The University Of Sheffield.

ArgonCube

Reference TPC - Sheffield activity

Neil Spooner, Dom Barker, Trevor Gamble, Nicola McConkey, Matthew Thiesse, Matthew Wright

General LAr Activity

(1) SBND - built the 4 APA frames, involved in installation etc

(2) ProtoDUNE - built the 3 APA 6.5m frames, involved in installation etc

(3) DUNE - APA consortium (UK now funded at £65M to build 150 APAs and DAQ); cosmics simulation, SN and nucleon decay

(previous work on 35T at FNAL, cameras/analysis)

(4) ArgonCube, near detector

(5) R&D programme using in-house LAr test stand and purifyer

35T APA

Design based on smaller APA used in the 35 Ton tests at FNAL

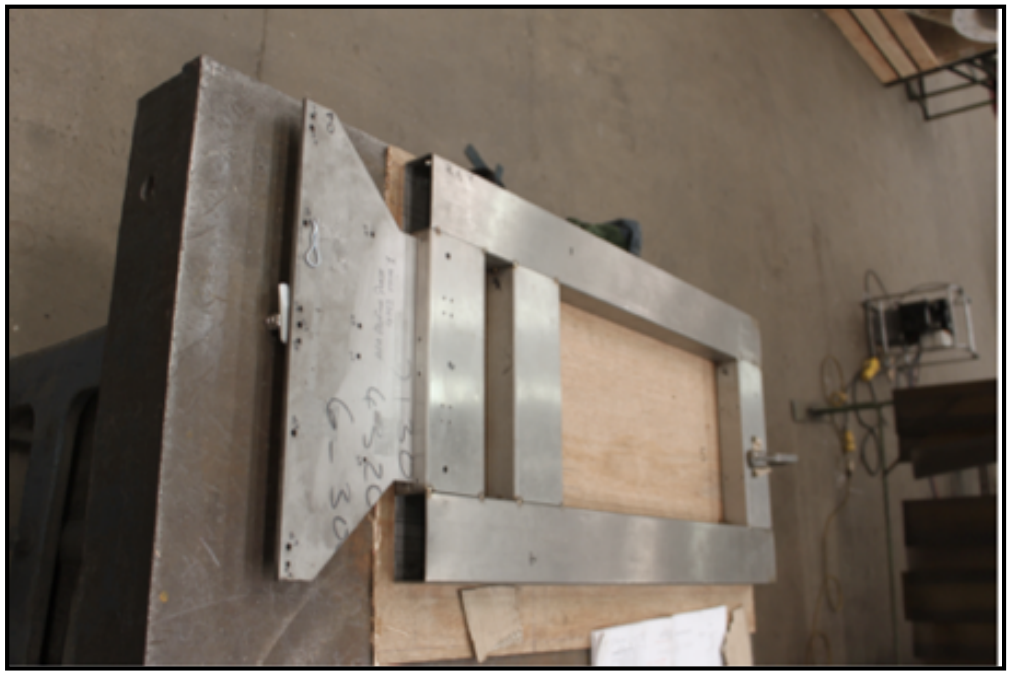
Dimensions ~ 1.5 x 0.5m

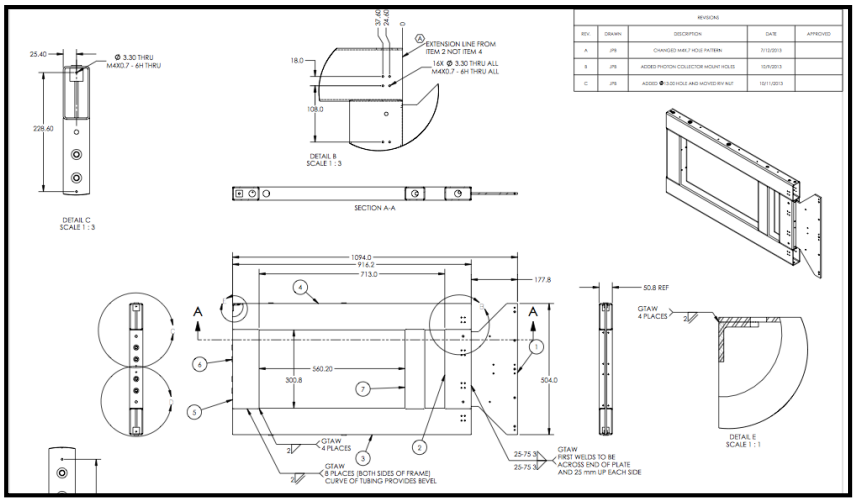
35T APA Fabrication

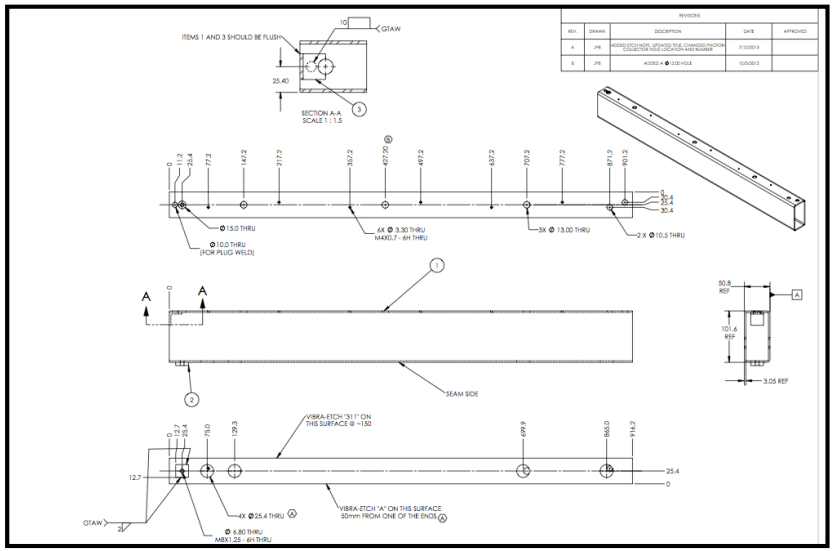
Built a new frame in-house at Sheffield using welded design

Aim was to test fabrication techniques for DUNE

The repurposed for ArgonCube







Trial cool down test in LN2

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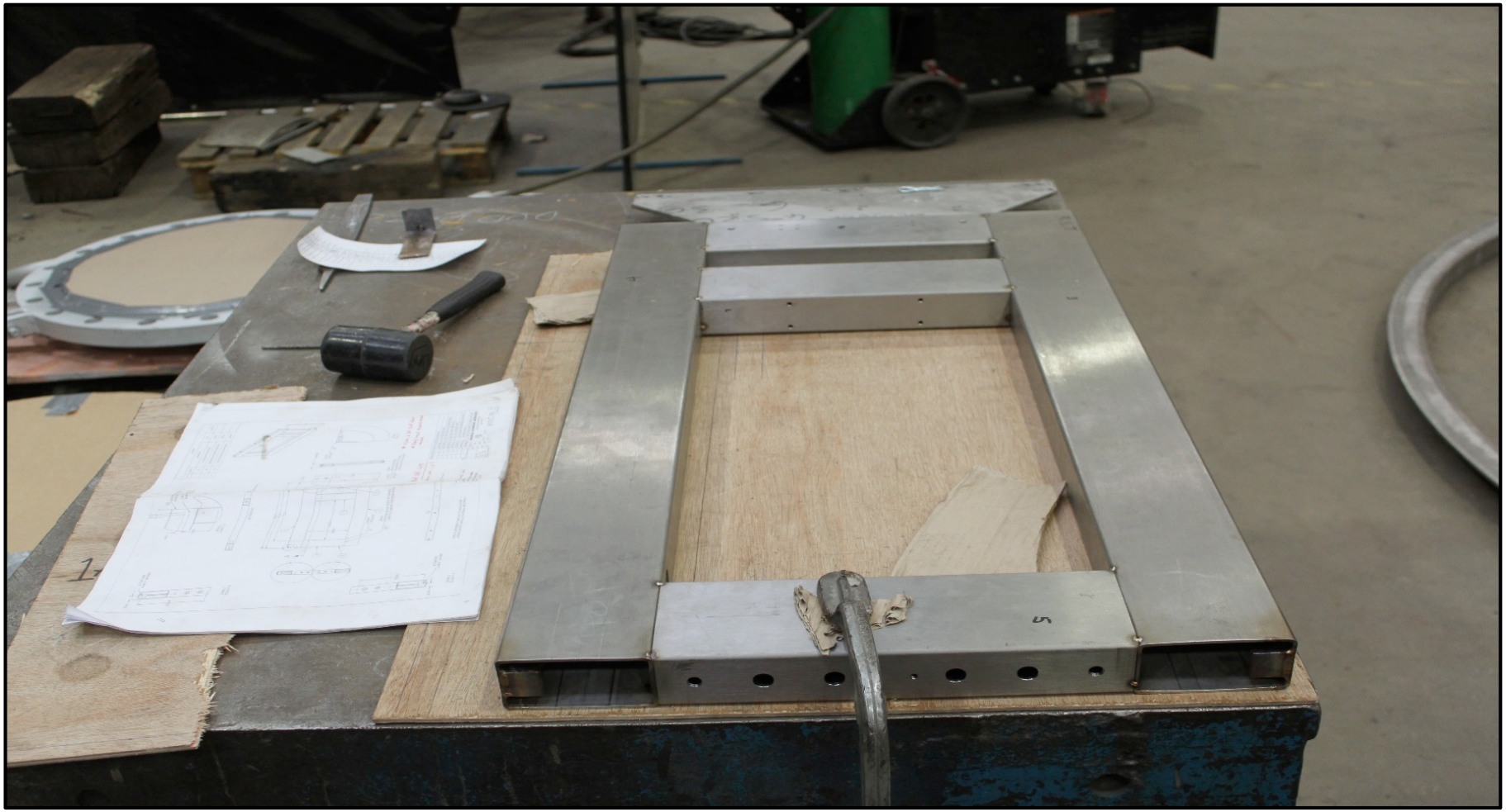
35T APA Fabrication



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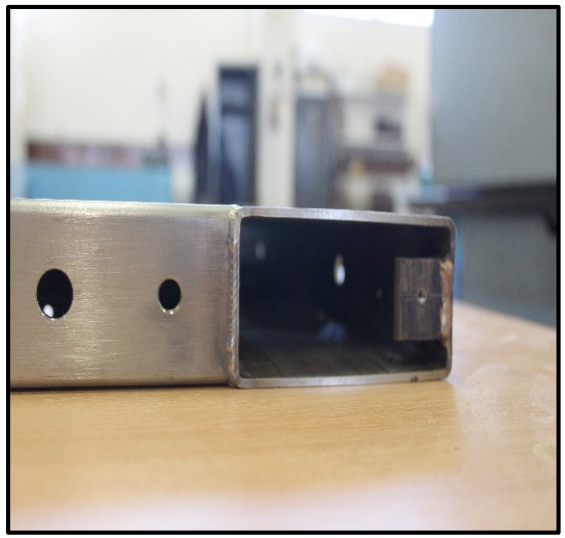
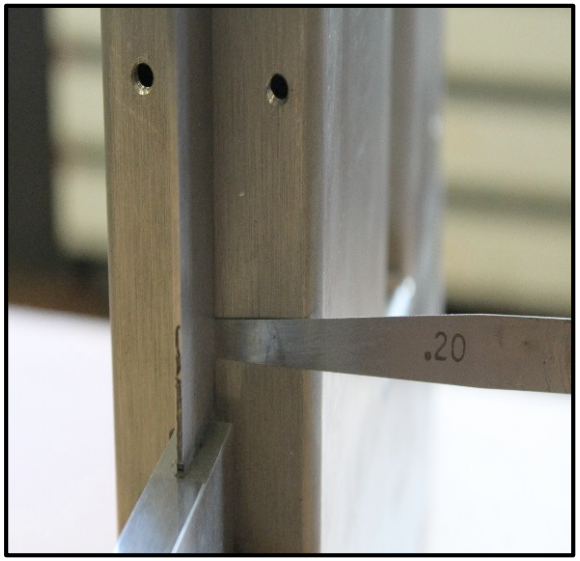
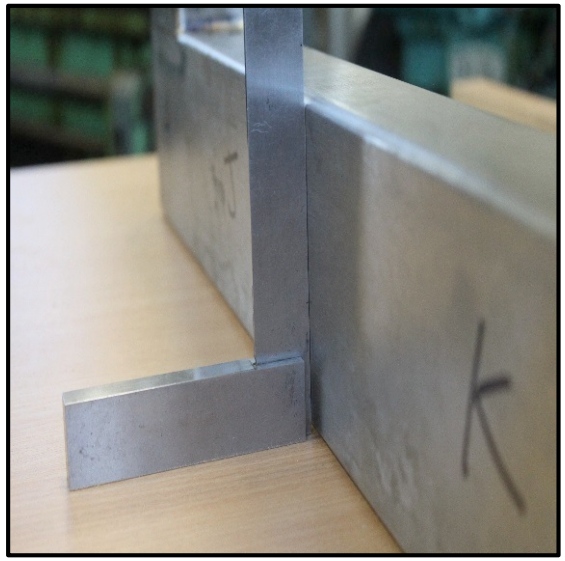
35T APA Fabrication

Metrology tests conducted to determine;

