

Production Update For DUNE-UK APA PCBs

By

Anthony Ezeribe, Nicola McConkey, Mark Langstaff, Matthew Wright, Tom Walsh, Pablo Murray, David Marsden, Slawek Kubecki, Justin Evans, Vitaly Kudryavtsev, Jaroslaw Nowak, Clark Griffith and Melissa Uchida.

Outline

- Boards on an APA
- Board Reception QC Measurement Setups
- PCBs for ProtoDUNE-II APAs
 - Geometry Board Assembly Tasks
 - Mill-Max Pin Insertion For Head Boards
 - Tooth-strip Attachment For Side, Foot & Edge Boards
- PCBs for DUNE APAs
- Summary

Boards on an APA



- PCBs are needed on the edges of an APA for soldering the signal wires.
- These PCBs are used to bias and route charge signals for readout.
- Tension measurement DWA will also connect to these APA boards.

Board Reception QC Tests at Manchester

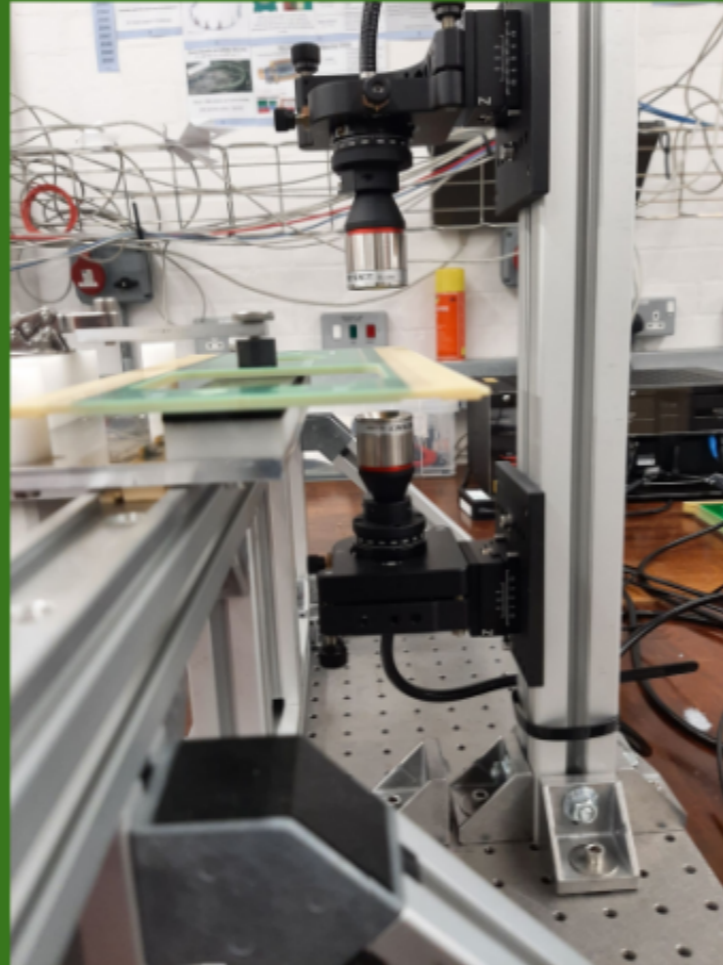
Keyence IM-7030T



Feature Measurement

e.g. Checks hole positions and diameters, tongue height, glue groove position.

Keyence CL-3000



Thickness Measurement

Measures board thickness at several points, including tongues and glue groove thicknesses.

Dial Indicator Setup



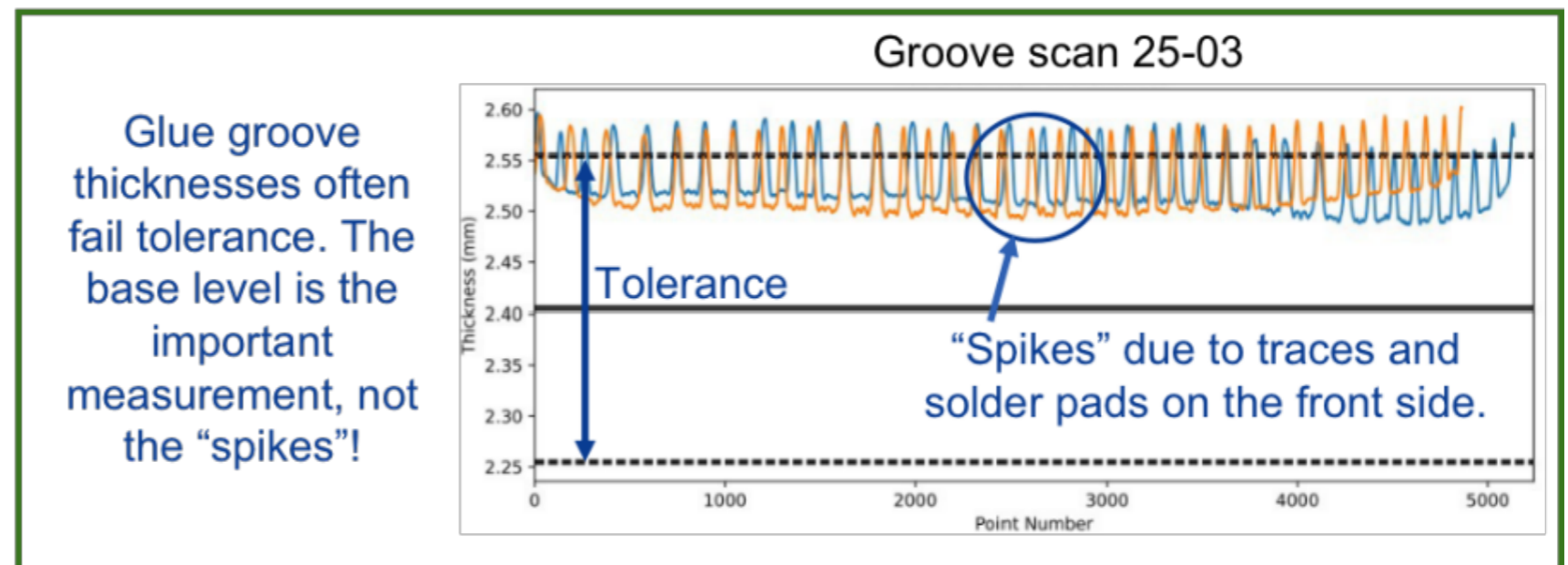
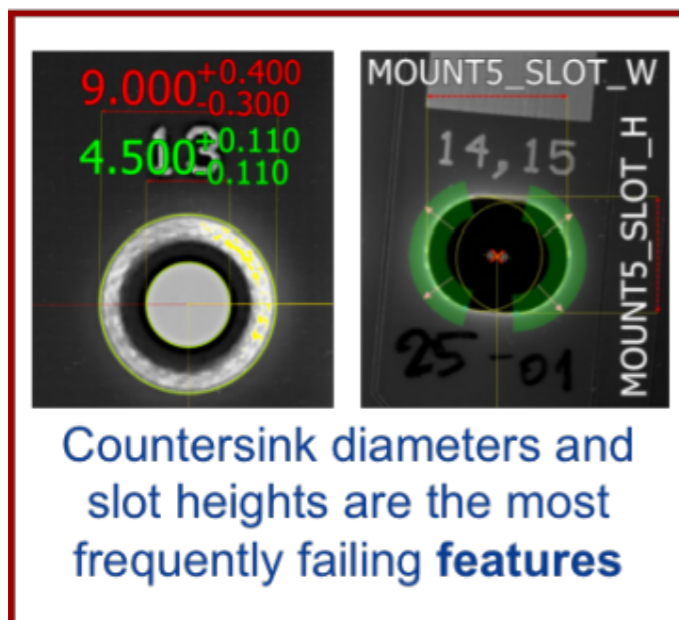
Tongue Depth Tests

