The MiniCLEAN Dark Matter Experiment

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DEAP and CLEAN Family of Detectors

DEAP 0
initial R&D detector

DEAP 1
7 kg LAr
2 warm PMTs
SNOLab 2008

Pico-CLEAN
initial R&D detector

Micro-CLEAN
4 kg LAr and LNe
2 cold PMTs
surface tests at Yale

Mini-CLEAN
500 kg LAr/LNe (150 kg fiducial mass)
92 cold PMTs
Under Construction at SNOLAB

DEAP-3600
3600 kg LAr (1000 kg fiducial mass)
266 warm PMTs*
Underground at SNOLab late 2012

50 ton LNe/LAr Detector
pp solar ν, supernova, dark matter < 10^{-46} cm^2
DUSEL or SNOLAB ~ 2016

10^{-44} cm^2

10^{-45} cm^2

10^{-46} cm^2

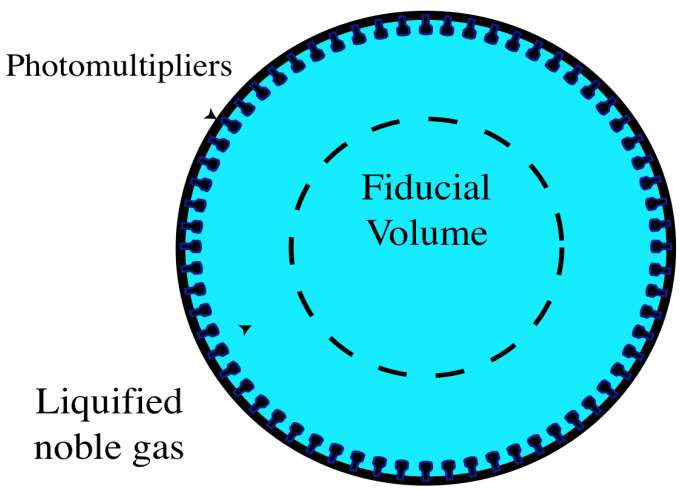
WIMP σ sensitivity

The Mini-CLEAN Approach

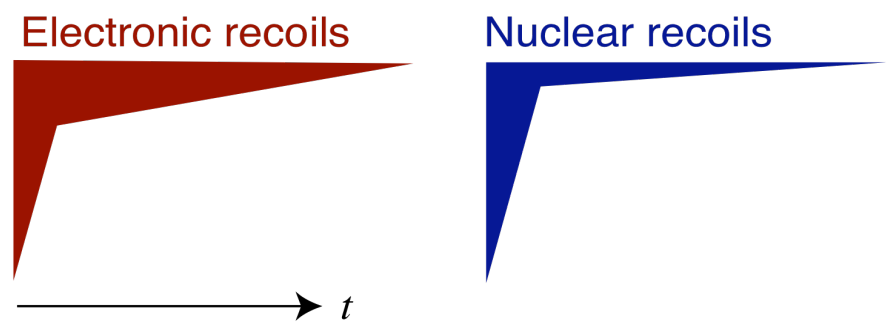
Scaleable technology based on detection of scintillation in liquified noble gases. No E field.
Ultraviolet scintillation light is converted to visible light with a wavelength-shifting film.

Liquid neon and liquid argon are bright scintillators (30,000 - 40,000 photons/MeV).
Do not absorb their own scintillation.
Are inexpensive (Ar: $2k/ton, Ne: $60k/ton).
Are easily purified underground.
Exhibit effective pulse shape discrimination.
Exchange of targets allows direct testing of A^2 dependence of WIMP scattering rate

Self-shielding



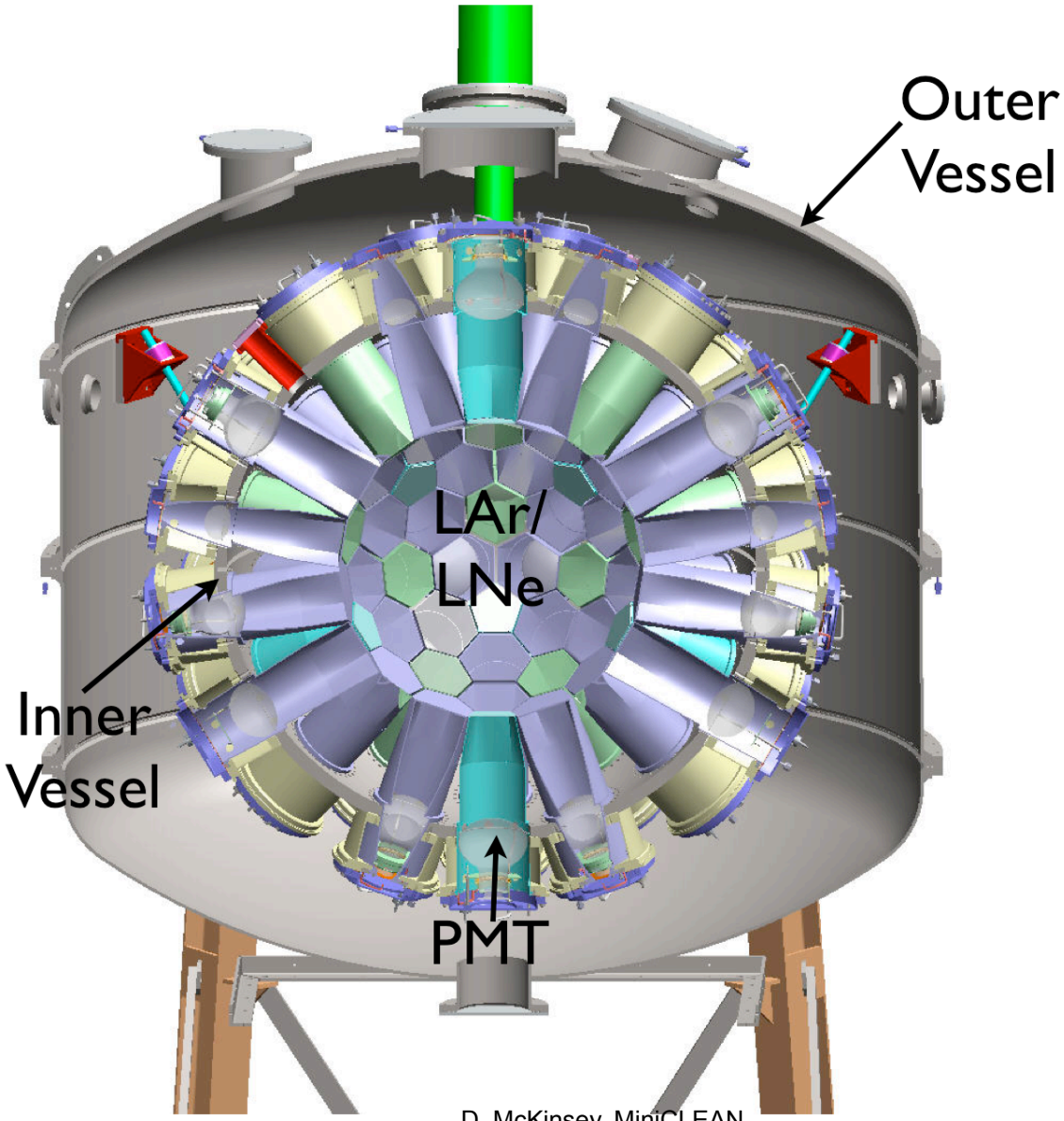
Pulse-shape discrimination



Fast component: < 10 ns
Slow component: 1.6 μs (LAr), 15 μs (LNe)
Discriminate based on fraction of light in first 100 ns (Fprompt)

