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Near detector at 2 km and the far detectors

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For the JHF-SK neutrino WG

Outline

- Far detector (Super-Kamiokande)
- Near detector
  - Motivation
  - Requirements for the near detector
  - Near/far ratio
  - Requirements from physics
- Far detector in the 2nd phased (Hyper-Kamiokande)
- Summary

JHF-SK neutrino project

< 1 GeV
ν_μ beam

Super Kamiokande

295km

JAERI
(Tokai)

Japan

KEK

Tokyo

Kawasaki

Yokohama

Nagoya

Kyoto

Osaka

50 kton
Water Cherenkov

Future

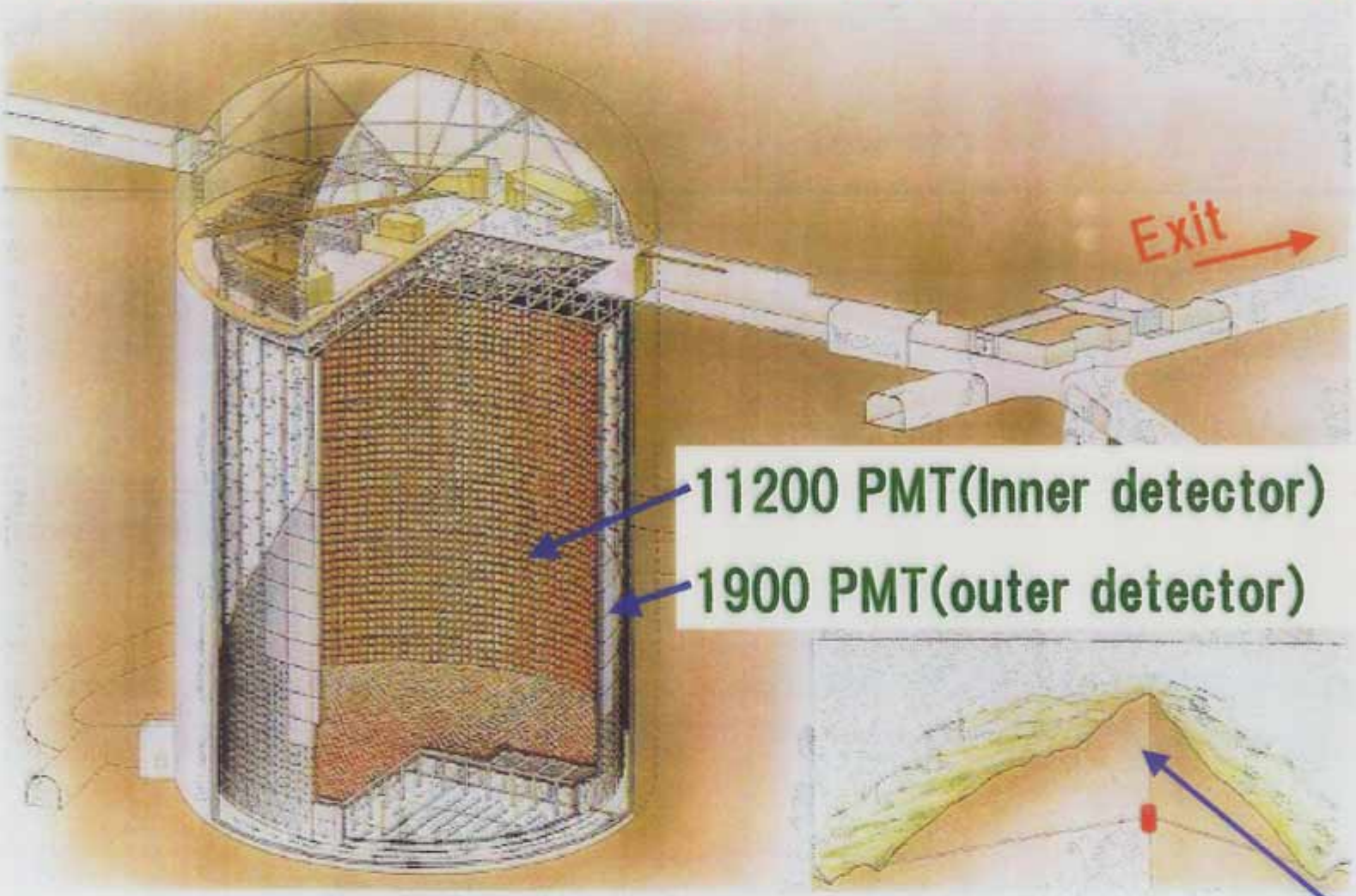
~1Mt "Hyper Kamiokande"

0.8 MW
50 GeV PS

Future

4MW 50GeV PS

Far detector (Super-Kamiokande)



50 kton water Cherenkov detector
(22.5 kton fiducial volume)

The recovery plan

(See; www-sk.icrr.u-tokyo.ac.jp for the full message from Yoji Totsuka, director of the Kamioka Observatory)

- Investigate the cause for this accident and find the best way not to repeat this.
- Restart Super-K with about 1/2 of the PMT's by the end of 2002.
- Full recovery by the time of the commissioning of the JHF machine.

We really need support and encouragement from all of you.

Near detector: Motivation

Physics goal in JHF-1 neutrino exp.

→ Precise determination of neutrino oscillation parameters.

Accuracy: $\sin^2 2\theta_{23}$ ····· 1%

Δm^2 ····· a few %

$\sin^2 2\theta_{13}$ ····· > 0.01

↓

Good neutrino beam monitor

↑

Physics goal in JHF-2 neutrino exp.

→ CP violation measurement.

Criteria for a "Good neutrino beam monitor"

- Event rate of the far detector (neglecting the volume):

  $\text{Event-rate(near)} \times \{ (L_{near}/L_{far})^2 + \varepsilon \}$

ε should be as small as possible

Near detector should be as similar as possible to the Far detector (Super-Kamiokande)

