Research Statement for the Fermilab Intensity Frontier Fellowship 2023

I am writing here to express my interest in the Fermilab's Intensity Frontier Fellowships (IFFs) 2023 for the neutrino physics, specifically track 1 application to support my research work to enhance and extend the current neutrino program at Fermilab.

I am currently a postdoctoral researcher at Queen Mary University of London. Over the last year, I have served as NOvA Run Coordinator, overseeing the day-to-day smooth operations of the experiment. This role involves a variety of responsibilities, including coordination between data acquisition and detector-related experts within the experiment and experts from the accelerator division. Under my coordination, we have managed to keep the NOvA Far Detector uptime to 99% and the near detector one to 96%.

I am also leading the measurement of the muon antineutrino charged current inclusive cross section using the reverse horn current data collected by the NOvA Near Detector. This will be one of the highest-statistics sample ever collected, and the first time NOvA performs a cross-section measurement in three dimensions, providing unprecedented insights into neutrino-nucleus interaction models. An improved understanding of antineutrino interactions will help oscillation experiments to answer important questions related to the CP violation and the ordering of the neutrino masses.

Under the support of the IFF, I plan to bring this analysis further and calculate the ratio of the antineutrino to neutrino CC inclusive cross section. This will be the first time when NOvA makes ratios of the antineutrino to neutrino cross sections. Currently, neutrino interactions represent one of the largest uncertainties and the ratios will constraint the cross section uncertainties. The antineutrino and the neutrino samples will have a large fraction of correlated uncertainties which will cancel out in the ratio. This will allow us to reach a few percentage precision in this measurement, and will help our understanding of neutrino (and antineutrino) interaction models.

To fully exploit out measurements, we need to compare our data results to the cross section predictions made by various neutrino generators developed by the international communities. NOvA already uses the GENIE generator for simulated predictions. The NEUT generator used by the Super Kamiokande and T2K experiments uses similar interaction models but with slightly different implementation. The NuWRO generator is more theory based, and GiBUU tries to describe the full dynamics of the neutrino-nucleus cross section. The comparisons of our data results to these other neutrino generators will help to further enhance the neutrino-nucleus physics program of NOvA, and consequently Fermilab. Currently, in NOvA no one is working to make generator predictions. Under the support of the IFF, my plan is to make the generator predictions to compare with our data. The generator predictions made under this project will also be used by other analyzers working on various NOvA cross section analyses.

To complete this project, I will need to spend time at Fermilab to touch base frequently with experimental and theoretical Fermilab staff working on the cross section analysis and generator predictions including Jon Paley and Bryan Ramson who are NOvA's cross section experts at the lab.

Thank you for considering my application.

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