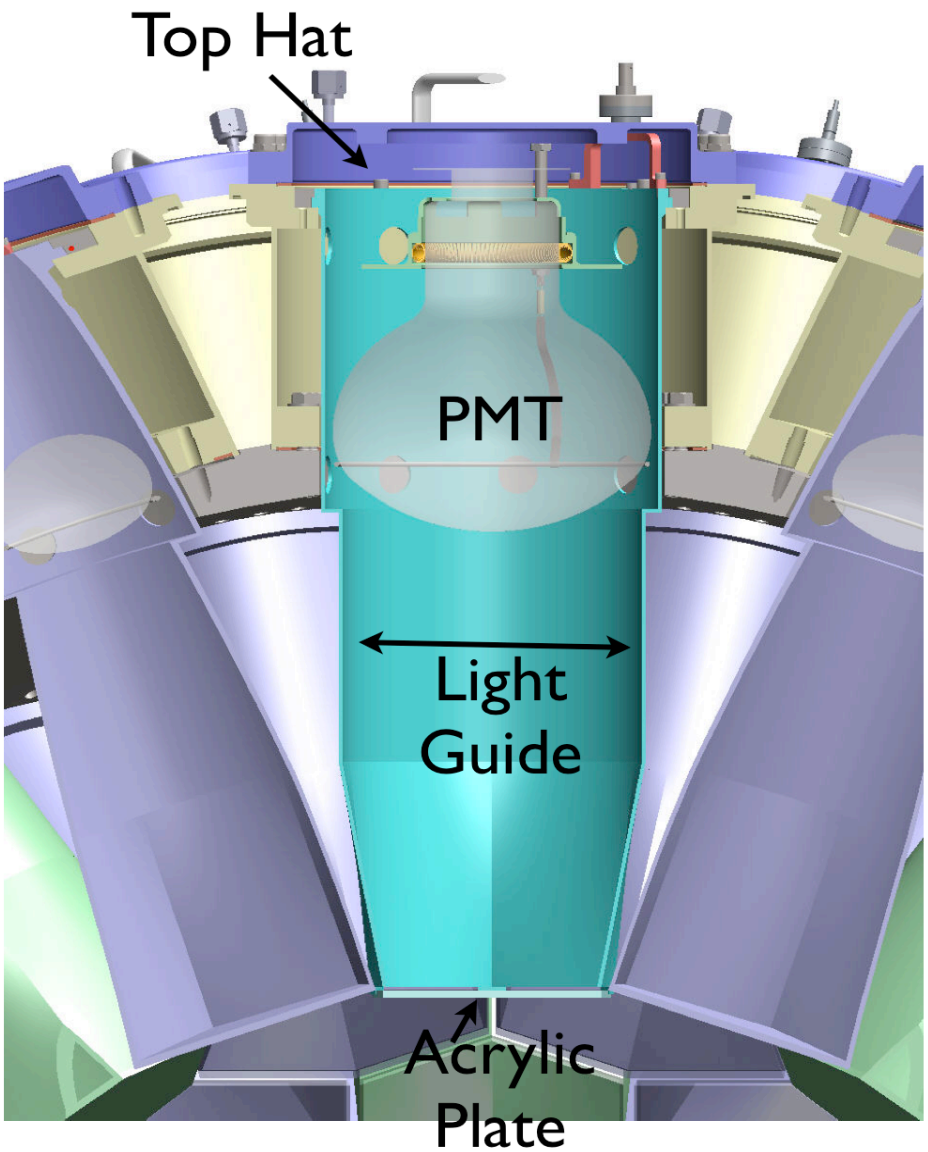
D. N. McKinsey and J. M. Doyle, J. Low Temp. Phys. 118, 153 (2000).
D. N. McKinsey and K. J. Coakley, Astropart. Phys. 22, 355 (2005).
M. Boulay, J. Lidgard, and A. Hime, nucl-ex/0410025
M. Boulay and A. Hime, Astropart. Phys. 25, 179 (2006).

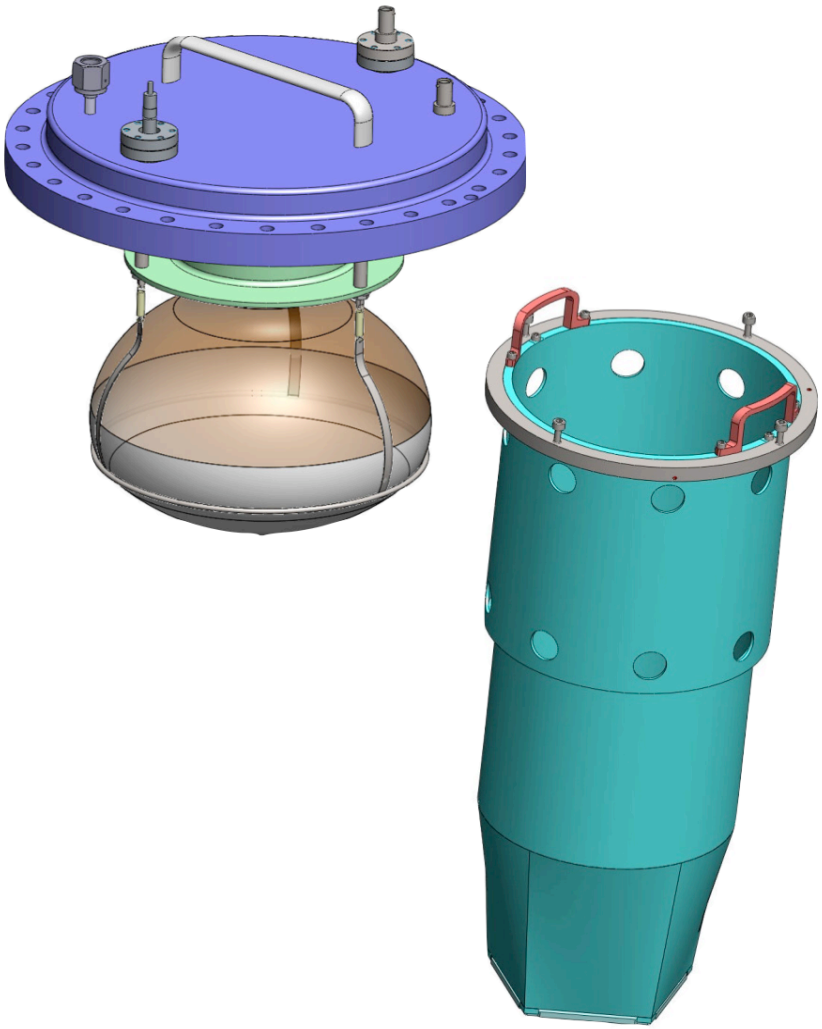
MiniCLEAN detector



Courtesy J. Griego

Optical Cassette





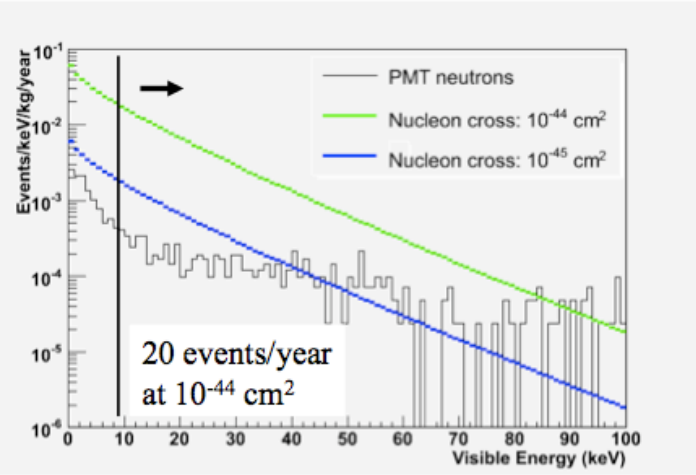
Signal and background in MiniCLEAN

- Signal:
  - Have measured LAr nuclear recoil scintillation yield, using MicroCLEAN.
  - Will calibrate MiniCLEAN directly using radioactive sources.

