Probing θ_{13} With The Daya Bay Antineutrino Detectors

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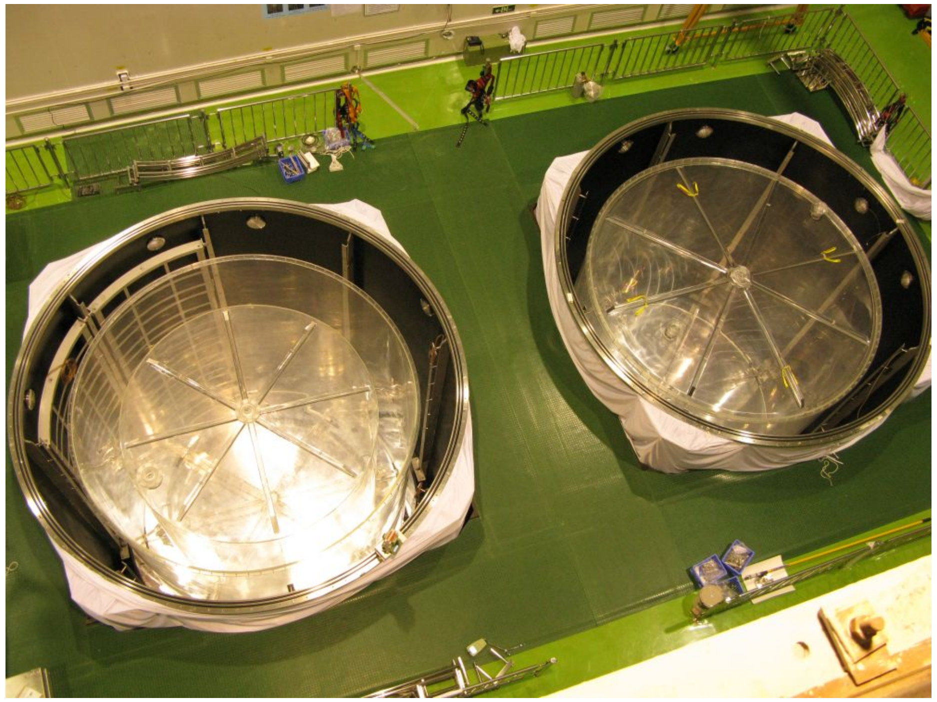
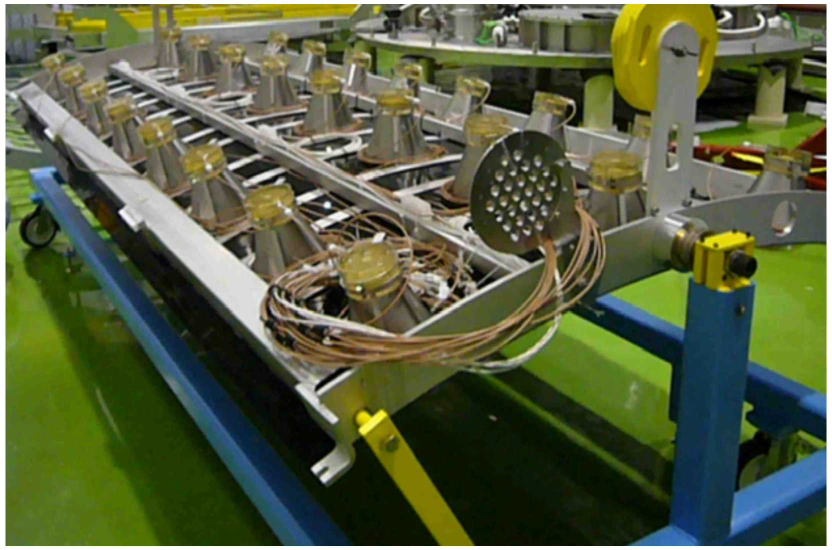
On Behalf of the Daya Bay Collaboration

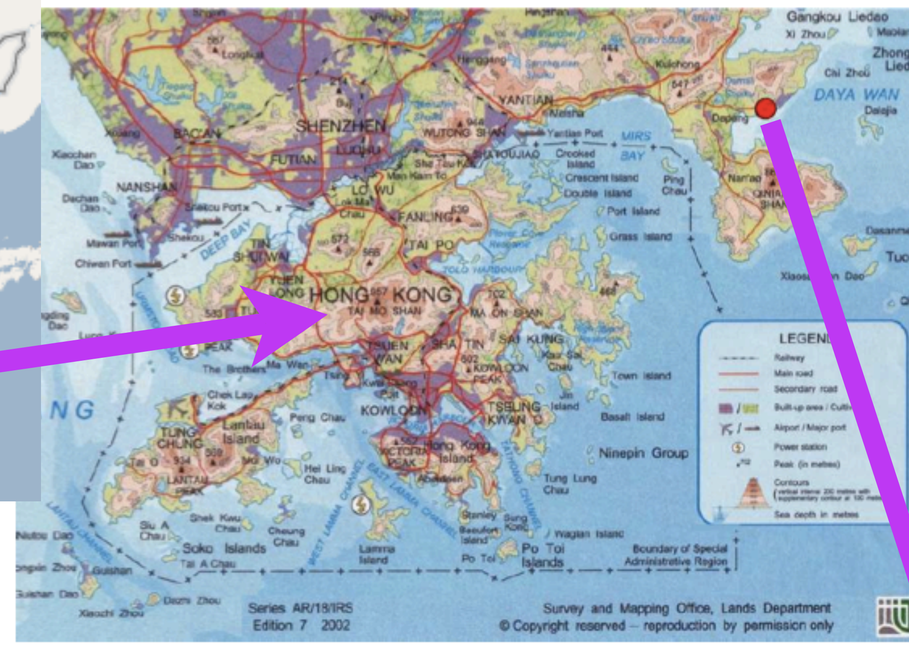
5/11/10

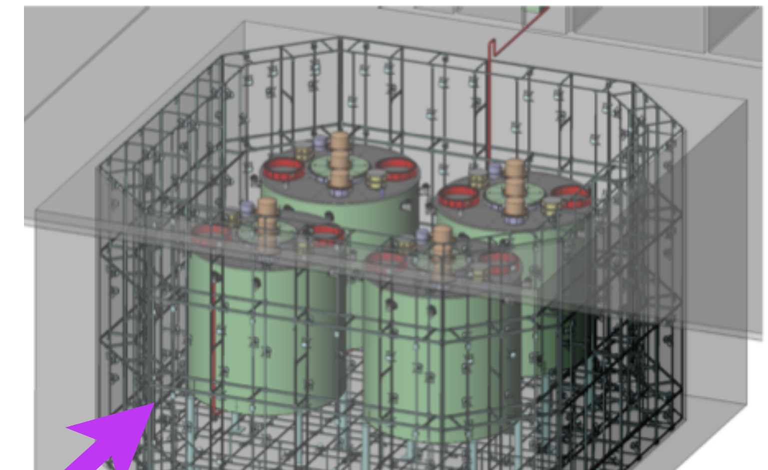




The Daya Bay Experiment

- Aims to measure reactor $\bar{\nu}_e$ disappearance:





- 6 reactor cores, 3 sites
- 4 near detectors, 2 sites, ~900 evts/day/site
- 4 far detectors, 1 site, ~90 evts/day
- Significant overburden
- RPC, Muon water veto

