T2K experiment

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OUTLINE

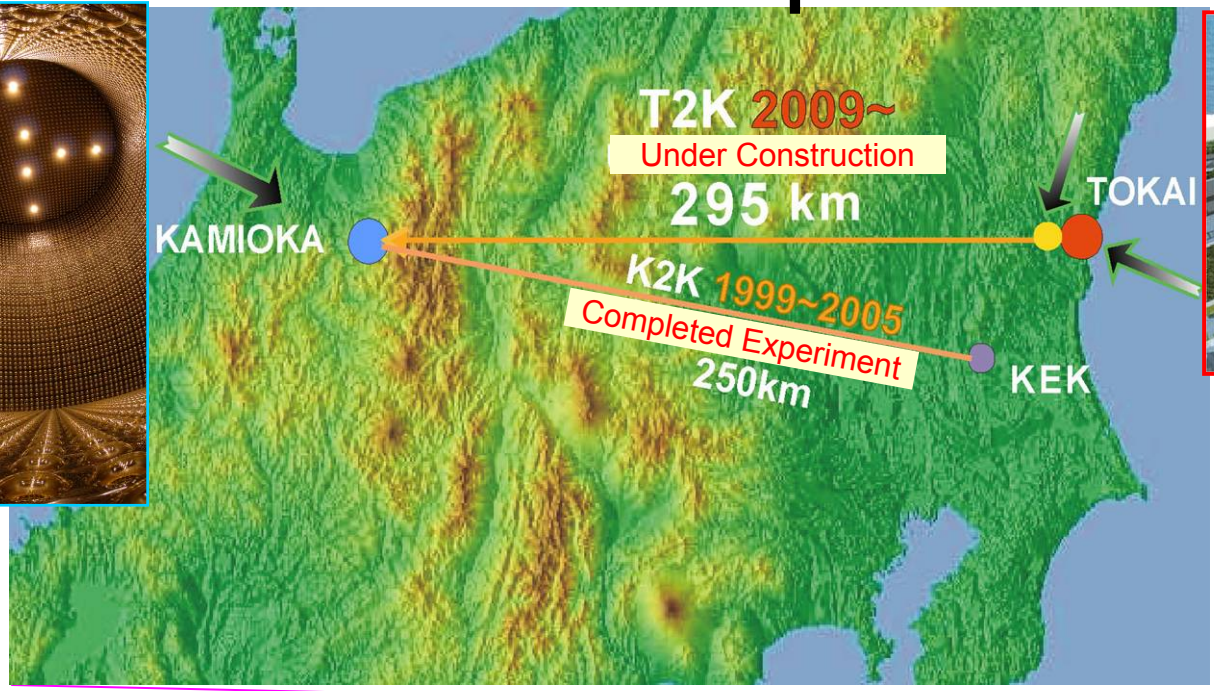
- Neutrino mass and mixings

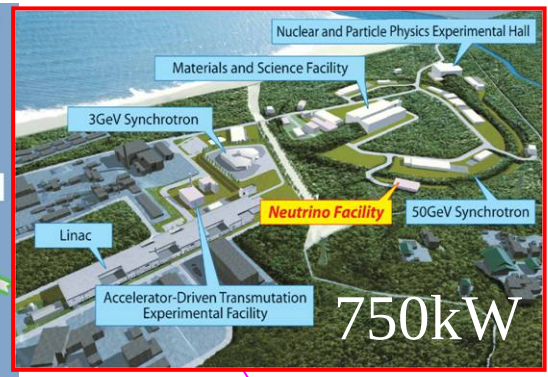
- T2K features and physics

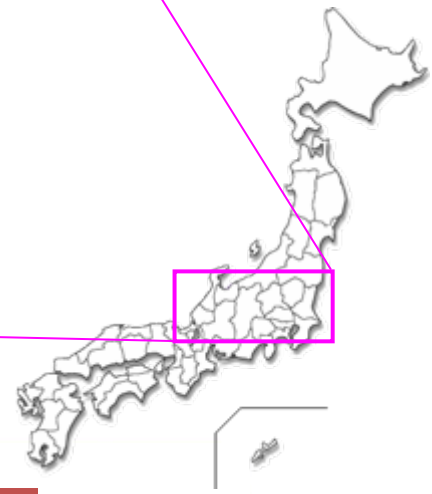
- Construction status
  accelerator
  beam line

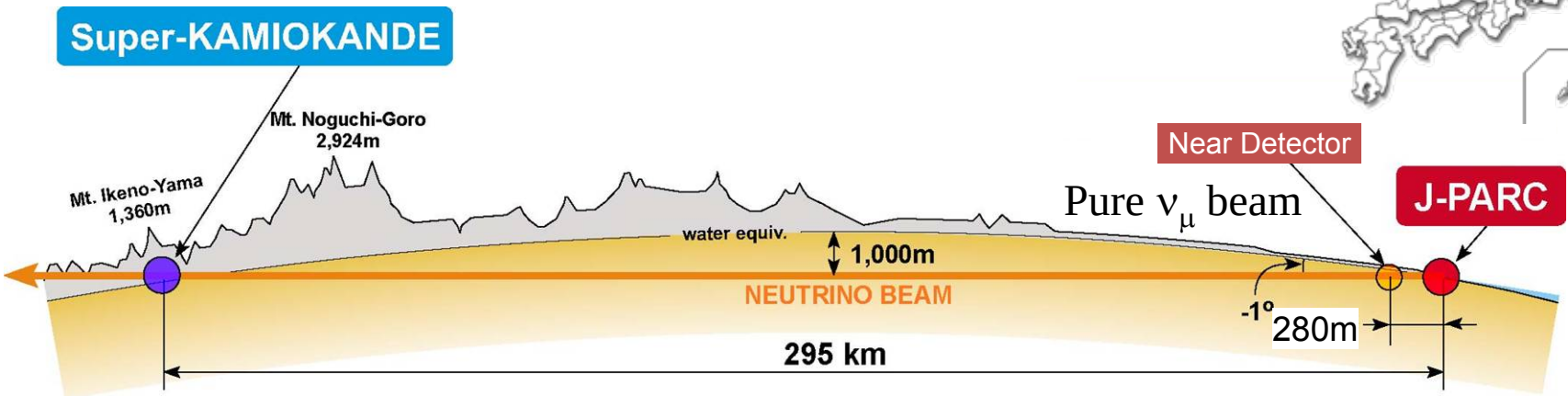
- T2K neutrino detectors

T2K (Tokai to Kamioka) LBL ν experiment









J-PARC

World Highest Intensity (~MW) proton accelerator facility @ JAEA. **Construction 2001~2008**

Materials and Life Science Experimental Facility

Hadron Experimental Facility

Neutrino to Kamioka

3 GeV Synchrotron (25 Hz, 1MW)

Main Ring (0.75 MW)

Linac (350m)

J-PARC = Japan Proton Accelerator Research Complex

T2K Collaboration

~350 members from 12 Countries

Japan, US, Canada, France, UK, Switzerland, Poland, Korea, Russia (INR), Spain, Italy, Germany

3 flavor mixing

$$|\nu_l\rangle = \Sigma U_{li} |\nu_i\rangle$$

Weak — Mass eigenstates

m_i: 3 masses,

$\Delta m_{ij}^2 = m_i^2 - m_j^2$: 2 differences

Maki-Nakagawa-Sakata Matrix $s_{ij}=\sin\theta_{ij}$, $c_{ij}=\cos\theta_{ij}$

$$U = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu 1} & U_{\mu 2} & U_{\mu 3} \\ U_{\tau 1} & U_{\tau 2} & U_{\tau 3} \end{pmatrix}$$

