

# DUNE APA PCB Updates

Anthony Ezeribe

for the DUNE APA PCB Team

DUNE APA Consortium Meeting, 24th June 2024.

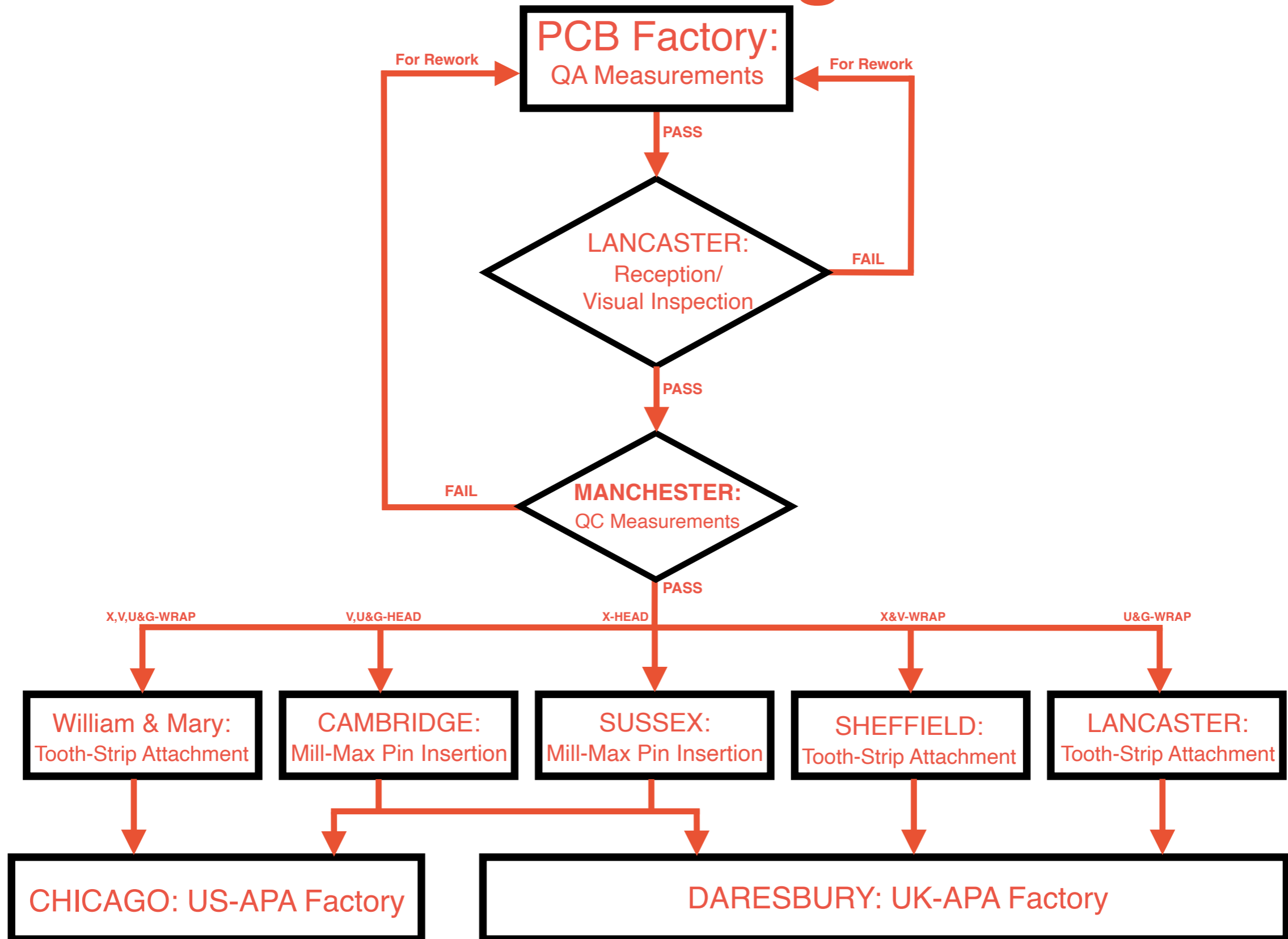
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University of  
Sheffield