⇓

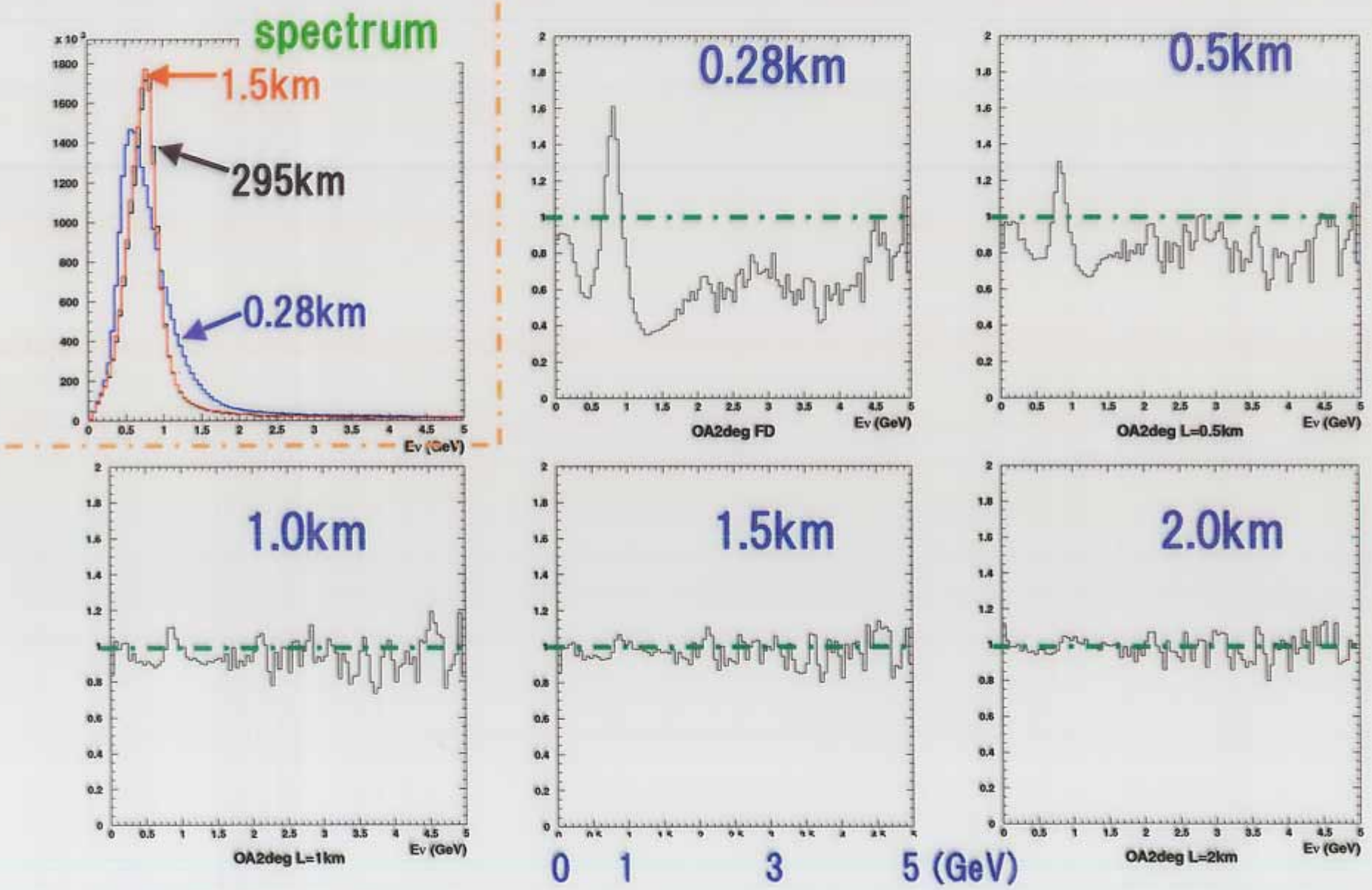
Water Cherenkov detector

Near detector position should not be too near to the neutrino production region.

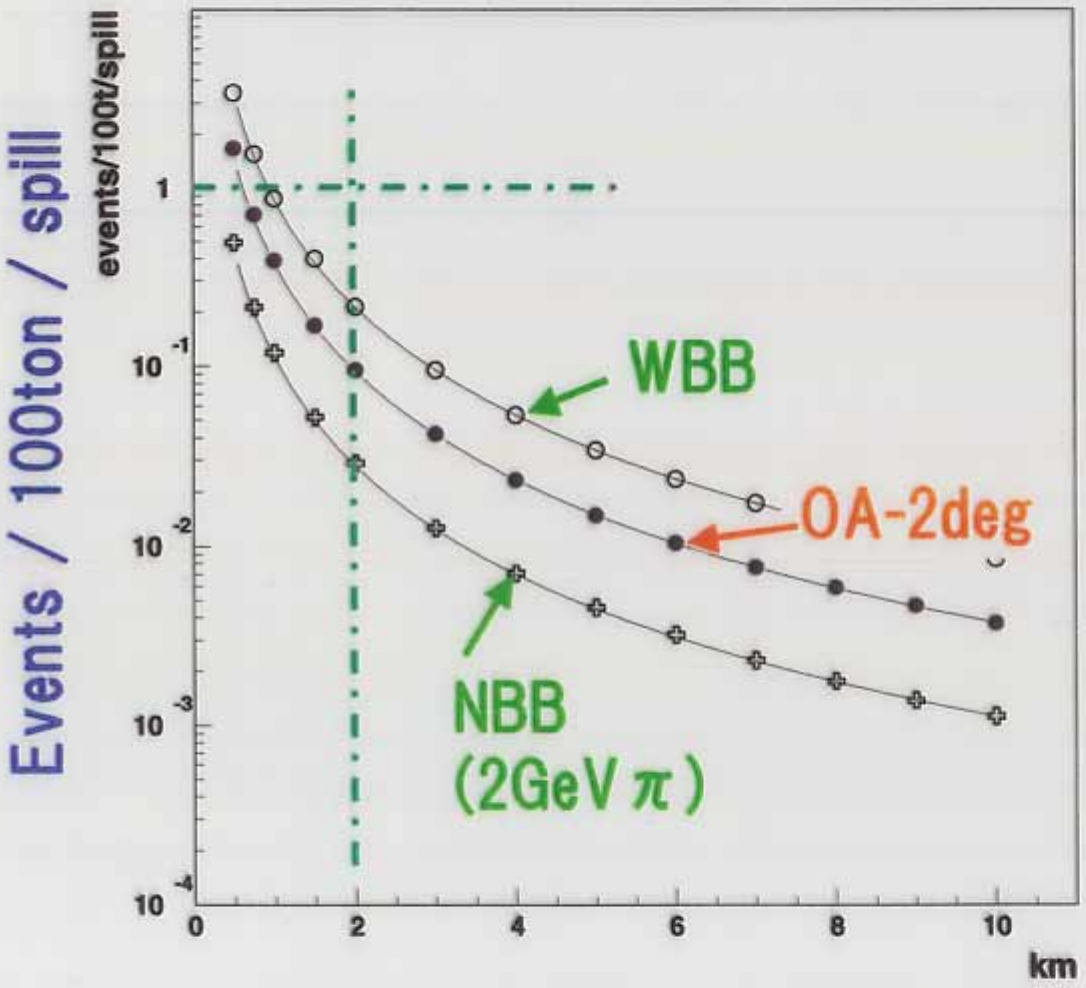
⇓

$L_{near} > 1\text{km}$

Far/near ratio (OA 2deg)

