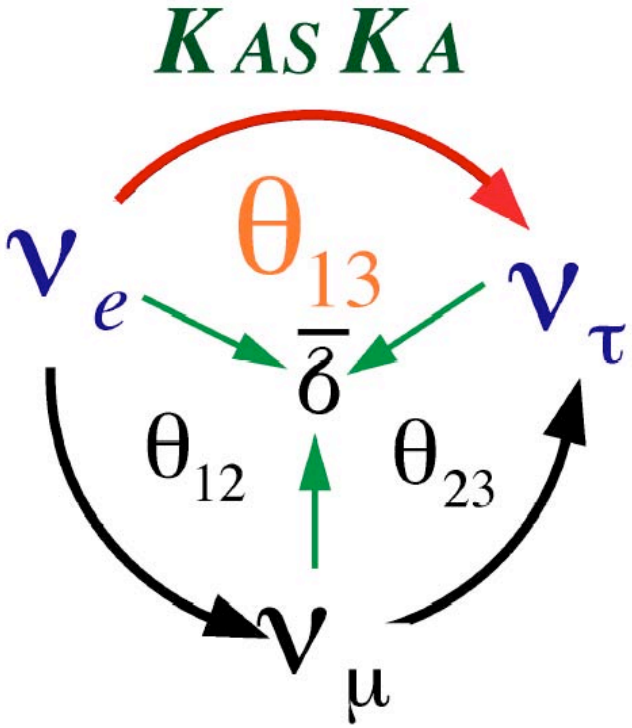
KASKA Project

(*Kas*hiwazaki-*Ka*riwa Nuclear Power Station)



F.Suekane

RCNS, Tohoku Univ. Japan

suekane@awa.tohoku.ac.jp

PANIC2005 Satellite meeting
@Santa Fe, NM, USA
2005.10.30

KASKA Members

Niigata University: N.Tamura, M.Tanimoto, H.Miyata, H.Nakano T.Kawasaki, M.Katsumata, T.Iwabuchi, M.Aoki, N.Nakajima, K.Sakai
Tohoku University: F.Suekane, Y.Sakamoto, S.Tsuchiya,
Tokyo Metropolitan University: T.Sumiyoshi, H.Minakata, O.Yasuda , K.Sakuma
Tokyo Institute of Technology: M.Kuze, K.Nitta, H.Furuta, J.Maeda, Y.Funaki
Kobe University: T.Hara
KEK: N.Ishihara, H.Sugiyama
Miyagi University of Education: Y.Fukuda, Akiyama
Hiroshima Institute of Technology: Y.Nagasaka

Outline

Reactor θ physics

KASKA-θ_{13} experiment

R&D status

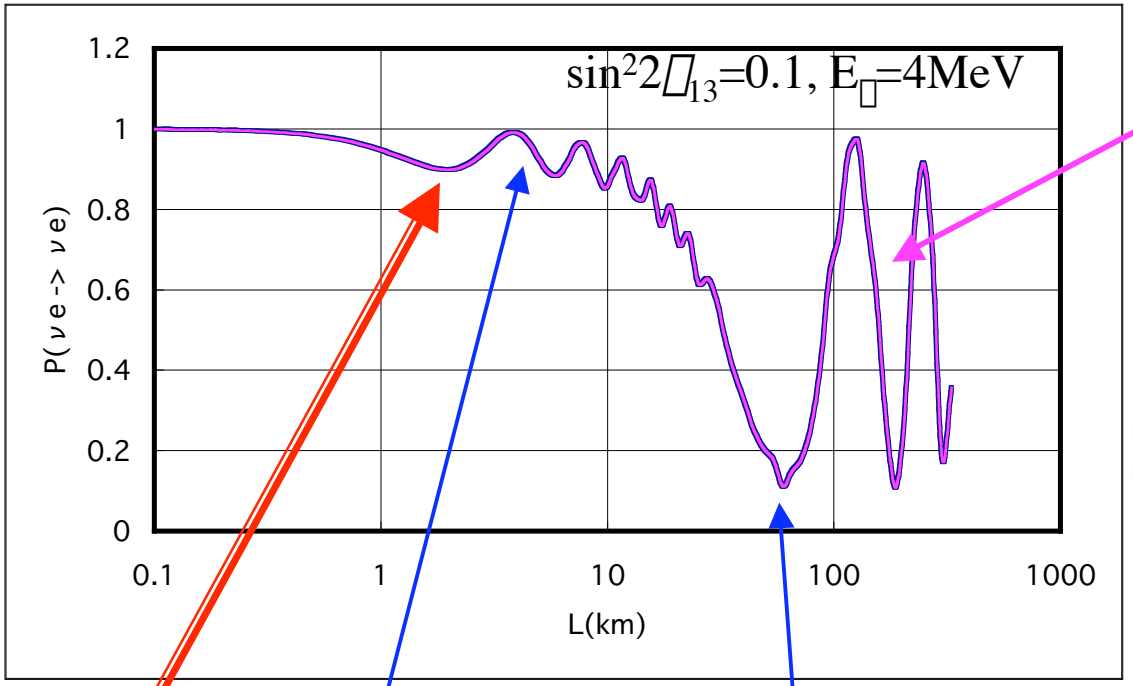
Possible Extension

Summary

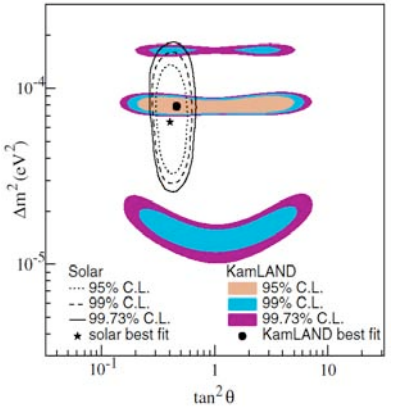
Physics Potential with Reactor Neutrinos

$$P(\bar{\nu}_e \to \bar{\nu}_e) = 1 - \sin^2 2\theta_{13} \sin^2 \frac{\Delta m^2_{13} L}{4E}$$

$$P(\bar{\nu}_e \to \bar{\nu}_e) \approx 1 - \sin^2 2\theta_{12} \sin^2 \frac{\Delta m^2_{12} L}{4E}$$



L~180km
KamLAND:
accurate Δm^2_{12}
moderate θ_{12}



L~1.8km: pure $\sin^2 2\theta_{13}$

L~5km: Δm^2_{13}

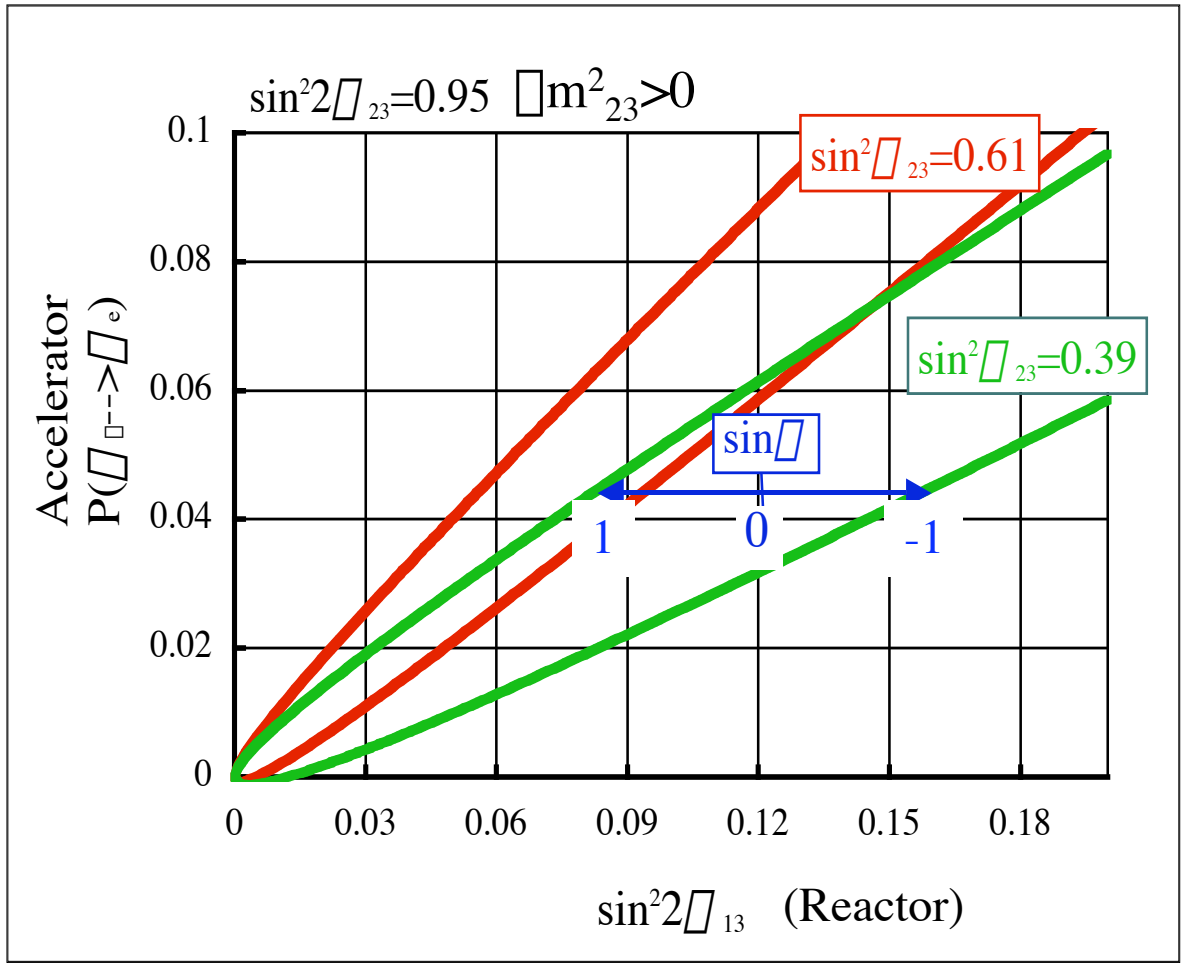
L~50km: accurate $\sin^2 2\theta_{12}$

Scope of KASKA Project

Compementarity of Reactor & Accelerator θ_{13}

$$P_{AC}(\nu_\mu \to \nu_e) = \sin^2 2\theta_{13}\sin^2\theta_{23} - \frac{\alpha}{2}\frac{\Delta m^2_{12}}{\Delta m^2_{23}}\sin 2\theta_{12}\sin 2\theta_{13}\sin 2\theta_{23}\sin\delta$$

