Status of T2K*

including likely U.S. involvement

Ed Kearns - Boston University
APS Neutrino Study -
Super Beams Meeting, Fermilab, Jan 30, 2004

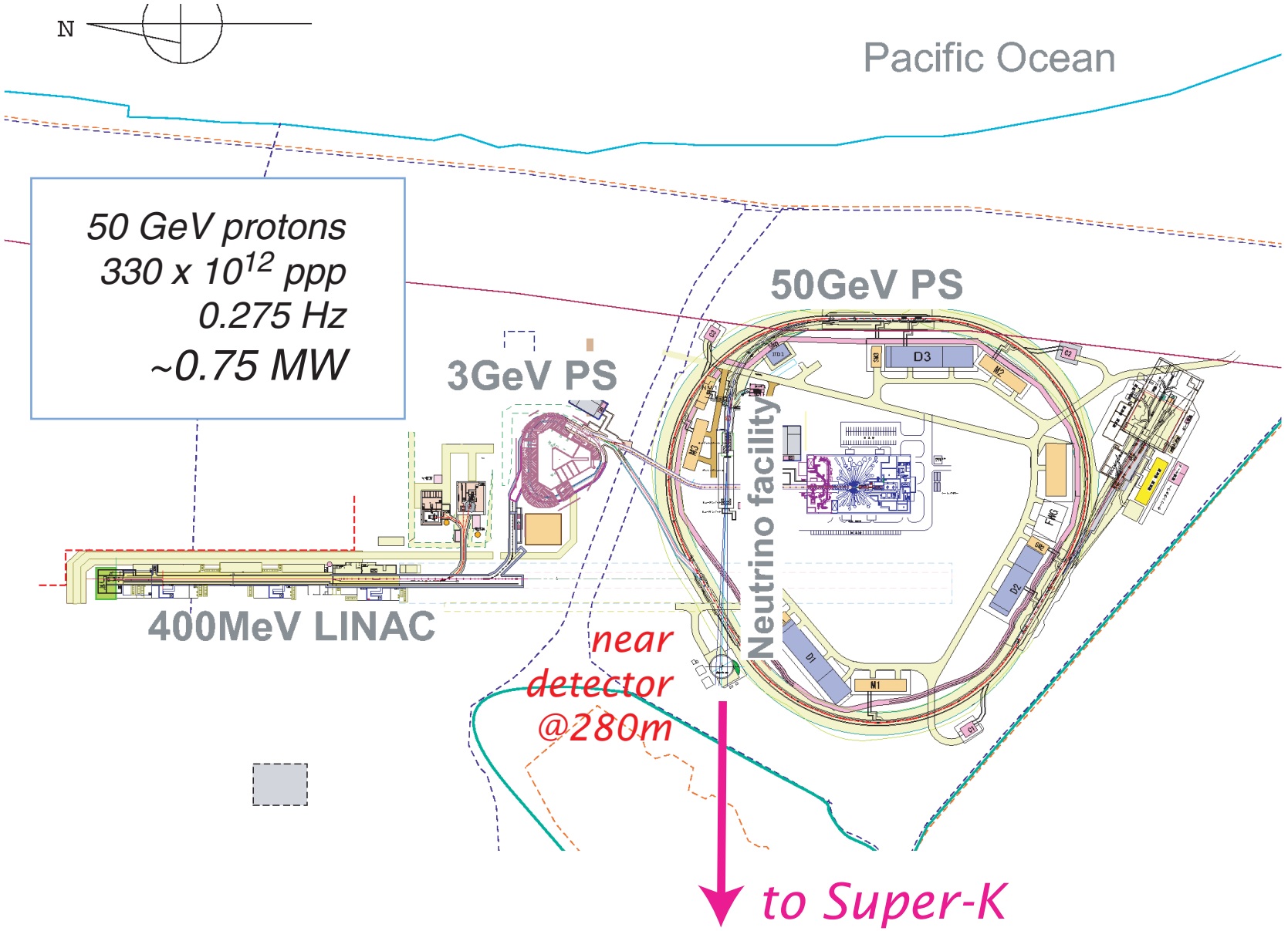
* Tokai-To-Kamioka**

** sometimes listed as J2K
** or J-PARCnu ***
** or JHFnu ****

***Japan Proton Accelerator Research Complex
**** Japan Hadron Facility (obsolete)

T2K Long Baseline Neutrino Beam

Japan Proton Accelerator Research Complex



J-PARC Construction - January 2004

J-PARC construction should be completed in 2008.
Last funding cycle for neutrino program is JFY 2008
Construction must be completed by March 31, 2009.
Low intensity neutrinos possible in 2008.

Scientific Goals

Phase I: 0.75 MW and Super-Kamiokande

Discover if $\theta_{13} > 0$ *by observing* ν_e *appearance*

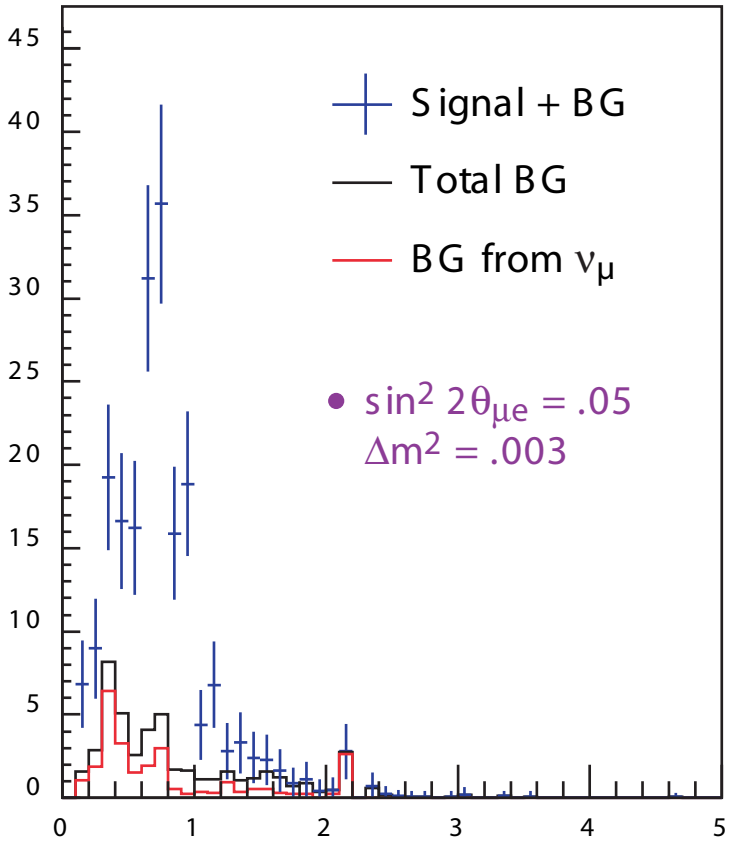
Attempt to resolve if θ_{23} *is non maximal*

