Cabling Tests at Ash River

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Manhong and I went to the NOνA Far Site last week

Installation work

- At Ash River we have a prototype of the assembly tower that will eventually be installed outside the cryostat at SURF
- Have 2 APA frames
- Goals of the workshop of last week
  - Exercise the assembly procedures (stacking APAs)
  - Understand cable routing
  - Measure time required for operations
  - Feed back in design of APA, cables, photon detector, infrastructure

Slotted Conduits (i)

- To facilitate the routing of the CE cables for the FEMBs attached to lower APA the design of the APA frame has been modified relative to ProtoDUNE
  - Increase the size of the frame tube to 4” x 4”
  - The CE cables are routed through a conduit (2.5” outer diameter) that is inserted in the APA frame and supported at one end
  - The conduit needs at least 1 slot for the connection between the two APAs
- The insertion of the conduit inside the frame is complicated
  - For the upper APA this could be done at SURF
  - Doing it for the lower APA would require lowering the APA on the conduit (the conduit is held on the head frame of the APA, which is at the bottom for the lower APA)

Slotted Conduits (ii)

- The next problem with the conduits is that they preclude access to the photon detectors
  - i.e. the photon detectors would have to be inserted first, and the conduits later, and in case of problems the conduits would have to be removed
- The APA consortium has been pushing a solution where each conduit has 5 sets of two slots corresponding to the window required to insert the photon detectors
  - This would allow the APA consortium to install the conduits at the APA assembly factories
  - Always have access to the photon detectors until CE cables are in place
- But
  - Slots could damage the CE cables

Slotted Conduits (iii)

- First test: route cables through slotted and non-slotted conduits
  - Only the first test was performed
  - Cables can be lowered (and then pulled back) very easily through the slotted conduit with minimal damage to the cable sleeve
  - Damage mostly from the conduit edge (needs to be flared, will also investigate deburring the slots)
- The CE consortium agrees that we will use a slotted conduit that will be installed at the APA factories

CE cables (i)

- These tests have been done with a bundle of ProtoDUNE cables for 9 FEMBs + 8 SHV cables
  - ProtoDUNE signal cable: 12 twinax pairs
  - ProtoDUNE power cable: 9 twisted pairs
- For DUNE:
  - Reduce the number of twinax pairs to 10
  - Reduce the number of twisted pairs to 8
  - At most 5 SHV cables
- We have not yet ordered DUNE cables
- The test is meaningful because
  - 9*12=108 > 10*10=100
  - 9*9=81 > 10*8=80

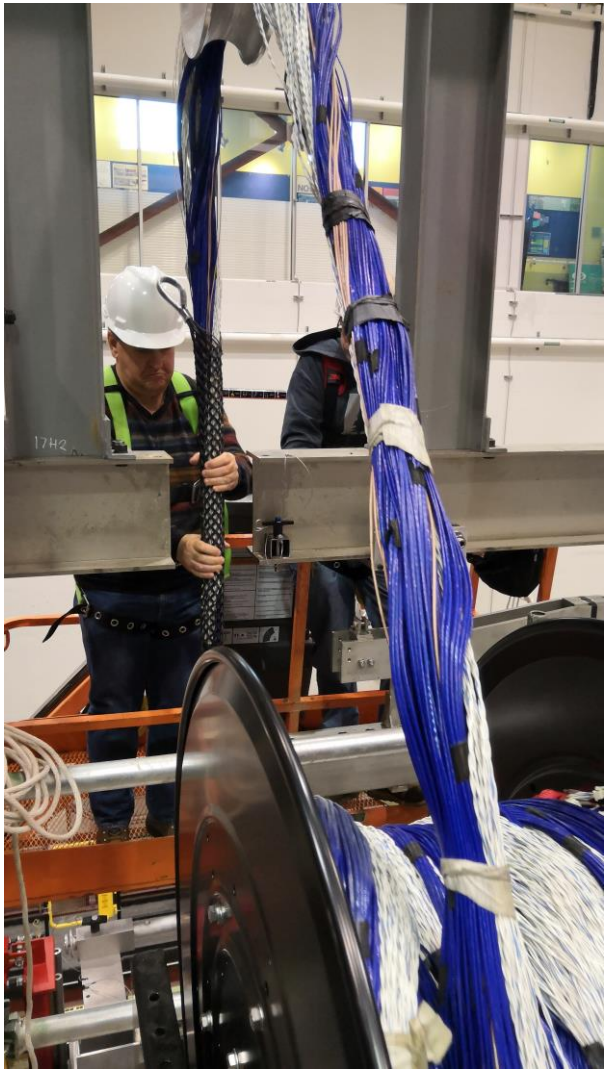
CE cables (iii)

