Overview of the KEK Neutrino Beam Facility and its Operation

Summary after December 2002 (Recovery of SK)

K.H. Tanaka

for the KEK-PS Beam Channel Group &

K2K Beam Monitor Group.

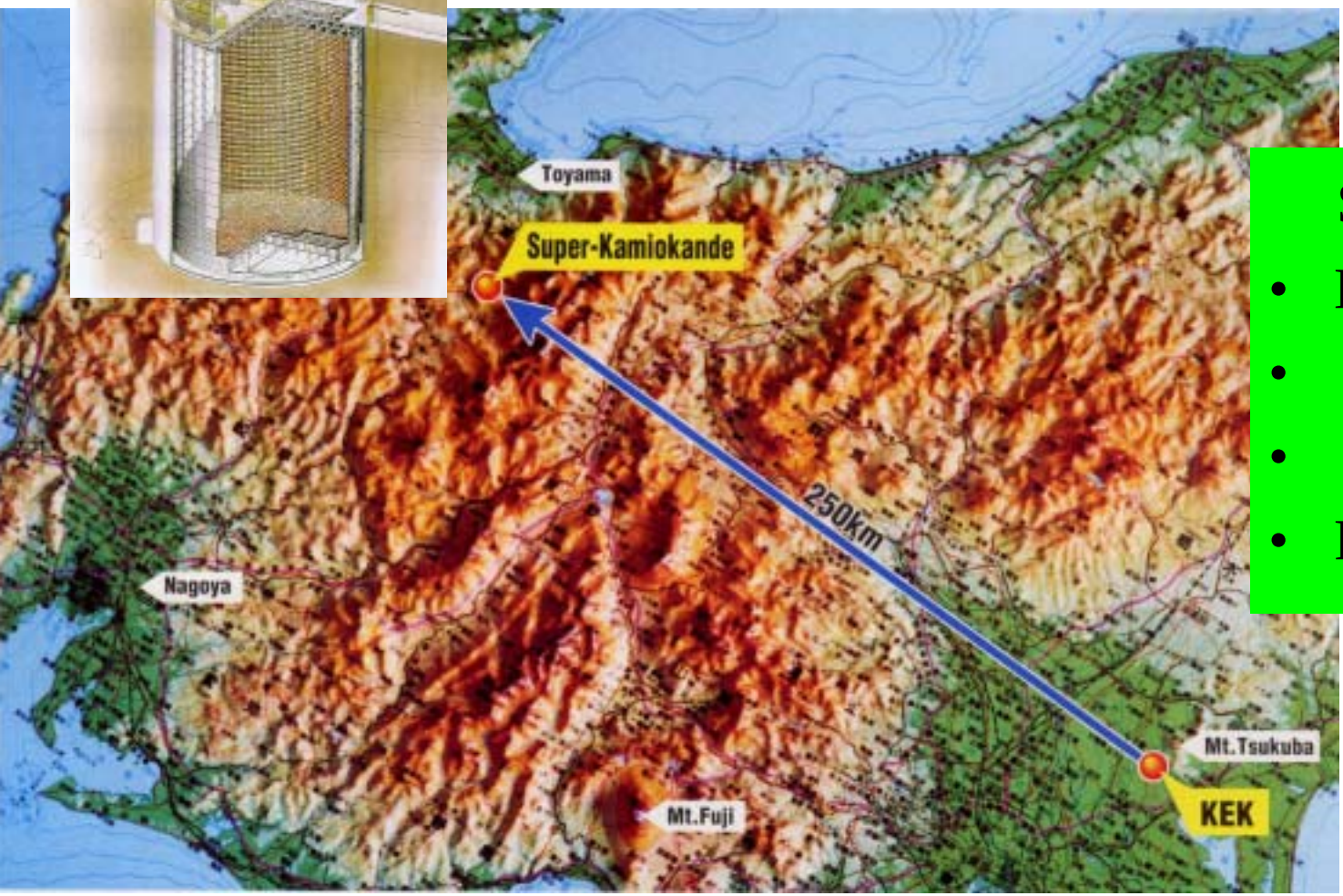
(Data presented here were prepared & compiled by Dr. Iwashita.)

Contents

K2K Experiment

The 2nd Phase of Long Baseline Neutrino Oscillation Experiment

Far Detector:
SuperKAMIOKANDE 50kt Water Cerenkov Detector



Shooting Side

- KEK 12GeV PS
- ν Beam Line
- ν Beam Facility
- Front Detectors

Recovery of SK

Accident:
November 12th, 2001

Photo by Kamioka Observatory, Institute of Cosmic Ray Research, The University of Tokyo

Recovery History

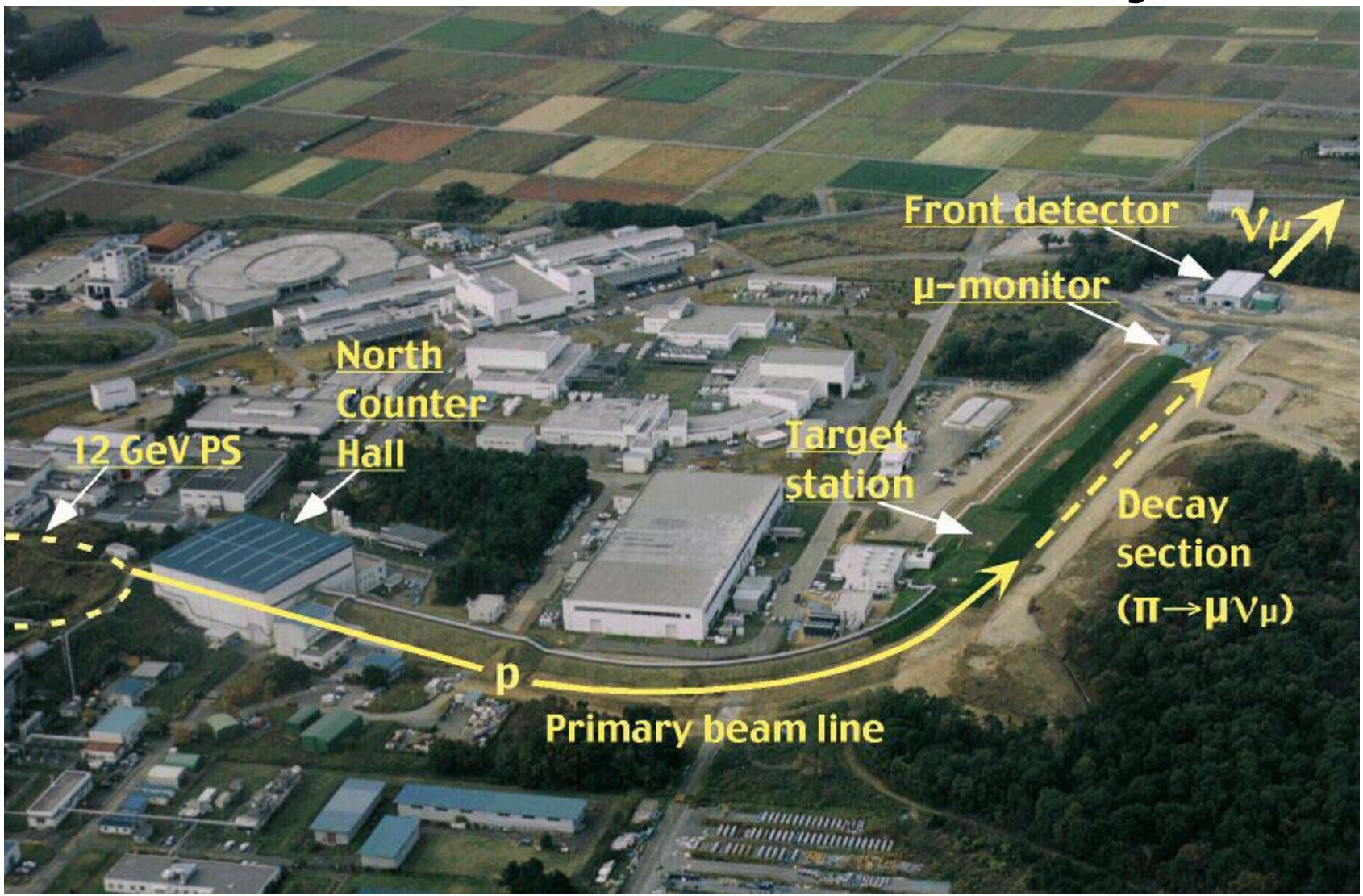
- Reconstruction Completed: December 10th, 2002
- Fast Extraction Tuning Start: December 17th, 2002
- Test Run Start: December 22nd, 2002
- Test Run End: December 25th, 2002
- K2K-II Start: January 18th, 2003
- Now: Running! till February 2004.

KEK

Accelerator Complex

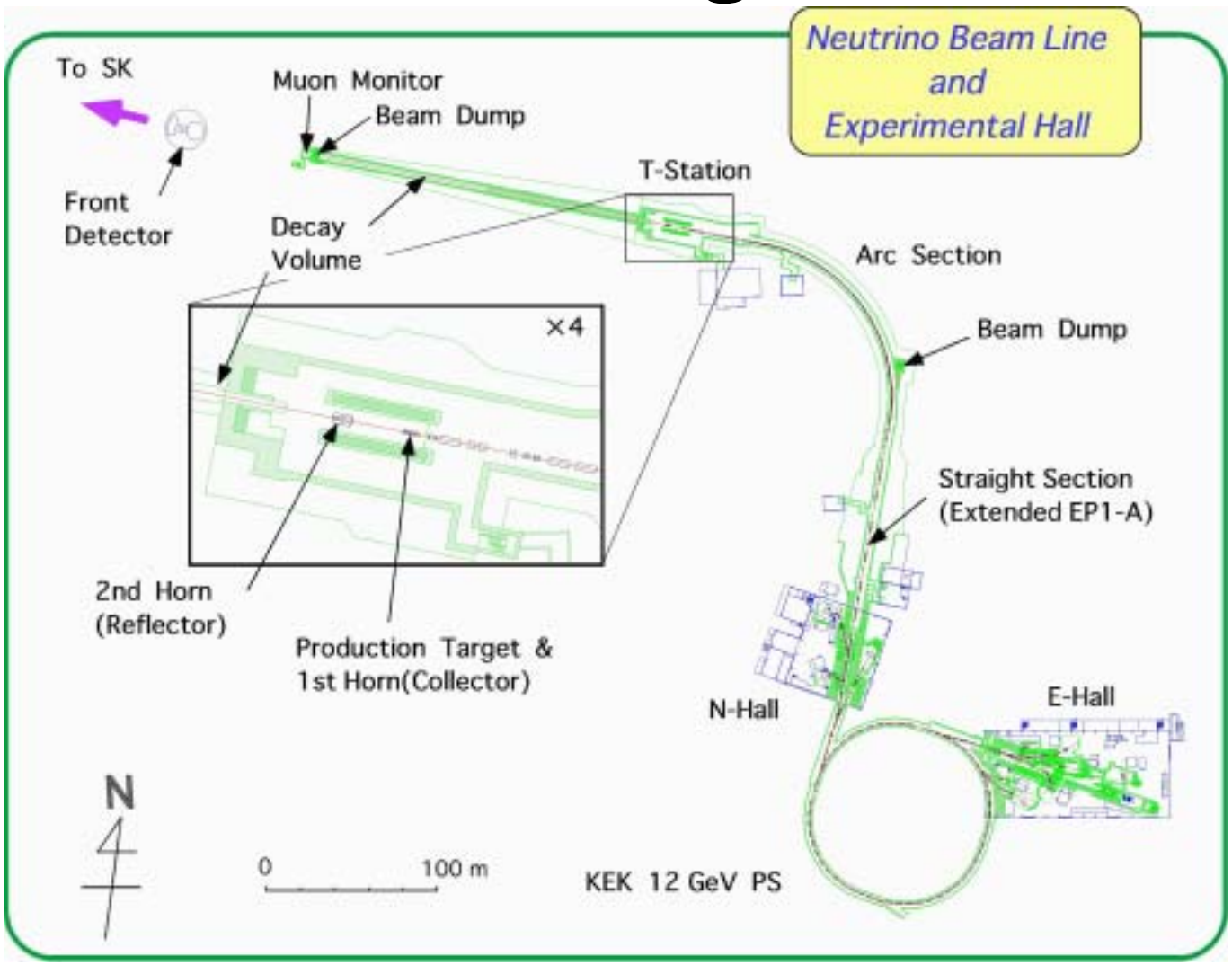
- 12GeV-PS
- 500MeV Booster
- 40MeV LINAC
- Photon Factory
- B-Factory
- ATF

Neutrino Beam Facility



Side View

Schematic Drawing of the Facility



Primary Proton Beam Line (Extended Part)

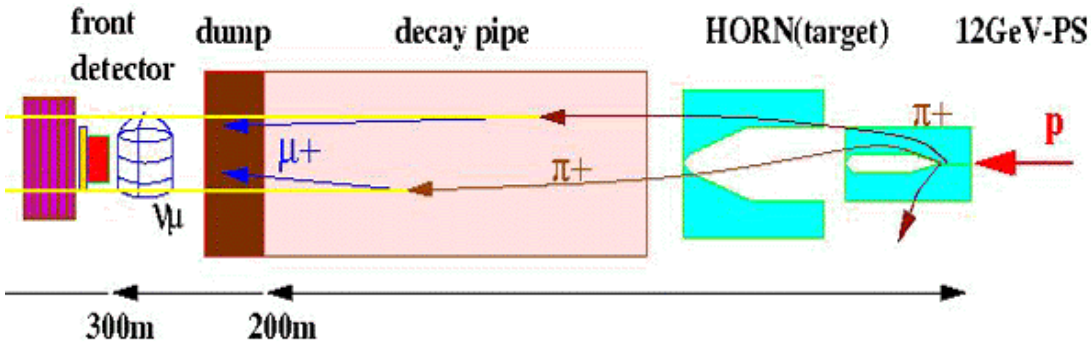
↑ Arc (Bending) Section,
No Crane is here.

