Carnegie Mellon University

Status of the D2O Detector for the COHERENT Experiment

DPF-PHENO 2024

Gen Li

Outline

Background

CEvNS and COHERENT

Neutrino Flux from ORNL SNS

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Status

Status of Module 1

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Next Steps

CEvNS and COHERENT

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- **C**oherent **E**lastic **Neutrino**-**N**ucleus **S**cattering

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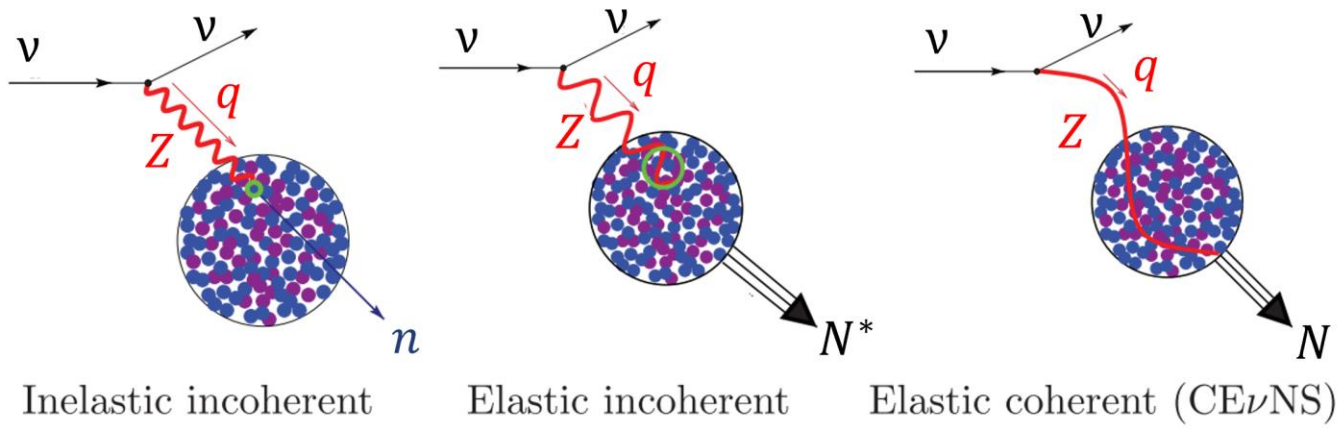

EPL, 143 (2023) 34001

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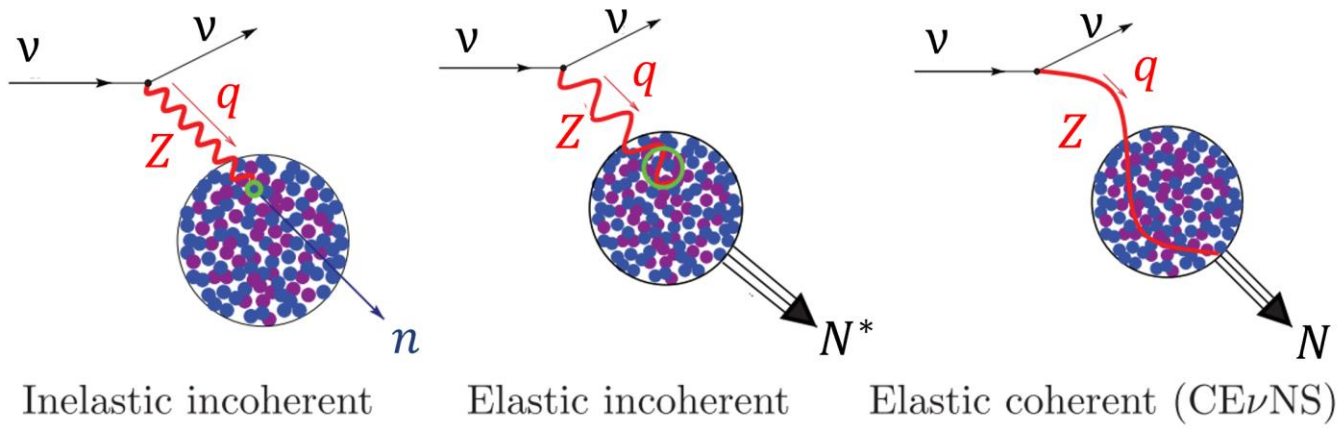
  - R is the nuclear radius
- Nuclear Recoil is tiny! $E_r \cong \frac{2E_\nu^2}{M}$ $(\sim keV)$



Inelastic incoherent Elastic incoherent Elastic coherent (CEνNS)

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CEvNS and COHERENT

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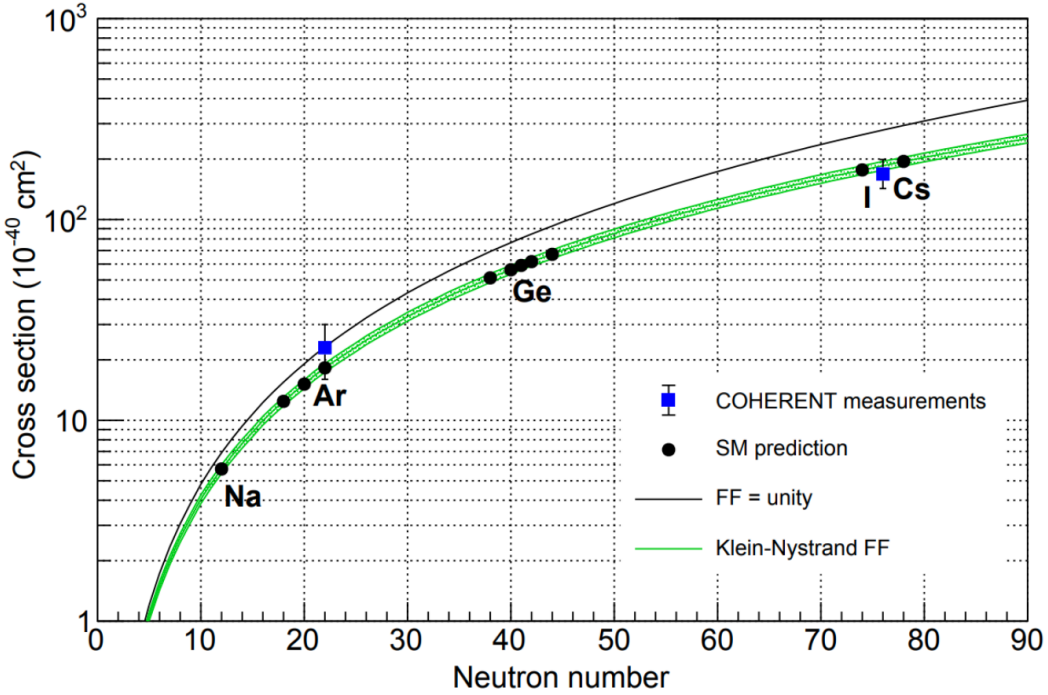
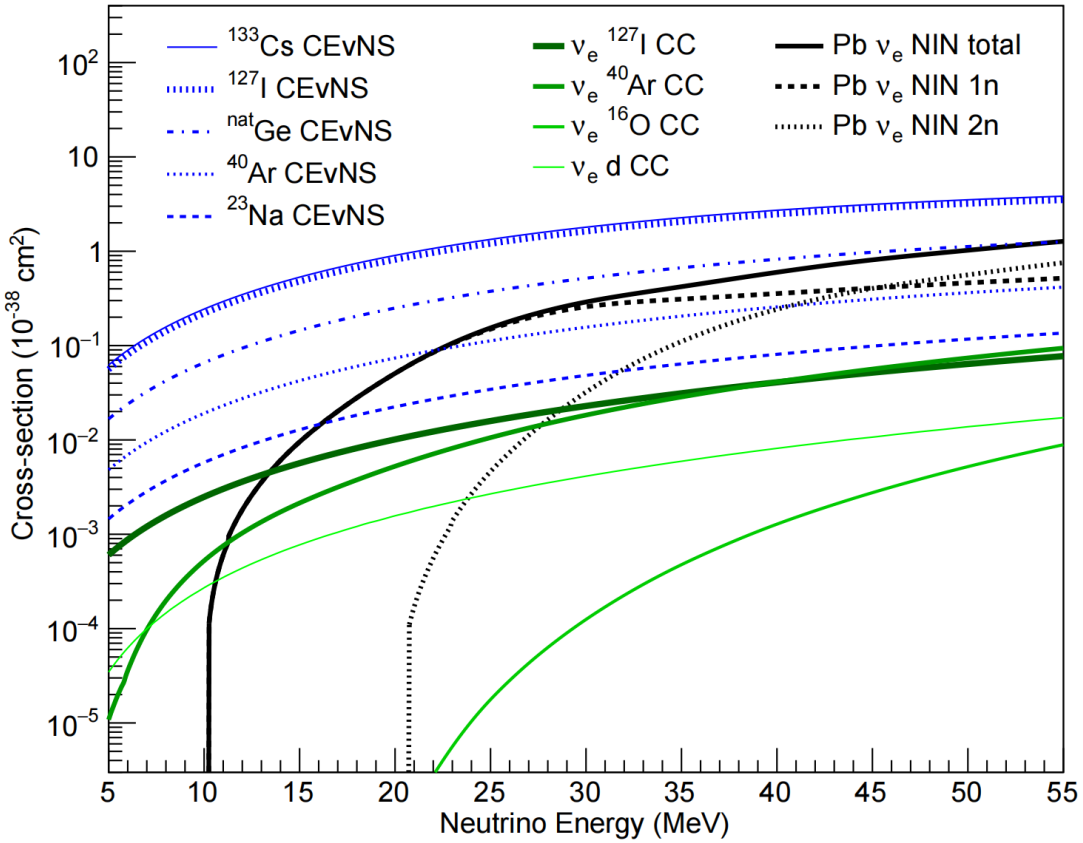
- When $T \ll E_\nu$: $\sigma \propto N^2$



arXiv:2111.07033

CEvNS and COHERENT

- When $T \ll E_\nu$: $\sigma \propto N^2$
- When $E_\nu < 100\ MeV$, CEvNS channel dominates.



