Extracting the parameters of the PMNS matrix from future neutrino oscillation experiments II

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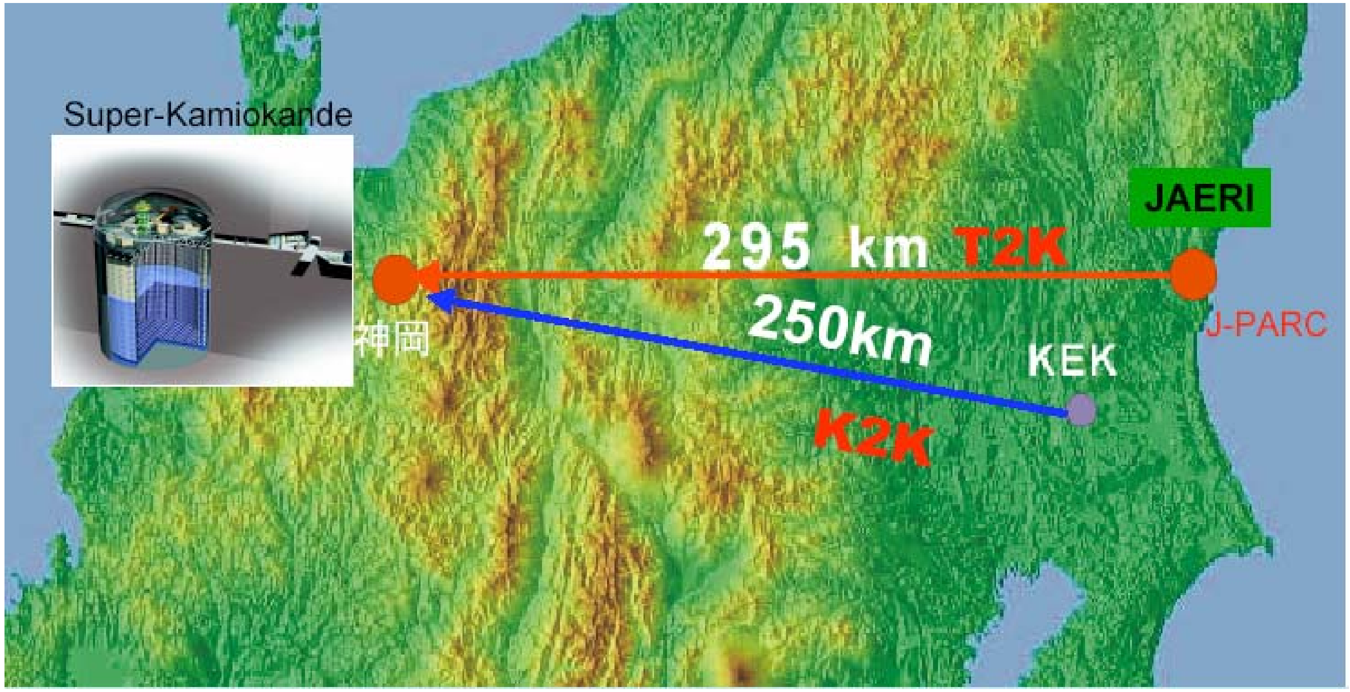
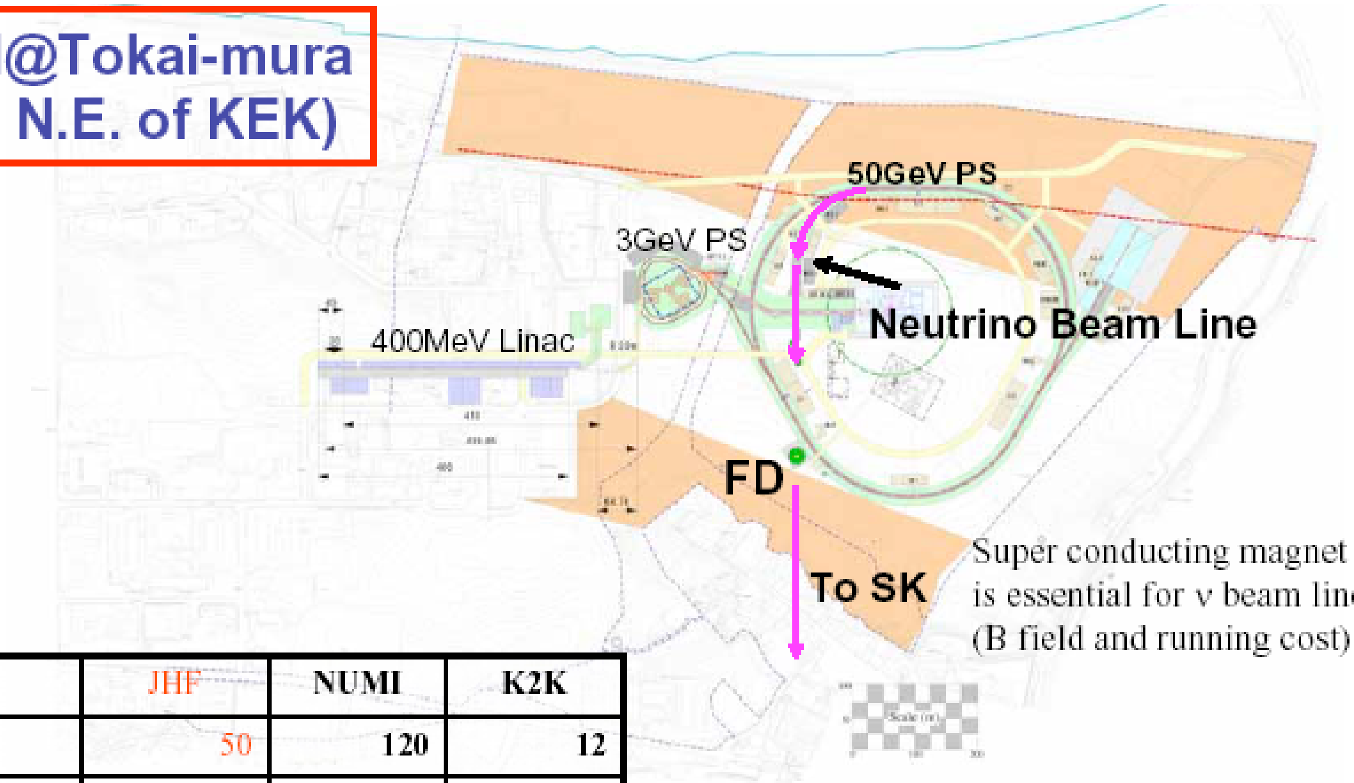
Original results presented in this talk based on work done in collaboration with P. Hernández, J. Burguet-Castell, D. Casper & P.Novella

The first Super-Beam: T2K



Neutrino beam line

JAERI@Tokai-mura
(60km N.E. of KEK)

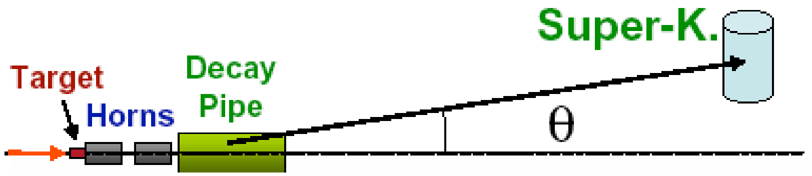


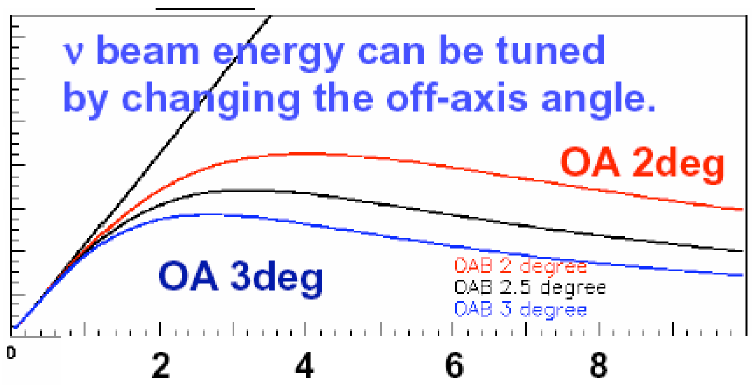
Super conducting magnet
is essential for ν beam line
(B field and running cost)

