Research & Development for a Low-Energy Neutrino Source Facility at the Booster Neutrino Beam

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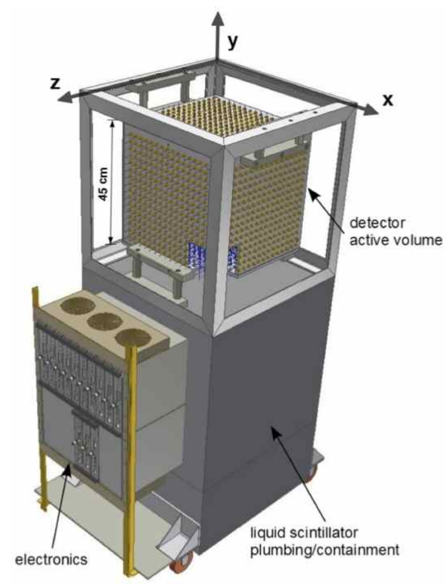
Fermilab has a world-leading suite of GeV-scale neutrino sources and experiments to explore a multitude of physics. Despite this, there remains a vast, unexplored low-energy regime that requires a facility capable of producing 10-MeV-scale neutrinos. The Snowmass process[1] has demonstrated the importance of low-energy neutrino interactions in the search for dark matter, coherent elastic neutrino-nucleus scattering (CENNS), supernova neutrinos, and sterile neutrinos. Unfortunately, many of these low-energy cross sections are completely unmeasured (e.g., CENNS). Our recent work in *Phys. Rev. D*[2] has demonstrated that the Booster Neutrino Beam (BNB) is a powerful source of pion decay-at-rest neutrinos at far-off-axis locations. Therefore, the BNB is crucial to studying low-energy neutrino interactions, but the backgrounds must be characterized. Our work will measure the dangerous beam-correlated neutron background at the BNB in order to facilitate a future low-energy neutrino physics program at the BNB at the Intensity Frontier.

Our previous work has shown a significant flux of fast neutrons correlated with the BNB (7.9×10^8 neutrons per m^2 per 10^{21} POT above 20 MeV and 20 m from the target). Therefore, future low-energy neutrino experiments will need to design a neutron shield. In order to design this shield, we hope to expand upon our previous work and characterize the following:

1. Neutron energy spectrum and flux
2. Neutron direction spectrum, (i.e., where do neutrons emerge?)
3. Neutron attenuation factors for shielding components



We will use a tandem of neutron detectors to address these questions at various places around the MI-12 target building that houses the BNB target. First, we will use the innovative SciBath-768 detector to measure 10-200 MeV neutrons[3]. SciBath-768 is a 70 kg, liquid scintillator tracking detector that was built at Indiana University. A cubic volume of scintillator is read out on each axis by a 16×16 array of wavelength shifting fibers with multi-anode PMTs. This readout gives SciBath unprecedented uniformity for particle track reconstruction. To complement SciBath, a 5 kg array of liquid scintillator detectors will also be deployed. This array is sensitive to 0.5-20 MeV neutrons, and in tandem with SciBath, a large range of dangerous neutrons can be measured. To improve our understanding of neutron attenuation and direction spectrum, we will deploy the detectors with adjustable concrete shielding "huts" in order to systematically modulate the incident neutron spectrum. These tests will constrain our shielding Monte Carlo models with direct measurements.

Currently, we are collecting neutron data with the 5-kg array while the BNB is off-target. After the BNB shutdown has concluded in November, we will deploy SciBath and run into 2015.

[1] See *Neutrinos* at arXiv:1310.4340 [hep-ex].
[2] *Phys. Rev. D* **89**, 072004 (2014) doi:10.1103/PhysRevD.89.072004.
[3] A more detailed description of the SciBath-768 detector is found at https://neutrino.indiana.edu/SciBath/