DEAP-3600 Dark Matter Search at SNOLAB:
Overview, Status and Future

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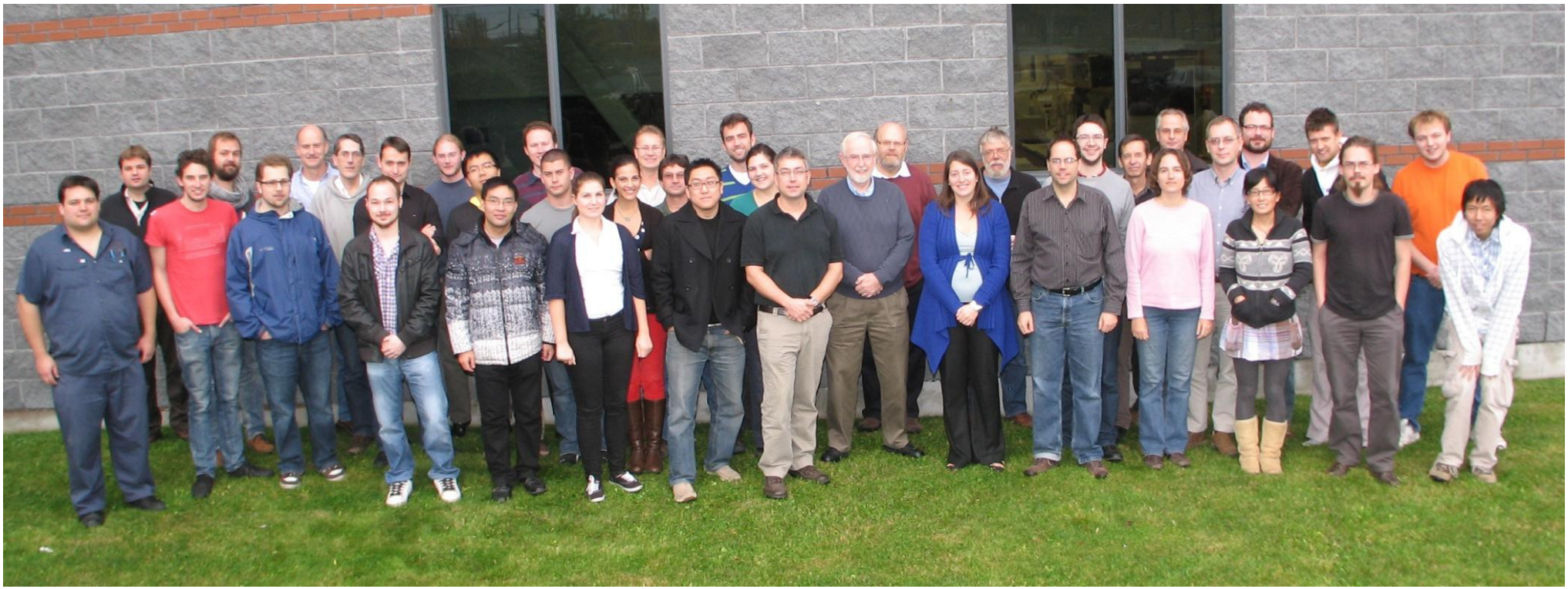
(for the DEAP collaboration)



University of Alberta

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Carleton University

K. Graham, C. Ouellet, K. Brown

Queen's University

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

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TRIUMF

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P. Majewski, Raj Shah

Royal Holloway University of London

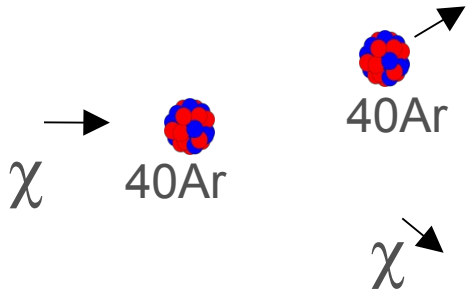
J. Monroe, J. Walding**,** A. Butcher

University of Sussex

Simon Peeters, Glenn Shayer

UK

Liquid argon as a robust and scalable dark matter target



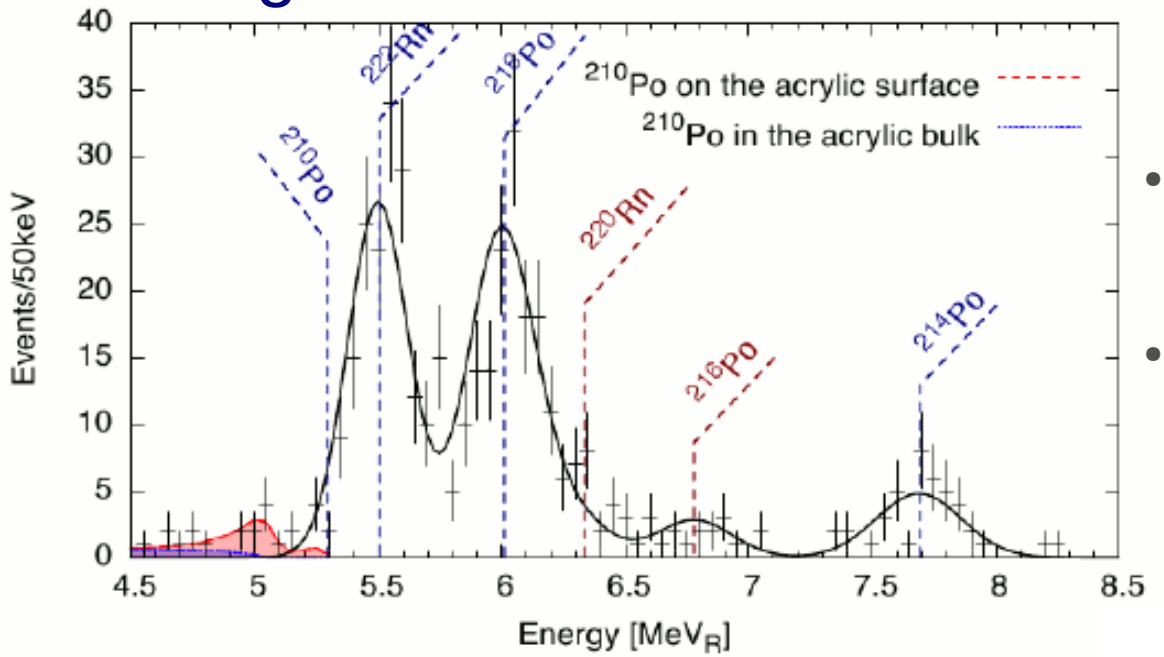
- Well-separated singlet and triplet lifetimes in argon allow for good pulse-shape discrimination (PSD) of β/γ's using only scintillation time information
- **PSD to 10^{-8} demonstrated with DEAP-1**
  (Astroparticle Physics 25, 179 (2006) and arXiv:0904.2930, analysis of extended dataset to be published)
- For DEAP-3600 projected to 10^{-10} at 15 keVee

