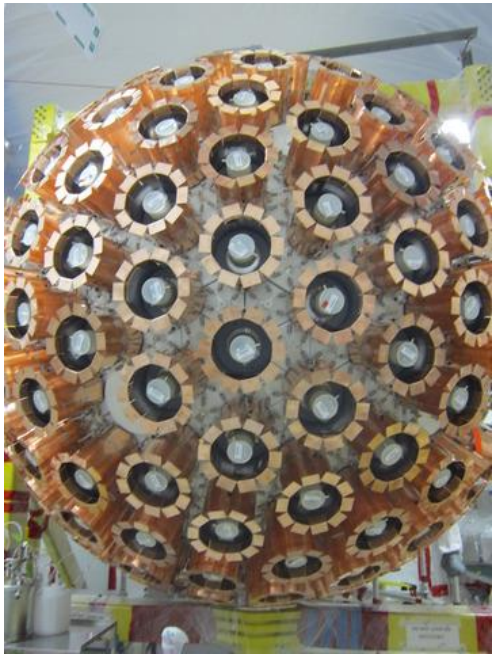
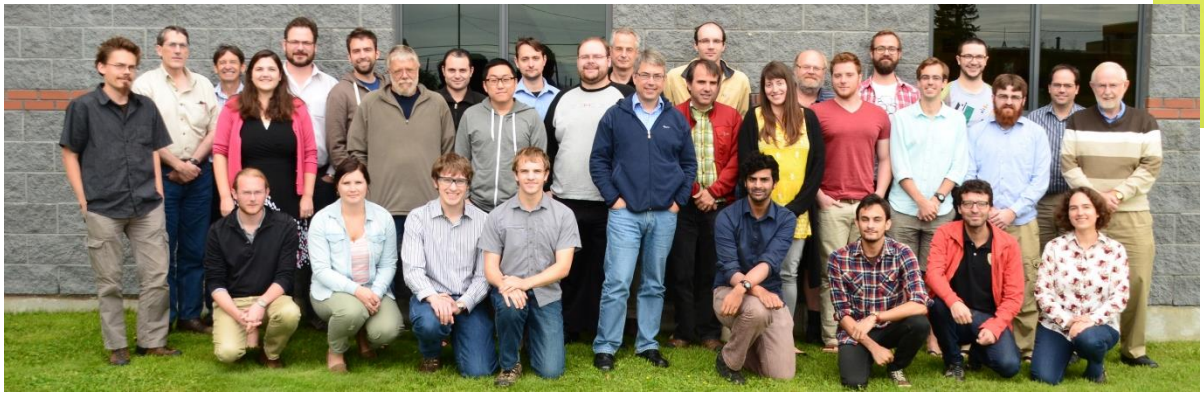
Acrylic Purity in DEAP-3600

@





DEAP Collaboration

University of Alberta

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Carleton University

K. Graham, C. Ouellet, Carl Brown

Queen's University

M. Boulay, B. Cai, D. B. Broerman, Bearse, J. Bonnat, K. Dering, **M. Chen**, S. Florian, R. Gagnon, V.V. Golovko, P. Harvey, M. Kuzniak, **A. McDonald**, C. Nantais, **A.J. Noble**, E. O'Dwyer, P. Pasuthip, L. Veloce, **W. Rau**, T. Sonley, P. Skensved, M. Ward

SNOLAB/Laurentian

B. Cleveland, F. Duncan, **R. Ford**, **C.J. Jillings,** T. Pollmann, C. Stone

SNOLAB

I. Lawson, K. McFarlane, P. Liimatainen, O. Li

TRIUMF

F. Retiere, Alex Muir, P-A. Amaudruz, D. Bishop, S. Chan, C. Lim, C. Ohlmann, K. Olchanski , V. Strickland

National Autonomous University of Mexico

E. Vazquez Jauregui

Rutherford Appleton Laboratory

P. Majewski

Royal Holloway University of London

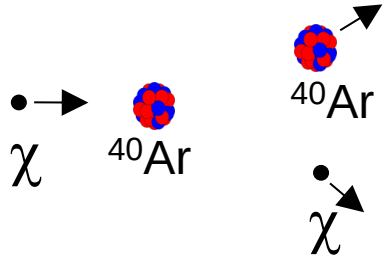
J. Monroe, J. Walding**,** A. Butcher

University of Sussex

Simon Peeters

DEAP-3600 Dark Matter Search

Liquid Argon for DM (Single-phase)



Scattered nucleus (several 10's of keV) is detected via scintillation in LAr

Good Pulse-shape discrimination between b/g and nuclear recoils with scintillation

Argon is easy to purify

Very large target masses possible, no absorption of UV scintillation photons in argon, no pileup until beyond tonne-scale

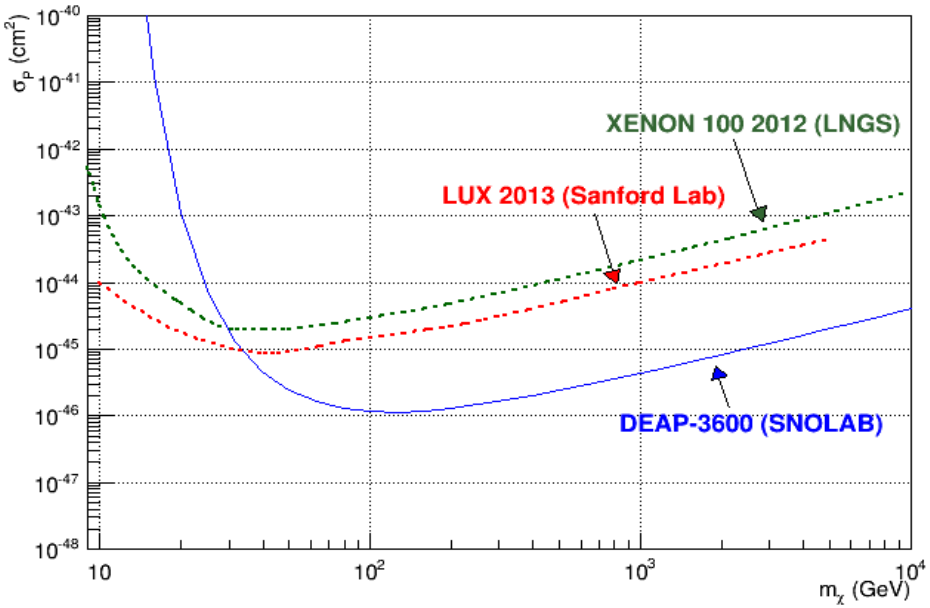
Position reconstruction based on photon detection allows mitigation of backgrounds from surfaces

