DUNE Single Phase Detector APA: Electrical Systems

(Preliminary Design Review)
November 18-19, 2019

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1 Executive Summary

This document is the report of the Preliminary Design Review (60% design maturity) of the electrical design for the DUNE single phase detector Anode Plane Assembly (APA). The review was held at the Physical Sciences Laboratory (PSL) on November 18-19, 2019 to evaluate the preliminary design of the electrical systems for the DUNE single phase detector APA.

The committee would like to commend the team for putting together a comprehensive overview of the APA electrical design and for responding to all the review committees questions promptly. The committee found the documentation and presentations useful in evaluating the maturity of the design. The committee believes the current design does meet the standard for a 60% maturity. In order for the electrical design to proceed to the 90% review, the committee has identified a number of recommendations which should be addressed. Many of these recommendations relate specifically to the printed circuit board (PCB) manufacturing, tolerances, and necessary QC in order to ensure uniformity in the APA production and the ability to find commercial partners which can make these boards.

The report address the specific charge questions with **findings** (statements of facts that summarize noteworthy information presented in the review), **comments** (judgement statements about the facts which should be evaluated by the project team and action taken where appropriate), and **recommendations** (actions that should be addressed by the project team). The answers the committee reached for each of the charge questions can be found at the end of this document

2 APA Electrical Design

2.1 Findings

- The system overview and grounding scheme presented, showed the nominal plan for the power distribution to the various wire plane boards and the grounding via paths through the various adapter boards and to the cold electronics enclosures to ensure that a robust grounding scheme is followed.
- For production, a significant amount of the APA wire assembly, PC board assembly and soldering, was described as being done in-house and by hand. There was not a clear path described that would enable much of this work to be automated or done using machines (CNC or similar).
- An overview of the placement and wiring of the various geometry boards was given showing the wrapped wire scheme. Each APA has 204 boards with 29 different types of boards per APA to accommodate the various wire routing needs of the APA.

- The manufactured board thicknesses and milling depths must be tightly controlled in order to meet the required specifications for wire plane spacing and planarity. In protoDUNE, a number of boards (all of the X-headboards) had to be machined after initial production by the company to meet the desired thickness tolerances. This extra machining requires extra cleaning and added a marginal amount of extra cost.
- An overview of the wire segment to channel mapping was provided, allowing a one-to-many mapping of electronic channel mapping and to indicate the various places tension measurements are made on the APA.
- An overview of the geometry board designs was given outlining the mechanical tolerances achieved in protoDUNE. The guidelines for the electrical standards targeted, as laid out by the Institute for Printed Circuits (IPC), is based on many years of failure analysis.
- Most of the current board designs meet IPC standards for their long term nominal operating voltages that will be used in DUNE. The boards, however, do not meet the IPC standards for the short-term voltages they will encounter during the electronic wire tension testing. An appropriate engineering review of each of these designs has not been performed at this time. Many of the board designs are considered to be almost final or final. It is estimated that a few weeks are necessary to update the designs in cases where additional revisions are deemed necessary.
- A presentation on the protoDUNE and DUNE wire mapping was given showing how the mapping of the cold electronic channel number to the adapter board, CR board, solder pad, and ultimately to the specific headboard is accomplished. This information was/is stored in a large spreadsheet and maps to the various board schematics shown.
- A brief overview of the various electrical interfaces between the APA, cold electronics, and field cage was given. The schematic used was noted as being outdated and will be corrected/updated in the documentation.
- The CR board (which provide the bias to the X and U planes) design and manufacturing process was presented with the soldering and assembly process that is intended to be used for DUNE. The CNC machine that is envisioned to help automate the insertion of the MillMax pins is still being designed.
- The G-Bias and adapter boards' design was presented, giving an overview of how the electrical contacts are made using the 55 spring loaded Mill-Max contact pins. For protoDUNE, the pins were hand-soldered but it is believed this could be done using a reflow solder process. This board has not been prototyped yet and is still in the design phase.
- The G-layer cover boards on the headtube are made from insulating material. These boards are mounted inside the field cage and are facing the cathode plane.