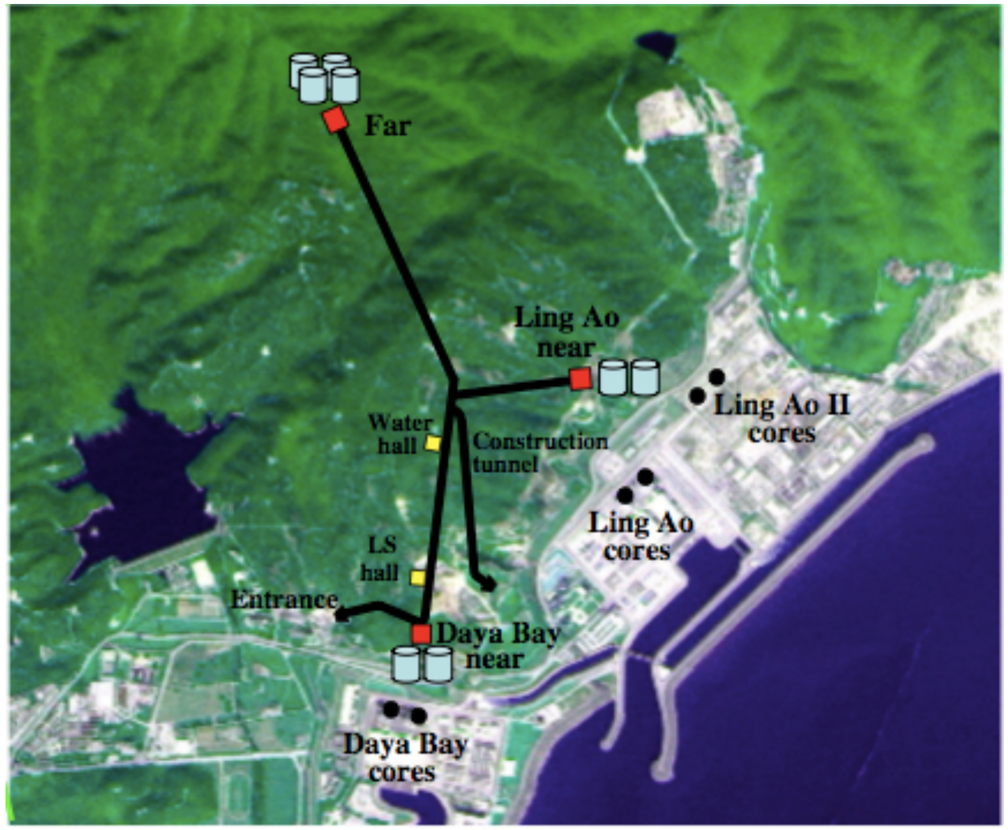
	DYB Site	LA Site	Far Site
Depth (m)	98	112	350
Bkg/Sig	0.3%	0.2%	0.2%

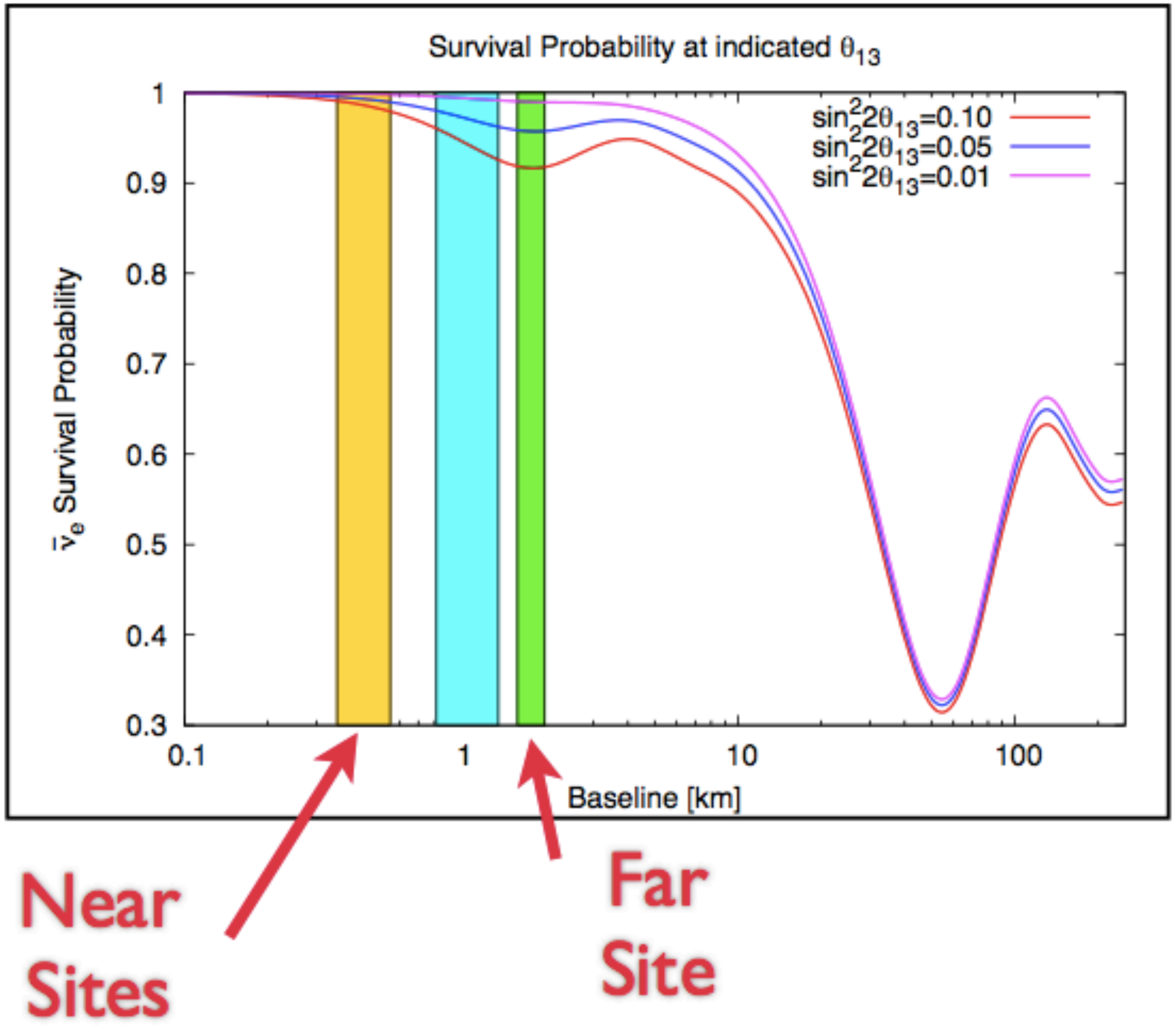
How does Daya Bay probe θ_{13}?

- Detect short-baseline reactor antineutrino disappearance:

$$P_{13} \approx \sin^2 2\theta_{13} \sin^2 \left[1.27 \Delta m^2_{31}(eV^2) \frac{L(km)}{E_\nu(GeV)}\right]$$

