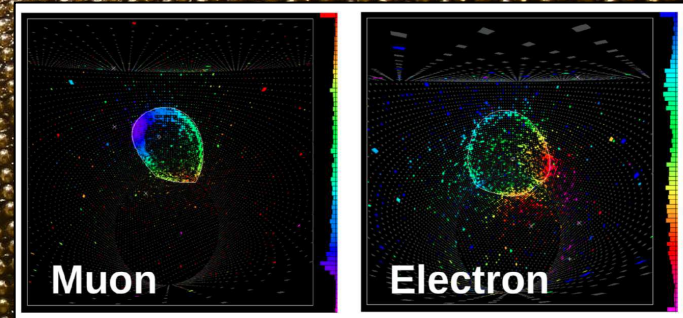
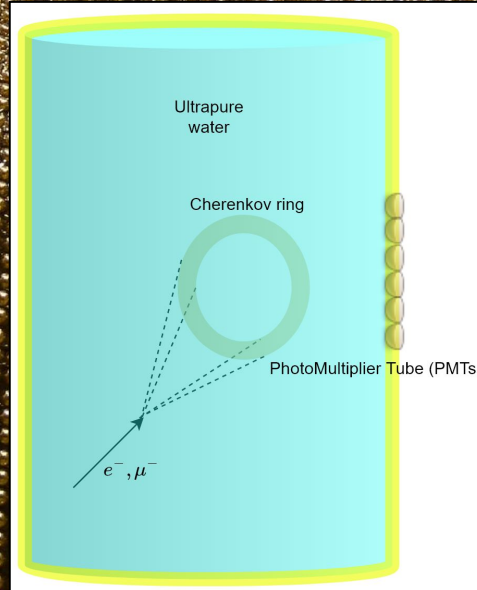
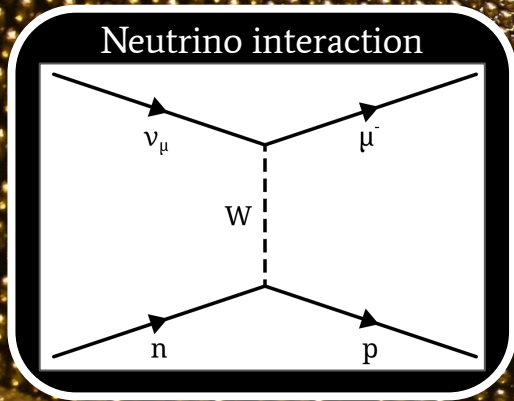


ICRR Inter-University Research Program 2022/2023

Neutrino and Astroparticle Research Division

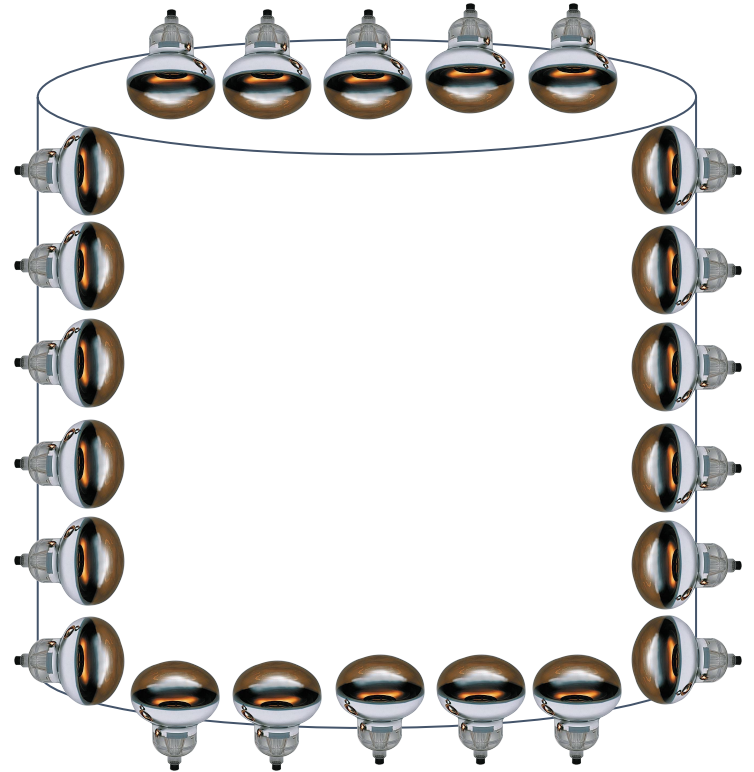
New Photogrammetry Calibration for Super-Kamiokande and Hyper-Kamiokande

Super-Kamiokande



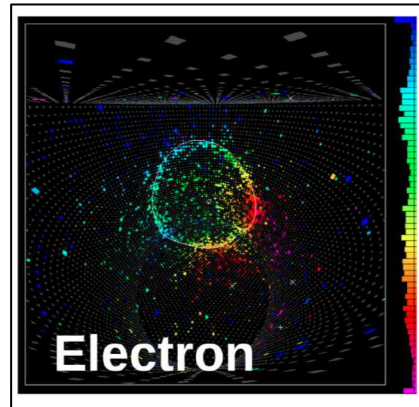
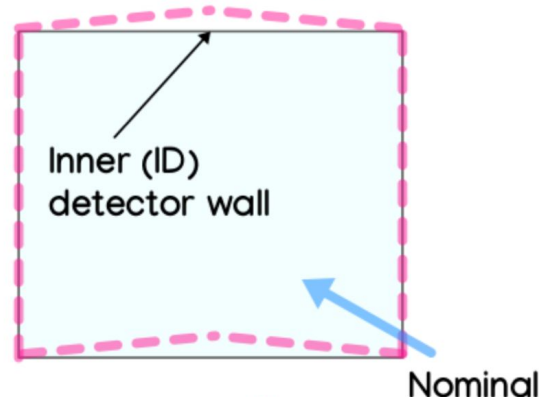
Systematic Error: Geometry

