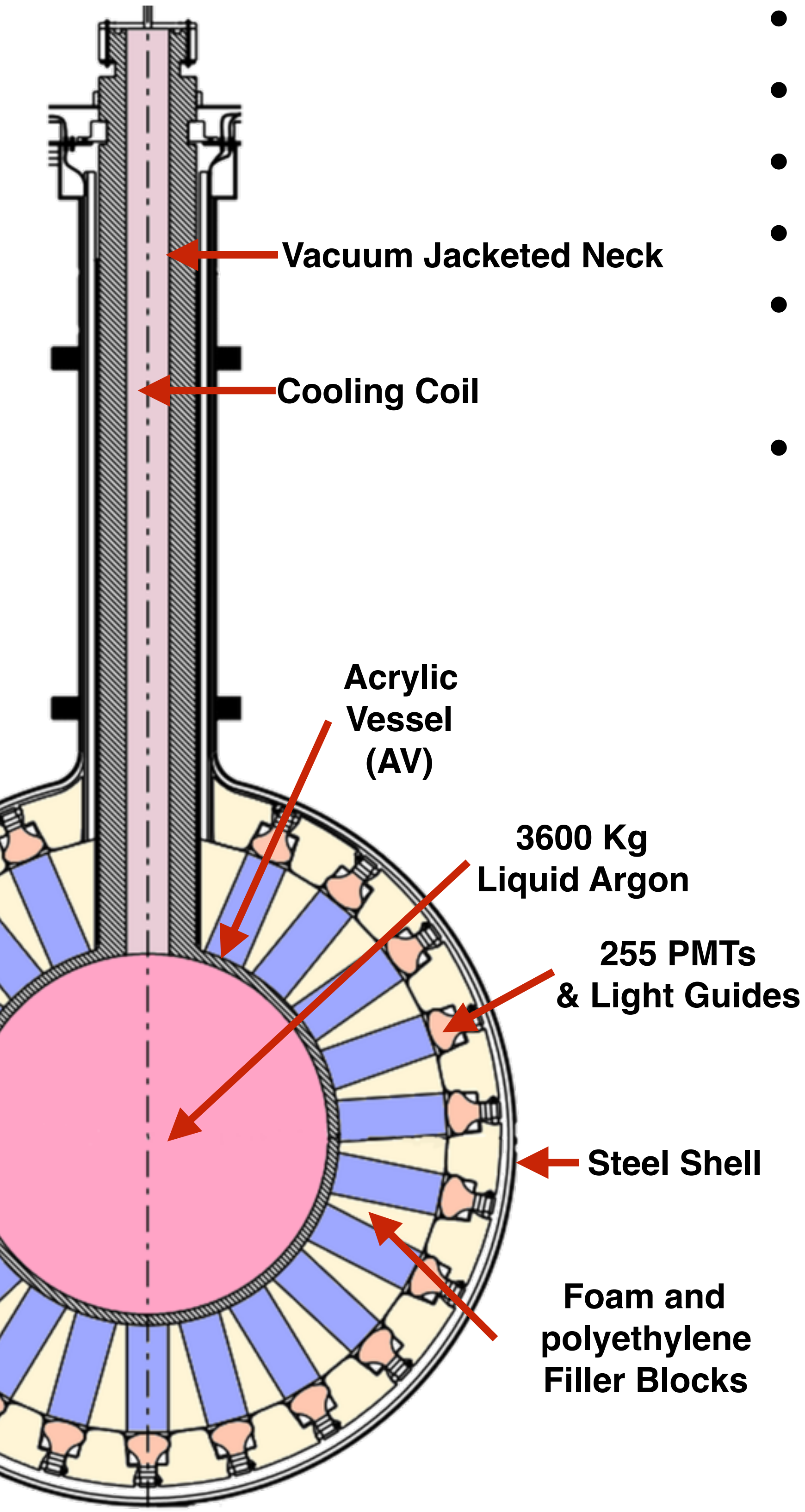
The DEAP-3600 Dark Matter Direct Detection Experiment

Pietro Giampa, 05-August-2016, ICHEP2016

DEAP-3600 Collaboration.

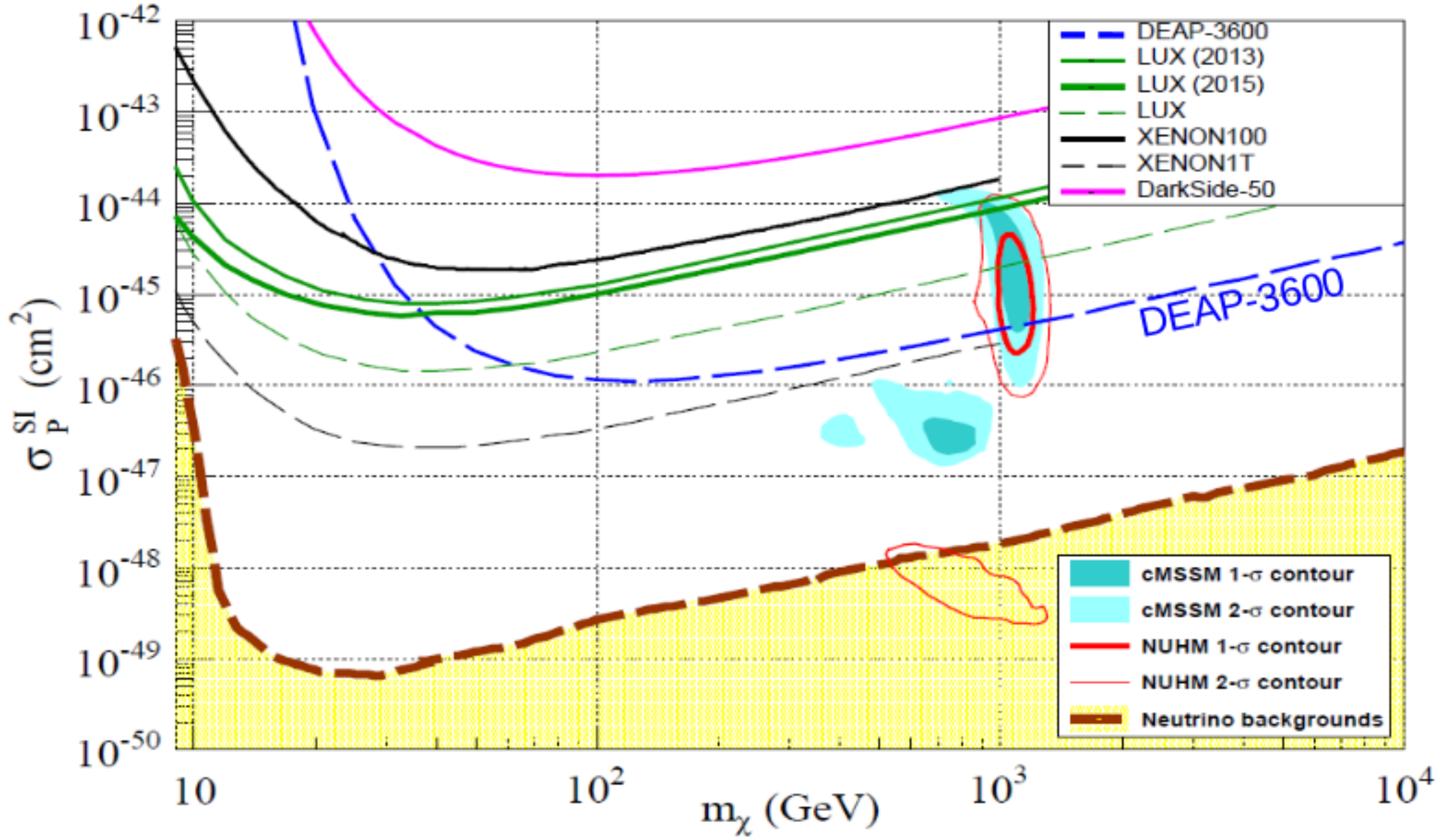
DEAP-3600 is located 2km underground at the SNOLAB Facility in Sudbury ON, Canada.

Overview of the DEAP-3600 experiment.

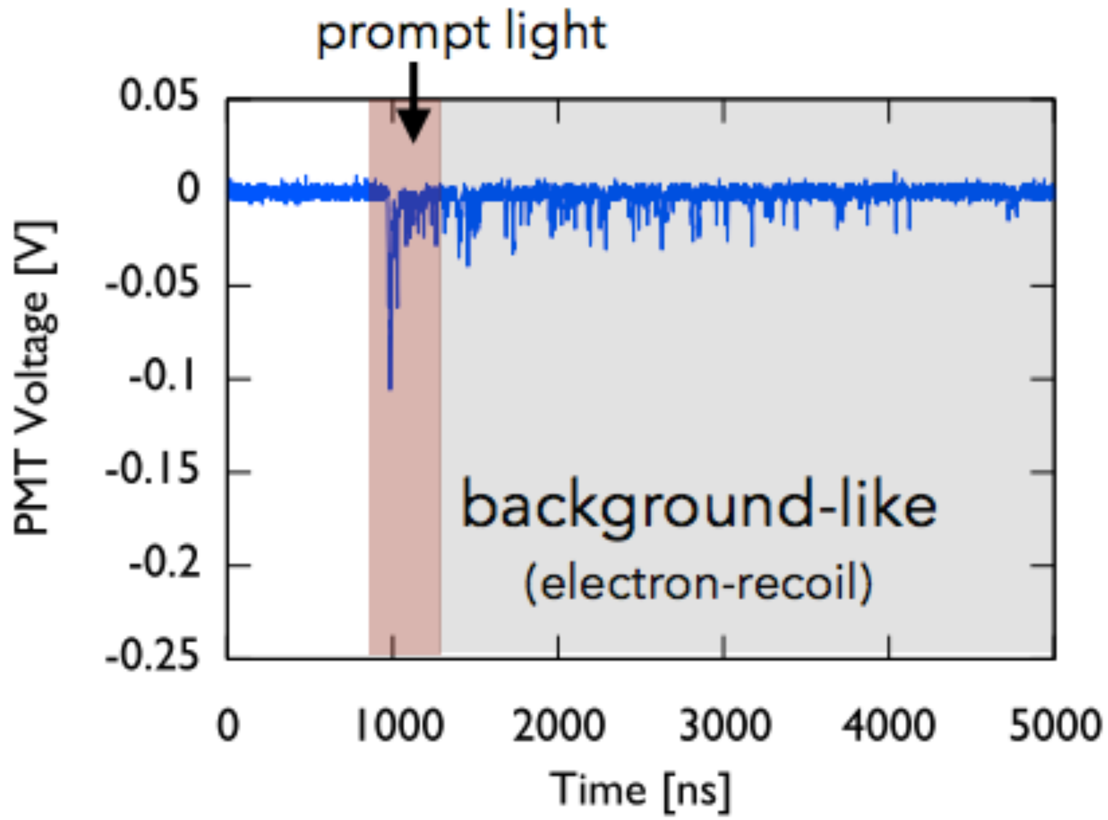


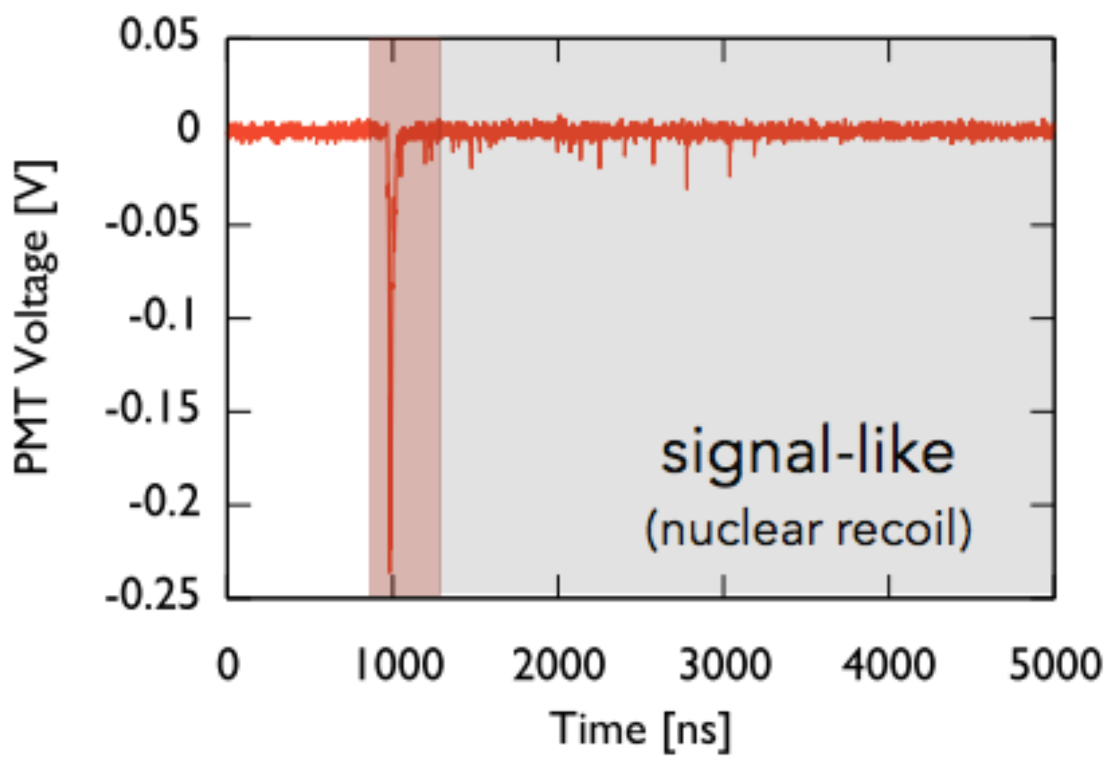
- Single phase LAr, 3.6 tonne (1 tonne fiducial).
- Spherical ultra-pure acrylic vessel (AV).
- 255 HQ Hamamatsu PMTs, coupled via acrylic light guides.
- Foam and polyethylene provide further shielding.
- 3 um layer of wavelength shifter (TPB) converts 128 nm scintillation list into the visible range.
- AV enclosed inside Steel Shell, immersed in 403 m^3 water tank with 45 veto PMTs

L. Roszkowski et al.. JHEP 1408 (2014) 067



Using data collected from previous prototypes, DEAP-3600 is projected to achieve PSD of 10^{10}.