# APA PCB Processing Work Flow



# Geometry Board Processing Sites

- University of **Cambridge (UK)**:
  - For Mill-Max pin insertion and QC on all **V, U and G** layer head boards for all UK and US APAs.
- University of **Sussex (UK)**:
  - For Mill-Max pin insertion and QC on all **X** layer head boards for all UK and US APAs.
- University of **Lancaster (UK)**:
  - For assembly and QC of all **U and G** layer wrap boards for **UK APAs**.
- University of **Sheffield (UK)**:
  - For assembly and QC of all **X and V** layer wrap boards for **UK APAs**.
- **William and Mary (US)**:
  - For assembly and QC of all **X, V, U & G** layer wrap boards for **US APAs**.

# Common Wrap Board Procedure at all Sites

- Initial tooth-strip assembly procedure was developed by UK institutions based on initial work done at PSL.
- To ensure that all DUNE APA wrap boards were consistently assembled and QC in each of the sites, the relevant UK and US labs met on:
  - Wednesday, the 24th day of April 2024 &
  - Tuesday, the 7th day of May 2024.
- In these meetings, the existing UK-based wrap board assembly procedure was reviewed to include W&M specific requirements (e.g the use of robot to apply epoxy).

# Who Was Present at the Meetings

- Thanks to the following people that were present in each of the meetings that helped to review the initial Wrap board assembly procedure:

- Justin Evans (Manchester, UK)
  - DUNE APA Consortium Lead
- Brian Rebel (Wisconsin, US)
  - DUNE APA Technical Lead
- Jeff Nelson (William & Mary, US)
  - Lead, US-APA Wrap Board Assembly Lab
- Zubair Dar (William & Mary, US)
  - Post-doc, US-APA Wrap Board Assembly Lab

- James Mateyack (Fermilab, US)
  - DUNE Senior Quality Assurance Specialist
- Kevin Fahey (Fermilab, US)
  - DUNE Quality Assurance Manager
- Anthony Ezeribe (Sheffield, UK)
  - DUNE-UK APA PCB Work Package Technical Lead/Manager

# Updated Tooth-Strip Assembly Procedure

Old Version

Current Version

Revisions			
Version	Description	Date	
01	Original document	15 April 2022	
02	Revision 1	18 July 2023	
03	Revision 2	27 February 2024	

**Tooth strip assembly and inspection procedure UK**  
Document number: EDMS 2616160

Originator	Matt Wright	University of Sheffield	26 August 2021
Quality assurance	Gwenn Mouster	Lancaster University	15 April 2022
PCB Assembly Technician	Shaun Smith	University of Sheffield	18 July 2023
Checker 1	Anthony Ezeribe	University of Sheffield	27 February 2024
Checker 2			

Revisions				
Author	Version	Revision Date	EDMS Ref	Description of Changes
Matt Wright	01	26 August 2021	2616160	Initial UK procedure release
Gween Mouster	02	15 April 2022	2616160	Reviewed Procedure
Shaun Smith	03	18 July 2023	2616160	UK Procedure update
Anthony Ezeribe	04	27 February 2024	2616160	Reviewed Procedure
Anthony Ezeribe	05	24 May 2024	2616160	Merged UK & US Procedure

**Tooth strip assembly and inspection procedure**  
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Document Approvals				
Approvals Required	Name	Laboratory	Signature	Date Approved
Originator:	Matt Wright	University of Sheffield		26 August 2021
Quality Assurance:	Gwenn Mouster	Lancaster University		15 April 2022
PCB Assembly	Shaun Smith	University of Sheffield		18 July 2023
Checker 1:	Anthony Ezeribe	University of Sheffield		24 June 2024
Checker 2:	Zubair Dar	William & Mary		24 June 2024
Approved by	Brian Rebel	University of Wisconsin - Madison		24 June 2024