  - A "clean" measurement of θ_{13}

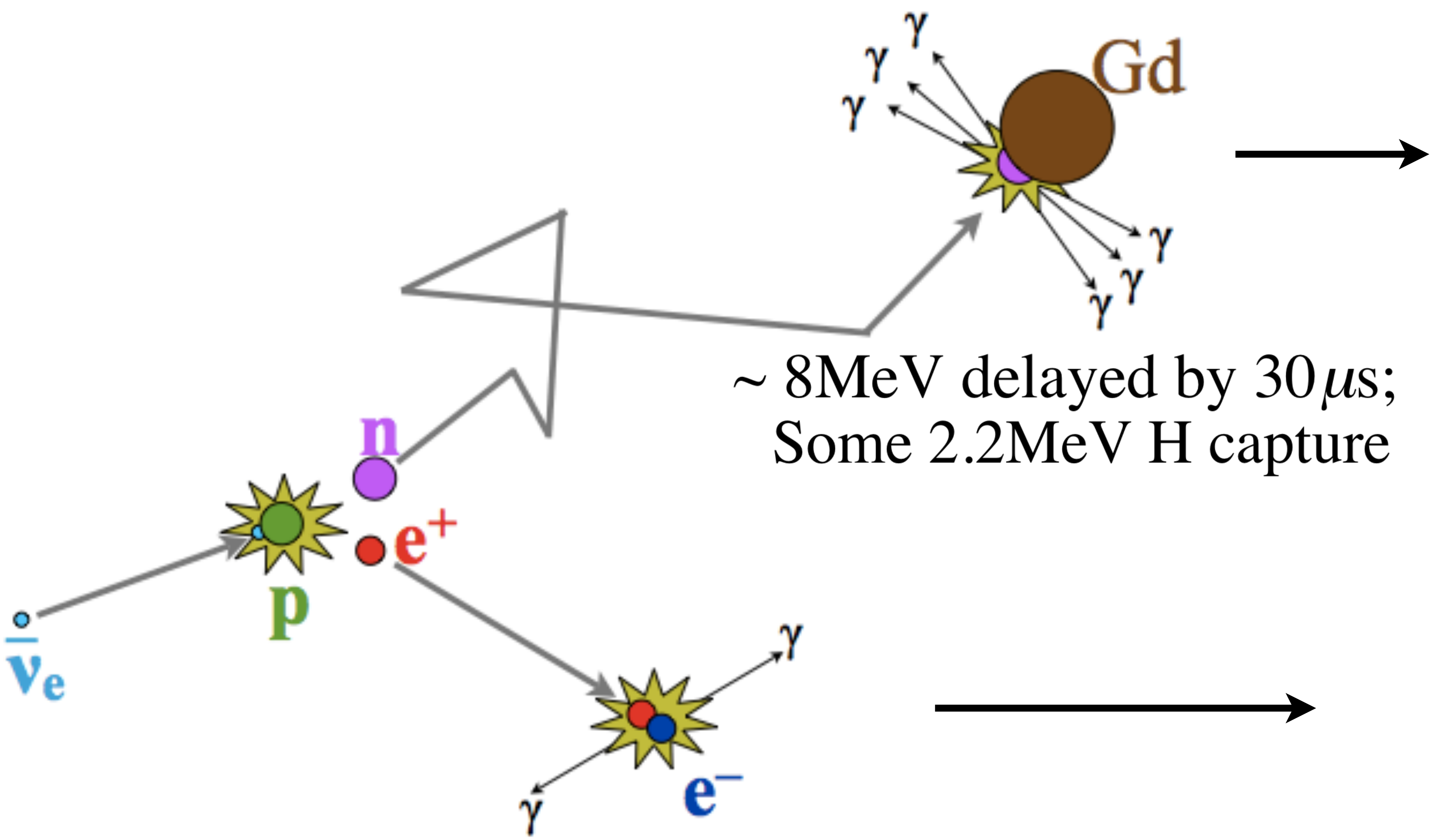


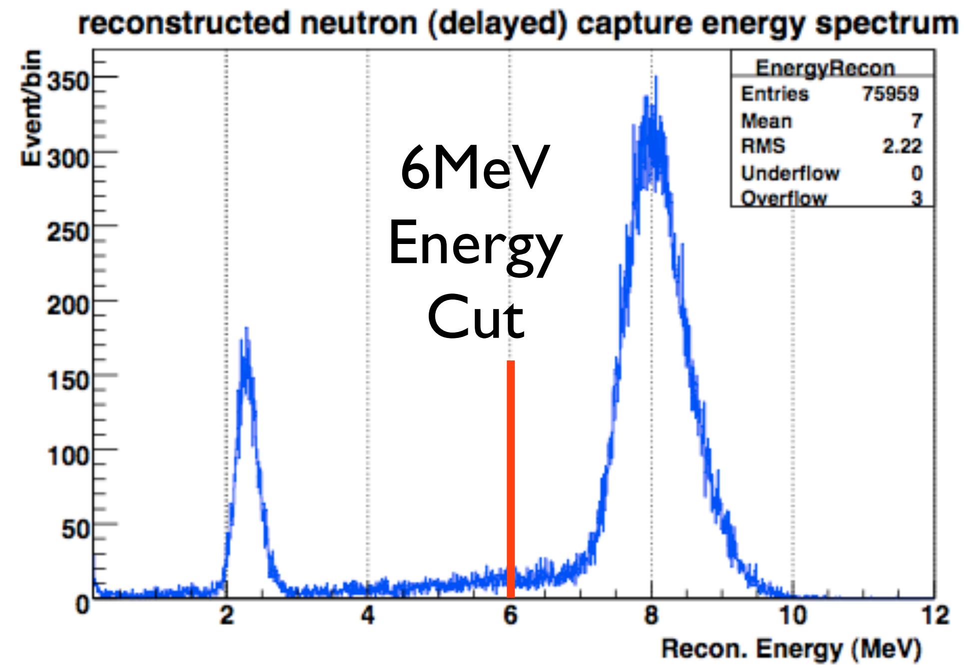


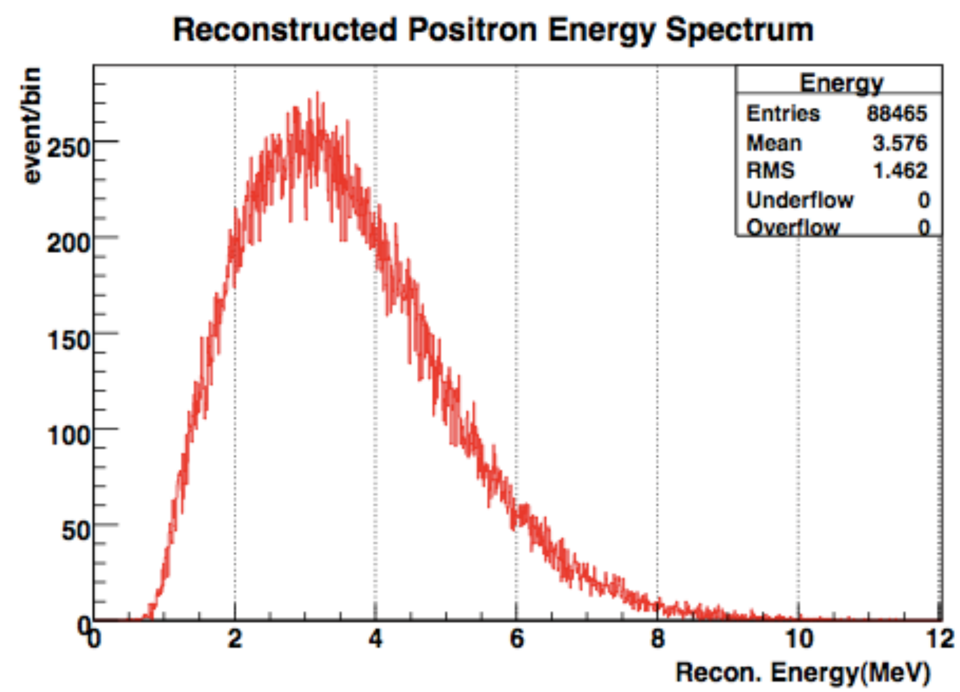
Detection Method

- 0.1% Gd-doped liquid scintillator as an inverse-beta target:

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





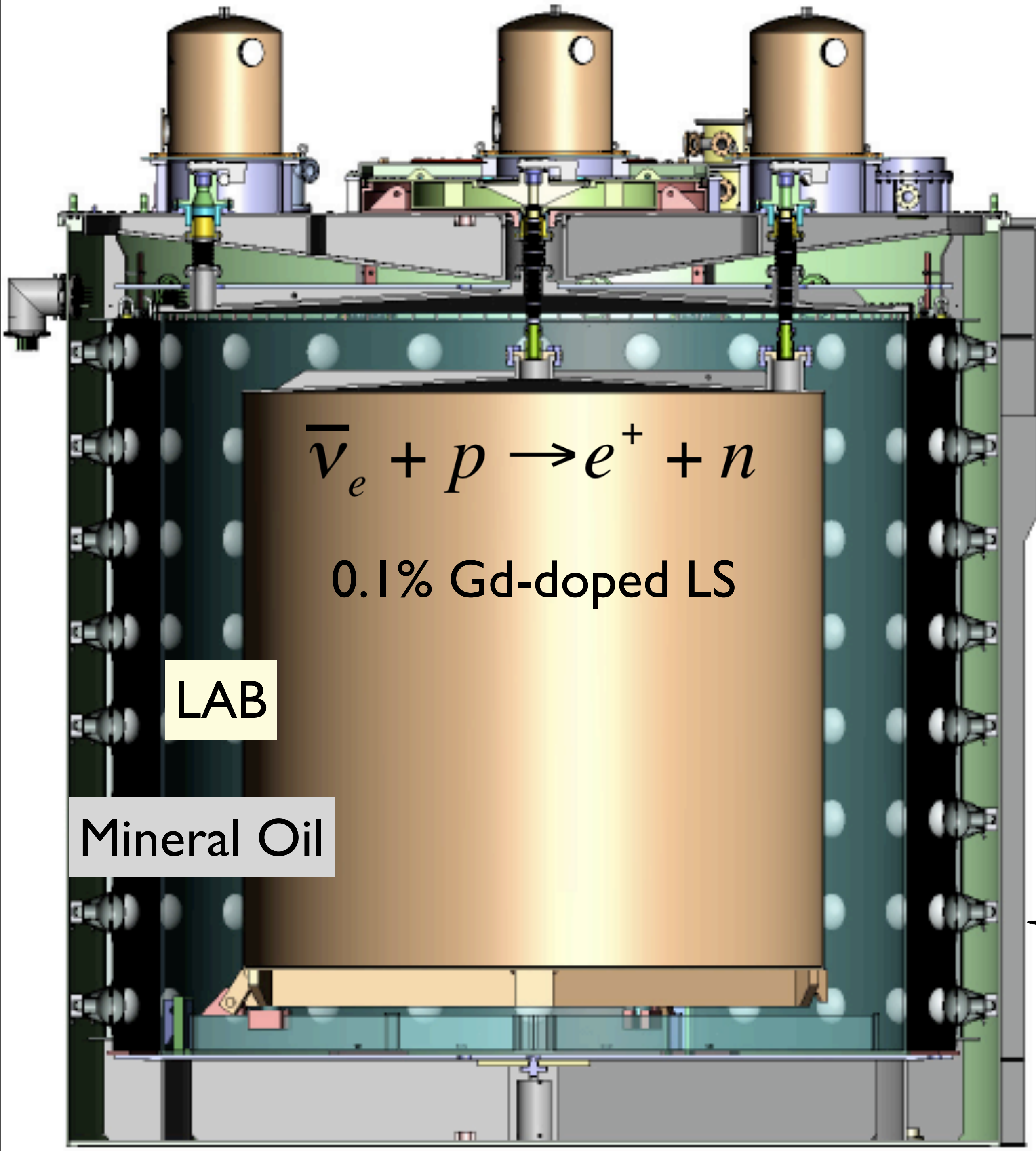


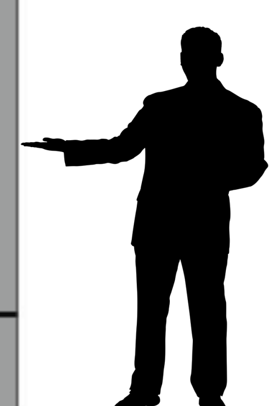
$$E_{e^+} = E_{\bar{\nu}_e} - 1.29\text{MeV}$$

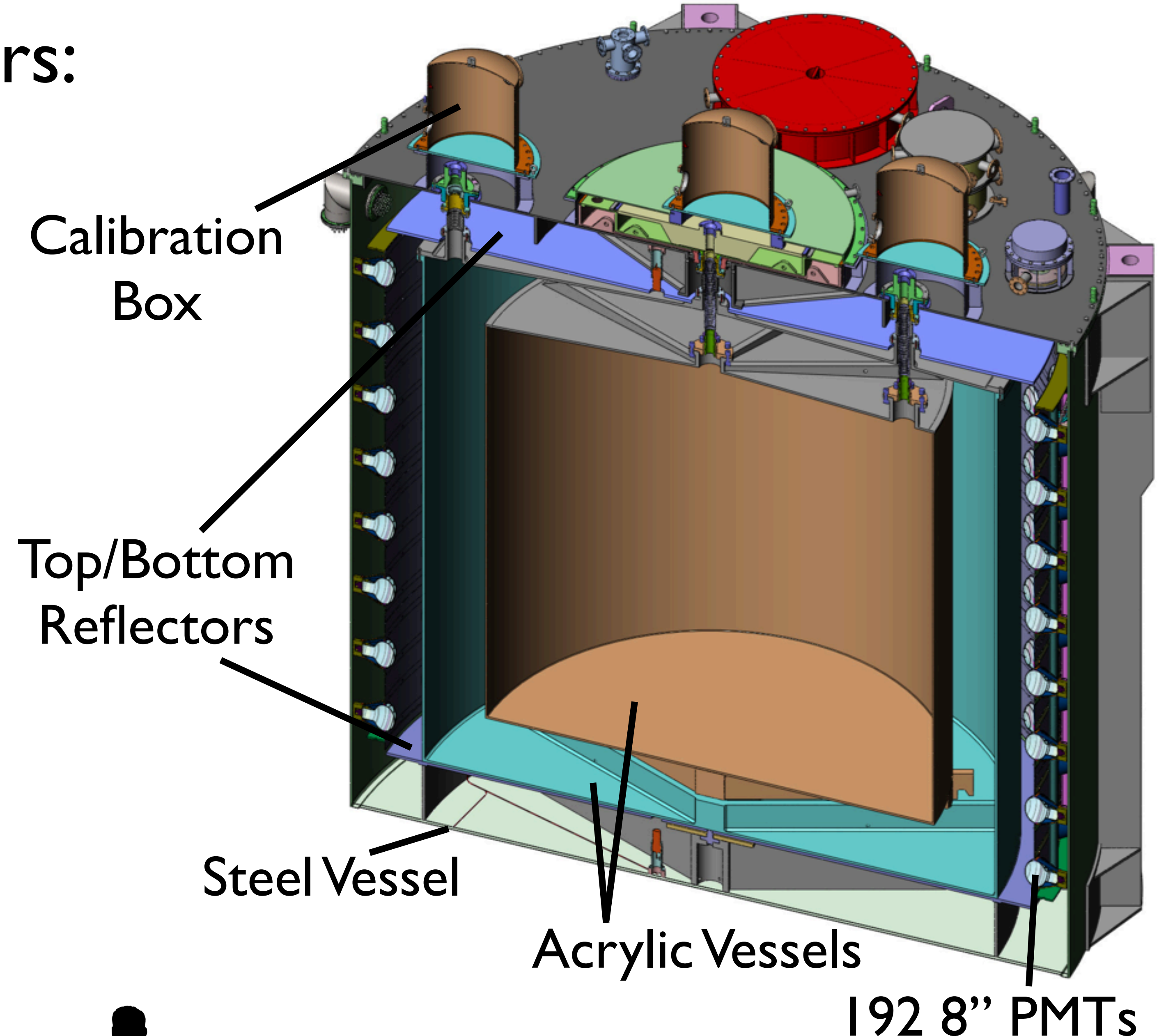
Daya Bay Monte Carlo Data

Daya Bay $\overline{\nu}_e$ Detectors (ADs)

- 8 'identical' 3-zone detectors:



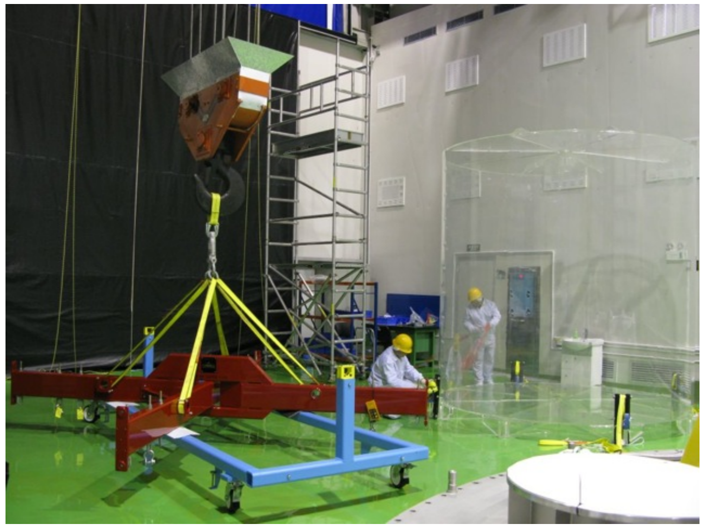


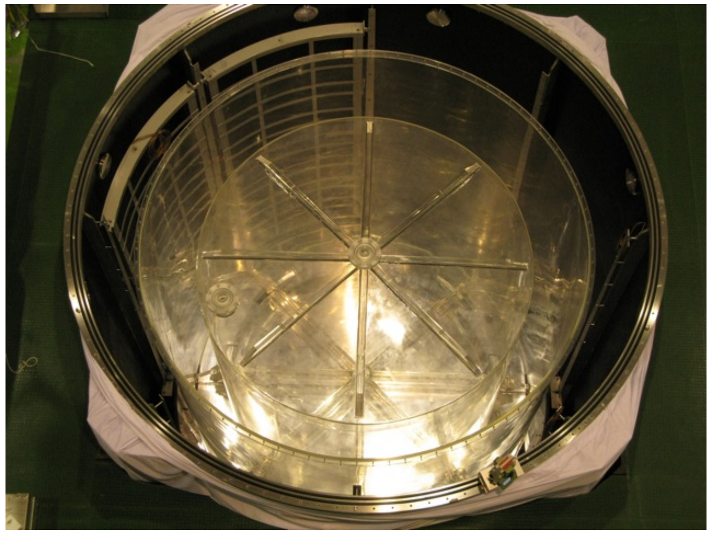


Target Mass: 20 tons
Detector Mass: 110 tons
Energy Resolution: 12%/$\sqrt{E}$
Light Yield: ~120 photoelectrons/MeV

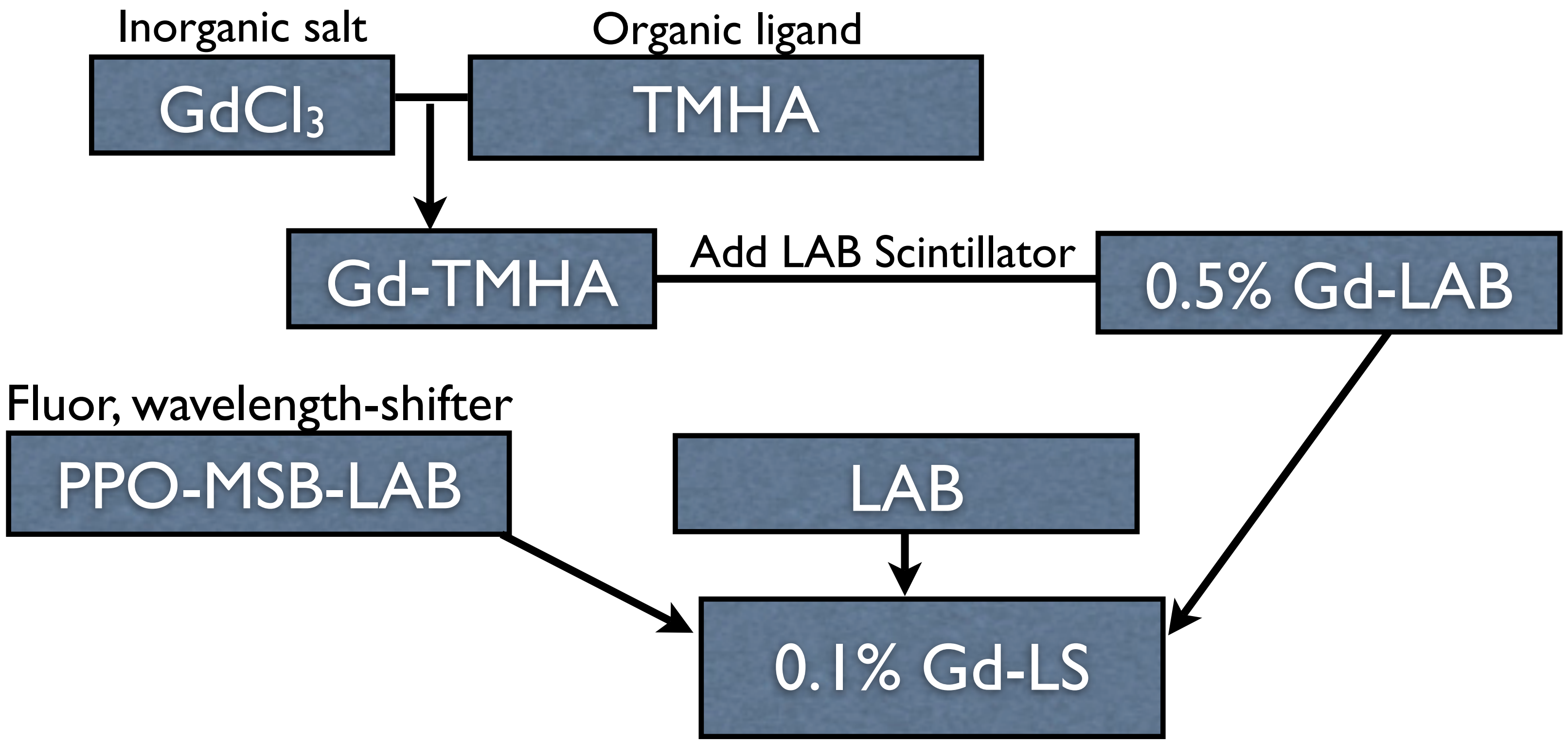
ADs: Current Status

- First 2 ADs being assembled:
  - SSV, bottom reflector: Installed, surveyed
  - Outer acrylic vessels installed, 1 inner vessel installed
  - PMT ladders being populated, installed late May, June
- Next few months:
  - Close stainless steel lids: June, July
  - Attach calibration boxes and overflow tanks: June, July
  - Dry-run data taking in July