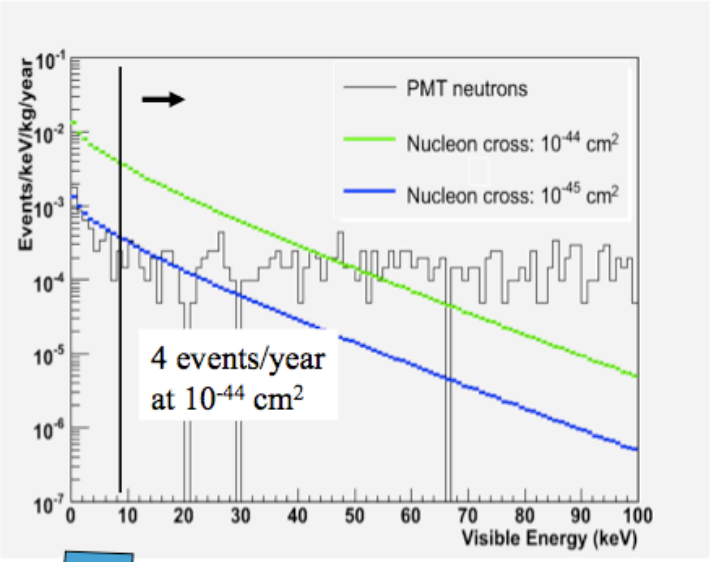
- Background:
  - Ar-39 betas and gamma rays: use Pulse Shape Discrimination (PSD)
  - Neutrons: shield, fiducialize, tag (see talk by K. Palladino)
  - Rn daughters: limit exposure, fiducialize

Exchanging LAr for LNe

100kg Mini-CLEAN-LAr



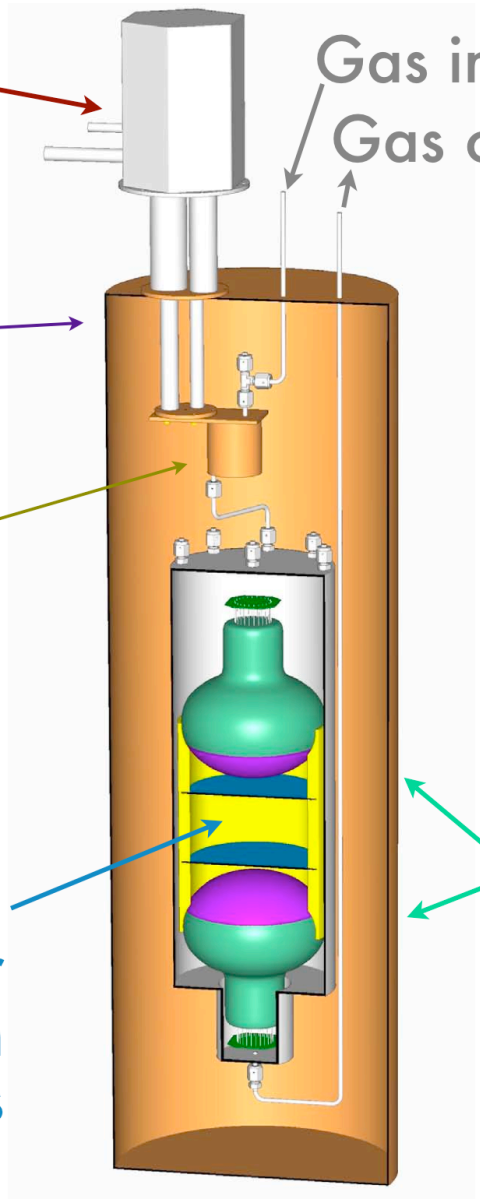
100kg Mini-CLEAN-LNe



Exchange Target in Identical Detector to "Exercise" Signal v.s. BGND

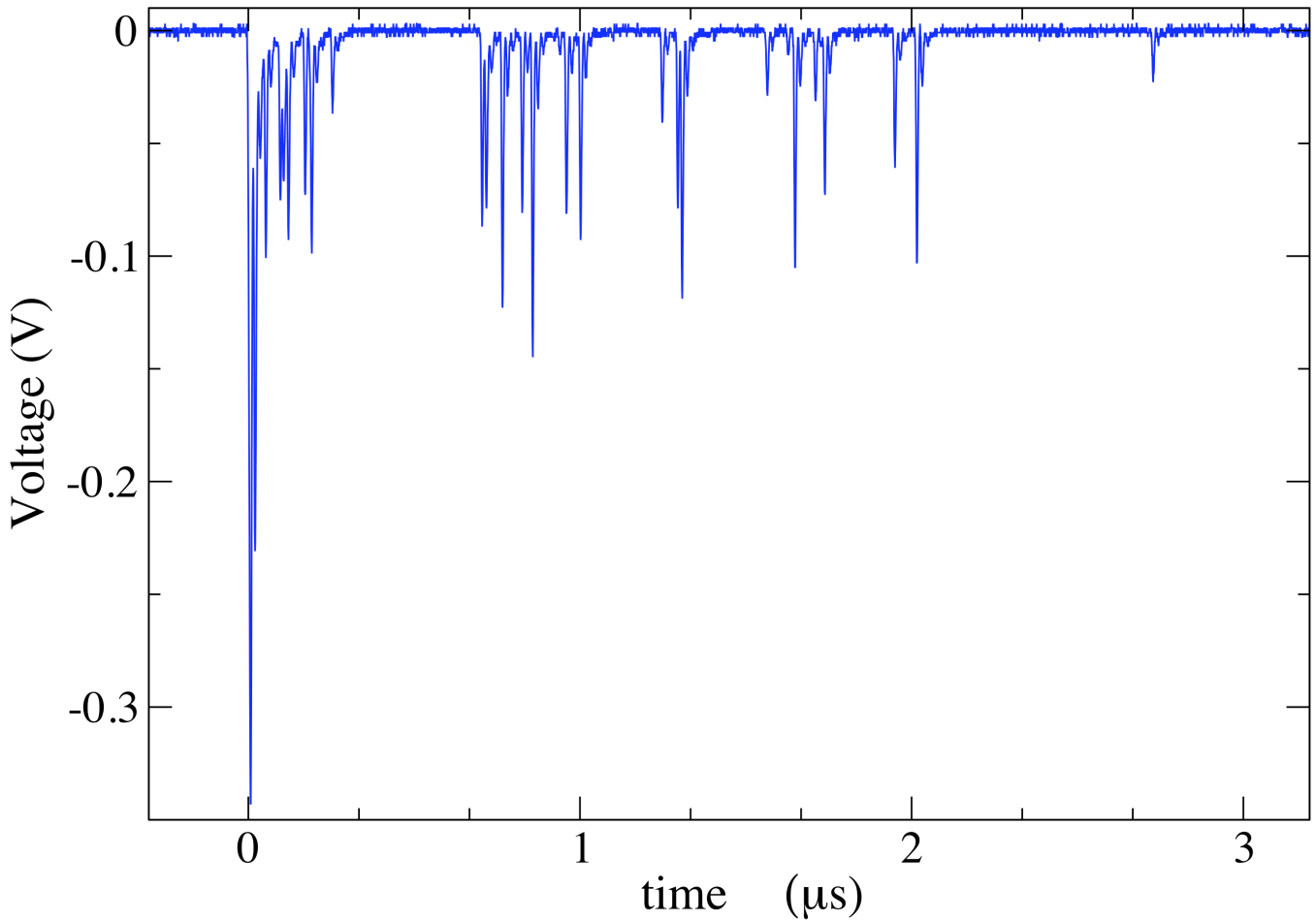
assuming a 100 GeV WIMP $\left\{ \begin{array}{c} S_{Ar} \sim 8\times S_{Ne} \\ B_{Ar} \sim B_{Ne} \end{array} \right\}$ **& similar energy threshold**