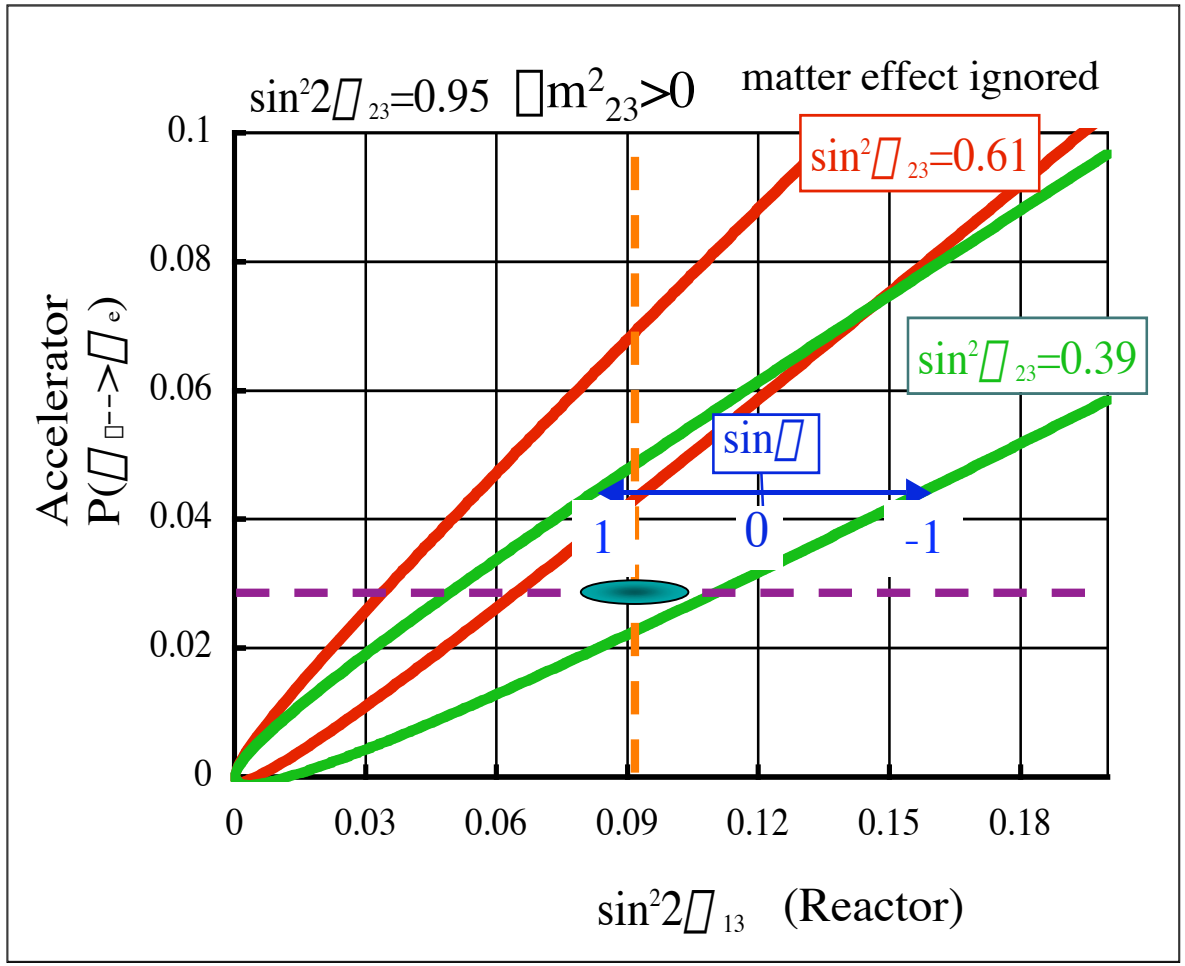
$$P_{RE}(\bar{\nu}_e \to \bar{\nu}_e) = 1 - \sin^2 2\theta_{13} \qquad \text{@oscillation maximum}$$



Compementarity of Reactor & Accelerator θ_{13}

$$P_{AC}(\nu_\mu \to \nu_e) = \sin^2 2\theta_{13}\sin^2\theta_{23} - \frac{\alpha}{2}\frac{\Delta m^2_{12}}{\Delta m^2_{23}}\sin 2\theta_{12}\sin 2\theta_{13}\sin 2\theta_{23}\sin\delta$$

$$P_{RE}(\bar{\nu}_e \to \bar{\nu}_e) = 1 - \sin^2 2\theta_{13} \qquad \text{@oscillation maximum}$$

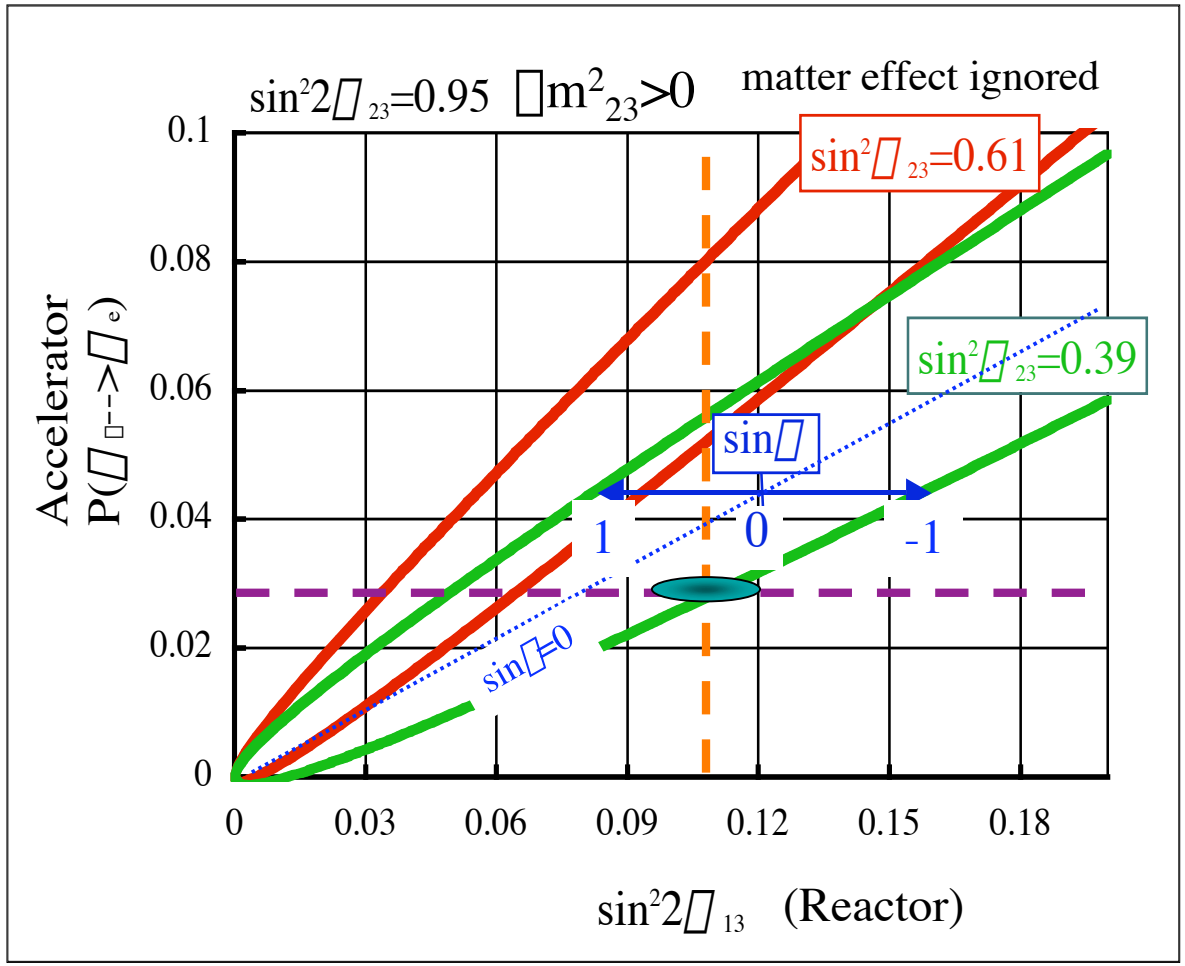


- $\sin^2\theta_{23} = 0.39!$

Compementarity of Reactor & Accelerator θ_{13}

$$P_{AC}(\nu_\mu \to \nu_e) = \sin^2 2\theta_{13}\sin^2\theta_{23} - \frac{\alpha}{2}\frac{\Delta m^2_{12}}{\Delta m^2_{23}}\sin 2\theta_{12}\sin 2\theta_{13}\sin 2\theta_{23}\sin\delta$$

$$P_{RE}(\bar{\nu}_e \to \bar{\nu}_e) = 1 - \sin^2 2\theta_{13} \qquad \text{@oscillation maximum}$$

