DEAP-3600 Dark Matter Search at SNOLAB

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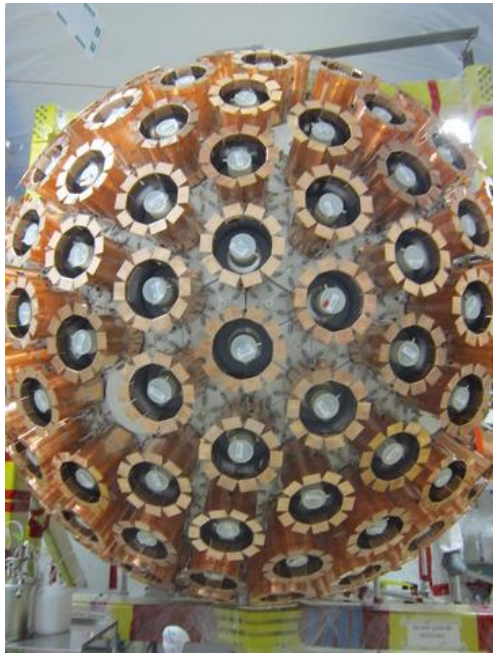


Mark Boulay
Queen's University, Kingston

DEAP Collaboration: over 60 researchers in Canada, UK, and Mexico

UNIVERSITY OF ALBERTA

Carleton UNIVERSITY

LaurentianUniversity
UniversitéLaurentienne

Queen's UNIVERSITY

ROYAL HOLLOWAY UNIVERSITY OF LONDON

Particle Physics
Rutherford Appleton Laboratory

SNOLAB
MINING FOR KNOWLEDGE
CREUSER POUR TROUVER... L'EXCELLENCE

US University of Sussex

TRIUMF

IF Instituto de Física

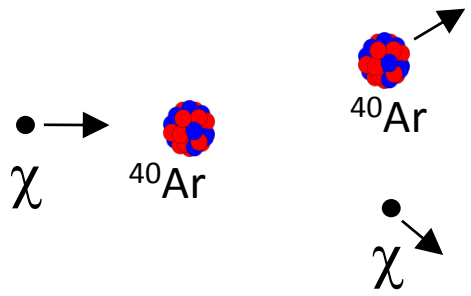
Collaboration Demographics

13 Faculty/PIs in Canada (+4 PIs UK and Mexico)
9 PDFs/RAs
8 GRAs
~5 undergraduates
Site Operations Staff (5 + 1 supervisor)
~9 technical support

Substantial support from MRS personnel
Alberta CPP: C. Ng, M. Cadabeschi, P. Davis, R. Soluk
Queen's: D. Bearse, P. Harvey
Carleton: Y. Baribeau, M. Bowcock, R. Schnarr

Strong support from SNOLAB and TRIUMF

Liquid argon as a dark matter target



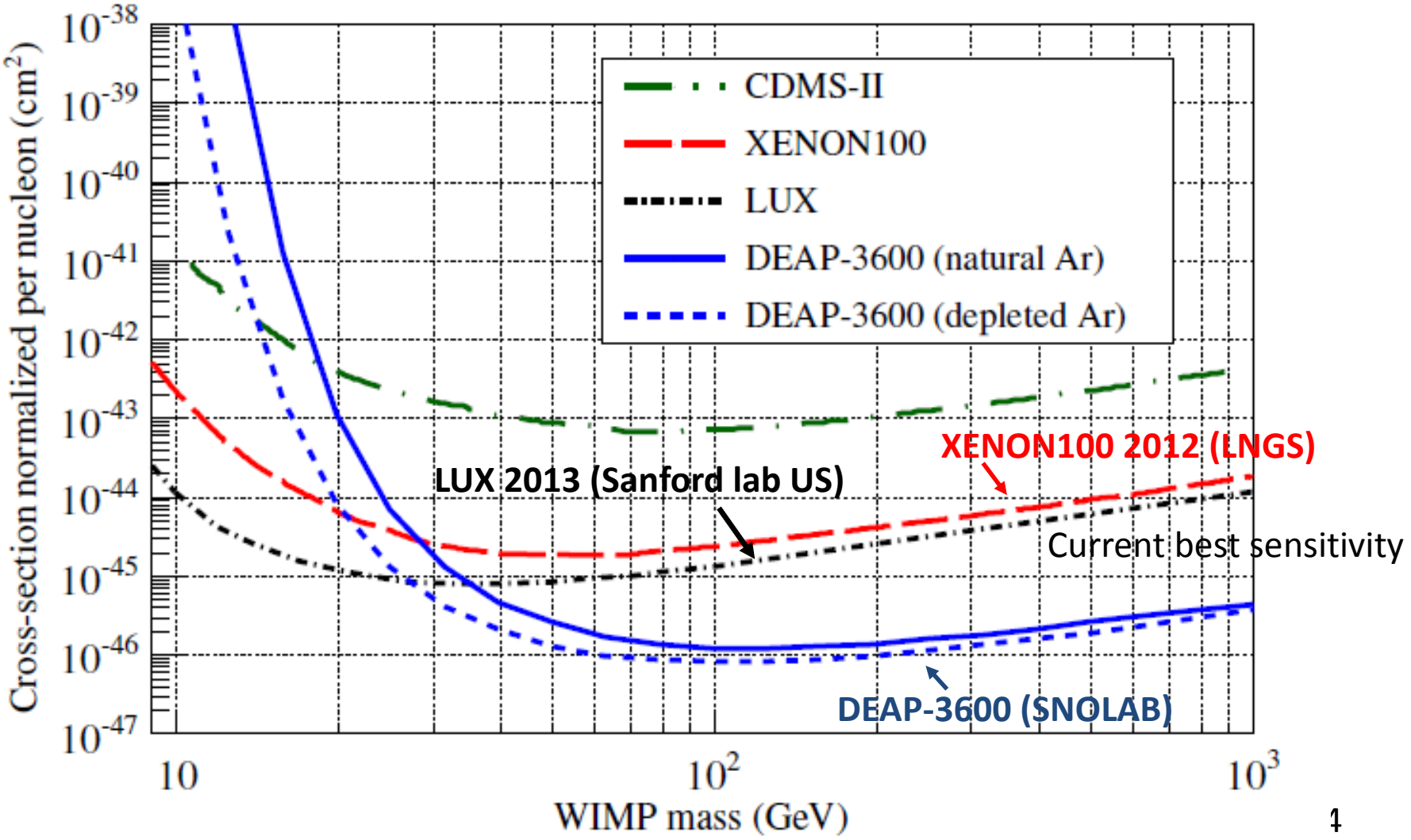
Scattered nucleus (with several 10's of keV) is detected via scintillation in liquid argon.

