35-ton Overview

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35-ton Review

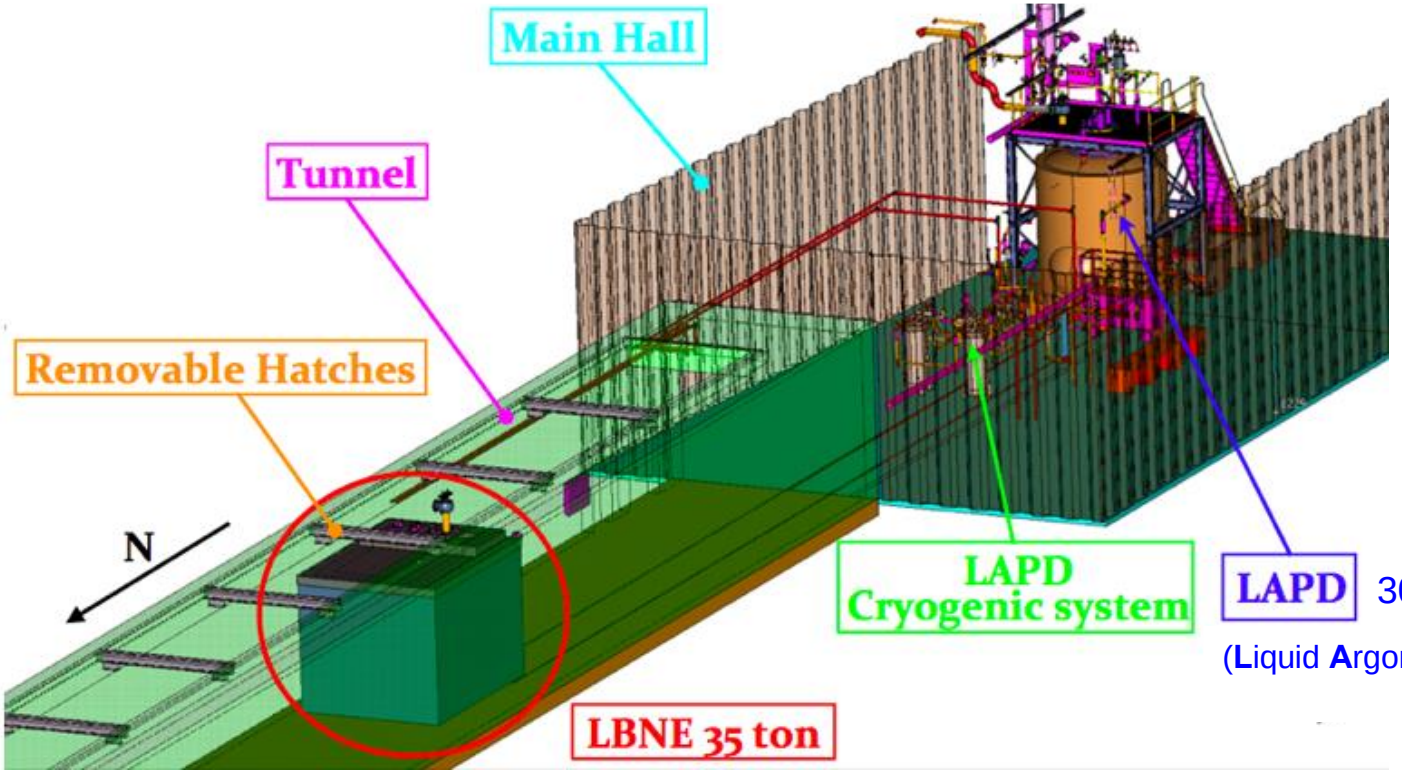
June 2, 2016

Introduction

- This talk is intended to give a very high-level overview of the 35-ton prototyping program (many additional details to follow in the subsequent overview presentations)

- Apologies in advance to Mark Convery, Michelle Stancari, and Jim Stewart from whose talks many of the slides have been taken

What is the 35-ton Cryostat?



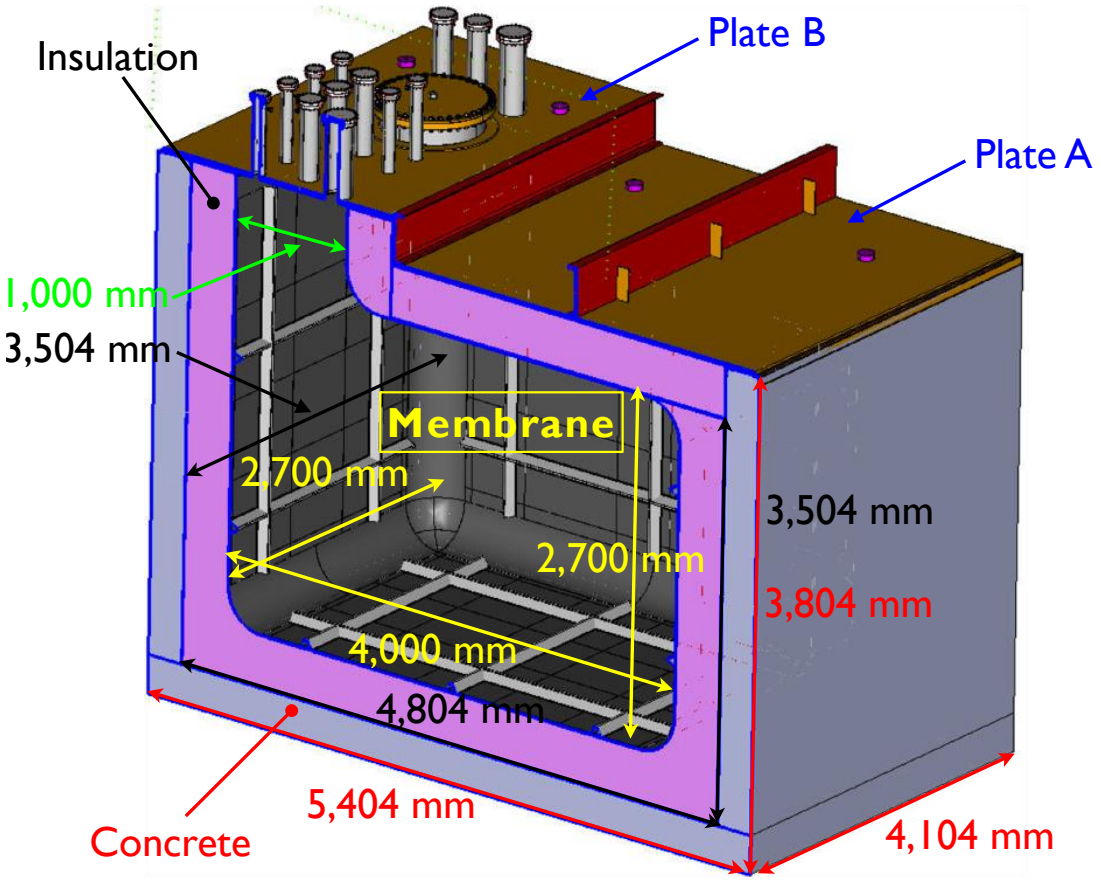
- The original purpose of the 35-ton cryostat was to demonstrate that liquid argon purity at the level required for TPC operation could be obtained in a non-evacuated, membrane cryostat (successfully demonstrated in early 2014)