3 mixing angles and 1 CPV phase

Unknown 2 parameters

$$= \begin{pmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & e^{-i\delta} \end{pmatrix} \cdot \begin{pmatrix} c_{13} & 0 & s_{13} \\ 0 & 1 & 0 \\ -s_{13} & 0 & c_{13} \end{pmatrix}$$

$\sin^2 2\theta_{12} \sim 0.8$ (Solar LBL reactor)

$\sin^2 2\theta_{23} \sim 1$ (Atm ν)

Reactor

LBL acc. experiments

Neutrino oscillation

- Flavor change during flight
  - Only when flavor mixing/finite&different m_i
- Unique & powerful way to probe ν flavor mixing and small masses

- Oscillation Probability (2 flavor) $U = \begin{pmatrix} \cos\theta_{23} & \sin\theta_{23} \\ -\sin\theta_{23} & \cos\theta_{23} \end{pmatrix}$

$$P(\nu_\mu \to \nu_\tau) = \left|\langle \nu_\tau(t) | \nu_\mu(0) \rangle\right|^2 = \sin^2 2\theta_{23} \sin^2\left(1.27 \frac{L}{E} \Delta m^2_{23}\right)$$

***L* (km), *E* (GeV)**

$$\Delta m^2_{23} = m^2_2 - m^2_3$$

Current status of neutrino mass and mixings

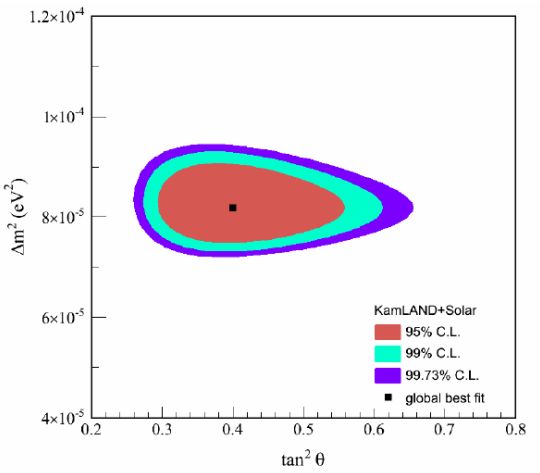
3 mixing angles (θ_{12}, θ_{23}, θ_{13})
1 CPV phase (δ)
2 (independent) mass differences ($\Delta m_{ij}^2 = m_i^2 - m_j^2$)

θ_{12}, Δm_{12}^2

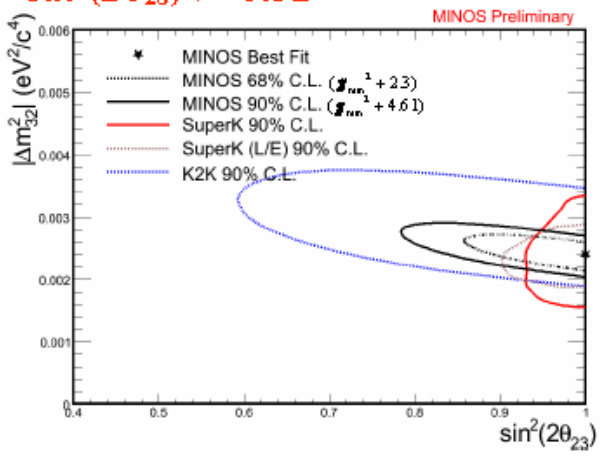
θ_{23}, Δm_{32}^2

θ_{13}, Δm_{31}^2

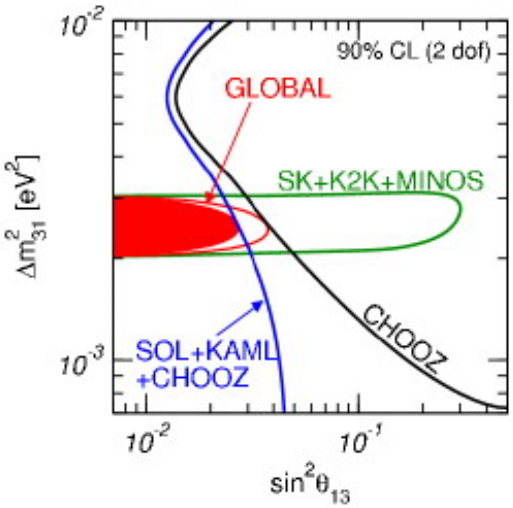
$\Delta m^2_{solar} = 8 \times 10^{-5}$ eV^2
$\sin^2(2\theta_{12}) = 0.86$



$\Delta m^2_{atm} = (2.2\sim2.6) \times 10^{-3}$ eV^2
$\sin^2(2\theta_{23}) > 0.92$



$\theta_{13} \leq 10^0$

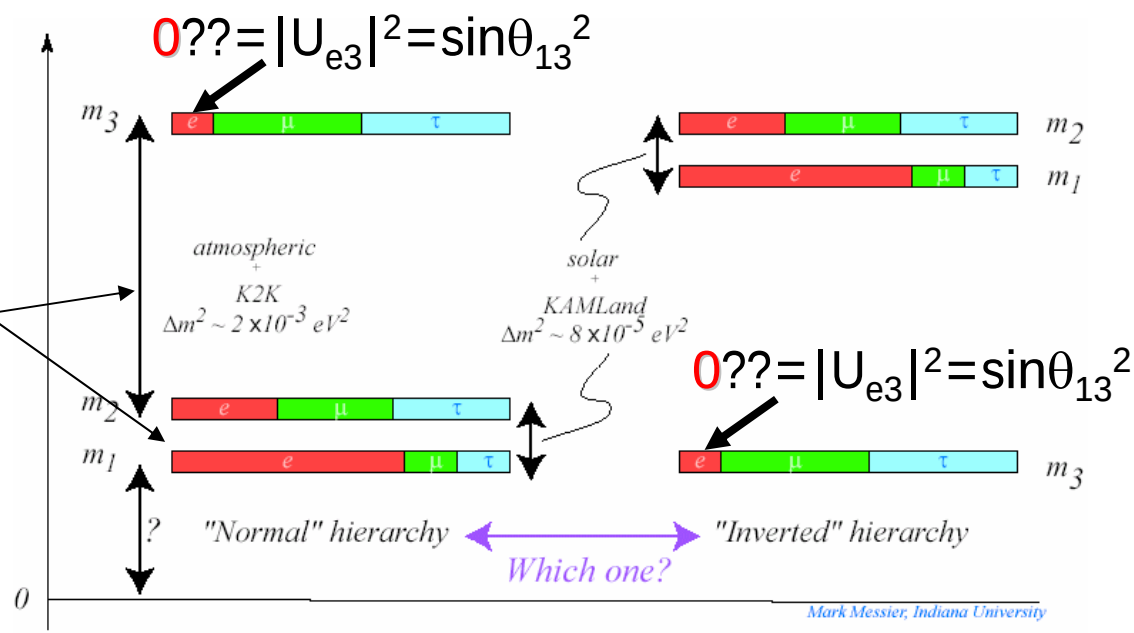


Solar + KamLAND

Only upper limit on θ_{13}
No info. on δ

Present knowledge and What's next?

θ_{12}~33° Δm_{12}^2~0.00008eV^2
θ_{23}~45° Δm_{23}^2~0.0025eV^2
θ_{13}<10° ($\Delta m_{13}^2 \sim \Delta m_{23}^2$)?
δ ???



