Status of the Daya Bay Reactor Neutrino Experiment

HE Miao, IHEP, Beijing, China

On behalf of the Daya Bay Collaboration

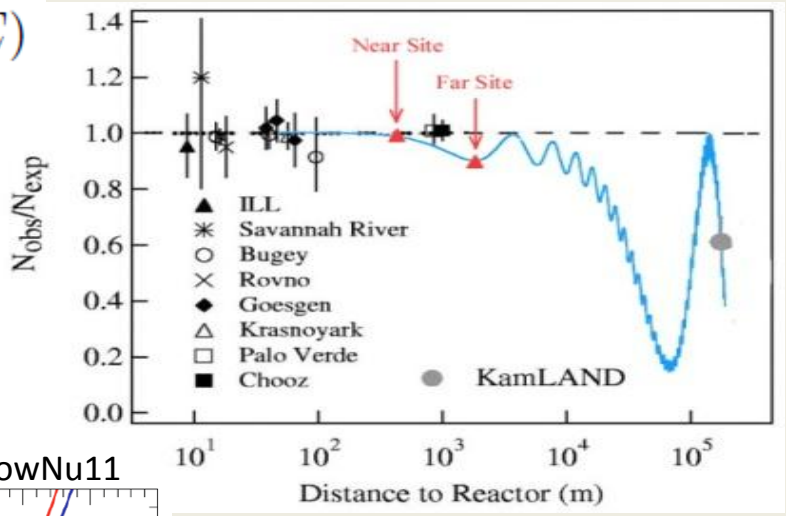
DBD11, 14th~17th Nov., Osaka, Japan

Goal of Daya Bay

- Determine θ_{13} : Last unknown mixing angle, sensitivity in $\sin^2(2\theta_{13})<0.01$
- Reactor short baseline disappearance experiment

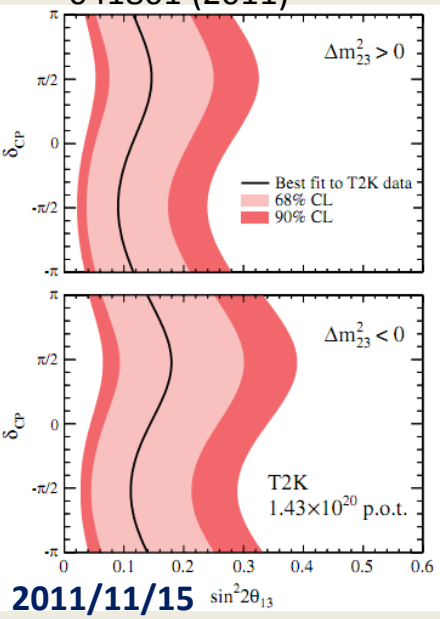
$$P(\bar{\nu}_e \to \bar{\nu}_e) \simeq 1 - \sin^2(2\theta_{13}) \sin^2(1.27\Delta m^2_{32} L/E)$$

An unambiguous measurement of θ_{13}, no interference with CP violation phase or matter effects

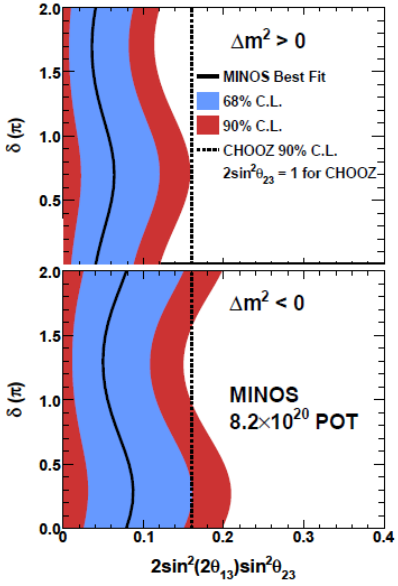


- Recent knowledge of θ_{13}

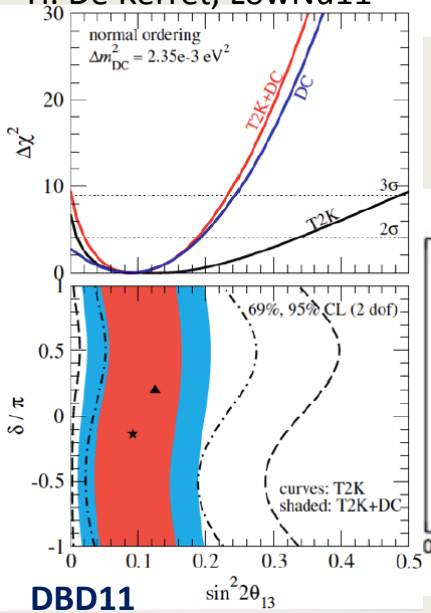
T2K:PRL 107, 041801 (2011)



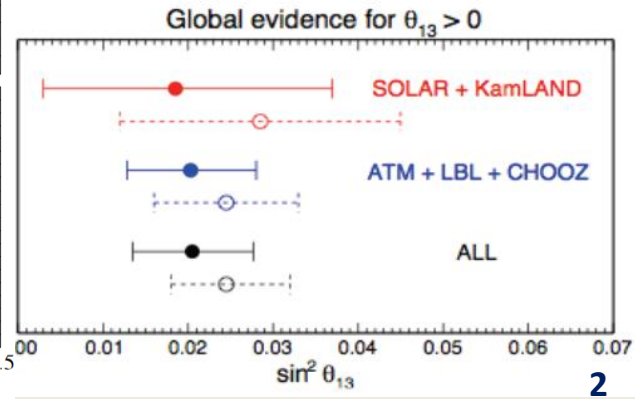
MINOS: PRL 107, 181802 (2011)



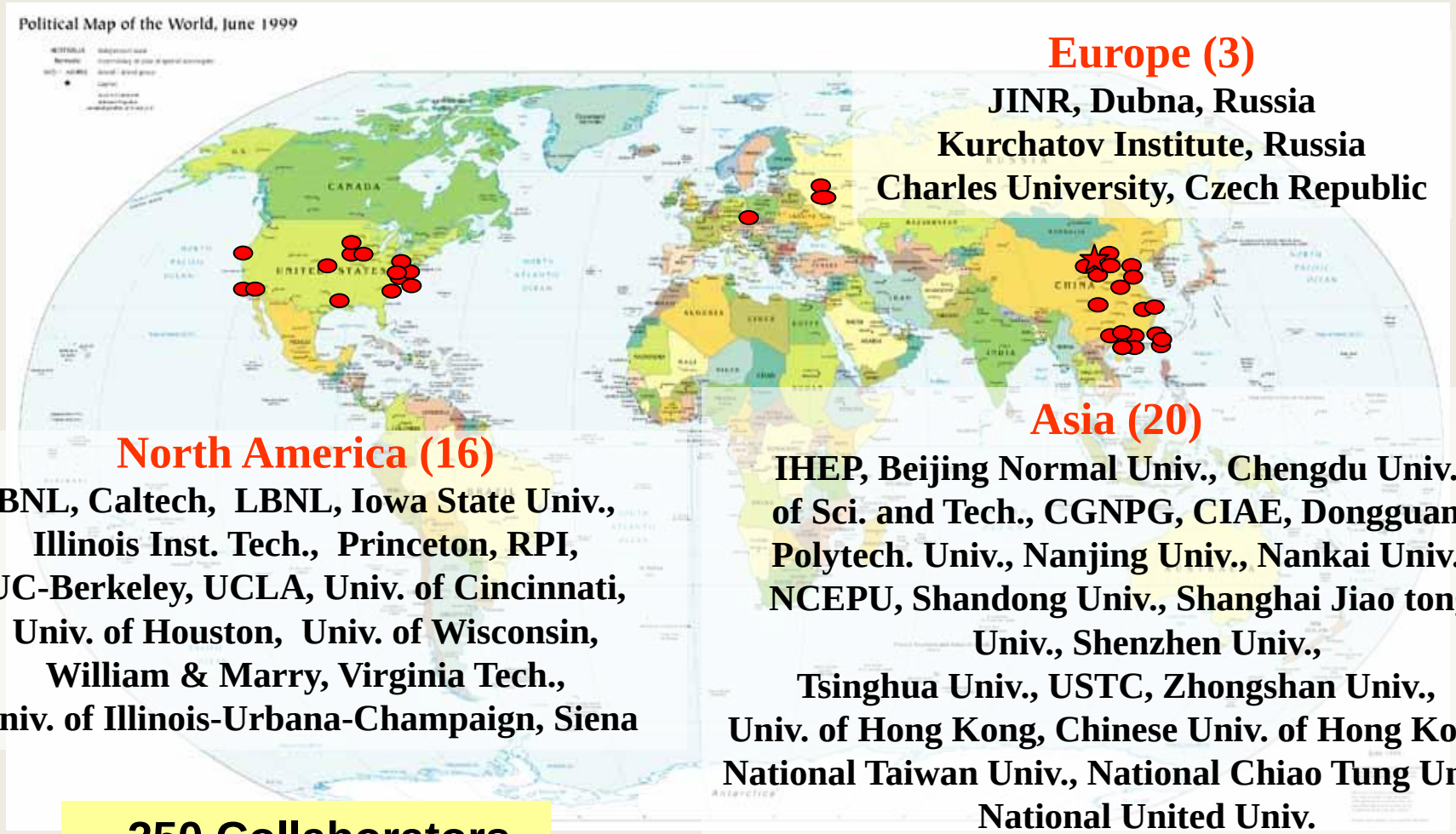
Double Chooz: H. De Kerret, LowNu11



Fogli et al., arXiv:1106.6028



Daya Bay Collaboration



Europe (3)

