

Recent results from the DEAP-3600 experiment

Michela Lai

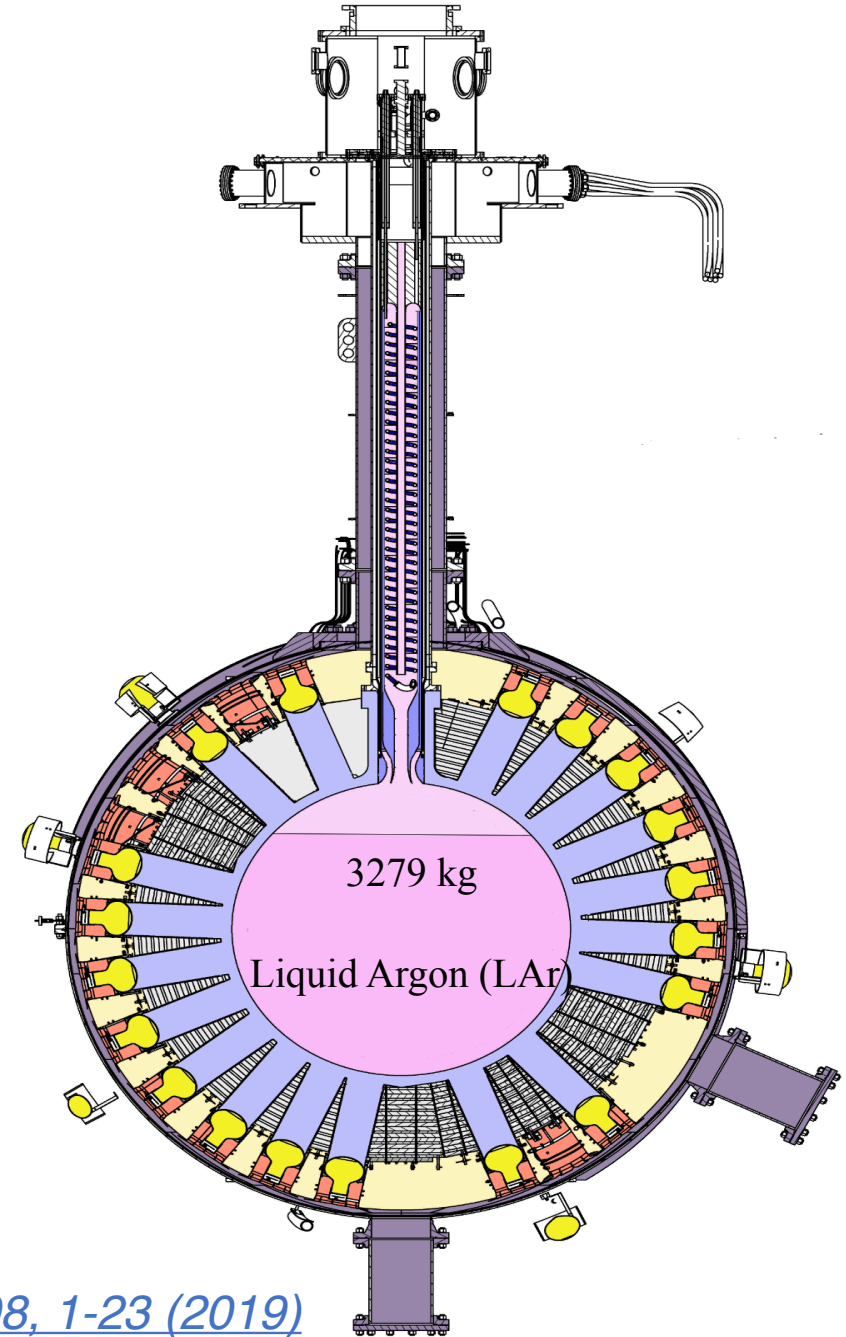
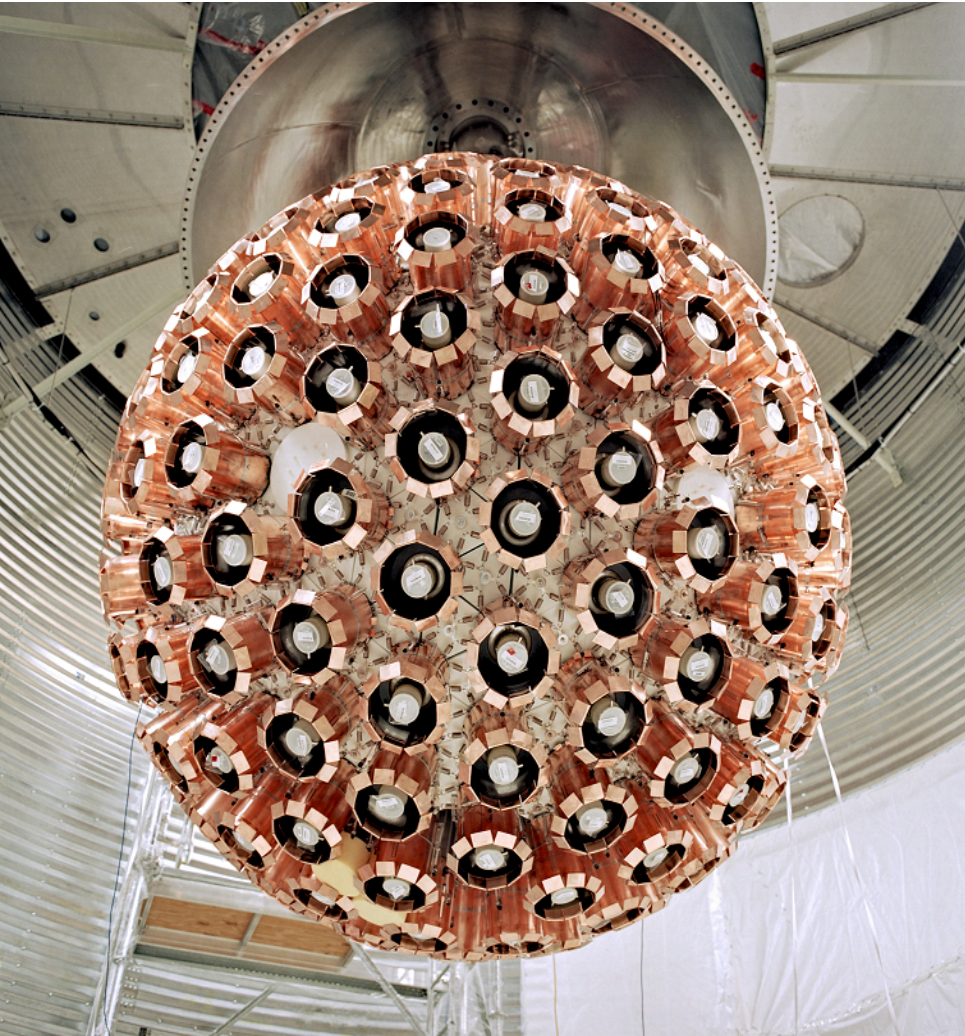
Assistant Professor - Queen's University

