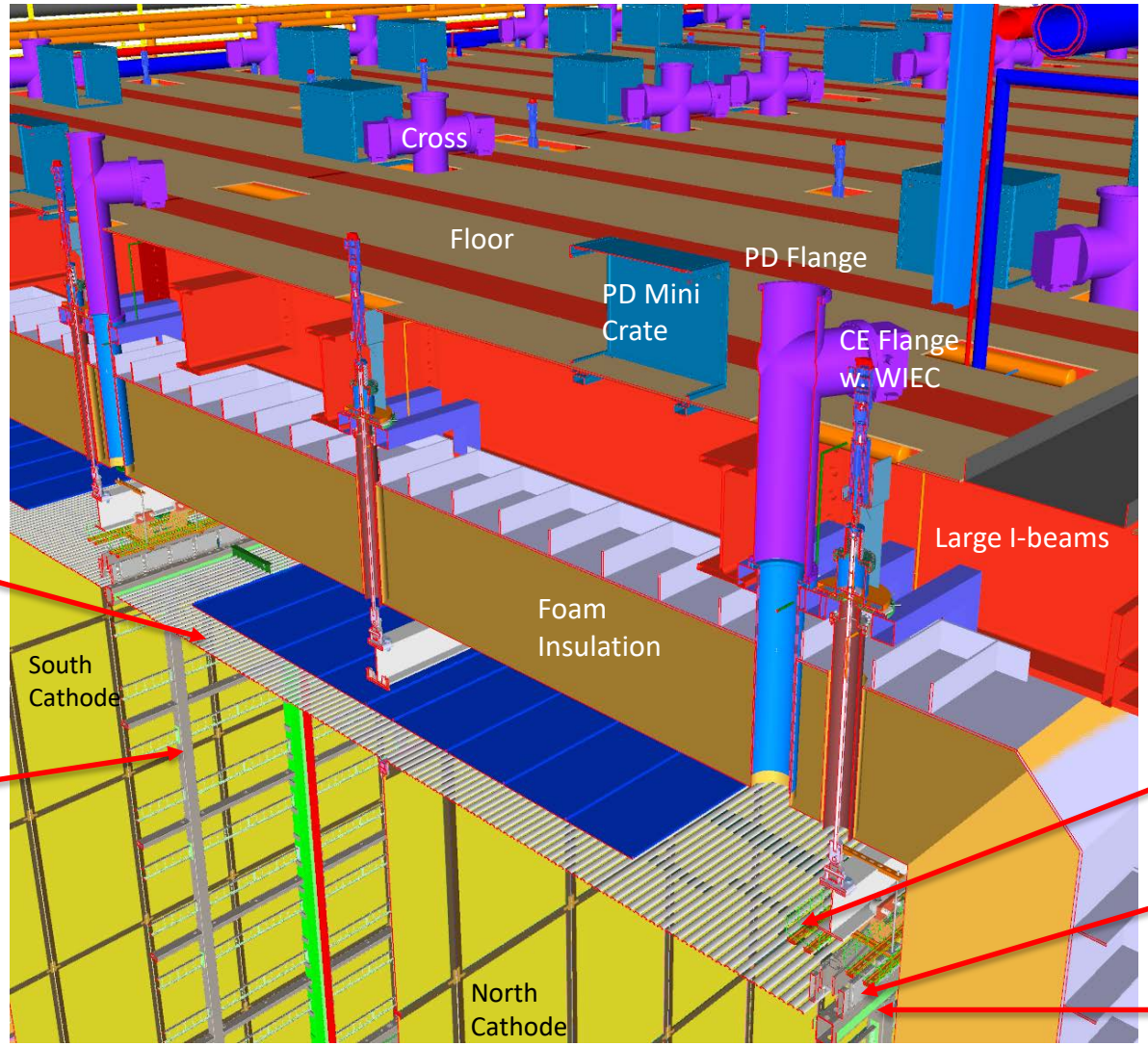
Warm Interface Electronics Crate Introduction

Bo Yu

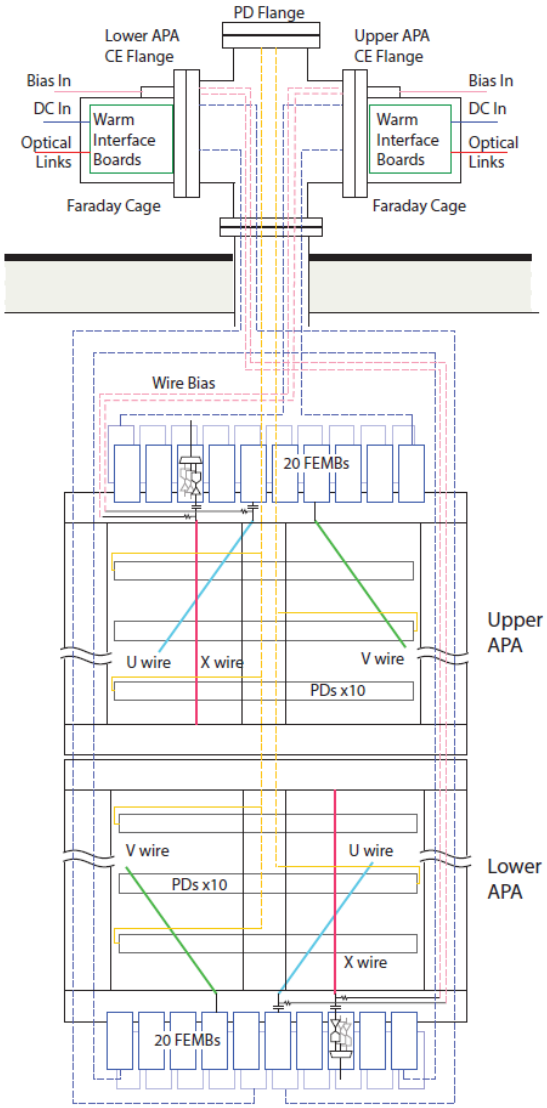
DUNE PDR: Cold Electronics WIB and System

10-Mar-2020

Layout of the Cryostat Top



Cryostat + WIEC + CE Flange = a Faraday Cage



To avoid coherent signals in group of read-out channels

- **Noise from digital circuits generated locally on a single read-out board in the crate**

  Cured by careful design of layout, filtering on the board, shielding of preamplifiers, minimization of digital operation on the board

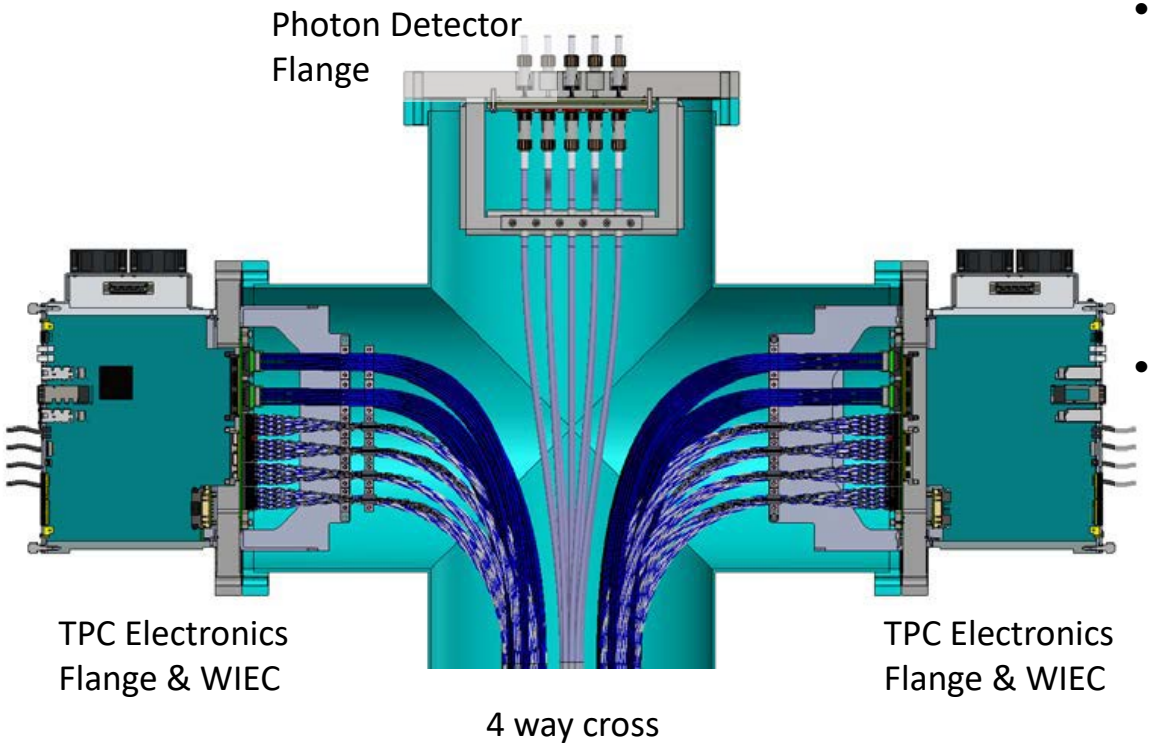
- **EM radiation surrounding the electronics and noise induced by penetration into cryostat/crates**