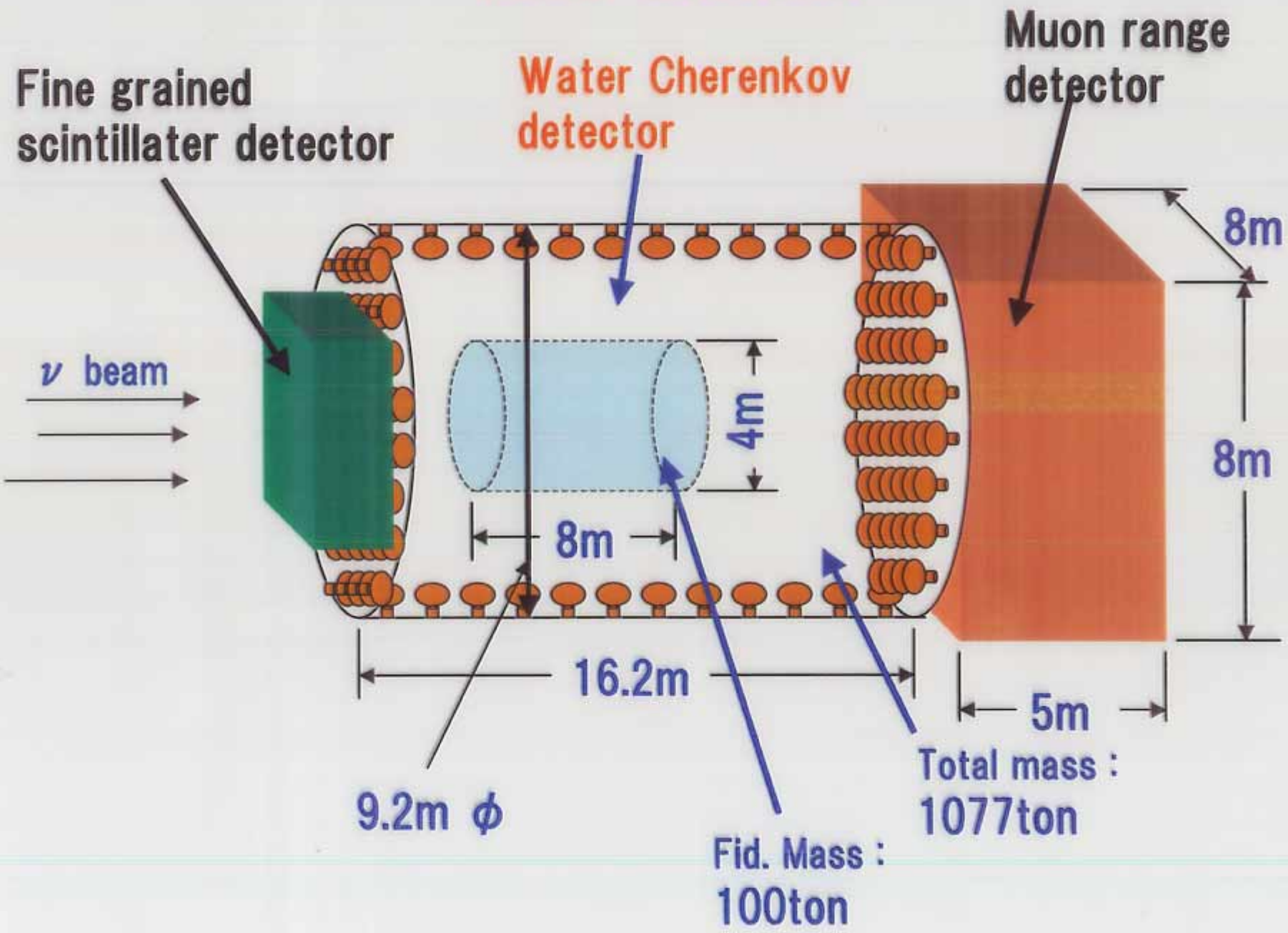


Event rate

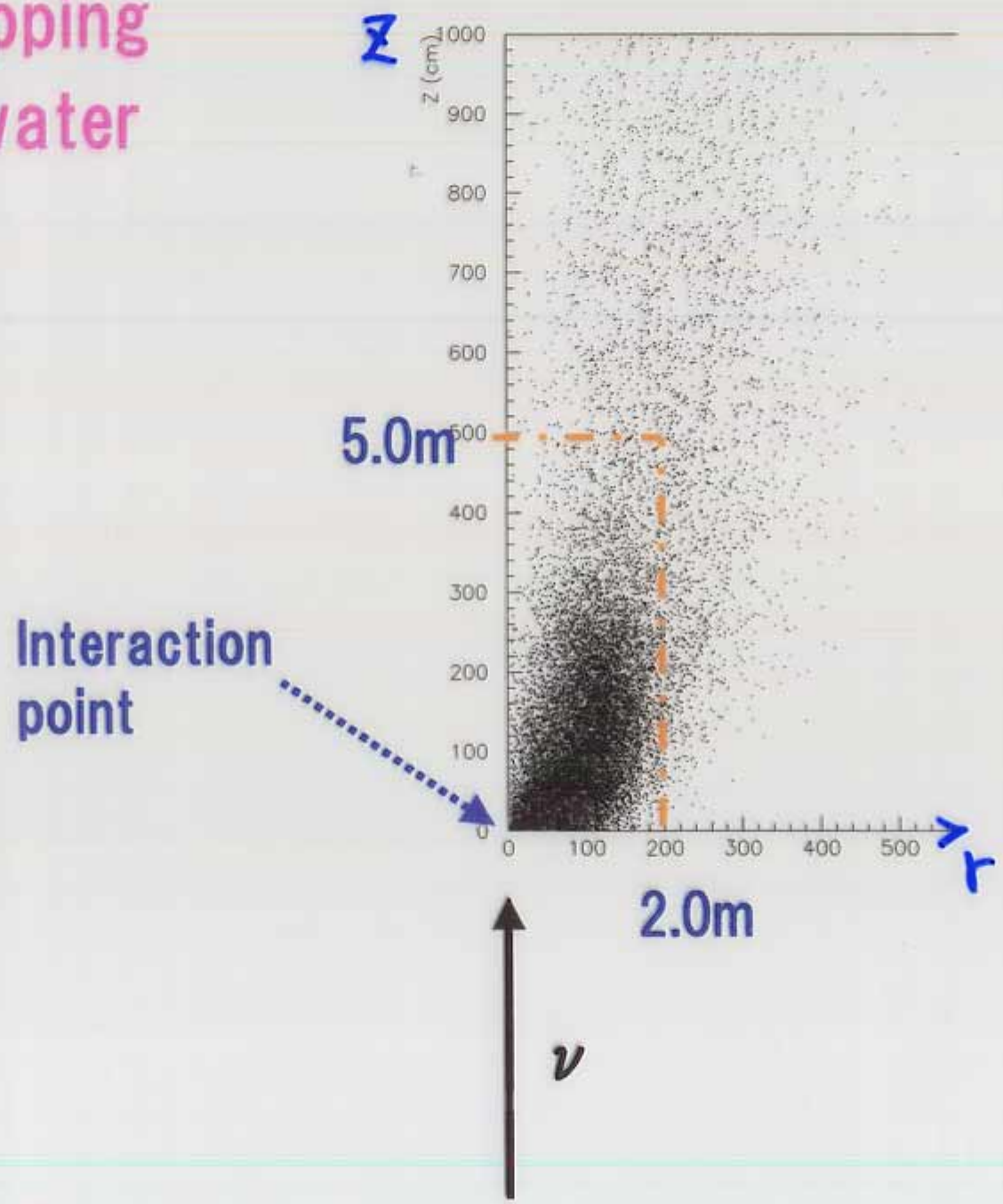


● 100 ton fiducial volume is enough for a near detector at 2 km.

Near detector



Muon stopping point in water



Near detector @2km

(Fine grained detector)

