



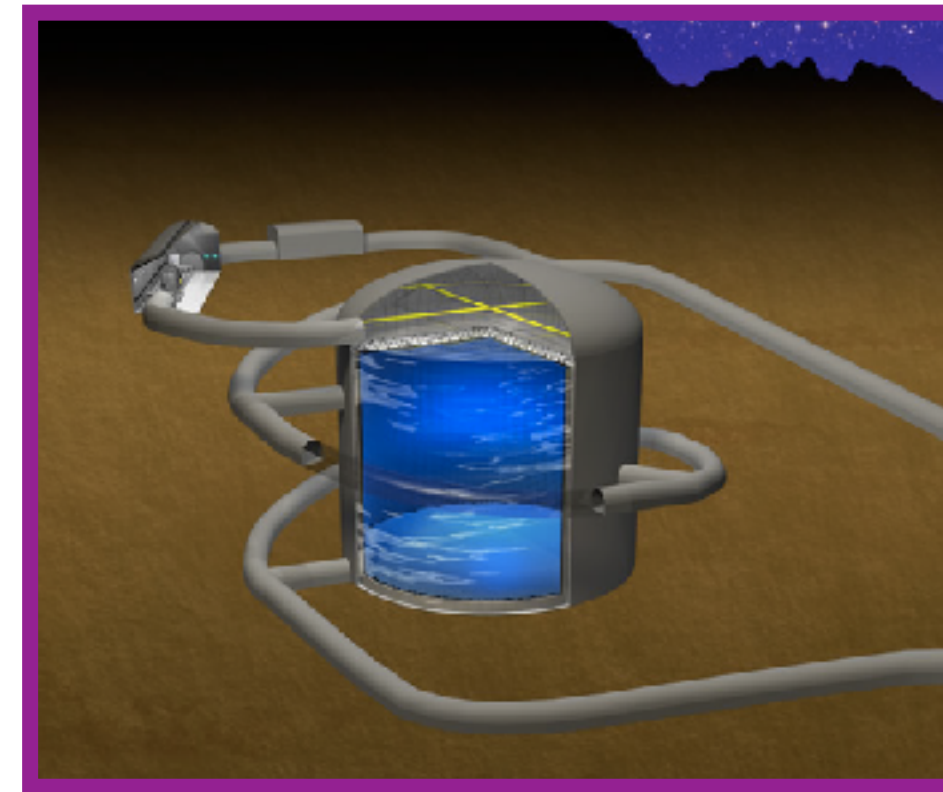
IWCD Overview, Status and TRIUMF/Canadian Contributions

Mark Hartz

TRIUMF- KEK Symposium 2026

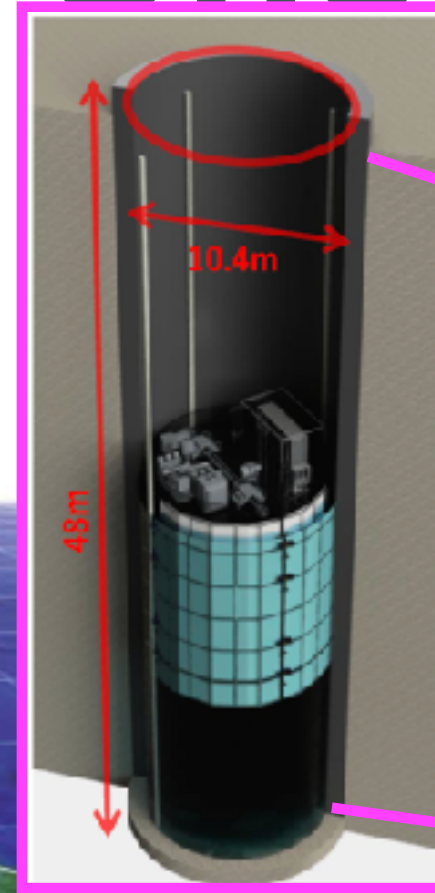
September 28, 2026

Intermediate Water Cherenkov Detector



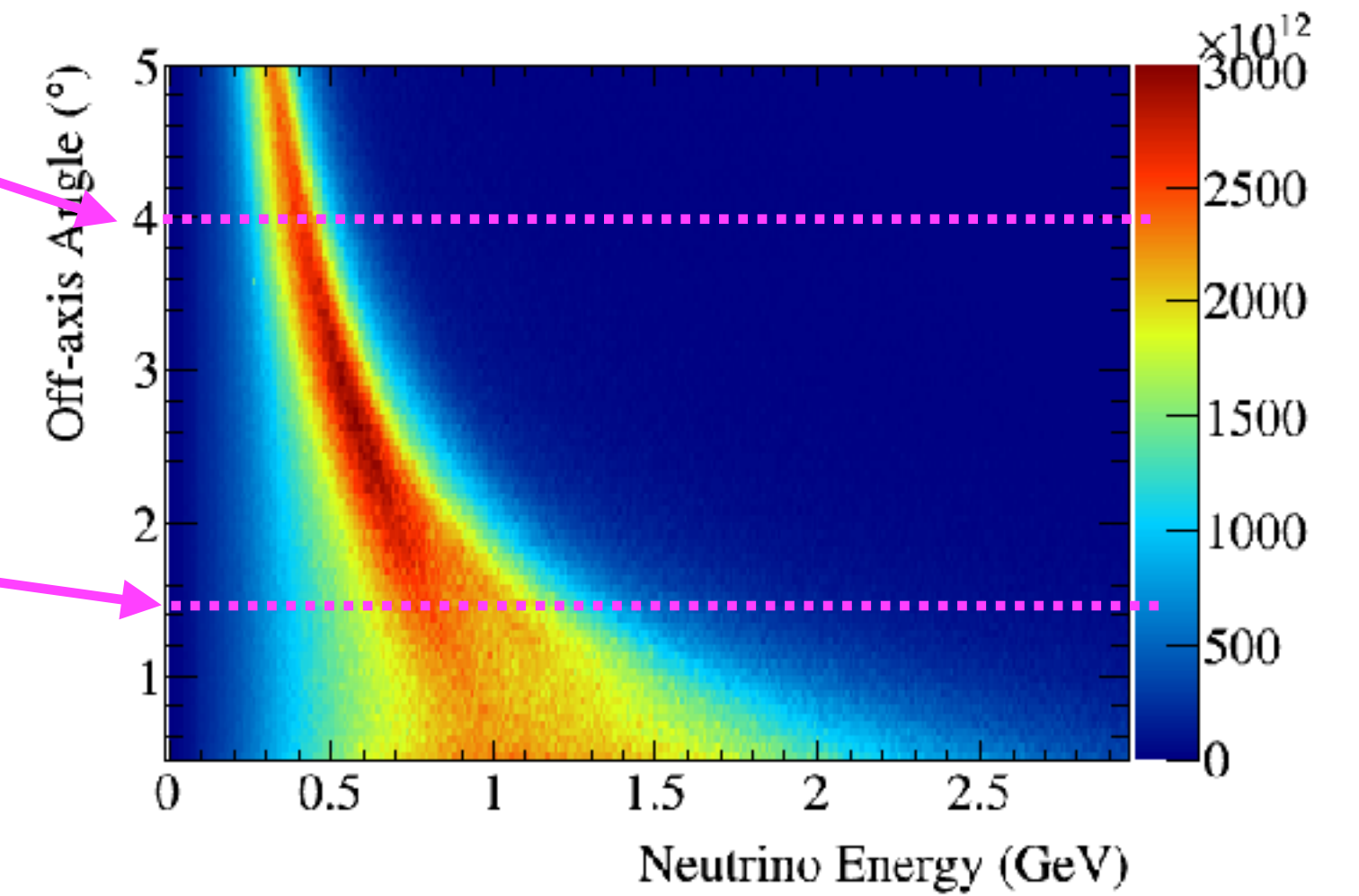
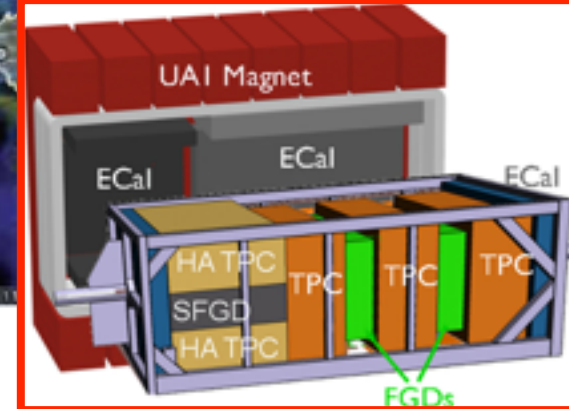
Hyper-Kamiokande