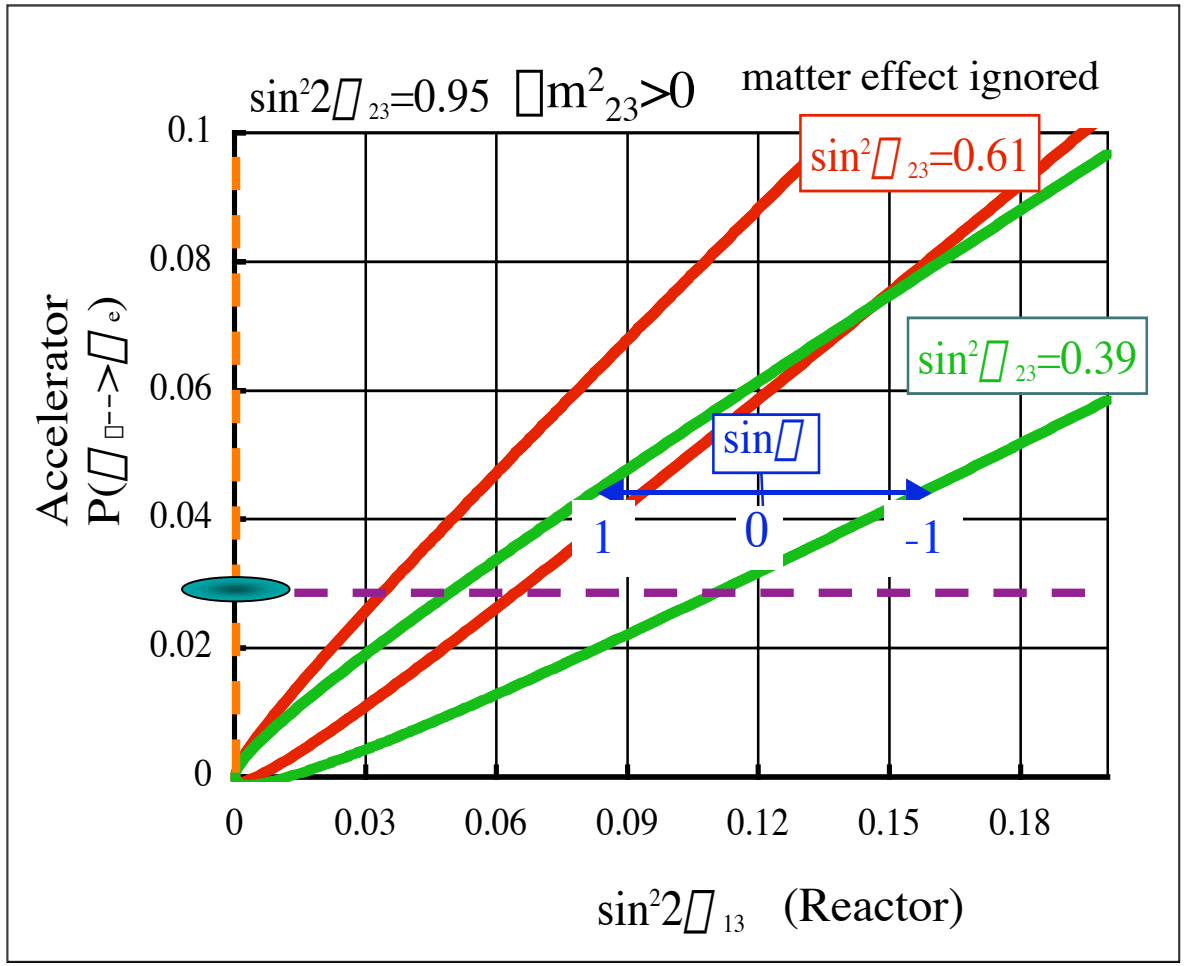


- $\sin^2\theta_{23} = 0.39!$
- $|\sin\delta| > 0!!$

Compementarity of Reactor & Accelerator θ_{13}

$$P_{AC}(\nu_\mu \to \nu_e) = \sin^2 2\theta_{13}\sin^2\theta_{23} \mp \frac{\alpha}{2}\frac{\Delta m^2_{12}}{\Delta m^2_{23}}\sin 2\theta_{12}\sin 2\theta_{13}\sin 2\theta_{23}\sin\delta$$

$$P_{RE}(\bar{\nu}_e \to \bar{\nu}_e) = 1 - \sin^2 2\theta_{13} \qquad \text{@oscillation maximum}$$



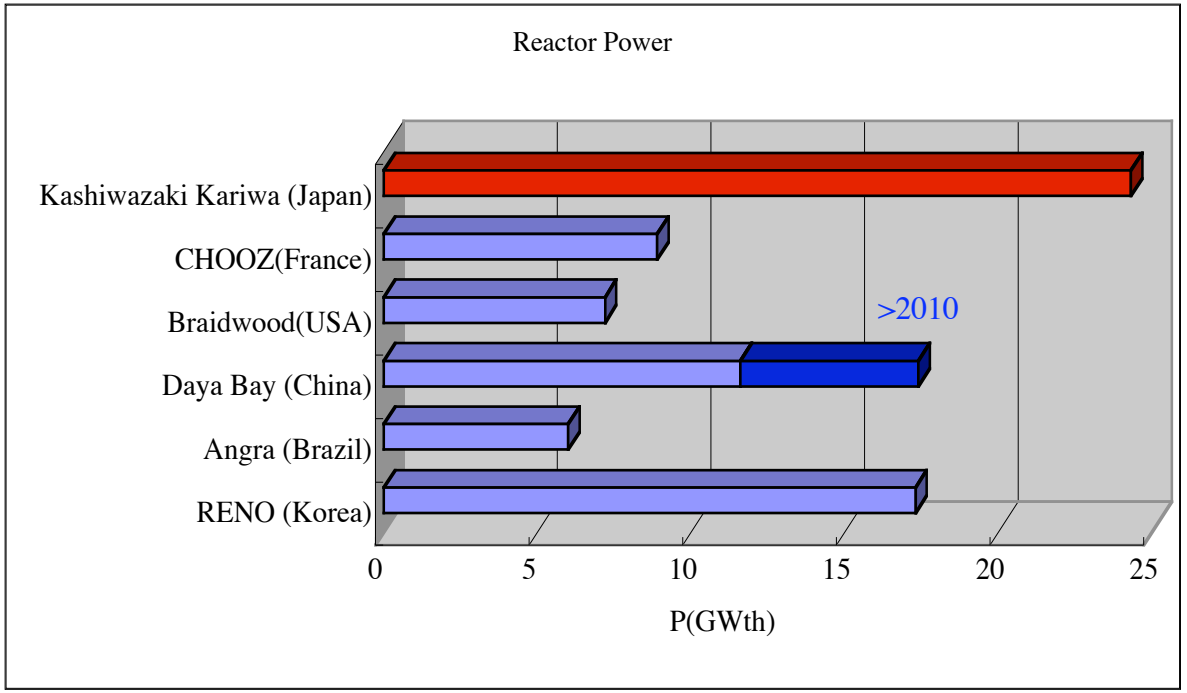
- New physics *!!!*

Reactor $$= a few months of operation $$$ of Accelerator

Kashiwazaki-Kariwa NPS

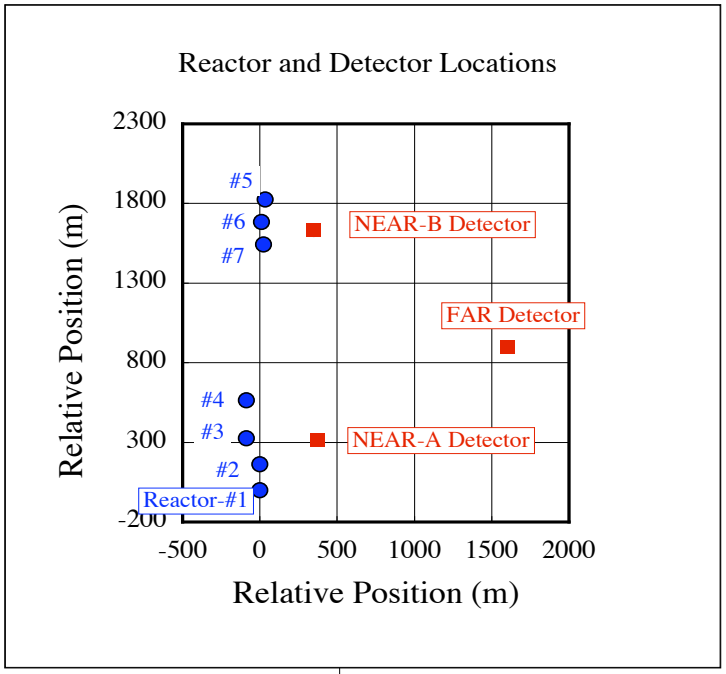
7 powerful reactors
cluster into two group.
(5BWR+2ABWR)

