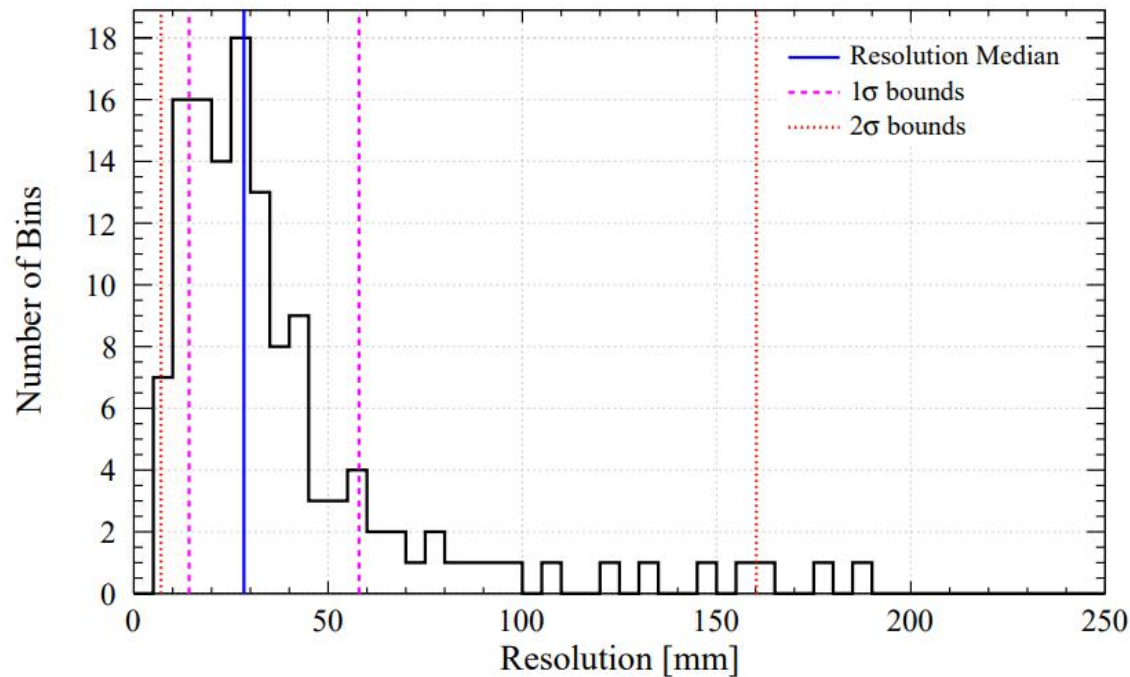
Published in EPJ C: <https://doi.org/10.1140/epjc/s10052-025-14289-5>
ArXiv 2501.13196