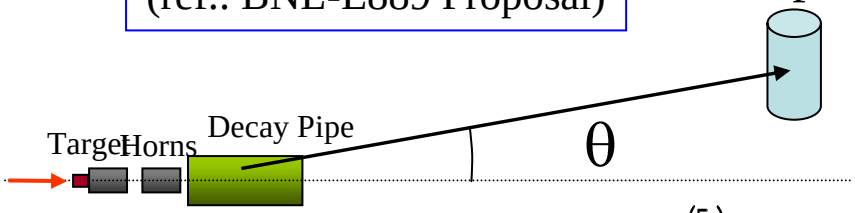
- Only unknown mixing θ_{13} (and really $\Delta m_{13}^2 \sim \Delta m_{23}^2$?)
- Mass hierarchy (sign of Δm^2)
- CP violation
- Approaches
  - LBL experiment: Multi purpose (θ_{13}, sign(Δm^2), CPV, θ_{23}, Δm_{23}^2)
  - Reactor-based ν_e disappearance: single purpose (θ_{13}), complementary

Goals of T2K experiment

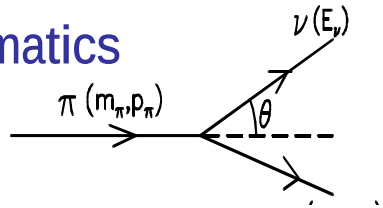
- Establish framework of 3 flavor mixing (or find something else)
  - Discovery of ν_e appearance ($\theta_{13}>0$?)
    - At the same Δm^2 as ν_μ disapp. →Firm evidence of 3gen. mix.
    - Open possibility to search for CPV ($\theta_{any}=0$ → No observable CPV in ν osc)
  - Precision measurements of osc. params.
    - Really $\sin^2 2\theta_{23}=1$?? (disappearance)
    - Test exotic models (decay, extra dimensions,….)
  - Confirmation of $\nu_\mu \rightarrow \nu_\tau$
    - NC measurement
- Search for CPV in lepton sector
  - Give hint on Matter/Anti-matter asymmetry in the universe

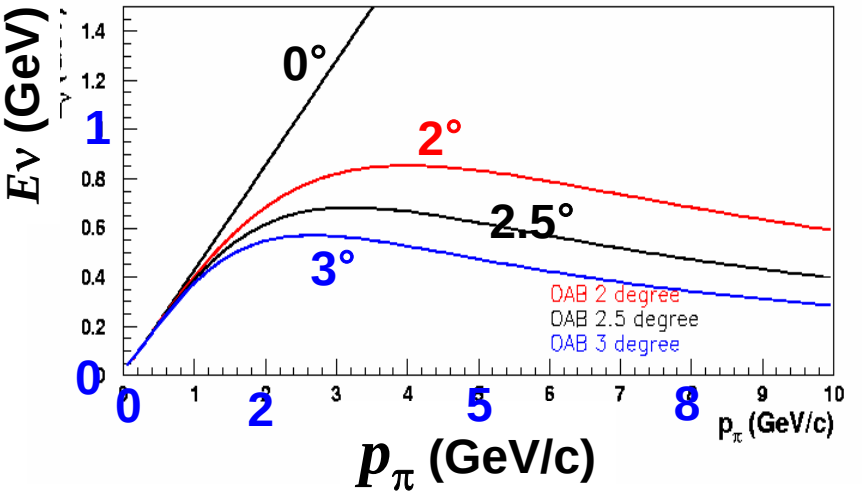
Narrow intense beam: Off-axis beam

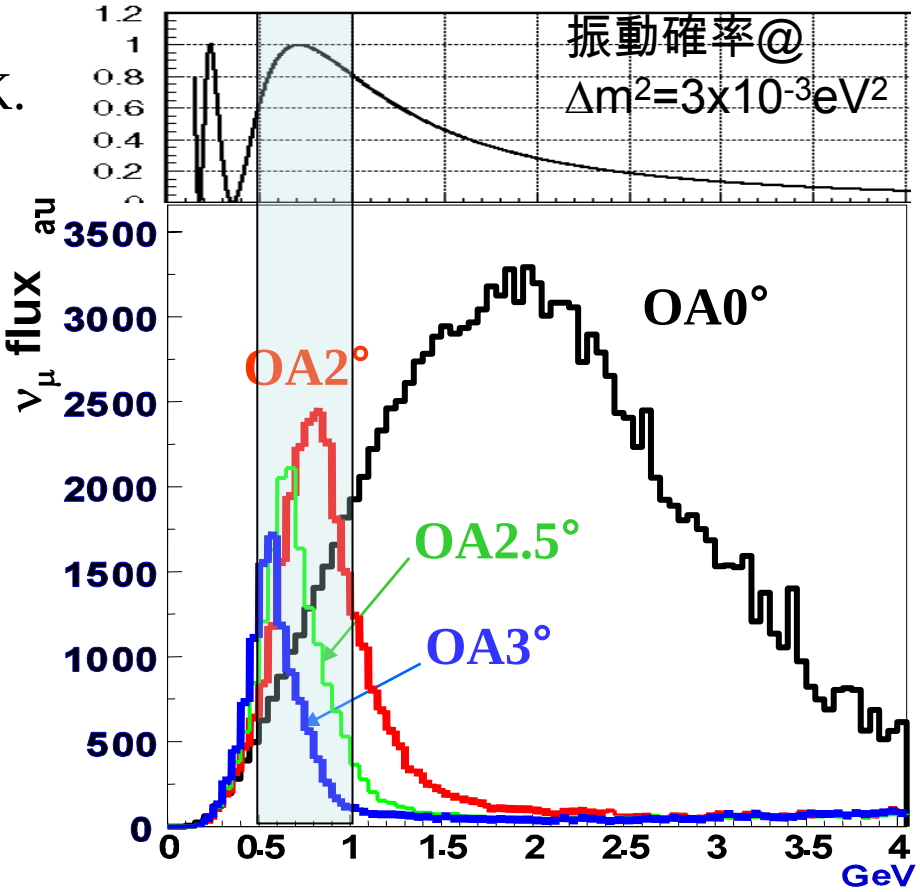
First Application
(ref.: BNL-E889 Proposal)



π decay Kinematics







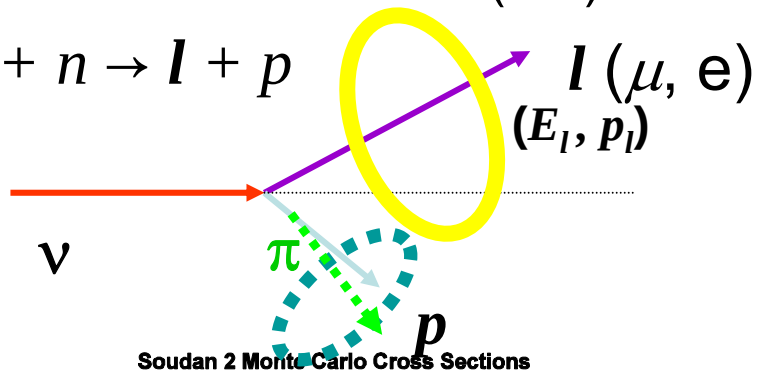
- Quasi Monochromatic Beam
- x 2~3 intense than NBB
- Tuned at oscillation maximum

Statistics at SK
(OAB 2.5 deg, 1 yr, 22.5 kt)
~ 2200 ν_μ tot
~ 1600 ν_μ CC
ν_e ~0.4% at ν_μ peak