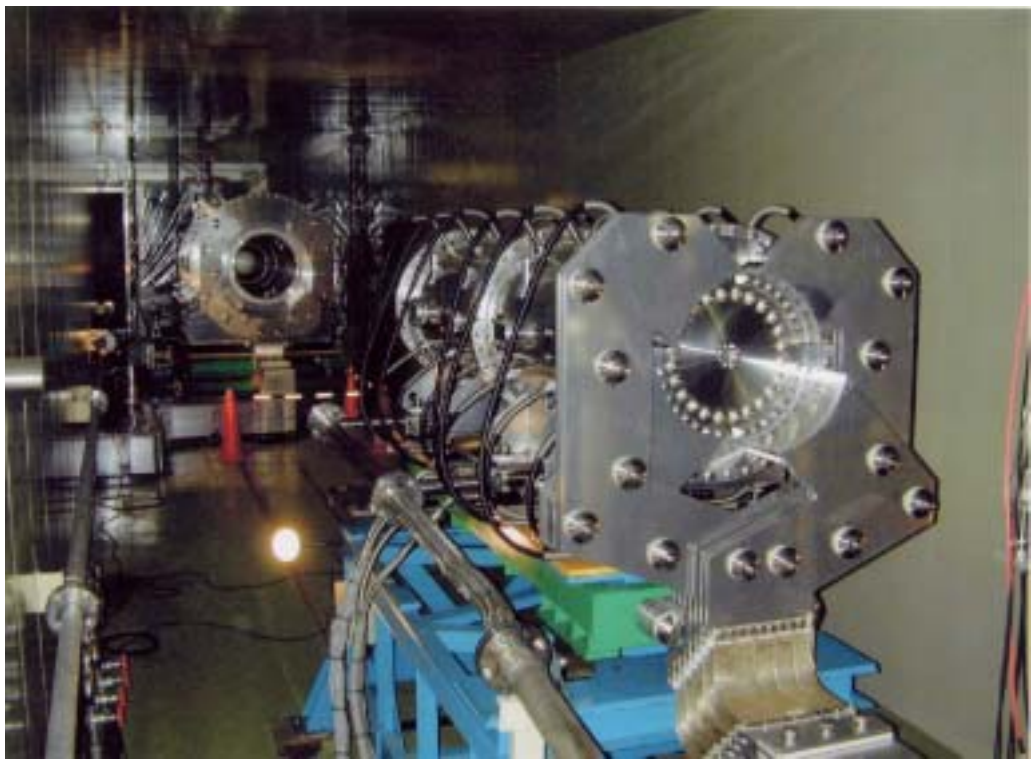
←Slope (Straight) Section,
5m/72m. 20t Crane is here.

Primary Proton Beam Line (Final Focus Part)

Q-triplet and Correction Magnets → Horns

Horns, Target & Decay Volume





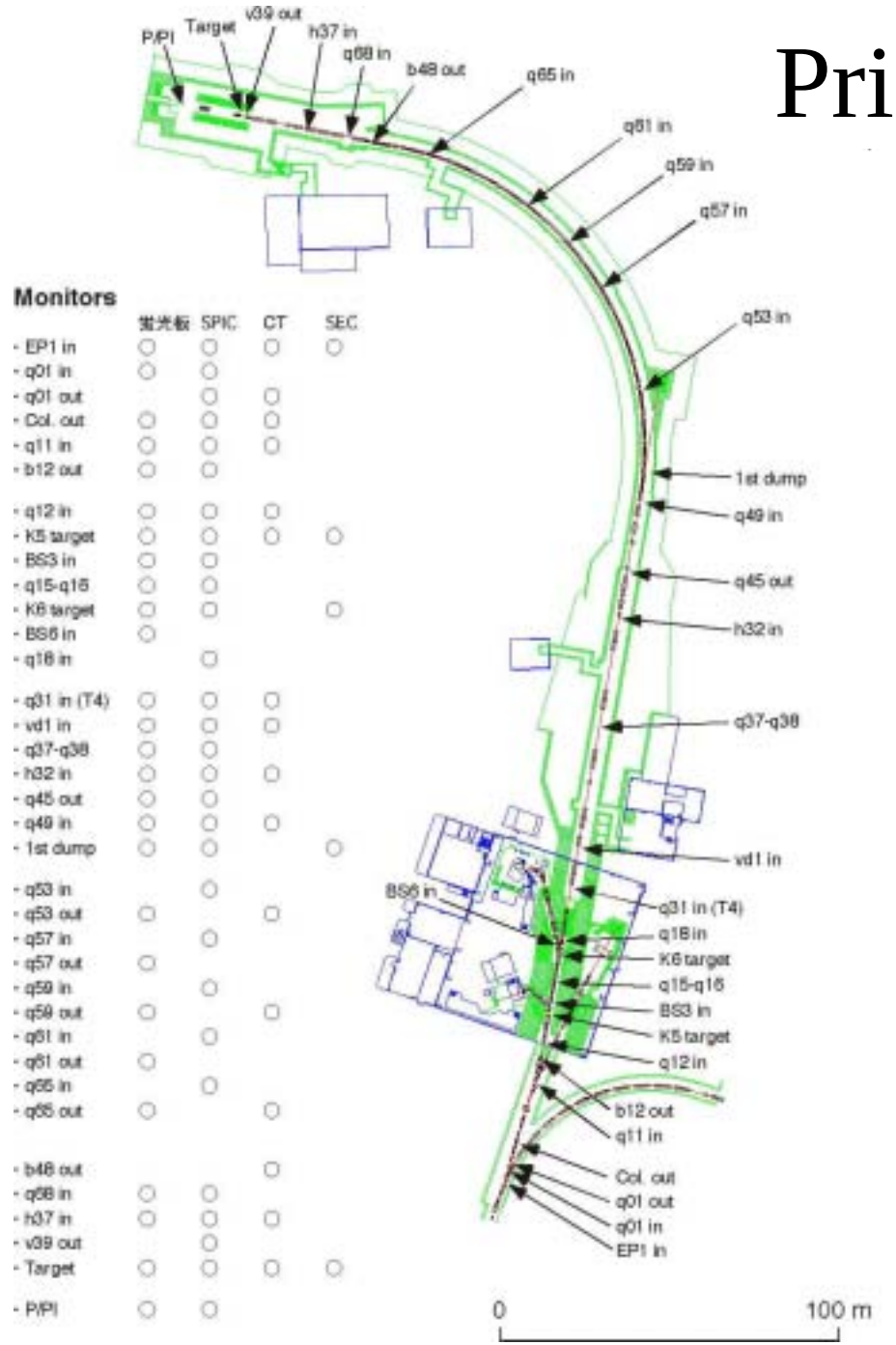
- Two Horns

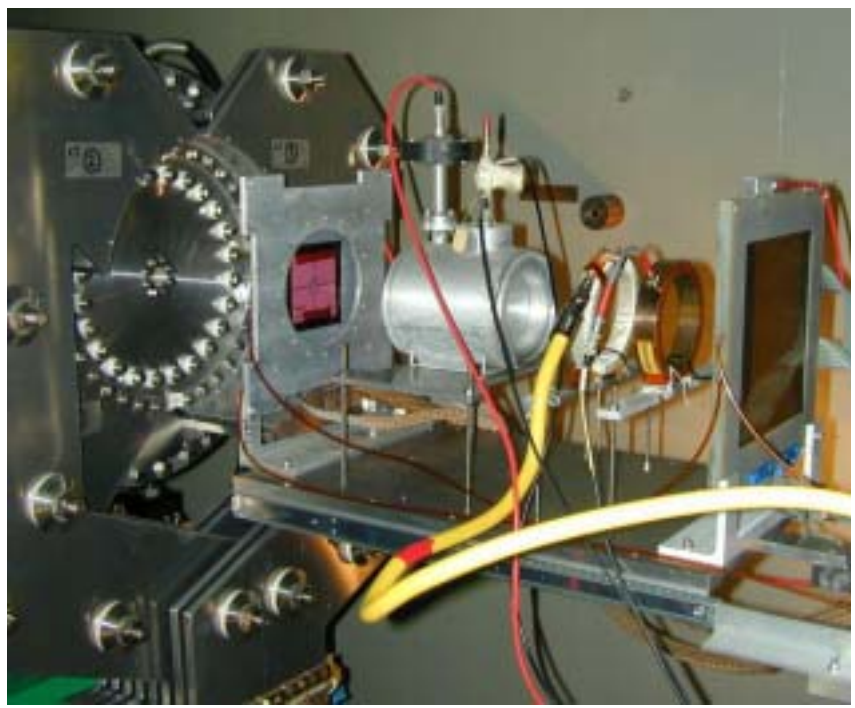
(Collector & Reflector).

- Built-in Target in Collector
- 250kA Operation
- 10M Excitation with 30mmΦTarget
- Transformer near-by
- 200m Decay Volume filled with He.

Primary Proton Monitors

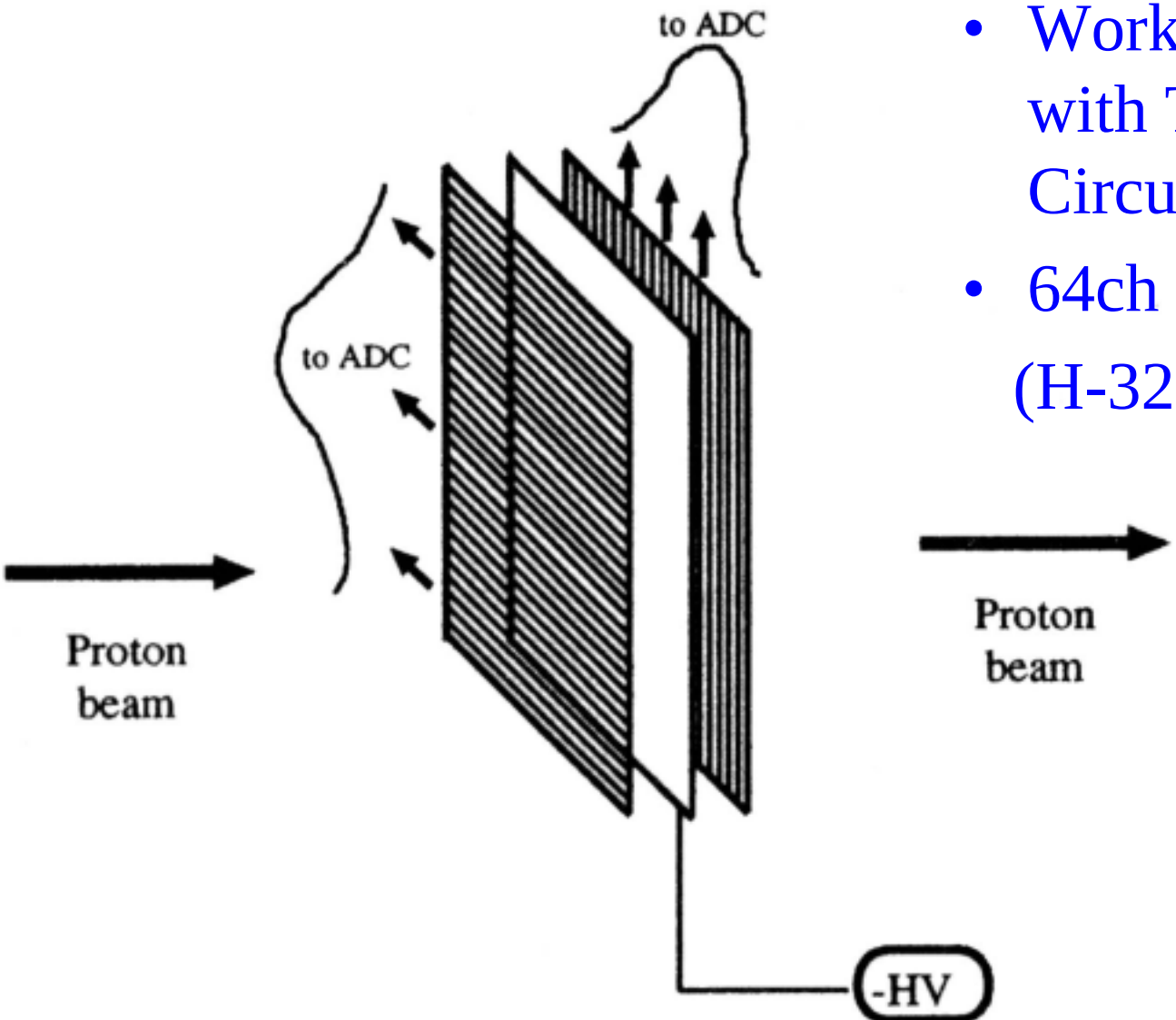
- Profile
  - Luminescence Screen (**蛍光板**)
  - SPIC
- Intensity
  - CT
  - SEC



