Design review – ProtoDUNE-SP Purity Monitor Connections

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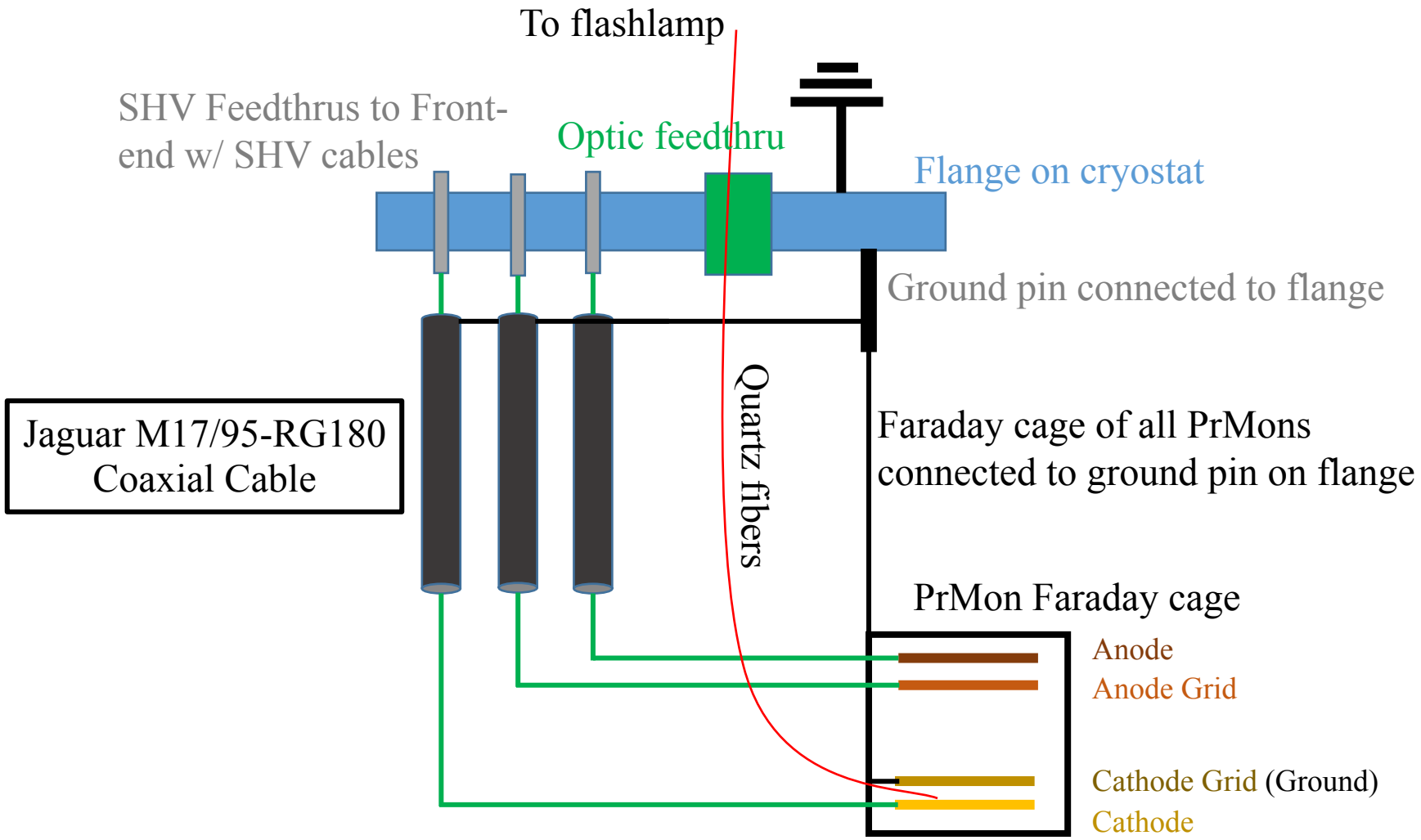
Q3. Are all system and subsystem ground connections sufficiently well understood and documented? Are there any critical single point failures?