26 May 2026 - SNOLAB User Meeting

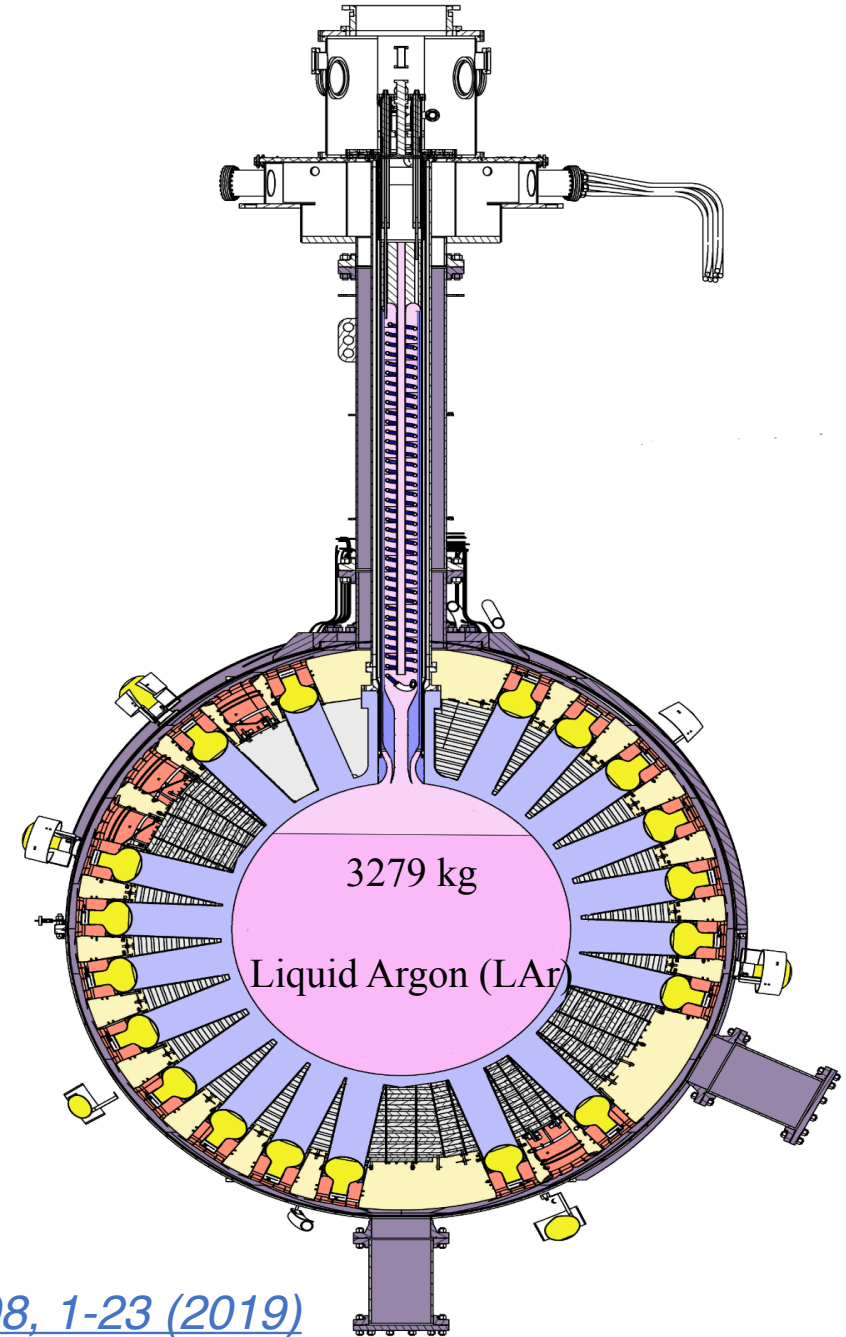
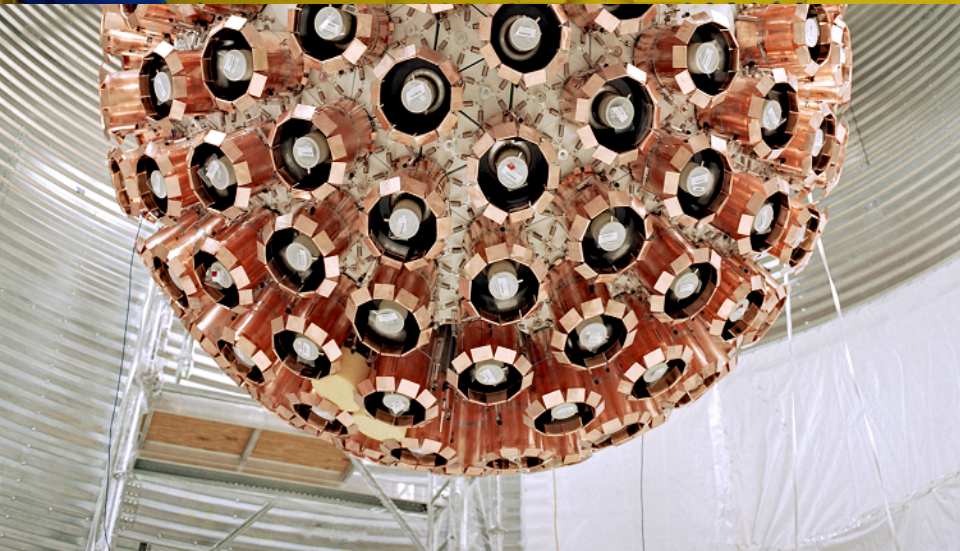
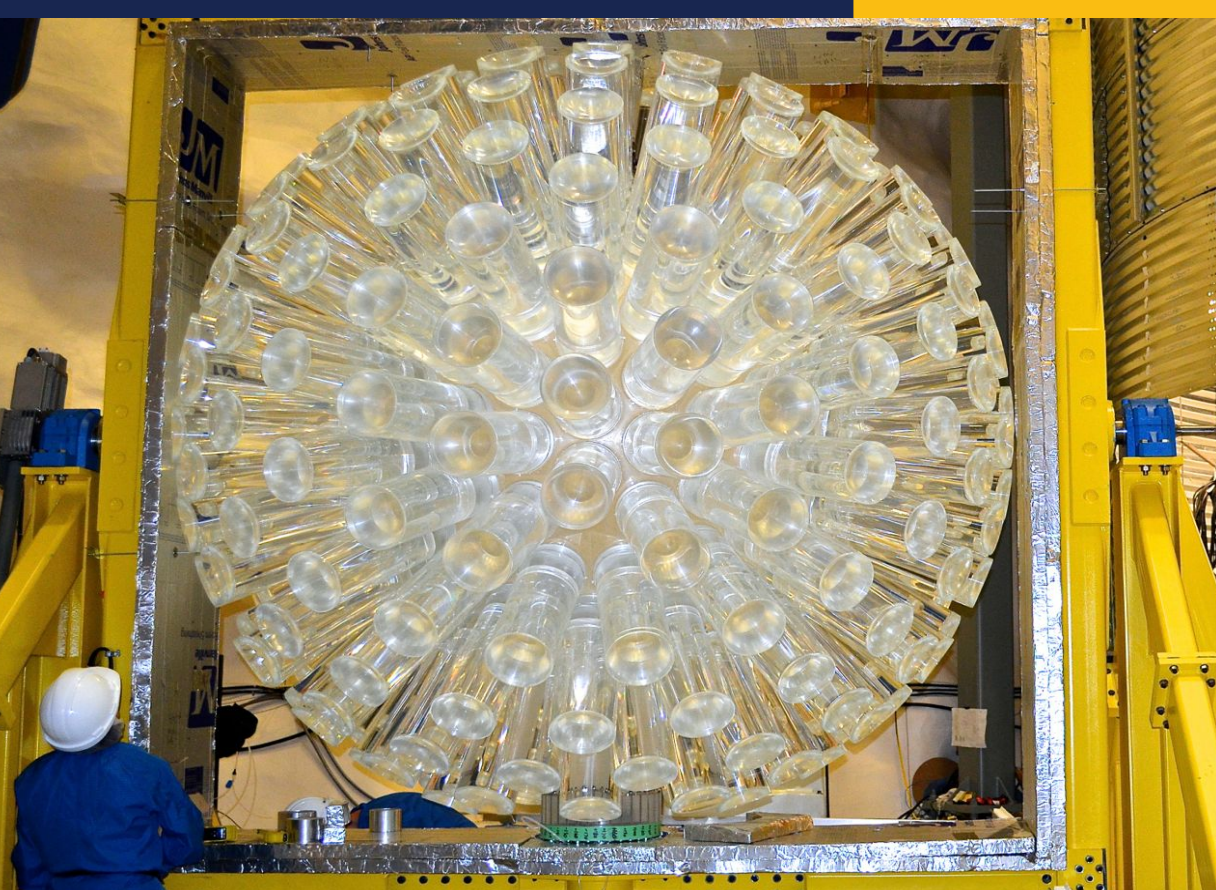
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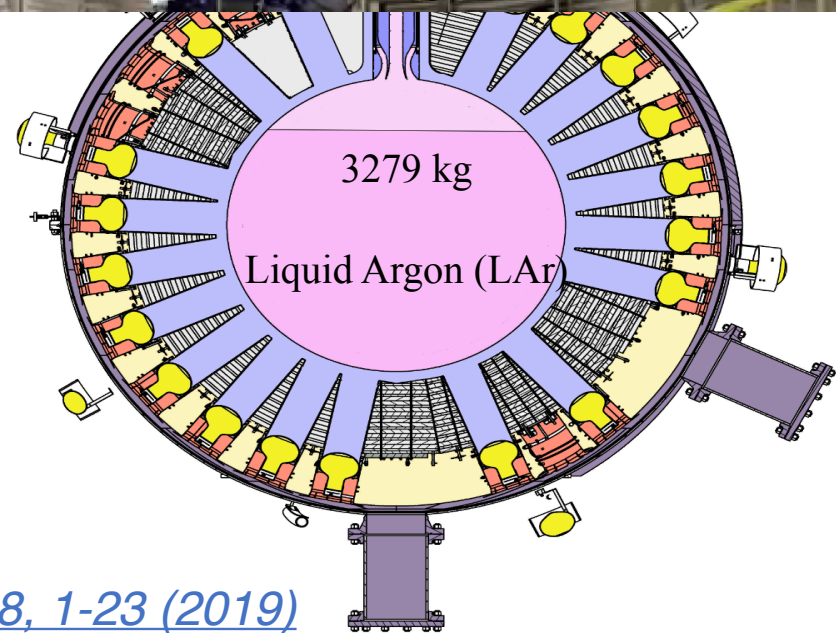
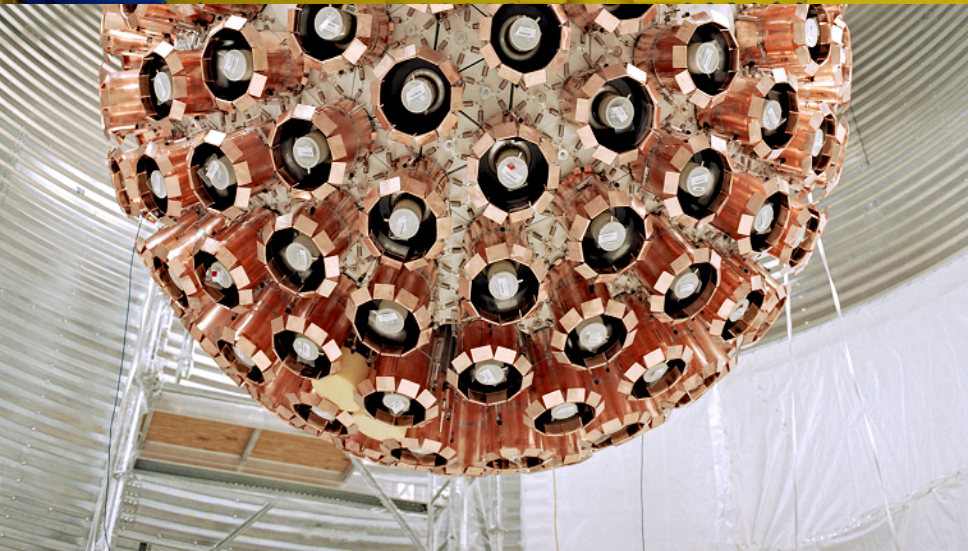
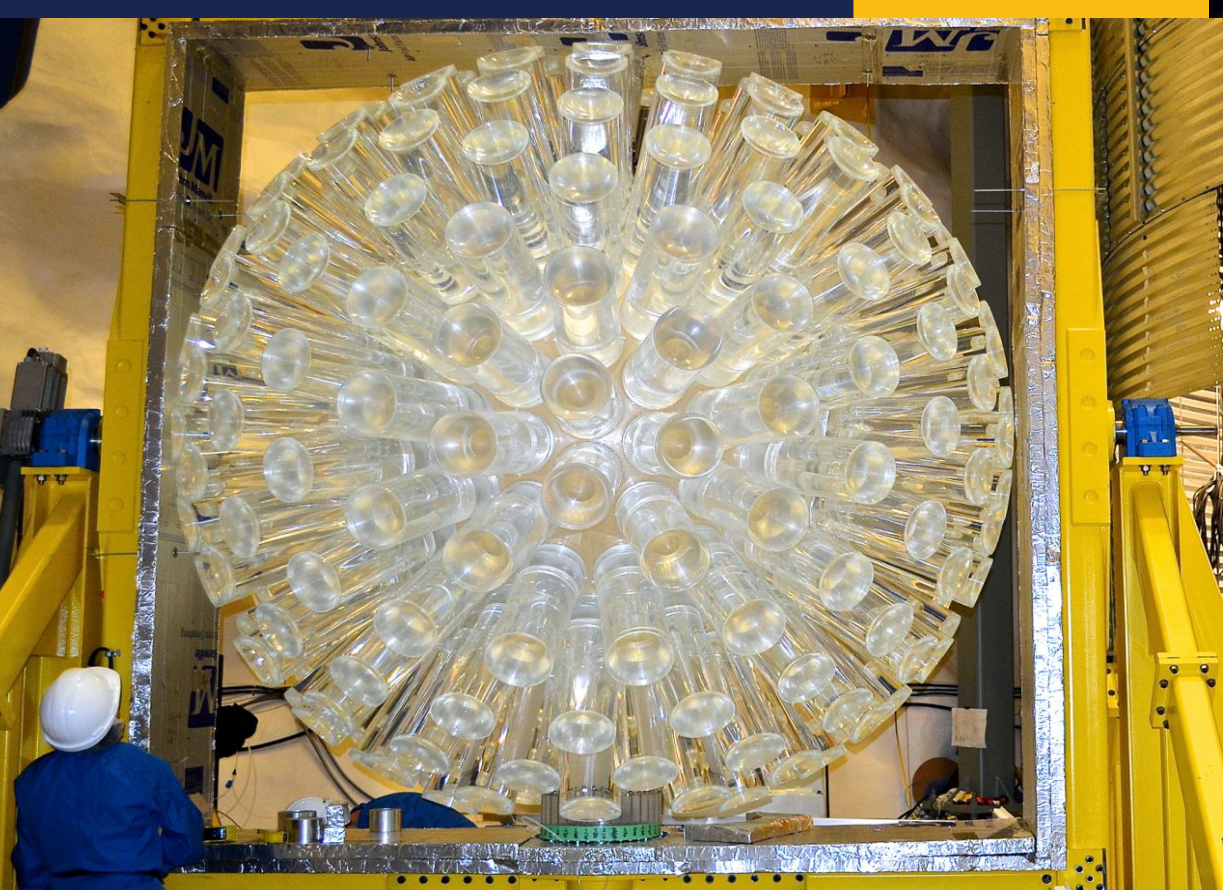


The Dark matter Experiment using Argon Pulse shape Discrimination



Argon

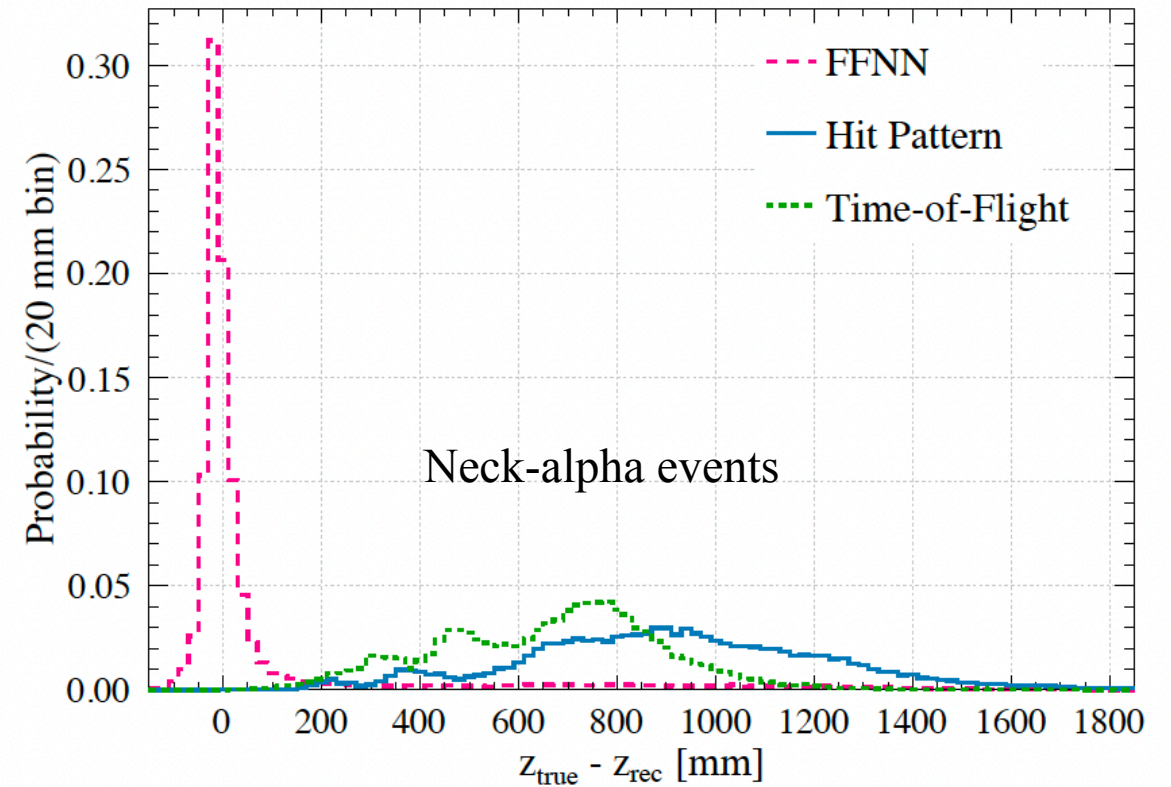
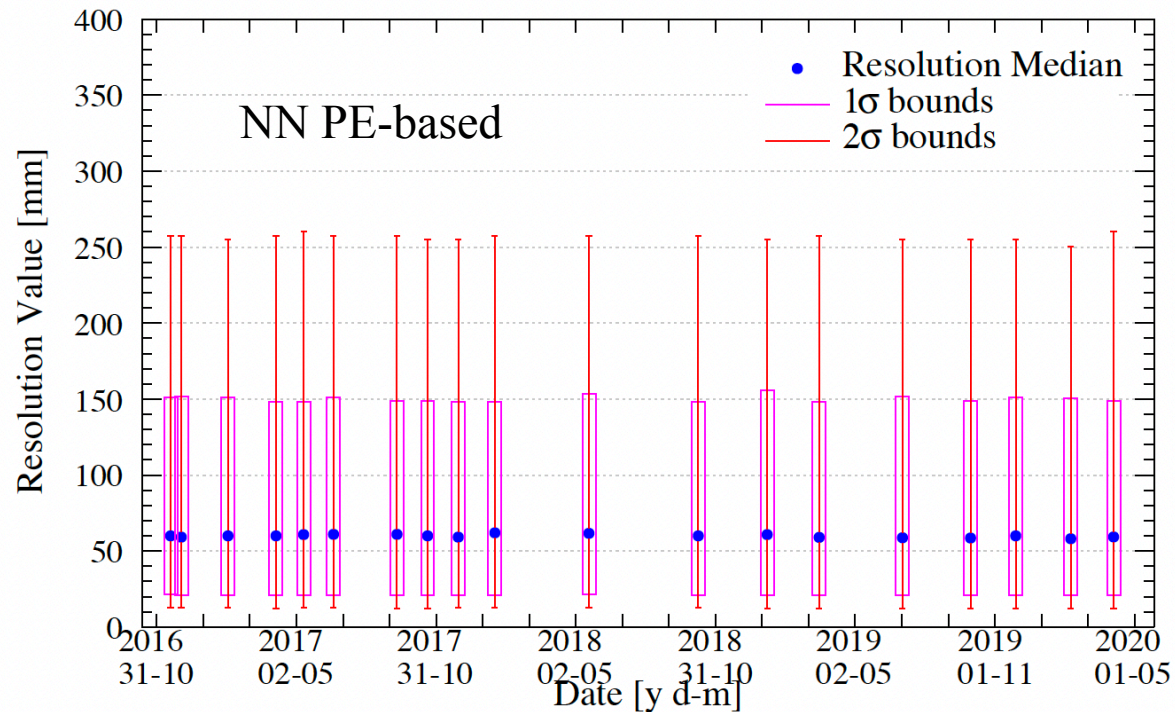




