

# The Daya Bay Muon Veto System



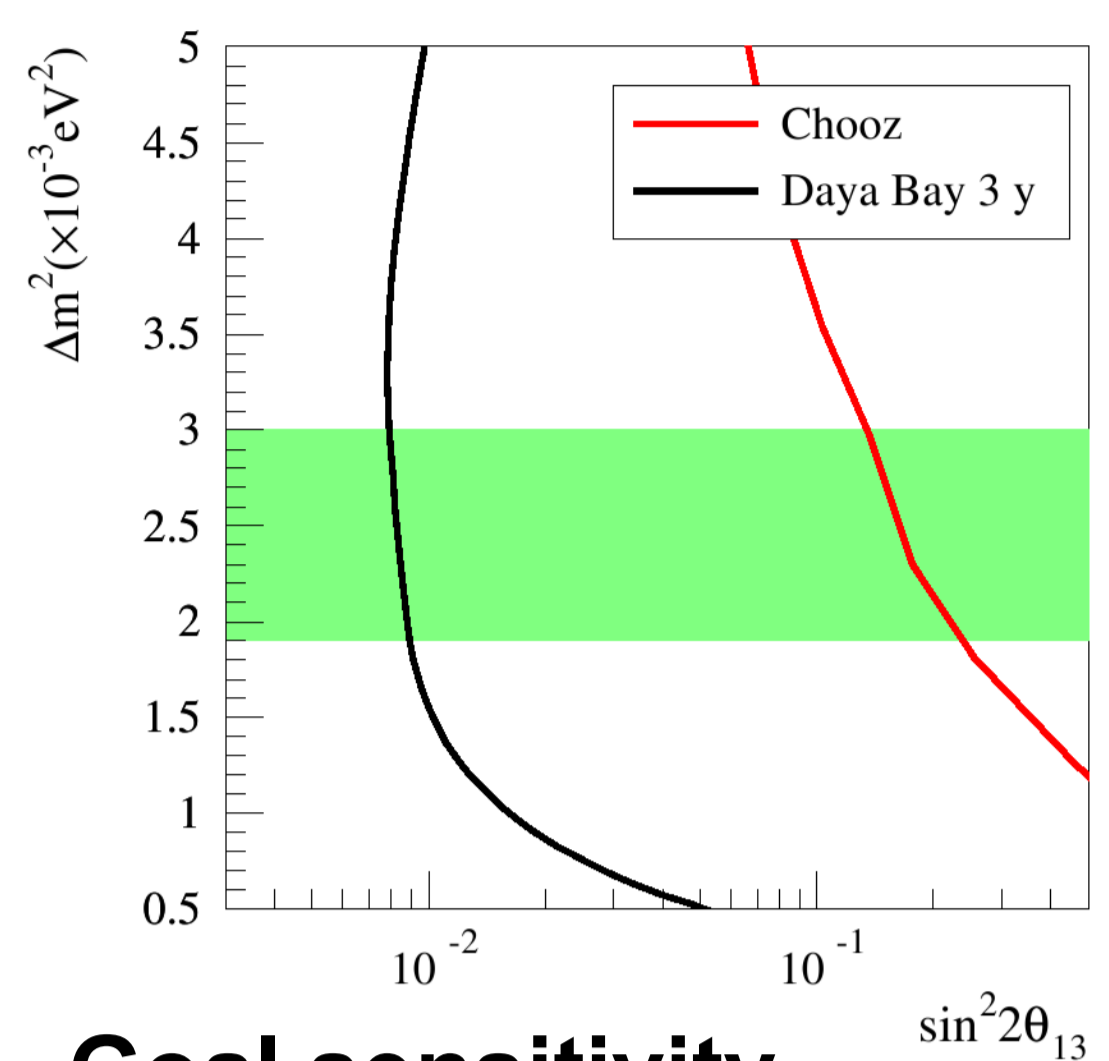
Lisa Whitehead (Brookhaven National Laboratory)  
for the Daya Bay Collaboration



