Developing the Booster Neutrino Beam for Low-Energy Neutrinos and the MiniBooNE Dark Matter Search

Robert L. Cooper, *Indiana University, Bloomington, IN 47408*

Fermilab has a world-leading suite of high-energy neutrino experiments that use the laboratory's GeV-scale neutrino sources 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. Unfortunately, many of the important neutrino cross-sections at these energies are unmeasured (e.g., CENNS). The CENNS collaboration has shown that the Booster Neutrino Beam (BNB) is an ideal location to study low-energy neutrino interactions[1]. I have also been involved with the MiniBooNE-DM experiment to search for low-mass dark matter[2]. Much like low-energy neutrino experiments, MiniBooNE is a single detector and relies on absolute flux predictions. To support a new, low-energy neutrino program and help complete the MiniBooNE dark matter search, I propose to characterize the BNB for the Intensity Frontier.

Fast neutron backgrounds from the accelerator are indistinguishable from the low-energy neutrino interactions in the CENNS and CAPTAIN-BNB experiments. Therefore, we will use the Indiana-built SciBath detector[3] to measure 10-200 MeV accelerator-correlated neutrons at multiple locations around the BNB. Our previous work shows a significant beam-correlated neutron flux (7.9×10^8 neutrons per m^2 per 10^{21} POT above 20 MeV and 20 m from the target), and these proposed measurements will improve upon them. We hope to learn about the neutron energy spectrum, flux, and direction as well as neutron attenuation factors for shielding components.

Low-energy neutrino experiments require accurate neutrino flux predictions. In MiniBooNE, we found that the existing beamline simulation for beam-off-target running is incomplete. Figure 1 (left) shows the CCQE reconstructed neutrino spectrum, and despite the good shape agreement, a scaling factor is needed. We have identified a number of beamline components that are crucial for beam-off-target running and for low-energy neutrino production (in any running configuration). To complete MiniBooNE-DM and understanding low-energy neutrino production, a significant improvement of BNB beamline simulation is needed.

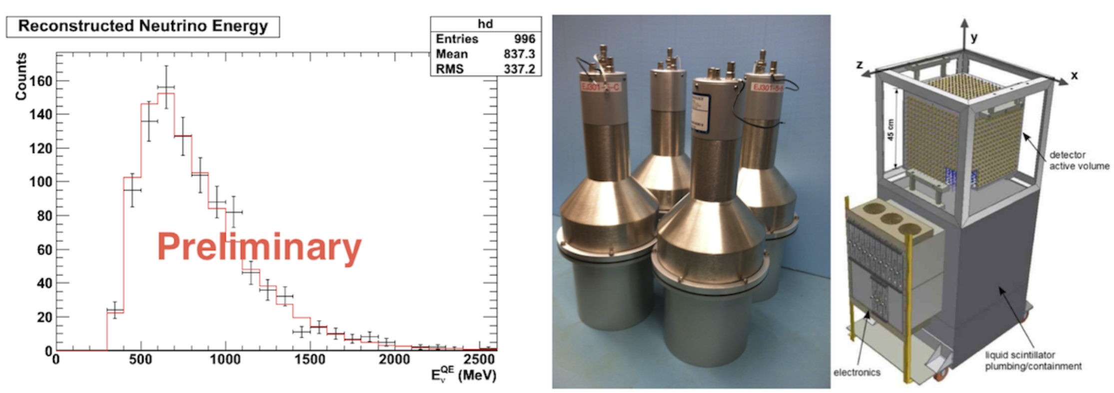

Figure 1: Left: CCQE reconstructed neutrino flux delivered to MiniBooNE-DM in beam-off-target mode. A scale factor is applied to the MC. Middle: 5 kg portable neutron detector array. Right: A schematic of the SciBath detector.

[1] CENNS collaboration, *Phys. Rev. D* **89**, 072004 (2014) doi:10.1103/PhysRevD.89.072004.
[2] MiniBooNE low-mass dark matter search http://arxiv.org/abs/1211.2258 [hep-ex]
[3] More SciBath information and papers is located at http://neutrino.indiana.edu/scibath/