Status of DayaBay Reactor Neutrino Experiment

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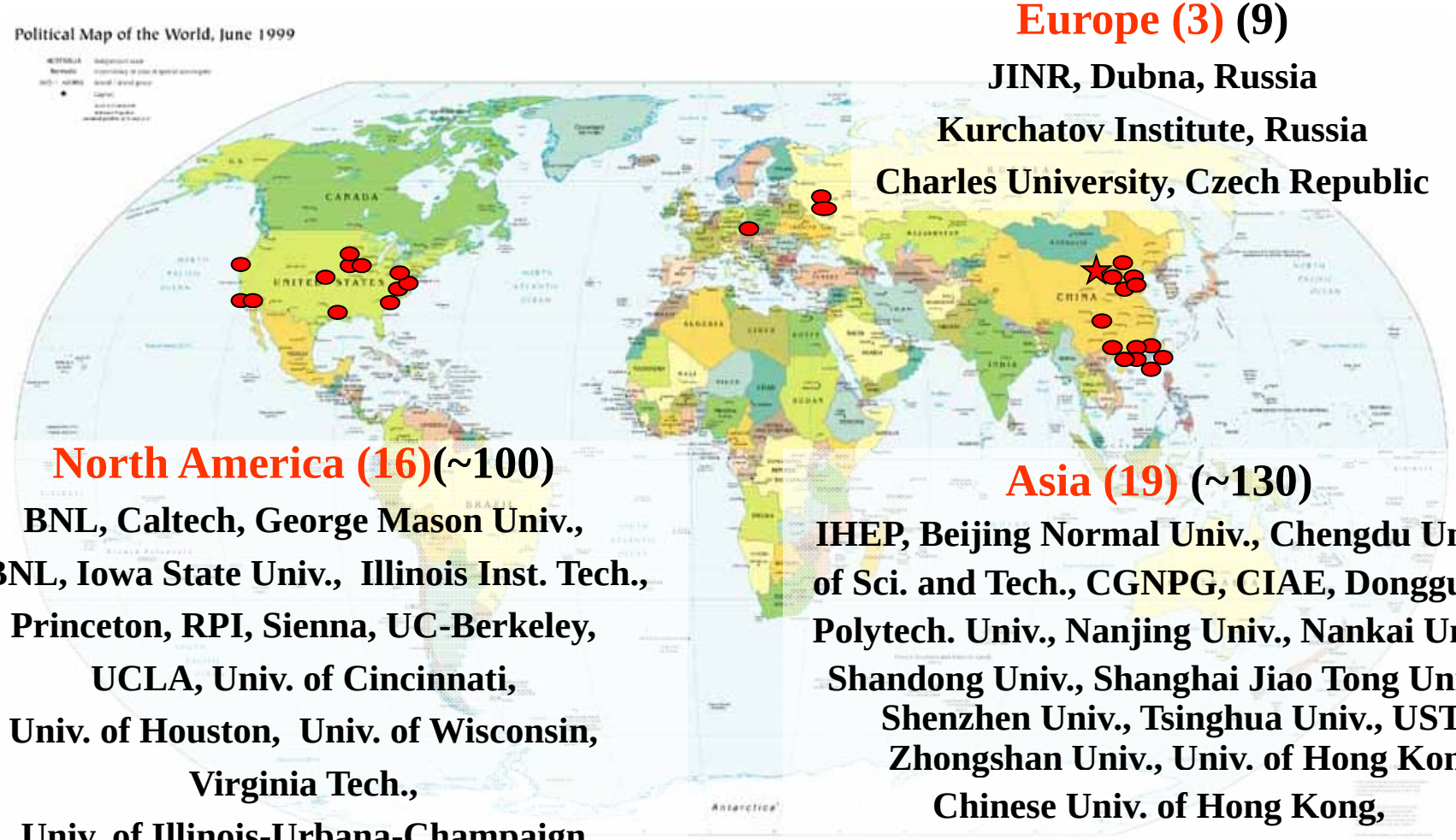
(On Behalf of the Daya Bay Collaboration)
NuFact10,October20-25

The Daya Bay Collaboration



Europe (3) (9)

JINR, Dubna, Russia

Kurchatov Institute, Russia

Charles University, Czech Republic

North America (16)(~100)

BNL, Caltech, George Mason Univ., LBNL, Iowa State Univ., Illinois Inst. Tech., Princeton, RPI, Sienna, UC-Berkeley, UCLA, Univ. of Cincinnati, Univ. of Houston, Univ. of Wisconsin, Virginia Tech., Univ. of Illinois-Urbana-Champaign

Asia (19) (~130)

IHEP, Beijing Normal Univ., Chengdu Univ. of Sci. and Tech., CGNPG, CIAE, Dongguan Polytech. Univ., Nanjing Univ., Nankai Univ., Shandong Univ., Shanghai Jiao Tong 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.

