Long baseline neutrino experiments

Introduction

Abstract poster #2

Over the last 10 years, tremendous progress have been achieved in neutrino physics. It was found that neutrinos have mass and that they oscillate from one flavor to another similarly to quarks. Two of the three mixing angles have already been measured, the two mass splittings have also been measured but some questions remains.

The last undetermined mixing angle of the neutrino mixing matrix is θ_{13}. In the case of a non-zero θ_{13}, determining if there is leptonic CP violation will be the next logical question to solve. Determining the mass hierarchy of the neutrino mass eigenstates is another goal. These two issues can be addressed with very long baseline electron neutrino appearance experiments.

Two different approaches are often considered. The first approach consists of using two detectors situated on the path of a narrow energy beam, where one detector scans the first oscillation maximum and the other detector scans the second. The second approach uses a wide-band energy beam and plans to scan the first and second oscillation maxima with one detector. Using Monte Carlo simulation, we studied the sensitivity of such experimental setups when using water Čerenkov detectors as far detector(s).

In this poster, we will review the basics of neutrino oscillation and define leptonic CP violation and mass hierarchy. We then present our analysis regarding the sensitivity of these two types of experiments.

Mass hierarchy

Which neutrino mass eigenstate
is the heaviest?

Why do we care?
Allow us to validate/rule out models (for example Grand Unified Theory models favor a normal hierarchy)