Checks how “centred” and straight the tongues are.

PCB QCs For ProtoDUNE-II APAs

| S/N | Board Type | No of Tested Batches | Batch Source | No of Tested Boards | Average Pass Rate (%) |
|-----|----------------|----------------------|------------------------------|---------------------|-----------------------|
| 1 | X-Layer Boards | 11 | Company A: 6 Company B: 5 | 228 | 60 |
| 2 | V-Layer Boards | 14 | Company A: 9 Company B: 5 | 346 | 40 |
| 3 | U-Layer Boards | 2 | Company A: 0 Company B: 2 | 80 | 60 |

- Board pass rate varies from batch to batch. So far, average pass rate is ~52%.
- Company-A Board Pass Rate: ~40%; Company-B Board Pass Rate: >60%.
- The pass rate of Company-B is improving as we feed our QC results back to their production process.

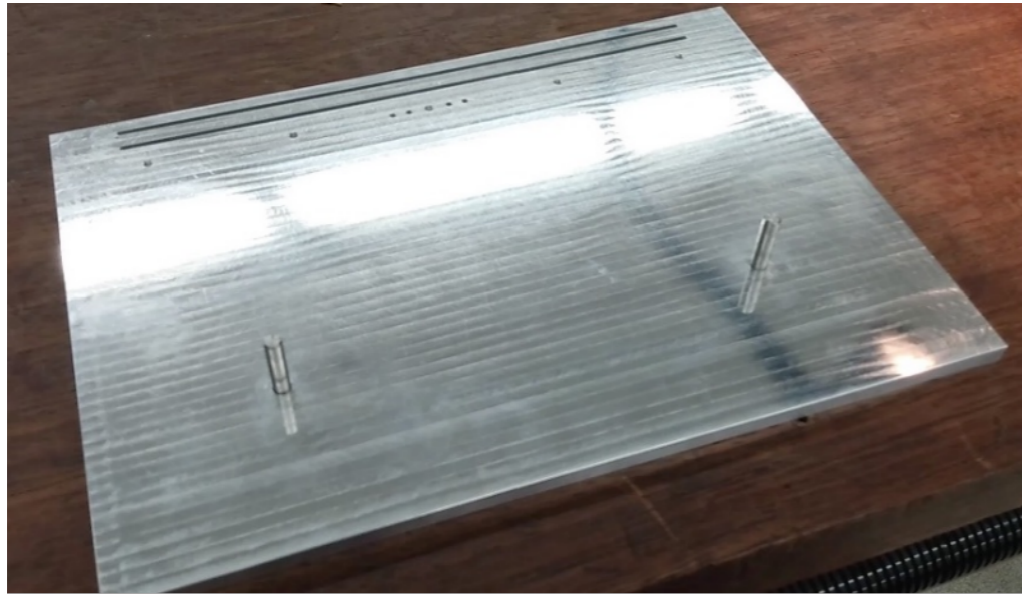


Geometry Board Assembly After Reception Tests.

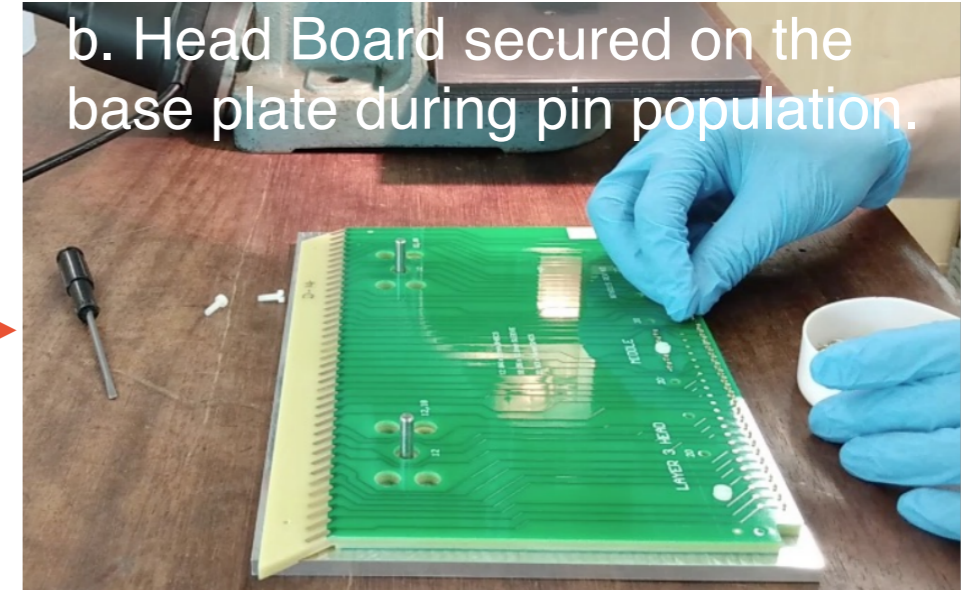
Geometry Boards Assembly Tasks

| S/N | Geometry Board Type | Required Assembly | Assembly Jig | Assembly Location |
|-----|---------------------|------------------------|----------------------------|------------------------------|
| 1 | Head Boards | Mill-Max Pin Insertion | Modified Arbor Press Setup | Sussex/ Cambridge |
| 2 | Foot Boards | Tooth-Strip Attachment | Bespoke PCB Clamping Setup | Sheffield: V Lancaster: U |
| 3 | Side Boards | Tooth-Strip Attachment | Bespoke PCB Clamping Setup | Sheffield: V Lancaster: U |
| 4 | Edge Boards | Tooth-Strip Attachment | Bespoke PCB Clamping Setup | Sheffield: X Lancaster: G |

