Overview of the KEK Neutrino Beam Facility and its Operation

Summary after September 2000 (NBI2000 @ FNAL)

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for the KEK-PS
Beam Channel Group &
K2K Beam Monitor Group.

March 14th 2002
@NBI2002,
CERN.

Contents

K2K Experiment

The First Long Baseline (250km)
Neutrino Oscillation Experiment

Far Detector: SK
50kt Water C Detector

Shooting Side

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

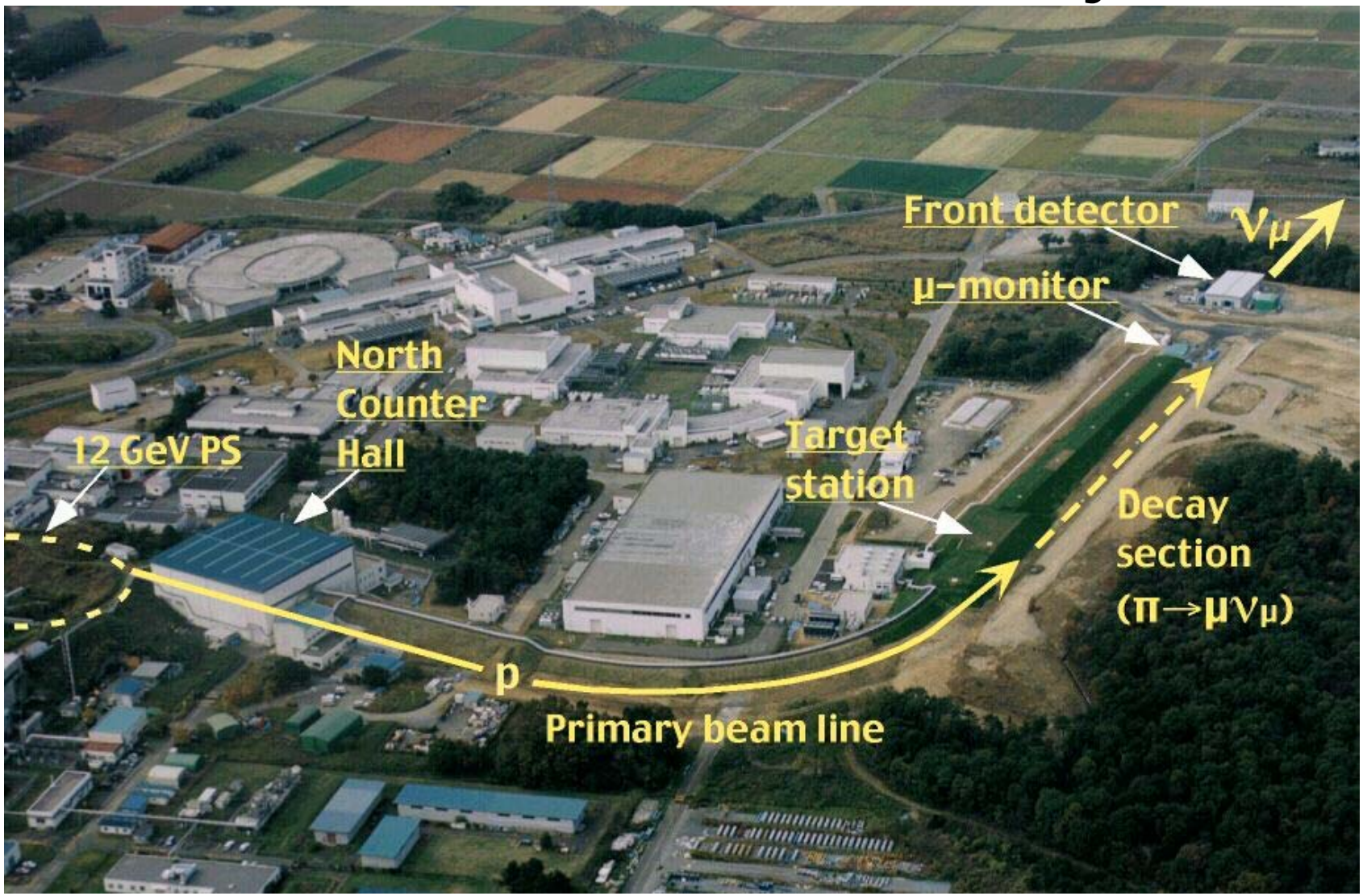
KEK Neutrino Beam Facility

Bird’s Eye View of KEK

KEK Neutrino Beam Facility I

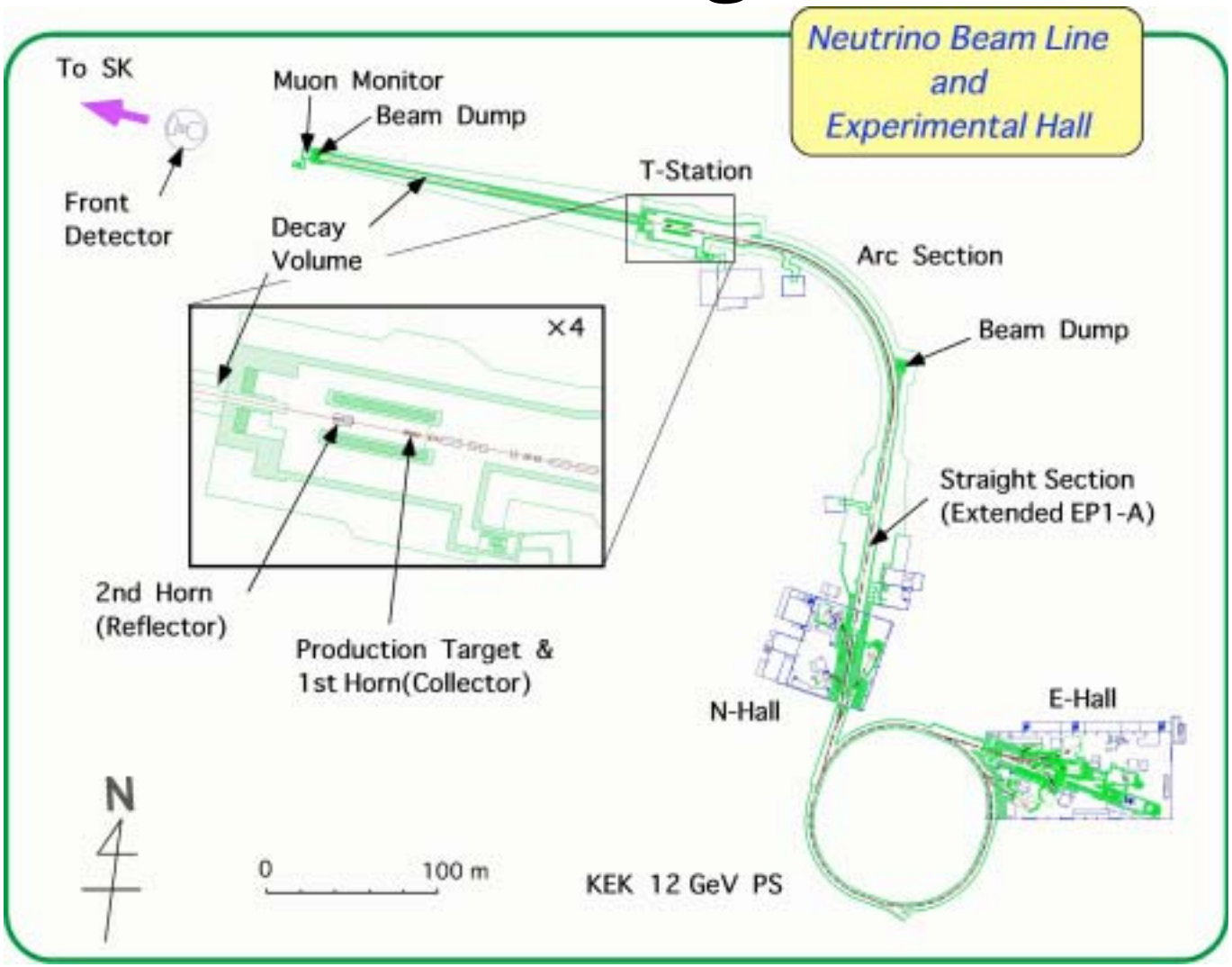
Top View

Neutrino Beam Facility II



Side View

Schematic Drawing of the Facility

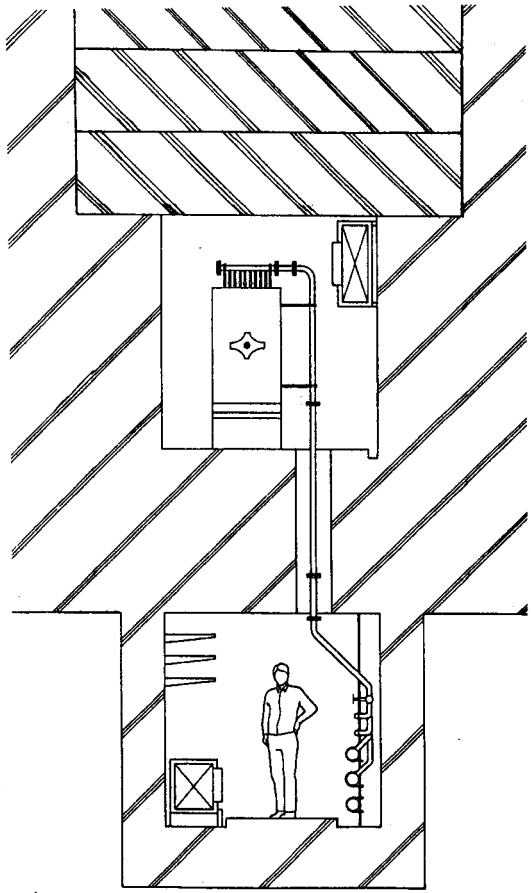


Primary Proton Beam Line (Extended Part)

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

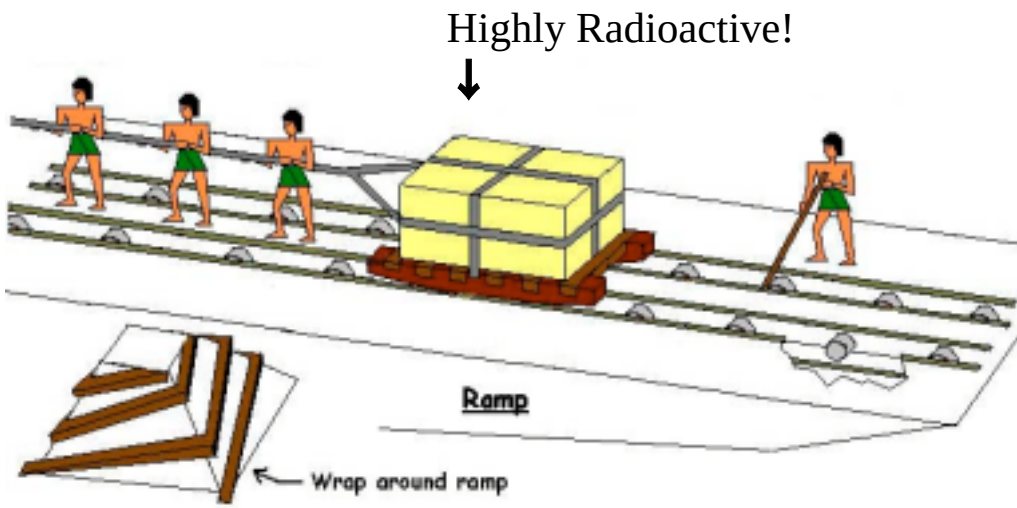
↑ Slope(Straight) Section
ARC Section (No Crane) ↓

Primary Proton Beam Line (N-Hall)



- Small Beam line room, however top can be opened!
- Service tunnel is prepared at downstairs
- Quick disconnect devices of Water&Electricity were developed.

