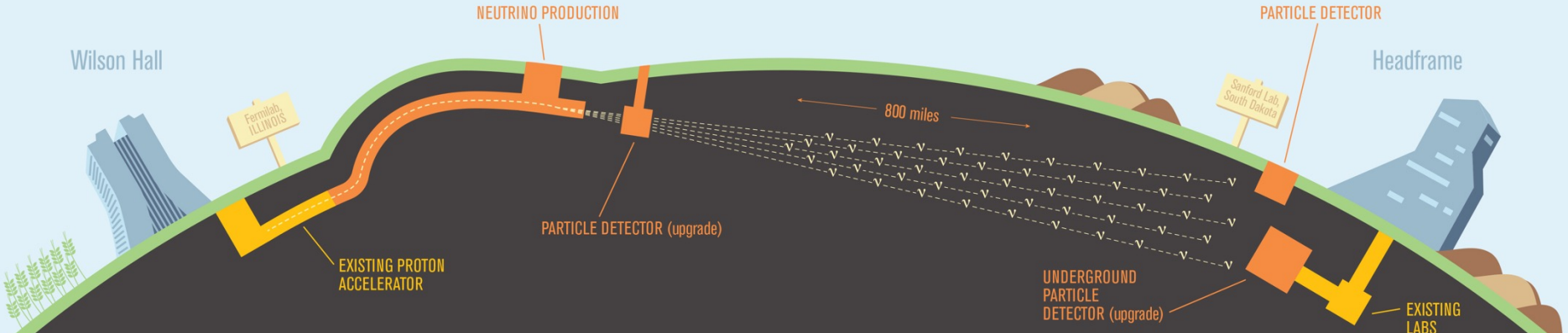
MANCHESTER 1824
The University of Manchester

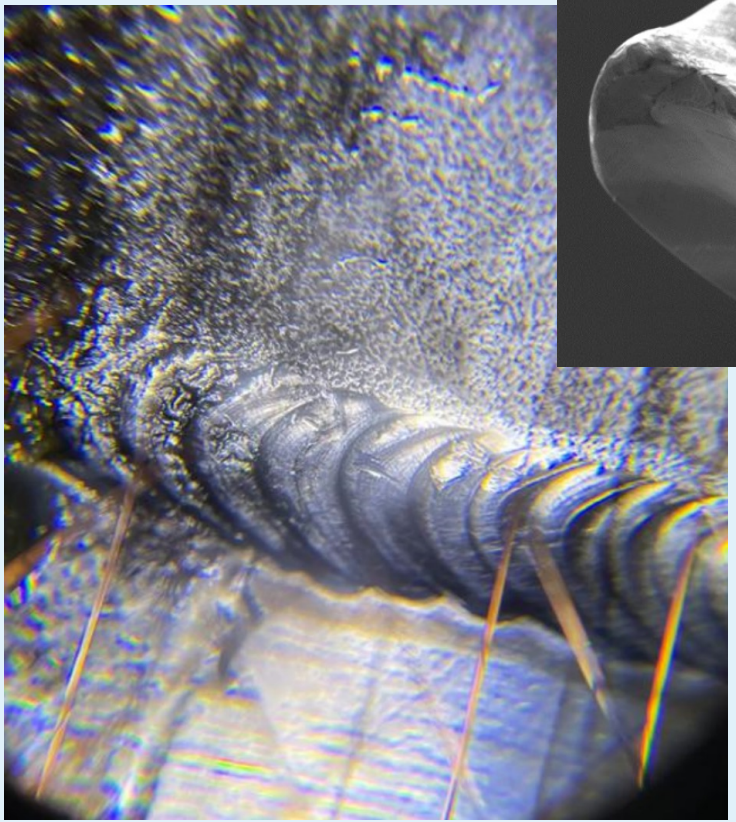
DUNE
DEEP UNDERGROUND NEUTRINO EXPERIMENT

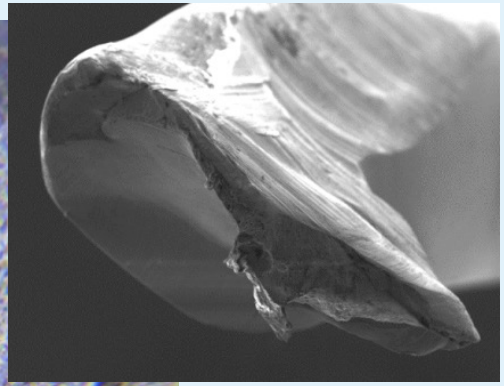
Module 0 lessons learnt

Justin Evans



ProtoDUNE 1: Broken X-wire





Broken X-wire was caused by pre-existing damage

- Scratch on frame indicates contact by a sharp object, which also damaged the wire

