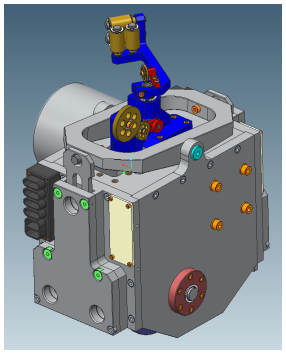
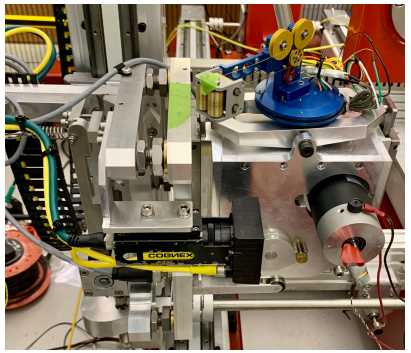
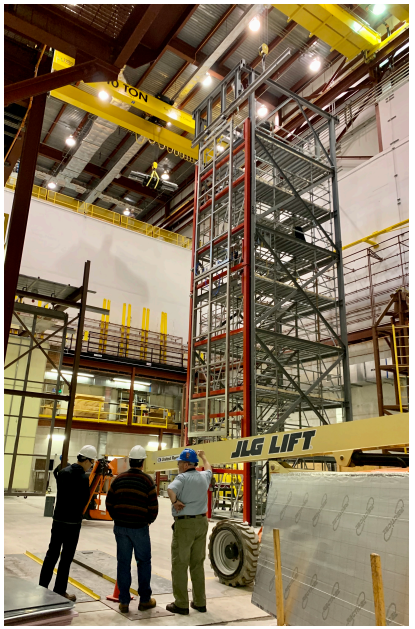




APA status & plans including Integration and Installation

Christos Touramanis
LBNC
6 December 2019



Outline

- Funding
- Options / decisions
- Design completion
  - Frame, boards, interfaces, transportation
- Integration & Installation
  - Ash River tests
  - Transportation
- Production preparations
  - Wiring machines
  - Factories
  - Procurements
- Boards, electrical review, procurement
- 2020 major milestones

Funding

- UK: grants awarded, accounts now active in the institutes
- USA: NSF proposal submitted and under review

Decisions

- Electron Diverters
  - Consortium Task Force concluded: no ED
  - APA consortium recommendation passed on to TB, EB
  - Active (biased) EDs ruled out
  - Passive EDs: in the last round of TB-EB consideration
- Removal of g-plane
  - Would result in production time & cost savings
  - Risk for CE charge damage
  - Considered too risky at this stage, also taking into account the excellent protoDUNE-SP data quality
  - Ruled out

Design completion

- Frame detailed design, analysis completed, in EDMS
- Boards: see dedicated slides
- Transport frame/box: see I&I slides
- Interfaces:
  - CE cables routing tested, closed
  - PD detectors mounting: more tests planned at Ash River
  - PD cables routing, APA-to-APA connection: PD consortium to provide new cables with new connectors for more tests at PSL and Ash River

Integration, Installation

- APA consortium underground plan within the I&I framework
- Plan developed to a considerable degree of detail and continuing to be refined. Basis for staff requirements estimates and costing.

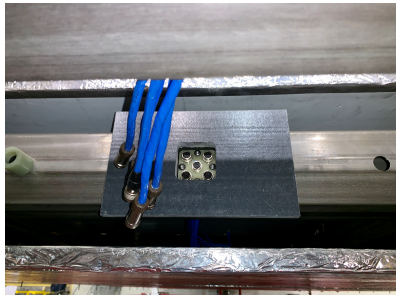
- Excellent results at Ash River so far
- More tests to do, specially for PD integration and cables
- Detailed plan to fully demonstrate the complete process with prototype APA transport frame and box