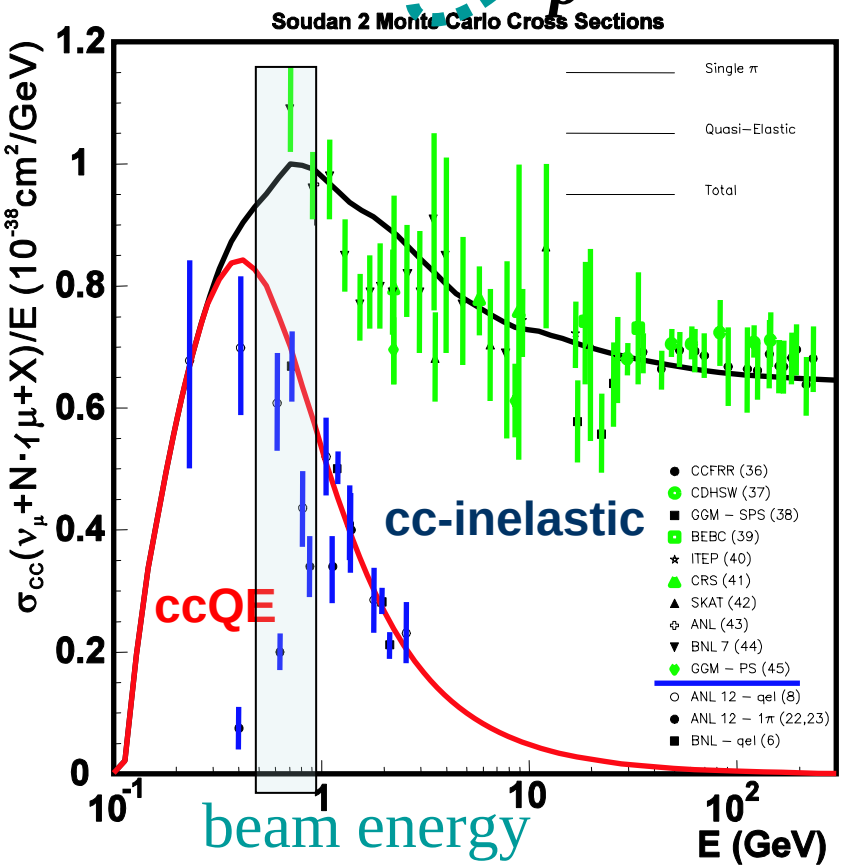
Eν reconstruction in water Cherenkov

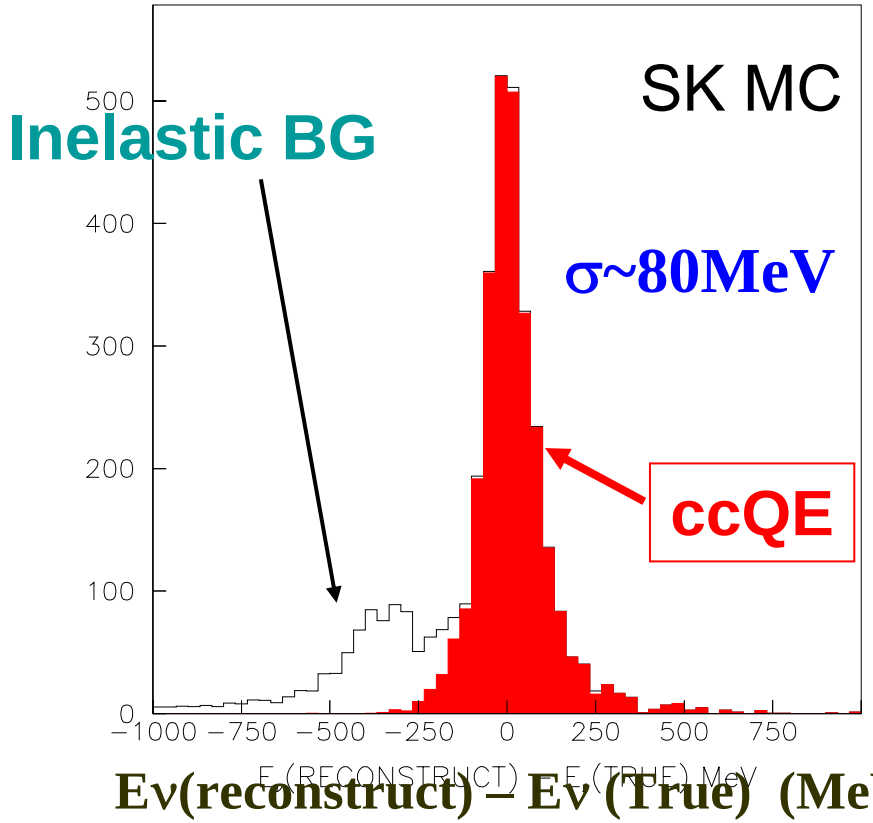
Assume CC Quasi Elastic (QE) reaction

$$\nu_\mu + n \rightarrow l + p$$



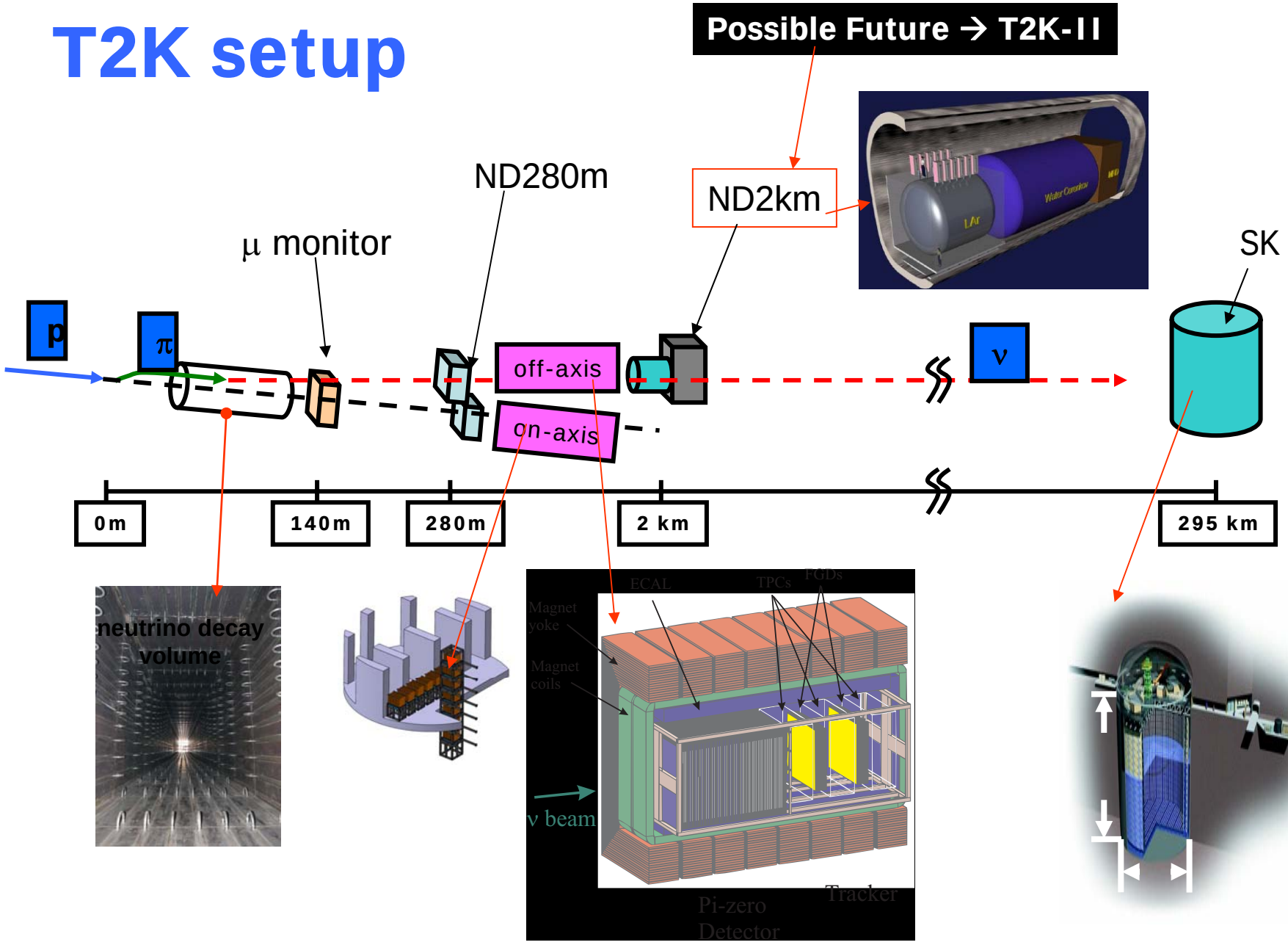
$$E_\nu = \frac{m_N E_\mu - m_\mu^2/2}{m_N - E_\mu + p_\mu \cos\theta_\mu}$$





