# The Intermediate Water Cherenkov Detector for the Hyper-Kamiokande long-baseline neutrino oscillation program

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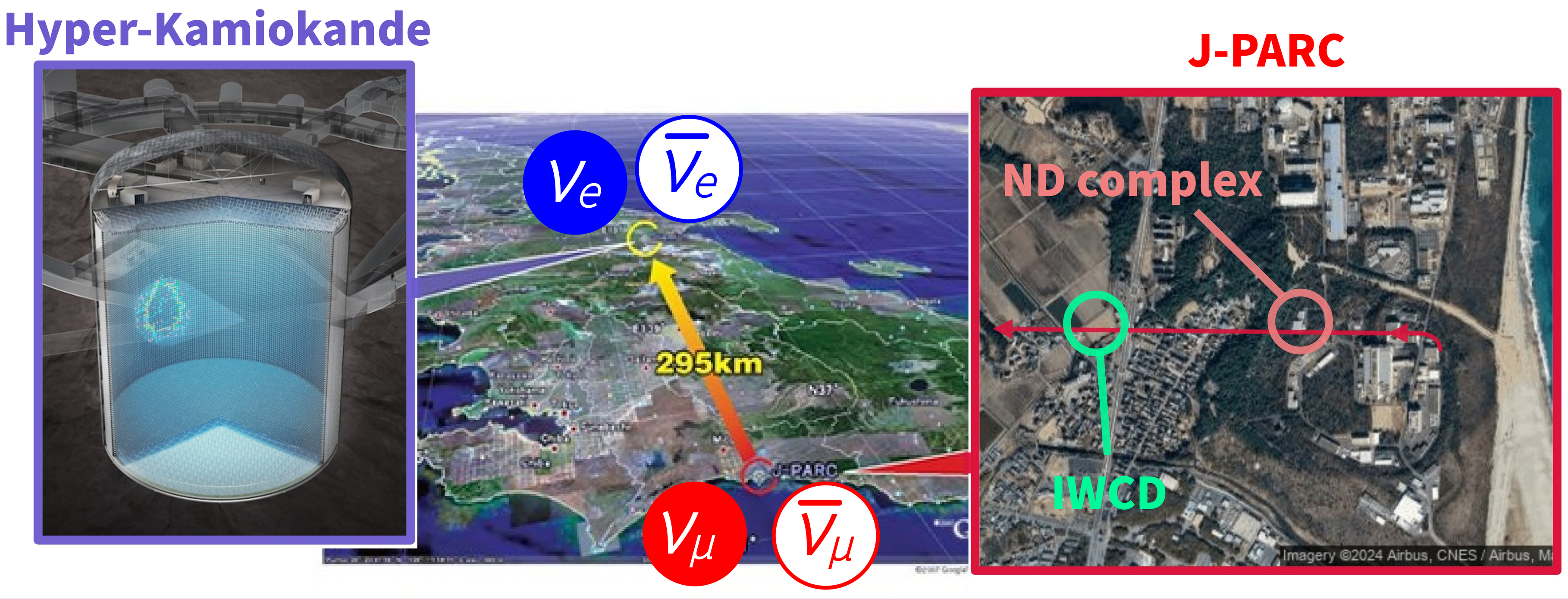
Ryosuke Akutsu (rakutsu@post.kek.jp), IPNS, KEK, for the Hyper-Kamiokande collaboration

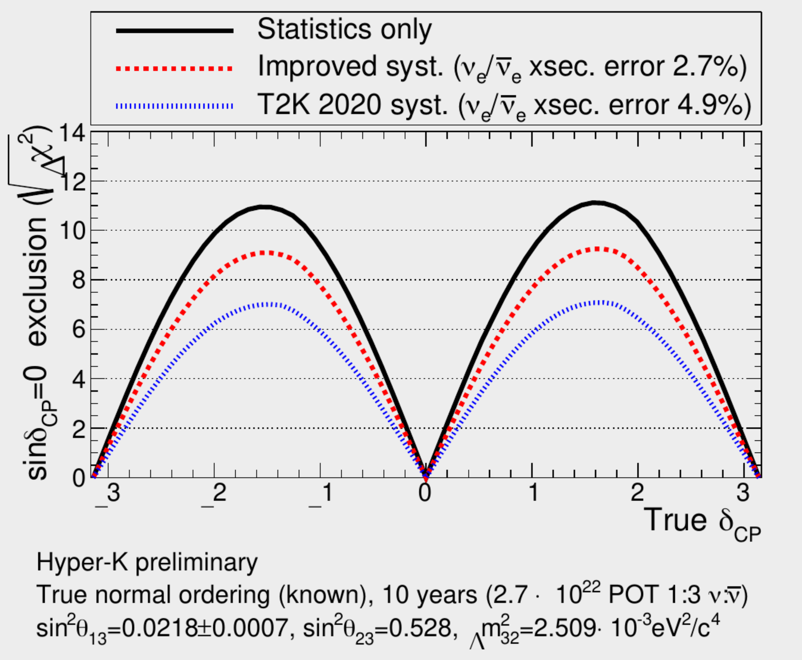
## 1. Long-baseline neutrino oscillation program