Improvements to procedures

- Culture of always reporting any inadvertent APA contacts, or other incidents that could cause damage to production manager
- Any wires with any suspicion of damage are removed from the APA

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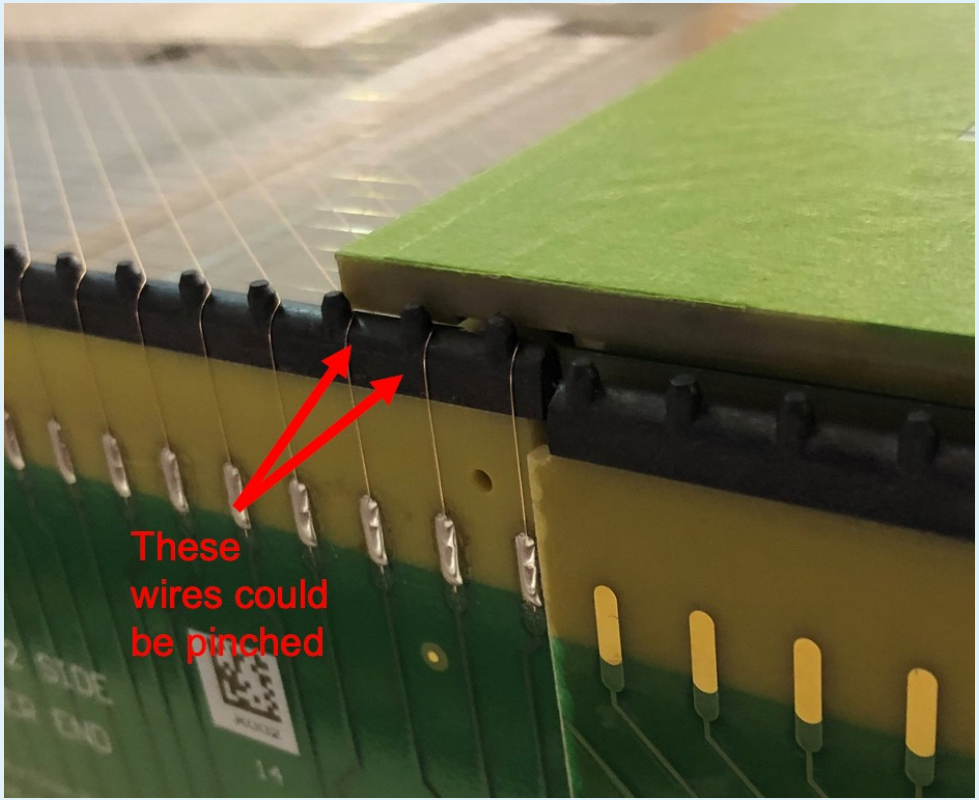
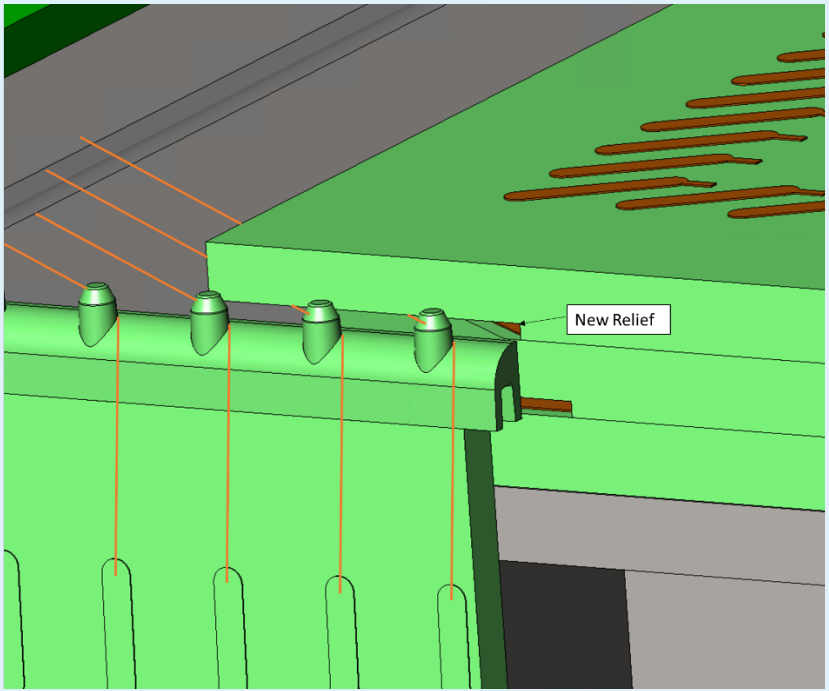
ProtoDUNE 1: Broken V wires



- Corner V-wires were bonded to the U-head board above, creating a short wire length

