5/31/01
@JHF-SK nu WS

Near detector at 280m from a target

T. Nakaya (Kyoto Univ.)

1. Introduction
2. Detectors
3. Summary

1. Introduction

Purpose of a near detector.

① Measure the quality of neutrino beam.

② Give a constraint to estimate the neutrino flux and the energy spectrum at Kamioka site (or Super-K).

③ Study neutrino interactions to estimate background events for oscillation analysis.

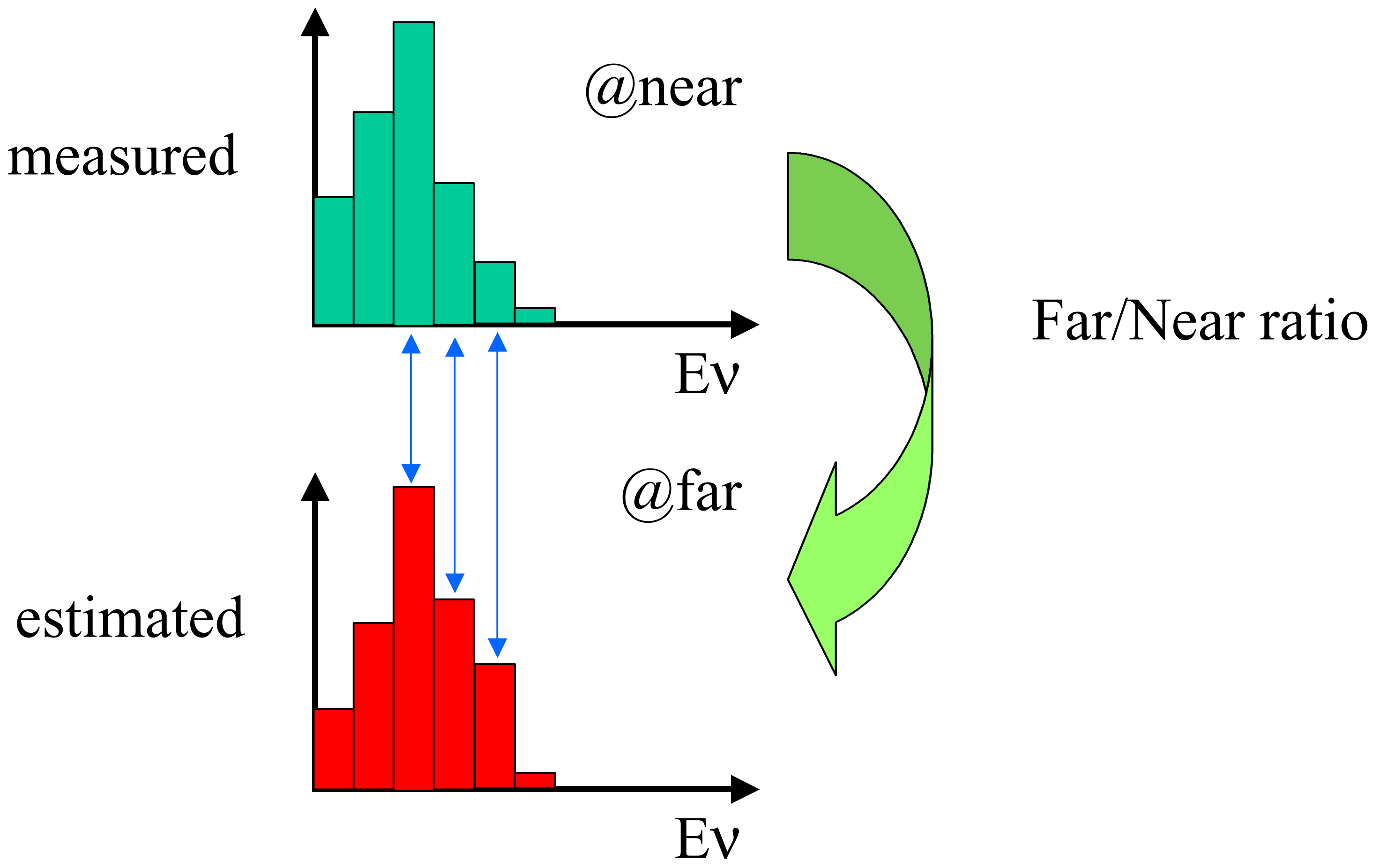
Measurements of the ν beam at the near detector.

