Research Statement

The coming three years will be critical for the field of neutrino oscillations. T2K will continue to push on anti-electron neutrino appearance while NOνA will continue to take data from the upgraded NuMI beam. Indeed, plans are now firmly in place for an upgrade to the JPARC facility to deliver 1.2MW (presently 350kW) by 2018/19. The first results from NOνA delivered an additional surprise: with one of the analyses, the Inverted Hierarchy has been disfavored at the 2.2σ level. T2K already disfavor the IH but at a lower level of significance. It could be that within 3 years, and likely within 5 years, the hierarchy of the neutrino masses will be known. The dominating uncertainty will likely be that on θ_{23} especially now that T2K and NOνA seem to favor maximal mixing. Together with my student who will come to FNAL for between 6 months and one year, and my postdoc who will spend some shorter periods at FNAL, our focus will be on the study of muons in the NOνA detectors with the objective of reducing the systematics associated with their measurement and the measurement of the ν_μCC events. We will start with an evaluation of the MC simulation of the horn off configuration using the data taken without the horn current. This is particularly interesting given that the NOνA ND sits off axis with respect to a given position in the decay pipe: neutrinos produced upstream of the first horn could potentially effect the neutrino energy spectrum in the ND but not that in the FD and so it is critical that these neutrinos are properly accounted for. Reducing the uncertainty on θ_{23} is the focus of the first strand of this research plan.

Another outstanding question in the neutrino oscillation field is that of the LSND and MiniBOONE event excesses. These will be directly answered by MicroBOONE, which should be able to say definitively, whether the excess is due to photons or electron neutrinos within the next three years. A parallel approach to searching for a signal of sterile neutrinos is via the measurement of the disappearance of both neutral and charged current events in the NuMI beam which the extra running proposed for MINOS+ in the medium energy beam was chiefly designed for. A significant amount of work has been invested in this analysis for MINOS+, and in addition, a joint effort with the Daya Bay experiment will be capable of delivering the world's best sensitivity over a very expansive region of parameter space. This combination is presently underway for the MINOS data, and will be extended to MINOS+ with additional Daya Bay data when MINOS+ finishes data taking in the summer.

Another interesting aspect of the MINOS+ data is the fact that the largest number of electron neutrinos per kilo-ton of all the the present long baseline experiments are delivered to the MINOS detector. Capturing these neutrinos above a very large background is very challenging. However, we are pushing on the identification of electron neutrinos in the MINOS+ data to both search for sterile neutrinos via the appearance of high energy electron neutrinos as ICARUS has done (we have already presented an initial analysis of the first year of MINOS+ data at Neutrino 2014) as well as for the more standard electron neutrino appearance. Overseeing the completion of all the MINOS+ analyses is a top priority for me in my position of Co-Spokesperson: the electron neutrino appearance analysis is the present focus of one of my postdocs and one student at UCL. MINOS+ analysis constitutes the second strand of this research plan.

Depending on the landscape of funding in the US in the future, there may be an opportunity for a second experiment at LBNF, which would bring the precision measurements presently planned for the DUNE experiment to a faster conclusion. I am presently carrying out a program of R&D into the concept of a very inexpensive and massive water Cherenkov detector, which has significant support from the Leverhulme trust in the UK and from the University of Wisconsin at Madison where I have been a visitor for the last year. We are presently working on a Cockroft-Walton positive HV base board for the 1000 PMTs which have been loaned to the CHIPS project by my French Super-NEMO colleagues. The existing technology for this electronics development in the US resides at FNAL within the electronics group. I would propose to take this design to fruition for our particular needs. Spending time at FNAL would enable this technology transfer. This constitutes the third strand of the research plan.

In summary, over the next year, and during the period of the IF Fellowship request, I will focus on three research strands:

1. Precision Measurement of θ_{23} with the NOνA experiment
2. MINOS+ Co-Spokesperson duties with special focus on electron neutrino appearance
3. Technology transfer from FNAL for the CHIPS R&D effort for CW positive HV