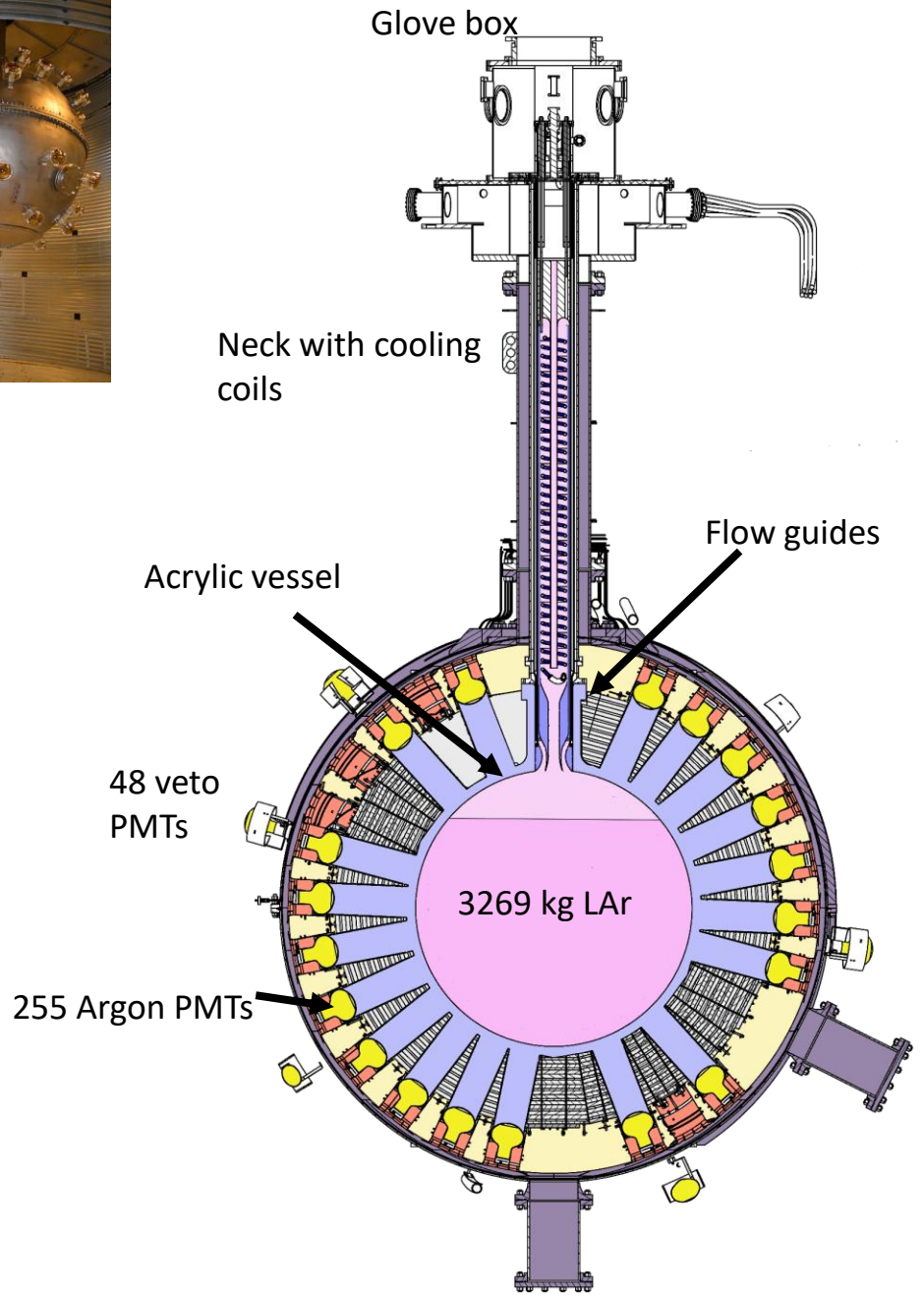
DEAP-3600 Hardware Upgrades and Third Fill

Austin Murray on behalf of the DEAP-3600 Collaboration

June 9th, 2025

What is DEAP?

- DEAP is a single-phase liquid argon detector that probes for Weakly Interacting Massive Particles (WIMP) dark matter candidates.
- Located in the Cube Hall at SNOLAB, DEAP-3600 has previously run from 2016-2020.
- From this previous run and our detailed background model, we expect a small leakage of events in our WIMP region of interest (ROI) from two main sources.
- Since 2020, upgrades have been installed to address these backgrounds



How does DEAP detect dark matter?

- DEAP uses the scintillation light given off by liquid argon (LAr) to detect events.
- LAr emits light around 128nm, so TPB (a wavelength shifter) coats the inner surface of the acrylic vessel.
- The excited LAr molecules can decay in two different timescales, singlet or triplet, and the ratio between these varies based on the type of event