History

- At the time it was built, the 35-ton cryostat was intended to be followed by the construction of a 1-kton cryostat at FNAL (LAr1) that would house a large-scale LAr-TPC prototype
- When LBNE went through the CD-1 process in 2012, the total project cost was capped leading to scope reductions including the elimination of the LAr1 program
- Since there was still a strong need for a detector prototyping program, a decision was made to design prototype detector components that could be installed and operated within the 35-ton cryostat

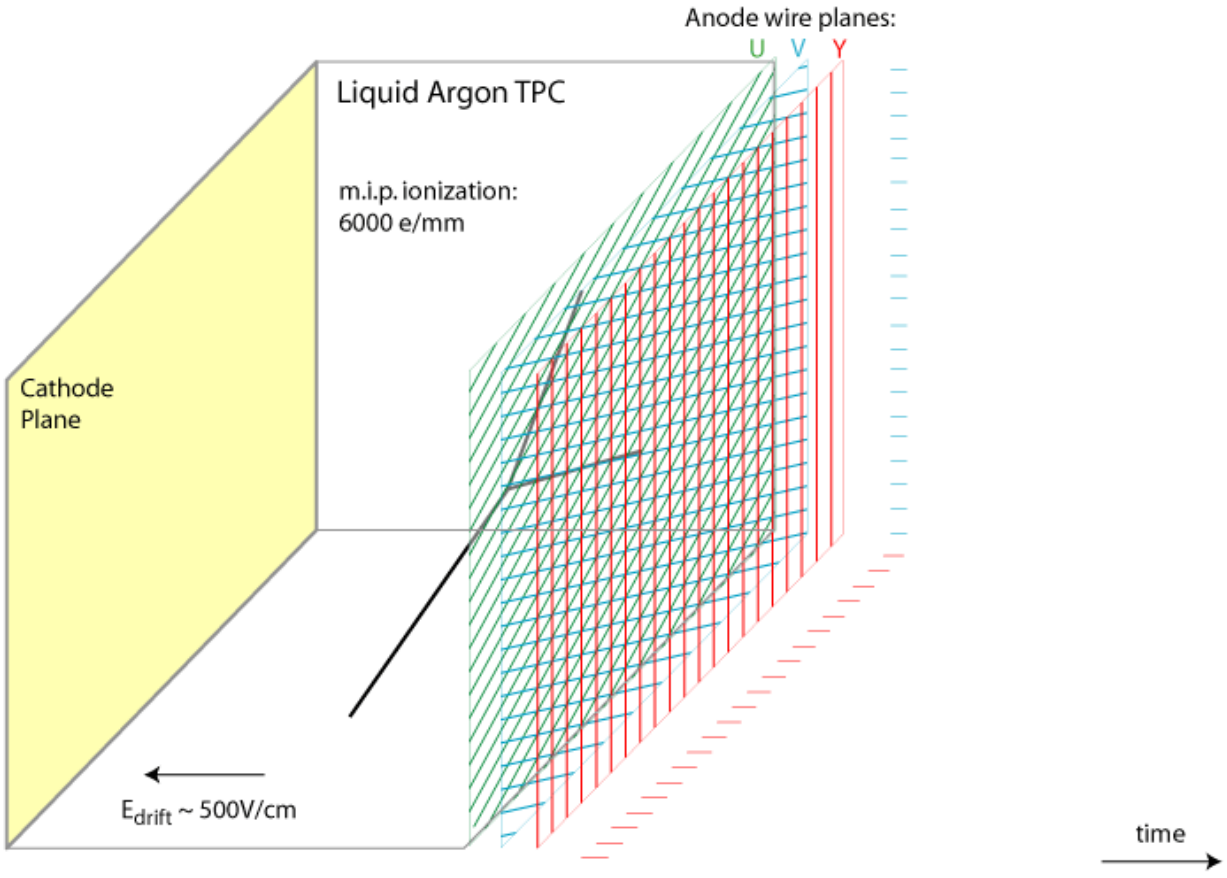
35-ton Cryostat

IHI construc. on

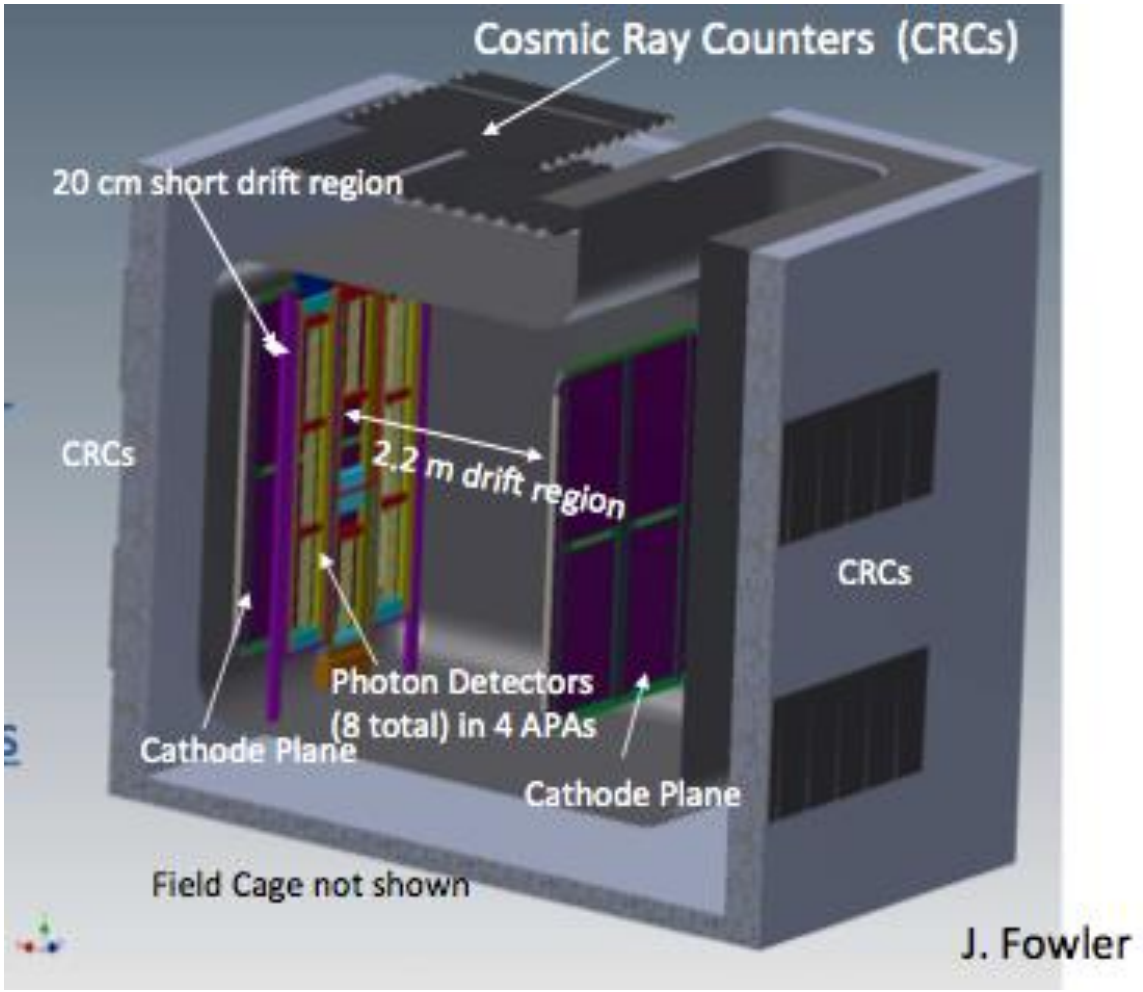