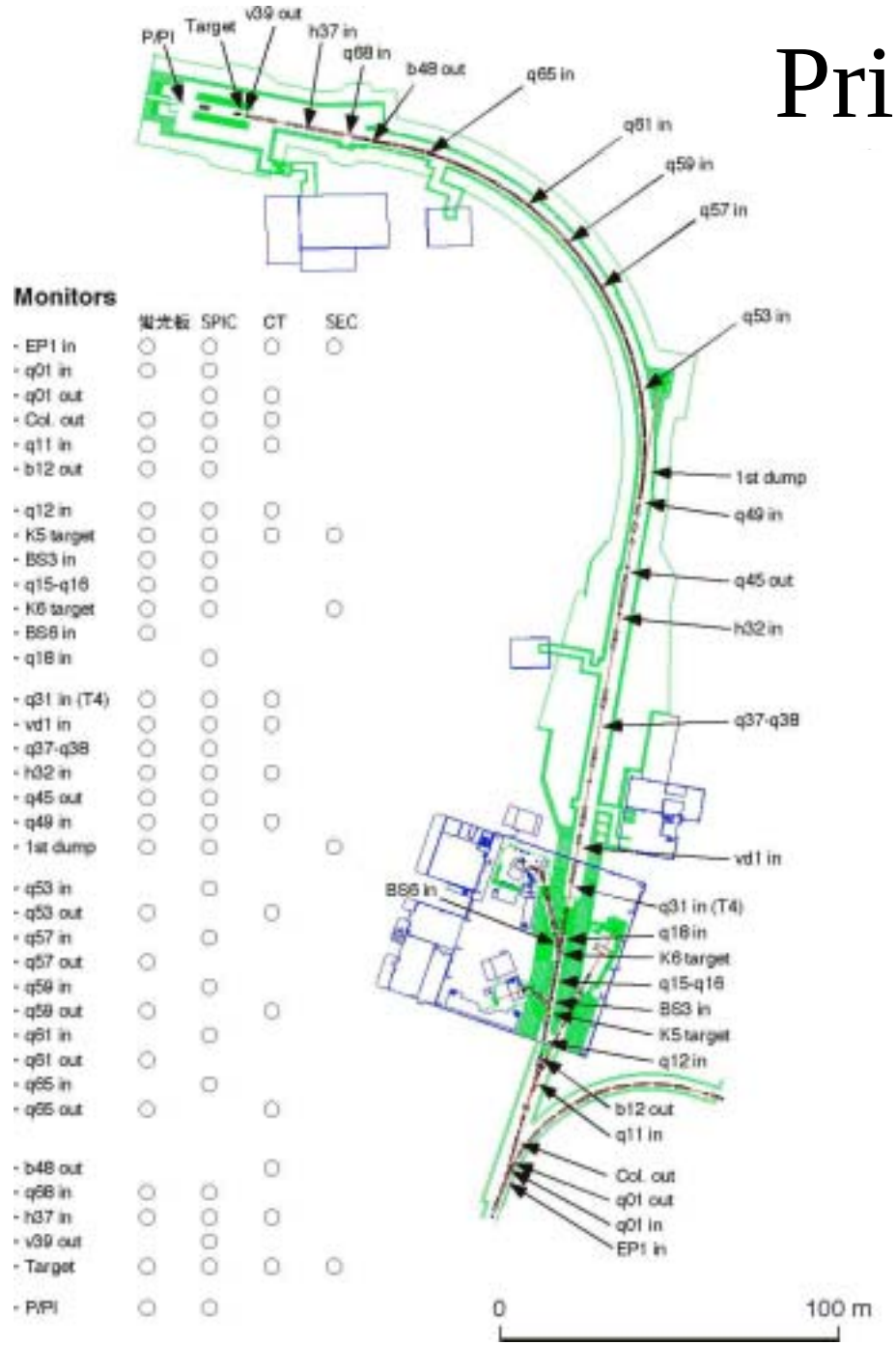
For the Safety Construction & Maintenance

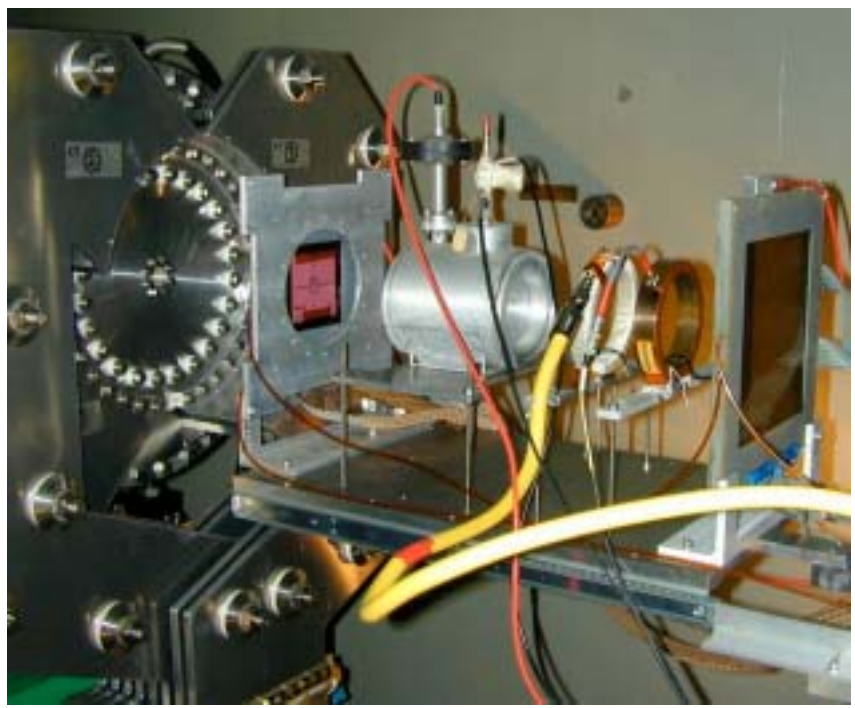


- Often our high-class people says that we should learn Egyptian Technology to save MONEY.
- This may be wrong. We need wider space & Crane to handle highly radioactive beam line elements!

Primary Proton Monitors

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

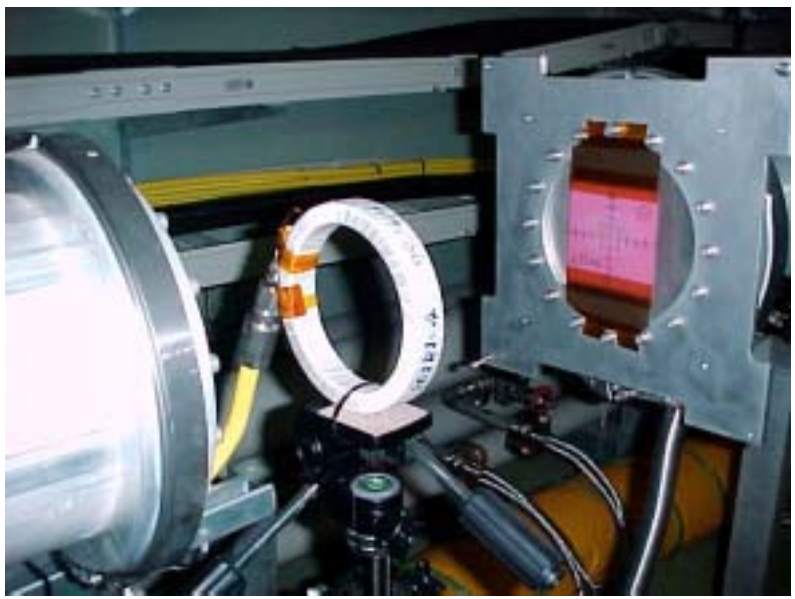




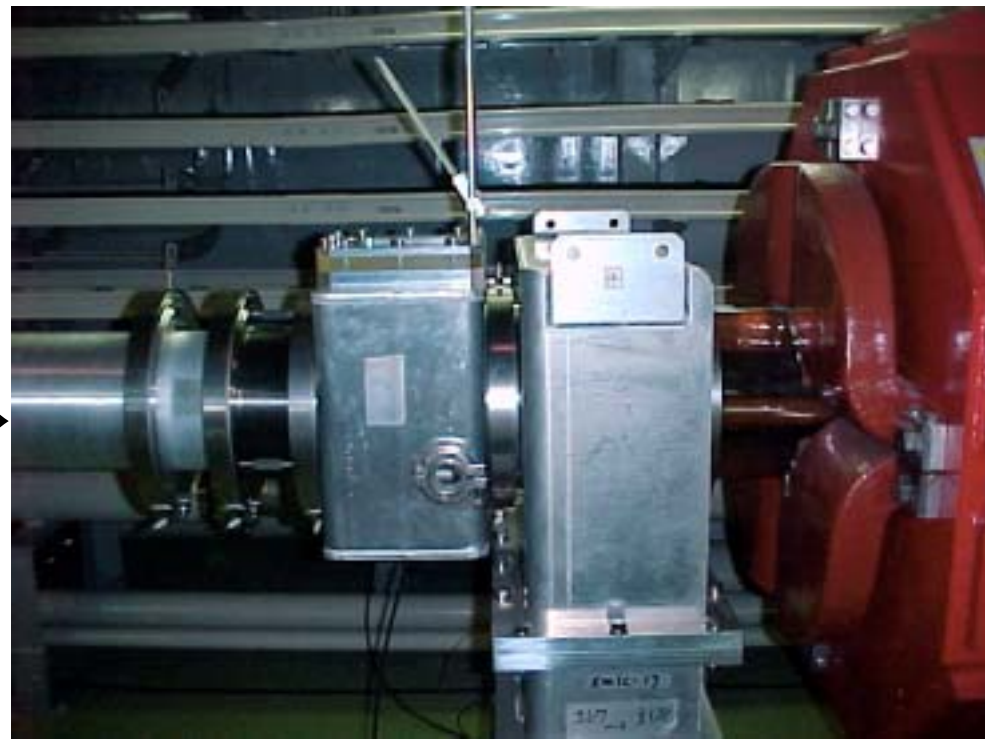
The Latest Upgrades

- Vacuum system improvement
  - Many vacua → Single vacuum section
  - Most Monitors were put into vacuum.
- Magnets were replaced to larger acceptance ones.

