JHF Preview

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JHF Neutrino Working Group

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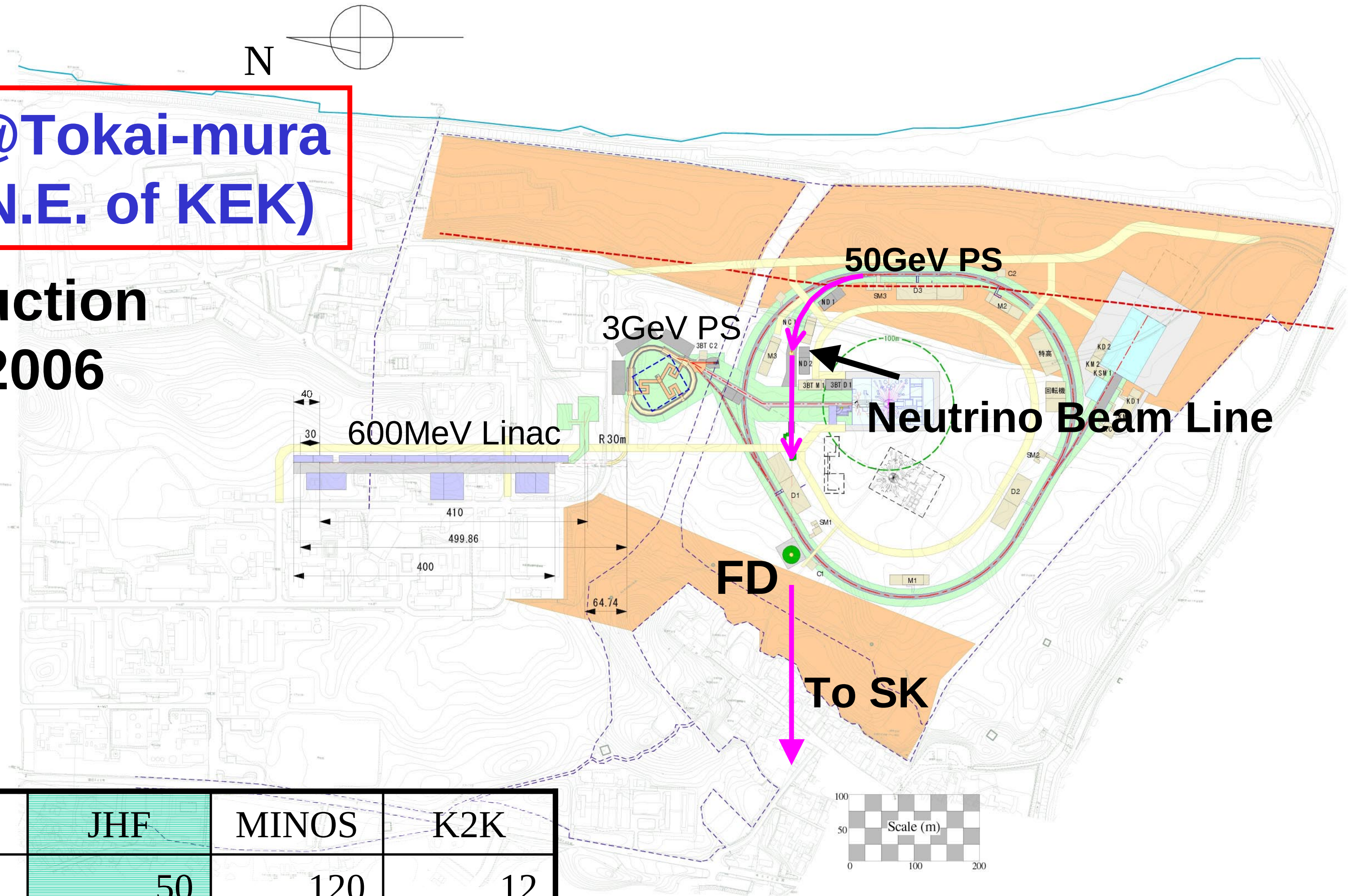
Dec.99: Working group formed.
Mar.00: Letter of Intent prepared (http://neutrino.kek.jp/jhfnu)
Now : Working to prepare "proposal"

Japan Hadron Facility (JHF) project

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

Construction
2001～2006



	JHF	MINOS	K2K
E(GeV)	50	120	12
Int.(10^{12}ppp)	330	40	6
Rate(Hz)	0.37	0.53	0.45
Power(MW)	0.98	0.41	0.0052

10^{21}POT(130day)≡ "1 year"

ν physics @ JHF

Super Kamiokande as Far Detector

L=295km

Δm^2=2～5x10^{-3}eV^2

➡ osc. max @ E_ν=0.5～1.2GeV

Need Low Energy Beam

Goal

(3flavor, $\Delta m_{12} \ll \Delta m_{23} \sim \Delta m_{13}$)

- $\nu_\mu \rightarrow \nu_x$ disappearance $\quad p = \cos^4\theta_{13}\sin^2 2\theta_{23}\sin^2(1.27\Delta m_{23}^2 L/E_\nu)$

  Precision measurements of osc. params Δm_{23}, $\sin^2 2\theta_{\mu x}$ $\equiv \cos^4\theta_{13}\sin^2 2\theta_{23}$

  $\delta(\Delta m_{23}{}^2) \sim 2\text{x}10^{-4}\text{eV}^2$, $\delta(\sin^2\theta_{\mu x}) \sim 0.01$

- $\nu_\mu \rightarrow \nu_e$ appearance $\quad p = \sin^2\theta_{23}\sin^2 2\theta_{13}\sin(1.27\Delta m_{23}^2 L/E_\nu)$

  Explore down to $\sin^2 2\theta_{\mu e}(\equiv \sin^2\theta_{23}\sin^2 2\theta_{13}) \sim 3\text{x}10^{-3}$

Present Status

1. Optimization of beam line
   - Physics Potential
   - Cost (shielding)
2. Studying event selection at SK to improve ν_e detection
3. Started design and R&D of front detector

Neutrino Beam @ JHF

Possible Options

- Wide Band Beam (WBB)
  - 2 Horns almost the same as K2K
- Narrow Band Beam (NBB)
  - Horn(s) + Bending
- Off axis
  - Another option of NBB