MicroCLEAN



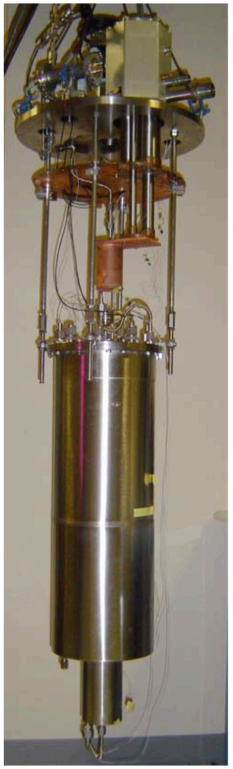
Start with ultra-high purity gas, run through a getter before introducing to central volume. Circulate at ~2 l/min through getter.

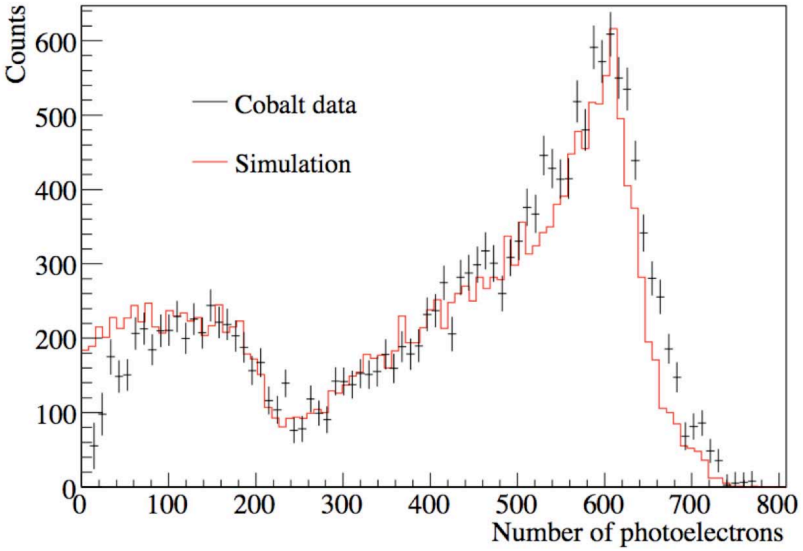
Sample scintillation pulse in LAr



Large and well-understood signal yield

MicroCLEAN provides a baseline for MiniCLEAN optical signal yield simulations. Require 6.0 pe/keV to reach MiniCLEAN spec)