Prompt Light (150 ns)

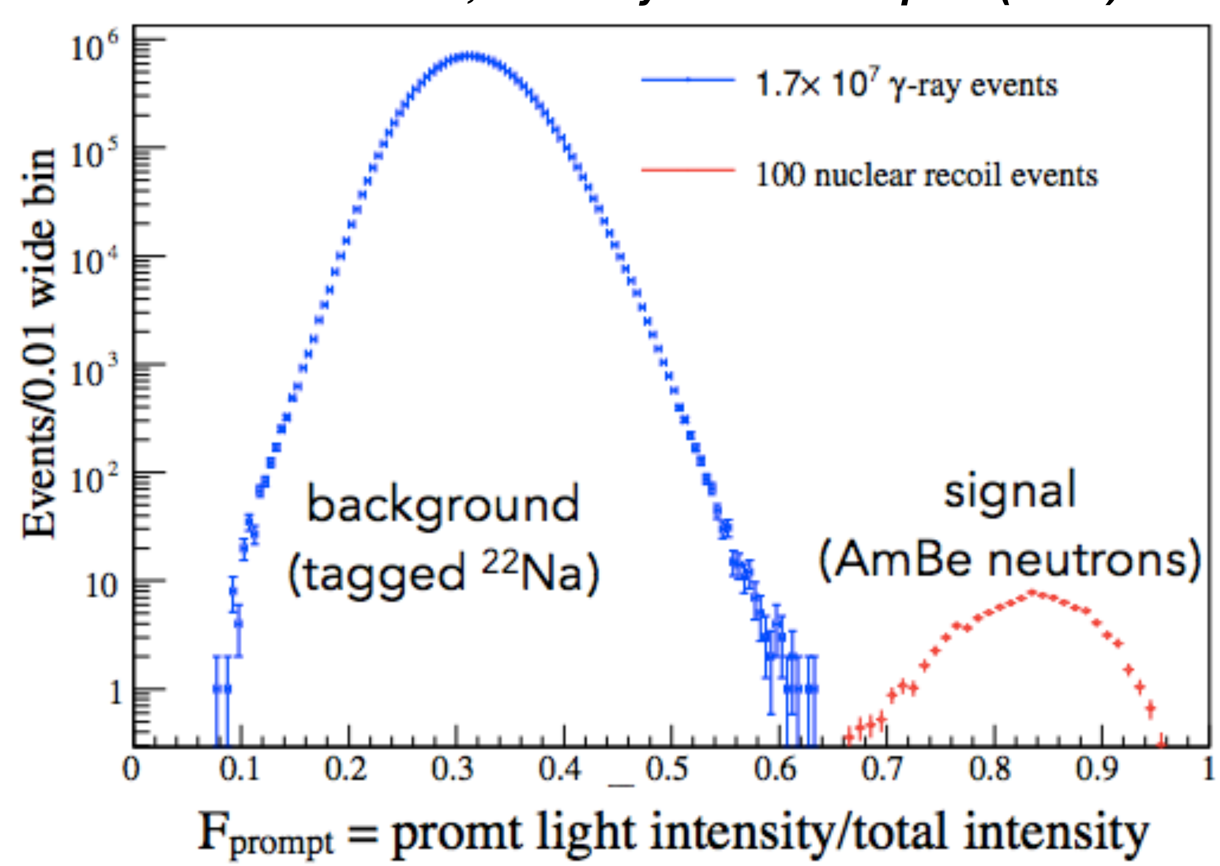
Late Light

Total Light = Prompt + Late

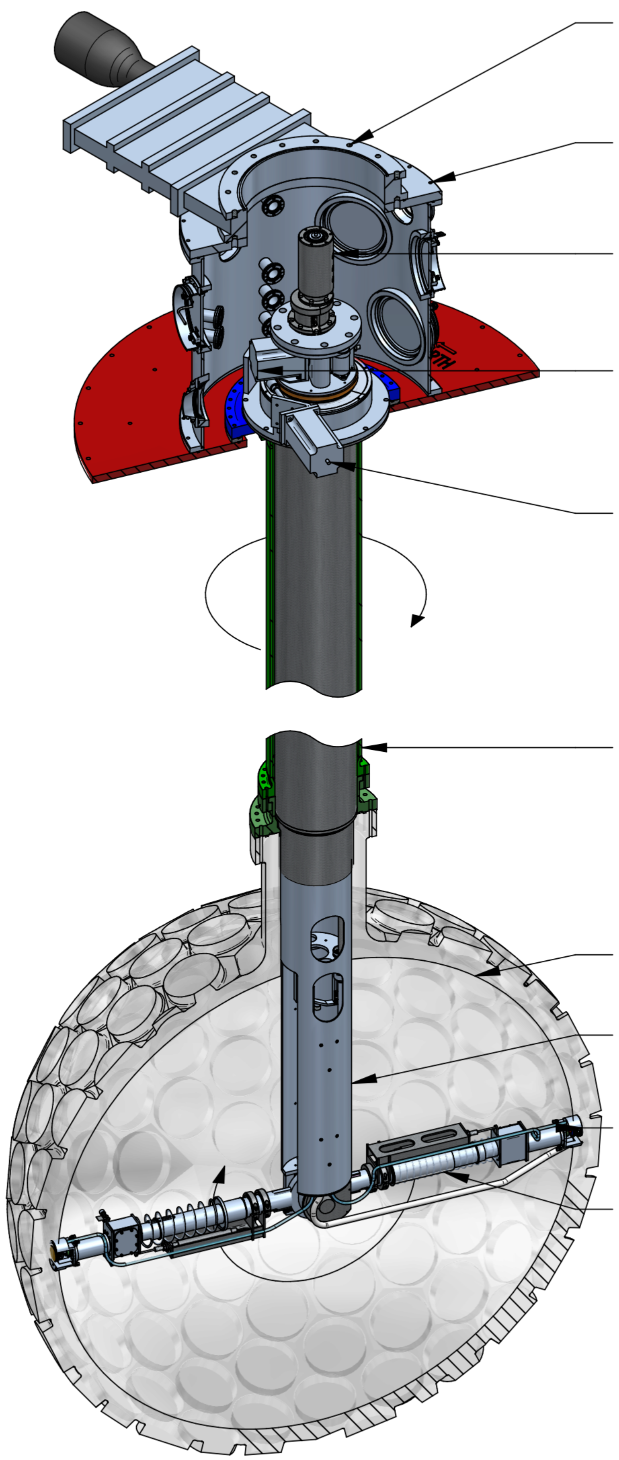
Pulse Shape Discrimination (PSD)

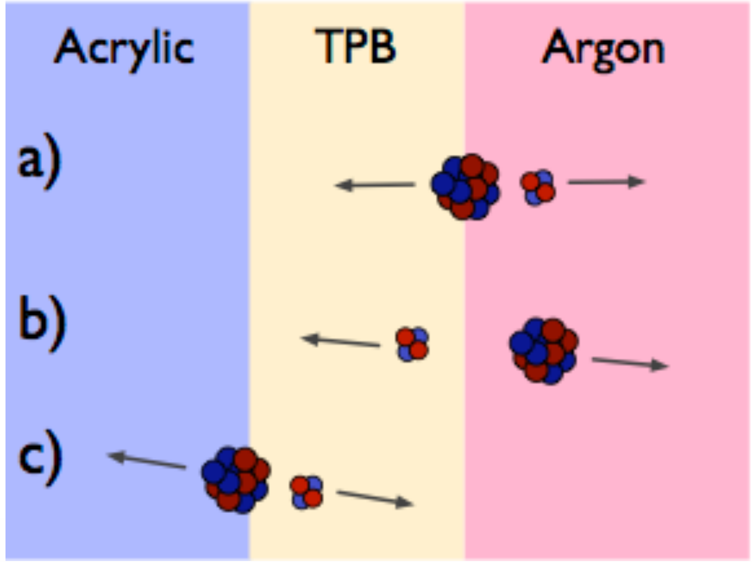
Fprompt = Prompt light / Total Light

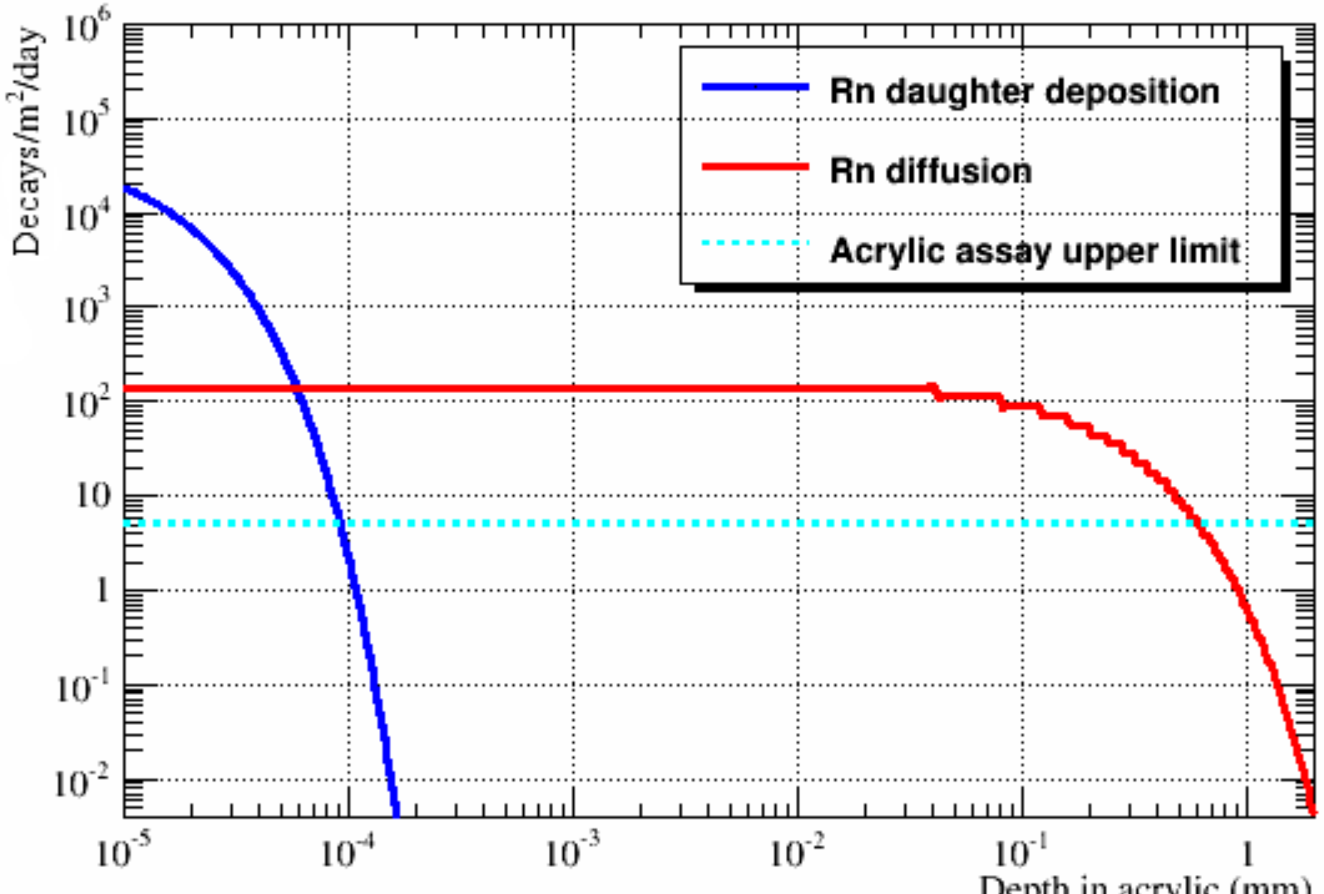
M. Kuzniak et al., Nuc Phys B Proc Sup 00 (2014) 1–7



500 [μm] of acrylic removed from the AV inner surface. Reducing surface alpha backgrounds in the ROI to projected 0.6 events in 3 years.

