Muon Veto System and Backgrounds of the Daya Bay Experiment

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(on behalf of the Daya Bay Collaboration)

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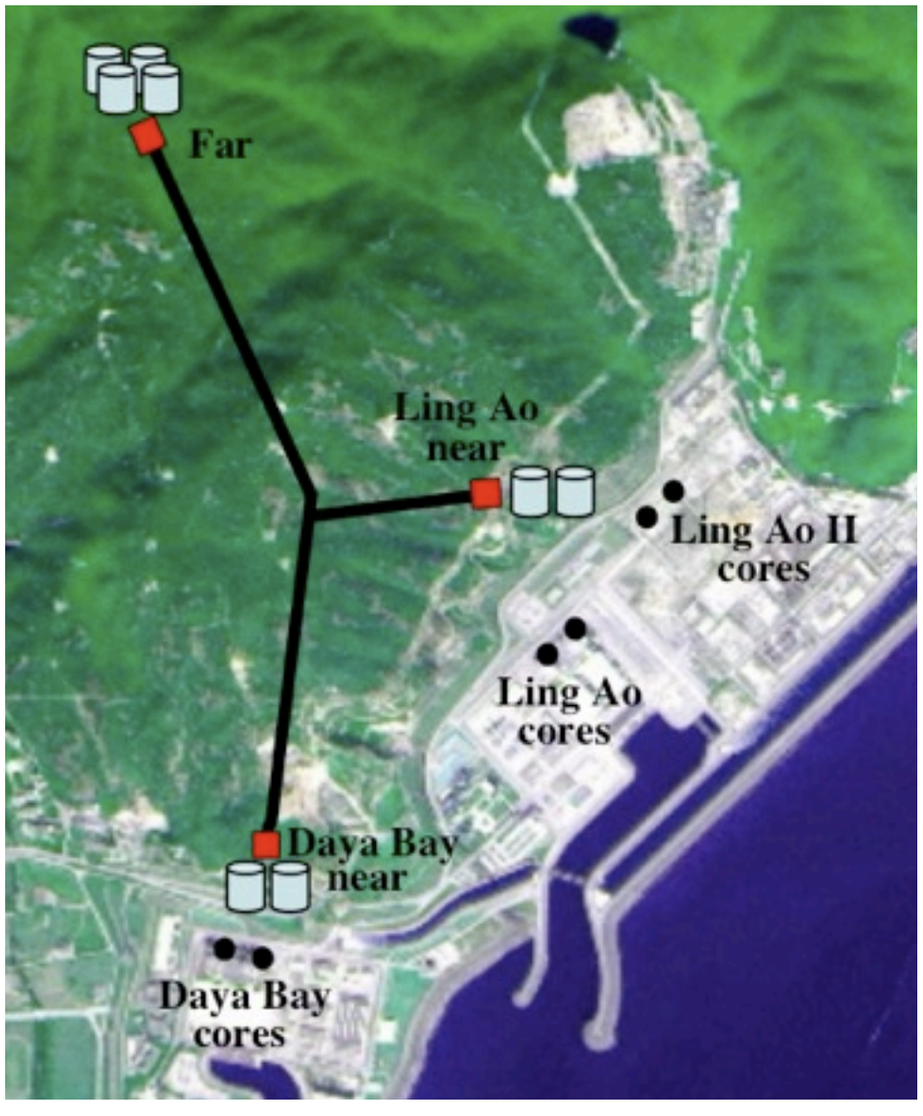
Outline

- Brief Introduction to Daya Bay
    - More detail in Mike McFarlane's talk (Saturday P1.4)
- Potential Backgrounds
- Muon Veto System
- Summary

Daya Bay Experiment

The goal of the Daya Bay reactor neutrino experiment:
sensitivity of $\sin^2 2\theta_{13}$ <0.01 at 90%CL.



Location:

Daya Bay, Guangdong, China

Baselines:

350m (DYB near)
500m (LA near)
1.6km/1.9km (far from LA / DYB)

Overburden:

112m / 98m (LA / DYB near sites)
350m (far site)

Reactors:

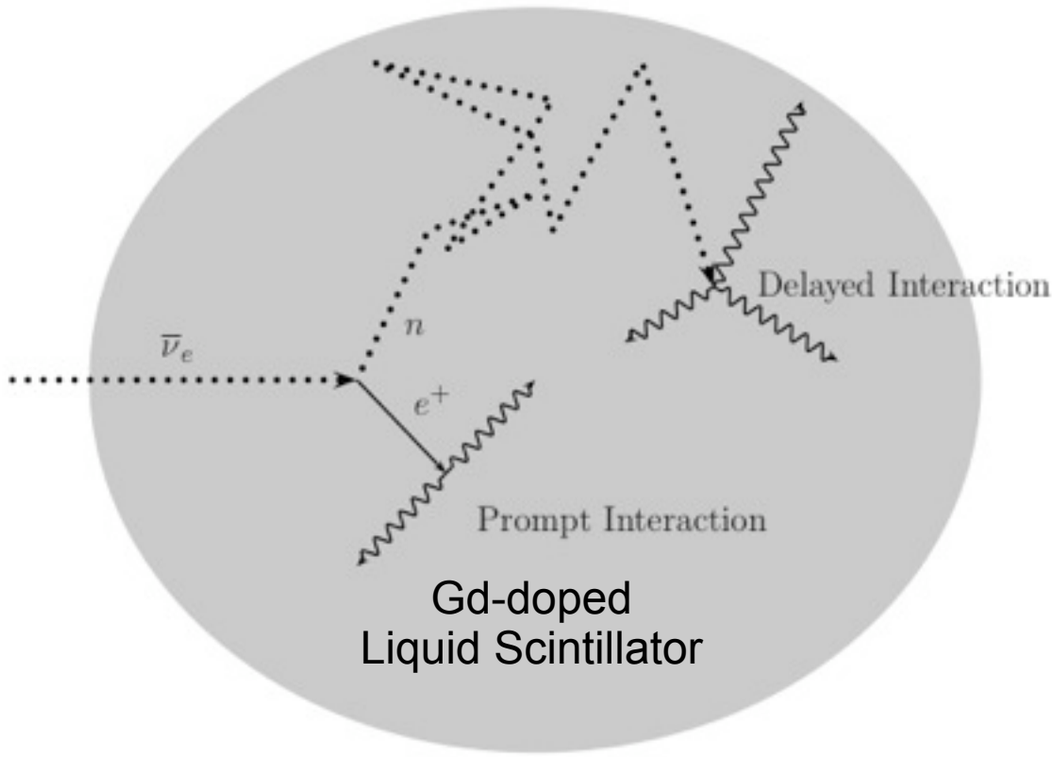
4 cores, 11.6 GW_{th} (current)
6 cores, 17.4 GW_{th} (2011)