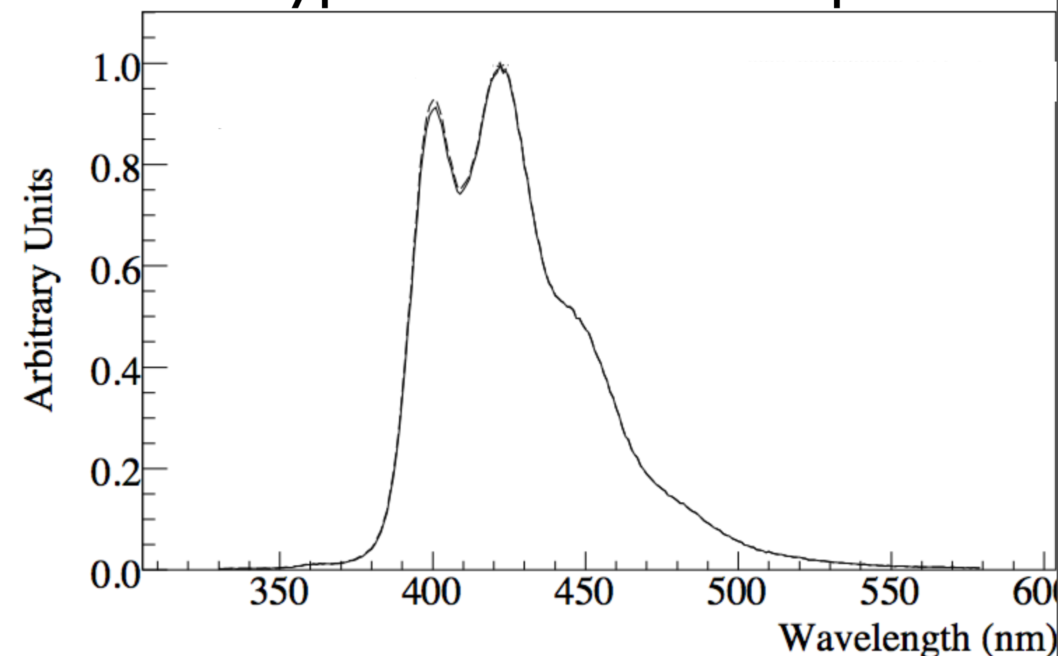


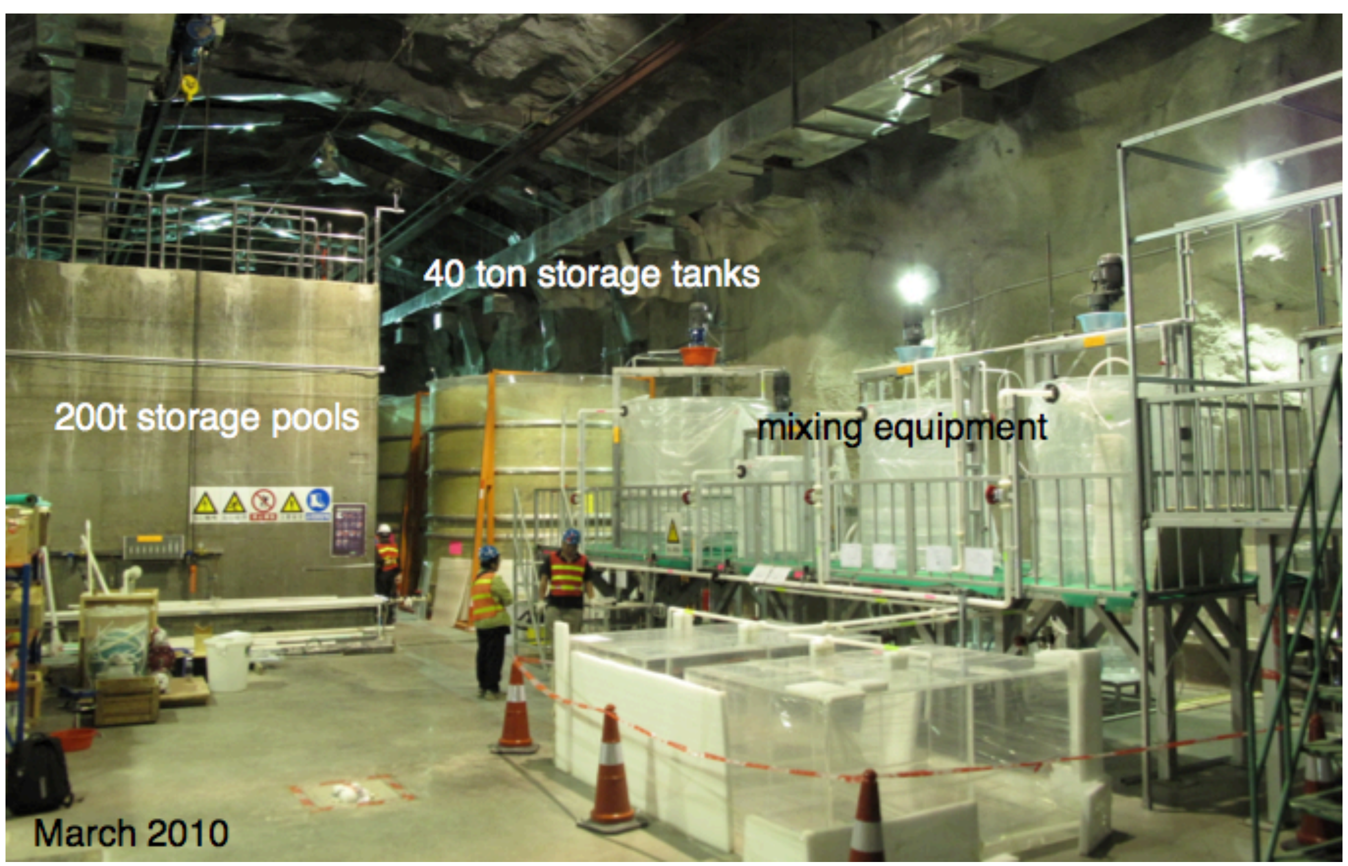


AD Liquids: Description and Status

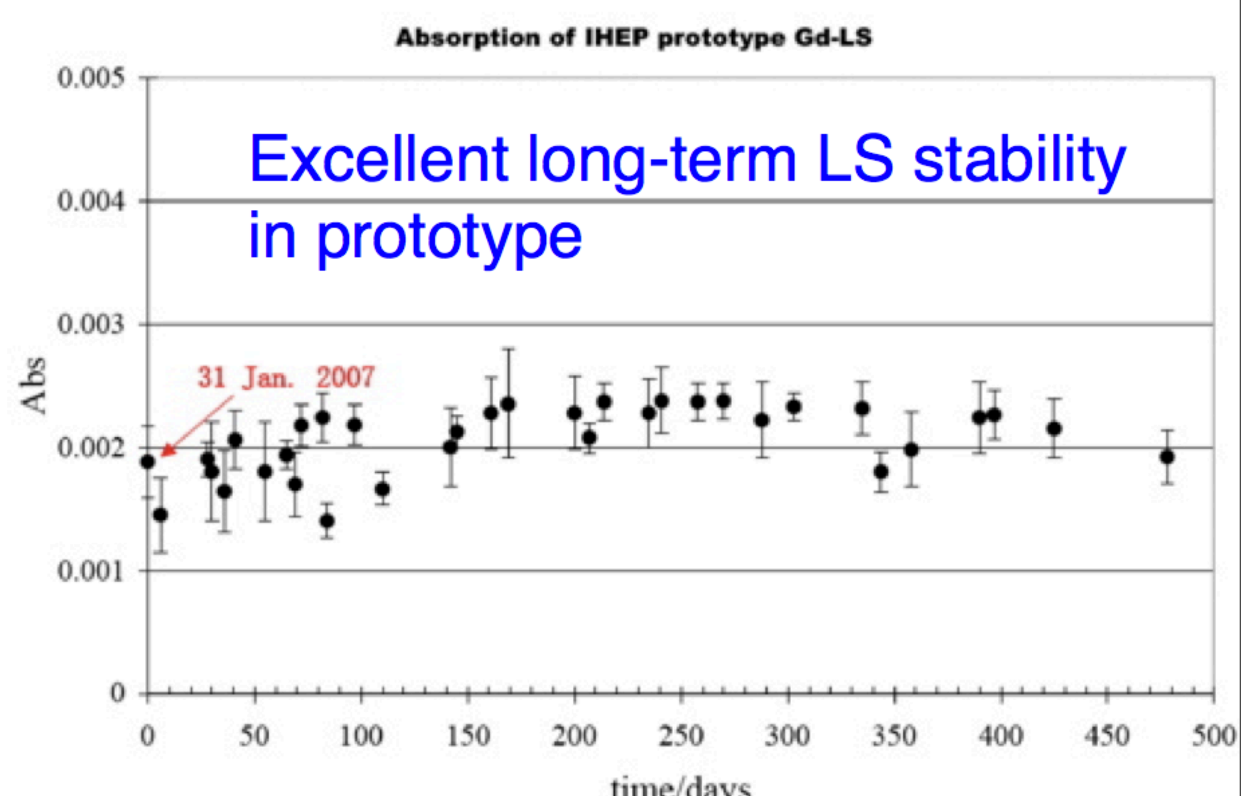


Prototype GdLS Emission Spectrum



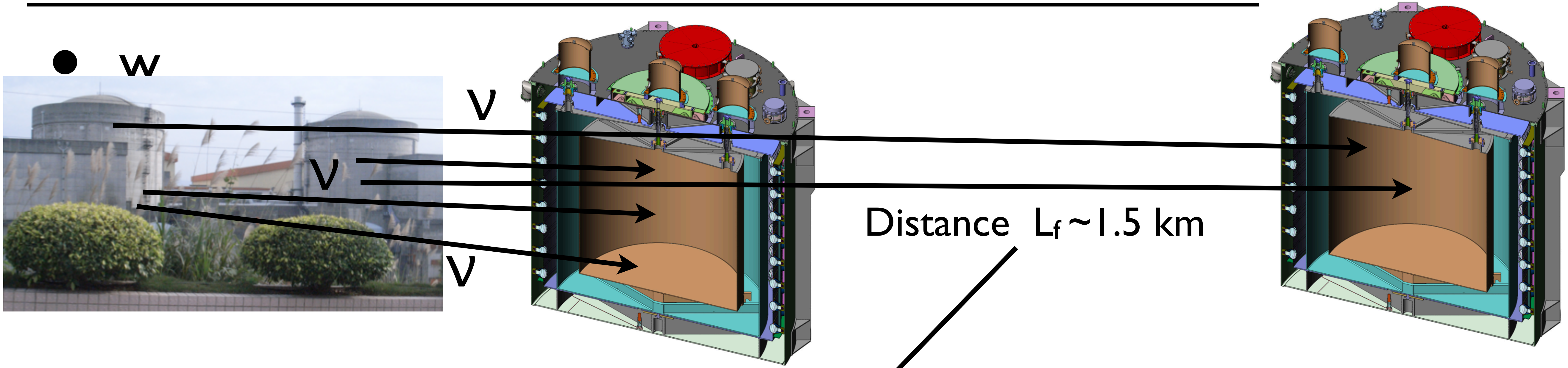


Daya Bay LS Hall



Measurement Method

- w



$$\frac{N_f}{N_n} = \left(\frac{N_{p,f}}{N_{p,n}}\right)\left(\frac{L_n}{L_f}\right)^2\left(\frac{\epsilon_f}{\epsilon_n}\right)\left[\frac{P_{sur}(E,L_f)}{P_{sur}(E,L_n)}\right]$$

Event Rate Ratio

Proton Number Ratio → Mass Measurement

Relative Detection Efficiencies → Calibration

→ $\sin^2 2\theta_{13}$

