Contribution ID: **244** Type: **Poster**

Measurement of neutrino oscillation parameters $\sin^2 2\theta_{13}$ and Δm^2_{ee} at Daya Bay, and joint sterile neutrino limits with MINOS/MINOS+ and Bugey-3

The Daya Bay reactor neutrino experiment continues to refine its world-leading measurements of the mixing angle θ_{13} and the effective mass splitting Δm^2_{ee}, while also shedding light on various other topics in neutrino physics. At Daya Bay, electron antineutrinos are provided by six nuclear reactors in southern China, totaling 17.4 $\mathrm{GW_{th}}$, and they are observed by eight identically designed liquid scintillator detectors divided among two near sites and one far site. By measuring the relative antineutrino rates and spectral shapes at the near and far sites, Daya Bay benefits from a virtually complete cancellation of all systematic uncertainties related to the reactor flux and absolute detection efficiency.

In addition to the measurement of θ_{13}-driven oscillation, Daya Bay is also well-positioned to search for hypothetical "θ_{14}-driven" oscillation caused by a light sterile neutrino with a sub-eV^2 mass-squared splitting. Such a particle could potentially explain, first, the anomalous electron (anti)neutrino excess in muon (anti)neutrino beams observed by the LSND and MiniBooNE collaborations, and second, the global deficit observed in the reactor neutrino flux compared to model predictions. With the addition of data from the shorter-baseline Bugey-3 experiment, sensitivity can be extended to higher values of Δm^2_{41}. Going further, the data from the two reactor experiments can be combined with that from the MINOS/MINOS+ accelerator experiments, allowing limits to be set on the ν_μ-to-ν_e effective mixing angle $\sin^2 2\theta_{\mu e} \equiv 4|U_{e4}|^2|U_{\mu 4}|^2$.

In this talk, we describe Daya Bay's measurements using our primary data sample, in which electron antineutrinos are identified via the inverse beta decay interaction, with subsequent neutron capture on gadolinium. From a 1958-day data sample, we obtain $\sin^2 2\theta_{13} = 0.0856 \pm 0.0029$ and $\Delta m^2_{ee} = (2.522^{+0.068}_{-0.070}) \times 10^{-3}$ eV^2. In addition, from a 1230-day sample, we set 90% CL limits of $\sin^2 2\theta_{14} < 0.01$ for approximately $4 \times 10^{-3} < \Delta m^2_{41} < 0.1$ eV^2, strongly disfavoring a sterile neutrino in this mass range as the explanation of the flux discrepancy. For $\sin^2 2\theta_{14} > 0.1$, the 90% CL excluded mass splittings span a wide range of approximately $4 \times 10^{-4} < \Delta m^2_{41} < 0.3$ eV^2, which we extend up to 3 eV^2 via the addition of Bugey-3 data. Finally, the two reactor datasets, when combined with MINOS/MINOS+ data, exclude the LSND/MiniBooNE allowed regions for $\Delta m^2_{41} < 5$ (1.2) eV^2 at 90% (99%) CL, increasing the tension (within the four-flavor framework) between LSND/MiniBooNE and other experiments.

Working group

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Session Classification: Poster session NB: do not use Safari; use Firefox, Chrome or Edge