Inverse Beta Decay Signal

prompt $e^+ + e^- \rightarrow 2\gamma$

$$\bar{\nu}_e + p \rightarrow e^+ + n$$

delayed H or Gd capture

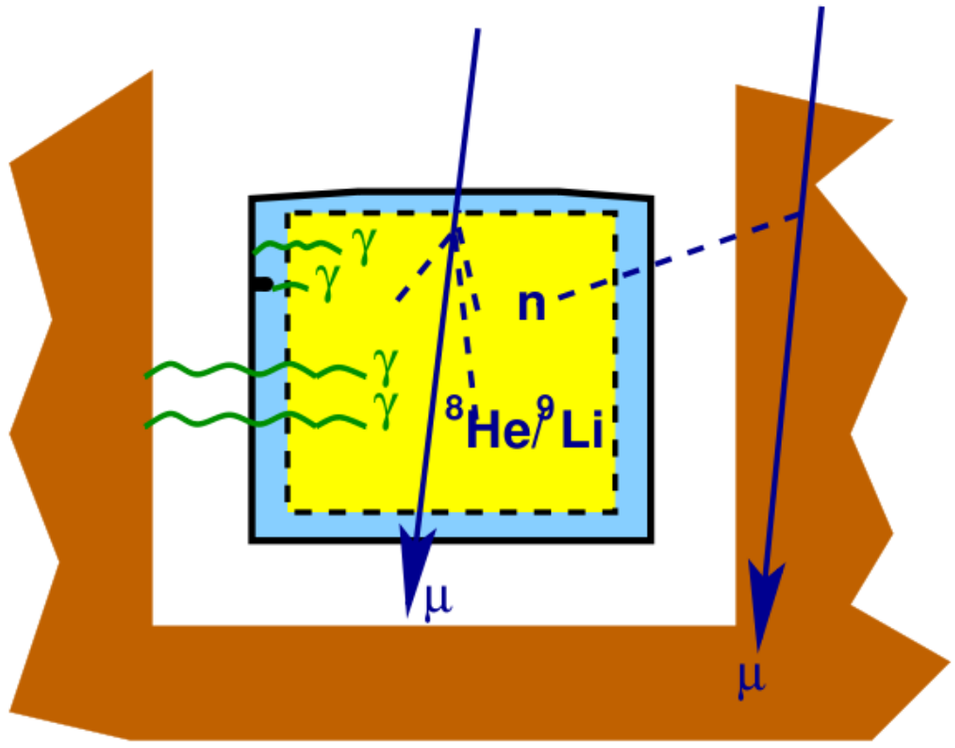


Mean neutron capture time: ~30μs

Delayed event provides powerful background-rejection

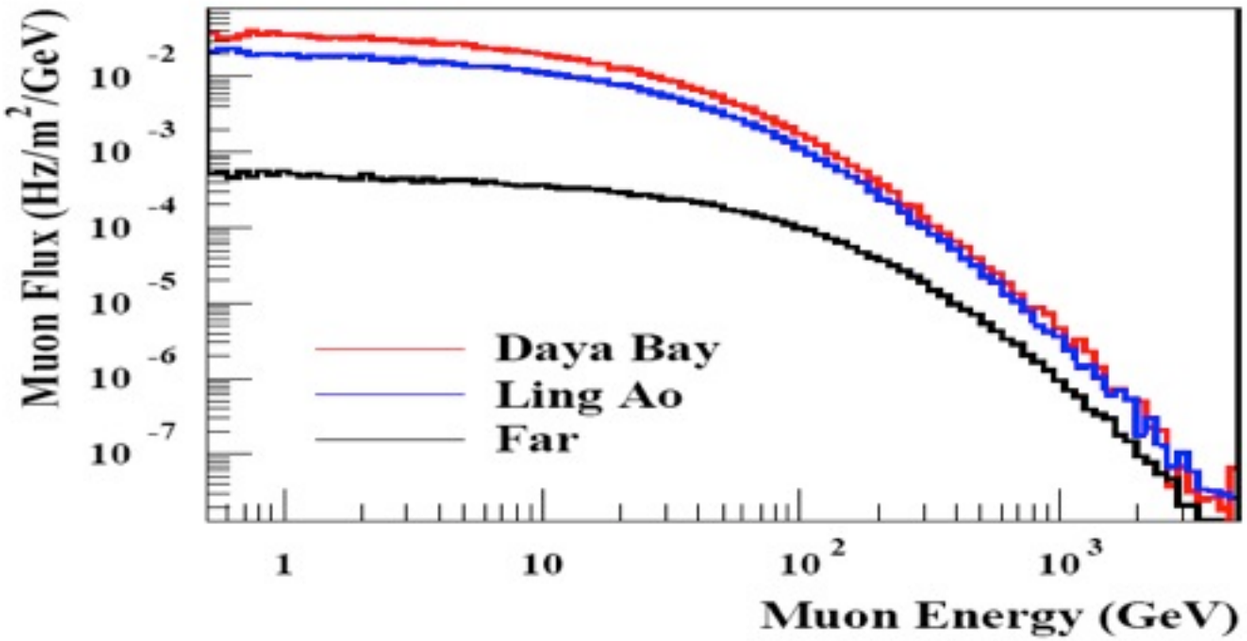
Backgrounds

- Accidental background
  - Natural radioactivity faking prompt and delayed signal.
  - Untagged neutrons.
- Fast neutron background
  - Prompt signal from proton recoil.
  - Delayed signal from neutron capture.
- $^{9}Li/^{8}He$ from cosmic muons
  - Long lived (1.8s and 1.2s).
  - Beta decay followed by neutron emission mimics IBD signal.



Cosmic Muons

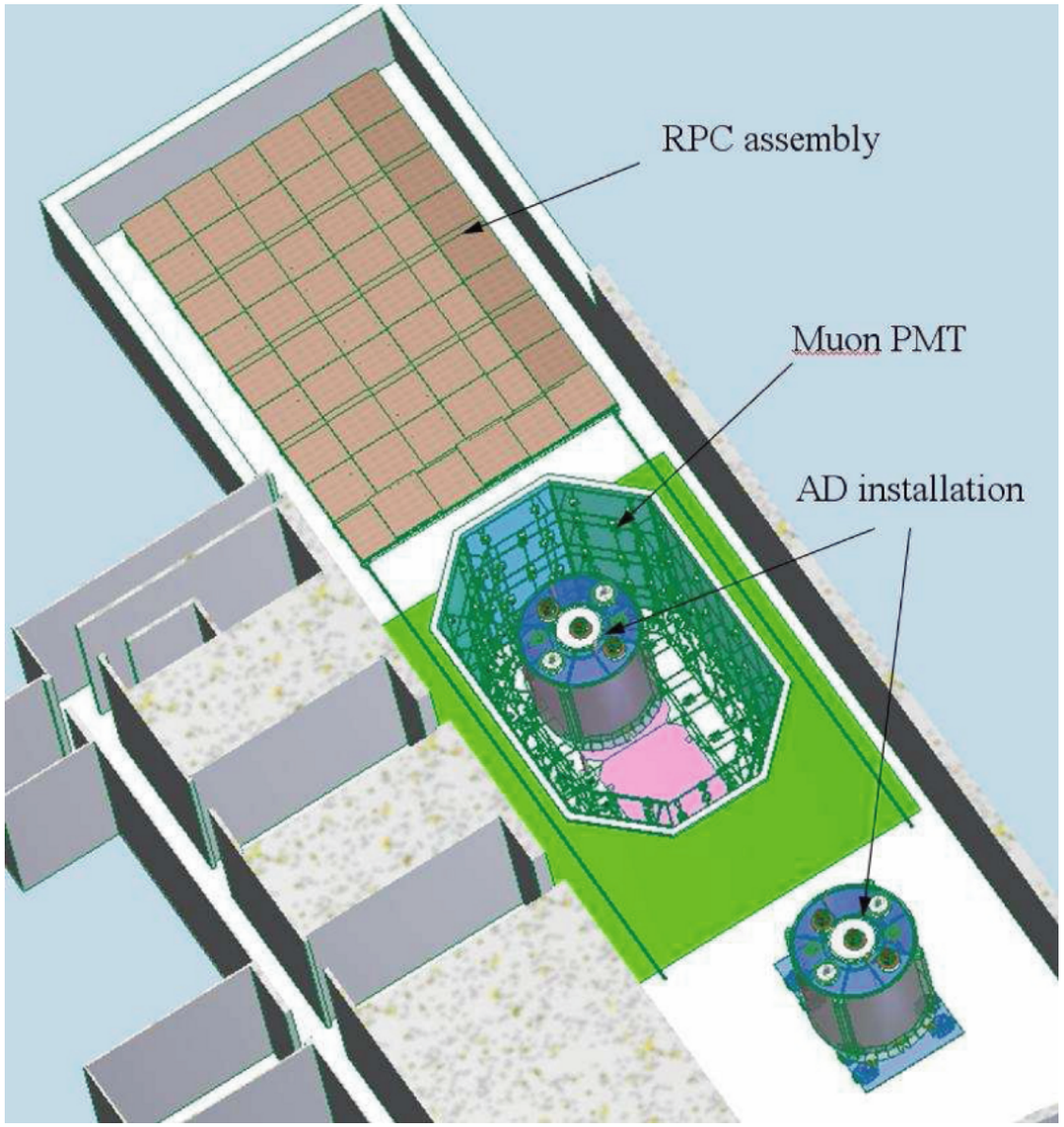
Detailed topo map, modified Gaisser formula, and MUSIC