Technical paper on position reconstruction

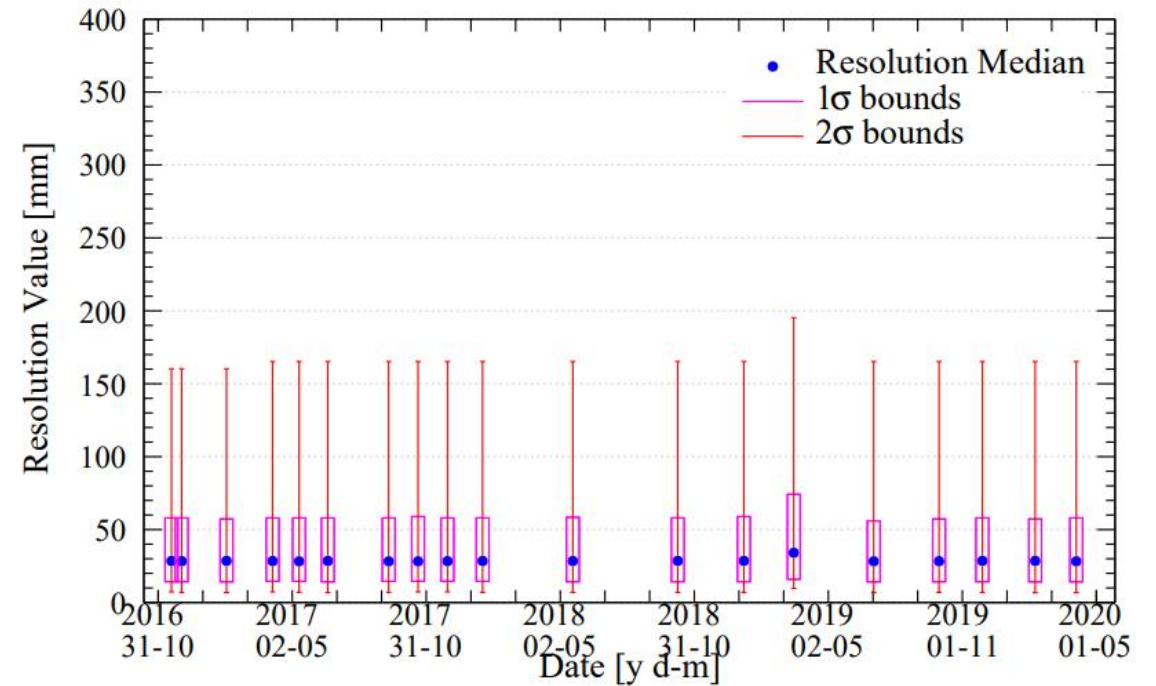
Published in JINST

10.1088/1748-0221/20/07/P07012

<https://arxiv.org/abs/2503.10383>



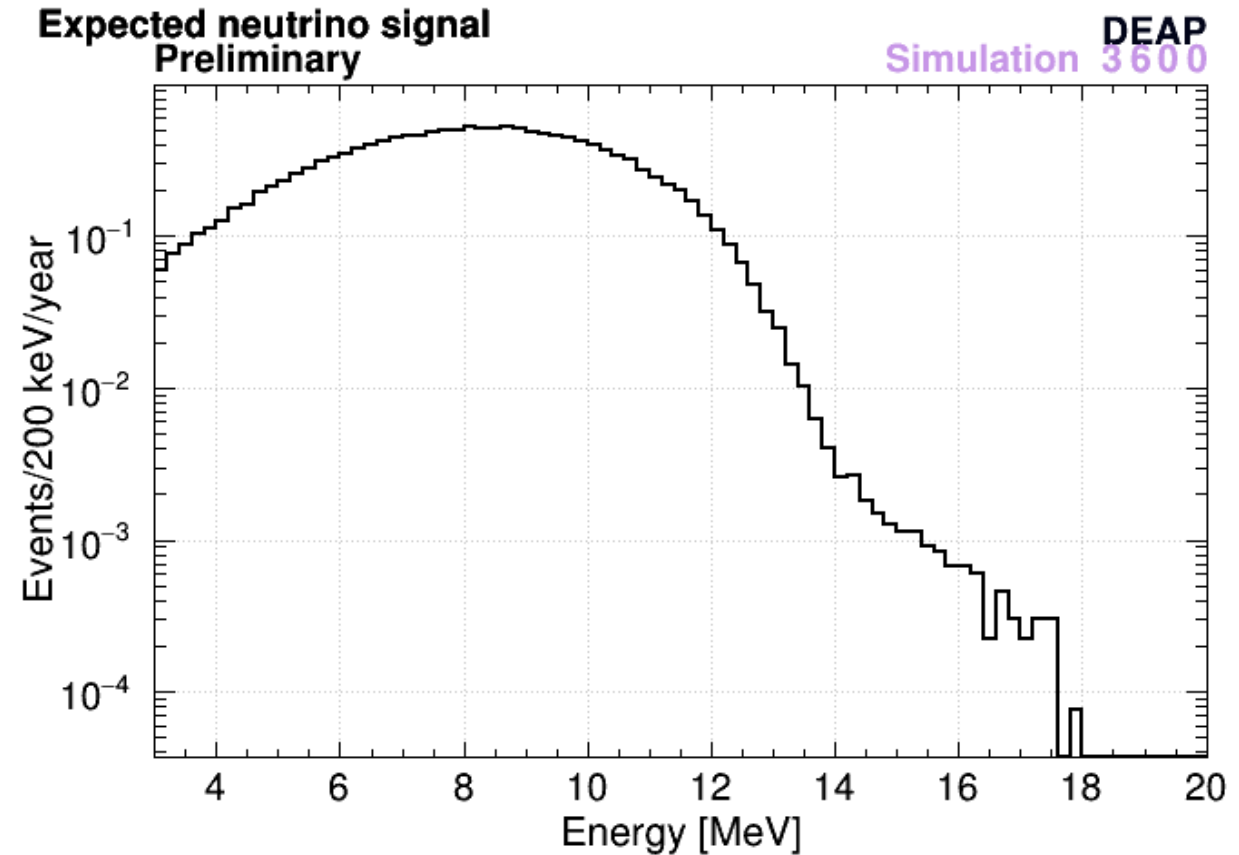
(a) Example 1D distribution — Likelihood PE-based



(b) Likelihood PE-based position resolution

Boron-8 Solar Neutrinos

- Our high-energy B-8 solar neutrino ROI has been unblinded.
- Two analyses (differing mostly in method to constrain the high-E n-capture) are completed/very advanced.
- Andrew Erlandson defended his PhD thesis and was awarded the University [Carleton] Senate Medal for Outstanding Academic Achievement after being nominated by his thesis exam committee.
- Emma Ellingwood will defended her PhD.
- Journal publication draft is advanced.



