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New Approaches to Precision Neutrino Cross-Section Measurements

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The last two decades have witnessed remarkable progress in the measurement of neutrino cross sections relevant to oscillation experiments. At the same time, this growing body of data has exposed significant limitations in our theoretical understanding of neutrino-nucleus interactions and has stimulated the development of new experimental approaches. This effort is particularly timely, as the physics reach of next-generation long-baseline experiments, most notably DUNE and Hyper-Kamiokande, will strongly benefit from a substantial reduction of cross-section uncertainties.

In this talk, I will review some of the emerging strategies for high-precision neutrino cross-section measurements at the GeV scale. These include ancillary hadron-interaction measurements aimed at improving the knowledge of neutrino fluxes, as well as a new generation of short-baseline experiments specifically designed for precision cross-section studies.

Special emphasis will be given to the nuSCOPE proposal, which aims to exploit, for the first time, a monitored and tagged neutrino beam. By providing unprecedented control of the neutrino source in terms of flavor, energy, and flux, this approach brings neutrino beams closer to the level of source characterization routinely achieved with conventional charged-particle beams. It therefore opens the way to a new precision regime in neutrino-nucleus scattering, bringing weak-interaction measurements closer to the level of control traditionally associated with electron scattering, while providing unique access to the axial response of nuclei.

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