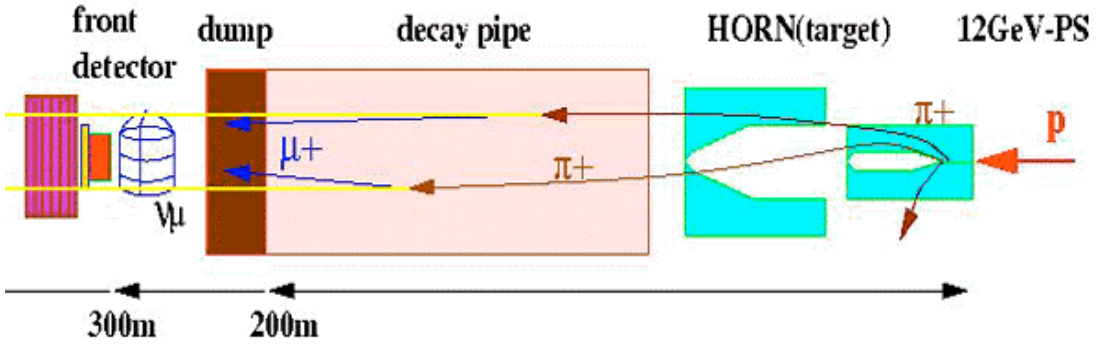
Beam Transmission: 5% up

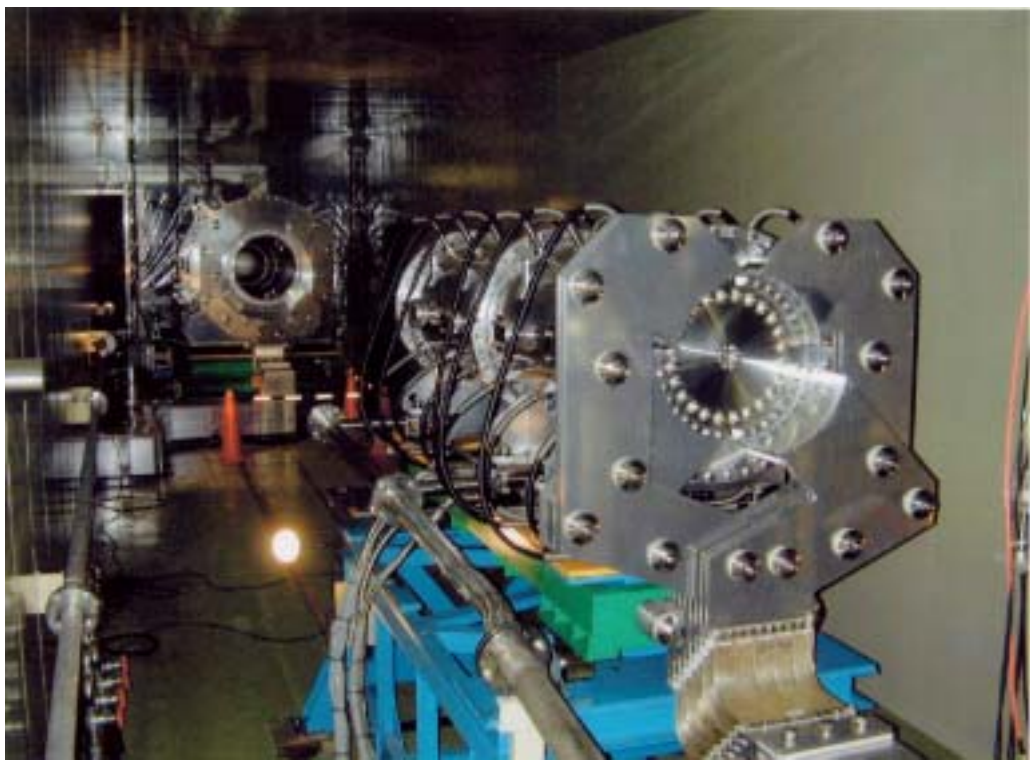


→



Horns, Target & Decay Volume

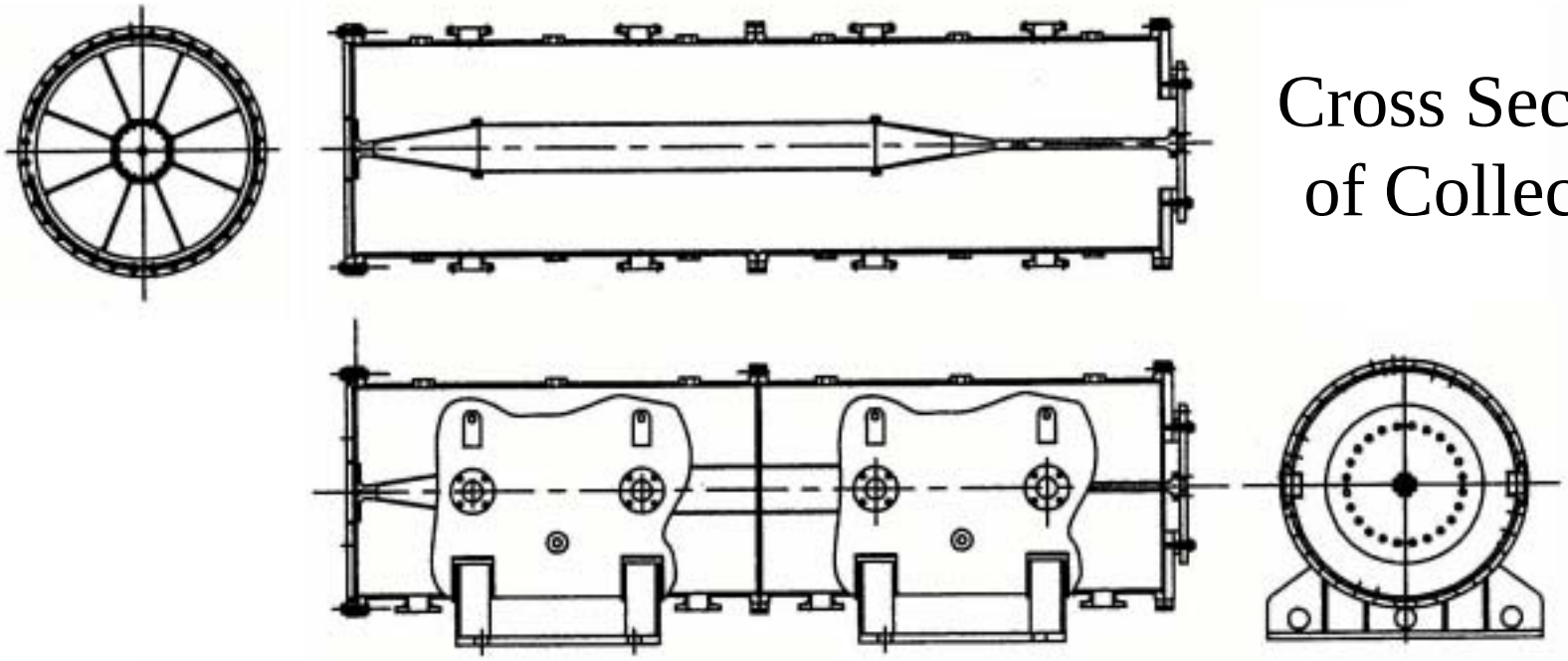




- Two Horns

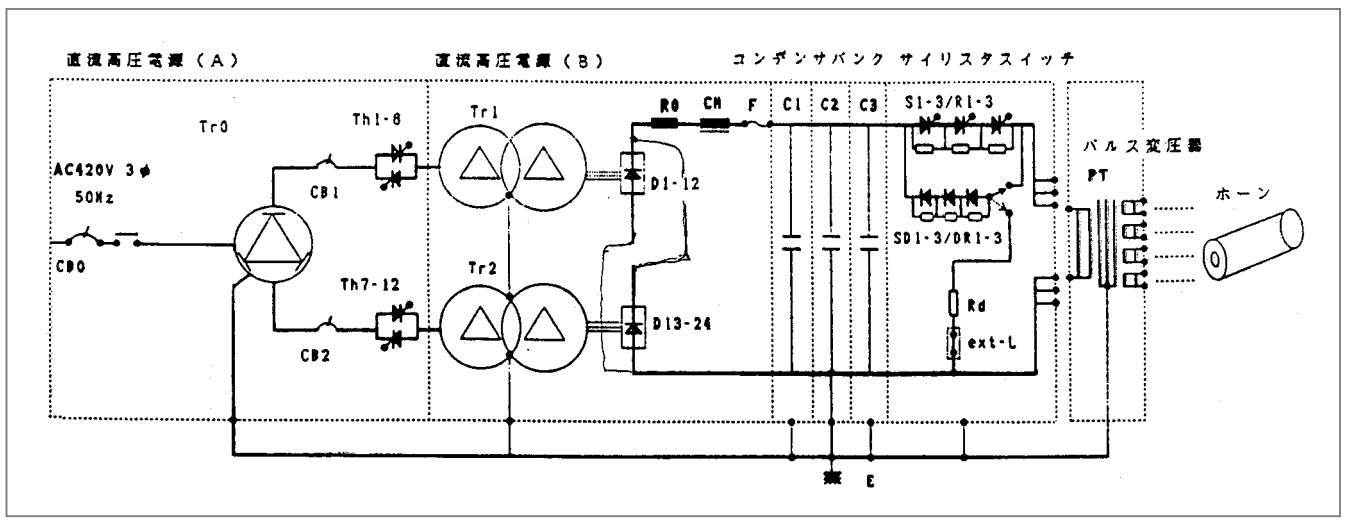
(Collector & Reflector).

