DUNE FD LAr Purity Monitor (PrMon) System Considerations

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DUNE Instrumentation Consortium Meeting

September 15th, 2017

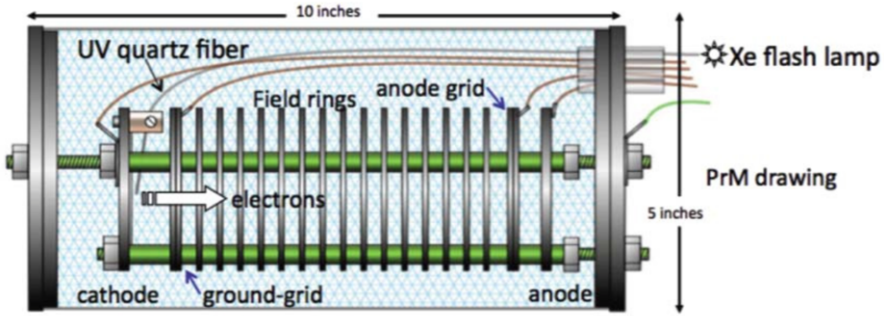
PrMons Inside DUNE FDs

- Continuously monitoring the purity of the liquid argon is crucial
  - With the amount of LAr in the detectors it is critical to be aware of any contaminations ASAP
  - In cryostat monitoring allows for detection of spatially distributed contaminations and how they vary
- What happens if the detector is initially in a state which does not allow for reliable data reconstruction?
  - One of the most crucial times is during detector commissioning
  - Want to monitor LAr purity during cryostat fill and LAr purification
  - A noisy detector will not allow for this
- Sure, we can use the TPC to do monitoring with cosmics once operations are stable, but rate of cosmics is quite low
  - This may not allow for readily available data for real-time monitoring of the detector

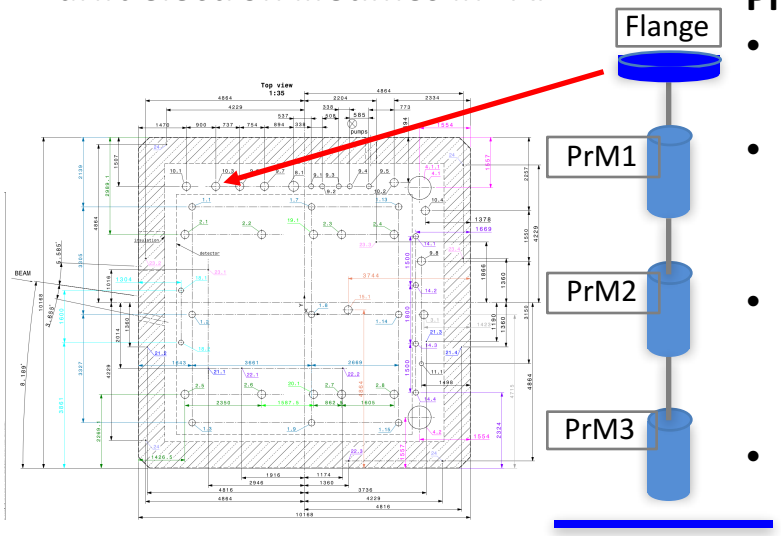
ProtoDUNE-SP PrMon System

Individual PrMon:

- Xe flash lamp UV light source
- Al-Ti-Au photocathode for drift electron generation
- Cathode/anode gates for charge screening at readout
- Ability to measure multi-ms drift electron lifetimes in LAr



M. Adamowski et al., JINST 9, P07005 (2014).



PrMon System:

- Three PrMons will hang from flange
- Vertical string inside cryostat placed through cryostat port 10.3
- PCI digitizer readout and data analysis via LabVIEW custom software
- Integration with CERN DCS for data taking coordinated with physics data operations

Extrapolation to DUNE FDs

- The PrMon system being built for ProtoDUNE-SP can be extrapolated for the DUNE FDs, both the SP and DP options
  - SP – Should have PrMons at each end of the cryostat, help to validate impurity flow modeling, 3 PrMons per port (6 total per cryostat)
  - DP - same concept as above, but would need to consider more carefully the field gradients around the PrMons
- PrMons hanging from rods in the cryostat can get down to depths on the order of 6-8 m no problem, anything deeper may need more engineering for mechanical stability, but surely simple solutions available
  - Also possible to place single PrMon on cryostat floor, then service it through same port as those on rods hanging above it
- DUNE-FDs cryogenics system should also have inline PrMons
  - These are separate from the cryostat, but would at least monitor the LAr after filtration and could be serviceable for very long-term usage

ProtoDune-SP Port Sizing (per David M.)