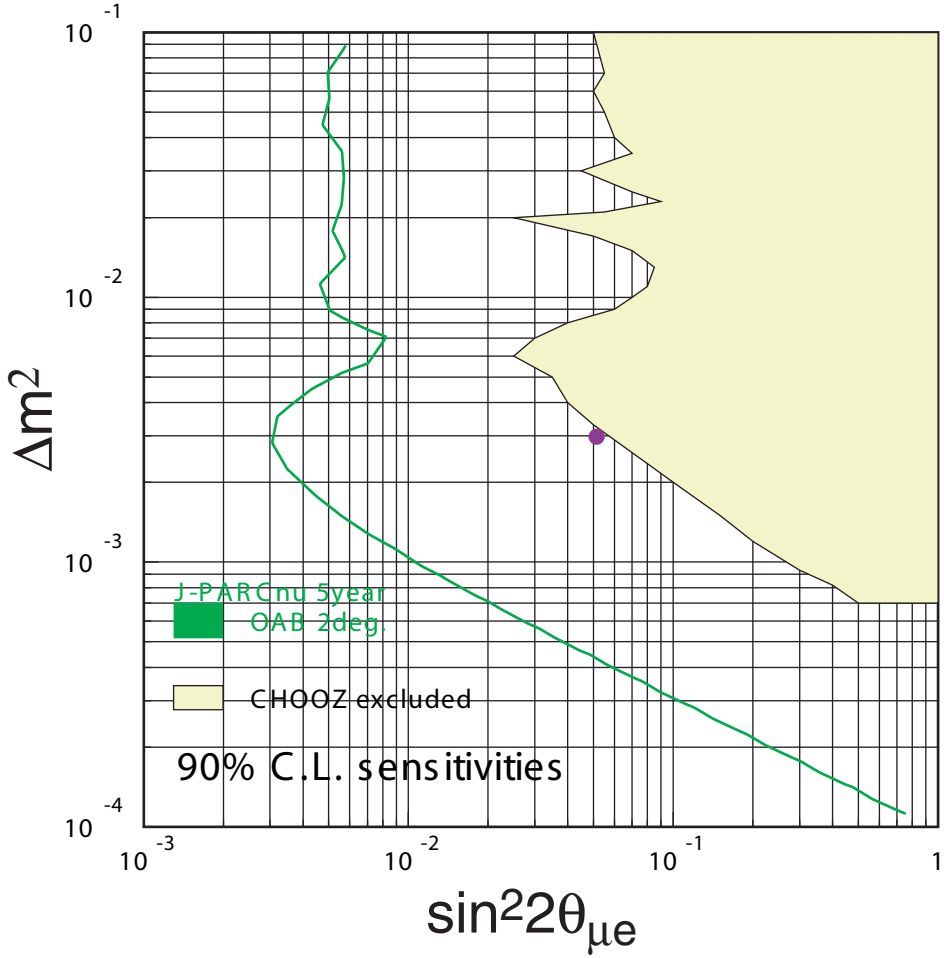
Precisely determine Δm^2

Phase II: 4 MW and Hyper-Kamiokande

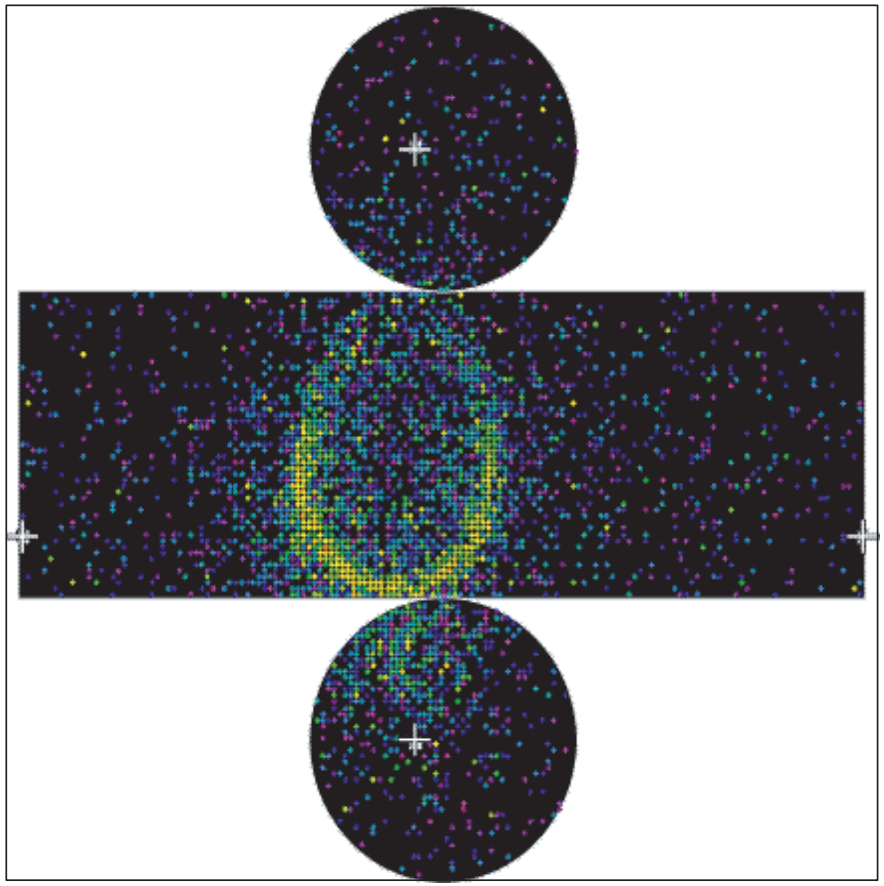
Discover non-zero CP phase

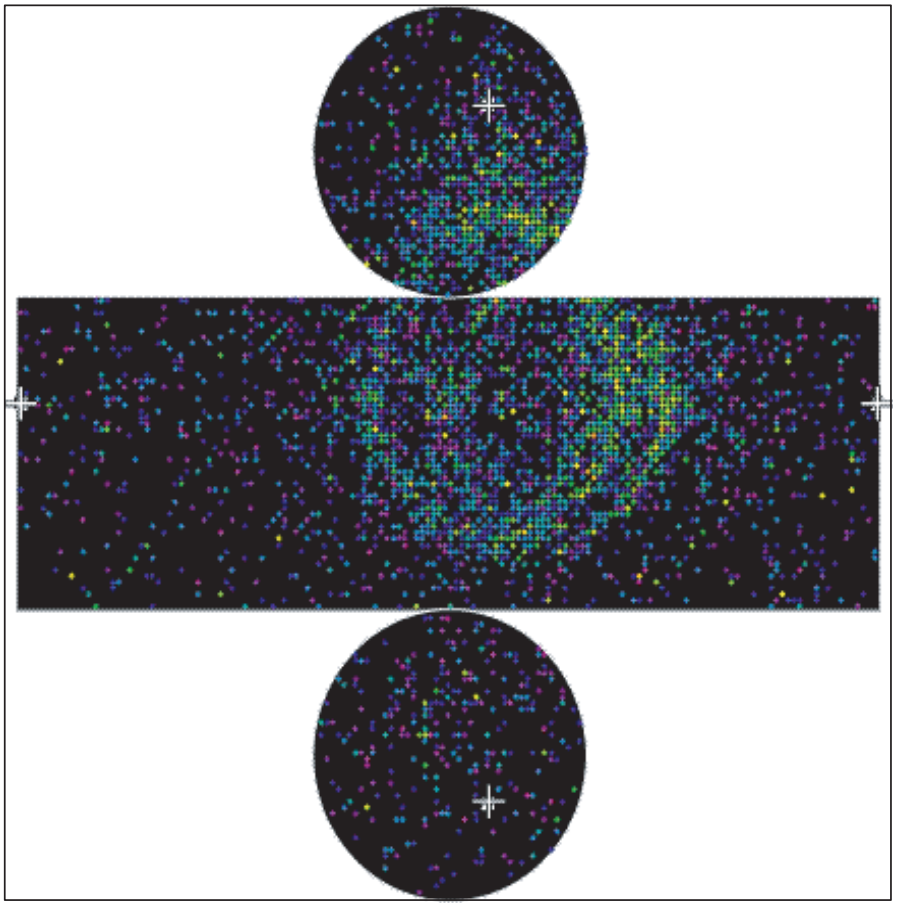
Electron Neutrino Appearance





Background is Single Pizero Events

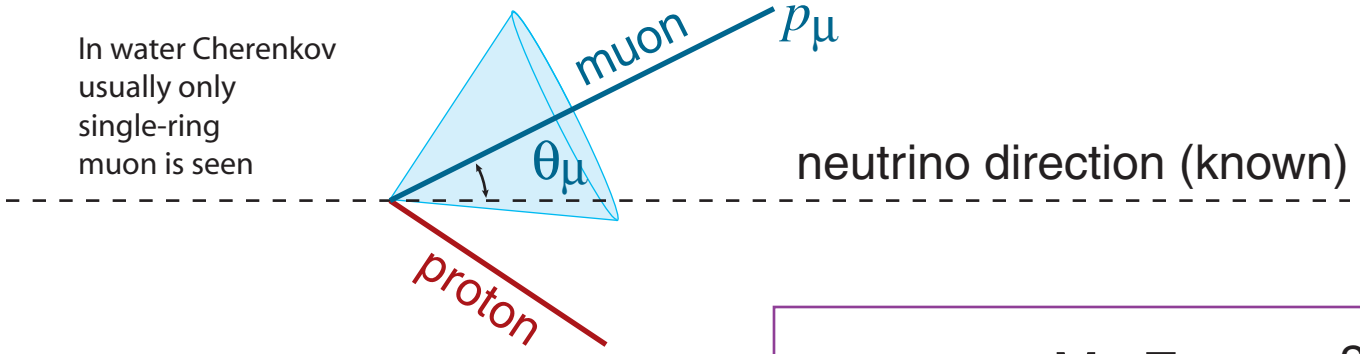




signal: ~40% efficiency

~11 events BG / 5 years (0.4-1.2 GeV)
+10 events ν_e contamination

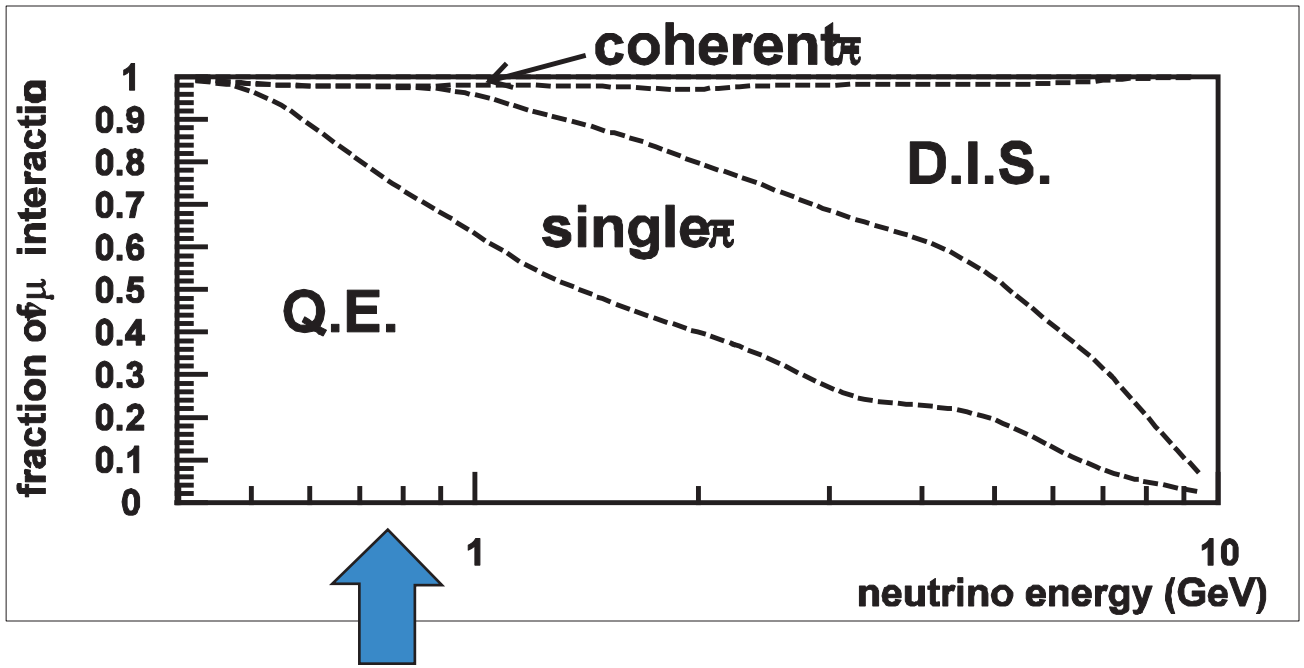
Muon Neutrino Disappearance



charged current quasielastic

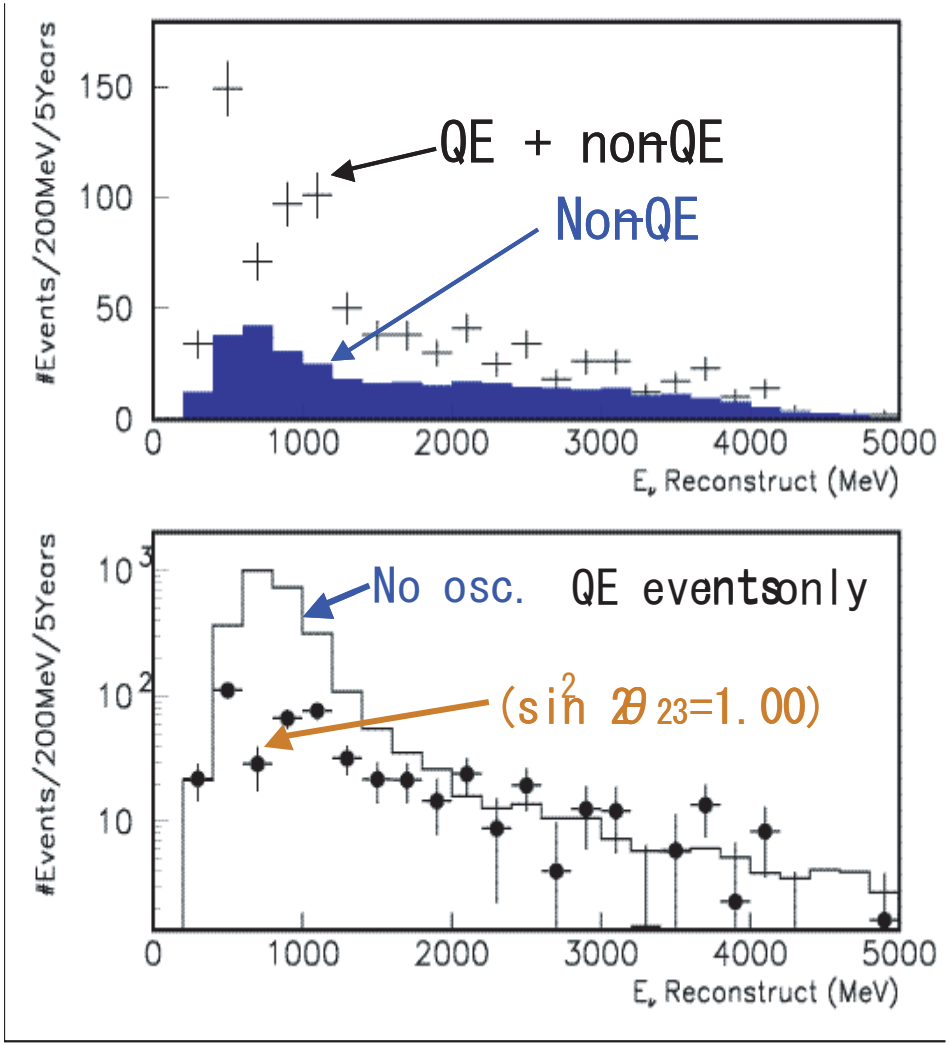
$\nu_\mu\ n \rightarrow \mu^-\ p$

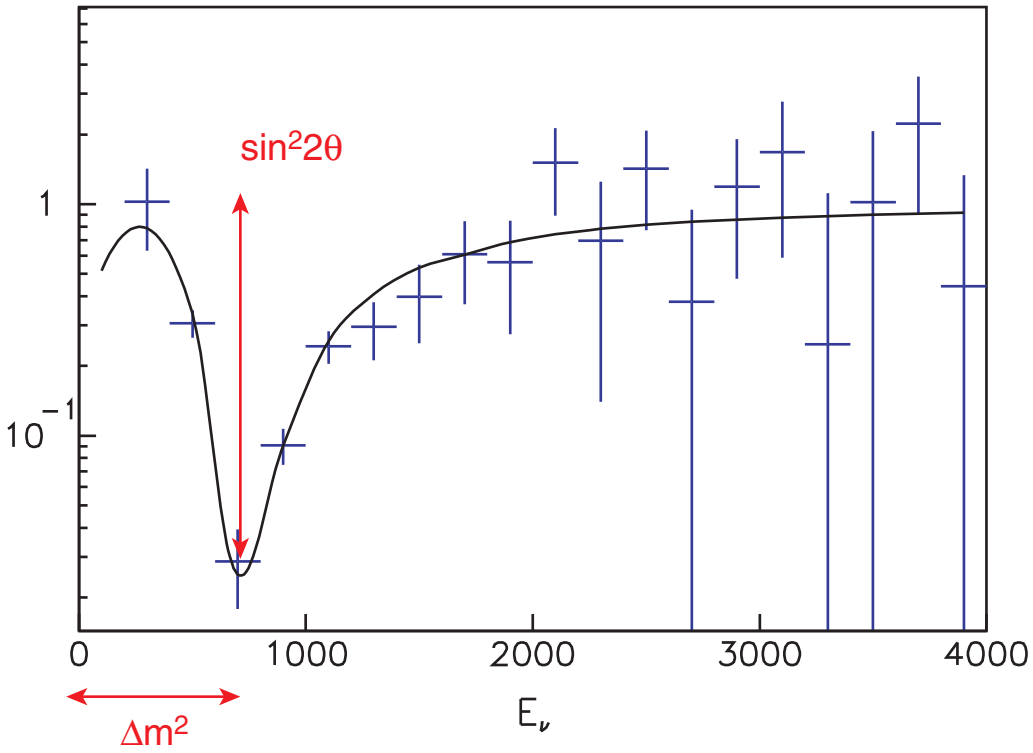
$$E_\nu = \frac{M_n E_\mu - m_\mu^2/2}{M_n - E_\mu + p_\mu \cos\theta_\mu}$$