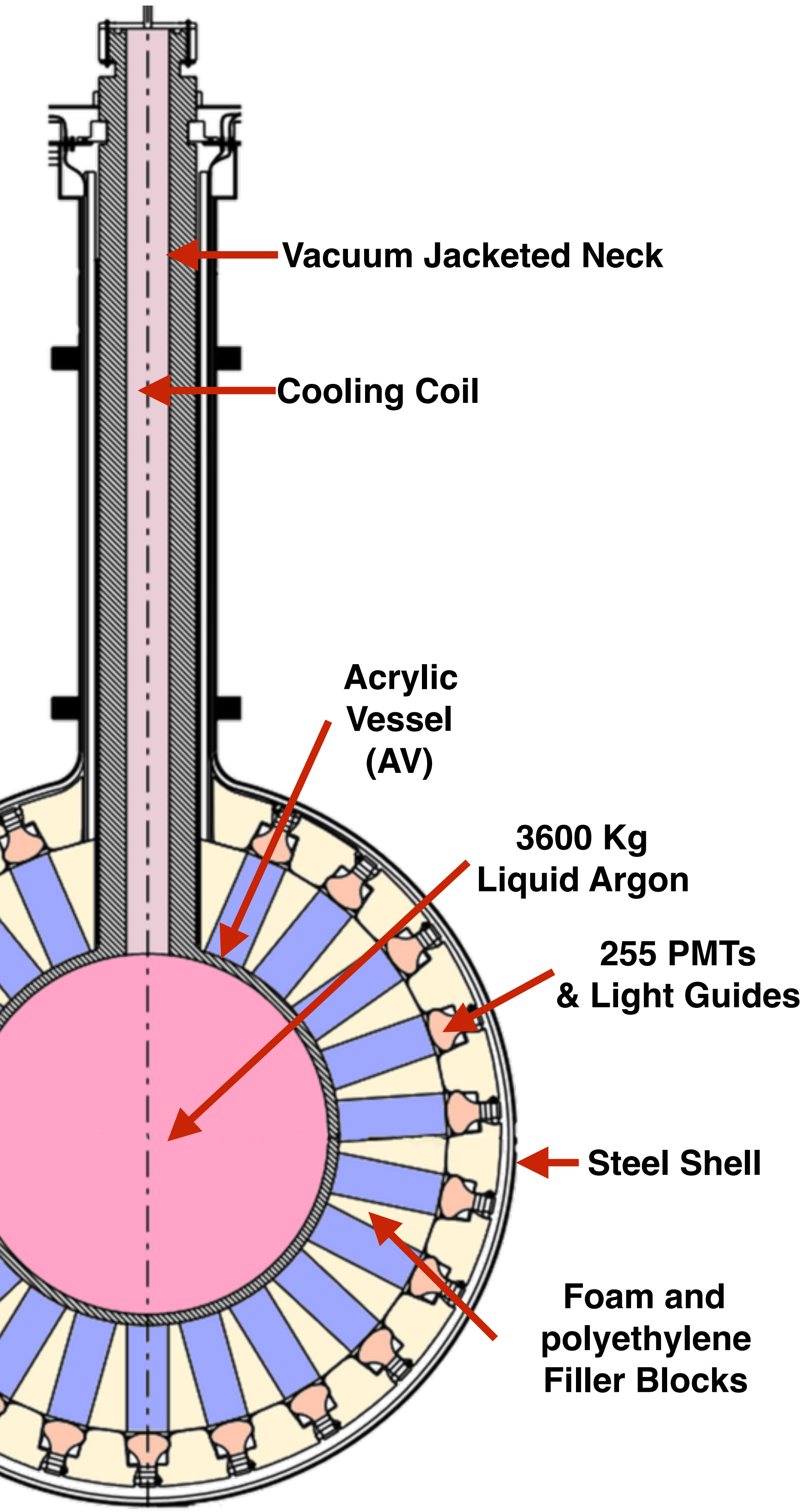


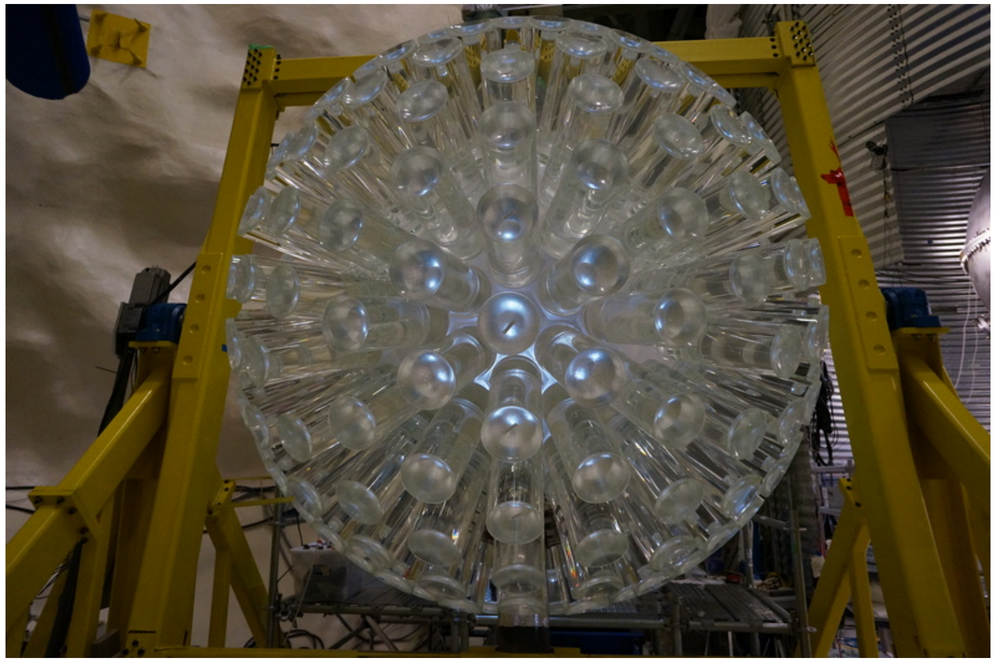


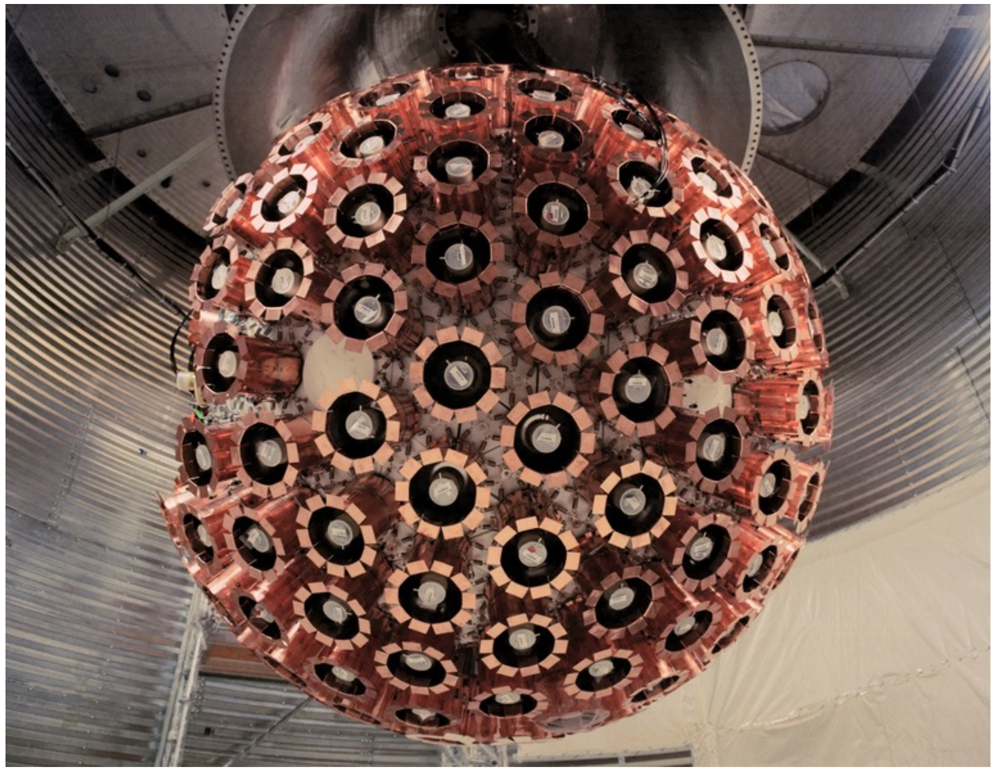


P. Giampa, 2016 J. Phys.: Conf. Ser. 718 042025

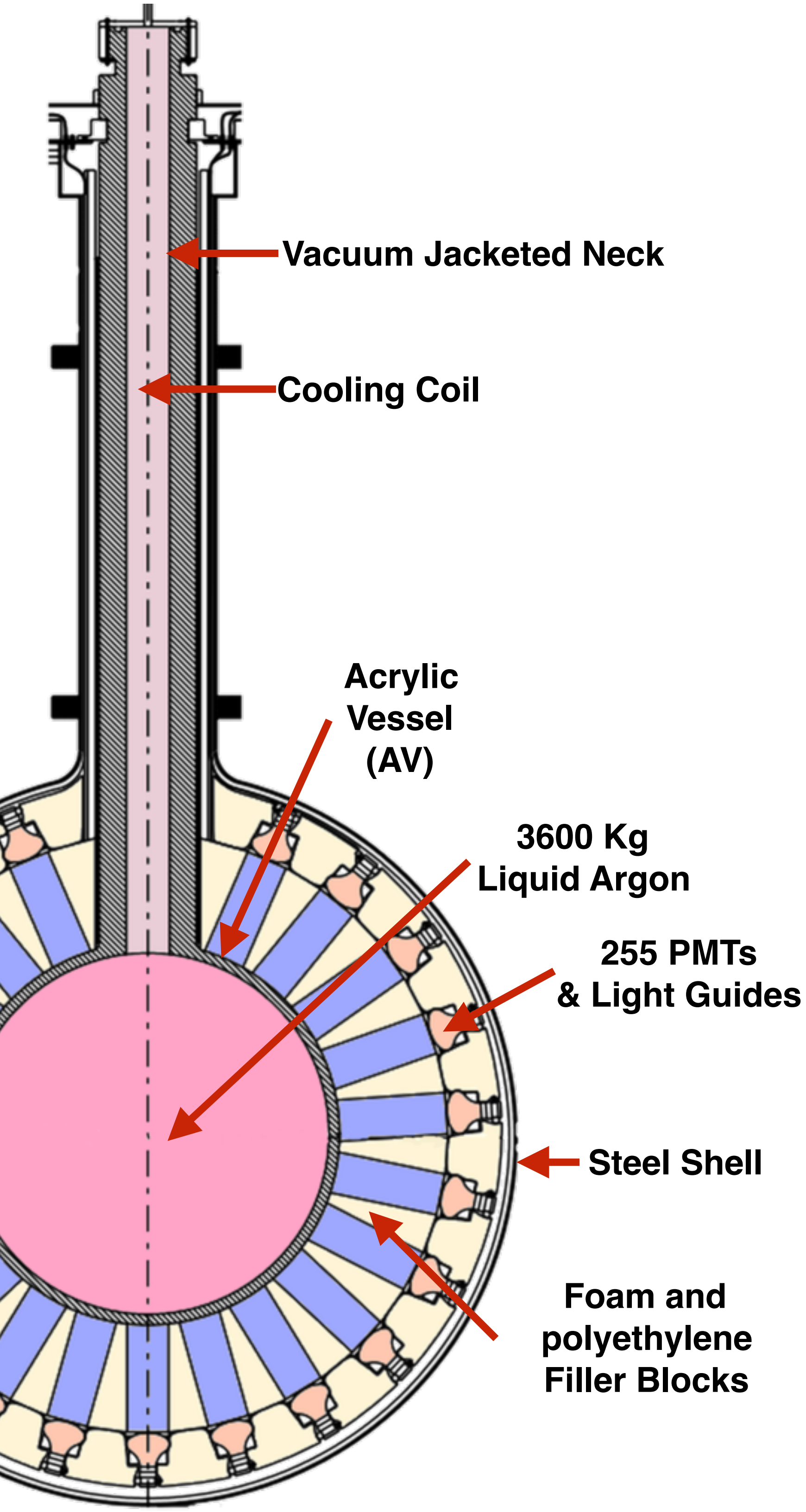
The inner vessel was covered with two types of reflector materials to maximize light collection.

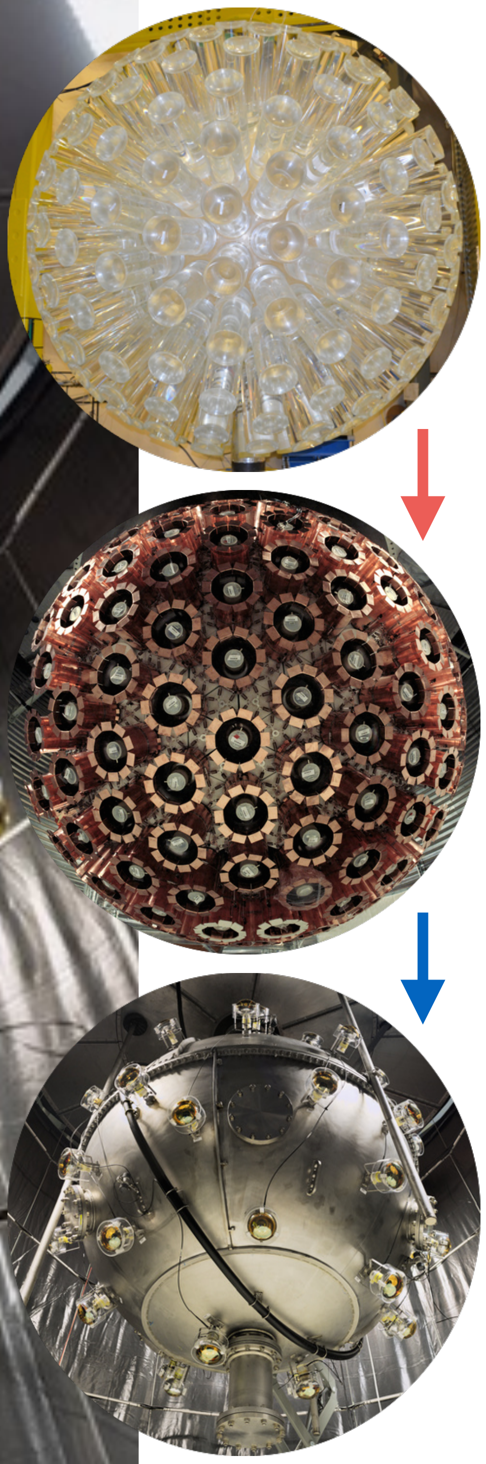




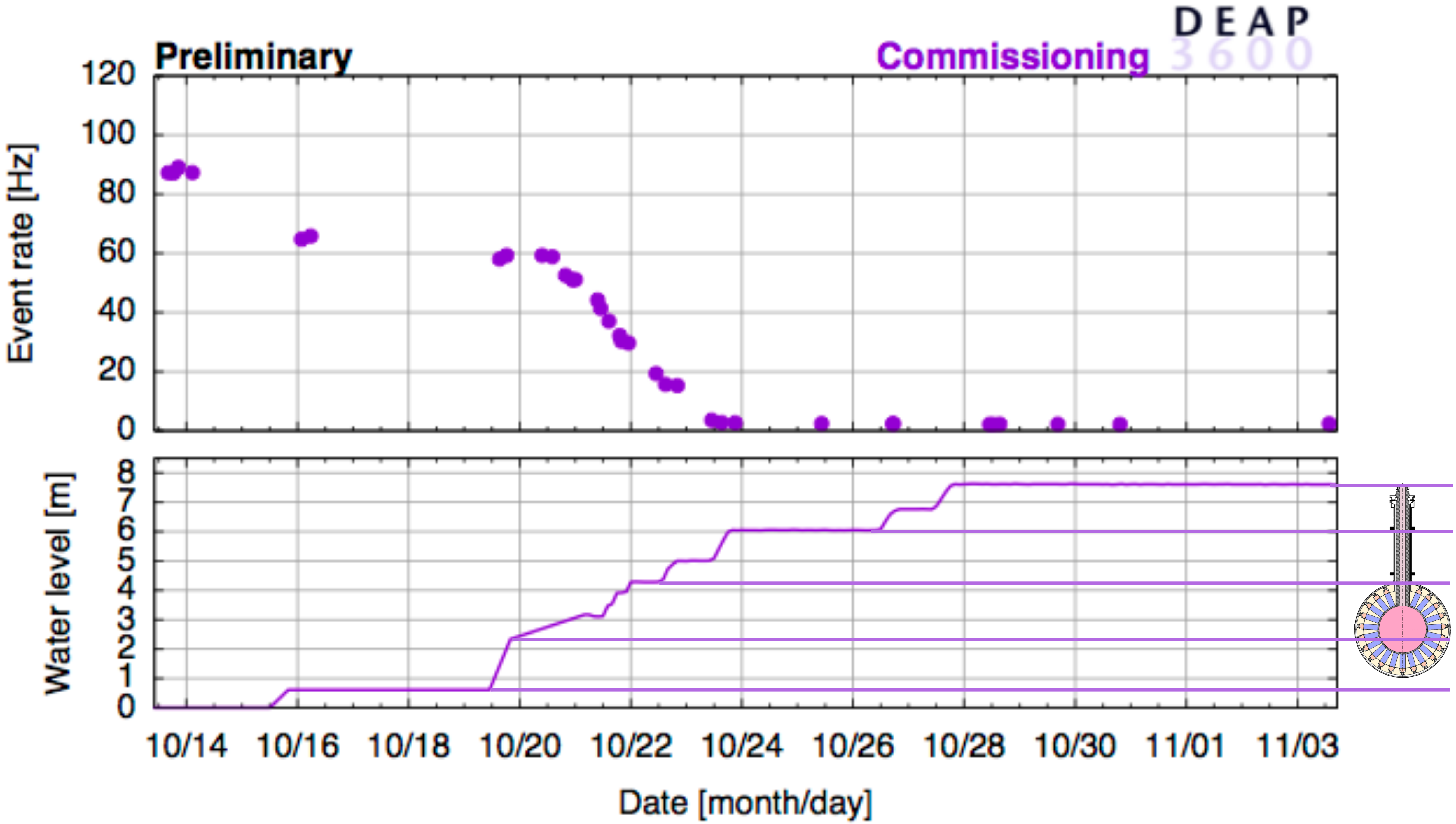


Construction of the experiment was completed in early January 2015.





The contribution from Cherenkov activity in the acrylic, was considerably reduced as the water shielding tank was filled with ultra-purified Water.