⇦ **Expected Muon Flux from Simulation.**

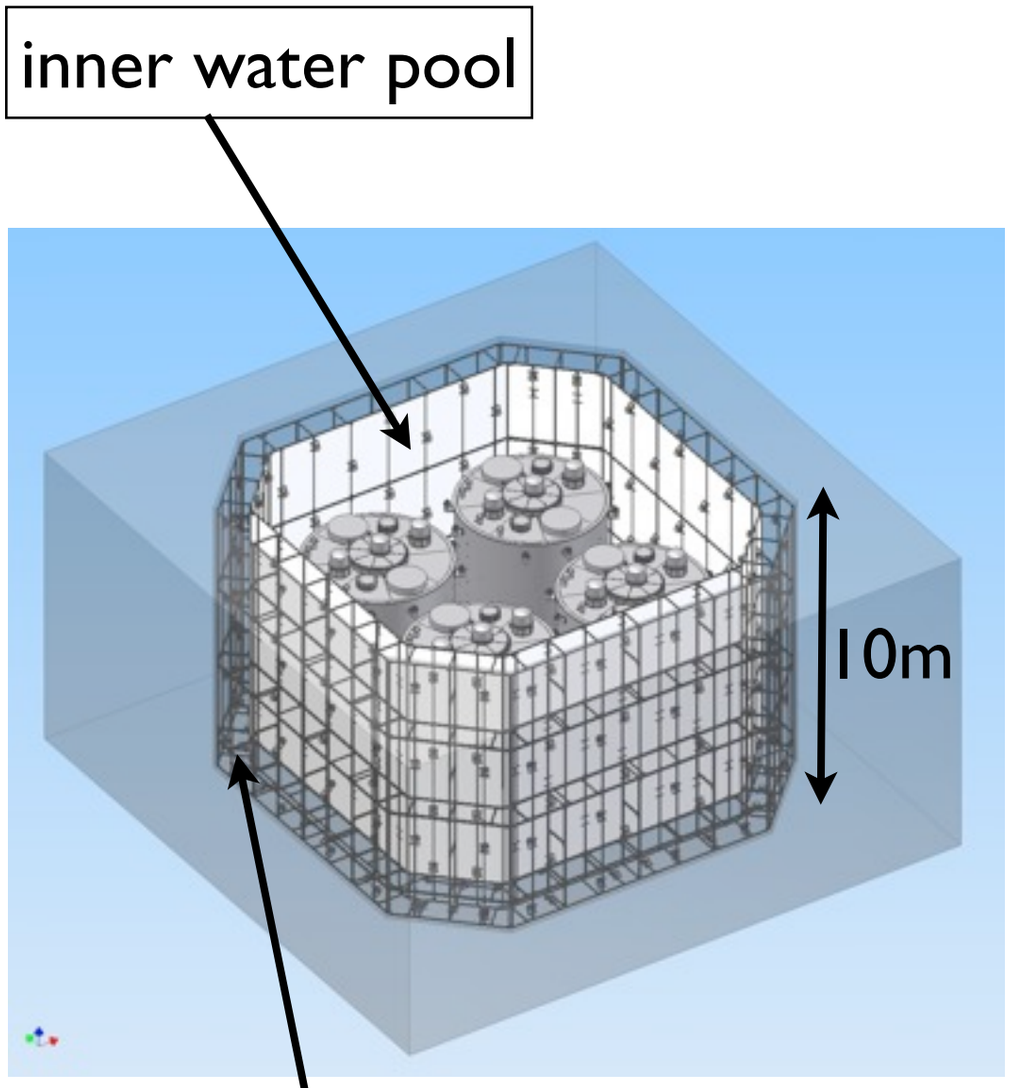
	DYB site	LA site	Far site
Vertical overburden (m)	98	112	355
Muon Flux (Hz/m^2)	1.16	0.73	0.041
Muon Mean Energy (GeV)	55	60	138

