Form 8

Research Result Report

ICRR Inter-University Research Program 2022

Research Subject:

Seal, mechanical and functional tests on the mPMT prototype for external vessel optimizzations

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Summary of Research Result：

The last fiscal year, in March 2022, the mPMT successfully passed the anti-implosion test, that was a critical test to check the resistance and the sealing of the detector. In this fiscal year (Apr. 2022 - Mar. 2023), further tests and improvements concerning the design were done.

Over August and September 2022, a long pressure test was carried out at the Charles University, thanks to the collaboration of Dr. Bedrich Roskovec and facility at his institute. An updated acquisition system was developed by me and Filippo Masci of the INFN-Naples, while the final software details were developed by a PhD student at the University of Studies of Naples Federico II, Aurora Langella. In practice, three different comparators measured deformations of the acrylic dome, the HDPE cylinder, and the stainless-steel back plate. As regarding this long-pressure test, the mPMT was put in a pressure chamber for 11.1 days and at 10 bars. During this test, no leakage was measured by the inner sensors (i.e., humidity and pressure) and after the test nothing relevant was observed by a visual inspection. The mPMT preserved the sealing and there were no external damages (e.g., cracks or permanent deformations).

Nuclear contamination tests were carried out on new acrylic samples and HDPE samples at the Gran Sasso Laboratoties in Italy. Acrylic is under the threshold allowed, HDPE presents some value over the threshold, probably because of the black-coloring additive. POM-C samples are under analysis.

Soak tests on POM-C, acrylic samples are ongoing in Olomouc (Czech Republic) at the Joint Laboratory of Optics of Palacky University. Soak tests on samples of MacArtney cables were carried out too. As for the cable, no relevant elements were dissolved in water from the cable to be considered problematic for light detection by PMTs. However, further tests are still ongoing.

With Maurizio Mongelli (INFN-Bari), several upgrades were designed on the mPMT, and a summary of them is reported in the following list:

- the cylinder is now in POM-C material. POM-C is harder and more stable (i.e., maintains its shape after manufacturing) than HPDE material, hence it did not show any issue concerning the mPMT assembly (as a reminder from the previous fiscal year, the HPDE cylinder showed problems during the mPMT-prototype assembly because of a very small ovalization happened after manufacturing);
- the back plate was modified, and now it has a spherical profile and a thinner thickness, in order to reduce cost and its weight;
- the PMT support was updated as well, in order to reduce the quantity of the optical gel and, consequently, to reduce overall cost and the weight of the mPMT.

As for the PMT support, many efforts were dedicated to this component. In fact, it was designed to be made by injection-mold method, but, eventually, it will be printed by 3D printer, because the final number of about 850 mPMT to install in the Hyper-Kamiokande (HK) Far-Detector (FD) was defined recently. 850 pieces can be supplied by 3D-printer method, with the advantage to modify some detail also during the production phase (if it needed).

Apart from the mPMT design, the support base frames were updated as well. The support bases are the frames that will allow the connection between the FD-HK tank frame and the mPMT. The final design of the tank frame is ongoing, so the mPMT base supports are under development. Currently, this is a task followed by me, the Mexican colleagues and Dr. Bedrich Roskovec. Installation procedures are under study too, in according with the HK collaboration.

Thanks to the important ICRR grant, 8 photomultiplier tubes (PMTs) by Hamamatsu were ordered. These PMTs will be characterized and used for the next mPMTs. Furthermore, the data obtained from their characterizations will be shared with company to give some relevant information to it.

The mPMT detector design can be considered ready, but some last tests will have to confirm it. A pre-production of 5 prototypes started on March 2022 and these detectors will be assembled, tested, and then installed in the next Water Cherenkov Test Experiment (WCTE) at the CERN in Geneve to acquire first real data. In addition, thanks to collaboration with Prof. Saul Cuen Rochin and his colleagues, the dummy mPMT with the HDPE cylinder was sent to Mexico for vibration tests to simulate both transportation to and earthquake in Japan (but results are not ready yet).
As future proposal, if a sixth no-electronics-inside prototype will be assembled, it could be used to arrange a second test during one of the 20”-PMT-cover anti-implosion tests to carry out in Spain by the Laboratorio Subterráneo de Canfranc (LSC).

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