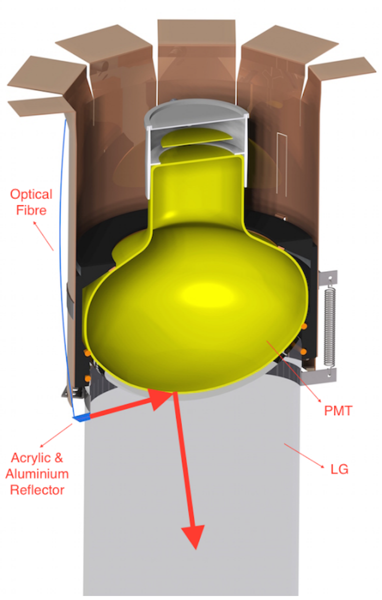


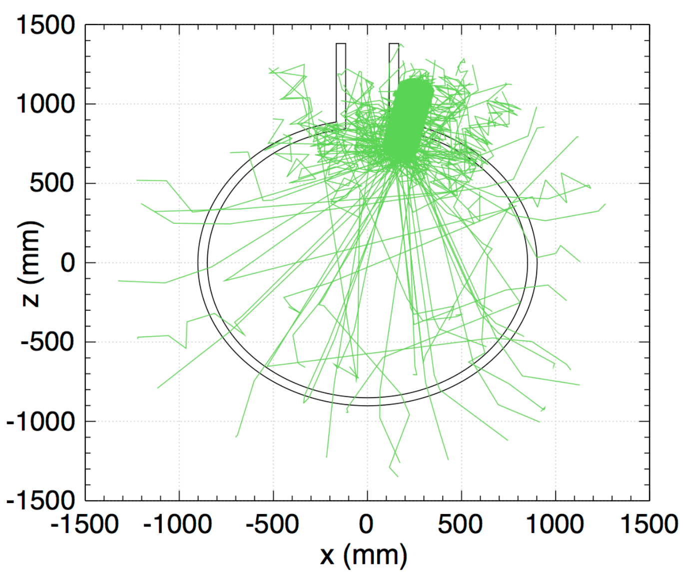
A LED Light injection system was used to commission and calibrate multiple aspects of the experiment.

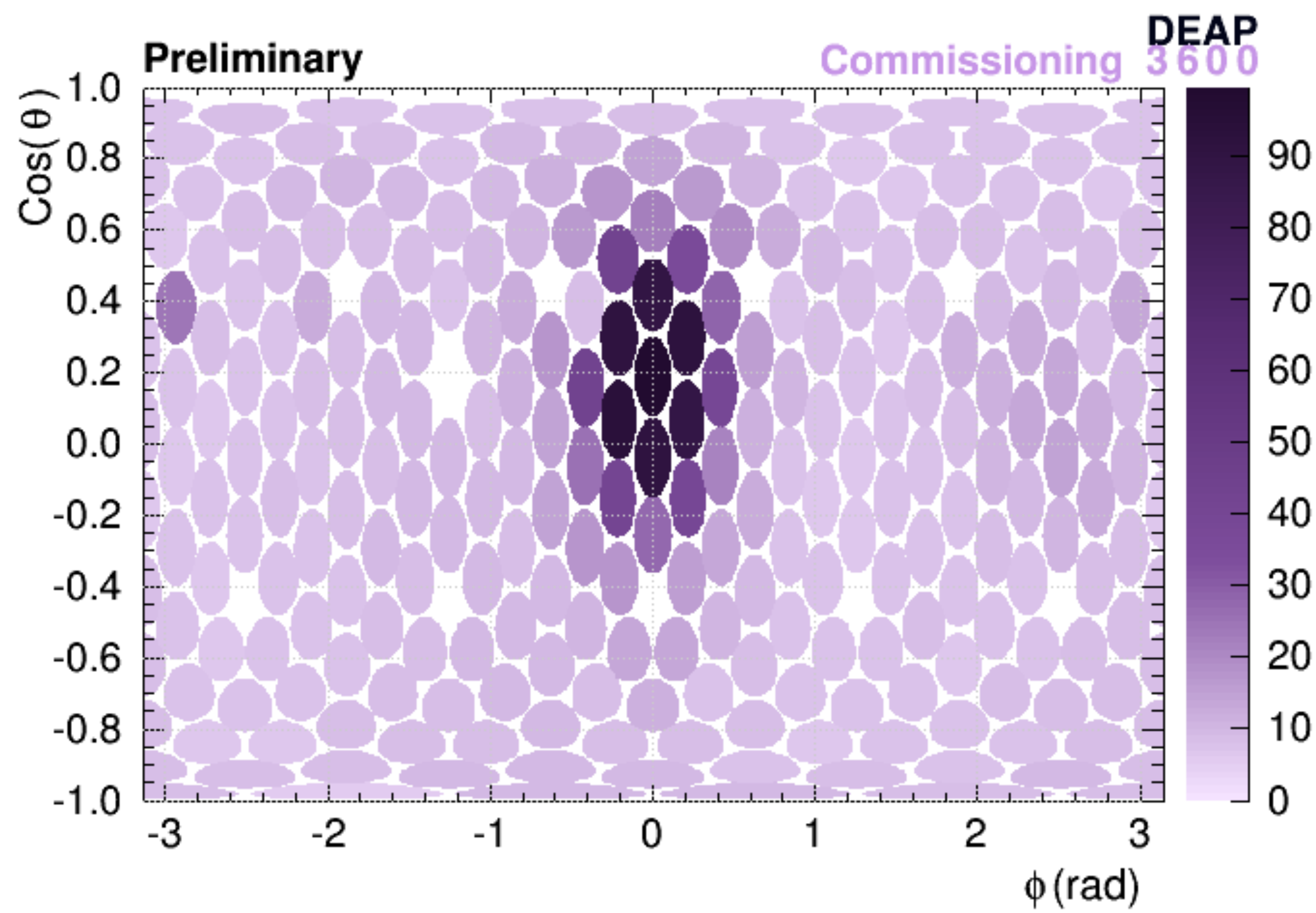
N2 Gas	*Vacuum*	*GAr*	*LAr Fill*
AARFS	AARFS	AARFS	AARFS
Th Source	Th Source	22Na Source	22Na Source
Laserball		AmBe Source	AmBe Source

AARFS (Acrylic and Aluminum Reflective Fibers System)

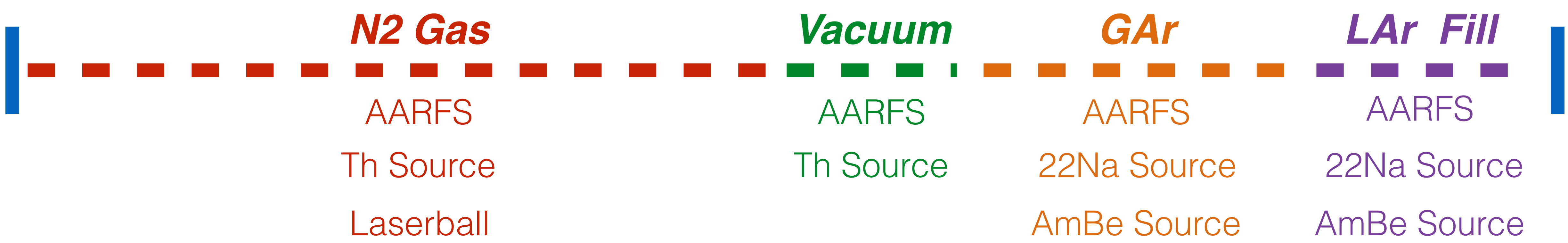
- Electronics Commissioning
- Optical Calibration
- PMTs Response Calibration





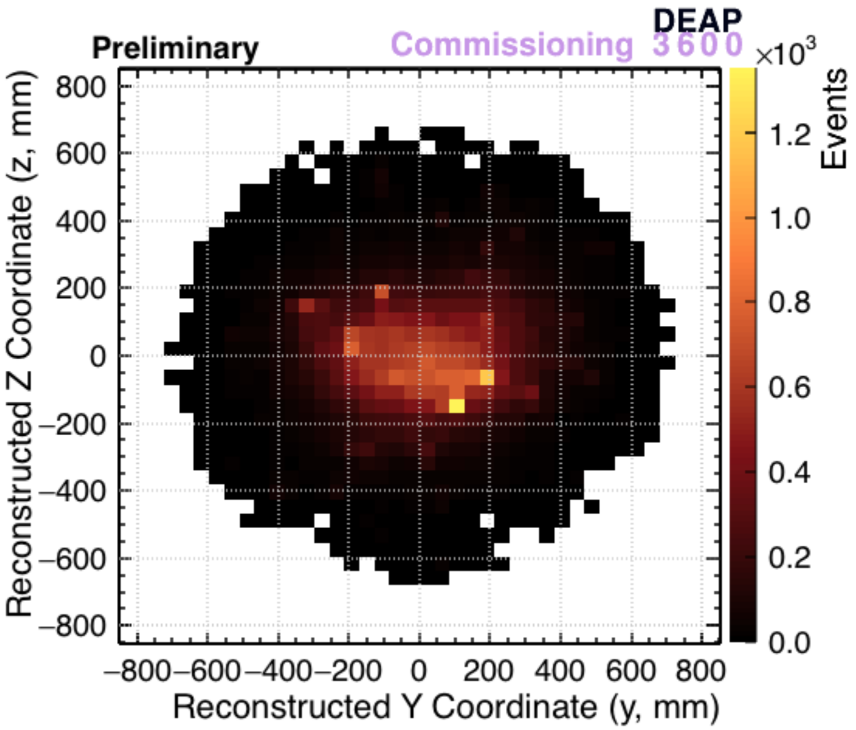


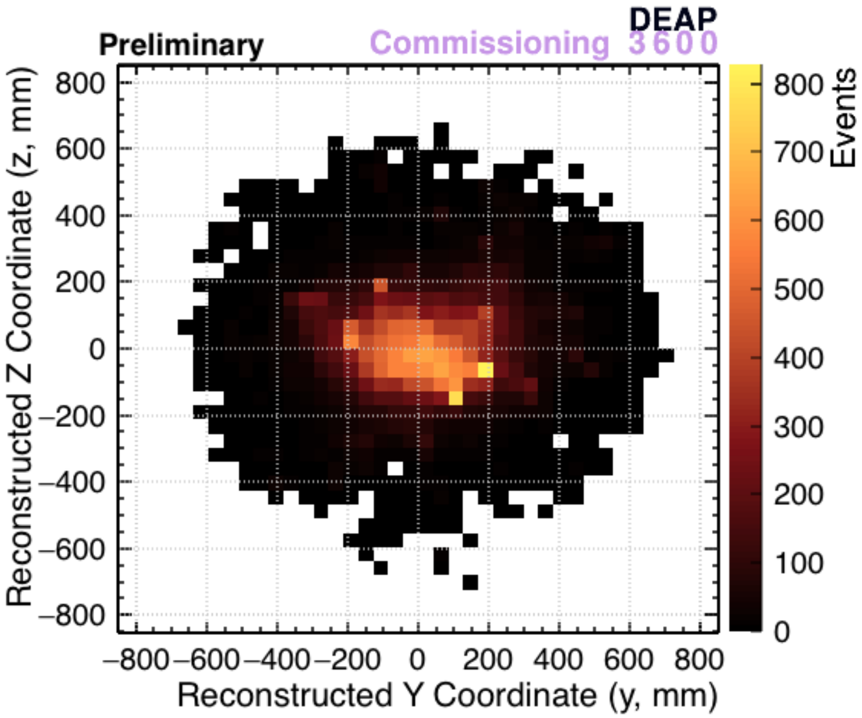
An homogenous light source was deployed at the center of the AV to performed an accurate time calibration.



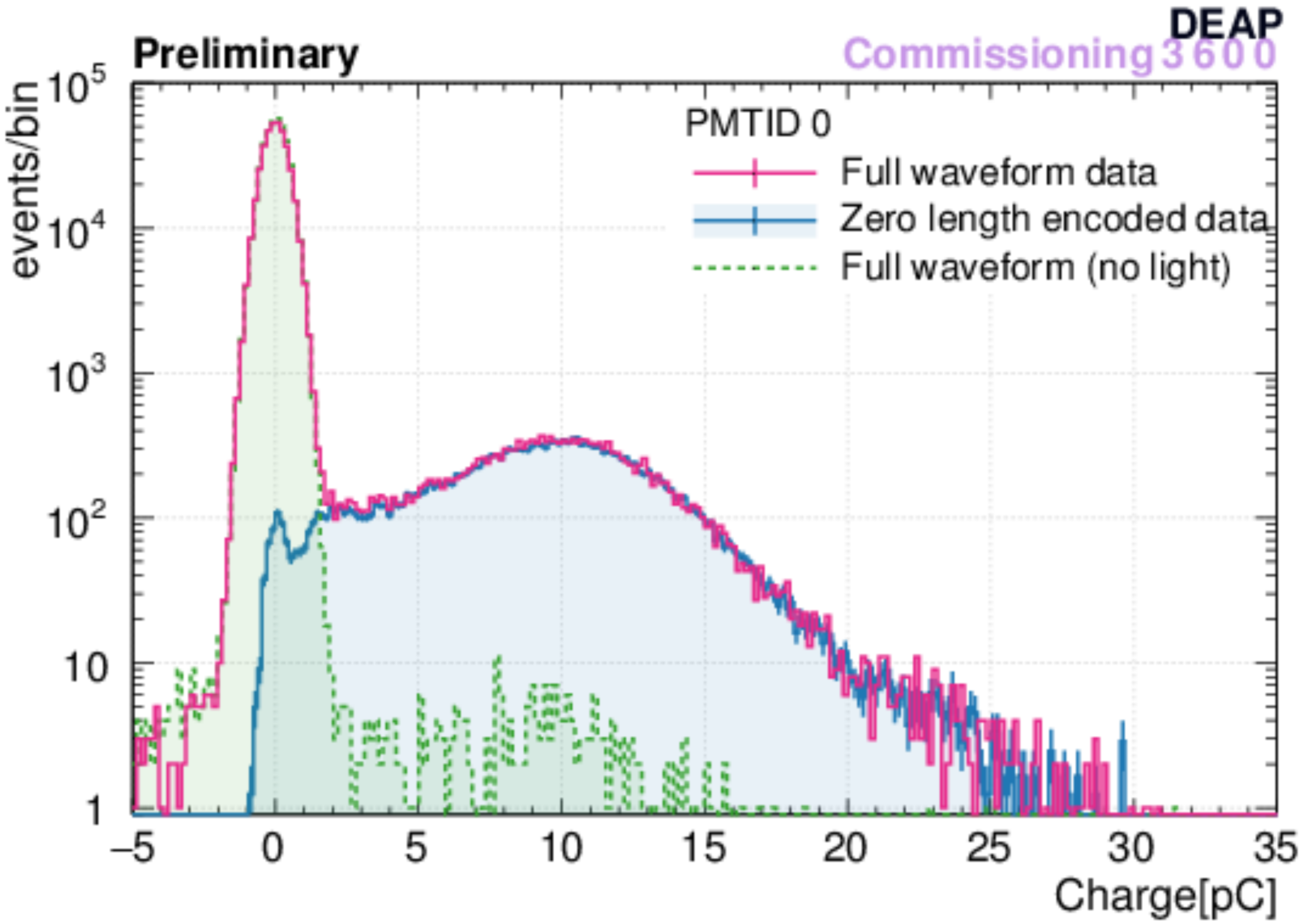
Laserball (homogeneous light source inside the AV)

