The Daya Bay Experiment: Overview and Timeline

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(on behalf of the Daya Bay Collaboration)

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Outline

- **Goal:**
  Measure neutrino mixing angle $\theta_{13}$

- **Description of the Experiment**

- **Systematics and Sensitivity**

- **Schedule**
Why $\theta_{13}$?

\[ |\nu_f\rangle = \sum_i U_{fi}^* |\nu_i\rangle \]

Interaction eigenstates $\neq$ Mass eigenstates

\[ U_{if} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{pmatrix} \times \begin{pmatrix} c_{13} & 0 & s_{13}e^{-i\delta} \\ 0 & 1 & 0 \\ -s_{13}e^{i\delta} & 0 & c_{13} \end{pmatrix} \times \begin{pmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix} \]

$\theta_{23} \sim 45^\circ$
Atmospheric $\nu$
Accelerator $\nu$

$\theta_{13} < 10^\circ$
Short-Baseline Reactor $\nu$
Future Accelerator $\nu$

$\theta_{12} \sim 35^\circ$
Solar $\nu$
Long-Baseline Reactor $\nu$

Goal: Measure $\sin^2 2\theta_{13} < 0.01$ (90% CL)
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Dan Dwyer / Caltech

Daya Bay Collaboration

Europe (3) (9)
JINR, Dubna, Russia
Kurchatov Institute, Russia
Charles University, Czech Republic

North America (14) (~73)
BNL, Caltech, George Mason Univ.,
LBNL, Iowa State Univ., Illinois Inst. Tech.,
Princeton, RPI, UC-Berkeley, UCLA,
Univ. of Houston, Univ. of Wisconsin,
Virginia Tech.,
Univ. of Illinois-Urbana-Champaign

Asia (18) (~125)
IHEP, Beijing Normal Univ., Chengdu Univ. of Sci. and Tech., CGNPG, CIAE, Dongguan Polytech. Univ., Nanjing Univ., Nankai Univ.,
Shandong Univ., Shenzhen Univ.,
Tsinghua Univ., USTC, Zhongshan Univ.,
Univ. of Hong Kong,
Chinese Univ. of Hong Kong,
National Taiwan Univ., National Chiao Tung Univ., National United Univ.

~207 Collaborators
Reactor Anti-neutrinos

Well-established experimental technique.

Target + Detector: Gd-doped Liquid Scintillator

Detect using inverse-β decay:

\[ e^- + p \rightarrow n + A^{1}Gd \]

\[ n + A^{1}Gd \rightarrow e^- + p \]

Mean neutron capture time: \(~30\mu s\)

Delayed event provides powerful background-rejection
The Daya Bay Experiment

Reactor site:
Daya Bay, Guangdong, China

Reactor Power:
11.6 GW_{th}
(17.4 GW_{th} in 2011)

Baseline:
0.3-0.5 km to near sites
1.6-1.9 km to far site

Overburden:
~100 m at near sites
~350 m at far site

Identical 20 ton modular detectors
2 at each near site (~800 ν/day)
4 at far site (~100 ν/day)
Anti-neutrino Detectors

8 identical detectors:
Reduce systematic uncertainties

Each detector 3 nested cylinders:
Inner: 20 tons Gd-doped LS (r=3m)
Mid: 20 tons LS (r=4m)
Outer: 40 tons mineral oil buffer (r=5m)

Each detector:
192 8-inch Photomultipliers
Reflectors at top/bottom of cylinder
Provides 12% / $\sqrt{E}$ energy resolution
Muon Veto

Multiple muon veto detectors:

Water Cherenkov:
- Detectors submerged in water
- Optically separated into inner/outer regions using Tyvek sheets
- 8-inch PMTs mounted on frames:
  - 289 at each near site
  - 384 at far site

RPC:
- Provides independent veto above water pool
### Expected Systematics

<table>
<thead>
<tr>
<th>Detector Uncertainty Sources</th>
<th>Baseline</th>
<th>Goal</th>
<th>Chooz Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of protons</strong></td>
<td>0.3%</td>
<td>0.1%</td>
<td>0.8%</td>
</tr>
<tr>
<td><strong>Detector Efficiency</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy cut</td>
<td>0.2%</td>
<td>0.1%</td>
<td>0.8%</td>
</tr>
<tr>
<td>H/Gd ratio</td>
<td>0.1%</td>
<td>0.1%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Time cut</td>
<td>0.1%</td>
<td>0.03%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Neutron Multiplicity</td>
<td>0.05%</td>
<td>0.05%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Trigger</td>
<td>0.01%</td>
<td>0.01%</td>
<td>0.01%</td>
</tr>
<tr>
<td>Live time</td>
<td>&lt;0.01%</td>
<td>&lt;0.01%</td>
<td>&lt;0.01%</td>
</tr>
<tr>
<td><strong>Total uncertainty</strong></td>
<td>0.38%</td>
<td>0.18%</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

Most systematic uncertainties reduced through detector design

See hep-ex/0701029 for details
Expected Sensitivity

Sensitivity (90% CL) assuming:
Baseline systematic uncertainties
3 years of data

See hep-ex/0701029 for details
Schedule

Nov 2007: Civil Construction Began

Aug 2008: CD-3b Approval

Nov 2008: Occupancy of onsite assembly building

Winter 2009: Install first pair of detectors at Daya Bay near site

Winter 2010: Begin data taking with both near and far sites
More Details...

Session MC: Neutrino Physics: Instrumentation II
Sunday, October 26, 2008
10:30AM - 12:30PM

The Daya Bay Calibration System: Key to $\theta_{13}$
Jianglai Liu

Design and Simulation of the Daya Bay Antineutrino Detectors
Wei Wang

The PMT testing system for the Daya Bay Experiment
Wenqin Xu

Muon Veto System and Expected Backgrounds at DayaBay
Hongshan Zhang
Summary

- It is an exciting time for Neutrino Physics.

- The Daya Bay Experiment will provide the most sensitive measurement of $\theta_{13}$ in the next few years.

- The experiment has funding approval and civil construction is progressing.

- For more details about the experiment come to: *Session MC: Neutrino Physics: Instrumentation II*