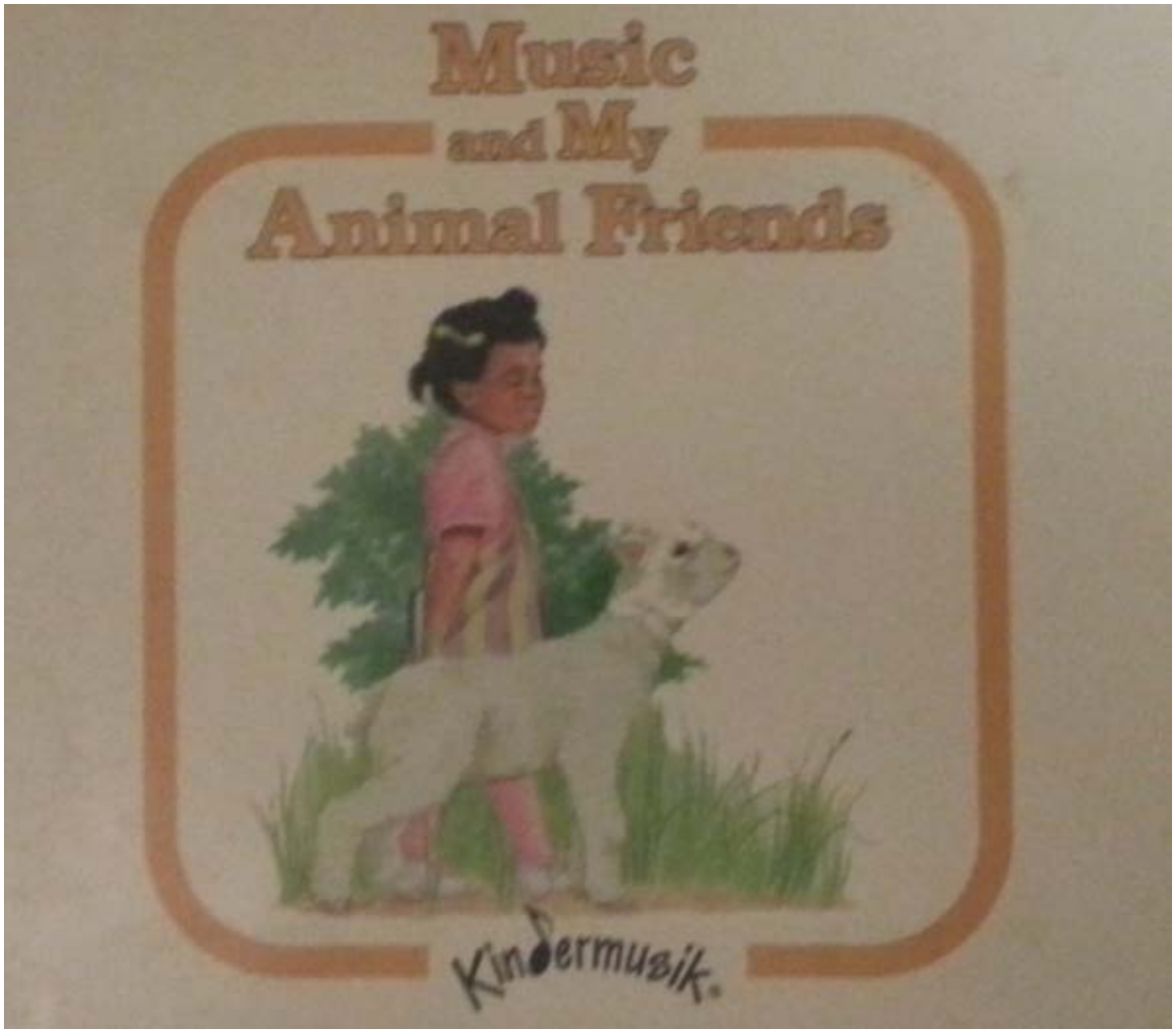
Dark matter **E**xperiment using **A**rgon **P**ulse-shape discrimination DEAP-3600

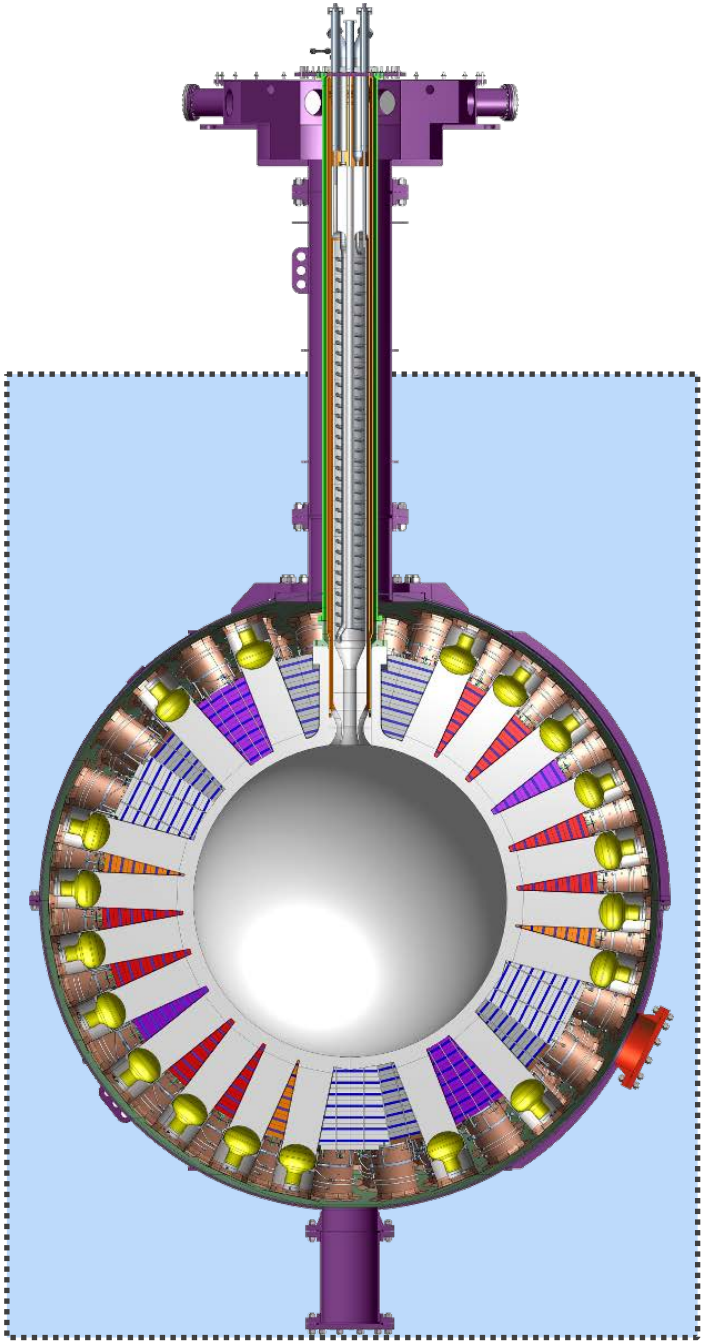
Chris Jillings, SNOLAB and Laurentian University
on behalf of the
DEAP-3600 Collaboration

ArtFest
May 31, 2014

Many of Art’s students know these Kindermusik CDs well.

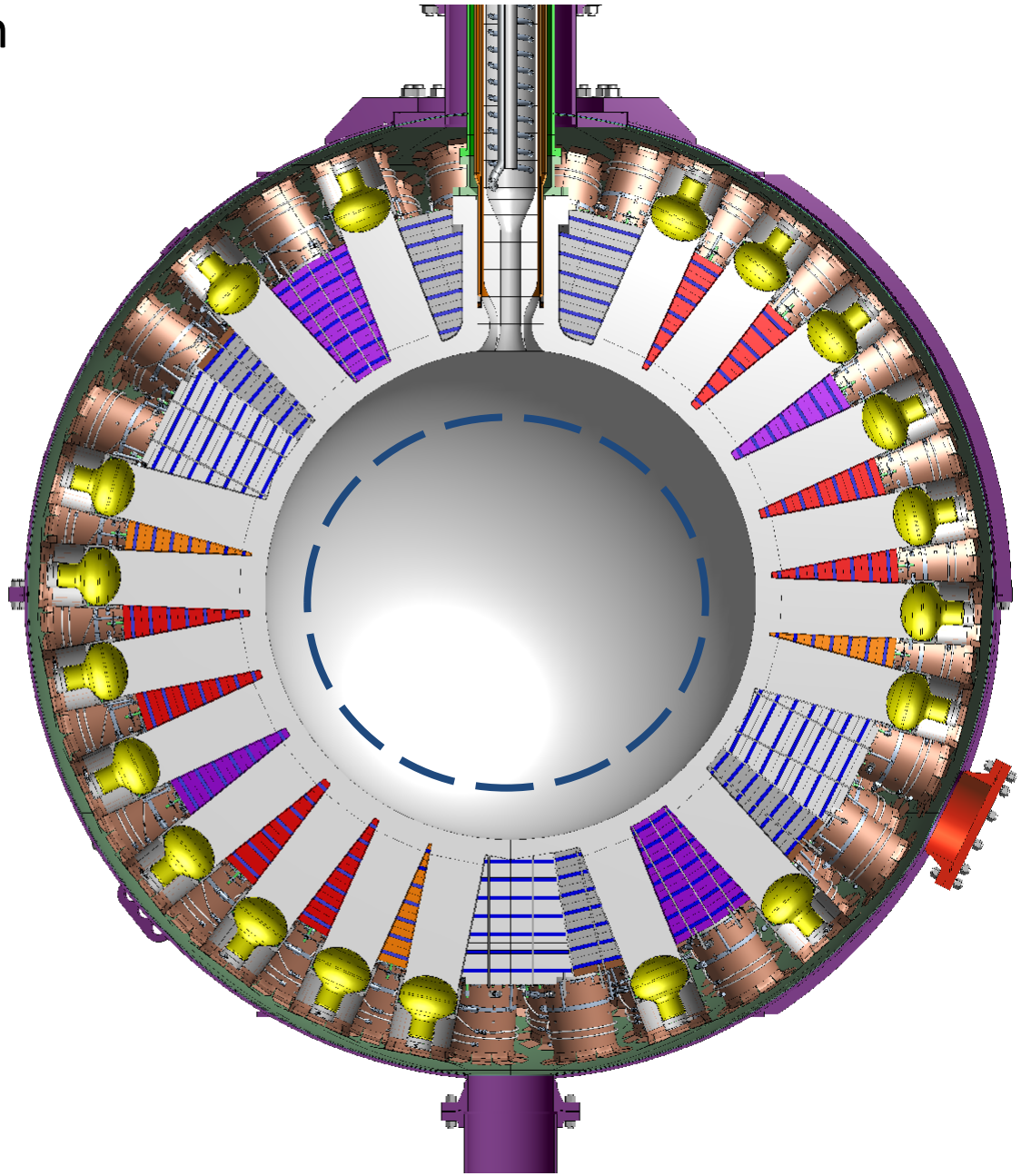


DEAP-3600 was designed from the inside out to achieve WIMP-nucleon recoil sensitivity of **10^{-46} cm^2 at 100 GeV** in 3 tonne-year's exposure using single-phase liquid argon.



