May 29, 2001
νFact01 WG3

Conventional Neutrino Beam at K2K and JHF

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K2K Neutrino Beam

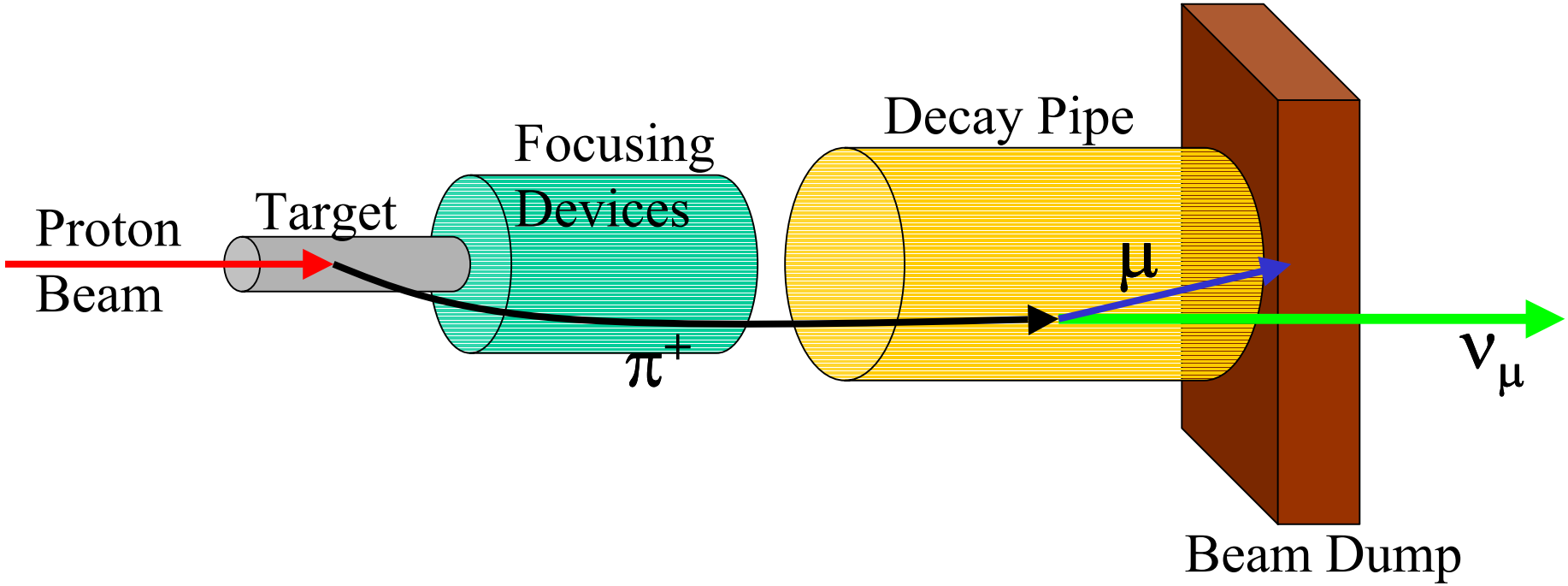
for KEK Beam Channel Group

and K2K Beam Monitor Group

JHF Neutrino Beam

for JHFnu Working Group

Neutrino Beam Production (conventional method)



- Pure ν_μ beam (~99%)
- ν_e ($\lesssim$1%) from $\pi \rightarrow \mu \rightarrow e$ chain and K decay(K_{e3})
- $\nu_\mu/\bar{\nu}_\mu$ can be switched by flipping polarity of focusing device

General Requirements on Conventional Neutrino Beam

(for long baseline experiments)

- **Fast Extraction** w/ precise beam timing info.
  - to identify ν event from acc. at far detector

  →Kicker magnet

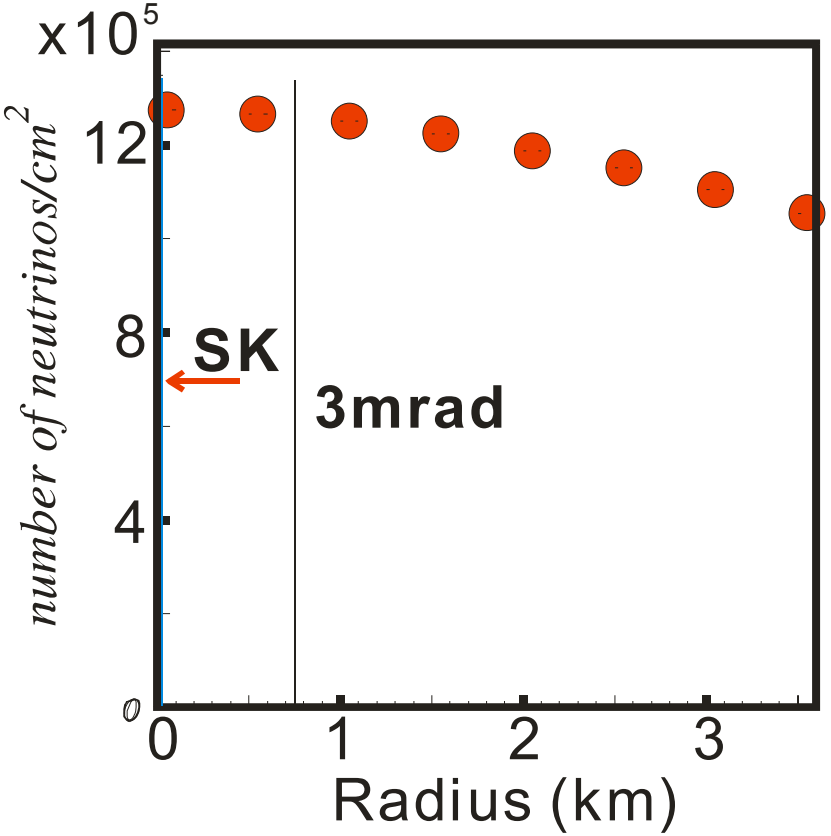
  →GPS time stamp (Δt~200ns)
- As **high intensity** as possible

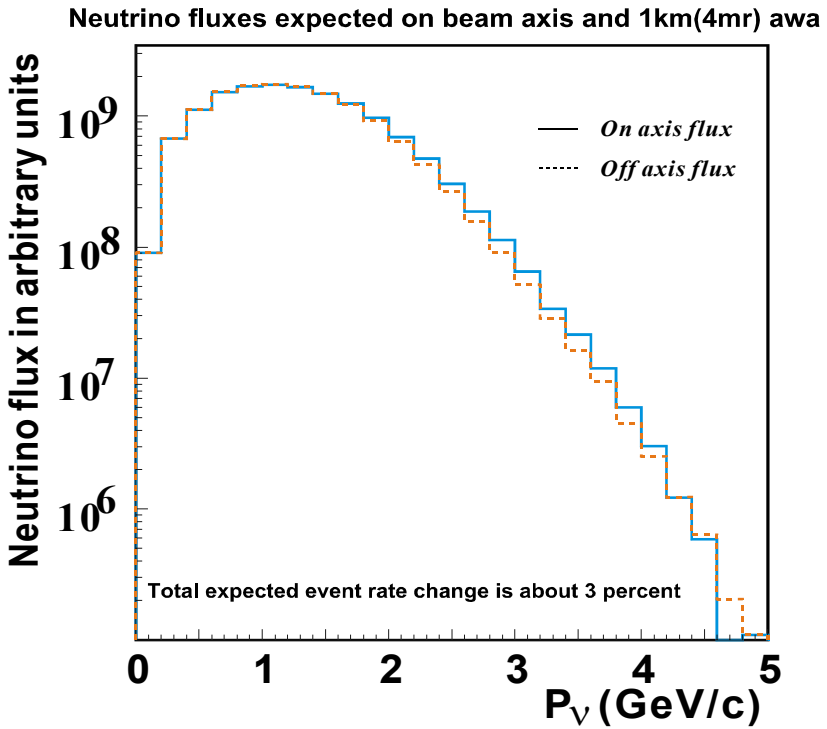
  →High transmittance beam transport

  →Electromagnetic Horn
- **Precise directioning** (<3mrad)

  →GPS survey
- **Stable**

Neutrino Spectra and Radial Distributions at 250km (MC)