JINR, Dubna, Russia
Kurchatov Institute, Russia
Charles University, Czech Republic

North America (16)

BNL, Caltech, LBNL, Iowa State Univ., Illinois Inst. Tech., Princeton, RPI, UC-Berkeley, UCLA, Univ. of Cincinnati, Univ. of Houston, Univ. of Wisconsin, William & Marry, Virginia Tech., Univ. of Illinois-Urbana-Champaign, Siena

Asia (20)

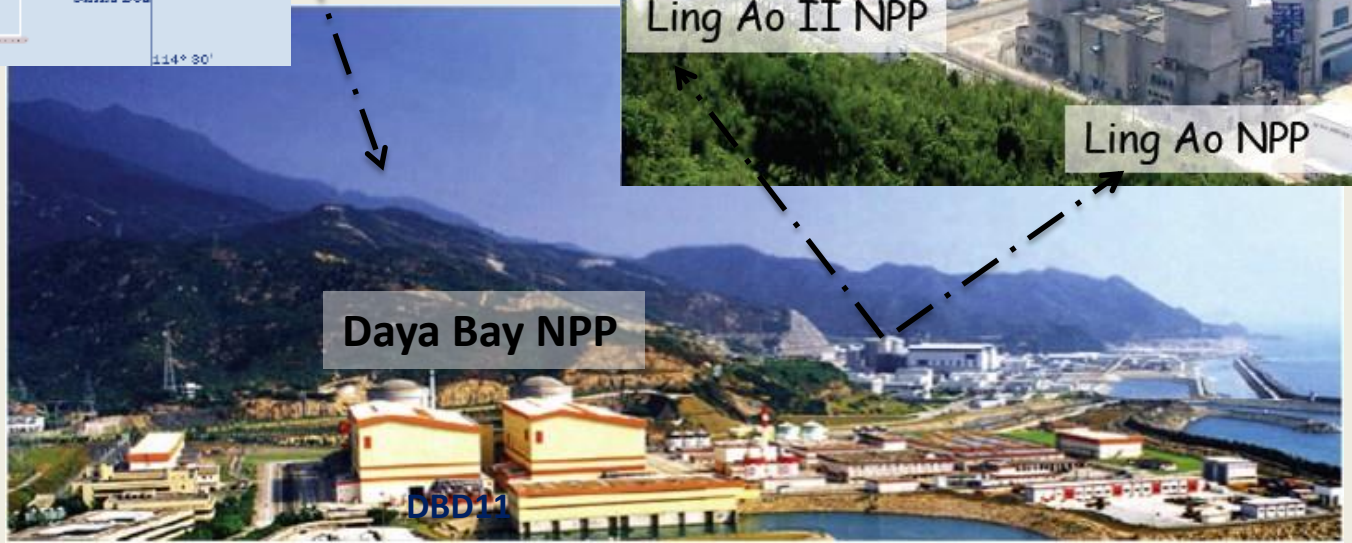
IHEP, Beijing Normal Univ., Chengdu Univ. of Sci. and Tech., CGNPG, CIAE, Dongguan Polytech. Univ., Nanjing Univ., Nankai Univ., NCEPU, Shandong Univ., Shanghai Jiao tong Univ., Shenzhen Univ., Tsinghua Univ., USTC, Zhongshan Univ., Univ. of Hong Kong, Chinese Univ. of Hong Kong, National Taiwan Univ., National Chiao Tung Univ., National United Univ.

~250 Collaborators

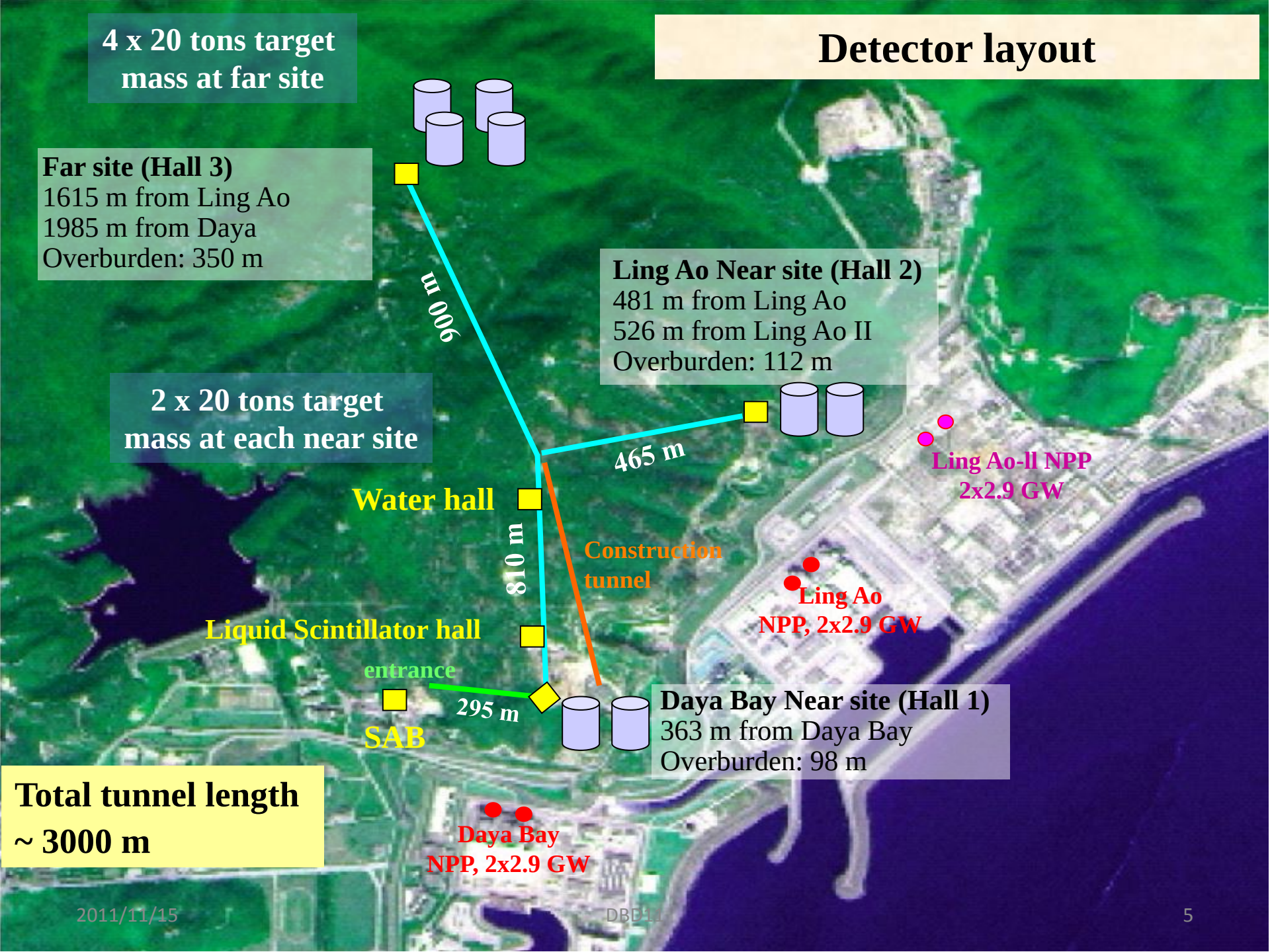
Experiment site and nuclear power plant

- Very powerful nuclear power plant:
  - Daya Bay: 2 X 2.9GW
  - Ling Ao I: 2 X 2.9GW
  - Ling Ao II: 2 X 2.9GW (already in operation)
- Total power: ~17.4 GW

