ProtoDune Grounding Review

Photon Detector Grounding & Connections

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Outline of Talk

- Review Charge & Content
- Photon Detector Readout Concept
- Overview of the Readout Module
- ProtoDUNE Photon-Detector Grounding Plan
- ProtoDUNE Photon-Detector Signal Cables and Connector Status
- ProtoDUNE Photon-Detector Signal Feed-thru Status
- Signal Cable and Feed-thru Connection Tests
- Tests in warm cryostat and Signal Connectivity Verification

Review Topics to be Covered

"The Committee is requested to review the ProtoDUNE-SP detector plan for electrical connections and grounding and determine if it is sound and that the plan for testing the connections is sufficiently robust and complete…."

(From charge):

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

6. Is the electrical connection plan for the photon detector readout from SiPM to SSP and the QC 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 by the DAQ?

Photon-Detector Readout Concept

- Block Diagram of the Instrumentation System for ProtoDUNE

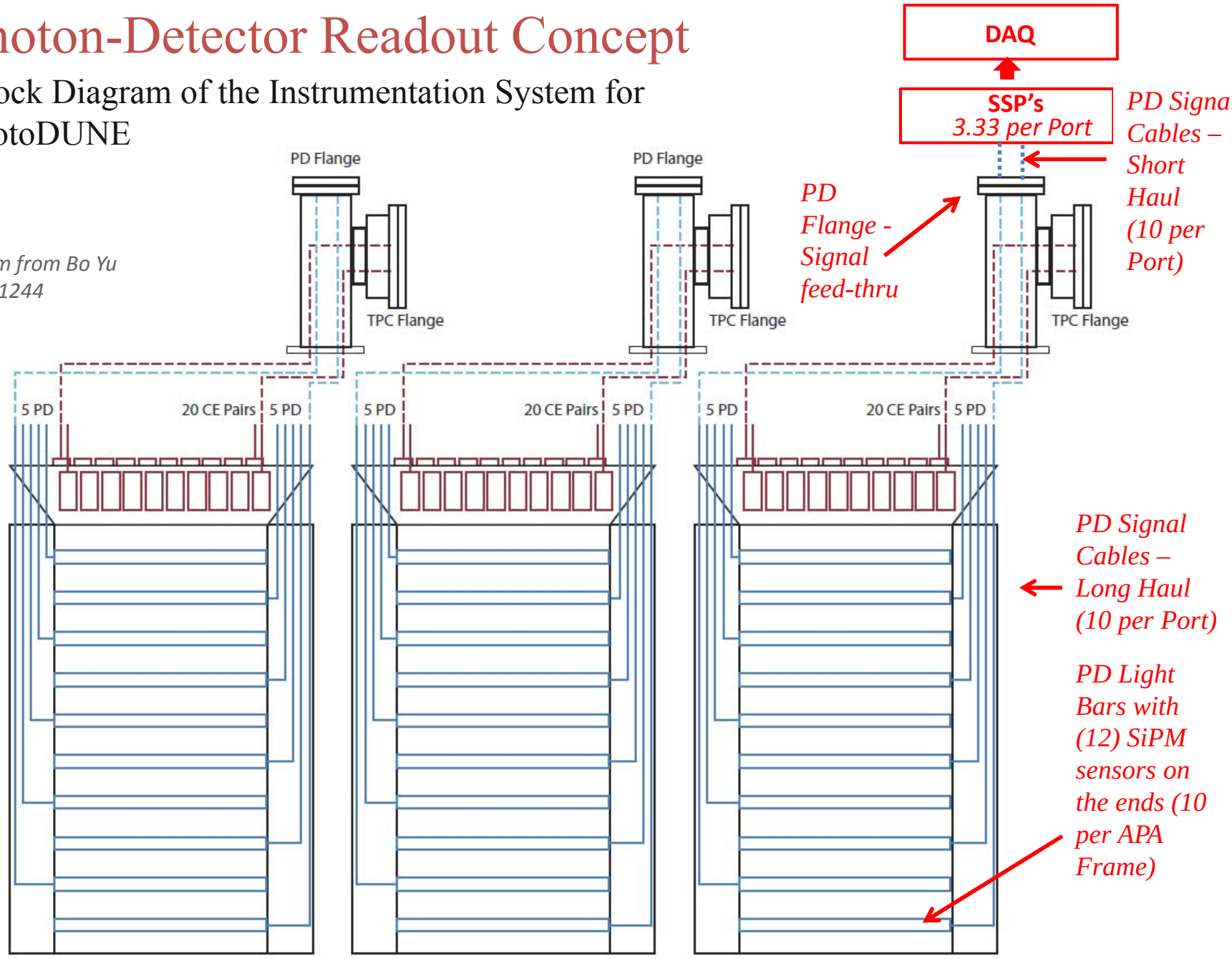
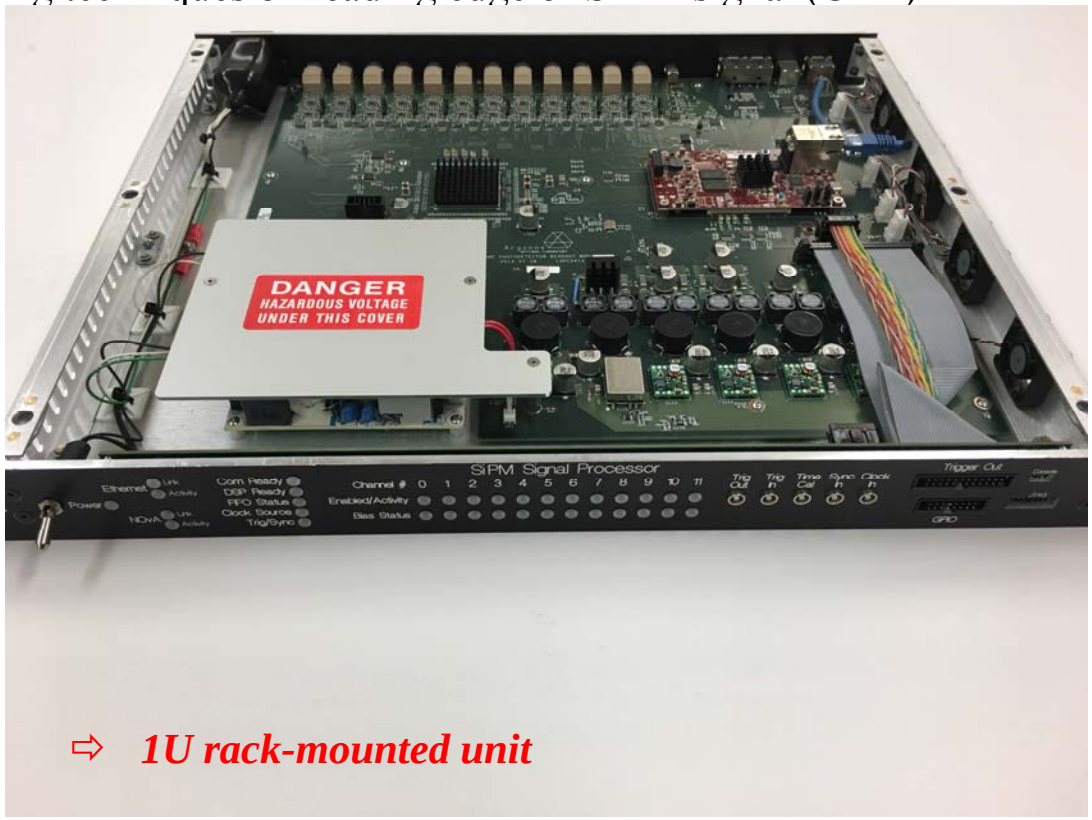


