

Secondary beam monitoring system for JHF-Kamioka neutrino experiment

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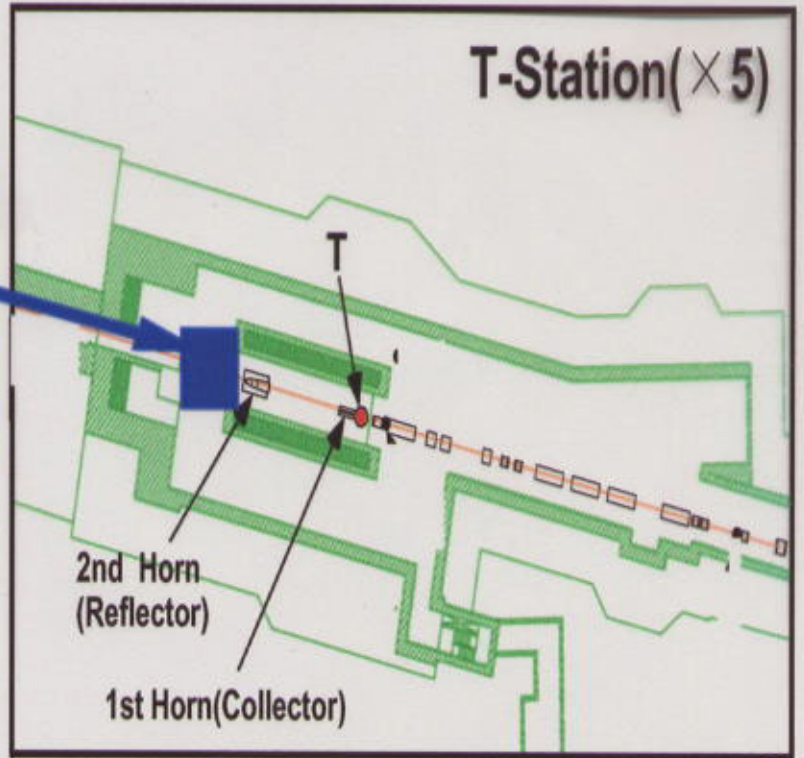
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1. In the case of K2K experiment
2. JHF case
 - a. Goal
 - b. Ideas
3. Summary

Secondary beam monitors

Pion Monitor

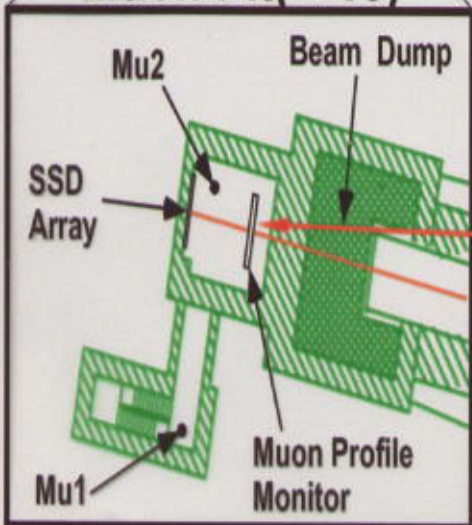
ν Energy Spectrum
 ν Flux Ratio
(ϕ_{SK} / ϕ_{near})
Prediction



To SK

Muon Monitor

Muon Pit($\times 10$)



Direction of ν spill by spill

0 100 m

Muon monitors

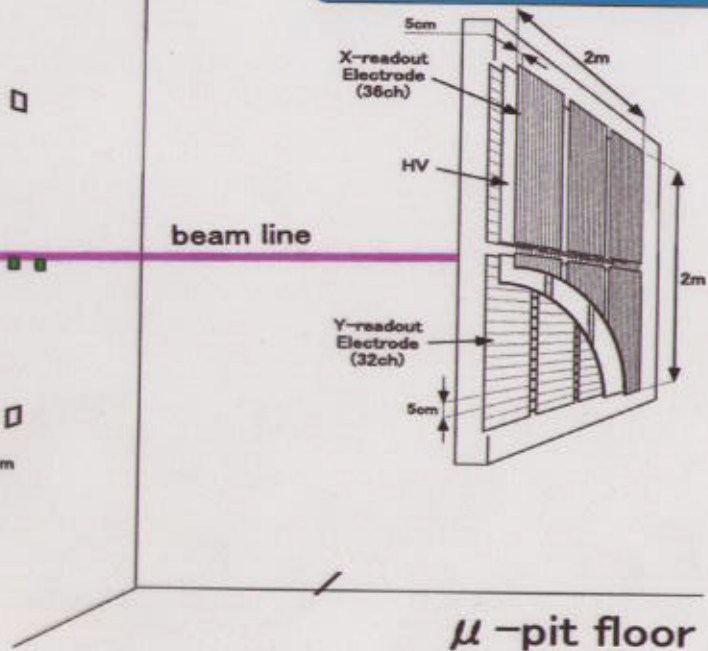
Large area Ionization chamber
Silicon pad detectors

- Measure **muon profile** after beamdump spill by spill
- monitor the **direction** of the beam indirectly

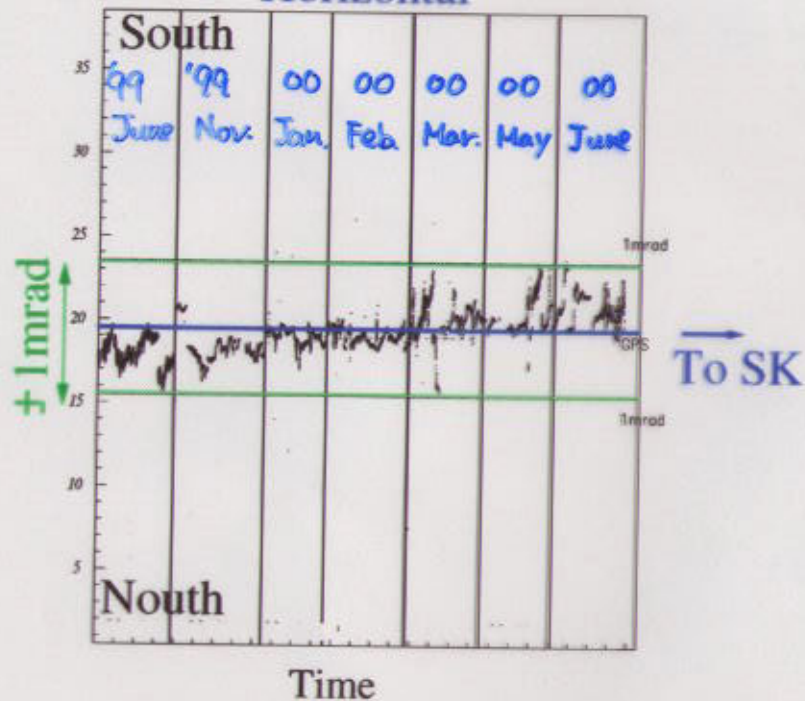
Silicon pad detectors



Ionization Chamber (2m x 2m)



