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Abstract

Expanded ν_e CC1π^+ sample selection and improved systematic treatments for neutrino oscillation parameter determination with T2K data

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The thesis describes the development of a new electron neutrino (ν_e) event sample targeting charged-current single pion production interactions (CC1π^+) at T2K's far detector. The T2K experiment located in Japan studies neutrino oscillations with an accelerator-produced (anti)neutrino beam, an ensemble of near detectors, and Super-Kamiokande, the far detector. T2K's most ambitious objective is to measure the leptonic CP-violating phase, δ_{CP}, which could potentially explain the origin of the matter-antimatter asymmetry observed in the Universe. The appearance of electron (anti)neutrinos in the beam of muon (anti)neutrinos at the far detector provides sensitivity to measuring δ_{CP}. The new ν_e CC1π^+ sample is identified by tagging its electron-like and pion-like Cherenkov rings at the far detector. Combined with the existing single-ring ν_e CC1π^+ sample, which lacks a visible pion-like ring, the new sample increases T2K's second-most dominant ν_e interaction statistics by 27%. In order to support the new sample, systematic uncertainties related to the far detector have also been recalculated. Furthermore, resolutions of the kinematic parameters employed for binning at the far detector were studied in depth. This facilitated a re-evaluation of the kinematic binning of the ν_μ samples and the expanded ν_e CC1π^+ sample. An oscillation analysis was conducted with T2K's Markov Chain Monte Carlo fitter based on Bayesian inference, incorporating the expanded sample, the re-evaluated detector systematic uncertainties, and the updated binning, all of which represent the novelties described in this thesis. We report that CP-conserving values of $\delta_{CP} = 0, \pi$ are excluded at the 90% credible interval, and that a value of δ_{CP} attributing to maximal CP violation is preferred. Furthermore, the data also show a mild preference for the normal neutrino mass hierarchy and the upper octant of θ_{23} mixing angle. The improvements presented in this thesis will be included in T2K's official oscillation analysis for 2024. The thesis also presents sensitivity studies with the scenario of improved FD statistics for the ν_e CC1π^+ sample.