ProtoDUNE II APA Performance

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Outline

- Overall performance

- Bias voltage issue

- Dead channels

- Current draw

- Post-warm up checks

APAs in ProtoDUNE II

- There are 4 APAs in ProtoDUNE II
  - 3 UK made APAs: numbers 1 - 3
    - All use UK made frames
    - 2/3 use UK produced boards
  - 1 US made APA: number 4
    - US made frame
    - US produced boards
- All SHV, CR, G-bias, CE adapter boards and cable harnesses made in US
- There are 2560 channels read out for each APA

Bias Voltage Issue

- SHV board assembly shown at right

- 3 BNC-type locking SHV connectors

- 2 sets of 8 and 10 pin connectors distribute bias voltage to cable harness, which mates to the CR and G-bias boards on the APA

- Redundant connections for the 3 SHV connectors to the 8 and 10 pin connectors

- APA 1 has no bias voltage on the collection plane; the second induction plane is seeing unipolar signals

- There is likely a bad connection between the SHV board assembly and the SHV cable coming into the cryostat

SHV Assembly

Cable Harness

Bias Voltage Issue
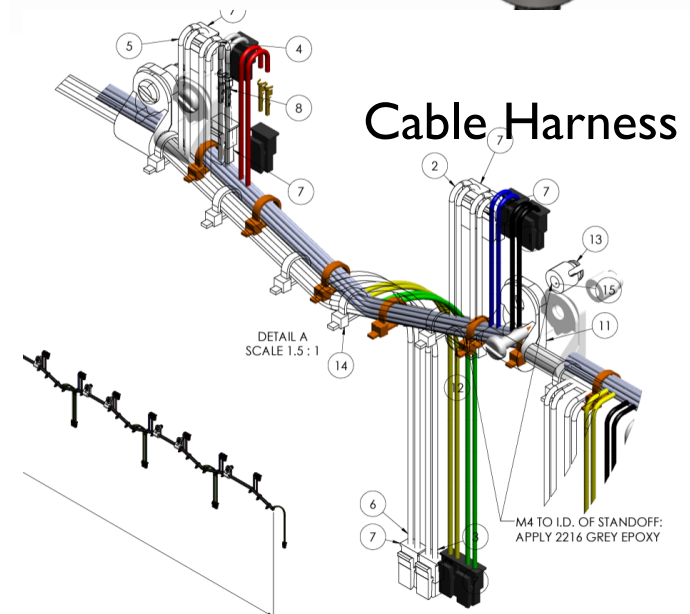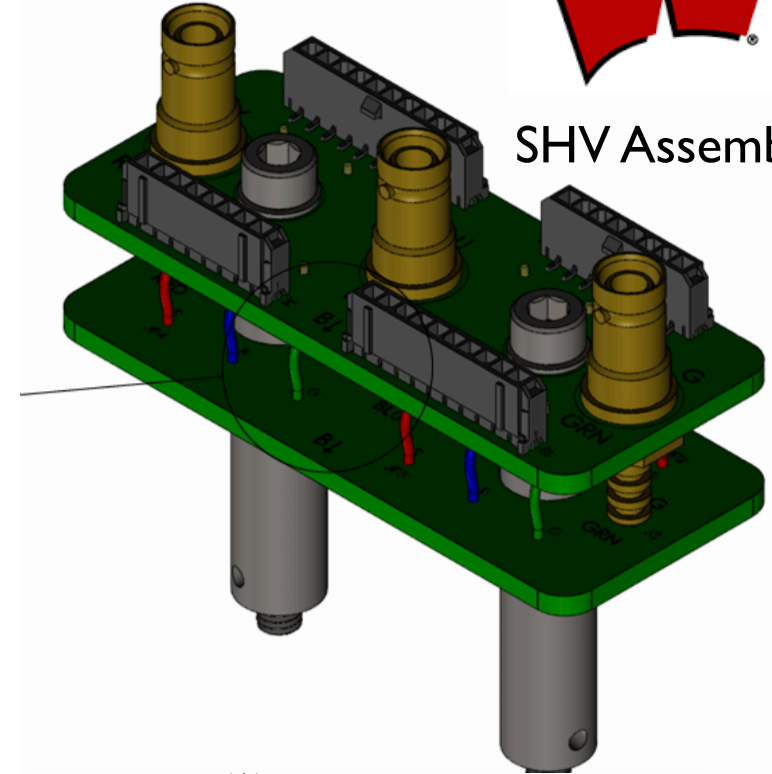
- The area where the SHV assembly is installed was constricted during installation, but does not need to be
  - We propose installing and connecting the SHV assembly before installing one side of the CR boards on the head board stack near the SHV assembly
  - That allows more room for making and checking the connection
- Improved QA checks should include use of a test kit that receives 5V from the board assembly and lights LEDs to indicate good connections
- These changes must be implemented to ensure robust connections

