Form Factor Comparison for Neutrino-Induced Coherent Pion Production to Constrain Neutrino Flux at DUNE: General Audience Abstract

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Neutrino-induced coherent pion production is an interaction between a neutrino, a tiny, near-massless fundamental particle, and a target nucleus under conditions of low momentum transfer that leaves the nucleus in the ground state. This interaction allows for easy energy reconstruction of the incident neutrino since its products can be detected and have their energy recorded in modern neutrino detectors. If the probability of this interaction was well known, then a neutrino experiment such as the Deep Underground Neutrino Experiment (DUNE) could count how many times this interaction is seen and compare that with the probability of the interaction taking place to determine how many neutrinos pass through their detector. Furthermore, if the neutrino energies are then matched to their respective events, the number-energy distribution (flux) of neutrinos can be constrained. However, the probability of this interaction is poorly defined due to uncertainties on the nucleon axial form factor, which is a description of the weak charge distribution in nucleons. In this work, we compared three form factor descriptions: a dipole approximation based on a variable called "axial mass," M_A, a z power series expansion based on deuterium bubble chamber data, and z expansions for two Lattice Quantum Chromodynamics calculations. Over relevant variable ranges, the curves for the form factors as a function of momentum transfer were compared along with reweighted event data for kinematic variables in events simulated using GENIE. The relative differences between various form factor descriptions and the dipole approximation with $M_A = 1.00$ GeV were under 11%. The relative differences for the momentum transferred from the neutrino, momentum transferred to the nucleus only, and energy of the neutrino were under 13%. With this in mind, neutrino-induced coherent pion production can be used to constrain neutrino flux in DUNE within these uncertainties.

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