1. Direction
2. Flux / Spectrum for ν_μ and ν_e
3. Profile
4. Stability
5. Event types (QE, single μ, NC π0 etc..)

Physics Requirement

- ν_μ disappearance
  - Precise estimation of ν_μ spectrum at SK.
  - μ energy spectrum in neutrino interactions for various interaction channels (simply QE vs non-QE, π background to fake μ, …).
- ν_e appearance
  - π^0 yield and the momentum distribution as a function of ν energy.
  - Beam ν_e contamination.
  - High energy tail of ν_μ spectrum (for BG estimation)?
- ν_τ confirmation or search for ν_s
  - NC cross section as a function of ν energy.
  - High energy tail of ν_μ spectrum

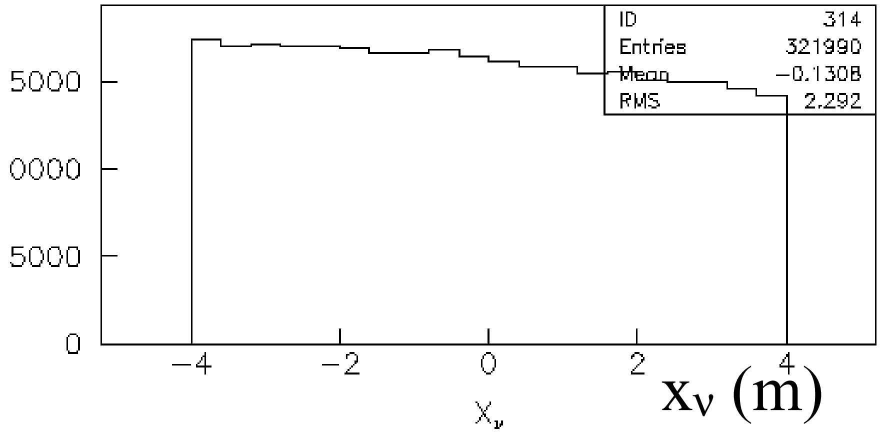
Spectrum extrapolation

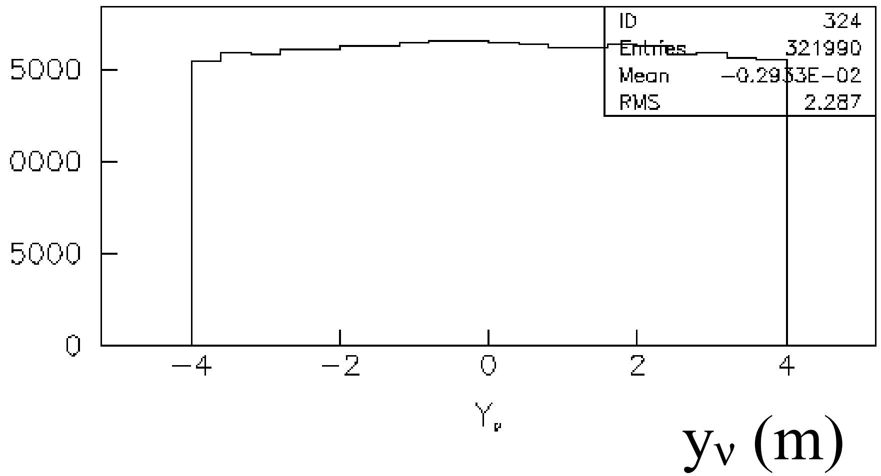


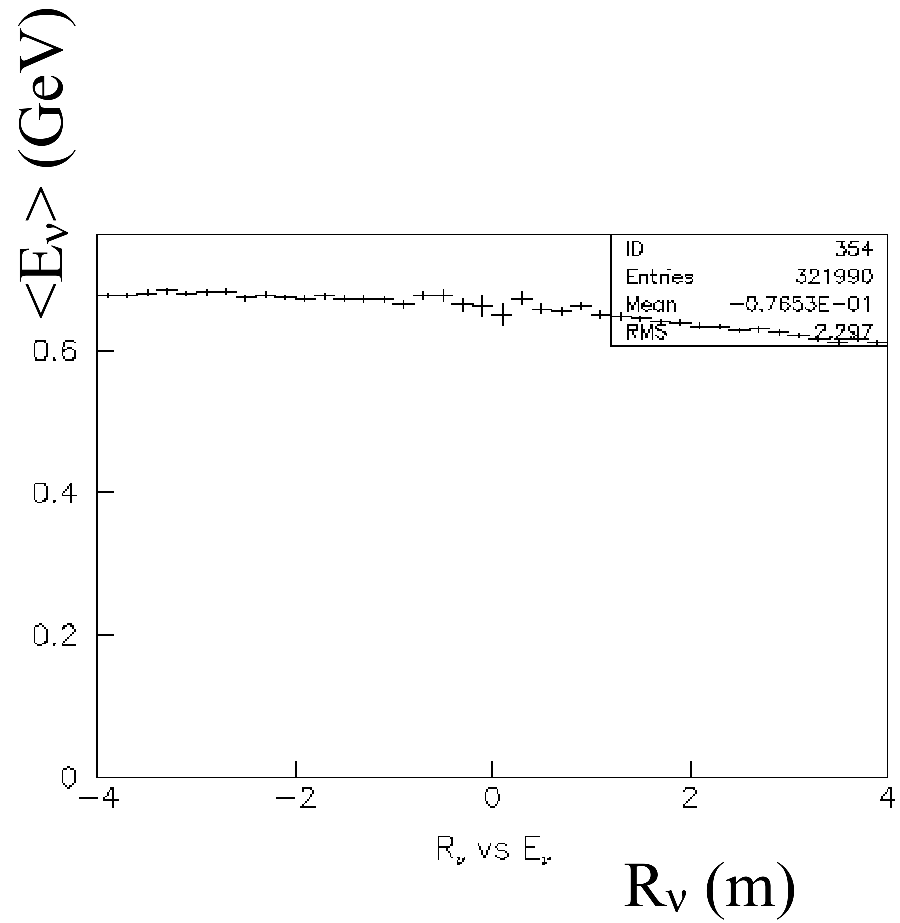
2. ν detector

1. Measure ν flux and the spectrum as a function of (x,y).
   - A constraint to the "far/near ratio"?
2. Rate: ~5.6 events/spill/100ton (for OAB, NBB is ~1/3)
3. $\delta\Delta m^2 = 1 \times 10^{-4} \Leftrightarrow$ 24 MeV ν energy.
4. A water target or a water detector is necessary.
5. An example: Liquid Scintillator Tracker (for K2K upgrade)
6. Muon detector
   - To measure high energy muon up to a few GeV.

