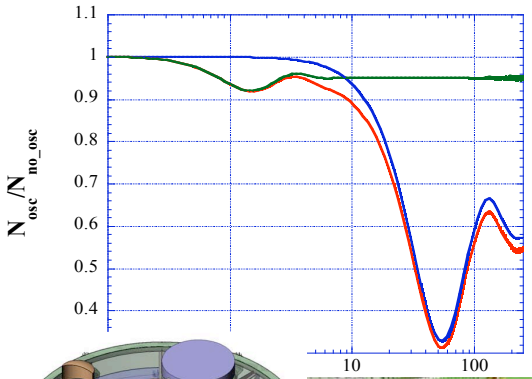
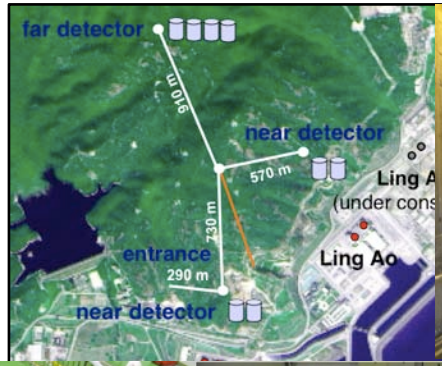
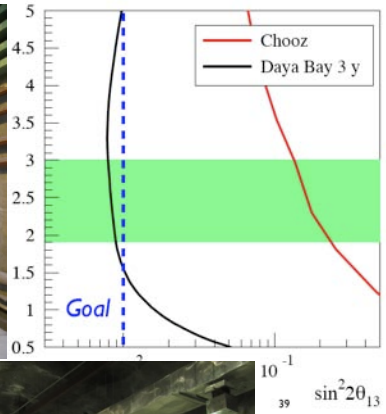
A Precision Measurement of $\sin^2 2\theta_{13}$ at Daya Bay (Task L)

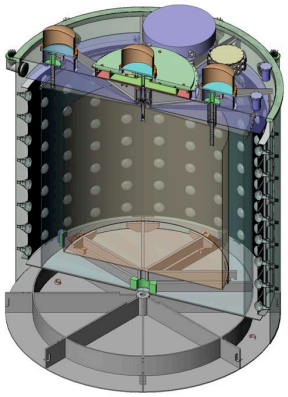
Karsten M. Heeger

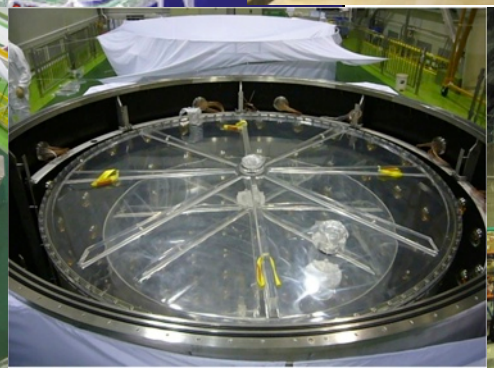
University of Wisconsin











DOE HEP Review, August 26, 2010

Daya Bay at University of Wisconsin

Scientists

Karsten Heeger*	(faculty, *experimental)*
Baha Balantekin	(faculty, *theory)*
Henry Band*	(senior scientist
Tom Wise	(researcher)
Wei Wang*	(postdoc)
Bryce Littlejohn*	(graduate student, 5th year)
Mike McFarlane*	(graduate student, 5th year)
Christine Lewis	(graduate student, 3rd year)
Paul Hinrichs	(graduate student, 2nd year)
Alex Green	(undergraduate student)

4 senior people
1 postdoc
4 PhD students
1 undergraduate

+ some 11 technical people

* receive support from this grant

Past Group Members

Dante Passmore	graduated with MSc in 2008
Ho Ling Li	undergraduate, now at U Chicago
Dan Zou	undergraduate, now at U Chicago
Patrick Mende	undergraduate, now at Carnegie Mellon

Technical Personnel

Jeff Cherwinka, Lee Greenler, Dan Wenman, Phil Robl, Jack Ambuel, Harold Mattison, Amy Pagac, Dan Wahl, Andy Arbuckle, Darrel Hamilton, Qian Xiao

PSL
ENGINEERING AND INSTRUMENTATION
UNIVERSITY OF WISCONSIN - MADISON

Physical Sciences Laboratory
http://www.psl.wisc.edu/

Neutrino Physics at Reactors

Next - Discovery and precision measurement of θ_{13}

2008 - Precision measurement of Δm_{12}^2 . Evidence for oscillation

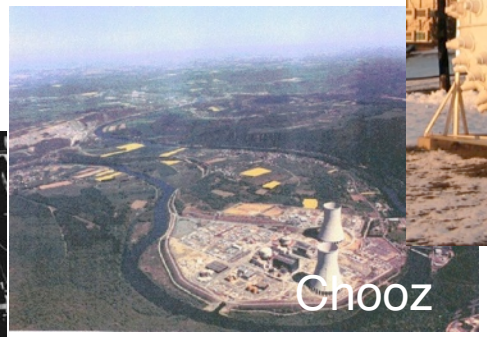
2004 - Evidence for spectral distortion

2003 - First observation of reactor antineutrino disappearance

1995 - Nobel Prize to Fred Reines at UC Irvine

1980s & 1990s - Reactor neutrino flux measurements in U.S. and Europe

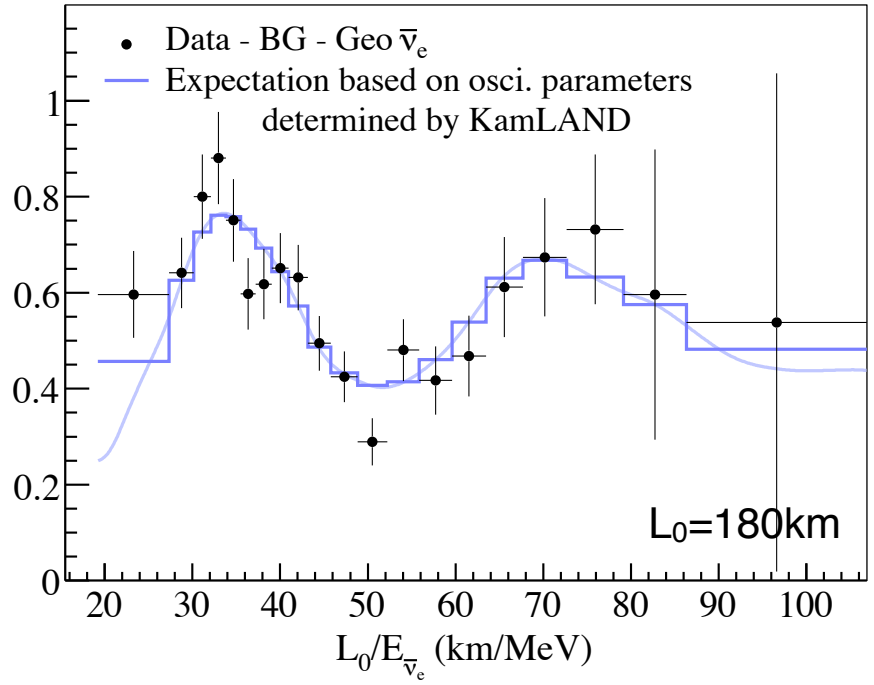
1956 - First observation of (anti)neutrinos

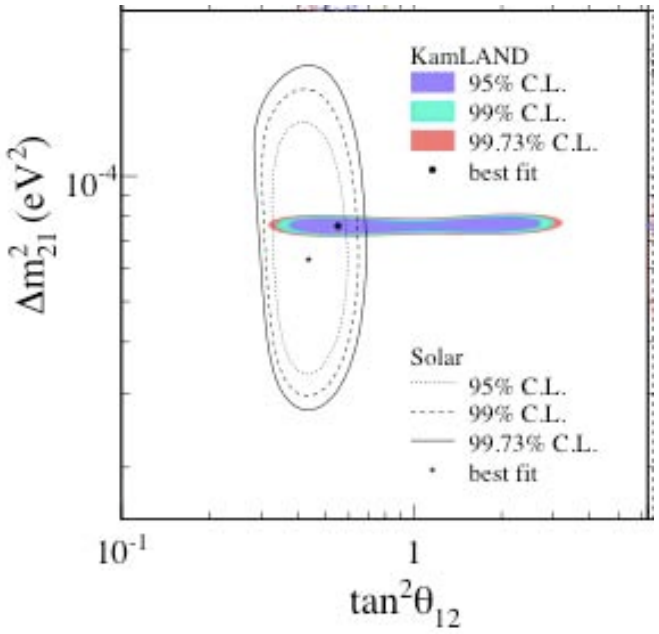


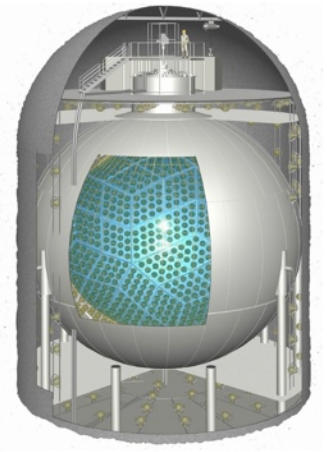
Past Reactor Experiments
Hanford
Savannah River
ILL, France
Bugey, France
Rovno, Russia
Goesgen, Switzerland
Krasnoyark, Russia
Palo Verde
Chooz, France

Measurement of Reactor $\overline{\nu}$ Oscillation at KamLAND

L/E Dependence







Phys.Rev.Lett.100:221803,2008

KamLAND+solar

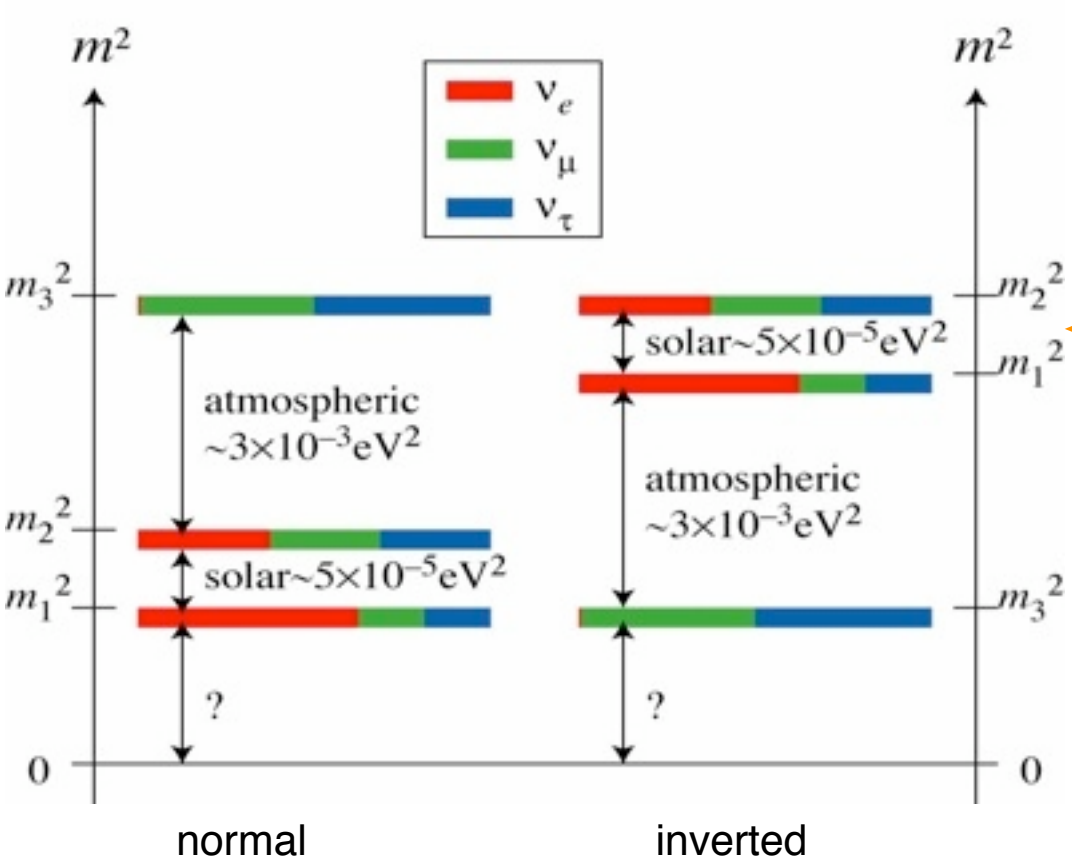
(combined under assumption of CPT invariance)

$$\tan^2\Theta = 0.47\ ^{+0.06}_{-0.05}$$

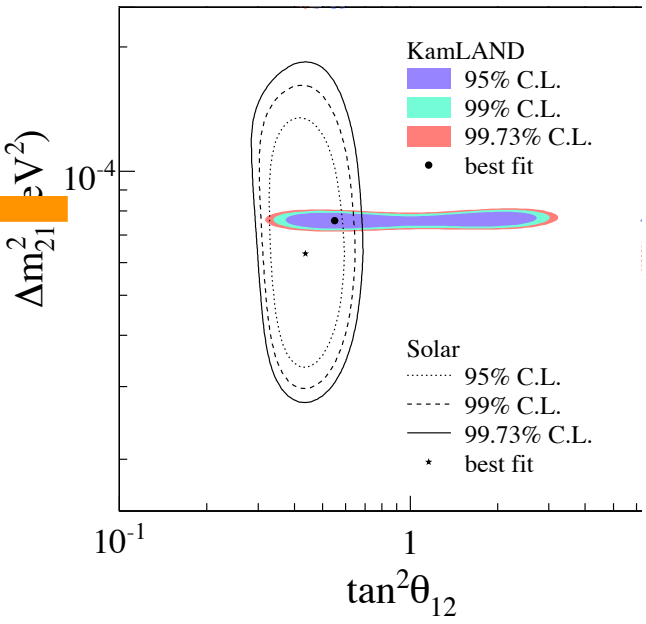
$$\Delta m^2 = 7.59\ ^{+0.21}_{-0.21}\ \times 10^{-5}\ \text{eV}^2$$

Precision Measurement of Oscillation Parameters

Neutrino Mass Splitting



KamLAND 2008



- KamLAND provides most precise value of Δm_{12}^2 (~2.8%)

Neutrino Oscillation

Mixing Angles

$$U = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} \\ U_{\tau 1} & U_{\tau 2} & U_{\tau 3} \end{pmatrix} = \begin{pmatrix} 0.8 & 0.5 & U_{e3} \\ 0.4 & 0.6 & 0.7 \\ 0.4 & 0.6 & 0.7 \end{pmatrix}$$

