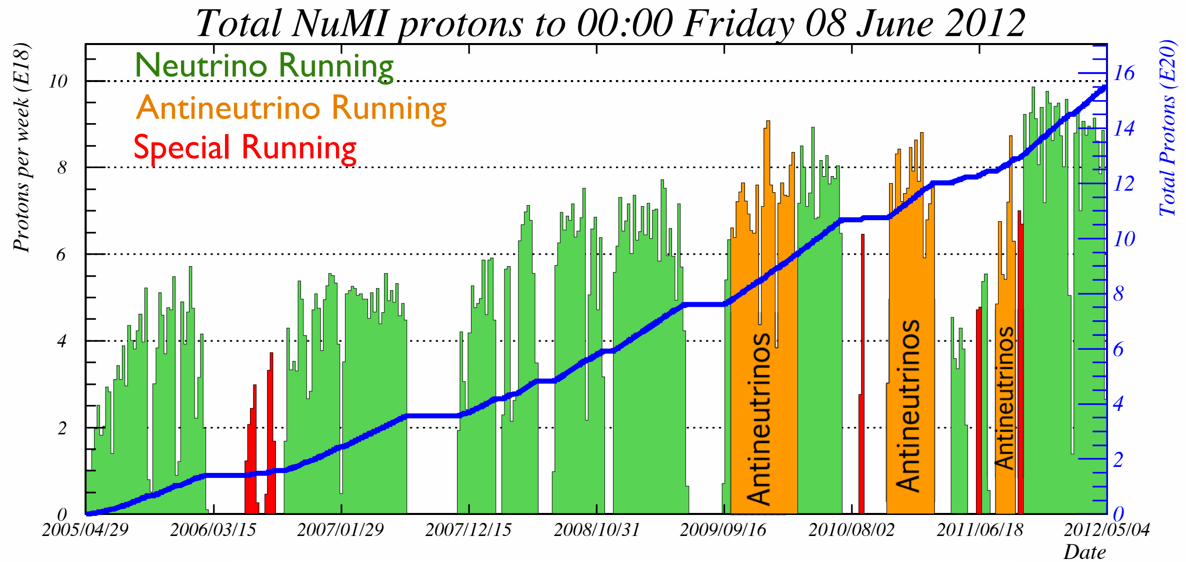
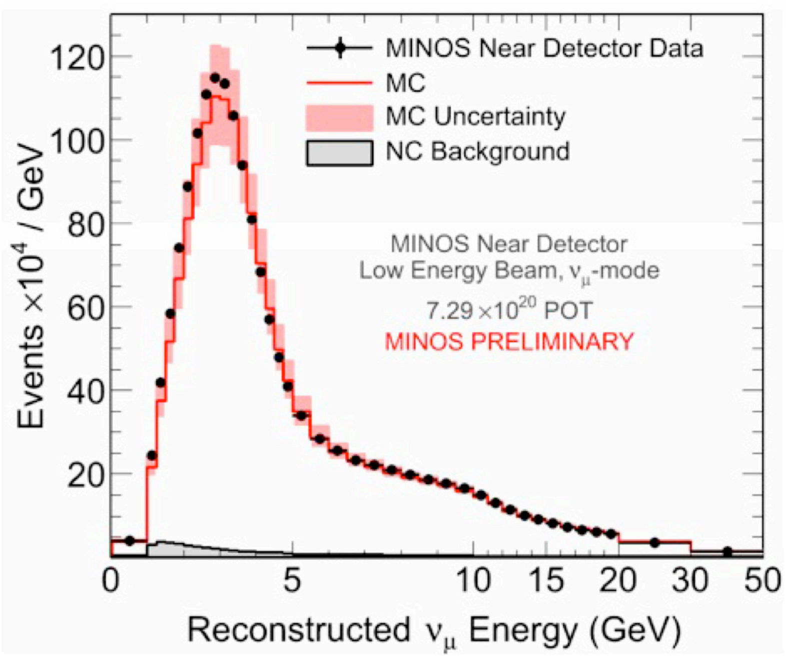
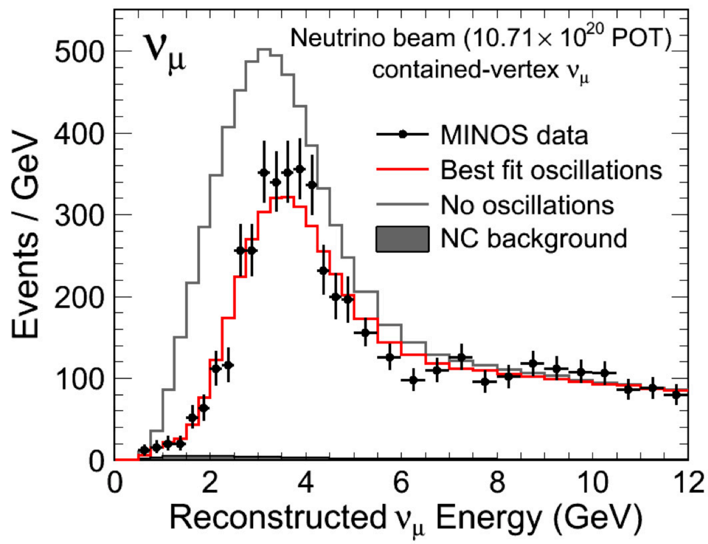
MINOS ν_μ and $\bar{\nu}_\mu$ Charged-Current Disappearance Analysis (hep-ex:1304.6335)