  • *Cured by well designed Faraday cage comprised of the cryostat, the feedthrough and the crates.*

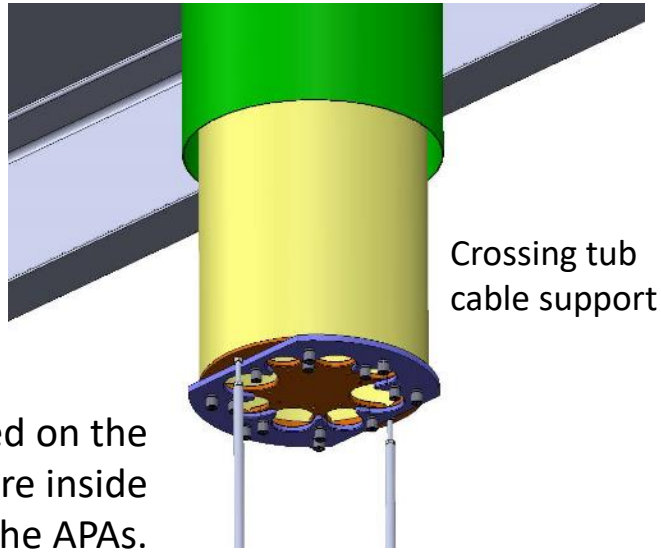
  • *No electrical penetration in the cryostat except for signal and high voltage feedthrough*

  • *All services (pressure and temperature) filtered in the crates and fed into the cryostat on shielded cables*

Cable Routing to the Flanges

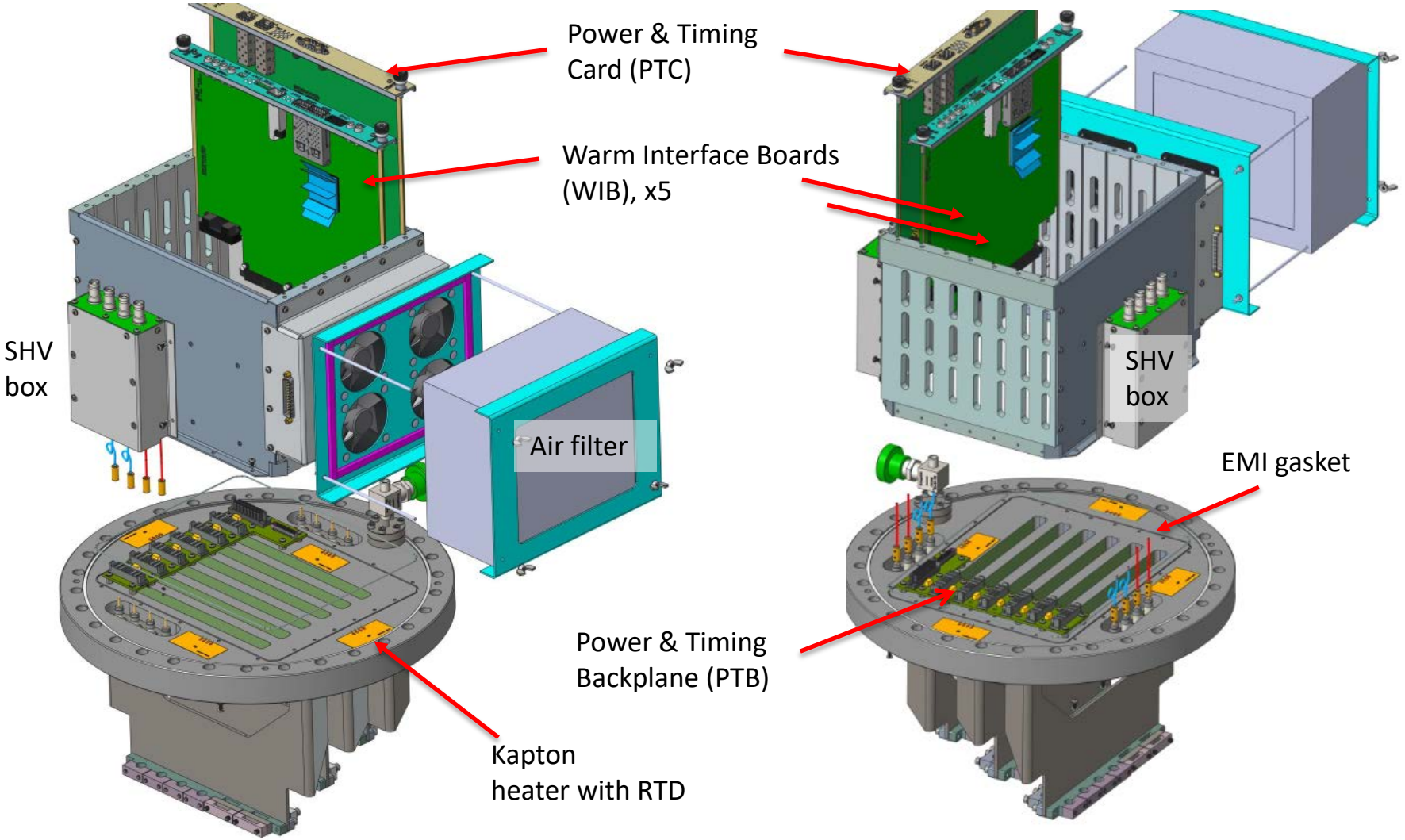


- All CE power and data cables, PD cables/fibers serving two APAs, plus APA wire, field cage termination, and ground plane monitoring cables are routed through the 4 way cross above a CE penetration and terminate on the respective flanges.
- One CE flange will provide services to the upper APA while the other flange to the lower APA.

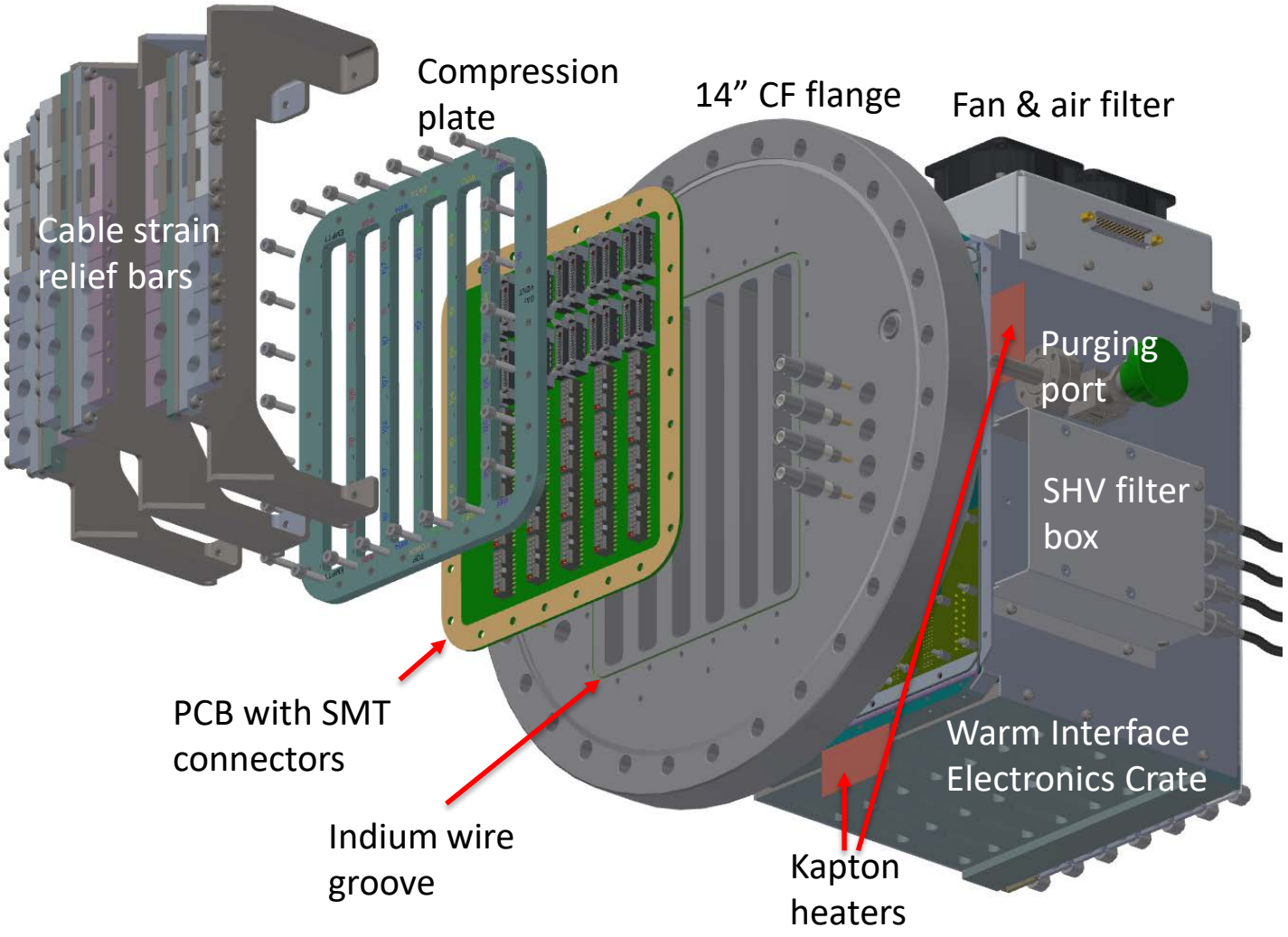


All cables form 6 bundles and strain-relieved on the bottom of the crossing tube support structure inside the crystat, before reaching the cable trays on the APAs.