Diagram from Bo Yu DocDB 1244

Total of 240 PD readout channels distributed across 24 Readout Boards; No Cold Electronics in the PD system!

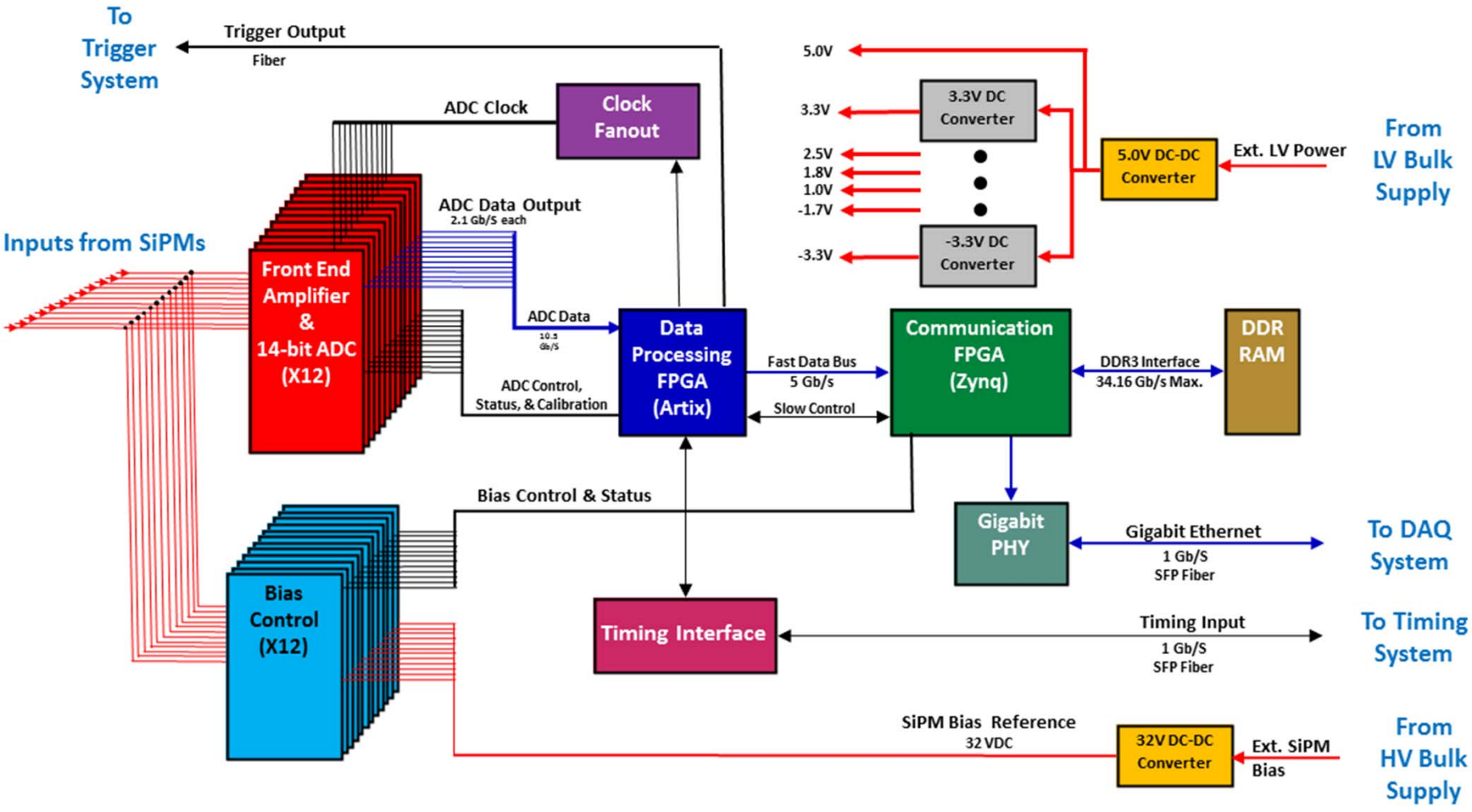
Overview of the ProtoDUNE SSP Module

- **The Silicon Photo-multiplier Signal Processor (SSP) prototype module:**
  - High-speed waveform digitizer
  - ***Current sensitive, differential input amplifiers*** → Optimal noise performance over long cables
  - Each channel has a ***14-bit, 150 MSPS ADC***
  - ***Timing*** obtained using signal processing techniques on leading edge of SiPM signal (CFD)
  - 12 channels per module
  - Uses Artix FPGA for sig. proc.
  - Has ProtoDUNE Trigger/Timing Optical Interface
  - ***Uses external floating DC power***
  - Has internal prog. SiPM bias (30V)
  - Trigger: self or external
  - ***Has Trigger Out signal via Optics***
  - Deep data buffering – 13 μS
  - ***No dead-time*** (up to 30 KHz/ch)
  - Programmable DAQ interface
  - ***Optical GbE communications***
  - Internal charge injection
  - Internal bias monitoring