- We have reviewed our ground connections and have modified the grounding design according to the review, see DUNE-doc-4115.
- The electronic connections are parallel for the three purity monitors → No SPOF
- PrM system doesn't rely on any other sub-system, and only communicates with slow control → No SPOF

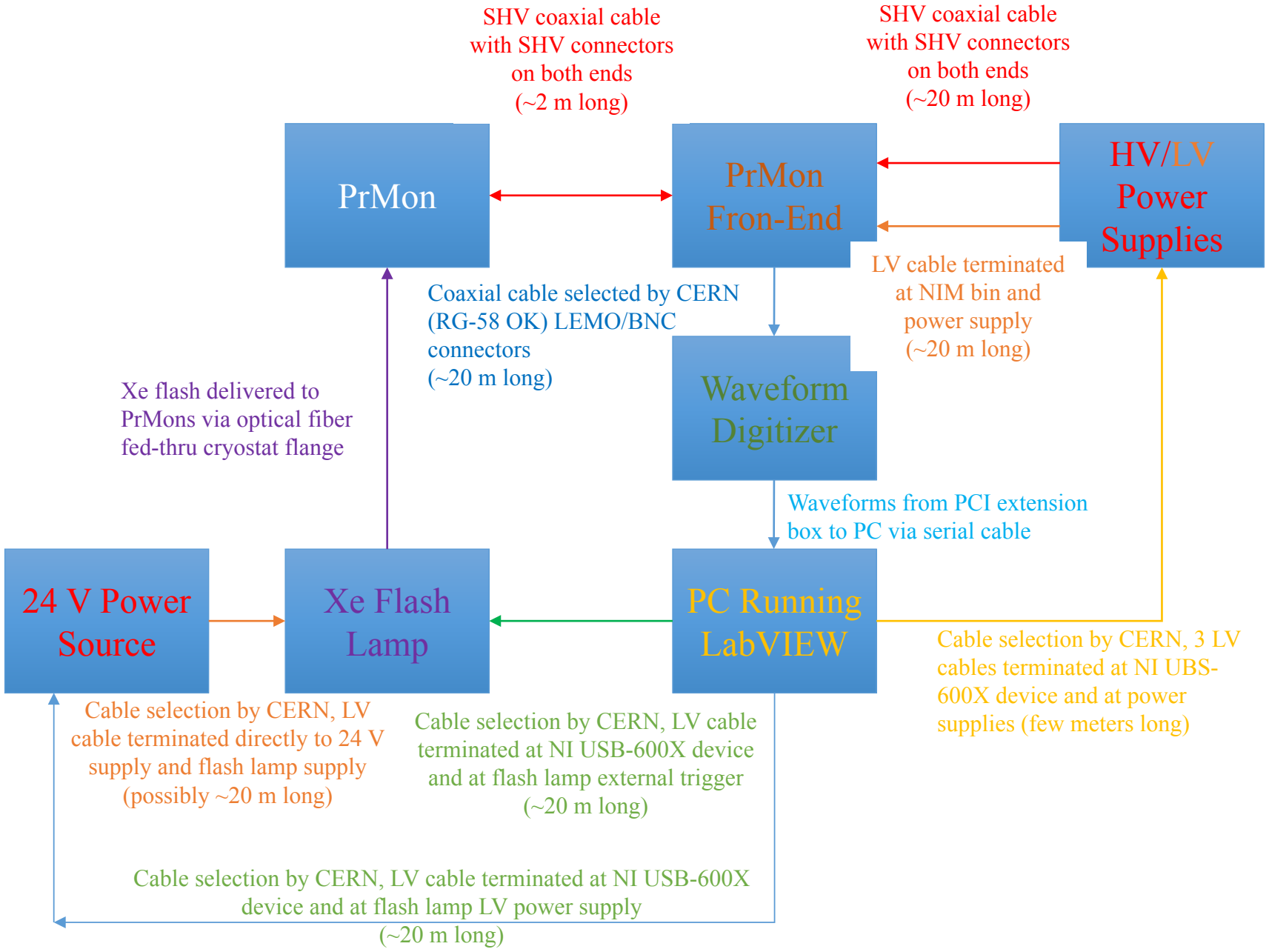
Q7. Is the electrical connection plan for the cryogenic instrumentation and more general slow control readout to verify signal connectivity sufficiently well developed? Do written procedures exist to insure these connections are all properly made and tested during installation? Is the channel mapping well documented and understood? Is the grounding understood and documented?