Bias Voltage Issue
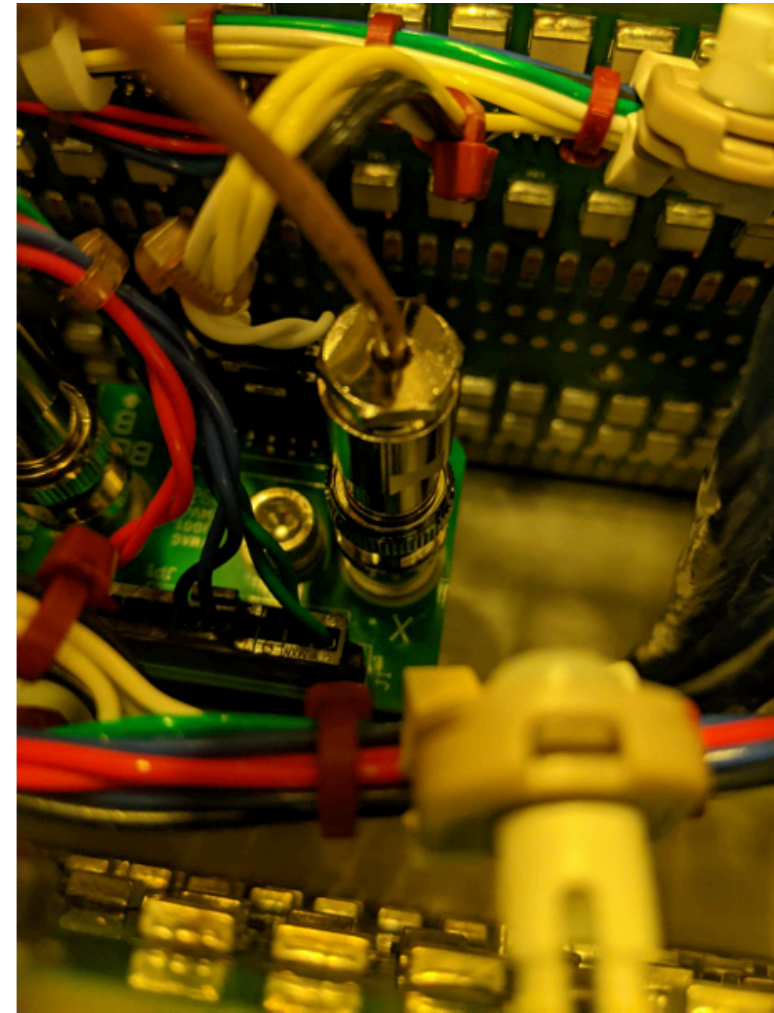
- Adding a redundant X layer connector has also been proposed

- Initial sizing tests show that we can make a larger assembly to accommodate the extra connection

- Do we want to change the design of a critical item without testing it in a ProtoDUNE run?

