Research at the Intensity Frontier: NOvA, ANNIE and DUNE

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For over a decade I have made major contributions to the long-baseline neutrino program at Fermilab. I have lead the MINOS and NOvA experiments in the development, release and publication of the flagship analyses of electron neutrino appearance. I have also been responsible for coordinating roles in computing and production for both of these key experiments. I have recently been named general analysis co-coordinator for NOvA. This new role will allow me to have a major impact on all of the upcoming physics results of the experiment.

Over the past few years, I have also been co-leading ANNIE. This experiment was approved for Phase I by the Fermilab directorate in early 2015. The experiment primary goal is to measure the neutron yield from neutrino interactions. In addition, it will allow for the demonstration of a promising new technology for neutrino detectors.

Finally, I have also contributed to the crafting of the future US long-baseline neutrino program. In the past by making significant contributions to the Conceptual Design Report of LBNE (the precursor to DUNE) of the calibration system for the Water Cherenkov detector and now as deputy Working Group Leader of the Far Detector Performance Physics group in DUNE.

Over the next year, I will be on teaching leave from Iowa State University. In this proposal I request funds to arrange an extended stay at FNAL. During this time I will accomplish the following goals:

1. Coordinate closely the many on-going analyses in the NOvA experiment with the resources and personnel available at Fermilab in order to target results for Summer/Fall conferences in 2016.
2. Lead the installation and commissioning of the ANNIE experiment at the SciBooNE Hall during the Winter/Spring of 2016. Complete data analysis of Phase I during the Summer/Fall of 2016.
3. Collaborate with the physics and detector working groups on DUNE in order to accomplish the goals of the Far Detector Physics Performance working group.

The NOvA experiment

In the Summer of 2015, the NOvA Collaboration released results from the first year of data collected by the experiment. The observation of the oscillation of ν_μ into ν_e at the atmospheric mass scale is confirmed to 3.3σ disfavoring the range $0 < \delta_{CP} < 0.65\pi$ at greater than 90% confidence level (CL) in the inverted mass hierarchy. A secondary analysis of the same data observes a 5.4 σ disfavoring more all of the inverted mass hierarchy. The Collaboration also reports the observation of muon neutrino disappearance (33 events seen out of 201 predicted) and θ_{23} measured to be consistent with maximal mixing.

Over the coming year, NOvA will at least double the 2.74×10^{20} proton on target (POT) scaled-exposure used in the first analysis. A major of focus of my work in early 2016 will be to coordinate the oscillation analyses using the recently acquired data. In order to use these data, the collaboration will need to carefully orchestrate data quality and validation, generate new simulations and calibrations matching new data conditions, and introduce a variety of improvements to the reconstruction and analysis to maximize scientific impact. While it is possible to coordinate some of this work remotely, given the fast approaching deadlines for summer conferences, it is most efficient to work closely with the NOvA collaborators that are leading these efforts at Fermilab. The fellowship will allow me to significantly augment my presence on-site to allow this.

At the same time that the data in the Far Detector of NOvA is being doubled, we are rapidly acquiring a wealth of Near Detector data that is very relevant for studies of neutrino interactions. The potential for many different analyses and publications on this topic is high. After the oscillation analyses are underway, I plan to shift my focus to working closely with the Near Detector conveners, such as Jonathan Paley (FNAL) to help prioritize and coordinate resources to topics in this area.

The ANNIE experiment

The primary physics goal of ANNIE is to study the abundance of final state neutrons from neutrino-nucleus interactions. Measurements of final-state neutron multiplicity will improve understanding of the neutrino-nucleus interactions. ANNIE is also a test bed for a promising new photodetector technology, the so called LAPPDs. The experiment consists of a small Water Cherenkov detector, instrumented with both photomultiplier tubes and LAPPDs, and deployed on the Booster Neutrino Beam (BNB) at Fermilab. The experiment plans an initial partially-instrumented test-beam run using only PMTs (Phase I) for the purpose of measuring critical neutron backgrounds to the experiment. The construction effort for Phase I is underway. Installation and commissioning is expected to begin in January 2016 with data taking to be completed by the Summer BNB shutdown.

The ANNIE collaboration is a group of about 30 physicists, during the crucial phase of installation and commissioning we expect to have a group of 4-5 postdocs and graduate students present at the Laboratory. During this time I plan to be involved in the coordination and hands-on installation of the detector with this group of young scientists. Over the summer, my work will be shift to the analysis of the data acquired at the same as preparations for the Phase II of ANNIE continue.

The DUNE experiment

The DUNE science program includes precision measurement of oscillation physics but also a range of low-energy neutrino physics such as searches for supernova neutrino bursts. Given the potential for installing modules of the Far Detector in advance of the availability of the neutrino beam, it is imperative that this detector proves to have excellent performance at low neutrino energies.

I currently hold the position of deputy Working Group Leader of the DUNE Far Detector Physics group. This group is charged with ensuring that the performance and design decisions of the Far Detector allow the successful completion of all DUNE science program goals. The group must work closely with all Physics Working Groups as well as Project Engineering to evaluate the impact of any design decisions on the physics output. In particular, significant work must be done to ensure that the very important low-energy physics at the start of the program is possible.

At ISU, we have recently begun collaborating with Alexander Himmel (FNAL) in order to assess the impact of proposed technologies and algorithms (e.g. the design of the light detection system, merged vs parallel readout of the TPC and photodetectors, supernova neutrino burst trigger, zero suppression algorithms) on the physics potential for the low energy science program. Early studies will rely on DUNE simulations and data available from the 35 ton prototype where significant resides at Fermilab. These studies will benefit significantly by being able to directly collaborate with these experts.