

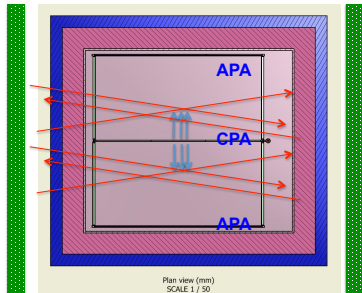
# Calibration Effort for ProtoDUNE

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- Event reconstruction and measurements depend on electric field, purity, temperature
  - ▶ Electric field determines the electron drift speed and the recombination effect
  - ▶ Electric field will not be uniform, either due to hardware (field cage edges, wire sagging) or the space charge build in the detector
  - ▶ Drift velocity drift dependency on temperature is about  $-2\%/K$
  - ▶ Purity would determine how many electrons survive eventually – pulse finding,  $dE/dX$  PID
- So far, we are focusing on calibrating TPC and electron drift. There are other calibration should be carried out on electronics (e.g.,  $ADC \rightarrow \text{charge}$ ) and photon detection system

- Measuring electric field would be the most challenging. Options:
  - ▶ Cosmic Ray
  - ▶ UV Laser
  - ▶ Radioactive source?
- Monitoring temperature, pressure doesn't draw too much effort either from installation or interface in the cap.
- Purity monitor would be useful, but might only be used as a monitoring device to tell a rough picture on purity instead of providing more precise data.

# Muon system



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- A muon detector is proposed to record the muons passing the detector from one side to the other along the beam direction
- Cryostat sits in a pit with 1 meter space in the upstream side. Not much limitation in the downstream
- An integrated system to tagged beam halo?

# Muon system

- Need to find out
  - ▶ What energy regime would be useful for us (e.g.,  $> 10$  GeV)? Cosmic ray with low energy would have more chance to be scattered in the detector.
  - ▶ What precision would be needed in terms of spacial resolution? This would imply the detector choice, size, and cost.
- An integrated system to also tag beam halo muons, veto horizontal cosmic muon from beam events?

# Laser system

- UV laser at 266 nm corresponds to 4.6 eV energy in terms of photons. 2-3 photons can excite an argon molecular
- It produces a controllable uniform track through the detector
- Already demonstrated at U. Bern (inc. uBooNE) and Los Alamos (CAPTAIN and DUNE)
  - ▶ Laser system design itself is fairly well known. Los Alamos group recently submitted a design report to DUNE management, that one would work for protoDUNE. Or we can go after the one designed by U. Bern for uBooNE.
  - ▶ However, the position detector for laser is a bit underdeveloped
  - ▶ The choice of laser system and the position detector would make some impact to the TPC field cage and interface on the cap.

# Coordinate with other systems

- Many feedthroughs on the cap:
  - ▶ Normal feedthroughs for temperature sensors, purity monitors
  - ▶ Accommodate laser periscope
- Define muon system technology the space requirement

## Current resource

- Prof. Tom Coan from SMU will be committed to the muon system development
- U. Bern and Los Alamos have expertise in developing the laser system
- U. Hawaii is working on different laser position detection options
- Meanwhile, we're consolidating the effort with DUNE. The future calibration meetings will be hold together with DUNE calib meetings.