Starting with the liquid argon

Will use event reconstruction to create a one-tonne fiducial volume away from surfaces.



Cooling achieved with coils in neck fed with liquid nitrogen from and vapour return to a large dewar.

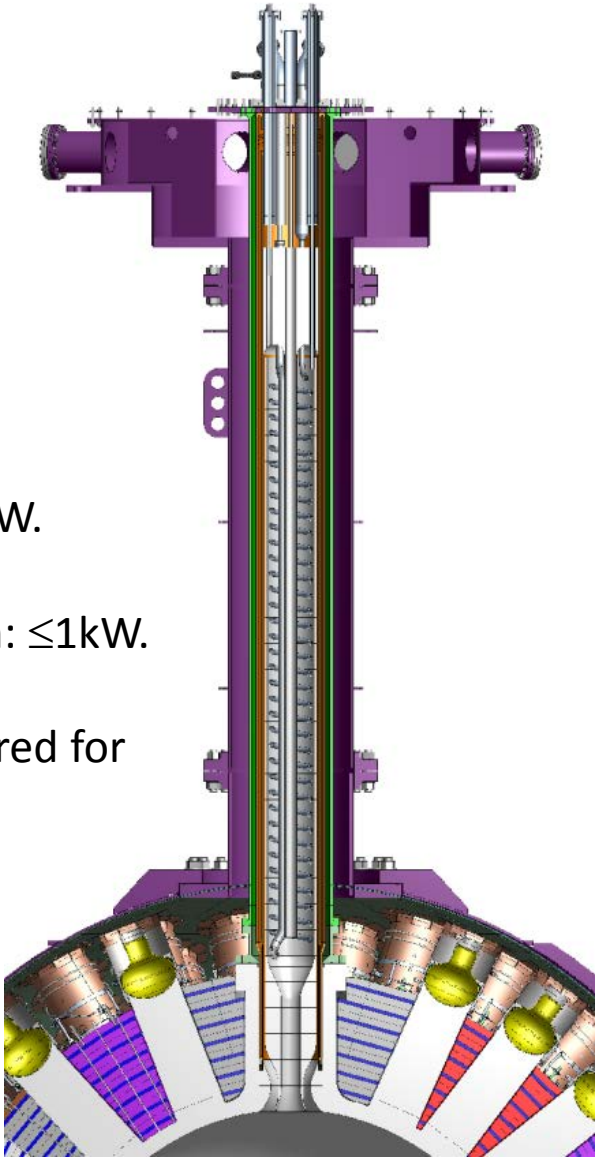
Do not need to pump argon to cool it.

Nitrogen cooling will last four days without power.

Cooling system: 3kW.

Heat load on argon: ≤1kW.

(Cooling also required for radon trap.)



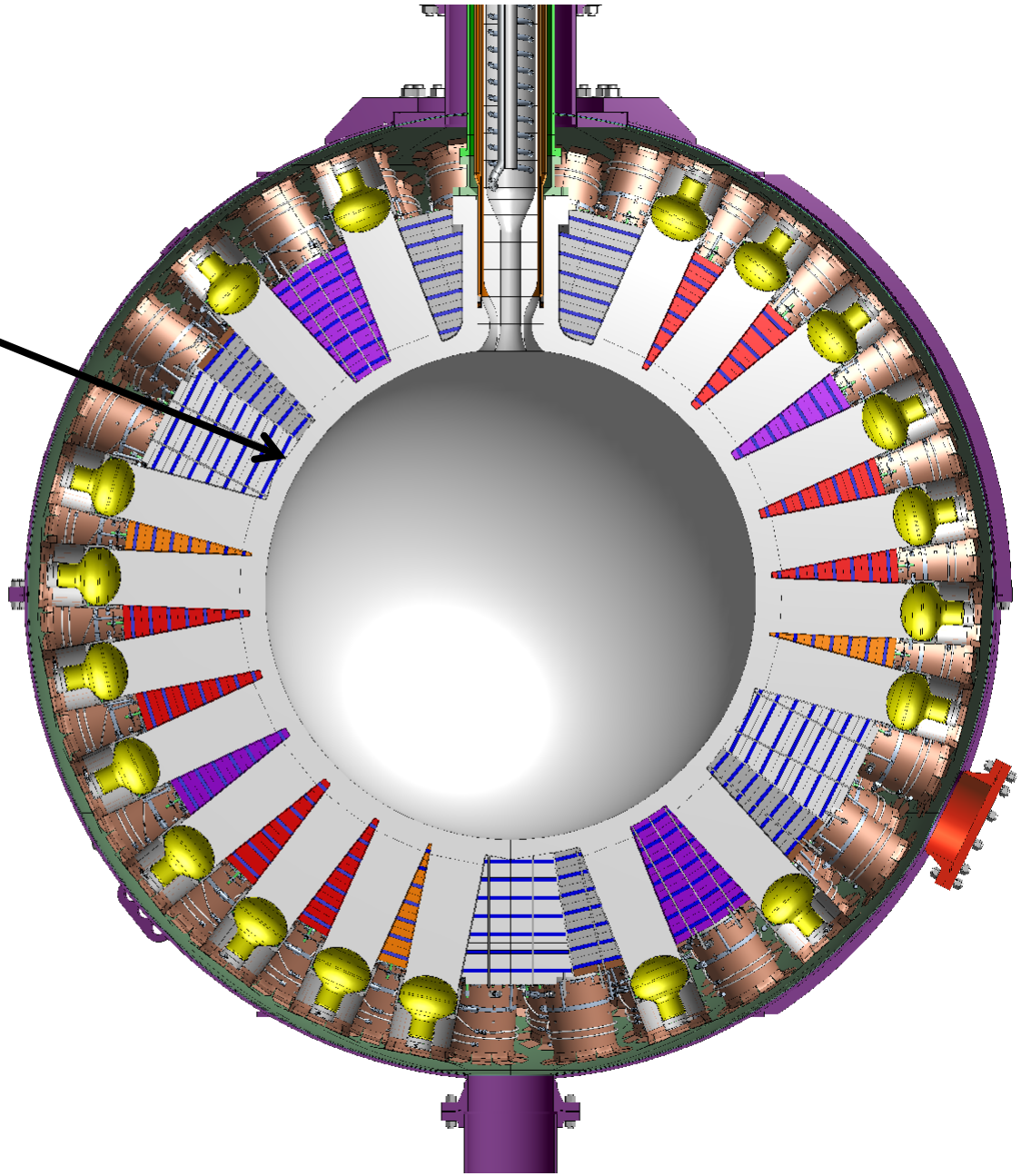
All Argon process system components tested for radon emanation. Cooling without pumping argon.

Design of process systems based on minimizing sources of radon:

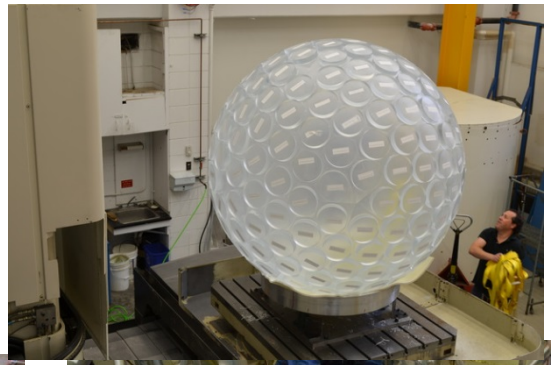
All valves and components considered a source of radon and justified against that risk.

Workers at Queen's Prepare the Radon Trap

The Acrylic Sphere

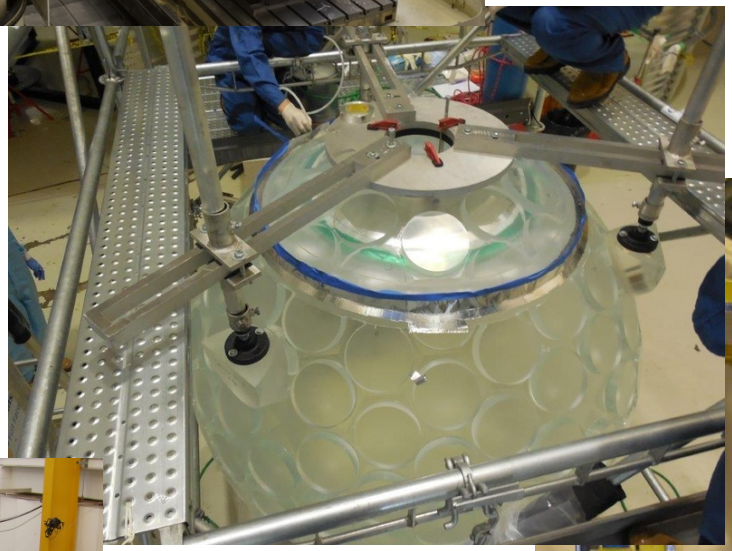


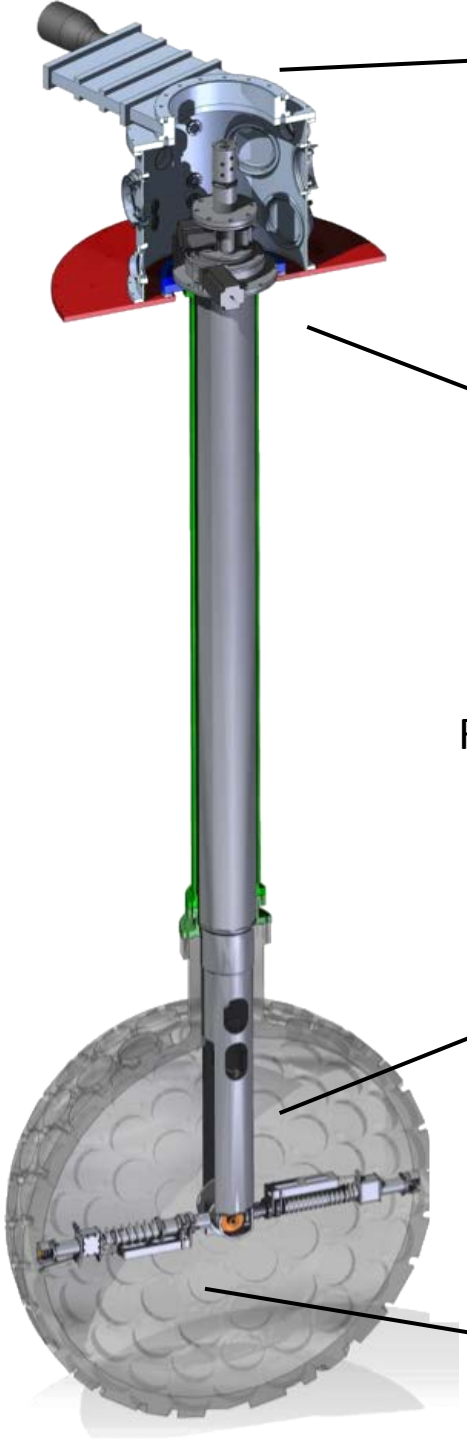
Radon History of **Acrylic Vessel** Tracked Throughout Production at ThaiMMA, RPT Asia, RPT Grand Junction, the University of Alberta and SNOLAB



Reported at Low Radioactivity Techniques, LRT2013 at LNGS.