Oak Ridge National Lab Spallation Neutron Source (ORNL SNS)

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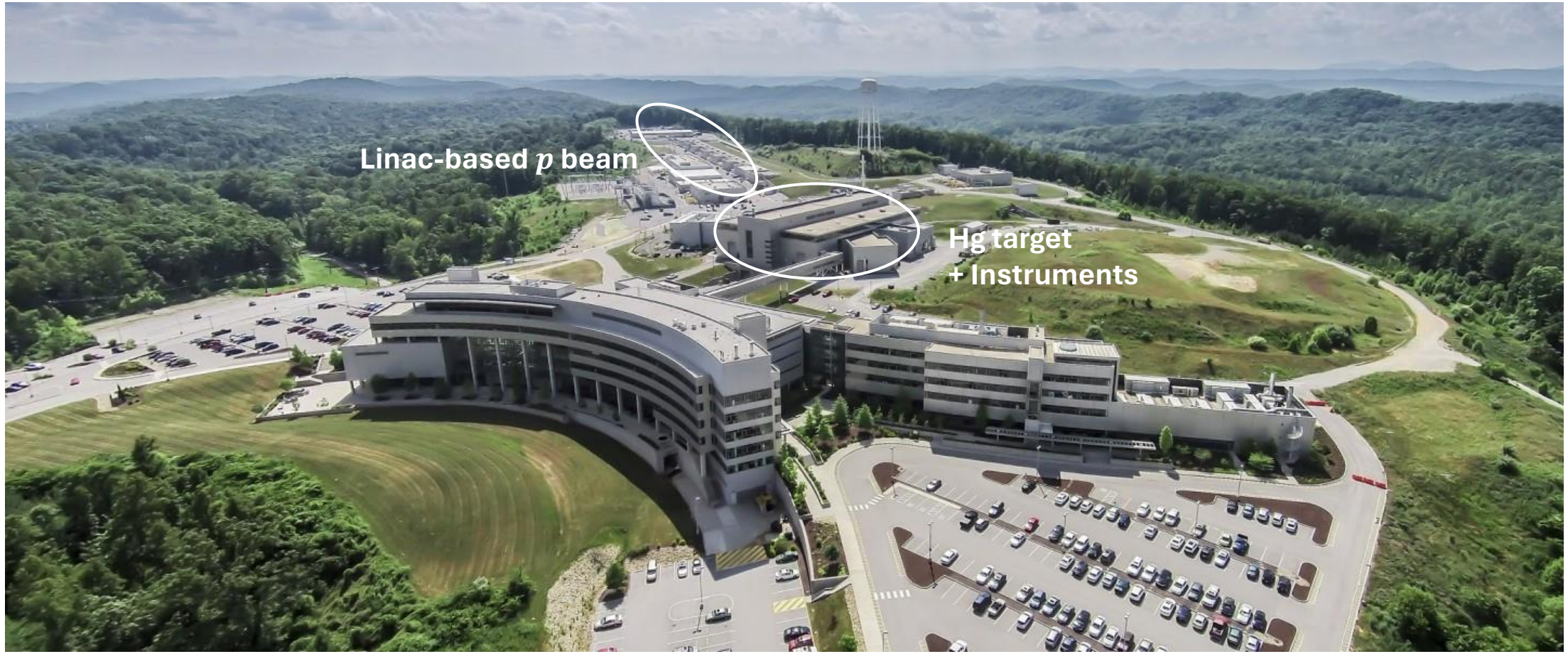

Neutrino Flux from ORNL SNS

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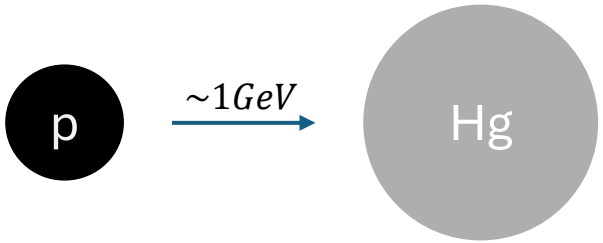

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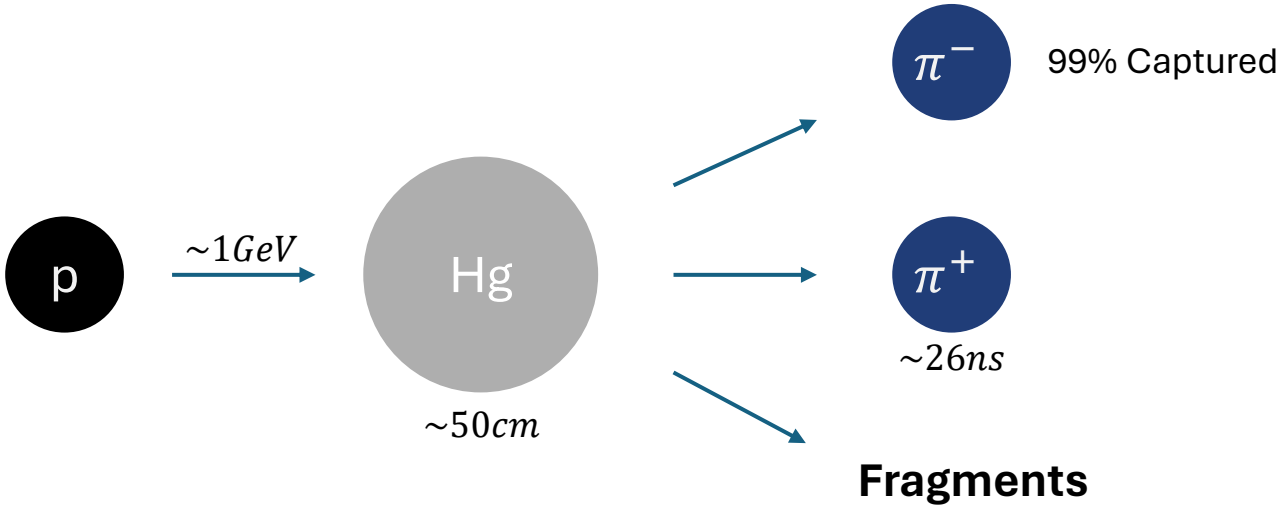

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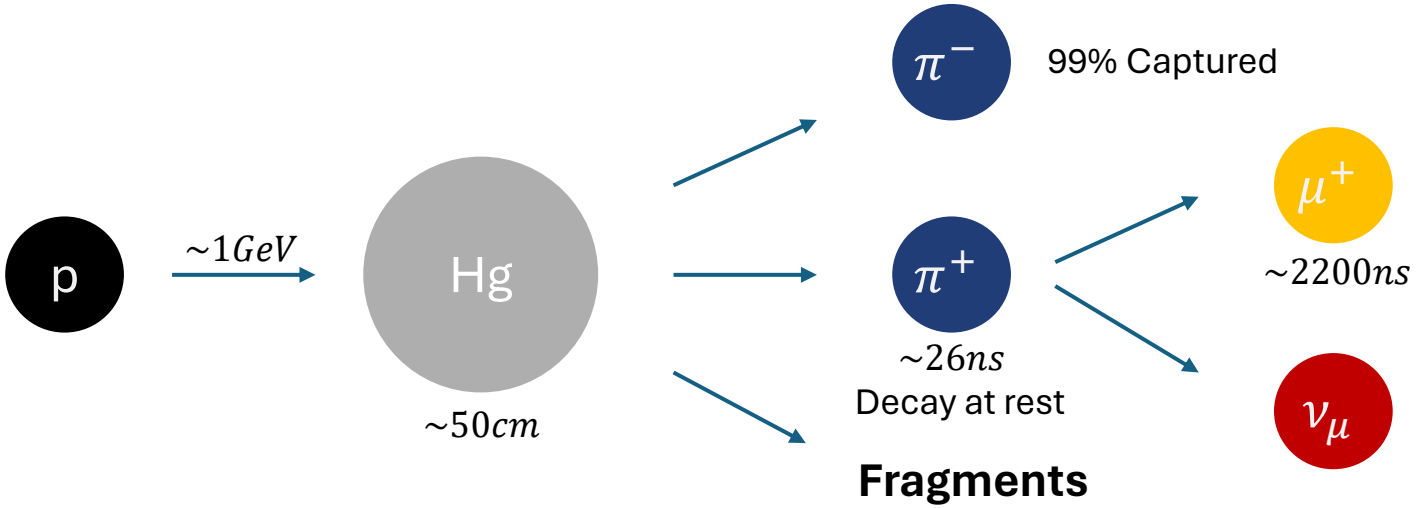

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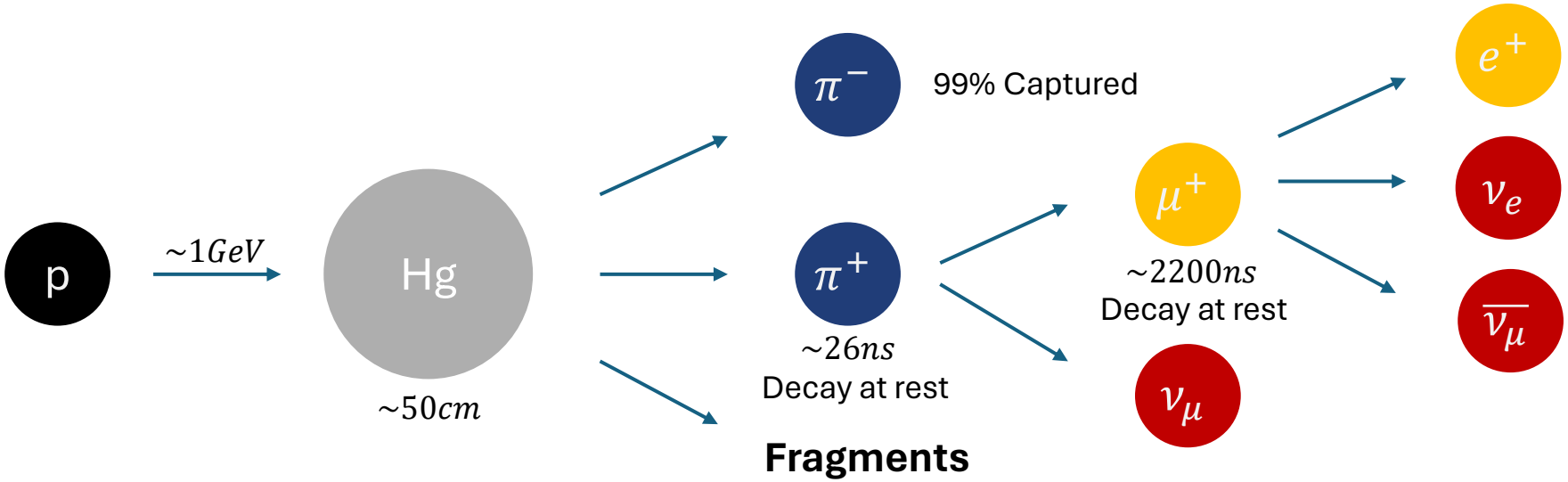

