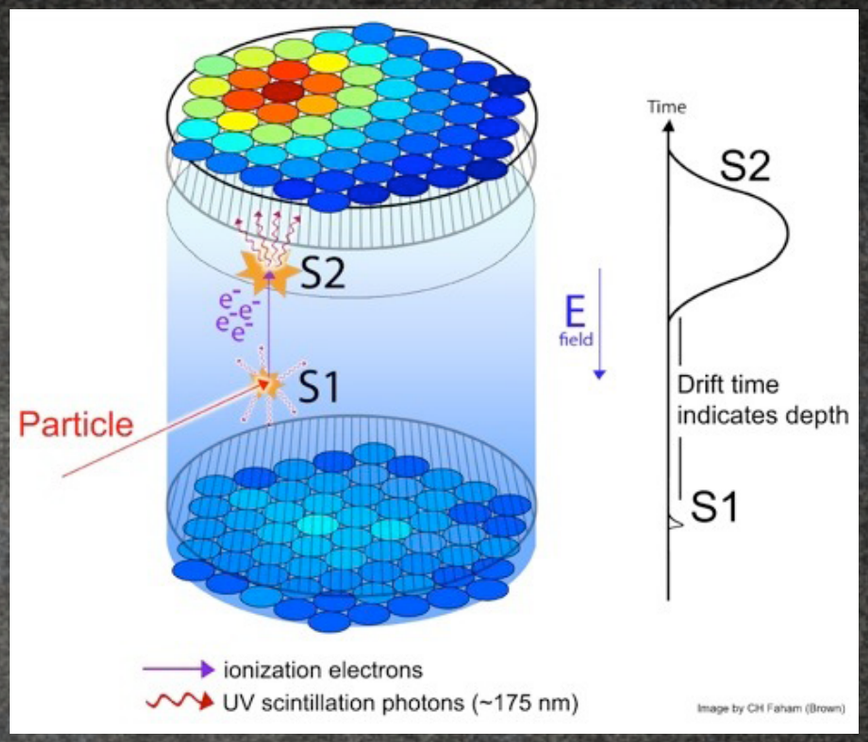
Some slides on MiniCLEAN

KJ Palladino

6/7/16

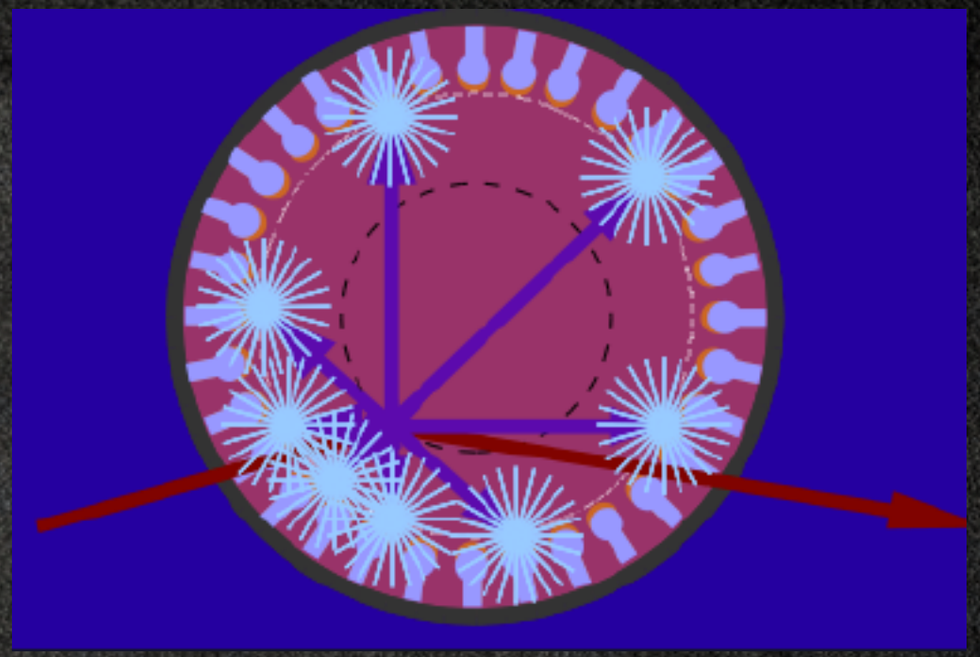
Double vs Single Phase

Double



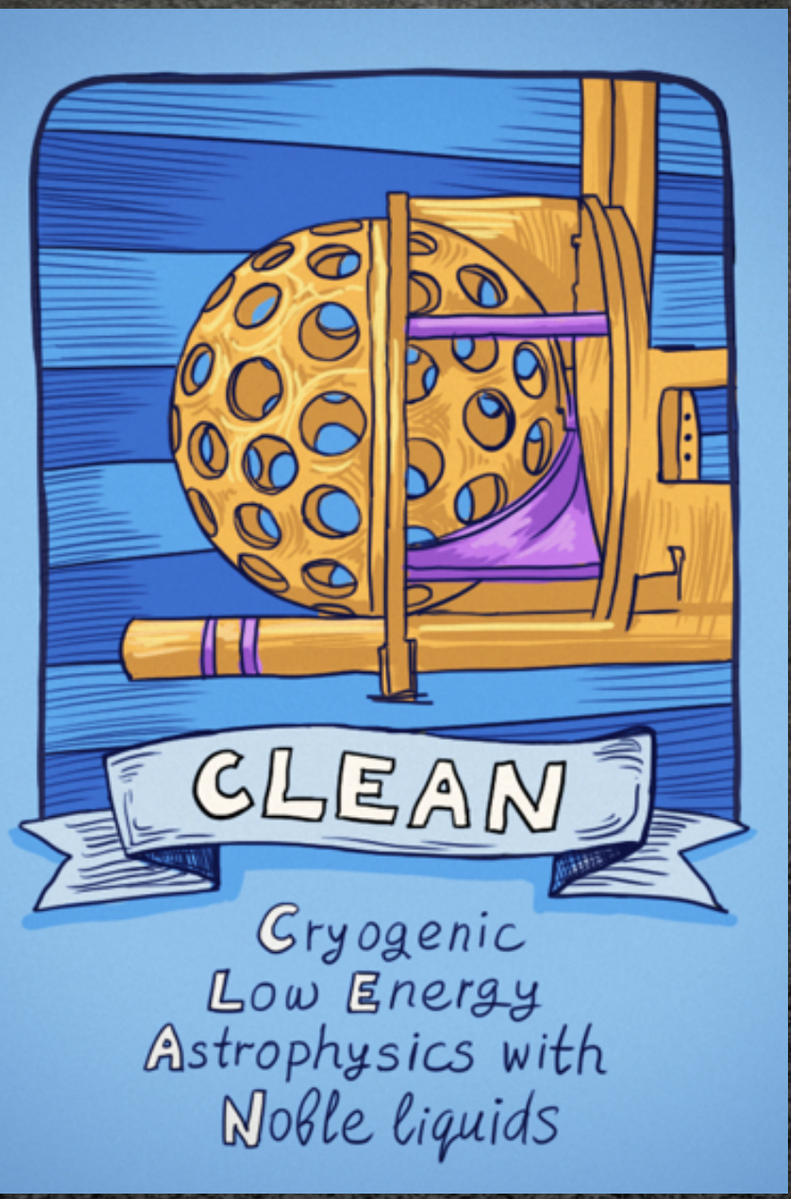
- Ionized and excited states
- Primary Scintillation (S1) with some recombination and de-excitation in the liquid
- Ions drift in TPC electric field
- Amplification region in gas creates proportional light (S2)
- S2/S1 provides particle ID
- Events are hundreds of microseconds (set by electron drift velocity)
- Strong position reconstruction

Single



- Ionized and excited states
- Scintillation with recombination and de-excitation in the liquid
- Pulse shape discrimination provides particle ID
- Events are tens of microseconds (set by triplet lifetime)
- Position reconstruction with charge distribution, t.o.f. with larger detectors

MiniCLEAN



CLEAN

AREA OF RESEARCH:
Direct detection of dark matter and low-energy neutrinos

TECHNOLOGY:
Single-phase liquid argon detector

FUN FACT:
CLEAN can operate with interchangeable targets of liquid argon and liquid neon

INSTITUTIONS:
Boston University; Los Alamos National Laboratory; MIT; National Institute of Standards and Technology; Royal Holloway University of London; SNOLAB; Syracuse University; University of New Mexico; University of North Carolina, Chapel Hill; University of Pennsylvania; University of South Dakota; Yale University

CLEAN

TARGET:
LAr, LNe

Mass:
500 kg target, 150 kg fiducial

Light collection:
92 8" Hamamatsu R5912-02 MOD PMTs

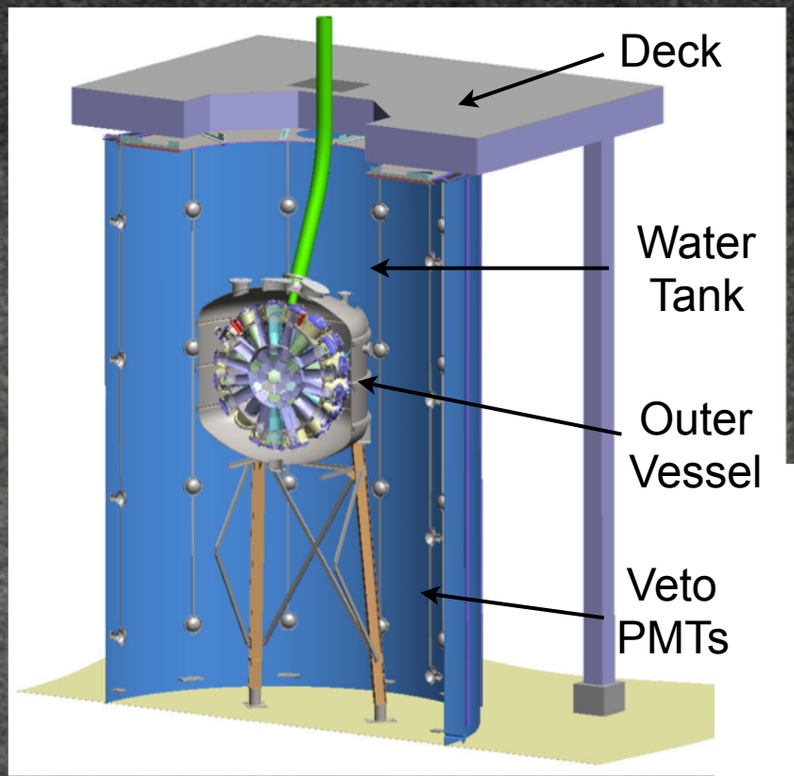
Vessel:
stainless steel, with modular optical cassettes inserted