U_{MNSP} Matrix

Maki, Nakagawa, Sakata, Pontecorvo

$$= \underbrace{\begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_{23} & \sin\theta_{23} \\ 0 & -\sin\theta_{23} & \cos\theta_{23} \end{pmatrix}}_{\text{atmospheric, K2K}} \times \underbrace{\begin{pmatrix} \cos\theta_{13} & 0 & e^{-i\delta_{CP}}\sin\theta_{13} \\ 0 & 1 & 0 \\ -e^{i\delta_{CP}}\sin\theta_{13} & 0 & \cos\theta_{13} \end{pmatrix}}_{\text{reactor and accelerator}} \times \underbrace{\begin{pmatrix} \cos\theta_{12} & \sin\theta_{12} & 0 \\ -\sin\theta_{12} & \cos\theta_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix}}_{\text{SNO, solar SK, KamLAND}} \times \underbrace{\begin{pmatrix} 1 & 0 & 0 \\ 0 & e^{i\alpha/2} & 0 \\ 0 & 0 & e^{i\alpha/2+i\beta} \end{pmatrix}}_{0\nu\beta\beta}$$

$$\theta_{23} = 45.0^{+4.0}_{-3.5}$$

$$\theta_{13} < 7.2^{+2.0}_{-2.8}$$

$$\sin^2\theta_{13} < 0.056$$

90% C.L.

$$\theta_{12} = 33.5^{+1.3}_{-1.0}$$

maximal?

small? zero?

large, but not maximal!

because of small $\sin^2 2\theta_{13}$, solar & atmospheric ν oscillations almost decouple

Neutrino Oscillation

Mixing Angles

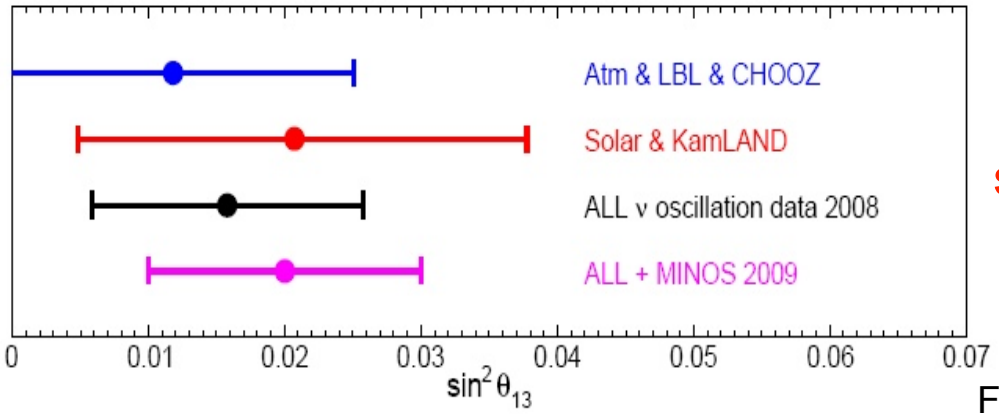
$$U = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} \\ U_{\tau 1} & U_{\tau 2} & U_{\tau 3} \end{pmatrix} = \begin{pmatrix} 0.8 & 0.5 & U_{e3} \\ 0.4 & 0.6 & 0.7 \\ 0.4 & 0.6 & 0.7 \end{pmatrix}$$

U_{MNSP} Matrix

Maki, Nakagawa, Sakata, Pontecorvo

$$= \underbrace{\begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_{23} & \sin\theta_{23} \\ 0 & -\sin\theta_{23} & \cos\theta_{23} \end{pmatrix}}_{\text{atmospheric, K2K}} \times \underbrace{\begin{pmatrix} \cos\theta_{13} & 0 & e^{-i\delta_{CP}}\sin\theta_{13} \\ 0 & 1 & 0 \\ -e^{i\delta_{CP}}\sin\theta_{13} & 0 & \cos\theta_{13} \end{pmatrix}}_{\text{reactor and accelerator}} \times \underbrace{\begin{pmatrix} \cos\theta_{12} & \sin\theta_{12} & 0 \\ -\sin\theta_{12} & \cos\theta_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix}}_{\text{SNO, solar SK, KamLAND}} \times \underbrace{\begin{pmatrix} 1 & 0 & 0 \\ 0 & e^{i\alpha/2} & 0 \\ 0 & 0 & e^{i\alpha/2+i\beta} \end{pmatrix}}_{0\nu\beta\beta}$$

small? zero?



$\sin^2 2\theta_{13} \sim 0.06\text{-}0.08$?

Fogli, et al., arXiv:0905:3549

Precision Measurement of θ_{13} with Reactor Antineutrinos

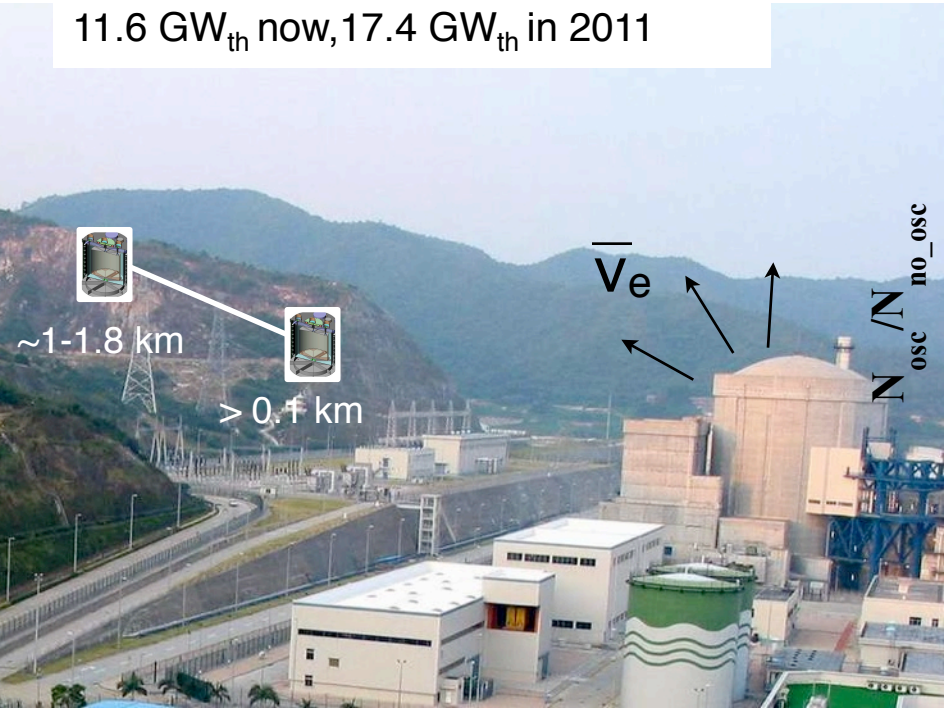
Search for θ_{13} in new oscillation experiment with multiple detectors

$$P_{ee} \approx 1 - \sin^2 2\theta_{13} \sin^2\left(\frac{\Delta m_{31}^2 L}{4E_\nu}\right) - \cos^4\theta_{13} \sin^2 2\theta_{12} \sin^2\left(\frac{\Delta m_{21}^2 L}{4E_\nu}\right)$$

Daya Bay Reactors:

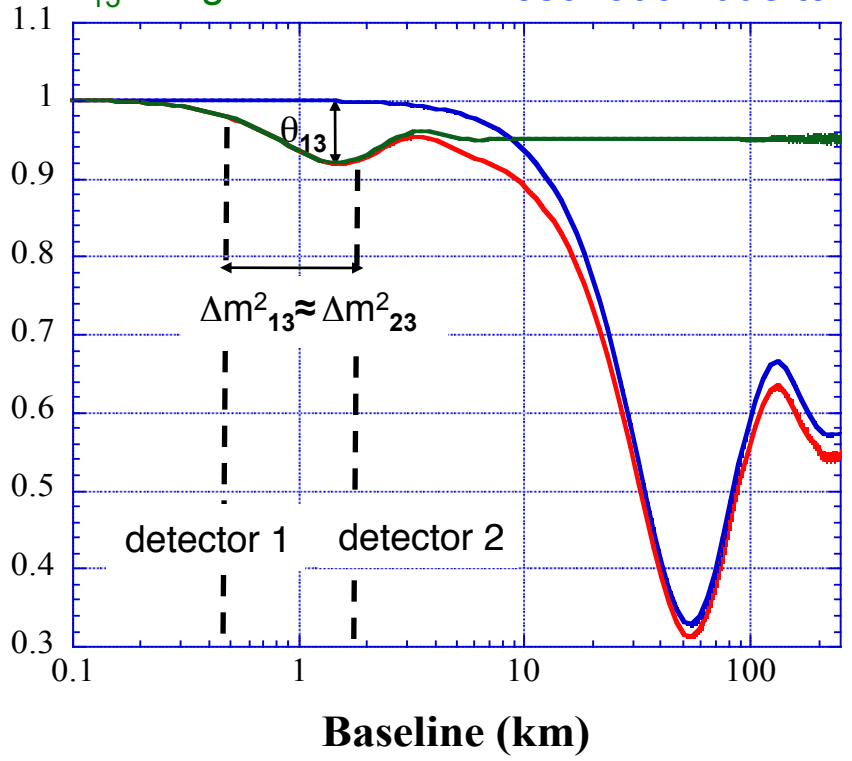
Powerful $\bar{\nu}_e$ source, multiple cores

11.6 GW_{th} now, 17.4 GW_{th} in 2011



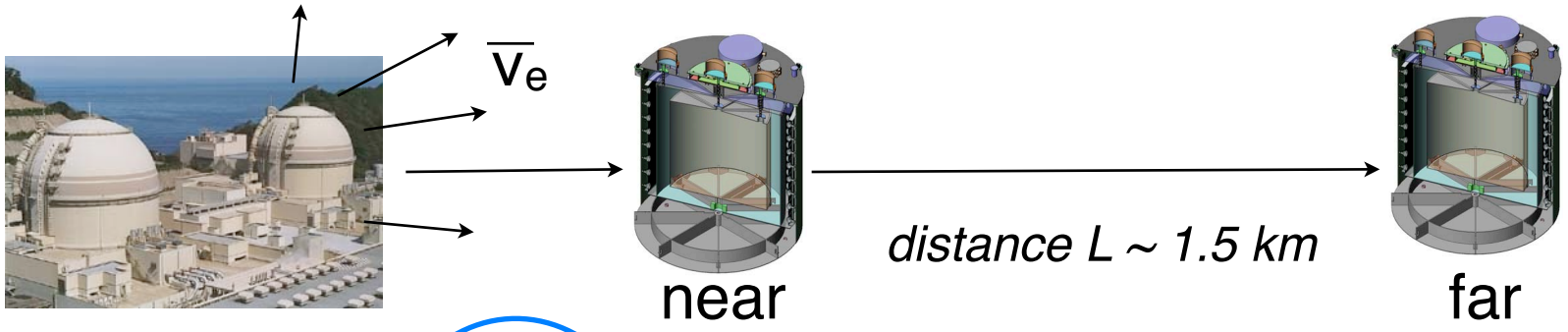
Small-amplitude oscillation due to θ_{13} integrated over E

Large-amplitude oscillation due to θ_{12}



Concept of Reactor θ_{13} Experiments

Measure ratio of interaction rates in multiple detectors



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

Measured Ratio of Rates

Detector Mass Ratio, H/C

mass measurement

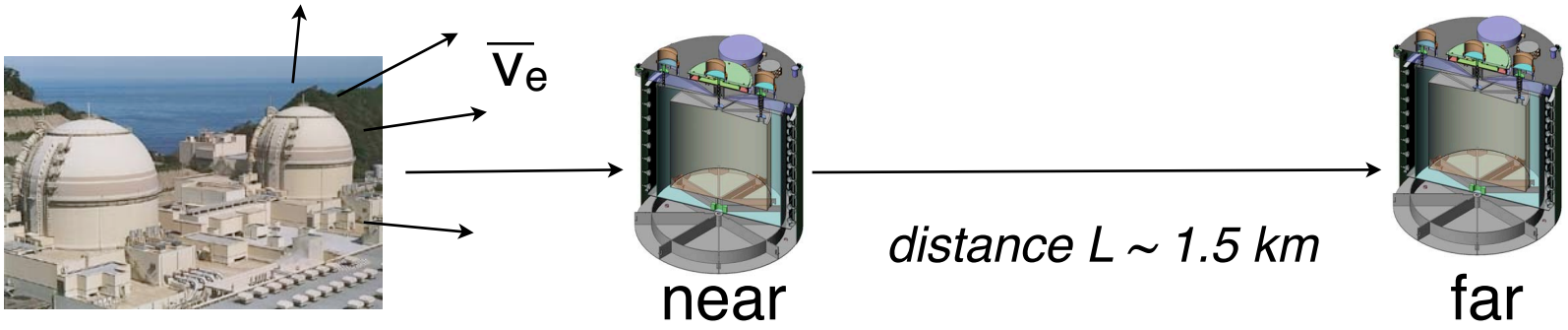
Detector Efficiency Ratio

calibration

$\sin^2 2\theta_{13}$

Principle of Relative Measurement

Measure ratio of interaction rates



Relative measurement between detectors at different distance to cancel source (reactor) systematics.

→ need *"identical detector pairs" at near and far site*

Between pairs of detectors we measure and control

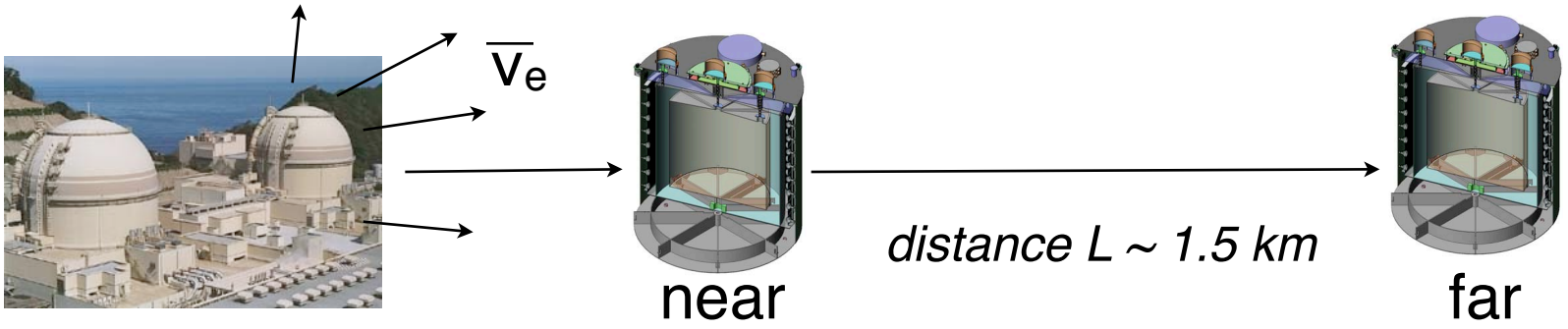
→ relative target mass & composition

→ relative antineutrino detection efficiency

key concept:
pairwise identical detectors

Principle of Relative Measurement

Measure ratio of interaction rates



Relative detector systematics

aim to reach < 0.4% relative uncertainty

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%

Wisconsin group designs, builds, and characterizes "identical" antineutrino detectors.