Current Default Strategy

1year WBB → pin down $\Delta m_{23}{}^2$ to $\pm$10% level
5year NBB → precise meas. osc. parameters

Wide Band Beam

Target : Cu 1cm$^{\phi}$ x 30cm
Horn : 250kA
Decay Pipe : 50m x 1.5m$^{\phi}$
Gcalor

2 horns (almost same design as K2K)

Advantage

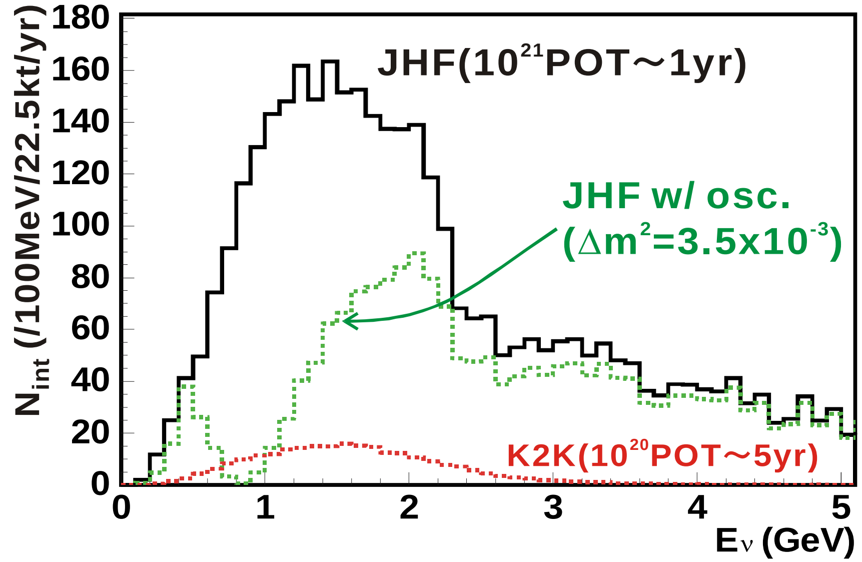
- Intense
- Wide sensitivity in Δm^2
- Established

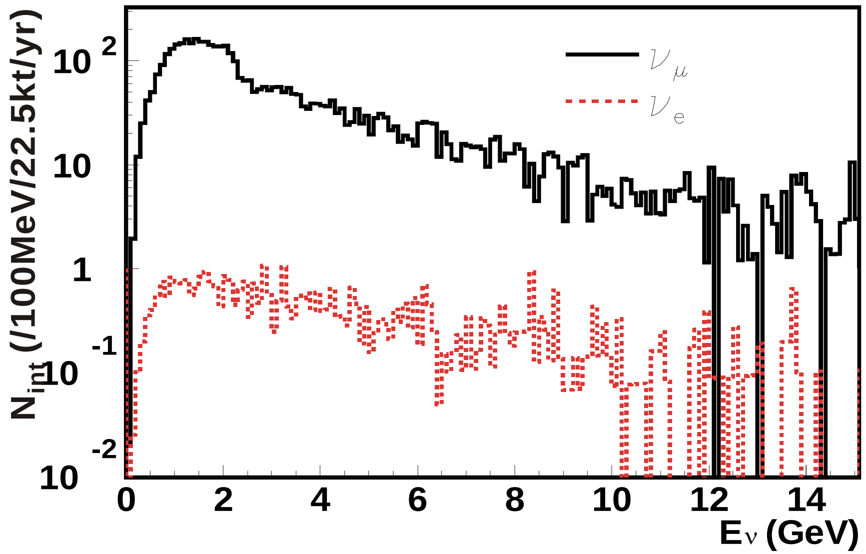
Disadvantage

- Background from HE tail
- Spectra diff. btw near&far
  → syst. err.
- Heavy shielding needed
  → decay pipe have to be short

~4200 ν_μ int./22.5kt/yr

ν_e:0.8%

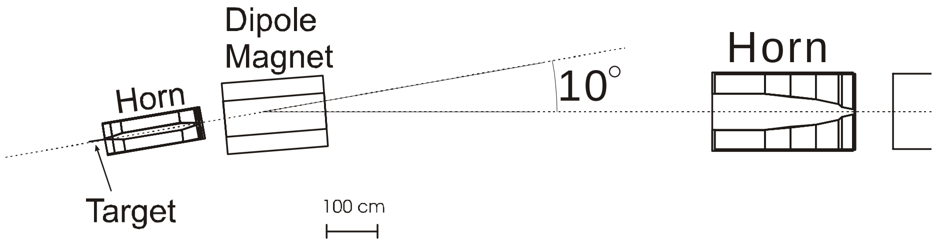


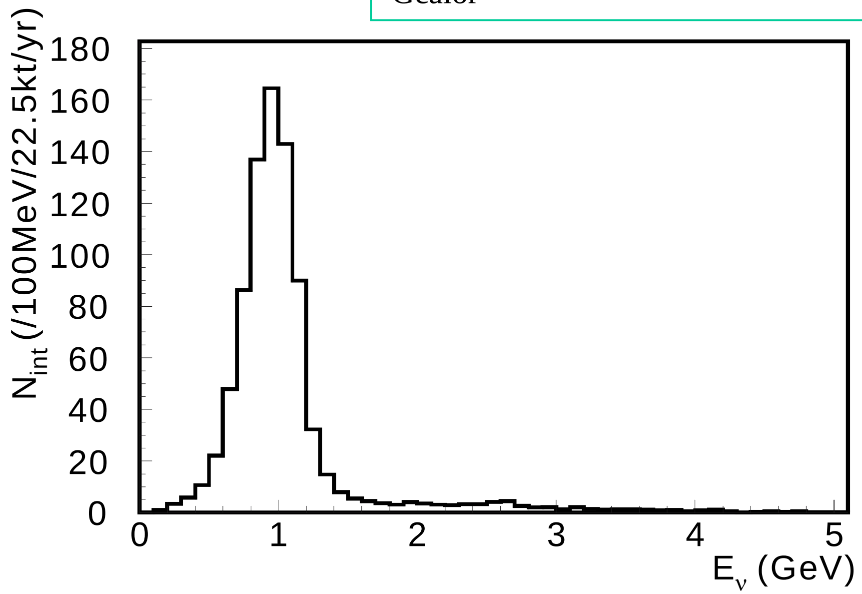


yet to be optimized

Narrow Band Beam

Target	: Cu 1cm$^{\phi}$ x 30cm
Horn	: 250kA
Decay Pipe	: 155m x 1.5m$^{\phi}$
Dipole	: 50cm(V)x70cm(H)x2m(L)
	0.58T (10deg@2GeV/c)
Gcalor	