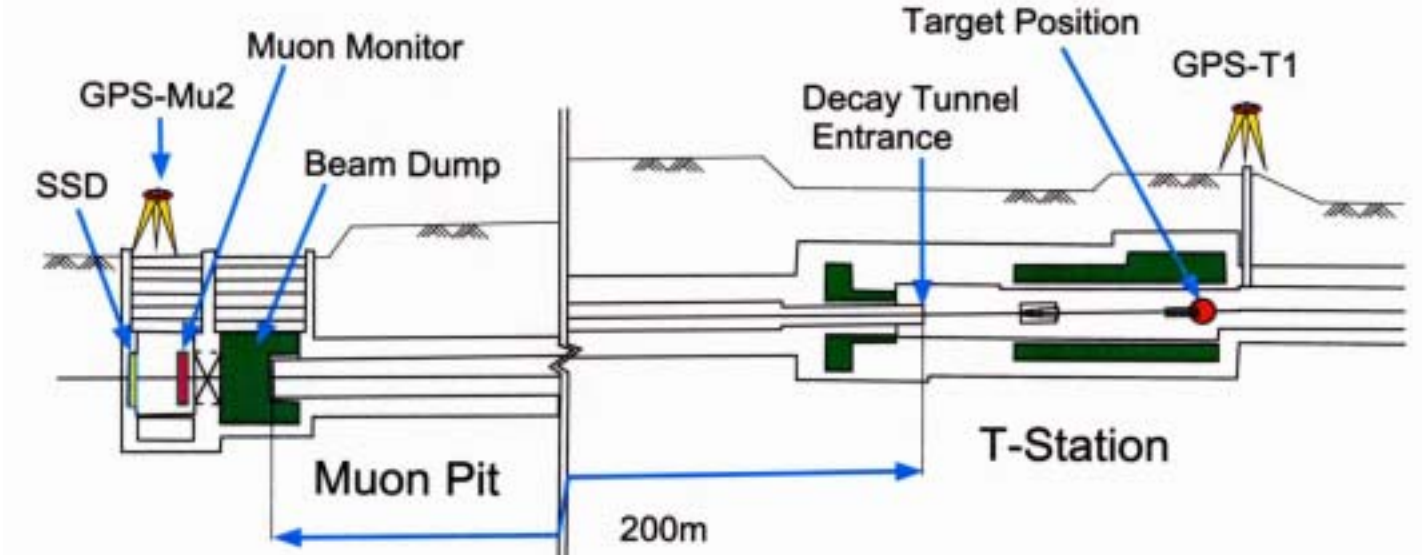


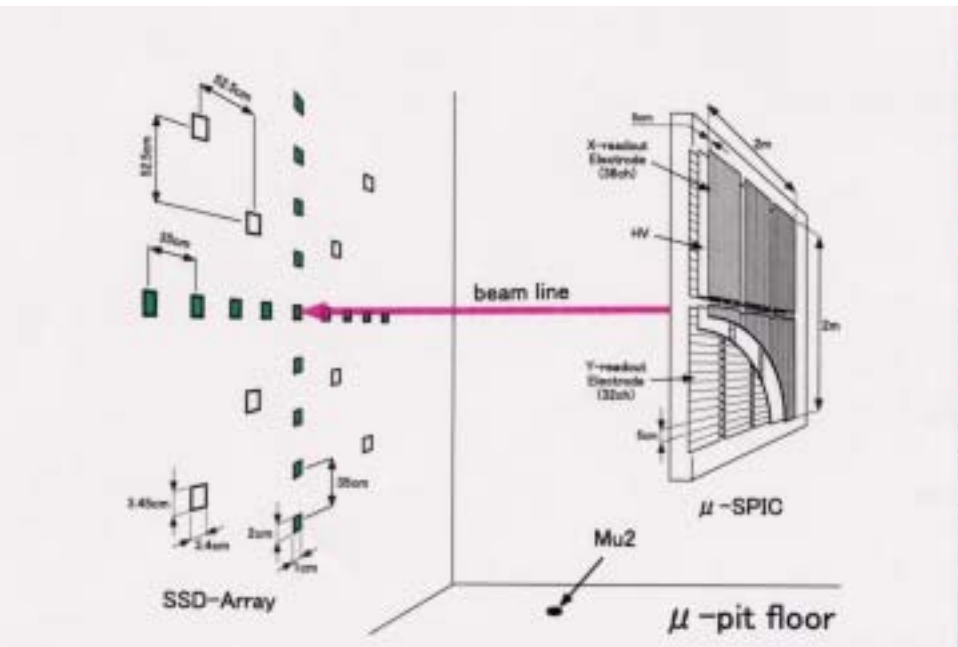
Segmented Parallel Plate Ion Chamber (SPIC)

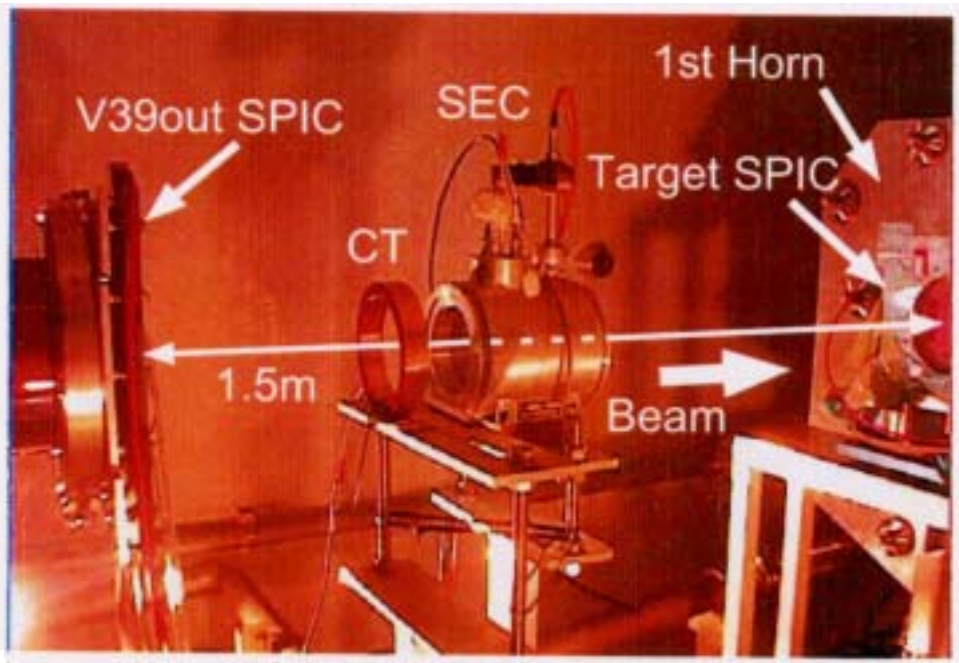
- Operated in He.
- Work in fast Beam with Time Constant Circuit.
- 64ch ADC readout (H-32ch, V-32ch)



Decay Volume & Muon Monitor

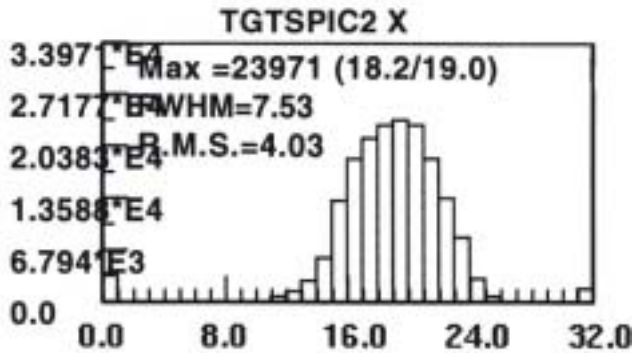




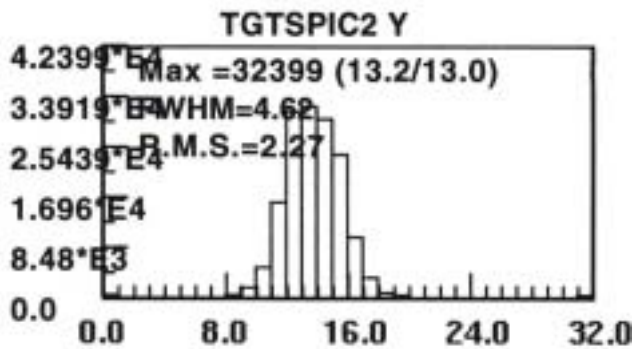


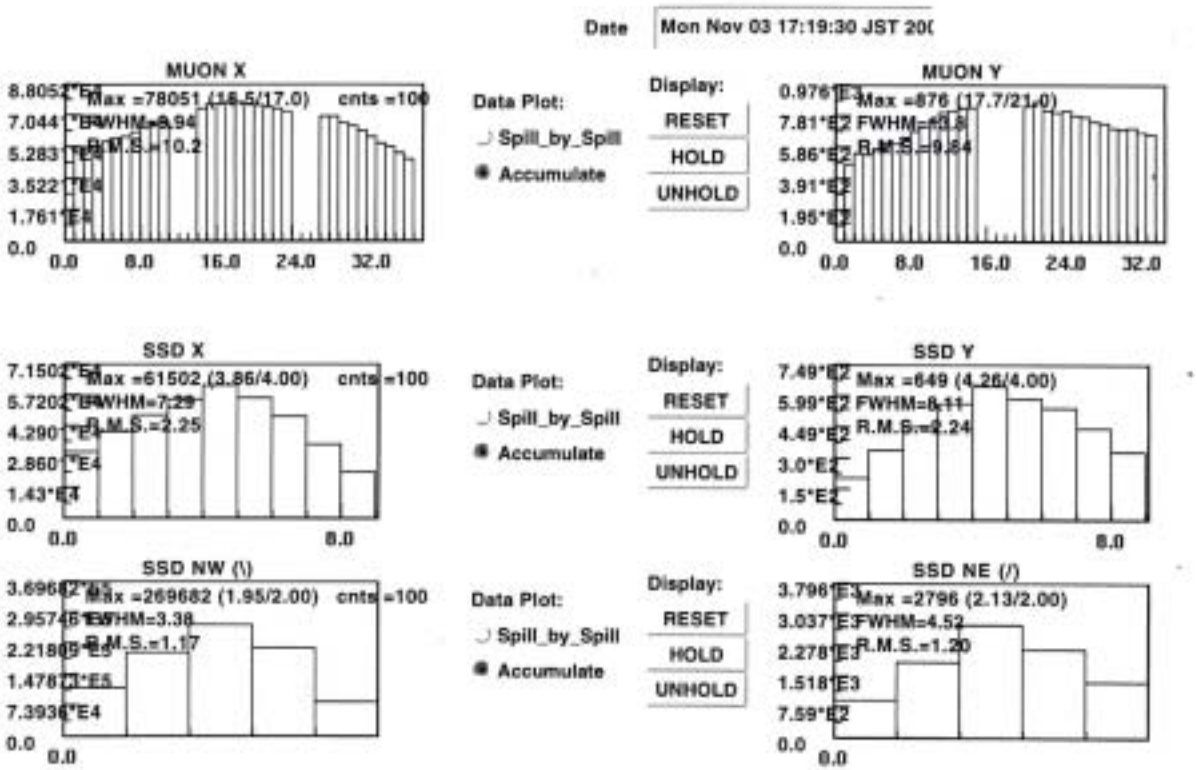
Muon/Proton Beam profiles

Proton Profile measured by SPIC. ↓



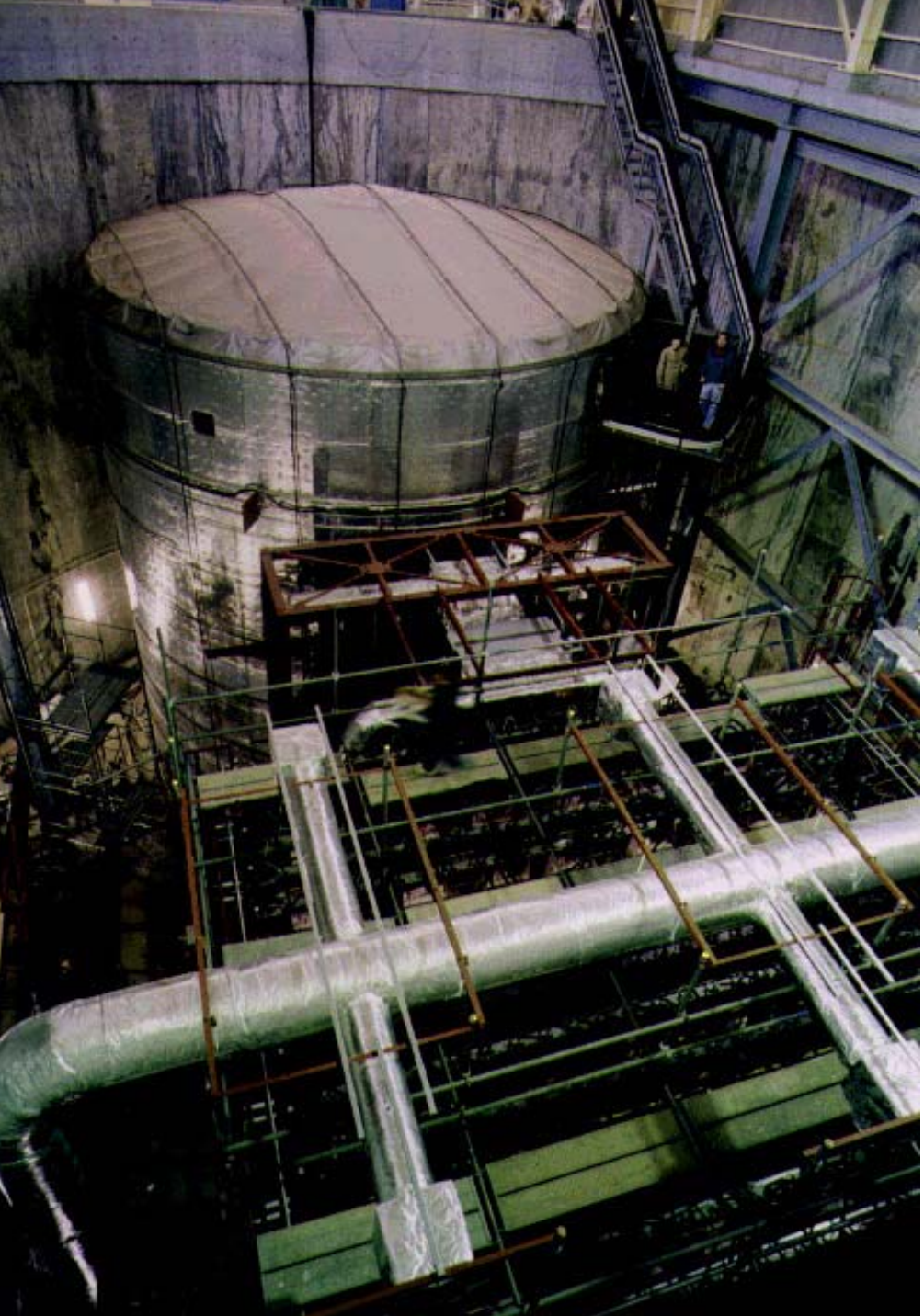
1ch=1.27mm





↑ Muon Profile measured by Muon Chamber and SSD's.