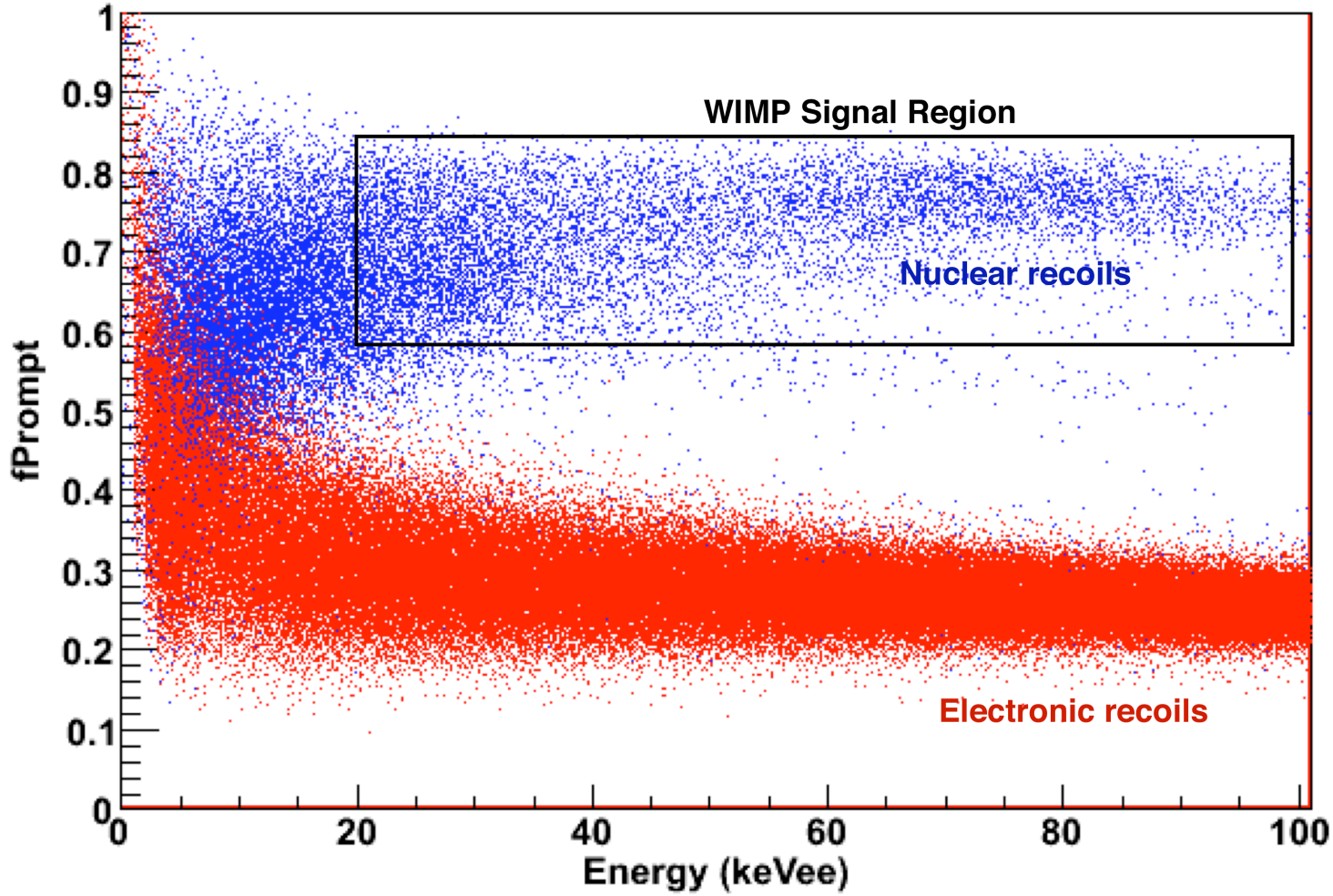




Expected Mini-CLEAN
Light Yield: 6-7 pe/keV

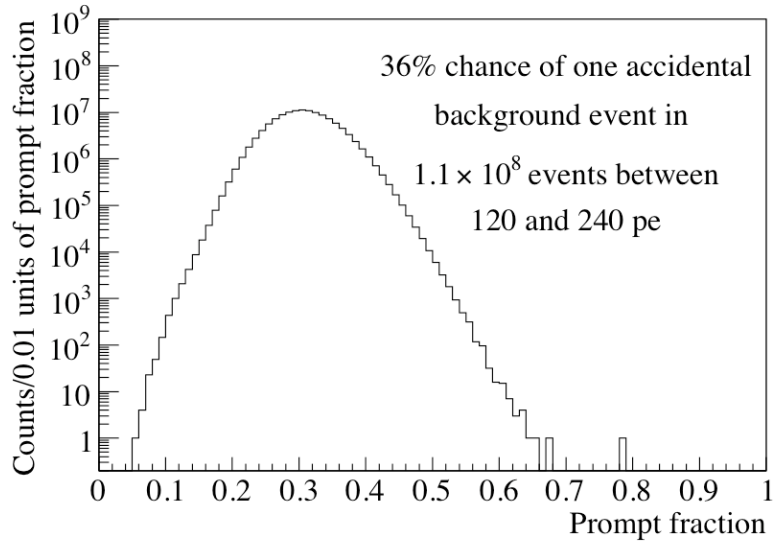
PSD in MicroCLEAN

We measure an electron recoil contamination of 1.7 x 10^{-6} from 64-128 keVr



Lippincott et al., Phys. Rev. C 78, 035801 (2008).

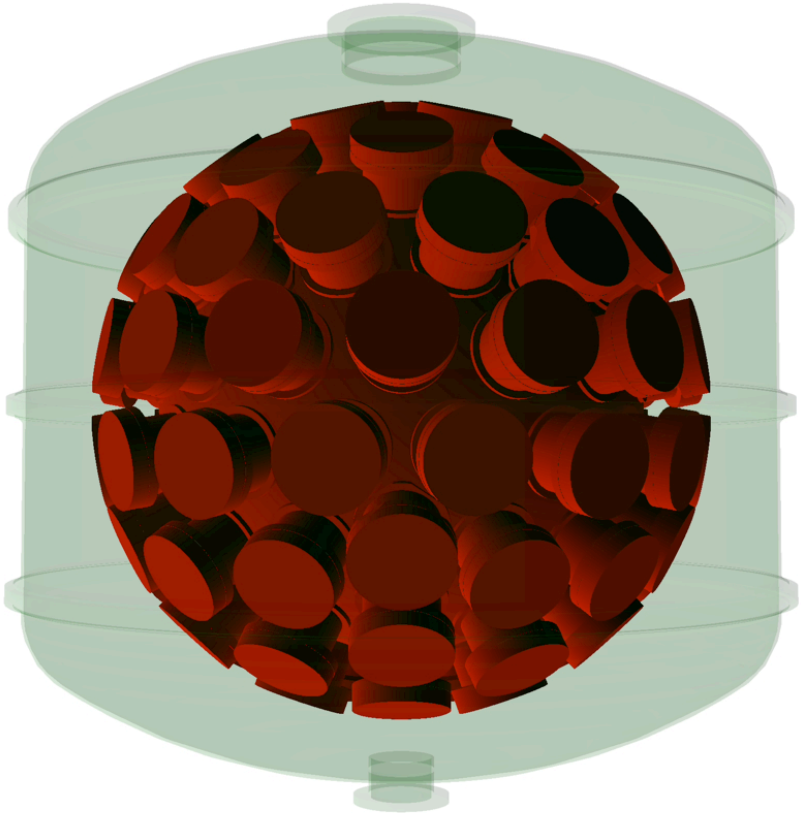
PSD in DEAP-I (preliminary)



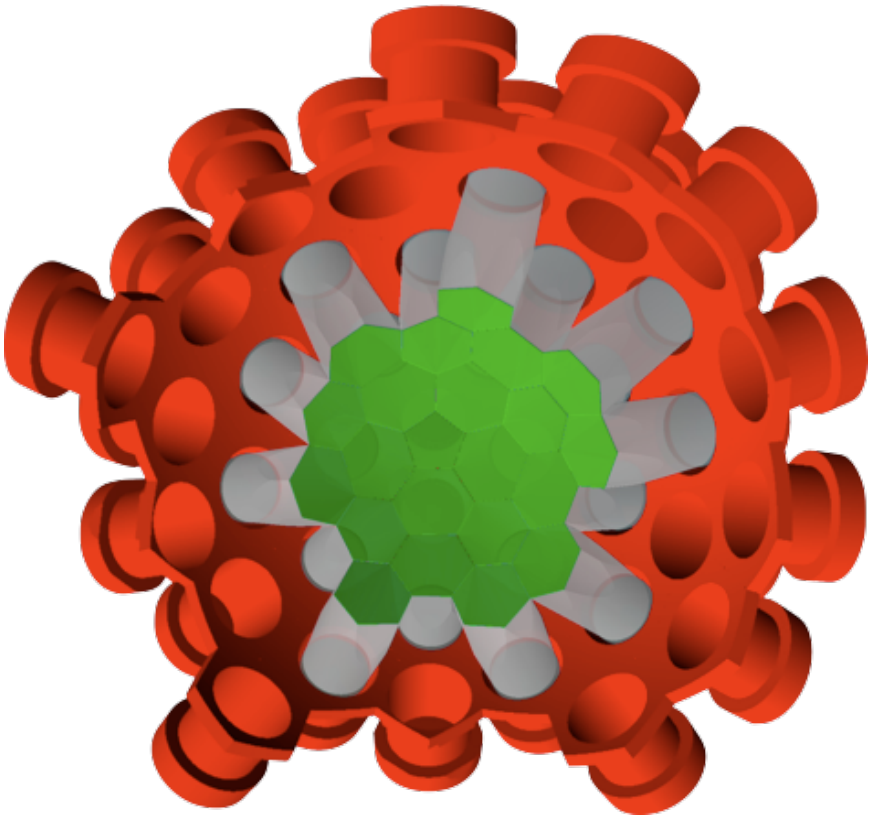
- An ERC of 9.3×10^{-9} with 1 event in the nuclear recoil region of interest
- This event is consistent with accidental backgrounds

Need 4π coverage, fiducialization to reduce radon daughter backgrounds and thereby further improve PSD limits.