Spatial resolution in DEAP-3600

Three position reconstruction algorithms:

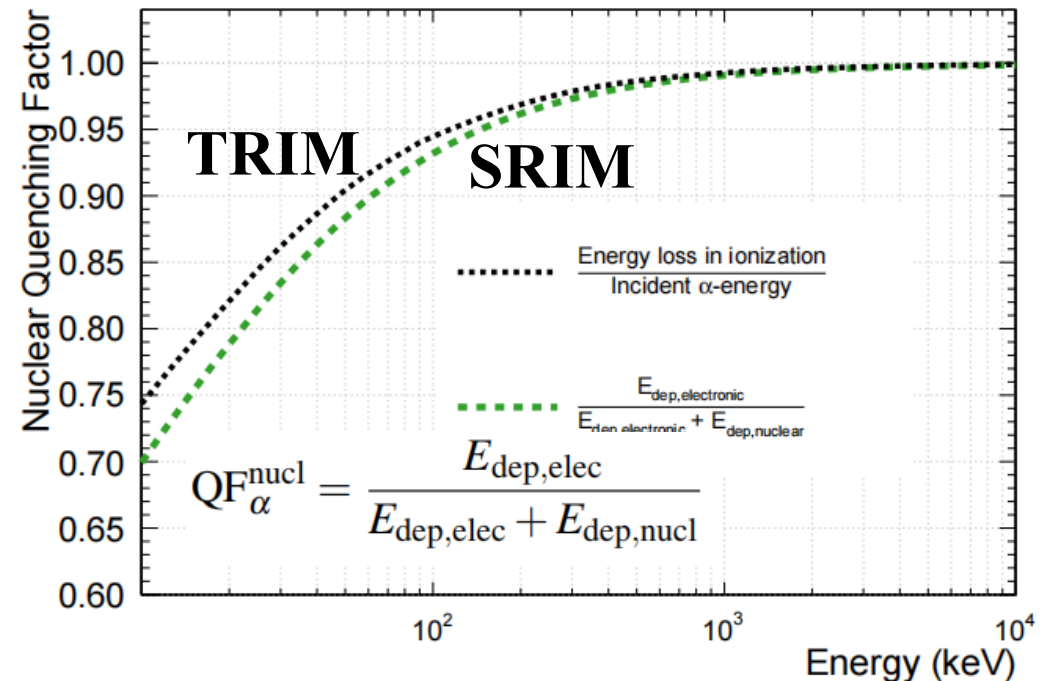
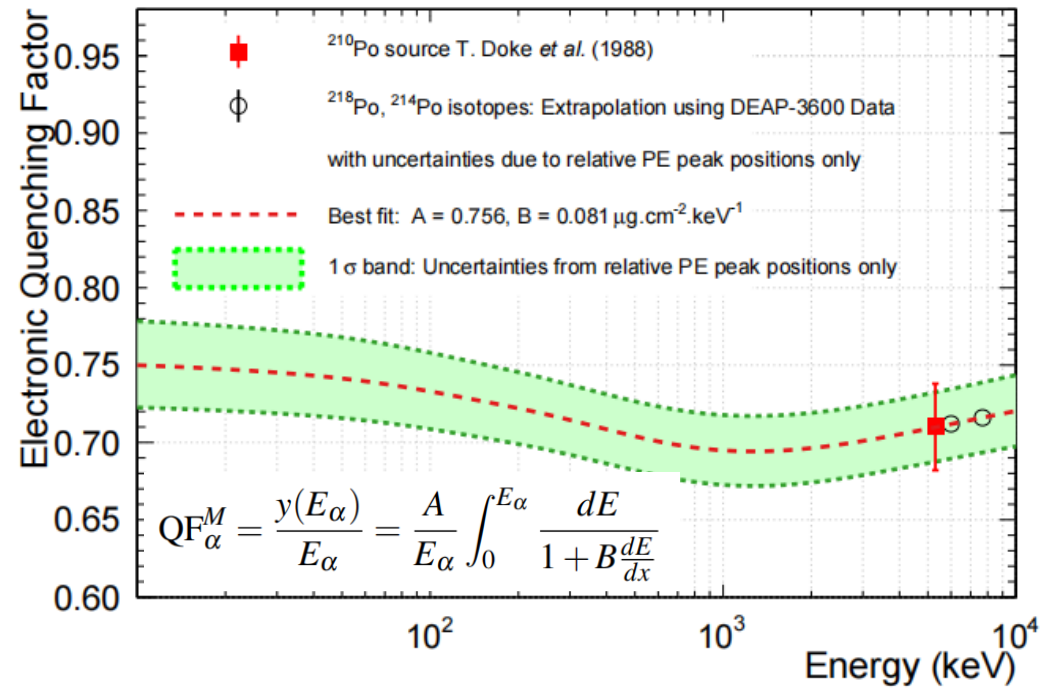
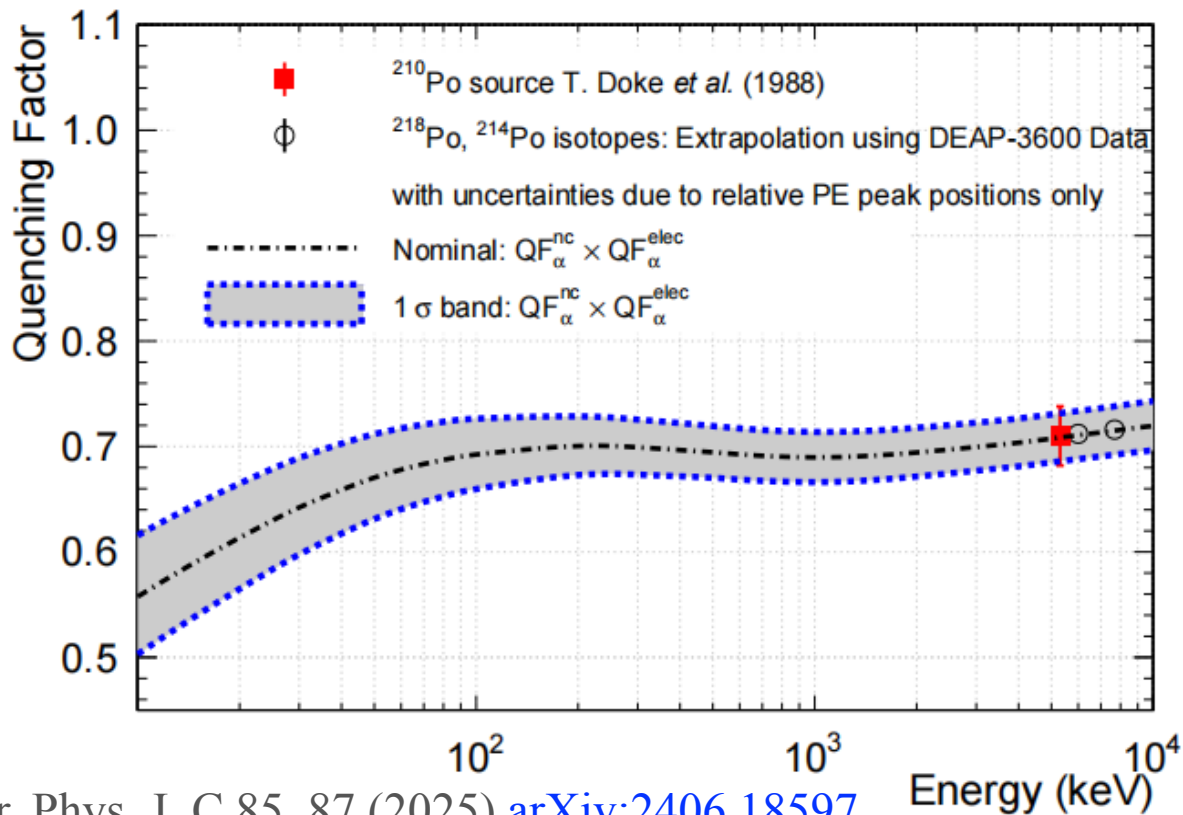
- Likelihood PE-based
- Likelihood Time-of-Flight—based
- Neural network PE-based
- **Demonstrated stable spatial resolution at about 60 mm**



- General agreement with Monte Carlo for events in the LAr
- Only the NN-based position reconstruction reconstructs efficiently neck-alphas induced events
- Performances mostly confirmed with a ^{22}Na calibration source

Quenching for degraded alphas

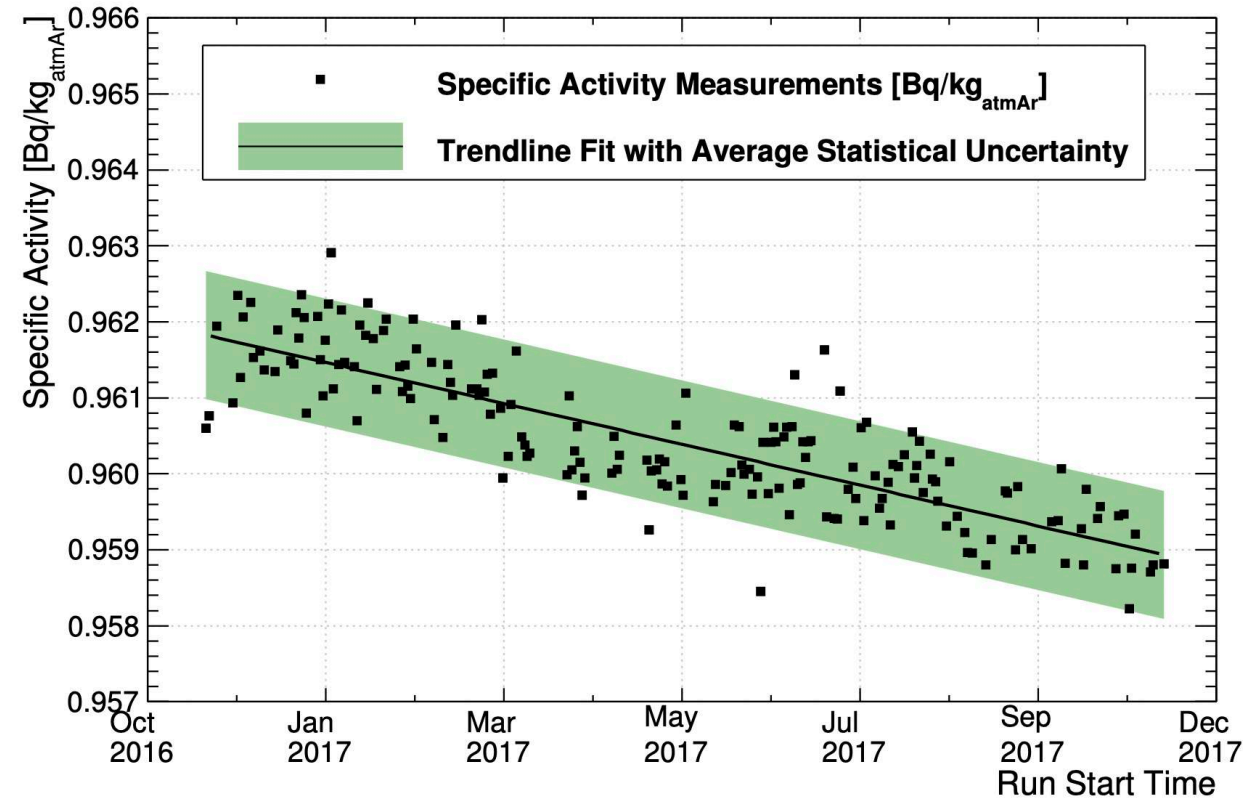
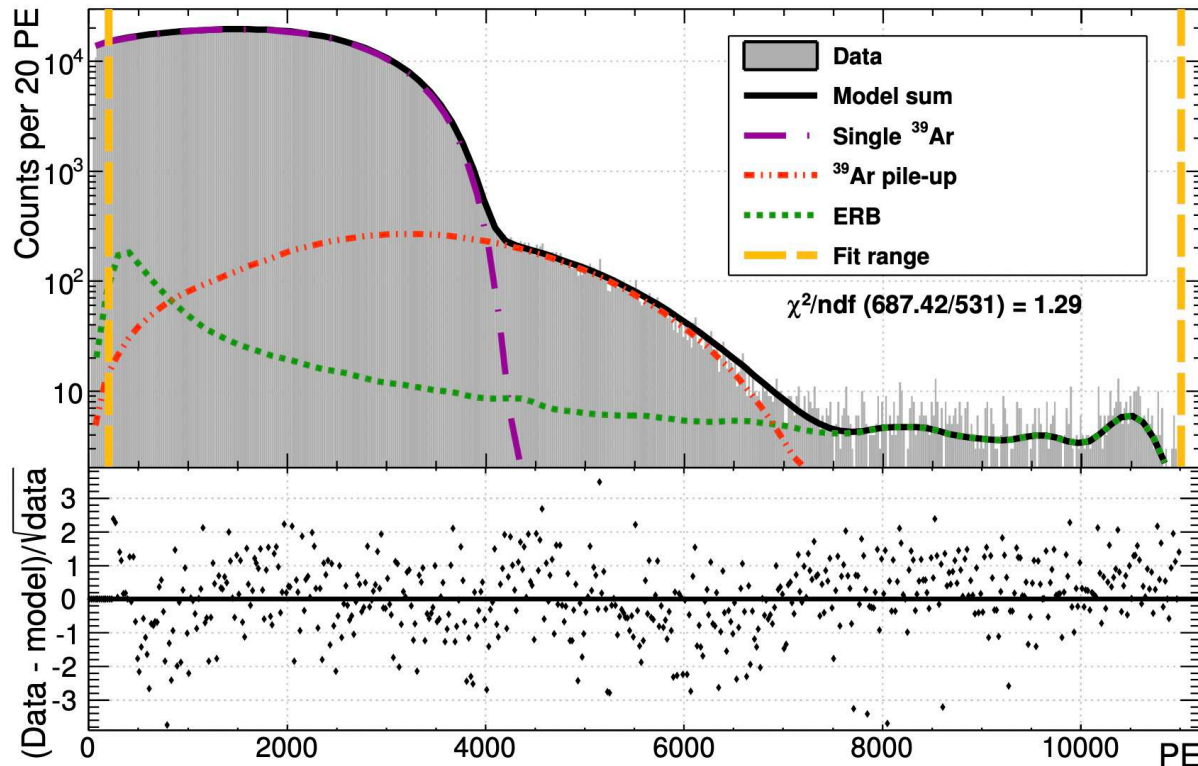
- Extrapolation of the electronic quenching factor values into the low-energy region down to 10 keV
- For the nuclear quenching factor, TRIM model, with 10 % relative uncertainty on the energy partition
- QF product of the best-fit electronic QF curve and the nuclear QF curve from TRIM