NBB1.5 profile and the energy dependence at FD

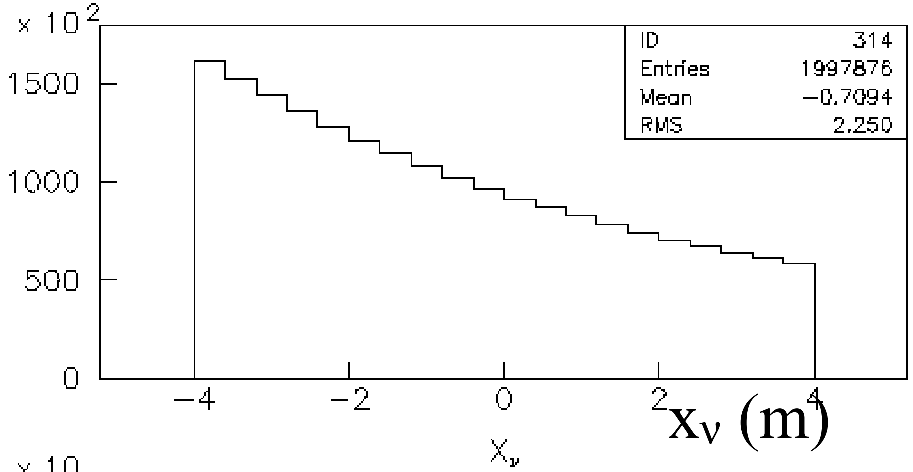


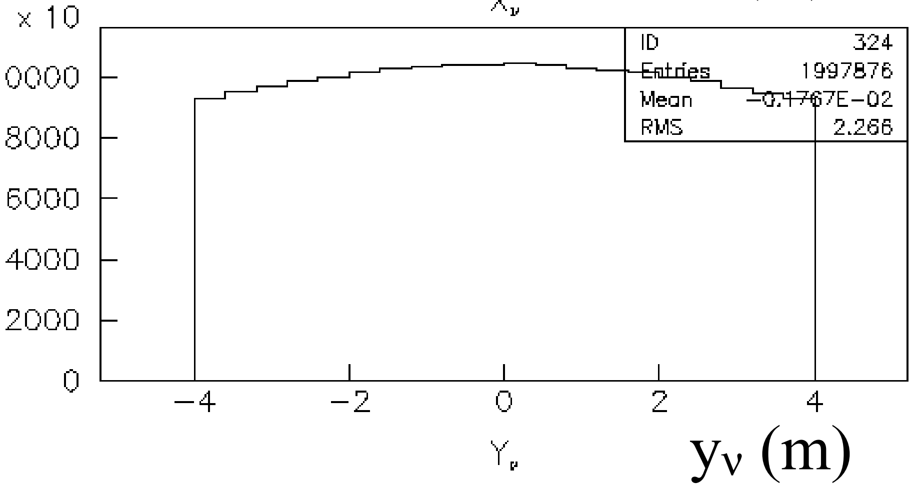


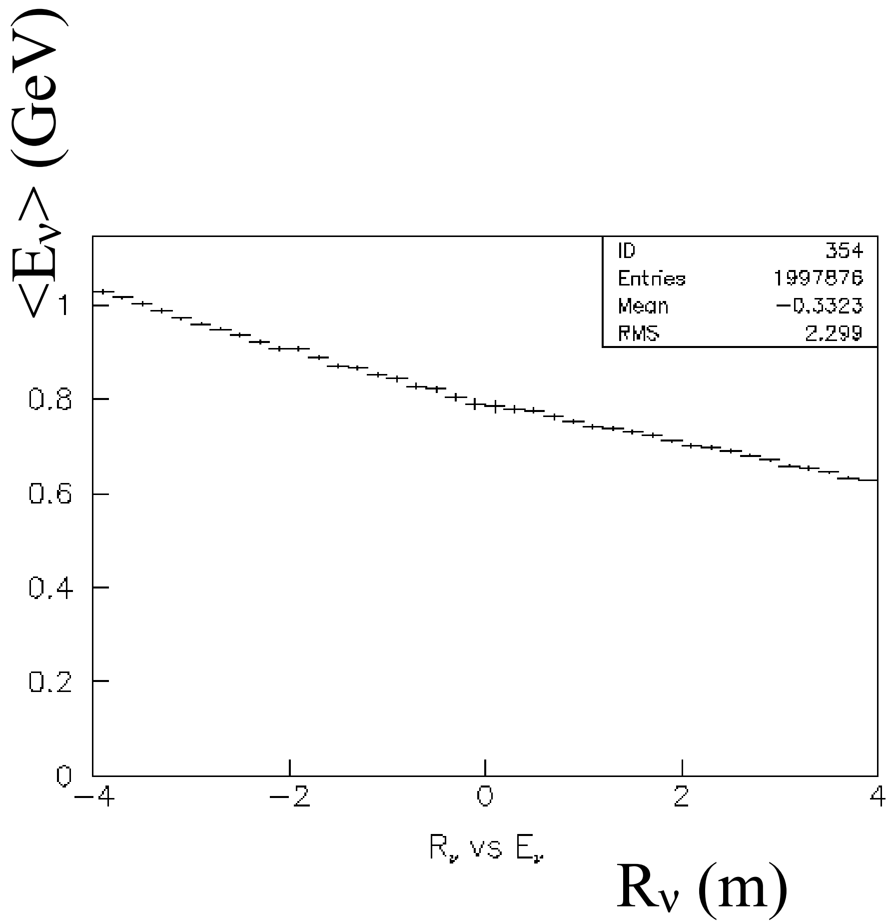