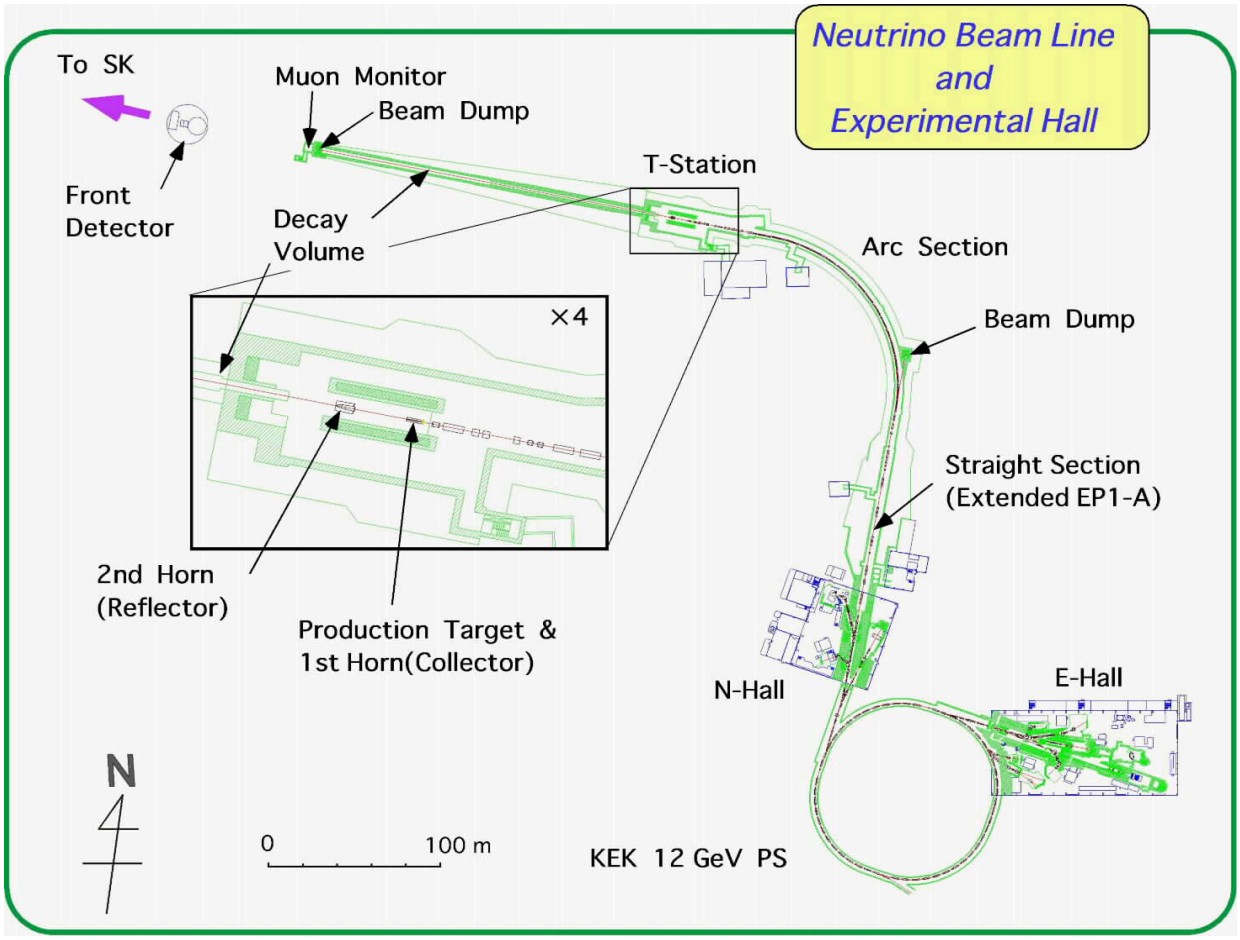


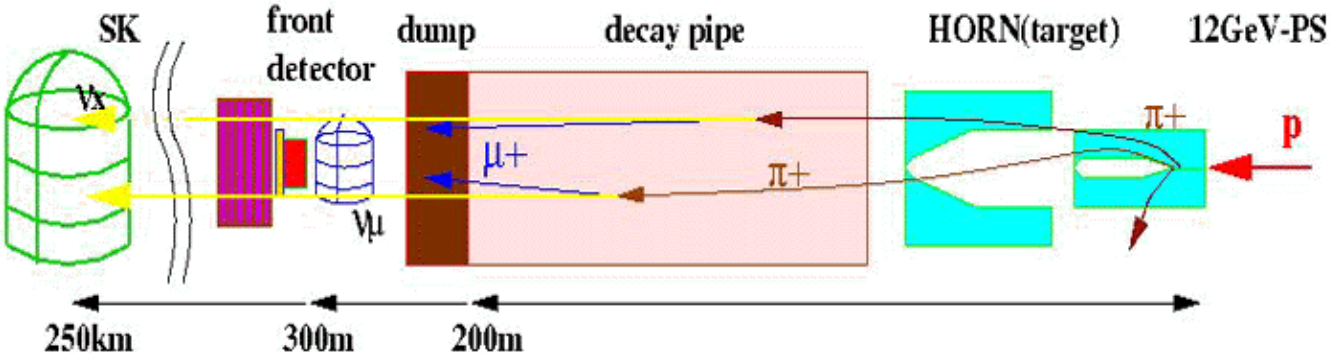


Change in flux/spectrum < 3mr(750m) @ SK negligible

General Layout
of the KEK Neutrino Beam Facility

The Apparatus for the Longest Shooting Game





Proton Beam Line

(400m Long, 114 Magnets)

Single turn fast extraction

9bunches/1.1μsec spill/2.2s

- **Protons@Entrance**

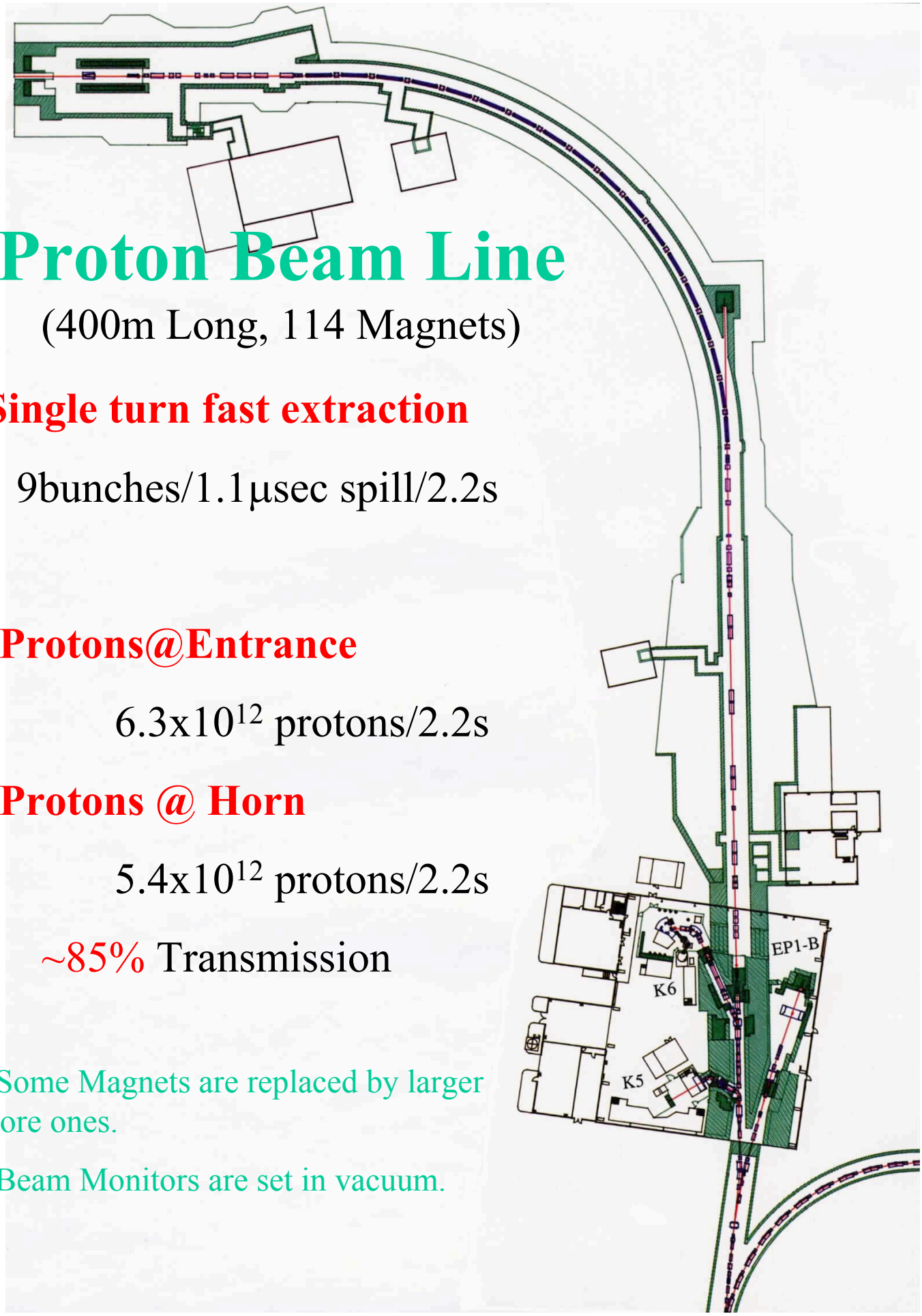
  6.3×10^{12} protons/2.2s

- **Protons @ Horn**

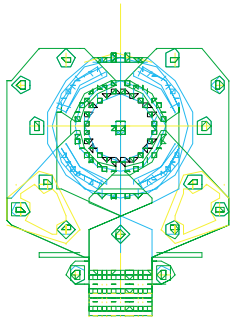
  5.4×10^{12} protons/2.2s

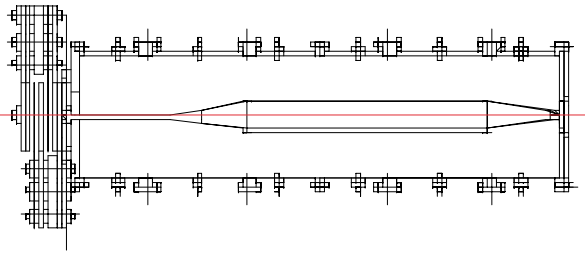
  ~85% Transmission

- Some Magnets are replaced by larger bore ones.
- Beam Monitors are set in vacuum.