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

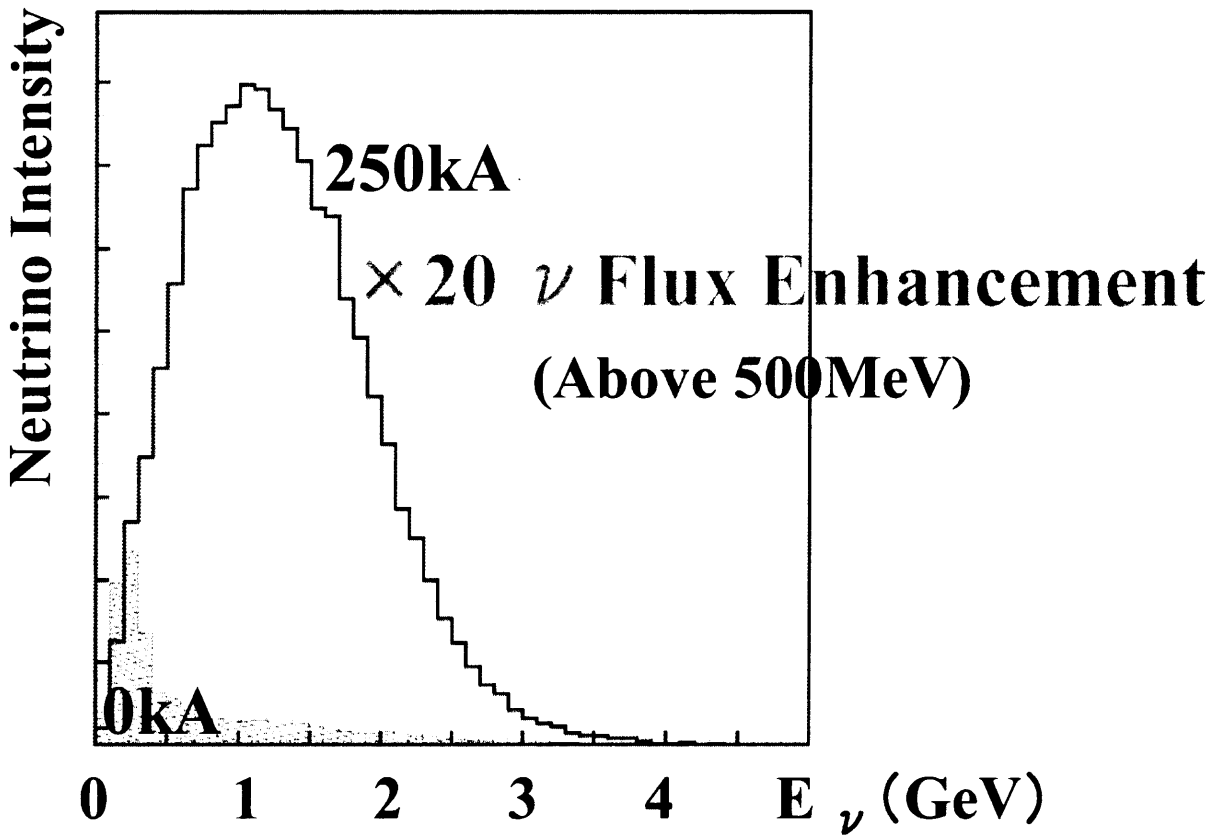


Cross Section of Collector

Power Supply for Horns

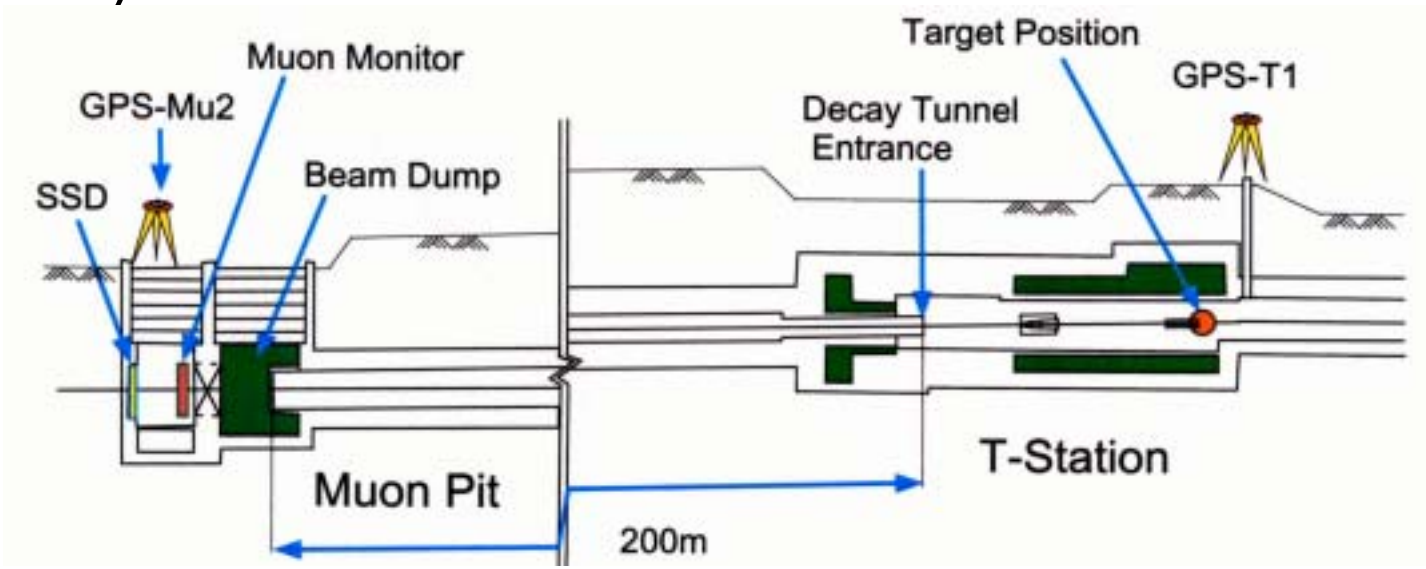


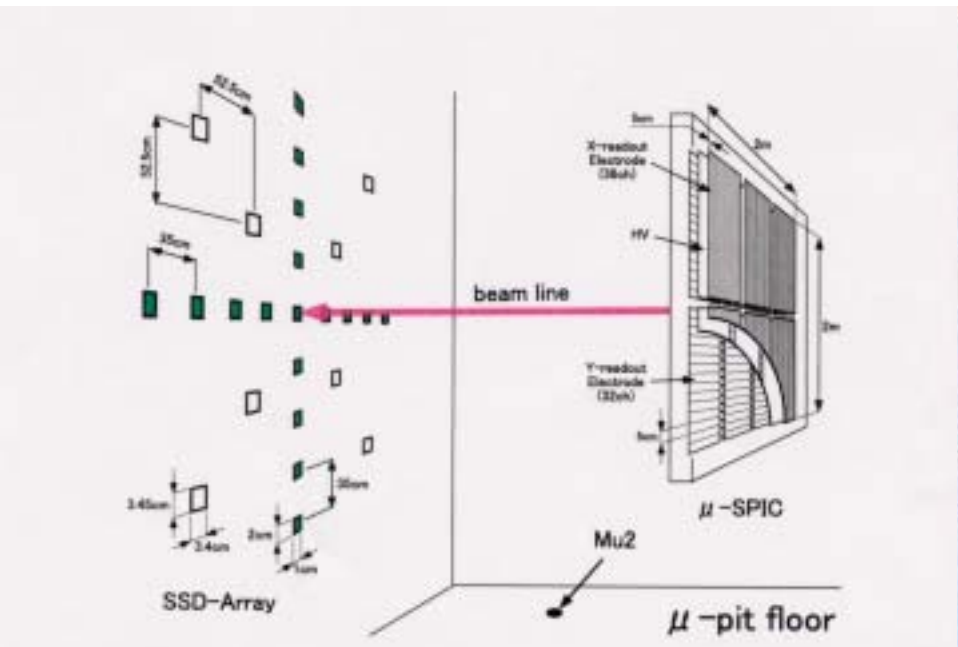
Neutrino Intensity Enhancement by Horns

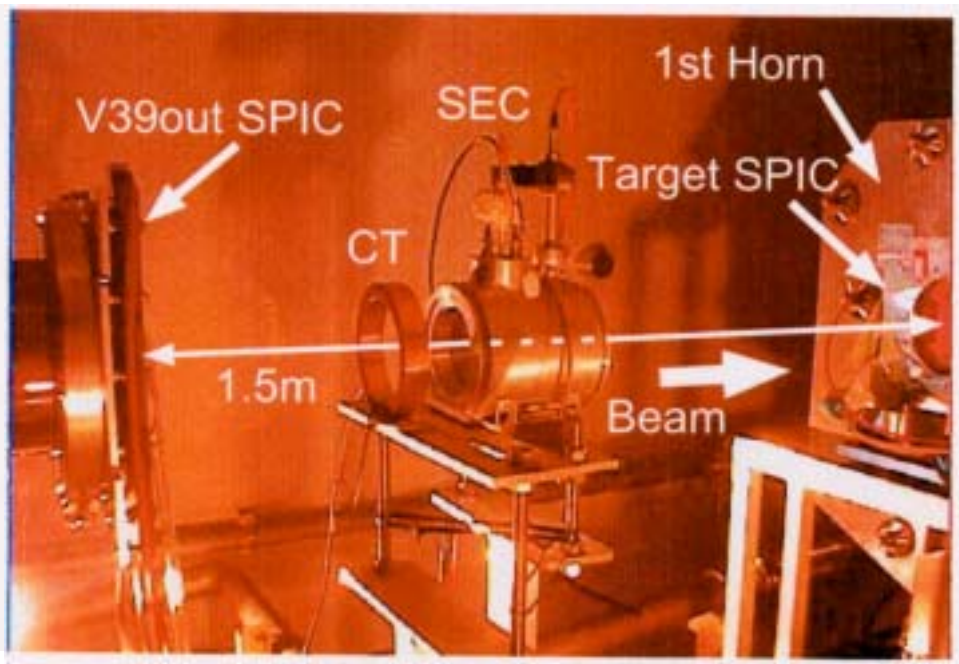


Neutrino Energy

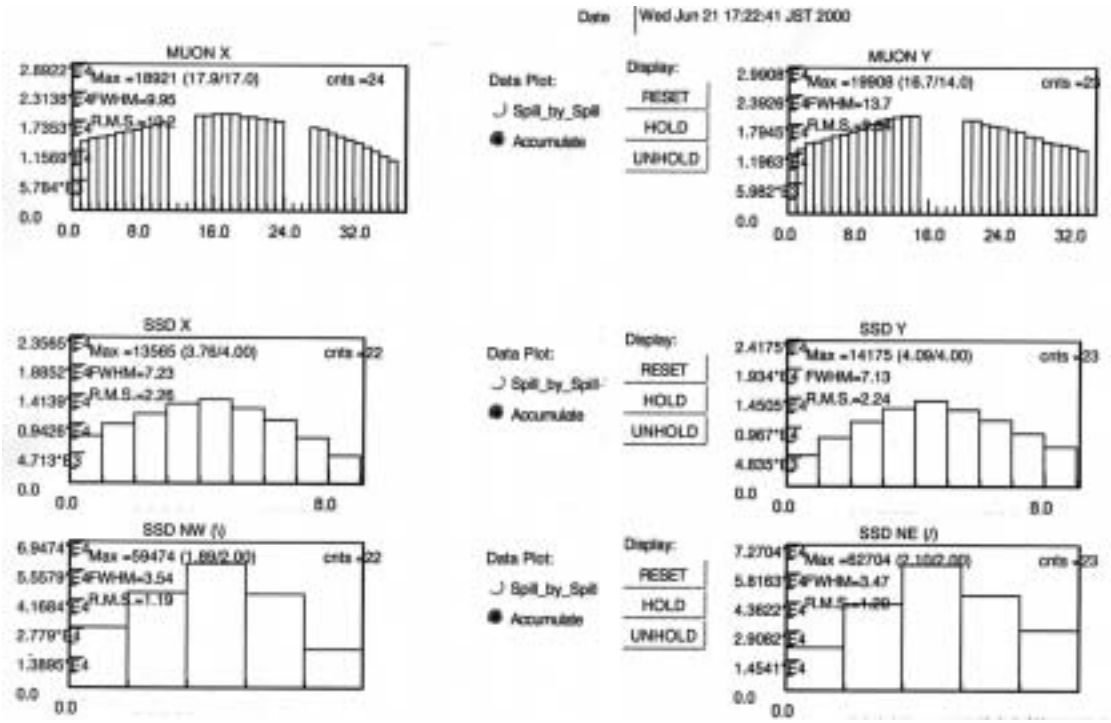
Decay Volume & Muon Monitor





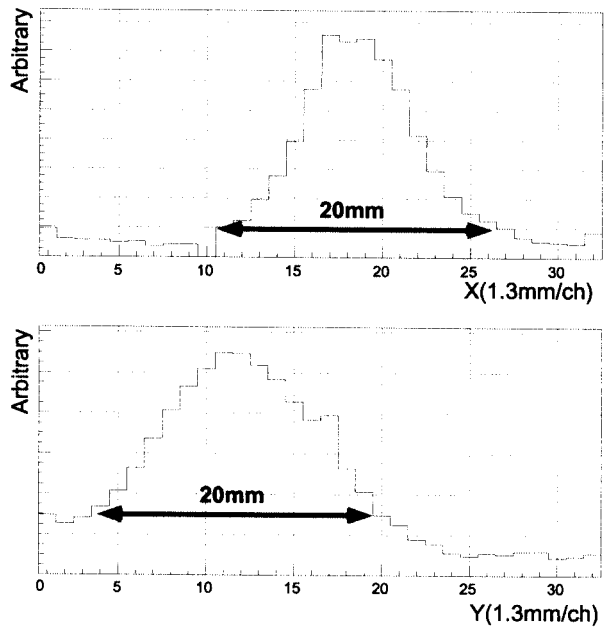


Muon/Proton Beam profiles

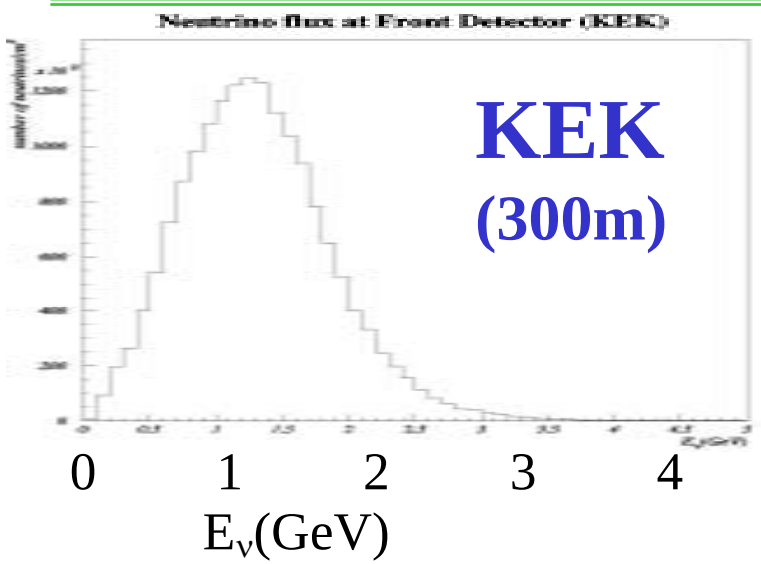


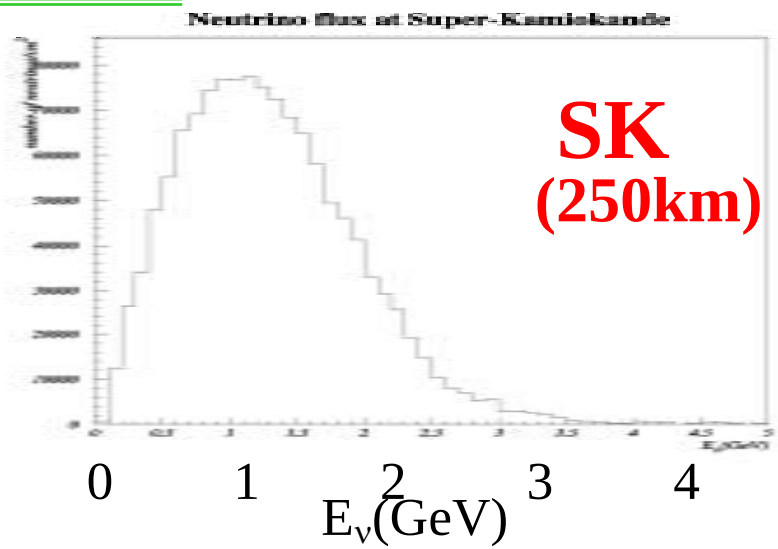
↑ Muon Profile measured by Muon Chamber and SSD's.

Proton Profile measured by SPIC. ↓

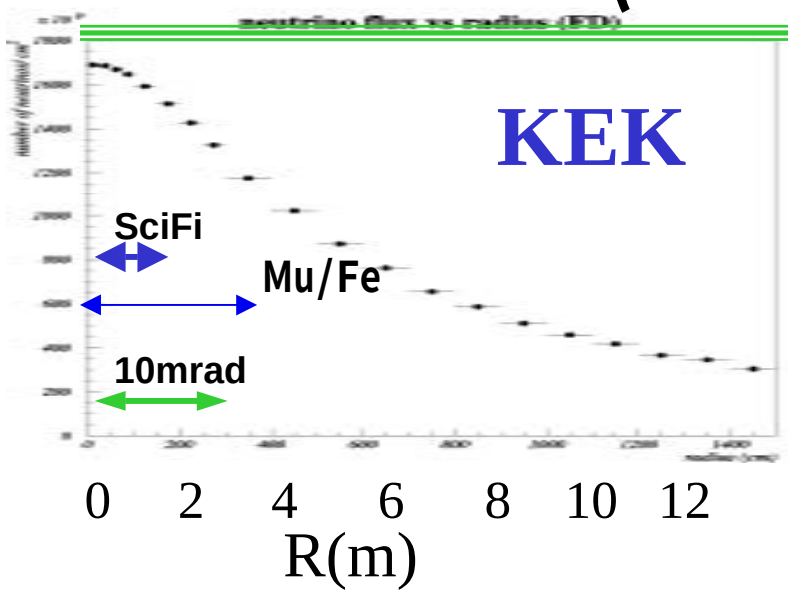


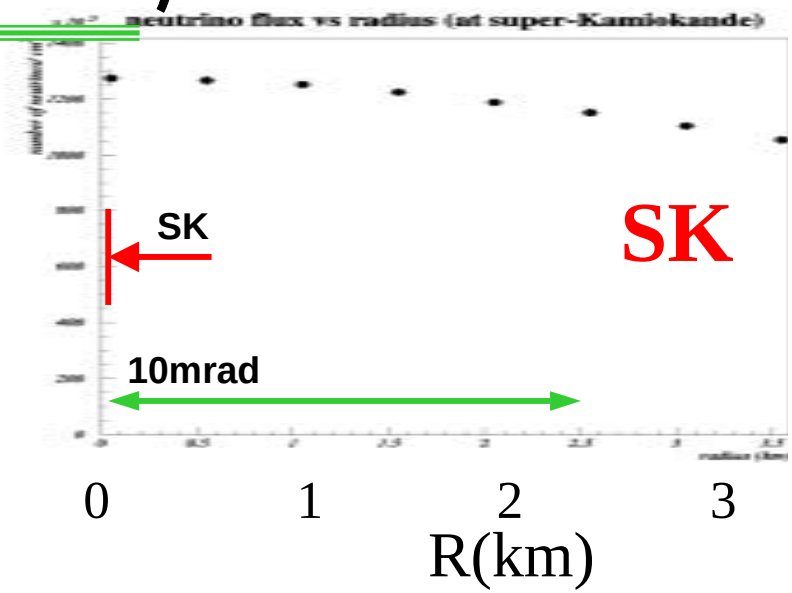
Neutrino Energy (Monte Carlo)





