Report of the Production Readiness Review of the ProtoDUNE Dual Phase Field Cage

May 24, 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 University of Texas Arlington (UTAU) on May 24, 2017. The DUNE ESH Manager participated in the review at UTA. The Project Electrical and Mechanical Engineers and the DUNE-US Project Manager participated in the review by teleconference. The UTA personnel who participated are listed at the end of this report.

2.0 Comments

The ProtoDUNE Dual Phase Field Cage team at UTA are very experienced and very knowledgeable. The processes for the fabrication of the Field Cage are very well documented. Jae Yu of UTA gave an overview of the Field Cage design and fabrication.

The Production & QC process for the Dual Phase Field Cage (DP-FC) consists of: Receipt inspection of the parts for QA, Cleaning of the parts, Pre-assembly of the DP-FC sub-modules, Disassembly, Packaging and Shipping. The I-Beams and FRP parts are fabricated by outside vendors. During Receipt, the I-beams and other FRP parts will be inspected for their dimensions, structural damage and functional qualification. The most critical dimension is the distance between the holes for the inter-submodule connecting plates and the profile slots on the I-Beams. There initially were two vendors providing the parts. There had been an issue with one vendor regarding dimensional inspection results. This vendor will not be used for production parts.

The I-Beams and parts are deburred and defibered in an open unclean area. The technicians wear disposable lab coats, N95 masks and non-latex nitrile gloves. The deburred holes and slots are sanded to remove as much fiber as possible. All FRP parts are cleaned with simple green without coloring agent and de-ionized water, using Kimwipes in a semi-clean room. The I-Beams are dried and moisture is removed with a hot air heat gun. Small parts, such as threaded rods, nuts, screws, slip-nuts and inserts, in an ultrasonic cleaner w/ ethanol. Each part is inspected for cleanliness after the above processes. Cleaned parts are stored on a shelf in a semi-clean storage room.

The assembly process is done in a class 100,000 clean room. The assembly team will wear disposable lab coat, hairnet, beard net and powder-free gloves. UTA is refining the procedure for two people to perform the assembly at CERN. The time to put assemble module zero was about 1 hour with two people. The process can be further shortened with repeated assembly.

The DP-FC modules are disassembled prior to packaging and shipping to CERN. As for assembly, the disassembly is performed in a class 100,000 clean room and all members of the disassembly team will wear disposable lab coat, mask, hairnet and powder-free gloves. After disassembly, all small parts are

cleaned in ethanol in an ultrasonic cleaner to ensure cleanliness, the ethanol is dried off and the parts are put in zip-lock bags. The I-beams are inspected for cleanliness and any damages.

For packaging the I-beams, L-brackets and the bags of screws, nuts, threaded rods, inserts and FRP nuts are stacked into as small a package as possible. This package will then be sealed with shrink wrap, bubble wrapped, edge protected and plastic strapped. The plan is to ship 12 sub-modules at a time in early Sept. and late Oct. 2017.

The Al profiles and profile clips are being fabricated by vendors in Europe and will be shipped directly to CERN. Receipt inspection will be performed at CERN. Al profiles will be inspected for deformations, surface damage, bend angle, straight segments length. Clips will be inspected for uniformity of surface shape and matching with AL profile shape. Further QC checks will be performed after installation at CERN.

UTA is also responsible for providing the High Voltage (HV) Divider Boards. The printed circuit board will be the same as the Single Phase Field Cage. There will be two columns of ten boards totaling twenty boards for the Field Cage. 30% of resisters and 110% of varistors are on hand at UTA. The bare boards are expected to be delivered to UTS by June 15, 2017. Complete component testing and certification (Test all resisters and varistors in warm and cold up to 10kV, Measure resistance using Ohm's law, Measure clamping voltage of each varistor, Test the continuity of the bare boards in warm and after a cold shock) will be completed by July 15 2017. The stuffing of the boards will be completed by August 15, 2017. The completed stuffed boards will be tested in warm and in cold and all boards will be certified, including the 10% spare by September 15, 2017 with a ship to CERN date of October 1, 2017. The receipt inspection and testing procedures and QC Plan for the HV Divider Boards still need to be developed.