Total 38 Institutes,~ 240 collaborators

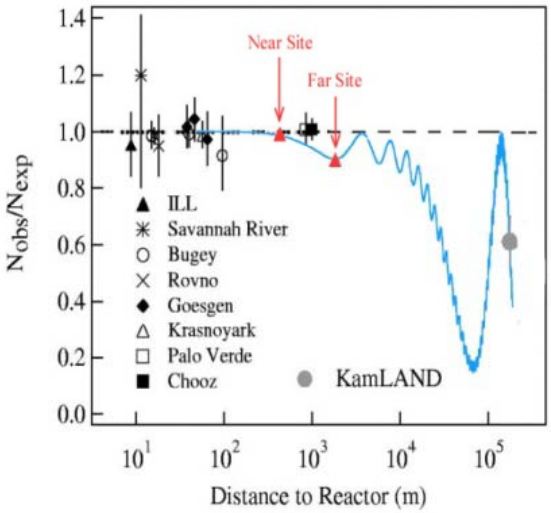
DayaBay experiment

•DayaBay is in Shenzhen, southern China; ~55km to HK.
•Discovery of $\overline{\nu}_e$ disappearance by Inverse-β reaction;
•Determine θ13 : Last unknown mixing angle;
•Open possibility to explore CP violation in lepton sector;

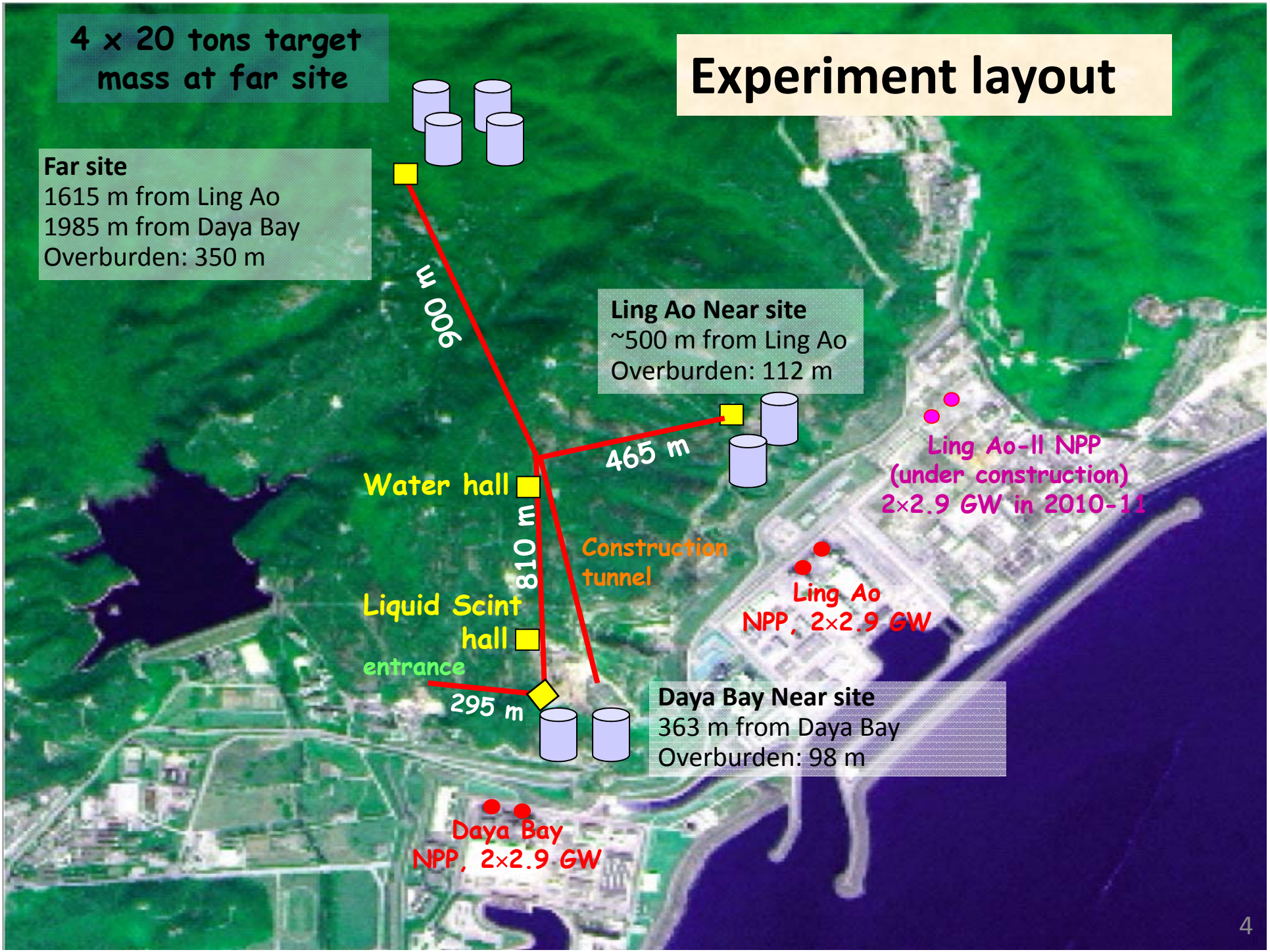
$$P(\overline{\nu}_e \to \overline{\nu}_{\mu,\tau}) \approx \sin^2(2\theta_{13})\sin^2\left(\frac{\Delta m^2_{32} L}{4E}\right) + \sin^2(2\theta_{12})\cos^4(\theta_{13})\sin^2\left(\frac{\Delta m^2_{21} L}{4E}\right)$$

Feature of DayaBay

- Powerful plant:12th most powerful in the world (11.6 GW_{th}), One of the top five most powerful by 2011 (17.4 GW_{th});
- Overburden to reduce backgrounds: Adjacent to mountain, easy to construct tunnels to reach underground labs with sufficient overburden to suppress cosmic rays;
- Identical near and far detectors to cancel reactor-related errors;
- Multiple modules for reducing detector-related errors and cross checks;
- Multiple muon detectors for reducing backgrounds and cross checks;



