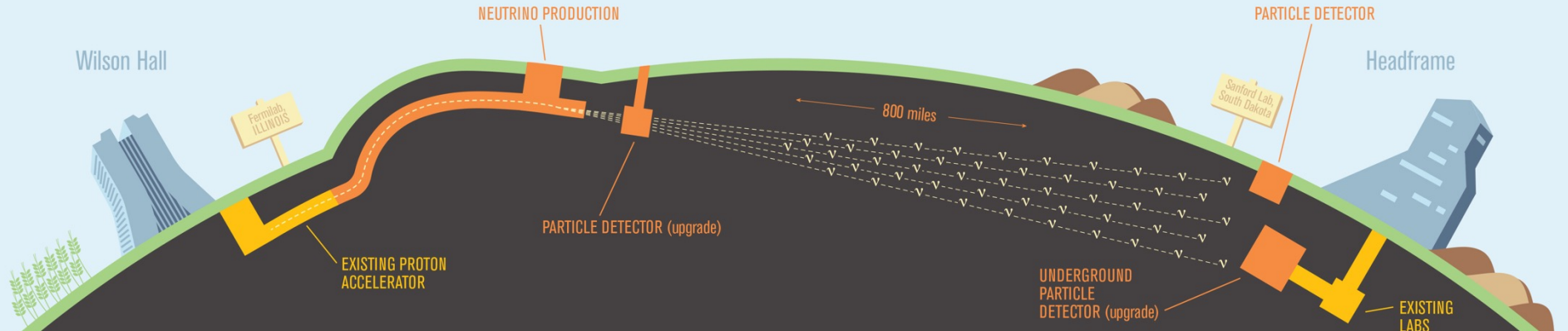


APAs in ProtoDUNE-2

Justin Evans, Pip Hamilton & Brian Rebel

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ProtoDUNE-2

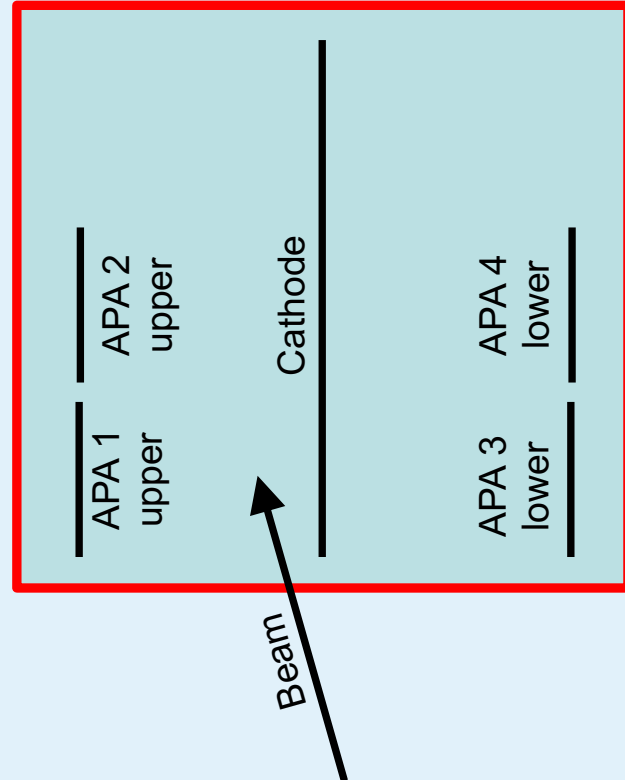
We have four APAs in ProtoDUNE-2

- Two upper APAs and two lower APAs

All APAs were tested in the cold box prior to installation into ProtoDUNE-2

Pip Hamilton (Imperial) is our APA consortium lead on ProtoDUNE-2

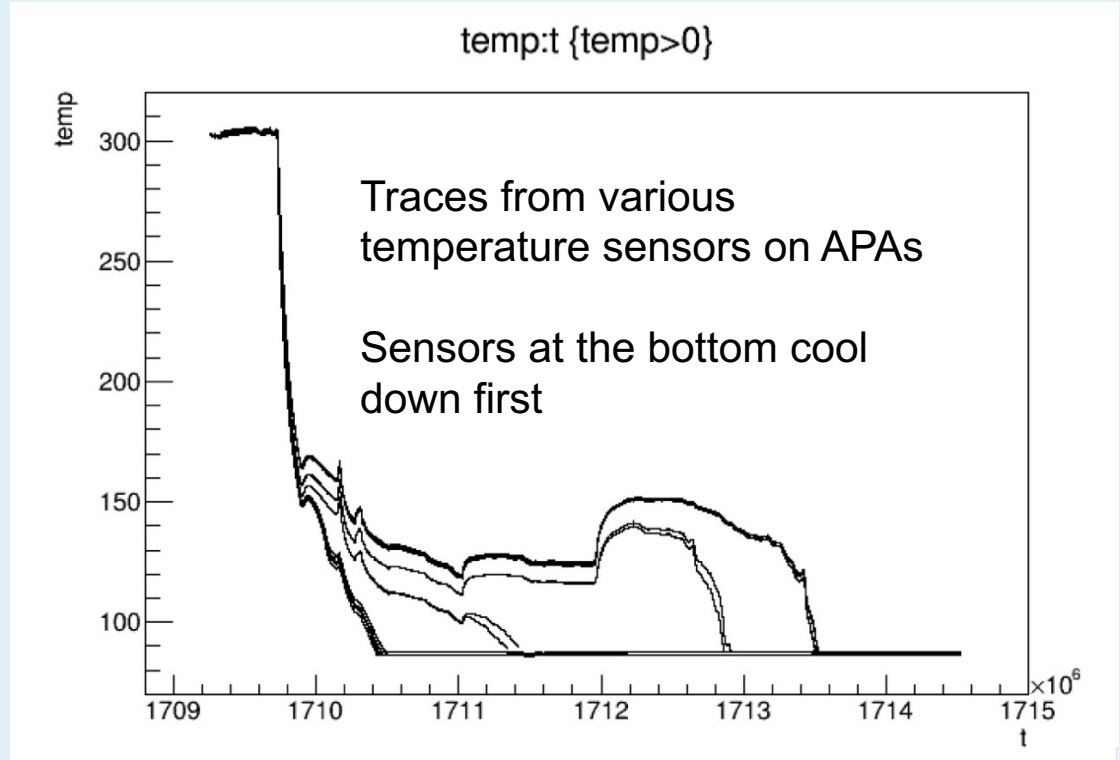
- Most of the information in this talk is provided by him



APA cooldown

APA cooldown went smoothly with the temperature difference between top and bottom of any APA not going above 60° C

- Our requirement is to keep this below 100° C



Disconnected channels

	APA 1	APA 2	APA 3	APA 4	TOTAL
Wires removed during construction	1	3	3	2	9
Sideboard PCB discontinuity		2			2
Headboards stack discontinuity		2			2
Contact lost in transportation		2			2
Contact lost in Cold Box cooldown		2	1	1	4
Broke after cold box test			1		1
Contact lost in NP04 cooldown		2	2	1	5
Total dead channels	1	13	7	4	25
Lost-and-found Cold Box cooldowns		6			6
Lost-and-found NP04 cooldown		7	2		9

In total ~34 channels of 10,240 have had some kind of issue (although some have recovered)

- This is 0.3%, which is well within our 1% requirement

Possible causes for channels that disconnect during cool-down

- Insufficient plating of the through holes for the Mill-Max pins such that the pin does not contact the sides of the hole well
- Poor insertion of the Mill-Max pins (hard to come up with a scenario for this)
- Problem with the CR board to CE adapter board connection
- Problem with the CE adapter board connector solder joints for those channels (done by hand at PSL for these boards; now being done by selective solder machine)
- Insufficient contact between the FEMB and CE adapter board connectors for those channels