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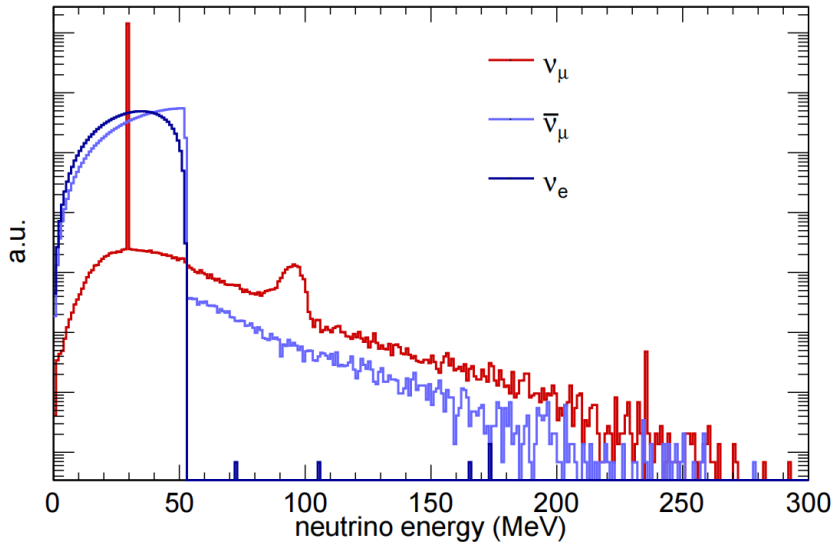
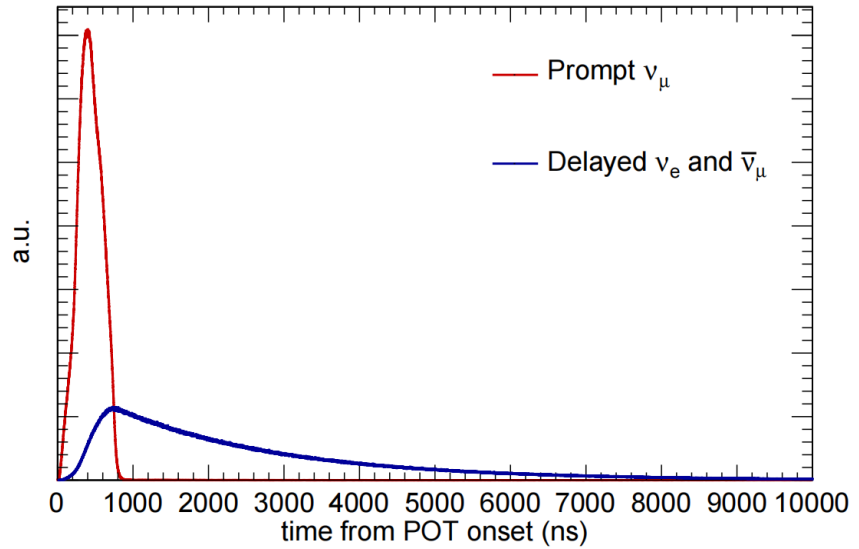
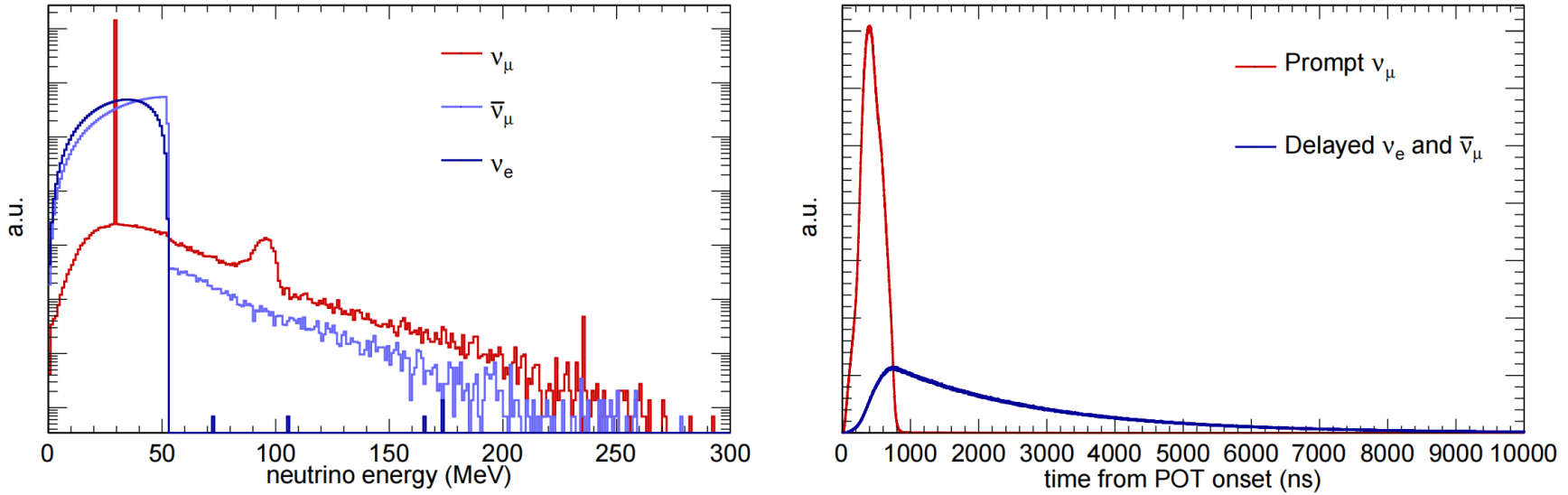




PRD106, 032003 (2022)

Neutrino Flux from ORNL SNS

- $\pi^+ \rightarrow \nu_\mu + \mu^+; \quad \mu^+ \rightarrow \overline{\nu_\mu} + \nu_e + e^+$
- $\sim 4.3 \times 10^7 cm^{-2} s^{-1}$ at Neutrino Alley ($20m$ from Hg target).



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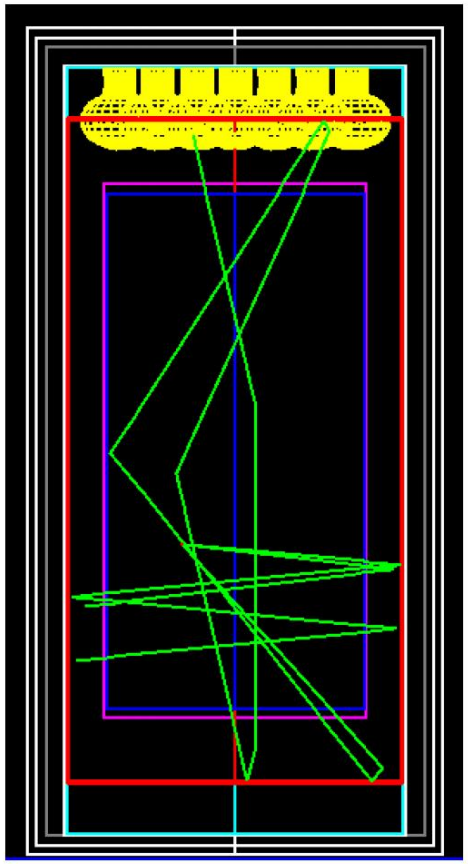
Design of D2O Module 1



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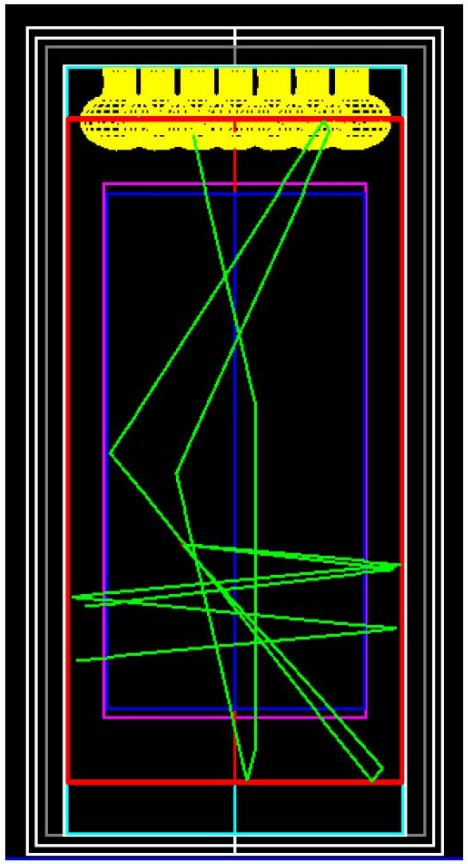
Design of D2O Module 1

- Water Cherenkov Detector



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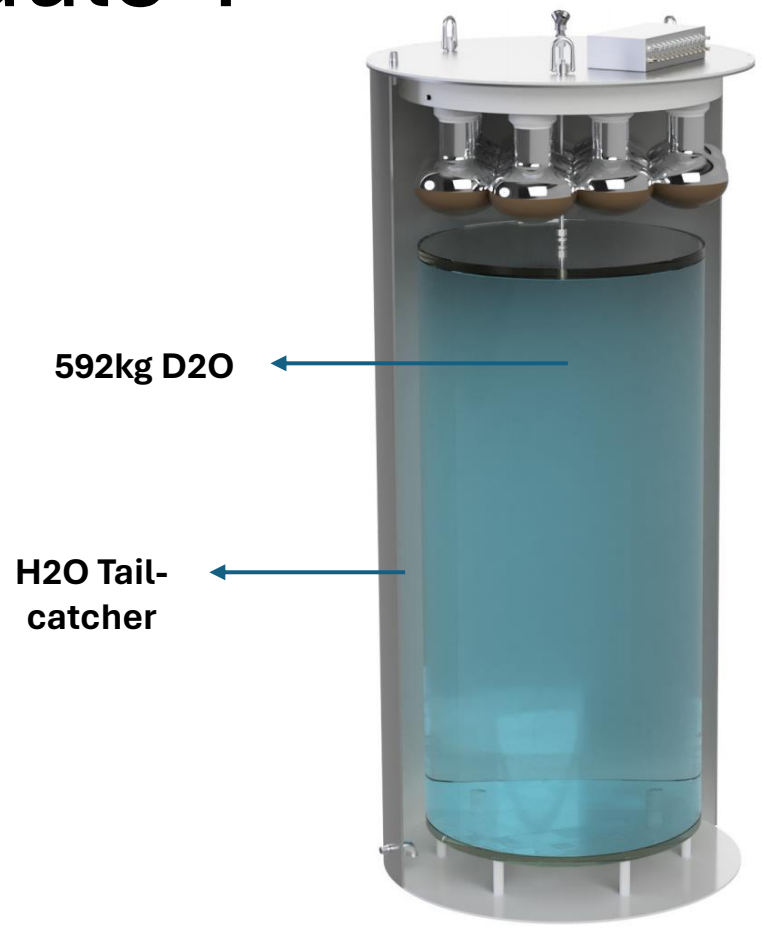
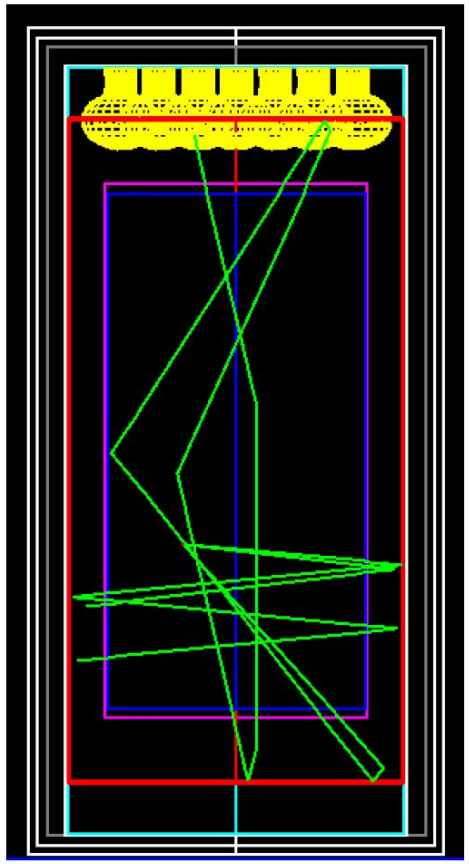
Design of D2O Module 1

- Water Cherenkov Detector
- 592kg D2O in acrylic tank





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- Water Cherenkov Detector
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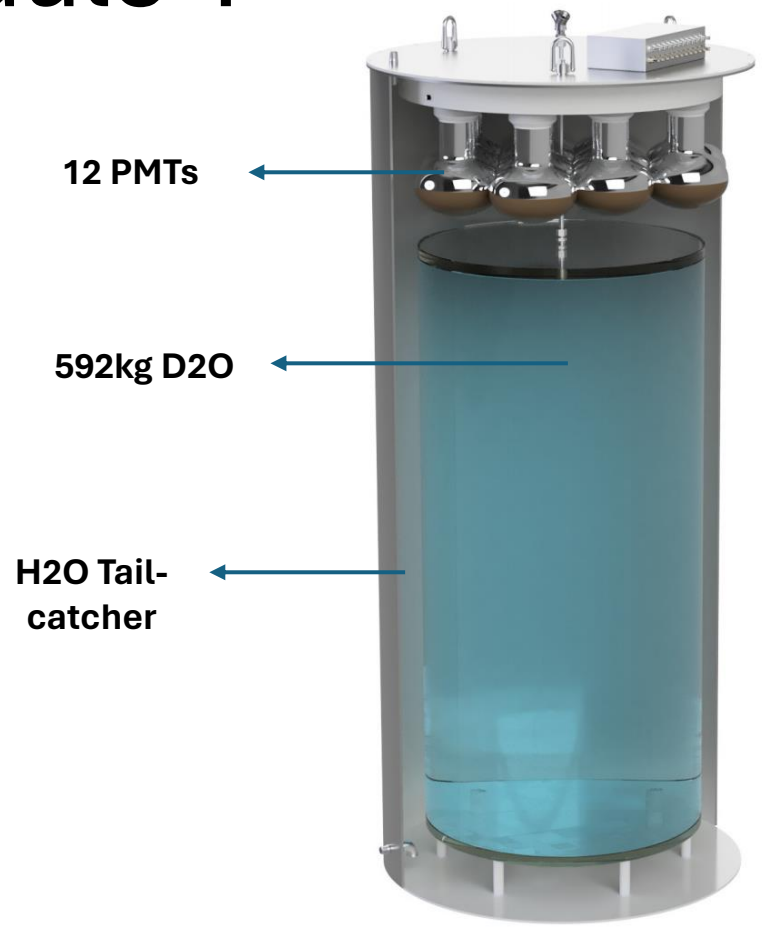