The roles and responsibilities for Environmental, Safety, and Health support and oversight are defined and integrated into the management of the ProtoDUNE Dual Phase Field Cage activities at the University of Texas Arliington. Jaehoon Yu, the DP Field Cage Manager, understands his ESH oversight responsibilities for the work taking place at UTA. Jaehoon utilizes ten UTA students in support of the DP Field Cage activities and all have received the training required which is verified by both the supervisor and the ESH Department. In Addition, the University of Texas Arlington ESH Department provides ESH support and oversight to validate that the ProtoDUNE work activities are compliant with UTA ESH requirements. The UTA ESH organization also provides subject matter experts (industrial hygiene, etc.) in support of the DP Field Cage activities. The UTA ESH Office Environmental & Laboratory Program Manager Ramon Ruis and the Associate Director Fire & Life Safety Robert Smith attended the review and walkthrough.

During our walk-through of the laboratory space it was observed that the lab space was equipped with a wet pipe fire sprinkler system; however, no smoke detection was available. The UTA ESH Fire specialist agreed that smoke detection should be installed in the lab space. While reviewing procedures and Hazard Analysis documentation it was recommended that the specific requirements for accessing and egressing the lab space (two-person rule, unzipping the secondary egress door while personnel are in the space, and protocol for managing the locks/cables) be added to the documentation. We reviewed the deburring process and recommended that the use of goggles and a shop vacuum be added to procedures and hazard analysis documentation.

3.0 Recommendations

3.1 Add the Critical dimension to the QC Plan, QC Checklist and inspection procedure.
3.2 Develop torque values for the screws and nuts and incorporate into the assembly procedure.
3.3 Upload the Field Simulation Calculations and the Load Testing Report performed by ETH into Docdb.
3.4 Complete the design of the shipping crate.
3.5 Add the labelling requirements to the procedure.
3.6 Revise the Profiles QC Checklist to remove the reference to ID No. since the profiles will not have ID numbers. The Checklist can reference the number satisfactory and unsatisfactory with a space to describe disposition of unsatisfactory profiles.
3.7 Add the coating inspection requirements to the QC Checklist and procedure.
3.8 Develop Receipt Inspection, assembly and test procedures for the HV Divider Boards.
3.9 Add the HV Divider Board requirements into the QC Plan.
3.10 Install smoke detection in the lab space.
3.11 Document lab access/egress procedures to include all requirements, as stated above.
3.12 Update deburring procedure to include the use of googles and shop vacuum.

4.0 Dual Phase Field Cage 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

5.0 UTA Dual Phase Field Cage Team

Name	Title
Jaehoon Yu	Faculty (UTA) (DP Field Cage Manager)
Jonathan Asaadi	Faculty (UTA)
Thomas Bates	Grad Student (UTA)
Garrett Brown	Grad Student (UTA)
Brad Hale	Grad Student (UTA)
Douglas Zenger	Undergrad Student (UTA)
Anrimesh Chatterjee	Postdoc (UTA)
Shashank Kumbhare	Grad Student (UTA)
Alex Weiss	Chair of the Physics Dept. (UTA)
Matthew Rupp	Undergrad Student (UTA)
Eric Amador	Undergrad Student (UTA)

6.0 Summary

The processes for the DP Field Cage are very well documented. The Review Team recommends the UTA DP Field Cage Team begin production once procedures and QC Checklists are finalized in accordance with the recommendations. 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

Dual Phase Field Cage Production Readiness Review Documentation

- Assembly Procedure
- DP Field Cage Drawings (Performed by ETH)
- Validation of the FRP production: samples for the qualification of the FRP vendors and experience from module-zero assembly
- UTA Hazard Analysis Form
- Inspection Checklists
- QC Plan
- Vendor Document on FRP Material Properties
- DP Field Cage Fabrication Overview

Note: These documents are filed in Docdb 3009