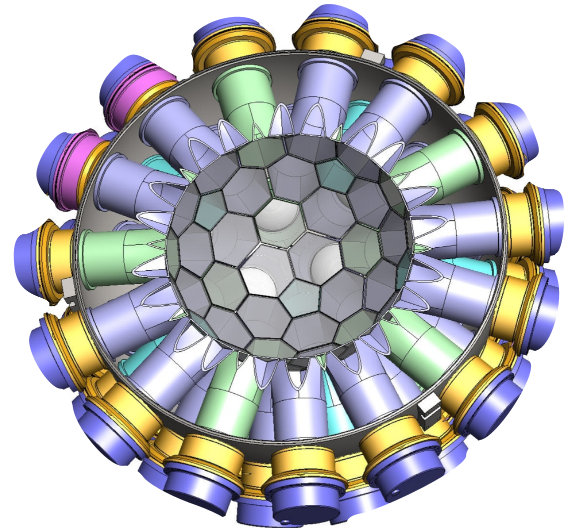
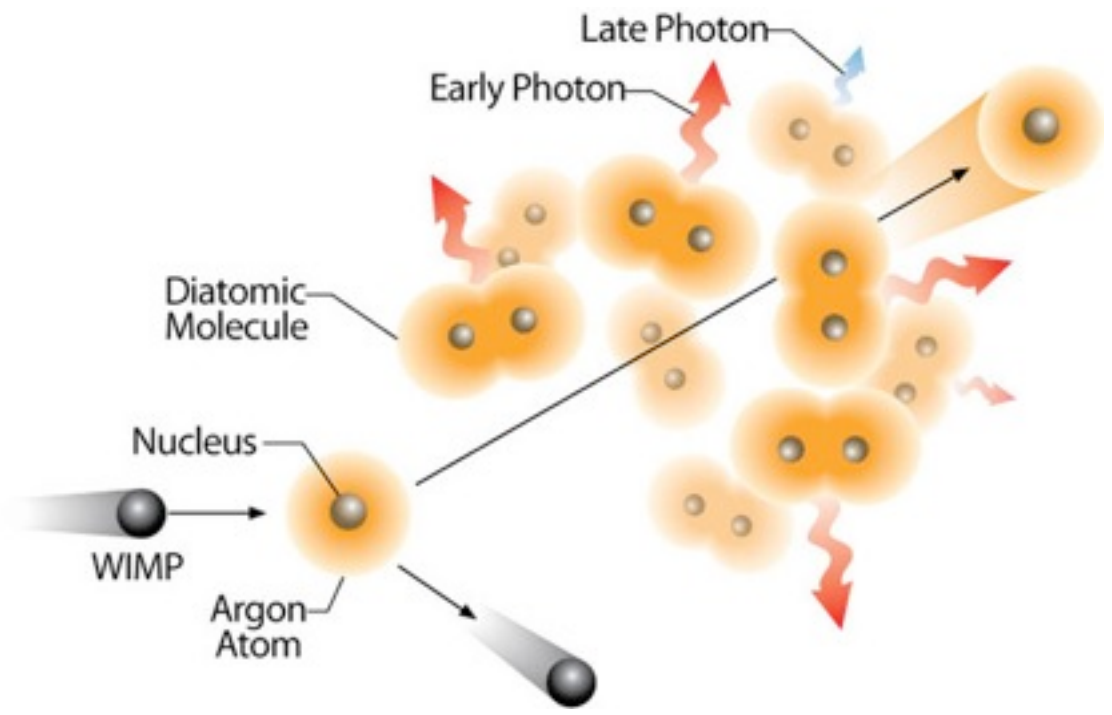


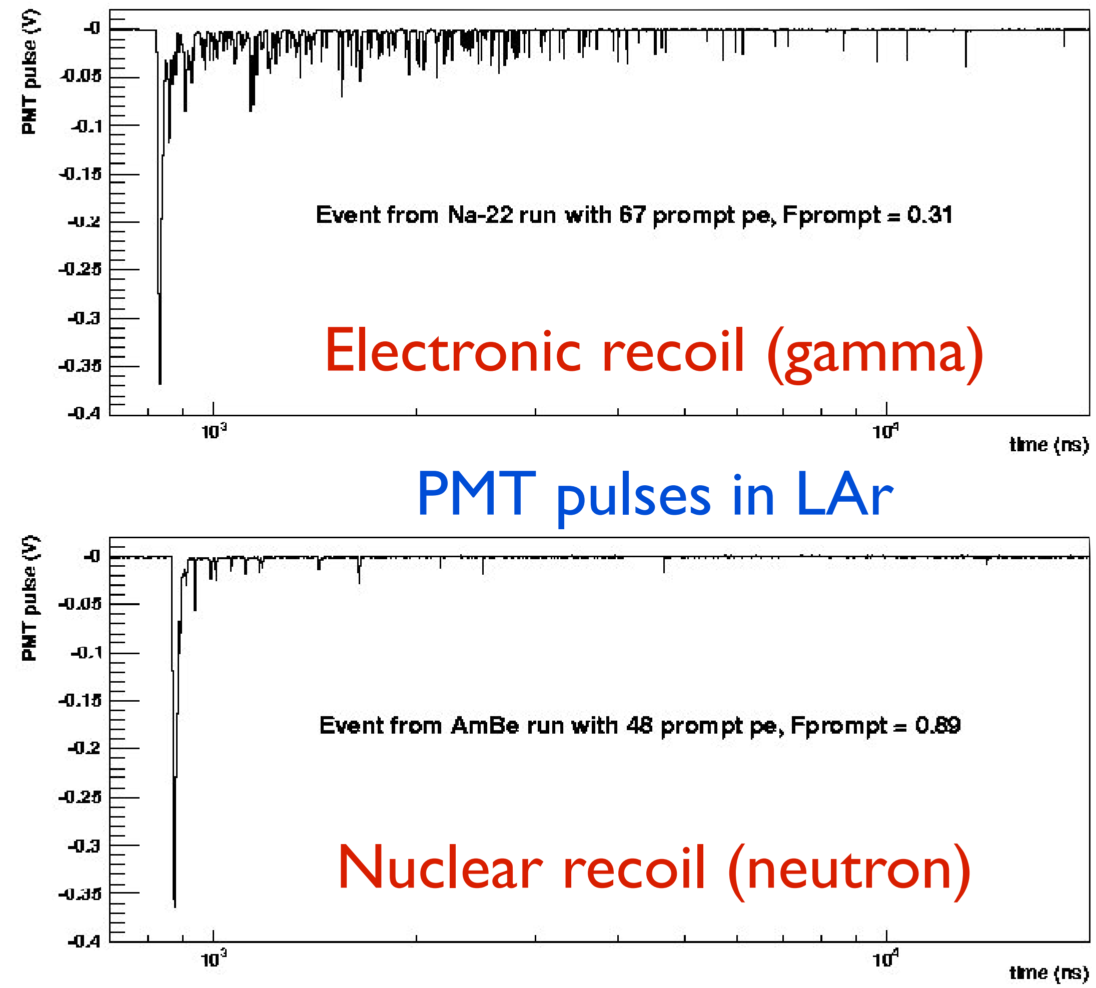
# Update on the MiniCLEAN Dark Matter Experiment

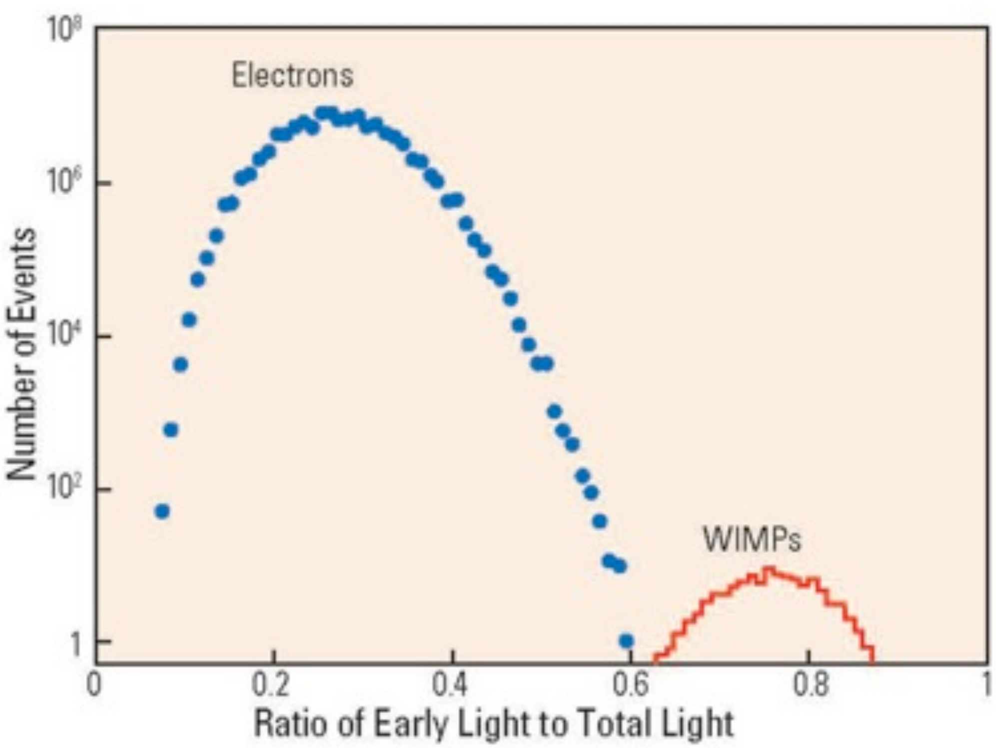
Keith Rielage, for the MiniCLEAN Collaboration
Los Alamos National Laboratory