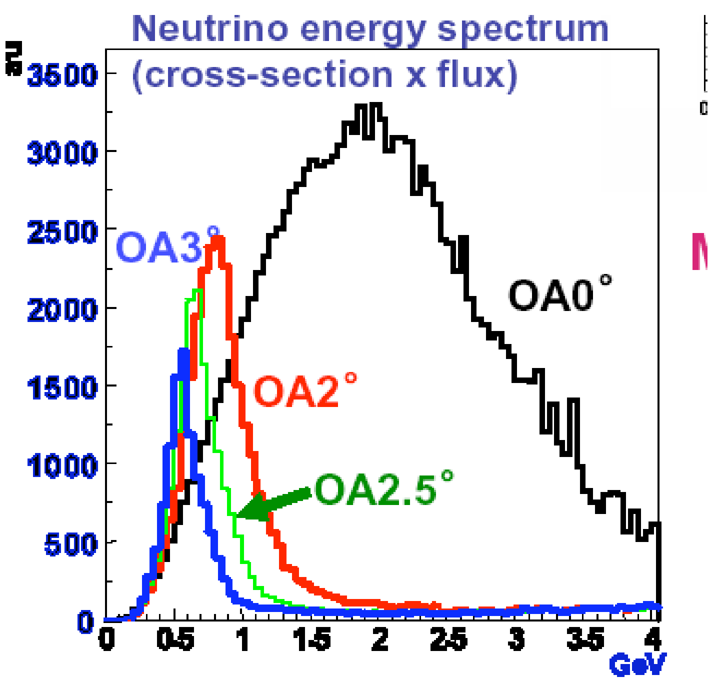
	JHF	NUMI	K2K
E(GeV)	50	120	12
Int.(10^{12}ppp)	330	40	6
Rate(Hz)	0.292	0.53	0.45
Power(MW)	0.77	0.41	0.0052

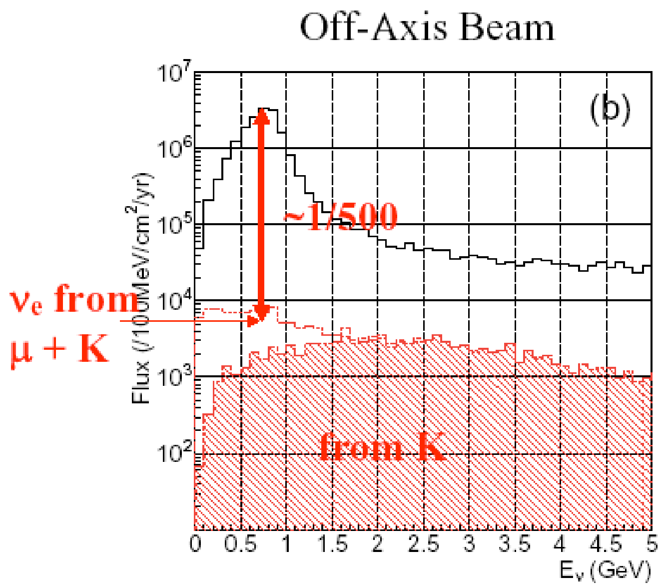
10^{21}POT(130day)≡ "1 year"

Off-Axis beam





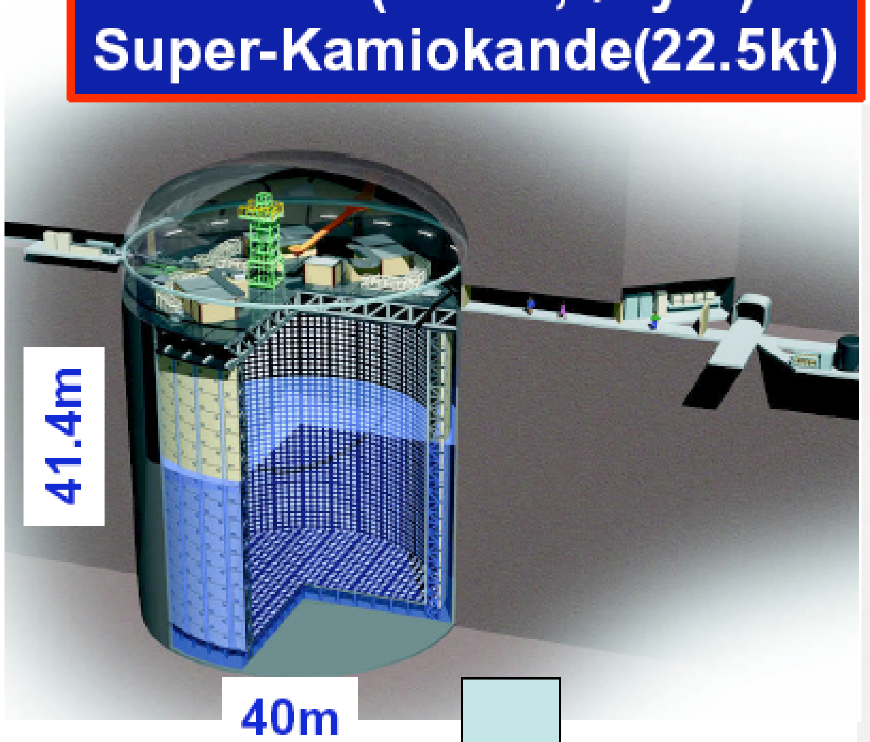




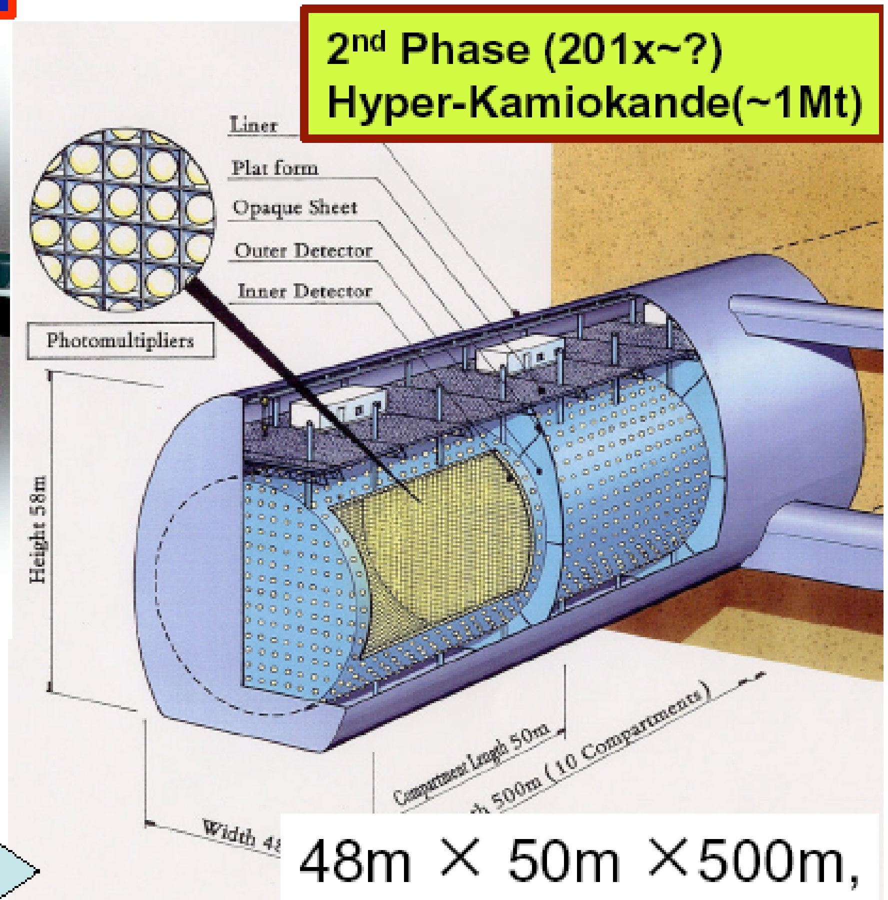
Intrinsic background: ν_e / ν_μ (peak) ~ 0.002

Water detectors

1st Phase (2009~, ?5yrs)
Super-Kamiokande(22.5kt)

