Photon Detector Calibration/Monitoring

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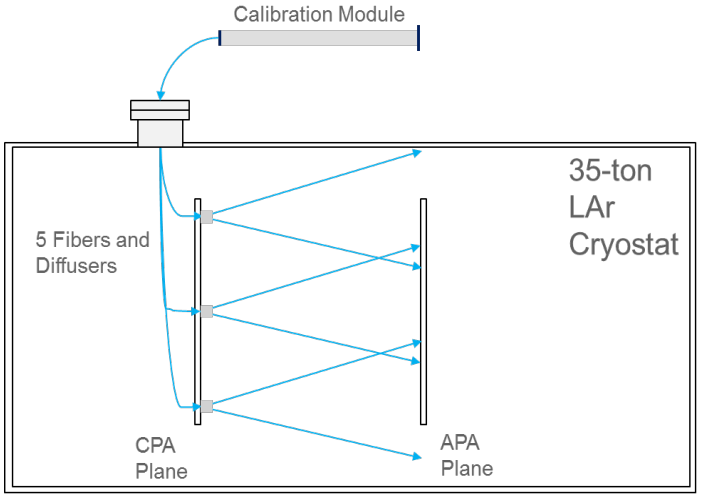
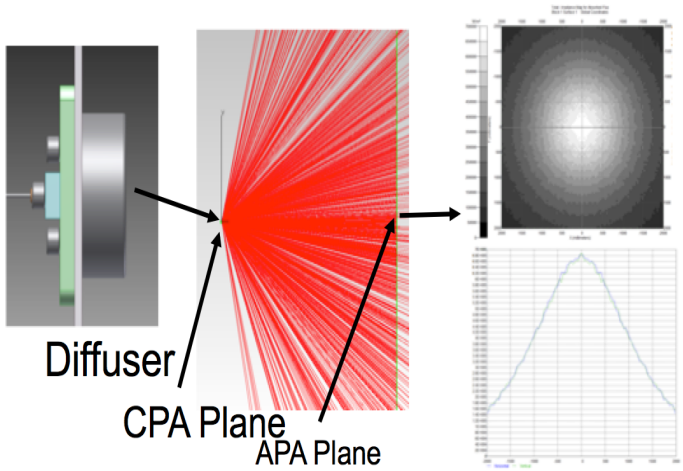
Motivation for UV-light Calibration System

- Verify the photon detector gain and timing resolution
- Monitor stability and response over time
- Use the UV calibration/monitoring system as the detector commissioning tool: before closing the cryostat, in the cool-down phase, and when filled with LAr- to test the photon detectors
- Make use of it for a quick reliable test of PDS when a change is made
  => Don't have to wait for cosmic muon coverage of entire detector





Optical Simulation of Single Diffuser at APA distance

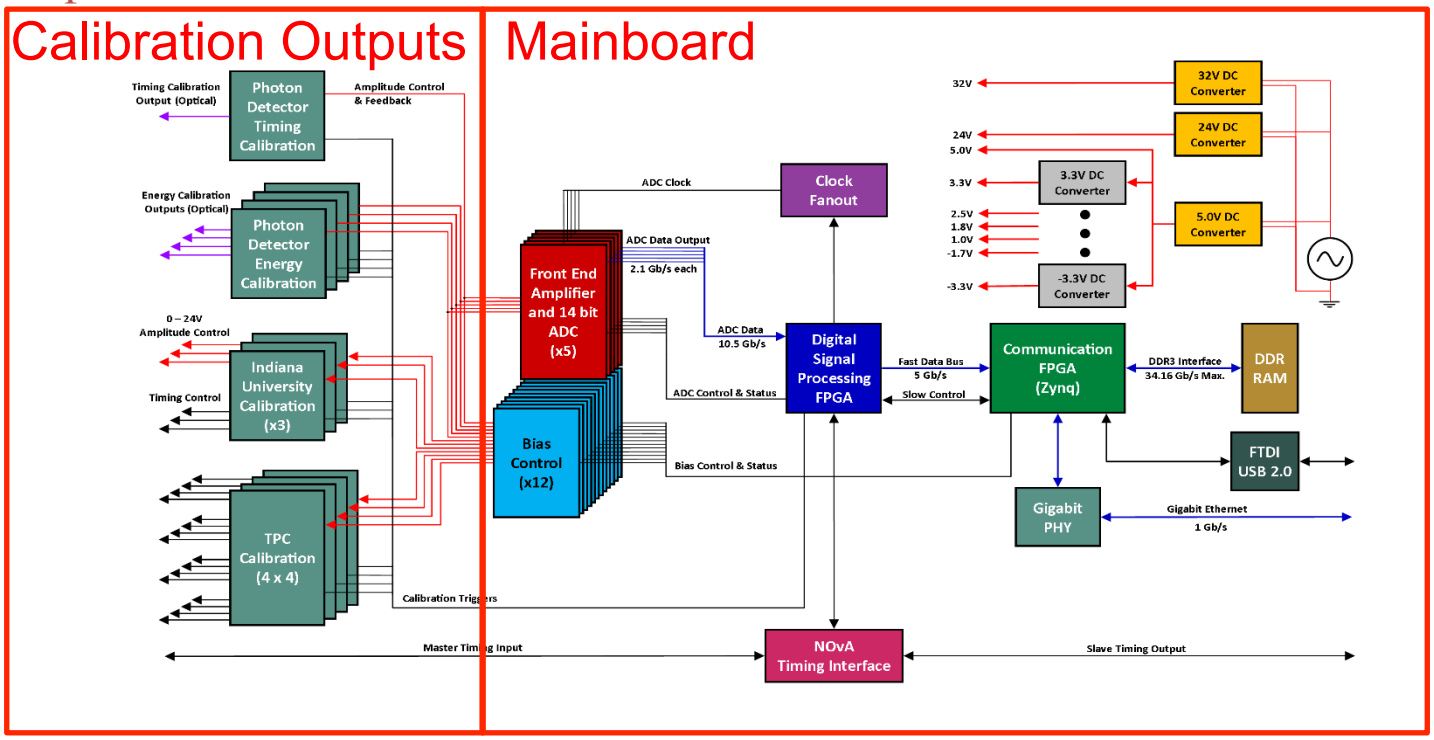
In DUNE 35t performance of various photon detectors was tested

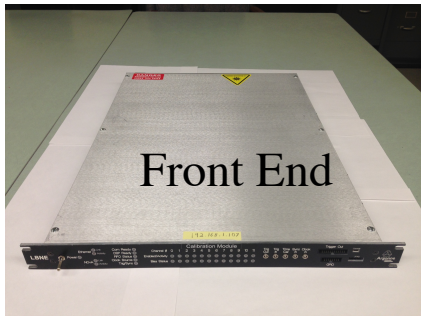
=> Plan to use ProtoDUNE to optimize the requirement for DUNE PDS calibration system

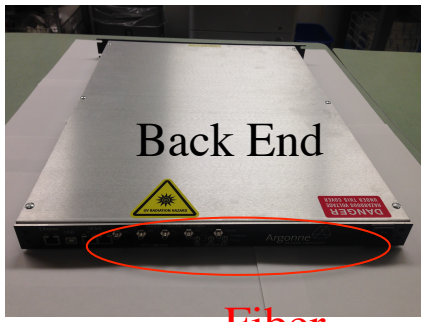
See also Ranjan's talk:
https://indico.fnal.gov/getFile.py/access?contribId=3&resId=0&materialId=slides&confId=15243

DUNE Calibration Module

- Utilizes the SSP mainboard as a controller
  -Ethernet communication, timing control, internal/external triggering, etc.
- Light source controllable in terms of pulse height, pulse width, pulse repetition rate, double pulses.