$$R_i \equiv sign(x_i)\sqrt{x_i^{\ 2} + y_i^{\ 2}}$$

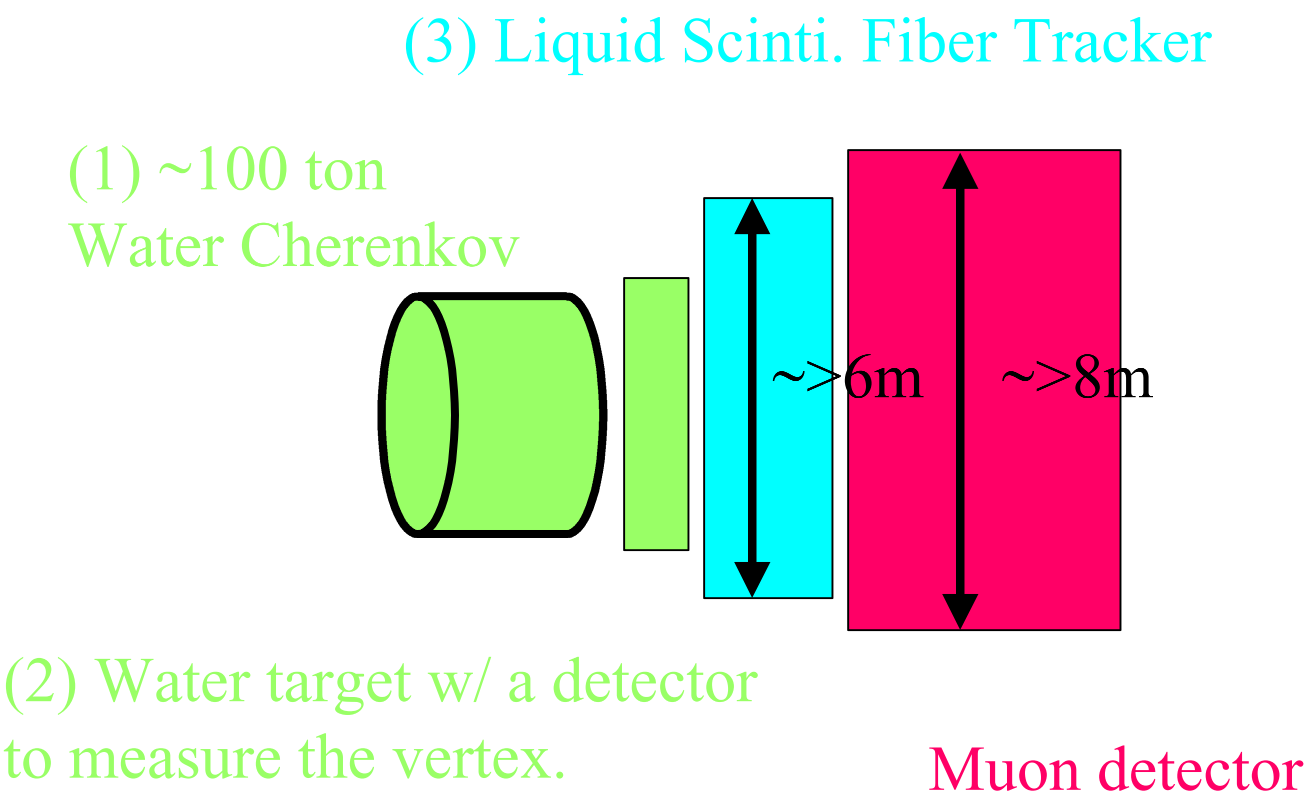
OAB2 profile and the energy dependence at FD







