Water Cherenkov Test Experiment

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on behalf of the WCTE collaboration

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Motivation

- Many existing and next-generation neutrino experiments use water Cherenkov technology
- With increase in collected data reducing systematics is of crucial importance
- Detector systematics are one of the dominant systematic contribution

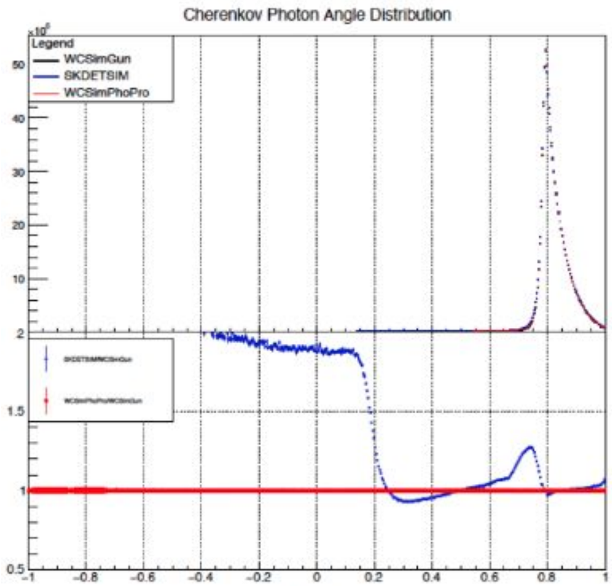
Water Cherenkov Test Experiment (WCTE)

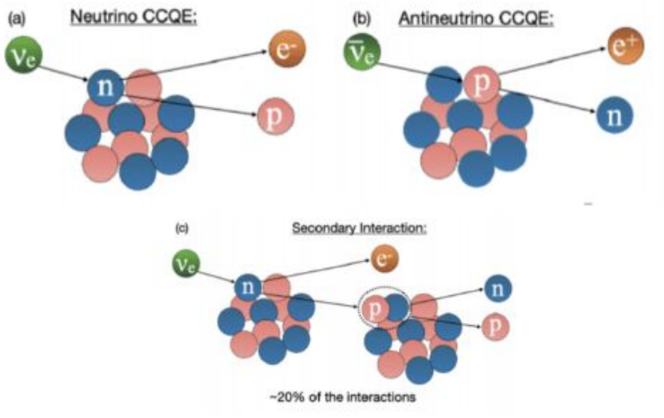
- Proposed experiment in East Area at CERN
- Small (d = 4 m, h = 4 m) water Cherenkov detector that will be used for
  - developing percent level calibration of water Cherenkov detector
  - measuring physical processes (pion scattering in water, Cherenkov light profile, secondary neutron production)
  - testing new technologies: multi-PMT, water based liquid scintillator
- WCTE will use electron, muon and hadron beams (0.2 - 1.2 GeV/c)
  - Secondary beam for electrons and muons
  - Tertiary beam for pions and protons

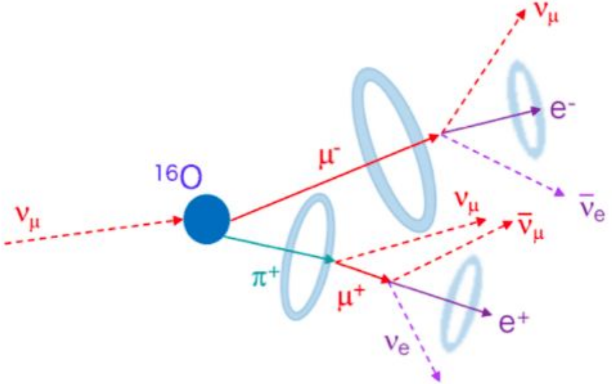
http://cds.cern.ch/record/2712416/files/?ln=en

Physics goals

- Measurement of Cherenkov light production
    - Simulations not consistent
- Study of energy scale calibration
    - Defined by muons crossing the detector
    - Reduction from 2% to 0.5% needed for Hyper-Kamiokande
- Measurement of secondary neutron production
- Study of pion scattering