Intermediate
Water
Cherenkov
Detector



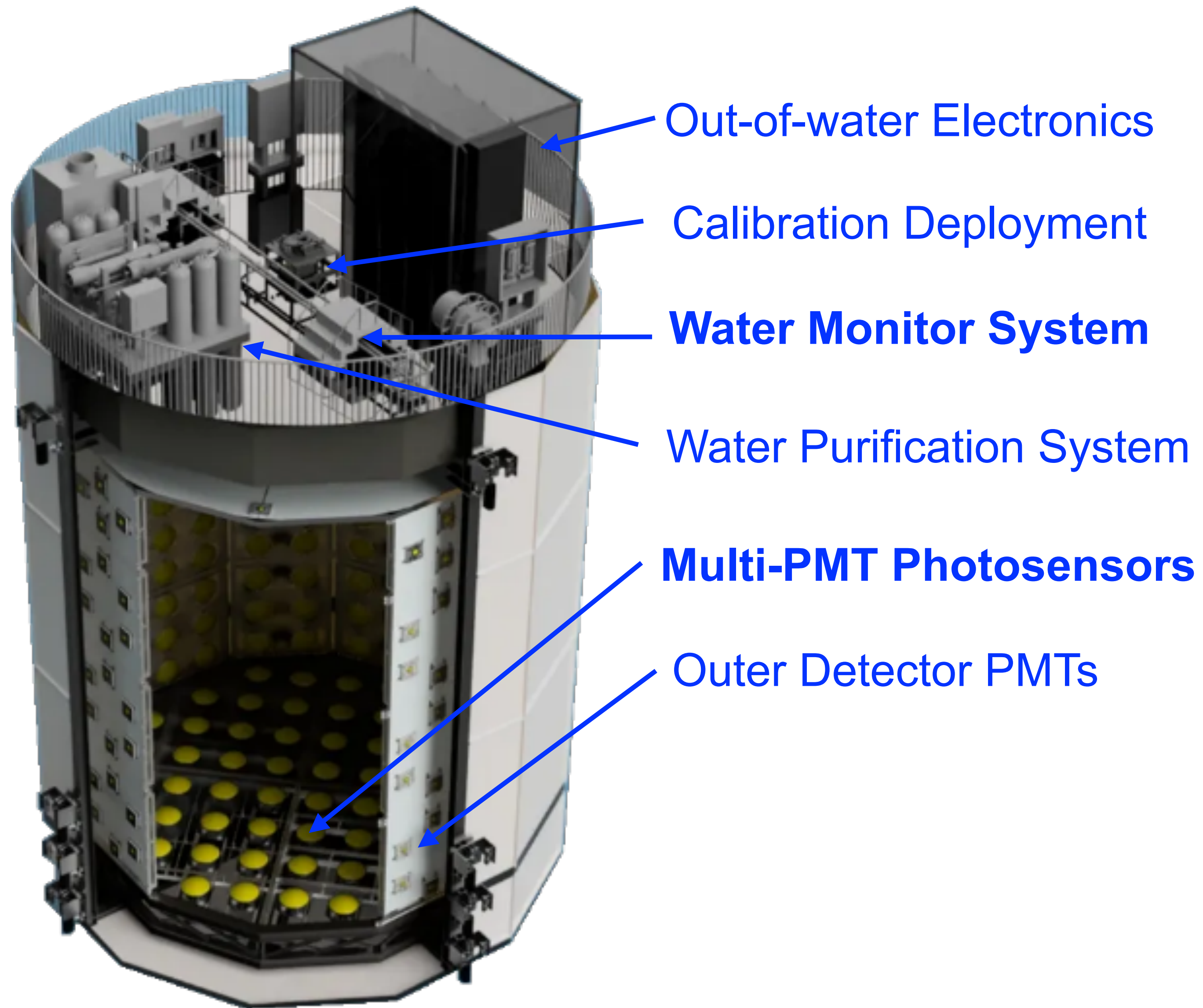
J-PARC Main Ring
(KEK-JAEA, Tokai)

ND280 Upgrade



- New intermediate detector located 850 m downstream of neutrino source in J-PARC - control systematic errors
- Key oscillation neutrino probabilities we will measure in HK are: $P_{\nu_\mu \rightarrow \nu_e}(E_\nu)$, $P_{\bar{\nu}_\mu \rightarrow \bar{\nu}_e}(E_{\bar{\nu}})$
 - IWCD has unique capability to move vertically to probe different neutrino energy spectra and study energy reconstruction
- IWCD will measure the neutrino-nucleus cross section ratios: $\frac{\sigma_{\nu_e}(E_\nu)}{\sigma_{\nu_\mu}(E_\nu)}$, $\frac{\sigma_{\bar{\nu}_e}(E_{\bar{\nu}})}{\sigma_{\bar{\nu}_\mu}(E_{\bar{\nu}})}$

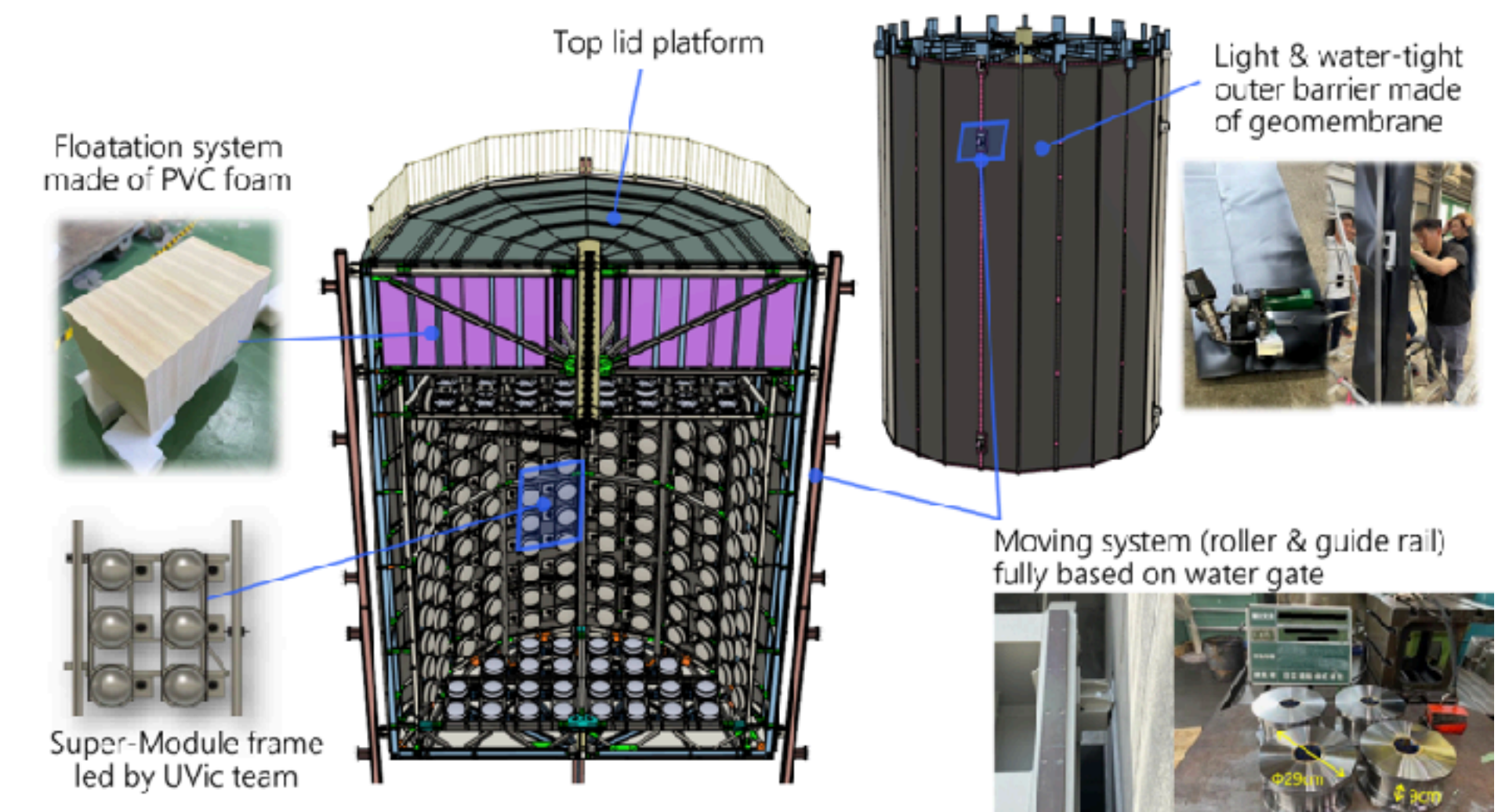
Detector Overview



Multi-PMT photosensor developed primarily at TRIUMF by Science and Technology Department working with HK group

