Measuring Inelastic-Neutrino Scattering on Lead(Pb) using a Cherenkov Detector at the SNS at ORNL.

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Background

- There are two types of neutrino interactions:

$$\nu_e + {}^{208}\mathrm{Pb} \Longrightarrow {}^{208}\mathrm{Bi}^* + \mathrm{e}^- \qquad \text{(CC)}$$

$$\Downarrow$$

$${}^{208-y}\mathrm{Bi} + x\gamma + y\mathrm{n}$$

$$\nu_x + {}^{208}\mathrm{Pb} \Longrightarrow {}^{208}\mathrm{Pb}^* + \nu_x^{'} \qquad \text{(NC)}$$

$$\Downarrow$$

$${}^{208-y}\mathrm{Pb} + x\gamma + y\mathrm{n}$$

Motivation for the Study

- Study first stage of charged-current (CC) interactions in ^{208}Pb
- Are we sensitive to beam-related neutrons (BRNs)?

Neutrinos at the Spallation Neutron Source (SNS)

- World-leading neutron research facility that runs a 1.7 MW pulsed beam accelerator
- Mainly produces **neutrons** but also creates **some flavors of neutrinos** ($\nu_\mu, \nu_e, \bar{\nu}_\mu$).

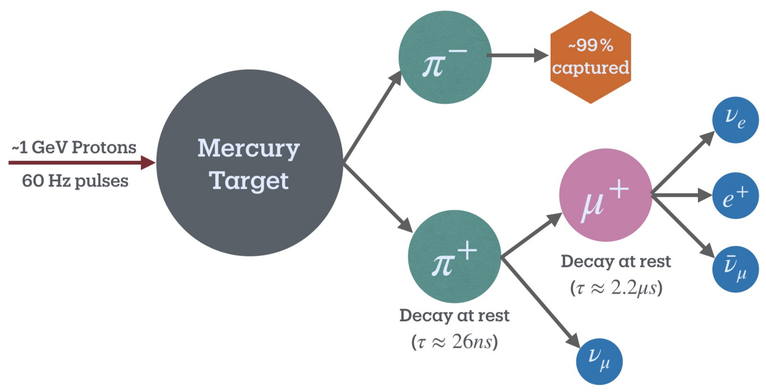

Fig. 1: Neutrino production from proton beam at the SNS

- Existence of **Neutrino Alley** at the SNS:
  – Shielded **neutron-quiet** basement hallway
  – Allows for placement of detectors for neutrino research

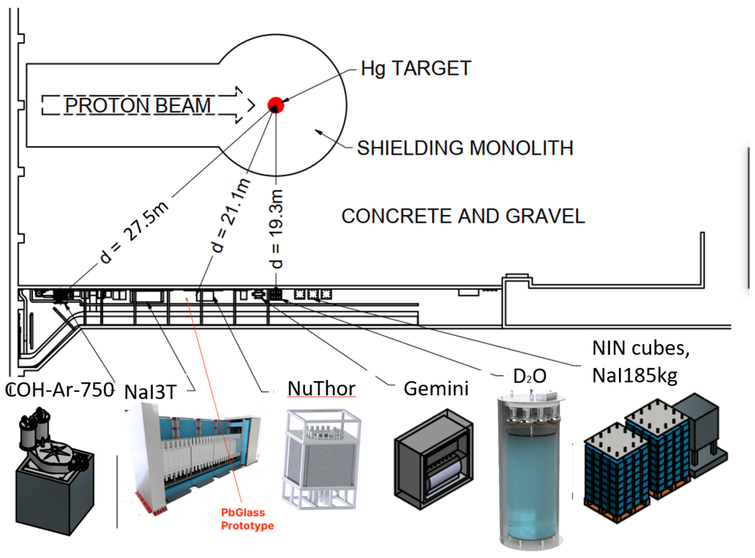

Fig. 2: Diagrammatic representation of detector systems deployed by COHERENT collaboration in Neutrino Alley

Prototype design

- The prototype detector consists of:
  – **40kg Lead glass block**
  – **2 photomultiplier tubes (PMTs)**
  – **No shielding**
- **Cerenkov detector** (sensitive to electrons)

