

APA FDR Answers To Committee Questions

B. Rebel, C. Touramanis, J. Evans

September 1-2, 2021

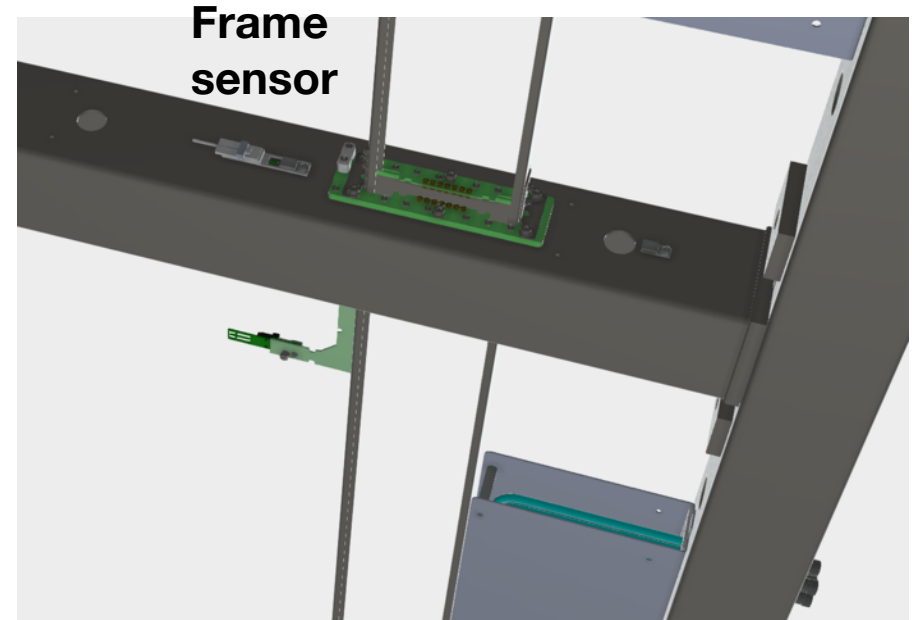
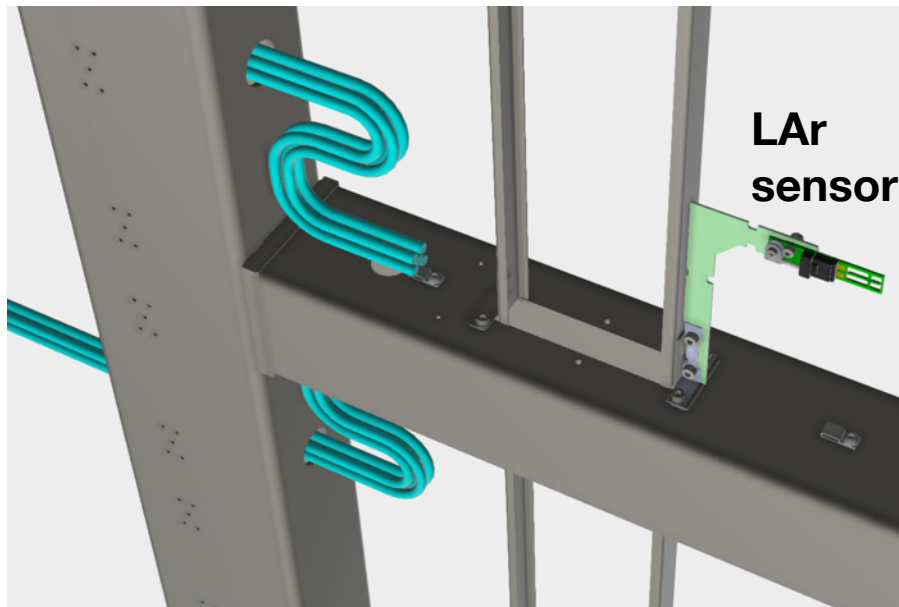
Questions from First Day

Can you please provide details for the RTD's including a bill of material, schematic, and justification for why specific things were chosen for the RTD's? (e.g. types of cables, the insulation, the connectors, etc...)

