Study of $\nu\mu$ disappearance sensitivity

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JPARC-2km video meeting 8-July-2003

Introduction

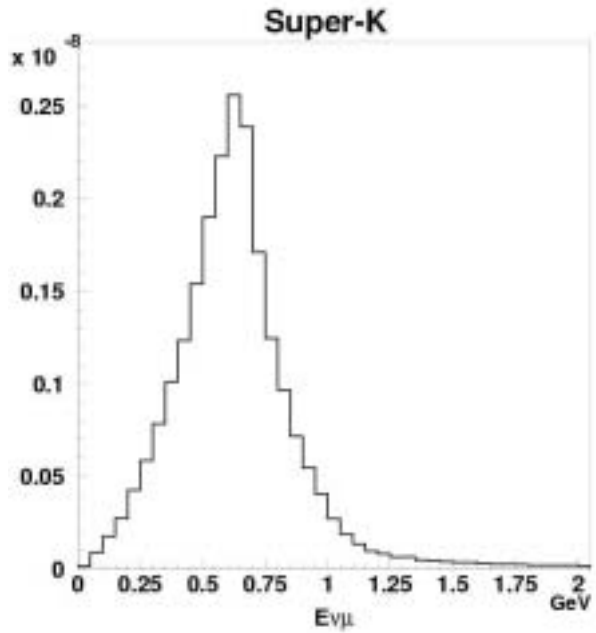
- Precise measurement of (Δm^2,$\sin^2 2\theta_{\mu\tau}$) parameters is one of the main purposes in JPARC ν experiment
  - ~1% accuracy in $\sin^2 2\theta_{\mu\tau}$ expected

- Large systematic uncertainties might affect significant systematic shift in measured parameters and allowed region

- Based on Monte-Carlo simulation, how the allowed region (Δm^2,$\sin^2 2\theta_{\mu\tau}$) was affected by systematic error sources was studied

Simulation and oscillation analysis

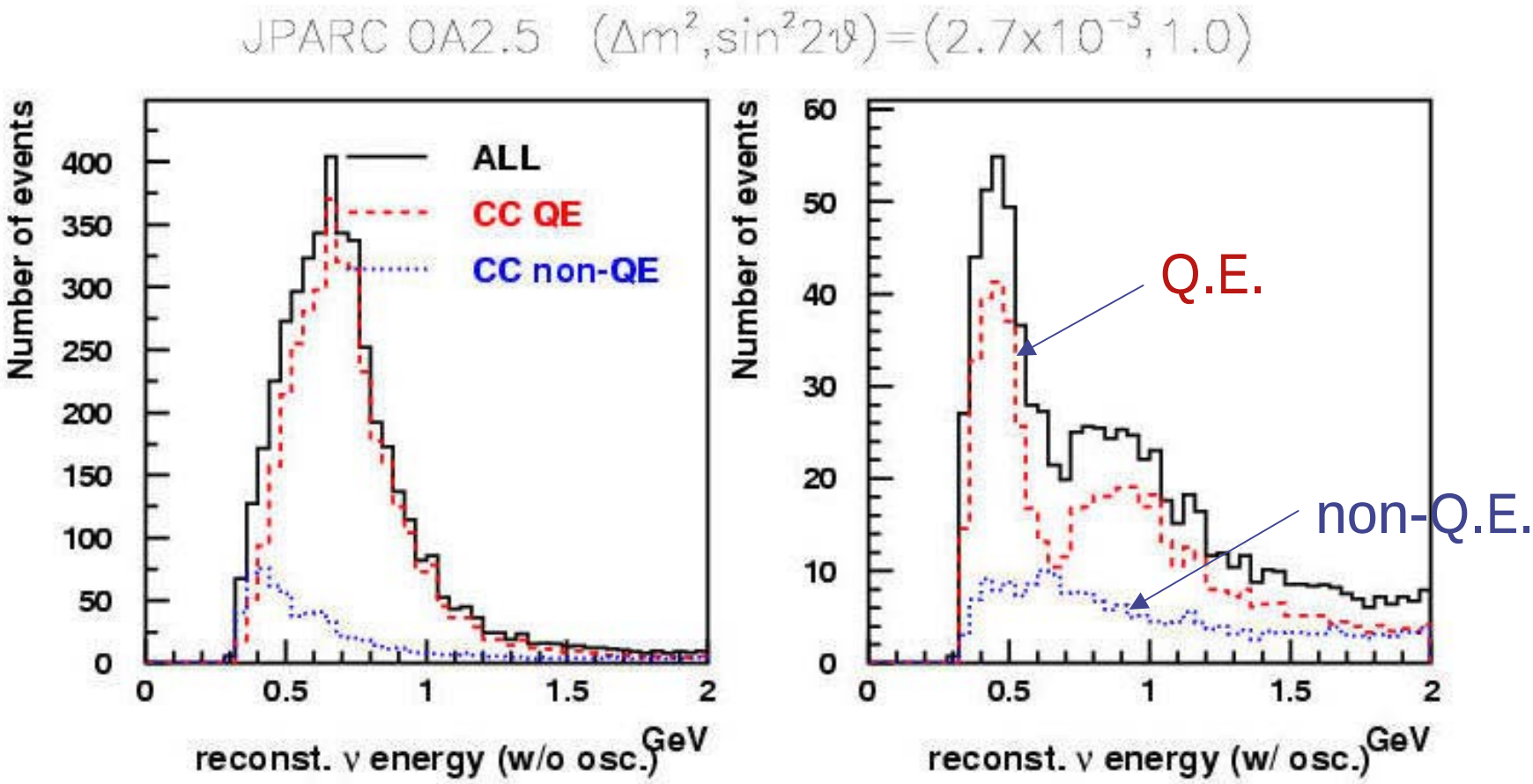
- JPARC off-axis 2.5° neutrino beam flux (ntuple supplied by ichikawa-san)
- full detector simulation and event reconstruction
  - based on old Neut4.3
- weighting method used to derive JPARC-expected energy spectrum @ SK
- Neutrino energy reconstructed with Pμ and scattered angle θ
- same cut criteria as used in LOI
  - FCFV 1-Ring μ-like
  - assumed 5 years run
- Allowed region was obtained based on chisqare of energy spectrum with 5% abs. flux error