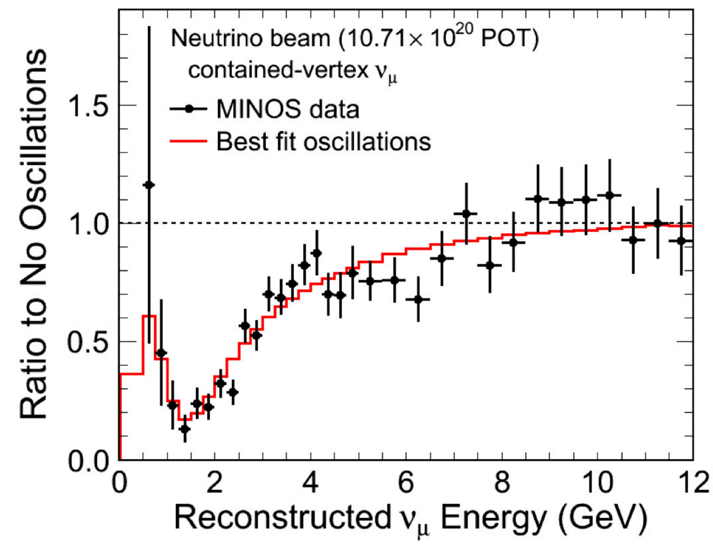
- The results presented are obtained using the complete MINOS beam data sample collected between 2005 and 2012.
- A total of 10.71×10^{20} POT collected in neutrino mode and 3.36×10^{20} POT collected in antineutrino-enhanced mode are used in the analysis.
- Muons from ν_μ, $\bar{\nu}_\mu$ charged-current (CC) interactions are selected by multivariate algorithm based on a k-Nearest-Neighbor technique.
- The MINOS detectors are magnetized, enabling ν_μ and $\bar{\nu}_\mu$ to be separated on an event-by-event basis, by analyzing the muon curvature. $\bar{\nu}_\mu$ CC events are identified by a positive muon charge sign.
- The neutrino energy is reconstructed by summing the muon momentum and hadronic shower energy. The plot on the right shows the energy spectrum in the Near Detector (ND) for selected ν_μ CC events. The extrapolated ND spectrum is used to obtain the Far Detector unoscillated spectrum.

