

Prospects for a Sterile Neutrino Search at MINOS+

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On behalf of the MINOS+ Collaboration

MINOS+

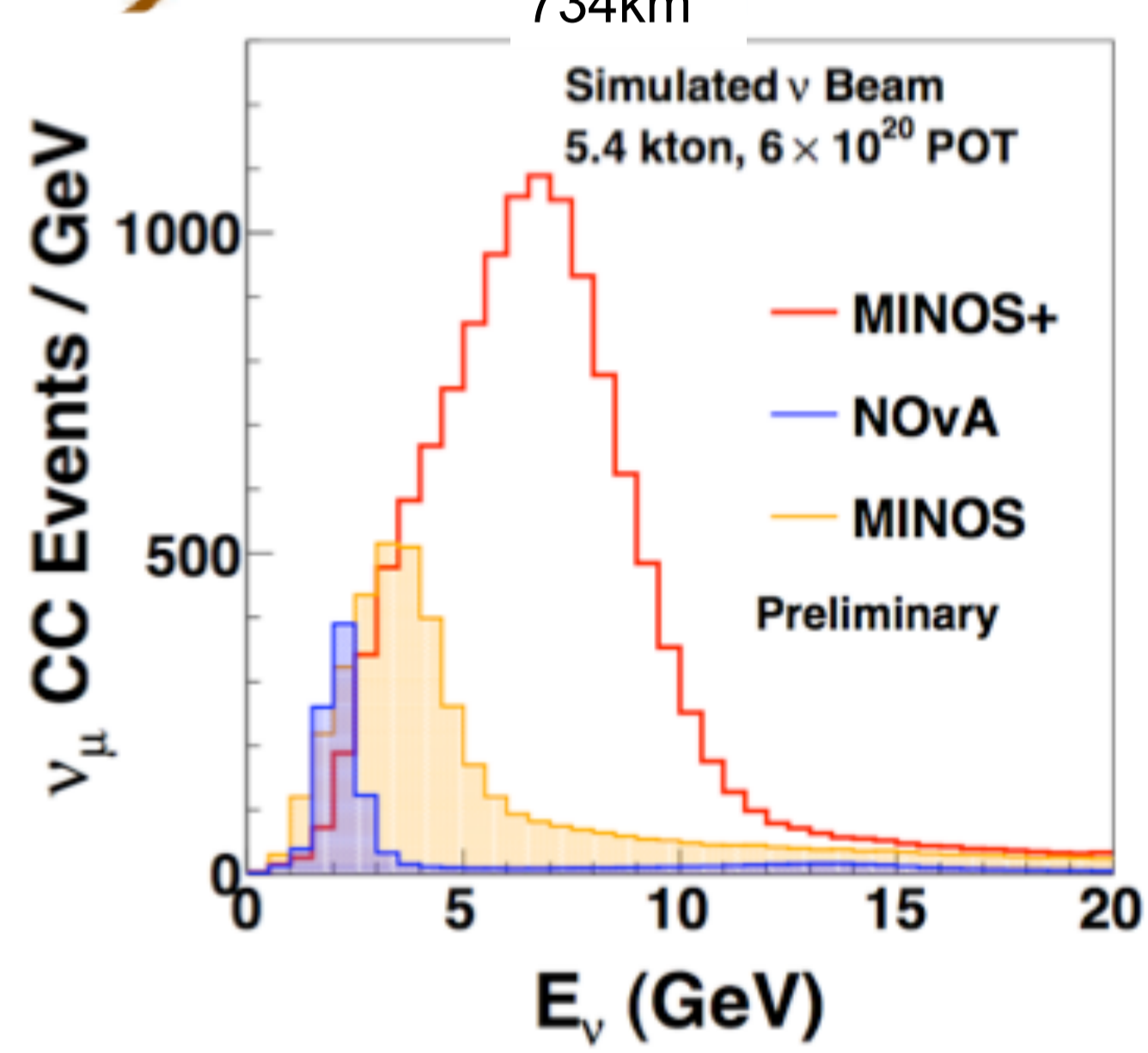
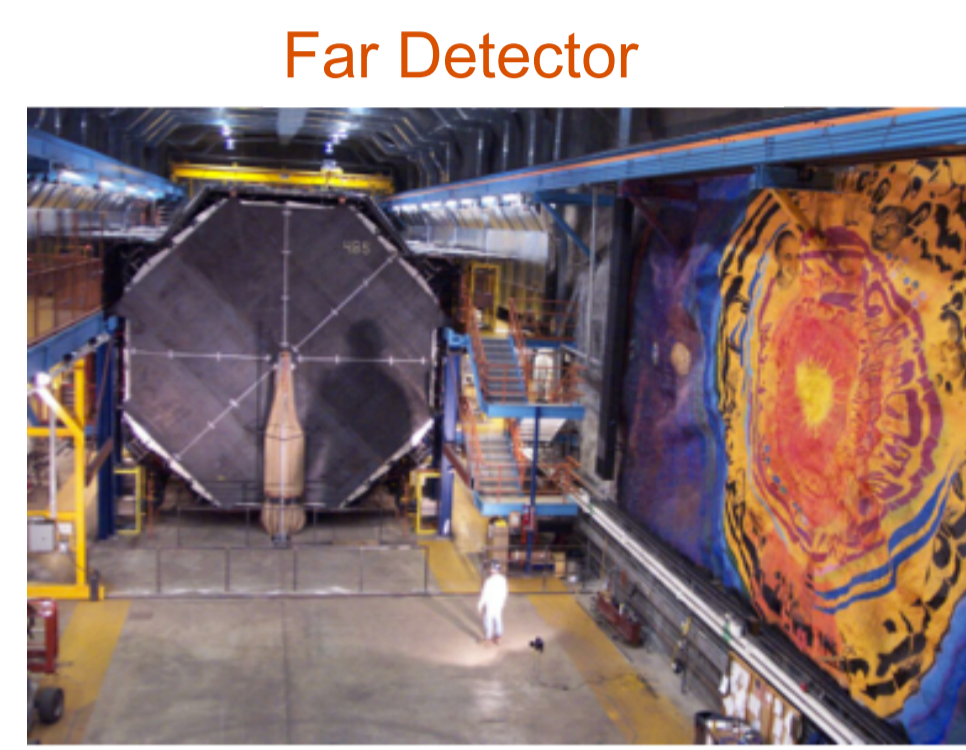
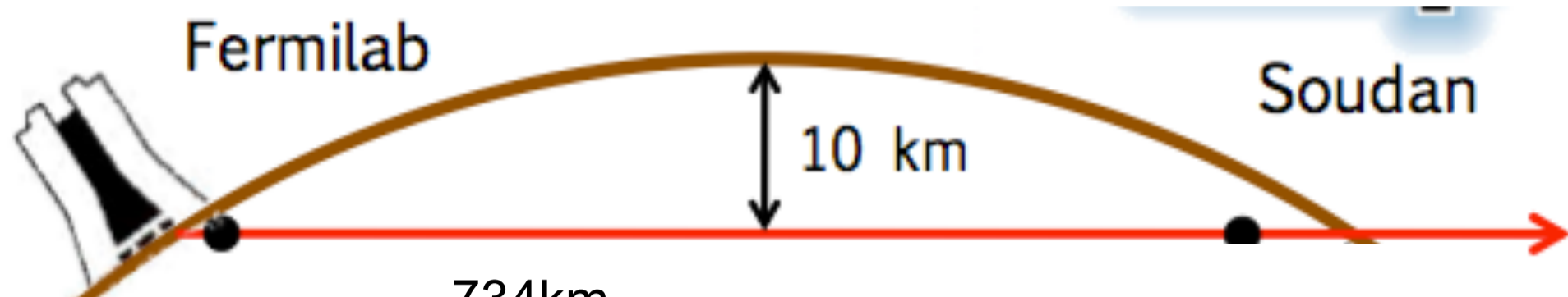