- The CALCI consortium is responsible for specifying these details of the RTDs, while the APA consortium is responsible for providing mounting points for the RTDs and real estate for the cable runs
- We agree that the concerns raised are important to address for the whole of DUNE to ensure stable operation of the detector
- ProtoDUNE experience showed that RTDs, either on the APA itself or anywhere inside the Cold Box, can introduce noise. As long as we can easily ground the whole RTD system externally we are safe.
- We contacted Anselmo Cervera to answer these questions

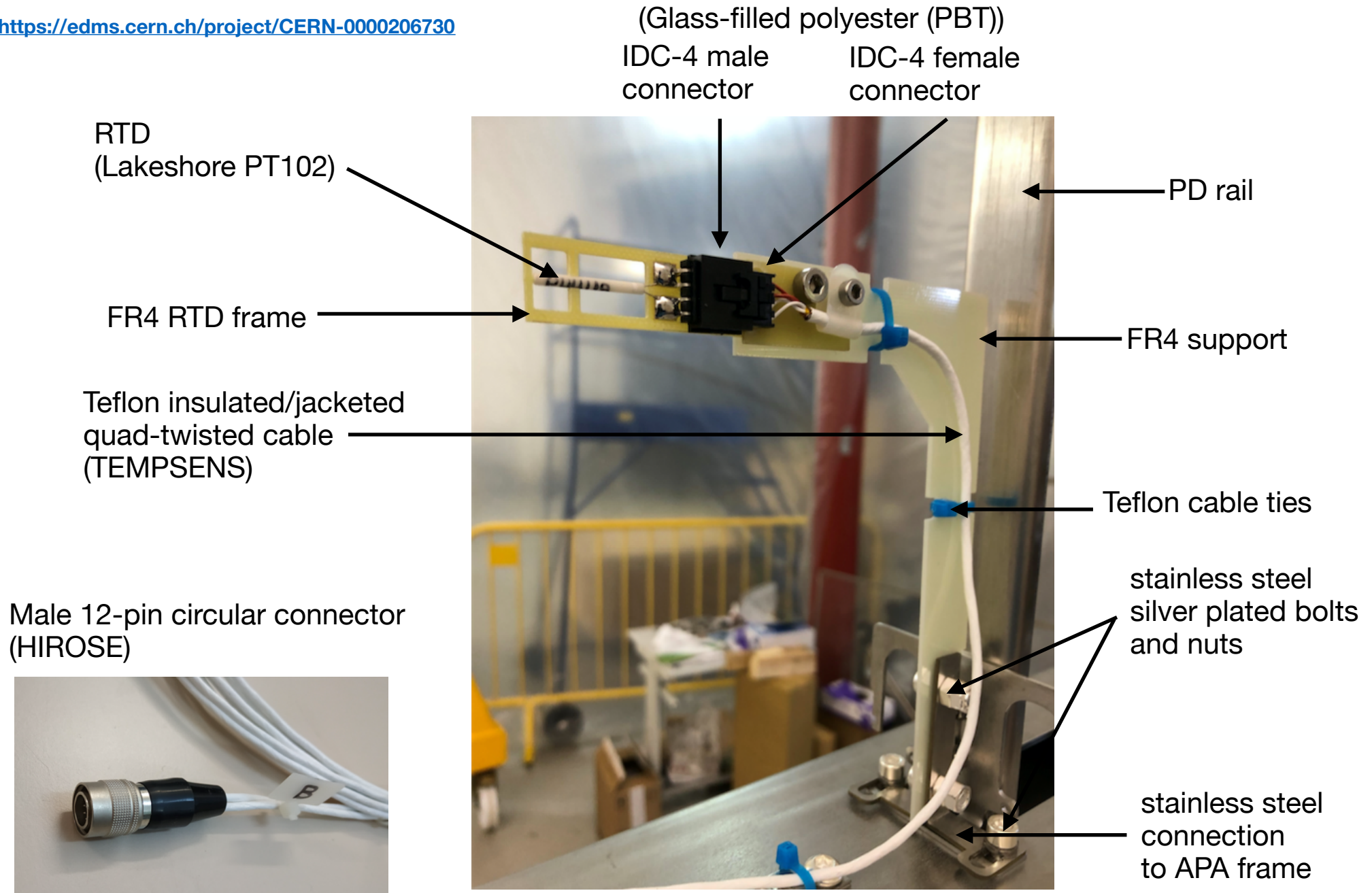
APA temperature sensors

- Design choices:
 - Use photon detector cable routing and connectors
 - Number of sensors (4 per APA) limited by cable routing
 - Materials choice: Stainless steel, teflon and FR4
 - RTDs are decoupled from the rest (intermediate IDC-4 connectors) to allow precise calibration and avoid unnecessary manipulation during installation
 - Uninterrupted 1 mA DC current
 - quad-twisted cables with external EMC shielding individually grounded at flange and floating at sensor's end



APA temperature sensors

<https://edms.cern.ch/project/CERN-0000206730>



For the Photon Detectors (PD's) can you point us to documentation which shows how the PD cable is connected to the PD module, how the particular connector was chosen and how it was cold tested / stress tested?

- The PD consortium is responsible for specifying these details of the their connectors, and providing the PD hardware (rails and cables). The APA consortium is responsible for providing the real estate for the hardware, and interfacing with the various mechanical connections to the APA frame.
- As we saw in Dan's talk yesterday, the PD cables were installed during the PSL cold test of an APA and there were no obvious problems with them
- We contacted Dave Warner to answer these questions

Q2: For the Photon Detectors (PD's) can you point us to documentation which shows how the PD cable is connected to the PD module, how the particular connector was chosen and how it was cold tested / stress tested?

Answer: The connection is described in general in the Photon Detector Cable Harness Rev. 6.20, which is included in the PD review documentation package. In general, mill-max pins mounted to a PCB attached to the PD module automatically mate to the sockets included in the connector board mounted to the APA during assembly. Connections went through multiple cryo tests at CSU, at PSL, and in Milano. See details in following slides.

Cable Harness document EDMS 2383682: <https://edms.cern.ch/ui/#!/master/navigator/document?P:100255026:100931280:subDocs>
PD Review documentation: <https://edms.cern.ch/ui/#!/master/navigator/project?P:100255026:100931288:subDocs>