- A presentation of the soldering procedure and quality assurances utilized for protoDUNE was given, highlighting the focus on maintaining the IPC standards and improving the access to the work space as well as minimizing the impact on the workers (fatigue and safety).
- An overview of the component selection and qualification was given including the ceramic capacitors, thick film resistors, bias connectors and the Mill-Max receptacles. Small samples of each component were tested, both warm and cold (liquid nitrogen), and passed all the required leakage current and nominal value variances. Larger samples for testing are planned as the design proceeds.
- The bias wire harness design and its construction were presented. The bias wire harness brings the voltages to the CR and G-Bias boards which come from the SHV receptacles. This design includes a looped daisy-chain architecture for redundancy to mitigate single point failure. The HV bias wire harness was described in detail for the top section of the dual APA assembly. However, the bias wire harness and its corresponding routing, dress, and restraint that will be used for the bottom APA assembly was not discussed.
- A plan for APA production testing, including continuity and low-impedance isolation tests, was presented to enable the testing for multiple channels (~4 - 12 channels) at a time. If a problem is identified, then individual channels can be probed. The test boards to be used for these tests are still to be designed (but the footprint for such tests on the X & G planes already exists in the design).
- The plan and challenges for procurement of the printed circuit boards and components was highlighted in a presentation. The fact that the quantities of boards to be ordered are small by industry standards but have tight tolerances proves to be especially challenging. For the components, the fact that the individual components may be discontinued at any time (with no prior notice) can make individual items a high risk (the capacitor currently envisioned for use being the example given). Pre-buying components can help mitigate this risk, but doesn't necessarily completely alleviate this problem.
- The documentation for all of the printed circuit boards (29 different geometry boards, the CR boards, the adapter card, and the G-layer bias card) is complete and available in EDMS. For each board, the documentation includes schematics, Gerber files, and bill of materials, as well as fabrication and assembly instructions. The only exception is the SHV board, which is being redesigned following the decision to either remove the electron diverters or to have only passive electron diverters, and following the decision of using a different connection scheme for the field cage termination electrodes.
- The requirements for the fabrication of many of the printed circuit boards exceed the standard fabrication procedures set by the IPC standards. As a consequence, vendors are not set up to meet the requirements set forth by the DUNE project, resulting in the need for additional work on the boards, which for ProtoDUNE, was mostly performed at PSL.

Meeting the tight requirements put forward by DUNE could result in low yield for the fabrication and for cost increases. The main issues in this regard are the control of the total thickness of the boards, controlled depth milling, and the size of the holes for the Milli-Max pins.

- Not all the interface documents between the APA consortium and other consortia have been finalized. In particular the description of the electrical interfaces between the APA and TPC electronics, and APA and high voltage consortia are both at a very preliminary stage due to a design change on the part of the HVS. The same is also true for some of the documentation for interfaces between the different areas of the APAs.
- Most of the assembly of the CR boards, adapter cards, and G-layer filter boards for ProtoDUNE was performed at PSL. Optimized procedures for the soldering of components on the boards have been developed.
- The CE-CR adapter board was revised according to the EDMS, at least the silkscreen layers (both top and bottom) were updated, though PSL declared it is unchanged from ProtoDUNE. There are modifications to the mounting features of these boards based on ProtoDUNE experience.

2.2 Comments

- In the current protoDUNE design the option of grounding the G-Bias board directly to the head tube was present. A final decision as to whether or not this option will be maintained should be made and the design for this finalized.
- All drawings used to lay out the electrical bias and grounding schematic should be updated to reflect the actual DUNE APA design (no active electron diverters, different connection scheme for the field cage termination electrodes, etc.). The appropriate grounding symbols, cable lengths, and nominal operating voltages should also be updated. These drawings should use consistent symbols to indicate connections to the reference voltage on the front-end motherboards. The connections between the APA frame and the Cold Electronics box, and between the Cold Electronics box and the reference voltage on the front-end motherboards should also be properly indicated.
- The committee strongly urges the production team to find a solution to the problem with the board tolerances so that they do not require machining of boards once they arrive from the manufacturing company.
- Additional failure mode testing of the geometry boards should be completed to ensure they can safely withstand both the wire tension testing voltages and the operating voltages with a sufficient safety margin to allow for the possibility that they will have to be operated at higher than nominal voltage for long periods to ensure 100% electron transparency.