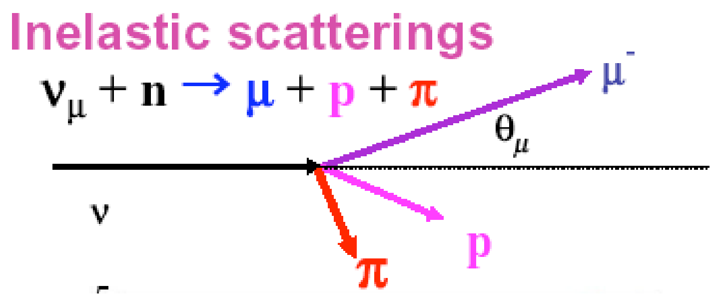


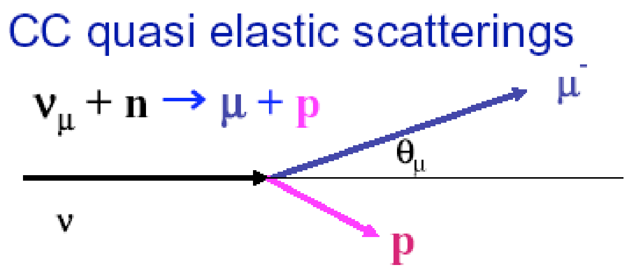
2nd Phase (201x~?)
Hyper-Kamiokande(~1Mt)

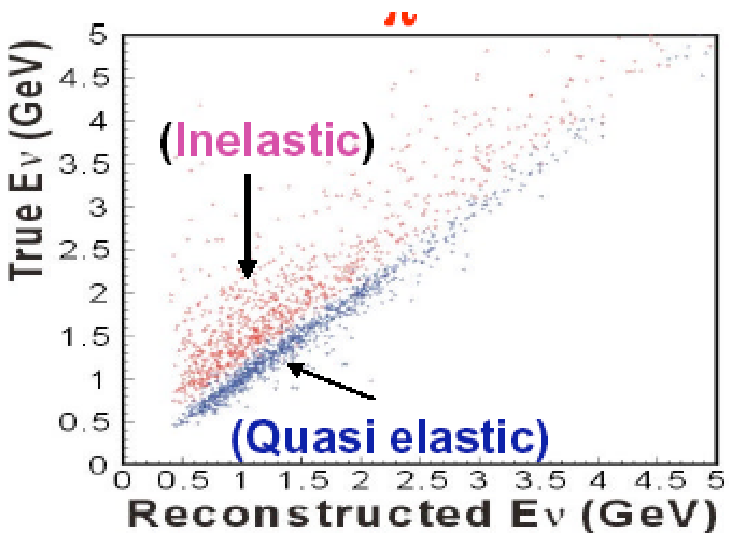


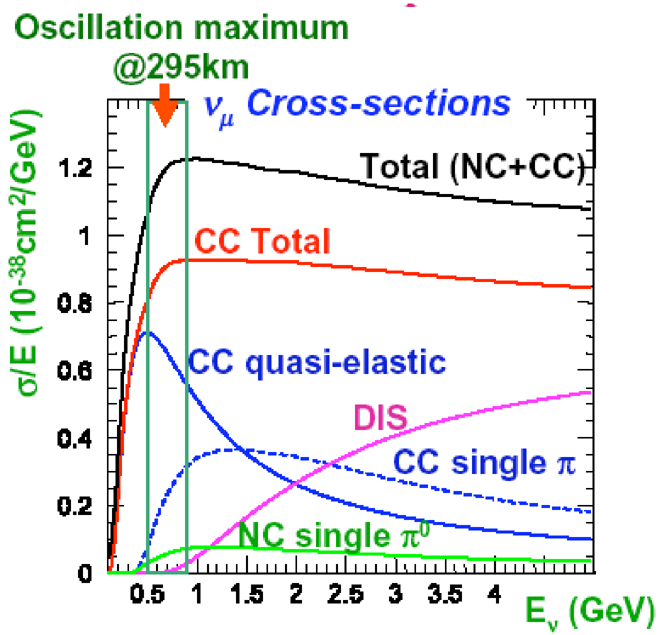
48m × 50m ×500m,
Total mass = 1 Mton

Cross sections and energy reconstruction

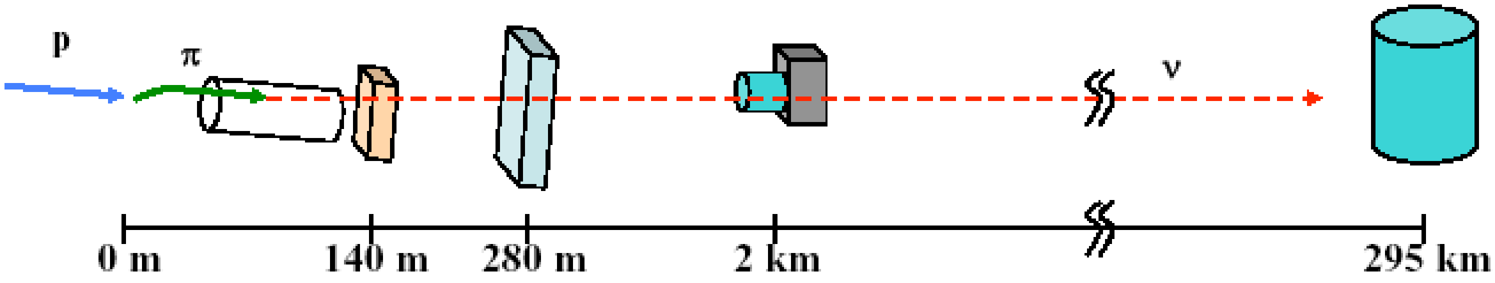








Measurement of neutrino flux



Muon monitors @ ~140m

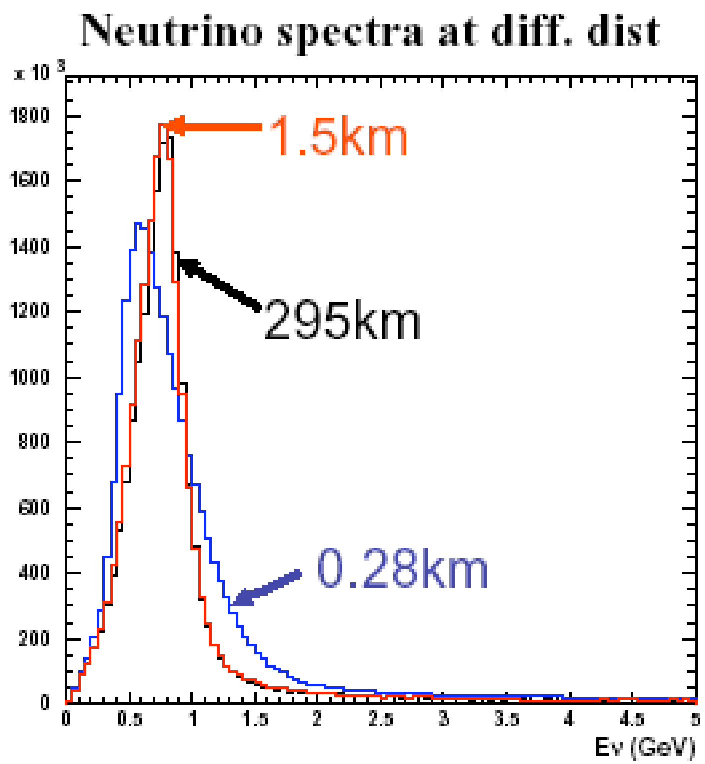
Fast (spill-by-spill) monitoring of beam direction & intensity

Front detector @280m

Neutrino energy spectrum, intensity and direction

Far detector @ 295km

Super-Kamiokande(50kt)