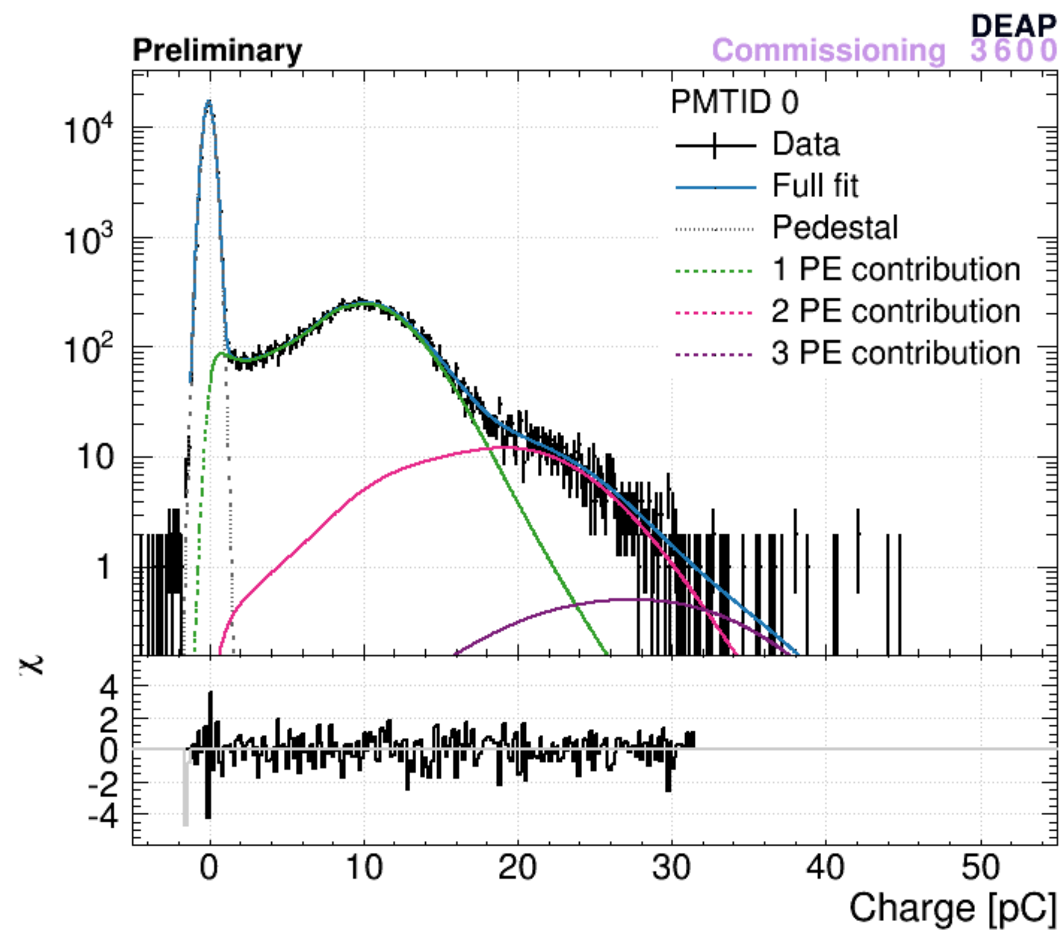
- Time Calibration
- Optical Calibration
- PMTs Response Calibration

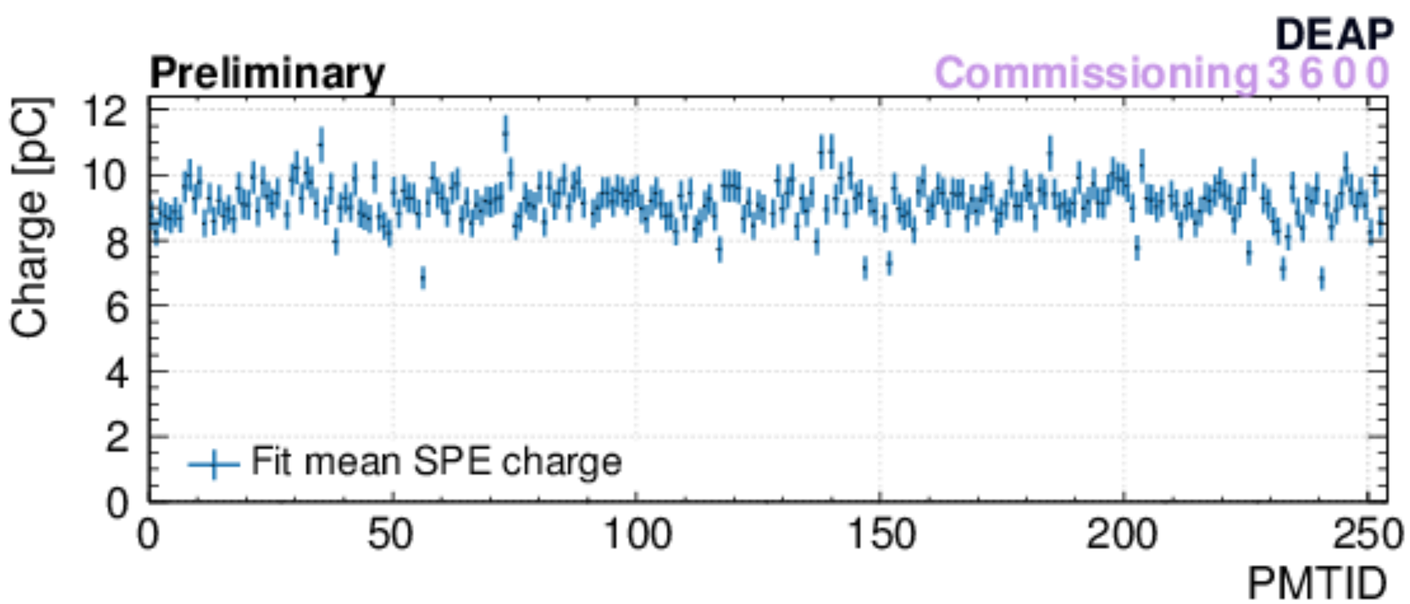




Advanced PMT characterization was achieved during the commissioning phase of the experiment.

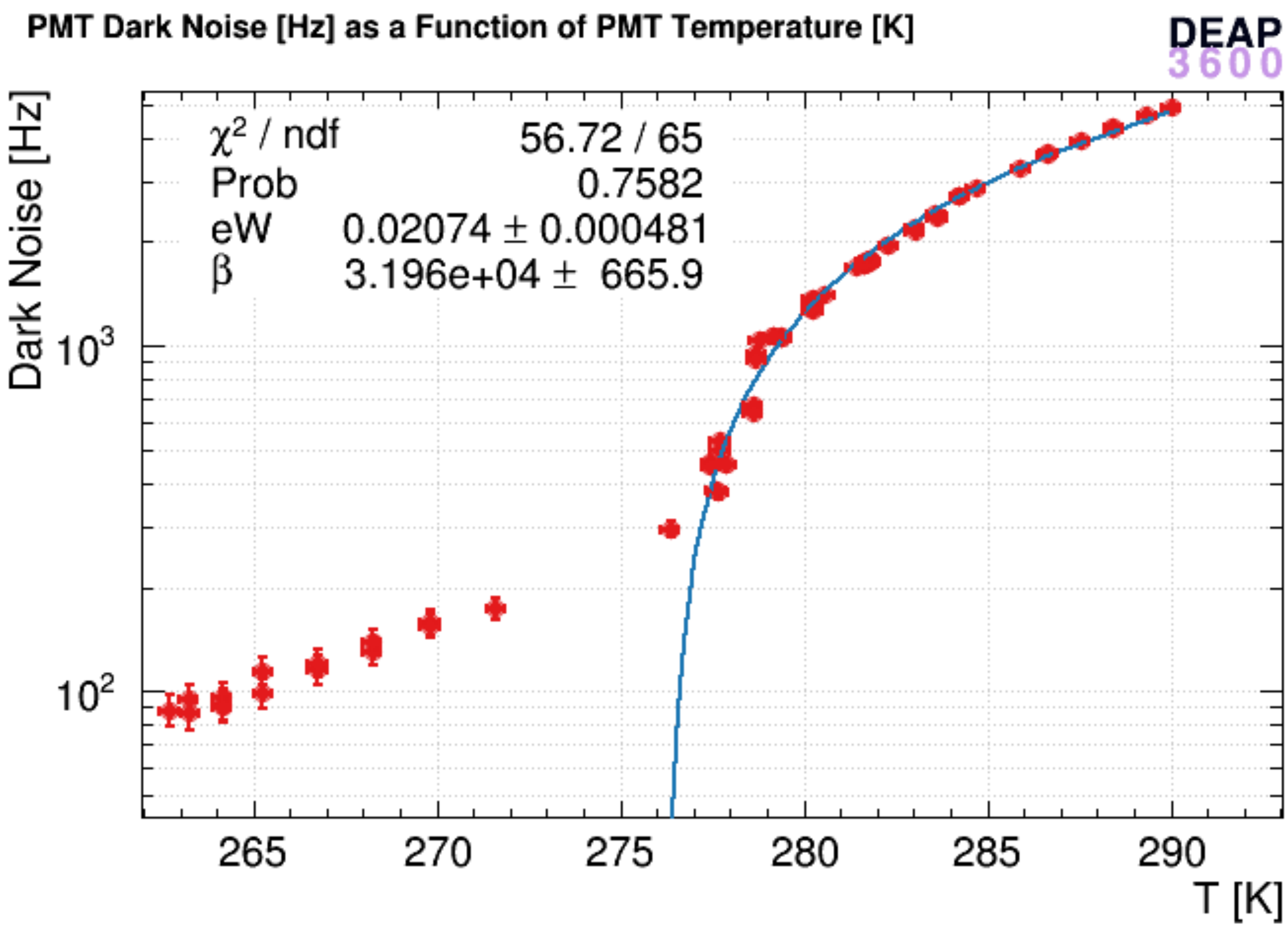




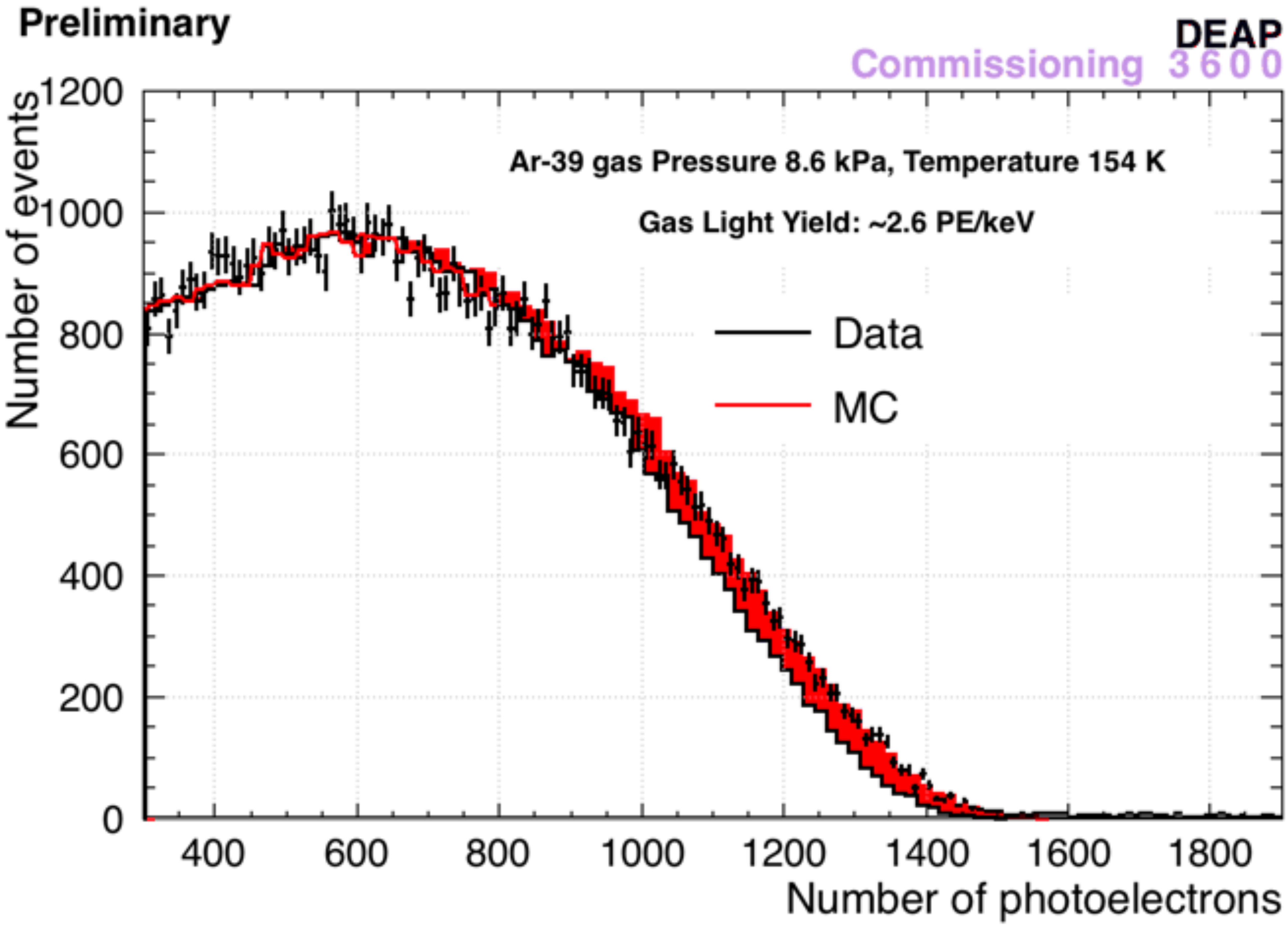


- Advanced PMT Characterization from commissioning AARFS data.
- Full model constructed for extraction of the photoelectron number from PMT charge.
- SPE module is now fully automated.
- Detailed paper will be published soon.

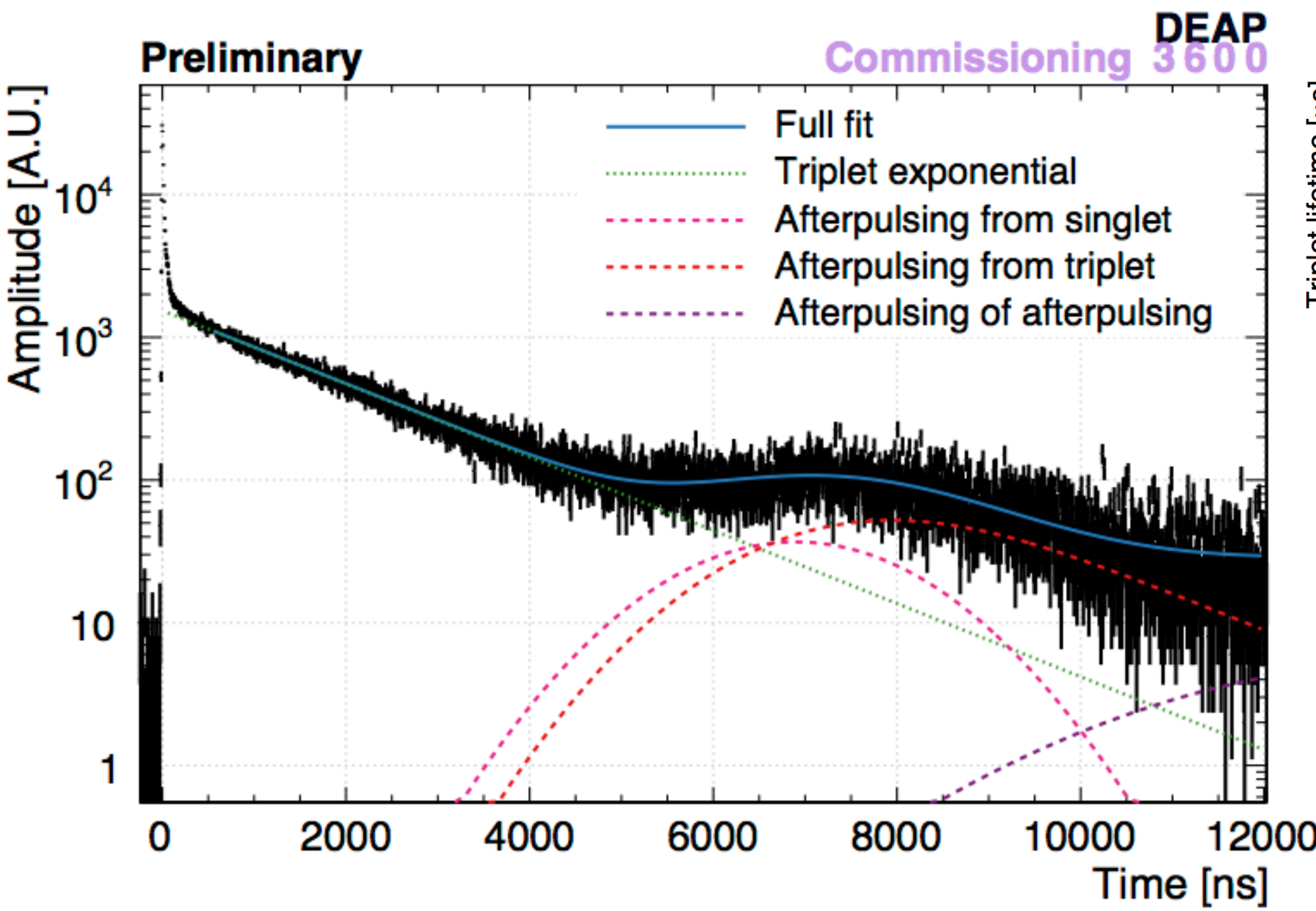
Via RTDs coupled to the PMTs, it was possible to characterize the Dark Noise behavior as a function of Temperature.