- Well-separated singlet and triplet lifetimes in argon allow for good pulse-shape discrimination (PSD) of β/γ's using only scintillation time information, projected to 10^{-10} at 15 keV_{ee}
  (see Astroparticle Physics 25, 179 (2006) and arxiv/0904.2930)

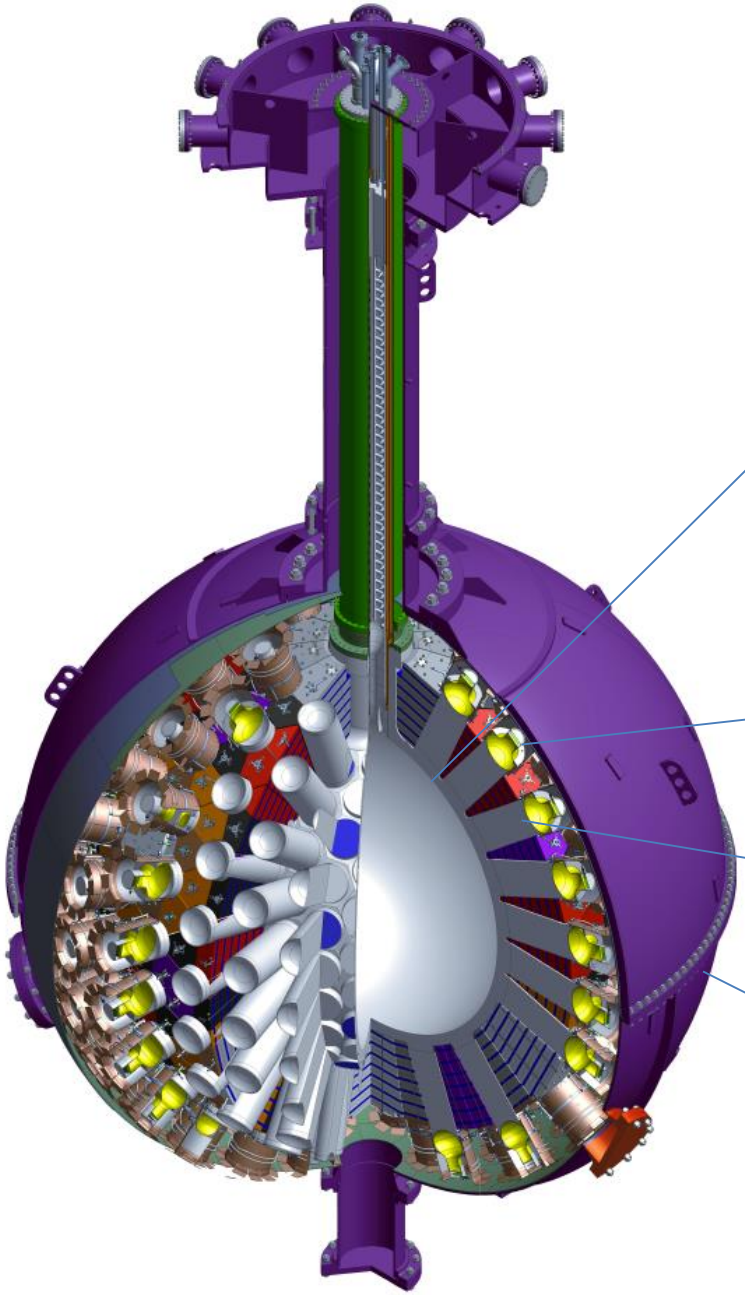
- Very large target masses possible, since no absorption of UV scintillation photons in argon, and no e-drift requirements.

- **1000 kg** argon target allows **10^{-46} cm^2** sensitivity (SI) with ~15 keV_{ee} (60 keVr) threshold, 3-year run

DEAP-3600 Projected Physics Sensitivity



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

DEAP-3600 Background Budget (3 year run)

Background	Raw No. Events in Energy ROI	Fiducial No. Events in Energy ROI	
Neutrons	30	<0.2	Acr+H_2O shield
Surface α's	150	<0.2	Resurfacer
^{39}Ar β's (natural argon)	1.6x10^9	<0.2	PSD
^{39}Ar β's (depleted argon)	8.0x10^7	<0.01	

Need to resurface inner vessel and ensure purity of acrylic.

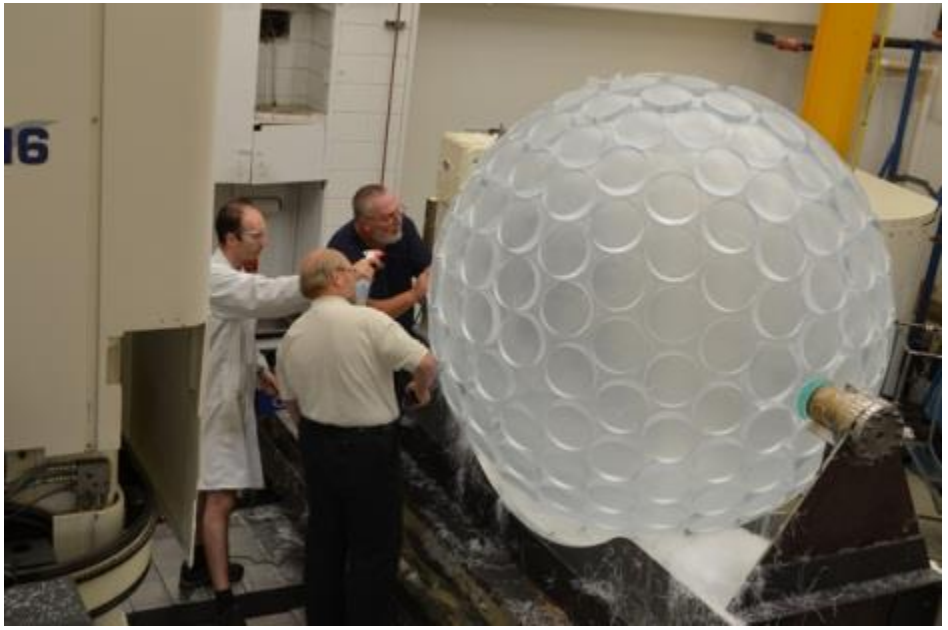
- removal of order 1/2 mm acrylic
- ^{210}Pb < 1.1x10^{-19} g/g for 0.1 events/3 years (strict control of Rn exposure)

Fabrication of DEAP Acrylic

- Fabrication from MMA monomer, strict control of radon exposure for all steps
- Moulds were prepped in a HEPA-filtered clean room made especially for DEAP (RPT Asia)
- DEAP Collaborators present during fabrication
- Control to < 10^{-20} g/g ^{210}Pb from radon exposure