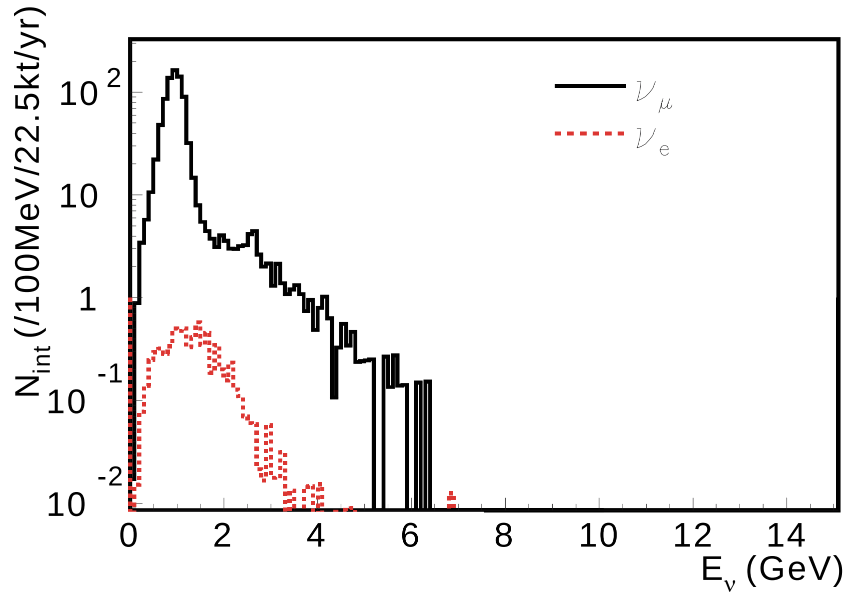


Advantage

- Easy to tune E_ν
- Less systematic error
  "counting experiment"
- Less shielding →long dec. pipe
- Less BG from HE tail

Disadvantage

- Less intense



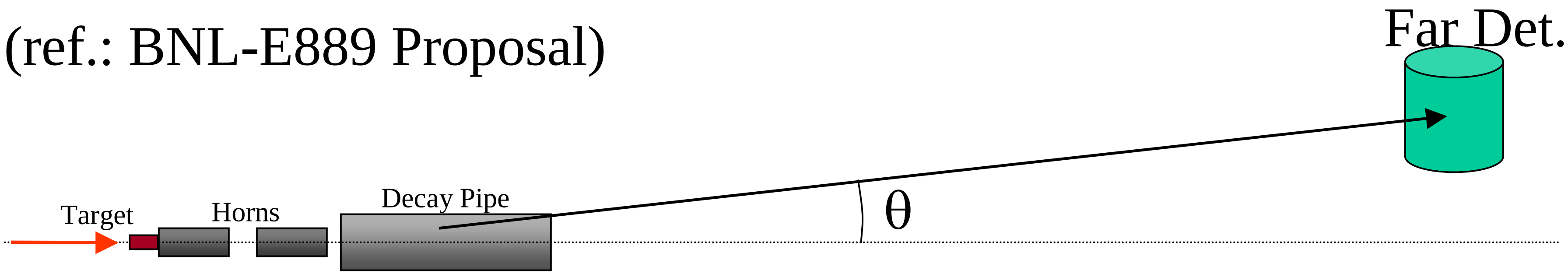
～830 int./22.5kt/yr

ν_e:0.8%(0.3% @ peak)

yet to be optimized

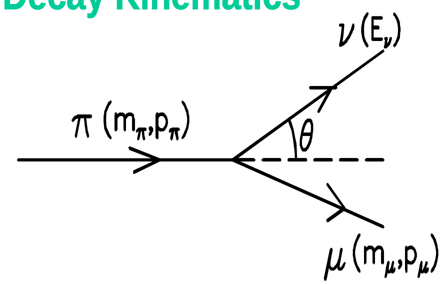
Off Axis Beam (another NBB option)

(ref.: BNL-E889 Proposal)

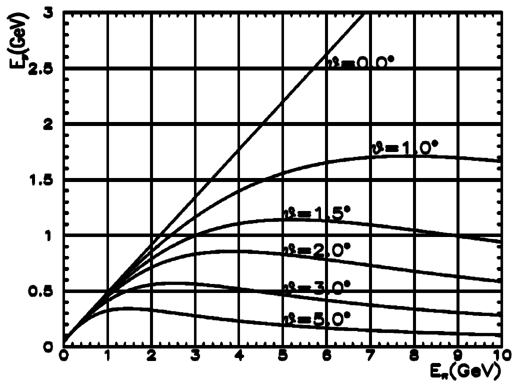


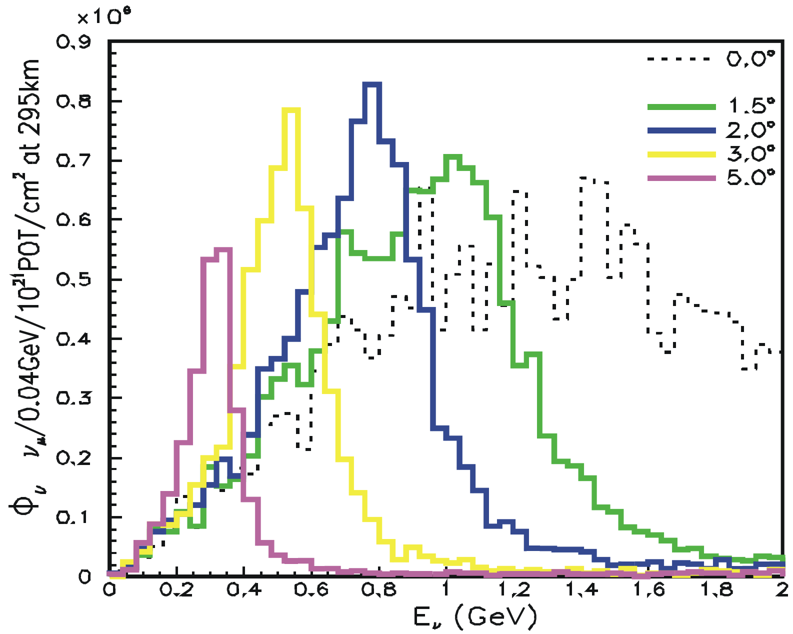
WBB w/ intentionally misaligned beam line from det. axis