EDMS-2614531 & 2570615

ProtoDUNE 1: Broken V wires



- Corner V-wires were bonded to the U-head board above, creating a short wire length
- New wire relief added to U- and G-head boards to prevent this bonding

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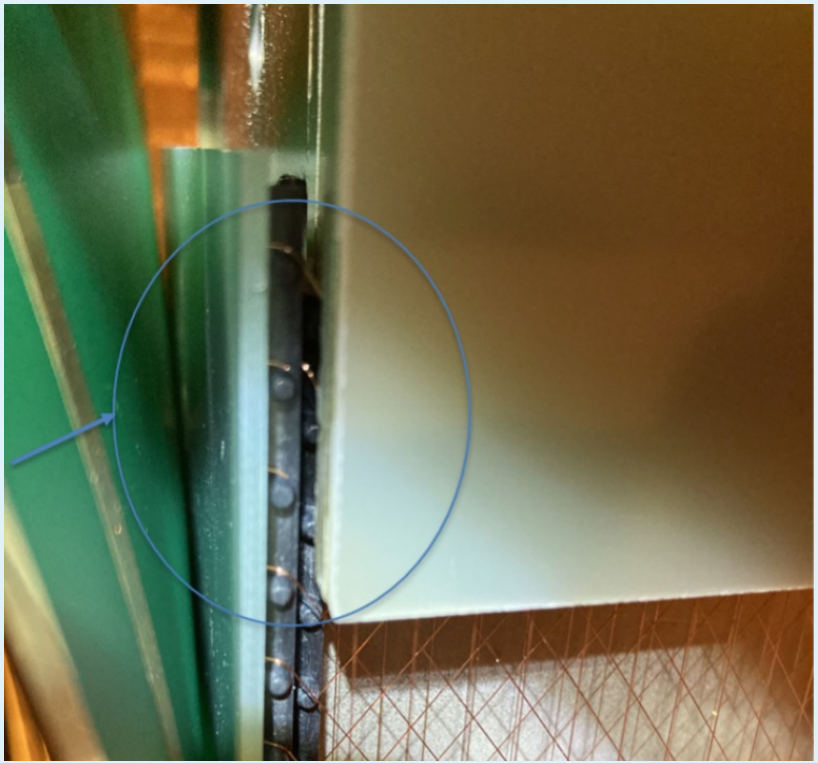
ProtoDUNE 1: Broken U-wires

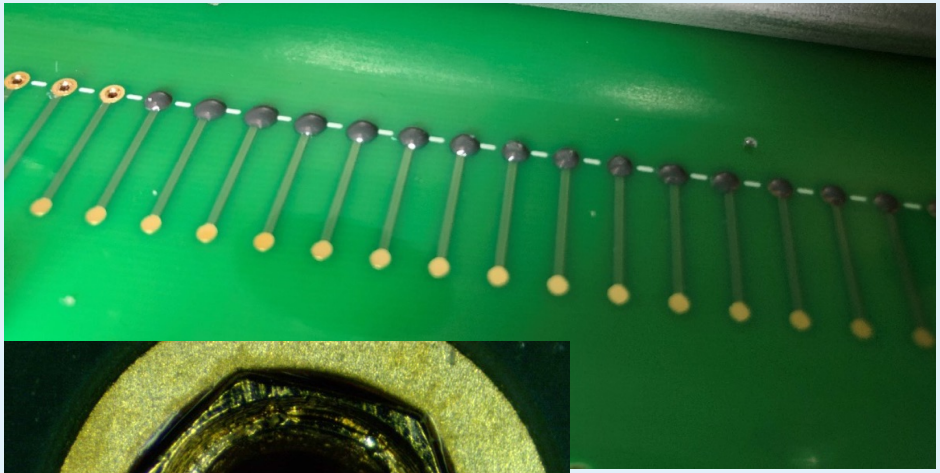


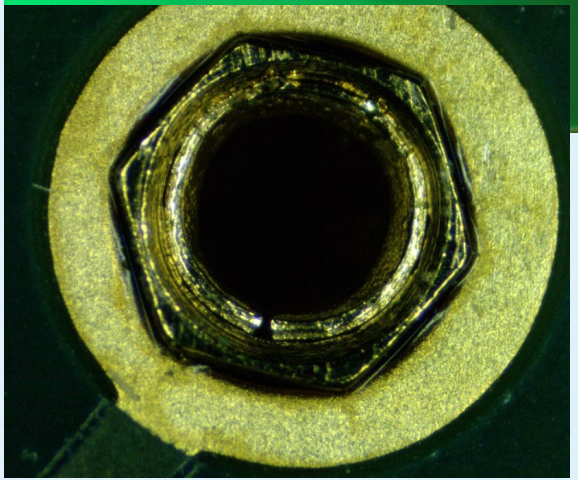
Short U-wires are broken

- Due to short wire lengths between boards

Short corner wires will be soldered at zero tension

New Mill-Max pins





Epoxy flowed through new Mill-Max pins

- New hexagonal shape creates a gap in the pin

A new groove has been added in the back of the V-head boards to prevent epoxy flowing to the Mill-Max pins