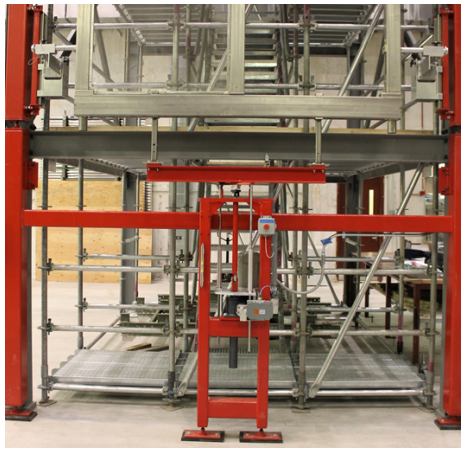
Ash River 30/09-03/10

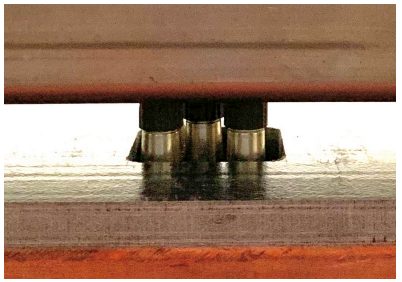
- APAs mounted – removed on the frame multiple times
- Doublet join – take apart ~ 10 cycles
- CE cables routed through the doublet – removed multiple times
- PD connections between APAs done multiple times
- Electrical isolation validated
- Improvements identified all round
- Broad attendance (APA, CE, PD, I&I, ESH, P.M.)