AIP Proceedings v1549

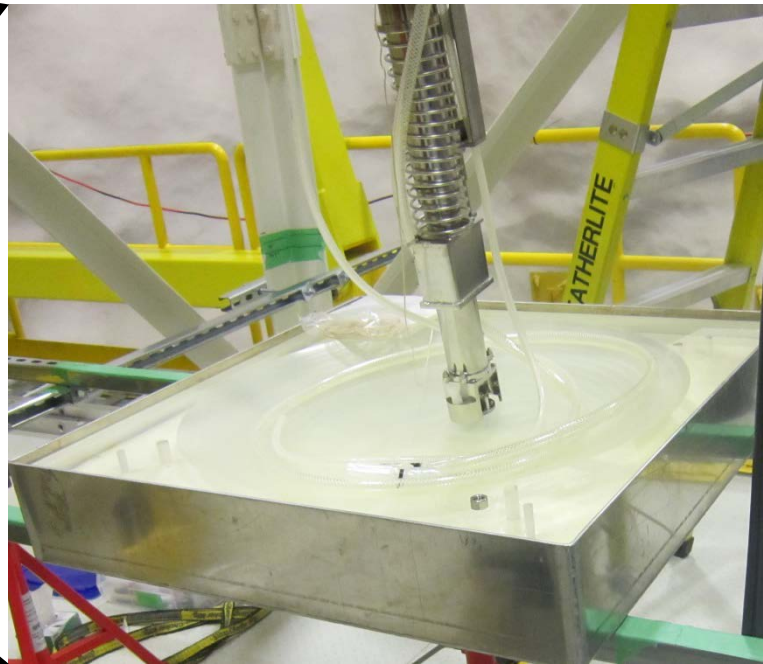




Radon can diffuse into the acrylic or decay near it during construction. Control radon progeny with resurfacing.

(Reported at Low Radioactivity Techniques 2013)

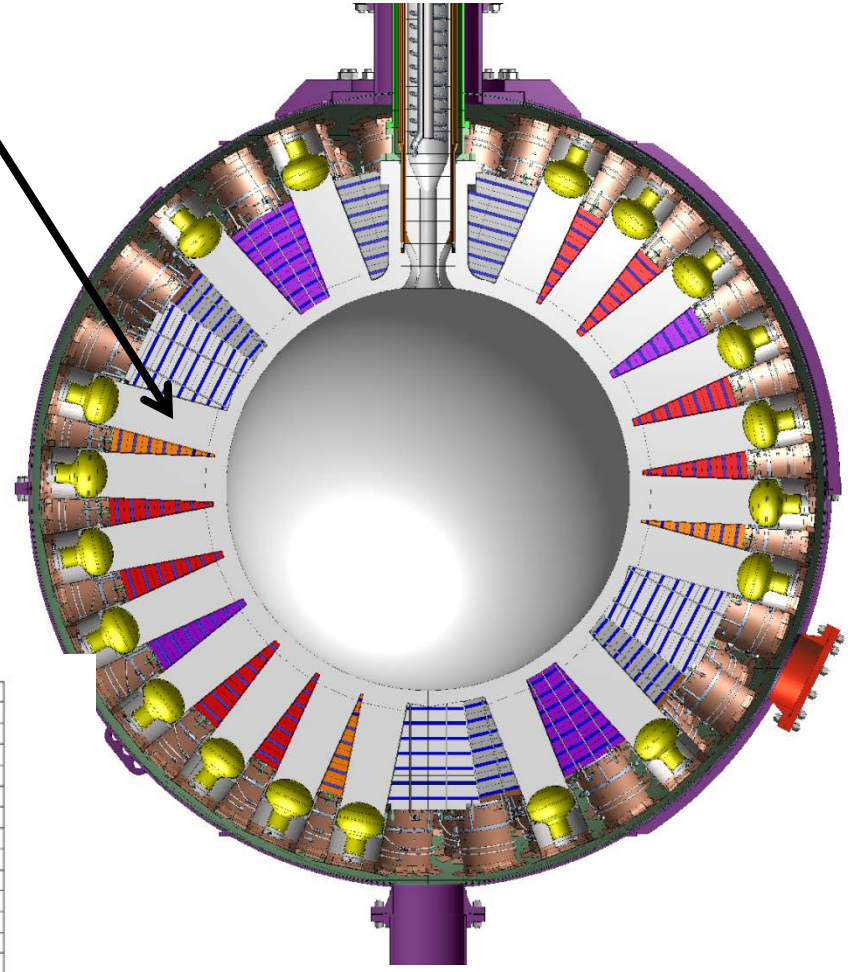
Photos from commissioning at SNOLAB.

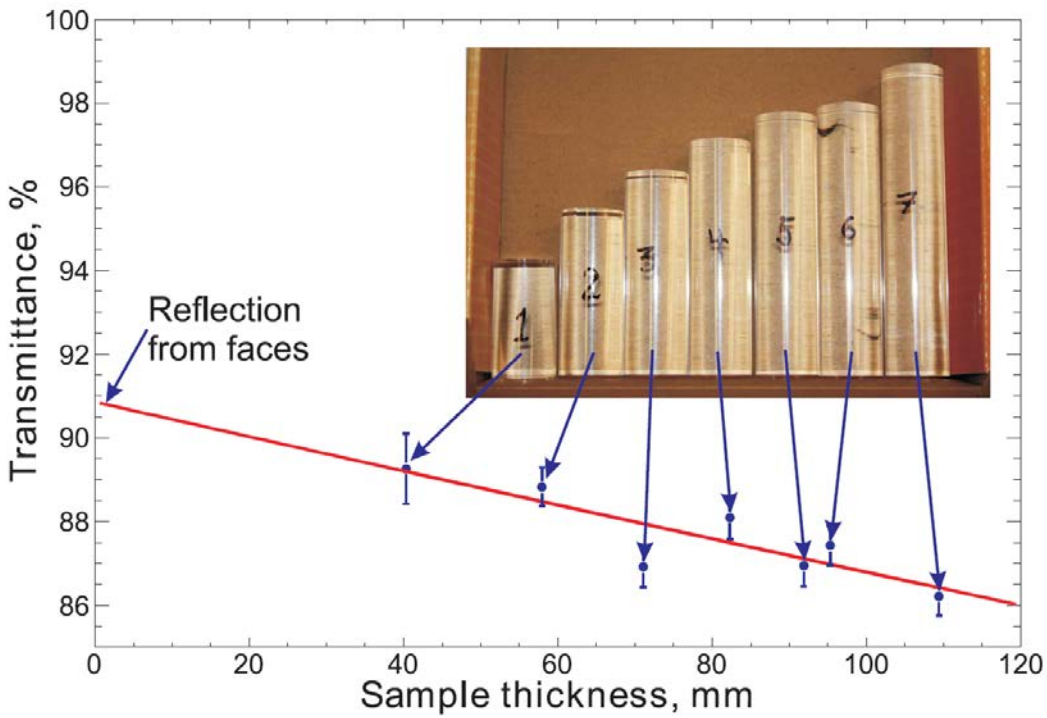


The light guides allow the PMTs to operate warm.

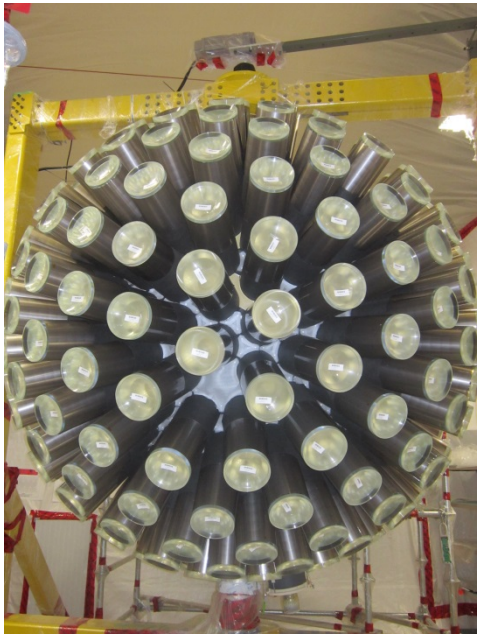
An enormous effort qualified the light guide acrylic for transparency as pulse-shape discrimination

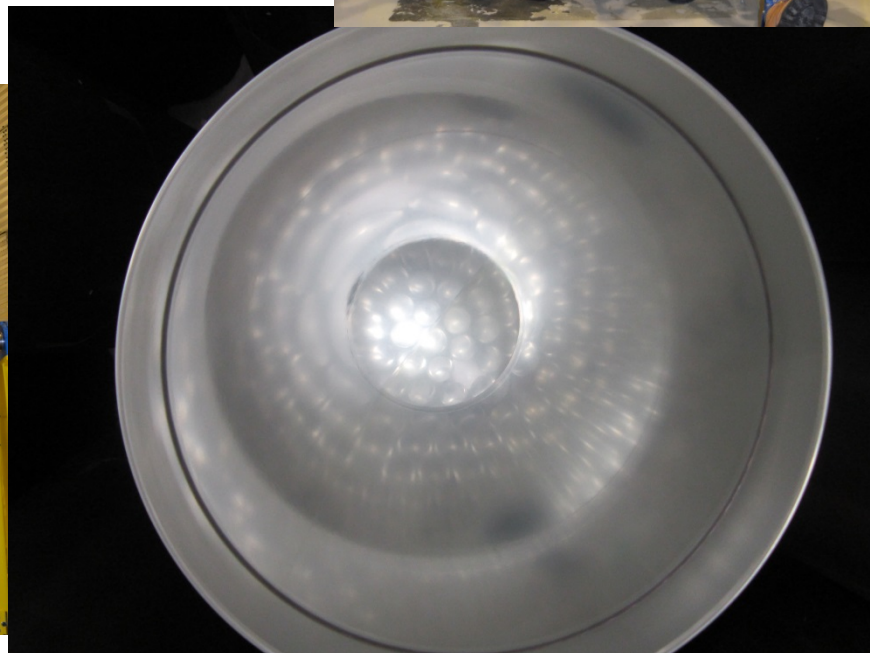
They provide shielding from PMT neutrons



