PROCEEDINGS OF SCIENCE

Latest Results from the Daya Bay Reactor Neutrino Experiment

Wenqiang Gu[*†]
Brookhaven National Laboratory, Upton, New York 11973
E-mail: goowenq@gmail.com

Utilizing six powerful nuclear reactors as antineutrino sources, and eight identically designed underground detectors for a near-far relative measurement, the Daya Bay Reactor Neutrino Experiment has achieved unprecedented precision in measuring the neutrino mixing angle θ_{13} and the neutrino effective mass squared difference $|\Delta m^2_{ee}|$. With a growing dataset that constitutes the largest sample of reactor antineutrino interactions ever collected to date, and the improved systematic uncertainties such as the energy model and the antineutrino detection efficiency, Daya Bay is also able to perform a number of other measurements in neutrino physics, such as a high-statistics determination of the absolute reactor antineutrino flux and spectrum, as well as a search for sterile neutrino mixing, among others. In this talk, I will present the latest results from Daya Bay.

The 20th International Workshop on Neutrinos (NuFact2018)
12-18 August 2018
Blacksburg, Virginia

[*]Speaker.
[†]On behalf of the Daya Bay collaboration.

1. Introduction

In the past 20 years, neutrino oscillation has been confirmed and precisely measured in a three-flavor framework. It is commonly parameterized by the three mixing angles (θ_{12}, θ_{23}, θ_{13}), a charge parity (CP) phase and two mass-squared differences (Δm^2_{32}, Δm^2_{21}). For reactor-based experiments, the survival probability of the electron antineutrino can be expressed using

$$P(\bar{\nu}_e \to \bar{\nu}_e) = 1 - \sin^2 2\theta_{13}\sin^2(\Delta m^2_{\rm ee}\frac{L}{4E}) - \sin^2 2\theta_{12}\cos^4\theta_{13}\sin^2(\Delta m^2_{21}\frac{L}{4E}), \tag{1.1}$$

where $\sin^2(\Delta m^2_{\rm ee}\frac{L}{4E}) \equiv \cos^2\theta_{12}\sin^2(\Delta m^2_{31}\frac{L}{4E}) + \sin^2\theta_{12}\sin^2(\Delta m^2_{32}\frac{L}{4E})$. In 2012, the Daya Bay experiment first observed the last unknown mixing angle θ_{13} with more than 5σ significance [1].

The Daya Bay reactor neutrino experiment is built close to the Daya Bay Nuclear Power Plant (NPP), one of most powerful nuclear reactor complex in the world. The experiment is designed to precisely measure θ_{13}, benefitting from the near-far relative measurement which cancels most of the reactor related systematic uncertainty. The inverse beta decay (IBD, $\bar{\nu}_e + p \to e^+ + n$) reaction is utilized to detect electron antineutrinos from the reactor, where a coincidence of consecutive signals are produced. The "prompt" signal arises from the kinetic energy deposition and the annihilation of the positron, while the "delayed" signal comes from the de-excitation γ of the neutron capture on hydrogen (2.2 MeV) or gadolinium ($\approx$8 MeV) in the liquid scintillator.

2. Latest Results

With 1958 days of data collection, Daya Bay experiment has accumulated nearly 4 million inverse beta decay interactions, the largest sample of reactor antineutrino interactions ever collected to date. By selecting the IBD candidates with the neutron capture on gadolinium (n-Gd) and by performing a relative measurement on the rate deficit and energy spectrum distortion through the detectors in the near halls and in the far hall, the parameters controlling the electron antineutrino oscillation are obtained [2]

$$\sin^2 2\theta_{13} = 0.0856 \pm 0.0029, \tag{2.1}$$

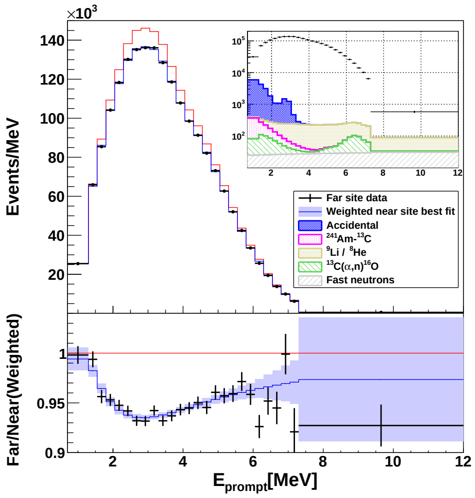
$$\Delta m^2_{32}(\text{normal}) = (2.471^{+0.068}_{-0.070}) \times 10^{-3}\text{eV}^2, \tag{2.2}$$

$$\Delta m^2_{32}(\text{inverted}) = -(2.575^{+0.068}_{-0.070}) \times 10^{-3}\text{eV}^2, \tag{2.3}$$