DEAP Acrylic Panels at RPT Asia in 2010

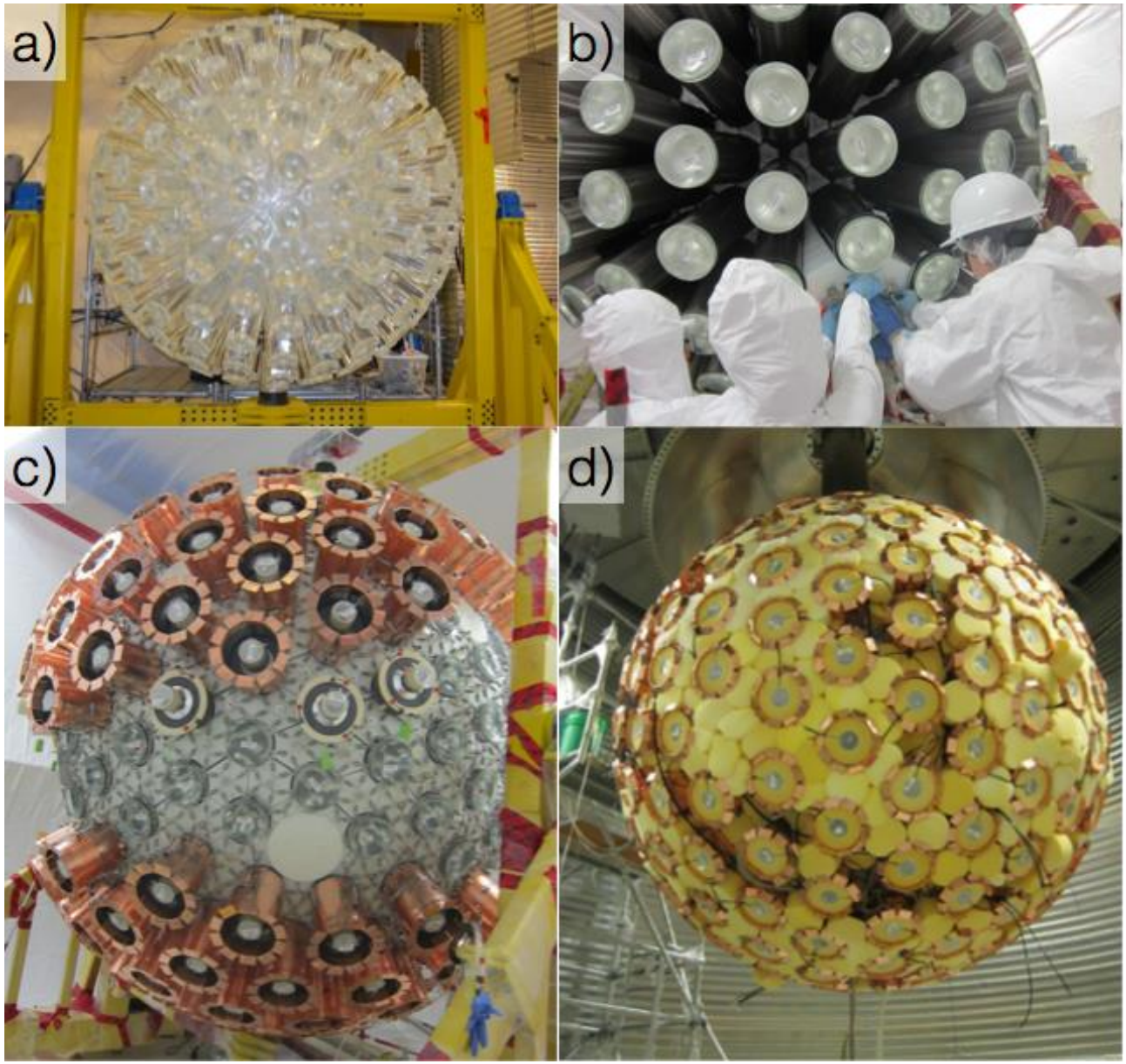
AV Fabrication (RPT Colorado and U of A)



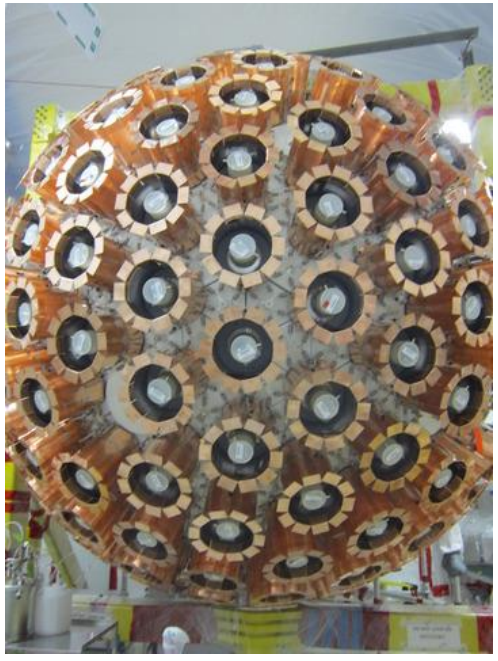
AV neck bonding underground (December 2012-January 2013)

