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Physics and Performance of the Upgraded T2K's Near Detector

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The upgraded T2K off-axis near detector (ND280) will allow to improve constraints on the systematic uncertainties that are currently limiting the neutrino oscillation sensitivity. A better understanding of the flux and neutrino-nucleus interactions models are indeed essential to determine the neutrino mass hierarchy and the extent of CP-violation generated in the lepton sector. In particular, one of the main challenges in achieving such precision stems from the absence of knowlegde of nuclear physics processes that obfuscate the reconstruction of neutrino energy and therefore the characterisation of neutrino oscillations. To overcome these difficulties, the upgraded detector will feature lower threshold for proton reconstruction, measurement of neutrons through time of flight and increased phase space of track reconstruction at high and backward angles. Thanks to these new capabilities, the upgrade of ND280 will be able to measure the neutrino energy spectrum to an unprecedented level of accuracy, and thus guarantee the reliability of the near-to-far detector extrapolation of systematics constrains. In addition, the measurement of neutrons will allow to select interactions of antineutrino on hydrogen, providing thus a very clean sample; absent of nuclear physics uncertainties; to measure the rate and energy distribution of the neutrino flux.

After a brief overview of the status of such uncertainties in the latest T2K analysis, the physics program of ND280 upgrade will be introduced by demonstrating how the expected detector performance will allow us to probe the aspects of neutrino interactions responsible for the largest systematics in T2K's neutrino oscillation analyses. We further show the results of a simplified sensitivity analysis were the simulation of the detector effects is benchmarked by present data collected at T2K and in various test-beam prototypes. The analysis framework is based on realistic assumptions extracted from present T2K analysis on flux and neutrino-nucleus interaction measurements and models.

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