Specific activity from ^{39}Ar

- 167 live-days of data from the second-fill
- Fit of the ^{39}Ar spectrum, including also pile-up events
- **Most precise measurement in atmospheric argon**
- Consistent with previous measurements

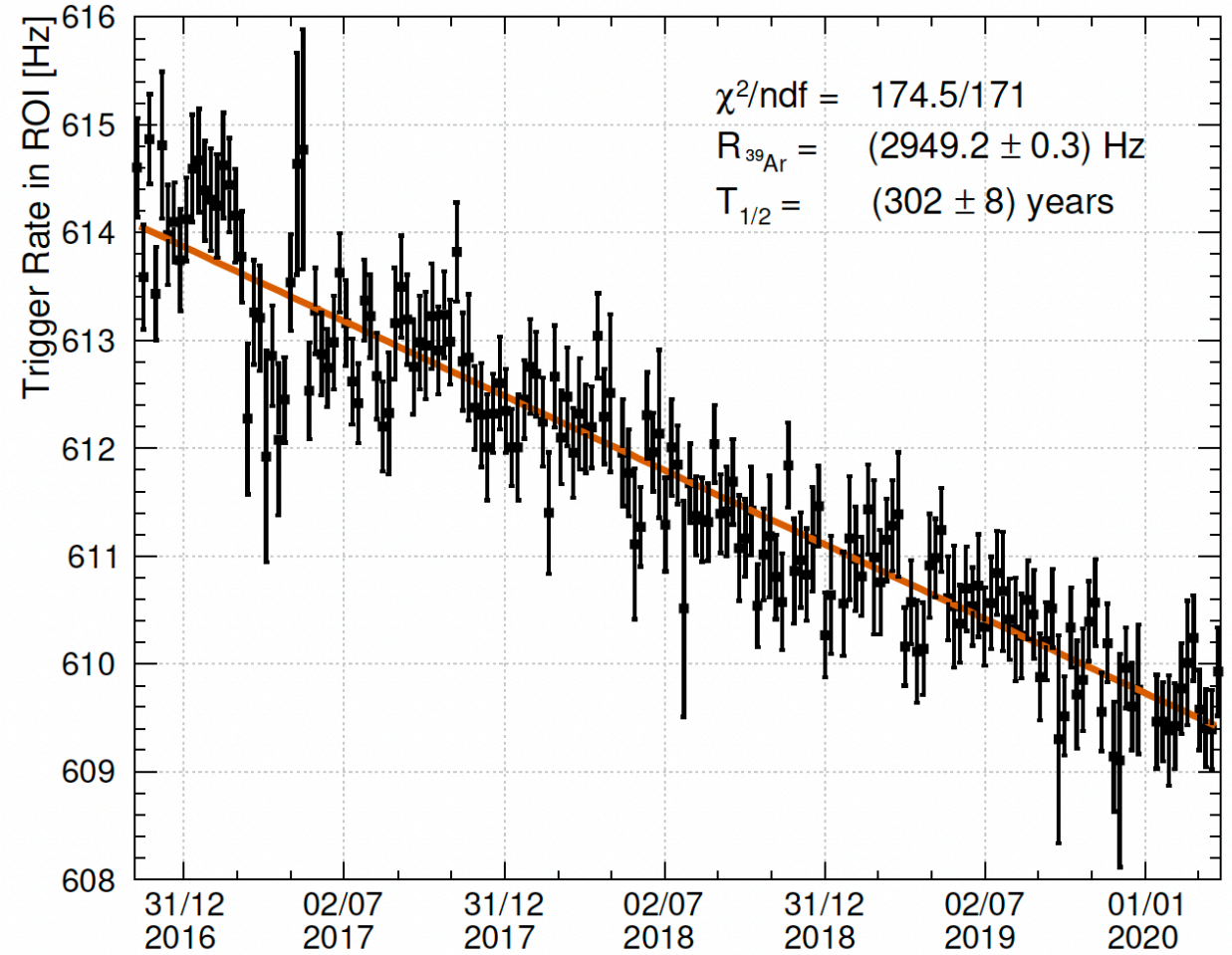
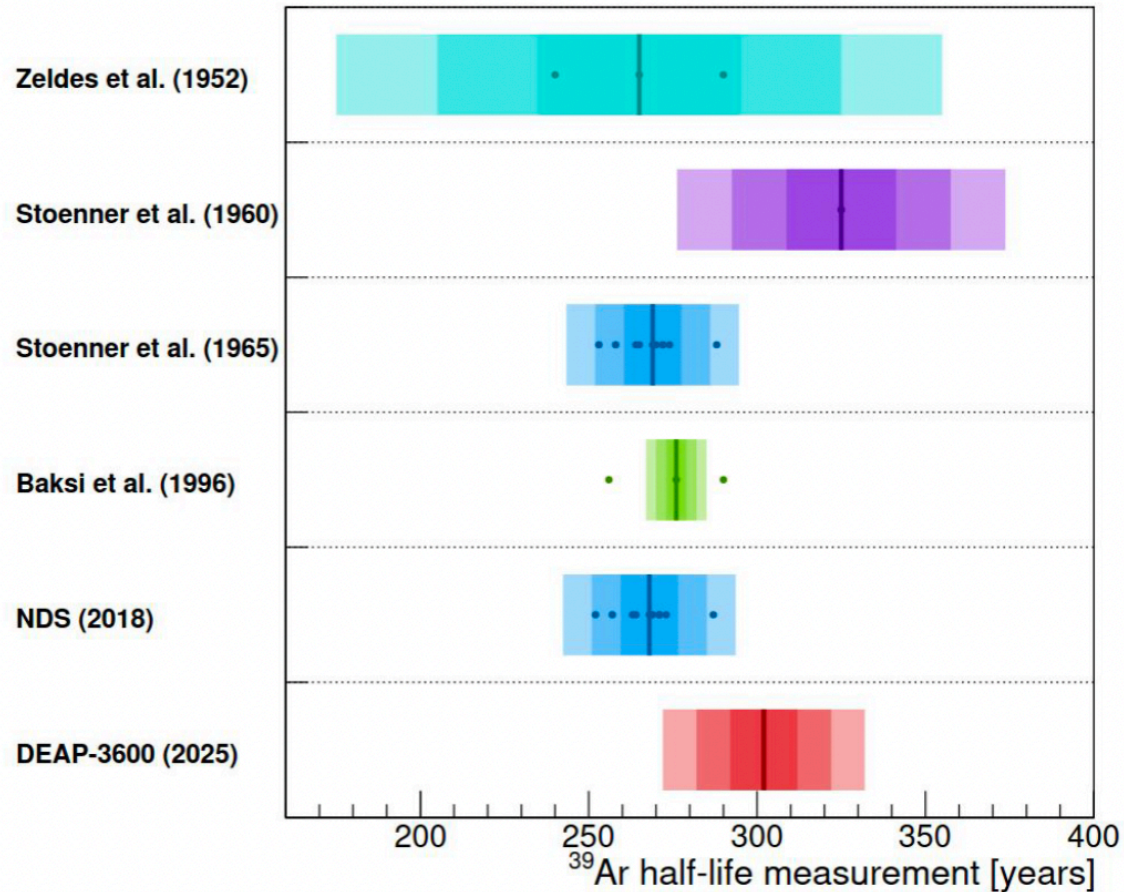
$$S_{^{39}\text{Ar}} = \frac{N_{\text{single}} + N_{\text{pile-up}}}{m_{\text{LAr}} T_{\text{lifetime}}}$$



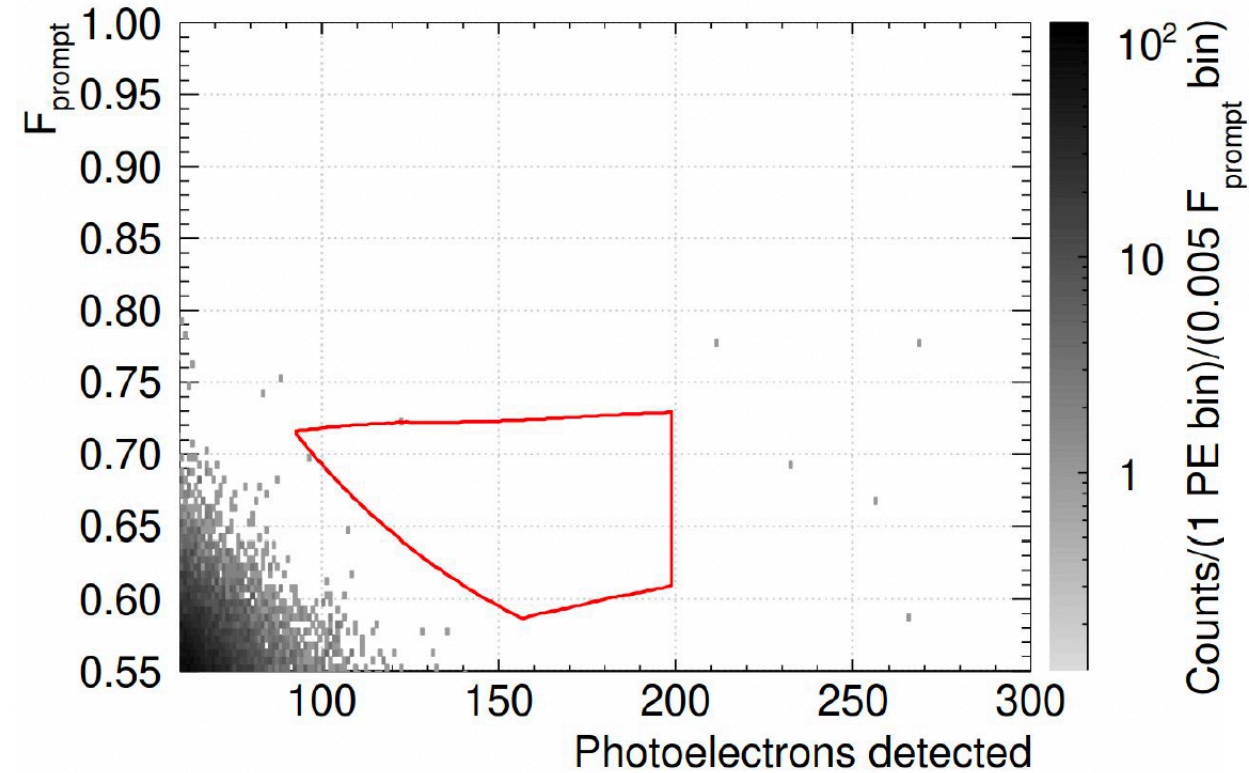
Measurement	Specific activity [Bq/kg _{atmAr}]
WARP [13]	1.01 ± 0.08
ArDM [14]	0.95 ± 0.05
DEAP-3600 (this work)	0.964 ± 0.024

39-Argon half-life

- Longest measurement ever performed, over 4 years data
- **Our result at $[302 \pm 8 \text{ (stat)} \pm 6 \text{ (syst)}]$ years is at 2.5σ tension with Nuclear Data Sheets (NDS), reporting (268 ± 8) years**