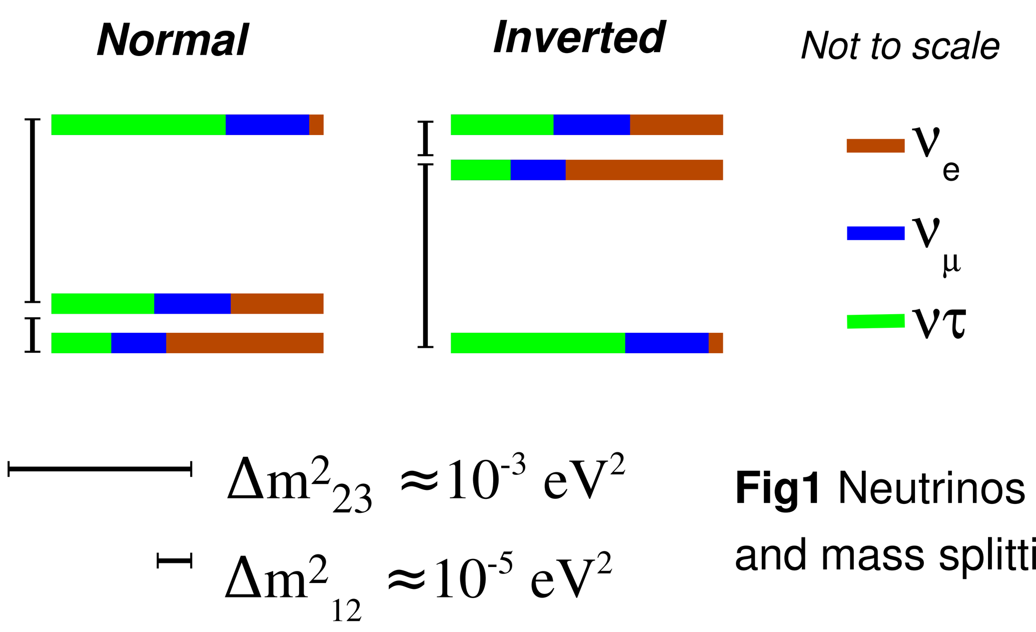


Fig1 Neutrinos mixing and mass splitting

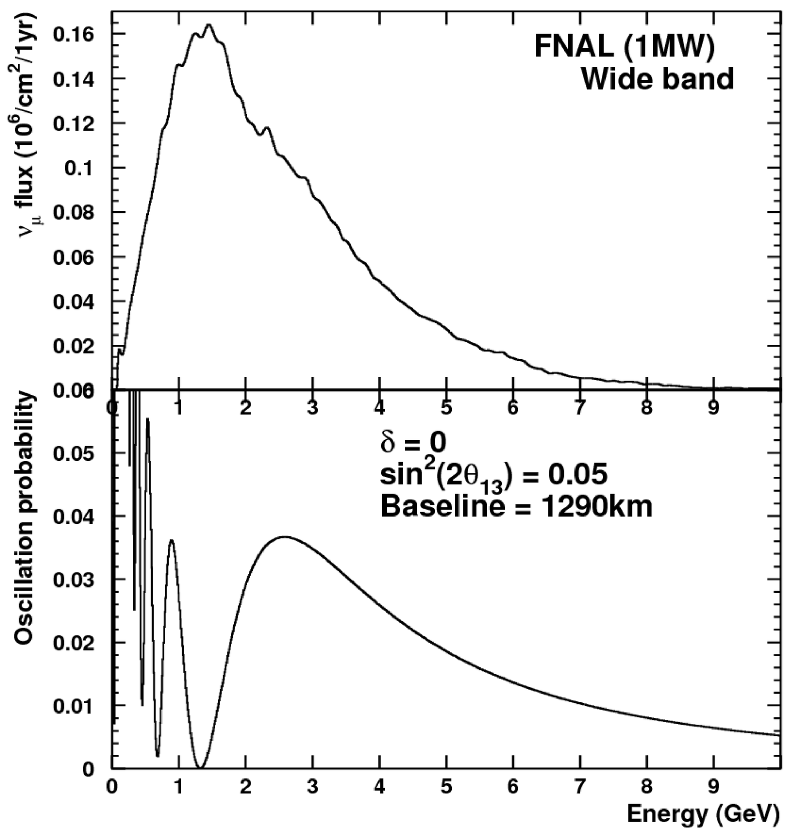
CP violation

C= Charge conjugation (particle ↔ anti-particle)
P= Parity (image ↔ mirror image)

Why do we care?
Because CP violation is a key element to understand the matter-antimatter asymmetry of the universe

Experimental Setup: One detector approach

For the one detector approach, we consider a a setup in the US. The beam would be 1MW with 28GeV protons and would be generated at Fermilab. The detector would be a 300Kton water Čerenkov and would be located in the DUSEL facility 1290km away from Fermilab.



Conclusions

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Experimental setup: Two detectors approach

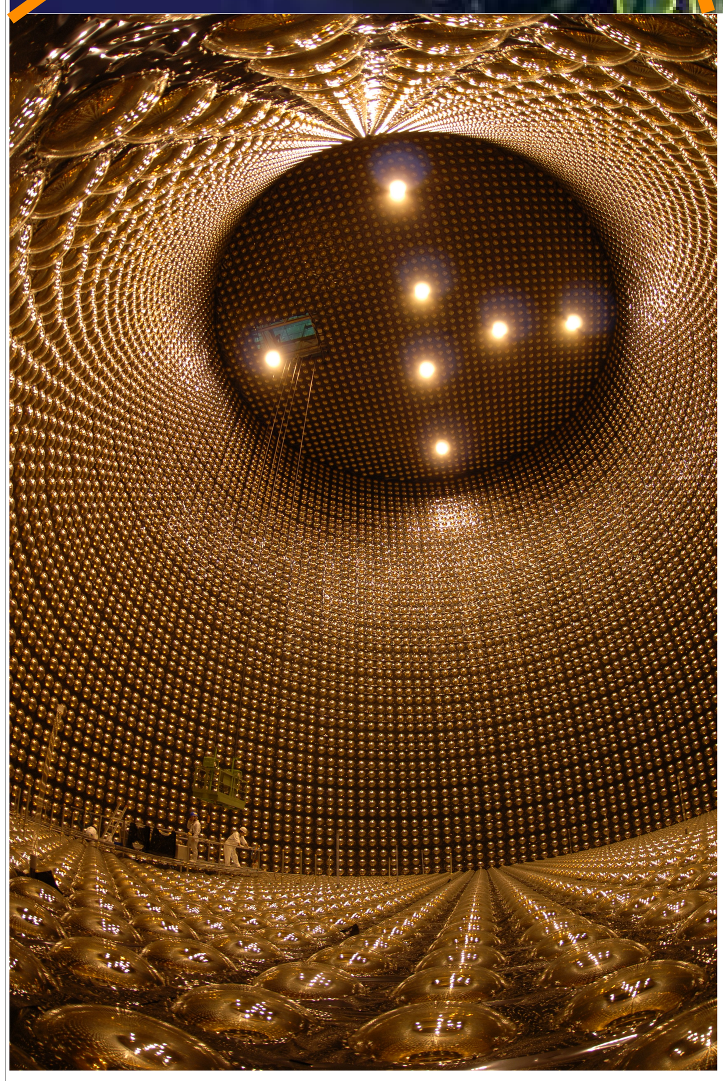
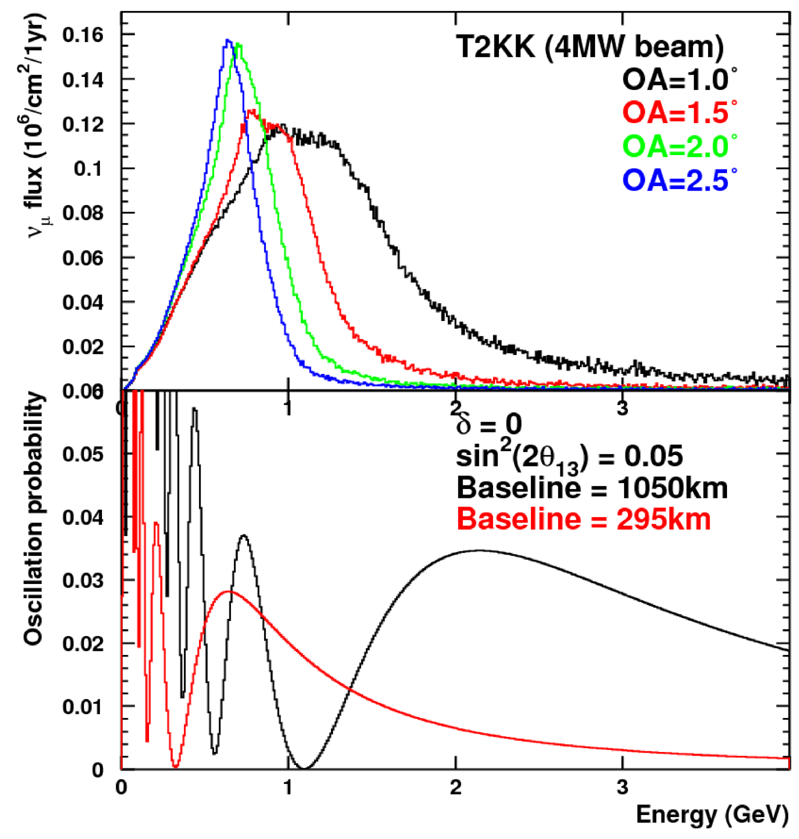


