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Measuring the Invisible: Neutrino Cross Sections using the Forward Folding Method

DUNE, the next generation of neutrino experiments, requires high-precision neutrino-argon cross sections. A cross section cannot be measured directly: it is inferred from the number of observed interactions, correcting for detector effects and background, and propagating the uncertainties from the flux, the detector, and other systematic effects. In this work, we show how to extract a differential cross section as a function of muon momentum for a ν_μ CC signal in a toy Monte Carlo, using a binned likelihood fit with GUNDAM, as employed in experiments such as ICARUS, SBND, T2K, and MINERvA. The model has a control region (sideband), and three systematic parameters to showcase the extraction method. The fit minimizes a Baker-Cousins-type Poisson likelihood with Gaussian priors. The cross section and its uncertainty are obtained from 2000 toy throws of the post-fit parameters. This exercise illustrates how a differential cross section is obtained from reconstructed events and where its uncertainty comes from.

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