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Intensity Frontier Fellowship Closeout Report

Overview

My Intensity Frontier Fellowship proposal outlined work to be done on the MicroBooNE and LBNE (now DUNE) experiments at Fermilab. As I am a Postdoctoral Research Assistant at the University of Oxford, the fellowship was a crucial factor in being able to work onsite at Fermilab for an extended period. I was able to work closely with Fermilab staff and users on both hardware and software issues. The bulk of my time was spent on hardware and software for MicroBooNE's Muon Counter System.

MicroBooNE's Muon Counter System

The MicroBooNE Muon Counter System (MuCS) is an external calibration tool for the MicroBooNE detector. By using an external cosmic-ray trigger system, muons that either cross or stop in the primary detector can be collected and studied. The external cosmic-ray trigger system consists of two muon counters that can be placed at various points around the detector. At the shallow depth of the detector, the cosmic muon rate is roughly 3 kHz so these muons serve as a rich calibration source for the detector. In the current configuration, muons that cross the muon counters will then enter the detector and either stop in the detector and produce a decay electron or cross the detector. These well known cosmic-ray muon behaviors can then be compared with the reconstruction results to validate and calibrate the reconstruction algorithms. The work that I performed over the course of the fellowship was on two aspects of the MuCS: hardware and software.

For the MuCS hardware it was necessary to reconfigure an existing electronics rack for use in the Liquid Argon Test Facility (LArTF) at Fermilab. Along with another Fermilab user, Leonidas Kalousis (Virginia Tech), I reconfigured the MuCS rack to comply with changes necessary for unattended operation at LArTF. I worked closely with Linda Bagby

from Fermilab's Particle Physics Division to evaluate the existing system and implement these changes, primarily for safety. I was also able to take advantage of the Physics Research Equipment Pool (PREP) at Fermilab to secure components for this work.

In conjunction with these hardware changes a series of documents were prepared to document the system configuration and prove its ability to run unattended. These documents, stored in the MicroBooNE internal document database, were necessary for the Operation Readiness Clearance (ORC) process where the MuCS was inspected and approved for unattended operation.

The reconfiguration, testing, and preliminary review for operating the MuCS was carried out in the D0 Assembly Building. The detector checkout and installation was performed at LArTF. My presence at Fermilab was therefore critical to be able to perform this work.

In addition to the hardware work for MuCS I developed Monte Carlo simulations of the MuCS in order to study possible configurations of the detector boxes and also to make use of the data coming out it. I developed the MuCS MC simulations initially to optimize the positions of the muon counters. Initially a configuration with one box above the TPC and the other below the TPC was planned. Due to space constraints at LArTF it was only possible to implement this setup in a fashion that yielded a very low rate. With the simulations I was able to show that having both muon counter boxes on the platform would yield a much higher rate and still provide adequate tracking of muons passing through the system. This software was also used to develop expected spatial and angular distributions necessary to interpret the data that is readout from the system. The software written during the fellowship period is currently being used by various MicroBooNE collaborators to help analyze data from the system.

The MuCS is having a longer life than initially intended--it was proposed for use only during the commissioning phase--because it has proven useful in providing triggers for TPC and PMT readout that are useful for evaluating trigger efficiencies in the MicroBooNE light collection system. Upgrades are currently being considered to make the system controllable remotely. MicroBooNE now has a working Muon Counter System that is being used to calibrate the detector partially because of the work I was able to do at Fermilab under this fellowship.