Precision Measurement of Disappearance Parameters

4500 νμ/yr





resolution:

sin^{2}2θ ~ 1%

Δm^2 ~ 10^{-4} eV^2

T2K Collaboration

spokesman = Ko Nishikawa, Kyoto U.

Canada - France - Italy - Japan - Korea - Poland - Russia - Spain - Switzerland - United Kingdom - U.S.A.

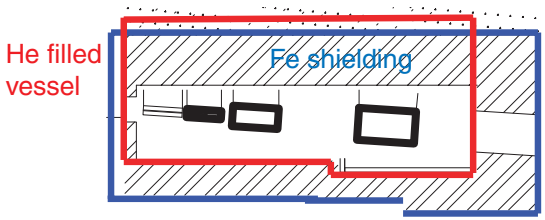
U.S. groups (at Jan-04 meeting):

Boston • Duke • L.S.U. • Rochester • SUNY-SB • U.C.Irvine • U.Washington

(others have expressed interest, attended some meetings)

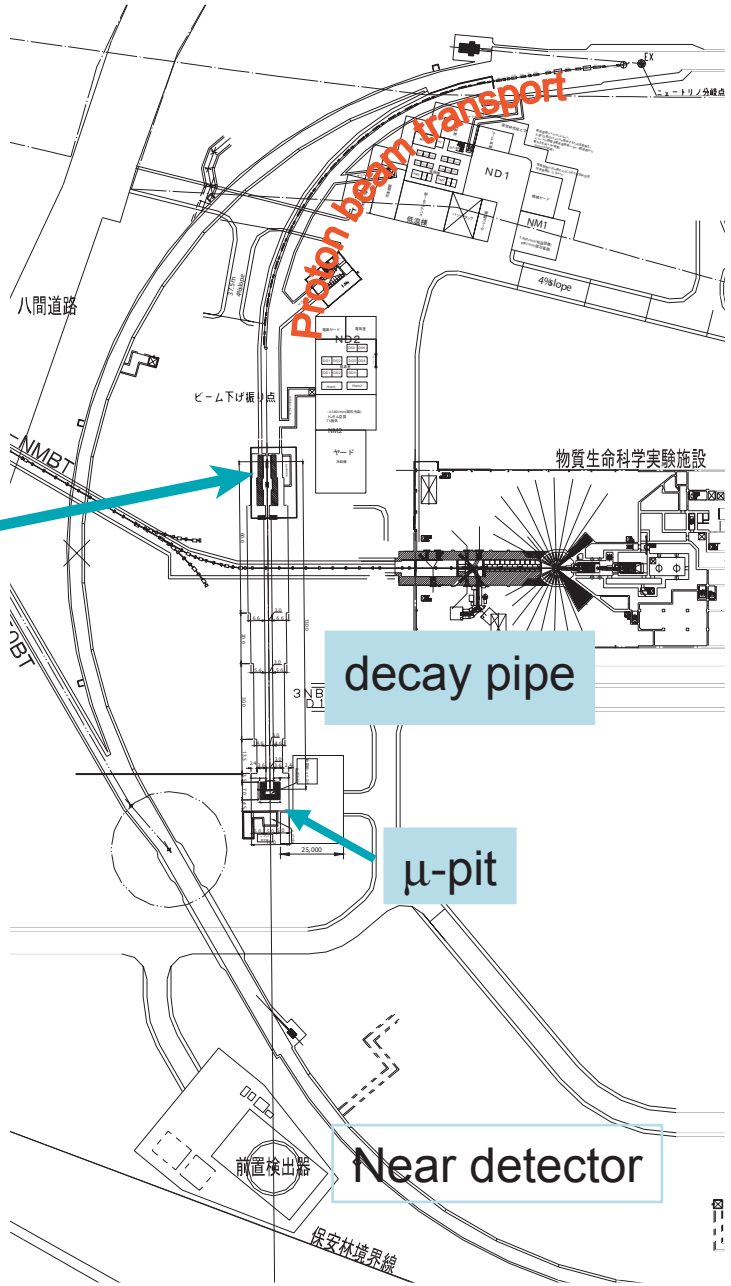
Neutrino Beamline

5us spill every 3.53 sec
8 bunches x 58 ns
20 Normal Magnets
28 Combined Function SC Magnets
(collab with BNL)
1 W/m loss