- The need for increasing the size of the traces was not clear as there is no evidence from protoDUNE that the smaller trace size led to any problems. A return to smaller trace sizes may allow the boards to meet IPC standards, with respect to trace separation, during all phases of testing and operation and should be explored before the board designs are finalized.
- The mapping done of the cold electronic channels to the various aspects of the boards was characterized as “traceable but not well organized” and as a result, does not appear to have been used yet by protoDUNE to aid in the diagnosis of any unusual behavior. The useability of this data to help diagnose any problems is very important and the scale required at DUNE makes the current “spreadsheet” solution untenable. This is complicated by the fact that the APA consortium on one side and the TPC electronics consortium (and the offline) have used, in ProtoDUNE, the opposite convention for the numbering of front-end motherboards and wires.
- Electrical interface documents between the APA and the Cold Electronics and Field Cage need to be updated. It was noted that good communication between the various consortium has been used to mitigate possible interferences between these interfaces. While the committee commends this use of the collaboration, the documentation should still be produced.
- There is a need to explore the “upside down” version of the adapter board which will be used on the “bottom” APA to ensure that the L-bracket configuration will work in this orientation.
- The procedure documentation for the CR boards currently exists inside the DUNE docDB and should be updated and migrated to EDMS.
- The selection of the APA’s passive electrictronic components, mainly the resistors and capacitors, is made. The procurement of these components, in sufficient quantities for production, may be a risk. There was mention of “pre-buyng” in bulk. However, when buying components from different manufacturers, even with the same part numbers, these components may exhibit subtle differences. It would be important to sample test these components, procured from the various manufacturers, to ensure there are no significant differences.
- The defined range of allowed wire bias voltages relative to the nominal has not been given and thus it is unknown what possible values the wire bias could be placed at and still adhere to the safety factors. These values should be defined (e.g. +/- 10%? , +/- 20% of the nominal per plane) and failure tests should be performed.
- Concern over the spring loaded Mill-Max pins was expressed by the committee and the need for testing and prototyping should be given a good deal of importance.
- The outer insulating surfaces of the G-layer cover boards will charge up as they intercept the incoming electrons, and cause drift field distortions. The impact of these field

distortions should be analysed by the reconstruction group to see if mitigation measures need to be implemented.

- The procedure for the soldering practices should be written up into a technical document and uploaded in EDMS and include details such as the typical wait time between soldering and cutting the wire as well as the number of people performing the various tasks.
- The CE chassis' interface to the APA CR board is clearly defined and follows that used for ProtoDUNE. At present, the mechanical design does allow the electrical connections to be made. However, the mechanical means by which the adaptor board is secured to the CR board is not finalized. The risk here is that if any change in the design, made on either side of this interface, will directly affect the electrical connections and any change must be clearly vetted by the working groups involved.
- The mounting of the CE chassis and its input connections were not described during this review. It is thus assumed that the mounting of the chassis to the T-bracket, the restraint and dress of the input cable harness, and any isolation mounts were covered during the design review of the CE chassis.
- The HV bias connector choice, as described, is not finalized. The main deficiency in using this connector is that it is not a secure connection, meaning that it can be inadvertently pulled out/disconnected. This is a risk to the APA frame's reliability and can be a safety issue during testing.
- The APA's inherent design means that there are many high voltage components available to the touch (pads, wires, capacitors, etc.). For safe operation, especially during testing, assembly and checkout, additional procedural precautions need to be incorporated and documented. With the HV utilization on the APA, all nonelectrical metal components, exposed to touch, is described or implied as being grounded at some point. This is a safety requirement and any floating or electrically isolated metal components, by design, will need to be closely examined.
- The current connector for the bias voltage, as described, uses a knife edge to grab the thin stranded wires. These connectors are typically used for solid wire connectors and concern was expressed on the robustness of this type of connector. Using a machine crimper to add ferrules to the wires could make the connection more robust and should be considered.
- The testing procedure for the wire harness needs to be developed and should be documented.
- The documentation is hard to navigate. The task of the reviewers would be easier if an EDMS document was made available to help the navigation, including a list of the boards that clearly indicate their status (final, ready for the final design review, in progress, ...), as well as instructions indicating what is the content of each file. The APA consortium

should also make use of all the features of EDMS and make new versions of a document, when appropriate, declaring previous versions obsolete, rather than storing multiple versions of the drawings of a single component under the same EDMS identifier.