- 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 keVee (60 keVr) threshold, 3-year run

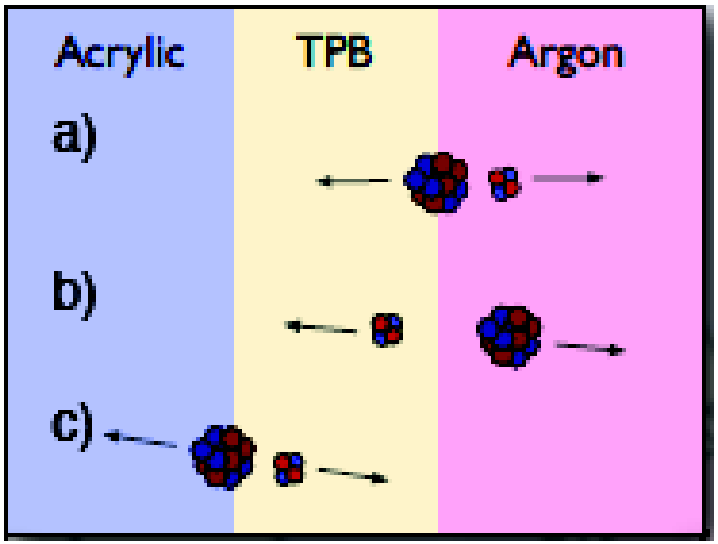
Background targets

Background	Target
Radon in argon	< 1.4 nBq/kg
Surface α's (tolerance using conservative pos. resolution)	< 0.2 μBq/m2
Surface α's (tolerance using ML position resolution)	< 100 μBq/m2
Neutrons (all sources, in fiducial volume)	< 2 pBq/kg
Bg events, dominated by 39Ar	< 2 pBq/kg
Total Backgrounds (3 Tonne-year in fiducial volume and Region of Interest)	**< 0.6 events**

DEAP-1: Good understanding of surface backgrounds



- Find ^{214}Po "sticks" to wall,
- Ratio of ^{214}Po : ^{222}Rn only explained with rough surface



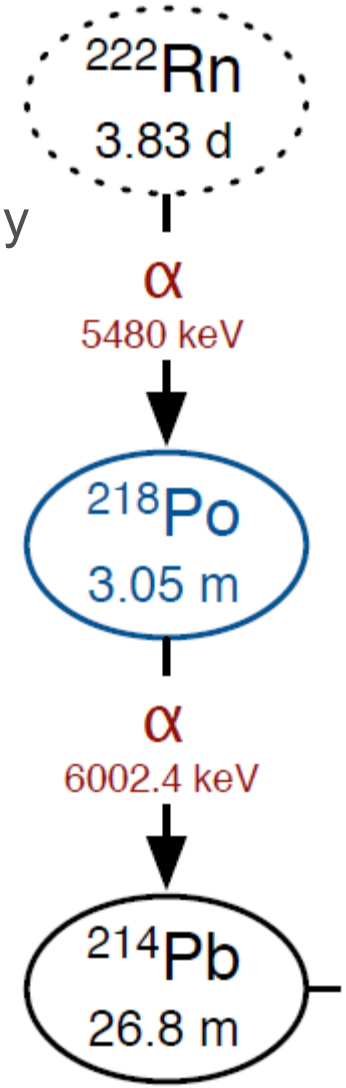
^{222}Rn :

120 μBq in DEAP-1

Compare for example:

360 μBq in EXO-200

[PRL 109 032505 (2012)]



