ProtoDUNE/SBND Grounding and Voltage Distribution Plans

Linda Bagby

ProtoDUNE/SBND CE Design Review

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In collaboration with:

Purpose

This talk addresses Charge Item 6.

Is the grounding and shielding plan for the detectors and its impact on the CE systems understood and adequate?

Overview

- Premise of Design
- Grounding Points
- Key Isolation Features
- AC Distribution
- SBND Ufer ground
- Isolation Bandwidth
- Grounding Concept Graphic
- DC LV ASIC Power Distribution
- Summary

Premise

- ProtoDUNE and SBND utilize extremely sensitive electronics to measure the charge from the TPC wires.

- To achieve extremely low noise levels (ENC < 650 e^-), such that the low level TPC signals may be captured, it is vital that building utility noise sources are minimized and the front end ASIC preamp ground is stable.

- To achieve this low noise signal ground, we utilize an adapted AC power ‘isolation’ technique successfully implemented on the DZero, Atlas, and MicroBooNE experiments.

ProtoDUNE/SBND Grounding Points

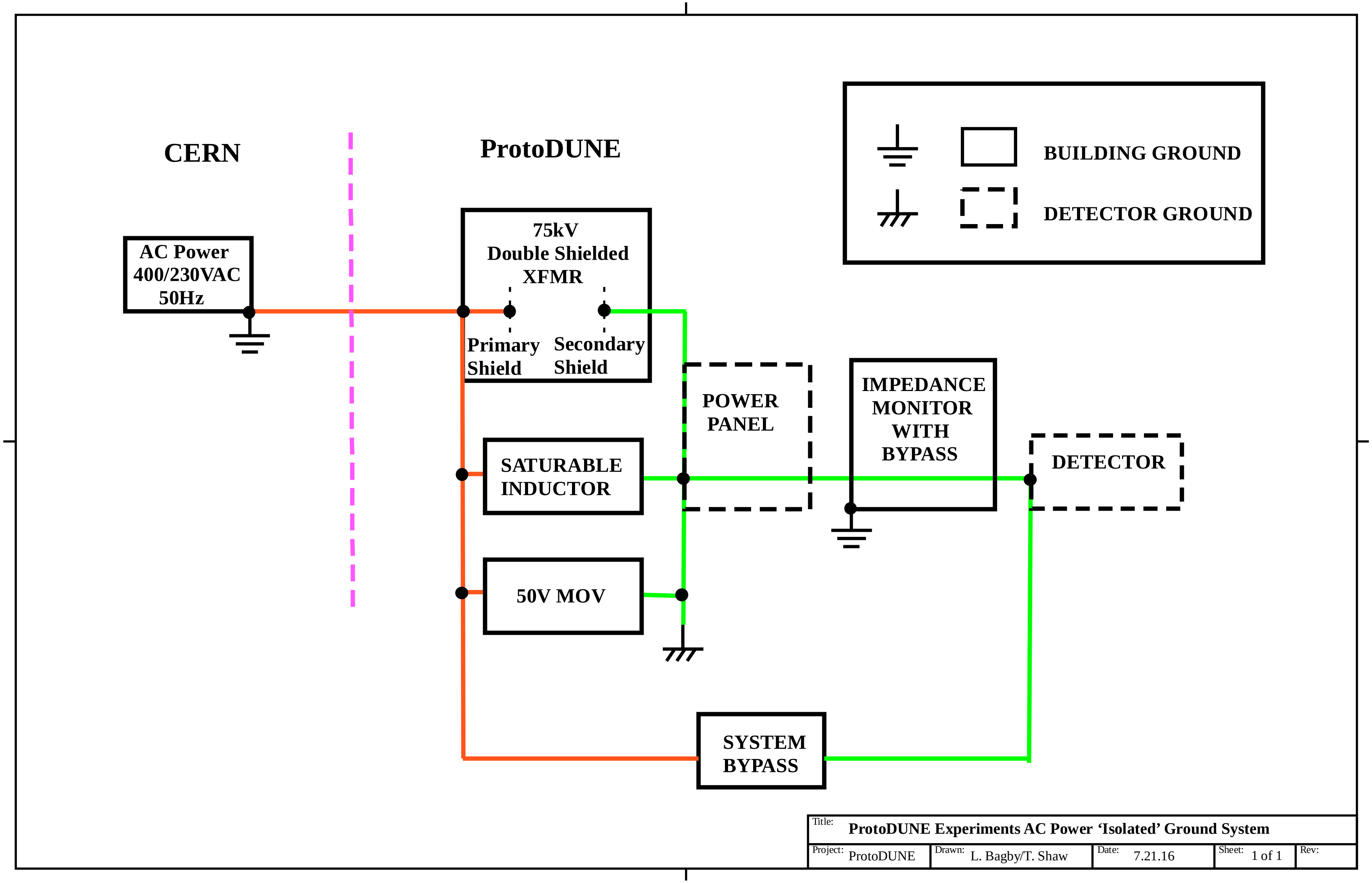
Since both of the experiments utilize a membrane type containment vessel enclosing the TPC detector and the same cold electronics, the Grounding Points are the same for both of the experiments.

