Status of the D_2O Detector for the COHERENT Experiment

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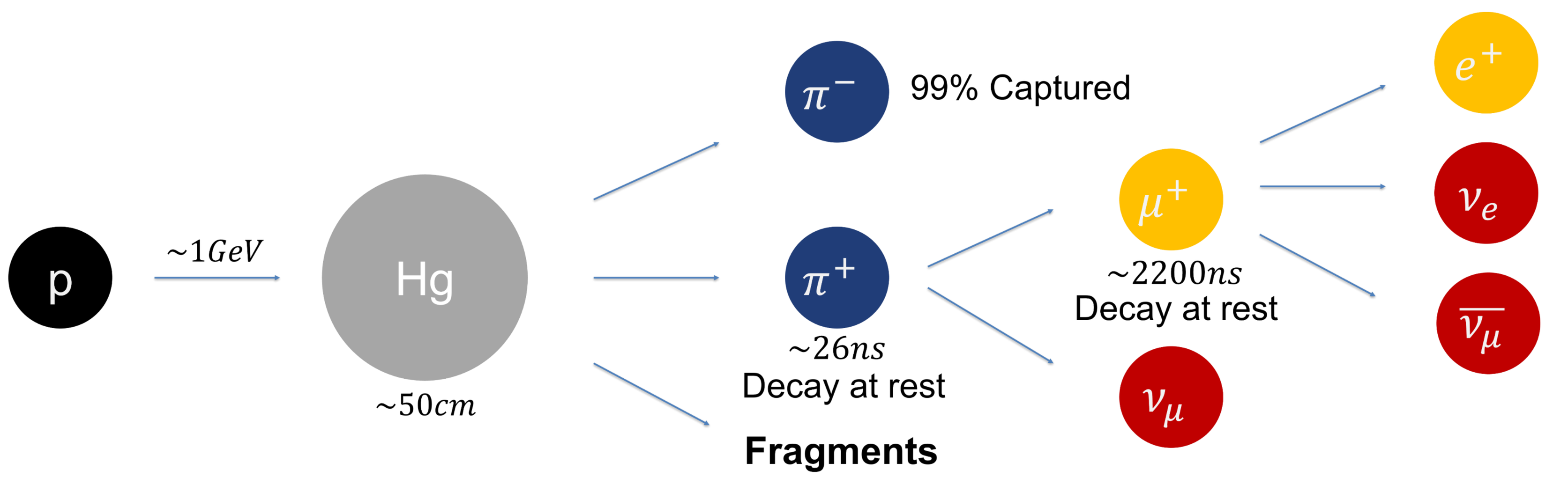
ν Flux in SNS and COHERENT

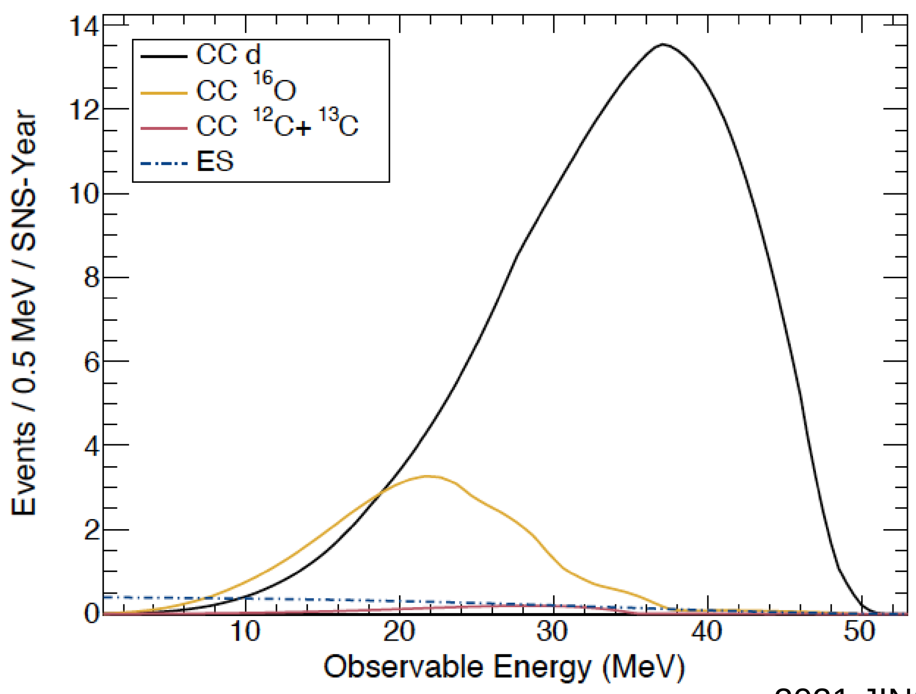
Neutrino flux in the Spallation Neutron Source (SNS) at ORNL is produced when 1 GeV protons strike a 50-cm-thick mercury target. This generates prompt neutrinos ν_μ from π^+ decay at rest, followed by ν_e and $\bar{\nu}_\mu$ resulting from μ^+ decay at rest.