Experiment layout



Antineutrino Detectors (AD)

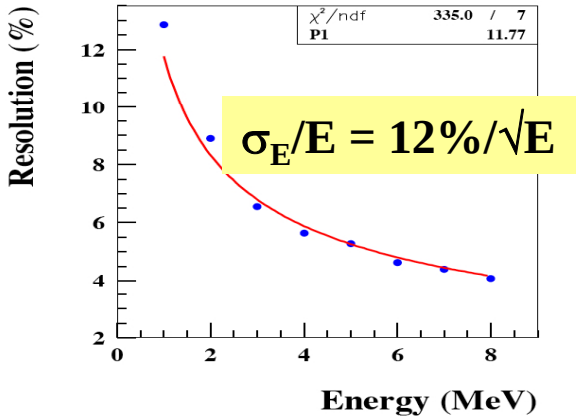
- **Three zones modular structure**

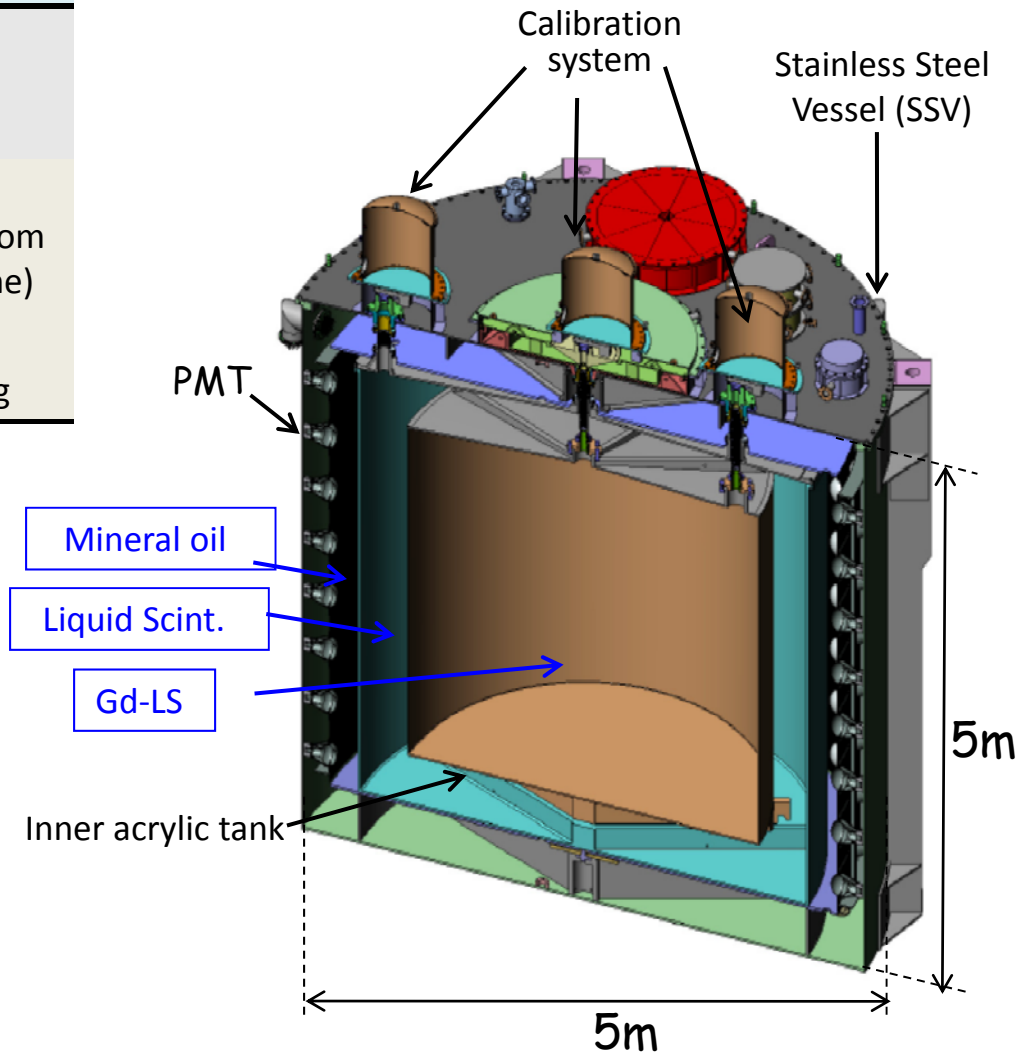
Zone	Mass	Liquid	Purpose
Inner acrylic vessel	**20 t**	**Gd-doped liquid scintillator**	**target**
Outer acrylic vessel	20 t	Liquid scintillator	Gamma catcher (from target zone)
Stainless steel tank	40 t	Mineral Oil	Buffer shielding