ν Energy spec. @ SK

JPARC ν beam OA2.5°

ν_μ energy spectrum @ SK

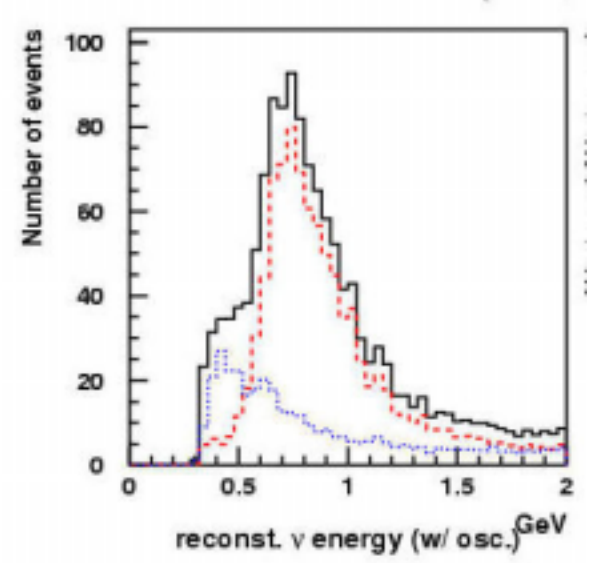


w/o oscillation

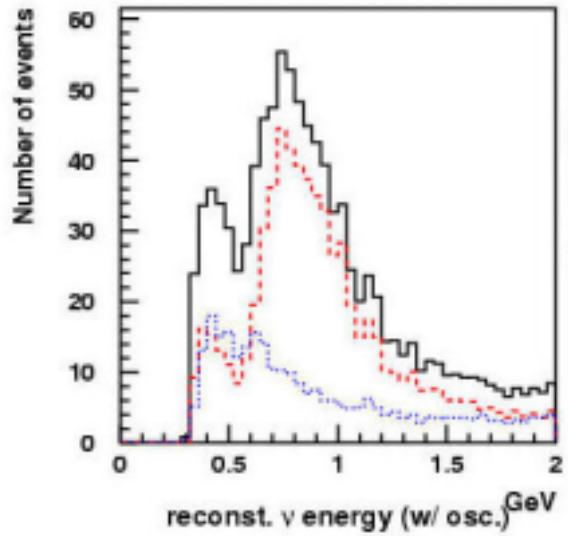
w/ oscillation

$(\Delta m^2, \sin^2 2\theta\mu\tau) = (2.7 \times 10^{-3}, 1.0)$

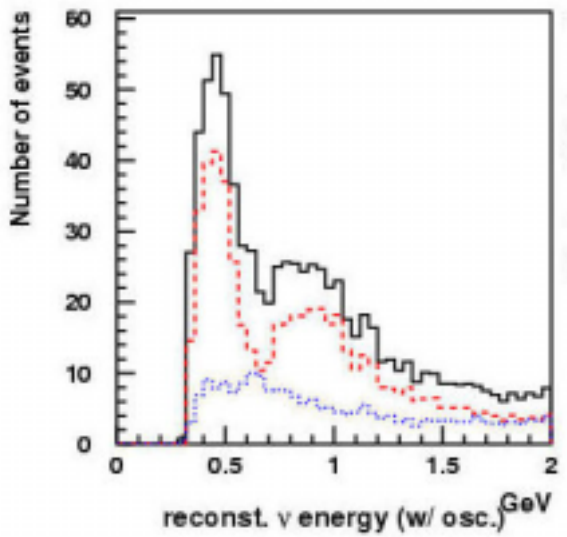
$(\Delta m^2, \sin^2 2\theta) = (2.0 \times 10^{-3}\ \mathrm{eV}^2, 1.0)$



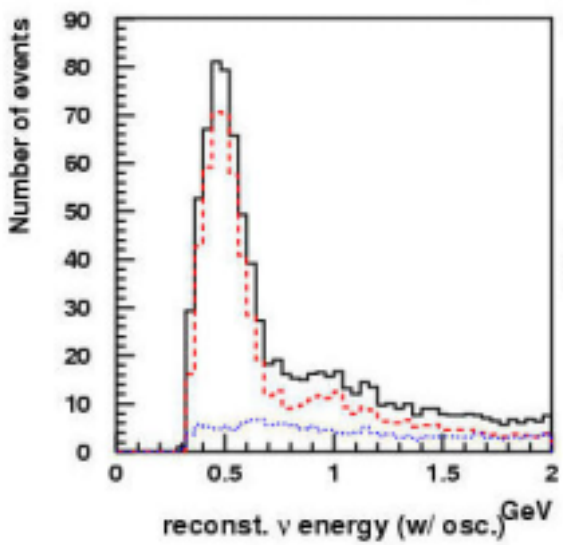
$(\Delta m^2, \sin^2 2\theta) = (2.3 \times 10^{-3}\ \mathrm{eV}^2, 1.0)$



$(\Delta m^2, \sin^2 2\theta) = (2.7 \times 10^{-3}\ \mathrm{eV}^2, 1.0)$



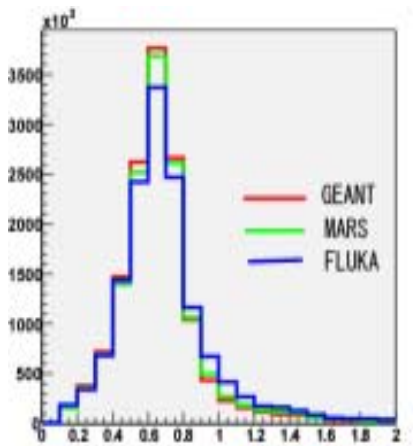
$(\Delta m^2, \sin^2 2\theta) = (3.0 \times 10^{-3}\ \mathrm{eV}^2, 1.0)$

