MINOS Atmospheric Neutrino Oscillation Parameters

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Outline

- Introduction
- MINOS Detector Overview
- Data Analysis
- Results

Introduction

- MINOS (Main Injector Neutrino Oscillation Search) is a long-baseline (735 km) neutrino oscillation experiment.
- MINOS Physics Goals include

➢ Precise measurement of θ_{23} and Δm^2_{32}

➢ Look for ν_e appearance.

$$P(\nu_\mu \rightarrow \nu_e) \approx \sin^2\theta_{23} \sin^2 2\theta_{13} \sin^2(1.27\Delta m^2_{31} L/E)$$

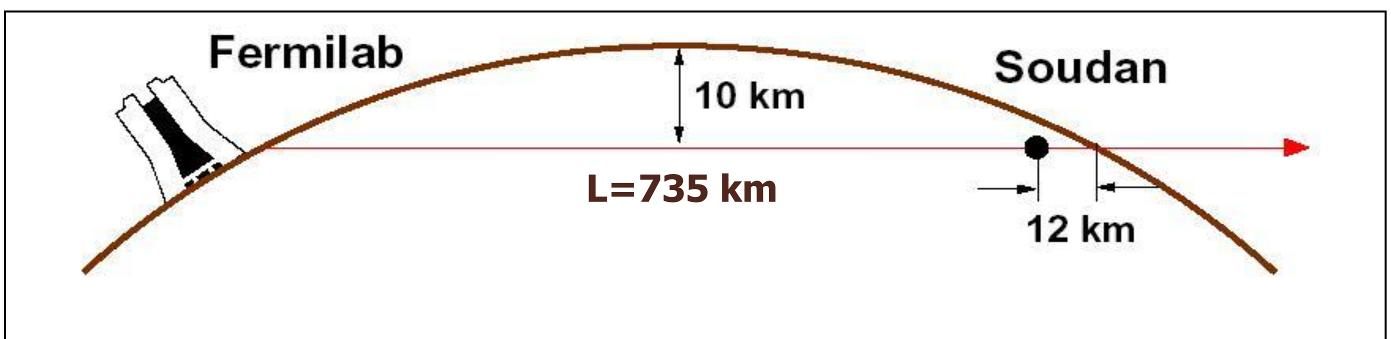
➢ Compare $\nu, \bar{\nu}$ oscillations - Test of CPT violation.

MINOS Experiment

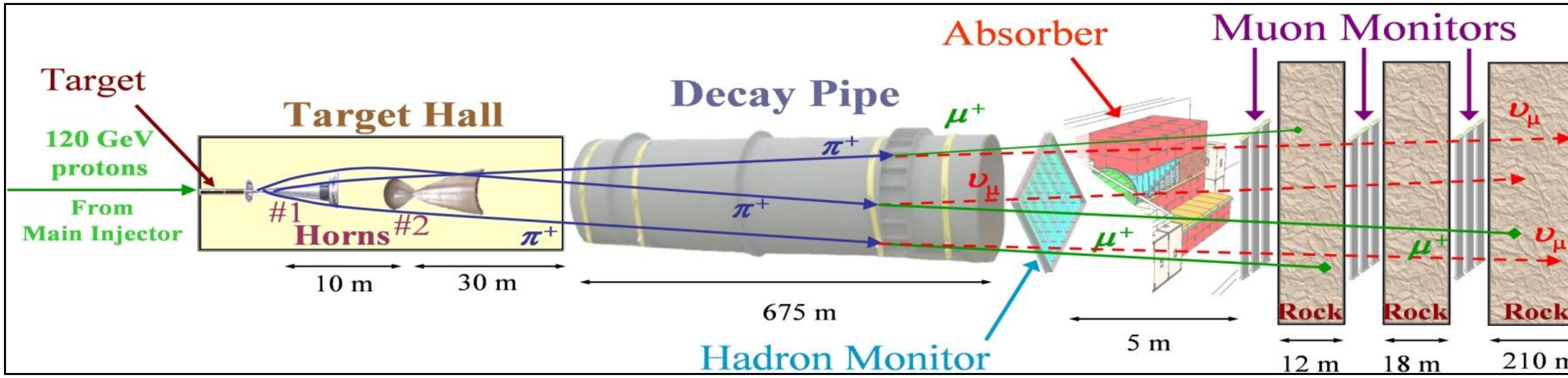
- NuMI beam line produced at the Fermilab uses 120 GeV protons from the Main Injector .

