Latest Neutrino Oscillation Results from the Daya Bay Experiment

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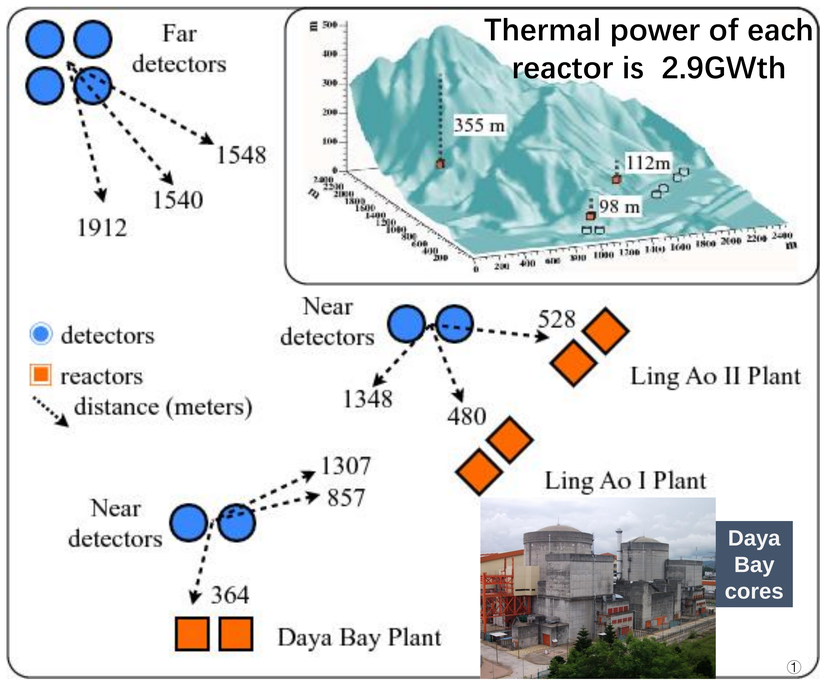
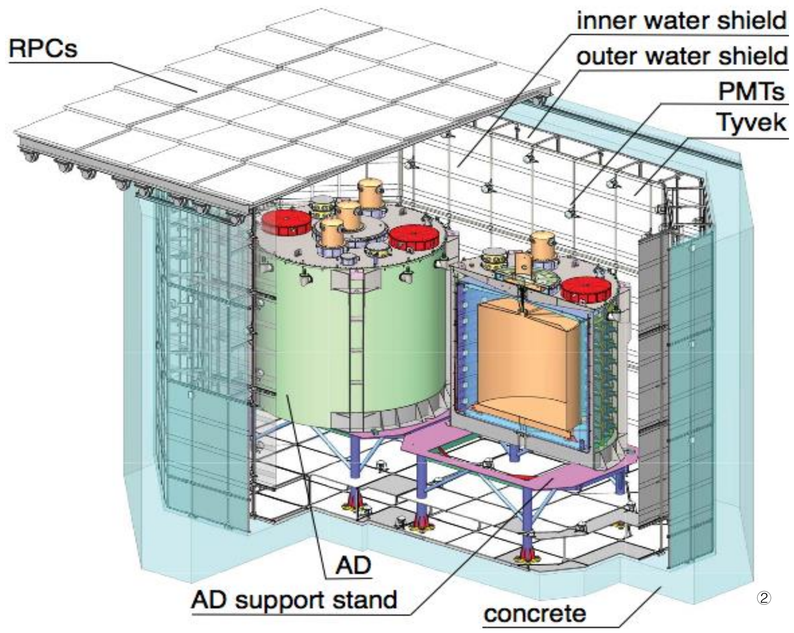
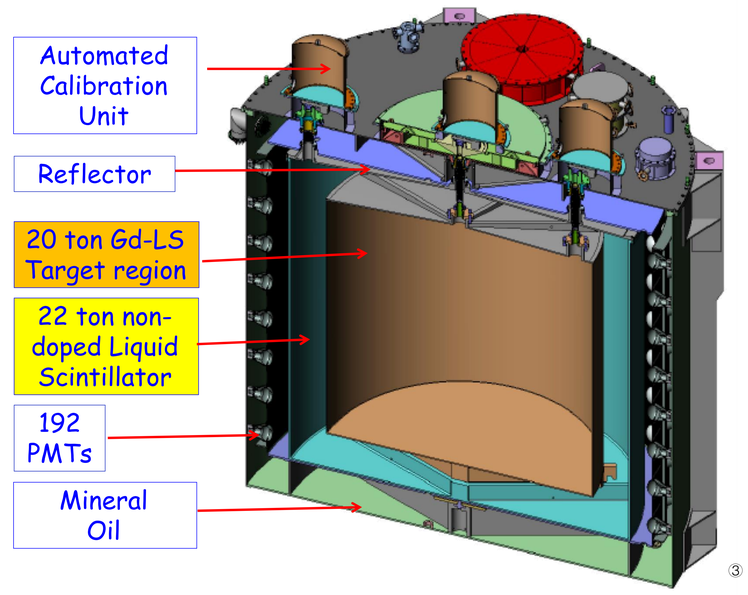
Aug. 5, 2019 at Lepton Photon 2019, Toronto, Canada