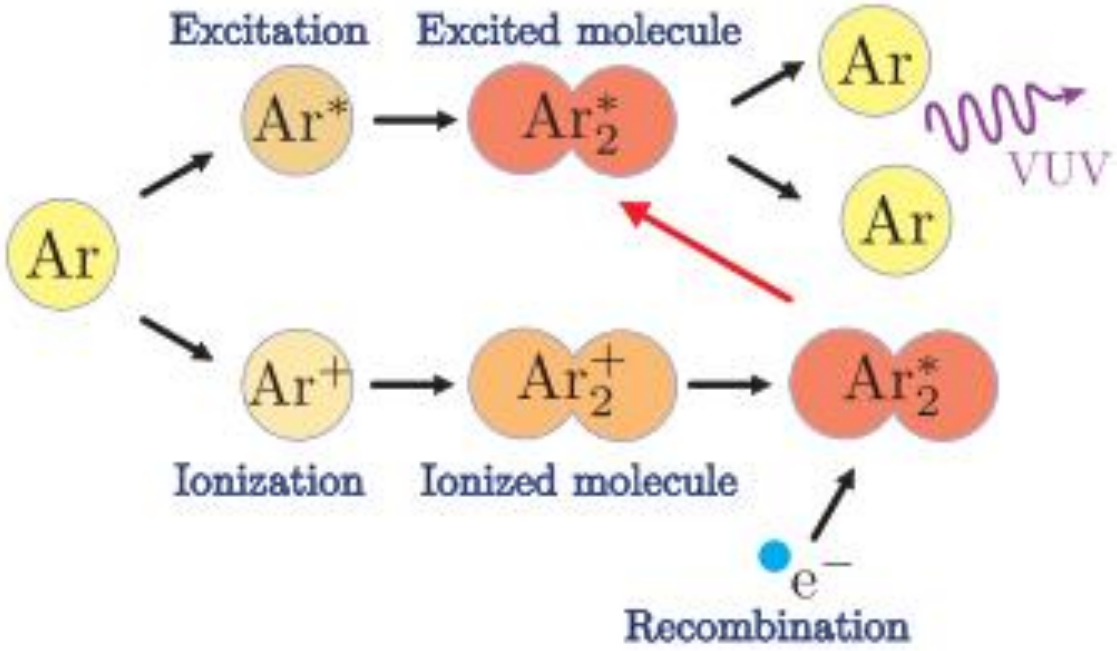
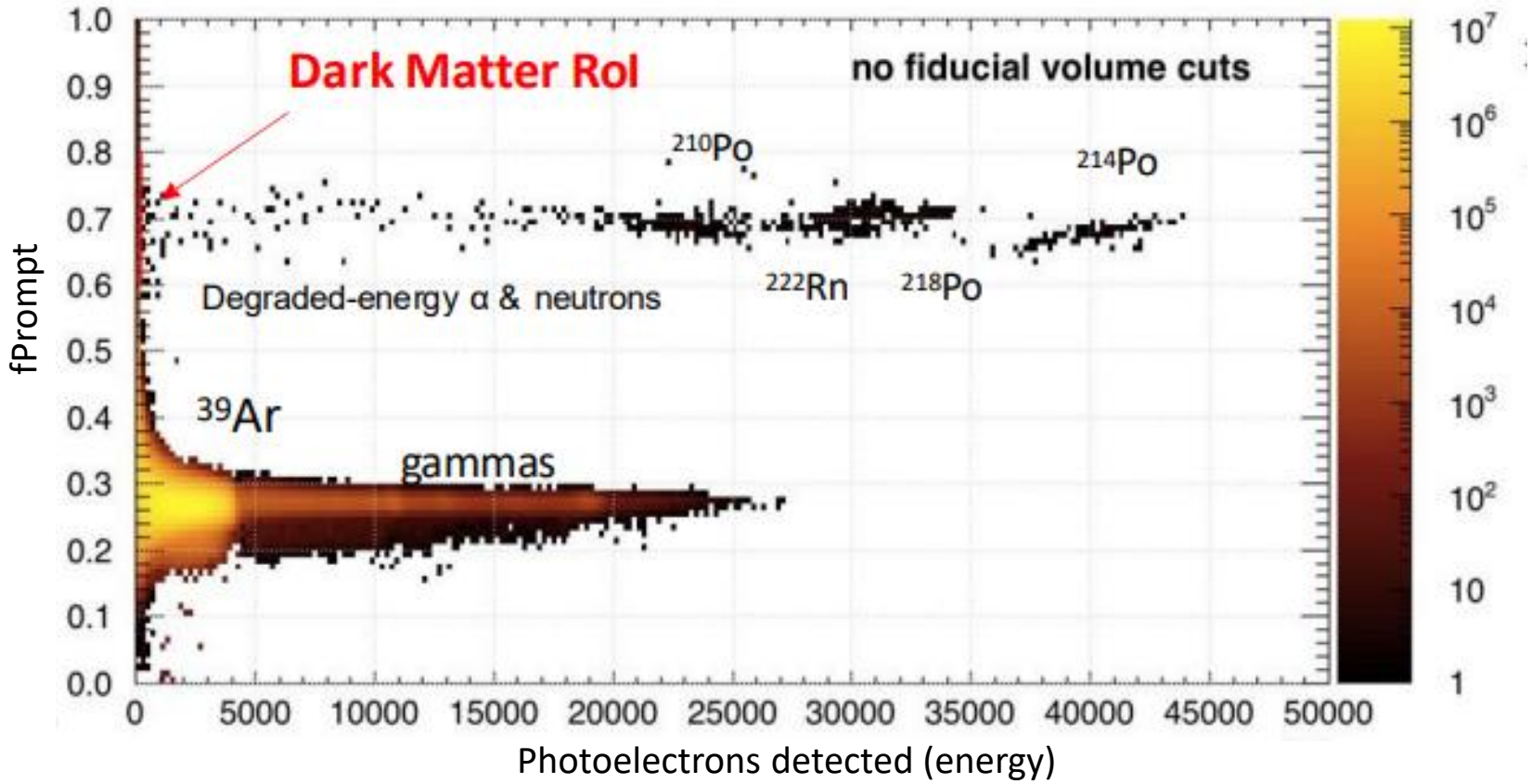


Fig. 1. *The two mechanisms leading to the emission of 128 nm photons (adapted from ref. [6]).*