Eν(reconstruct) – Eν (True) (MeV)

T2K setup

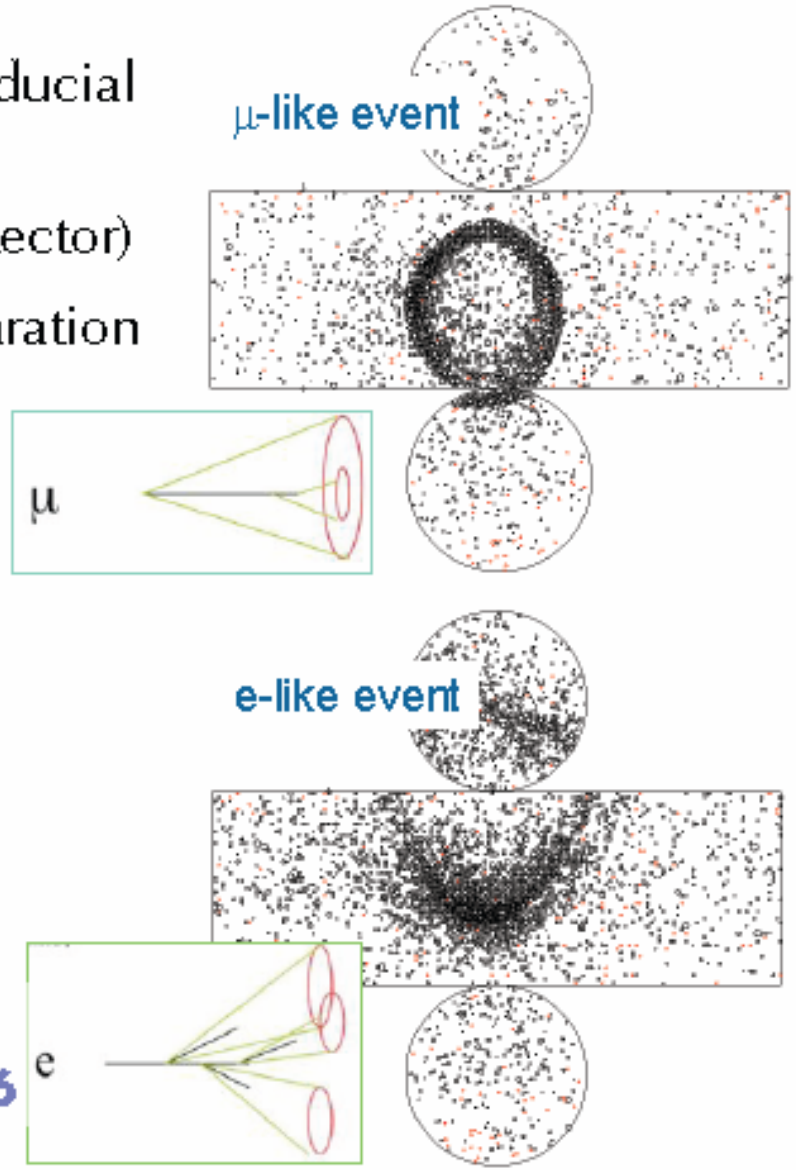

Possible Future → T2K-II
ND2km
ND280m
μ monitor
SK
p
π
off-axis
on-axis
ν
0m
140m
280m
2 km
295 km
neutrino decay volume
ECAL
TPCs
FGDs
Magnet yoke
Magnet coils
ν beam
Tracker
Pi-zero Detector

Remarkable Features of T2K

- Neutrino energy reconstruction by using **Quasi-elastic** (QE) interaction.
  - Oscillation pattern measurement
  - BG due to miss-reconstruction of inelastic interaction
    - Greatly improved by using narrow spectrum
- **Narrow spectrum tuned at the oscillation maximum**.
  - High sensitivity $\Delta m^2 = 1.6 \sim 4 \times 10^{-3}\,\mathrm{eV}^2$
  - Less background $E_\nu = 0.4 \sim 1\,\mathrm{GeV}$
- **Gigantic water Cherenkov detector**
  - High statistics
  - High efficiency for low energy
  - Good PID (e/μ) capability

Super Kamiokande (far detector)

- 50 kton water Cherenkov detector (fiducial volume: 22.5 kton)
  - ~11000 x 20 inch PMTs (inner detector)
- good e-like(shower ring) / μ-like separation
- $\delta E_{scale} \sim 2\%$



(Possible) strategy of F/N extrapolation & NA61

- Spectrum at far site is different from near site even w/o oscillation
  - Effect of non-point-like source
- T2K analysis

Exp'ed flux at SK

$$\Phi_{SK}^{\exp} = R_{F/N} \cdot \Phi_{ND}^{obs}$$

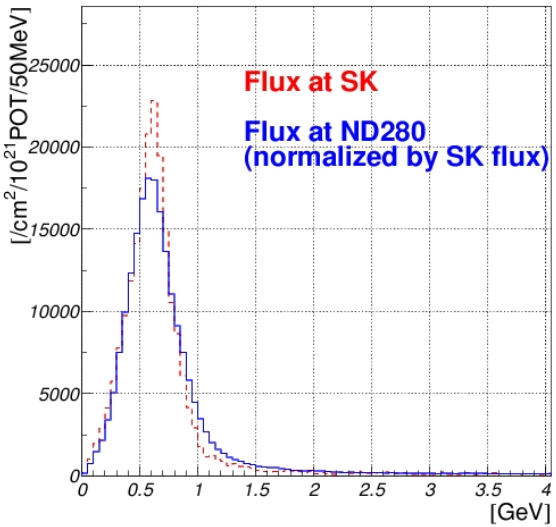
σ, ε ⇒ SK exp'ed obs.

Osc? ⇔ SK observation

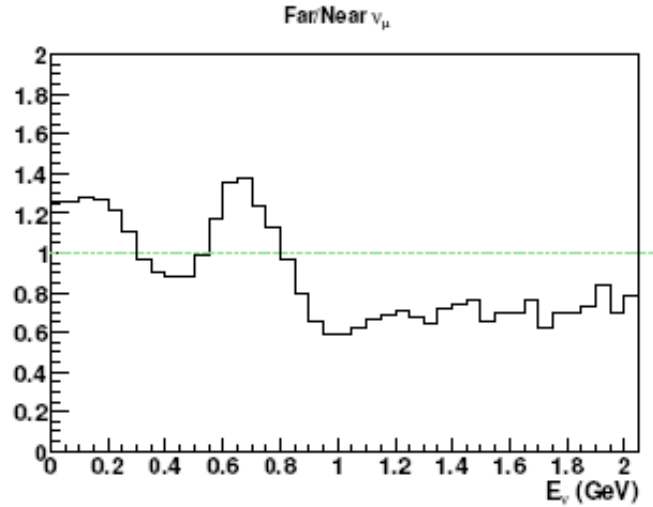
Far/Near ratio

$$R_{F/N} = \Phi_{SK} / \Phi_{ND}$$

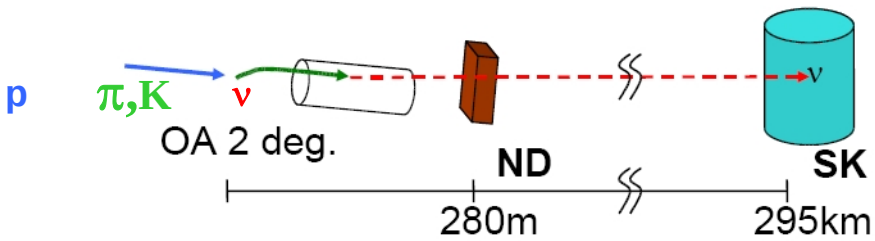
Determined by Hadron prod. (&geometry)



