Daya Bay Neutrino Experiment: Goal, Progress and Schedule

Zhe Wang, Brookhaven National Lab
(on behalf of the Daya Bay Collaboration)
APS April meeting, Anaheim
May 1st, 2011
Daya Bay collaboration

North America (15)

Europe (3)
JINR, Dubna, Russia
Kurchatov Institute, Russia
Charles University, Czech Republic

Asia (19)
IHEP, Beijing Normal Univ., Chengdu UST, CGNPG, CIAE, Dongguan Univ. of Tech., Nanjing Univ., Nankai Univ., Shenzhen Univ., Shandong Univ., Shanghai Jiaotong Univ., Tsinghua Univ., USTC, Zhōngshan Univ., Hong Kong Univ., Chinese Hong Kong Univ., Taiwan Univ., Chiao Tung Univ., National United Univ.

~ 250 collaborators
Why $\theta_{13}$?

- Based on an assumption of three generations, a 3x3 neutrino mixing matrix was proposed – PMNS.

$$U = \begin{pmatrix}
1 & 0 & 0 \\
0 & \cos \theta_{23} & \sin \theta_{23} \\
0 & -\sin \theta_{23} & \cos \theta_{23}
\end{pmatrix} \begin{pmatrix}
\cos \theta_{13} & 0 & \sin \theta_{13} e^{-i\delta} \\
0 & 1 & 0 \\
-\sin \theta_{13} e^{i\delta} & 0 & \cos \theta_{13}
\end{pmatrix} \begin{pmatrix}
\cos \theta_{12} & \sin \theta_{12} & 0 \\
-\sin \theta_{12} & \cos \theta_{12} & 0 \\
0 & 0 & 1
\end{pmatrix}$$

1. The SM has no prediction power on the values of these mixing angles and the CPV phase. It relies on experimental input.

2. $\theta_{13}$ is the last unobserved mixing angle.

3. Provide knowledge of the basic assumptions:
   - The unitarity of PMNS matrix
   - Three generations of neutrinos

4. A critical input for other researches, for example:
   - Search for leptonic CP violation
   - Determine the neutrino mass hierarchy
   - Understand the ‘effective’ neutrino Majorana mass limit
Measure $\sin^2 2\theta_{13}$ to the precision 0.01

- We plan to measure $\sin^2 2\theta_{13}$ to the precision 0.01 at 90% CL in three years.

- Far-near Inverse-Beta-Decay (IBD) events ratio:

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

- A few key factors:
  1. Near-Far error cancelation
  2. Optimized baseline
  3. High reactor power
  4. Overburden and muon veto
  5. High target mass
  6. Identical Antineutrino detector
  7. Detector swapping

Details about sensitivity and design can be found in arXiv:hep-ex/0701029

- Zhe Wang
Far
Target mass: 80 ton
1600m to LA, 1900m to DYB
Overburden: 350m
Muon rate: 0.04Hz/m²
IBD rate: 90/day

Daya Bay near
Target mass: 40 ton
Baseline: 360m
Overburden: 98m
Muon rate: 1.2Hz/m²
IBD rate: 840/day

Ling Ao near
Target mass: 40 ton
Baseline: 500m
Overburden: 112m
Muon rate: 0.73Hz/m²
IBD rate: 740/day
The second reactor of Ling Ao II will start commercial running this summer. By then the total power will be $6 \times 2.9 \text{ GW}_{\text{th}}$. 
Far hall – hall 3 to be completed this summer

Liquid Scintillator (LS) fabrication & filling hall
Antineutrino Detector

- Fully populated AD
- AD test installation
- Instruments on lid (calibration unit, etc.)
- Image of inside an AD
- AD1 moved to hall 1

Zhe Wang
May, 1st. 2011
Hall 1 construction is complete.

Redundancy: two water cerenkov detectors

Hall 1 RPCs are all installed and gas is flowing.
Liquid scintillator

185 tons 0.1% GdLS stored in 5 40-ton tanks

180 tons LS stored in 200 ton pool

Engineer’s plot of LS hall

5x40ton Gd-LS storage tank

Mixing

2x200 ton storage pool

Filling

N2 room

LS hall in March

Filling system

UV-vis of 4-ton Dry Run Gd-LS

Absorption @ 430nm

Days

0.001 0.0015 0.002 0.0025 0.003 0.0035 0.004 0.0045 0.005
0 100 200 300 400 500
Electronics

Hall 1 electronics room in April.

PMT Front End Electronics

RPC Electronics

DAQ system

Clock system

Trigger system

PMT Front End Electronics

RPC Electronics

DAQ system

Clock system

Trigger system
Dry run and offline analysis

- Before AD and pool filling, PMTs and other instruments are tested, from analog signal to data processing.
  1. Dry run at surface: AD PMTs, calibration units, liquid level sensors, temperature sensors, cameras
  2. Hall 1 dry run: Water pool PMTs, pool calibration LEDs, RPC

- Offline analyses
  1. Reasonable PMT gain, timing offset, noise rate measurement
  2. Cosmic ray moun and LED event identification in dry AD
  3. RPC efficiency measurement

Offline Data Performance Monitor in China and the US
Summary and outlook

To achieve the challenging goal of measuring $\sin^2 2\theta_{13}$ to the precision 0.01, great efforts were put into the design and construction of the Daya Bay Neutrino Experiment. All these key concepts now are being turned from blueprint to reality.

In near term:
1. Two ADs for hall 1 are ready for filling.
2. Hall 1 muon veto system is almost finished.
3. Data taking of hall 1 by this summer

In long term:
1. Hall 2 installation next month, hall 3 after summer
2. Full data taking next year

Please see my colleagues’ reports for more detail.

Thank you.