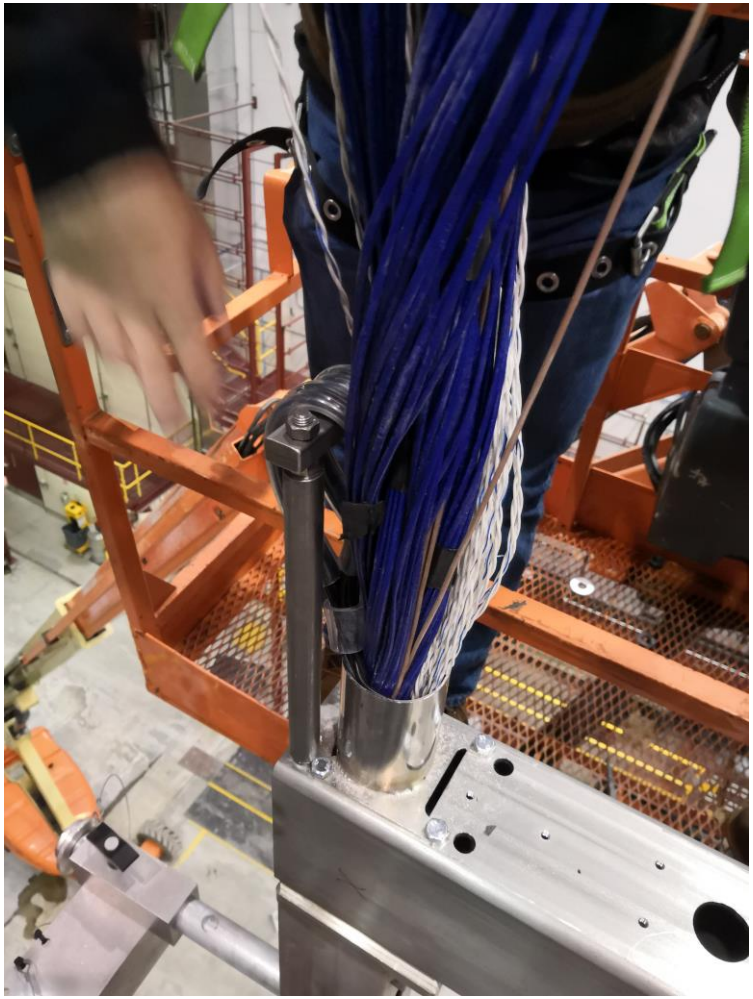
- We need to demonstrate that we can achieve this reduction of the cable plant (test to be performed with 23 m long cables)
- Signal cables for 3 ASIC solution
  - Four 1.28 Gbps data (two from each COLDATA)
  - Two 62.5 MHz clocks (one input to each COLDATA)
  - One fast command line (shared between two COLDATA)
  - Three I2C-like control lines (2nd COLDATA fed from 1st)
- Signal cables for CRYO solution
  - Four 896 Mbps data (two from each CRYO)
  - Two 56 MHz clocs (one for each CRYO)
  - Four shared SACI signals
- For power, it's mostly about the voltage drop and heat dissipation that can be accepted (small)