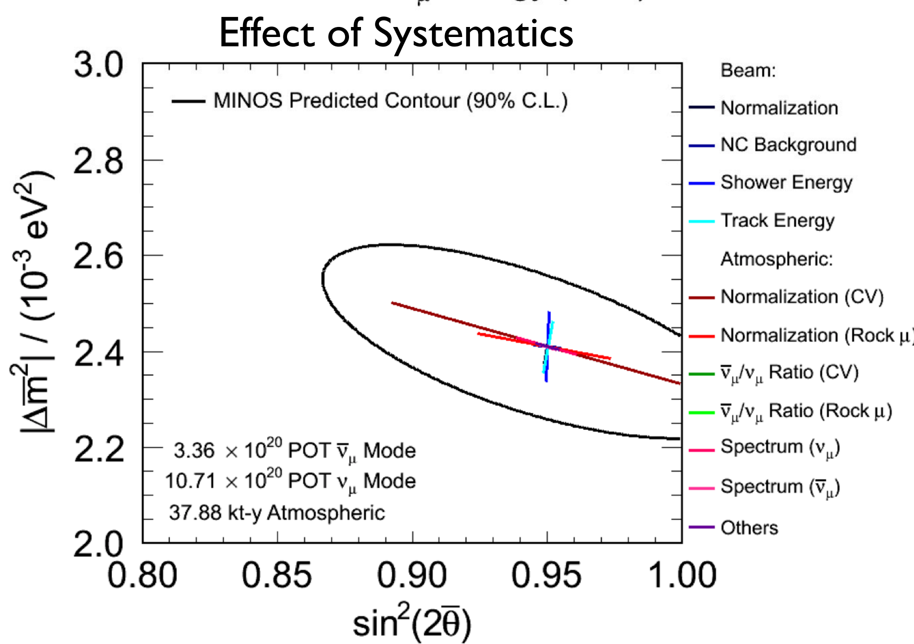




ν_μ Charged-Current Disappearance Results





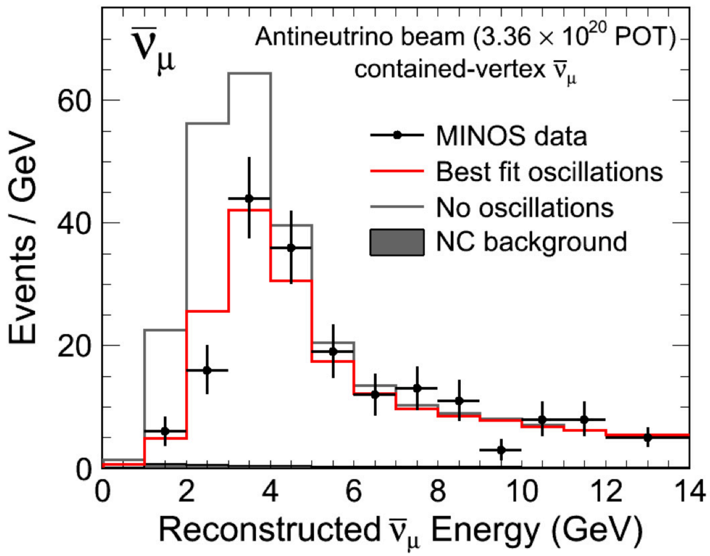


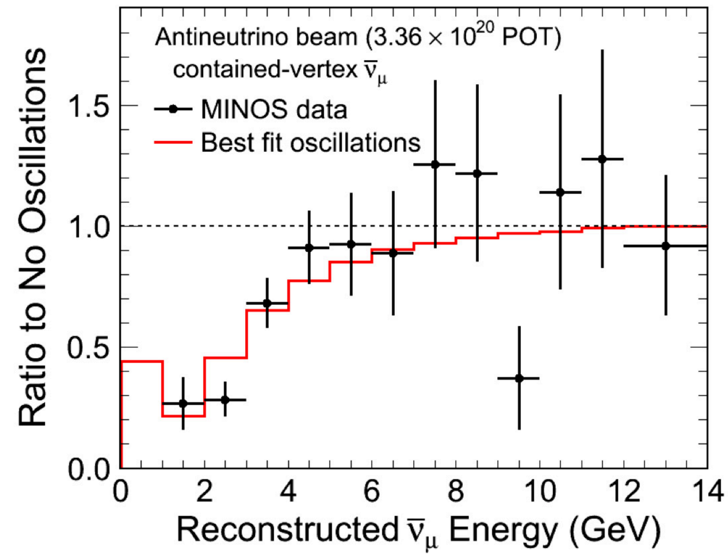
For $0 < E_{reco} < 200$ GeV

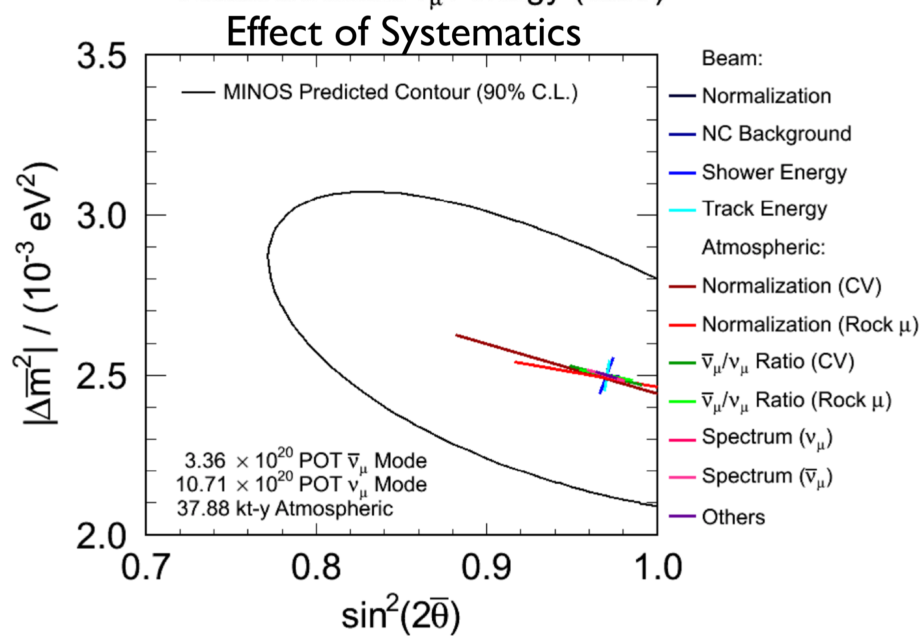
Prediction, No Oscillations: **3564 events**

