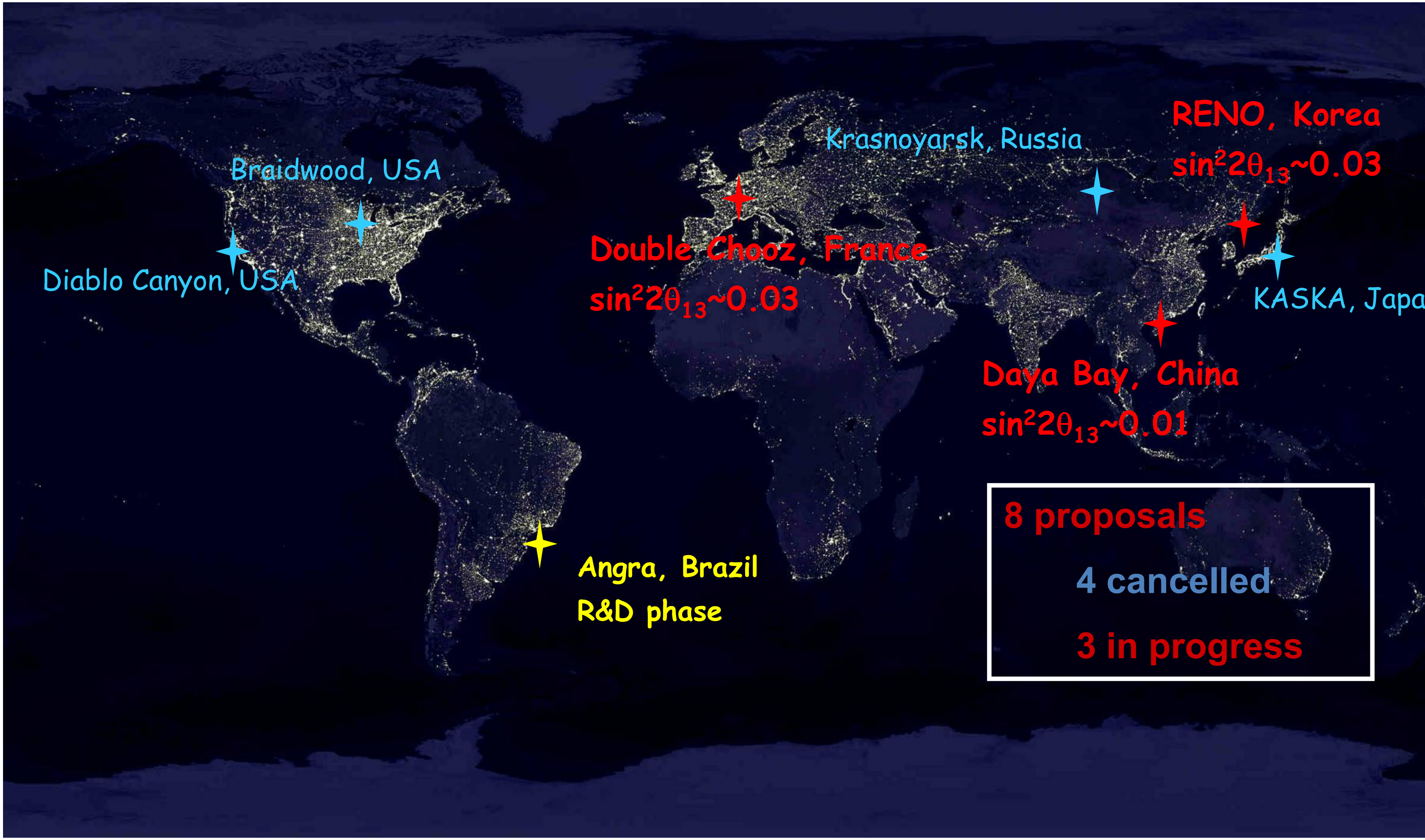
Daya Bay Reactor Neutrino Experiment

On behalf of the DayaBay collaboration

Virginia Polytechnic Institute and State University
Joseph ykHor

Table of Content

Physics Goal



Physics Goal

Determine θ_{13} better than any past experiments

$$= \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_{23} & \sin\theta_{23} \\ 0 & -\sin\theta_{23} & \cos\theta_{23} \end{pmatrix} \times \begin{pmatrix} \cos\theta_{13} & 0 & e^{-i\delta_{CP}}\sin\theta_{13} \\ 0 & 1 & 0 \\ -e^{i\delta_{CP}}\sin\theta_{13} & 0 & \cos\theta_{13} \end{pmatrix} \times \begin{pmatrix} \cos\theta_{12} & \sin\theta_{12} & 0 \\ -\sin\theta_{12} & \cos\theta_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix} \times \begin{pmatrix} 1 & 0 & 0 \\ 0 & e^{i\alpha/2} & 0 \\ 0 & 0 & e^{i\alpha/2+i\beta} \end{pmatrix}$$