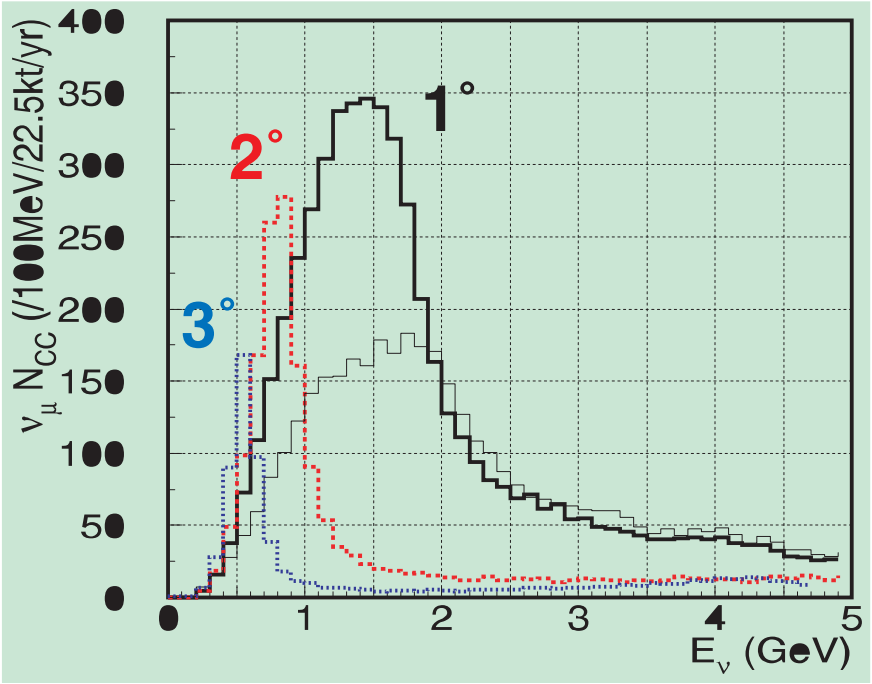


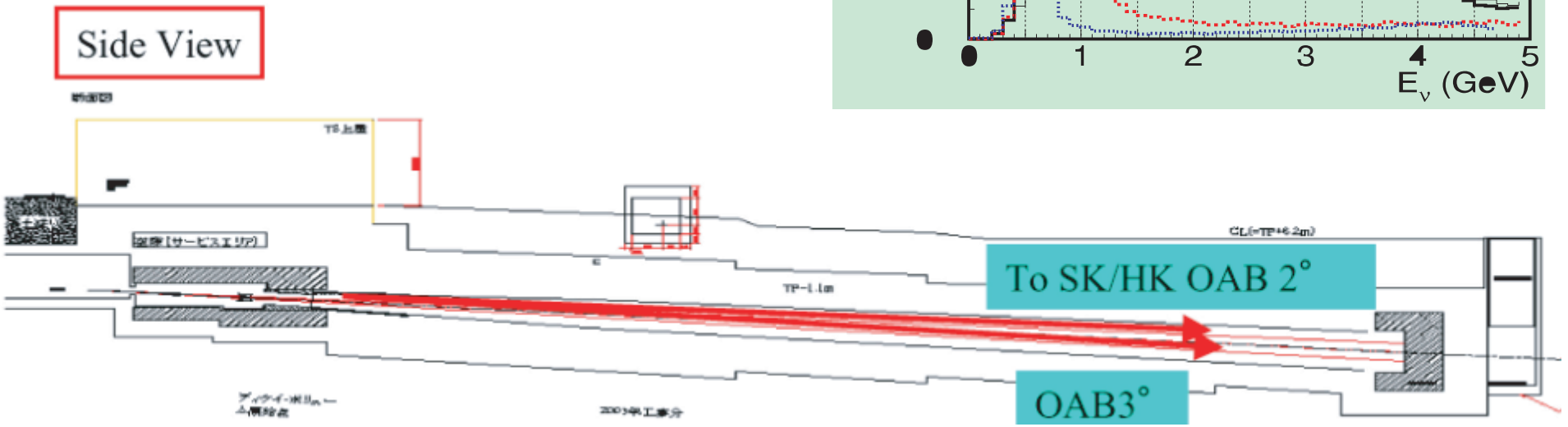
Water cooled graphite target
3 horns @ 320 kA