Detector Systematics

- Daya Bay is a systematics-limited experiment
  - With near-far ratio measurement, detector systematics become dominant:

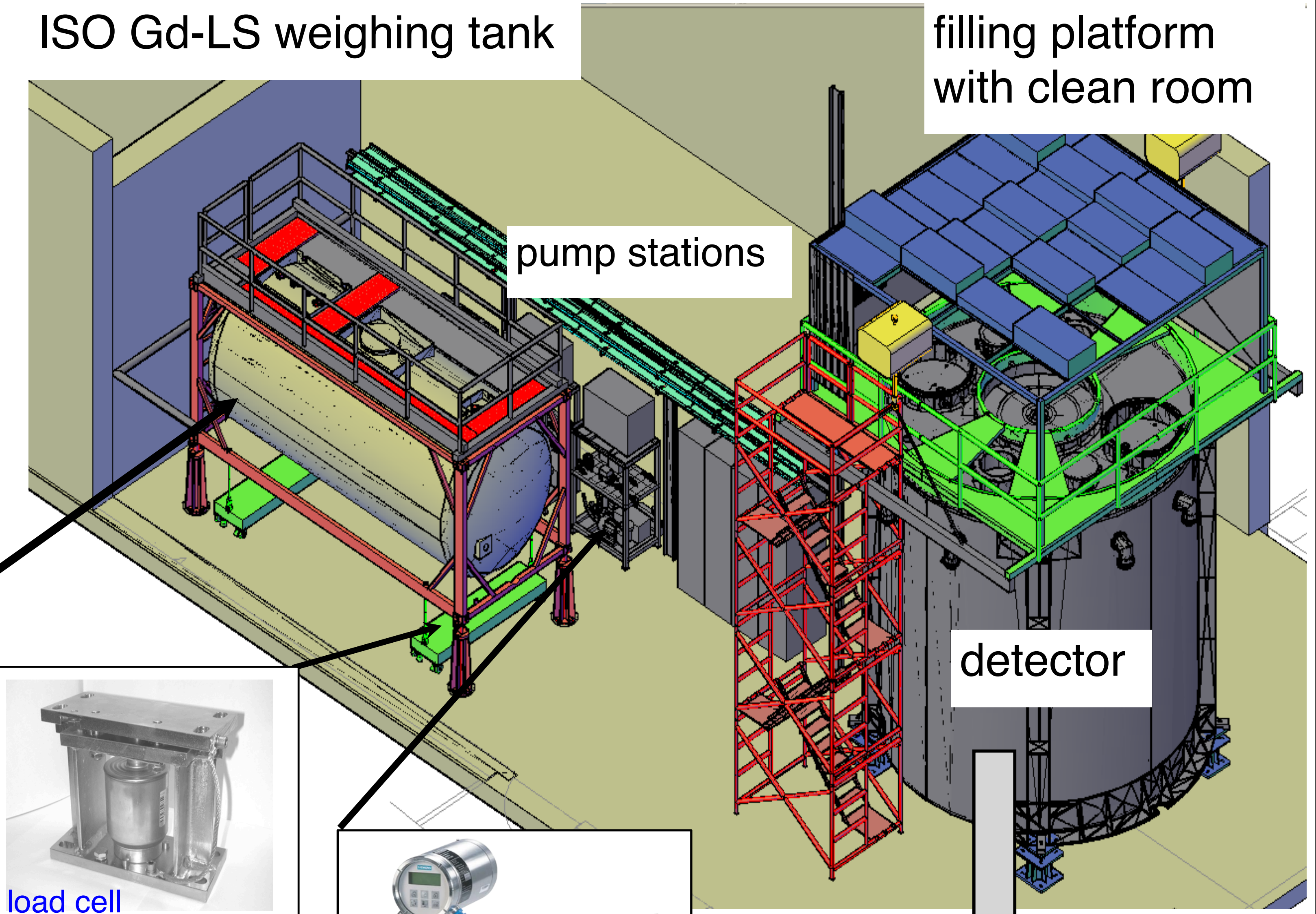
Source of uncertainty		Baseline	Goal
Number of Protons		0.3%	0.1%
Detector Efficiency	Energy Cuts	0.2%	0.1%
	Time Cuts	0.1%	0.03%
	H/Gd Ratio	0.1%	0.1%
	n multiplicity	0.05%	0.05%
	Trigger	0.01%	0.01%
	Live Time	<0.01%	<0.01%
	Total Efficiency	0.25%	0.15%
Total detector uncorrelated uncertainty		0.38%	0.18%

  - Largest: number of protons and 6MeV energy cut efficiency
  - Working hard to minimize these dominant uncertainties