- The Hyper-Kamiokande (Hyper-K) project [1] will study long-baseline neutrino oscillations with an unprecedented precision by observing electron neutrinos oscillating from muon neutrinos , following the successful T2K experiment
- Thanks to a 184 kiloton of the fiducial mass of Hyper-K and an upgraded 1.3 MW J-PARC neutrino beam, event rates will be approximately 20 times larger than T2K, limiting oscillation measurements systematically



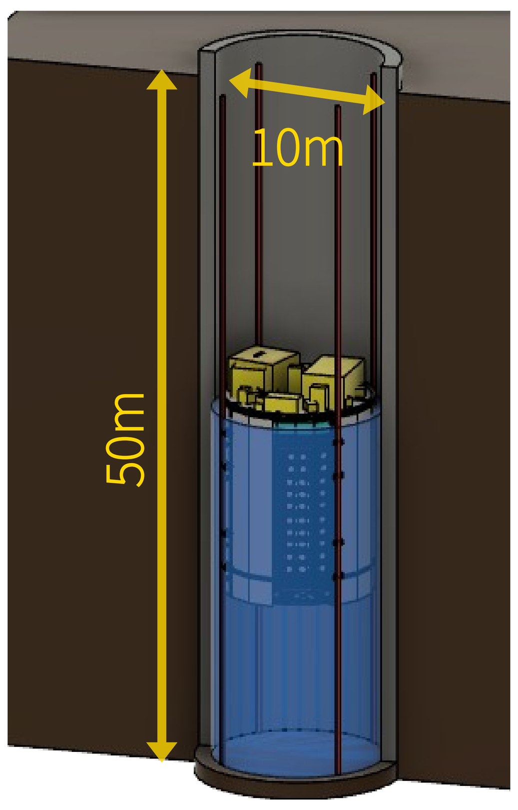

## 2. Electron neutrino interaction cross-sections

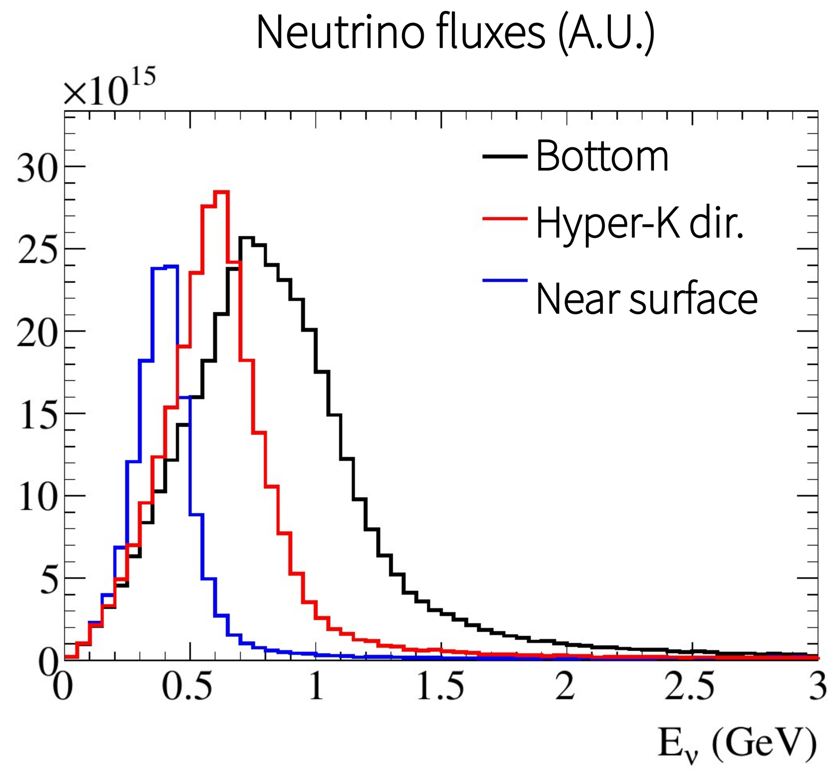
- Hyper-K aims to precisely measure the neutrino CP violation, believed to be a key to understand the matter-antimatter of the universe, that has not been discovered yet
- The sensitivities will be systematically limited mainly due to the uncertainty on (anti-) electron neutrino interaction cross-sections for water target
- It is vital to precisely measure the cross-sections in a robust way to control the uncertainty that is currently based in theory [2]