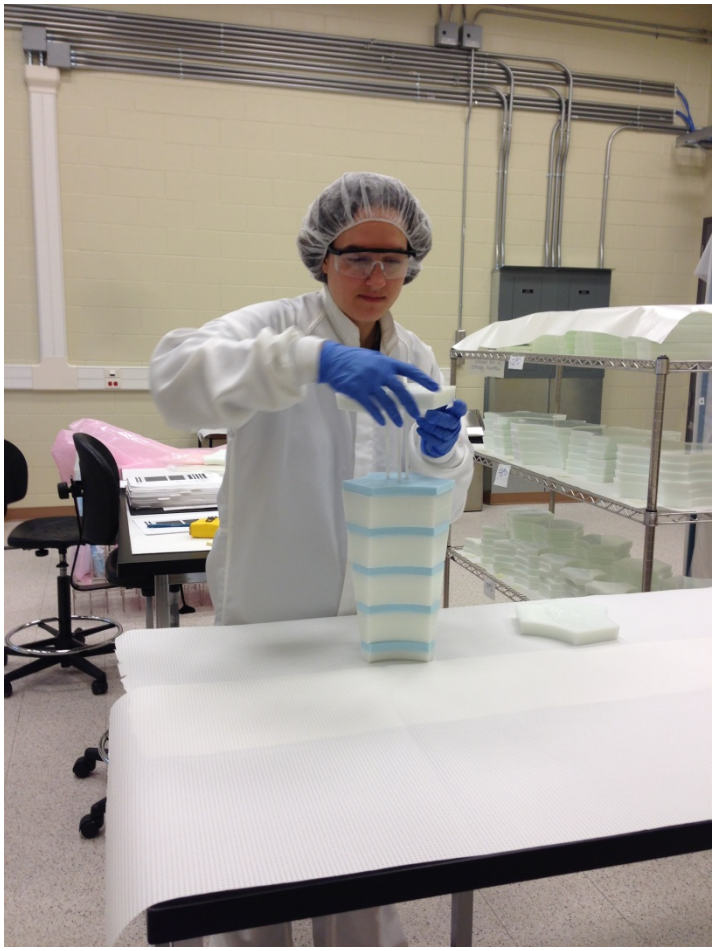


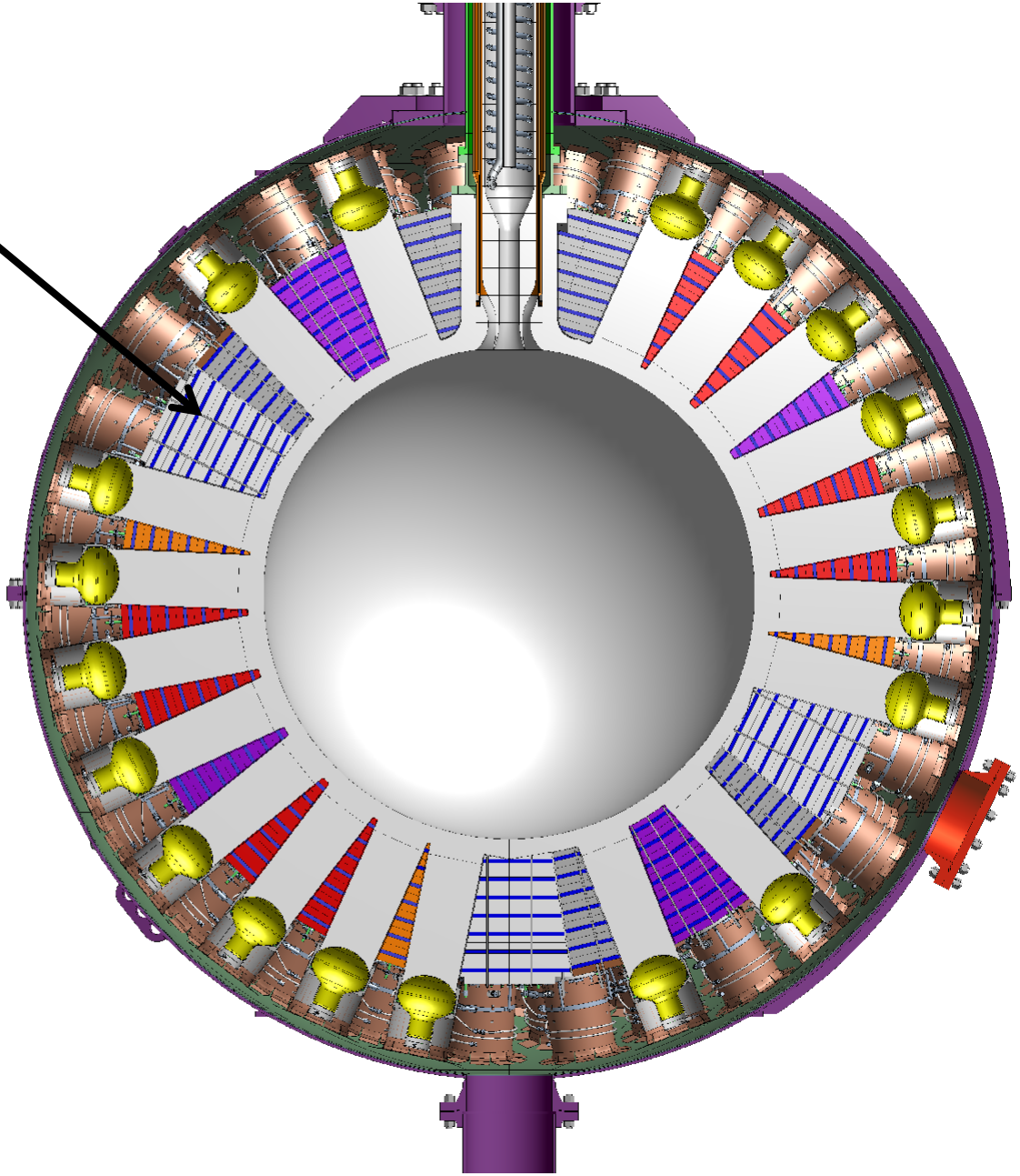
Hundreds of measurements such as this at various wavelengths on different samples.





The Filler Blocks are alternating layers or HDPE and polystyrene.