Light guides on AV

Reflectors on light guides



PMT installation Oct 2014



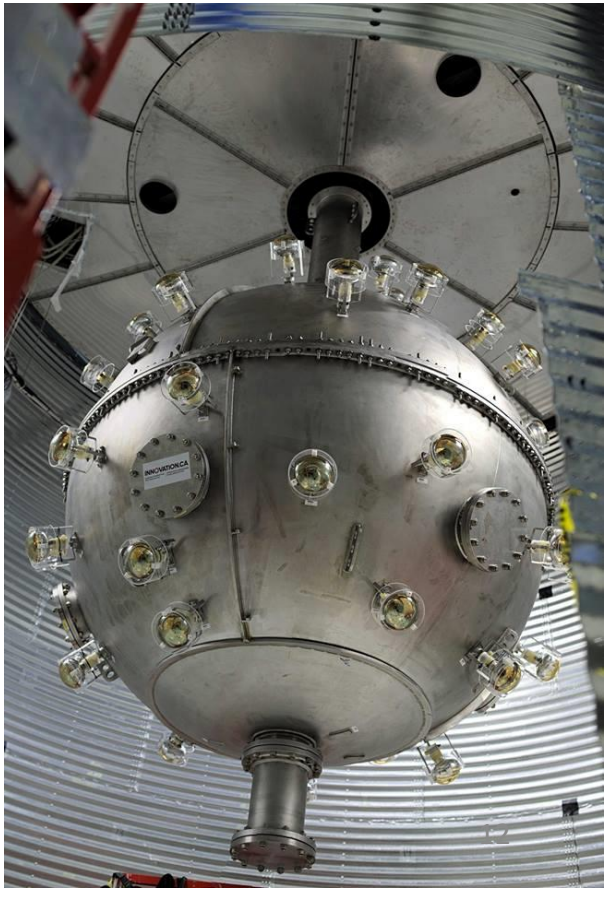
Completed inner detector

Detector ready for Final Lift onto Neck

Steel Shell closing Dec 2014

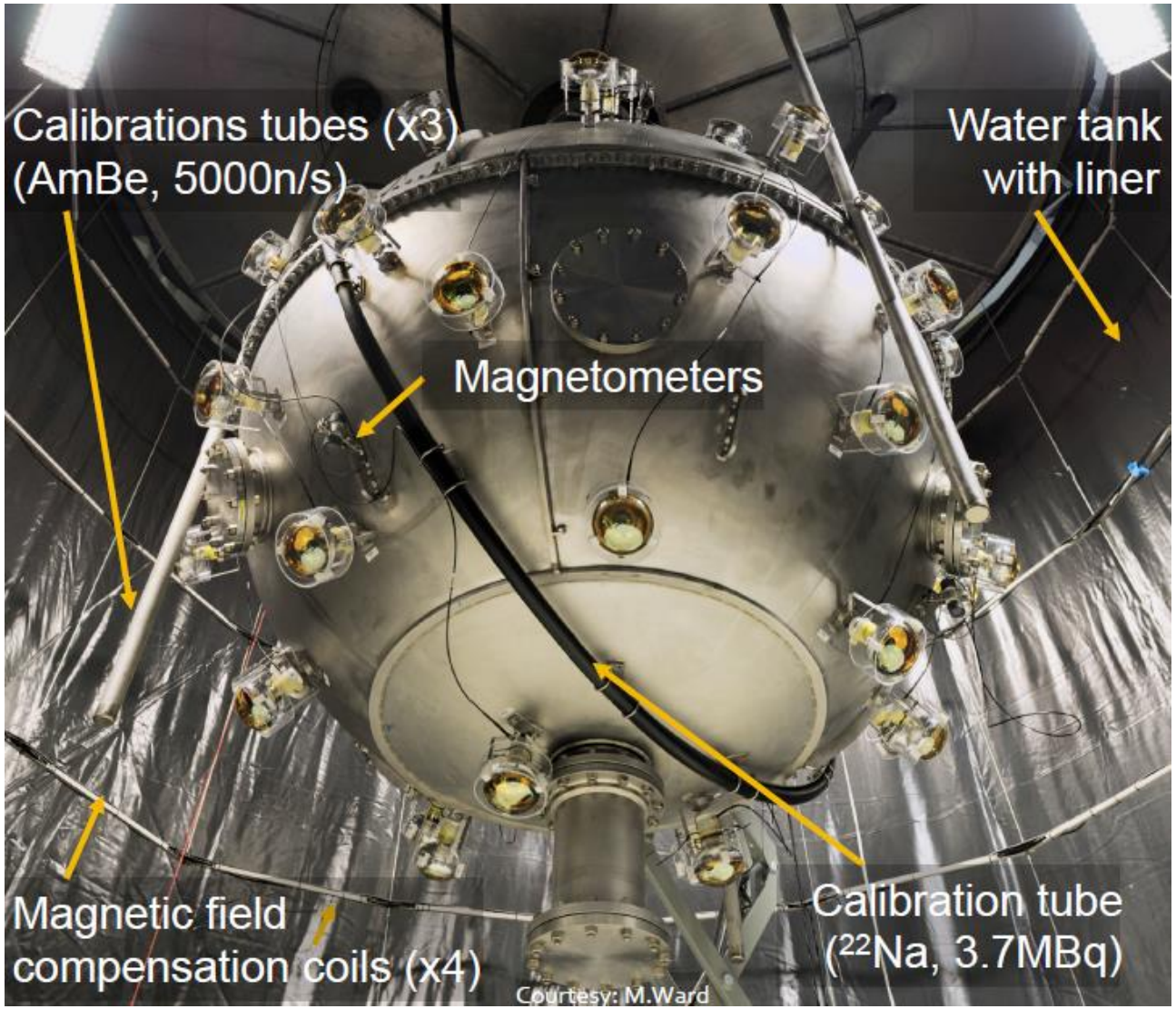
Steel Shell in shield tank

B. Cai



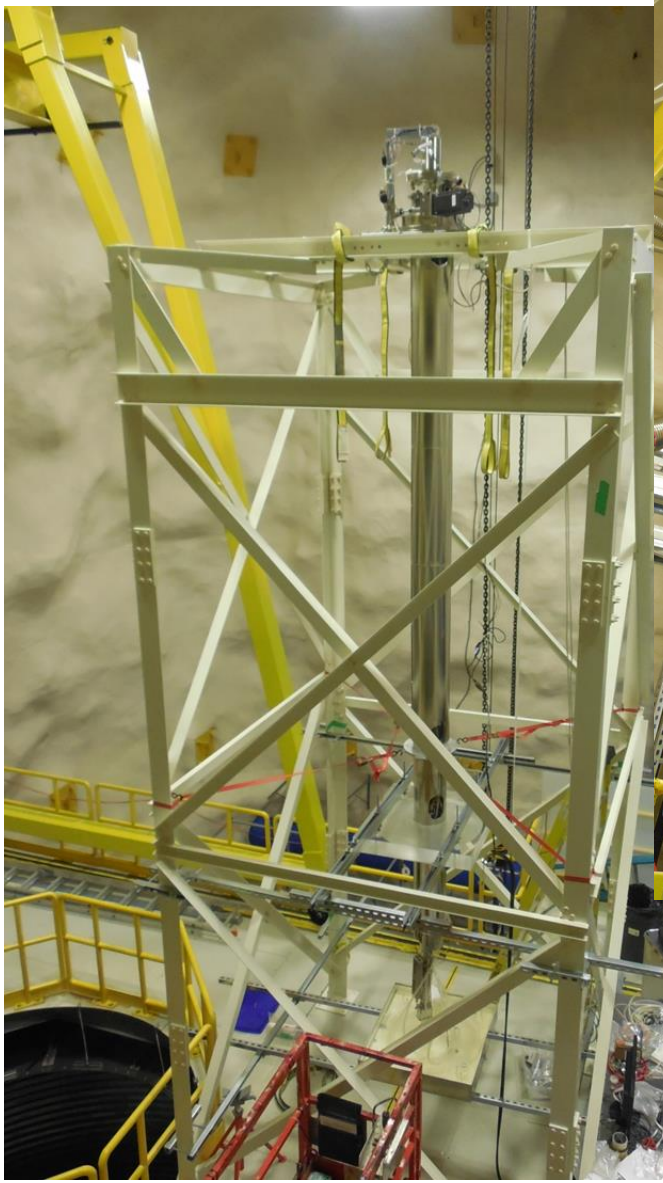
Veto PMTs installed Mar 2015