Observed: **2891 events**

$\overline{\nu}_\mu$ Charged-Current Disappearance Results





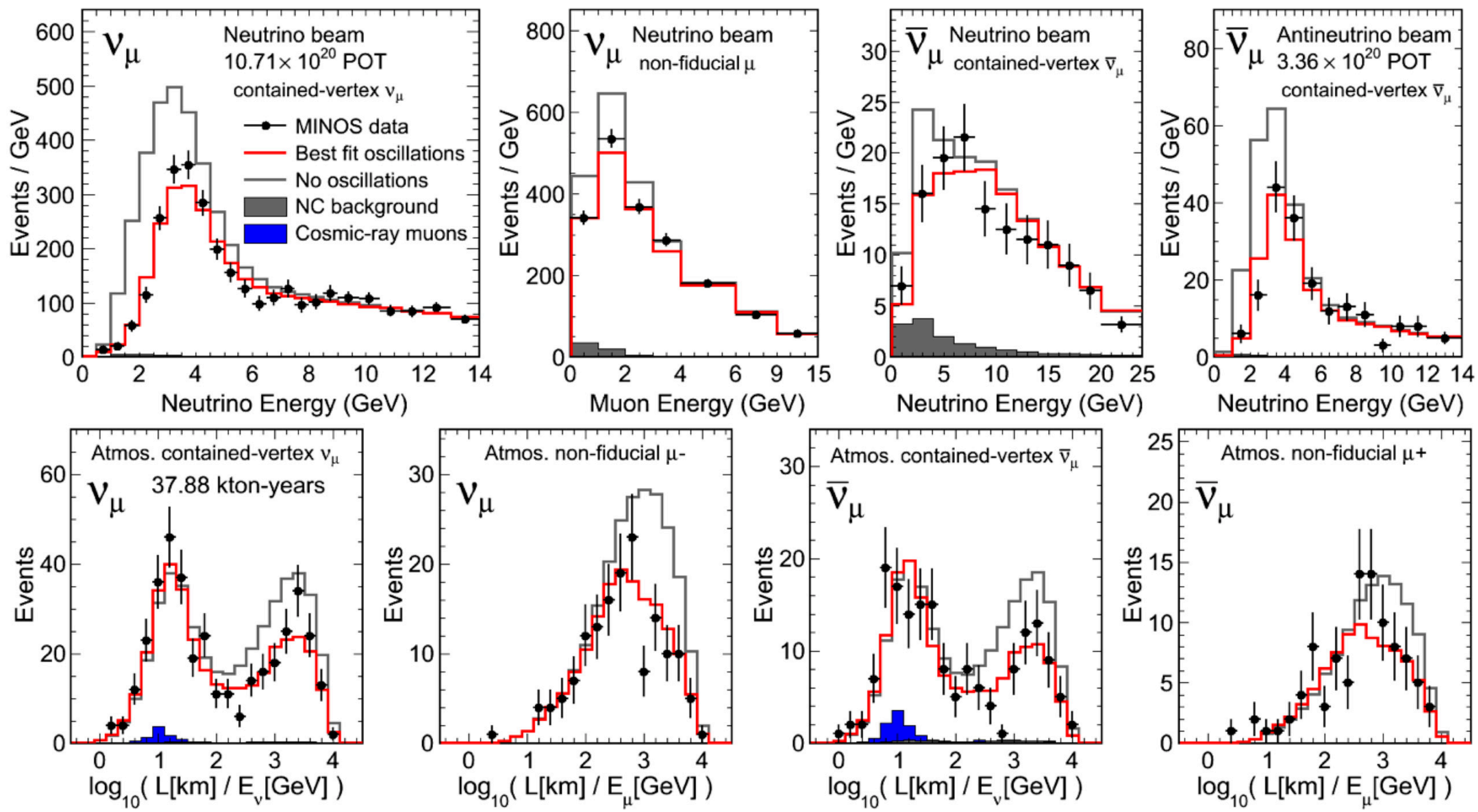


For $0 < E_{reco} < 200$ GeV

Prediction, No Oscillations: **313 events**

Observed: **226 events**

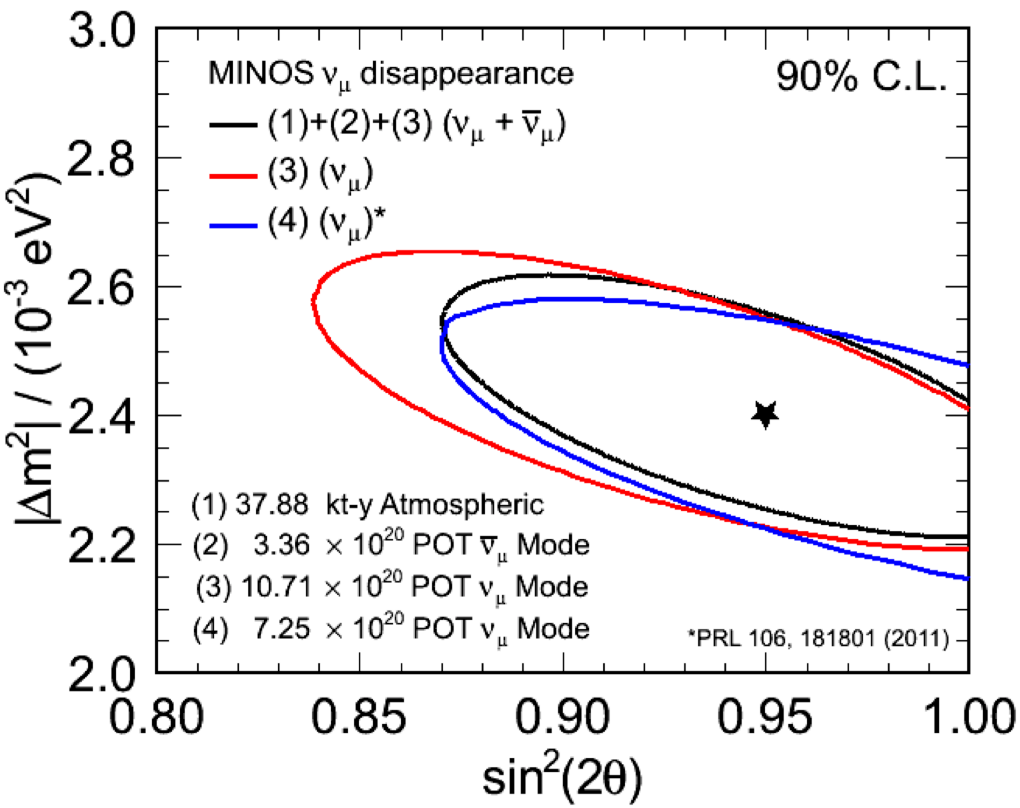
Combined Beam+Atmospherics Disappearance Results



- Red histogram shows the result from fitting a two-neutrino flavor oscillation scenario to the combined beam and atmospheric neutrino and antineutrino data samples. Fit includes 15 sources of systematic uncertainty as nuisance parameters.
- Oscillations are a good fit: 19.1% of pseudo-experiments have worse χ^2.

Combined Beam+Atmospherics Disappearance Results

Neutrinos+Antineutrinos



$$|\Delta m^2| = 2.41^{+0.09}_{-0.10} \times 10^{-3}\mathrm{eV}^2$$
$$\sin^2(2\theta) = 0.950^{+0.035}_{-0.036}$$