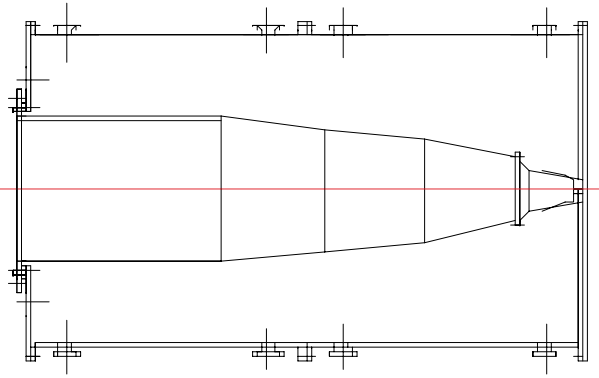


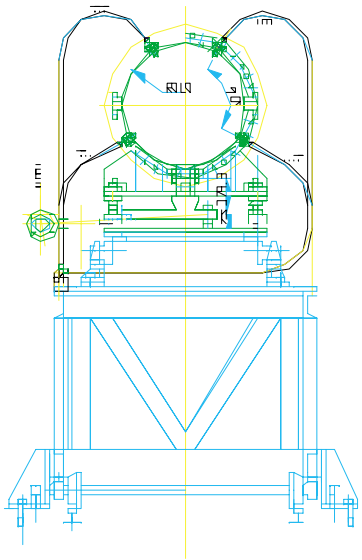
K2K Electromagnetic Horns

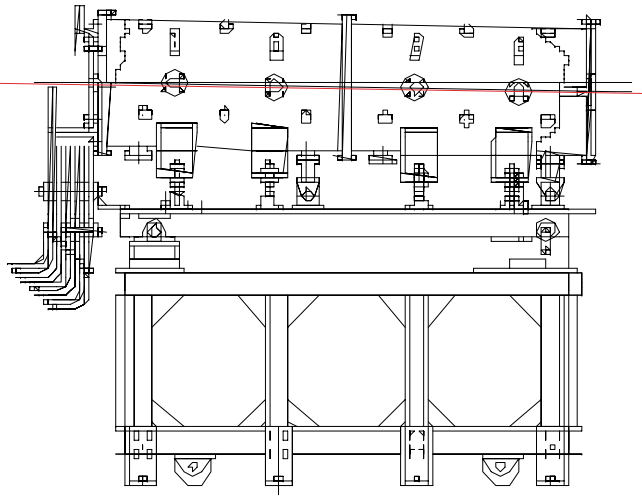




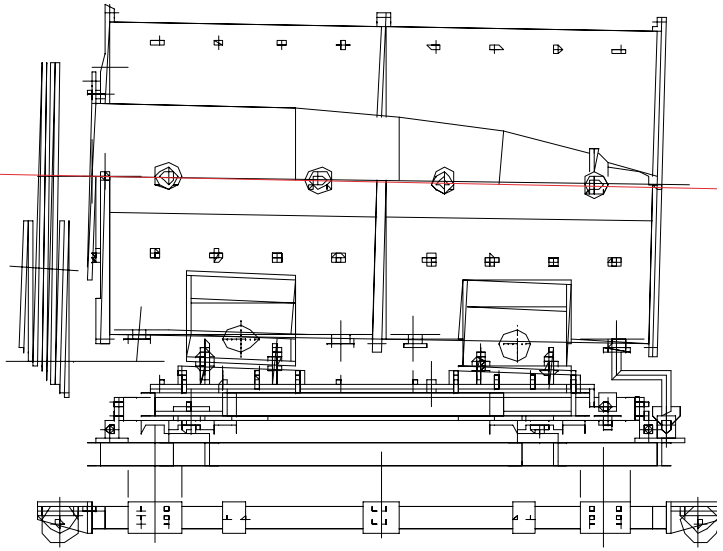
Top View







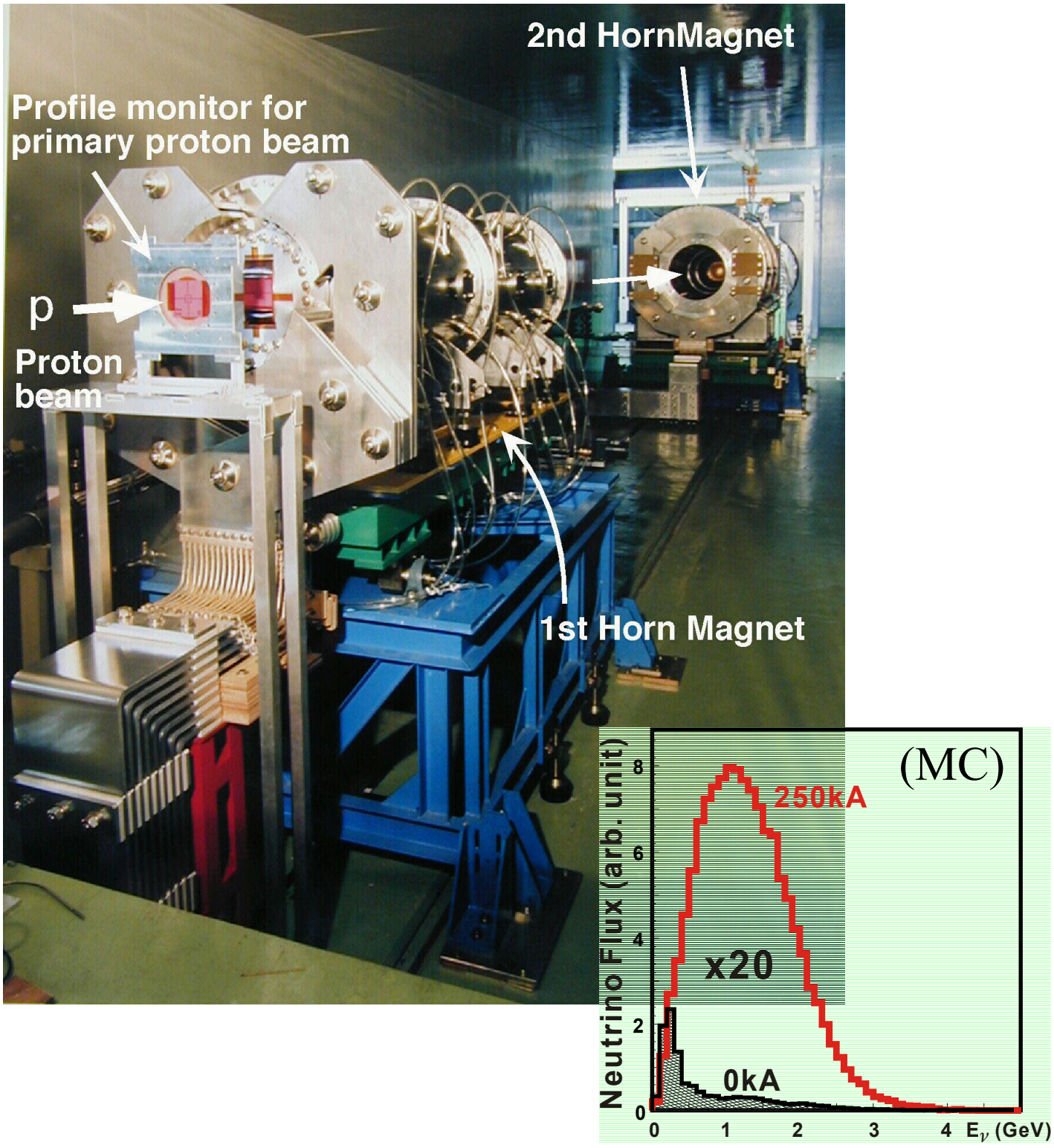
Side View



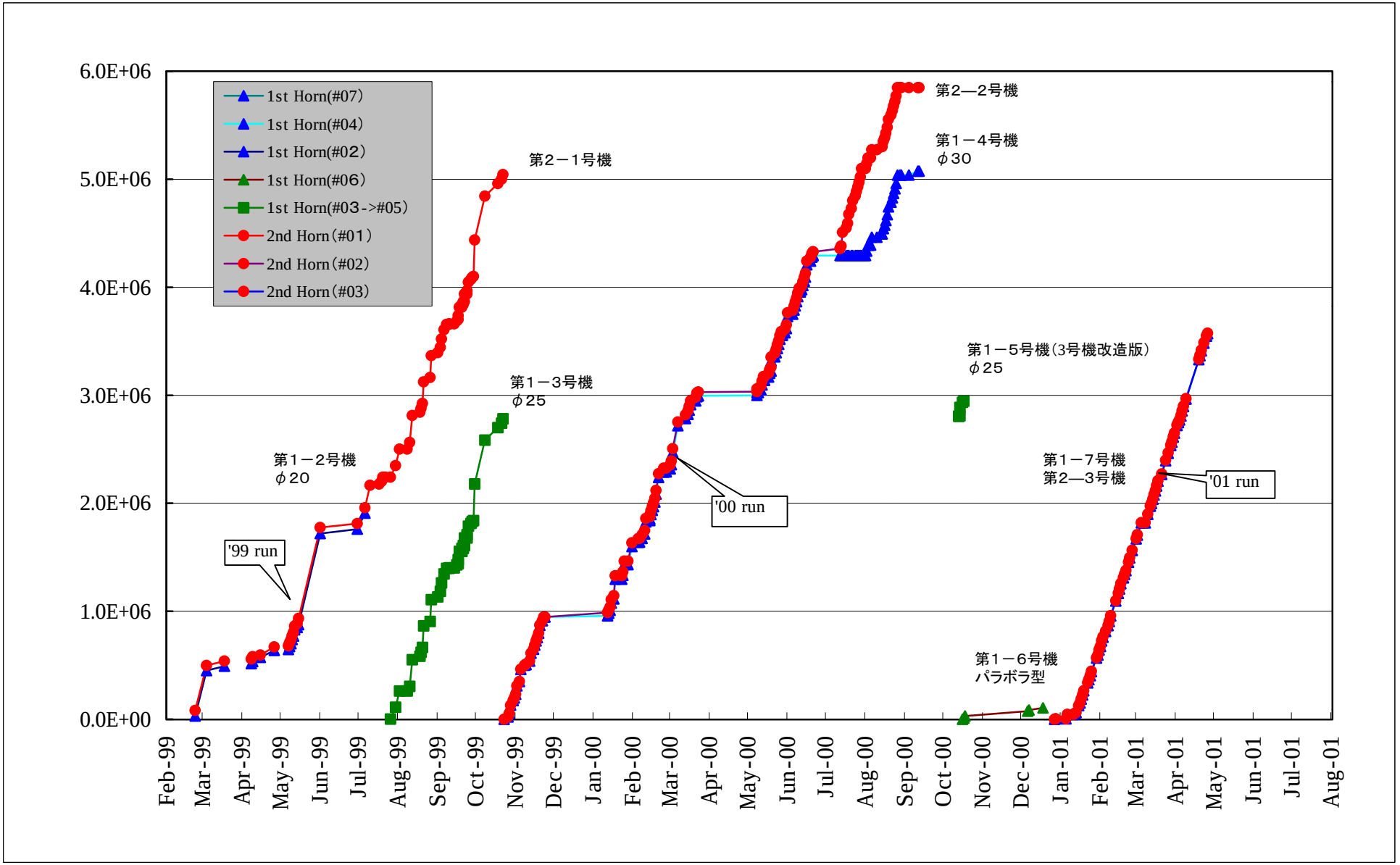
- Tandem horn system
- 1st Horn : Outer diameter= 0.62m, Length= 2.42m
  - Built-in production target (<ϕ30mm)
  - High magnetic field (5 Tesla)

- 2nd Horn : Outer diameter= 1.65m, Length= 2.76m
  - Thin inner conductor (thickness 3mm)
  - Large magnetic volume
- Operation current 250kAmp at both horns
- High pulsed current 2.5ms width, 2.18s cycle
- Total Joule's heat= 7740 kcal/h

Electromagnetic Horns



2001/5/8
yamanoi



Positioning of SK and KEK

(1) Procedure

Local GPS at KEK
Long Baseline GPS btwn KEK and Kamioka
Local GPS in Kamioka
Optical Survey in the Mozumi Mine(SK)

(2) Precision of Positioning

GPS:

Nominal error:

$\Delta = 10^{-6} \times D + b$, b~5-10mm, D=250km

= 0.3m(KH)

Optical Survey:

the Error of Closure:

$\Delta_{traverse}$=0.9m(SK)

$\Delta_{leveling}$ =0.4m(SK)

$\Delta_{Horizontal}$ = 1.2m

$\Delta_{Vertical}$ = 0.7m

positioning precision = 5×10^{-6}

Summary

(1) Beam Line Construction & Operation

Stably Running since 1999.6

(2) Positioning of SK and KEK

$\Delta_{Horizontal}$ = 1.2m
$\Delta_{Vertical}$ = 0.7m
positioning precision = 5×10^{-6}

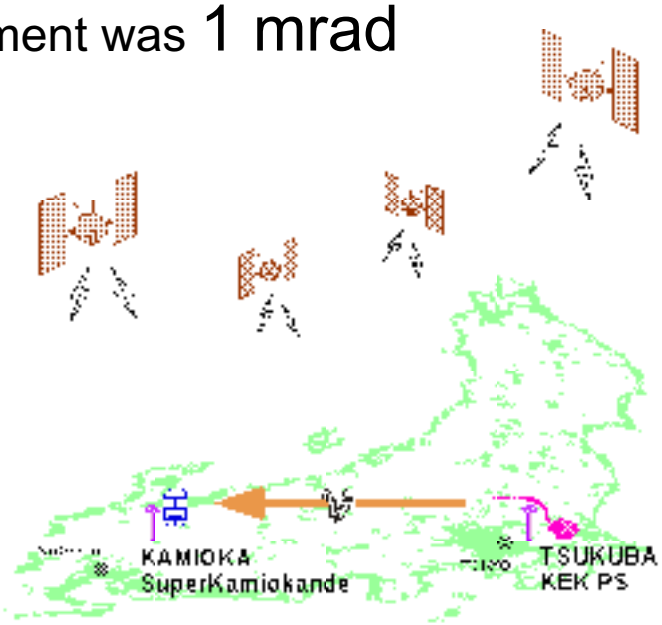
(3) Beam Line Alignment to the SK Direction

Monitoring the Beam Line Direction
$\pm$0.02 mrad in Hor.
$\pm$0.05 mrad in Ver.