- Some issues:
  - Restrictive inner dimensions
  - All detector components need to enter through small manhole at top of cryostat
  - Rebar within concrete casing connected directly to building ground

LAr TPC Basics

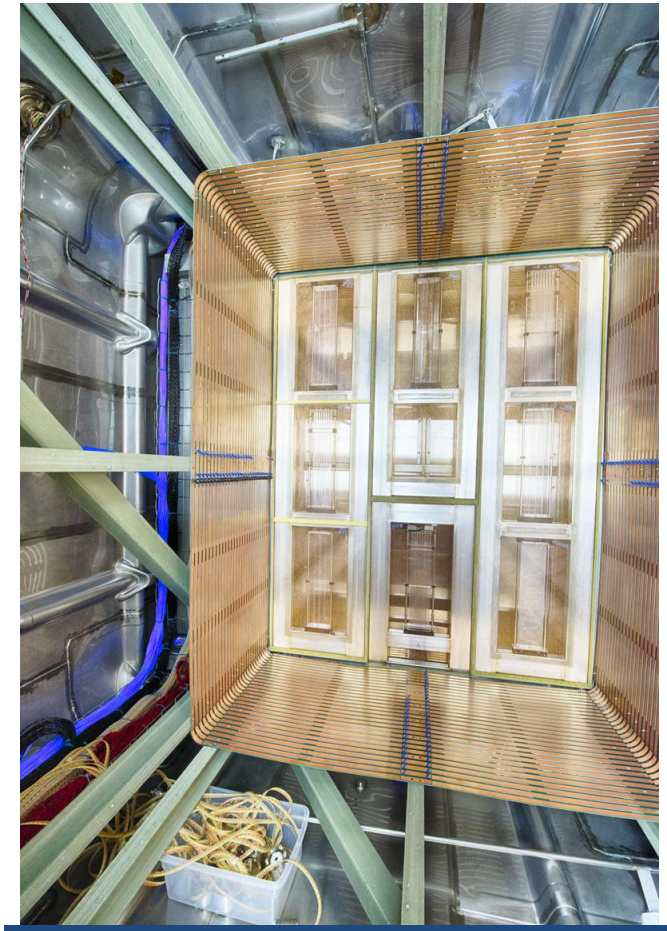


35-ton Detector



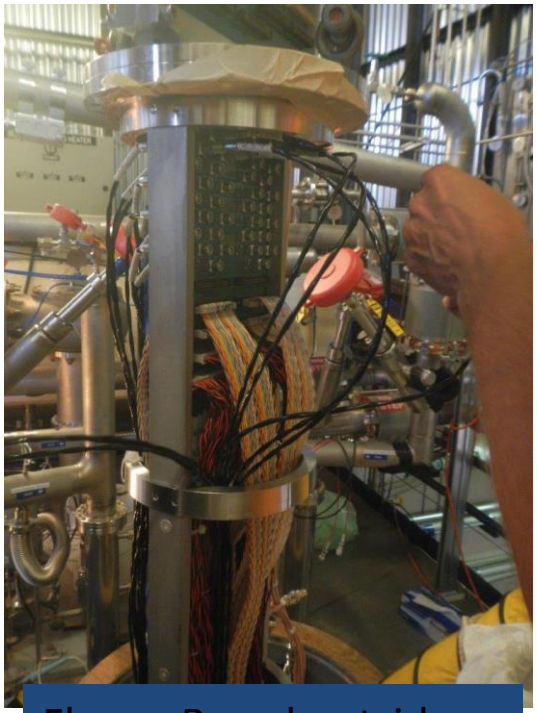
- Detector highlights:
  - Module Anode Plane Assemblies (APAs) with wrapped wires
  - Cold TPC electronics including digitization of the readout inside the cryostat
  - Photon detection using light-collecting bars
  - DAQ system with potential capability of un-triggered, continuous readout using zero suppression