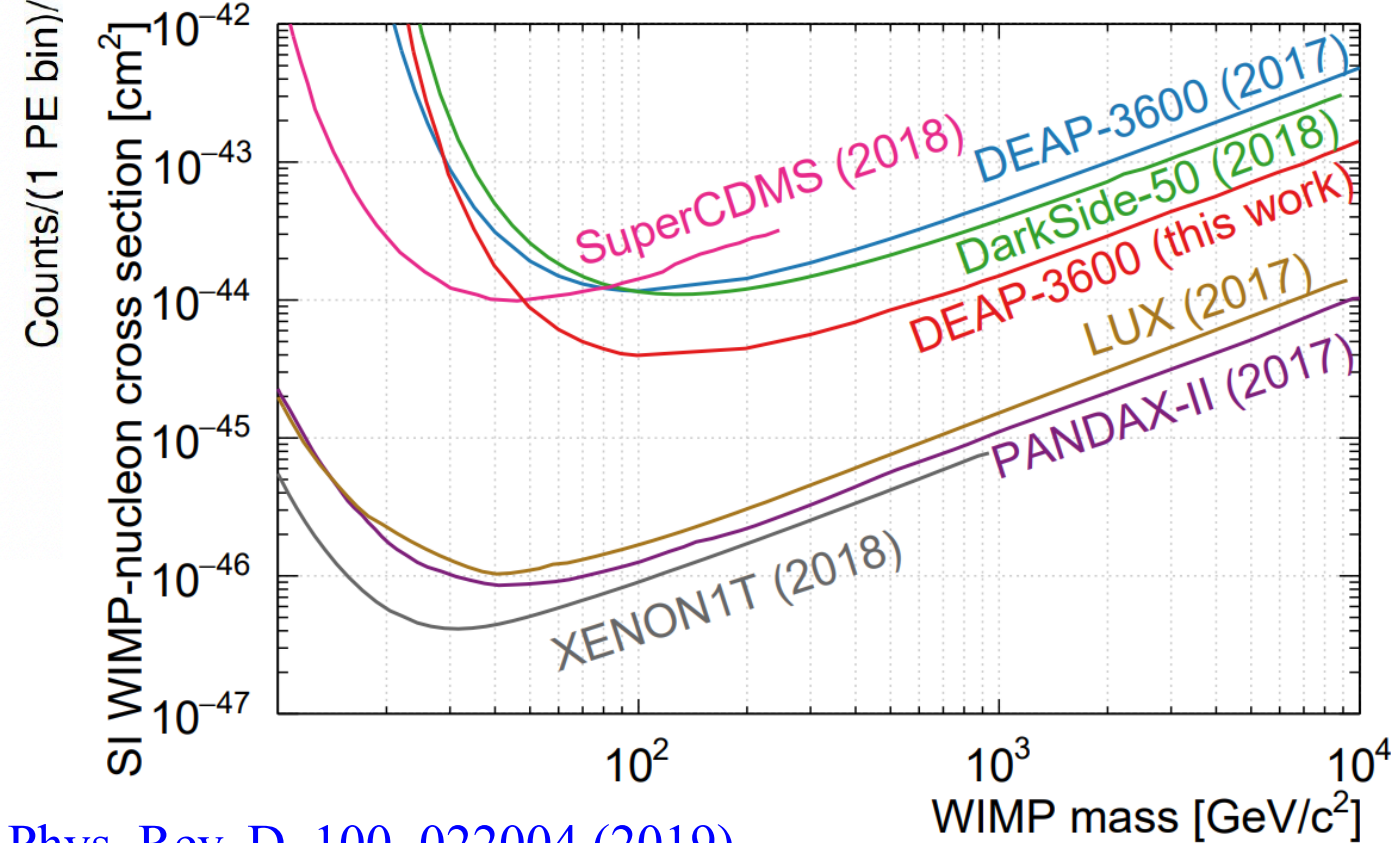
WIMP Search - 2019 results in a glance



Main sources of backgrounds:

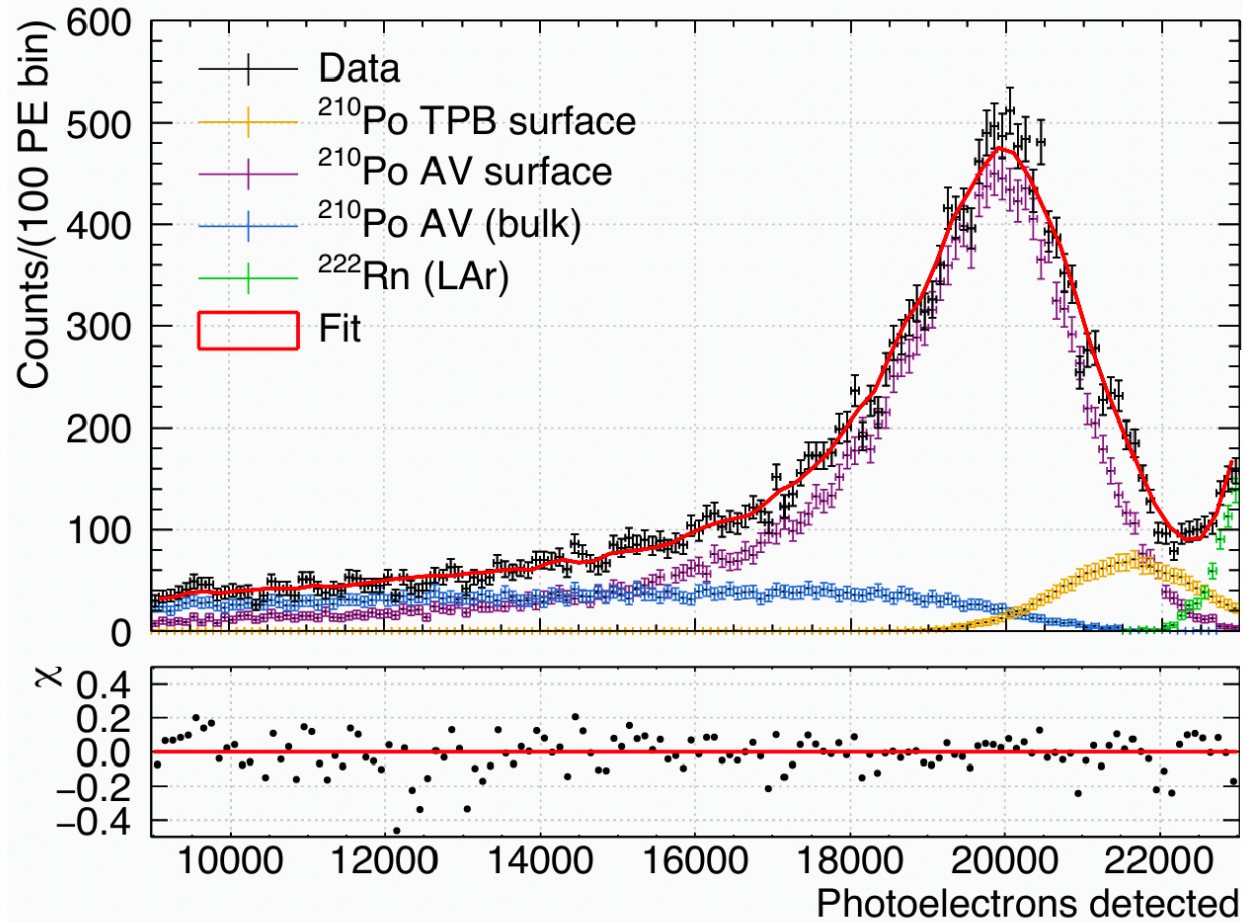
- Surface alphas, from the Acrylic vessel
- Shadowed alphas from the neck
- Alphas from particulate dust

- “Cut and Count” analysis: 231 live-days
- No signal in the ROI
- Most stringent exclusion limit in LAr
($\sigma_{SI} < 3.9 \times 10^{-45} \text{cm}^2$ at $100 \text{GeV}/c^2$)

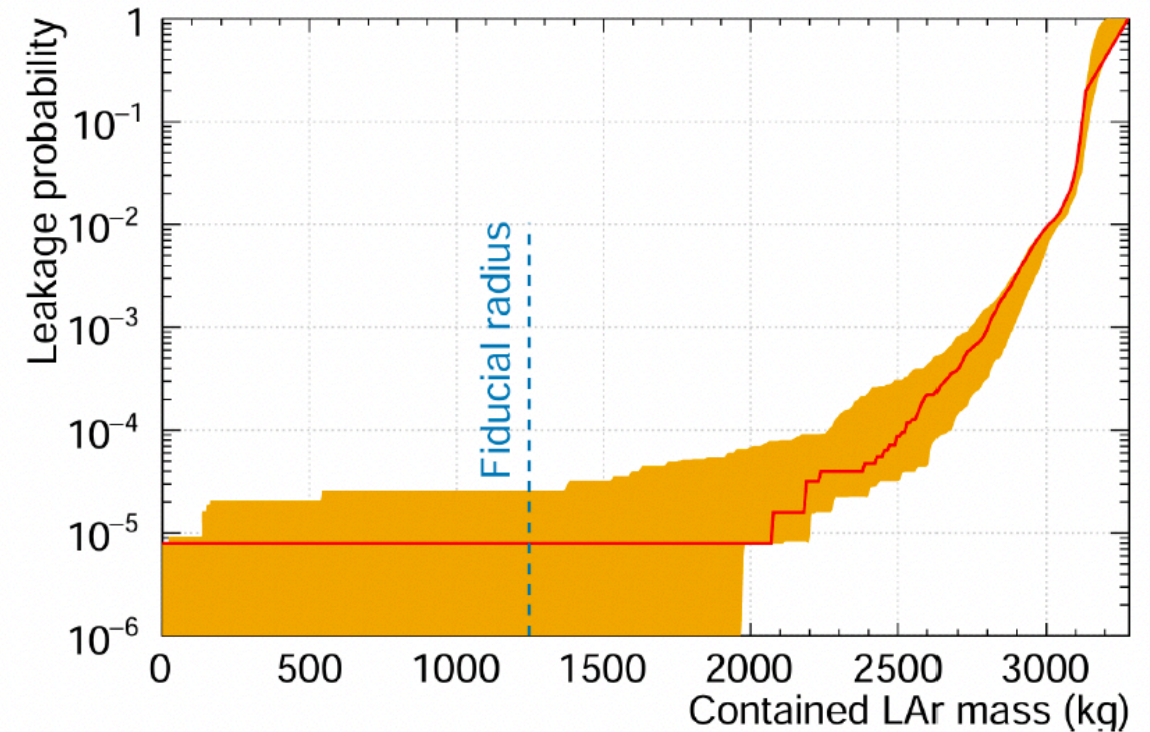


Phys. Rev. D. 100, 022004 (2019)

Surface alphas



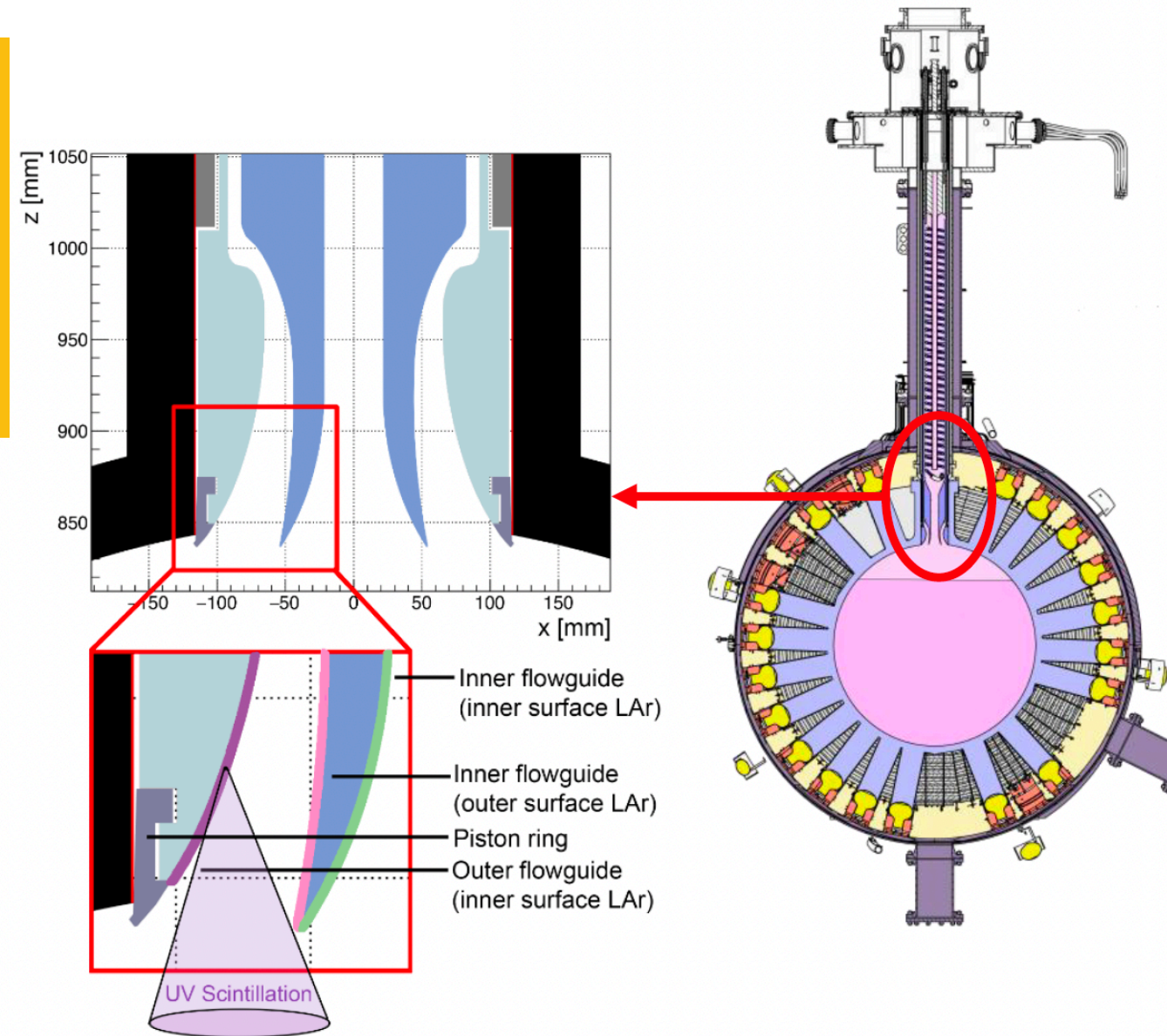
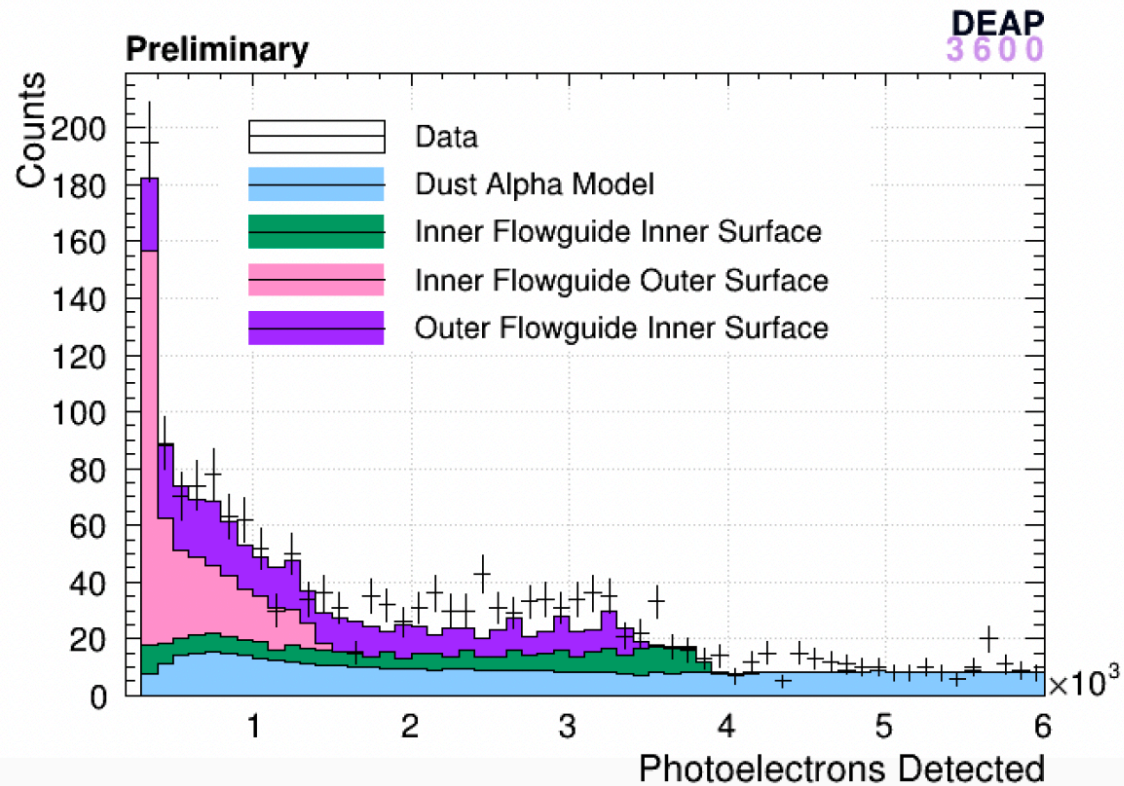
- Degraded alphas released from the detector materials
- Successfully modelled according to the volume fiducialization selection cut