Figure 1 from: arXiv:0708.2621

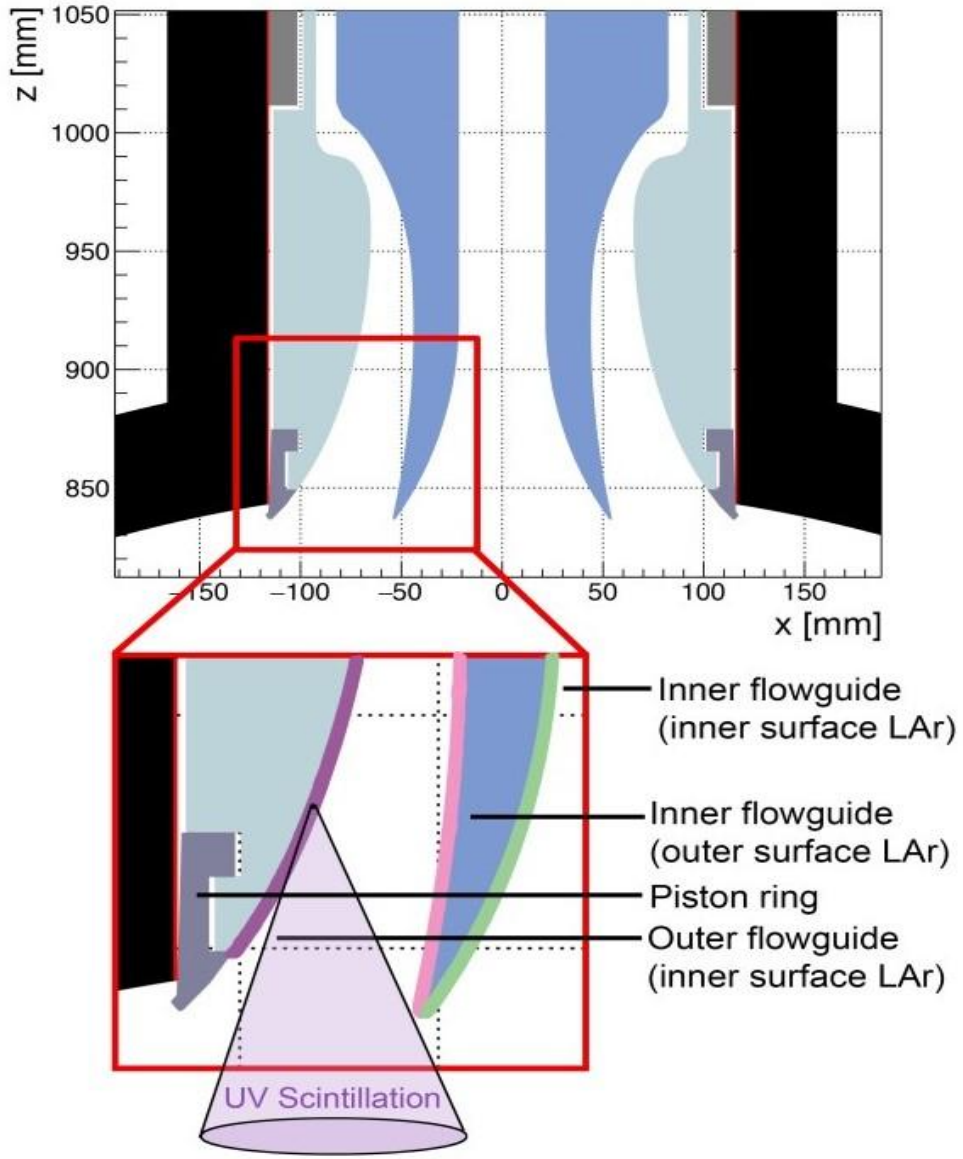
Pulse Shape Discrimination

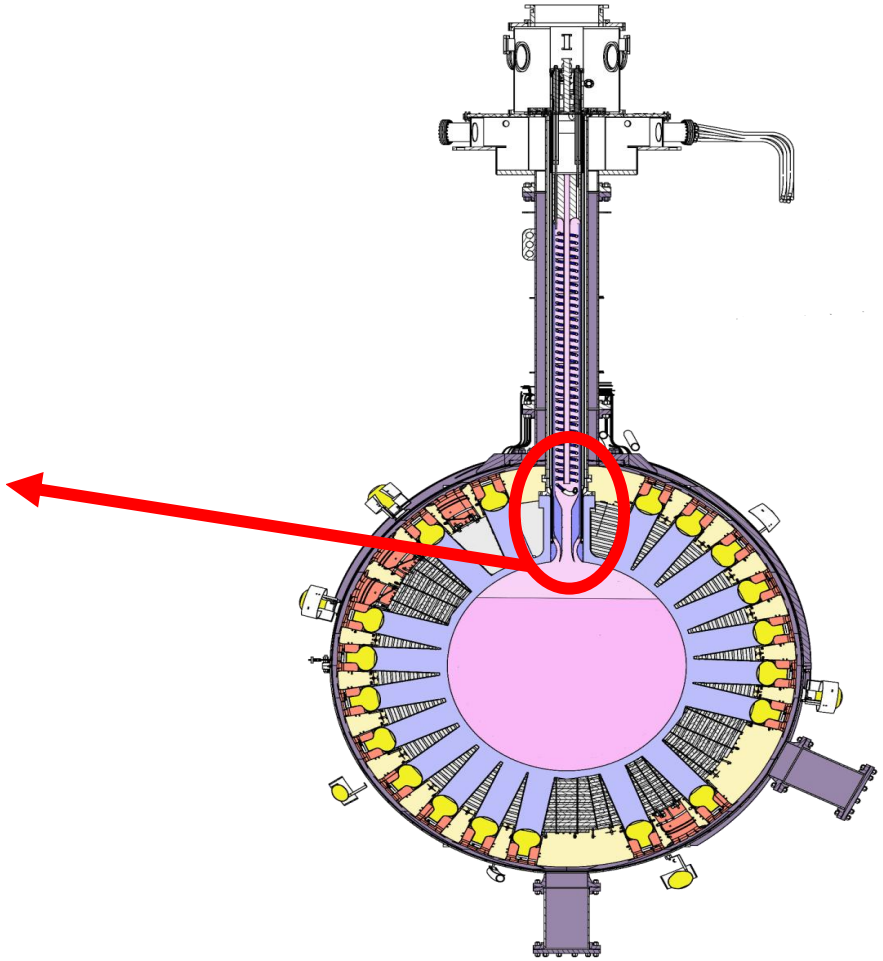
- The singlet/triplet ratio allows us to distinguish events based on the ratio of early light to total light in the pulse (fPrompt)
- Leakage from the nuclear recoil band, mainly degraded α particles, can leak into the WIMP region of interest