Electric/Optic connections Inside Cryostat

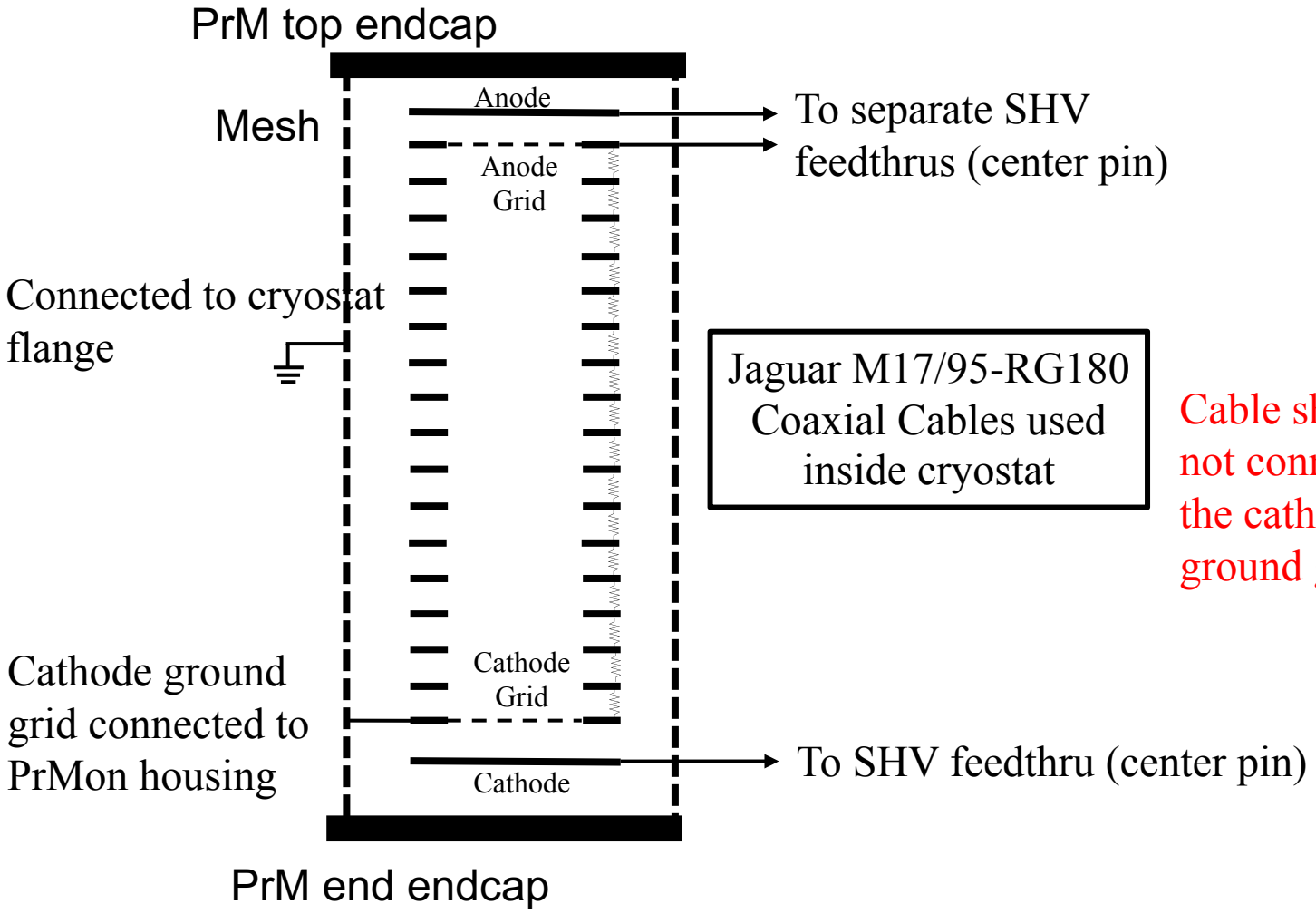


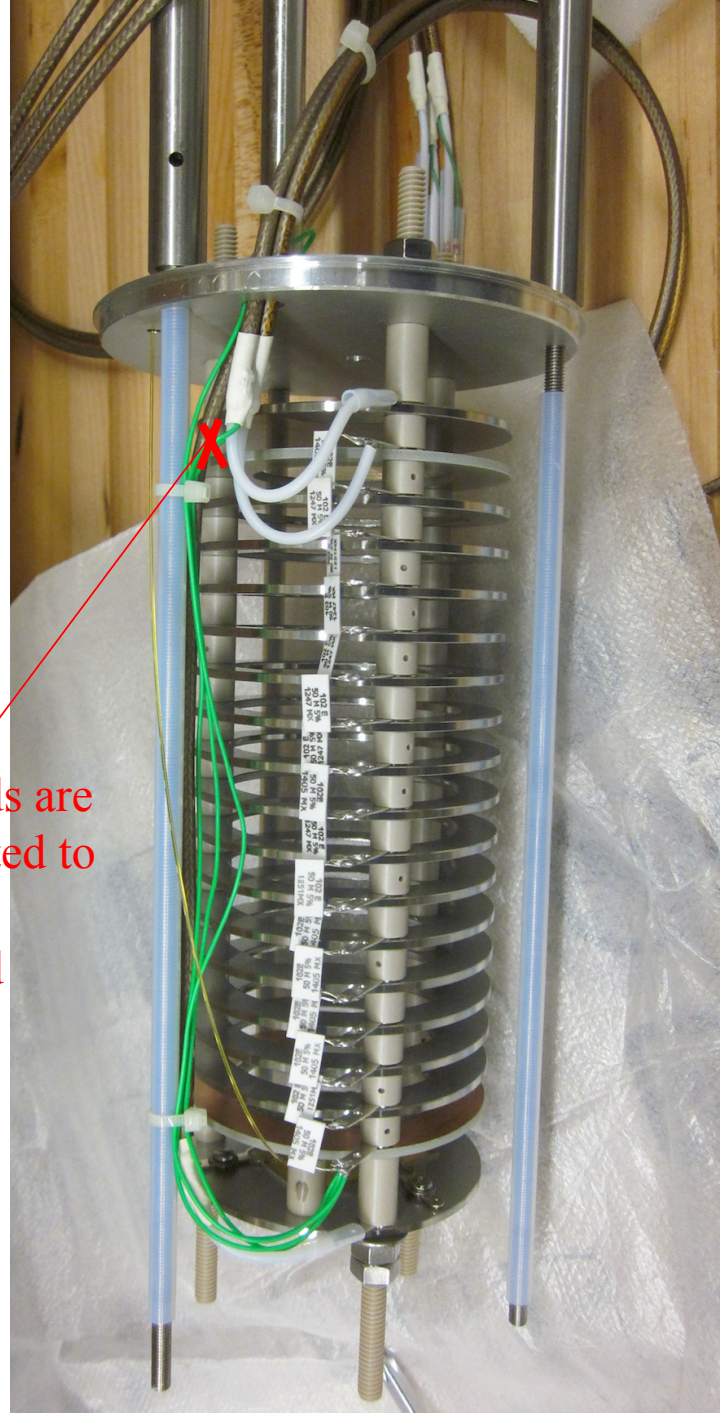
- Bias HV and anode/cathode signals fed-in and read-out through SHV feedthrus (3 for each PrMon)
- Coaxial cable inside cryostat, conductor connects feedthru pins to cathode, anode and anode grid
- Shield of cables connected to flange on feedthru side
- Other side of shield not connected anywhere
- Cathode grid connected to cryostat ground through PrMon Faraday cage

