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Impact of final-state de-excitation on modeling neutrino-nucleus interactions

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As neutrino oscillation physics enters the precision era, the modeling of neutrino-nucleus interactions constitutes an increasingly challenging source of systematic uncertainty for new measurements. To confront such uncertainties, a new generation of detectors is being developed to measure the exclusive final state of neutrino interaction. Precise simulations of the nuclear effects on the final-state nucleons are needed to fully benefit from the improved detector capabilities.

To address this problem, we focused on the re-interactions of final state nucleons with the nuclear medium (FSI) by comparing NuWro and INCL cascade models and considering the de-excitation model from ABLA. INCL is an evolved nuclear cascade code primarily designed to simulate nucleon-, pion- and light-ion-induced reactions on nuclei. ABLA is a de-excitation code coupled to INCL that can simulate all the particles emitted by de-excitation. This is the first detailed study using the INCL model in the framework of neutrino physics and the first study investigating the effect of de-excitation on the hadronic final state of neutrino interactions. The results feature various novelties, including the production of nuclear clusters (e.g., deuterons, α particles) in the final state and the release of removal energy during the de-excitation stage.

We present a characterization of the hadronic final state after FSI and de-excitation, comparisons to available measurements of transverse kinematic imbalance, an assessment of the observability of nuclear clusters, and the impact of de-excitation on the energy released around the vertex.

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