Completed Detector in Shield Tank



The Resurfacer

B. Cai



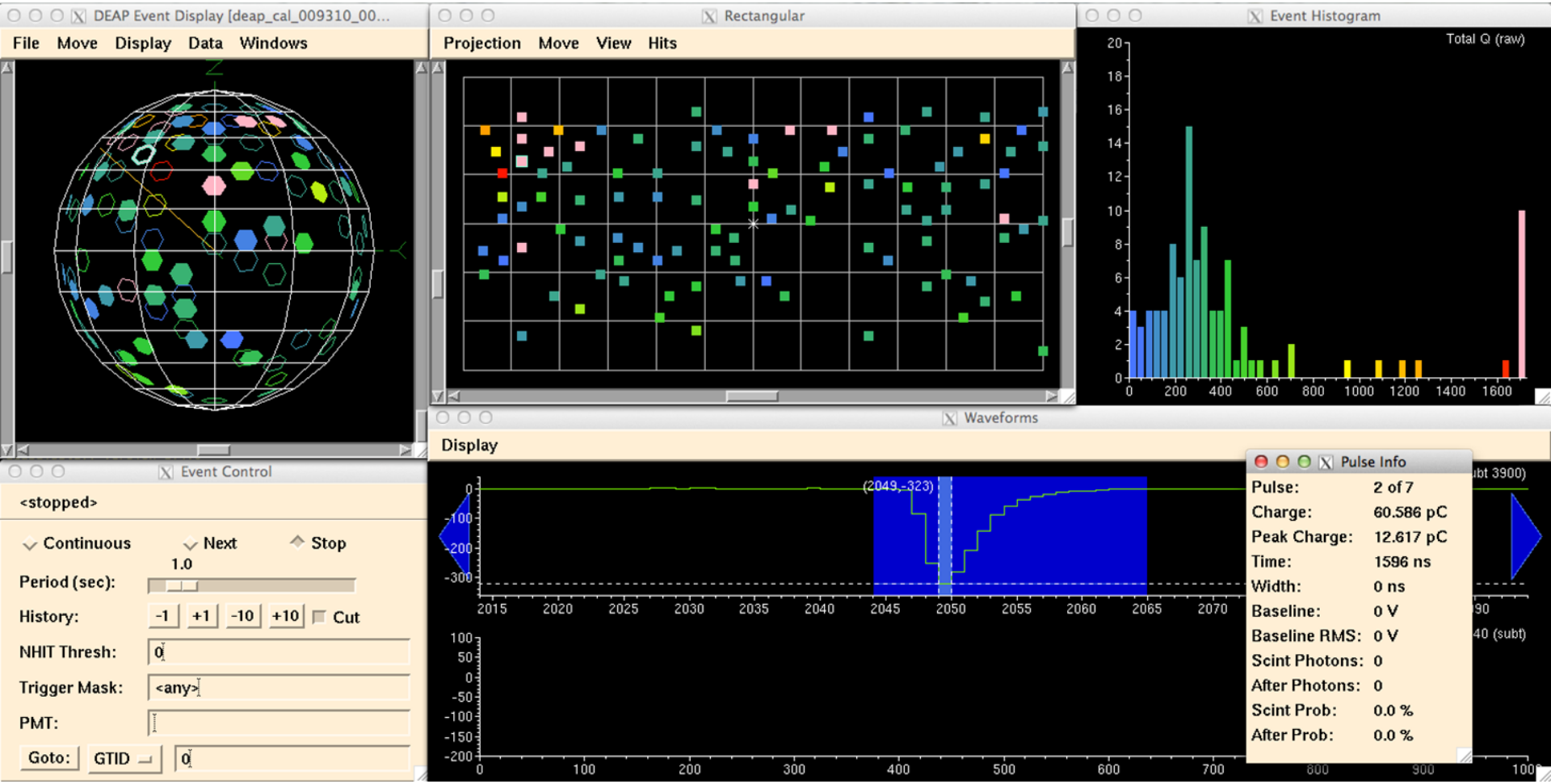
Low-radon emanation

Removes acrylic surface in-situ after construction

Completed Dec. 2014

Data acquisition system

Light injection through fibers (Commissioning Data Spring 2015)



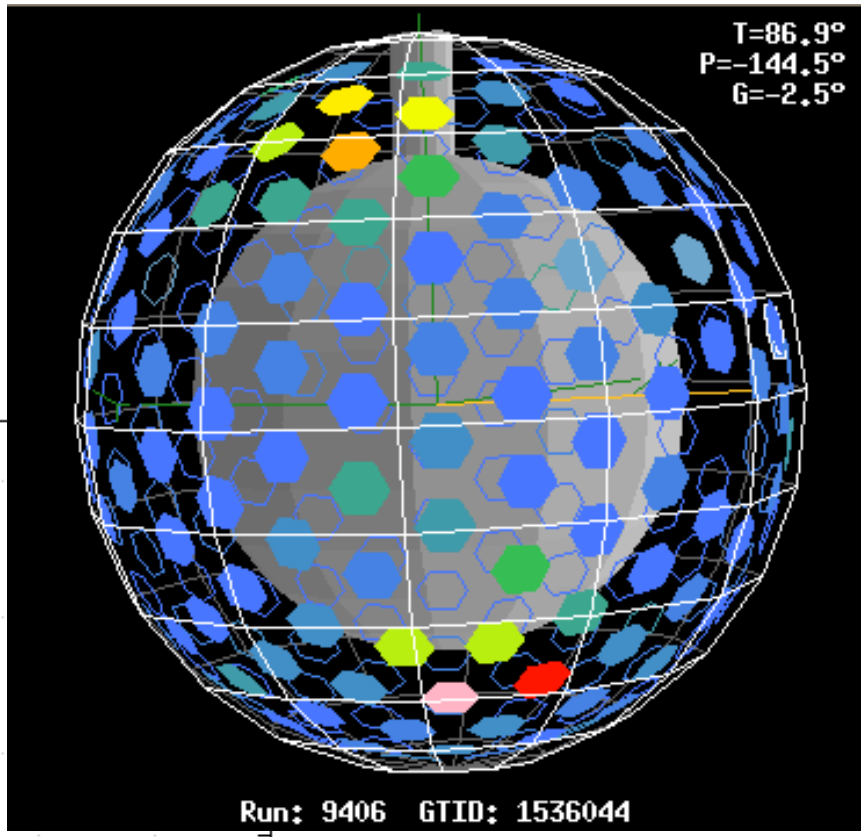
A high energy event (Commissioning running, Spring 2015)

