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Dune Grounding and Shielding Guidelines

1.0 Introduction

The DUNE detector is being constructed such that it will operate as an "isolated" system. It will have its own dedicated **Detector Ground** which is distinct from the **Cavern Ground** (used for such services as lights, cranes, cyogenic pumps, etc). Only a dedicated safety ground connection will be allowed to bridge the two distinct grounding networks. The DUNE infrastructure grounding scheme is documented in DUNE DocDB 285. This note will provide guidance on how to properly ground and shield all cavern-based electronics associated with detector readout and cryogenic instrumentation.

The grounding scheme requires the detector cryostat to be treated as a Faraday cage. Any penetration of this Faraday cage must include the appropriate connections, filters and shielding to preserve the "ideal" Faraday cage as much as possible. Some guidance and examples will be given in this note. However, because many situations are unique, all connections will be subject to review by DUNE Technical Coordination.

2.0 General Rules for penetrating the cryostat

The cryostat top plate is to be considered the center reference point of a "star" ground system. All penetrating flanges are to be well bonded to the top plate and the inner membrane. All penetrations into the cryostat will go through a flange.

All power and signal connections are to be designed to eliminate any stray ground currents from penetrating the cryostat. The use of baluns, ferrites, common mode chokes and resistors (in the case of low current paths) are encouraged to create a higher impedance path for noise currents and prevent these noise sources from entering the faraday cage of the cryostat.

Below are some examples which are meant to give guidance on how some types of connections may be realized. Each implementation is unique and may require modification.

2.1 Shield Connections

The shield connection of a cable requires special attention. When a cable has an overall shield, the best way to protect the signals being carried on that cable from electrical noise is to connect the shields at both ends. A shield connected at both ends also serves as a faraday cage around the cable and protects other systems from any electromagnetic interference from those signals.

It is acknowledged that in large systems such as DUNE, there is a concern that multiple shield connections may cause unintended ground loops. Many large systems, therefore, try to enforce a rule where the shield is connected only at one end (usually the source end). We will not follow this rule at DUNE, but will allow for a "soft" ground to be implemented at the detector side of a cable shield if a subsystem shows that it is required. A soft ground consists of a low impedance connection which could be a resistor, capacitor, inductor or a more complex filter. A soft ground allows the shield to still be

referenced to **Detector Ground** while presenting a small impedance to currents which should be returning on the signal/power wires protected by the overall shield.

At DUNE, it will be necessary to look at all shield connections as they apply to individual subsystems. In general, cables must be constructed following the guidance below. Cable connectors should be selected such that it is easy/possible to make or break the shield connections in the field when shield options require testing.

General Shield Guidance (Warm cables outside of the cryostat)

- All conductive cables should be shielded.
- All cable shields should be connected at both ends of the cable.
- Connectors should be selected to give a full 360 degree connection to the shield when possible.
- Filter elements should be placed on printed circuit boards which are close to or plug into the connectors located on the penetrating flange.
- A shield connection may not directly pass through into the cryostat; this is a violation of the faraday cage and will bring outside environmental noise into the cryostat.

General Shield Guidance (Cold cables inside of the cryostat)

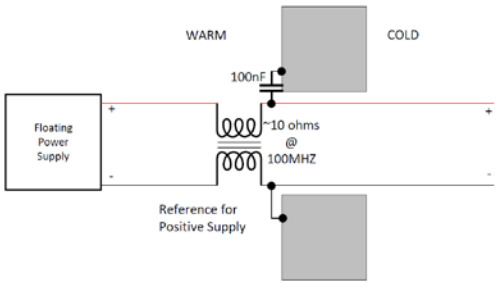
- Shield MUST be connected to the inside of cryostat at penetration point (flange).
- Shield at the far end of the flange can ONLY be connected to the destination instrumentation when the instrumentation is floating with respect to the rest of the cryostat; no ground loops allowed inside the cryostat.

2.2 Power Connections

Any power connections into the cryostat through a flange **MUST** be referenced to the cryostat as close to the point of penetration as possible. Power supplies should float at the source and be referenced to **Detector Ground** at the flange. Filters, such as high frequency capacitors (~100nF) connected between the power leads and the Flange **Detector Ground**, should be utilized when possible.

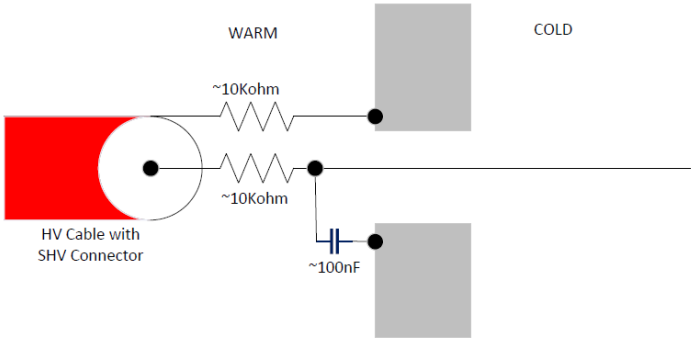
2.2.1 LV Power Connections

Use of common mode chokes should be considered to suppress common mode noise.



2.2.2 HV Low Current Power Connections

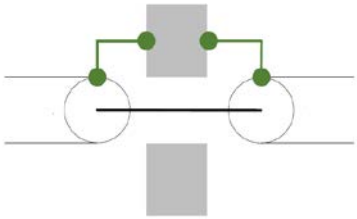
Use of resistive elements (low current applications) should be incorporated in the filter design.



2.3 Signal Connections - Examples

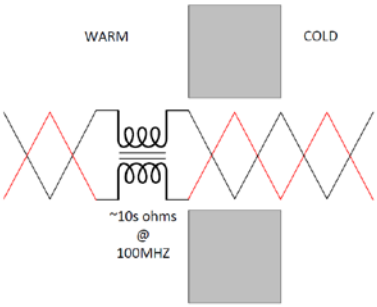
2.3.1 Coax Connections

Shield of coax cable must be referenced to the Detector Ground (flange).



2.3.2 High Speed Differential Twisted Pair

Use of common mode chokes should be considered to suppress common mode noise.



3.0 Single Phase Detector – APA wire Readout Requirements

The protection of the signal integrity at the front-end has led to several system requirements. These requirements are important to understand and are listed below. They effect mechanical and ground connections of the APA, as well as cable and shield connections of the readout electronics.

APA Readout Front-end Requirements:

- The **APA frame** shall be connected to the **circuit common of all FE ASICs.**
- **All electrical connections (power and signal) from an APA shall lead to a single feedthrough.**
- **APAs shall be insulated from each other. In DUNE, insulating links shall be used to suspend the bottom APA.** This is to prevent DC return currents due to different lengths of power supply cables from flowing via mechanical links from frame to frame. Any contact resistance variation between the frames will translate into FE ASIC Vdd variation (noise).
- Feedthrough design, including the Warm Interface, shall preserve the cryostat as a Faraday Cage. Any other cryostat penetrations (RTDs, purity monitors, cameras, calibration, …) must include appropriate filters and shielding.
- The **circuit common of the FE ASIC** and of the rest of cold readout shall be connected to the **common plane/enclosure** of the **cold FE module**.
- APA Power line return leads and any shields shall be connected to the **circuit common plane** of the **cold FE module** at one end and to the **flange of the feedthrough** at the other end. This shall be the only connection of the APA frame to the cryostat.
- Any APA mechanical suspension from the frame to the cryostat shall be insulated.
- The last stage of the sense wire and grid bias filters shall be connected to the frame (i.e., ASICs common).