- **192 low backgorund 8”PMTs**
- **Reflector at top and bottom:**

Photocathode coverage

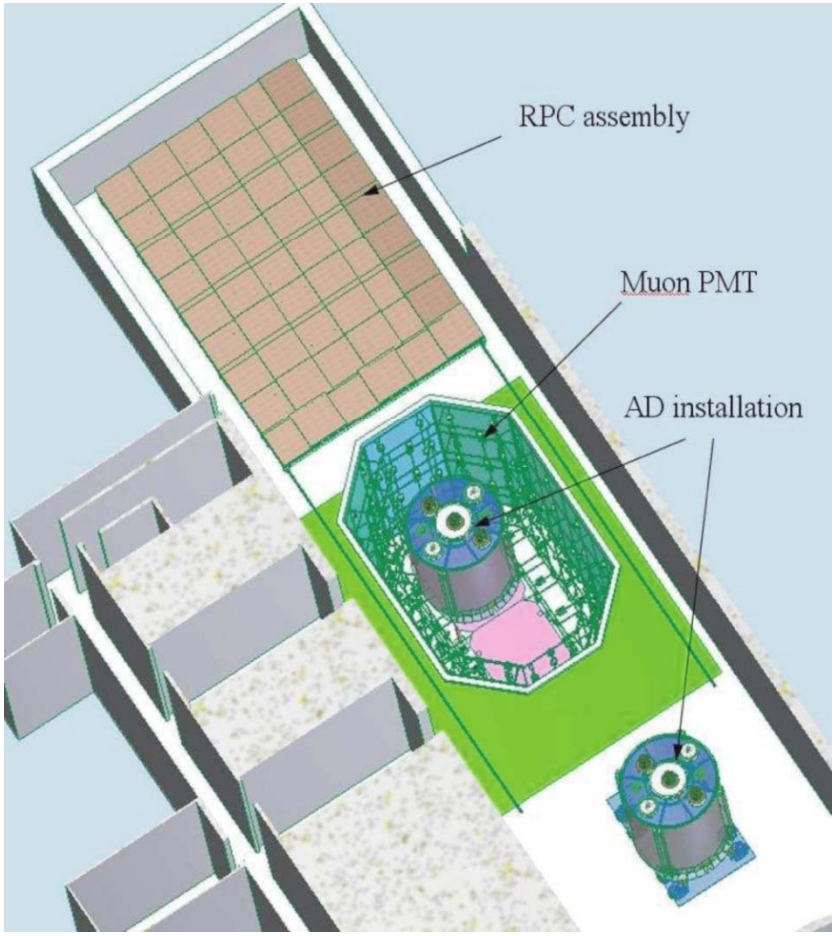
5.6 % ➔ 12%(with reflector)





Muon system

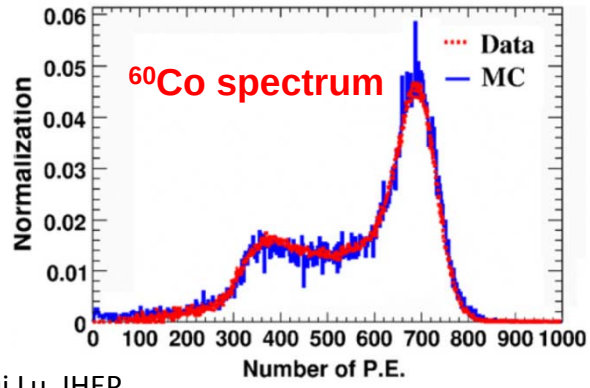
Near Hall

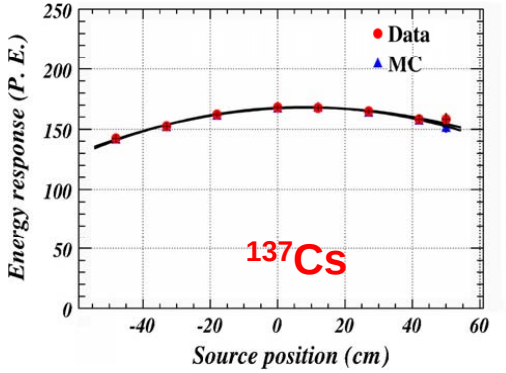


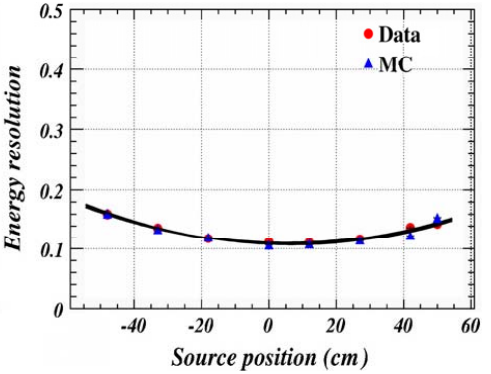
- The ADs are immersed in pool with thickness of water at least 2.5 meters, to shield backgrounds from neutrons and gamma's from lab walls .
- The water pools are equipped with PMTs as a water Cerenkov detector. The water pools are covered with RPC detectors.
- Utilize multiple detectors cross check each other to control uncertainties.
- Water Cerenkov detector and RPC system with efficiency>99.5% and error<0.25%.

