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Probing the mass hierarchy in reactor neutrino oscillations

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One of the most promising method to probe neutrino mass hierarchy is studying medium-baseline reactor neutrino oscillations. The requirements are huge statistics, high energy resolution, precision calculations and refined statistical analyses of event spectra. In such a context, we consider essential to take into account the following ingredients: nucleon recoil in inverse beta decay and its impact on energy reconstruction and resolution, hierarchy and matter effects in the oscillation probability, spread of reactor distances, irreducible backgrounds from geoneutrinos and from far reactors, and degeneracies between energy scale and spectrum shape uncertainties. We also introduce a continuous parameter α, which interpolates smoothly between normal hierarchy ($\alpha = +1$) and inverted hierarchy ($\alpha = -1$). The determination of the hierarchy is then transformed from a test of hypothesis to a parameter estimation, with a sensitivity given by the distance of the true case (either $\alpha = +1$ or $\alpha = -1$) from the "undecidable"case ($\alpha = 0$). Our numerical simulations show that for the specific set up envisaged for the JUNO project there is a sensitivity of about 2σ to mass hierarchy, which, however, will decrease significantly if energy scale and spectrum shape systematics are not under control.

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