Detector Model



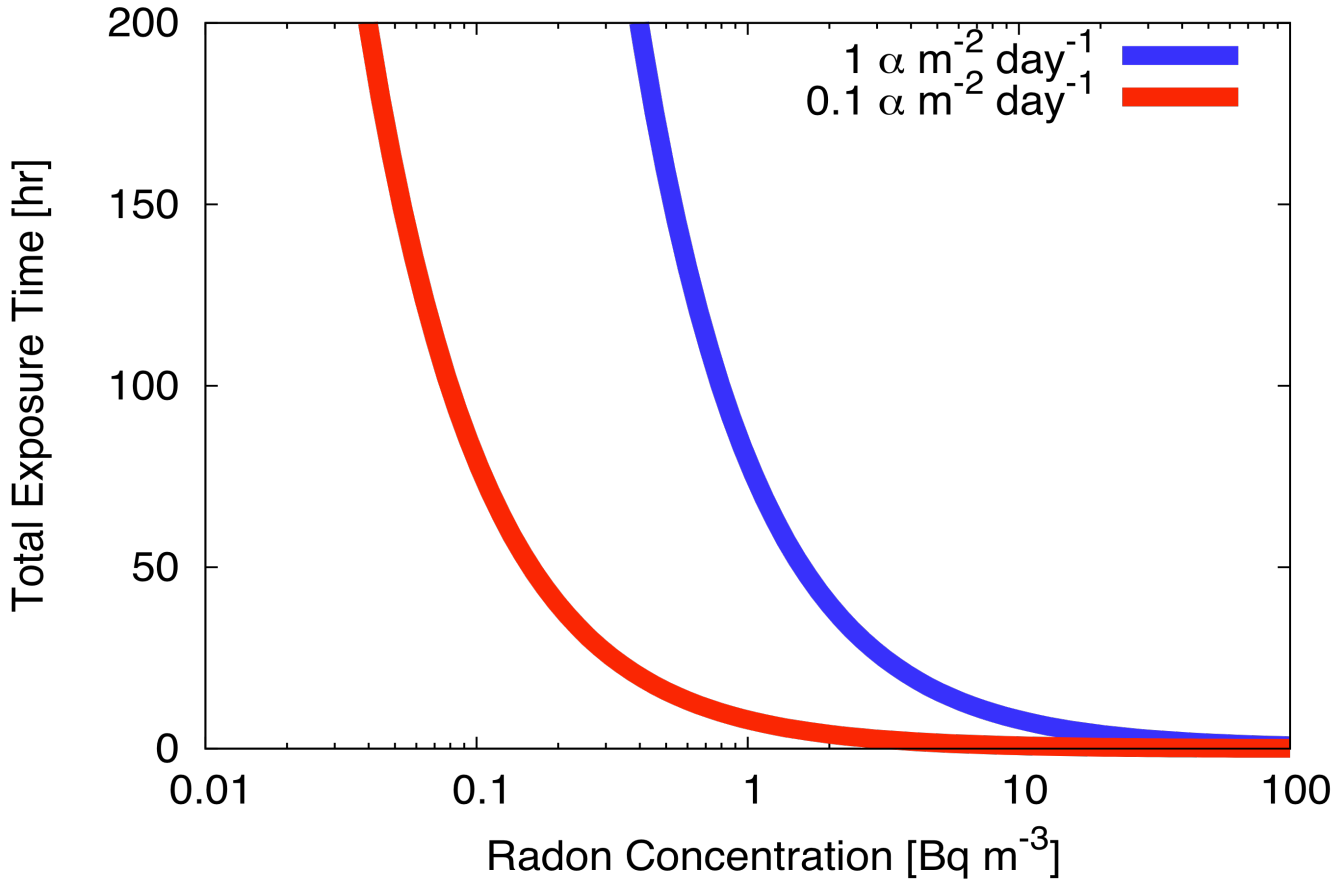
Inner vessel with spools inside outer vessel



Cut-away view showing light guides and TPB plates

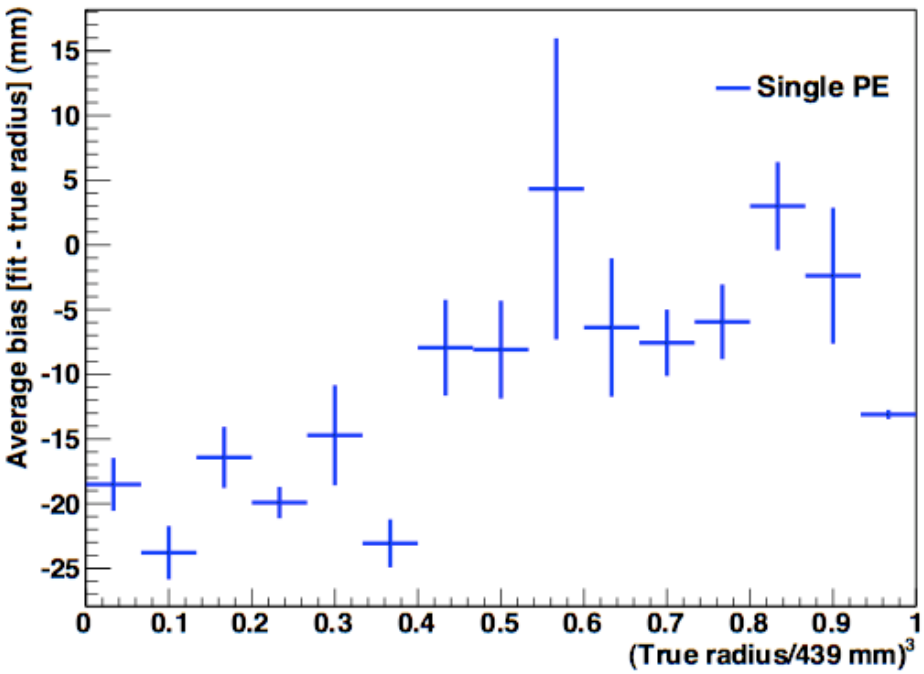
Radon Daughter Deposition

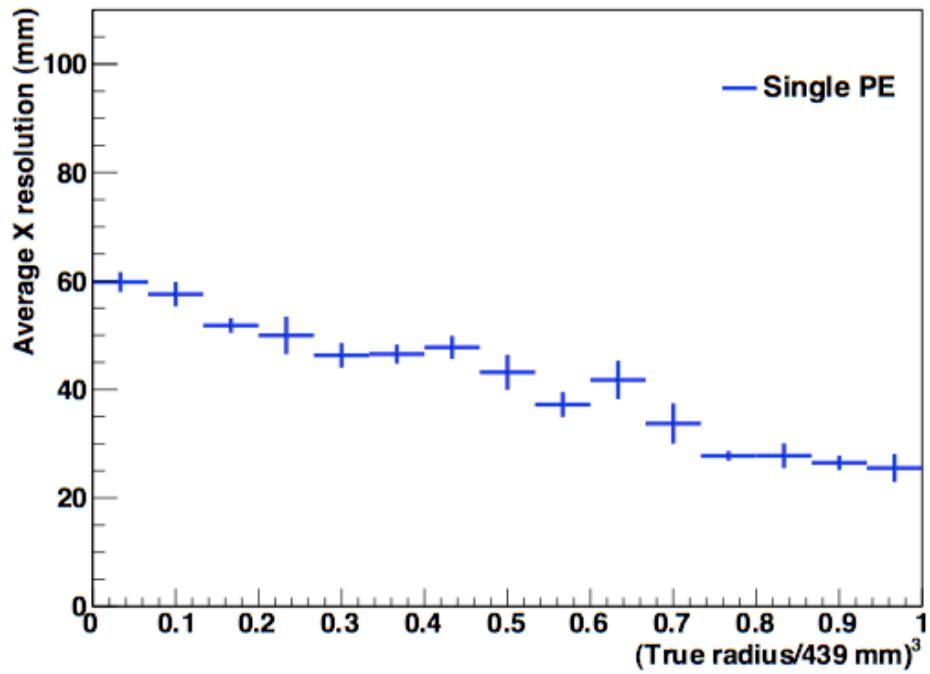
- Radon exposure limits can be placed to achieve a desired surface activity. 1 m^{-2} day^{-1} is the MiniCLEAN spec, equal to the surface activity achieved in the SNO neutral current detectors.
  - i.e. Exposure limits for class 3000 clean room at 25 C and 20% RH



