

LANL MicroBooNE Quarterly Report – October 25, 2013

BNB hardware and commissioning (Richard Van de Water)

With the FNAL accelerator complex coming out of a ~1.5 year shutdown, the BNB is getting prepared for running. The new beam dual multiwires and the new fiber RWM system have both been installed. With the turn on of the BNB, which began the week of Oct 21, the commissioning of these new elements has begun. A vacuum leak with one of the multiwires (875B) required repairs to the wires. After both the wires and vacuum leak were repaired, the system now holds vacuum and we are determining if the multiwires are recording beam signals. The RWM is also being tested and initial signs are encouraging, but it is still too early to know if it is operating as desired.

After a couple weeks of beamline work, replacing two ion pumps and various seals, cables and connectors, good vacuum has been established and beam has run through the entire length of the beamline onto the Be target. The horn is on in antineutrino mode (negative polarity) and is pulsing normally. We will run the beamline in antineutrino mode for $\sim 7E18$ POT to collect ~ 500 antineutrino events in the MiniBooNE detector. A detailed measurement of the rate and energy response of the antineutrinos will let us know if the beamline, target, and horn are working properly after the long shutdown.

Beam DAQ & Neutrino Fluxes (Zarko Pavlovic)

The beam data is essential for data analysis in MicroBooNE. It provides the beam quality information and proton intensity per pulse, which are necessary for all measurements. Fermilab has developed a new Intensity Frontier Beam Database used to distribute these data to experiments. At LANL we have developed software to interface with the beam database and merge beam data with detector data on a pulse by pulse basis. We continue to maintain this software and update versions to match the developing detector DAQ software. Furthermore, we have developed a new software package that reads a raw binary file produced after merging with beam data and converts it to a format used by downstream calibration, reconstruction and analysis packages that are being developed within the LArSoft framework.

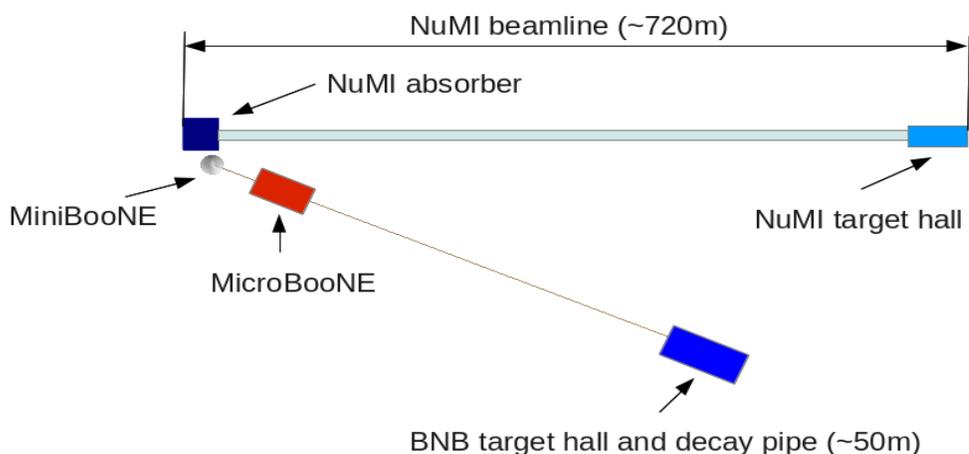


Figure 1: BNB and NuMI beamlines from above. The MicroBooNE detector is ~ 470 m downstream of the BNB target and ~ 70 m upstream of MiniBooNE. (Not to scale.)

We continue to maintain flux calculations from the NuMI and BNB beamlines for MicroBooNE. Simulation of the NuMI flux has been improved, and it is now possible to run the full simulation of NuMI neutrinos in the MicroBooNE detector. The neutrino origin and direction are now being correctly treated. This is particularly important for NuMI neutrinos since the MicroBooNE detector lies parallel to the NuMI beamline (Fig. 1). While a majority of NuMI neutrinos will come from the NuMI target hall area, many will be produced along the beamline and in the NuMI absorber. Therefore, unlike the BNB, the NuMI neutrinos will enter the detector from all sides, not just in front. The production of high statistics NuMI MC samples is in progress. The number of neutrinos from NuMI is expected to be comparable to that from the BNB and, therefore, provides an opportunity for many important measurements.