Front Detector as Neutrino Beam Monitor



Front Detector Photograph

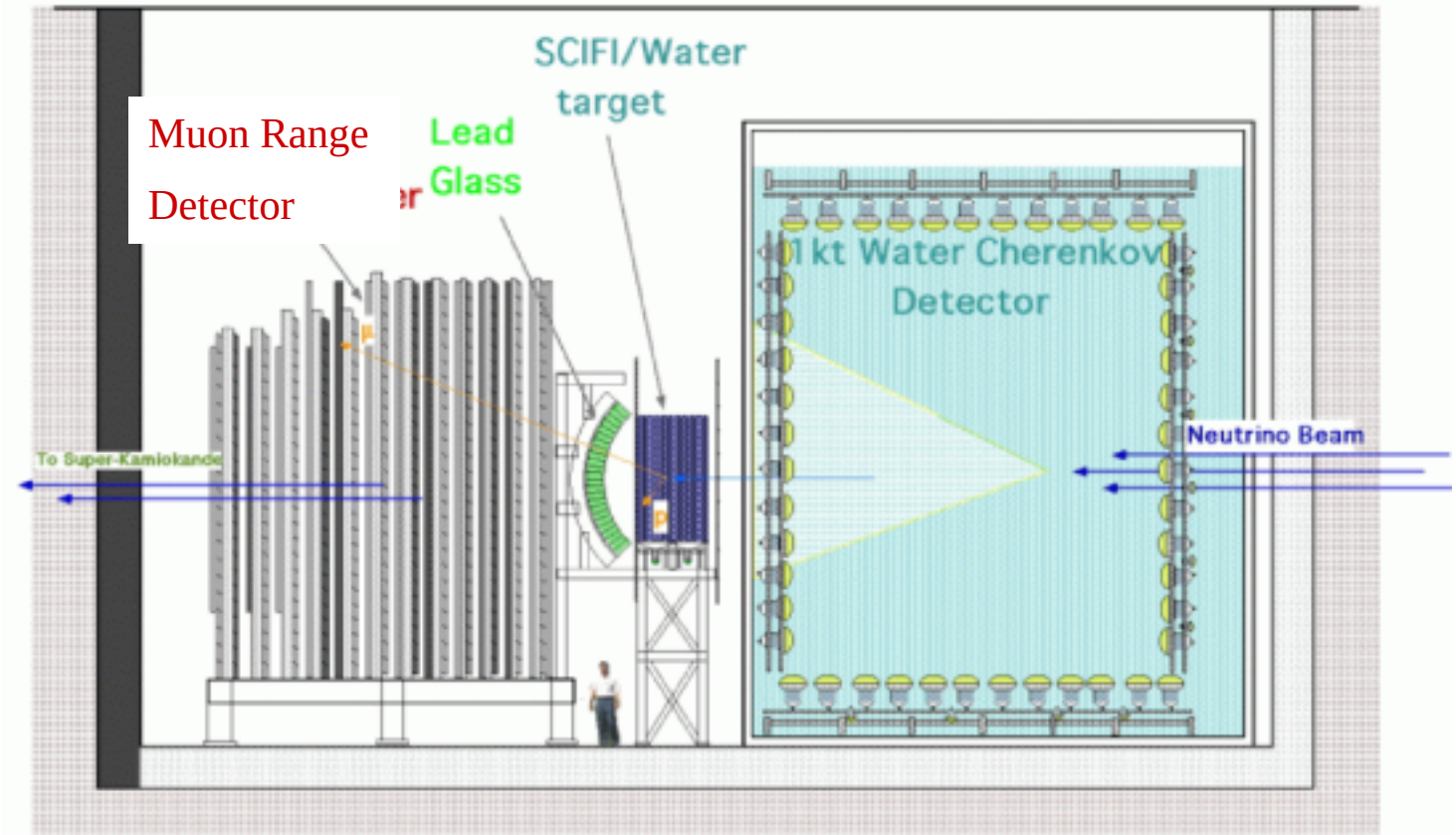
←1kt Baby Kamioka

←SciFi

←Lead Glass

←Muon Range Detector

Front Detector Configuration

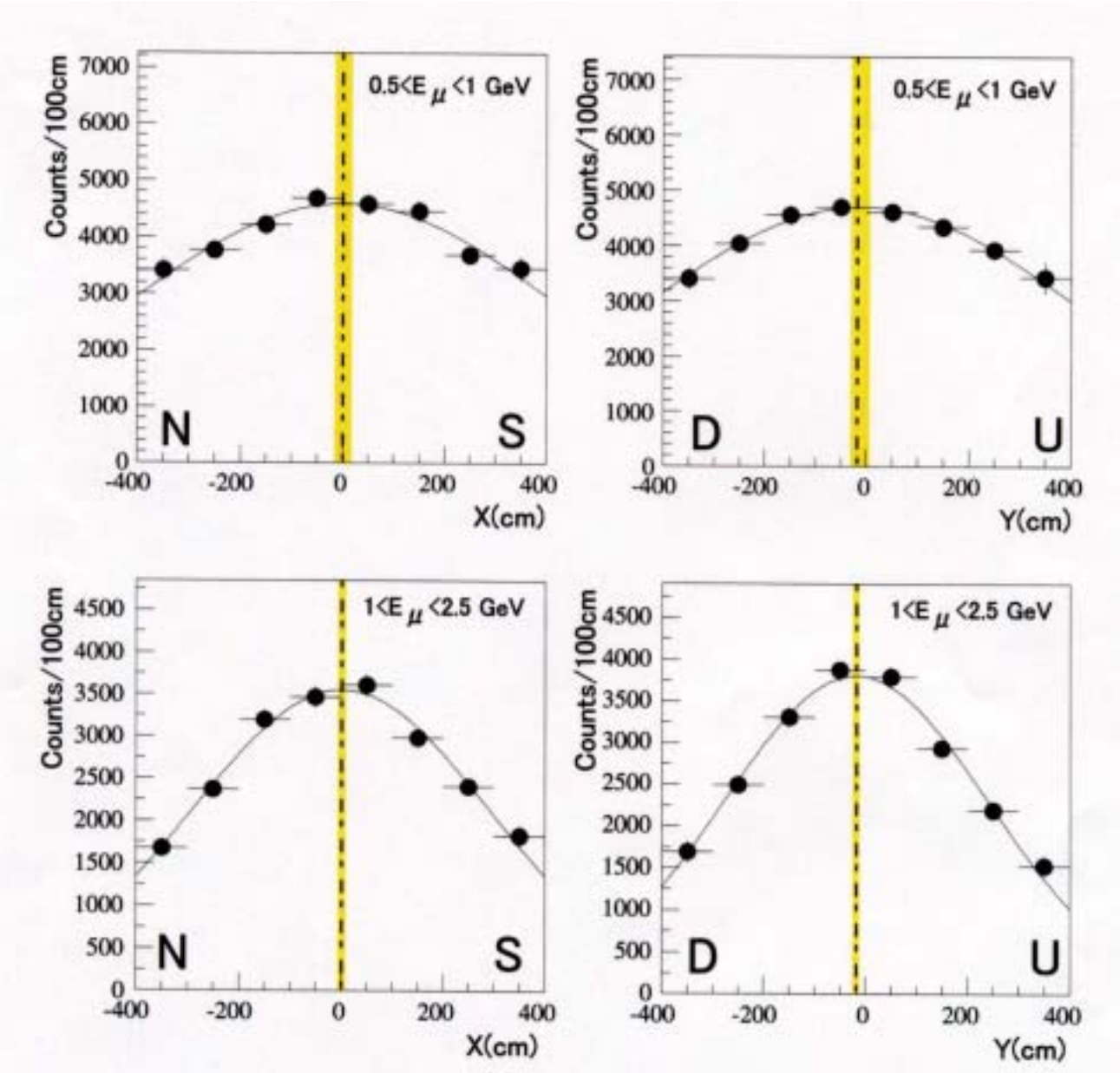


1ktWCD: Same Type Detector as SK

MRD and SciFi: Fine Grained Precise ν Detector

MRD: Massive and Large Solid Angle ν Detector

Neutrino Beam Profile (MRD)



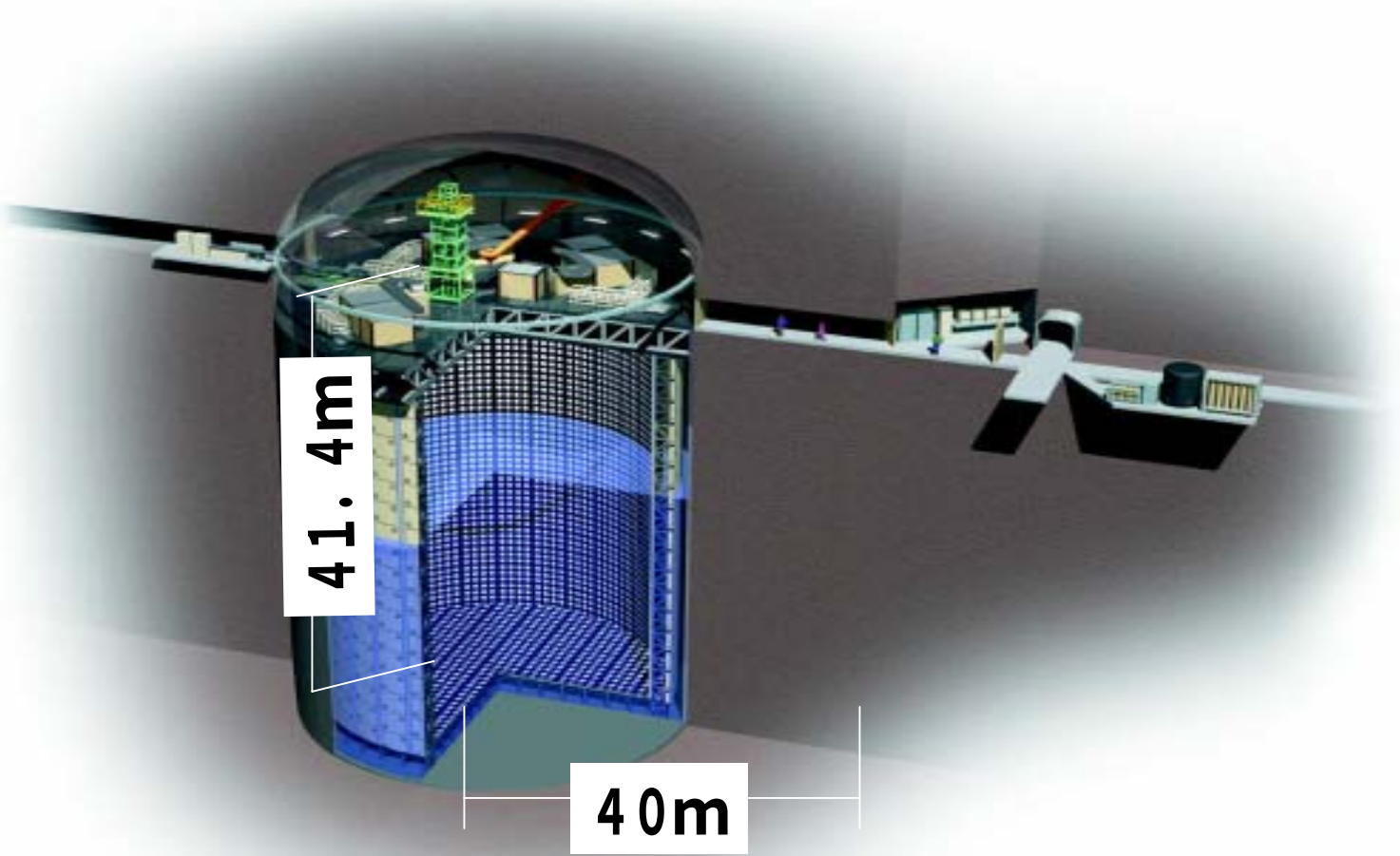
- One Month Data
- Yellow belt: Fitting Error
- Dot-dashed line: Center from GPS survey

Super-Kamiokande

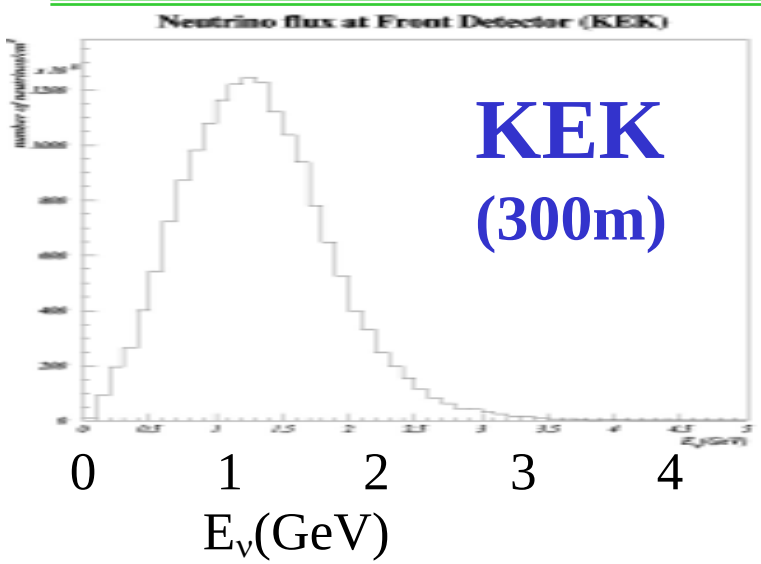
(Completed in April, 1996)