Horizontal

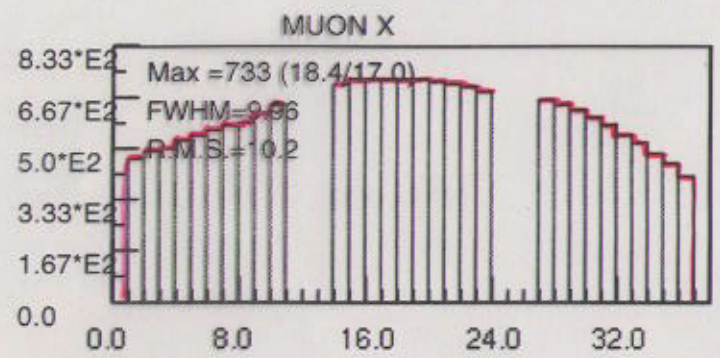


Spill by spill information
→ For beam steering

Horizontal

Date Sat Jan 27 18:51 JST 2001

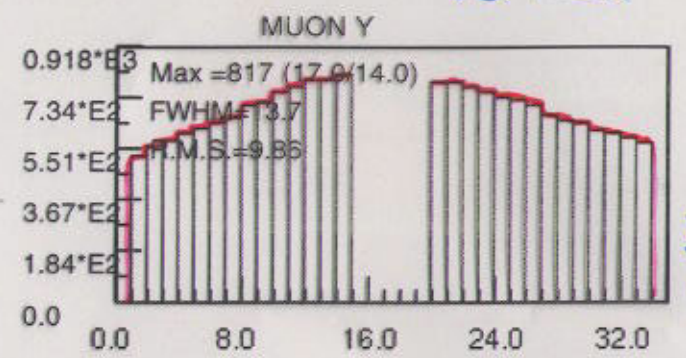
vertical



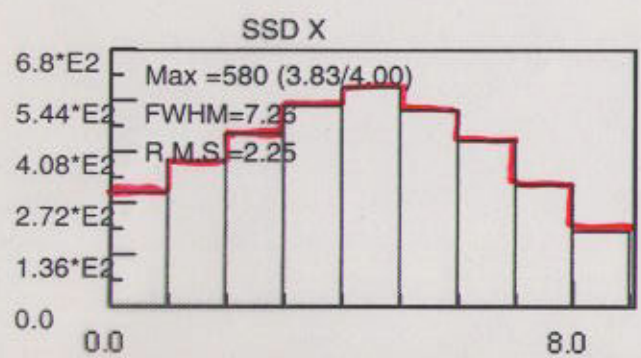
Ion chamber

Data Plot:
 Spill_by_Spill
 Accumulate

Display:
 RESET
 HOLD
 UNHOLD



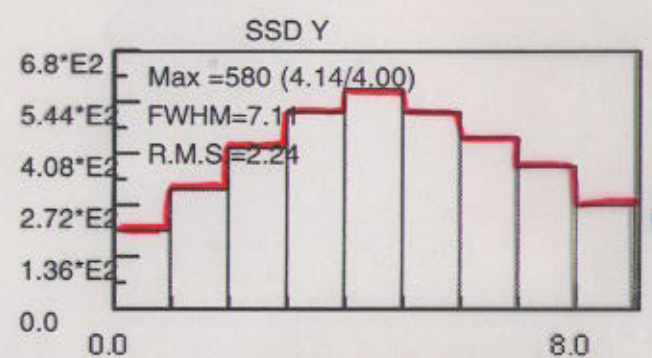
Ion chamber



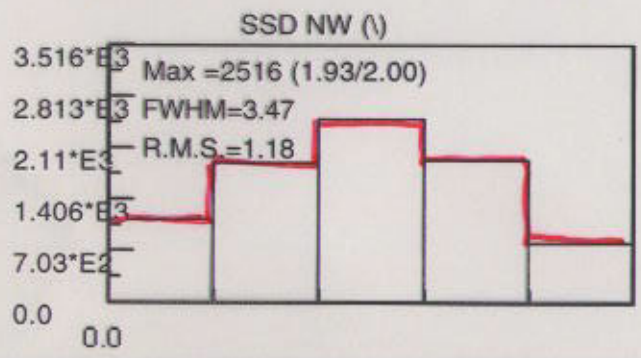
Si (.....)

Data Plot:
 Spill_by_Spill
 Accumulate

Display:
 RESET
 HOLD
 UNHOLD



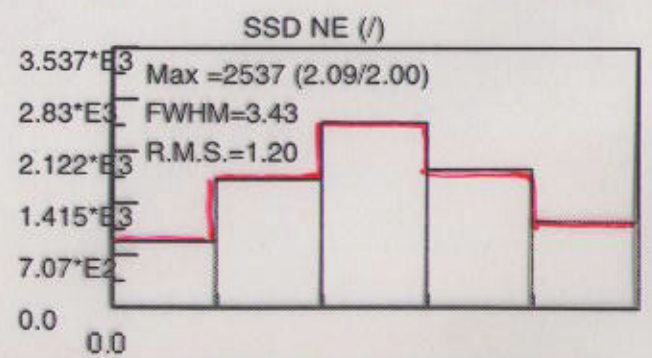
Si (.....)



Si (.....)

Data Plot:
 Spill_by_Spill
 Accumulate

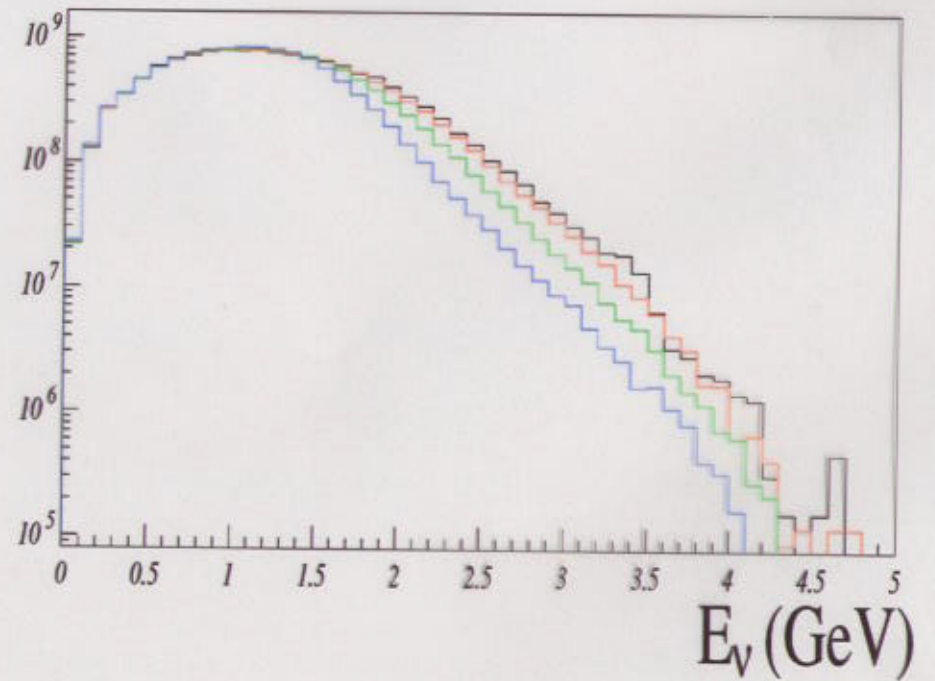
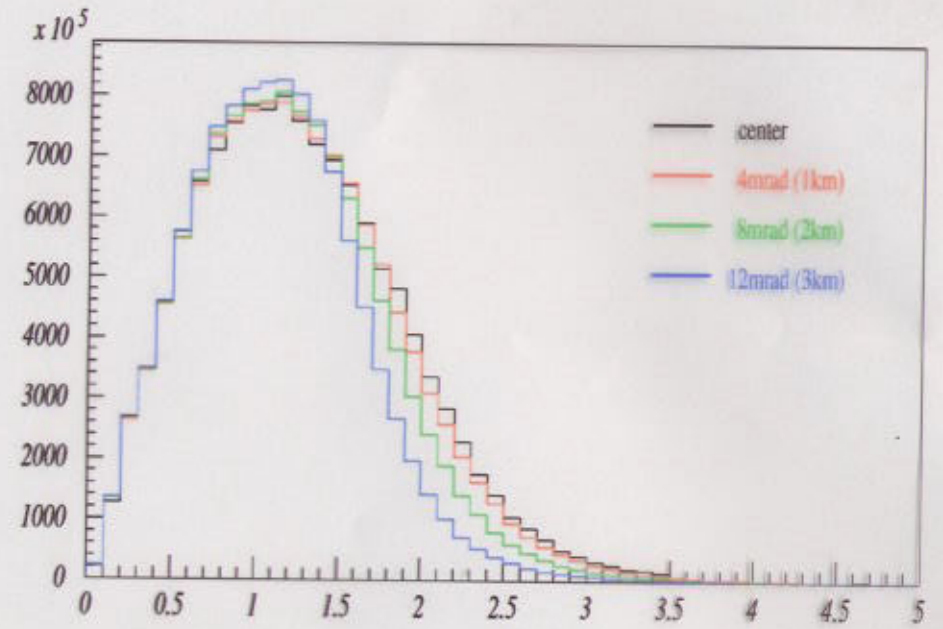
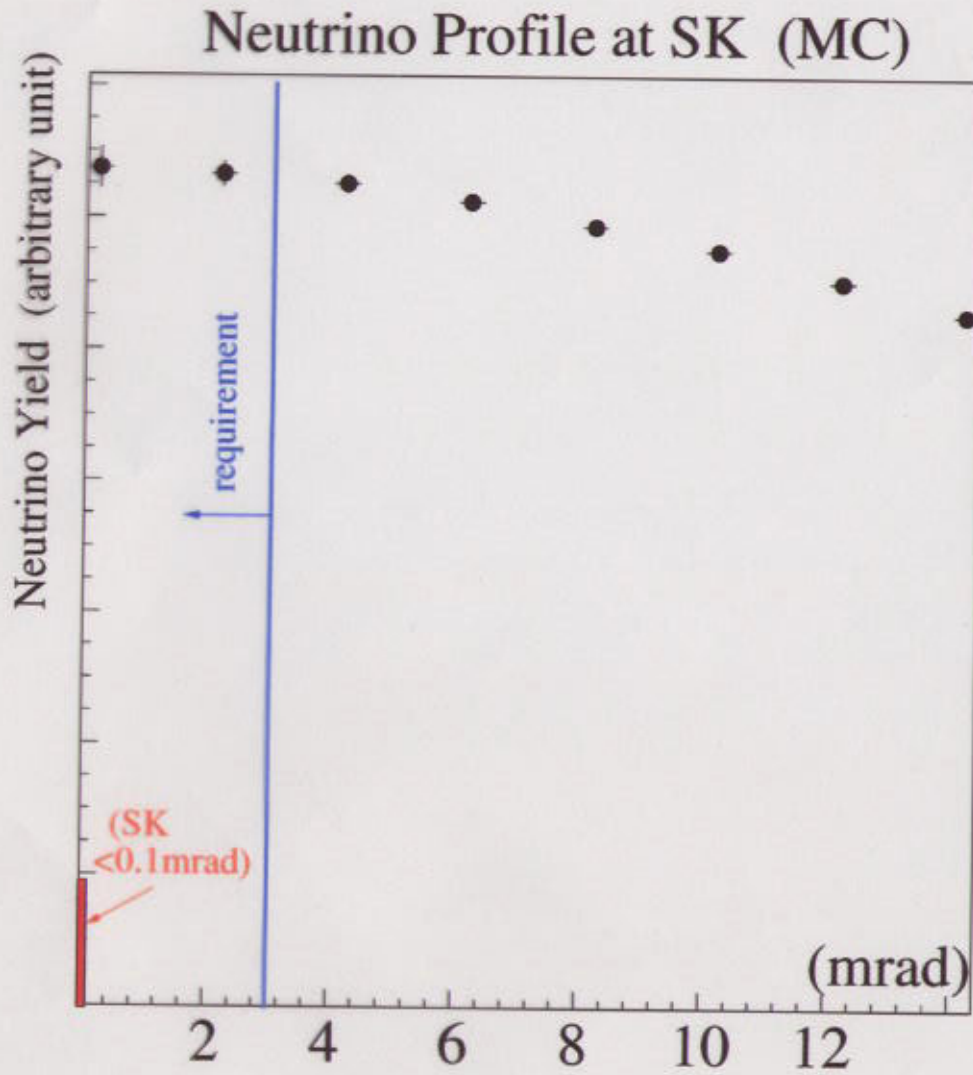
Display:
 RESET
 HOLD
 UNHOLD



Si (.....)