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)

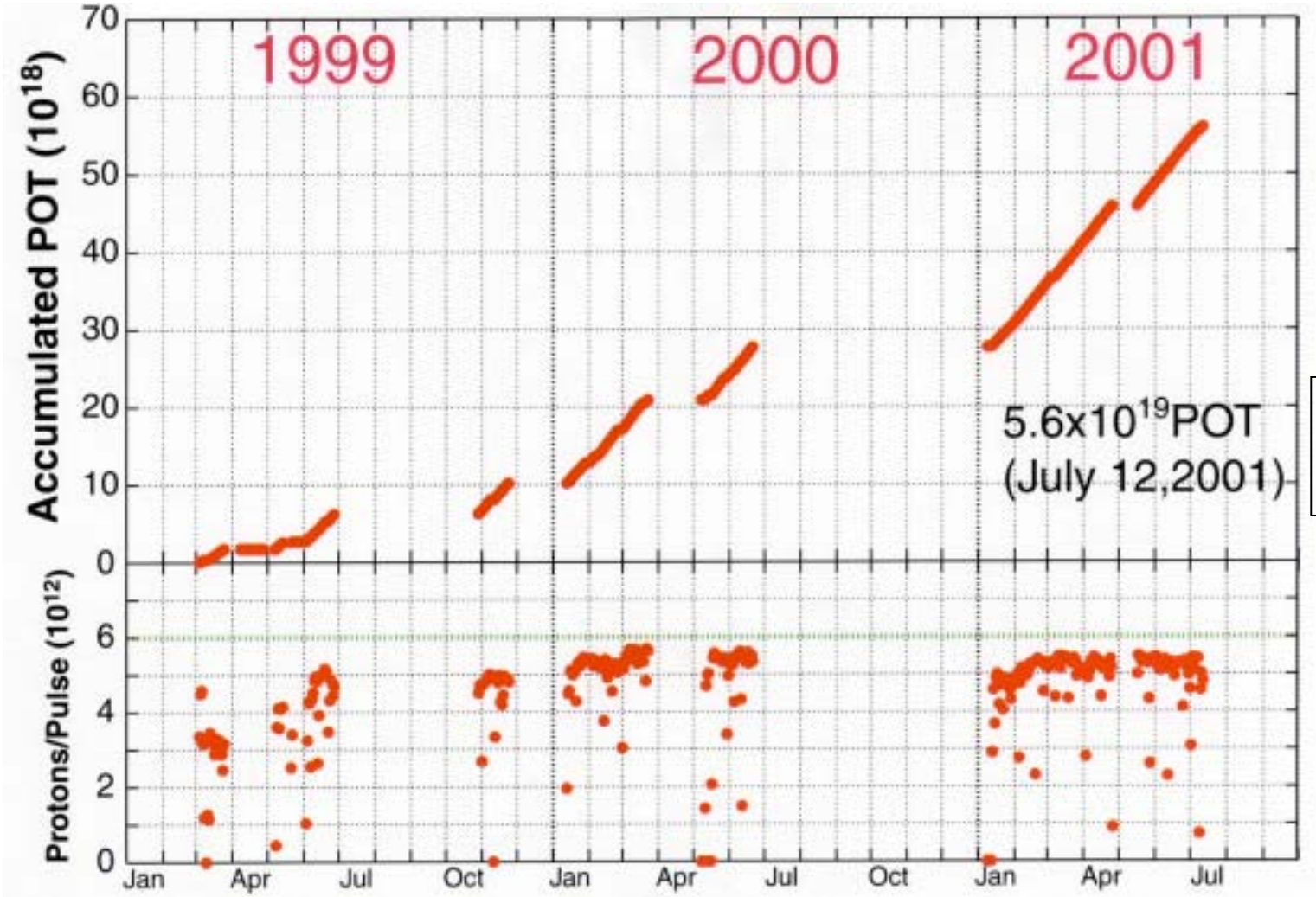
  Horizaintal～±0.03mr,

  Vertical ～±0.06mr,

Performance
June 1999 - July 2001

Or, Long Range Beam Stability!?

Delivered Protons on Target (POT)