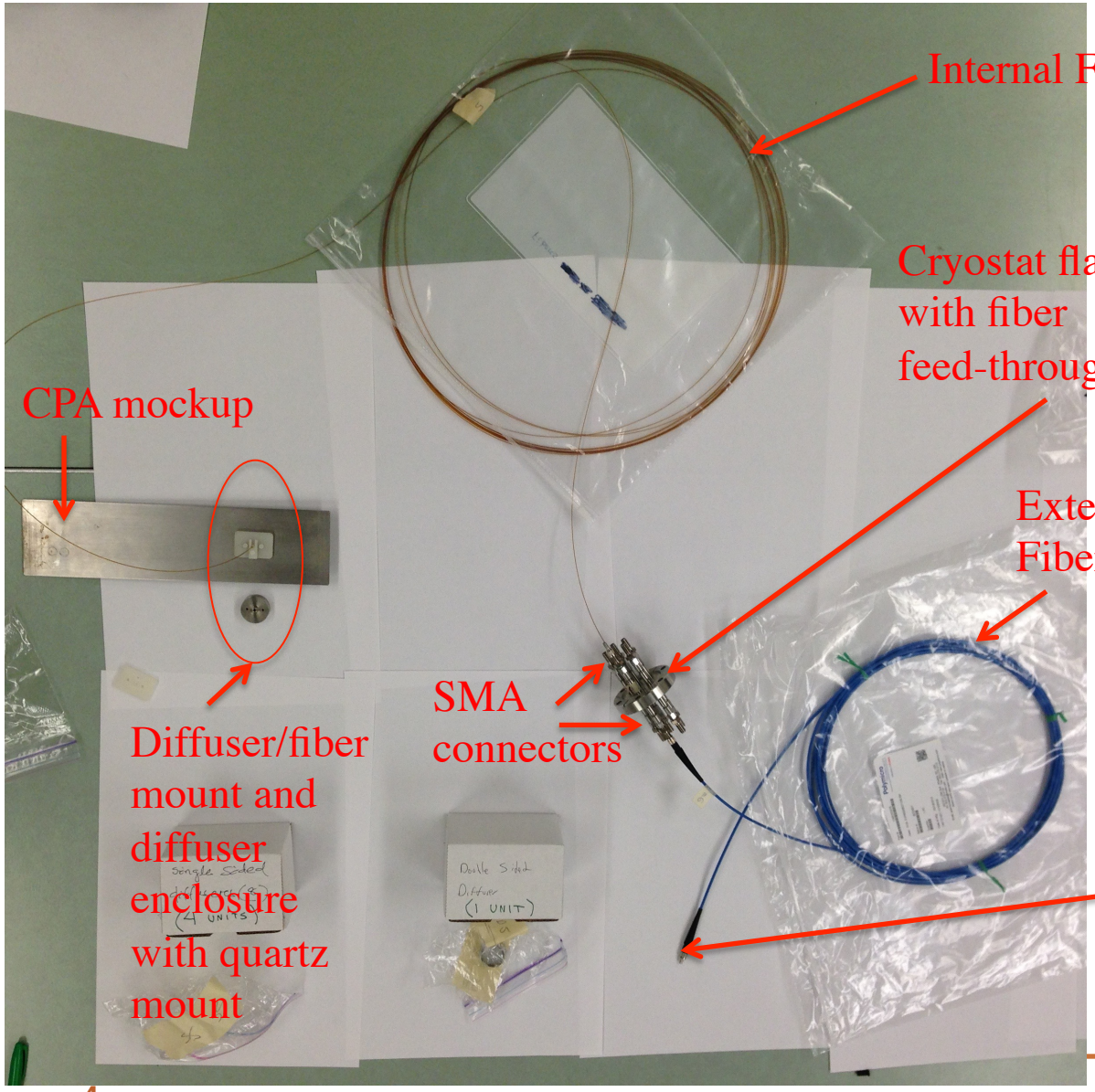
Fiber SMAs

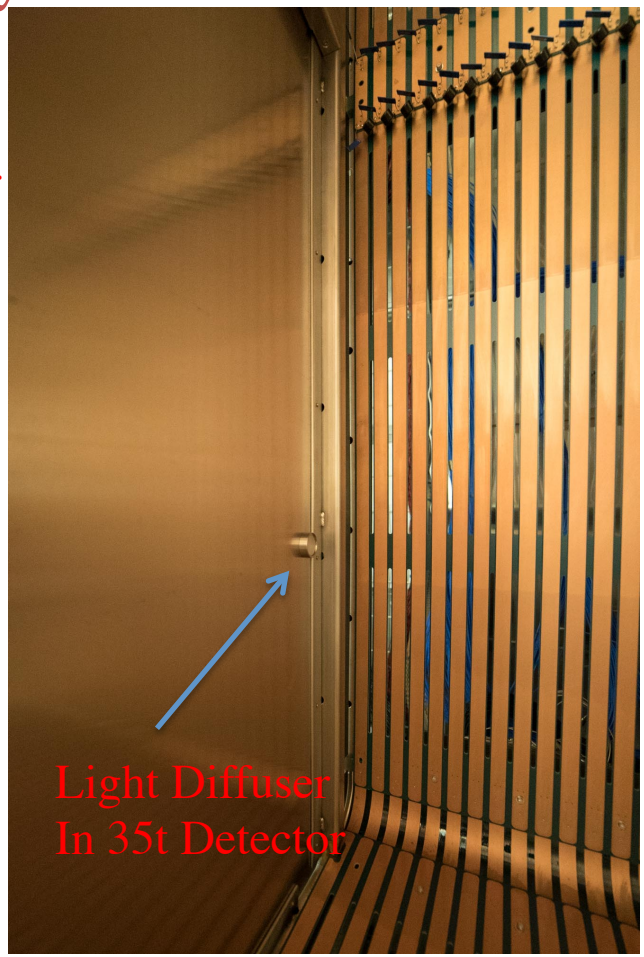
(also see the Backups)