Reconstruction Performance

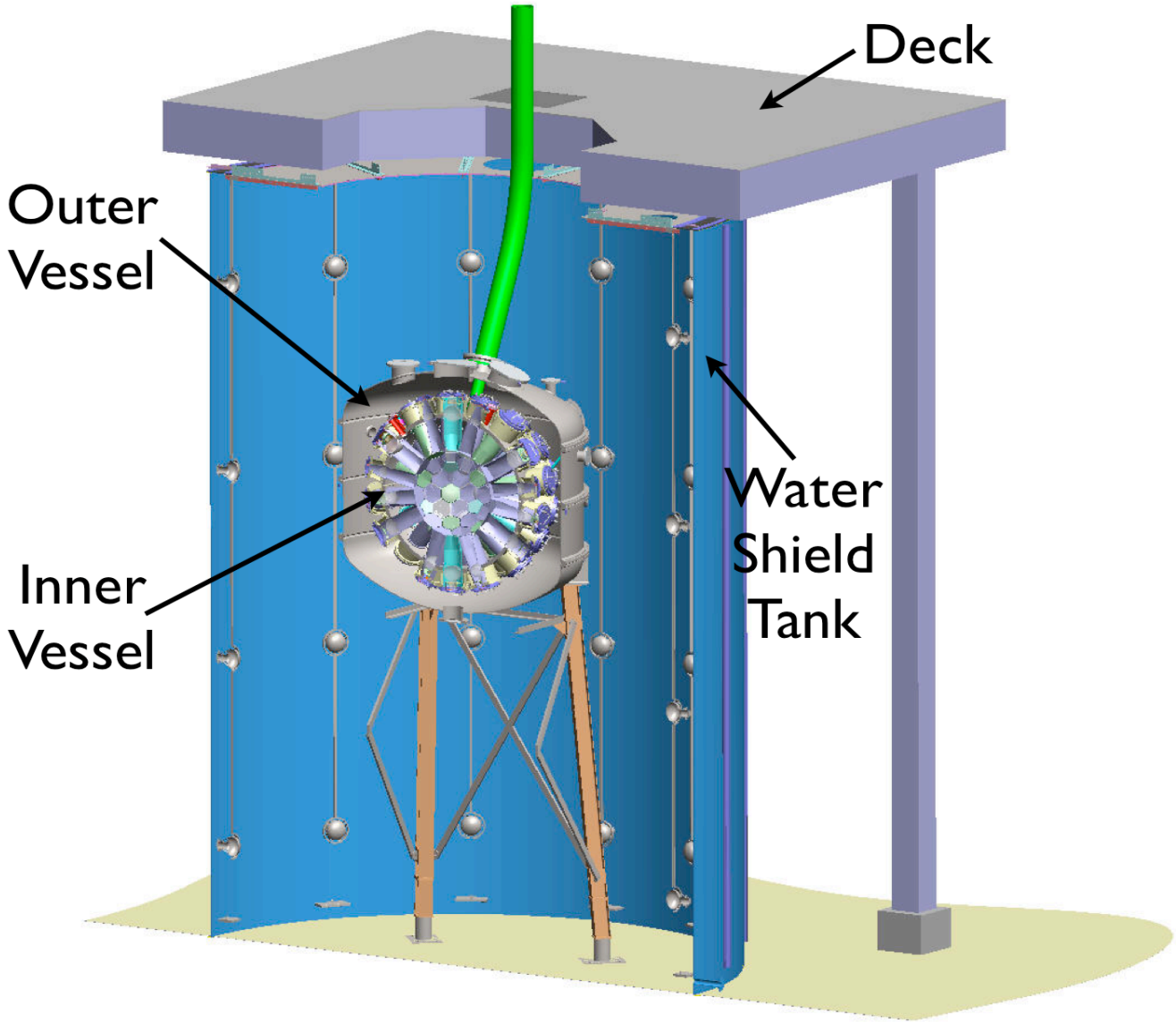
- 20 keV electrons, reconstruction bias and resolution





- With fiducial volume cut of reconstructed radius < 29.5 cm, predict alpha leakage <1x10^{-3} = <0.025/yr in ROI

