Requirements for Bias, Low Voltage and Control Signal Distribution

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Single Phase ProtoDUNE
Warm Interface Board Working Meeting

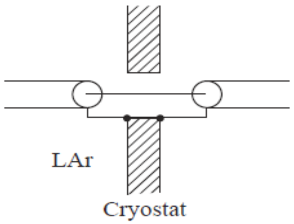
Cable Requirements

Important Aspects of Cables and Connectors

- Must conform to Grounding/Shielding Plan
  - Review by Grounding/Shielding Committee
- Must conform to Safety Standards
  - Cables and Connectors should be rated/tested for conditions
- Cold Cables should be tested in Materials Test Stand
- Other aspects
  - Cable strain relief
  - Mechanical fit
  - "Easy" to Install
  - Robustness

Shielding Cable Penetrations

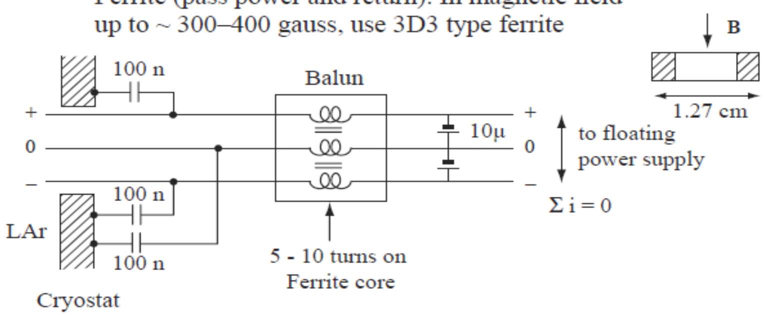
1. Coaxial Cables



- Shield connected to cryostat before penetrating Faraday cage
- Short connection, low inductance
- Performed on standard feedthroughs

2. Power Supplies

- Capacitors with short leads, close to cryostat low inductance connection
- No net DC Current in Balun to avoid saturating Ferrite (pass power and return). In magnetic field up to ~ 300–400 gauss, use 3D3 type ferrite



3. Probes, HV

- Capacitors with short leads, close to cryostat, low inductance connection
- R > 1 kΩ can be replaced by L > 1mH when no current flows

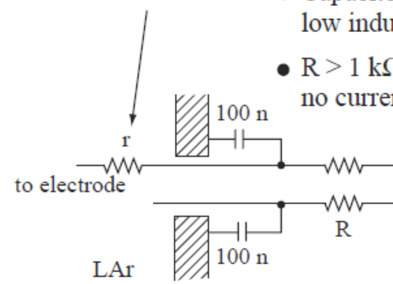


Figure 5. Rules for Entering a Shielded Detector Enclosure (e.g., cryostat).

SHIELDING AND GROUNDING IN LARGE DETECTORS*

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ProtoDUNE Infrastructure Grounding

Documentation gathered in dune docdb 879

Document Database (DocDB) for DUNE and LBNF

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protoDUNE Grounding and Shielding

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Abstract:
This document provides reference material for the protoDUNE Grounding plan.
Additional Material -
-Docdb 1162 references similar MicroBooNE scheme.
-MicroBooNE AC distribution/grounding Electrical Equivalency
-Power point presentation attempts to provide a background of the grounding plans used for the 35-Ton and for the DUNE FD and then to describe the grounding plan for the protoDUNE detector.

Files in Document:

- ProtoDUNE Grounding Diagram (ProtoDUNE_GNDing_diagram.pdf, 130.2 kB)
- ProtoDUNE Infrastructure and External Grounding Points (ProtoDUNE Grounding Points.pdf, 69.8 kB)
- Safety - HV discharge analysis to cryostat wall (VR_Discharge within cryostat_041216.pdf, 559.3 kB)
- Safety - Resistive Cathode discharge calculations (LBNE-Dune_Cathode_Discharge_modeling_BNL_Integration_w...pdf, 1.9 MB)

Other Files:

- Electrical equivalency for MicroBoone power distribution to detector and instrumentation (Equivalency.pdf, 1.4 MB)
- Power Point Presentation - protoDUNE Grounding Plan pdf version (ElectricalGrounding_protoDUNE_rev2_24FEB2016.pdf, 1.1 MB)

Get all files as tar.gz, zip.

Topics:

- Prototyping:ProtoDUNE

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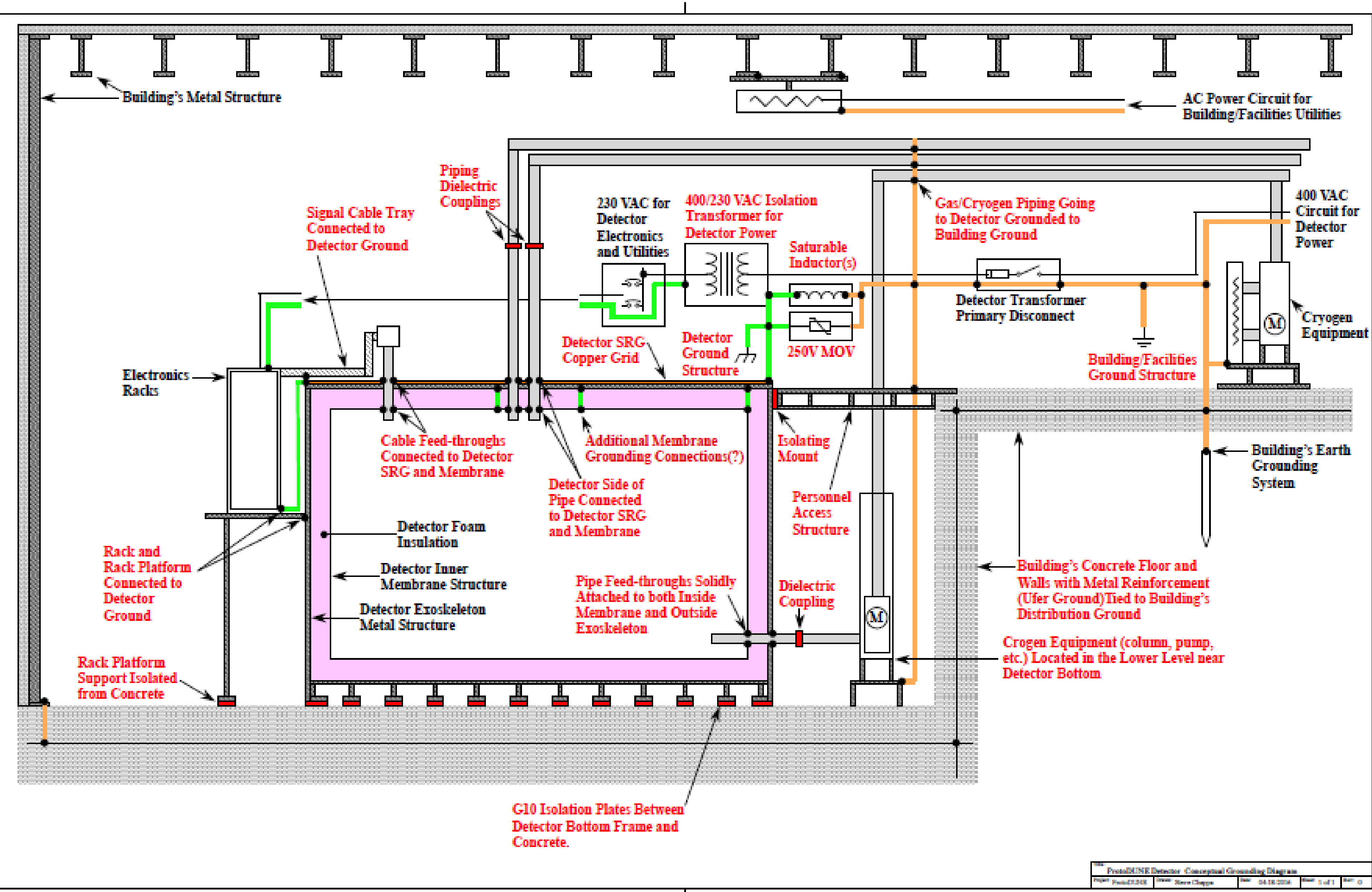
Related Documents:

- DUNE-doc-1162: MicroBooNE AC Power Distribution



Building's Metal Structure
AC Power Circuit for Building/Facilities Utilities
Piping Dielectric Couplings
Signal Cable Tray Connected to Detector Ground
230 VAC for Detector Electronics and Utilities
400/230 VAC Isolation Transformer for Detector Power
Saturable Inductor(s)
Gas/Cryogen Piping Going to Detector Grounded to Building Ground
400 VAC Circuit for Detector Power
Detector Transformer Primary Disconnect
Cryogen Equipment
Detector SRG Copper Grid
Detector Ground Structure
250V MOV
Building/Facilities Ground Structure
Electronics Racks
Cable Feed-throughs Connected to Detector SRG and Membrane
Additional Membrane Grounding Connections(?)
Isolating Mount
Building's Earth Grounding System
Detector Side of Pipe Connected to Detector SRG and Membrane
Personnel Access Structure
Detector Foam Insulation
Rack and Rack Platform Connected to Detector Ground
Detector Inner Membrane Structure
Pipe Feed-throughs Solidly Attached to both Inside Membrane and Outside Exoskeleton
Dielectric Coupling
Building's Concrete Floor and Walls with Metal Reinforcement (Ufer Ground)Tied to Building's Distribution Ground
Detector Exoskeleton Metal Structure
Crogen Equipment (column, pump, etc.) Located in the Lower Level near Detector Bottom
Rack Platform Support Isolated from Concrete
G10 Isolation Plates Between Detector Bottom Frame and Concrete.
ProtoDUNE Detector Conceptual Grounding Diagram