130m long decay pipe
He filled iron vessel, water cooled concrete

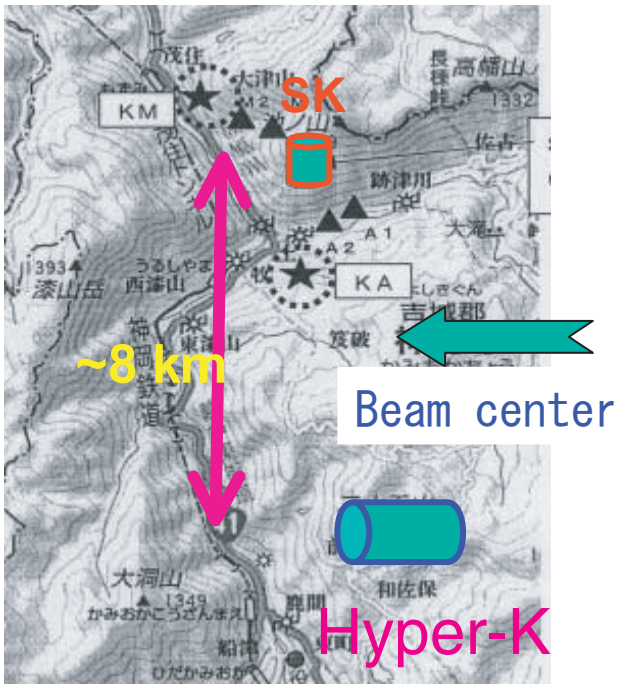


Off-Axis Angle May Be Adjusted

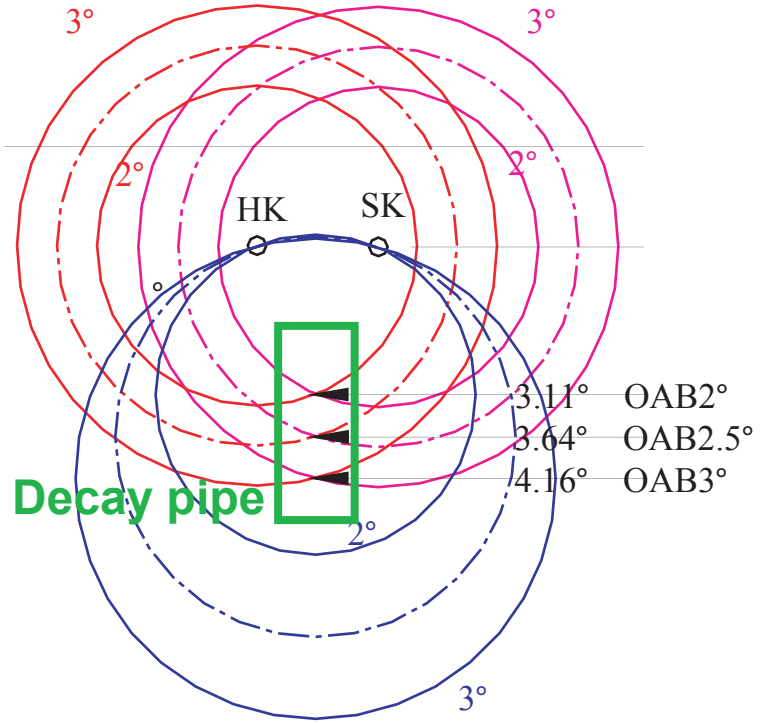




Hyper-Kamiokande Siting Accomodated

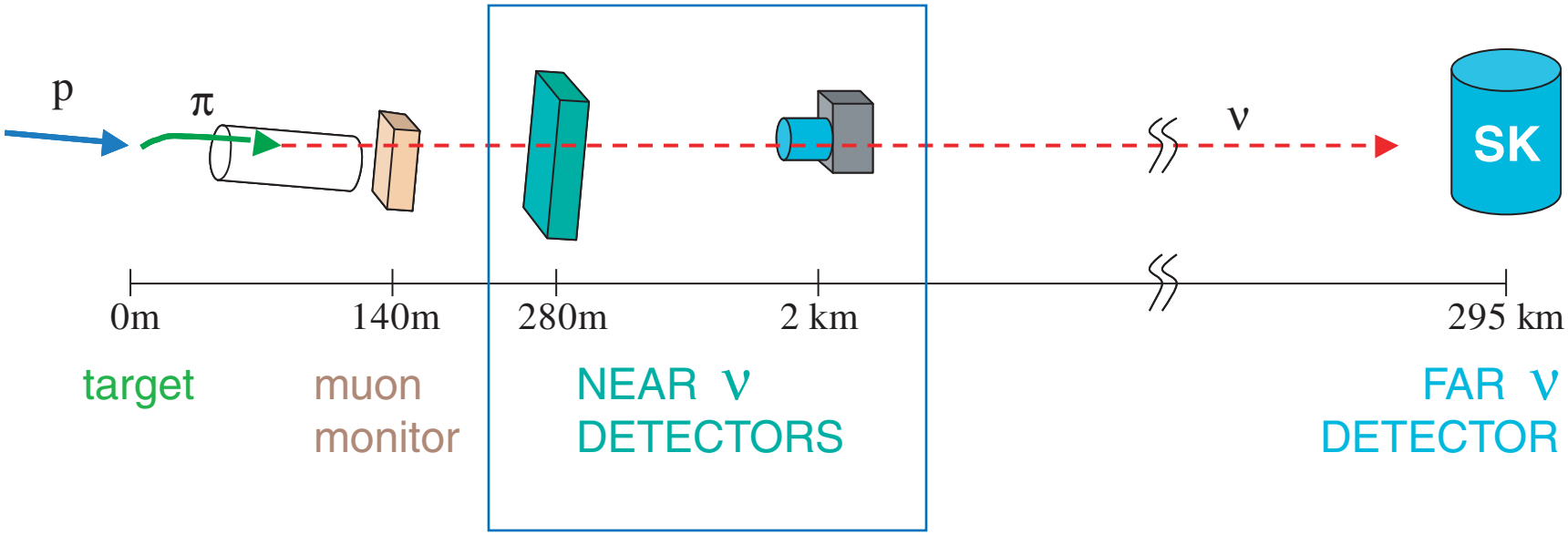


500-600m
overburden



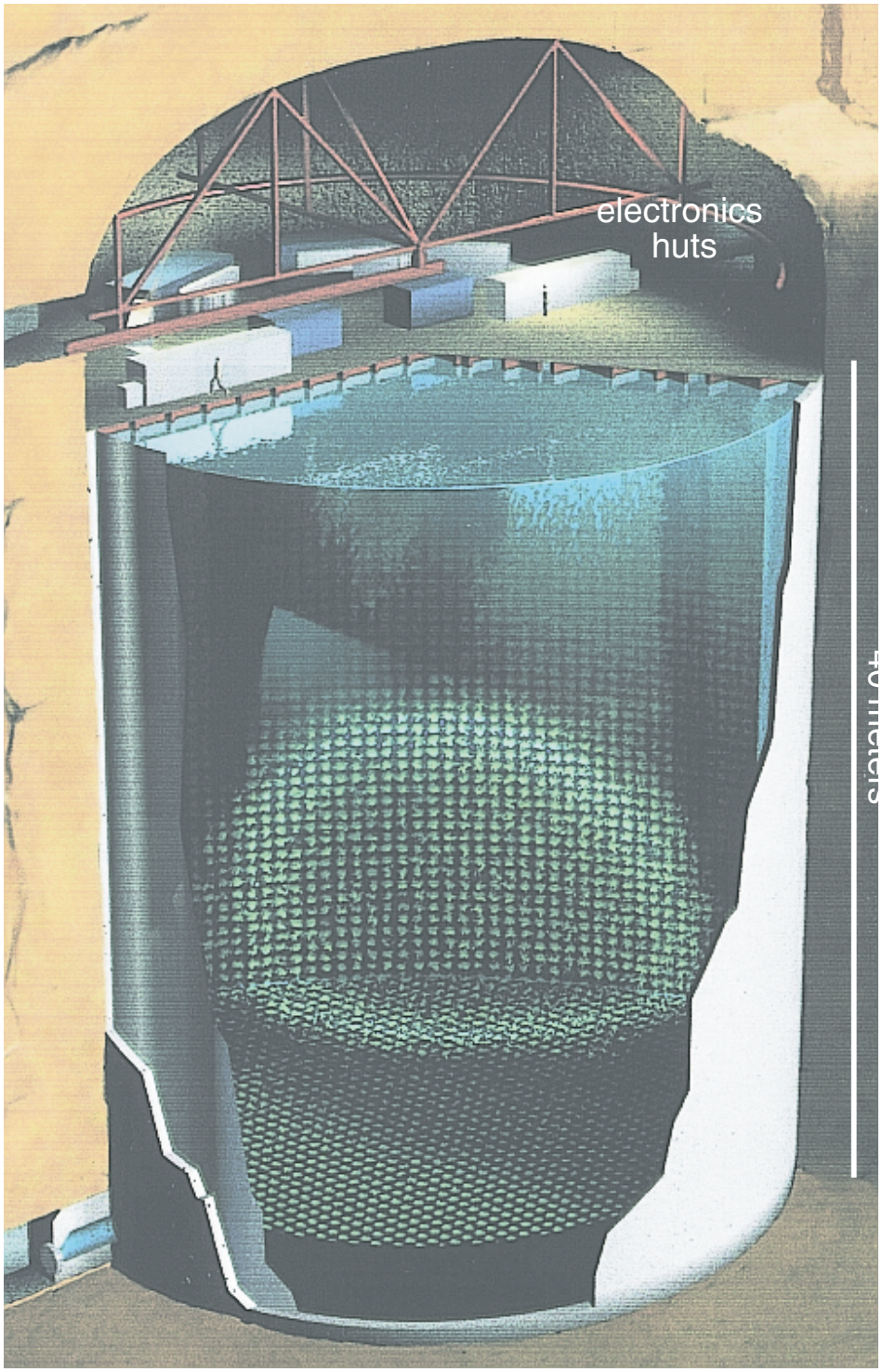
beams-eye view

Detector Systems



Characterize neutrino beam:

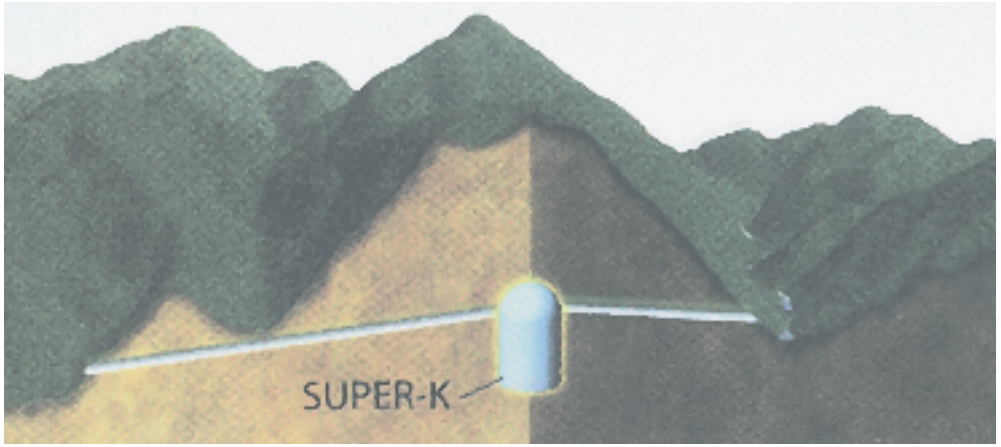
- monitor neutrino intensity and profile
- measure ν_e contamination
- measure E_ν spectrum
- measure backgrounds: non-QE ν_μ, NC π^0
- measure ν interactions



Super-Kamiokande

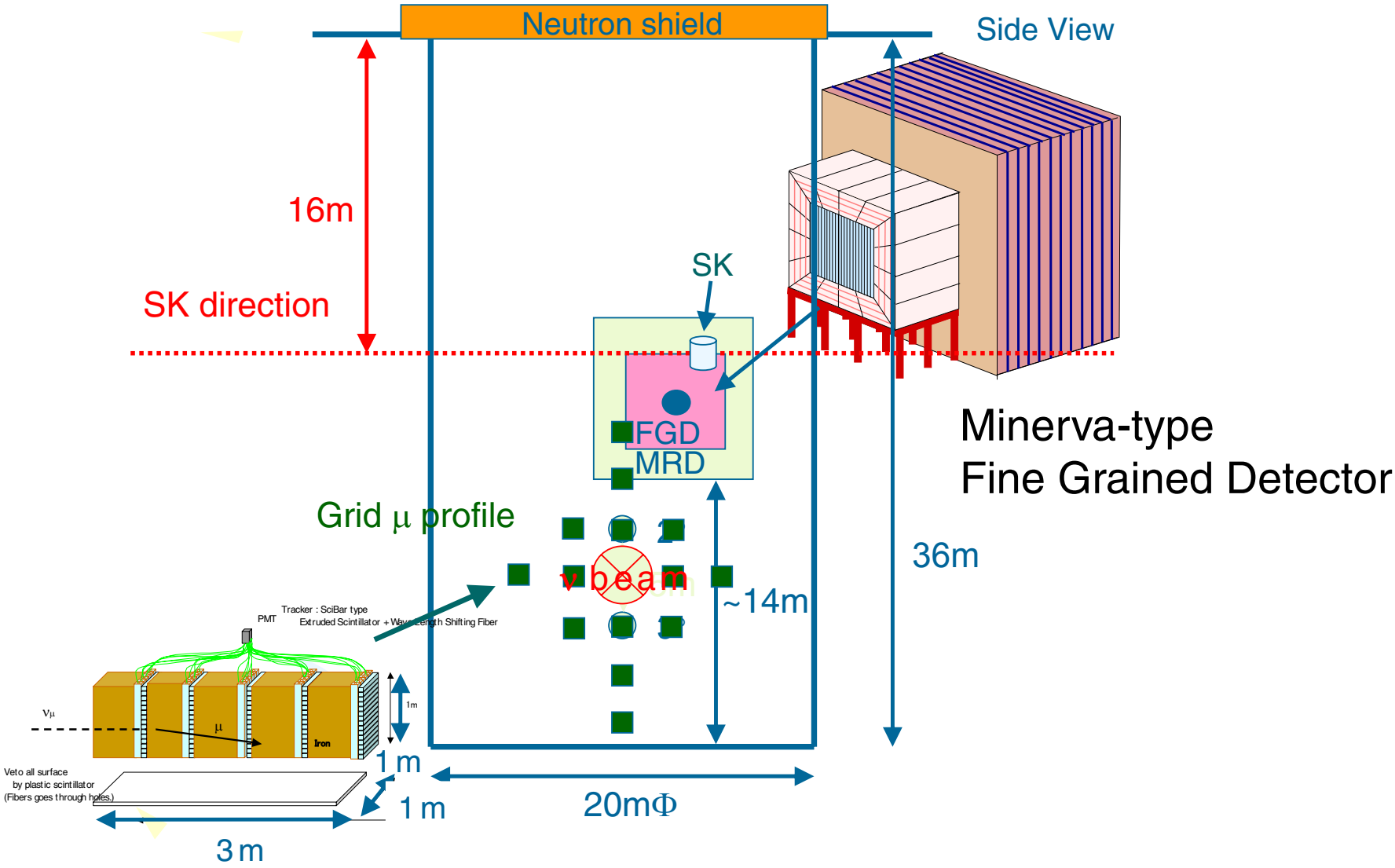
Far Detector will be SK-3

- 22.5 kton fiducial mass (2m from wall)
- 1885 20-cm pmts in outer detector
- Acrylic shields on all inner detector PMTs
- ADC/TDC electronics upgrades
- Recovery from accident:
  ~6000 PMTs to be installed starting Nov. 2005
  restoring total to 11100