- Accuracy
- Flatness
- Rectangularity
- Weld Integrity







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APA Cryogenic Test

Custom manufactured cryogenic test vessel

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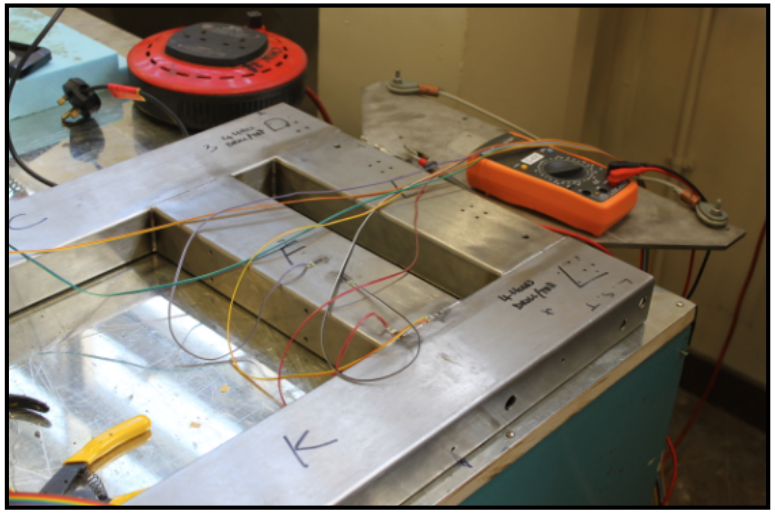
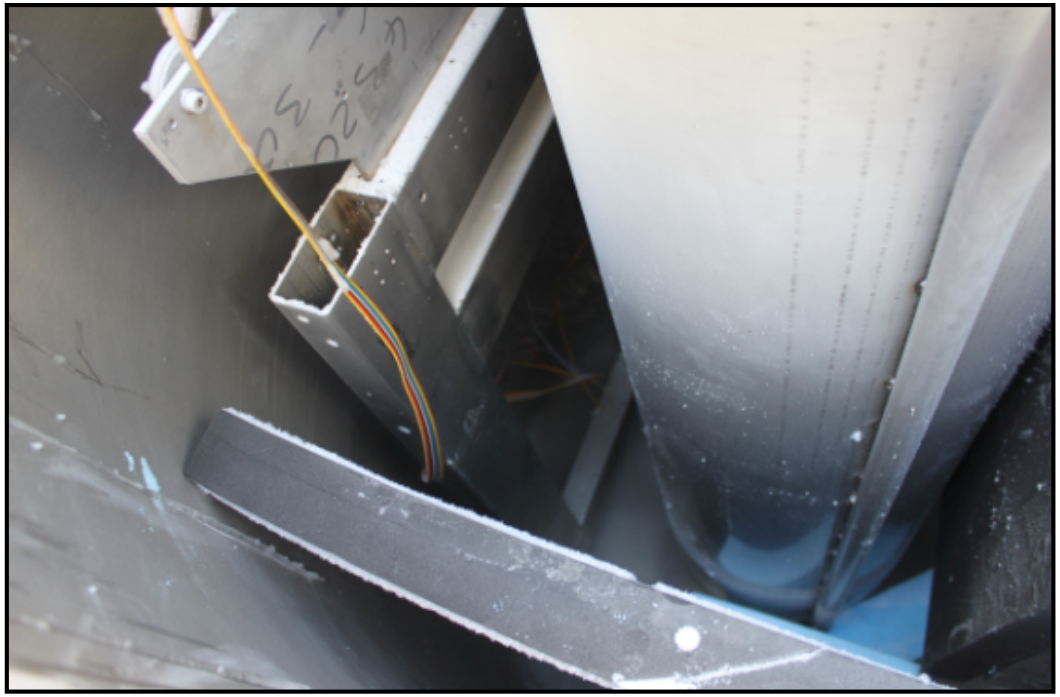
- LN2 robustness test at Sheffield





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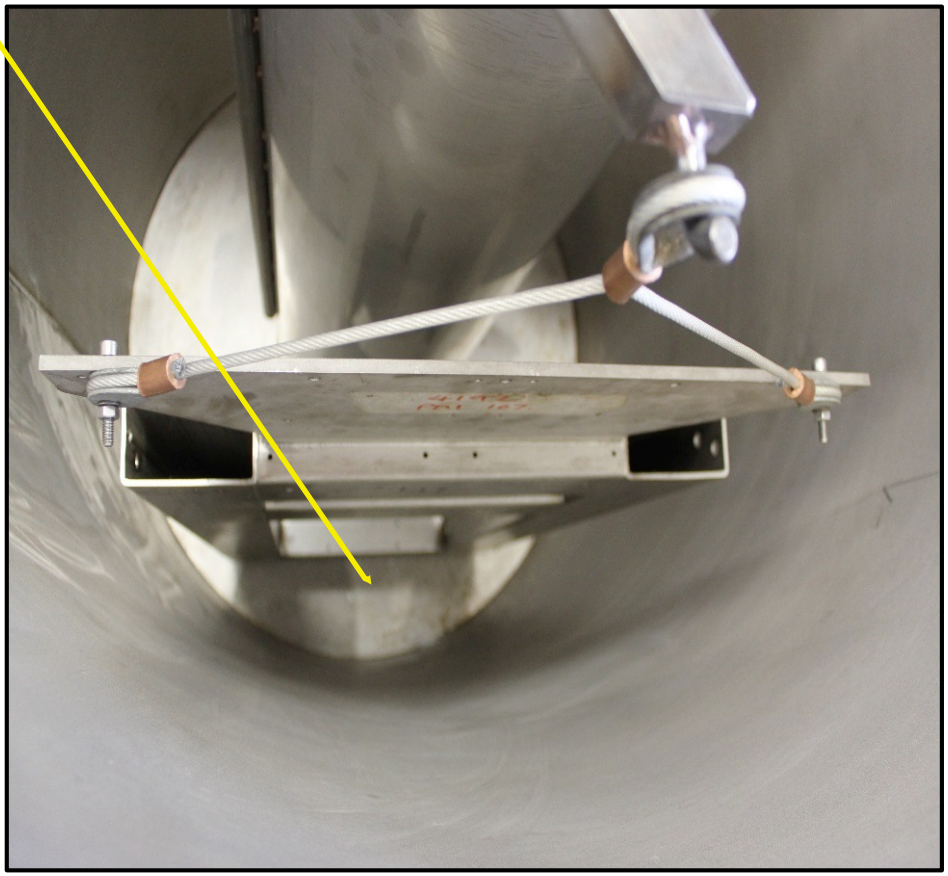
APA Cryogenic Test

Inside the test vessel prior to cool down
APA suspended 10mm away from the vessel base



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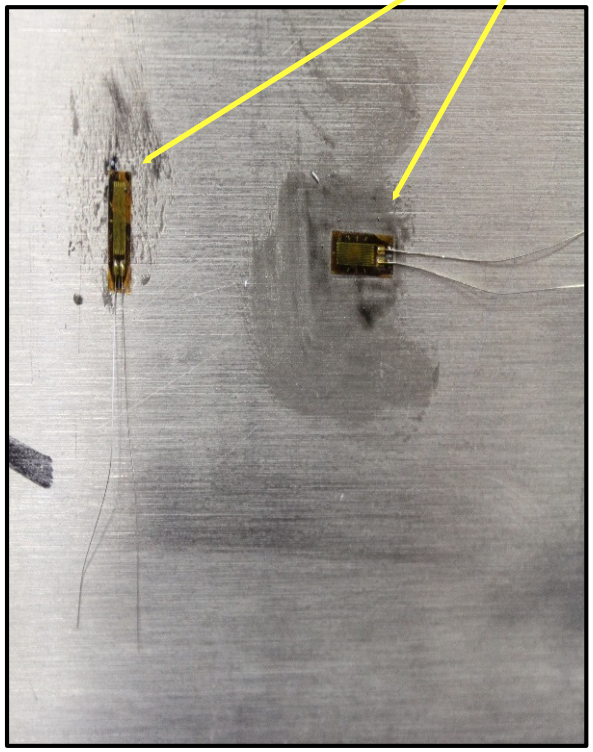
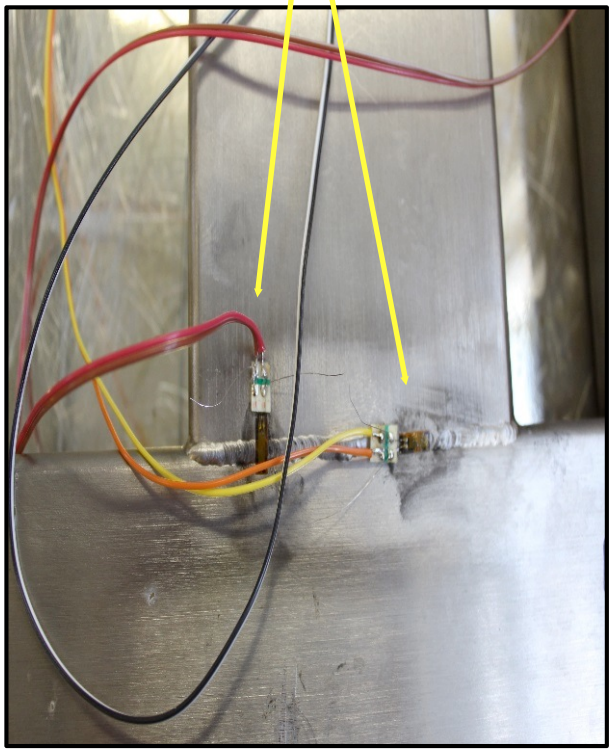
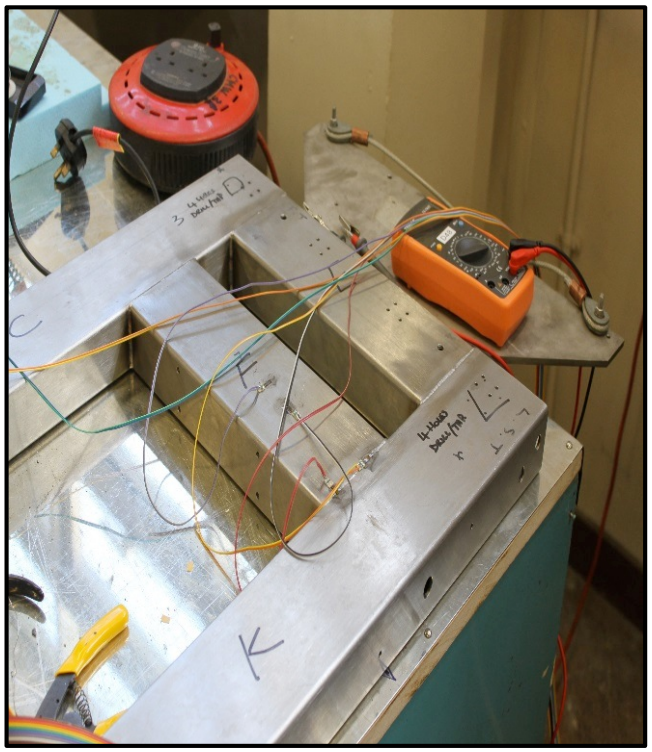
APA Cryogenic Test

Strain gauges affixed to APA at strategic positions







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APA Cryogenic Test

- Nitrogen level dropped by 300mm due to natural losses
- APA checked in the morning for any significant changes
- Insulation jacket removed to increase boil off

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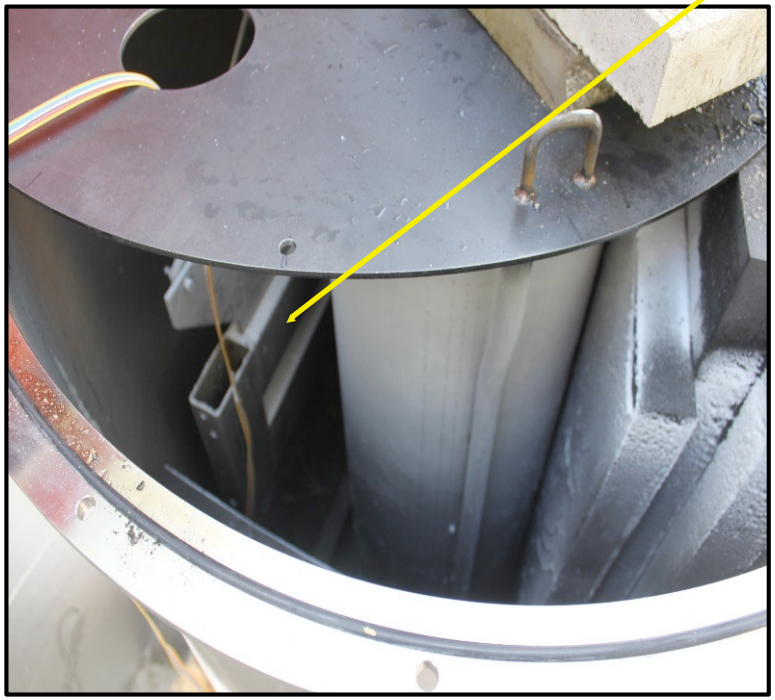
APA Cryogenic Test

24 hours for vessel to empty "naturally"

APA continually monitored



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APA Cryogenic Test

APA removed from vessel and further metrology test conducted including weld integrity

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APA Cryogenic Test

Results

Stress strain results, no significant changes.

Metrology results determined no structural deformation.

SCC (stress carrion cracking) not evident through visual inspection.

Further work

APA frames with G10 and Peek wire geometry boards attached.

1/ Determine the behavior of G10 and Peek materials under cryogenic conditions

2/ Manufacture G10 and Peek wire geometry boards to determine their comparative machining time and characteristic behaviour.