ProtoDUNE Grounding

ProtoDUNE Grounding Points – Building Infrastructure and External Grounding

- ProtoDUNE requires a ground structure which isolates the detector and local detector racks from all other electrical systems.
- ProtoDUNE defines two distinct ground systems: **Detector Ground** and **Building Ground**.
- A safety ground, consisting of two or more saturable inductors, will connect the two ground systems and maintain a low impedance current path for equipment short circuit and ground fault currents. This will insure personnel safety by limiting equipment/equipment and equipment/ground touch potentials.
- **Detector Ground** consists of the steel containment vessel enclosing the cryostat, the cryostat, and all metal structures attached to or supported by the detector vessel. Dielectric breaks will be required on all cryo piping and any other metal structures which are referenced to **Building Ground.**
- **Building Ground** consists of the network of grounding bus bars and inter-connected rebar which exists in the ENH1 Facility.
- An insulated barrier, ~0.10 inch G10, shall be installed between the floor of the facility and the bottom cryostat containment vessel to minimize low frequency ground and noise currents conducted between **Building** and **Detector** grounds.
- Detector Readout racks should be located on top of/or near the top of the cryostat so that all the readout racks can be on a common **Detector** ground system and the cable runs minimized.
- All cable trays going from the racks to the ports will be solidly connected to the top plate reference ground and will be considered part of **Detector** ground.
- All cryo or gas piping, needs to be connected to **Building** ground at intervals before arriving at the cryostat. These pipes are required to have dielectric breaks located near the top of the cryostat.

ProtoDUNE Grounding Points

- A 230/400 VAC, double shielded, isolation transformer will be required, located close to the detector or on it. The service panel from this transformer will need surge protection.
- All connections between the detector racks (**Detector** ground) and the Control room/barracks (**Building** ground) need to be optic fiber or isolated copper connections.
- The top plate of the cryostat serves as the signal reference plane and **Detector** ground. A copper grid, solidly connected to all ports and to the racks, needs to be provided.
- All local detector racks (not DAQ racks located in barracks) must be solidly connected to the platform and to the cryostat top reference grid/plane which represents **Detector** Ground.
- Copper grounding bus bars should be provided near the racks and any other equipment mounted on the cryostat to aid in maintaining the low-impedance inter-connections to **Detector** ground.
- All VFDs near the cryostat need careful design to prevent ground currents from coupling to the cryostat.
- The port penetrations need to utilize a “360-degree” connection to the outside surface of the cryostat and to the inside surface of the inner membrane.
- The HV power supply needs to be mounted somewhere on or next to, the cryostat.
- The HV cable shield needs to be solidly bonded to the cryostat. This shield must not be able to be charged up in the event of damage to the cable.

List of Cables which Penetrate Cryostat

APA Readout (6 APAs in ProtoDUNE)

- **20 FE Signal/Control Cables**
- **20 FE Power Cables**
- **10 PD Readout Cables**

Other

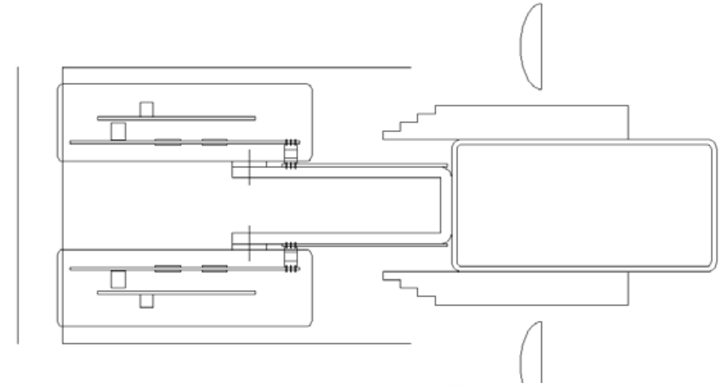
- **Wire Bias Cables (HV)**
- **Drift HV**
- Camera System
- Calibration systems
- Purity Monitors

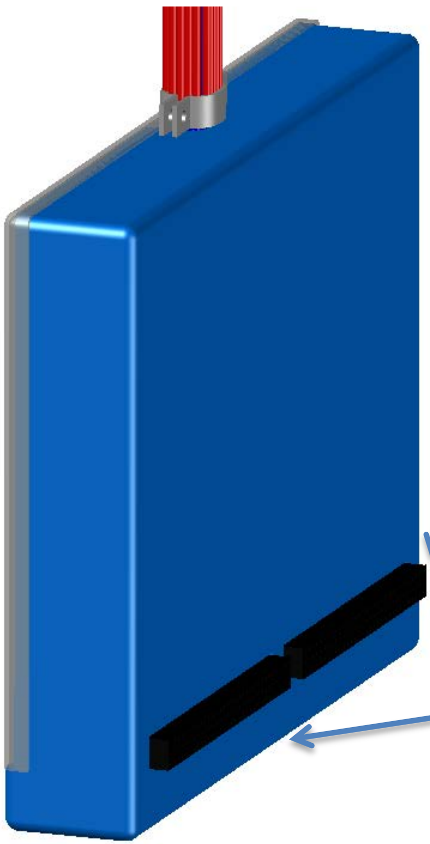
Cold FE Board Cables

Each FE Board will require two cables

- Signal/Control Cable
  - 12 Differential Signal Pairs
    - Will carry high speed data and control signals
- Power Cable
  - Will carry power to FE Analog Mother Board and FPGA Mezzanine
    - 14 wire (7 Voltage/Return Pairs)
    - 20 AWG