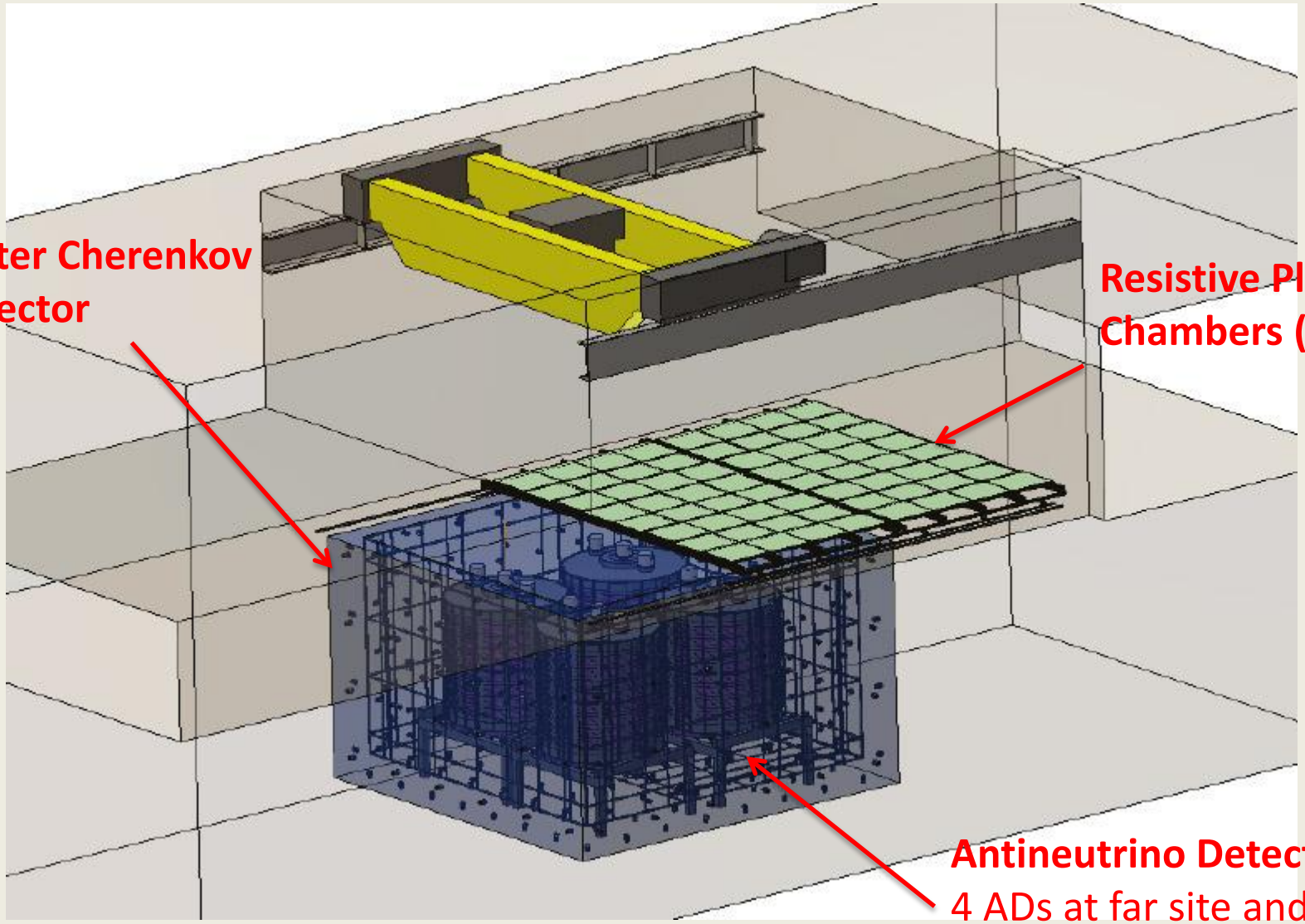
Southern China



Detector layout

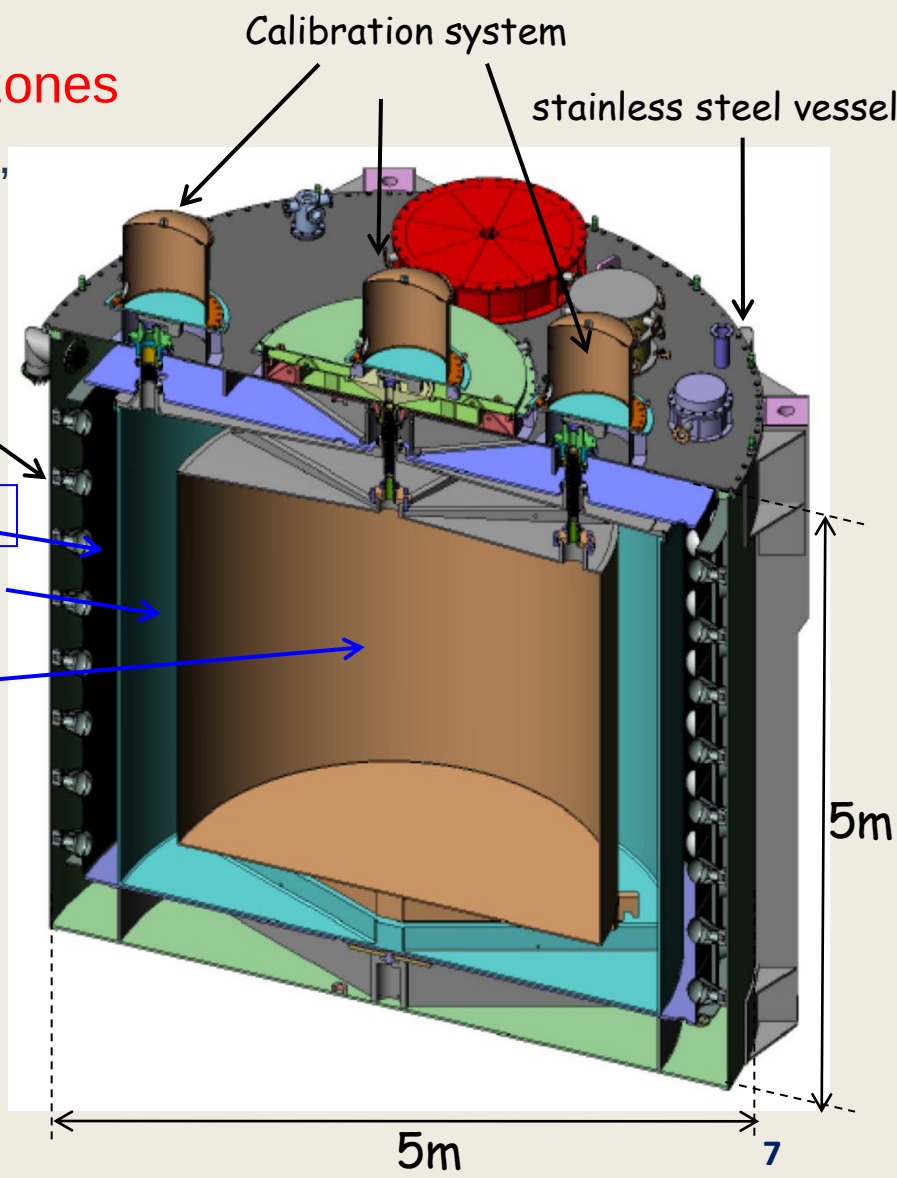


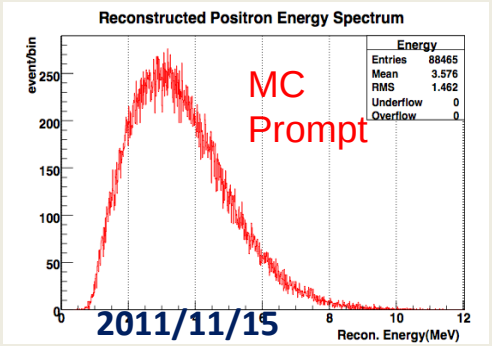
Experiment hall

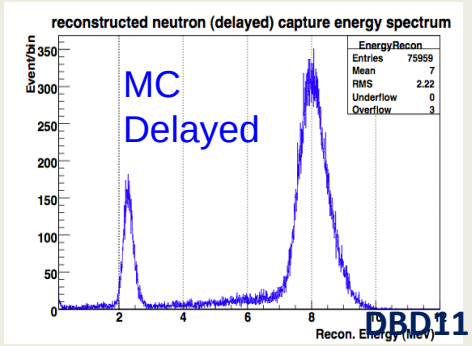


Antineutrino Detectors (AD)