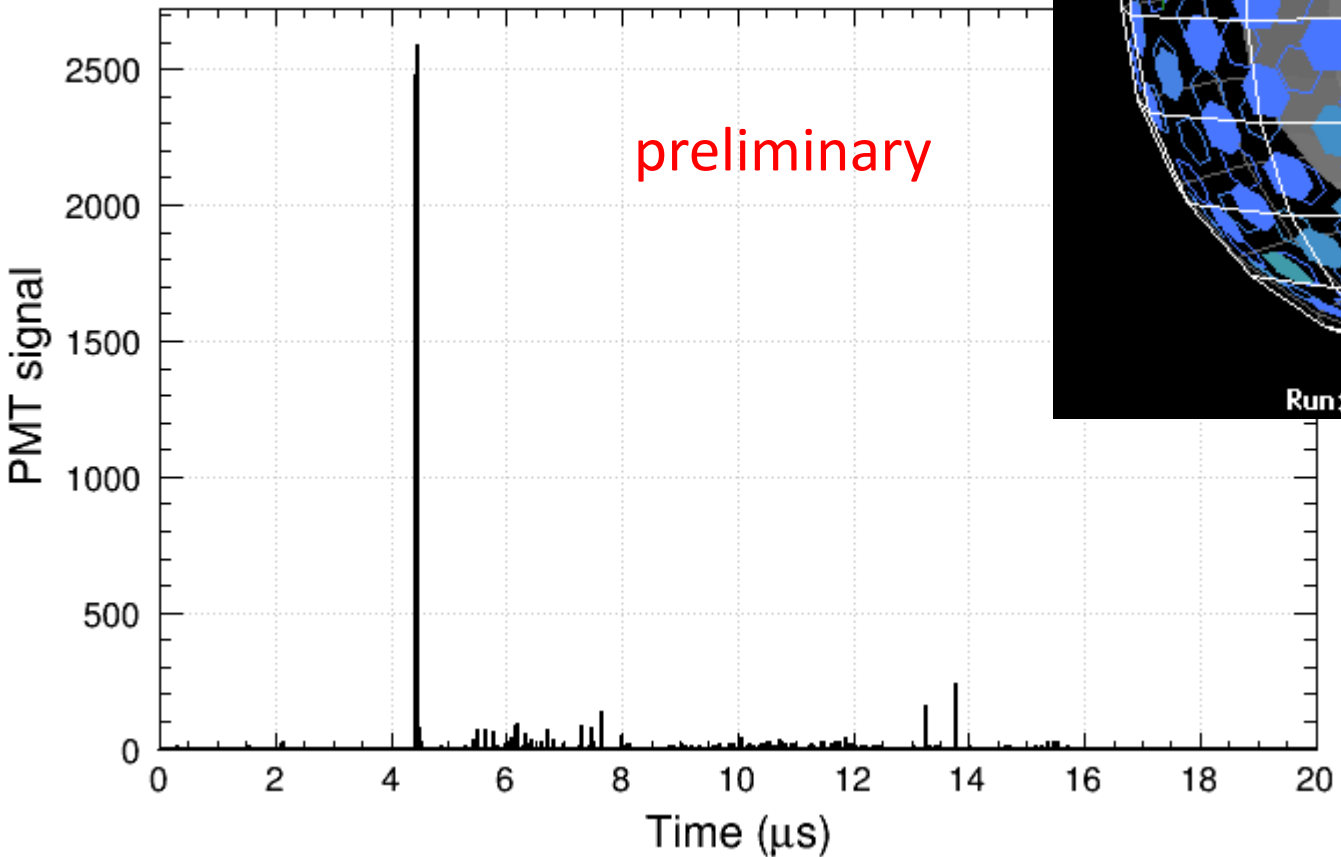
Run: 9406 Subrun: 3 Event: 300460

Total energy: 1520 PE

High event rate: ~1 event/day

Expected muon rate: 1.6 muons/day

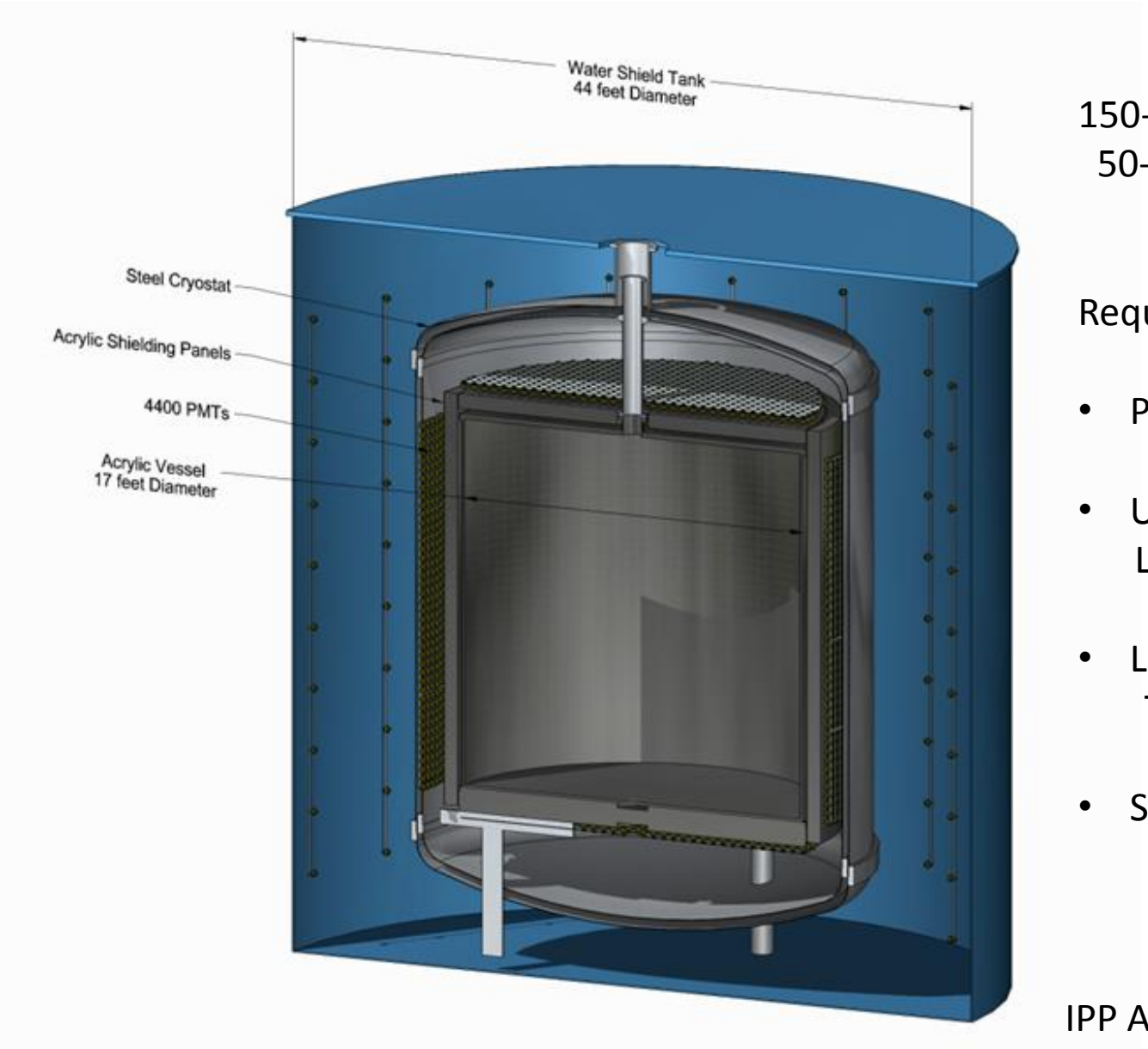




Current Status of DEAP-3600

- Acrylic vessel resurfacing was completed at the end of 2014
- Detector optical calibration, PMT and electronics commissioning ongoing (winter 2014/spring 2015)
- Commissioning cryogenic system (winter 2014/spring 2015)
- Vacuum-baked acrylic vessel, prep. for WLS (spring 2015)
- Completion of shield tank components, calibration hardware, veto PMT system (late spring 2015)
- Inner wavelength shifter is being deposited on the AV
- Next steps are commissioning with argon gas followed by cool down/liquid argon fill (starting summer 2015)
- Fill the shield tank with ultrapure water (July 2015)

DEAP-50T: Possible follow-up with 50-tonnes of liquid argon



150-tonnes DAr in AV
50-tonne fiducial

Requires development of:

- Photodetector/light readout
- UG screening/storage of Low Radioactivity Argon
- Low Background Cryogenic Test Facility