Current Design



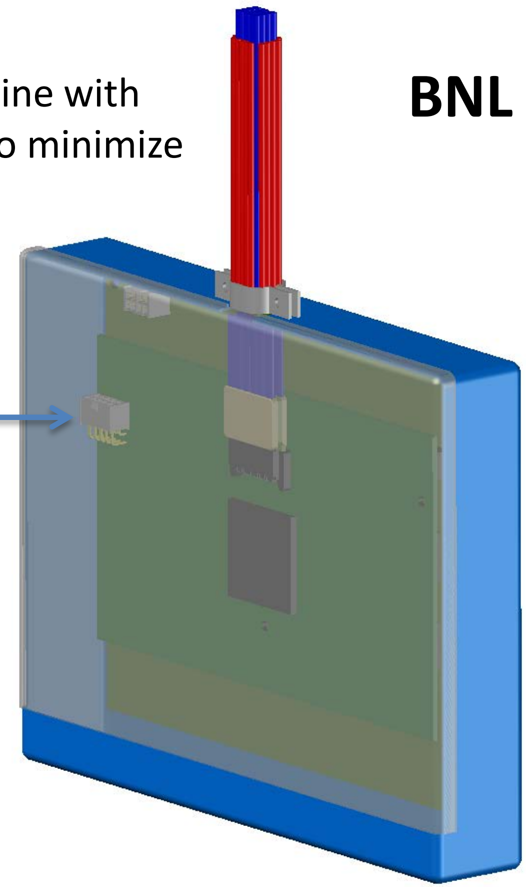


Input connectors on the back of the box (straight connector from the FEM).

Box opening in line with the data cable to minimize cable bending

BNL

Right angle power connector to reduce box thickness



Bottom edge of the box leak tight to trap and divert boil off gas

Plugged in →

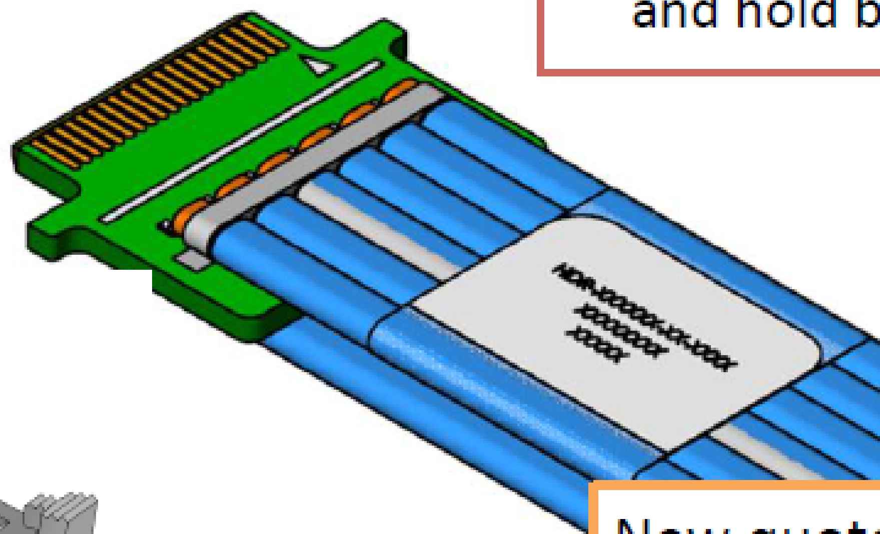
Samtec Bundles

BNL

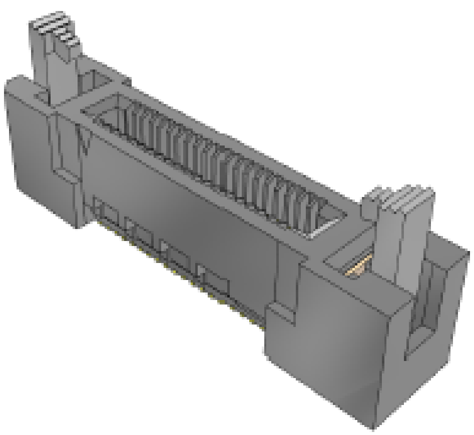
Outer insulation now THV (replacing PVC)

30-gauge THV insulated cable sample being tested at FNAL materials test stand.