Warm Interface Electronics Crate Assembly

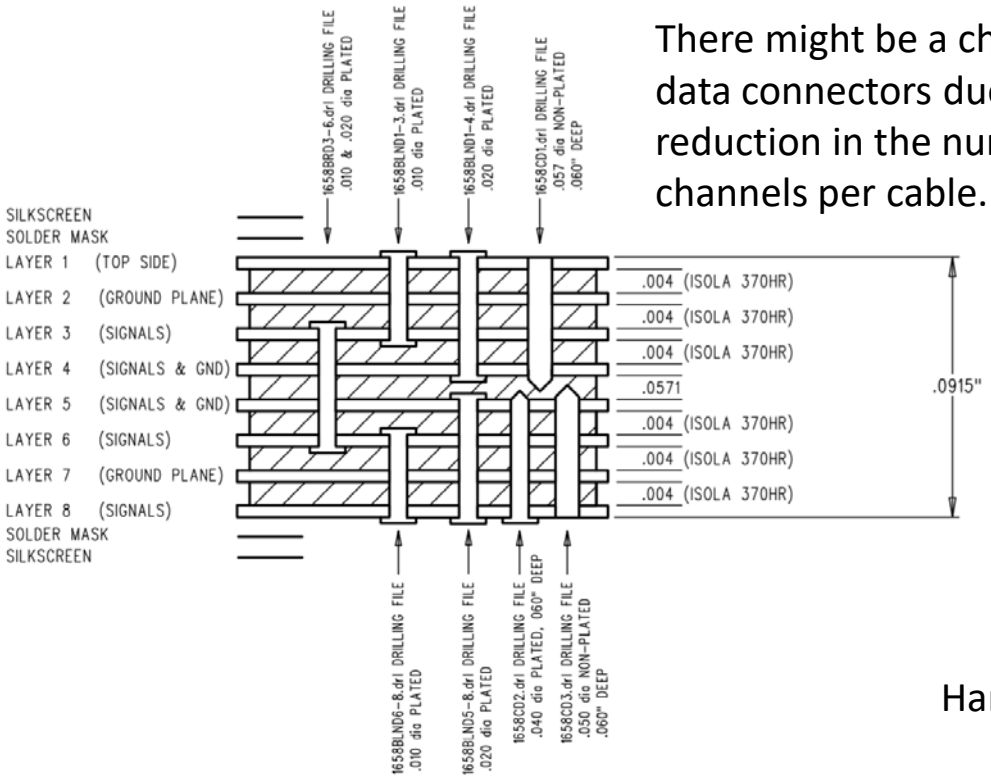


CE Flange Assembly

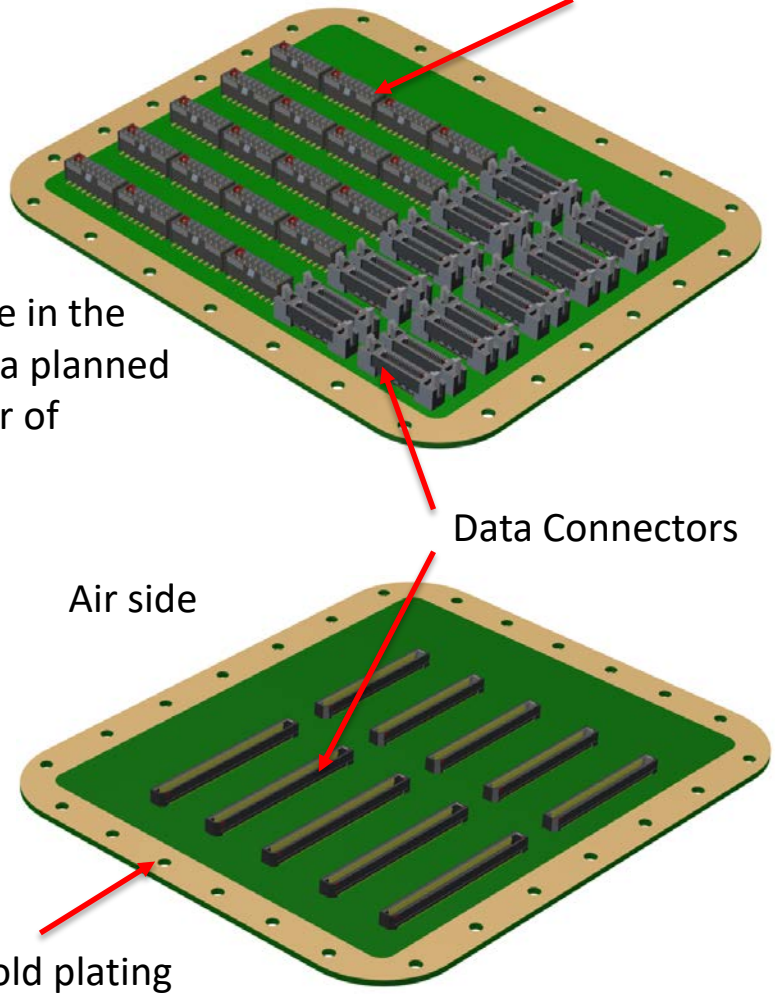


Flange Board

- 8 layer printed circuit board with blind vias to form a vacuum tight construction
- 2 ground planes to provide good EM shield
- All surface mount connectors
- Hard gold plating to ensure good bond to indium wire seal and electrical contact to the flange.



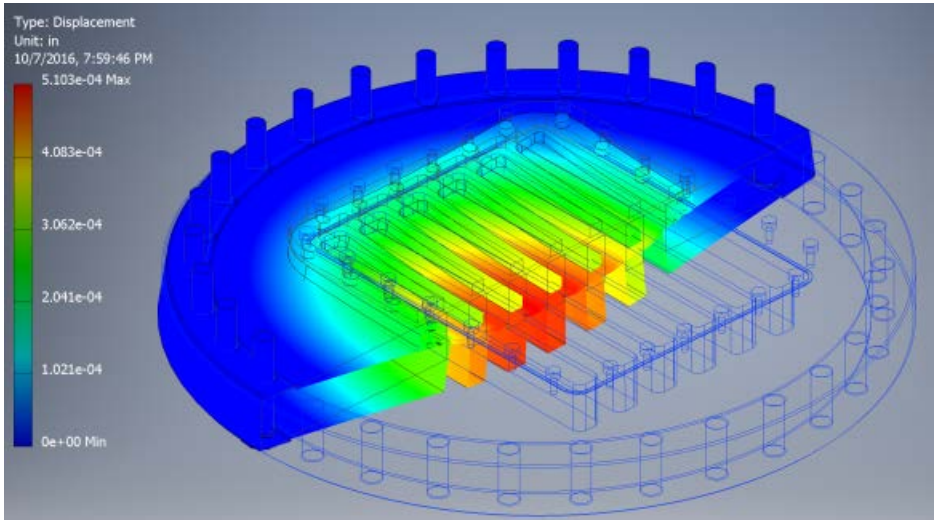
There might be a change in the data connectors due to a planned reduction in the number of channels per cable.