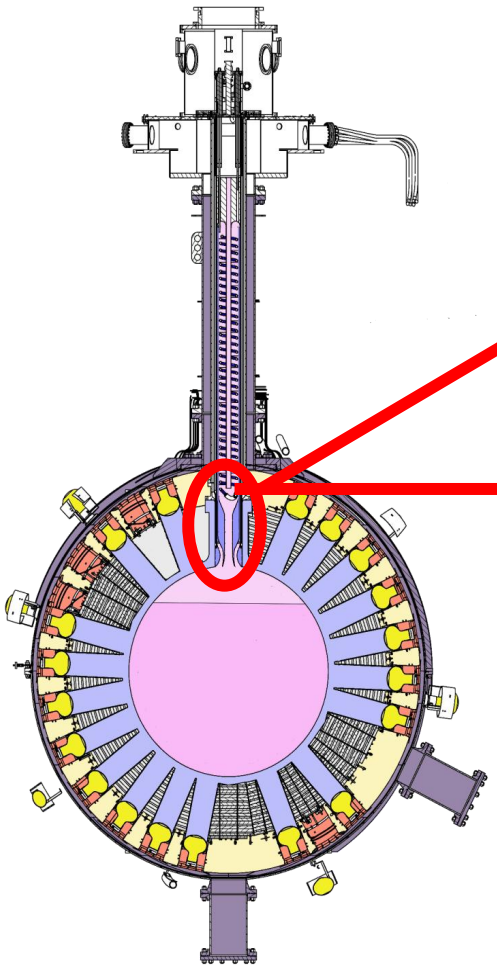


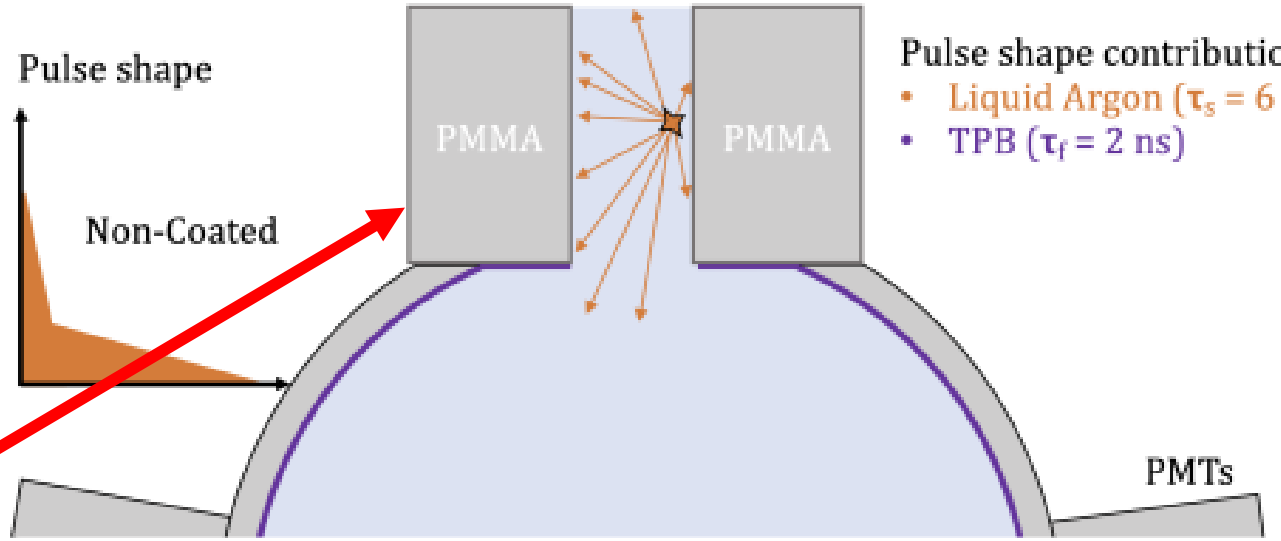
Neck Alphas

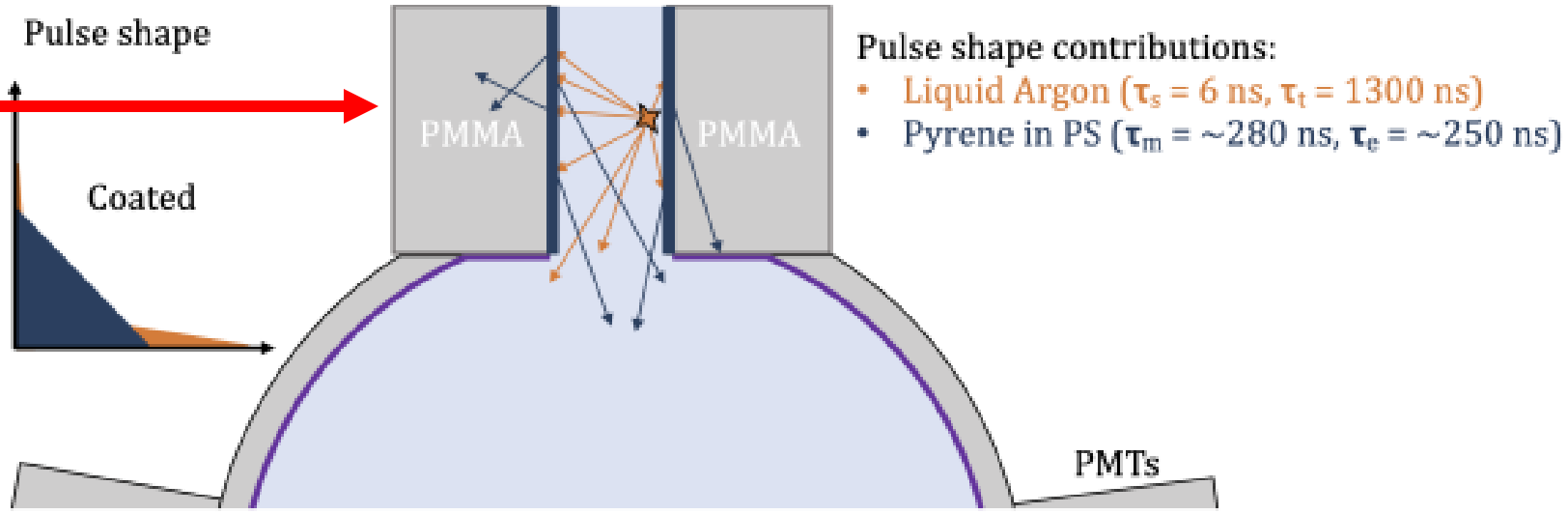
- α-decays that originate in the neck can have their scintillation light shadowed
- Shadowing can also interfere with position reconstruction