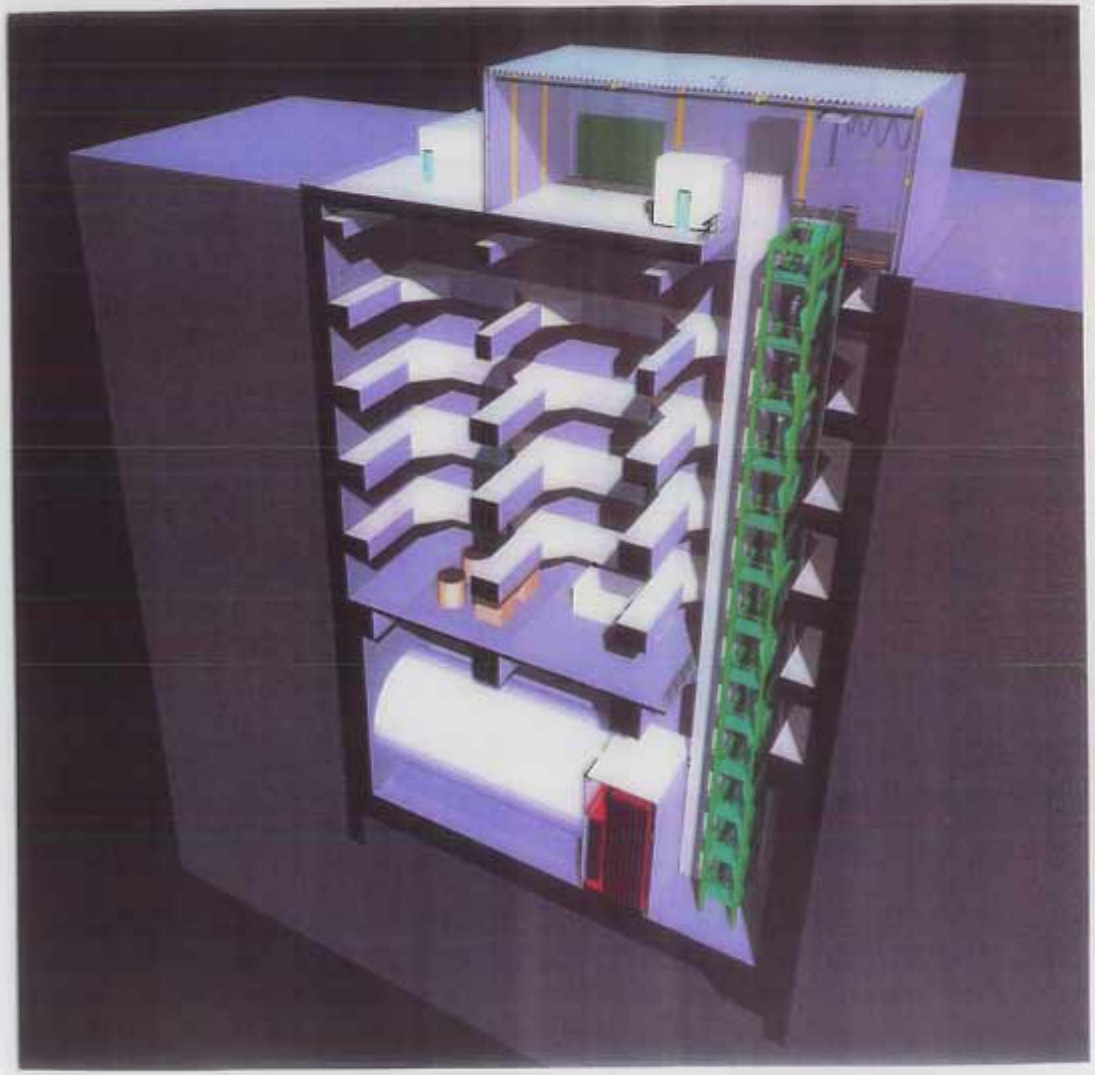
+

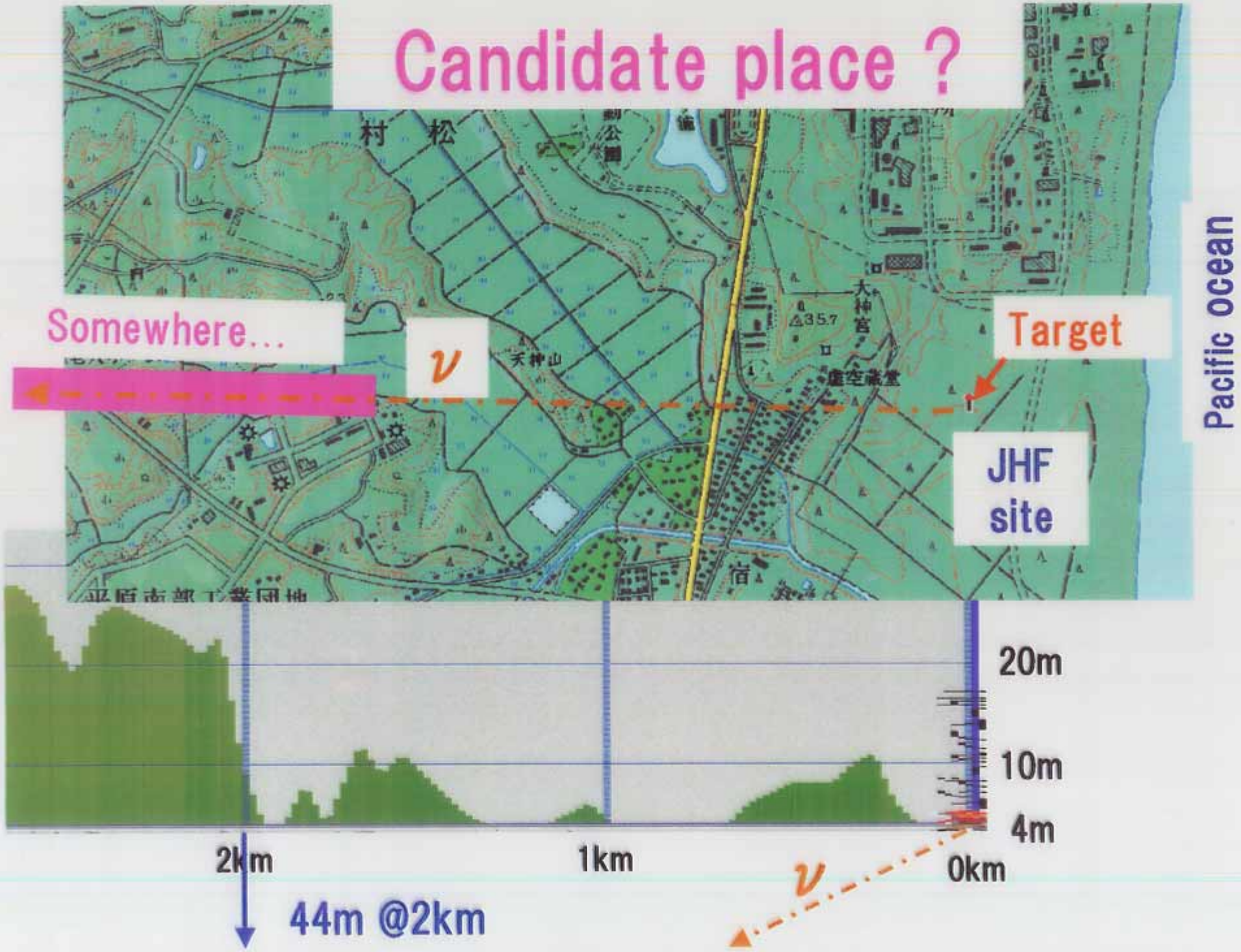
1 kton water Ch.
(Fid. Vol. = 100 ton)

+

~2 kton muon range detector (Study high energy tail)