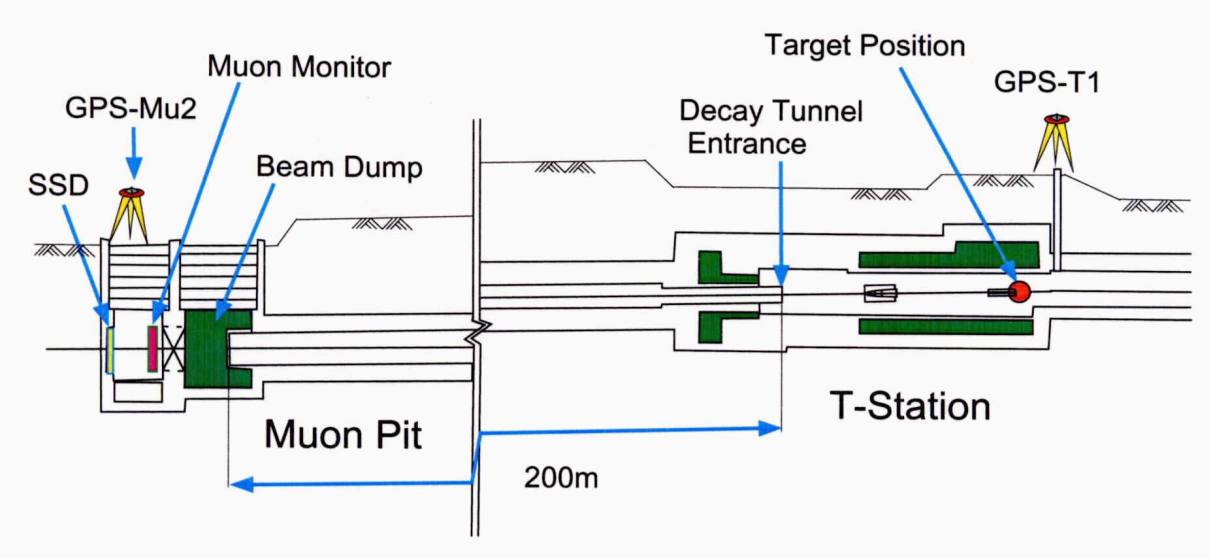
(4) Beam Control

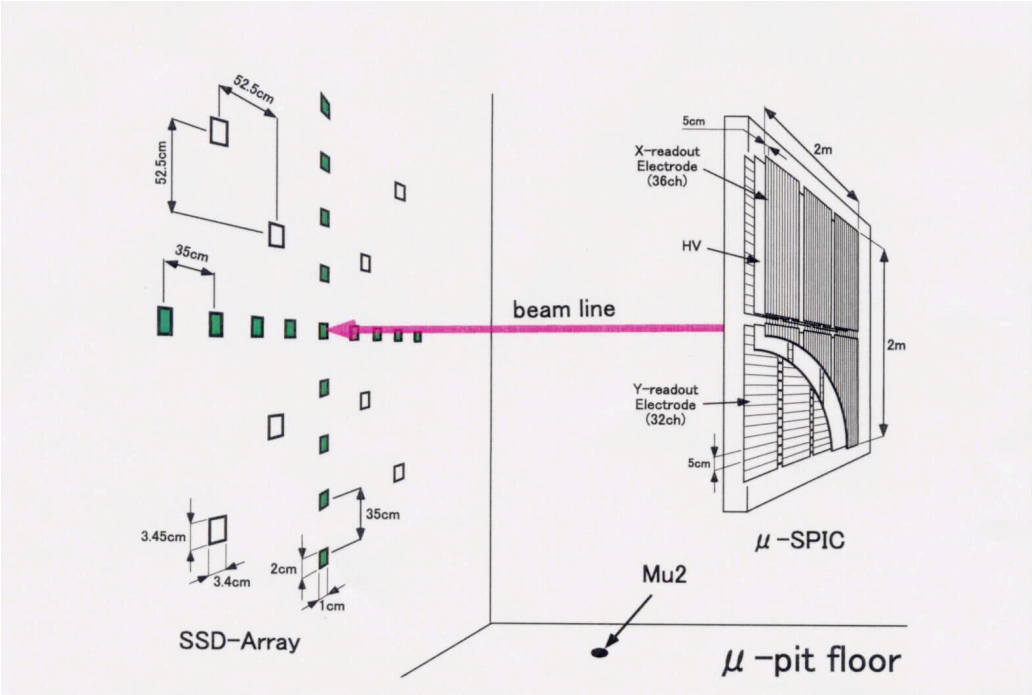
Established the Tuning of Beam Direction
$\pm$0.03 mrad in Hor.
$\pm$0.06 mrad in Ver. in finite time range

Experimetal Requirement was 1 mrad

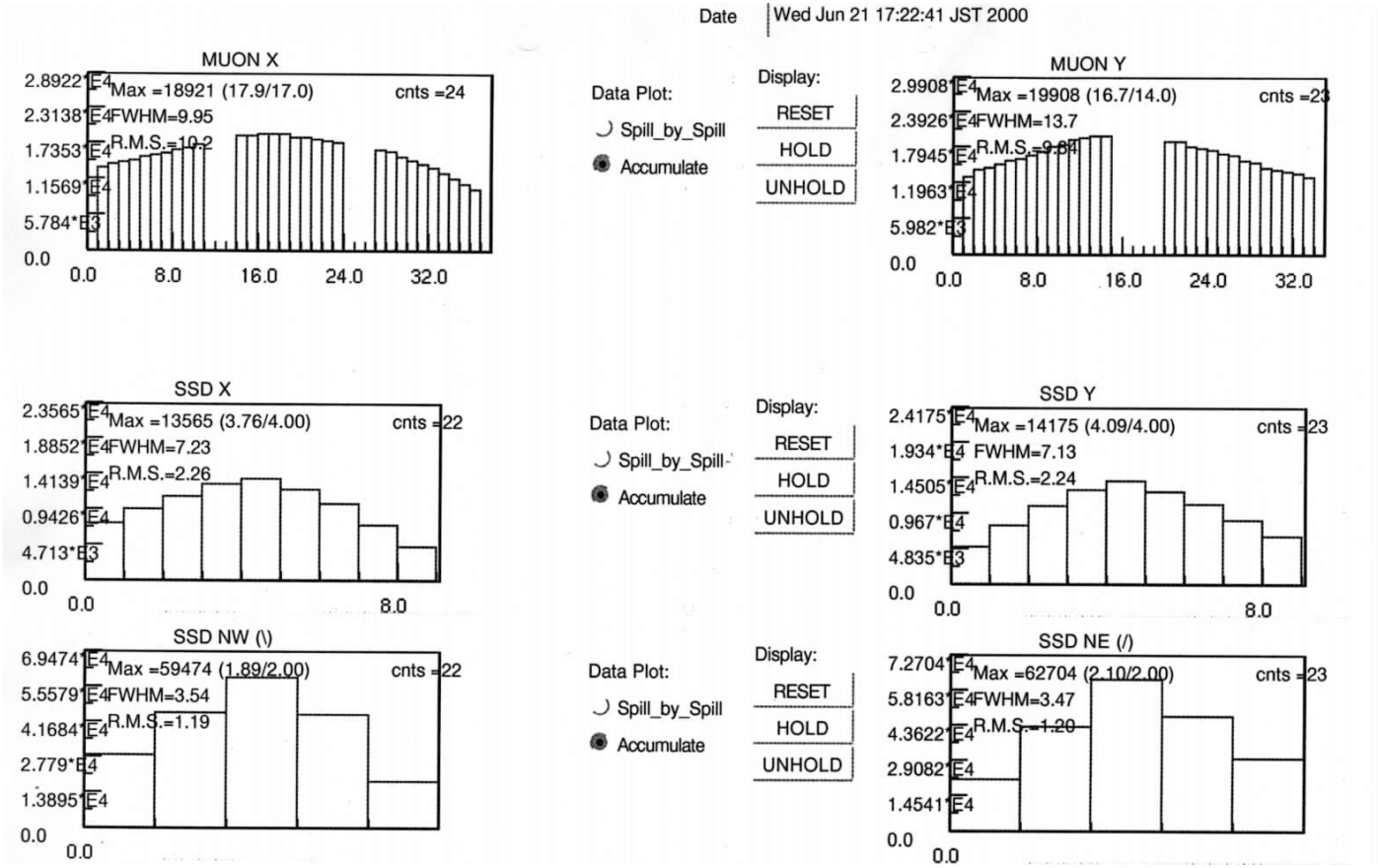


Decay Volume and Muon Monitor





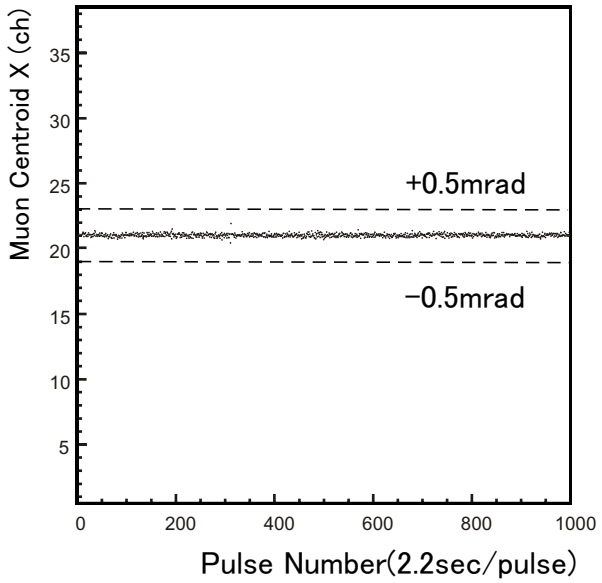
μ -beam profile measured by muon monitor (Segmented PPIC & SSD)