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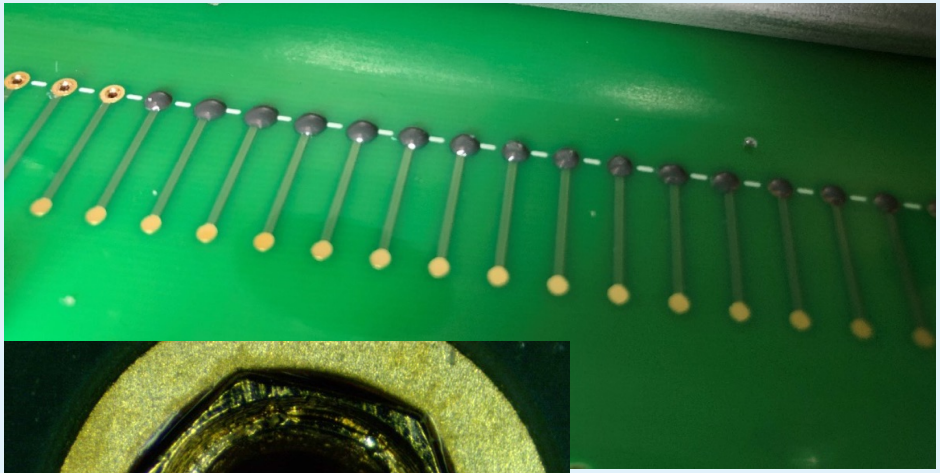
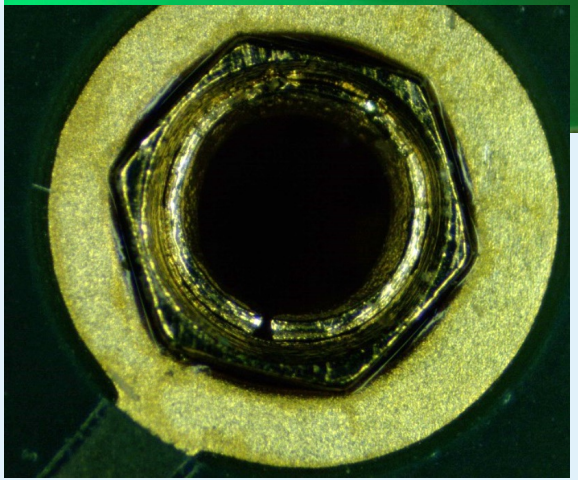
New Mill-Max pins





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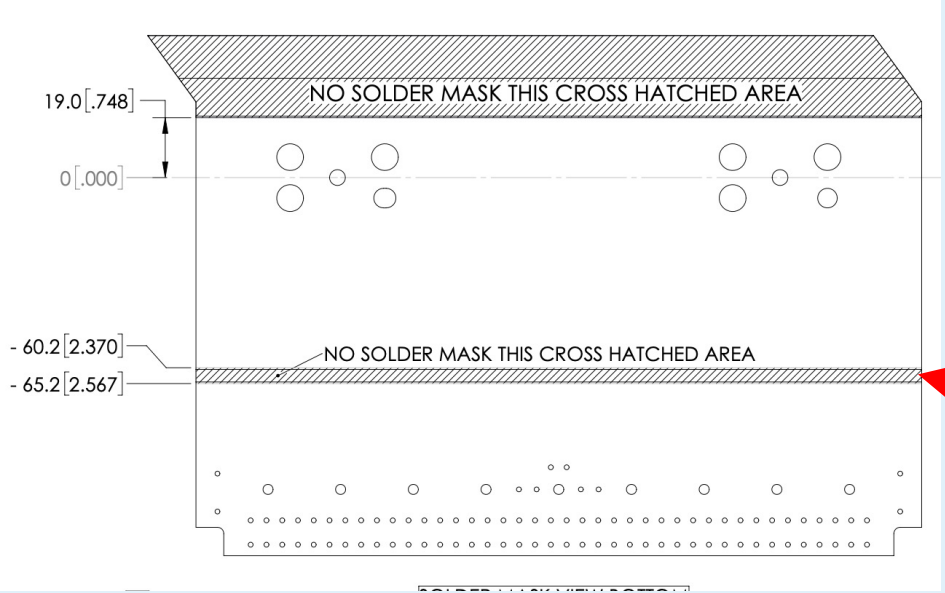