Possible loose material in TPC

Intermittent shorts are being observed

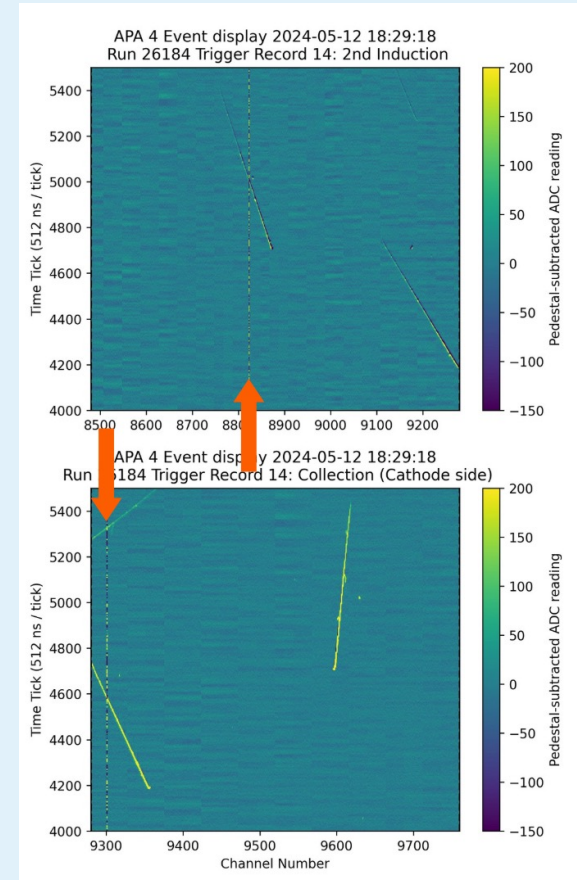
- Move around in the detector
- Appear and reappear on timescales of days, with some correlation to circulation and field ramps
- Sometimes between channels, sometimes whole layers

Currently the APA 1 G layer and the APA 4 U layer are shorted to ground

- Drawing μA currents, which does not stop us from operating

Hypothesis is some small amount of conductive debris in the detector

- Important to focus on minimizing the risk of any debris from our construction and installation



APA 1 collection-layer bias

There is no bias voltage on the collection layer of APA 1

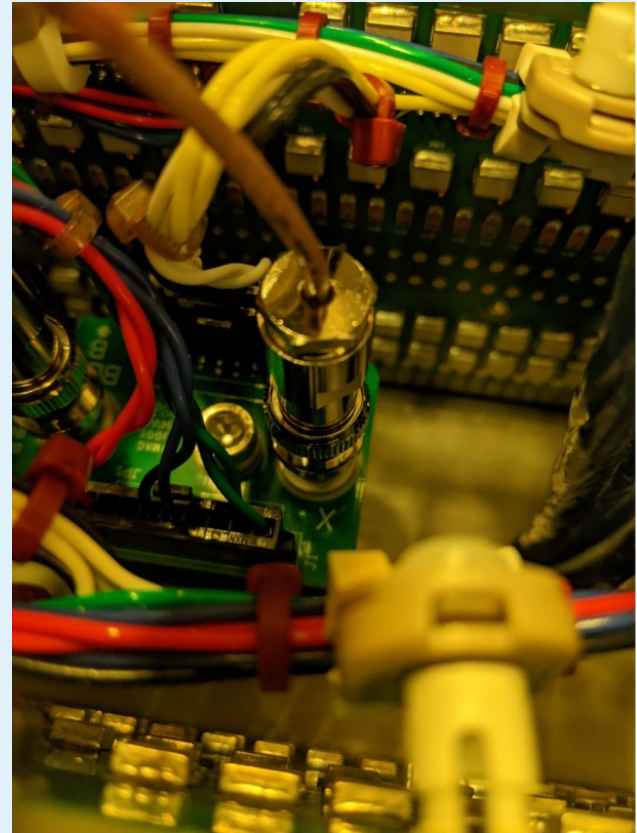
- This means the last induction layer (V) is acting as the collection layer with unipolar signals, and there is very little signal on the collection (X) layer

Impedance measurements from the flange show that the loss of connection is between the HV cable and the APA itself

- Potentially a bad SHV connection into the SHV board

Installation procedures will be reviewed to make the SHV connection step easier and add additional QC testing

- Leave the CR board immediately in front of the SHV board off the APA until the SHV connection has been made
- Add an additional visual QC step to this connection, and use impedance measurements to check the connection
- A redundant X-layer SHV connection is being considered, but this has associated electrical and mechanical issues



Summary

APAs 2, 3 and 4 are working well

APA 1 has an issue with the collection-layer bias voltage coming in

- Issue is in between the HV cable and the APA itself

Disconnected channels are well within our requirements and will be monitored over the run

Possible conductive debris in the TPC