

Research Report
ICRR Inter-University Research Program 2021

Research Subject:

Development and testing of cost-effective, high-performance PhotoDetector anti-implosion covers for Hyper-Kamiokande

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Summary of Research Result :

This grant has been used to help the main works towards establishing the so-called Sp-cover or TC-cover (Truncated Cover) design for the shockwave arresting “anti-implosion” PMT covers for the Hyper- Kamiokande project in conjunction with other funding from the institutions involved in the project (UAM, *Laboratorio Subterráneo de Canfranc* – LSC).

This ICRR-IURP 2021 is a follow-up of two similar, granted to UAM, ICRR-IURP projects: 2019 and 2020 (the 2019 one had D. Bravo as IP) and predecessor of a new ICRR-IURP 2022 project just granted. Most important expenses covered are:

- Research trips inside Japan
- Finite Element Modeling of the V3 approach (with flangeless acrylic window).
- Acquisition of HK PMTs with no vacuum for mechanical tests
- Shipping of prototypes, material parts etc. between Japan and Spain
- Acquisition of HK flanged acrylic windows for the final Sp-cover test program

Within this ICRR-IURP 2021, many activities have been carried out:

- Approximately 20 Sp-cover prototypes were built with designs V2.3, V2.4 (acrylic window with flange) and V3.2, V3.2 (flangeless acrylic window). Many of them were tested within the final certification test program. This consisted into a series of Hydrostatic tests in Spain and Implosion tests in Hokkaido, Japan. Unfortunately, the results of the Implosion tests were not fully satisfactory and therefore those designs could not be certified (see below for further details)
- Protocols for technical reviewing and approval by PAC / HK of the HK cover
- Works on preparing logistics, procedures etc. for mass production:
 - on the production itself
 - on the procedure systems for Quality Control

- on the Storage and Transport of covers within Spain and to Kamioka
- on the general idea of the unit station for PMT + cover (photo-detection unit) assembly in mass production
- on the assembly of the 20K photodetection units in Kamioka
- plans and responsibilities during the whole process up to mounting at HK
- All the needed components to mount two full covers V3.2 and V2.3, including the attachment pieces PMT - cover and cover - HK_structure, were shipped to ICRR in Kashiwa campus for mounting tests and learning.

After lots of R&D work, it seemed that we had arrived at a sturdy sp-cover design (from versions V2.3, V3.2 to V2.4, V3.3). In the process we had to:

- increase thickness of the flangeless acrylic window by 3 mm
- increase thickness of Truncated-Cone part (from 2.5 to 3 mm)
- change join scheme between the Truncated-Cone and End-Cap parts

Even though V2.4 and V3.3 did pass well all the Hydrostatic tests considered in the certification program, the Implosion tests were not fully successful. Some comments and conclusions follow

- From the point of view of fabrication, quality assessment, assembly method and speeds etc., we did spot several defects that have to be addressed
- Three out of five Sp-covers failed the implosion tests.
- A partial reason is, I believe, that we had “optimized” that design based on HT results; but the dynamics at IT and HT seem to be significantly different.
- We must move to the Jp-SUS cover (not discussed in this report) as the baseline for HK and rebuild the current “set of companies” to mass produce it in Spain
- However, I strongly believe that we should not give up the Sp-cover designs yet. They are still, probably, significantly cheaper for a mass production of ~20K units
- Also, we should invest significant funding for a thorough, extensive, and detailed FEM program, that stresses the dynamical behavior and the connection between the parts. It could not be done before the Implosion test because of the no possibility to access the already granted funds. Its results might point to just minor changes that provide the additional robustness needed.

All the above is discussed and documented thoroughly in the Hyper-K's *TechNote026* [<https://wiki.hyperk.org/do/view/HyperK/TechNote0026>]