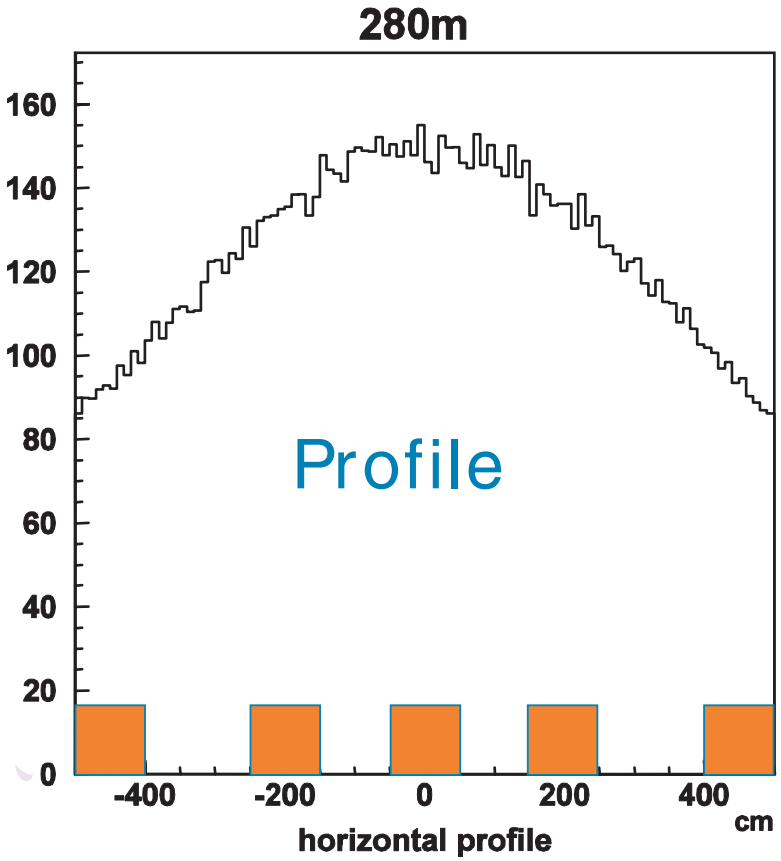
Near Detector at 280 meters

possible design - not final

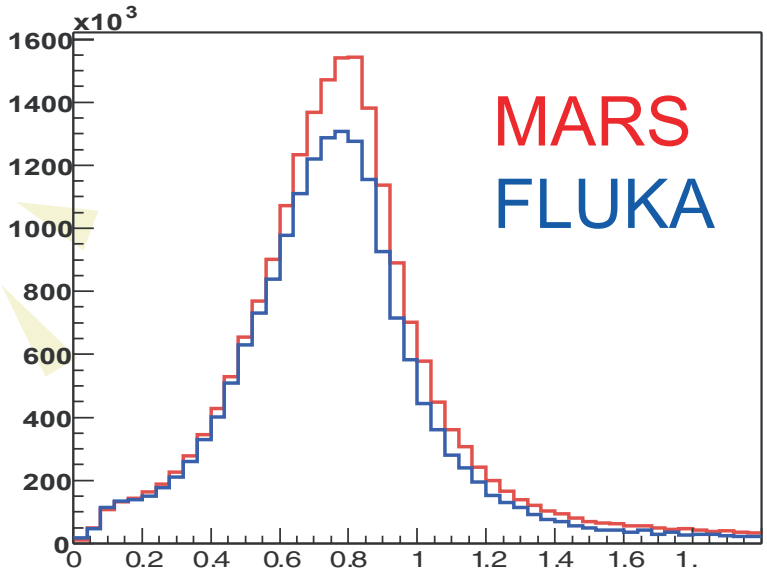


Measurements with 280m Near Detectors

~0.2 events / ton / spill
at 0 degrees



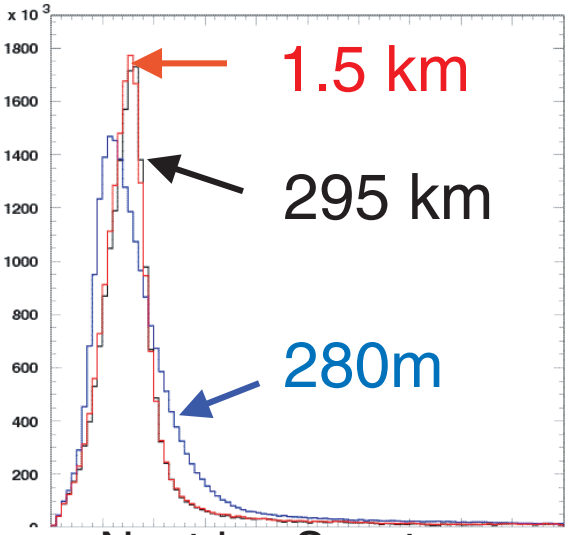
~0.06 events / ton / spill
at 2.5 degrees off axis



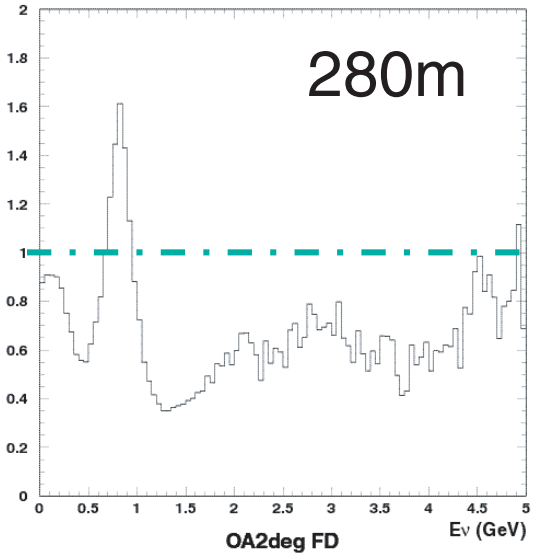
E_ν @280m off-axis

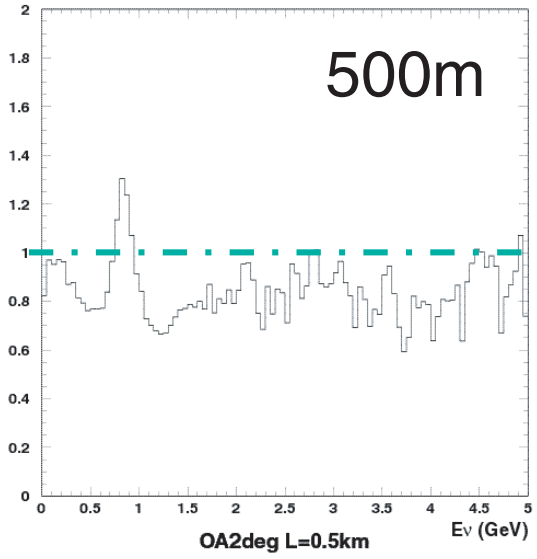
high statistics studies
of neutrino production

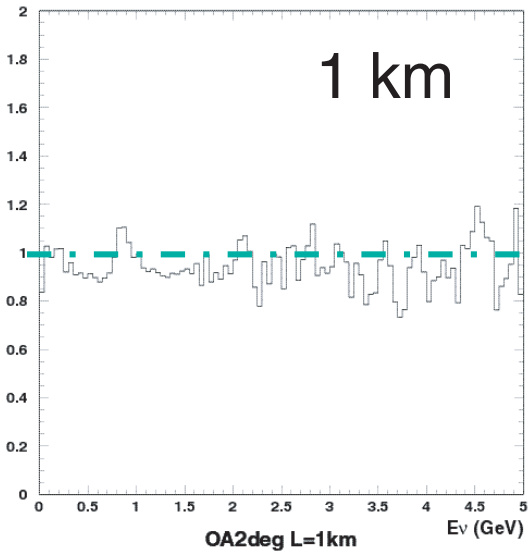
Far/Near Ratio versus Near Detector Distance