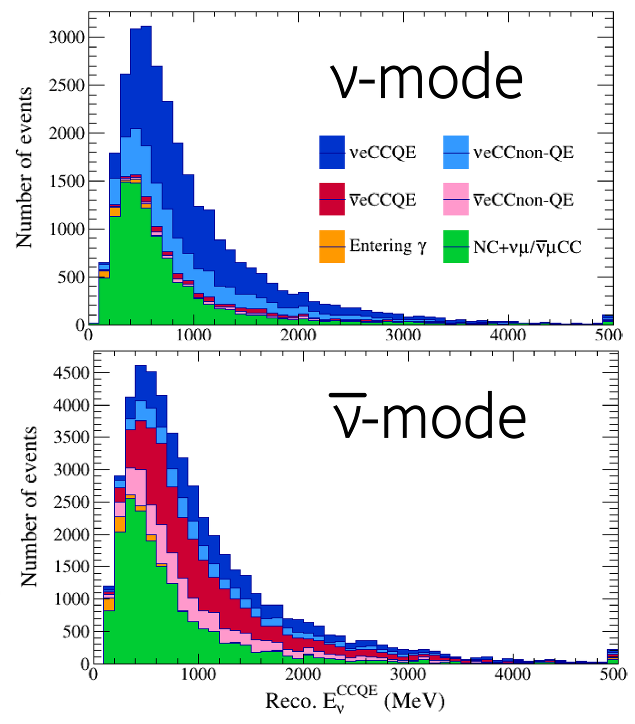



## 3. Novel water Cherenkov detector – IWCD

- IWCD, a 600 ton scale water Chereknov detector having the same detection principle as Hyper-K, will be newly built at approximately 800 m away from the neutrino source
- The detector can move vertically in the pit, allowing data taking to be done with various different neutrino energy spectrum
- Thanks to the NuPRISM concept[3], IWCD can effectively measure the cross-sections at the neutrino energies relevant for the CP violation study, minimizing the systematic effects on near detector constraints, from which the existing experiments are suffering