- Experts at UW PSL believe improving the procedures and QA for the connection should resolve the issue and have expressed the concern about design change at this stage
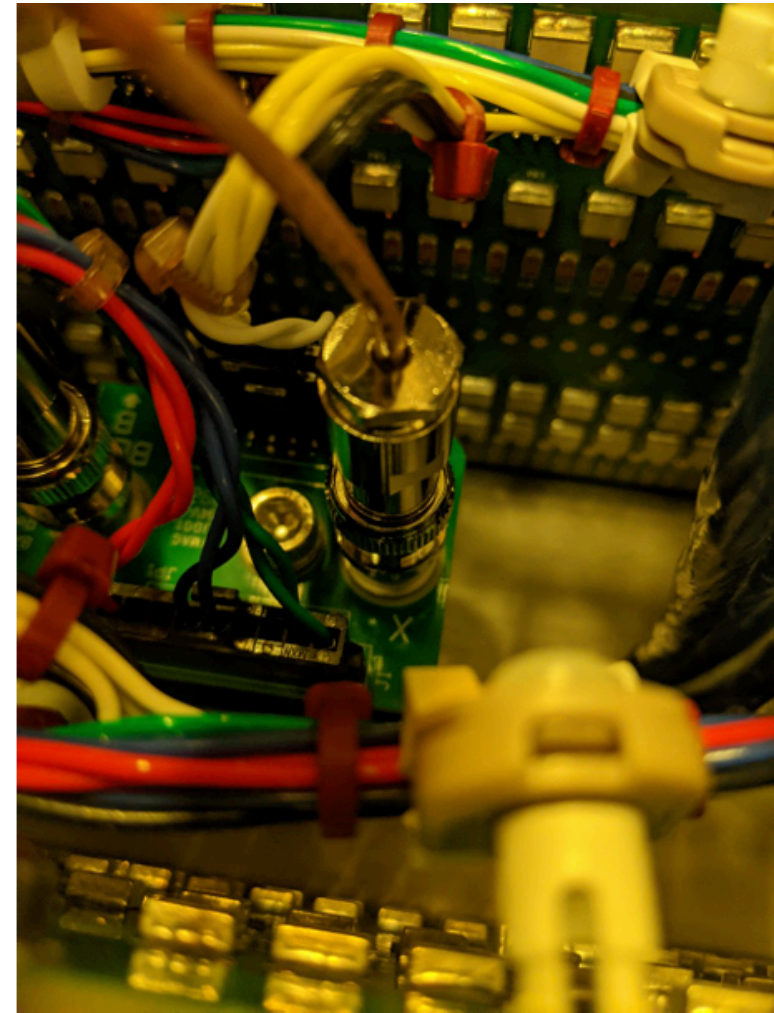
Dead Channels

- There were 32 dead channels observed in the detector after cooldown (0.2% of total channels)

  - 14 first observed in cold box

  - 1 wire broke after cold box testing; cause is uncertain

  - 17 new dead channels after cooldown, 11 eventually recovered

- Generally the dead channels are distributed around the detector, but there were a couple of places with clusters:

| APA	Layer/Side	Headboard Stack	Pads
4	X/B	5	5, 35, 36, 37
2	U/A	10	2,4,6
2	U/B	2	2,6,8

Dead Channels

- 9 channels were damaged during operation, possibly due to a discharge of some kind

- All were on APA 4, but no obvious clustering in terms of side or headboard stack on the APA

- If the cause of the damage was a discharge, it makes sense to see multiple channels from neighboring pads on the same headboard

APA	Layer/Side	Headboard Stack	Pads
4	U/B	6	4
4	V/A	7	1,6,7,8
4	X/B	1	27,28,30,31

Current Draw

- Christos reported to us that the X layer of APA4 has a current draw that seems to mimic the daily cycle of the cryostat absolute pressure

- Could there be a connection in the ullage that is loose?