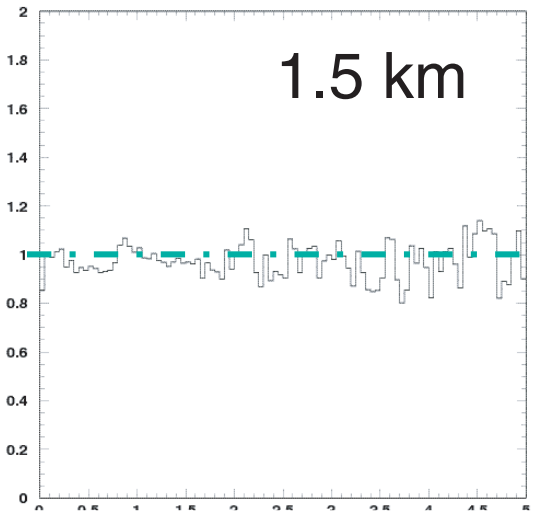


Neutrino Spectrum

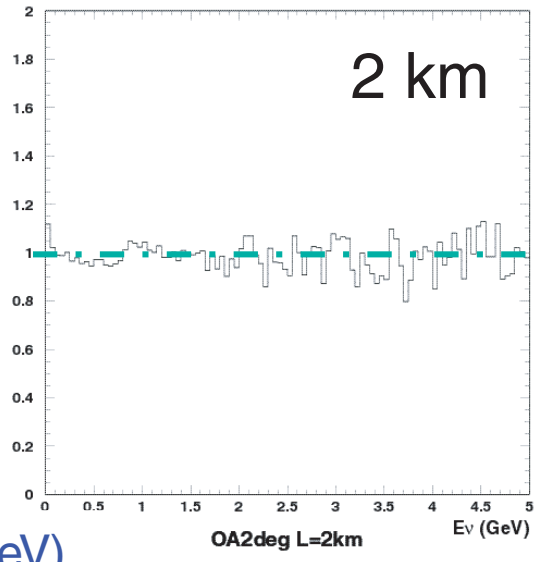








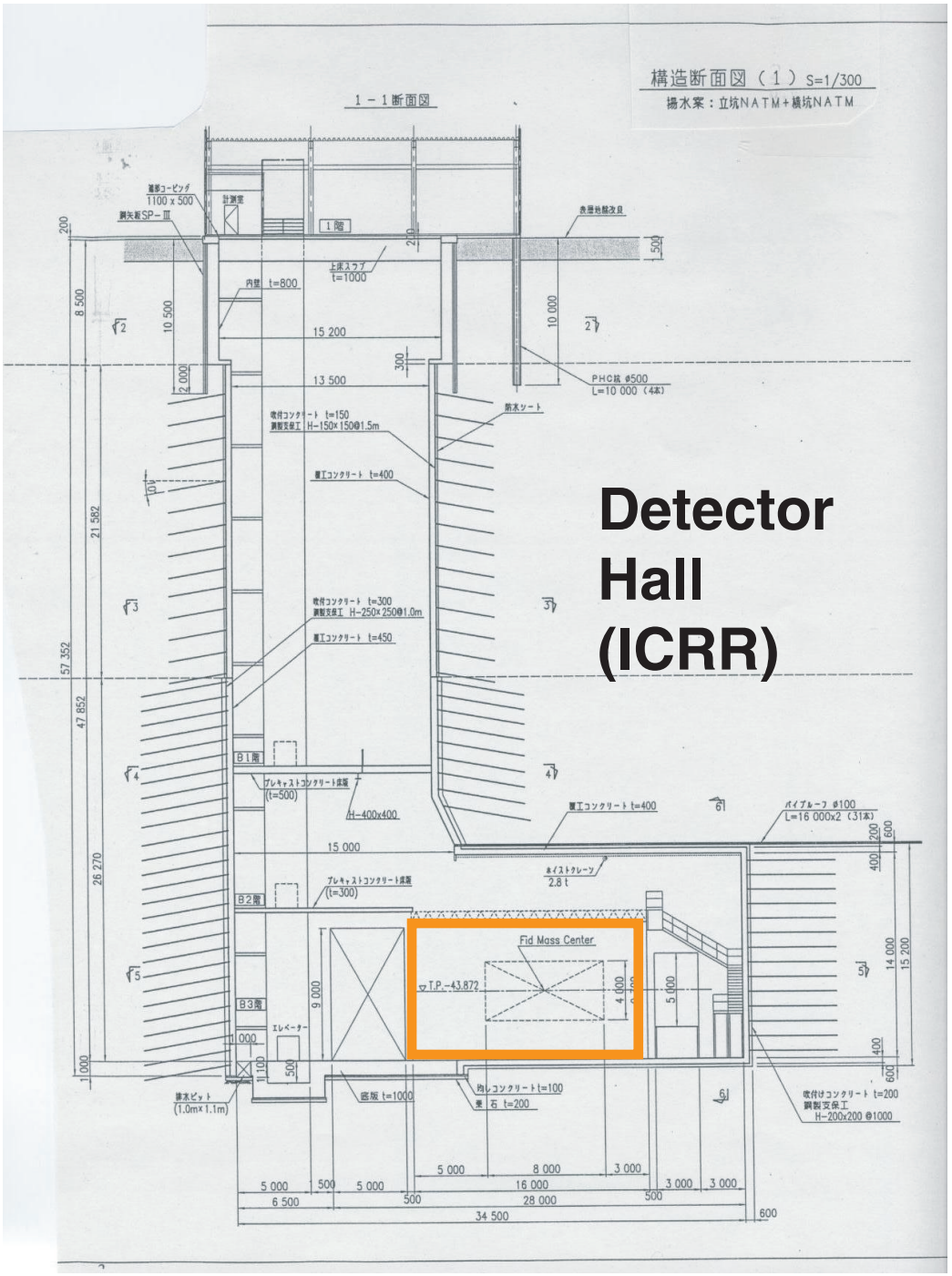
0 1 3 5 (GeV)



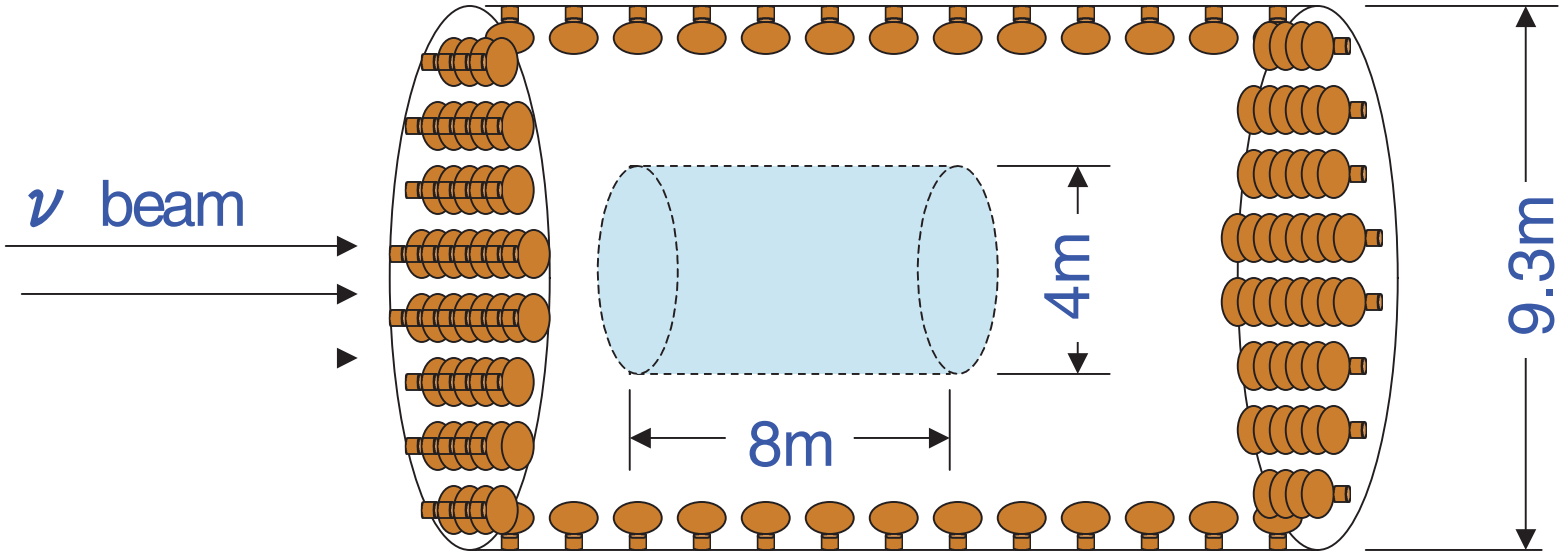
2KM Detector Site

Tokai Village owned land
They have kindly agreed to
rent-free use

@1.84 km



Near Water Cherenkov Detector



desirable to have water Cherenkov near detector

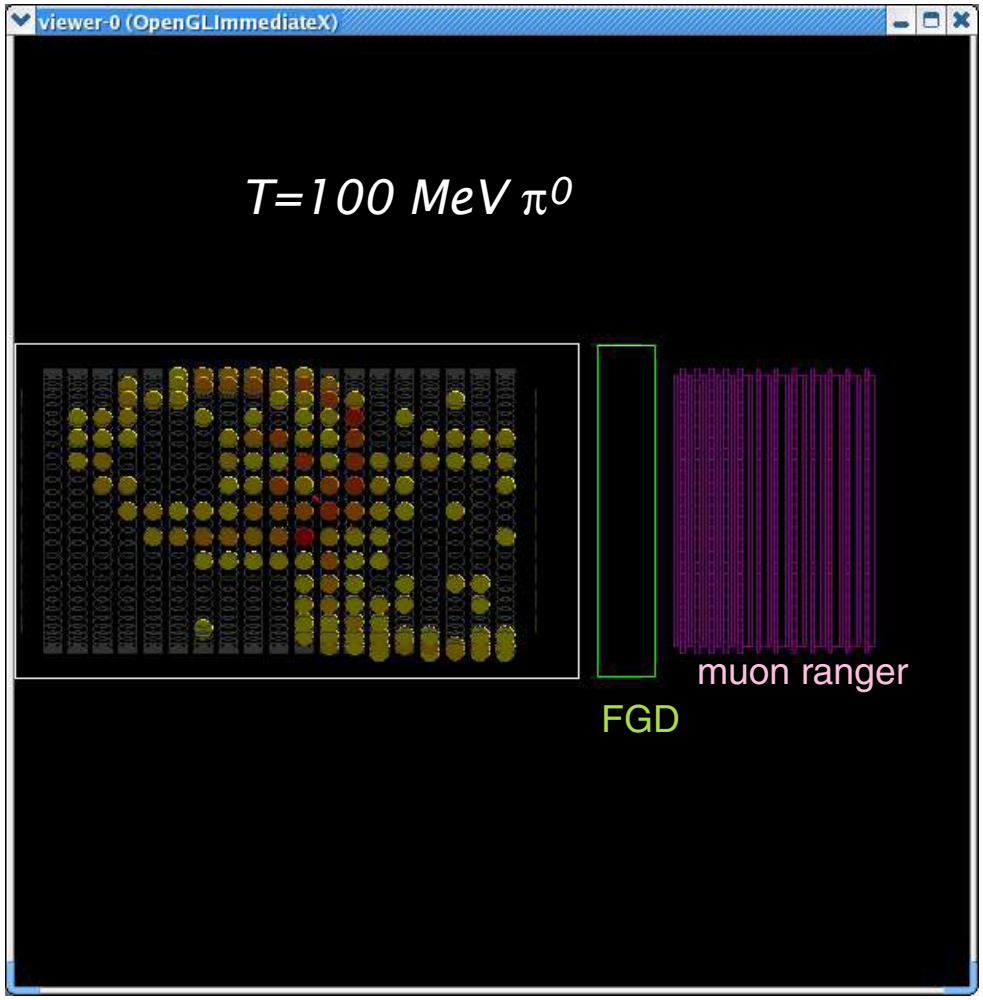
- same nuclear target as far detector
- cancel experimental systematics
- low cost per ton
- study π^0 background