- Drawing not final, but lead time now estimated 8 weeks
- HSEC8-DV latch to attach and hold bundle



Carries Data/Control



<u>New quote from Samtec</u>
7m long cable bundle
$360 per bundle (>100)

Low Voltage Cable

BNL – From Matt

LV

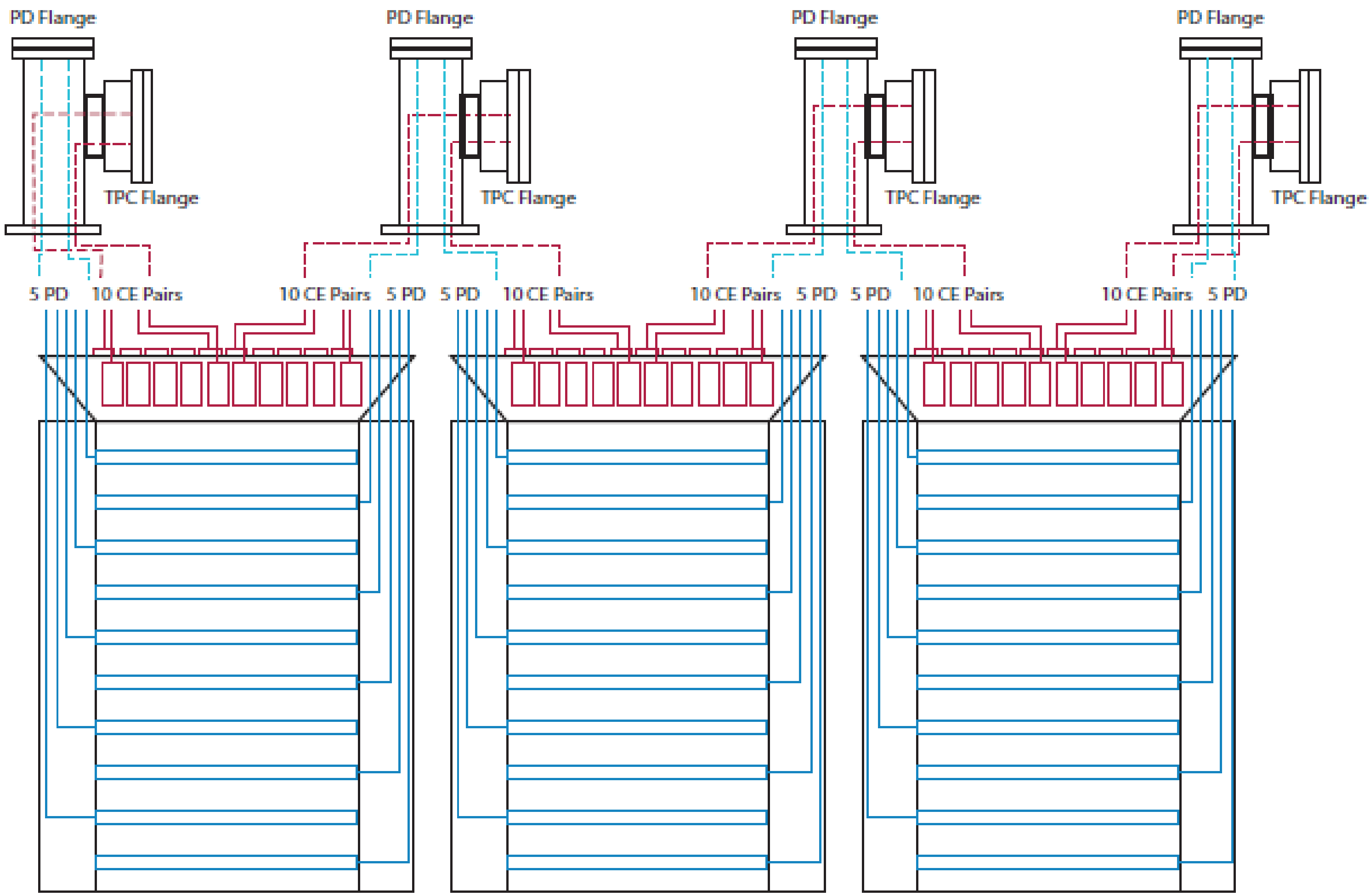
- Current plan is Teflon-coated single wires
  - Bundle produced inexpensively by Samtec
- Suggestion to use shielded twisted-pair wires
  - Need to identify who would be responsible and cost

Photon Detector Cables

Plan for ProtoDUNE

- Use multi-conductor twisted pair with individual shield, Teflon jacket, CAT6A
- The cable has 4 twisted pairs in one jacket
- Plan to read out gang of 3 SiPM