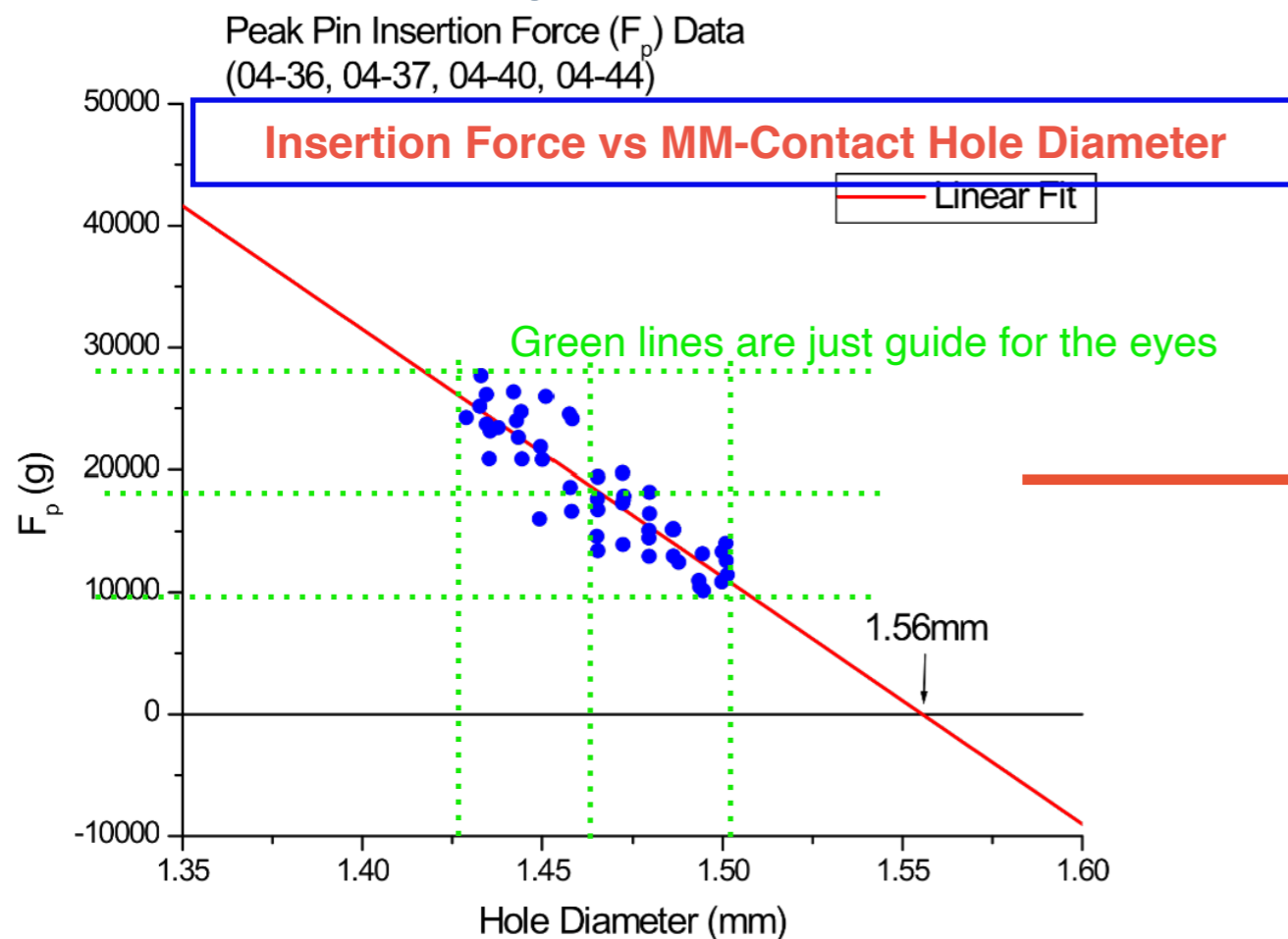
Mill-Max Pin Insertion at Sussex



a. Base Plate with groove for pin clearance.