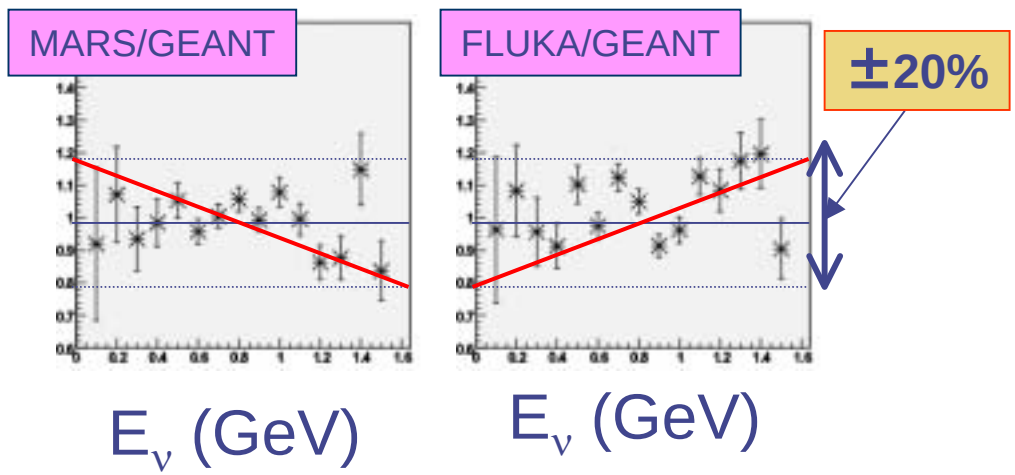


Systematic error sources

- absolute neutrino flux
  - assumed 5 % (default)
- non-QE/QE ratio
  - ±20 % (indendent on energy)
- Nuclear model
- model dependence of flux calculation
  - hadron model GEANT/MARS/FLUKA
  - assumed energy correlated error
    - -20% → +20% or +20% → -20% in E= 0 – 1.6 GeV
    - flat in E>1.6GeV