# Key Changes

## Old Version

### 6.0 Materials / Equipment / Tools Needed

- 6.1 Scotch-Weld 2216 Gray epoxy cartridge (not past use-by date!)
- 6.2 Suitable epoxy gun
- 6.3 1cc syringes
- 6.4 Syringe tips (ideally 19 gauge)
- 6.5 Mixing tips
- 6.6 Wipes
- 6.7 Disposable nitrile gloves
- 6.8 Pure alcohol in suitable dispensing bottle
- 6.9 2 PCB racks
- 6.10 Timer (mobile or otherwise)
- 6.11 Permanent marker pen (fine tipped)
- 6.12 Permanent marker pen (standard)
- 6.13 Dremel bristle brush tool
- 6.14 Ruler
- 6.15 Tooth strip cutting saw
- 6.16 Jigs for tooth strips assembly on boards, see table 2 for drawing numbers
- 6.17 Injection molded Tooth Strips with the following details:

## Current Version

### 6.0 Materials / Equipment / Tools Needed

- 6.1 Scotch-Weld DP-2216 Gray epoxy cartridge (not past use-by date!).
- 6.2 Suitable DP-2216 epoxy gun.
- 6.3 1cc syringes.
- 6.4 Syringe tips (19 gauge).
- 6.5 DP-2216 epoxy mixing tips.
- 6.6 Lint free Wipes (e.g. Texwipe TX609).
- 6.7 Disposable nitrile gloves.
- 6.8 Pure ethyl alcohol (Sigma-Aldrich 459836) in suitable dispensing bottle.
- 6.9 2 x PCB racks.
- 6.10 Timer (mobile or internet based).
- 6.11 Permanent marker pen (fine tipped).
- 6.12 Permanent marker pen (standard).
- 6.13 Dremel bristle brush tool (Dremel 26150403JA).
- 6.14 Ruler.
- 6.15 Tooth strip cutting saw (Cutwel DIN 1837 A) or a preset CNC machine.
- 6.16 Jigs for tooth strips assembly on boards, see table 2 for drawing numbers
- 6.17 ESD Mats (to stand on to cut tooth-strips: RS 466-1643 & RS 787-3114 to place the tooth-strip cutting machine).
- 6.18 Sand paper (P400).
- 6.19 Masking Tapes (3M model 101E).
- 6.20 Cling film.
- 6.21 Injection molded Tooth Strips with the following details:

# Key Changes

## 9.4.1 Apply Epoxy Through a Manual Process (as in Lancaster)

9.4.1.1 Assemble the epoxy cartridge and gun as shown in Figure 3 below. Remove the protective cap of the cartridge and lock on a mixing tip. Now gently pump the gun lever so the epoxy mix flows through the mixer. Stop when the epoxy reaches the tip. Place the epoxy gun down on a few clean wipes so no excess epoxy drips directly onto your work bench.



Figure 3: Filling the syringe with Epoxy

9.4.1.2 For manual epoxying: Take a 1.0cc syringe and remove the plunger. With the tip end of the syringe facing 45 degrees or so upwards, place the tip of the mixer inside the plunger-end of the syringe and dispense epoxy directly into the syringe as shown in Figure 3 below. When the upper meniscus of the epoxy reaches the 0.8cc mark (approximately), gradually withdraw the mixer tip from the syringe continually dispensing as you do so. This will ensure that you will have approximately 1.0cc of epoxy in the syringe after you depress the plunger to the 1.0cc graduation mark, avoiding excess waste. You need to make sure that there is epoxy present right up to the open plunger-end of the syringe, so there are no trapped air bubbles when you reinsert the plunger.

9.4.1.3 Reinsert the plunger, gently push it in until the epoxy level just reaches the needle end of the syringe. Wipe away any excess epoxy.

9.4.1.4 Attach the syringe needle to the syringe. Depress the plunger until epoxy flows out of the needle. Use a wipe to remove any excess epoxy. Repeat this process until the

## 9.4.2 Applying Epoxy Through a Pneumatic Process (as in Sheffield)

9.4.2.1 For Semi manual epoxying: Take a barrel, with the tip end of the syringe facing 45 degrees or so downwards, place the tip of the mixer inside the barrel and dispense epoxy directly into the barrel. Ensure you do this slowly, so the epoxy dispenses into the barrel evenly to ensure there are no pockets of air as shown in Figure 6 below. When the barrel is almost to the top, (leave enough room for the piston) insert the piston, attach to the applicator, and join the needle to the end of the barrel by inserting and turning clockwise.



