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Physics prospects of second oscillation maximum at the Deep Underground Neutrino Experiment

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The precision measurement of neutrino parameters can be achieved by studying $\nu_\mu \rightarrow \nu_e$ oscillations over a large L/E range. In the context of long baseline neutrino experiments (with fixed L), this amounts to examining oscillations over a wide energy range. Most of the current and future long baseline experiments such as Deep Underground neutrino experiment (DUNE) are mainly sensitive to the neighbourhood of first oscillation maximum of the $\nu_\mu \rightarrow \nu_e$ probability. In the present study, we elucidate the role of second oscillation maximum in investigating the sensitivity to the standard unknowns in oscillation physics. At the second oscillation maximum, one expects higher sensitivity to δ as the size of the δ-dependent interference term is a factor of ~ 3 larger than that at the first oscillation maximum. We demonstrate that a beam tune optimized for coverage of the 2^{nd} oscillation maxima at DUNE is possible using proposed accelerator upgrades that provide multi-MW of power at proton energies of 8 GeV. We perform sensitivity studies in the context of DUNE by utilising this new multi-MW 8 GeV beam tune inaddition to wide-band beam tune that fully covers the region of the 1^{st} oscillation maxima and part of the 2^{nd}. We highlight the importance of second oscillation maximum in deciphering the intrinsic CP phase and also explore its impact on the precision measurement of the CP phase. We find that addition of the 2^{nd} maxima beam tune to DUNE running with the standard wide-band CP optimized beam tune provides some improvement in sensitivity to the 3 flavor oscillation parameters. Further studies with improved detector resolution and beam optimizations will need to be carried out to fully exploit the capabilities of the 2^{nd} maxima beam options at DUNE.

Collaboration name

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