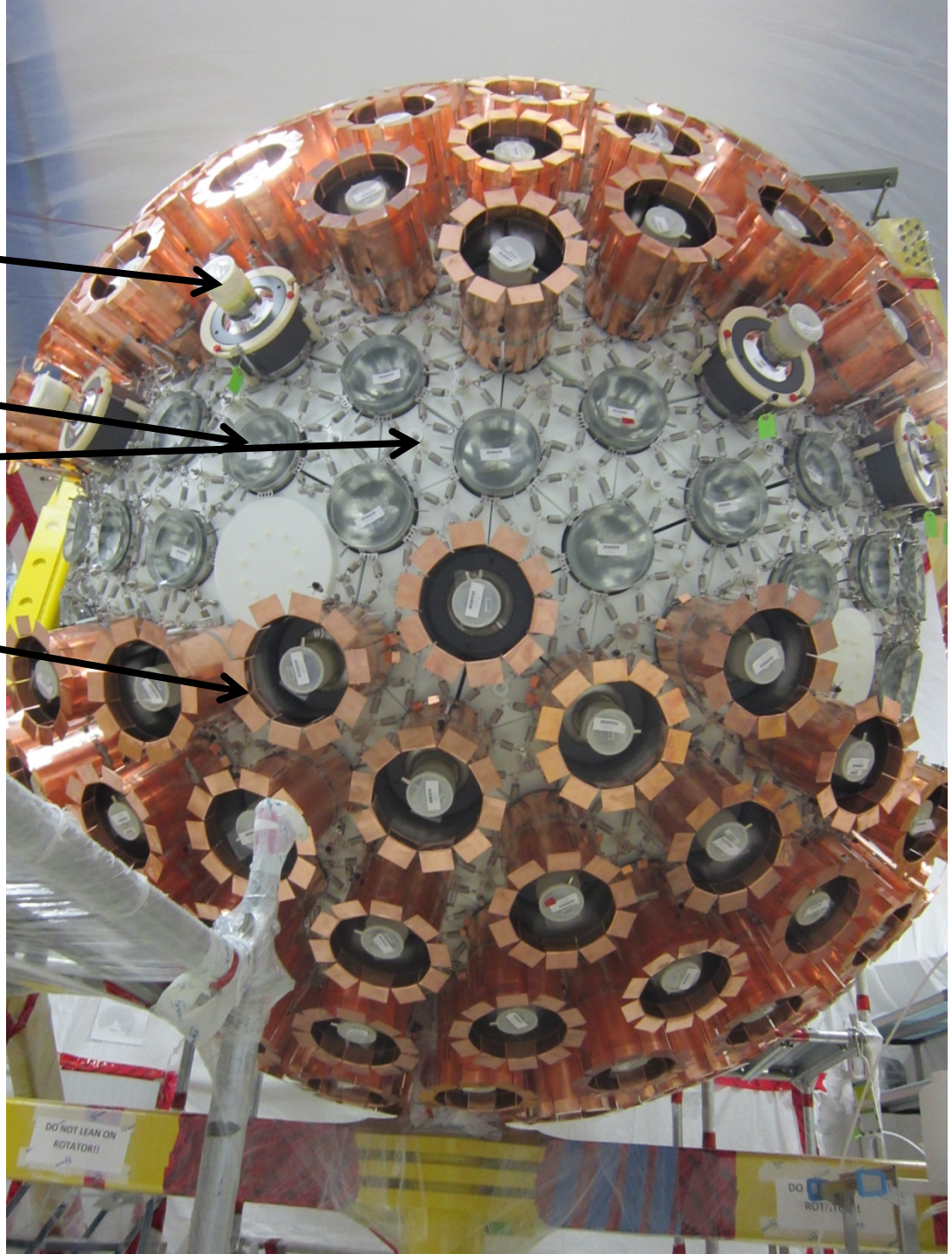
The near-final assembly

PMTs

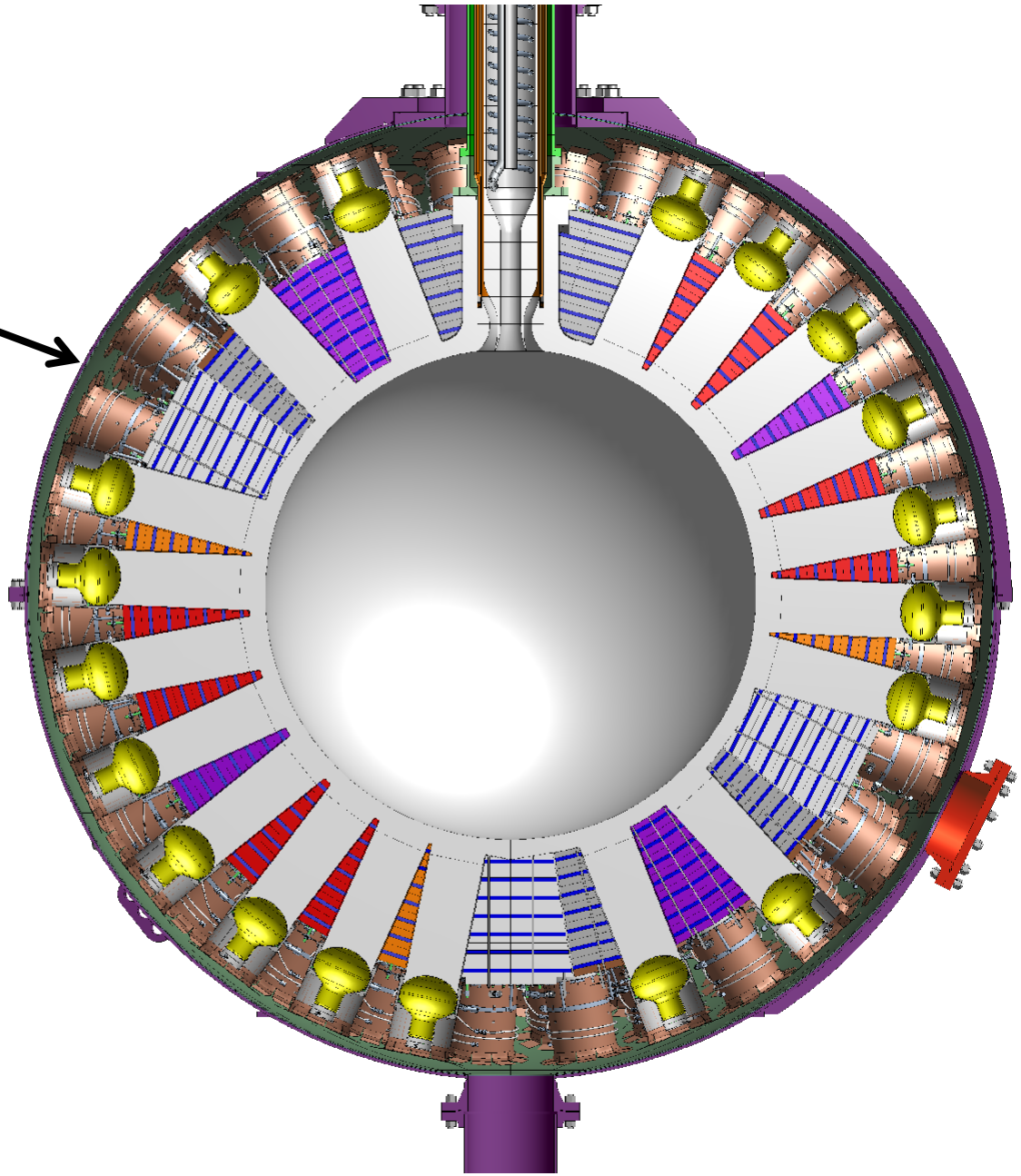
light guides

filler blocks

Copper thermal shorts around PMT



The Steel Shell



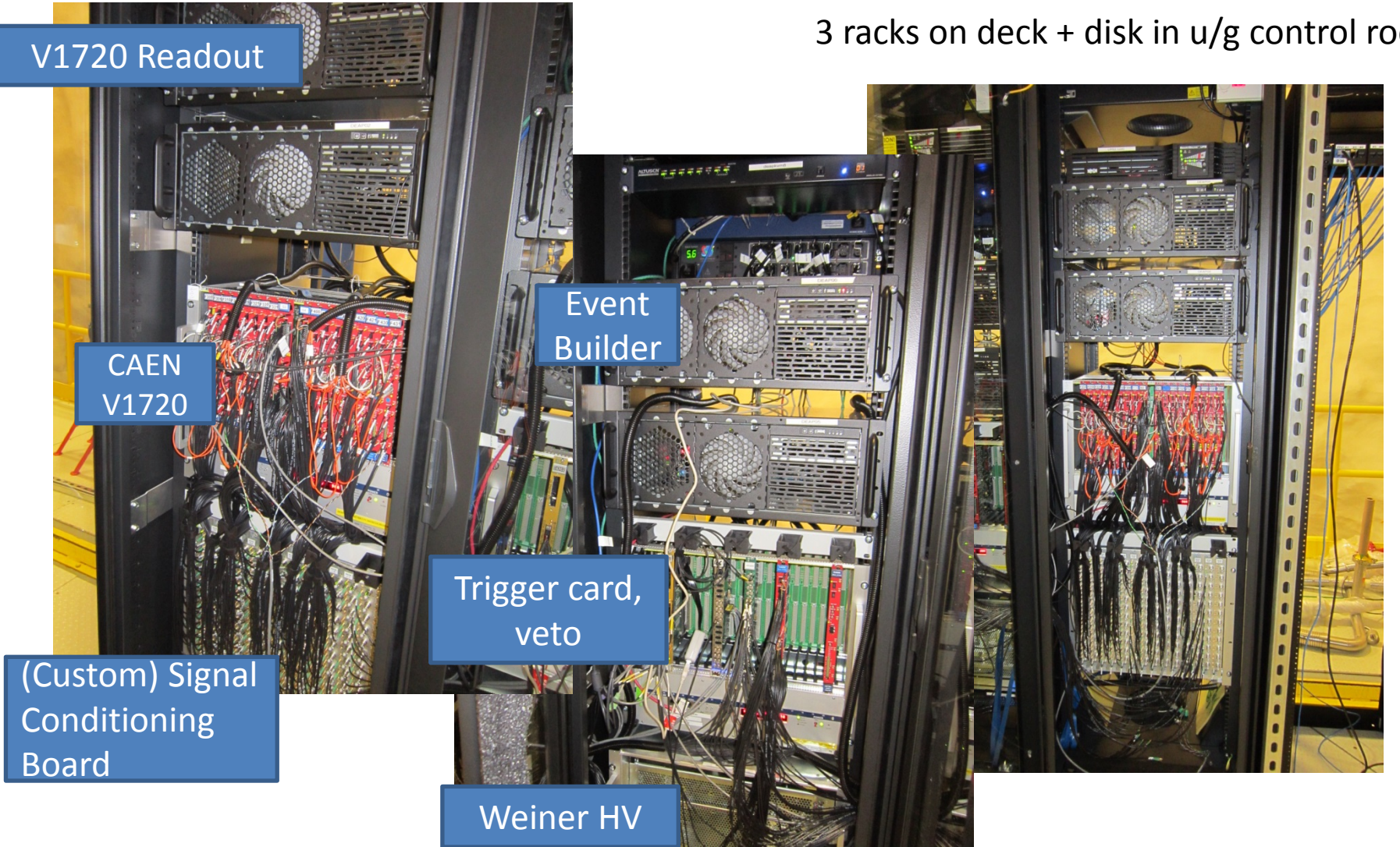
The Steel Shell is a Section-8 Pressure Vessel designed for human safety in event of upset conditions

A large bladder will line the water tank.

Veto PMTs will create a Cherenkov veto for cosmic rays.
(2.9/m^2/day at SNOLAB)

Electronics and DAQ must reduce in hardware the data from 10^{10}Argon betas while measuring a few WIMPS.

3 racks on deck + disk in u/g control room

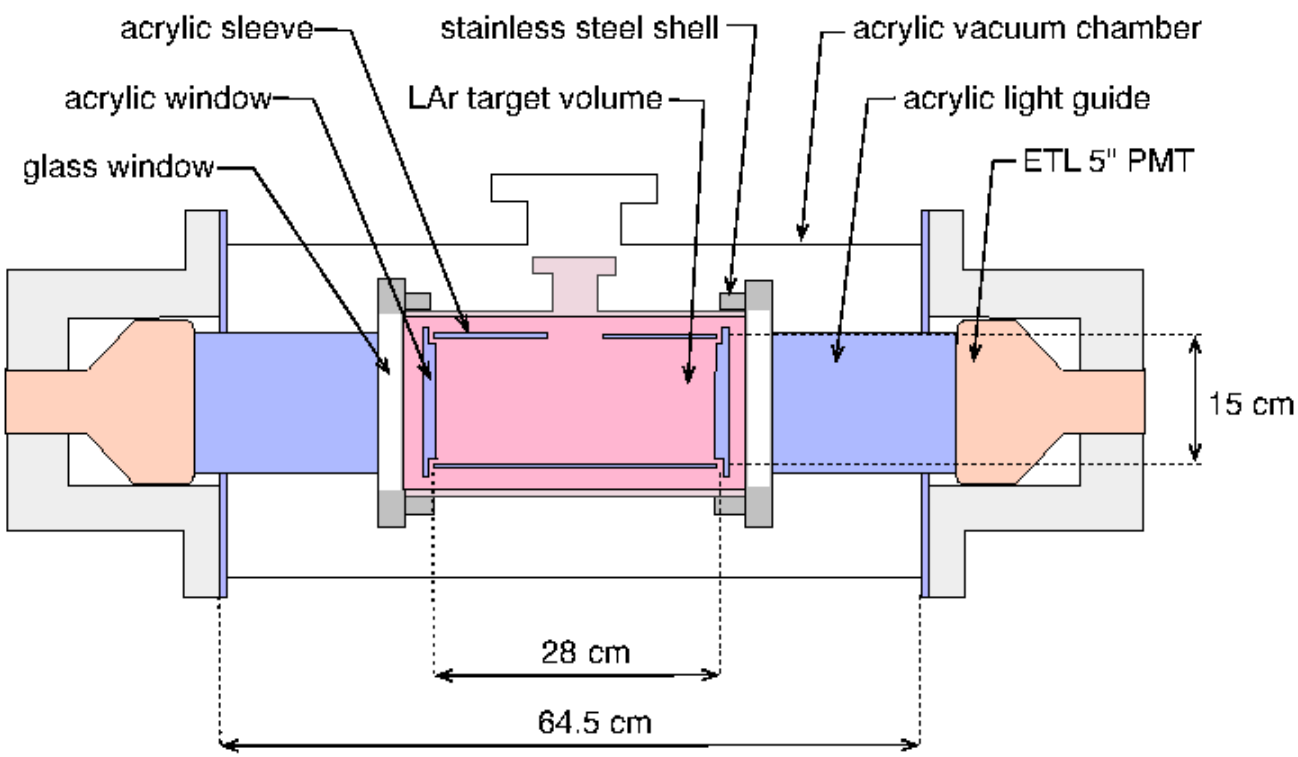


Calibration sources inserted into detector are a contamination risk: No sources to be placed in Argon

Calibration Tools	Optical Response	Energy Reconstruction	Radius Reconstruction	Detector response and stability vs time
LED, lasers, in-situ single PE tails	✔	✔		✔
Gamma sources (tagged ^{22}Na)		✔	✔	✔
Neutron source (AmBe)		✔	✔	✔
In-situ ^{39}Ar	✔	✔	✔	✔

Table from P. Gorel (Rencontres Moriand)