$\theta_{23} \sim 45^o$

Super K + Accelerator

+ atmospheric

CP-phase + small θ_{13}

DayaBay

Double Chooz

$\theta_{12} \sim 35^o$

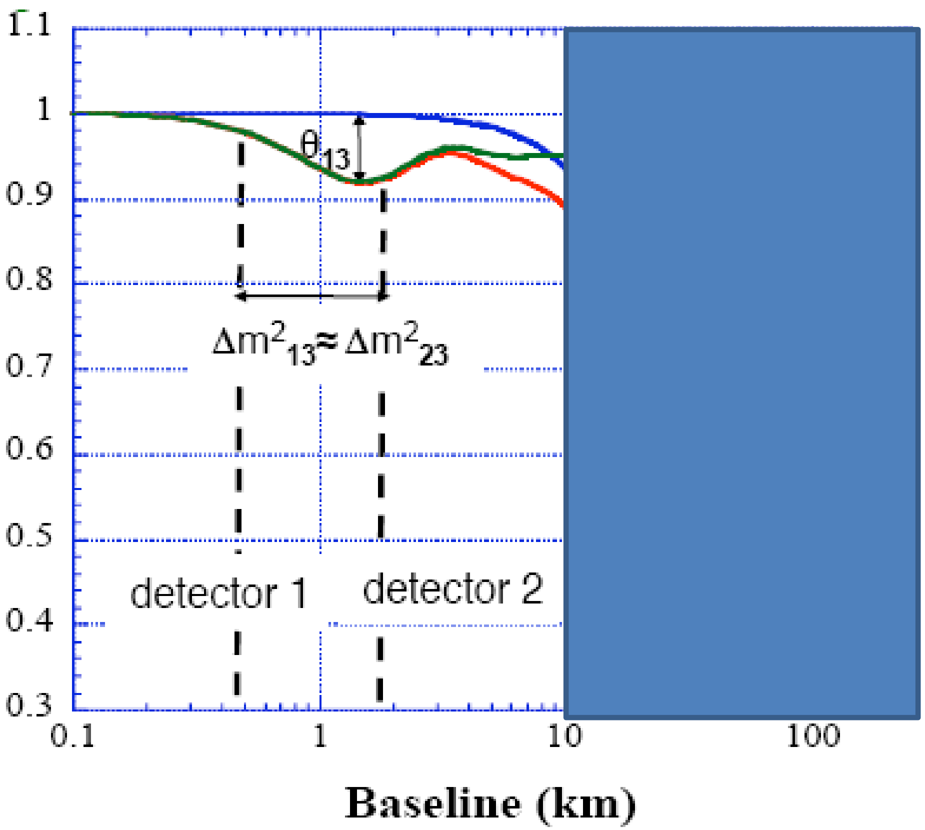
KamLand + Solar

Neutrinoless double beta decay

PMNS Matrix Parameterization: $\nu_\alpha = \sum_{i=1}^{3} U_{\alpha,i}\nu_i$

Relative measurement & disappearance probability

$$P_{ee} \approx 1 - \sin^2 2\theta_{13} \sin^2\left(\frac{\Delta m_{31}{}^2 L}{4E_\nu}\right)$$



- **near detectors** measure ν_e flux and spectrum to reduce reactor-related systematic uncertainties
- **far detector** at the oscillation maximum provides the highest sensitivity

Relative measurement & disappearance probability

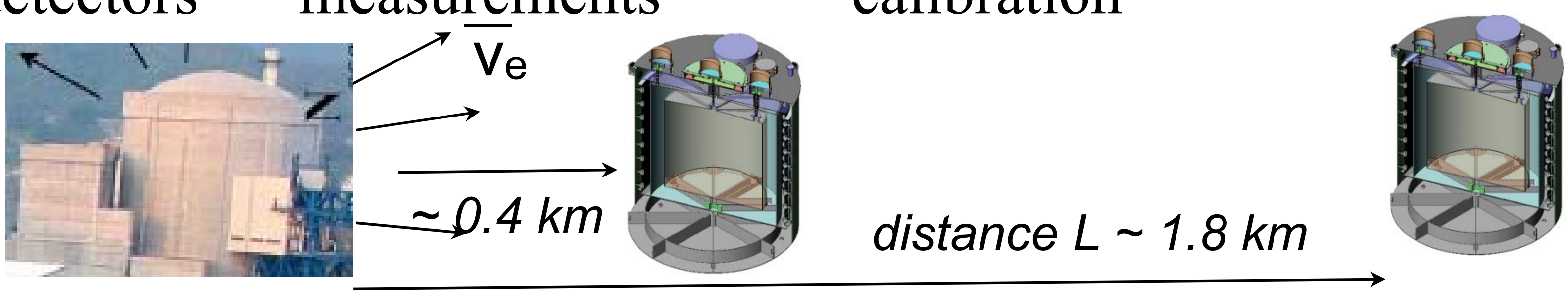
$$\frac{N_{\rm f}}{N_{\rm n}} = \left(\frac{N_{\rm p,f}}{N_{\rm p,n}}\right)\left(\frac{L_{\rm n}}{L_{\rm f}}\right)^2\left(\frac{\epsilon_{\rm f}}{\epsilon_{\rm n}}\right)\left[\frac{P_{\rm sur}(E,L_{\rm f})}{P_{\rm sur}(E,L_{\rm n})}\right]$$

