The Daya Bay Experiment: Overview and Timeline

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(on behalf of the Daya Bay Collaboration)

Oct. 24, 2008

Outline

- Goal:

Measure neutrino mixing angle θ_{13}

- Description of the Experiment

- Systematics and Sensitivity

- Schedule

Why θ_{13}?

$|\nu_f\rangle = \sum_i U^*_{fi}|\nu_i\rangle$ Interaction eigenstates ≠ Mass eigenstates

$c_{ij} \equiv \cos\theta_{ij}$ and $s_{ij} \equiv \sin\theta_{ij}$

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

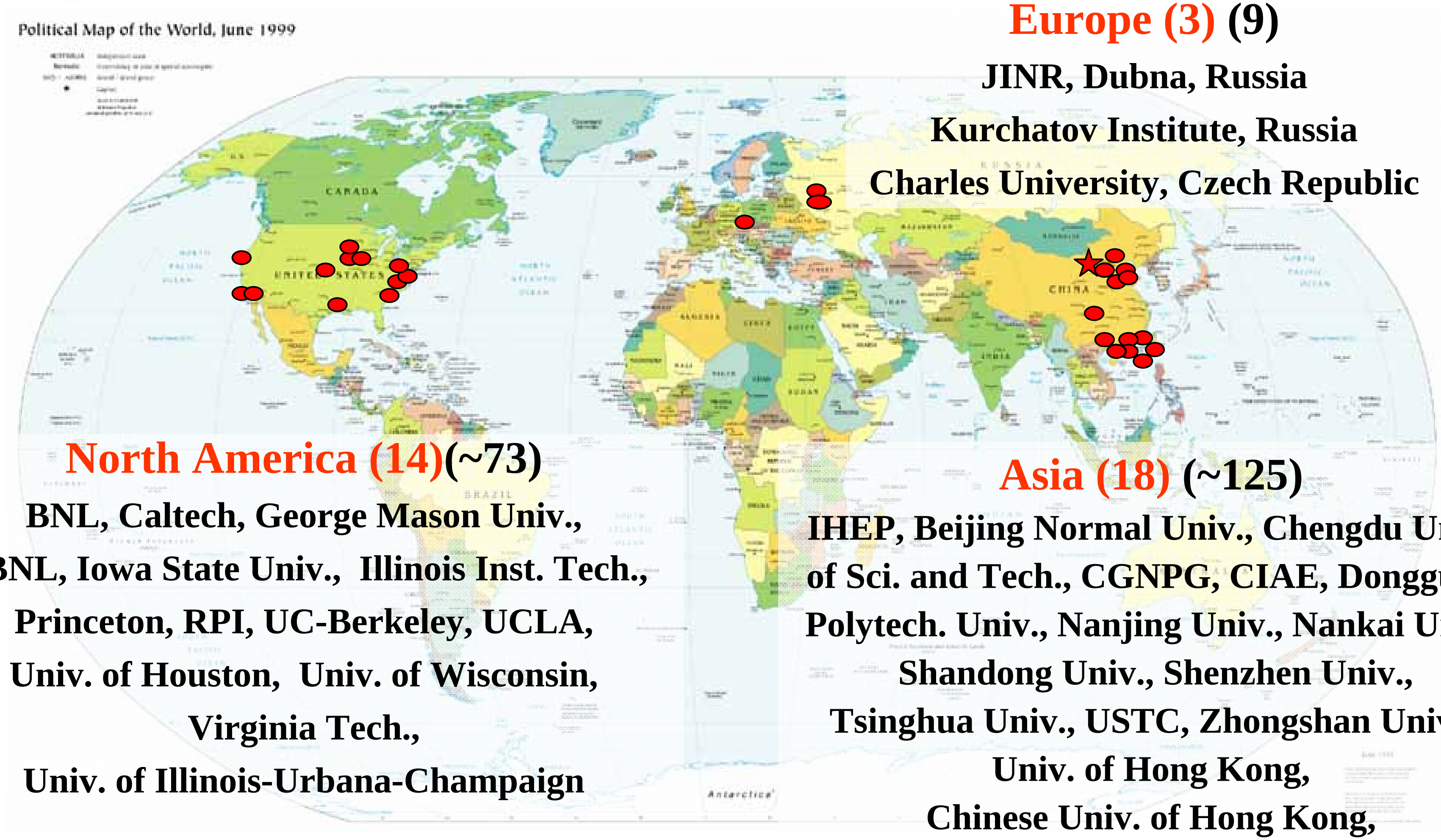
θ_{23} ~ 45°
Atmospheric ν
Accelerator ν