One idea of ν detector

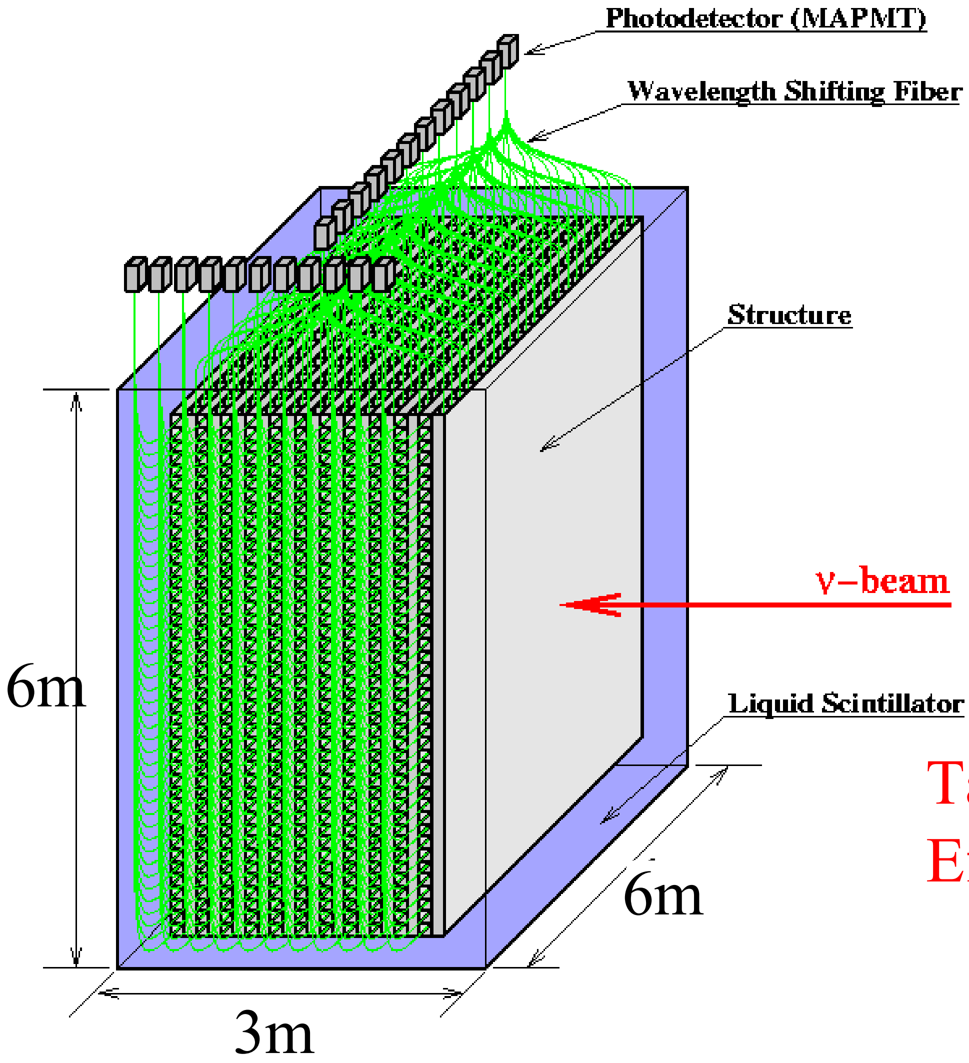


- (1) 100 ton Water Cherenkov detector
  - For π^0 and NC measurement.
  - High rate capability is not good (**only work for NBB or in the lower intensity.**).
  - Position dependence vs neutrino energy for OAB?
  - Fiducial Volume error?

- (2) Water target w/ a detector to measure the vertex.
  - Compare the water target to the carbon target.
  - Vertex position has to be determined.

(3) Liquid Scintillator WLS-Fiber Tracker

- The detector is sensitive to low energy ν (Eν > 500 MeV).
- High rate capability with fine segments.



<PE>=20~30PE/cell

1 cell = 2 × 2 × 600cm^3

Particle ID:

π/p : dE/dx

π/μ : range

Fully active.

Target is mainly Carbon.

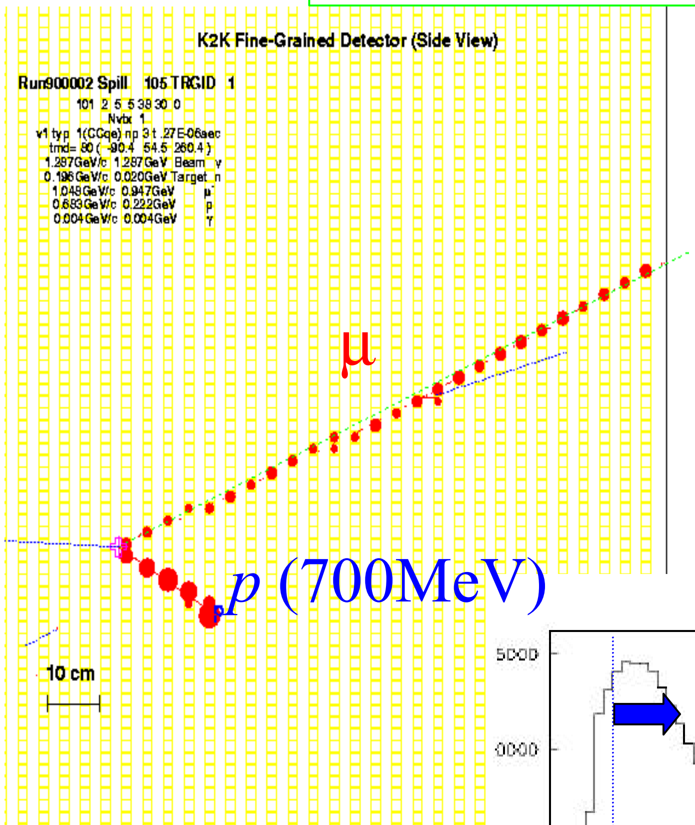
Efficiency for π^0 has to be studied.