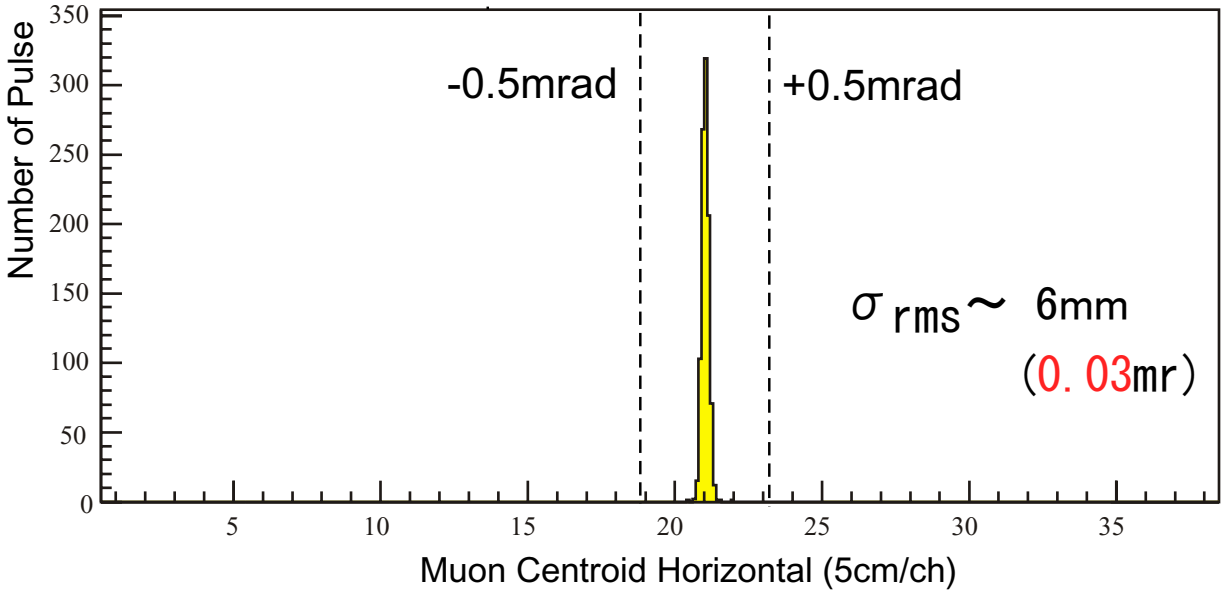


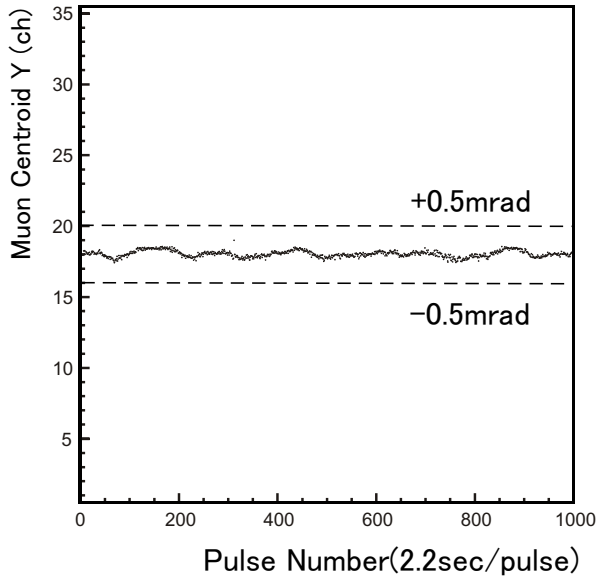
Measurement/Control Accuracy is <0.1 mr.

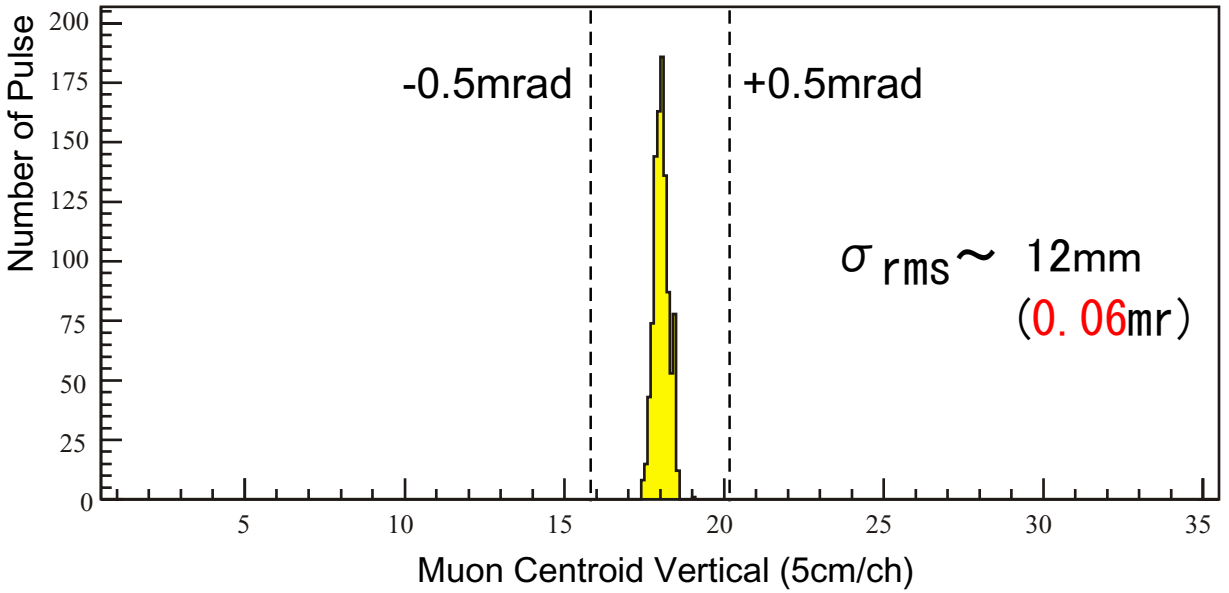
Requested Stability is $\pm$1mr.