Ash River 30/09-03/10



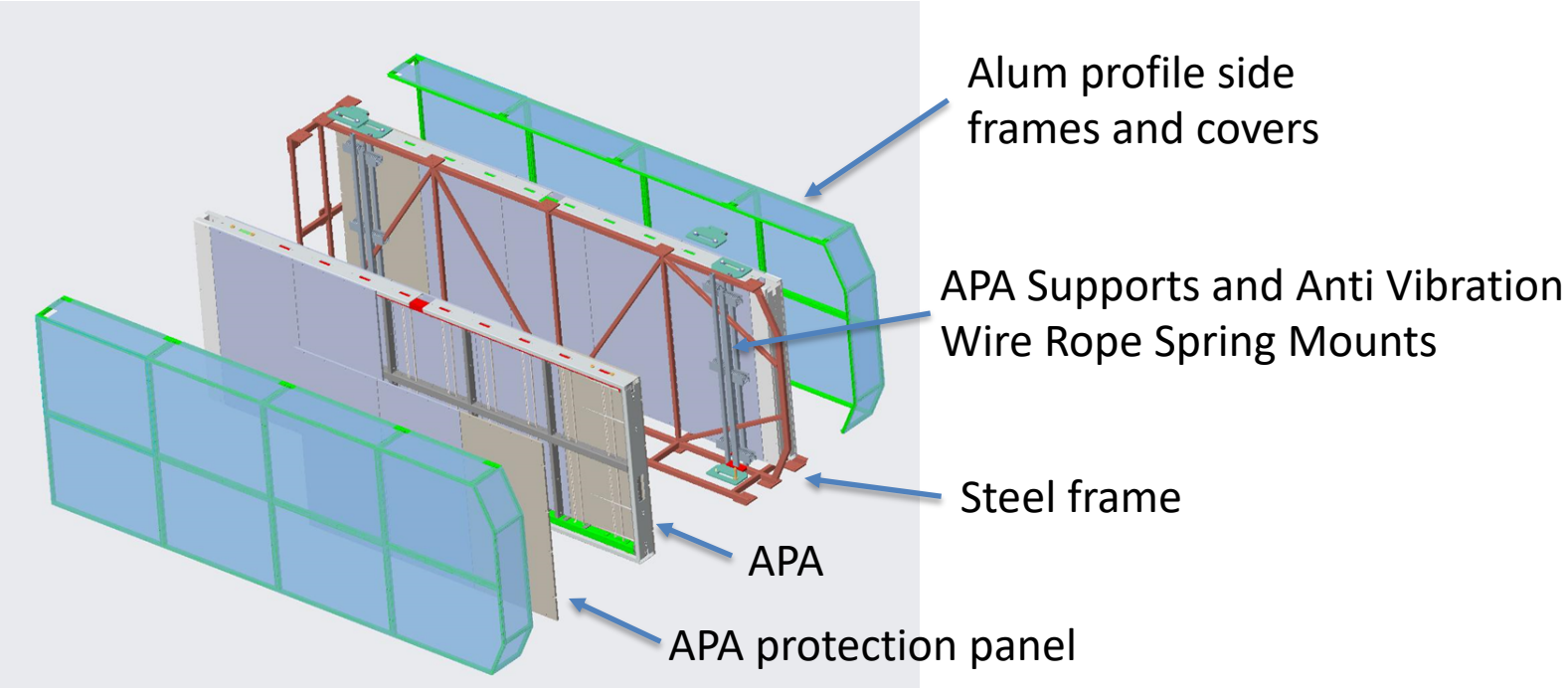





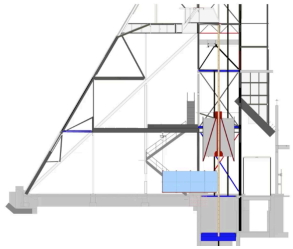
Transportation

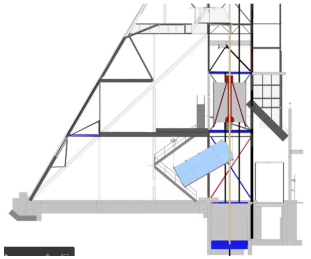
- 2 APAs mounted on a shipping frame at the factory, taken off at the underground integration area at SURF
- Use cases & requirements document done
- Design (frame including damping system) done, on EDMS
- FEA ongoing; more analysis required to meet DUNE and SDTA reqs.

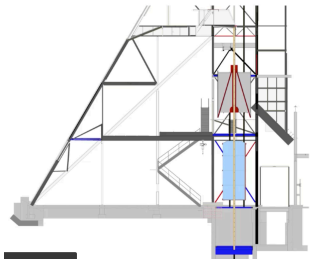


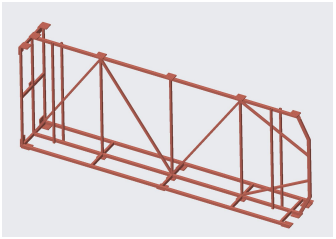
Shipping frame

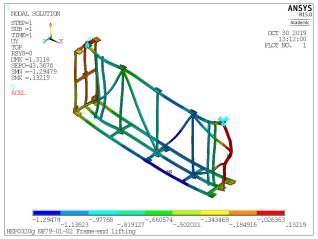
- U. Liverpool: design, FEA
- Formed APA Transport Frame Working Group
  - APA consortium engineers (Daresbury, PSL, Manchester)
  - Fermilab engineers (design, analysis support)
  - I&I engineers, leadership
- Aiming to complete analysis and documentation in January
- Design review at Liverpool, 24 January
- First prototype in the USA for tests at Ash River