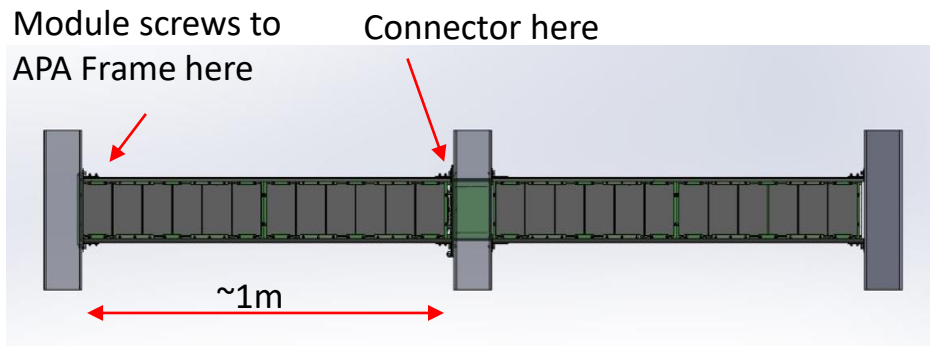
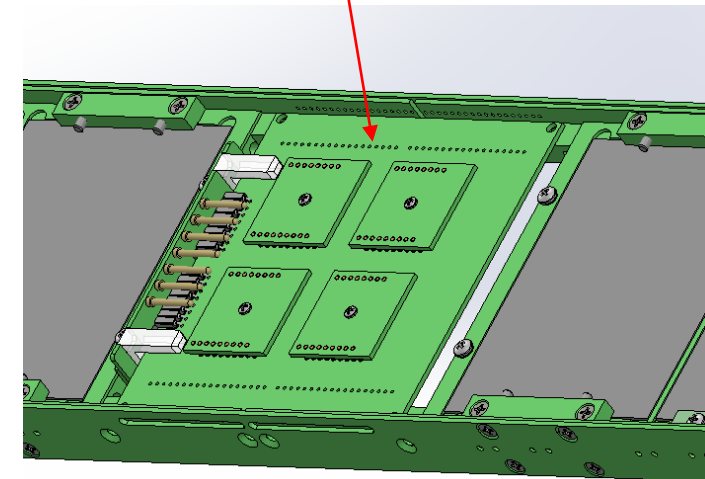
