

# DUNE SP Preliminary Design Review (60%) of Cold Electronics Mechanical Systems

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## General Comments

The committee would like to thank the DUNE team for the impressive amount of work that has been done in preparation for this review

General:

- The design is fairly well advanced, and there is a good team assembled for completing the testing, development, and design



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

- Findings
  - The team has done a good job of identifying design choices to meet detector requirements, working from the elegant protoDUNE design that meets most of the requirements for DUNE
- Comments
  - Several potential problems with the flexible teflon duct were observed by the committee, including forces on the cryostat crossing tube, and a virtual leak from the interior of the teflon duct's metal tubing
- Recommendations
  - Perform a simulation to determine if the flexible teflon duct is actually needed, or if it may be simplified



## **2. Are specs and drawings substantially complete and available in EDMS? Of sufficient maturity to proceed to final design?**

- Findings
  - The drawings that were shown are in an appropriate state of completion, and are available in EDMS
  - We did not look at any specifications, although some have been uploaded to EDMS
- Comments
  - Not all drawings are currently available in EDMS
  - A good plan was shown to define the necessary drawings
- Recommendations
  - Proceed with the plan to complete the list of drawings



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

- Comments
  - For the interface of the CE box and its electrical connection with the CR board and the APA board stack, mounting hardware and connectors should be documented in an interface drawing
  - Bubble management interface should be revisited after the BNL bubble test
  - Cryostat flange interface requires formal documentation and simulation
  - CE should urgently provide APA with forces and moments acting on the APA yoke from the CE cable tray during the installation phase
  - CE should provide APA with the support point location and forces acting on it for the CE cable grip
  - The interface of CE and cryostat at the flexible teflon tube should be documented
  - The committee sees no significant risk of design changes from other systems
- Recommendations
  - Interface documents need to be updated and actively managed



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

- Findings
  - Three engineering notes have been uploaded and presentations followed those notes
  - The committee has not yet reviewed the notes carefully, but we will do this before writing the final report
- Comments
  - The project needs to inform the team which codes are the standards to be used
    - Materials safety should be included (e.g., fire codes)
- Recommendations
  - Analyses should include weld stresses according to design code



## 5. Does the design support a reasonable procurement strategy and manufacturing plan?

- Findings
  - The team has a substantial amount of experience from ProtoDUNE for procuring parts
- Comments
  - Lessons learned from protoDUNE have allowed improvements in assembly of CE boxes
  - The cable bundle assembly will require testing
- Recommendations
  - None



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

- Comments
  - No formal QA plan was presented, but the engineering and testing thus far demonstrates adherence to the principles of integrated quality
  - Ensure that the overall QA plan includes mechanical aspects of CE installation
- Recommendations
  - Follow through with plans to do bit error rate testing of cables under mechanical stress
  - Document the QA and testing plan



## 7. Have lessons learned from ProtoDUNE been implemented? Are the issues with the connectors on the FEMBs understood?

- Comments
  - Many of the lessons learned have been implemented, but the Lessons Learned document has not been updated
  - The FEMB connector issue has been understood and a promising mitigation strategy has been implemented, but remains to be tested in cold
- Recommendations
  - Update Lessons Learned document to capture all known LL. Someone should be assigned to curate this list



## 8. Are plans for additional prototyping reasonable and sufficient?

- Comments

- Mockups

- Upper APA mockup should be done with all cables used for complete pair of APAs (upper and lower and PDS)
      - Tests should cover both work done in the clean room and work done in the cryostat with appropriate space constraints
      - Cabling mockup should include maximum offset of feedthrough relative to APA center
      - Test replacement of CE box on cryostat-side of APA, after installation of cable trays



## 8. (continued) Are plans for additional prototyping reasonable and sufficient?

- Comments
  - Mockups
    - Bottom APA mockup should be done, including a test of pulling back the cable bundle to simulate shrinkage of cables during cooldown (shorter cable test is sufficient)
    - Test assembly of CE box on APA and transport, both in horizontal orientation
    - Test upper and lower cabling assemblies with vertical orientation of APA
    - Test of strain relief in CE box should be done in cold
    - Hang a bundle of long cables: look at mechanical stresses on cables and grip. If possible, do this in the cold. If possible, leave cables hanging (warm is ok) to evaluate changes in signal quality over time.
    - Test cable grip under load in liquid argon (concern about lubricating properties of argon relative to air)
  - Safety aspects of procedures should be considered during the tests
- Recommendations
  - Proceed as soon as possible with a extensive set of assembly and installation tests on mockups



## 9. Have appropriate cost estimates and schedule been determined? Are plans for required technical and scientific resources consistent with scope of remaining work?

- Comments

- To reach final design

- Labor estimates (schedule) to finish the final design were not fully presented, but the project and BNL seem committed to making the necessary resources available
    - M&S estimates for remaining work on prototypes and mockups were not presented

- To reach assembly/installation

- M&S estimates (to build the complete system) seem reasonable, given past experience from pDUNE
    - Labor estimates will be informed by experience on mockups

- Recommendations

- Provide a table of engineering and technical resources required to reach final design, including additional mockup efforts