



Latest Results from K2K

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July 28, 2000

ICHEP(Osaka, Japan)

K2K collaboration

(18 institutions from Korea, US and Japan)
~100 physicists

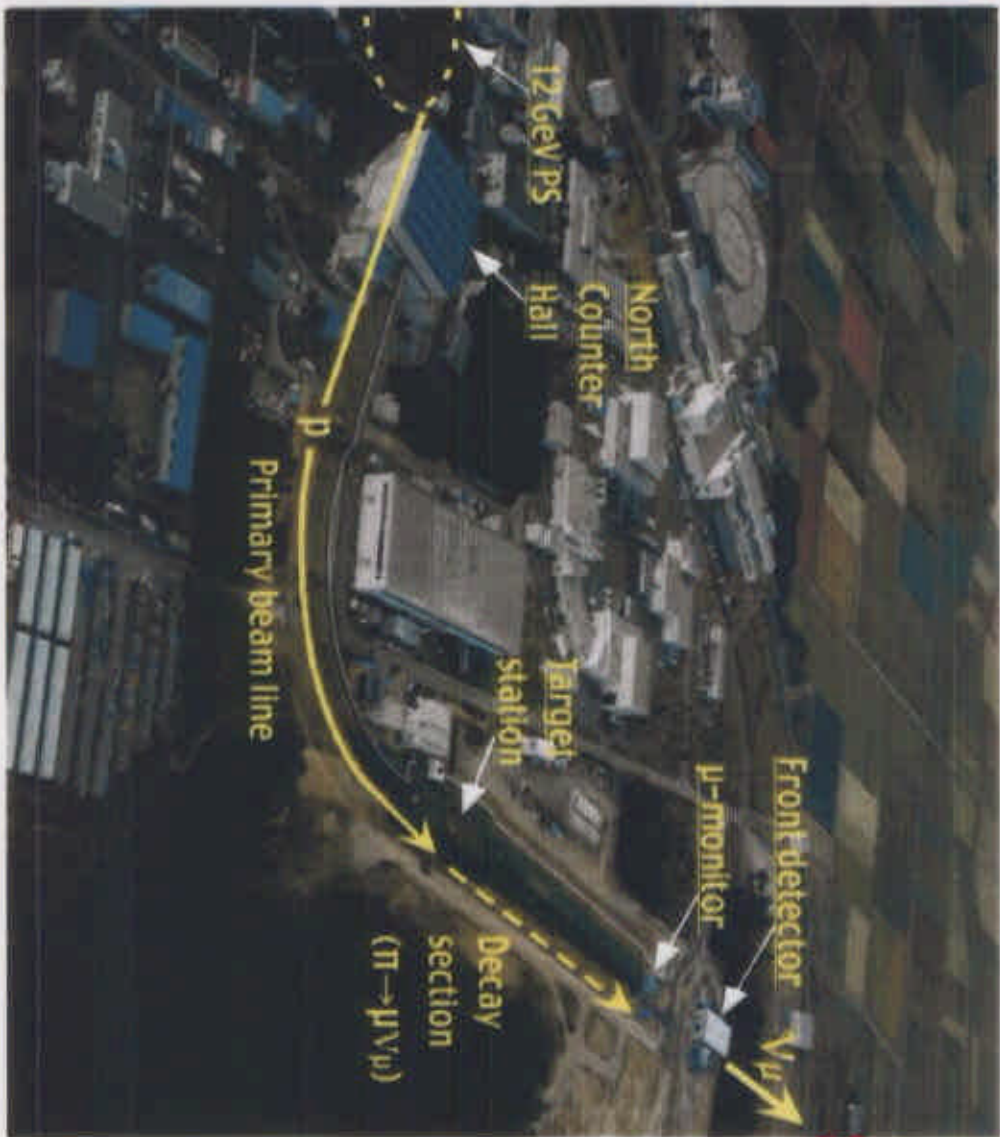
Confirm ν_{μ} disappearance and
pin down Δm^2 and $\sin^2 2\theta$