MINOS+ Experiment



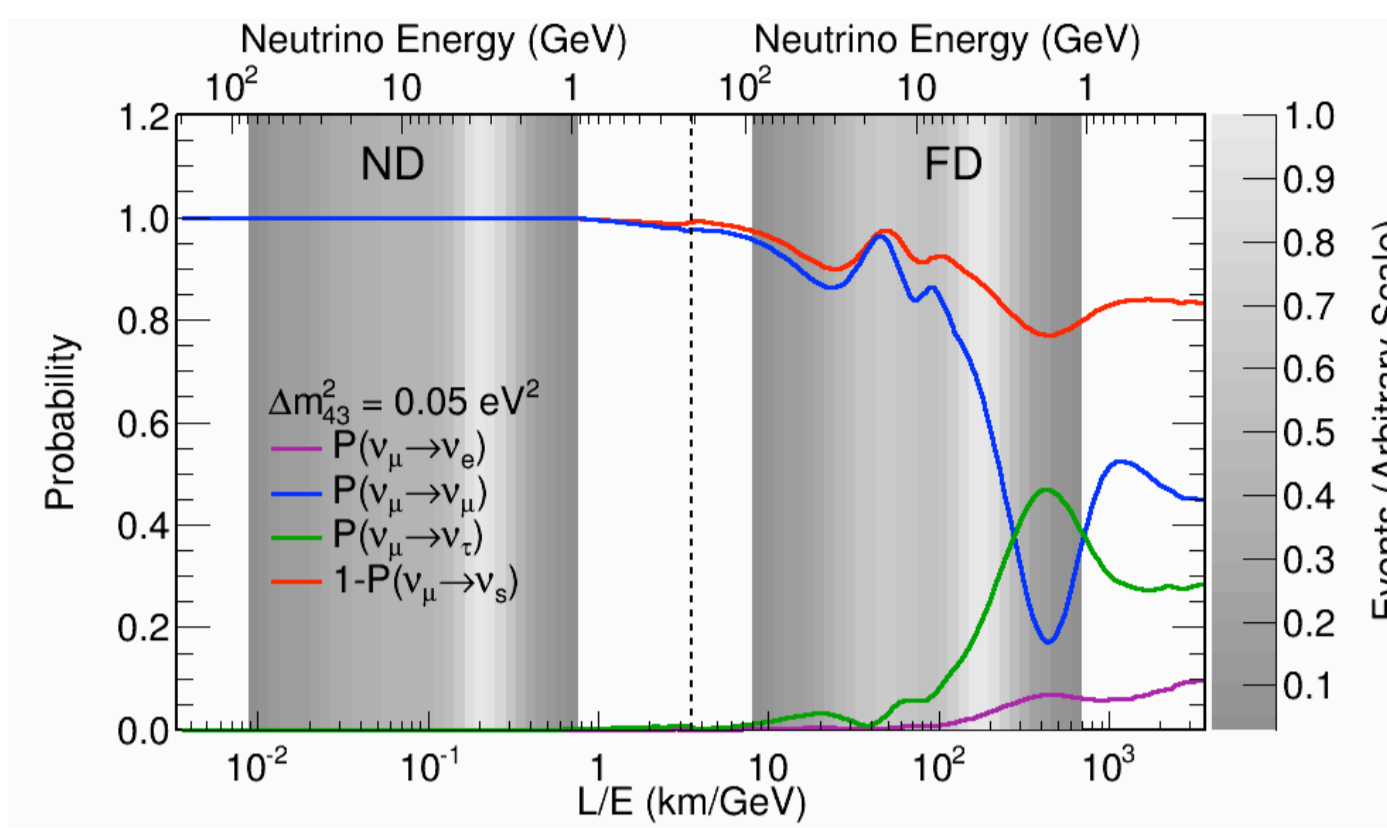
MINOS+ is a two-detector long baseline neutrino experiment
It uses two functionally identical steel sampling calorimeters

- Near Detector at Fermilab, 1km from the target
- 1 kton
- Far Detector is 734km away at Soudan
- 5.4 kton



MINOS+ uses the upgraded NuMI Beam.
MINOS+ will collect high statistics neutrino events of energy 4-10 GeV. Improved sensitivity in searches for physics beyond the Standard Model