- ProtoDUNE Grounding Points: DUNE DocDB# 879
  - http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=879
- TPC_APA_Electrical_Connections: DUNE DocDB# 1244
  - http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=1244
- SBND Grounding Points: SBN DocDB# 1077
  - http://sbn-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=1077

Key Isolation Features

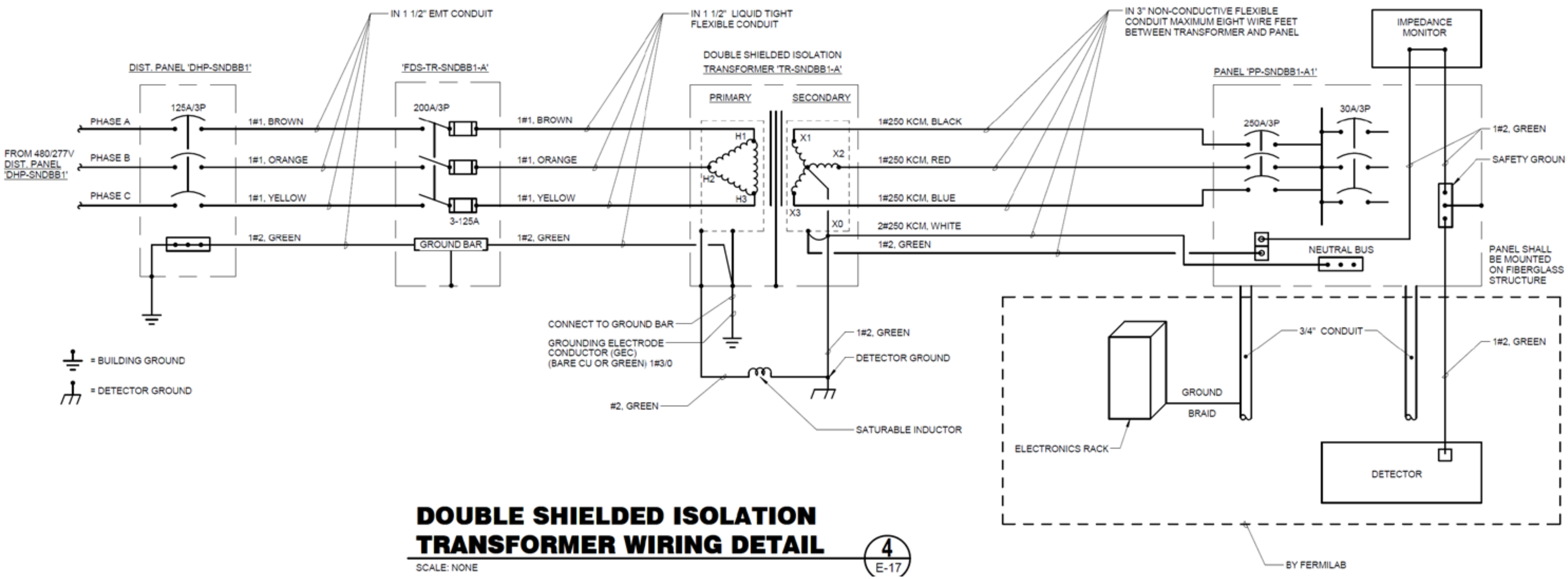
- A grounding scheme which isolates the detector and local detector electronics racks from all other electrical systems.
- Safety ground between the Building Ground and Detector Ground are connected via a saturable inductor.
- A double shielded ‘isolation’ transformer provides power to detector electronics.
- Dielectric breaks on all cryogenic piping entering the cryostat
- The APA frame is connected to the circuit common of all FE ASICs.
- For ProtoDUNE: All electrical connections (power and signal) from an APA shall lead to a single feedthrough.
- The circuit common of the FE ASIC and the rest of the cold readout are connected to the common plane/enclosure of the cold FE module.
- The APA Power line return leads, and any shields, are connected to the common plane of the cold FE module at one end and to the flange of the feedthrough at the other end. This is the sole connection of the APA frame to the membrane cryostat.