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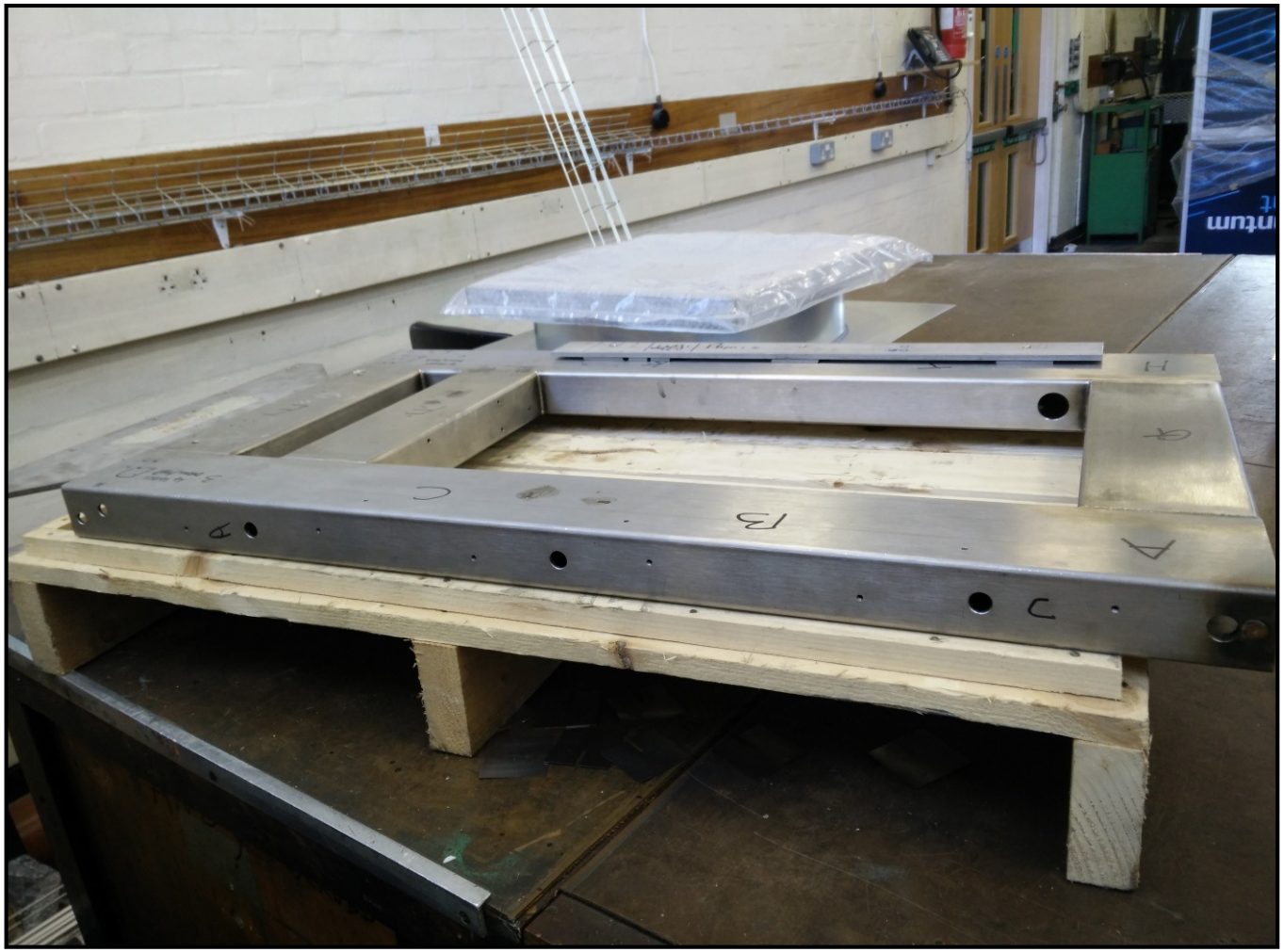
APA Fabrication

Original bare frame prior to cleaning and attaching of M10 threaded inserts removal of weld material, new holes for supports, new holes for borads in the wrong place



APA Fabrication

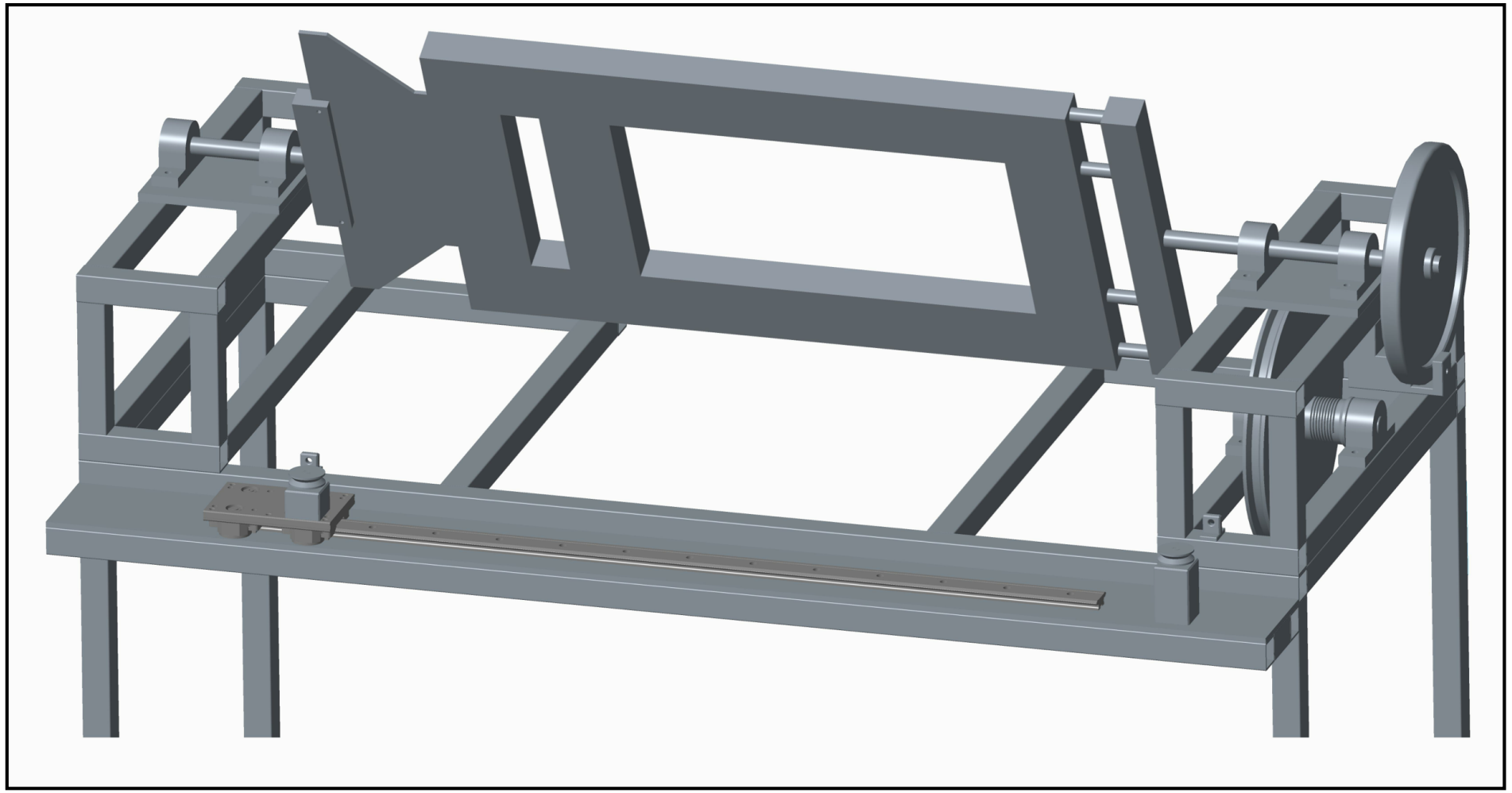
M10 threaded inserts riveted in place (8 in all) for moving, addedd for supporting in argoncube 3 on each side, 4 on back strut . Frame cleaned via pickle and passivation process.

APA Winding Machine

New manual wire winding machine built in-house at Sheffield

Design allows for X, V, U and G wire plan winding

Larger frames up to ~1.0 x 1.0 m could also be used



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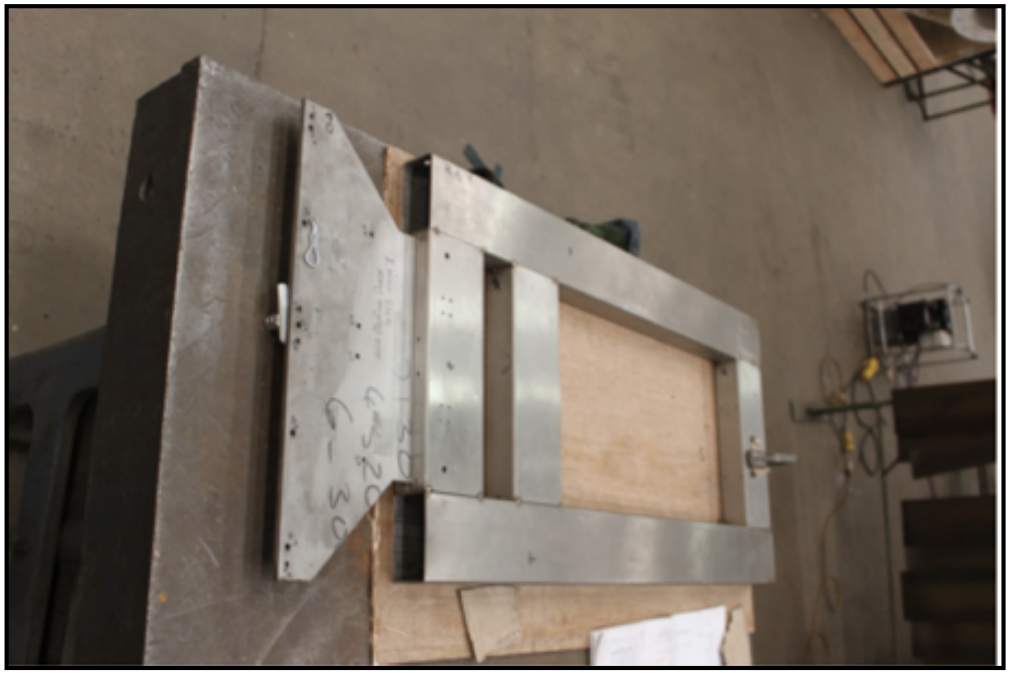
APA Winding Machine