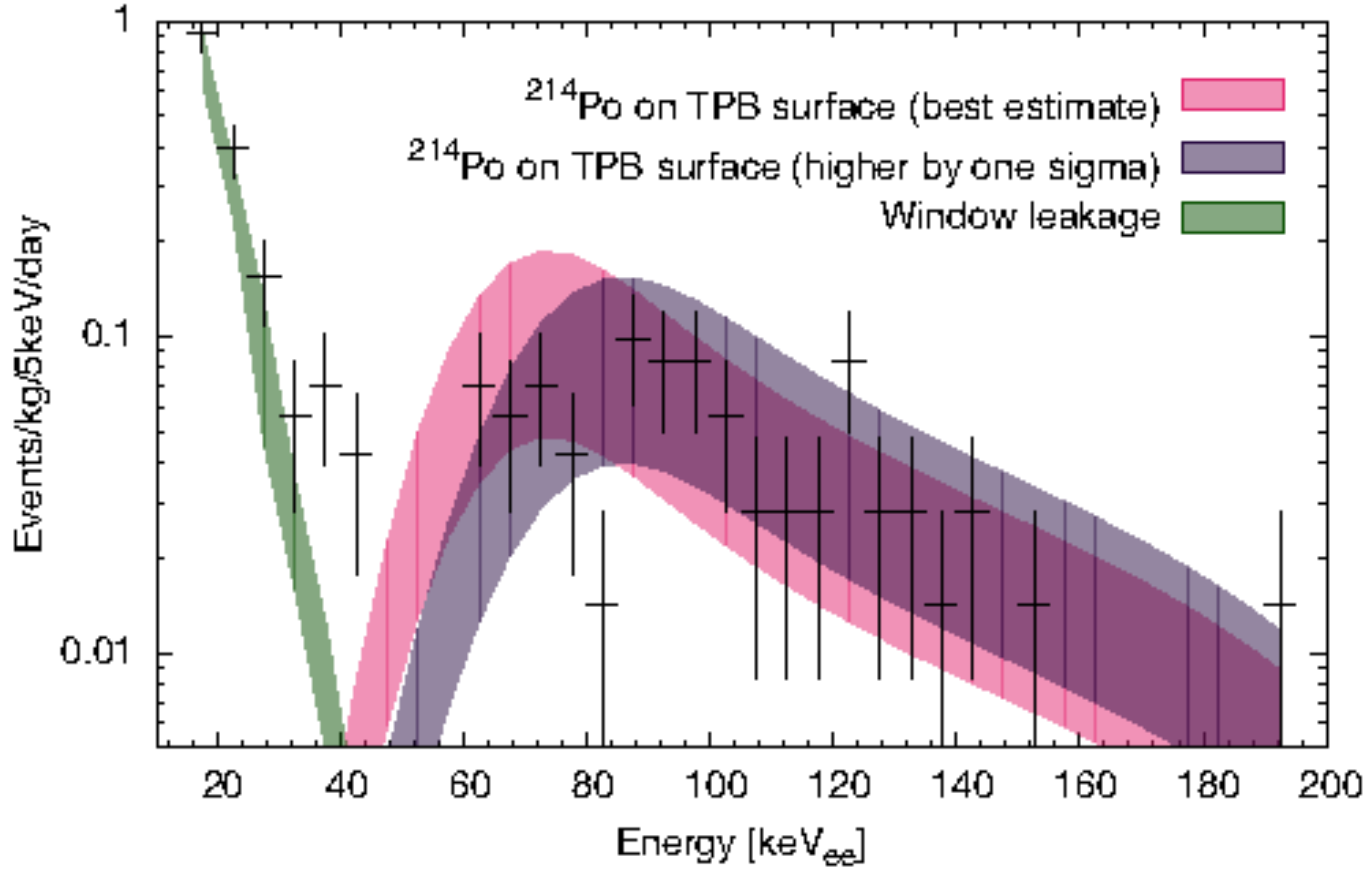
DEAP-1, our prototype, was run at Queen's University and at SNOLAB



DEAP-1 demonstrated low rates of Radon and backgrounds from surface alphas

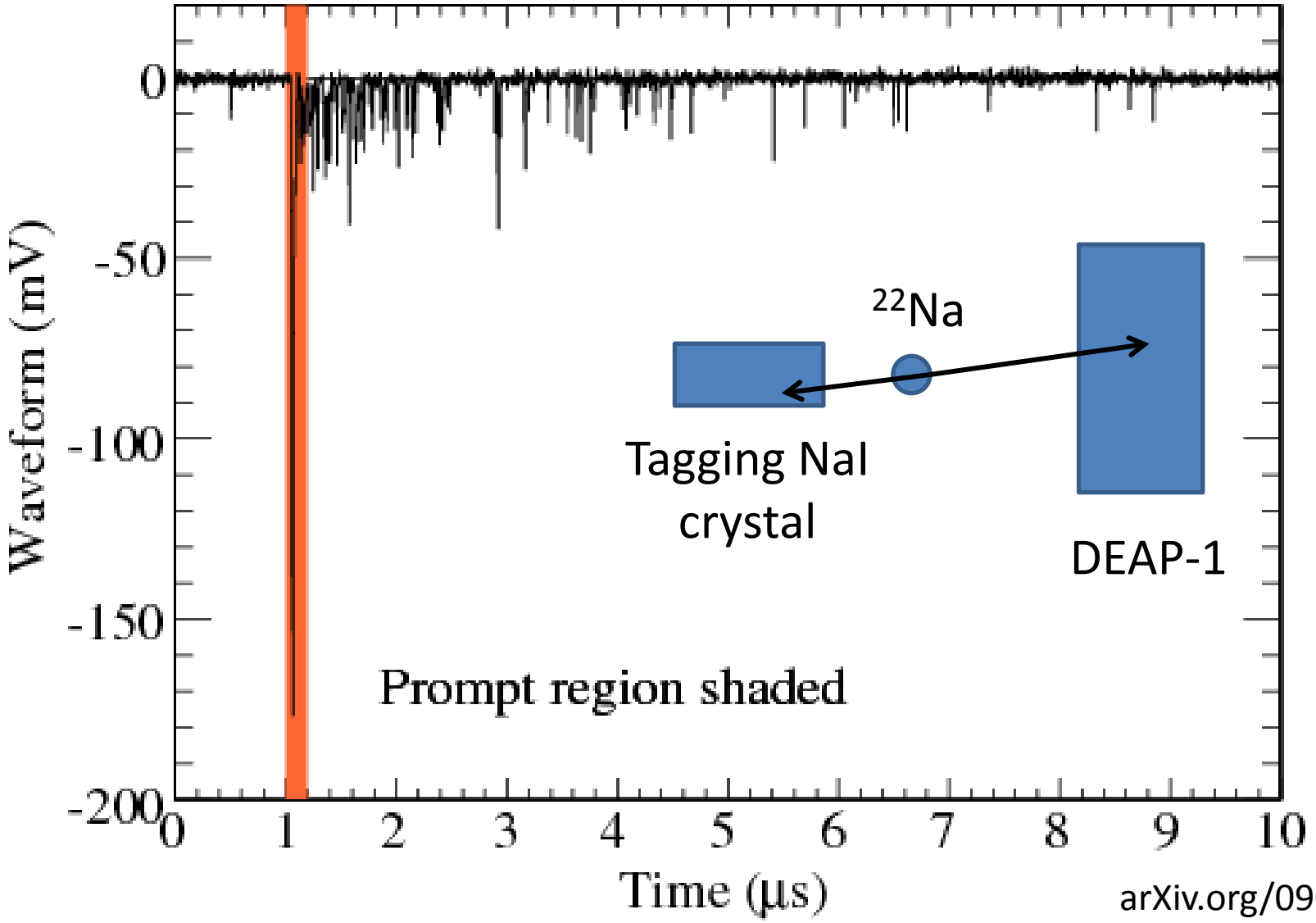
Acrylic surface activity < 1.6 x 10^{-19} g/g ^{210}Pb

Radon decay rate of 16 to 26 micro Bq/kg



arXiv/1211.0909

DEAP-1 Pulse Shape Discrimination



arXiv.org/0904.2930

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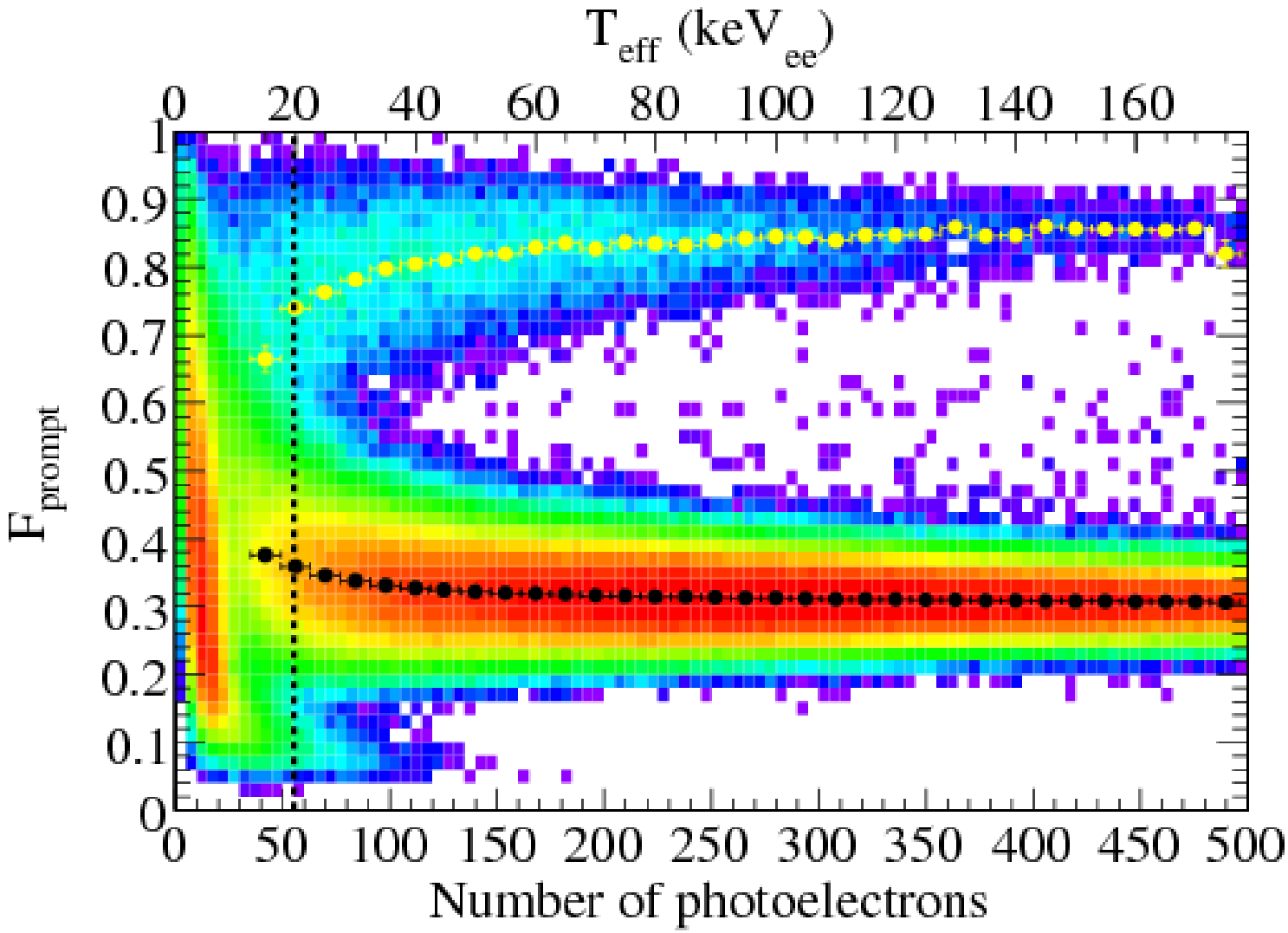

