Report of the Production Readiness Review of the ProtoDUNE Single Phase Photon Detector

May 11, 2017

DEEP UNDERGROUND NEUTRINO EXPERIMENT

1.0 PURPOSE/ SCOPE

The purpose of this review is to ensure there is a fabrication process in place and documented. The fabrication process should include the fabrication steps taken to complete the component and the define the quality control inspections and tests that will be performed to ensure the component meets its design and intended function.

The scope of the review included a review of the applicable documentation that had been uploaded to an Indico site and Docdb. The documentation reviewed is listed at the end of this report in Attachment A. These documents were reviewed by the Project Electrical and Mechanical Engineers, the Project ESH Manager, the Project QA Manager and the DUNE-US Project Manager. The Project QA Manager held the review at Colorado State University (CSU) on May 11, 2017. The DUNE ESH Manager participated in the review at CSU. Jack Fowler, Project Mechanical Engineer and Flavio Cavanna, DUNE Manager, participated by teleconference. The CSU personnel who participated are listed at the end of this report.

2.0 Comments

The ProtoDUNE Single Phase Photon Detector team at CSU are very experienced and very knowledgeable. The processes for the fabrication of the Photon Detector are very well documented. Dave Warner of CSU gave an overview of the photon detector design, fabrication and the APA interface.

There will be ten photon detector modules mounted on each APA frame. There are two photon detector module designs. The Indiana University (IU) module has radiator plates. The Fermilab module has TPB dipped light guide bars. CSU is responsible for receiving the WSL Bars from IU and FermiLab, assembling the readout ends onto the bars and preparing the module for assembly into the APA. The SiPMs used in the photon detector are acquired and tested for basic operation at NIU prior to being shipped to CSU for assembly of the SiPM readout boards and thermal shock testing. CSU has the process very well documented through drawings, procedures and travelers. The Photon Detectors will be assembled into the APA at CERN.

Two of the modules in the final APA frame will be ARAPUCA modules. ARAPUCA modules, while very different in concept from the existing PD modules, have been designed to fit in the same slots in the APA as “Standard” PDs. The ARAUPCA will be tested head-to-head against IU-style PDs in TallBo in August. A Production Readiness Review of the ARAUPCA design can be scheduled in early September with fabrication in September-October timeframe and ready for shipping with final PD modules in December. The SiPM selection for ARAPUCA still under consideration.

Module assembly consists of the following steps:

- Assemble modules in accordance with the module assembly procedure documents.
- Complete appropriate assembly traveler as module is assembled and tested.
- QC checks: Go-no-go gauge(width and thickness) at 7 test points along module, Check length against length test bar, visually inspect SiPM/light guide gap, check PCB flatness with straight edge & Shims.
- Scan module in warm scanner to test response/attenuation length.
- Immerse PD into LN2 bath for 4 hours, flash with LED, check SiPMs.

- Perform QC Check: Physical inspection of light guides, radiators (if appropriate) for integrity and lack of crazing/damage. Check screw tightness with torque screwdriver.
- Re-scan module in warm scanner
- Check all QC against standards
- Pack in light-tight, airtight shipping bag
- All assembly and testing to occur in class 100,000 clean assembly area

The PD modules will ship to CERN by air in 6 crates. 10 PDs + 2 spare per crate. Crates are currently being designed at CSU. PD QC scanner will ship in a crate. No on-site assembly or fabrication of PDs is expected.

The recommendations from the 2014 design review have been completed.

The roles and responsibilities for Environmental, Safety, and Health support and oversight are defined and integrated into the management of the ProtoDUNE Single Phase Photon Detector activities at Colorado State University. Norm Buchanan and David Warner understand their ESH oversight responsibilities for the work taking place at CSU. In Addition, the Colorado State University ESH Department provides ESH support and oversight to validate that the ProtoDUNE work activities are compliant with CSU ESH requirements. The CSU ESH organization also provides subject matter experts (industrial hygiene, etc.) in support of the Photon Detector activities.

During our walk-through of the laboratory space no issues were identified.

3.0 Recommendations

3.1 Develop schematic for the Hover Board and post the schematic to Docdb.

3.2 Upload calculations that have been performed for the Photon Detector design and/or fabrication to Docdb.

3.3 To document conditions that do not meet the design or fabrication criteria during fabrication, add the Exception Category to each traveler. Ensure that conditions that are accepted as is, have a documented technical justification for their use.

3.4 Develop drawing approval/revision block on the drawings to indicate the approval signatures of the drawings, the current revision and the revision history.

3.5 Develop the SiPM Mounting Procedure including details of Diode Checking instructions.

3.6 Add the Name of the person performing the procedure and the date of the check on the Checklist for the SiPM Mounting Boards (Pre-Cold Tester and Post-Cold Tester PCB Procedures)

3.7 Complete the Excel template for the QC Plan of the Photon Detector.

4.0 Photon Detector Production Readiness Review Team

Name	Title
Kevin Fahey	LBNF/DUNE QA Manager
Michael Andrews	LBNF /DUNE ESH Manager
Theresa Shaw	DUNE Project Electrical Engineer
Jack Fowler	DUNE Project Mechanical Engineer
Jolie Macier	DUNE-US Project Manager
Steve Kettell	BNL/DUNE Project Coordinator

5.0 Photon Detector Team

Name
Norm Buchanan (CSU)
Dave Warner (CSU)
Leon Mualem (CalTech)

6.0 Summary

The processes for the Photon Detector is very well documented. The Review Team recommends the CSU Photon Detector Team begin production once procedures, travelers, QC Plan are finalized. A written response to the recommendations is requested within two weeks of the receipt of this report. The response should be sent to Kevin Fahey at Kfahey@fnal.gov. If there any questions or a need for more information, contact Kevin Fahey at 630-840-2693.

Attachment A

Photon Detector Production Readiness Review Documentation

- Pre-Cold Tester and Post-Cold Tester PCB Procedures
- SiPM/SiPM Mounting Assembly Board Thermal Cycle Test Record
- Assembly Instructions for Fermilab Design PD Module 05-04-17-Rev2
- FNAL Design Photon Detector Bar Assembly Drawings
- FNAL Design PD Module Traveler
- Assembly Instructions for IU Design PD Module 05-04-17-Rev2
- IU Design Photon Detector Bar Assembly Drawings
- IU Design PD Module Traveler
- Incoming Material Traveler
- PD Assembly Cleaning Procedure 05-04-17-Rev 2
- Photon Detector Bill of Material
- ProtoDUNE Photon Detector Hardware Database
- Photon Detector Mounting System Assembly Drawings
- Quality Control Procedures for SiPM Mounting Boards
- SiPM Mounting Board Drawings
- Cable Shrinkage Calculation Document

Note: These documents are filed in Docdb 2877