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Time Slicing of Neutrino Fluxes in Oscillation Experiments at Fermilab

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The next-generation of long baseline neutrino experiments will use higher-power proton beams and massive detectors to overcome statistical limitations. The DUNE experiment at LBNF will test the three neutrino flavor paradigm and directly search for CP violation by studying oscillation signatures in the high intensity ν_μ (anti-ν_μ) beam to ν_e (anti-ν_e) measured over a long baseline. To achieve their goals, these experiments must minimize systematic errors, particularly in neutrino-nucleus interaction cross sections. The "stroboscopic approach" is a novel technique presented here, which slices the neutrino flux based on measured arrival time of the neutrinos to constrain cross-section uncertainties. By exploiting the correlation between the true neutrino energy and the measured neutrino arrival time, this technique selects different neutrino energy spectra from a wide-band neutrino beam. It uniquely allows access to true energy information at the Far detector, which is not possible from any other existing part of the DUNE experiment. Muons can also be used for normalization for the neutrino flux by binning them with neutrinos in the same time intervals. Three thrusts are required for implementing stroboscopic approaches: short proton bunch lengths, fast timing in detectors, and synchronization between detector and target proton times. These approaches are critical for DUNE and US neutrino physics. Neutrinos and muons will play a key role in future neutrino experiments. Stroboscopic techniques allow us to exploit neutrino and muon beams to their fullest potential.

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