Neutrino energy reconstruction is one of the largest sources of uncertainty in modern oscillation experiments. The neutrino oscillation probability directly depends on the energy, and failure to determine this energy leads to errors in measuring the theoretical oscillation parameters. Neutrino energy is measured from the final state particles after an interaction with a target nucleus in the detector. Any failures in reconstructing these final state particles leads to errors in determining neutrino energy.

These errors arise particularly from two sources: Final State Interactions (FSI) and Secondary Interactions (SI). FSI occur while the final state particles traverse the nuclear medium after a neutrino interaction. If a particle experiences FSI, some of its energy will be unable to be detected. SI occur after the final state particles exit the nucleus and interact within the detector medium. This also leads to incorrect energy measurement. Both FSI and SI must be accounted for in simulations for neutrino experiments. These simulations use the probability – also known as the cross section – for the particle to interact with the nucleus as a direct input.

Updating these inputs for future oscillation experiments is key to their success. One of these upcoming experiments is the Deep Underground Neutrino Experiment (DUNE). Its detectors – 4 monolithic Liquid Argon detectors – will be the largest of their kind, and require validation and calibration prior to their use. This will be done using ProtoDUNE – a smaller version of the detectors that will sit in a charged particle beam at CERN. One type of particle in the beam will be the positive-charge pion (π^+). This is commonly produced in neutrino-nucleus interactions and is subject to FSI and SI. A measurement of the π^+-Argon interaction cross section will provide new data to update and validate FSI and SI models in neutrino interaction simulations for DUNE.