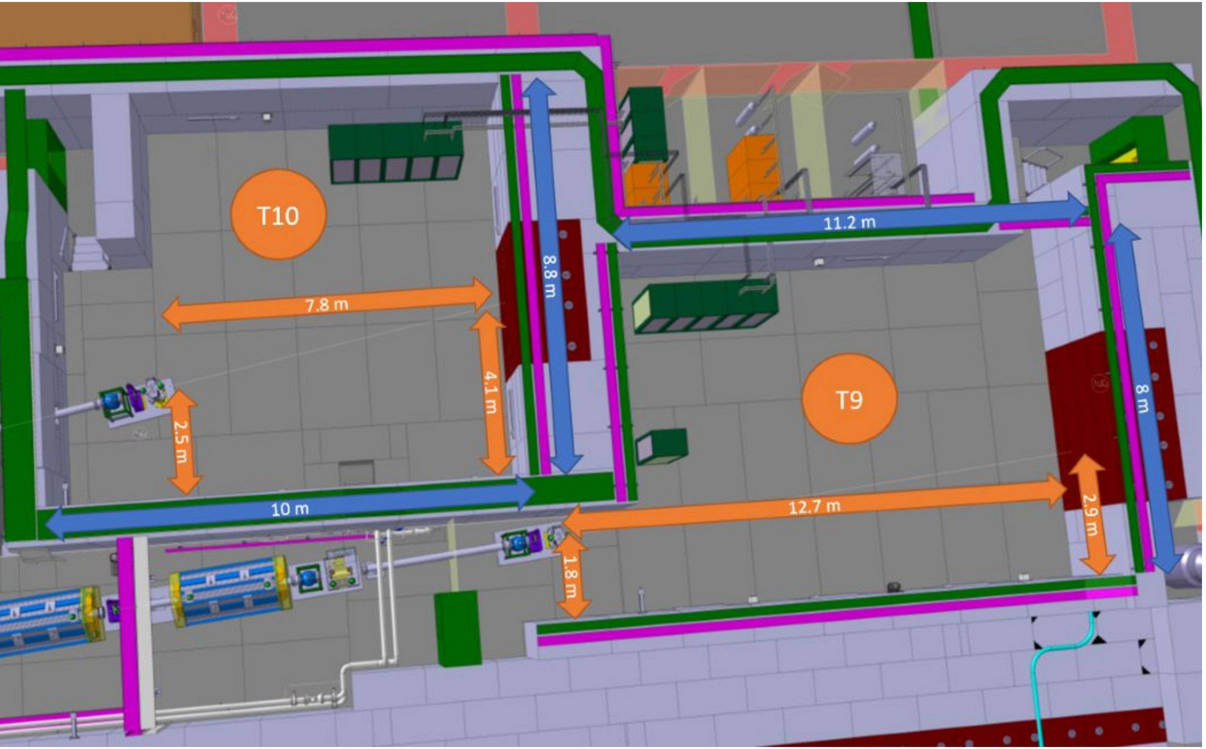


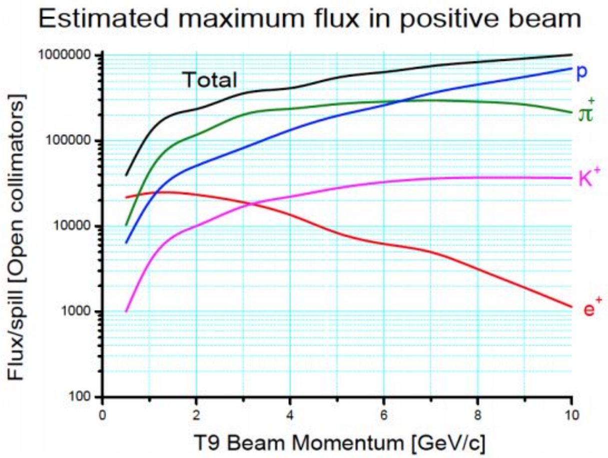


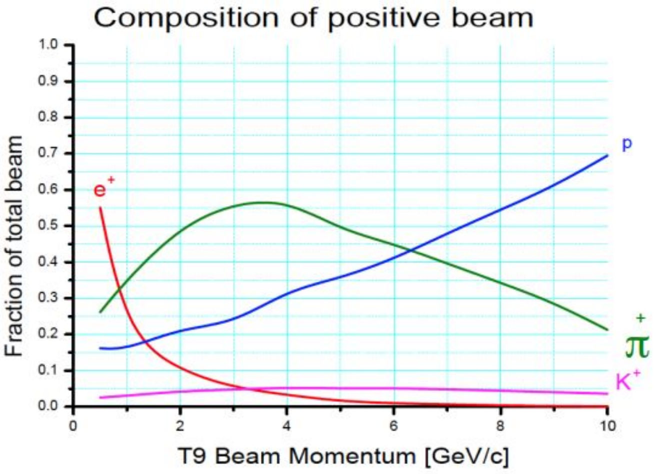


East Area T9 beamline

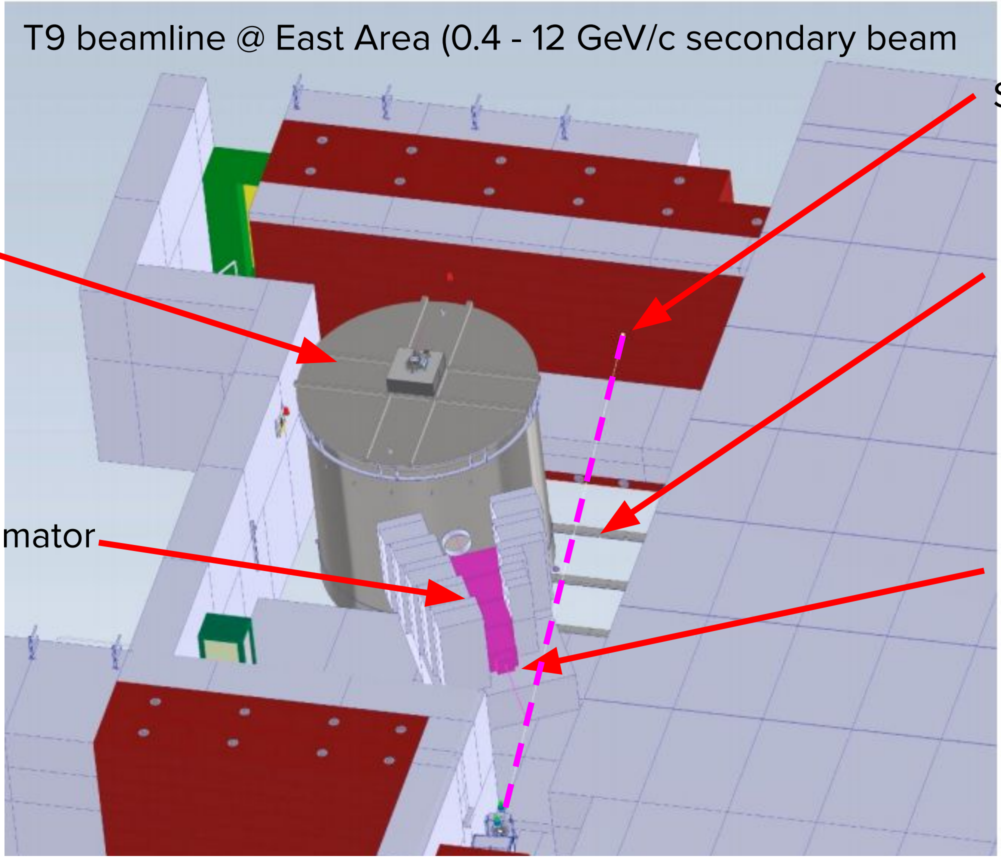
- T9 beamline has been chosen for the experiment
- Max intensity: $5x10^6$
- Secondary beams 0.4 - 15 GeV/c