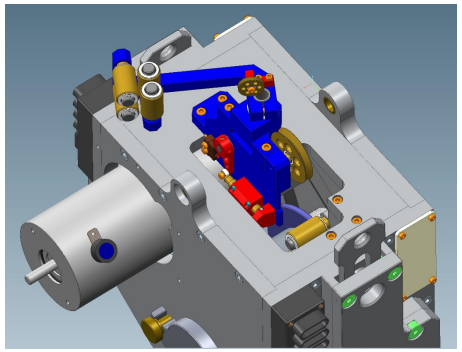


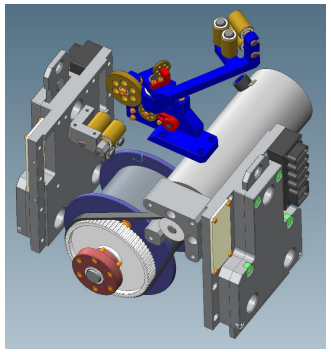


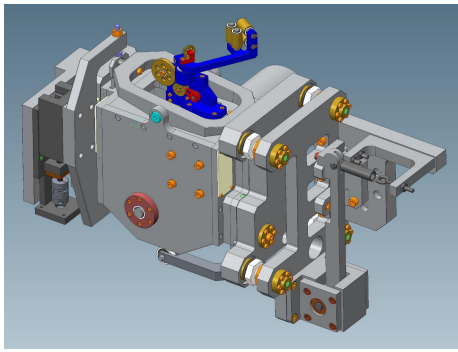


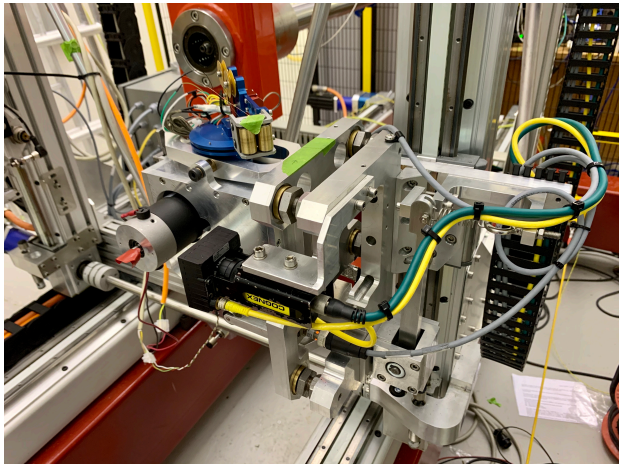
Production: wiring machine

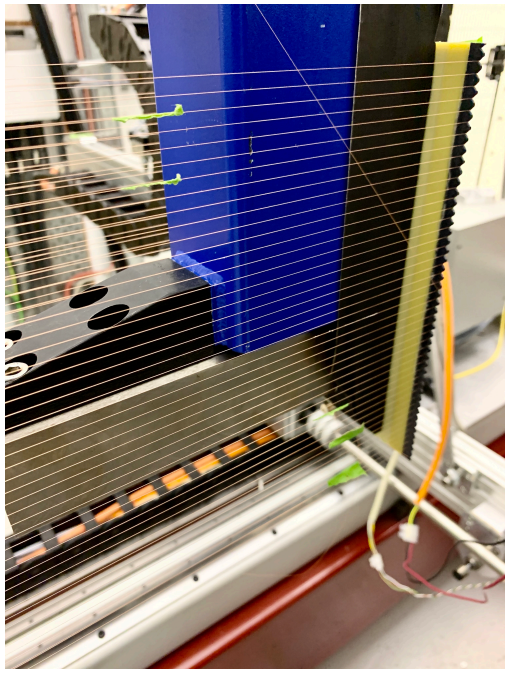
- Active Tension Control wiring head successfully tested at Daresbury by September
- Final version: DC motor for better precision; many design improvements
- Final version initial tests: <10% tension tolerance
- 3 more heads for Daresbury being manufactured at U. Liverpool
- Parts for 4 machines (frames, cables, electronics) being delivered
- First final design US wiring machine to be completed by early spring