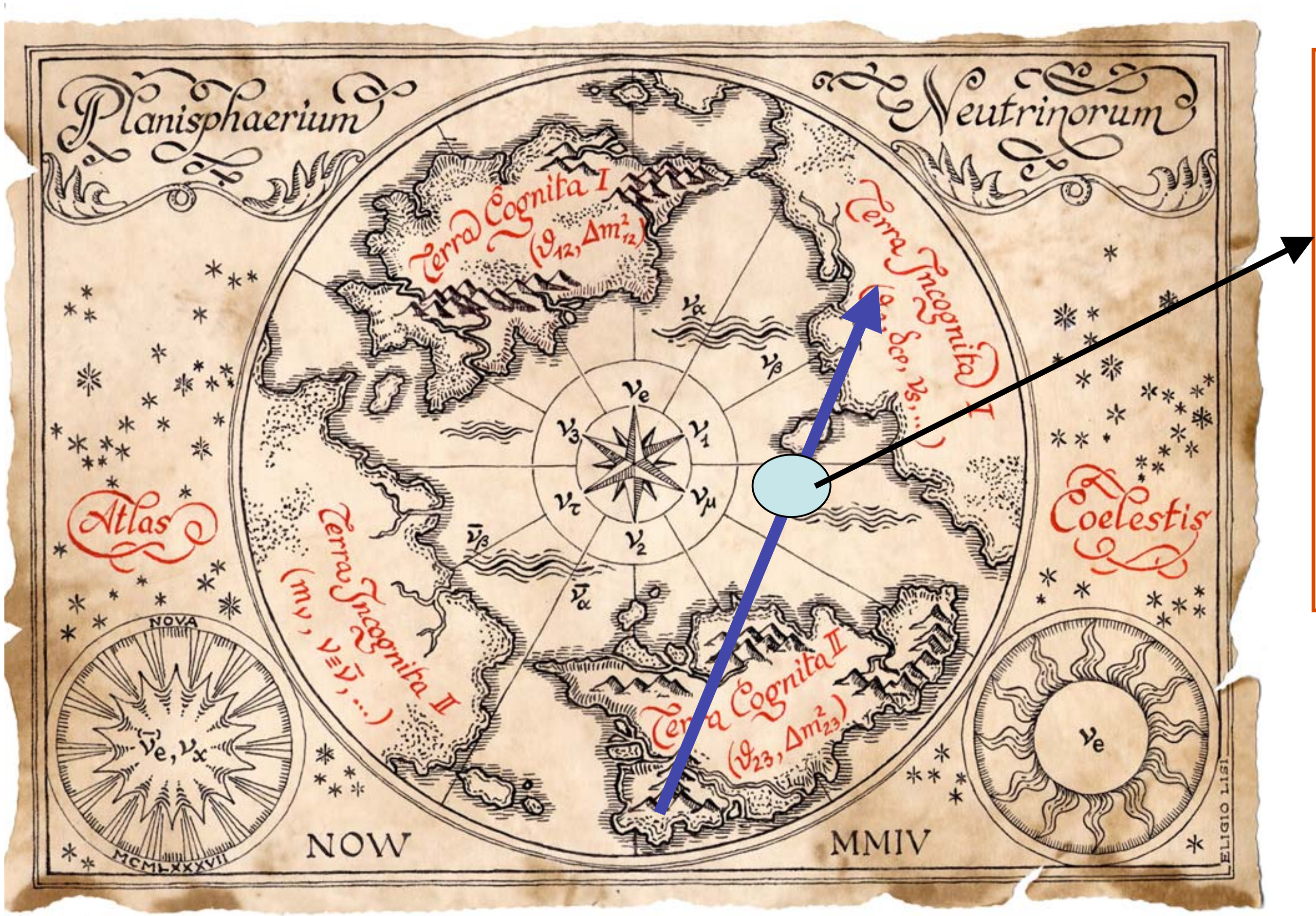
Future upgrade

Second Front Detector @ ~2km

Almost same E_ν spectrum as SK

T2K Phase I

5-10 years

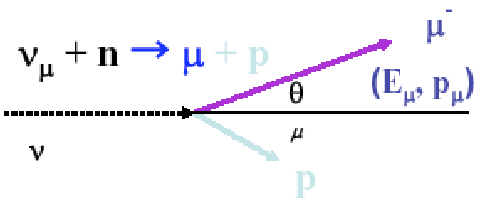


Observe subleading oscillation

Measure θ_{13}

Measure θ_{23} , Δm_{23} to O(1%)

Measurement of atmospheric parameters



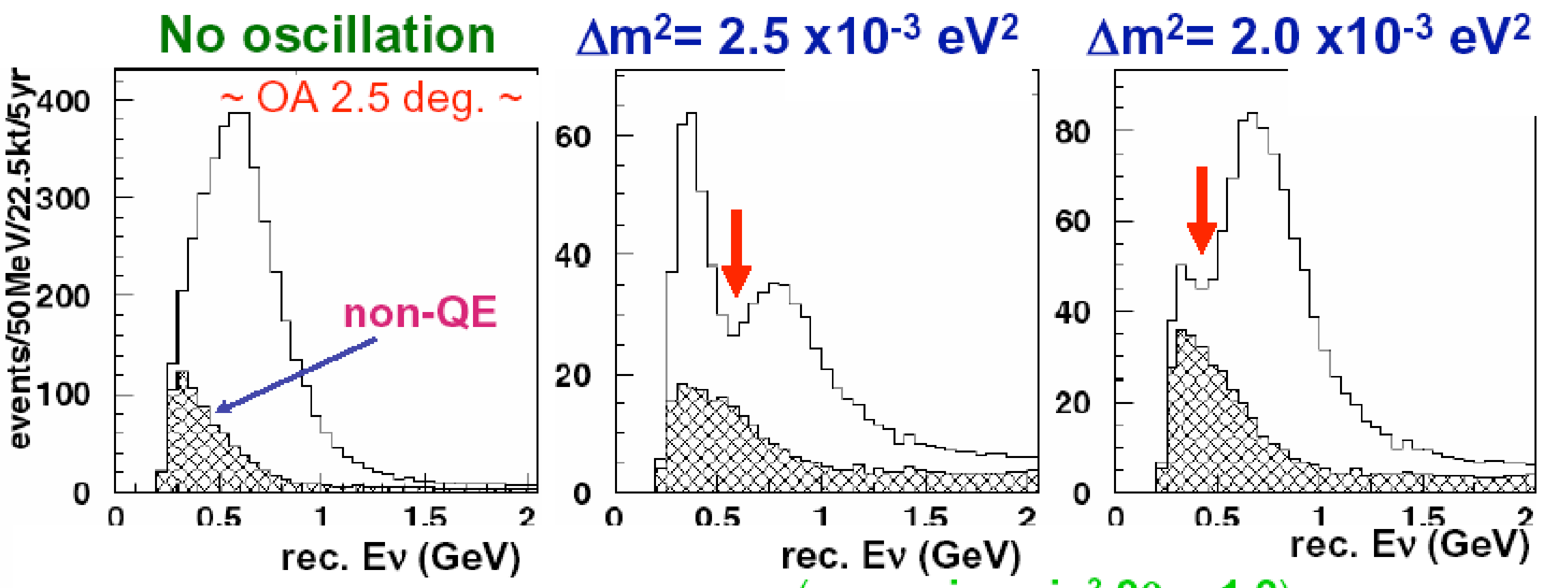
✧ CC QE

✧ can reconstruct Eν ←(θ_μ,p_μ)

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

systematic errors

normalization	(5%)
non-qe/qe ratio	(5%)
E scale	(1%)
Spectrum shape	(20%)
Spectrum width	(5%)

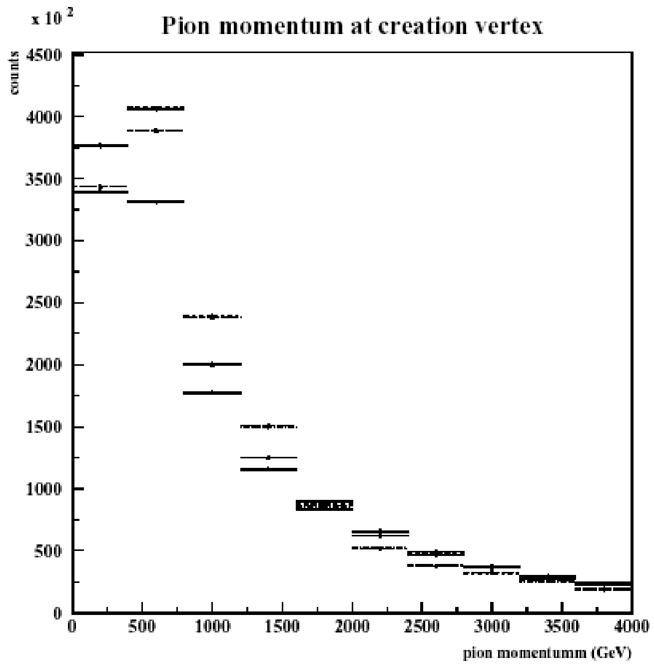


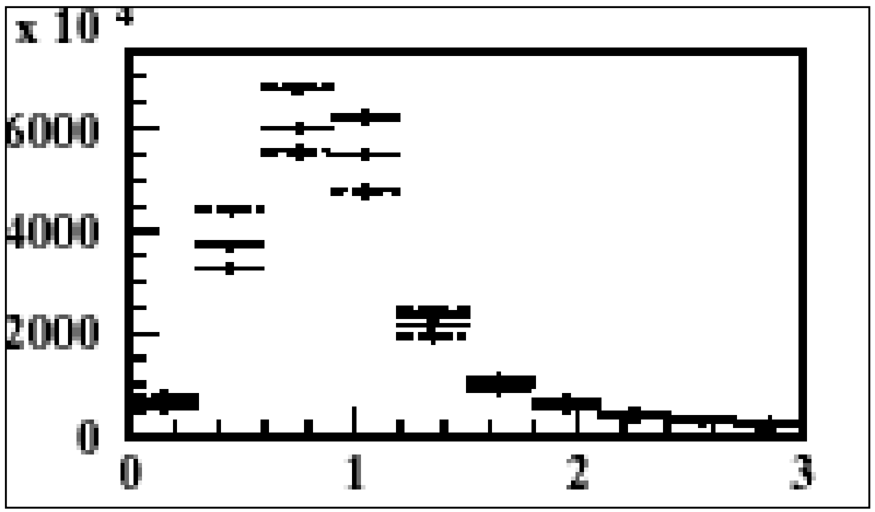
(assuming $\sin^2 2\theta_{23}$=1.0)

Measurement of neutrino flux

K2K Direct measurement of hadron (pion) spectrum.