Far/Near ratio



no measurement of particle production off carbon with 30 (40,50) GeV protons ➔ NA61

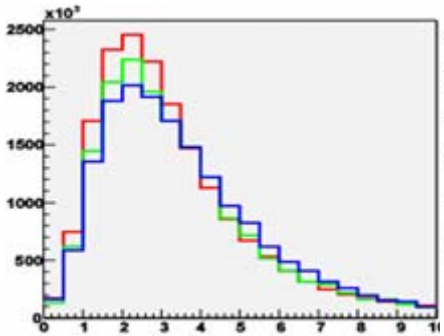


Expected syst. uncertainties w/o NA61

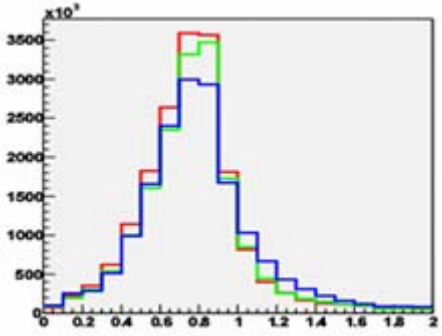
It is difficult to evaluate the validity of the hadron production model !!

→ The uncertainty is probably not less than the difference among several models inspired by similar data sets

G-FLUKA vs. MARS vs. FLUKA



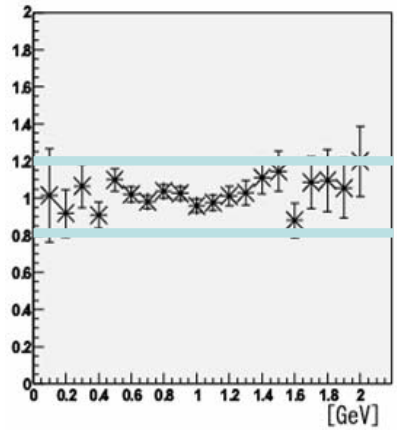
π^+ momentum [GeV]



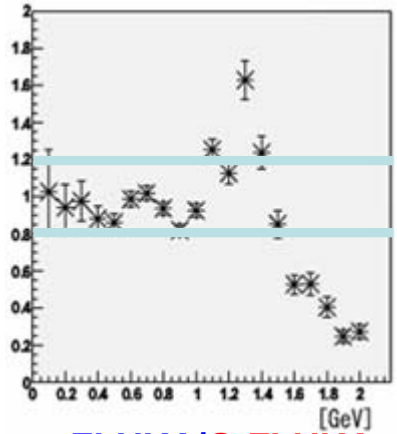
$E\nu_\mu$ flux [GeV]

Ratios of F/N ratios

up to ~20% difference!



MARS/G-FLUKA



FLUKA/G-FLUKA

F/N ratio difference among hadron production models:

~ 20% @$E\nu \leq 1$GeV

Syst. error due to F/N

ν_e *appearance*

$\delta(N_{bg}) \sim 15\%$

ν_μ *disappearance*

$\delta(\sin^2 2\theta_{23}) \sim \pm 0.015$ -0.03,

$\delta(\Delta m_{23}^2) <\sim \pm$ 5-10 10^{-5}eV^2

>>

Goal of T2K

ν_e *appearance*

$\delta(N_{bg}) \leq 10\%$

ν_μ *disappearance*

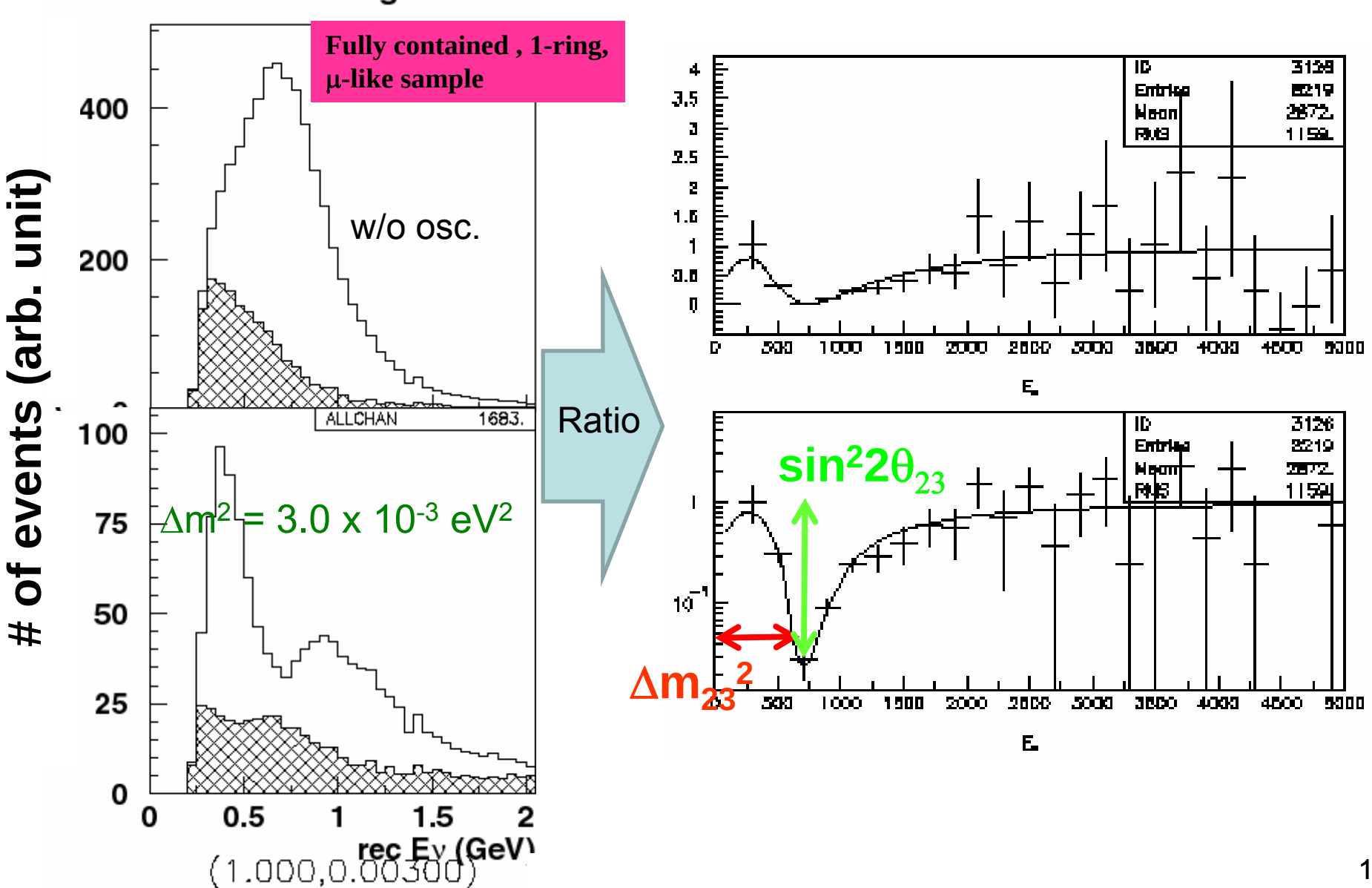
$\delta(\sin^2 2\theta_{23}) \sim \pm 0.01$,

$\delta(\Delta m_{23}^2) <\sim \pm 3\ 10^{-5}$eV^2

Impossible to achieve T2K GOAL!