Electric Connection Scheme Outside Cryostat



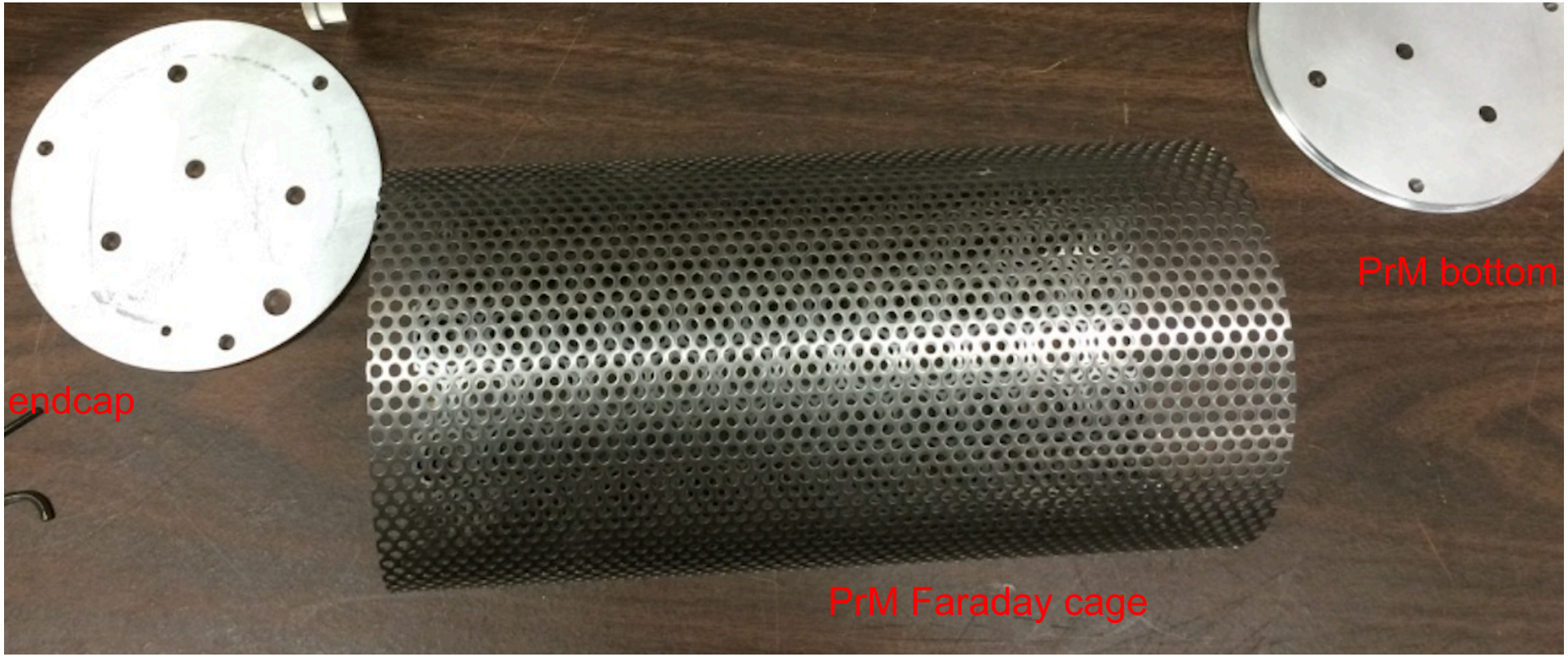
Line Diagram: Inside Cryostat





Cable sheids are not connected to the cathode ground grid

PrM Faraday cage and endcaps

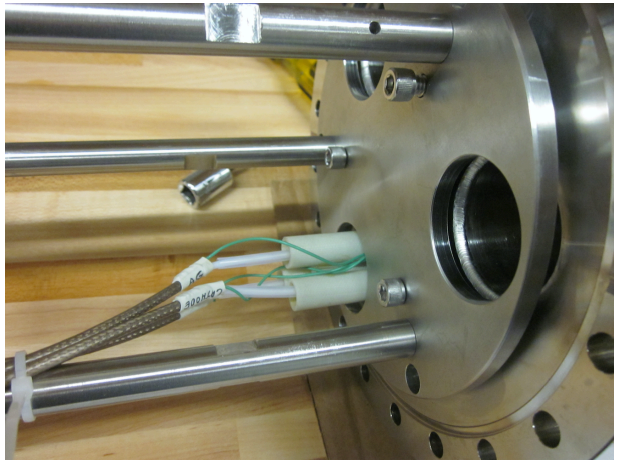


Electric Connection

- Solder cables on lugs at PrM cathode plate, anode plate, and anode grid ring
- Solder a wire on the lug at the cathode ground grid ring, the other end of the wire is connected to the top end cap of the purity monitor, so the ground grid is connected to the PrM housing
- Install the purity monitors without the Faraday cage on the mounting rods, then install the mounting rods to the PrM top flange
- Connect cables from PrM cathode, anode and anode grid to the 3 pins of the PrM HV feedthrough. Connect the shields of these cables to the ground screw on the PrM HV feedthrough
- Fix the PrM HV/Signal feedthrough on the PrM top flange

Lugs at anode and anode grid

PrM HV/signal feedthrough and brass ground screw



Electric connection test 1

- How you know cathode, anode and anode grid is connected?
  - Use ohmmeter to measure resistances between PrM cathode/anode/anode grid and the three outside connection points of the PrM HV/signal feed through
- How you know ground grid is connected
  - Use ohmmeter to measure the resistance between the PrM cathode grid and the surface of the PrM top flange
- How you know grounds are connected or not as designed
  - Use ohmmeter to measure the resistance between the top endcap of the PrM and the surface of the PrM top flange
  - Use ohmmeter to measure resistance between mounting rods of the PrM and the surface of the PrM top flange