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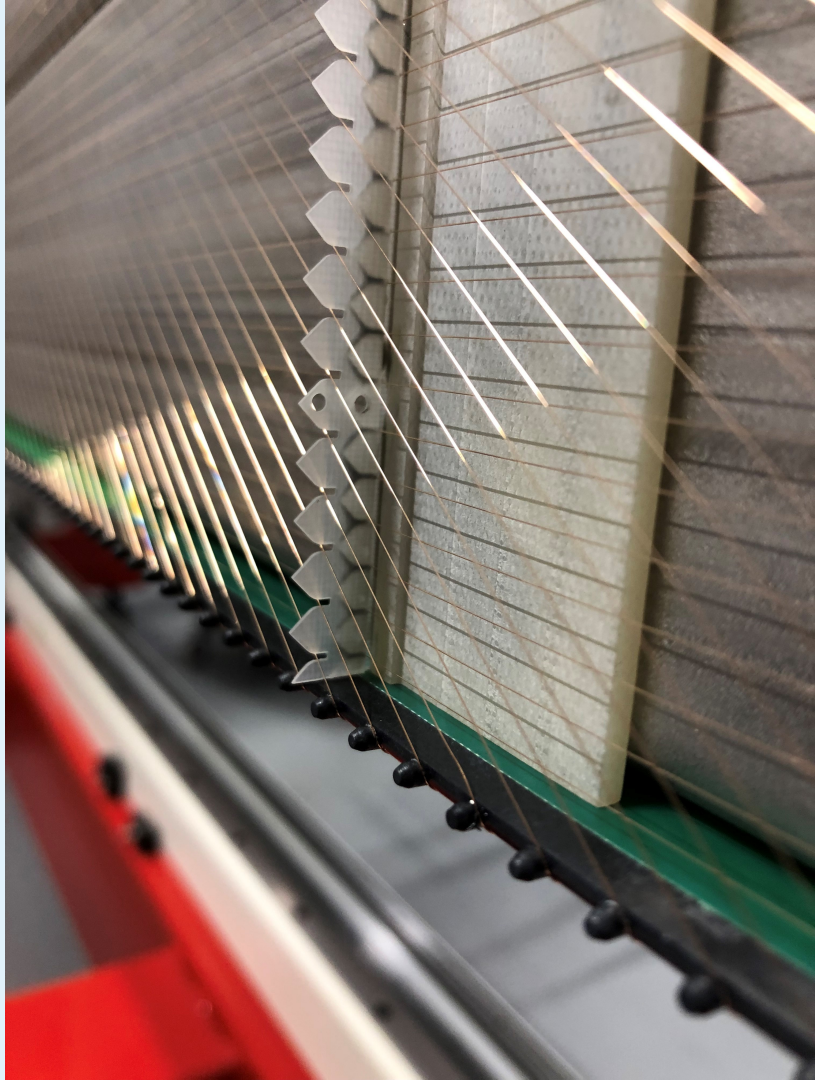
APA 2 V-layer: misaligned holes

The V-layer, when first wound, was not planar with the X-layer

- The boards along the high-slot edge are just under 1 mm offset from the centre of the tube, due to the holes drilled in the tube being offset
- In the picture, you're looking for the fact that the wires do not sit at the bottom of the gaps in the combs

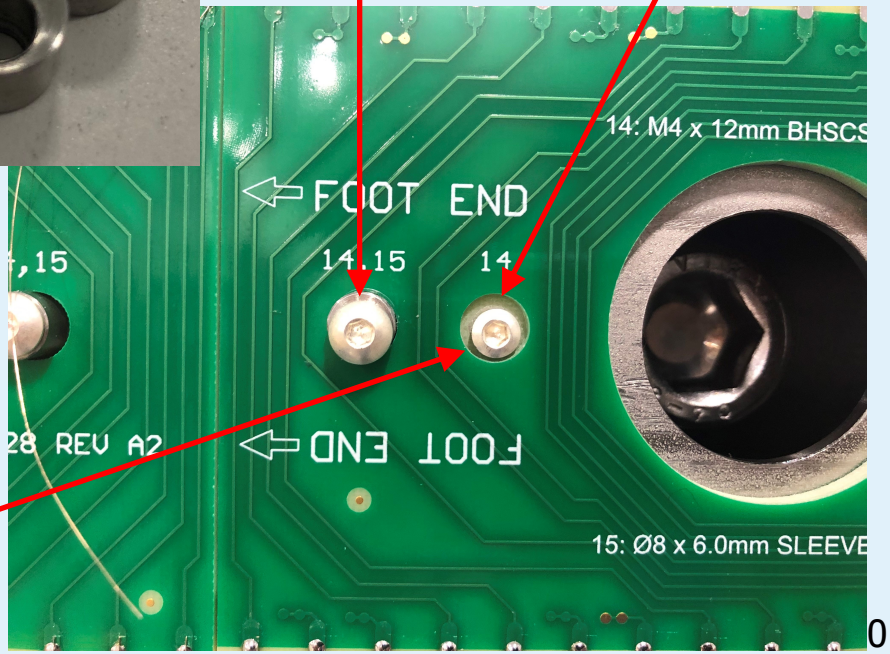


Addressing the non-conformity

- V-layer is being re-wound
- Board-locator dowels have been remade with off-centre holes
- These new dowels shift the high-slot V-wrap boards by enough to bring them back into alignment
- Screw holes marginally reamed out (fraction of mm) to ensure no collision with screws

