PROCEEDINGS OF SCIENCE

Resolving oscillation degeneracies with a single neutrino polarity

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Within the future programme of neutrino oscillation experiments that is currently under discussion, long baseline experiments will play a crucial role in providing information on the value of θ_{13}, the type of neutrino mass ordering and on the value of the CP-violating phase δ, which enters in 3-neutrino oscillations. Here, we consider a beta-beam setup with an intermediate Lorentz factor $\gamma = 450$ and a baseline of 1050 km. This could be achieved in Europe with a beta-beam sourced at CERN to a detector located at the Boulby mine in the United Kingdom. We consider a neutrino run alone and show that, by exploiting the oscillatory pattern of the signal, a very good sensitivity to CP-violation and the type of hierarchy can be reached. We analyse the physics potential of this setup in detail studying two different exposures (1×10^{21} and 5×10^{21} ions-kton-years). In both cases, we find that the type of neutrino mass hierarchy could be determined at 99% CL, for all values of δ, for $\sin^2 2\theta_{13} > 0.03$. In the high-exposure scenario, we find that the value of the CP-violating phase δ could be measured with a 99% CL error of $\sim 20^o$ if $\sin^2 2\theta_{13} > 10^{-3}$, with some sensitivity down to values of $\sin^2 2\theta_{13} \simeq 10^{-4}$.

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1. Introduction

In this poster, we discuss how neutrino oscillation degeneracies could be overcome through the use of a single neutrino polarity, taking an intermediate boost beta-beam as a case study. We present a detailed numerical simulation confirming the analytical study presented in [1].

2. Simulation and results

We consider boosted ^{18}Ne ions directed along the CERN-Boulby baseline (1050 km) with a conservative Lorentz factor (for an upgraded SPS) of $\gamma = 450$. We first consider an exposure corresponding to 10^{21} ions-kton-years. This could be obtained, for example, assuming 2×10^{18} useful ion decays per year and a 50 kton detector with 100% efficiency located at Boulby with 10 years of data taking. We also upgrade the first scenario by a factor of five in statistics. We assume a 200 MeV bin width and an energy detection threshold of 400 MeV. The muon-neutrino appearance signal has been binned in eleven bins with a bin width of 200 MeV in the [0.4, 2.0] GeV energy range, plus a unique, last bin, filled with the neutrino events from 2.0 GeV up to the end point of the spectrum at 3.06 GeV. We have taken overall systematics of 2 %, an intrinsic beam background of 0.1 %, and used atmospheric backgrounds of 0.03 per kton-yr assuming a duty factor of 10^{-3}.

We present in Fig. 1 the 90%, 95% and 99% CL contours for a fit to the simulated data from the beta-beam experiment described in the previously. The simulations are for the normal mass hierarchy and θ_{23} in the first octant ($\sin^2\theta_{23} = 0.41$ which corresponds to $\theta_{23} = 40^\circ$). The statistics considered corresponds to the optimistic high-statistics scenario. The analysis depicted in Fig. 1 includes the study of the discrete degeneracies.