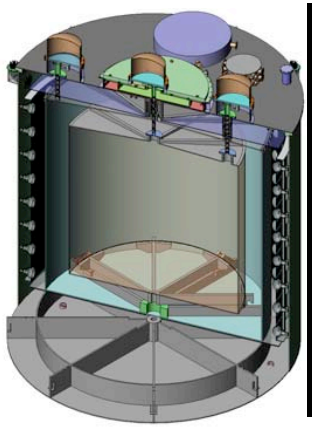
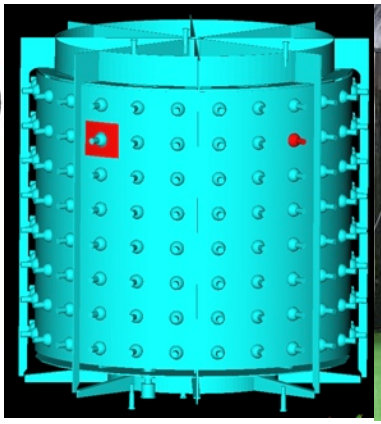
Daya Bay at University of Wisconsin

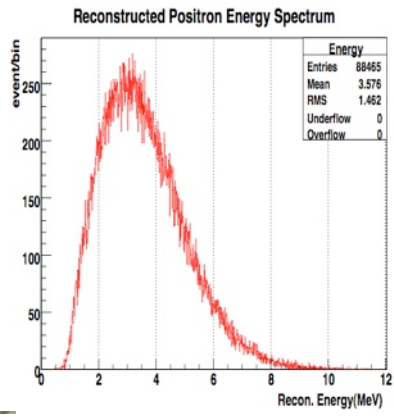
Intellectual Leadership in Design, Simulations, Construction, and Physics Studies

2003-2007: develop conceptual idea for reactor θ_{13} experiment

2007-2009: detailed detector design and R&D
2008-2010: detector simulations, sensitivity studies, detector construction
2010/11: characterization of detectors, detector dry run analysis

2011: near-site data taking and commissioning
2012 - data taking with full experiment
2013? measurement of θ_{13} ?

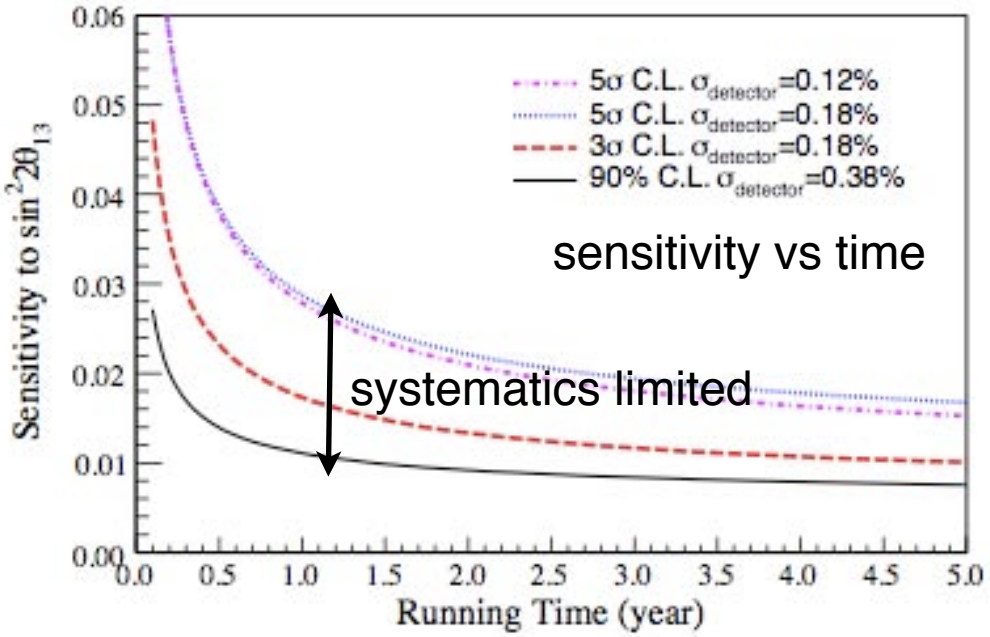



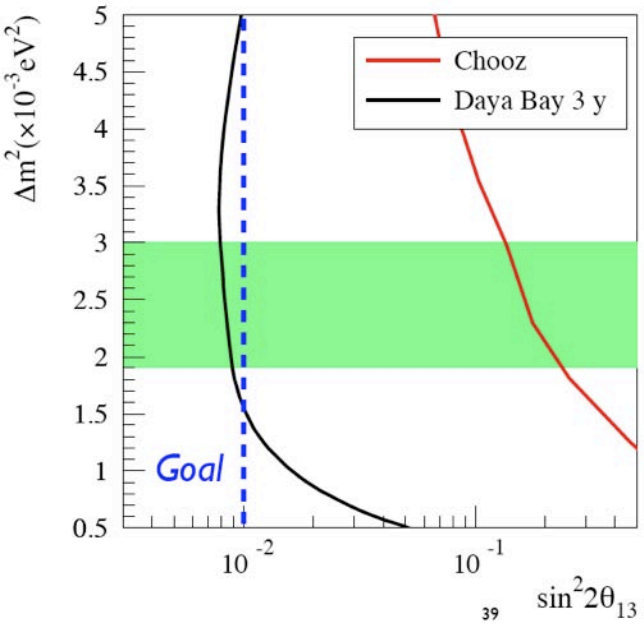



Daya Bay at University of Wisconsin

Wang, McFarlane, Lewis, KMH

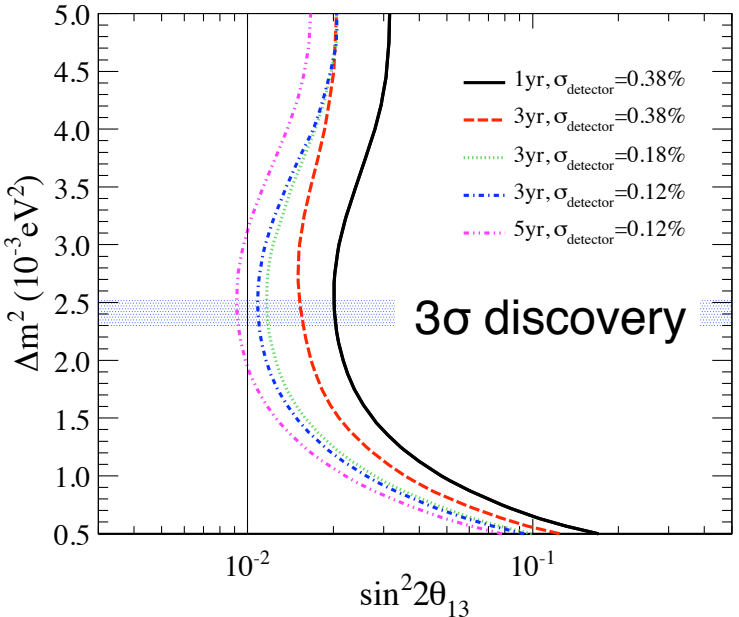
Sensitivity and Discovery Potential





Daya Bay sensitivity to $\sin^2 2\theta_{13}$

$\sin^2 2\theta_{13}$ < 0.01 @ 90% CL
in 3 years of data taking



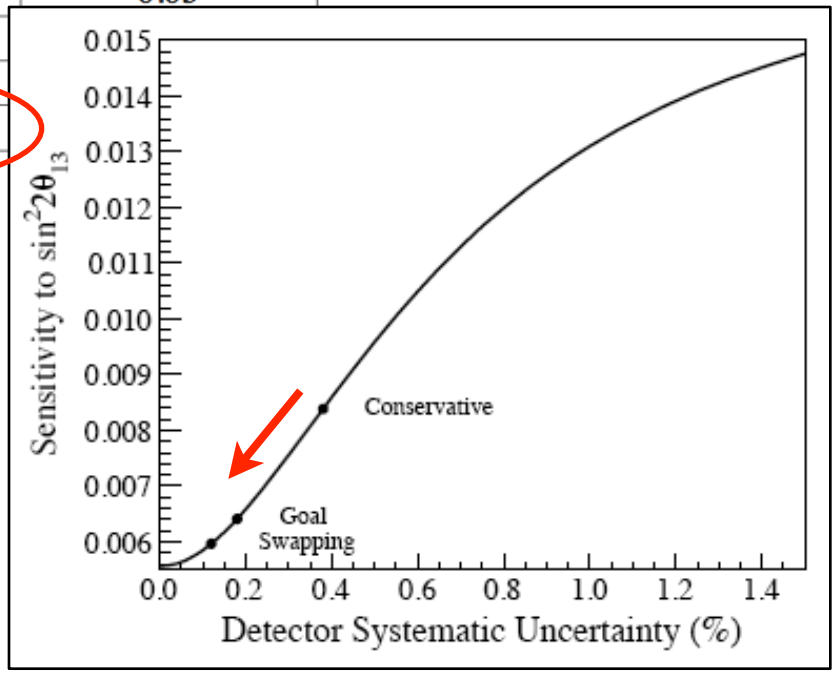
Daya Bay at University of Wisconsin

Sensitivity and Physics Studies

Wang, McFarlane, Lewis, KMH

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%

θ_{13} sensitivity and detector systematics



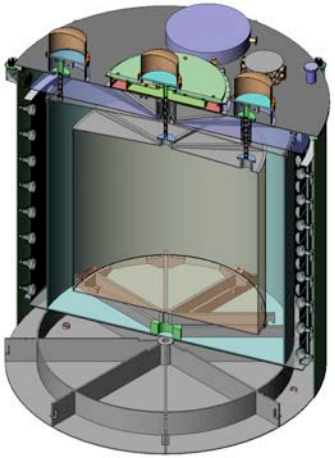
critical (relative) detector systematics:

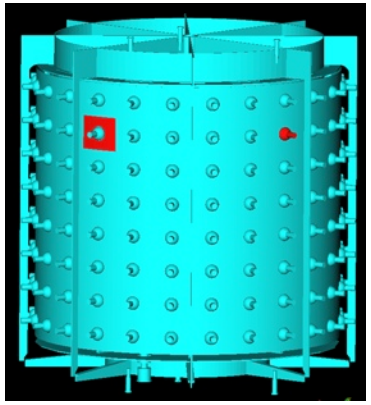
- target protons (mass)
- energy scale uncertainty

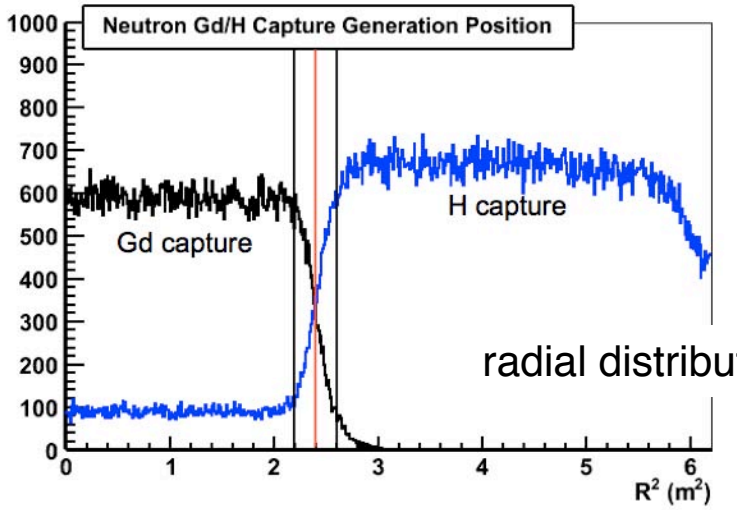
Daya Bay at University of Wisconsin

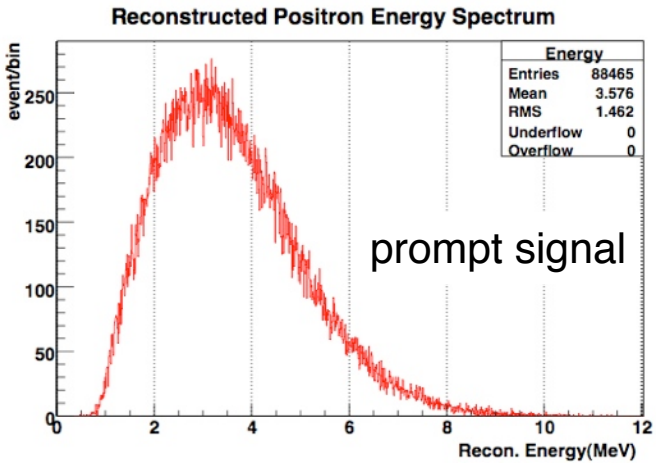
Monte Carlo Studies of Detector Performance: Event Simulations

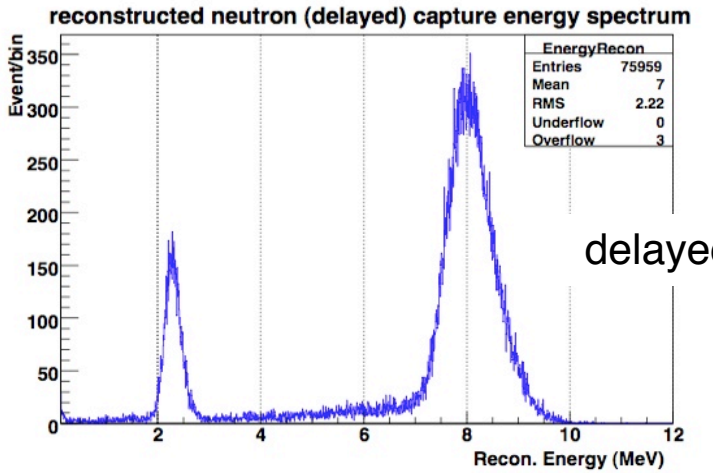
Wang, Littlejohn, et al.