Shielding:
10 cm acrylic & 20 cm Ar, in ~8m water shield

Sensitivity:
SI cross section 2 x10^{-45}cm^2

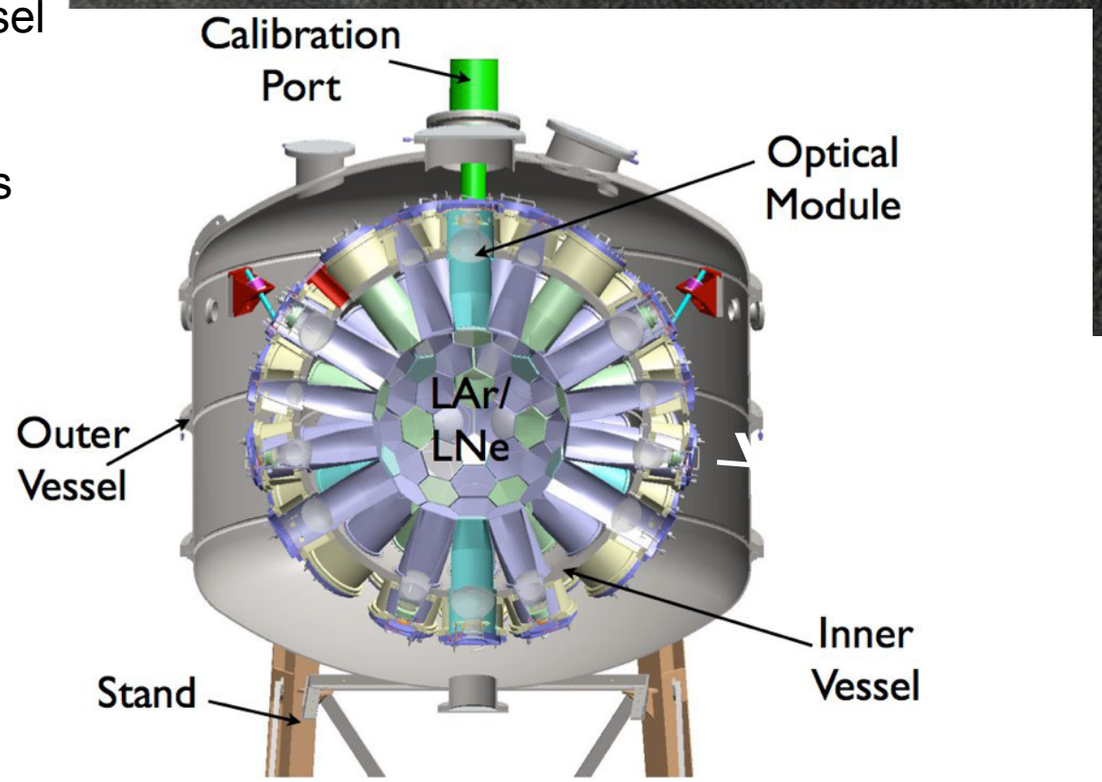
http://www.symmetrymagazine.org/article/november-2012/voyage-to-snolab

MiniCLEAN Design

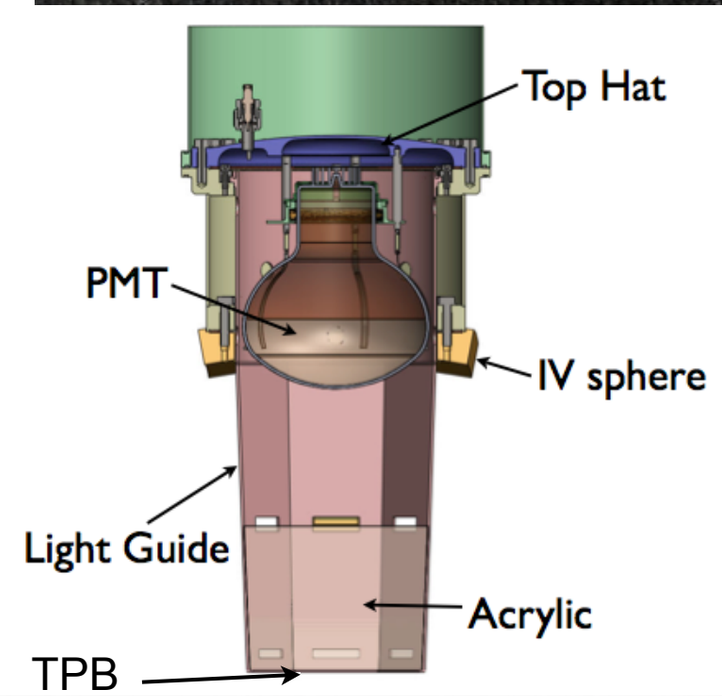


Water veto tank:
25 ft. tall
18 ft. diameter
48 veto PMTs
~1.5 m water on sides
~3.5 m water from bottom

Outer Vessel: ~1.25 m radius
Inner Vessel: ~ .7 m diameter,
~500 kg LAr
Target radius: ~.4 m
Fiducial radius: ~.3 m, 150 kg LAr



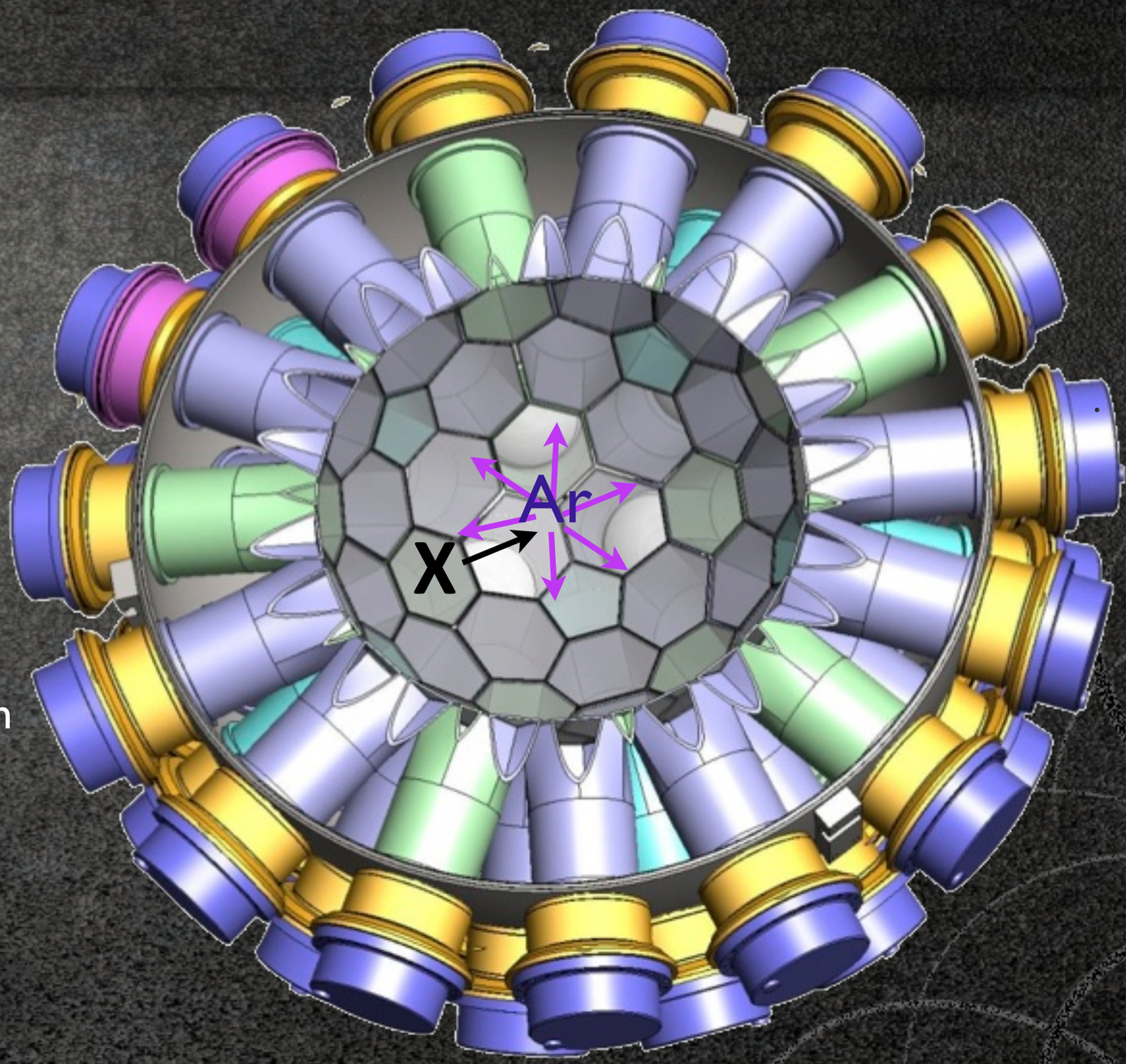
4π coverage
92 modular optical cassettes
PMTs are cold