Project Overview

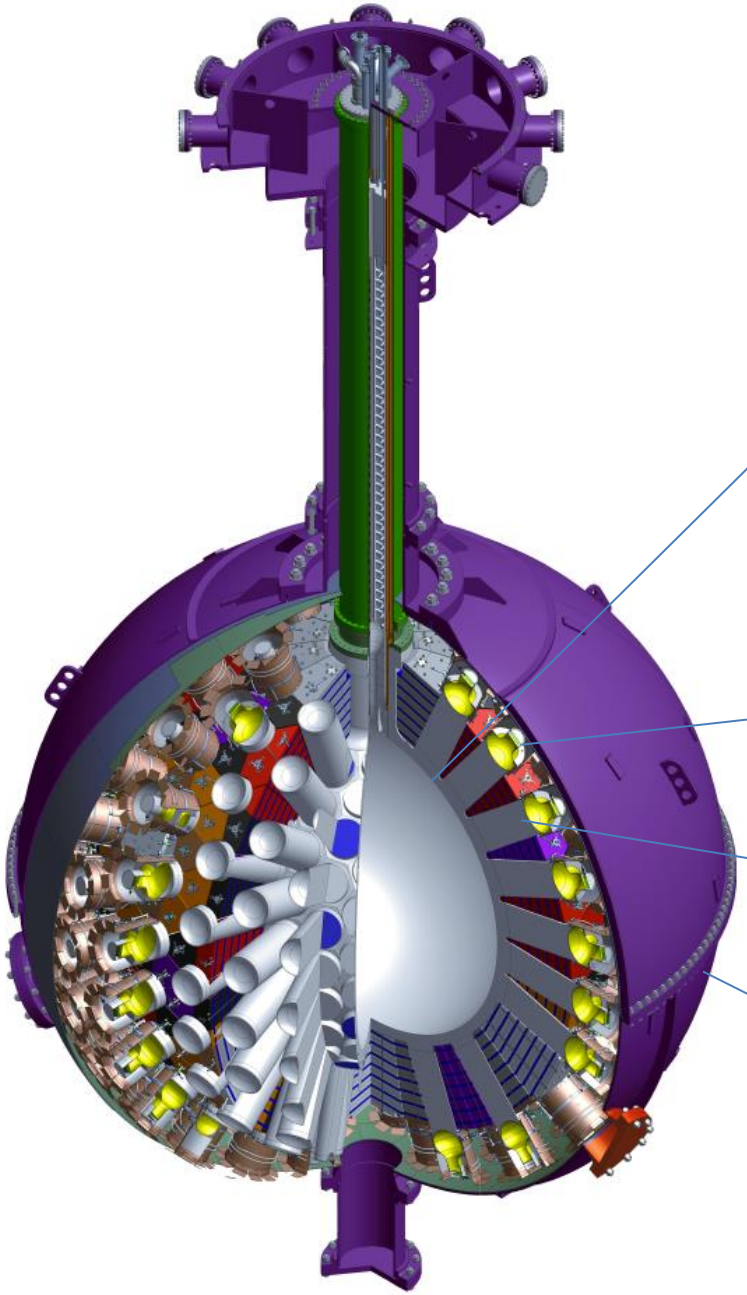
3.6 tonnes liquid argon in ultraclean acrylic vessel, 255 8-inch HQE PMTs

1 tonne fiducial mass designed for < 0.2 background events/year

10^{-46} cm^2 sensitivity for ~100-GeV WIMP with 3-year exposure



DEAP-3600 Detector



3600 kg argon target
(1000 kg fiducial)
in sealed ultraclean
Acrylic Vessel

Vessel is “resurfaced”
in-situ to remove
deposited Rn daughters
after construction

255 Hamamatsu
R5912 HQE PMTs 8-inch
(32% QE, 75% coverage)

50 cm light guides +
PE shielding provide
neutron moderation

Steel Shell immersed in 8 m
water shield at SNOLAB

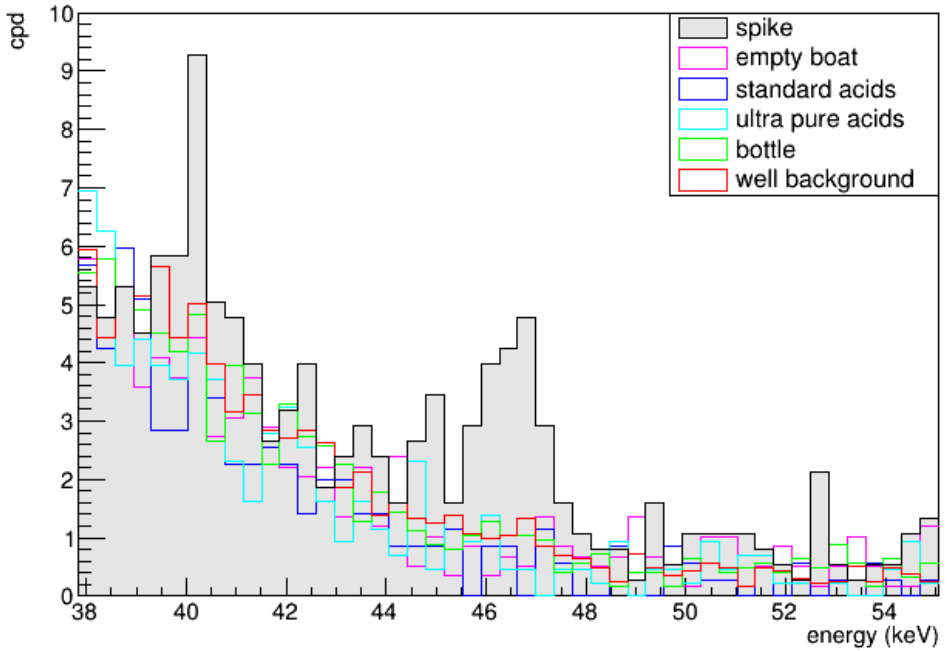
Fabrication and Assay of DEAP Acrylic

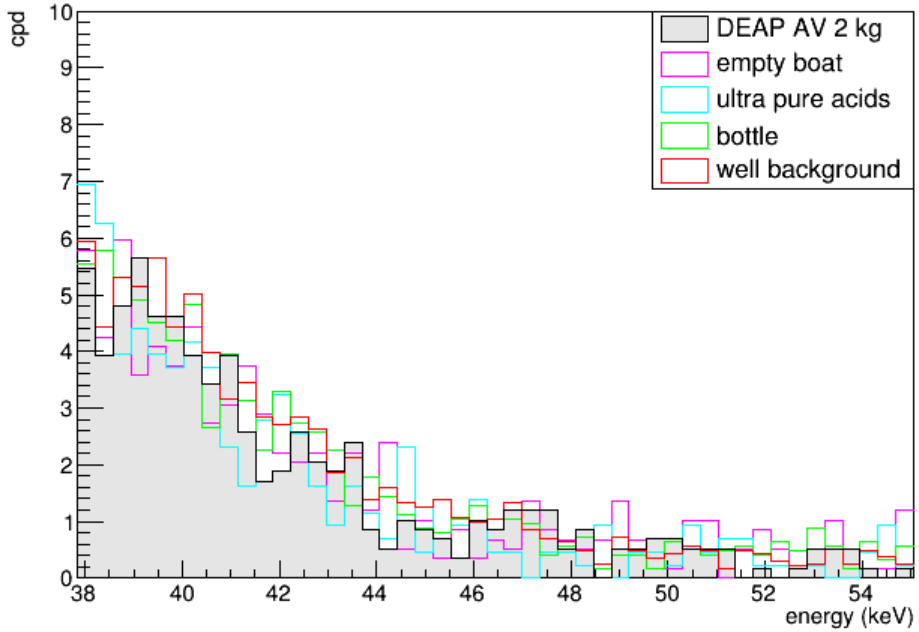
- Fabrication from pure MMA monomer at RPTAsia (Thailand), strict control of radon exposure for all steps
- DEAP Collaborators present during fabrication
- Control to < 10^{-20} g/g ^{210}Pb from radon exposure
- Developed system to vaporize and assay large quantities of acrylic (10 kg samples), count residue with Ge well detector for ^{210}Pb peak, and with alpha counter for ^{210}Po; (Corina Nantais M.Sc. Thesis)

Monomer cast at RPT Asia

Thermoformed Panel at RPT Colorado

Spike with ^{222}Rn into acrylic cylinder





DEAP AV acrylic assay and backgrounds

Nantais M.Sc. Thesis result (Queen's, 2014):

^{210}Pb : $< 2.2 \times 10^{-19}$ g/g

(<0.2 bkd events in 3 years)