Water Cherenkov Test Experiment (WCTE)



Secondary beam trajectory

Water tank

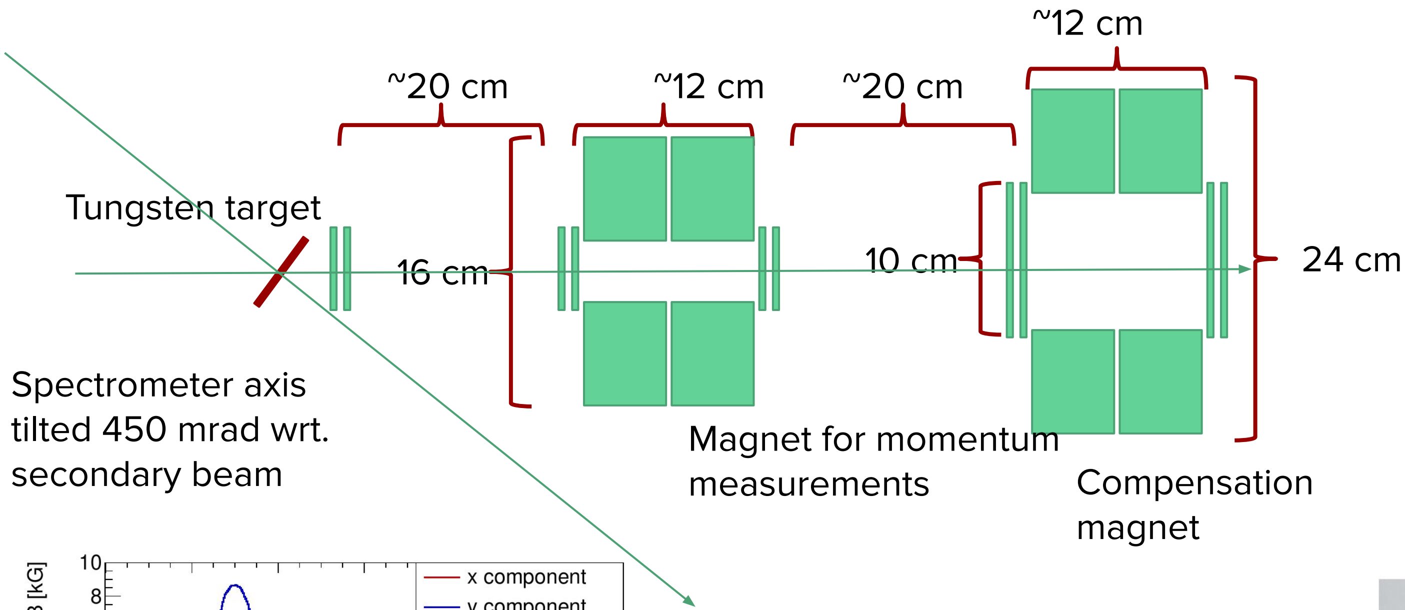
The tank can slide between secondary and tertiary beams

Shielding and collimator

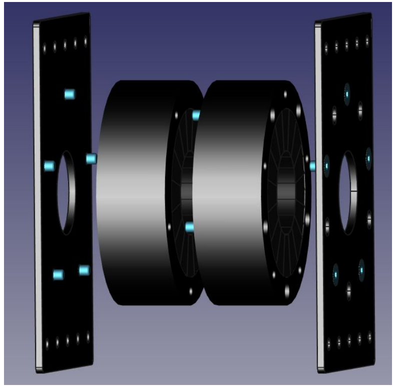
Compact spectrometer and tungsten target (not shown here)