Sterile Neutrinos in MINOS+

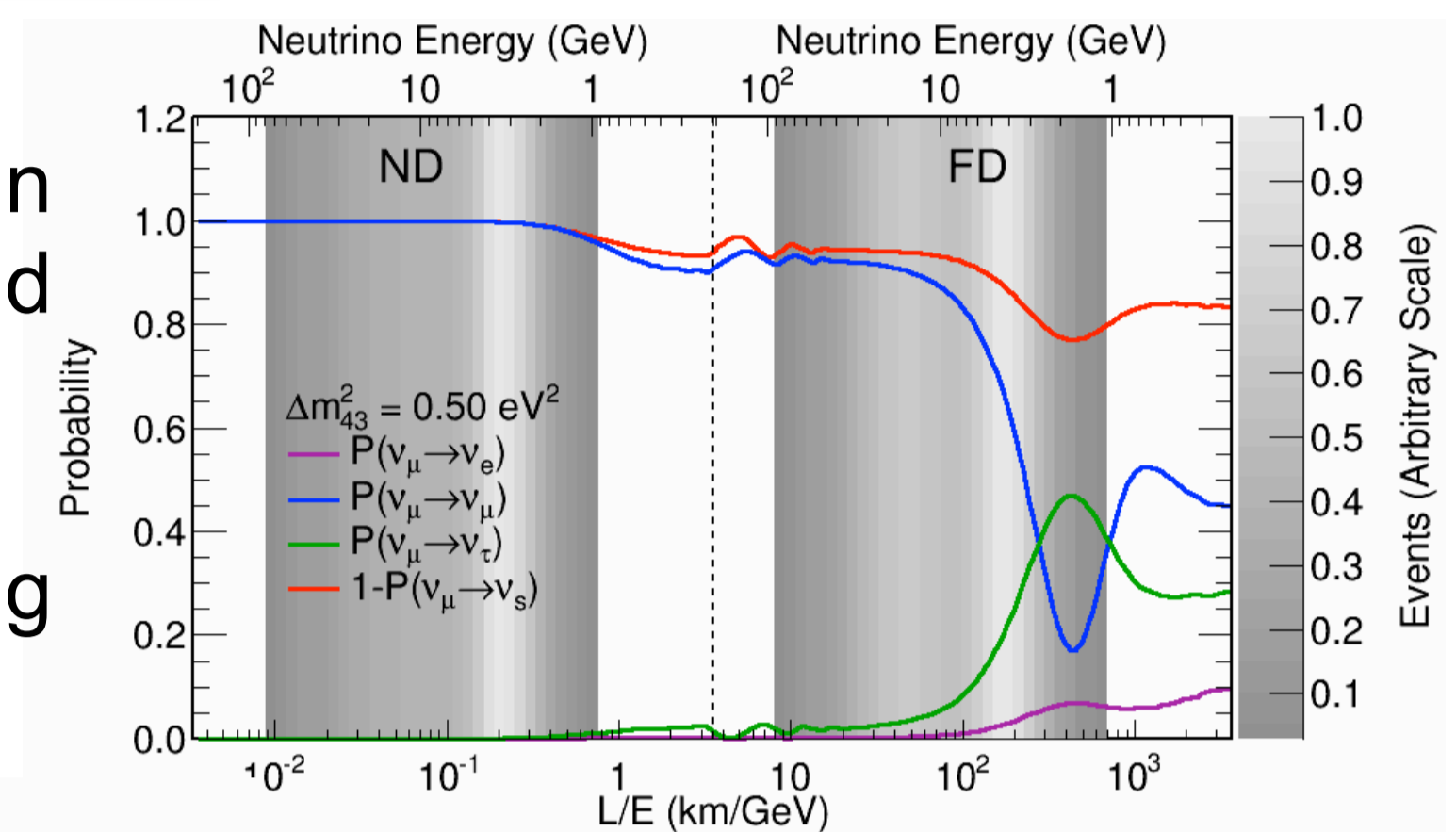


At small Δm^2_{43}

- Spectral distortions in FD at higher energies
- No ND effect
- Larger effect where beam flux systematics least well known

At medium Δm^2_{43} .

- Overall normalization shift in FD from rapid oscillations
- No ND effect
- Effectively a counting experiment



