Search for V.S. @ J.H.F.

KEK / IPNS
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- Introduction.
- Method.
  - N.C. π^0 search
- Results.
  - Wide band beam
  - Narrow band beam
  - Off axis beam
- Summary.

Introduction

Atmospheric ν

→ ν_μ disappearance.

→ $\nu_\mu \rightarrow \nu_?$

? : τ or s.

⇒ 100 % $\nu_\mu \rightarrow \nu_s$

rejected @ 99 % C.L.
(Super Kamiokande)

1) matter effects.

$\nu_\mu - \nu_\tau$: same

$\nu_\mu - \nu_s$: different.

→ high energy upward going ν_μ

oscillation suppressed.

for $\nu_\mu - \nu_s$

ii) Neutral Current

ν_s : Disappearance

Search for $\nu_\mu \to \nu_s$ @ JHF ν.

If $\nu_\mu \to \nu_s$.

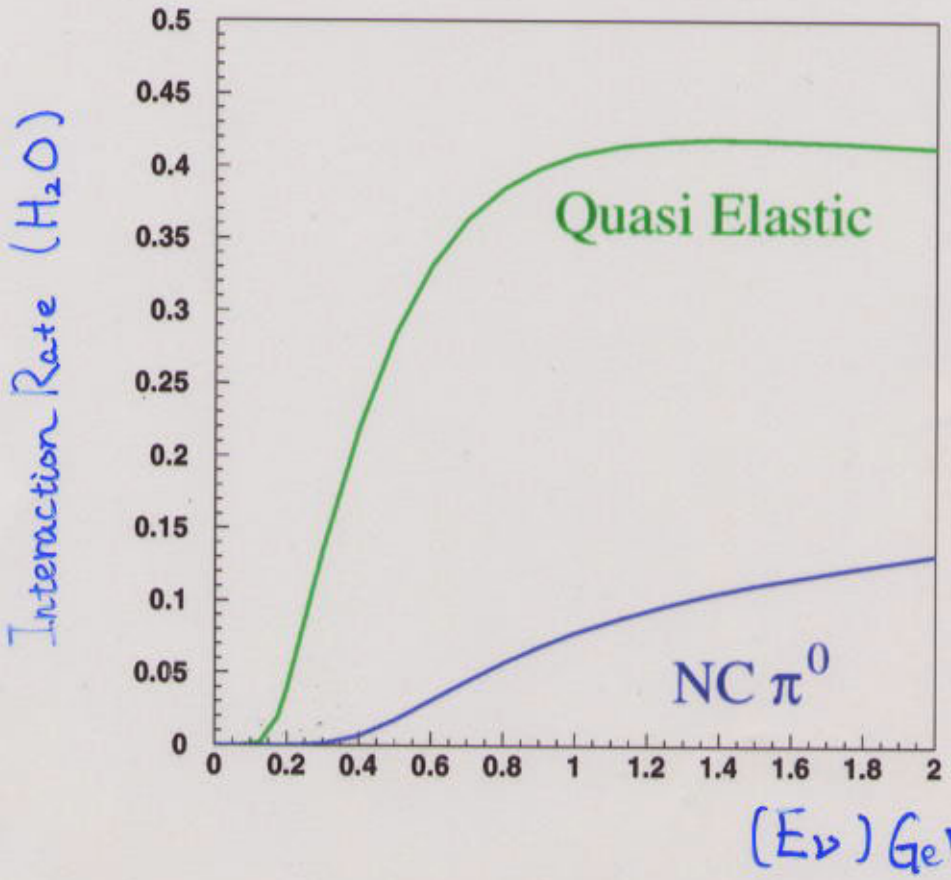
# of Neutral Current interaction

$\Rightarrow$ decrease.

$\Rightarrow$ Count # of N.C. events.

at Super Kamiokande.

$\rightarrow$ N.C. π^0 production.



Neutral Current Single π^0 production.

$$\nu N \rightarrow \nu N \pi^0 \hookrightarrow 2\gamma.$$

- Only the showering rings are identified (e-like)
- Mass & momentum of π^0 can be reconstructed if both of the rings are identified.
- No μ-like rings
- No decay-electrons.

$\Rightarrow$ Clearly identifced.

But. no way to reconstruct E_ν...

$\Rightarrow$ Use total deposit energy to reject high energy events.

Neutral Current π^0 Search @ Super Kamiokan

Selection Criteria

i) Fully Contained event.

ii) Evis. (Electron equivalent total energy)

$100 \sim 1500$ MeV.

$\Rightarrow \Delta m^2 \sim 3 \times 10^{-3} eV^2$.

$L = 295$ km

$\Rightarrow E_\nu \lesssim 2$GeV.

$\Rightarrow$ Reject energetic νe etc.

iii) # of rings = 1 or 2

$\pi^0 \to 2\gamma$.

iv) All rings must be e-like (showering)

γ generates e-like ring.