- It is unclear from the documentation whether ENIG plating is planned for all the boards. In some of the "Fabrication.pdf" files it is indicated that "Immersion Silver Plating over copper" will be used. The APA consortium should check the documentation for errors / consistency and update it when appropriate.
- The committee did not perform a full review of the Gerber files and of the fabrication and assembly instruction. Such reviews should be performed prior to the final design review. The APA consortium should not wait until a few weeks prior to the final design review to ask for such reviews. When components are thought to be ready for the final design review the APA consortium should ask Terri Shaw to perform or commission such a full engineering analysis of the design.
- Vendors may not be able to meet the tight specifications placed on the boards' thickness. These specifications should be reviewed in light of the capabilities of the manufacturers, of the total cost of the boards, and of the physics requirements. In turn, these specifications may also influence the requirements on the maximum voltage that can be applied on the boards, and therefore have consequences on the board design.
- It is unclear to the committee that the IPC standards can be respected for every design in case the bias voltages are increased from their nominal voltages. This could also be true for some of the wire tension measurements where the difference in voltage between two nearby traces can be larger than the voltage applied during normal operations. The critical points for the IPC standards are the traces in the side boards close to holes in the printed circuit boards as well as the area between the two rows of the decoupling capacitors for the collection wires. In both cases there is not much room for increasing the separation between traces / pads. In cases where the IPC standards cannot be met if the voltage required for operating the APAs exceeds the current design values, tests of the boards should be performed to identify the maximum bias voltage that can be applied without damaging the boards.
- For ProtoDUNE a final step of machining was performed by PSL. The production procedures should be set up in such a way that this final step of machining is not necessary. The committee is not convinced that additional grinding of the back of the boards can be performed without damaging the plating of through holes.
- Prior to the final design review all the electrical interface documents, both those between the APA consortium and other consortia, and those between different parts of the APAs, need to be fully developed and stored in EDMS. Despite the unavailability of these documents, the committee thinks that there are not significant risks that some of these interfaces could change, and thus necessitate a redesign of some of the other APA

components, given the good communication on these topics that exist between the various consortia.

- The number of boards that need to be fabricated and then assembled for ProtoDUNE is such that it would be very beneficial to the project to transfer almost all operations to external vendors. The expertise gained with the in-house board assembly for ProtoDUNE should be transferred to external vendors to ensure high yields during the fabrication process.
- The connections between the front-end motherboards and the adapter card, and between the latter and the CR boards are seen as very critical, since improper connections can result in damage to the connectors or boards, and / or to the loss of readout channels. The use of pins to guide the insertion of the boards should be investigated. The mechanical stability of the connection between the adapter card and the CR boards should be investigated including a proper study of what happens for the lower APA.
- In some cases, more than two versions of the printed circuit board drawings are stored in the same EDMS version of the document, with a naming convention that was not explained to the reviewers. In such cases, the reviewers had difficulties understanding which drawing should be reviewed.
- The APA production team should ensure that all ES&H standards regarding the solder and epoxy are being followed. Various documents suggesting the necessary ventilation and manufacturing PPE can be found here and here
- The committee suggests to add mated shorting board(s) for the connectors (SSW-136-23-G-D-RA) on the CR board before it is installed on the APA. The shorting board should be kept installed all the time before the CE box is installed. The shorting boards can be temporarily removed for testing purposes. SHV connectors on the SHV board is recommended to be shorted (connected to a ground potential to mitigate the possibility of electro-static discharge) as well.

2.3 Recommendations

- The tolerances (thickness and hole milling) for the existing design need to be clearly defined (as motivated by the physics requirements). A comparison of these requirements to the available manufacturing capabilities such that sourcing of a company for manufacturing can be made urgently and done at a production scale without custom modifications being done should be followed
- The APA consortium should report regularly to DUNE Technical Coordination on the progress and preparation for production of the APA boards. Depending on the progress, the APA consortium should work with the DUNE-US management to ensure that a

sufficient number of boards are available both in the UK and in the US to assemble the APAs required for the 2nd run of ProtoDUNE (for example by fabricating more boards in the US).

