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New results for muon neutrino to electron neutrino oscillations in the MINOS experiment

Justin EVANS[*a], **Lisa WHITEHEAD**[b †]
[a]*University College London*
[b]*Brookhaven National Laboratory*
E-mail: evansj@hep.ucl.ac.uk, lwhitehead@bnl.gov

MINOS is a long-baseline neutrino oscillation experiment situated along Fermilab's high-intensity NuMI neutrino beam. MINOS has completed an updated search for muon neutrino to electron neutrino transitions, observation of which would indicate a non-zero value for the neutrino mixing angle θ_{13}. The present 7×10^{20} protons-on-target data set represents more than double the exposure used in the previous analysis. The new result and its implications are presented.

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[*] Speaker.
[†] for the MINOS Collaboration

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Neutrino oscillations occur due to quantum mechanical mixing of the weak flavor states of neutrinos. The probability for oscillations depends on three mixing angles (θ_{12}, θ_{13}, θ_{23}), one CP-violating phase (δ_{CP}), the difference in the squares of the neutrino masses, the neutrino energy, and the distance the neutrino has traveled. MINOS is a long-baseline neutrino oscillation experiment that uses the NuMI beam at Fermilab. A Near Detector (ND) is located at Fermilab, and a Far Detector (FD) is located at a baseline of 735 km. MINOS has performed a search for $\nu_\mu \rightarrow \nu_e$ oscillations as a probe of the neutrino mixing angle θ_{13}.

Cuts are optimized to select electromagnetic showers produced by ν_e charged current (CC) interactions in the detectors. An artificial neural network (ANN) is constructed with 11 variables related to the shower topology. The output of the ANN is used as the final selection variable.

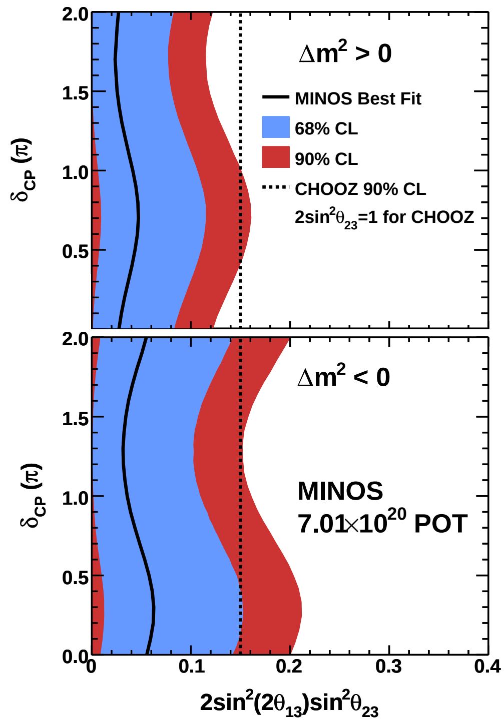

Figure 1: Values of $2\sin^2(2\theta_{13})\sin^2\theta_{23}$ and δ_{CP} that produce a number of candidate events in the FD consistent with the observation for both possible values of the sign of the mass splitting. Black lines show those values that best represent our data. Red (blue) regions show the 90% (68%) C.L. intervals. The 90% C.L. from the CHOOZ experiment[1] is drawn for $\Delta m^2_{32} = 2.43\times10^{-3}\text{eV}^2$, $\sin^2(2\theta_{23}) = 1.0$.

The oscillation probability is negligible at the ND, and therefore data from the ND is used to form a prediction for the expected background at the FD. The signature of ν_e appearance is an excess of events over the expected background at the FD. The background sample is made up of neutral current interactions, ν_μ CC interactions, and ν_e CC interactions from ν_e's that are intrinsic to the beam. The separation of the ND background sample into these three components is achieved by a fit to ND data taken with different configurations of the neutrino beam. The extrapolation of the background sample to the FD is then performed for each component using far-to-near ratios from the MC simulation.

In an exposure of 7.01×10^{20} protons-on-target, 54 events in the FD data passed the ν_e event selection, compared to the predicted background of 49.1 ± 7.0 (stat.) $\pm\,2.7$ (syst.). Figure 1 shows the resulting limits on θ_{13}. These results are reported in [2].

References

[1] M. Apollonio *et al.* [CHOOZ Collaboration], Eur. Phys. J. C **27**, 331 (2003) [arXiv:hep-ex/0301017].

[2] P. Adamson *et al.* [The MINOS Collaboration], Phys. Rev. D **82**, 051102 (2010) [arXiv:1006.0996 [hep-ex]].