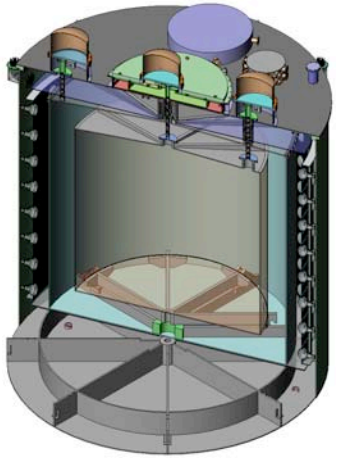


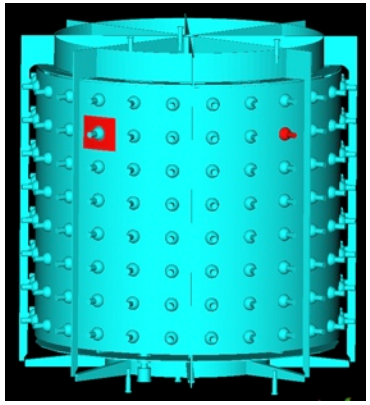


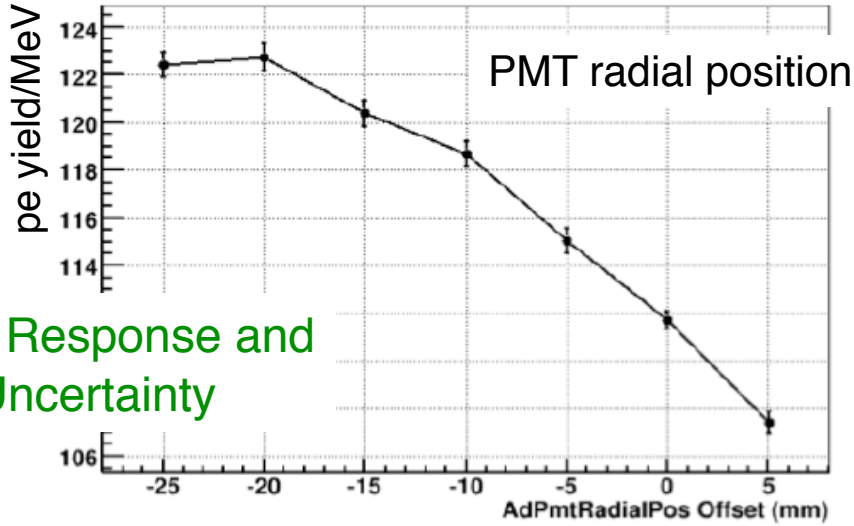
Daya Bay at University of Wisconsin

Monte Carlo Studies of Detector Performance: Evaluating Identicalness and Design Constraints

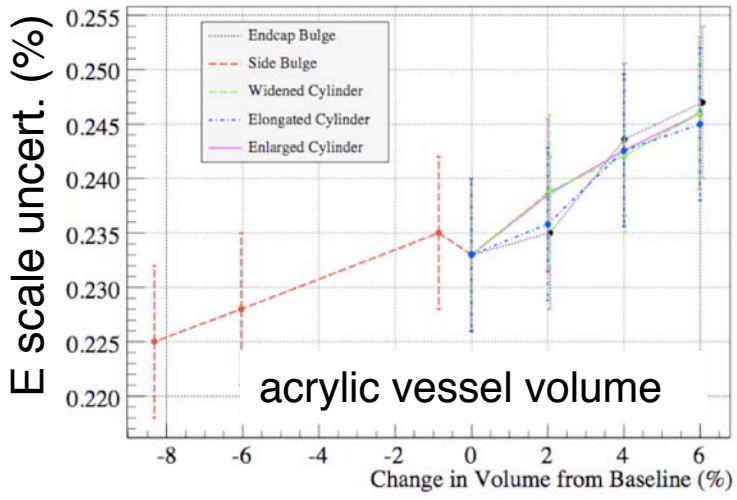
Wang, Littlejohn, et al.

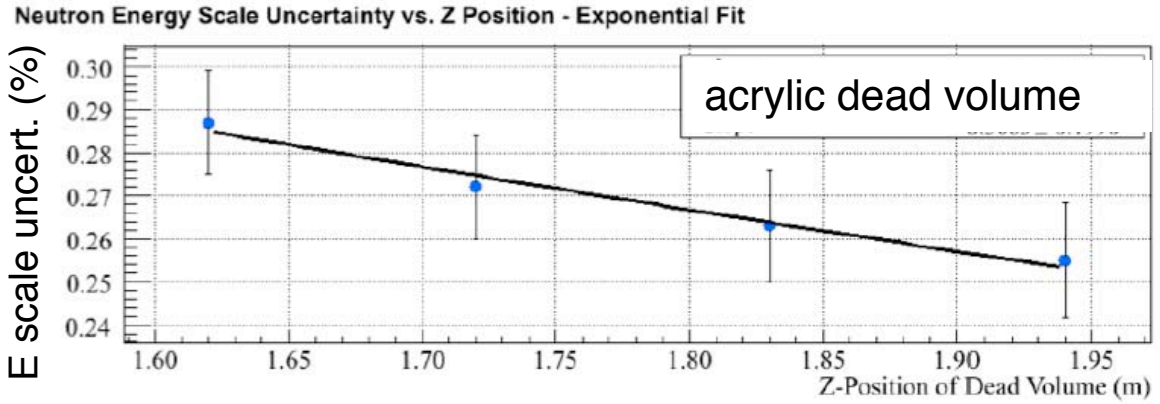






Energy Response and Scale Uncertainty





Daya Bay at University of Wisconsin

Computing at Wisconsin

Daya Bay benefits from the large-scale HEP computing infrastructure at UW

hardware

- access to 600+ nodes for simulation
- appropriate space and maintenance of servers
- seamless integration of dedicated Daya Bay computing hardware, essential for code development
- addition of ARRA servers (50TB of disk space) for 1st year of Daya Bay data

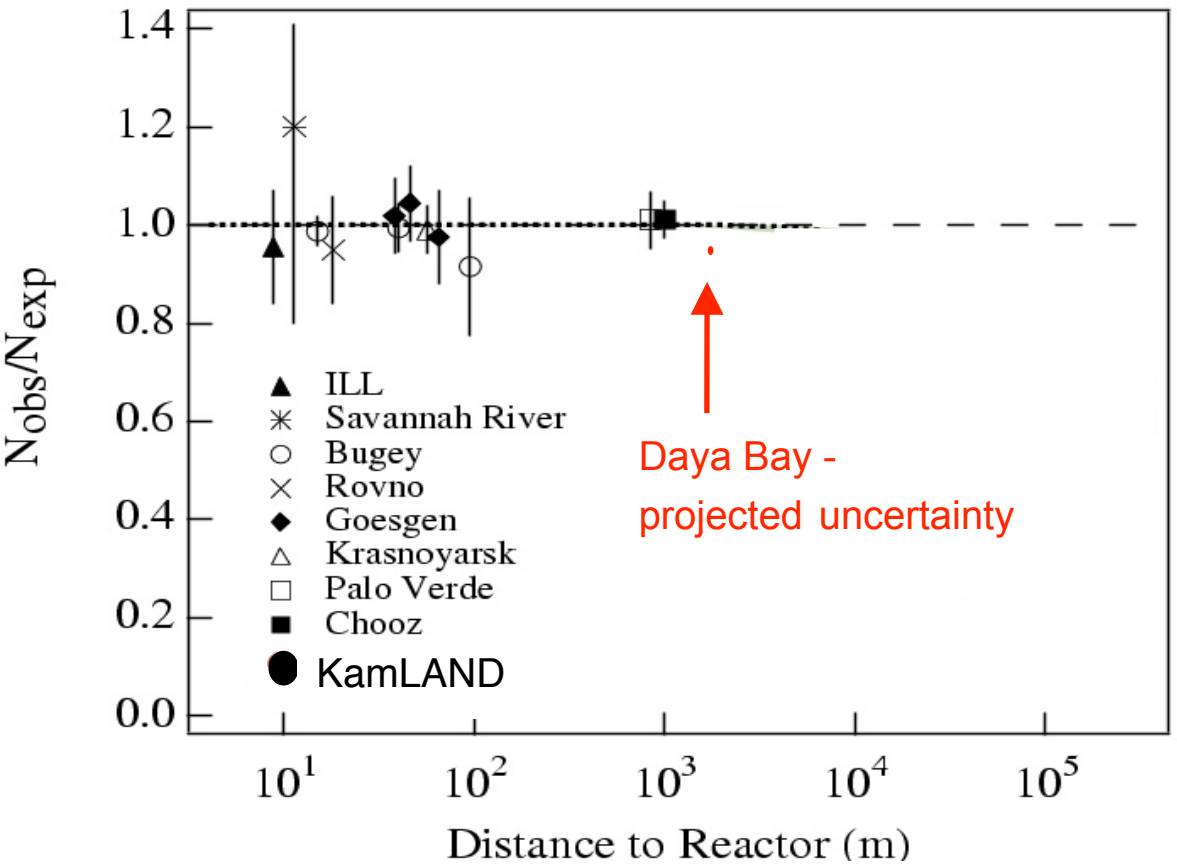
personnel (Rader, Radtke)

- computing staff has been essential in helping set up
  - > data and file transfer between LBNL NERSC and UW through SPADE protocol
  - > install and maintain servers
  - > maintain wikis and general software packages

Shared computing support and infrastructure critical for productivity and scientific output of Wisconsin Daya Bay group.

Expected Precision and Sensitivity of Daya Bay

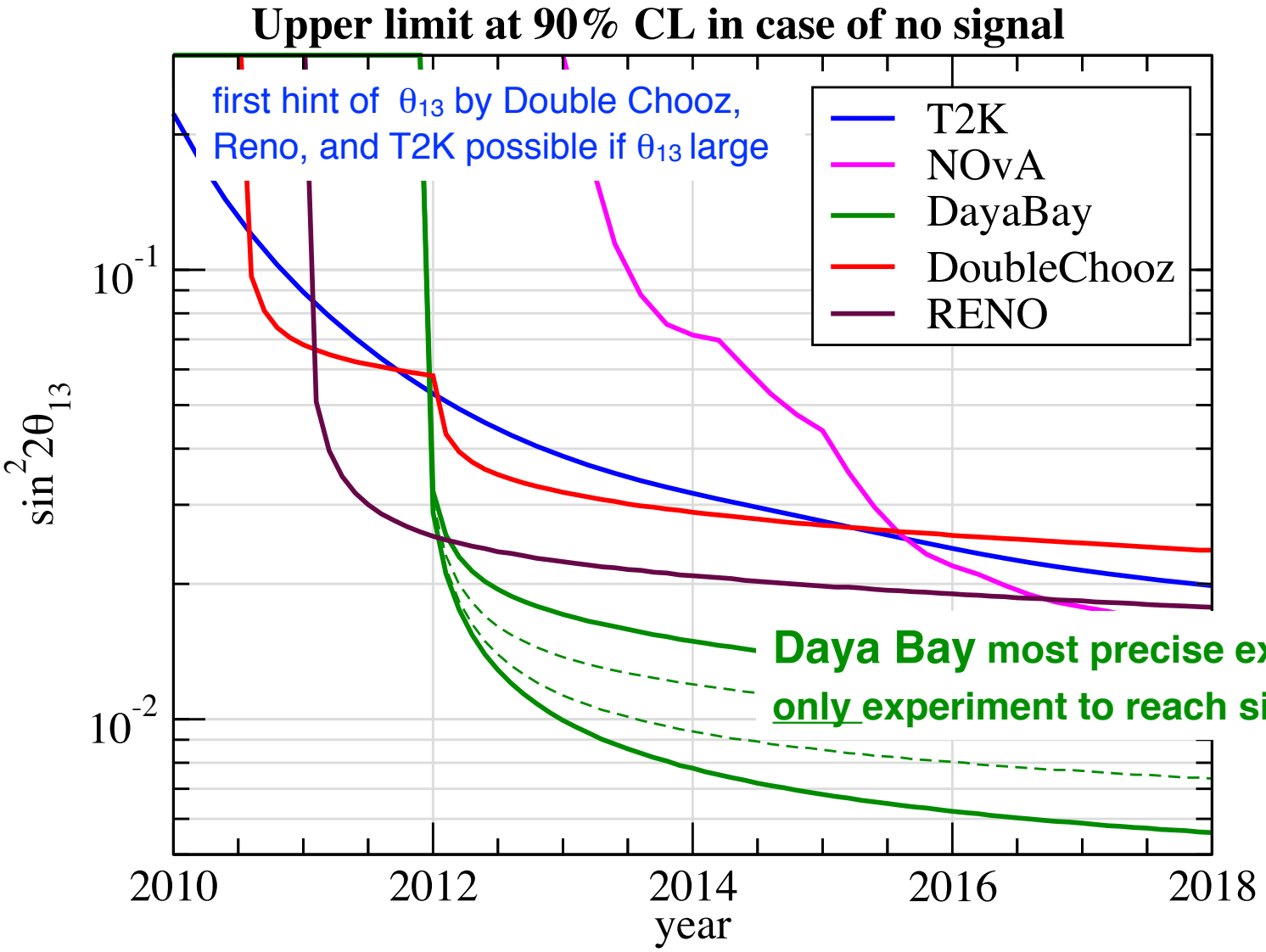
Expected Precision to $\overline{\nu}_e$ Flux



past reactor experiments
= 1 detector

next generation of experiments
> 2 detectors

Measuring θ_{13}: A Possible Scenario

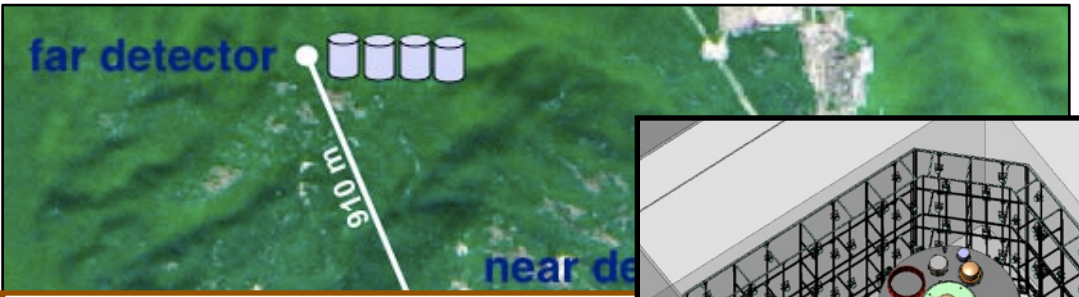


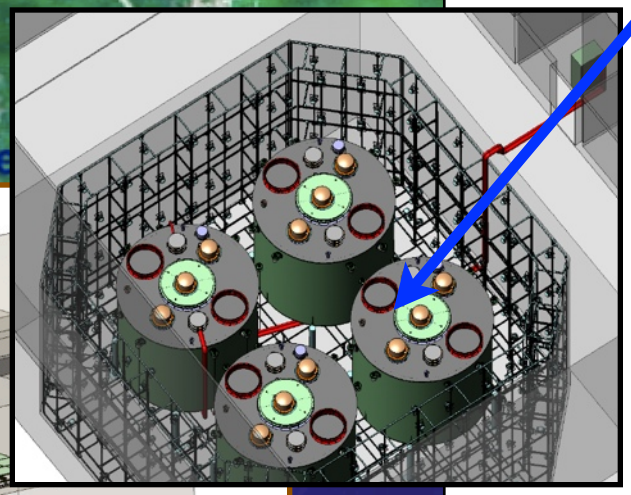
Daya Bay most precise experiment, only experiment to reach $\sin^2 2\theta_{13} < 0.01$