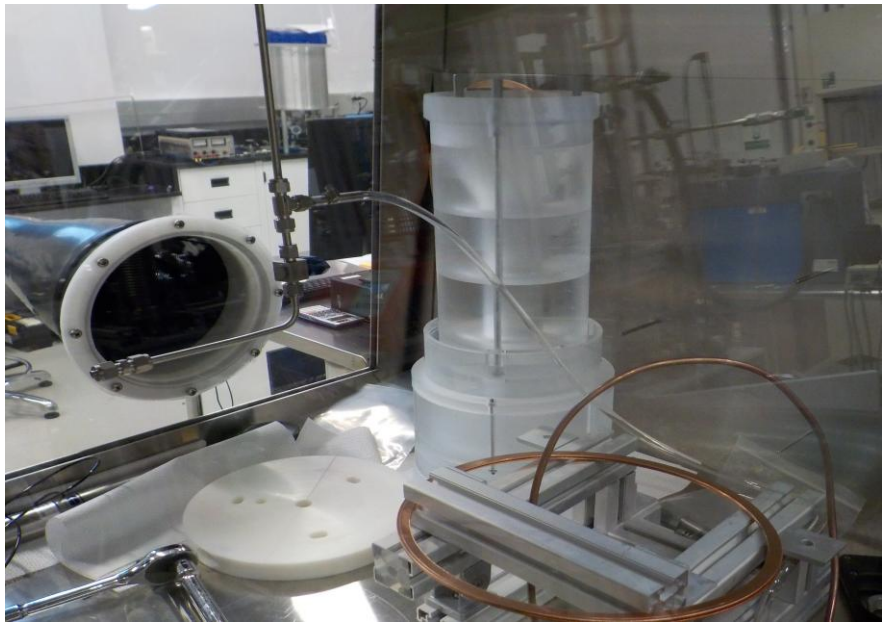




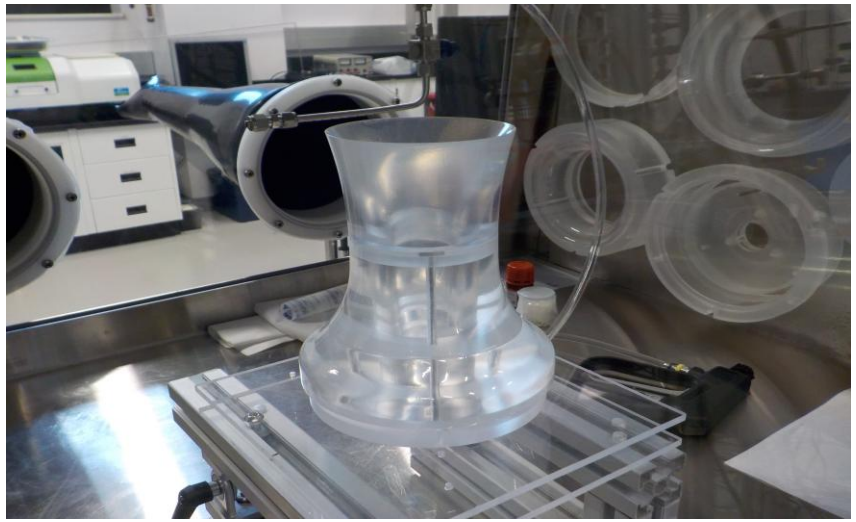


D. Gallacher et al. arXiv:2109.06819

Low radon facility at UofA



Machined flowguides ready to be coated at Carleton

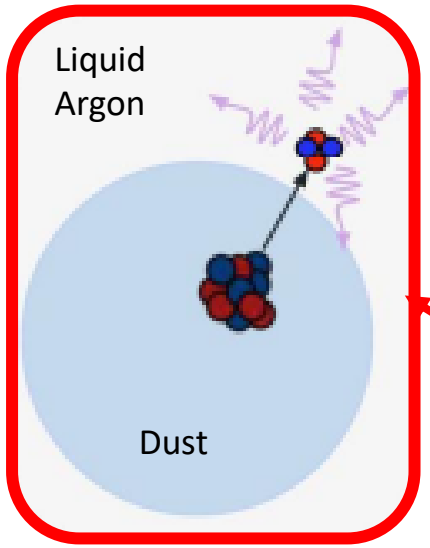


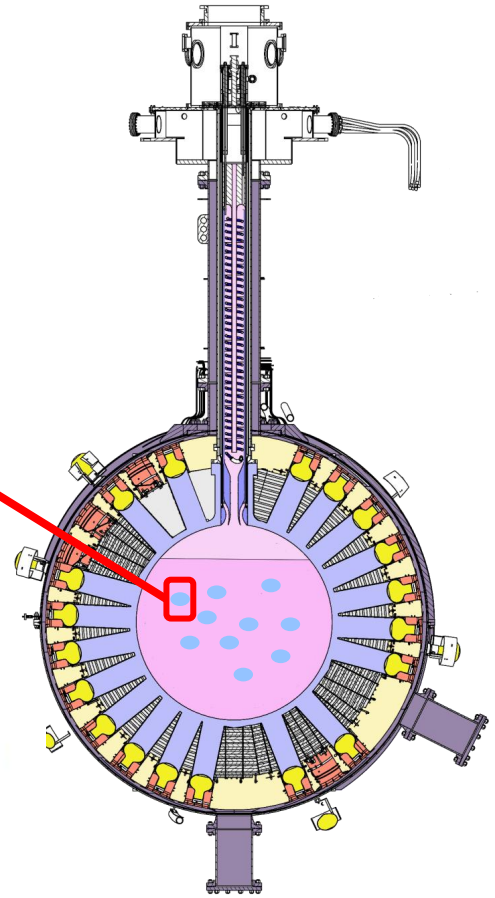
Coated piece ready to be sealed and shipped to Sudbury