- Development of a production database to help track boards from production to final installation which include the ability for an end user to map the location and associated boards, connectors, and routing paths should be done. The APA and TPC electronics consortia should work together with the offline group to develop an official mapping of the readout channels such that it is possible to quickly trace back issues observed in data to the tests of the boards performed at PSL (in addition to being able to investigate problems once the ProtoDUNE APAs are extracted from the cryostat).
- Procedures for testing and manufacturing need to be made into technical documents which can be used by both the US and UK APA collaborators to ensure a uniform quality control.
- Involvement with the physics groups should be expanded in order to understand if larger tolerances in the geometry boards, with respect to the 0.5 mm wire plane spacing tolerance, can be made while maintaining electron transparency between the wire planes. This would ease in the identification of companies which can meet the board manufacturing limitations/requirements.
- Mitigation of the possibility to confuse the wire bias cables needs to be done in order to remove the possibility that the wrong bias is applied. This can be done with unique connectors or different and unambiguous wire color schemes and needs to be explored. If a locking mechanism does not exist on the selected connectors then we recommend one should be chosen as well as implement a wire strain-relief feature for the wires and connectors.

3 Answers to Charge Questions

1. Have electrical design choices been fully identified and do they meet detector requirements?

   No. At the current state of the design not all electrical design choices have been fully identified and made to reach the detector requirements. Examples include the design of the G-Bias boards, the choices of trace placement and electrical requirements, and the details of all the interfaces with other systems. For the design choices made thus far, the detector requirements for grounding and isolation, wire plane planarity and spacing, and the nominal voltages are being considered. However, not all needed safety margins for operations have been clearly defined to finalize the design. Additional clarity from the project is needed in order to determine if the IPC standards have to be strictly adhered to or used as guidance.

2. Are the specifications and drawings for standard and custom components substantially complete and available in EDMS? Are they of sufficient maturity to proceed to final design?

   Yes, in part. Specifications and drawings, including schematics and Gerber files, as well as fabrication and assembly instructions are available in EDMS for the 29 geometry boards, for the CR board, the adapter card, and the G-layer filter board. Some of these designs require updates. The documentation is not yet available for the SHV board that is currently being redesigned following the decision to not have active diverters and to separate the connections for the field cage termination electrodes. Work is ongoing to finalize the design of all the components, making changes to the design of some of the boards, when needed. In order to finalize the design, the requirements for the maximum operating voltage and for the board thickness need to be agreed upon with the physics group. These requirements need to be compatible with the capabilities of manufacturers. Prior to declaring a design final an engineering review should be completed to ensure that either all IPC standards have been met or that tests have been performed indicating that the risk of breakdown on the boards are negligible.

3. Have interfaces with other detector components been addressed and documented? Do risks of design changes in other systems have appropriate mitigation strategies?

   Only partially. Interface documents are well developed for the mechanical aspects, but require more work for the electrical aspects, particularly for the interface between the APA and the TPC electronics, and the interface between APA and HV. While this has not lead to any problems, due to the good communication between the two consortia, interface documents should be finalized as soon as possible and posted in EDMS for review. Decisions regarding the connector part numbers between the CE box, the adaptor PC board, and the CR PC board must be agreed upon between the working groups within the consortia.

4. Are engineering analyses sufficient to ensure the design is safe during all phases, and have applicable design codes and standards been satisfied?

   Yes. So far IPC rules have been used in the design of the boards. All the IPC criteria are respected by the current design under the assumption that the maximum voltage seen by the traces corresponds to the design value for the bias voltages. It is not clear that the IPC rules continue to be respected if the bias voltages need to be increased even by small amounts (~10%) or during the electronic measurements of the wire tension. The APA consortium should define as soon as possible the maximum operating voltage for the traces and perform tests of the boards under these operating conditions in cases where the IPC rules cannot be met. More analysis is required for the spring loaded connectors between the CR board and the G-layer filter board. These connections should be tested before and after thermal

cycles to LN2 temperature. The tolerances on the holes for the Mill-Max pins and for the machining of the back side of boards should be added to the specification documents.

We note that the procedure to attach the wires to the electronics boards utilizes tin-lead solder and 3M 2216 grey epoxy. Air flow is provided by area fans. PPE consists of wearing gloves. The local ES&H officer should be consulted using the SDS for both materials and the needed safety requirements should be reviewed.

5. Does the design allow for practical manufacturing, procurement and QC plans?

   No, in part. Most of the PC board manufacturing requires very specific and tight constraints not normally followed by most PC board manufacturers. In addition, a significant amount of APA assembly requires specialized procedures not easily automated. The plan for selection of a PC board manufacturer(s) was not clearly defined at this time.

   Lots of good ideas but few procedures were presented. Board thickness and hole tolerances are a worry. The capacitor being single source will provide a problem and needs a remediation strategy.