ProtoDUNE AC Distribution Scheme



SBND AC Distribution Schematic

http://sbn-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=284



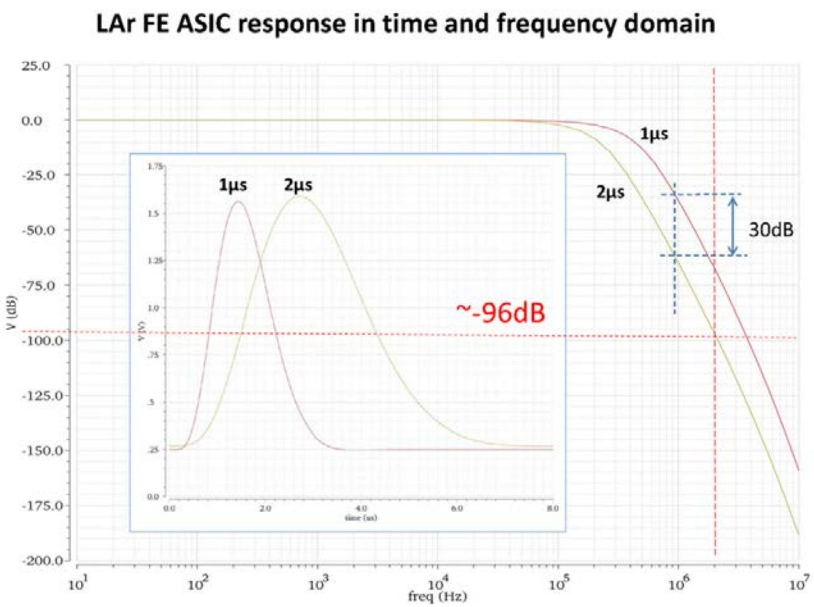
SBND Building Ground

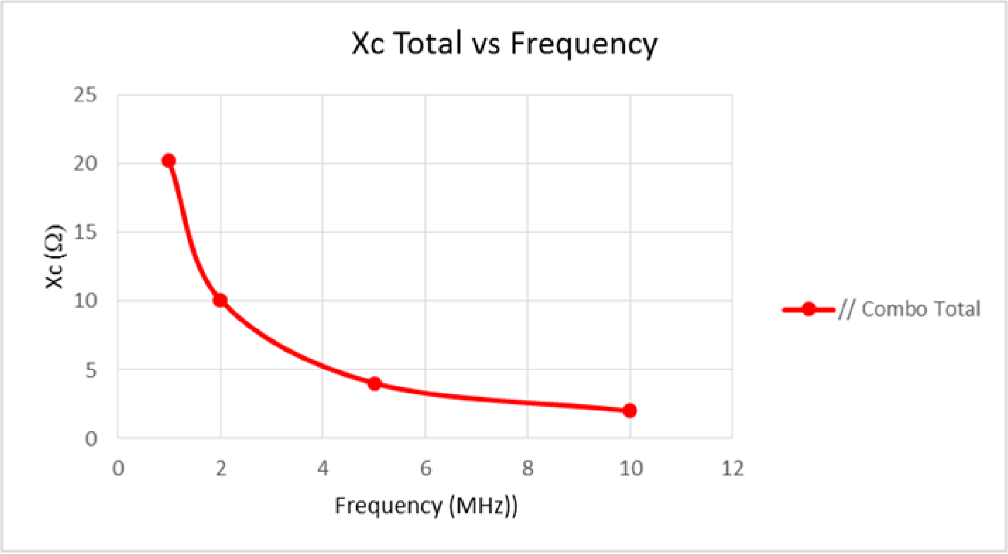
To establish a solid building ground, an Ufer ground was constructed within the Near Detector building. Measurements have been taken with a Fluke 1630 Earth Ground clamp throughout the construction. The latest resistivity measurement of the Ufer ground structure is < .3 Ohms.

Expected Isolation Bandwidth

DC isolation between the detector and the building is relatively easy to achieve. AC isolation is more difficult. An analysis was conducted to determine the spacing thickness between the detector I-beam structure and the building concrete to achieve 10 Ohms at 2 MHz capacitive reactance.