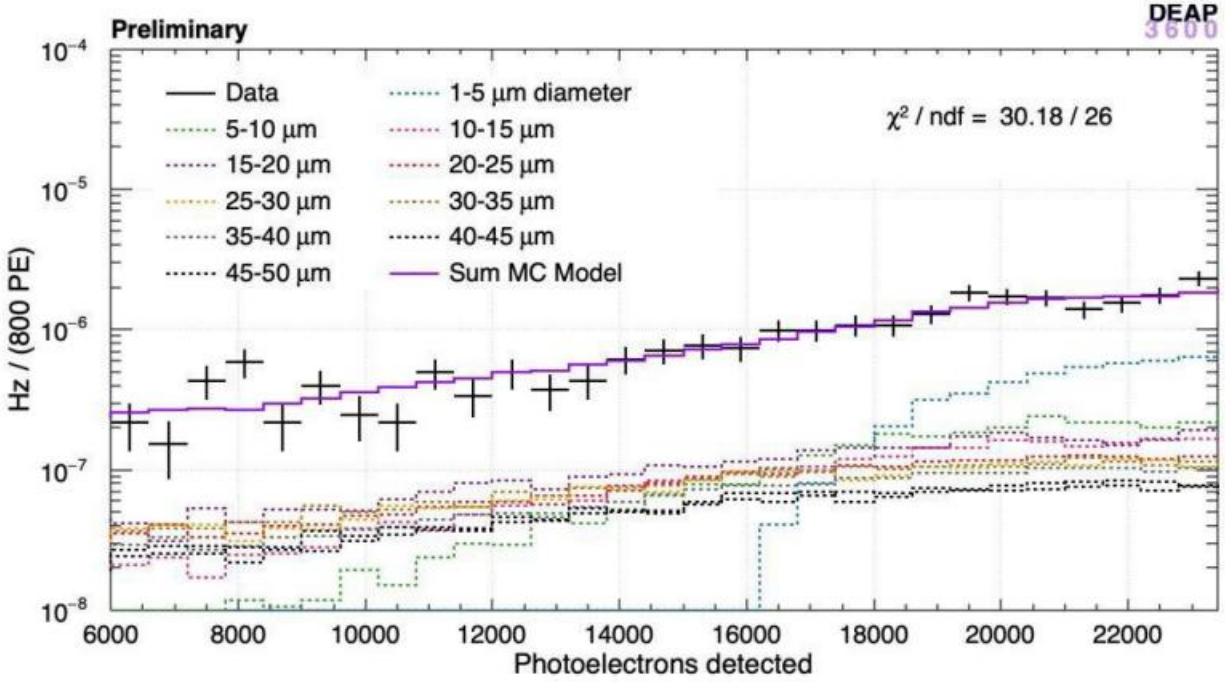
Flowguides and neck installed in the glovebox and being lowered into the detector

Dust Alphas

- α-decays can originate within trace amounts of dust within the detector and then attenuate within the dust.
- At high energies our model works very well but becomes less accurate as it approaches the ROI