Figure 6: Filling a barrel with Epoxy

9.4.2.2 Turn on the power to the dispenser, turn on the compressed air and turn the regulator to 7bar of pressure. The timer can then be set to the required time. The amount of epoxy is checked by using a 1cc syringe and ensuring the correct amount of epoxy.

26 seconds will dispense 0.32ml  
18 seconds will dispense 0.25ml  
12 seconds will dispense 0.2ml

9.4.2.3 Place the syringe tip inside the tooth strip slot 3-5mm away from the edge, press the foot/hand pedal, moving the syringe tip to the right along the slot. If right-handed, see

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Tooth strip assembly and inspection procedure UK

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Figure 5 & 7 below. It is helpful if a back-and-forth motion is superimposed upon this movement. This ensures the epoxy is more evenly distributed and helps steady the hand. Constantly maintain awareness of the time on the dispenser you should be halfway across the tooth strip when the time to dispense is at half the time it takes to dispense the correct amount of epoxy for the tooth strip to be epoxied. Endeavor to make reaching this point coincide with reaching the halfway point mark identified next to the tooth strip. Continue this effort as you move toward to the end point of the deposition (as marked on the tooth strip rack and the time on the dispenser).

- There are now 3 sections on how to apply epoxy in tooth-strip grooves covering the
  - Lancaster,
  - Sheffield and see the next slide.



# Key Changes

## 9.4.3 Applying Epoxy Through an Automated Process (as in William & Mary)

- 9.4.3.1 Select 6 boards to assemble and the corresponding 12 tooth strips.
- 9.4.3.2 Match the tooth strips with the corresponding board numbers based on the drawings as in Table 2.
- 9.4.3.3 The strips are then inlaid into the channels of our specially designed gluing fixture (see Figure: GlueBot)

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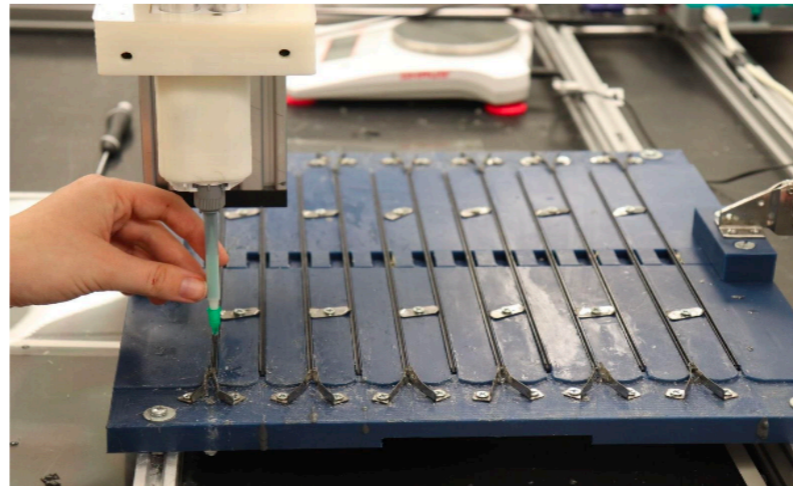