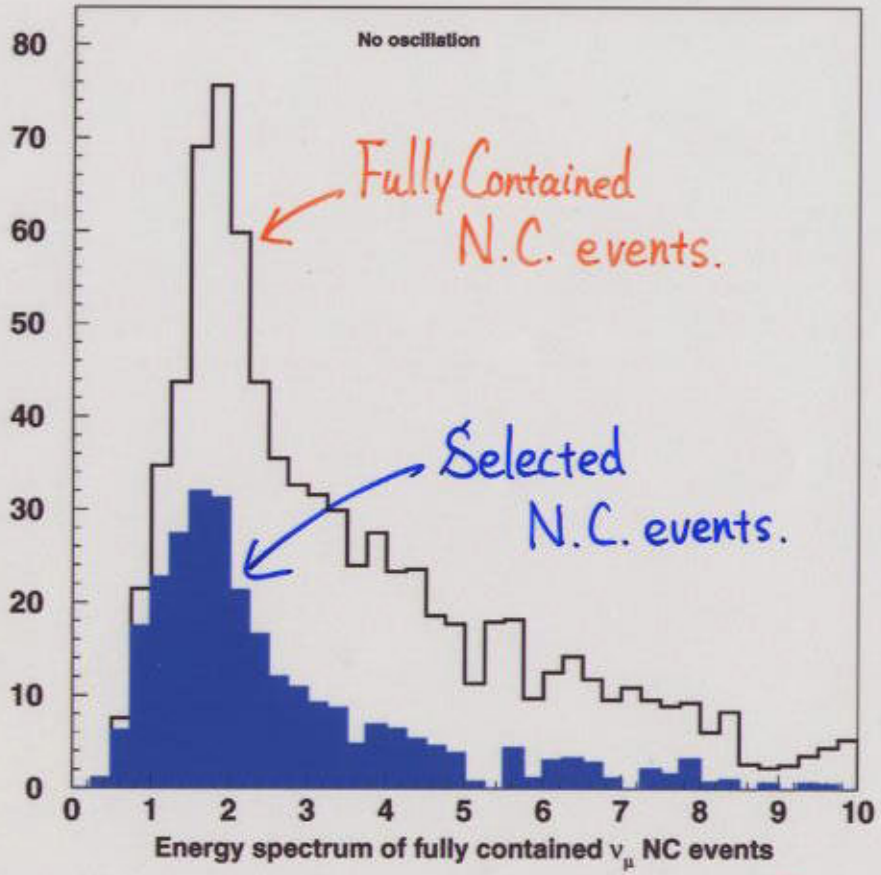
v) No decay electrons.

Reject invisible μ or $\pi^\pm$

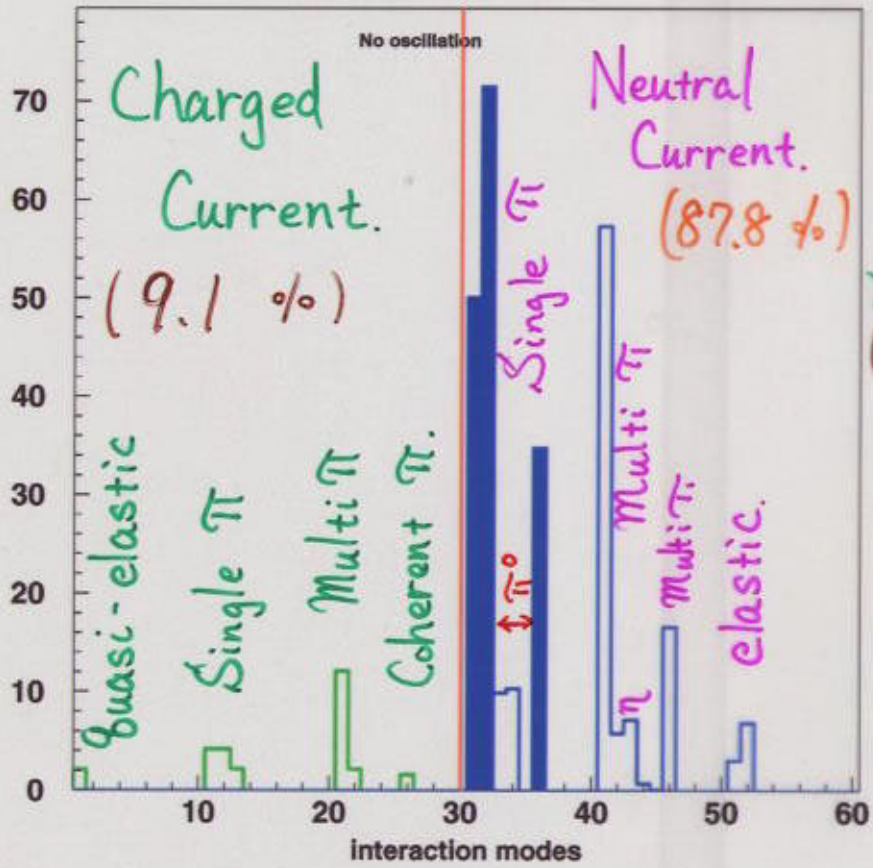
· Results.