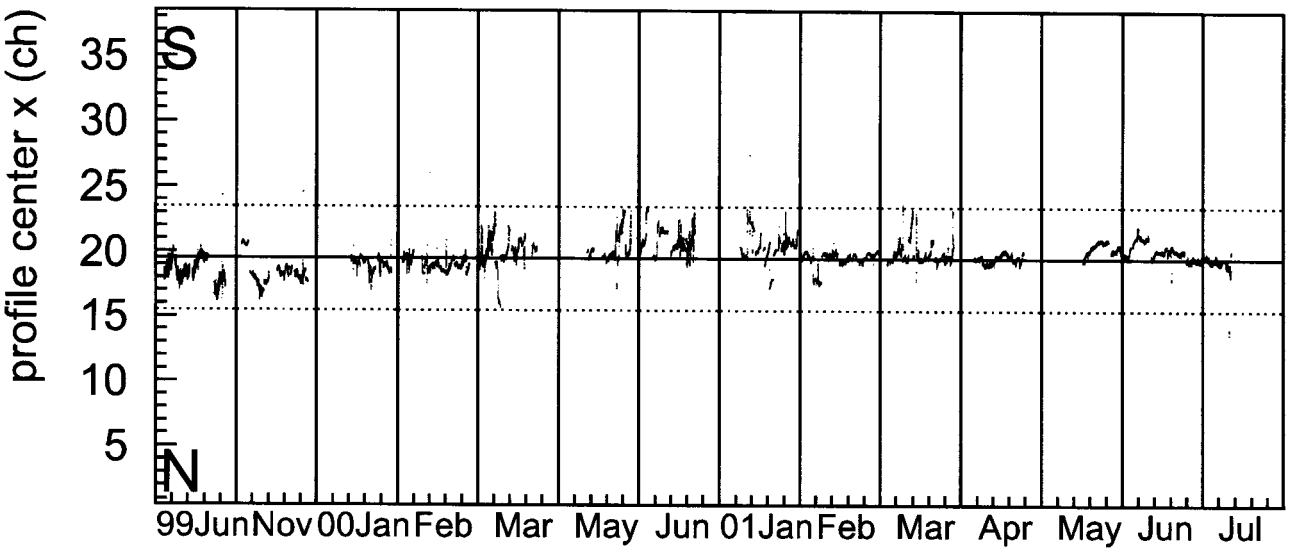


4.8x10^{19} POT for Analysis

Date

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

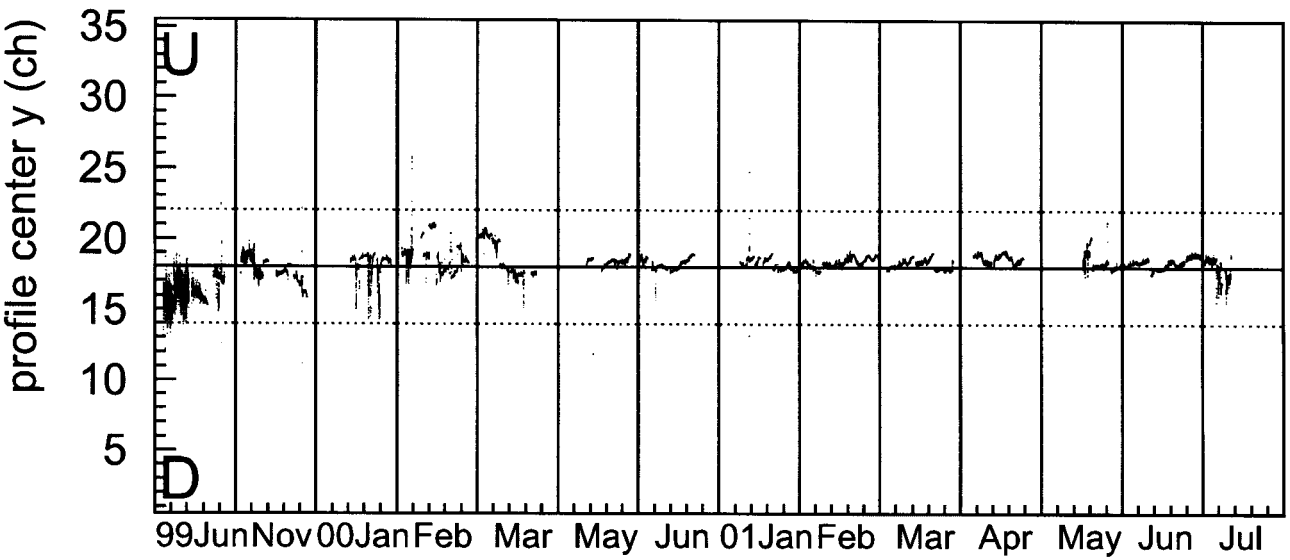
Muon Profile: Centoroid Stability



Horizonral

← +1 mrad

← -1 mrad

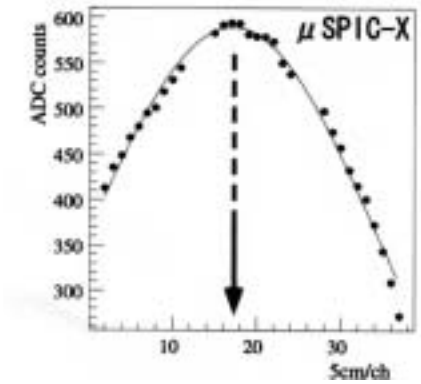


Vertical

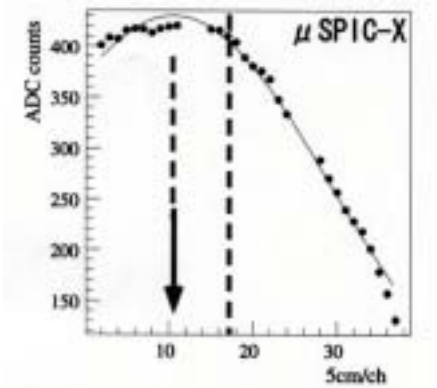
← +1 mrad

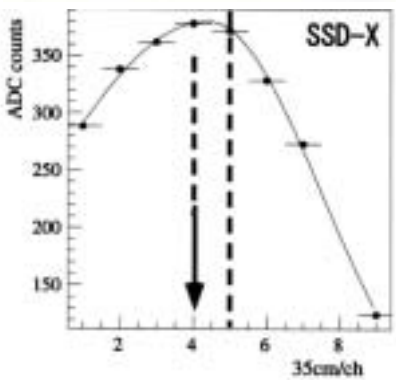
← -1 mrad

Beam Shift Correlation

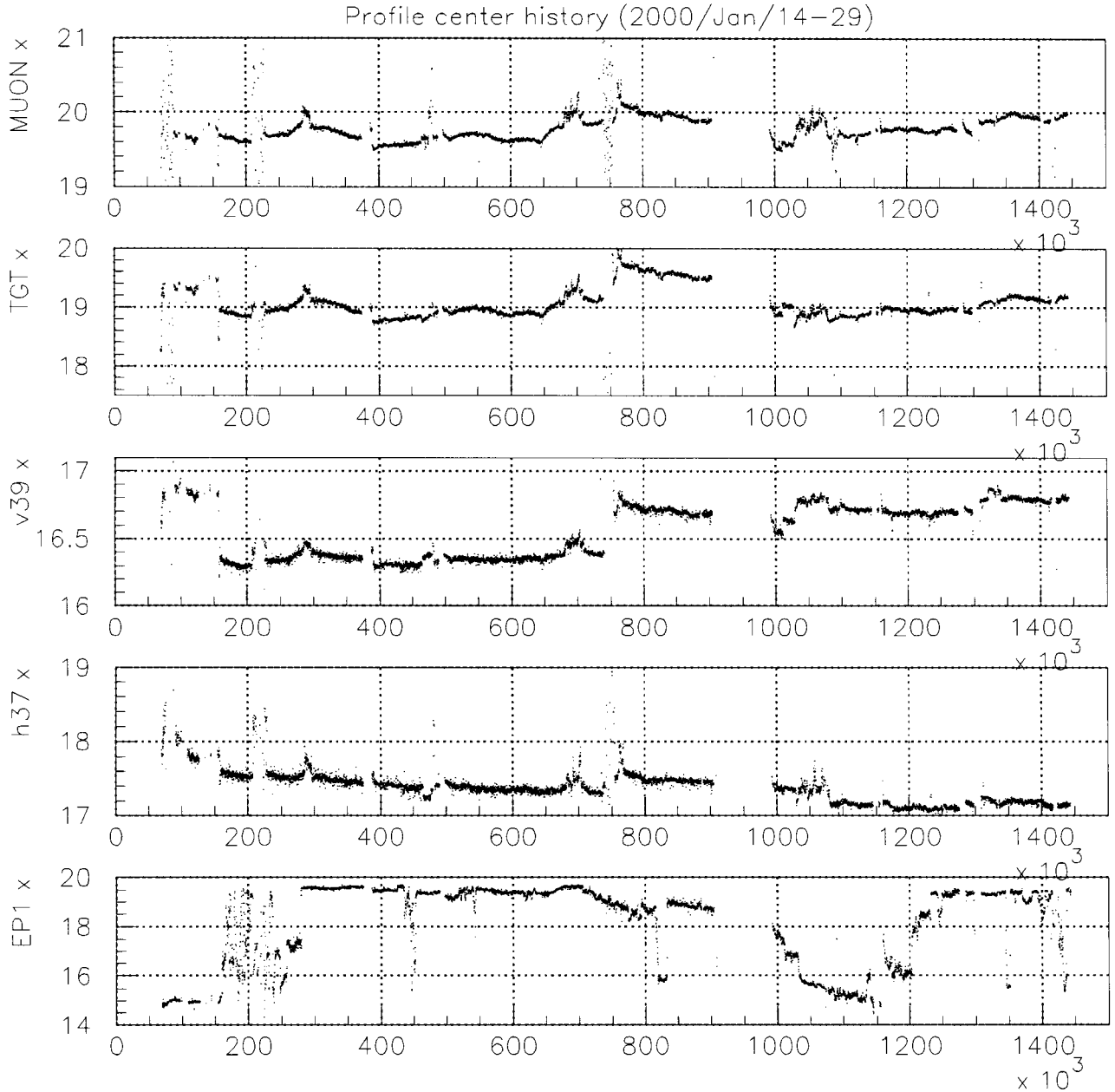


X_p^{target} = Center

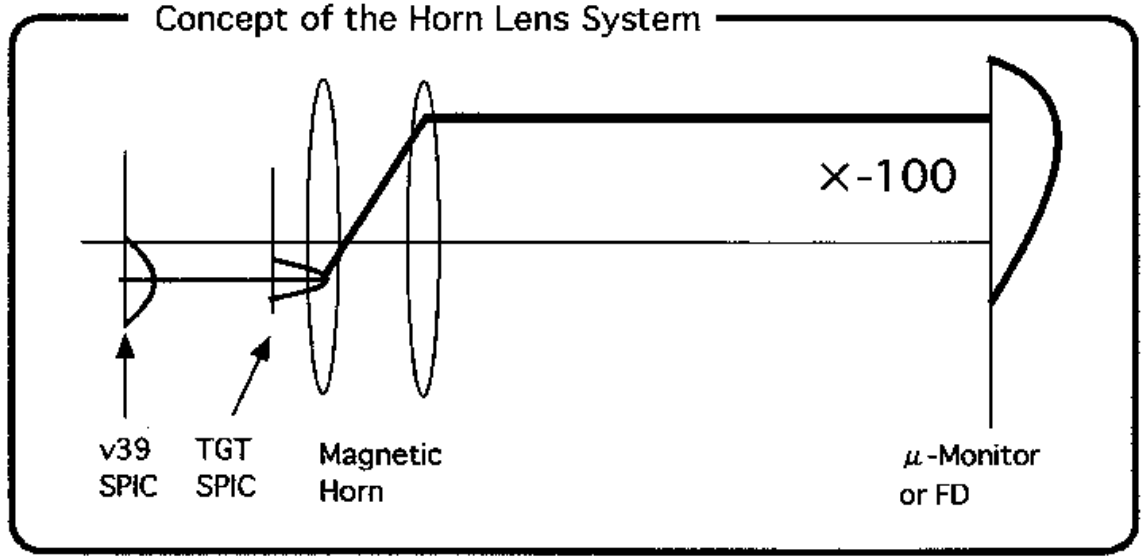


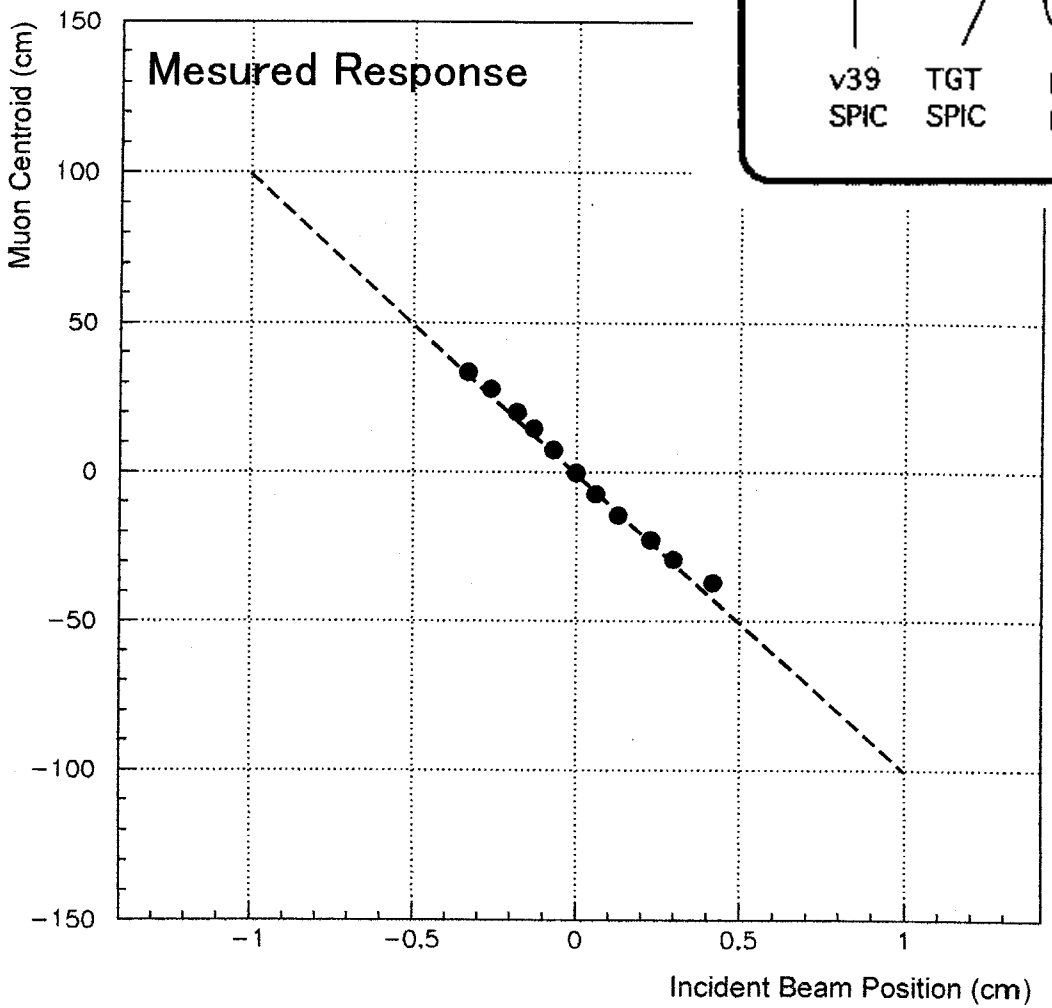


X_p^{target} = 3mm OFF



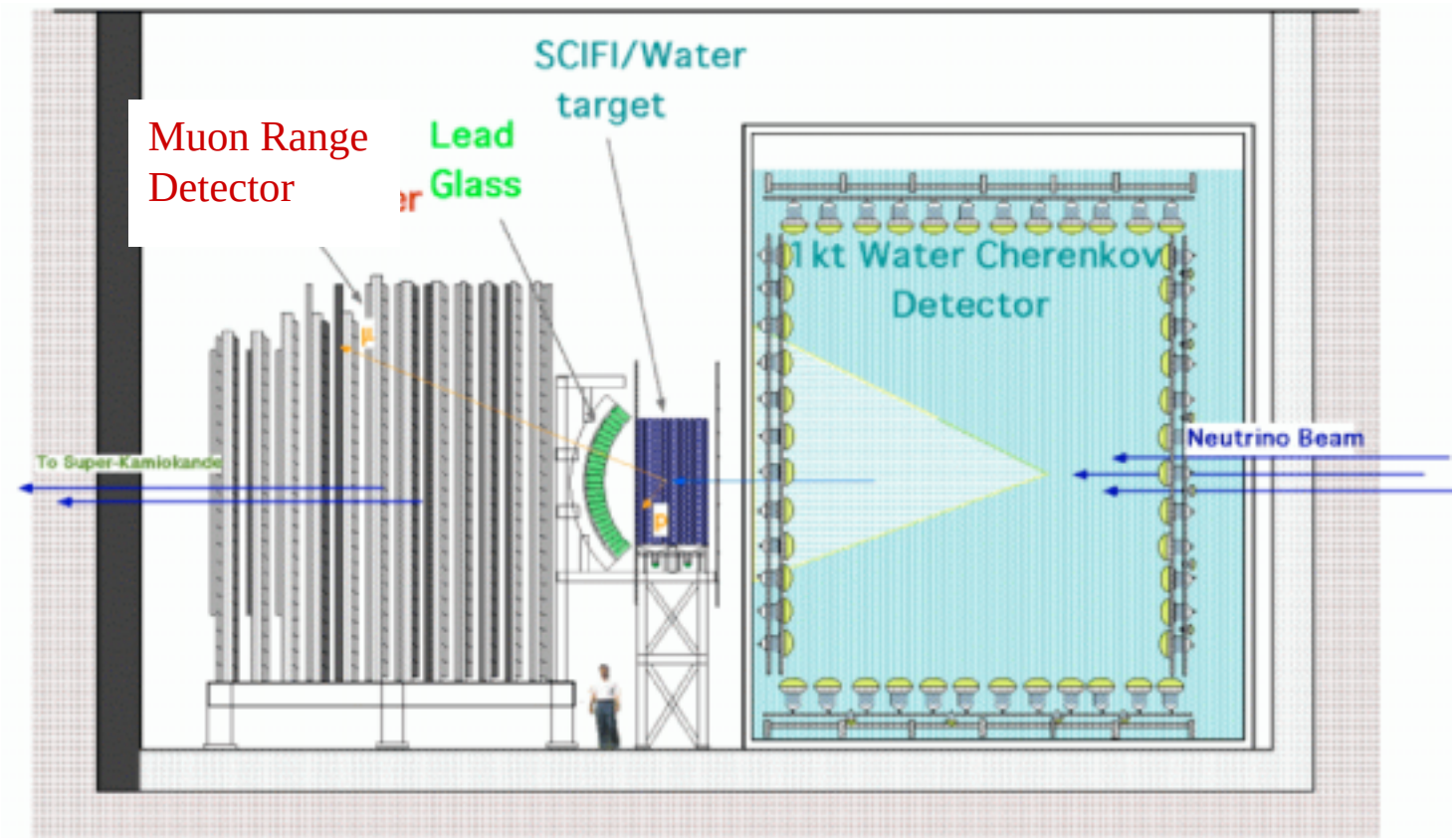
Muon/Proton Correlation





- 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.