*Nu.2000 (Jun 99 - Mar 00)
ICHEP (Jun 99 - Jun 00)*

Outline

- Neutrino Beamline
- Near Detector
- SK events
- Conclusion

Neutrino Beamline



SK Horn Magnets

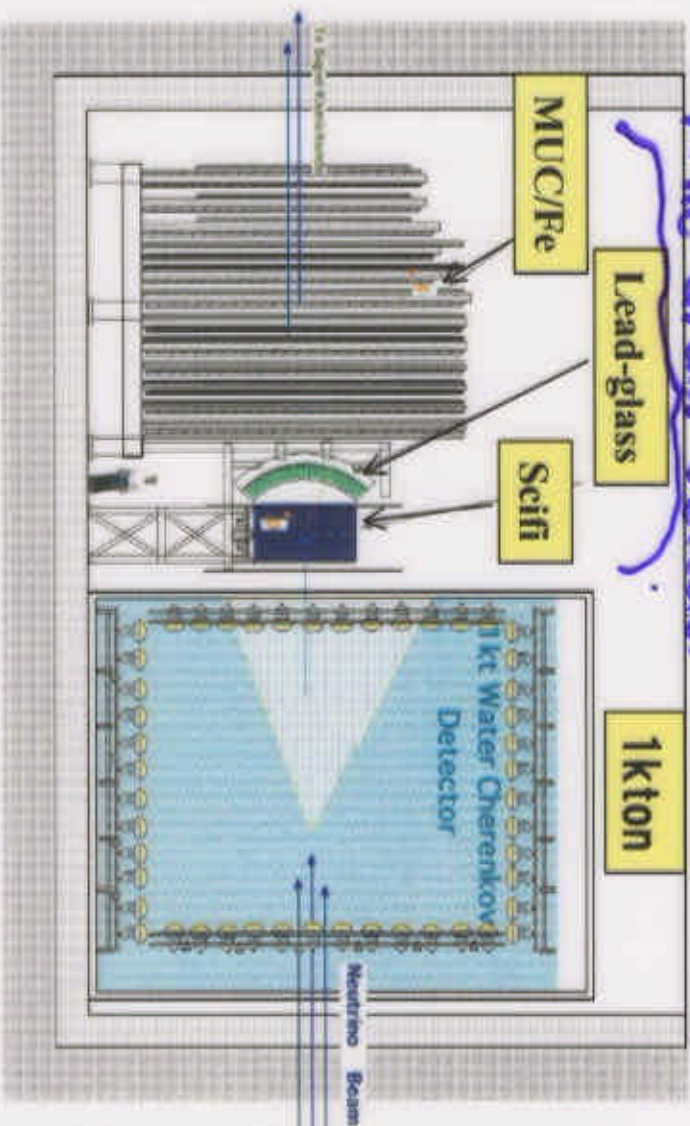


K2K Near Detector

Function

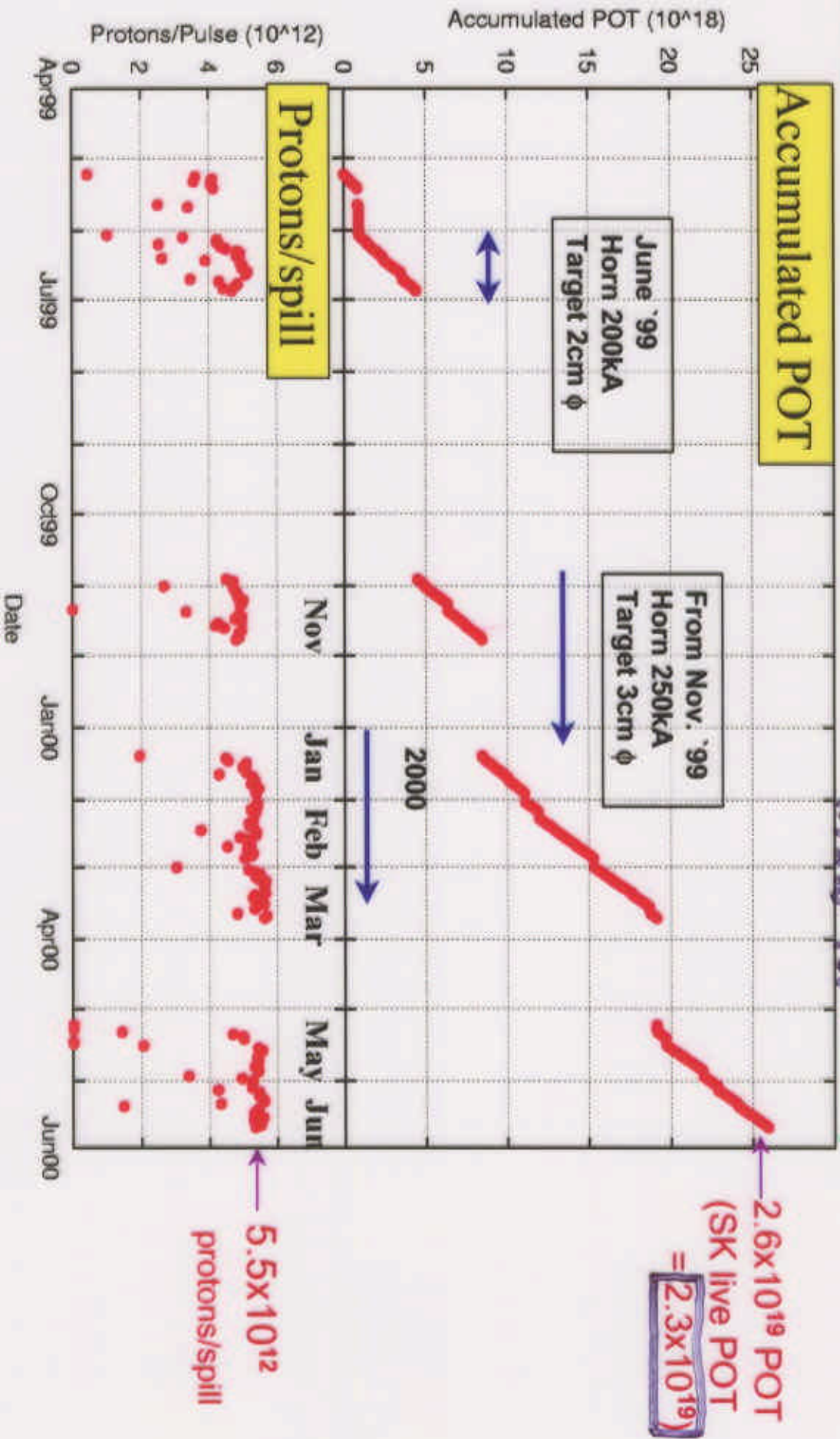
- Measure ν_μ flux, spectrum, profile
- Study ν_μ interactions at ~ 1 GeV

Fine-Grain Detector



- 1 kton water Cherenkov detector
 - Same type as SK
 - Common water target
- Scintillating-Fiber (Scifi) tracker
 - 2.4 m \times 2.4 m \times 20 (x,y) modules
 - 19 layers of 60-mm thick water target
 - $\sigma_x = 1$ mm
- Muon Range detector (MUC/Fe)
 - 12 layers of iron plates (total mass \sim 1kton) sandwiched by drift chambers
 - $\Delta E_\mu = 150$ MeV.
- Lead-glass counter
 - $\Delta E_e / E_e = 10\%$
- Scintillation Counters

Protons on Target (POT)



Typical Events at Near Detector

1kton

Fiducial Mass 50.3 ton (water)

Event Selection

Single event,
Q > 1000 p.e.