Veto System and Antineutrino Detectors



Eight Electron-Antineutrino Detectors



Principle of Antineutrino Detection & Oscillation Measurement

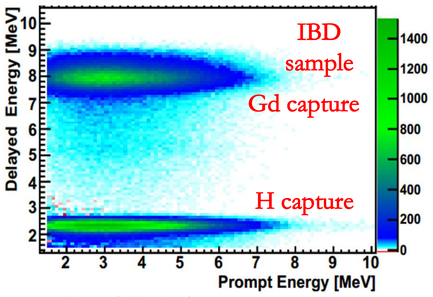
- Detection of electron-antineutrino: Inverse-Beta Decay (IBD)

$$\bar{\nu}_e + p \rightarrow e^+ + n$$

$+H \rightarrow D + \gamma$ 2.2 MeV 200 μs

$+Gd \rightarrow Gd^* \rightarrow Gd + \gamma's$ 8MeV 30 μs

Prompt: e^+.
Delayed: n capture on H or Gd.



- Principle: extract θ_{13} from
  - IBD events ratio at different site, and
  - IBD spectral distortion

$$\frac{N_f}{N_n} = \left(\frac{N_{p,f}}{N_{p,n}}\right)\left(\frac{L_n}{L_f}\right)^2\left(\frac{\epsilon_f}{\epsilon_n}\right)\left[\frac{P_{sur}(E,L_f)}{P_{sur}(E,L_n)}\right]$$

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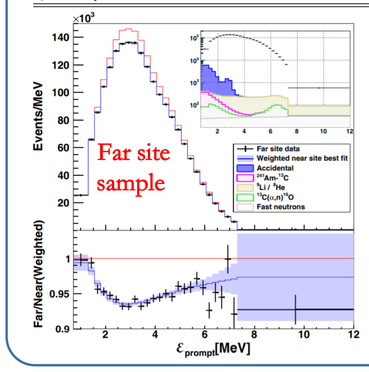
Summary of the Latest IBD Dataset – 1958 Days

TABLE I. Summary of signal and backgrounds. Rates are corrected for the muon veto and multiplicity selection efficiencies $\epsilon_\mu \cdot \epsilon_m$. The procedure for estimating accidental, fast neutron, Am-C, and (α, n) backgrounds is unchanged from Ref. [7].

	EH1		EH2		EH3			
	AD1	AD2	AD3	AD8	AD4	AD5	AD6	AD7
$\bar{\nu}_e$ candidates	830 036	964 381	889 171	784 736	127 107	127 726	126 666	113 922
DAQ live time (days)	1536.621	1737.616	1741.235	1554.044	1739.611	1739.611	1739.611	1551.945
$\epsilon_\mu \times \epsilon_m$	0.8050	0.8013	0.8369	0.8360	0.9596	0.9595	0.9592	0.9595
Accidentals (day^{-1})	8.27±0.08	8.12±0.08	6.00±0.06	5.86±0.06	1.06±0.01	1.00±0.01	1.03±0.01	0.86±0.01
Fast neutron (AD^{-1} day^{-1})	0.79 ± 0.10		0.57 ± 0.07			0.05 ± 0.01		
^{9}Li/^{8}He (AD^{-1} day^{-1})	2.38 ± 0.66		1.59 ± 0.49			0.19 ± 0.08		
Am-C correlated (day^{-1})	0.17±0.07	0.15±0.07	0.14±0.06	0.13±0.06	0.06±0.03	0.05±0.02	0.05±0.02	0.04±0.02
^{13}C (α, n) ^{16}O (day^{-1})	0.08±0.04	0.06±0.03	0.04±0.02	0.06±0.03	0.04±0.02	0.04±0.02	0.04±0.02	0.04±0.02
$\bar{\nu}_e$ rate (day^{-1})	659.36±1.00	681.09±0.98	601.83±0.82	595.82±0.85	74.75±0.23	75.19±0.23	74.56±0.23	75.33±0.24



Some highlights:

- More than 3.9 million antineutrino interactions (0.5 million at far site)
- Statistical error in $\bar{\nu}_e$ rates: ~0.11% (near ADs), ~0.29% (far ADs)
- Background uncertainty in $\bar{\nu}_e$ rates: ~0.12% (all ADs)
- Relative efficiency uncertainty: 0.13% (all ADs)

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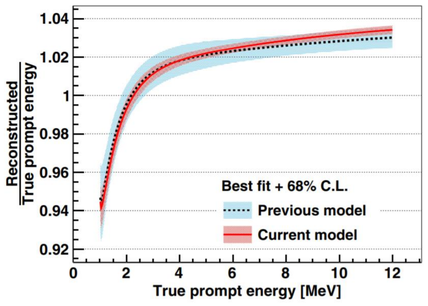
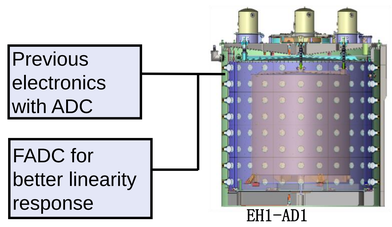
Improvement in Detector Energy Response Modeling