A WIMP Event

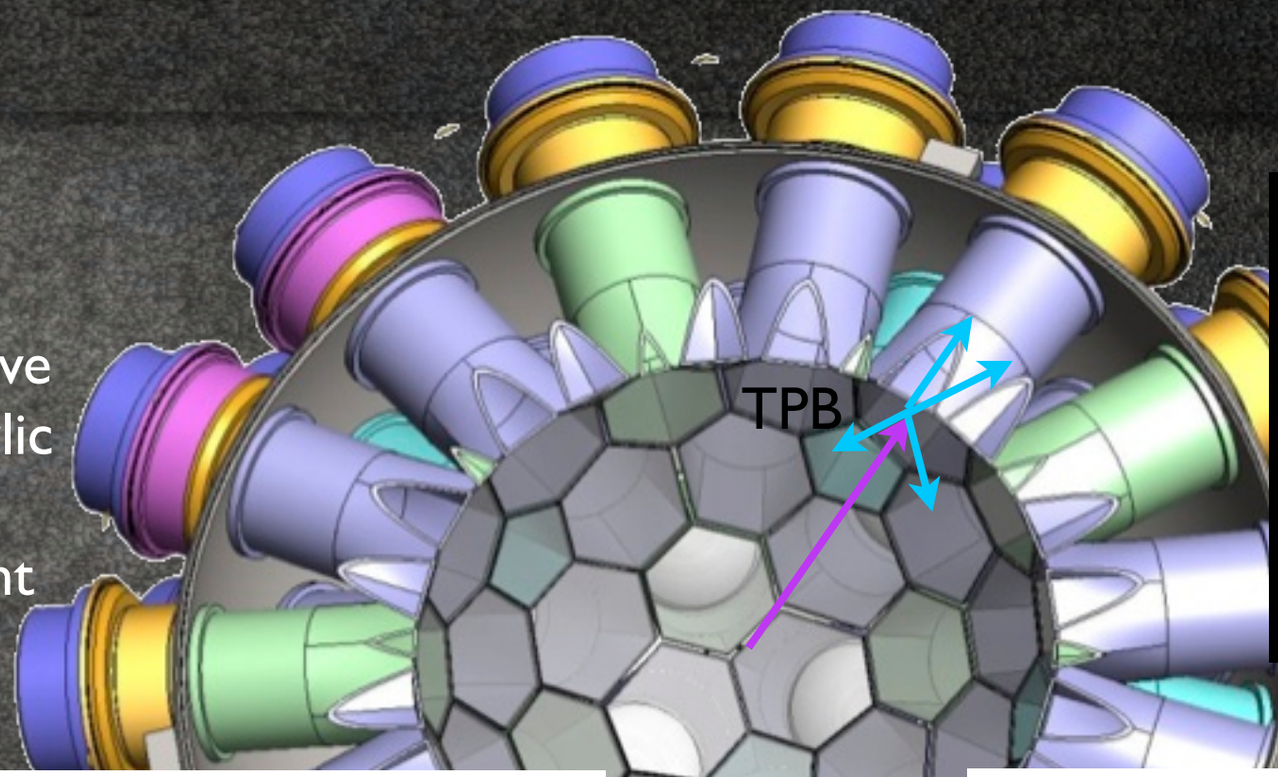
A WIMP, **X**, has a coherent elastic scatter with an argon nucleus

The nuclear recoil then causes EUV scintillation, 128 nm

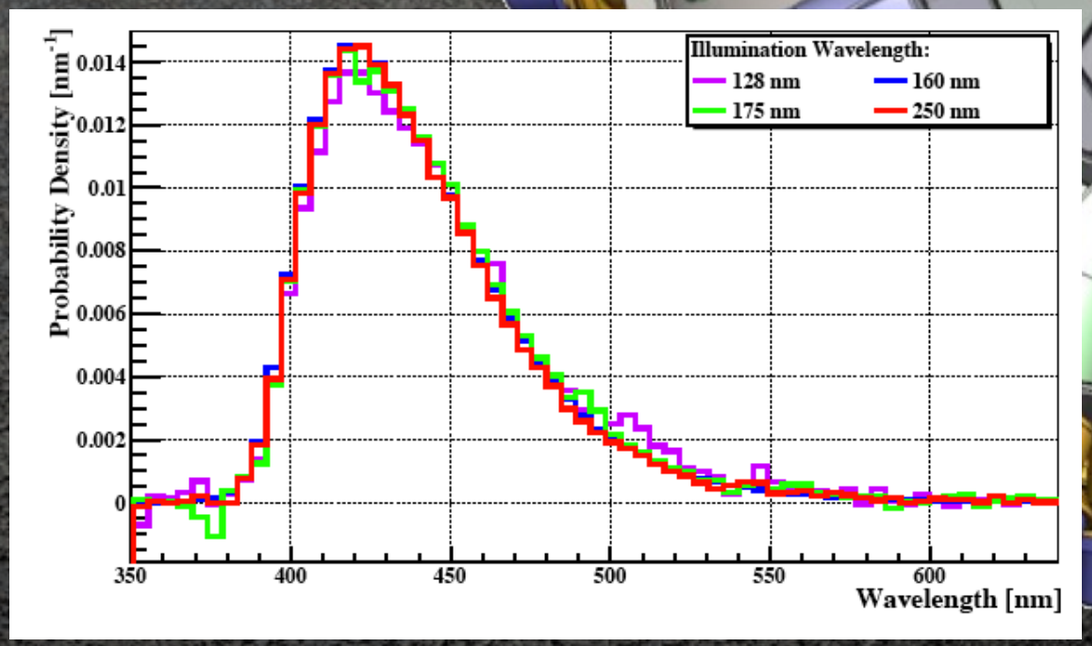


TPB Re-emission

The UV light is absorbed by the TPB wavelength shifter, an evaporative coating on the acrylic face, which re-emits visible light