N.C. π^0 Search. Wide band beam (1 year)

	ν_μ N.C.	ν_μ C.C.	ν_e
# of events (No osc.)	274.3	28.5	9.5



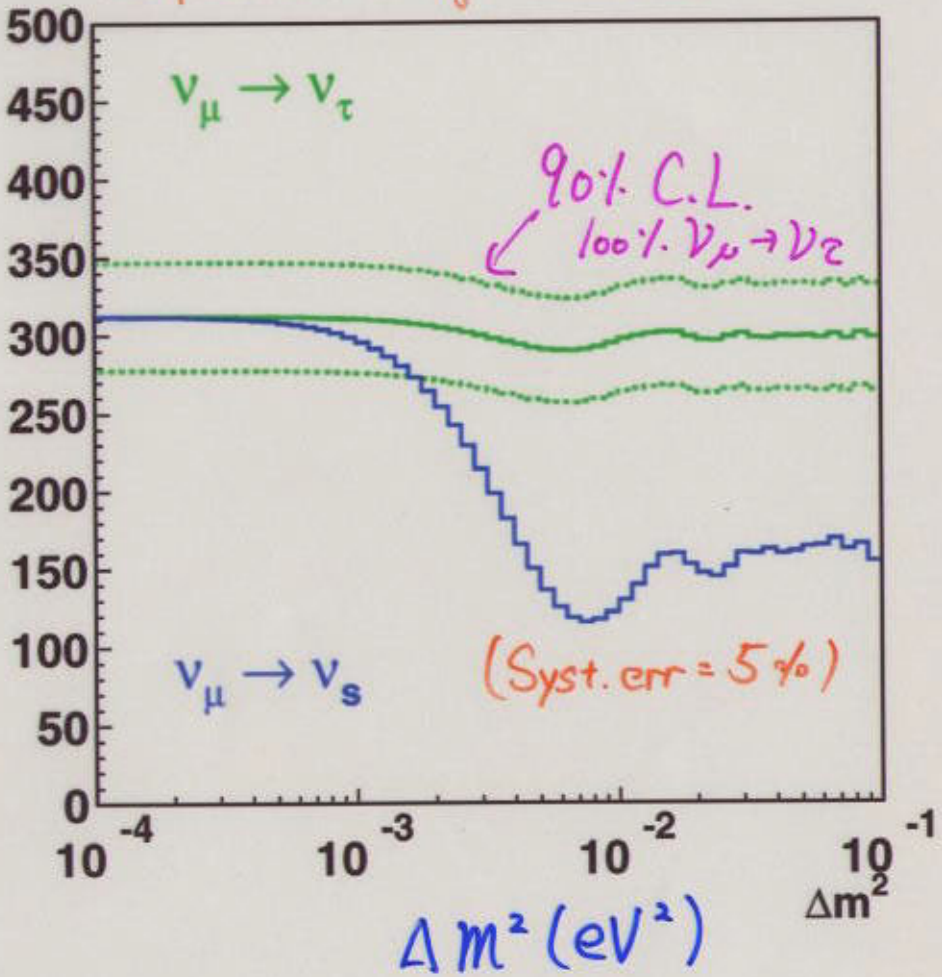
Eν.



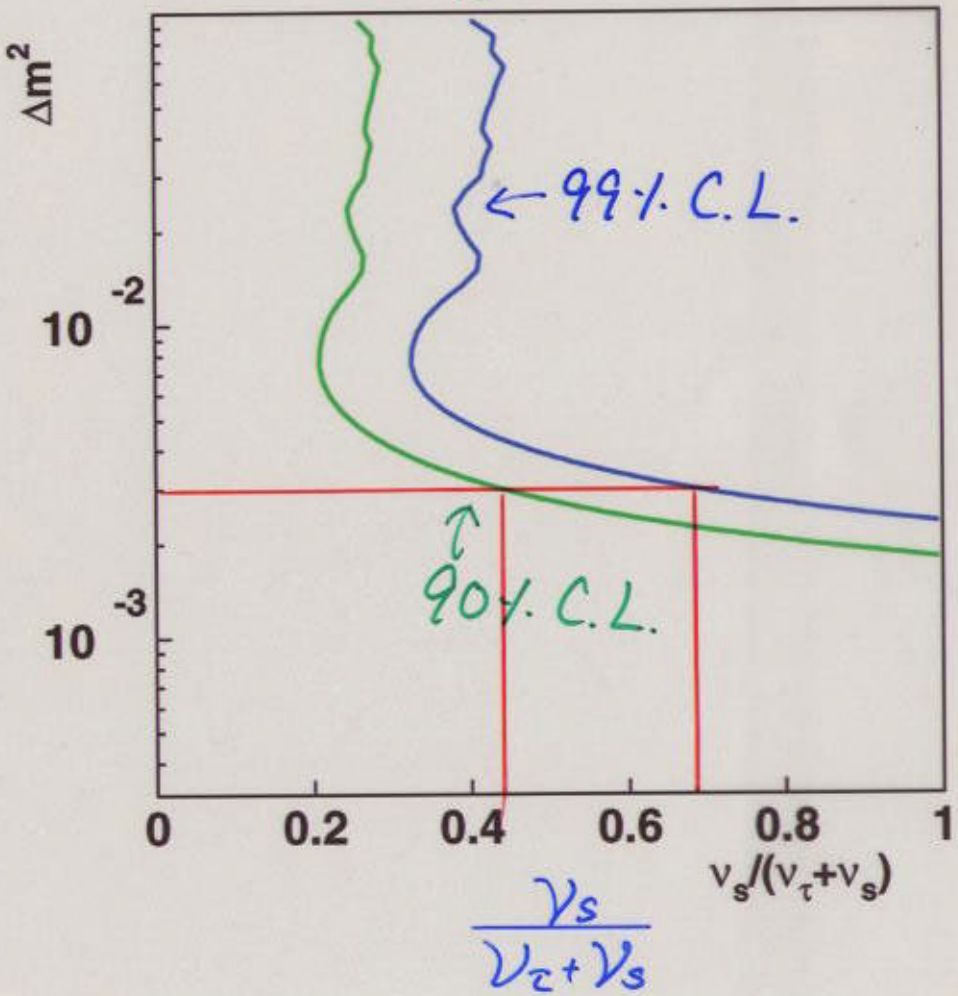
Interaction modes of selected events.