T2K Impossible due to high momentum and high intensity.

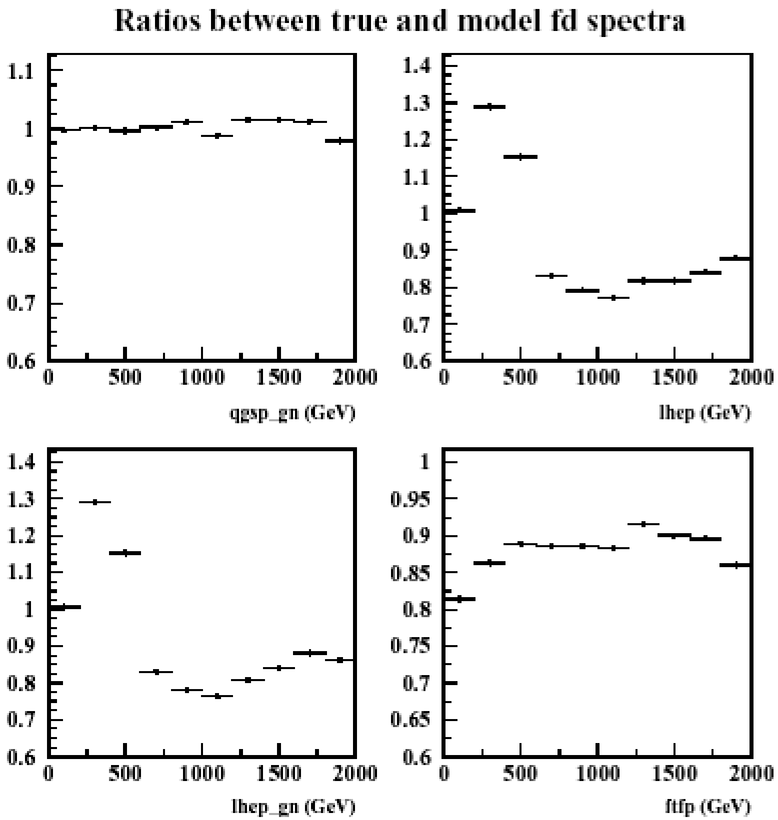




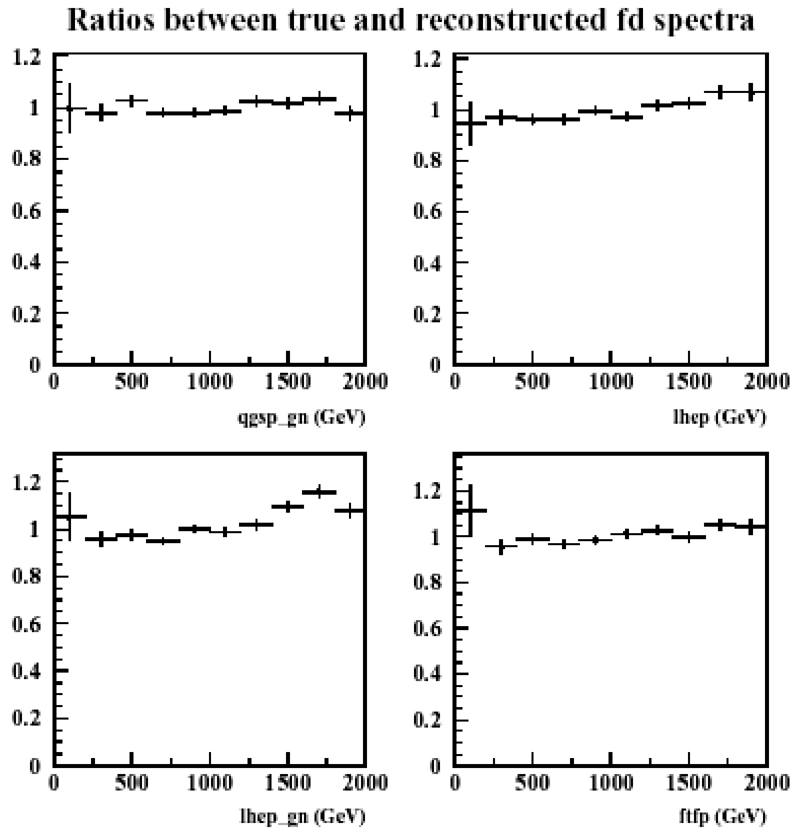
G4 hadronic models

Uncertainties on neutrino flux

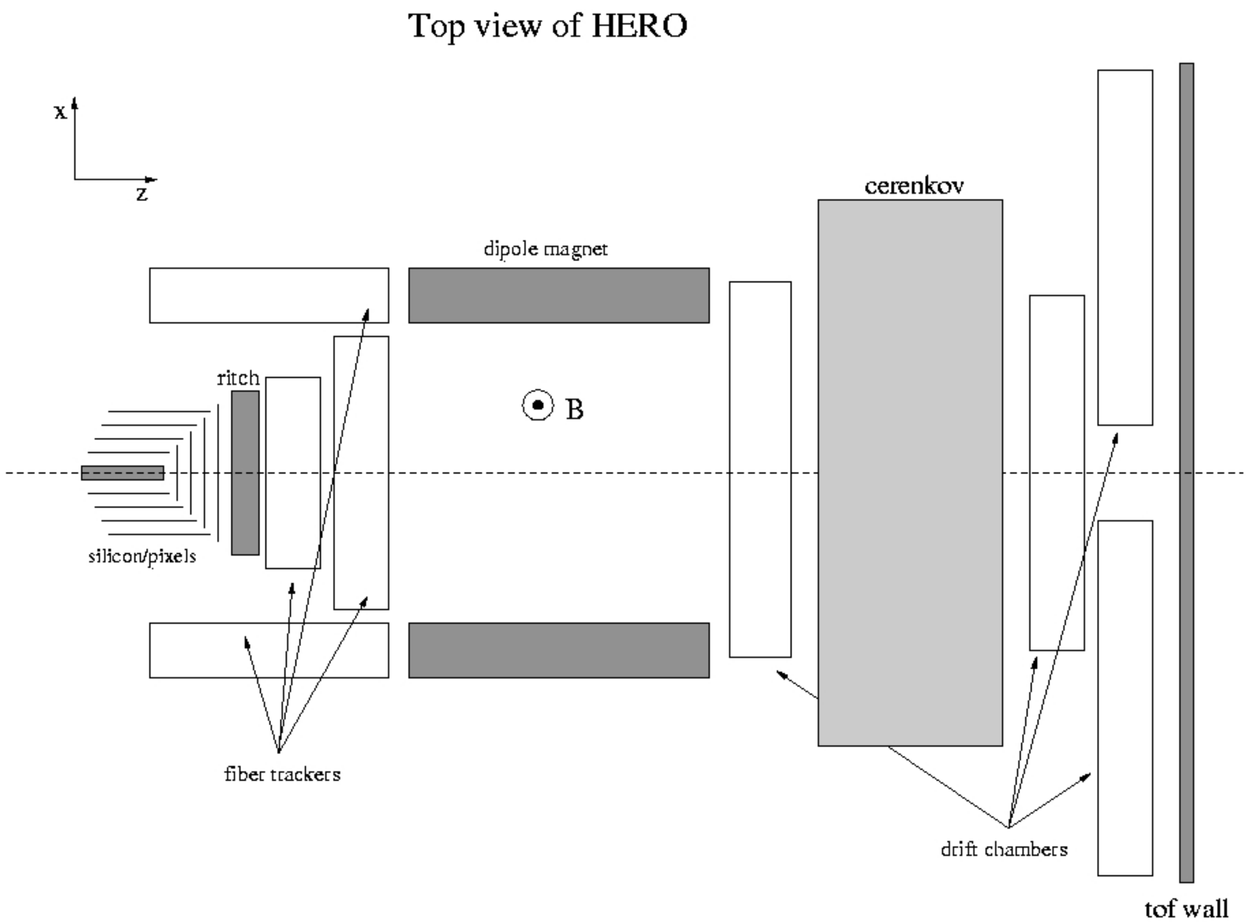
Relative differences on spectrum



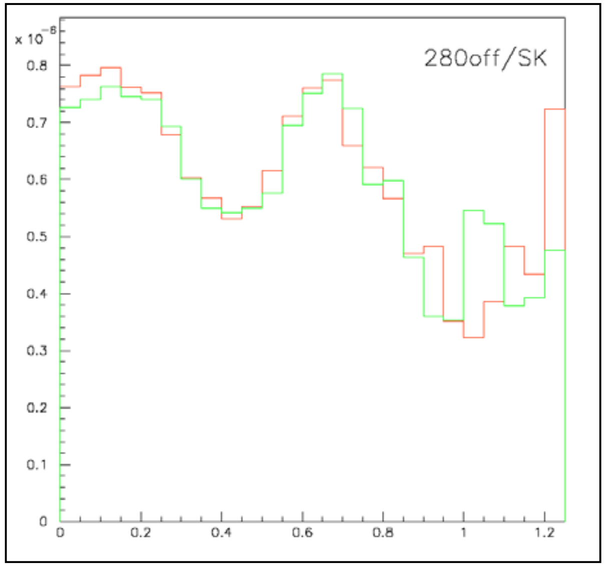
Far/Near ratio predictions

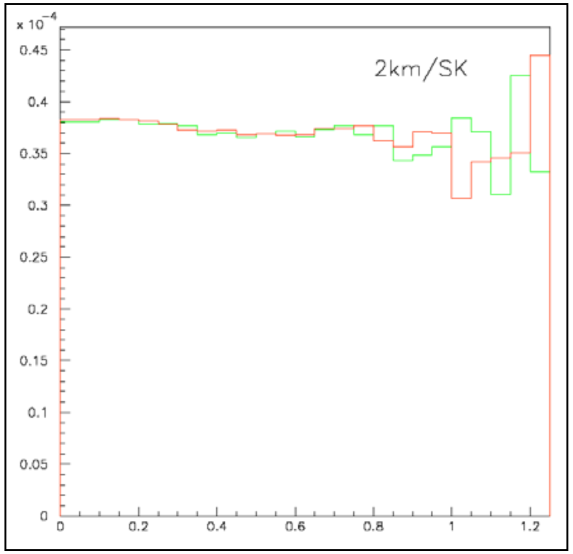


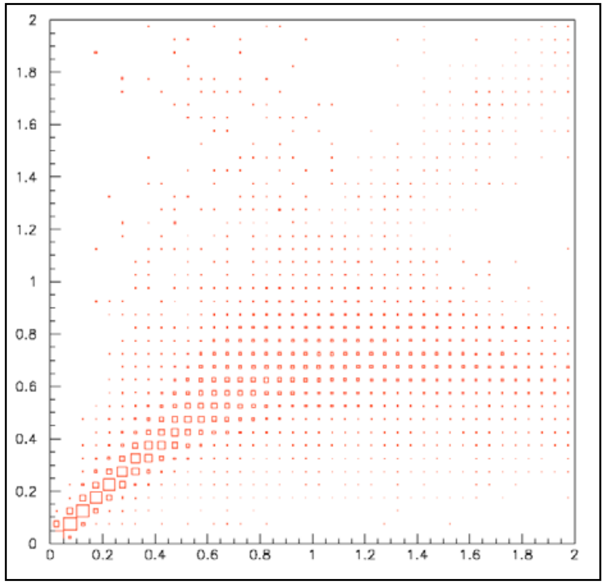
Hadronic Experiment for the Research of Oscillations (HERO)

