NATIONAL CENTRE FOR NUCLEAR RESEARCH

Abstract

Constraining neutrino cross-section and flux models using T2K Near Detector with proton information in Markov chain Monte Carlo framework

Kamil Skwarczyński

T2K (Tokai to Kamioka) is a long-baseline neutrino oscillation experiment located in Japan. It uses the near detector ND280 and the far detector (FD) Super-Kamiokande to measure neutrino oscillations and determine whether CP is violated in the lepton sector or not. The work presented herein details the process of using data collected by ND280 to constrain the predicted event spectra at Super-Kamiokande. The analysis uses the Markov chain Monte Carlo method without assumptions on the underlying posterior probability density function. The Thesis describes new event samples splitting data based on the presence of protons, as well as new systematic parameters describing neutrino cross-section. Thanks to the use of the ND280 data, it was possible to decrease the uncertainty on FD spectra prediction by a factor of six. This error reduction enabled the precise measurement of neutrino oscillation parameters. T2K data show a preference for nearly maximal CP violation in the lepton sector, with the value of δ_{CP} close to $-\pi/2$ and exclude CP conserving values of 0 and π within 90% credible intervals. In addition, T2K data suggest the normal mass hierarchy and lower θ_{23} octant, and provide the most precise measurement of $\sin^2 \theta_{23} = 0.552^{+0.022}_{-0.053}$. The work described in the Thesis has been included in the T2K official results presented at the Neutrino 2022 conference. The Thesis presents exploratory studies using proton kinematic variables and sensitivity studies with the use of the upgraded ND280 detector.