

Research Result Report
ICRR Inter-University Research Program 2025

Research Subject: New Photogrammetry Calibration for Super-Kamiokande and Hyper-Kamiokande

Principal Investigator: Patrick de Perio

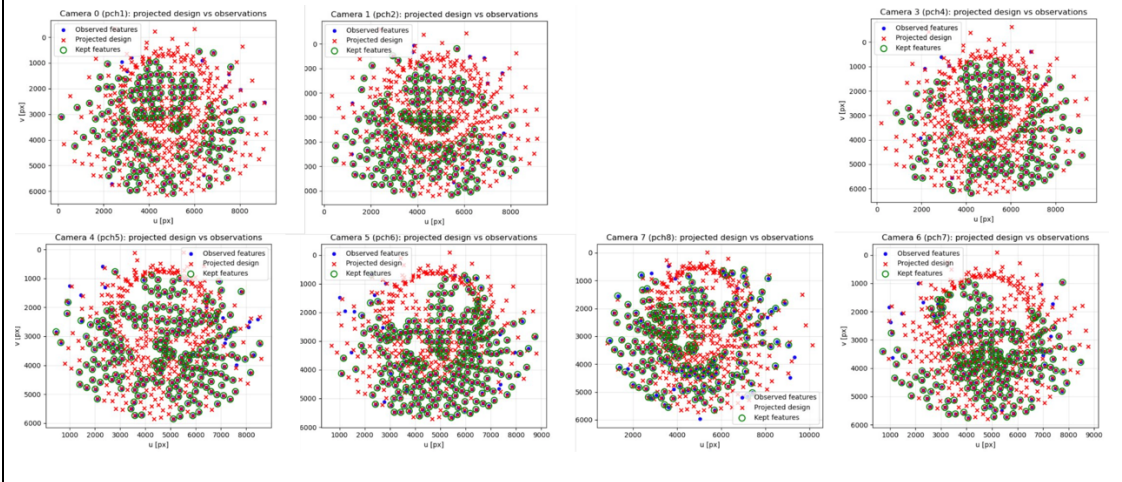
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Summary of Research Result :

Operation of seven photogrammetry cameras in the Water Cherenkov Test Experiment (WCTE) at CERN was completed in June 2025. Below are example photos of multi-PMT LEDs (left) that were analyzed to detect and label the points (middle), and overlaid on the corresponding ambient-lit photo (right) to verify positioning. Analysis is ongoing for all cameras to perform the full geometric reconstruction.

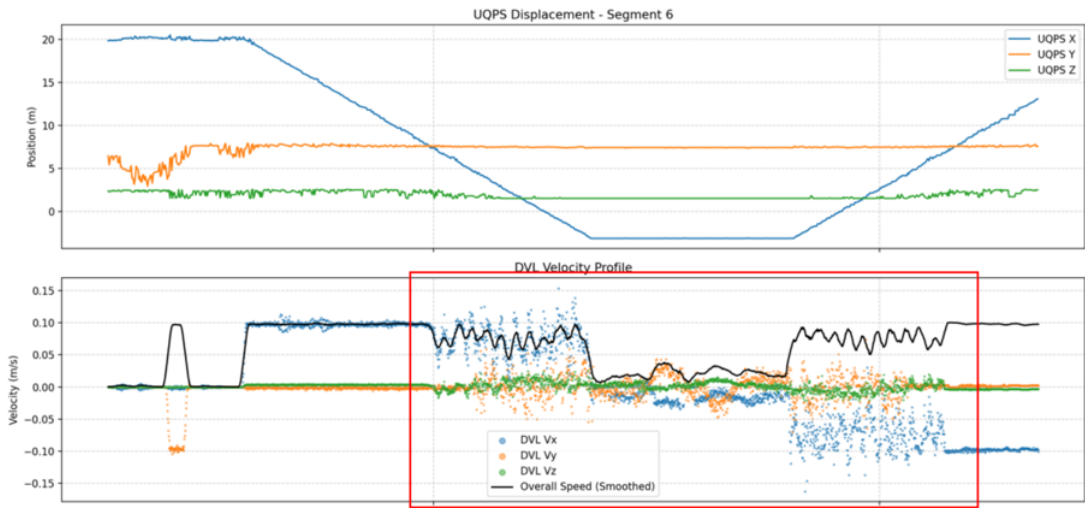


Checking the point detection in more detail, the below figure shows for each camera, observed (detected) LED points that overlap with the projected (expected) positions. Many expected positions could not be detected either due to LEDs inactive or over-crowding of the points making separation difficult. The kept (well-matched) points will be used for 3D geometry reconstruction.



This is a good demonstration of the entire system in a realistic environment, including all the detrimental effects from optics smearing of the LEDs through the mPMT acrylic dome, water, and camera lens. For example, this informed to upgrade the camera system with remote controlled focusing to improve the sharpness of the images for Hyper-Kamiokande and its Intermediate Water Cherenkov Detector. The dataset is also useful to further optimize the point/feature detection algorithm.

The deployment of a remote operated vehicle (ROV) in Super-Kamiokande (and proposed for Hyper-Kamiokande and IWCD) for a comprehensive underwater geometry survey posed safety concerns about collisions with the PMTs. Positioning systems, to enable automated safety control, were procured in-part by this grant and tested at the Institute of Industrial Science Ocean Engineering Basin (IIS OEB) in 2023. The analysis was resumed this year and discovered several issues with data quality that are delaying this analysis. For example, instability issues in the doppler velocity log (DVL) data (right, bottom panel), suggesting we may not be able to rely on this sensor. Analysis is ongoing to cross-check the underwater global positioning system (U-GPS) data (right, top panel) against IIS OEB facility's carriage motion settings and the ROV's onboard sonar sensors.



However, in the last two years, the underwater ROV industry has made much progress in improving their positioning systems and integration to allow reliable absolute and relative-to-wall positioning. Furthermore, companies have integrated this positioning information into automated piloting functions that stop the ROV prior to collision, as well as programmable paths to perform large scale surveys that can ease the piloting burden we experienced in Super-K. Consultation with one company has started to understand the actual capabilities and applicability inside the Hyper-K tank.