World's Highest Power
P=24.3GWth
=highest □luminosity



05.10.30

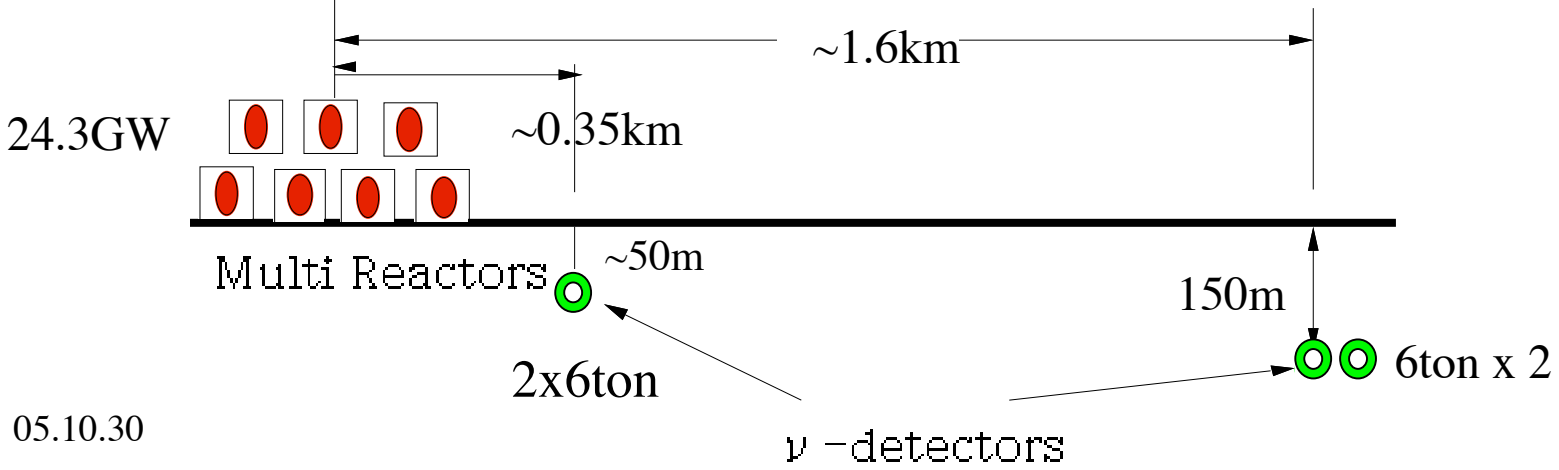
KASKA Geometry



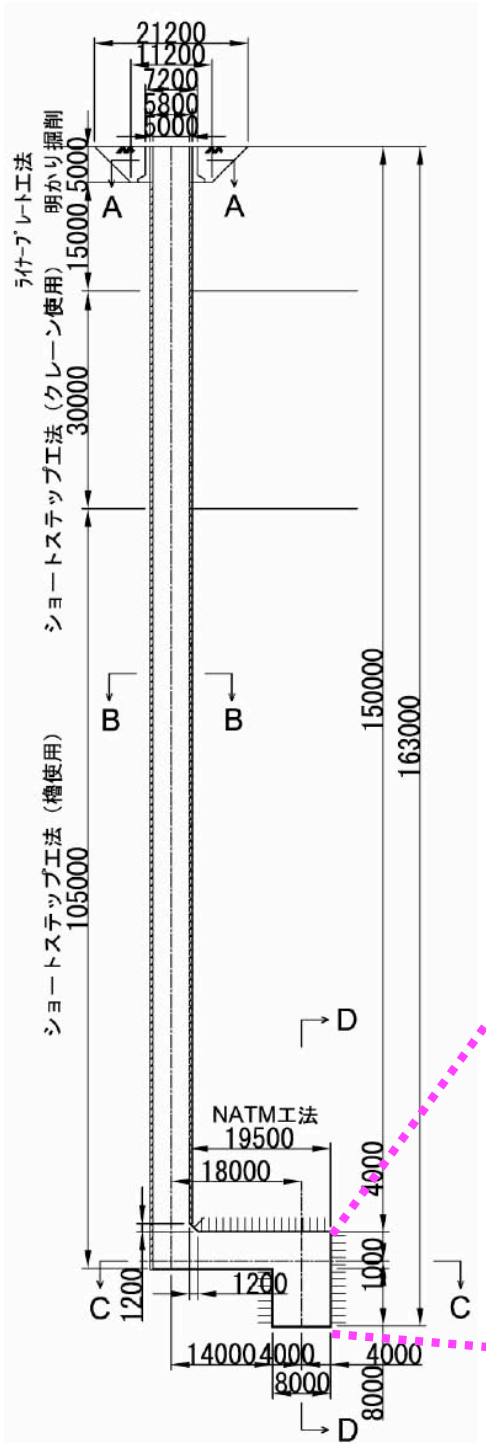
Shaft holes =>
Optimum baseline &
Optimum depth

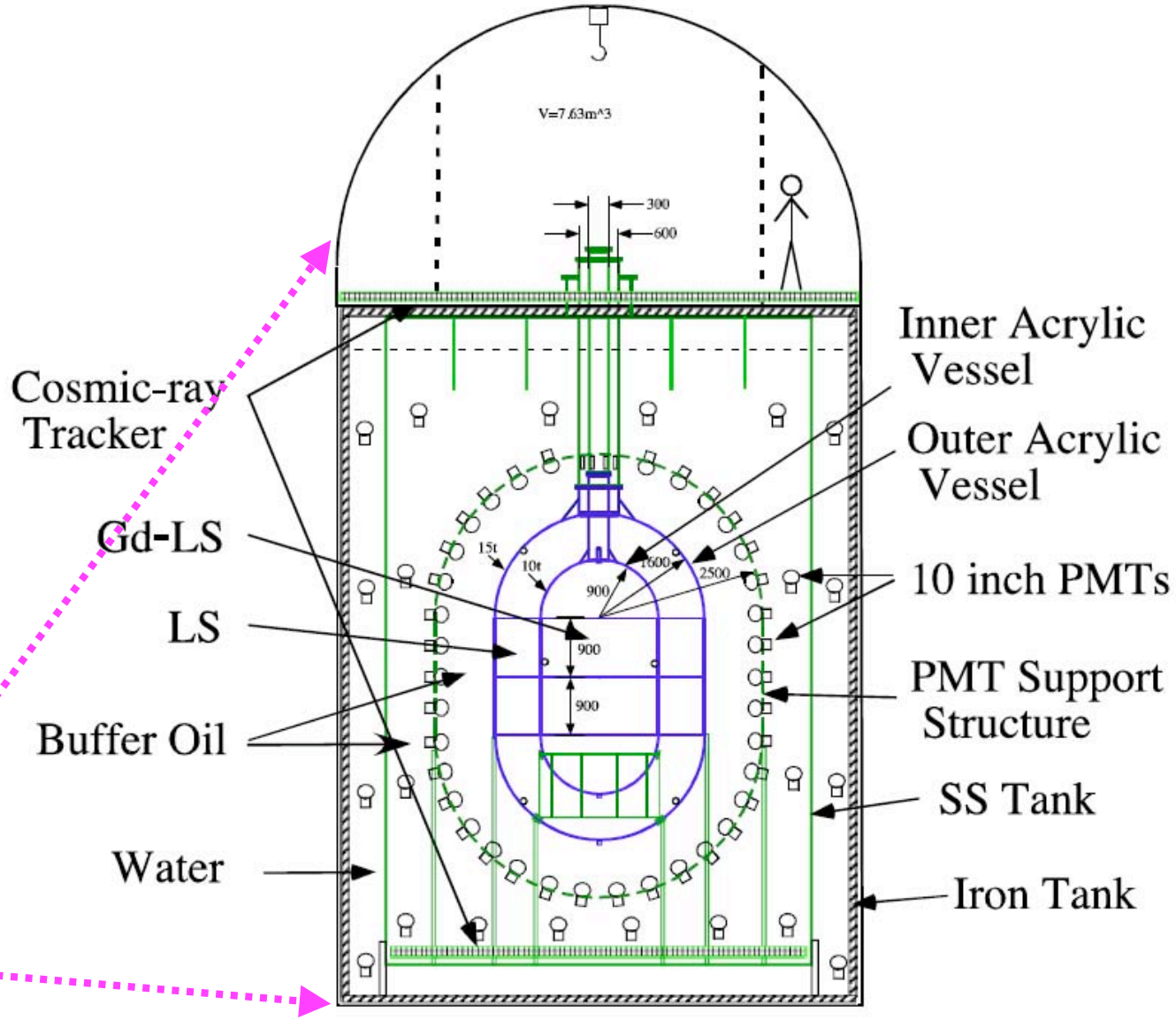
$$(\square_{spallation}(\bar{\square})\square/\square)_{near}$$

$$\sim(\square_{spallation}(\bar{\square})\square/\square)_{far}$$



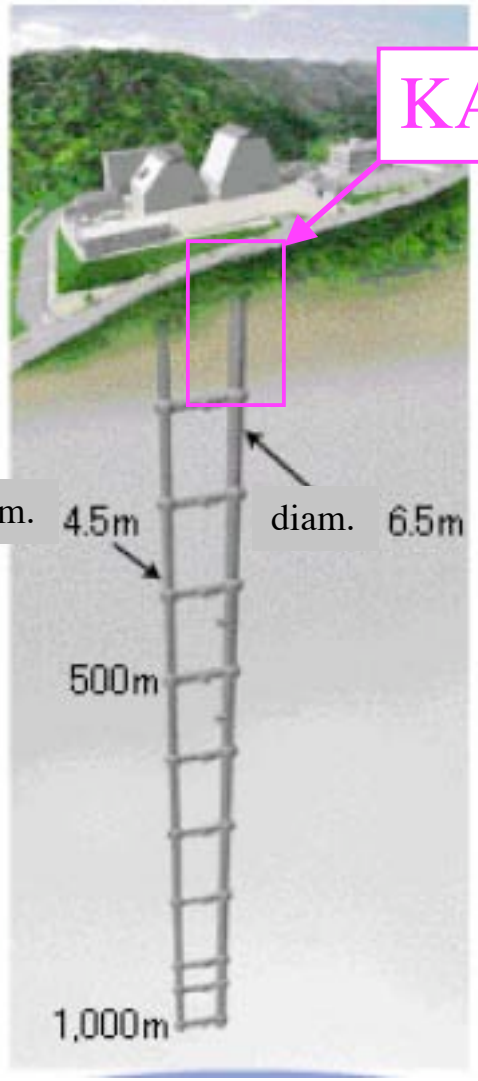
Detector & Shaft Hole



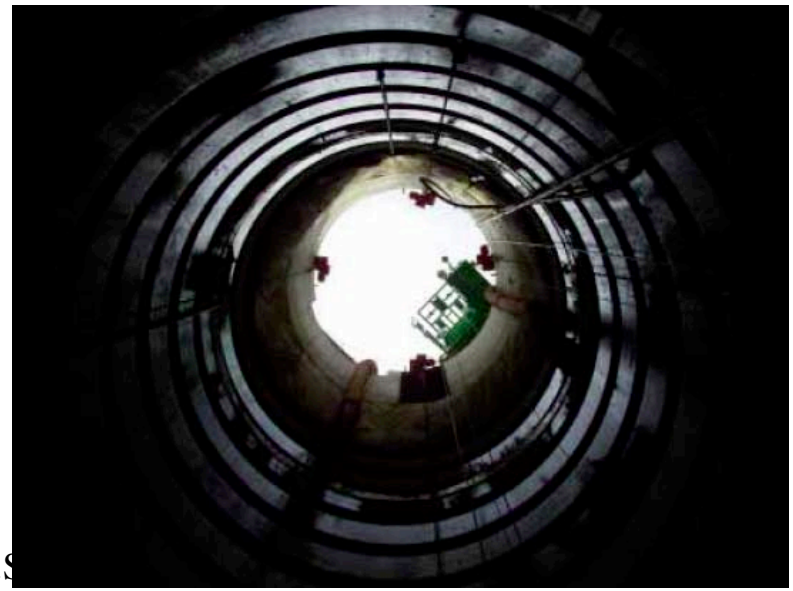


Technical Example; JAEA 1,000m shaft hole

(Gifu Pref. Japan)