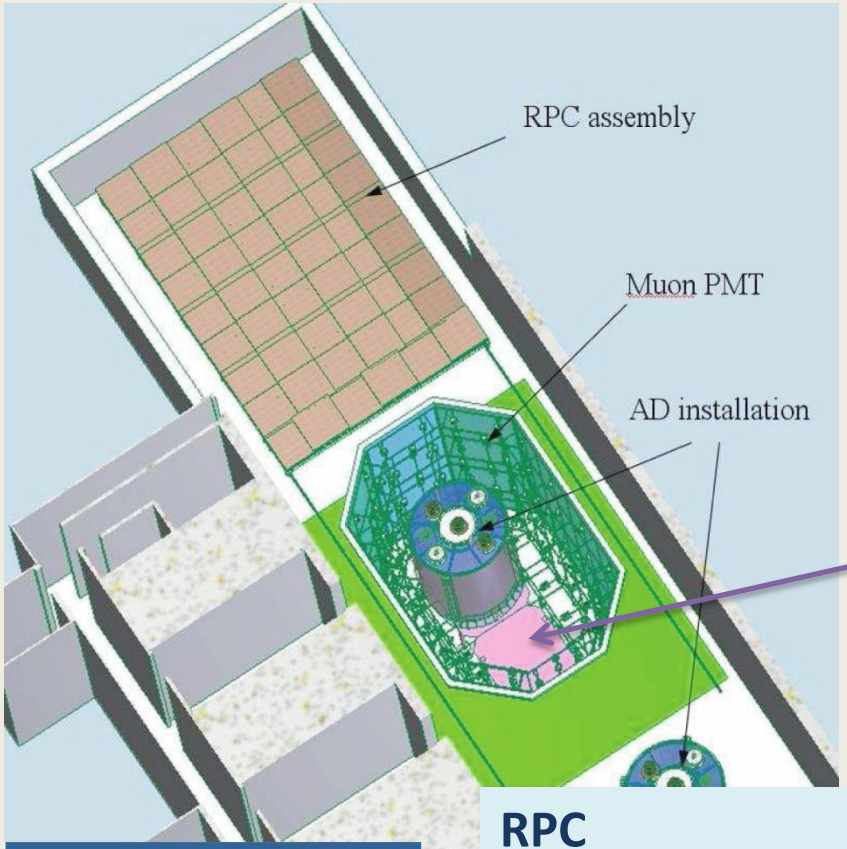
- 8 identical modules at 3 sites
- Each module consists of 3 cylindrical zones
  - inner acrylic vessel (IAV), 20ton Gd-LS, *antineutrino target*
  - outer acrylic vessel (OAV), 20ton LS, containing escaped gammas from IAV
  - stainless steel vessel (SSV), 40ton mineral oil, radiation shield
- 192 8” PMTs/module
- Reflectors on the top and bottom
- Expected antineutrino signal from MC







Muon system



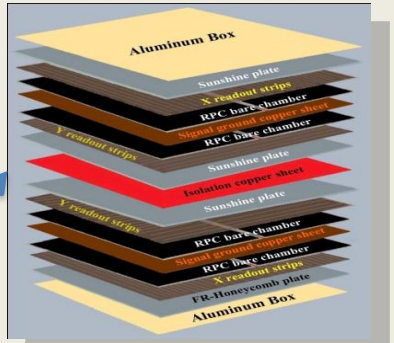
- Combined measurement of muon by the Water Cherenkov detector and the Resistive Plate Chambers (RPC)
- High efficiency: ε > (99.5 +/- 0.25)%

Water Cherenkov (Water Pool)

- Provide at least 2.5m shield against radioactivity and neutron
- Divided into two parts, forming two independent detectors

RPC

- 54 modules at near sites and 81 modules at far site
- 2 extra telescope modules at each site
- 4 layers with X or Y strip in each module

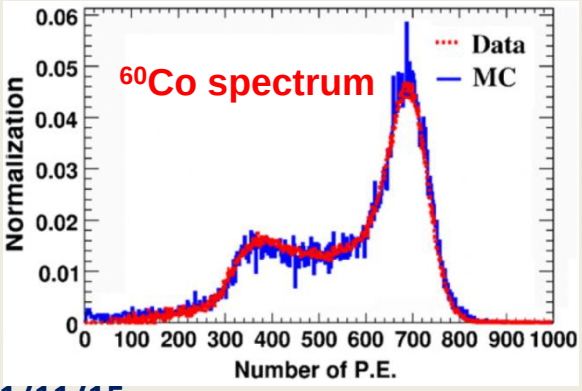


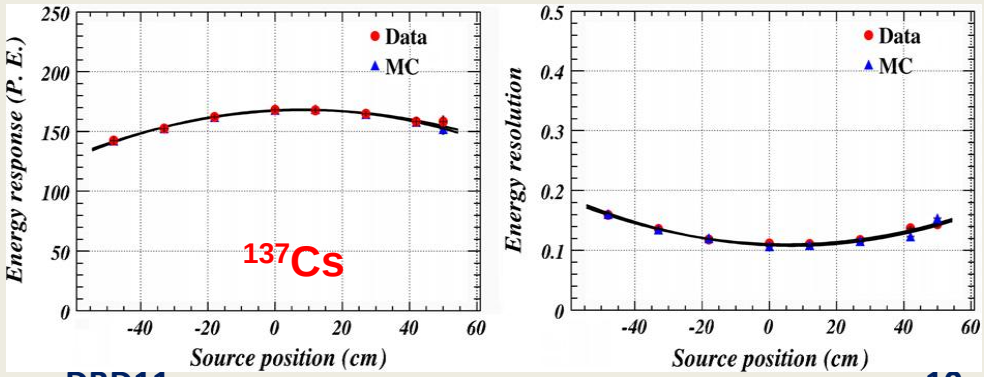
Detector construction and installation

AD Prototype

Nucl. Instrum. Meth. A Volume 602, 489-493 (2009)

- **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 property and stability





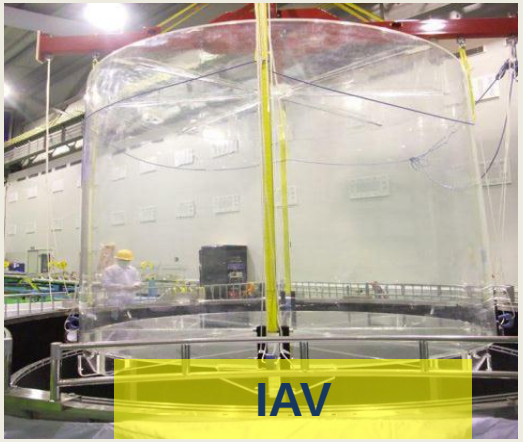
AD installation


SSV


Bottom reflector


OAV


PMT ladder


IAV

AD Installation in the clean room of the Surface Assembly Building (SAB)

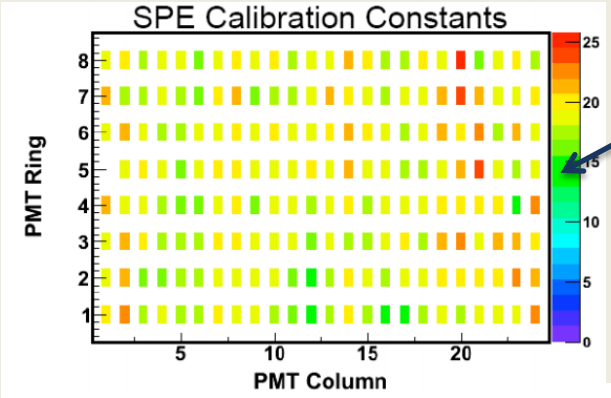

Top reflector


SSV cover


Calibration system

AD dry run

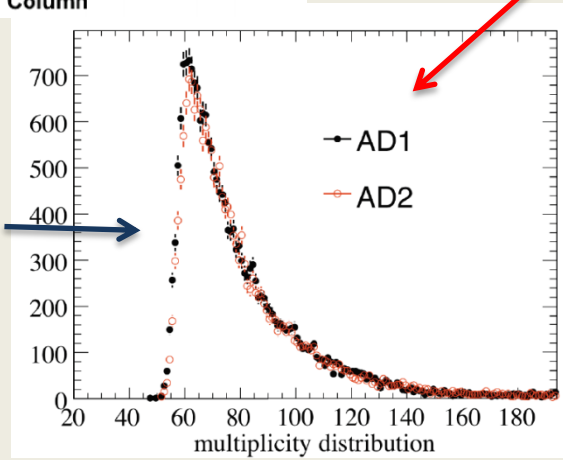
- An integration test for the first pair of ADs before filling with liquid
  - AD + electronics + DAQ+ slow control + data storage + network transfer + database + online/offline analysis



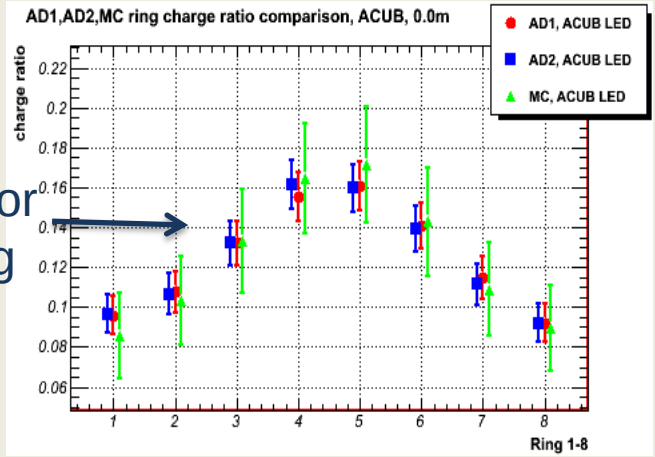
All PMTs are working

Functionally identical ADs!