Other lessons learned

- Motorized spool is very nice
- Cables will be delivered to SURF on a spool and then transferred to the motorized spool before being lowered in the conduit
  - Design of motorized spool will be improved
- Cables need to be supported
  - Have a cable grip that extends over ~70cm, requires support
  - Support of cable grip may interfere with brackets that support the CE boxes
    - To be investigated in the CAD drawings (PSL) and in a mockup of the top of the APA (Manhong)
  - Will come back to this point later

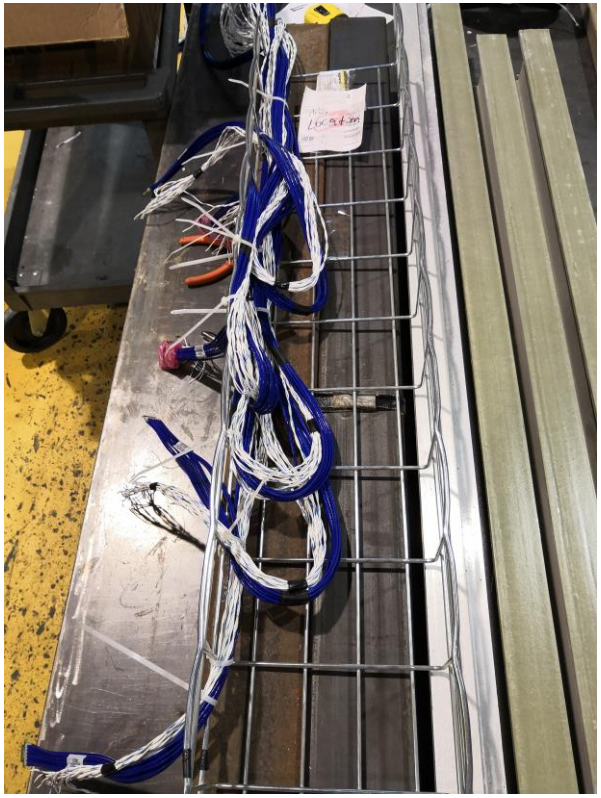
More Photos





Cable Trays (i)

- While the APA and PD consortia were working on the APAs Manhong and I investigated cable routing in the cable trays