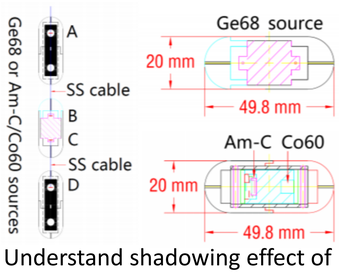


The absolute energy calibration uncertainty was reduced to less than 0.5% for visible energies larger than 2 MeV

1. Installation of a flash analog-to-digital converter readout system
2. Special calibration campaign using different source enclosures



Understand ADC non-linearity



Understand shadowing effect of calibration sources

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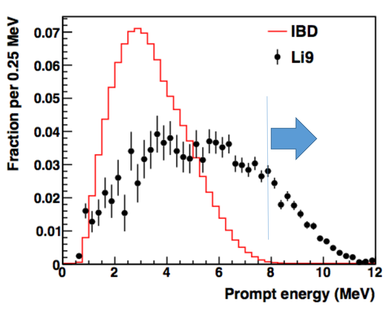
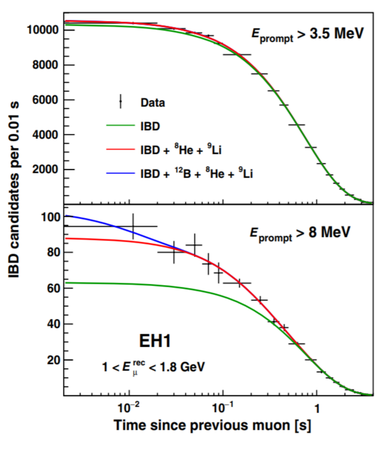
Improved Li9/He8 Background Measurement

High statistics and a higher prompt energy cut helps to improve the S/N of Li9/He8 background





The uncertainty in the cosmogenic ^{9}Li and ^{8}He background is reduced from 45% to 30% in the near detectors

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Results on Oscillation Measurement

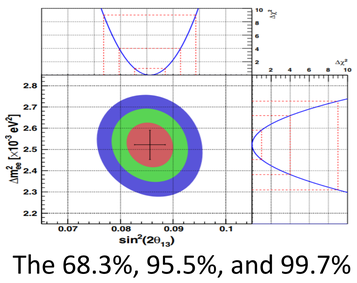
Results of 1958 days' Gd-Capture data

$\sin^2 2\theta_{13} = 0.0856 \pm 0.0029$
$\Delta m^2_{32} = (2.471^{+0.068}_{-0.070}) \times 10^{-3}$ eV^2 for normal hierarchy
$\Delta m^2_{32} = -(2.575^{+0.068}_{-0.070}) \times 10^{-3}$ eV^2 for inverted hierarchy

Independent result based on a rate-only analysis using 621 days' H-Capture data

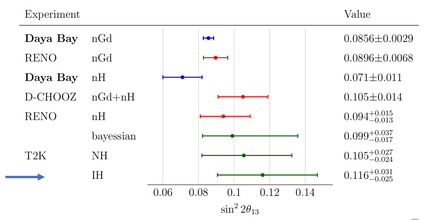
$\sin^2 2\theta_{13} = 0.071 \pm 0.011$

PRL 121, 241805 (2018)
PRD 93, 072011 (2016)



The 68.3%, 95.5%, and 99.7% allowed regions in the Δm^2_{ee}-$\sin^2 2\theta_{13}$ plane.

Global θ_{13} comparison →



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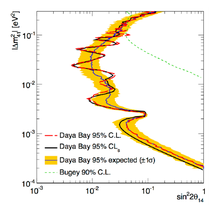
Other Oscillation-related Results

Improved search for a sterile neutrino (with Bugey-3 + MINOS)

Phys. Rev. Lett. 117, 151802 (2016)
Phys. Rev. Lett. 117, 151801 (2016)



Search for neutrino decoherence

Study of the wave packet treatment of neutrino oscillation at Daya Bay
Eur. Phys. J. C77, 606 (2017)

Search for a time-varying electron antineutrino signal at Daya Bay

Search for CPT or Lorentz violation and other new physics
Phys. Rev. D98, 092013 (2018)

Results Related Cosmic-ray

Seasonal Variation of the Underground Cosmic Muon Flux
JCAP01(2018)001

Cosmogenic neutron production at Daya Bay
Phys. Rev. D97, 052009 (2018)

⋆ Please also see the "Reactor Antineutrino Flux and Spectrum Measurement at Daya Bay" talk on 6 Aug 2019.

A full list at http://dayabay.ihep.ac.cn/twiki/bin/view/Public/DybPublications

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