Calibration Back-Panel

Components of the PD UV Calibration System

- Components installed with 35t DUNE prototype





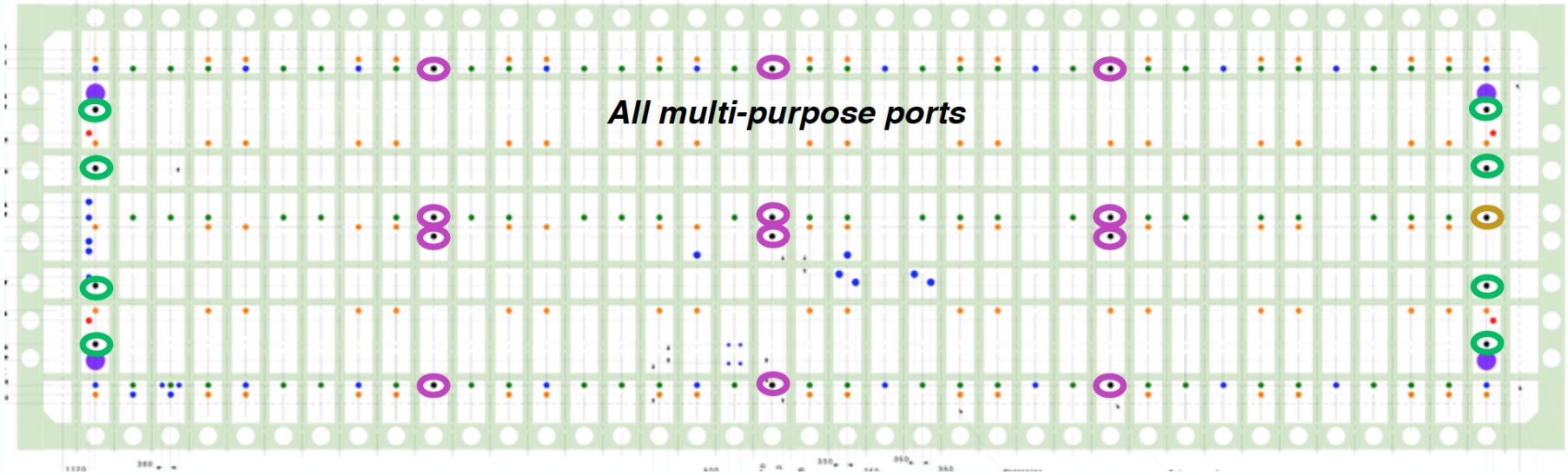
DUNE FD Cryostat Penetrations

Slide from Sowjanya's DUNE Collaboration Meeting talk:
https://indico.fnal.gov/event/14581/session/0/contribution/10/material/slides/0.pdf

= Calibration FTs

= Calibration FT (outside the FC)

= Cryogenic Instrumentation FT



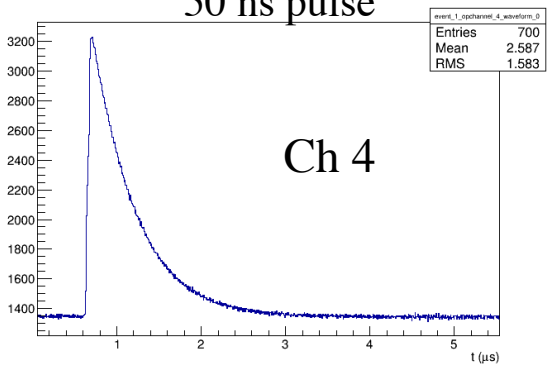
Pos.	Diameter [mm]	Quantity	Description
1	Ø250	100	Support
2	Ø250	75	Cable
3	Ø250	4	High voltage
4	Ø250	21	Instrumentation
5	Ø800	4	Manholes

Laser FTs (Magenta & Green) every 14 m or so. 10 m laser range demonstrated in MicroBooNE.