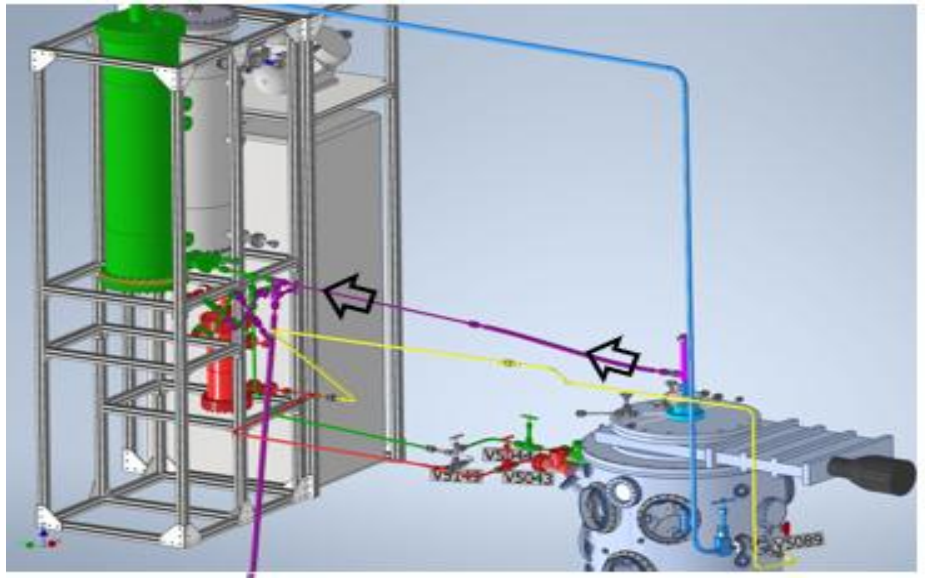


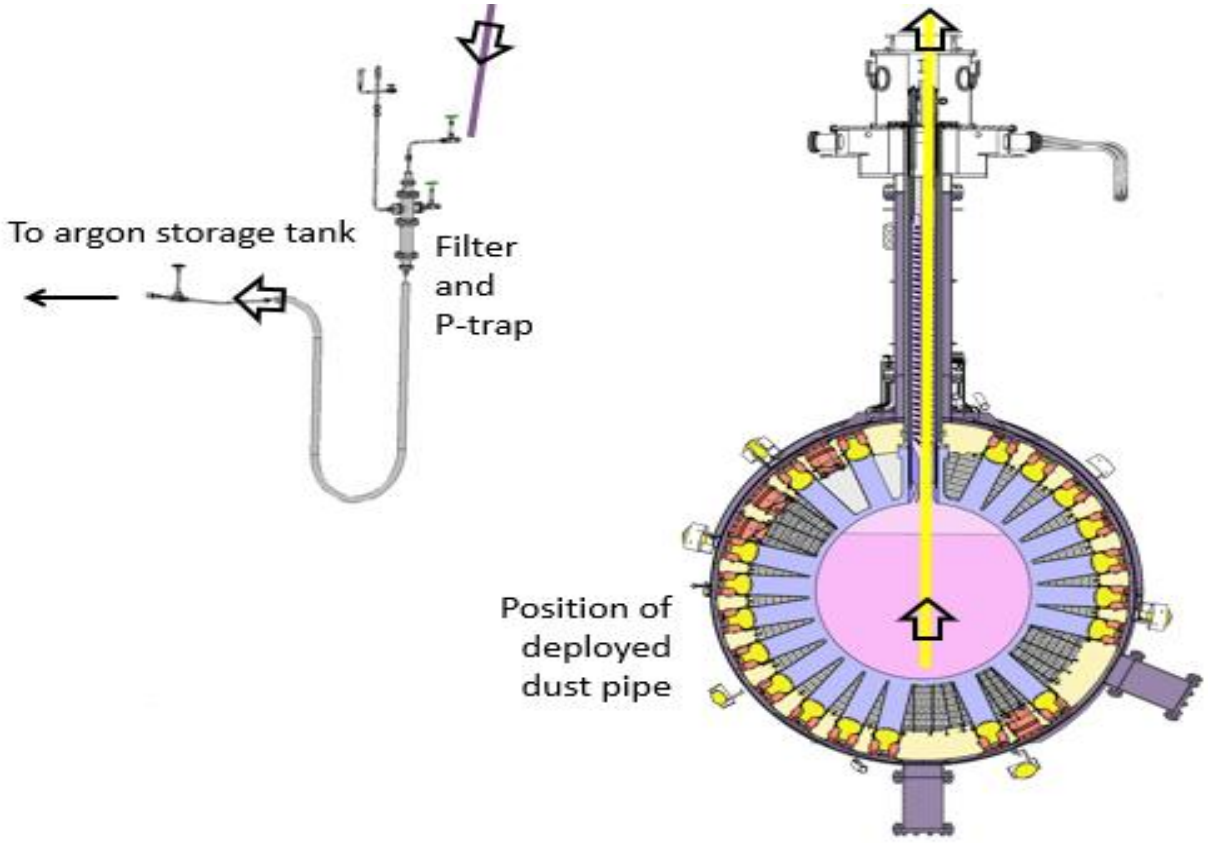




Dust Filtration System

- With the installation of the new neck a dust particulate removal system was also added.
- This also gives the ability to externally cool the argon, letting liquid argon flow directly into the AV and avoiding the possibility of coating the flow guides in LAr.