http://sbn-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=1077

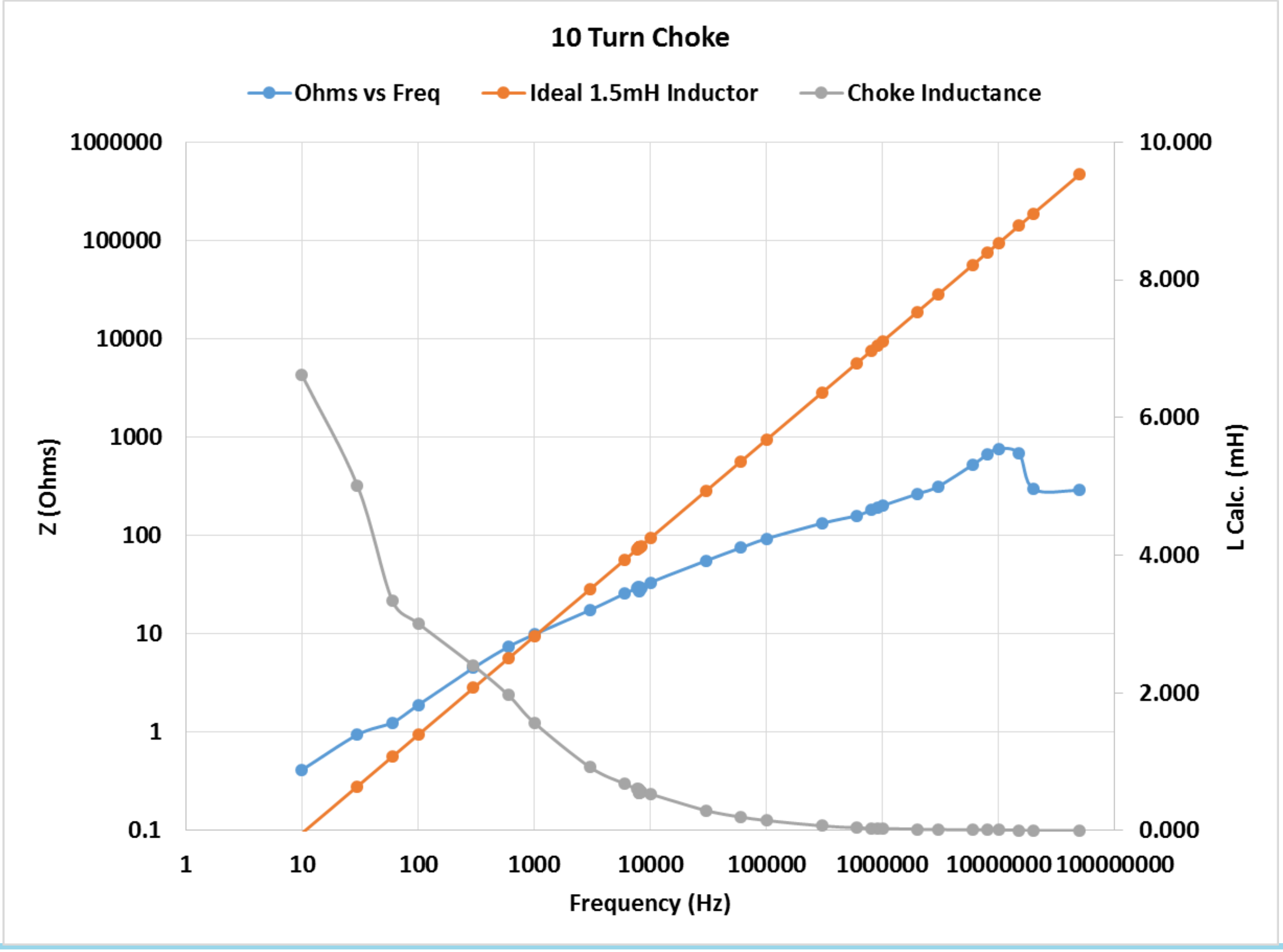




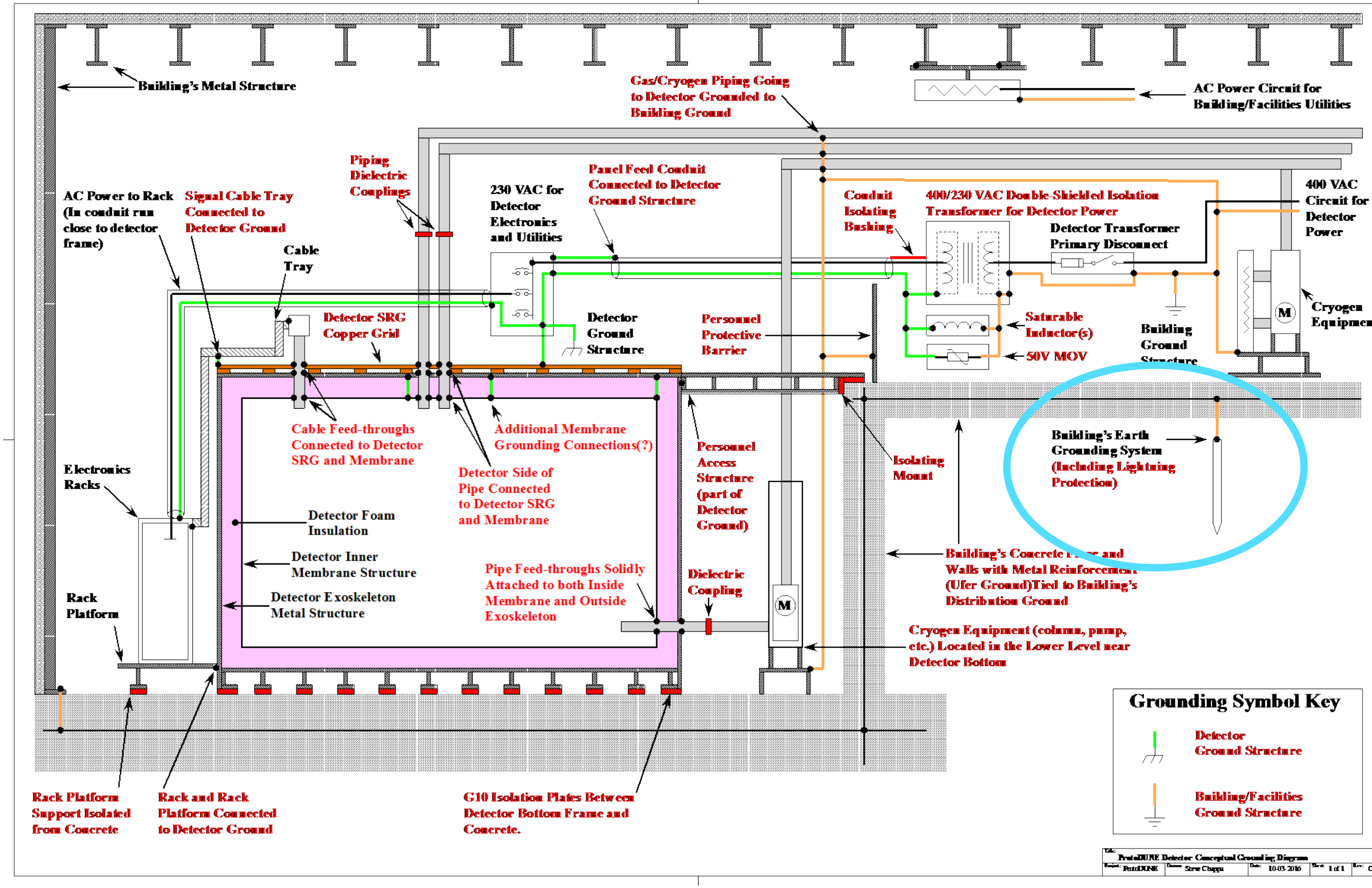
Response with 2" G-10 Garolite

Saturable Inductor Response