PMTs assembled in air

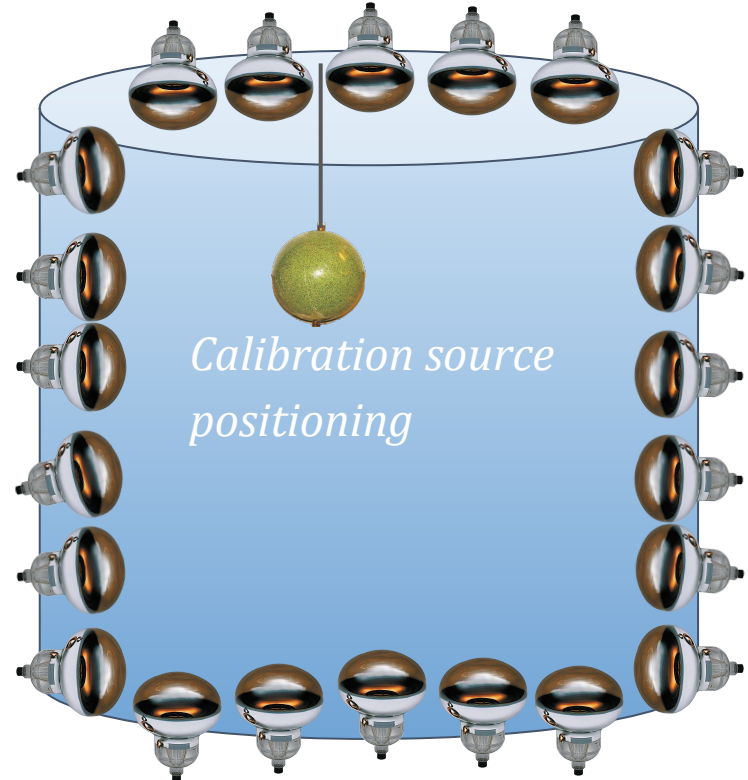


Systematic Error: Geometry

- Example systematic deviation of ID PMT geometry
- Nominal assumption in analysis can produce incorrect results
 - Critical for precision measurements

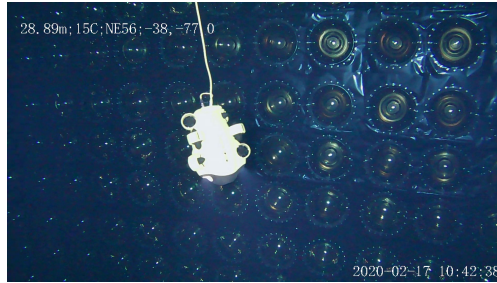
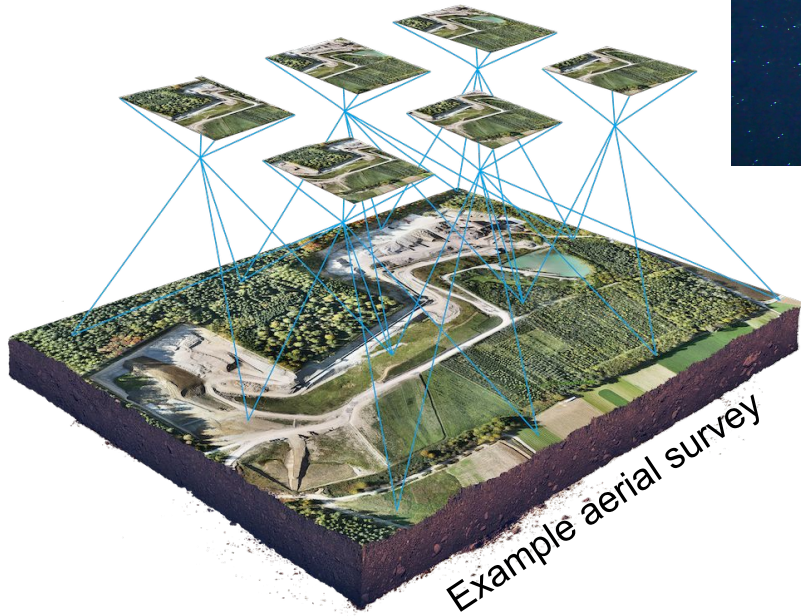


Potential PMT shifting due to buoyancy after water filling

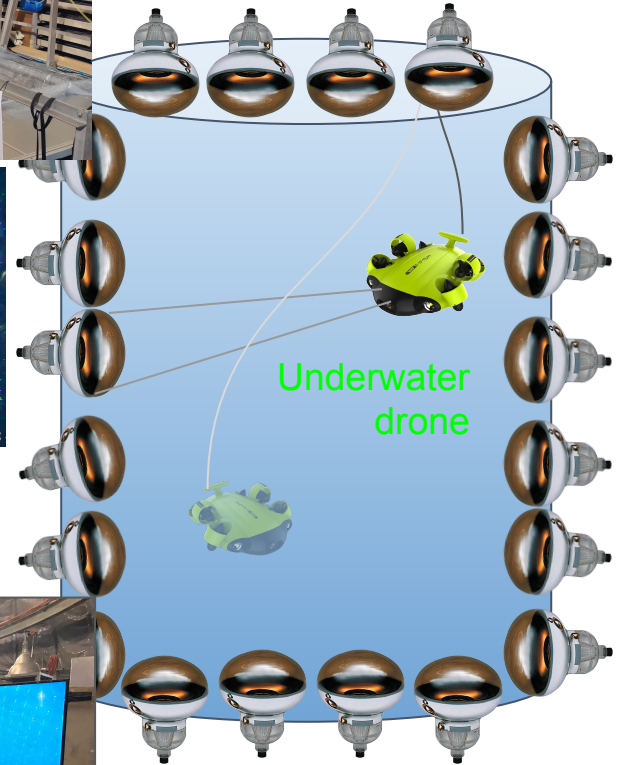
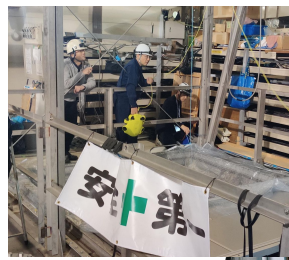


Photogrammetry Review

Reconstruct the 3D structure from multiple 2D photographs to mitigate systematic error

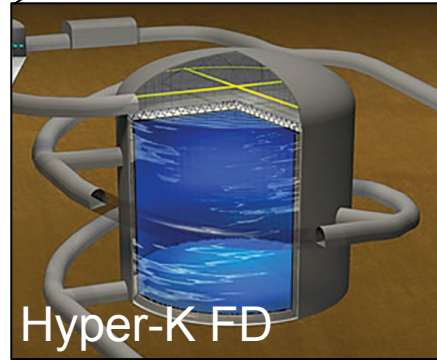


Feb. 2020
Took ~13000 photos
(~1800 positions)

