Introduction

My research interest is in testing the standard models of particle physics and cosmology through searches for new phenomena. These paradigms are intimately linked, and there have recently been tantalizing indications of new physics for both models in the areas of neutrino oscillations, dark energy, the weak mixing angle, and possibly in CP violation in the b quark sector and the apparent relatively heavy mass of the Higgs boson. The large number of hints leads me to believe that the fields of HEP and cosmology are on the verge of an unprecedented period of discovery. To meet this great potential, I have chosen to pursue anomalies in the neutrino sector and in cosmology through new physics searches. In the future, I think progress in these areas will depend critically on precision measurements of rates and kinematics. To this end, I have pursued my interests in developing new detector technologies and in making more precise neutrino interaction cross section measurements.

On the Milagro cosmic gamma ray telescope [1] experiment I used high energy cosmic rays to probe the matter/anti-matter asymmetry in the universe for my Ph.D. thesis. As a post-doctoral researcher, I am investigating the participation of sterile states in high mass neutrino oscillations with the MiniBooNE [2] experiment. On MiniBooNE, I lead the charged current single pion (CC1π) event analysis group, which is performing an oscillation search complementary to the quasi-elastic (CCQE) neutrino oscillation measurement. I am currently pushing the analysis toward MiniBooNE's first physics measurement: the CC1π/CCQE cross section ratio. I am also co-convener of the Detector Calibration and Monte Carlo Working Group. In particular, I have developed a novel cosmic muon calibration system, whose data analysis is critical to MiniBooNE's oscillation analysis. Two years ago, I joined the FINeSSE [3] collaboration, for which I developed and commissioned one of the prototype detectors for the experiment's proposal. Most recently, I have been leading an effort to bring the K2K SciBar detector from Japan to Fermilab and use it in the Booster neutrino beamline.

Research on the Milagro Experiment

As a graduate student on Milagro, my analysis centered on studying the shadow of the moon in cosmic rays [4],[5]. This is a compelling topic because, by using the geomagnetic field as a spectrometer, one can use the moon's shadow to search for anti-protons in the primary cosmic ray flux at TeV energies, well above the effective energy range of the Alpha Magnetic Spectrometer (AMS) [6]. The cosmic ray moon shadow had been previously observed by the CYGNUS air shower array, among others, but my analysis employed a more sophisticated likelihood method to search for specific event populations within the data set. This technique gives the experiment sensitivity to negatively charged primary particles despite the low angular resolution of the Milagrito prototype detector. It is also of interest to the field because it allows an external and completely model-independent calibration of the energy scale of air shower arrays, which had never been done by previous arrays. The techniques I pioneered in the Milagro analyses have proven valuable to other cosmic ray experiments as well [7].

As one of the first graduate students to join Milagro, I had the opportunity to contribute to the experiment at every stage. The hardware expertise I gained was quite varied, and I participated in the running and analysis of Milagrito, the prototype stage of Milagro. I also contributed to the full installation of Milagro.

Research on the MiniBooNE Experiment

With an understanding of the close connections between astrophysics and particle physics, I chose to join MiniBooNE. I did so for a variety of reasons. I am interested in the implications of a third Δm^2 oscillation range, as I discuss below. I am interested in neutrino astrophysics, especially the detection of neutrino signals from supernovae and gamma-ray bursts. I wanted to expand my experiences to include accelerator physics and to deepen my knowledge of particle physics, and I again wanted the experience of working on an experiment from installation through analysis because I find all aspects compelling. Finally, I believe

that MiniBooNE is good science because it will resolve the controversial LSND result. MiniBooNE is a small experiment, and so I was fortunate that there was a job opening at Louisiana State University. I began working on MiniBooNE in April, 2001. My operational responsibilities include deputy Detector and Operations Coordinator, for which I coordinate all activities in the detector hall and coordinate all operational activities when needed.

On MiniBooNE, I am co-convener of the Detector Calibration/Monte Carlo working group. I installed, commissioned, and currently maintain our laser PMT calibration system and the cosmic muon calibration system. The laser system is used to calibrate the time and charge response of the PMTs, and is also critical for modeling the optics of the detector. The MiniBooNE cosmic muon calibration system [8] uses stopping muons and their decay electrons to calibrate the event reconstruction algorithms. This system provides a precise calibration of the energy, direction and position of muons for the complete range of muon energies of interest in the experiment. It is also useful for studying the detector optical model, by providing a clean sample of muons whose exact event topologies are known through measurements independent of the PMTs in the MiniBooNE detector. This muon calibration system is the first of its kind used in an open volume detector, and, given its success, will likely be used in future neutrino experiments with similar detectors.

I have also been pursuing supernova physics at MiniBooNE, where I developed the supernova event trigger. MiniBooNE would expect to observe approximately 190 neutrino events in 10 seconds from a galactic core-collapse supernova [11], and so we could make a valuable contribution to the world's data set should a supernova occur. I have worked on a near-line second level trigger designed to search for bursts in the supernova trigger rate, which could allow MiniBooNE to participate in the Supernova Early Warning System (SNEWS) [12] network if we reduce our false alarm rate. Studies of the false alarms in the supernova triggers have taught us much about instrumental backgrounds in the detector, improving the experiment as a whole. These data have allowed me to perform offline searches for event excesses coincident with notable astrophysical events, such as GRB030329/SN2003dh.

