TPC Electronics Integration and Installation

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Production, Integration, Installation

- With respect to these consortia talks, four key elements are required:
- (1) Parts Breakdown Structure for your system. This should include the list of deliverables & all tooling. In addition, identify any items that require special handling (i.e., deliverables that exceed the cage dimensions identified in Section 2.d. Hoisting Parameters for Ross Shaft, Docdb#328 facility access specification);
- (2) Personnel requirements during installation & integration
- (3) QA & testing plans.
- (4) expectations about services provided by detector installation team and facility services team

Parts Breakdown Structure (i)

- Excel spreadsheet attached to Indico, also in EDMS under interface document between TPC consortium and installation
- See the README tab for an explanation of the columns / color coding

Column A

Blue lines indicate boxes or items that are transported through the shaft

While lines are used to give more detail about the content of boxes

I am using a convention where objects have a name that contains TPCELE if that item was purchased/procured/fabricated by the TPC electronics consortium. There are a few items that are actually provided by the APA or PDS consortia

Column B

I have left space for a unique serial number (a range of serial numbers is suggested). There will be parts for which no serial number will be provided.

Column C

Number of parts or number of items to be transported. I usually add the "+spares" under the assumption that some spares will be transported underground.

Column D

List of parts if there is more than one object, otherwise more explanation about the object. Could be replaced in the future by a list of identifiers.

Column E/F

Dimensions (in m) and weight (in kg). In most cases these are rough estimates

Column G

Origin (highlighted for the few cases where parts come from another consortium)

Column H

Earliest delivery date. This is usually way too early with respect to the needs and/or the availability of the SDWF / SURF

Column I

When are the parts required at SURF ? This is usually Integration (but we may need different granularity, some parts are needed very early). There are a few parts that are marked cryostat because they are needed to complete the

Column J

Where should the parts be delivered ? This is either Clean Room, Top of the Cryostat, or 4910 (the latter indicate objects that are left outside the clean room)

Column K

Indicates whether some of the material used for transport will be reused (the spools for the cables are a candidate)

Column L

Comments: the ones highlighted in yellow and orange indicate areas where the plans are yet unclear (do these parts go to SURF or not)

Parts Breakdown Structure (ii)

- Large number of boxes (1,350) required for detector installation
  - Box contents optimized for detector construction (i.e. today we need box A123, B456, C789, D012, E345, F678)
  - Multiple boxes could fit on single pallet for transport to cavern
- Jigs / tools required for installation listed separately
  - This is where some of the uncertainties are (some tools have not been designed yet)
  - But not expecting this to increase the box count significantly
- Only objects to be brought back to surface for reuse are the spools for the cold cables (and after X uses these will be sent back to the seller for recycling)
- Will continue updating the version of the spreadsheet in EDMS as understanding of installation process is improved

Personnel Requirements (i)

- Phase 1
  - Install cryostat penetrations and WIECs
    - Work happens on top of the cryostat, could be done in parallel (or slightly behind) installation of DSS (or earlier if needed to seal the cryostat)
    - Team of 2-3 people (2 TPC electronics + 1 JPO ?), 2 cryostat penetrations per shift (40 shifts total ?)
  - Install power supplies and ancillary electronics on detector mezzanine
    - Work happens on detector mezzanine, team of 2-3 people (all TPC electronics) (20 shifts total ?) to be done in parallel with installation of first end wall
  - Cable/fibre connections between cryostat penetrations and detector mezzanine
    - Work happens on top of cryostat, would like to complete first few rows in parallel with installation of first end wall

Personnel Requirements (ii)

- Phase 1
  - Not yet included in Bill's planning
  - Require access to top of cryostat, will design fixtures if needed (decide on fixture to lower crossing tube, fixture to position spool piece)
  - When do we install crossing tubes / spool pieces ?
    - If install blank flanges to seal cryostat (delay installation crossing tubes / spool pieces) will want tent (portable "clean room" to ensure dust doesn't flow into the cryostat)
    - If crossing tubes / spool pieces installed before cleaning the cryostat, do not need tent
  - False flooring on top of the cryostat, carts for transporting parts (both on top of the cryostat / mezzanine), DAQ + slow controls available at the time of cabling / fibre connections

Personnel Requirements (iii)