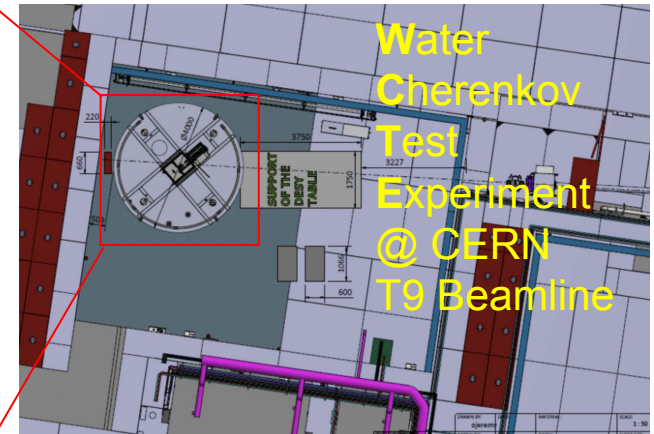
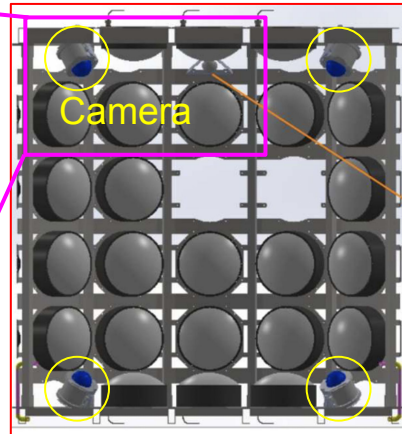
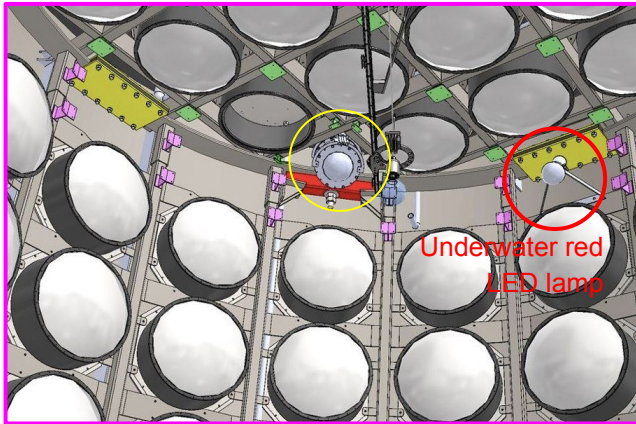
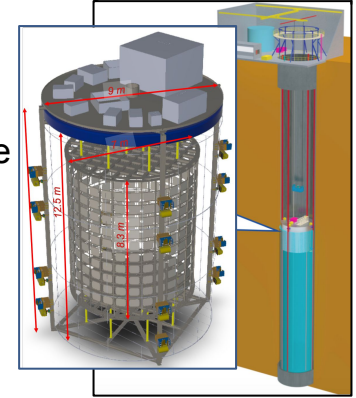


Fixed Camera System

- Developing an 8-camera system for WCTE, which will be re-used in Hyper-K IWCD
- Hyper-K FD design and funding request is ongoing



Hyper-K
Intermediate
Water
Cherenkov
Detector



Funding Summary

Approved amounts:

Year	Goods	Travel	Top-up	Total
2019	700,000	300,000	500,000	1,500,000
2020	200,000	300,000		500,000
2021	300,000	200,000		500,000
2022	150,000	300,000		450,000
2023	50,000	300,000		350,000

*Reported
this time*

Actual spending:

Year	Goods	Travel		Total	Remainder
2019	832,236	653,170		1,485,406	14,594
2020	0	127,739		127,339	372,261*
2021	872,234	0		872,234	27
2022	124,309	156,940		281,249	168,751*
2023	518,751	0		518,751	0

Funding Summary

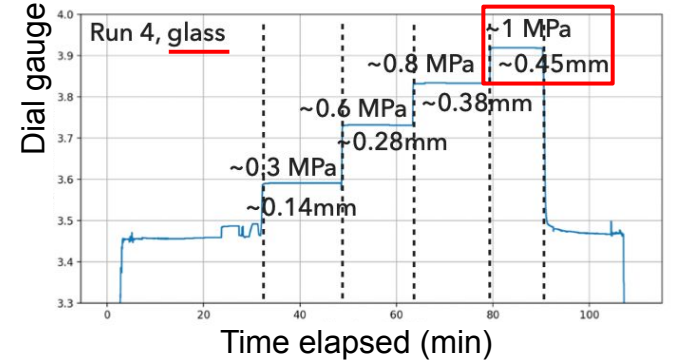
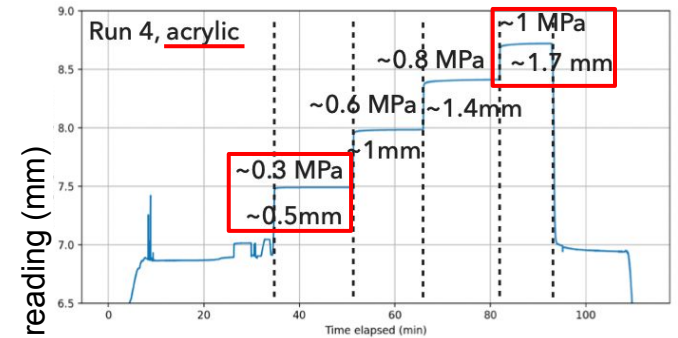
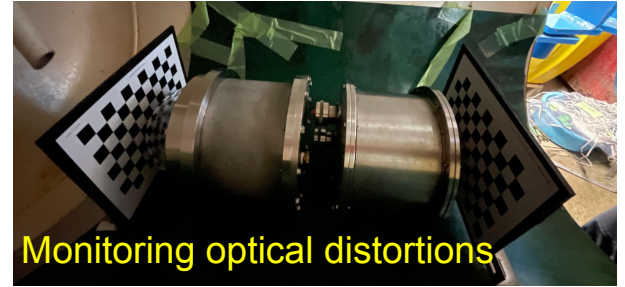
- 2019 Goods: Drone, cameras and lamps, deployment hardware
- 2019 Travel: Detector survey and reporting at collaboration meetings
- 2020 Travel: Shipping to Canada to continue calibrations
- 2021 Goods: Underwater red LED lamp
- 2022 Goods: Pressure testing equipment
- 2022 Travel: Pressure testing camera vessels at Kamioka Lab-F
- 2023: Underwater acoustic locator, rental of pool facility for testing