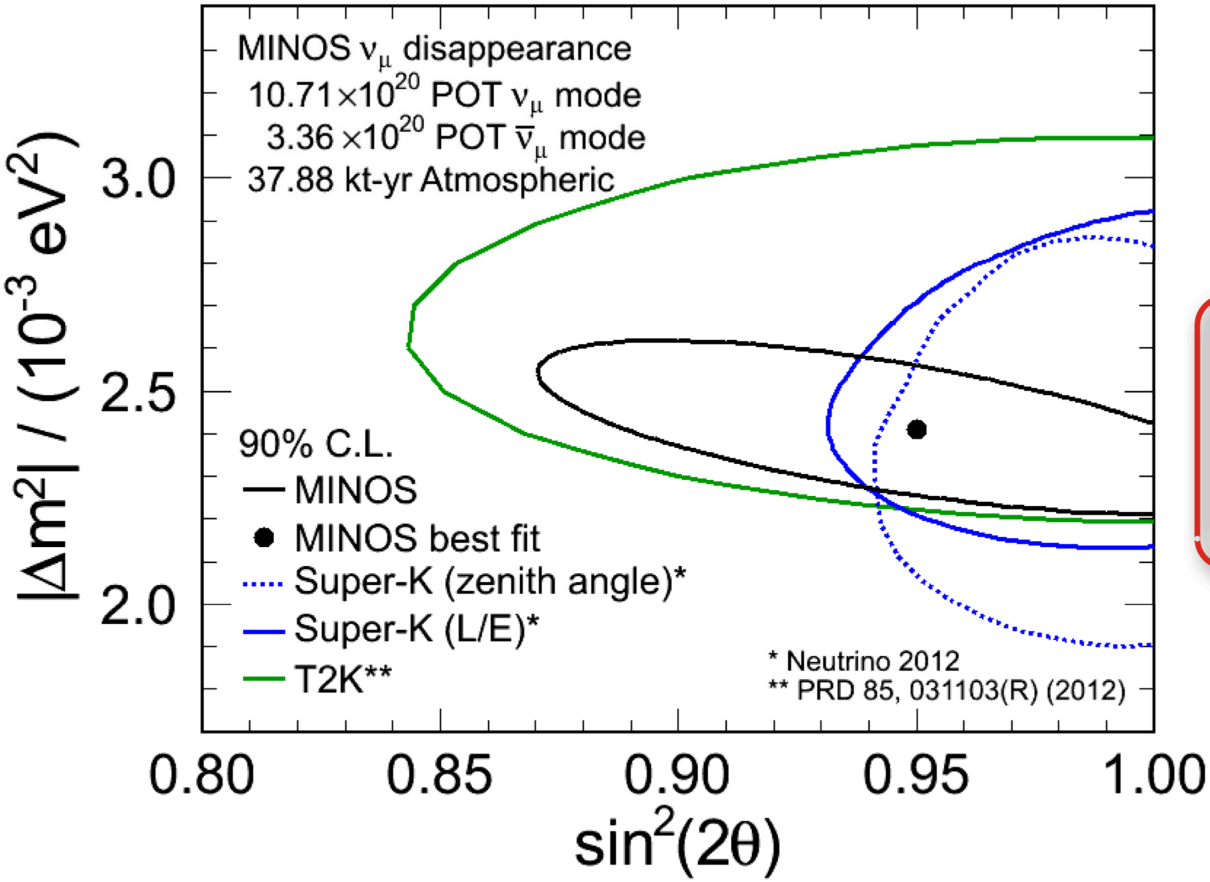
The MINOS beam and atmospheric neutrinos and antineutrinos are combined into a single oscillation analysis using an extended version of the fitting framework developed for the previous analysis.

The analysis includes 15 sources of systematic uncertainty, fitted as nuisance parameters,

A maximum-likelihood fit is used to determine the two-flavour oscillation parameters.

- An extension of the analysis from two to three-flavour oscillations is in progress