This reaction has never been observed.

Our measurement will be the first: allows experimental constraint on the cross section.

First observation of solar neutrinos with argon

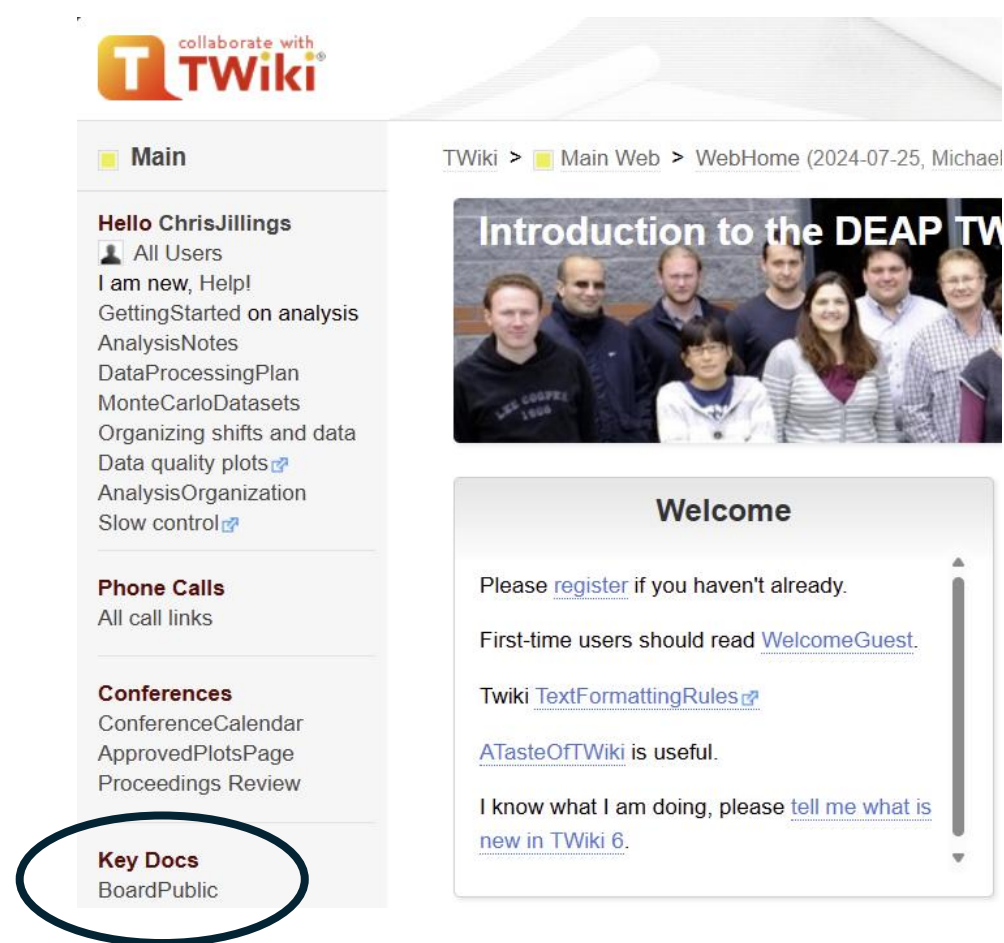
WIMP Search with Profile Likelihood Analysis

- Better sensitivity with a larger fiducial volume and a more detailed background model.
- Dust TPB coverage fraction and Cherenkov backgrounds are under final evaluation and this will complete the background model.
- Work is being finalized.

Collaboration Health

DEAP

- DEAP has detailed EDI plan, ombudspeople, and a clear place to find collaboration information.
- Meetings are minuted; plots are colour friendly.
- There are young members on the DEAP Scientific Board.
- Young members are given leadership roles in analysis and ops



Everyone can find our
EDI Committee's work

DEAP-3600 Active Pages

HardwareFixOrganization
OnSiteDEAP3600
PipeSupportAdjustments
Analysis Organization
Master Cuts
Master MVA
Master Systematics
PrettyPictures
EngineeringModel
ProcessSystems
ThirdFillRunPlan
EquityDiversityInclusion
AnalysisOverviewPages

The Global Argon Dark Matter Collaboration

- 400 scientists in 100 institutions in 14 countries
- Has ombudspeople and methods to ensure new/young scientists can be involved
- DarkSide-20k: A formal working group structure and group leaders have considerable responsibility
- A review office for internal reviews of systems for the detector and for design changes (DarkSide-20k only)

ARGO

- We have defined a steering council within the GADMC to enable strong and efficient science collaboration between the DS20k and ARGO projects.
- Each project within the GADMC maintains its own project execution structure.
- The Canadian groups are submitting a CFI request aimed at development of ARGO, occurring mostly after our construction activities on DS20k are completed, which include a new prototype detector (ARGOlite) at SNOLAB that will replace the existing DEAP-3600 detector.