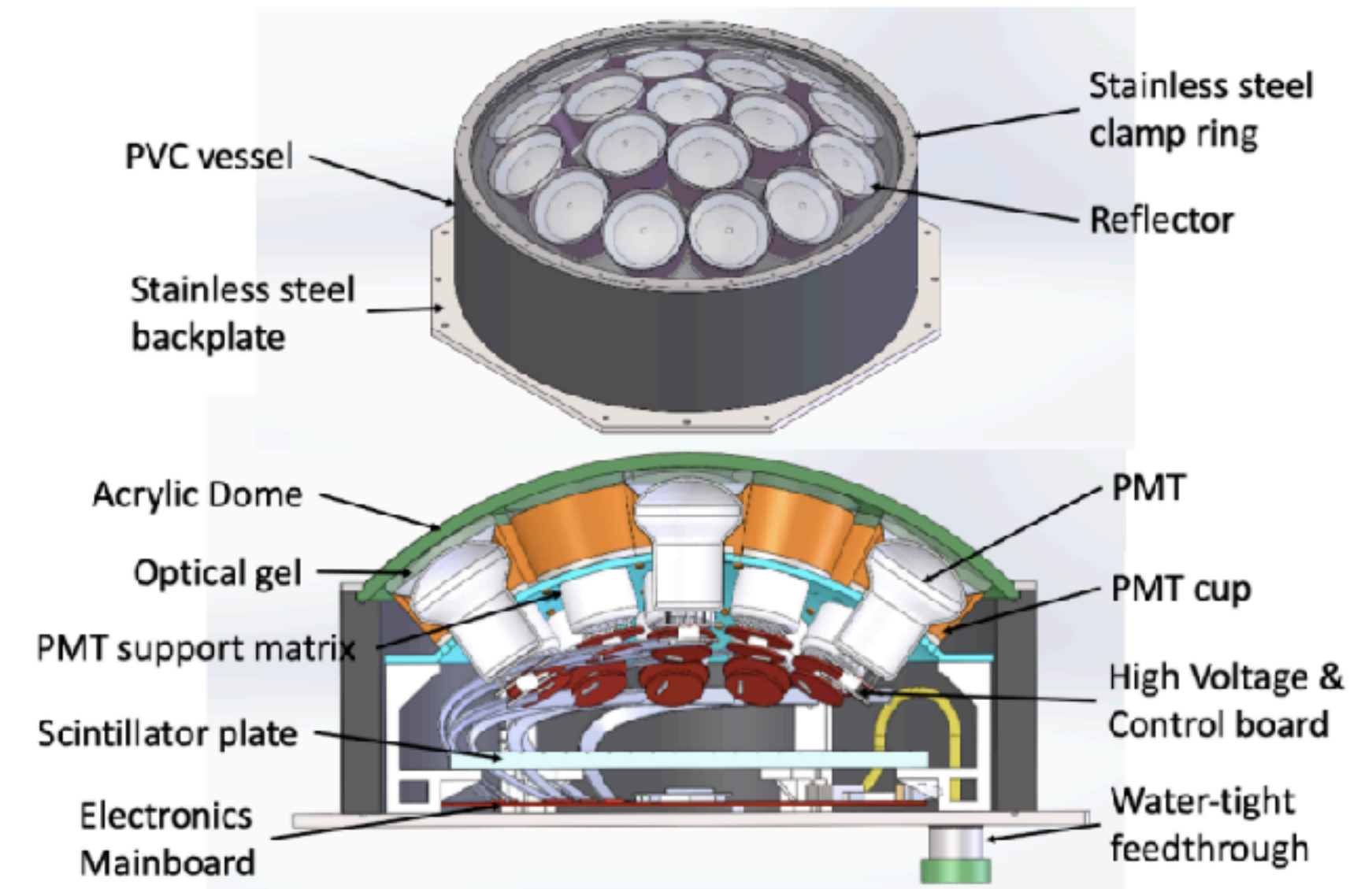
Facility/Detector Construction Progress

- Details in the following talk by R. Akutsu
- IWCD Facility construction began in 2025, with start of the pit excavation in 2026
- Good progress on the pit excavation with 5th of 11 sections nearing completion
- Detailed design of the detector including all structural elements is nearing completion
- IWCD collaborators working to finish integration of all detector components
- Start of detector construction in Tokai from Nov. 2027



Multi-PMT Photosensors

- Multi-PMT photosensors are main photon detection system for IWCD
- Design developed at TRIUMF, collaborating with Warsaw University of Technology in Poland
- TRIUMF Project Manager: T. Lindner
- Highly capable mainboard with FADC digitization developed by SciTech electronics group
 - Capable of both full waveform readout and on-board hit finding
- Water-tight vessel and assembly procedure developed with SciTech detector group
- LED pulser board provides pulsed light source for timing calibration and beacons for photogrammetry position measurements
- **Pilot production of 50 multi-PMTs at TRIUMF in 2023-2024**



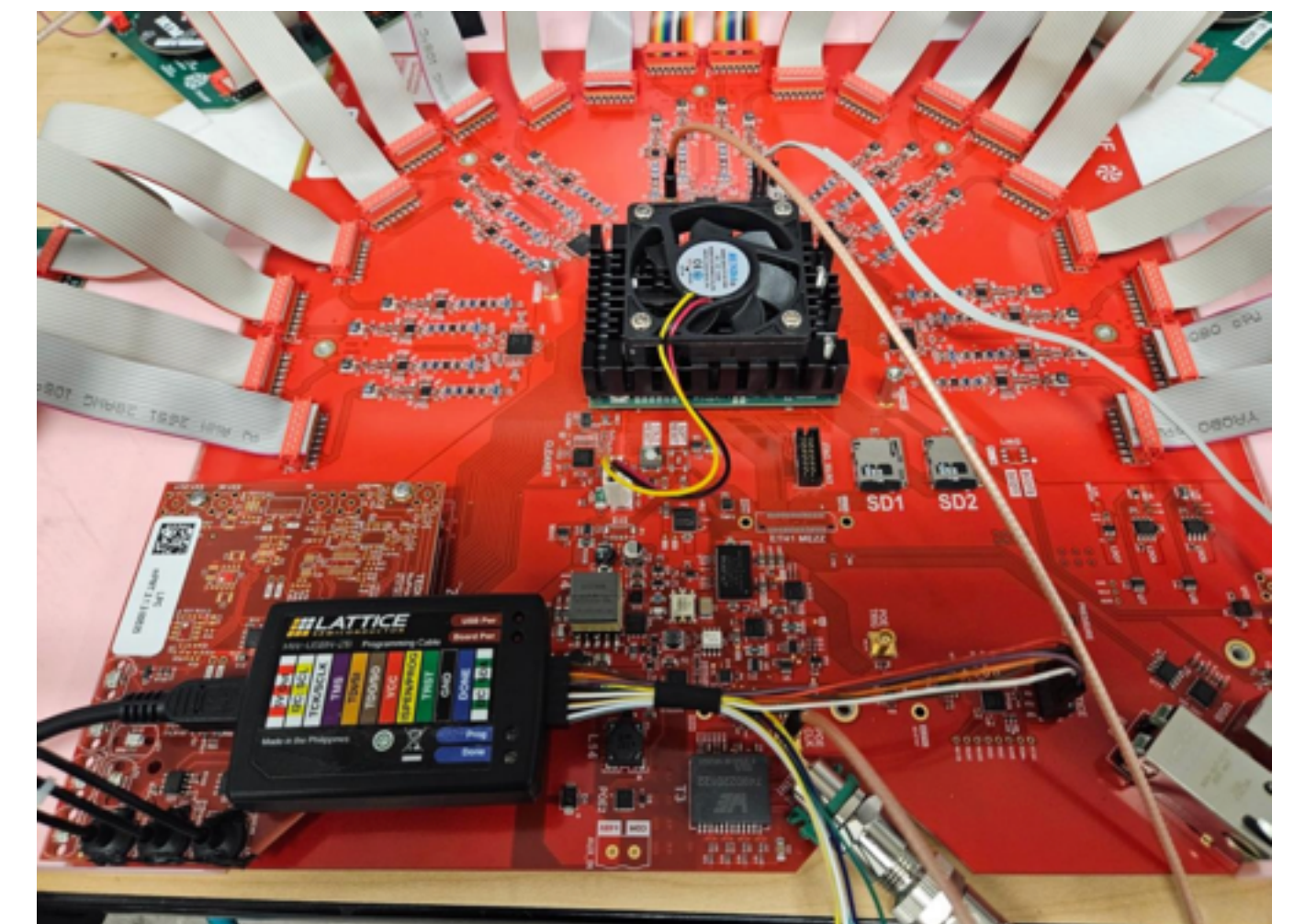
Multi-PMT Status

- Multi-PMT production for IWCD at University of Victoria has started with expected completion by March 2027
 - Being led by TRIUMF postdoc M. Gola, originally trained at TRIUMF during pilot production, bringing expertise to UVic
- SciTech electronics group has completed the procurement, production and QC of 320 electronics mainboards for the full IWCD production
- Proceeding with multi-PMT production depends on delivery of some components impacted by electronics shortages and global supply chain issues (FPGAs)
 - We still expect completion of the multi-PMT production well in advance of the start of detector construction

Produced mPMTs undergoing temperature test to ensure good optical gel contact



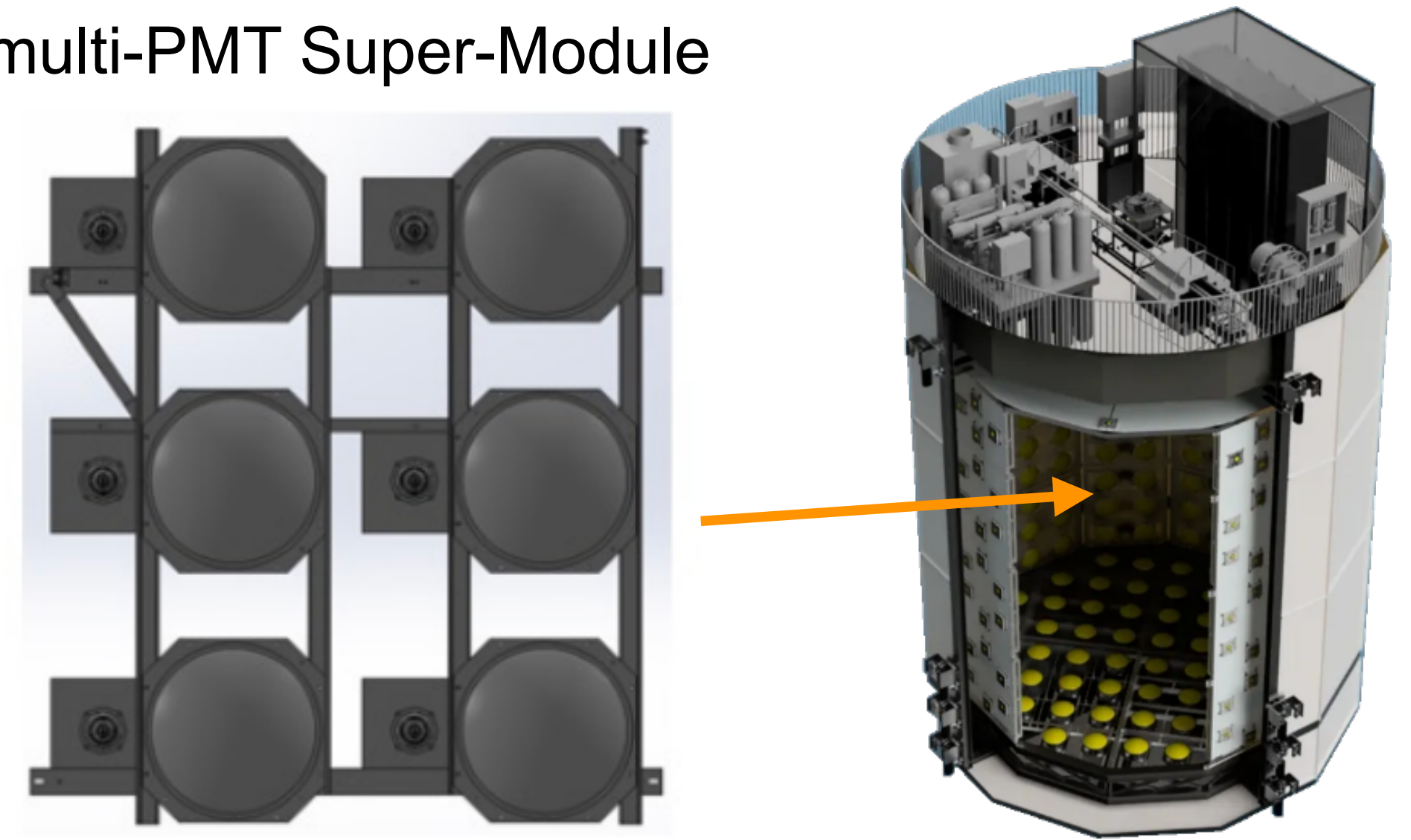
Mainboard QC Setup at TRIUMF



Multi-PMT Mounting

- Canada has taken responsibility for the method of multi-PMT mounting in IWCD and the corresponding structural elements
- Concept of pre-assembled “super-modules” to be installed in detector developed at TRIUMF
- Design of “super-module” frames for multi-PMTs at University of Victoria by TRIUMF engineer M. Lenckowski working with D. Karlen
- Prototype super-module assembled and multi-PMTs mounted at UVic last week (right)