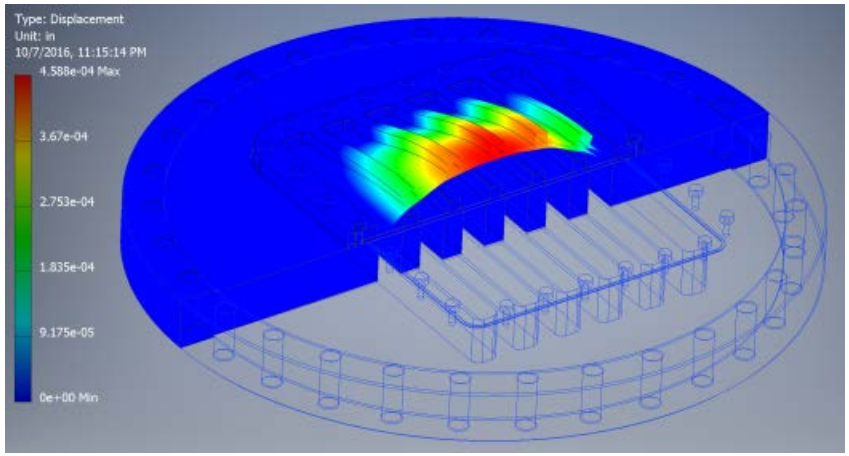


CE Flange FEA

Cryostat design pressure range: 950 – 1350 mbar

5 psi from inside cryostat: ~13μm max deflection
Max stress: ~ 2000 psi

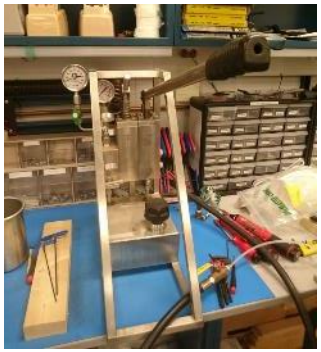


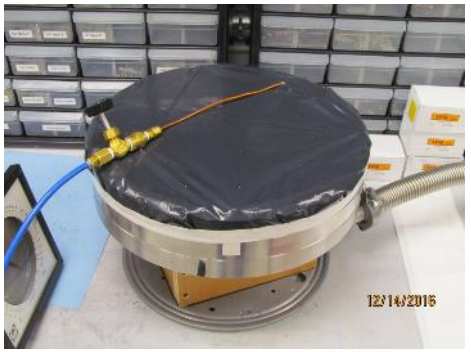


1 psi from outside cryostat: ~12μm
Max stress: ~ 900 psi

Tests Performed on the CE Signal Flanges

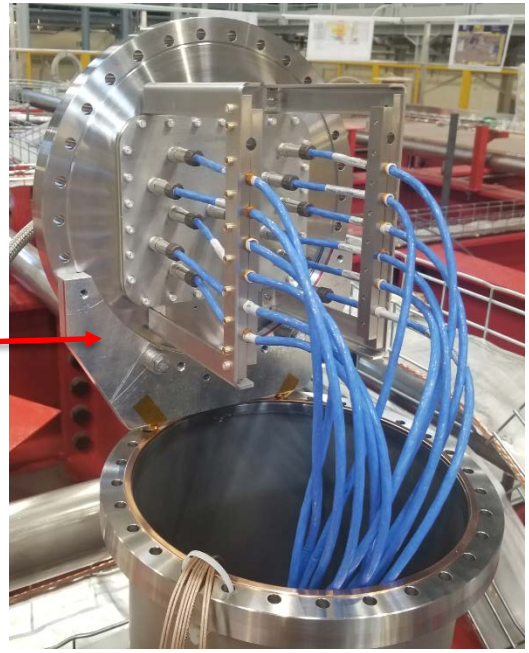
- Leak tests
  - Vacuum leak rate at or below ~2e-9 mbar.l/s
  - Leak rate requirement on cryostat: 1e-8 mbar.l/s local, 1e-6 global (https://edms.cern.ch/project/CERN-0000198204)
- Pressure tests
  - All flanges have been pressure tested to 20psig based on the GTT membrane cryostat pressure rating. (4x MAWP per ASME BPV Code)
  - 120 psi hydrostatic test on an SBND flange without surface mount connectors @ BNL for LARIAT VST. (SBN docdb 6873)
  - 80 psi pneumatic test of a ProtoDUNE CE flange, a PD flange, and a Tee @ FNAL for ICEBERG
- Units in use
  - 6 @ ProtoDUNE, one on the cold box
  - 1 @ LARIAT VST (SBND version)
  - 1 @ ICEBERG (DUNE version)

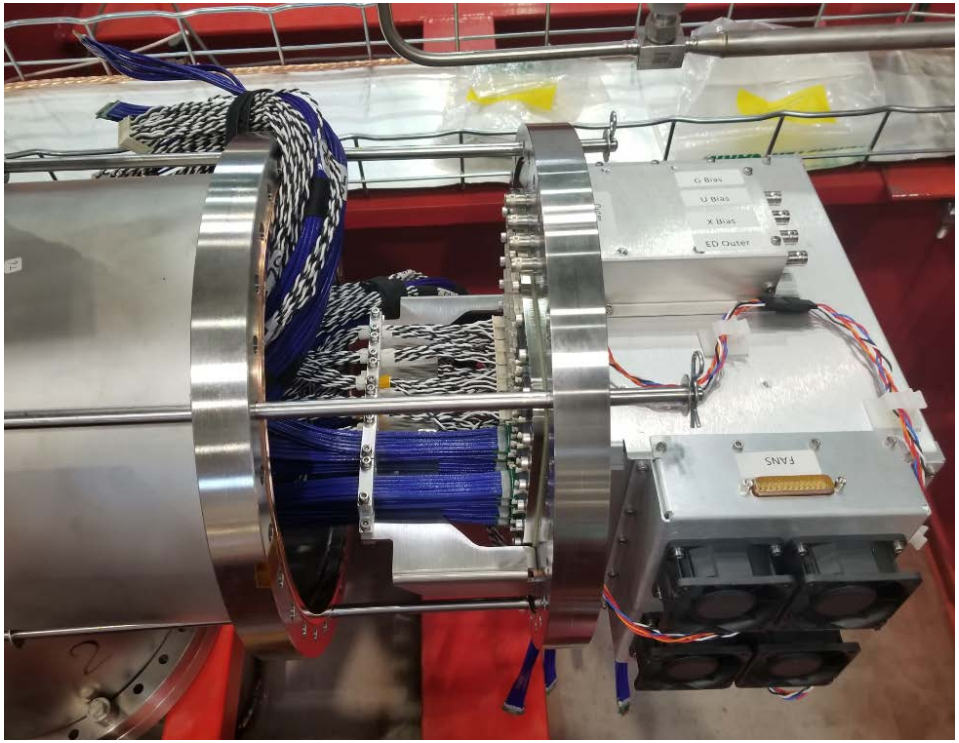


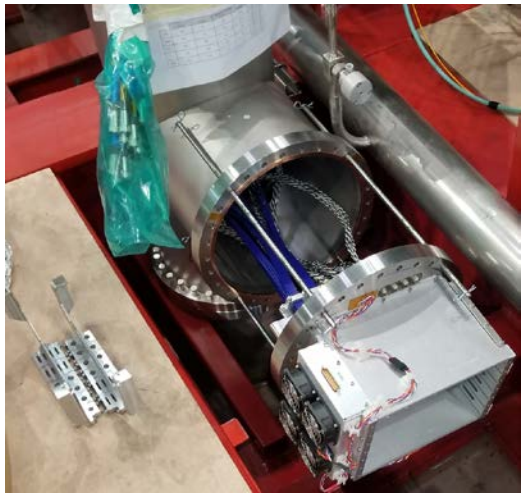


Flange Installation Tools

- A set of 4 stainless steel rods were used in ProtoDUNE to provide safe and convenient access to the argon side of the CE flange for cable connection and strain relief. The same scheme is planned for the FD installation.
- CE also provided a tool for the PD flange installation in ProtoDUNE.