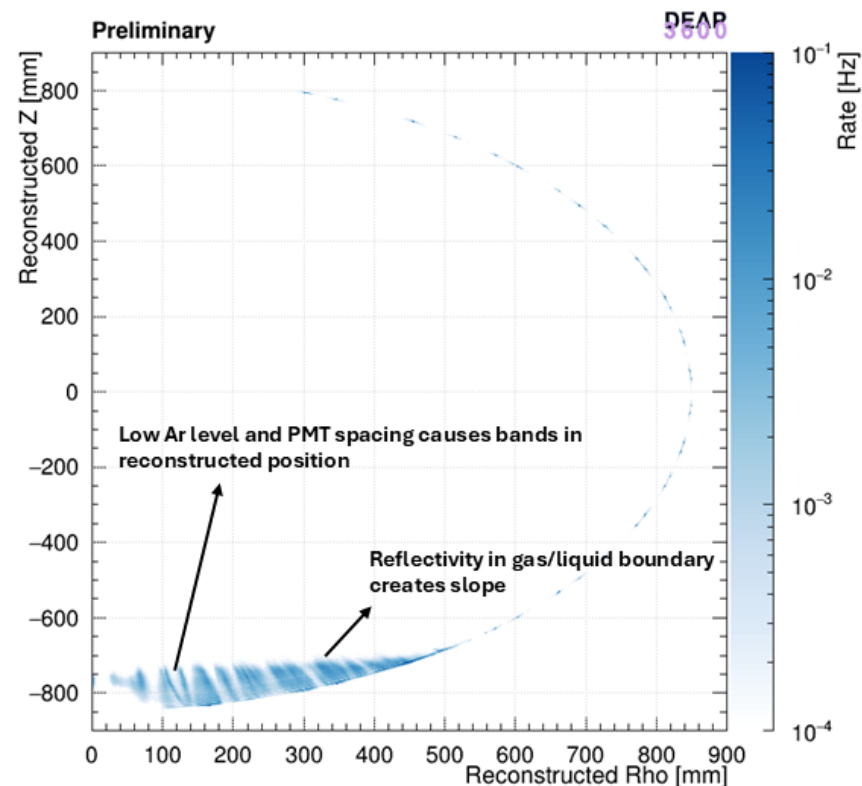
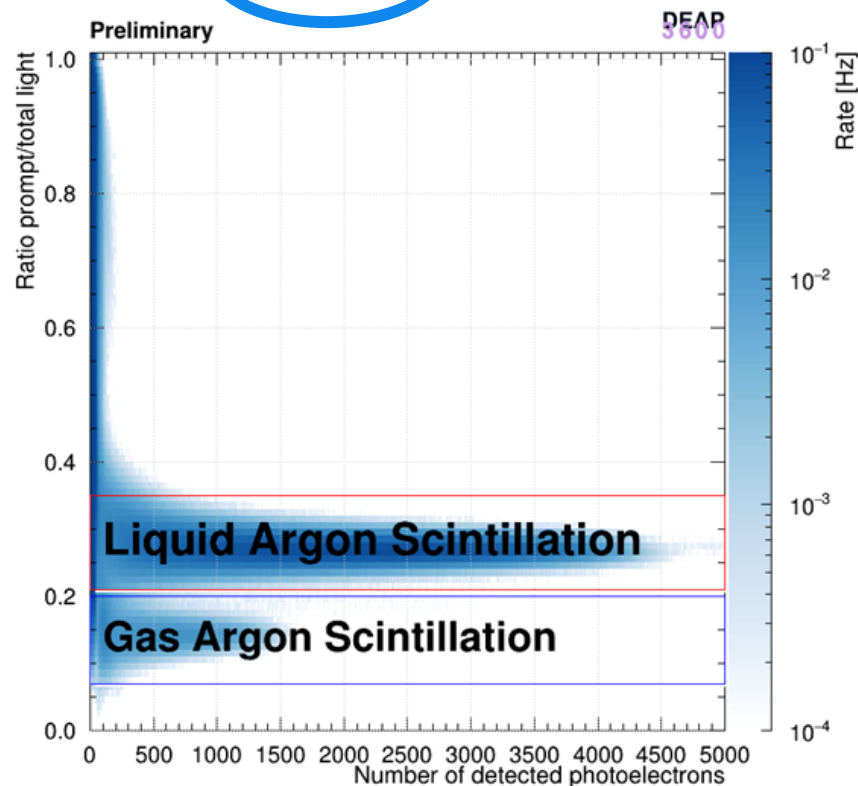
Experiment Status