- The purity monitors themselves are only 4.75” in diameter, so on their own they do not require a large port
  - But need to supply HV/readout signal and provide fibers for UV light
  - Adds an additional ~1” to the “effective” diameter, so ~6” needed in reality

- System is installed from the top of the cryostat, so sufficient clearance require around the PrMons as the system is inserted into the port

- The port size for the ProtoDUNE-SP system is CF DN 250, which has a 250 mm OD tube (230 mm ID) and a 304 mm OD CF flange.

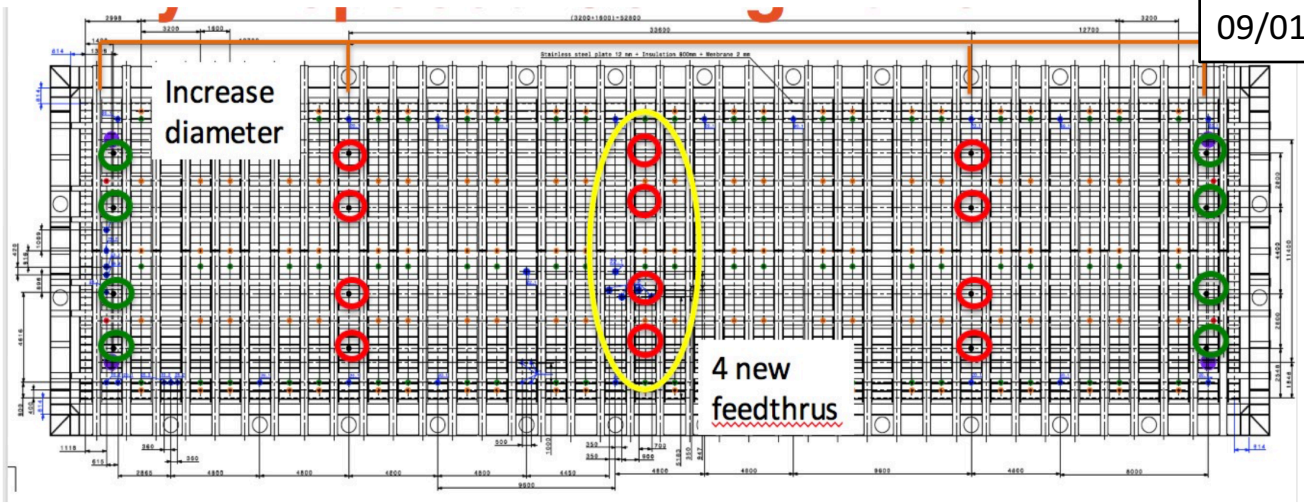
- Note that CERN will install non rotatable CFs with tapped holes on the roof. Our equipment is not sensitive to orientation and so we do not need the orientation of this CF to match it.

DUNE-SP FD Penetration Map

One proposed design for penetrations – Jim Stewart

(only showing the instrumentation ports)

From Sowjanya's 09/01/17 presentation



- **Increase the size of penetrations to accommodate multiple systems:**
  - Change 250 mm → >275 mm (maximum allowed); 300 mm is risky
  - It is not clear what is actually needed based on width requirements from Multiple systems?