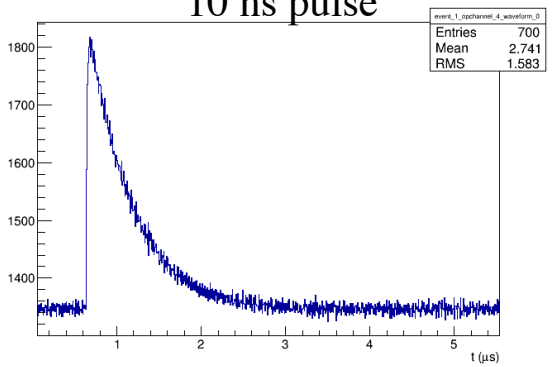
35-ton Experience

- Standard Channels

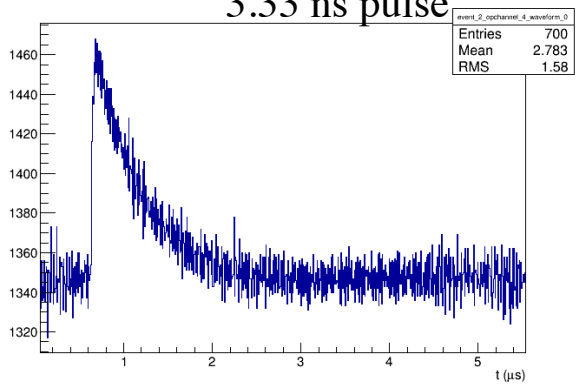
50 ns pulse

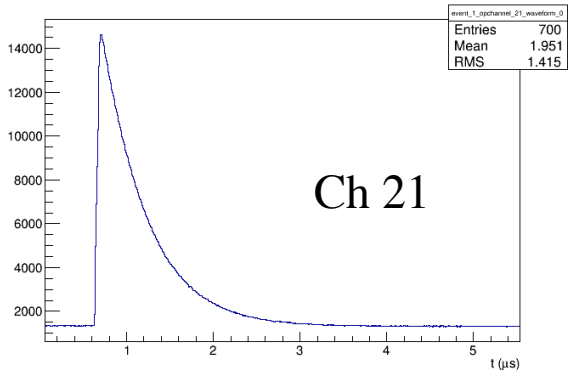


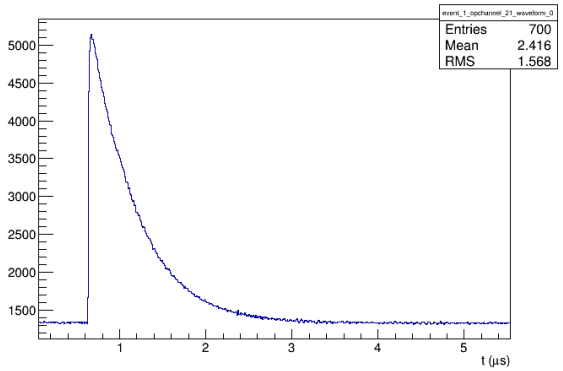
10 ns pulse

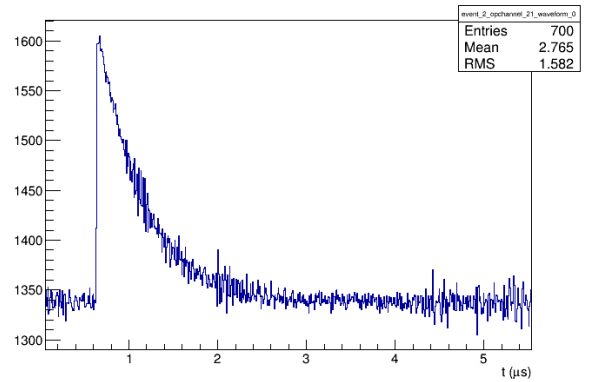


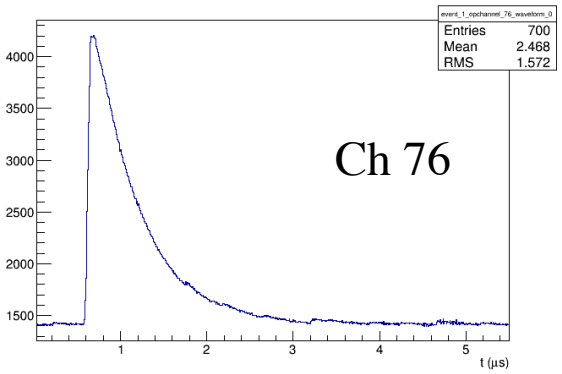
3.33 ns pulse

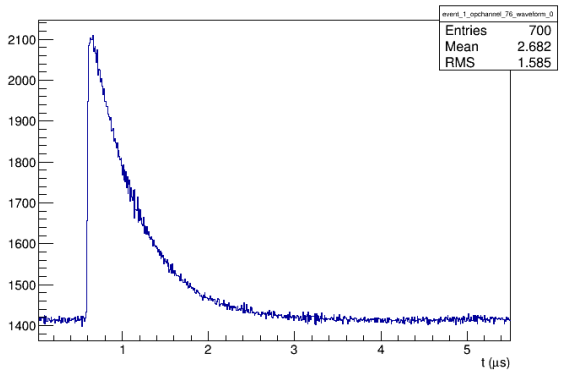


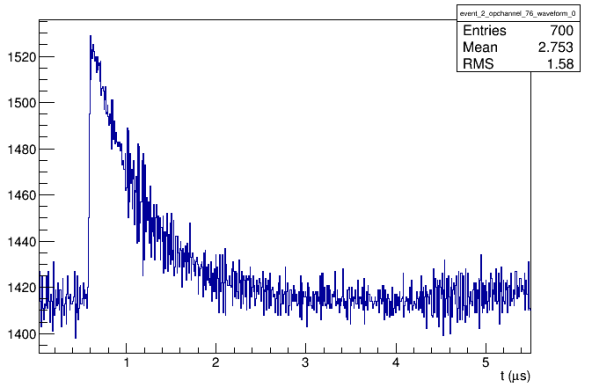