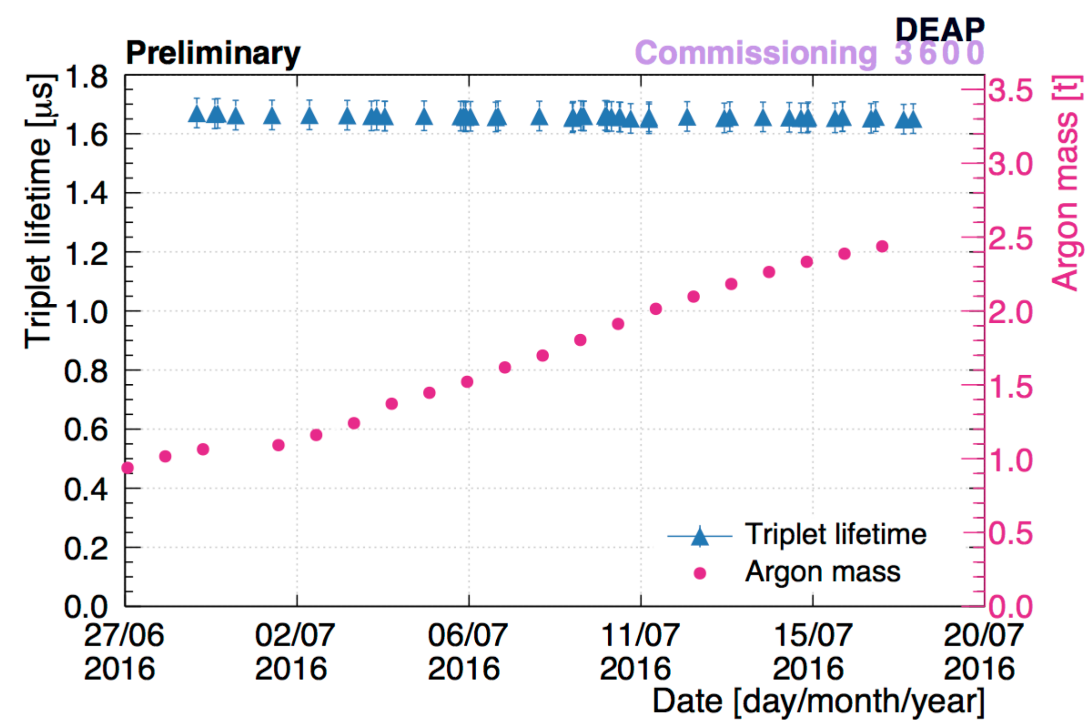


39Ar Spectrum was used in the gaseous phase for an early estimate of the light yield, and comparison to MonteCarlo simulations.



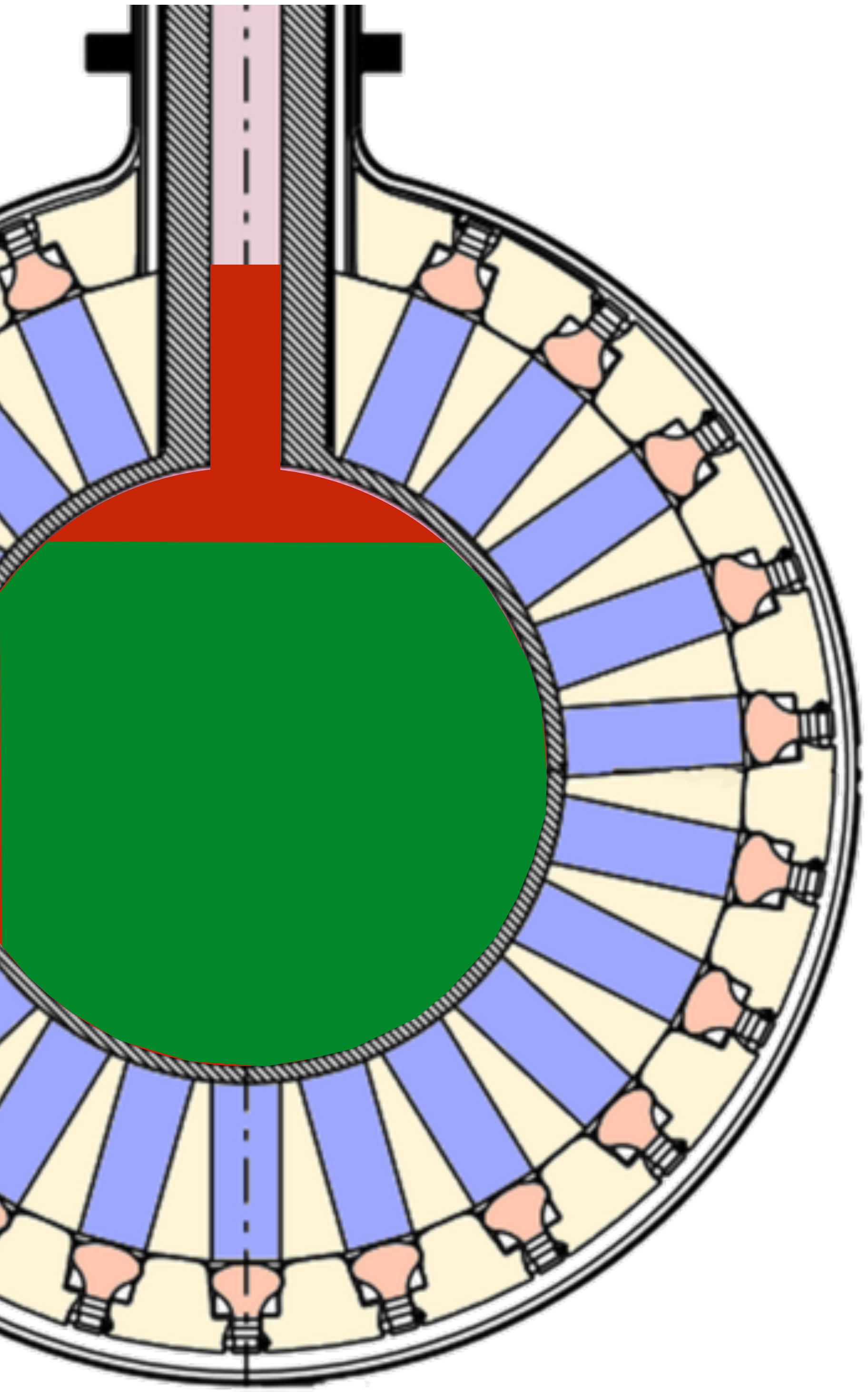
The Argon triplet lifetime is stable throughout the filling phase of the AV. Showing that the argon remained pure.

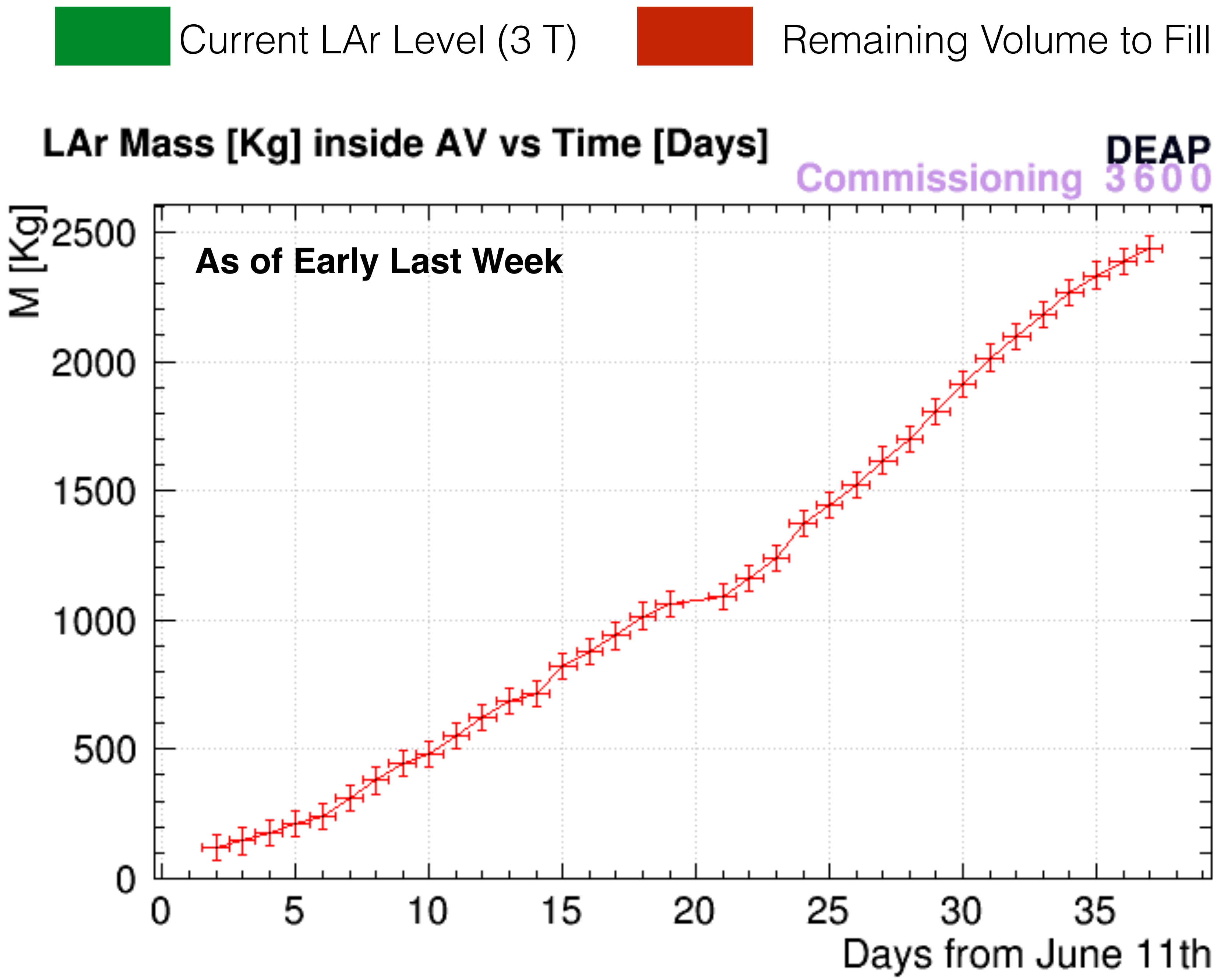




- Continuous filling for the past month.
- The process system can be run in re-circulation model, to further purify the argon.

DEAP-3600 currently contains more than 3100 Kg of LAr. The filling phase will be completed in the coming week. Followed by the first physics run.





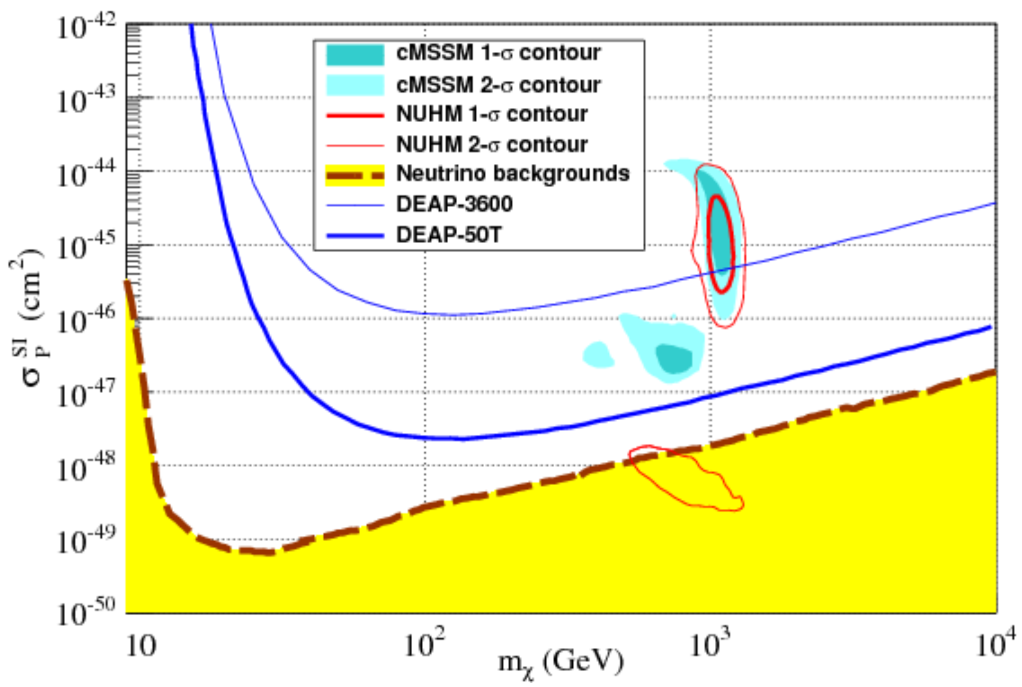
Outlook and future plans.