N.C. π^0 Search. Wide band beam (1 year)

Expected # of events.

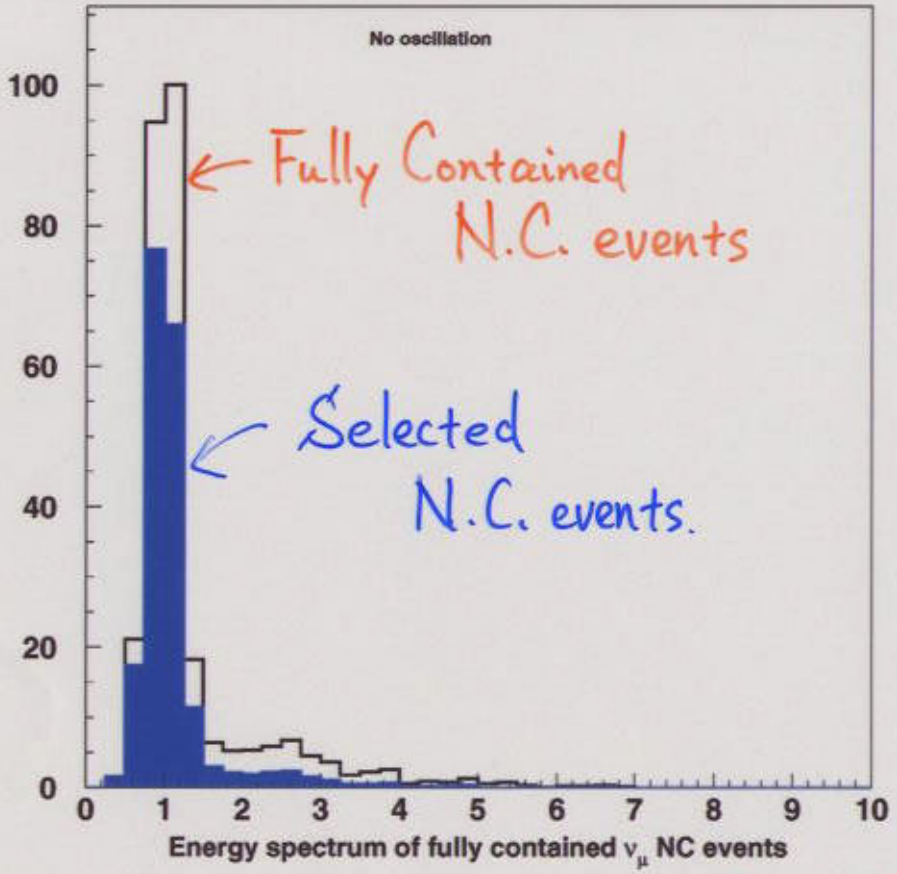


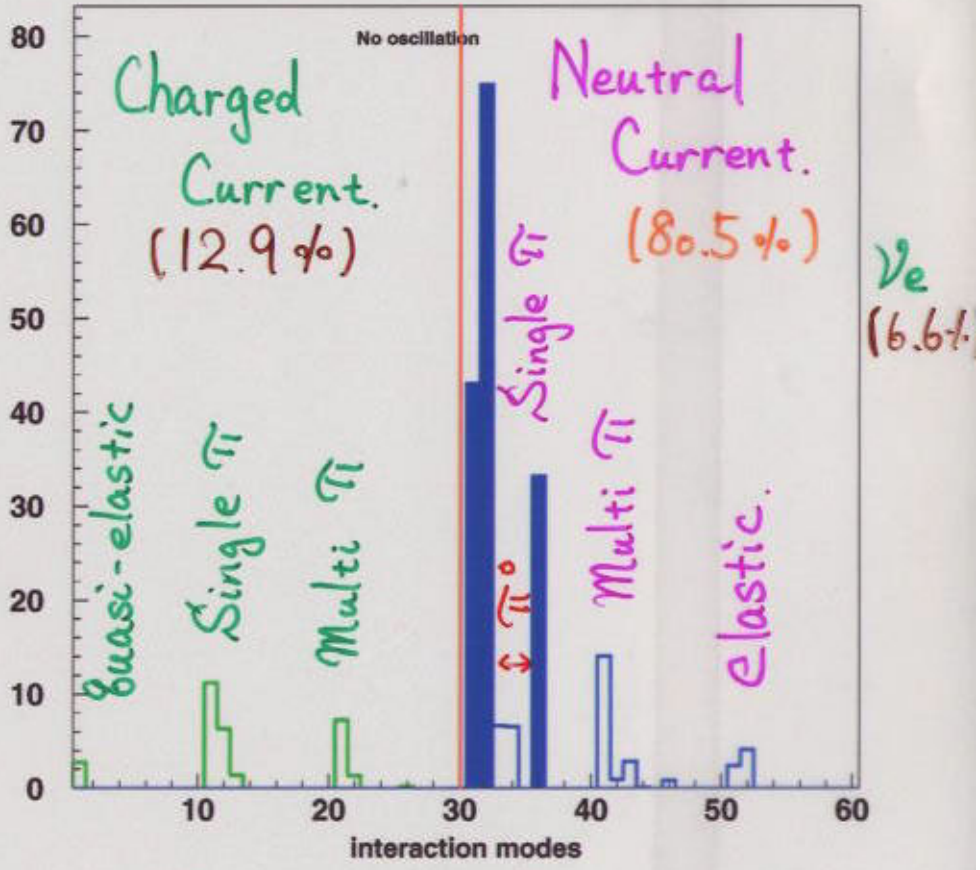
Sensitivity



N.C. π^0 Search. Narrow band beam (2GeV π 5yrs.)