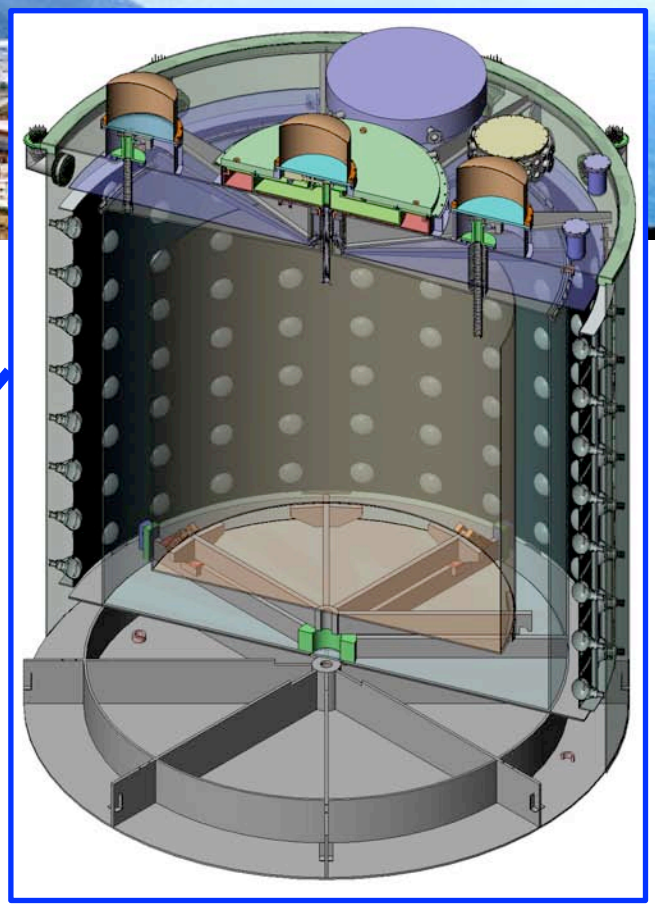
Mezzetto et al
arXive/1003.5800v1

A Precision Measurement of $\sin^2 2\theta_{13}$ at Daya Bay

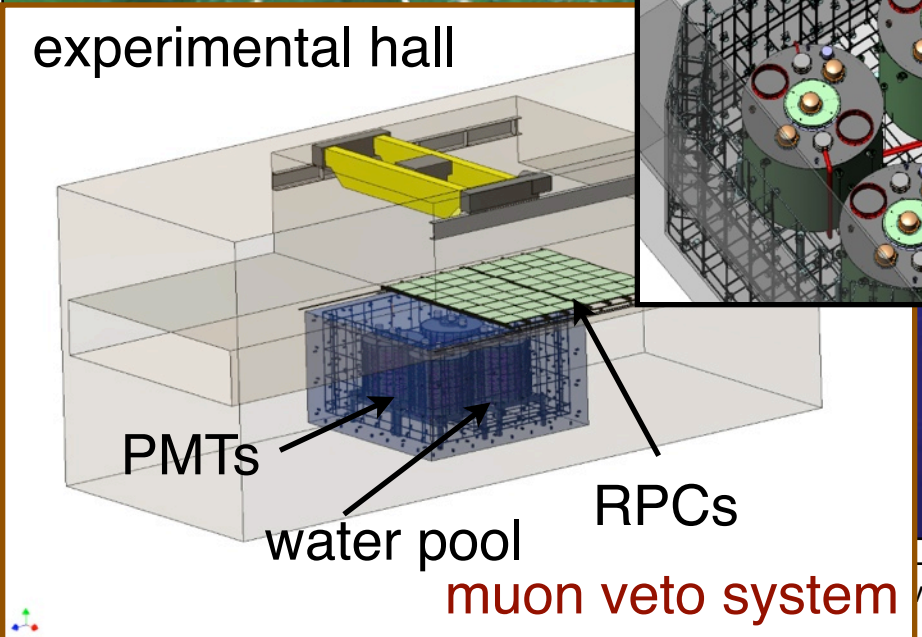
http://dayawane.ihep.ac.cn/







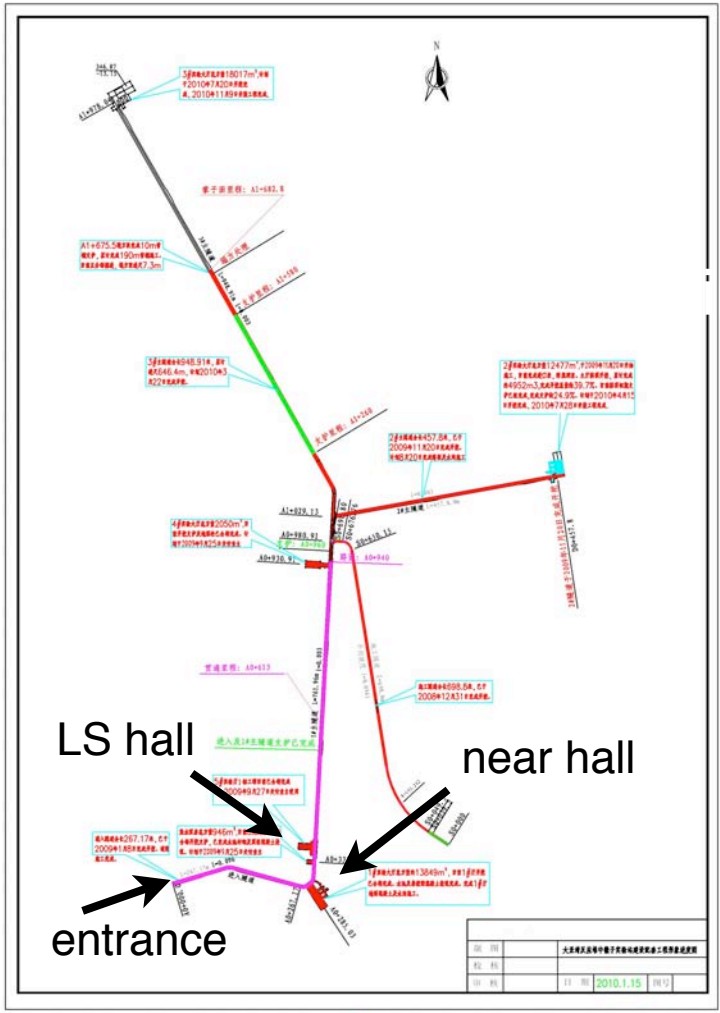
antineutrino detectors



muon veto system

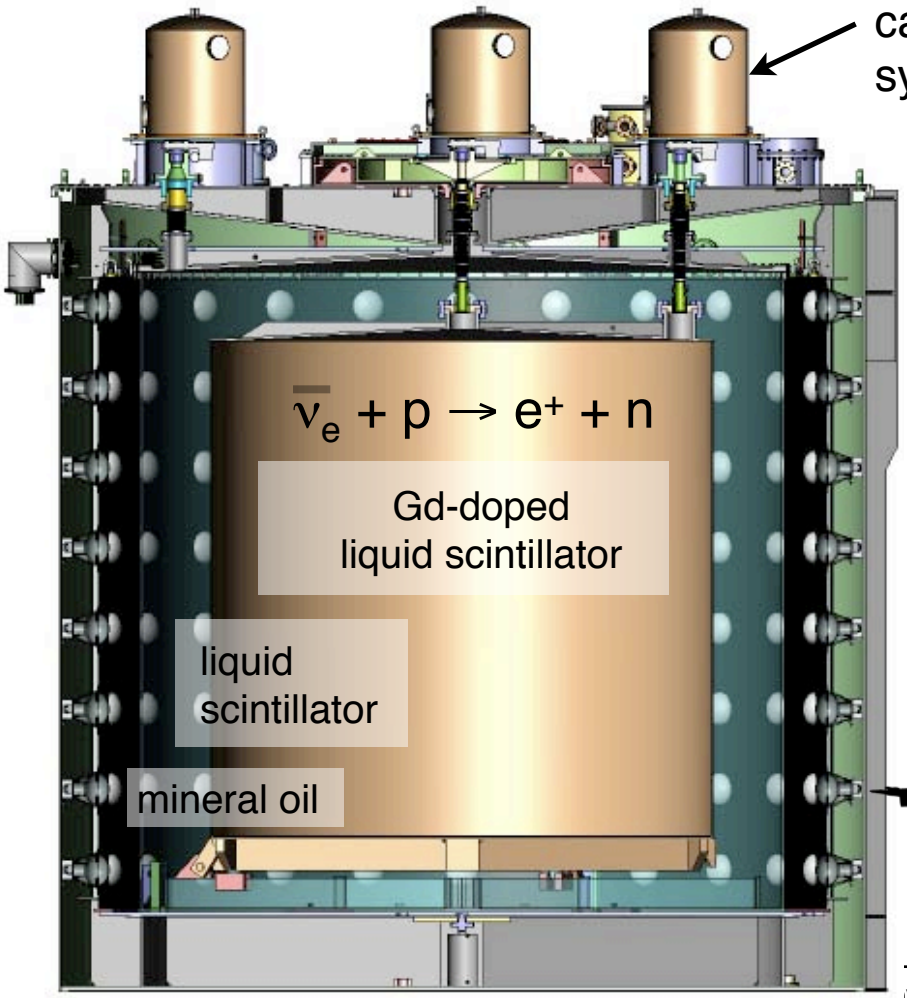
multiple detectors per site
cross-check efficiency

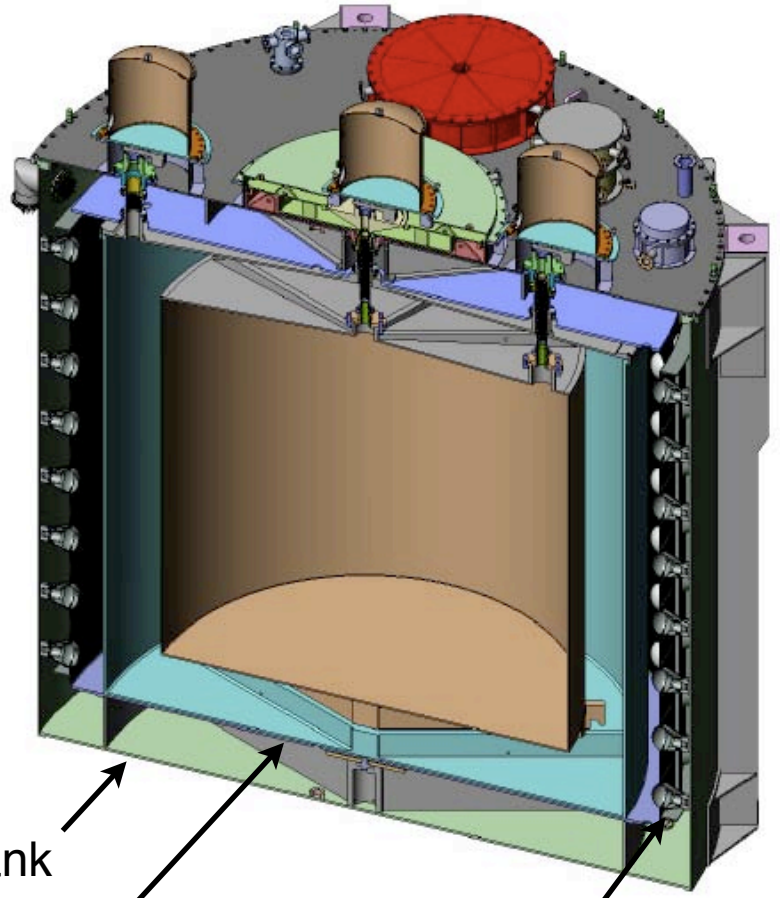
Civil Construction Progress



Daya Bay Antineutrino Detectors

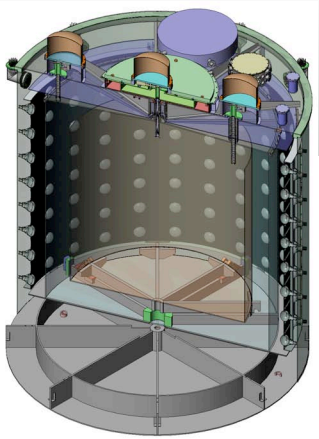
- 8 "identical", 3-zone detectors
- no position reconstruction, no fiducial cut





target mass:	20t per detector
detector mass:	~ 110t
photosensors:	192 PMTs
energy resolution:	12%/√E

Antineutrino Detection



Signal and Event Rates

Daya Bay near site	840
Ling Ao near site	760
Far site	90

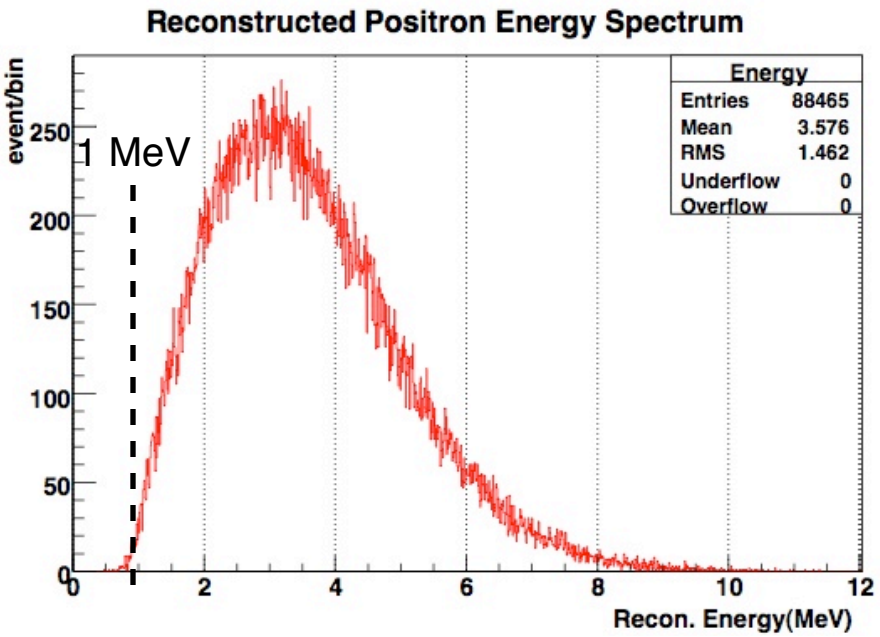
events/day per 20 ton module

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

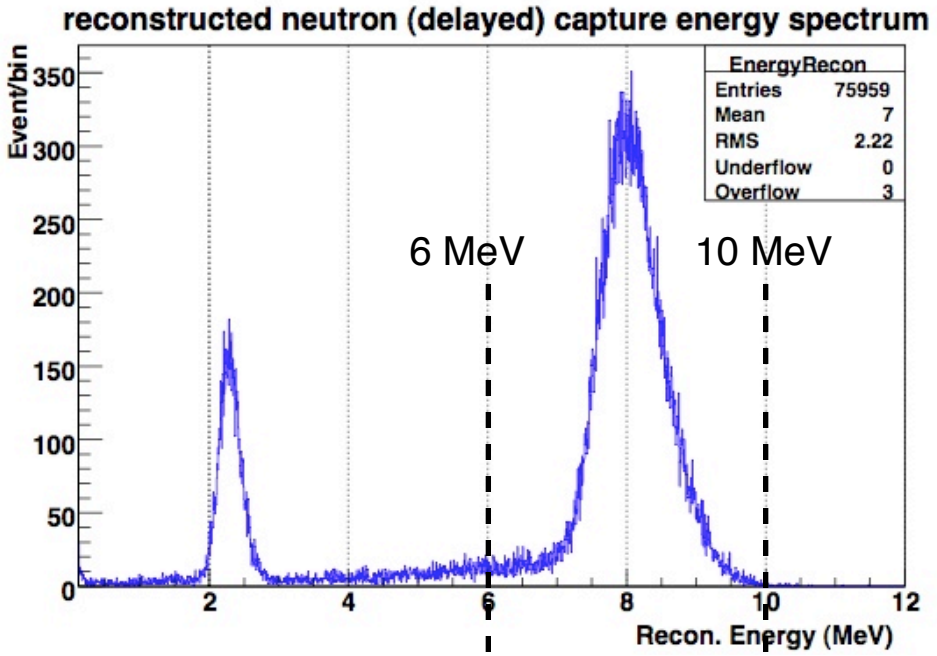
0.3 b → $+ p \rightarrow D + \gamma$ (2.2 MeV) (delayed)