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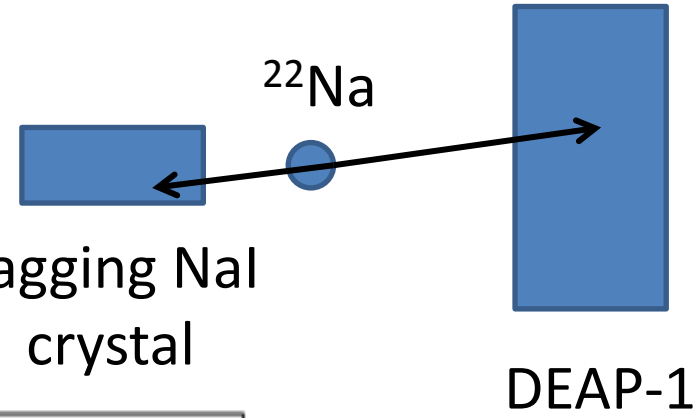
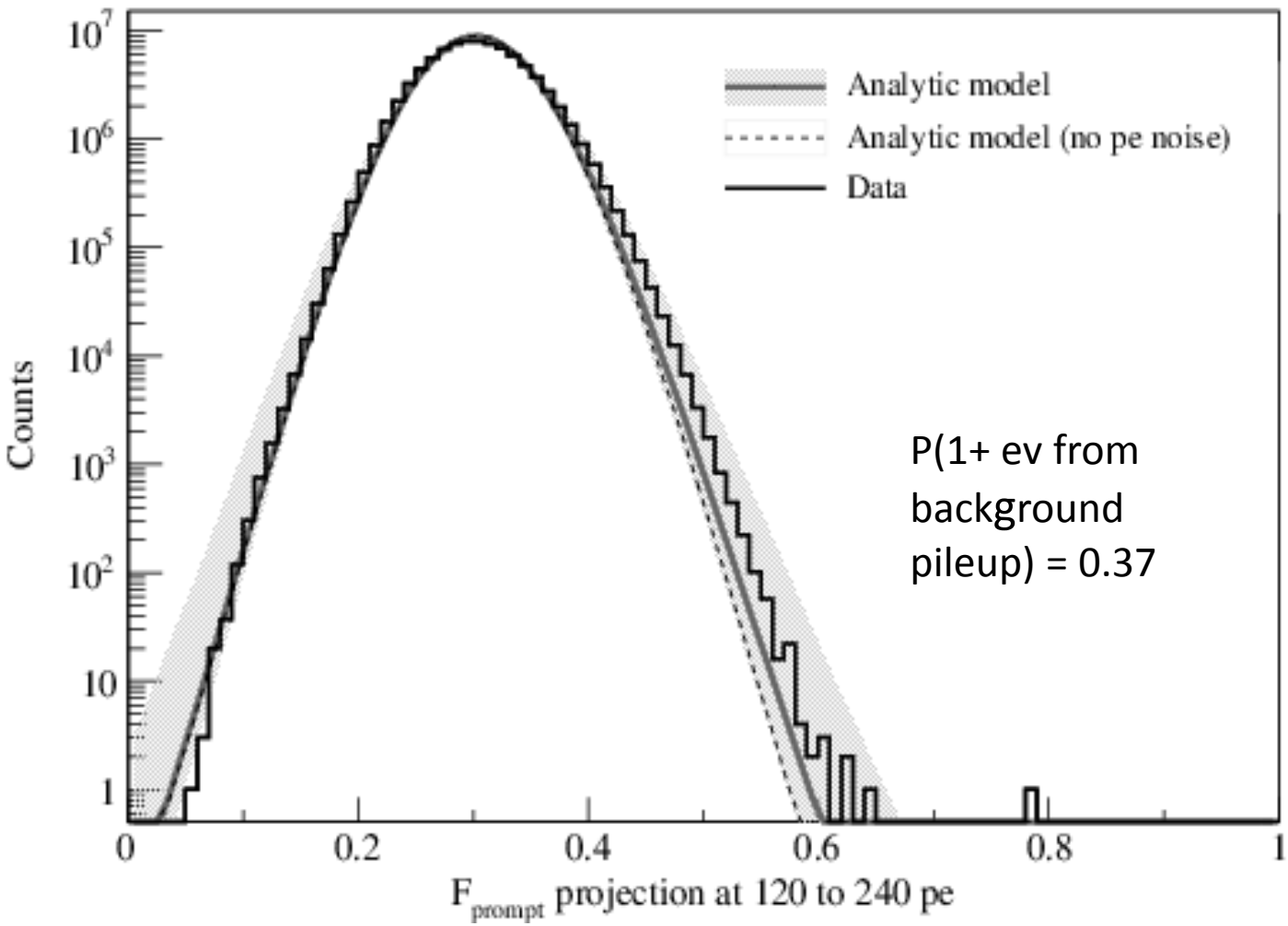
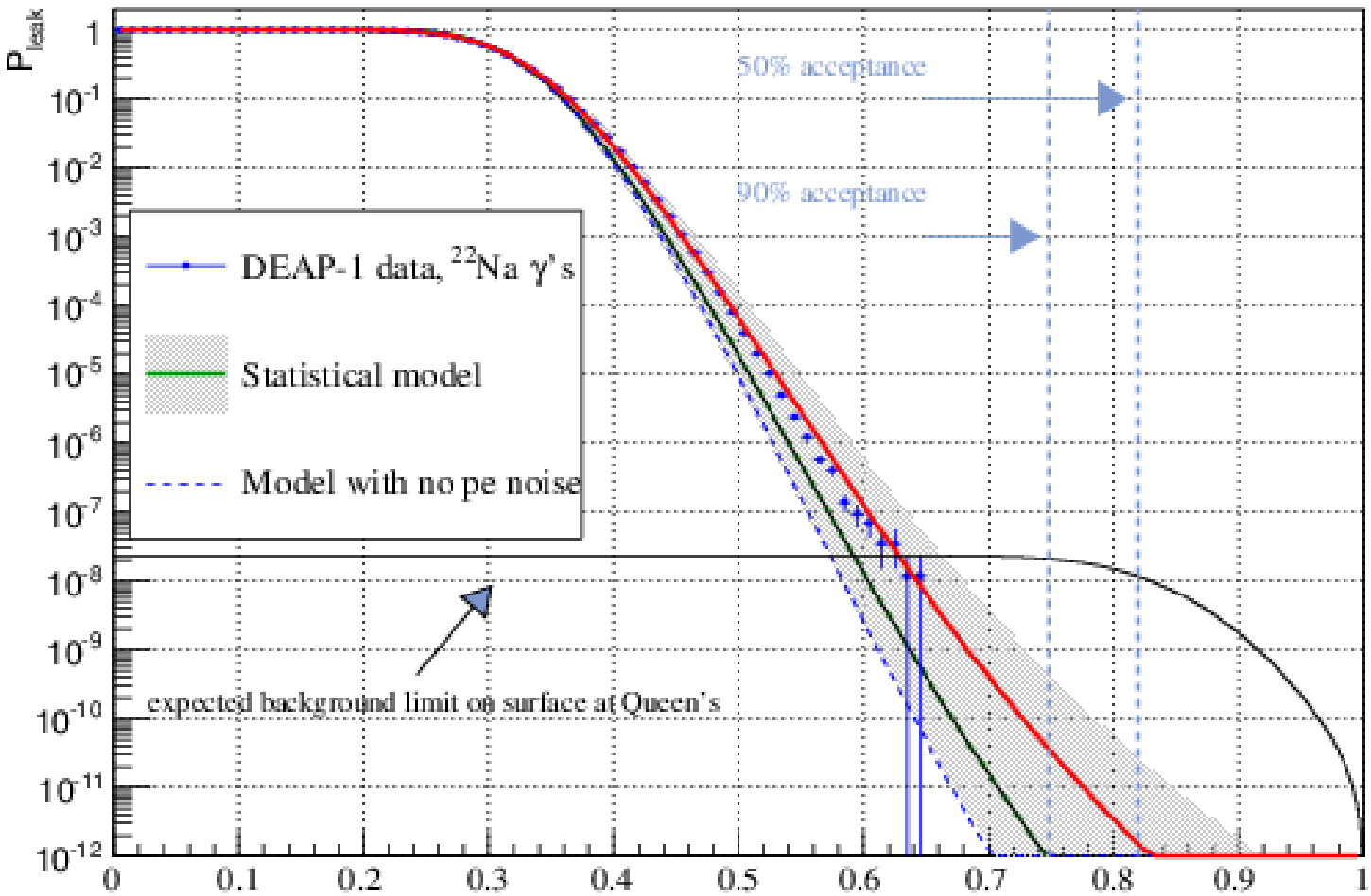