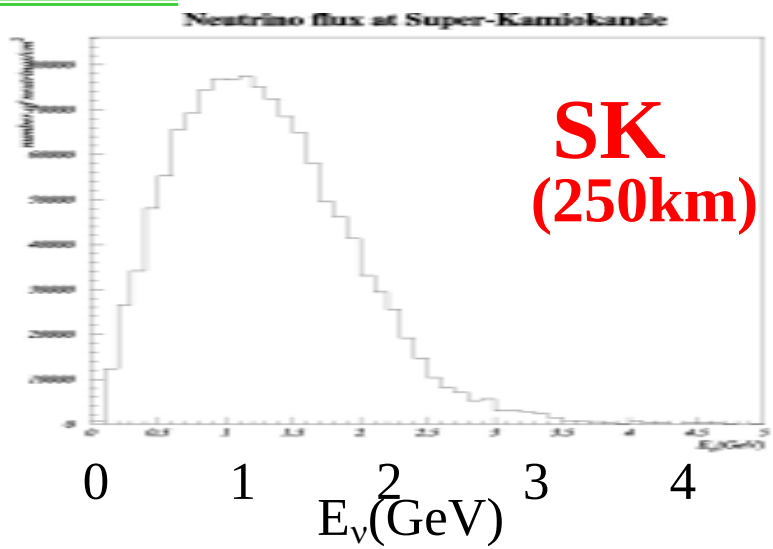
50,000 ton water Cherenkov detector (22.5 kton fiducial volume)

Livetime (exposure): 1289 days (79.3 kt･yr)

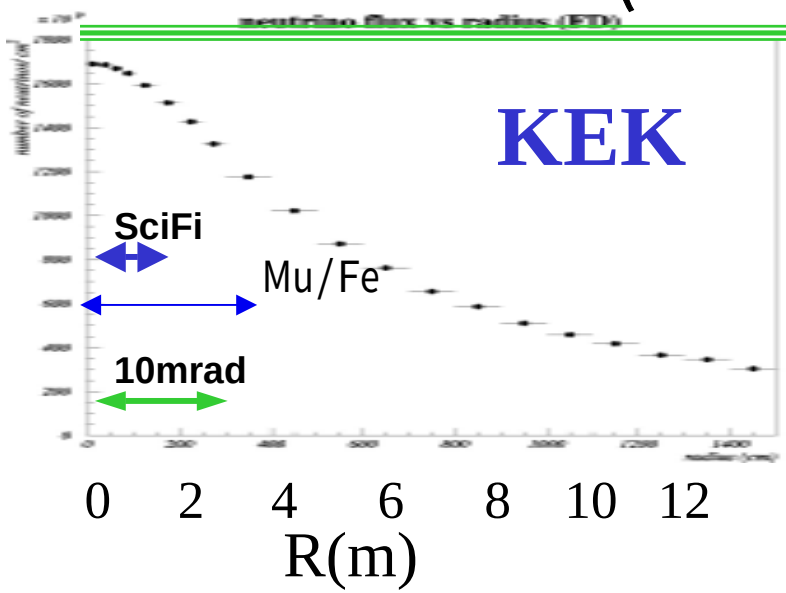


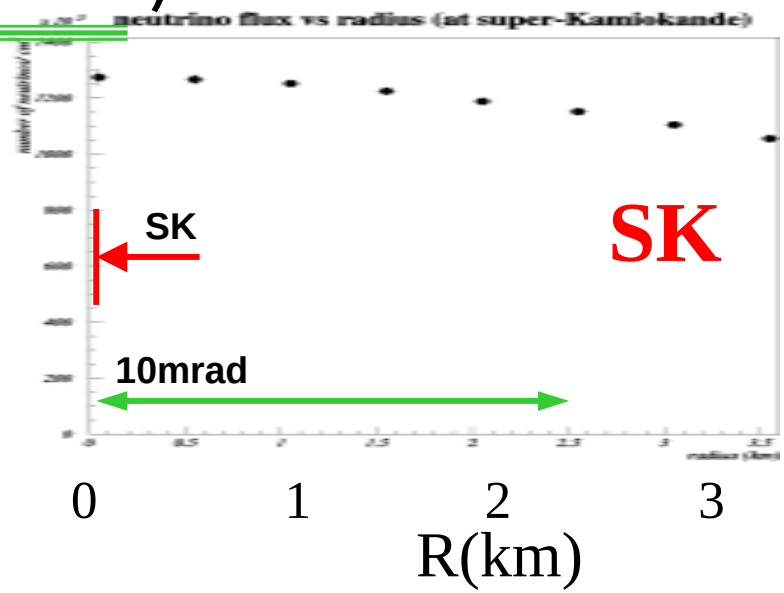
Neutrino Energy (Monte Carlo)





Neutrino Profile (Monte Carlo)





Positioning Precision from KEK to SK

Experimental Requirement:

±1mrad (Long Term)

- Positioning by GPS and Optical Survey

  $\Delta_{Horizontal}$=1.2m, $\Delta_{Vertical}$=0.7m,

  ～±0.005mr,

- Beam Line Alignment and Monitoring

  Horizaintal～±0.02mr,

  Vertical ～±0.05mr,

- Beam Control and Tuning (Short Term)

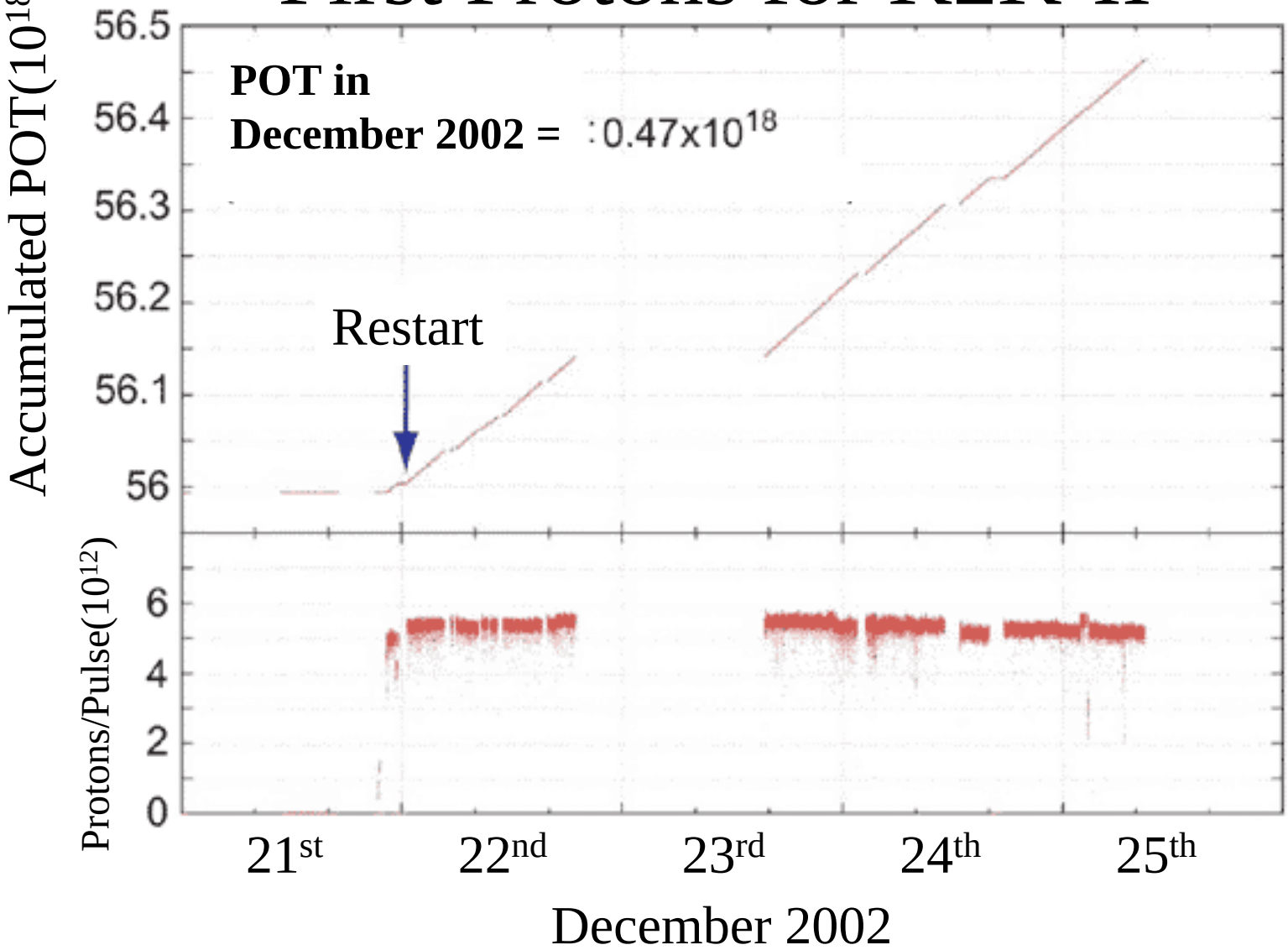
  Horizaintal～±0.03mr,

  Vertical ～±0.06mr,

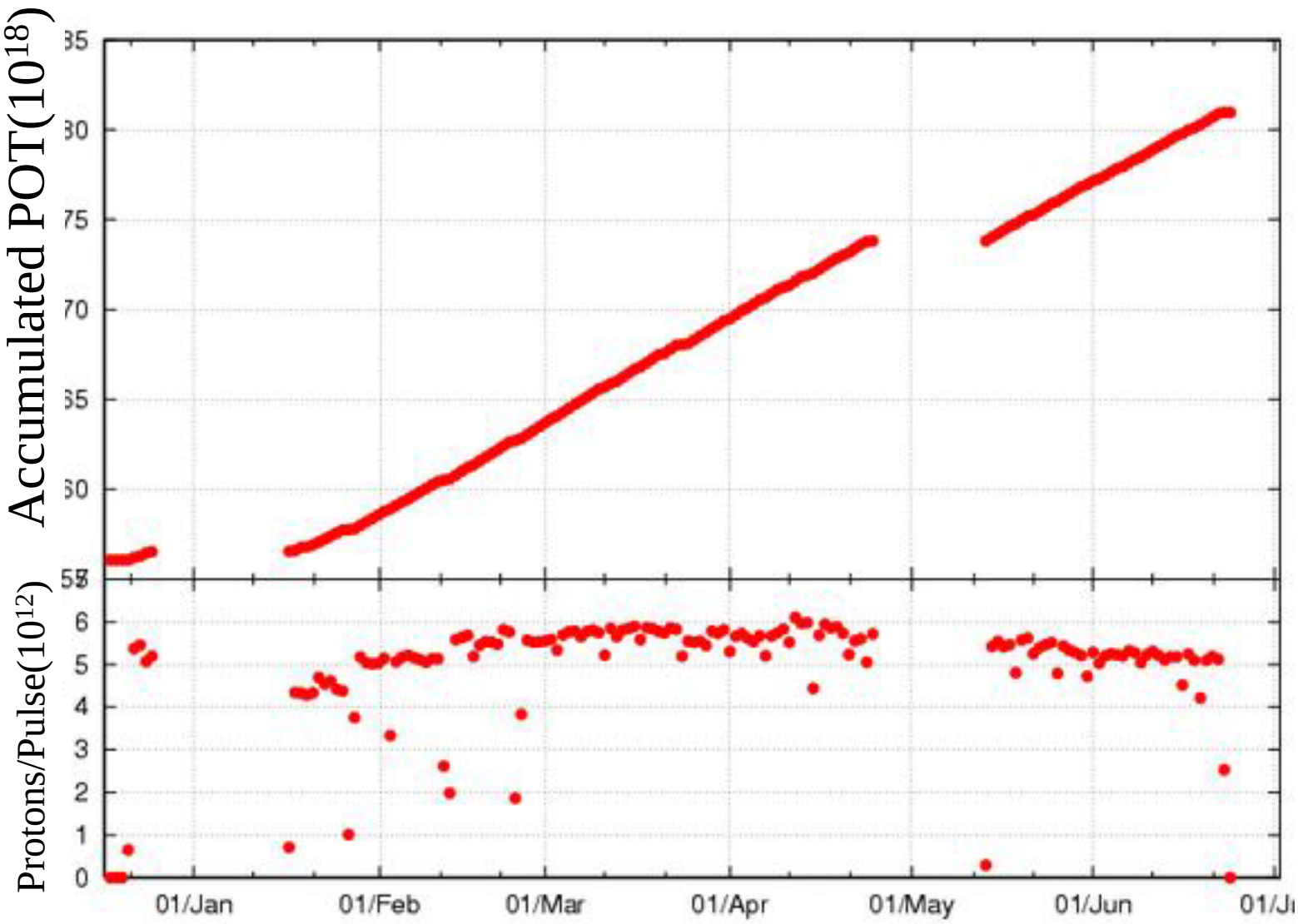
Performance December 2002 - November 2003

Or, Long Range Beam Stability!?