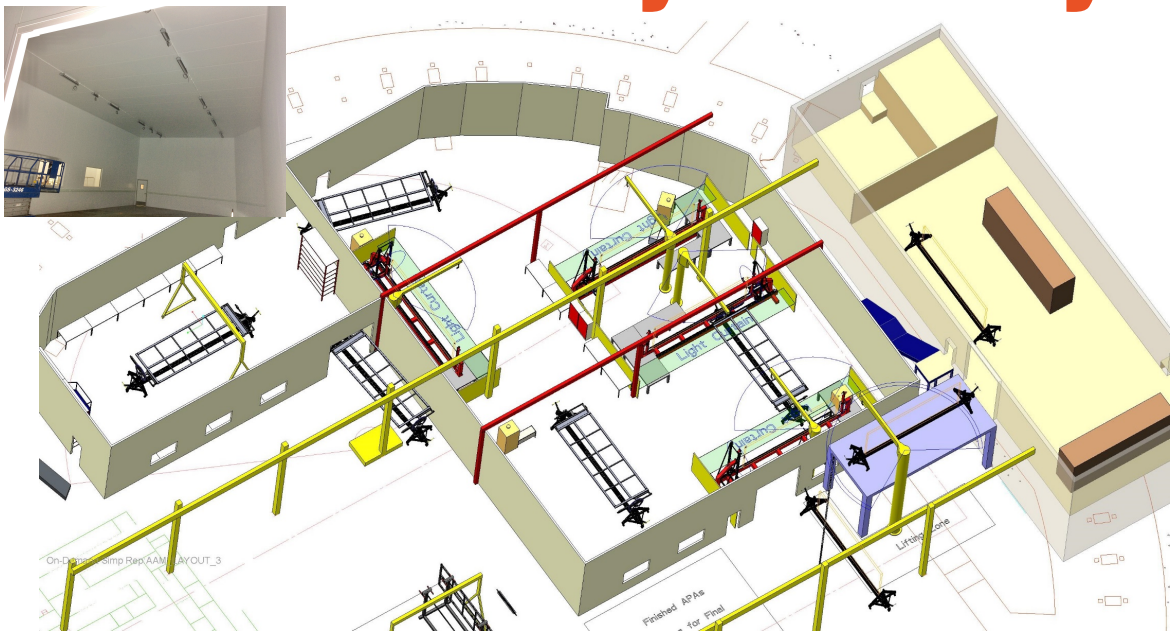






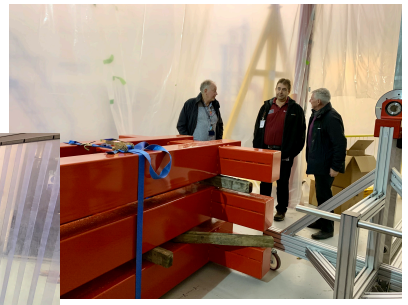
Production: Daresbury factory

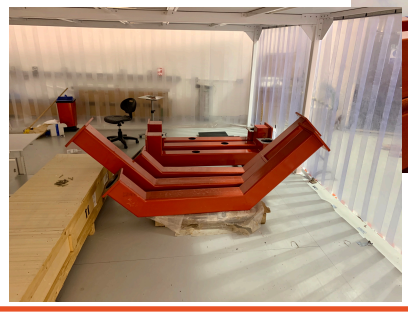
- Purpose built factory room inside old SRS accelerator hall
- 4 winding machines, 10 process carts being made. One operational in January.
- 5 new dedicated swing arm pillar cranes installed
- 1,085 m^2 (11.7 ksqf) including pre- and post- processing areas
- Safety: laser light curtains, interlocks, pull-wire emergency stops
- Consortium review: January 22, 23
- US APA production sites design review: April 2020