At large Δm^2_{43}

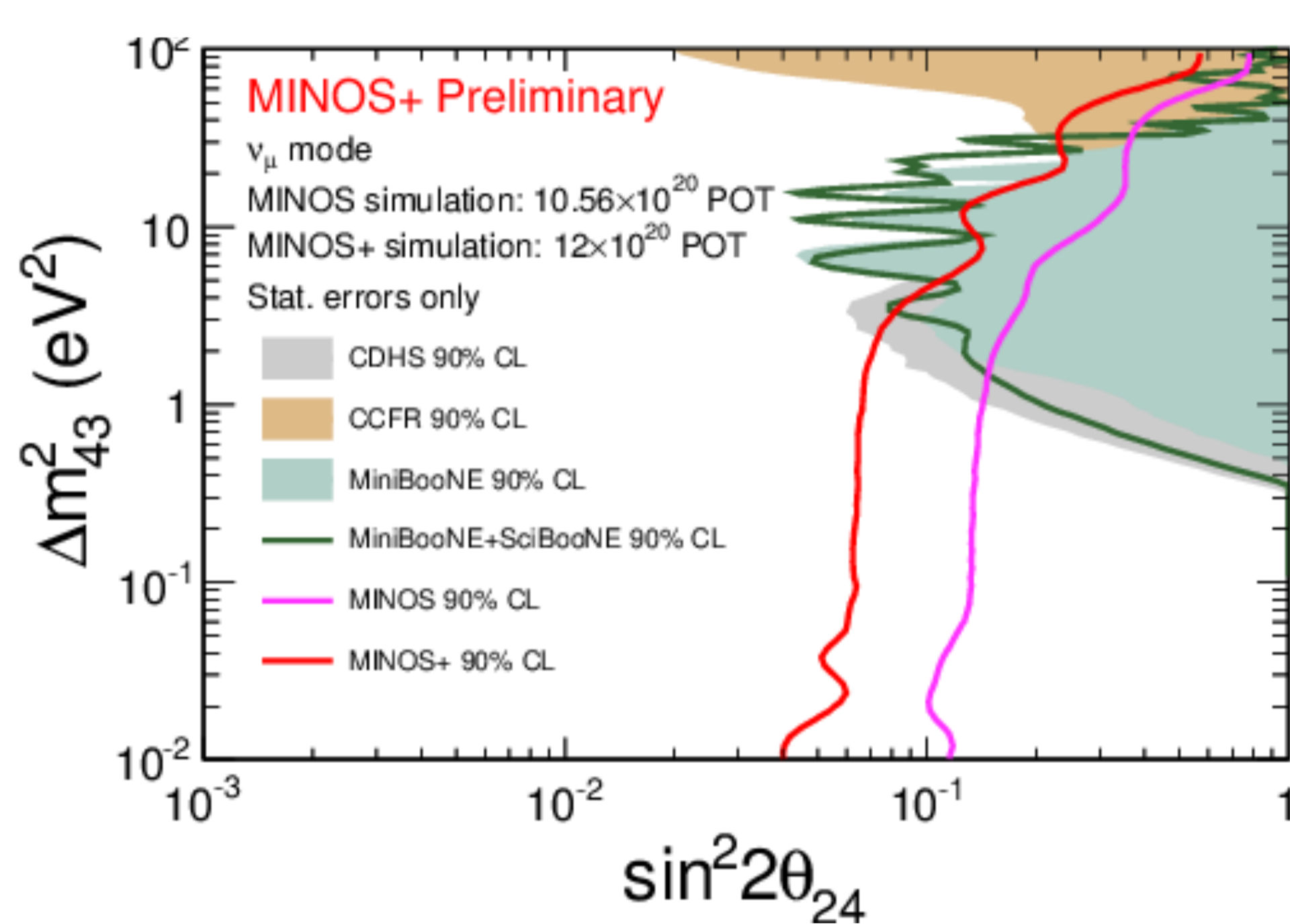
- Overall normalization shift in FD from rapid oscillations
- Spectral distortions in ND

MINOS+ Sensitivity to Sterile Neutrinos

To account for spectral distortions in both the FD and ND, fit the Far/Near ratio directly and allow oscillations in both detectors. This permits searching for sterile neutrinos over a wide range of Δm^2_{43} [1]