New manual wire winding machine built in-house at Sheffield

Neil Spooner, University of Sheffield

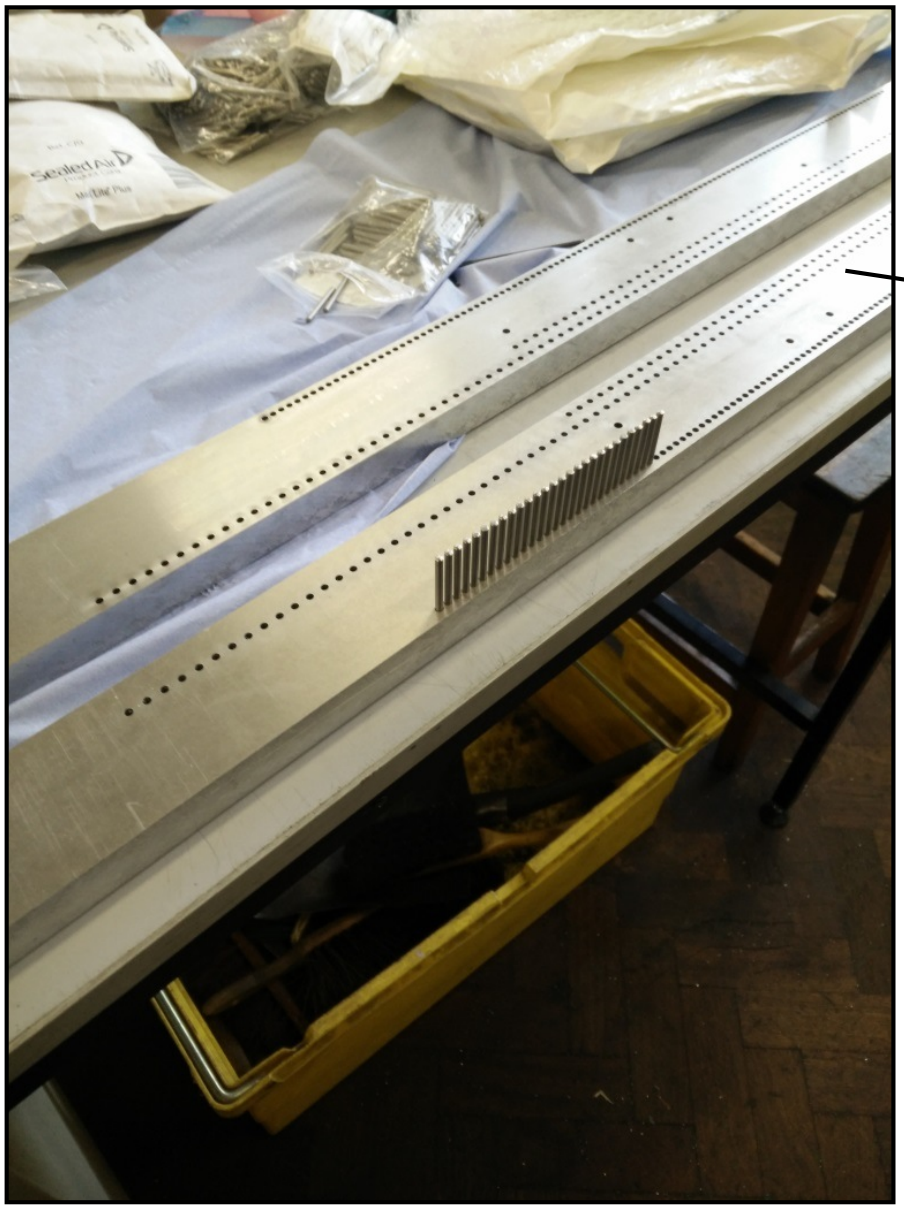
APA Winding

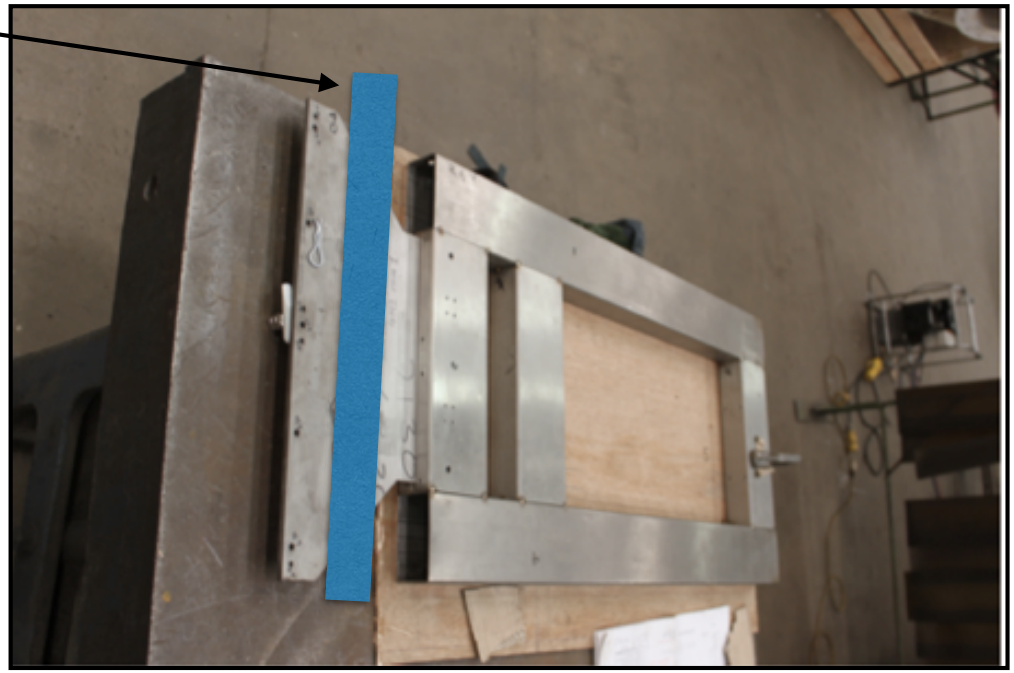
Wire alignment dowel boards then assembled.



APA Winding

Wire alignment dowel boards then assembled.



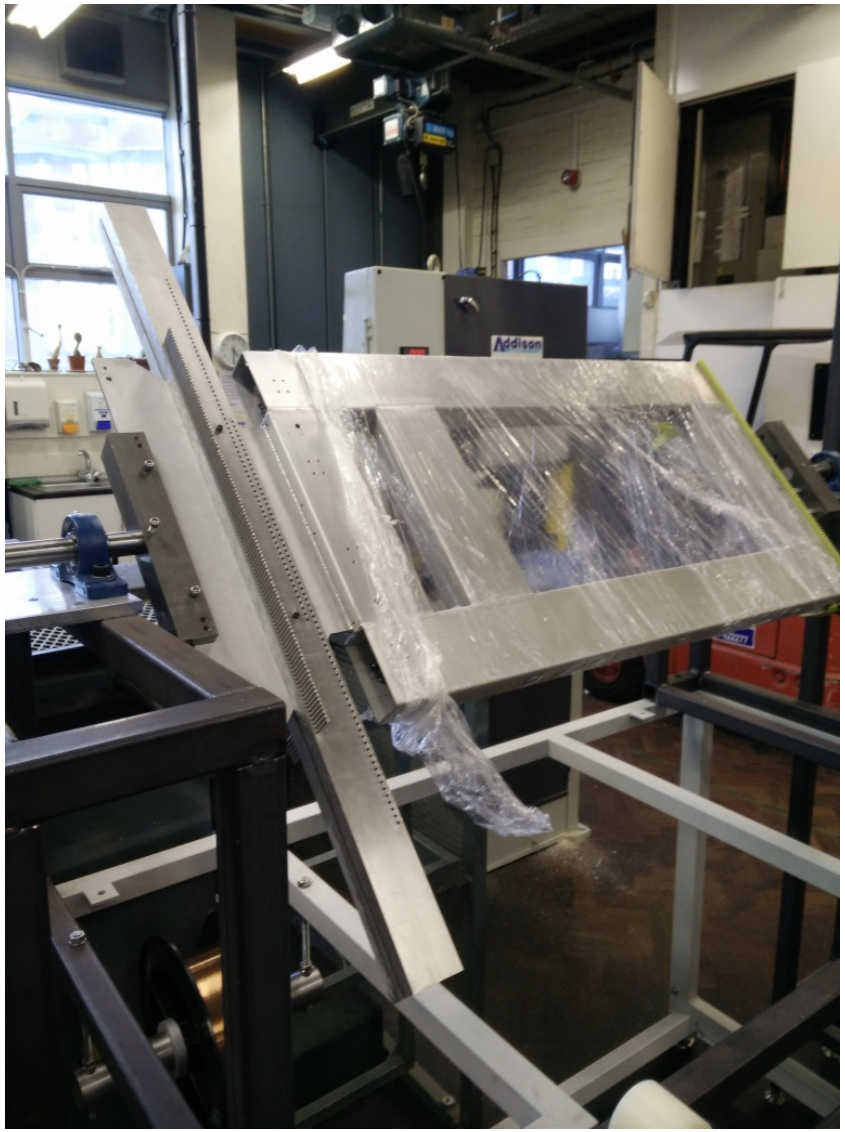


APA Wiring Boards

X Bottom Boards bolted into position. Attachment of Pentaxia boards

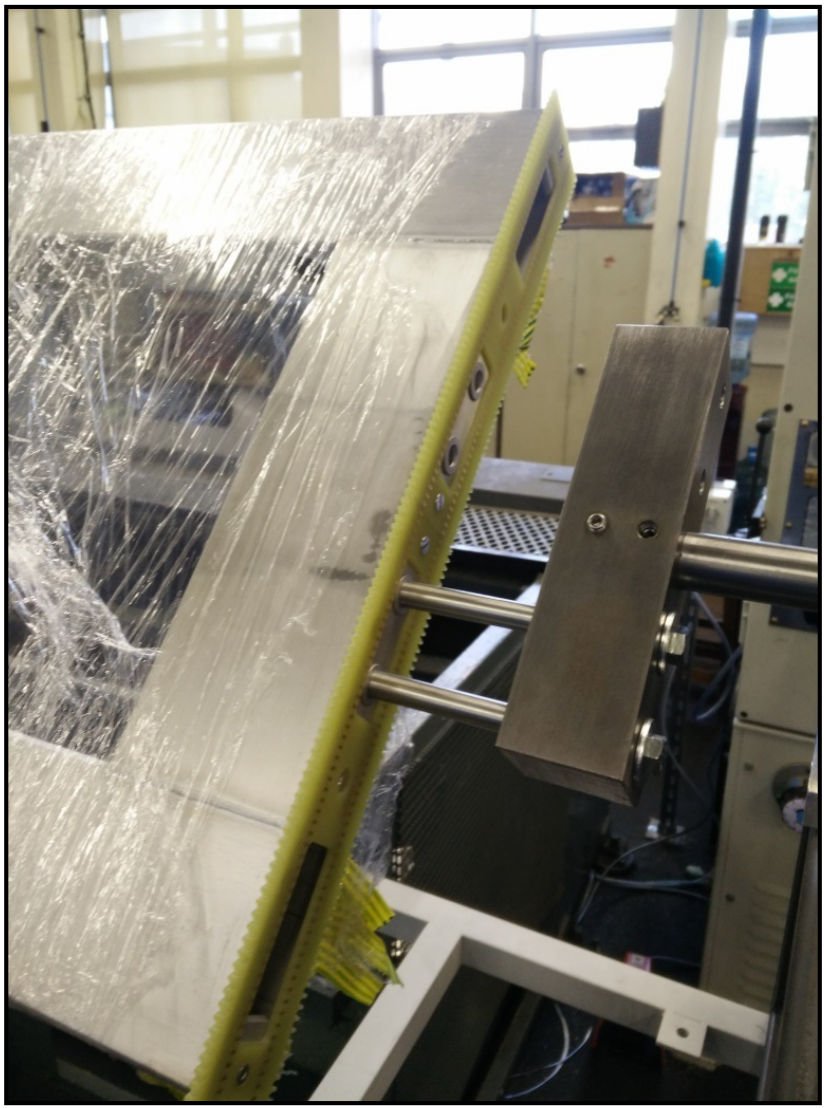
APA Winding

Frame hoisted into position and attached to winding gantry.
Dowel boards then attached to 'fin' of APA.



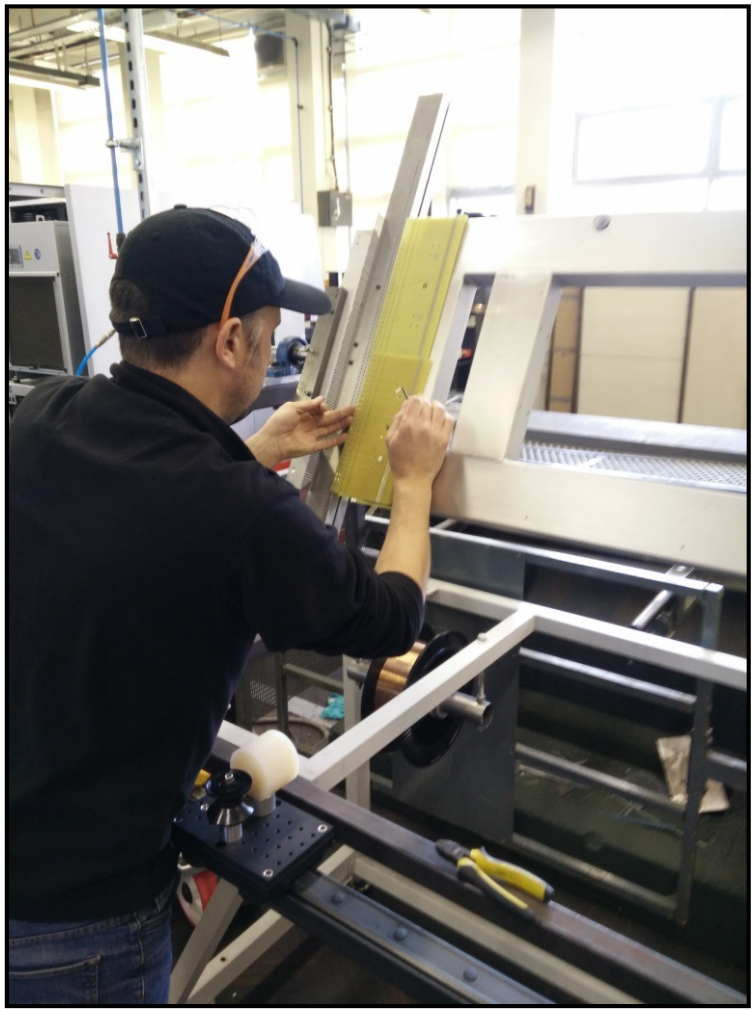
APA Winding

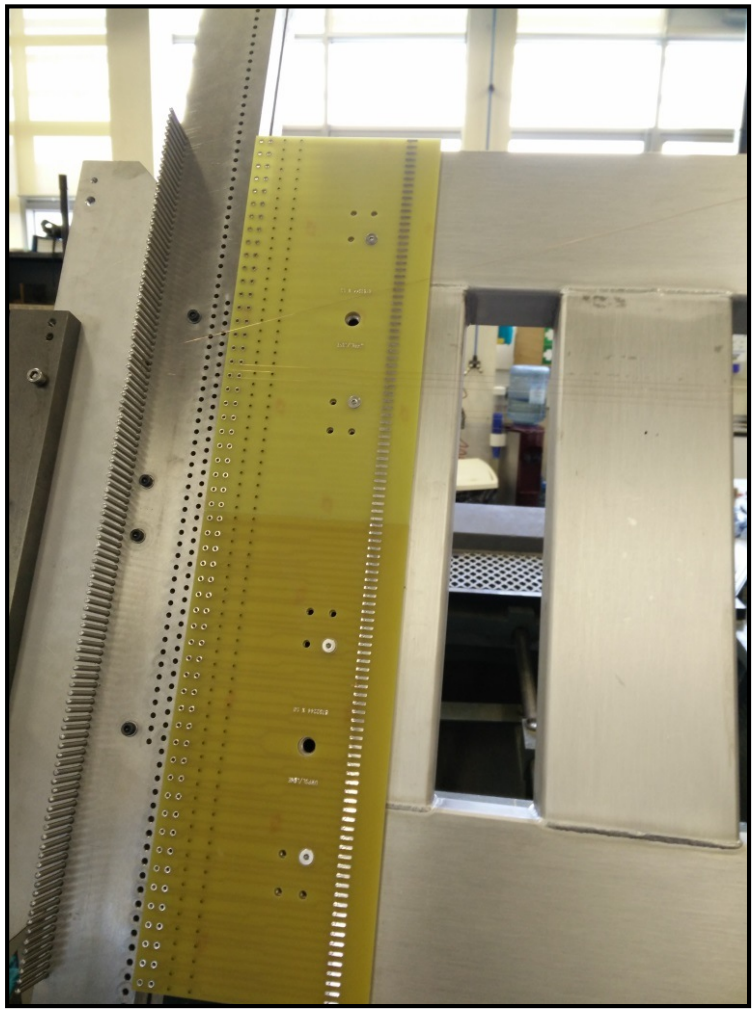
Bottom of APA supported on only one side by 2 x M10 bolts. This allows passage of wires around right-hand X Bottom Board. i.e. the first half is wound, then the mounting swapped to allow the second half