ProtoDUNE Routing Scheme



Longest cable = 6.4m including contingency, same as DUNE upper APAs

A Combined TPC + PD Nozzle

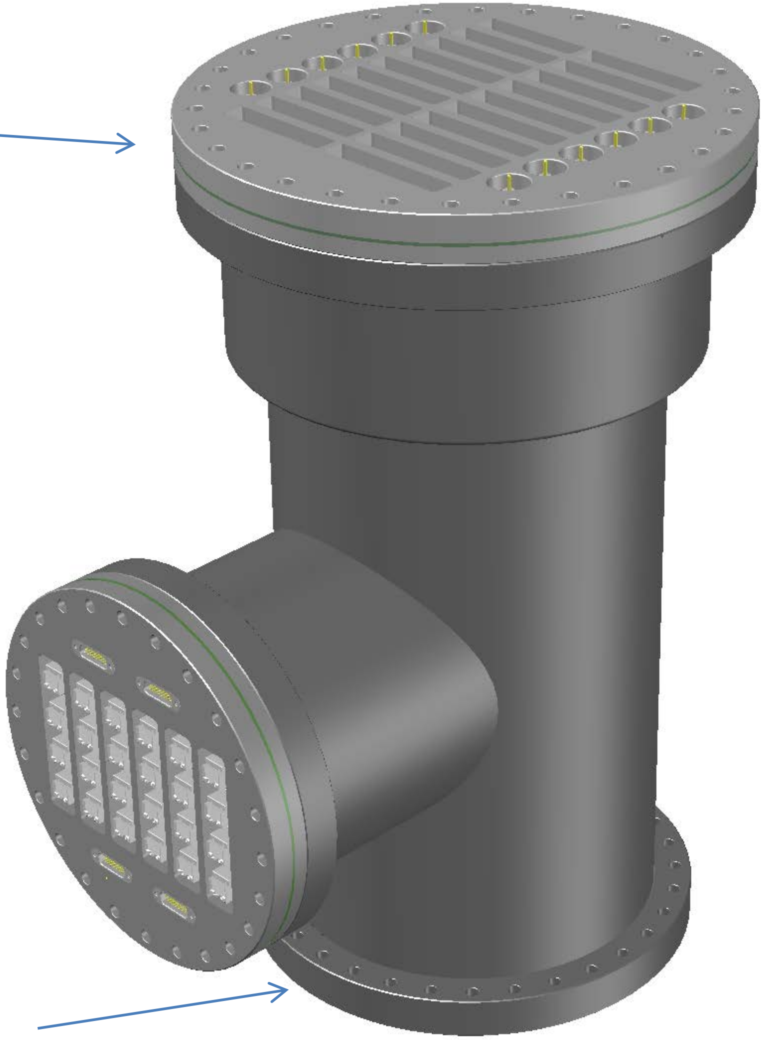
BNL

14" CF flange for the cold electronics and bias cables from TWO APAs

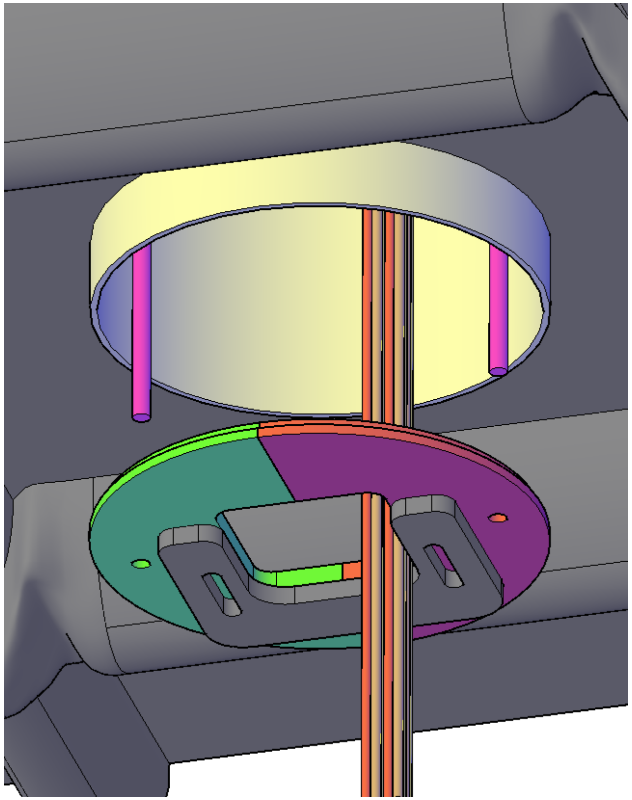
10" CF flange for the PD cables from TWO APAs plus 4 DB15 connectors

Lifting the field cage panels through these ports remains possibility.

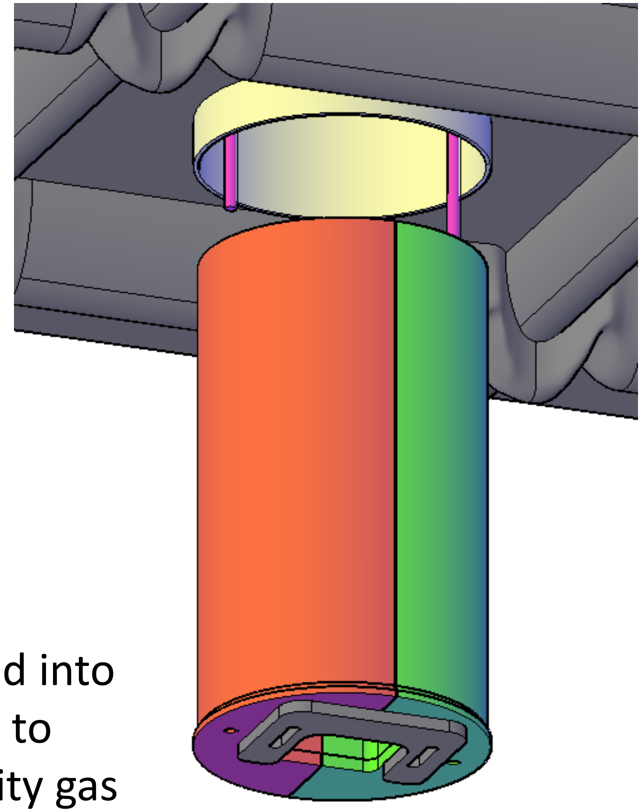
10" pipe, 12" CF flange for the cryostat nozzle