Thermoforming sheets for DEAP Acrylic Vessel
Reynolds Polymer, Colorado

Thermoforming tool

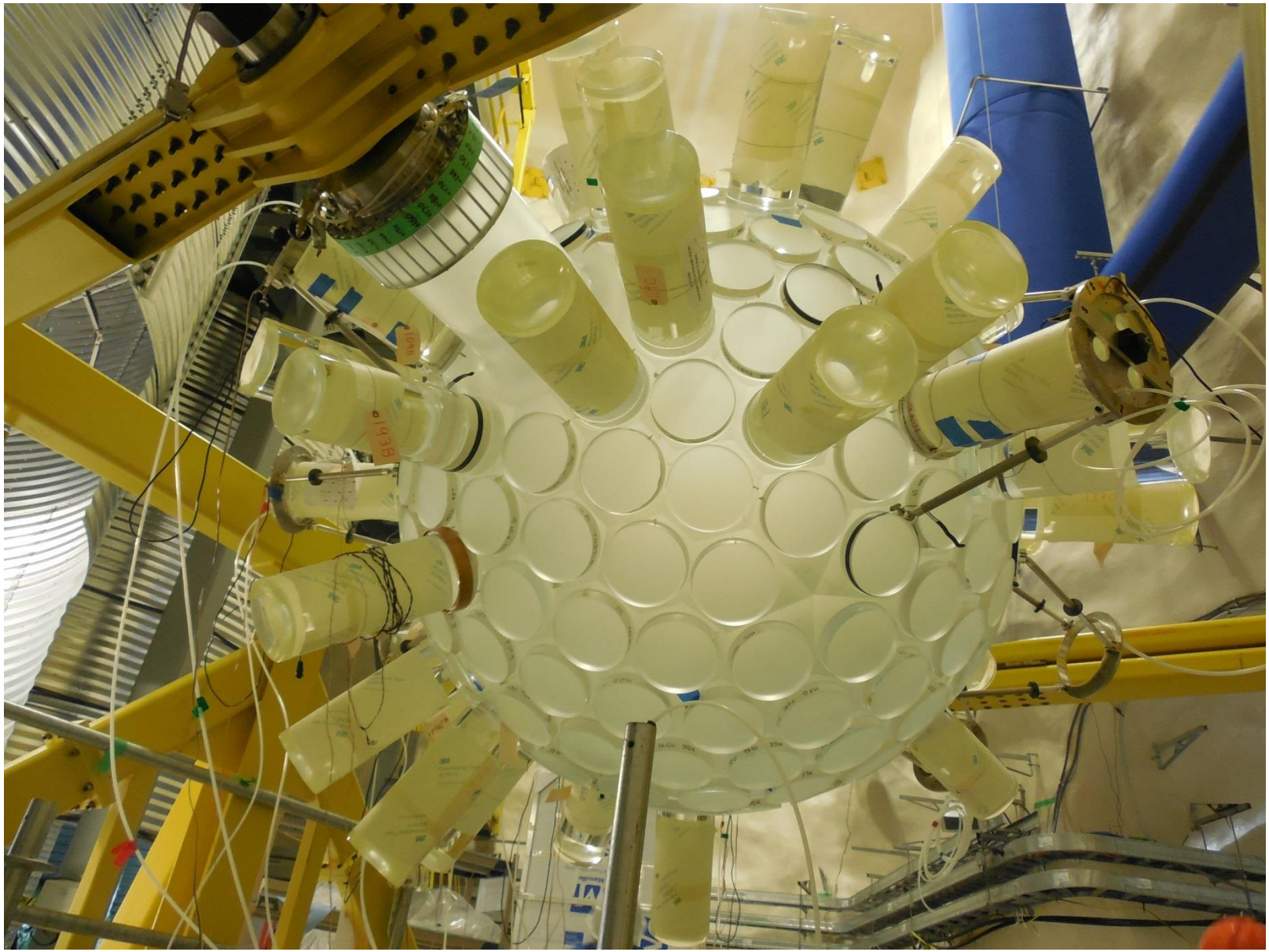
Successfully thermoformed panel

- Thickness/radius of curvature ratio larger than had been attempted
- R&D contract with Reynolds Polymer to develop thermoforming technique
- Special mold/stamping tool designed and fabricated
- R&D Completed early 2012

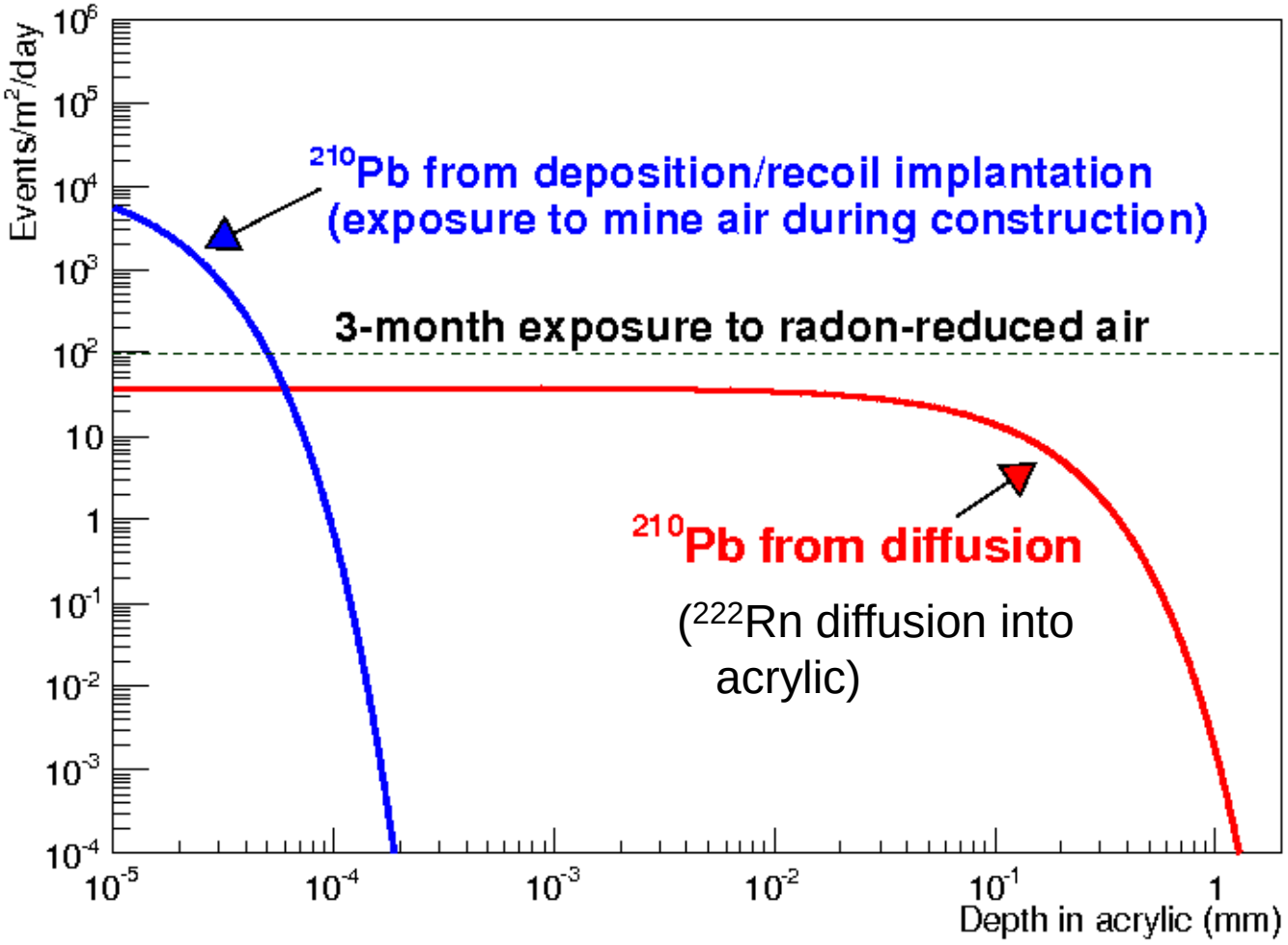
AV Fabrication (RPT Colorado and University of Alberta) 2011 to present

