

Electronics Grounding during Integration and Installation

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Outline

- I will discuss everything from the perspective of the TPC electronics
- Discuss starts with the APAs on the assembly tower, ends with the APA in their final position inside the cryostat
- There are some small changes suggested by Terri Shaw to the procedures used in ProtoDUNE
- This procedure has not yet been discussed with other members of the TPC electronics consortium (lack of time), and may be amended in the next few days
- Jim Stewart and Bill Miller will be provided with final procedure for inclusion in the installation documents in preparation

1) APA pair on the assembly tower

- After the connection between the upper and the lower APA is made a test is made to check that they are electrically insulated from each other
- Then a temporary electrical connection is established between the two (use a copper braid / wire)
 - We need an anchor point on the frame of both APAs for this, preferably with easy access
- A conductive braid is used to connect the upper APA to the support beam, which itself is connected to the cavern ground
- The assembly tower is also at cavern ground
- Personnel installing the FEMBs on the APAs will be using ESD protections that have dissipative connection to the assembly tower, i.e. to cavern ground
- During the cable installation we will be using caps (both for signal and power cables) on the side of the cables that would be connected to the CE flange

2) FEMB testing

- After the FEMBs are installed on the APA and the cables have been properly routed, connected to the FEMBs, and arranged on the cable trays we proceed to a first test of the FEMBs
- During this test the APA frame provides the reference ground for the TPC electronics (i.e. cavern ground)
- Power to the FEMBs is provided via a WIB (also used for the readout) that is attached to a floating power supply
- Only other connections on the WIB are optical (Ethernet link to a portable PC)
- The caps at one end of the cables are removed prior to testing and reinstalled after testing

3) Moving APAs in the cold box

- The beam supporting the APA pair inside the cold box is connected to detector ground
- The CE/PD flanges on the chimney of the cold box are connected to detector ground
- During the movement of the APA frame to the cold box the electrical connection between the two APA frames remains in place and the braid connecting the upper APA to the support beam is also in place
- When the APA is moved into the cold box there is a possibility of establishing a temporary short between detector and cavern ground
 - For ProtoDUNE the braid between the APA frame and the support beam (outside the cold box) was removed before inserting the APA into the cold box
 - Terri suggests keeping it in place until the APA is inside the cold box and removing it before detaching the section of the support beam that is used to connect the rails inside / outside the cold box

4) Cable connections

- Terri suggests to add a braid with a $O(10\text{ M}\Omega)$ resistor to connect the APA frame to the cold box support beam after the movable section of rail has been detached
 - If the APA is somehow charged up, this will provide a dissipative path
- At this point the power and signal cables can be connected to the patch panel inside the cold box (a second set of cables connects the patch panels to the CE flange)
 - Remove the caps at the end of signal and power cables
 - Plug into the patch panel
 - Disconnect the dissipative braid from the upper APA
 - Remove the electrical connection between upper and lower APA

5) Tests in the cold box

- At this point the APAs and the TPC electronics have the same configuration expected in the final position inside the cryostat, i.e. the reference voltage is the detector ground
 - Reference voltage on the FEMBs/APA through the return wires
 - Use floating power supplies from detector row 25, with same configuration of shielding as in ProtoDUNE
- Perform all the tests
 - Do we need to have the PTCs disconnected from their power supplies while installing the APA pair inside the cold box ?

6) Taking APAs out of the cold box

- Repeat the steps at point 4) in the reverse order
 - Reestablish the electrical connection between the upper and lower APA
 - Reestablish the connection between the upper APA and the support rail inside the cold box using the dissipative braid
 - Remove the TPC electronics cables from the patch panel and reinstall the caps at the end of signal and power cables
 - Put again in place the removable section of rail
 - Disconnect the dissipative braid
 - Move the APA out of the cold box
 - Connect first the dissipative braid and then (after a short wait time) a normal conducting braid between the upper APA and the support beam
 - The APAs are again referenced to the cavern ground

7) Moving the APAs into the cryostat

- Use a procedure similar to that discussed at points 3) and 4)
 - The open end of cables is still protected by caps
 - The two APAs are shorted together and electrically connected to the support beam (at cavern ground) by an conductive braid
 - When the APA moves through a removable (?) beam section into the cryostat there is a possibility of creating a short between cavern and detector ground
 - Once the APA is inside the cryostat, disconnect the conductive braid from the external support beam (cavern ground)
 - Connect the dissipative braid to the support beam inside the cryostat (detector ground) and then install a conductive braid that is connected to the support beam
 - Repeat the procedure when jumping from one beam to another if there is any risk that the two beams are at different reference voltages.

8) APA in their final position

- The APA remains connected to the trolley until all the cabling is completed
 - Keep conductive braid between upper APA and detector support beams in place
 - Route cables through the cryostat penetrations (with the caps still in place)
 - Remove the caps and connect the cables on the CE flange
 - At this point remove the electrical connection between the upper and lower APA
 - Remove the conductive braid between the APA and the support beam and replace it with a dissipative braid
- Remove the trolley and then the dissipative braid
 - At this point the upper APA should be insulated from the support beam

Questions / Comments ?

- Any mistakes / misunderstandings are my fault
- I almost forgot about this presentation and had little time for discussion with Terri and Matt