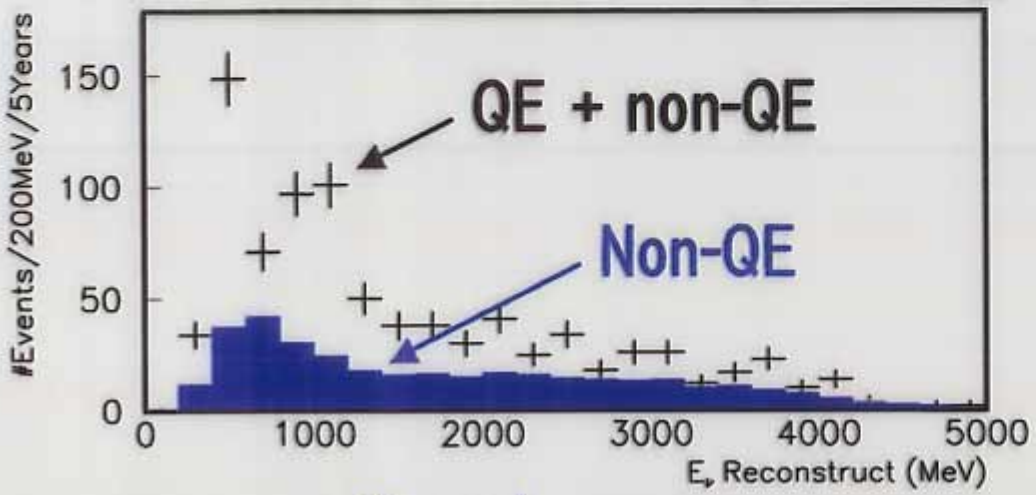
Goal: Far/near uncertainty < a few %

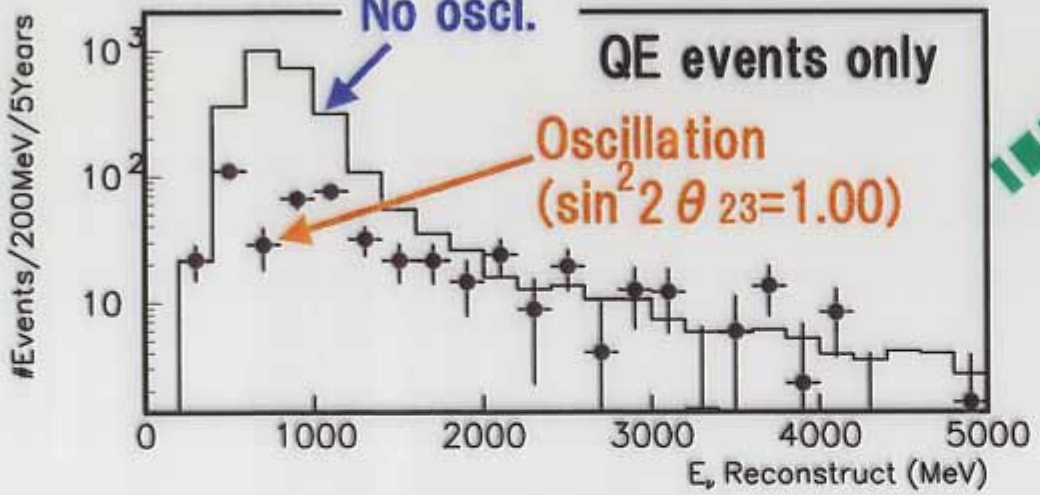


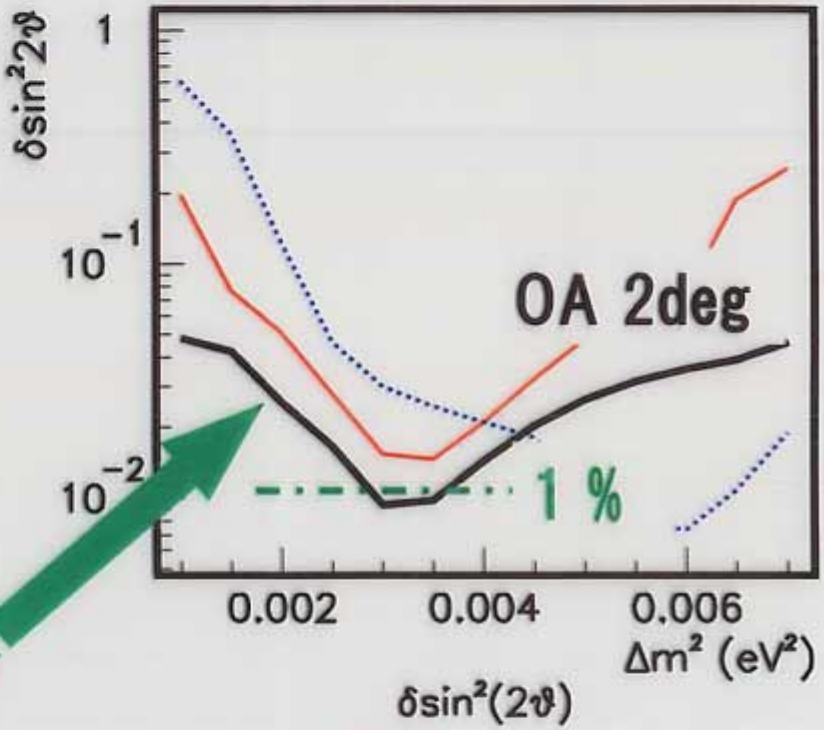

Candidate place ?
Somewhere...
ν
Target
JHF
site
Pacific ocean
20m
10m
4m
2km
1km
0km
44m @2km
ν

Measurement of $\sin^2 2\theta_{23}$

For $\sin^2 2\theta_{23}=1.00$ (OA 2deg)