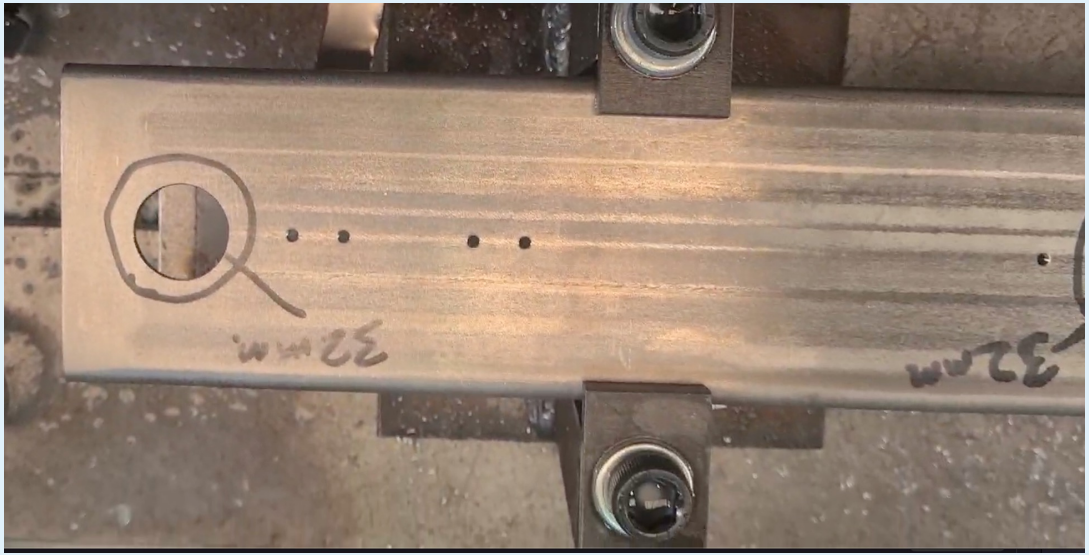
Dowel with off-centre hole

You can see the board has shifted up



This hole is slightly reamed out to ensure no collision with screw

Getting it right for future APAs



- New clamping system implemented when machining APA beams to ensure correct location of holes with respect to datum points