Short Range Stability of Muon Centroid



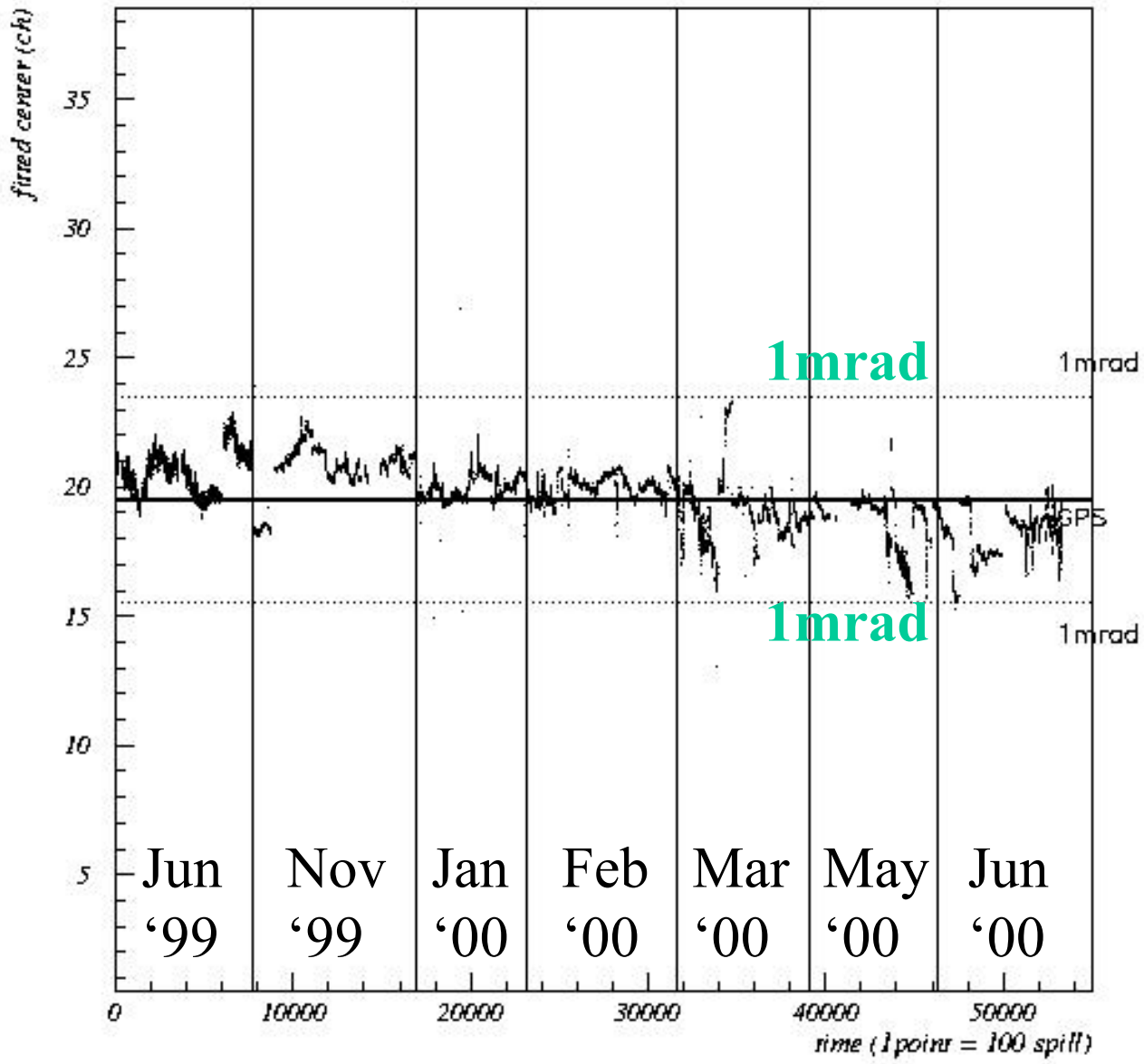




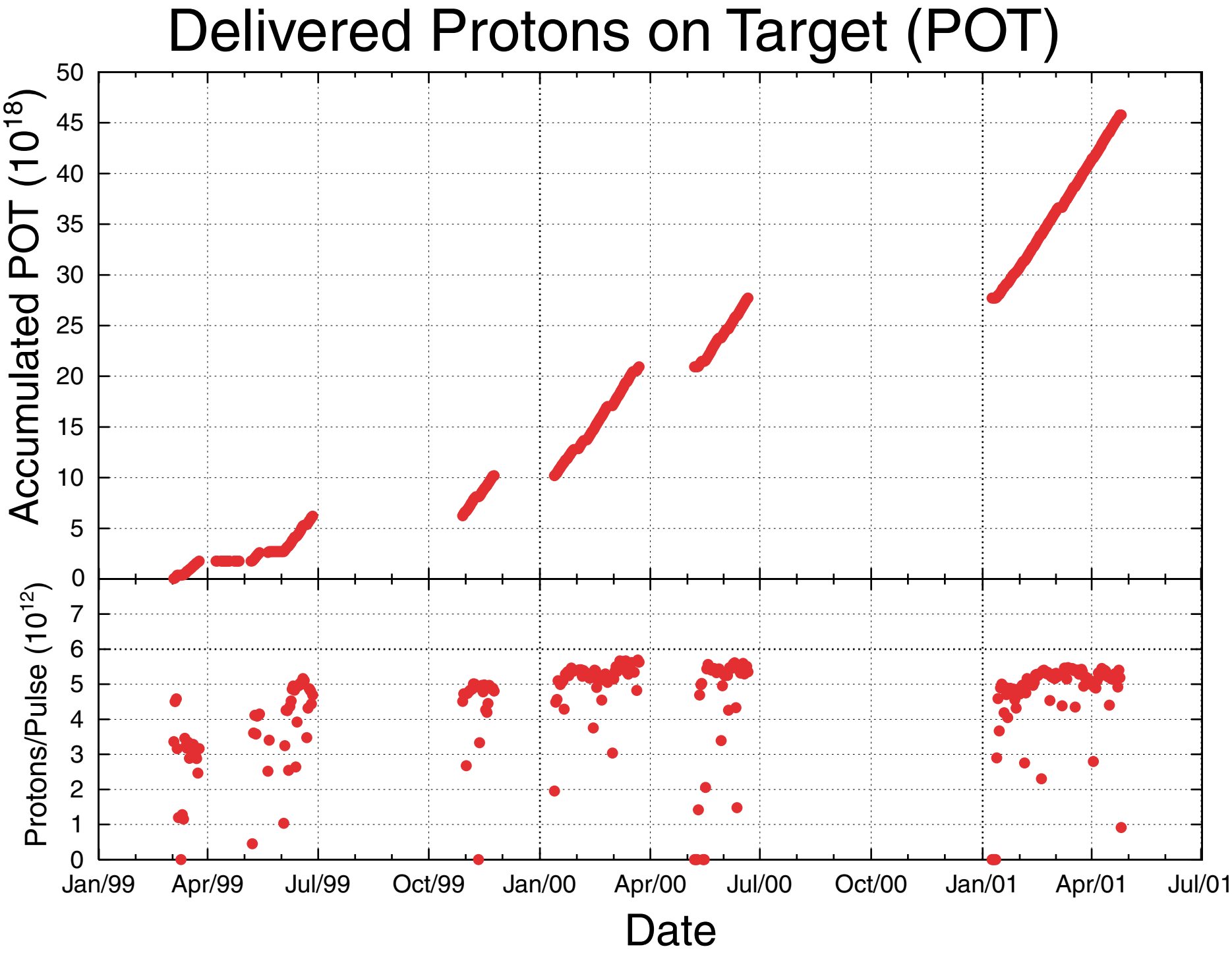


Stability of Muon Profile Center @ Muon Monitor

Fast (spill-by-spill) but indirect monitor

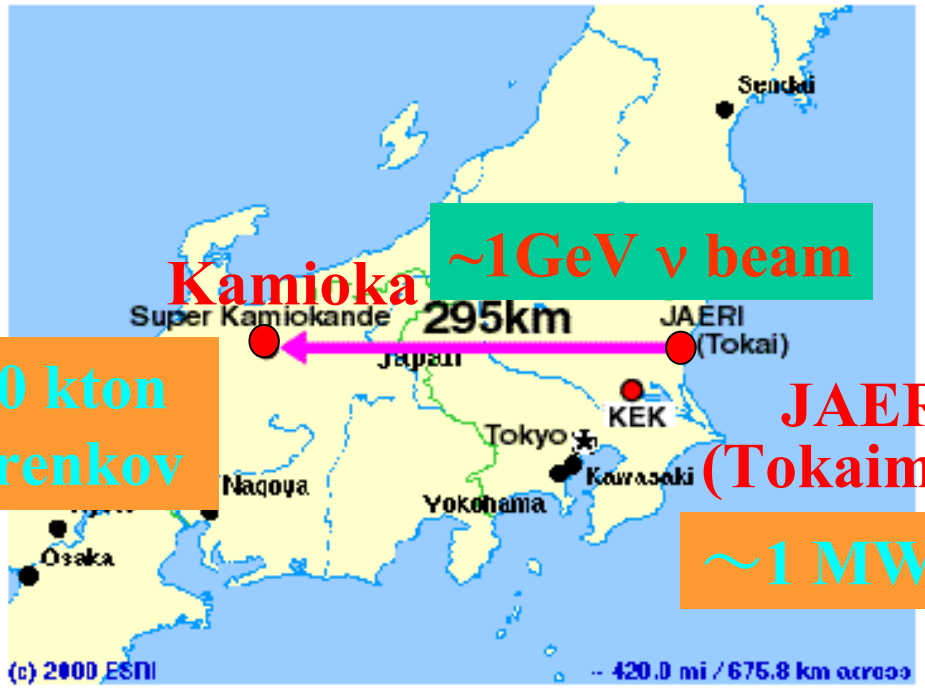


Stable within ±1mrad


Delivered Protons on Target (POT)
Accumulated POT (10^{18})
0
5
10
15
20
25
30
35
40
45
50
Protons/Pulse (10^{12})
0
1
2
3
4
5
6
7
Jan/99
Apr/99
Jul/99
Oct/99
Jan/00
Apr/00
Jul/00
Oct/00
Jan/01
Apr/01
Jul/01
Date

Neutrino Beam @ JHF

"Super" conventional low energy beam



Super-K: 50 kton
Water Cherenkov

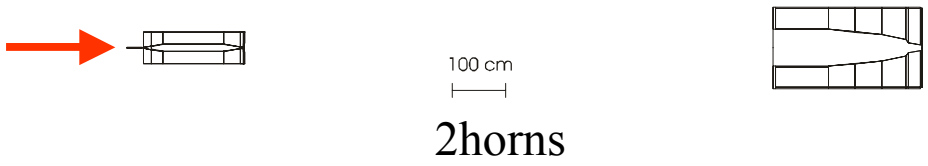
JAERI
(Tokaimura)

~1 MW 50 GeV PS

- $\Delta m^2 = 1.6 \sim 4 \times 10^{-3} eV^2$ from atm. ν at SK
- → $E_\nu \sim 1$GeV

Three Beams

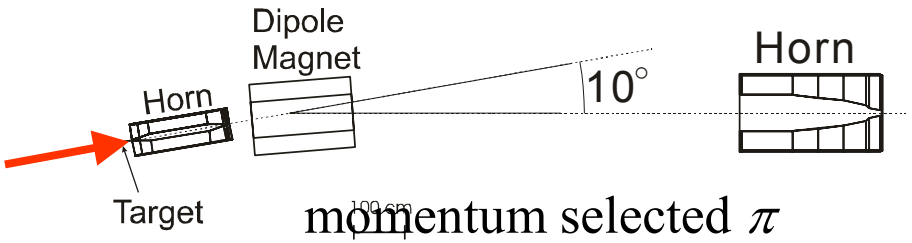
Wide Band Beam



2horns

- Intense
- Wide sensitivity in Δm^2
- BG from HE tail
- Syst. err from spectrum extrapolation

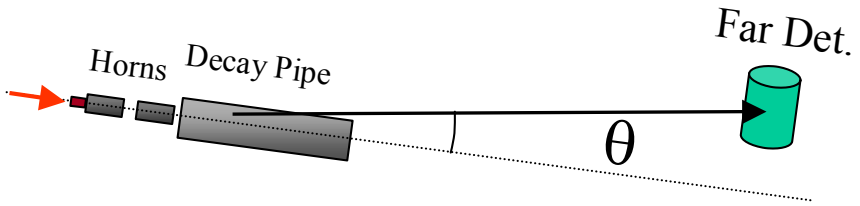
Narrow Band Beam



momentum selected π

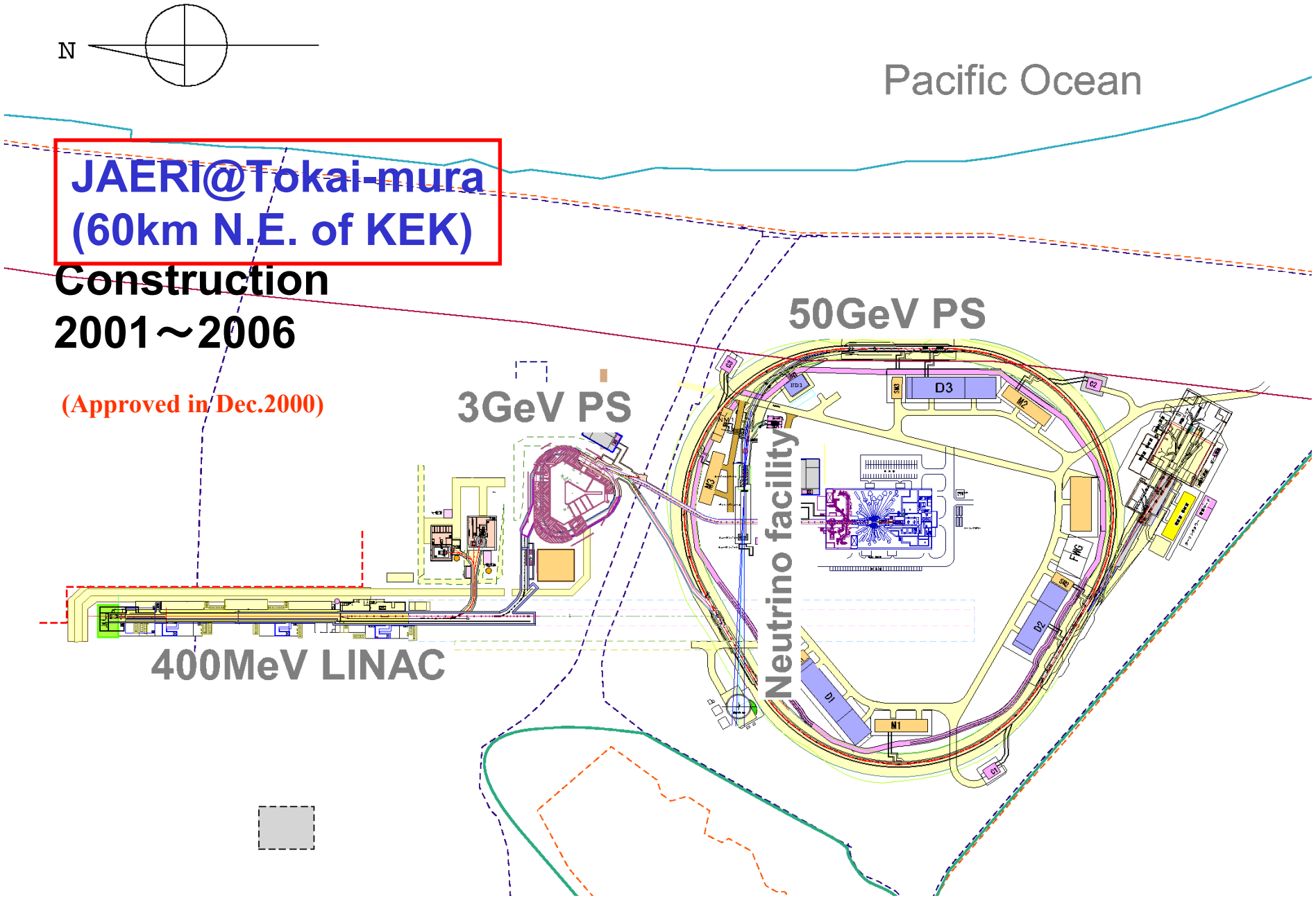
- Less HE tail
- Less sys err from spectrum
  "counting experiment"
- Easy to tune E_ν