Low momentum pions decay in secondary beamline

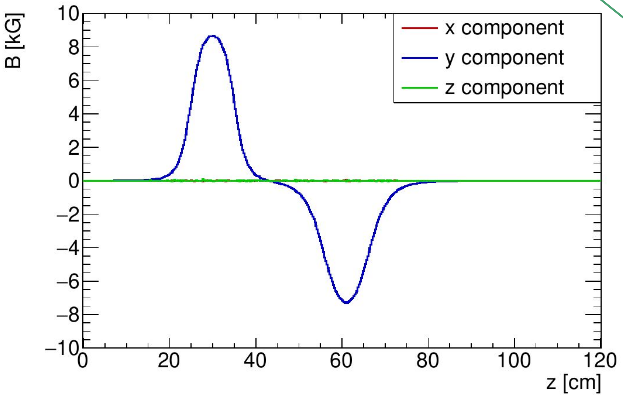
WCTE Tertiary Beam Spectrometer

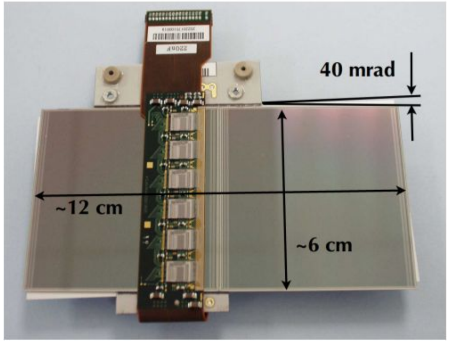


Halbach array



ATLAS SCT
(8 modules approved)



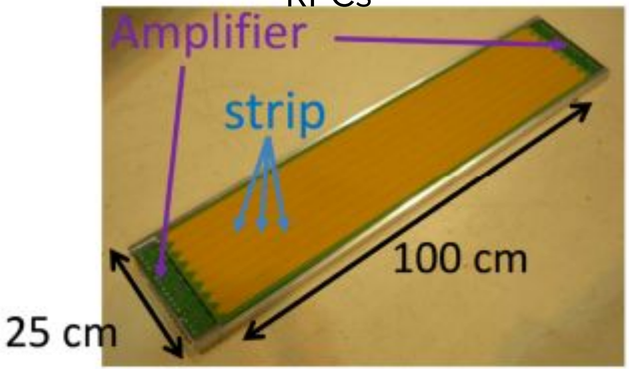


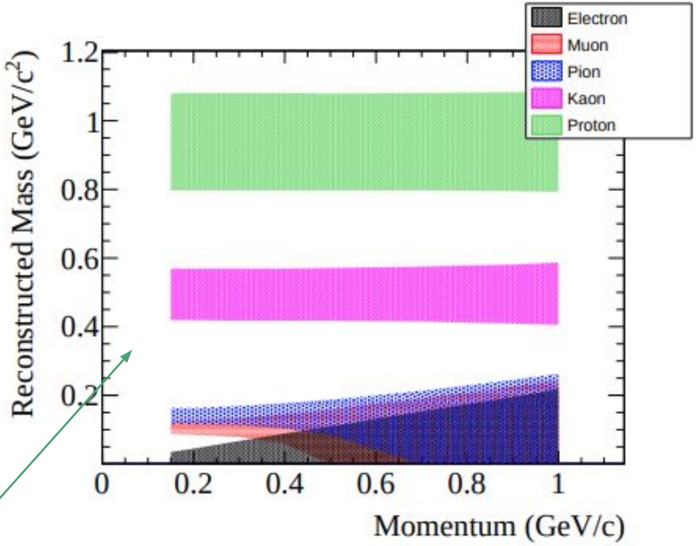
Bending power (first magnet) = 0.075 Tm

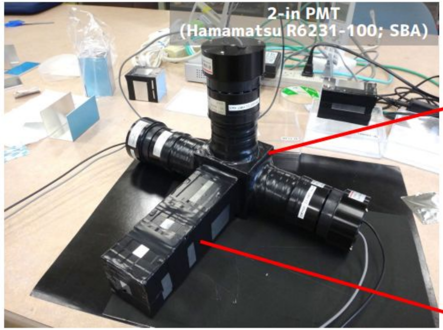
WCTE Tertiary Beam Spectrometer

- Tertiary beam particle ID will be done by measuring time-of-flight (with RPCs) and aerogel threshold Cherenkov detectors
  - Aerogel with index of refraction of 1.0026 was produced → it can be used to identify electrons (p > 350 MeV/c)
- RPCs can be used to detect pion decays (kinks in trajectory)

