Contribution ID: **266** Type: **Poster session only**

A New Approach to Probe Non-Standard Interactions in Atmospheric Neutrino Experiments

We propose a new approach to explore the neutral-current non-standard neutrino interactions (NSI) in atmospheric neutrino experiments using oscillation dips and valleys in reconstructed muon observables, at a detector like ICAL. We show that the non-zero value of NSI parameter $\varepsilon_{\mu\tau}$ shifts the oscillation dip locations in L/E distributions of the up/down event ratios of reconstructed μ^- and μ^+ in opposite directions. We introduce a new variable Δd representing the difference of dip locations in μ^- and μ^+, which is sensitive to $\varepsilon_{\mu\tau}$, and is independent of the value of Δm^2_{32}. We further note that the oscillation valley in the $(E, \cos\theta)$ plane of the reconstructed muon observables bends in the presence of NSI, its curvature having opposite signs for μ^- and μ^+. We illustrate how the measurement of contrast in the curvatures of valleys in μ^- and μ^+ can be used to estimate $\varepsilon_{\mu\tau}$. Using these proposed oscillation dip and valley measurements, the achievable precision on $|\varepsilon_{\mu\tau}|$ at 90\% C.L. is about 2\% with 500 kt·yr exposure including the effects of statistical fluctuations, systematic errors, and uncertainties in oscillation parameters.

arXiv number (if applicable)

2101.02607

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Session Classification: Poster Session