A study was done by Dave Huffman to determine the response of the 10-turn saturable inductor.



ProtoDUNE Grounding Concept Graphic



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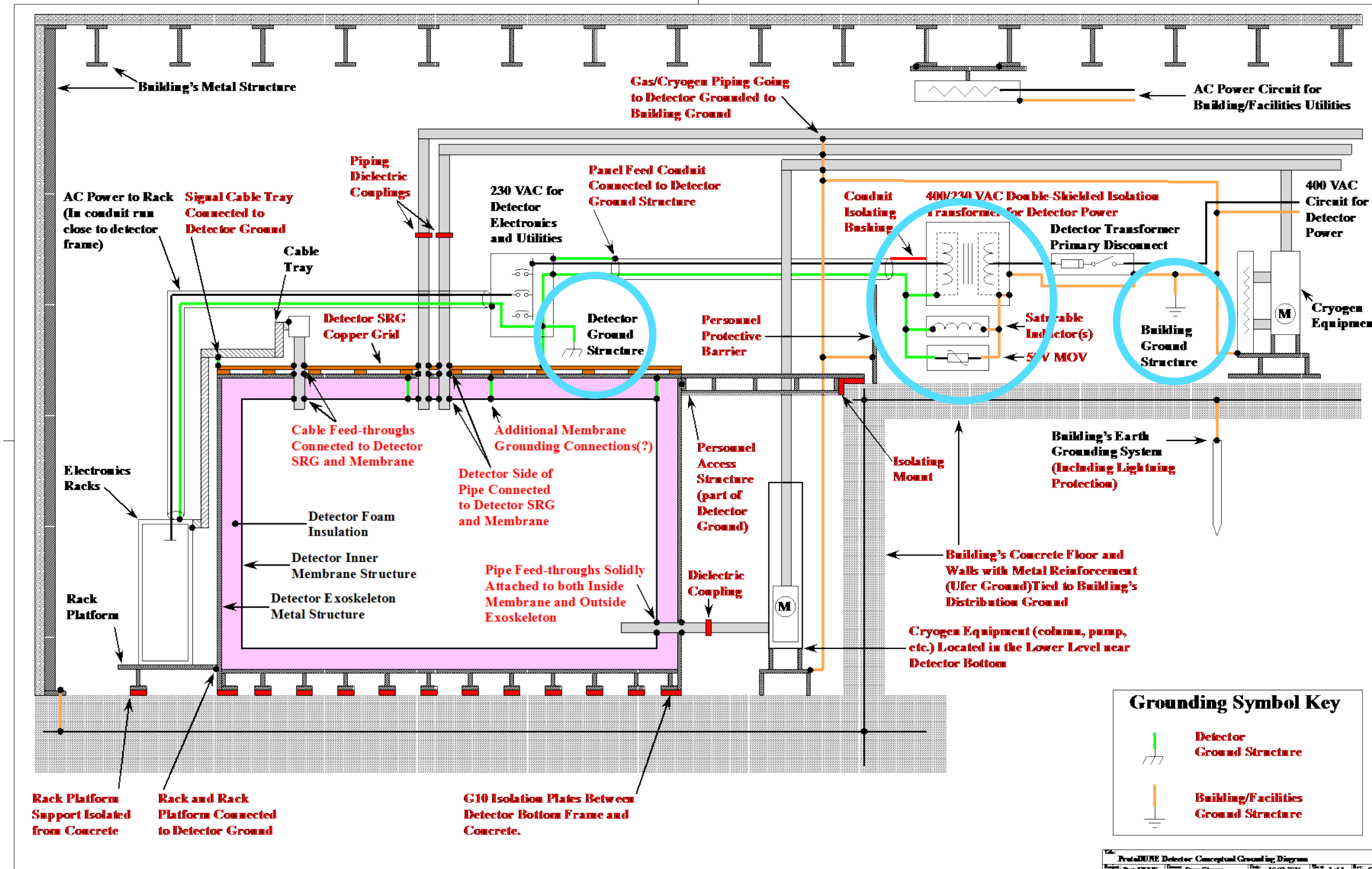

