Feasibility Study of Neutrino-Argon Interaction Measurement in ANNIE

J. Wang[1] and N. Everett[1]

[1] *Department of Physics, South Dakota Mines*

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.

1 Introduction

Accelerator Neutrino Neutron Interaction Experiment (ANNIE) [1, 2] is a 26 ton Gd-doped water Cherenkov detector on the Booster Neutrino Beam (BNB) at Fermilab.

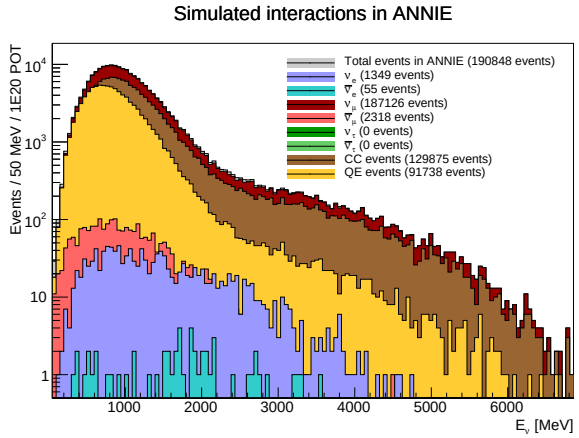

Figure 1: Neurtino cross section divided by neutrino energy. Fermilab's BNB produces E_ν between x GeV and y GeV. Figure adapted from [3].

ANNIE's primary physics goal is to make precision measurements of neutrino-nucleus interactions, focusing specifically on neutron production. To do this, ANNIE uses Gadolinium-doped water (0.1% Gd by mass) to reduce the neutron capture distance, combinded with photo multiplier tubes (PMTs) and Large Area Picosecond PhotoDetectors (LAPPDs) to precisely reconstruct. Charged Current Quasi-Elastic (CCQE) is the preferred mode of interaction as the energies of the leptons and number of final-state neutrons can be measured.

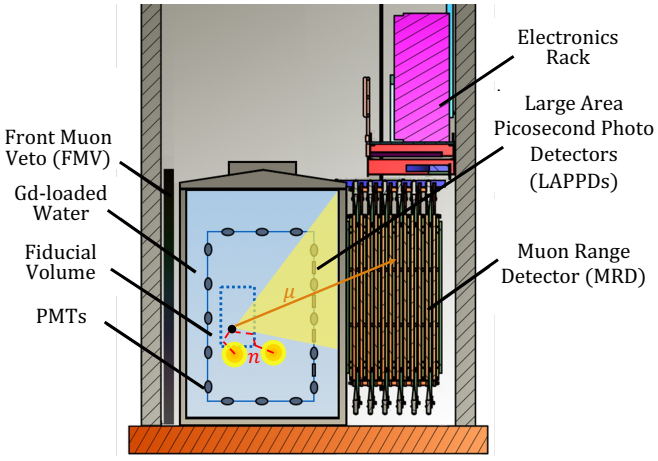

Figure 2: Depiction of a CCQE interaction with a single μ in ANNIE with labeled detector components. Figure adapted from [2].

In this paper, we will discuss the feasibility of using ANNIE to measure the neutron multiplicity of ν_μ-Ar interactions. This measurement would help constrain free parameters in current neutrino interaction models. Improving these models will help liquid argon (LAr) neutrino experiments reduce systematic uncertainties that result from their inability to measure the number of final-state neutrons produced in ν-Ar interactions.

2 Motivation

3 Event Reconstruction

4 Results

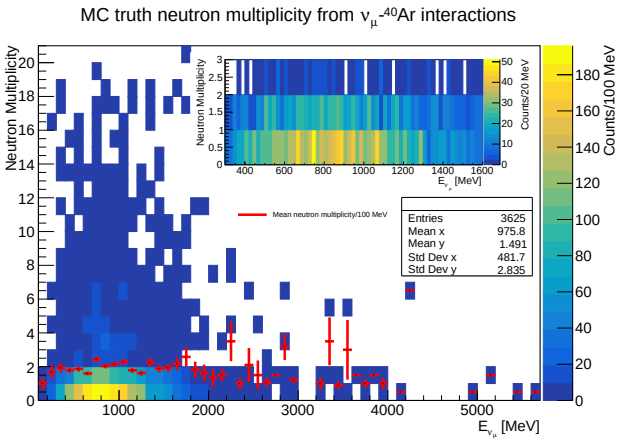

Figure 3: Caption here

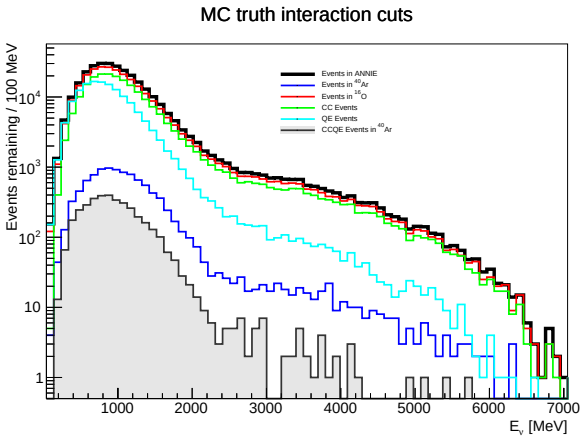

Figure 4: Caption here

References

[1] I. Anghel et al. *Letter of Intent: The Accelerator Neutrino Neutron Interaction Experiment (ANNIE)*. 2015. DOI: 10.48550/ARXIV.1504.01480. URL: https://arxiv.org/abs/1504.01480.

[2] A. R. Back et al. *Accelerator Neutrino Neutron Interaction Experiment (ANNIE): Preliminary Results and Physics Phase Proposal*. 2017. DOI: 10.48550/ARXIV.1707.08222. URL: https://arxiv.org/abs/1707.08222.

[3] J. A. Formaggio and G. P. Zeller. "From eV to EeV: Neutrino cross sections across energy scales". In: *Reviews of Modern Physics* 84.3 (Sept. 2012), pp. 1307–1341. DOI: 10.1103/revmodphys.84.1307. URL: https://doi.org/10.1103%2Frevmodphys.84.1307.