⇨ ***1U rack-mounted unit***

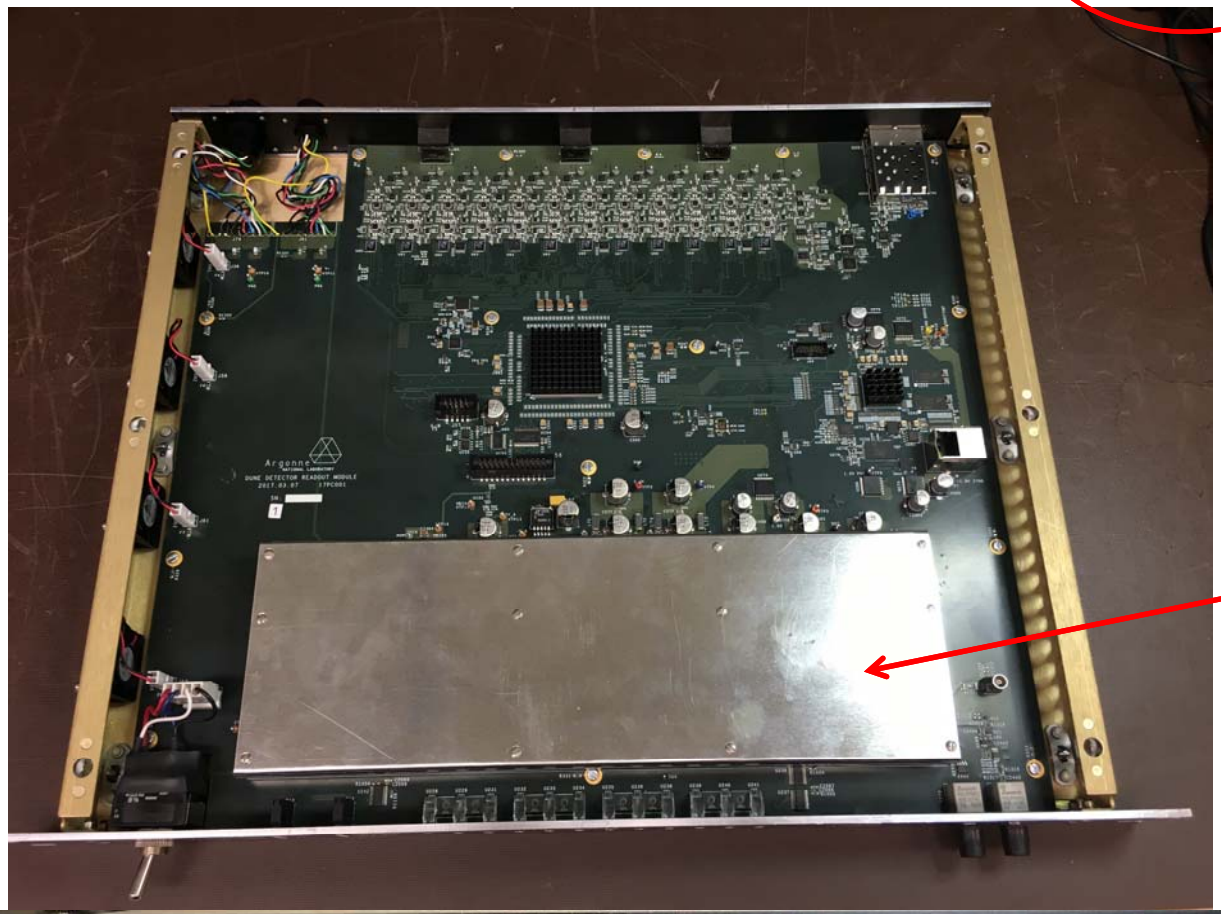
SSP (SiPM Signal Processor) Block Diagram