multi-PMT Super-Module

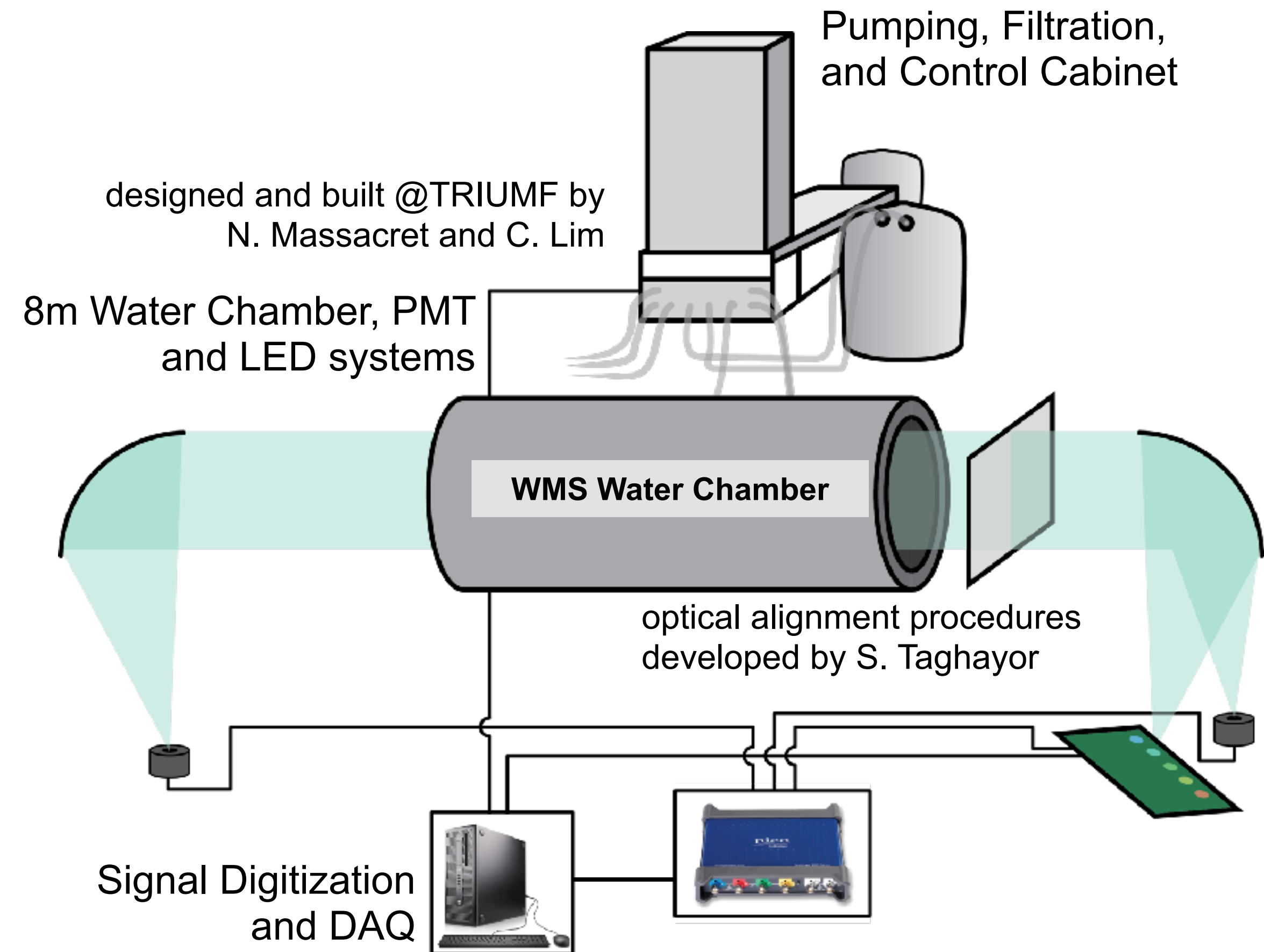


Assembly of Prototype Super-module



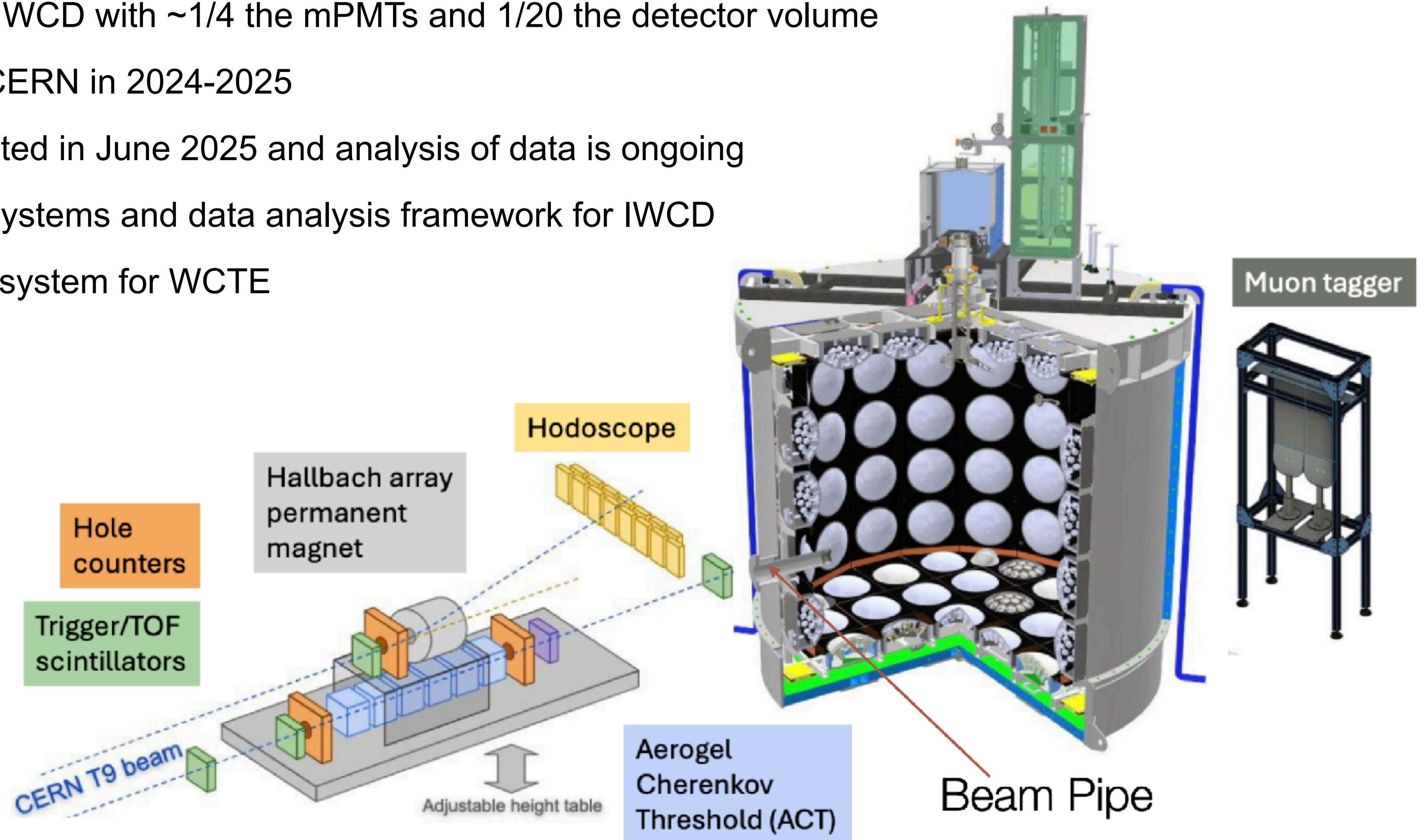
Water Monitoring System

- Monitoring the light attenuation in water is important for IWCD and Hyper-K
- Water Monitor System (WMS) developed with the SciTech department at TRIUMF
 - Concept developed by A. Konaka, also for environmental water quality monitoring
 - B. Smithers leading the project, started at postdoc in TRIUMF HK group
 - Design and construction by SciTech department
- Pulsed LED system to inject parallel focussed light into long water pipe
- PMTs on both sides measure light level before and after attenuation in water volume