The Muon neutrino disappearance in 4 flavor is given by

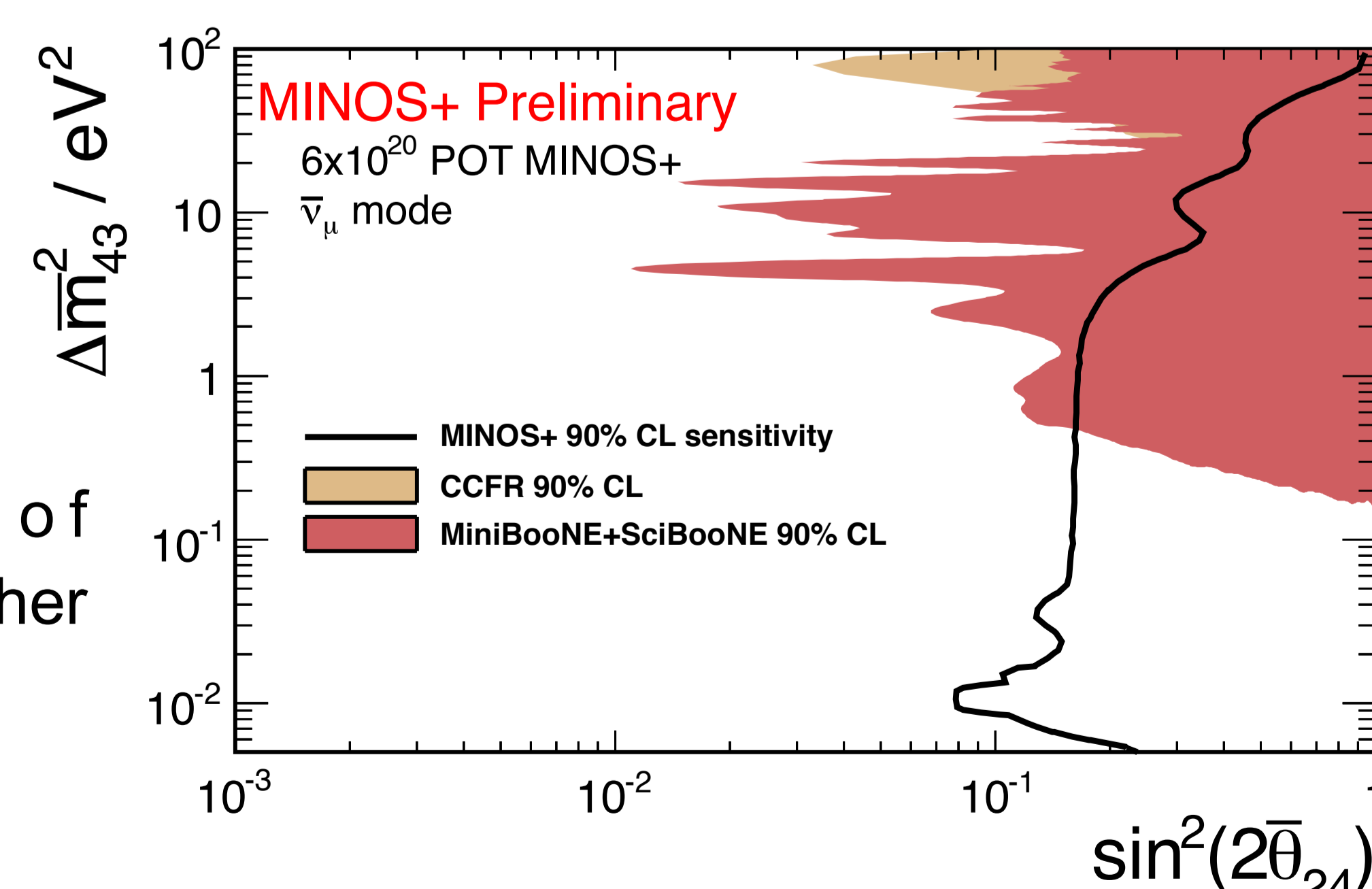
$$P(\nu_\mu \rightarrow \nu_\mu) = 1 - 4\{|U_{\mu 3}|^2(1 - |U_{\mu 3}|^2 - |U_{\mu 4}|^2)\sin^2\Delta_{31} + |U_{\mu 4}|^2|U_{\mu 3}|^2 \sin^2\Delta_{43} + |U_{\mu 4}|^2(1 - |U_{\mu 3}|^2 - |U_{\mu 4}|^2)\sin^2\Delta_{41}\}$$



MINOS+ 90% CL sensitivity to $\sin^2 2\theta_{24}$

- Statistics only
- 2 years of exposure in neutrino mode + full MINOS sample
- Fit includes both NC and ν_μ -CC spectra