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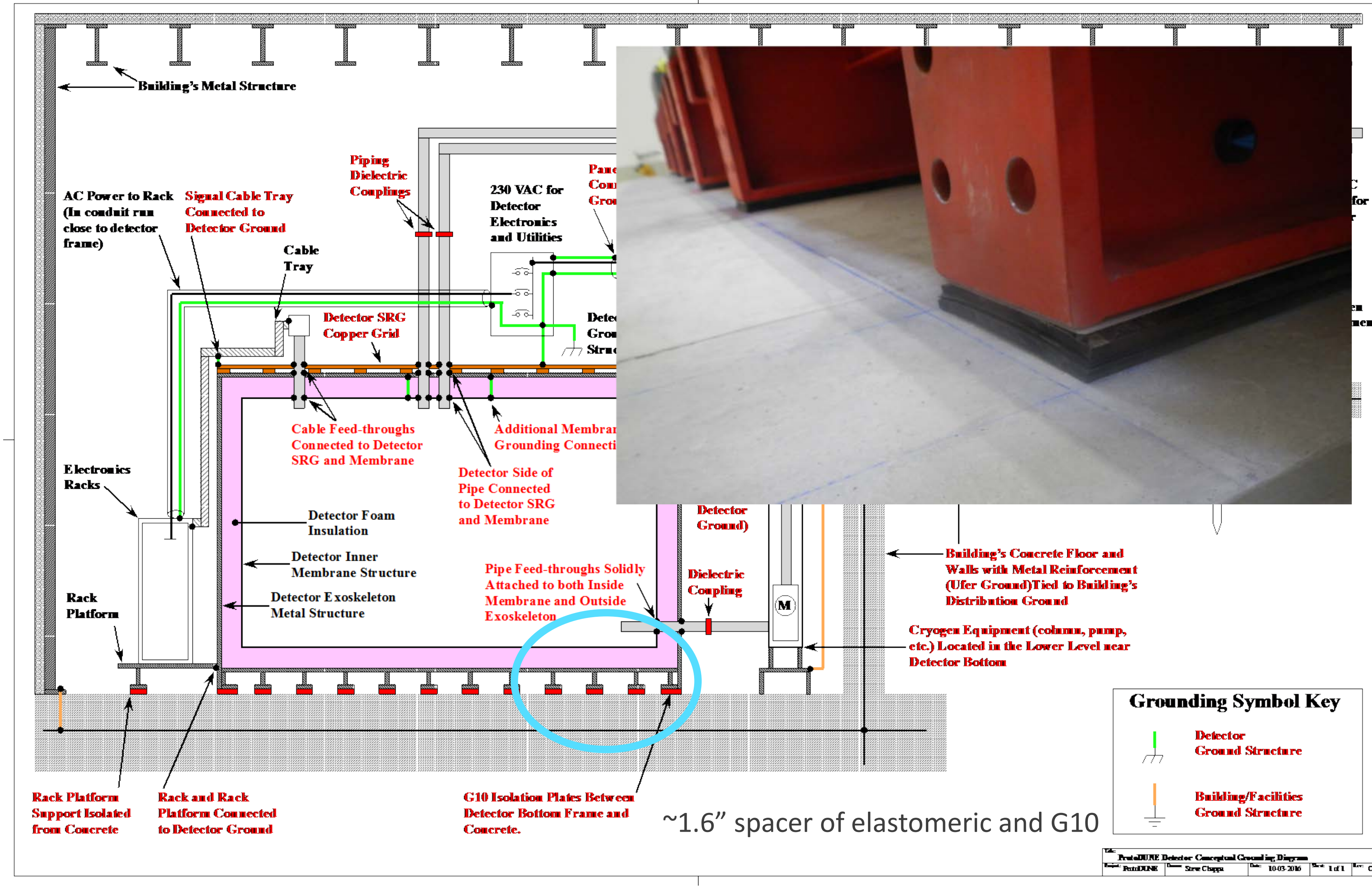
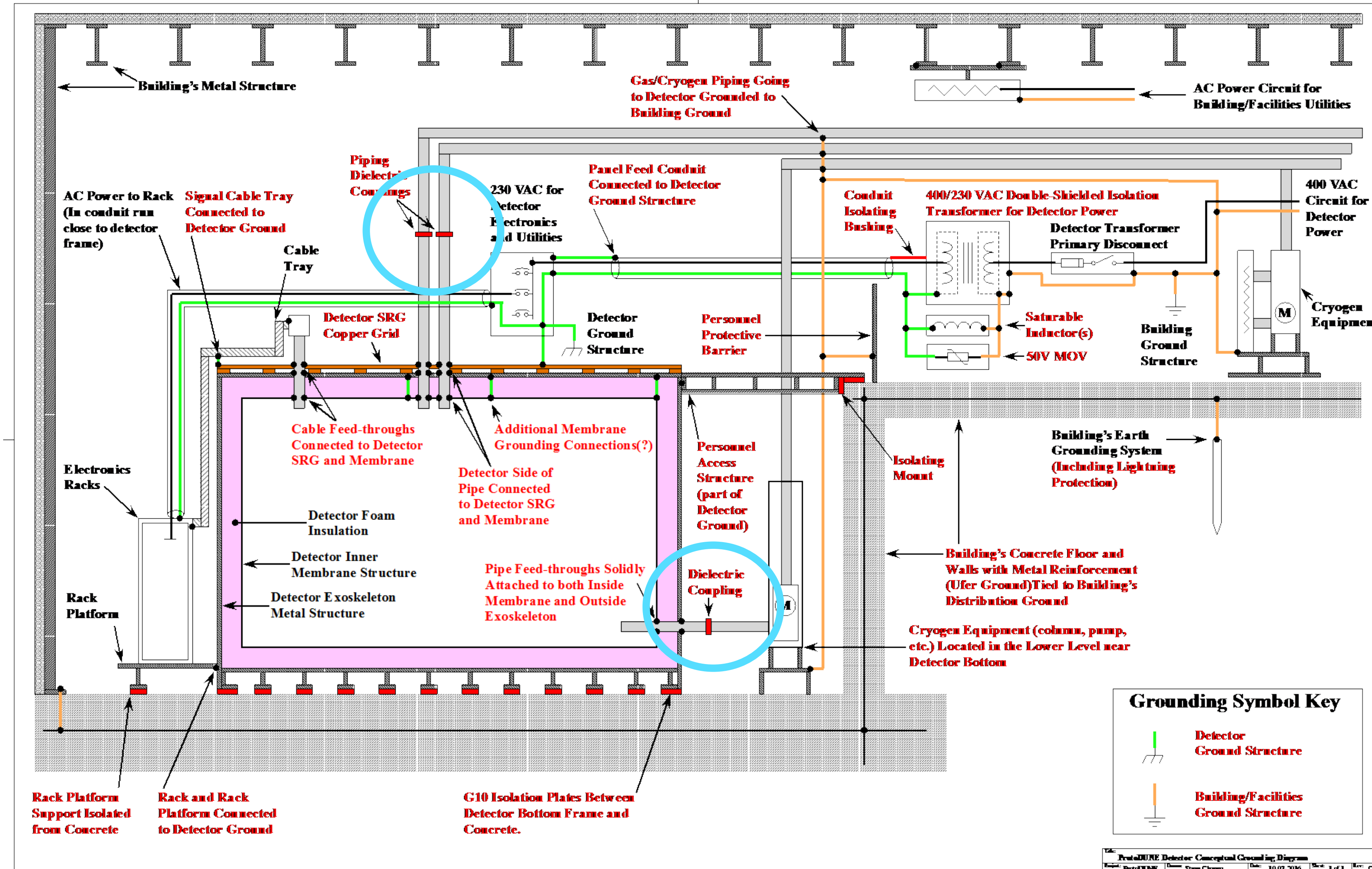
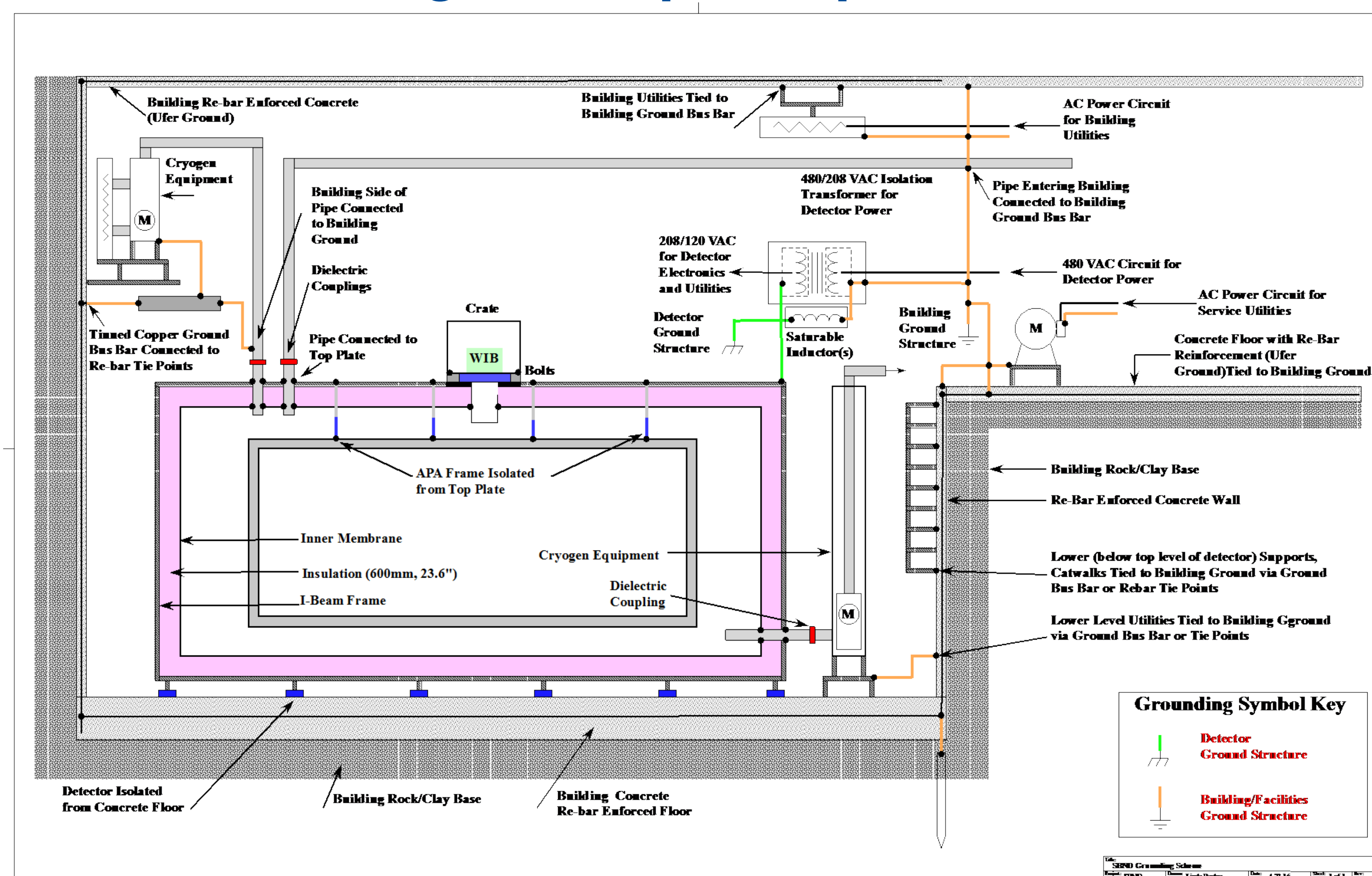