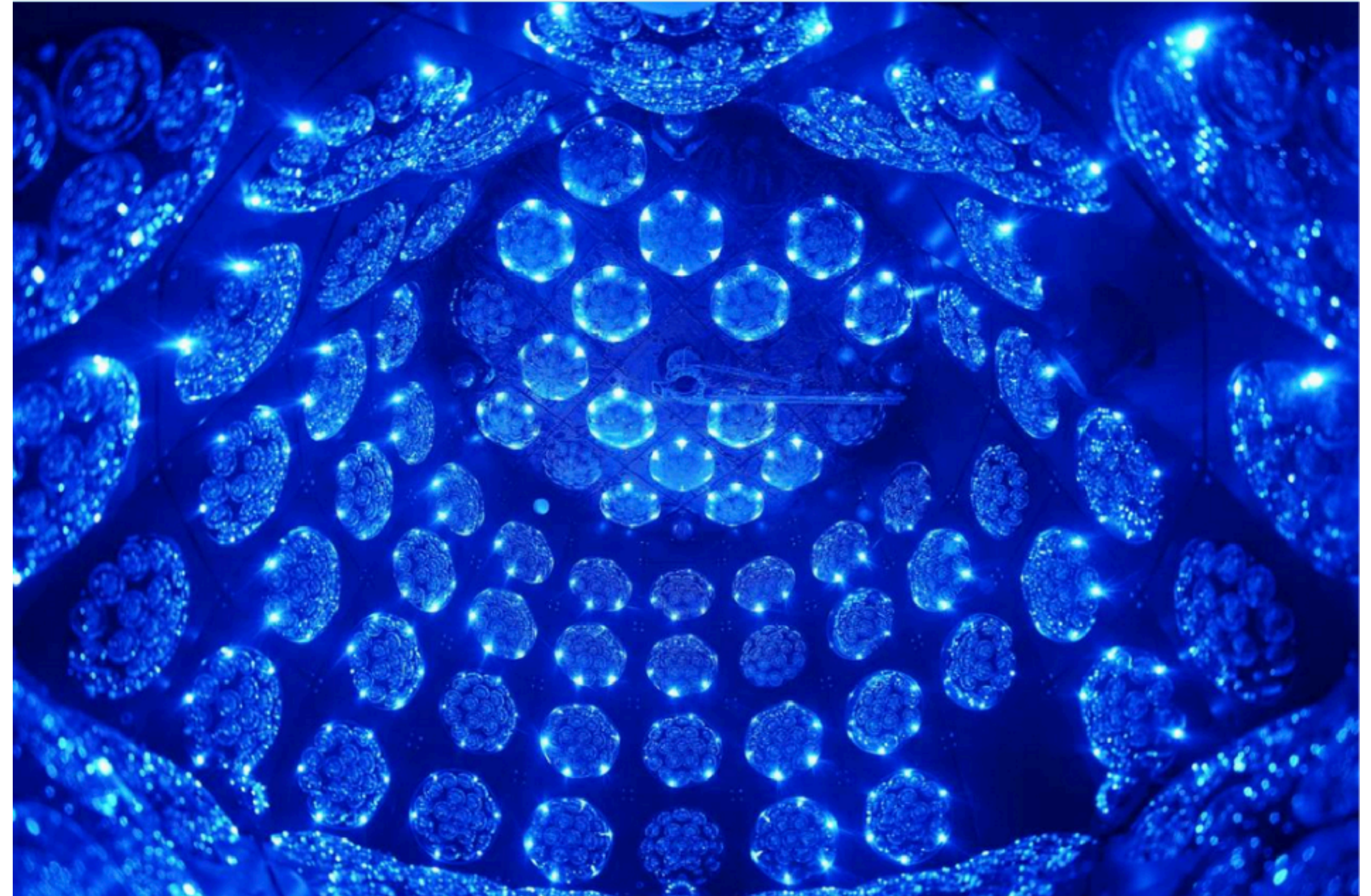


Water Cherenkov Test Experiment

- WCTE - Prototype for IWCD with $\sim 1/4$ the mPMTs and $1/20$ the detector volume
- Built and operated at CERN in 2024-2025
- Data collection completed in June 2025 and analysis of data is ongoing
- Establishing detector systems and data analysis framework for IWCD
- KEK involved in water system for WCTE



WCTE Installed at CERN



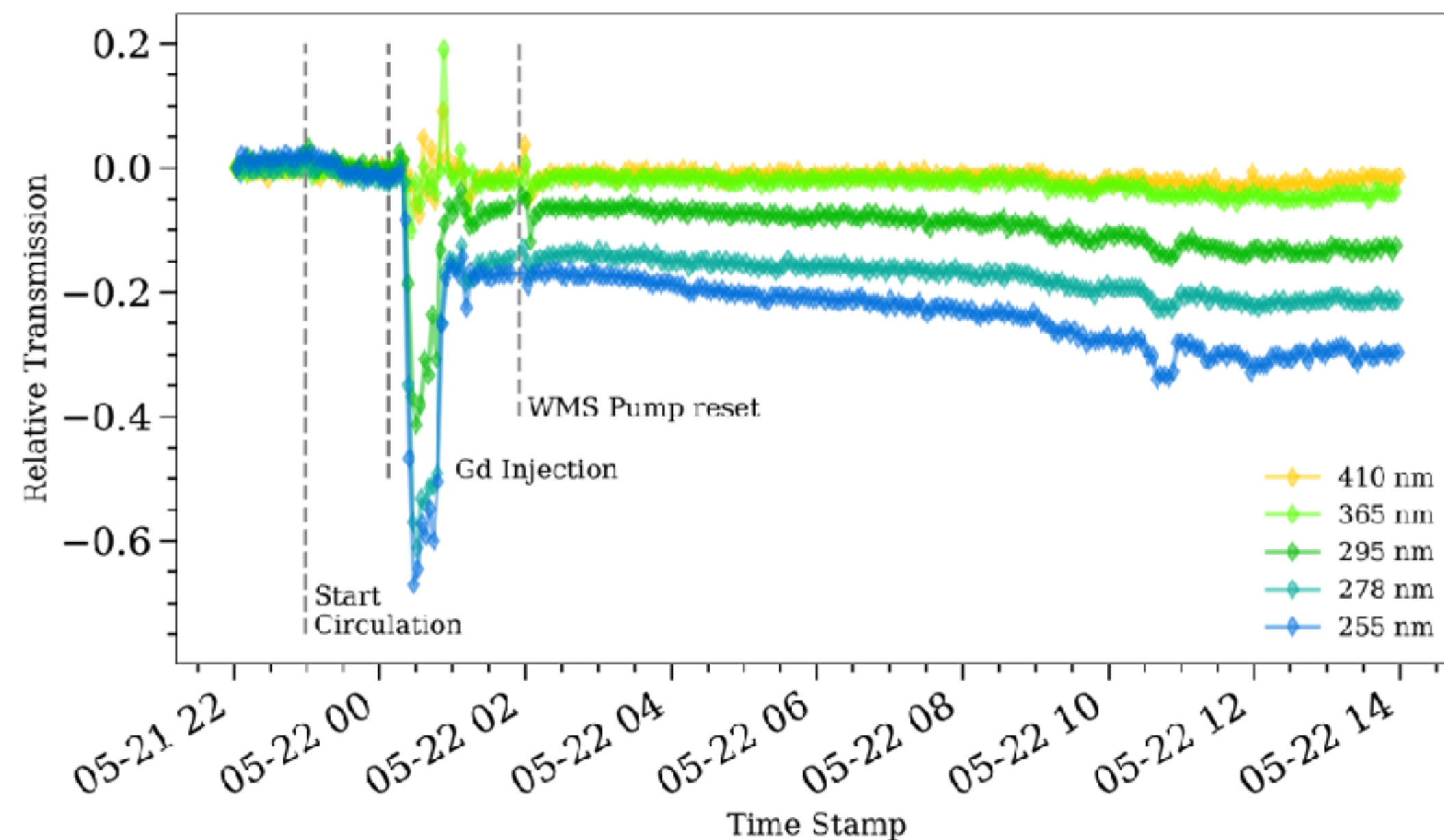
Picture inside WCTE detector with calibration lights turned on

WCTE Installed in East Area T9 Beamline

TRIUMF-KEK Symposium

Water Monitoring System at WCTE

- Prototype WMS installed in WCTE experiment at CERN with support from N. Massacret and A. Stockton from SciTech department
- Operated throughout WCTE providing important feedback, particularly during Gd loading