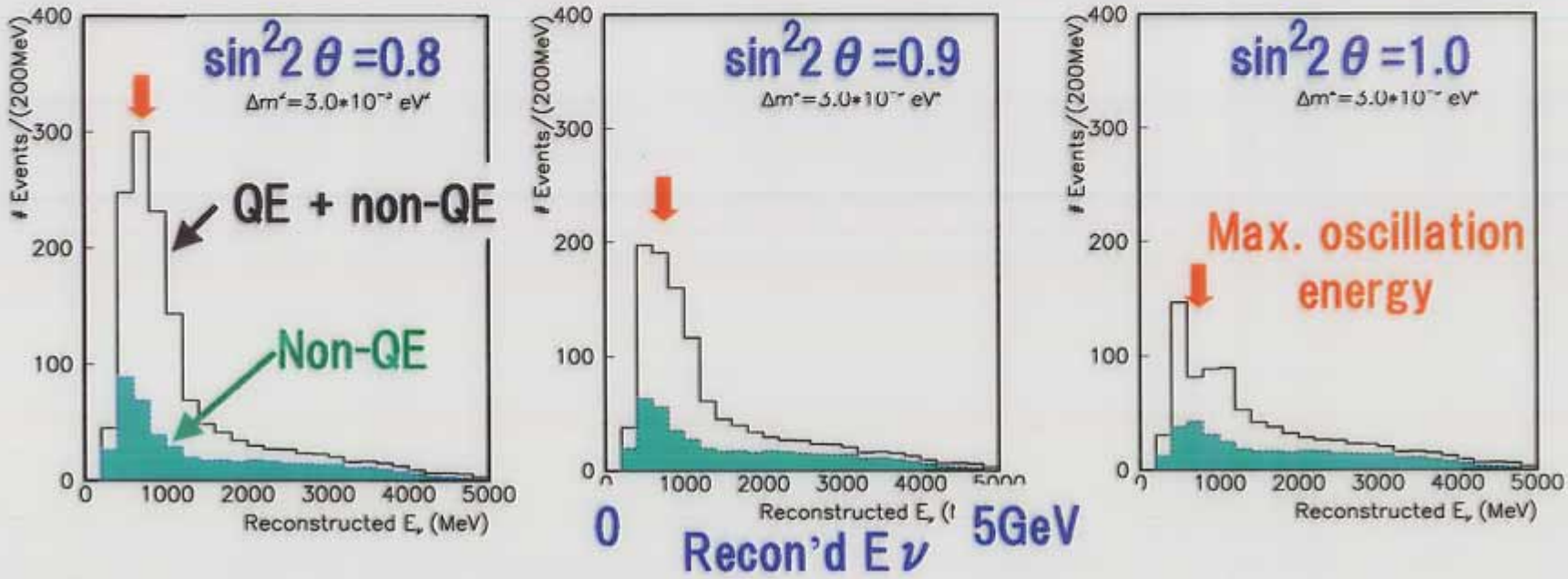


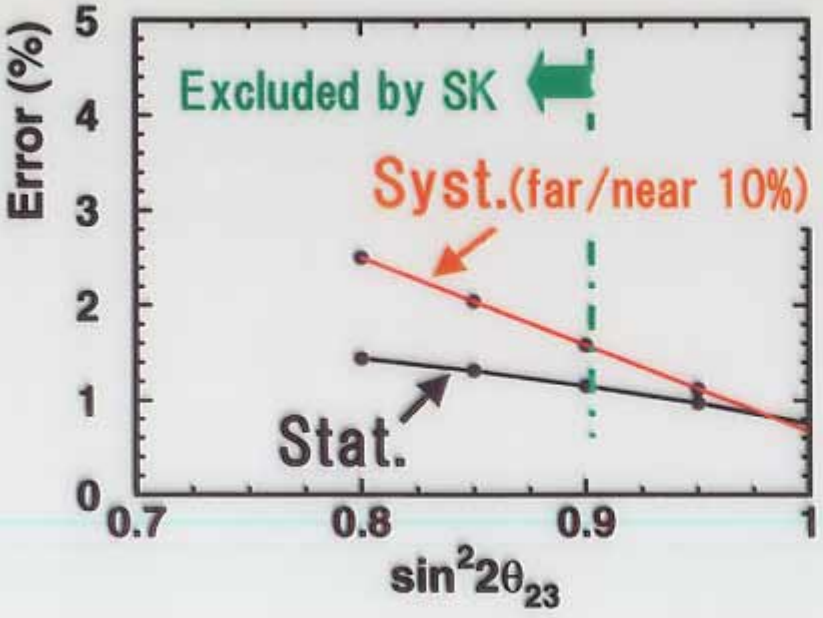


※ Absolute normalization is not very important because osc./no-osc. = 0.03.

If $\sin^2 2\theta_{23} < 1.0$?

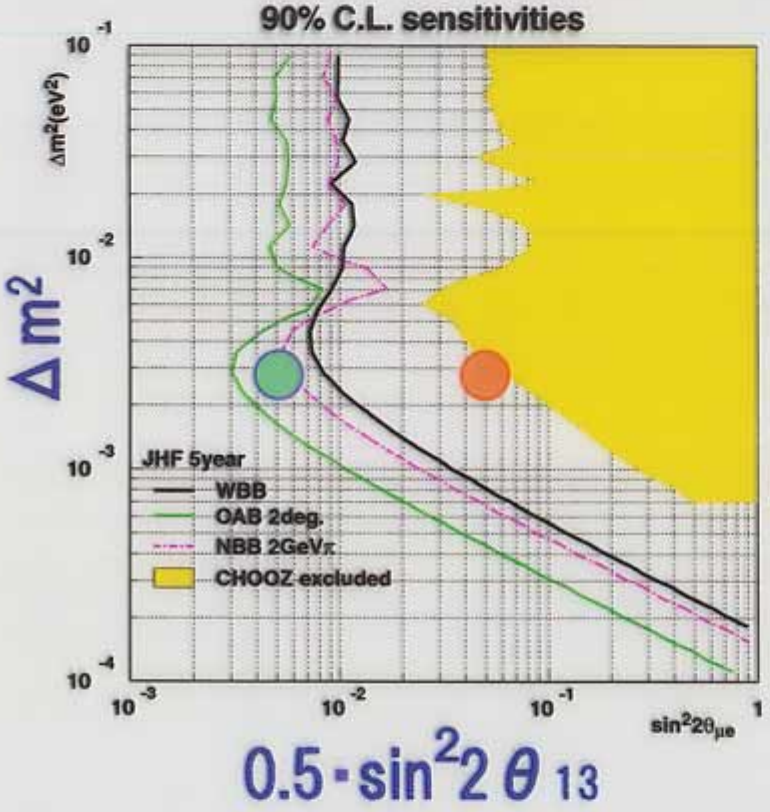
Measurement error of $\sin^2 2\theta_{23}$



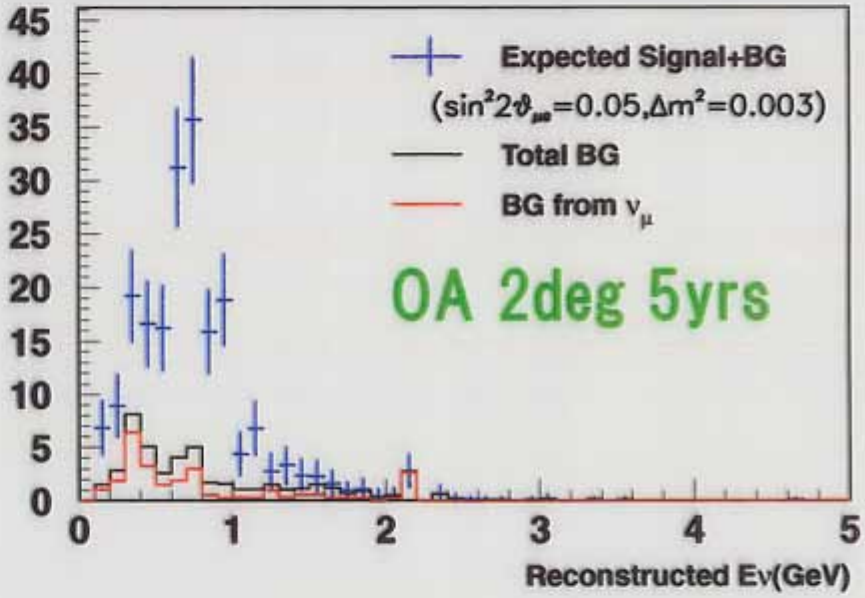


In order not to limit the measurement by syst., far/near syst. must be smaller than ~5%.

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



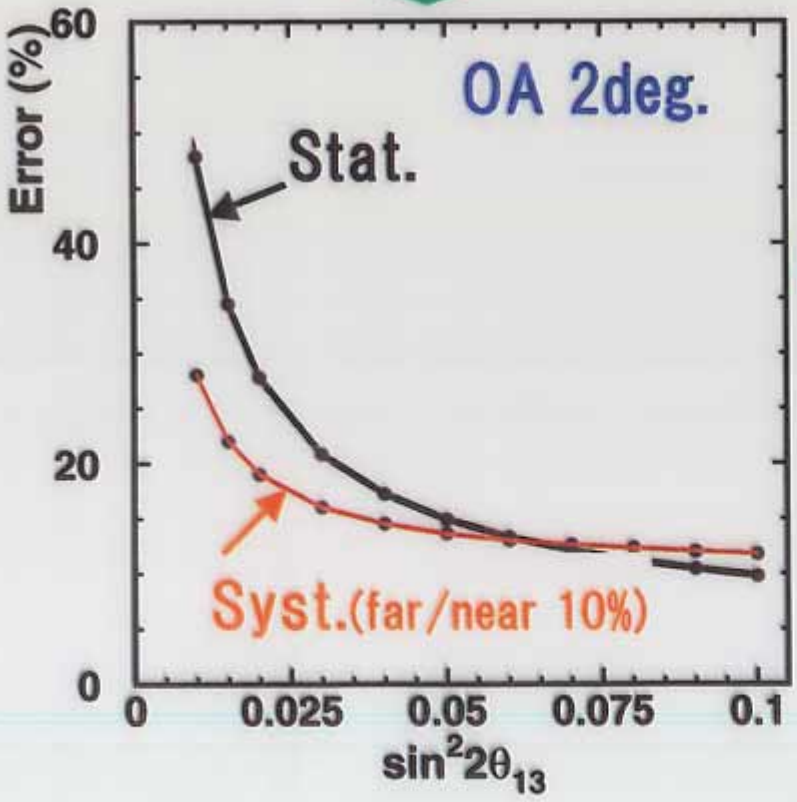
Expected signal for ●



$\sin^2 2\theta_{13}$	ν_μ (CC+NC)	Beam ν_e	Osc'd ν_e	Signal+BG
0.1	11.1	11.1	123.2	145.5
0.01	11.1	11.1	12.3	34.5

Measurement error of $\sin^2 2\theta_{13}$?

