Electronics Layout Overview

DUNE Far Detector #2 Photon Detector System Workshop

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Readout Flavors

- Primary factors:
 - a. Signal quality
 - b. Long-term cold qualification trade-offs
 - c. Topology cost
- Where is the cold/warm boundary?
- Where is the analog/digital boundary?
- Otherwise same components:
 - a. Passive/active SiPM ganging
 - b. Buffer stage
 - c. Digitizer

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d. Aggregation & DAQ interface layer







Digitizers

- Optimal readout solution: signal quality, long-term cold qualification tradeoffs, and overall topology cost.
- **Cold analog** is simplest for long-term cold qualification and warm digitizer flexibility.
- However, digitizing closer to SiPMs should be beneficial to signal quality.
- <u>Digital electronics</u> count (and thus power/cost) can always be reduced in exchange for lower sampling/bit rate/0-suppression and longer analog signal runs. We have assumed 14-bits @ 80Msps and 1m runs
 - If we assume <4m analog runs & ½ digitizer data-rate...
 - 1 CE box per 20 PD modules, 16 FPGAs
 - If we assume <6m analog runs & 1/4 digitizer data-rate...
 - 1 CE box per 36 PD modules, 9 FPGAs
- **Warm digital/analog electronics** in cryostat trade electronic qualification for mechanical qualification.
- **Redundancy** may be the best path to long-term cold qualification.

Warm Electronics

- Fibers/cables from feedthroughs to racks; digitizing of analog signals and aggregation (i.e. PDS FPGA layer, e.g. DAPHNE) of timestamped data.
- High-speed serial data sent to DAQ FELIX cards.
- DAQ-PDS scope boundary at warm patch panel where timing/data/GbE arrive
 - DAQ defines connectors on DAQ-side of patch panel, PDS defines other side of patch panel
- Power Supplies for Membrane and Cathode Power-over-Fiber transmitters in racks.



Multi-module Topology

- Pro: Multi-module topologies allow for shared SiPM bias and readout power among PD modules ⇒ <u>big cost saving</u> (\$2M risk)
- Con: Reduces redundancy
- E.g. 0-suppress and aggregate at cold-FPGA:
 - If we assume <4m analog runs & ½ digitizer data-rate...
 - 1 CE box per 20 PD modules, 16 FPGAs
 - \$0.5M C. + \$1.2M FC. = \$1.7M
 - 0.3 kW C. + 0.6 kW FC. = 0.9 kW
 - If we assume <6m analog runs & 1/4 digitizer data-rate...
 - 1 CE box per 36 PD modules, 9 FPGAs
 - \$0.4M C. + \$0.9M FC. = \$1.3M
 - 0.15 kW C. + 0.36 kW FC. = 0.5 kW



Baseline Fiber/Cable Plan

- 320 Cathode modules
 - 2-channels per module. 4 modules share readout power. 20 modules share SiPM-bias.
 - 1 analog optical transmitter per channel. 1 readout power fiber per transmitter.
 - 640 data fibers
 - 640 readout power fibers

\$2M Risk: Cathode plane HV potential variation requires modifications to power distribution.

- 64 SiPM-bias fibers
 - OR resistive mesh \Rightarrow 1280 SiPM-bias fibers
- 2560 fibers. 8 fibers per \Rightarrow 320 feedthroughs. 12 feedthroughs per flange. 27 flanges.
- 320 Membrane modules

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- Model HD copper plant. Superior-essex cable provides 4 readout channels and power.
- 640 channels. 160 cables. 20 cables per 14" flange. 8 flanges.

Buffer Stage

- Plan for 10x gain
- Considering copy buffer stage for redundant readout paths



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Grounding Plan

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Cathode: voltage reference from conductive mesh forming a cage around PD module.



Rigid interface board:

Active ganging, PoF, readout fibers.

Reference voltage to case of PoF Receivers.

All cold electronics references to negative leg of (PoF) SiPM Bias.

Readout Demonstration Progression

- Cold Box 1
 - Goals: Cathode mounted detector module, power-over-fiber, analog readout
 - Stretch: Cryosub readout
- Cold Box 2
 - Improved Cathode mounted detector module, power-over-fiber, analog and digital/Cryosub readout
 - Membrane mounted detector module, power, readout.
 - DAQ integration
- Cold Box 3
 - Improved Cathode mounted detector module, power-over-fiber, analog and digital/Cryosub readout
 - Improved Membrane mounted detector module, power, readout.
 - "Field-cage" type module mounted on Cathode, with isolated readout
 - Improved DAQ integration
- Cold Box 4

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- Improved Cathode mounted detector module, power-over-fiber, analog and digital/Cryosub readout
- Improved Membrane mounted detector module, power, readout.
- Improved "Field-cage" type module mounted on Cathode, with isolated readout
- Improved DAQ integration
- ProtoDÜNE2 module-0
 - 3 module types (Cathode, Field-cage, and Membrane), power-over-fibers, readout, DAQ integration
 - Study Field-Cage occlusion for Membrane module type