- 0.9 kton Near detector (ND) of dimension 3.8 × 4.8 × 15 m located 1.04 km from the NuMI target at Fermilab to measure the beam composition and energy spectrum.

- 5.4 kton Far Detector (FD) of dimension 8 × 8 ×30 m located 735 km away from the target , in the Soudan Mine, Minnesota to search for evidence of oscillations



MINOS Detector

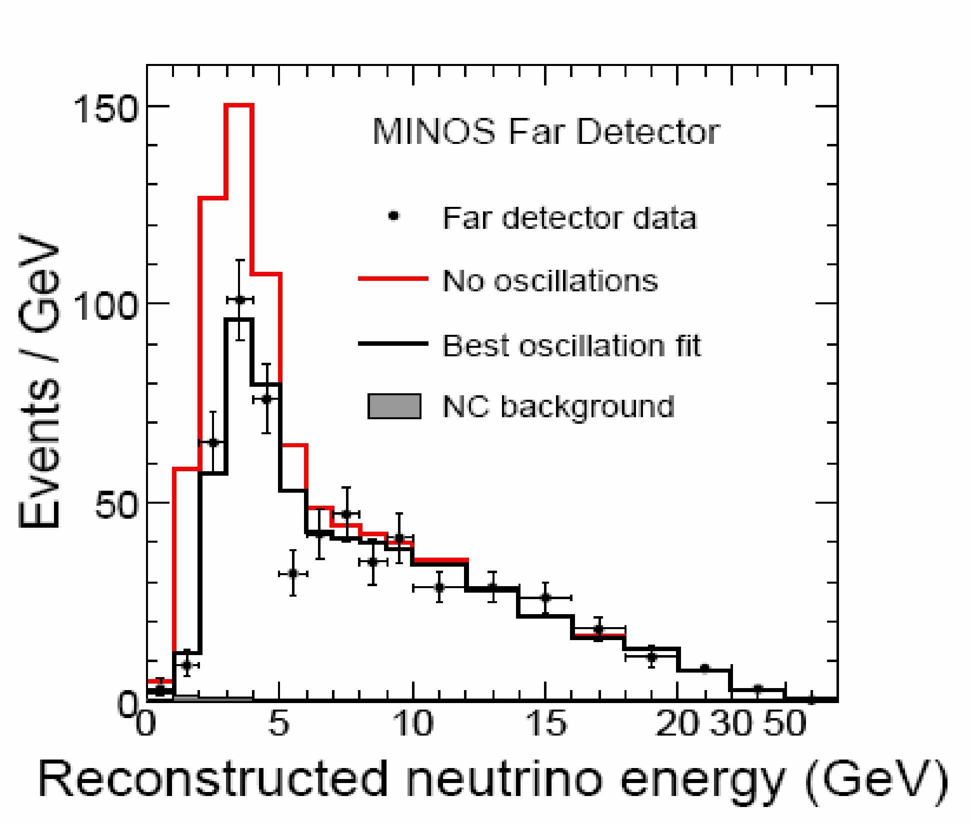


MINOS Near Detector

MINOS Far Detector

Analysis

ν_μ Disappearance - Energy Spectrum



ν_μ Disappearance Oscillations

The observed survival probability is given by,

$$P(\nu_\mu \to \nu_\mu) = \frac{FD_{oscillated}}{FD_{unoscillated}}$$

A ν_μ of energy E_ν (GeV) observed after travelling some distance L (km) from its production point has a probability of being detected as ν_μ is given by,

$$P(\nu_\mu \to \nu_\mu) \approx 1 - \sin^2(2\theta)\sin^2\left(1.27\frac{\Delta m^2 L}{4E}\right)$$

Analysis (contd..)