LA-UR 10-07217

# Pulse-Shape Discrimination in LAr



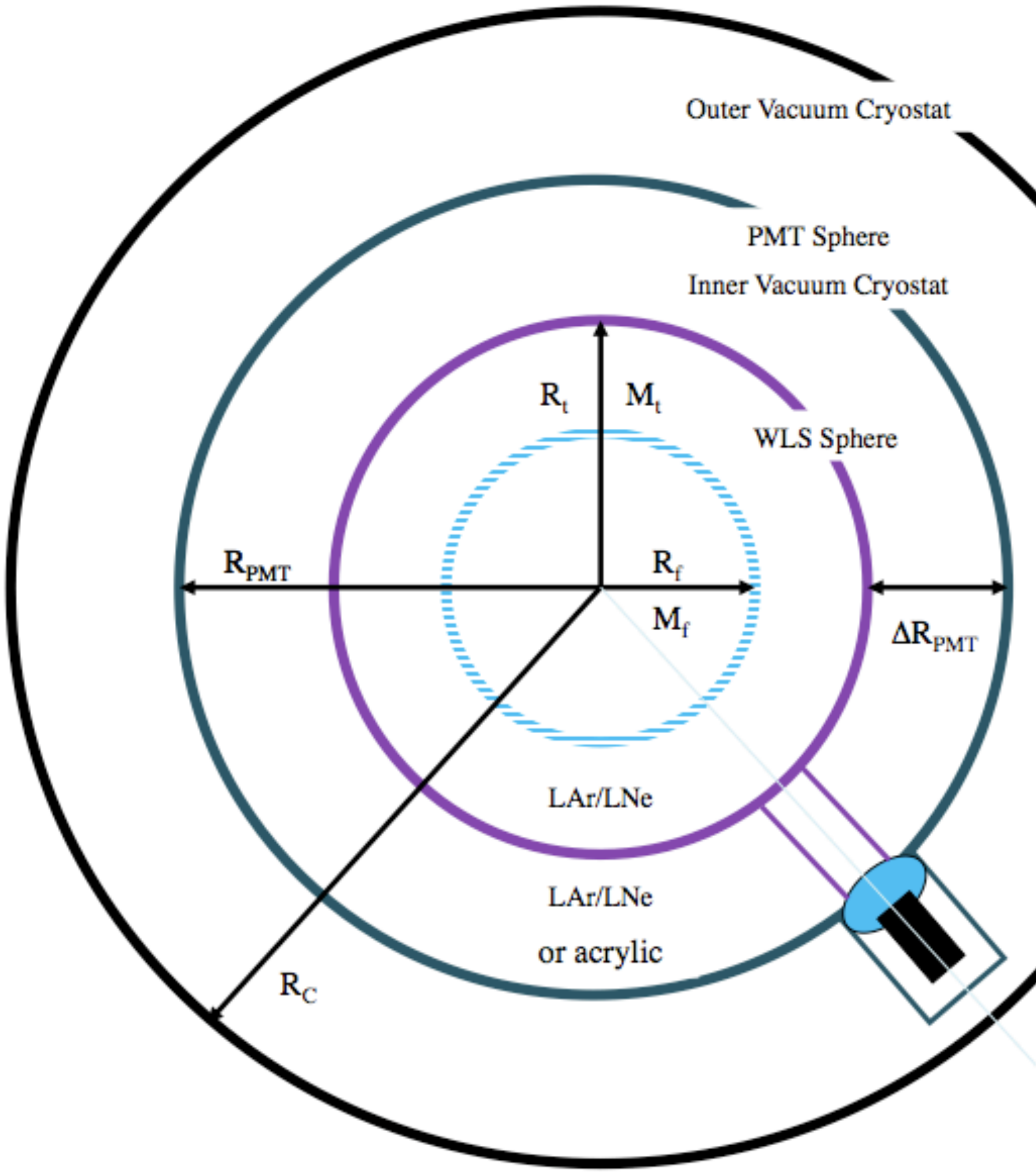




- Noble liquids have singlet and triplet excited states
- For argon and neon, decay times for these states are different and long enough to provide discrimination between electronic and nuclear recoils
- Electronic recoils result in creation of more triplet states so more late light
- Data shows pulse shape discrimination of $10^{-10}$ achievable, demonstrated $10^{-8}$

# MiniCLEAN Goals

- Based on the 95% (almost 4π) coverage design:
  - Measurement of light yield compared to simulation
  - Demonstration of 3D position reconstruction
- At that light yield:
  - High statistics measurement of background PDF due to PSD leakage of 39Ar decays
  - Informs future performance of large argon detectors
- With MiniCLEAN:
  - Measure backgrounds (surface alphas, neutrons, etc.)
  - Test analysis and background rejection techniques
- With additional funding:
  - Replace argon target with liquid neon to inform future large detector designs for dark matter, p-p solar neutrino experiments

# Conceptually Simple Detector




- Sphere of argon or neon serves as target for WIMPs
- Scintillation light from recoils at 80-128 nm
- Converted to visible by wavelength shifter on acrylic
- Light guide brings visible light to photomultiplier tube where signal recorded

# MiniCLEAN Detector

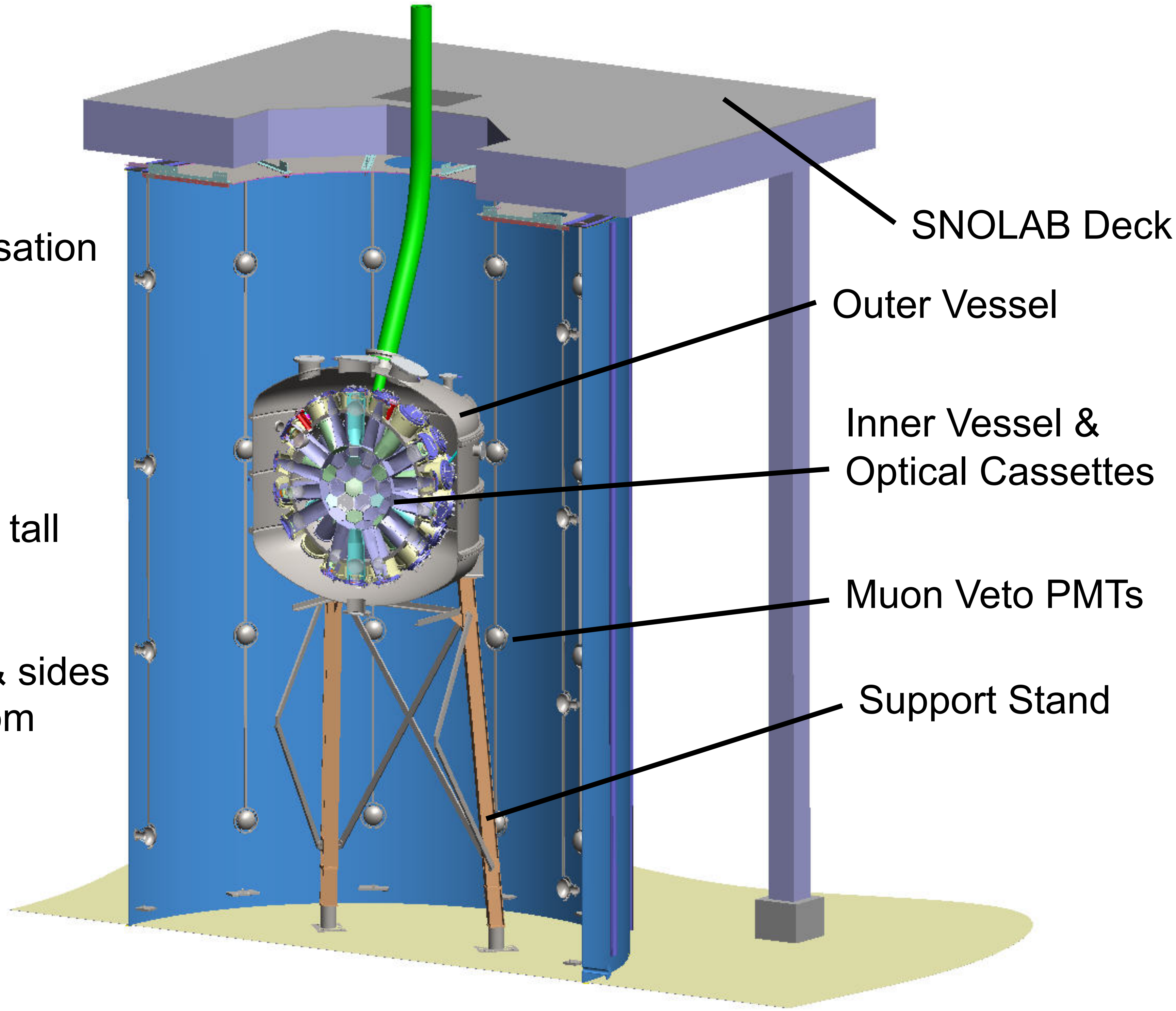
- Liquid cryogen can be argon or neon
- ~150 kg fiducial volume, 500 kg active volume
- PMTs - Hamamatsu R5912-02MOD operating in cryogenic liquid
- Cryogen, PMTs and wavelength shifters contained in stainless steel Inner Vessel (IV)
- IV is surrounded by stainless steel Outer Vessel with vacuum insulation and thermal blanket
- PMT and wavelength shifter (TPB) on acrylic plate are part of modular optical cassette
- 92 optical cassettes
- Operates 6800' underground at the SNOLAB underground laboratory in Sudbury, Ontario, Canada