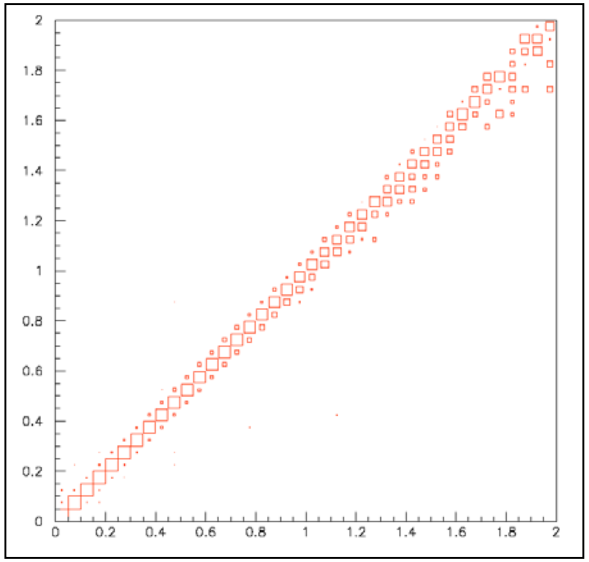


Detector at 2 Km

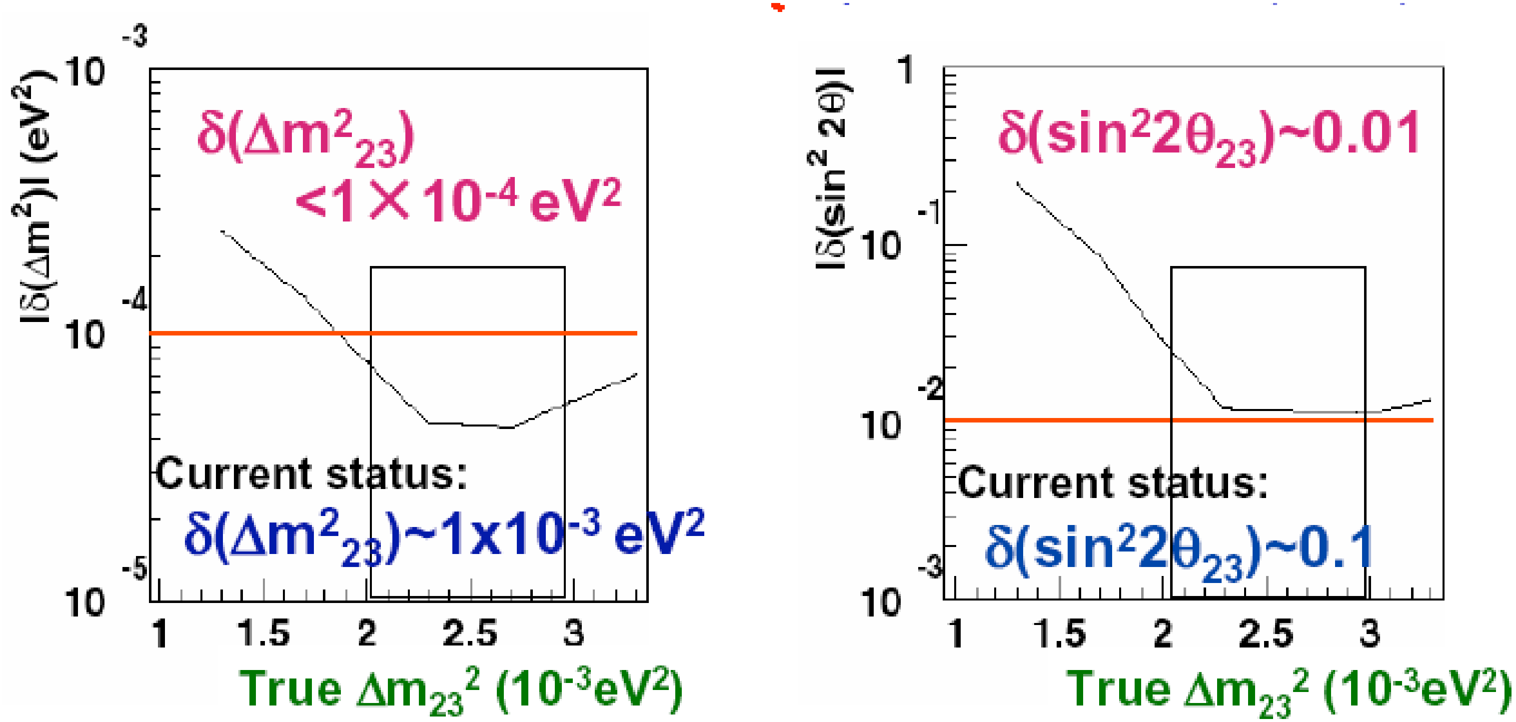








Precision on θ_{23}, Δm_{23}



Improve one order of magnitude LBL measurements

Search for subleading oscillations

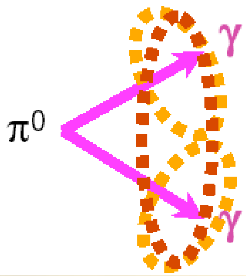
Possible background sources

1) Beam ν_e

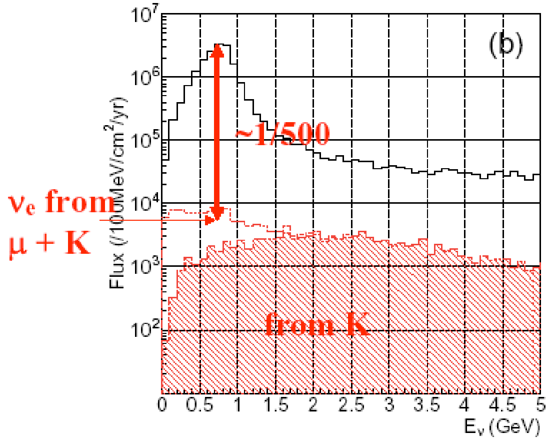