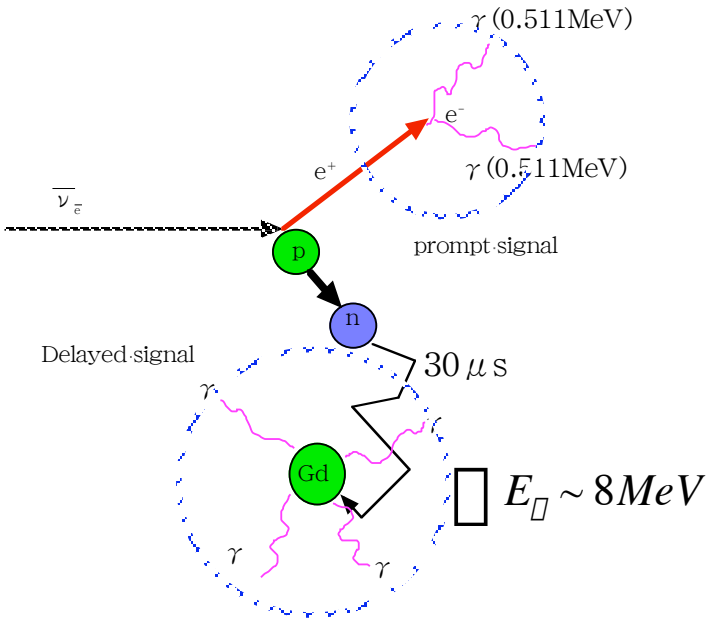


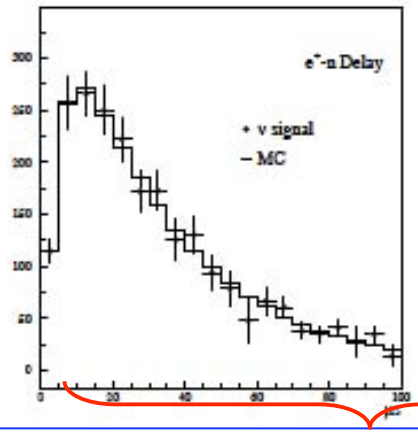
KASKA-far shaft equivalent size



http://www.jaea.go.jp/04/tono/index.htm

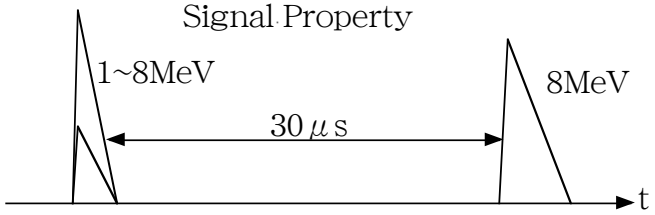
Principle of Neutrino Detection

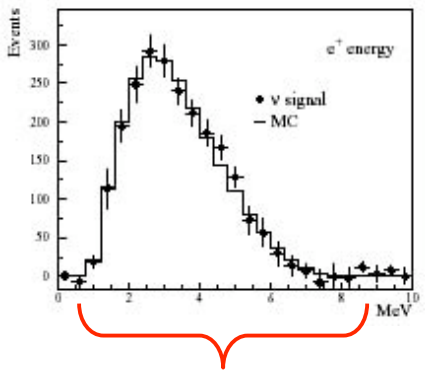




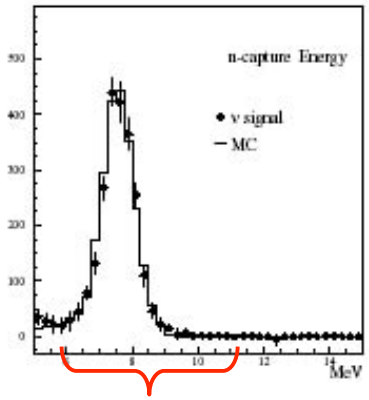
data from CHOOZ
hep-ex/0301017v1

(3) $1\,\mu s < \Delta T < 200\,\mu s$





(1) $0.7 < E_{prompt} < 9MeV$



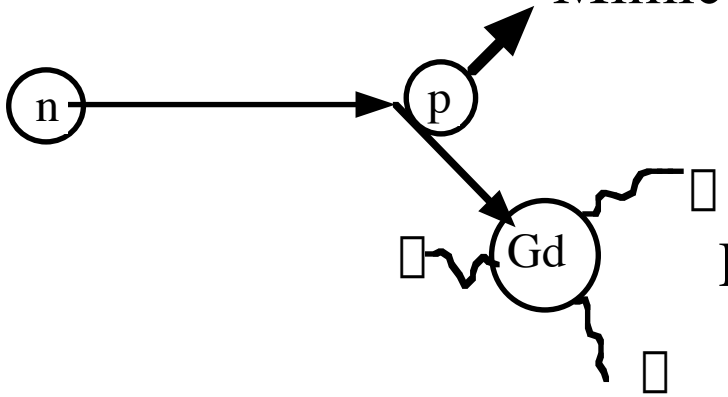
(2) $5 < E_{delayed} < 11MeV$

Efficiency is insensitive to cuts
&
No Fiducial Cut

BackGrounds

Fast Neutron

(small due to thick shield)

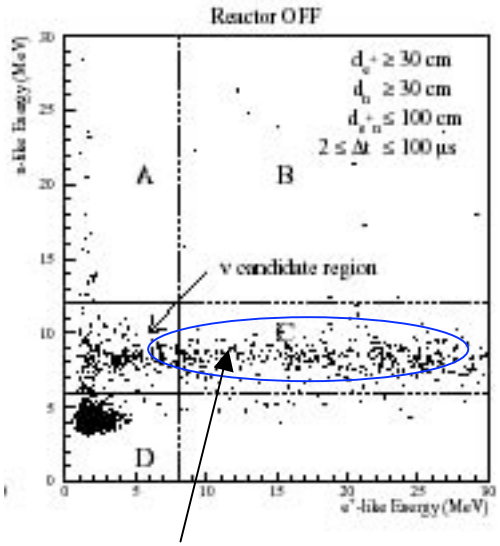


Mimic prompt signal

Delayed signal

BKG << 0.4%

CHOOZ
hep-ex/0301017v1



n backgrounds
have flat distribution

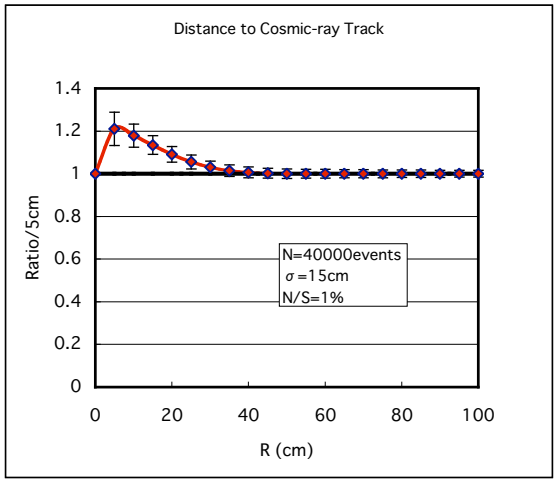
Spallation

$$\square + {}^{12}C \rightarrow {}^{9}Li + X$$

$${}^{9}Li \rightarrow {}^{8}Be + \square\ (Q=13MeV) + n\ ,$$

($\square$=0.26s, Br=48%)

BKG < 0.3%



d(track-signal)

Error

efficiency related

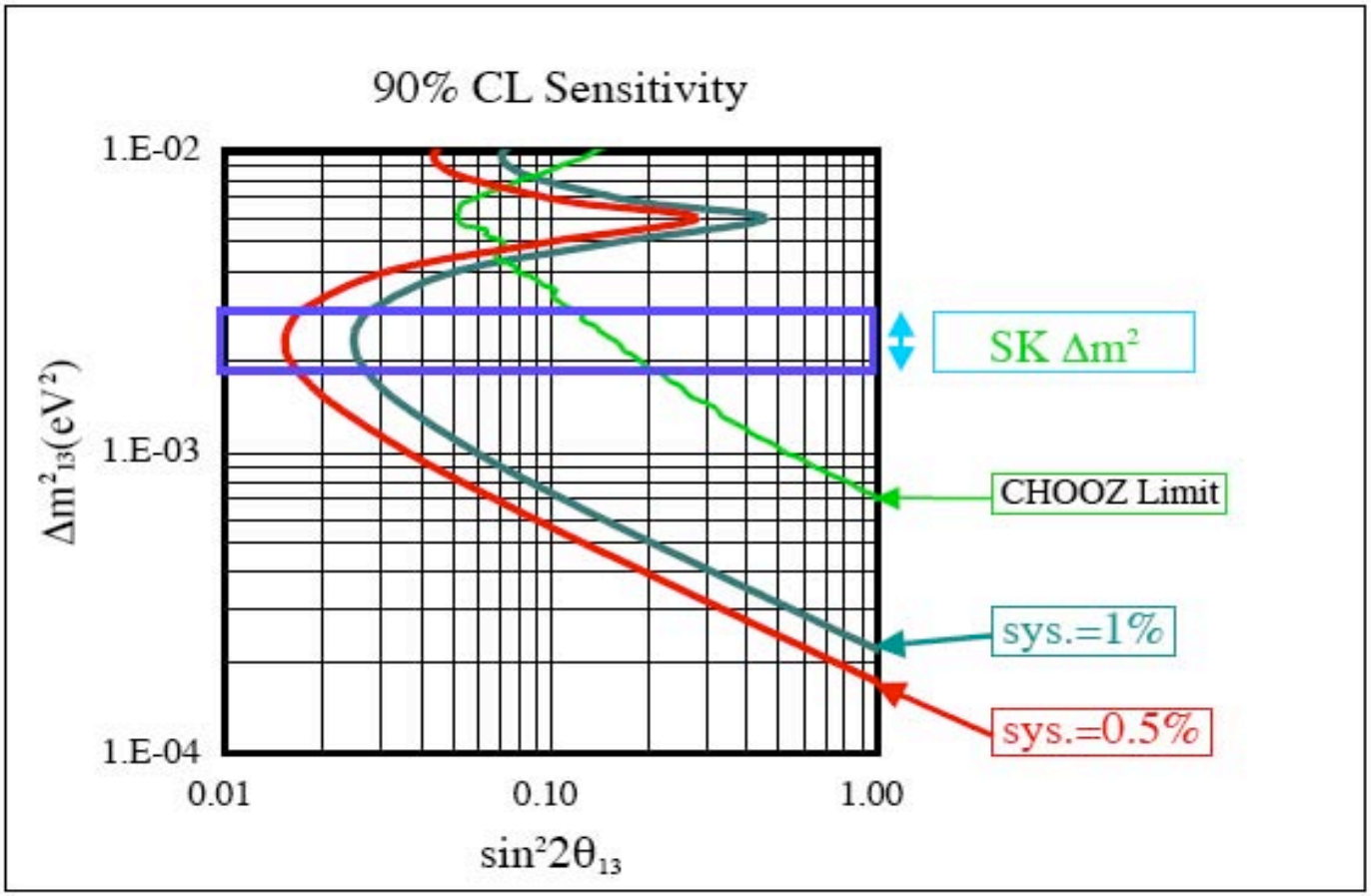
selection	CHOOZ	KASKA
positron energy	0.8%	<0.1%
positron position	0.1%	-
neutron capture	1.0%	<0.5%
capure energy containment	0.4%	<0.4%
neutron position	0.4%	-
neutron delay	0.4%	<0.2%
positron-neutron distance	0.3%	-
neutron multiplicity	0.5%	-
number of protons	0.8%	<0.5%
Combined	1.76%	<0.85%