Good match between data and MC in the second-fill data

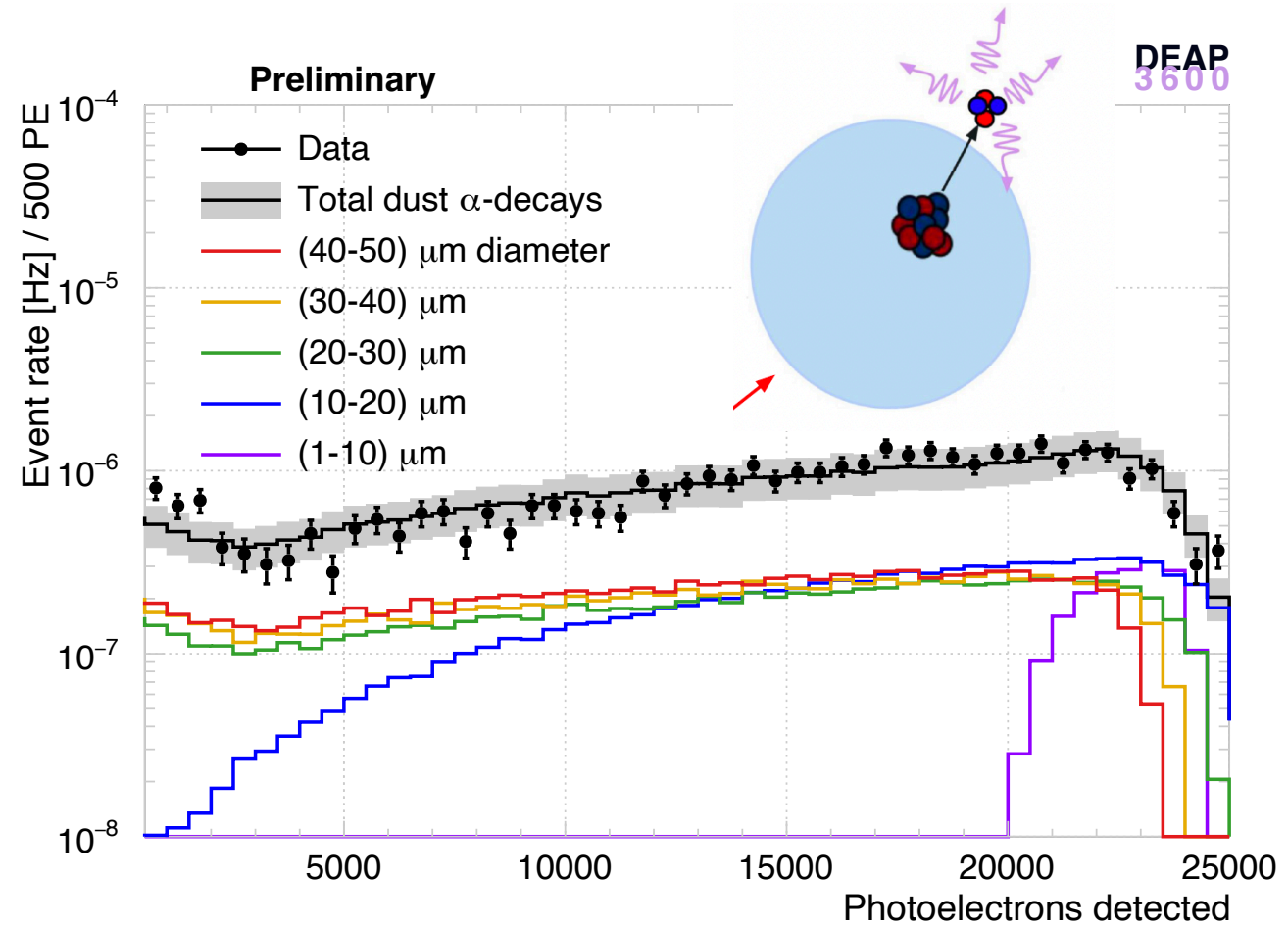
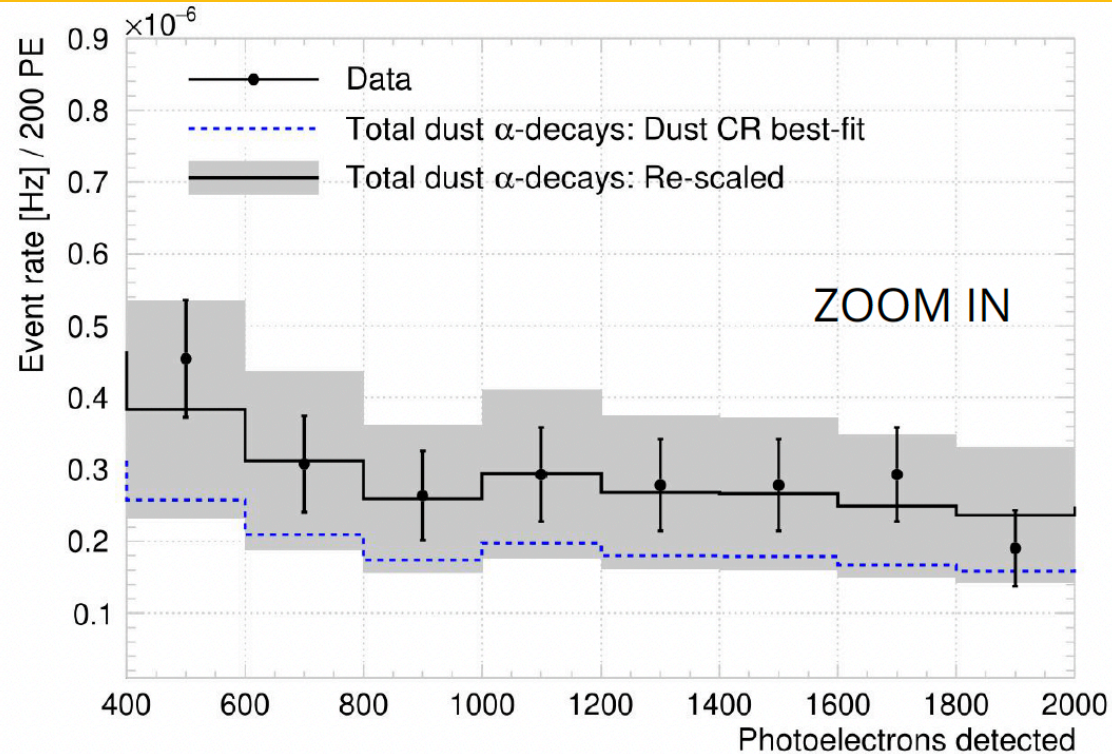
Shadowed alphas from the neck

- ^{210}Po alphas released from the acrylic in the flow guides induces scintillation in the condensed argon
- Modelled as three surfaces, as their geometry strongly affects the observed amount of light reflected at the LAr/GAr interface



Dust alphas

- Particulate dust within the LAr bulk
- Modeled with multiple sizes and w/o TPB coverage
- Observed systematically more dust event just above the ROI in the 400–2000 PE sideband, the dust-alpha controlled region



- In the 2026 PLR WIMP Search, a renormalization of X 1.49 is applied to the prior in the WIMP ROI

Profile Likelihood Ratio WIMP Search (2026)

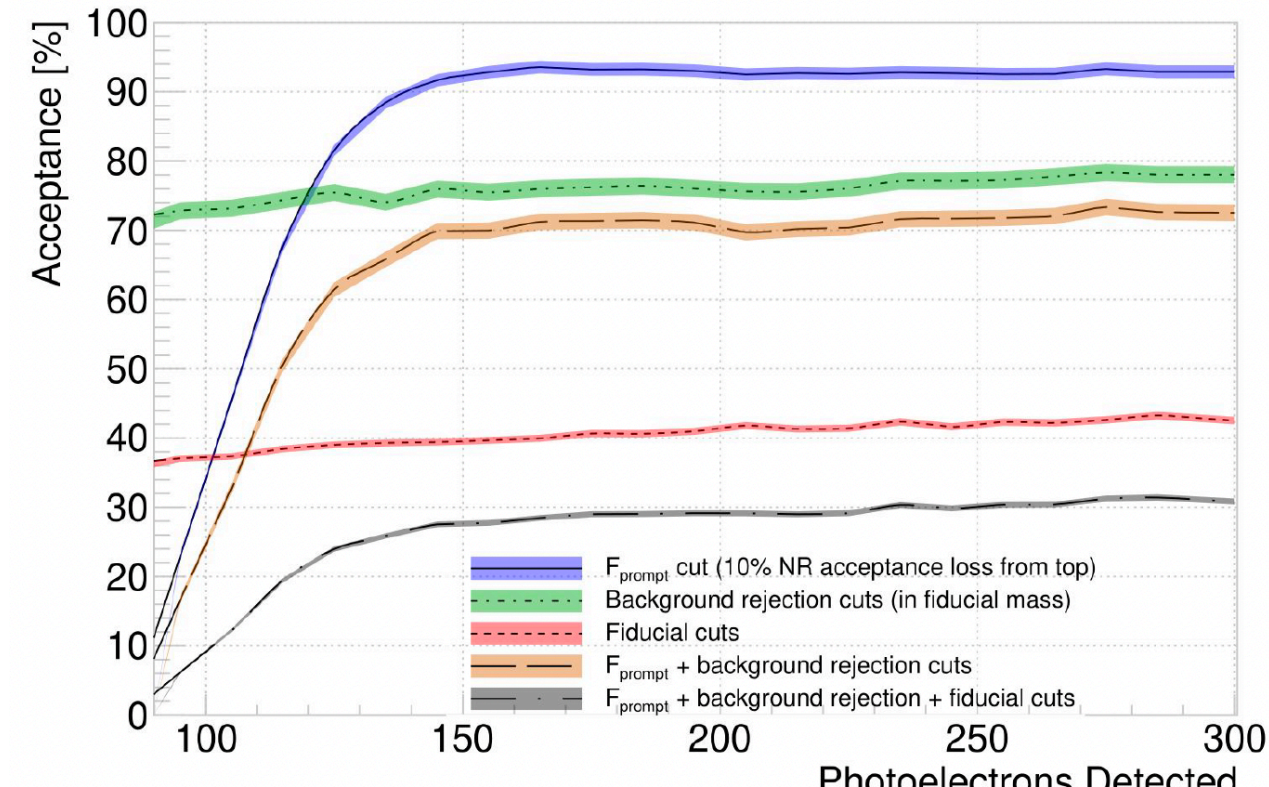
- Dataset of 790.8 live-days (Second-fill, Nov 2016 - Mar 2020)
- 80% blind since Jan 2018
- Unblinded in Nov 2025 after collaboration approval and analysis freeze

$$\lambda = \frac{\mathcal{L}(\mu, \hat{\hat{\theta}})}{\mathcal{L}(\hat{\mu}, \hat{\theta})}$$

Fixed WIMP cross-section, maximum likelihood estimators for all nuisance parameters.