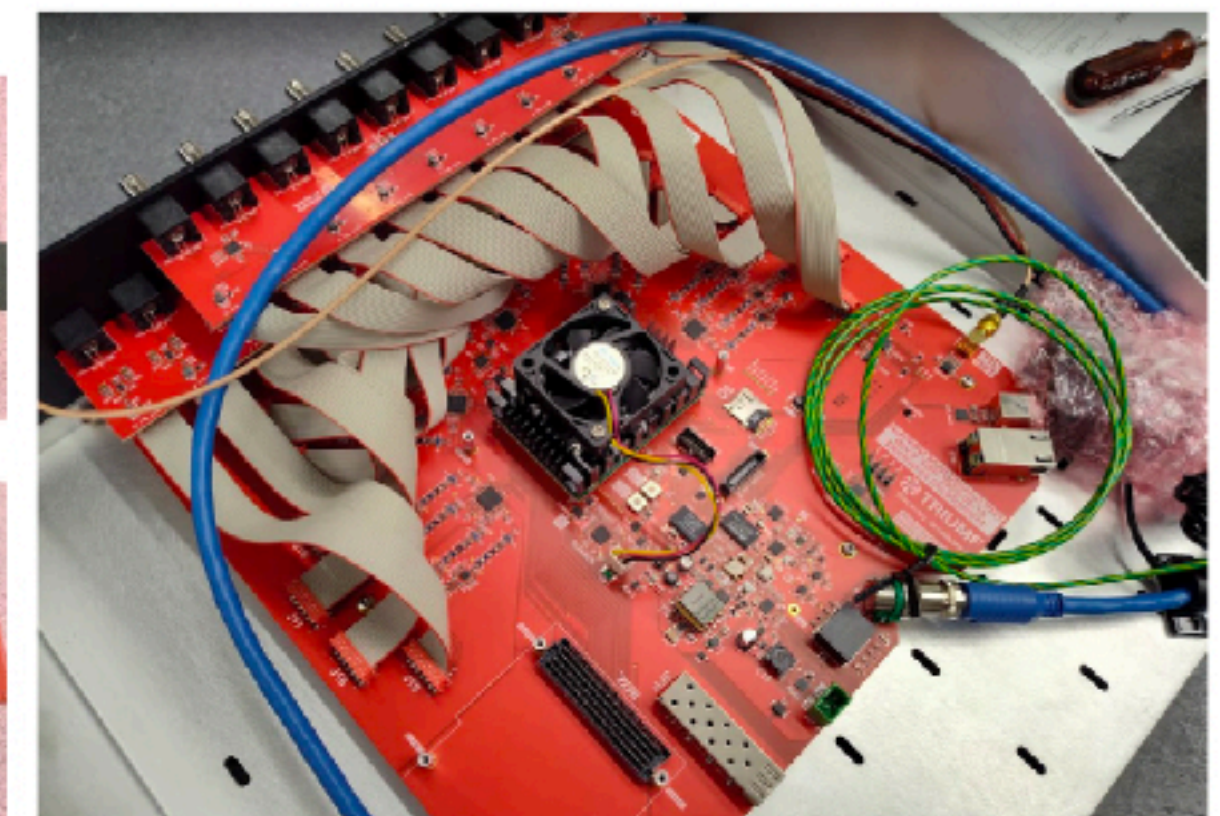
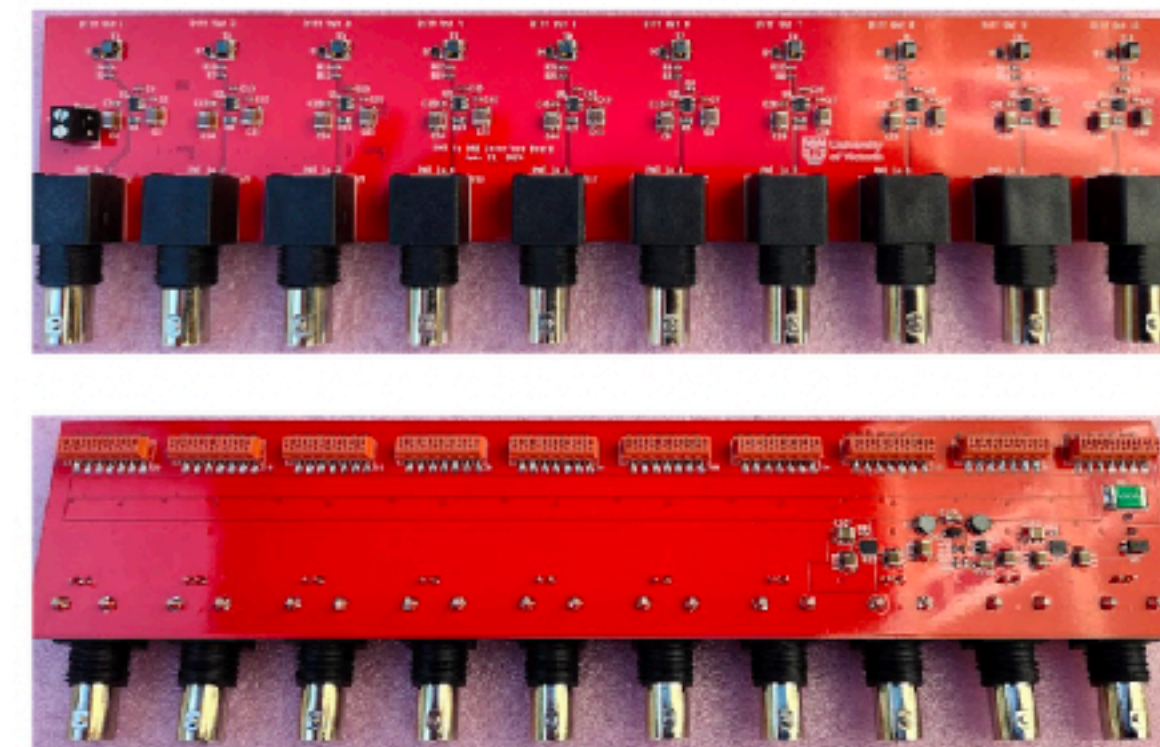


Important Outputs from WCTE → IWCD

- A number of multi-PMT failure modes were identified in WCTE and have been mitigated for the IWCD production
 - **Optical gel delamination fixed** by overpressure step during assembly
- **A new external triggering mode with digitized waveform readout** of all PMTs was developed
 - KEK to install a direct fiber connection to IWCD for beam trigger transport, allowing this triggering mode to be adopted for IWCD
- multi-PMT electronics mainboards also used outside of mPMTs for beam monitor signal digitization

multi-PMT mainboard adapted for external use

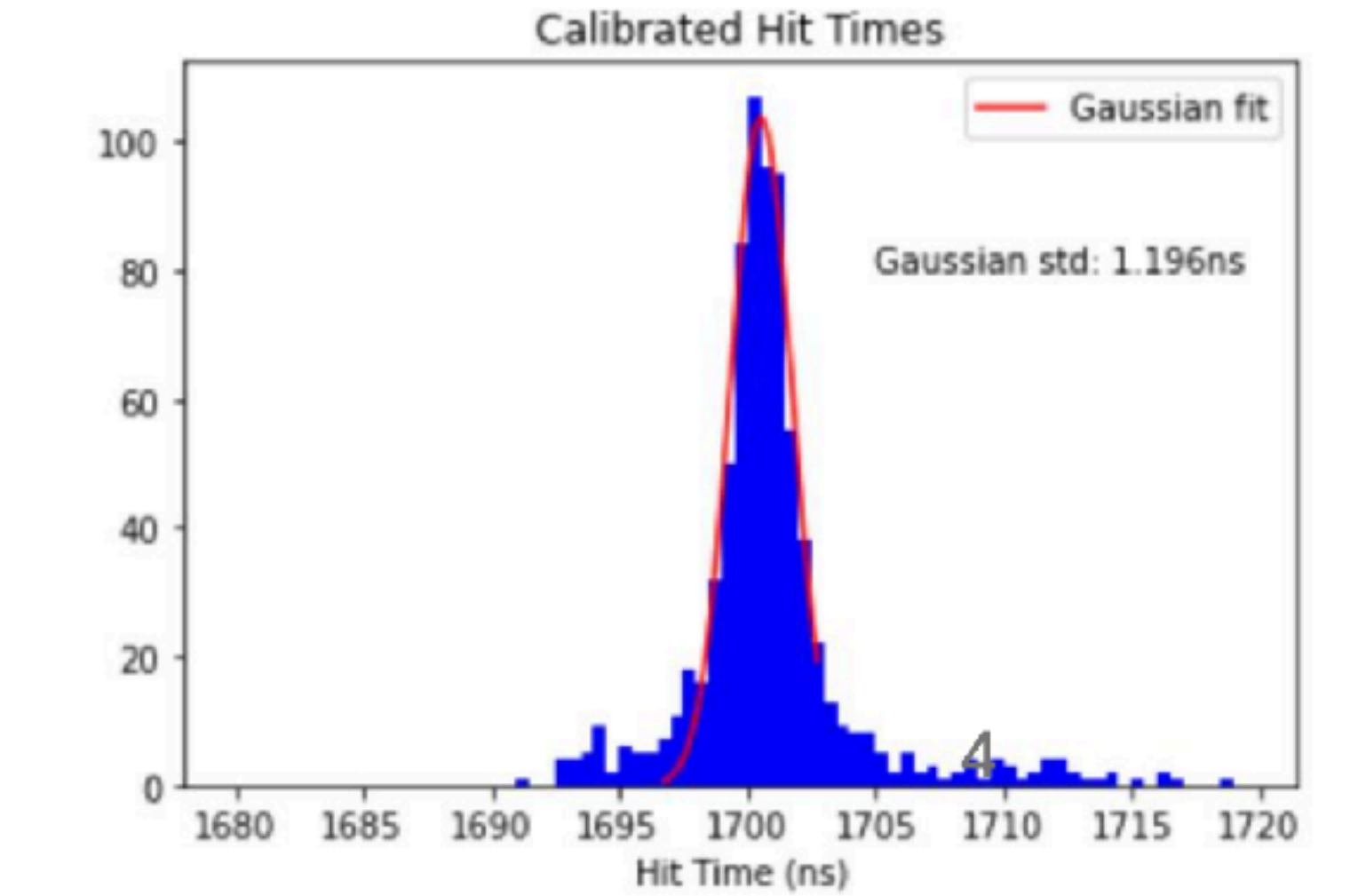
- **multi-PMT electronics boards will also be used to digitize signals from IWCD outer detector PMTs** in this type of configuration