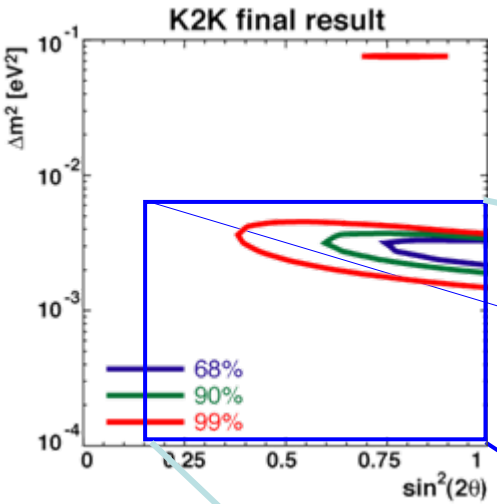
Measurement of $\sin^2 2\theta_{23}$, Δm^2_{23}

ν_μ disappearance

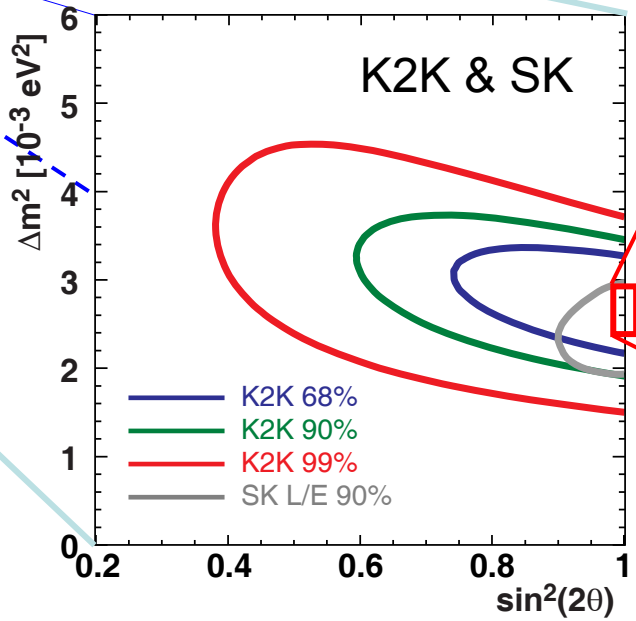


ν_μ disappearance

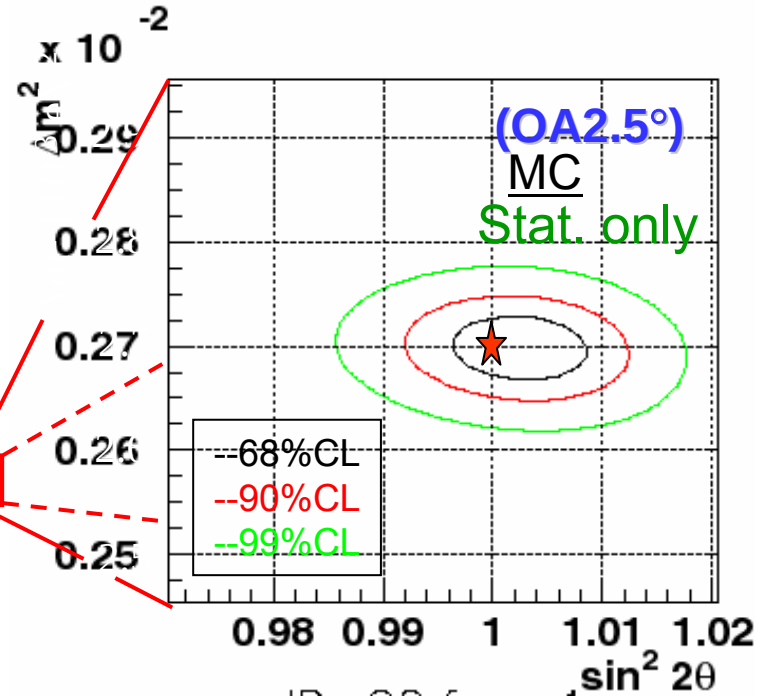
Goal : $\delta(\sin^2 2\theta_{23}) \sim 0.01$, $\delta(\Delta m^2_{23}) < 1\times10^{-4}$ [eV^2]



Statistics ×**100**



T2K 5×10^{21} POT (Stat. only)
~ 5years @ full Intensity



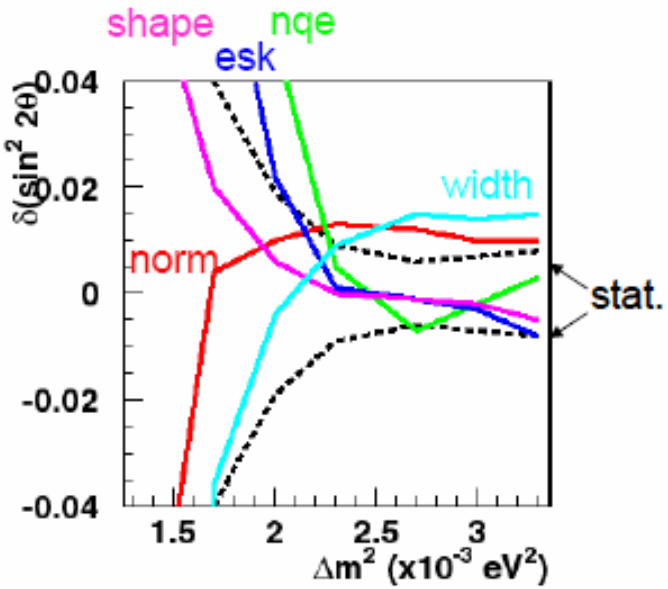
Precision measurement of θ_{23} , Δm^2_{23} possible systematic errors and phase-1 stat.

- Systematic errors
  - **normalization (10% (→5%(K2K))**
  - **non-qe/qe ratio (20% (to be measured))**
  - **E scale (4% (K2K 2%))**
  - **Spectrum shape (Fluka/MARS →(Near D.))**
  - **Spectrum width (10%)**

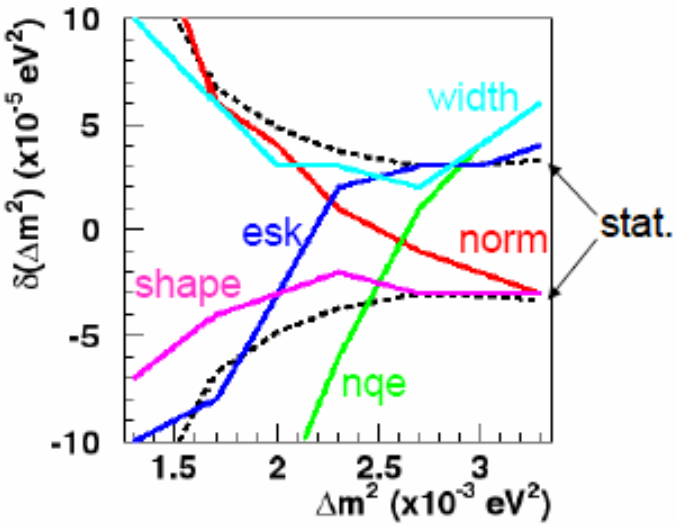
Goal

$\delta(\sin^2 2\theta_{23}) \sim 0.01$
$\delta(\Delta m^2_{23}) < 1\times10^{-4}\ eV^2$

