The Water Cherenkov Test Experiment:
Preparing for the Next Generation

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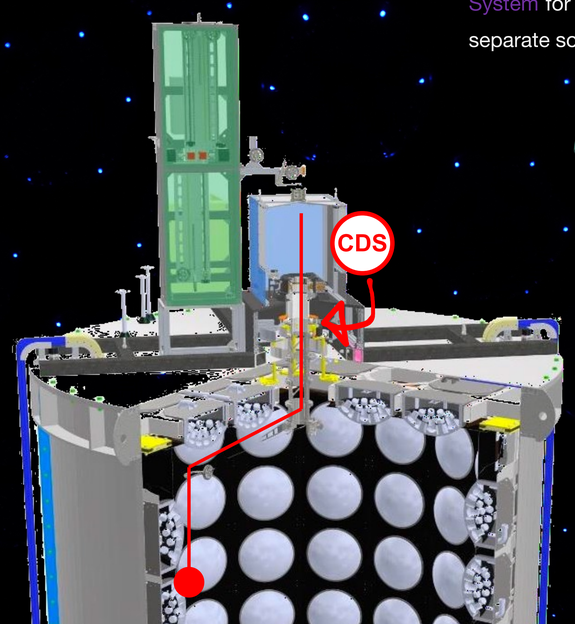
Overview

The Water Cherenkov Test Experiment (WCTE) was a 30-ton water Cherenkov detector built in the CERN East Area T9 beam line receiving a flux of electrons, muons, charged pions, and protons ranging in momentum from 100-1500 MeV/c. It served both as a testbed for new technologies to be used in Hyper-Kamiokande and the Intermediate Water Cherenkov Detector (IWCD), as well as the first ever water-Cherenkov detector built in a fully characterised beam. This yielded the opportunity to test and validate event reconstruction using real data, to make direct measurements of interactions relevant to charged particles in-water, and it enhances our potential for future studies of neutrino oscillations.

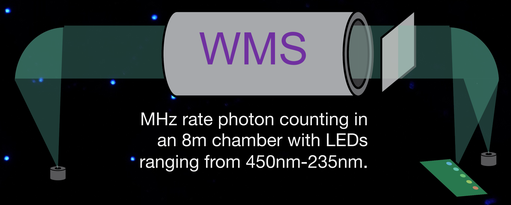


multi-PMT Modules

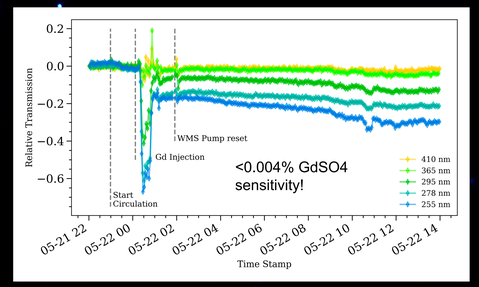
In the IWCD – considerable event pileup necessitates more granular PMT spacing, motivating these multi-PMT modules. Built with 19 PMTs sharing a single digitization system and HV supply, these address pileup while providing diffuse and collimated sub-ns pulsed and continuous LEDs charge and timing calibration plus photogrammetry.

Calibration Systems

The WCTE served as a testbed for numerous calibration systems under development for Hyper-Kamiokande: the Central Deployment System can insert radioactive sources (NiCf+AmBe) and a laser ball, LEDs built into the mPMTs, the cap-mounted UK Light-Injector, photogrammetry cameras, and the TRIUMF Water Monitoring System for real-time high-precision water quality monitoring. PMT angular response has been studied with three separate sources: LEDs, NiCf, and cosmic muons.



MHz rate photon counting in an 8m chamber with LEDs ranging from 450nm-235nm.

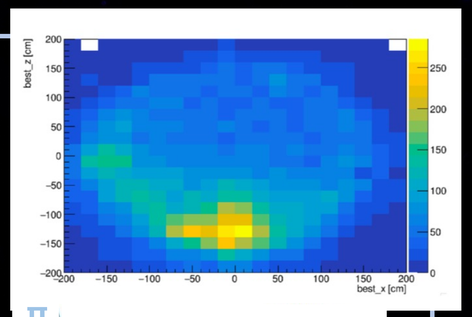


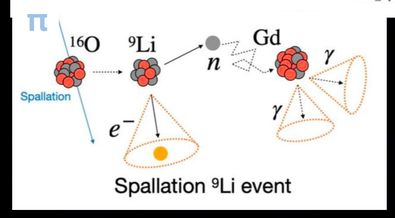
Water Monitoring

The TRIUMF Water Monitoring system uses sub-ns MHz pulsed LEDs to measure light attenuation from 450nm down to 235nm. By using a continuous flow of water with photon-counting techniques with PMTs, this allows for real-time and high-precision measurements of water quality: an impossible task using conventional water monitoring systems.

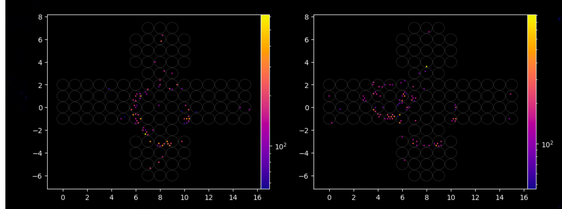
Physics Analyses

The WCTE provides an ideal testbed for various physics and reconstruction studies: cosmogenic Li-9 production, detector response to known gammas, machine learning based event reconstruction validation, proton/kaon ring analysis, pion photoproduction, pion interactions, and neutron capture on 0.03% Gd by mass.

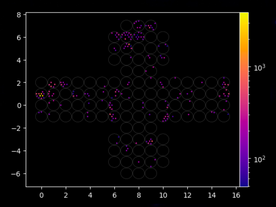




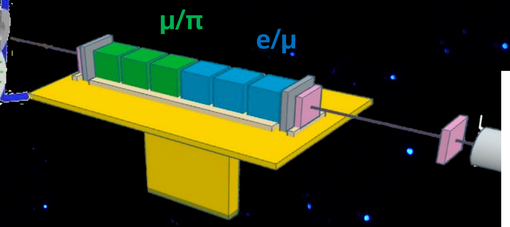
Spallation ^{9}Li event

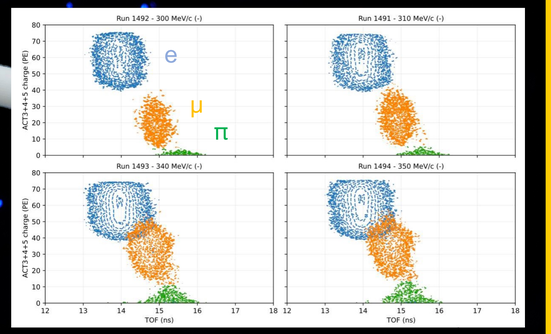


absorption scattering



charge exchange w/ EM shower





WCTE Beam Monitor

Aerogel Cherenkov Threshold detectors provide $e^{\pm}/\mu^{\pm}$ and $\mu^{\pm}/\pi^{\pm}$ separation plus kaon and proton isolation. These along with hole counter vetoes, trigger scintillators, and TOF detectors are leveraged for high-purity particle identification. A 1.5T Halbach array permanent magnet with a hodoscope array allows for tagged gamma analyses by measuring deflected positron positions.

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