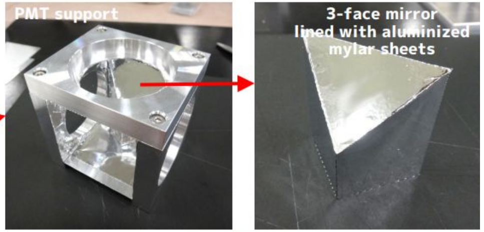
RPCs

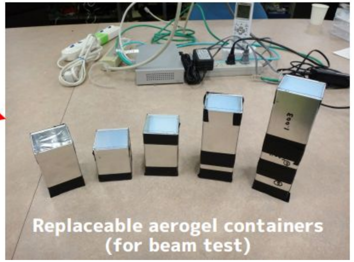






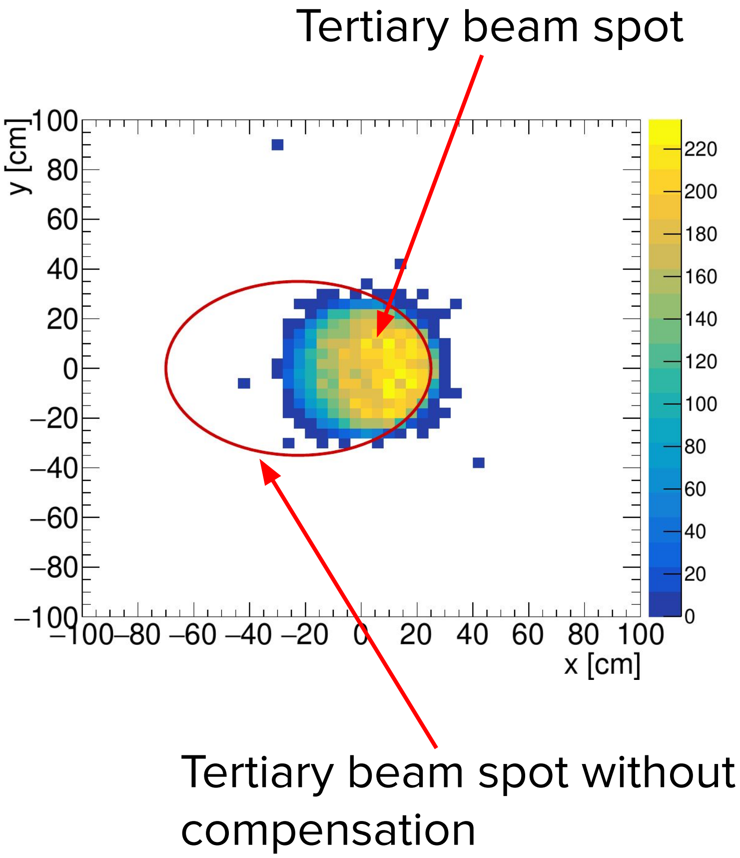
Aerogel threshold Cherenkov detector

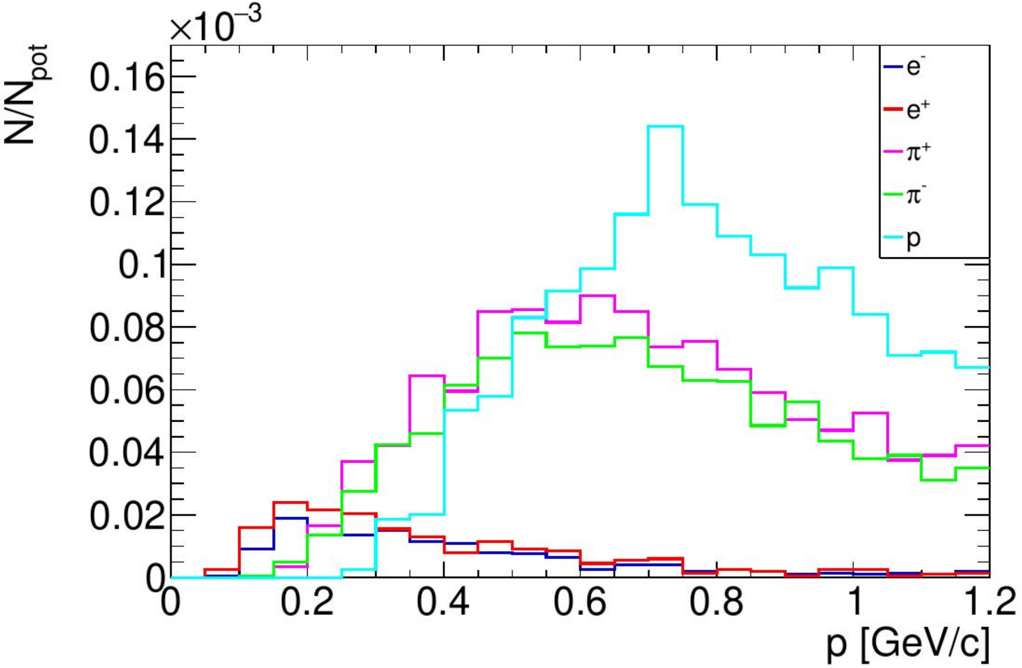




Assuming 100 ps timing resolution