Off Axis Beam



- High int. narrow band beam
- More HE tail than NBB
- Hard to tune E_ν

JHF


N
Pacific Ocean
JAERI@Tokai-mura
(60km N.E. of KEK)
Construction
2001～2006
(Approved in Dec.2000)
50GeV PS
3GeV PS
Neutrino facility
400MeV LINAC

50GeV PS & Extraction

- Intensity **3.3x10^{14} proton/pulse (ppp)**
- Repetition rate **0.292 Hz**
- Power **0.77 MW** (2.64 MJ/pulse)
- Single turn fast extraction (~**5.23μsec** spill)
- 8 bunches/spill (2 out of 10buckets empty)
- Kicked **4.9°** inside PS ring
- Straight matching section **43 m**
  (conventional magnets)

Arc & Final focus

Bend ~85° to SK direction

50GeV, 110 m curvature

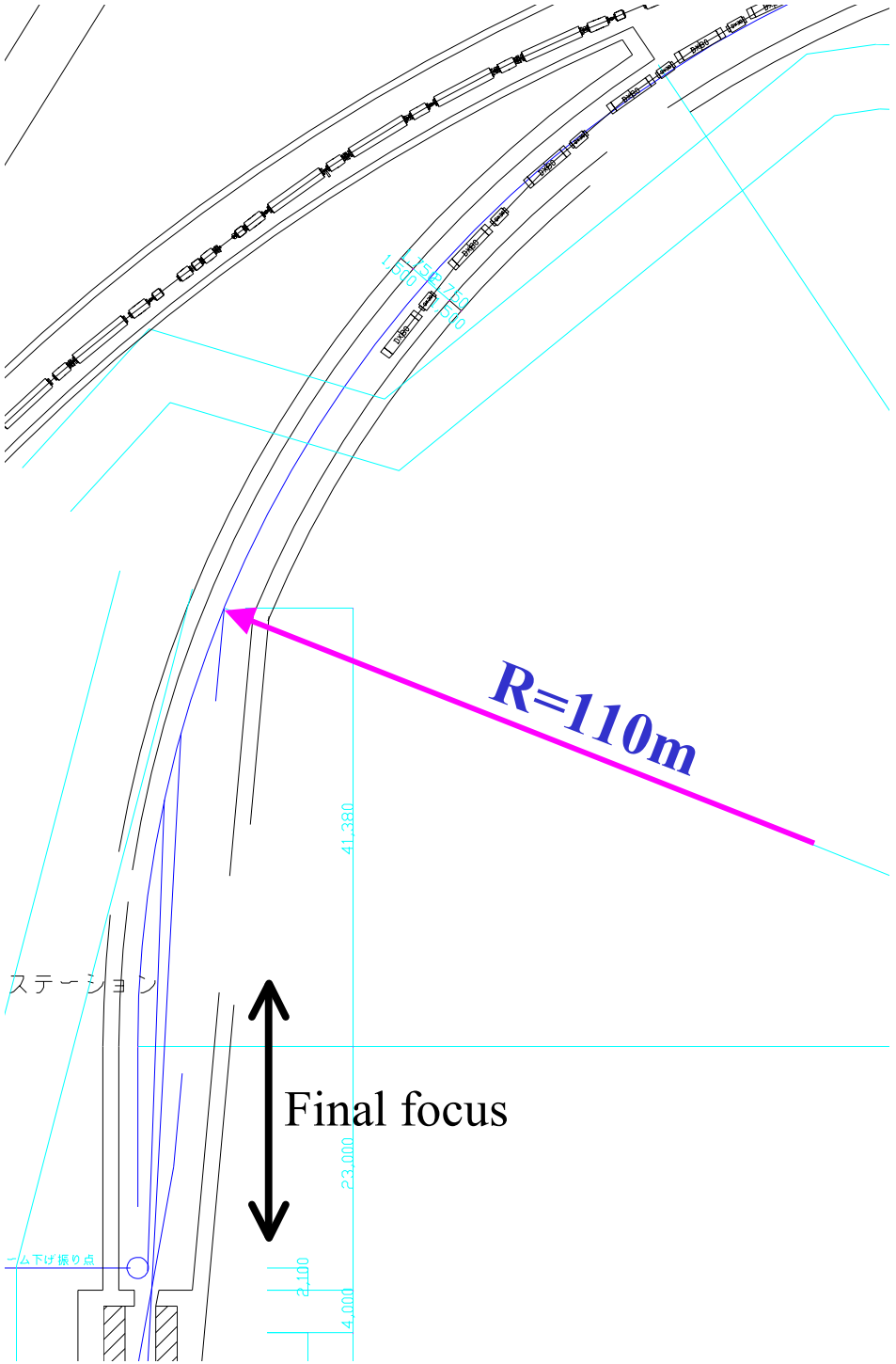
→Need super con. mag.

Typical magnet parameters

~4T, ~4m long(to be decided)

