ProtoDUNE
Construction of the UK APA

STFC Daresbury Laboratory

22nd January 2018
Floor Layout for SBND & ProtoDUNE

There was limited space at Daresbury for building ProtoDUNE APA’s, solution was to share same facility with SBND APA
APA Facility

SBND APA facility September 15
SBND & ProtoDUNE Area

Area cleared & ready for build Dec 15

SBND clean room completed Mar 16

Winder Machine parts start to arrive Nov 17

Winder commissioning Jun 17
APA Facility Construction

- **Project was approved August 17**
- PSL shared drgs files and models as required and as they became available. Still lots of unknowns and design development work at this stage.
- Winder machine parts start to arrive Nov 17
- Issues around sourcing materials for US component suppliers
- Some design tweaks required by Daresbury to overcome these supply issues
- Metric vs Imperial material stock issues
- Tubes were sourced through the USA

- Winder nearing completion May 17
- US & UK voltage supply different which meant we could not use exactly the same motor gearbox components as PSL
- Local agent for Allen Bradley control systems helped us with the drive system and during commissioning
APA Hardware

- APA Frames
- Winding machine
  - winding head
  - Compensator
  - Interface frames
  - Drives controls, sensors, racks
  - Guide rails, slides
  - Camera
  - Wire spools
- Carts
  - Process cart
  - Soldering cart
  - Transport cart
- Gantry Crane
- Clean tent and filter system
- APA Boards
  - X-plane
  - V-plane
  - U-plane
  - G-plane
  - Bias boards
  - CR boards
  - Cover boards
  - Wiring harness
  - Combs & comb bases

- Photon rails
- Adhesive
  - Glue jigs
    - V-boards
    - U-boards
    - G-boards
    - Cover - boards
- Mesh
- Tooling
  - Lifting beam
  - Mesh jigs
  - Access platforms, different sizes
- Shipping tooling
  - Yoke
  - Tees
  - Cover panels
  - End covers
- Shipping Crate

PSL supplied all boards, wire spools, glue jigs & some shipping tooling
APA Facility Construction

• First APA frame delivered June 17
• Frame mounted in winder to carry out wire winding tests
• Did have some problems with riv-nuts slipping when moving handling frame
• HEPA filter units and rigging for the tent in place

• First wire placement July 17
• Commissioning continued throughout July and into August to ensure could run x & v-plane recipes
• This was not trivial lots of discussions and support from PSL to overcome these issues on a daily basis
Photon Rails & Mesh Installation

- Photon rails installed prior to mesh
- Interface frames must be removed to install end rails

- We install the mesh on the process cart unlike PSL
- We have added clearance holes down the centre of the central tube to attach mesh jigs
- We incline the frame and roll out the mesh into position and work the mesh using the clamps to achieve flat even tension
- 1hrs to fit mesh jigs, approx. 2hrs for each panel roll & tension then further 8hrs for glue cure so work on 1 shift for each of the 4 panels
- Installation made easier as we can stand next to the frame
UK – APA1 x-plane 1st half wire

- Began winding the 1st APA towards end August
APA – Build

• APA wiring…..relatively straight forward unless issues with winding machine.
• Most winder issues occurred with the z stage passing the wire from the winding head to the compensator head…..latching issues
• Soldering relatively straight forward and does not take as long as first thought…..approx. 2hrs for x-plane
• Gluing of boards
  ➢ x boards no gluing required
  ➢ v & u boards over 70 for each wire plane
  ➢ Glue volume measured and applied over glue jigs
  ➢ Cover boards over 70 in total
  ➢ **Cure time for adhesive 8hrs….**
• Tension testing…very time consuming
  ➢ x & g planes standard length wire can be reasonably quick, need to test both sides A & B
  ➢ v & u planes, varying length wire, over 2200 wires for each wire plane.
• Winding the g-plane Dec 17 approx. 4mths
APA in Process cart in tent area all covers in place

APA on radial crane and lowered into shipping crate

Lowering the APA into the shipping crate is an easy operation…..better than loading through either end.

Fitted both long side panels and roof panel with aluminium angle section approx. 4m long. This made the panels stiffer and allowed us to carry out vertical lifts using eyebolts and shackles…..safer lifting procedure

Shock log recorder mounted to the frame of the shipping crate.
2 fork lifts used for loading shipping crate on to air ride suspension vehicle

Not the safest method of lifting, need to take care when carrying out this operation

My understanding is that all APA have been handled this way.

Better vehicle would be a low loader which could be reversed under the lifted crate

This vehicle only just high enough

UK APA shipped Friday 12\textsuperscript{th} Jan 18, arrived Tuesday 16\textsuperscript{th} Jan 18.
Lessons Learned

- Need more space than you think, moving things around things get quite tight.

- Will need even more space when full safety systems are introduced for production runs…..discussions on going for such a system.

- Important to have same design CAD package to share drg and models.

- Should decide metric or imperial….Europe favour metric, difficult to source imperial stock and components

- Lots of hardware required to set up factories, need to start ASAP.

- Tube design needs to be agreed by all interested parties. Need to be able to wind complete wire plane without removing from winder…..handling issues.

- Need to avoid the use of riv-nuts, caused many problems.

- Need to re-visit plc & gui programmes so they are more user friendly…..writing recipes caused some issues in the initial stages.

- Install photon rails before interface support bars are in place in the process cart.
Lessons Learned

• Consider using “picture frame mesh panels”, outsourced and simply bolt in position on the frame

• Investigate using automated soldering head…..believe there is a system in CERN.

• Develop system for tension testing……ongoing

• Agree tension testing policy

• Do we need to glue all boards?......if so are there other adhesives with shorter cure times?

• Develop winder head to include tension closed loop operation to maintain correct tension at all times.

• Need to design crates that are easy to load preferably not using 2 forklift trucks

• Need to decide how many APA’s will be shipped in a “standard crate”