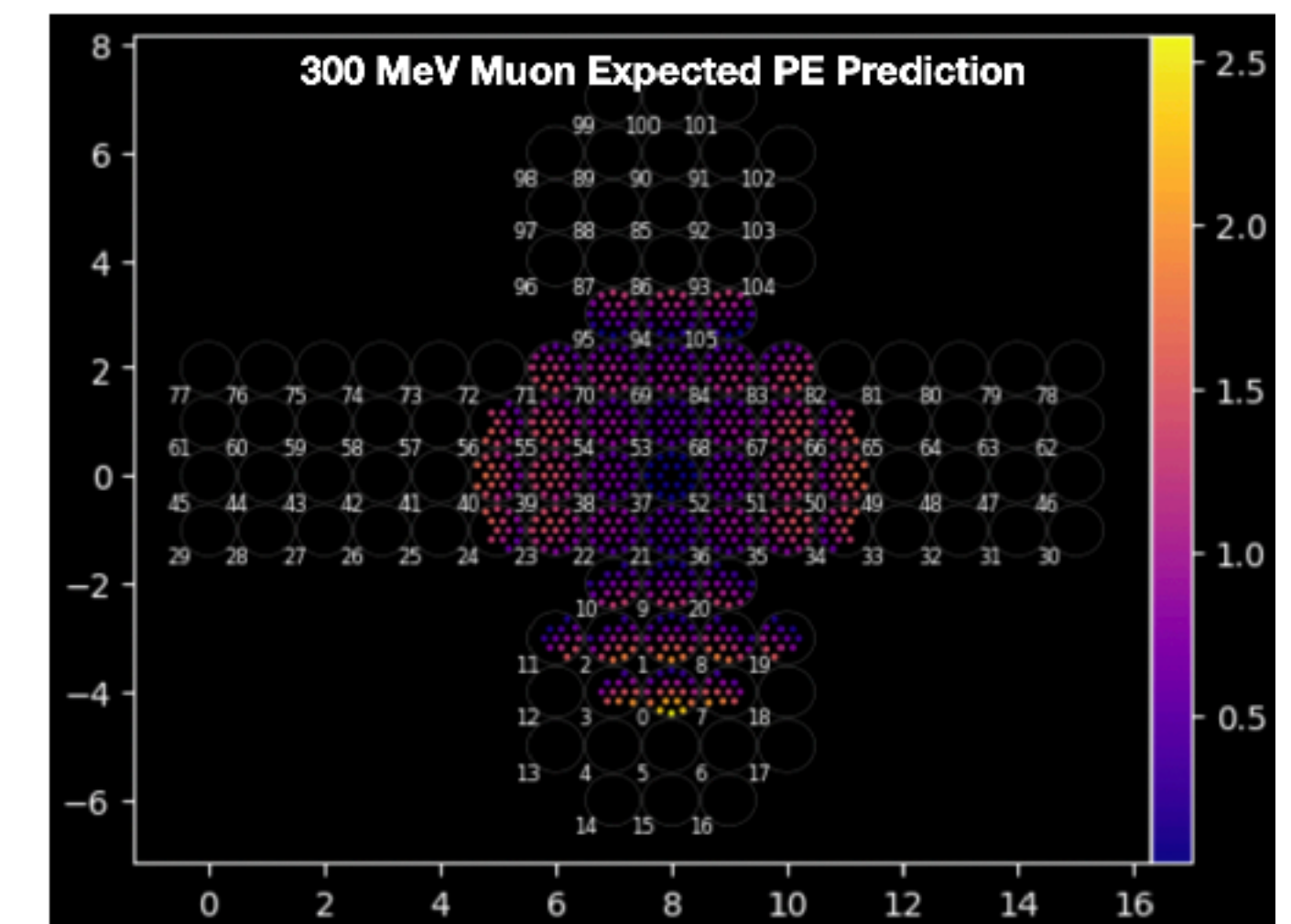
Important Outputs from WCTE → IWCD

- X. Li is leading the WCTE calibration efforts to establish the procedure that will be used in IWCD
- **Timing calibration sufficient to match PMT/electronics performance** has been achieved
- In-situ measurements of the PMT angular responses with LED light sources, radioactive source and
- TRIUMF postdocs L. Cook and A. Craplet are developing the data processing framework, that will also be applied to IWCD
- UVic/TRIUMF graduate student, J. Rimmer has developed a first principles likelihood fitter for muons that is leading to significant understanding of how second-order effects (multiple scattering, delta rays) impact event reconstruction

Time spread after calibration



Example predicted charge from new muon fitter

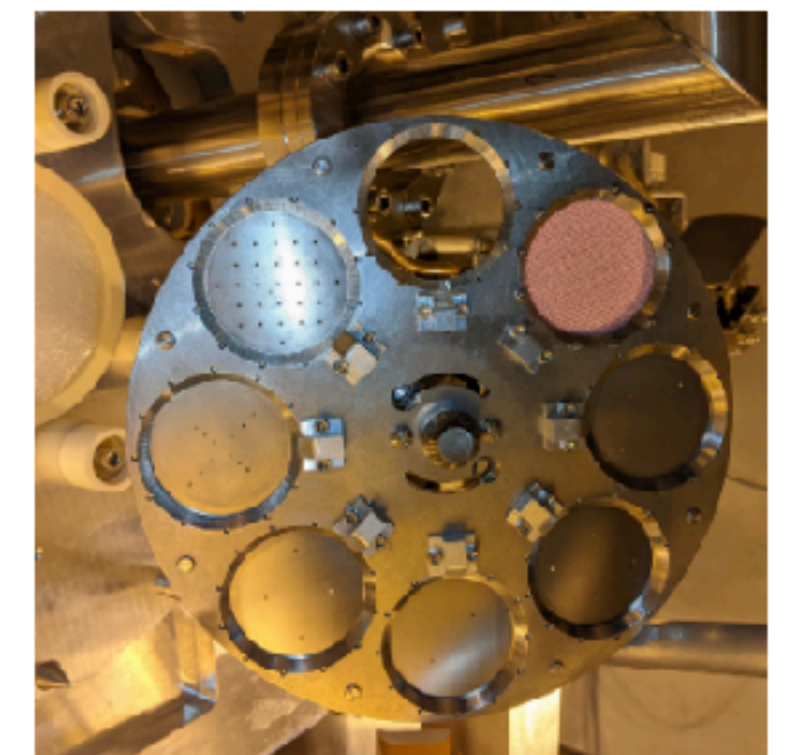
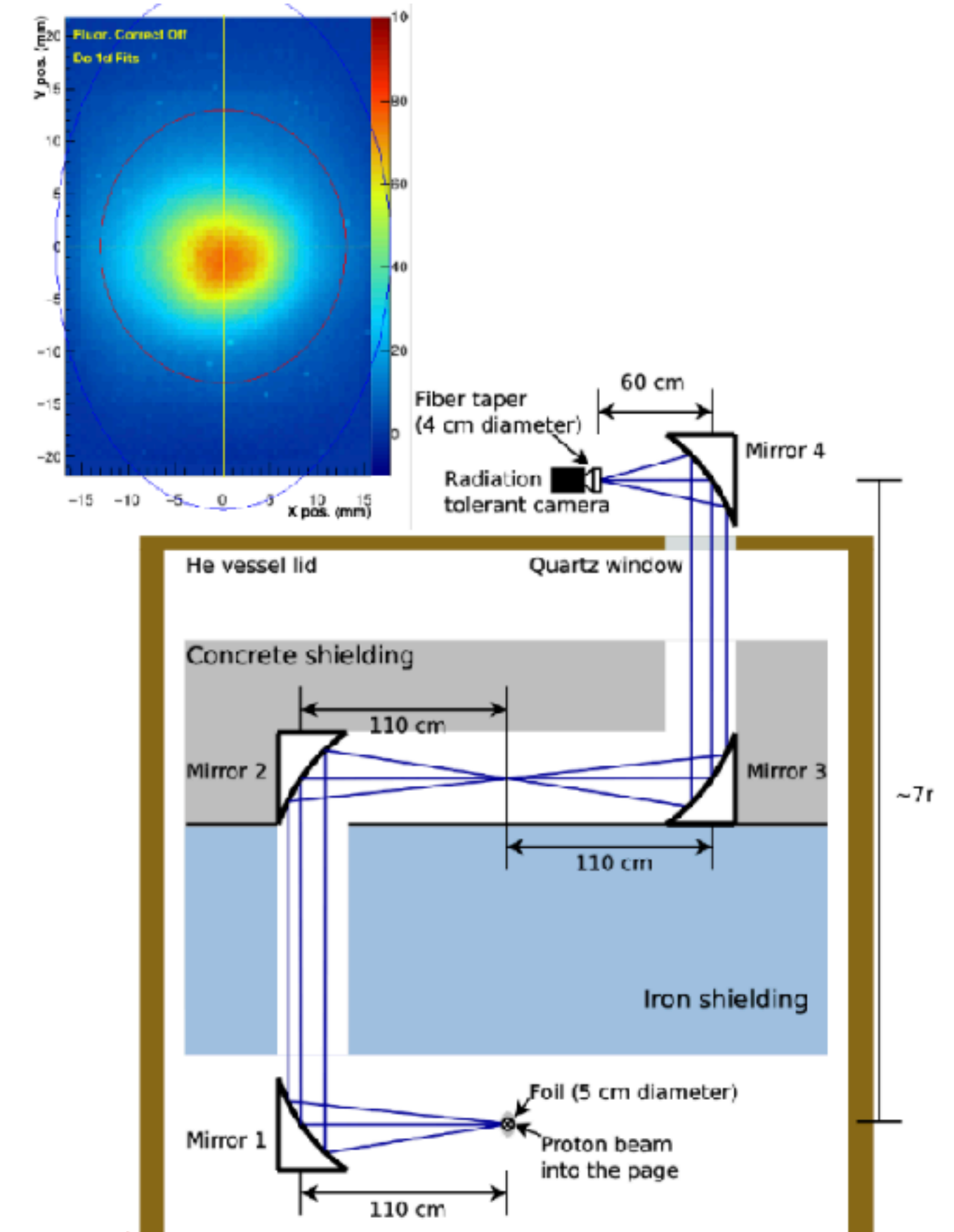
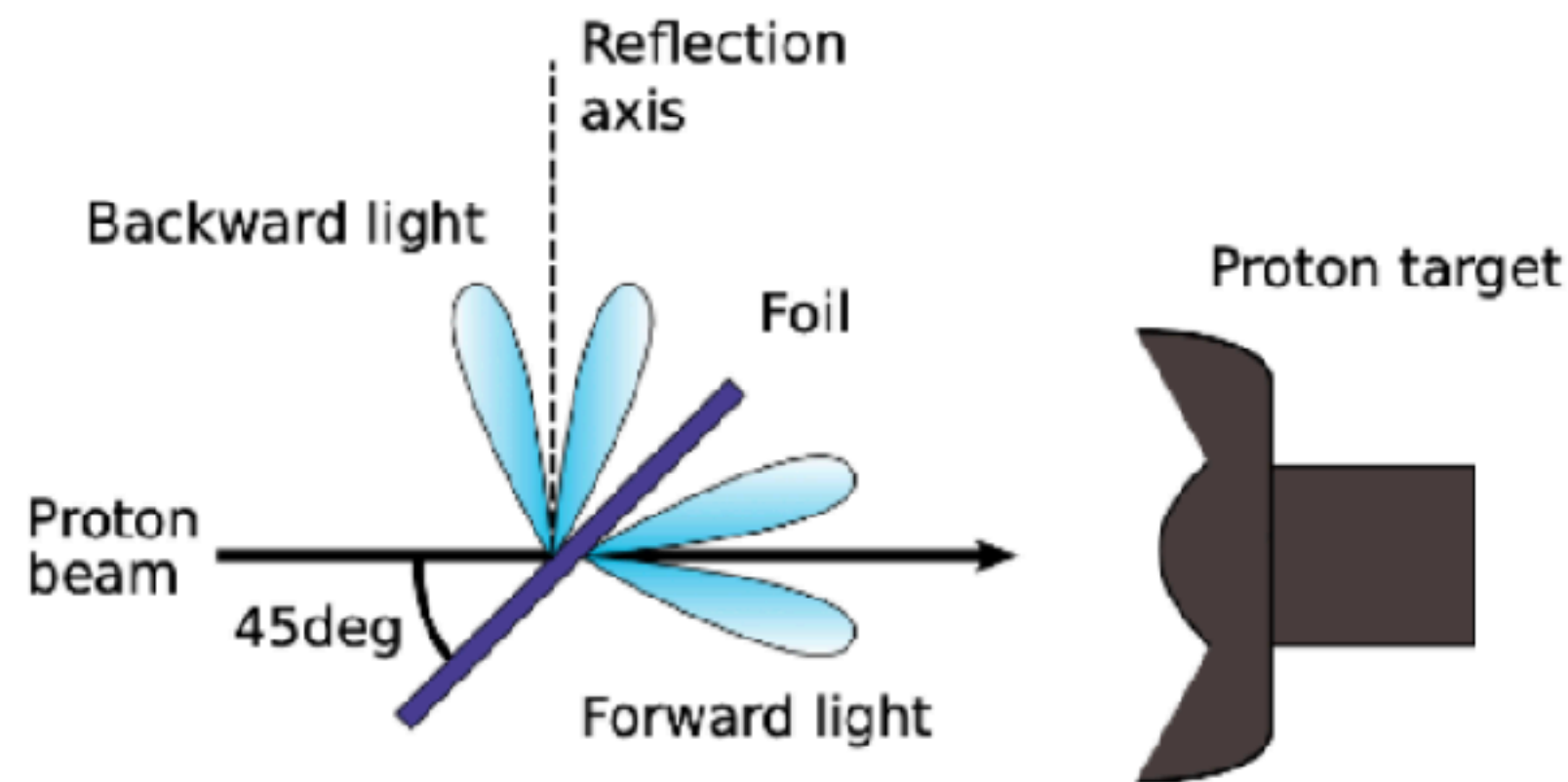