In the fall of 2004, I led a team of four postdocs in writing the proposal to the Fermilab PAC for an extension of MiniBooNE's data run [13]. This document focused on the significant improvements MiniBooNE could make in antineutrino cross section measurements with just one year of antineutrino data. I played a key role in the development of several novel techniques for measuring the background of *neutrino* events in the antineutrino beam, which significantly improves the physics potential of a MiniBooNE antineutrino run. The result of this proposal was an extension of the MiniBooNE run by at least one year.

Recently I have taken the lead role in the analysis of CC1π, $\nu_\mu C \rightarrow \mu^- \pi^+ X$, production in MiniBooNE. This is an important event channel because its cross-section is of comparable size to the CCQE cross section in MiniBooNE's energy range. With the LSU group, I have "opened a box" of CC1π events. This means that we have developed a set of cuts that allow us to isolate CC1π events, which is necessary because of the blind analysis scheme employed by MiniBooNE. The result of the open box is a sample of over 44,000 neutrino events, which is larger by a factor of five than all the published bubble chamber data sets for resonant pion neutrino events. I developed event reconstruction methods for these data, and am now finishing MiniBooNE's first physics result, which is a measurement of the CC1π/CCQE cross section ratio. We are releasing only a cross section ratio, and not an absolute cross section so that we do not compromise our ν_μ disappearance oscillation analysis.

I am also using the CC1π data for a ν_μ disappearance oscillation analysis. This channel has different backgrounds, and different cross section and reconstruction systematic errors, than the CCQE ν_μ disappearance analysis, so it provides an orthogonal check of the CCQE result. This is the first analysis of neutrino oscillations explicitly in the CC1π channel, and is highly relevant for other CCQE-channel oscillation experiments since this event class is typically treated as a background. Explicitly including CC1π events as signal in an oscillation analysis can increase the statistics by a factor of $\sim$2, and provides sensitivity to a somewhat larger Δm^2 range since the CC1π cross section probes a higher neutrino energy range than the CCQE cross section.

Research on the FINESSE Experiment

Through my work on the ν_μ disappearance analyses on MiniBooNE, I became interested in the FINeSSE proposal. FINeSSE was originally proposed as a small detector to be placed upstream of MiniBooNE, whose primary measurement was to be Δs, the strange spin of the nucleon, which is made possible by the high-precision tracking ability of the detector design. FINeSSE would also greatly enhance the ν_μ disappearance sensitivity of MiniBooNE by reducing the systematic uncertainties on the ν_μ flux.

My work on FINeSSE was focused primarily on the design and testing of a prototype detector.I worked on the scintillator stack prototype, constructing it at Fermilab and testing the light gathering efficiency of the scintillator strips using cosmic muons. This prototype was tested in the Indiana University Cyclotron Facility (IUCF) proton beam in August, 2003, and I led the analysis of the test beam data.

Research with the K2K SciBar Detector

I am now coordinating an effort to bring the K2K SciBar detector [14] to Fermilab, and install it as a near detector in the Booster neutrino beamline. I have been leading the efforts at Fermilab. Together with the Japanese group, we are developing a case for physics measurements that can be accomplished in a short timescale because the detector components are needed back in Japan in 2008 for the T2K experiment.

SciBar offers a broad neutrino scattering program, which breaks down into three categories, each of which cover several measurements. First, are measurements which improve existing or planned MiniBooNE neutrino cross section measurements and the understanding of the Booster Neutrino Beam, both in neutrino and antineutrino mode. Second, are neutrino cross section measurements of processes that are the signal and primary background channels for the upcoming T2K experiment. Third, are measurements which are interesting in their own right, including analyses of multi-particle final state neutrino interactions, with unprecedented statistics. In particular, the excellent tracking capability of the SciBar detector would allow better kinematic reconstruction of CC1π events than is possible with MiniBooNE alone. This complementary data set would allow me to continue the pursuit of sterile neutrino physics that I began with MiniBooNE.

Because of the short timescales involved, the budget is necessarily small. We submitted a report detailing the physics arguments in favor of this concept to the directorate of Fermilab in early June [15]. We are scheduled to have a Director's review of the physics case on 11 October, 2005. We expect to ship the detector components to Fermilab beginning in the winter of 2006, and to begin taking beam data in the fall of 2006.

Conclusions

I have always sought to understand the fundamental constituents and properties of matter, whether it be through cosmic rays or accelerator research. Indeed, I think that a broad program of experiments is the best way to address the physics problems of today. I bring significant expertise in particle detection and data analysis techniques along with open eyes and a curious mind to the challenges we face in a mature and ever diversifying discipline entering a new century. I believe that I can make a significant impact across these inter-related fields with a strong department.

References

[1] `astro-ph/9912456`.

[2] FERMILAB-PROPOSAL-0898, Dec 1997

[3] `hep-ex/0402007`.

[4] Wascko, M.O., "Study of the Shadow of the Moon in VHE Cosmic Rays with the Milagrito Water Cherenkov Detector," Ph.D. Thesis

[5] astro-ph/9906388.

[6] hep-ex/0002048.

[7] Astropart.Phys. 23 (2005) 411-434

[8] "Calibration System for MiniBooNE", to be submitted to NIM

[9] hep-ex/0009001 (revised 4 August, 2004)

[10] Foot, R., Mod.Phys.Lett.A18:2071-2077, 2003

[11] hep-ph/0205035

[12] http://cyclo.mit.edu/snnet/

[13] http://www-boone.fnal.gov/publicpages/loi.ps.gz

[14] Nucl.Instrum.Meth. A535 (2004) 147-151

[15] Brice, S.J., *et al.*,"Bringing the SciBar Detector to the Booster Neutrino Beam," 2005, http://home.fnal.gov/ wascko/scibar.pdf