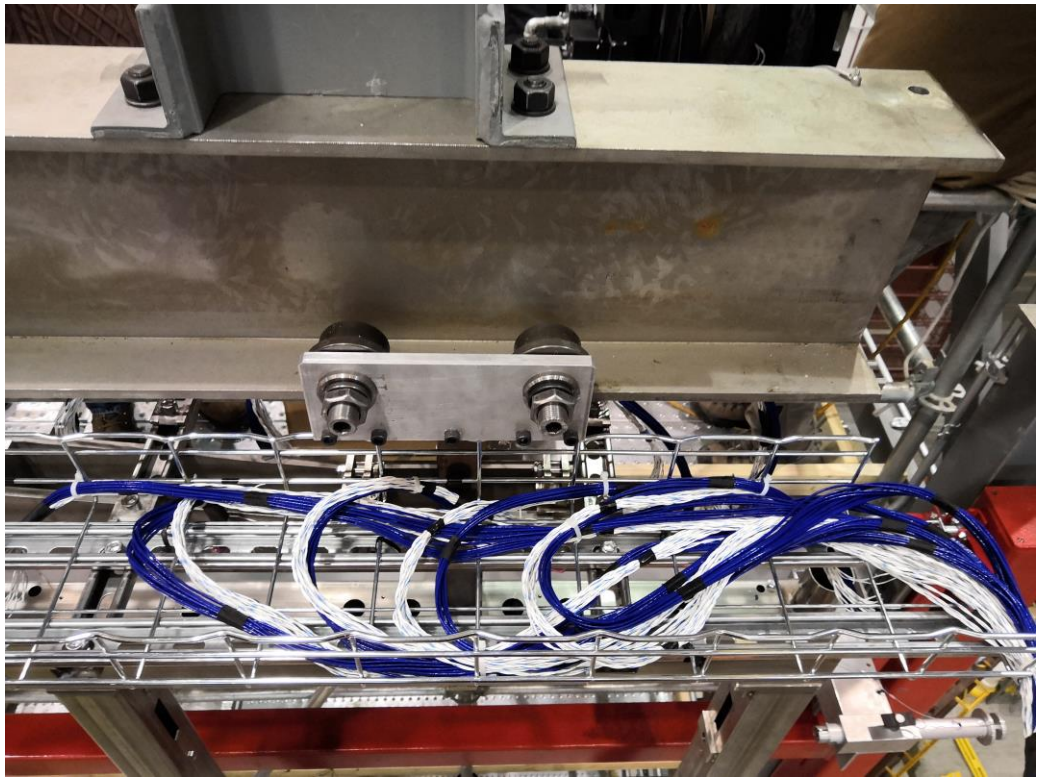


Cable Trays (ii)

- This is what happens when you try to put the cables for half of the FEMBs of the lower APA in a cable tray
  - What you see in the picture is the length of cable that goes from the top of the conduit to the CE flange
  - This needs to be on the cable tray while we are moving the APA from the assembly tower to the cold box and then into the cryostat
- The cable tray needs to hold also the other half of the cables, plus the corresponding length for the 10 FEMBs on that side from the upper APA, plus the PD cables

Cable Trays (iv)

- More tests:
  - Cable trays attached to the APA
  - Insert cables for 5 FEMBs attached to the upper APA



Cable Trays (v)

- More tests:
  - Cable trays attached to the APA
  - Insert cables for 5 FEMBs attached to the upper APA
  - Route cables for 10 FEMBs to the lower APA and arrange cable slack in the cable trays
  - Then move the cables from one side of the APA to the other

More lessons learned (i)

- Installation of cable trays can be done quickly
  - Make sure that we have marks on the cables trays (assembly at 15m height ? Facilitate routing of cables to FEMBs)
- Routing of cables in the cable trays can be done quickly
  - Provided the cables are properly tied and/or have sleeves
- Accessing cables on the cable tray close the cryostat wall can be very difficult
  - Should we enlarge the cable tray on the field cage side ?
    - Make sure that there is no interference with field cage latches, trolleys
      - To be studied in CAD and in the BNL mockup

More lessons learned (ii)

- All cables will come in 2 lengths (lower and upper APA)
- Spread of lengths in signal cables is significant
- Connectors will be staggered on the FEMB side, all at the same length on the CE flange side
- For the upper APA cables the slack will be accommodated on the cable tray of the upper APA (sleeve will go from there to the CE flange)
- For the lower APA cables the slack will be accommodated on the cable tray of the upper APA (first sleeve in the conduit, second sleeve will go from the cable tray to the CE flange)
- Need a strap to support the weight of the cables during routing from the spool to the conduit (otherwise the weight will be supported by shortest segment of power or signal cable)
  - We made that mistake and the cables did not break….

Final test

- When we move the APAs from the assembly tower to the cold box and later to the cryostat the weight on the cable trays will be distributed asymmetrically between the two cable trays
- What is the lateral displacement of the APA ?
  - 1” for upper APA, 1.25” for lower APA with ~80 Kgs on one side

Future plans

- The tests performed last week were very useful
  - Stress importance of mockups
- Understood that there are some minor design changes required (support of cable grip, wider cable trays) and some things that are not understood (how to remove the cable trolleys)
- Everything needs to be repeated
  - With the full set of cables (20+20 FEMBs, 10+10 PDs)
  - Using an improved assembly tower that is closer to the design planned for SURF
  - Late Spring 2020 or early Fall 2020 ?
- In the mean time BNL mockup will be used to validate design of cable grip, test wider cable trays, further tests of installation procedures