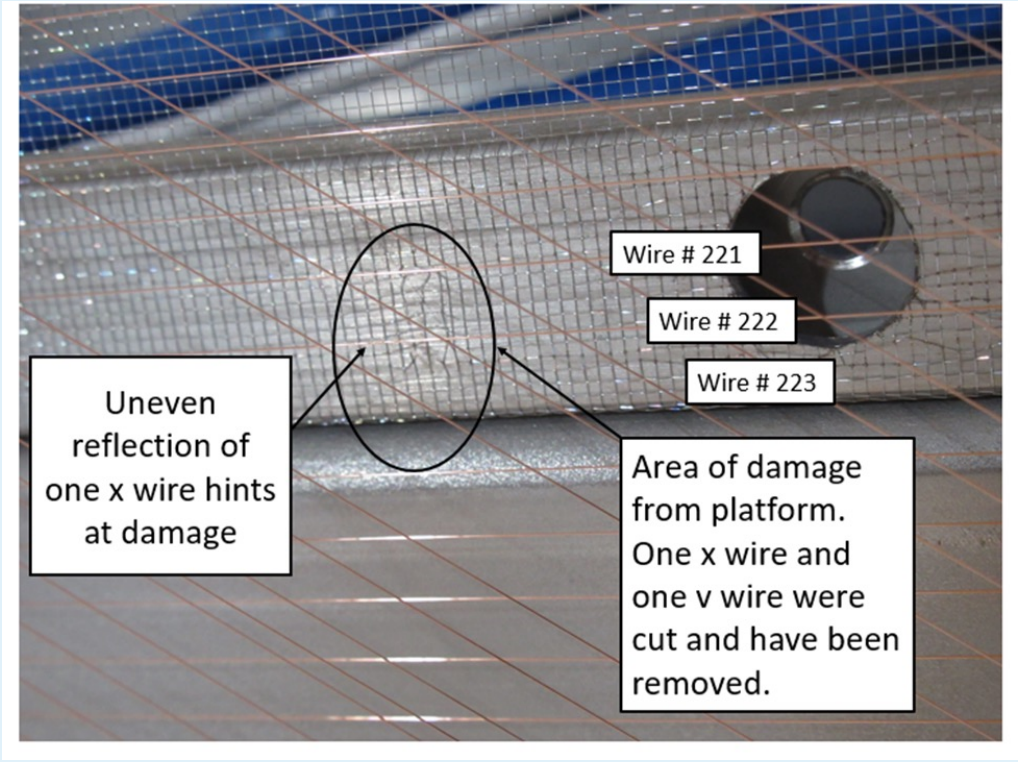
Sharp edges on protection channels

- Aluminium protection channels have sharp edges that could damage APAs during removal
- Padding will be added to the edges of future channels

Ladder contact

Ladder made contact with APA 4

Ladder contact



Ladder made contact with APA 4

Damage to mesh

2 damaged X-wires

- Removed

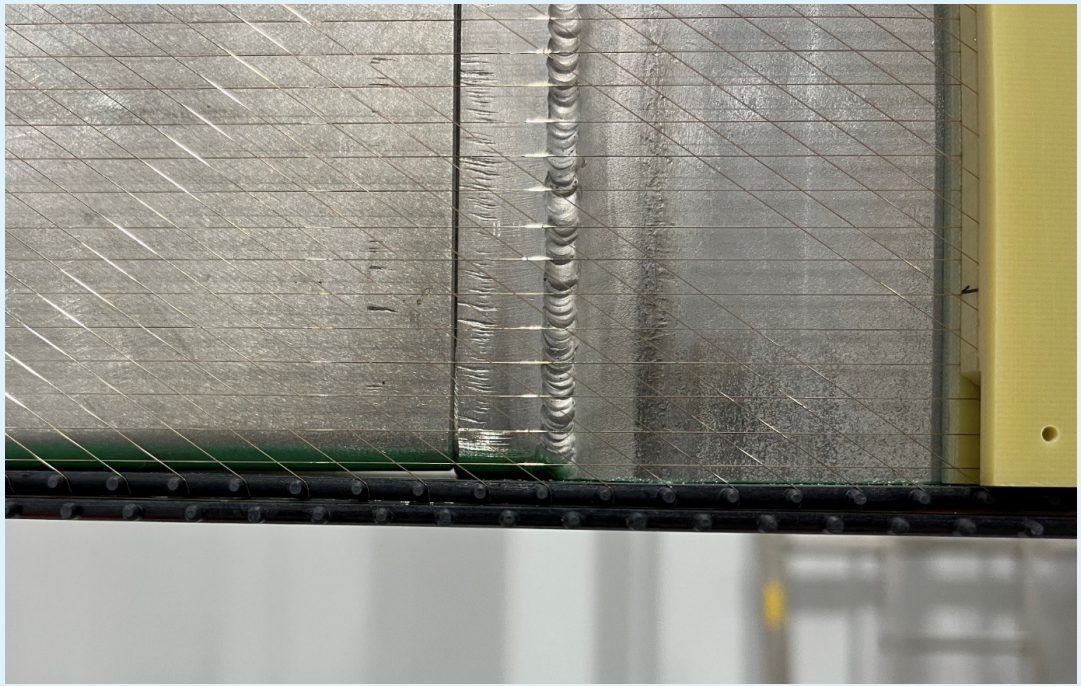
2 damaged V-wires

- Replaced

Ladder contact

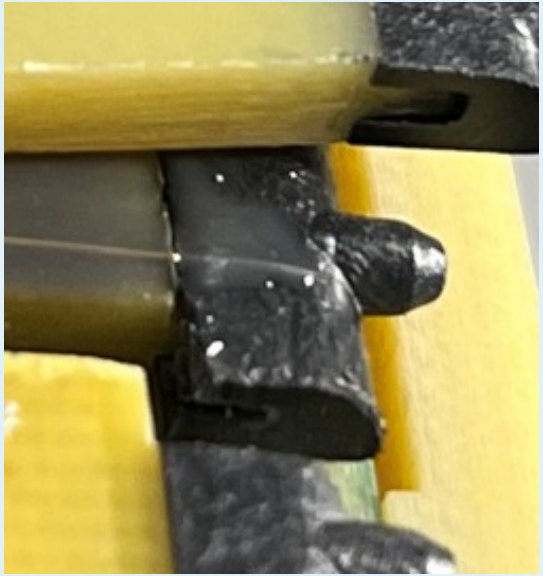
Bumper added to ladder to prevent future contact with APA