+ □ flux + BKG

parameter	CHOOZ	KASKA
Reaction Cross section	1.9%	-
detection efficiency	1.76%	<0.85%
reactor power	0.7%	-
energy released per fission	0.6%	-
baseline difference	-	<0.2%
background	0%	<0.5%
combined	2.7%	<1.0%

Statistic error = 0.4% in 3years

Expected Sensitivity



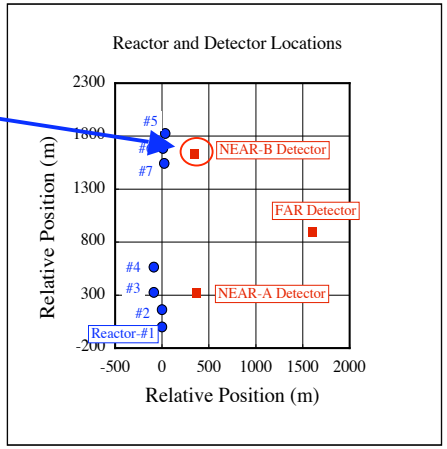
10x better sensitivity than current limit

R&D

Several R&D budgets have been approved

* Boring study at near-B site
* Prototype detector
* Low BKG PMT
* Electronics development
* LS developments
* Detector and Shaft hole design study
* Calibration system
* Cosmic-ray tracking system
* Design and tests of acrylic vessels

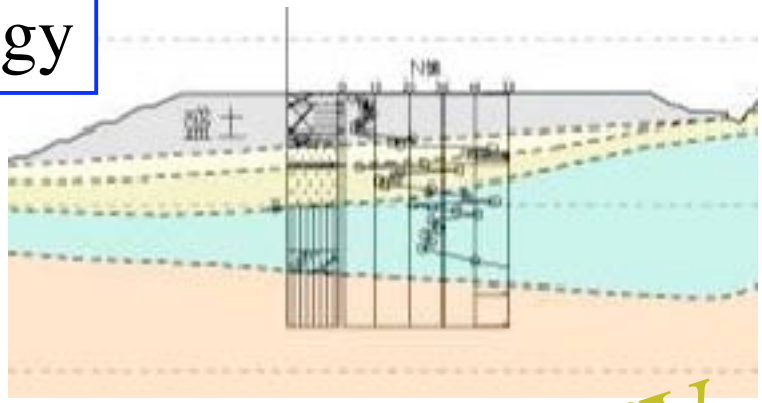
Boring Study @ near-B site (2004.10~11)



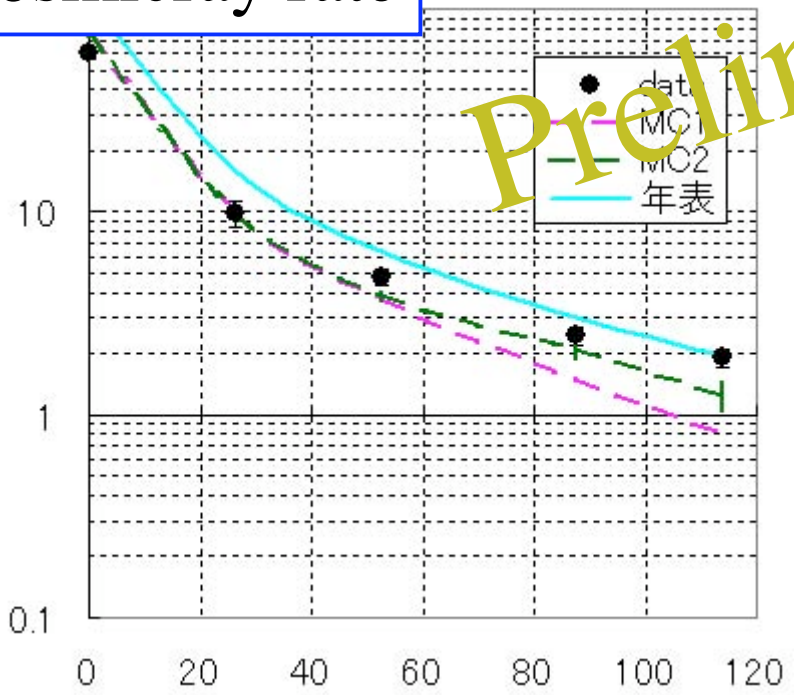
Study of
- Geology
- Cosmic-ray BKG
- γ-ray BKG