Overview of ProtoDUNE SSP

Rear Panel

DC Power Inputs



View with top cover removed

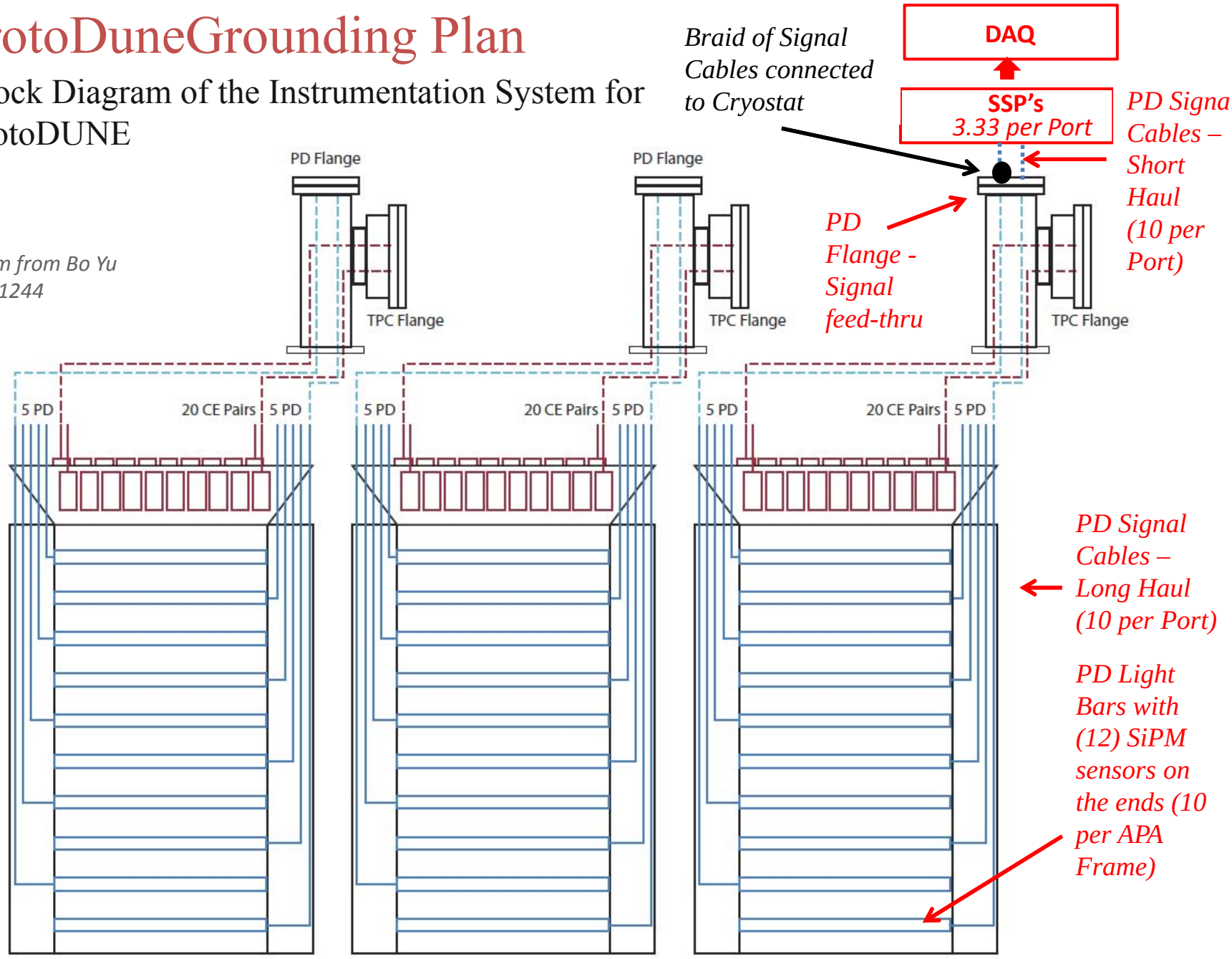
Magnetic Shield over DC-DC Converters

Front Panel

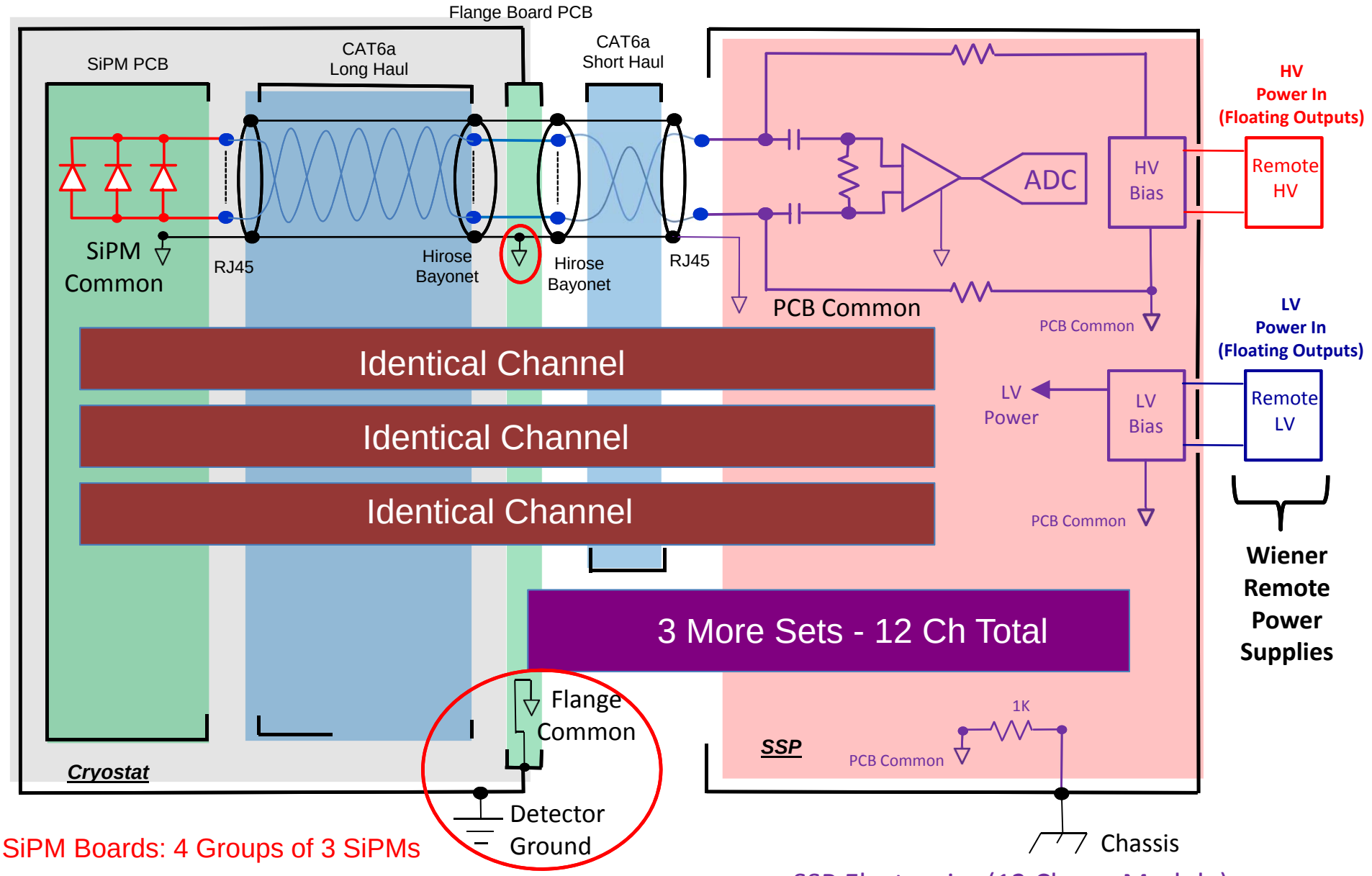
ProtoDuneGrounding Plan