49,000 b → $+ Gd \rightarrow Gd^* \rightarrow Gd + \gamma$'s (8 MeV) (delayed)

Prompt Energy Signal



Delayed Energy Signal



Systematic Uncertainties

Detector-Related Uncertainties

Absolute measurement **Relative measurement**

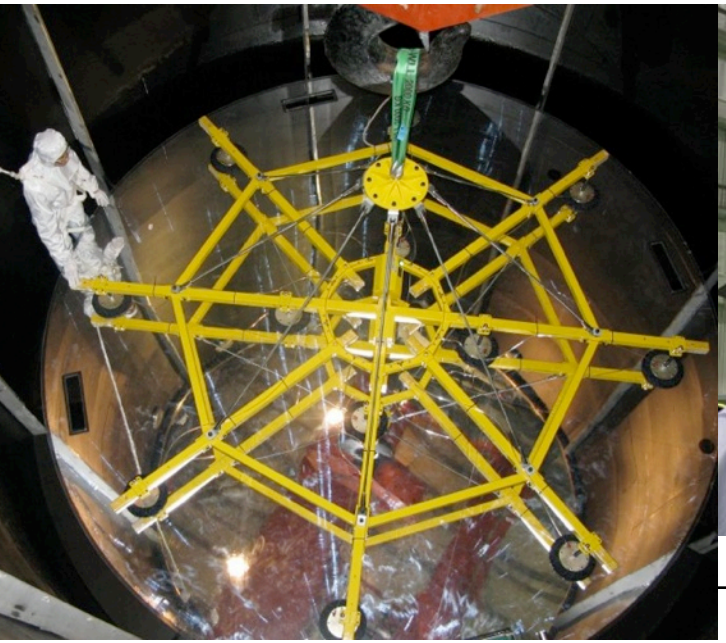
Source of uncertainty		Chooz (*absolute*)	Daya Bay (*relative*)		
			Baseline	Goal	Goal w/Swapping
# protons		0.8	0.3	0.1	0.006
Detector Efficiency	Energy cuts	0.8	0.2	0.1	0.1
	Position cuts	0.32	0.0	0.0	0.0
	Time cuts	0.4	0.1	0.03	0.03
	H/Gd ratio	1.0	0.1	0.1	0.0
	n multiplicity	0.5	0.05	0.05	0.05
	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%

Ref: Daya Bay TDR

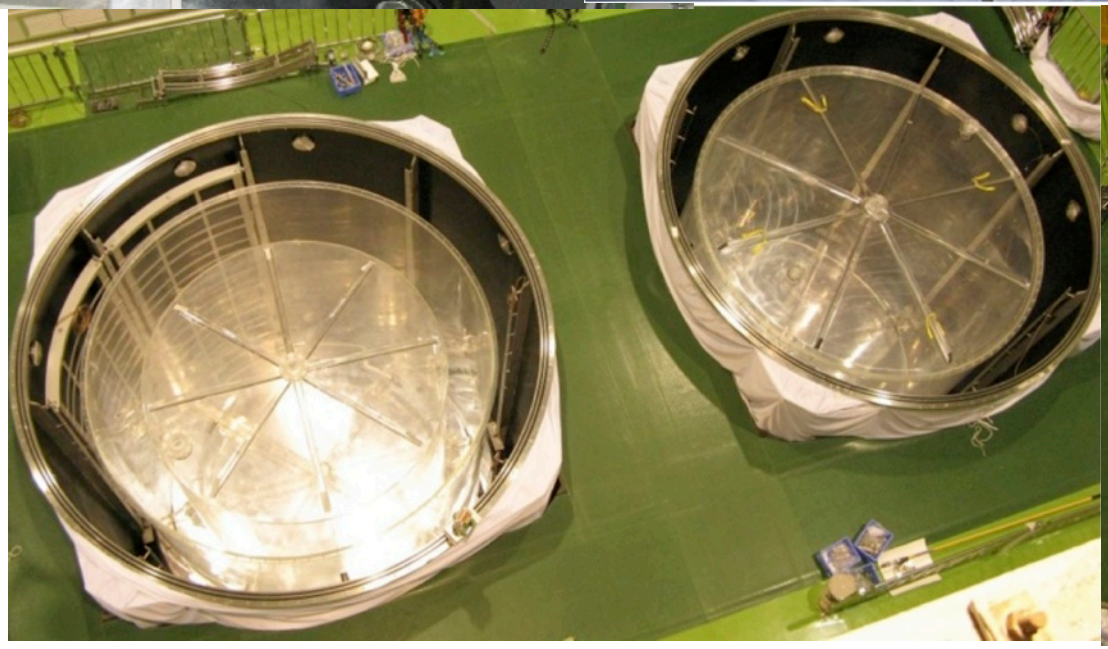
O(0.2-0.3%) precision for relative measurement between detectors at near and far sites

Antineutrino Detector Assembly



Antineutrino Detector Assembly

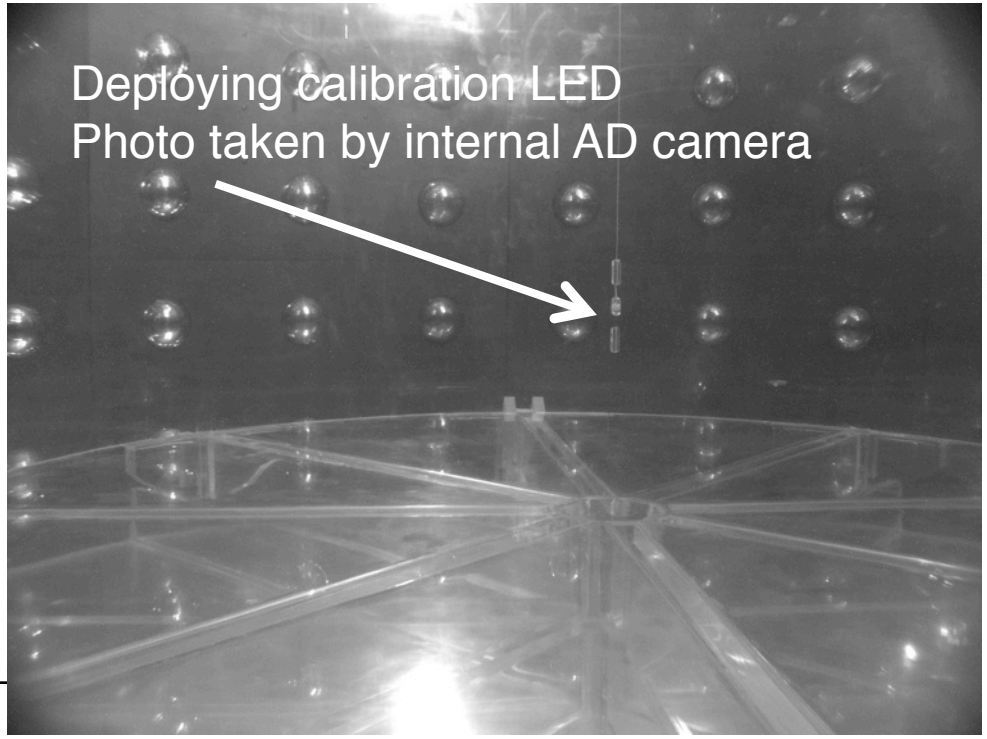


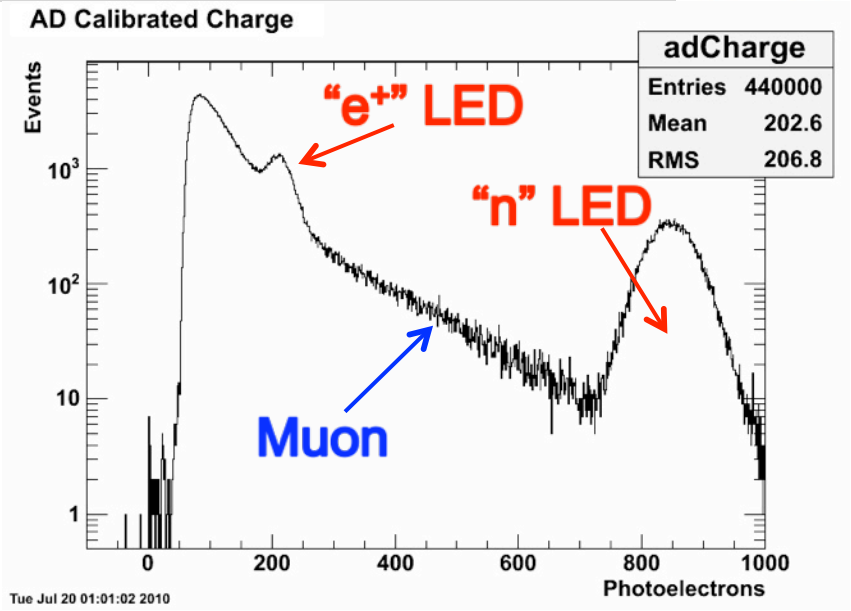
Antineutrino Detector Dry Run

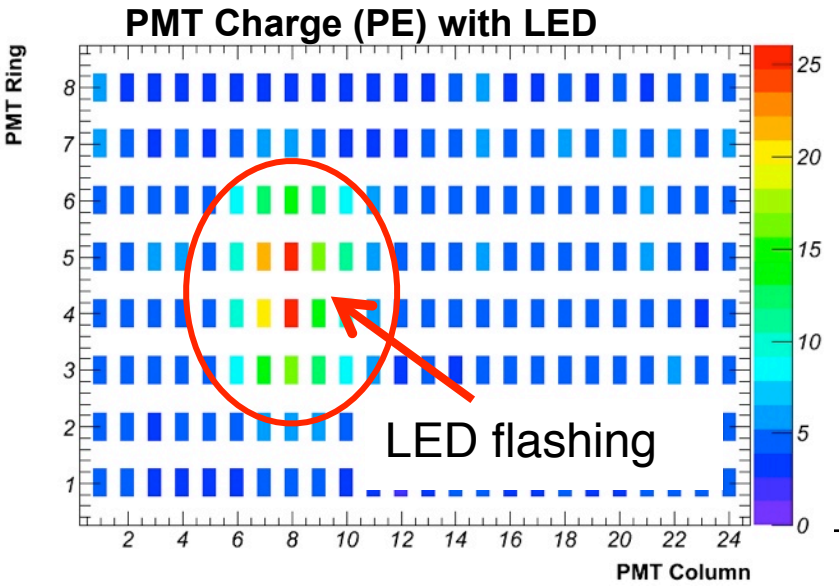
First Detector Data

Double-pulse LED to mimic $\overline{\nu}$ interaction

Detector dry run took place in assembly building (above ground). Can clearly see muon events.x