# MiniCLEAN Conceptual Design

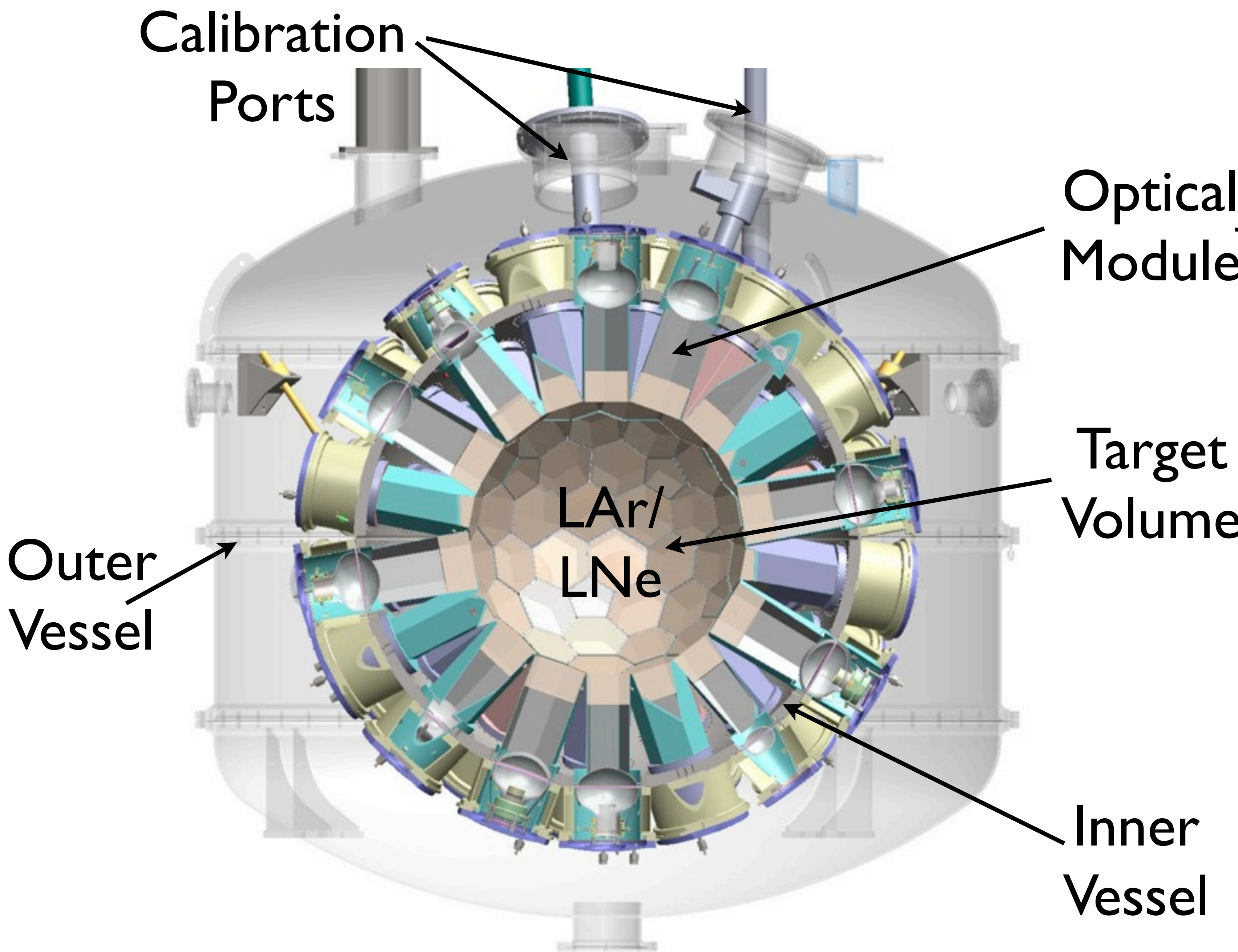
Not Shown:
Magnetic Compensation
Process Systems
Cable Bundles