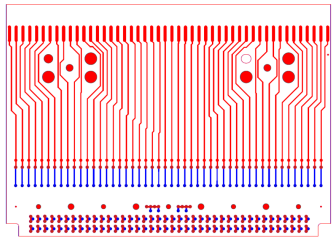
Production: procurements

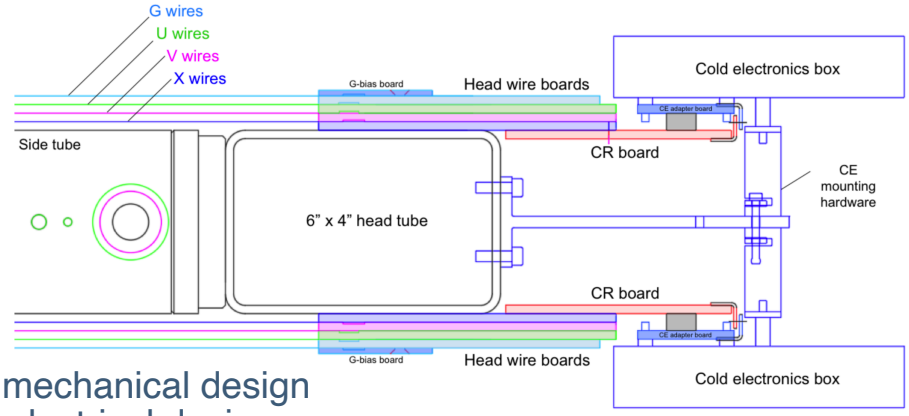
- Frames:
  - Steel supplier identified, 3 assembly companies (UK) fully engaged
  - 5 (US) + 2 (UK) frames for early 2020 delivery
- Mesh:
  - 40 panels for 2 APAs ordered to UK supplier
  - Tender for production in UK ongoing
  - In contact with companies in the US
- Materials for winders (UK) being delivered
- Boards: see dedicated transparency



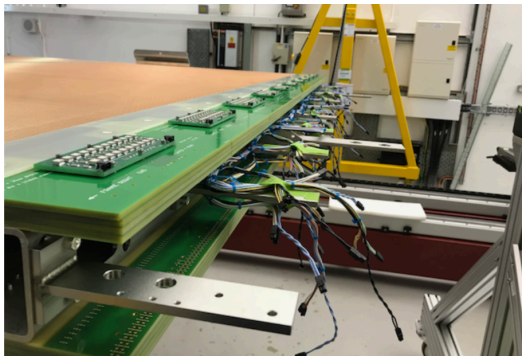


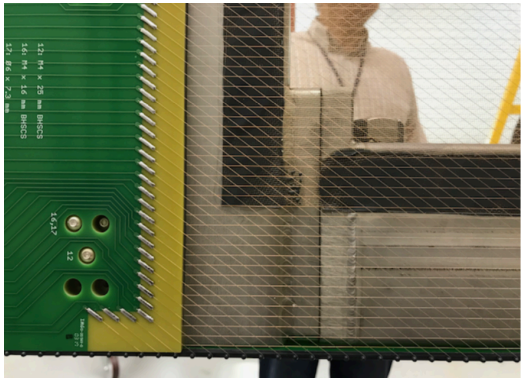
Boards





- Each APA has 204 boards of 29 different types. Their mechanical design determines the 3D position of wires and planes. Their electrical design provides the required connectivity around the APA frame and to the CE, and the application of the bias voltages (over a 1kV range). Moreover we have CR boards, the adapter card and the G-layer bias card.
- Boards have been redesigned from protoDUNE to match the wider frame and to withstand higher voltages (400 V between adjacent wires) for the wire tension measurements. G-layer head boards have additional capacitance to further mitigate long range induction effects
- Custom Mill-Max sockets and pins are used
- The boards were reviewed as part of the APA Electrical (60%) Preliminary Design Review (November 18-19 at PSL). They were found to meet the standard for 60% maturity.
- More than 10 manufacturers have been approached in the US. Stringent thickness requirements (0.5mm) and relatively small production quantity result in difficulties to find suppliers. Most ProtoDUNE boards were machined for thickness.
- Market scan to identify UK suppliers starting.
- Boards are becoming a main focus of the consortium in the next months.





Conclusions, 2020 milestones

- Design, I&I planning, tests ongoing in parallel
- Production preparations in full swing
- Final Design review: (still aiming for) May 2020
- First APA prototypes (Daresbury, PSL) ready Q1/20-Q2/20
- Start UK production: Q3/20
- Production timeline compatible with 2024(2025) installation start for FD modules 1(2)