Decay Kinematics



$$E_\nu = \frac{m_\pi^2 - m_\mu^2}{2(E_\pi - p_\pi \cos\theta)}$$





Quasi Monochromatic Beam

Off axis beam

Advantage

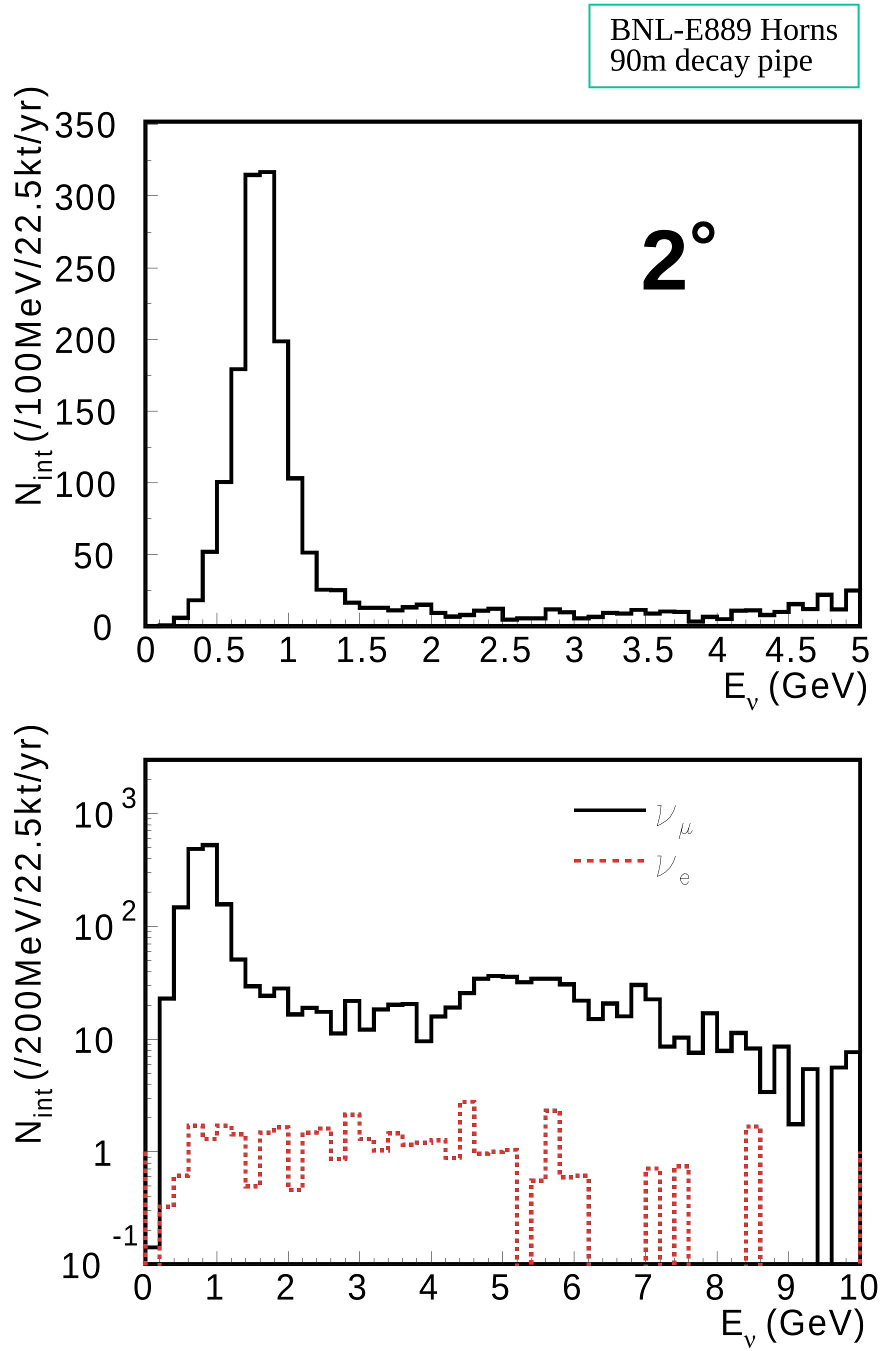
- More intense than NBB (∼twice)

Disadvantage

- Heavy shielding
- More HE tail than NBB
- Hard to tune E_ν
- Not established (monitor, near/far)

∼2200 int./22.5kt/yr

ν_e: 0.8% (0.2% @ peak)



Shielding (cost driving factor)