Event Rate

~ 0.02 events/spill



Scifi

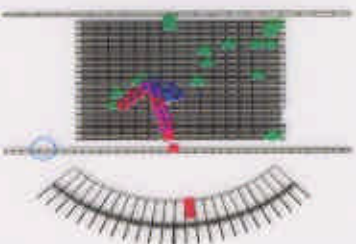
4.9 ton
(70%water + 30%Al+C)
1 Scifi & MUC track + X

~ 0.001 events/spill

KITK Event/Channel Database / Scifi Visual

RW

MUC 0

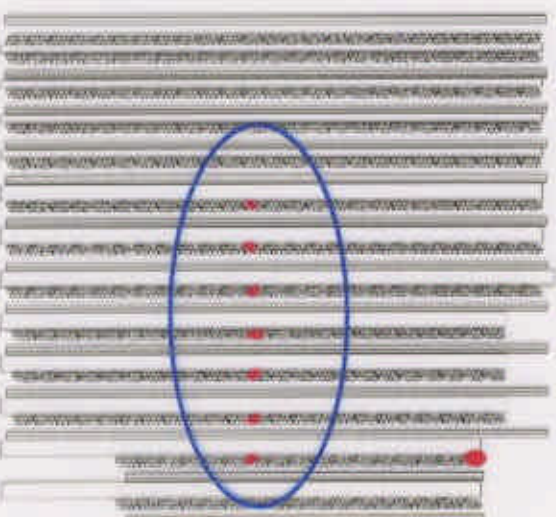


100 cm

MUC/Fe

312 ton (Fe)
1 MUC track

~ 0.05 events/spill



8m

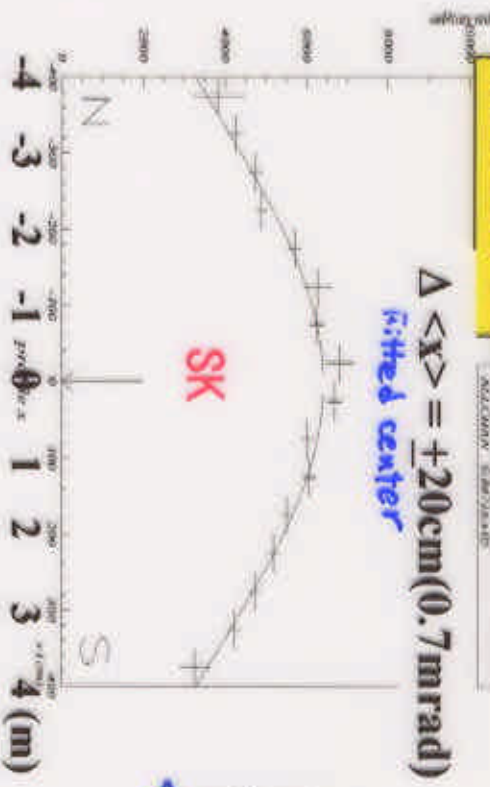


ν_μ Beam Profile & Its Time Stability

MUC/Fe

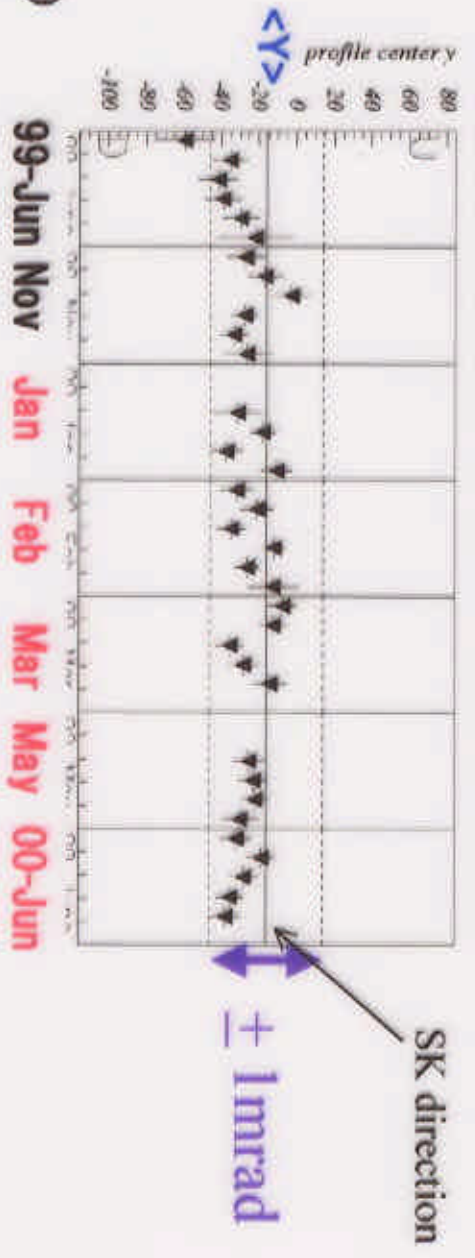
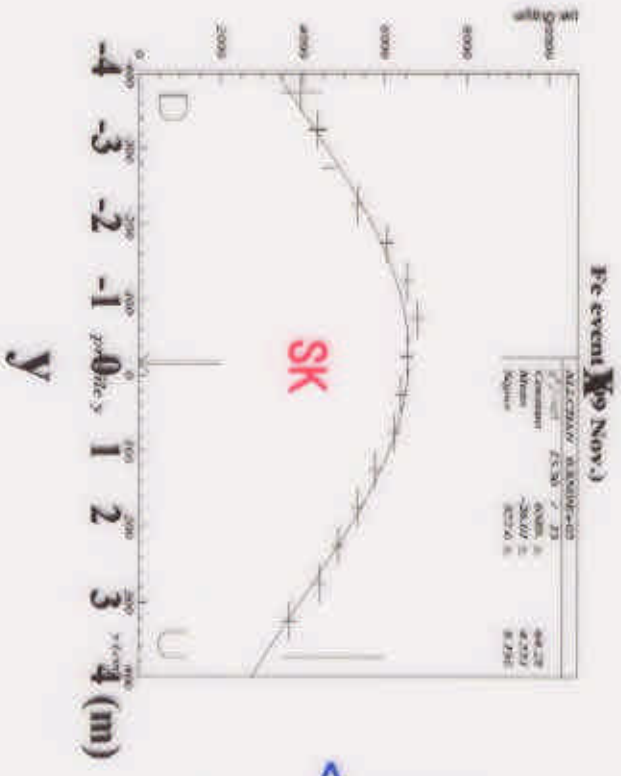
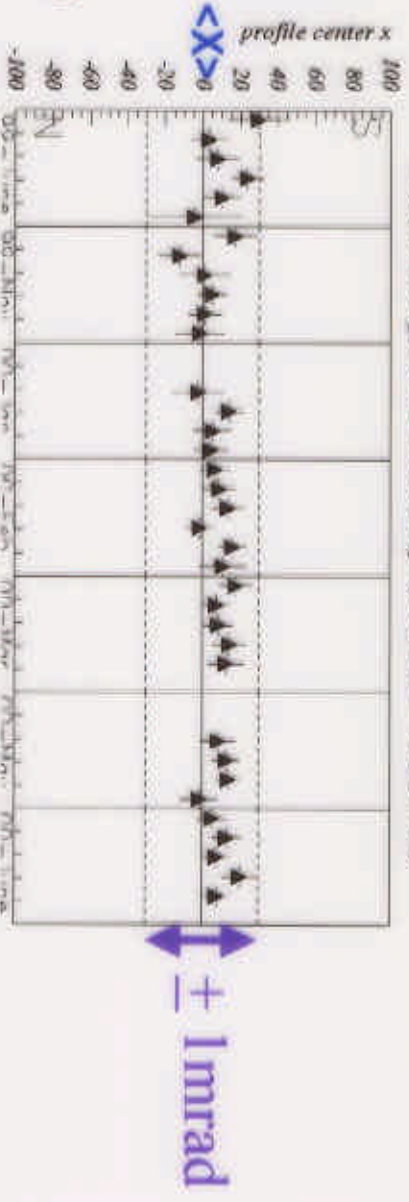
cut (99 Nov.)