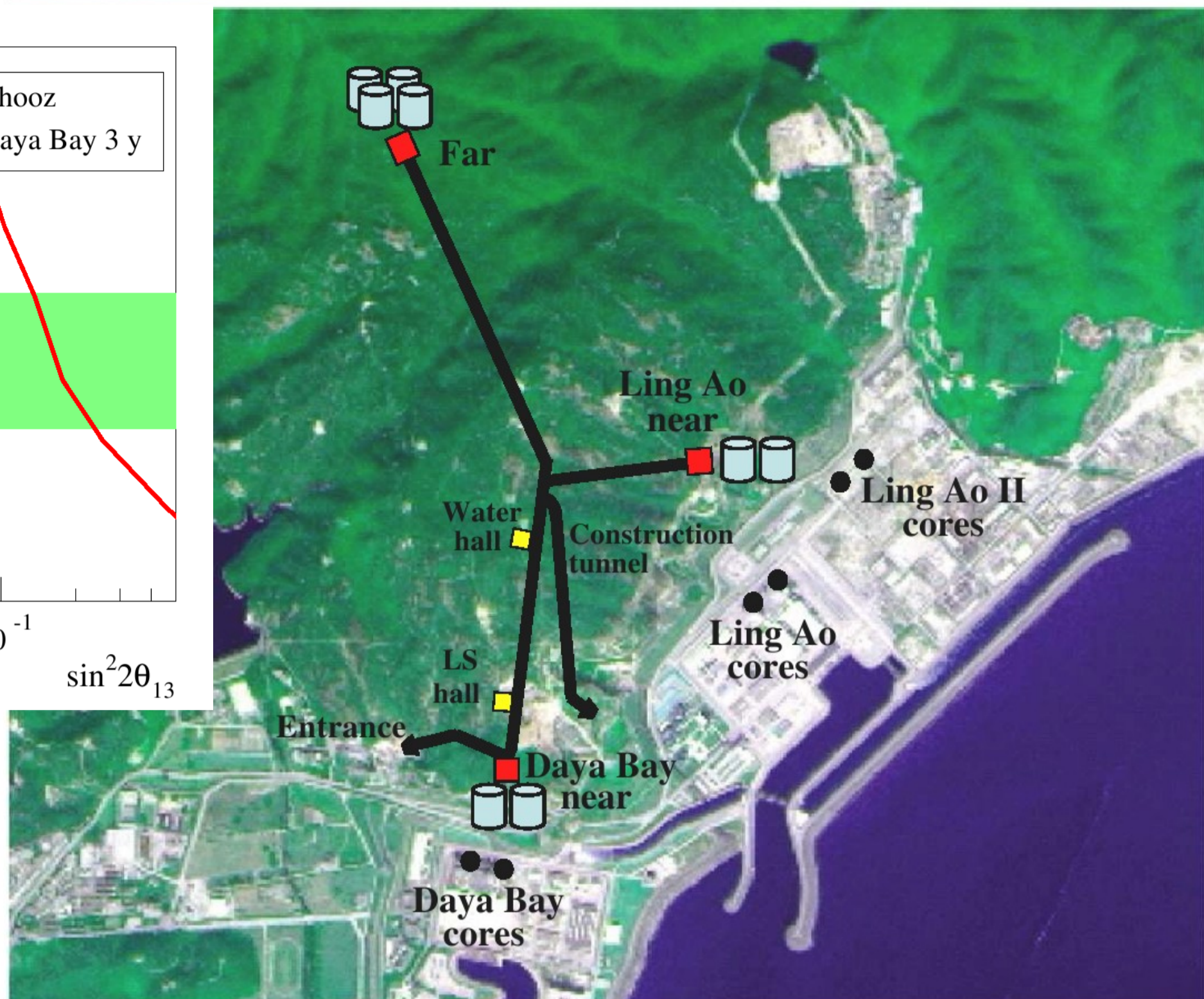
## The Daya Bay Reactor Neutrino Experiment

Search for the disappearance of anti-electron neutrinos from a reactor to measure the mixing angle  $\theta_{13}$