Ratio of measured event rate from far and near site detectors

Ratio of number of protons in Gd-LS. Obtained by mass flow measurements

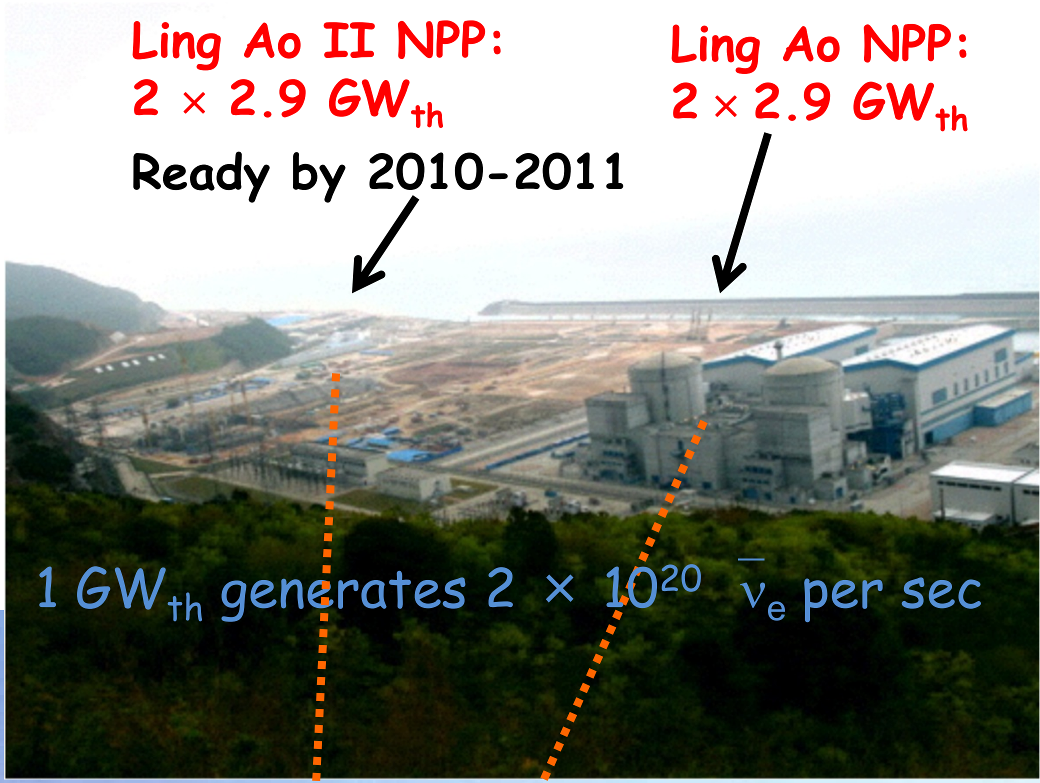
Ratio of the detector efficiency Obtained by calibration

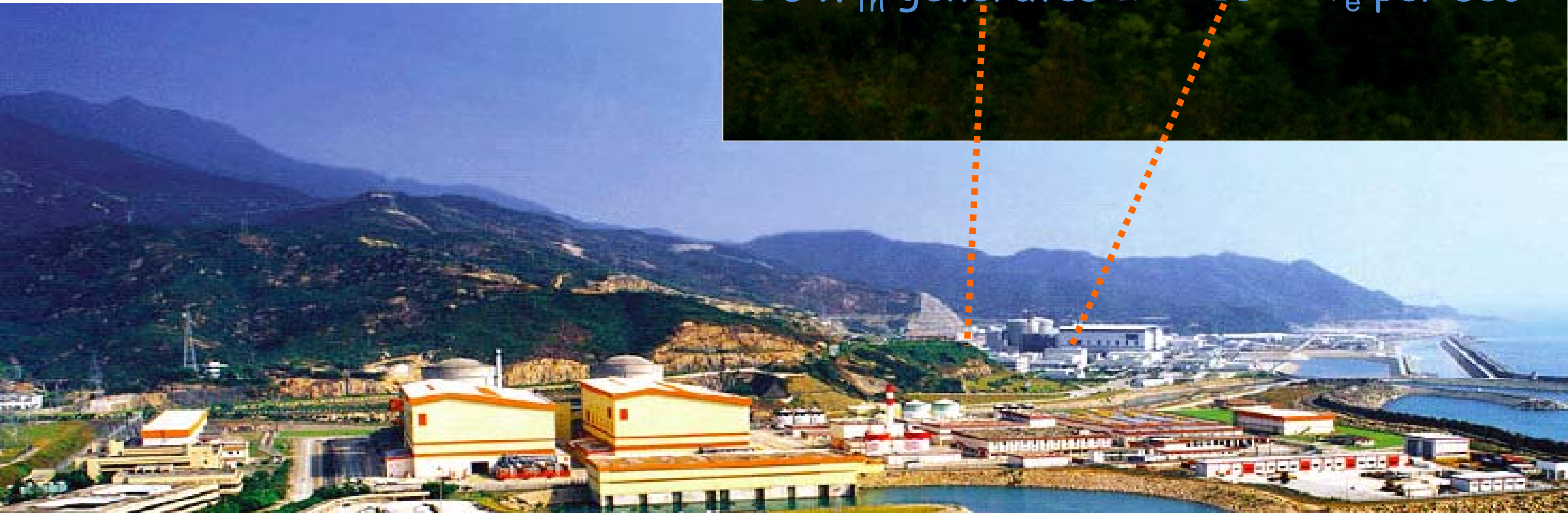
Probability ratio determine $\sin^2(2\theta_{13})$



