Analyzing Prototype Solid State Detector Performance and Suitability for the Deep Underground Neutrino Experiment

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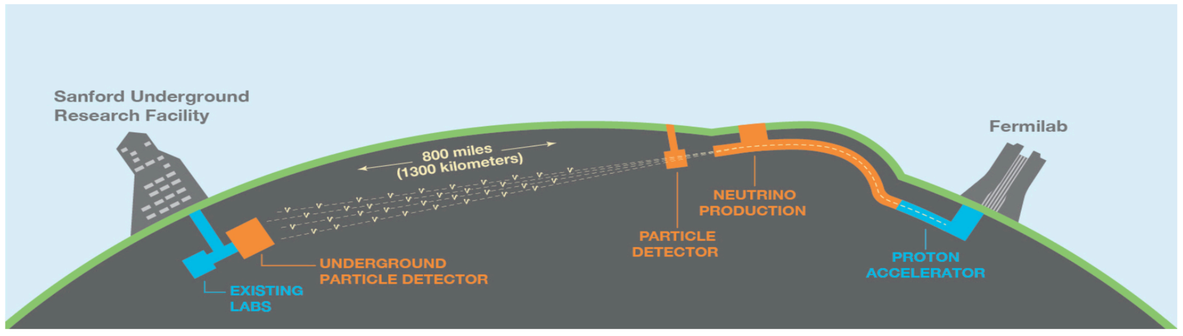
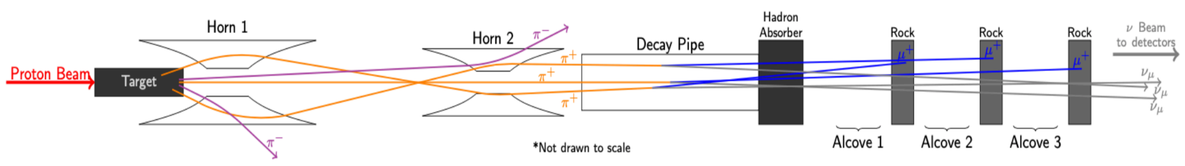
DEEP UNDERGROUND NEUTRINO EXPERIMENT

DUNE



- The Deep Underground Neutrino Experiment (DUNE) plans to begin its study of neutrino physics in the mid-late 2020's.
- DUNE will study neutrino oscillation parameters in hopes to explain the role they play in the universe and any part they have in the matter, anti-matter asymmetry.
- For DUNE to gather data from a neutrino beam it must have a reliable way to monitor the beam.
- Because neutrinos are hard to detect we can detect the muons in the beamline giving us real-time information about the neutrino beam.



(NuMI neutrino beam at Fermilab)

(DUNE's LBNF neutrino beam will use a similar concept)

- After accelerating protons to high energies (60-120 GeV), they are smashed into a graphite target giving positive and negative muons. For anti-neutrinos the negative pions are selected with magnetic horns whereas positive pions are selected for neutrino mode.

$$p^+ \rightarrow \pi^+ + \pi^- + N$$

(Protons collide with graphite nuclei)

$$\pi^+ \rightarrow \mu^+ + \nu_\mu$$

(Positive muons picked for neutrino mode)

$$\pi^- \rightarrow \mu^- + \overline{\nu}_\mu$$

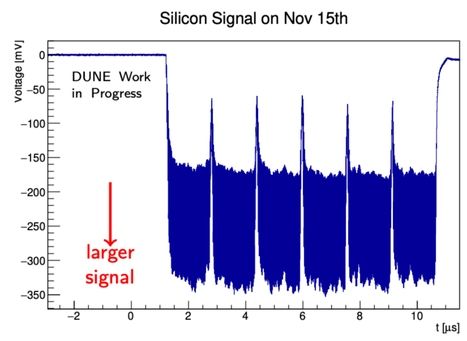
(Negative muons picked for anti-neutrino mode)

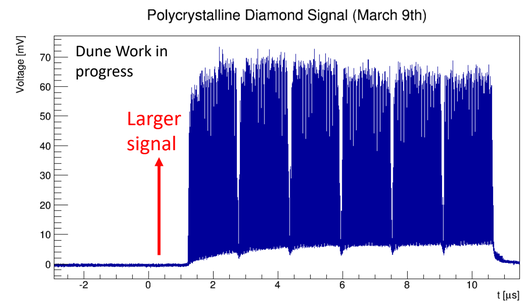
Solid State Detectors

- We are investigating an alternative beam monitor from the standard gaseous argon detector.
- The detectors should be stable and radiation tolerant.
- There are currently four prototype detectors in the NuMI beamline, including a polycrystalline diamond and silicon pin diode detector.
- Prototype detectors are currently located in NuMI alcove two.

Diamond VS Silicon

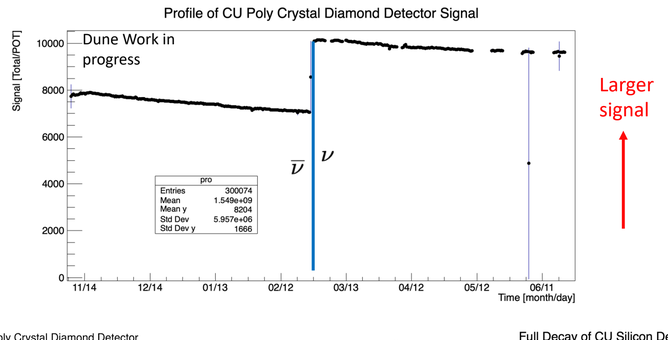
- Muons deposit charge in the detector which gives a current readout.
- Silicon detectors are cheaper but the tradeoff is that the diamond detector has a faster time response than the silicon detector and diamonds are expected to be about eight times more radiation tolerant.
- We can see the expected structure of the six batches that make up the beam pulse in NuMI.

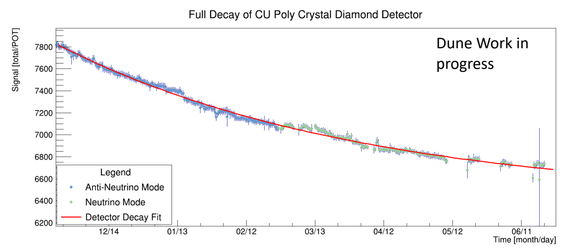


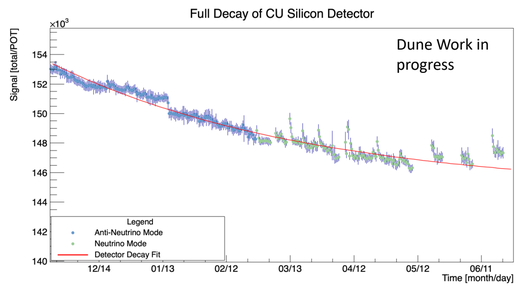


Detector Behavior

- We take the waveform readout and integrate the output voltage and normalize it with protons on target (POT). We then bin the data in 12 hour time intervals to make profile of the signal.
- When the beam is in neutrino mode there is a larger flux of particles so obtain a larger signal.
- To observe the overall performance of the detectors we merged the neutrino mode data to the anti-neutrino mode data.
- Unfortunately signal is decreasing over time, fitting best to an exponential which could be due to charge building up in the detector.







Future Work

- ❖ Continue to monitor for stabilization of detectors.
- ❖ Monocrystal diamond detector is in process of being made.
- ❖ Looking into other detector options such as electron multiplier tubes (EMT).

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