Muon System



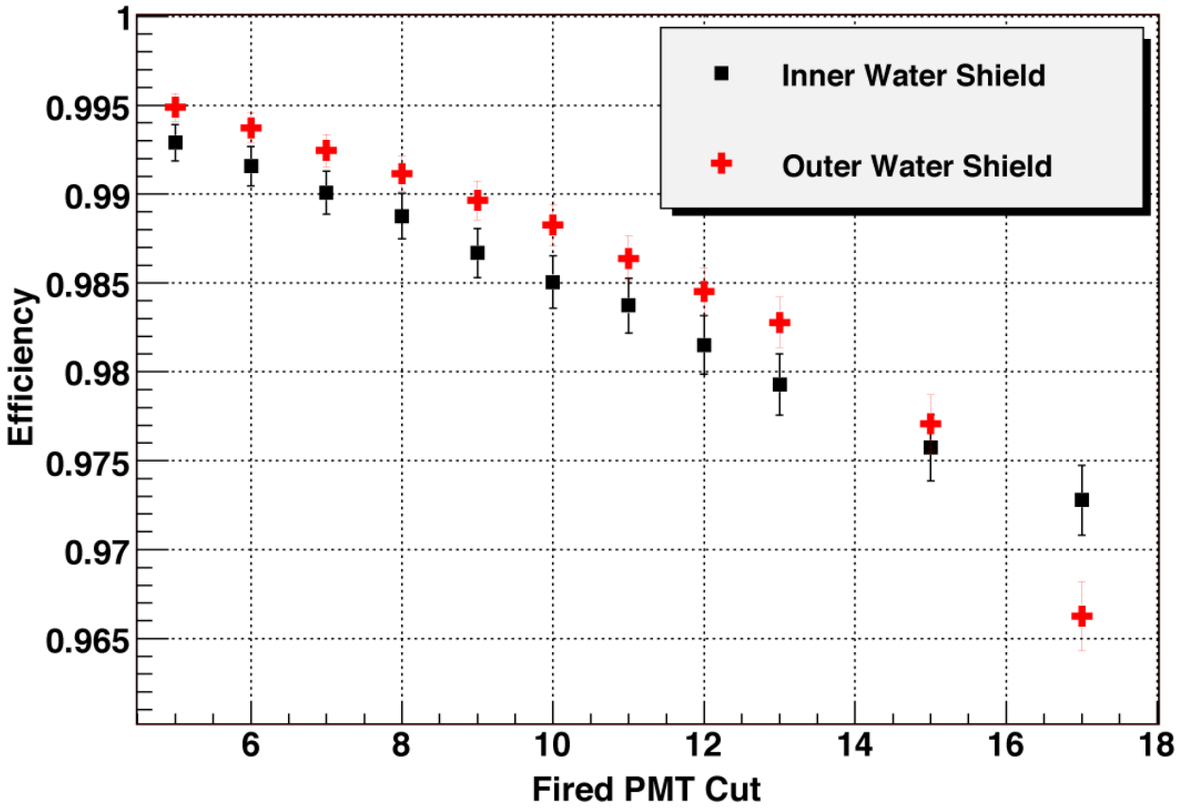
- Detects muons with >99.5% efficiency to reduce backgrounds correlated with muon interaction
- Attenuates radioactivity from surrounding rock and air with at least 2.5m of water

Water Pools



- Water Cherenkov detector
  - ~1000 total pmt's
  - 1PMT/8m^2 (inner)
  - 1PMT/6-7m^2 (outer)
- Divided into 2 optically separated regions
  - 2 region design provides independent triggers
  - When combined give a 98% muon efficiency