- Block Diagram of the Instrumentation System for ProtoDUNE

Diagram from Bo Yu DocDB 1244



ProtDUNE PD Grounding Plan

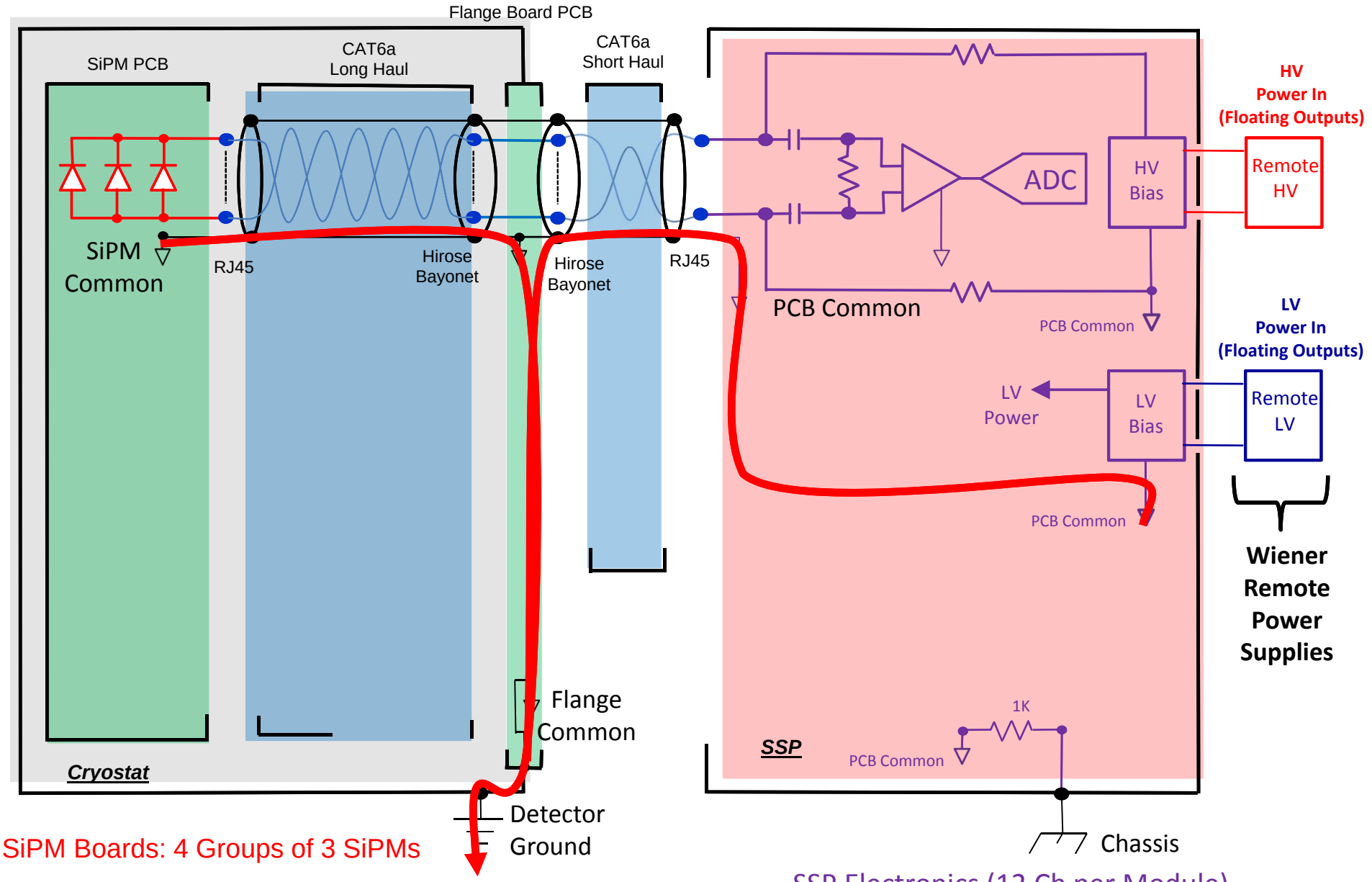


SiPM Boards: 4 Groups of 3 SiPMs

Signal Cables: 4 individually-Shielded Twisted Pairs

SSP Electronics (12 Ch per Module)