$$P_{dis} \approx \sin^2 2\theta_{13} \sin^2(1.27 \Delta m^2 L/E)$$

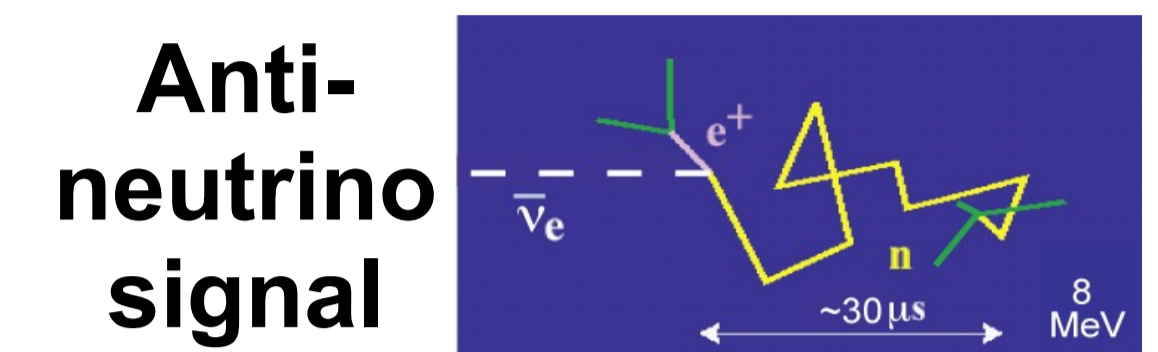
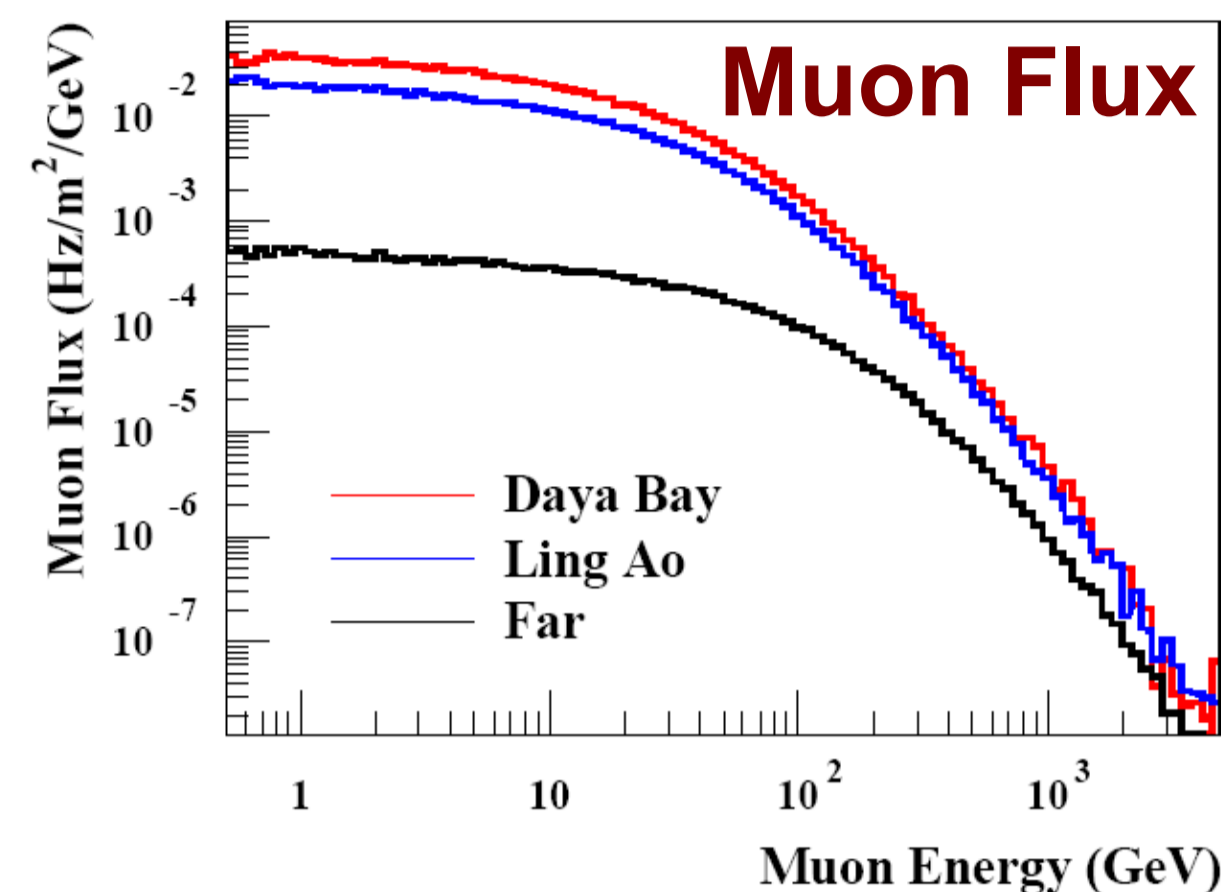