ACCOUNTING: SMOU/BAID



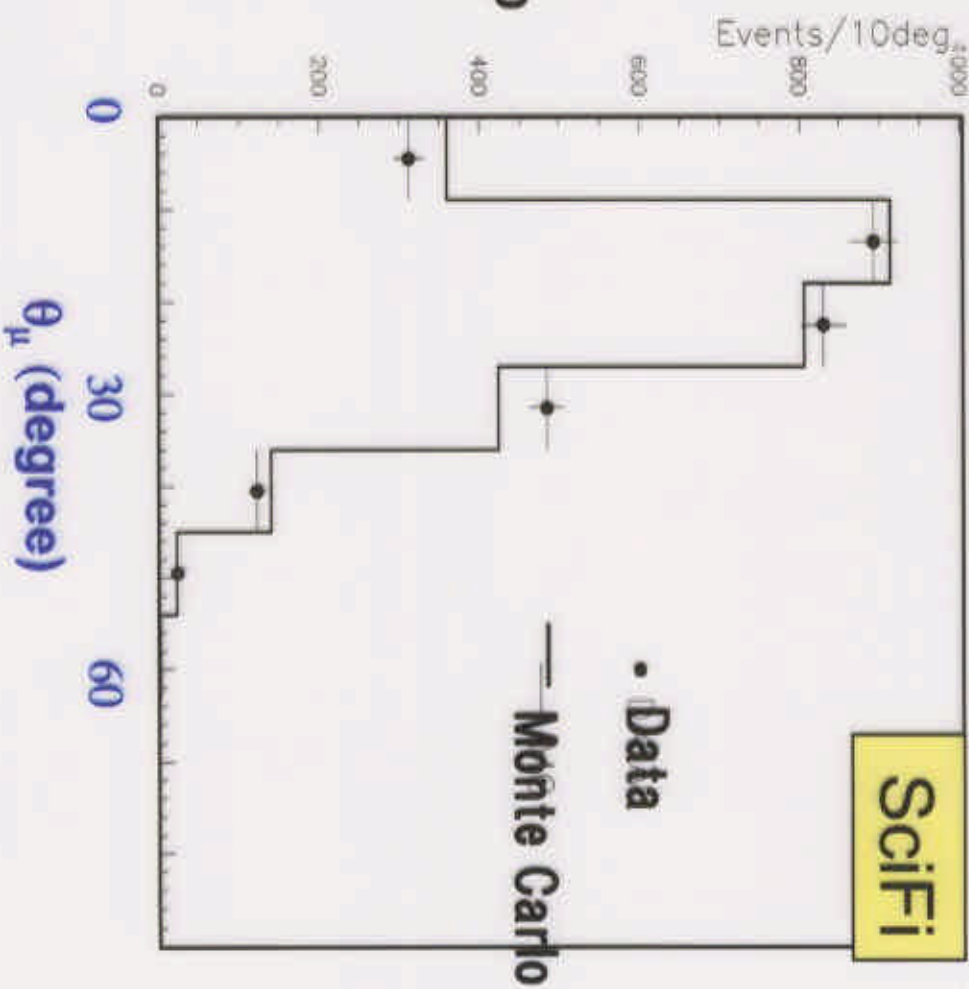
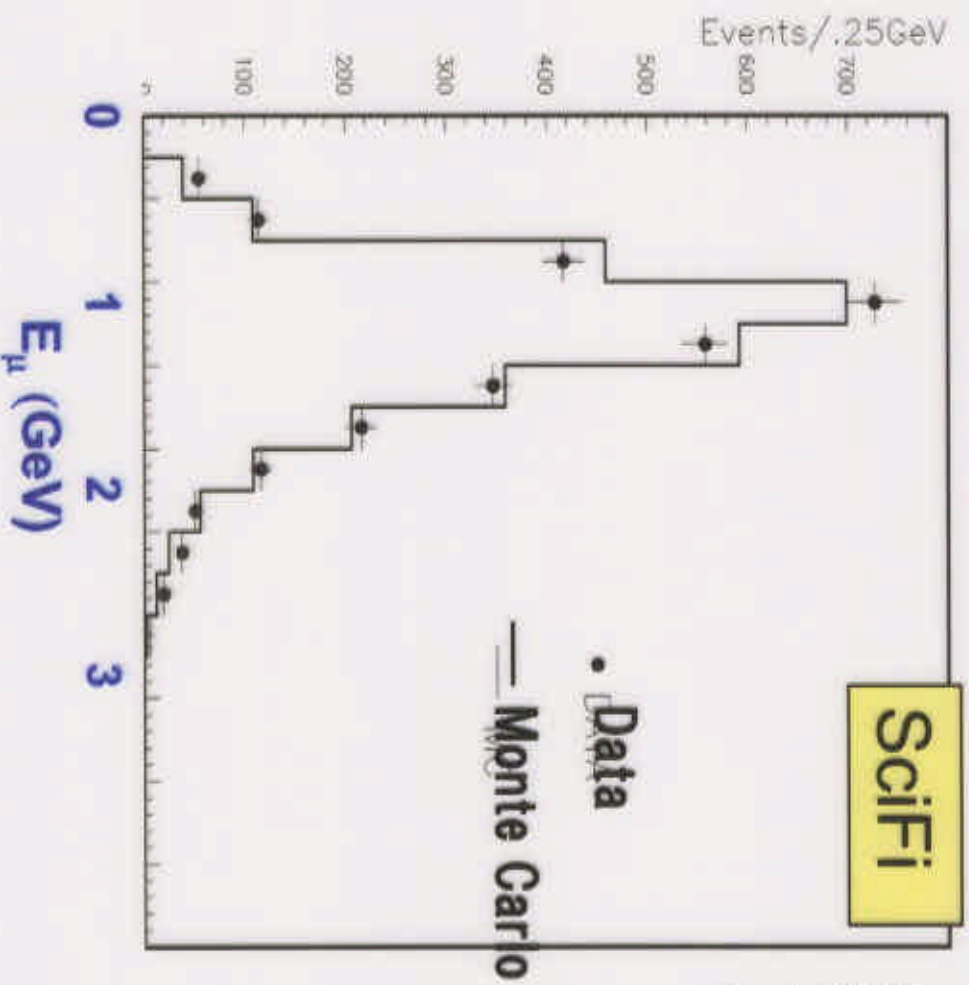
Beam direction to SK <math>< 1 \text{ mrad}</math>.