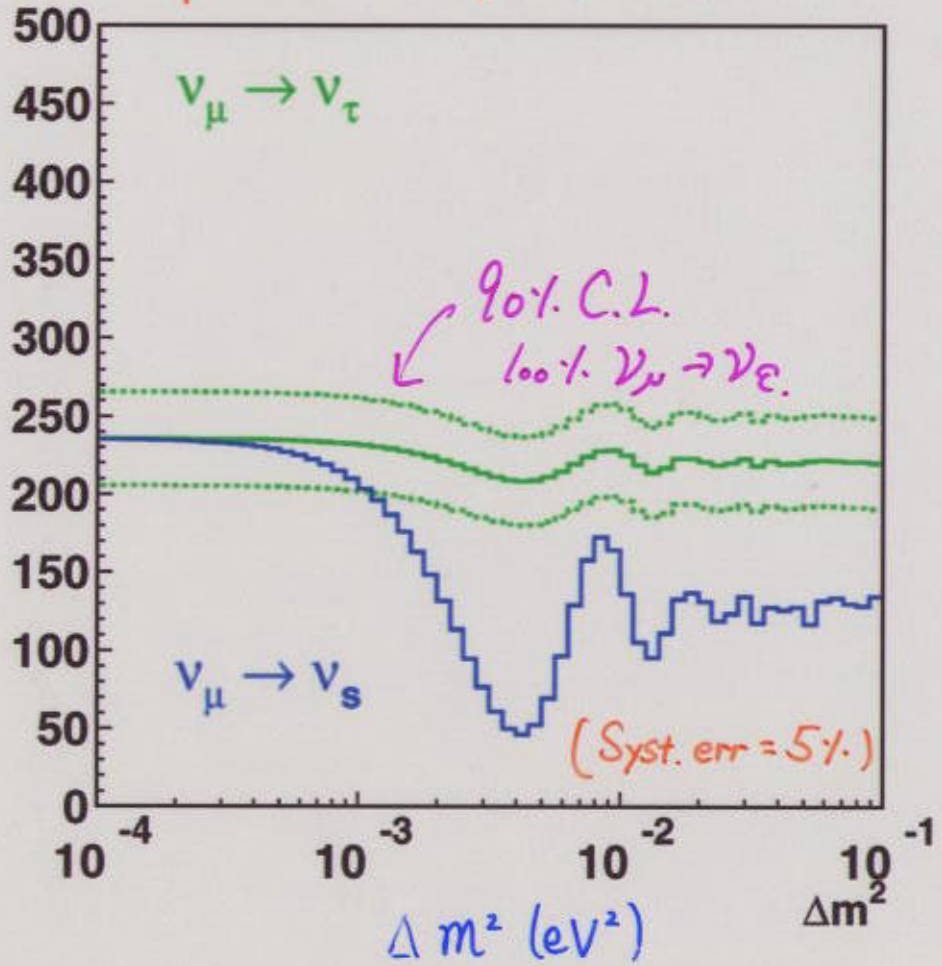
	ν_μ NC	ν_μ CC	ν_e
# of events (No. osc.)	189.6	30.5	15.6





N.C. π^0 Search. Narrow band beam (2 GeV π. 5 yr.)

Expected # of events.