Radiation dose at boundary is being estimated by using MARS

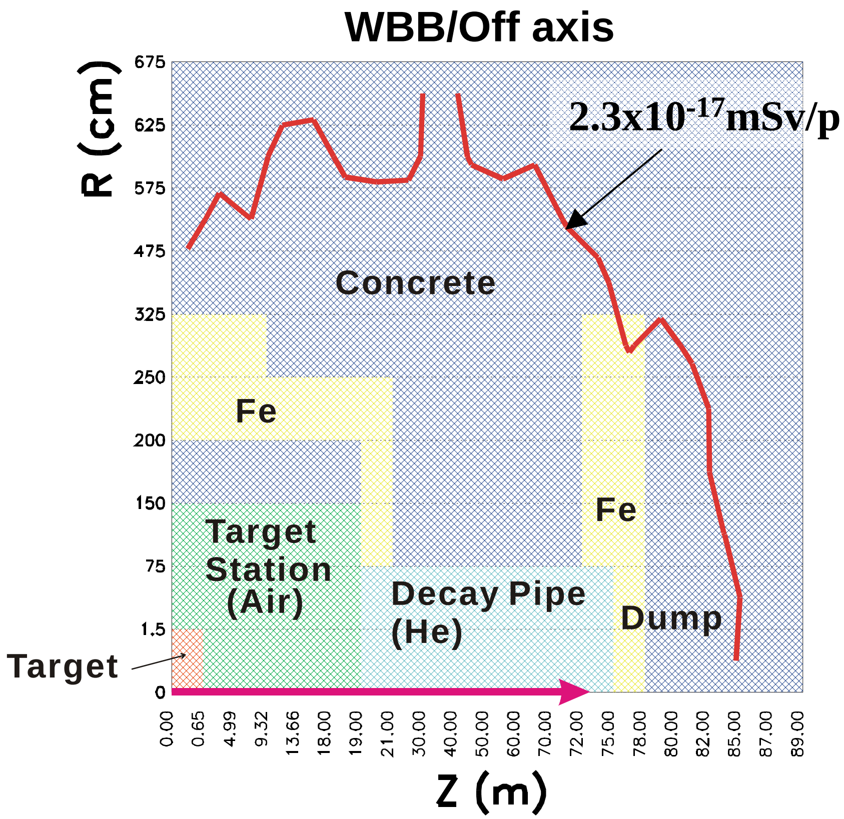
Required to be less than 11.4mSv/h ($2.3x10^{-17}$mSv/p)

On the way of optimization

An example of preliminary results

- Decay pipe need **>6m** of concrete shielding
- Dump need **4m** Fe + **4.4m** concrete

WBB&Off axis can not be long.