- Phase 2
  - Integration of TPC electronics and photon detectors on APAs
  - Fully described in Bill's spreadsheet, minus the recent decision that supports for CE boxes may be installed at SURF
  - TPC electronics consortium needs access to head tube of upper and lower APA (platforms preferred, not lifts/elevators)
  - TPC electronics consortium would like to have connections to the detector ground available ALSO outside the cryostat and inside the cold box
  - Need to understand whether APA frames should be grounded when moving the APA
  - TPC electronics consortium would like to have electrical connection between upper/lower APA prior to insertion in the cold box and while moving the APAs in place into the cryostat (first check the two APA are insulated from each other, then add electrical connection, remove it later)

TPC Electronics Activities (i)

1. Install Tees and Omega brackets (support for FEMBs / CE boxes) [not in original plan]
   - 2 h per APA pair, 2 teams of 2 people working in parallel on the upper/lower APA
2. Install FEMBs on upper and lower APA
   - 16 h per APA pair, 2 teams of 2 people working in parallel on the upper/lower APA
3. Install cable trays for upper and lower APAs, route cables through APA frames, connect cables to FEMBs, cable management
   - 24 h per APA pair, 2 teams of 2 people working in parallel on the upper/lower APA

TPC Electronics Activities (ii)

4. Test 40 FEMBs with portable system
   - 16 h per APA pair, 1 team of 2-3 people (reduce size relative to Bill's spreadsheet), working on top platform of APA assembly tower
5. Move APA pair to cold box and connect cables
   - 8 h per APA pair, team of 2 people from JPO + 2 people from TPC electronics
6. Perform warm check on APA pair
   - 16 h per APA pair, team of 2 people
   - This includes both tests on TPC electronics and photon detector
   - Bill indicates these as "Collaborators", most likely personnel from TPC electronics consortium though extra contributions are welcome

TPC Electronics Activities (iii)

7. Cool Down
   - Listed as 16 h with 2 collaborators overseeing
8. Cold test
   - 8 h per APA pair, team of 2 people
   - This includes tests of both TPC electronics and photon detector
   - Collaborators / TPC electronics
9. Warm Up
   - Same as 7.
10. Uncable / move out of cold box
   - 16 h per APA pair, team of 2 people from JPO + 2 people from TPC electronics

TPC Electronics Activities (iv)

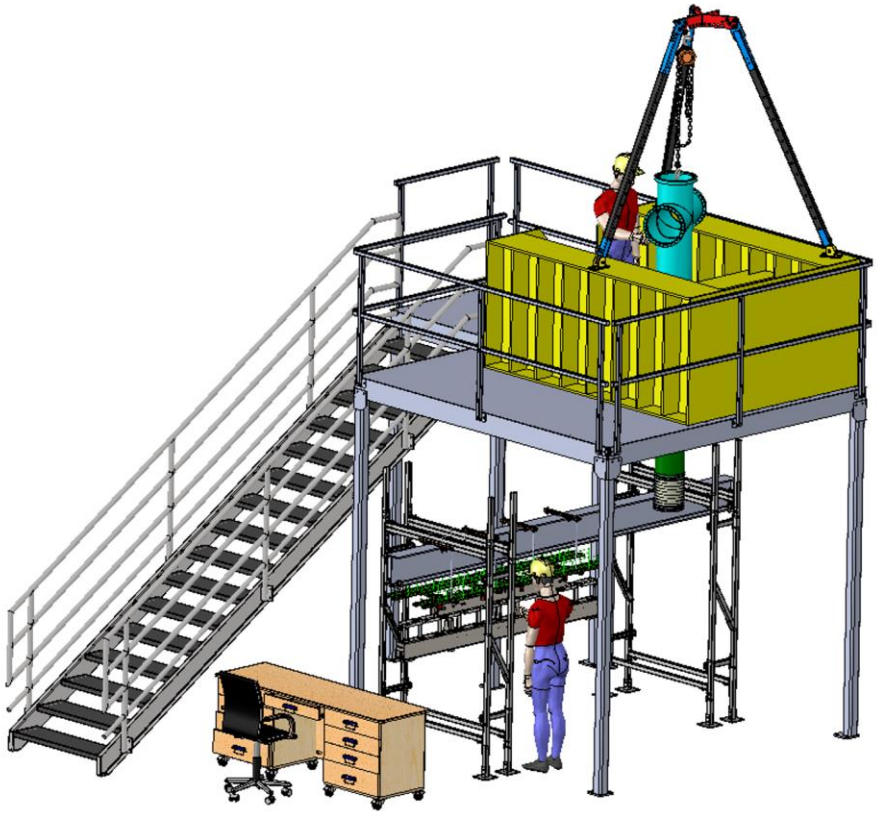
11. Route cables through cryostat penetrations and connect them to the CE and PDS flanges
    - 16 h per APA pair, team of 2 people from JPO + 2 people from TPC electronics (2+3 or 3+3), involves one team inside the cryostat, one outside the cryostat
12. DAQ test and seal flanges
    - 8 h per APA pair, team of 2 people from JPO + 2 people from TPC electronics (excessive ? 2 TPC electronics only, 1+2)
13. Final test after CPA deployment
    - 8 h per APA pair, team of 2 people from HV + 1 person from TPC electronics