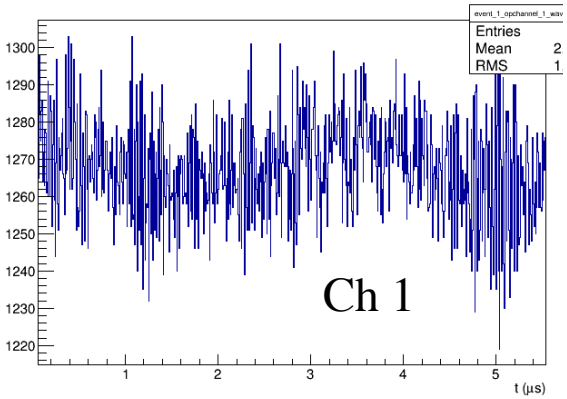


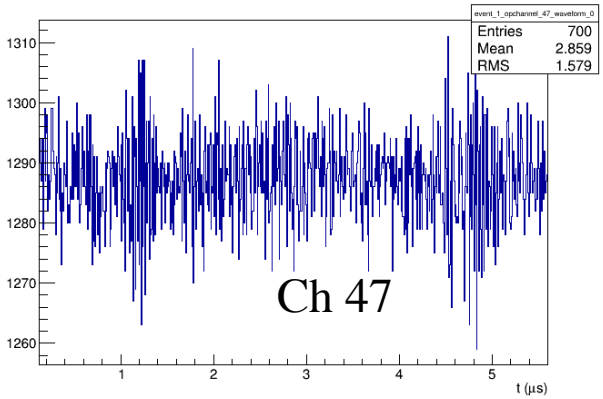




35-ton Experience

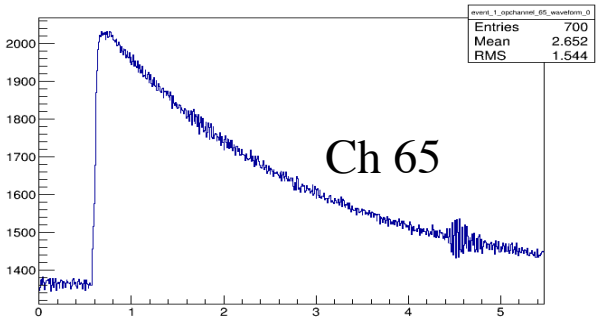
- Malfunctioning Channels

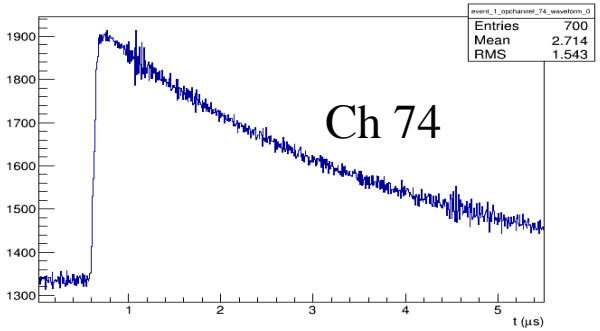




Ch 36

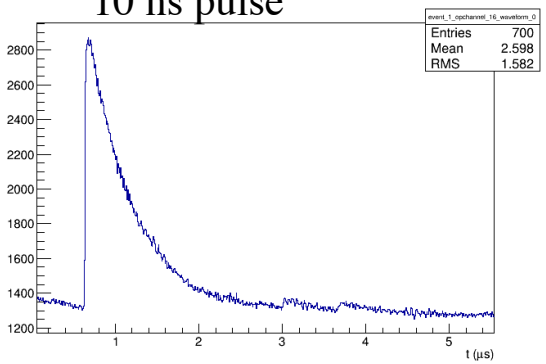
- "Slow" PD Channels



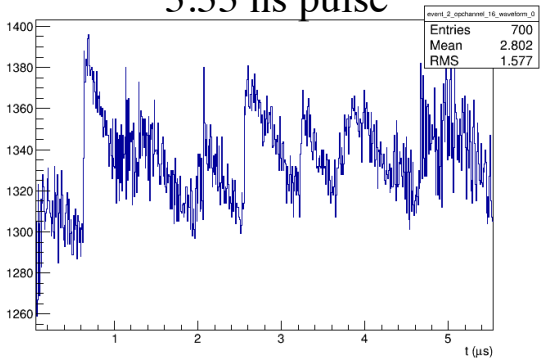


- Channels with p.e.-like noise

10 ns pulse

