Feasibility Study of Neutrino-Argon Interaction Measurement in ANNIE

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The Deep Underground Neutrino Experiment (DUNE) aims to measure the neutrino CP-violating phase and determine the mass ordering, using the Liquid Argon Time Projection Chamber (LArTPC) technology. These measurements rely on the precise reconstruction of the incoming neutrino energy. However, the nuclear effects on neutrino-nucleus interactions are not well understood in argon, which could affect the precision of the experiment. Of particular interest, the measurement of the number of final-state neutrons from neutrino interactions can help constrain the theoretical neutrino-nucleus interaction models. To study neutrino-argon interactions, we propose to use the currently existing Accelerator Neutrino Neutron Interaction Experiment (ANNIE) at the Booster Neutrino Beam (BNB) at Fermilab. ANNIE is currently a water-based neutrino detector but can be modified to study neutrino-argon interactions such as those in DUNE. A feasible experimental strategy is to deploy a liquid argon target at ANNIE's fiducial volume location.

Accelerator Neutrino Neutron Interaction Experiment (ANNIE) [1, 2] is a 26 tonne Gd-doped water Cherenkov detector on the Booster Neutrino Beam (BNB) at Fermilab. ANNIE's primary physics goal is to make precision measurements of $\nu_\mu$interactions. To do this, ANNIE uses 0.1% gadolinium by mass which reduces the neutrino capture distance, and Large Area Picosecond PhotoDetectors (LAPPDs) which enables more precise vertex reconstruction. Charged Current Quasi-Elastic (CCQE) is the preferred mode of interaction as it allows for the most accurate energy reconstruction because the energies of the final-state leptons and neutrons can be measured.

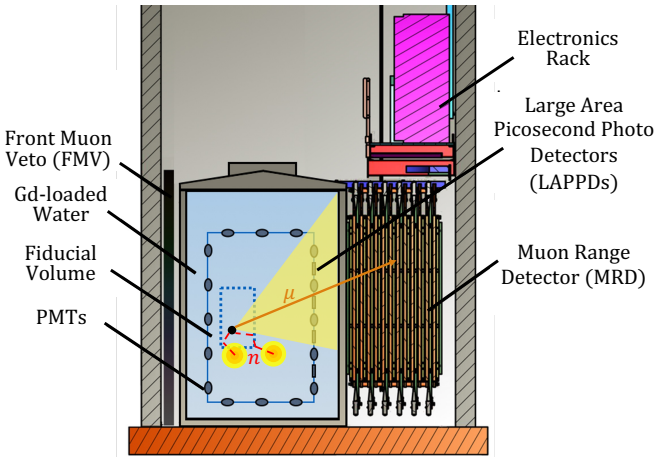

Figure 1: Depiction of a CCQE interaction with a single μ in ANNIE with labeled detector components. Figure adapted from [2].

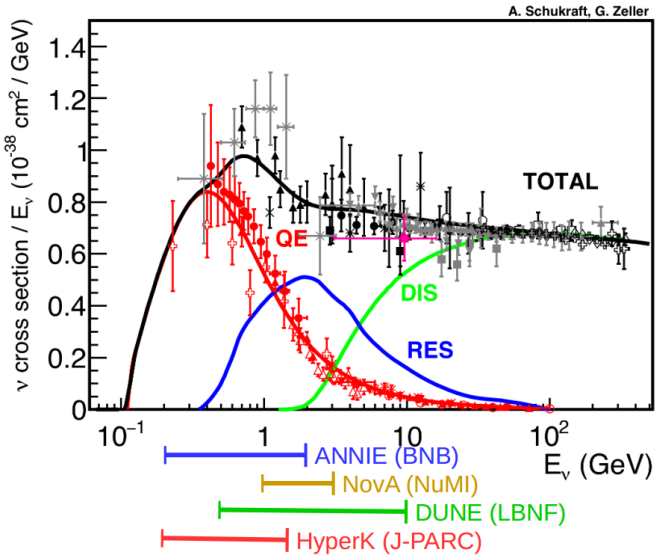

Figure 2: Neurtino cross section divided by neutrino energy. Fermilab's BNB produces E_ν between x GeV and y Gev. Figure adapted from [3].

ANNIE uses Gd-loaded water to

To constrain the theoretical models of neutrino interactions.

References

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