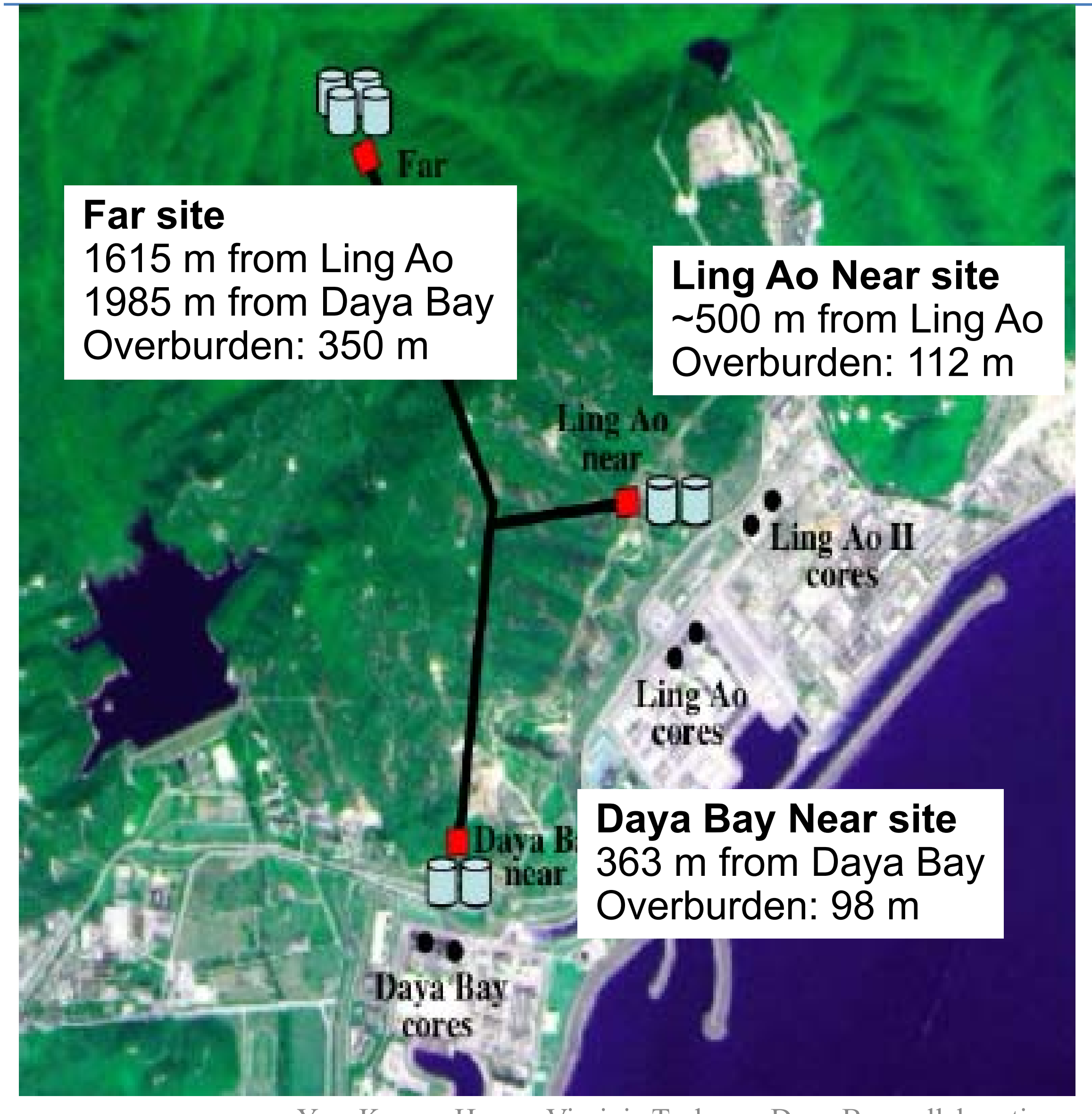
Baseline & detector design

- currently running at 11.6 GW
- one of the top five most powerful by 2011 (17.4 GW)
- Adjacent to mountain, easy to construct tunnels to reach underground labs with sufficient overburden to suppress cosmic rays