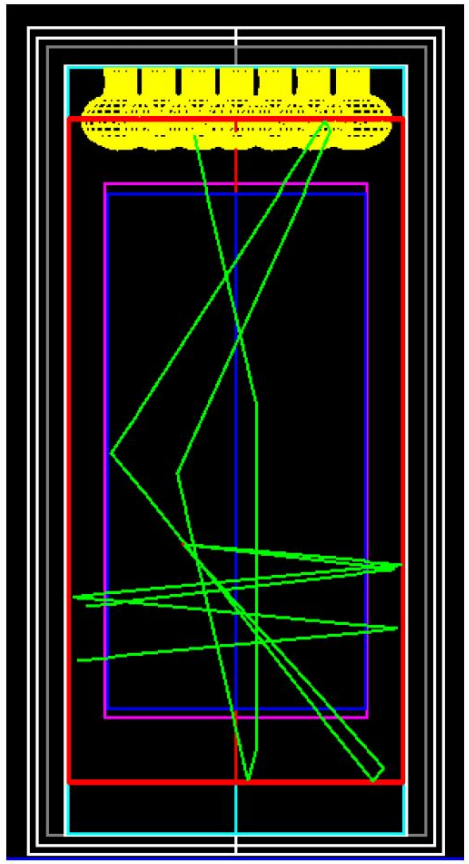

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Design of D2O Module 1

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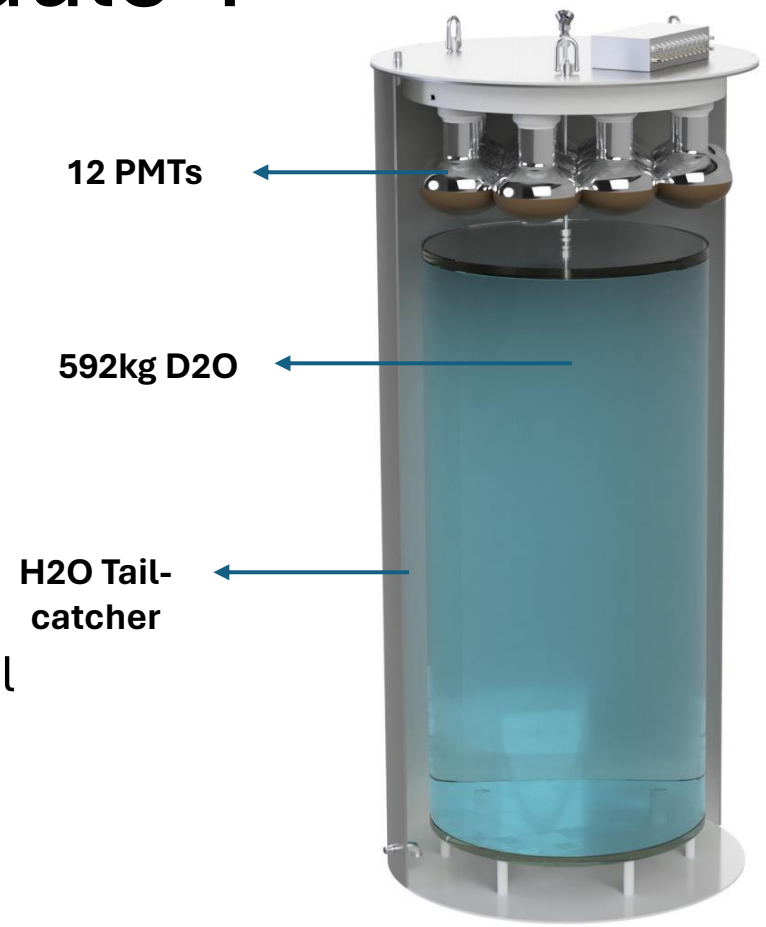

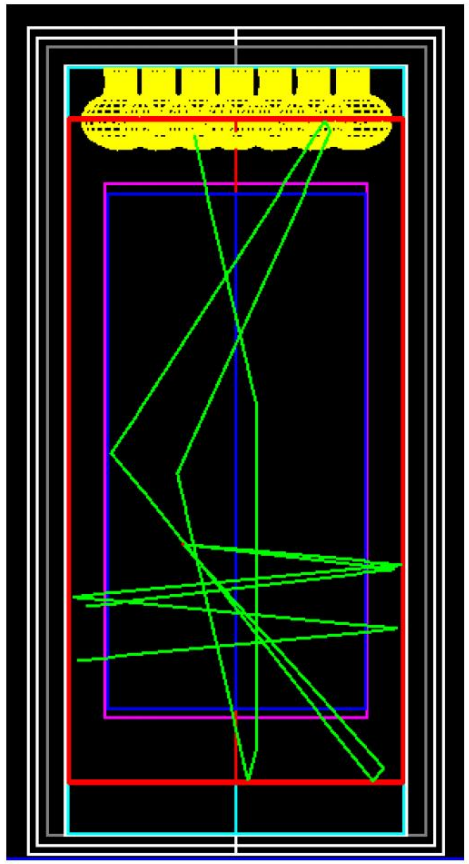

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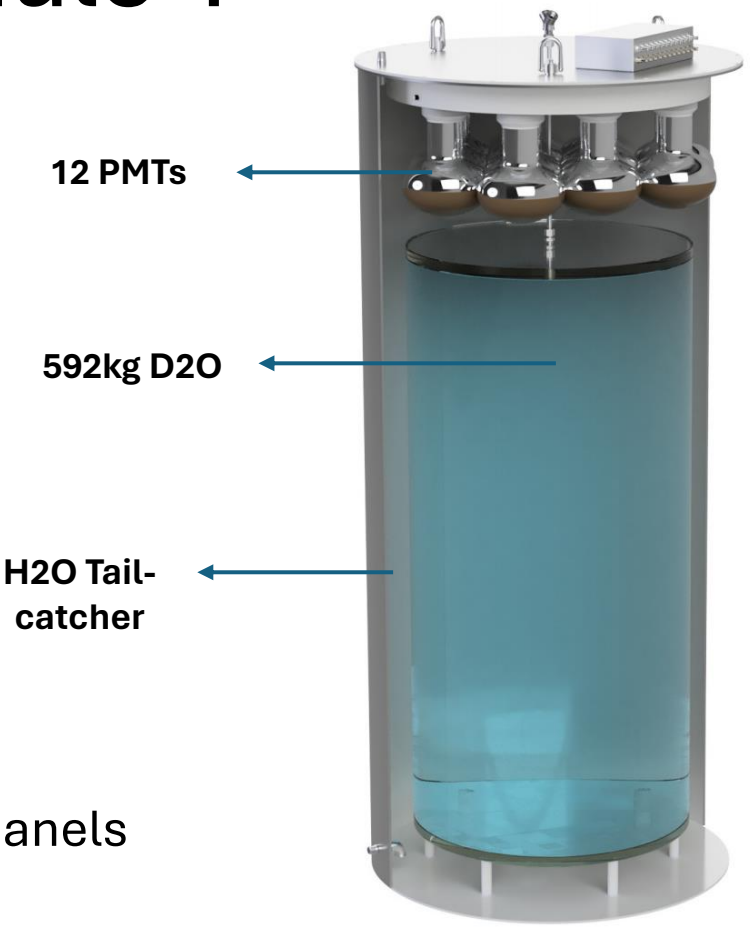
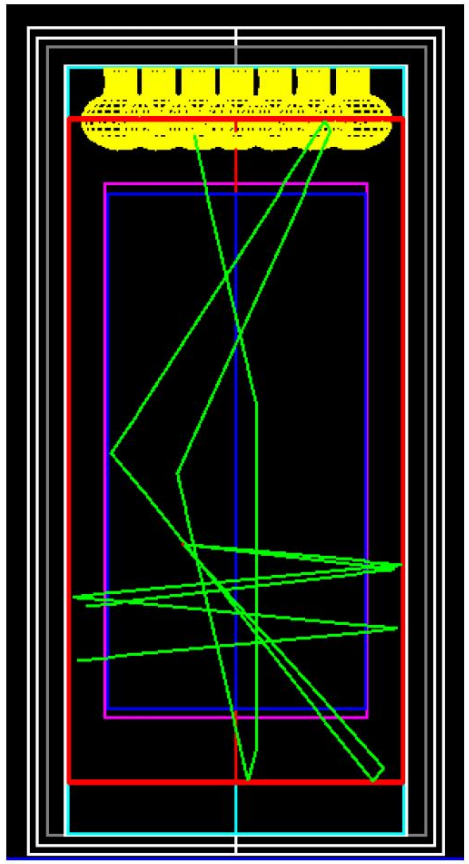
- Outside: lead shielding + muon veto panels





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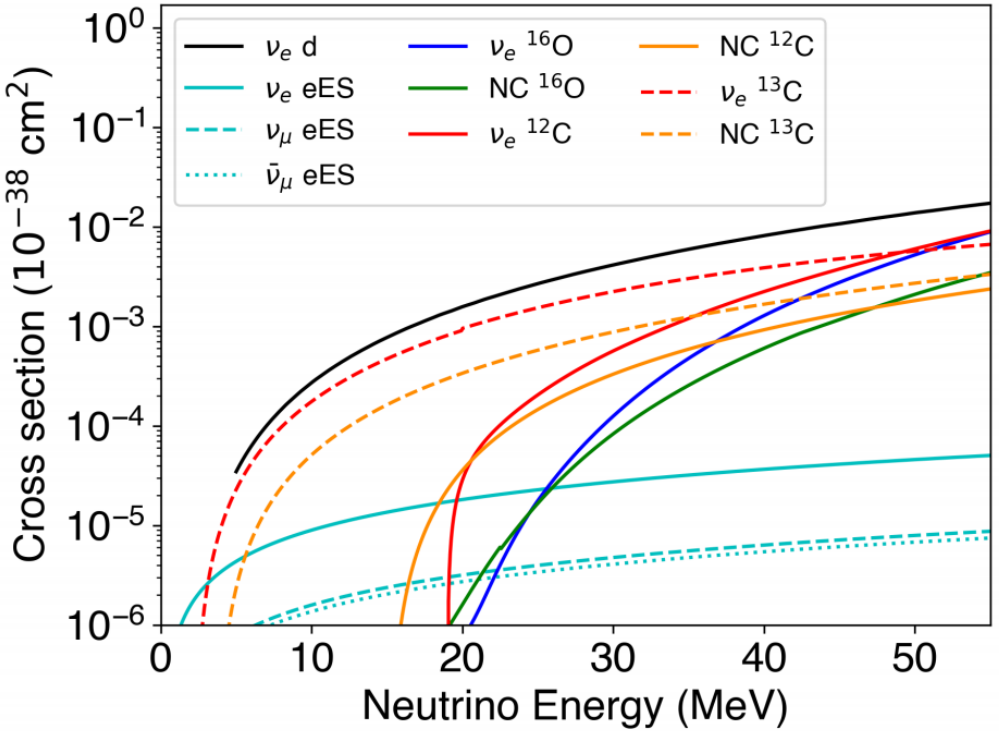