MINOS+ 90% CL sensitivity to $\sin^2 2\bar{\theta}_{24}$



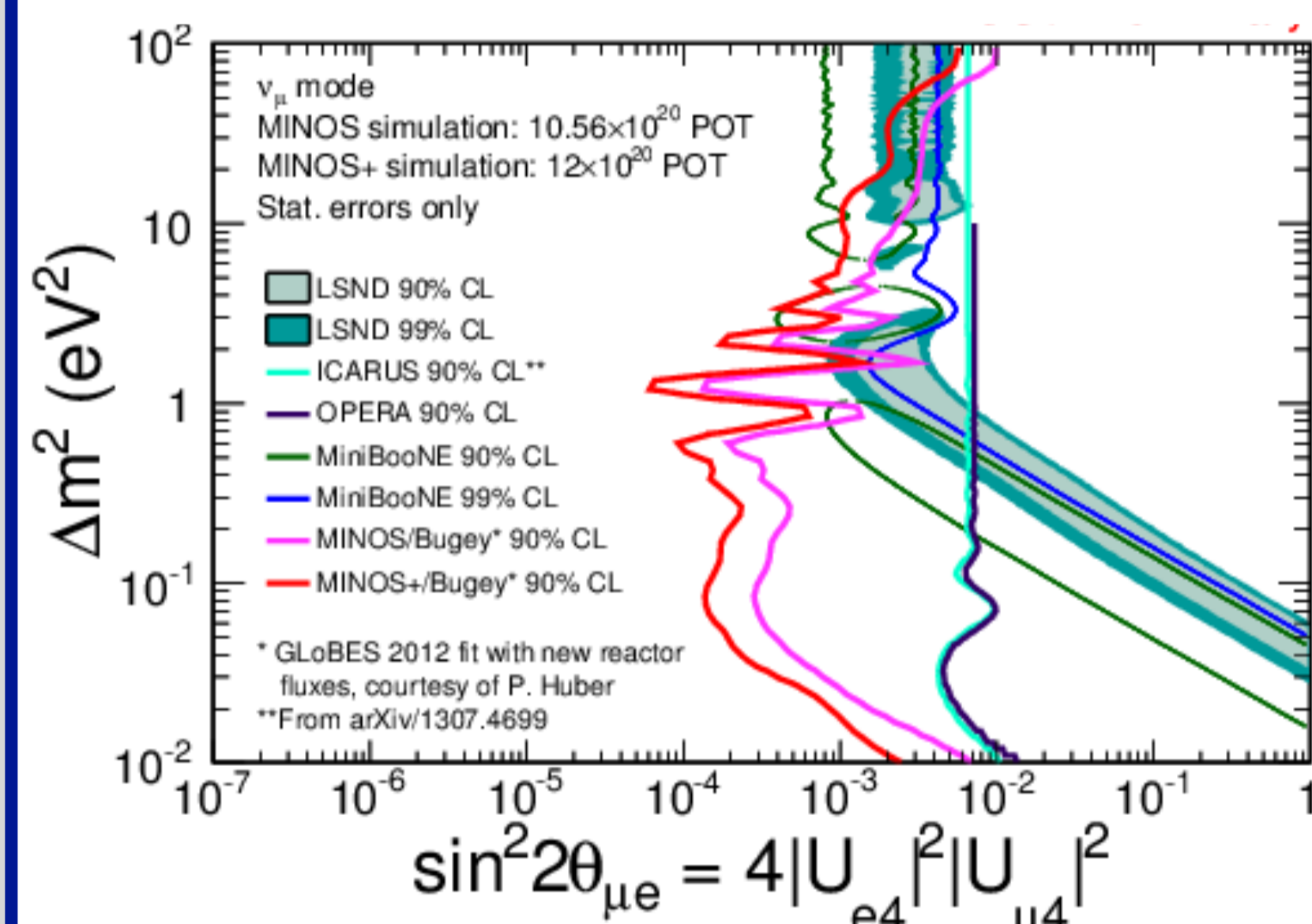
- Statistics only
- 1 year exposure of antineutrino mode with other experiment [2]
- Fit includes both NC and $\bar{\nu}_\mu$ -CC spectra

In both modes, MINOS+ can set significantly stronger limits on $\sin^2 2\theta_{24}$ in the 10^{-2} to 1 eV^2 range than previous experiments

Combination With Bugey

Can test ν_e appearance signal at LSND and MiniBooNE by combining the MINOS+ disappearance sensitivity to θ_{24} with the Bugey reactor experiment disappearance sensitivity to θ_{14} by writing the appearance angle in terms of matrix elements [3]

$$\sin^2 2\theta_{\mu e} = 4|U_{e4}|^2|U_{\mu 4}|^2 = \sin^2 2\theta_{14}\sin^2 2\theta_{24}$$