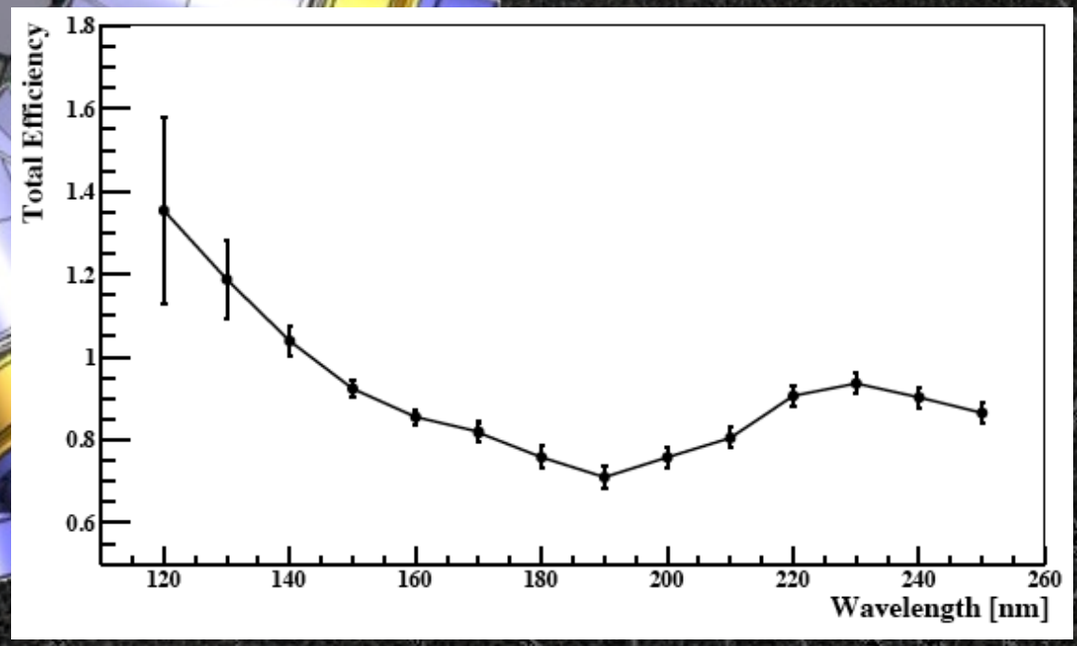


TPB Coating done at International Vacuum



TPB Re-emission spectrum

Gehman et al. NIM A654 (2011) 116-121

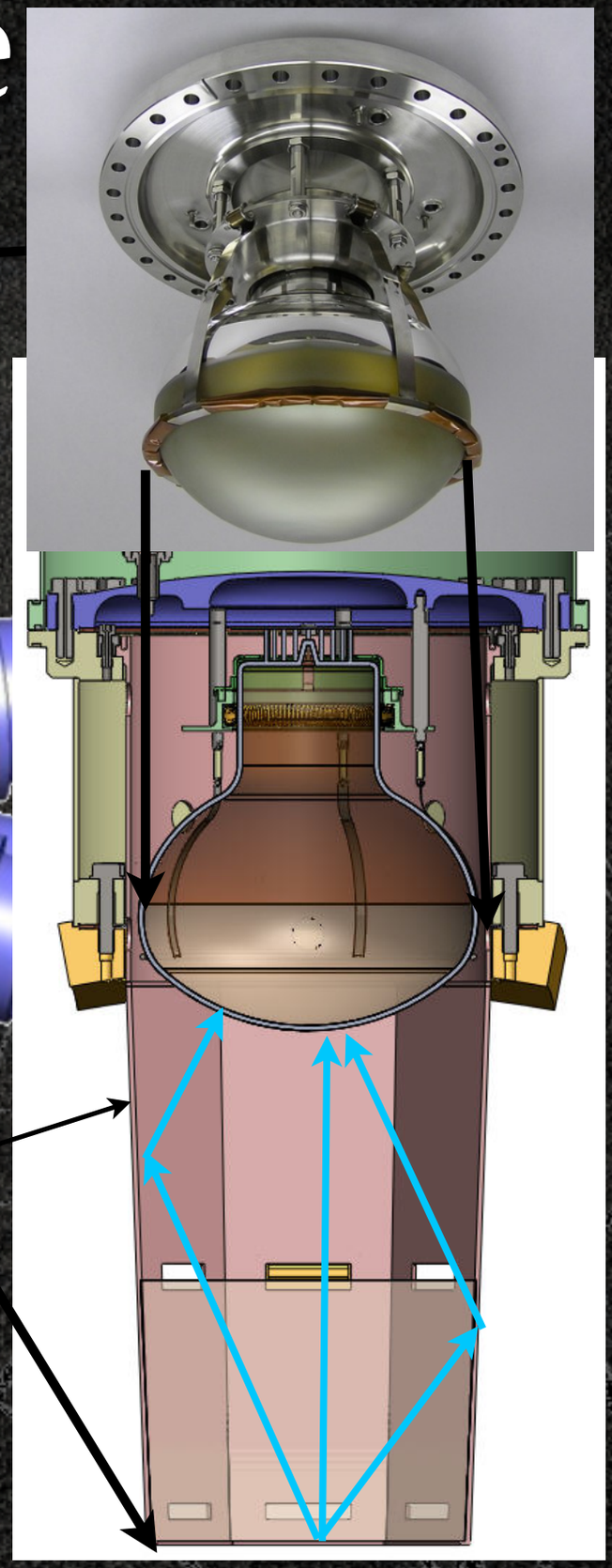


TPB Emission Efficiency

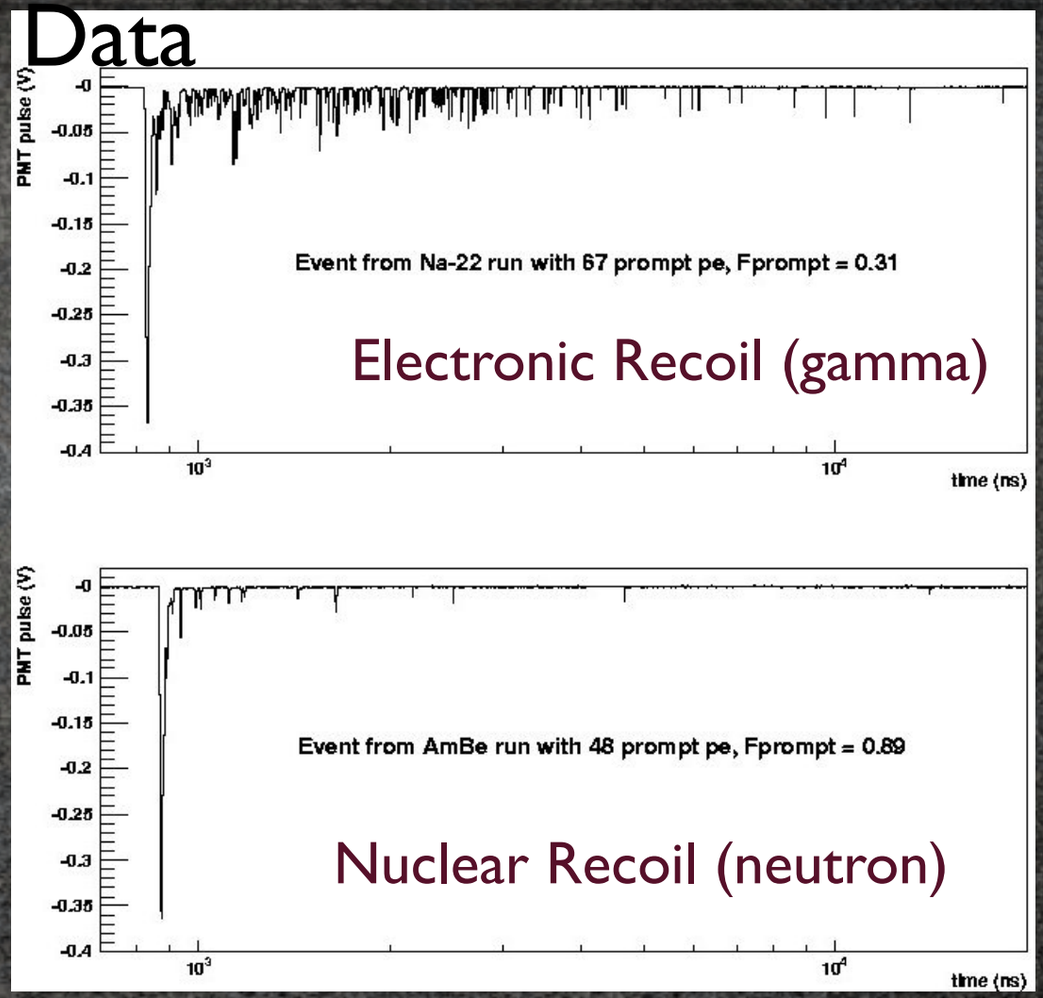
Optical Cassette

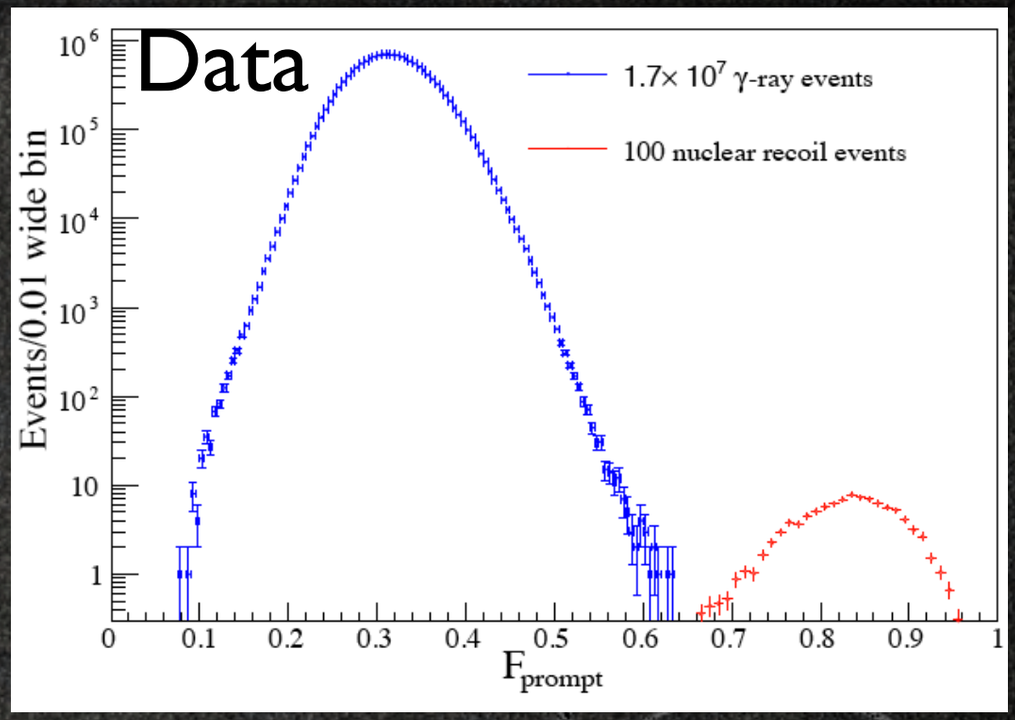
Light then travels through transparent acrylic. UV absorbing acrylic was surprisingly found by our DEAP colleagues to be best, absorption lengths of ~few meters at 420 nm.

Lightguide covered with 3M DESR foil reflector.