280 meters is too close (60 interactions/spill)

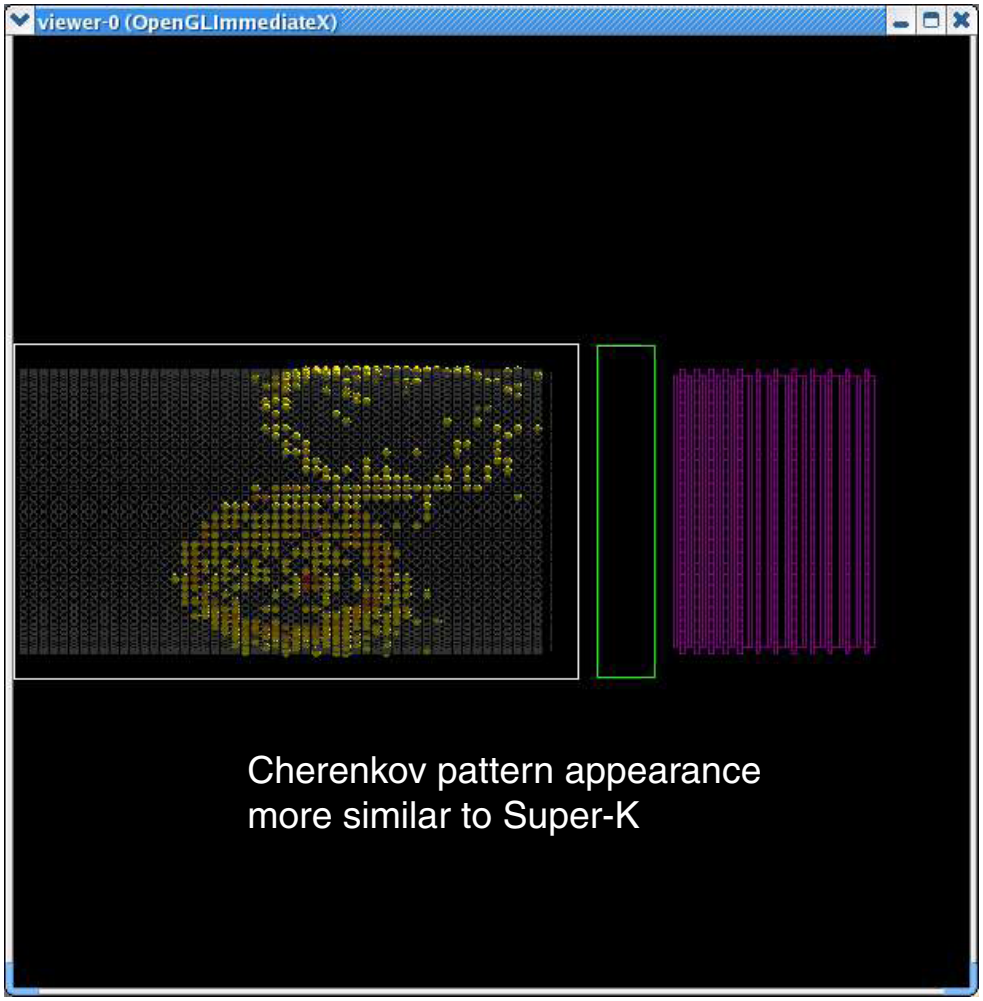
2km is good: 1/spill (0.1/spill in 100 ton fiducial volume)

Maybe More, Smaller, PMTs in Near Detector

(being studied... this is a new GEANT4 simulation... work in progress)



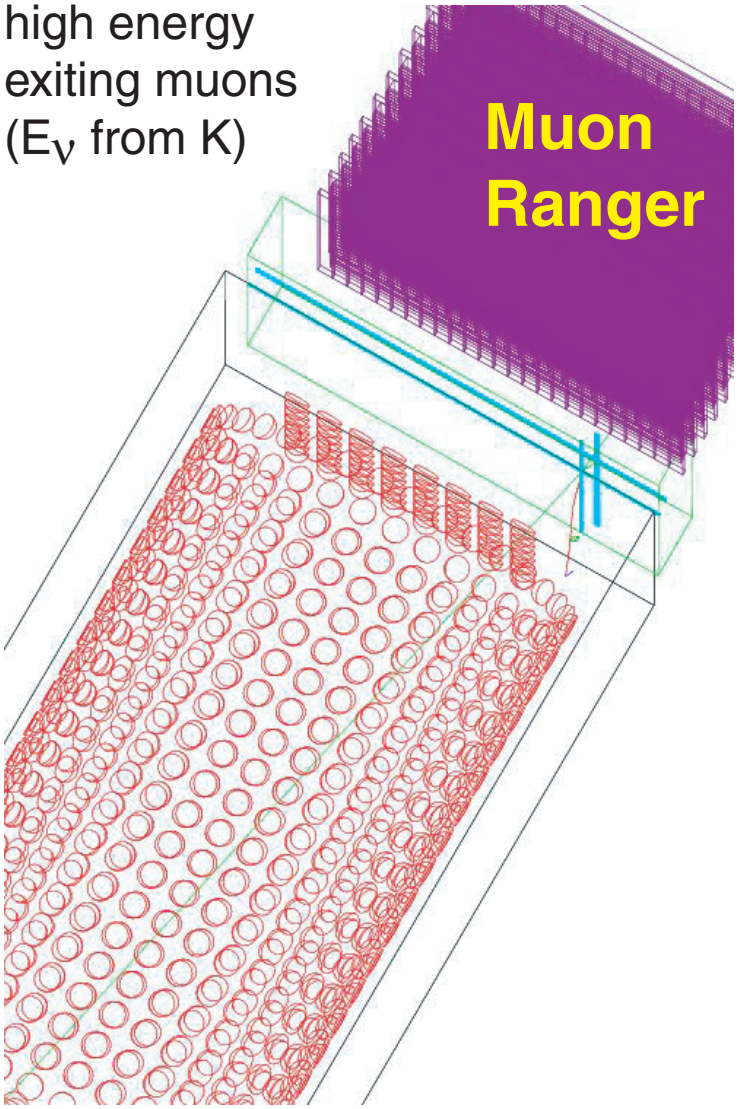
50-cm PMTs (same as K2K, SK)



20-cm PMTs

Other 2KM Detectors

Measure high energy exiting muons (E_ν from K)



detector choices still under study

FGD display below based on NuMI liquid scintillator cells

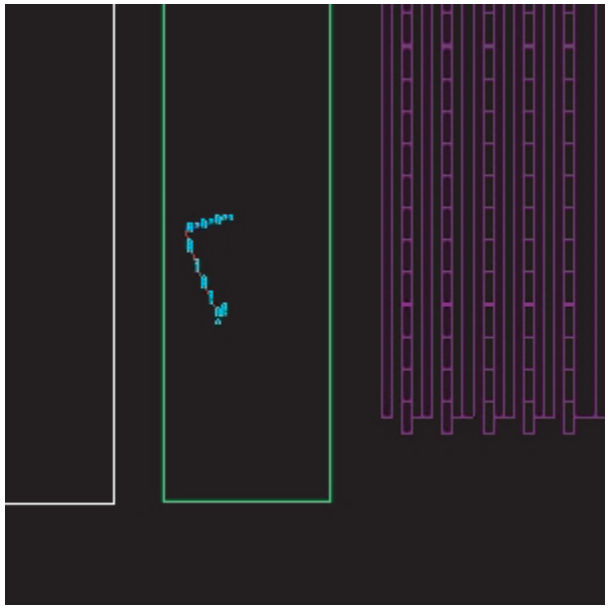
SciBath? Magnetic toroid? Other ideas welcome...

Fine Grained Detector

Separate QE and non-QE events

Cross check n spectrum

Cross section studies (CC-1π, NC π^0) with same spectrum as SK



Notes on T2K Participation

*Right now, the beamline and 280m near detector are the officially funded part of J-PARC neutrino. The spokesman is **strongly seeking contributions** to these areas specifically. Some U.S. groups and many foreign groups are interested in this route.*

U.S. Super-K group members can participate in T2K automatically in light of existing contribution to Super-K: eg. 2003 reconstruction, 2005 reconstruction, and detector upgrades.

*The majority of U.S. Super-K sees the **2km detector**, especially the water Cherenkov, as a very natural place to focus effort. We are **welcoming newcomers** to work on this project.*

Continuing this successful U.S.-Japan collaboration makes sense regardless of the choices made in the U.S. program. A particularly strong point is the hopeful second phase involving Hyper-K.

Next steps: LOI was sent to D.o.E. last year. First presentations anticipated this spring, to get on the roadmap and get a sense of the outlook for funding.