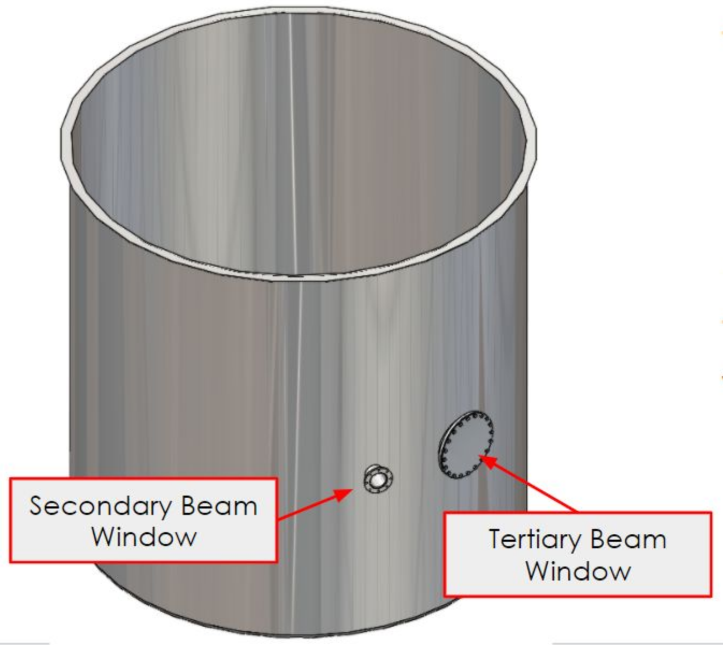
WCTE Tertiary Beam

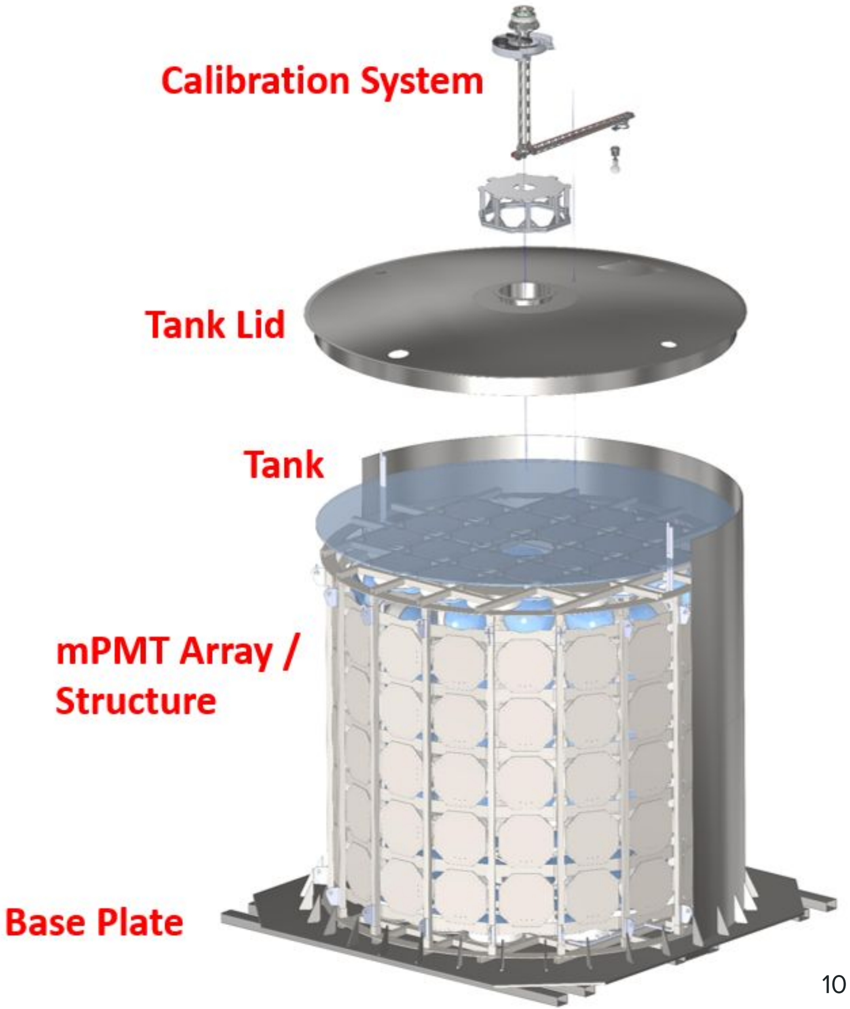




Water Cherenkov Detector

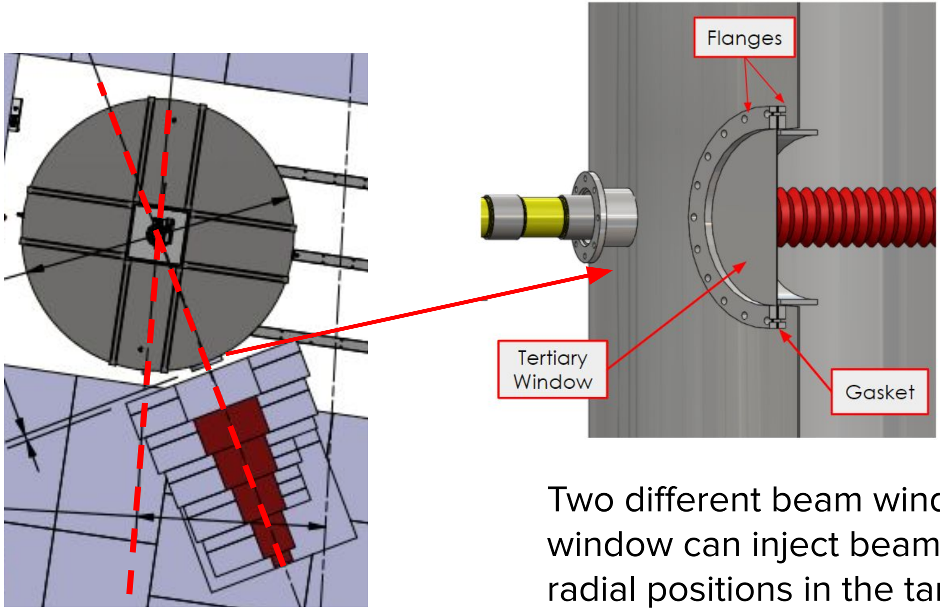
- ~4 m diameter
- 128 mPMT modules
- Two beam windows