- Not clear how fluctuations related to pressure could affect components submerged in the LAr

- The current draw is ~10^{-5} A compared to $\lesssim 10^{-8}$ A for other layers

- Is the draw related to the damaged channels?

X layer current

Absolute Pressure

9

Post-Warm Up Checks
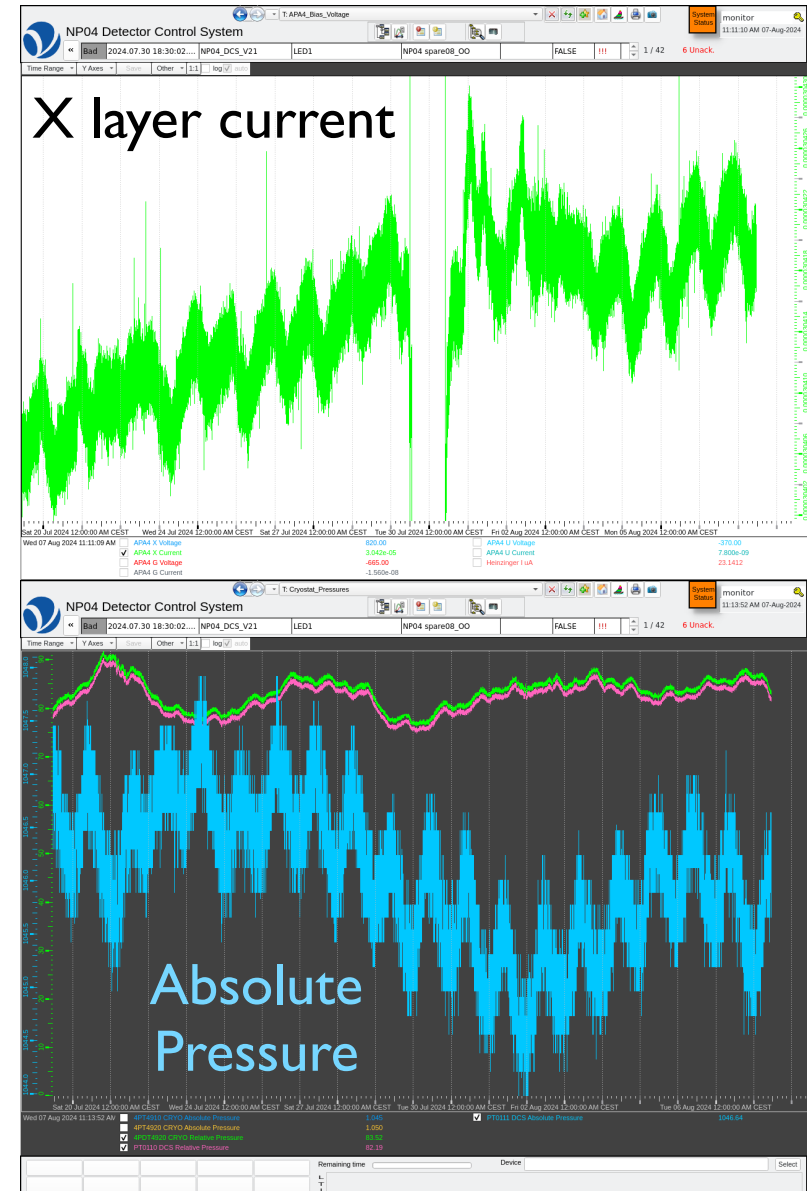
- Checks to be done after warm-up

  - Carefully check the X layer SHV connection for APA 1 to determine whether the connection was faulty

  - If the connection is robust, we would like the SHV board assembly and cable harness returned to UW for tests

  - Check the Mill-Max pins on the CR boards where dead channels were reported to see if the pins were damaged

  - Examine the continuity between wires and the Mill-Max receptacles for dead channels

  - Check boards of shorted channels for evidence of damage

  - Look for debris in the APAs or cryostat that could explain shorted channels

  - Attempt to determine if current draw on APA 4 X layer is in a headboard stack