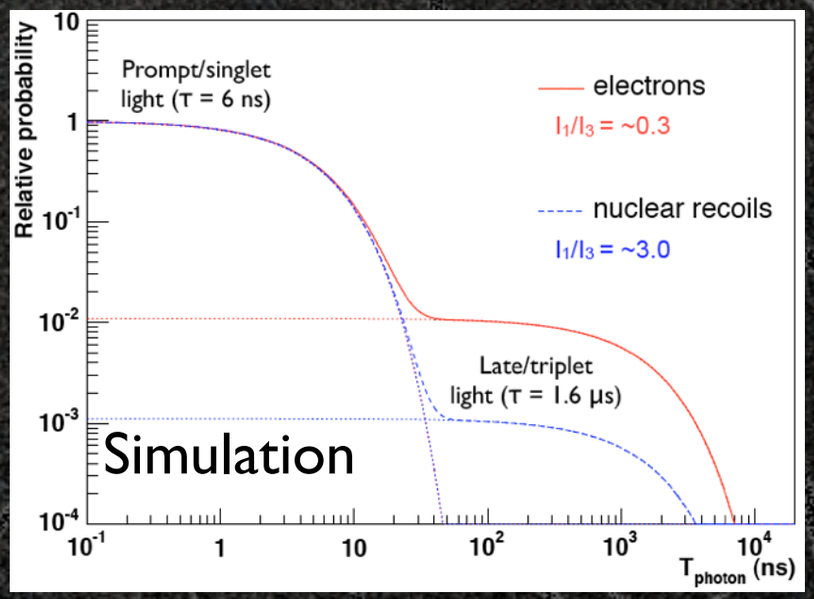


Pulse Shape Discrimination





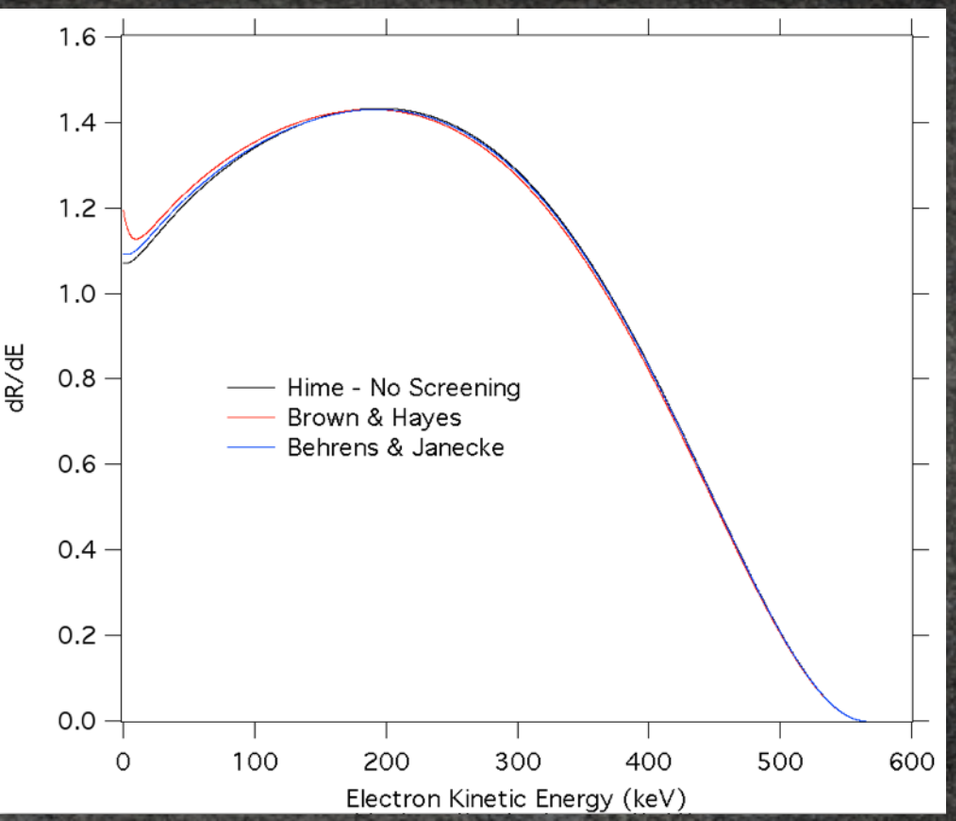
Boulay et al. arXiv:0904.2930



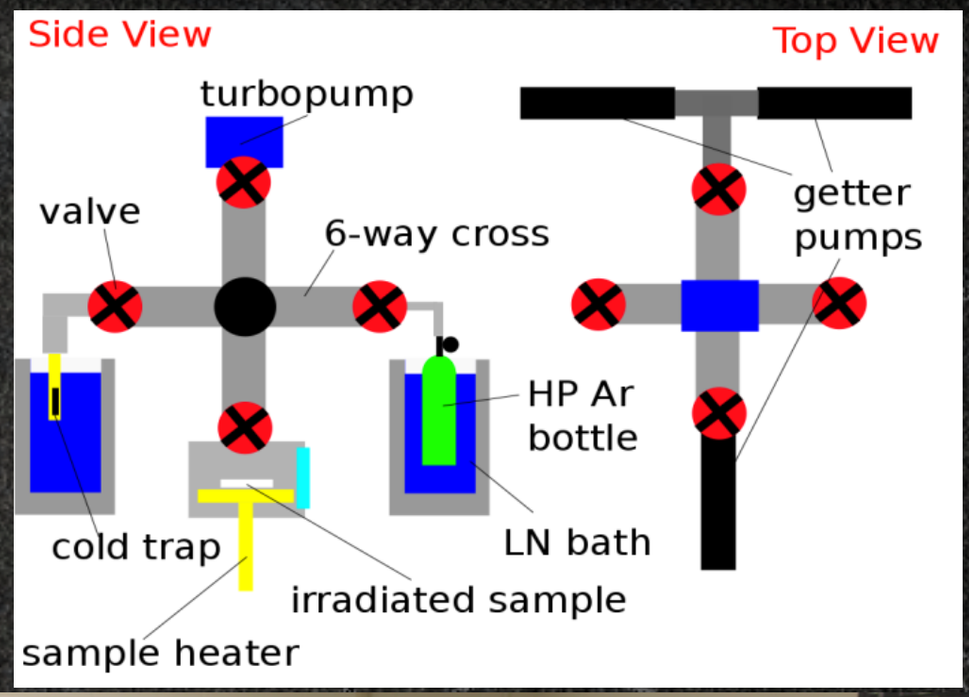
Boulay and Hime, Astropart. Phys. **25**, 179 (2006)

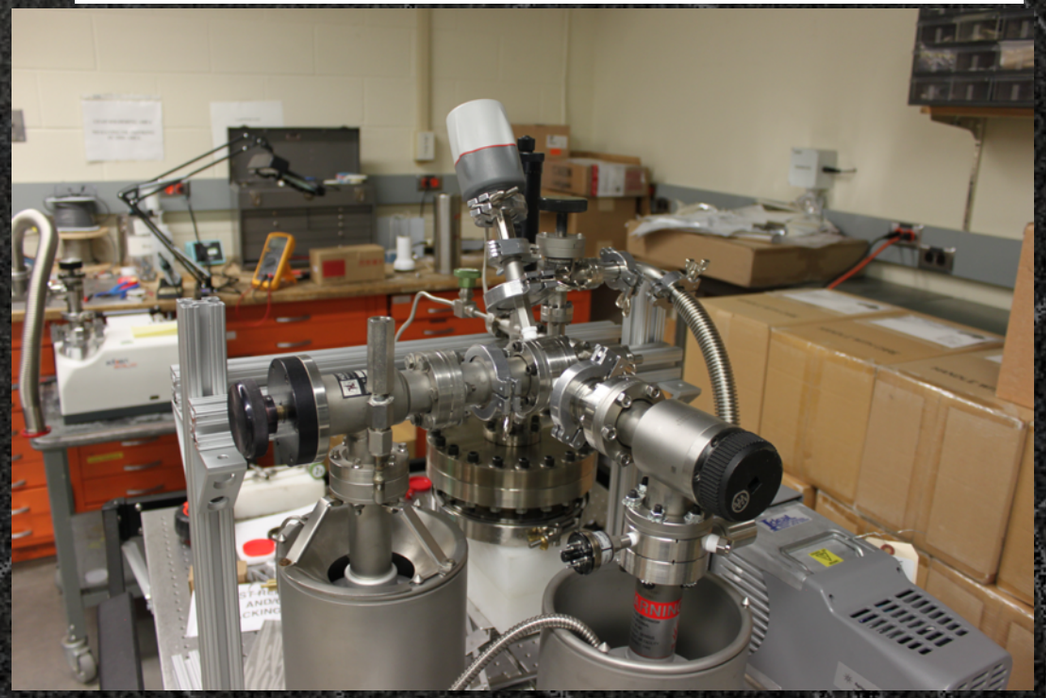
In LAr, $t_{singlet}$ = 6 ns, $t_{triplet}$ =1.6 us
F_{prompt} ~ .3 for electron recoils, .7-.8 for nuclear
How well can discrimination work?
DEAP-1 has demonstrated (stat. Limited)
< 6 x 10^{-8} 43<E< 86 keVee
Necessary in LAr because of ^{39}Ar

^{39}Ar Spike



MiniCLEAN will dope with ^{39}Ar to establish PSD for larger detectors (rejection of 10^{-10}) plan to increase event rate 3-10 x

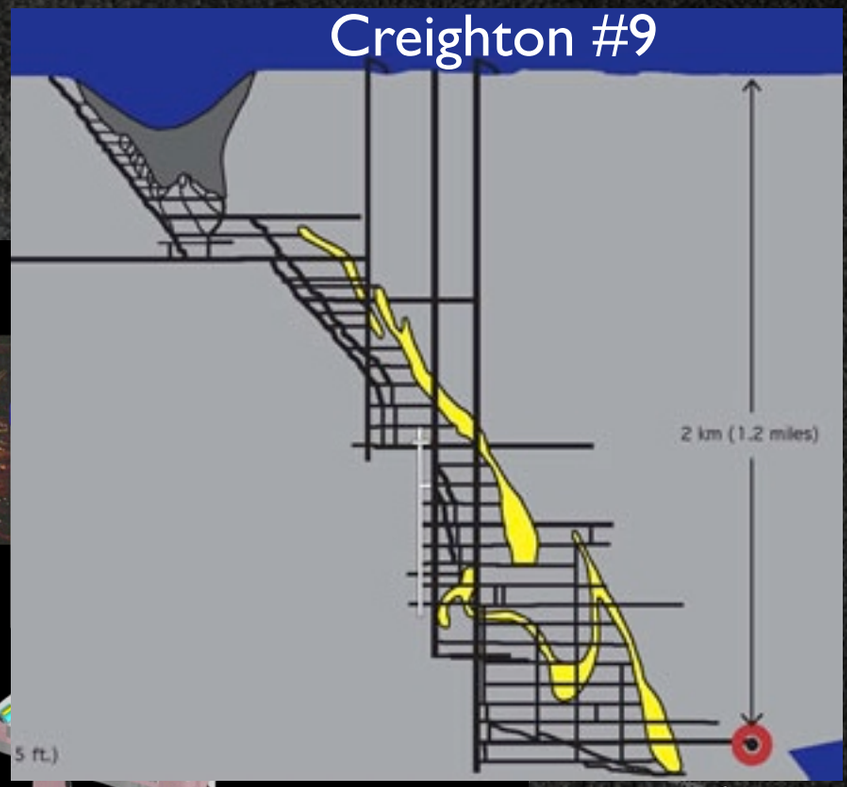




KCl target from TRIUMF proton beam, other LANL groups want Si and Al isotopes, we have obtained