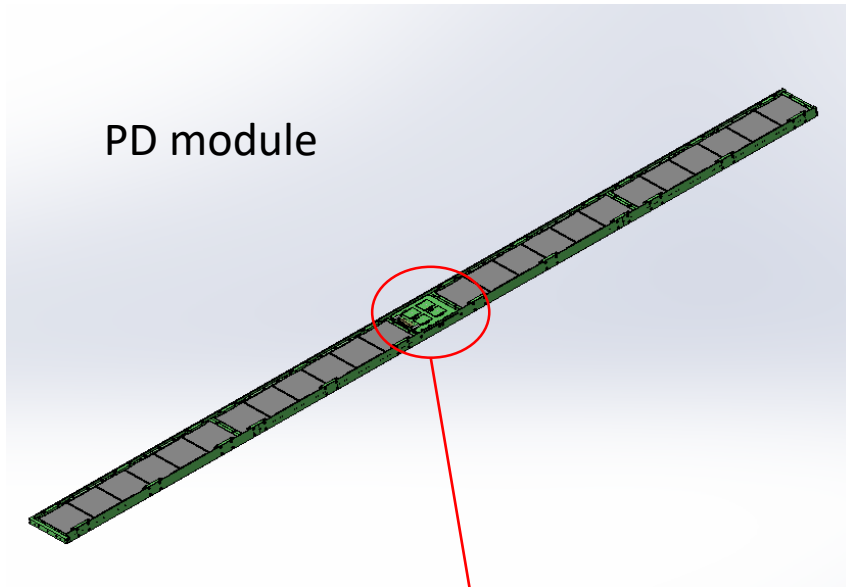
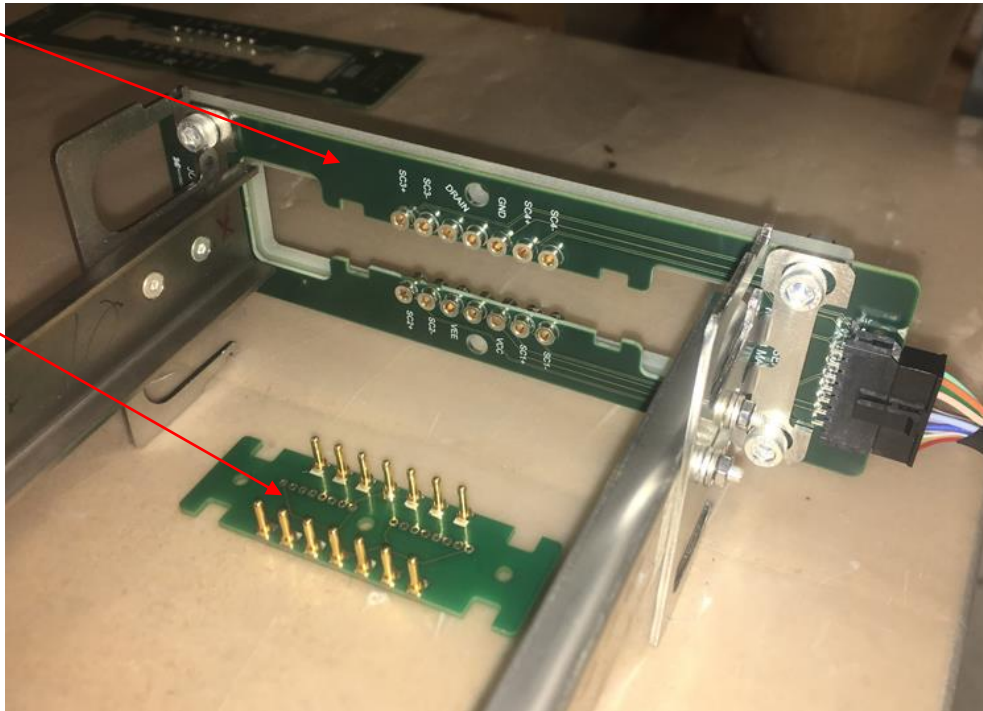
PD module connections