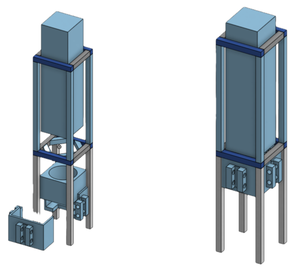

Fig. 3: Rendering of the PbGlass prototype

Building the Prototype

- Lead glass block wrapped in highly reflective mylar and black vinyl

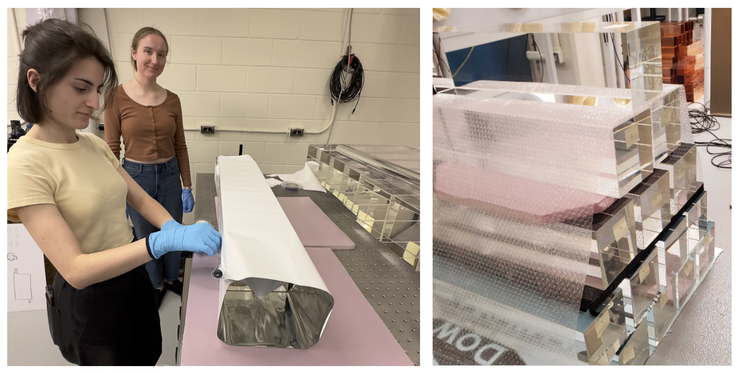

Fig. 4: Anna and Natalie wrapping lead glass (left) and a pile of lead glass blocks (right)

- Home-made bases for PMTs
- Manually calibrated PMTs:
  – 3.5 inch Bicron PMTs (2)
- Data Acquisition (DAQ) configuration:
  – CAEN 4 channel **12 bit 250 MS/s** desktop digitizer
  – Waveform recording software
- Deployed **Cerenkov prototype detector** in July 2023 at the Neutrino Alley at the SNS

Fig. 5: Some COHERENT collaboration members assembling the PbGlass prototype in Neutrino Alley

Fig. 6: PbGlass prototype in Neutrino Alley

Challenges

- Reusing Lead glass with radiation damage:
  – Reduced light transmission
  – Heat treatment to increase transmission
- Better PMTs optimized for Cherenkov signals
- Space constraints in Neutrino Alley at SNS

Fig. 7: Current deployment in Neutrino Alley and space considered for full PbGlass detector

Proposed Initial Detector

- Horizontal design for space considerations
- Planned deployment at SNS for summer 2024

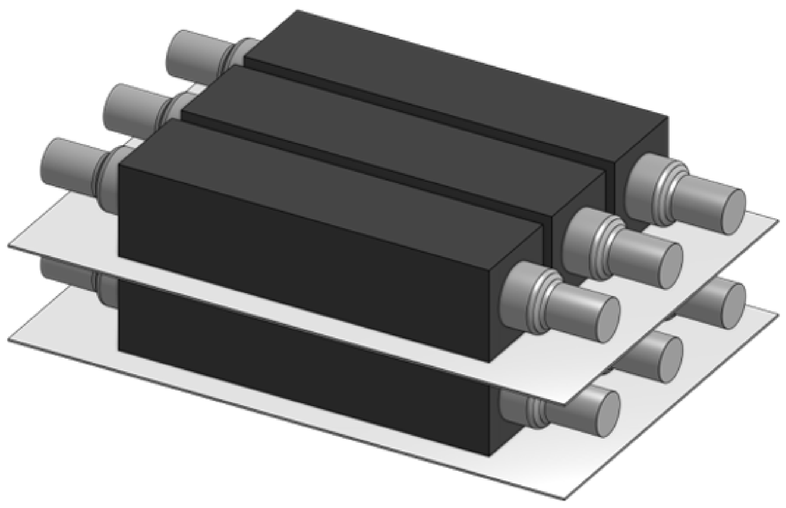

Fig. 8: Initial PbGlass detector rendering by Ana

Future work

- Currently analyzing ≈ **12 TB of beam-on** data with additional beam-off data
- Fine-tune prototype to minimize background noise and maximize signal:
  - Hardware optimizations
  - Software (advanced analysis techniques)
- Use findings to **design initial detector**
- Deploy initial detector by 2024 summer
- Study the **electromagnetic component** of CC neutrino interactions on ^{208}Pb

Acknowledgements

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