PINGU receiving accelerator neutrinos

Jian Tang, Walter Winter
Institut für Theoretische Physik und Astrophysik,
Universität Würzburg, D-97074 Würzburg, Germany

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Abstract

This short note explains the basic ideas presented at the Neutrino Working Group Meeting@Fermilab on Oct. 24th, 2011. See the reference [1] in details.

References

[1] J. Tang and W. Winter, arXiv:1110.5908 [hep-ph].

If one is able to increase the photomultiplier density in the IceCube detector array beyond that of DeepCore, this initiative, known as "Phased IceCube Next Generation Upgrade" (PINGU) detector, would provide an unprecedented fiducial volume with a low energy threshold suitable for accelerator neutrino oscillation experiments.

We study the detector requirements of PINGU for a beta beam, a neutrino factory beam, and a superbeam, where we consider both the case of a small θ_{13}, and that of a large θ_{13}, based on the discovery reach of CP violation, the determination of mass hierarchy and the confirmation of non-zero θ_{13}.

A neutrino beam from one of the major accelerator laboratories in the Northern Hemisphere to such a detector will cross the Earth's core with a distance far beyond the magic baseline, which is often proposed as a second baseline for the neutrino factory or a high γ-beta beam experiment to measure the mass hierarchy and to resolve degeneracies. As a peculiarity, the oscillation probability becomes parameterically enhanced between about 2 and 5 GeV, which means that a large fiducial volume is required in that energy range.

We illustrate that a flavor-clean beta beam best satisfies the requirements of such a detector, in particular, that PINGU may replace a magic baseline detector for small values of θ_{13}; see Fig. 1 (right panel), for the dependence on energy resolution and comparison to the reference beta beam (shaded area: one or two baselines). For a large θ_{13}, however, a single-baseline beta beam experiment cannot compete if it is constrained by the CERN-SPS. For a neutrino factory, without the charge identification possibility in the detector, a very good energy resolution of about $\Delta E = 10\%\, E$ is required. If this can be achieved, especially a low energy neutrino factory, which does not suffer from the tau contamination, may be an interesting option for a large θ_{13}. For the superbeam, where we use the LBNE beam as a reference, electron neutrino flavor identification (with a mis-identification rate of about 1% to 10%) and statistics are two of the main limitations. See Fig. 1 (left panels) for the performance and comparison to the reference setups, if these requirements can be met.

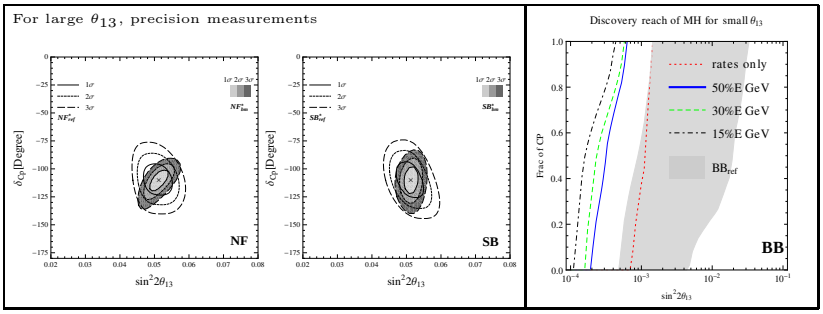

Figure 1: *The shaded region replaces the single baseline with PINGU at the NF and SB, respectively in the left box. Figure taken from Ref. [1].*