SASEBO-D1
 (Screw and Socket Electrical Board)
 Mill-Max Pin Socket
 P/N 9837-0-15-80-14-27-10-0

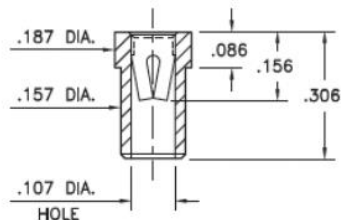
AECB
 (ARAPUCA Electrical and Contact Board)
 Mill-Max Pin
 P/N 9837-0-15-80-14-27-10-0

n.b.: Relative thermal contraction of the module relative to the APA is small, but was addressed in the design.

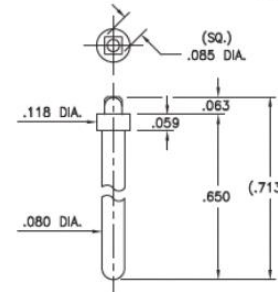
Thermal contraction and tolerance buildup are addressed in the PD structural analysis note (Sec. 3.1) presented at the PDR (EDMS 2380229).



9837-0-15-XX-14-XX-10-0
 Solder mount in .159 min. mounting hole

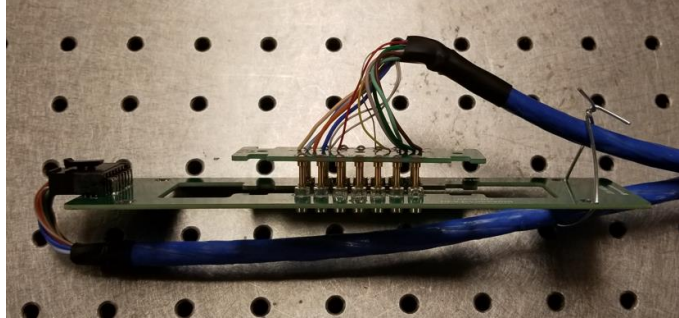


5920-0-00-XX-00-00-03-0
 Solderless press-fit pin for plated through-hole
 Recommended drilled hole size: .086 (2,18mm)

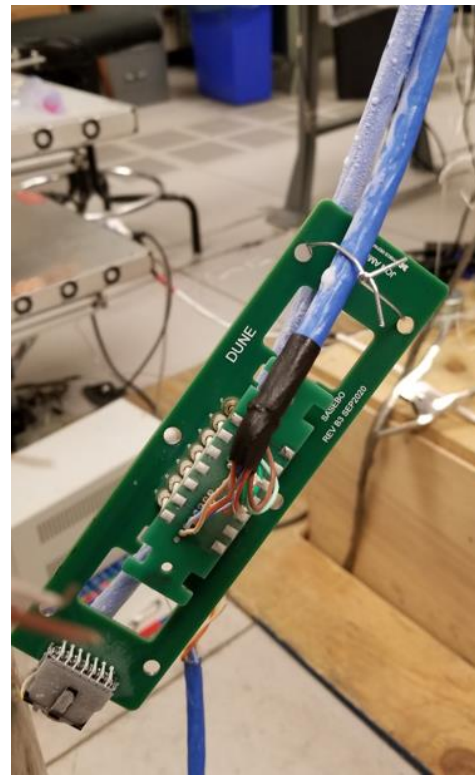


Cold amplifier board
 Inside center APA tube

Cryogenic testing



Prior to test (Dummy mockup)