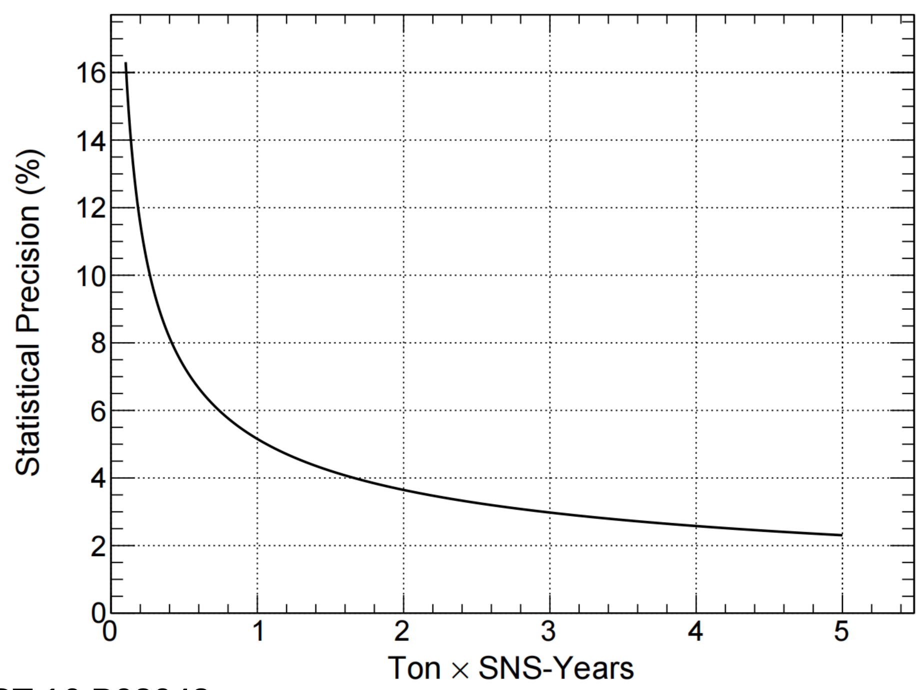


The high luminosity and low-energy range of the neutrino flux at SNS make it an ideal source for measuring Coherent Elastic Neutrino-Nucleus Scattering (CEνNS). The COHERENT collaboration has successfully conducted CEνNS measurements using CsI, liquid argon and Ge detectors located in neutrino alley at the SNS.

Motivations of D_2O Detector

Neutrino flux uncertainty is a dominant systematic effect in COHERENT. In the D_2O Module 1 heavy water detector, we measure the ν_e flux with well-understood $\nu_e + d \rightarrow p + p + e^-$. In Module 2, we will conduct a clean measurement of the cross section of $\nu_e + ^{16}O \rightarrow e^- + ^{16}F^*$, which serves as a major background to Module 1. Beyond this, this measurement is also of interest to large-scale water Cherenkov detectors like Super-K and Hyper-K.