APA Winding

Two X Wire Boards and four spacer boards bolted to both sides of frame.
Quickcircuits wireboards





Seen here is the X (parallel). Then V, U and (G parallel). Spacers then two boards each side, then spacers then 1st Bern boards for V layer boards on side with profiled teath…
Quickcircuits did the G layer

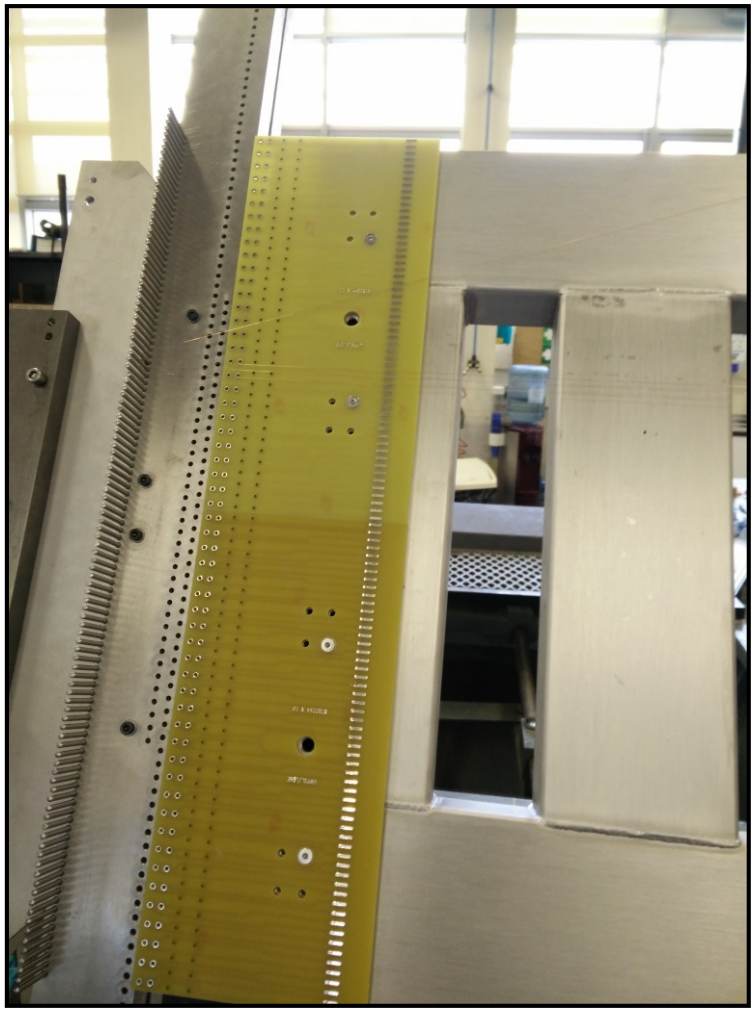
APA Wiring Scheme

- 1. X Layer: This layer is 4.8mm above the mesh. The wires are spaced 4.5mm apart and
- run parallel to the long side of the APA.

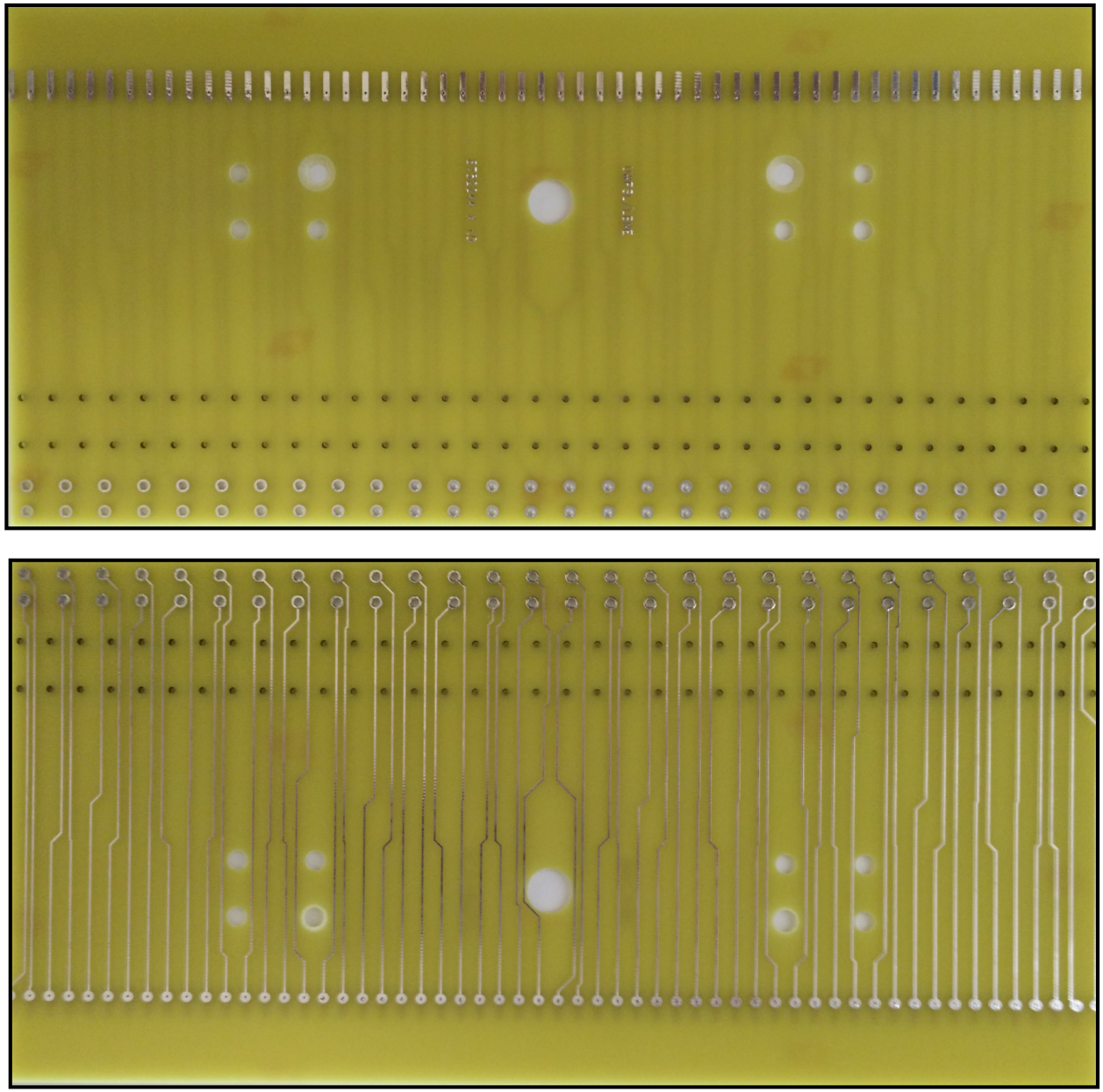
- 2. V Layer: Wires in this layer are oriented 44.275 degrees from the long edge and are
- 5.01mm apart.

- 3. U Layer: These are wires are oriented 45.707 degrees from long edge and are spaced
- 4.89mm apart.

- 4. G Layer: This layer also runs parallel to the long edge. The wires are 4.5mm apart.



APA X Board Details

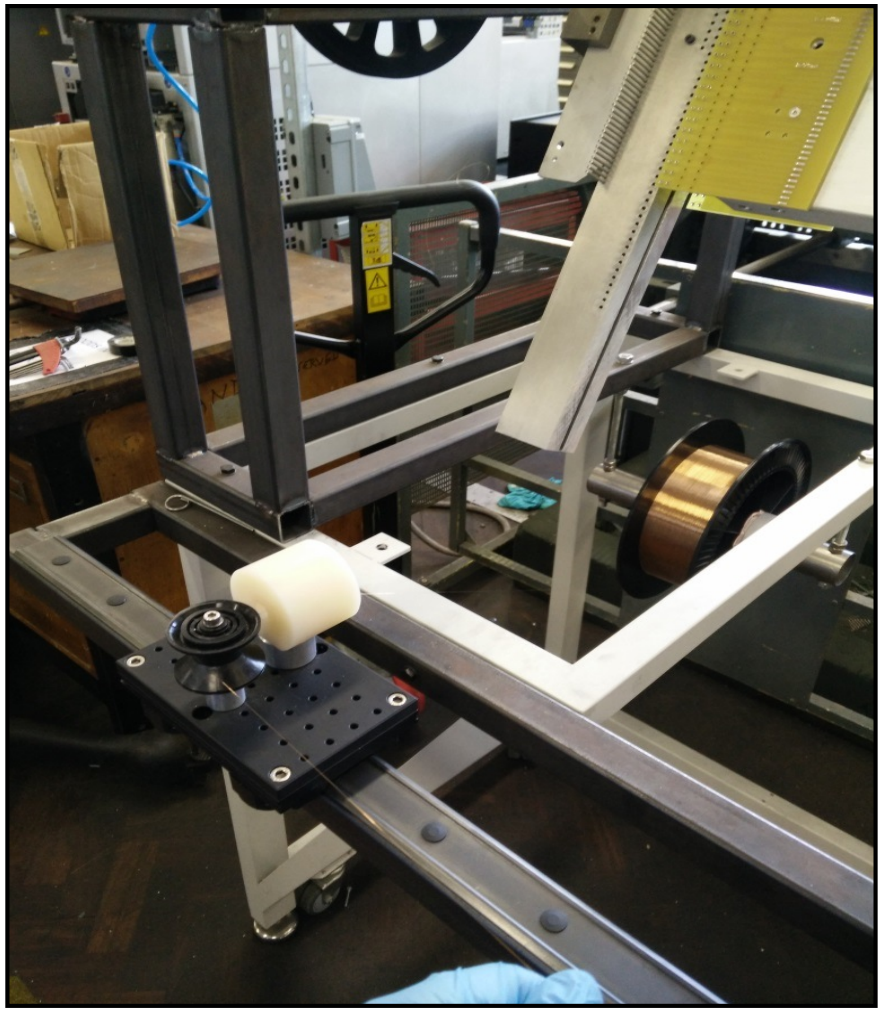


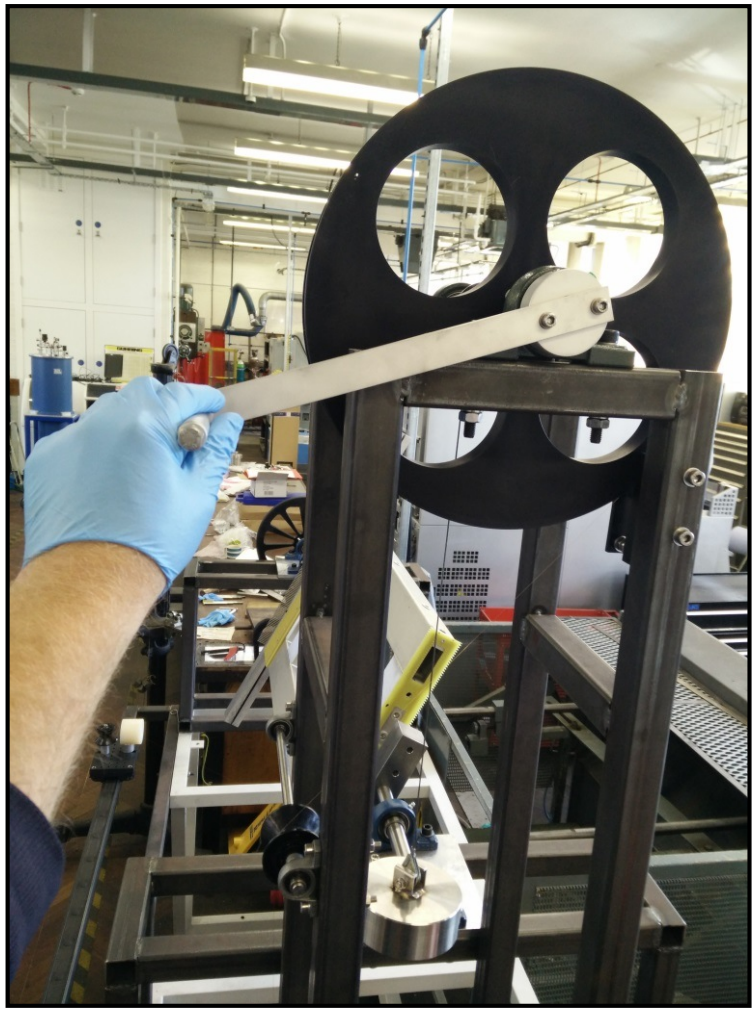
APA Winding

Tensioning weight is wound up to top of spool tower.

