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Benchmarking neutrino interaction models through a comparative analysis of kinematic imbalance measurements from the T2K, MicroBooNE and MINERvA experiments

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The description of neutrino-nucleus interactions in the few-GeV regimes constitutes the dominant source of systematic uncertainty for current and future long-baseline neutrino oscillation experiments. In this work, based on the recent manuscript available at arXiv:2407.10962, neutrino-nucleus cross-section measurements of transverse kinematic imbalance from the T2K, MicroBooNE and MINERvA experiments are used together to benchmark predictions from widely used neutrino interaction event generators. Given the different neutrino energy spectra and nuclear targets employed by the three experiments, comparisons of model predictions to their measurements break degeneracies that would be present in any single measurement. In particular, the comparison of T2K and MINERvA measurements offers a probe of energy dependence, whilst a comparison of T2K and MicroBooNE investigates A-scaling effects. In order to isolate the impact of individual nuclear effects, model comparisons are made following systematic alterations to: the nuclear ground state; final state interactions and multi-nucleon emission strength. The measurements are further compared to the generators used as an input to DUNE/SBN and T2K/Hyper-K neutrino oscillation measurements. Whilst no model is able to quantitatively describe all the measurements, evidence is found for mis-modelling of A-scaling in multi-nucleon interactions and it is found that tight control over how energy is distributed among hadrons following final state interactions is likely to be crucial to achieving improved agreement. Overall, this work provides a novel characterization of neutrino interactions whilst offering guidance for refining existing generator predictions.

Working Group

WG 2: Neutrino Scattering Physics

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