AV Neck Bond (Reynolds Polymer, Tech. (RPT) at SNOLAB Jan 2013)

Vessel sealed and purged, approx. 50 LGs bonded (September 2013)



^{210}Pb distribution in acrylic from deposition, diffusion



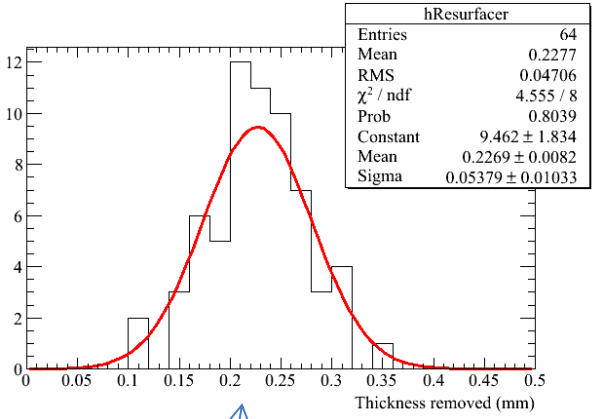
Will remove ~ 0.5 mm with Resurfacer

DEAP-3600 Acrylic Vessel Resurfacer

Removes ~1 mm acrylic in-situ after construction

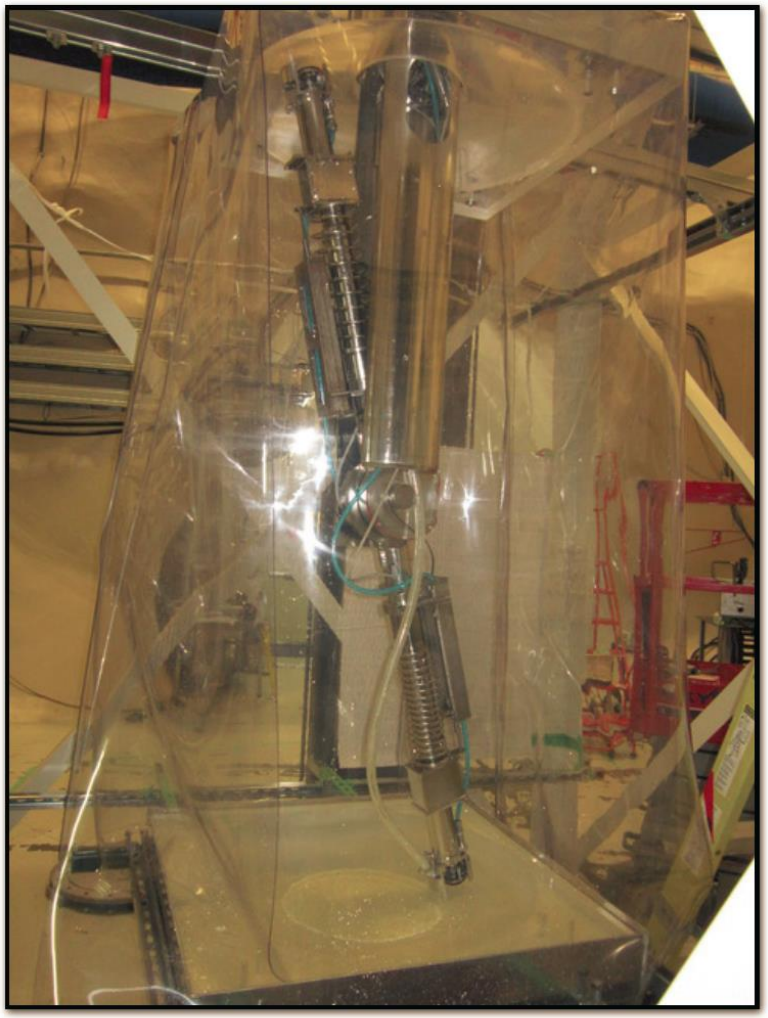
Radon-scrubbed N_2 purge gas and UPW flushing to extract residue