Fig 2 *Top: 2 Detectors setup. Bottom: SuperKamiokande detector.*

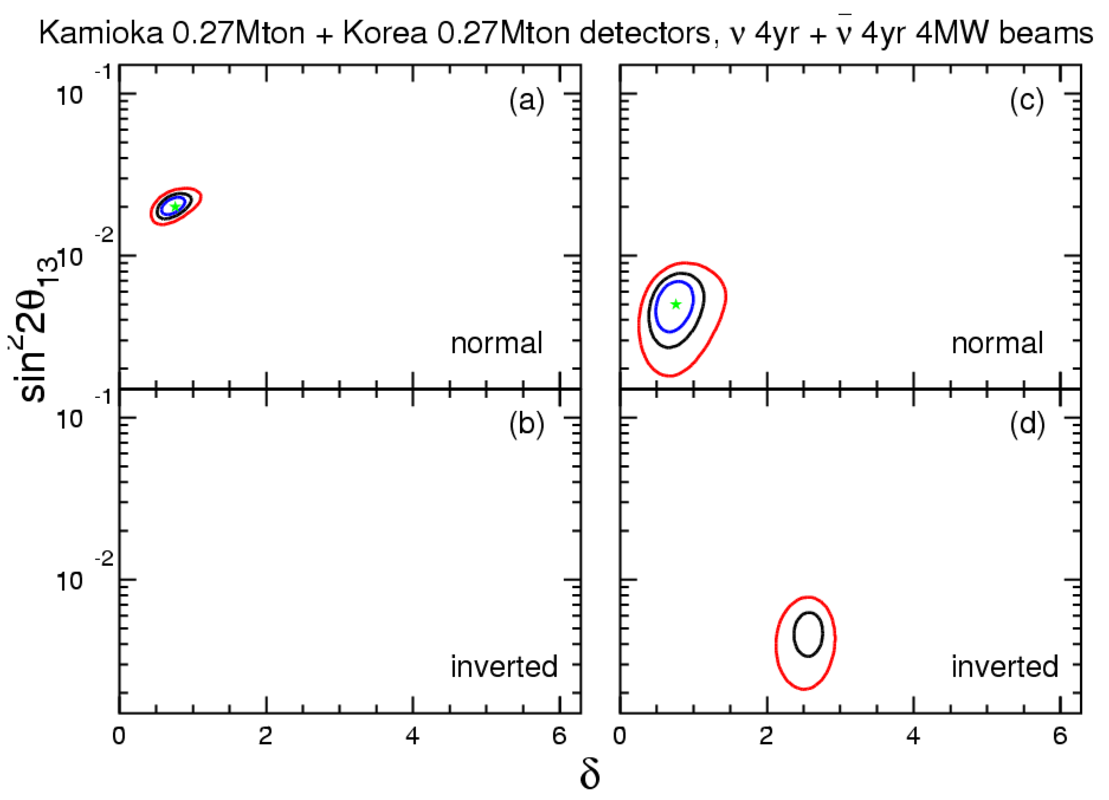
Fig 2 is an example of a 2 detectors setup located in Japan and Korea. The neutrino beam would be generated at the Tokai facility. A 4MW beam with 40GeV protons is assumed.