Water Shield Efficiency

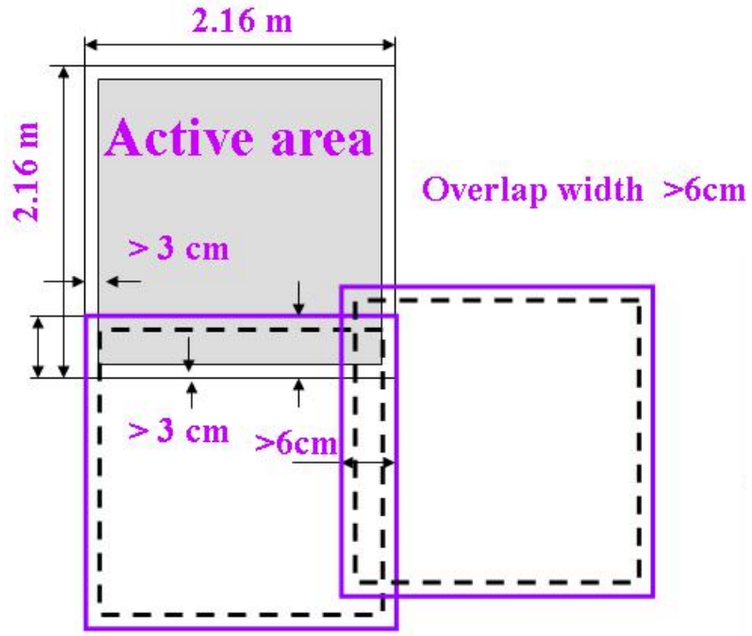


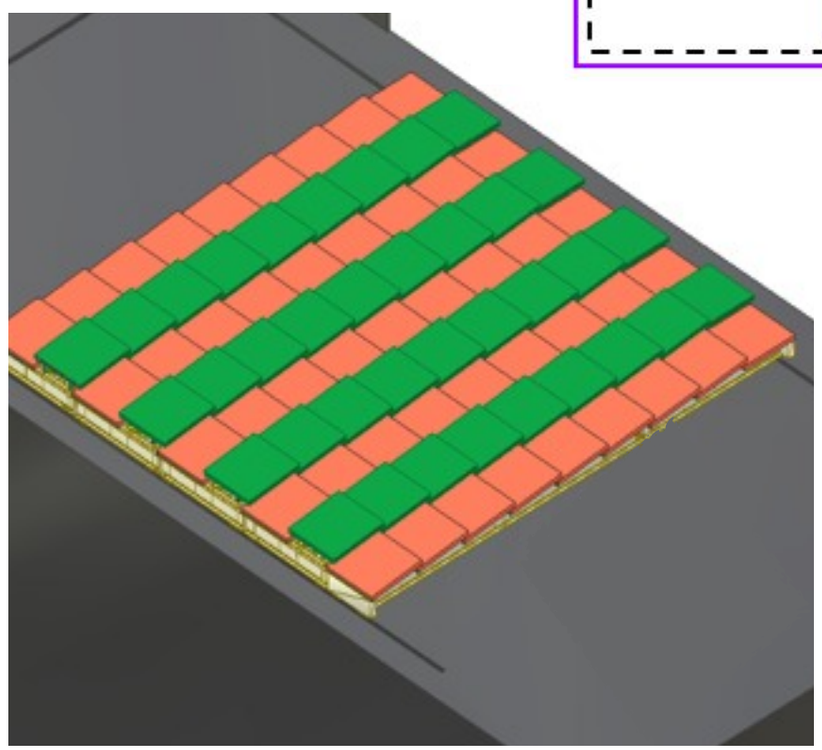
11 Fired PMT cut gives >98% efficiency in both inner and outer water shields.

Inefficient muons (red) are typically short tracks in the outer water shield.