Actual spending:

Year	Goods	Travel		Total	Remainder
2019	832,236	653,170		1,485,406	14,594
2020	0	127,739		127,339	372,261*
2021	872,234	0		872,234	27
2022	124,309	156,940		281,249	168,751*
2023	518,751	0		518,751	0

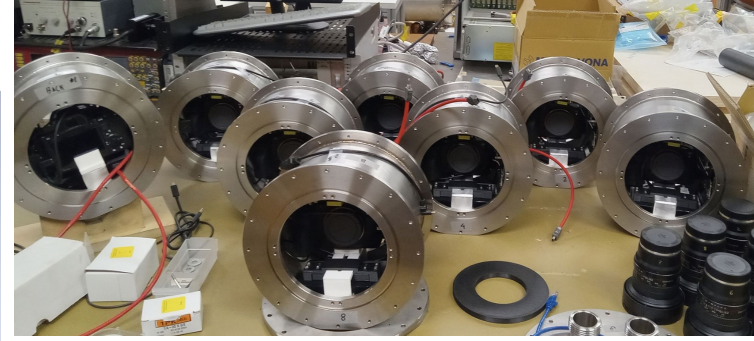
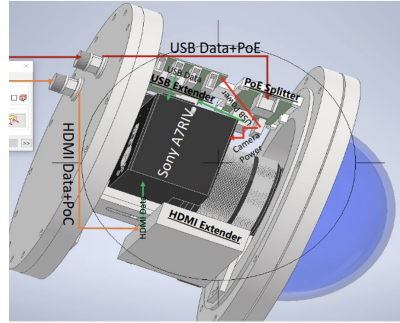
Pressure Tests

- Purchased dial gauges, lamps, weights, etc. for pressure testing camera housing prototypes at Lab-F in Kamioka Lab
- Acrylic dome is fine for WCTE/IWCD depths
- Glass is preferable (less deformation) for HK-FD
 - However, a leak was found in current prototype, so need to develop new design



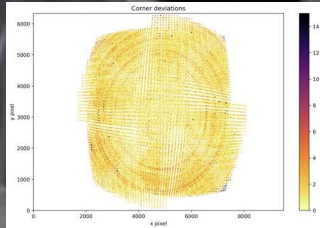
Production Progress

Assembly and calibration is on-track for delivery to WCTE this summer 2024



Test Tank Facility at U.Winnipeg

Calibration pattern



Moveable gantry



View from camera



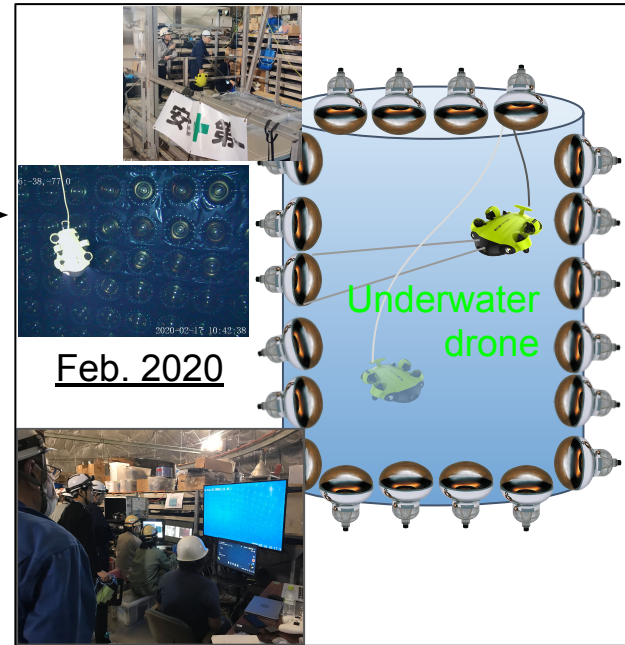
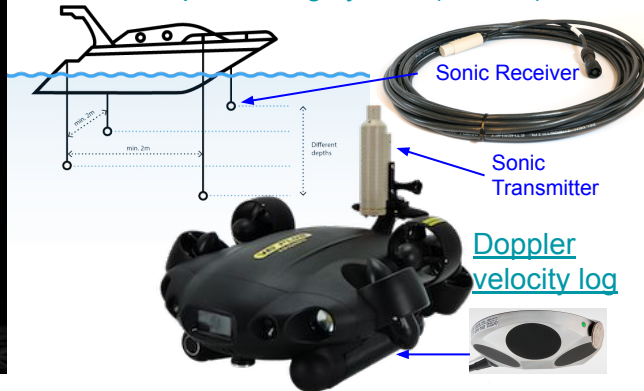
Moveable Camera System

- Concerns and challenges raised at last Super-K Tank-Open Work drone camera deployment:
 - Potential collision with detector walls (PMTs, blacksheet)
 - Manual piloting fatigue → limited data taking time
 - Incomplete tracking of position → Missing parts of detector
- Company has integrated new systems for absolute (and relative-to-wall) position determination:

Sonar distance monitoring



Acoustic positioning system (U-GPS)

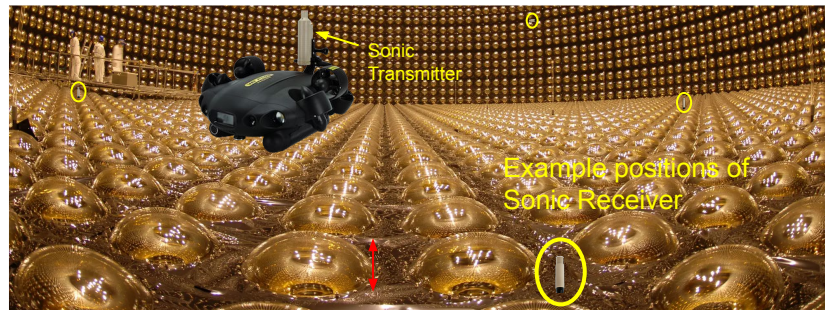


- Can develop automatic piloting for data taking, and safety interlocks to shut down or reverse in case of proximity to wall