at real location and depth
&
- Real experience to work in the reactor site

Geology

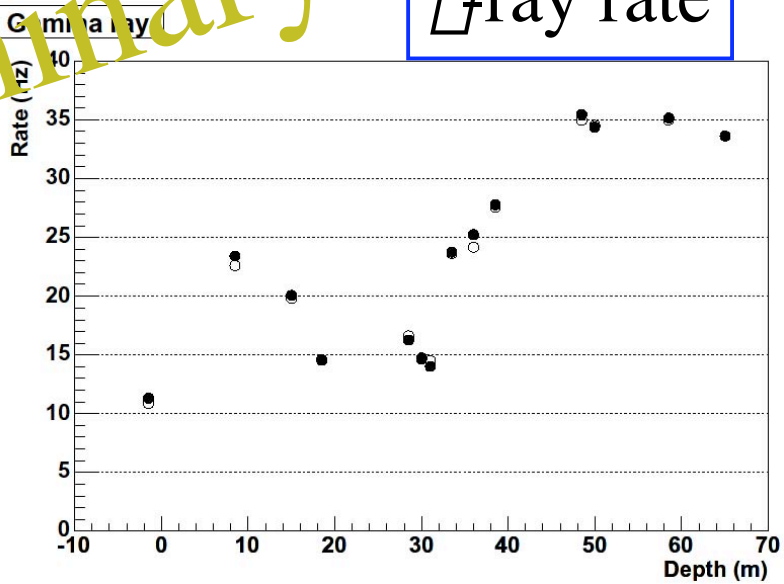


Cosmicray rate



Preliminary

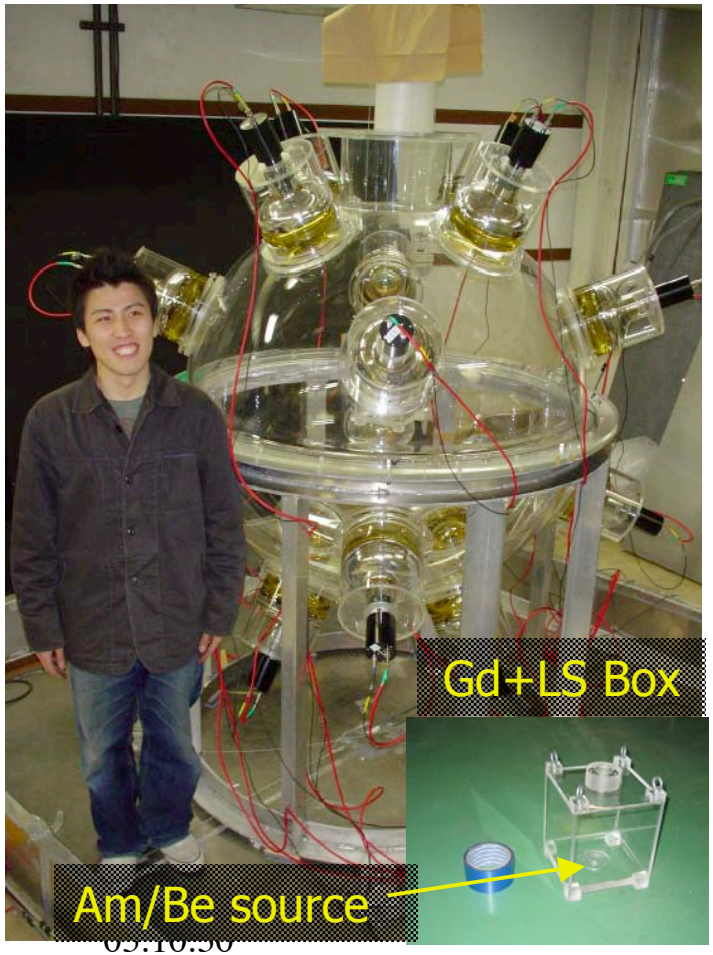
γray rate

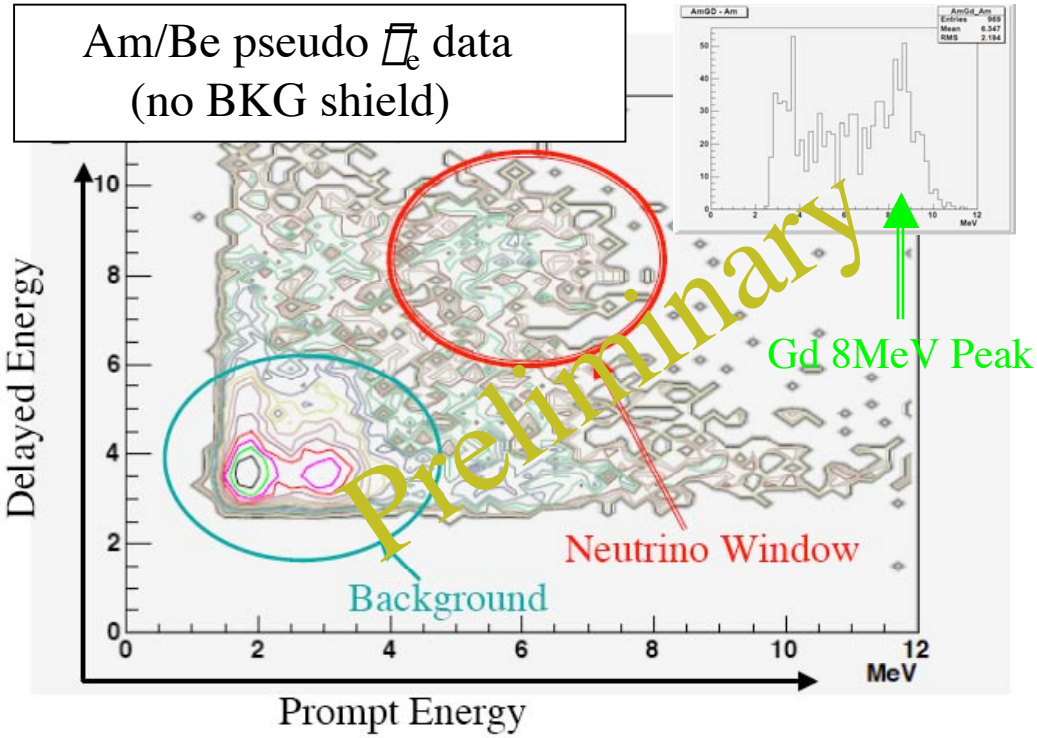


Data are consistent with expectation.

Prototype Detector

* Test of $\bar{\nu}_e$ catcher
* Am/Be neutrino like signal
* Gd systematics
* Systematic Cancellation
* Cosmic-ray spallation BKG

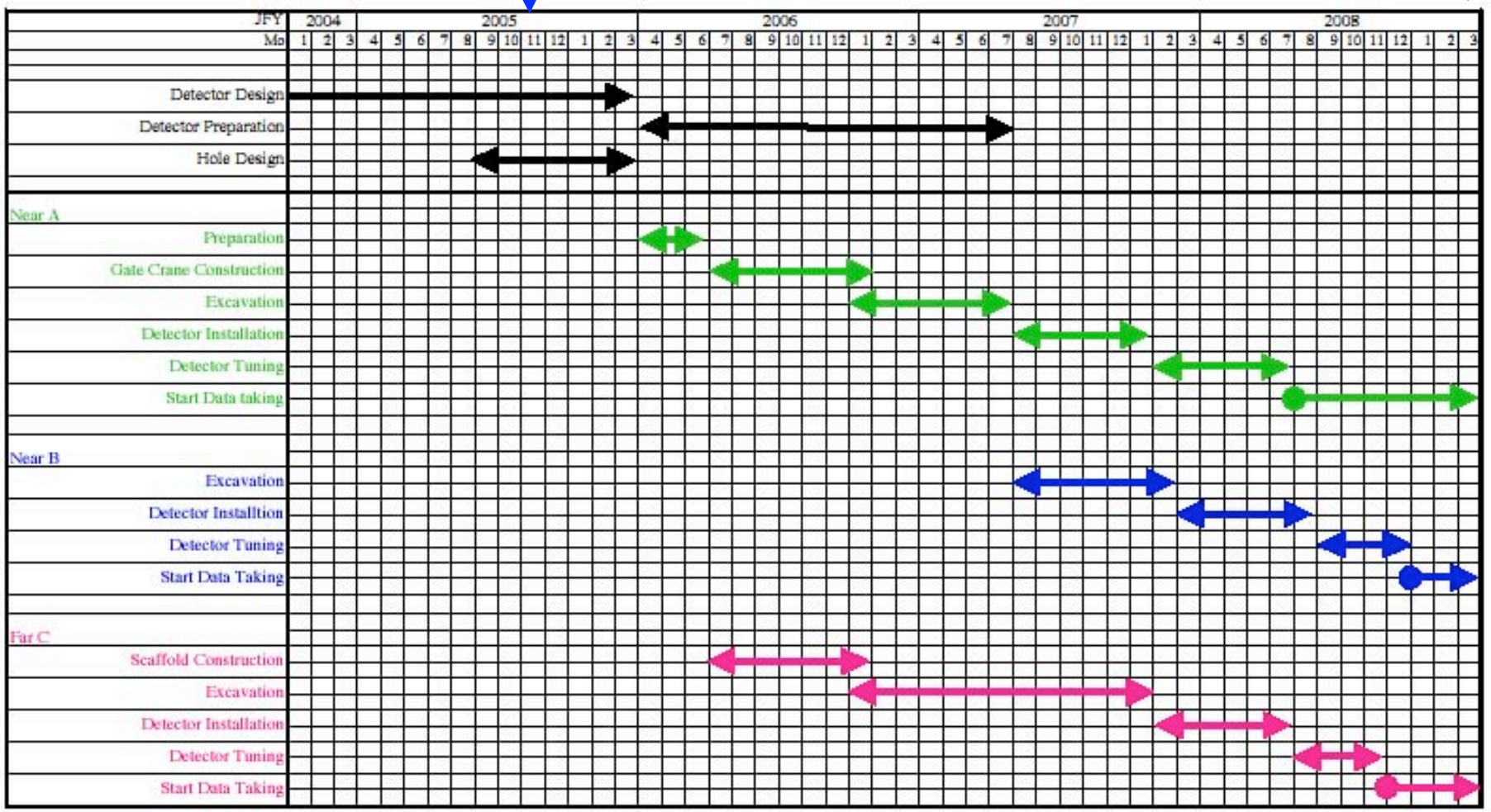




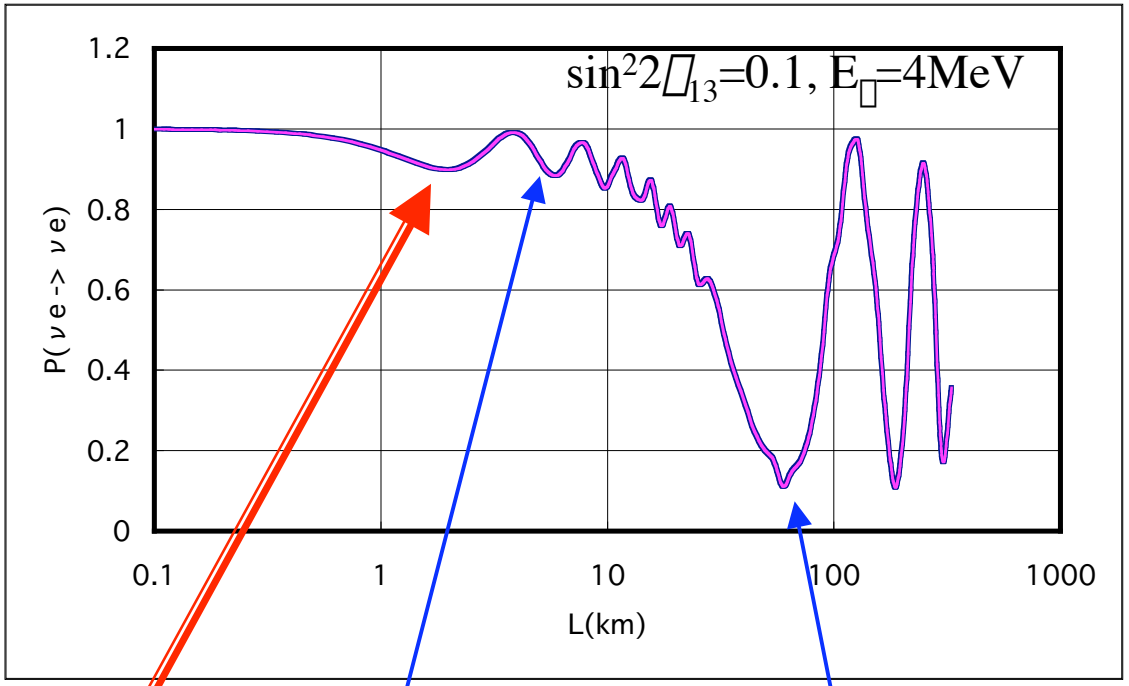
Possible Schedule

Now(struggling for funding)