ν_e/ν_μ flux ~ 0.2% (@peak)

2) π^0 production

2-ring merged to 1-ring

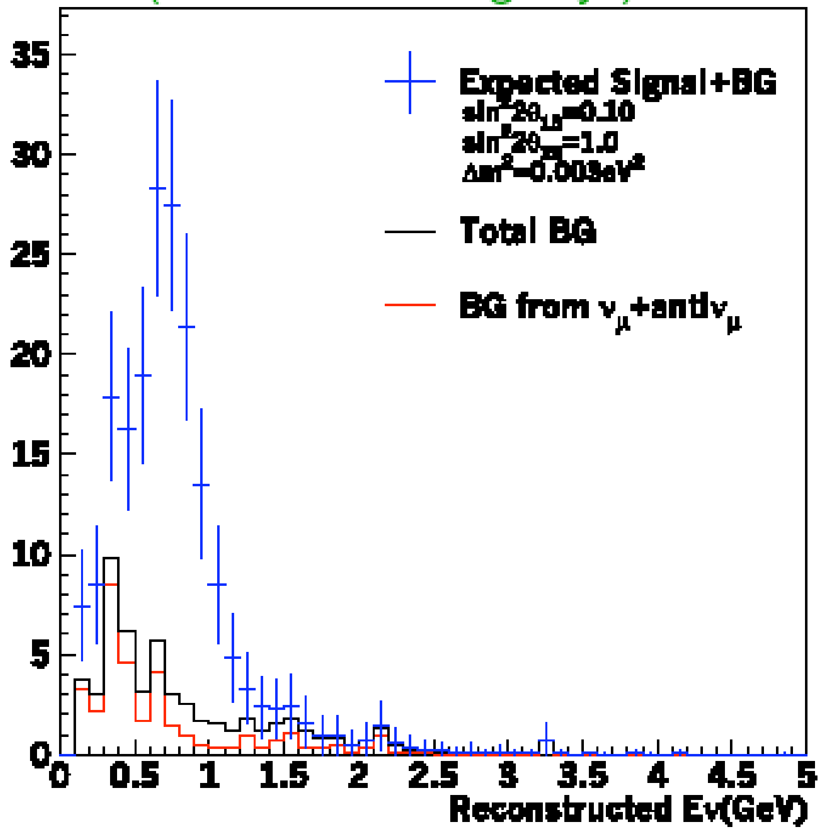


Off-Axis Beam

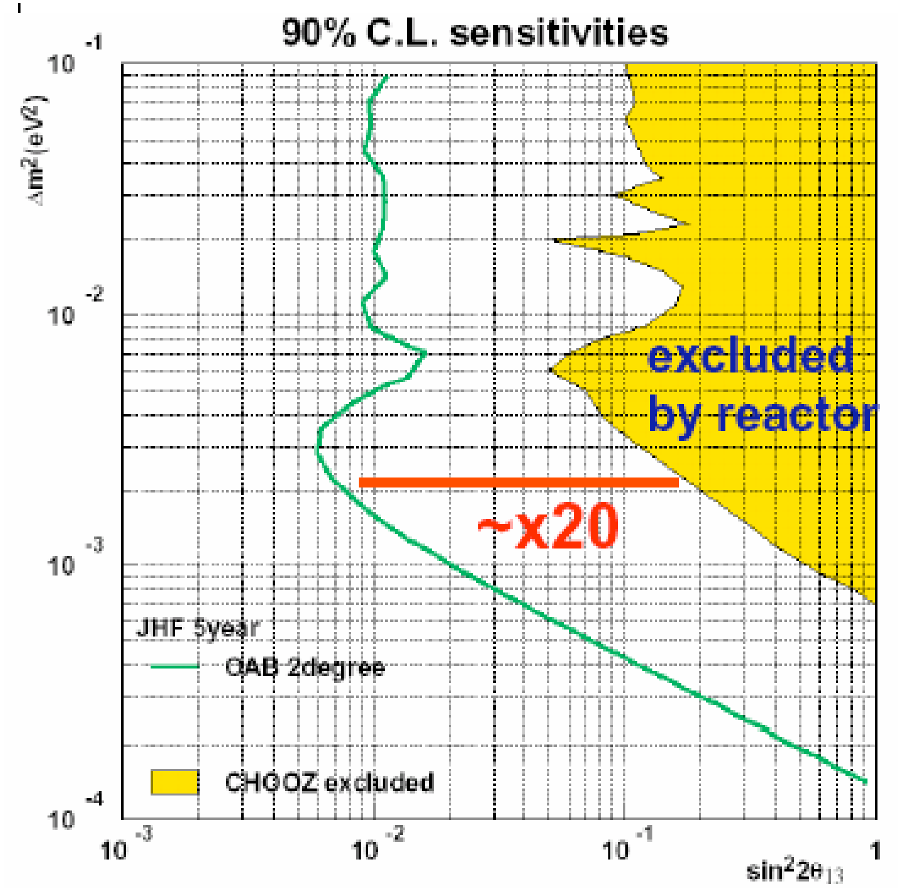


Intrinsic background: ν_e/ν_μ (peak) ~ 0.002

(Off axis 2.0deg. 5yr)



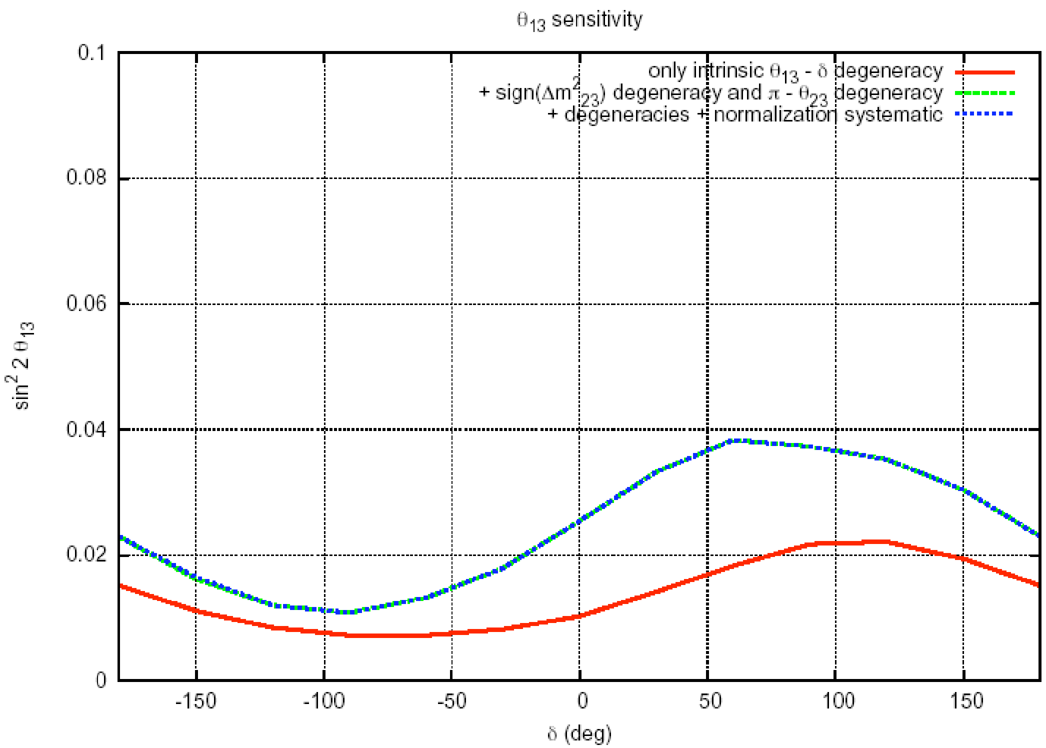
Sensitivity at fixed delta



$\sin^2 2\theta_{13} > 0.006$ (90%)