MINOS Allowed Regions Compared to Other Experiments



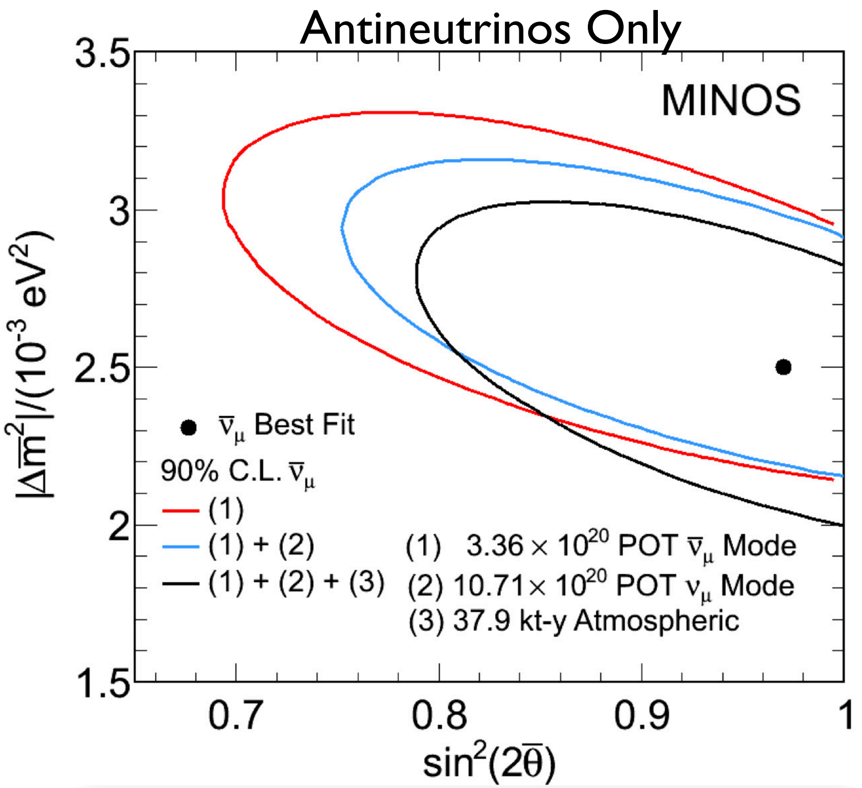
MINOS Best Fit Parameters

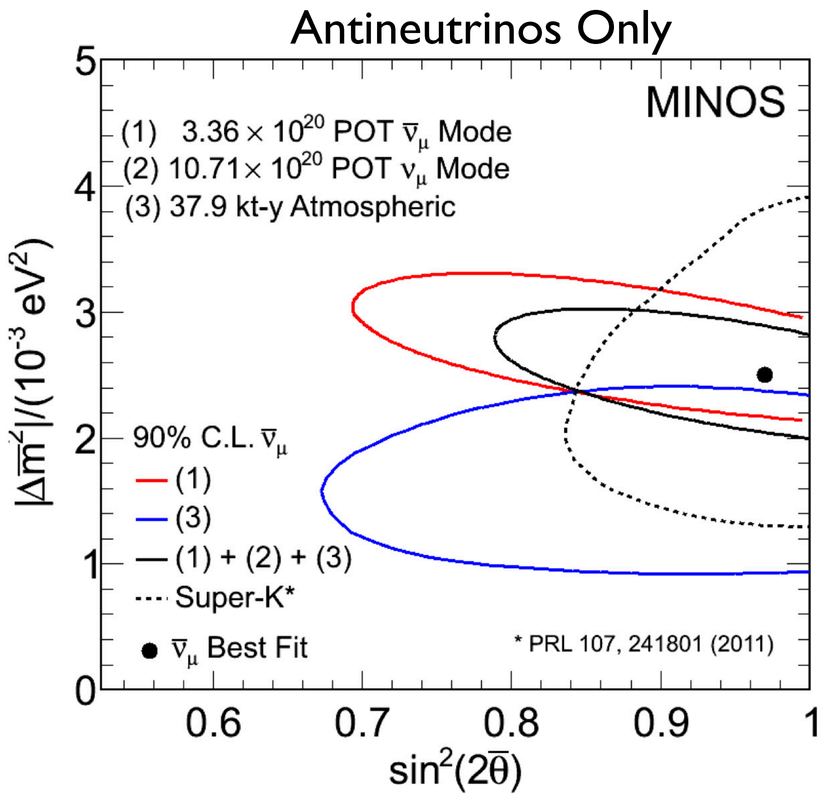
$$|\Delta m^2| = 2.41^{+0.09}_{-0.10} \times 10^{-3}\mathrm{eV}^2$$
$$\sin^2(2\theta) = 0.950^{+0.035}_{-0.036}$$
$$\sin^2(2\theta) > 0.890 \ (90\%\,\mathrm{C.L.})$$

- MINOS makes the leading measurement of $|\Delta m^2_{atm}|$ with 4.1% precision.

Combined Beam+Atmospherics Disappearance Results

- The MINOS oscillation fit is extended to allow different oscillation parameters for ν_μ and $\bar{\nu}_\mu$.
- The extended fit is used to determine confidence limits on the antineutrino oscillation parameters by marginalizing over the neutrino oscillation parameters.