~1.6” spacer of elastomeric and G10

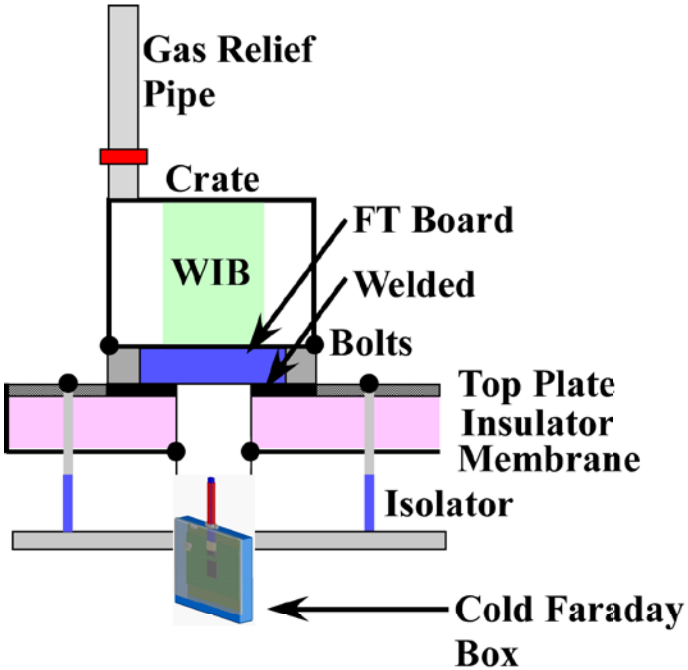
ProtoDUNE Grounding Concept Graphic

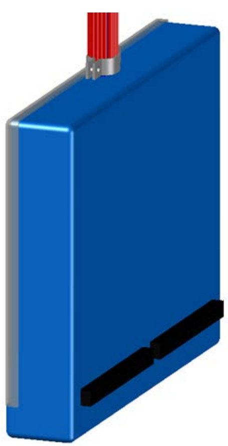


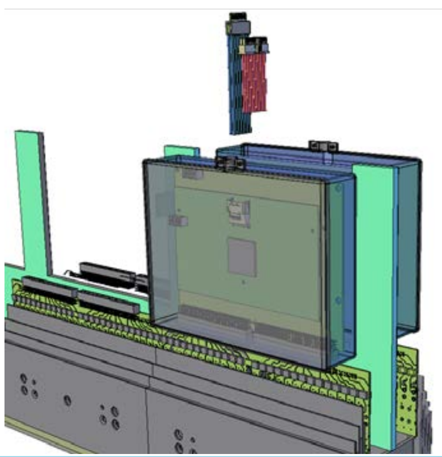
SBND Grounding Concept Graphic



ProtoDUNE/SBND Voltage Distribution Grounding Connections



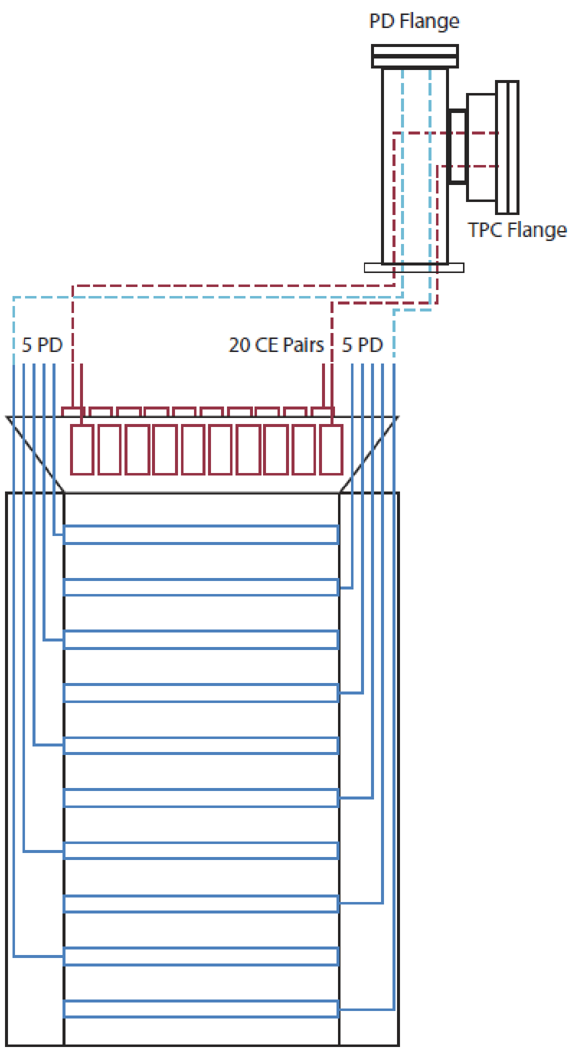




The signal ground of the FE ASIC is connected to the Detector Ground via the power returns in the warm electronics crate mounted on the top of the detector.