35-ton Detector in Pictures



APAs and partially assembled Field Cage

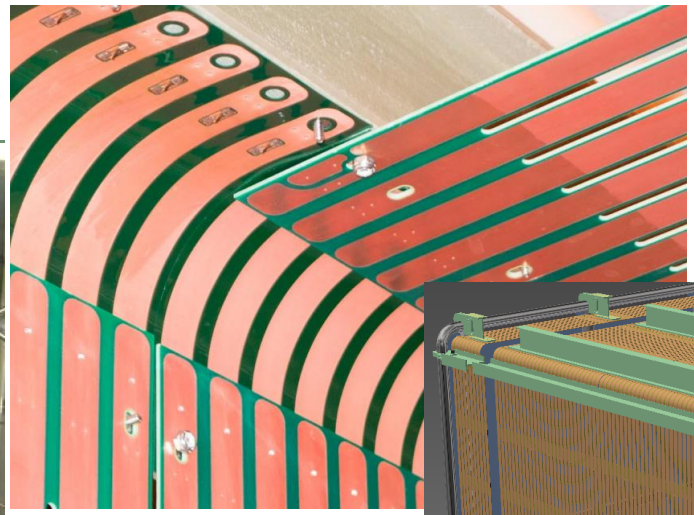
Cable Plant inside



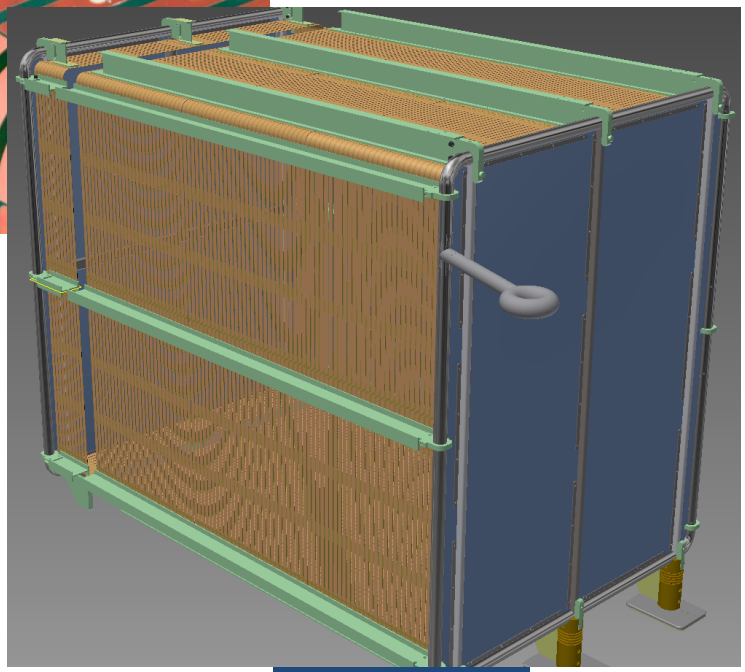
Flange Board outside

35-ton Detector in Pictures

Field Cage Components



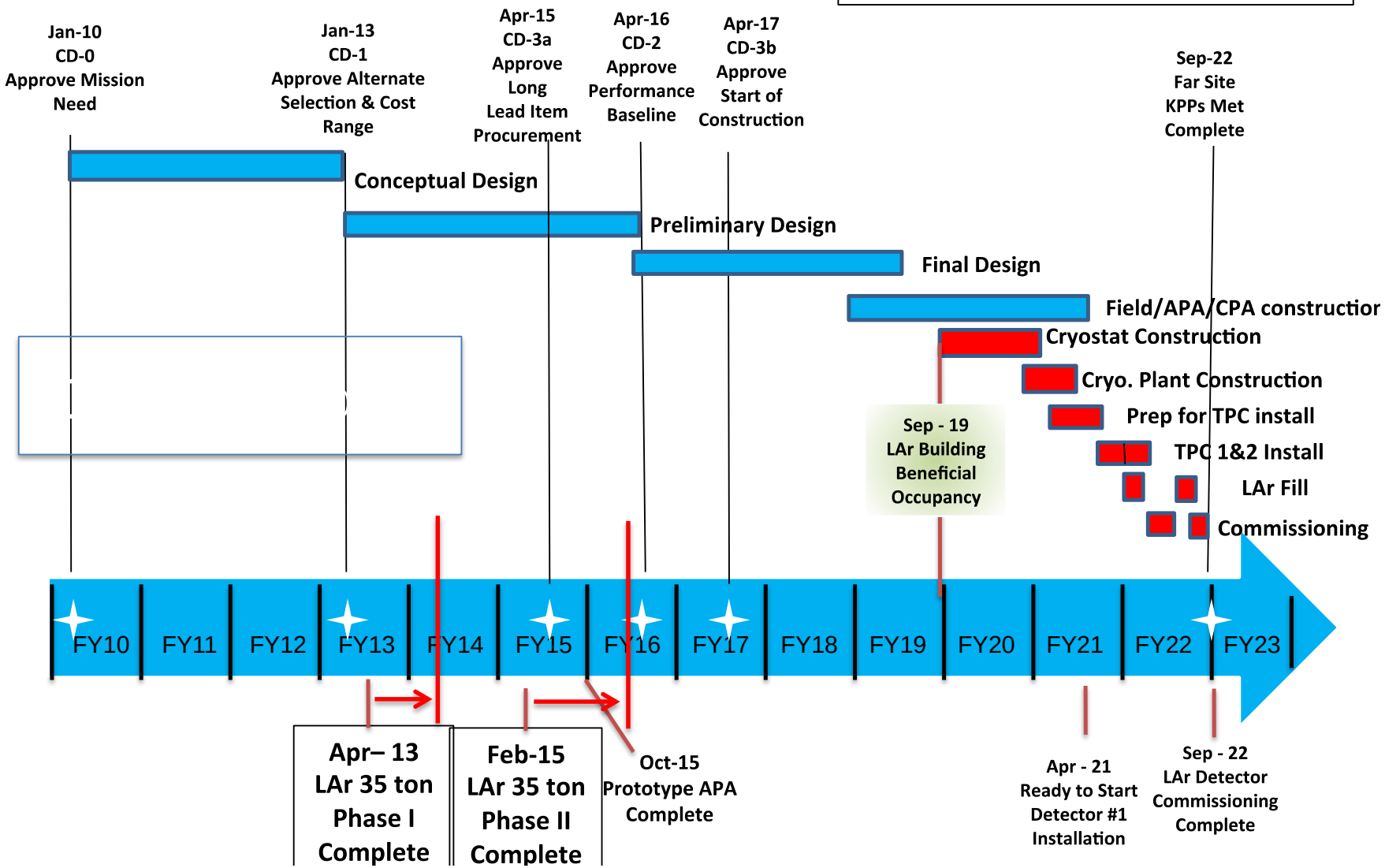
CPA and field cage components comprising short drift volume