AD Prototype at IHEP

- Motivation
  - Validate the design principle
  - Test technical details of tanks
  - Test Gd-LS
  - Test calibration source
- Achievements
  - Energy response & MC Comparison
  - Reconstruction algorithm
  - Neutron response
  - Effects of reflectors
  - Gd-LS





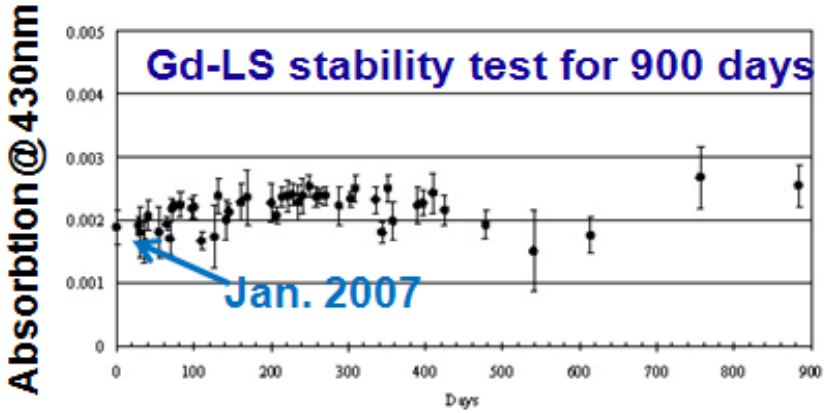


Status of Civil Construction

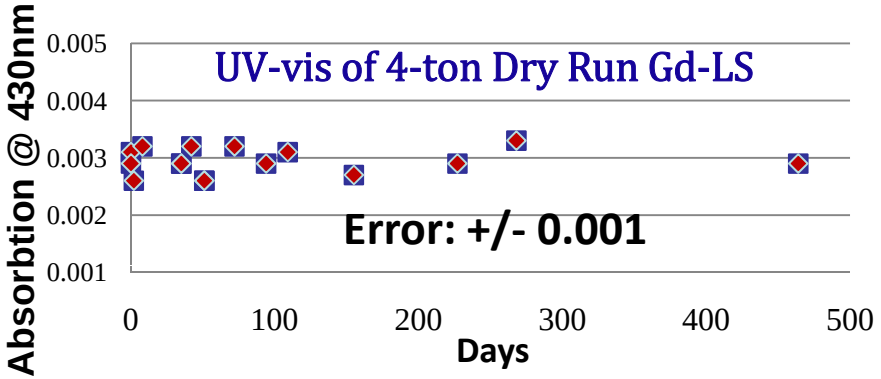
Status of Gd-LS production

- Daya Bay will use 185 ton 0.1% Gd-doped LS:
  - Gd-TMHA + LAB + 3g/L PPO + 15mg/L bis-MSB;
- Device and procedure for mass production has been designed, made and tested. Raw materials have been prepared and will be mixed soon.
- All Gd-LS will be produced in multiple 4-ton batches and mixed in one reservoir on-site, to ensure the samples uniform for all ADs.

Stability of the Gd-LS has been tested with a prototype detector since Jan. 2007



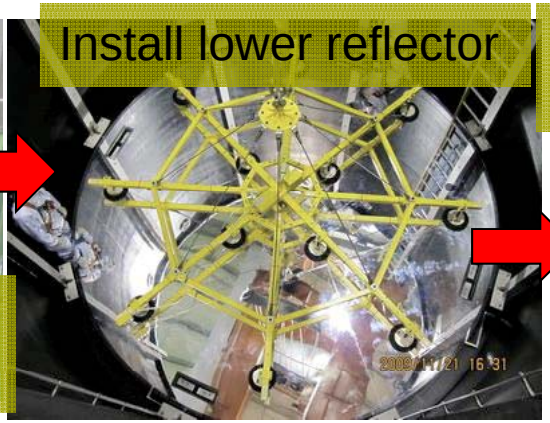
March 2009, a batch of 4 ton Gd-LS was produced successfully.



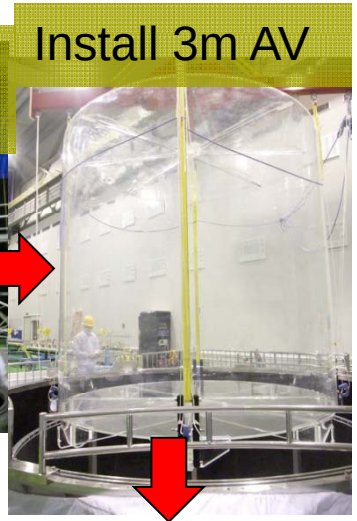
Status of Anti-Neutrino Detector

- The first and second anti-neutrino detectors (AD #1, AD #2) are already assembled.
- Installation process