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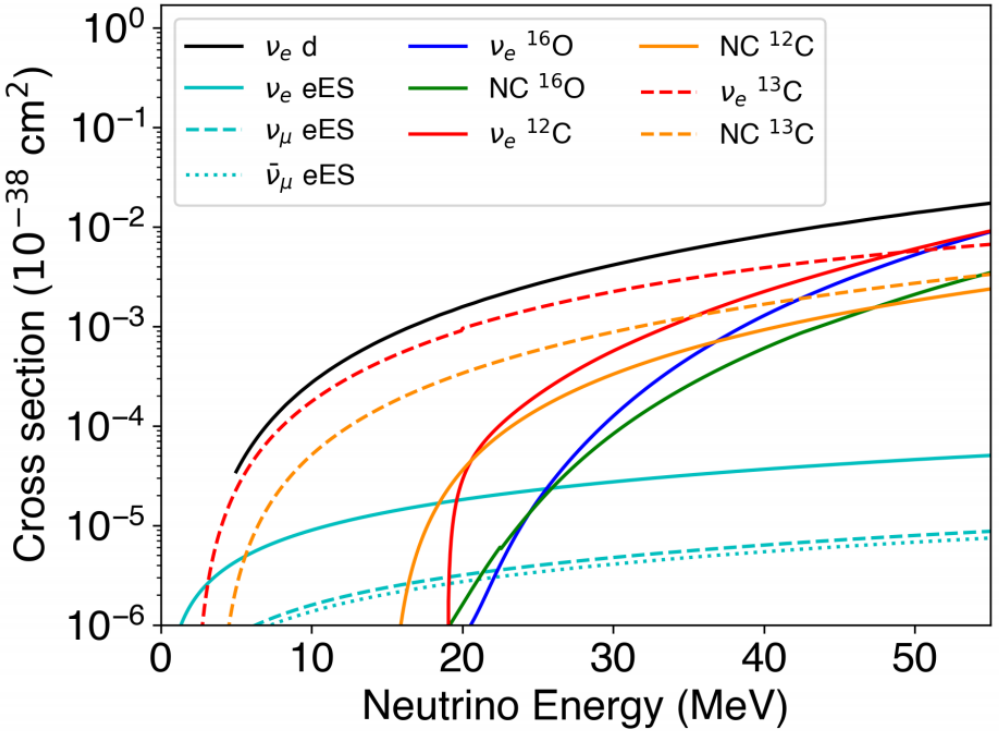
Design of D2O Module 1

- ν flux is simulated at $\sim 10\%$ uncertainty.
- 592kg D2O: $\nu_e + d \rightarrow p + p + e^-$
- Cross section for CC $\nu_e + {}^{16}O$ has never been tested at this energy range → Module 2



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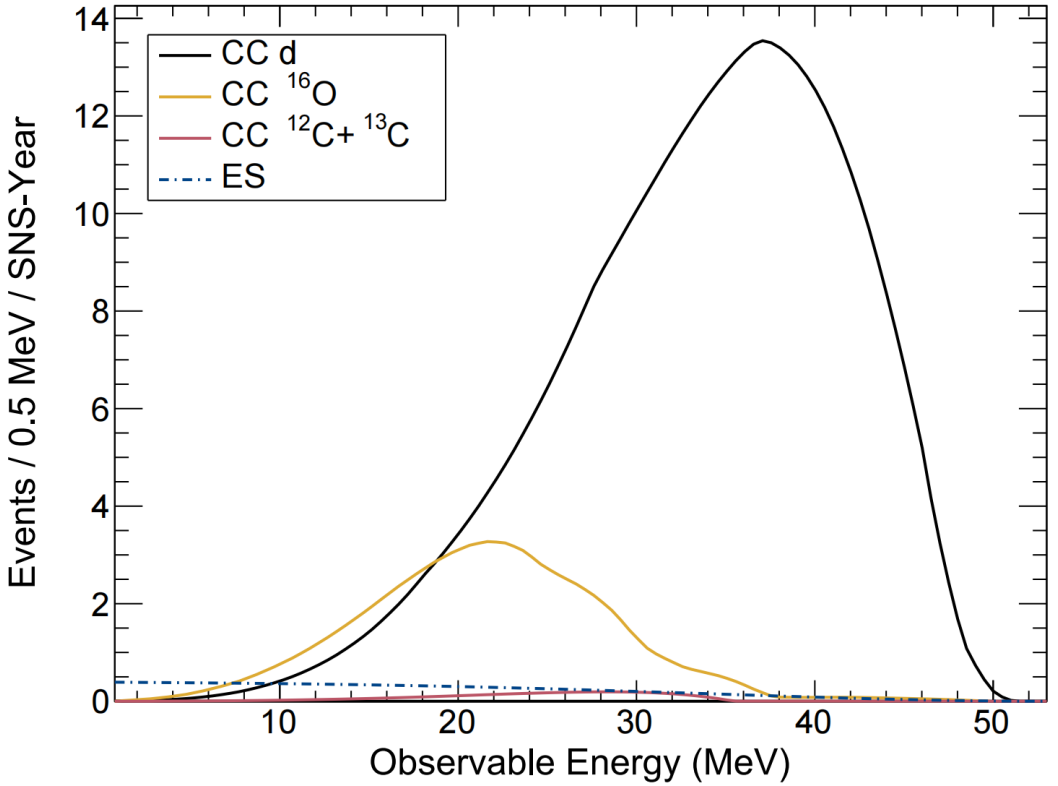
- The observable electron energies are distinguishable, which makes it possible to reconstruct CC d events.



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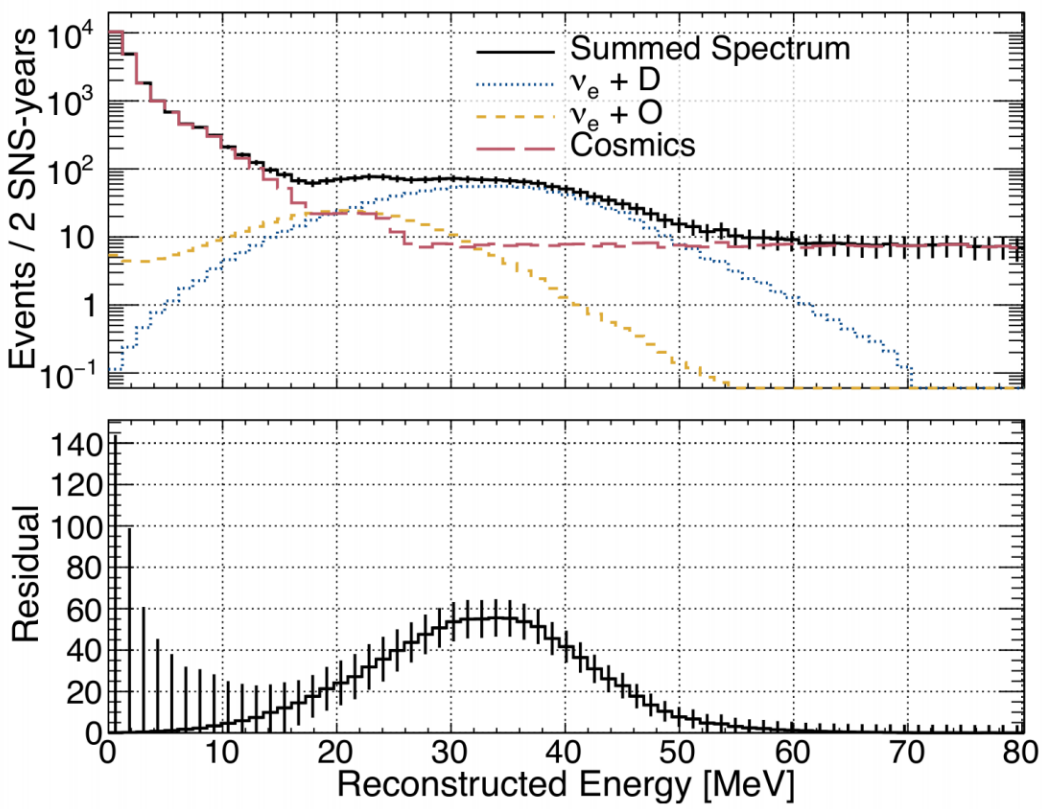
Design of D2O Module 1

- The observable electron energies are distinguishable, which makes it possible to reconstruct CC d events.
- After considering the smearing effect, we can simulate signal and background energy spectra.



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Goals and Predictions

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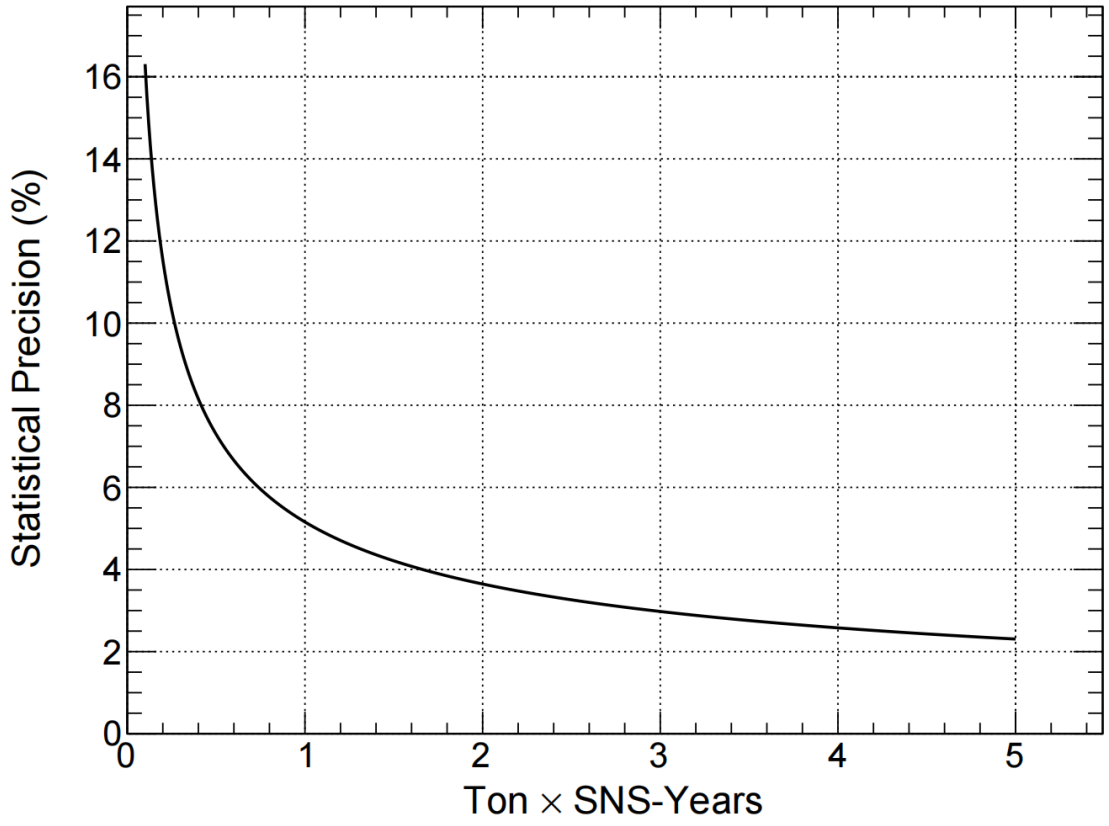
- The statistical uncertainty will decrease significantly from 10% after several years of running.



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- Better sensitivity to physics beyond the Standard Model.