Goal sensitivity  $\sin^2(2\theta_{13}) < 0.01$



Daya Bay nuclear power complex located in Shenzhen, China

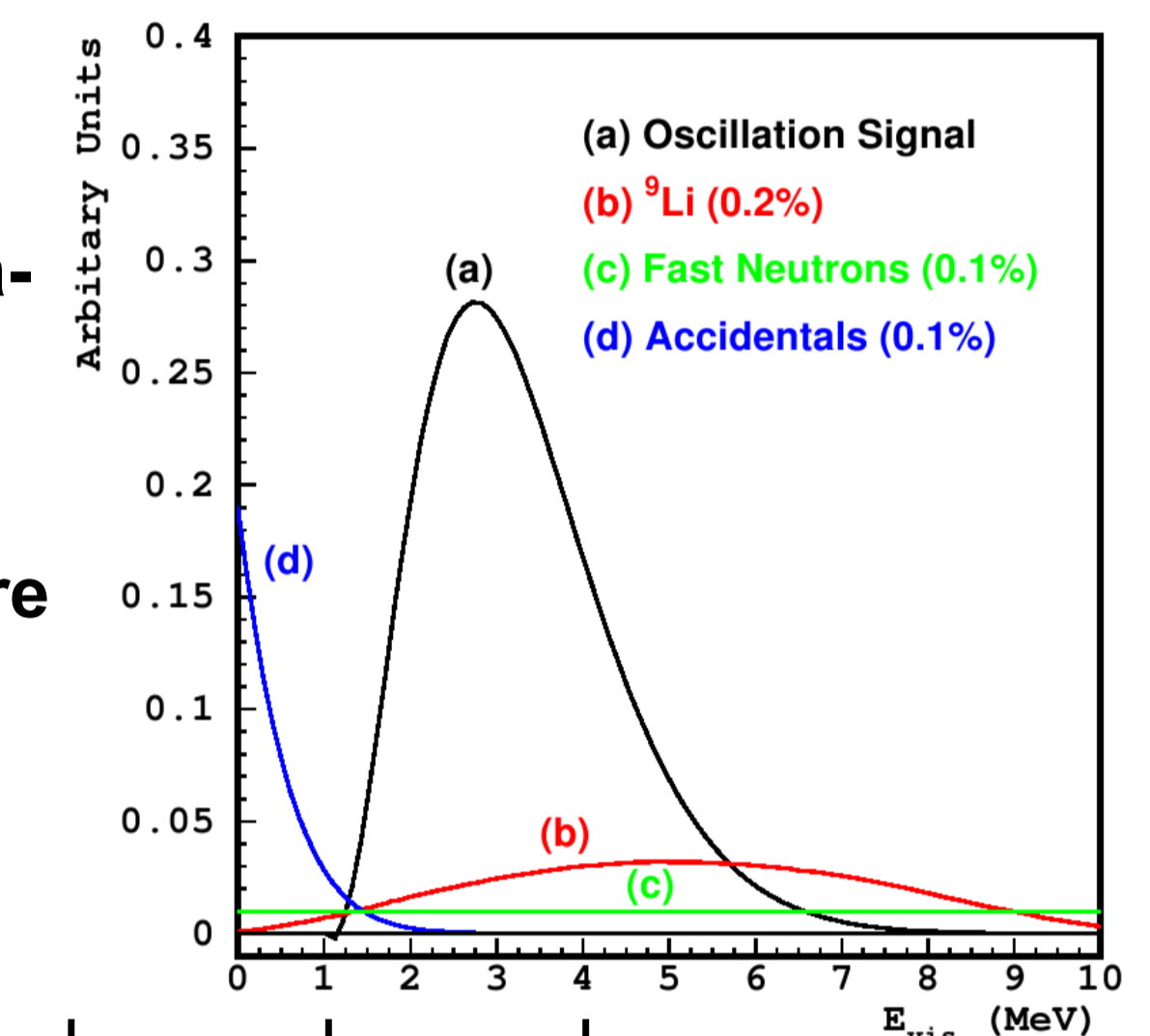
	Daya Bay	Ling Ao	Far
Overburden (m)	98	112	355
Muon Flux (Hz/m <sup>2</sup> )	1.16	0.73	0.041
Mean Muon Energy (GeV)	55	60	138