APA Winding

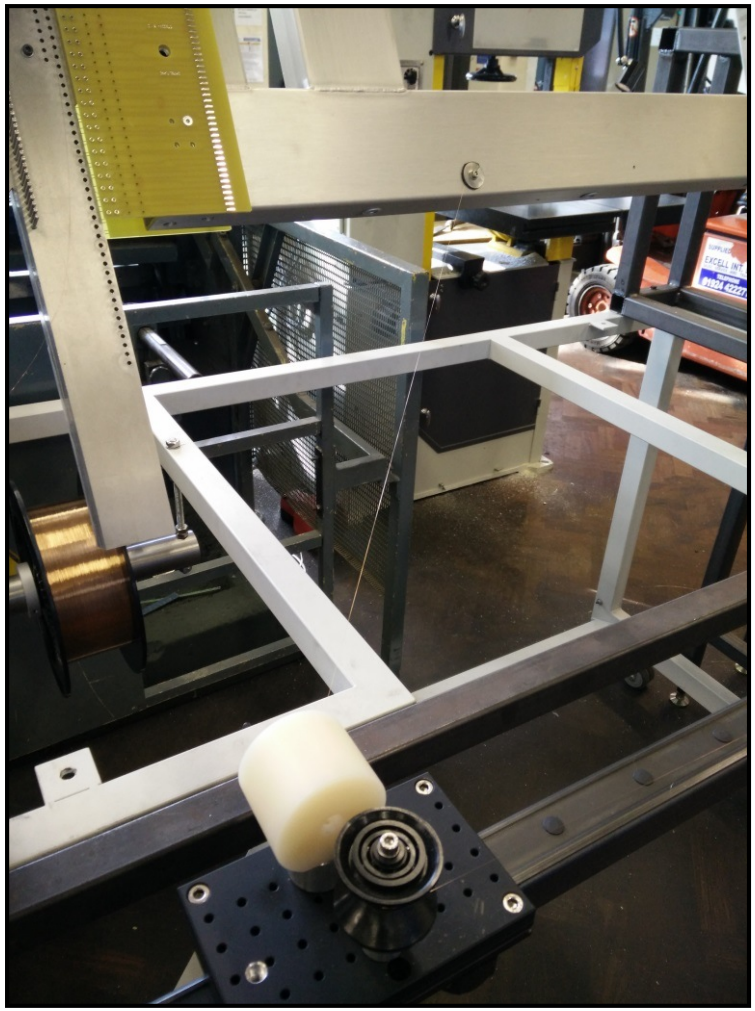
Wire pulled from wire reel around a series of pulleys and attached to spooling wheel. Spooling wheel (RH image) is then rotated to allow tensioning weight to drop to a point just above its minimum height.

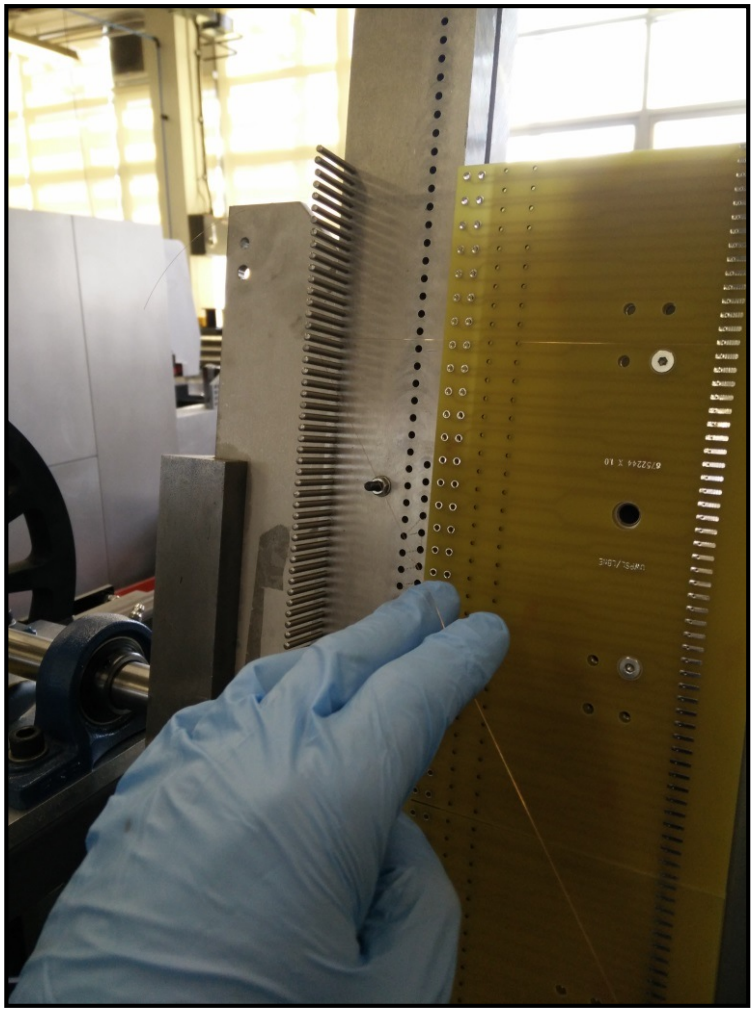




APA Winding

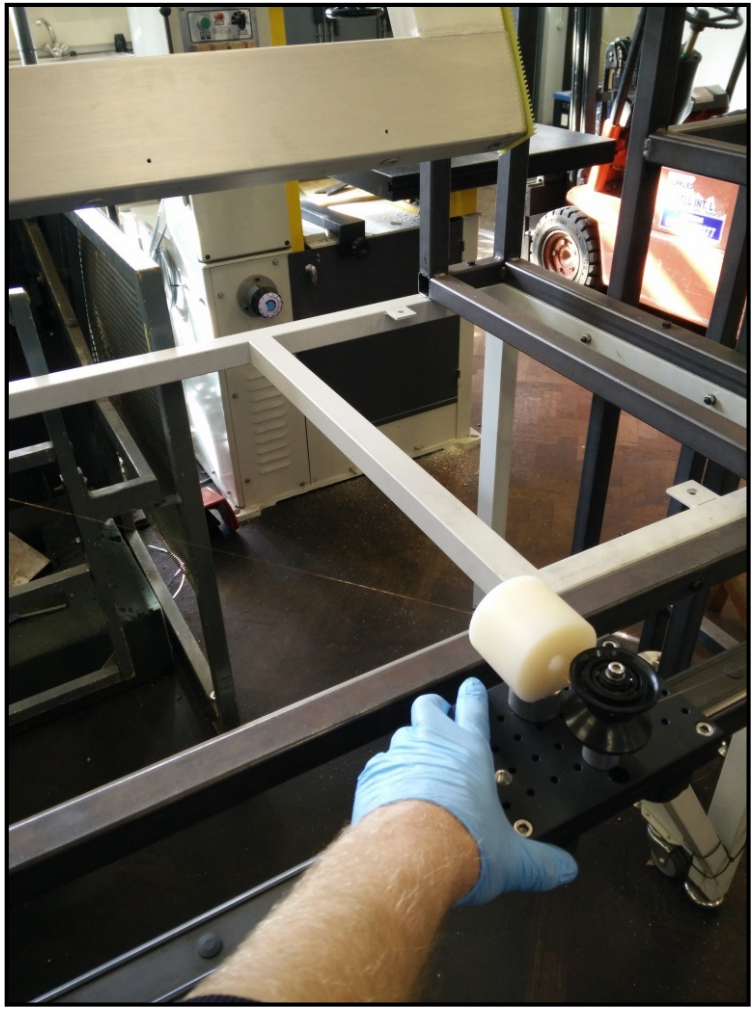
Wire is then cut from reel and attached to frame (LH image). Wire is then pulled to dowel board and wrapped over appropriate dowel pair. Wire is tenisione by wt, now pick up wire to the first dowel under tension, pull by hand

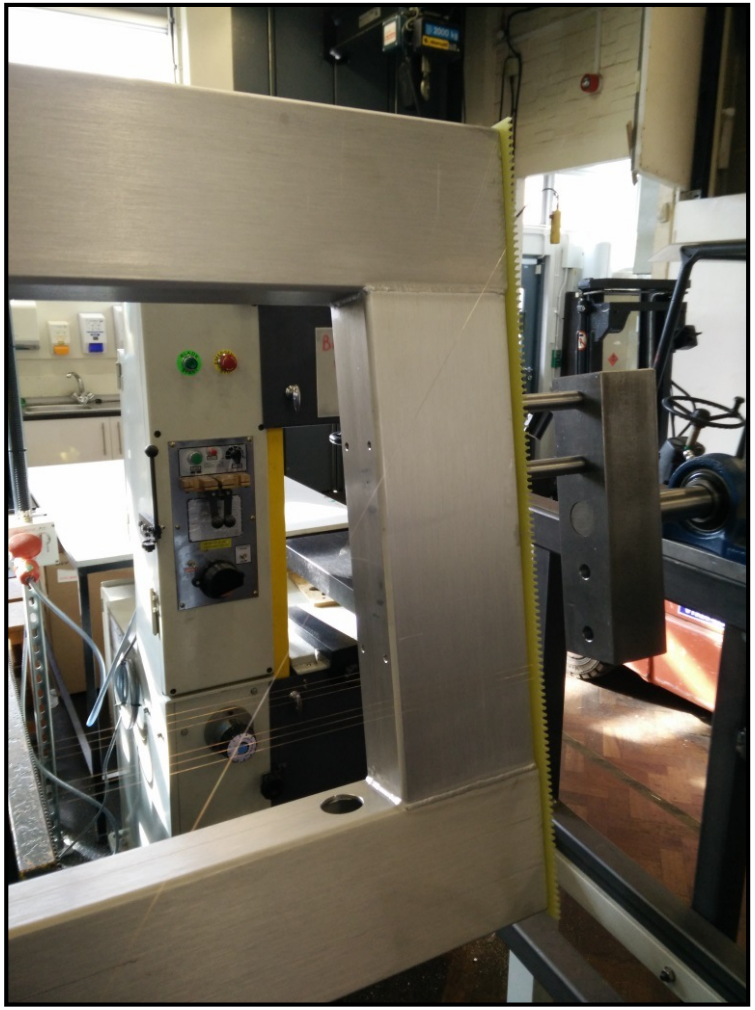




APA Winding

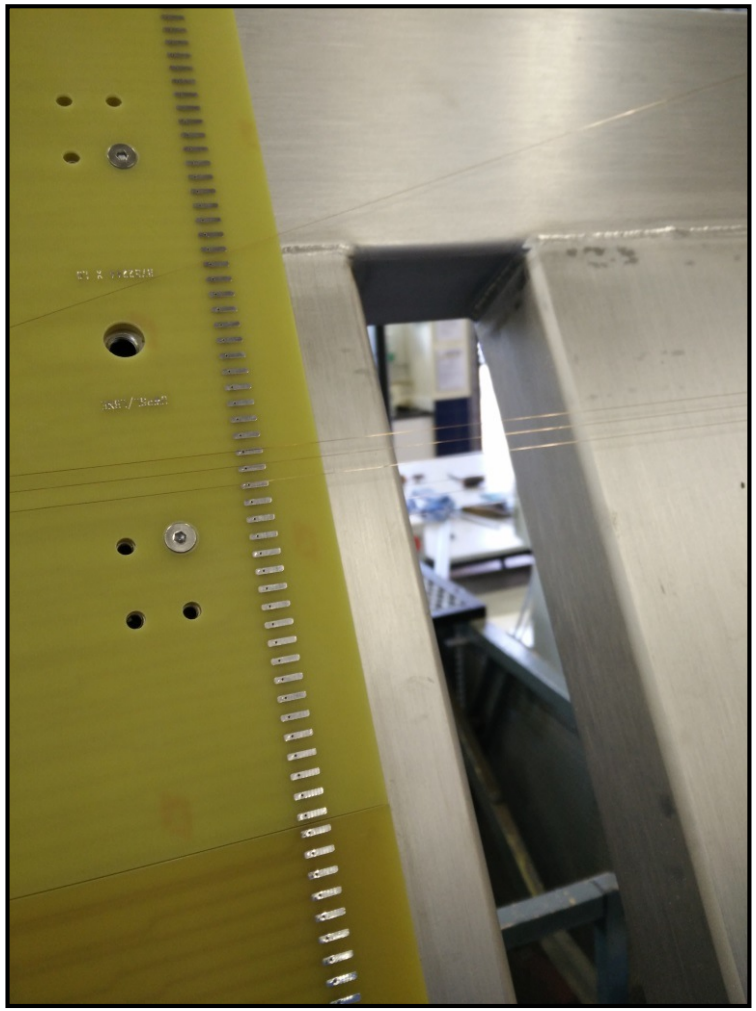
Wire then pulled towards rear of frame using wire-feed car (LH image) and wrapped over appropriate tooth in X Bottom Board (RH image). Frame is rotated during this process and wire guided to the opposing tooth on the other side of the X Bottom Board. Wire is then returned to top of frame and the process is repeated. Tension measured by strobe light 5N +/- 1N needed