Floating WIMP cross-section, maximum likelihood estimators for all nuisance parameters.

$$\mathcal{L}(\mu|\{\theta\}) = \mathcal{L}_{\text{Model}}(\mu|\{\theta\}) \cdot \mathcal{L}_{\text{constraint}}(\{\theta\})$$

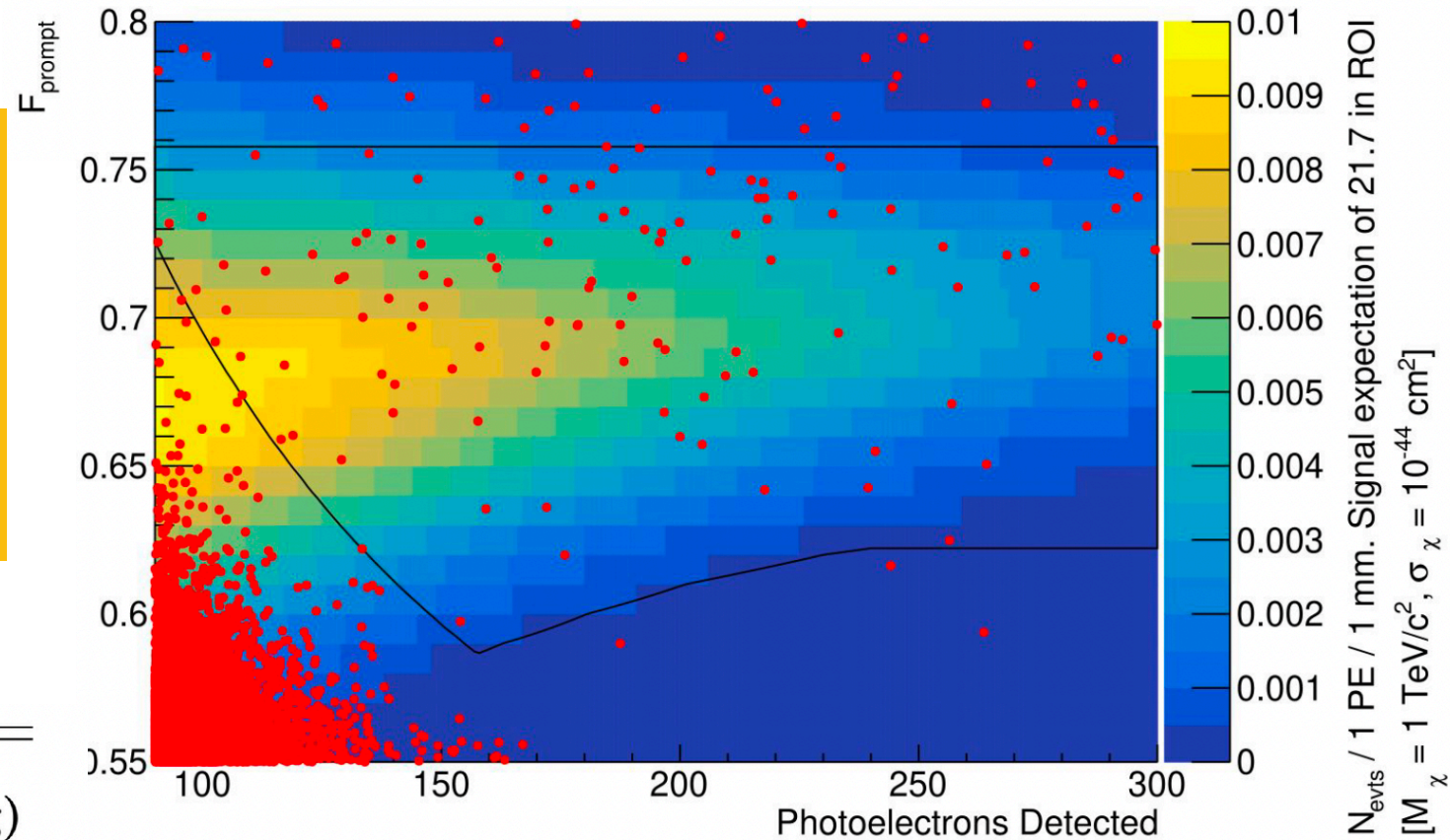


- Profile Likelihood Ratio Method according to:
 - Number of reconstructed photoelectrons
 - Fraction of the prompt scintillation light
 - PE-likelihood based reconstructed position
- All in two bins on the number of PMTs submersed in LAr recording scintillation light

Profile Likelihood Ratio WIMP Search (2026)

- **Observed: 115 events in the WIMP ROI**
- **40 open + 75 blind.**
- **Background-only best fit: 111.1 events, driven by the dust α component (best-fit ~ 92)**
- **Measured $p = 0.15$ — no significant excess; data compatible with the background-only hypothesis.**

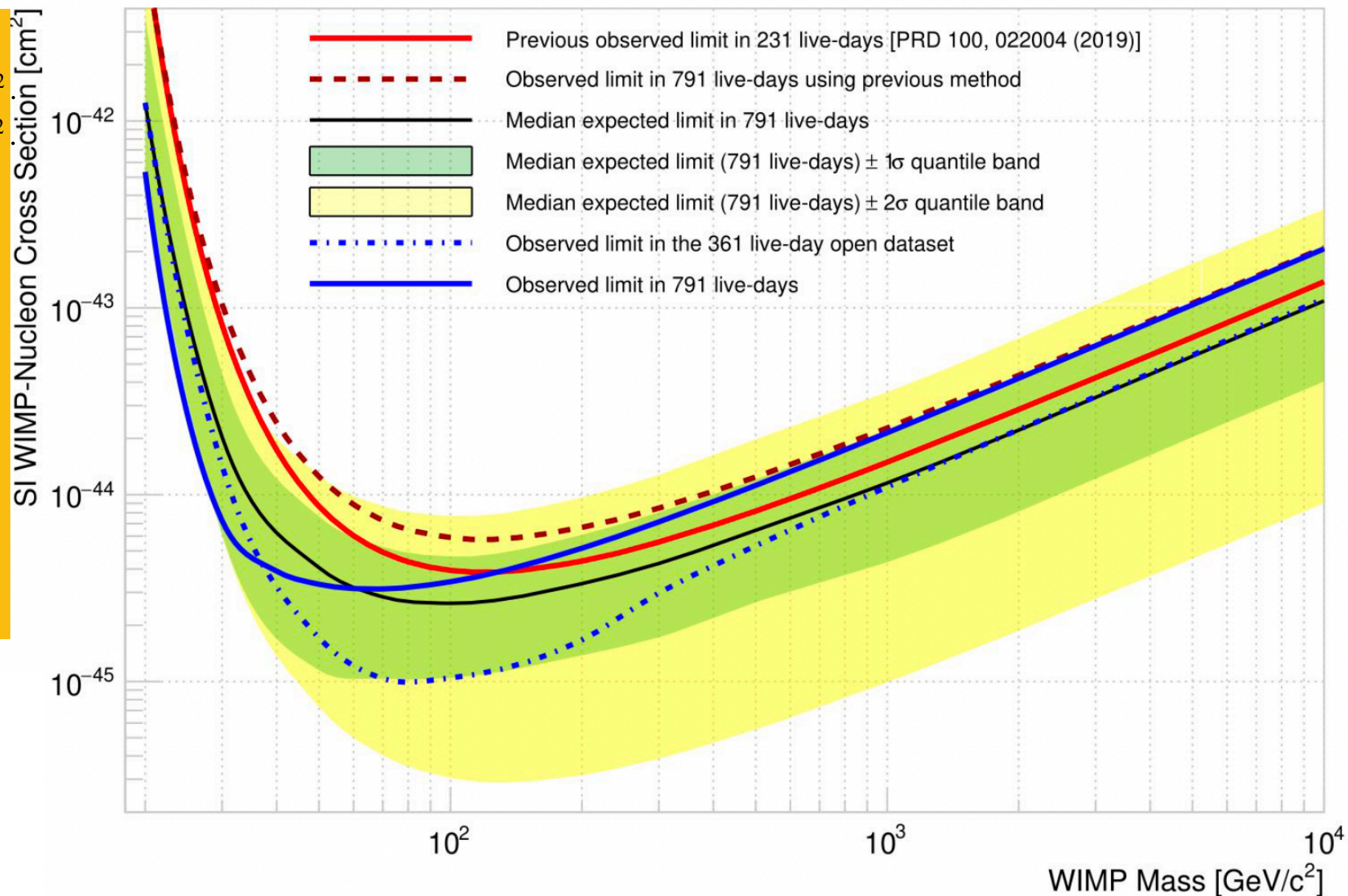
Source	Prior	Best-fit (bkg-only)	Best-fit (sig+bkg)
Radiogenic n	$1.2^{+1.0}_{-1.0}$	$1.2^{+0.9}_{-0.9}$	$1.2^{+0.9}_{-0.9}$
Surface α	$7.4^{+15.2}_{-15.4}$	$0.0^{+3.1}_{-3.1}$	$0.0^{+1.8}_{-1.8}$
Shadowed α	$15.2^{+12.3}_{-10.3}$	$18.3^{+8.9}_{-7.4}$	$16.5^{+8.2}_{-6.9}$
Dust α	$44.2^{+39.9}_{-40.4}$	$91.6^{+10.6}_{-11.9}$	$64.1^{+15.9}_{-16.2}$
Total Bkg	$68.0^{+49.9}_{-45.2}$	$111.1^{+16.3}_{-15.2}$	$81.7^{+20.3}_{-18.0}$
$M_\chi = 1 \text{ TeV}/c^2$	—	—	$32.0^{+23.9}_{-22.4}$



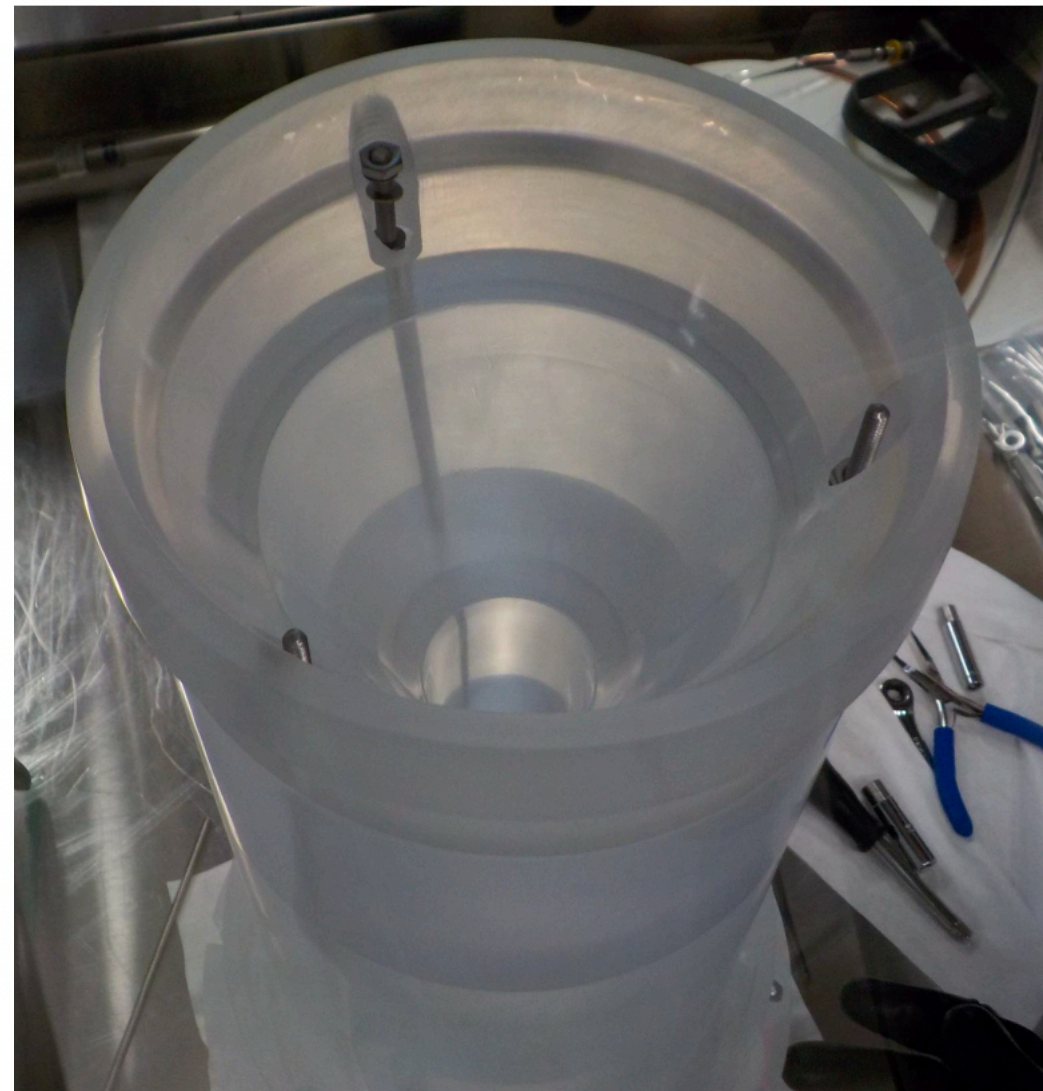
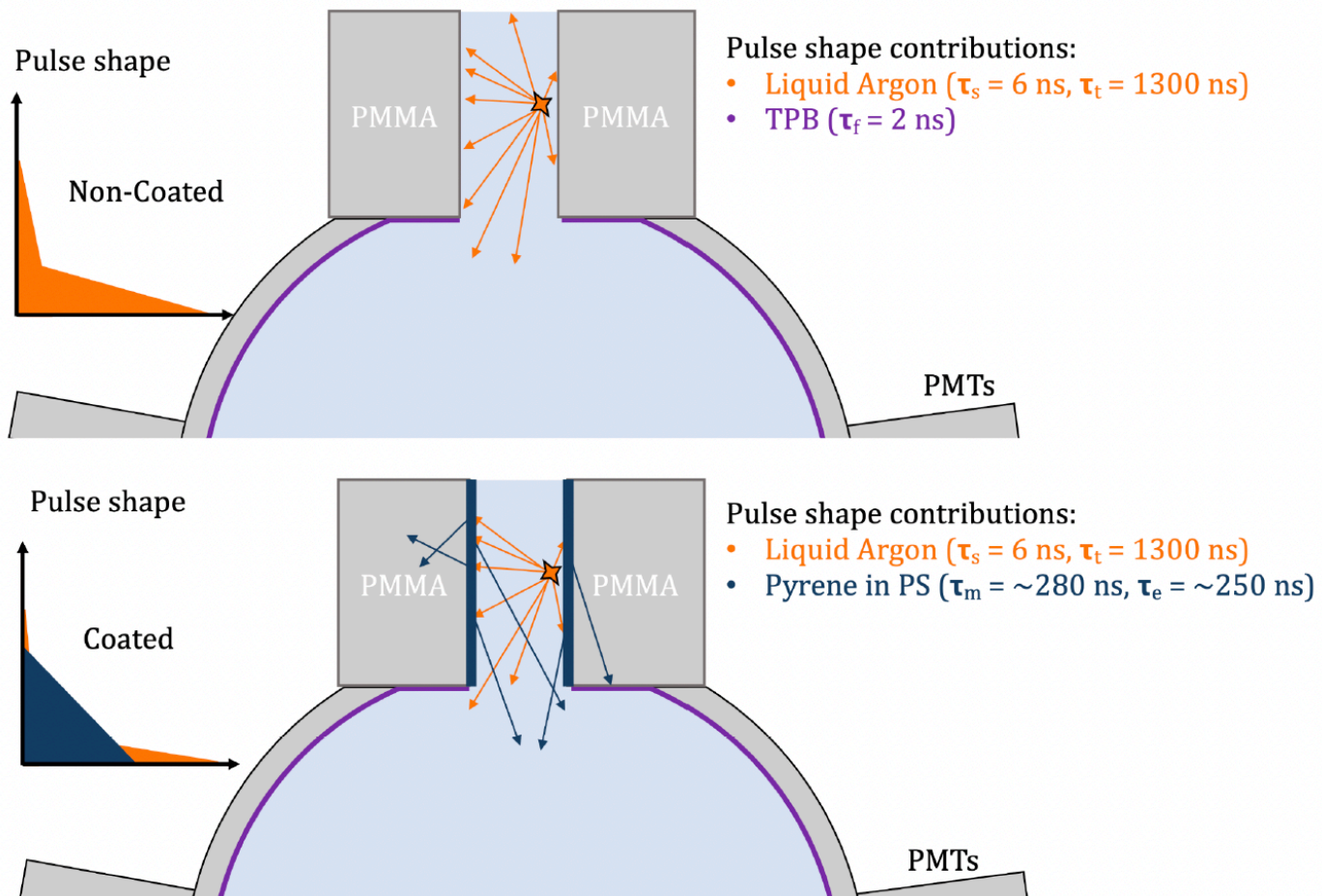
- **No WIMP excess**
- α -decays from a small number of dust particulates, not well modelled in the PLR method, within the LAr target are the dominant source of background events and limit the sensitivity of this search.