MiniCLEAN - Outer Vessel & Shield



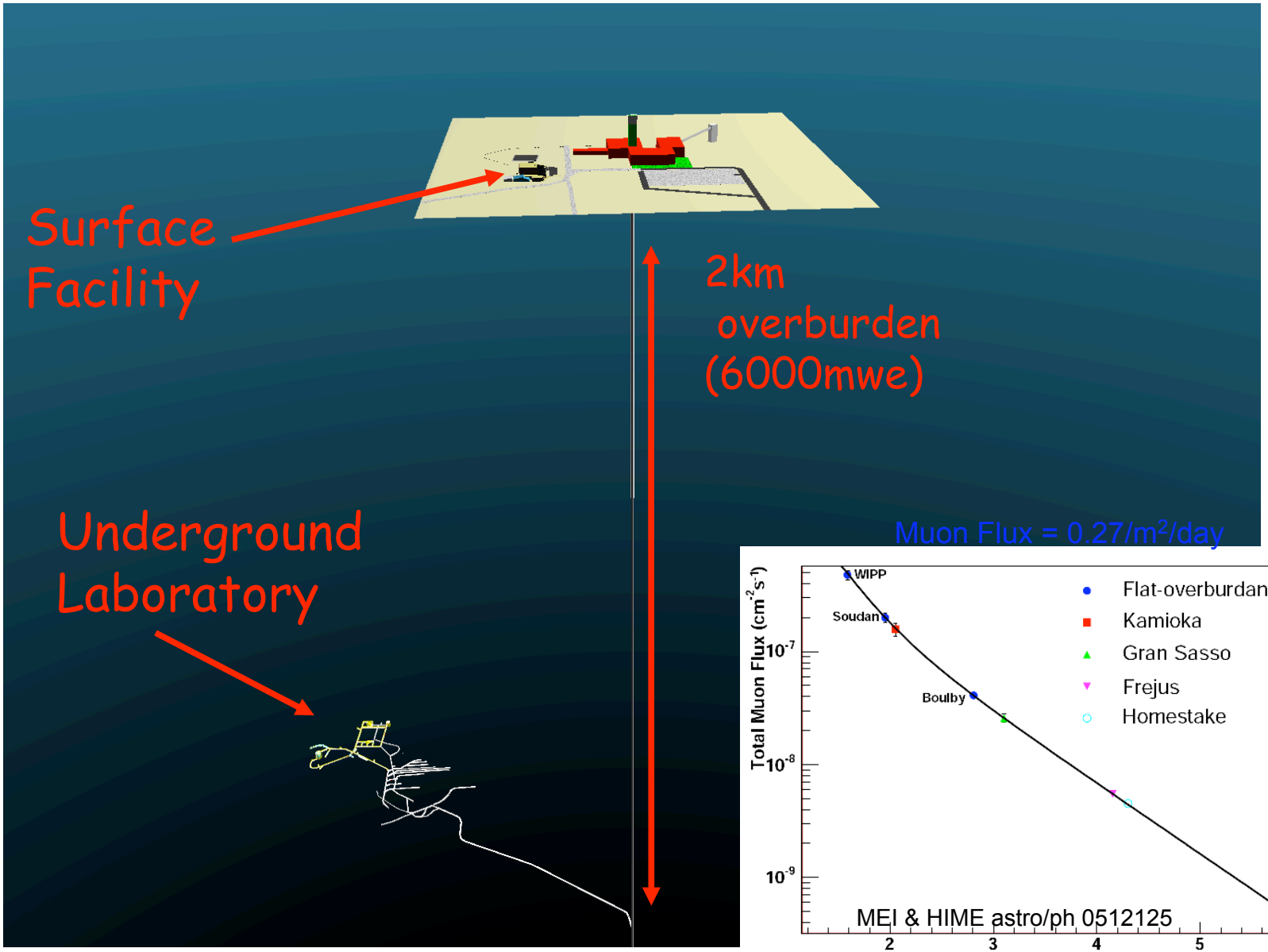
Courtesy J. Griego

Outer Vessel Manufacturing

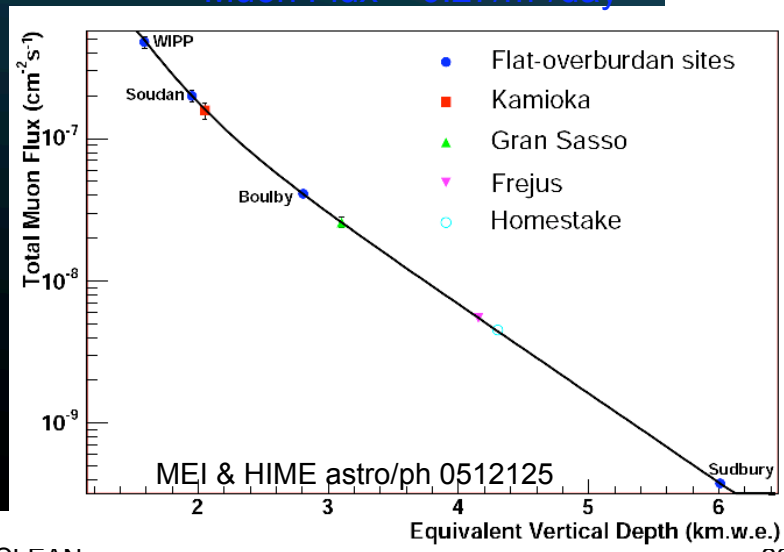
Inner Vessel Progress

- Stainless steel hemispheres made by Trinity Heads, Inc in Texas
- Contract awarded to Winchester Precision Technologies for fabrication

SNOLAB



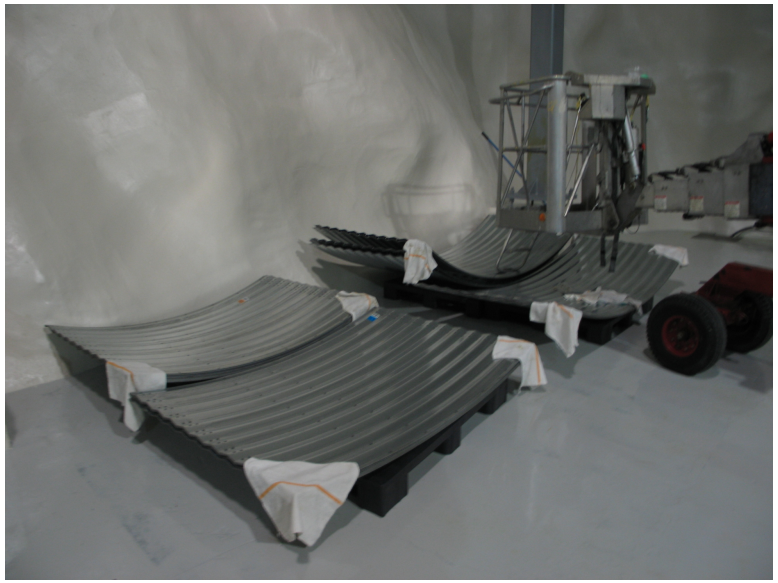
Muon Flux = 0.27/m^2/day

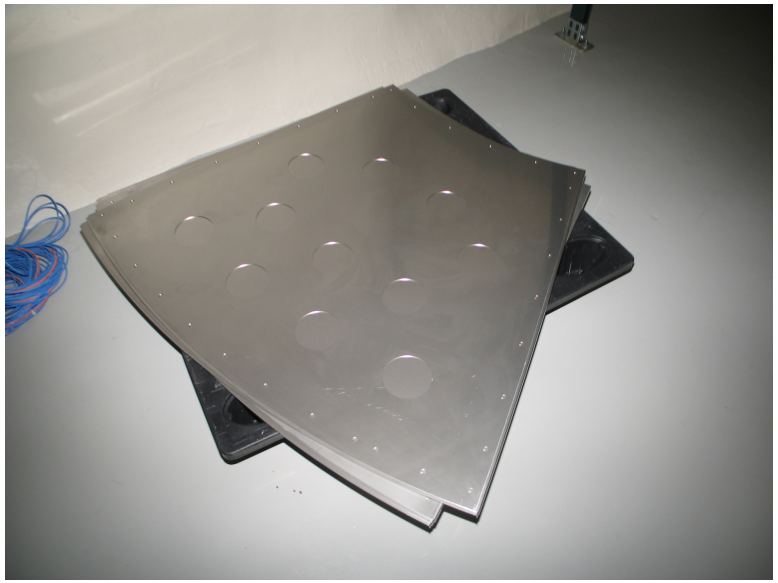


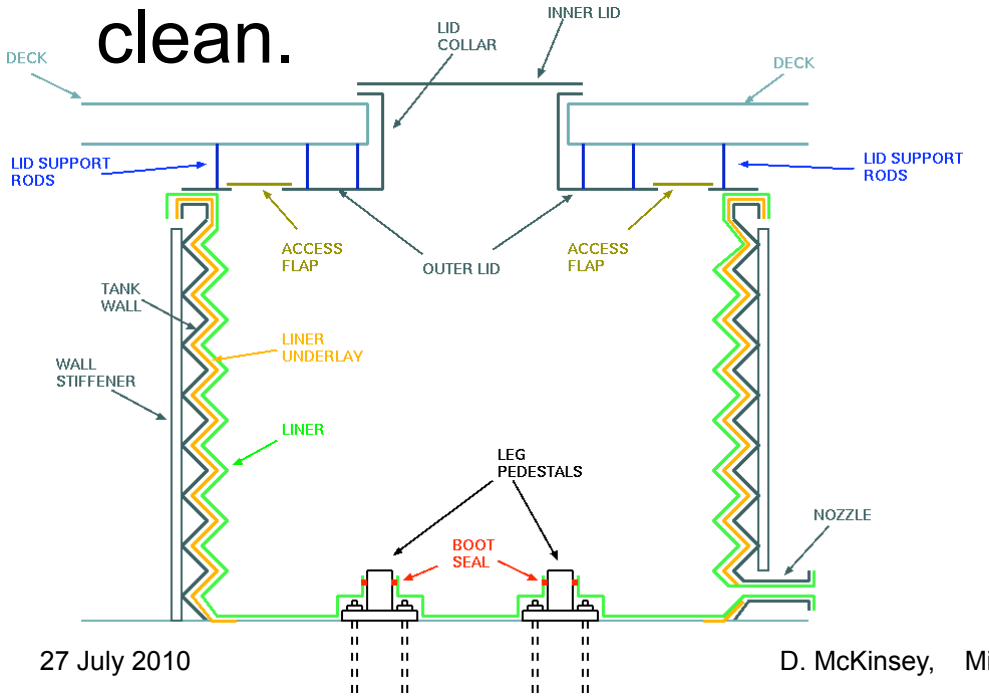
Underground – Cube Hall at SNOLAB

Shield Tank

- Prefabricated commercial tank with plastic liner.
- Custom designed stainless steel lid.
- All parts are on site, most of the walls and lid ug and clean.





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Current Schedule

- OV will be underground by end of year in tank with stand
- Underground infrastructure (utilities, deck, water tank) ready in September
- IV scheduled for completion in May 2011
- Assembly scheduled for Summer 2011
- Commissioning in Fall 2011
- Liquid argon dark matter run at end of 2011

Need Scalable & BGND-Free Technologies