Anti-neutrino signal  
Inverse Beta Decay  
 $\bar{\nu}_e p \rightarrow e^+ n$   
prompt positron energy + delayed neutron capture

### Backgrounds produced by cosmic muons

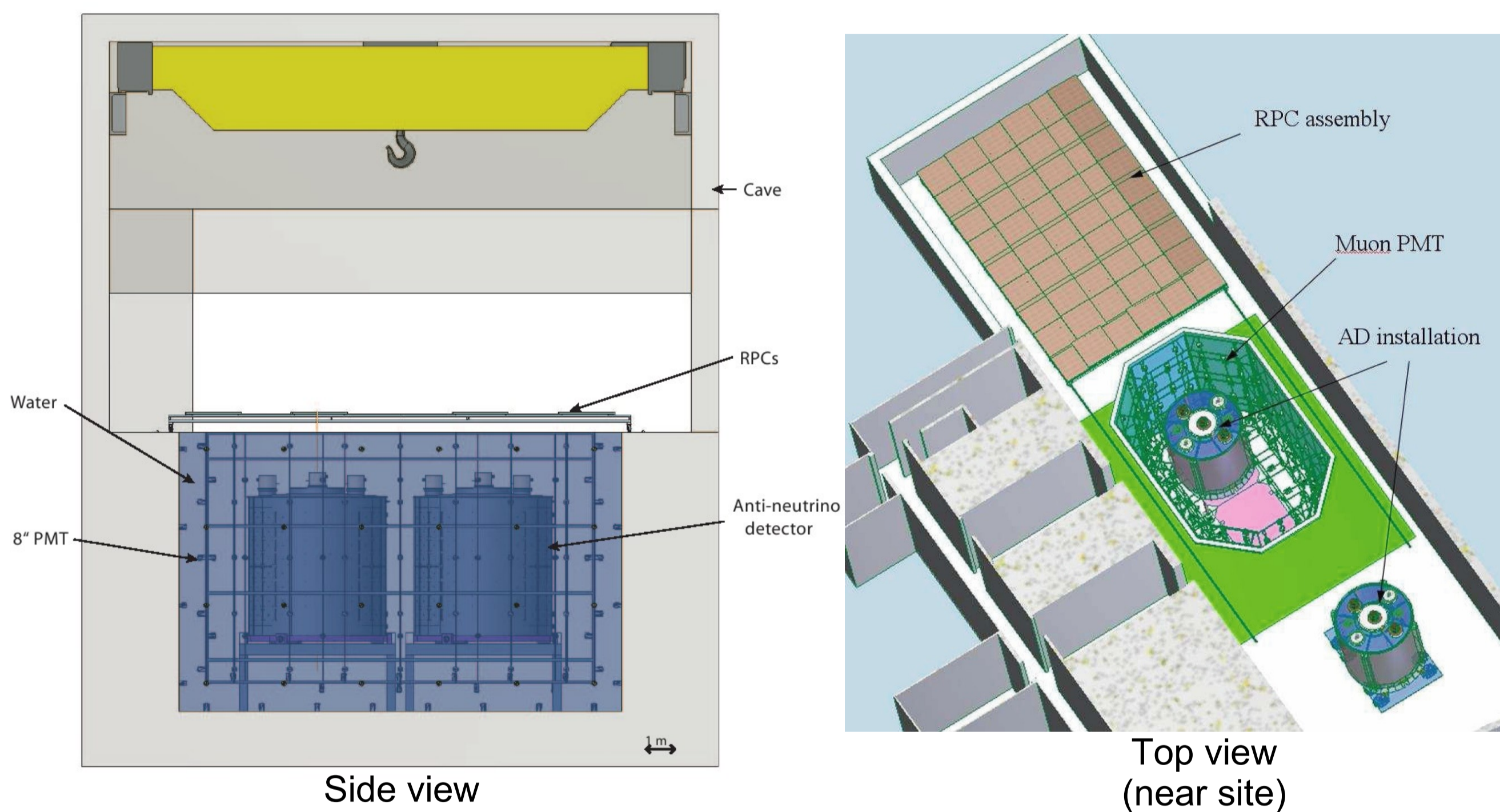
- <sup>9</sup>Li/<sup>8</sup>He isotopes** – have significant beta-neutron decay branching fractions
- Fast neutrons** – recoil proton gives prompt signal followed by neutron capture
- Accidentals** – coincidence of neutron capture with natural radioactivity in the detector