Profile Likelihood Ratio WIMP Search (2026)

- $\sigma_\chi \leq 3.4 \times 10^{-45} \text{cm}^2 - 100 \text{GeV}/c^2$
- $\sigma_\chi \leq 3.2 \times 10^{-45} \text{cm}^2 - 60 \text{GeV}/c^2$
- PLR recovers \sim factor 2 in σ vs. cut-and-count on the same dataset (dashed red)
- When the PLR fit is run on the full-dataset, a weaker limit is set compared to the open dataset: more dust is found here. Cause is under investigation.

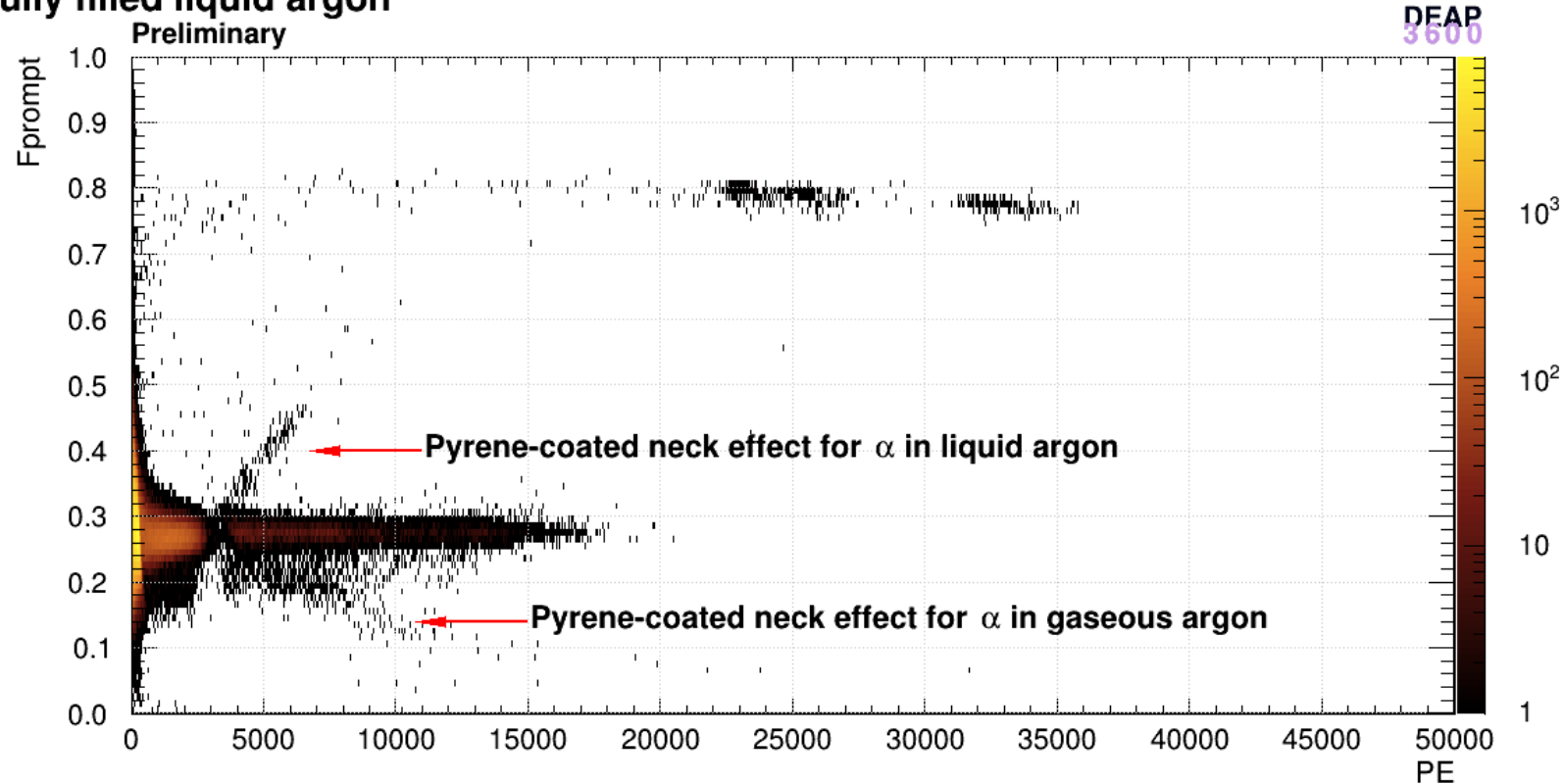


Detector upgrades: pyrene coating of the flowguides



Pyrene coating: first results from the third fill

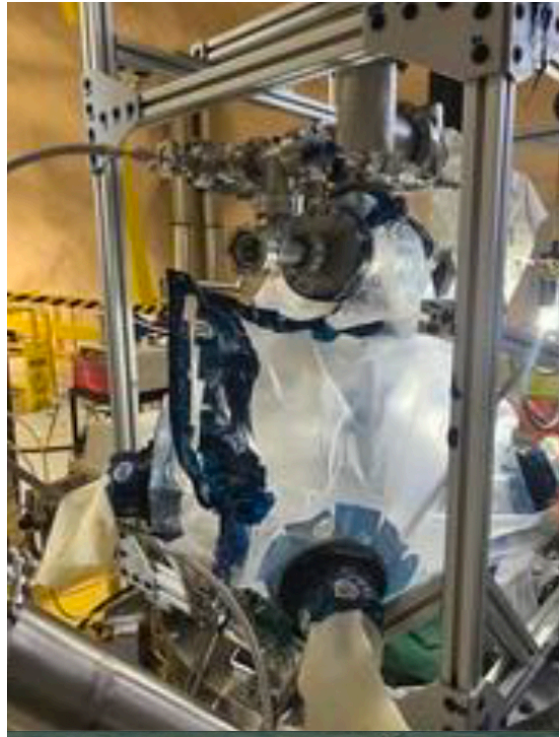
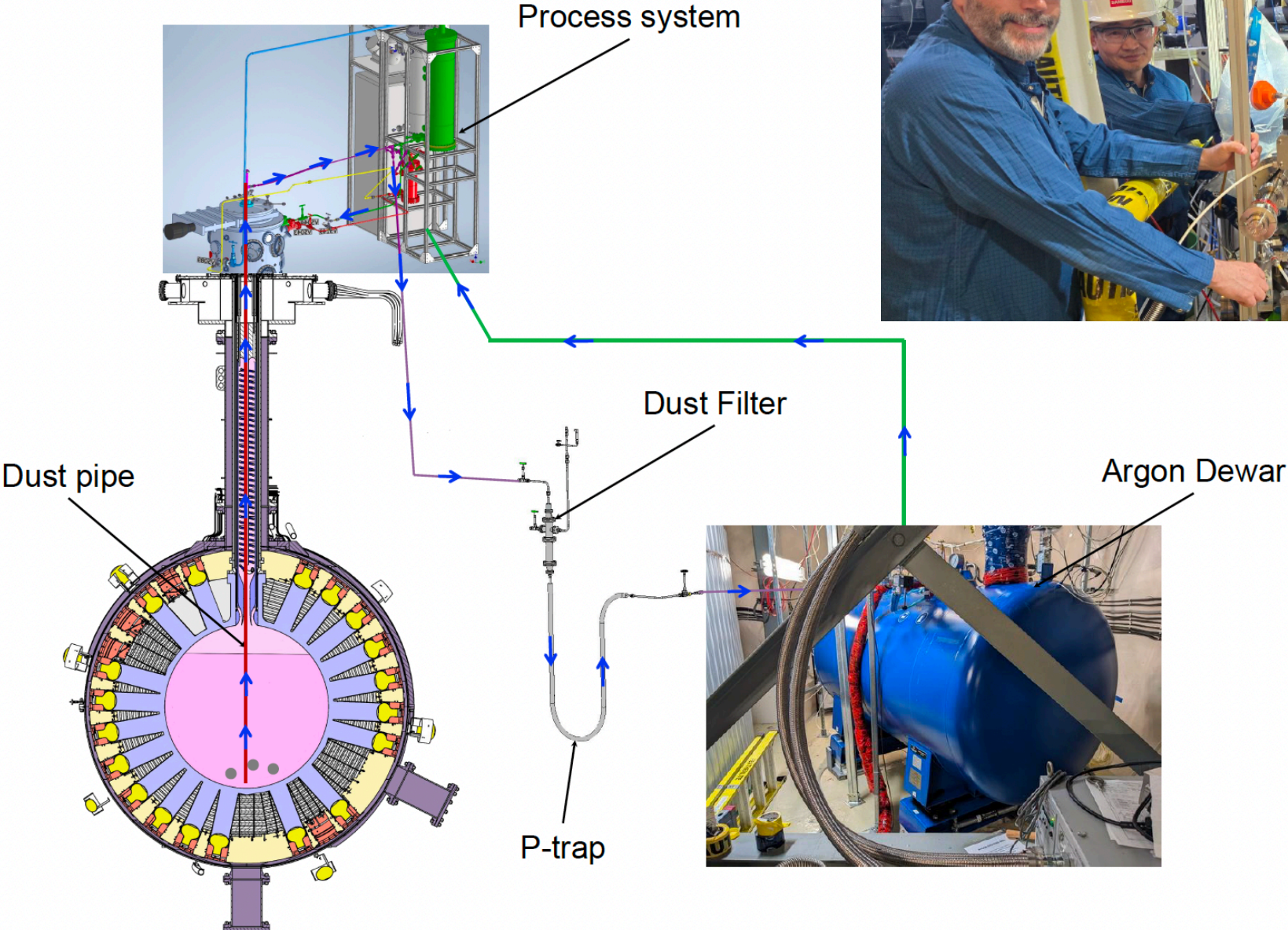
Fully filled liquid argon



- Run 36366, filling completed, liquid level at approximately 510 mm above the equator
- “This thing works!”, ongoing update of our background models



Going for the fourth fill: dust alpha pipe deployment



Latest results from DEAP-3600 experiment

- Fundamental studies of the argon nuclear properties
- Determined the position resolution achievable in a tonne-scale single-phase chamber
- WIMP search based on a Profile-Likelihood Approach over the second-fill dataset
- **Very first observation of the Charged-Current interaction of neutrinos in argon! (See talk from Abhijit tomorrow)**
- Third-fill dataset: preliminary confirmation of the pyrene efficiency in shifting the neck alpha out the WIMP ROI
- Just installed the dust pipe! Analysis of the extracted samples & dust alpha background essay in the fourth fill!

Backup slides

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26 May 2026 - SNOLAB User Meeting

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Profile Likelihood Ratio WIMP Search (2026)

- +54 % fiducial mass (from 630 mm to 720 mm of reconstructed radius)
- Higher F_{prompt} cut, resulting in + 36 % at 100 GeV
- Energy ROI extended from 90 PE to 30 PE

- 2 bins for the First light in the LAr PMTs
- Overall improvement of the signal acceptance!