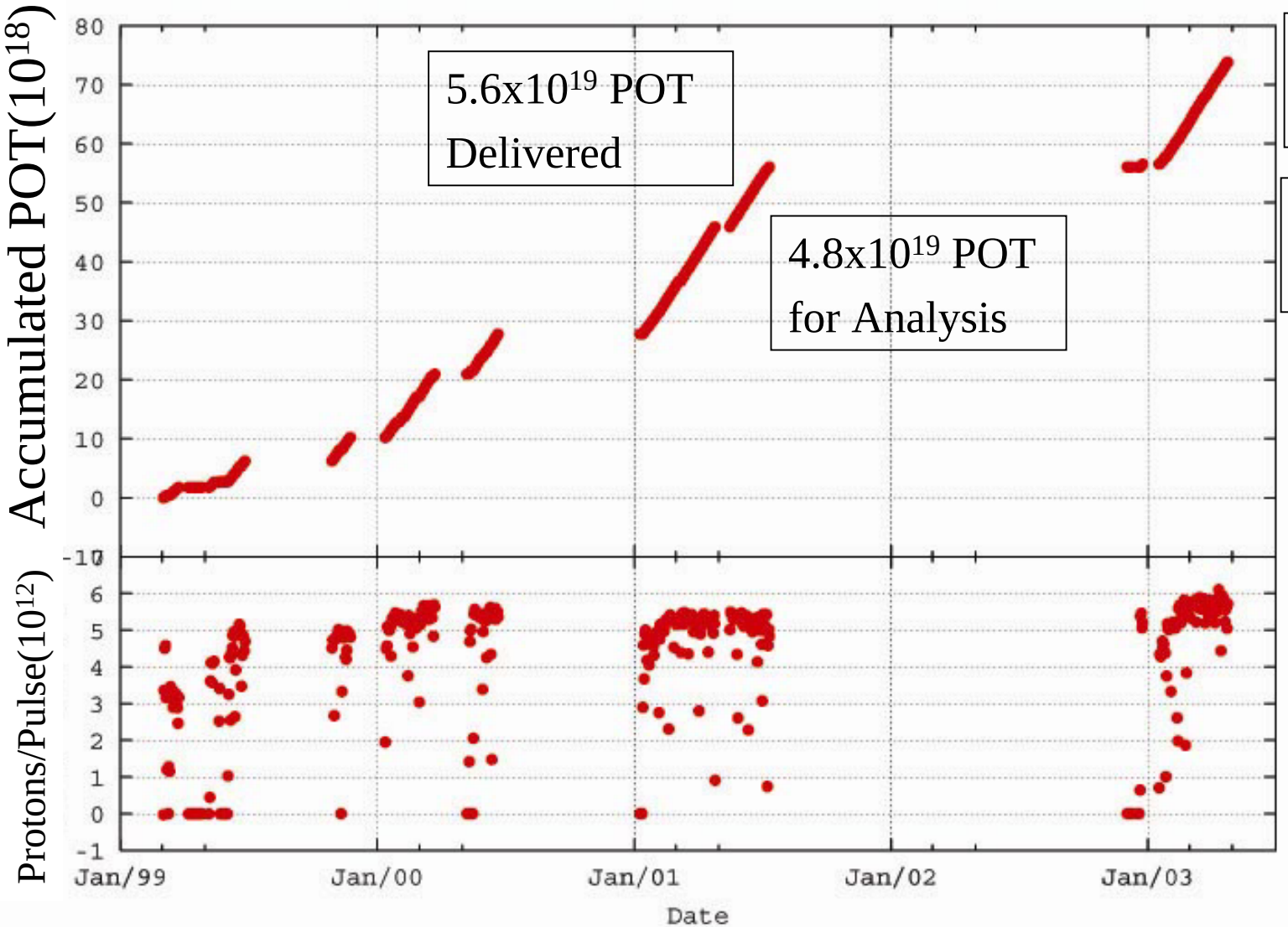
First Protons for K2K-II



POT for K2K-II



Delivered Protons on Target (POT)



$7.3x10^{19}$ POT Delivered

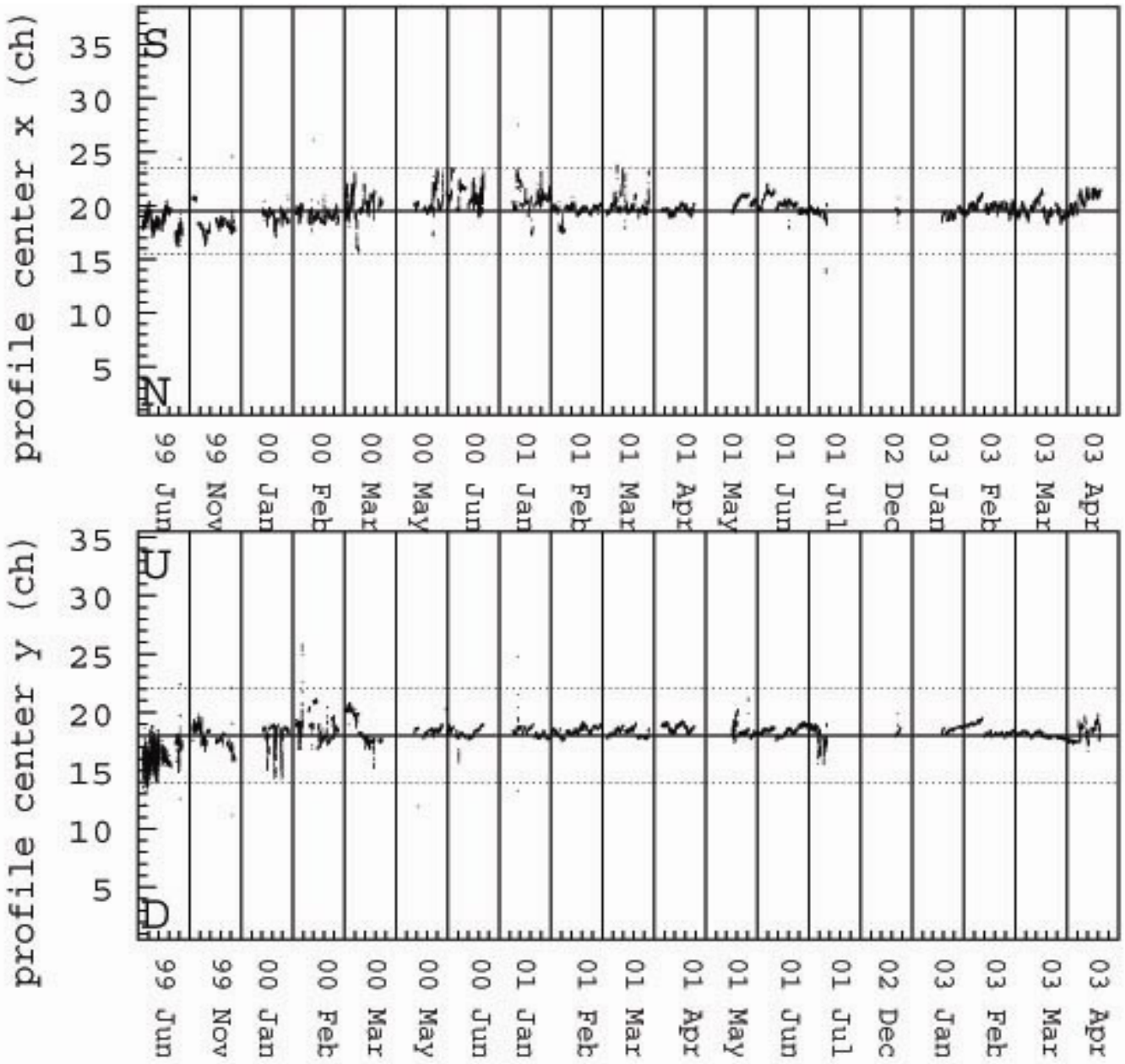
$6.3x10^{19}$ POT for Analysis

Plotted until End of April

Date

Goal:10^{20} POT (for Analysis)

Muon Profile: Centoroid Stability



Horizonral

← +1 mrad

← -1 mrad

Vertical

← +1 mrad

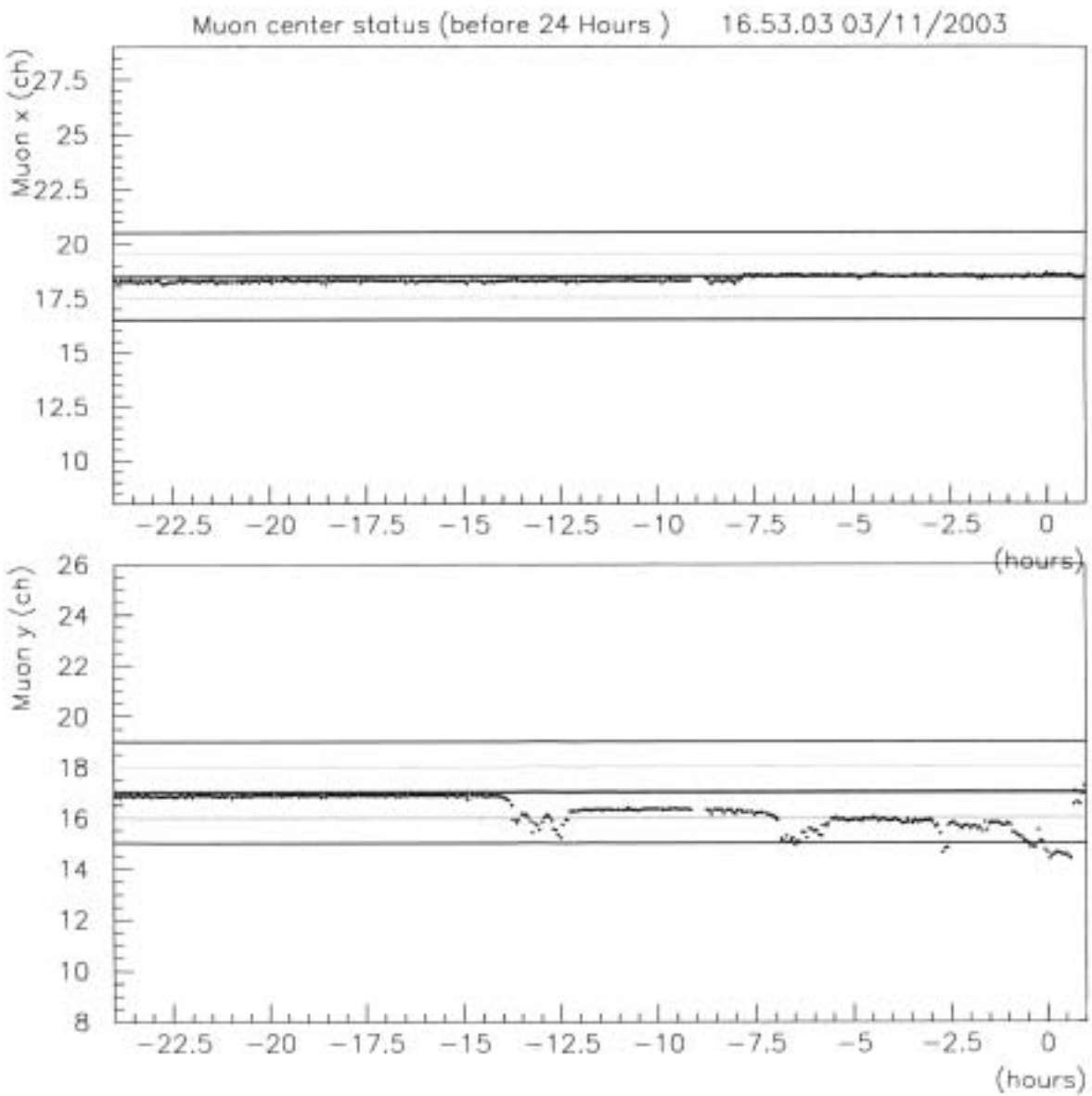
← -1 mrad

Beam Shift Correction

- 1ch shift (day)
- 2ch shift (night)

