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Multinucleon knock-out in neutrino-nucleus scattering

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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 hadronic and nuclear physics of these interactions 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 levels involves conducting research beyond the first approximation, incorporating the effects of nucleon correlations and multinucleon knock-out processes.

The presented research involves a novel, multidirectional approach to tackling these problems by combining the theoretical experiences of the Ghent group and the Monte Carlo neutrino event generator NuWro. The nuclear physics of Ghent involves a non-relativistic, mean-field-based model for both the initial and final hadronic states. On top of that, we add dynamically generated short-range nucleon correlations and explicit two-body dynamics with meson-exchange currents involving isobar degrees of freedom. This framework, exhaustively compared against electron scattering, provides predictions of inclusive, semi-inclusive, and exclusive cross sections for neutrino-nucleus interactions leading to 1-particle-1-hole and 2-particle-2-hole final states. Together with auxiliary advancements in other aspects of Monte Carlo simulations, we will present the implementation of the obtained two-nucleon knock-out model in NuWro and compare it to experimental neutrino data, therefore completing the bridge between the theoretical and experimental sides of accelerator-based neutrino research.

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