Project 1

Study of cosmic-ray induced electromagnetic background in MicroBooNE
Supervisors: Roxanne Guenette, Matt Bass, Roberto Soleti

The existence of sterile neutrinos has been brought forward to explain several anomalies in the field of neutrino physics. Such a particle, not interacting with normal matter, would be a definitive proof of physics beyond the Standard Model. A powerful way to search for sterile neutrinos is to study short-baseline oscillations at the short-baseline neutrino (SBN) programme at Fermilab.

The MicroBooNE Liquid Argon detector, first of the SBN programme, is located near the surface and is subjected to high cosmic-ray flux. While track-like events, caused by muons for example, can be handled and removed, isolated electromagnetic events induced by cosmic rays could enter the signal samples used to search for neutrino oscillations at short baseline. This project will make use of the MicroBooNE cosmic-ray tagger system data to search for isolated electromagnetic events and understand their impact on the physics analysis.

The student will learn how to generate particles and interpret the different particle interactions in the MicroBooNE detectors. By the end of the internship, the student's analysis will provide an estimate for cosmic-ray induced showers in the MicroBooNE detector, critical for the flagship analysis of the experiment searching for a low-energy excess of events.

Project 2

Study of muon neutrinos in MicroBooNE
Supervisors: Roxanne Guenette, Matt Bass, Marco Del Tutto

Understanding neutrino interactions in argon is essential for the success of current and future Liquid Argon experiments. The MicroBooNE experiment, located in the Booster Neutrino Beam at Fermilab, currently taking data since October 2015 is the perfect environment to study neutrino cross-sections.

The first cross-section analysis that MicroBooNE will perform is an inclusive study of muon-neutrino interactions via charged current. This analysis will also lay the groundwork for future specific channel studies.

The student will get familiar with the analysis software and will develop new computing tools to perform cross-section analyses. With the new software tools in place, the student will perform an event selection that will allow the cross-section analysis. By the end of the internship, the student will have a deep understanding of neutrino interactions and of cross-section analyses. This work will be highly relevant to any future neutrino experiments.

Project 3

Study of NuMI neutrino events in SBND
Supervisors: Roxanne Guenette, Matt Bass, Marco Del Tutto

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The SBND detector will serve as the near detector for SBN. This Liquid Argon detector will be located in the Booster Neutrino Beam but will also observes neutrino coming for the NuMI beam, located at a very large off-axis angle. This location provides a sample of low-energy electron neutrinos that will allow the SBN project to study the signature of these low-energy events, which could be crucial for the search of sterile neutrinos. This project will study the expected event rates and topologies in a simulated sample of neutrinos coming from the NuMI beam.

The student will be expected to perform Monte Carlo simulation of neutrinos from the NuMI beam and study the events observed in SBND. By analyzing such a large off-axis angle, the student will get familiar with the challenges of neutrino beam simulations. By the end of the internship, the student should have a complete analysis of the expected NuMI interactions in SBND, potentially demonstrating that certain samples of electron-neutrinos can be isolated to study performances of the most crucial neutrino interaction for the SBN searches.

Project 4

Study of the Michel electron spectrum expected in the SBND experiment
Supervisors: Alfons Weber, Justo Martin-Albo, Wouter van de Pontseele

The existence of sterile neutrinos has been brought forward to explain several anomalies in the field of neutrino physics. Such a particle, not interacting with normal matter, would be a definitive proof of physics beyond the Standard Model. A powerful way to search for sterile neutrinos is to study short-baseline oscillations at the short-baseline neutrino (SBN) programme at Fermilab.

The SBND detector currently under construction, will serve as the near detector for SBN. This Liquid Argon detector will have a substantial photon detector coverage which will enhance the physics capabilities of the experiment using mainly the ionization signals. Using state-of-the-art reconstruction techniques, combined to the light collection information, this study will aim to demonstrate the capabilities of the detector at studying Michel electrons. This project will use simulated data in the SBND detector and will necessitate the full reconstruction of these events.

The student is expected to simulate Michel electron events in SBND, getting familiar with the SBND analysis and simulation software. After developing new software tools to perform this study, the student will perform the full analysis. By the end of the internship, the student will have a complete analysis based on simulations that will provide crucial information for the SBND design. This analysis will also be the groundwork for the first SBND data.