Baseline & detector design

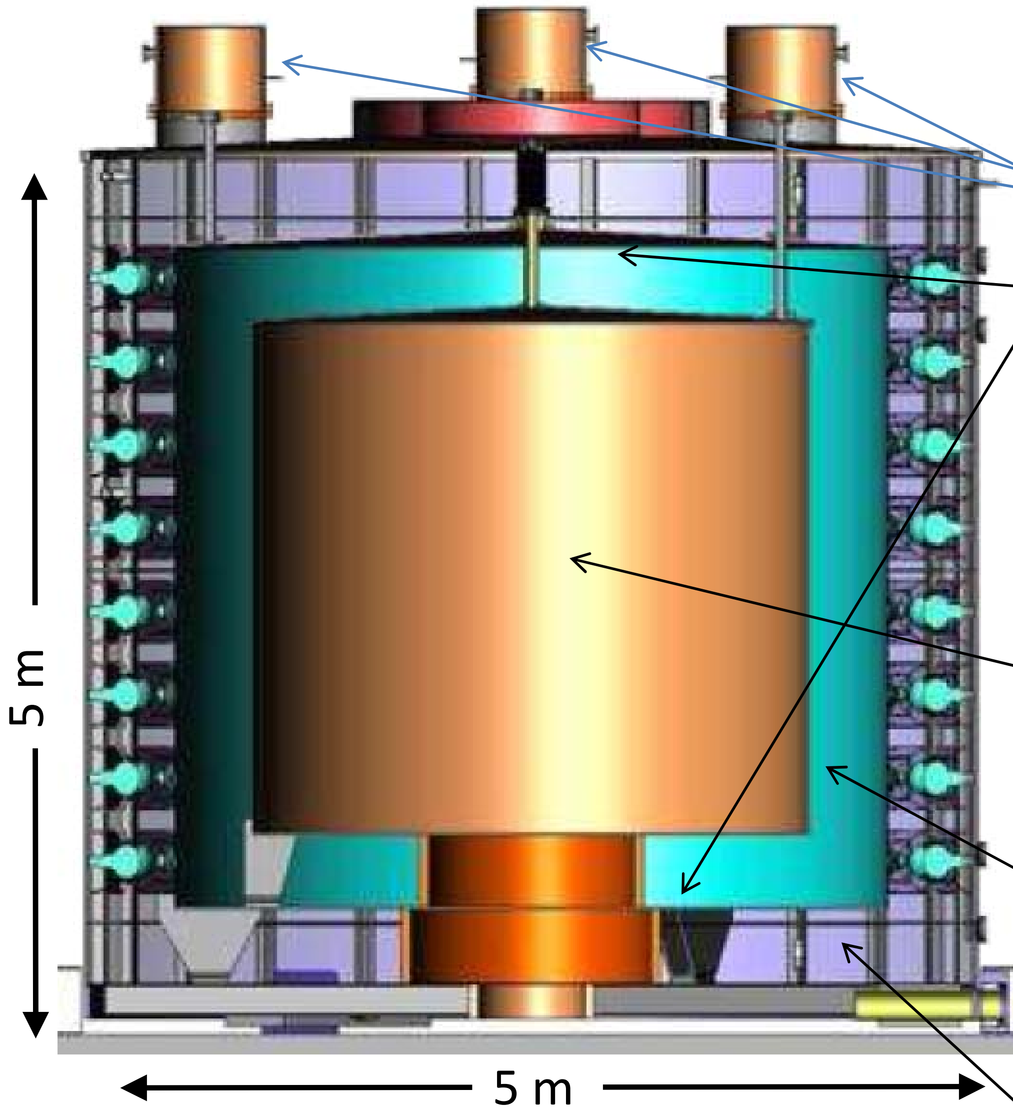


Deep down the mountain to suppress cosmogenic background

Deploy identical detectors in all sites to isolate systematic uncertainties

Optimize baseline distance for disappearance oscillation

Baseline & detector design



Antineutrino Detector(AD)

Automatic calibration system

Top and bottom reflectors

192 8" PMTs

Three-zone design:

Gd-doped LS, 20 tons

Inner acrylic vessel

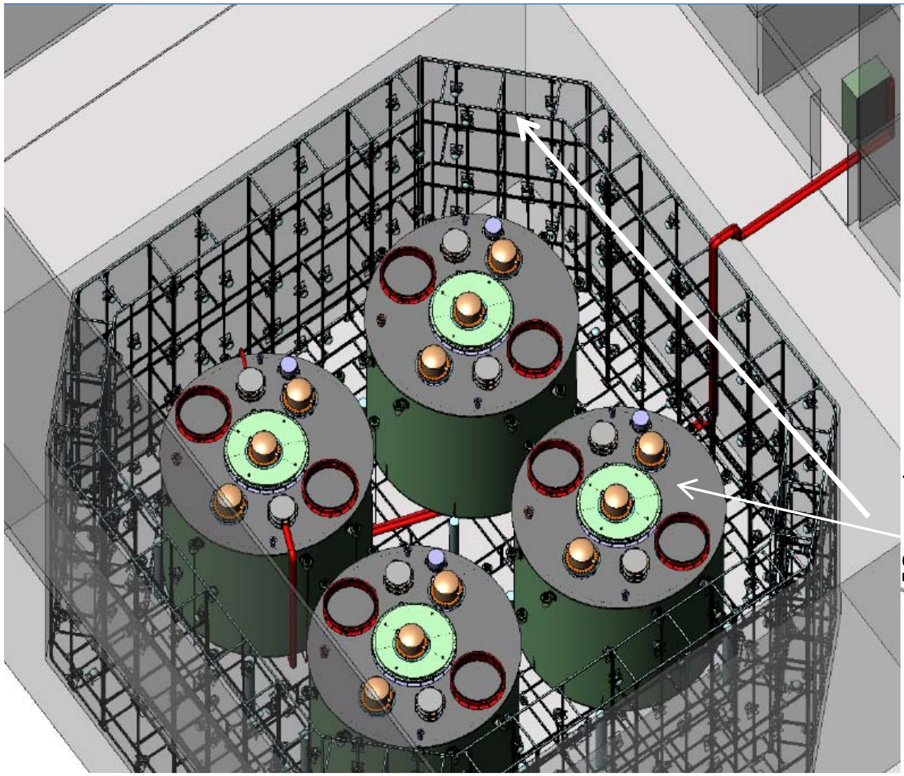
LS as Gamma Catcher, 20 tons

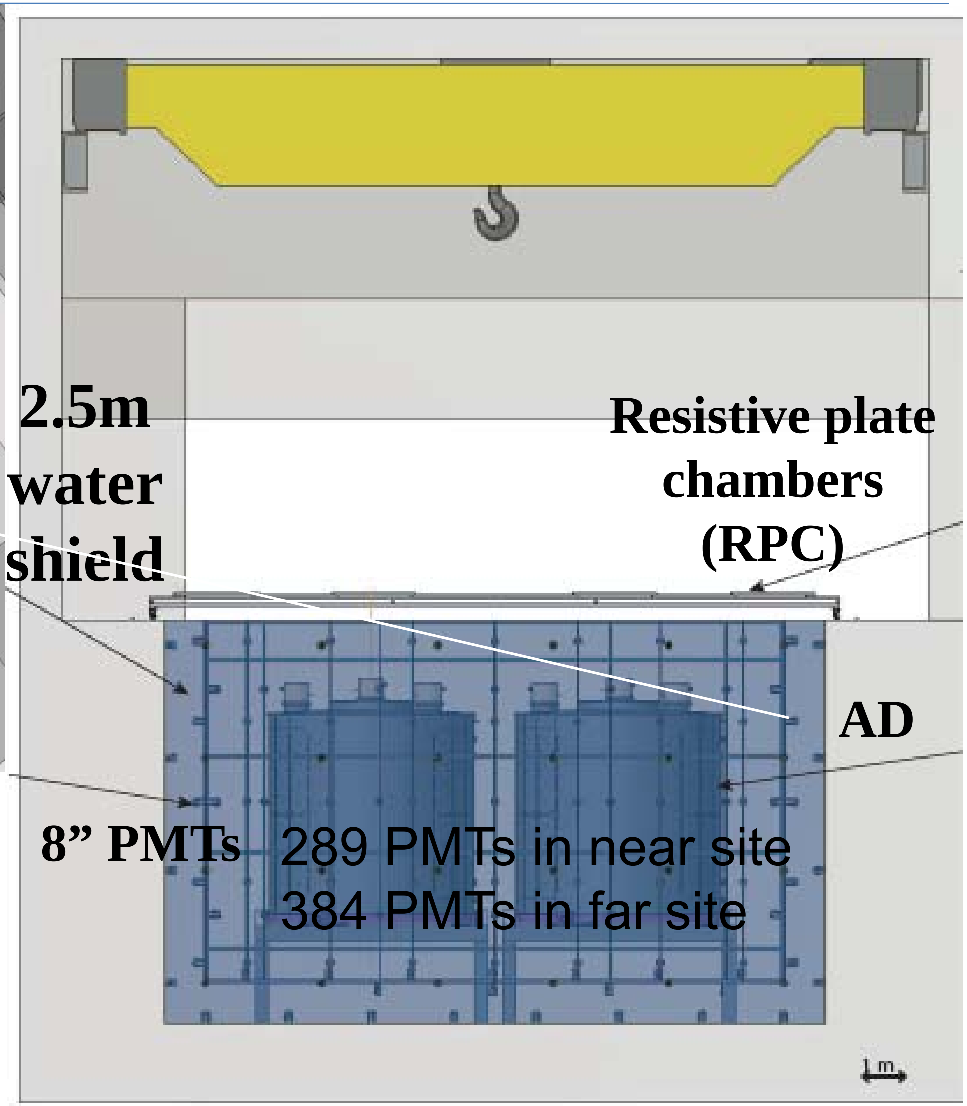
Outer acrylic vessel

Mineral oil as buffer, 40 tons

Stainless steel tank

Baseline & detector design



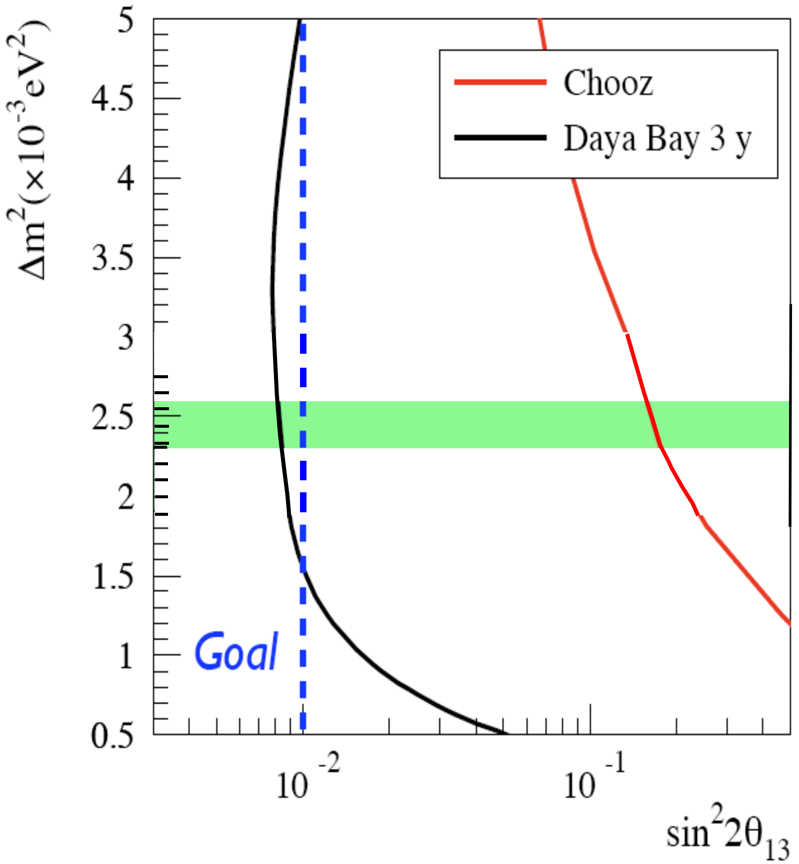


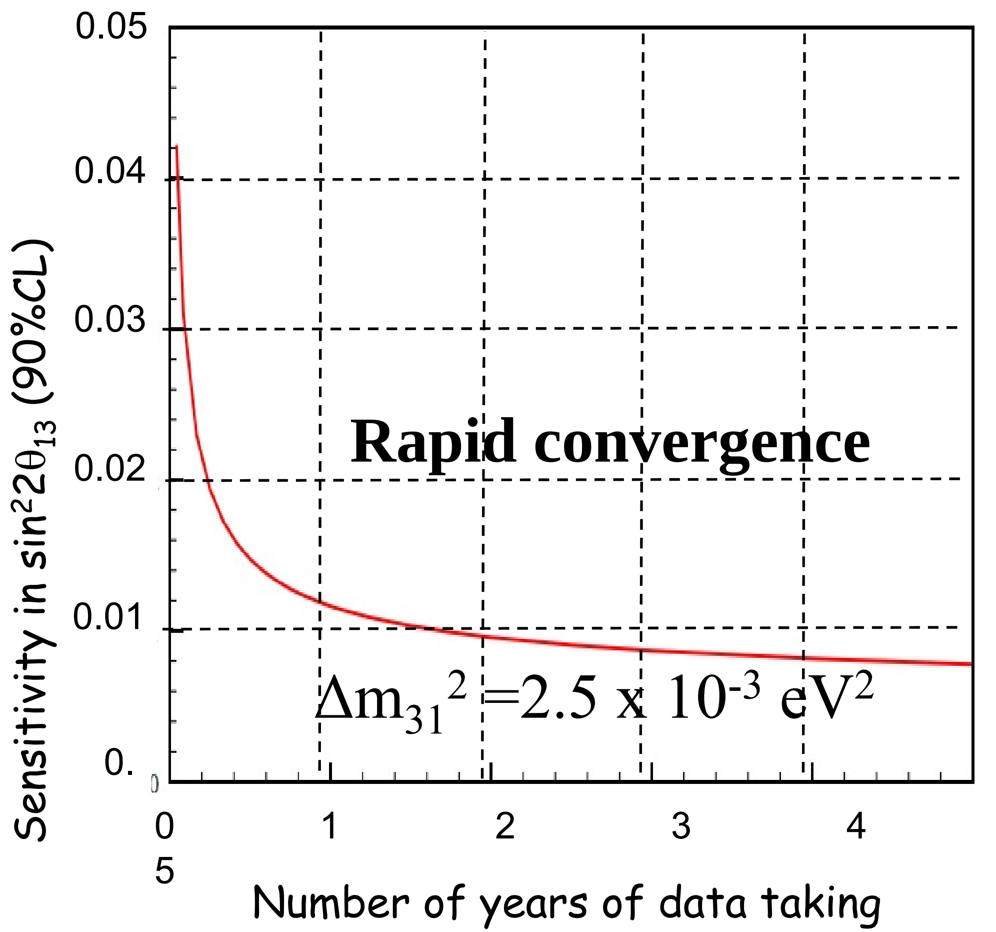
Muon tagging

Shielding of background radiation

RPC as muon veto on top of water Cherenkov

Sensitivity



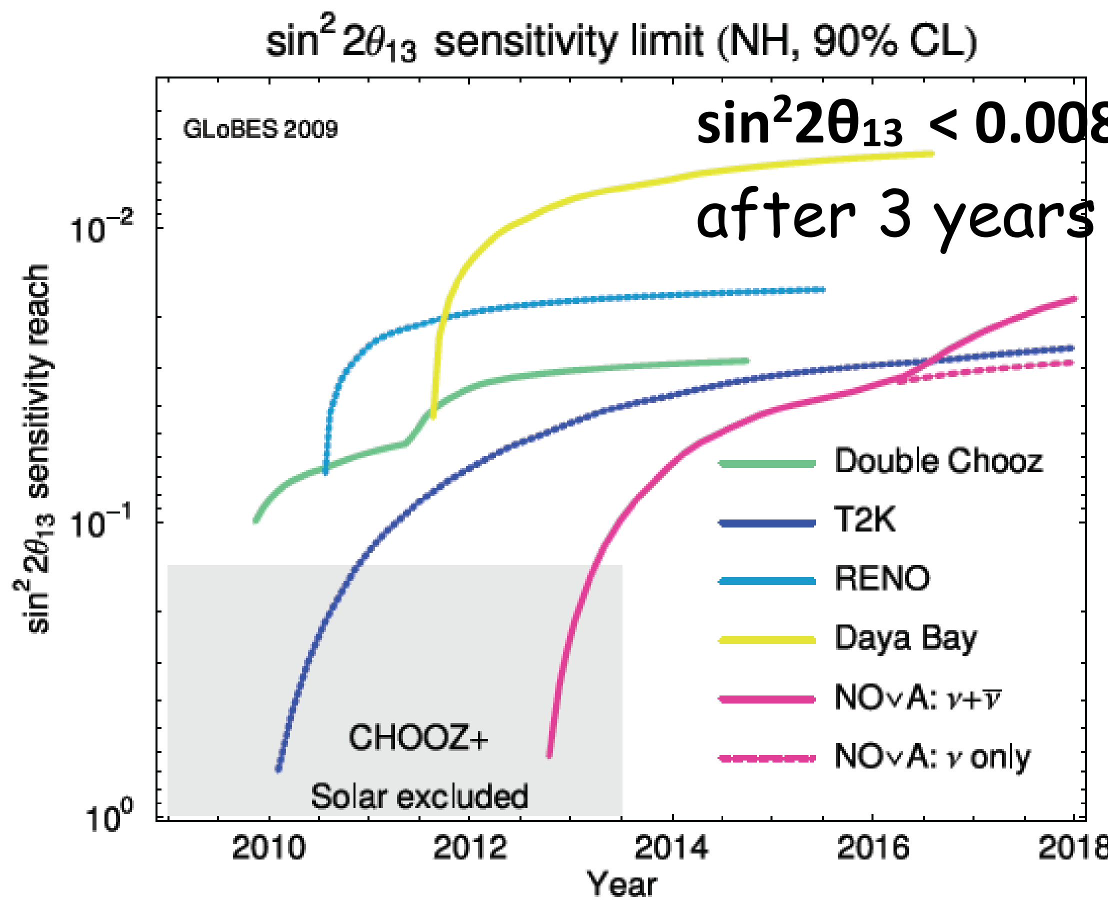


$\sin^2 2\theta_{13}$ < 0.008 @ 90% CL

after 3 years of data taking

Sensitivity

Sensitivity Comparison



$\sin^2 2\theta_{13} < 0.008$ @ 90% CL

after 3 years of data taking

P. Huber, M. Lindner, T. Schwetz, W. Winter, arXiv:0907.1896.

Current status, schedule and dates

- CD-0 (DOE Mission Need): 11/2005
- Daya Bay proposed at OHEP Briefing 4/2006
- Successful Physics Review 10/16/06
- CD-1 site selection approved 9/2007
- Groundbreaking for civil construction 10/2007
- CD-2 & 3a Baseline approved 3/2008
- CD-3b Construction start 8/2008
- Occupancy of SAB 3/2009

- **Occupancy of first underground halls, 2009**
- **Expected start of first operations, 2010**
- **Full operations start, 2011**

Current status, schedule and dates

Current status, schedule and dates

- LS Hall is ready
- Near Hall #1 will be ready in Nov 2009

Red indicates current construction progress

Summary

DayaBay experiment is the most sensitive $\boldsymbol{\theta_{13}}$ experiment under construction