DEAP is filling: 2600 of 3300 kg deployed.

1. Fprompt (Pulse Shape Discrimination) looks great → Argon is pure
2. Light Yields similar to 2016-2020 data
3. Early indications suggest pyrene coatings are working well.

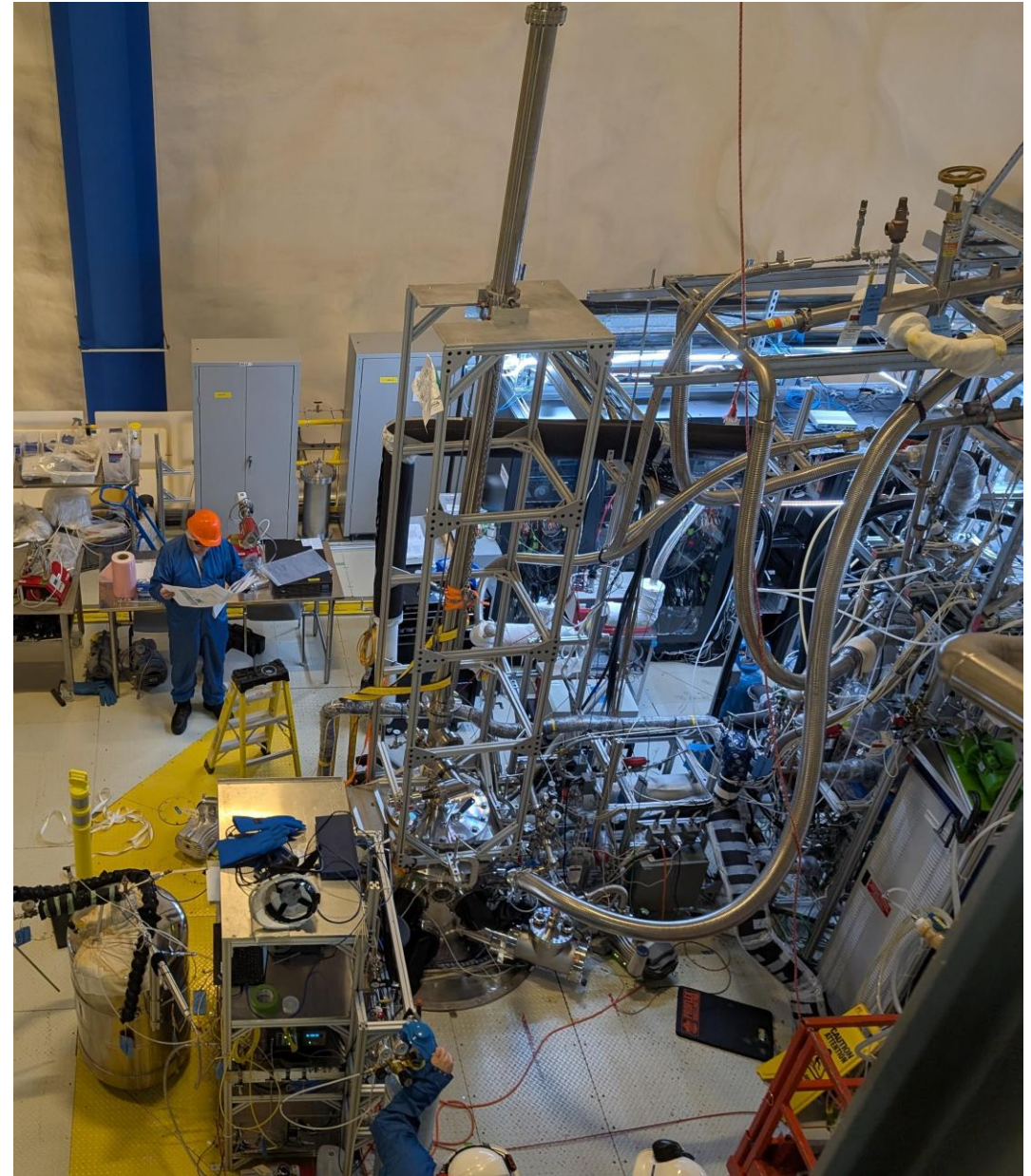
One of two main goals of third fill.