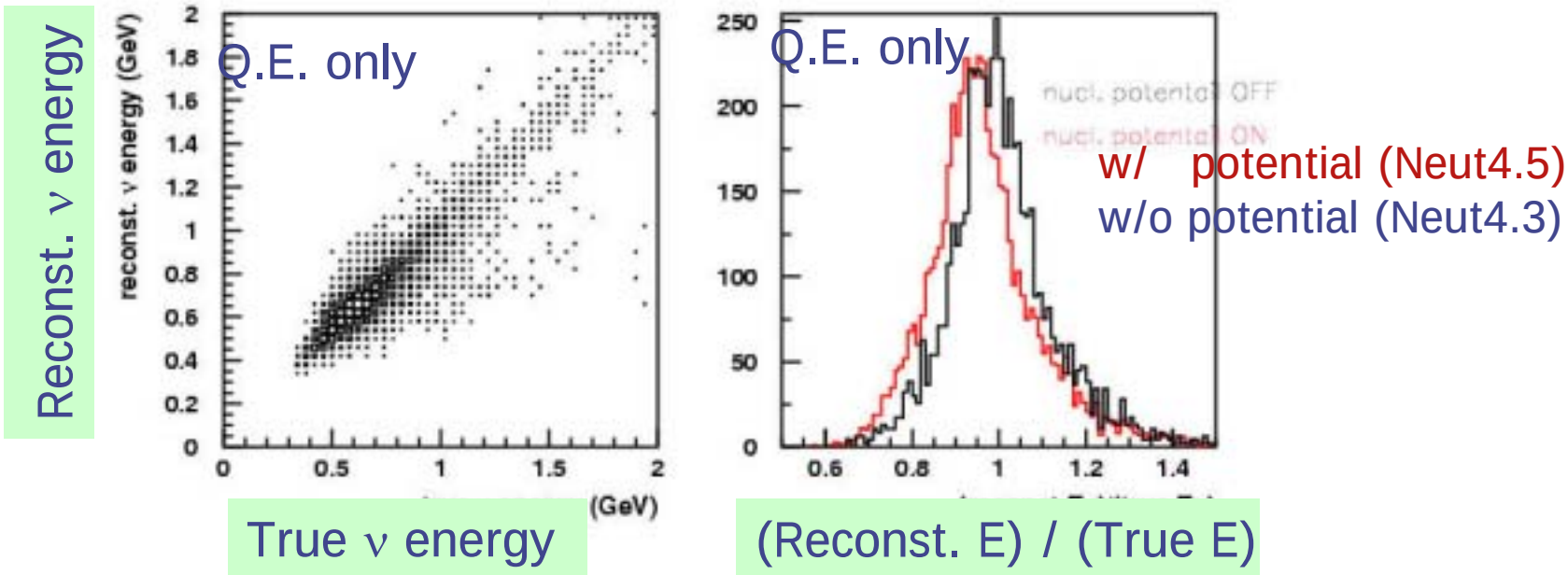
R.Ishida





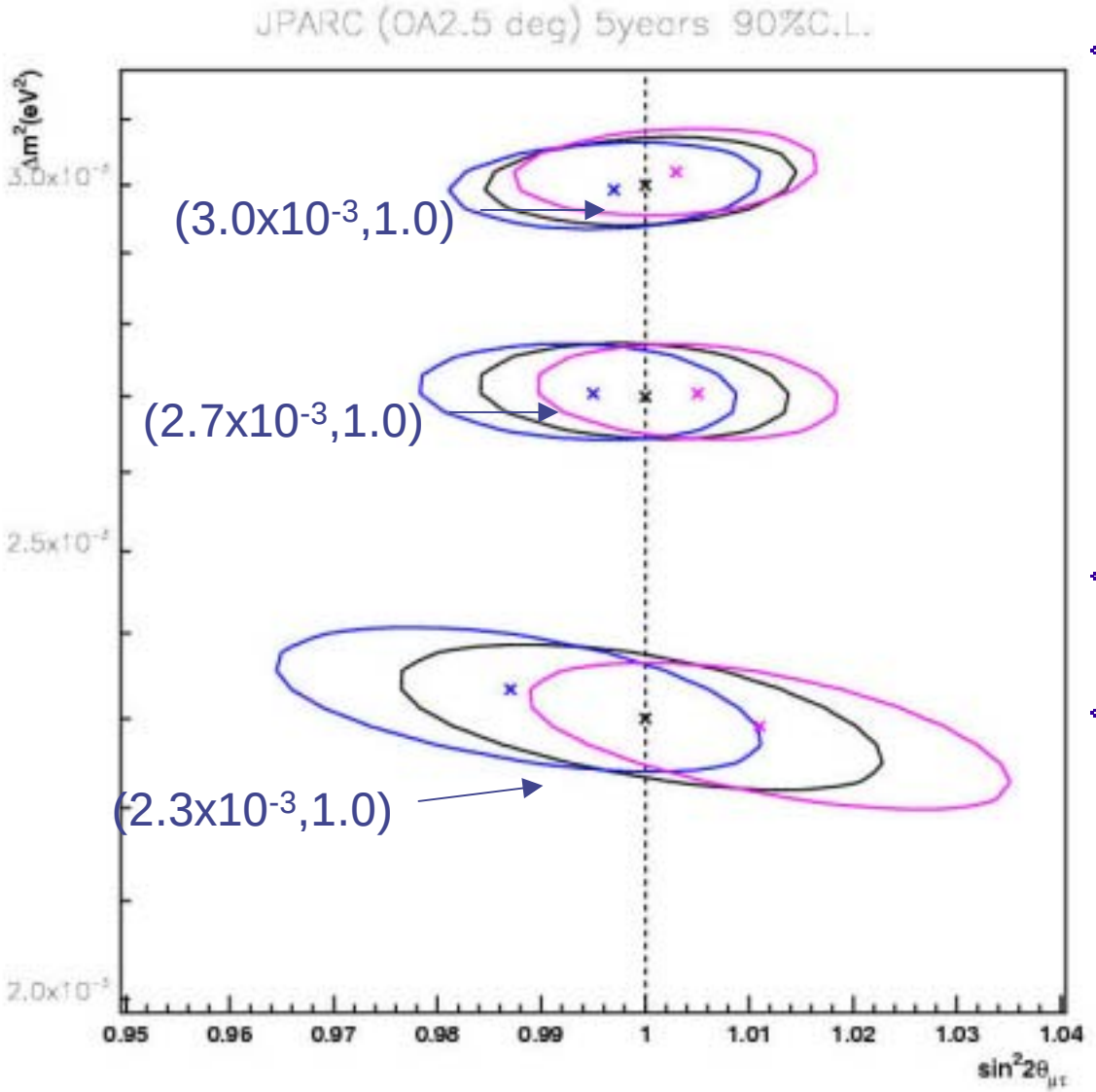
http://neutrino.kek.jp/jhfnu/CollabM/0305/kobayashi.hadrprod.ppt

Systematics in reconst. ν energy by nuclear potential



- Neutrino energy can be well reconstructed using leption Pμ and scattered angle
- However, uncertainty in nuclear model causes systematics in relation between true and reconstructed neutrino energy
  - inclusion of nuclear potential reduces leption momentum
- ~4% error in neutrino energy estimated between w/ and w/o nuclear potential (25MeV)