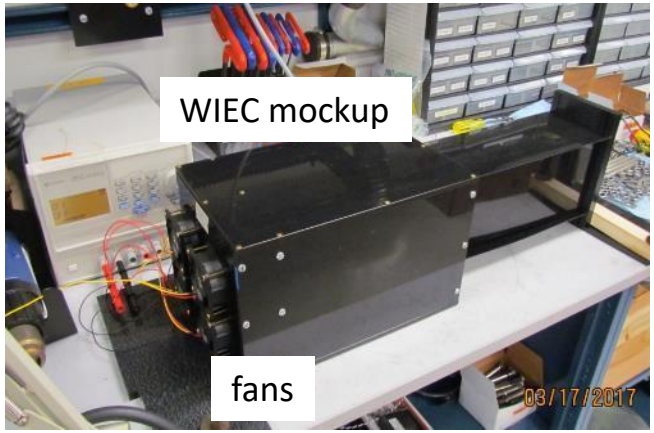


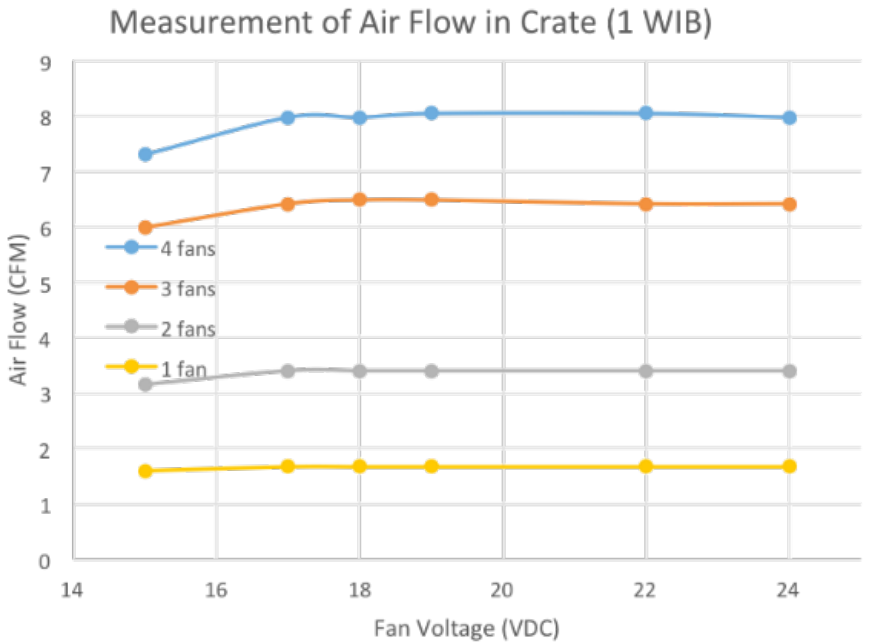




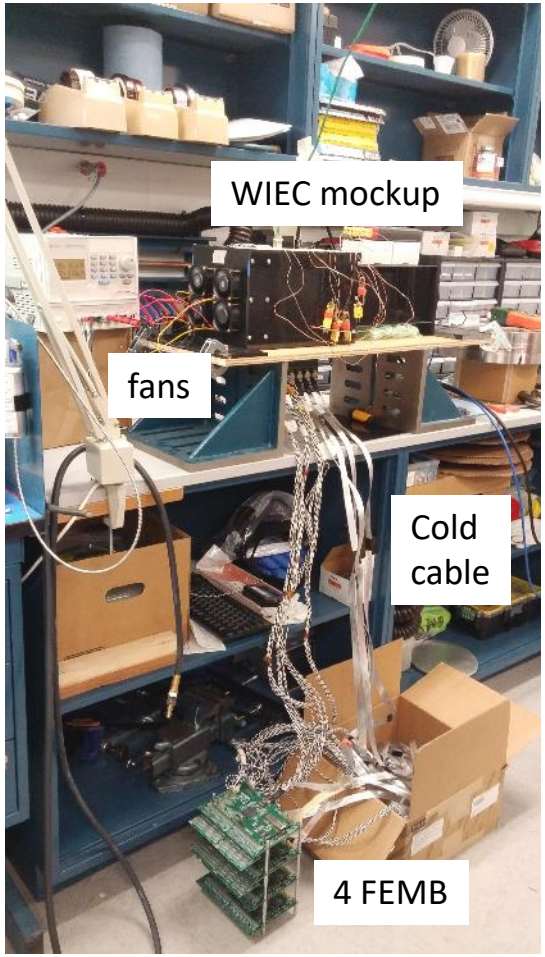
WIEC Mockup Air Flow

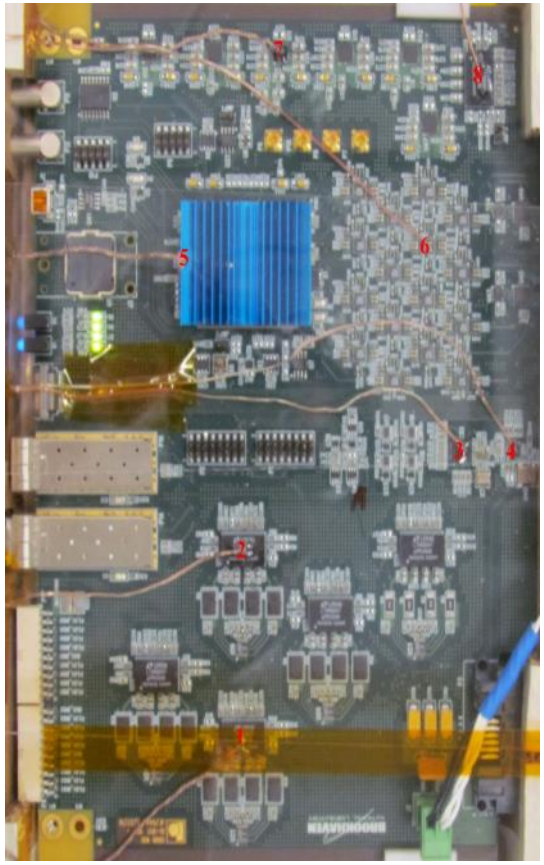
- Each WIEC is cooled by 4 brushless fans supplied by a variable power supply up to 24V
  - Aavid PEAD26025BH (data sheet)
  - Each fan independently powered and monitored by CERN DCS slow control
  - Interlock at a Weiner PL506 48V channel to each signal feed-through if a WIEC fan is disabled
- Air flow measured with mock WIEC and WIBs
  - Test results in DUNE DocDB 1809





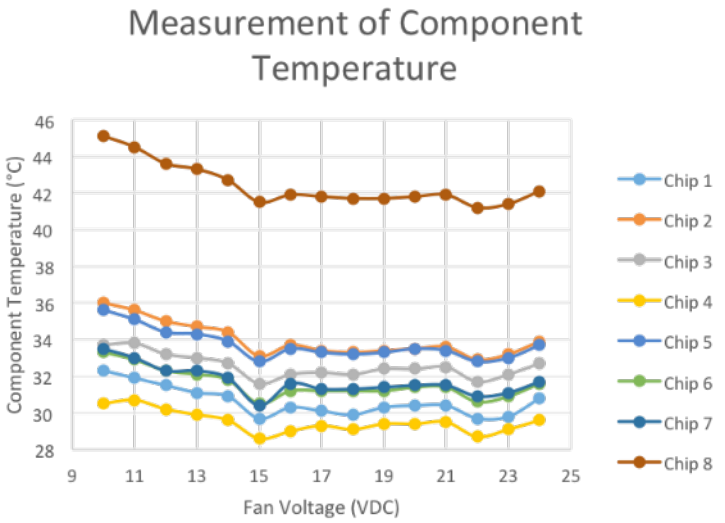
WIEC Mockup Temperature



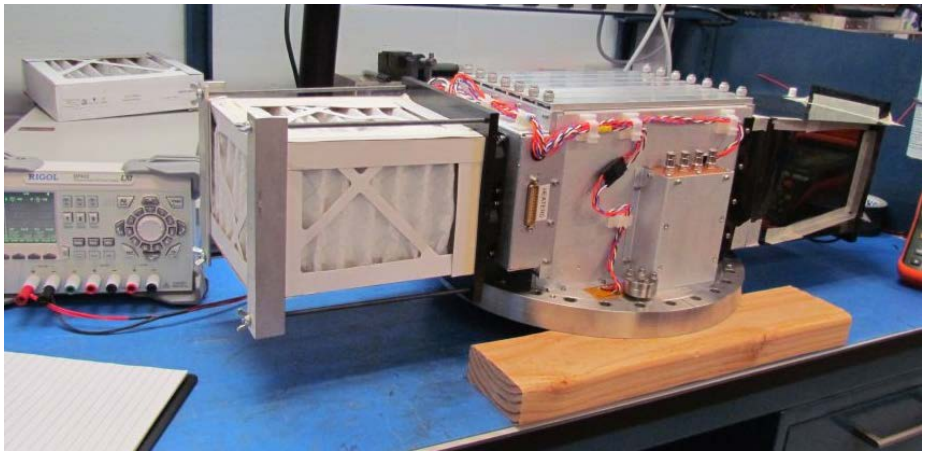


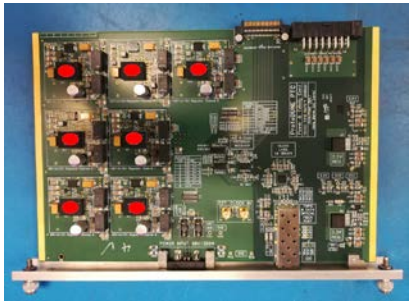
WIB with temperature sensors

- In addition to airflow, thermal measurements were made on a WIB reading out 4 FEMB (fully loaded)
  - Temperature sensors on 8 components on WIB
  - Test results: [DUNE DocDB 1809]