Integrated Cable Strain Relief and Baffle



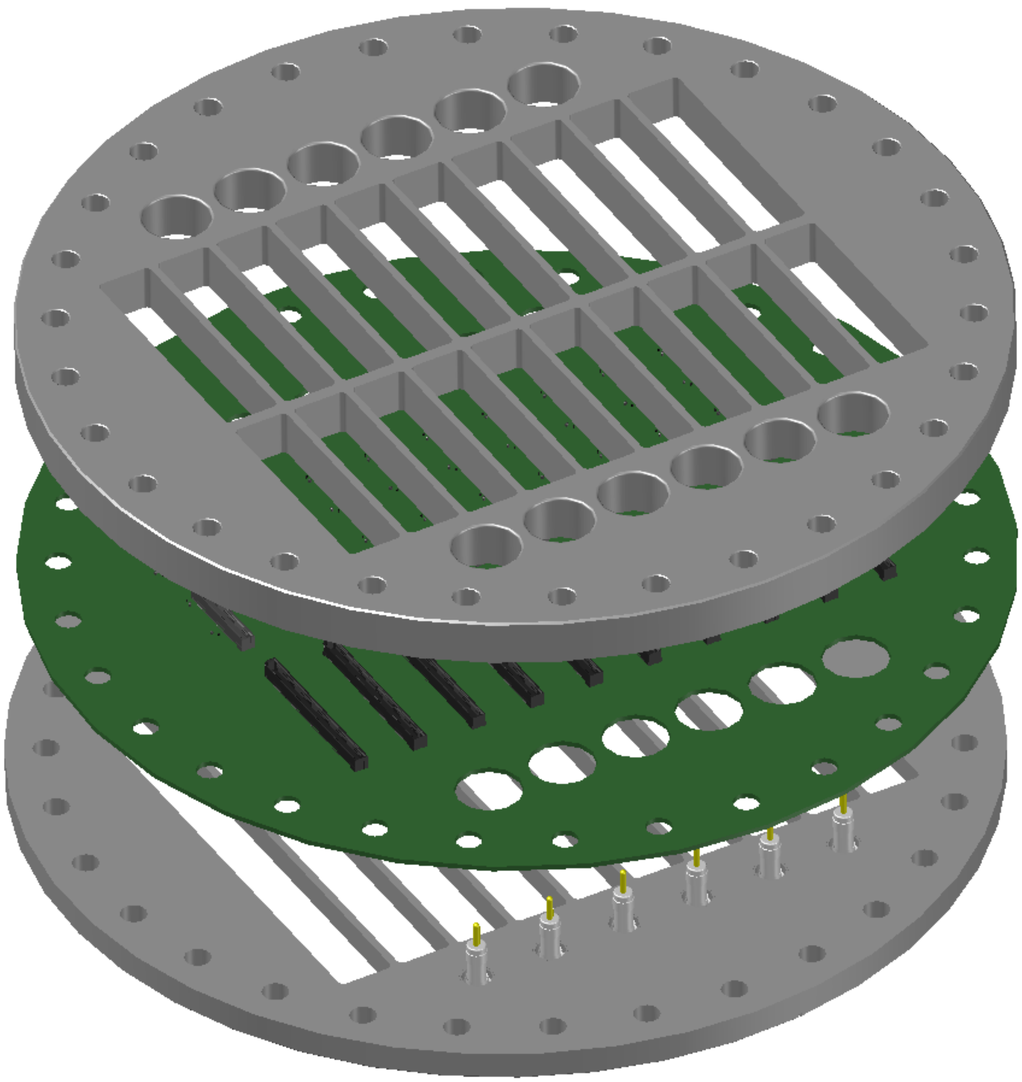
Simple baffle plate to create local high velocity purging flow



Baffle plug pushed into the crossing tube to create high velocity gas flow over extended distance

CE Signal Feedthrough Flange Construction

BNL



The flange is constructed from a standard 14” CF flange, sliced into two halves, with a PCB glued in between.

The PCB has 40 power connectors and 40 data connectors on the cold side. On the warm side, 10 edge connectors supply the power, and 10 connectors link the data lines.

12 SHV ceramic feedthroughs are welded on the flange. They provide the bias voltages for the wire planes and the electron diverters.