IWCD Construction Timeline

- TRIUMF and Canadian collaborators will start spending significant time in Japan for IWCD construction work
 - **April 2027:** Large-scale mockup of IWCD inner structure and super-modules to finalize installation procedure
 - **May - June 2027:** Repair of WCTE multi-PMTs that will be installed in IWCD
 - **July - Nov. 2027:** Initial assembly of super-module frames and installation of multi-PMTs
 - **Dec. 2027-Feb. 2028:** Final preparation of super-module frames
 - **Mar. - June 2028:** Installation of all detector components in IWCD
 - **July - Dec. 2028:** IWCD commissioning
 - **Jan. 2029:** Operation of IWCD (Hyper-K) with beam
- Important to establish logistical framework for significant work by TRIUMF and Canadian collaborators staying at J-PARC/KEK

Optical Transition Radiation Monitor

- OTR monitor with foil placed just upstream of the neutrino target
- Monitors proton beam transverse profile:
 - Input to neutrino flux calculation, important for getting correct off-axis angle
 - Helps ensure operating condition that is safe for the target



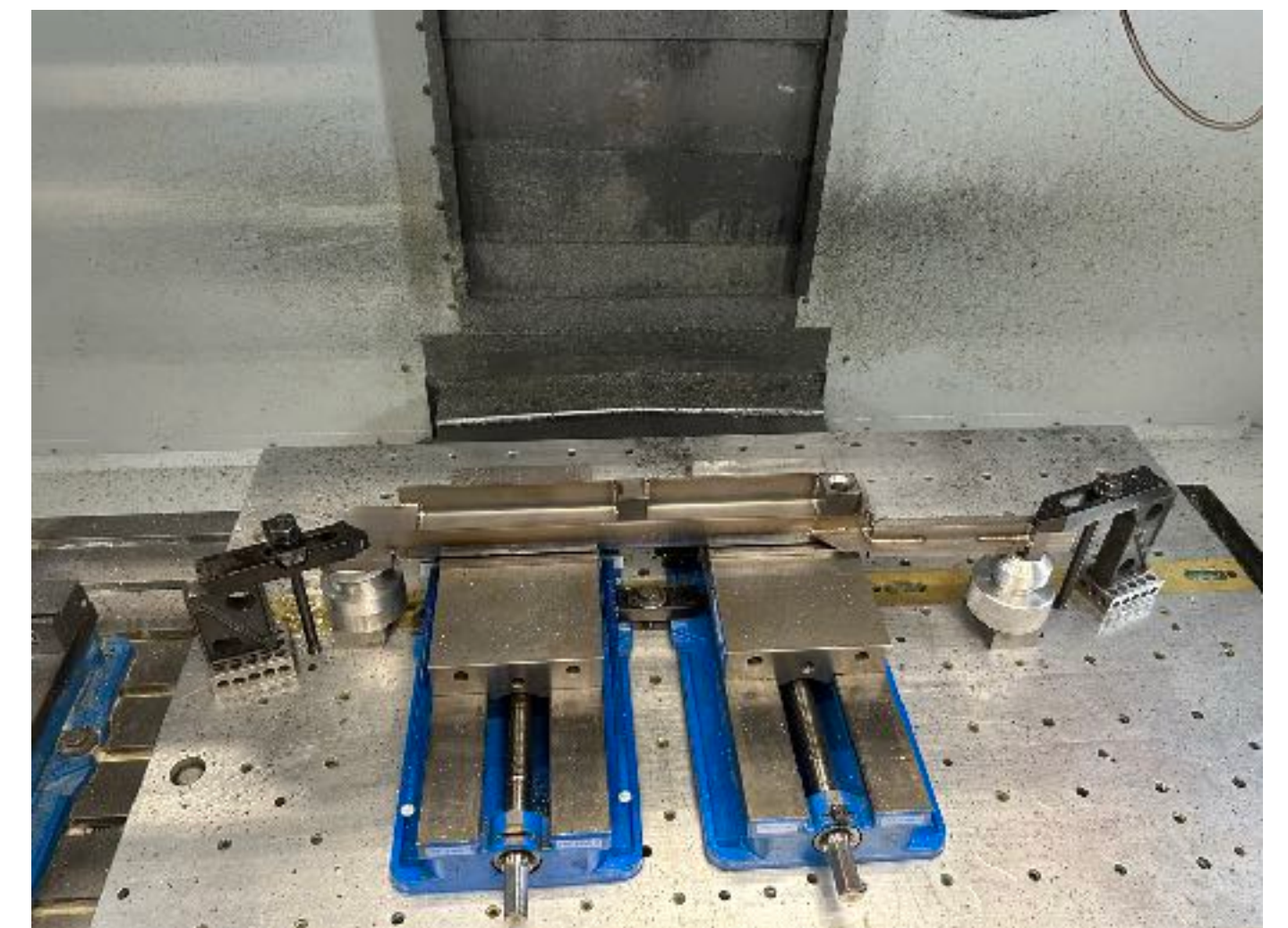
OTR in Hyper-Kamiokande

- OTR monitor has operated throughout the T2K experiment since 2009, must continue for Hyper-K
- New target rotation using Geneva mechanism to improve reliability
- Originally developed by U. of Toronto, York U. and TRIUMF - U. Of Toronto and York U. contributions finishing due to retirements
 - Imperial College London has taken responsibility for DAQ
 - TRIUMF is taking responsibility for mechanical components
- Most components are operating stably, but target disk and supporting arm must be replaced whenever first horn is replaced
- TRIUMF postdoc, F. Cormier, with SciTech engineering support producing 3 new arms, giving two spares for start of Hyper-K
- Significant support for machining at the TRIUMF Detector Support Facility

New Geneva Mechanism for Disk Rotation



Arm feature machining at DSF



Summary

- IWCD is an important part of the Hyper-K program that will constrain systematic errors related to neutrino-nucleus interaction modeling
- IWCD is progressing well with facility construction underway, detector component production started and detector assembly scheduled to start in late 2027
- WCTE operation at CERN successfully completed and is having a significant impact on the IWCD design and the preparation for IWCD calibration and data analysis
- Major IWCD construction activities by collaborators at J-PARC will start around April 2027
- It is also important to continue to support the operation of the OTR beam monitor during Hyper-K
- Many activities for Hyper-K at J-PARC are benefiting from and will continue to benefit from strong collaboration between TRIUMF and KEK