6. Are quality assurance and testing plans sufficiently developed to proceed to final design?

   Yes. A detailed procedure and testing is being utilized to ensure the necessary quality assurance is maintained, but the documentation for these tests and procedures needs to still be formalized. This will be especially important for the UK members of the APA consortium as their production begins to ramp up.

7. Have lessons learned from ProtoDUNE been implemented?

   Yes, the lessons learned from protoDUNE are present in the design and were presented in the follow-up session on the second day. The generation of a document highlighting these electrical lessons learned should be produced.

8. Are plans for additional prototyping reasonable and sufficient?

   Yes. As presented, there were plans that were followed for prototyping of the various PC boards and versions of those boards. Preproduction of these boards was discussed.

9. Are sufficient technical resources available to complete the design?

   Yes. All the remaining design and prototyping work can be done at PSL with resources that are available to the DUNE project. The leadership of the APA

consortium thinks that bringing in additional engineering resources in the project at this point could have a detrimental effect. Given the number of boards to be fabricated, an engineer with the appropriate expertise to manage the procurement of all the printed circuit boards and their assembly should be added to the project, ideally before the finalization of the design. Physicists from institutions planning to participate in the QC testing during the production should start contributing to the project by reviewing and improving the documentation.

Preparations for the production in the UK are starting. Their progress should be monitored carefully to ensure that boards for the APA assembly in the UK are available on the timescale required for the installation of APAs for the second run of ProtoDUNE.

10. Are system grounding details documented and in EDMS? Are electrical connections specified and do schematics exists in EDMS? Are all wires, cables and connections documented?

    No. The grounding details and electrical connections are not documented in EDMS. The entire range of wires, cables and connectors are not documented in EDMS. The electrical connections, grounding, wires and cables were presented but without supporting documentation.

4 Summary of Recommendations

- The tolerances (thickness and hole milling) for the existing design need to be clearly defined (as motivated by the physics requirements). A comparison of these requirements to the available manufacturing capabilities such that sourcing of a company for manufacturing can be made urgently and done at a production scale without custom modifications being done should be followed
- The APA consortium should report regularly to DUNE Technical Coordination on the progress and preparation for production of the APA boards. Depending on the progress, the APA consortium should work with the DUNE-US management to ensure that a sufficient number of boards are available both in the UK and in the US to assemble the APAs required for the 2nd run of ProtoDUNE (for example by fabricating more boards in the US).
- Development of a production database to help track boards from production to final installation which include the ability for an end user to map the location and associated

boards, connectors, and routing paths should be done. The APA and TPC electronics consortia should work together with the offline group to develop an official mapping of the readout channels such that it is possible to quickly trace back issues observed in data to the tests of the boards performed at PSL (in addition to being able to investigate problems once the ProtoDUNE APAs are extracted from the cryostat).

- Procedures for testing and manufacturing need to be made into technical documents which can be used by both the US and UK APA collaborators to ensure a uniform quality control.
- Involvement with the physics groups should be expanded in order to understand if larger tolerances in the geometry boards, with respect to the 0.5 mm wire plane spacing tolerance, can be made while maintaining electron transparency between the wire planes. This would ease in the identification of companies which can meet the board manufacturing limitations/requirements.
- Mitigation of the possibility to confuse the wire bias cables needs to be done in order to remove the possibility that the wrong bias is applied. This can be done with unique connectors or different and unambiguous wire color schemes and needs to be explored. If a locking mechanism does not exist on the selected connectors then we recommend one should be chosen as well as implement a wire strain-relief feature for the wires and connectors.

5 Appendices

5.1 Review Website and Agenda

Website: https://indico.fnal.gov/event/21913/overview

Agenda:

Monday, 18 November 2019

08:30 - 08:55	Executive Session *25'* Speakers: Dr. Jonathan Asaadi (University of Texas Arlington), Dr. Sam Zeller (FNAL) Material: Slides
08:55 - 09:00	Welcome *5'* Speaker: Mr. Bob Paulos (University of Wisconsin)
09:00 - 09:20	System overview and grounding *20'* Speaker: Andrew Laundrie (UW Physical Sciences Lab) Material: Slides
09:20 - 09:40	Geometry Board Overview *20'* Speaker: Lee Greenler (University of Wisconsin - Madison) Material: Slides
09:40 - 10:00	Geometry Board Design *20'* Speaker: Andrew Laundrie (UW Physical Sciences Lab) Material: Slides
10:00 - 10:20	Signal and Grounding *20'* Speaker: Andrew Laundrie (UW Physical Sciences Lab) Material: Slides
10:20 - 10:40	coffee break
10:40 - 11:00	Interfaces *20'* Speaker: Andrew Laundrie (UW Physical Sciences Lab) Material: Slides
11:00 - 11:40	CR Boards *40'* Speaker: Andrew Laundrie (UW Physical Sciences Lab) Material: Slides
11:40 - 12:00	G-layer and adaptor boards *20'* Speaker: Andrew Laundrie (UW Physical Sciences Lab) Material: Slides
12:00 - 12:40	lunch
12:40 - 13:00	Soldering and QA *20'* Speaker: Andrew Laundrie (UW Physical Sciences Lab) Material: Slides
13:00 - 13:20	Component Qualification *20'* Speaker: Andrew Laundrie (UW Physical Sciences Lab) Material: Slides
13:20 - 13:40	Bias wire harness *20'* Speaker: Andrew Laundrie (UW Physical Sciences Lab) Material: Slides
13:40 - 14:00	coffee break
14:00 - 14:20	Plans for manufacture, procurement and QC *20'* Material: Slides
14:20 - 15:00	Tests and QC *40'* Speaker: Andrew Laundrie (UW Physical Sciences Lab) Material: Slides
15:00 - 16:30	Executive Session/Writing *1h30'* Speakers: Dr. Jonathan Asaadi (University of Texas Arlington), Dr. Sam Zeller (FNAL)
16:30 - 17:00	Closeout *30'* Speaker: Dr. Jonathan Asaadi (University of Texas Arlington)
18:30 - 20:30	dinner (on your own) (TBD)

Tuesday, 19 November 2019

08:30 - 09:00	Executive Session (if needed) *30'* Speaker: Dr. Jonathan Asaadi (University of Texas Arlington)
09:00 - 10:00	Answers to questions *1h0'* Speakers: Mr. Bob Paulos (University of Wisconsin), Christos Touramanis, Dr. Alberto Marchionni (Fermilab) Material: Slides

<u>Homework which was given for the second day</u>

List of boards and highlight the ones that are finalized, and if not finalized what stage of completeness are they in (design process, preproduction, etc)

Presentation from the UK on their preparations for production

Do any of the boards need additional probe points for testing?

Outline the testing of the Mil-Max spring connectors and what will be measured to ensure good contact warm and cold?

Please provide a succinct summary of the electrical lessons learned from protoDUNE which accompanies the document in EDMS

Provide plans and schedule for prototyping and testing of the geometry, SHV, and CR boards

Provide a couple of slides which outline the total cost of the boards relative to the overall cost of the project.

Provide an overview of the timeline which highlights the period from preliminary design to beginning production.

5.2 Committee Members

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5.3 Charge

DUNE Preliminary Design Review (PDR)

Single Phase Detector Anode Plane Assembly Electrical Systems

November 18-19, 2019

The committee is requested to review the DUNE anode panel assembly (APA) electrical design and determine if it meets the requirements of the preliminary electrical design as outlined in the

DUNE Far Detector Design Review Plan (DocDB-9564). As reference, the final design review report for ProtoDUNE- SP APA is available in DocDB-4565 and the DUNE APA mechanical design review report is available at https://indico.fnal.gov/event/18815

Specifically:

1. Have electrical design choices been fully identified and do they meet detector requirements?
2. Are the specifications and drawings for standard and custom components substantially complete and available in EDMS? Are they of sufficient maturity to proceed to final design?
3. Have interfaces with other detector components been addressed and documented? Do risks of design changes in other systems have appropriate mitigation strategies?
4. Are engineering analyses sufficient to ensure the design is safe during all phases, and have applicable design codes and standards been satisfied?
5. Does the design allow for practical manufacturing, procurement and QC plans?
6. Are quality assurance and testing plans sufficiently developed to proceed to final design?
7. Have lessons learned from ProtoDUNE been implemented?
8. Are plans for additional prototyping reasonable and sufficient?
9. Are sufficient technical resources available to complete the design?
10. Are system grounding details documented and in EDMS? Are electrical connections specified and do schematics exists in EDMS? Are all wires, cables and connections documented

Review Findings:

The committee should present its findings, comments and recommendations in a closeout meeting with DUNE Technical Coordination on November 19. The committee should provide a final written report by **December 2**.