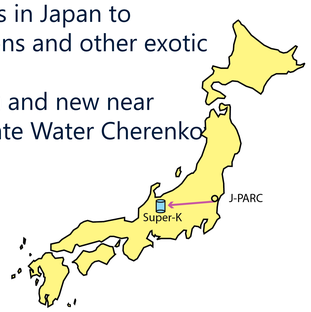
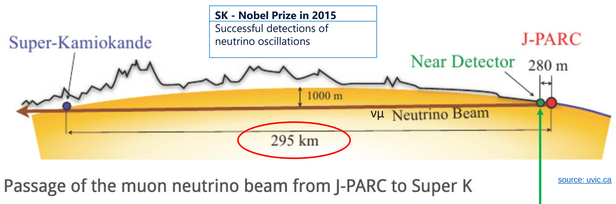
Photogrammetry in Super-K and Future Water Cherenkov Neutrino Detectors

Michael Sekatchev, 2nd Year Honours Physics
TRIUMF, University of British Columbia
MichaelSekatchev@live.ca

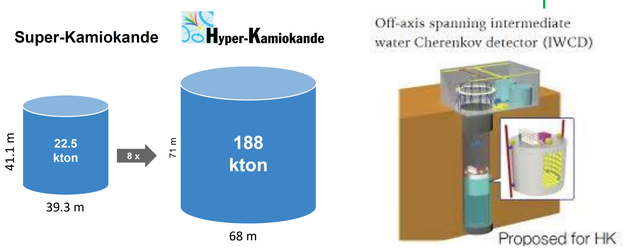
1. The Hyper-K Experiment

- Water Cherenkov Detectors in Japan to measure neutrino oscillations and other exotic physics processes
- New far detector (Hyper-K) and new near detector (IWCD, Intermediate Water Cherenkov Detector)



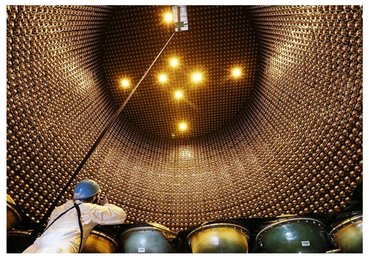


Passage of the muon neutrino beam from J-PARC to Super K



2. How are neutrinos detected?

- Neutrino interaction products travelling through water **release Cherenkov light**.
- Photons interact with the **photomultiplier tubes** (PMTs) surrounding the walls of the detectors

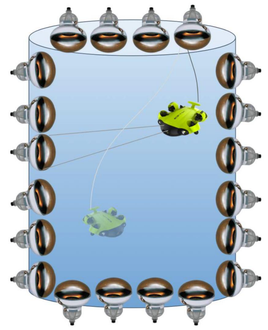


3. Photomultiplier Geometry Problem

- **Goal: Minimize errors due to detector/calibration source geometry**
  - PMT positioning within ~10 cm for Super-K and ~1 cm for IWCD
- **Challenge: Require in-situ measurements of PMT and calibration source positions**

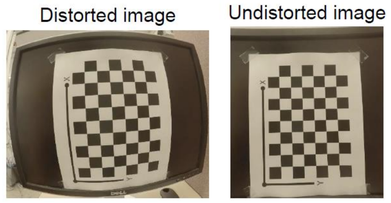
4. Super-K Photogrammetry

- **Photogrammetry is a solution**
  - Take many photographs of the detector in a drone survey
  - Detect and label the PMTs in each photograph
  - Reconstruct their positions in 3D using labelled 2D positions

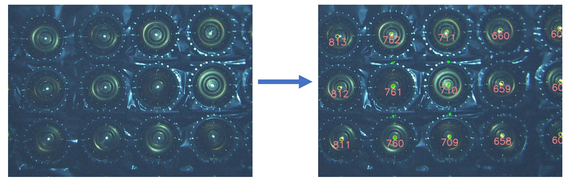


5. Feature Detection and Matching

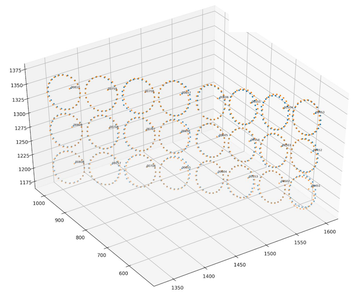
- Parametrized lens distortion
  - Used in reconstruction analysis



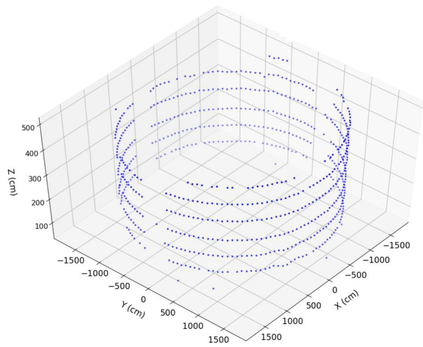
- **Identify** and **label** PMTs in each photo
  - Manual or Machine Learning
  - Image Processing and labelling



6. First Photogrammetry Reconstruction of Super-K



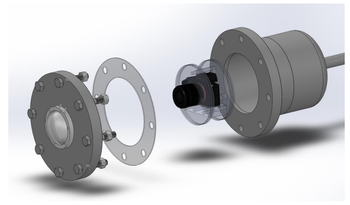
24 PMTs and their bolts

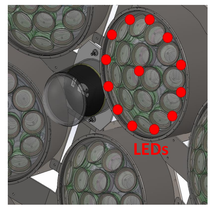


Barrel section of the SK detector

7. Water Cherenkov Test Experiment (WCTE)

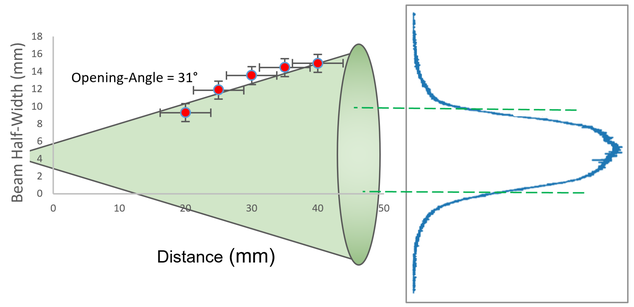
- WCTE: Prototype detector planned for operation in CERN beamline ~2023
- Photogrammetry system will be **built-in**
  - **Multiple stationary cameras** inside the detector
- **LEDs integrated** into mPMT for photogrammetry and calibration





8. mPMT LED Characterization

- Light beam characterization of LED pipe for detector simulations



9. Conclusion

- Challenge: **reducing uncertainties in PMT positions**
- Solution: **Photogrammetry**
- Drone survey performed to obtain images of Super-K
- Full analysis chain demonstrated
- Started design and prototyping built-in camera and LED systems for WCTE, IWCD, and Hyper-K