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Beyond the Inclusive Picture for Multinucleon Knockout in Neutrino-Nucleus Scattering

The precise measurement of neutrino properties is among the highest priorities in fundamental particle physics. Accelerator-based neutrino experiments provide a unique framework for such studies, providing oscillation measurements and hints of the CP violation in the leptonic sector. However, since these experiments rely on the interaction of neutrinos with bound nucleons inside atomic nuclei, understanding the underlying nuclear physics of the target response constitutes a challenging source of uncertainty. Modeling neutrino-nucleus scattering processes is a complex many-body problem, traditionally performed in the independent-particle picture, focusing on the quasielastic neutrino-nucleon interactions or the excitation of nucleon resonances. Improving our knowledge of such cross sections to the required percent-level precision involves conducting research beyond the first approximation, incorporating the effects of nucleon correlations and multinucleon knock-out processes.

In this talk, we present recent advancements from a microscopic, quantum-mechanical framework, where both the bound and scattering hadronic states are governed by a non-relativistic nuclear mean-field potential. Building upon extensive validation against inclusive electron-scattering data, where we show how short-range correlations (SRC) and meson-exchange currents (MEC) provide necessary contributions to describe the quasielastic and dip regions, we extend this formalism to neutrino-induced multinucleon knockout. We then discuss the consequences of proper Distorted Wave Impulse Approximation (DWIA) modeling on exclusive observables. Finally, we address the critical bottleneck of implementing such computationally intensive, exclusive cross section models into Monte Carlo event generators.

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