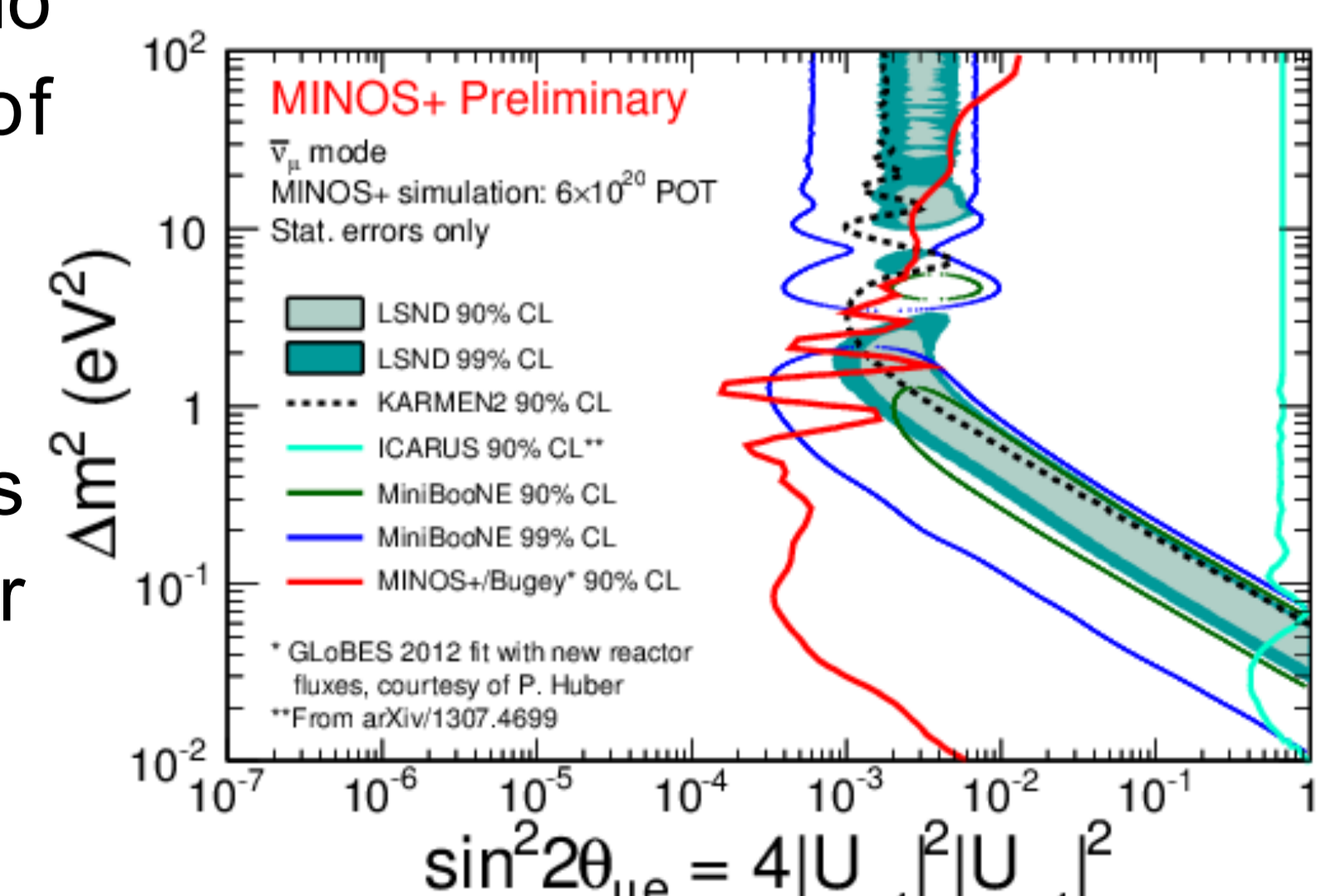


MINOS+ in neutrino mode with 2 years of exposure

- Statistics only
- Comparison from other experiments [4,5,6] is also shown as well

MINOS+ in antineutrino mode with 1 year of exposure

- Statistics only
- The other experiments limits are also shown for comparison



The combined MINOS+/Bugey sensitivity can exclude almost all of the LSND and MiniBooNE allowed regions

References

- Searching for Sterile Neutrinos at MINOS - Ashley Timmons - Neutrino 2014 Poster
- MiniBooNE + SciBooNE Collaboration, Phys. Rev. D85, 032007 (2012)
- Private communication with Alexei Smirnov
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- KARMEN Collaboration, Phys. Rev. D65 (2002) 112001
- OPERA Collaboration, JHEP07(2013)004