Electric connection test 2

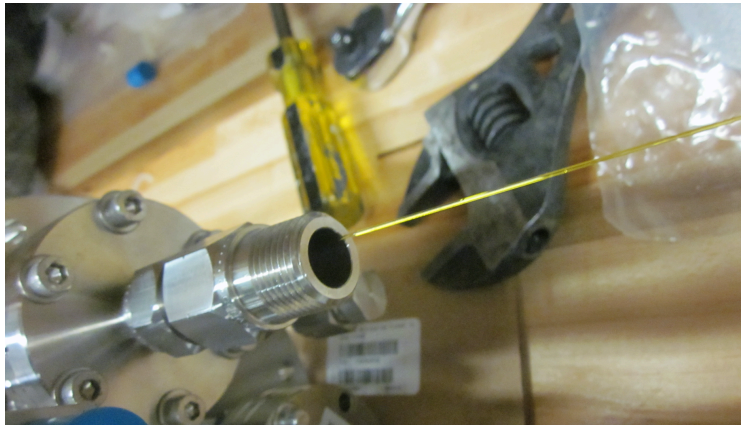
- How you know that the drift-region resistors are connected to their field rings
  - (a) Use ohmmeter (50M Ohm) to measure the resistance between each two adjacent rings on the PrM
  - (b) Use electrometer (high resistance meter, ~1000V, 0.01fA, >10000M Ohm) to measure the over resistance between cathode and anode/cathode and anode grid/anode and anode grid, from outside connection points of PrM HV/signal feedthrough
  - (c) In case an electrometer is not available at CERN: Measure the capacitance of the various purity monitor connections from the outside of the vacuum vessel. This measurement is done directly at the PrM HV/signal feed through to reduce the number of variables and is a relative type of measurement. The Cathode normally will show the greatest capacitance to ground (surface of the top flange), the Anode Grid next and the Anode is expected to be the least. Typically the three readings should be within 20% of each other. If you get a large difference in one or more of the readings then something is disconnected or there is a broken wire internally in the purity monitor connections. (This method was used by Walter Jaskierny from Fermilab for LAPD and 35t PrM connection test)