Specifically designed to achieve the sensitivity of $\boldsymbol{\sin^2(2\theta_{13})}$ down to 0.01(goal) at 90% C.L. and 0.008(projected) in three years of data taking

It is now on track to take initial data in the next year and become fully operational in 2 years

The End

Thank You

Back up

Source of uncertainty		Chooz (*absolute*)	Daya Bay (*relative*) Baseline	Goal	Goal w/Swapping
# protons		0.8	0.3	0.1	0.006
Detector Efficiency	Energy cuts	0.8	0.2	0.1	0.1
	Position cuts	0.32	0.0	0.0	0.0
	Time cuts	0.4	0.1	0.03	0.03
	H/Gd ratio	1.0	0.1	0.1	0.0
	n multiplicity	0.5	0.05	0.05	0.05
	Trigger	0	0.01	0.01	0.01
	Live time	0	<0.01	<0.01	<0.01
Total detector-related uncertainty		1.7%	0.38%	0.18%	0.12%

Back up

	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
$^8He+^9Li$ B/S (%)	0.3	0.2	0.2

Accidental coincidence:

natural radioactivity

neutrons from cosmic muons

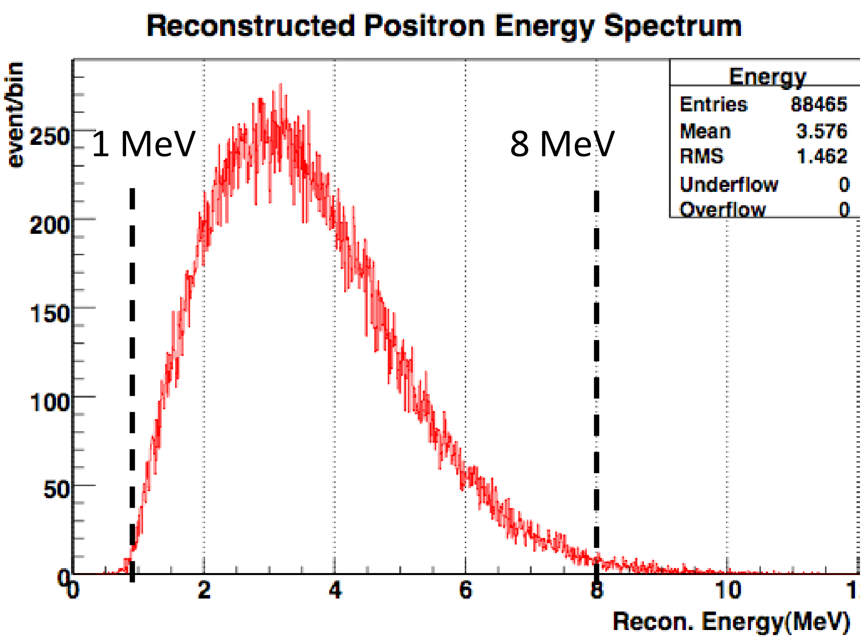
Correlated events:

Fast neutron capture + recoil proton

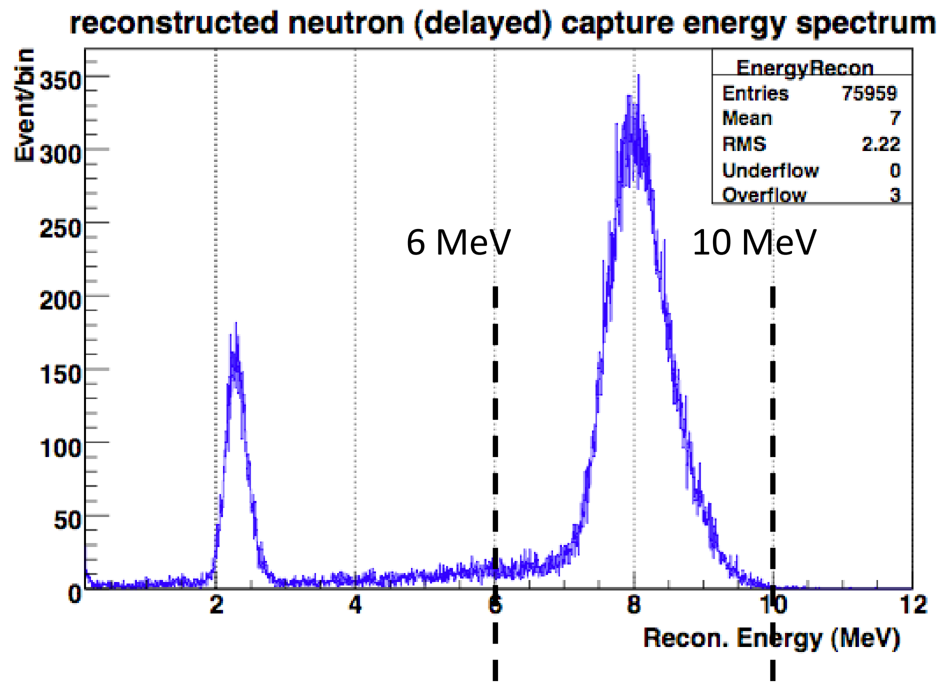
Beta + neutron decay from Helium & Lithium

Back up

Prompt Energy Signal



Delayed Energy Signal



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

0.3b $\rightarrow + p \rightarrow D + \gamma(2.2\ \mathrm{MeV})$ (delayed)

50,000b $\rightarrow + Gd \rightarrow Gd^* \rightarrow Gd + \gamma's(8\ \mathrm{MeV})$ (delayed)

Energy spectrum of two processes in inverse-beta decay