Personnel Needs

- The requirements of the TPC consortium are higher than those of any other consortium
  - Work planned also for Fridays / Weekends
  - If we still maintain 40 h / week working maximum, need 30 FTEs to cover all shifts during installation activities
  - Original plan was 2 engineers + 2 technicians + scientific personnel
  - We could not get commitments from all the TPC consortium institutions for this
  - Changed to 2 engineers + 8 technicians + scientific personnel
  - Bill lists “Collaborators” for some testing activities
    - These still need to be done under supervision of TPC electronics consortium
    - Need to find mechanism to avoid last minute surprises
    - Prefer to have people commit to participation to integration and installation activities as members of the TPC electronics consortium

Quality Assurance

- QA of assembly process starts at BNL with small mockup, will continue at Ash River
- QA of the detector elements starts from the ASICs and FEMBs and continues with system integration tests
  - 7th ProtoDUNE APA and later DUNE prototype APAs at CERN
  - ICEBERG test stand at Fermilab
  - 40% APA prototype at BNL



Quality Control (i)

- FEMBs tested multiple times
  1. With standalone system after cable connection (allow for replacement of FEMBs that fail, check for connection)
  2. Warm test with DAQ readout chain after insertion in the cold box
  3. Full test at cold temperature inside the cold box using the DAQ readout chain
  4. Warm test with DAQ readout chain after insertion in final position in the cryostat

  - For tests 2-4 the TPC electronics consortium may also perform tests on behalf of PDS consortium
- After final test continue monitoring TPC electronics as more rows of APAs are installed / CPAs deployed
- Naturally continues with monitoring during LAr filling and commissioning

Quality Control (ii)

- Initial QC performed with portable system(s) on the platform at the top of the APA assembly tower
- All other QC steps are performed with final DAQ setup (use row 25 for tests in the cold box)

- Not yet understood:
  - Required QC on TPC electronics crossing tube / spool piece / flanges
  - He leak checking after installation is the last step
  - Pressure testing at vendor ? Leak testing of spool piece + flanges prior to shipment to SURF
  - Need guidance

Services

- Assembly tower / cold boxes (access to top of cold boxes for installation of TPC electronics chimneys)
- Early access to top of cryostat / detector mezzanine
- Availability of detector ground connections in the clean room outside the cryostat
- 110V power available in multiple places in the clean room, including top of APA assembly tower, 110V power for laptops on top of the cryostat (PDS mini-racks ?)
- Assembly tower should be insulated from cavern ground and connected instead to detector ground ?
- Connection points for ESD safe mats
  - Responsibility for ESD safety equipment ?
- Storage cabinets (1 on top of cryostat, 1 inside clean room, 1 outside clean room)
- Shelves on platforms on top of cryostat
- Carts in multiple locations

Other Comments (i)

- TPC electronics personnel work at height
  - Mostly on platforms, exceptions are
    - Connection of cables to the patch panel inside the cold box
    - Arranging of cables on the cable trays after extraction of the APA pair from the cold box
    - Routing of cables through the cryostat penetrations and final cable arrangement on the cable trays (work performed by JPO personnel, with 1 TPC electronics consortium member as spotter ?)
- ESD safety
  - Training of JPO personnel working on APAs (once the FEMBs are installed) ?

Other Comments (ii)

- Work on Fridays / weekends
  - Train some member of the TPC electronics consortium as SURF guides ?

Conclusions

- Would really like to see details in a Installation Planning Document
- Draft of interface document with facility provides more details
  - Try to finalize first draft soon (we're late relative to other consortia, but probably have more details)