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Future sensitivity of the T2K experiment with its upgraded neutrino beam and optimisation of neutrino/antineutrino running modes

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T2K is a long-baseline neutrino oscillation experiment located in Japan. Its aim is to undertake precise measurements of the atmospheric parameters $|\Delta m^2_{23}|$, $\sin^2\theta_{23}$ and to search for CP-violation within the leptonic sector, which would manifest as a discrepancy between neutrino and anti-neutrino oscillations. Thanks to its focusing horns, the T2K experiment has the faculty to produce low-background fluxes in neutrino and anti-neutrino modes, separately. The complementary use of these two modes is crucial to help break degeneracies between oscillation parameters, notably in the search for CP-violation. Hence, the ratio between neutrino and antineutrino beam modes has to be tuned on the basis of the physics goals of the experiment. We conducted a new sensitivity study to address this question, in particular taking into account the effects of the recent upgrade of the focusing horn current, increased from 250kA to 320kA. The study implements a novel algebraic method in order to estimate the constraining power of future near detector data as a function of statistics. The sensitivity is estimated for all the oscillation parameters accessible at T2K and considering different possible values of such parameters. In some cases, the objective of reaching a 3sigma evidence of CP-violation proves to be promisingly close. The detailed study of the degeneracies between the different oscillation parameters paves the way for the next high-statistics era of
long-baseline experiments. While the impact of the ND constraints is quantified in a simplistic way in these studies, the importance of the new capabilities of the upgrade of the ND280 detector in reducing systematics uncertainties will be discussed, opening the door for further analysis improvements.

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