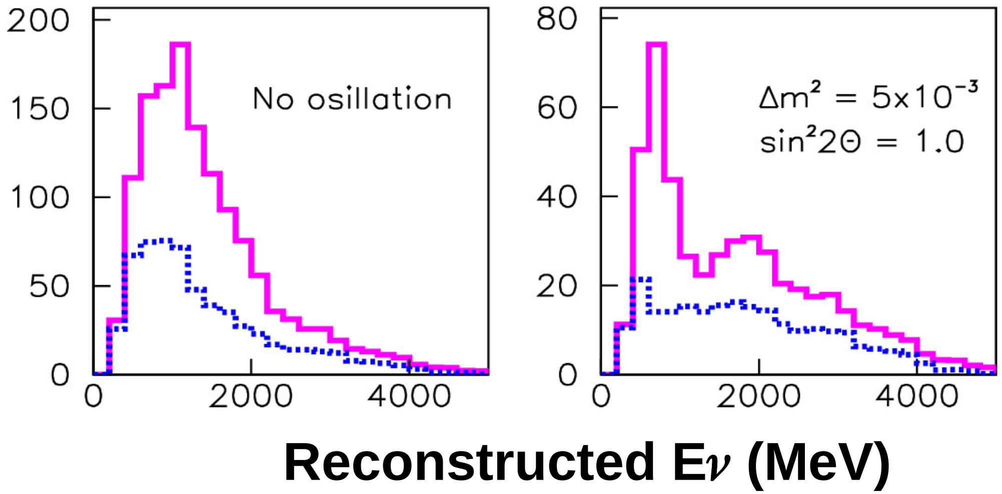


Physics Potential

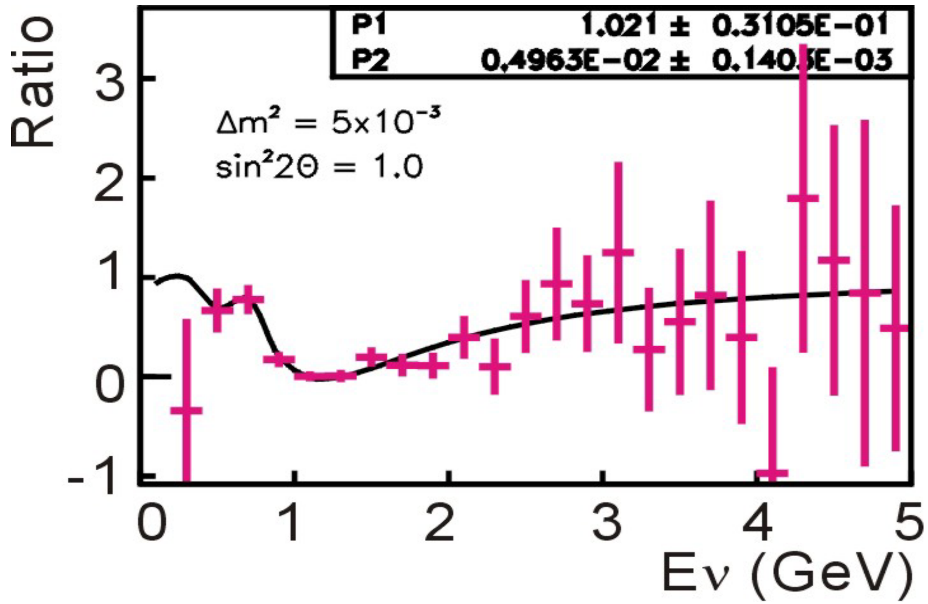
ν_μ disappearance

1ring FC μ-like

Total
Inelastic



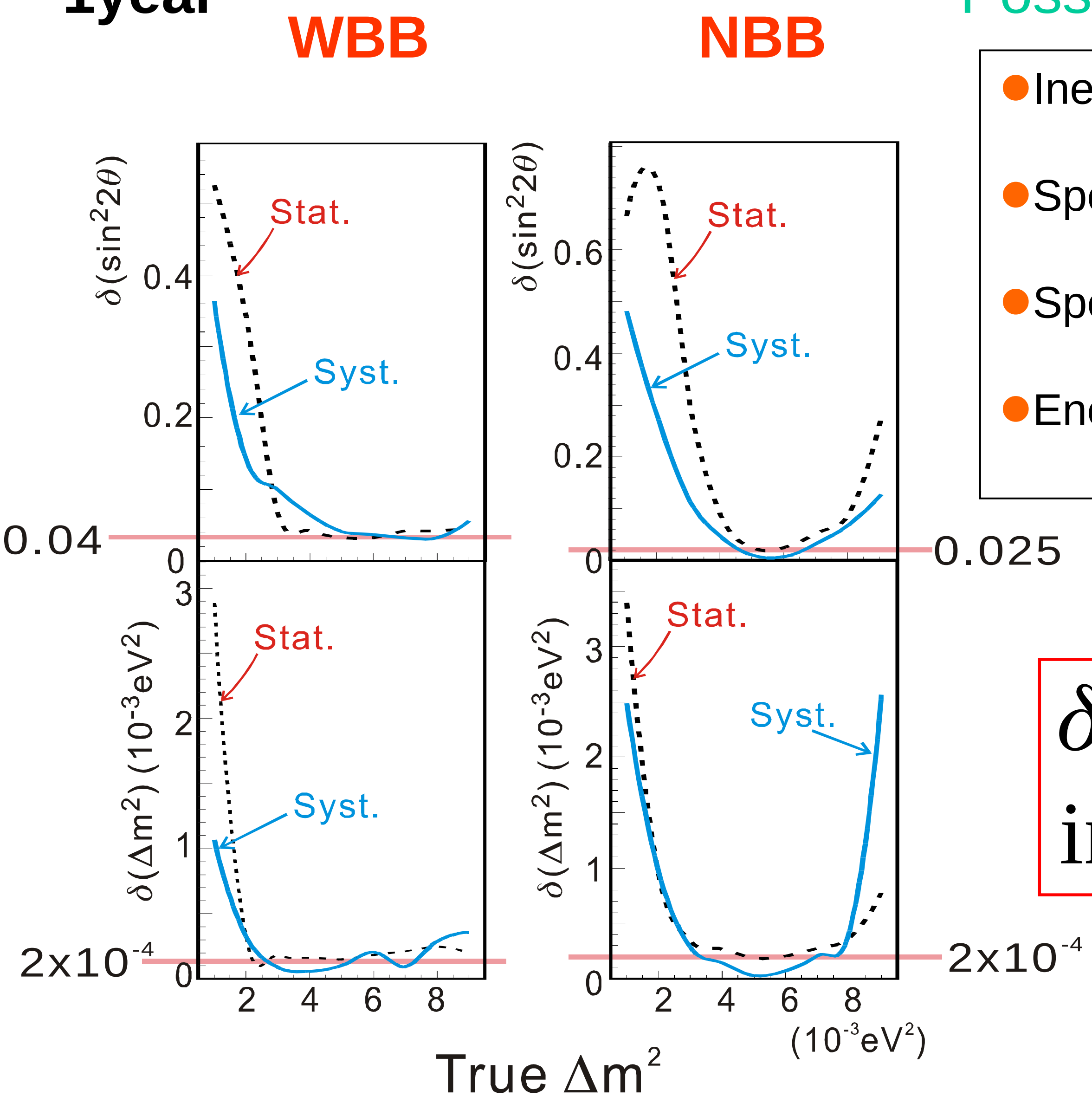
Ratio aft. BG subt.