Neutrino profile stability (99 June - 00 June)



Charged-current muon spectrum measured with Fine-Grained Detector

Fair agreement between Data and MC.



Expected Number of SK Events

N_{SK} (expected) = N_{KEK} (measured) $\cdot R \cdot \epsilon_{SK} / \epsilon_{KEK}$

R : Far-to-Near event ratio

$$R = \frac{\int F_{SK}(E_\nu) \sigma(E_\nu) dE_\nu}{\int F_{KEK}(E_\nu) \sigma(E_\nu) dE_\nu} \cdot \frac{N_{target}^{SK}}{N_{target}^{KEK}}$$

1kton MUC SciFi

N_{SK} (expected): ^{Multi-site effects} **40.3** ^{+4.7} _{-4.6} (sys) **41.4** ^{+6.2} _{-6.4} **40.0** ^{+5.2} _{-5.5} (SK FC events in 22.5kton)
Jun99 - Jun00

Good agreement within systematic errors.

We use the rate of 1kton detector, since the total systematic

error is the smallest.

1kton ~ SK

Common syst. errors cancel.
 - water target

-> Table

Systematic errors for N_{SK} (expected)

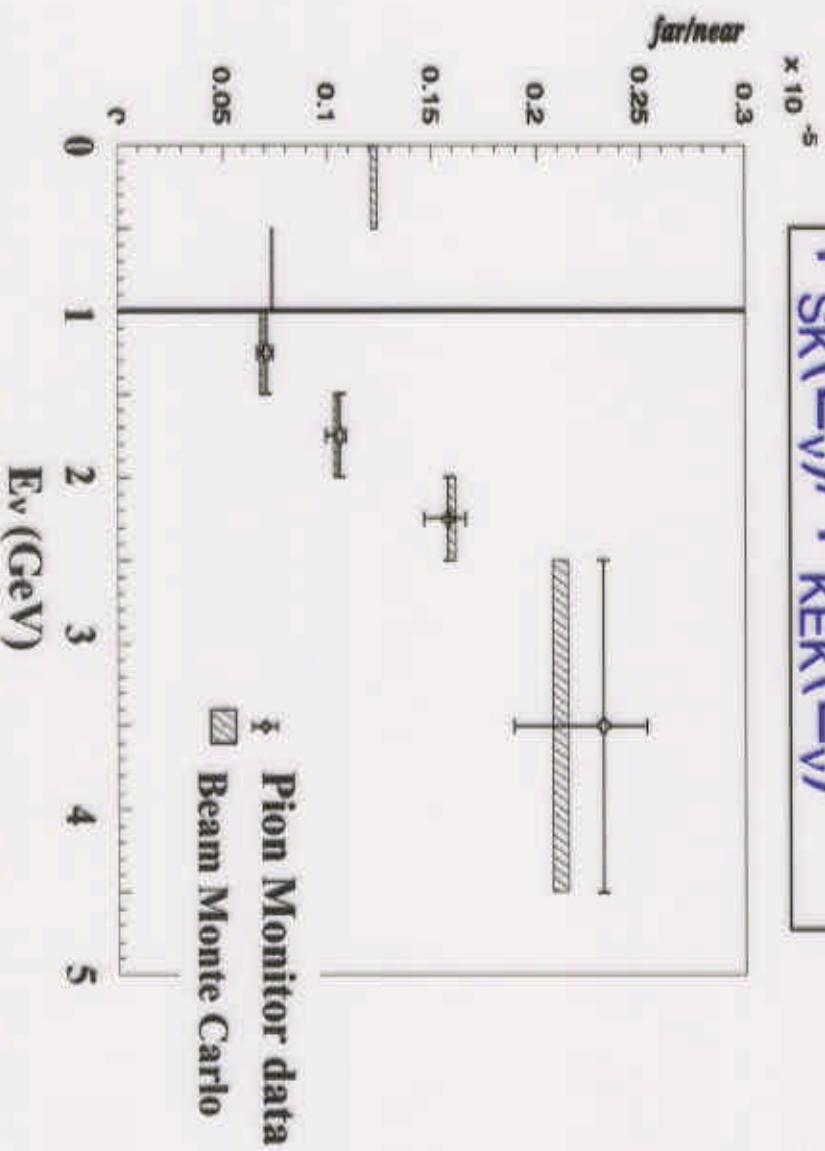
N_{SK} (expected) 40.3^{+4.7-4.6} 41.4^{+6.2-6.4} 40.0^{+5.2-5.5}