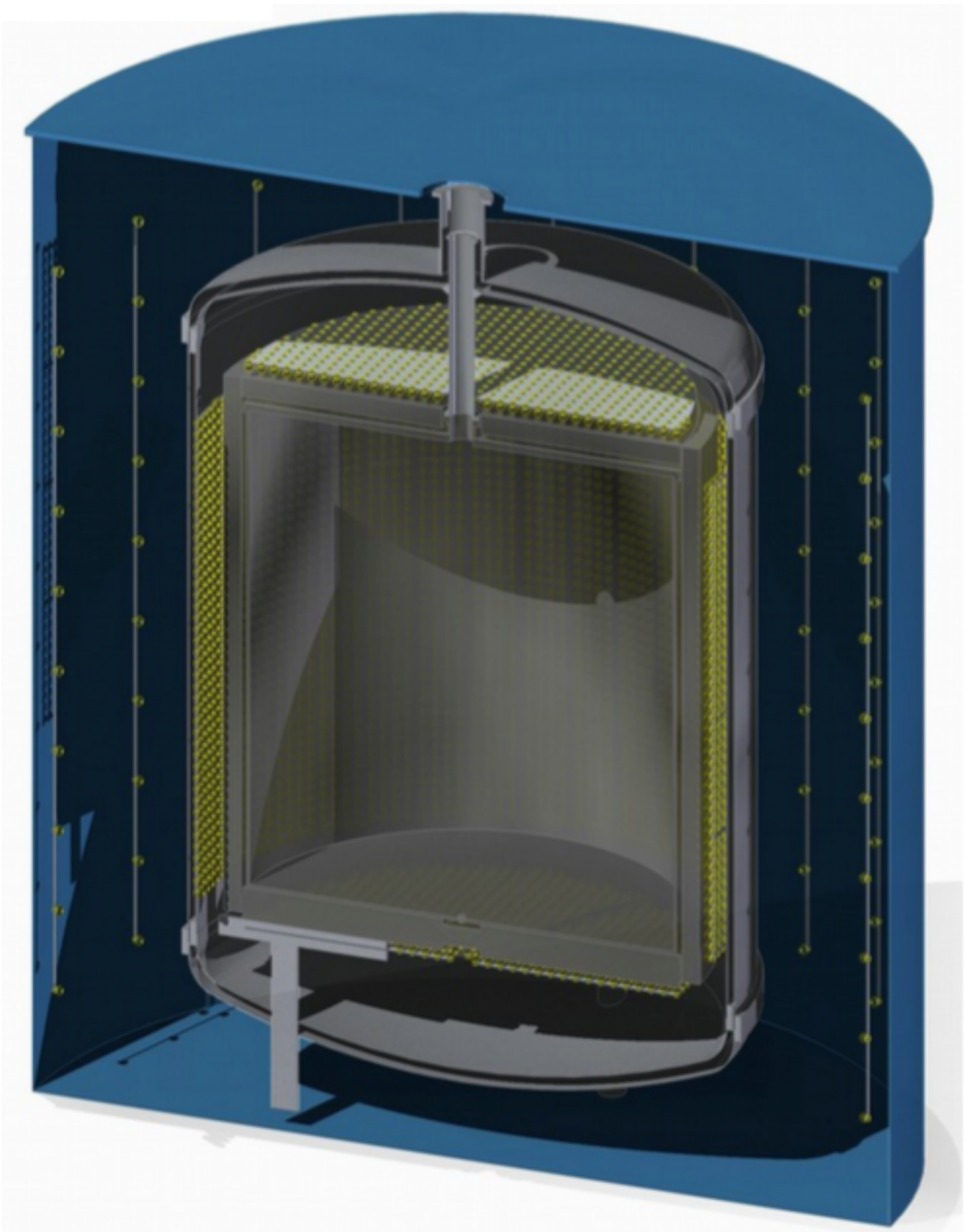
DEAP-3600

- Advanced calibration.
- Ready for first physics run.

DEAP-50T

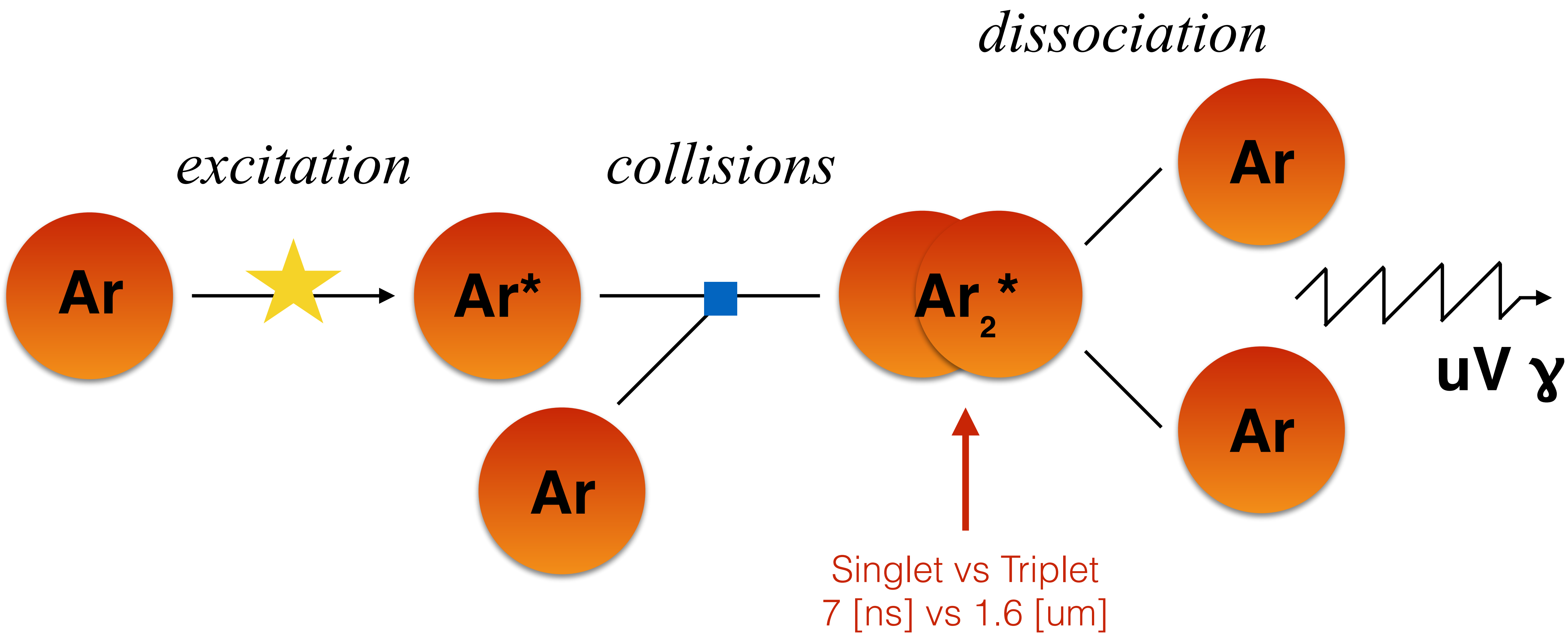
- Plan for a multi tonne DEAP. (150 tonne, 50 tonne fiducial).
- Approaching the neutrino-wall and probing the remaining parameter spaces.
- Possible transition from PMTs to SiPMs.
- Early design and R&D start up at Carleton University.





BACK-UP

Argon scintillation via excitation can be produced vy two different states (singlet & triplet), with distinct lifetime 7 [ns] vs 1.6 [us]

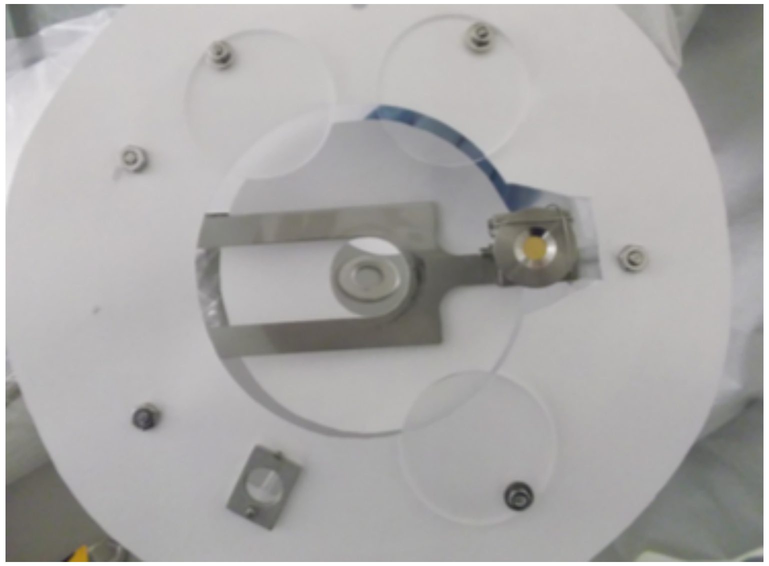


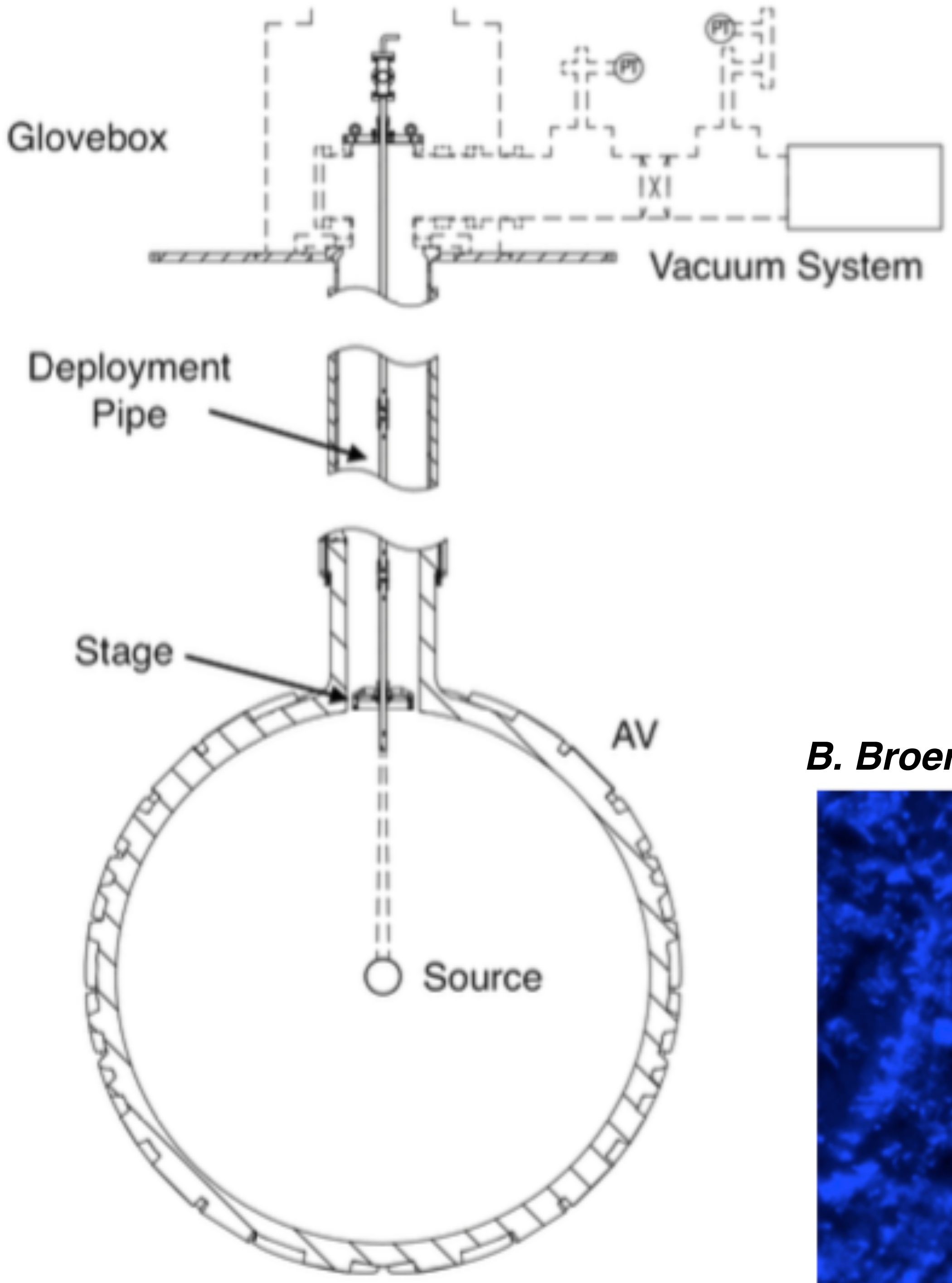
Expected background budget for the DEAP-3600 experiment for an exposure of 3 tonne-years.

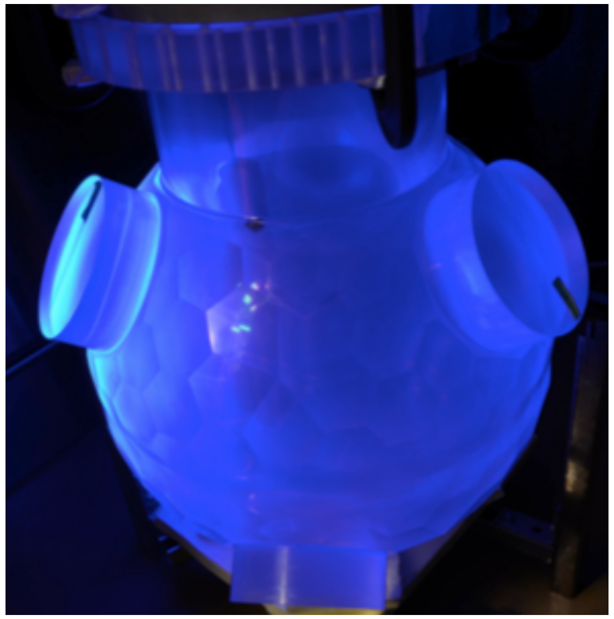
Background	Raw No. Events in Energy ROI	Fiducial No. Events in Energy ROI
Neutrons	30	<0.2
Surface α's	150	<0.2
^{39}Ar β's (Natural Argon)	1.6x10	<0.2
^{39}Ar β's (Depleted Argon)	8.0x10	<0.01
Total	—	**<0.6**

Using conservative values for the light yield and position reconstruction resolution.

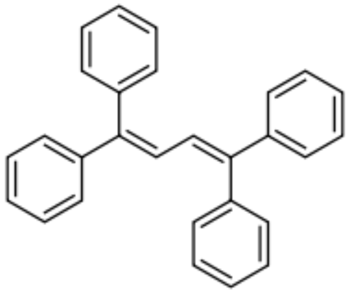
3 microns of wavelength shifter (TPB) were deposited on the AV surface.



