Investigating Low-Energy Neutrino Detection in Liquid Argon with Decay-at-Rest Neutrinos from NuMI

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An experiment called the Deep Underground Neutrino Experiment (DUNE) proposes to build a 40-kt liquid argon Time Projection Chamber (LArTPC) neutrino detector in the Sanford Underground Research Facility, 1300 km away from a ν_μ neutrino beam at Fermilab, in order to make precision measurements of neutrino oscillation parameters and probe the neutrino mass ordering via ν_e appearance and ν_μ disappearance. Additionally, an argon detector would have the unique ability to measure the pure electron neutrinos produced during the neutronization burst of core-collapse supernovae. We have yet to demonstrate detection of neutrino absorption reactions on argon at supernova energies. This is, in fact, a very complicated nuclear physics problem where experimental data is currently lacking.

As an Intensity Frontier Fellow at Fermilab, I'm seeking to further our understanding of the signals in argon detectors like DUNE by measuring neutrino absorption on argon using decay-at-rest (DAR) sources. Neutrinos produced by mesons and muons decaying at rest have well known energy spectra and would provide an excellent test of our ability to reconstruct the incoming neutrino energy in LArTPCs. NuMI was designed as a decay-in-flight (DIF) facility to provide neutrinos of several ∼GeV to neutrino oscillation experiments, and as such, significant effort has been invested into understanding the DIF neutrino flux from NuMI.

Recently, I've used NuMI beam simulations to make flux predictions for DAR neutrinos and I'm planning to further study the possibility of running ton-scale experiments at these locations. The most significant neutrino production along the NuMI beam line along with DAR flux estimates at 25 m distance from the NuMI target are shown in Figure 1. Furthermore, the LBNF neutrino beam for DUNE will have a proportionally higher flux coming from the scale-up of beam power from 0.7 MW (NuMI) to 2.4 MW (LBNF). These figures and the results of my research as an Intensity Frontier Fellow are reported in arXiv:1510.08431.

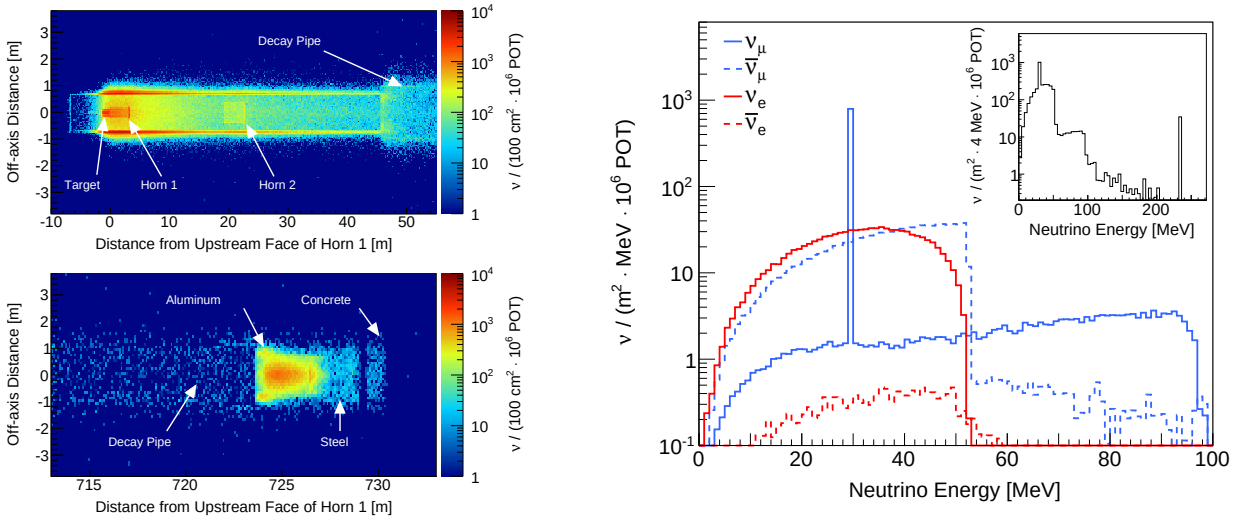

Figure 1: Neutrino origin distributions inside the NuMI target hall (top left) and hadron absorber (bottom left), as viewed from above, and the neutrino flux at 25 m distance from the NuMI target with an inset showing the total flux for all flavors (right). Referenced from arXiv:1510.08431.