Fit with $1-\sin^2 2\theta \cdot \sin^2(1.27\Delta m^2 L/E)$

ν_μ disappearance

1year



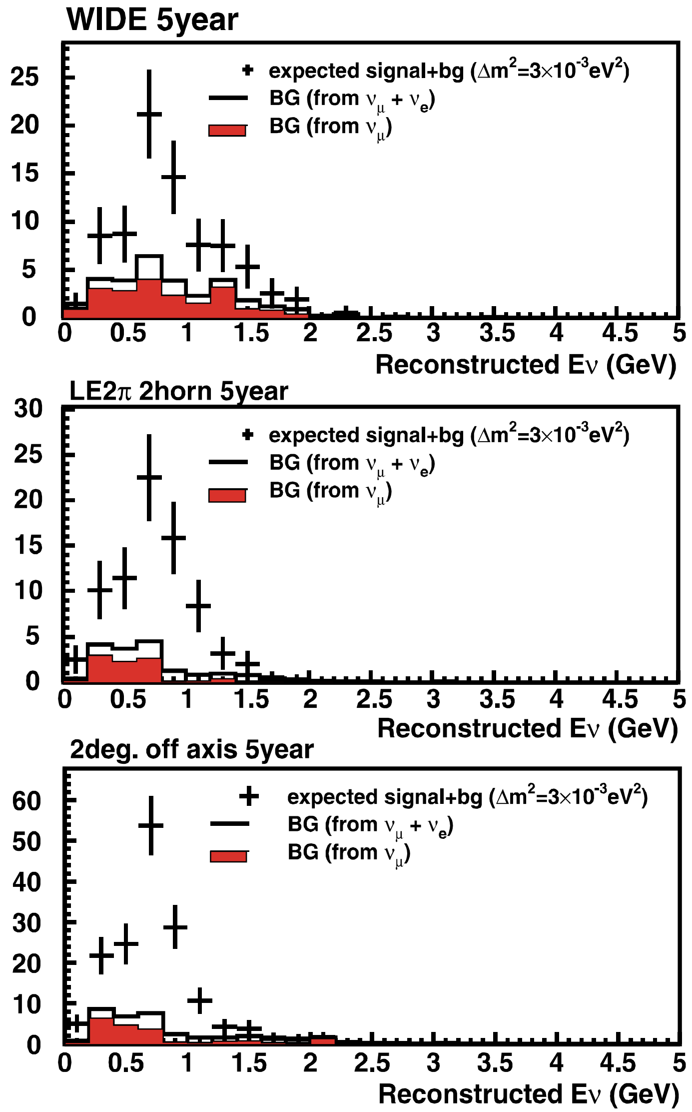
Possible syst. errors

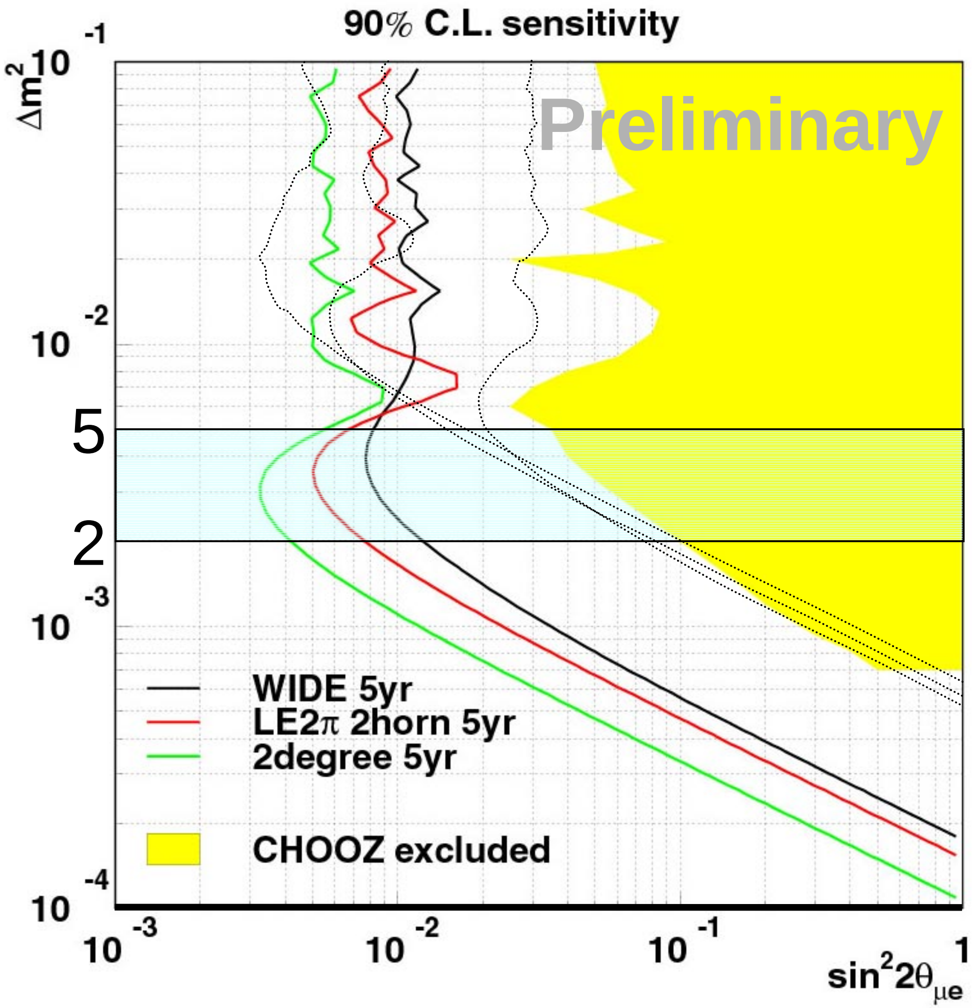
- Inelastic cross section
  20%
- Spectrum measured at FD
  4%*E*
- Spectrum difference (near to far)
  10%
- Energy measurement
  3%

$\delta(\sin^2 2\theta) \sim 0.01$
in 5 years

Sensitivity on $\nu_\mu \rightarrow \nu_e$ appearance

w/ improved π^0 rejection (from LOI)





Dashed lines: MINOS Ph2le, Ph2me, Ph2he from right
(A.Para, hep-ph/0005012)

Summary

1. Goal of ν physics @ JHF (hope to start in 2006)

   Precise determination of oscillation parameters

   - with low energy ν_μ beam (～1GeV)
   - with Super Kamiokande @ L=295km

2. Neutrino Beam: three options

   - WBB ～4200 ν_μ N_{int}/22.5kt/yr
   - NBB ～ 830 ν_μ N_{int}/22.5kt/yr
   - Off axis ～2200 ν_μ N_{int}/22.5kt/yr

3. Strategy: 1year WBB → $\delta(\Delta m_{23}^{2})$～±2x10^{-4}eV^2

   5years NBB (or Off axis beam) →$\delta(\sin^2 2\theta_{\mu x})$～0.01

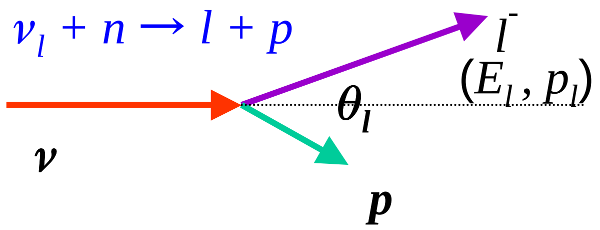
   →$\sin^2 2\theta_{\mu e}$～0.005 (0.003)

4. To decide beam config.
   1. optimize each beam and compare the potential
   2. estimate the cost (shielding, ….)

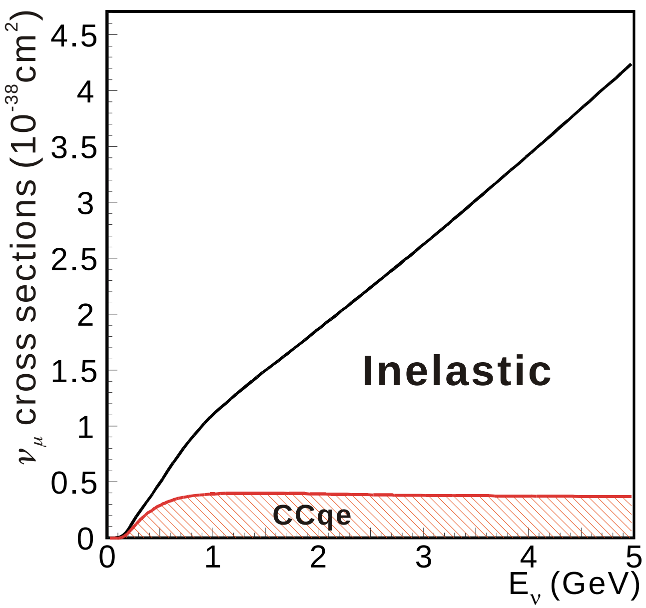
5. R&D required on target and beam monitoring
6. Started design and R&D of the front detector

Neutrino Energy Reconstruction (GeV region)