Number of fired PMTs by muon



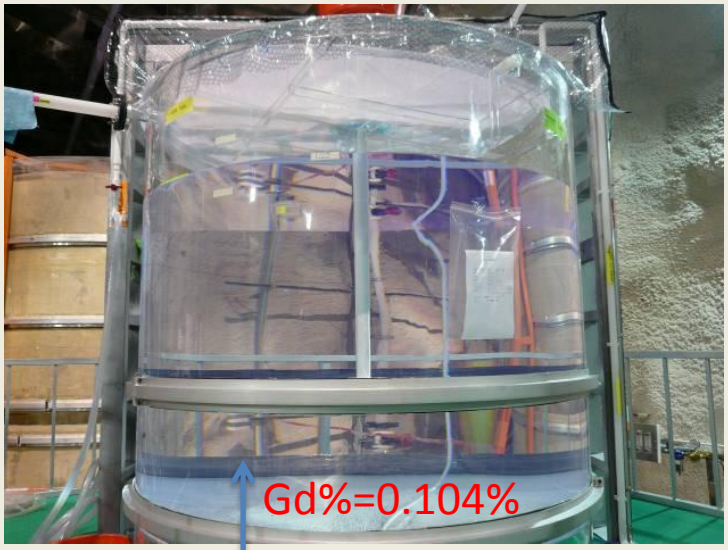
Charge ratio for each PMT ring



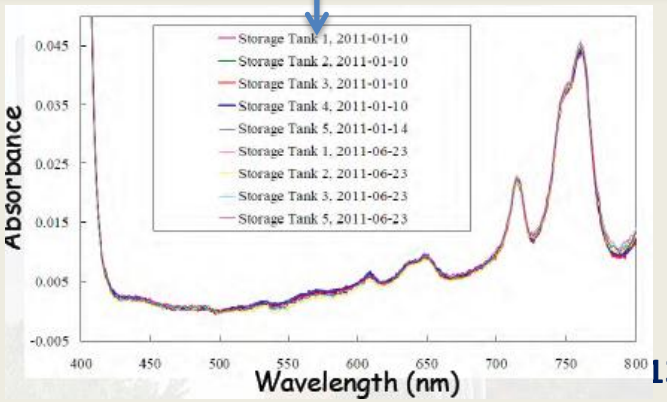
Gd-doped liquid scintillator

Nucl. Instrum. Meth. A Volume 578, 329-339 (2007)
Nucl. Instrum. Meth. A Volume 584, 238-243 (2008)

- Daya Bay uses 185 ton 0.1% Gd-doped LS:
  Gd-TMHA + LAB + 3g/L PPO + 15mg/L bis-MSB
- Stability of the Gd-LS has been tested with a prototype detector since Jan. 2007
- All Gd-LS produced in 50 4-ton batches and mixed in one reservoir on-site, to ensure the samples uniform for all ADs.



- 1st batch of 4-ton Gd-LS in Oct. 2010
- Mixing equipment in the underground hall
- Monitoring of Gd-LS in underground storage tanks

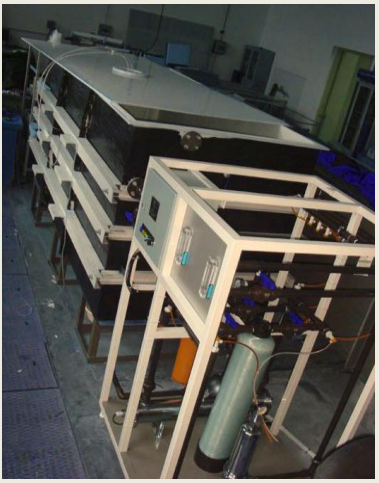


GDLS/LS filling

- Requirement: precise mass, equal liquid level and tem., chemical compatibility, …
- First two pairs of ADs have been successfully filled

Water pool prototype

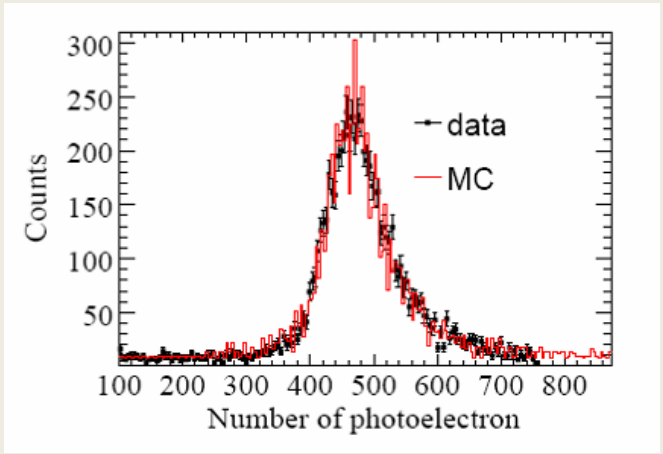
Chinese Phys. C33 (2009) 567-571

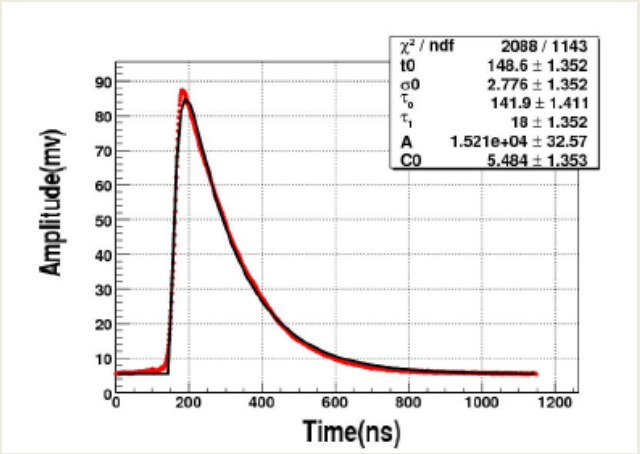


circulation

- Purpose: to study pure water circulation, material compatibility, detector performance, …
- Reach: Established a water circulation model for purification system design. Tyvek reflectivity 99%, water attenuation length ~80m with the circulation system.
- MC modeling for light transport & light collection

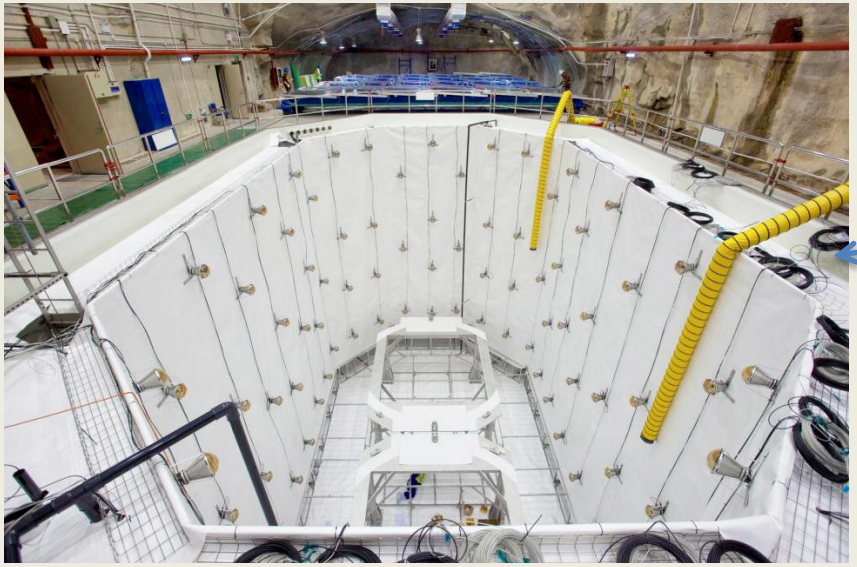
2.8x1.2x1.3 m^3 water tank





PMT signal with reflected photons

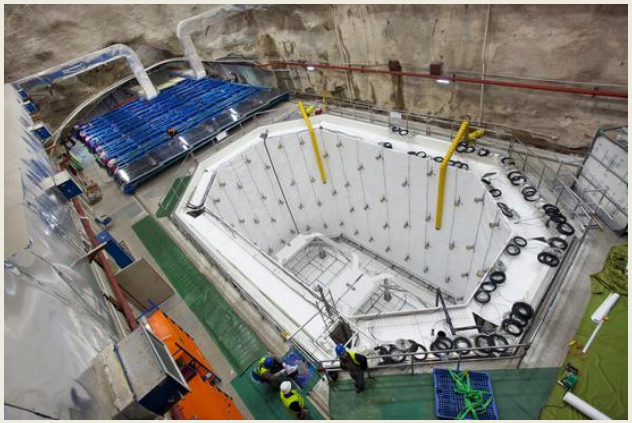
Water pool Installation

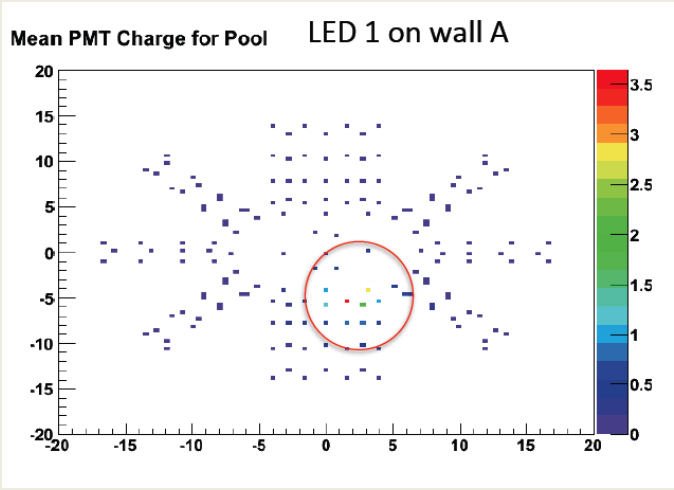


Installation in Hall 1 is finished

Dry water pool test

- Goals:
  - Check the hardware status
  - LED calibration system
  - Cover light tightness
  - Basic detector performances