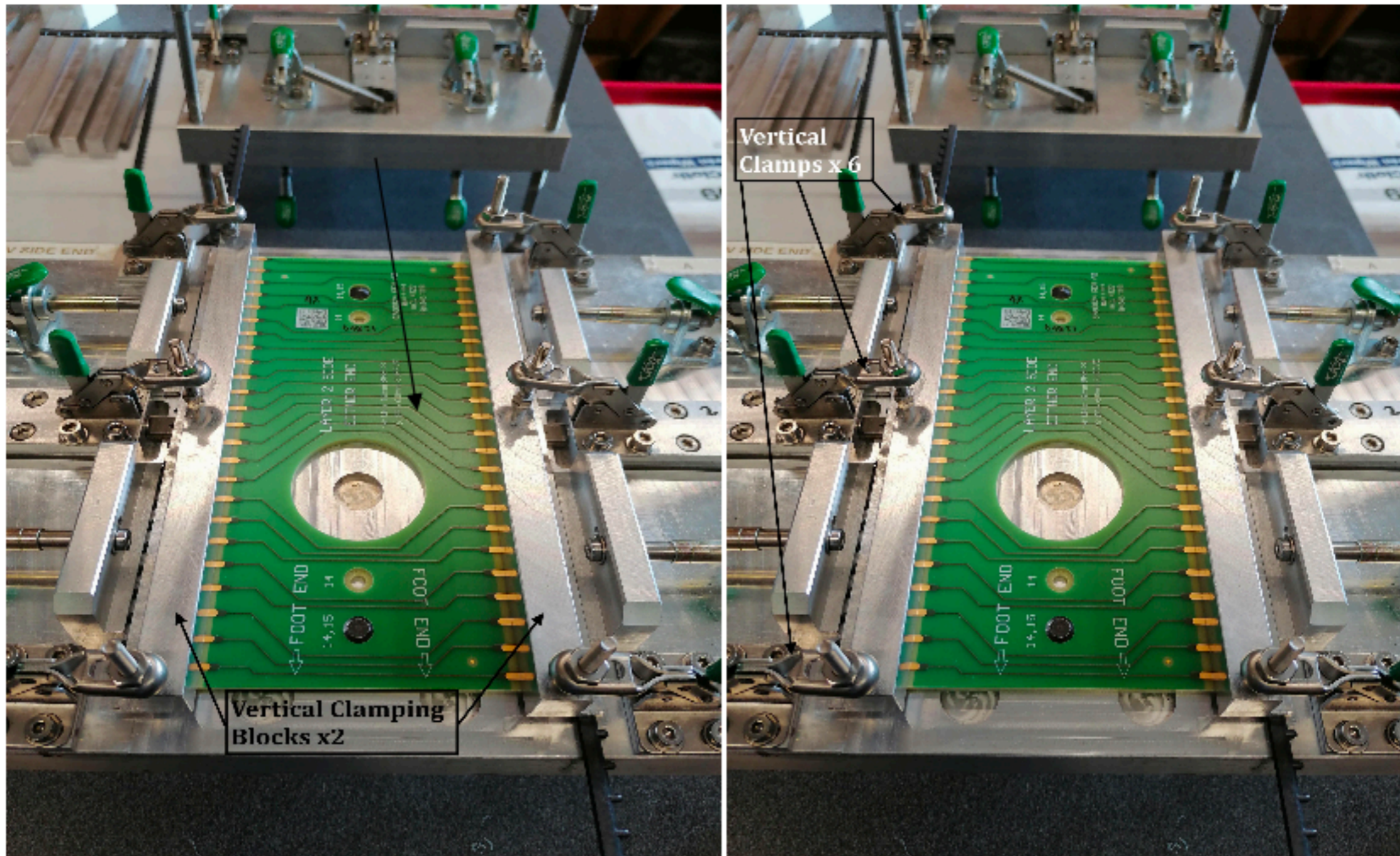
Figure 8: Epoxy application with GlueBot

- 9.4.3.4 Check the epoxy cartridge to make sure there is at least a third of the tube left so that it does not run out in the process. If there is not enough left, the rest is expunged and properly mixed for disposal.

- There are now 3 sections on how to apply epoxy in tooth-strip grooves covering the
  - Lancaster,
  - Sheffield and
  - William and Mary specific processes



# Modified Jigs Now in the Procedure



**Figure 12:** The vertical clamping blocks and vertical toggle clamped set into place



# Improved QC Data Entry Guide

12.1.4 To enter the data for the PCB you are processing click on Perform New Action of This Type as shown in Figure 29 below.