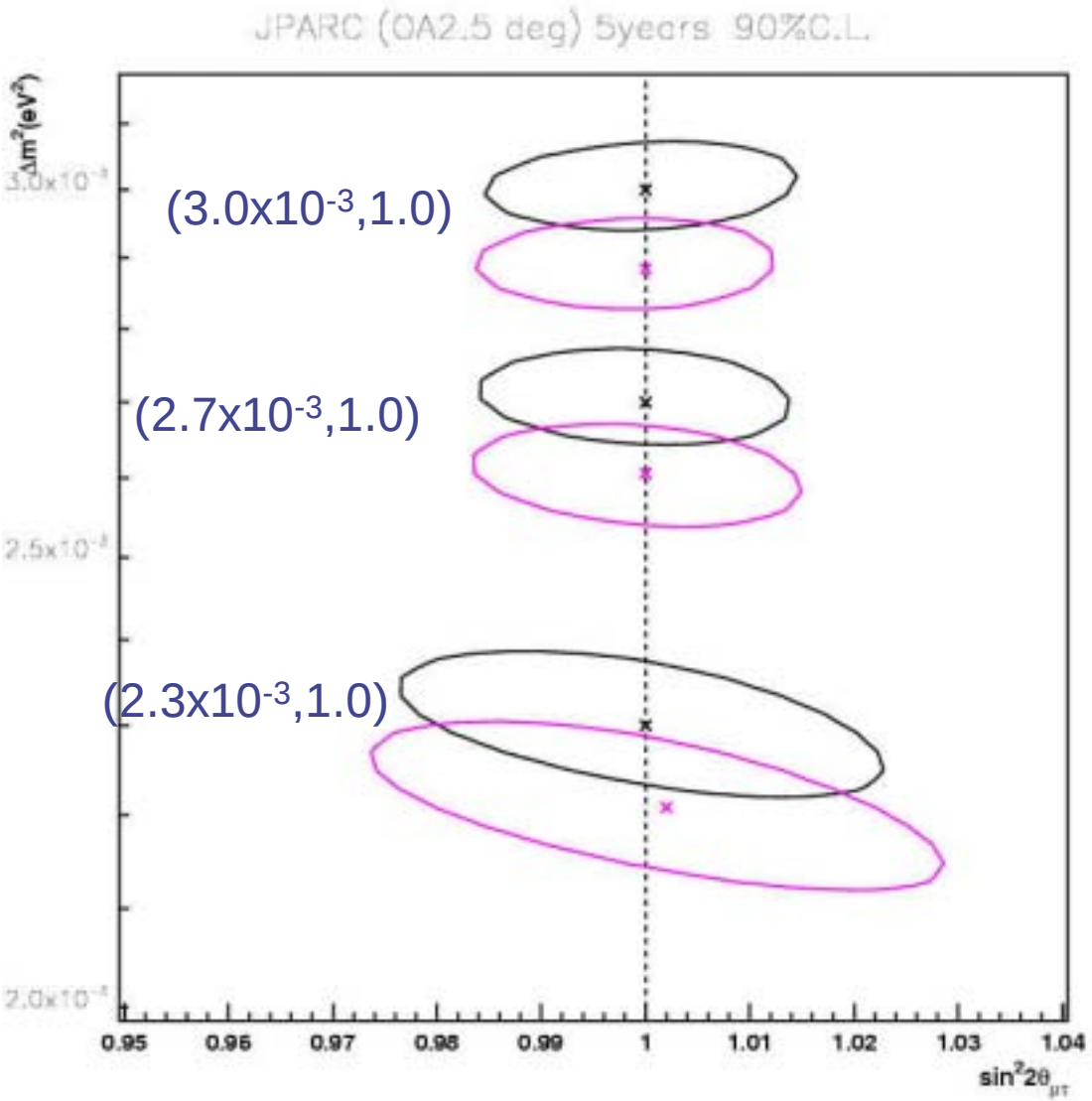
Effects by non-QE/QE ratio uncertainty



- Systematic error in non-QE/QE ratio added by 0%, +20%, -20% and obtained how allowed region affected
  - 0 % (black)
  - +20 % (purple)
  - -20 % (blue)
- abs. flux error (5%) included in all case
- Allowed region obtained for each Δm^2
  - 3.0x10-3 eV2
  - 2.7x10-3 eV2
  - 2.3x10-3 eV2