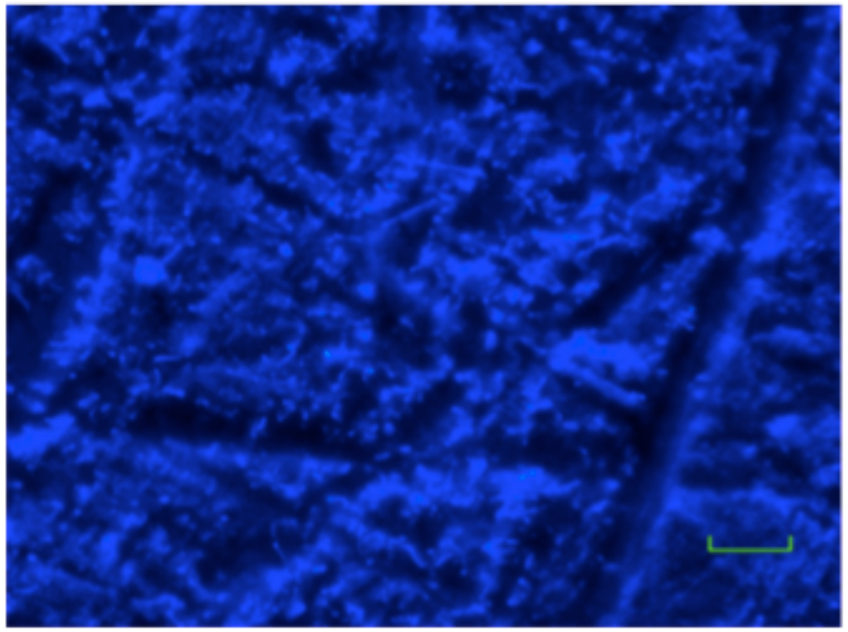




1,1,4,4-tetraphenyl-1,3-butadiene



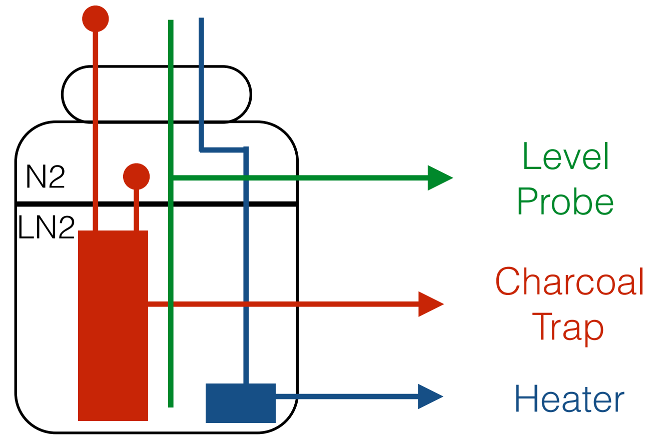
B. Broerman et al., 2016 JINST 11 C02058

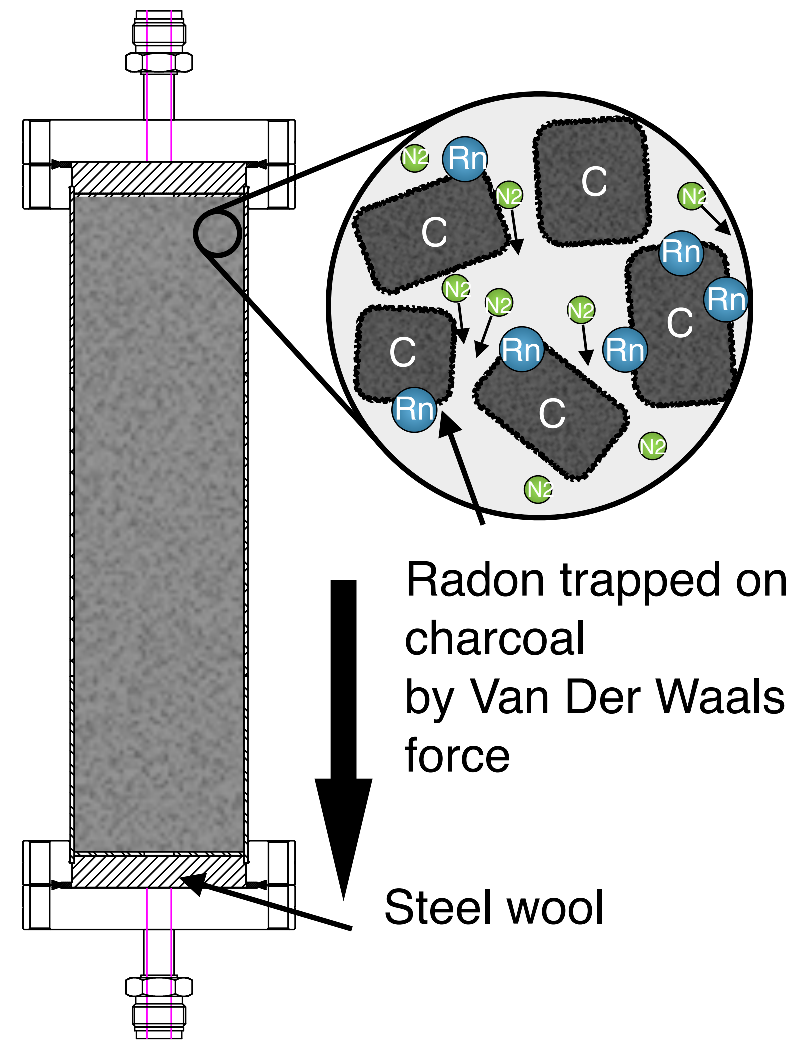


Resurfacer Purge Gas System, Designed to deliver ultra purified N2 gas during sanding.

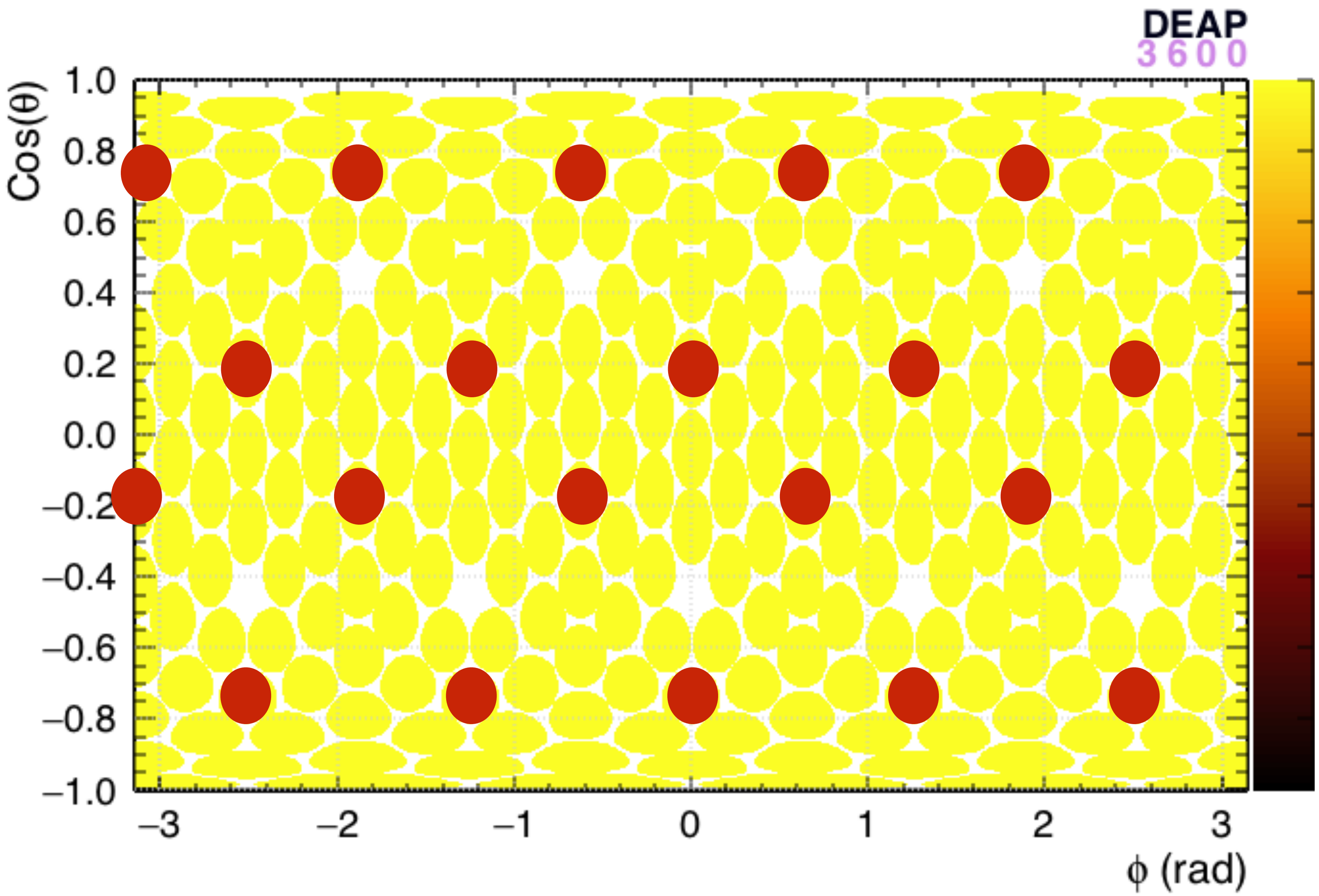
- Purifies boil off nitrogen with a 50g activated charcoal trap.
- Designed so that the internal dewar pressure creates flow through the Rn trap.
- U.L. of 1 mBq of 222Rn inside the AV.
- Generates 0.039 mBq/m3 of Purge Ultra-Purified N2 Gas.
- Purge maintained at a flow of 9 L/m, to balance the in/out of UPW.
- Pressure maintained with a (MKS-640) auto pressure control valve (3 psig).
- Not just for the AV, but used to ensure cleanliness in all other active volumes.

http://www.sciencedirect.com/science/article/pii/S0168900204023356

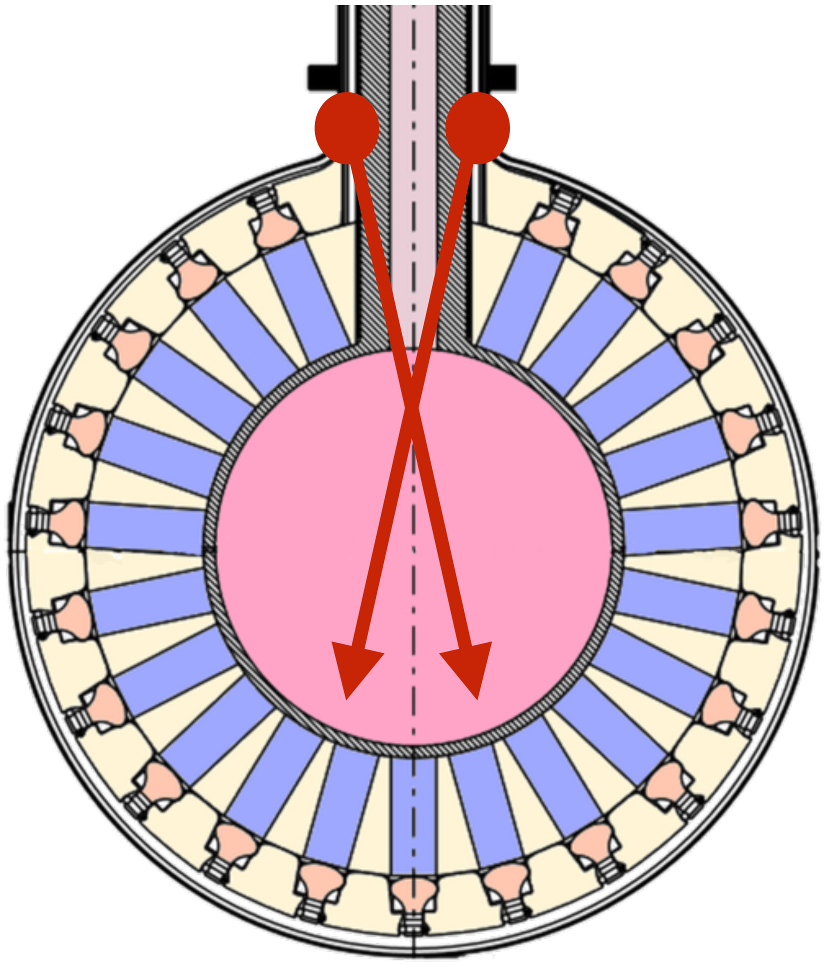




The Acrylic & Aluminum Reflectors and Fibers System inject 450 nm light in 22 points inside the detector.

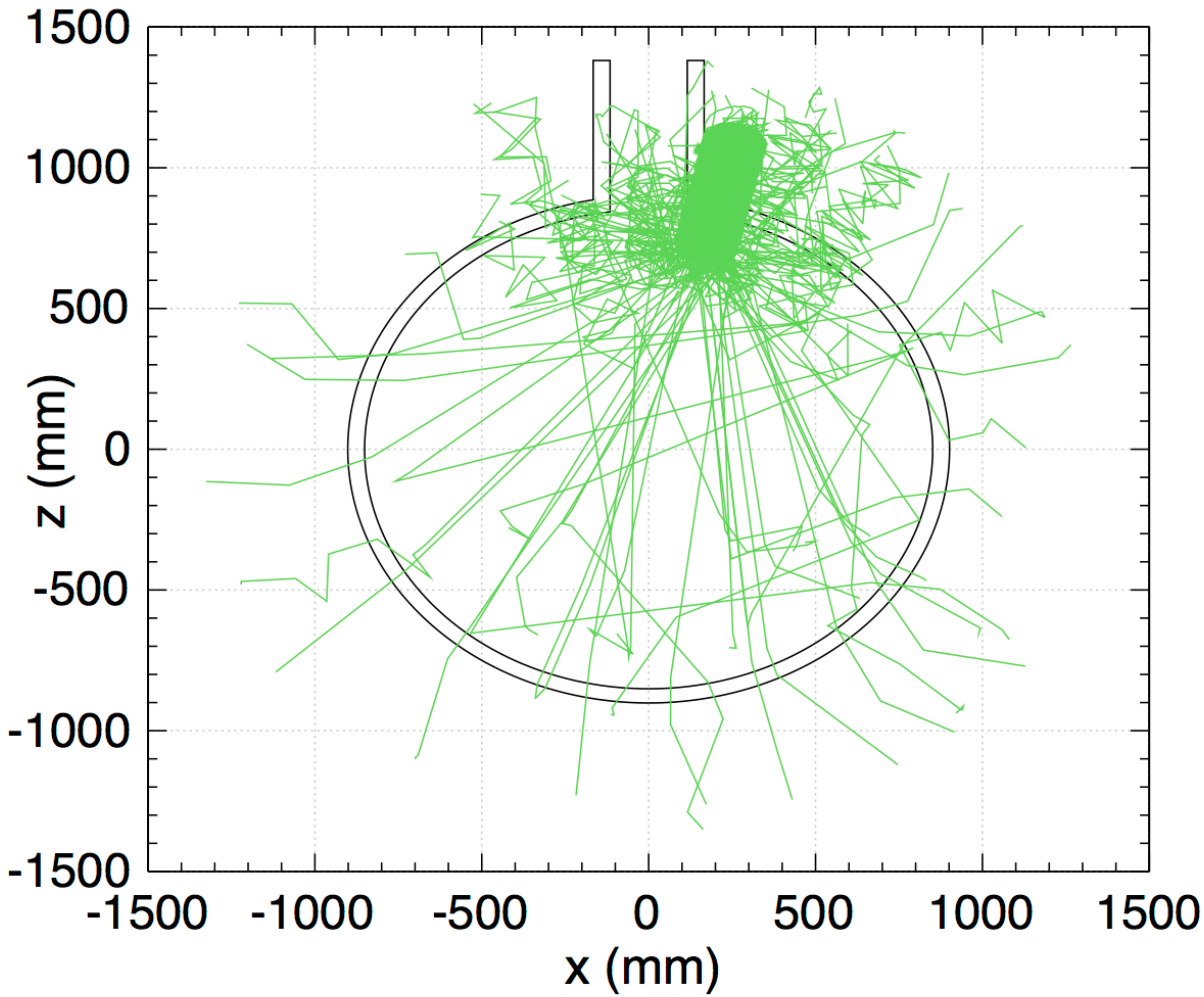


Light Injection Position in the cosine theta - phi plane. Each circle corresponds to a PMT.



2 more AARFS were installed in the acrylic portion of the neck.

Light propagation through the AV sphere (and LGs) for a simulated AARFS event.



The Dark Matter Outlook for the next proposed phased of the experiment.