	1 kton	MUC	SciFi
$\Delta V / V$	6%	<2%	3%
multi event	3%	-	-
Background	1%	-	1%
Flux error (Fe)	+1.3%	3%	3-4%
	-1.7%		
Detection efficiency	--	3%	5%
NC/CC (+-30%)	+0.8%	6%	6%
	-0.9%		
Target cross section	--	10%	3%
$\Delta V / V$ (SK)	3%	3%	3%
ΔR (event ratio)	+6%	+6%	+7%
ΔR (Flux)	-7%	-7%	-9%
Total Sys. error	10-11%	15%	13%
Statistical error	1%	< 1%	4% / month

]: extrapolation error

Pion monitor and Beam Monte Carlo

$$F_{SK}(E_\nu) / F_{KEK}(E_\nu)$$



Pion monitor data validates our beam Monte Carlo.

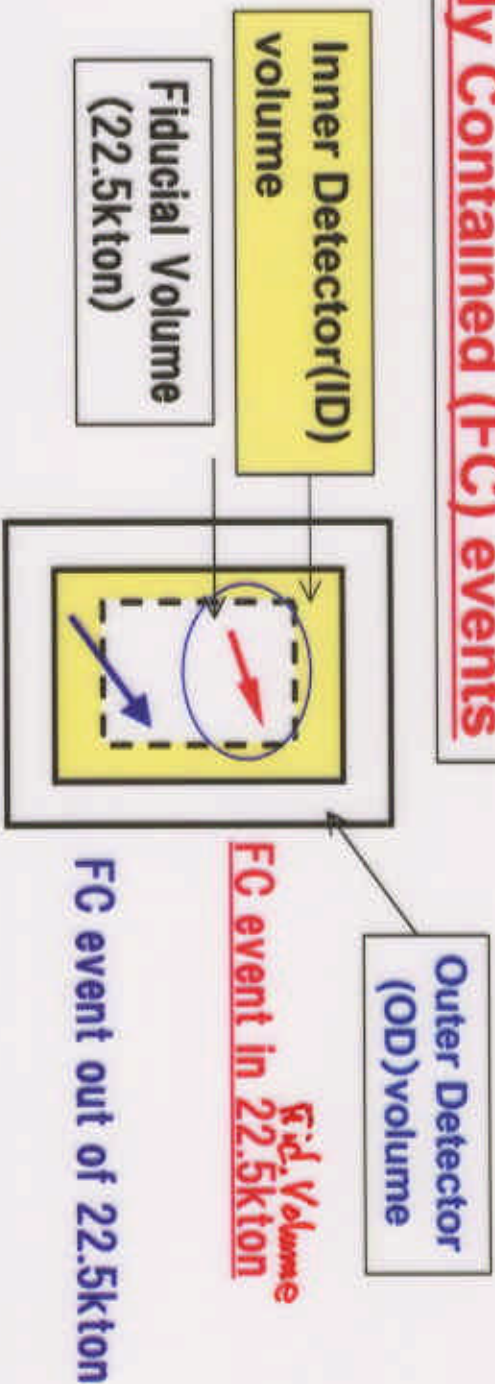
+6%

The combined systematic error in R is $\Delta R = -7\%$.

K2K Beam-induced Events in SK

Event Definition:

1) Fully Contained (FC) events



FC event Selection

(light in ID only)

$$200 < Q^{\text{ID}}_{\text{TOT}} < 50,000 \text{ p.e.}$$

No OD cluster

2) OD events

OD selection

(light in OD)