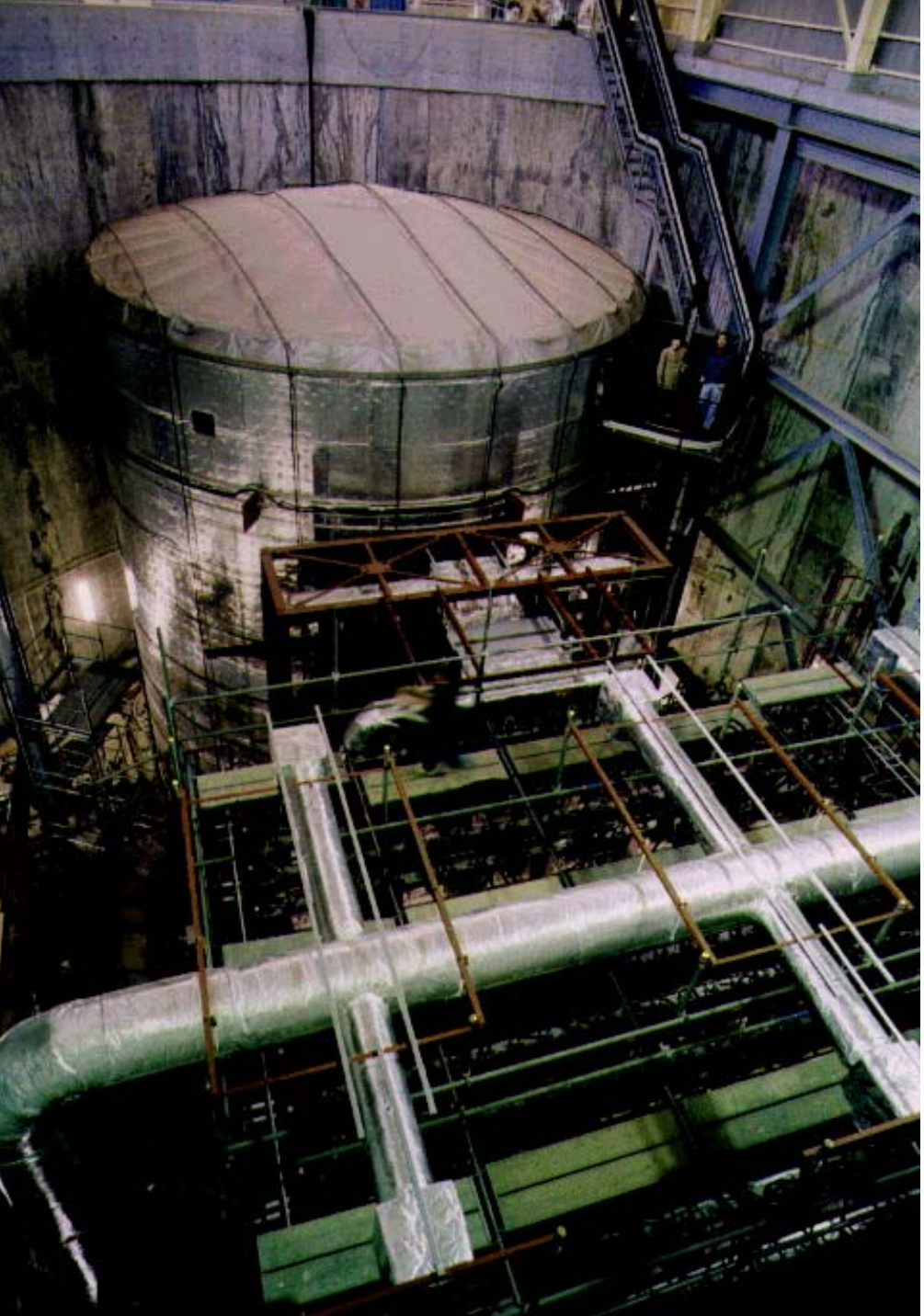
Front Detector Configuration



1ktWCD: Same Type Detector as SK

MRD and SciFi: Fine Grained Precise ν Detector

MRD: Massive and Large Solid Angle ν Detector



Front Detector Photograph

←1kt Baby Kamioka

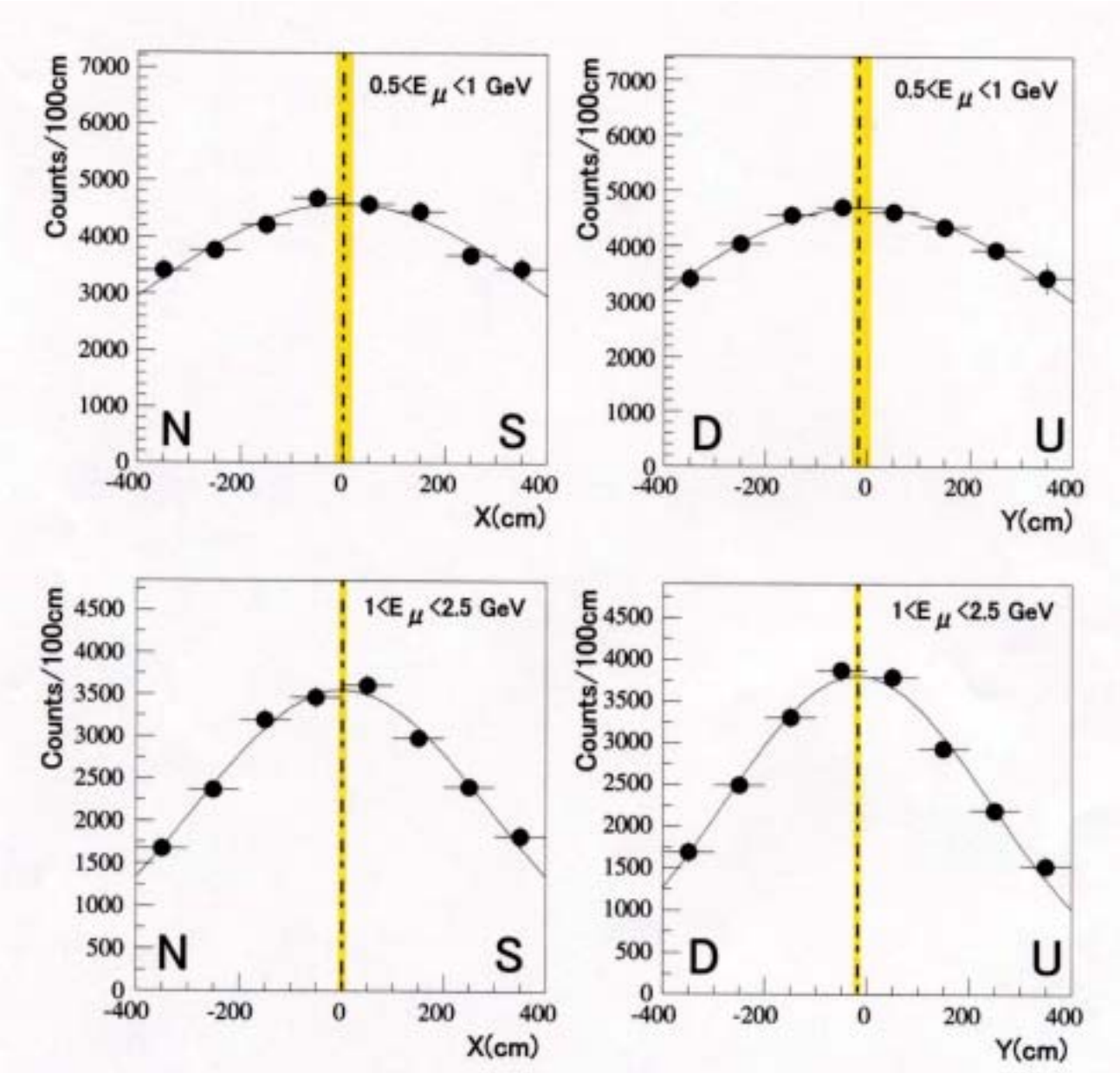
←SciFi

←Lead Glass

←Muon Range Detector

Front Detector as Neutrino Beam Monitor

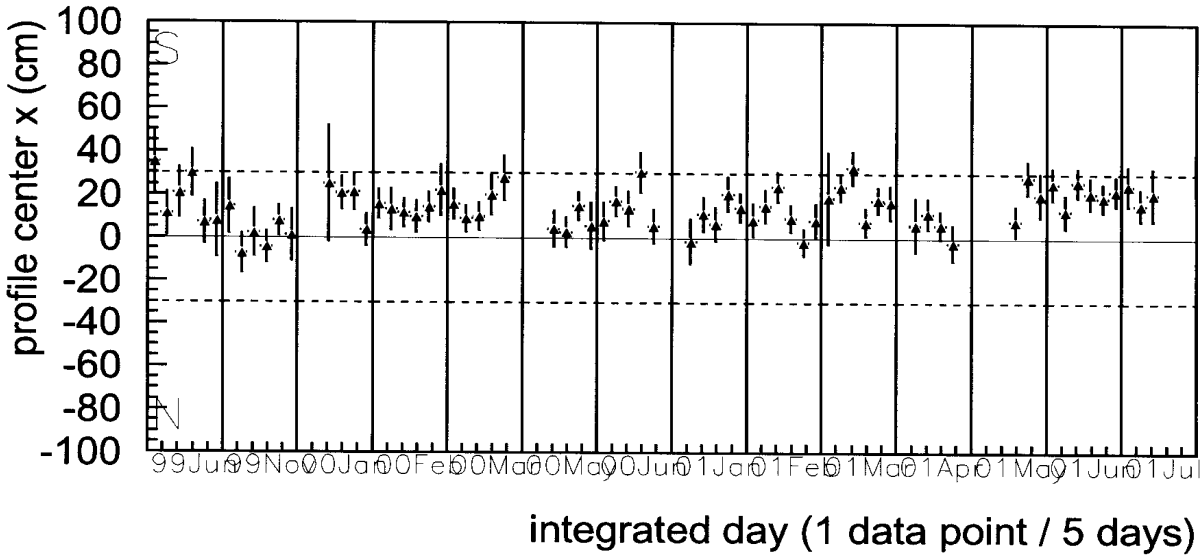
Neutrino Beam Profile (MRD)



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

Neutrino Profile: Centroid Stability

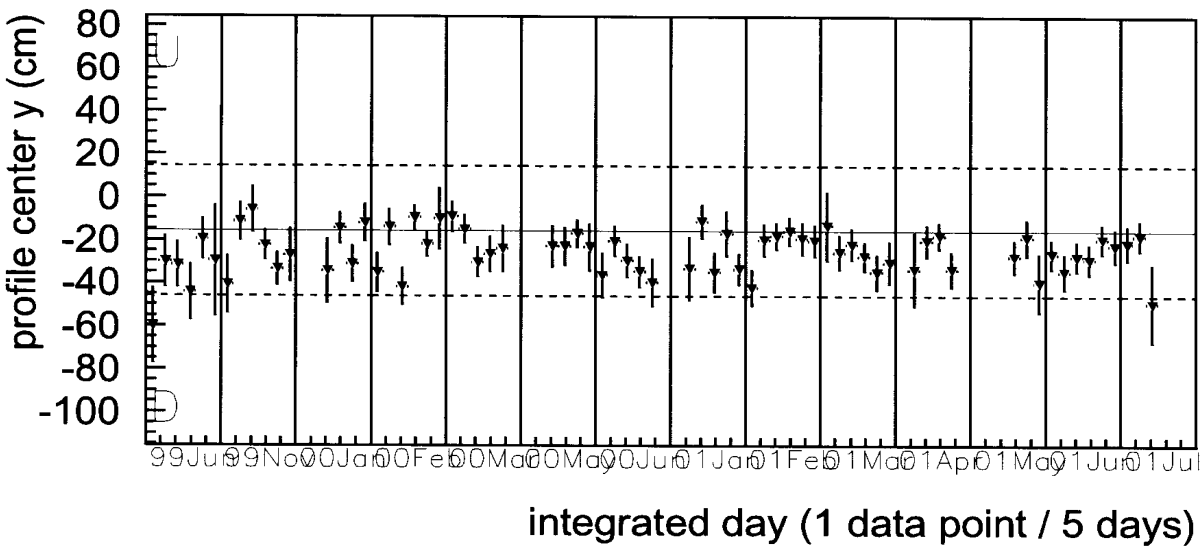
(Muon Range Detector)