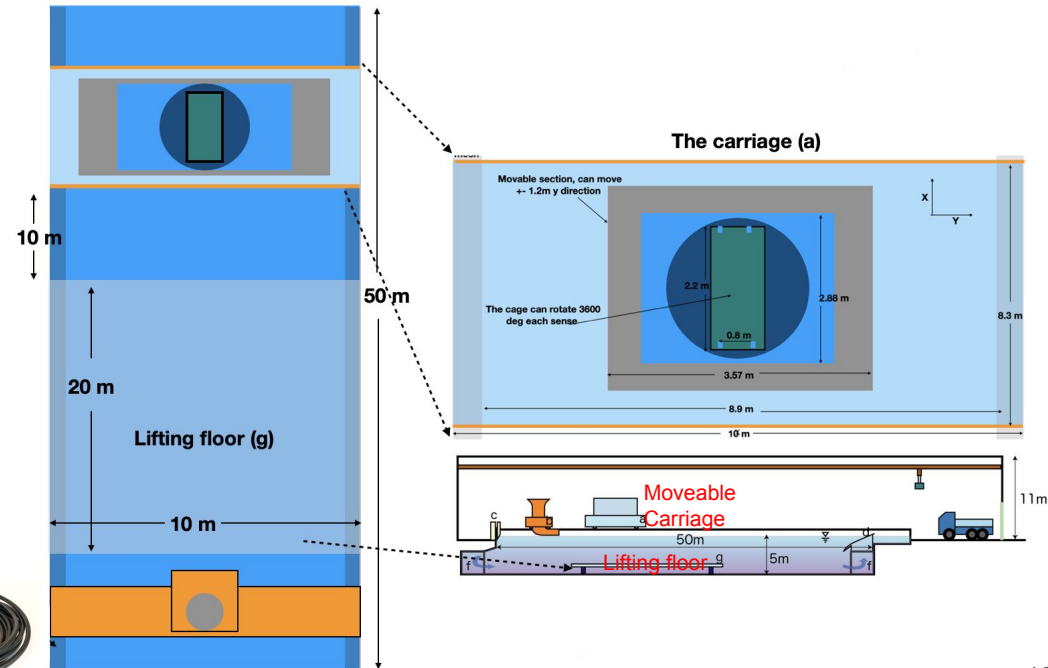
Positioning System Testing

- [University of Tokyo, Institute of Industrial Science, Ocean Engineering Basin](#)
 - Rented for 1 week (Sep. 11-15, 2023) for ¥300k (¥141.5 from this fund)
- Translational carriage (and rotational platform) that can be controlled to the mm (sub-°) level to cross-check drone positioning systems
 - Evaluate precision and accuracy

Example positionings of receivers in a WC detector



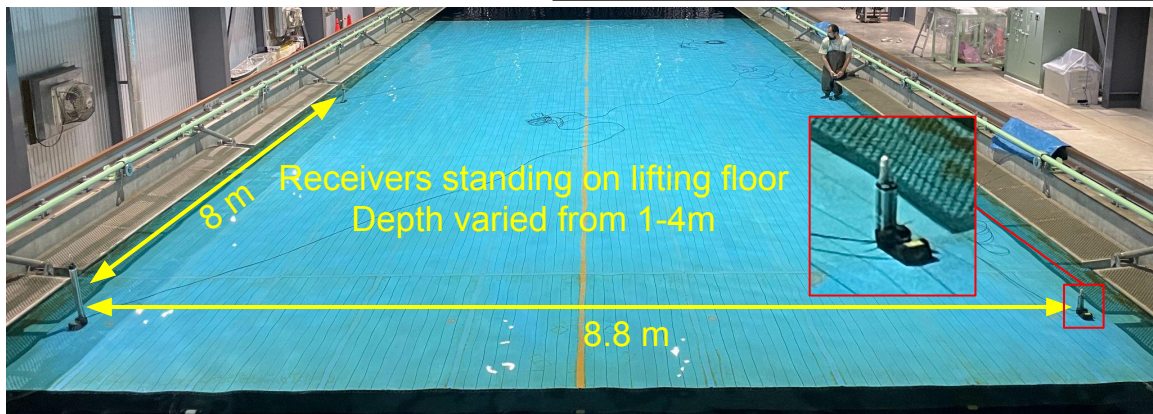
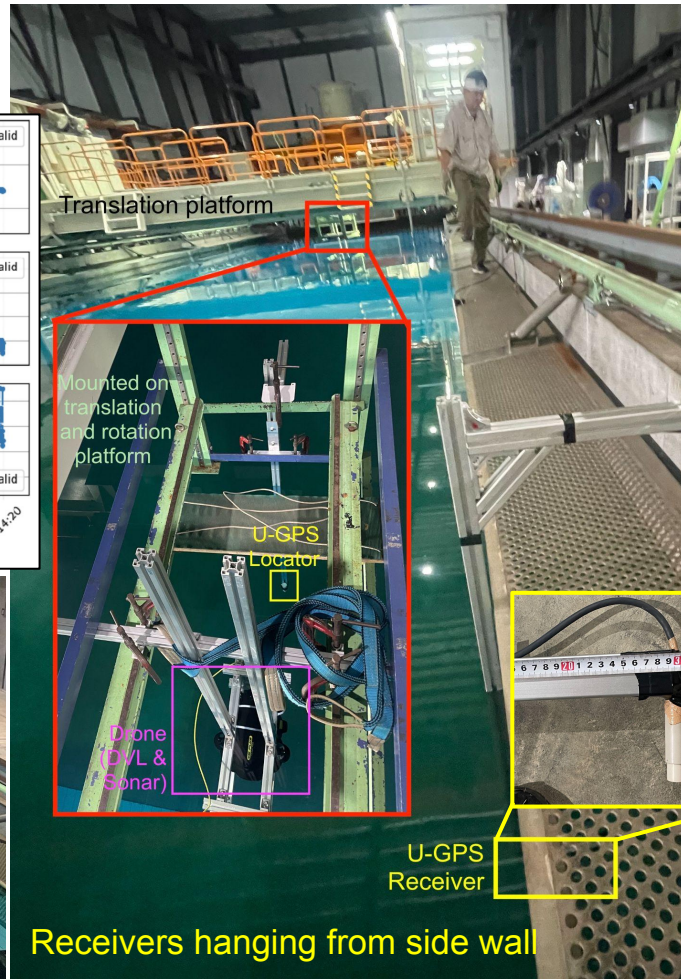
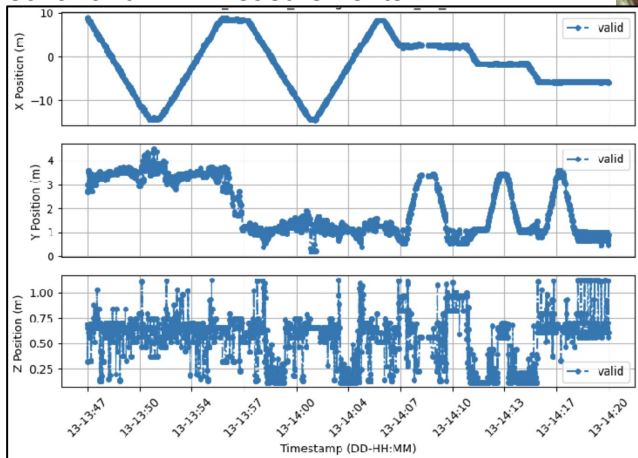
Height of photomultiplier tube (PMT) dome above wall = ~17 cm