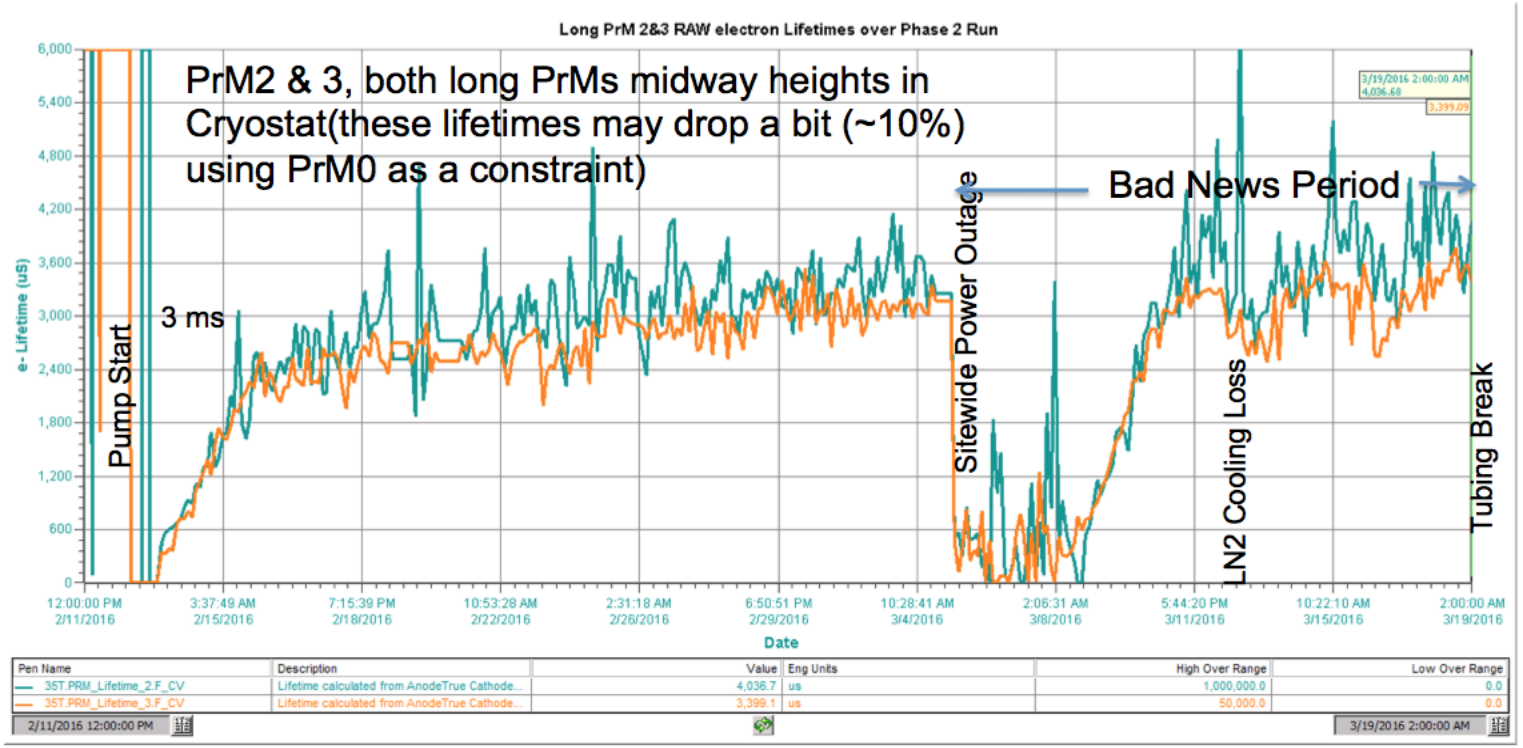
Closed TPC

Schedule

Schedule shown at late 2012
CD-1 LBNE Review



Performance Summary - Cryogenics

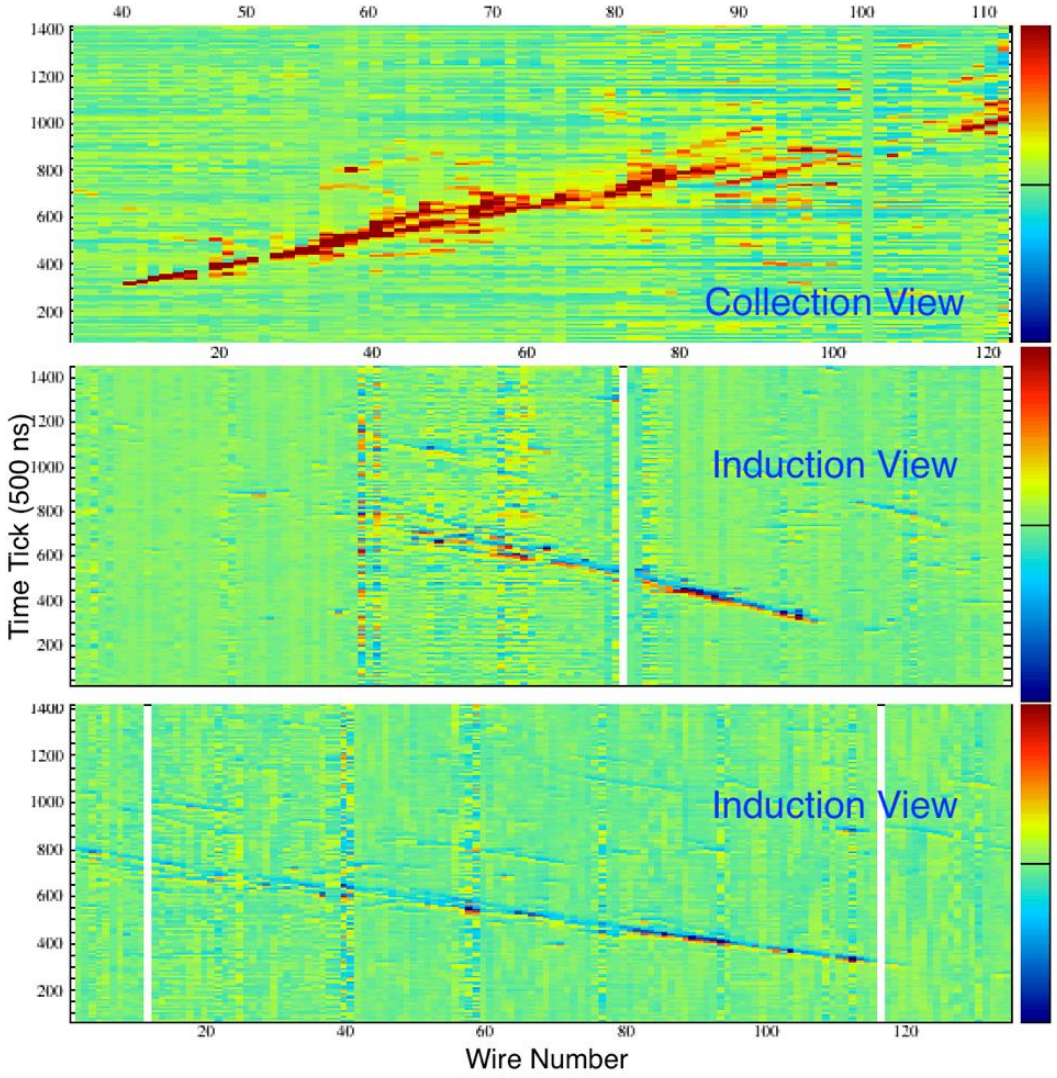


- Required 3ms lifetime obtained quickly (~weeks)
- Tubing break in late March lead to introduction of air into the systems and irreversible contamination of liquid argon

Performance Summary - TPC

- TPC held high voltage at 60 kV for several weeks (50% of nominal HV setting) in purified liquid argon