θ_{13} < 10°
Short-Baseline Reactor ν
Future Accelerator ν

θ_{12} ~ 35°
Solar ν
Long-Baseline Reactor ν

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

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

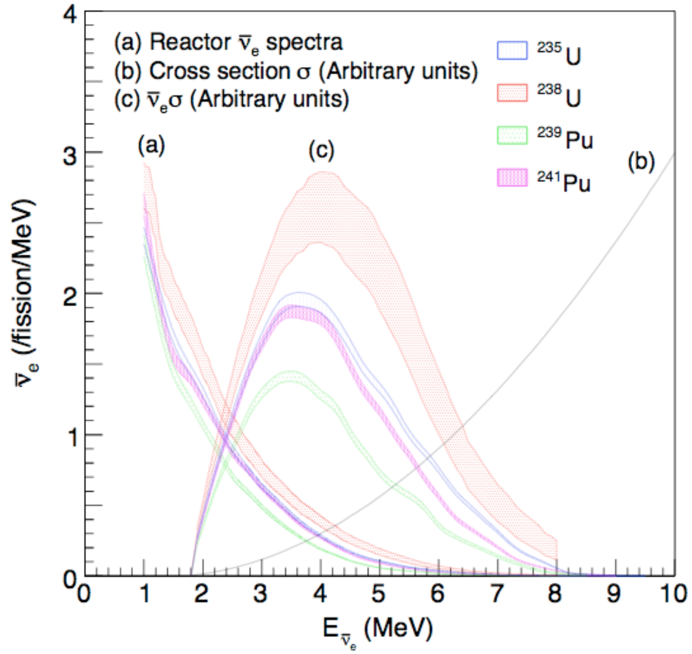
Well-established experimental technique.

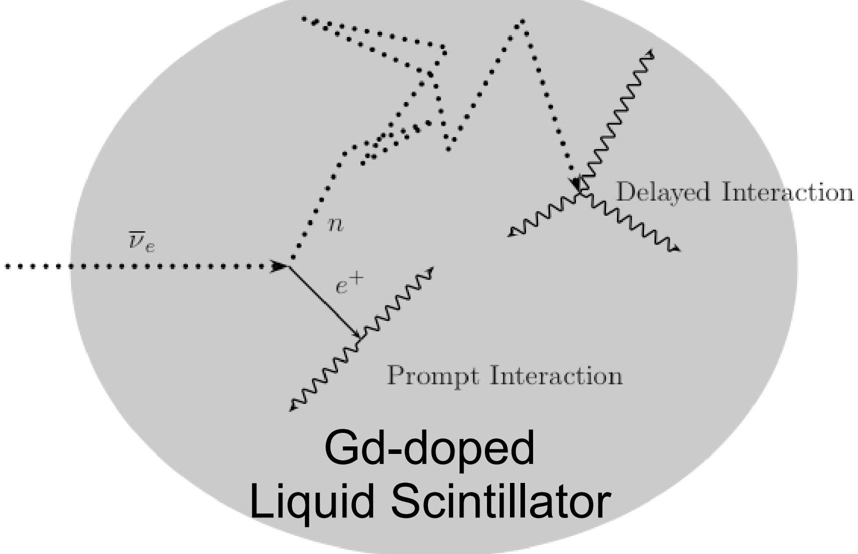
Target + Detector: Gd-doped Liquid Scintillator

Detect using inverse-β decay:

$_e \quad p \quad e \quad n$

$n \quad {}^{A}Gd \quad {}^{A\ 1}Gd \quad 's$





Mean neutron capture time: ~30μs

Delayed event provides powerful background-rejection

The Daya Bay Experiment

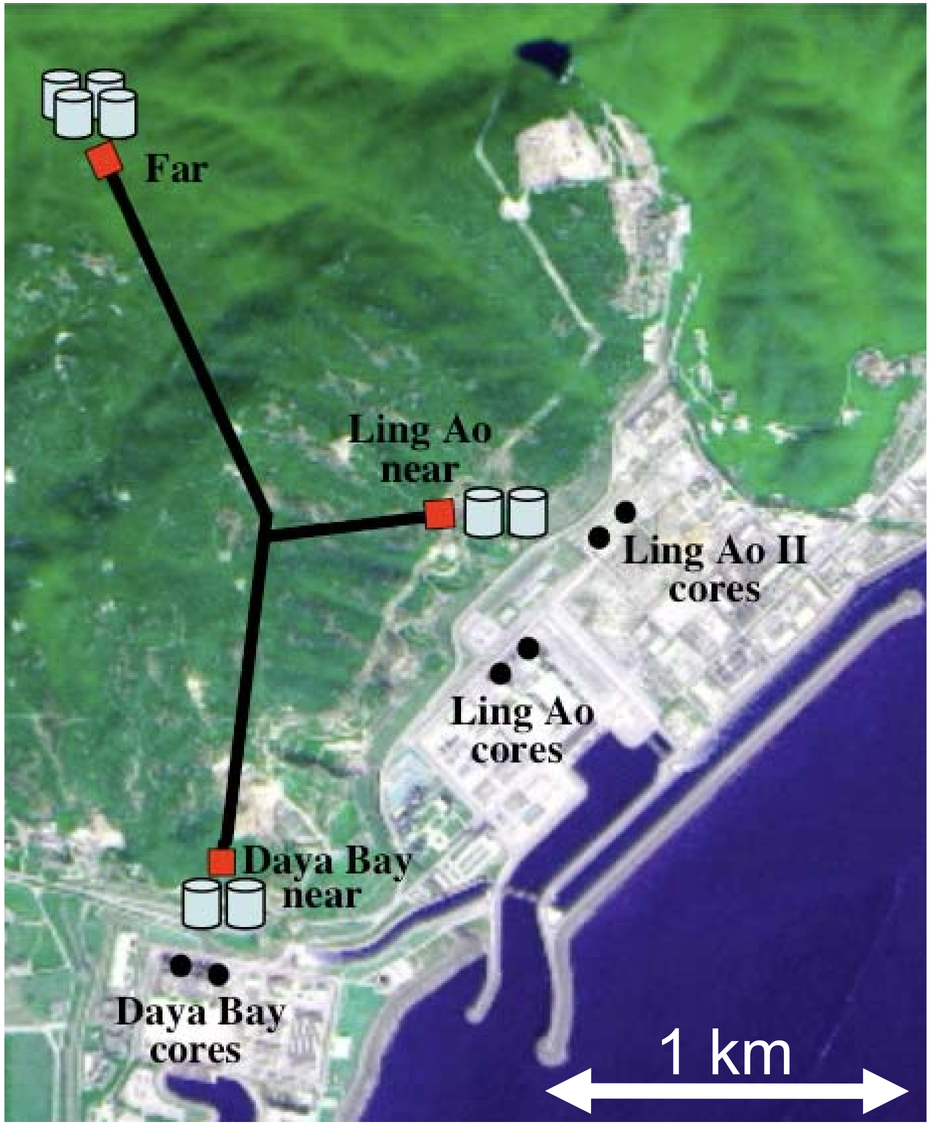
Reactor site:
Daya Bay, Guangdong, China

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

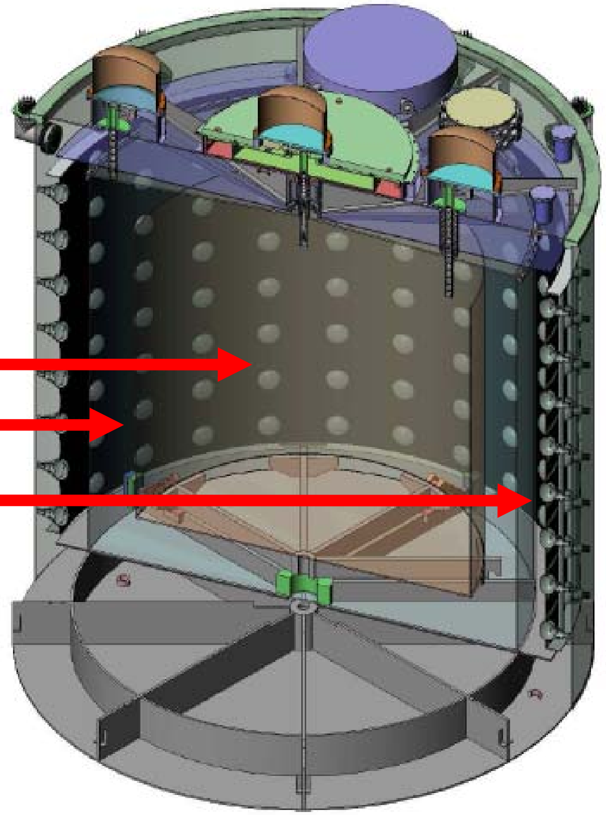
Identical 20 ton modular detectors
2 at each near site (~800 ▯ ν/day)
4 at far site (~100 ▯ ν/day)



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)