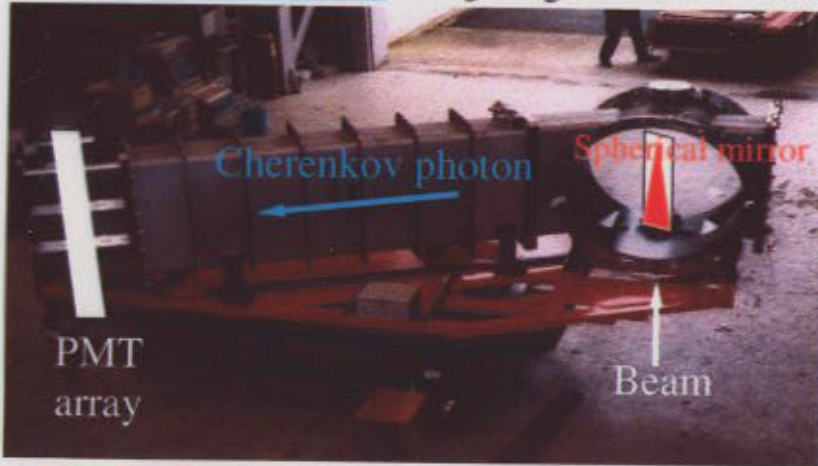
typical profile (μ monitor @ k2k)

3. Neutrino Beam Properties - 5



5. Expected number of Neutrino Events at SK - 3

Pion monitor Ring image Cherenkov counter

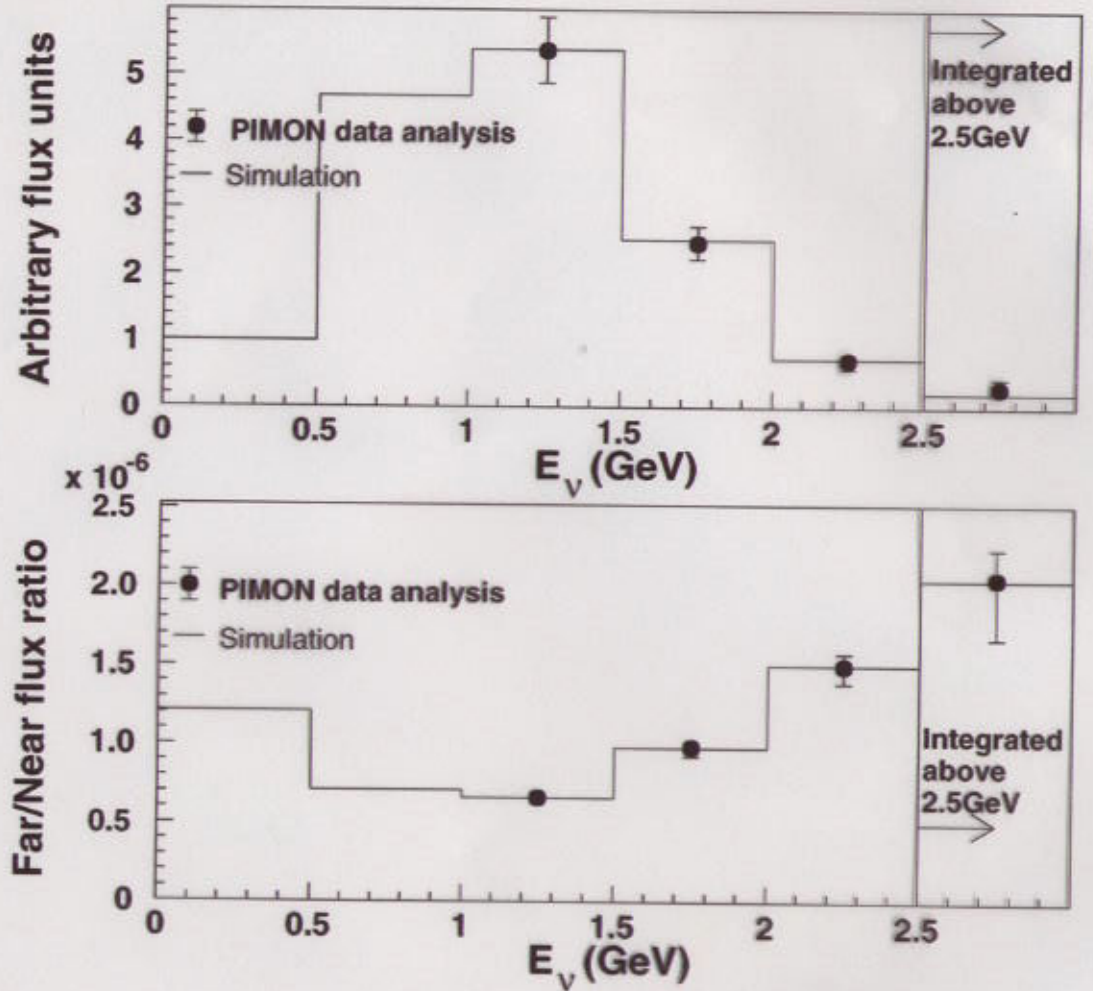


to reduce the uncertainty of pion production

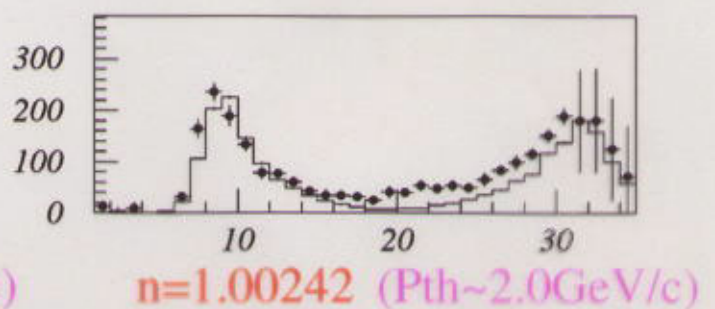
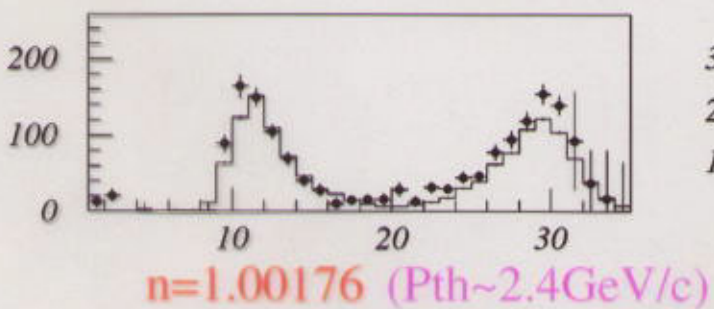
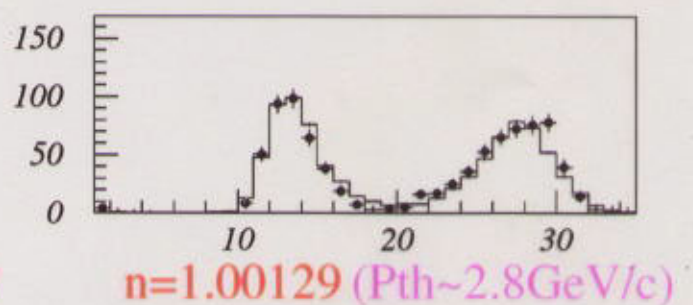
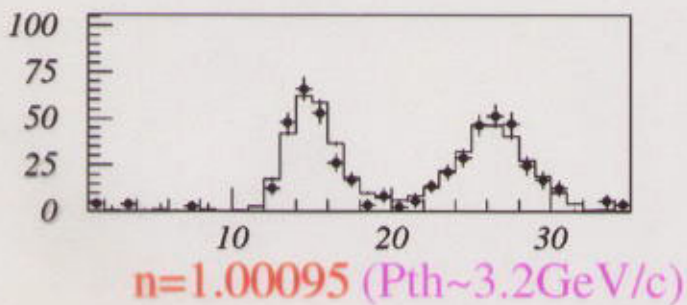
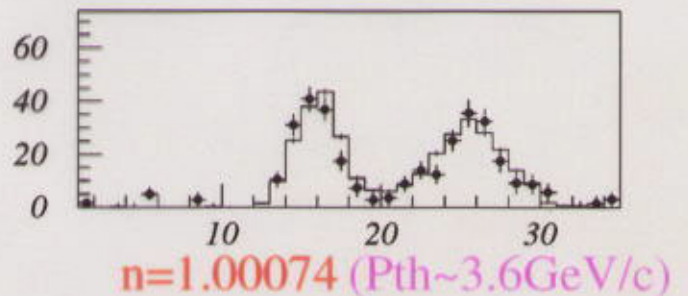
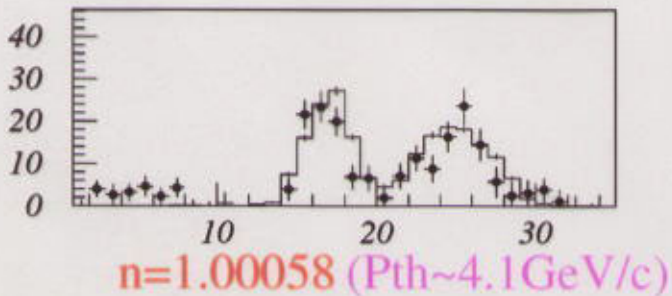
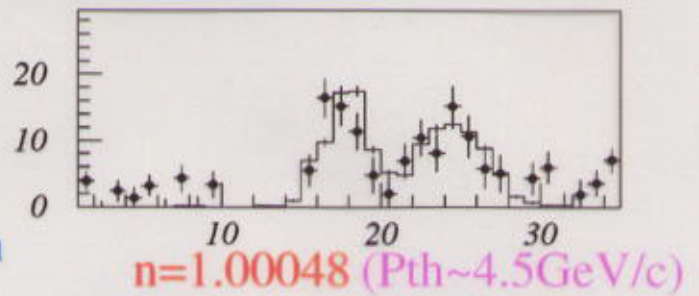
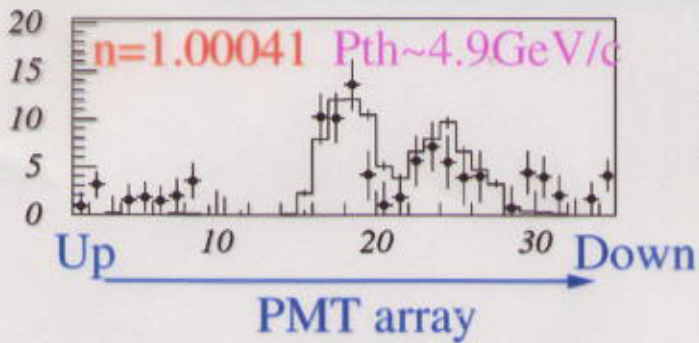
Measure **pion momentum** just after
pion angle **Horn/Target system**