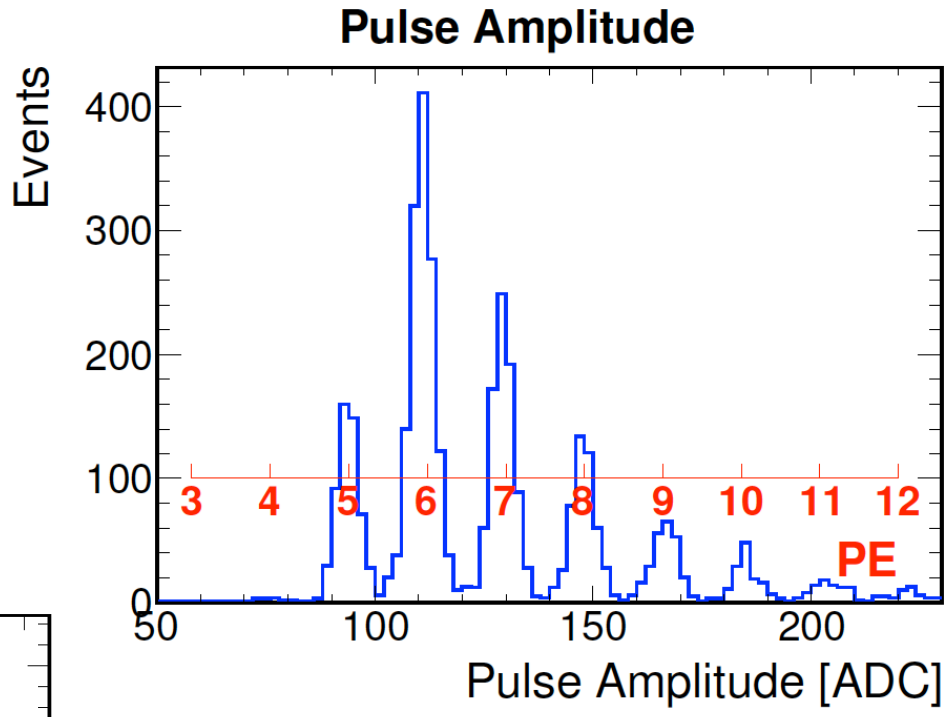


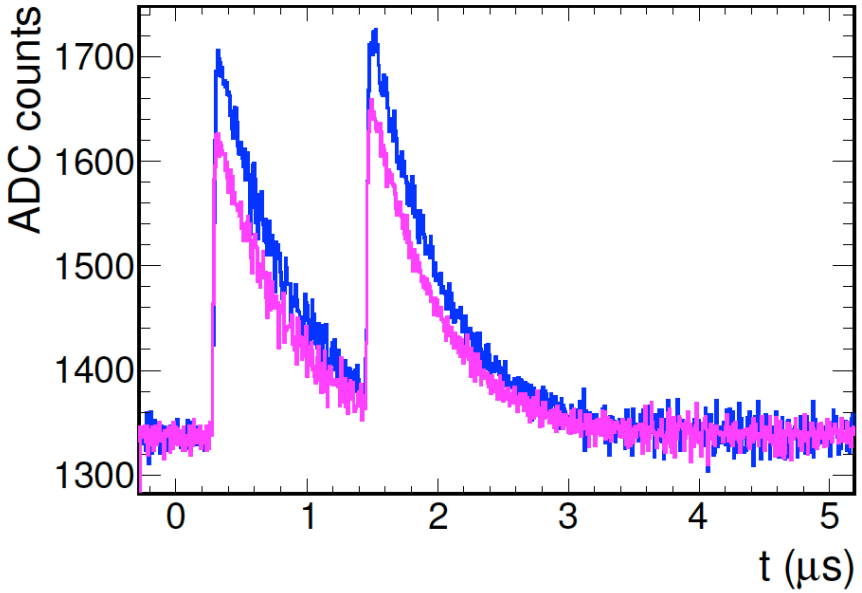
3.33 ns pulse

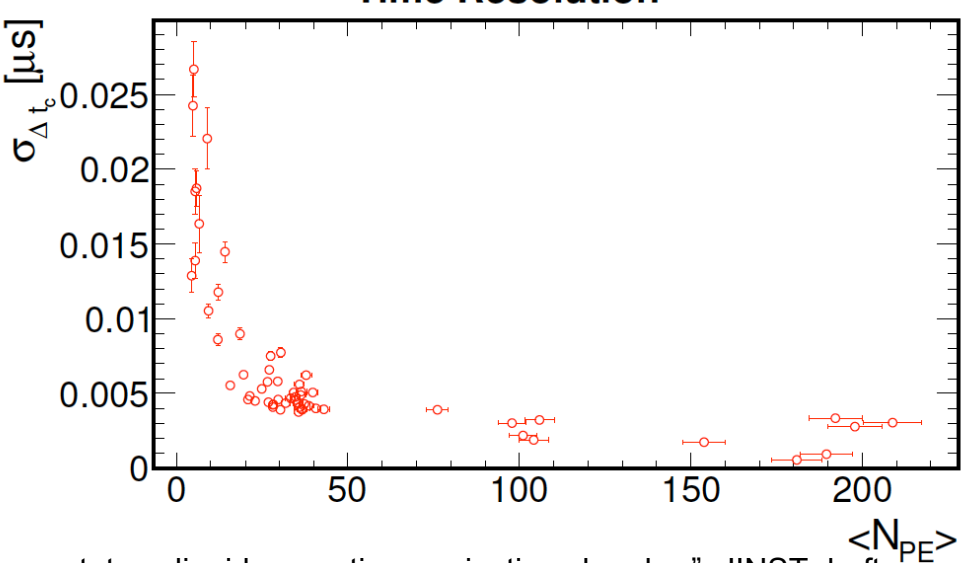


35-ton Experience

-Use of PDS Calibration System



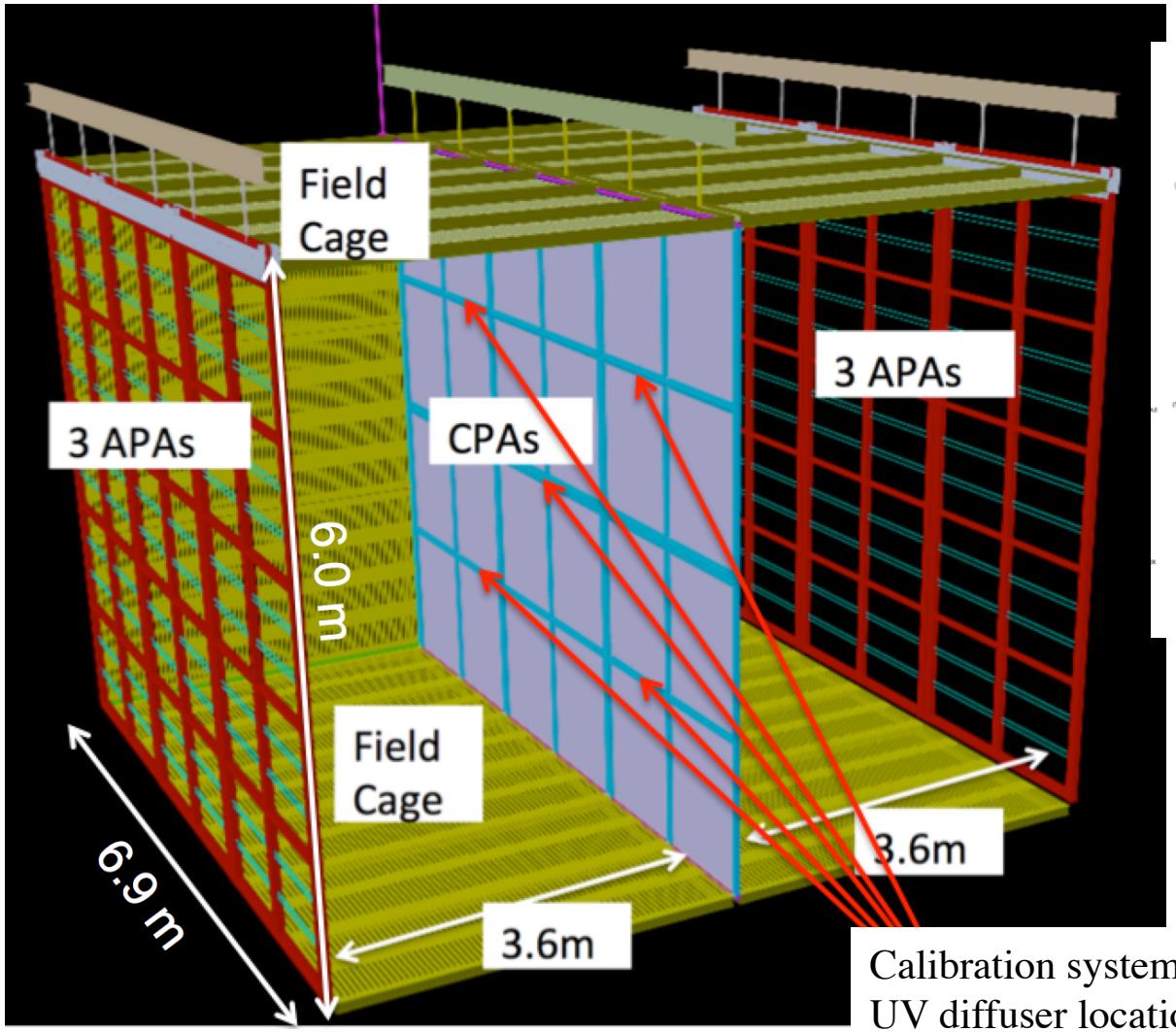


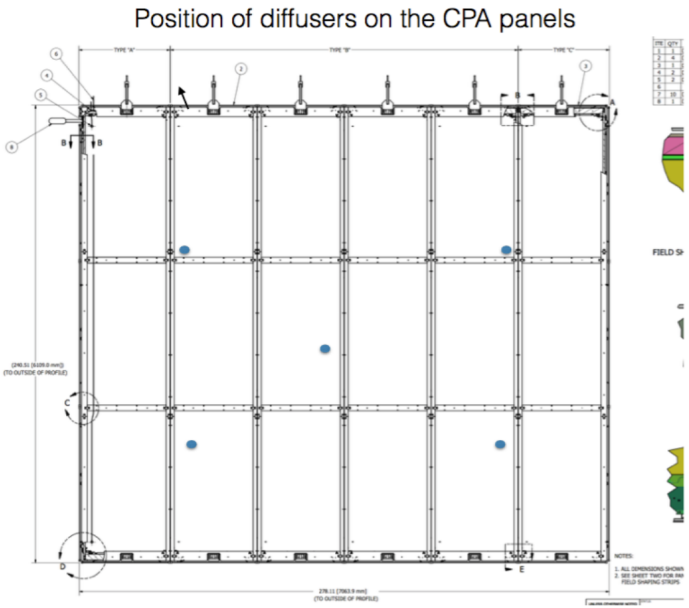


From “Photon detector system performance in the DUNE 35-ton prototype liquid argon time projection chamber”, JINST draft.