Horizontal

←+1 mrad

← -1 mrad



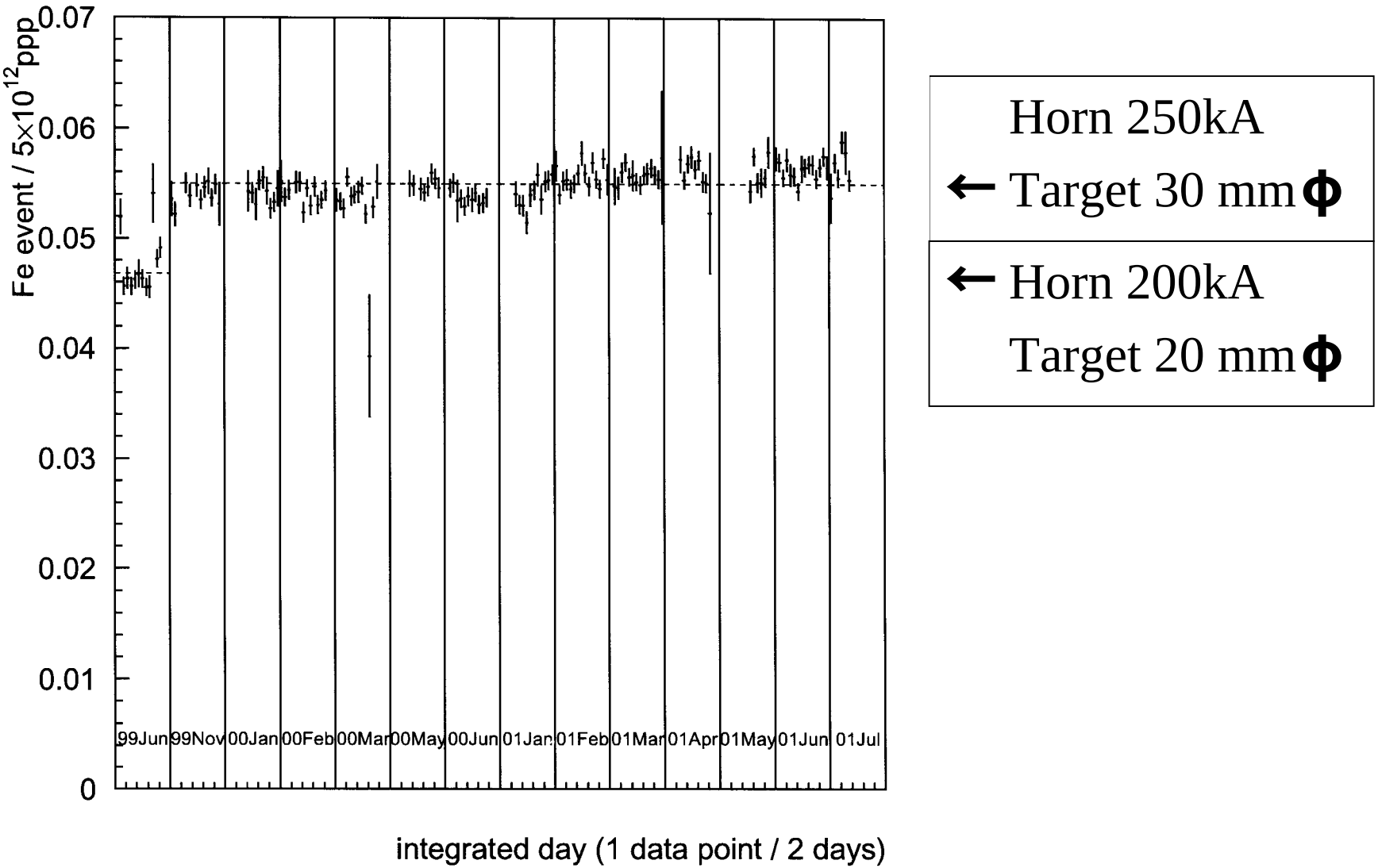
Vertical

←+1 mrad

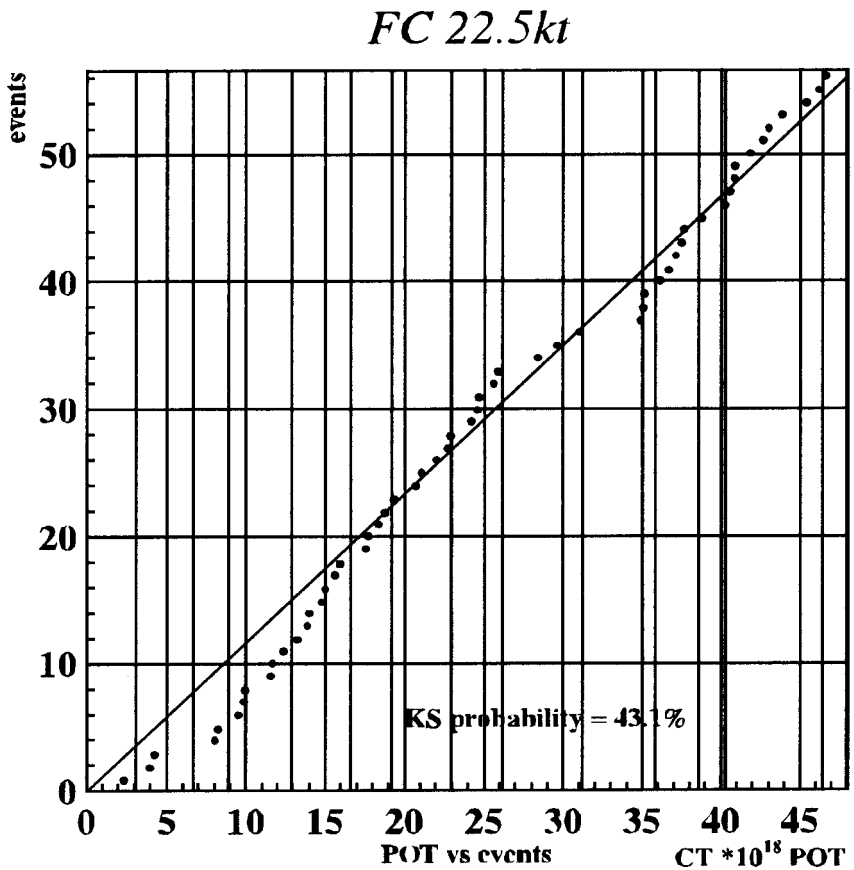
← -1 mrad

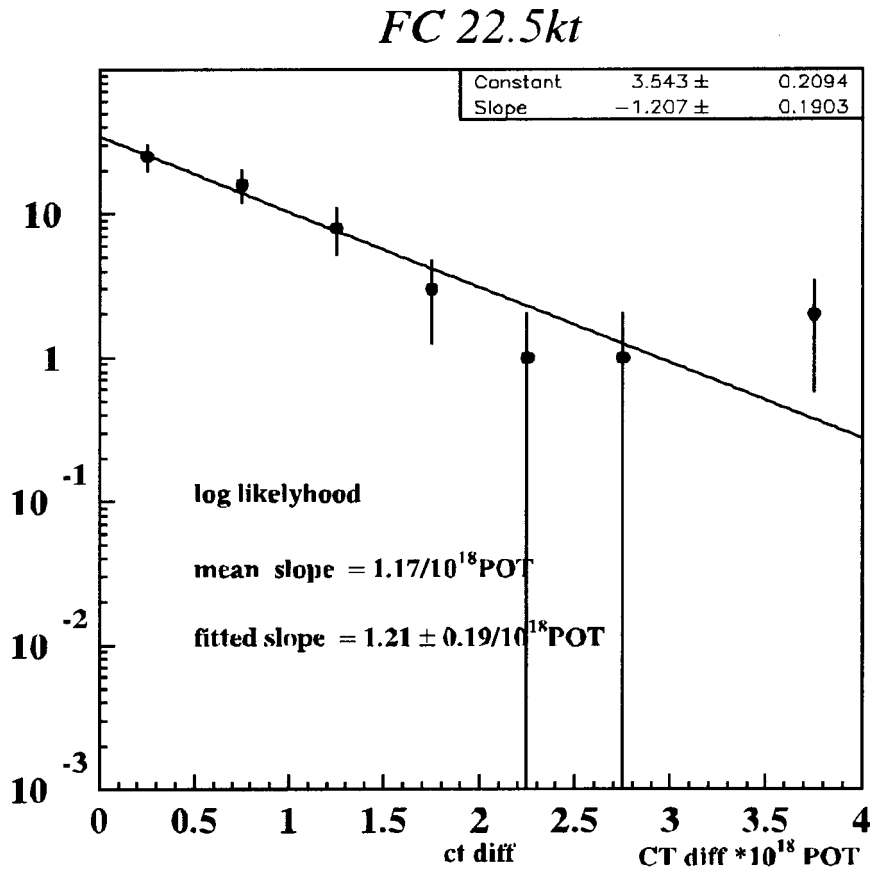
Neutrino Event Rate Stability

(Muon Range Detector/POT)



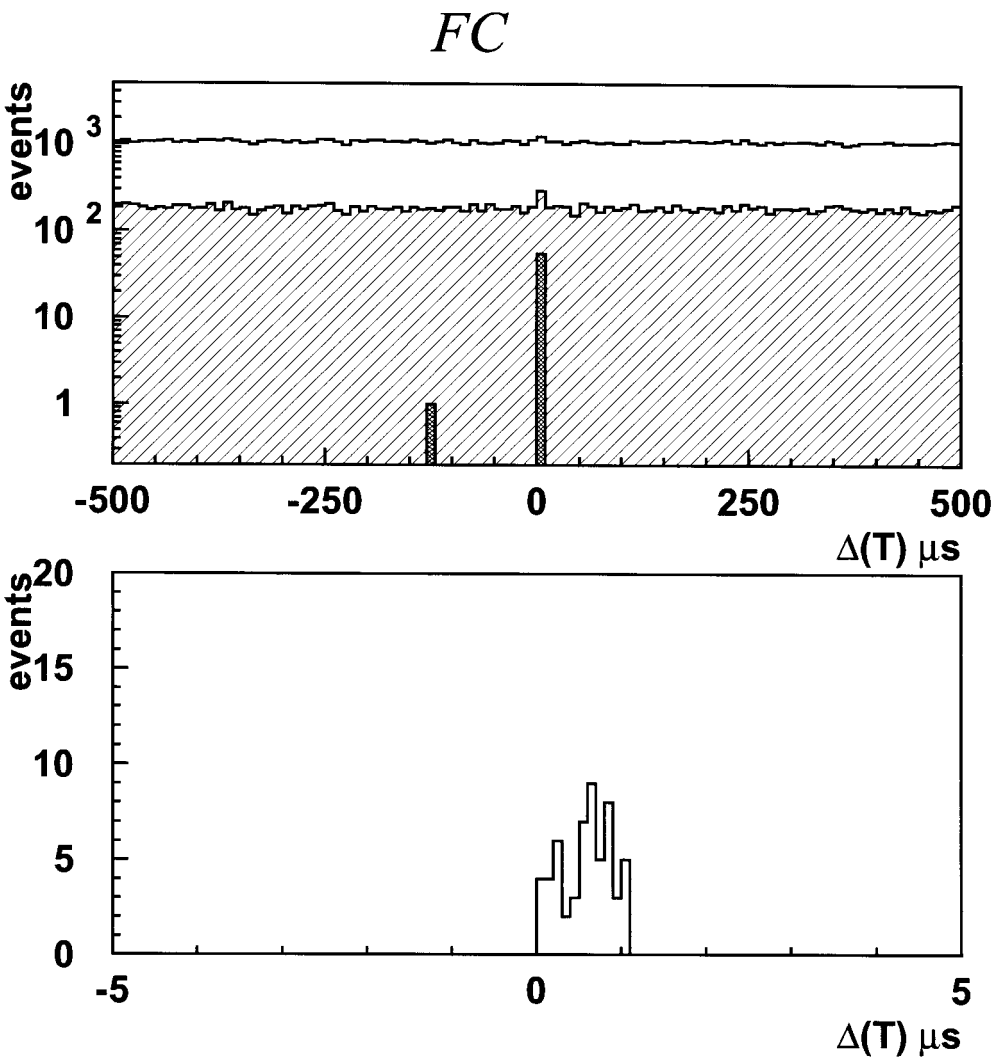
Event Number at SK/POT





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

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

No oscillation hypothesis is disfavoured at 97% CL.

Summary or Present Status

- Accelerator, Beam channel, Horns, and Beam Monitors are all stable and ~5x10^{19} POT was Achieved.
- Excitation number our Magnetic Horns recently exceeded ~10 M with 250kA.
- Nice aiming to Super-K continues and we have stable event rate at Super-K.
- Beam side is now OK! We are waiting for the recovery of Super-K.

Strategy of the HORN Operation/Replacement

- September(2002)
  - Replacement of Horns
- December (2002)
  - SK will re-start with a reduced PMT density
  - 6-7 months Continuous Operation with fast beam
  - 6M Excitation
  - 2.5×10^{19}POT
- July (2003)
  - Cooling Down
  - Slow Extraction
- November (2003)
  - Horn Replacement
- December (2003)
  - 6-7 months Continuous Operation
  - 6M Excitation
  - 2.5×10^{19}POT
- August(2004)
  - Shut Down for JHF Construction
- January(2005)
  - Magnet Transfer to Tokai