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Challenges in resolving neutrino mass hierarchy in medium-baseline reactor experiments

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The value of the last mixing angle theta13 has been measured the Daya Bay Reactor Neutrino Experiment, followed by consistent results from RENO and Double Chooz. Its large value, compared with most speculated values before its discovery, creates a unique opportunity in resolving neutrino mass hierarchy (MH) using medium-baseline reactor antineutrino experiments employing massive liquid scintillator (LS) detectors like JUNO and RENO-50. Such medium-baseline reactor experiments have both the solar and the atmospheric oscillation signals presented in their data. Due to the nature of the MH signal in such experiments and the small ratio between the solar and the atmospheric mass-squared differences, we find the energy scale uncertainty places a challenge besides the well-known factors like energy resolution. Under a certain class of energy non-linearity biases allowed by its uncertainty, normal hierarchy (NH) and inverted hierarchy (IH) can exhibit similar oscillation patterns in a LS detector. To make such experiments successful in resolving neutrino MH with high confidences, energy scale uncertainty needs to be constrained well. In addition to the energy scale challenge, we also find that the MH determination confidence level and the so-called delta-chi-square obtained in model comparison follow a different relation from the conventional squared-root one. To reach the same confidence levels, compared with physics quantities whose measurements can be approximated by normal distributions, larger chi-square differences are needed.

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