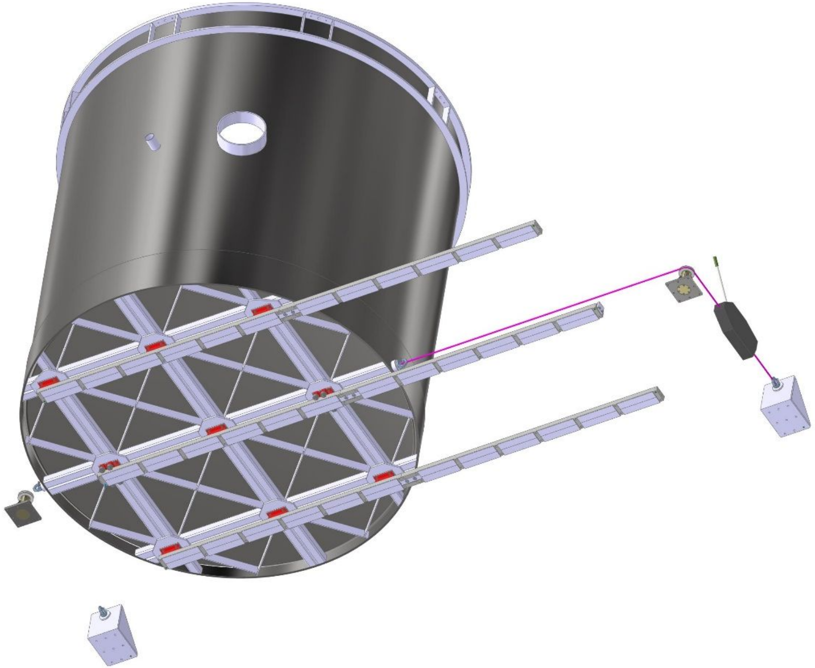




Water tank movement

- Water tank can slide on rails between secondary and tertiary beam position





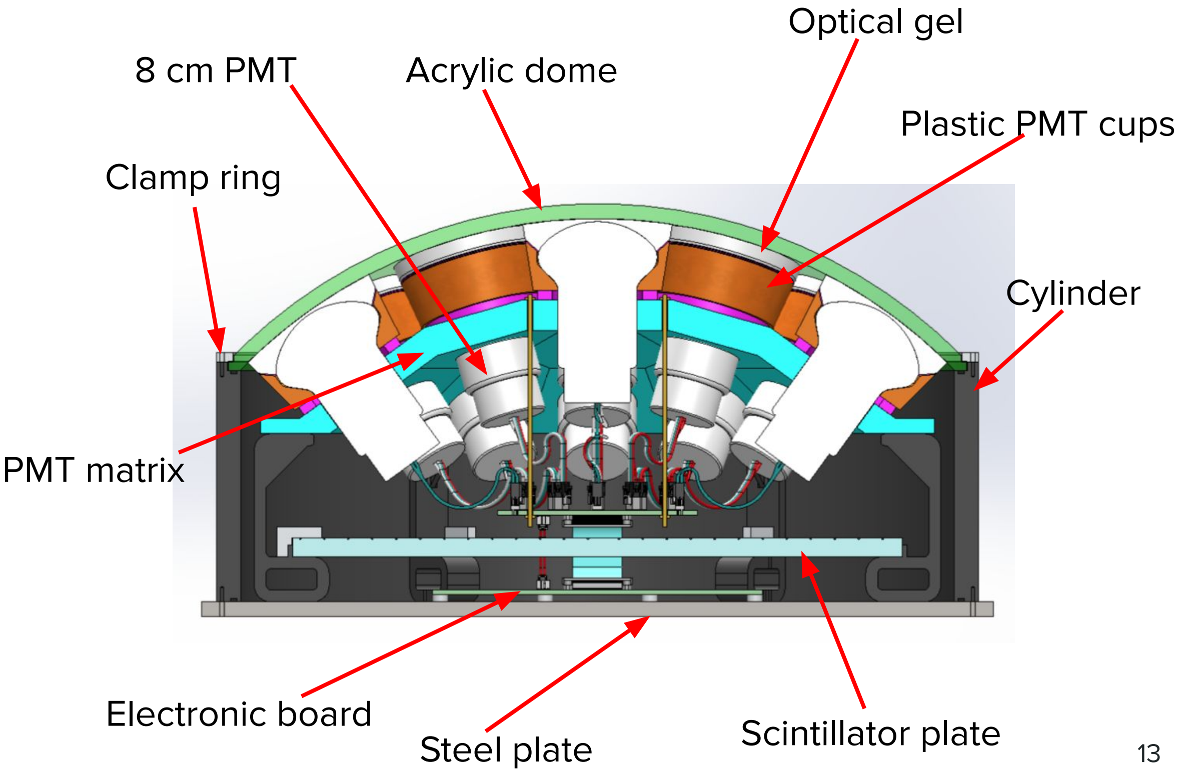
Two different beam windows → secondary beam window can inject beam particles at different radial positions in the tank