Stainless Steel Vessel (SSV) in assembly pit


Install lower reflector


Install 4m Acrylic Vessel


Install 3m AV


Install PMT ladders

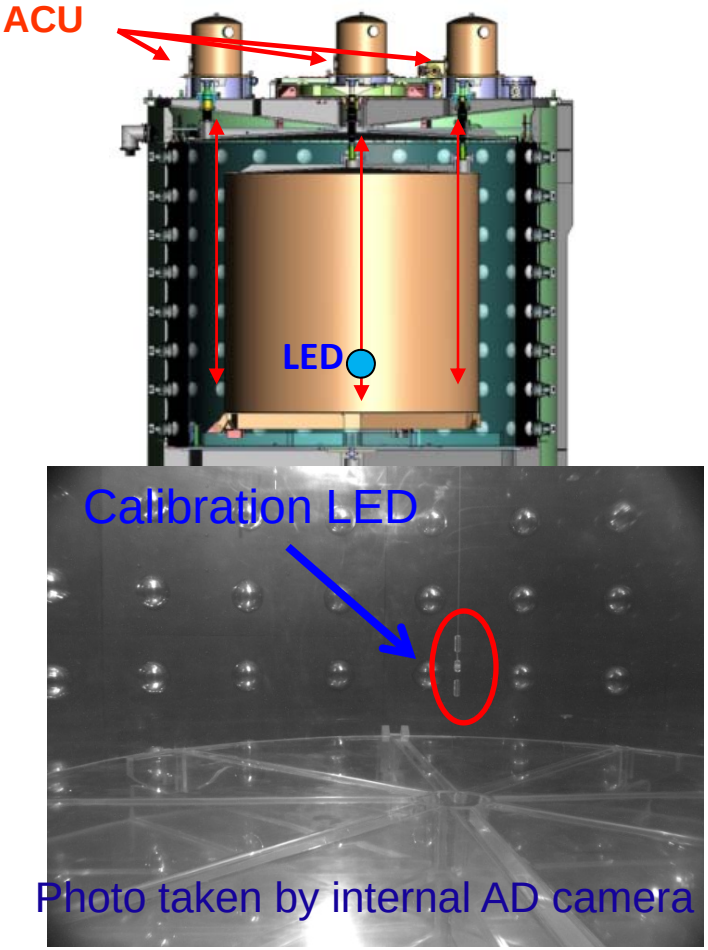

Install top reflector

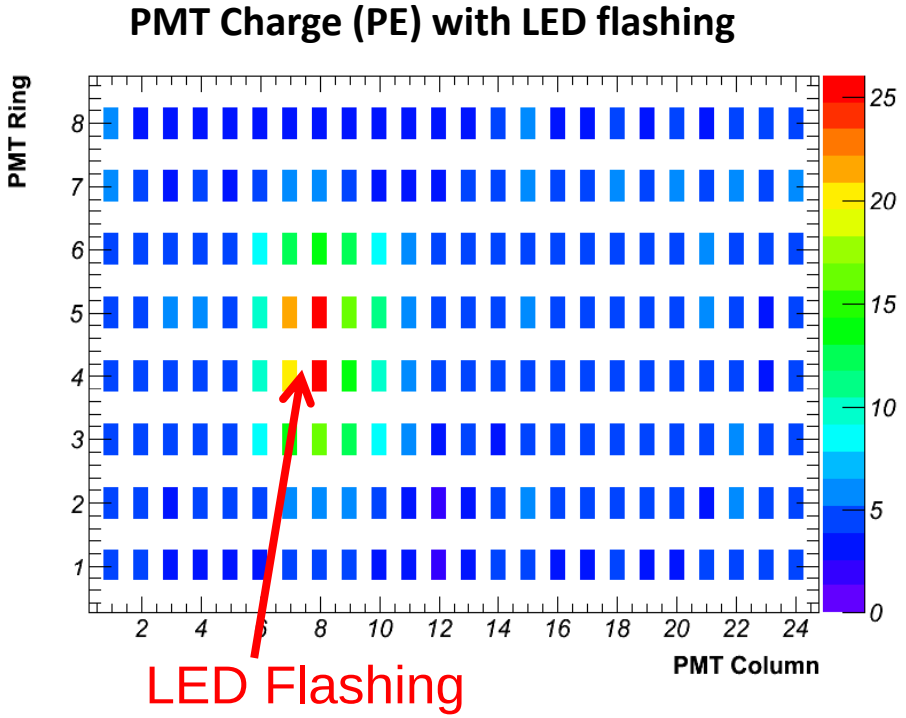

Close SSV lid


Install calibration units

Dry run with AD#1(I)

- Dryrun: After AD has been assembled (without LS/GdLS). Test for the whole system of AD + electronics + DAQ+ slow control + data storage + network transfer + online +offline analysis !
- Calibration data from LED has been collected.

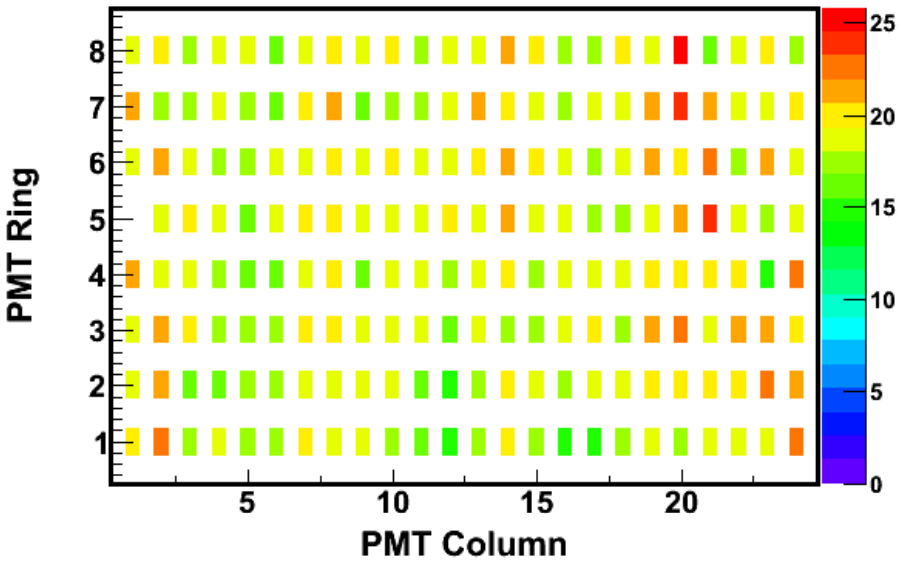




Can clearly see the space effect(LED flashing) from charge pattern.