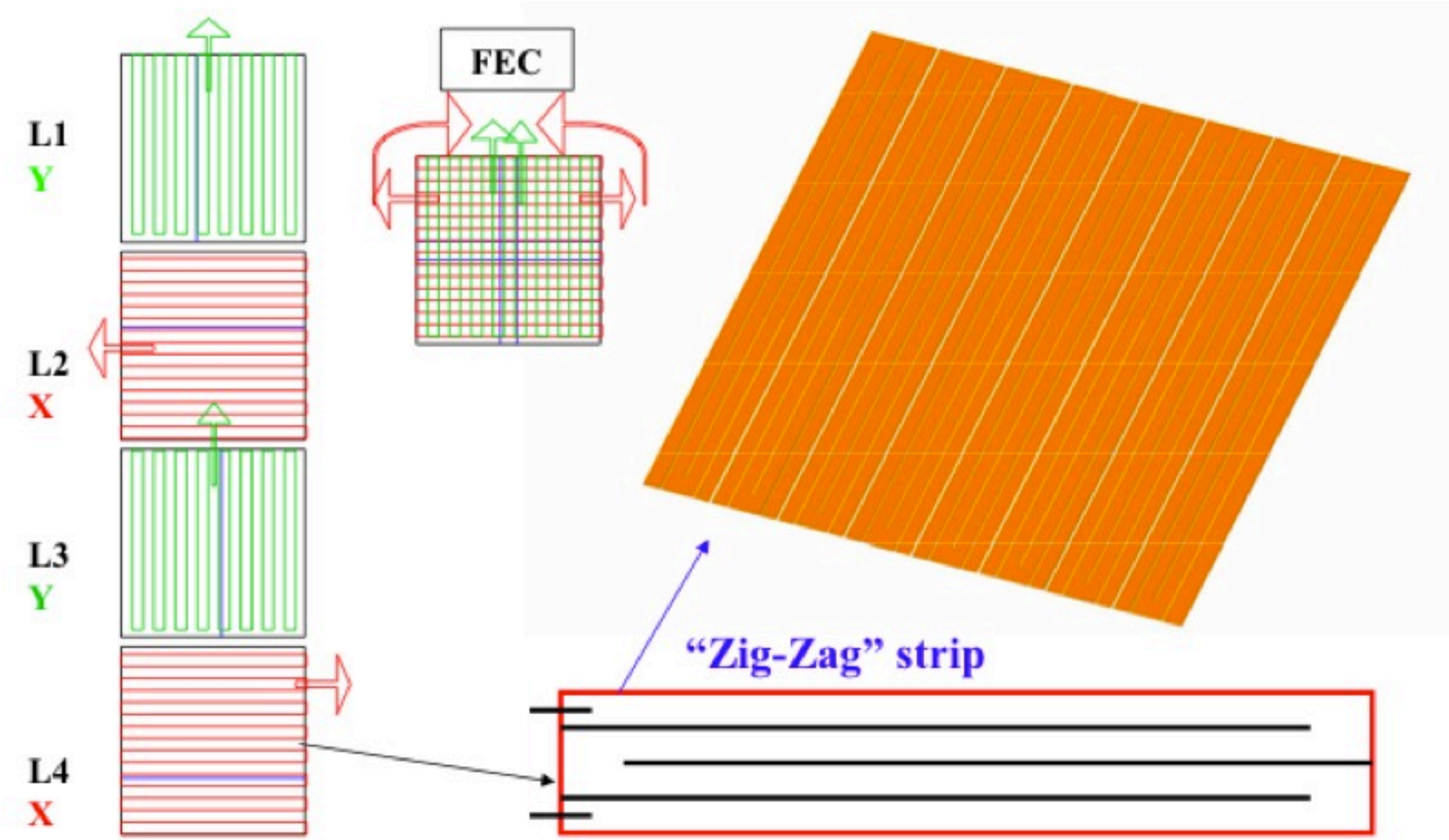
RPC System

- 1512 RPC's
  - 189 modules (8 RPC's per module)
  - Modules overlap to eliminate dead space
- 6048 readout strips
  - 4 readout strips per RPC
  - Each strip is 2m x 25cm
  - Zigzag design (6cm pitch)
- 4 layer structure
  - Trigger on 3 of 4 layers hit
  - Alternate direction
  - 0.5m spatial resolution