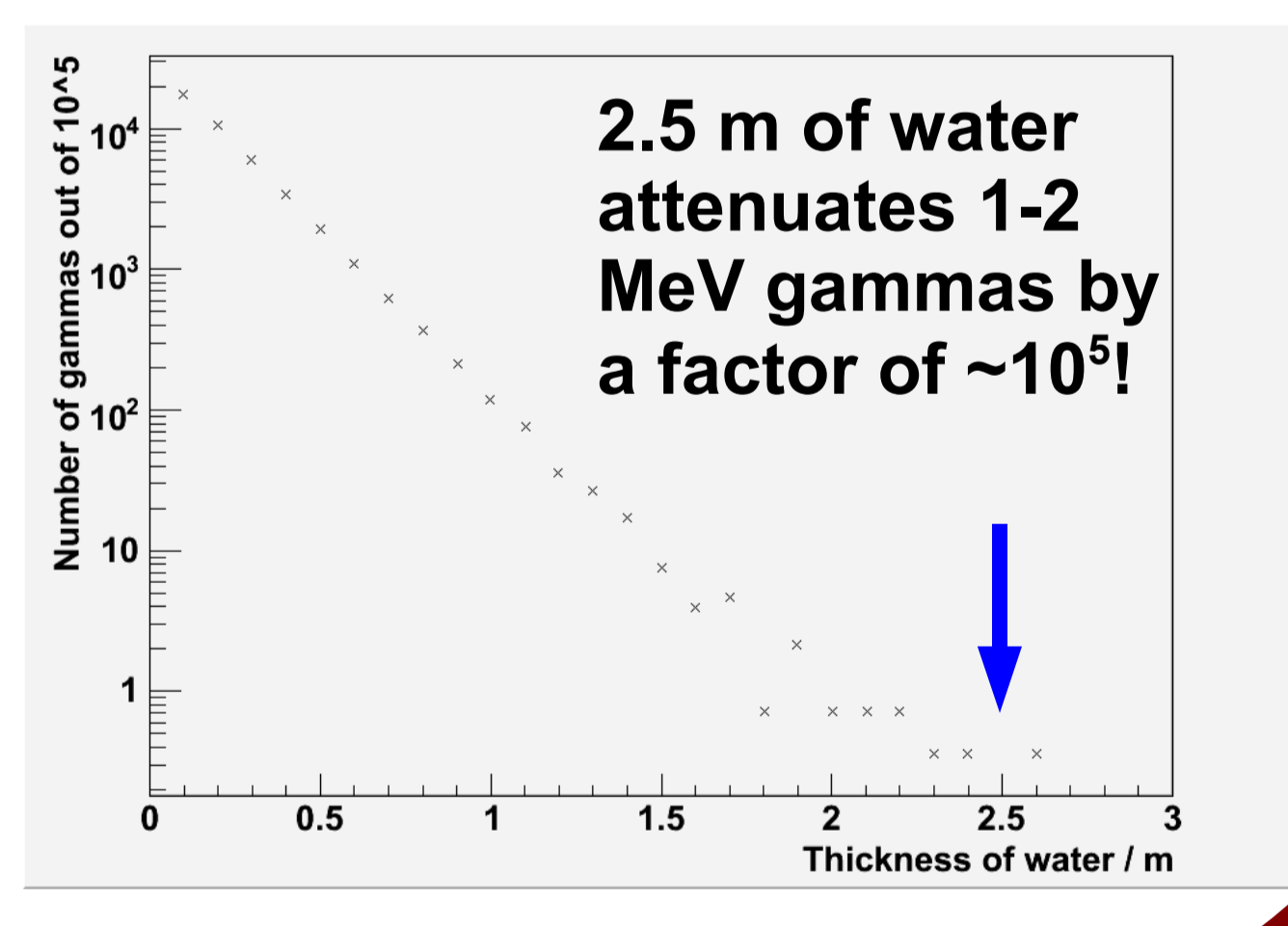
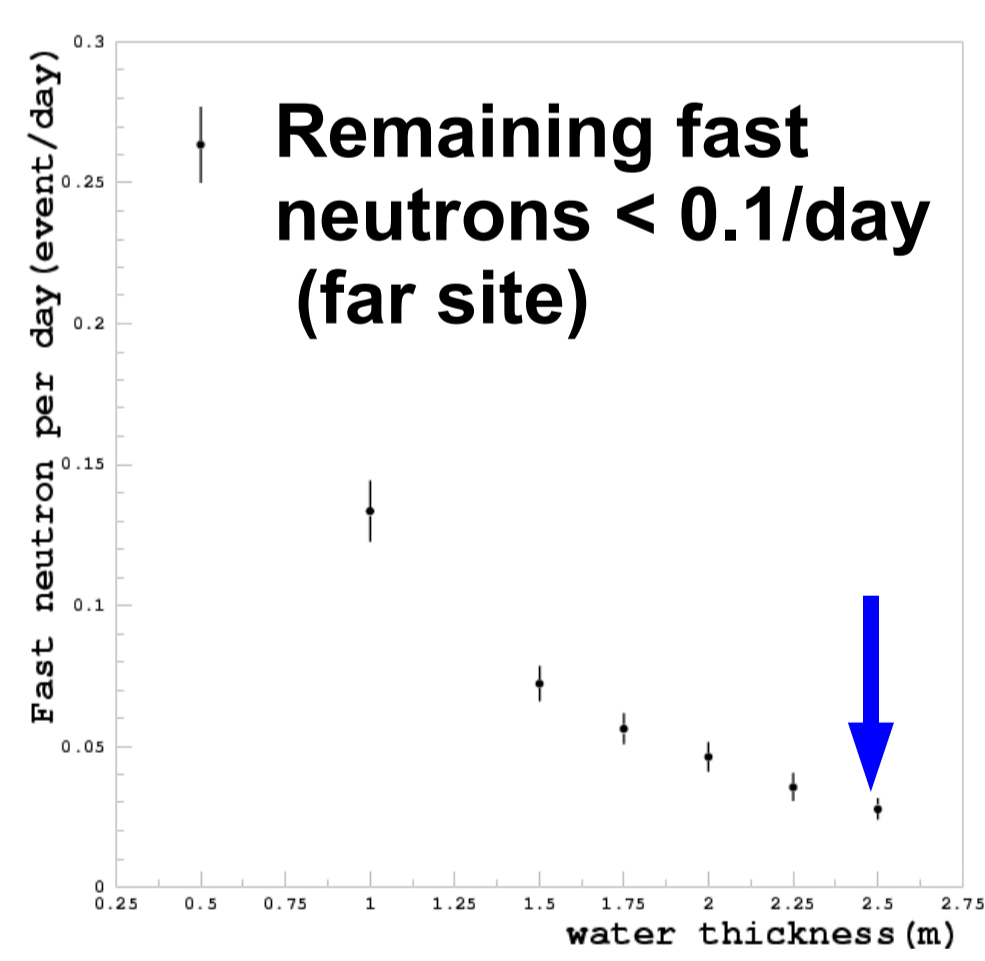
	DB	LA	Far
Antineutrino rate (/day/module)	840	740	90
Natural radiation (Hz)	<50	<50	<50
Single neutron (/day/module)	18	12	1.5
$\beta$ -emission isotopes (/day/module)	210	141	14.6
Accidental/Signal	<0.2%	<0.2%	<0.1%
Fast Neutron/Signal	0.1%	0.1%	0.1%
<sup>9</sup> Li/ <sup>8</sup> He/Signal	0.3%	0.2%	0.2%