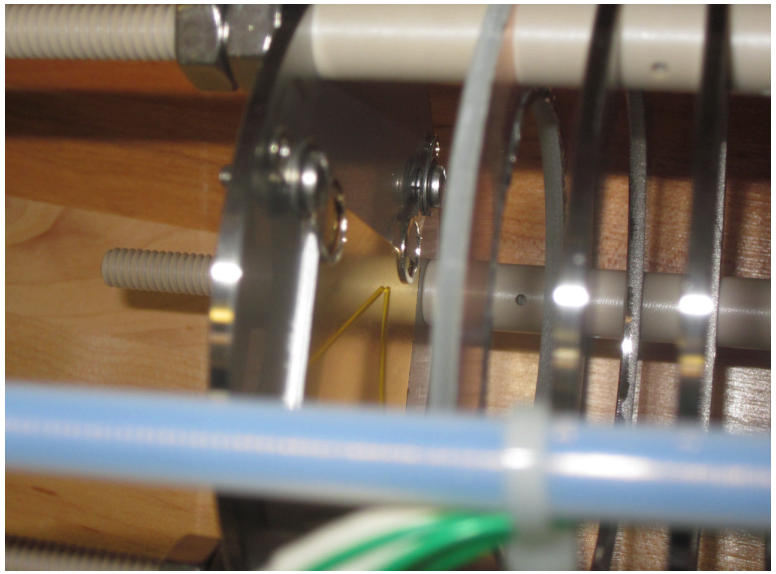
Electrometer

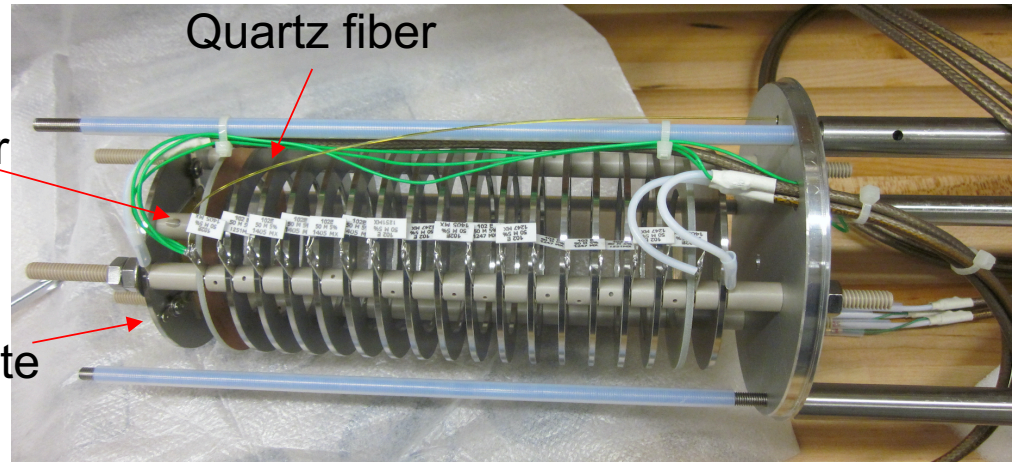
Electrometer (High Resistance Meter) 1000V, 0.01fA → 10^10 Ohm

Optical Connection

- Thread quartz fibers through the optic feedthrough
- Thread the fibers through the fiber hole on the top end cap of each purity monitor
- Thread the fibers through the fiber holder on the purity monitor cathode plate
- Tune the length of the fibers, make fibers (almost) attach to the surface of the cathode
- Fix the optic feedthrough on the top flange
- Use a flashlight to light the outside end of each fiber to check if light can reach the cathode







Install purity monitor assembly in ProtoDUNE-SP

- Install the PrM assembly (top flange, mounting rods and 3 PrMs, all cables and fibers in place, PrM faraday cage not installed) to the protoDUNE top flange port 10.3
- Repeat Electric Connection Test 1 and 2(b)/(c) to make sure that all connections are still good
- Tune the length of the fibers, make fibers (almost) attach to surfaces of the cathodes, tighten the rubber on the feedthrough and the screws on the fiber holders
- Use a flashlight to light the outside end of each fiber to check if light can reach the cathodes
- Install faraday cages on PrMs

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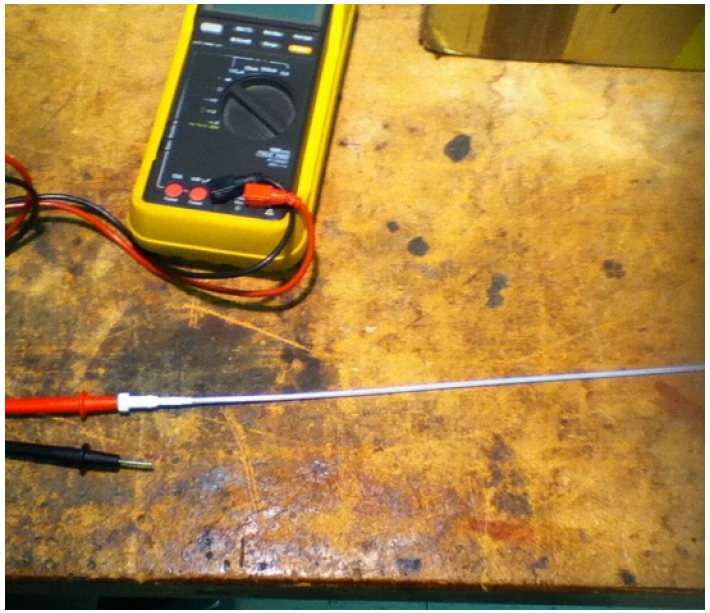
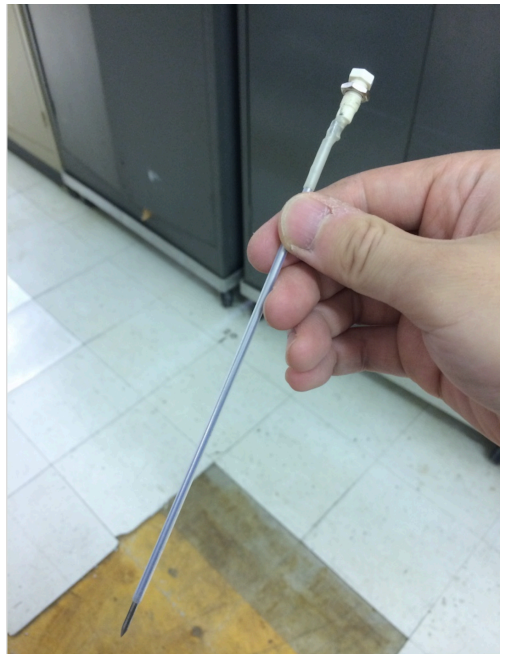
Install purity monitor assembly in ProtoDUNE-SP