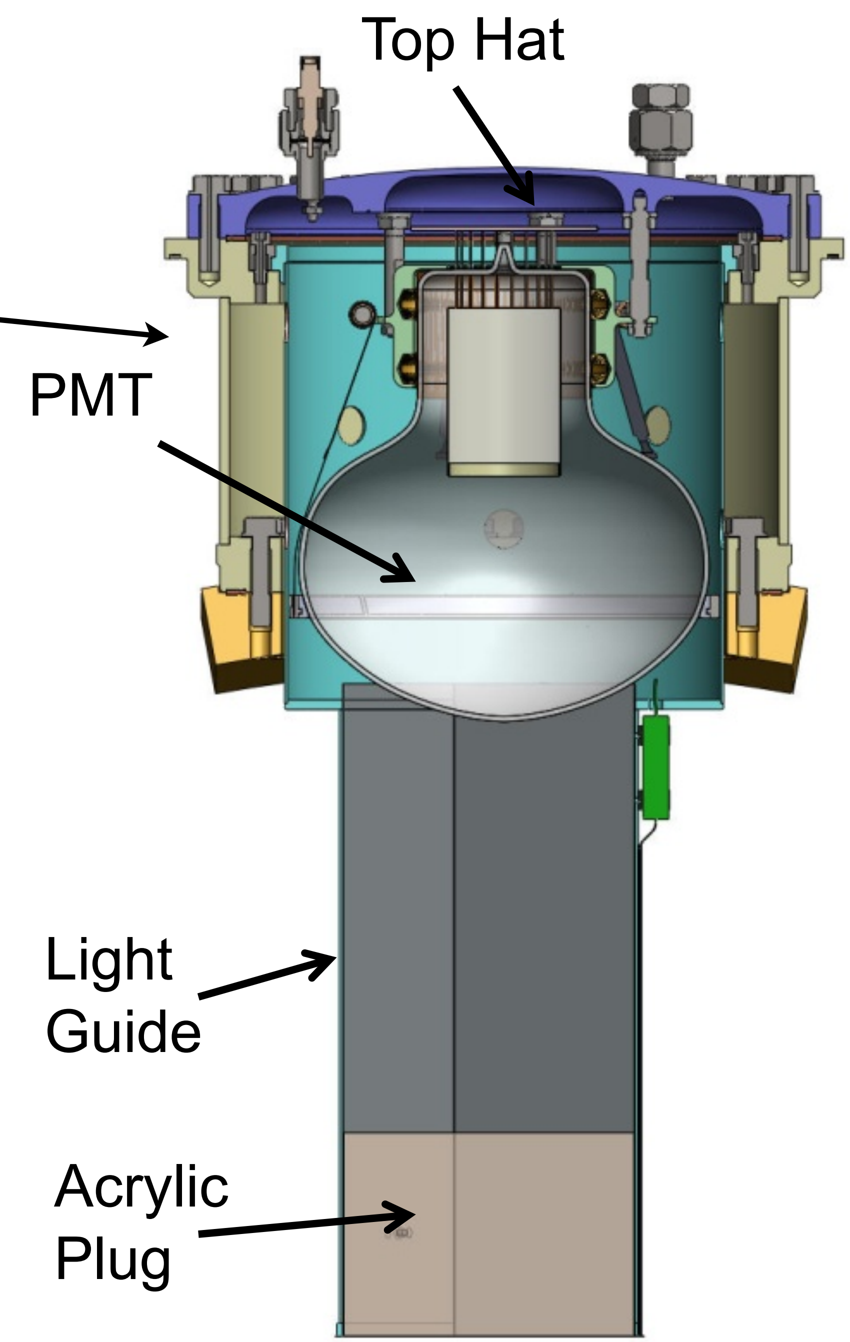
Tank 18' dia. x 25' tall
47,600 gallons

~1.5m water top & sides
~3.5m water bottom



# MiniCLEAN Conceptual Design



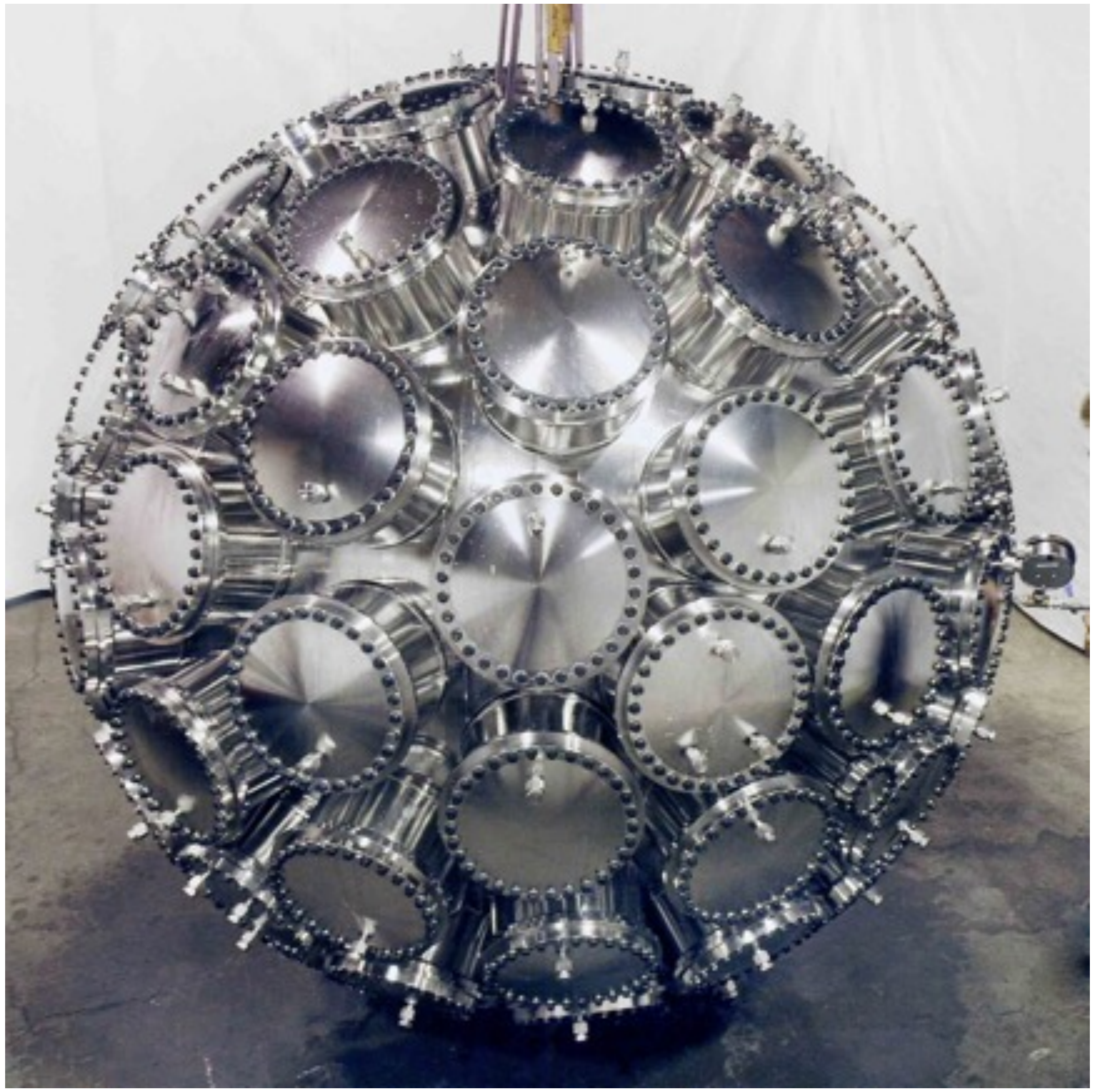



# Outer Vessel Progress

Underground in January, installed in May

# Inner Vessel Progress

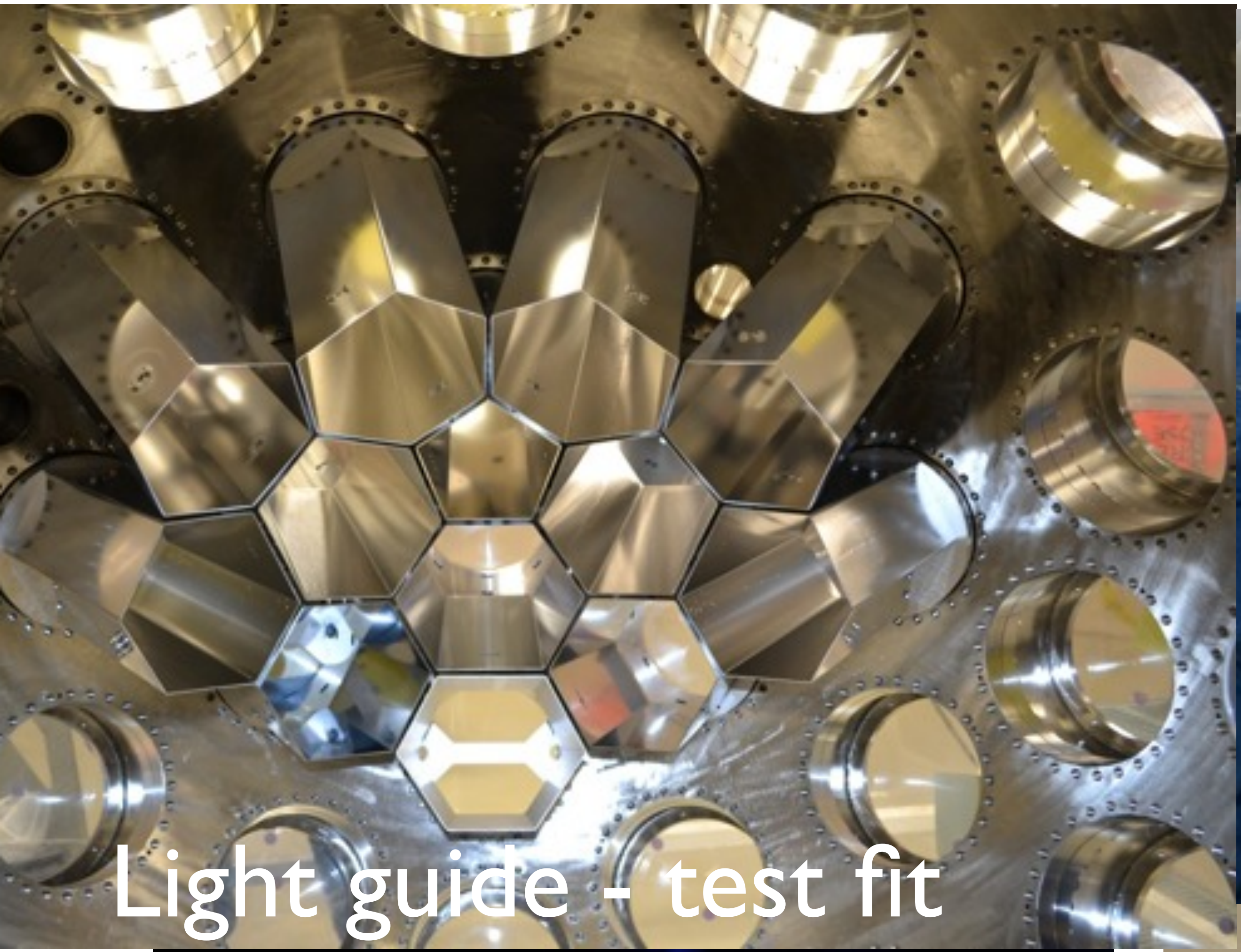
- Manufacturing completed and tested in September 2012