Third Fill Date (2025-06-24)



Dust Pipe Operations

- September/October

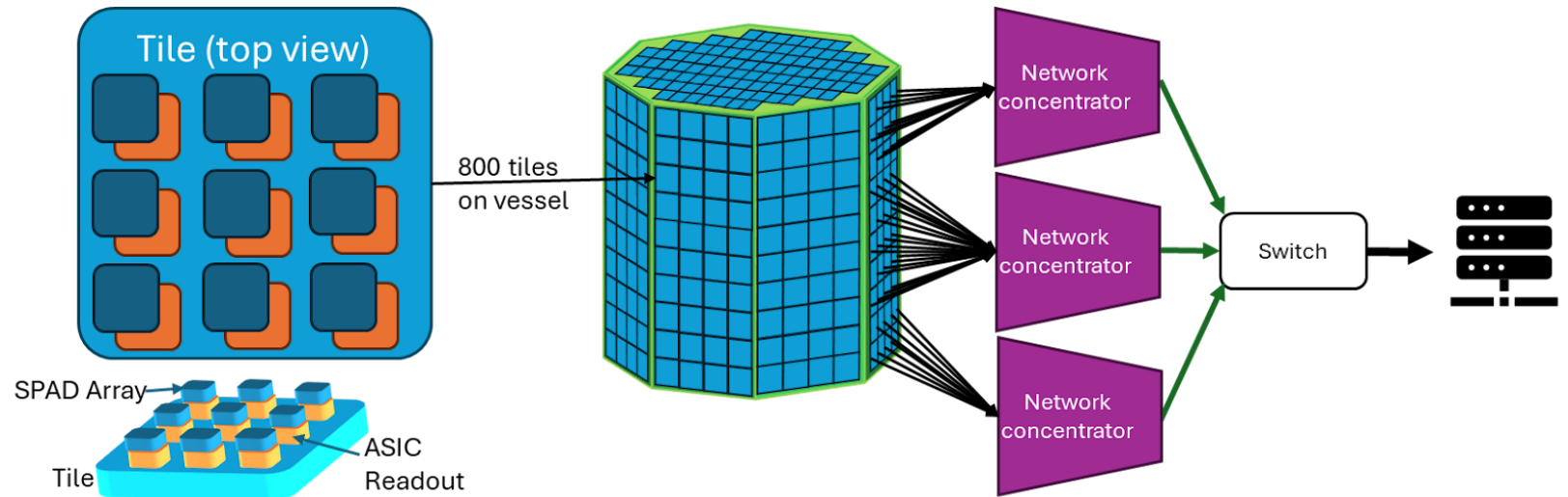


ARGO Development CFI-IF25 Proposal 1/4

- Conceptual Design of ARGO
- Development of pixelated digital silicon photodetectors:

Unique 3mm pixels over a 2m² area will enable powerful new background rejection

Reminder of information shown in February!