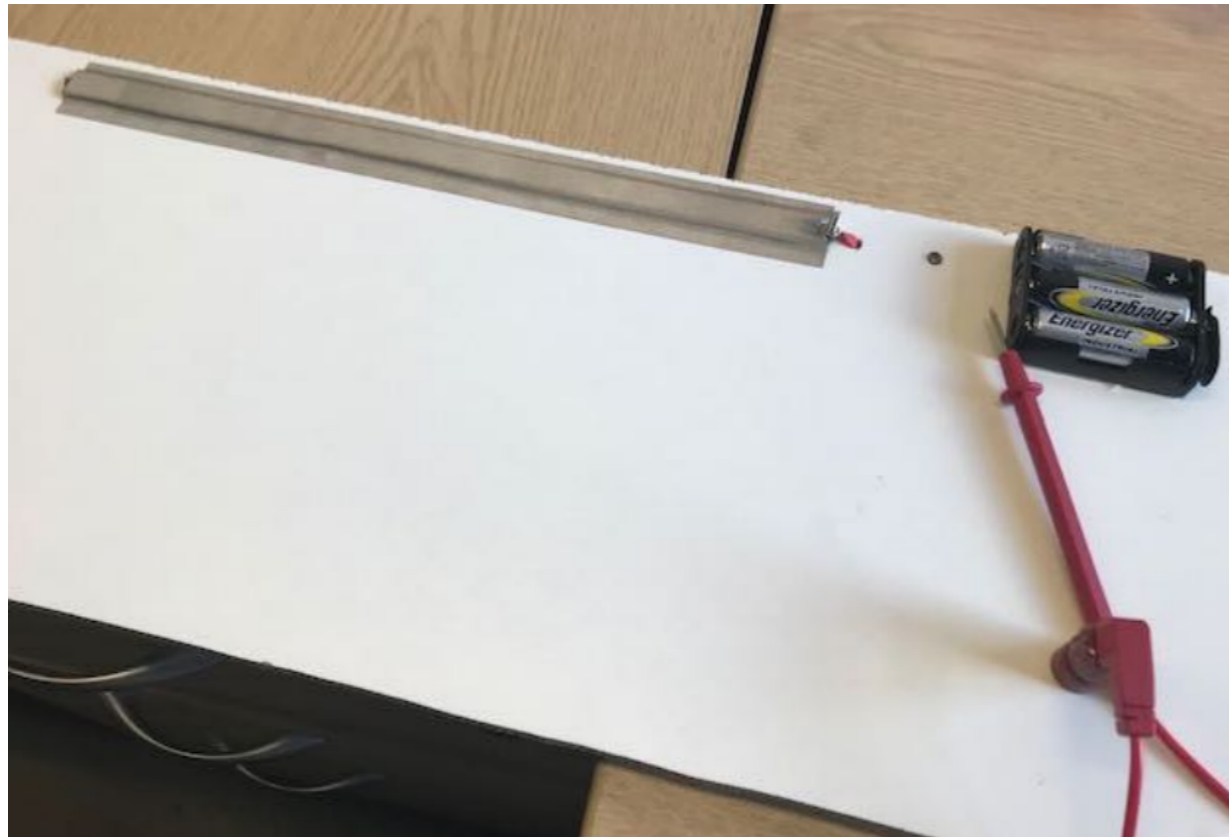


b. Head Board secured on the base plate during pin population.



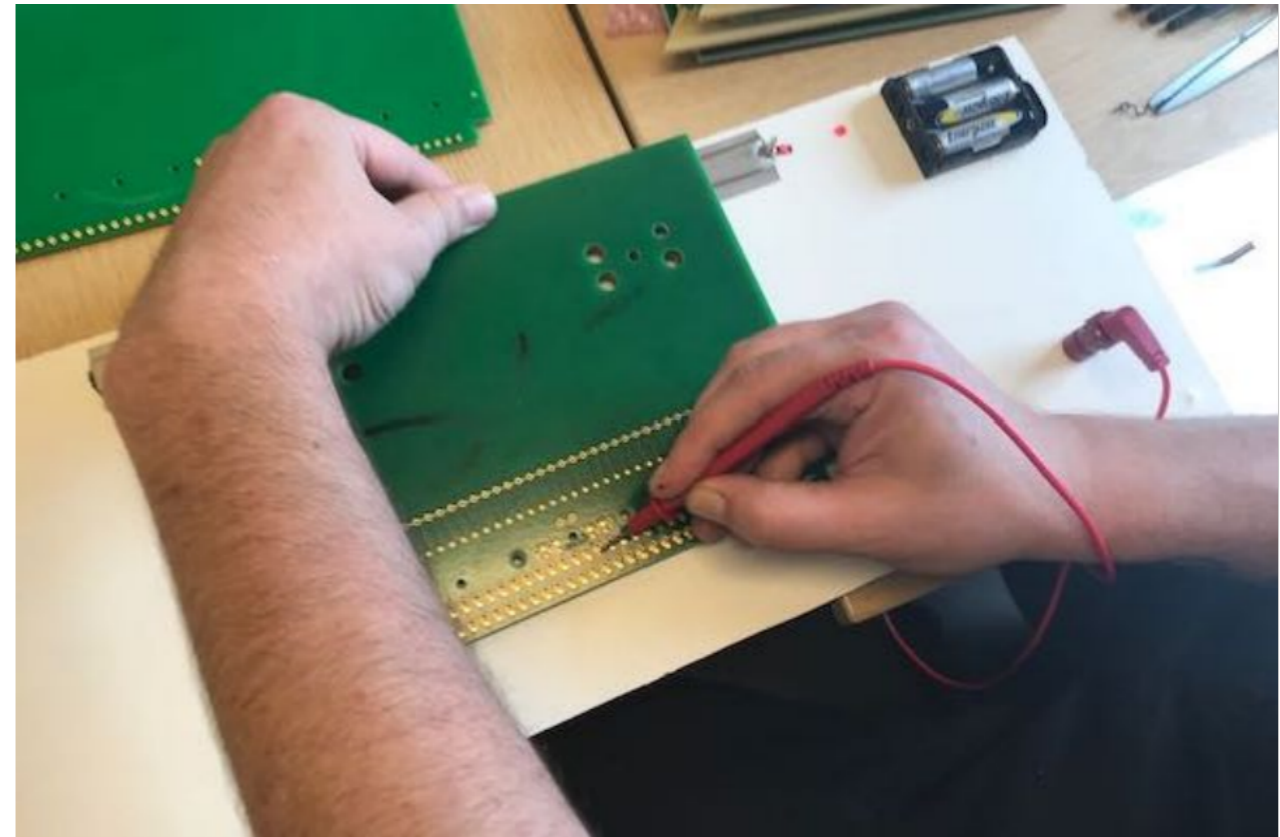
c. Head board secured on a base plate, positioned for pin insertion with an Arbor press setup.

Post Mill-Max Pin Insertion QC Tests



Test Setup:

A conductive strip contact traces on board connected to a probe.