$\sin^2 2\theta_{13}$	ν_μ (CC+NC)	Beam ν_e	Osc'd ν_e	Signal+BG
0.1	11.1	11.1	123.2	145.5
0.01	11.1	11.1	12.3	34.5



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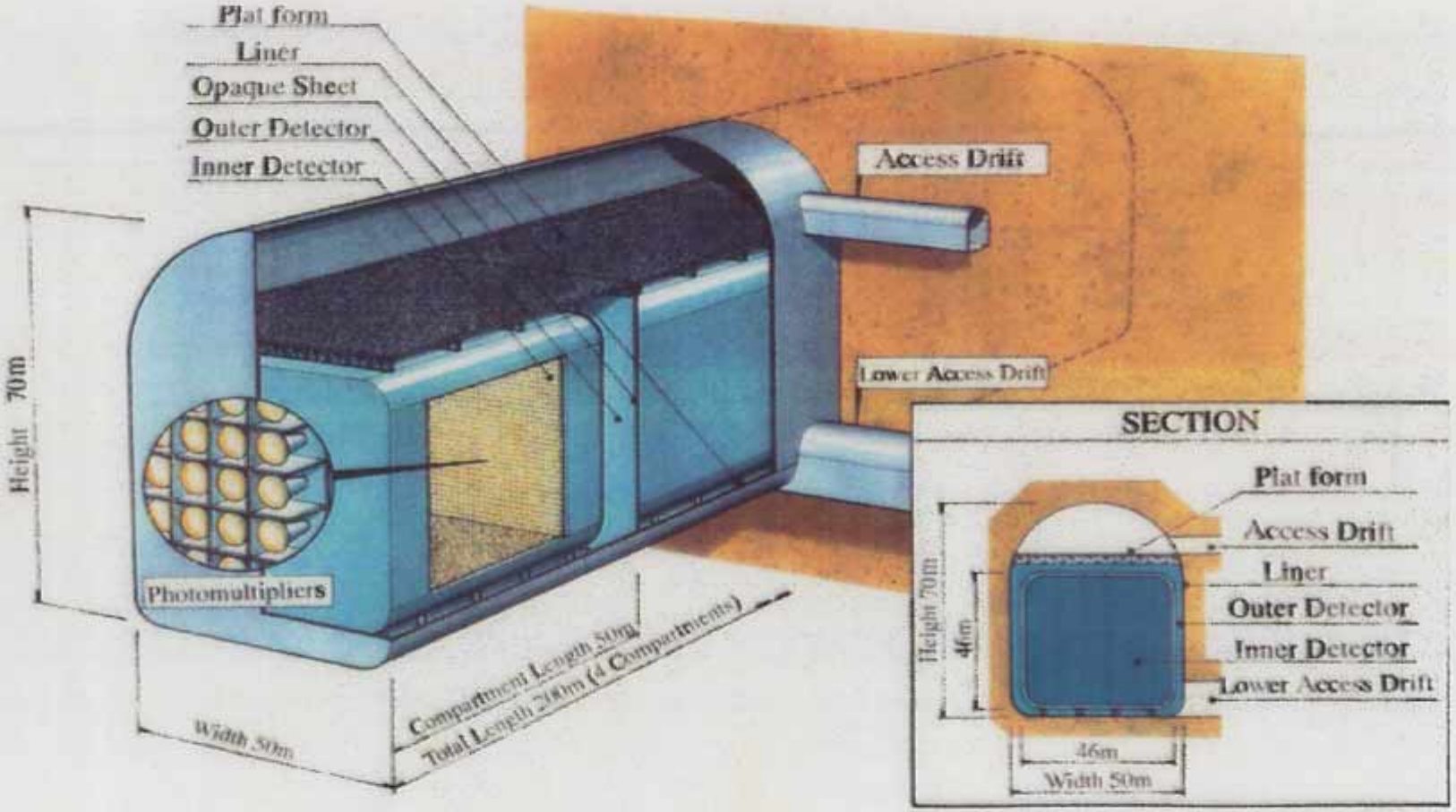
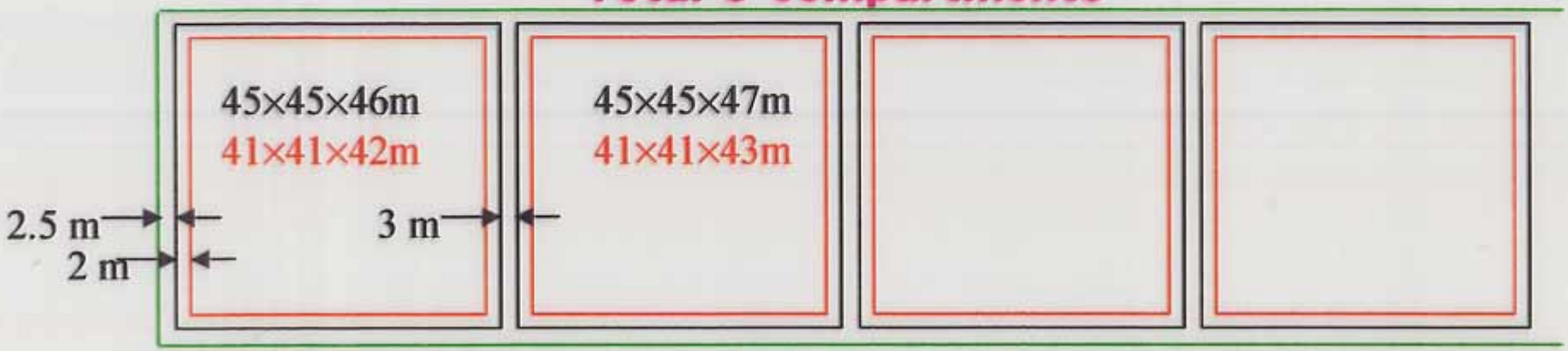
Far detector in the 2nd phase (Hyper-Kamiokande)



(STRAIGHT TYPE)