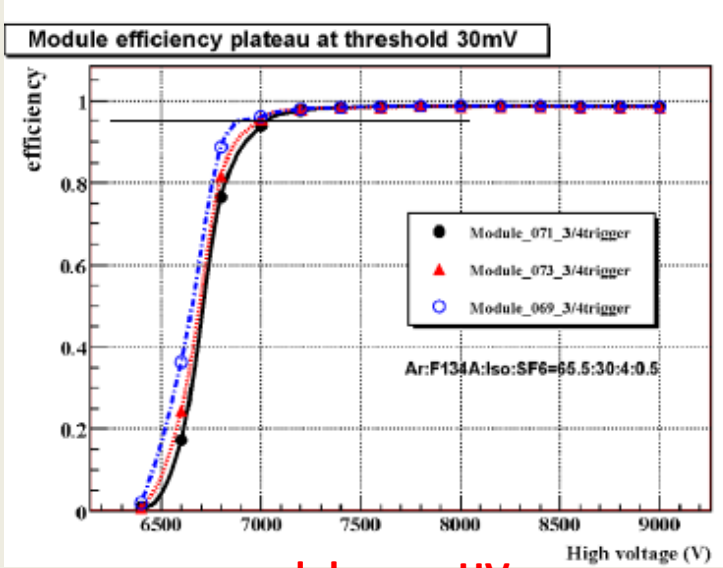


RPC production and test

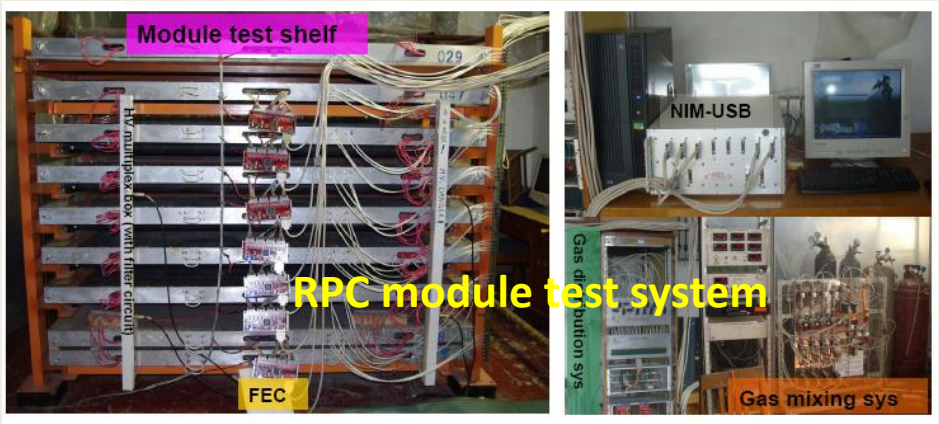
Nucl. Instrum. Meth. A Volume 583, 278-284 (2007)

Chinese Physics C 2010 34 (08): 1116-1121

- Almost all RPC bare chambers have been produced and tested.
- Efficiencies of all tested modules meet requirement (> 95%).
- 176 modules have been transported to Daya Bay.



module ε vs. HV



RPC module test system

RPC support structure

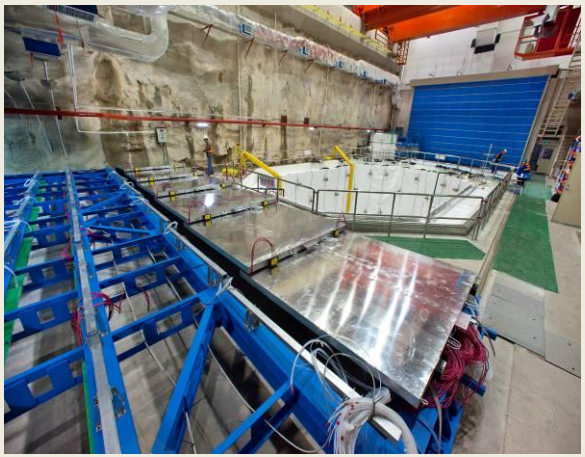
transportation

RPC modules in SAB

RPC installation

RPC supporting structure

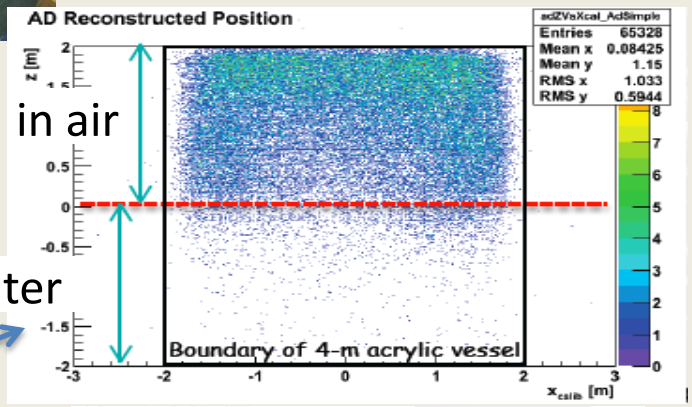
Install modules

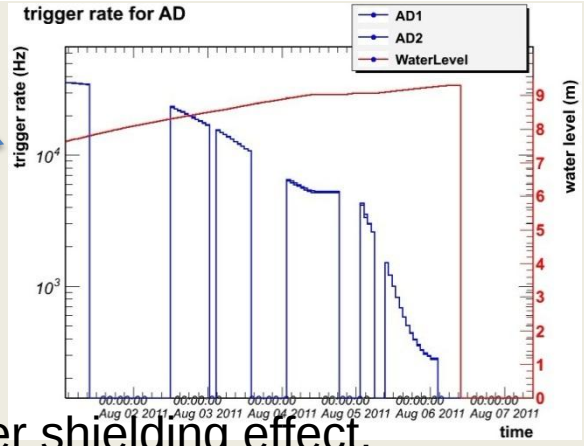


Gas system

Fully installed RPC

Hall 1 detector installation

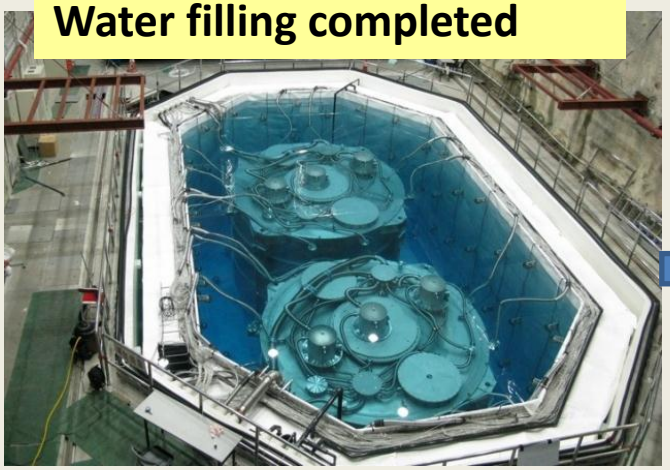




Clear demonstration of the water shielding effect.

Hall 1 detector installation

Water filling completed



Water pool covered

Covered by RPC

Hall 1 installation was finished and started taking data on Aug. 15!