## Muon veto system

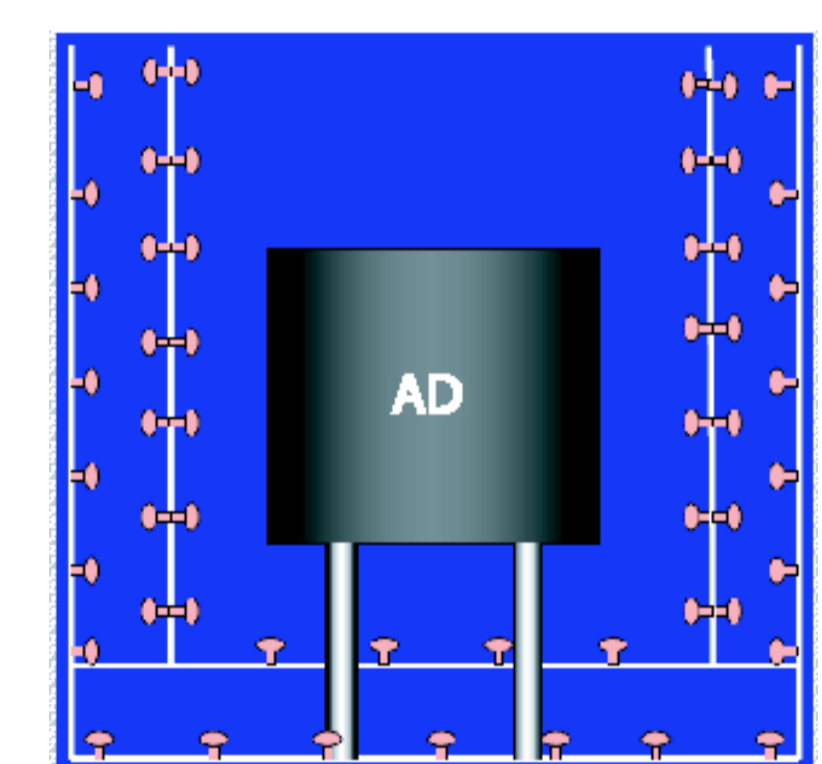
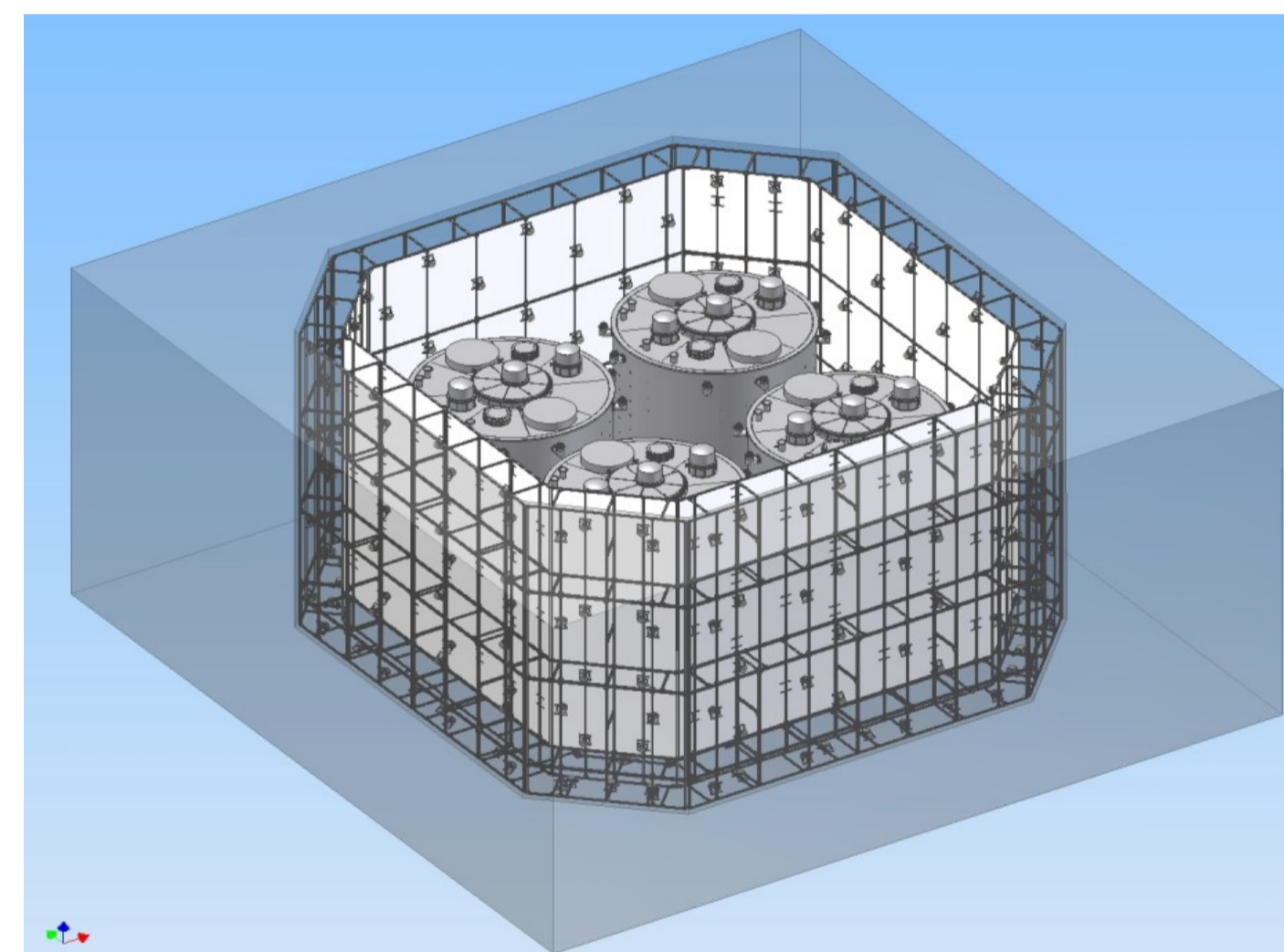
2.5 m active water shield with RPCs on top



shields against natural radioactivity/fast neutrons and tags cosmic muons producing background in the anti-neutrino detectors



## Water Cherenkov Detector



water shield divided into inner region and outer region separated by reflective Tyvek partitions

instrumented with 8-inch PMTs (288 at Daya Bay/Ling Ao, 384 at Far)