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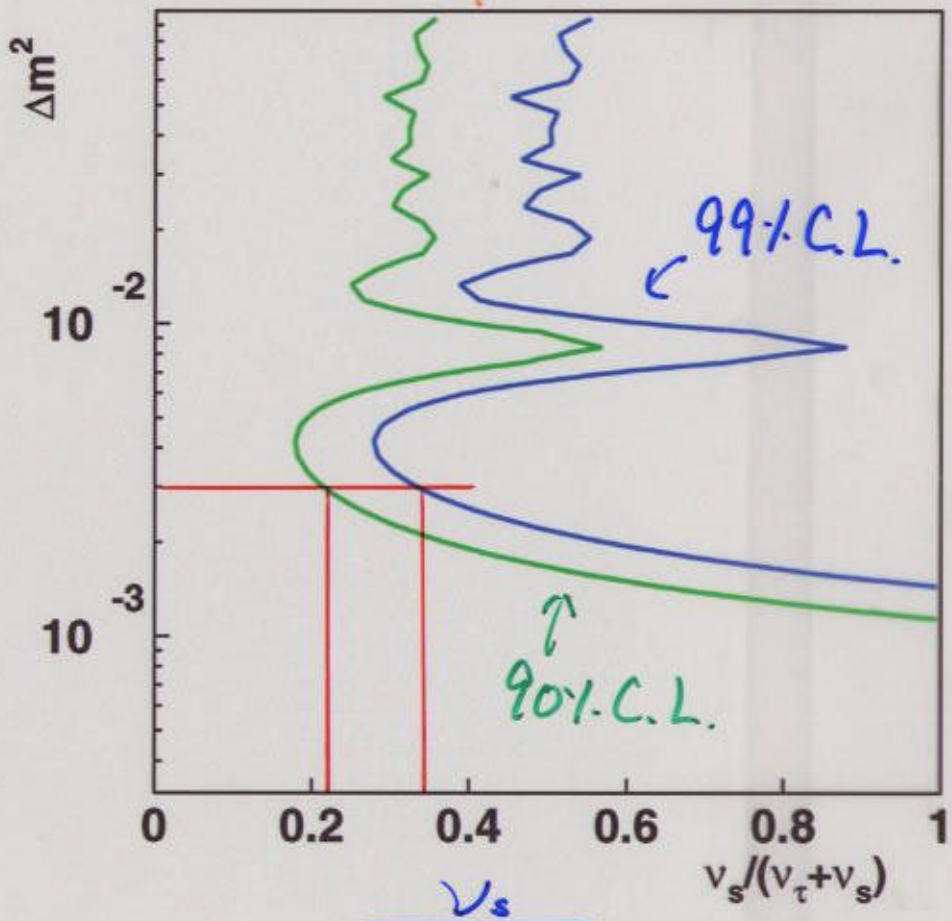
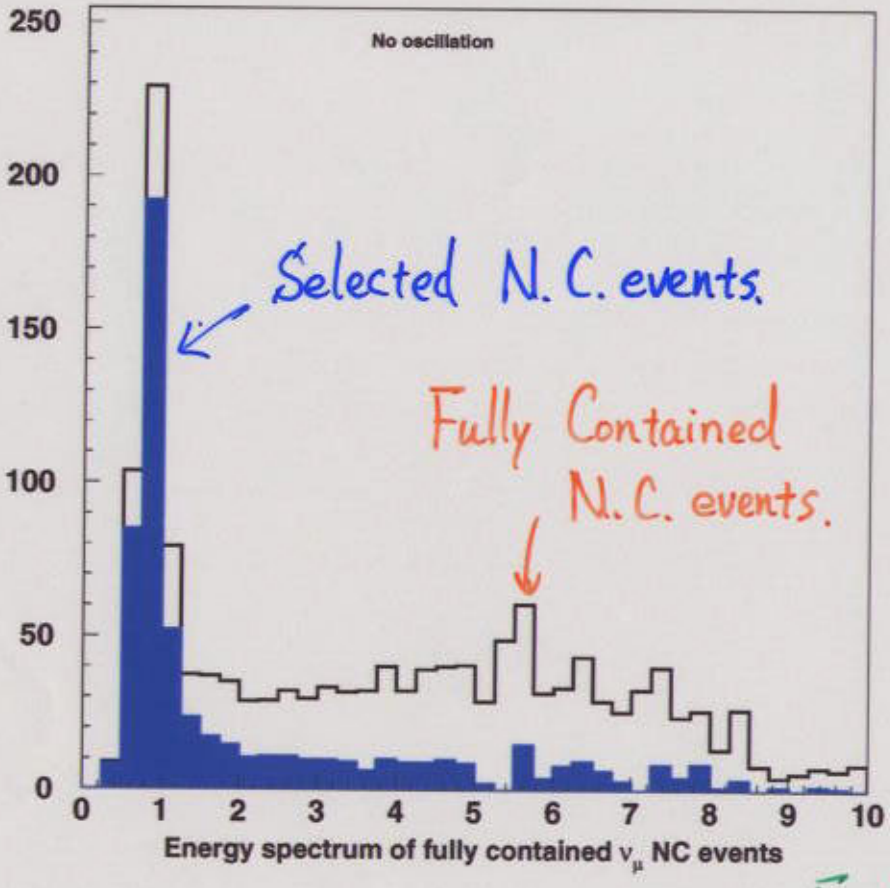
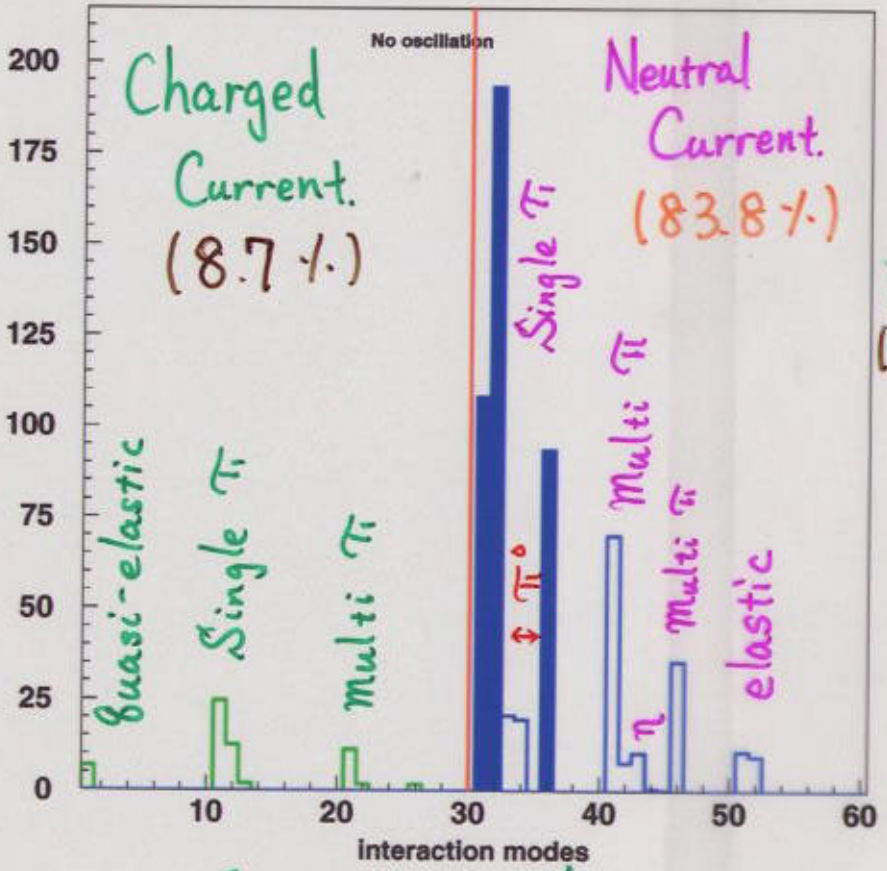