Possible design of Hyper-Kamiokande

Total 8 compartments

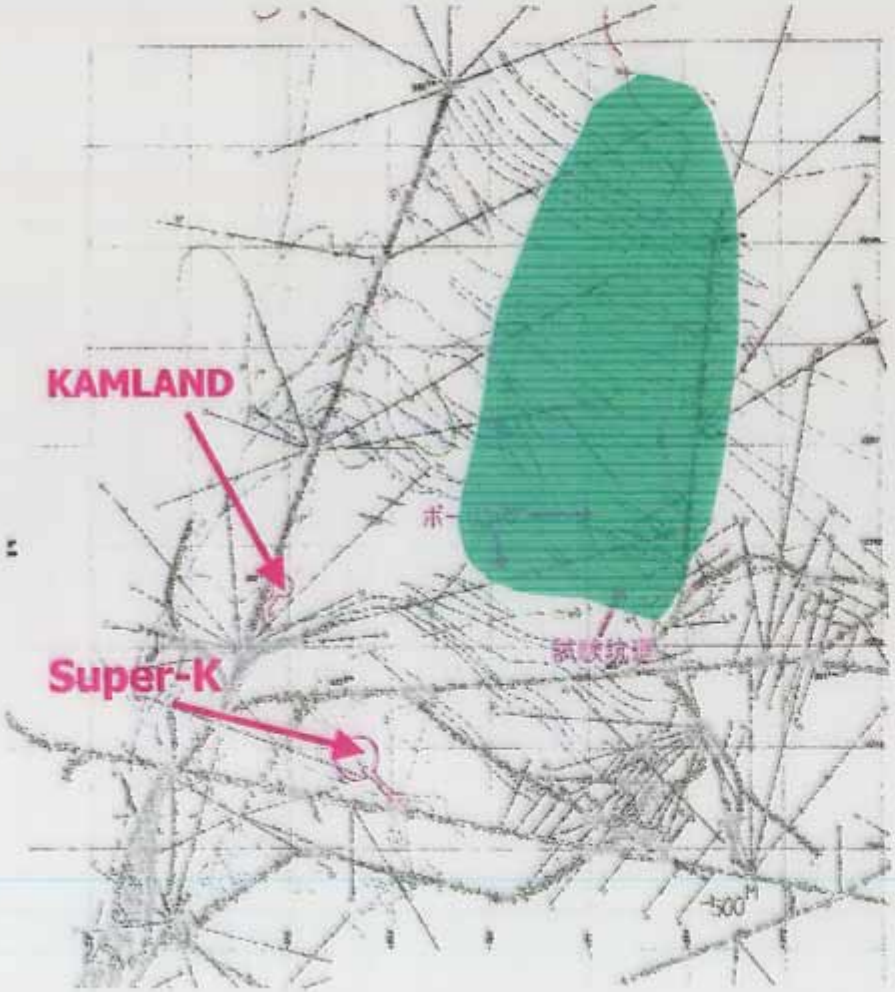


- Size: 50m × 50m × 400m
- Total mass: 1 Mton
- Fiducial mass: 0.6 Mton
- Number of PMTs: 100,000 if 1 PMT/ m^2

★ R & D for new PMTs is in progress

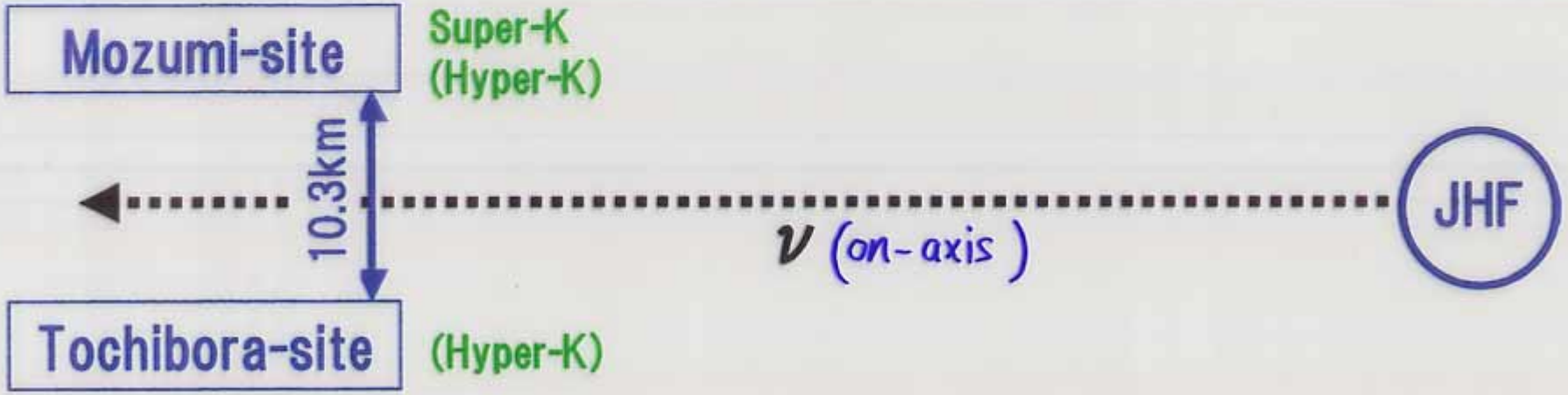
Candidate sites

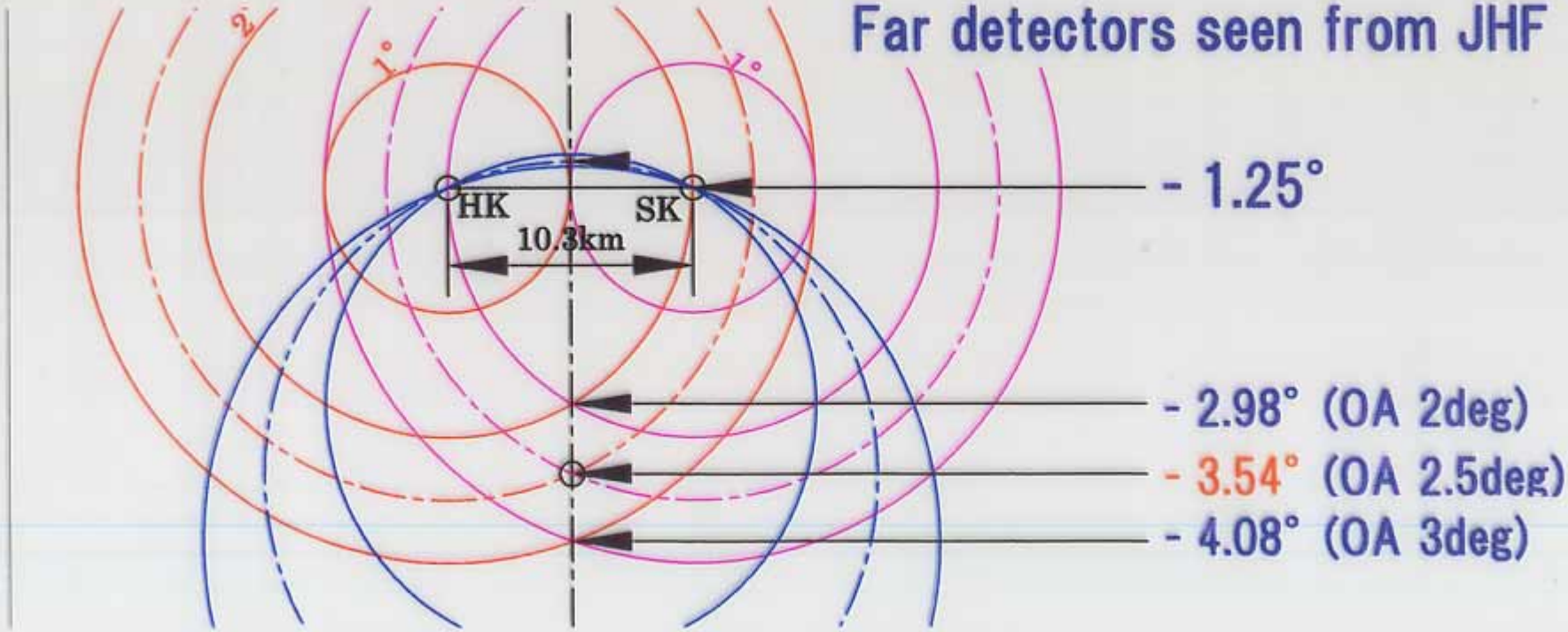
Mozumi site



Tochibora site

Candidate cites and the beam line





Summary

- Super-Kamiokande is the far detector for JHF-I.
- A good near detector is the key element of the JHF-SK neutrino experiment.
- The detector should be composed of a fine grained detector, a water Cherenkov detector and a muon range detector.
- The distance of the detector from the target must be about 2 km.
- Basic design and R&D for Hyper-Kamiokande (far detector for JHF-II) is in progress.