WIEC Air Flow with Air Filters





Tests using the actual WIEC, 6 WIBs & 1 PTC, 4 fans					
7.375" x 5.25" x 4" MERV-8 filter		7.375" x 6.25" x 4" MERV-11 filter		7.375" x 6.25" x 4" MERV-13 HEPA filter	
VDC	CFM	VDC	CFM	VDC	CFM
24	30.4	24	30.8	24	24.8
23	30.4	23	30.8	23	24.8
22	30.4	22	30.8	22	24.8
21	30.4	21	30.8	21	24.8
20	30.4	20	30.8	20	24.8
19	29.5	19	30	19	24.4
18	28.1	18	28.7	18	23.3
17	26.8	17	27.4	17	22.2
16	25.4	16	26.1	16	21.1
15	24.2	15	24.8	15	19.9
10	16.9	10	16.9	10	13.8

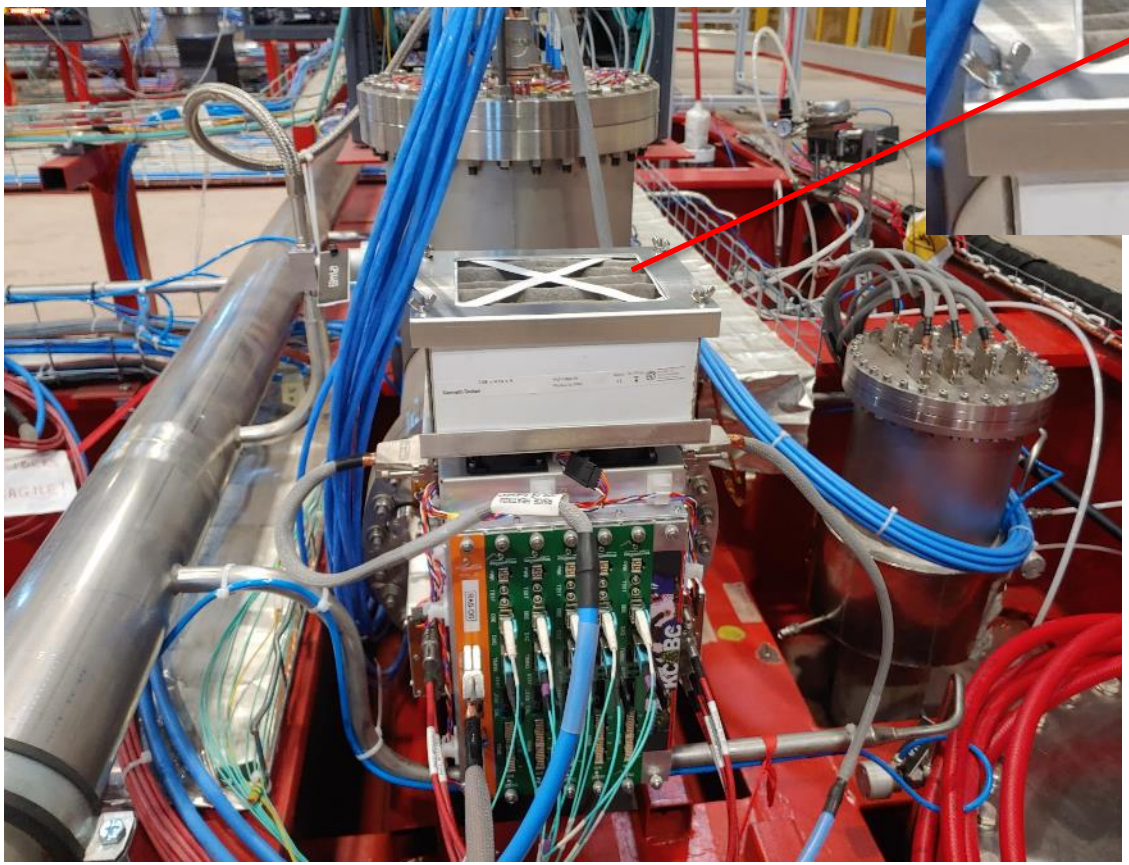
MERV 8 & 11 filters flow virtually the same. The MERV 13 (HEPA) filter restricts airflow about 20% less

Filtration Media (thickness & filter quantity)	Volts (DC)	Flow in CFM	WIB Chip Temp C						PTC Chip Temp						
			1	2	3	4	6	7	5	8	9	10	11	12	13
4" Merv 8	24	31.4	48.2	31.1	46.2	46.8	46.7	47.1	28.6	38	42.9	52.3	44.2	49.4	46.6
4" Merv 8	20	31.4	48.2	31.1	46.2	46.7	46.7	47	28.6	38	42.9	52.4	44.3	49.5	46.6
4" Merv 8	15	25.2	50.4	32.9	48.7	49.4	49.1	49.4	29.8	40.8	45.9	55.9	47.5	53	49.7
4" Merv 8	10	17.7	54.6	36.9	52.7	54.2	53.4	53.8	32.8	46.5	52.1	63.4	54.1	59.6	55.3

Concluded by Kenneth Sexton: the MERV 11 filter is the best choice

Air Filters Added to ProtoDUNE WIECs

Dust accumulation on the air filter in 3 months

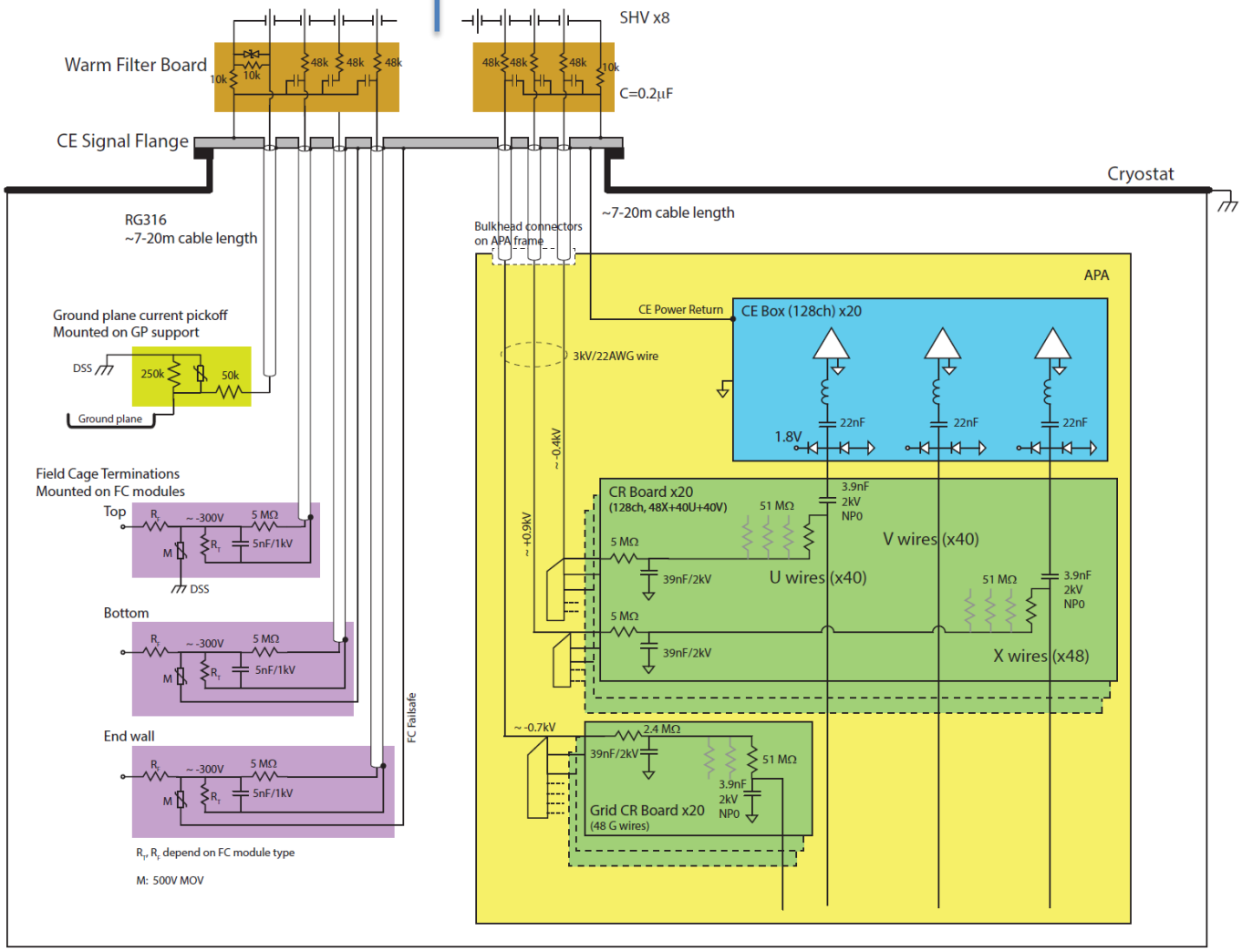


We have planned to evaluate the dust accumulation inside the FD cavern as soon as the cryostat top is accessible in order to determine the filter replacement interval for the far detector.