- Because of broken tube, did not have the opportunity to test TPC at full high voltage in purified liquid argon
- TPC did hold full high voltage (120 kV) in dirty liquid argon for several days after accident

Event Display

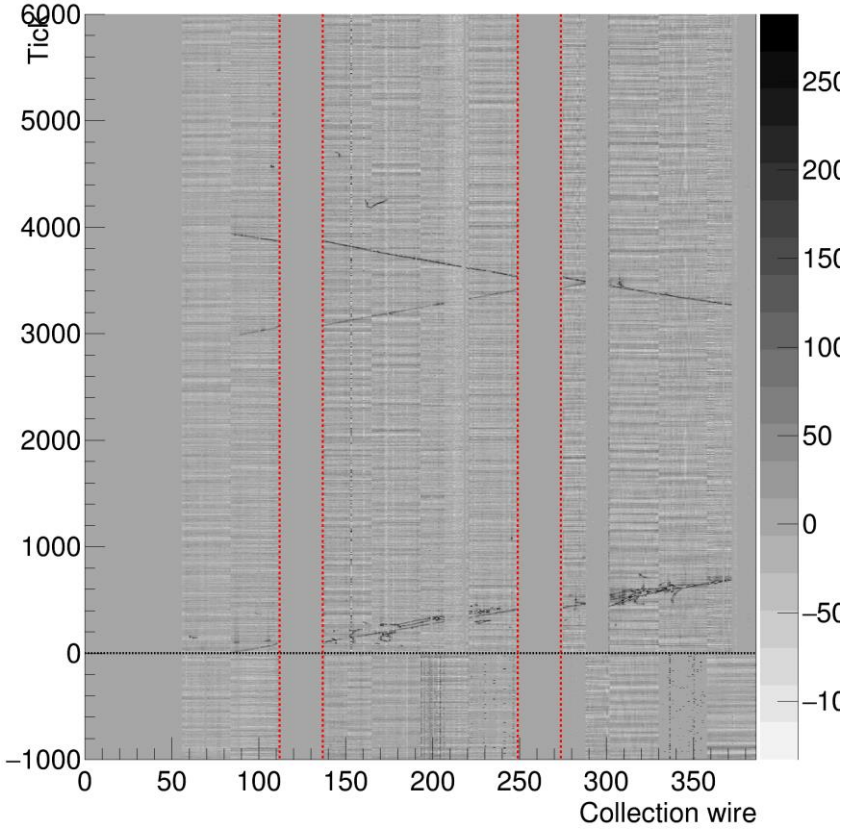


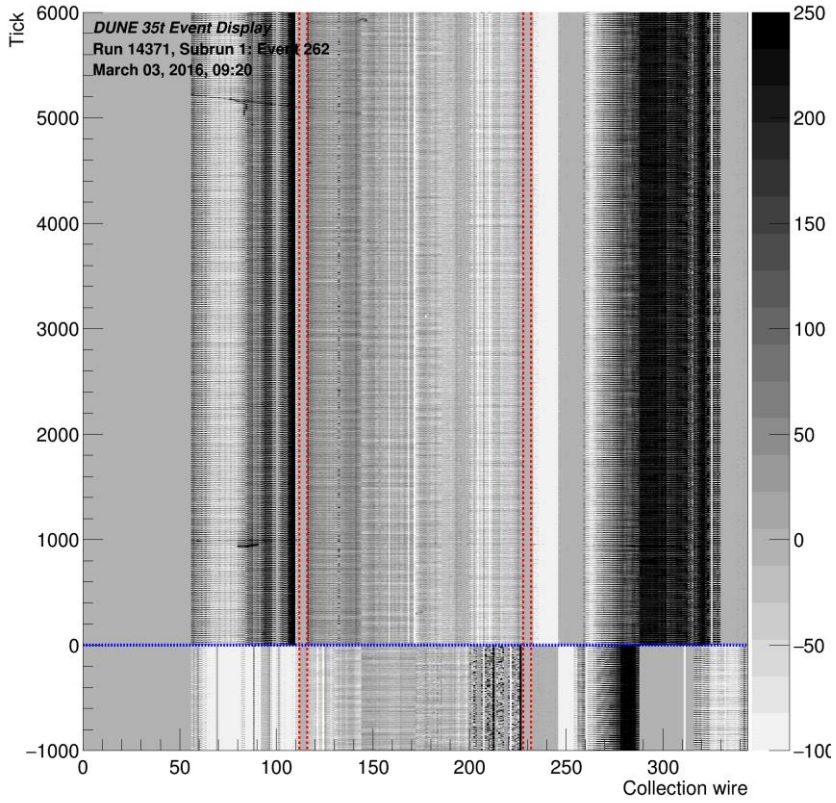
Coherent noise subtraction and mitigation of ADC ASIC "stuck code" issue required