Radon backgrounds in the DEAP-1 liquid argon based Dark Matter detector

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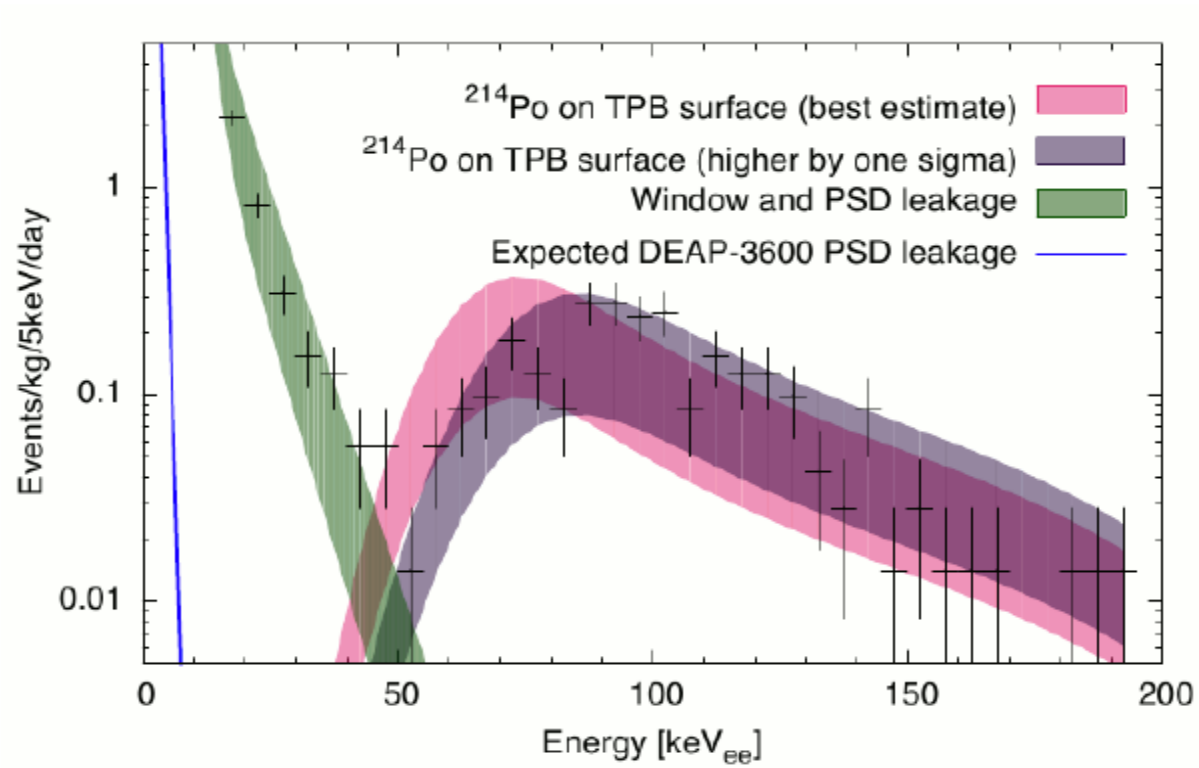
arXiv:1211.0909v1 [astro-ph.IM] 5 Nov 2012



Low-energy spectrum well-described by ^{222}Rn in argon, normalized to high-energy α-rates.

Gap between 15 keVee and 40 keVee for DEAP-3600.

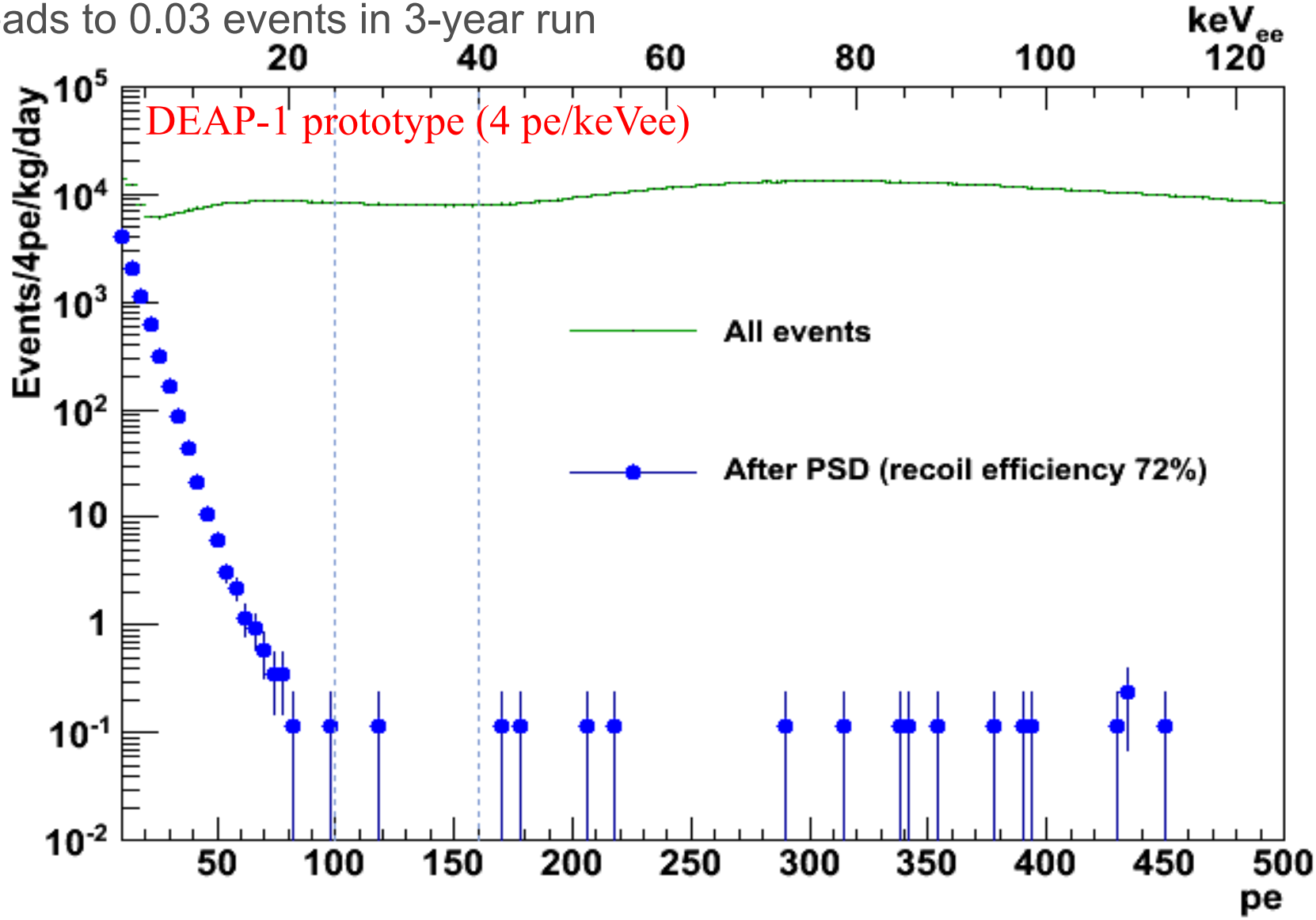
By-product:

"Surface roughness interpretation of CRESST-II result"

Astropart. Phys. 36, 77 (2012)

In DEAP-3600 surface background better discriminated with fiducialization

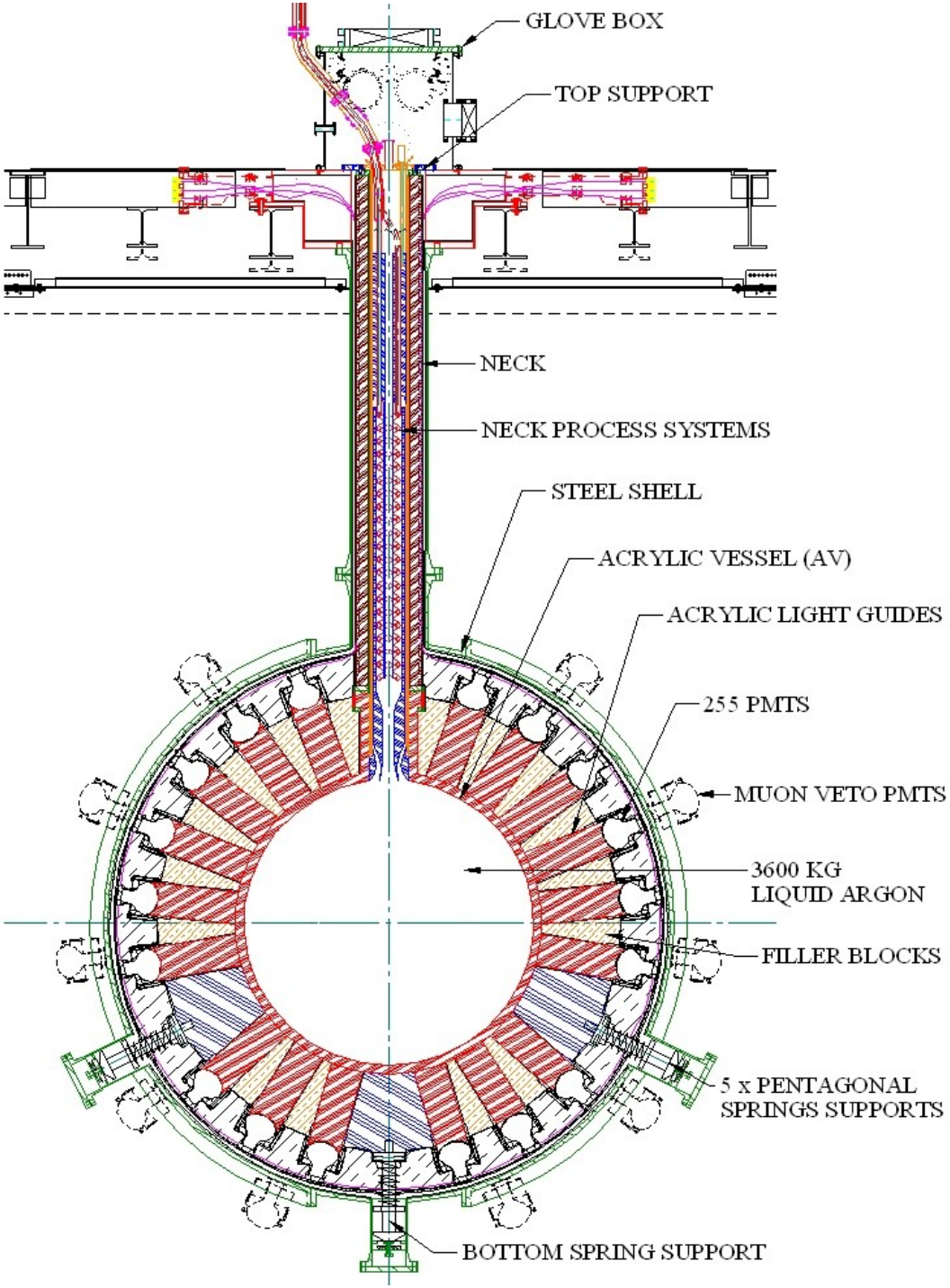
With position reconstruction surface contamination of 100 μBq/m2 leads to 0.03 events in 3-year run



DEAP-3600 neutron backgrounds

- Dominated by (alpha, n) neutrons from PMT glass (Hamamatsu R5912 HQE)
- Extensive Geant4 simulations to set the purity targets for U/Th and ^{210}Pb
- Quality assurance and assay campaign to validate the material purity and limit exposure to Rn