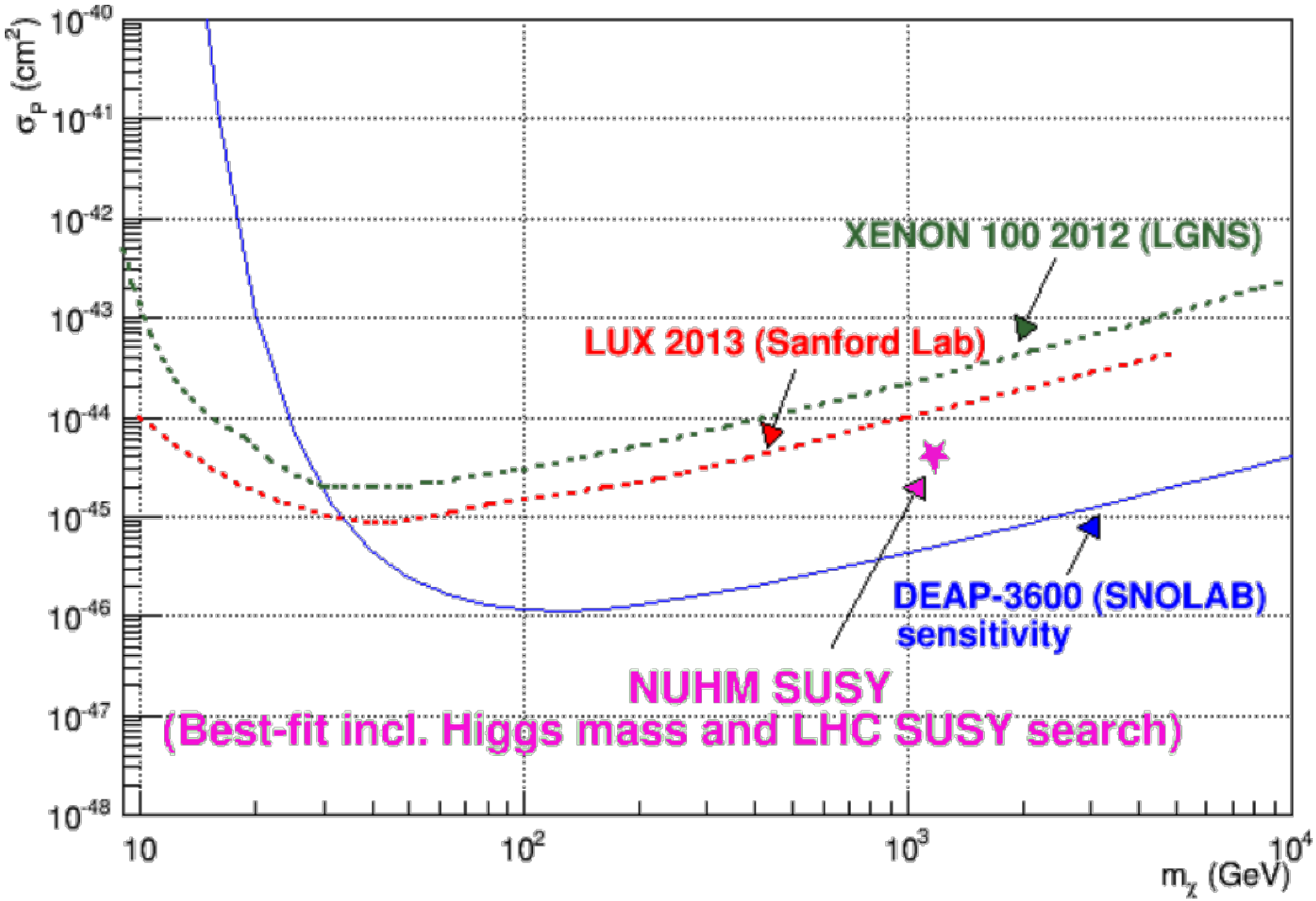


P(1+ ev from background pileup) = 0.37

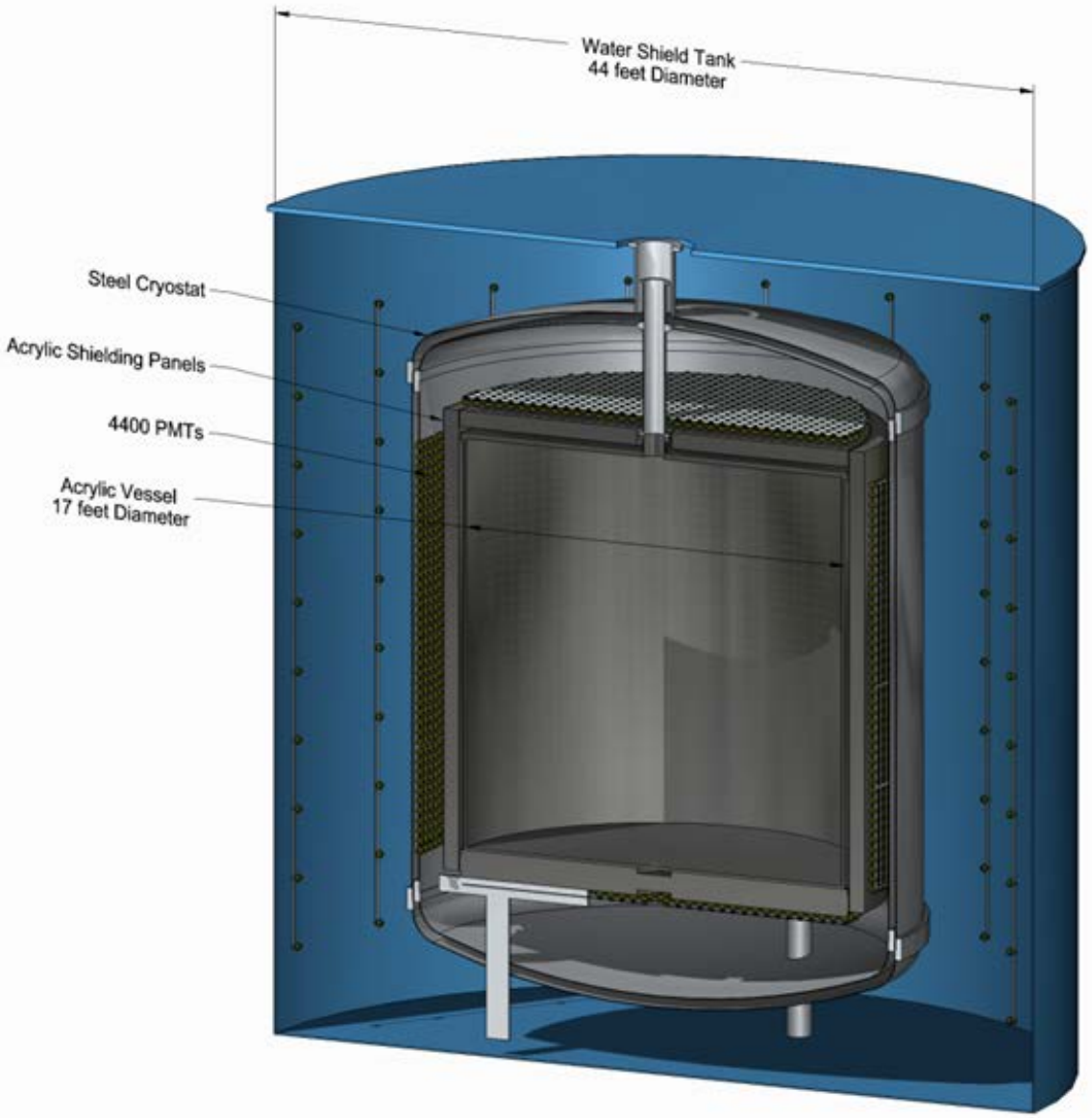
DEAP-1 PSD measurements agree with a model based on counting statistics and measured noise parameters. The model was applied to DEAP-3600 parameters.



Leading Sensitivity After 2 months exposure (Plot assumes 3 tonne-years)



Looking To the Future: Concept for 50 Tonne Detector



"Conventional"
ultra-clean acrylic vessel, constructed UG

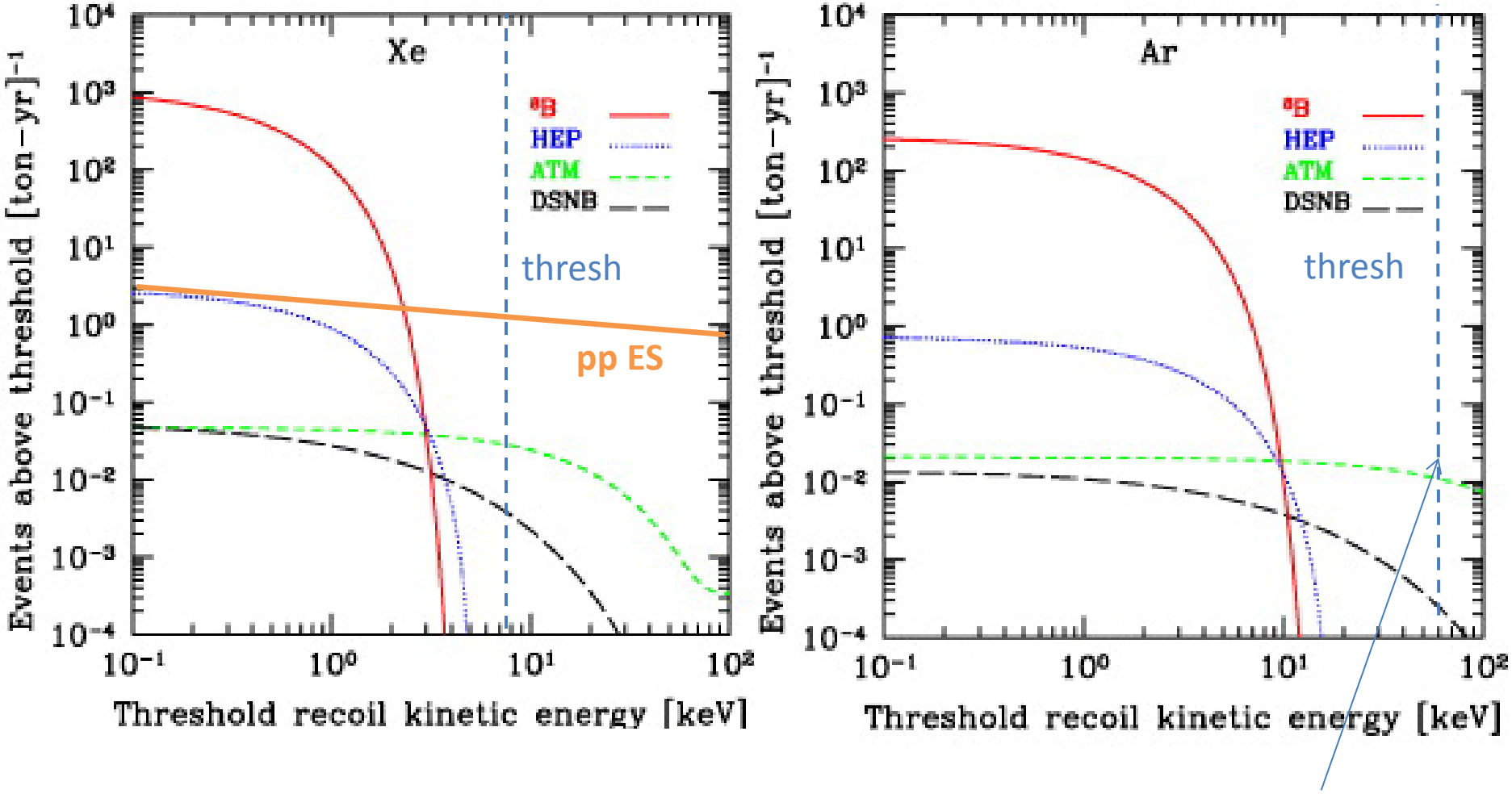
Sanded over ~months to remove deposited daughters, meets requirement

150-tonnes DAr in AV
50-tonne fiducial

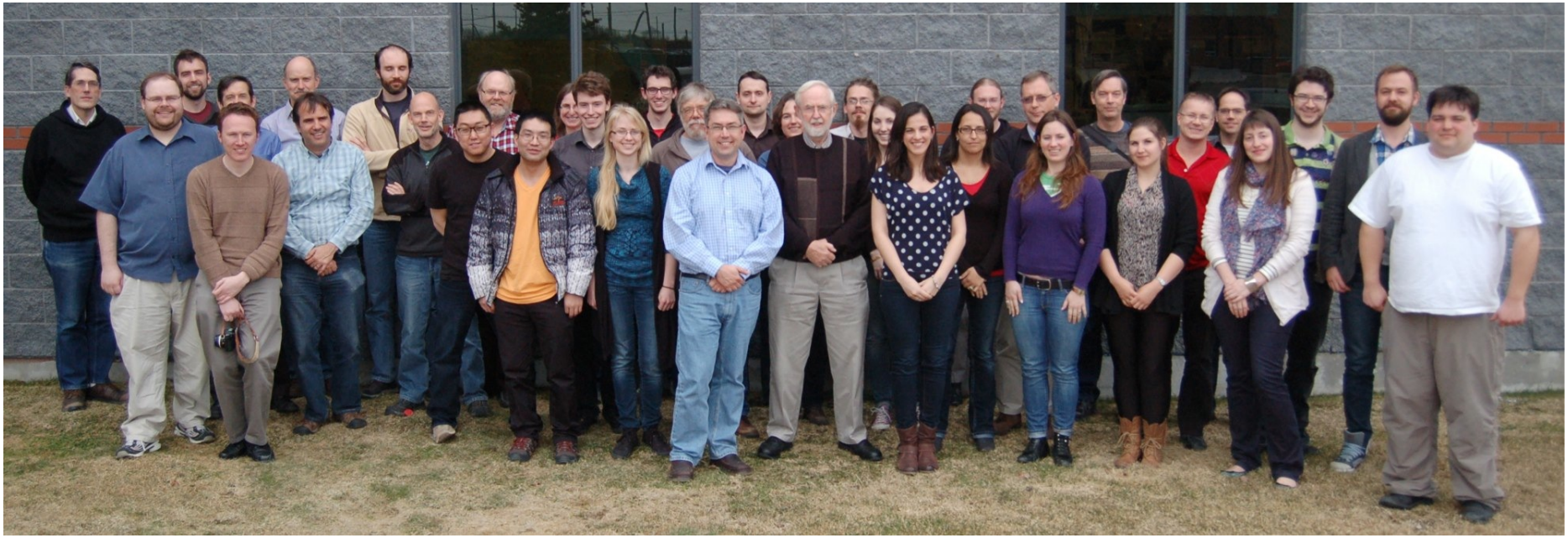
Requires UG storage of argon target

Will investigate PMTs versus SiPMs

Neutrino backgrounds in 50-T argon are manageable



Target sensitivity for DEAP-50T (50 Tonne Fiducial Argon) is at ultimate limit of atmospheric neutrinos



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