Broken wires APA 2



- Two broken V-wires on APA 2

Broken wires APA 2

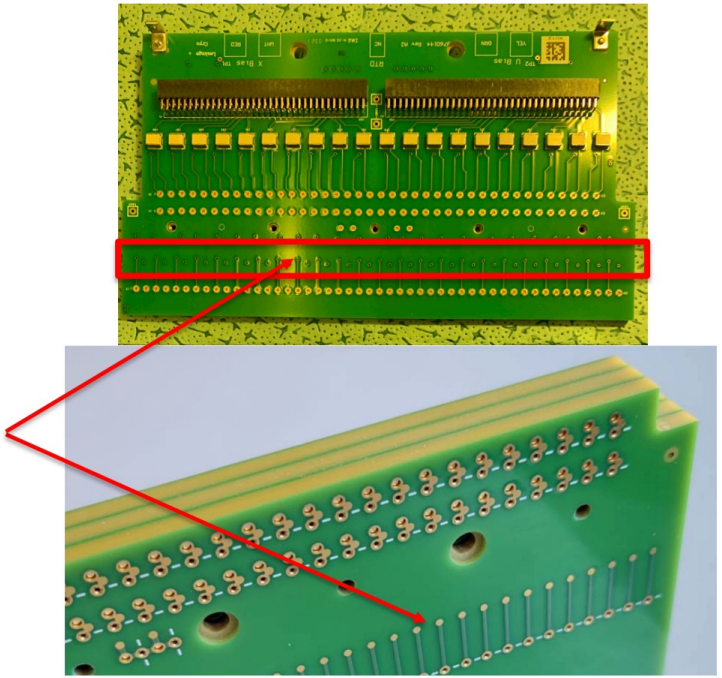


- Two broken V-wires on APA 2
- Occurred due to insufficient glue on teeth of one V-board
- Teeth were knocked when installing U-board
- In future, board assembly to ensure teeth are glued all the way to the end, and technicians will be more vigilent, and masking tape will be used to prevent wires being epoxied to the teeth

CR boards problem

- Overlapping vias and contacts on the X layer headboards and the CR boards(shown by the arrows) caused current leak when bias voltage was applied to the X layer wires.
- Inconsistent card set produced by mistake; found during the APA 1 test.
- The error was on the CR boards, the headboard stack is correct.
- Mitigated temporarily with a strip of Kapton (area in the red box) to allow the APA 1 test to proceed while the correct set of CR boards is being made.

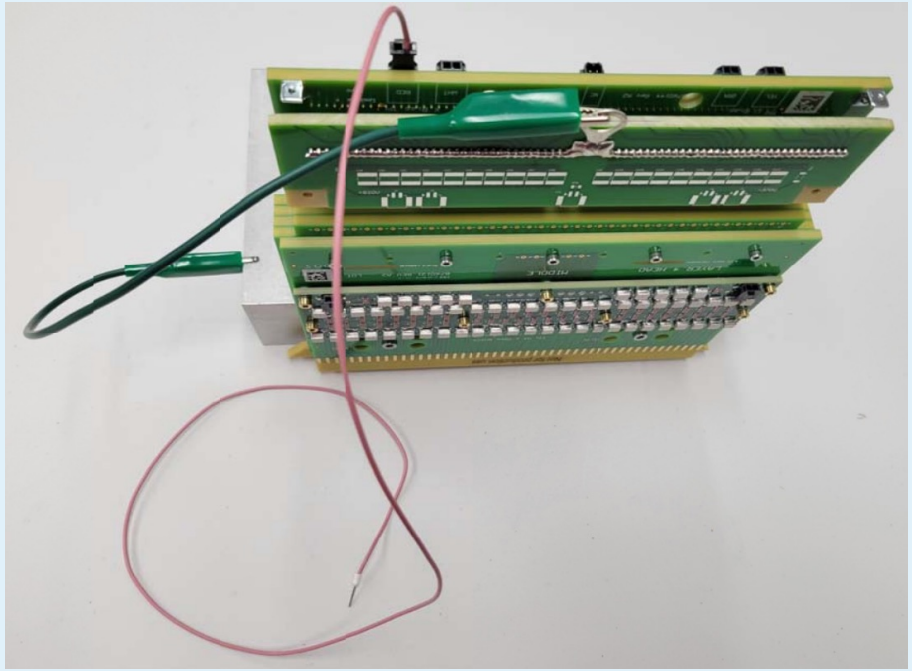
CR boards



Headboard stack, exposed side of the X layer board

CR board problem

- CR boards being remade with blind vias rather than through-holes
- An important lesson is to test a full board stack, which has now been done at PSL



EDMS-266800 & 2666798

Summary

- Broken wires in ProtoDUNE-1
- Mill-max pin epoxy path
- Misaligned holes on APA side beams
- Sharp edges on protection channels
- Ladder contact
- Broken V-wires due to tooth-gluing
- CR boards