Positioning System Test Progress

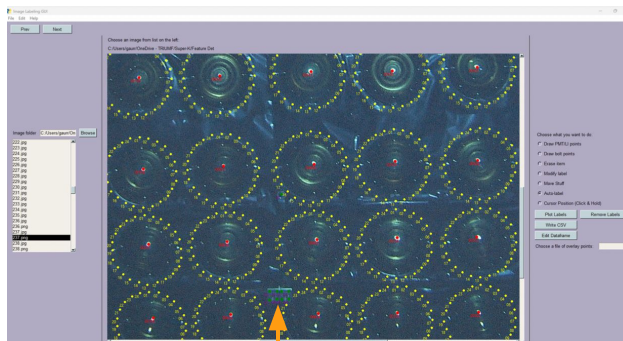
- Mounted receivers in various configurations
- Mounted new drone (sonar, DVL) and acoustic locator on moveable carriage
- Performed several (x,y) translations across whole baseline, and rotations
- Analysis ongoing

U-GPS (x,y,z) Readings, to be correlated with sonar and DVL measurements

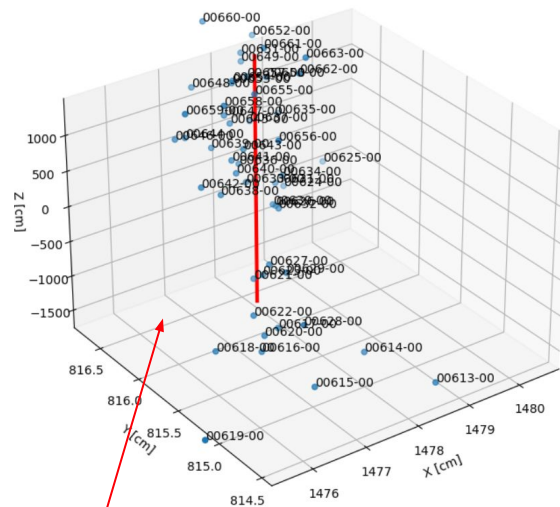


Super-K Analysis Progress

- New semi-automatic image labeling software
 - Labelled ~69 new images: >14k features
- Checked verticality around LI column:
 - Radial RMS: 1.1 cm
 - Tangential RMS: 0.5 cm

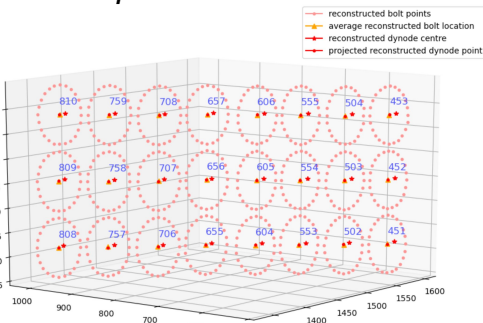


Light injector (LI)



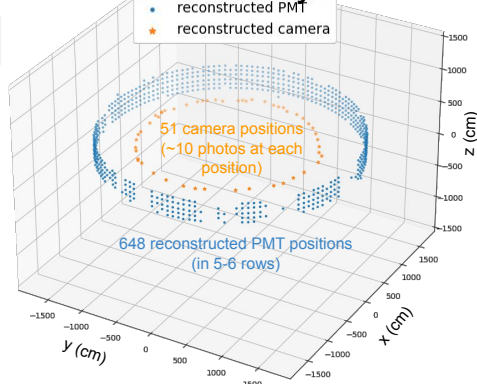
May 2020: 24 PMTs

Develop reconstruction code



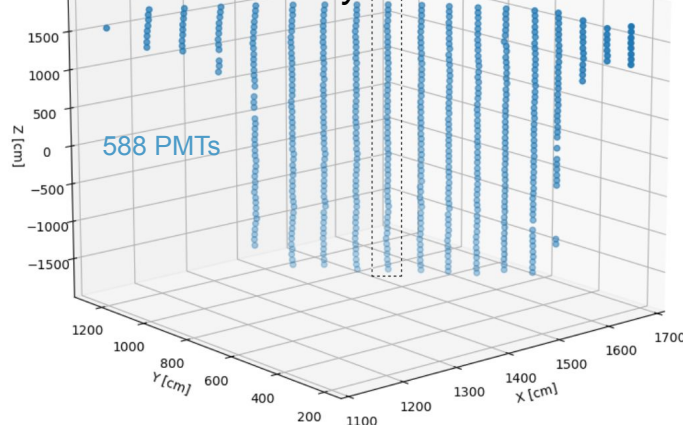
March 2021: Barrel Rings

Confirm circularity



Dec. 2023: Vertical Columns

Confirm verticality



Future Complete Entire Detector

Summary

- Camera housing production for WCTE (and HK-IWCD) proceeding well after successful pressure tests in Kamioka
- Evaluating performance of drone positioning systems in large pool laboratory
- Analysis of Super-K photos is progressing
- *Thanks to ICRR-IURP for supporting this work!*