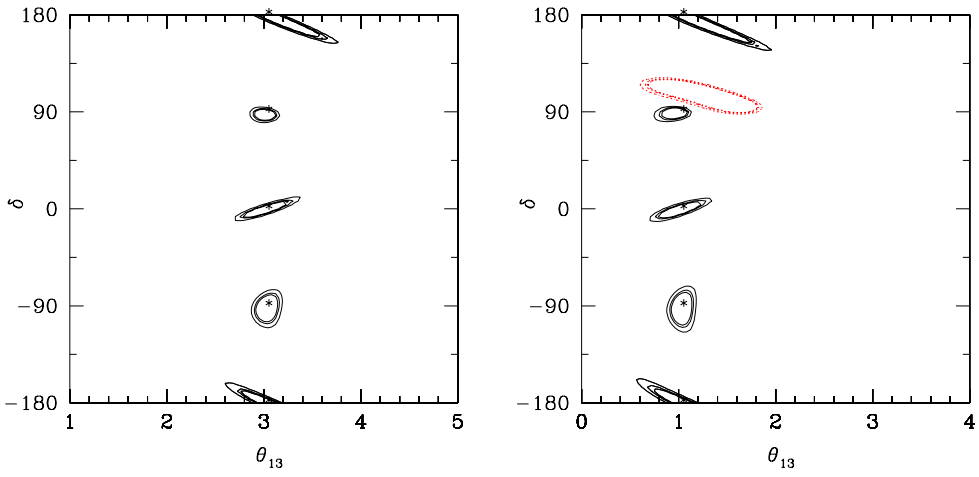

Figure 1: *For an exposure of* 5×10^{21} *ions-kton-years,* 90%, 95% *and* 99% *(for 2 d.o.f) CL contours resulting from the fits if the true values Nature has chosen are* $\theta_{13} = 3^\circ$ *(left panel) or* $\theta_{13} = 1^\circ$ *(right panel), and* $\delta = 0^\circ, 90^\circ, -90^\circ$ *or* 180°. *Dashed-red contours represent the hierarchy-clone solution.*

Figs. 2 summarises, for the low- and high-statistics scenarios, the physics reach of the beta-beam experiment considered here. The analysis takes into account the impact of both the intrinsic

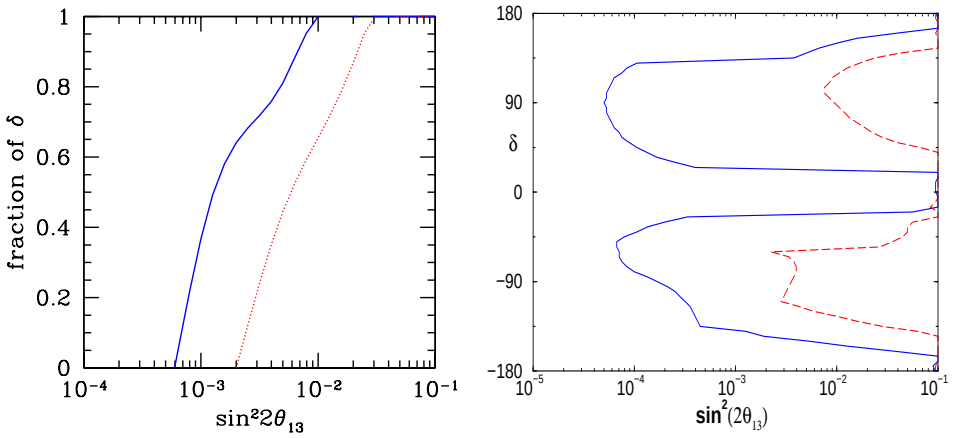

Figure 2: *Left:* 99% *CL hierarchy resolution (2 d.o.f) and right: :Discovery at* 99% *CL of CP violation (2 d.o.f). The solid blue curve depicts the results assuming the statistics quoted before is improved by a factor of five.*

and discrete degeneracies. Fig. 2 (left) shows the region in the ($\sin^2 2\theta_{13}$, "fraction of δ") plane for which the mass hierarchy can be resolved at the 99% CL (2 d.o.f). Fig. 2 (right) shows the region in the ($\sin^2 2\theta_{13}$, δ) plane for which a given (non-zero) value of the CP-violating phase δ can be distinguished at the 99% CL (2 d.o.f.) from the CP-conserving case, i.e., $\delta = 0, \pm 180^\circ$. The results are given for both the low- and high-statistics scenarios.

3. Summary

In the present article, we have reviewed the physics reach of a beta-beam with intermediate γ and long baseline. We have considered a neutrino beam sourced by ^{18}Ne decays with $\gamma = 450$ and a baseline of 1050 km corresponding to the CERN-Boulby mine distance. We have shown that, by exploiting the oscillatory behaviour of the signal, it is possible to fully resolve such degeneracies in a large part of the allowed parameter space.

Acknowledgments

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References

[1] D. Meloni, O. Mena, C. Orme, S. Palomares-Ruiz and S. Pascoli, JHEP **0807** (2008) 115 [arXiv:0802.0255 [hep-ph]].