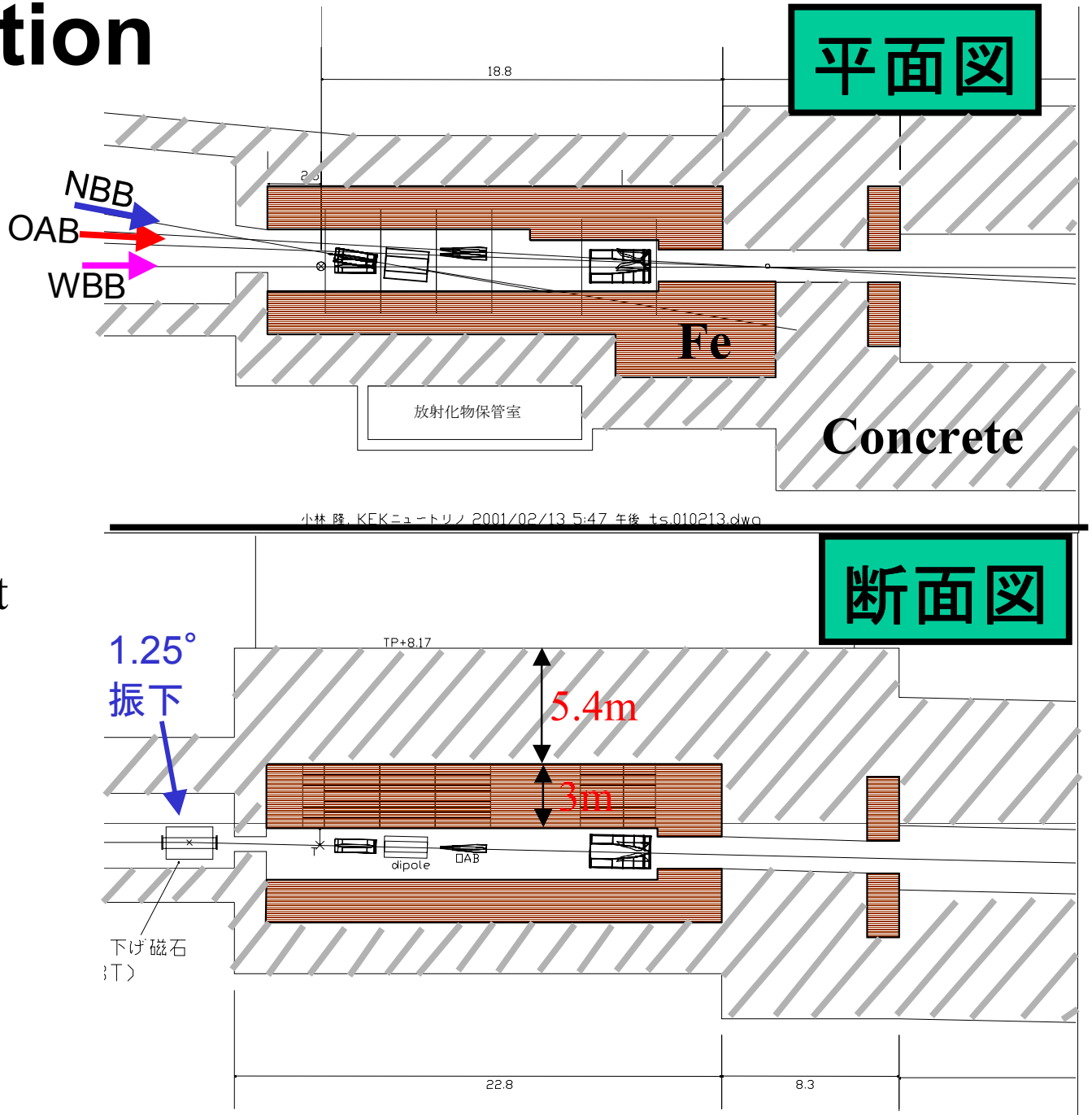
→need 15~20 dipole magnets

Proton directed 1.25° downward

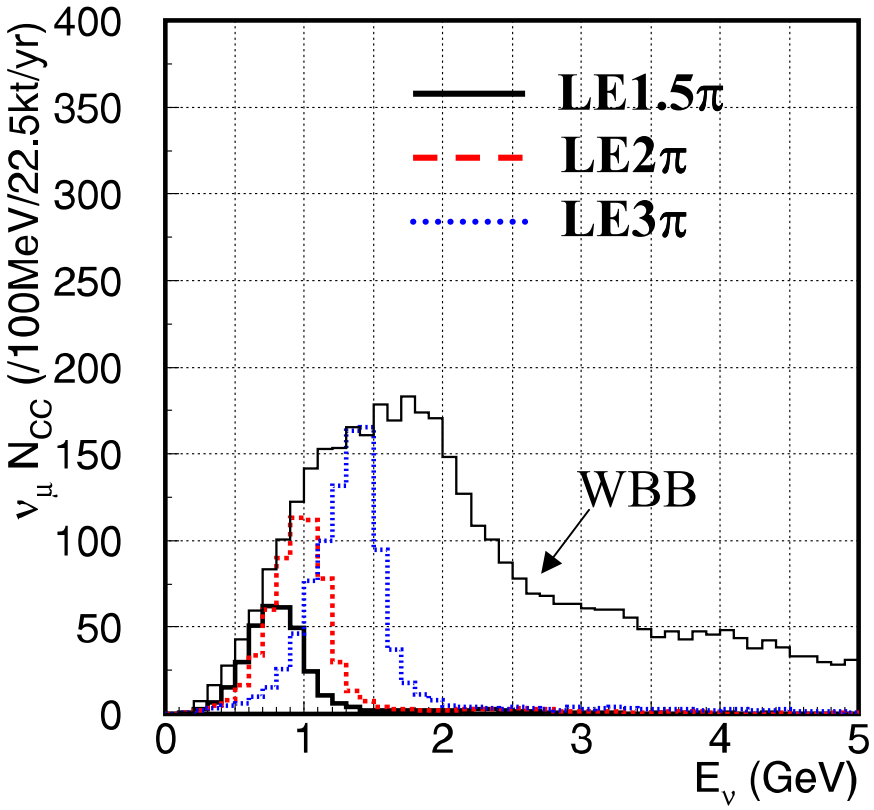


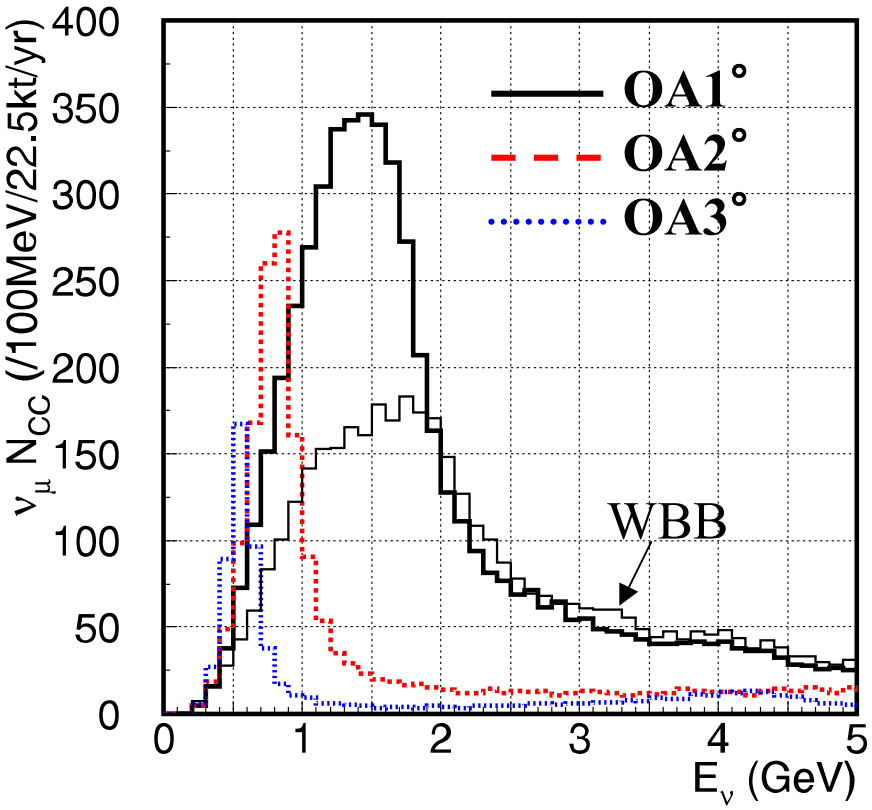
Target Station

- Accommodate 3 beam options
- No free space for maintenance
  (to reduce shield)
- Horn replacement from ceiling



of CC events of various beams





WBB:**5200** CC int./22.5kt/yr

NBB: **620** CC int./22.5kt/yr (2GeV/c π tune)

OAB: **2200** CC int./22.5kt/yr (2degree)

Summary

K2K neutrino beam

- **First** neutrino beam facility for long baseline neutrino experiment
- Proton beam transport >85% eff.
- Tandem horns with 250kA pulsed current operation
- Life time of horns is ~6 M excitations
- Beam direction

  GPS survey ±20μrad(H), ±50μrad(V) in KEK

  Beam control : ±30μrad(H), ±60μrad(V) (short term)

  <±1mrad for whole running period

  → Satisfy experimental requirement
- **~4.6x10^{19}POT** has been delivered since 1999.

JHF neutrino beam

- 3.3x10^{14}ppp, 0.77MW→~10^{21}POT/yr
- Technical design of facility going on
- Use super conducting magnets
- 3 beam configurations

  WBB **5200** ν_μCC int/22.5kt/yr

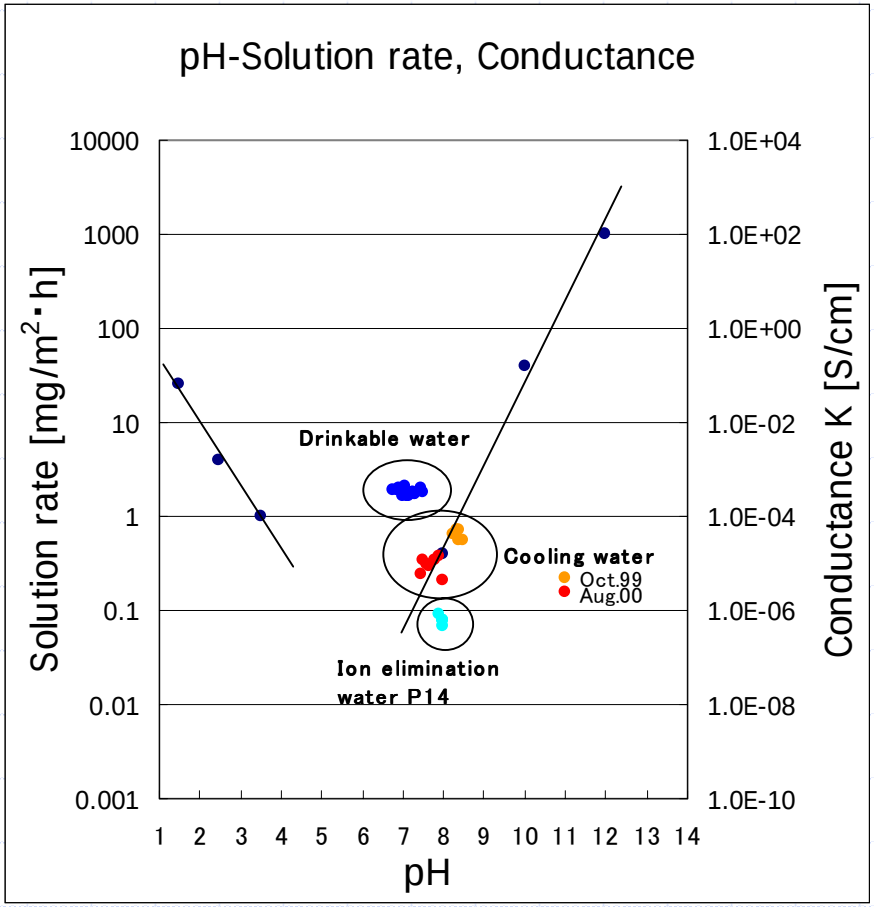
  NBB **620** ν_μCC int/22.5kt/yr

  OAB **2200** ν_μCC int/22.5kt/yr
- Tunable peak energy
- Aim to complete at the same time as acc.(2007)

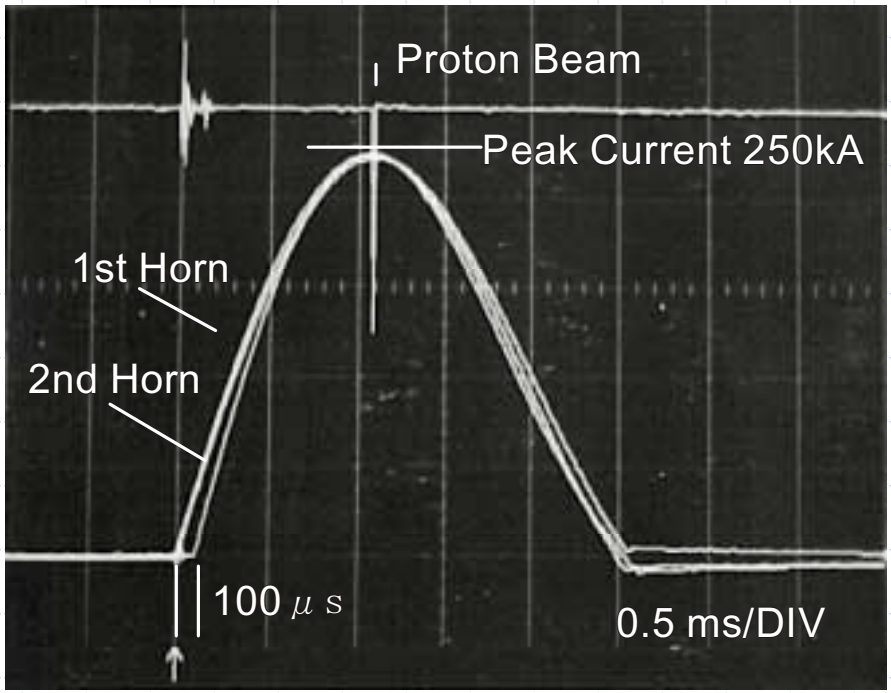
pH control & Corrosion

- pH7.4~8.5
- Floating ion: $[Al(H_2O)_2(OH)_4]^-$
- Conductance ≒10 μS/cm
- Solution rate≒0.4mg/cm^2・h
- Self healing

  Corrosion←→Alumite growth (~5 μm)
- Neutralize of cooling water every 2 weeks
- pH6~7 is a target condition



Incident proton beam and pulsed current



- The current of 2nd horn was delayed 100 μ s for synchronizing with the incident beam.