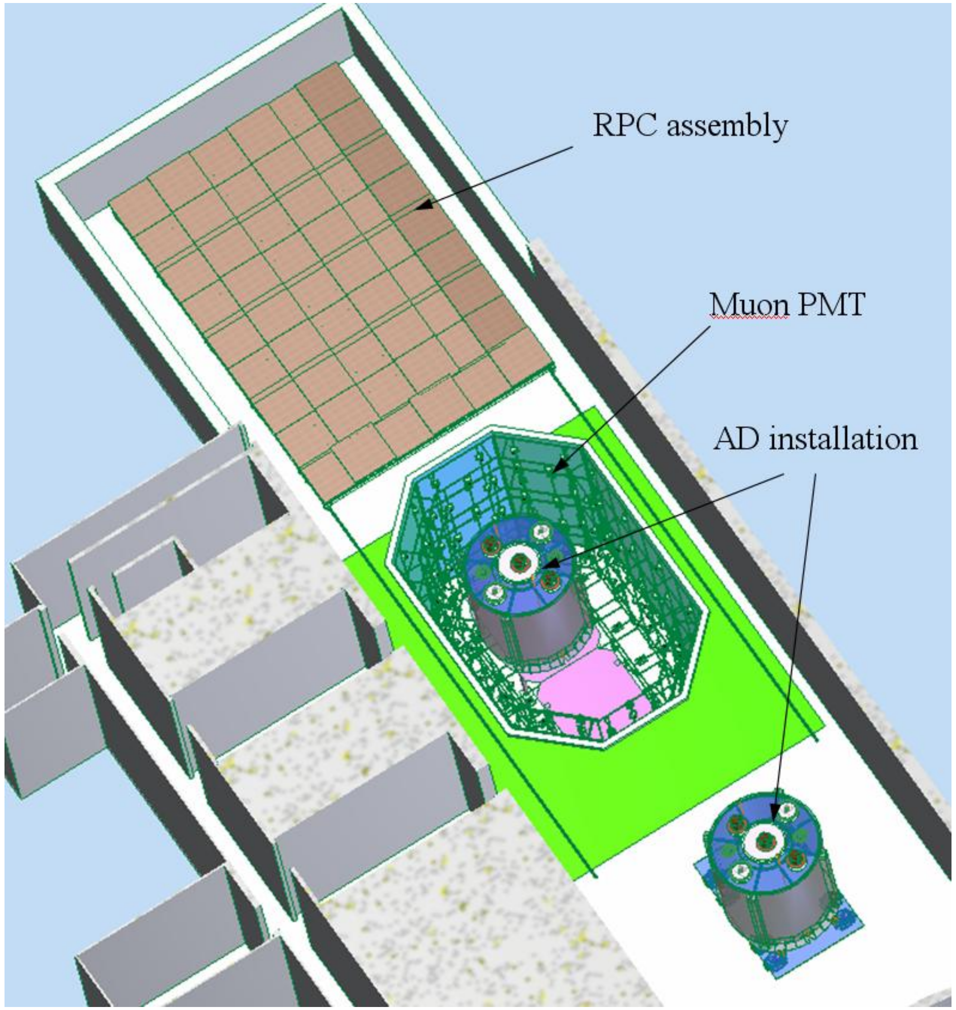
Each detector:
  192 8-inch Photomultipliers
  Reflectors at top/bottom of cylinder
    Provides 12% / $\sqrt{E}$ energy resolution

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

Detector Uncertainty Sources		Baseline	Goal	Chooz Experience
Number of protons		0.3%	0.1%	0.8%
Detector Efficiency	**Energy cut**	0.2%	0.1%	0.8%
	H/Gd ratio	0.1%	0.1%	1.0%
	Time cut	0.1%	0.03%	0.4%
	Neutron Multiplicity	0.05%	0.05%	0.5%
	Trigger	0.01%	0.01%	0.01%
	Live time	<0.01%	<0.01%	<0.01%
Total uncertainty		0.38%	0.18%	1.7%

Two detector relative uncertainty (Baseline, Goal)

One detector absolute uncertainty (Chooz Experience)