~1.7 μCi of ^{39}Ar to spike our natural argon

SNOLab Cube Hall

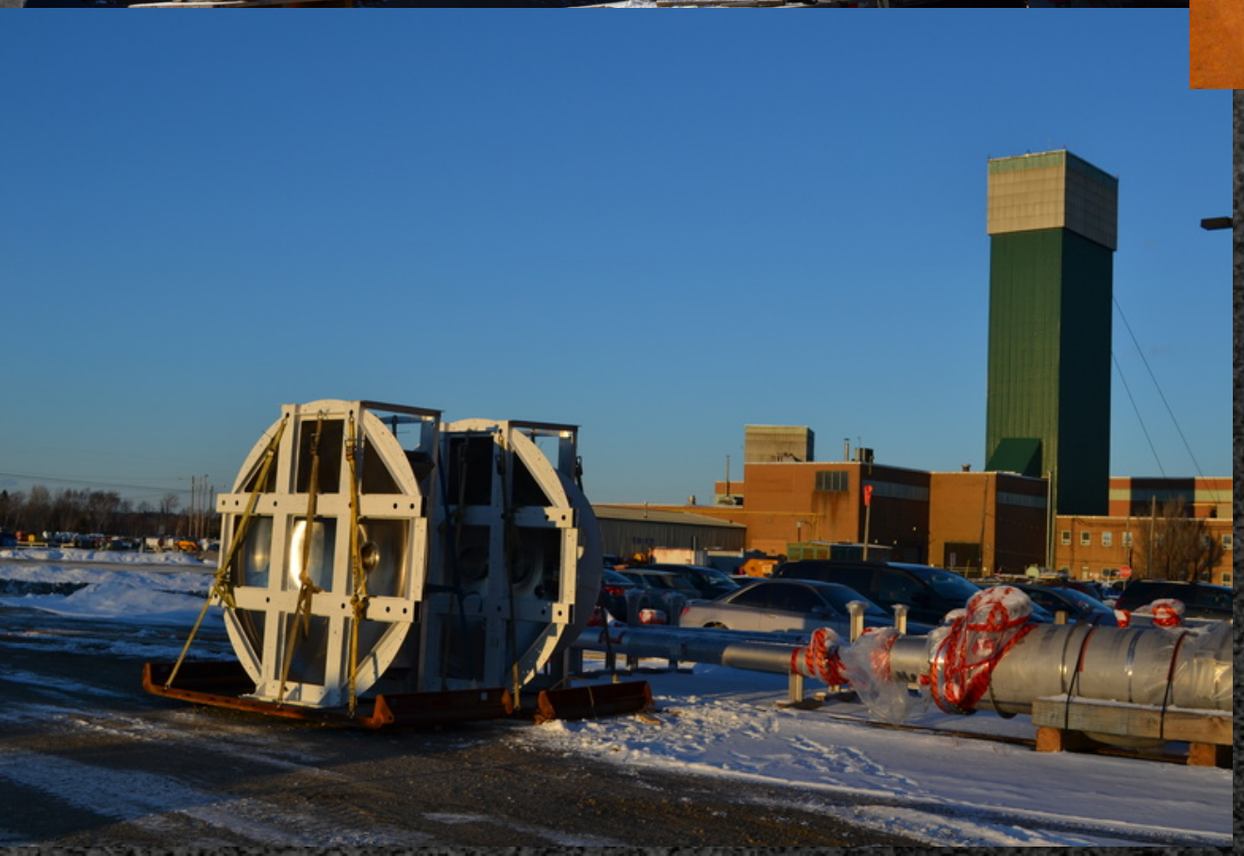


SNOLAB
MINING FOR KNOWLEDGE
CREUSER POUR TROUVER... L'EXCELLENCE

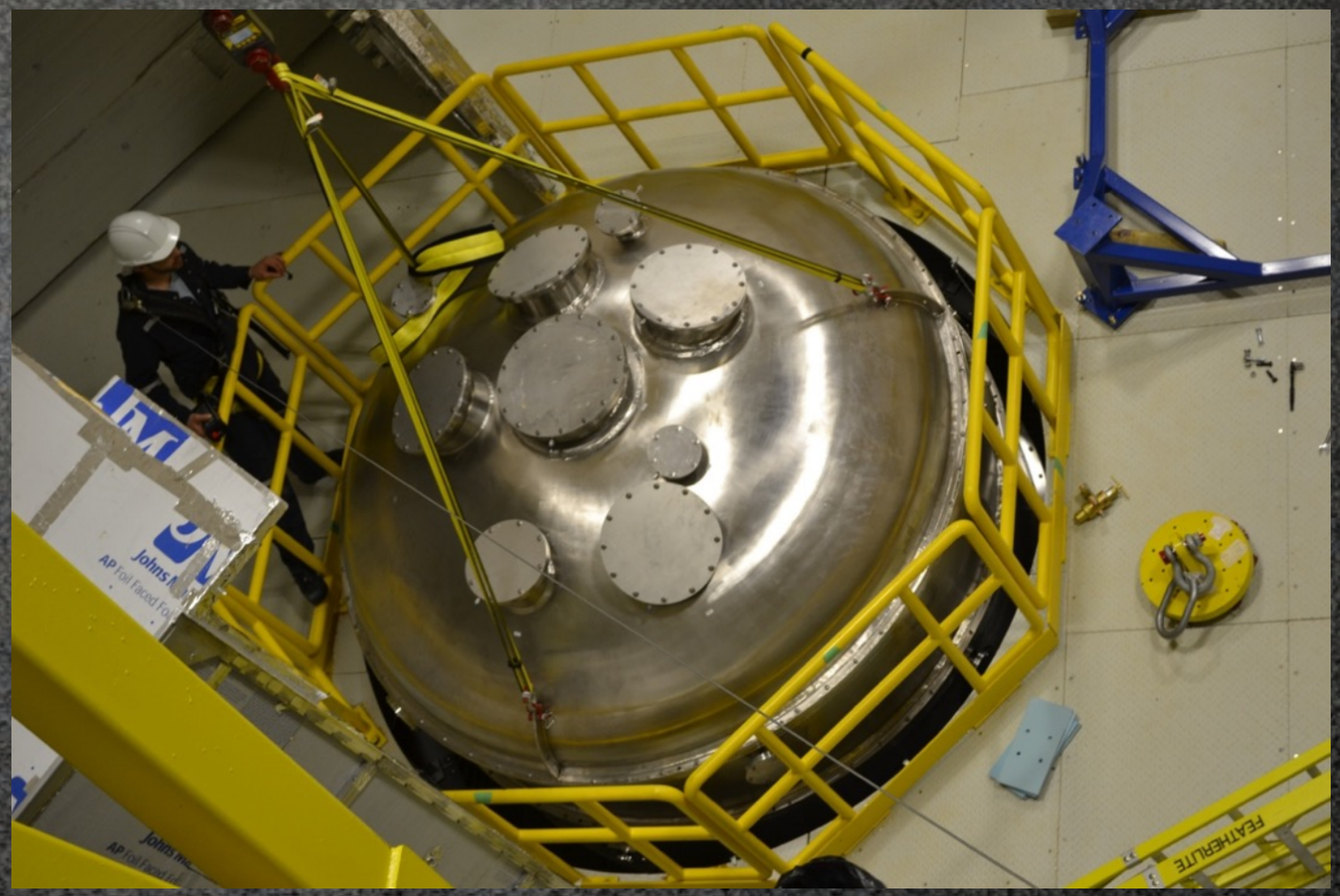
Construction: Veto Tank

Veto String Test Assembly at Bates Lab, MIT

