**Design Review:**

**DUNE Single Phase Anode Plane Assembly**

**13–14 July 2016**

**Charge**

The Committee is requested to review the DUNE anode plan assembly (APA) technical design and determine if it is at a state commensurate with that needed for producing the six units planned for the NP04 ProtoDUNE prototype detector operation at the CERN Neutrino Platform in 2018.

In particular, the review team is asked to address the following questions:

1. Does the APA design meet the requirements? Are the requirements/justifications sufficiently complete and clear? Yes, in most cases. However, it is unclear if the APA frame and the wires meet the absolute positioning requirements and how these map to the detector physics performance.
2. Are APA risks captured and is there a plan for managing and mitigating these risks? Yes, but there are some issues. It is not possible to mitigate the current risks using schedule contingency because the schedule has no float and therefore de-scoping of some parts of the program is the only viable option in case of major unexpected problems. Risks are not fully incorporated within risk register for ProtoDUNE but this task is in progress. Likelihood/impact and cost of mitigation of risks should be added to fully qualify and quantify the risk strategy. Health and safety risk assessment documentation needs to be in place for all processes including
   * winding machine
   * adhesives
   * lifting equipment
   * soldering
   * working at height
   * material cleaning processes
   * packing
   * ODH system
   * cryogenics handling
3. Does the design lead to a reasonable production schedule, including QA, transport, installation and commissioning? Yes, but more detail is needed in some areas. In particular, QA and transport need additional development.
4. Does the documentation of the APA technical design provide sufficiently comprehensive analysis and justification for the APA design adopted? Yes, the state of the documentation is sufficient for the current point in time. However, within a very short time frame (~months) additional documentation will be required. The APA design has been justified just for few load cases. We acknowledge that the safety factors are rather big, but several load cases are missing (e.g. cool down and transport). Also the global stiffness of the field cage and the cryostat itself should be introduced in the FEA calculations to check the impact on stresses in the various structural elements and in the wires. It is advisable to embed an installation review into the forthcoming detector support structure review as a follow up to this review.
5. Are all APA interfaces to other detector components and cryostat documented, clearly identified and complete?Doesthe TPC integrated 3D model adequately represents the mechanical interfaces to the APAs and between adjacent APAs? No. The Interface documents do not describe the interfaces in enough detail. Final interface documents should specify connection details such as pin size, pitch (CR board to CE), threaded hole-size and pattern, and forces or movements expected (CE board to APA top beam). The interface document between the field cage and the APA’s does not describe attachment features or loads. It does appear that the 3D model is in good shape and accurately models the mechanical interfaces within the TPC.
6. Are the APA 3D model, top-level assembly drawings, detail/part drawings and the material and process specifications sufficiently complete to demonstrate that the design can be constructed and installed? Yes, but it is noted that the drawing set is not yet complete and some changes to the top head tube are still in progress. Draft procedures for assembly exist and are very detailed.
7. Does the design provide adequate signal response characteristics? Is it optimized for the proposed electronics? Is the grounding and shielding of the APA understood and adequate? Yes. The signal formation and its noise immunity characteristics appear to be well understood. The values of the HV bias filter components have been well thought out. The basic principles for what is required by the front-end electronics are known and confirmed via experience with similar configurations used in MicroBooNe and in the 35-ton detector. However, some of the design details for ProtoDUNE still need to be finalized. These include implementation of the HV bias wire and cable connections from the feed-through to the various wire bias filter boards and their distribution as these voltages get connected to the wire bias filter boards. Significant work has been done on understanding the grounding and shielding plan but the complete system design is not yet in place. The need for implementing optimum grounding and shielding connections is clearly understood. APA-to-APA isolation is implemented within the frame design and appears to be adequate. Most grounding connections, and their function, are understood. However, some of the implementation details need to be finalized within the designs of the relevant PC boards. We recommend that this item be followed up on by the DUNE Grounding and Shielding Committee once all of the final designs are in place.
8. Are operation conditions (loads and temperature) listed, understood, and comprehensive? Yes, steady state loads are understood with the exception of loads imparted by the field cage and ground plane. However, the full FEA calculation has not been performed for some operating conditions such as the cool-down phase and for the filled cryostat.
9. Are the APA engineering analyses sufficiently comprehensive for safe handling, installation and operation at the CERN Neutrino Platform? Not yet. We got the impression that the APA handling and installation plan was still evolving. Handling fixtures need to be designed per CERN requirements. A complete set of load cases during installation also need to be completed. Interaction with CERN is mandatory at this stage to clarify the information needed for the acceptance of the parts by CERN. The analysis of the APA structure behavior during transportation on the clean/ cryostat rails should be checked. As above, we expect that the installation plan will be more thoroughly reviewed in the upcoming detector support system review.
10. Does the APA quality assurance plan include applicable and sufficient features of internationally recognized quality programs? Have applicable lessons-learned from previous LArTPC devices been documented and implemented into the QA plan? Does the plan appropriately account for APA production at multiple international sites with different standards (metric/imperial) for available stock materials? Yes, QA and Testing plan was presented and took into account previous LArTPC experiences. The one caveat is that planning for the UK effort is just getting underway. One might expect issues with European versus US standards and with the procurement of certain material. The procurement of material in US could be an option.
11. Are the APA quality control test plans and inspection regimes sufficiently comprehensive to assure efficient commissioning and safe and operation of the NP04 experiment? Does the QC plan appropriately account for APA production at multiple international sites? Yes, but there is risk associated with the fact that the first integrated test of an APA with CE occurs just prior to installation at CERN. We are not able to comment on the QC plan for the international site as this activity has only been recently approved and planning is just getting underway. Some specific recommendations have been made for further improving the current QA plan.

The committee should present its findings, comments, and recommendations in a closeout meeting with DUNE management on July 14. The committee should provide a final written report by July 22.