- +12V source must be floating from the supply chassis
- Supply returns are connected at ground plane of PTC card
- PTC card ground plane is connected to crate backplane
- Crate backplane ground plane is connected to crate housing
- Crate housing bolted to Feedthrough
- Feedthrough welded to membrane
- APA frame isolated from membrane
- CE boards mounted to APA frame inside cold faraday box.

ProtoDUNE SP APA Cable Routing Concept for PD



The PD cables for each APA are routed to a dedicated Feedthrough flange.

- 10 PD cables per APA frame
- Dedicated PD Flange port
- PD frame conductively connected to APA frame-no floating metal
- Shielded twisted pair cables used for signal
- Provisions for a variety of reference terminations are built into the design

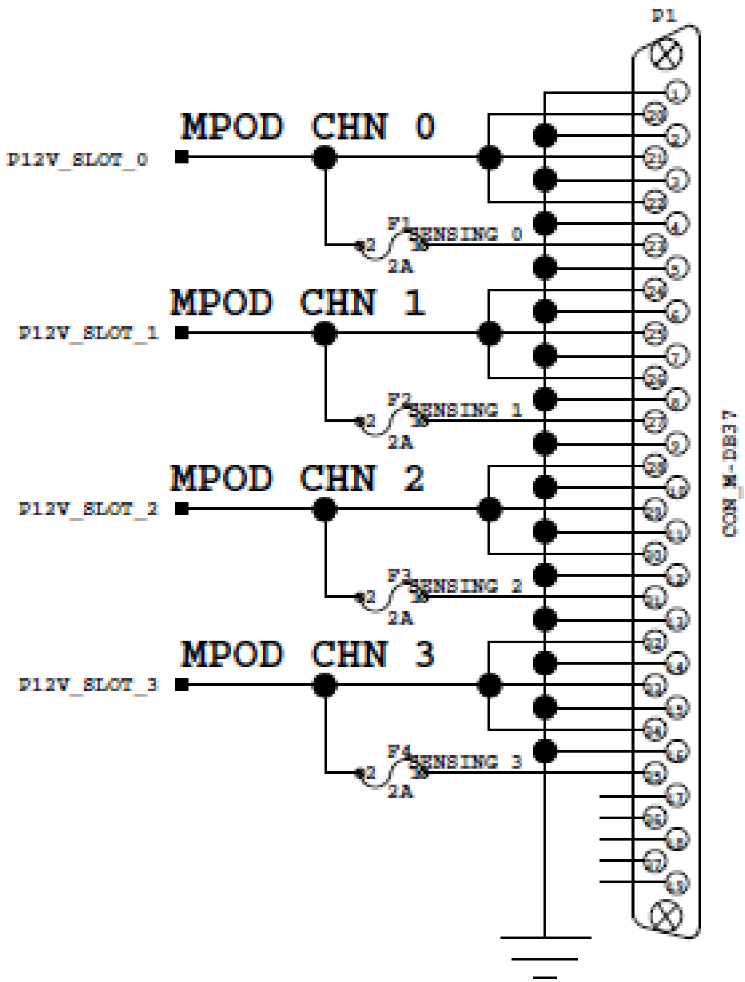
ProtoDUNE Voltage Distribution Requirements

- Provide +12V/20A of DC voltage to each WIB crate mounted on top of 6 TPC feedthrough ports, 5 WIBs/FT.
- Provide +12V/1A of DC power to PTC card, housed within the WIB crate, one per feedthrough.
- External Interlock capability.
- Ethernet network capable with integration into Slow Controls monitoring system.
- Over current/over voltage protection.
- Power control (granularity needs to be defined; crate or WIB level).
- Ripple: <2mVpp @ 20MHz.
- Readback resolution: 100mV/100mA
- Voltage ramp rate 1-500V/s.

SBND Voltage Distribution Requirements

- Provide +12V/24A of DC voltage to each WIB crate mounted on top of 4 TPC feedthrough ports, 6 WIBs/FT.
- Provide +12V/1A of DC power to PTC card, housed within the WIB crate, one per feedthrough.
- External Interlock capability.
- Ethernet network capable with integration into Slow Controls monitoring system.
- Over current/over voltage protection.
- Power control (granularity needs to be defined; crate or WIB level).
- Ripple: <2mVpp @ 20MHz.
- Readback resolution: 100mV/100mA
- Voltage ramp rate 1-500V/s.

ProtoDUNE/SBND Voltage Distribution Connections



Power, Timing, and Control card

- Two 37-pin D connector interfaces on front panel of PTC card.
- Sense fusing built into card.
- Investigating MPOD solution.
- Once power supply is identified, will be able to continue with interface engineering.

Summary

- Charge Item 6:

Is the grounding and shielding plan for the detectors and its impact on the CE systems understood and adequate?

- For both experiments:
  - Grounding Points finished
  - Grounding Concept graphics finished.
  - DC LV ASIC Power in progress.
- ProtoDUNE:
  - Isolated AC Power concept design finished.
- SBND:
  - Isolated AC Power design finished.

Back Up Slides

GIZMO: Ground Current Impedance MOnitor

- Successfully implemented on MicroBooNE.
- Part of the AC Distribution scheme.
- Consists of 4 components
  - Monitor chassis
  - Amplifier
  - Current transformer
  - Speaker
- Provides a stimulus current
- Imbalance in return current signifies a short between grounds.
- Runs 24/7 at MicroBooNE without affecting data.
- http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=1805
- http://sbn-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=1322

GIZMO Upgrade Design Features

Mike Utes has begun the upgrade design work on the Impedance Monitor for ProtoDUNE and SBND. Based on operational experience at MicroBooNE and 35-ton, the following upgrades will be implemented:

- Frequency locking amplifier
- C, L, and R front panel digital display
- Variable frequency stimulus