Improving Systematics: Proton Number

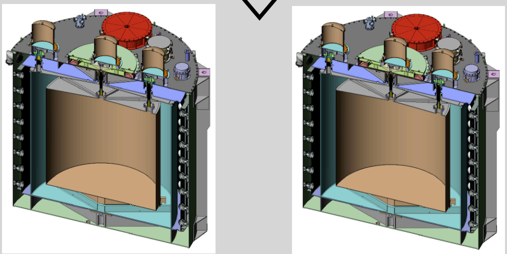
200-ton Gd-LS reservoir

20-ton ISO tank



load cell
accuracy < 0.02%

Coriolis mass
flowmeters < 0.1%

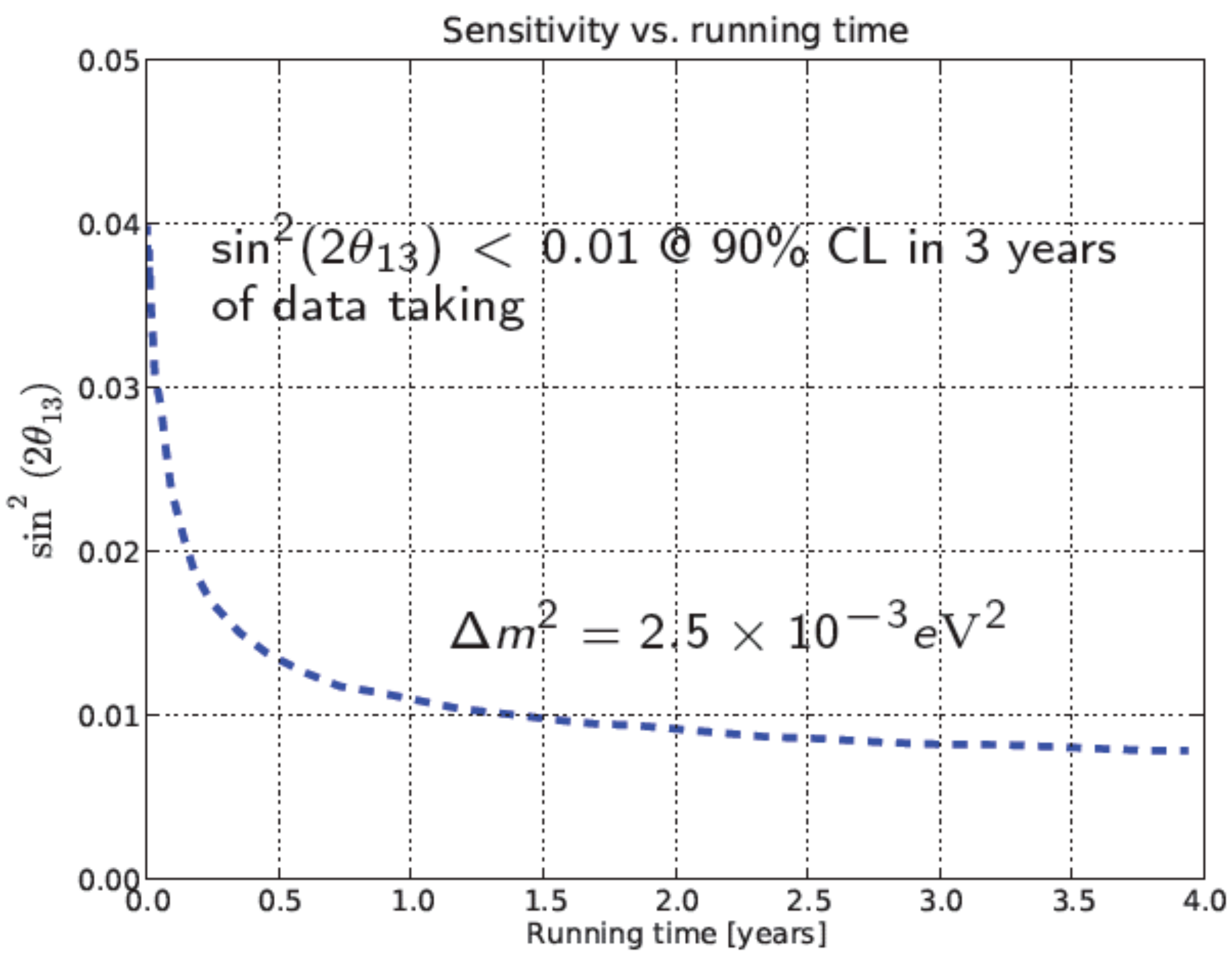


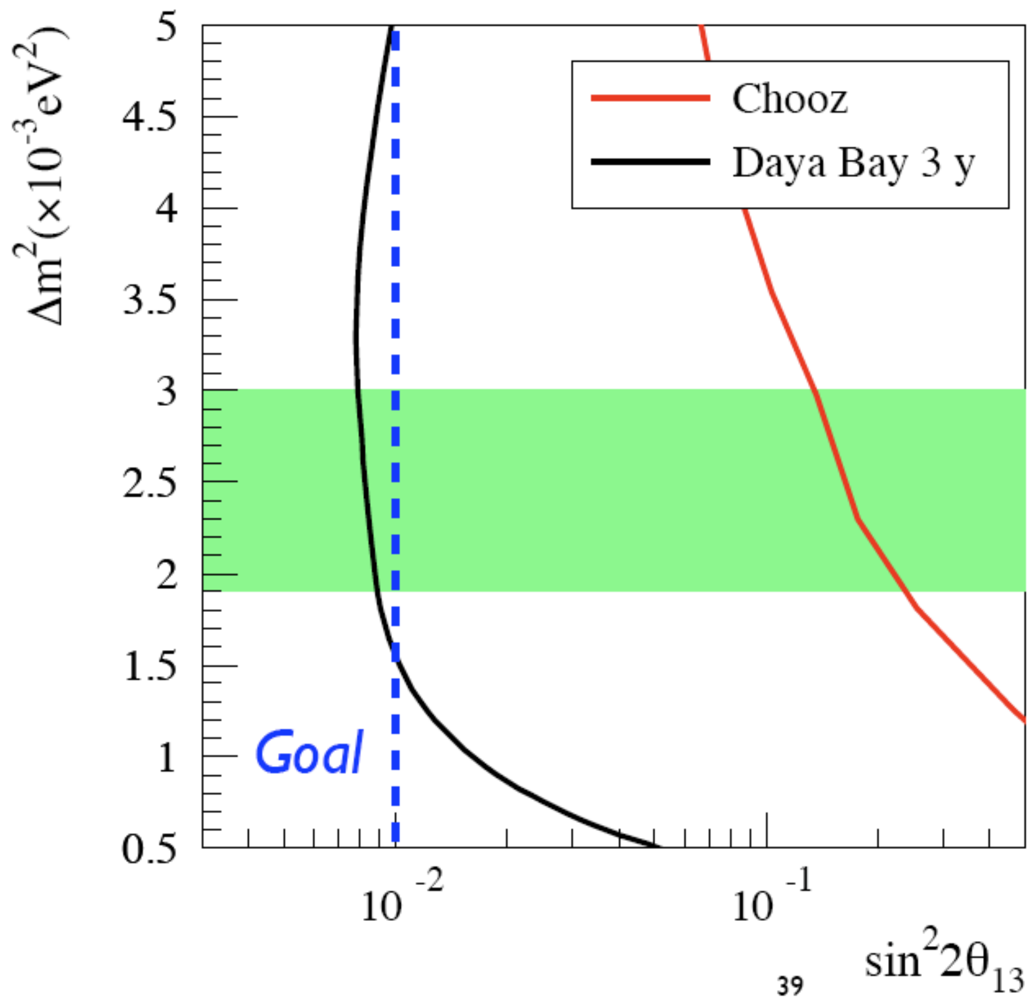
filling "pairs" of detectors

- To beat systematics goal:
  - Redundant mass measurement systems
    - Measure mass to 0.02%: +/- 4 kg out of 20 tons
  - Filling detectors in pairs from a common GdLS reservoir
    - Reduce differences between detector liquids

Schedule and Sensitivity

- Spring 2011: Near site turn-on
  - Reactor flux studies
  - Comparison of near site detectors and evaluation of systematics
- Spring 2012: Far site turn-on
  - Should achieve our goal sensitivity of $\sin^2 2\theta_{13} < 0.01$ at 90% CL





Conclusions

- AD 1,2 assembly is well underway; done by Summer 2010
- R&D has shown that we can meet or exceed goal systematics
  - Detector construction and filling in pairs
  - Mass Measurement R&D
- Spring 2011: Data taking at the near hall will start
- Spring 2012: Full data taking start
- Can reach $\sin^2 2\theta_{13} < 0.01$
- Chris White will provide more details next
- Questions?

End

- Thanks!

Neutrinos: Present Status

- Current limits on θ_{13} set by:
  - MINOS: accelerator ν_e appearance
  - CHOOZ: reactor $\bar{\nu}_e$ disappearance