Surface contamination returns to bulk purity level



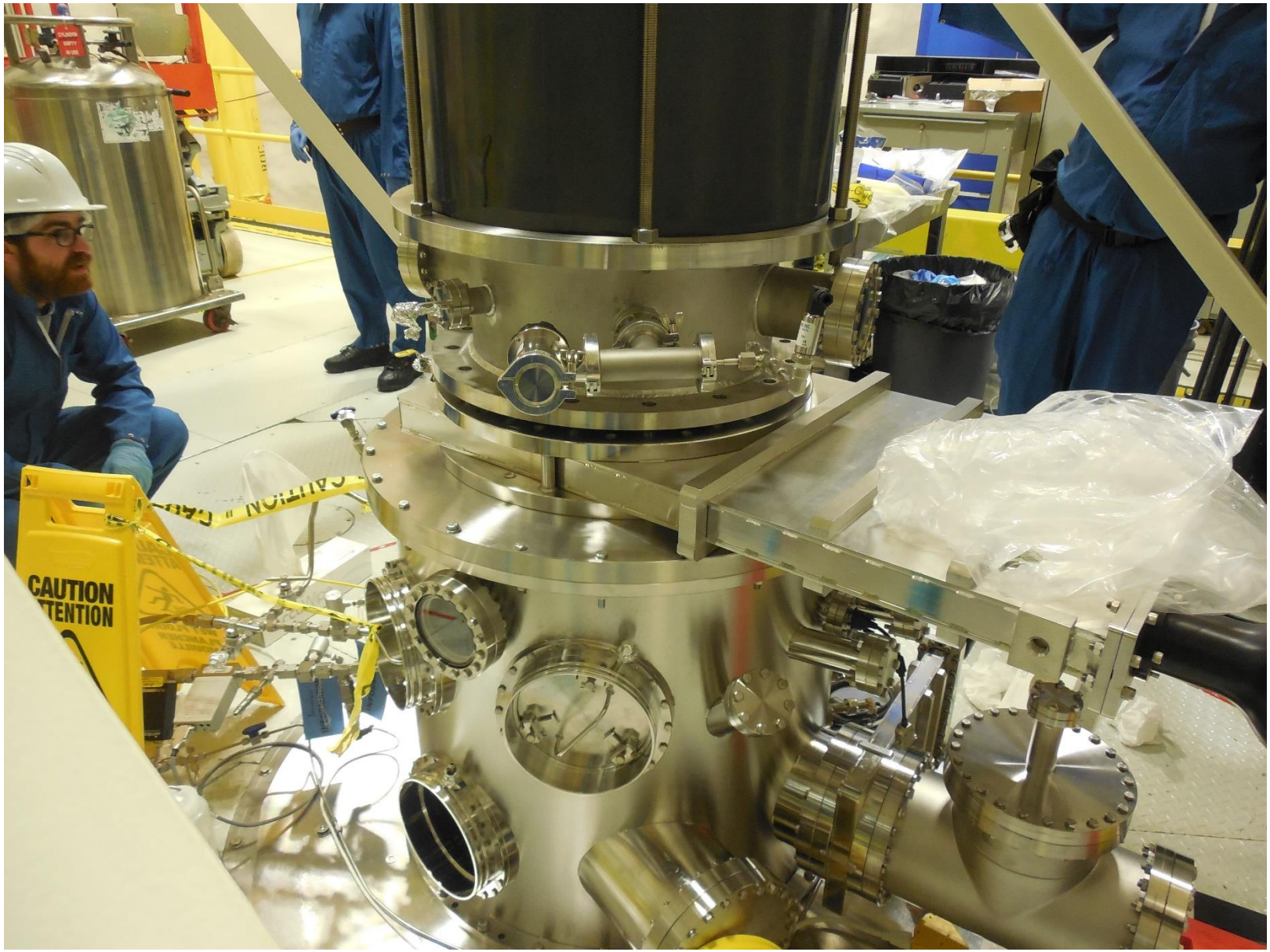
24% uniformity demonstrated

Installation @ SNOLAB



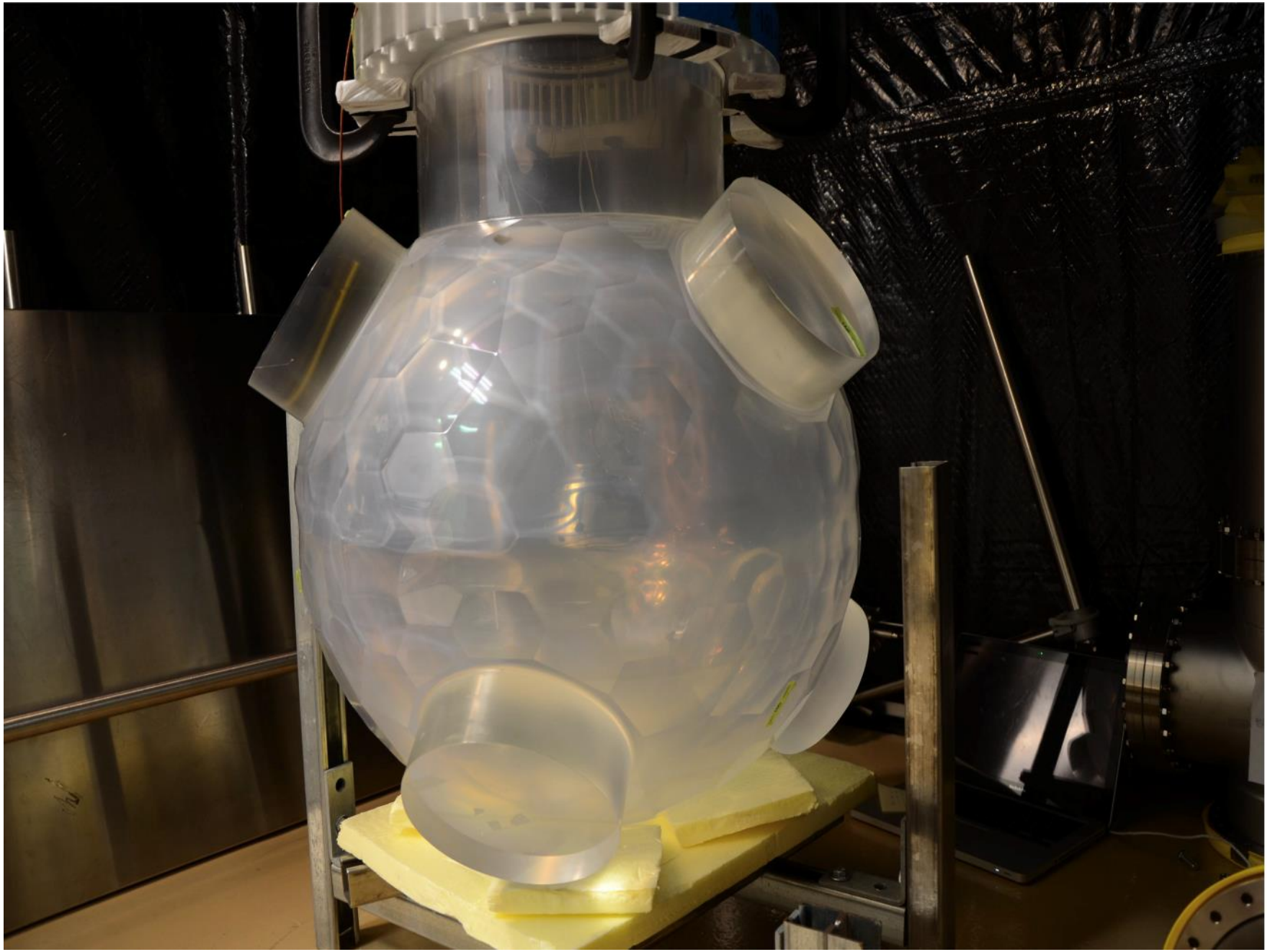
Moved the frame at the bottom of the cube hall, and started the test sanding runs.


CAUTION
CAUTION
NON-MAGNETIC
mks

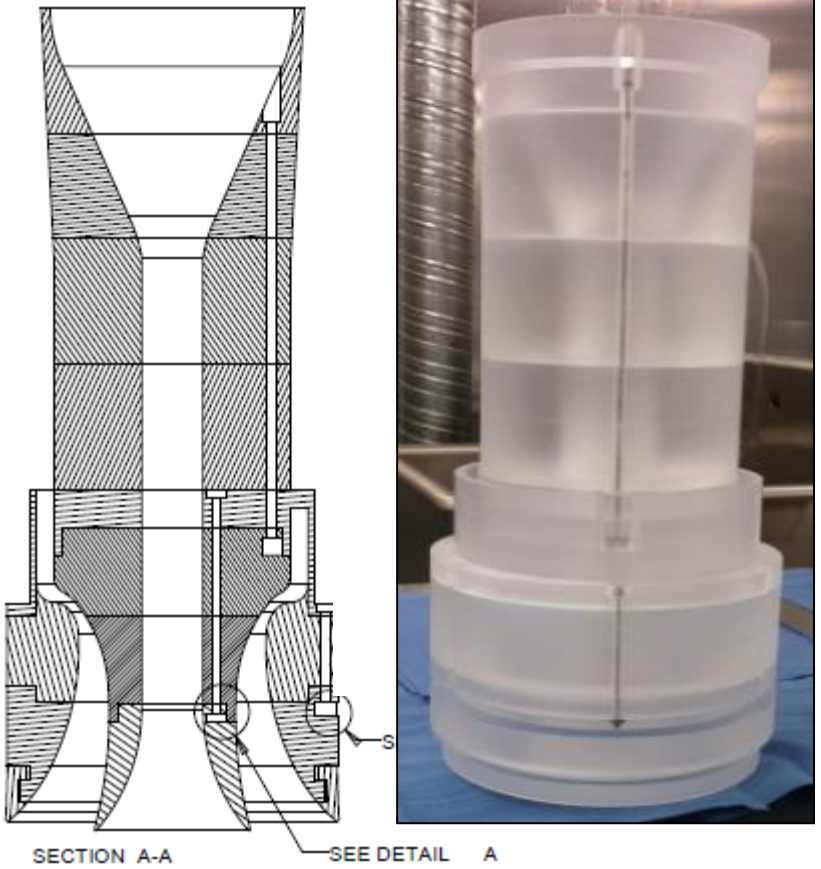

CAUTION
ATTENTION

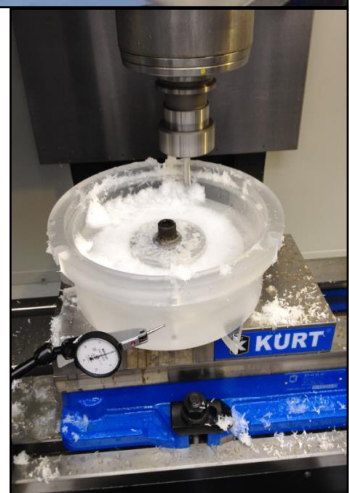
4π TPB (Organic WLS) deposition source developed for DEAP-3600