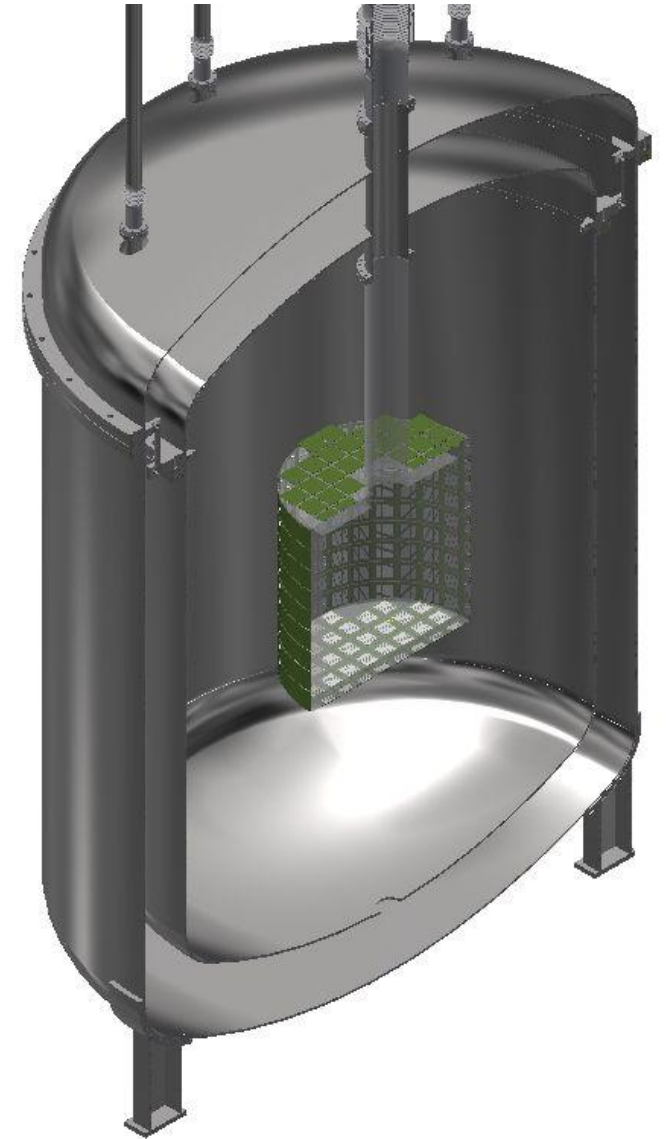
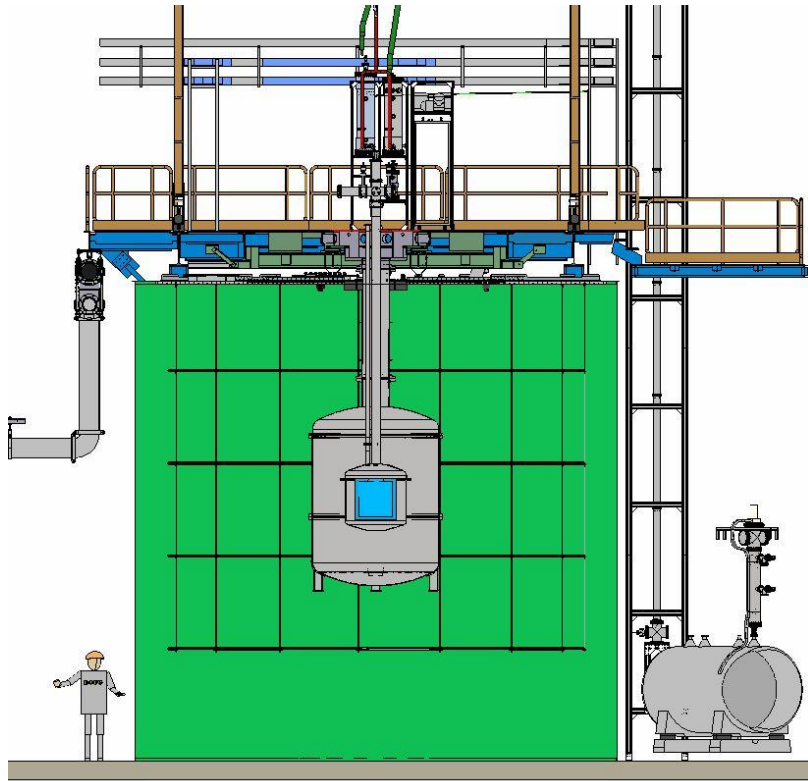


ARGO Development CFI-IF25 Proposal ^{2/4}

- Distillation for Isotropically Enriched Argon
 - Building on the xenon still project
 - Create a larger diameter (1" → 4") tower to benchmark requirements for a high-throughput argon distillation column
- TPC development: with Giuliana Fiorillo (Naples)
 - The DarkSide mockup will be moved to her lab
- ALARM2 LAr detector for security applications: with Katy Hartling (CNL)
- Improvements to University labs

ARGO Development CFI-IF25 Proposal ^{3/4}

Development and deployment of ARGOLite at SNOLAB in the DEAP water tank.

