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Results from the Daya Bay Reactor Neutrino Experiment

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Abstract

The Daya Bay Reactor Neutrino Experiment was designed to achieve a sensitivity on the value of $\sin^2 2\theta_{13}$ to better than 0.01 at 90% CL. The experiment consists of eight antineutrino detectors installed underground at different baselines from six nuclear reactors. With data collected with six antineutrino detectors for 55 days, Daya Bay announced the discovery of a non-zero value for $\sin^2 2\theta_{13}$ with a significance of 5.2 standard deviations in March 2012. The most recent analysis with 139 days of data acquired in a six-detector configuration yields $\sin^2 2\theta_{13} = 0.089 \pm 0.010(\text{stat.}) \pm 0.005(\text{syst.})$, which is the most precise measurement of $\sin^2 2\theta_{13}$ to date.

Keywords: Neutrino Oscillation, Neutrino Mixing, Reactor, Daya Bay

1. Introduction

It is well established that the neutrino weak eigenstates (ν_e, ν_μ, ν_τ) are mixtures of the mass eigenstates (ν_1, ν_2, ν_3). The transformation between the two sets of eigenstates can be described by the Pontecorvo-Maki-Nakagawa-Sakata (PMNS) matrix [1, 2, 3] in terms of three mixing angles (θ_{12}, θ_{13}, θ_{23}) and a CP-violating phase δ. For reactor-based experiments, the mixing angle θ_{13} can be measured via the survival probability of the electron antineutrino $\bar{\nu}_e$ at short distances from the reactors,

$$P_{\text{sur}} \simeq 1 - \sin^2 2\theta_{13} \sin^2(1.267\Delta m^2_{31} L/E), \qquad (1)$$

where Δm^2_{31} can be approximated by $\Delta m^2_{\text{atm}} = (2.32^{+0.12}_{-0.08})\times 10^{-3}\ \text{eV}^2$ [4], E is the antineutrino energy in MeV, and L is the distance between the reactor core and the detector in meters. The Daya Bay Reactor Neutrino Experiment made the first unambiguous measurement of a non-zero θ_{13} with a significance of more than five standard deviations in March 2012 [5]. These results were subsequently confirmed by the RENO Collaboration [6]. The recent update of Daya Bay results gives a more precise measurement of $\sin^2 2\theta_{13}$ with a precision of 12.6% [7]. A short review of the experiment and the most recent results are discussed in this report.

2. Experimental Setup

The Daya Bay nuclear power complex is located in the Southern part of China, approximately 55 km northeast of Hong Kong. It consists of a total of six nuclear reactors, providing a maximum total thermal power output of 17.4 GW. Three experimental halls (EHs) are connected by horizontal tunnels inside mountains to suppress backgrounds from cosmic rays. The layout of the experiment is shown in Fig. 1. Three antineutrino detectors (ADs) are deployed in the near sites (2 ADs at EH1, and 1 AD at EH2) to sample the electron antineutrino flux produced by the reactor cores. Three ADs are