Water system

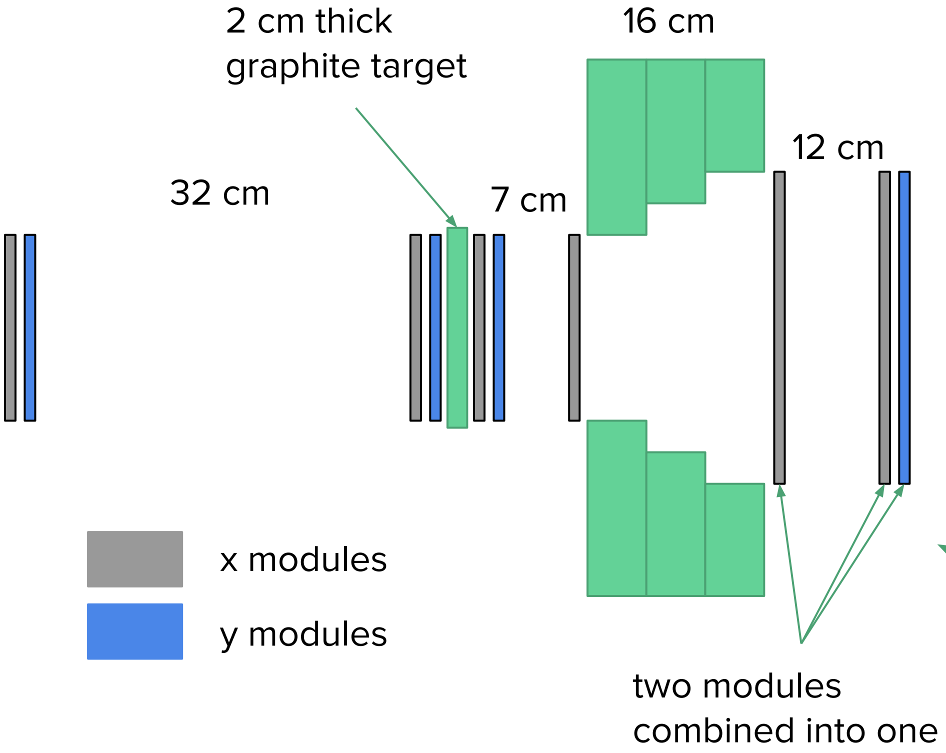
- Commercially available water purification system
- Micro/nano-filters
- UV system to suppress biological contamination
- Ion exchange resins
- Special resin for Gd loading

Multi-PMT photosensor

- 19 8 cm PMTs (Hamamatsu R14374)
- Less photo-coverage but improved vertex resolution



Hadron interaction measurements in WCTE facility

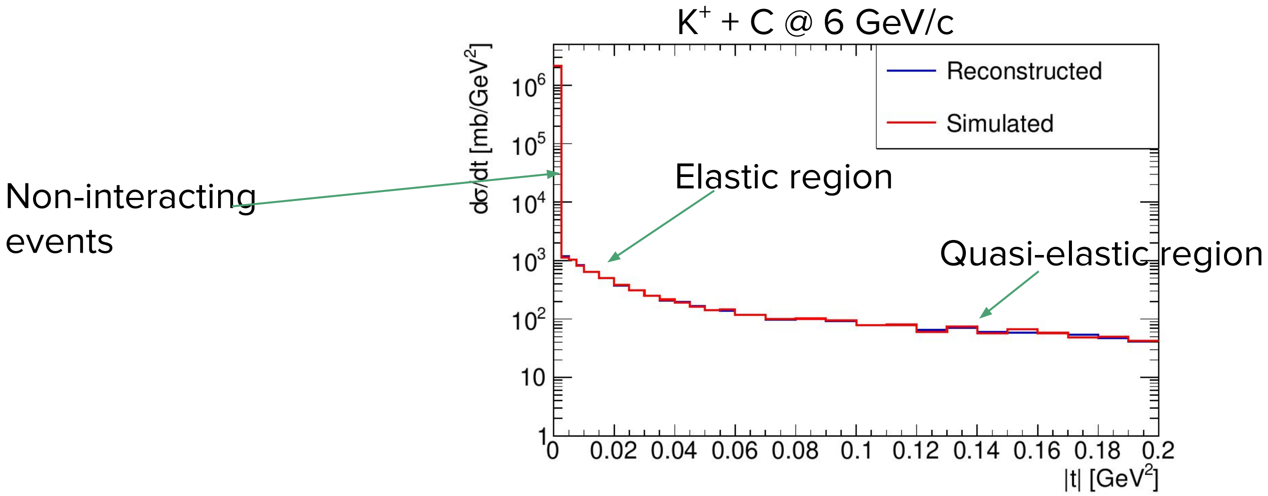


- WCTE facility can be reconfigured to measure forward hadron-nucleus interactions ➔ elastic and quasi-elastic scattering
- data is necessary to reduce neutrino flux uncertainty in long-baseline neutrino experiments
- Water tank can be used for muon/pion separation in the secondary beam

Possible spectrometer configuration

Hadron interaction measurements in WCTE facility

- We are preparing LOI for a independent experiment that will use WCTE hardware
- Measurements of forward pion and kaon scattering
  - $\pi^{\pm}$ + C, Al, Fe → $\pi^{\pm}$ + X and $K^{\pm}$ + C, Al, Fe → $K^{\pm}$ + X
  - Additional targets are possible
- Important for T2K, HyperK, DUNE, ...



Conclusion

- Reducing systematics in existing and future water Cherenkov detectors is of crucial importance
- WCTE will use the 50t water Cherenkov detector to study physics processes inside the detector with a well-defined beam and develop calibration techniques
- WCTE is a platform for testing new technologies (multi PMT, WBLS, ...)
- WCTE can become a facility ➡ independent experiments such as hadron interaction measurements