- Seismic/safety engineering

Summary

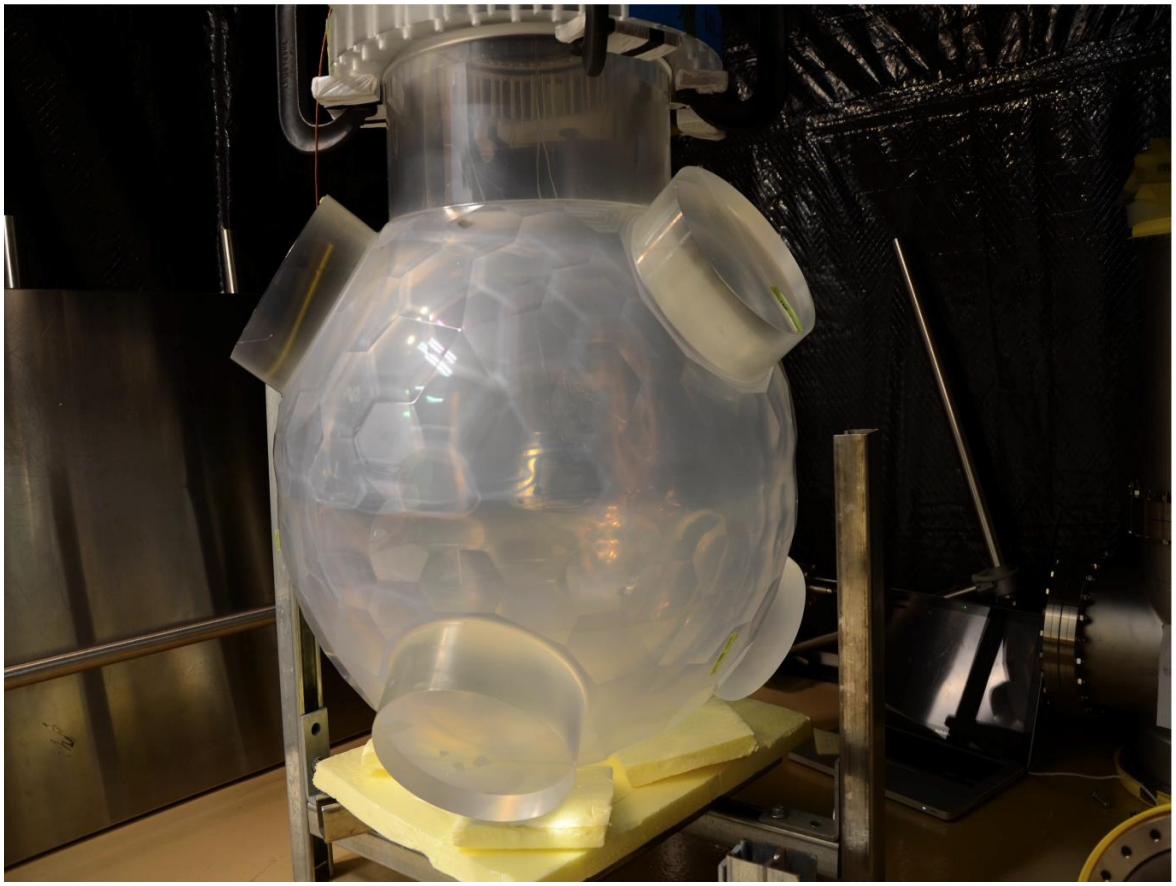
- DEAP-3600 sensitive to SI DM interactions at 10^{-46} cm^2; factor of >20X improvement at high WIMP mass over current LUX leading result
- Construction completed, currently depositing wavelength shifter
- Have been commissioning PMTs and electronics since late 2014, optical calibrations ongoing
- Start of argon running Summer 2015
- Possibility of 50T follow-up program, physics reach is near ultimate sensitivity of neutrino backgrounds

DEAP presentations at CAP

- Presentations (Tuesday afternoon)
  - DEAP-3600 trigger — B. Smith
  - Optical data — B. Beltran
  - Single photo-electron counting — T. McElroy
  - Neck alpha backgrounds — J. Bueno
  - Wavelength thickness studies — D. Cranshaw
- Posters (Wednesday evening)
  - Detector design and construction — DEAP Collaboration
  - The resurfacer — P. Giampa, B. Cai
  - Single PE calibration — C. Jillings, M. Kuzniak, T. Pollmann
  - Neck alpha backgrounds — C. Mielnichuk
  - ^{39}Ar energy calibration — C. Stone, C. Jillings