20-inch test vessel, 1/3 scale

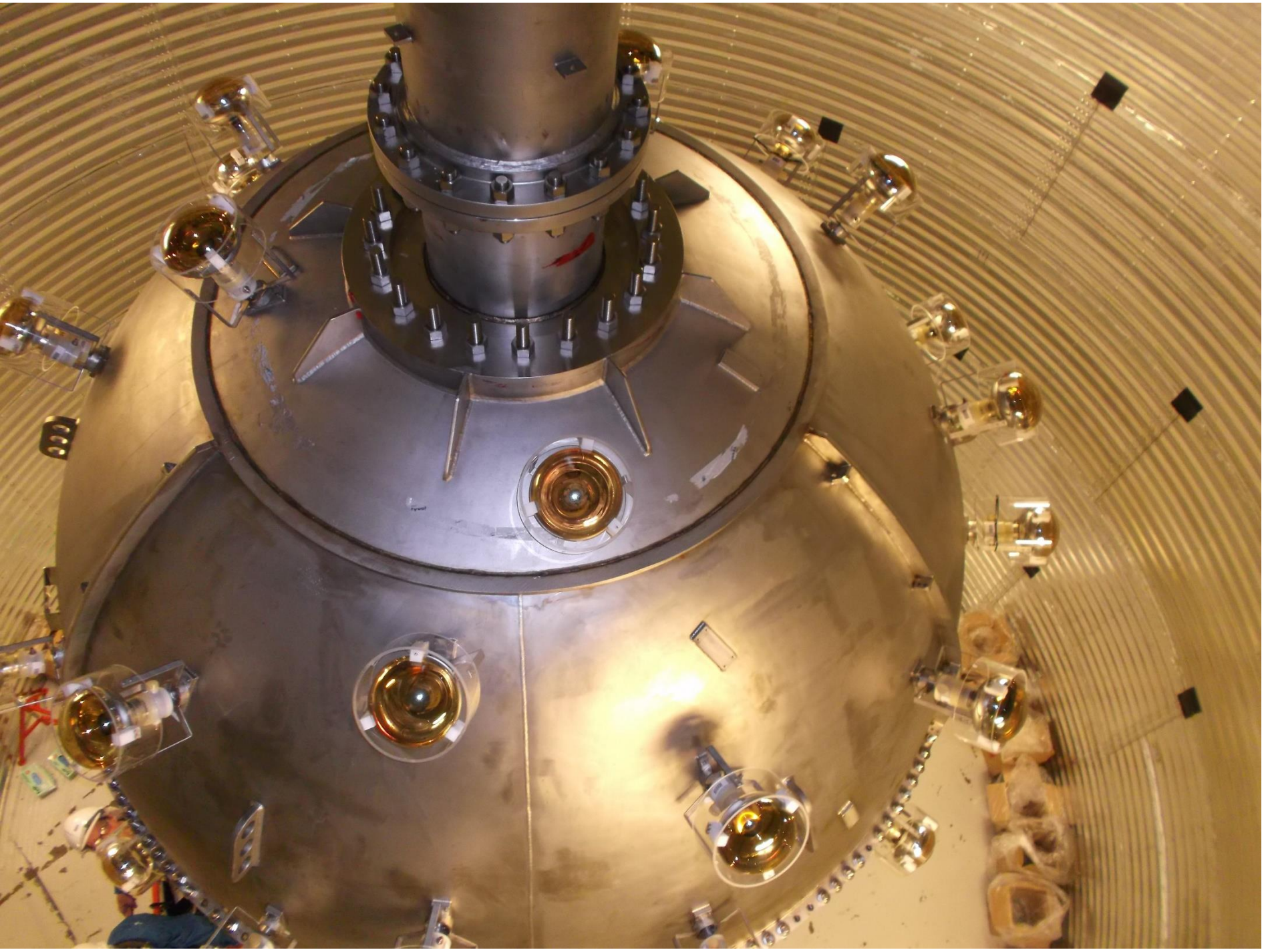


Flow Guides in Neck

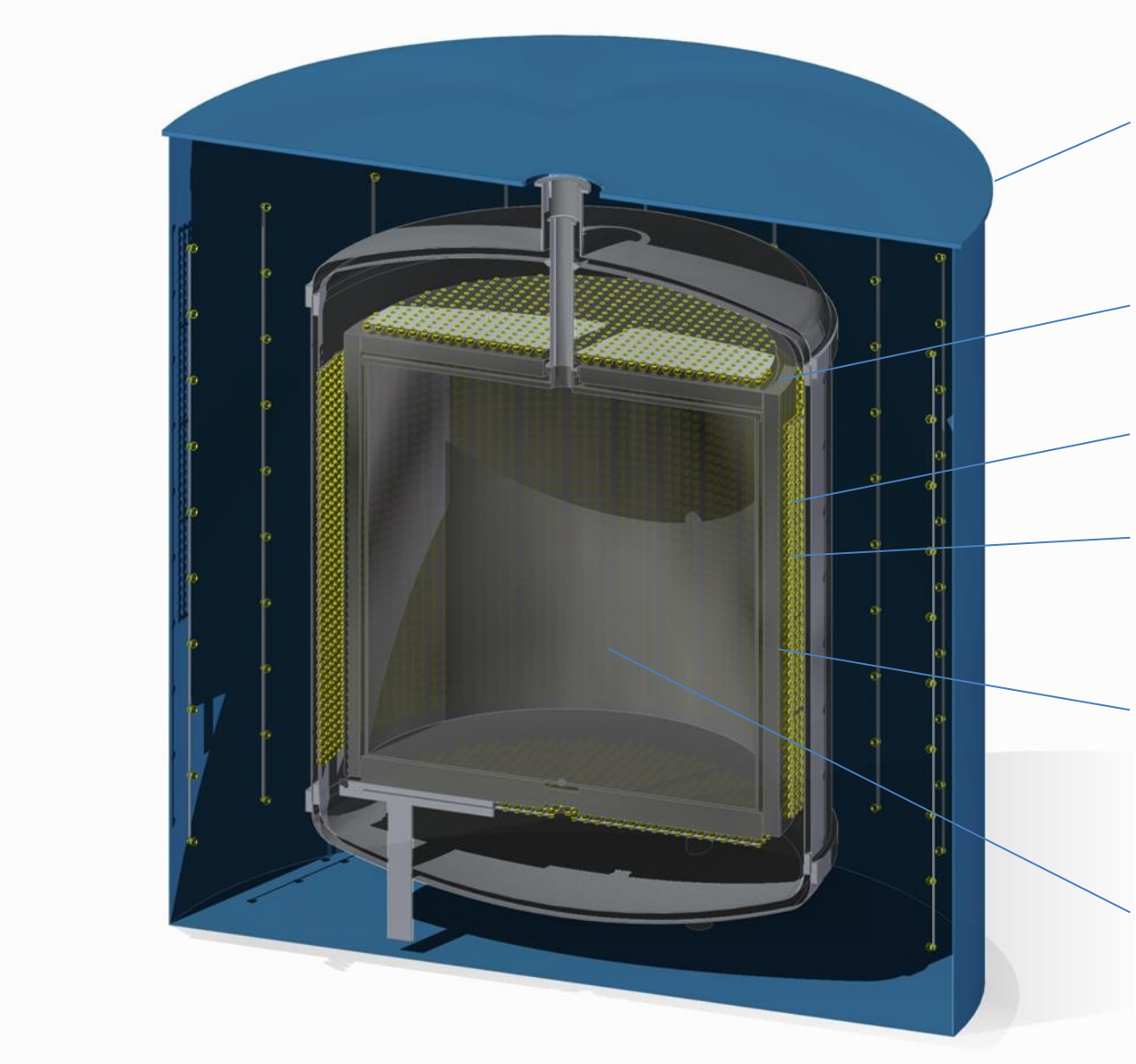




Machined in low-radon lab
Annealed in low-radon air
Final sanding in glovebox



Large LAr Detector (Conceptual) 10^{-48} cm^2 Sensitivity…



44’ diam. water tank

24’ diam. Steel Shells
(inner and outer)