The work on improving the BNB flux calculation is ongoing. We are developing an analysis to use high energy muons to further constrain systematic errors due to kaon production in the BNB hadron production target. The kaons are a major source of intrinsic electron neutrinos that present an irreducible background. Another important background is due to beam neutrinos interacting in the surrounding material (dirt background). We are studying methods to constrain the systematic uncertainty due to dirt background.

Electronics and DAQ (Wes Ketchum)

The MicroBooNE readout electronics take the data collected from the TPC's wires, transport them out of the detector and into the data acquisition system. CMOS ASICs are mounted on motherboards that attach to the wires, inside the liquid argon. These cold electronics amplify and shape the signal from the TPC, which is then transported by cold cables through liquid and gaseous argon to a feedthrough on the cryostat. Intermediate amplifiers sit on the warm side of the feedthroughs and drive the signal across long, warm cables to the TPC readout crates, where the signal is digitized and prepared for transmission into the DAQ.

We have been involved in the testing of the electronics, both immediately after production and as they have been installed on the TPC. In particular, we are responsible for the development, running, and analyzing of the electronics reception tests, where we test each component after it has been installed on the TPC. These tests have been integral in validating the behavior of each channel of the electronics (and identifying components that should be replaced) and determining the correct mapping of wires to readout channels. The testing procedure we have developed is also the groundwork of the electronics calibration procedure, in which LANL will take a leading role. Additionally, the flexibility of the setup has allowed us to perform a number of other studies, including studies of system performance over long periods of readout, and measurements of PMT-induced noise on TPC wires.

One of the main contributions of the LANL MicroBooNE group has been the development of the DAQ system. Each readout crate sends its data to a dedicated PC (called a sub-event buffer, or SEB). The SEBs perform some low-level checks on the quality of the data before sending it to an event-builder PC, which combines the data from each subsystem of the detector and writes the completed event to disk. Additional processes in the DAQ are responsible for the run control, configuration databases, slow-controls, and monitoring.

LANL has contributed to the development and testing of the low-level DAQ processes that collect the data on the SEBs and event-builder. We have successfully exercised a number of important functions

of the DAQ: collection of data from the TPC readout crates in both a triggered and continuous readout mode; packaging that data and transmitting it to the event-builder; building events using data from multiple SEBs; control of processes, via a message-passing system; and, the writing and reading of a serialized, versioned output data format. We have also begun to test readout and handling of data from the PMT system, processing of data that is compressed without losses, and simultaneous operation of triggered- and continuous-readout data streams. Figs. 2 and 3 show photographs of the MRT and DAQ Test Stands at Fermilab.



Figure 2: Photograph of the MRT Test Stand sitting next to the TPC.



Fig. 3: Photograph of the DAQ Test Stand with the DAQ PCs on the left, and a readout crate on the right.

Event Reconstruction (Wes Ketchum)

In addition to our efforts with the construction of the detector, the MicroBooNE group is working on the development of reconstruction software. Along with taking a leadership role in coordinating the reconstruction effort, we have worked on a number of different reconstruction tasks, including reconstruction of interaction vertices using image-processing-inspired techniques, and evaluation of tracking performance. We are ramping up efforts on algorithms to improve cosmic-ray identification and removal, which includes work on integrating data from the PMT system and the TPC.

Dark Matter Searches with MicroBooNE (Richard Van de Water)

We continue refining calculations of MicroBooNE's sensitivity to various dark sector models. On the LANL MicroBooNE web page, two plots show significant sensitivity coverage of the $g-2$ and relic density expectations in WIMP scattering cross sections and mass. Work is now focusing on developing dark sector Monte Carlo generators that can be implemented into the LarSoft analysis framework. This will allow more detailed estimates of signal and backgrounds with full beamline and detector simulations. This will be used to generate improved and more believable sensitivity estimates that can be part of a proposal to the PAC for a MicroBooNE beam off target run that could perform a significant search for light mass WIMPs ($\sim 100\text{MeV}$) in a compelling region of parameter space (overlap of $g-2$ and relic density estimates).