Status of Ling Ao and Far Hall

Ling Ao Hall

Being installed

Far Hall

Almost done with installing the infrastructure

Offline analysis and hall 1 detector performances

Offline data processing

Data transfer monitor

Data Archive, LBNL, Berkeley, USA

Data Archive IHEP, Beijing, China

Event Data

SPADE

Onsite disk

Online database

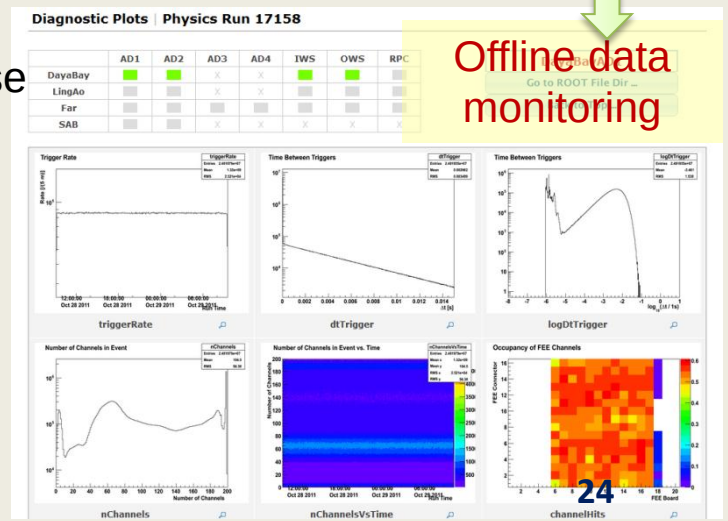
Detector Control System Database

Onsite database

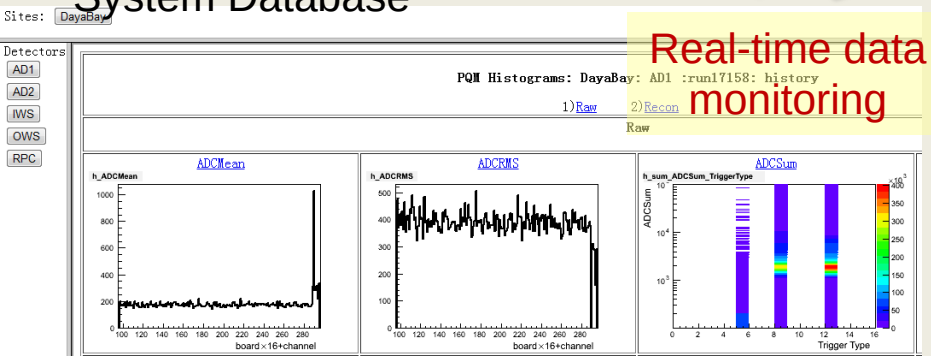
Offline database

Offline analysis（NuWa）

Offline data monitoring



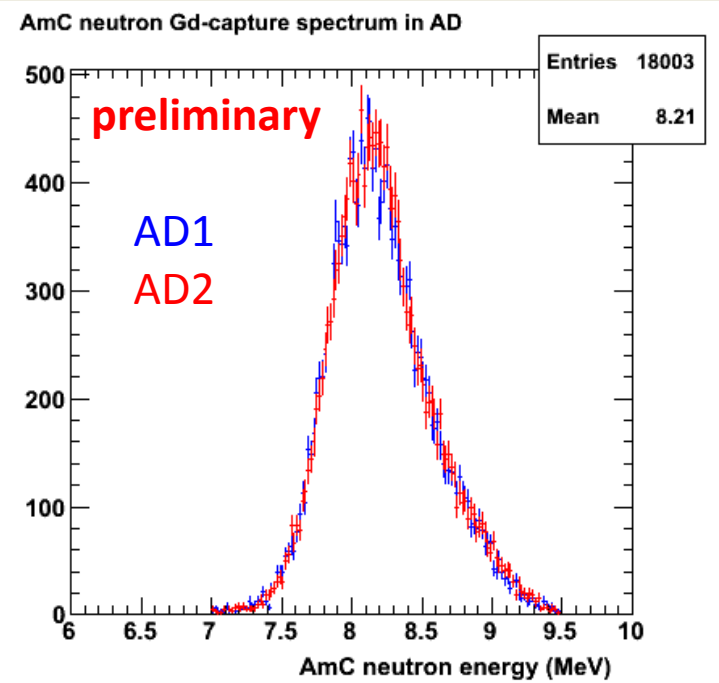
Real-time data monitoring



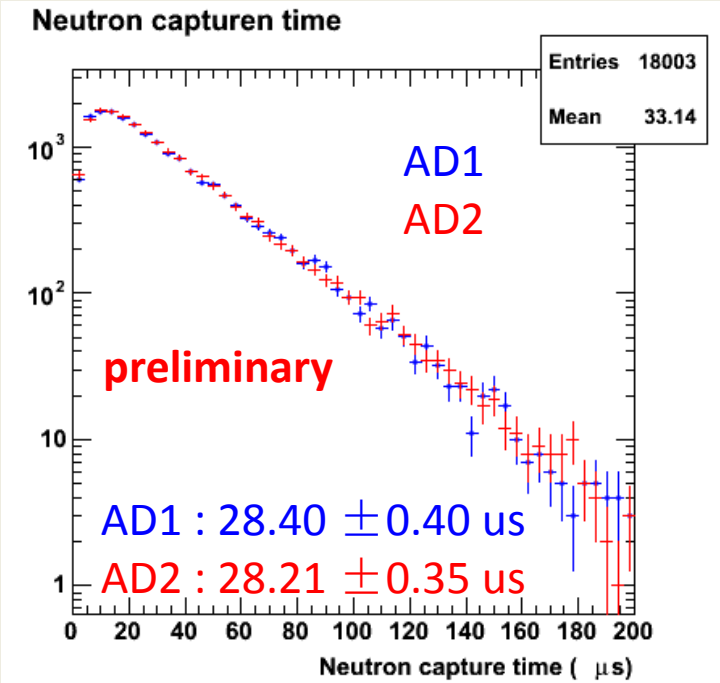
Detector performance(1)

Am-C Source at the center of AD

Neutron-capture energy spectrum

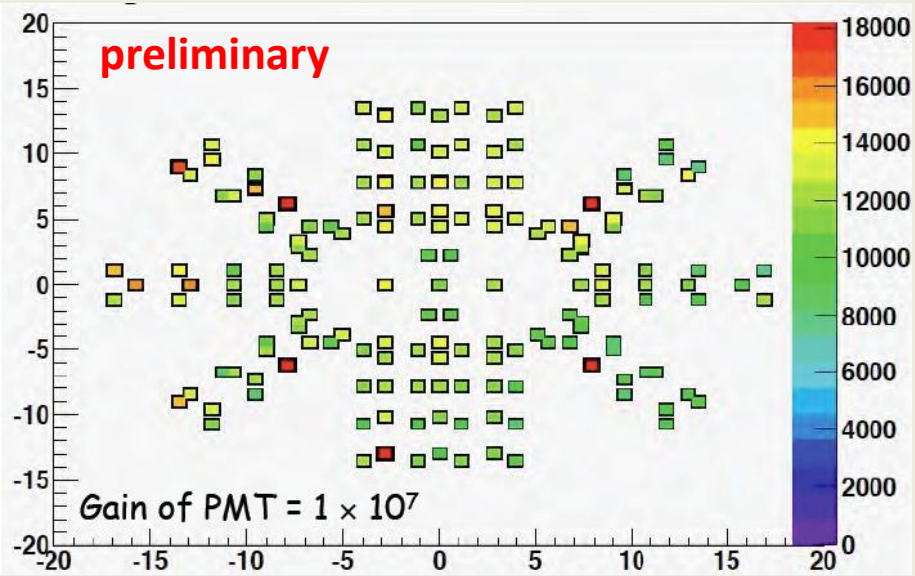


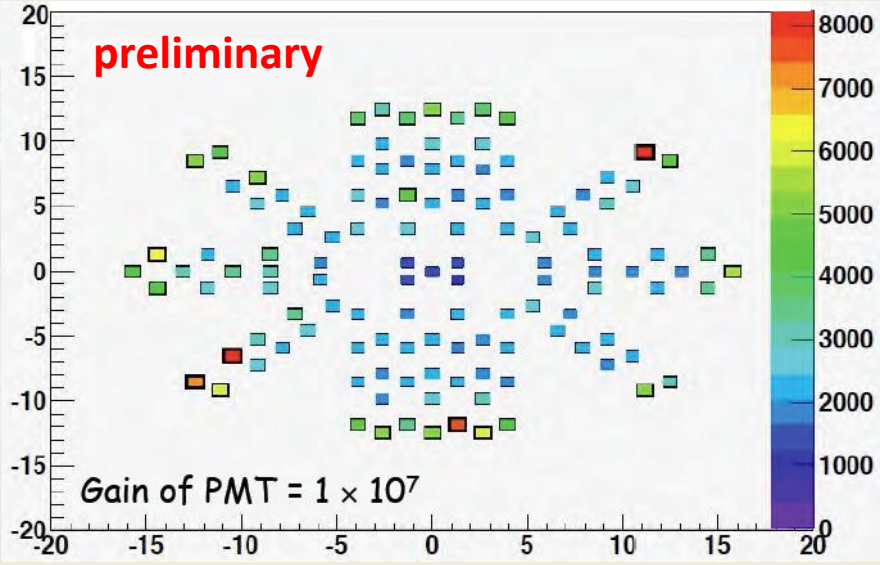
Neutron capture time



Detector performance(2)