- **Adding additional 4 feedthroughs**
  - motivated for Radioactive source calibration to get better position resolution
  - The argument for adding 4 new ports Vs spreading the existing (red) 8 ports need to compared/studied (8 vs 12)

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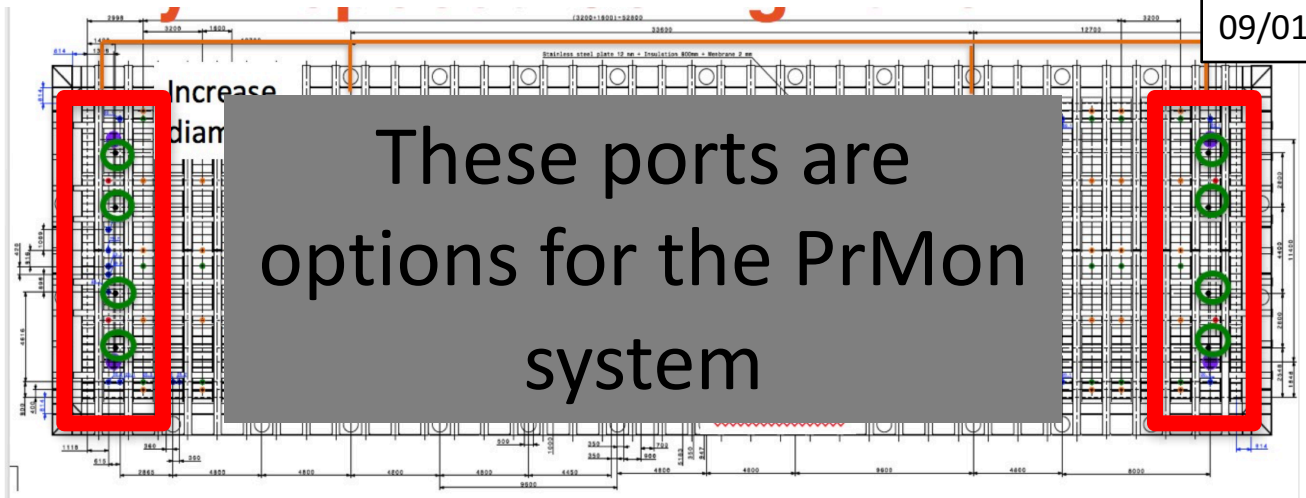
DUNE-SP FD Penetration Map

One proposed design for penetrations – Jim Stewart
(only showing the instrumentation ports)



From Sowjanya's 09/01/17 presentation

- Would be good if the PrMons on each end were located at opposite corner ports from each other, but dependent on clearance below ports

- Or, positioned at one of the corner ports on one side of the cryostat and at one of the middle ports on the other side

DUNE-SP FD Penetration Map

- The current design of the cryostat penetrations lends itself nicely to the PrMon system, as built for ProtoDUNE-SP, since there are multiple ports located behind each APA

- Port sizes of 250 mm work well
  - This flange size already allows extra space on the flange, could be used for thermometry feedthroughs or other instrumentation
  - 275 mm would give even more space

- PrMon system (current design) requires a clear path from the cryostat roof to the floor, ~6” in diameter and centered around the port

Other Considerations for Placement

- PrMon system has some components that need to sit on top of the cryostat
  - Space required around each port for a small NIM bin and metal box which houses the light source(s)
  - These components connect to power supplies and digitizers stationed at the electronics racks, so distances to these should be minimized, if possible

More Questions

- What drives the decision of how many Purity Monitors?
  - The geometry of the cryostat and the fluid flow models can give insight to the number of PrMons, but a reasonable first number is at least one location at each end of the cryostat have a string of at least 3 PrMons.
- What drives the decision of where the Purity Monitors will sit?
  - The PrMons must be outside the TPC, and away from high fields, so they should be at the ends of the cryostat behind the APAs
- There have been arguments on if the protoDUNE-SP and DP design might not be suitable for DUNE given the sizes of the purity monitors? How can this be assessed? Especially given that one feed through can be shared b/n multiple systems?
  - The PrMons for ProtoDUNE-SP would be sufficient to do the job in the DUNE FDs, as they would mostly be useful during the first part of the experiment when the detector is being characterized
  - For long term monitoring, cosmic and inline PrMons are better suited, inline monitors will be similar design, but possible to modify for improved sensitivty