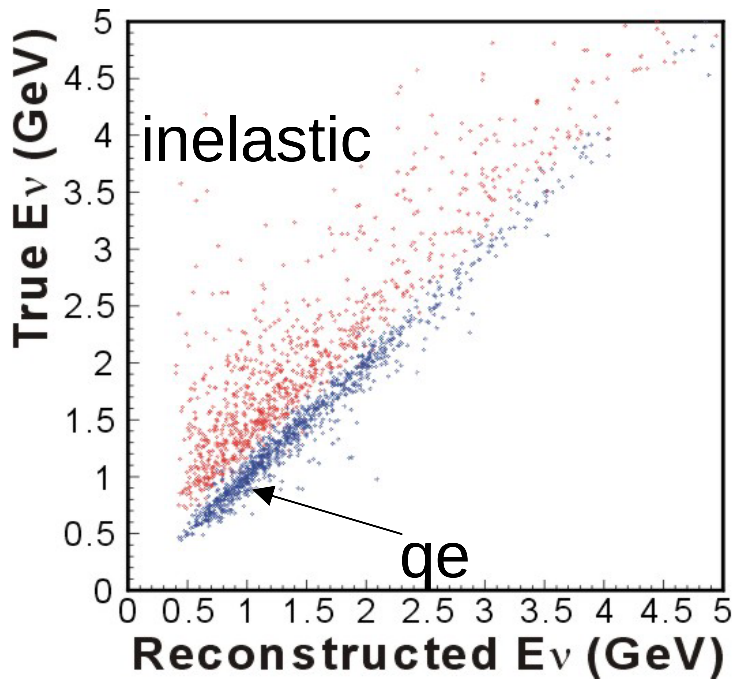
Assume CC quasi elastic (CCqe) reaction



$$E_\nu = \frac{m_N E_l - m_l^2/2}{m_N - E_l + p_l \cos\theta_l}$$

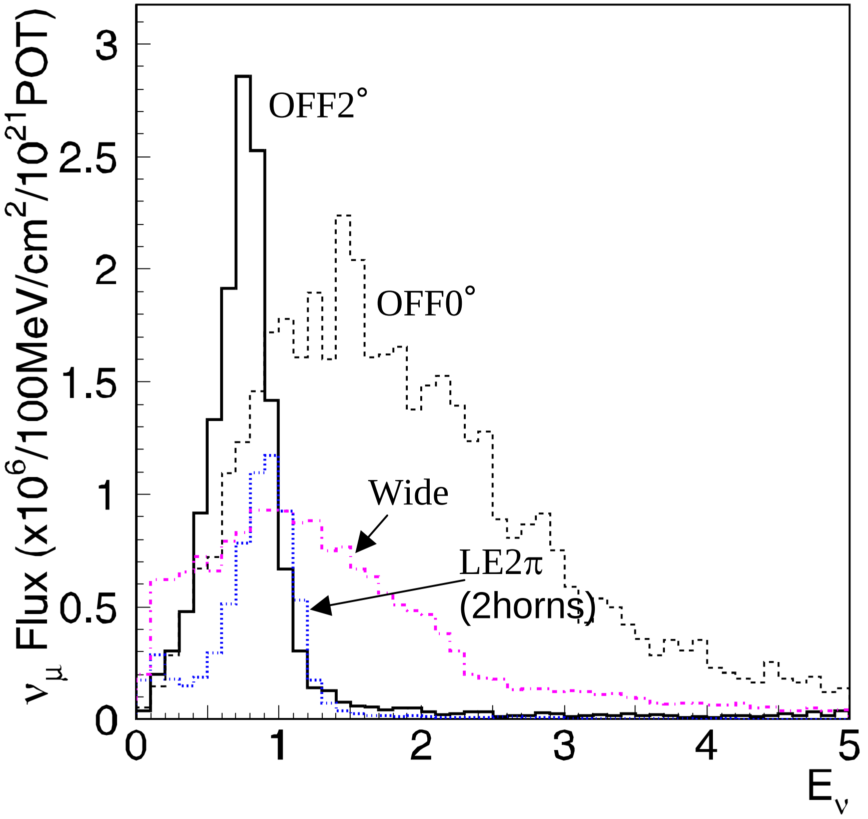


Water Cherenkov 1ring μ-like sample

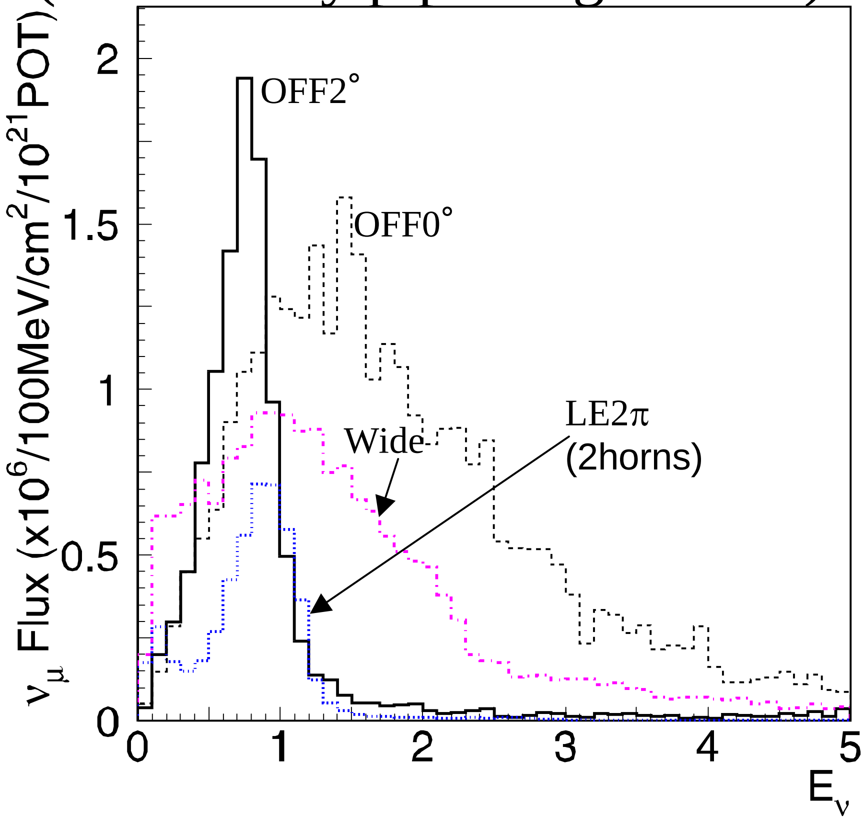


Comparison of Beams

"Realistic" Design



Fair Comaprison
(same decay pipe length=50m)



Decay Pipe Len. Off axis: 90m
LE2pi: 155m
Wide: 50m