	# of neutrons (produced in 3 years)	Events in ROI (3 years)
Acrylic vessel	<44 (Ge g-assay)	<0.096
Light guides	<127 (Ge g-assay)	<0.015
Filler blocks	<173 (Ge g-assay)	<0.034
PMTs	2.6x105	0.140
PMT mounts	7565	0. 010
Rn emanation	<44	<0.081
Rn deposition (3 months construction)	38	0.010
Other sources		0.04
Total	**<2.7x105**	**<0.35**



DEAP-3600

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

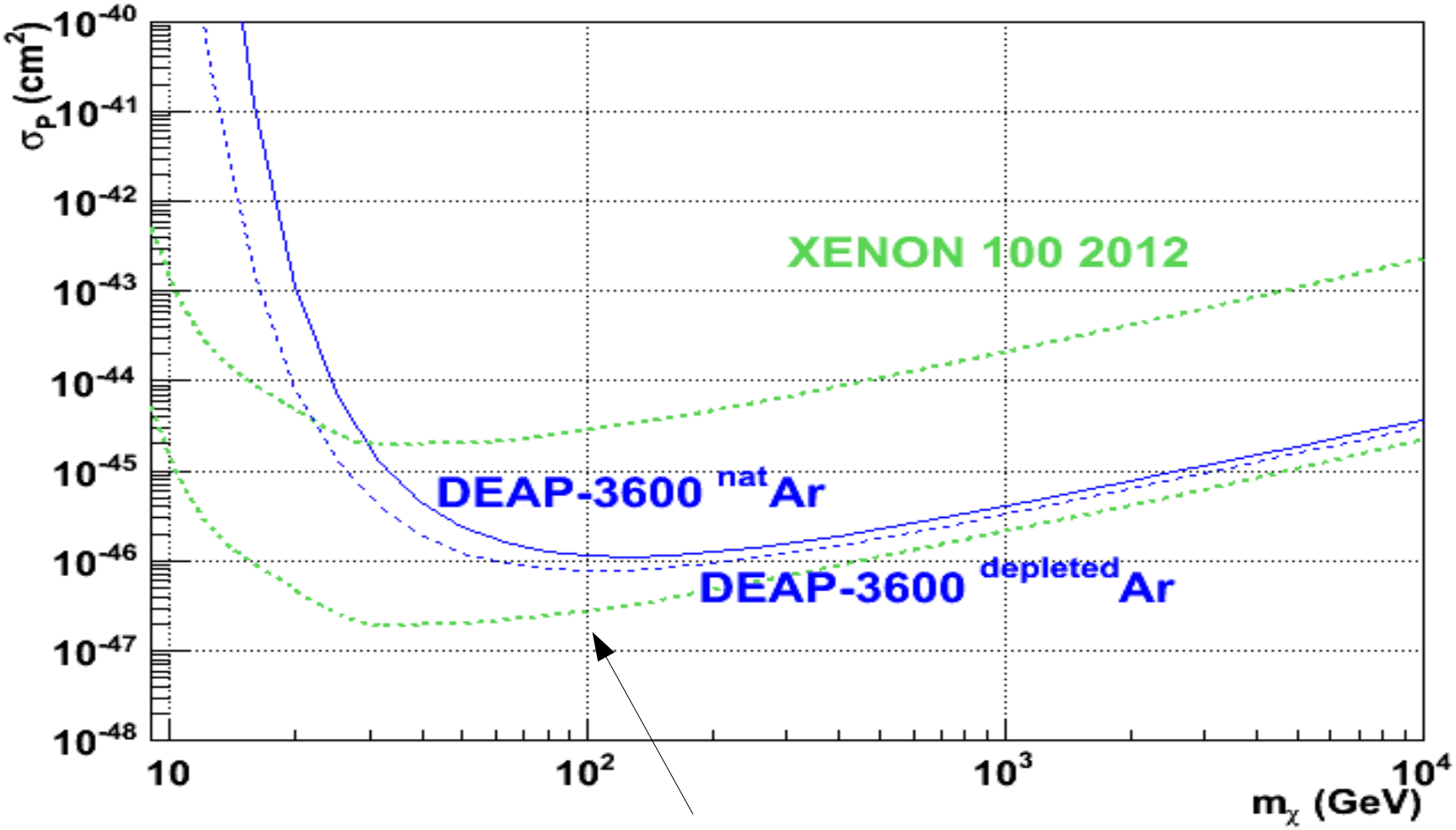
Vessel is “resurfaced” in-situ to remove deposited Rn daughters after construction