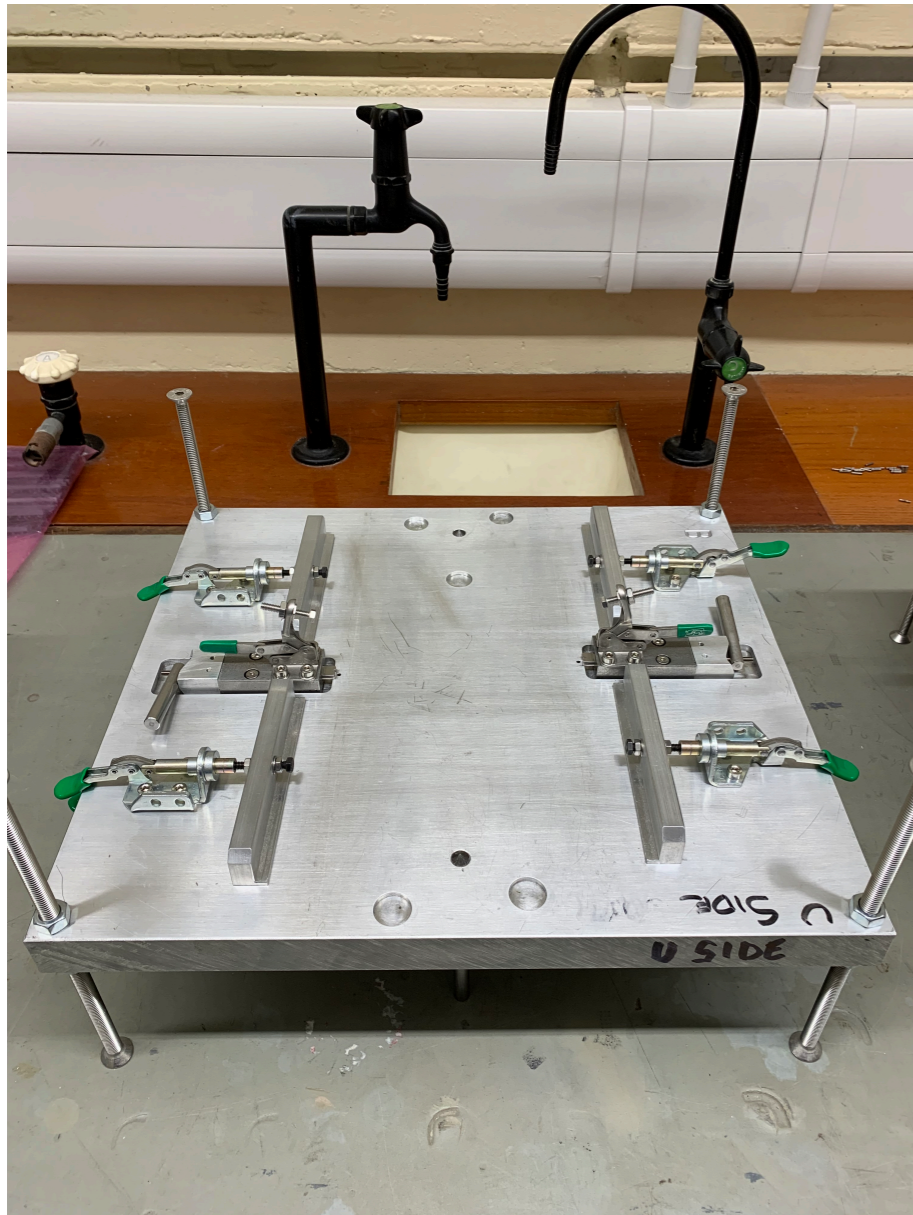
Head Board Stack Test:

Checks continuity through a board stack. In this case: Stacked V + X-layer head boards.

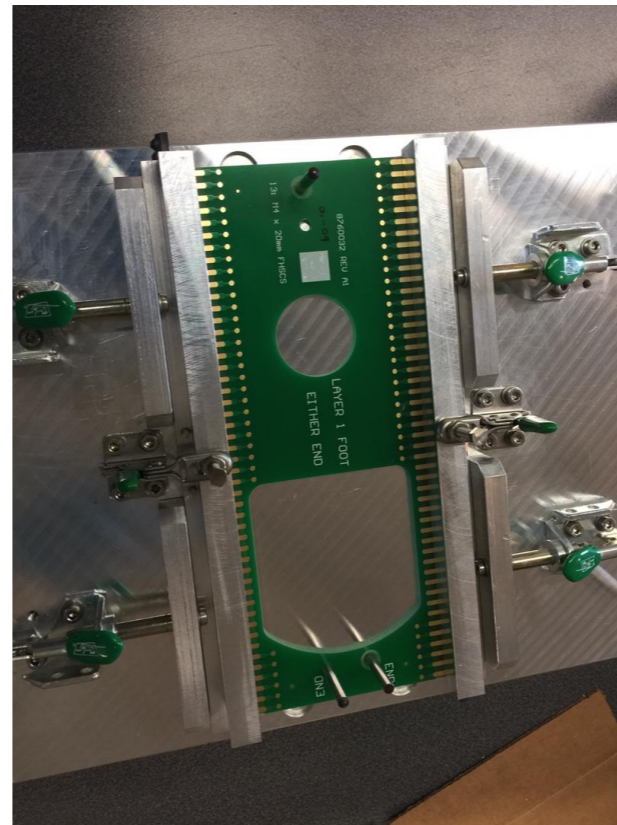
Head Boards For ProtoDUNE-II APAs

| S/N | Head Board Type | Status For APA-2 | Assembly Location |
|-----|-----------------|-------------------------------------------------------------|-------------------|
| 1 | X-Head Boards | Received at Daresbury | Out sourced |
| 2 | V-Head Boards | Shipping to Daresbury today | Sussex |
| 3 | U-Head Boards | Ongoing Reception/QC Tests (Expected at Daresbury 01/09/21) | Sussex/Cambridge |
| 4 | G-Head Boards | Ongoing Reception/QC Tests | Sussex/Cambridge |