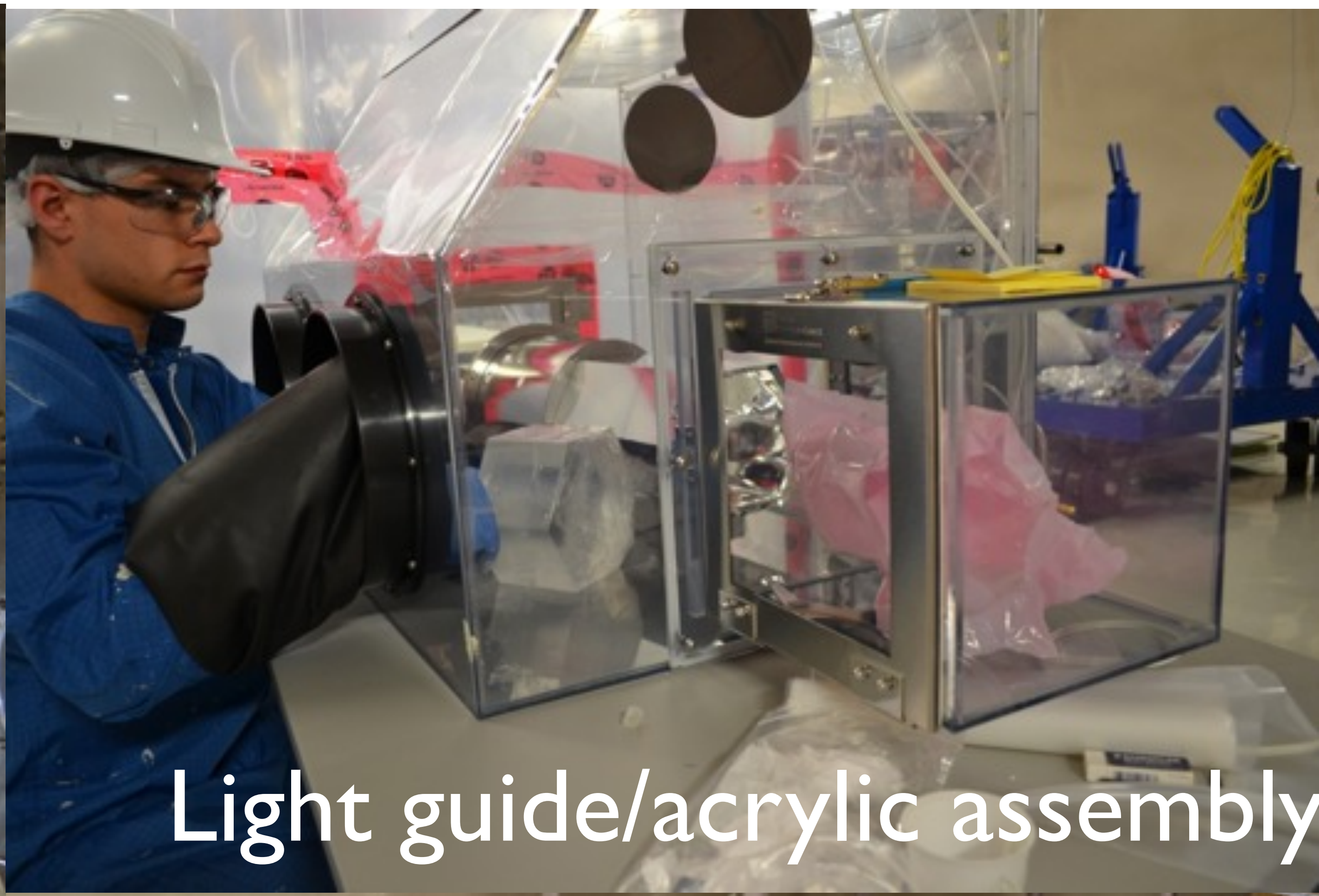


# Inner Vessel Progress



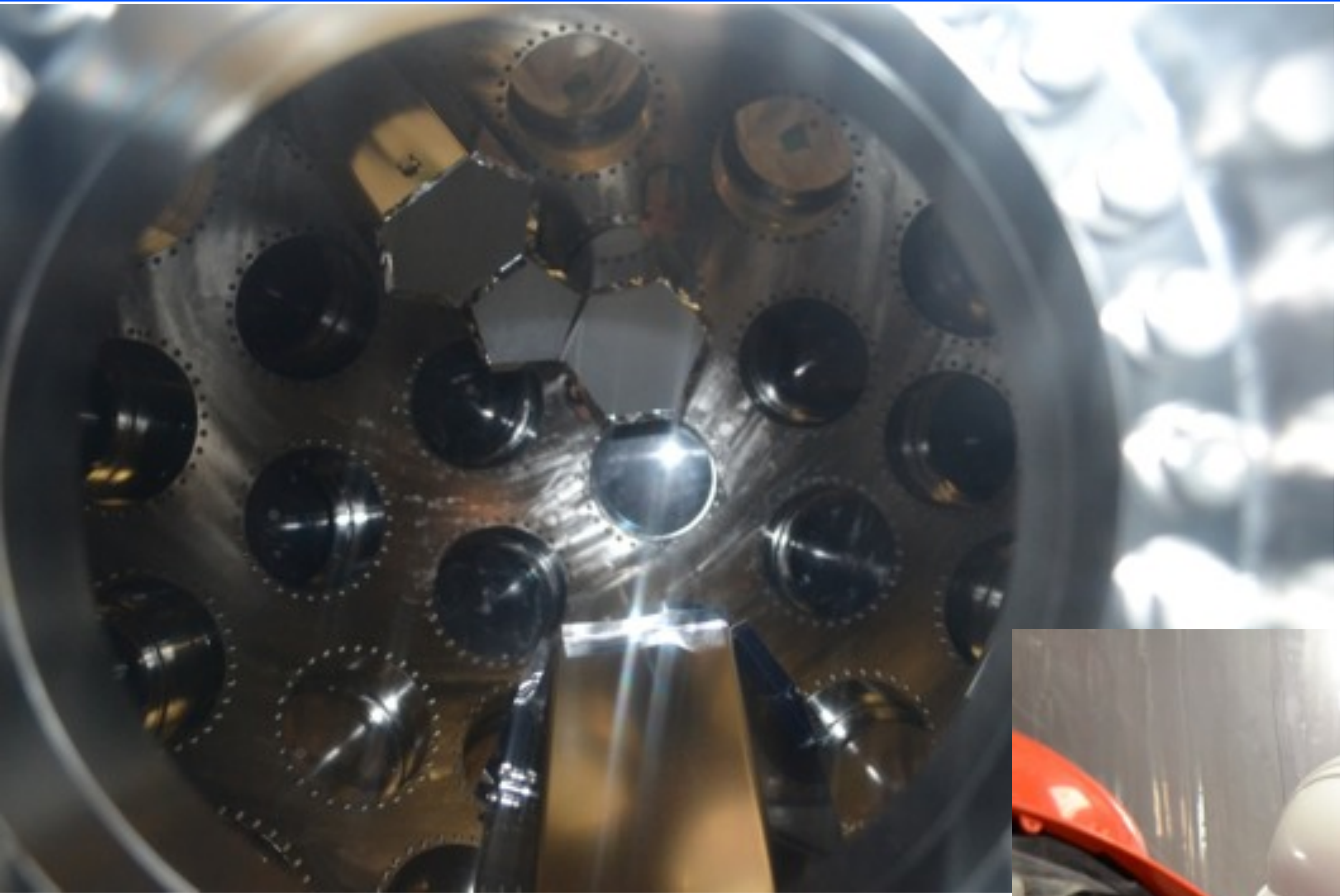
# Optical Cassette Progress





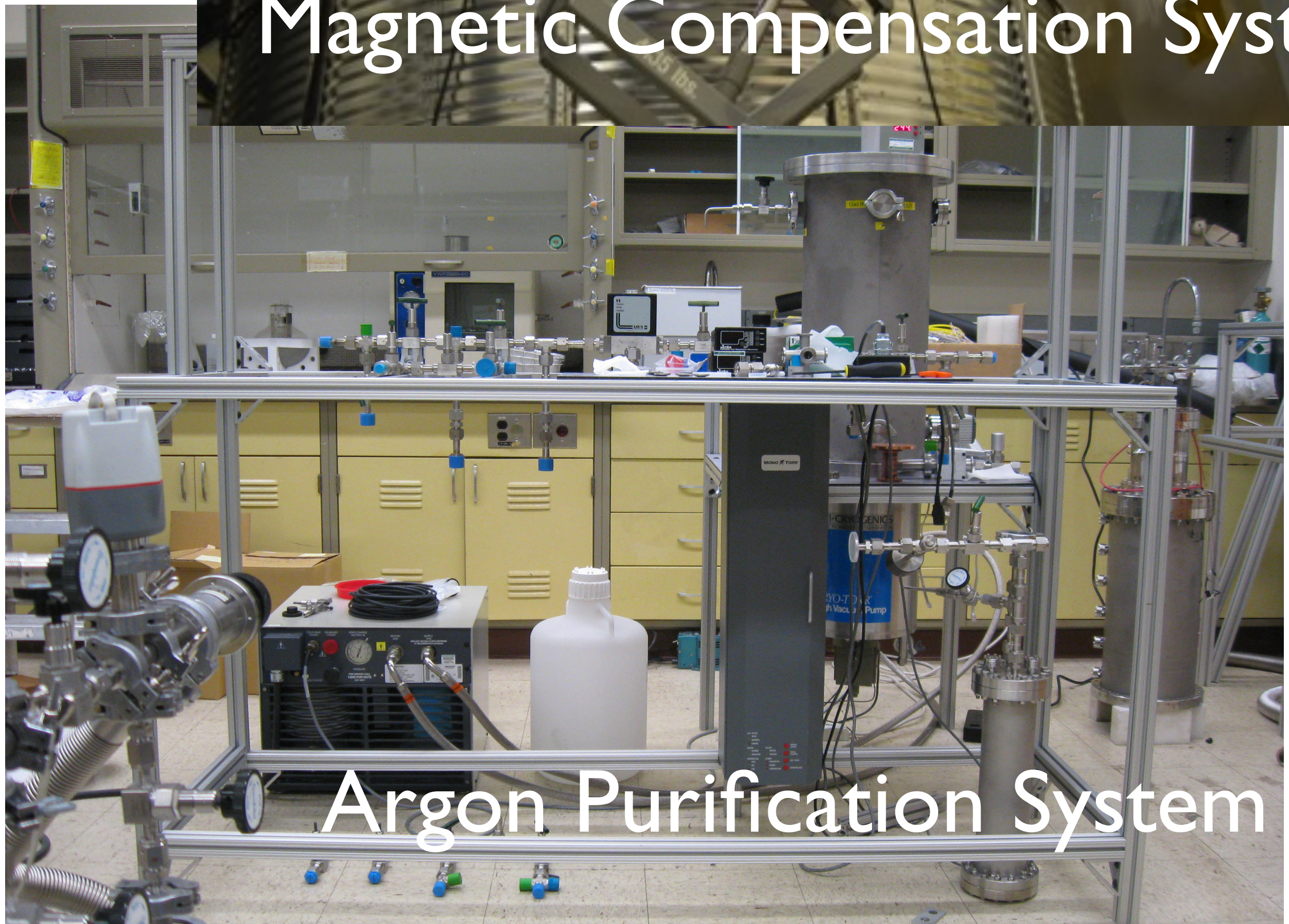
# Optical Cassette Progress

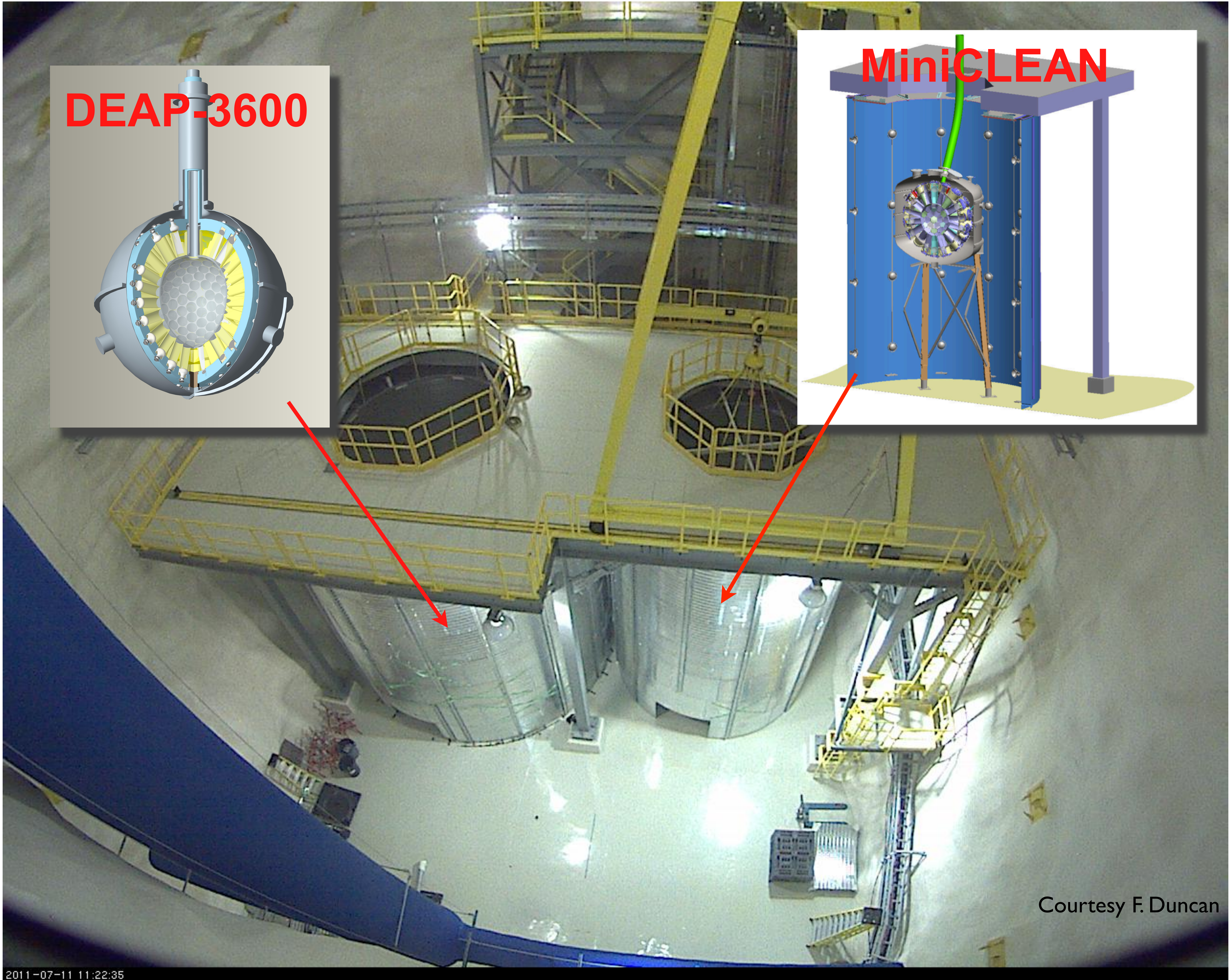


First optical cassettes installed last week

# Subsystem Progress








Courtesy F. Duncan

# PSD Demonstration with Enriched Argon

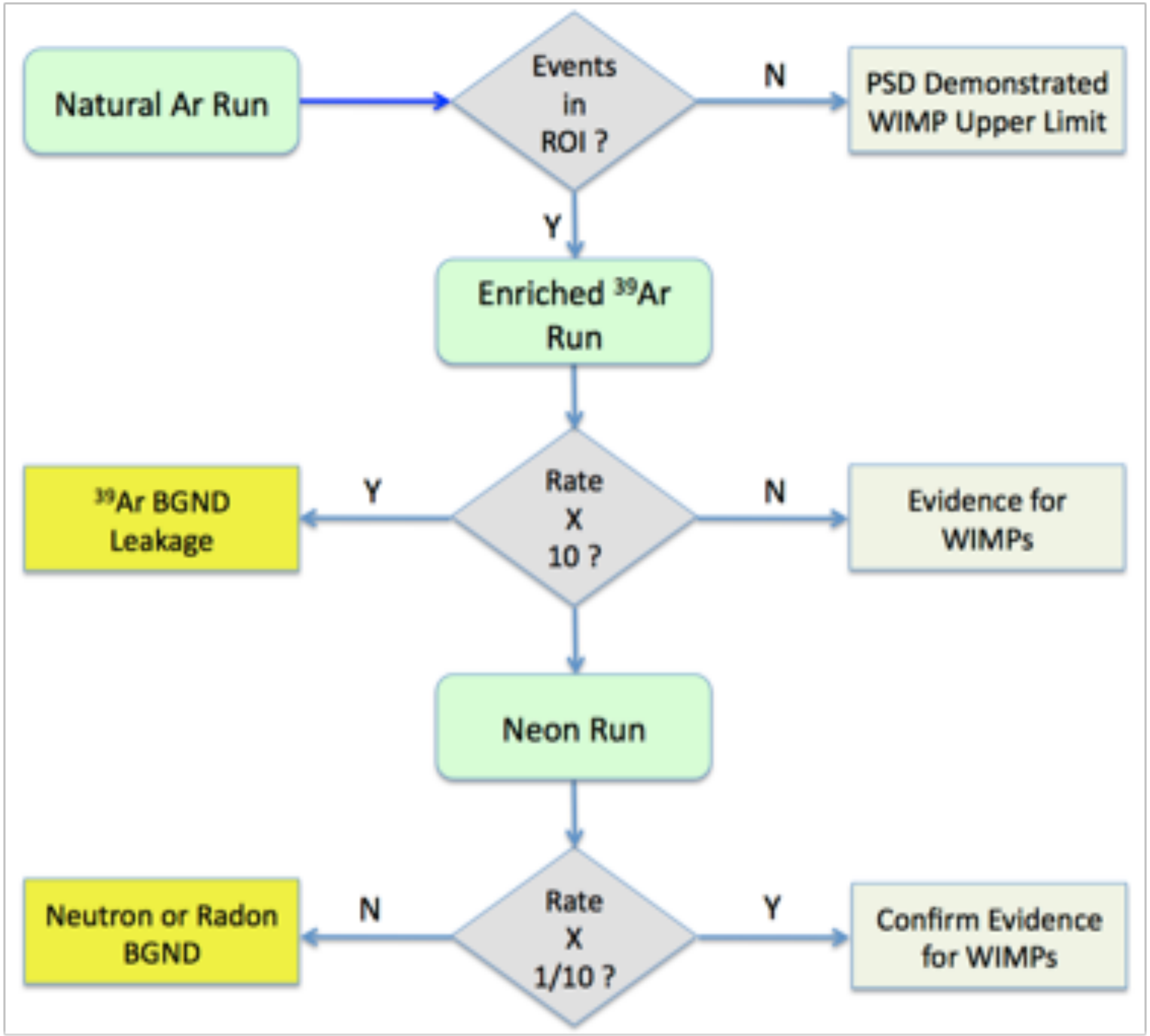
- Spike the detector with a sample of $^{39}Ar$ to increase the level of this background ~8x (and shorten time to perform measurement)
- Use to extract ultimate PSD leakage rate achievable
- DOE isotope program produced $^{39}Ar$ as byproduct in irradiated KCl target
    - About 138 MBq (need 25kBq)
- Extraction and purification will be performed at LANL soon