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

50 cm light guides + PE shielding provide neutron moderation

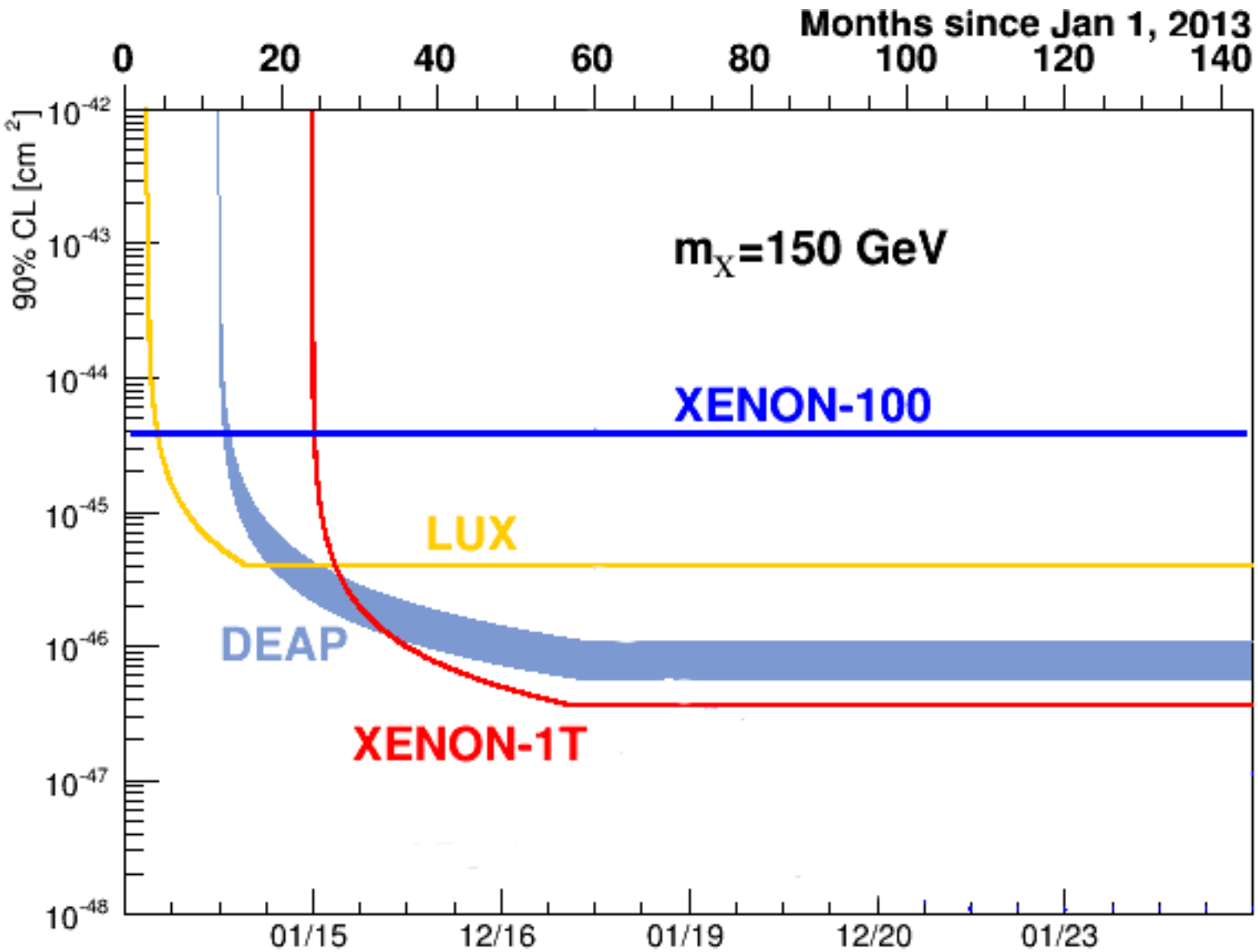
Detector in 8 m water shield at SNOLAB

Competitive SI sensitivity...



XENON-1Tonne
Design Goal (sensitivity @ 60 GeV)