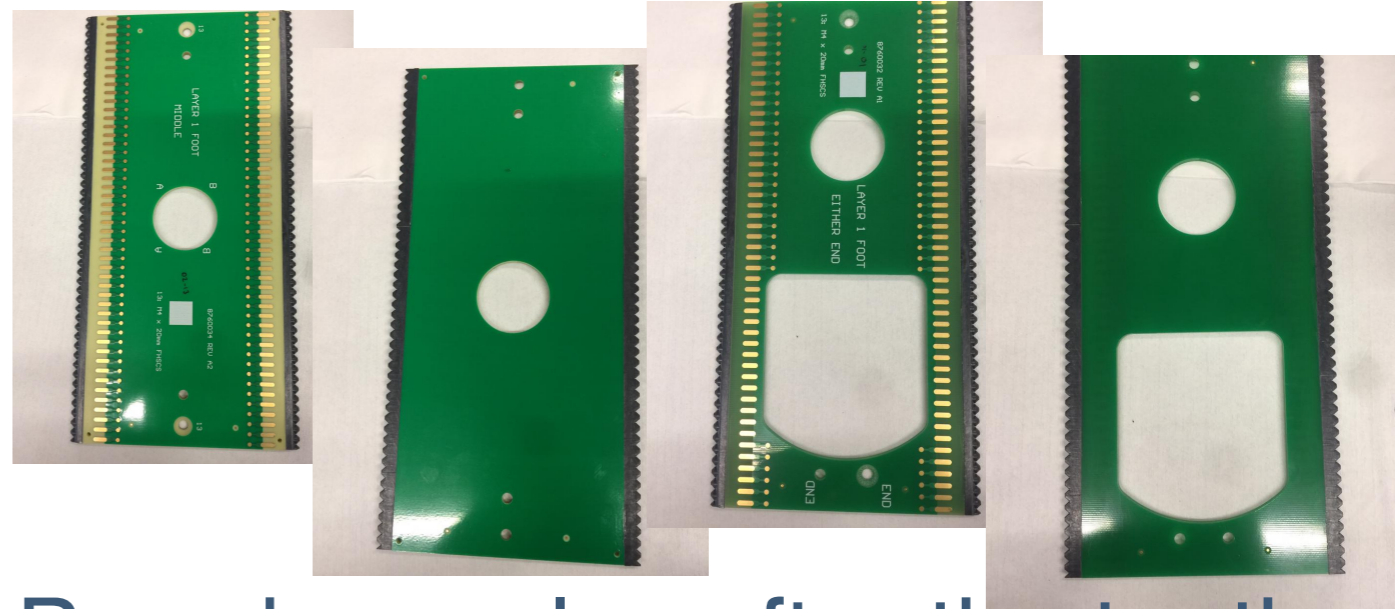
Tooth-Strip Attachment at Sheffield/Lancaster



(a) Example of a Tooth-Strip attachment jig.

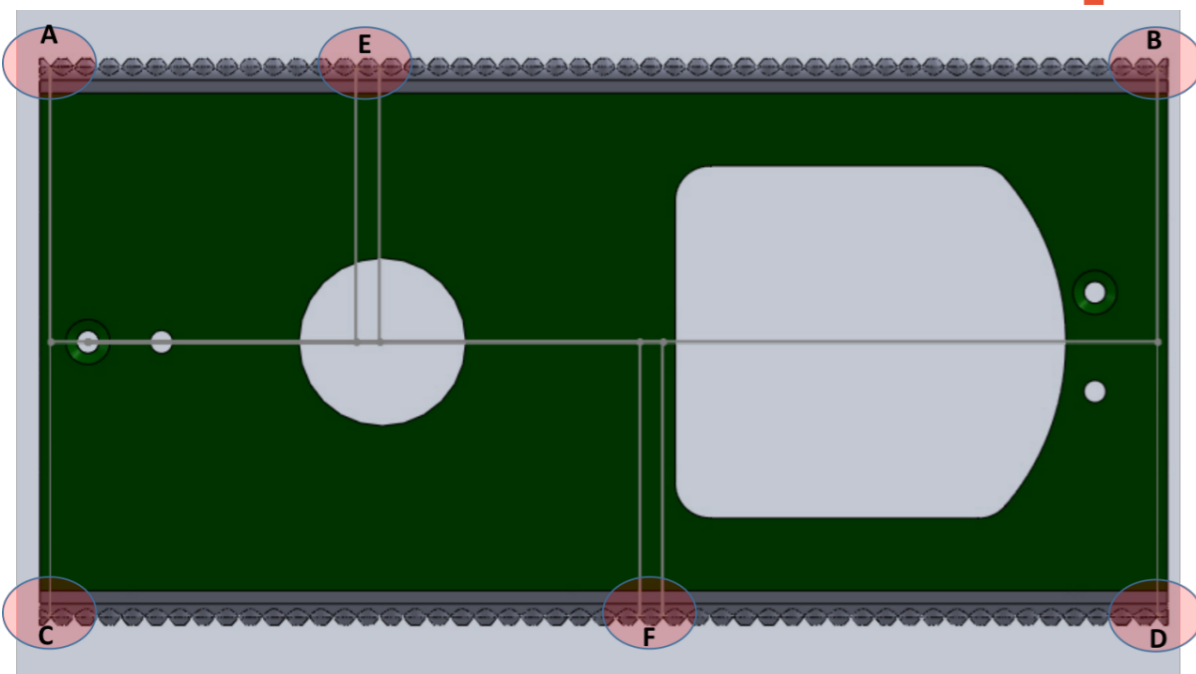


(b) Tooth-strips glued to a board using a tooth-strip attachment jig.

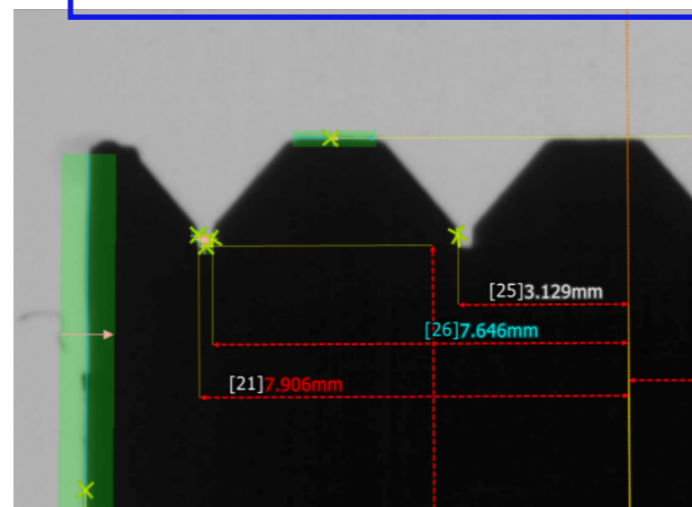


(c) Board samples after the tooth-strips have been attached.