Interface to Other Systems

Interface to JT-HVS

Interface to APA



Interface to Cryogenic

- Purging port on flange

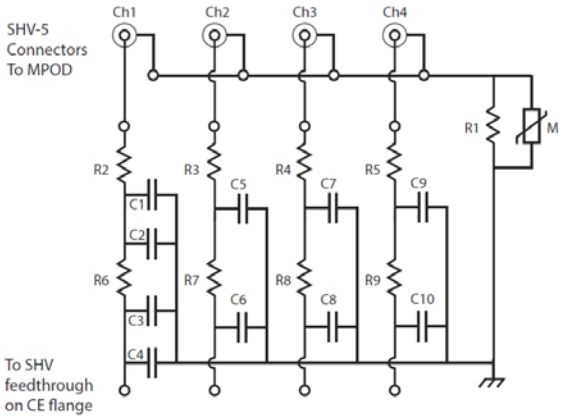
Interface to Slow Control

- RTDs and Heaters
- Fan control
- Bias supply control (APA/HV)
- Ground plane readout (HV)

Bias Filter Board (ProtoDUNE)

In ProtoDUNE, two identical filter boards were mounted on each CE flange inside the SHV boxes. These filters are used for 3 wire bias channels, 2 electron diverter channels, and 3 field cage termination channels.

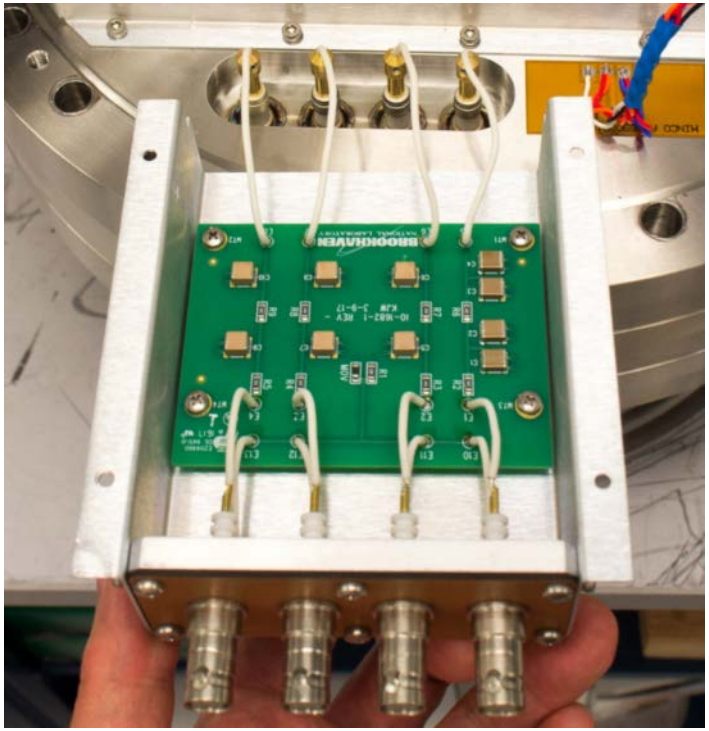
SBND/ProtoDUNE Warm Filter Board (IO1682)



Channel Map:

Filter 1
Ch1: Electron Diverter Outer
Ch2: X Wire Bias
Ch3: U Wire Bias
Ch4: G Wire Bias

Filter 2
Ch1: Electron Diverter Inner
Ch2: Field Cage Top
Ch3: Field Cage Bottom
Ch4: Field Cage Endwall



C1-4: 15nF/3kV/X7R (C2220X153KHRACTU)

C5-10: 100nF/2kV/X7R (2220Y2K00104KXTWS2)

R1: 10k/0.67W (P10KALCT)

R2-9: 24k/0.67W (P24KALCT)

M: MOV/5V/100A (F2208CT)

Bias Filter Boards (DUNE)

In DUNE, depending on the location of a CE flange, the channel configuration on the flange varies.

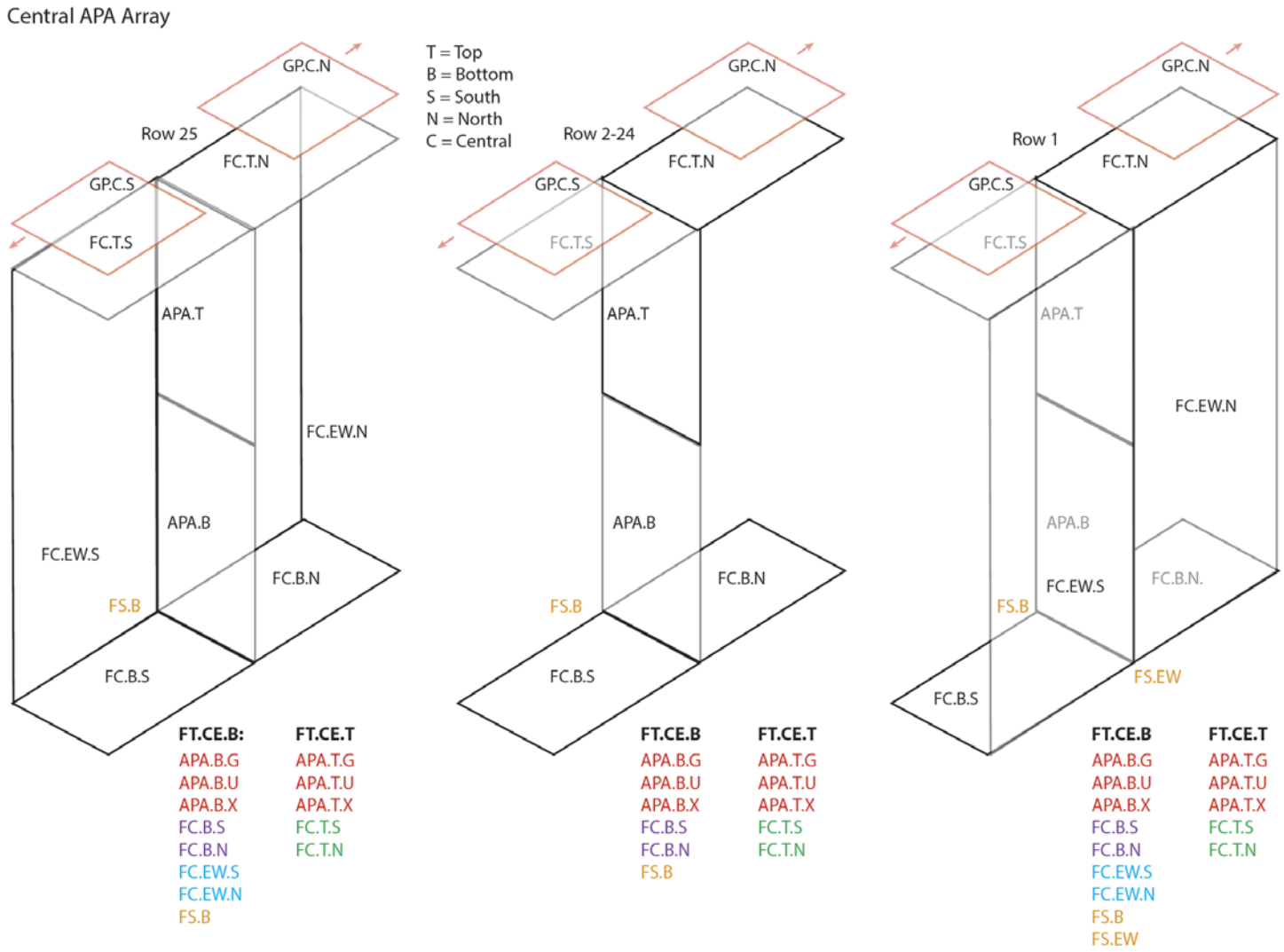
- The APA wire bias remains at 3 channels per flange. For these, we could keep the current 4-ch filter board design, with one “spare” channel. One SHV box per flange is dedicated to the APA wire bias channels.
- The number of FC termination channels ranges from a minimum of 1 to a maximum of 4 on a given flange. In addition, on the flanges serving the top APAs on the north and south arrays, there will be two ground plane monitor channels, needing a protection circuit instead of a filter circuit.
- The HVS will design a new filter board in collaboration with CE. This board will have 2 filter circuits plus 2 GP protection circuits and will be mounted in the other SHV box on the flange when the GP channels reside. In the rest of the boxes, the current 4-ch filter boards are used for the FC termination.
- This new filter board will be designed by HVS, fabricated and installed by CE as part of the flange assembly. The SHV connector labeling must be carefully controlled and tracked to avoid misconfiguration of channels.