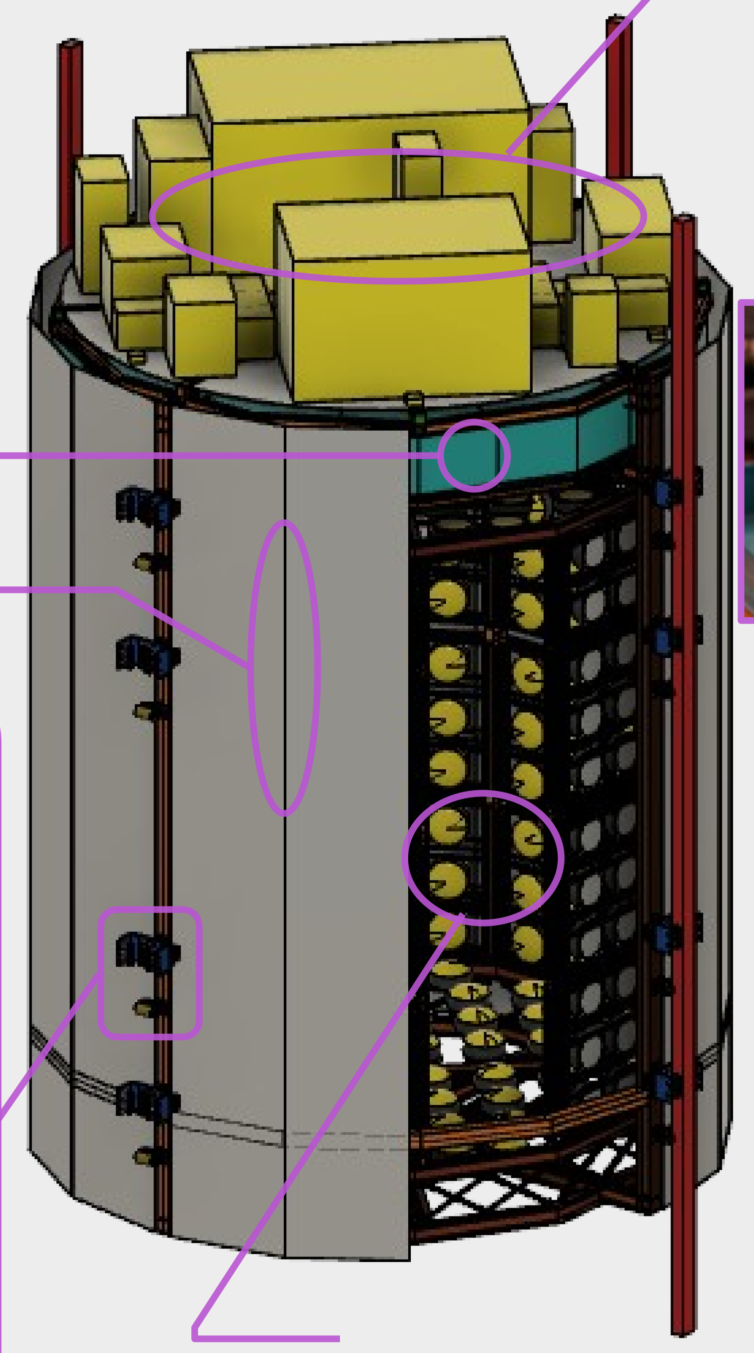


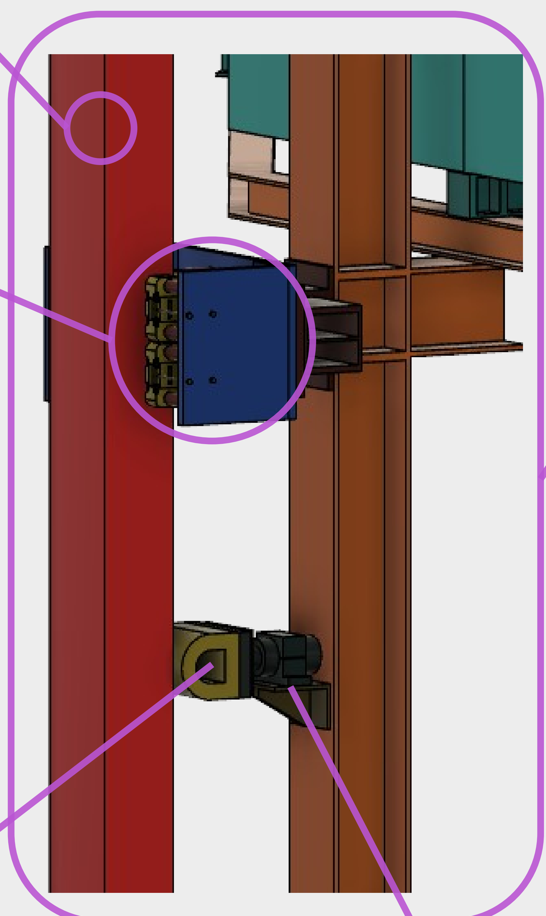



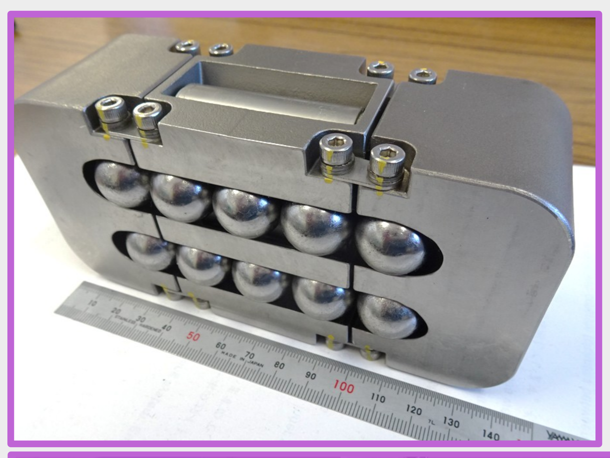



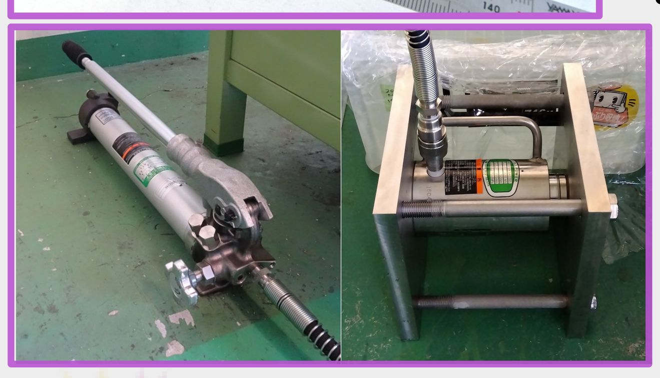

## 4. Detector components of the vertically movable light-weight detector

- Floatation allowing the detector to be able to move vertically
- Light-weight vessel
  - Approximately 50% lighter than conventional stainless steel tank for ease of the detector to float
- Reinforced concrete rails
  - Guiding the vertical movement of the detector
- Coupling system consisting of free bearings & springs
  - Connecting the detector with the guide rails loosely, allowing vertical movement of the detector to be smooth.



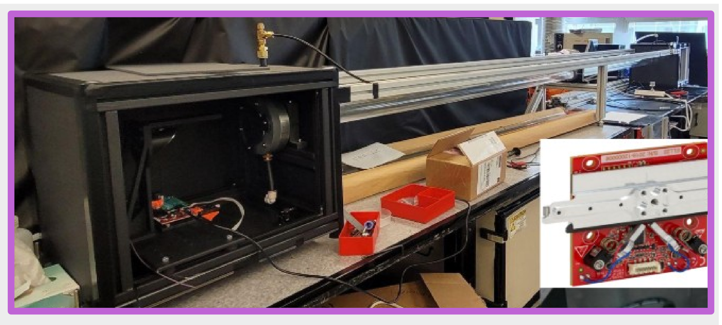






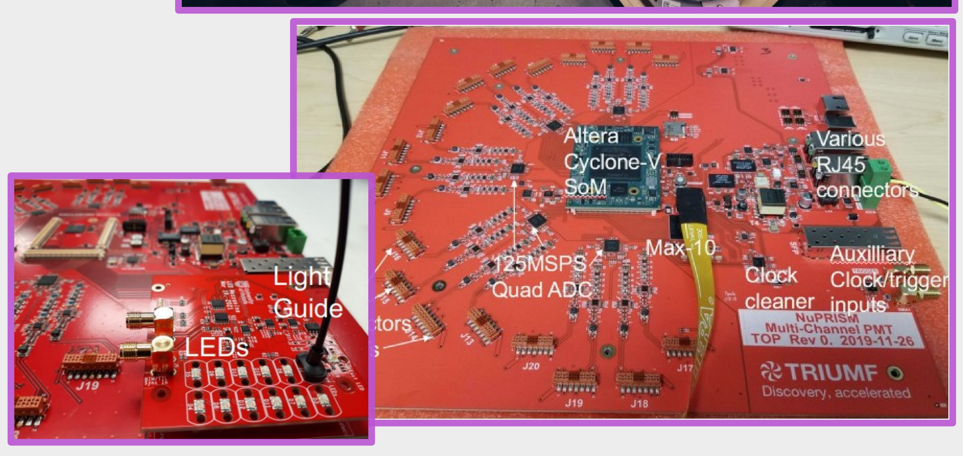
- Rubber fender protecting the detector against earthquake
- Water jacks controlling contacts between the fenders and guide rails

- Detector operation system on the lid
  - Electronics hut for DAQ system
  - Water purification & circulation system
  - Water monitoring system



- Calibration system
  - Calibration source deployment system
  - In-situ measurement of photosensor positions by a photogrammetry technique using a combination of fixed cameras and camera drone
  - In-situ measurements of PMT response, using various light sources

- Photosensor module consisting of 19 3-inch photomultiplier tubes (PMT) and 20-channel 125 MSPS FADC mainboard
  - Finer granularity compared to the same aperture of PMT
  - Directional information thanks to the placement
  - Digitization and pulse-finding on-the-fly
  - Full waveform information available
  - Pulsed LEDs to be used for detector calibration
  - Performance to be evaluated at WCTE [4]




## 5. Conclusion

- IWCD will play the key role in the Hyper-Kamiokande long-baseline neutrino oscillation program planned to start in 2027, including the neutrino CP violation study
- IWCD design work is ongoing, and the construction is planned to start in 2025

## References


[1] arXiv:1805.04163
[2] PRD 103 112003, 2021
[3] arXiv:1412.3086
[4] CERN-SPSC-2020-005