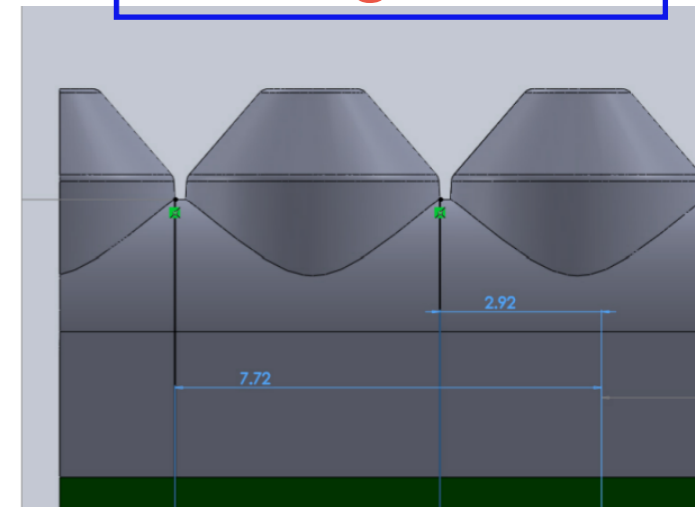
Post Tooth-Strip Attachment QC Tests



A: Measured values



A: Design Values



- Attached tooth-strips are visually inspected for faults.
- Tooth-strip groove positions are measured relative to the board mounting hole positions to maintain the required tooth position tolerances. This test is done for every new tooth-strip batch or for every new jig and after every 100th tooth-strip attachment from a given jig.
- Effective board heights (tooth-strip groove-groove height) are measured to ensure that they are within the allowed 100 microns tolerance.

Edge/Side/Foot Boards For ProtoDUNE-II APAs

| S/N | Head Board Type | Status For APA-2 | Assembly Location |
|-----|--------------------|---------------------------------------------------------------|-------------------|
| 1 | X-Edge Boards | Received at Daresbury | Sheffield |
| 2 | V-Side/Foot Boards | Shipping to Daresbury today | Sheffield |
| 3 | U-Side/Foot Boards | Attaching Tooth-Strips (Expected at Daresbury 01/09/21) | Lancaster |
| 4 | G-Edge Boards | Ongoing Reception/QC Tests | Lancaster |

All PCB reception QC tests are done at Manchester.

List of Boards And Documentations

| S/N | Description | Board Ref. | No for 1 APA |
|-----|--------------------------------------|------------|--------------|
| 1 | X Foot Board End | 8760032 | 2 |
| 2 | X Foot Board Middle | 8760034 | 6 |
| 3 | X Foot Board Position 4 And 7 | 8760109 | 2 |
| 4 | X Board Head | 8760104 | 20 |
| 5 | V Head Board Middle & Right End | 8760108 | 18 |
| 6 | V Head Board Left End | 8760116 | 2 |
| 5 | V Side Board End | 8760024 | 4 |
| 6 | V Side Board Middle Without Slot | 8760026 | 24 |
| 7 | V Side Board Middle With Slot | 8760028 | 14 |
| 8 | V Foot Board Middle | 8760030 | 6 |
| 9 | V Foot Board End | 8760036 | 2 |
| 10 | V Foot Board Middle Position 4 And 7 | 8760107 | 2 |
| 11 | G Head Board Middle | 8760121 | 16 |
| 12 | G Head Board Right-End | 8760120 | 2 |
| 13 | G Head Board Left-End | 8760122 | 2 |
| 14 | G Foot Board Low Slot End | 8760051 | 1 |
| 15 | G Foot Board Middle | 8760054 | 6 |
| 16 | G Foot Board High Slot End | 8760062 | 1 |
| 17 | G Foot Board Position 4 and 7 | 8760113 | 2 |
| 18 | U Head Board Middle | 8760115 | 16 |
| 19 | U Head Board Left End | 8760119 | 2 |
| 20 | U Head Board Right End | 8760123 | 2 |
| 21 | U-Side Board End | 8760038 | 4 |
| 22 | U-Side Board Without Slot Middle | 8760040 | 24 |
| 23 | U-Side Board With Slot Middle | 8760042 | 14 |
| 24 | U-Foot Board High Slot End | 8760044 | 1 |
| 25 | U-Foot Board Middle | 8760057 | 6 |
| 26 | U-Foot Board Low Slot End | 8760059 | 1 |
| 27 | U-Foot Board Position 4 And 7 | 8760111 | 2 |
| 28 | CR Boards | 8760144 | 20 |
| 29 | G-Plane Bias Filter Board | 8760196 | 20 |
| 30 | SHV Header Boards | | 1 |
| 31 | CE-CR Adapter Boards | | 20 |
| 32 | Cover, foot, low slot end | 8760064 | 1 |
| 33 | Cover, foot, middle | 8760067 | 6 |
| 34 | Cover, foot, high slot end | 8760069 | 1 |
| 35 | Cover, side, foot end | 8760071 | 2 |
| 36 | Cover, side, head end | 8760072 | 2 |
| 37 | Cover, side, w/o slot | 8760073 | 24 |
| 38 | Cover, side w/slot | 8760074 | 14 |
| 39 | Cover, foot, middle position 4 & 7 | 8760182 | 2 |
| 40 | Cover - head - left end | 8757267 | 2 |
| 41 | Cover - head middle & right end | 8757268 | 18 |

Geometry Board Types: **27**
 Geometry boards per APA: **204**

Bias, Filter and Adapter Board Types: **4**
 Bias, Filter and Adapter Boards per APA: **61**

Cover Board Types: **10**
 Cover Boards per APA: **72**

Board Documentations:

- **PCB Information on Twiki:**
https://dune-uk.pp.rl.ac.uk/twiki/bin/view/WP3_APAs/WebHome
- **Board Status and Locations:**
https://docs.google.com/spreadsheets/d/1Rgfk_s9ZndBEt6BQZDE7OMX Mf1IJ7mYu-jqFteqYe8E/edit#gid=217506684

PCBs For DUNE APA production

The screenshot shows the GOV.UK 'Find a Tender' page for UKRI-1308 DUNE APA Printed Circuit Boards. It includes a header with the GOV.UK logo, 'Find a Tender', and language options (English | Cymraeg). A blue banner at the top asks for feedback on the 'Find a Tender' service. Below this, a 'BETA' notice states that the service is new and feedback will help improve it. The main heading is 'UKRI-1308 DUNE APA Printed Circuit Boards'. On the left, it lists the publication reference (2021/S 000-014268), date (23 June 2021), and category (F01: Prior information notice). A 'Watch this notice' button is visible. On the right, there are links for 'Sections' (I. Contracting authority, II. Object, IV. Procedure, VI. Complementary information) and a 'Download Signed PDF' link. The contracting authority is listed as UK Research and Innovation, Polaris House, North Star Avenue, Swindon, SN2 1FL.