+ well known decay kinematics
 + well known decay volume

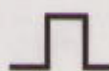
Predict **neutrino energy spectrum** at KEK
 at SK
flux ratio (Far/near)
 as a function of the neutrino energy



Comparison of Cherenkov photon dist. between meas. and MC



Data



MC used in K2K analysis

Goal of JHF secondary beam monitors

● Very crucial for experiment

○ Important

⊙ Crucial for experiment

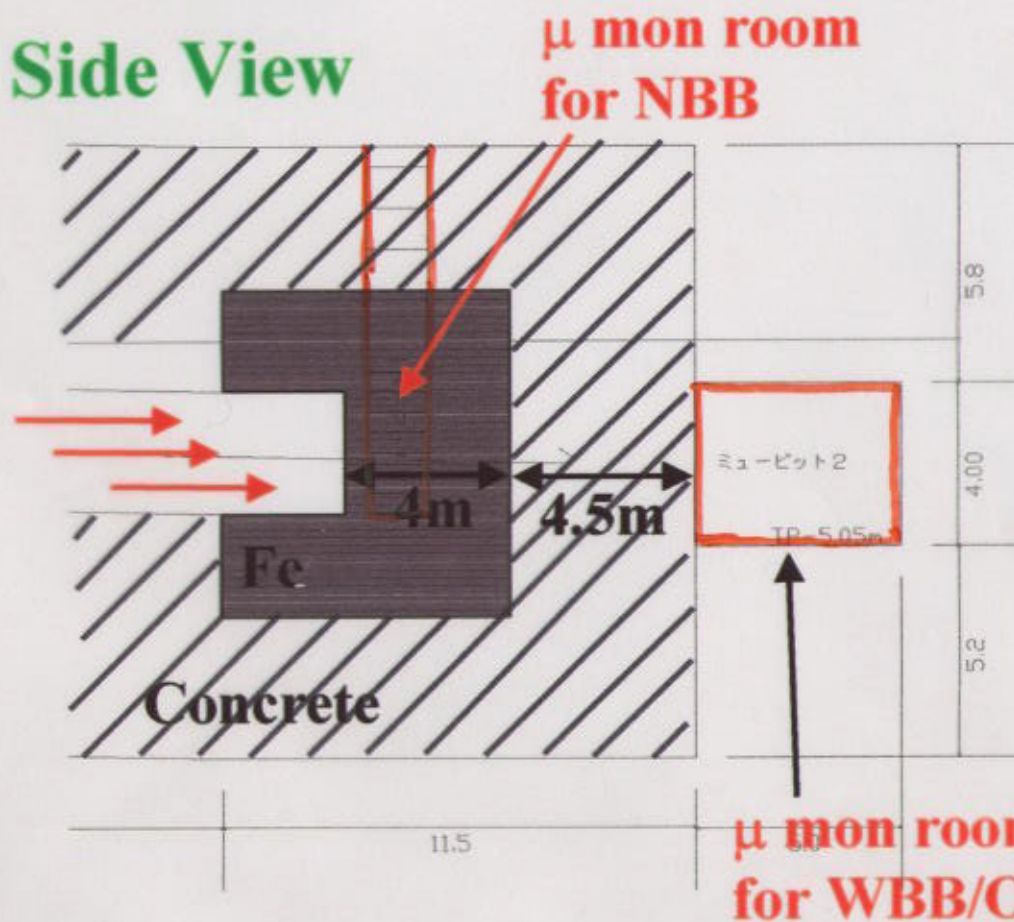
? Search for possibility

× Need noble ideas

	WBB	NBB	OAB
μ monitor			
Beam Direction	⊙ (steering) (stability)	⊙ (steering) (stability)	● (steering) (stability) (direction)
Beam Intensity	○	○	○
Pion kinematics meas.	?	?	?
π monitor			
Pion kinematics meas.	×	?	×

Beam Dump & μ monitor room

Side View



For WBB/OAB

50GeV p comes

→ thick shield

Fe:4m, Conc:4.5m

→ Only $\mu > 8.4\text{GeV}$

reach μ mon. room

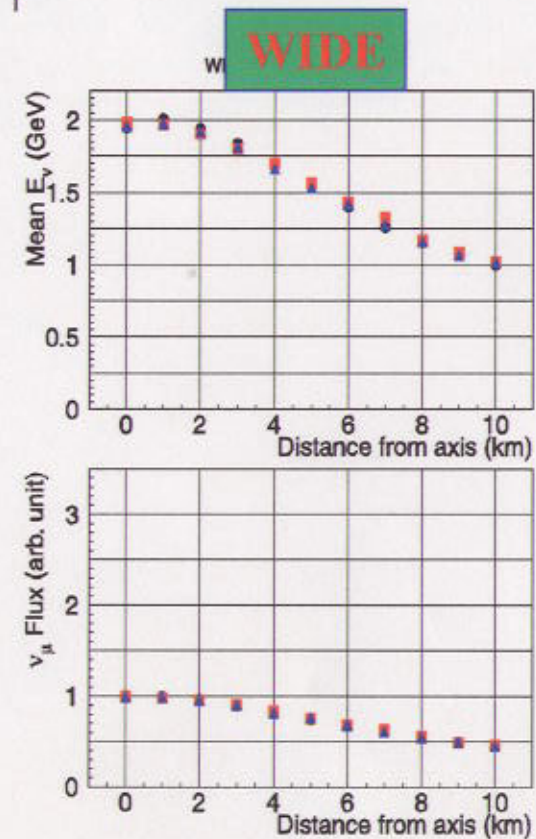
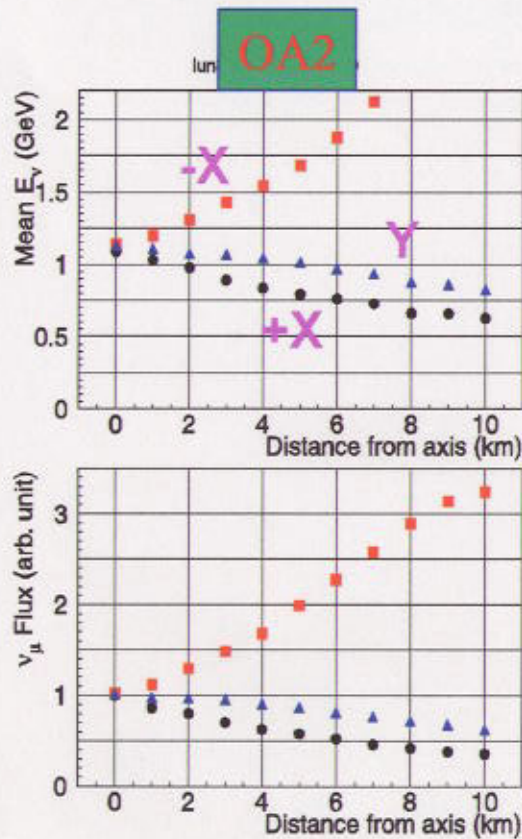
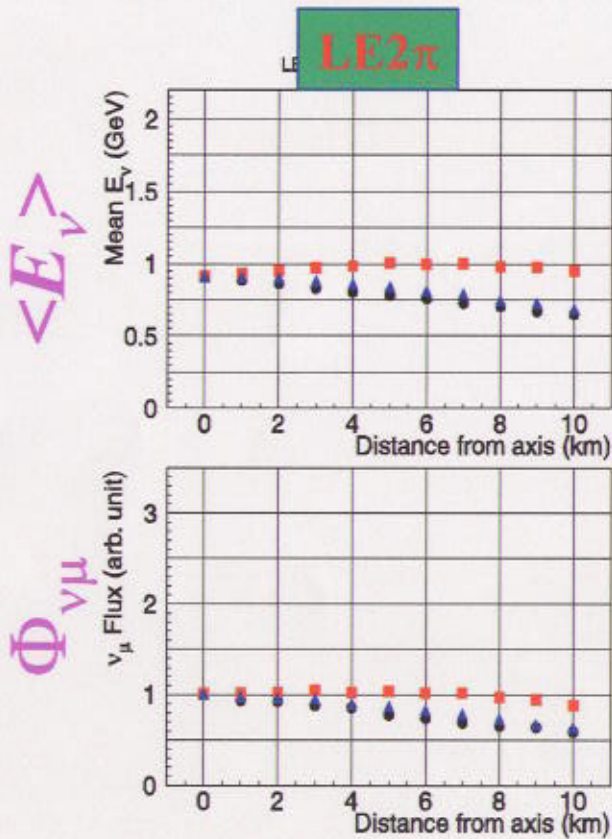
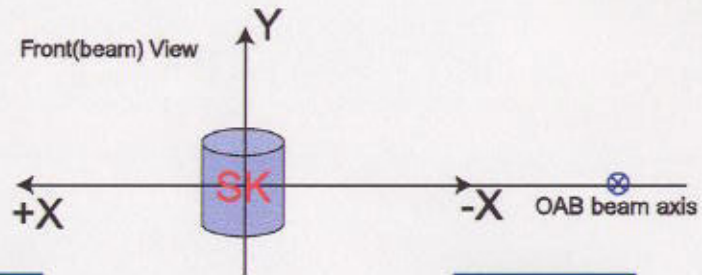
For NBB