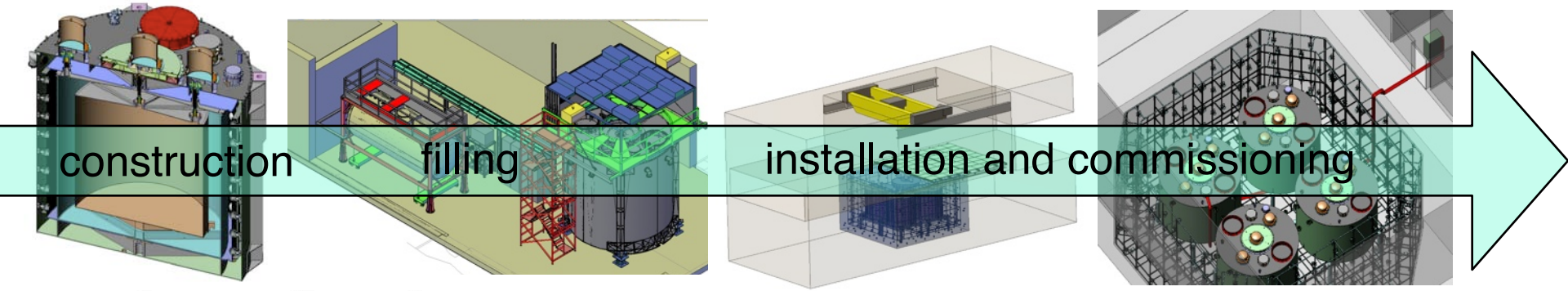


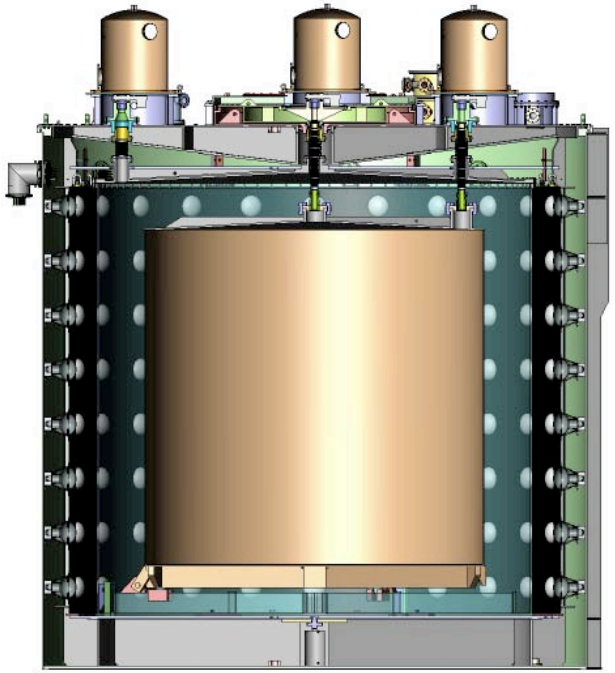




Daya Bay at University of Wisconsin

Antineutrino Detector Scope and Responsibilities



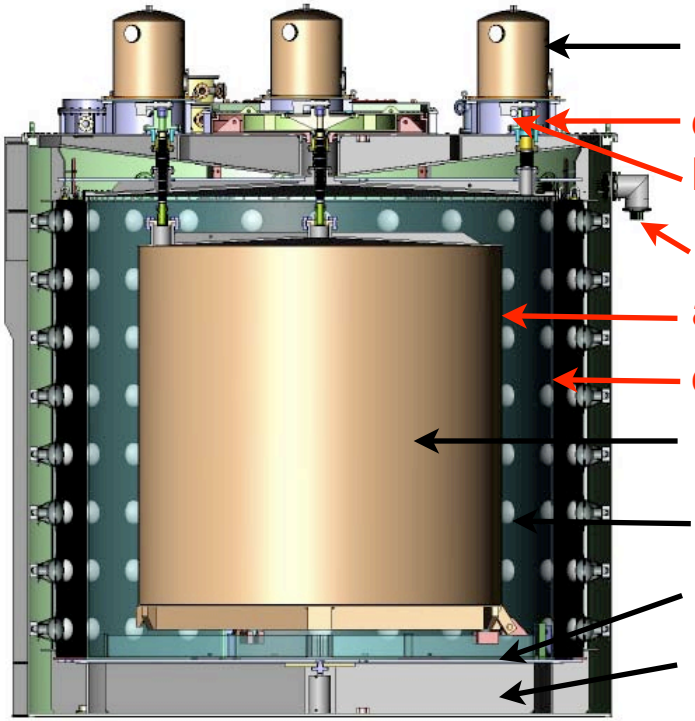


Major Responsibilities

- design of the **acrylic target vessel system** and fabrication of the 4m vessels and overflow tanks
- **liquid handling** system, **detector filling, and target mass measurement** system
- target mass monitoring and detector instrumentation
- **overall design and technical integration** of the antineutrino detectors
- technical **management of the detector assembly** and installation at Daya Bay

Daya Bay at University of Wisconsin

Antineutrino Detector (AD) Scope and Responsibilities



calibration (Caltech)

cover gas (UW)

lid sensors and monitoring (UW)

PMT cables and feedthroughs (UW)

acrylic vessel design (UW)

outer acrylic vessel fabrication (UW)

scintillator liquids (IHEP, BNL)

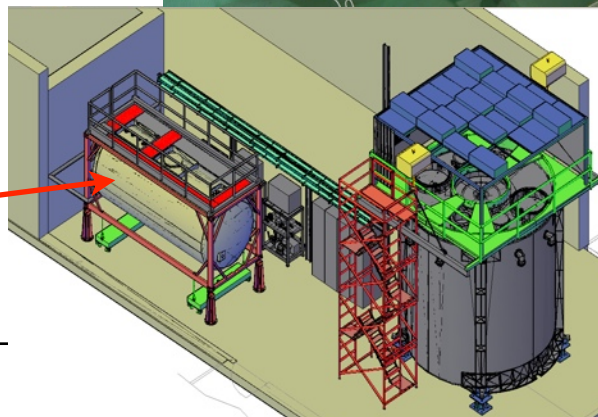
PMTs (LBNL)

reflector (IHEP)

steel vessel (IHEP)

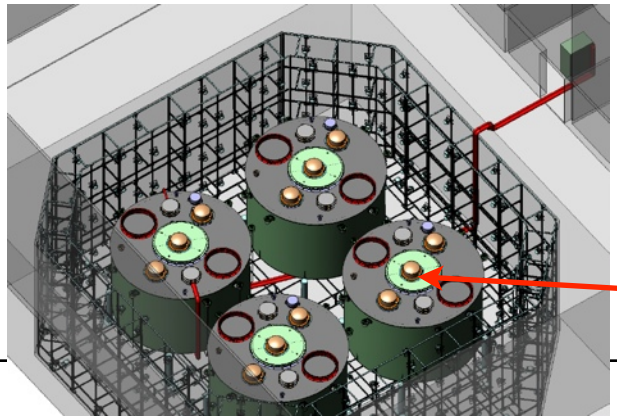
detector assembly (UW, IHEP)

detector integration (UW)

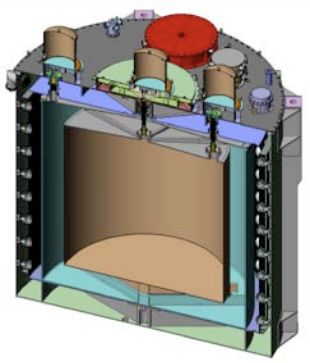


detector filling and target mass measurement (UW)

detector installation (UW, IHEP)



Daya Bay at University of Wisconsin



Leadership and Management Responsibilities

Scientists

Heeger (faculty)
- Antineutrino Detector, US L2 Manager
- Executive Board Member (elected)
- Institutional Representative

Band (senior scientist)
- AD Assembly, US L3 manager
- AD Testing and Commissioning, US lead
- AD Survey and Characterization, lead scientist

Wise (researcher)
- Liquid Scintillator Hall, US coordinator
- AD Filling and Target Mass Measurement, US L3 manager and lead scientist

Wang (postdoc)
- AD representative for “dry run”
- coordinates AD instrumentation and slow control interface
- coordinates AD geometry in simulations

Lewis (graduate student)
- responsible for target mass measurement

Technical Personnel

Cherwinka (PSL engineer)
- Antineutrino Detector, US L2 Deputy Manager
- AD Installation, US L3 manager
- US AD lead engineer

Greenler (PSL engineer)
- Acrylic Vessels, lead engineer

Wenman (PSL engineer)
- AD Filling and Target Mass Measurement, lead engineer

Xiao (PSL engineer)
- coordinates on-site AD assembly
- substitutes for US on-site safety officer

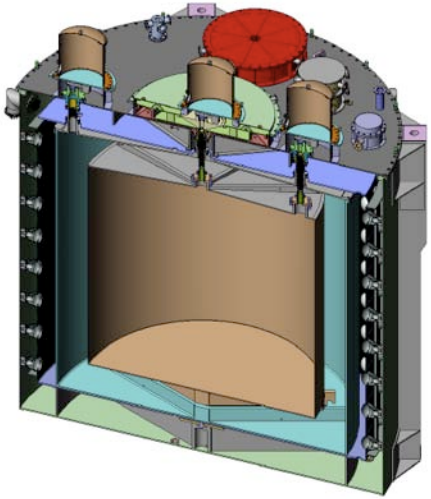
Wisconsin responsible for the **antineutrino detectors** - the core of the experiment.

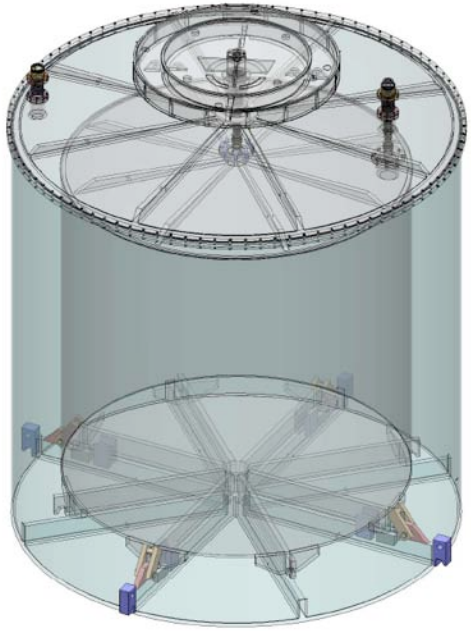
Daya Bay at University of Wisconsin

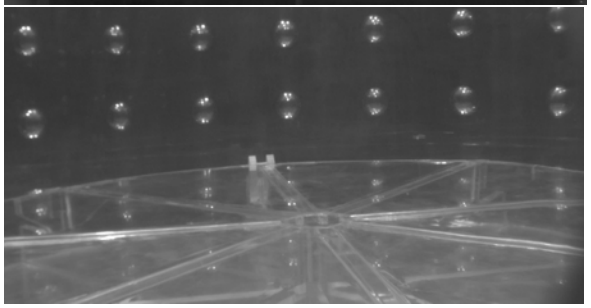
Greenler, Wise, Cherwinka, Band, Littlejohn et al.

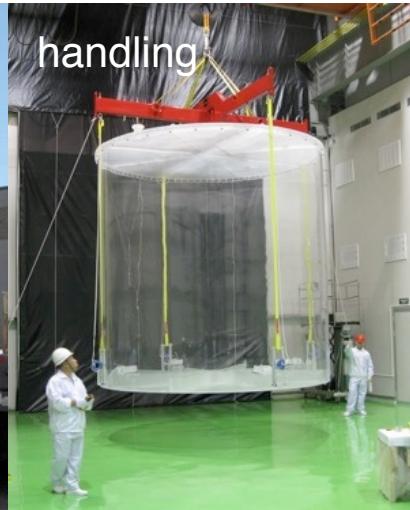
Detector Acrylic Target Vessels (technical effort)

design and integration





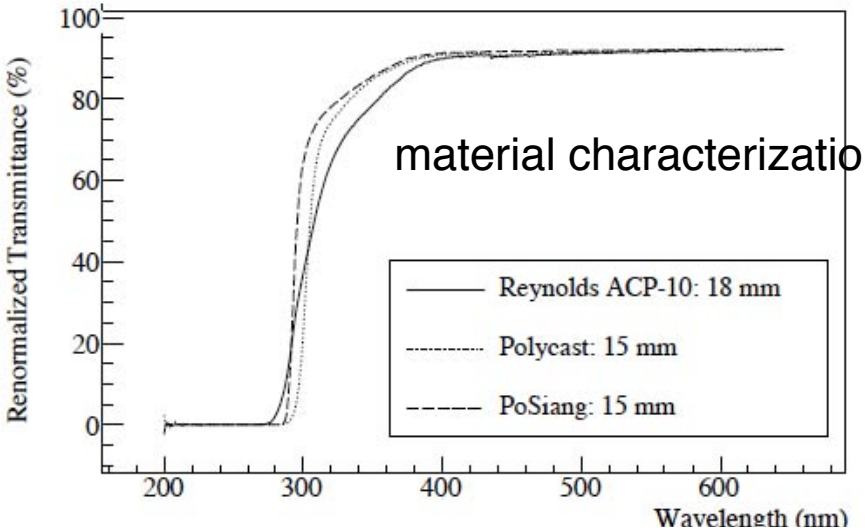


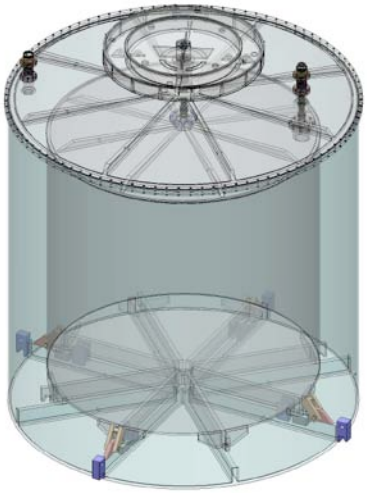


Daya Bay at University of Wisconsin

Detector Acrylic Target Vessels (research effort)

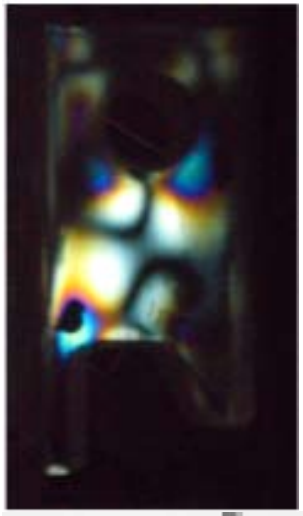
Littlejohn, Wise et al.

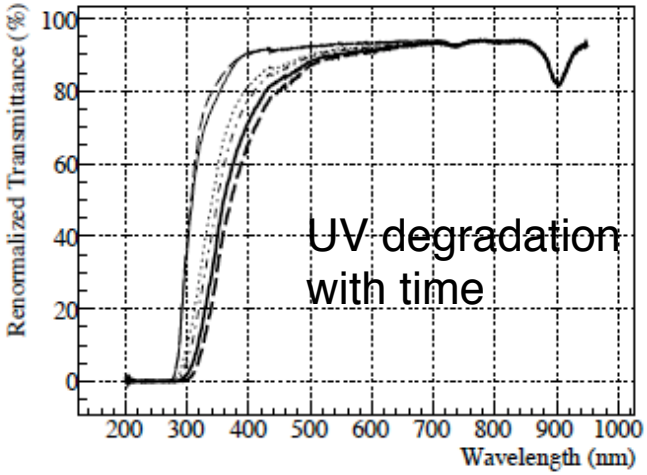


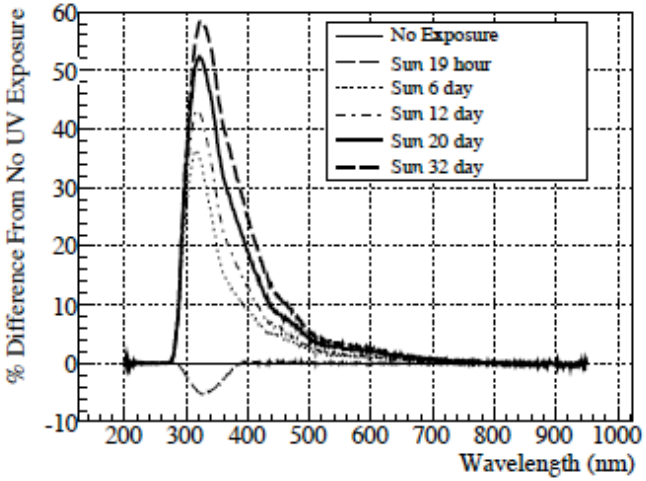


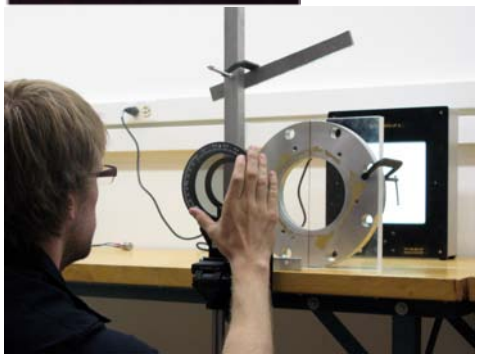
2 publications

stress analysis









Daya Bay at University of Wisconsin

Detector Filling & Target Mass Measurement

Wise, Wenman, Lewis, Hinrichs et al.