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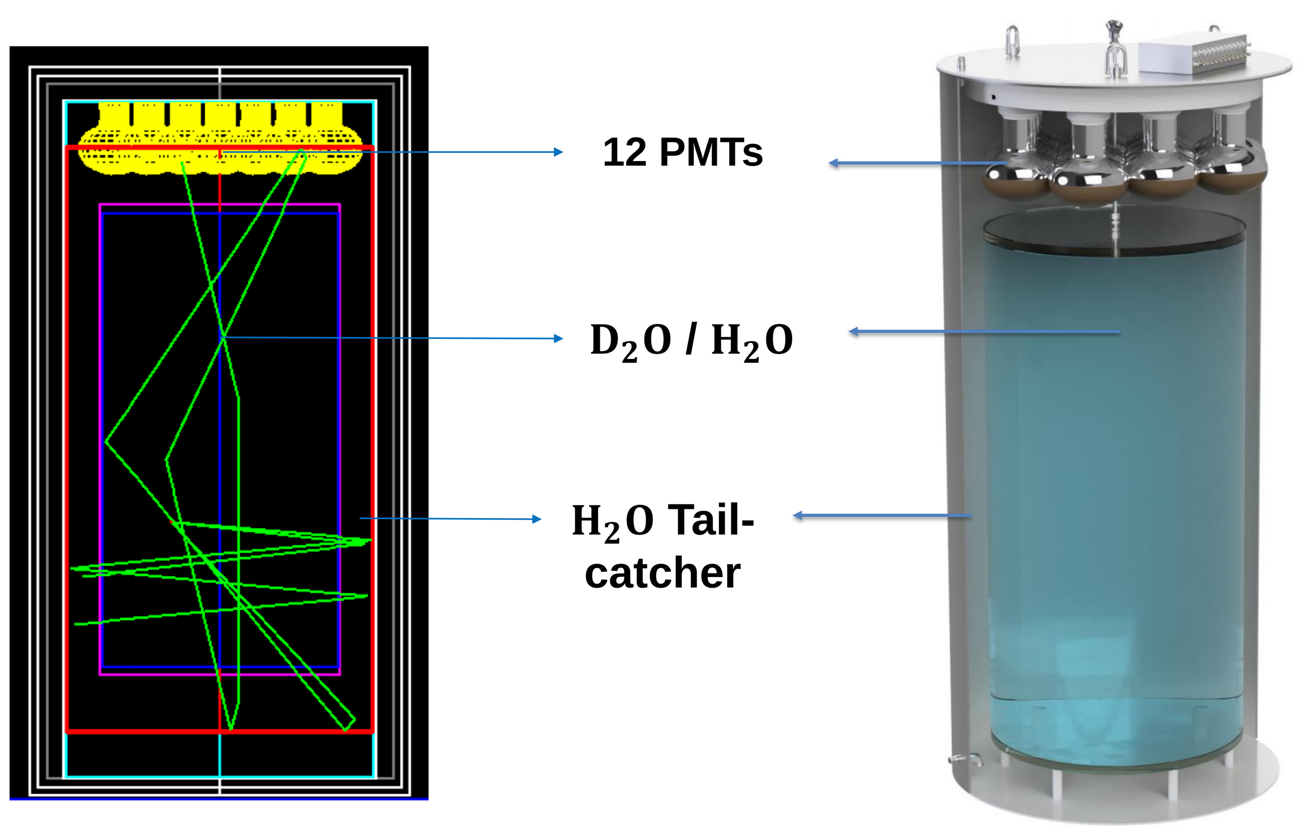
D_2O Detector Design