μ mon room behind 50cm

Fe shield

→ $\mu > 800\text{MeV}$ can reach

Beam Profile at SK



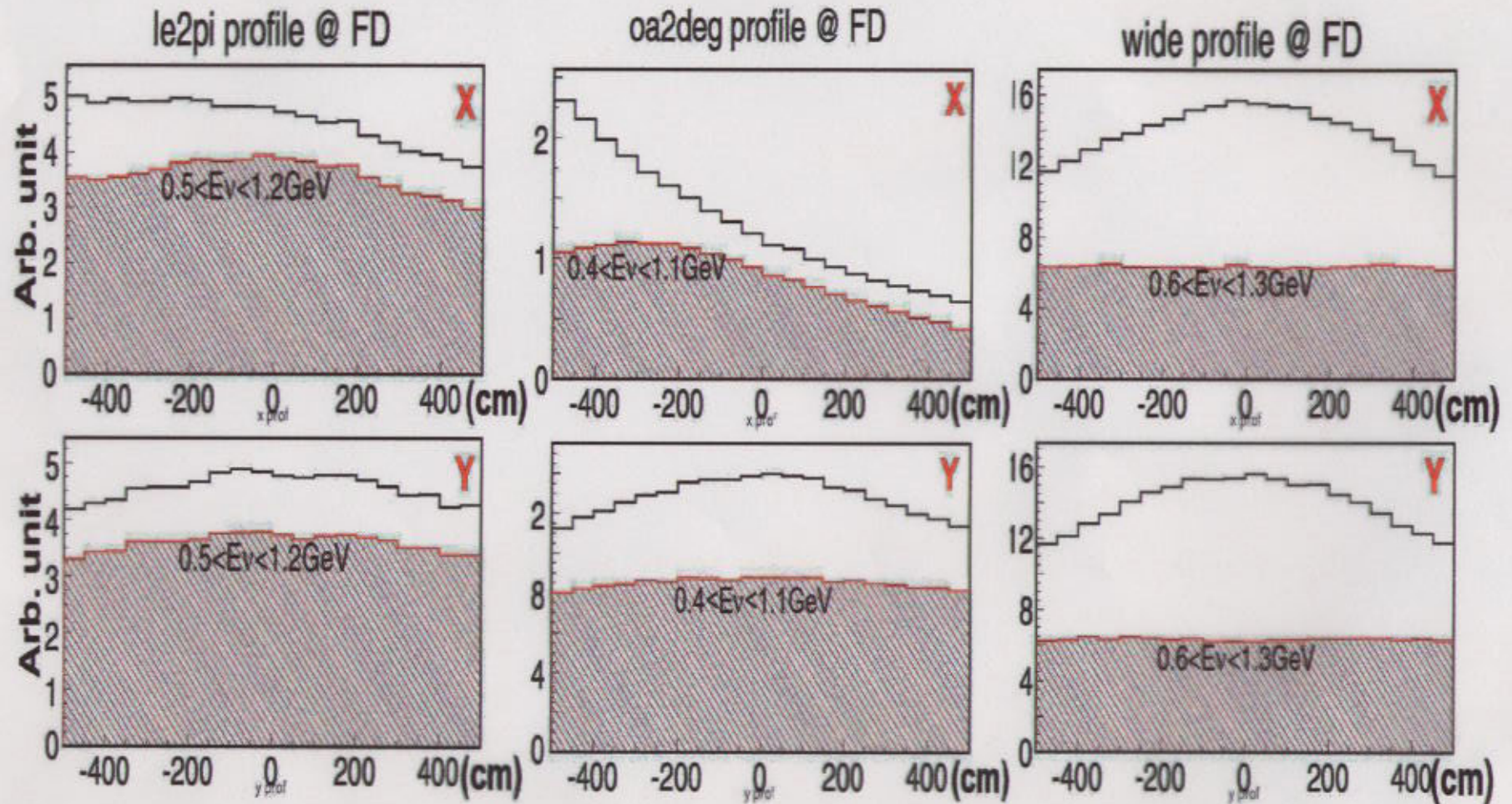
NBB/WBB mild behavior

OAB: $\langle E_\nu \rangle \sim 80 \text{ MeV/km}$ ($\sim 25 \text{ MeV/mrad} \rightarrow \delta(\Delta m^2) \sim 1 \times 10^{-4} \text{ eV}^2$)

$\Phi_{\nu\mu} \sim 13\%/km$ ($\sim 4\%/mrad$)

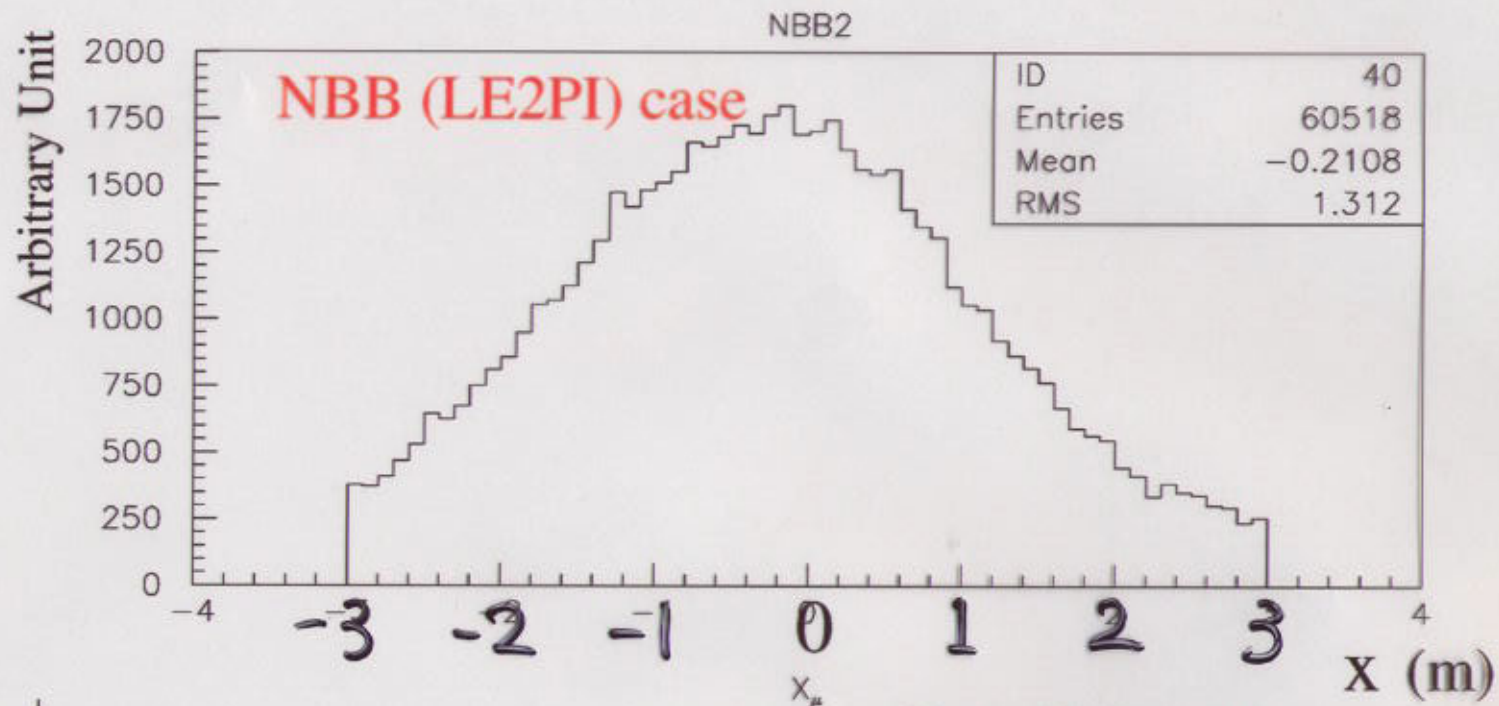
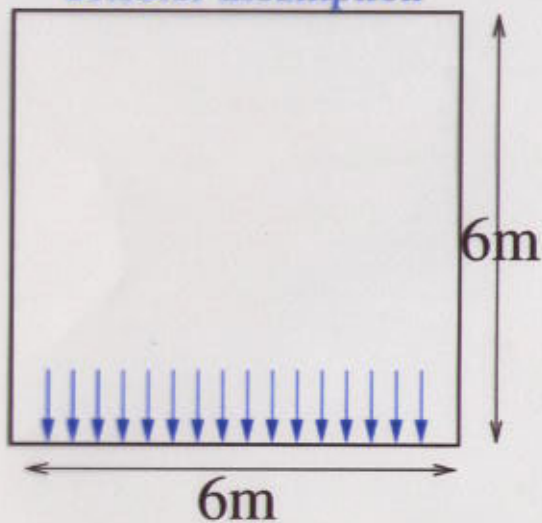
Possible syst. error!