ProtDUNE PD Grounding Plan

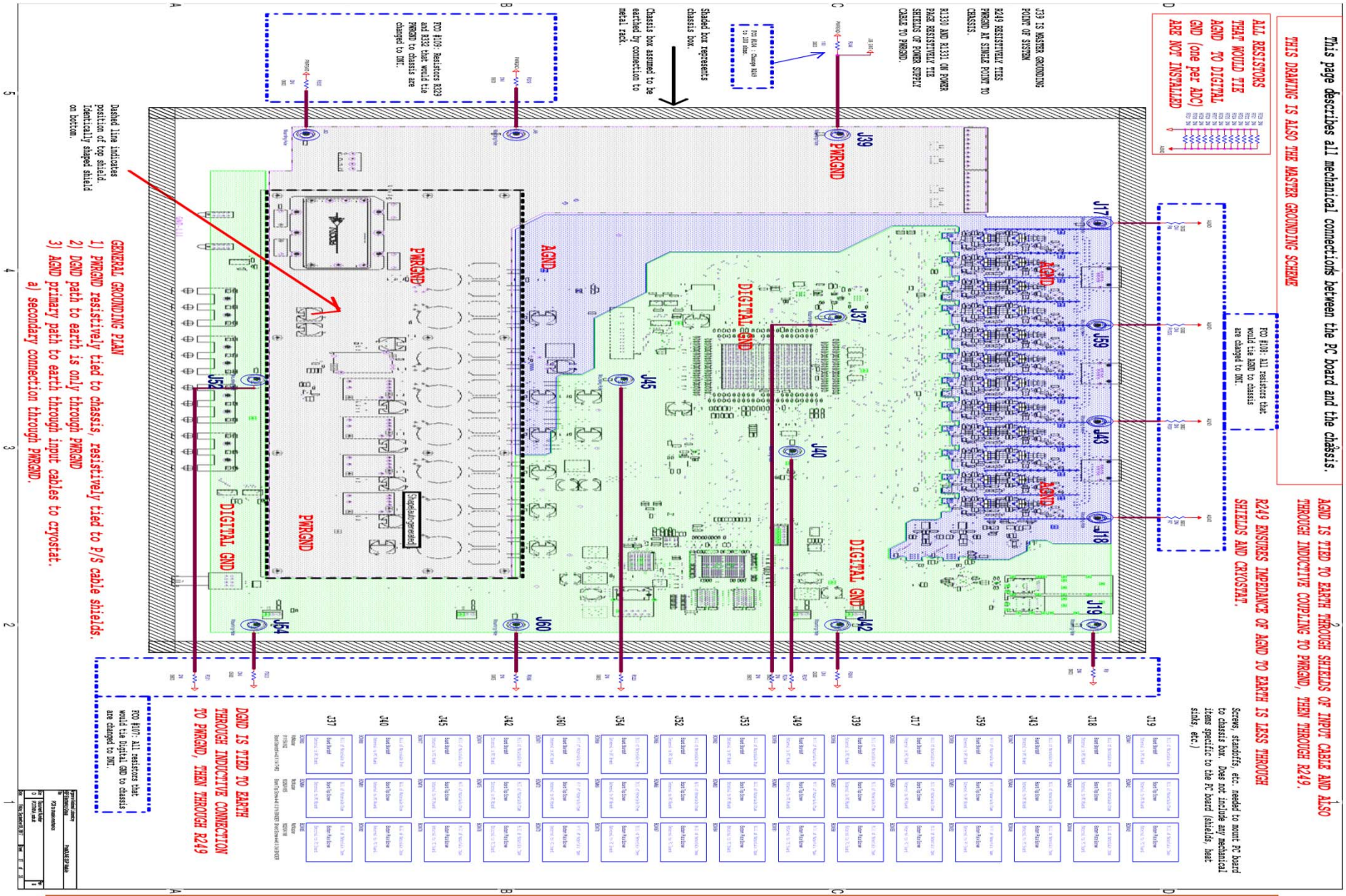


SiPM Boards: 4 Groups of 3 SiPMs

Signal Cables: 4 individually-Shielded Twisted Pairs

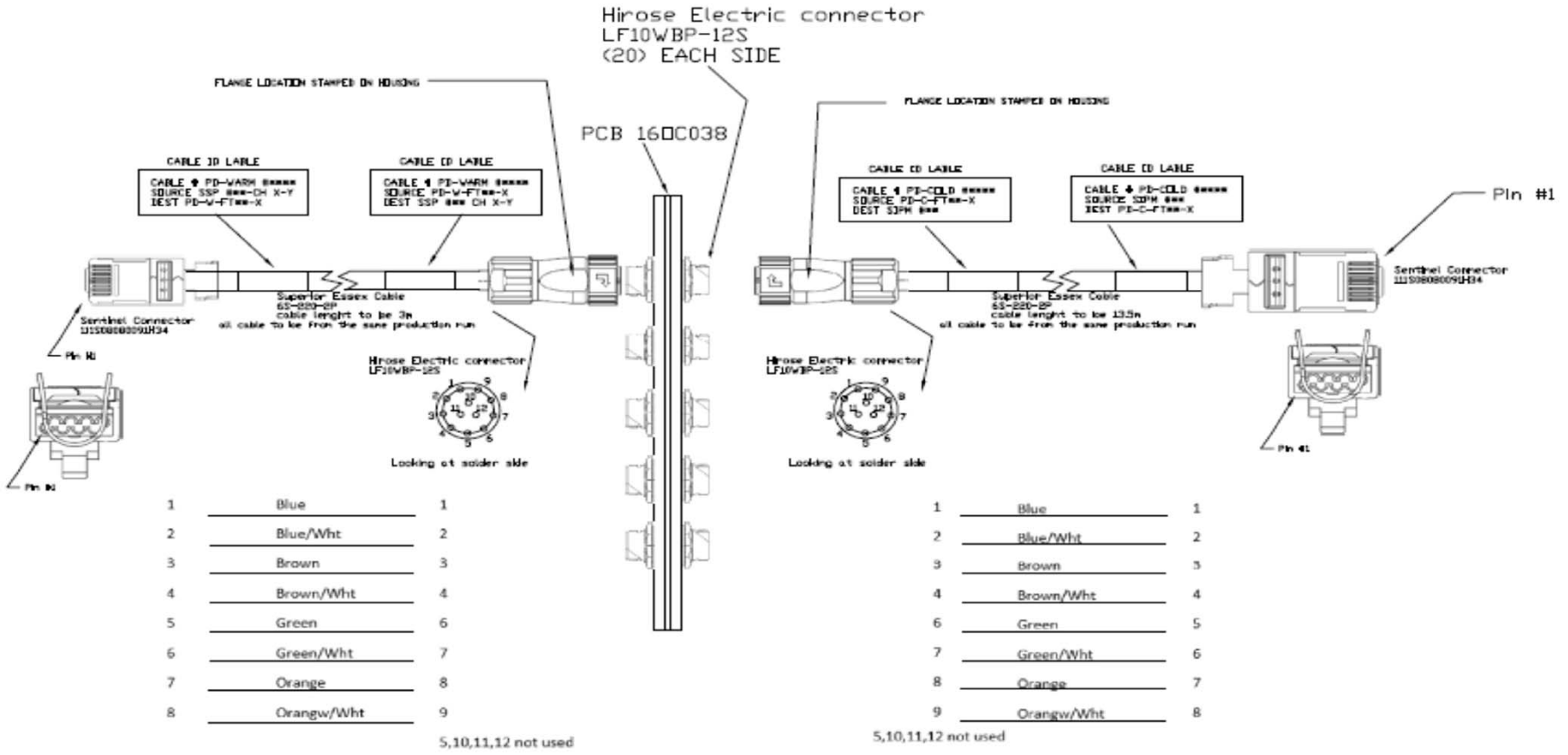
SSP Electronics (12 Ch per Module)