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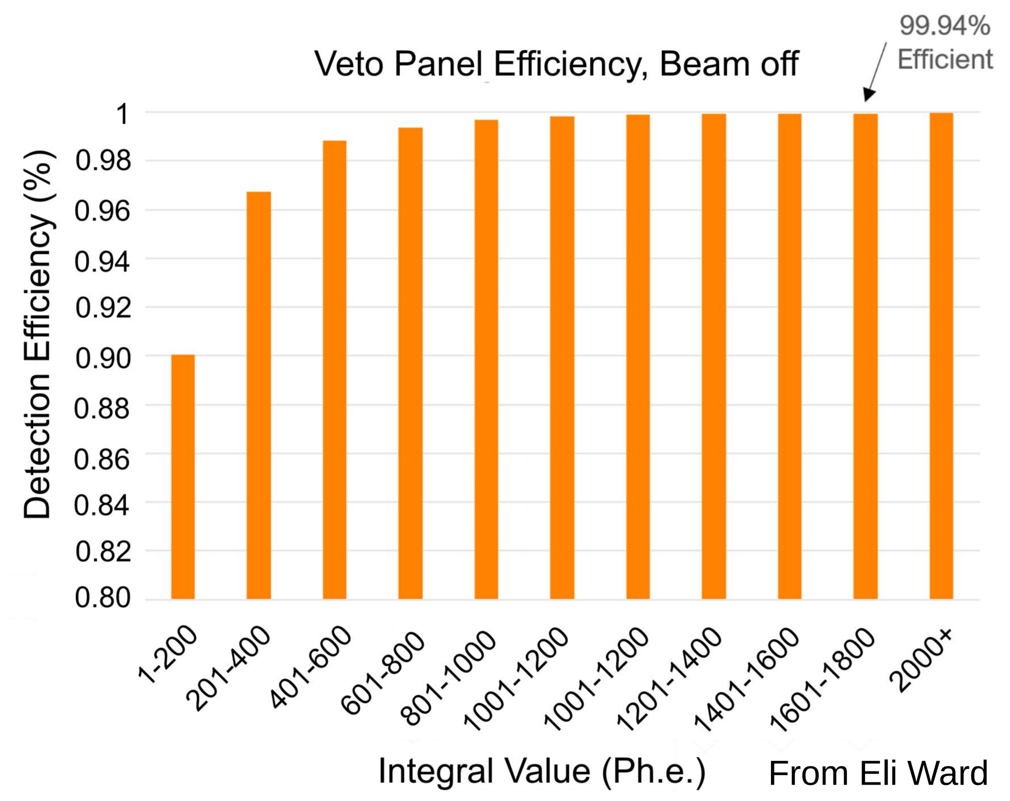
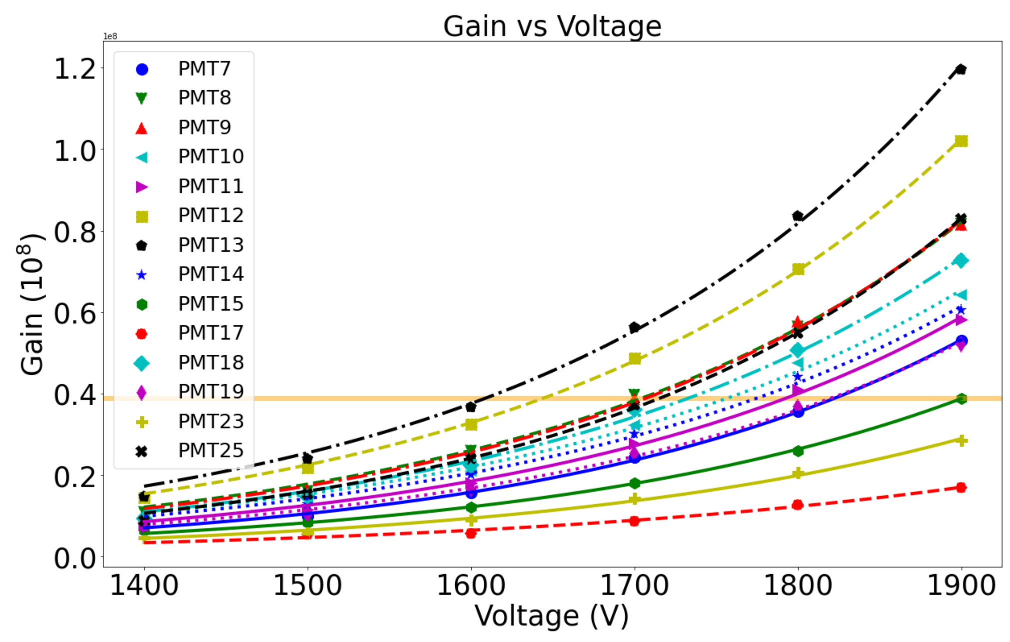
- 590kg D_2O / ~500kg H_2O in acrylic tank
- 12 PMTs for Cherenkov radiation
- Reflective Tyvek® covers inner wall of steel vessel
- Outside: lead shielding + muon veto panels