Neutrino profile @ FD

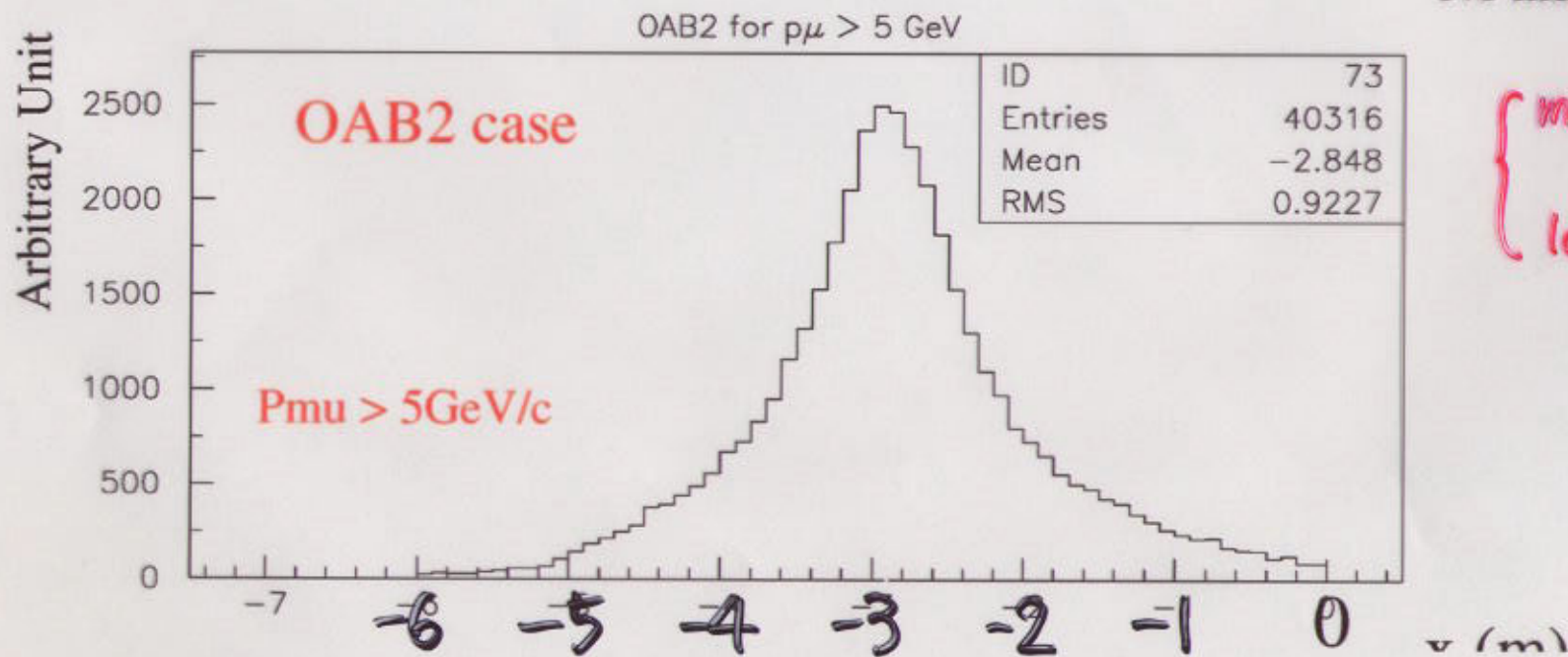


Very broad!

detector assumption



No multiple scattering



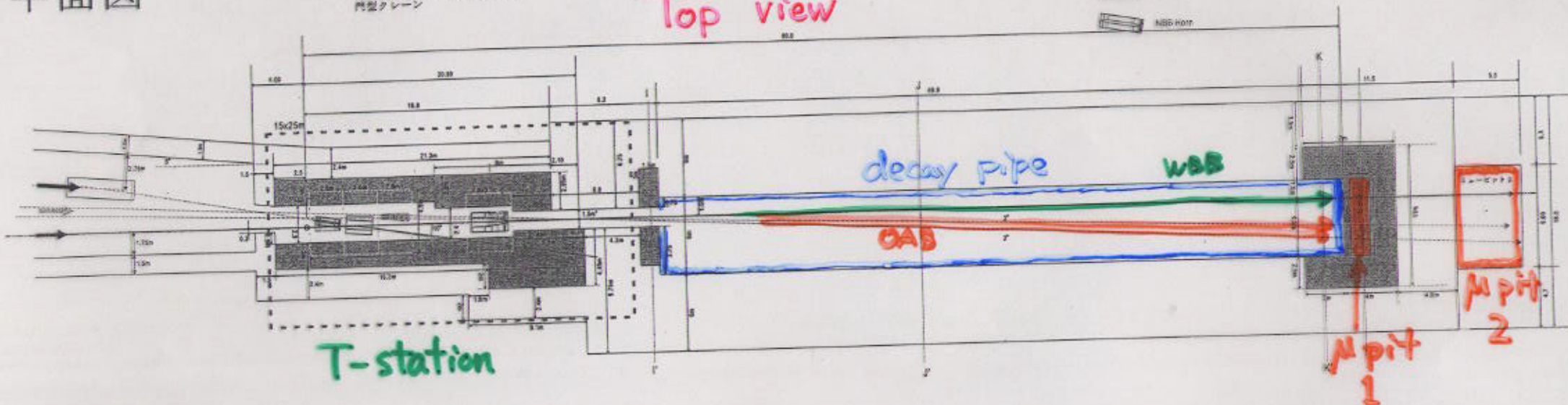
movable detector
or
large detector

can measure
center

平面図

建屋：幅15m、長さ28m、高さ12m
400m 天井走行クレーン(x-y)または
円型クレーン

Top view

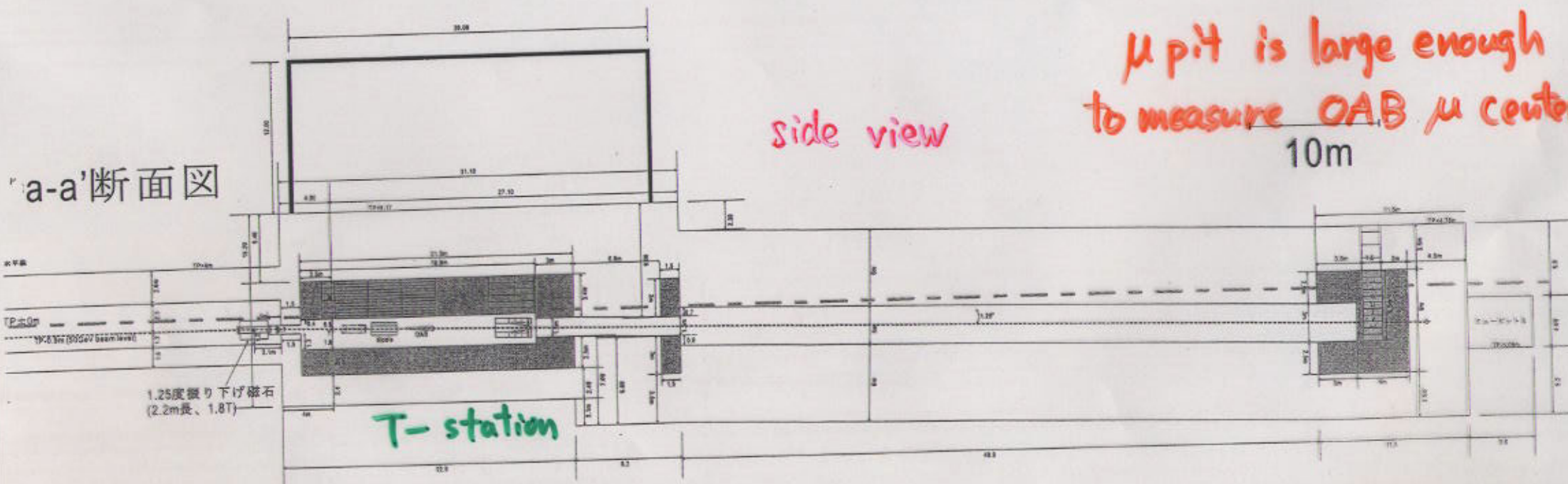


side view

μ pit is large enough
to measure OAB μ center.