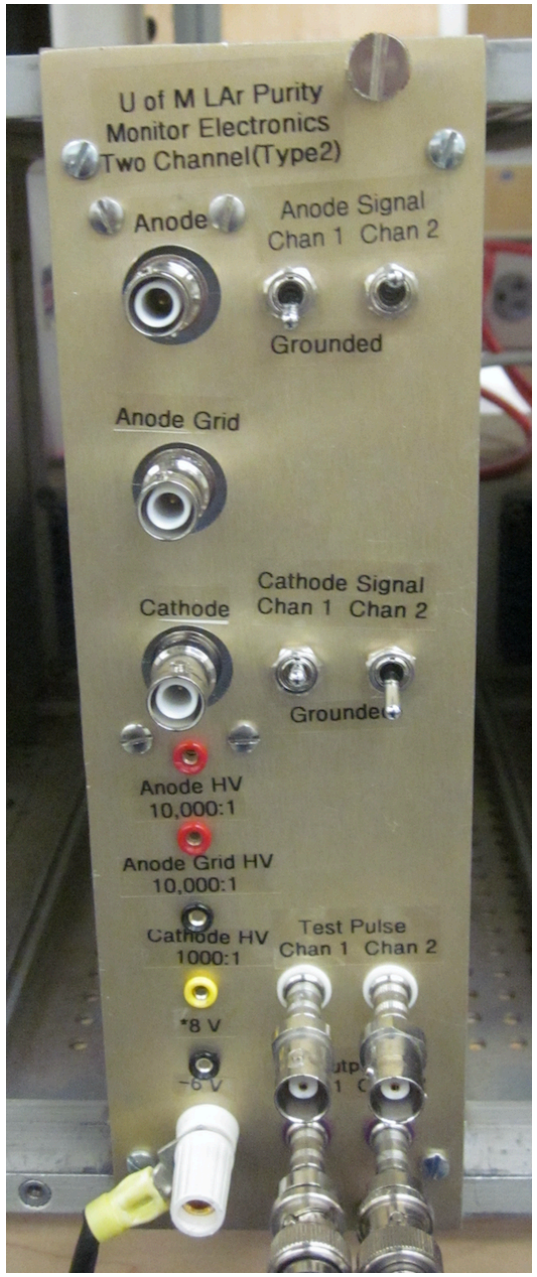
- Now the purity monitors are completely assembled and in Faraday cages. Before close the ProtoDUNE-SP top flange repeat Electric Connection Test 1 and 2(b)/(c)
- Since the PrM faraday cages are installed, we need to use a long thin metal rod (stainless steel welding rod) about 25 cm long, with a file sharpened the end, as the meter probe. Put Teflon sleeving on the outside to insulate it to prevent contact with grounded surfaces. (This meter probe was used by Walter Jaskierny from Fermilab for LAPD and 35t PrM connection tests)





Outside Electric Connections

- Cables from the PrM HV/Signal feedthrough to PrM Front-End electronics: Ohmmeter
- Cables from the PrM HV/Signal feedthrough to PrM Front-End electronics: Ohmmeter
- Grounding: Use an ohmmeter to test cable outer contacts, top flange, and the electronic box to check if grounds are connected as designed
- LV to PrM Front-End electronics: 8V,-6V test points on the electronic box
- HV to PrM Front-End electronics: Anode, Anode Grid and Cathod HV test points on the electronic box
- If the PrM Front-End electronics can properly work? Use pulse generator as input to test signals
- LV to the Xenon flash lamp: See if the flash lamp can flash
- USB connections: Check if LV, HV modules can be accessed by the PrM DAQ PC



After the protoDUNE-SP top flange is closed

- Test overall resistance/capacitance
  - (b) Use electrometer (high resistance meter, ~1000V, 0.01fA, >10000M Ohm) to measure the over resistance between cathode and anode/cathode and anode grid/anode and anode grid, from outside connection points of PrM HV/signal feedthrough
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