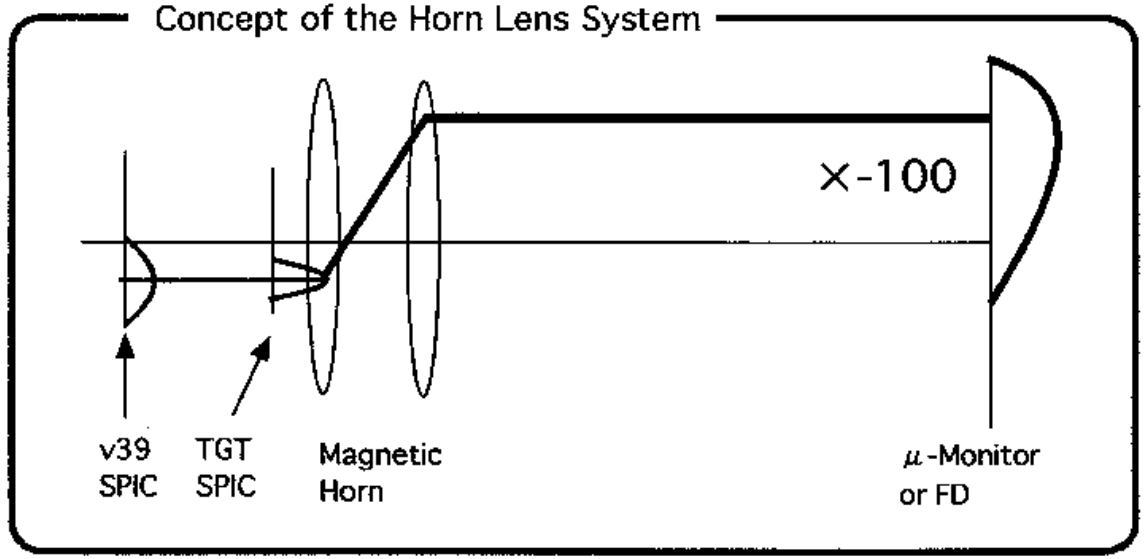
↓

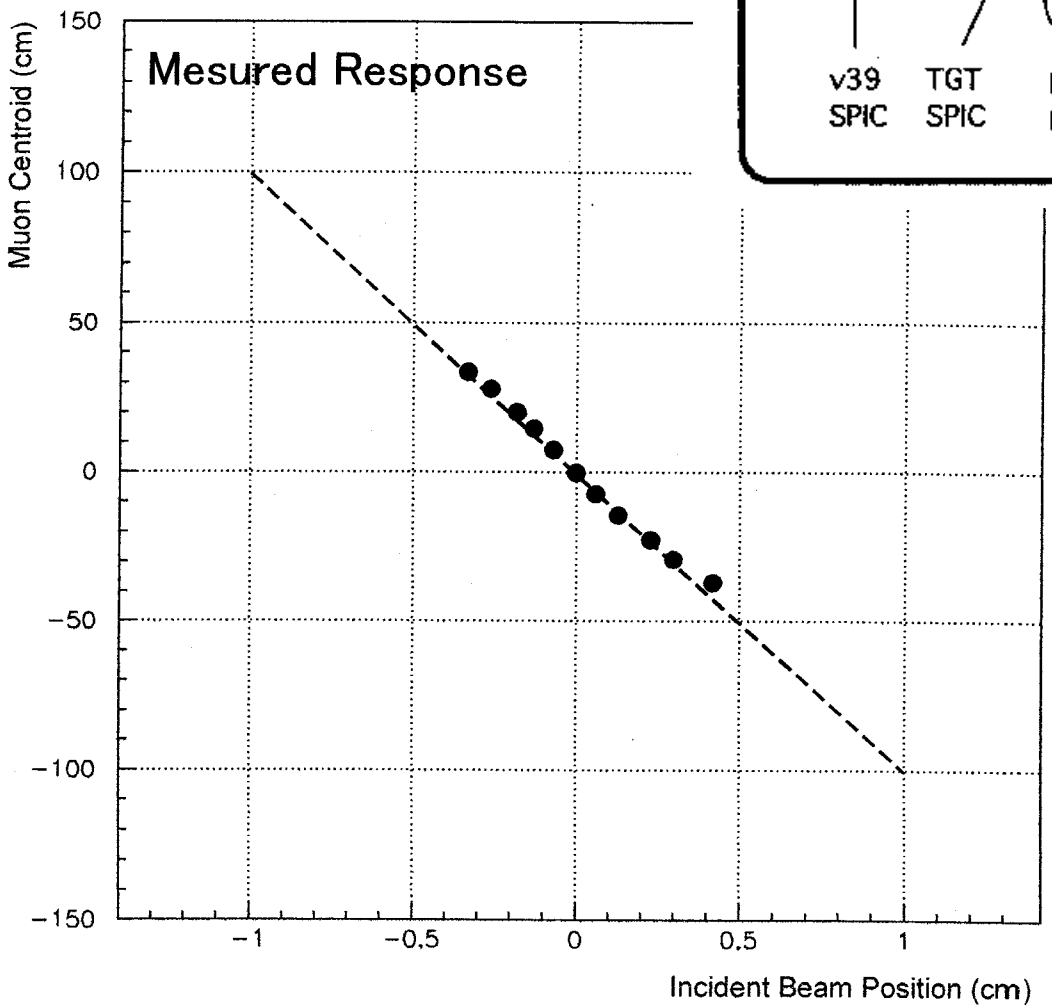
Human Correction



- DCCT error?
- Magnet coil?
- Ion source?
- EX septum?

Muon/Proton Correlation

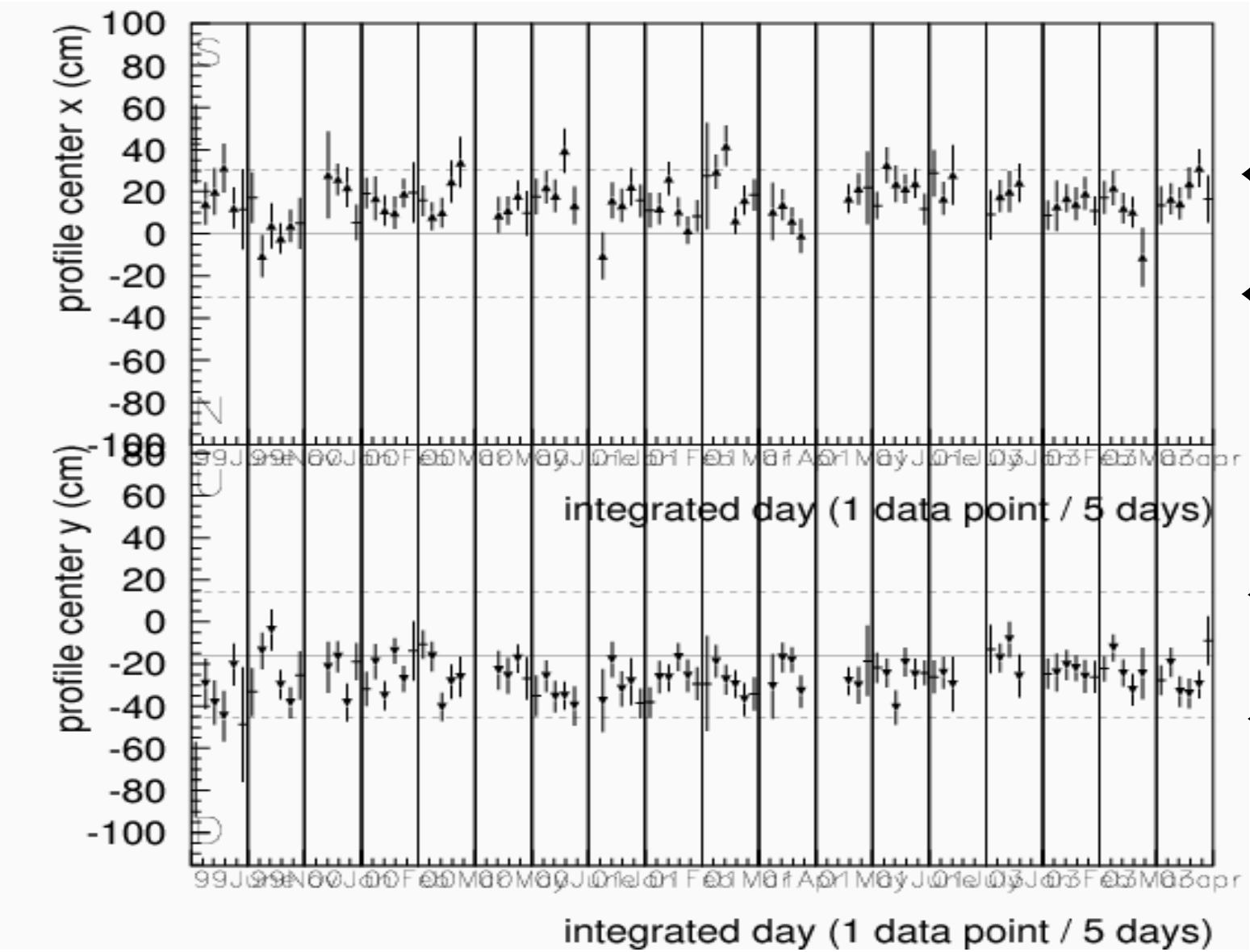




- Horn is –100 times Image Magnifier.
- For accurate aiming, stable positioning of proton beam on target is essential.
- Beam monitors of primary protons are very important.

Neutrino Profile: Centroid Stability

(Muon Range Detector)



Horizontal

←+1 mrad

← -1 mrad

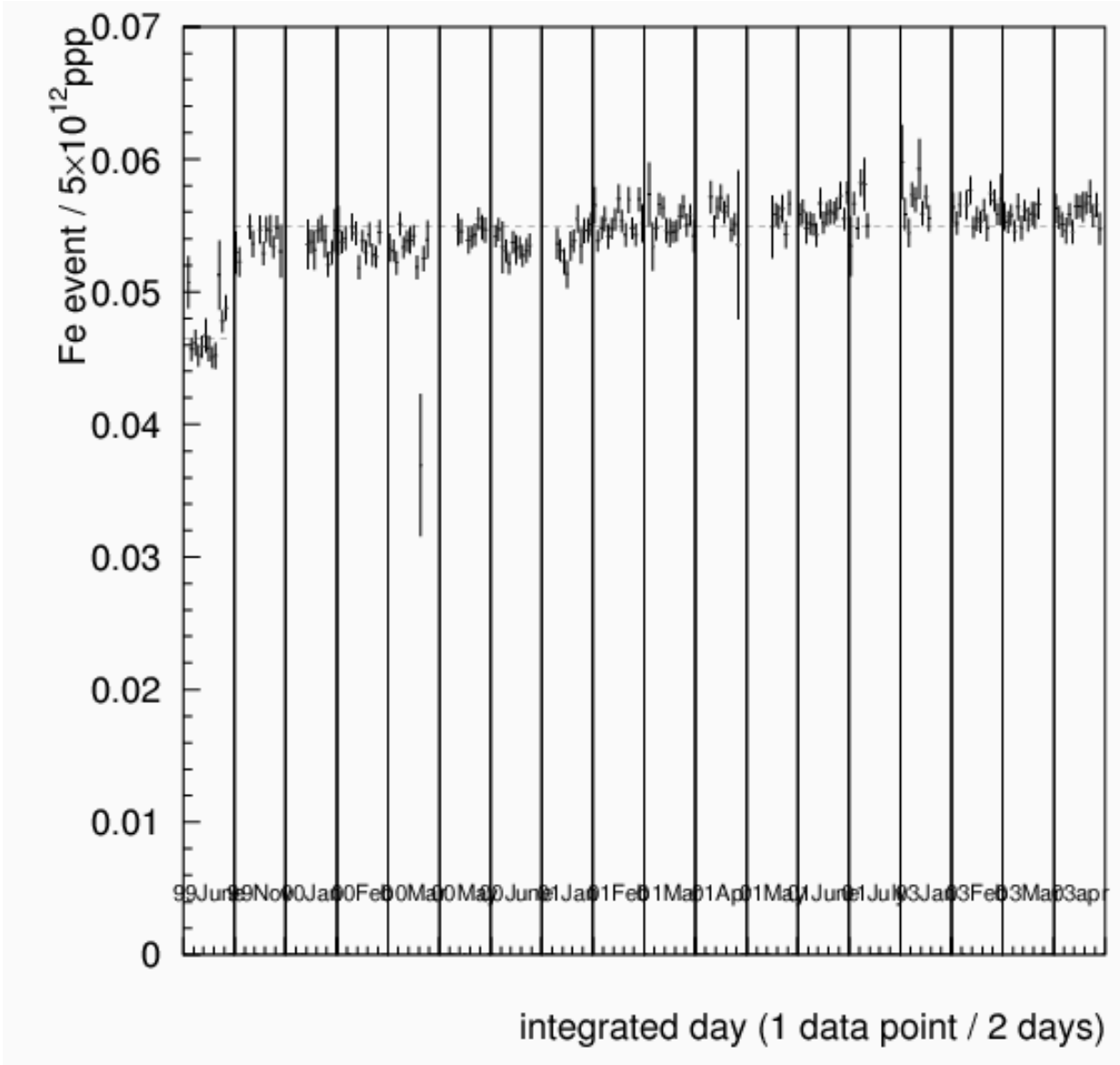
Vertical

←+1 mrad

← -1 mrad

Neutrino Event Rate Stability

(Muon Range Detector/POT)