10m

a-a'断面図



Number of muons (Average, Very Preliminary)

LE2PI

$$10^7 \sim 10^8 / \text{spill} / \text{cm}^2$$

OAB2

(in Phase I)

cf K2K --- a few $\times 10^4 / \text{spill} / \text{cm}^2$

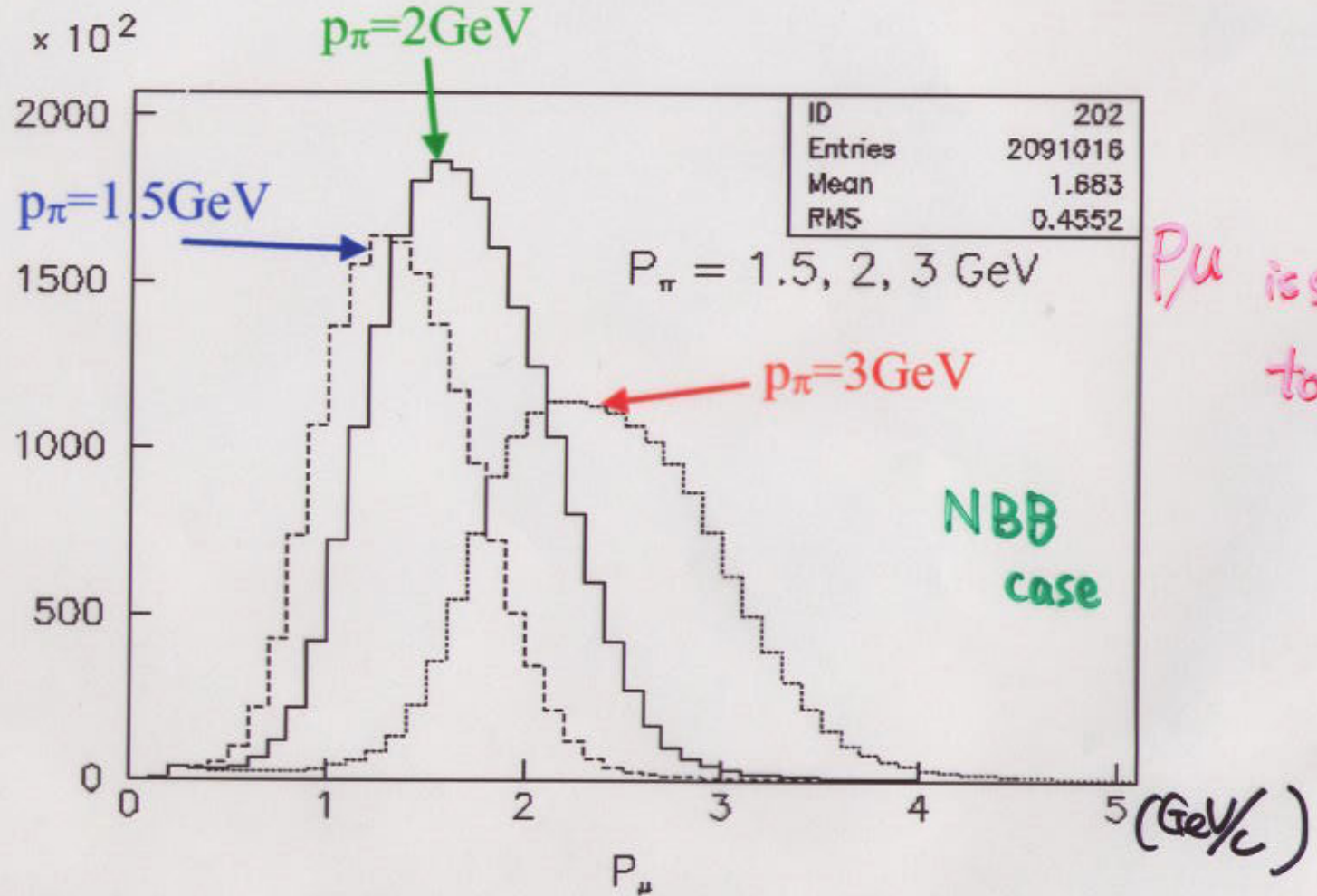
Detector --> Ion chamber? Silicon?, others?

He: 10 ion pairs/cm/MIP $\sim 10^4 e^- / 300 \mu\text{m} / \text{MIP}$
Ar: 10^3 ..

• Measurement of π kinematics

(to constrain hadron production uncertainty)

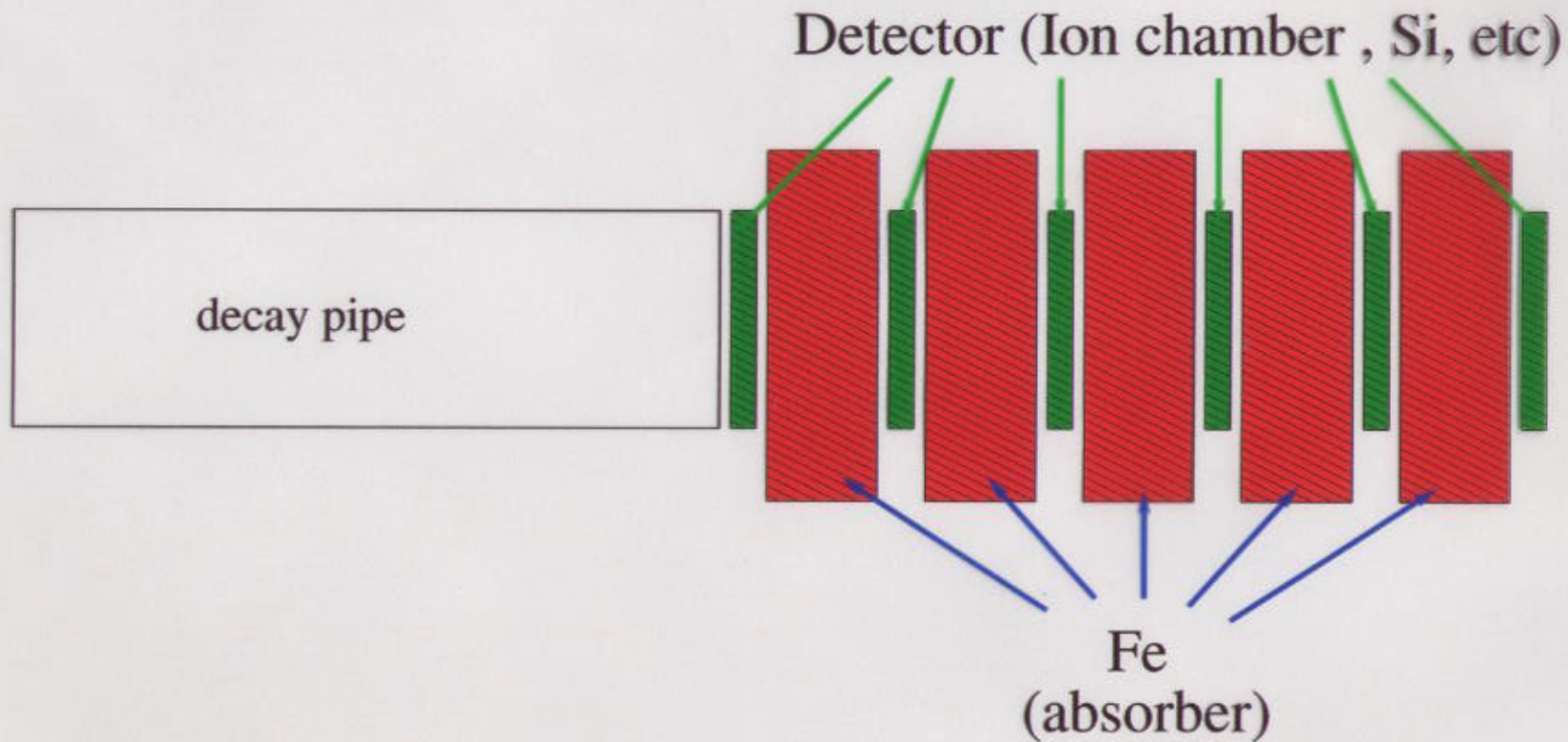
p_μ VS p_π



p_μ is sensitive to p_π

One way is to use μ information.

Traditional Way (To Use Muon Information)



μ yield of each detector ----> muon momentum

μ profile of each detector ----> muon angle

muon momentum

kaon contamination

Nuclear Inst. Meth 91 (1971)
605-612.