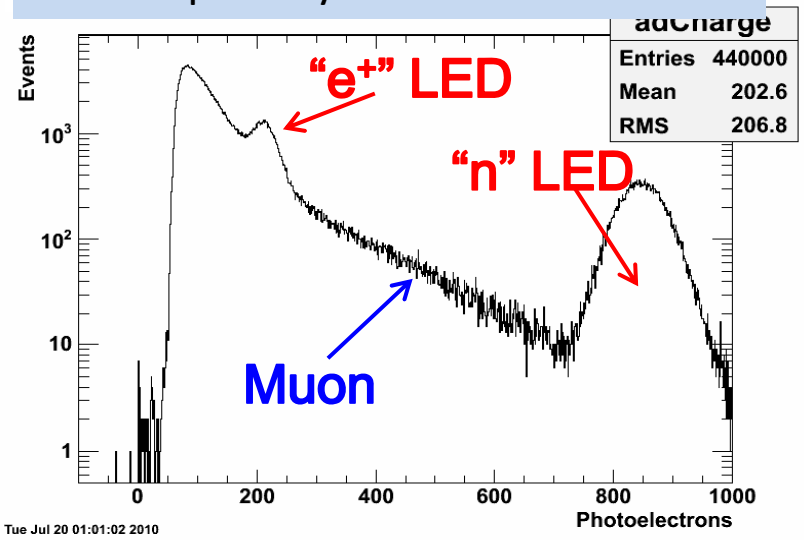
Dry run with AD#1(II)

Preliminary SPE calibration constants



Single photo-electron peak = ~ 20 ADC counts;
All 192 PMTs in AD#1are operational!

Double pulses(LEDs) signal mimic Inverse-β decay events



AD is assembled in SAB (above ground).
Muon events can be detected(Cerenkov in acrylic) .

Other ongoing AD #1 Dry Run data studies:

PMT linearity, timing, trigger efficiency, vertex reconstruction, pedestal stability, detector uniformity…. Etc.

Dry run with AD #2 has been done and data analysis started!

Status of water Cerenkov detector

- Waterproof 8” PMTs
  - The 400/1000 PMTs recycled from the MACRO experiment have been potted and tested.
  - All PMTs (R5912 and MACRO) have been tested and burned-in .
- Support frames for muon PMTs and tyvek reflectors onsite
- **Detector installation starts.**

potted & encapsulated base

MACRO PMT potting

Support frames Installation test

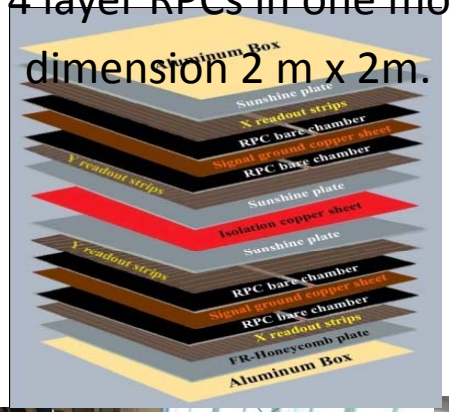
Status of RPC detector

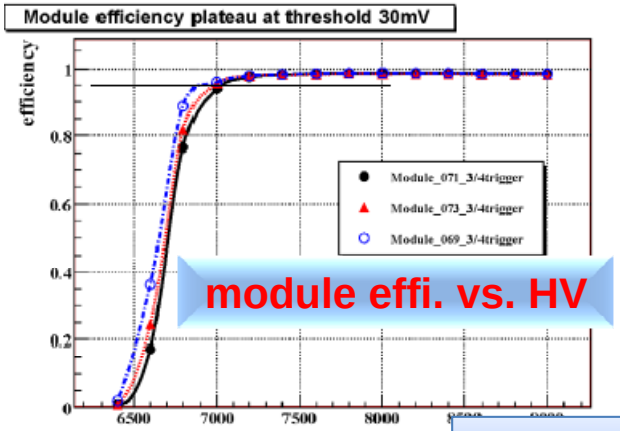
- Almost all (1600) RPC bare chambers have been produced and tested.
- Efficiencies of modules are ~98-99%. Efficiencies of all tested modules meet requirement (> 95%).
- 128 modules have been transported to Daya Bay.
- Support structure and RPC gas system installation are underway.

Gas system installation

RPC chamber design

- 4 layer RPCs in one module, dimension 2 m x 2m.