SSP Mechanical Connections Between PC Board and Chassis



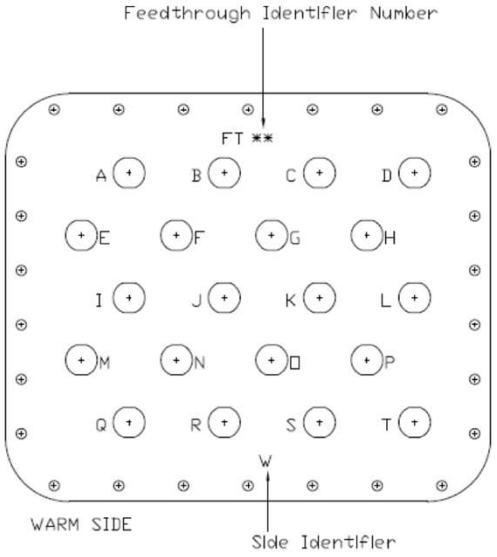
PD Signal Cable/Connector Status

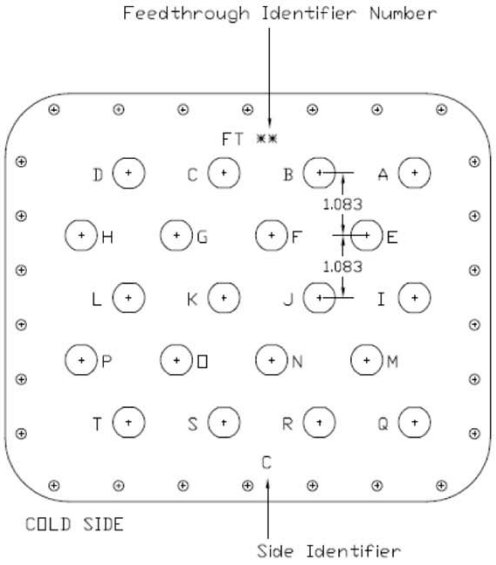
- Total of 60 + 10 cables with connectors to be delivered for ProtoDUNE
- The photon-detector signal cables for the first APA have been manufactured and delivered to CERN
  - -passed electrical continuity tests at CERN
  - -cold cables installed with first APA; “cold” cables + SiPMs tested for connectivity
- Photon-detector warm and cold cables, and feed-through (labeling) scheme shown below:

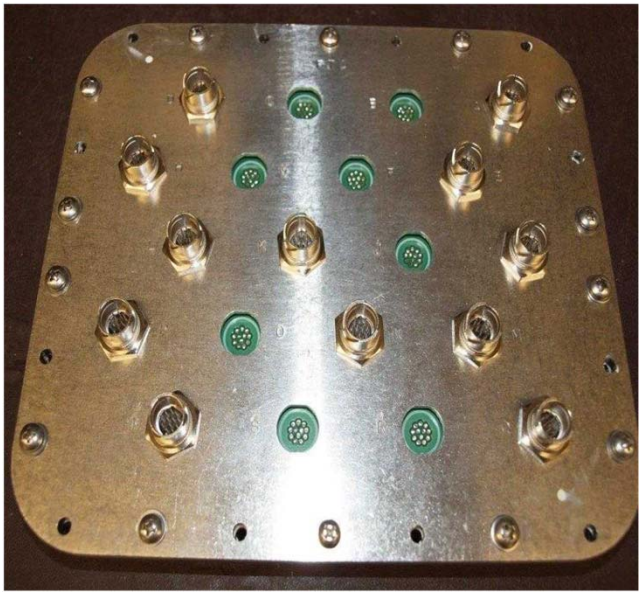


PD Signal Feed-Through Status

- A total of six PD cable feed-throughs (+ spares) will be delivered for ProtoDUNE
  - First feed-through for the Cold Box has been delivered to CERN







- The current PD feed-through will be used with APAs 1-4 tests in cold box
  -might need add more connectors for APAs 5-6
  -re-optimize gas seal for final cryostat feed-through

Signal Cable and Feed-through Labeling/Mapping Scheme

- Photon Detector Signal Cable and Feed-through Labeling Scheme described in DUNE docdb-4997
  - -currently describes first ten cable pairs and connectors (for the first APA) with feed-through
  - -same labeling scheme to be applied to rest of 50 cable pairs

Photon Detector Signal Cable and Feed-through Labeling Scheme

John Anderson, Zelimir Djurcic, Gary Drake et al.

In this note we describe an initial labeling scheme for the photon-detector cables (both cold and warm cables) and the photon-detector feed-through, as we propose to be implemented with the first APA in Cold Box at CERN. We assume that the Photon Detector (PD) group will be responsible for making the connection on the PD flange to the correct connectors.

The labeling scheme is summarized in the Figure 1. On the left side of Figure 1 we show the warm cable (type Cat6). Warm cables are 3 m long. The warm cable has attached an RJ45 connector on the SSP side, and it has a standard circular connectors (LF10WBP-12S) on the feed-through side.
The feed-though provides identical standard circular connectors on both sides of the photon-detector flange, as shown in the middle of Figure 1.
The cold PD cables (type Cat6) are 13.5 m long, schematically shown on the right of Figure 1. The flange side of the cold cable is equipped with the circular connector, whole the SiPM side does have an RJ45 to be attached to the SiPM hover-board.

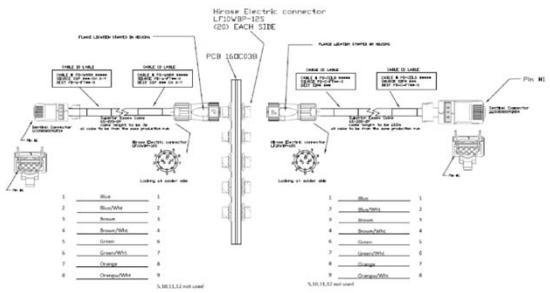


Figure 1: Photon-detector warm and cold cables, and feed-through labeling scheme.