Most systematic uncertainties reduced through detector design

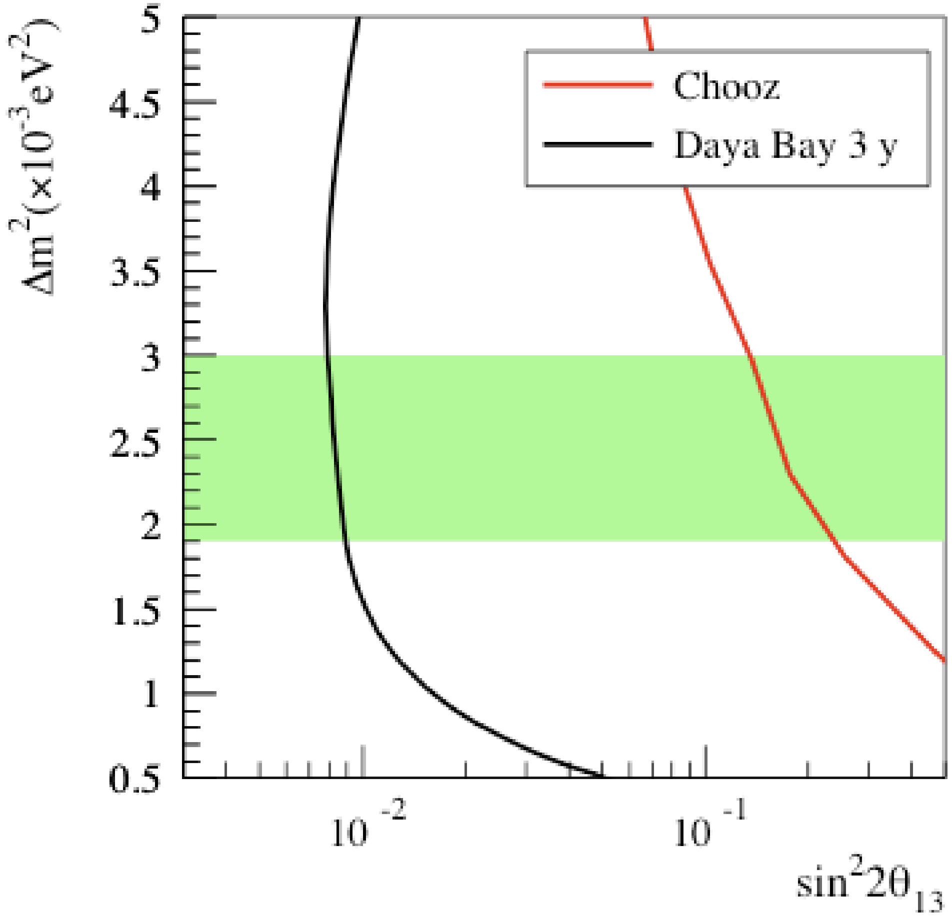
See hep-ex/0701029 for details

Expected Sensitivity

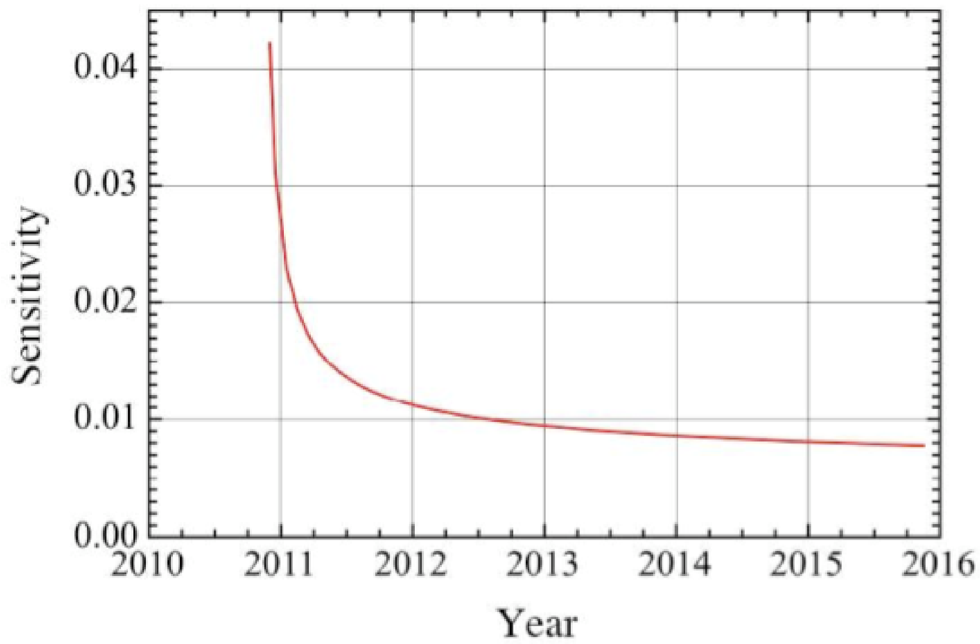
Sensitivity (90% CL) assuming:

Baseline systematic uncertainties

3 years of data



Sensitivity (90% CL) vs. time ($\Delta m^2 = 2.5 \times 10^{-3}\ eV^2$)



See hep-ex/0701029 for details

Schedule

Nov 2007: Civil Contruction 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 θ_{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 θ_{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*