4400 8” HQE PMTs

12” acrylic shielding panels

17’ diam. 2” thick acrylic
vessel with flanged lid

150 tonnes argon in AV
(50 tonnes fiducial)

Requires low ^{39}Ar activity

Summary

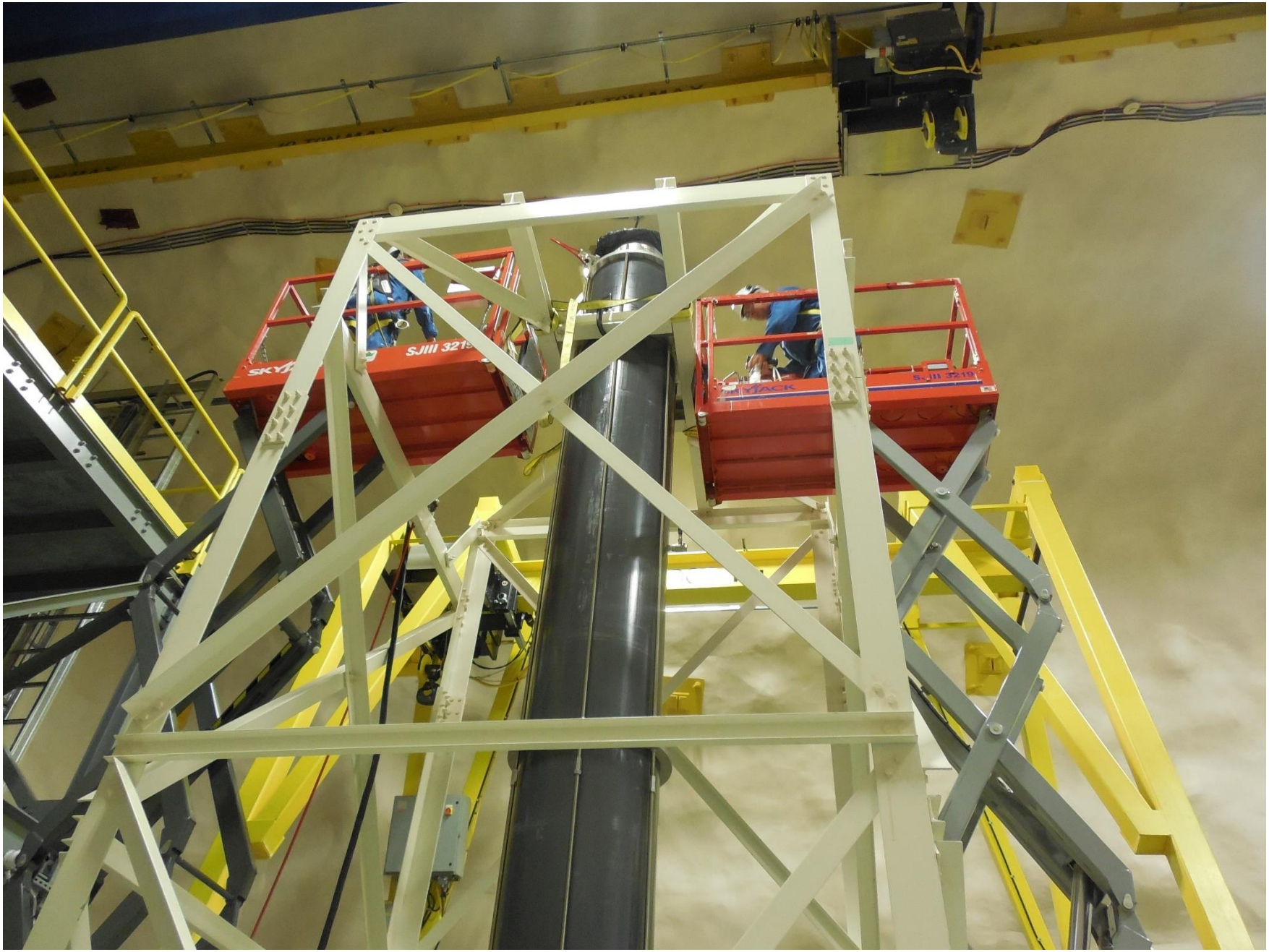
- DEAP-3600 detector assembly completed, currently completing wavelength shifter coating. Detector will have1000-kg fiducial liquid argon with < 0.2 background events/year background budget

- Extensive backgrounds and assay program, in particular ultralow background acrylic inner vessel and low radon emanation inner detector and purification system

- 10^{-46} cm^2 sensitivity for 100-GeV WIMP

- Potential for v. large target mass with argon, 50-tonnes for 10^{-48} cm^2 sensitivity, precision measurements…

