UNIVERSITY OF CAMBRIDGE

Intensity Frontier Fellowship on MINOS+, MicroBooNE and LBNE

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It has been a pleasure to spend the academic year 2014/15 as an Intensity Frontier Fellow at Fermilab. During my fellowship, I have collaborated on the MINOS+, MicroBooNE and LBNE 35t experiments. My research activities have included neutrino oscillation physics and detector operations (MINOS+), and the development of automated neutrino event reconstruction software for Liquid Argon detectors (MicroBooNE and LBNE).

This Intensity Frontier Fellowship has coincided with my year-long term as Analysis Coordinator for the MINOS+ experiment. Fermilab is the main centre for both the operation of MINOS+ and the scientific exploitation of its data. It has been incredibly valuable to be based at the lab this year, where I have been able to offer operational support for the MINOS+ detectors and to oversee the advancement of its physics analyses. Among the MINOS+ personnel with whom I have worked over the past year are: Fermilab Scientists Dr. Rob Plunkett and Dr. Phil Adamson; MINOS+ Run Coordinator Dr. Donatella Torretta; and two key postdocs, Dr. Adam Schreckenberger and Dr. Will Flanagan; along with several graduate students who are on long-term attachment at the lab. The year's highlights have included the first MINOS+ results on standard neutrino oscillations and the unblinding of a search for sub-dominant sterile neutrino oscillations using the first year of MINOS+ data. Both of these analyses are now well on the road to publication. In addition to my role as Analysis Coordinator, my main contributions to these analyses have been the verification of data quality for both the Near and Far detectors, and authorship of the fitting framework for the standard oscillations analysis. I also had the pleasure of presenting the latest MINOS+ results and prospects at the Fermilab Users meeting this summer.

On MicroBooNE and LBNE, the main focus of my research has been the development of pattern recognition algorithms for Liquid Argon TPC detectors. A fully-automated and high-quality pattern recognition is essential to exploit the precise spatial and calorimetric resolution offered by LAr-TPC technology. At my home institution of Cambridge University, I have been collaborating with Prof. Mark Thomson and Dr. John Marshall on an innovative multi-algorithm approach to pattern recognition using the Pandora Software Development Kit. This package was first developed at Cambridge for fine-grain calorimetry at ILC and CLIC, but lends itself readily to the Liquid Argon neutrino programme. I have used my Intensity Frontier Fellowship to implement the Pandora suite of pattern recognition algorithms within the LArSoft shared software framework, so that they can be used by all LAr-TPC experiments at Fermilab. With the assistance of Dr. Wes Ketchum and Dr. Erica Snider, I have applied the Pandora pattern recognition algorithms to simulated cosmic-ray and neutrino interactions in MicroBooNE, where the initial results look promising.

The Pandora reconstruction is now playing an important role in supporting the first data-taking and detector commissioning at MicroBooNE, and will likely form the basis of the first physics results from MicroBooNE next summer.

In addition to MicroBooNE, I have also worked on the implementation of the Pandora pattern recognition algorithms in the LBNE 35t detector environment. Working with Dr. Michelle Stancari, Dr. Tingjun Yang, and Dr. Tom Junk, I have applied the Pandora algorithms to simulated cosmic-ray events in the 35t detector. The performance looks good, and this software will be used to support the programme of measurements planned for the 35t detector.

In summary, the Intensity Frontier Fellowship has enabled me to make a number of useful scientific contributions to the Fermilab neutrino programme. It has been great to collaborate on a variety of projects with many scientists. I am particularly excited to be working on the programme of LAr-TPC neutrino experiments at Fermilab. As an international scientist, this fellowship has also enabled me to establish new projects and collaborations that will benefit the current and future UK research on neutrino physics. Overall, I am grateful for the opportunity to spend an extended period working onsite at Fermilab. Based on my experience over the past year, it is clear to see that the Fermilab neutrino programme is in great shape!