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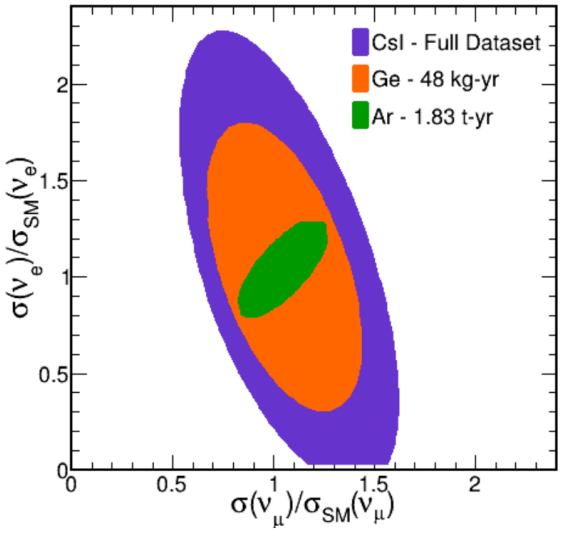
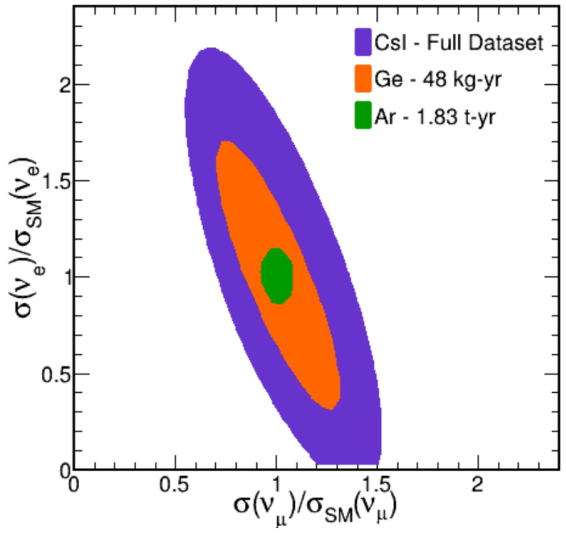


~10%



~3%

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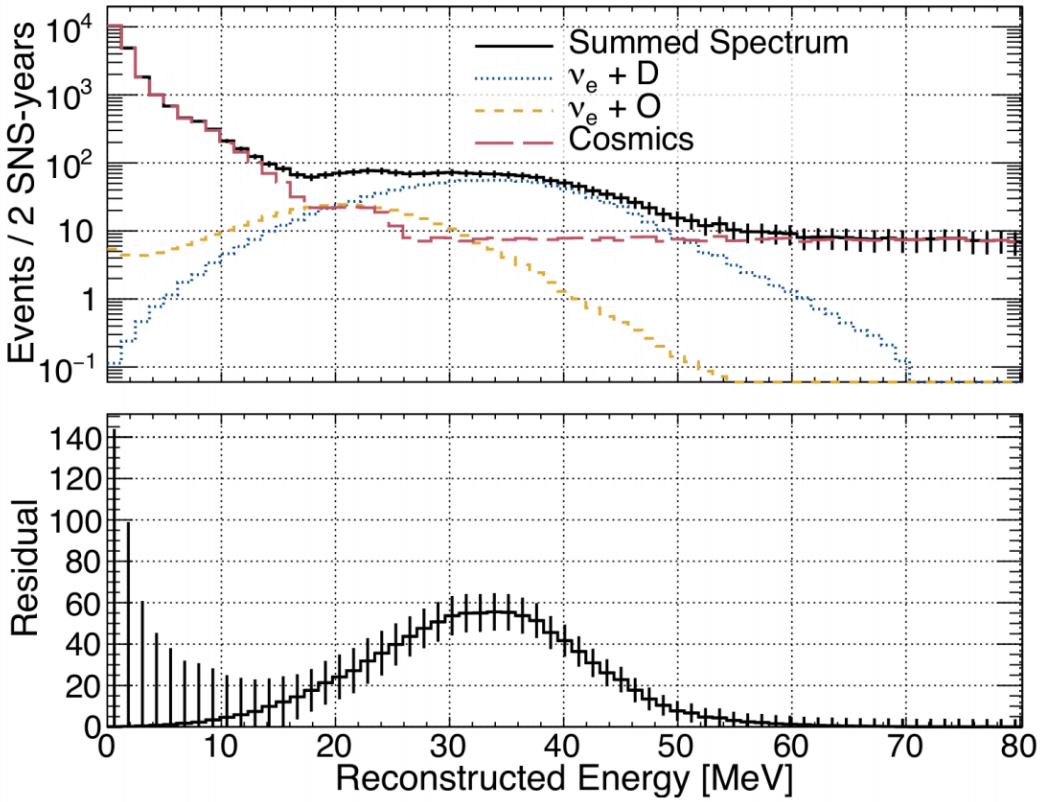
- Measure σ of $\nu_e + {}^{16}O \rightarrow e^- + {}^{16}O$ without the background from CC $\nu_e + d$.



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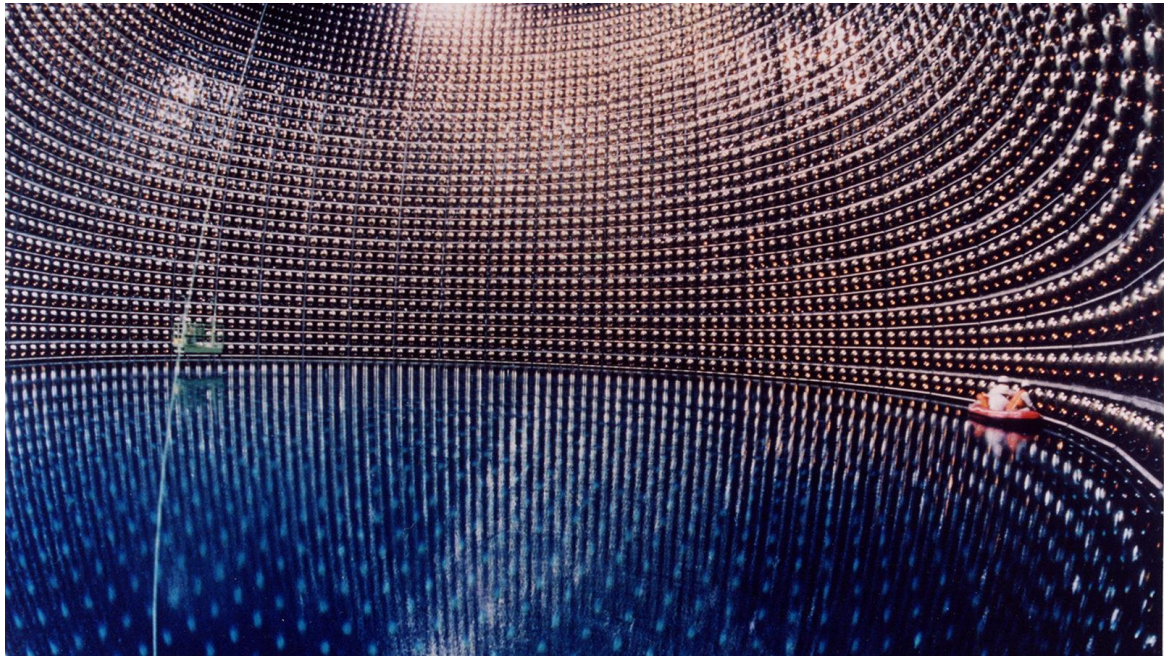
- Measure σ of $\nu_e + {}^{16}O \rightarrow e^- + {}^{16}O$ without the background from CC $\nu_e + d$.
- Interesting to large-scale water Cherenkov detectors (Super K and Hyper K) !



Kamioka Observatory, ICRR (Institute for Cosmic Ray Research), The University of Tokyo

Status of Module 1

- Module 1 is built and operated in summer 2023.
- Collected 982MWh of beam-on data in 2023.
- Data is still 90%+ blinded, we are currently working on analysis and preparation for next SNS run.

From Igor Bernardi, in APS April Meeting 2024

Status of Module 2

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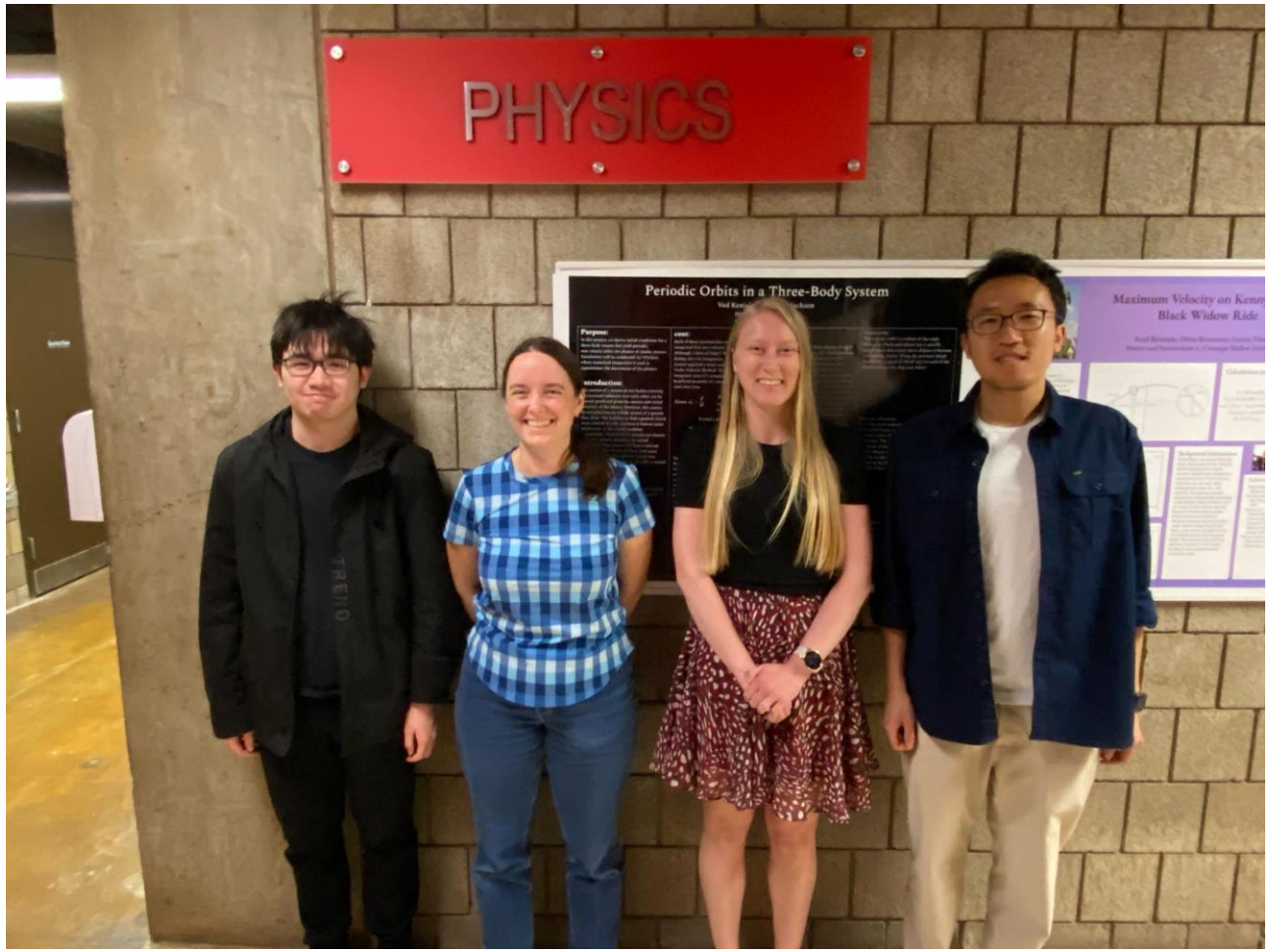