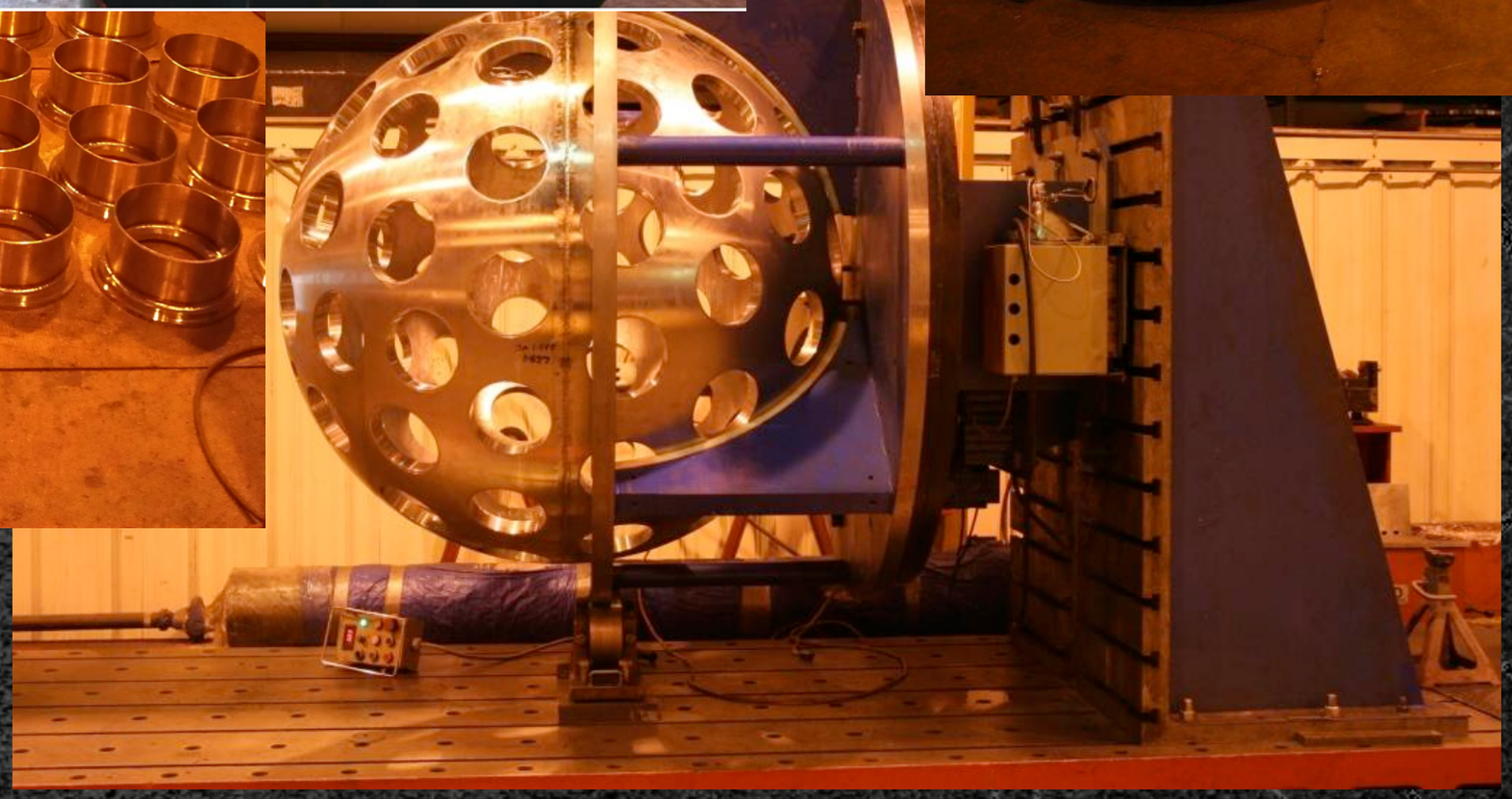
Outer Vessel Transport



Outer Vessel Assembly



Construction: Inner Vessel



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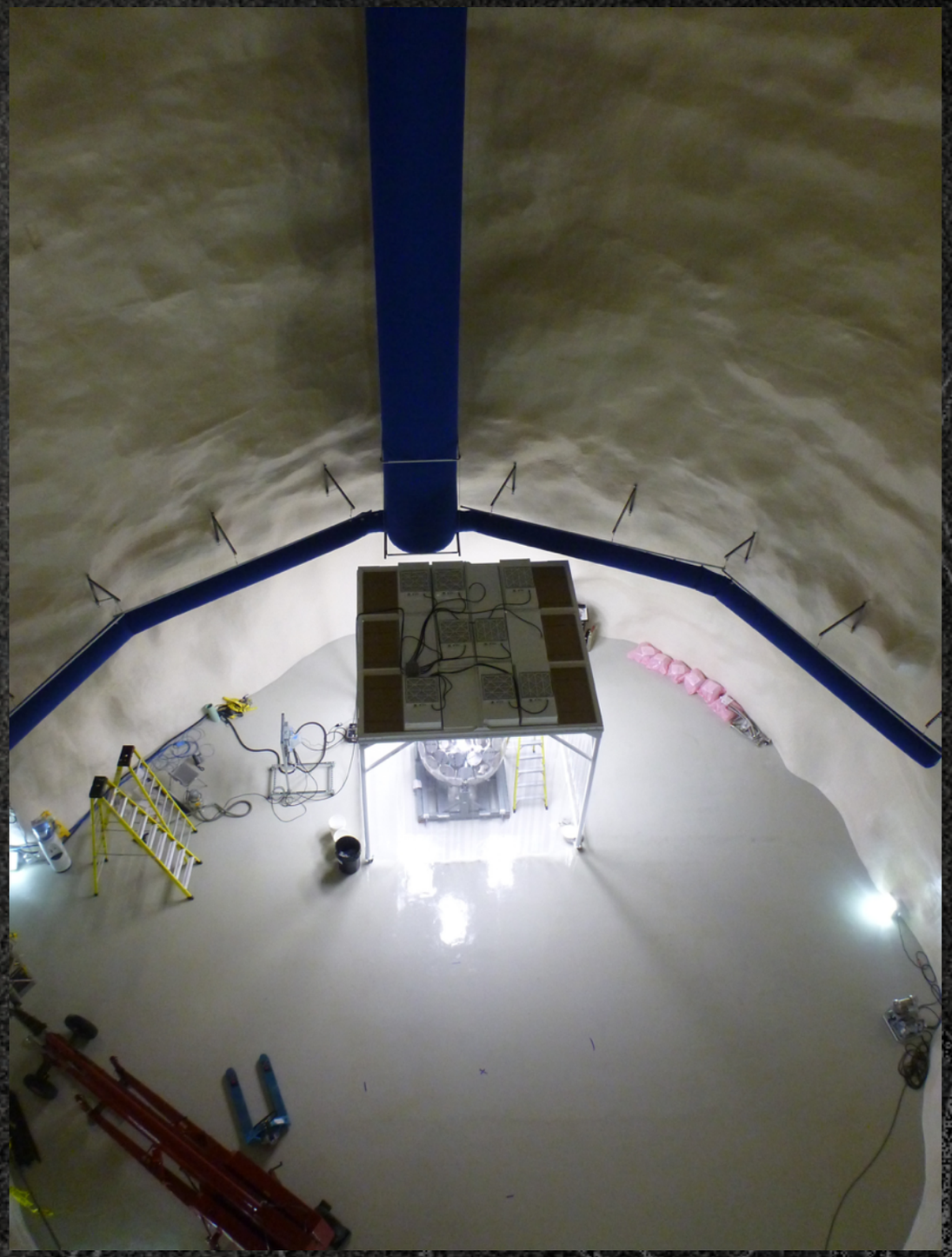
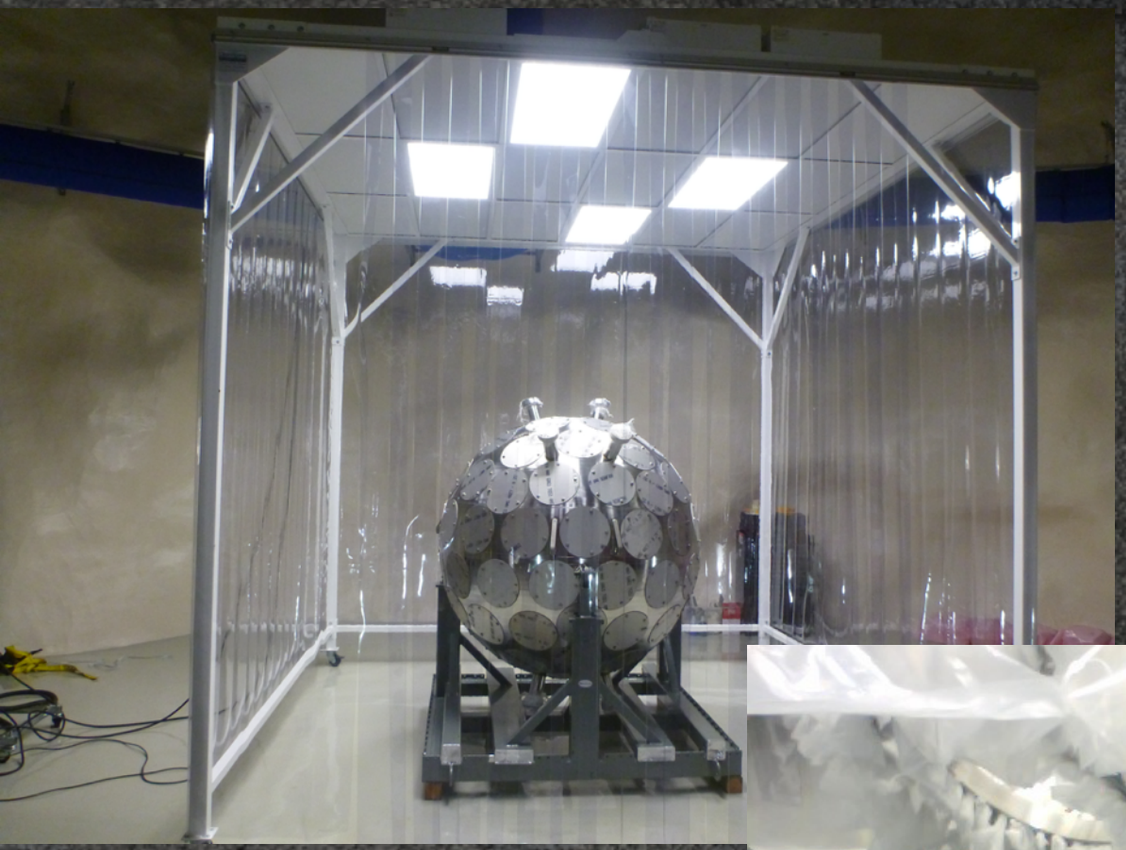
Inner Vessel Transport