2009.3



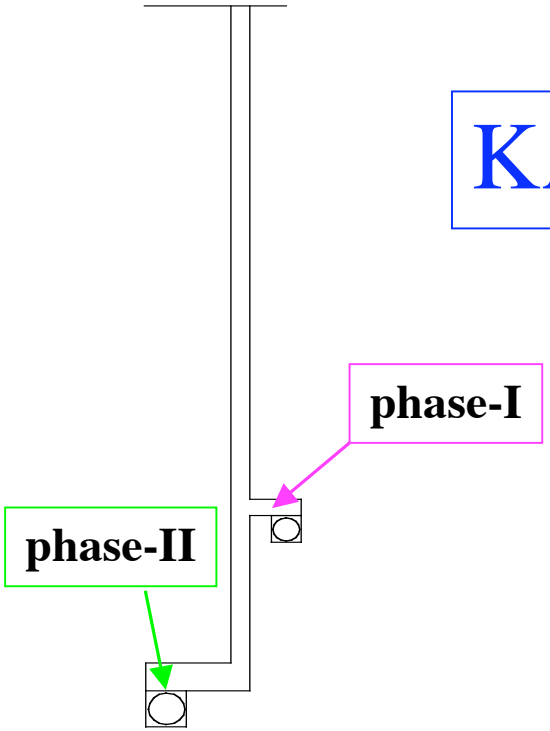
Possible Extensions



L~1.8km: KASKA-II

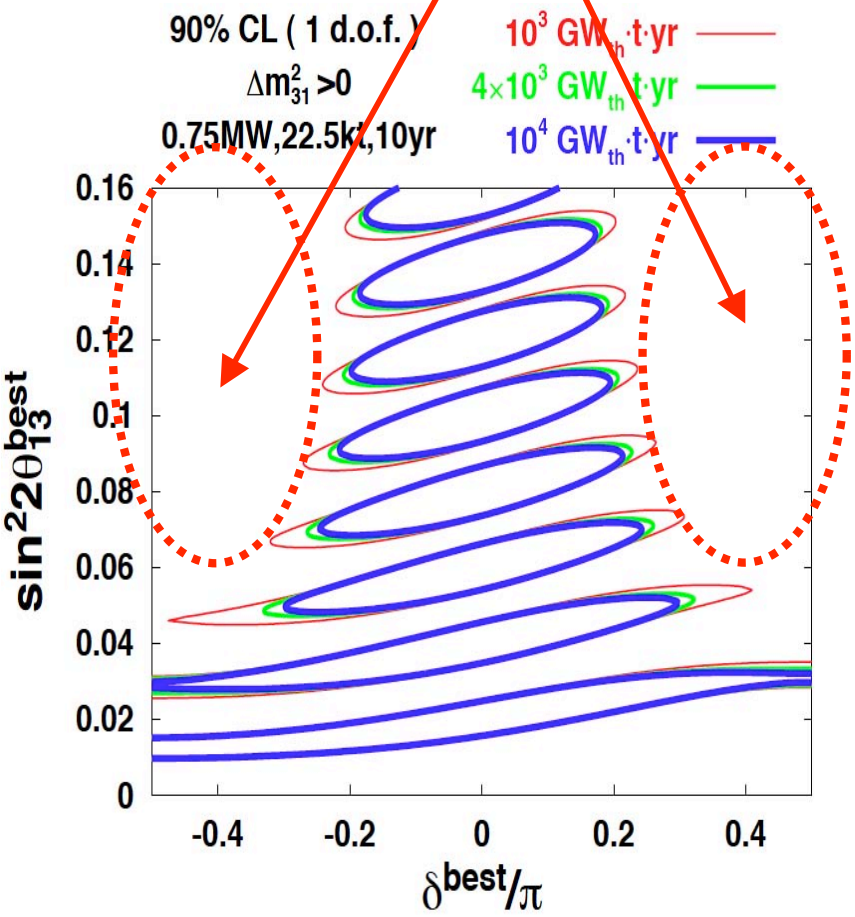
L~5km: KASKA-Δm²13

L~50km: KASKA-θ12



KASKA-II

Detection area of non-0 θ_{13}



(from H.Minakata hep-ph/0402197)

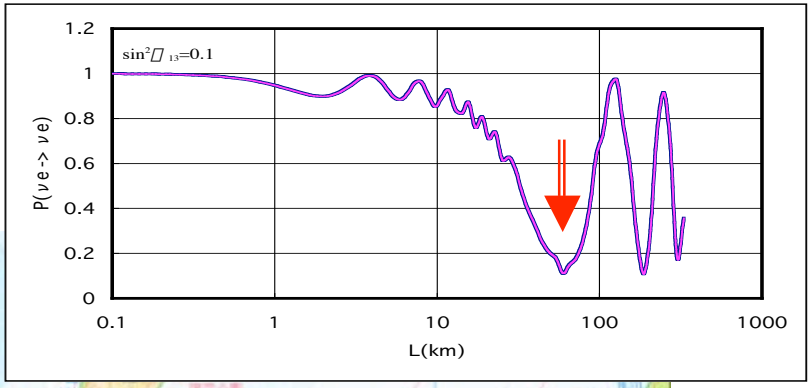
50ton KASKA detector

+

JPARC-SK 10 years

||

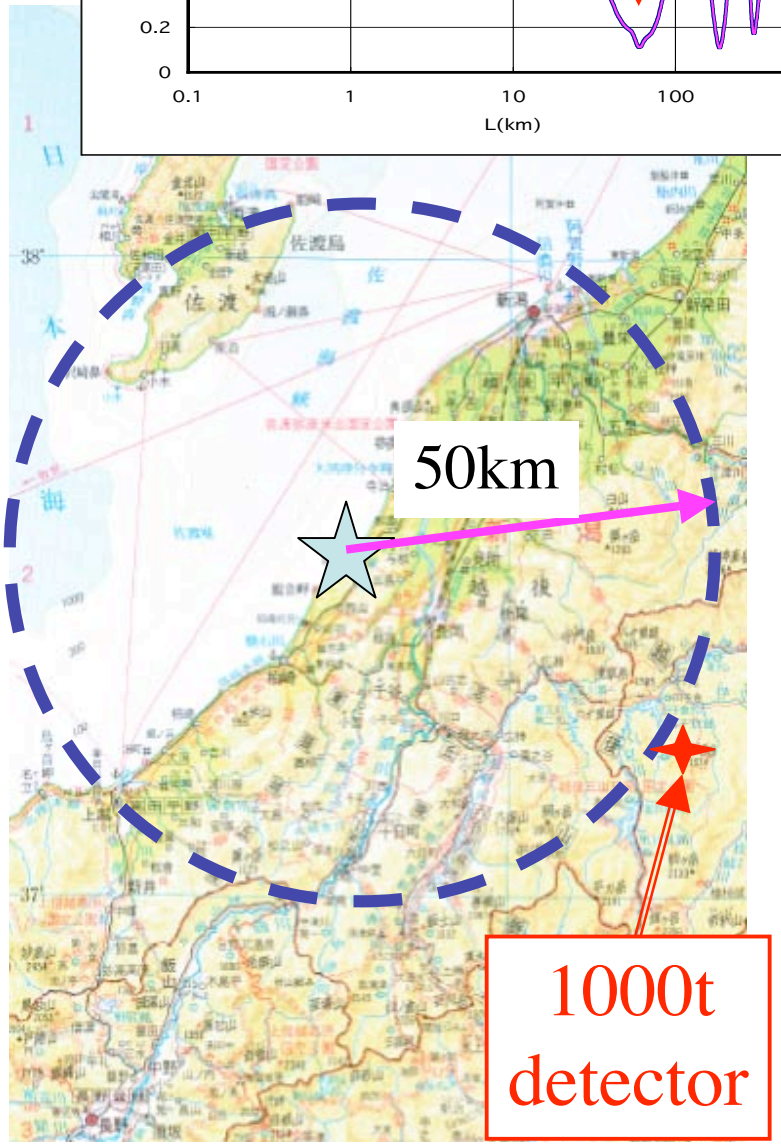
possibility of non-0 θ_{13} detection

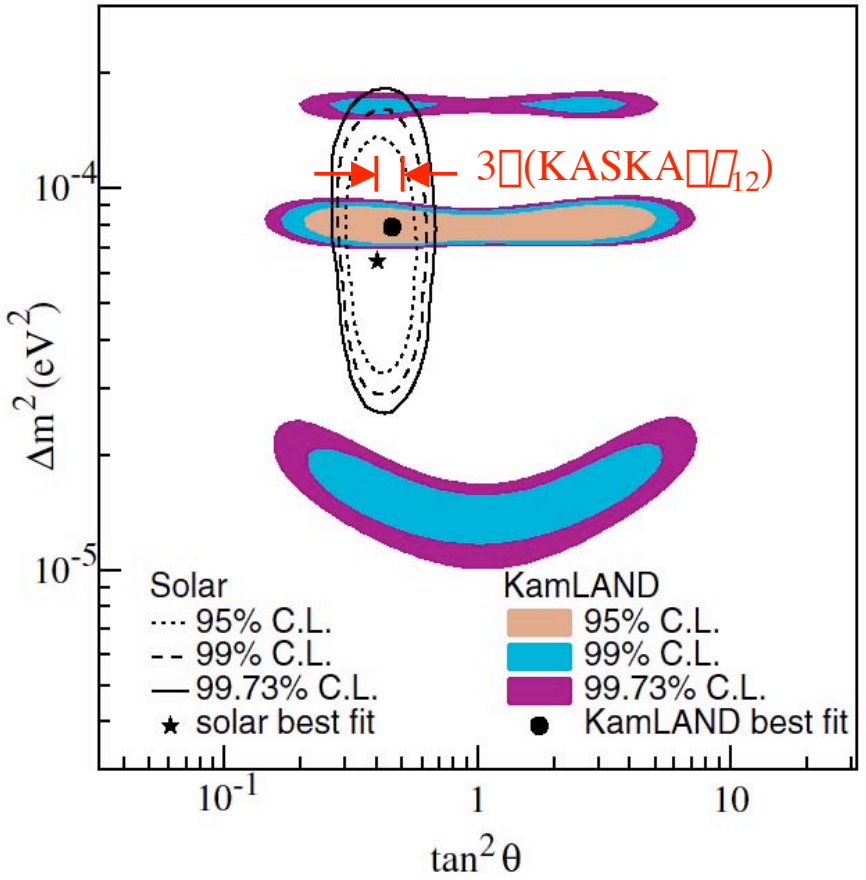


KASKA-□12

$$\frac{\Delta \sin^2 \theta_{12}}{\sin^2 \theta_{12}} \sim 2.4\%(1\sigma)$$

Minakata et al. hep-ph/0407326





Summary

(1) KASKA enjoys highest reactor power, optimum baseline and can measure $\sin^2 2\theta_{13}$ with 10 times better sensitivity of current limit.

(2) R&D has been progressing well.

(3) If everything goes well we can start data taking in early 2009.

(4) Thanks to the high reactor power there are some possible extensions of the project.