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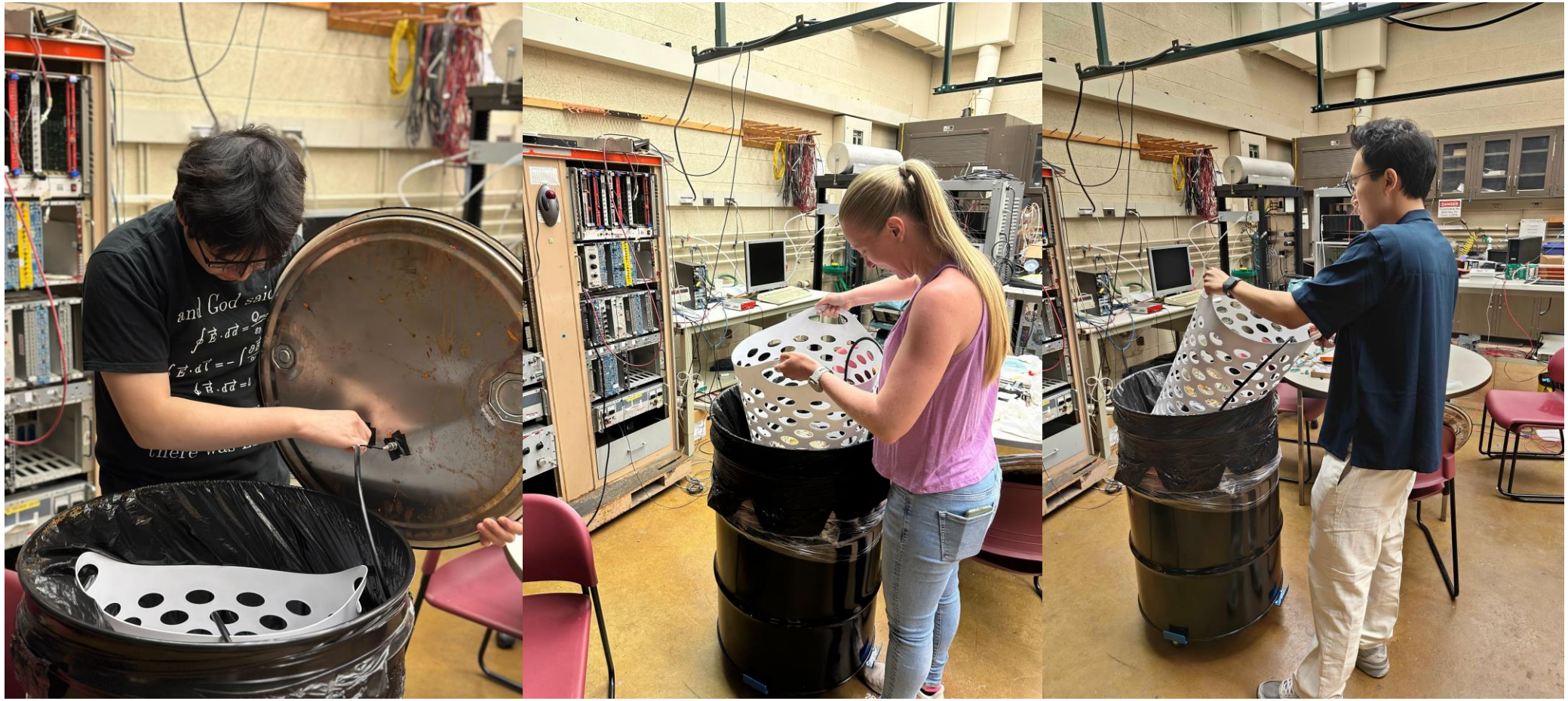

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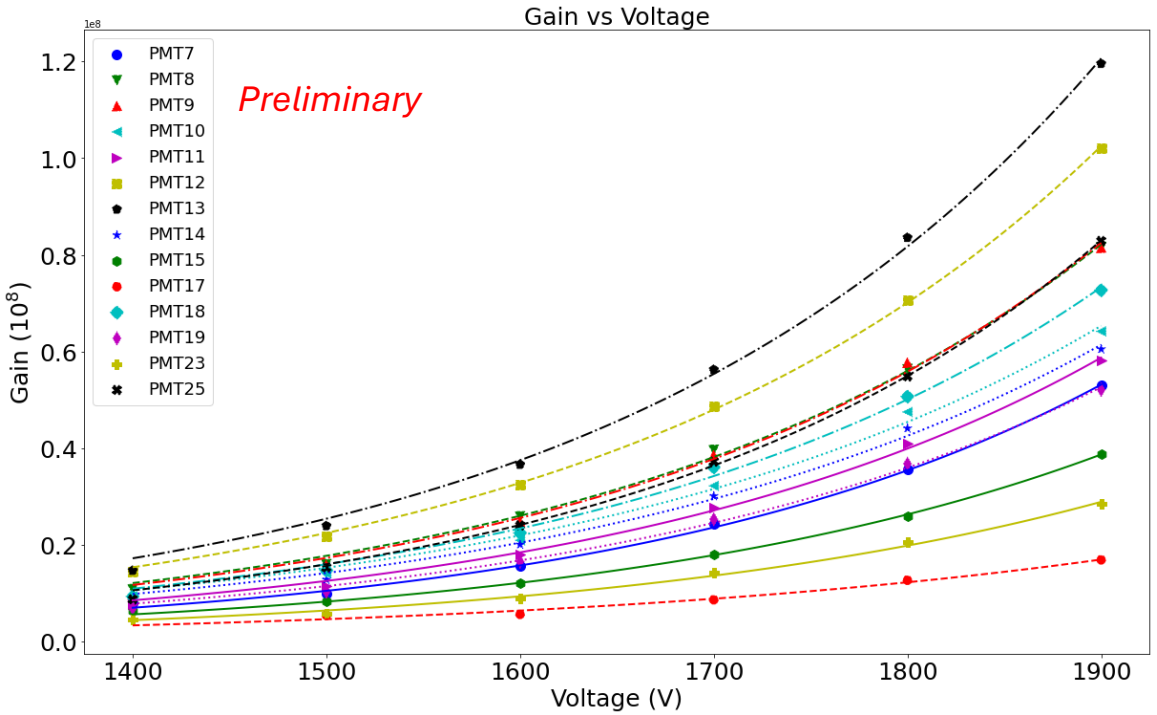

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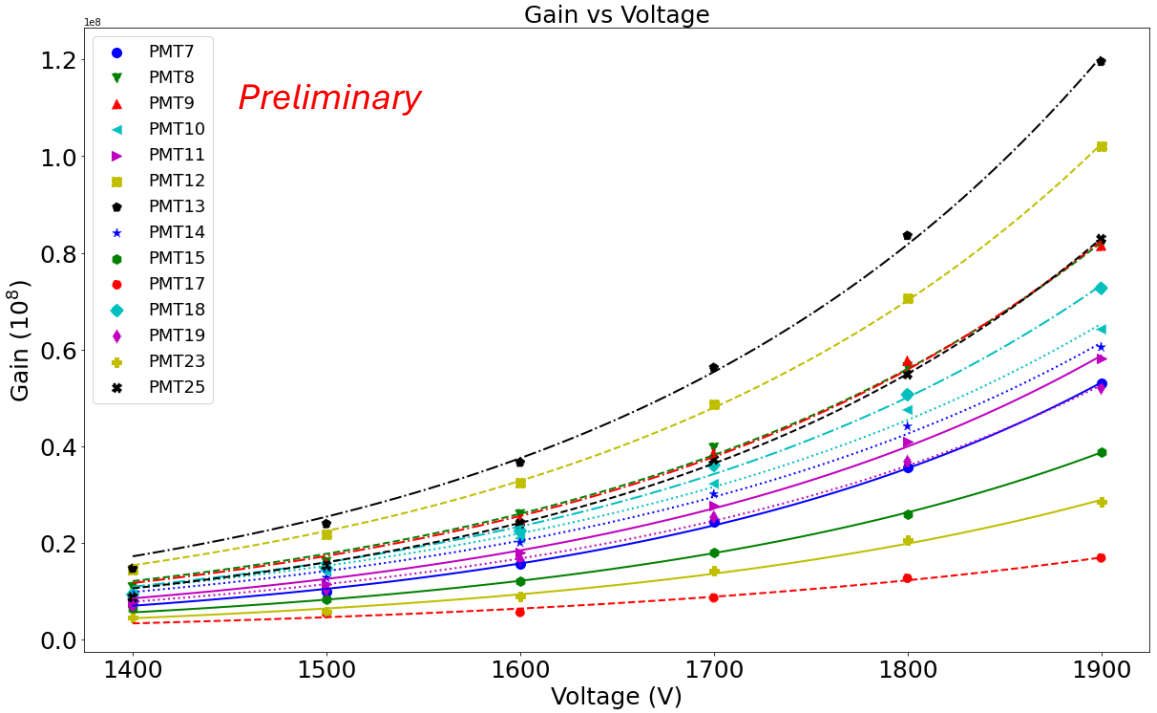