χ^2 is given by,

$$\chi^2(\vartheta, \Delta m^2) = \sum_i \frac{\left(P_i^{obs} - P^{\exp}(\vartheta, \Delta m^2)\right)^2}{\sigma^2{}_i}$$

Where P_i^{obs} is the observed probability and

$P^{\exp}$ probability expected

Now we minimize the standard χ^2

Confidence region contours are calculated by the equation,

$$\chi^2(\vartheta, \Delta m^2) = \chi^2_{\min} + \Delta\chi^2$$

$\Delta\chi^2$ for m parameters

CL	$m = 1$	$m = 2$	$m = 3$
68.27	1.00	2.30	3.53
90.	2.71	4.61	6.25
95.	3.84	5.99	7.82
95.45	4.00	6.18	8.03
99.	6.63	9.21	11.34
99.73	9.00	11.83	14.16

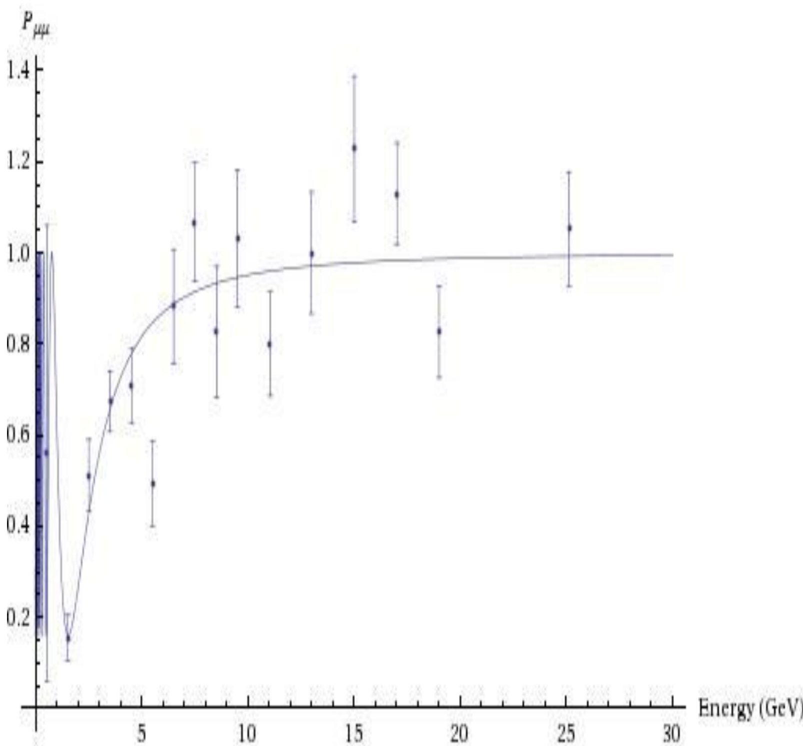
Ref: Particle Data Book

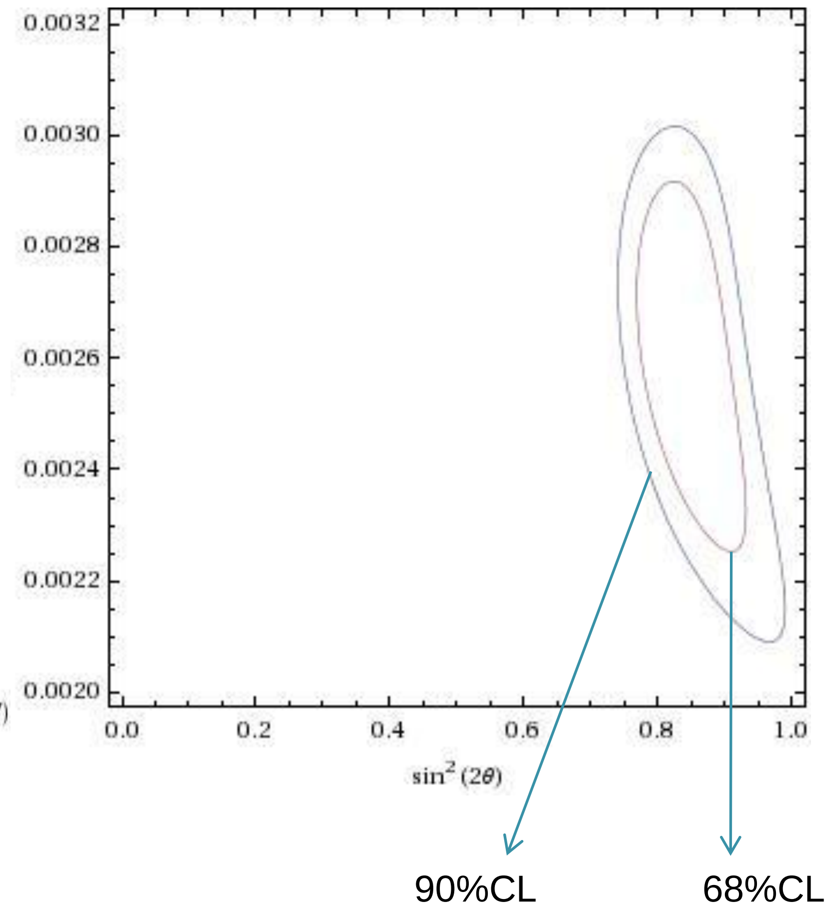
$\Delta\chi^2$ for 68% CL = 2.30 , m =2

$\Delta\chi^2$ for 90% CL = 4.61, m =2

Results

Oscillation Parameters Contour



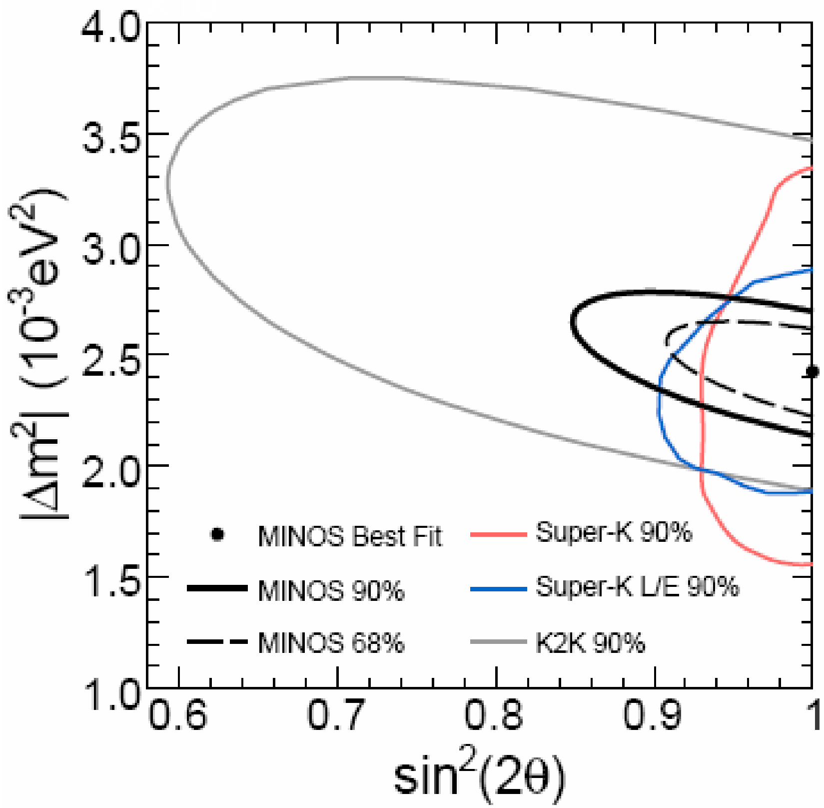


Best Fit Values from the Analysis

$\sin^2(2\theta)$ = 0.839818 Δm^2 = 0.0026165

$\chi^2_{\min}$ = 28.8521 ndf = 15

MINOS Result



Ref: http://www-numi.fnal.gov

$\Delta m^2=(2.43\pm0.11)\times10^{-3}$ and $\sin^2(2\Theta)=1.00\pm0.05$ which gives the best fit to the data, with a $\chi^2/\text{dof}=90/97$

THANKYOU