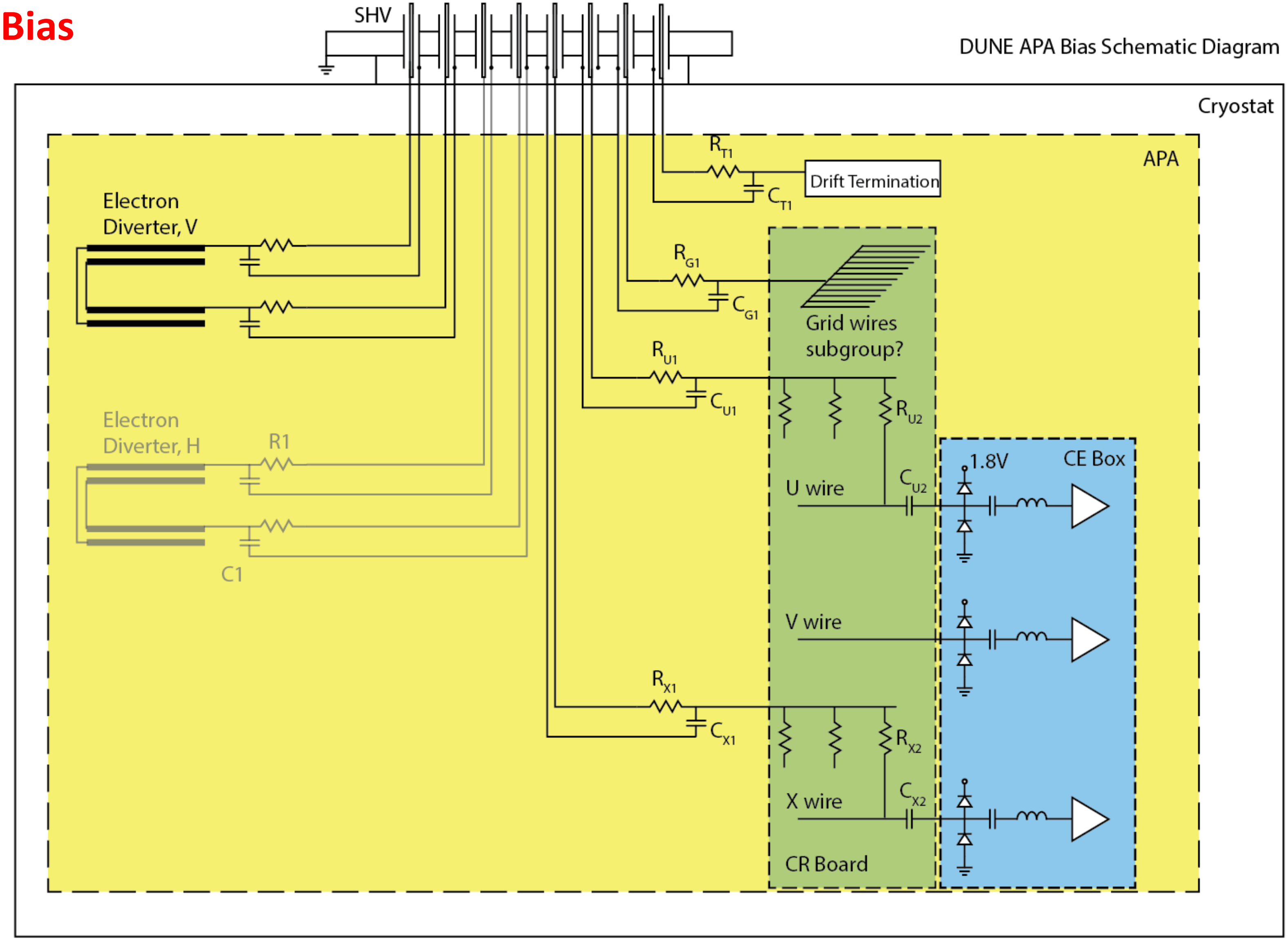
The ribs on the flange keep the deformation of the PCB due to cryostat pressure minimal.

High Voltage

APA Bias Schematic Diagram

BNL – From Bo Yu

Wire Bias



Wire Bias Cables

Wire Bias Cables

- SHV connectors
- HV filter should be incorporated on APA CR Boards
- At feedthrough port we want to follow grounding/shielding guidelines

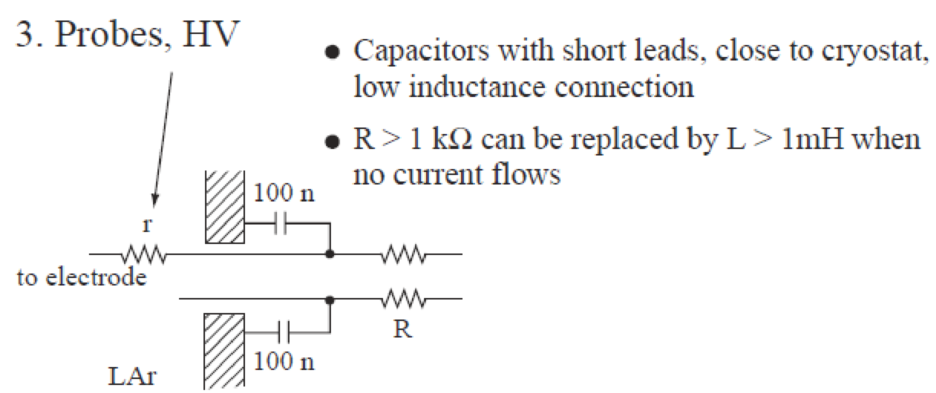


Figure 5. Rules for Entering a Shielded Detector Enclosure (e.g., cryostat).

HV System Schematic Diagram

BNL – From Bo Yu

HV Cable