**Design Review**

**ProtoDUNE Single Phase**

**Photon Detector System**

**2−3 August 2016**

**Charge**

The Committee is requested to review the Proto DUNE Single Phase Photon Detector system technical design and determine if it is at a state commensurate with that needed for producing the photon system needed 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:

SIPM

Findings

Comments

Recomandations

**SiPM:** SiPMs never been used in the past as photo-sensor in neutrino LAr detector-based experiment. Although they are considered a new technology for LAr, and the producers doesn’t guarantee them for the use in cold, I think the material presented yesterday (stress tests) concerning the robustness of SiPM in cold (and the existent literature) fully justifies the idea of using SiPMs in Liquid Argon as photo-sensors.

Obviously, for a complete judgment of the feasibility of involving SiPMs a full review of the performance and the (physics) requirements of the Photon Detector System need to be addressed (efficiency, triggering goals, etc.).

1. Does the Photon Detector System design enable validation and refinement of the DUNE photon detector requirements?

FINDINGS

The photon detector system will deploy sixty photon detectors with associated SiPMs. It will operate as part of a complete system. The light yield of the system is lower than expected - this is considered in the section on the optical system.

COMMENTS

Although the system is small and the duration short operating large numbers of SiPM at cryogenic temperatures as part of a full system will be a significant step towards validation of the choice of SiPM for DUNE.

1. Are Photon Detector System risks captured and is there a plan for managing and mitigating these risks?

FINDINGS

The stress tests conducted on SiPM in cold (at LN) are very valuable. Given the relatively small number of SiPMs in use in ProtoDUNE we think that the risks of SiPM failures (mechanical) will be minimal. In a presented test, their performance with time have been monitored for many days (>400days) with very high illumination (saturation) and no degradation on the performance stability of the sensor were recorded.

COMMENTS

The tests performed by the PDS group are adequate given the relatively small number of channels that will be deployed at protoDUNE and the relatively short duration of the tests. However, the test programme should continue in order to be confident of deploying SiPM in cryogenic temperatures over the lifetime of DUNE. Tests to estimate the lifetime could be performed. For example temperature cycling of the SiPM boards until the solder joints fail.

Room temperature testing of the breakdown voltage will be performed on each SiPM before assembling them onto SiPM sensor boards. However, no plan was presented to verify that the breakdown voltage evolves with temperature in a compatible way within a group of ganged SIPM. This could be done with tests on a small sample. Alternatively, by flashing light onto each SiPM in turn in a group of three variations in break-down voltage could be measured cold.

RECOMMENDATION

The SiPM tests for protoDUNE should be developed into a programme of tests for the PDS at DUNE.

1. Does the design lead to a reasonable production schedule, including QA, transport, installation and commissioning?

COMMENTS

Procurement of SiPMs should be rather fast. The number of SiPM for protoDUNE Is a small quantity for a company like SensL to supply.

The existing tests on SiPM should be developed into a set of requirements and “Go/No Go” limits when testing SiPM for use a protoDUNE.

1. Does the documentation of the Photon Detector System technical design provide sufficiently comprehensive analysis and justification for the Photon Detector System design adopted?

FINDINGS

Details of the current design were presented.

COMMENTS

A comprehensive analysis and justification was not presented. Although many results on testing SensL-Cseries-60035 SiPMs have been presented there was little consideration of other kind of SiPM (from other producers). No plans for testing better performance SiPMs (available on the market) have been presented. However, the level of analysis is probably sufficient for protoDUNE.

The committee would have liked the study of “ganging” multiple SiPMs to be matched with circuit simulation. We would suggest making a simulation of the full electronic chain to better understand the degradation of the signal when SiPM are “ganged”. For example, it was not clear to the committee the dominant factors that control the slow rise time of single SiPMs (>20ns) after digitization.

There is recent literature (e.g. from Biagio Rossi) on use of amplification and summing of SiPM signals in cold. We would suggest the PDS investigates use of cold amplification after protoDUNE

The constraints about the number of channels (feed-throughs, cabling) were not clearly presented. Hence it wasn’t clear what design parameters could be varied.

1. Is the Photon Detector system scope well defined and complete? Are all Photon Detector System interfaces to other detector components: APA, cryostat and DAQ systems documented, clearly identified and complete? Do the electronics feed-through port and TPC integrated 3D models adequately represent the mechanical, electrical and electronic interfaces to the Photon Detector System? Is the cabling, power and calibration well defined and understood? Is the grounding and shielding understood and adequate?
2. Are the Photon Detector System 3D model(s), top level assembly drawings, detail/part drawings and material and process specifications sufficiently complete to demonstrate that the design can be constructed and installed?

FINDINGS

3D models of the SiPM board were shown as well as the signal connector.

COMMENTS

We believe that the PDS team has the correct procedure in place for correct design. Assembly of the SiPM boards is unlikely to be problematic, since it will take place in, or close to, PDS home institutes.

1. Are operation conditions listed, understood and comprehensive? Is there an adequate calibration plan?

FINDINGS

Details of an LED monitoring system were presented.

COMMENTS

No plan for **calibration** of the SiPM in situ was presented. Only monitoring of the relative performance over time. However, we found the light monitoring system design very valuable, advanced and well presented.

1. Are the Photon Detector System engineering analyses sufficiently comprehensive for Safe handling, installation and operation at the CERN Neutrino Platform? Is the installation plan sufficiently well developed? Is the design for installation tooling adequate for installing the photon system?

COMMENTS

SiPM in use have an epoxy layer on the top of them and are relatively robust.

1. Have applicable lessons-learned from previous LArTPC devices been documented and implemented into the QA plan? Are the Photon Detector System quality control test plans and inspection regimes sufficiently comprehensive to assure efficient commissioning and adequate operation and performance of the NP04 experiment?

COMMENTS

Use of SiPM in large LAr detectors is novel, so there is relatively little experience from previous devices. Lessons about the SiPMs learned from the 35t prototype were not presented, but this can be justified since noise issues with the readout system precluded systematic study of SiPM performance in the system

The committee should present its findings, comments, and recommendations in a closeout meeting with DUNE management on August 3. The committee should provide a final written report by August 12.