- Hall 1 Water Cherenkov detectors PMT single rate



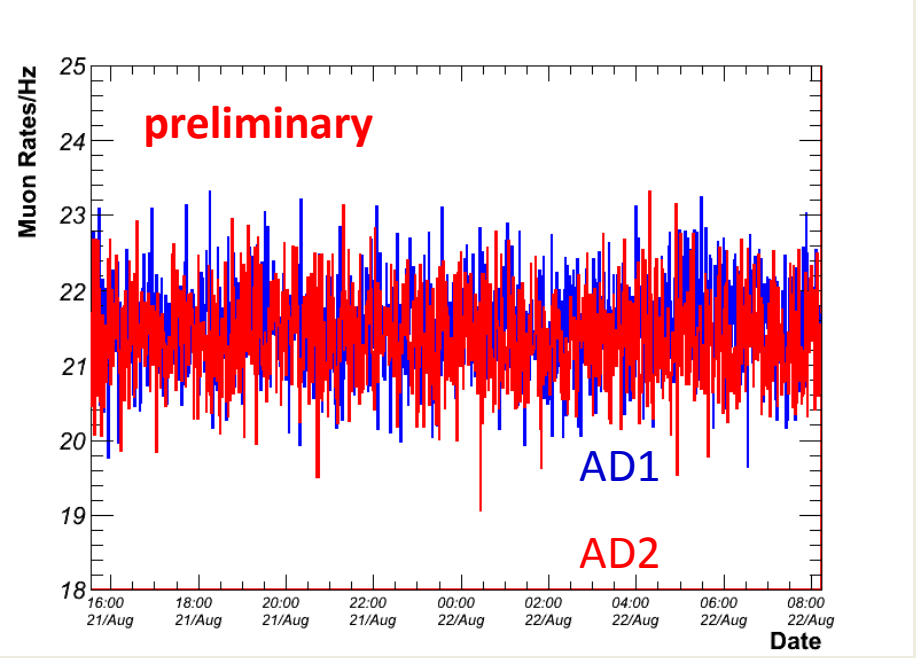


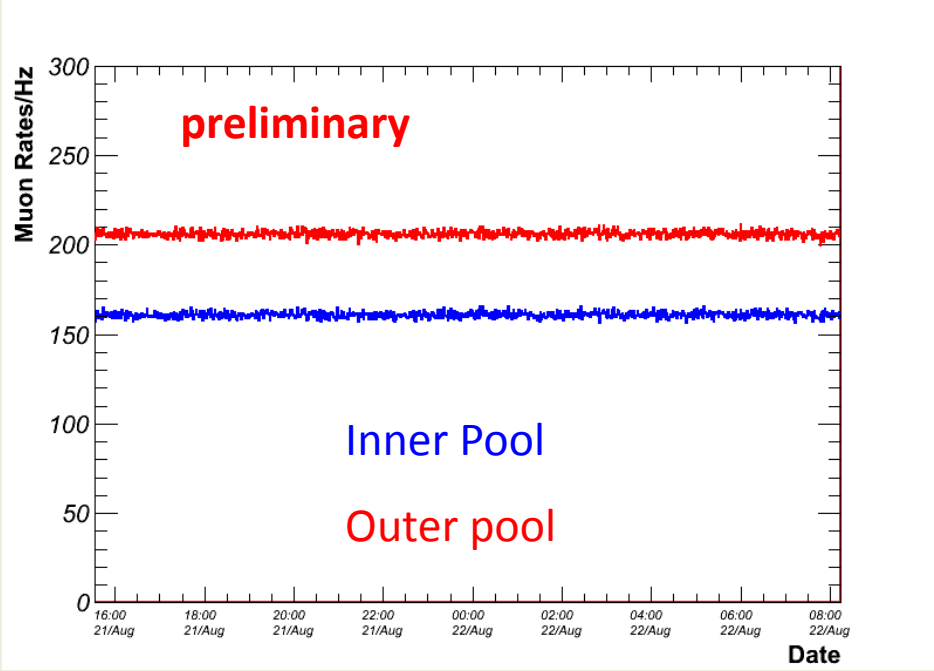
PMT single rate requirement <50 kHz:

- Observed rate is less than our requirements.

Detector performance(3)

Hall 1 Muon rate

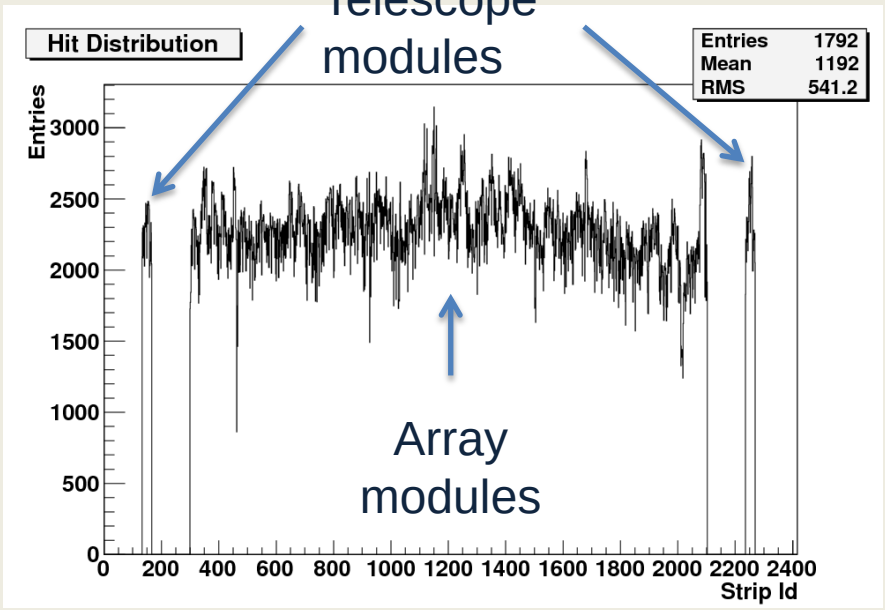




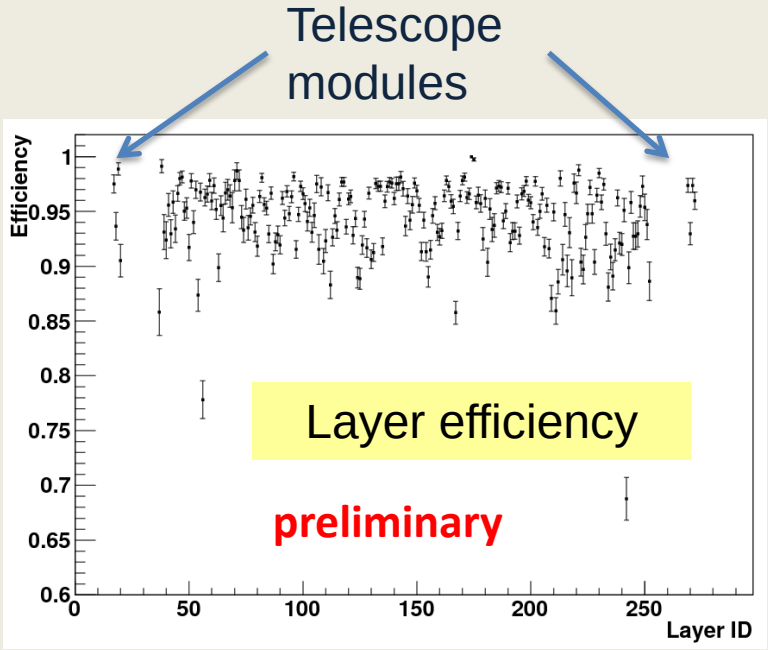
Detector performance(4)

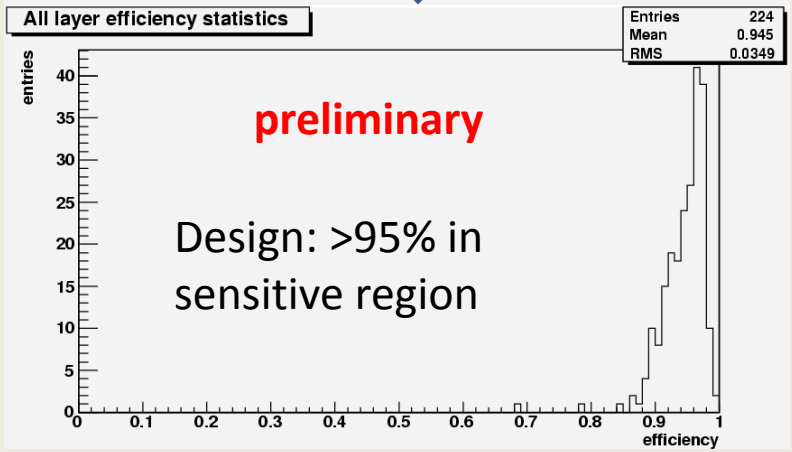
Hall 1 RPC

Hit map



No dead strip/channel





Summary and prospective

- Hall 1 started taking data since Aug 2011
- Hall 2 being installed
- Hall 3 almost done with installing the infrastructure
- Full experiment will start running in summer 2012!