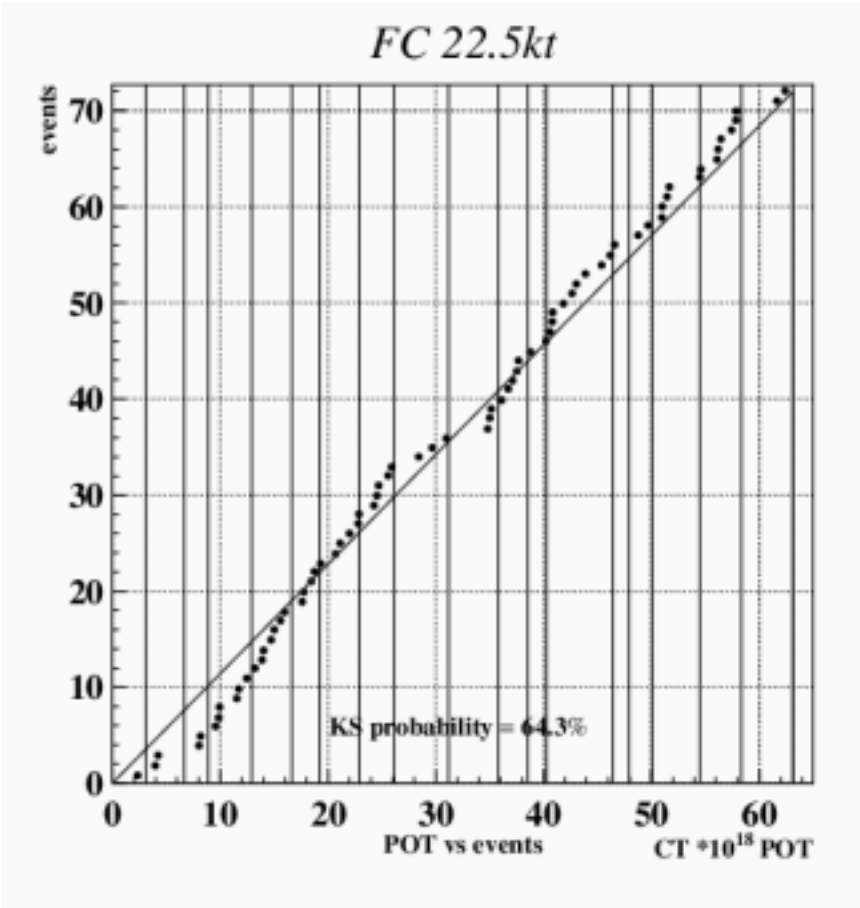
Horn 250kA

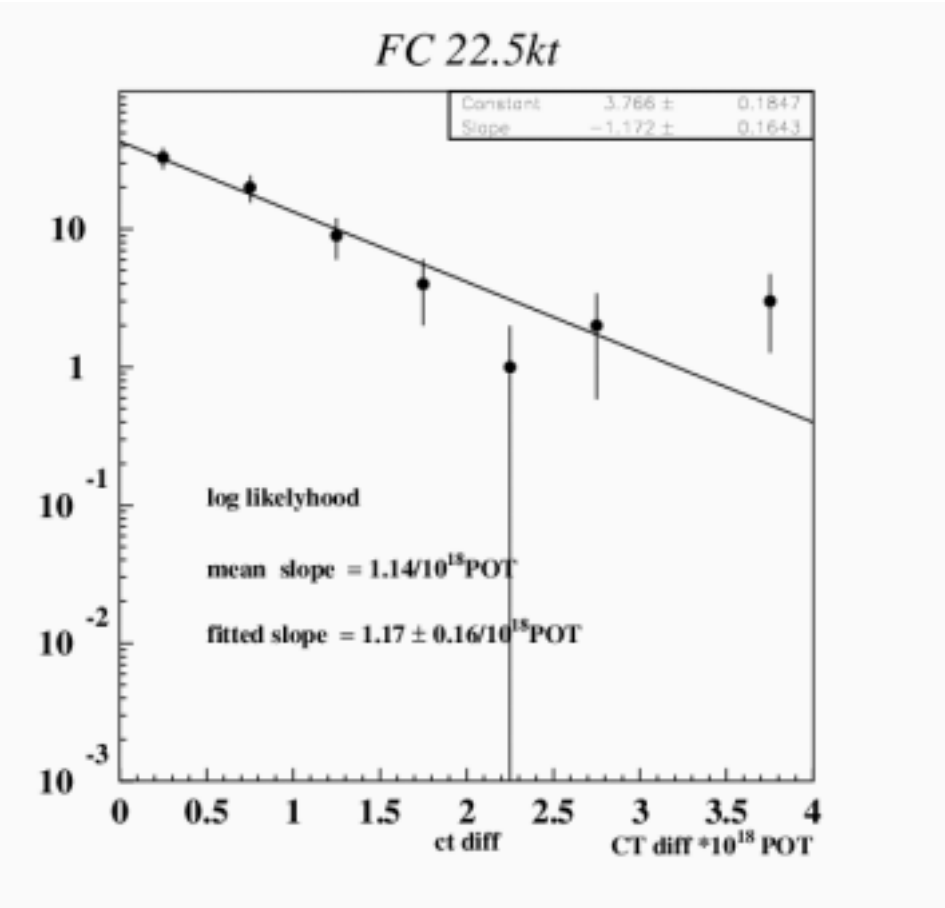
← Target 30 mmϕ

← Horn 200kA

Target 20 mmϕ

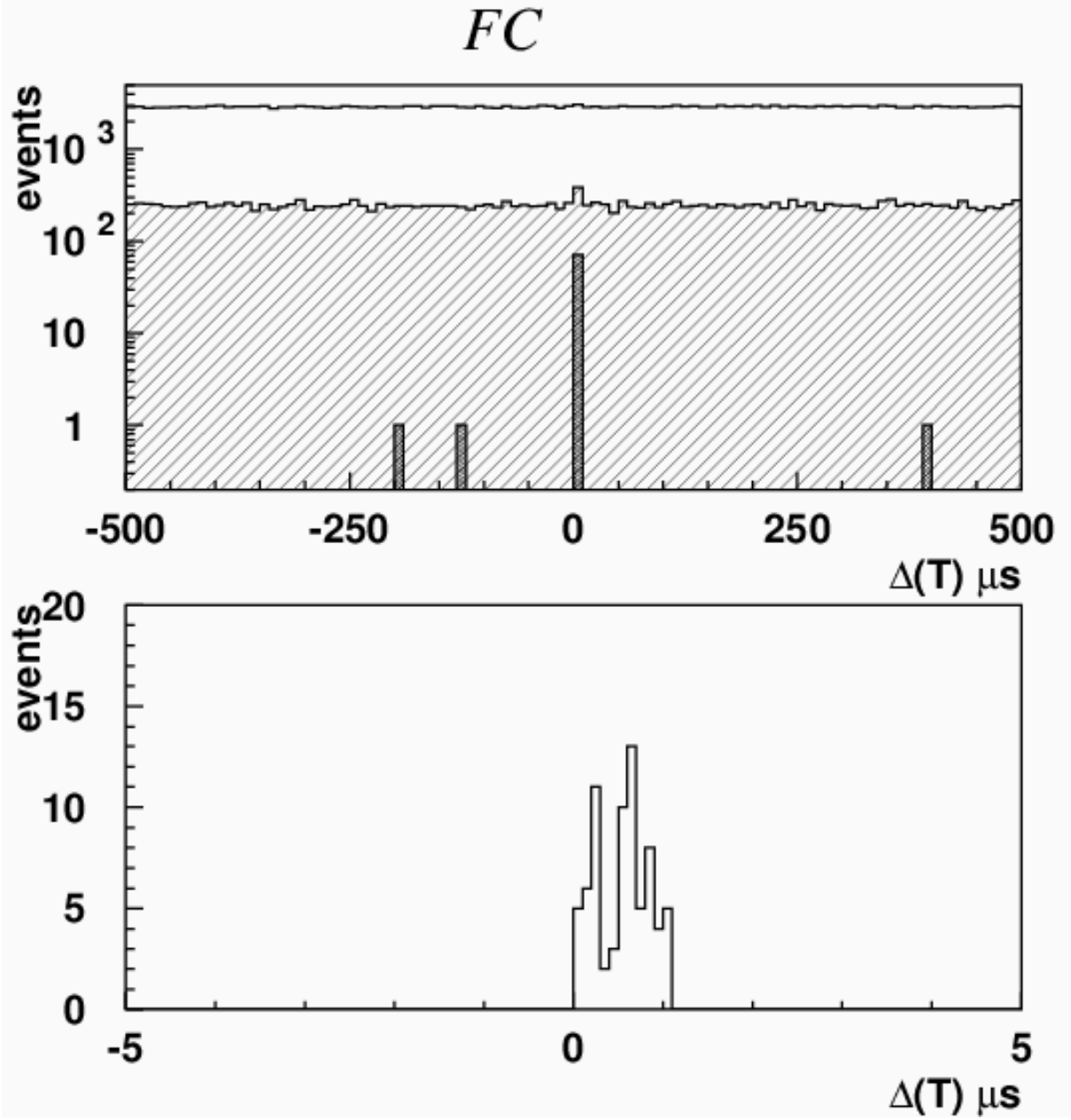
Event Number at SK/POT





こるもごろふすみるのふ検定

SK Event: Time Resolution



$-0.2\,\mu\text{sec} \leqq \Delta T = T_{sk} - T_{kek} - TOF \leqq 1.3\,\mu\text{sec}$

Observed SK events 4.8x10^{19}pot (Jun99-Jul01)

of observed events and expected events
1999/06-2001/07

	Obs.	No Ocsi.	$\Delta m^2(\times 10^{-3} eV^2)$ 3	5	7
FC 22.5kt	56	$80.6^{+7.3}_{-8.0}$	52.4	34.6	29.2
1-ring	32	48.4±6.7	28.1	17.8	16.6
μ-like	30	44.0±6.8	24.4	14.6	13.5
e-like	2	4.4±1.7	3.7	3.2	3.0
multi ring	24	32.2±5.3	24.3	16.8	12.6

FC 25.5kt 16 $26^{+2.3}_{-2.1}$ **1.5x10^{19}pot (Jan.03-April03)**

Cf. MRD: $87.4^{+12.7}_{-13.9}$ SciFi : $87.3^{+11.9}_{-11.9}$

No oscillation hypothesis is disfavoured at 97% CL.

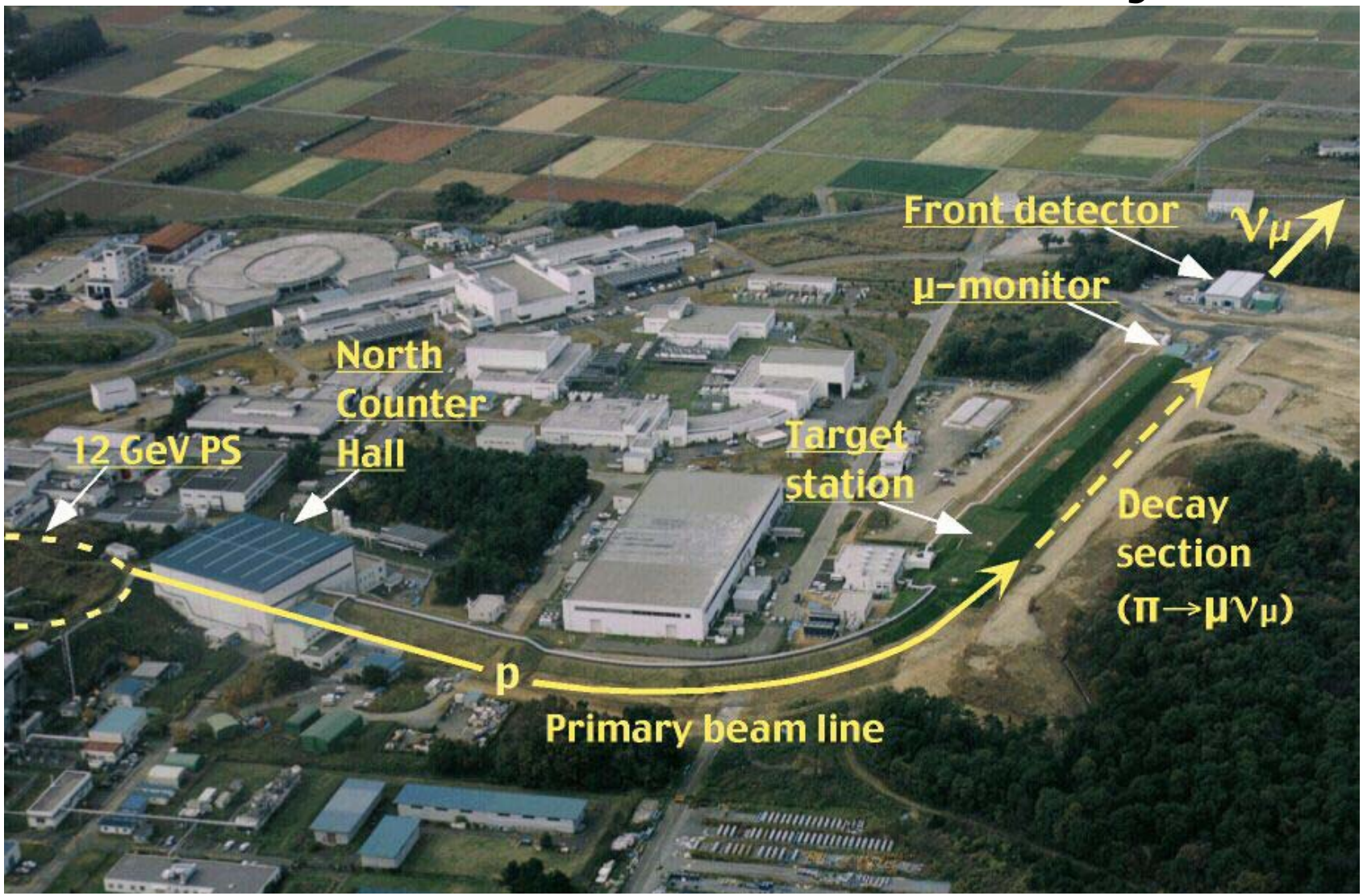
Summary of Present Status

- Super-K recovered with half density structure.
- Neutrino shooting immediately re-started!
- Accelerator, Beam channel, Horns, and Beam Monitors are all stable and ~7x10^{19} POT has been achieved before 2003 Summer Shutdown
- Nice aiming to Super-K continues and we have stable event rate at Super-K.
- Present Beam time started September 30th 2003 continues until February 15th 2004.
- 10^{20}POT will be reached in 2004.

KEK-PS Beam Channel Group

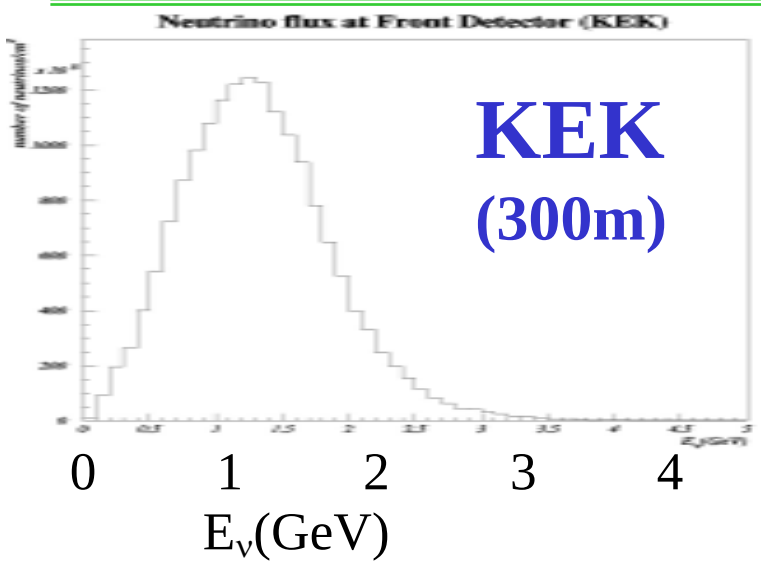
7 Physicists + 6 Engineers + 1 newcomer (Dr. A. Toyoda)
conducted by Prof. M. Takasaki.

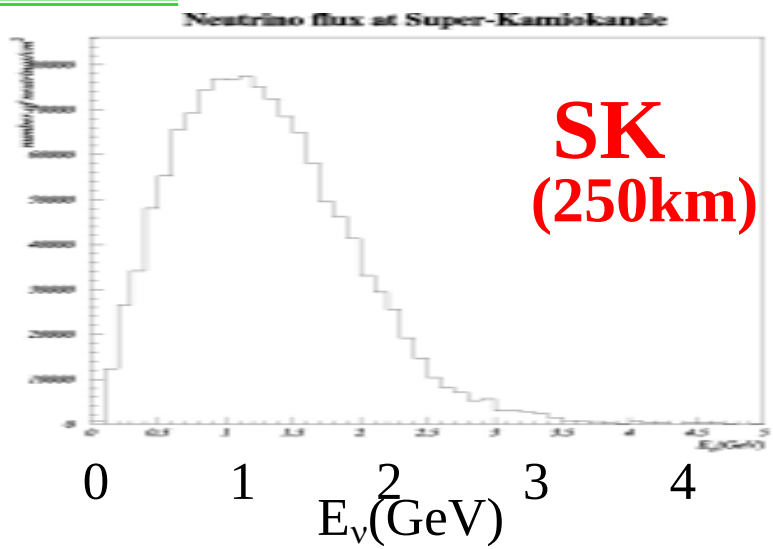
Neutrino Beam Facility



Side View

Neutrino Energy (Monte Carlo)





Neutrino Profile (Monte Carlo)