In the following text we list the labels attached to each cable (for each pair of Cold cable +Warm cable), as well as the PD feed-through labeling scheme:

PAIR 1)

Cold Cable

APA Side	Feed-Through Side
CABLE# PD-COLD-1-01-FT-1-A SOURCE: APA-1 SiPM-01 DEST: FT-1 POS-A TYPE CAT 6	CABLE# PD-COLD-1-01-FT-1-A SOURCE: FT-1 POS-A DEST: APA-1 SiPM-01 TYPE CAT 6

Warm Cable

Feed-Through Side	SSP Side
CABLE# PD-WARM-1-00:03-FT-1-A SOURCE: FT-1 POS-A DEST: SSP-1 CHAN-00:03 TYPE CAT 6	CABLE# PD-WARM-1-00:03-FT-1-A SOURCE: SSP-1 CHAN-00:03 DEST: FT-1 POS-A TYPE CAT 6

Signal Cable and Feed-through Labeling/Mapping Scheme

- Warm cables (picture on the left):
  -Middle: RJ45 connector to be attached to the readout board (SSP).
  -Right: Circular connectors (LF10WBP-12S) on a warm side of PD feed-through.

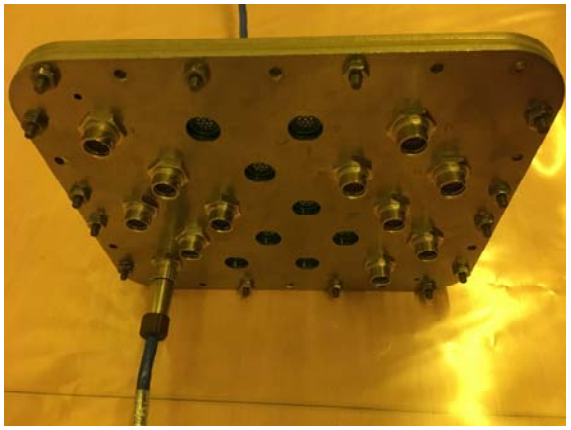


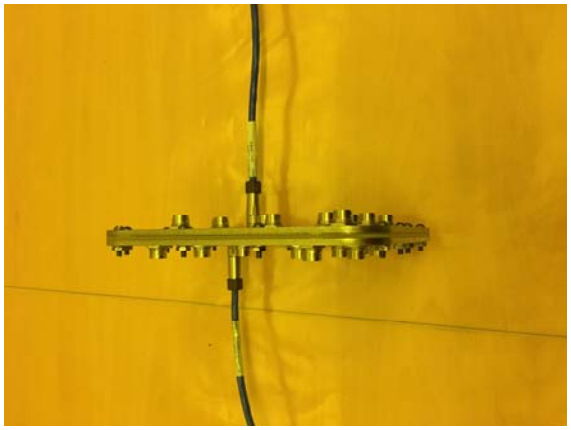
- Cold cable (picture on the left):
  -Middle: RJ45 connector to be attached to the SiPM hover-board.
  -Right: Circular connectors (LF10WBP-12S) on cold side of PD feed-through.

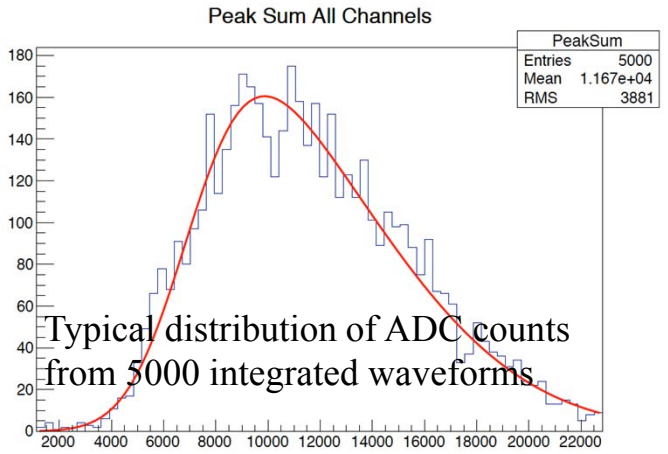


PD Signal Cable/Connector and Signal Feed-Through Status

- Cable/feed-thru connections tested after arrival at CERN; the idea is to perform onsite Electrical Signal Tests in ProtoDUNE clean-room with
  - -"cold" signal cables
  - -"warm" signal cables
  - -signal feed-trough
- Test of first 10 cold and warm cables performed by Z. Djurcic, E. Niner, E. Segreto, A. Machado
- Put together a setup with the dark box, photon-detector, UV LED + pulser, photon-detector readout board (old type SSP) + PC, photon-detector signal cables, and the photon-detector feed-through.
- Test successful for all cables/feed-through channels: clear signals observed.







Signal Connectivity Verification

- SiPM Diode Test
  - SiPM Hover Boards will be tested for functionality using DVM "Diode Test"
  - Can repeat after cables have been connected, before connection to SSP
- Ground Shield Integrity Test
  - Before connection to SSP, use ohm meter to check continuity of shield to cryostat
- Singles Test
  - After complete connection from SiPM to SSP, apply bias to SiPM
  - Set the SSP channel threshold at ~X3 of the RMS of the electronics (~10 ADC counts, because the RMS ~ 3 ADC counts)
  - Set SSP to self-trigger on singles
  - Should see the characteristic shape of a single pe (and/or multiple pe's)
  - Must have ~dark environment
  - Final test before closing & fill
- Test with Calibration Module
  - Install Calibration module and emit light from CPA diffusers to APA
  - With calibration module available before the TCO is closed we may emit light pulses and self-trigger SSPs to collect multi-pe waveforms.

Summary

- SSP Grounding Plan in place & being implemented
  - Conforms to ProtoDune Grounding & Shielding Plan
- Connectivity Tests have been developed
  - Diode test
  - Singles Test
  - Tests with Light Pulses from the Calibration module
- Cable Labeling Scheme in place
  - Documented in DUNE docdb-4997