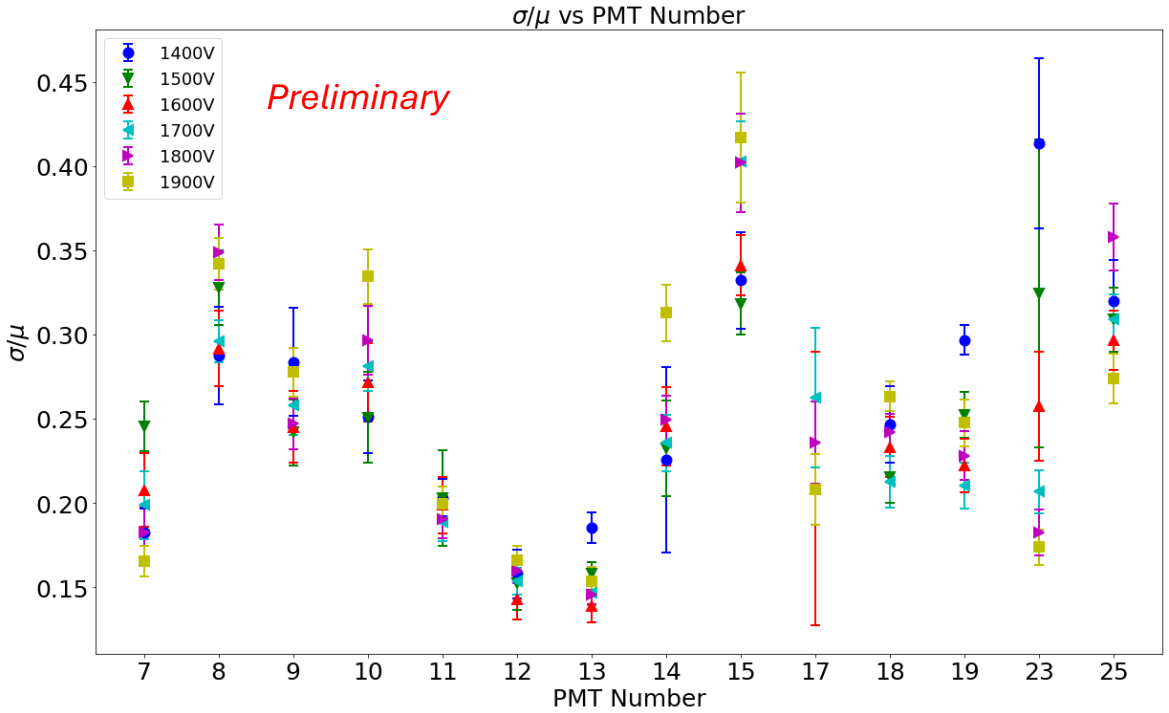

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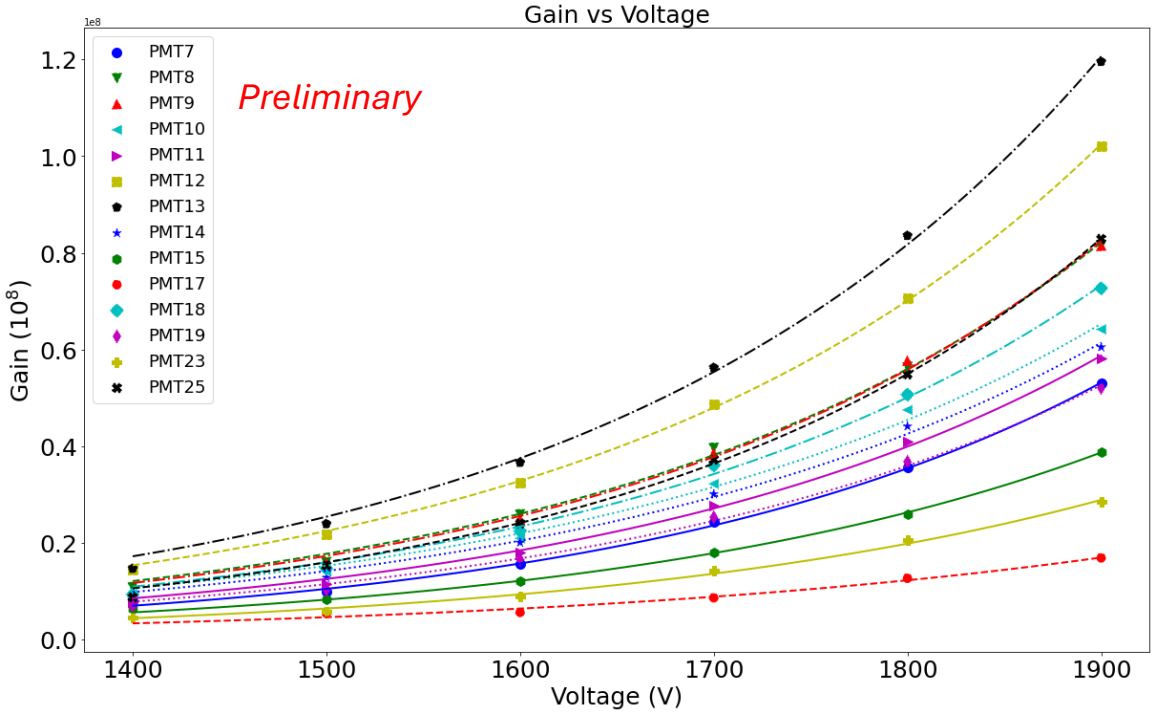
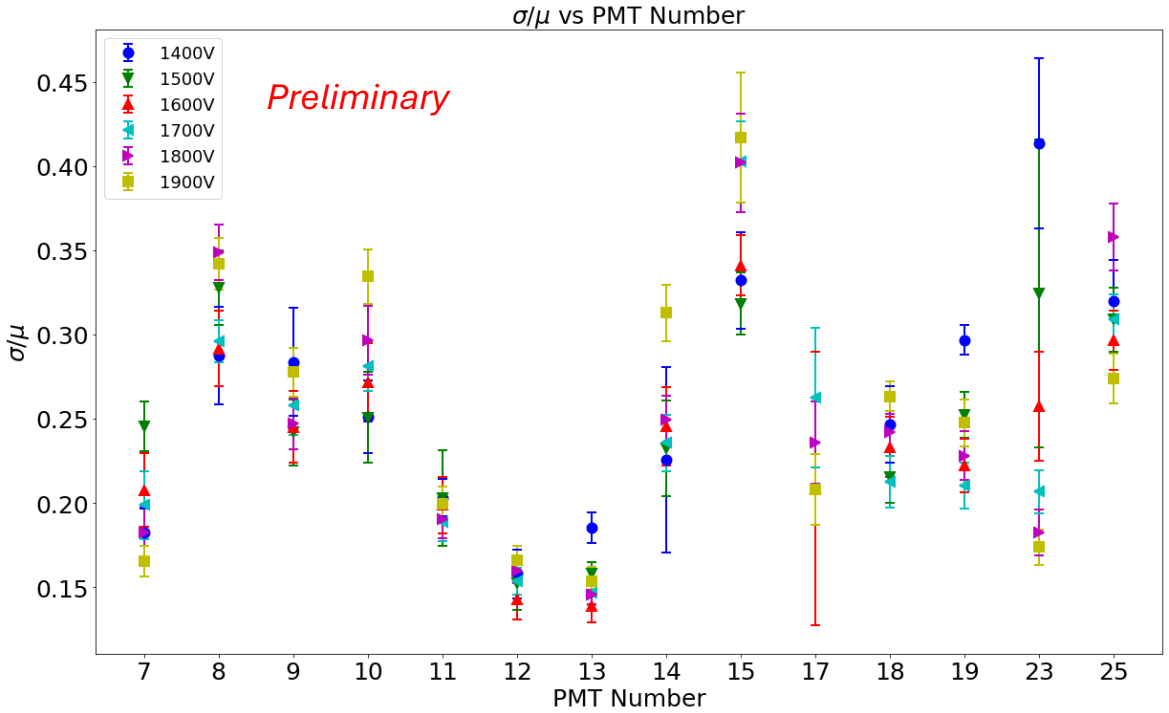
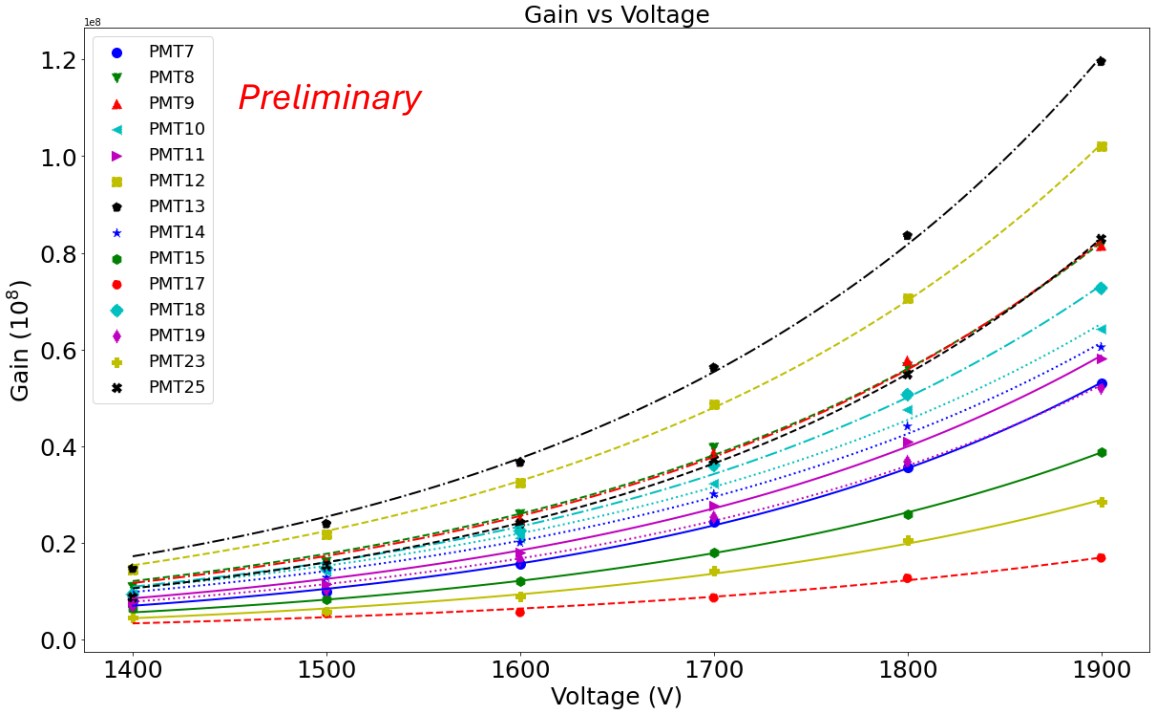
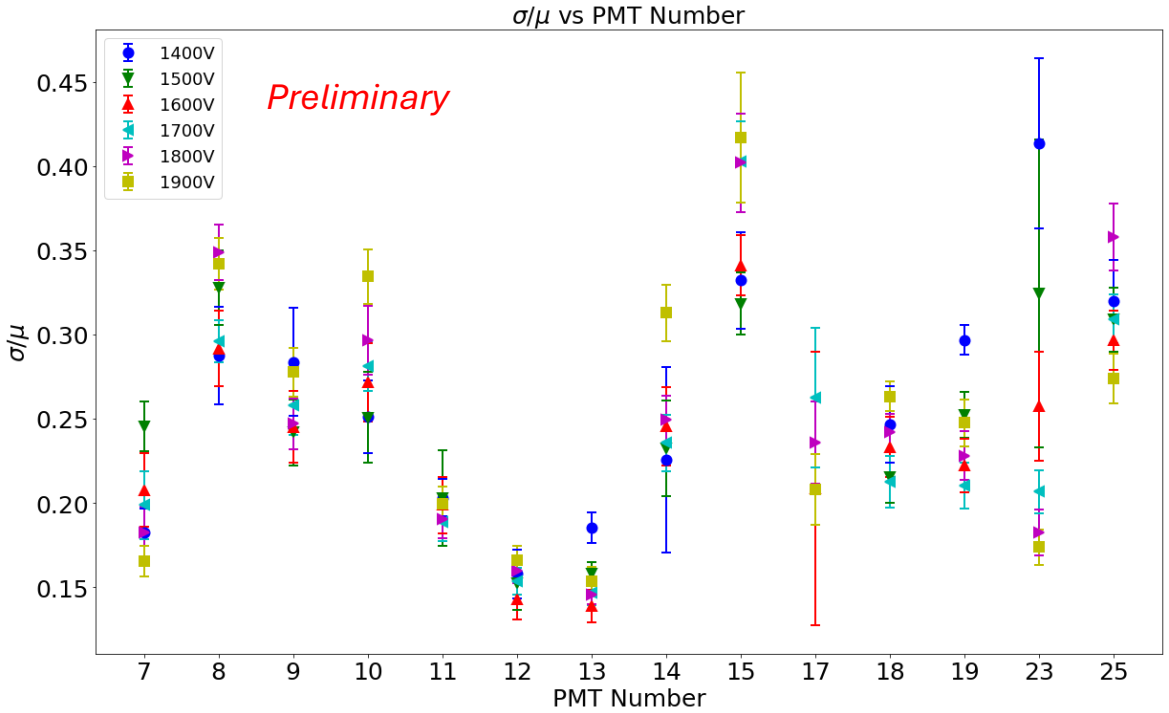




Status of Module 2

- All 14 PMTs have been tested and characterized.
- Muon veto panels are in progress. Test cut of grooves for optical fibers is ongoing.
- Acrylic tank and DAQ boards have arrived.





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- Module 2 will be commissioned in summer 2024.

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- Next multi-month run with both Module 1 and Module 2 aims to start in Summer 2024.

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- Next multi-month run with both Module 1 and Module 2 aims to start in Summer 2024.
- More simulation study to determine the operating time for Module 2 to measure cross section of CC $\nu_e + {}^{16}O$.

Acknowledgement

DOE Award Number: DE-SC0022125

Acknowledgement

- D2O group members: Manoj Adhikari, Igor Bernardi, Yuri V Efremenko, Karla Tellez-Giron-Flores, Gen Li, Jon Link, Kirsten McMichael, Jason Newby, Diana Parno, Daniell Shi, Joel Sander, Kate Scholberg, Tulasi Subedi, Keegan Walkup, Eli Ward.

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- COHERENT Collaboration
- Thanks for listening!

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