ProtoDUNE-SP Monitoring System

- Currently under fabrication for ProtoDUNE-SP

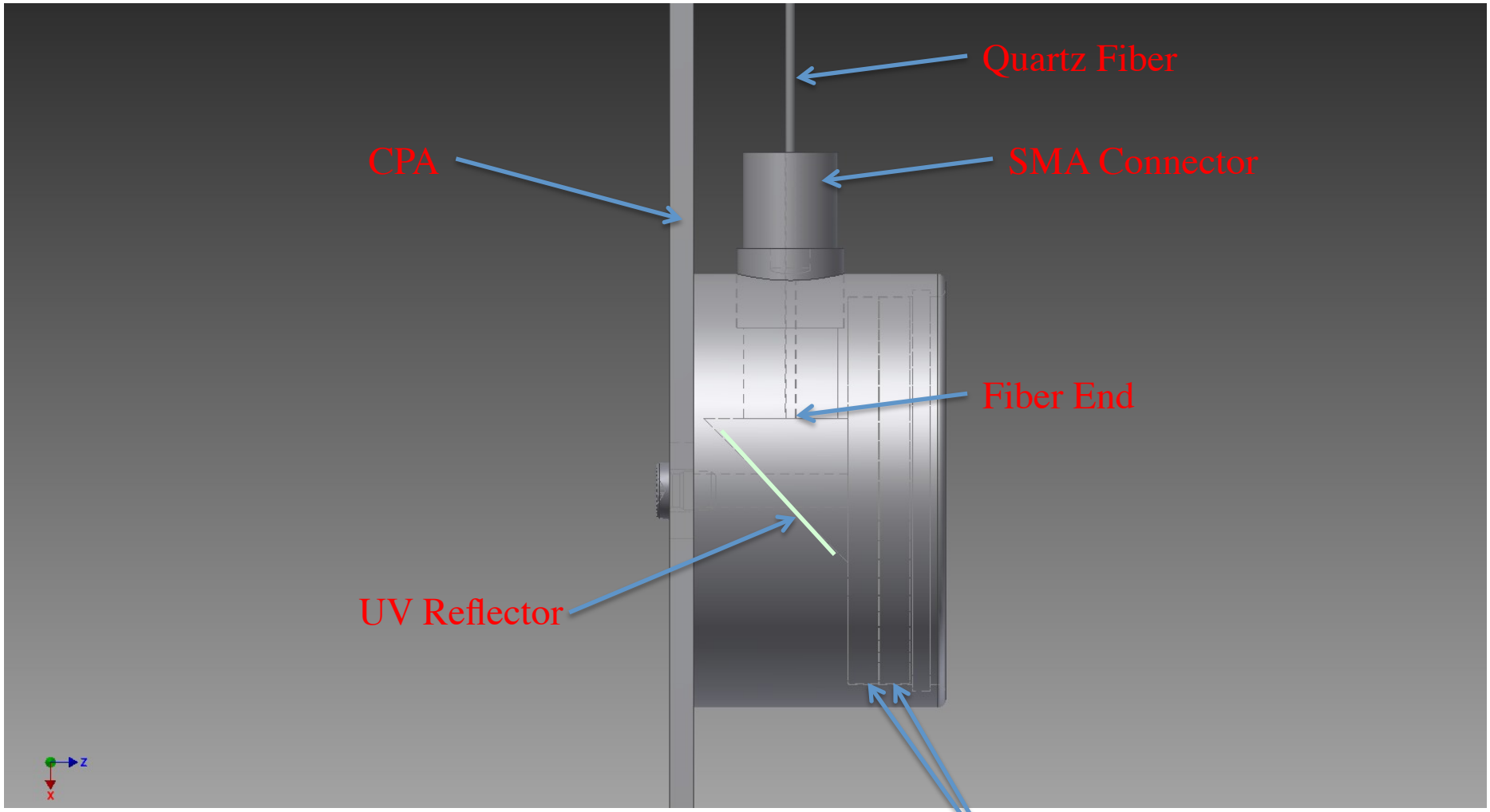




Calibration system
UV diffuser locations
At protoDUNE CPA

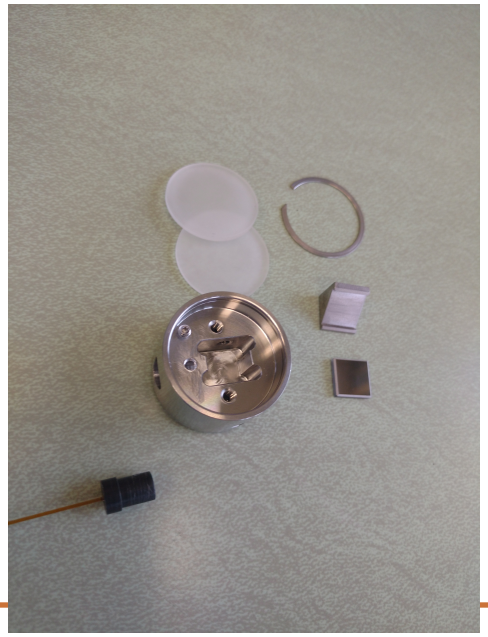
ProtoDUNE-SP Monitoring System

- Diffuser Design for ProtoDUNE's CPA

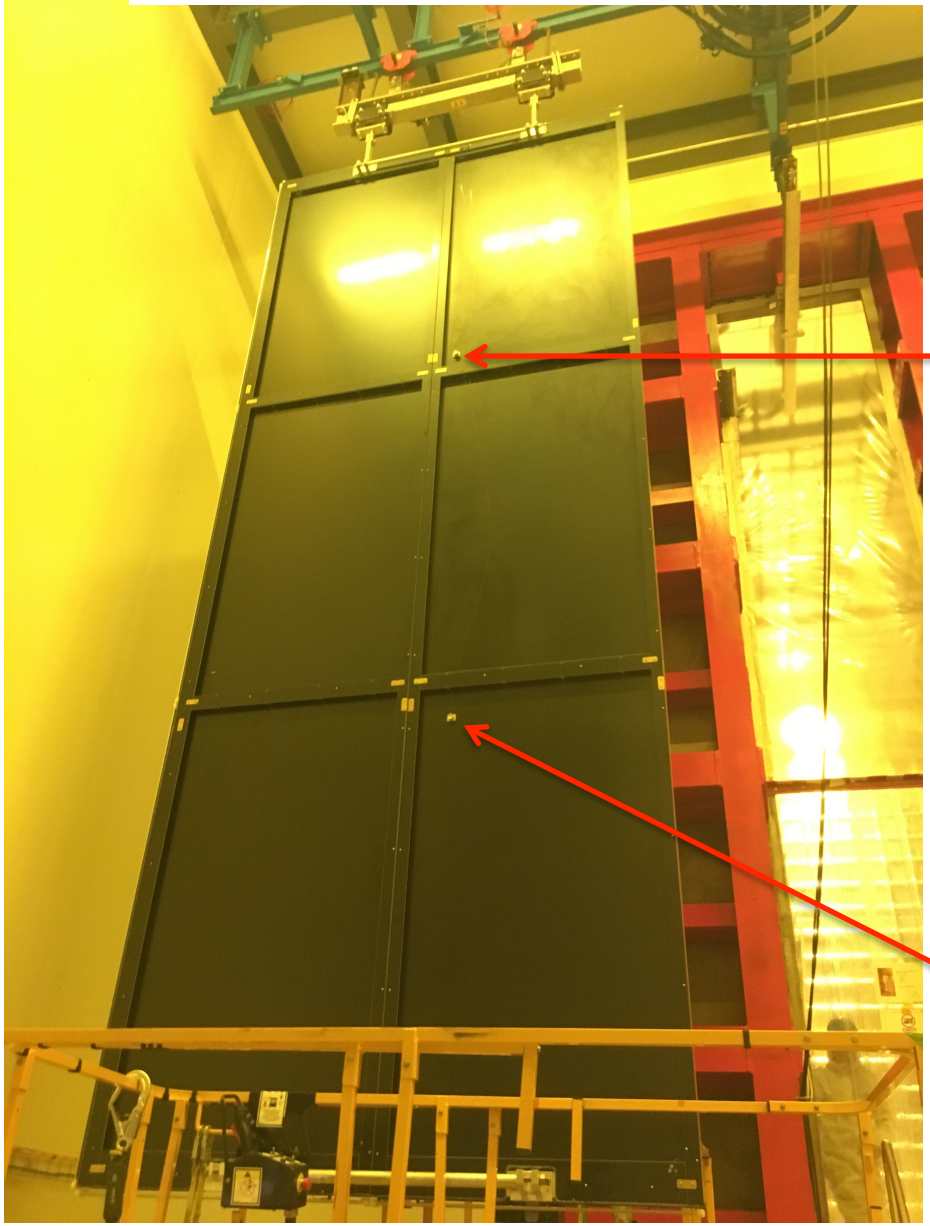


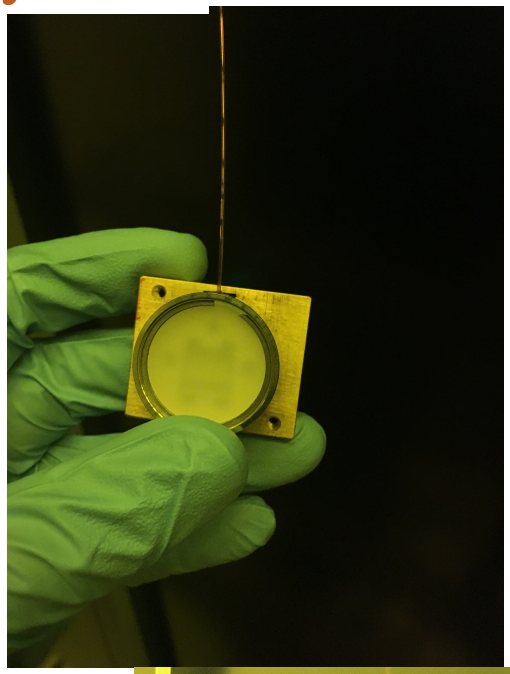
Diffuser Side View, based on older 3D model

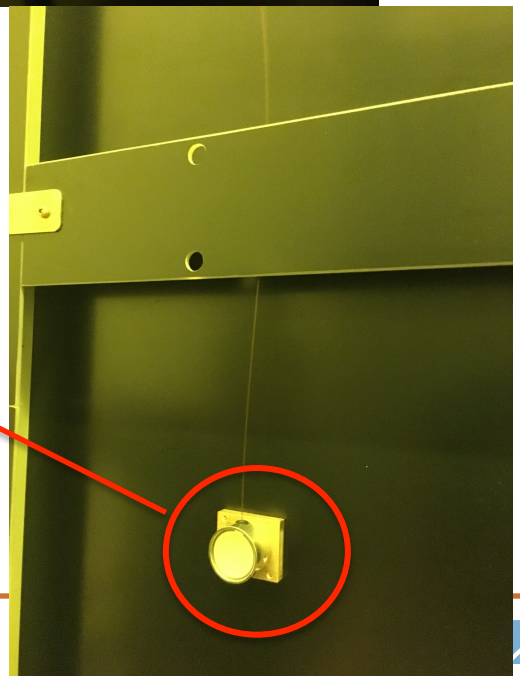
ProtoDUNE-SP Monitoring System



ProtoDUNE-SP Monitoring System







Absolute Calibration?

- The UV-light based Calibration System described above is useful for gain/timing calibration and for monitoring a health of PDS
  -Does not provide “physics” calibration

- How about absolute calibration: MeV to ADC Charge (or $N_{photons}$ to ADC Charge)
  => needed for physics

  -Radioactive Sources (Juergen, Jasaon, Bob, …))
  -Calibration with Cosmics (Tom, Josh, …)