Event Display (side view)

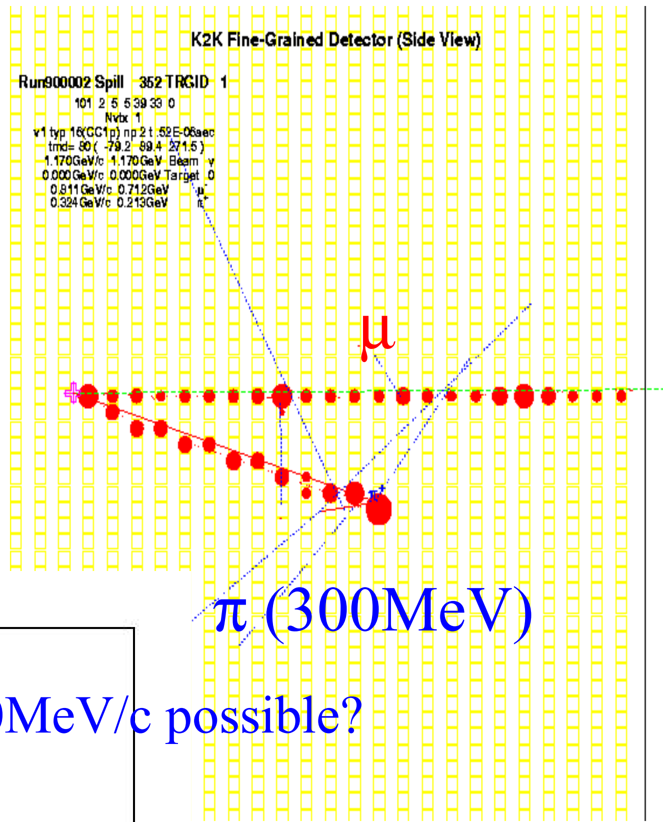
CC QE event

$$E_i = \frac{m_N E_i - m_i^{\,2}/2}{m_N - E_i + p_i \cos\grave{e}_i}$$

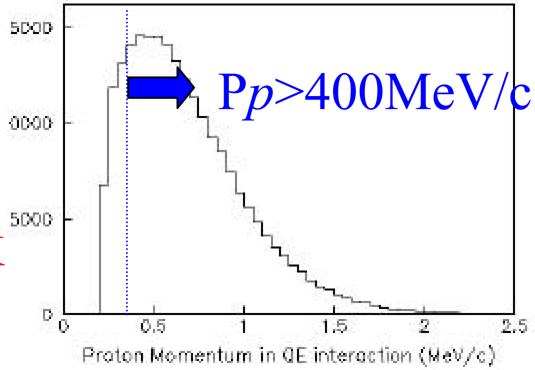
CC 1π event



p (700MeV)



π (300MeV)



P*p*>400MeV/c possible?

#2track > #1track

(4) Muon detector

- The similar one as K2K will work for NBB.
  - For OAB which has more high energy tail, we need to detect high energy neutrinos to estimate the background events.
- It is difficult to measure higher energy muons (>5GeV/c (4m Fe)) without a magnet.

  ⇒ High rate capability with segmentation.

NBB & OAB (without a detector @ a few km)

- With OAB, we need **another detector** at the position of 0 degree for OAB ($\rightarrow$ 10m away from the NBB center).
- The ν yield of NBB as a function of π energy might be proportional to the π production.

  ⇒ a reliable estimation of π production for OAB?
- NBB energy scan could be crucial to
  - measure the π yield for OAB
  - measure the ν cross section at FD
    - NC cross section, π^0 cross section
    - QE and non-QE response – μ spectrum.

If a detector is at a few km

- Measure the spectrum at a few km.
  - Near/Far ratio is flat.
- At 280m,
  - we measure the neutrino beam profile only.

3. Summary

- To make a proposal, we need to fix the designs of the near detectors.
  - We have to study the estimation and the validation of the far/near ratio with the measurement at FD.
  - We have to study how to measure NC and π^0 which might require a water cherenkov detector.

    ⇒ a detector @ a few km.
  - Systematic study for NBB energy scan.

Homework by the next workshop?