... on competitive timescale



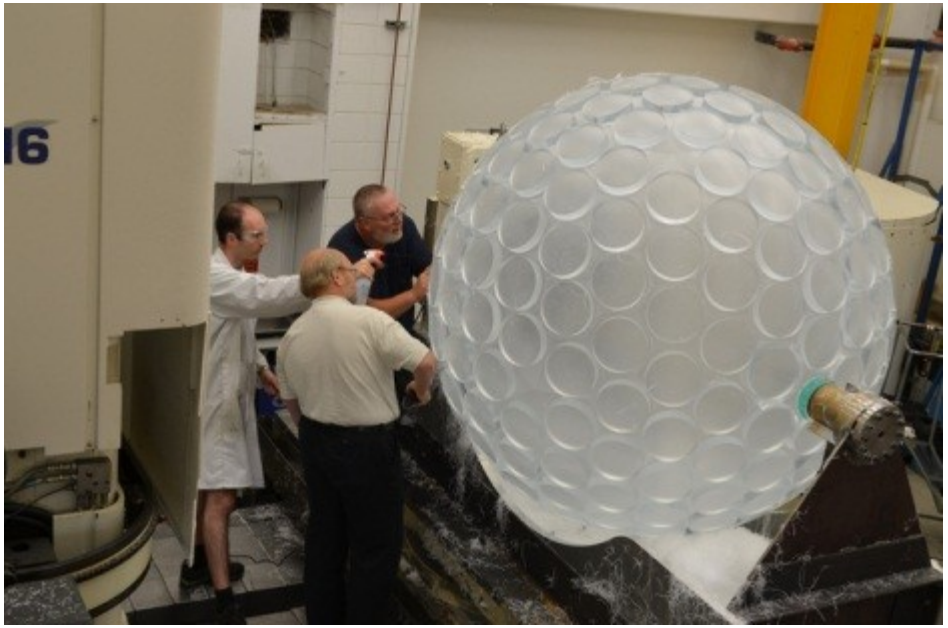
Construction highlights

Water shield tank

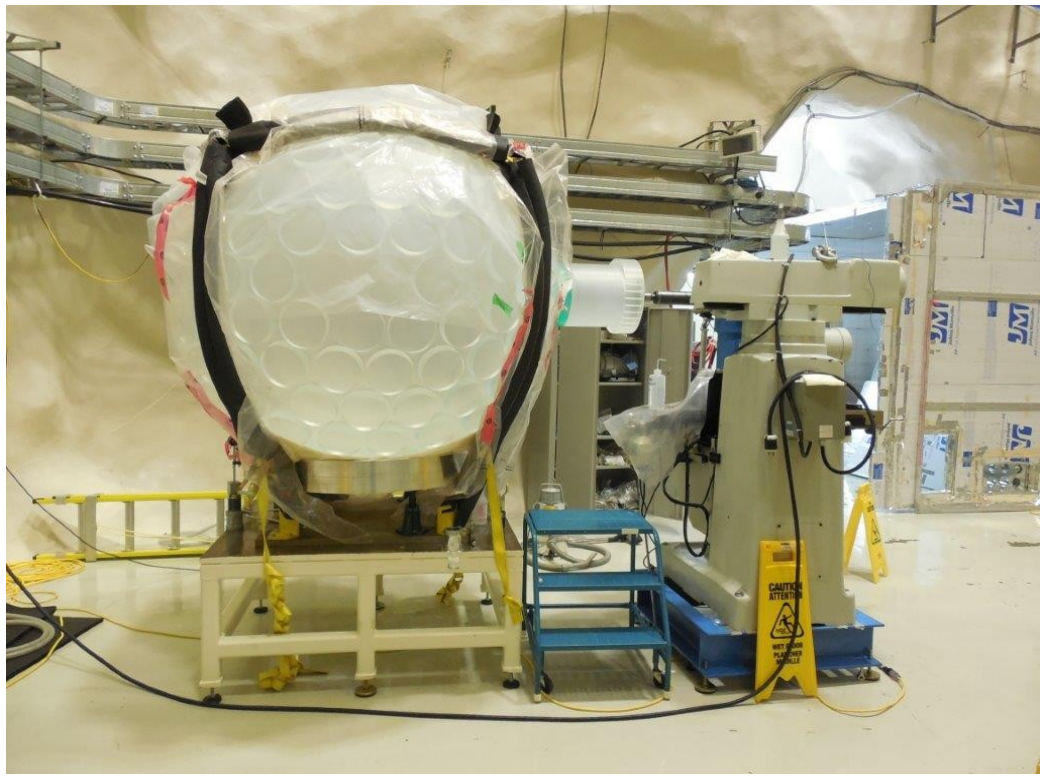
Steel shell

(Snowmass

AV Fabrication
(RPT and
University of Alberta)