Performance Summary – Cold Electronics

- "Stuck bit" issue for ADC ASIC chips – mechanism thought to be understood, new version of ADC ASIC to be submitted within next few weeks
- Large number of bad channels (~10%), on order of half appearing during cool down – need to perform post-mortem of boards to better understand failures
- Baseline noise level ~4-5 times higher than expected – at least some portion of this is attributed to inadequate power filtering (also observed in MicroBooNE)
- Periodically, TPC was observed to enter "high-noise" or "collective oscillation" state during which it was impossible to collect data – mechanism not yet completely understood

Performance Summary – Cold Electronics





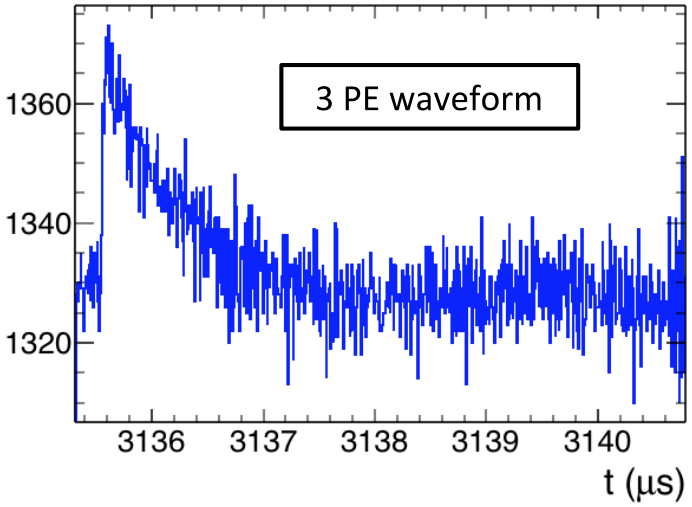
"Normal" Noise State

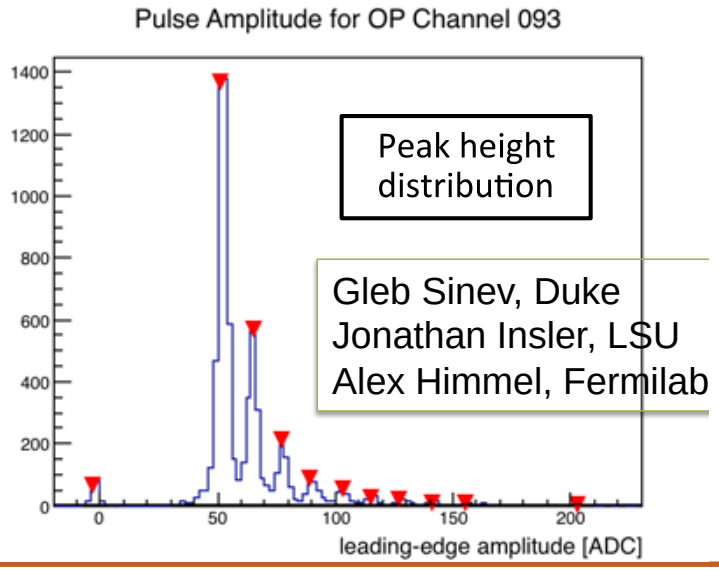
Very High Noise State

Fermilab DUNE

Performance Summary – Photon Detectors

- Photon detector was also somewhat noisier than expected
  - Readout threshold set at 2.2 PE or 3.3 PE as opposed to desired 0.5 PE
  - Many channels turned off or suppressed due to excess noise
- Indications that at least some of the observed noise is originating from TPC