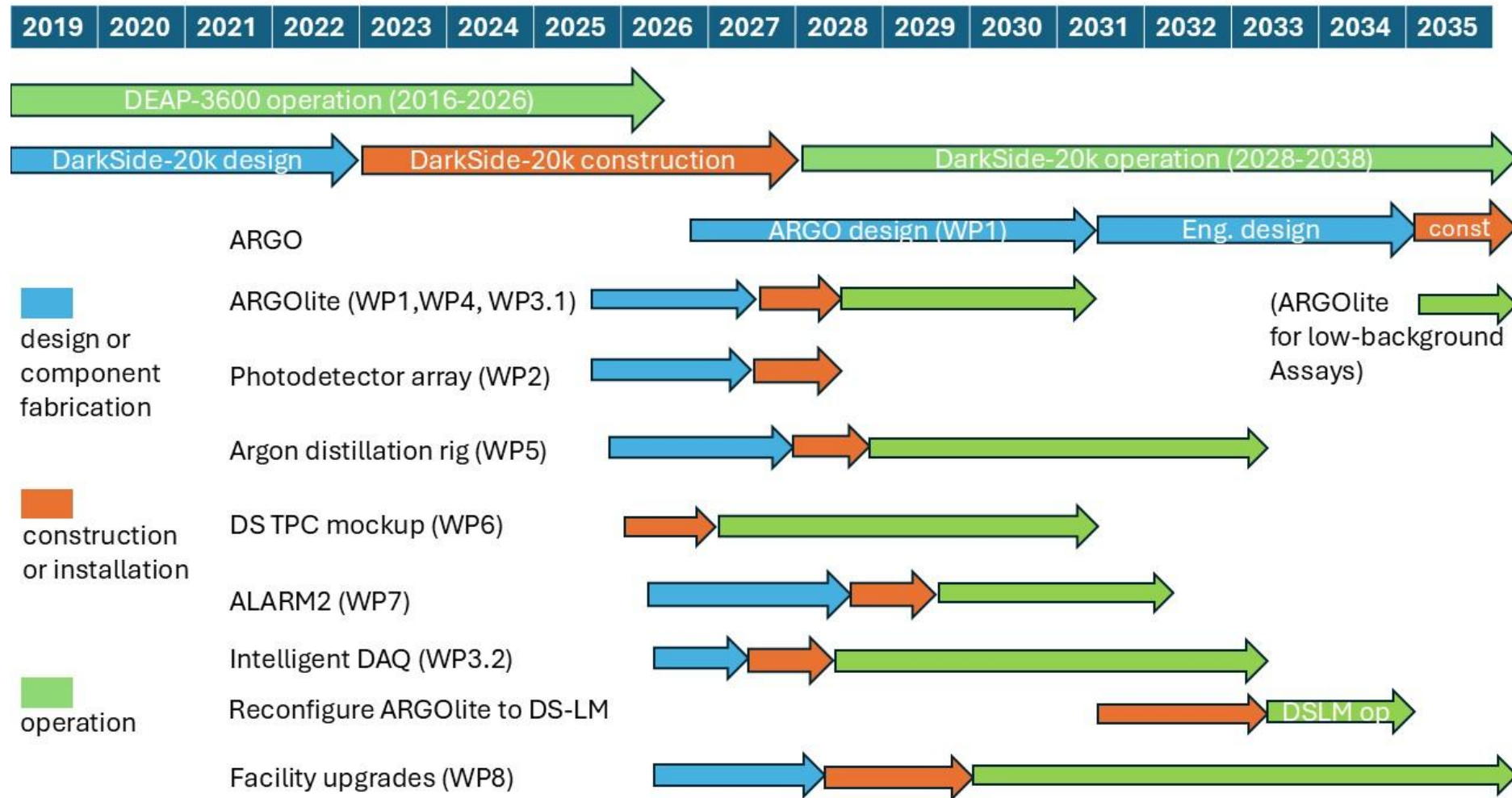


ARGO Development CFI-IF25 Proposal 4/4

ARGOlite will:

- give us a low-background testbed for SiPM detection systems (ie optical cross talk)
- be used to develop, optimize, and benchmark the design of ARGO and allow detailed characterization of the photodetectors
- be used to evaluate ER/NR PSD with digital photodetectors to the $1e-9$ level, and surface background to the $1e-7$ level, both necessary for ARGO.
- be available as a low background counter (for example for exquisite sensitivity to surface alphas) when our tests are done
- have infrastructure designed to hold DarkSide LowMass detector
→ future upgrade after this proposal period.

Schedule, Impacts, and Milestones



Challenges

Digital Research Alliance of Canada resources were cut back as Graham and Cedar are being upgraded

We are using SNOLAB's Nearline system to process our data.

Power outages

We appreciate the warning and such given for the power upgrade work. They are still disruptive. In particular, loss of cooling is a concern in outages.

Rigid shift schedules

Challenges

Unexpected technical problems

We have had help from other experiments, SNOLAB staff, and have used equipment available from Scientific Support

Conclusions

- The science program for low-mass and high-mass WIMPs is compelling
- DEAP-3600 is back in operations. It will run to mid calendar 2026.
- We have a CFI IF/25 proposal to
 - deploy ARGOLite for low-background single-phase development with SiPMs. ARGOLite can become a sensitive low-background tool for general use.
 - Develop a conceptual design for a full-scale ARGO.
 - Expand R&D capacity at university labs and partner institutions
- There is a bright future in liquid-argon dark-matter physics