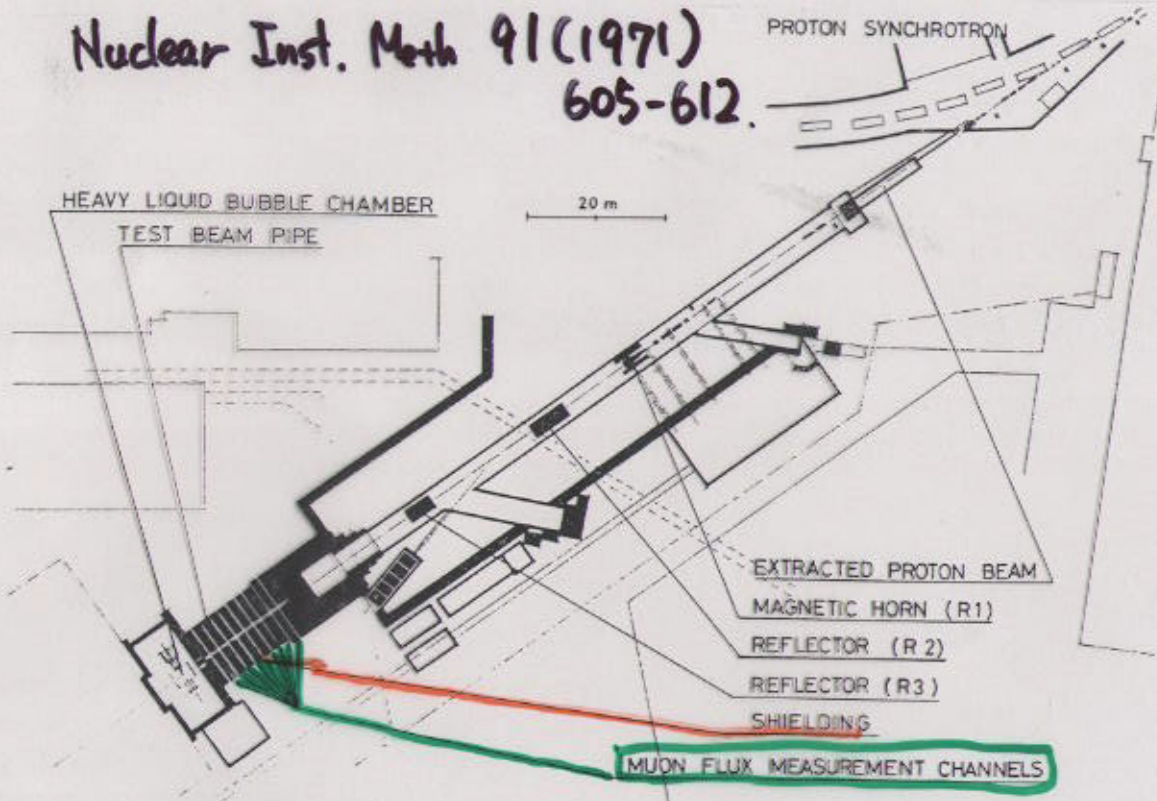
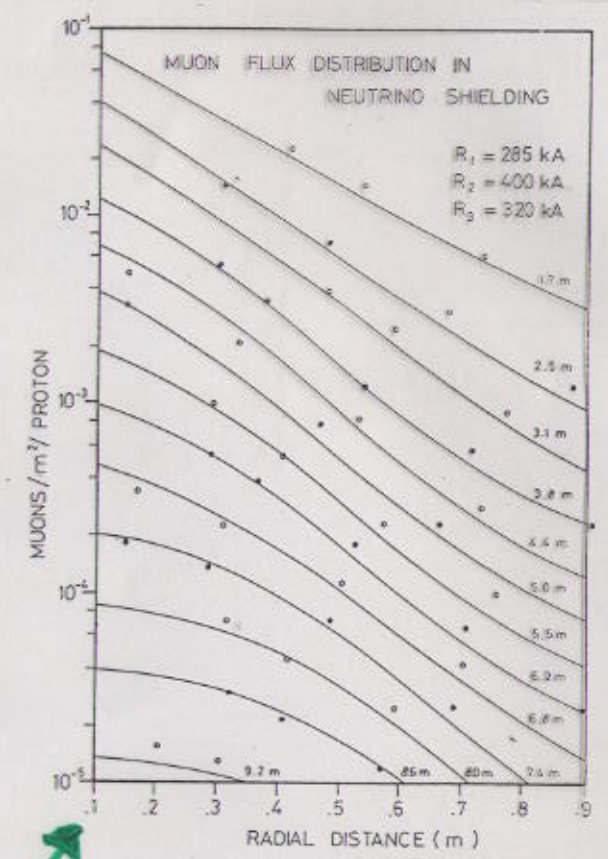


Fig. 1. Layout of the 1967 neutrino facility at the CERN PS.



- CERN 1967 neutrino exp.
- They calculate π/K production from μ (various profiles at different shielding)

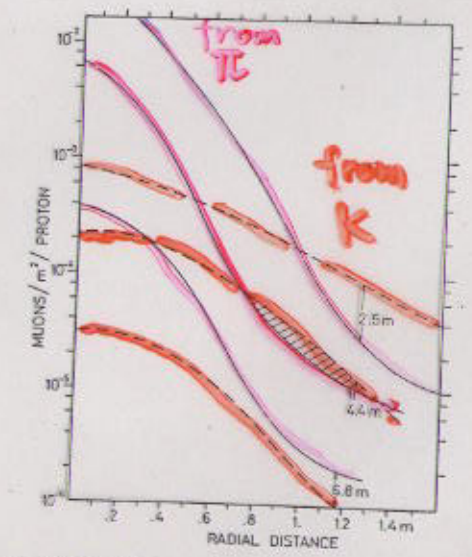
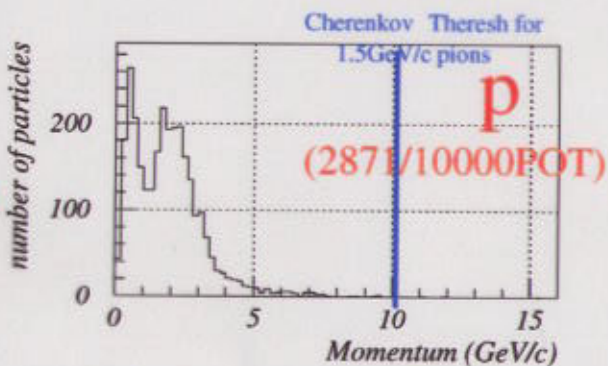
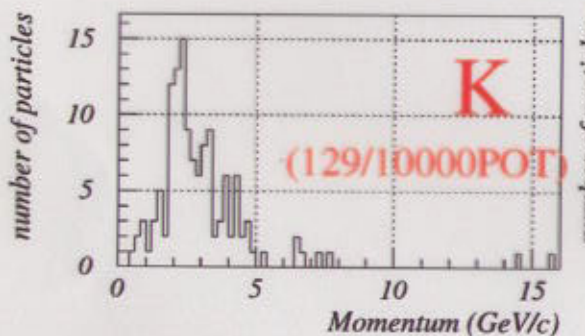
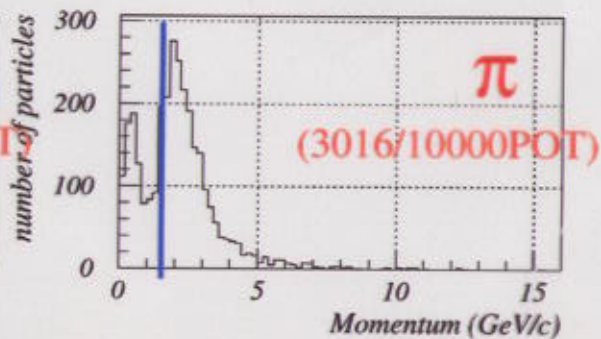
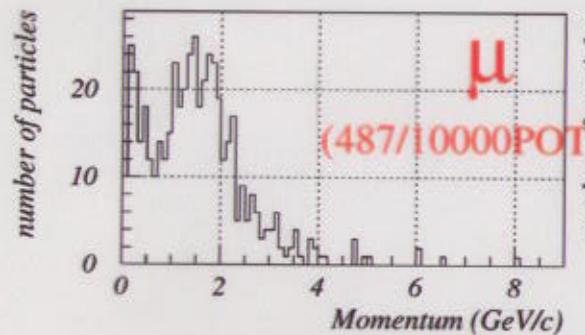
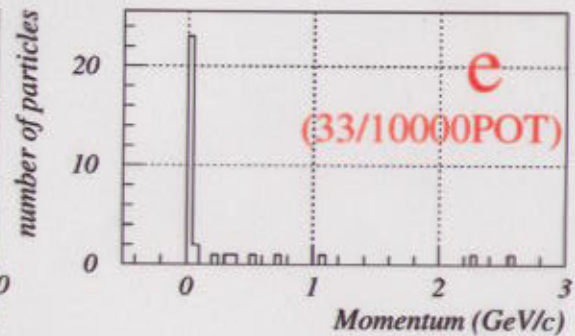
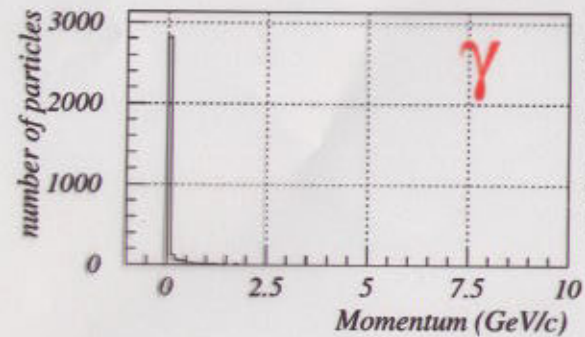


Fig. 4. Calculated muon flux distribution: — from pions; --- from kaons; (focussing currents 260 kA, 400 kA, 320 kA).

π monitor



For WBB
OAB



Difficult due to 50 GeV proton
Radiation hardness

For NBB

No 50 GeV proton

We might scan pion momentum
using Cherenkov counter

Momentum distribution at decay pipe entrance (R<75cm)
(LE2PI case)

Summary

1. Muon monitor is crucial element for JHF - SK neutrino experiment
 - a. For beam steering
 - b. For beam stability measurement (direction and intensity) spill by spill
 - c. For OAB direction confirmation

2. To constrain hadron production uncertainty from beam monitors (Neutrino Energy and Far/Near)
 - a. One possibility is to measure decayed muon distribution
 - b. Pion monitor? (NBB)
 - c. HARP III
 - d. Old data set



Need study to constrain this most effectively