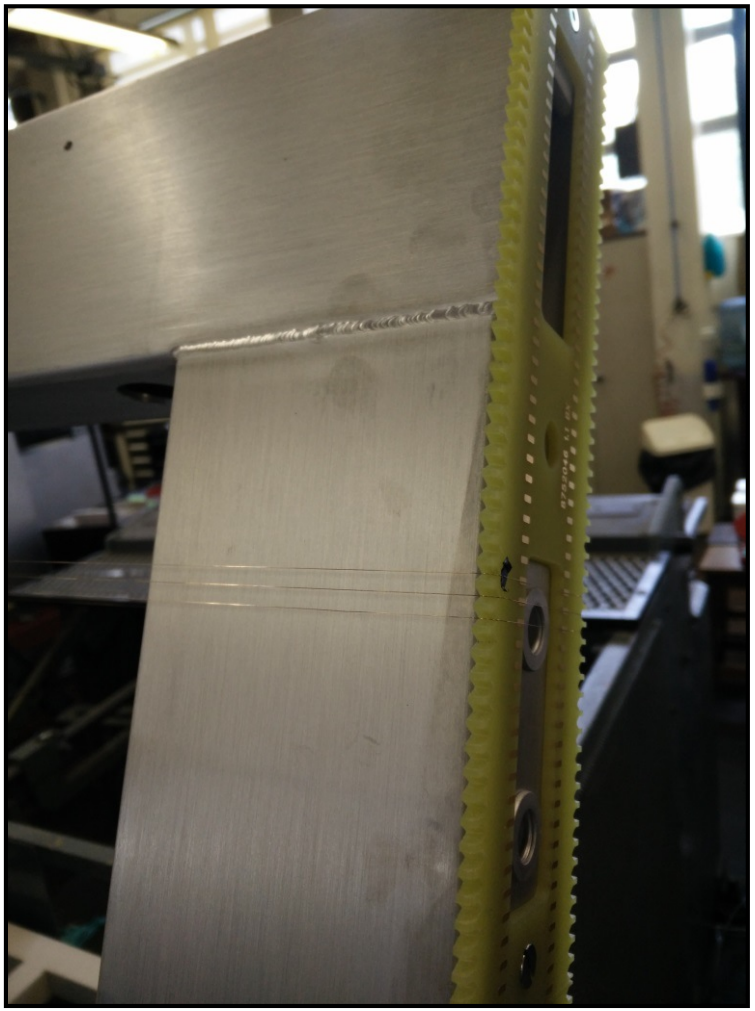




APA Winding

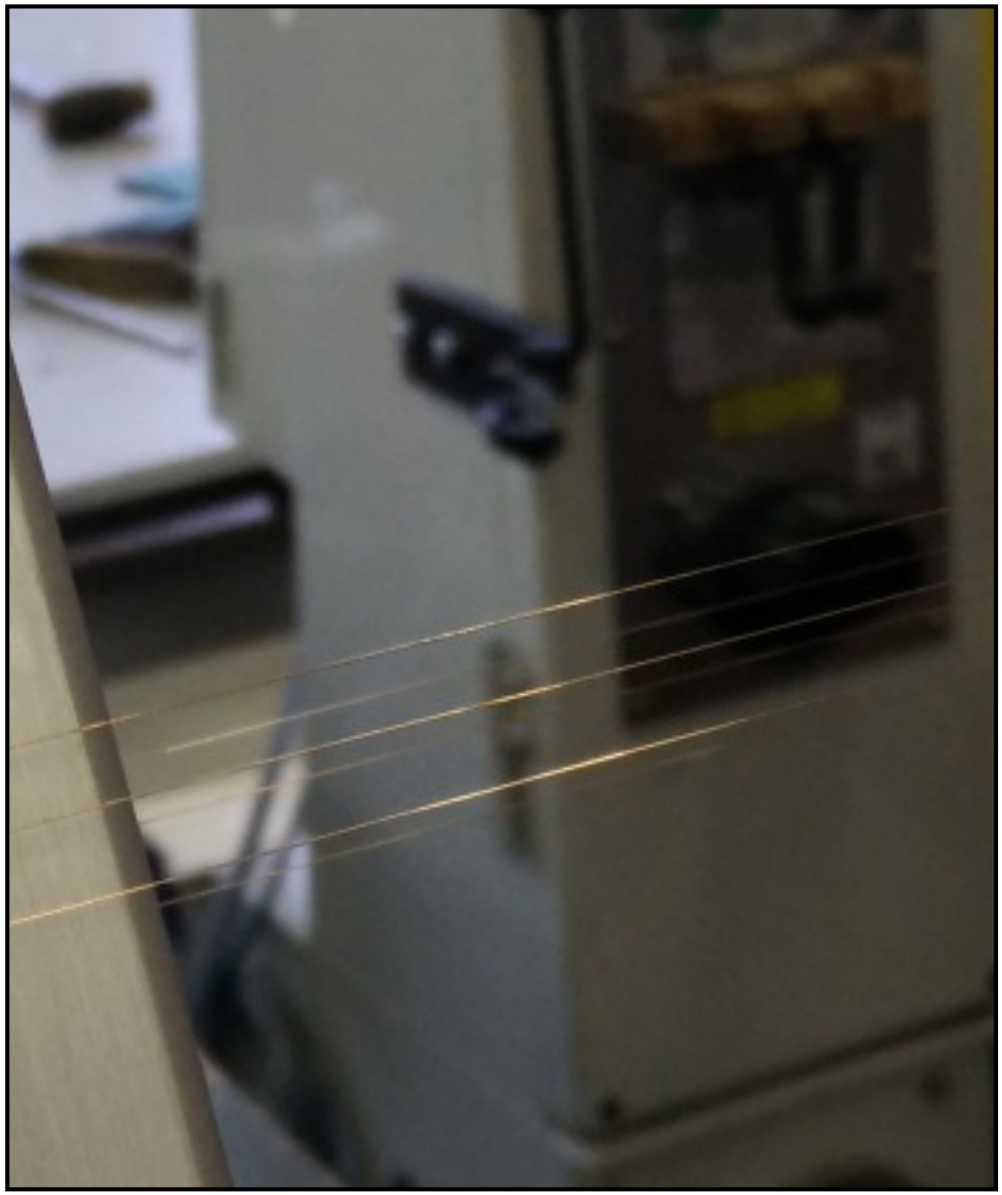
Wire winding test in progress. Three wires wrapped around frame. Left hand image shows wires passing over X wire board. Right hand image shows wires wrapping around X bottom boards. A maximum of 5 wires can be wrapped before the tensioning weight must be reset and the wire re-spooled.





APA Winding

More pictures of wires wrapped on frame. Wires on both top and bottom face can be seen.

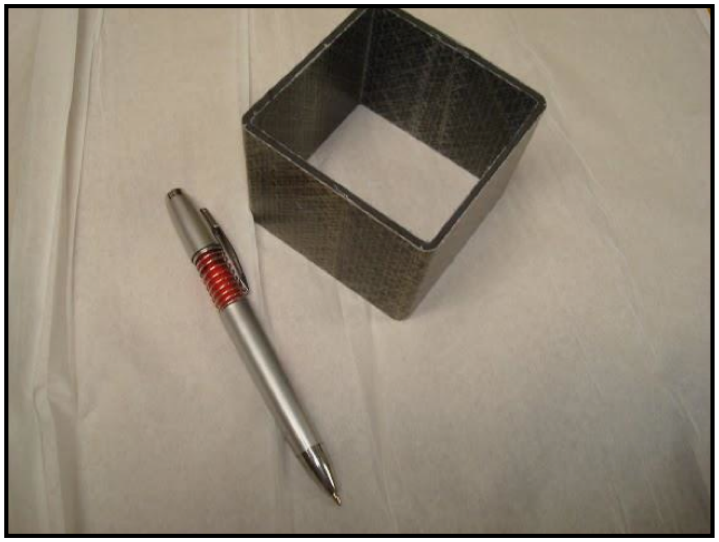


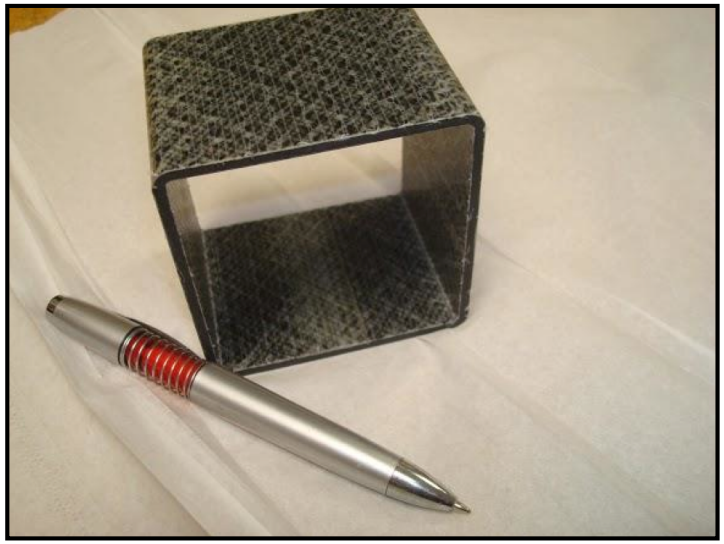
Other Relevant R&D at Sheffield

Alternative Frame Ideas

Study of using carbon fibre for APA frames in liquid argon

FNAL purity test in LAr





PAB Materials Test System	
Date of Receipt	6/18/2015 eLog entry # 5105
Sample Name/Description	piece of carbon fiber hollow box cross section beam
Sample	
Composition:	carbon fiber
Picture Location:	data base
Weight:	85.5 g
Dimensions/Area:	75 mm x 75 mm/wall 3 mm, length 60 mm
Source:	Trevor Gamble, University of Sheffield,UK
Preparation:	cleaned with alcohol
Submerging in LAr or LH2	x
Time in the airlock(hrs)	
Purge:	x
Vacuum:	25 hours
Liquid Test	
Start Time/Date, End Time/Date :	5/21/2015 5:52 PM, 6/3/2015 2:20 PM
PrM run # :	24247
Condenser state:	on
Filter state:	off
H2O reading:	no water reading
Liquid level:	25 inches
Temperature:	95 K
Lifetime:	slowly decreased from 7-10 ms to 3-5 ms.
Zero Test	
Start Time/Date, End Time/Date :	6/10/2015, 6/18/2015
PrM run # :	24444
Condenser state:	on
Filter state/settings:	off
H20 reading:	increased to 6 ppb
Temperature:	95 K
Lifetime:	slowly decreased, stayed in 3-5 ms range for the last few days
Results/comments	no difference in results for sample in cage / empty cage tests

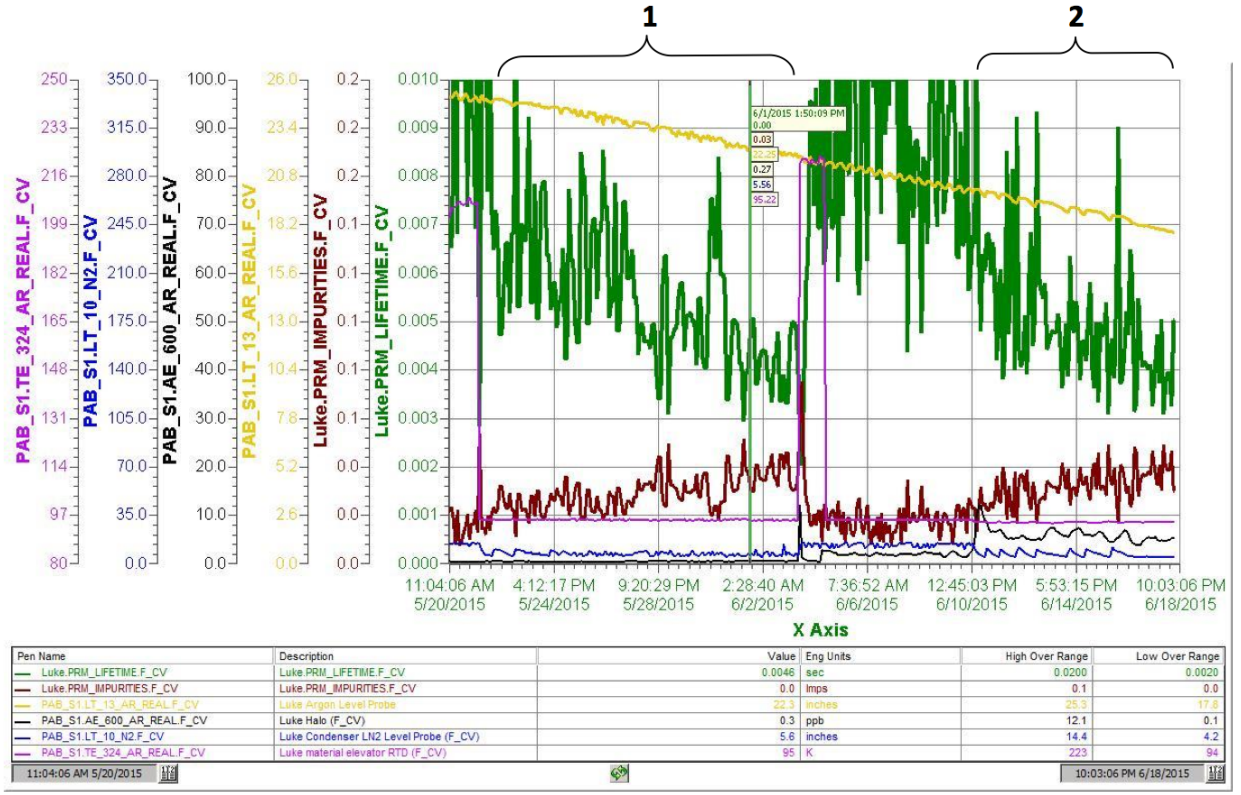
Alternative Frame Ideas

Study of using carbon fibre for APA frames in liquid argon
FNAL purity test in LAr