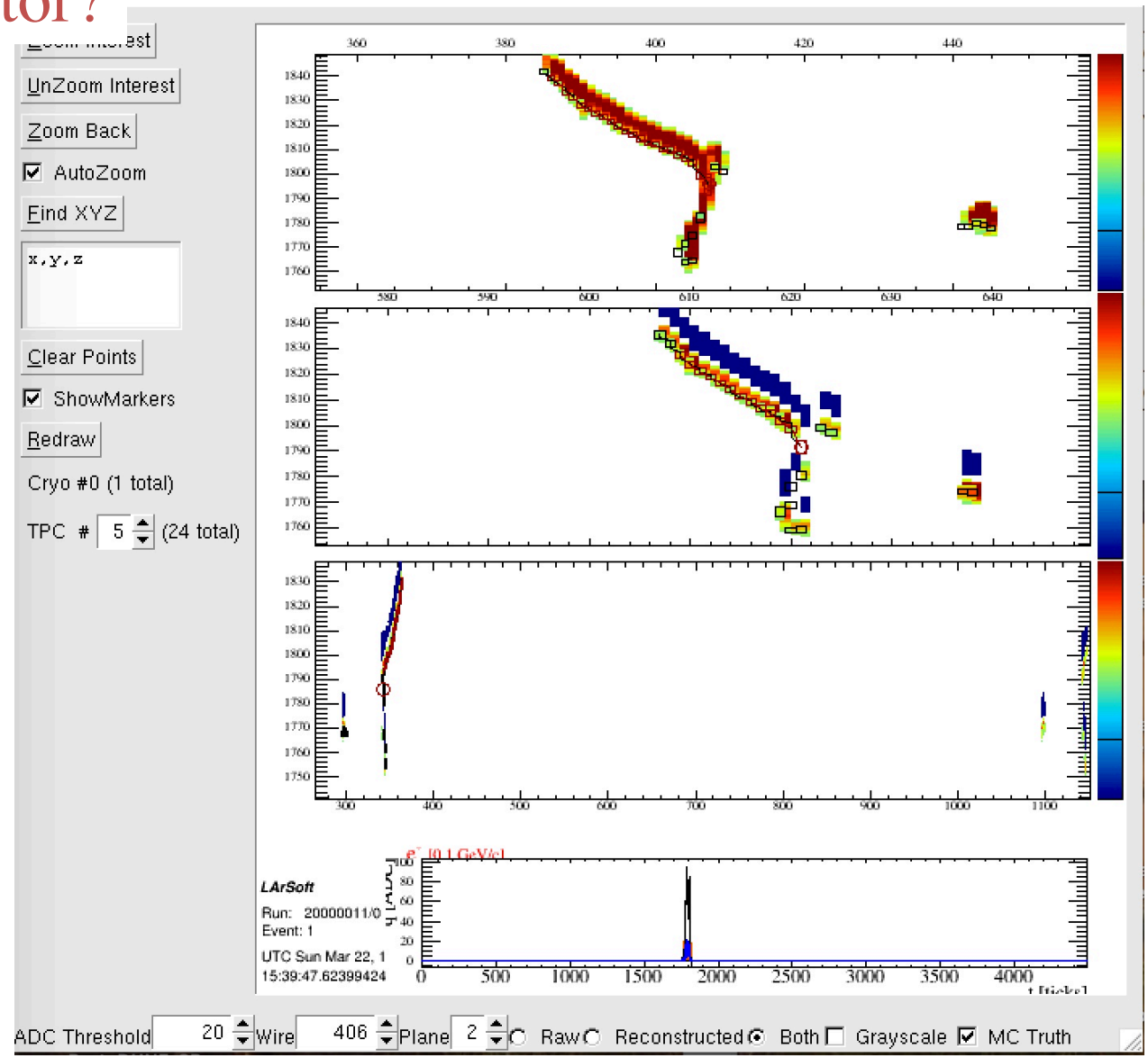
  -Electron Accelerator?

Electron Accelerator?

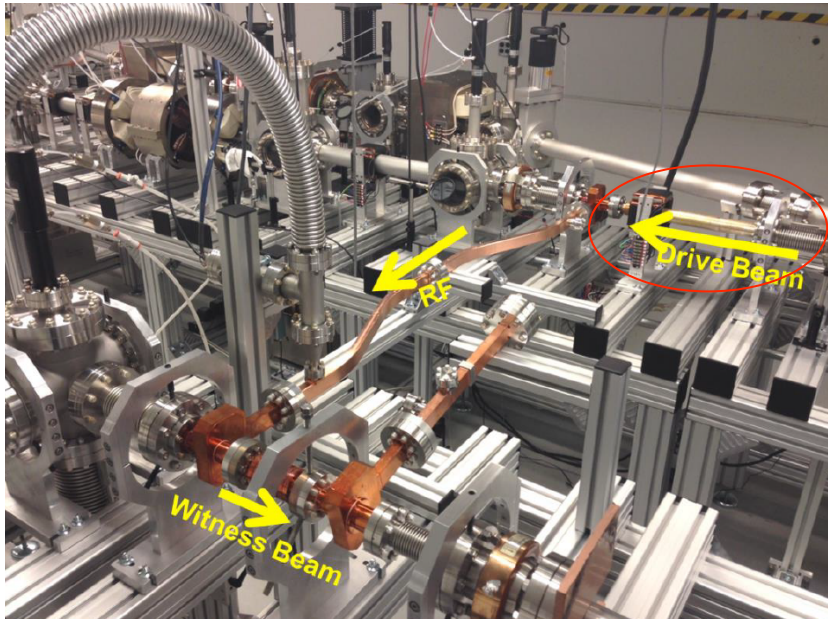
- Exploratory work on small electron accelerator in ~(0 – 70) MeV range.

  -Example of 70 MeV e^- in DUNE FD

- Useful for both TPC and photon-system physics calibration

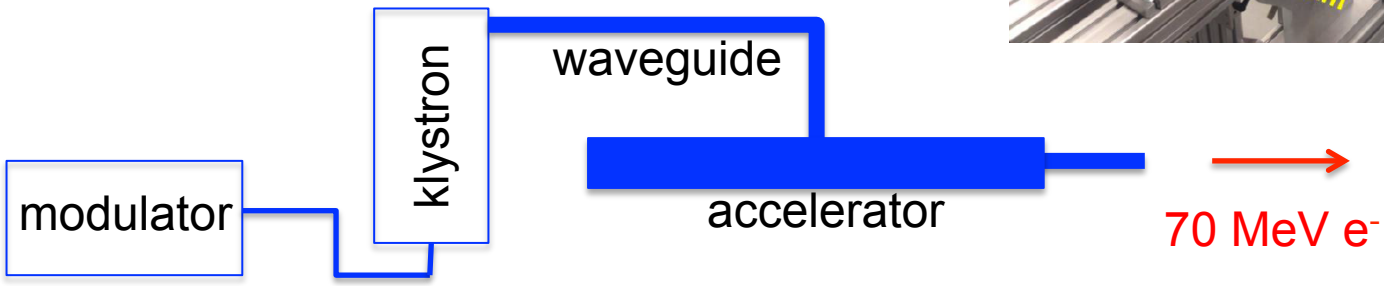


Electron Accelerator?



- ANL "hand-made" 70 MeV electron linac:

-50 kV HV Power Supply
-Modulator (~250k M&S)
-Klystron: L-Band 1.3 GHz (~$275k)
-Waveguide
-Accelerator Structure (L-band -100k)



- But all these components are commercially available: medical applications

Electron Accelerator Exploratory Study

- Is it “useful”?
  -What do we learn (low-E physics)?
  -Can the intensity dial-down to single electron?

- Interface with Cryostat/TPC
  -ProtoDUNE will bring the test-beam inside TPC, can we do the same with DUNE?
  -Beam pipe penetrations?

- Operational Requirements (power requirements, DAQ interface, cooling needs?)

- Noise issues?

- Space requirements?

- What else?

Summary

- Photon-Detector UV-light Calibration and Monitoring System tested in 35ton and ProtoDUNE detectors
  -useful to determine gain/timing and to monitor health of photon-system

- Need the means of “physics” calibration
  -Calibration sources, cosmics
  -Is the electron linac an option?