- OD cluster > 9 hit PMTs

Event Reduction for SK events

Δt of F.C. candidates

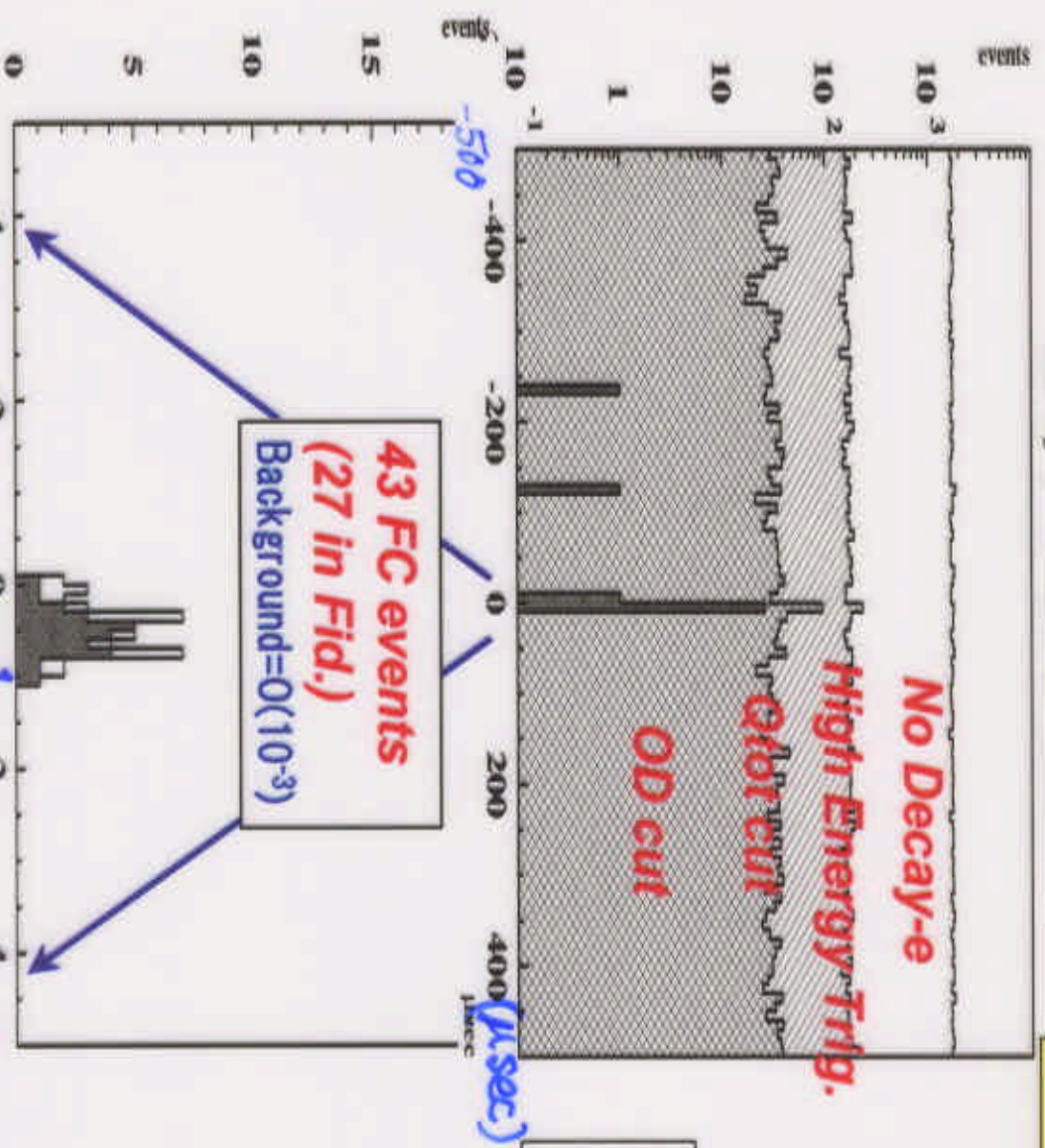
$-0.2 < \Delta T = T_{SK} - T_{KEK} - T_{TOF} < 1.3 \mu\text{sec}$

0.8233 ns



KEK beam events (FC+OD) at the right time.

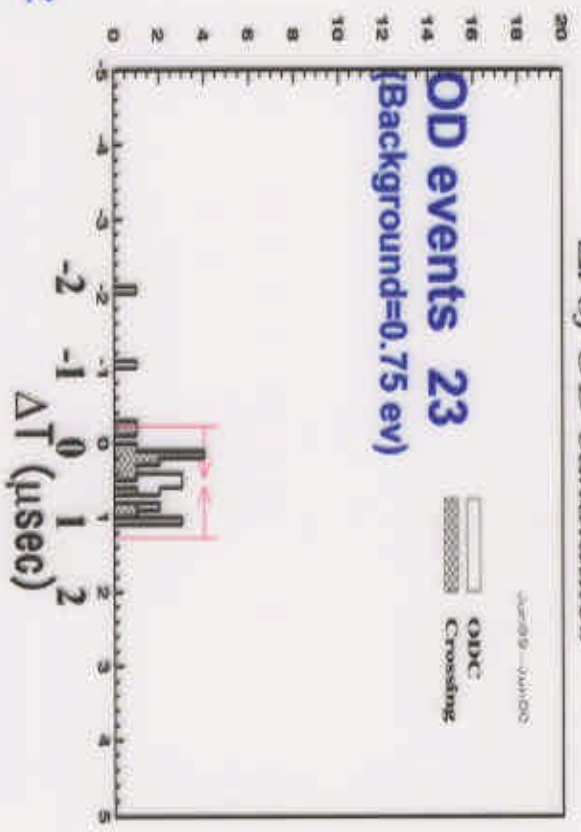
Δt of OD candidates



-500 μsec

ΔT (μsec)

500 μsec



ΔT (μsec)

Summary of FC events (Jun99-Jun00)

22.5 kt 

	N_{SK}^{obs}	$N_{SK}^{expected}$			
		null oscillation $\Delta m^2 = 3 \times 10^{-3}$ <small>$\sin^2 2\theta = 1$</small>	5×10^{-3}	7×10^{-3} (eV ²)	
FC (22.5 kt)	27	$40.3^{+4.7}_{-4.6}$	$26.6^{+3.4}_{-3.3}$	$17.8^{+2.3}_{-2.2}$	$14.9^{+1.9}_{-1.9}$
1-ring	15	24.3 ± 3.6	14.4 ± 2.3	9.4 ± 1.5	8.6 ± 1.4
μ -like	14	21.9 ± 3.5	12.4 ± 2.1	7.5 ± 1.3	6.8 ± 1.2
e-like	1	2.4 ± 0.5	2.1 ± 0.4	1.9 ± 0.4	1.8 ± 0.4
multi ring	12	16.0 ± 2.7	12.2 ± 2.1	8.4 ± 1.5	6.3 ± 1.1