Conclusion so far:

no concern about outgassing

costs may be higher



Green pen - lifetime

Yellow pen - liquid level

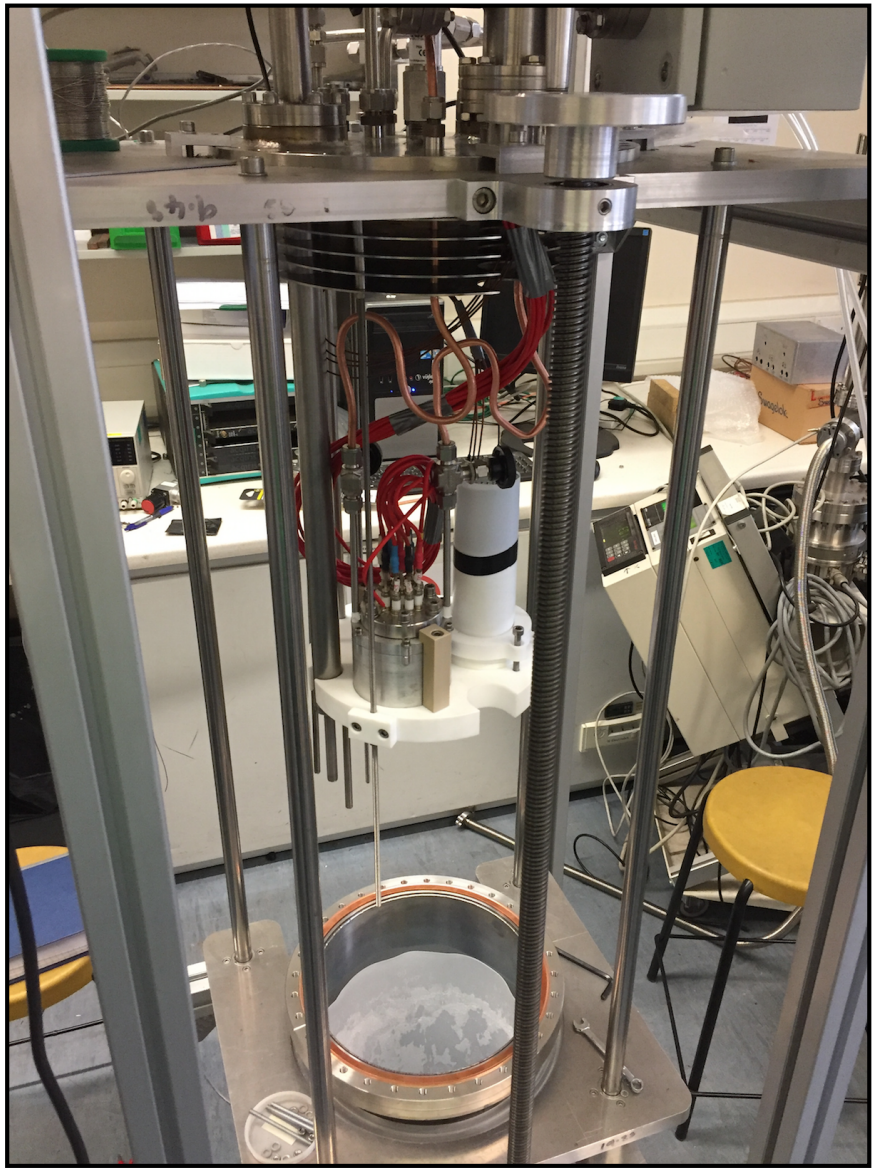
Magenta pen - temperature

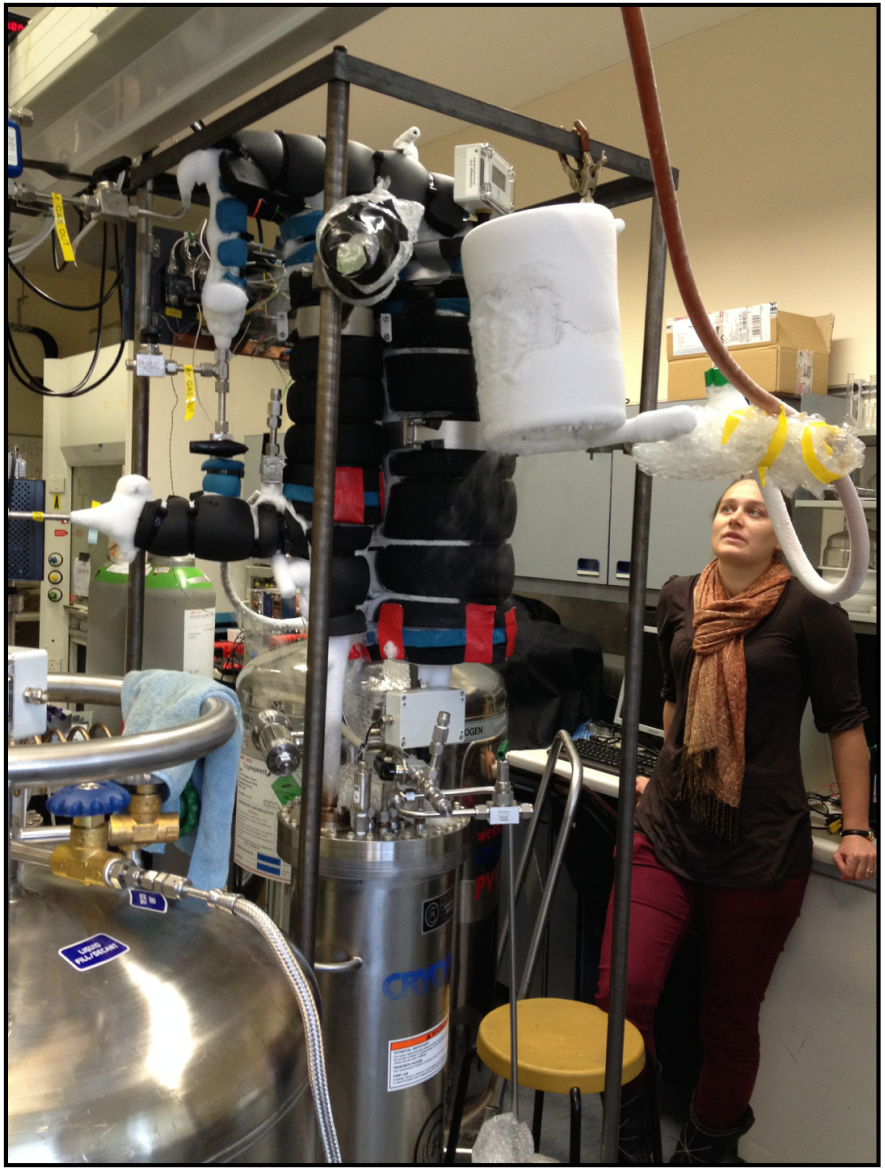
Brown pen - impurities

Black pen - water

LAr Rig at Sheffield

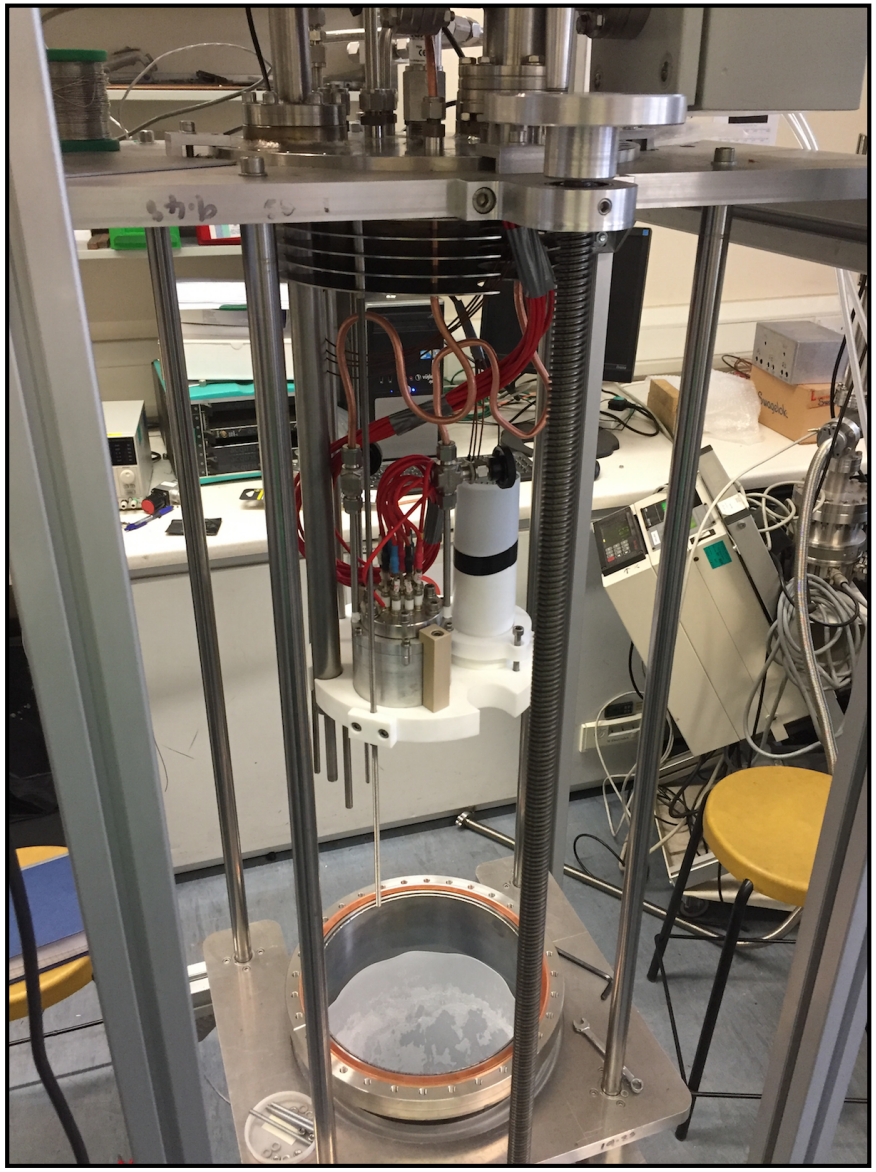
LAr test stand operating. Recently testing GPMTs for cryogenic operations



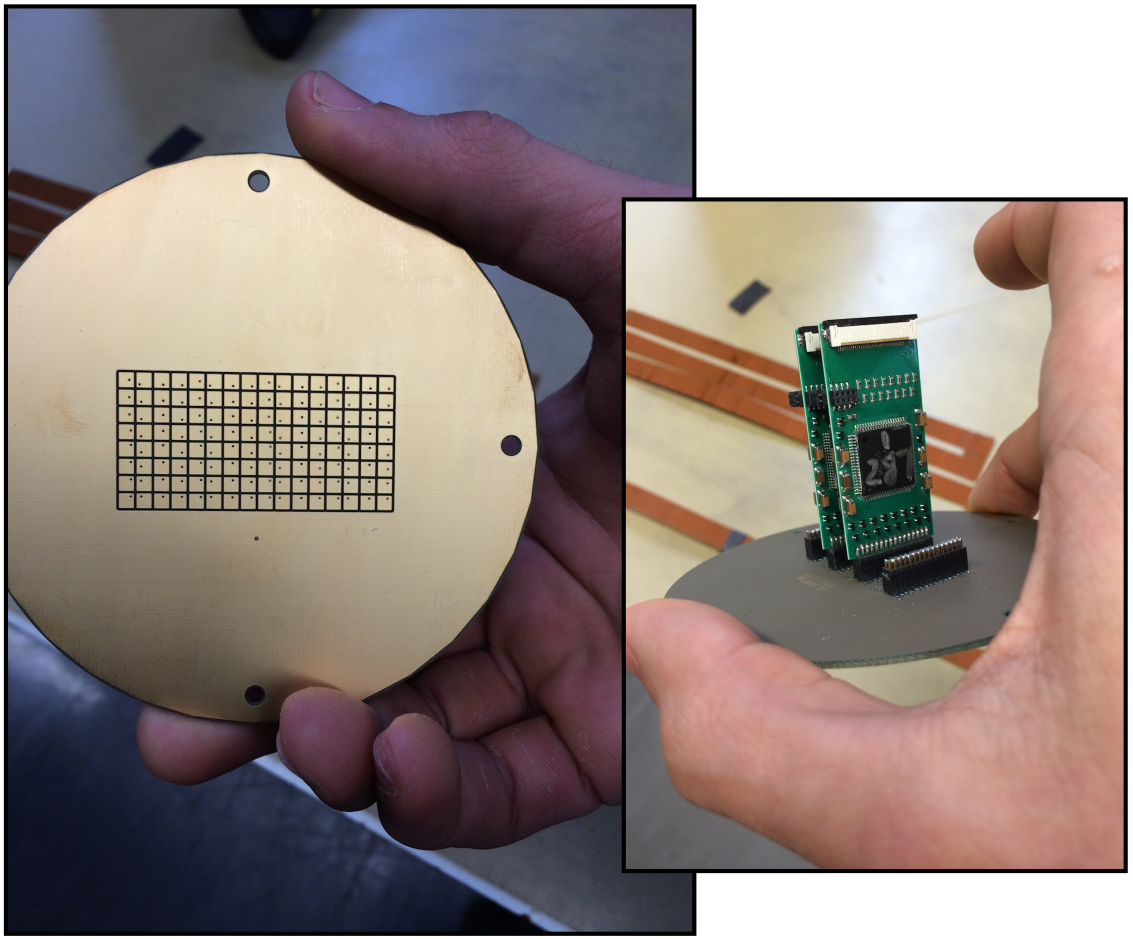


LAr Rig at Sheffield

LAr test stand operating.



Potential for pixel tests now
Student Dom Barker at FNAL



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