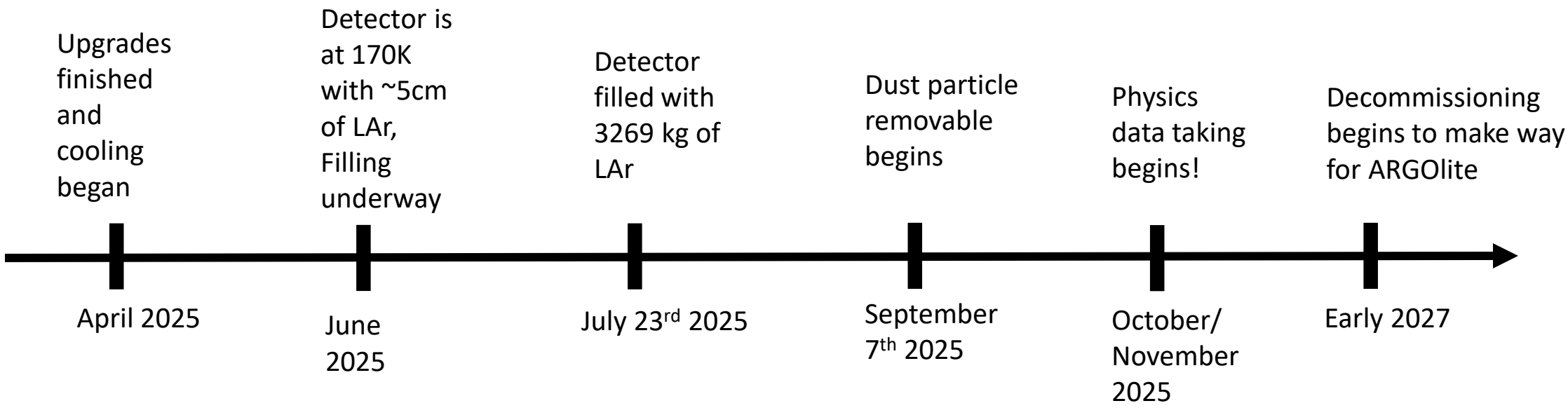




Third Fill run plan

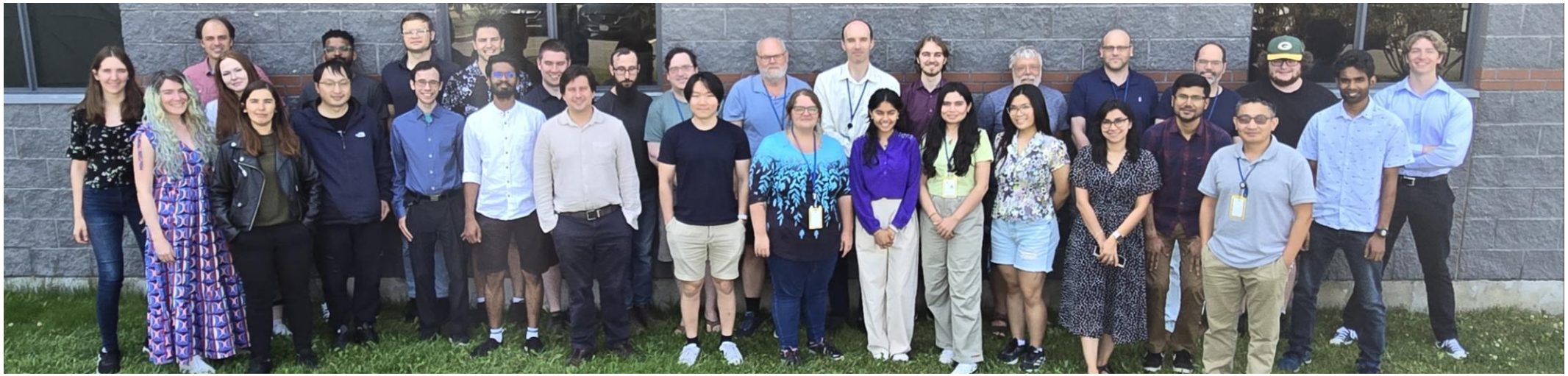
1. Recirculate liquid through the dust-pipe during fill
2. Fill detector to same argon level as previous fill. Make use of all detector modelling already performed.
3. Automated calibrations for PMTs single-photo-electron response, light yields, triplet lifetime (ie scintillation pulse shape.)
4. Apply our previous analysis with automated scripts, using cut flows to highlight the search for dark matter as well as studies of sidebands and review weekly
5. Monthly external calibrations
6. After 1 year of dark-matter search livetime, inject Kr-83m.

Status of upgrades and Third Fill



Conclusion

- Hardware upgrades to DEAP-3600 have been completed.
- The detector is currently being filled and is on track to be taking physics data by the end of the year.
- Both the new neck and dust filtration system aim to produce a zero-background run of DEAP-3600 and provide valuable information for future liquid argon dark matter searches.
- For information about recent DEAP-3600 analysis and the global search for dark matter using liquid argon (DarkSide-20k, ARGO) see Simon Viel's talk at 5:00pm on Thursday June 12th



References

- [1] C. Amsler et al. “Luminescence quenching of the triplet excimer state by air traces in gaseous argon”. In: JINST 3 (2007).
- [2] The DEAP collaboration: R. Ajaj et al. “Search for dark matter with a 231-day exposure of liquid argon using DEAP-3600 at SNOLAB” In: Physical Review D (2019)
- [3] The DEAP collaboration: P.Adhikari et al. “The liquid-argon scintillation pulseshape in DEAP-3600” In: The European Physical Journal C (2020)
- [4] D. Gallacher et al. “Development and characterization of a slow wavelength shifting coating for background rejection in liquid argon detectors” In: Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment (2022)