The screenshot shows a web application interface with a sidebar on the left and a main content area. The sidebar contains navigation options: Home, Components, Actions, Workflows, Users, and Search for ... The main content area has a header 'Production' and a 'Perform New Action of This Type' button circled in blue. Below the button is a table titled 'All Performed Actions (Single Type)'. The table has four columns: Type Name, Action ID, Performed on Component, and Last Performed On. Each row represents an action performed on a 'Board Tooth Strip Attachment' component.

Type Name	Action ID	Performed on Component:	Last Performed On:
Board Tooth Strip Attachment	665099a20b3ced7114c5ce2f	26256	May 24th 2024, 1:44:02 PM
Board Tooth Strip Attachment	665099210b3ced7114c5ce2d	26222	May 24th 2024, 1:41:53 PM
Board Tooth Strip Attachment	665098a70b3ced7114c5ce2b	26574	May 24th 2024, 1:39:51 PM
Board Tooth Strip Attachment	665098670b3ced7114c5ce29	26575	May 24th 2024, 1:38:47 PM
Board Tooth Strip Attachment	665097670b3ced7114c5ce24	26614	May 24th 2024, 1:34:31 PM
Board Tooth Strip Attachment	665096d00b3ced7114c5ce21	26567	May 24th 2024, 1:32:00 PM
Board Tooth Strip Attachment	665095d60b3ced7114c5ce1d	25624	May 24th 2024, 1:27:50 PM

Figure 29: Perform New Action of This Type option circled.

# Updated Procedure on EDMS

- The updated tooth-strip assembly procedure is now on EDMS link below:
  - [https://edms.cern.ch/ui/file/2616160/2/EDMS2616160\\_05\\_Tooth\\_strip\\_assembly\\_and\\_inspection\\_procedure\\_UK\\_24062024.pdf](https://edms.cern.ch/ui/file/2616160/2/EDMS2616160_05_Tooth_strip_assembly_and_inspection_procedure_UK_24062024.pdf)

# PCB Production Status

- PCB Production Factory:
  - The PCB factory is now ramping up to reach full production capacity after some unforeseen delays due to:
    - death of their Operation Director on Saturday the 1st day of June 2024 after a very brief illness.
    - break down of one out of their available two high-tech milling machine that are dedicated for DUNE APA board production.
  - Their current PCB production rate is between 100 to 250 DUNE APA PCBs per week relative to their nominal production rate of  $300 \pm 50$  DUNE APA PCBs per week.



# PCB Production Status

S/N	Board Ref N	Description	No Per AP	No passed Q	APAs Passed	APAs Delivered	No Ordered	% order passed	Yet To MAN Q	Yet To LAN INSI
1	8760024	V Side Board End	4	406	101.5	101.3	636	63.8%	-1	0
2	8760026	V Side Board Middle Without Slot	24	1478	61.6	81.8	3816	38.7%	503	95
3	8760028	V Side Board Middle With Slot	14	664	47.4	54.6	2226	29.8%	164	0
4	8760030	V Foot Board Middle	6	566	94.3	94.3	954	59.3%	-3	3
5	8760032	X Edge Board End	2	237	118.5	118.5	318	74.5%	0	0
6	8760034	X Edge Board Middle	6	463	77.2	114.3	954	48.5%	237	0
7	8760036	V Foot Board End	2	227	113.5	113.5	318	71.4%	0	0
8	8760038	U-Side Board End	4	306	76.5	101.1	636	48.1%	119	0
9	8760040	U-Side Board Without Slot Middle	24	1509	62.9	66.0	3816	39.5%	98	-7
10	8760042	U-Side Board With Slot Middle	14	460	32.9	41.6	2226	20.7%	203	0
11	8760044	U-Foot Board High Slot End	1	126	126	125.2	159	79.2%	-1	0
12	8760051	G Edge Board Low Slot End	1	91	91	90.4	159	57.2%	-1	0
13	8760054	G Edge Board Middle	6	449	74.8	88.8	954	47.1%	102	0
14	8760057	U-Foot Board Middle	6	473	78.8	87.2	954	49.6%	-11	94
15	8760059	U-Foot Board Low Slot End	1	86	86	86.0	159	54.1%	0	0
16	8760062	G Edge Board High Slot End	1	112	112	112.0	159	70.4%	0	0
17	8760104	X Board Head	20	976	48.8	52.3	3180	30.7%	105	-19
18	8760107	V Foot Board Middle Position 4 And 7	2	190	95	95.0	318	59.7%	0	0
19	8760108	V Head Board Right End	18	767	42.6	50.8	2862	26.8%	220	0
20	8760109	X Edge Board Position 4 And 7	2	229	114.5	114.5	318	72.0%	0	0
21	8760111	U-Foot Board Position 4 And 7	2	231	115.5	115.1	318	72.6%	-1	0
22	8760113	G Edge Board Position 4 and 7	2	179	89.5	89.5	318	56.3%	0	0
23	8760115	U Head Board Middle	16	818	51.1	51.9	2544	32.2%	10	10
24	8760116	V Head Board Left End	2	174	87	105.4	318	54.7%	48	0
25	8760119	U Head Board Left End	2	131	65.5	65.5	318	41.2%	0	0
26	8760120	G Head Board Right-End	2	153	76.5	76.5	318	48.1%	0	0
27	8760121	G Head Board Middle	16	943	58.9	59.2	2544	37.1%	6	0
28	8760122	G Head Board Left-End	2	107	53.5	55.0	318	33.6%	4	0
29	8760123	U Head Board Right End	2	183	91.5	63.3	318	57.5%	-87	7
		<b>Total</b>	204	12734			32436		1819	209
				39.3%				50.9%		