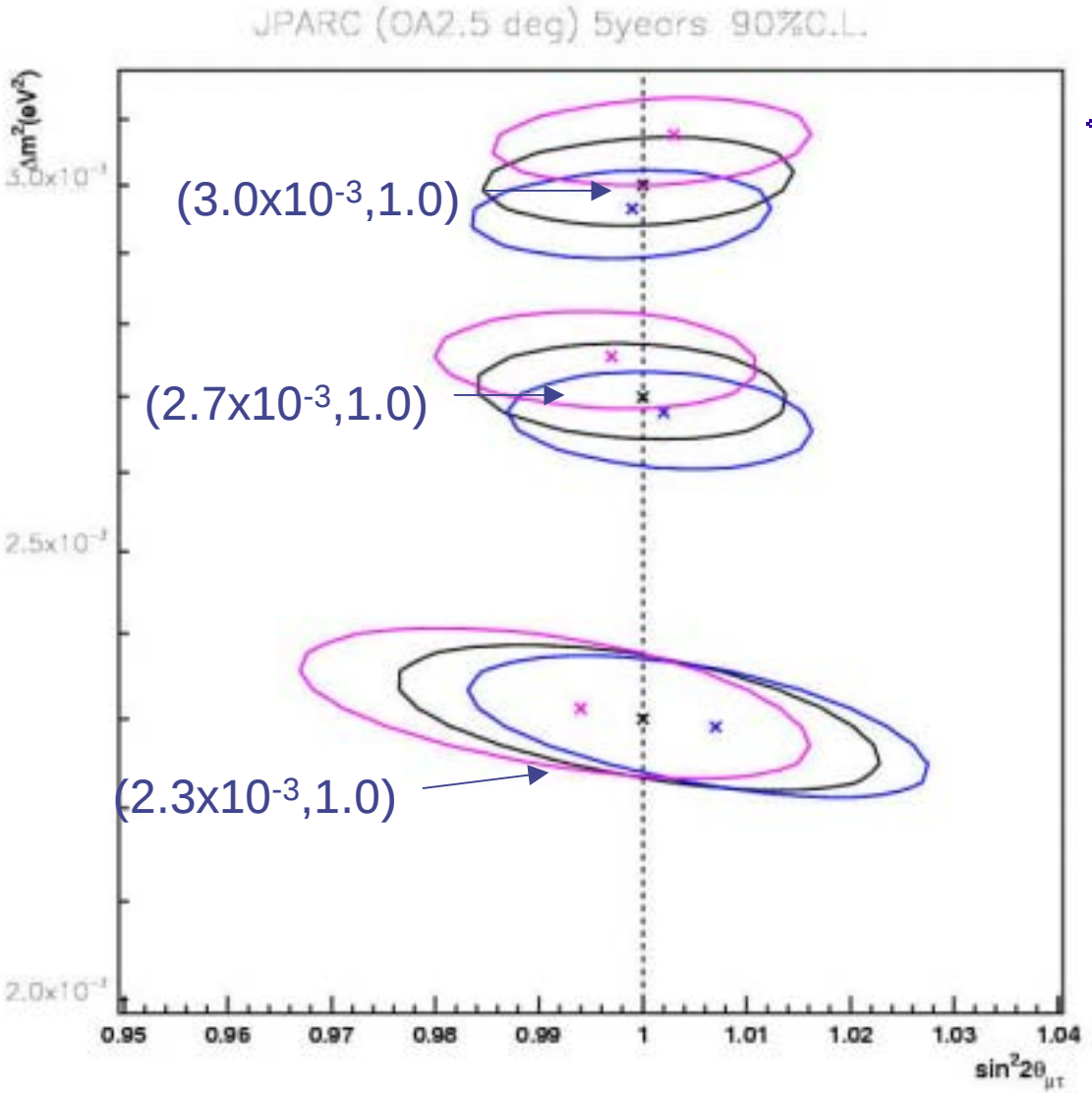
($\sin^2 2\theta\mu\tau=1$)

Effects by nuclear potential



- ~4% systematics expected by uncertainty of nuclear model
- Systematic effect was investigated for
  - no error (black)
  - 4% shifted in energy scale (purple)

Effects by hadrom model uncertainty



- hadron model uncertainty included
  - 0% (black)
  - +20% → -20% (blue)
  - -20% → +20% (purple)

Summary

- Effects on $\nu\mu$ disappearance allowed region, caused by some systematic error sources, were estimated
  - non-QE/QE ratio
  - hadrom model
  - Nuclear potential

- Systematic error could be a large effect for precise measurement of oscillation parameters
  - 0.003~0.01 in $\sin^2 2\theta_{\mu\tau}$ and ~0.1×10^{-3} in Δm^2, (depending on true Δm^2)

- We need to study how much these systematic errors can be reduced with 2km detector