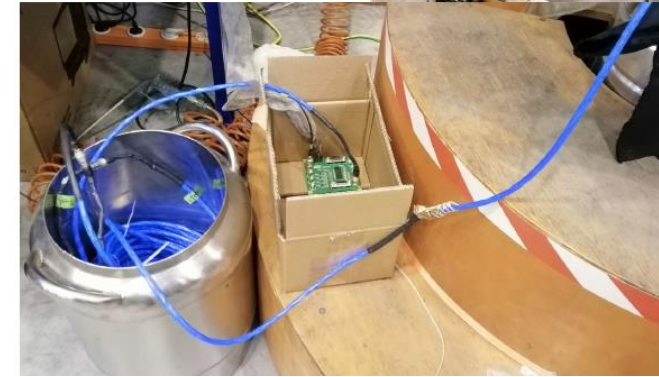


Board assembly during cycling

Tests performed:

- CSU: Multiple (>20) immersions into LN2, monitoring connectivity and high-frequency signal transmission.
- PSL: Cryogenic GN2 test of connector boards and module mockup in APA frame (2 cycles).
- Milano: Demonstrated >4 S/N ratio readout of supercell through full 35m cable harness including connector PCBs.

Readout of a supercell with 35m cable



Upcoming tests:

- NP-04 cold box test: 2 operational modules and 8 module frames to be tested in the CERN cold box as part of APA test
- ProtoDUNE 2

Is there documentation for the tests which were performed at Ash River? What additional testing remains to be done for the final DUNE APA design at Ash River and is there any FEM analysis of the final DUNE design with cables?

- There was a workshop held at Ash River (09/19) to go through the installation process and the result was a [summary of lessons learned](#) and a [set of procedures and other documents](#), both in EDMS (see linked documents)
- There are plans to practice manipulating the APAs from the transport frame and deploying the different cabling configurations at Ash River
- Certainly the ProtoDUNE II installation will be another test of the plan and allow for testing the trolley, DSS connection, and cabling schemes
- The cables are included in the model used for analysis
- There are two talks this morning that will provide more details:
 - Dan's talk on the structural analysis of the APAs
 - Tom's talk on the installation process

Can you please point us to the drawings for the cable conduit? We want to ensure the specification for deburring is called out on the drawing

- Please see [EDMS 2112694](#), specifically the drawing labeled 8760086_REV_-.pdf
 - This drawing specifies “Break all sharp edges, internal and external”
 - PSL also emphasized with the vendor that the conduit be carefully deburred, and they did a good job
 - We can add more detail to the deburring note if desired

During the talks, there was mentioned the process for the local drawings at PSL being stored on a Solid Works database and then eventually posted to EDMS. When other production sites (both in the US and the UK) need drawings, do these come from EDMS or from the PSL database? If from EDMS, what controls are present to ensure people are receiving the most recent version?

- EDMS is the source of all drawings for all production sites
- If a drawing is not in EDMS, it is not considered released for use by the consortium
- We are developing an engineering change request procedure that will have as a step the posting of any changed drawings on EDMS
- We will use EDMS to track and approve/reject the engineering change requests
- The ongoing construction of APAs at Daresbury, using EDMS, allows to identify any residual issues and resolve them.