Summary

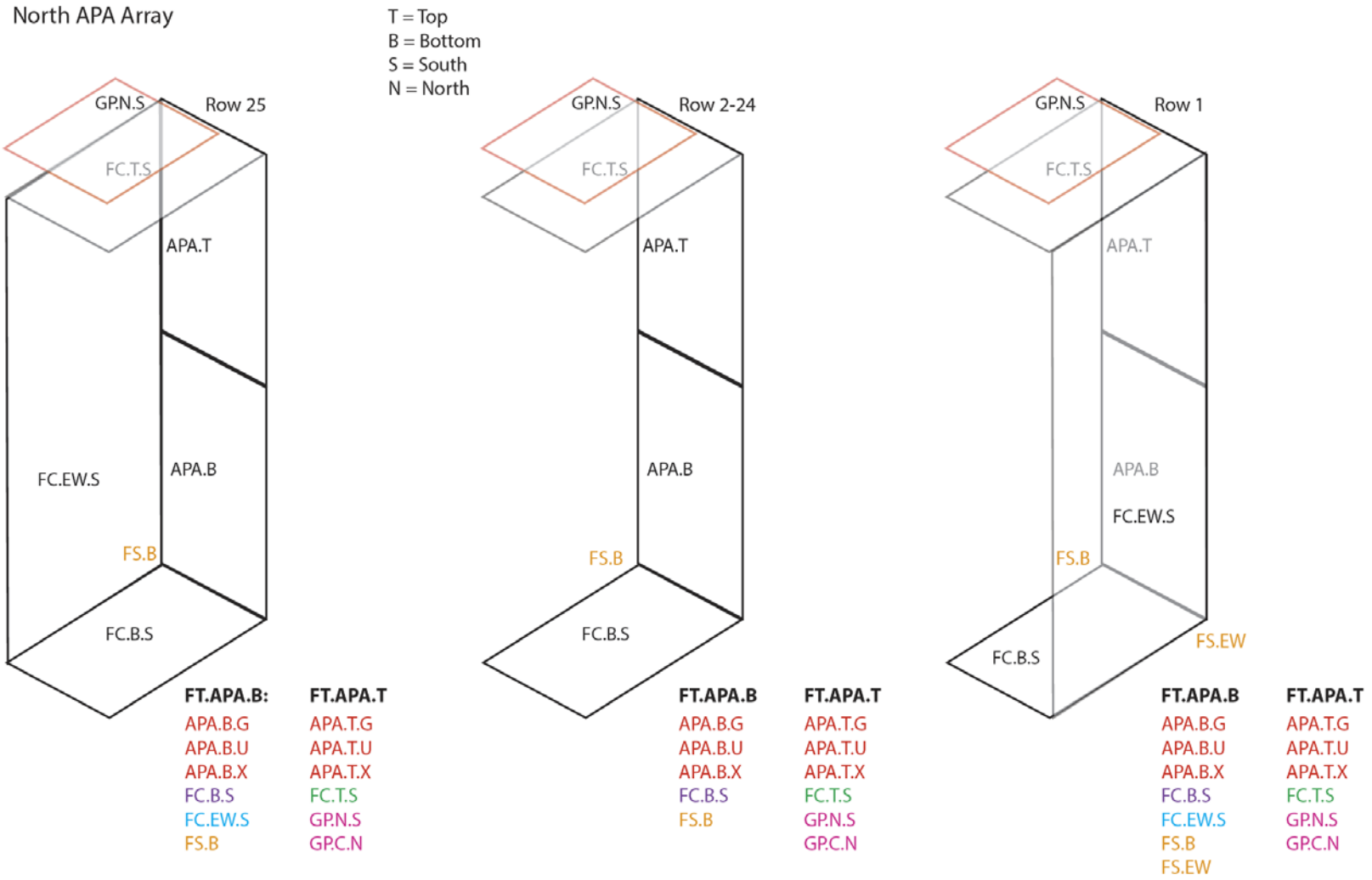
- The WIEC and CE signal flange have been shown to function as designed in the ProtoDUNE run. The ProtoDUNE signal flanges exceeded pressure safety and leak rate requirements.
- Lessons learned from ProtoDUNE led to the addition of the air filter on the WIEC and it has been retrofitted to ProtoDUNE.
- No major changes is expected for the DUNE FD. The minor planned changes are:
  - Reduction in flange board connector pin count
  - Changes in HVS interface on the FC bias filter boards (HV scope)
- Interfaces with HVS & APA are well defined and documented in the interface documents.
- The updated design will be implemented and validated in the ProtoDUNE Run 2.

Additional Slides

Bias Channel Configuration for the Central Array

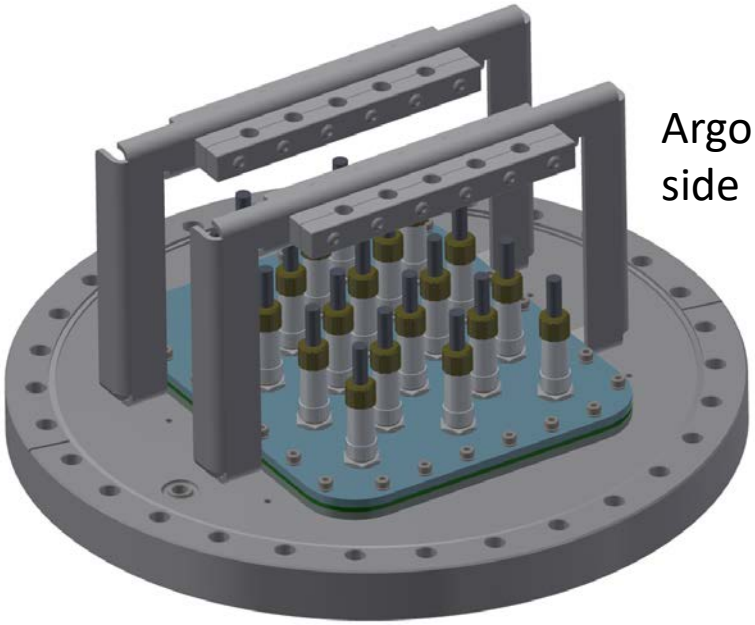


Bias Channel Configuration for the North Array

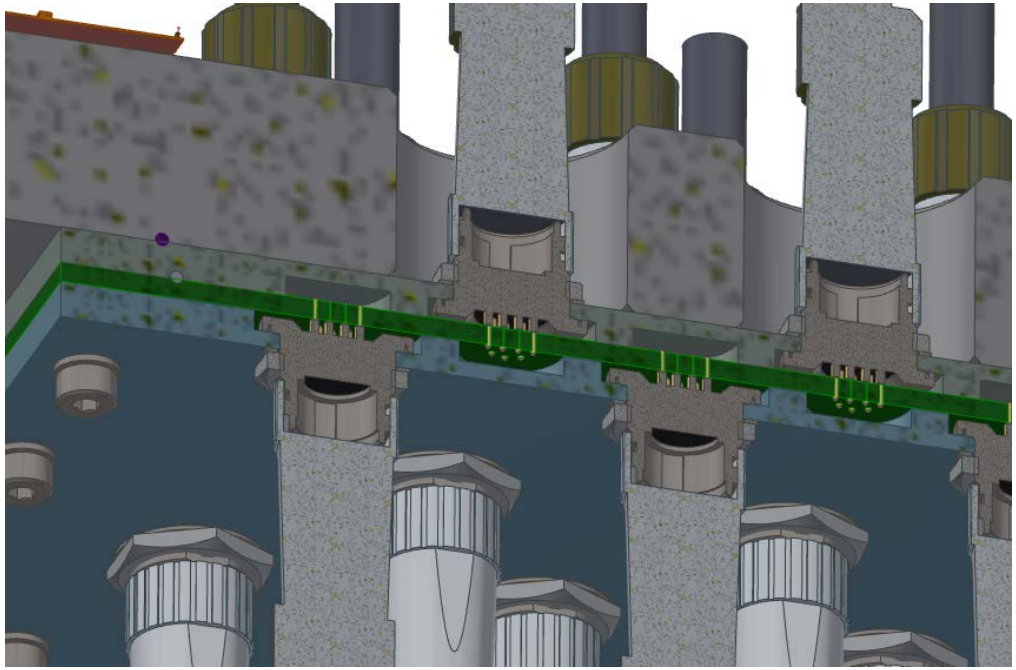


PD Flange Design

- Joint effort with ANL PDS group
- Up to 20 Hirose LF10WBR-12 connectors (through hole)
- PCB + double layer stiffening plate sandwich sealed against the 14” CF flange with indium wire
- Cable strain relief bars on the argon side
- Heaters and venting port



Argon side



Air side