Ref No: UKRI-1308

Specification for DUNE Printed Circuit Boards

1. Introduction

1.1. Printed Circuit Boards (PCBs) are needed to construct charge readout anode plane assemblies (APAs) for the Deep Underground Neutrino Experiment based at Sanford Underground Research Facility in South Dakota. These boards will be arranged along the edges of each APA frame for soldering the readout wires under tension and for connecting the wires to the bias power supplies/front end electronics during an operation in Liquid Argon (LAr). Each of these PCBs are required to operate reliably in LAr over several decades (>20 years) so Quality Assurance is a critical element to this project. An example of a single APA frame to which the boards will be attached is shown in Figure 1 below, B.Abi et al. (2018) The DUNE Far Detector Interim Design Report, Volume 2: Single-Phase Module, arXiv: 1807.10327. The vendor will be required to make 41,952 PCBs which includes 15% spares and enough to fit on 132 APA frames.

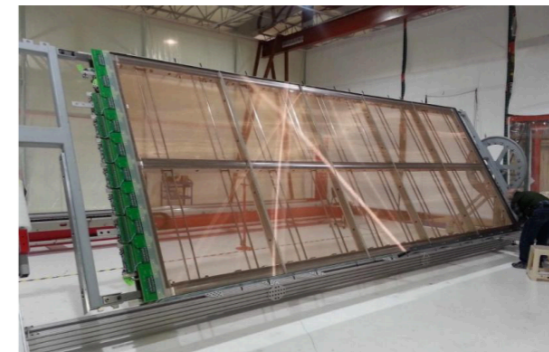
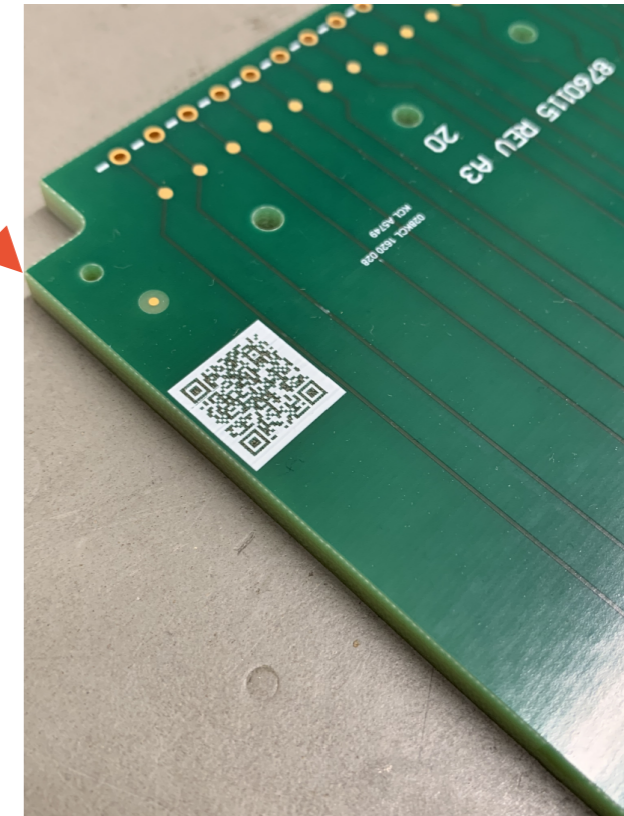
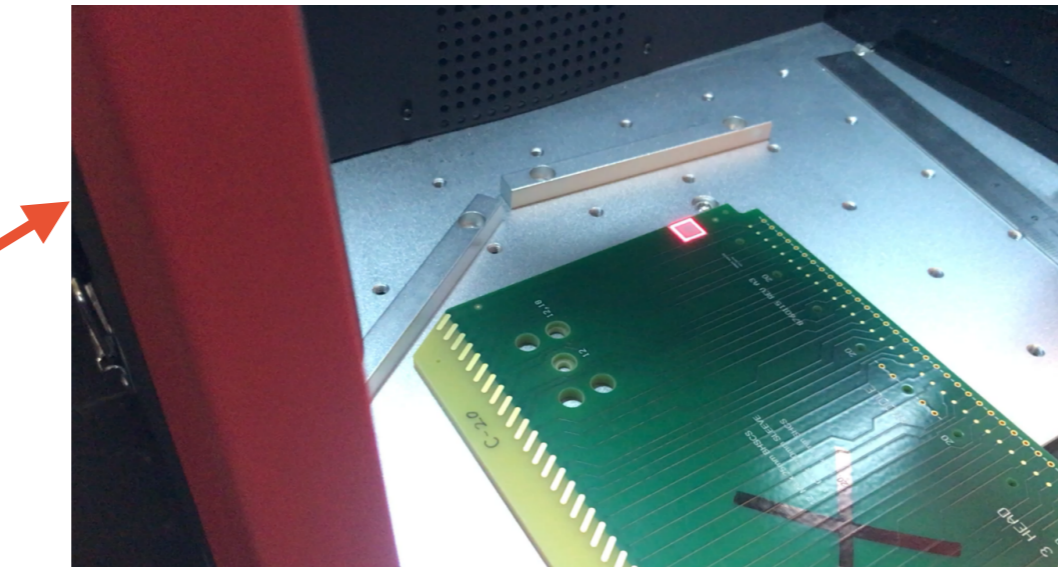


Figure 1: APA frame.

- PIN Notice for DUNE APA production was published in June 2021.
- Five new companies have shown interest in the PCB production.
- Two of the five companies came to our info session.

- Tender document is already in advanced stage.
- The team is ready to commence the tendering process after the Final APA Design Review scheduled for next week.
- Contract to be awarded within 4 months of starting the tendering process.

DUNE Board Labelling Setup at Lancaster



(b) Engraving QR code on a board.

(c) Board with engraved QR code label for the Sietch database.

(a) LSE110 Fiber Laser Engraver.

- Laser engraving/labelling setup at Lancaster for DUNE APA production.
- Boards will be labelled as soon as they are delivered before the reception QC tests.

Summary

- PCBs for ProtoDUNE-II APAs 2 and 3 have been ordered, produced and delivered!
- X-Layer boards for the two ProtoDUNE-II APAs are already at Daresbury.
- V-Layer boards will be shipped to Daresbury today from Sussex and Sheffield.
- U-Layer boards will be at Daresbury by the end of next week. G-Layer will follow, shortly.
- We are ready to start the PCB tendering process for DUNE APA production after the Final Design Review.

Thanks for listening!