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Determining ν mass hierarchy by precise measurements of two Δm^2 in ν_e and ν_μ disappearance experiments ‡

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Abstract. In this talk, we discuss the possibility of determining the neutrino mass hierarchy by comparing the two effective atmospheric neutrino mass squared differences measured, respectively, in electron, and in muon neutrino disappearance oscillation experiments. If the former, is larger (smaller) than the latter, the mass hierarchy is of normal (inverted) type. We consider two very high precision (a few per mil) measurements of such mass squared differences by the phase II of the T2K (Tokai-to-Kamioka) experiment and by the novel Mössbauer enhanced resonant $\bar{\nu}_e$ absorption technique. Under optimistic assumptions for the systematic errors of both measurements, we determine the region of sensitivities where the mass hierarchy can be distinguished. Due to the tight space limitation, we present only the general idea and show a few most important plots.

If one can tell the sign of $|\Delta m^2_{31}|$ -$|\Delta m^2_{32}|$, the neutrino mass hierarchy can be determined, namely, it is of normal (inverted) type if the sign is positive (negative). If θ_{12} *were* zero, and for small $\theta_{13} \neq 0$, with good approximations, electron and muon neutrino disappearance oscillation experiment directly probe $|\Delta m^2_{31}|$ and $|\Delta m^2_{32}|$, respectively. It was shown in Ref. [1] that this very simple idea can be formulated in a transparent way even in the presence of three flavor mixing, by introducing the two effective mass squared differences $\Delta m^2(\mathrm{ee})$ and $\Delta m^2(\mu\mu)$, measured, respectively, in electron and muon neutrino disappearance experiments, with an additional bonus of having some sensitivity also to the cosine of the CP phase δ.

We examine this possibility by assuming that $\Delta m^2(\mu\mu)$ can be measured by the second phase of the T2K experiments (with 2 years of neutrino running) with high

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precision of $\sim 0.5\%$ and $\Delta m^2(\mathrm{ee})$ by the Mössbauer enhanced resonant $\bar{\nu}_e$ absorption technique with precision of $\sim 0.6\times(0.05/\sin^2 2\theta_{13})\%$ [2]. In Fig. 1 we show the expected ranges of $\Delta m^2(\mathrm{ee})$ and $\Delta m^2(\mu\mu)$ under such optimistic assumptions, for the case where the true value of $\Delta m^2(\mathrm{ee})$ is fixed to be 2.5×10^{-3} eV^2. If the allowed regions for the two $\Delta m^2(\mathrm{ee})$ and $\Delta m^2(\mu\mu)$, are separated, or have little overlap, the mass hierarchy can be determined. (Note that the positions of $\Delta m^2(\mu\mu)$ depends on the hierarchy).

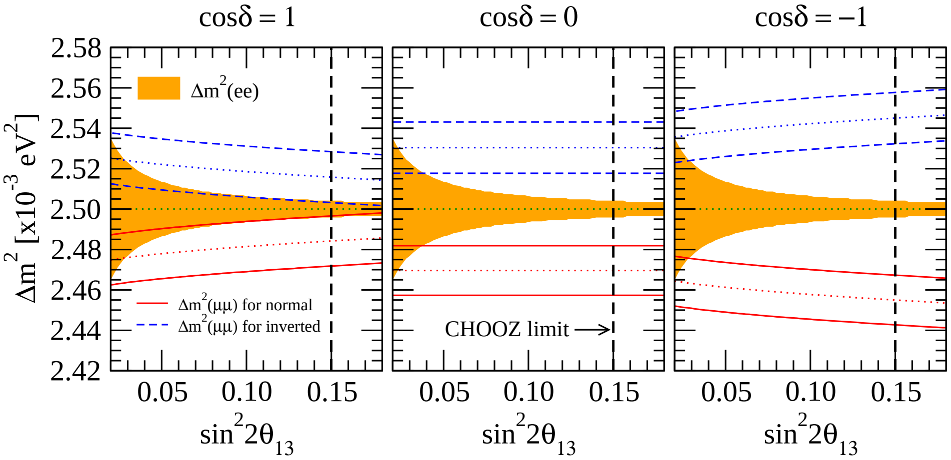

Fig.1: Expected 1 σ allowed ranges of $\Delta m^2(\mathrm{ee})$ (shaded by orange color) and $\Delta m^2(\mu\mu)$ (bands delimited by two solid and dashed curves), under the optimistic assumptions on the systematic errors. The true value of $\Delta m^2(\mathrm{ee})$ is assumed to be 2.5×10^{-3} eV^2.

By varying the assumed true (input) values of θ_{13} and δ, we can establish the regions of parameters where the mass hierarchy can be determined, which is shown in Fig. 2. For a wide range of θ_{13} and δ the mass hierarchy can be determined. See Refs. [1, 3] and references therein, for details.

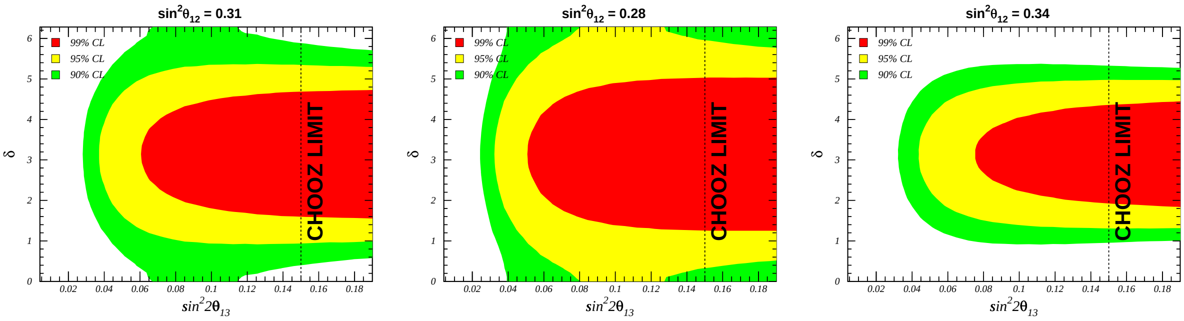

Fig. 2: Regions of $\sin^2 2\theta_{13}$ and the CP phase δ where the mass hierarchy can be determined at 90% (shaded by green color), 95% (yellow), and 99% (red) CL by the method discussed in this talk. Here other mixing parameters are fixed as $\Delta m^2_{21} = 8\times10^{-5}$ eV^2, $\sin^2\theta_{12} = 0.31$ (left, the best fit), 0.28 (middle), 0.34 (right) and $\theta_{23} = \pi/4$.

References

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