# Wrap Board Step Measurement Updates

Old Pre-Jig Modification Wrap Boards From Daresbury

Old Jig Assembled Wrap Boards							
S/N	Board Type	No @ Daresbury	Tested	Passed	%Pass	Not Tested	Layer
1	8760024	152	75	67	89.33%	77	V
2	8760026	912	645	484	75.04%	267	V
3	8760028	532	203	202	99.51%	329	V
4	8760030	228	196	163	83.16%	32	V
5	8760032	76	38	38	100.00%	38	X
6	8760034	228	143	141	98.60%	85	X
7	8760036	76	39	32	82.05%	37	V
8	8760038	96	134	120	89.55%	-38	U
9	8760040	576	564	466	82.62%	12	U
10	8760042	336	164	162	98.78%	172	U
11	8760044	24	57	44	77.19%	-33	U
12	8760051	24	42	32	76.19%	-18	G
13	8760054	144	174	168	96.55%	-30	G
14	8760057	144	206	178	86.41%	-62	U
15	8760059	24	54	44	81.48%	-30	U
16	8760062	24	56	43	76.79%	-32	G
17	8760107	76	48	34	70.83%	28	V
18	8760109	76	42	42	100.00%	34	X
19	8760111	48	94	57	60.64%	-46	U
20	8760113	48	89	88	98.88%	-41	G
<b>Summary:</b>		<b>3844</b>	<b>3063</b>	<b>2605</b>	<b>86.18%</b>	<b>781</b>	

Wrap Board Assembled on Modified Jigs

Modified Jig Assembled Wrap Boards					
S/N	Board Type	Tested	Passed	%Pass	Layer
1	8760024	4	4	100.00%	V
2	8760026	24	24	100.00%	V
3	8760028	14	14	100.00%	V
4	8760030	6	6	100.00%	V
5	8760032	2	2	100.00%	X
6	8760034	6	6	100.00%	X
7	8760036	2	2	100.00%	V
8	8760038	0	0	#DIV/0!	U
9	8760040	7	7	100.00%	U
10	8760042	44	44	100.00%	U
11	8760044	0	0	#DIV/0!	U
12	8760051	0	0	#DIV/0!	G
13	8760054	0	0	#DIV/0!	G
14	8760057	5	5	100.00%	U
15	8760059	2	2	100.00%	U
16	8760062	0	0	#DIV/0!	G
17	8760107	2	2	100.00%	V
18	8760109	2	2	100.00%	X
19	8760111	0	0	#DIV/0!	U
20	8760113	6	6	100.00%	G
<b>Summary:</b>		<b>126</b>	<b>126</b>	<b>#DIV/0!</b>	

# Thanks for listening!