module effi. vs. HV

RPC support structure installation

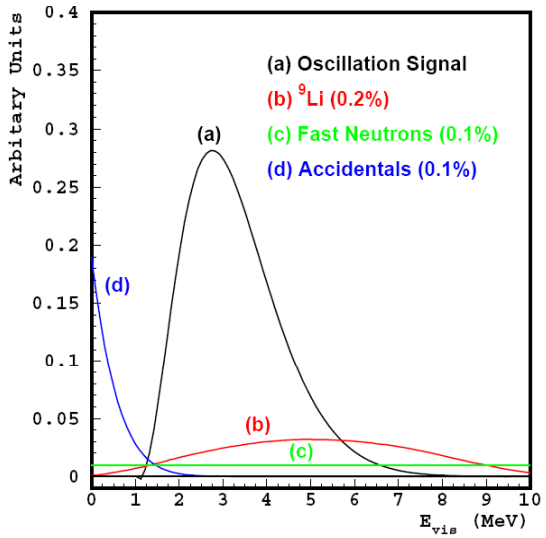
RPC modules in SAB

Expect events and background related error

Expected signal and background event rates for one detector module

	Daya Bay Near	Ling Ao Near	Far Hall
Baseline (m)	363	481 from Ling Ao 526 from Ling Ao II	1985 from Daya Bay 1615 from Ling Ao
Overburden (m)	98	112	350
Radioactivity (Hz)	<50	<50	<50
Muon rate (Hz)	36	22	1.2
Antineutrino Signal (events/day)	**840**	**740**	**90**
Accidental Background/Signal (%)	<0.2	<0.2	<0.1
Fast neutron Background/Signal (%)	0.1	0.1	0.1
^{8}He+^{9}Li Background/Signal (%)	0.3	0.2	0.2

Spectrum of backgrounds

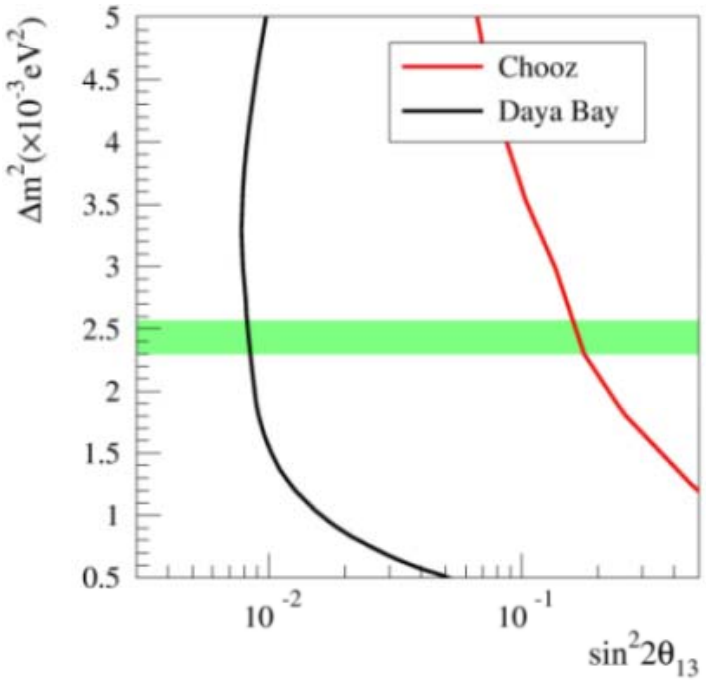


Summary of Systematic Uncertainties

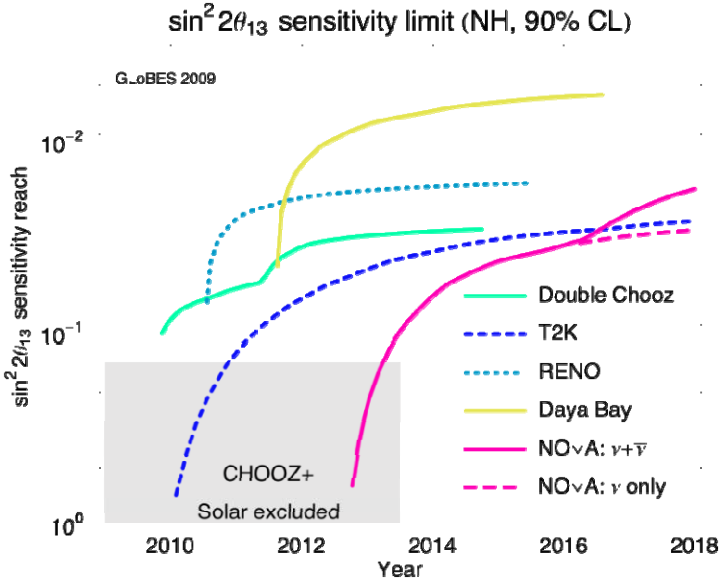
sources	Uncertainty
Reactors	0.13% (6 cores)
Detector (per module)	0.38% (baseline) 0.18% (goal)
Backgrounds	0.32% (Daya Bay near) 0.22% (Ling Ao near) 0.22% (far)
Signal statistics	0.2%

Expected sensitivity of DayaBay

- Goal: sensitivity to $\sin^2 2\theta_{13} < 0.01$;
- Measure $\sin^2 2\theta_{13}$ to 0.01 at 90% CL with 3 years' full operation as shown in solid black line. Green band shows the Δm^2 at 90% CL measured by MINOS.



(from arXiv:0907.1896; actual start dates may differ)



Daya Bay design sensitivity after ~6 months is greater than the sensitivity of any experiments currently under construction !

Summary

- **The Daya Bay Neutrino Oscillation Experiment is designed to make a precise measurement of θ_{13};**
  - The experiment samples the intense neutrino flux produced by the Daya Bay nuclear reactors in three different locations, with a total of 8 identical detectors.
  - Expected sensitivity to $\sin^2 2\theta_{13} < 0.01$.
- **The experiment is progressing steadily;**
  - The civil construction is nearing completion; the Near hall is already completed and the Far hall is being excavated
  - The first and second detectors are already assembled and data has been collected with they in dry configuration.
  - Muon system installation starts.
- **Schedule:**
  - Spring 2011: DayaBay near hall physics ready!
  - Fall 2012: all near/far halls physics ready!