200-ton Gd-LS reservoir

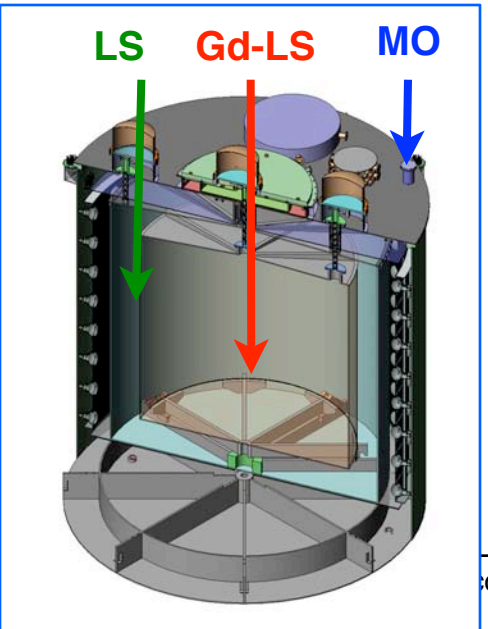
20-ton ISO tank

ISO Gd-LS weighing tank

filling platform with clean room

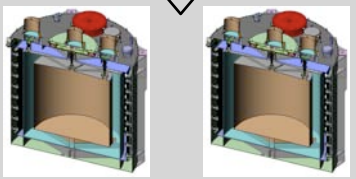
pump stations

detector



load cell accuracy < 0.02%

Coriolis mass flowmeters < 0.1%



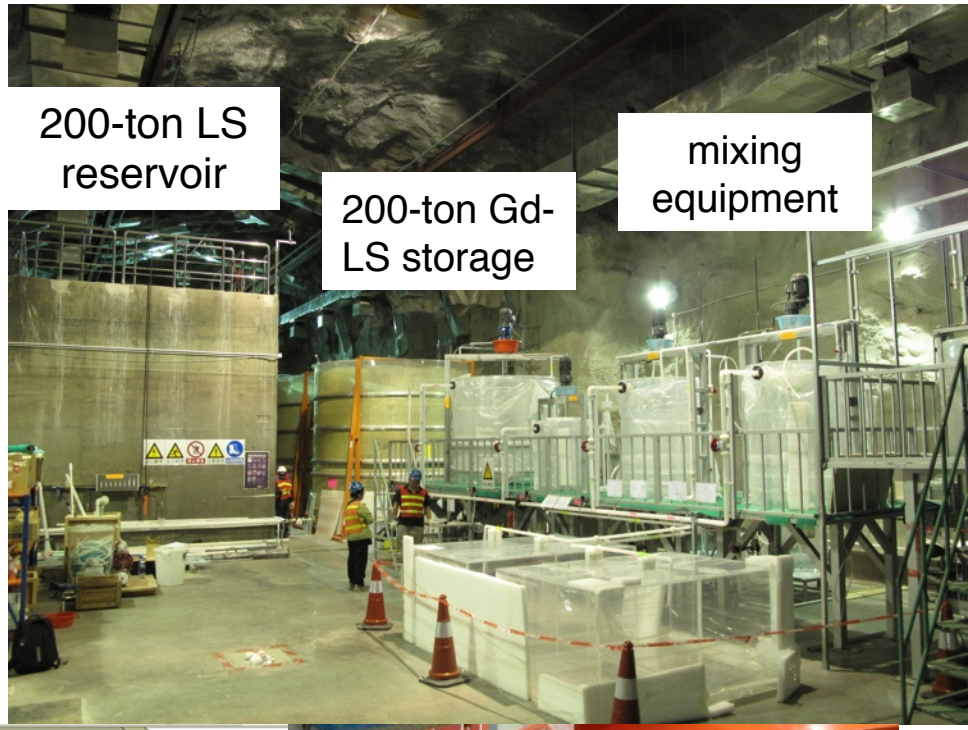
filling “pairs” of detectors

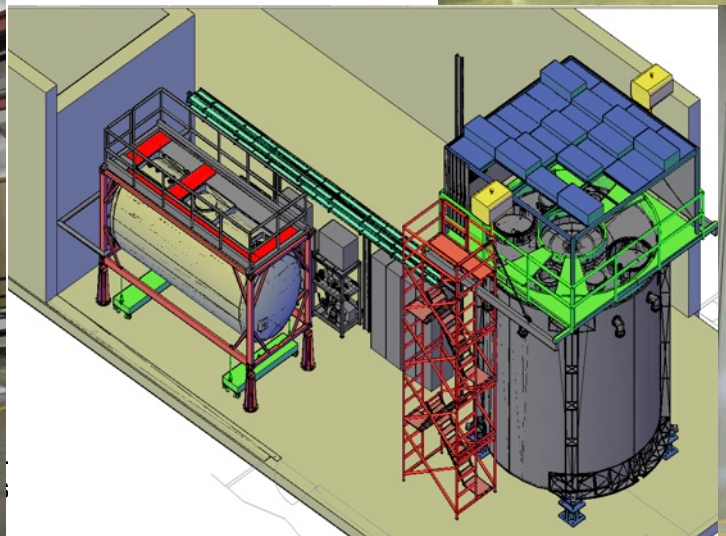
Daya Bay at University of Wisconsin

Detector Filling & Target Mass Measurement

Fall 2010: shipment of system
Winter 2010: underground installation
Spring 2011: commissioning and detector filling

filling and target mass measurement critical for antineutrino detectors and physics





Daya Bay at University of Wisconsin

Wise, Wenman, Lewis, Hinrichs et al.

Detector Filling & Target Mass Measurement (research effort)

ISO weighing tank and load cells

load cell accuracy < 0.02%

column test to simulate height of detectors

LabView based control system

Daya Bay at University of Wisconsin

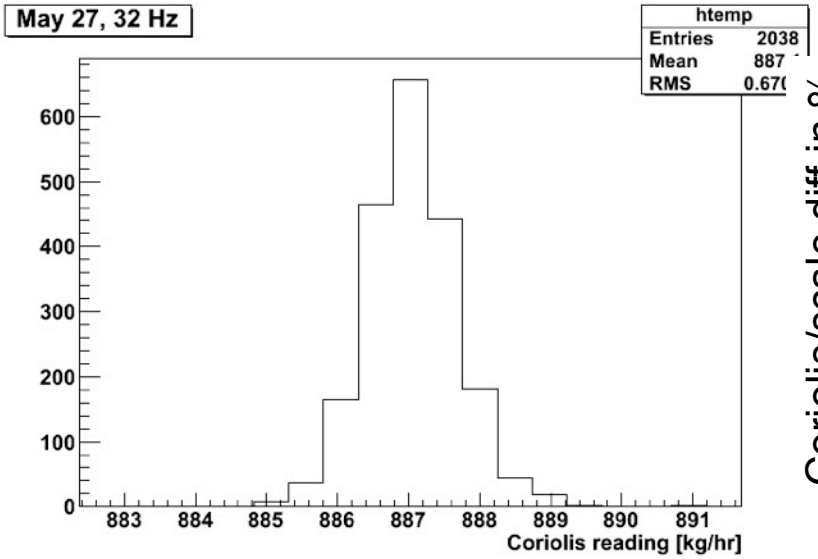
Wise, Wenman, Lewis, Hinrichs et al.

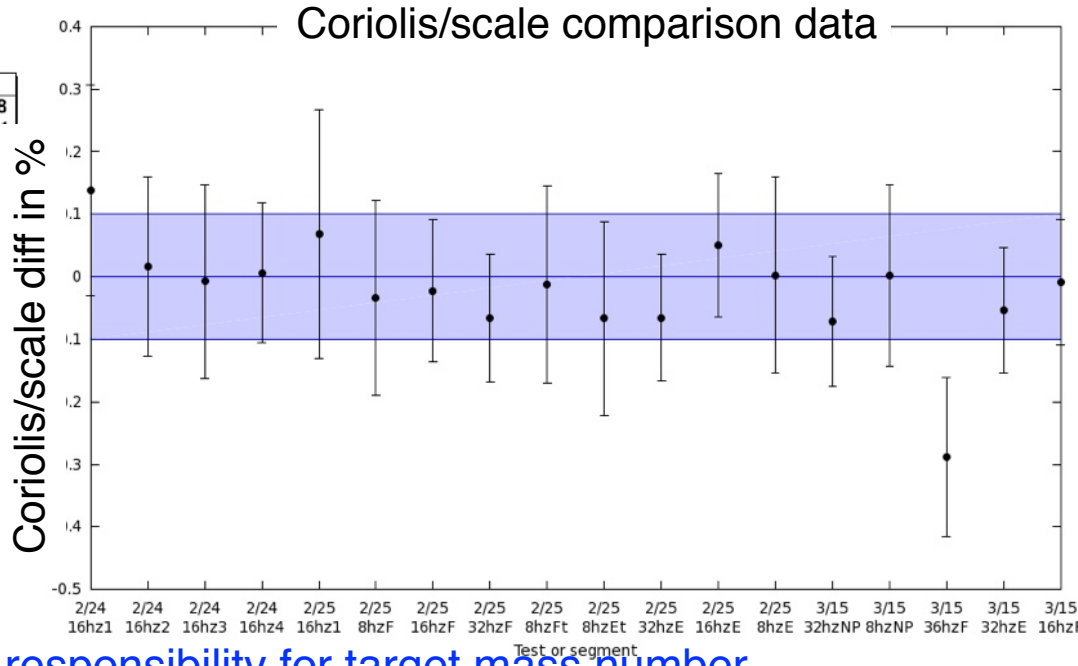
Target Mass Measurement (research effort)

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

Detector Mass Ratio, H/C
critical for oscillation physics

Coriolis mass flowmeters < 0.1%





Band, Wise, and Lewis have physics responsibility for target mass number

Daya Bay at University of Wisconsin

Cherwinka, Xiao, Band, et al.

Management of Detector Assembly and Installation

Wisconsin is lead institution for detector assembly on-site. Continuous presence on-site for assembly.

Daya Bay at University of Wisconsin

Antineutrino Detector Research Effort

• design, construction, and characterization of pairwise-"identical" antineutrino detectors **(Band, Wise, Littlejohn et al.)**

• precision measurement of number of target protons to < 0.1% **(Wise, Band, Wang, Lewis, Hinrichs, et al.)**

• ensure sufficiently-low radioactive backgrounds and materials compatibility of all detector components **(Wise et al.)**

• controlling and minimizing detector systematic error **(Wise, Band, Wang, Lewis, Hinrichs, et al.)**

Critical Contributions

• managing assembly of 8 antineutrino detectors from 2009-2012 (4 ADs to be built after start of data taking at near site) **(Band)**
• provide as-built data and characterization of detectors for physics analysis. requires continuity and oversight of scientist. **(Band)**
• absolute and relative precision measurement of target protons. calibration and instrumentation characterization **(Wise)**

Daya Bay at University of Wisconsin

UW Thesis Analyses Related to Antineutrino Detector Effort

"A High-Precision Measurement of the Reactor Electron Antineutrino Flux and Spectrum at Daya Bay",
Bryce Littlejohn, graduation expected in 2011

"Search for the Neutrino Mixing Angle θ_{13} at the Daya Bay Near Site and Systematic Effects in the Antineutrino Spectrum and Rate",
Mike McFarlane, graduation expected in 2011/2012

"First Oscillation Results from the Daya Bay Experiment: A Search for the Mixing Angle θ_{13}",
Christine Lewis, graduation expected in 2012/2013

"A High-Precision Measurement of θ_{13} at Daya Bay",
Paul Hinrichs, graduation expected in 2013/2014

Daya Bay Schedule

Spring/summer 2011	near detector data taking
Summer 2012	full experiment
Summer 2013	$\sin^2 2\theta_{13}$ sensitivity to ~0.01

Daya Bay at University of Wisconsin

Awards, Honors, and Distinctions During Grant Period

Karsten Heeger *(faculty)*
2009 Sloan Research Fellowship

Tom Wise *(researcher)*
2009 UW Chancellor's Award for Excellence in Research

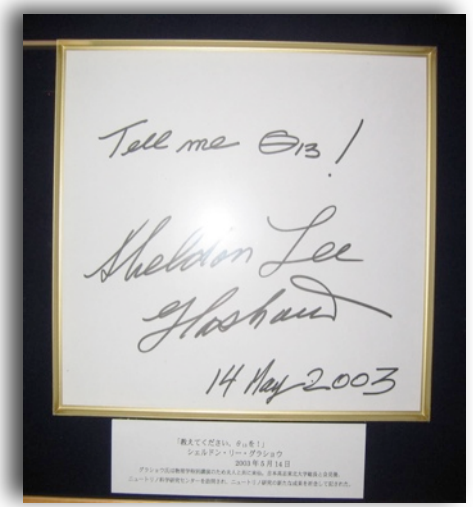
Bryce Littlejohn *(graduate student)*
2008 NSF East Asia and Pacific Summer Institute Fellowship

Alex Green *(undergraduate student)*
2010 APS Conference Experience for Undergraduate (CEU) fellowship

Patrick Mende *(undergraduate student)*
2008 APS Conference Experience for Undergraduate (CEU) fellowship
since 2009 graduate school at Carnegie Mellon

Ho Ling Li *(undergraduate student)*
2007 APS Conference Experience for Undergraduate (CEU) fellowship
since 2009 graduate school at Univ. of Chicago, works with Young Kee Kim at FNAL

Daya Bay Summary



- Non-accelerator experiments were key in discovering neutrino mass and oscillations in the past decade (1998-2008).
- Reactor experiments have made key contributions: KamLAND discovered reactor $\overline{\nu}_e$ oscillation and has made most precise measurement of Δm^2_{12} to < 3%
- The measurement of $\sin^2 2\theta_{13} > 0.01$ is a prerequisite for the search of leptonic CPV.

- UW makes key contributions to Daya Bay design, construction, commissioning, and physics studies. Single-largest university contribution to Daya Bay.
- UW has most detailed and comprehensive knowledge of the antineutrino detectors - the core of the Daya Bay experiment. In ideal situation to evaluate detector systematics for physics analysis.
- Ready to capitalize on large technical and financial investments (startup etc).
- Data taking with first detectors soon. Transition of UW science group to physics analysis while managing detector assembly.

Request for Support

Personnel

faculty *(Heeger)*	summer salary
senior scientist *(Band)*	100%
postdoctoral research associate *(Wang)*	1 FTE
graduate students *(Littlejohn, McFarlane)*	2 FTE
computing support *(Rader, Radtke)*	shared with other tasks

+ travel

Note: In Aug 2010 Daya Bay project asked if Tom Wise can be supported for his research effort on target mass measurement and instrumentation characterization with a one-time supplement to base grant.

Antineutrino Detector Transport

Detector Test Transport in June 2010