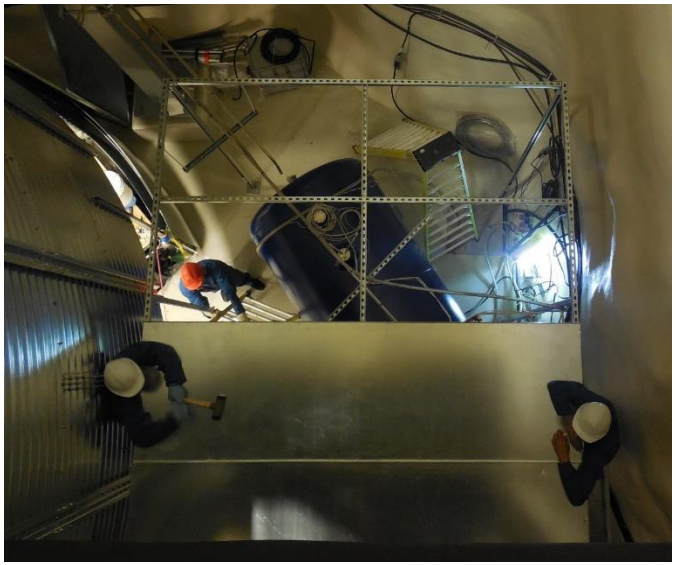
EXTRA SLIDES



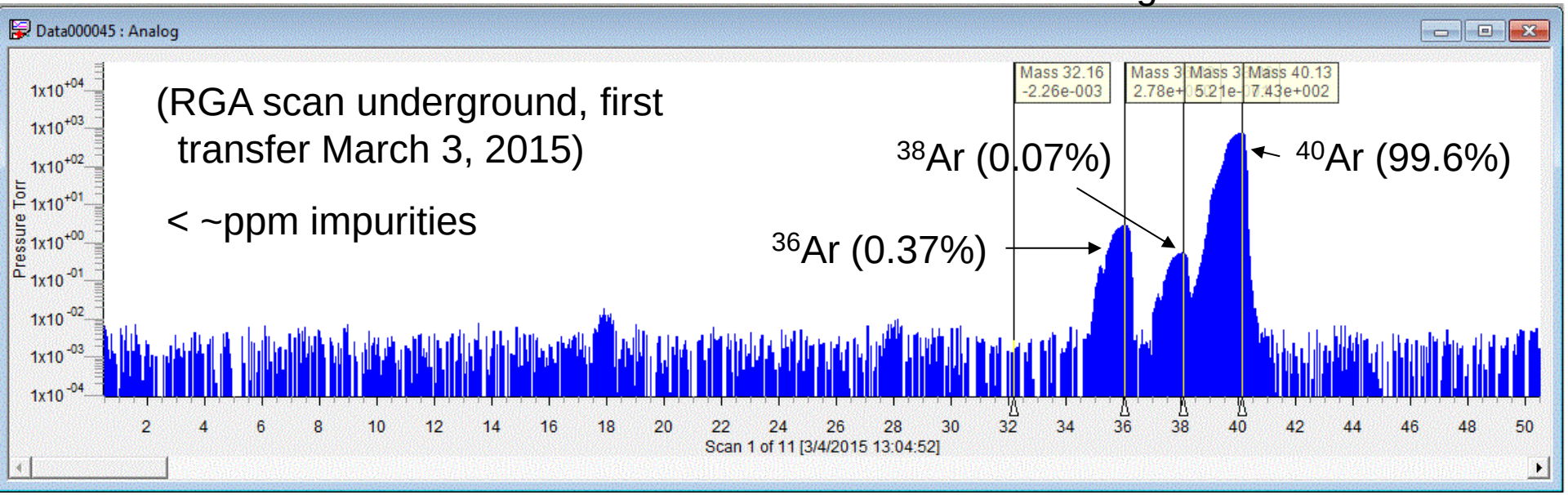
Liquid Argon Target Transfer

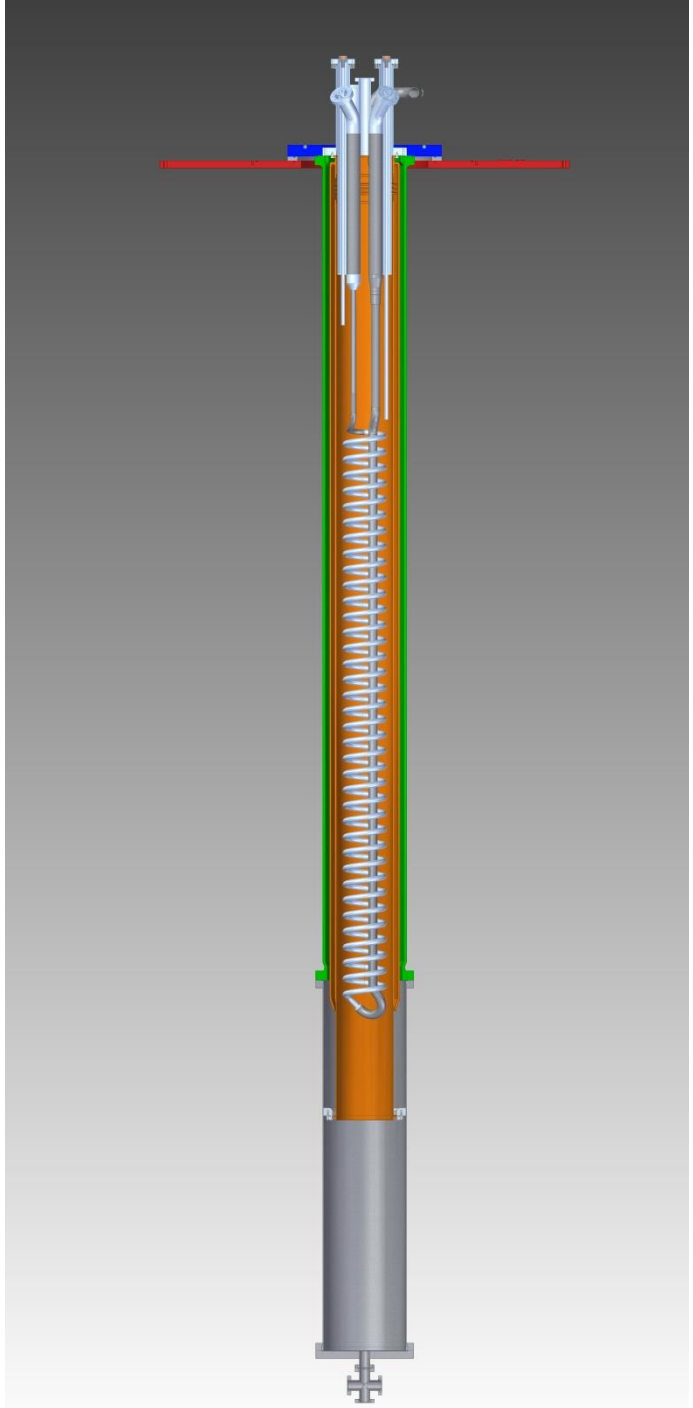
Bulk LAr storage on surface

2x240L
(transfer)

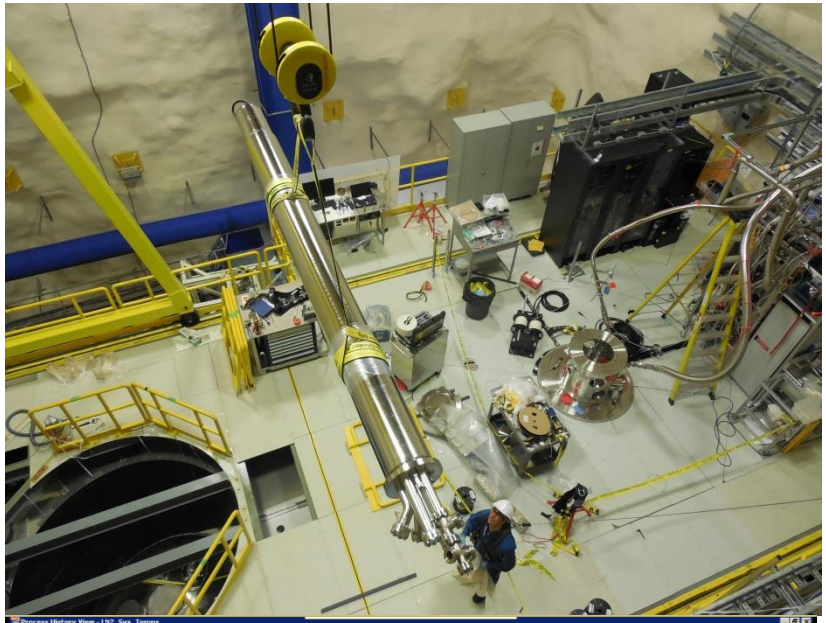


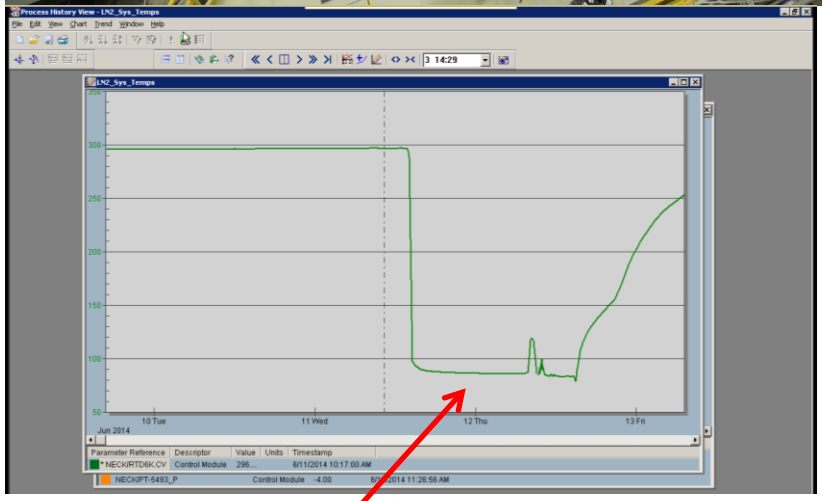
LN_2-cooled storage dewar
underground





DEAP-3600 Argon Cooling System





Commissioning at 86K, June 11 2014
LN2 system operating with cryogen since June 2014