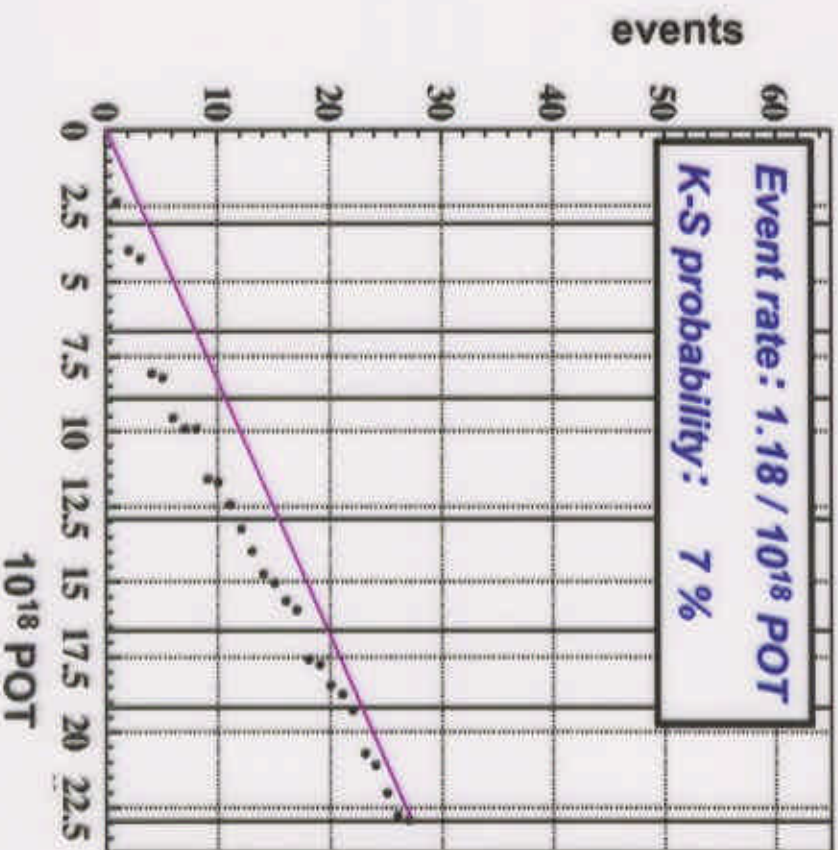
Conclusions

- From data (June'99-June'00), corresponding to 2.29×10^{19} POT, we observed 27 fully-contained events at SK (22.5kton), while we estimate N_{SK} (expected) to be $40.3^{+4.7}_{-4.6}$ (sys.error) events for the case of no oscillations.

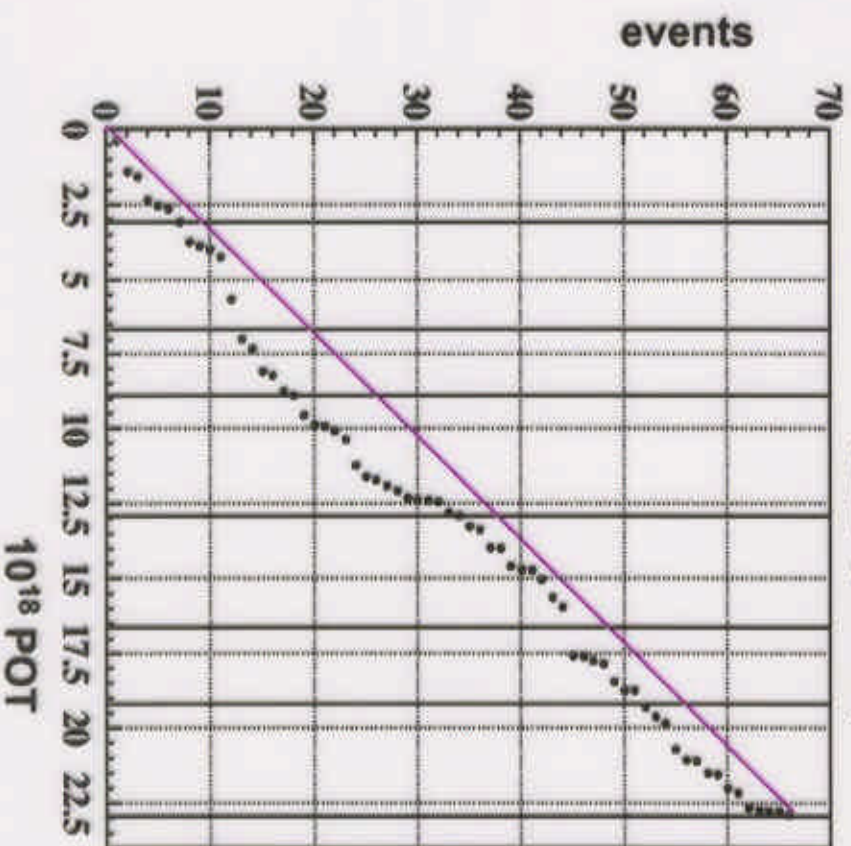
Our data disfavor null oscillations at the 2σ level.

Event Rate at SK

FC 22.5k1



ALL (FC+OD)



- Neutrino beam profile was measured by MUC/Fe to point to SK within 1mrad throughout the experiment.
- Neutrino events were measured with Near Detectors and the rate was stable.
- We have established the procedure to estimate the number of SK events. The predictions by 1kton (official value), MUC/Fe and SciFi detectors agree.
- Pion monitor data ($E_\nu > 1$ GeV) assures the beam Monte Carlo prediction.
- **Future:**
 - With more statistics, oscillation analysis with energy spectrum will be performed.
 - Study of ν_μ interactions at 1GeV with H_2O target.
- Accelerator, Beam monitors, Horns and Detectors are all stable. 10^{20} Protons on target in ~ 2005 .