# MiniCLEAN Schedule

- Assembly and initial commissioning complete in late Fall 2013
- 4-5 weeks to condense argon gas into LAr
- ~8 weeks of calibration and running:
  - Energy scale
  - Position reconstruction
  - Neutron calibration
  - Preliminary PSD
- Then ~100 days of enriched argon running
  - Produce at least $10^{10}$ $^{39}Ar$ events in the fiducial volume
- Use PSD run to compare to DEAP-3600, Darkside-50, etc
- Pursue addition of LNe

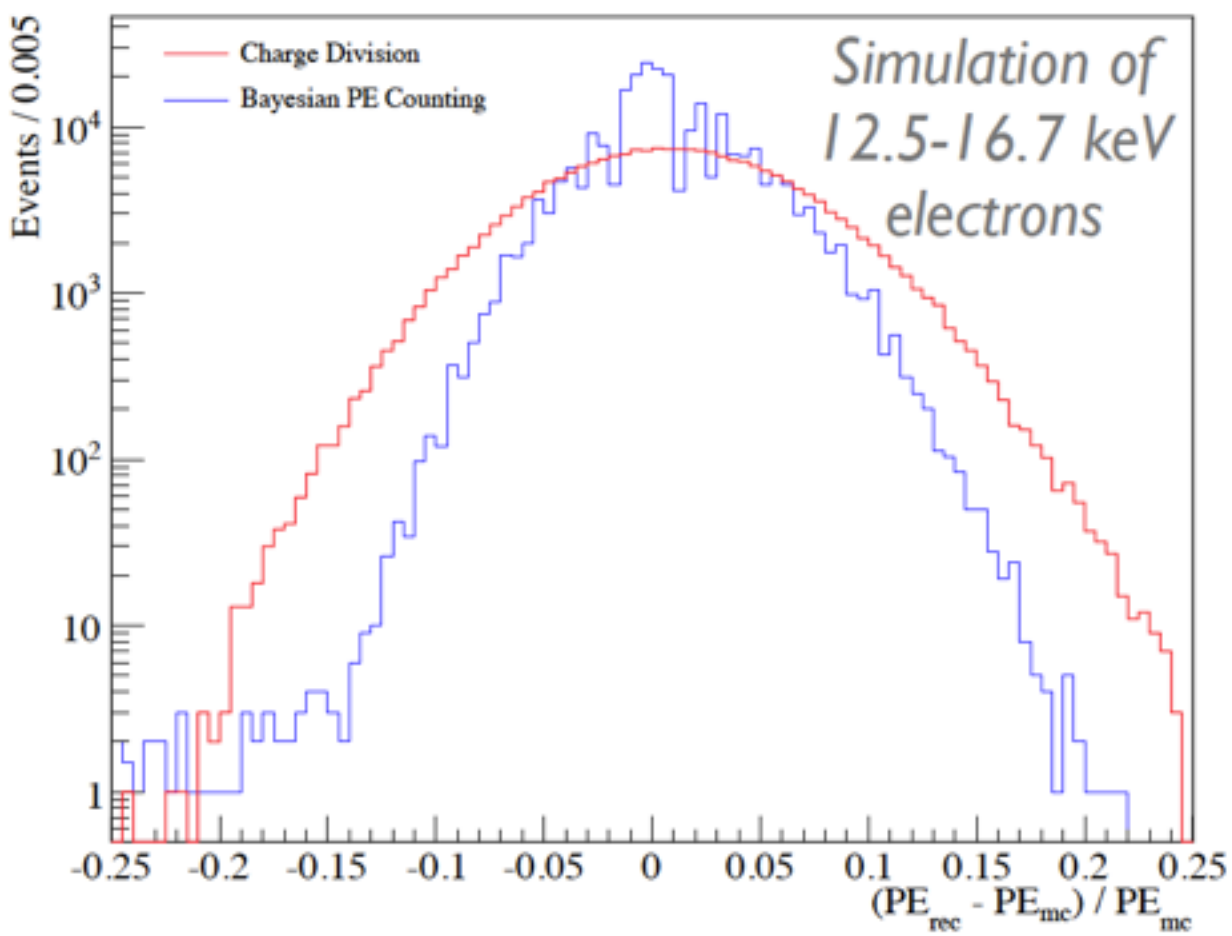
# Utility of LNe Run for Dark Matter

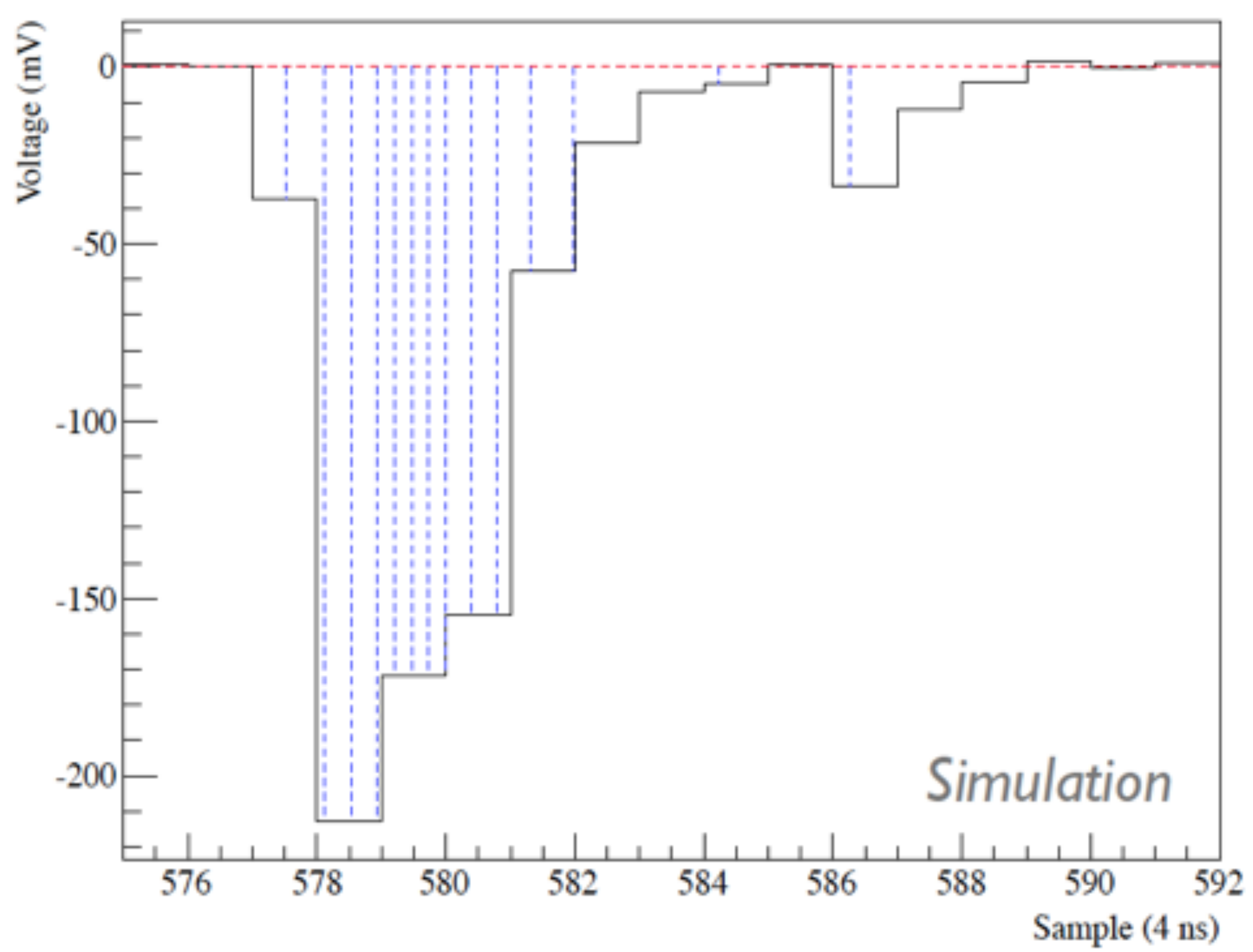
- Running with two different 39Ar rates, combined with neon run offers a powerful test of any possible WIMP signal