Backup slides

TPB wavelength shifter deposition



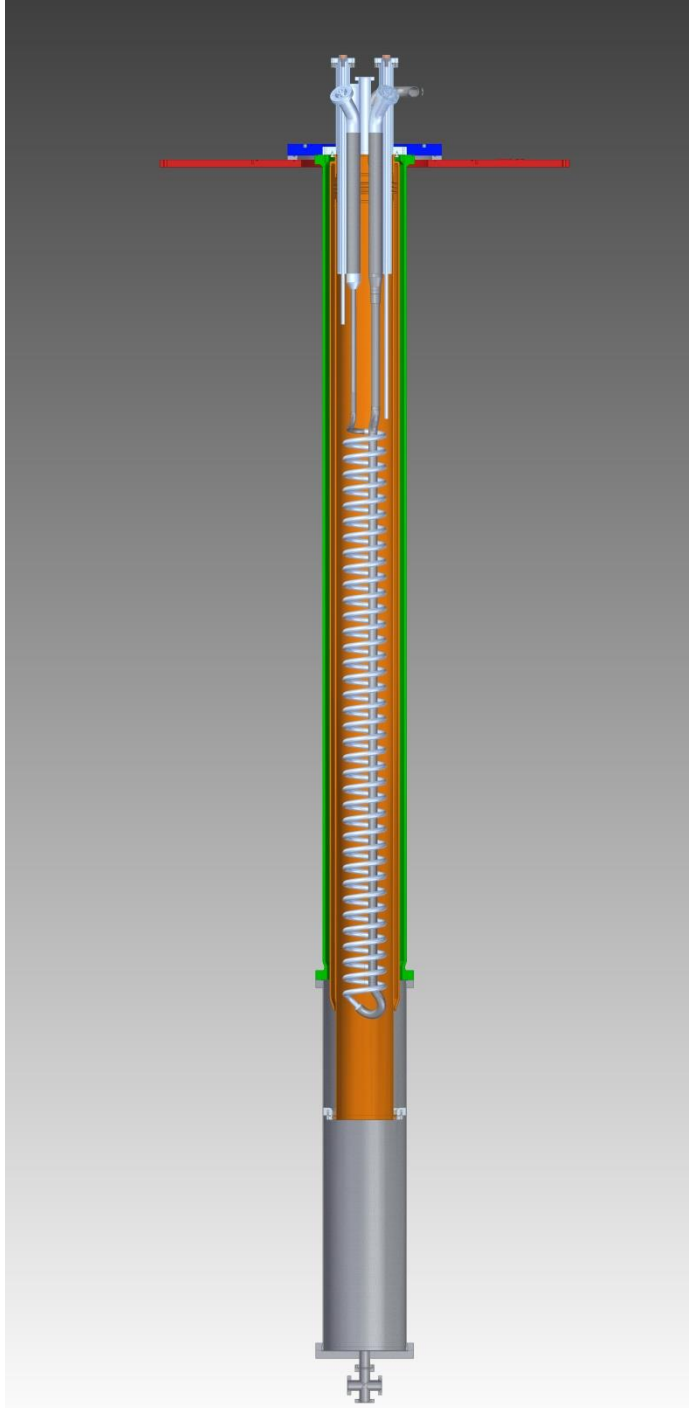
Process system

Ar purification getter and charcoal trap

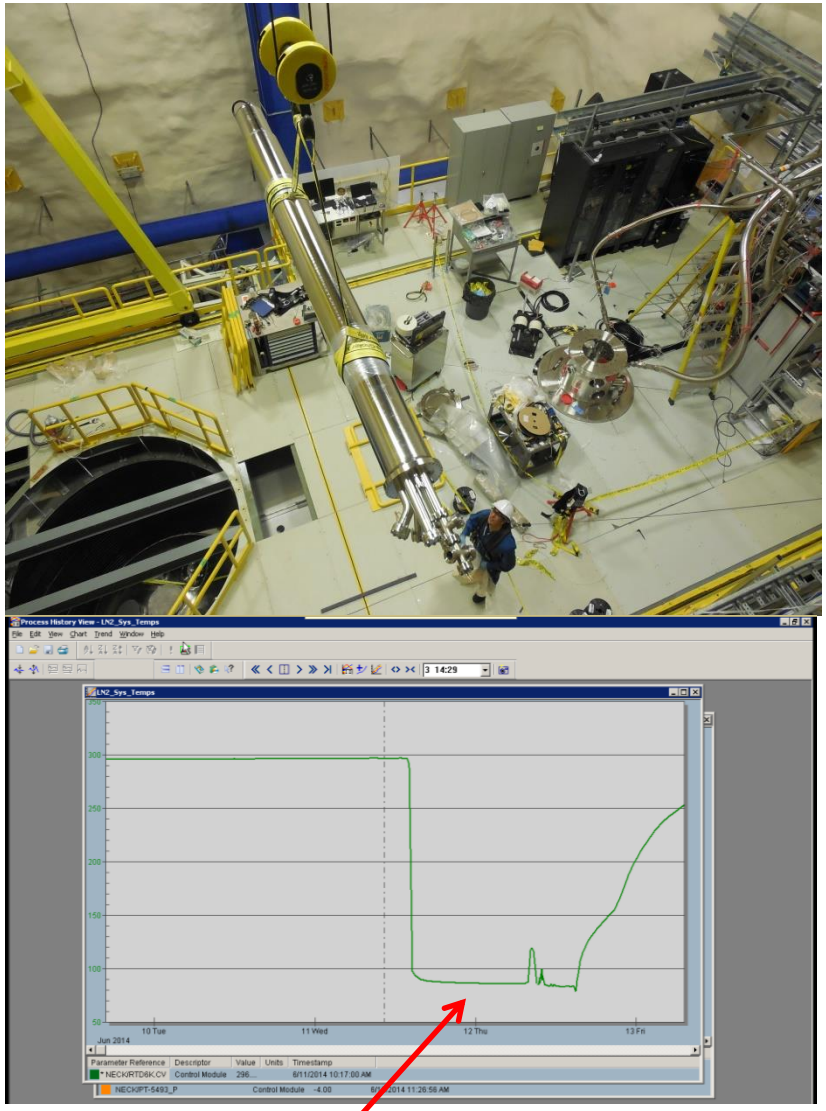

Cryocoolers and LN2 dewar


Ar dewar


Cooling coils being prepared for final acid bath



DEAP-3600 Argon Cooling System



Commissioning at 86 K, June 11 2014