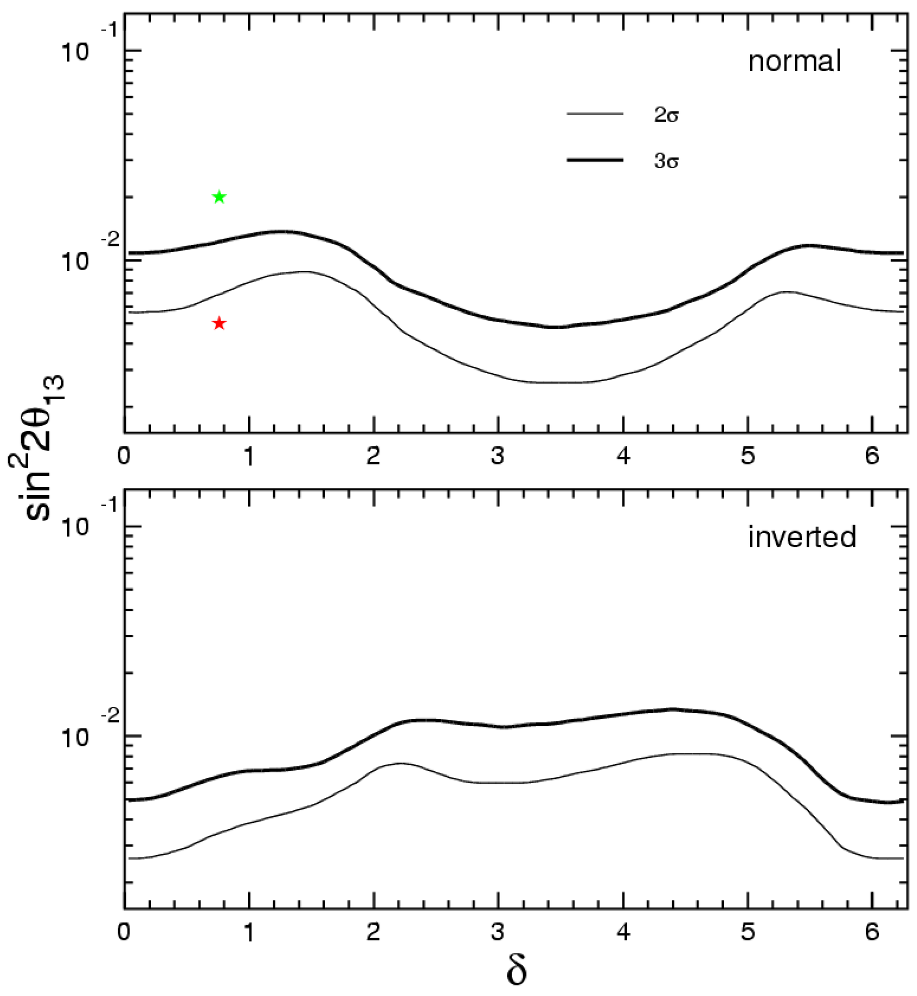
The neutrinos generated at Tokai travel 295km before entering the first detector located at Kamioka, they then travel 1050km before entering the second detector located in Korea. Both detectors are 270Kton water Čerenkov. The Kamioka detector is 2.5° off-axis with respect to the beam, and this angle was determined to be the best for the T2K experiment. The site for the Korean detector is not define yet, and we studied which off-axis angle would give the best results.

A 1.0° off-axis angle gives the best results.



Results





Water Cherenkov detectors