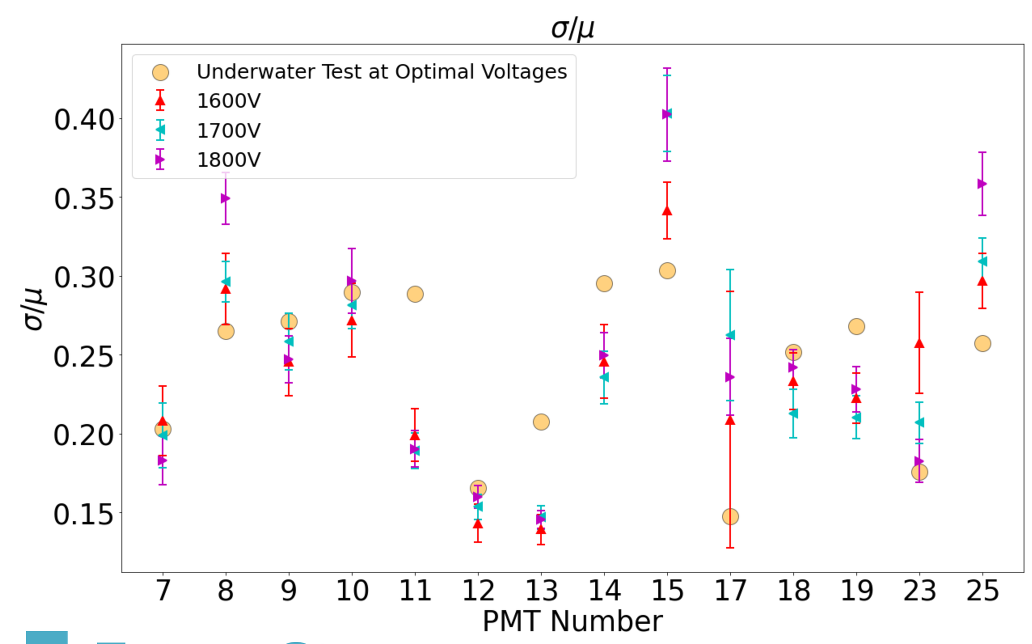
Status of D_2O Module 1

Module 1 was built and operated in summer 2023 and has collected 982 MWh of beam-on data that year. Currently, over 90% of the data remains blinded as we work on analysis and preparation for the next SNS run. We have decided to implement a 15-μs veto cut to eliminate Michel electrons and confirmed that the muon veto panel's efficiency exceeds 99.9%.



PMT Testing Results in D_2O Module 2

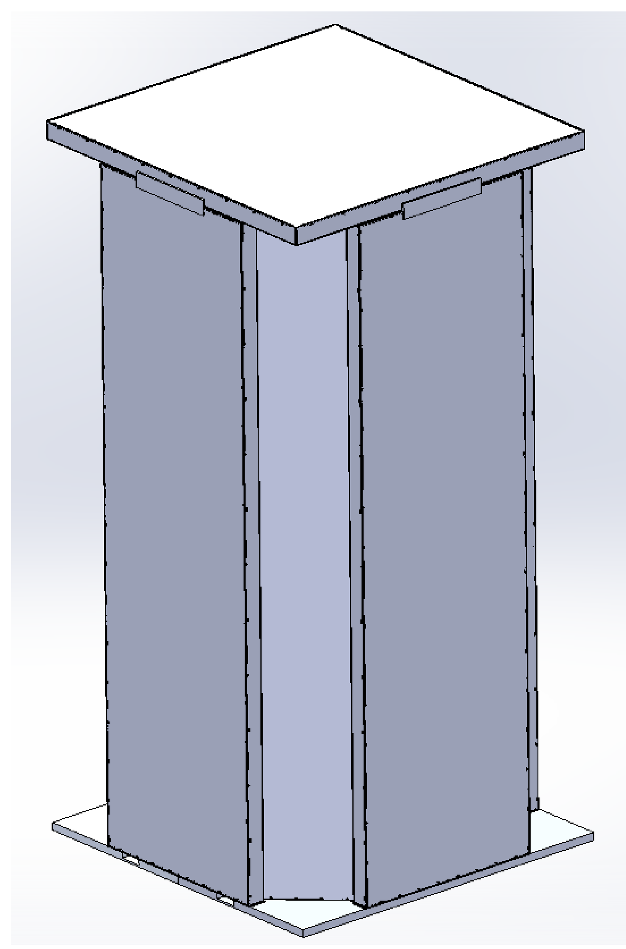




The plots show the results of PMT characterization testing that was completed at CMU for Module 2. Up: Gain vs voltage for each PMT. V_{opt} is the voltage required for gain matching and is demonstrated by the gold horizontal line. Down: Energy resolution (measured as σ/μ) vs PMT number for each PMT. The 12 PMTs to be utilized in Module 2 were selected based on energy resolution, dark rate, and operating voltage required for gain matching. Based on these criteria, PMT 1117 and 1125 have been rejected.

Future Steps

With PMT testing and selection complete, the next major commissioning step will be the completion of the muon veto system. The system (design shown to the right) will be composed of 10 plastic scintillator panels. Each panel will include milled grooves in the scintillator to hold wavelength-shifting fibers for light collection, while signal readout will be done by SiPMs. Each panel will be surrounded by several layers of Tyvek® and then sealed in aluminum casing. Machining of the muon veto panels is currently underway.



Full commissioning of Module 2 of the D_2O detector is expected to take place during late summer 2024.

ACKNOWLEDGEMENTS

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