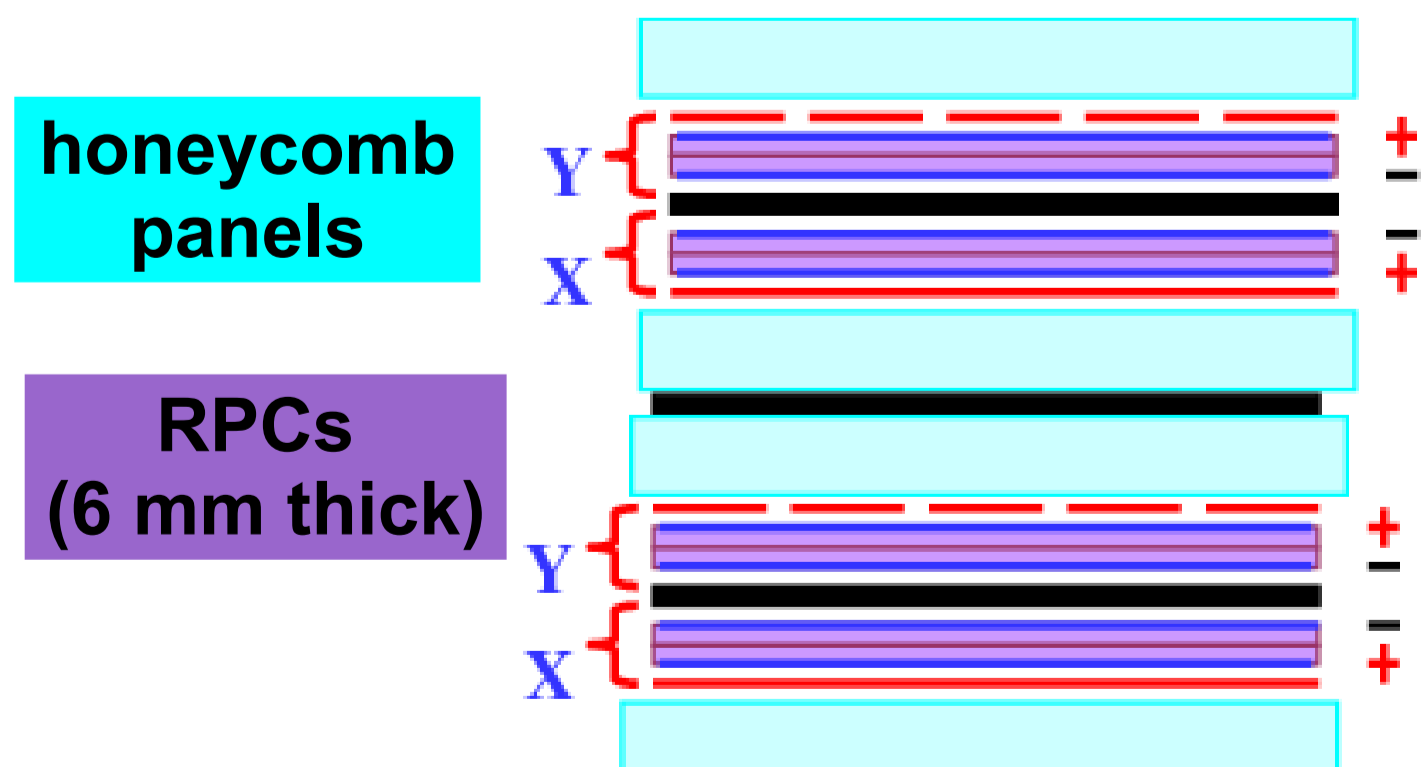
calibration system consisting of LED flashers enclosed in Teflon diffuser balls to monitor water quality, PMT gains and timing



Water conditioning: initial purification + continuous maintenance with mixed resin bed deionizers, particle filters and deaerators

## RPCs (Resistive Plate Chambers)

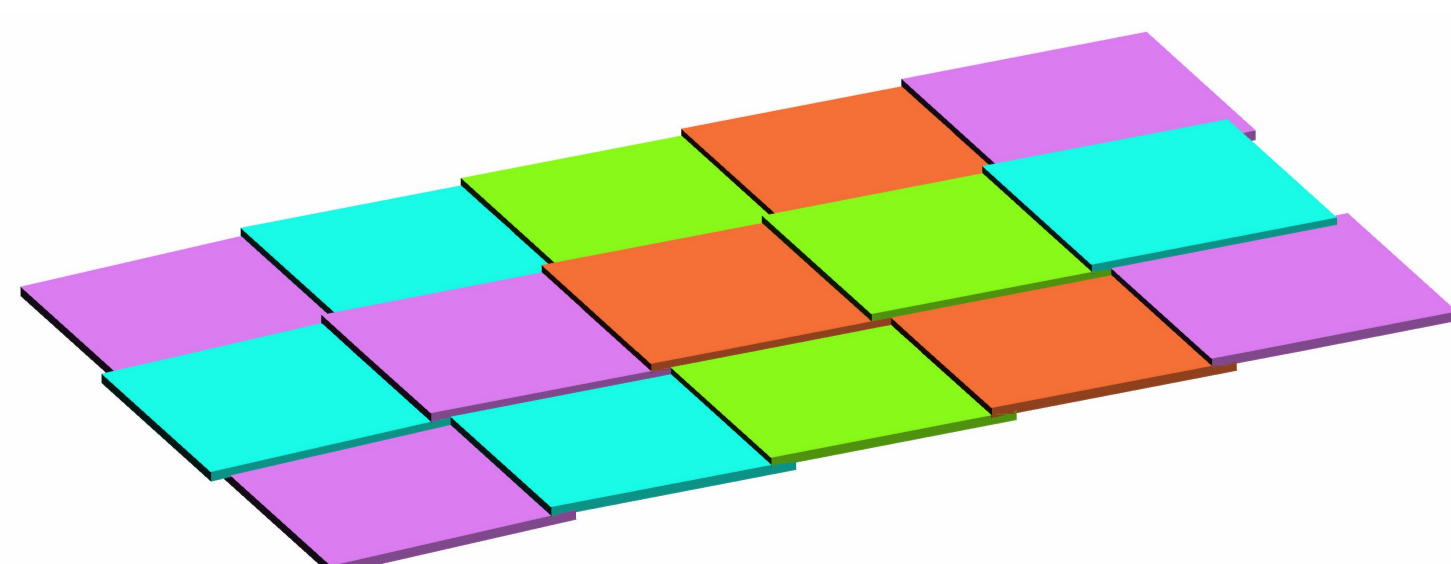
Module cross-section



4 layers of RPC in each module

non-flammable gas mixture: Ar/R134A/Isobutane/SF6 (65.5/30/4/0.5)

~8kV voltage gap



2 m x 2 m modules overlap slightly to avoid having dead area

## Muon Veto Efficiency:

- Water Cherenkov: 98.8%
- RPC: 98.6% (require hits in 3 of 4 layers)
- Combined: 99.5%



### Schedule:

Spring 2011: Daya Bay Near Hall ready for data-taking  
Fall 2012: All sites ready for data-taking