Underground bonding and machining

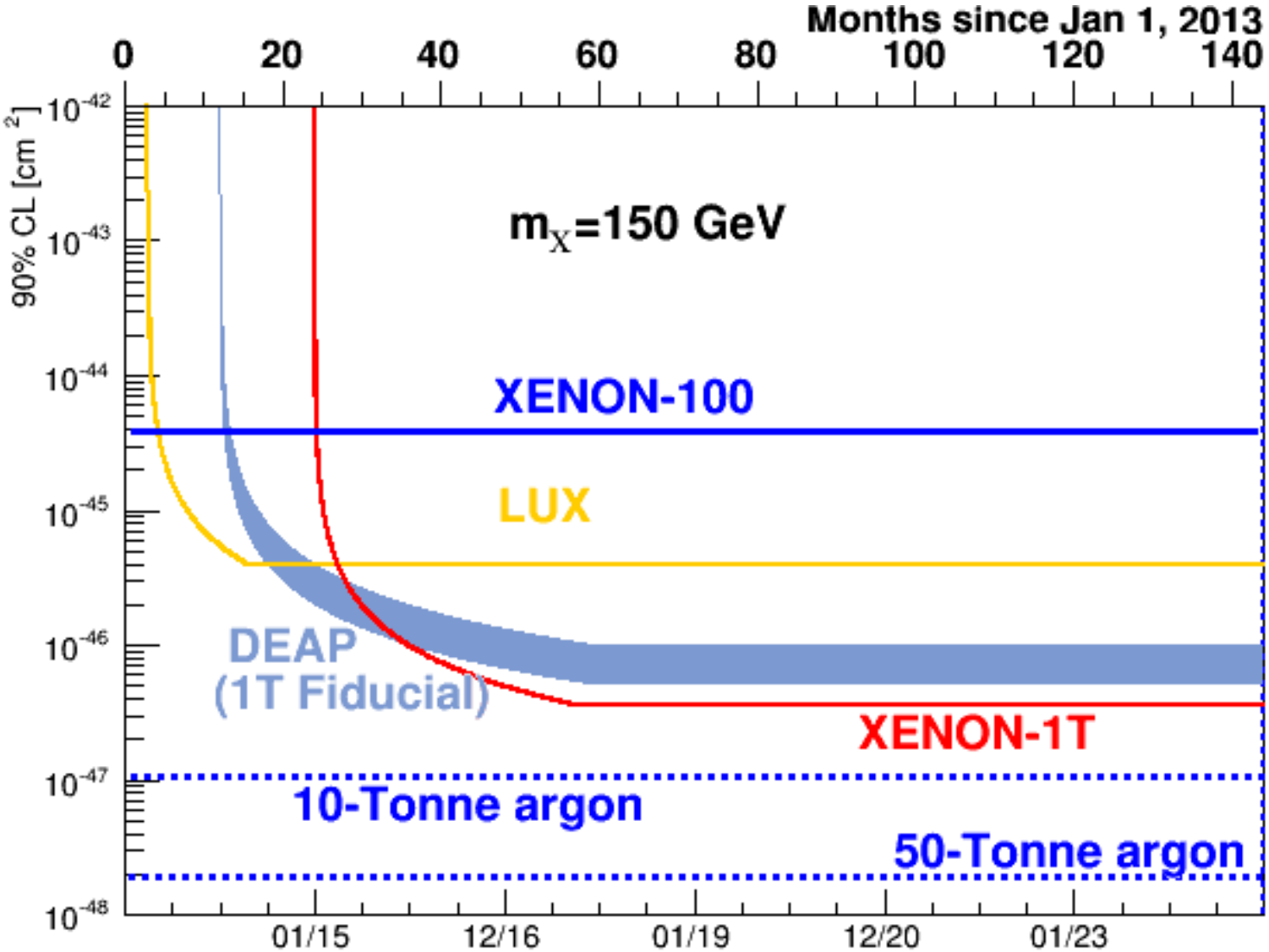



Annealing oven for
the acrylic vessel
JM
Johns Manville
CAUTION
CAUTION

Cooldown scheduled for January 2014

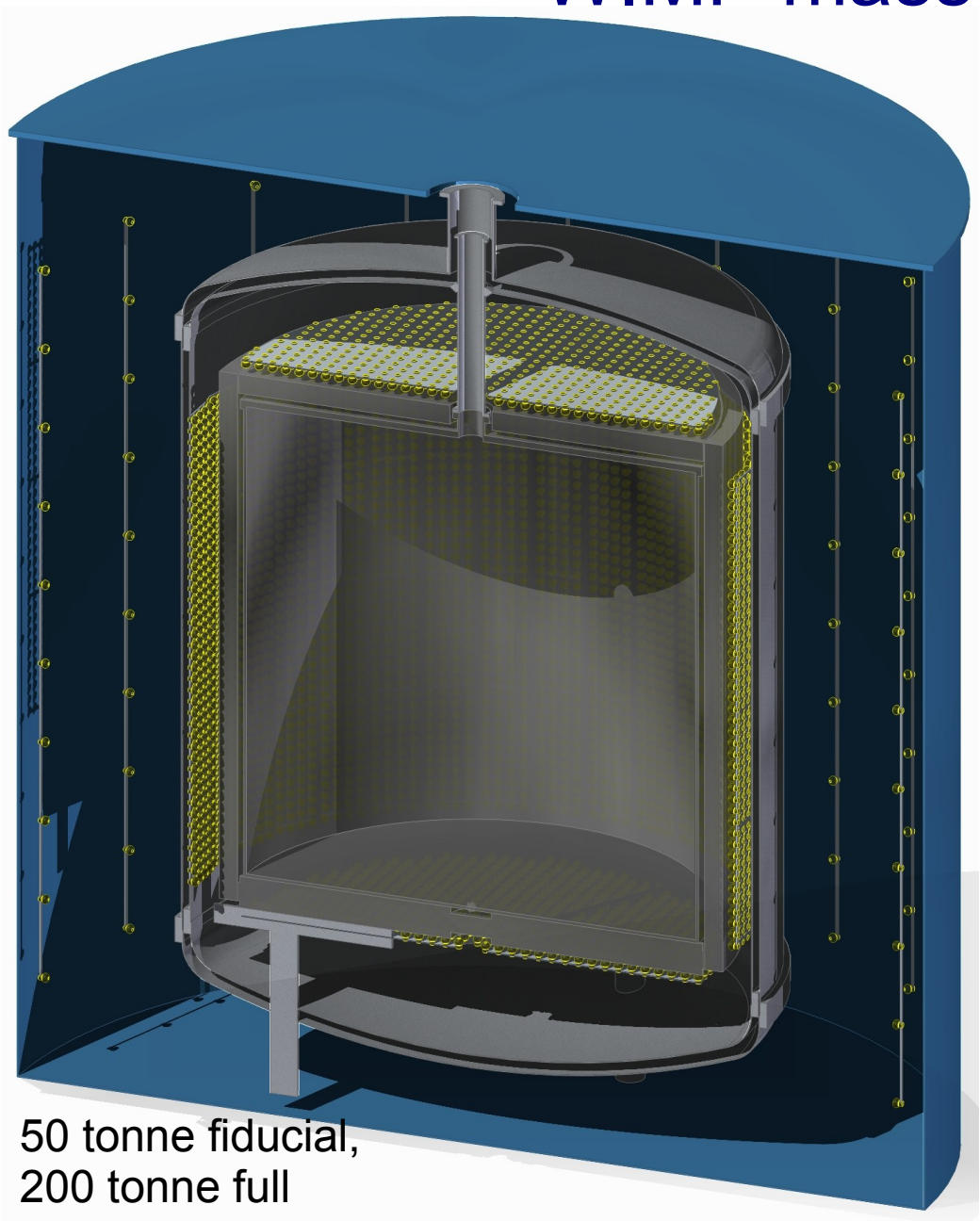
- Remaining construction milestones:
  - LG bonding
  - PMT installation
  - Resurfacing
  - TPB deposition
- Cooldown: January 2014
- Followed by a couple of months for commissioning

Thinking about future scale-up



- Our current focus on DEAP-3600
- But already starting to think about a competitive next generation detector
- Very attractive possibility for a precision measurement (if a signal at ~10^{-46} cm^2 is seen)
- Some modest R&D underway

WIMP mass sensitivity



50 tonne fiducial,
200 tonne full

- Technology can be scaled to very large target masses, > 100 tonnes or 10^{-48} cm^2 sensitivity
- Larger detector allows for better position reconstruction
- This makes surface contamination easier to mitigate
- Relaxed targets on surface contamination significantly simplify many aspects of construction and assembly (compared to DEAP-3600)
- Large detector will require Depleted Argon

Summary

- DEAP-3600 construction is progressing rapidly
- Detector online early next year, with competitive sensitivity for WIMP masses >150 GeV
- We have demonstrated sufficient control over surface backgrounds in DEAP-1

- Some conceptual effort on the next generation detector
- In the single-phase technology, larger scale makes life much easier
- Potentially, very attractive way towards a precision measurement (if a WIMP signal is seen by 1 tonne scale experiments)