ICRR Inter-University Research Program 2022/2023

Neutrino and Astroparticle Research Division

Water Purification R&D for Precision Neutrino Detectors

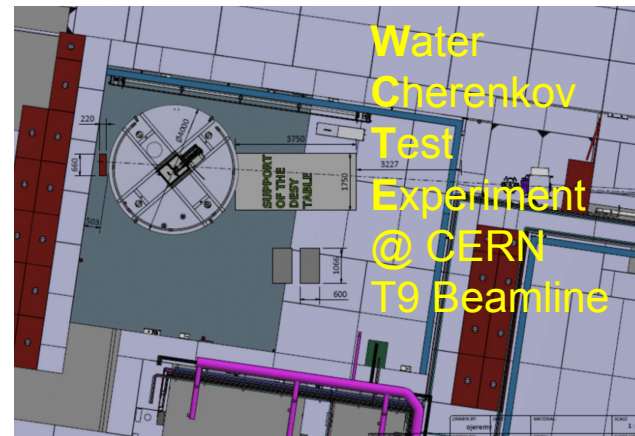
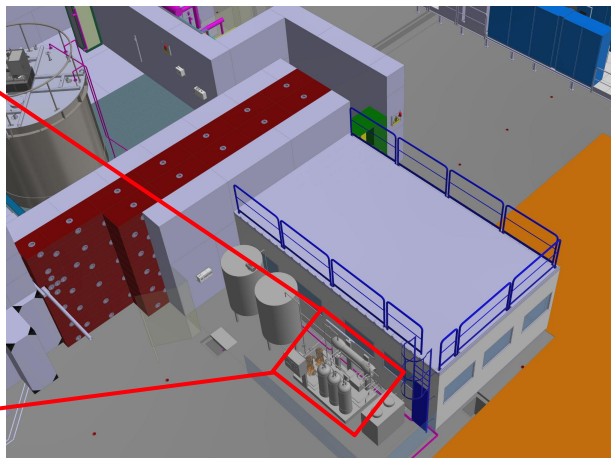
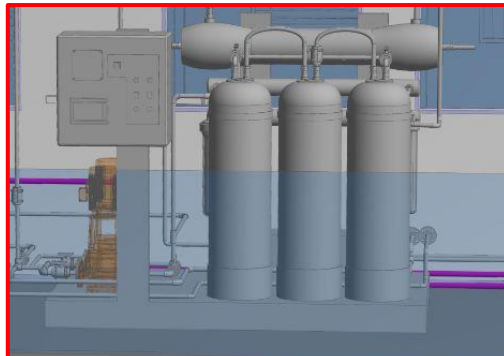
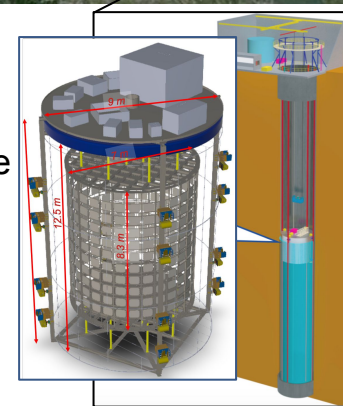
Patrick de Perio
February 21, 2024

Water Systems

- Maintain/operate a Gd-compatible ultra-pure water purification system at ICRR/IPMU
 - Test facility for experiments using water: materials compatibility soak testing, purification system studies, PMT testing
- Gain expertise and learn from Super-K experts
 - Inform the design and operations of WCTE and IWCD water purification systems



Hyper-K
Intermediate
Water
Cherenkov
Detector



Funding Summary

Approved amounts:

Year	Goods	Travel	Total
2022	760,000	0	760,000
2023	200,000	50,000	250,000

Actual spending:

Year	Goods	Travel	Total	Remainder
2022	~333,785	~112,319	~446,104	306,152*
2023	164,386	0	164,386	391,766

Funding Usage Details

Approved amounts:

Year	Goods	Travel	Total
2022	760,000	0	760,000
2023	200,000	50,000	250,000

Surplus from original request of an expensive water attenuation measurement device, but not enough funding approved to purchase

Lab materials and infrastructure: cleaning supplies, computer accessories, networking, chemistry supplies, plumbing, cuvettes for spectrophotometer, network camera for remote monitoring

Helped support PG pressure tests, consultation with SK Water Team, obtaining resin and Gd samples

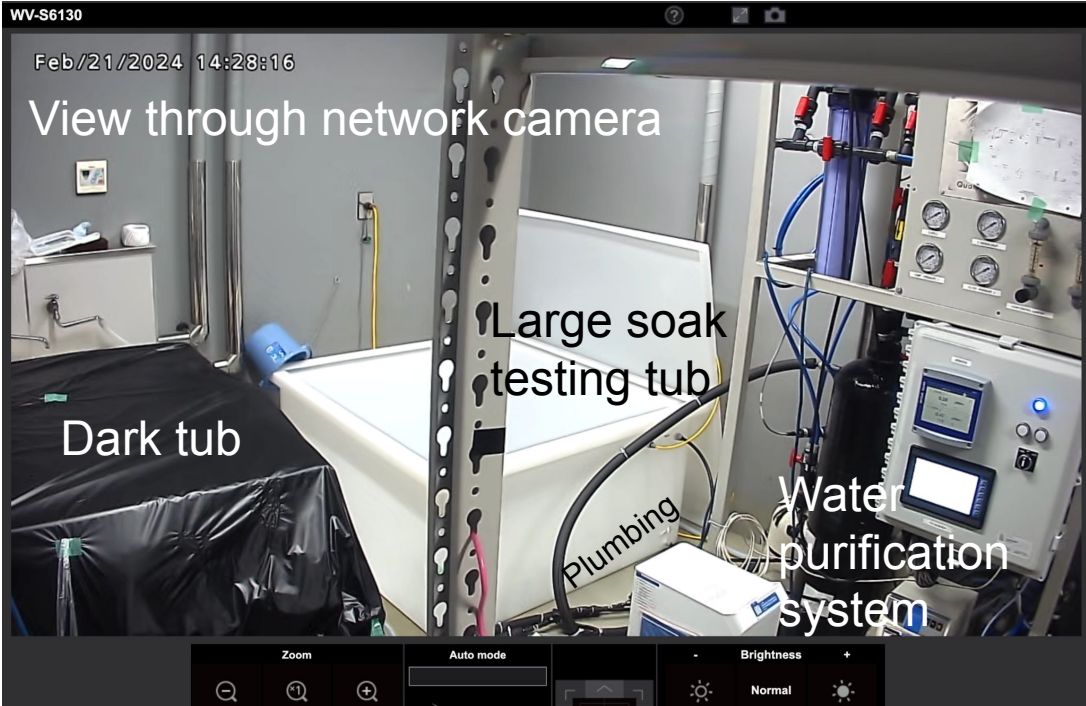
Actual spending:

Year	Goods	Travel	Total	Remainder
2022	~333,785	~112,319	~446,104	306,152*
2023	164,386	0	164,386	391,766

More lab materials to support PMT temperature dependence measurements and materials soak testing: tank insulation, dehumidifier, power supplies, depth sensors, plumbing and valves, fuses

IPMU/ICRR Water Purification System

Installed and commissioned in 2022, running stably since then



IPMU/ICRR Water Purification System Applications

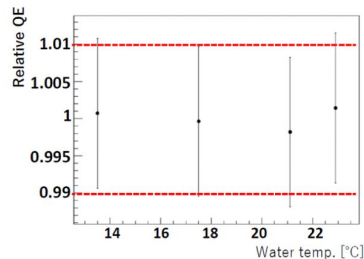
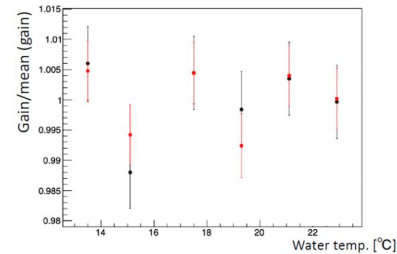
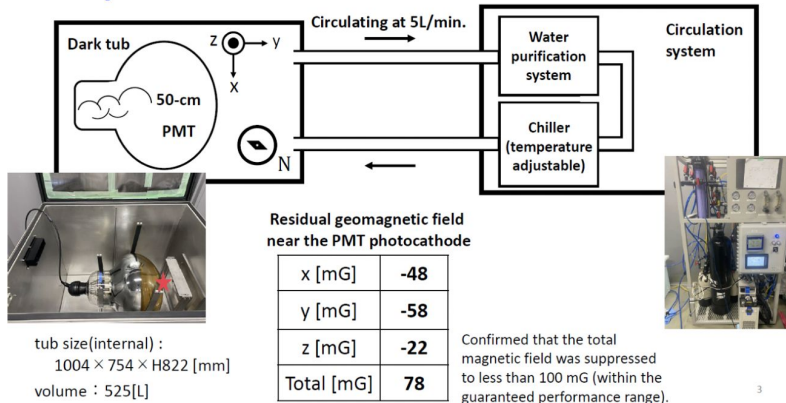
- Underwater PMT performance temperature dependence measurements

E. Watanabe, K. Yoshida

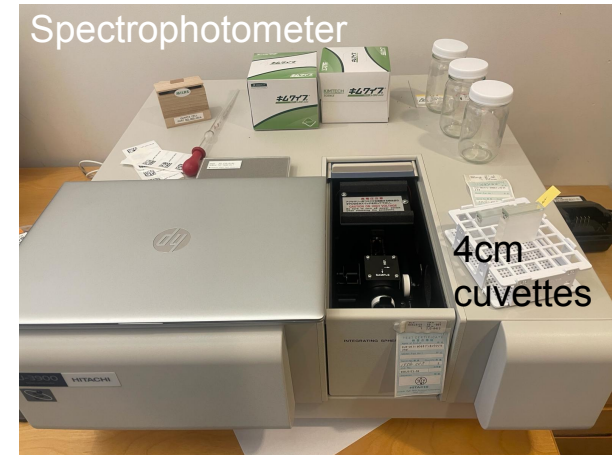
Tests in U Tokyo

- Verify difference between room temperature operation and detector conditions

Setup



- WCTE materials soak testing by visiting collaborator



Summary

- IPMU/ICRR water purification system operating well
 - Supplying temperature controlled water for HK PMT testing
 - Supplying ultra-pure water for materials soak testing
- *Thanks to ICRR-IURP for supporting this work!*

Appendix

Red Lamp Testing

- Spectrum of lamp and lamp+filter (720 nm cutoff) measured with spectrometer
 - Already showing some overlap with typical 3" PMT
- Measured hit count rate of PMT with lamp on and with filter
 - Observable increase

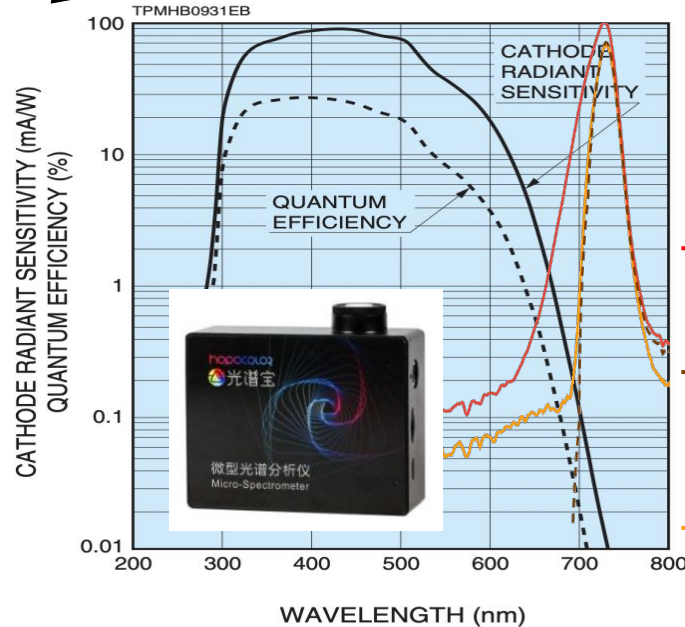
R14374



Hoya R72 filter



SubC lamp



Red Light State	Average Count Rate (Hz)	Increase relative to "Off"
Off	169	
On w/filter	203	20%
On	234	39%