# Analysis Techniques

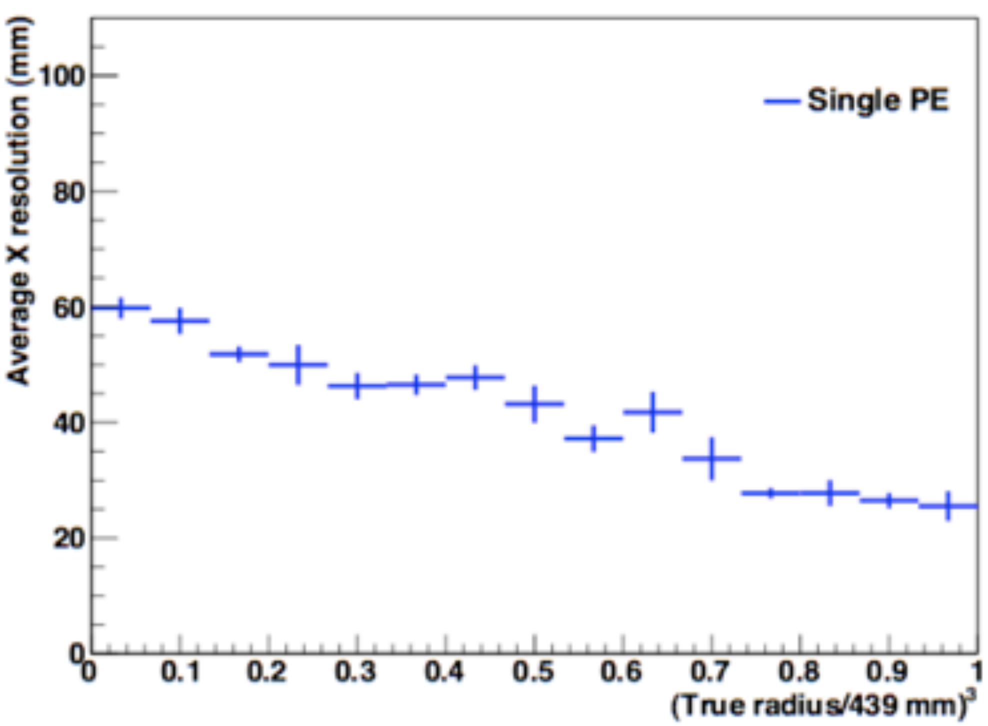
- Bayesian Single PE counting:
  - deals with PE pile-up in prompt region
  - better performance than simple charge division
  - determines number of PE and time for each waveform to improve energy resolution at low energy

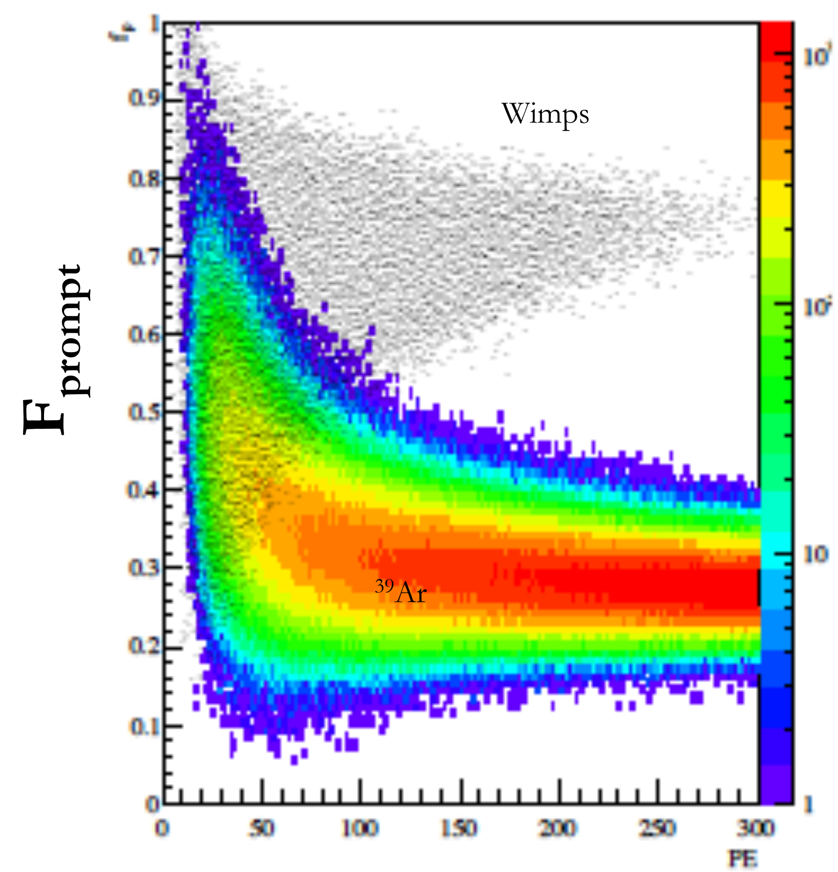


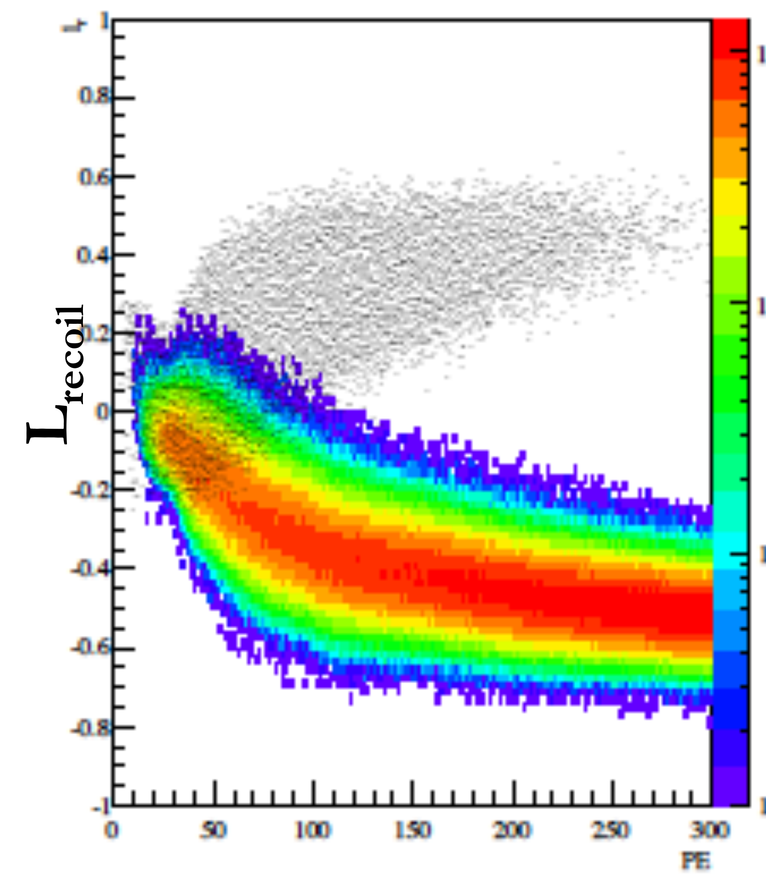



# Analysis Techniques

- Position Reconstruction: using likelihood based approach to predict location of event
- Pulse shape discrimination: Fprompt vs. Lrecoil
  - Lrecoil uses PE times from PE counter, singlet and triplet ratios and lifetimes as inputs
  - most improvement at low energy




MiniCLEAN Simulations

# Summary

- Assembly of MiniCLEAN is in final stage
- Expect to begin LAr fill by end of 2013
- Will study backgrounds and position reconstruction
- Enhance with 39Ar for PSD measurement
- Will pursue liquid neon R&D
- New analysis techniques will be tested
- MiniCLEAN will provide valuable data for future argon experiment plans

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