Gleb Sinev, Duke
Jonathan Insler, LSU
Alex Himmel, Fermilab

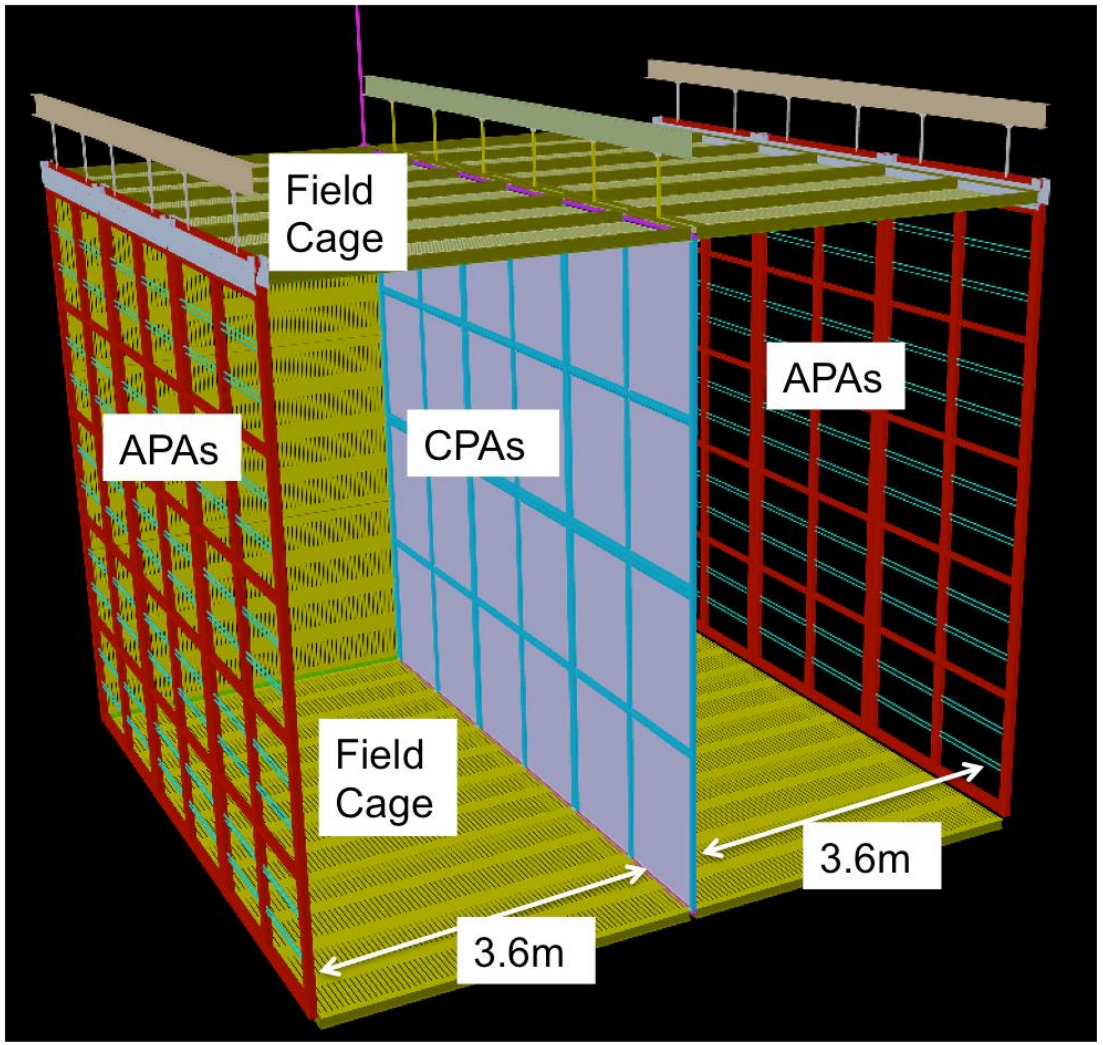
Performance Summary - DAQ

- Successes
  - 1 Gb/s cold->warm readout of cold electronics into back-end DAQ
  - Demonstrated continuous readout
  - Wrote ~500K cosmic ray events to tape
- Issues
  - Disk-writing bottleneck of ~60 Mbytes/second
  - Limited to ~1Hz event writing rate
  - Could not implement zero suppression due to high noise

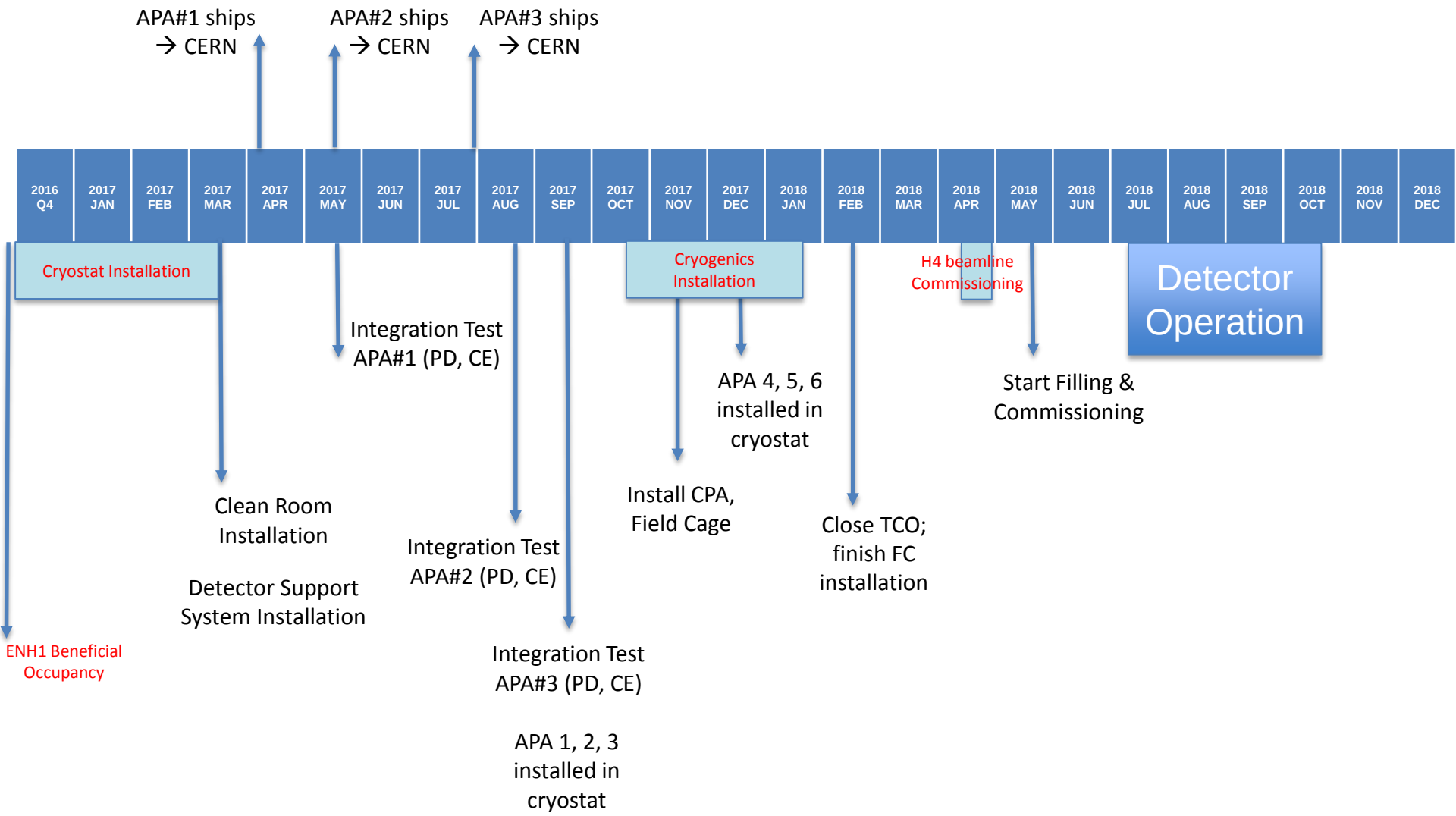
Next Steps - ProtoDUNE

- Plan to operate a much larger prototype detector in test beam at CERN in 2018 (prior to LHC LS2)
- ProtoDUNE will be constructed using full-scale prototype detector components (6/150 of components needed to build the 10 k-ton far detector at SURF)
- On a short time scale, need to mitigate the issues observed in the 35-ton detector

ProtoDUNE Detector



ProtoDUNE Schedule



Management Areas of Focus

- Identifying the team who will be on the ground at CERN to integrate, install, commission, and operate the experiment
- Developing the QA/QC plans needed to ensure detector performance
- Developing plans for integration testing in both 2016 using prototype components and at CERN in 2017 with the final components prior to their installation
- More details in tomorrow's presentation

35-ton Summary

- We learned a lot
- Some successes
  - Required liquid argon purity obtained within roughly one week of turning on filtration system
  - TPC held high voltage and was able to record a large sample of cosmic ray muons
- Some significant issues
  - Electronics noise levels about 4-5 times higher than expected along with periods of much larger noise levels
  - Failure of cryogenics components led to several issues and controls system was inadequate for preventing contamination of liquid argon