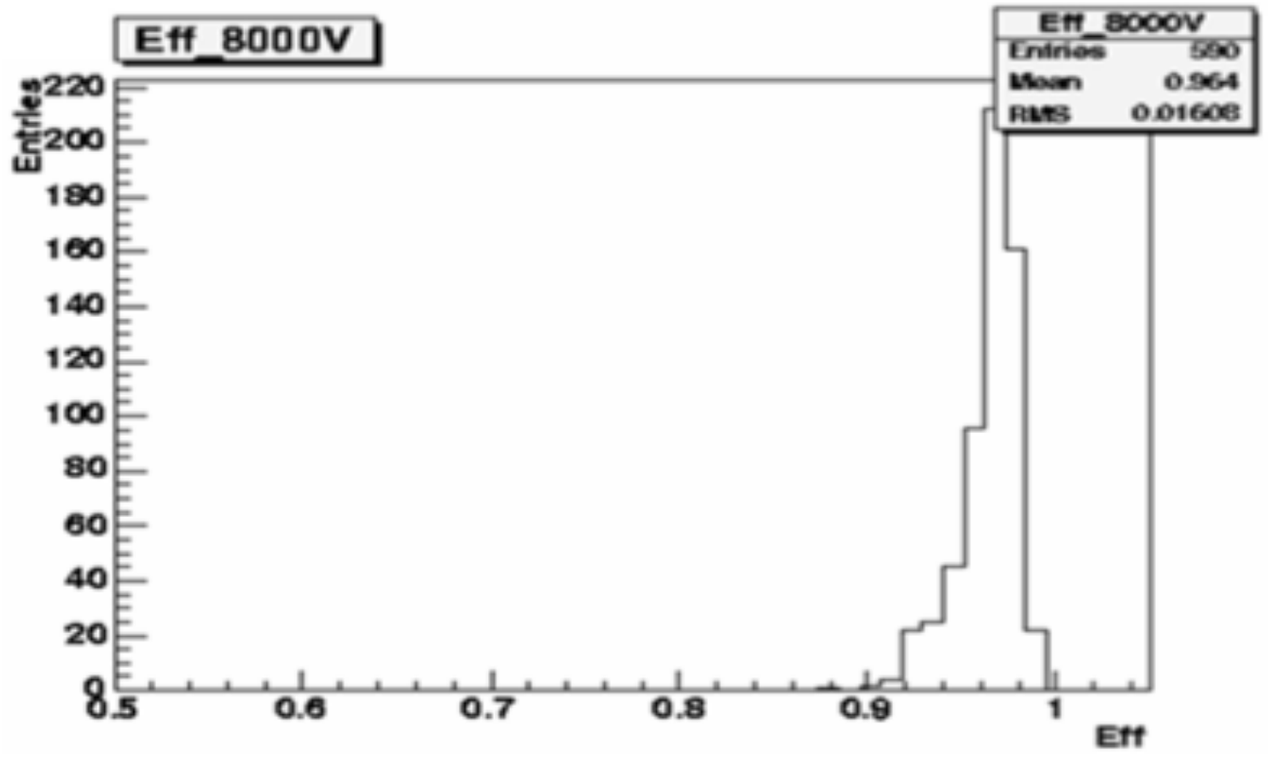




RPC Layout



RPC Efficiency



Single RPC layer
>95% efficiency

3 of 4 planes requirement yields >98.5% efficiency

Trigger Threshold

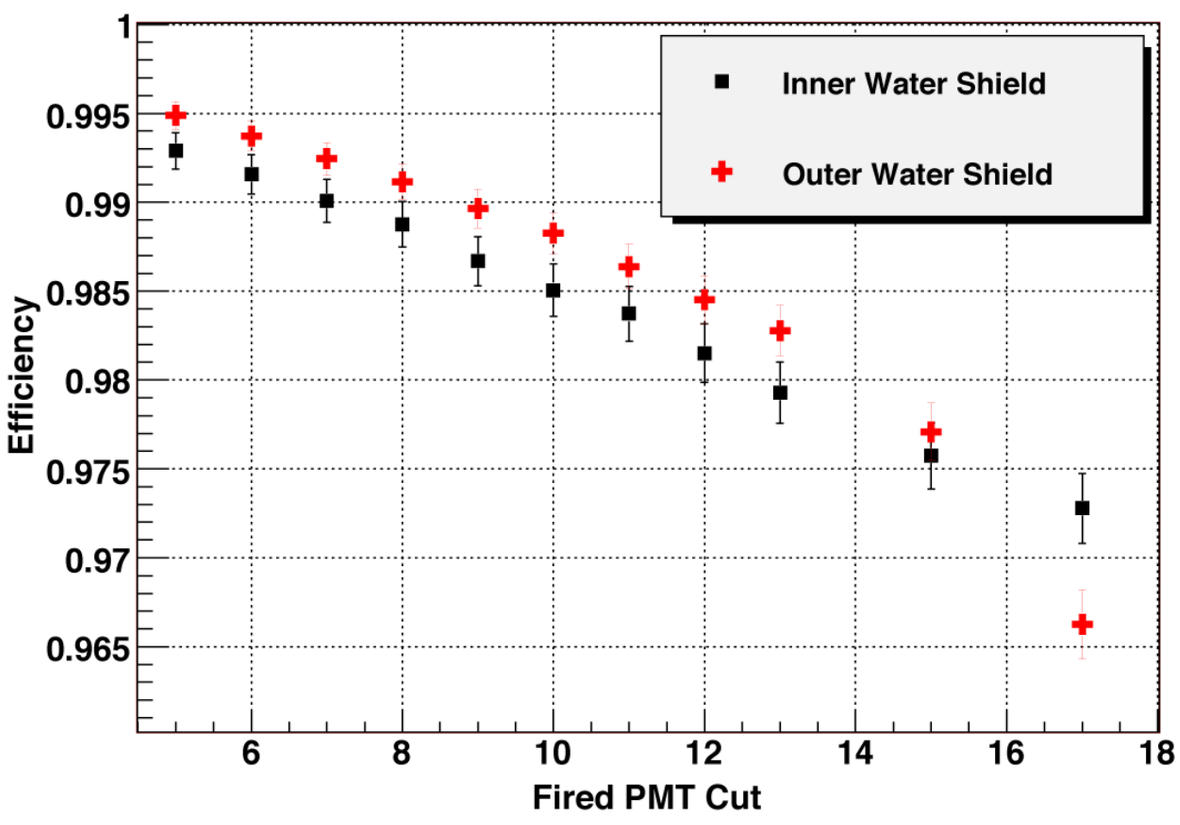
Total Planes	Layer	≥1	≥2	≥3	≥4
	1	95%			
	2	99.75%	90.25%		
	3	99.987%	99.275%	85.74%	
	4	99.999%	99.952%	98.598%	81.45%

Combined Efficiency

Water Pool + RPC

	Pool Only	Pool+RPC
Near	98.85±0.12%	99.43±0.09%
Far	98.81±0.12%	99.44±0.08%

Water Pool



RPC

Trigger Threshold

Total Planes

Layer	≥1	≥2	≥3	≥4
1	95%			
2	99.75%	90.25%		
3	99.987%	99.275%	85.74%	
4	99.999%	99.952%	98.598%	81.45%

Summary

- The Daya Bay muon system consists of two independent systems
- Together the RPC and Water Cherenkov detectors veto muons near the Antineutrino Detectors with >99.5% efficiency

Thank You

~ 233 collaborators

Europe (3) (9)

JINR, Dubna, Russia

Kurchatov Institute, Russia

Charles University, Czech Republic

North America (15)(~89)

BNL, Caltech, Cincinnati, 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 (19) (~135)

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

Backup Slides

Background Rates

	Daya Bay Near	Ling Ao Near	Far Hall
Radioactivity (Hz)	<50	<50	<50
Muon rate / AD (Hz)	36	22	1.2
$\bar{\nu}_e$-Signal (events/day)	840	760	90
Accidental B/S (%)	<0.2	<0.2	<0.1
Fast neutron B/S (%)	0.1	0.1	0.1
^{8}He+^{9}Li B/S (%)	0.3	0.2	0.2