Questions from Second Day

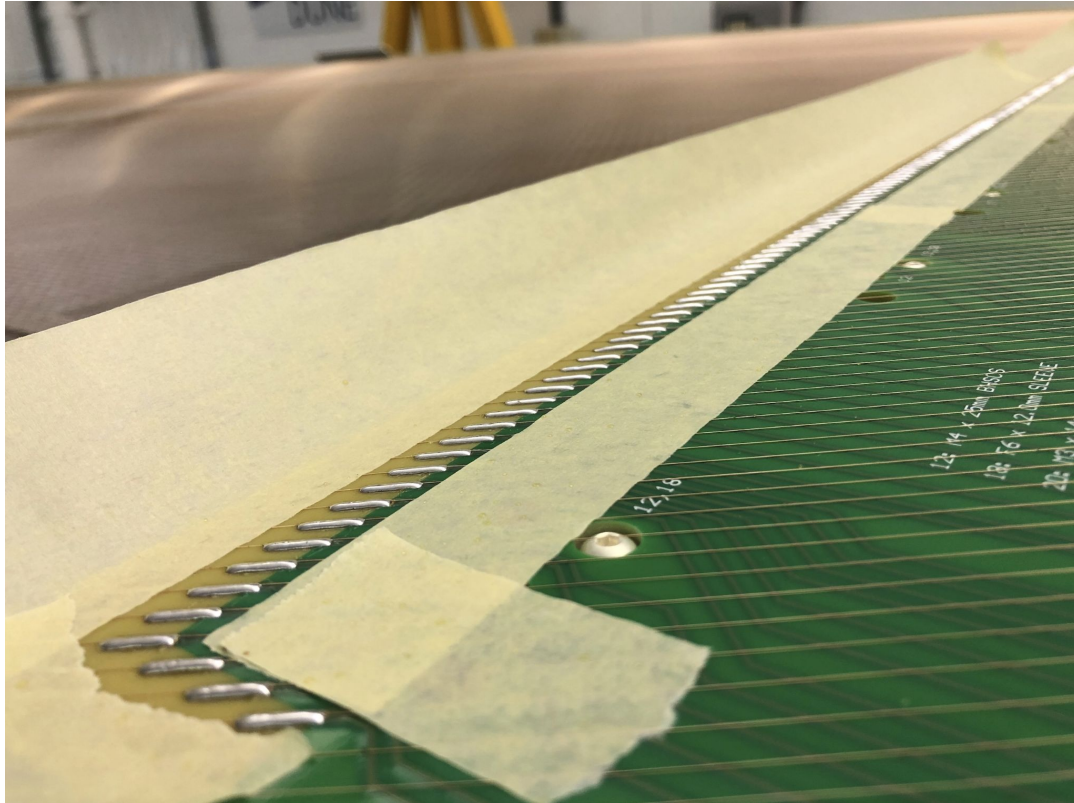
We wanted to ensure that sufficient detail about the monitoring of the APA's during shipping was included in Jeff's talk tomorrow, in specific some of the details about the monitors, requirements, and any interface between the shipping company and the consortium to make sure the requirements are met and thus damage to the APA is mitigated.

- Will defer this one until after Jeff's talk

Could we receive more clarification about what is the standard practice for soldering the wires in the instance that the wires are above the geometry board? There wasn't sufficient information available from the one photo we saw to understand if the spacing that appears to be present is typical and how it is dealt with during the soldering procedure

- The [procedure for soldering the wires](#) is available on EDMS, specifically section 9.2.1 of the file 8760Doc011_Tape_Solder_Trim.pdf
- Prior to soldering the frame supports are adjusted to minimize any frame distortions that could cause wire to be above the solder pads (section 9.2.1.5)
- The wires are taped to the board before soldering, which provides a mask to prevent solder splatters on the board and also traps any ends that will eventually be cut
- Taping also holds the wire against the pad before soldering

U-layer wires taped during soldering



The committee was also wondering if any unexplained wire breakage had been encountered during construction which might suggest defects in the wires from the manufacturer? If so, we would want to recommend a "pre-screening" of the wires prior to winding. If no such breakage had been seen, that would be helpful to know.

- A review of the PSL logs from ProtoDUNE showed there were no instances of unexplained breakage during construction
- Daresbury also confirms that after winding more than 100 km of wire they have seen no unexplained breakage
- Any breakage was the result of either tooling or operator actions and no break suggested a problem with the wire
- A materials certification comes with each order from the vendor
- PSL tested 3 samples from each spool for break strength during ProtoDUNE I and recorded the values - all were more than 25 N