$\sin^2 2\theta_{13} > 0.018$ (3σ)

The effect of correlation and degeneracies

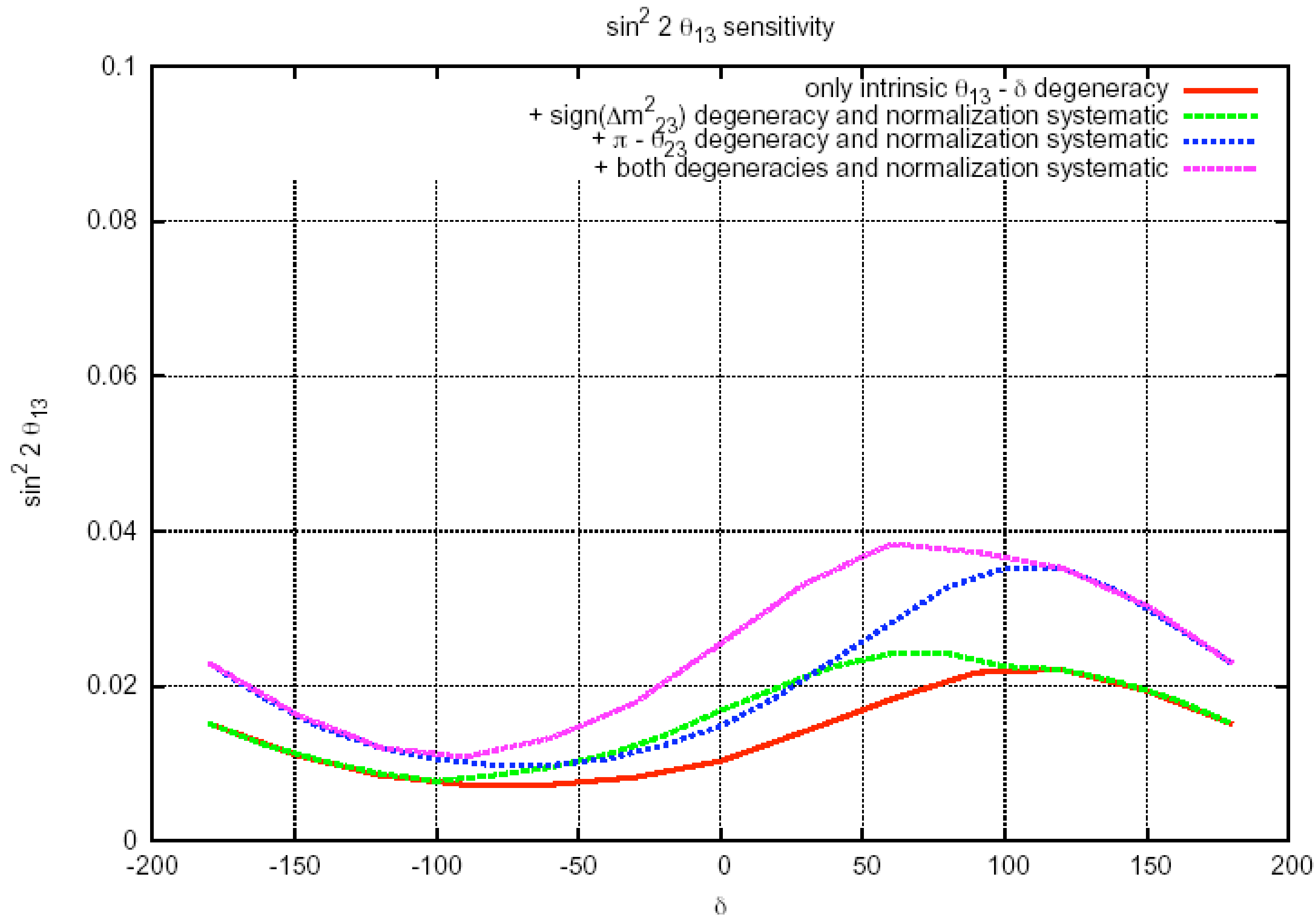


It spoils seriously the sensitivity to θ_{13}

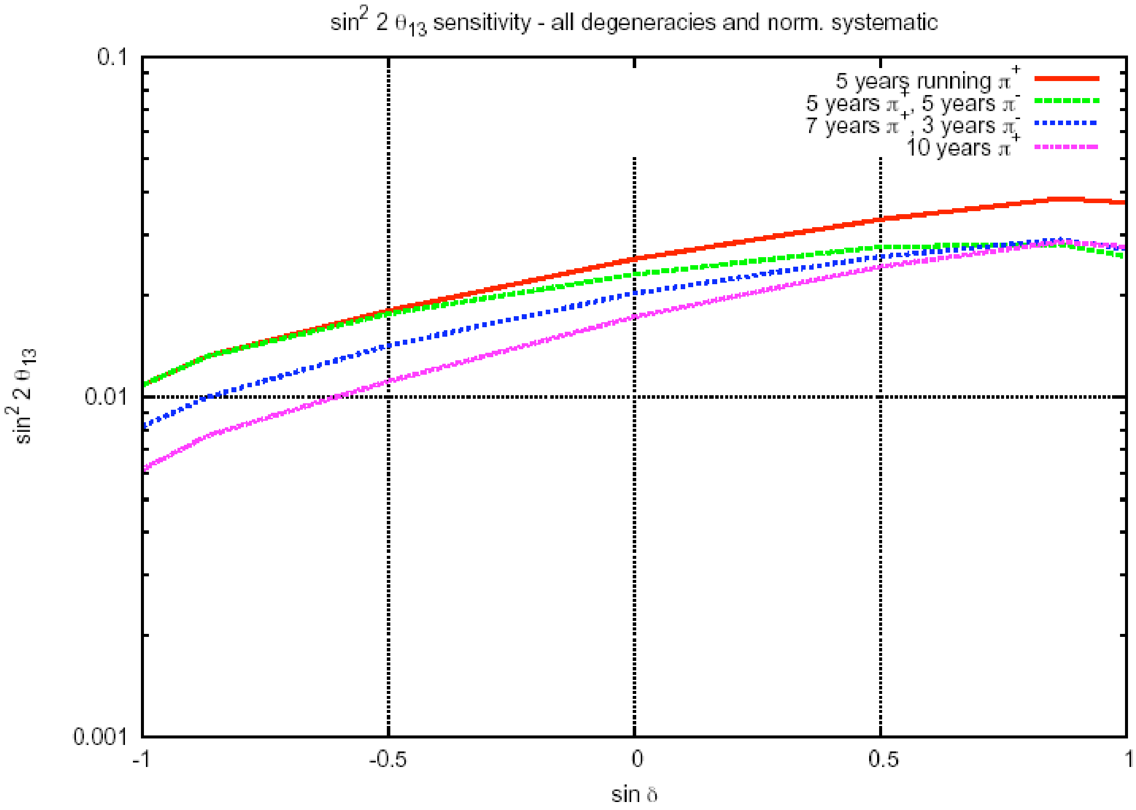
Depends on δ

T2K prospects must be updated to reflect this effect

The effect of correlation and degeneracies II



Running strategy for K2K-I



Running antineutrinos does not help to break the correlation with theta13 (for “low” statistics)

Summary on T2K-I

T2K is a discovery experiments.

If we see a signal,we will open the way to a next generation of neutrino experiments.

If no signal is seen uncertainties will be large.

Only neutrino run

We need a 2km detector/hadroproduction experiment to reduce to understand the neutrino flux at depth.