N.C. π^0 Search. Off axis beam (2 deg. 5 yrs.)

	ν_μ NC	ν_μ CC	ν_e
# of events. (No. Osc.)	579.8	60.3	51.7

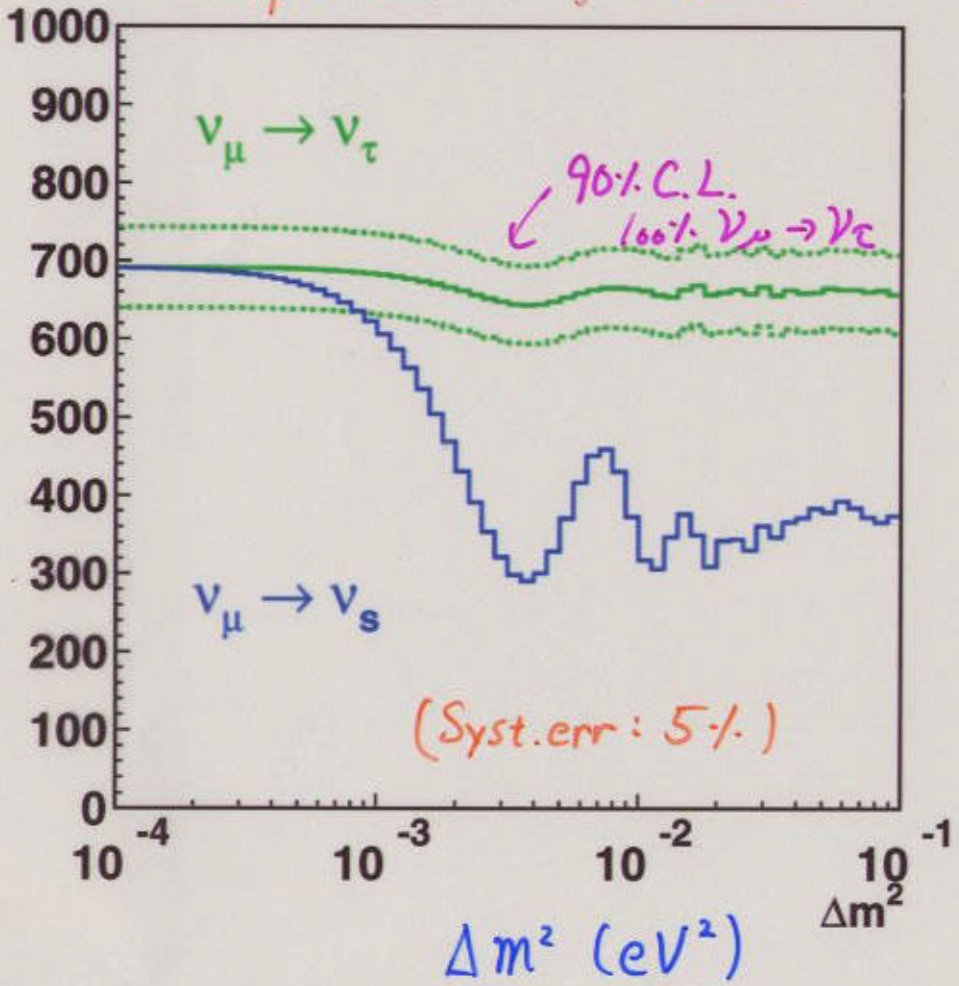




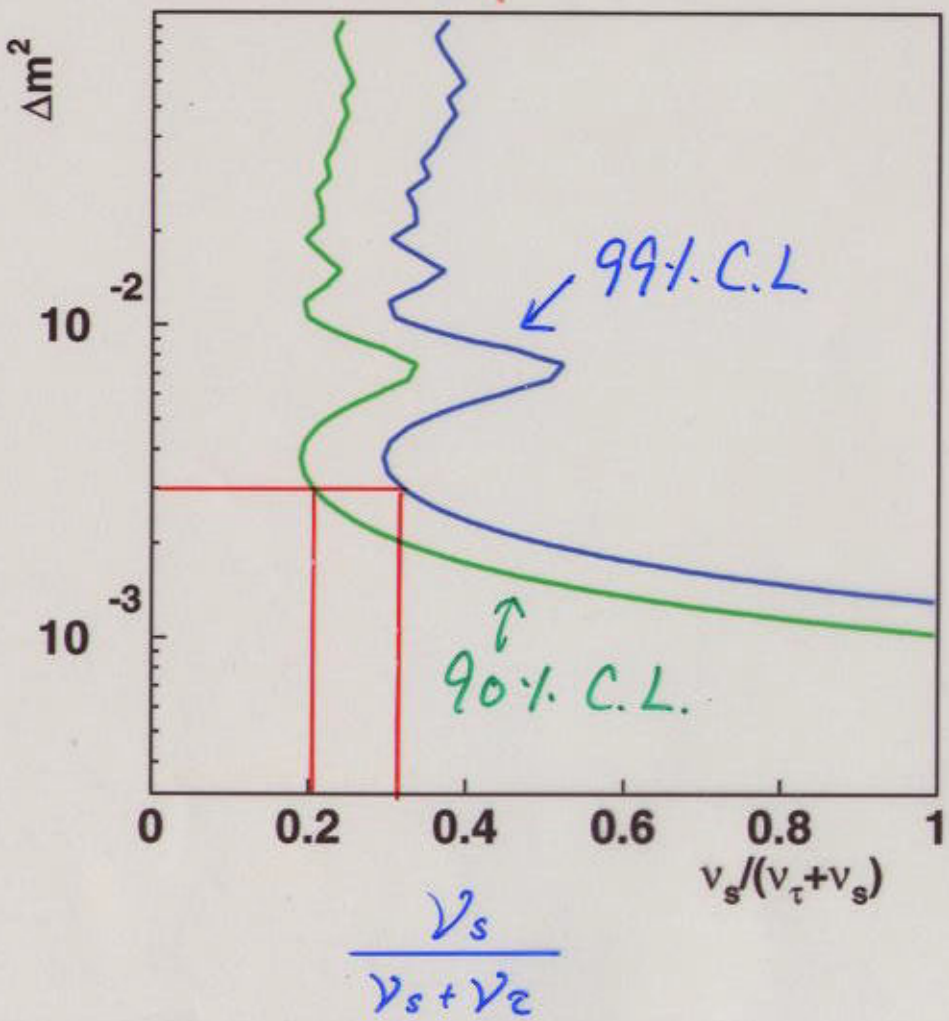
Interaction modes of selected events.

N.C. π^0 Search. Off axis beam (2 deg. 5 yrs.)

Expected # of events.



Sensitivity



Source of systematic errors.

i). ν energy spectrum.

Wide Band Beam → high energy tail.

→ Narrower E_ν

ii) ν interaction cross-sections.

→ Can be reduced by using front detector.

iii) Nuclear effects.

π interactions in ^{16}O

π interactions in H_2O

⇒ Important to know # of multi π events.

Probability to generate decay electron

$\pi^+ \to \nu_\mu \mu^+$

$\hookrightarrow e^+ \nu_e \bar{\nu}_\mu$

detected.

iv). Detection efficiency of decay electron.

In order to reduce systematic errors.

Low energy narrow band beam is useful.

i) Low energy

σ(multi π) → small.

ii). Measurements of σ

→ precise measurement can be done

@ Front detector.

(or Mid-range detector)

Water Cherenkov detector @ near site is also important. (incl. results from K2K exp.)

i) detection efficiency of π^0

ii) detection efficiency of decay electron.

Summary.

Search for $\nu_\mu \to \nu_s$ oscillation

Use N.C. π^0 production.

	Expected # of N.C. ν_μ No Oscillation.	Sensitivity @ $\Delta m^2 = 3 \times 10^{-3}(eV^2)$
Wide band beam 1 year	274.3	$\nu_\tau : \nu_s = 30 : 70$ (99% C.L.) $55 : 45$ (90% C.L.)
Narrow band (2GeV π) 5 yrs.	189.6	$\nu_\tau : \nu_s = 65 : 35$ (99% C.L.) $75 : 25$ (90% C.L.)
Off axis (2deg.) 5 yrs.	579.8	$\nu_\tau : \nu_s = 70 : 30$ (99% C.L.) $80 : 20$ (90% C.L.)

(Assume syst. err = 5%)