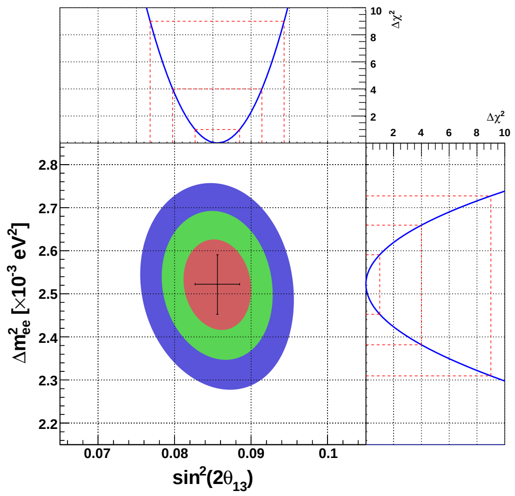
where $|\Delta m^2_{32}|$ differs slightly under the assumption of the normal mass ordering, or inverted mass ordering. Fig. 1a shows the reconstructed prompt-energy spectrum of the IBD candidates in the far hall. The expected spectrum assuming no oscillation, as well as the best-fit spectrum with oscillation and the background spectrum, is also overlaid. Fig. 1b shows the confidence interval for $\Delta m^2_{\rm ee}$ and $\sin^2 2\theta_{13}$. In the foreseeable future, Daya Bay will have the most precise measurement of θ_{13} from an individual experiment.

In addition, with a 1230-day dataset, the reactor antineutrino flux is precisely measured using 2.2 milliom IBD events collected by the Daya Bay near detectors [3]. An elaborate neutron calibration compaign was carried out in one of the near detector, resulting in a 56% reduction in the uncertainty of neutron detection efficiency - a dominant systematic uncertianty for the antineutrino detection. Furthermore, the ratio of measured to the predicted flux is found to be 0.952$\pm$0.014 (Huber-Mueller), which is consistent with the world average, 0.945$\pm$0.007, as shown in Fig. 2.

PoS(NuFACT2018)064



(a)



(b)

Figure 1: (a) Prompt-energy spectrum of the antineutrino candidates in the far hall (black dots), the prediction assuming no oscillation (red line) and the best-fit based on a three-flavor neutrino model (blue line). Underneath the energy spectrum is the ratio of the measured to the prediction assuming no oscillation. (b) The 68.3%, 95.5%, and 99.7% C.L. allowed region of Δm^2_{ee} and $\sin^2 2\theta_{13}$.

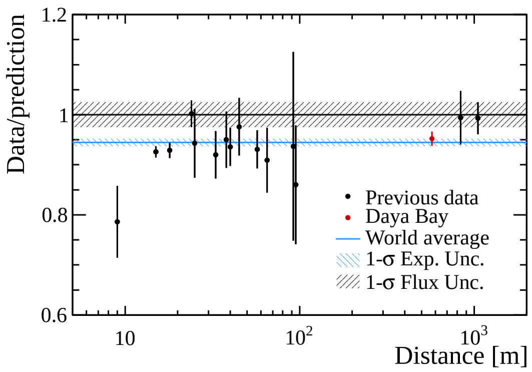


Figure 2: The ratio of the measured to the predicted antineutrino flux at Daya Bay and the results of previous short baseline reactor experiments, as well as the world average.

References

[1] F. P. An *et al.* [Daya Bay Collaboration], Phys. Rev. Lett. **108**, 171803 (2012) doi:10.1103/PhysRevLett.108.171803 [arXiv:1203.1669 [hep-ex]].

[2] D. Adey *et al.* [Daya Bay Collaboration], Phys. Rev. Lett. **121**, no. 24, 241805 (2018) doi:10.1103/PhysRevLett.121.241805 [arXiv:1809.02261 [hep-ex]].

[3] D. Adey *et al.* [Daya Bay Collaboration], arXiv:1808.10836 [hep-ex].