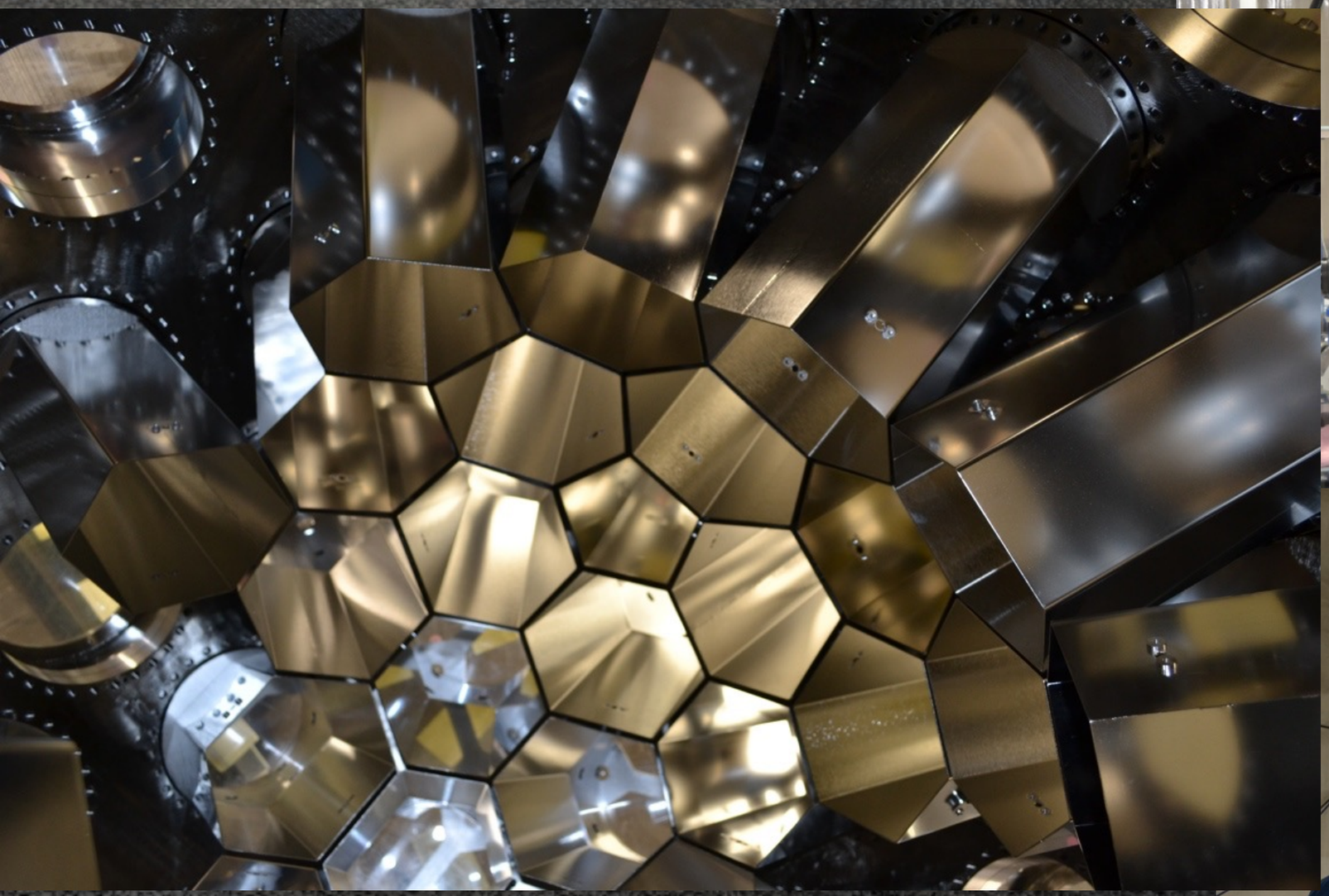
IV Underground

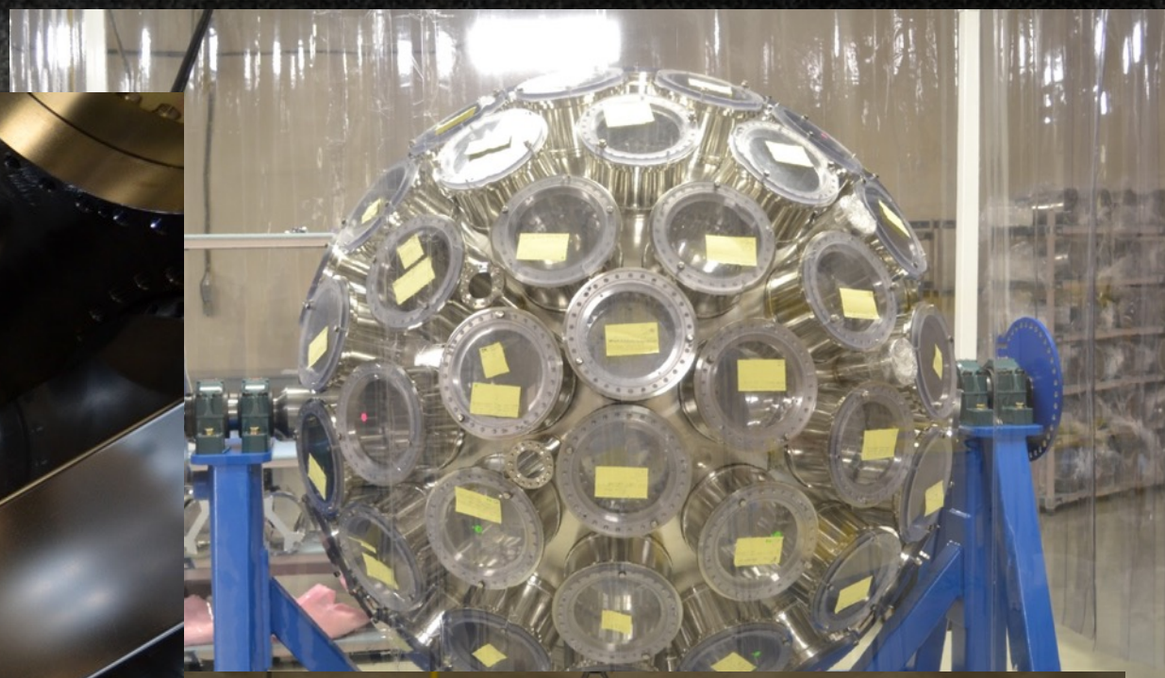


IV Preparation



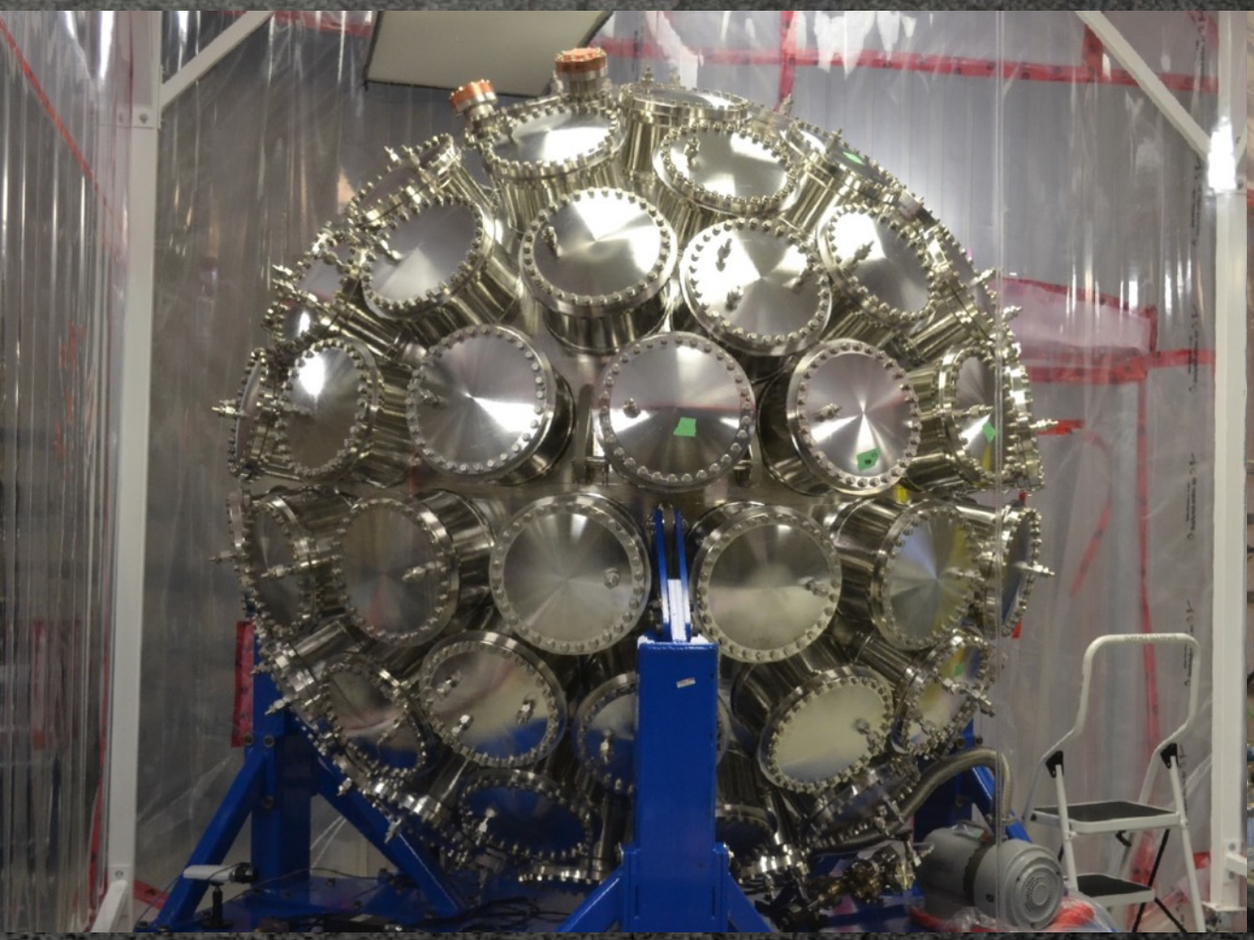
IV Assembly



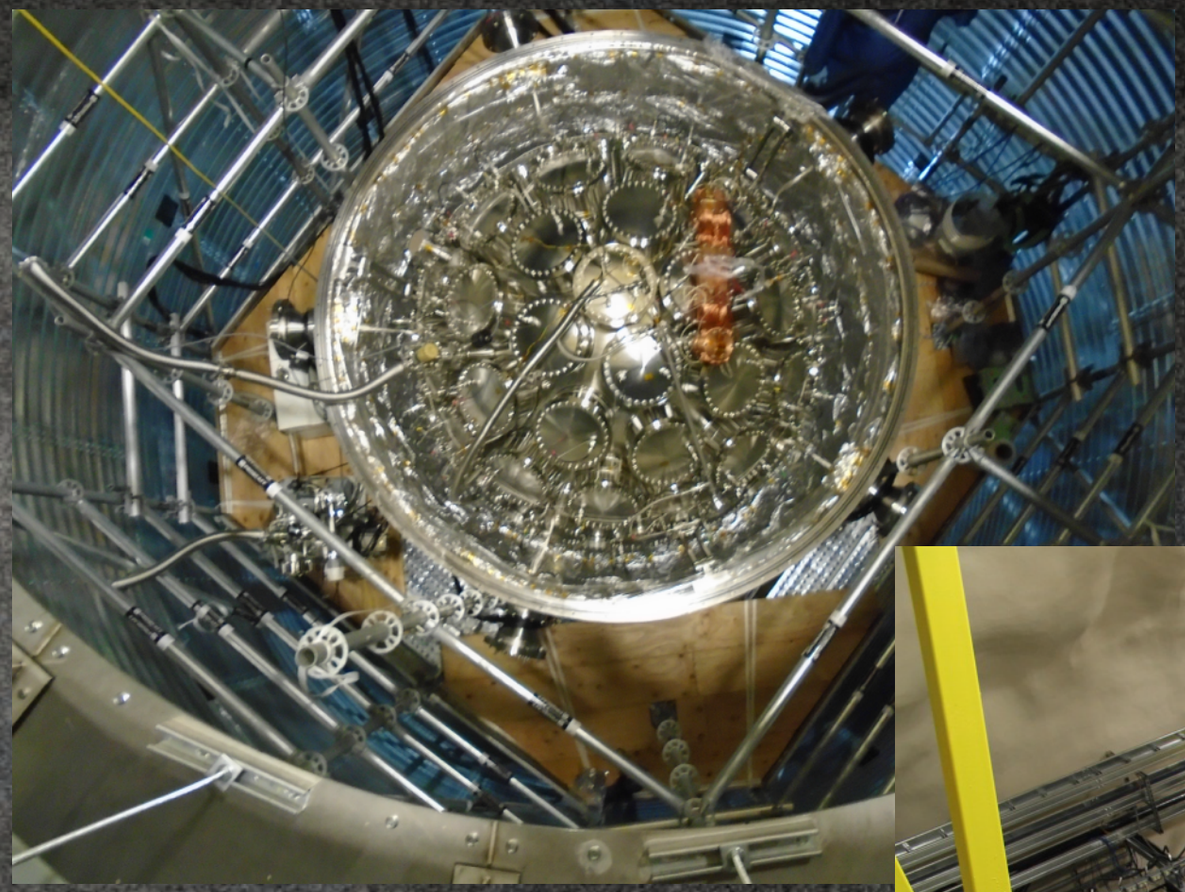


Cassette Insertion

IV Complete



Installed in Cubehall



Backgrounds

Event Selection	^{39}Ar	PMT (α,n)	Surface αs	γs
Raw Rate	1 Bq/kg	42000 n/yr	10000 α/yr	1.4 x 10^{10} γ/yr
Energy Between 12.5-25 kev_{ee}	4.2 x 10^{8}	352.2 +/- 2.1	3360	6.0 x 10^{6}
Fiducial Cut	1.2 x 10^{8}	91.6 +/- 1.1	0.82 +/- 0.09	3 x 10^{5}
Fraction of Prompt Light	75 +/- 1.1	7.1 +/- 0.3	0.24 +/- 0.05	<0.36
Bayesian Discriminant	0.3 +/- 0.2	3.8 +/- 0.2	0.14 +/- 0.04	-
Tagging	-	0.9 +/- 0.1	-	-
	PSD	**Fiducial**	**Fiducial**	**PSD**

Schedule

- **Technology Demonstration**
    - Energy scale, position resolution, pulse shape discrimination, surface alpha rate
- **Dark Matter** Search
    - expected ~2×10^{-45} cm^2
- **^{39}Ar Spike**
    - Test pulse shape discrimination at level required for 150 tonne Generation 3 detector (assuming underground Argon depleted of ^{39}Ar)
    - Inform DEAP-3600 in case of signal observation
- **Liquid Neon** Run
    - Demonstrate target exchange capability for Generation 3 dark matter detector
    - Prototype for precision pp-Solar neutrino measurement