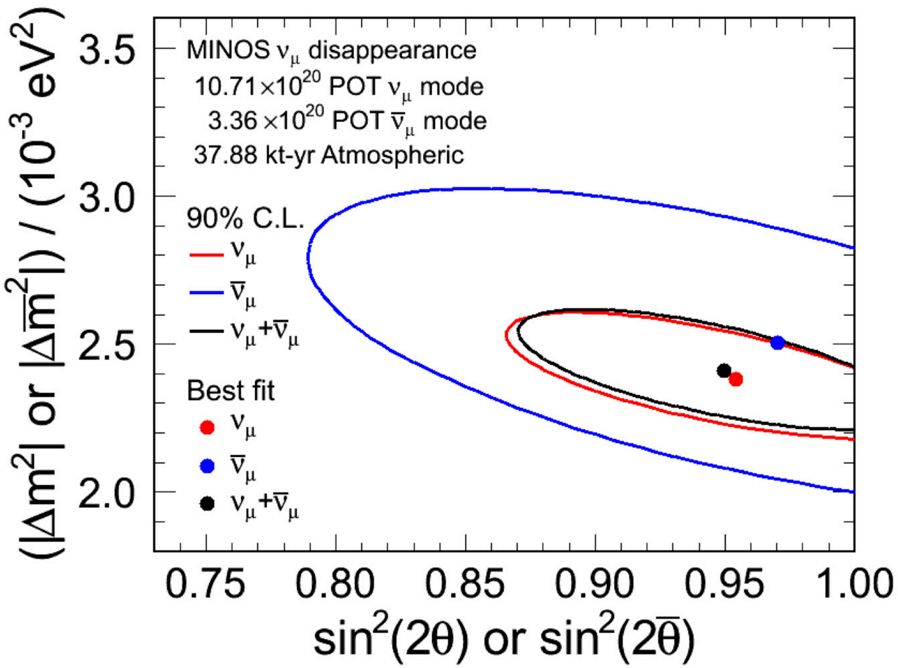


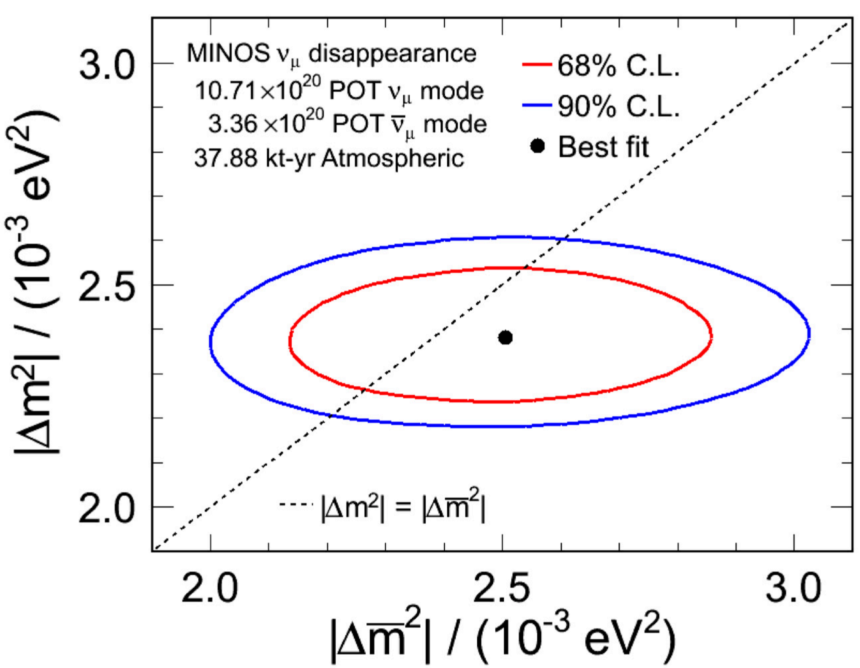


$$|\Delta\overline{m}^2| = 2.50^{+0.23}_{-0.25} \times 10^{-3}\mathrm{eV}^2$$
$$\sin^2(2\bar{\theta}) = 0.97^{+0.03}_{-0.08}$$

- Plot above shows a comparison of MINOS antineutrino results for beam, atmospheric and beam+atmospheric samples with results from the Super-Kamiokande experiment

Neutrino vs. Antineutrino Disappearance





$$\boxed{|\Delta\overline{\mathrm{m}}^2| - |\Delta \mathrm{m}^2| = 0.12^{+0.24}_{-0.26} \times 10^{-3}\mathrm{eV}^2}$$

- MINOS finds consistent values for neutrinos and antineutrino oscillation parameters measured via charged-current disappearance.