$\delta(\sin^2 2\theta)$

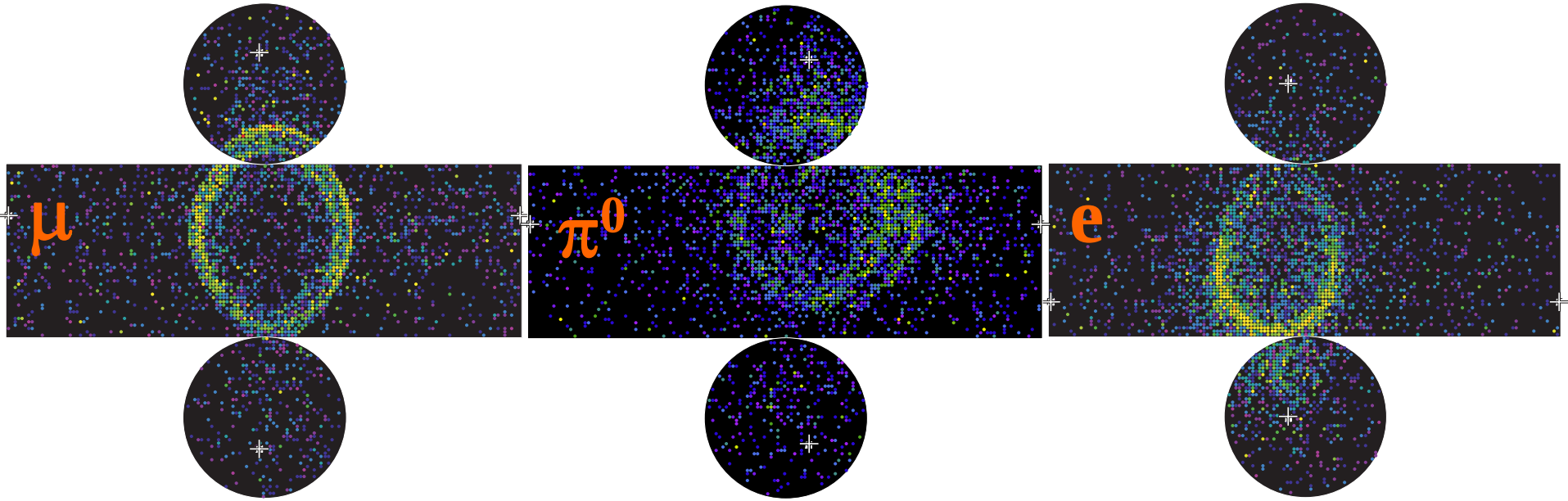


$\delta(\Delta m^2)$



OA2.5°

ν_e appearance in "T2K"



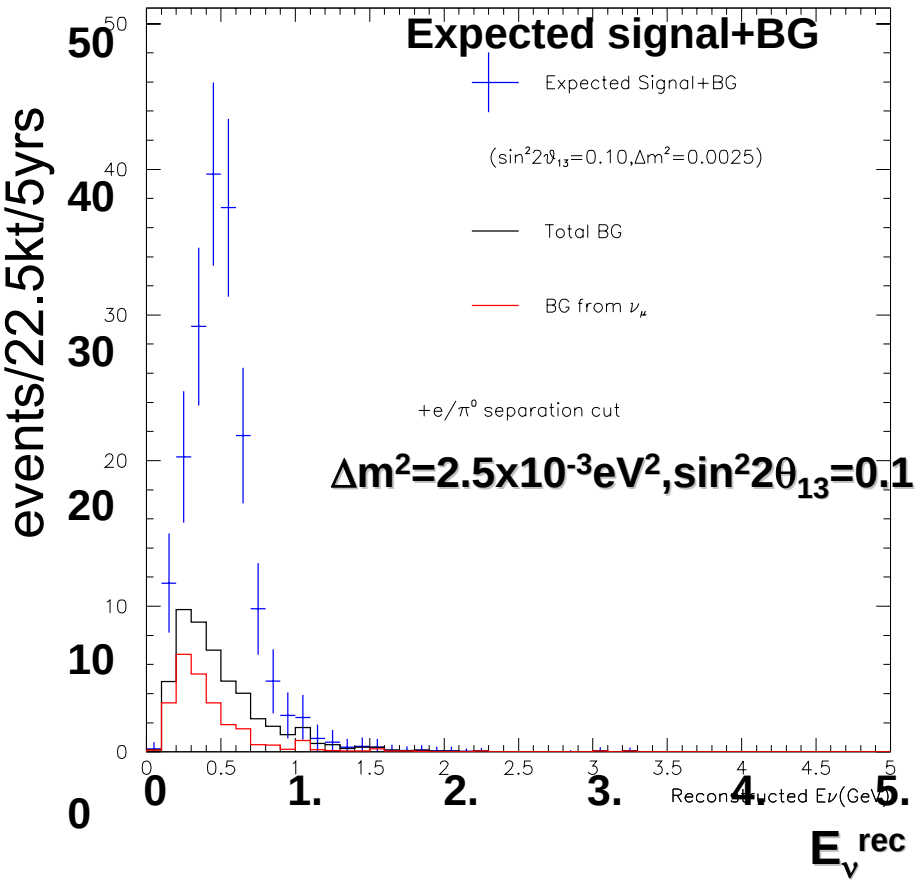
Back ground for ν_e appearance search

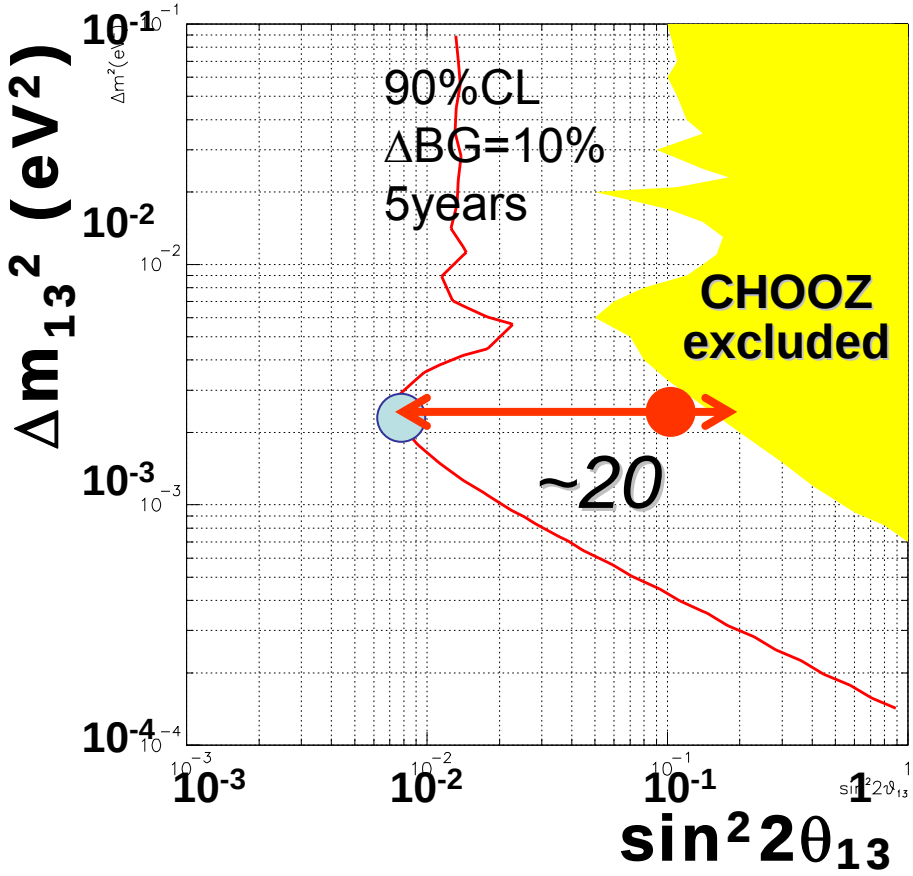
- Intrinsic ν_e component in initial beam
- Merged π^0 ring from ν_μ interactions

Requirement ⇨ 10% uncertainty for BG estimation

The K2K 1kt π^0 data will be studied for exercise

Sensitivity for the ν_e appearance

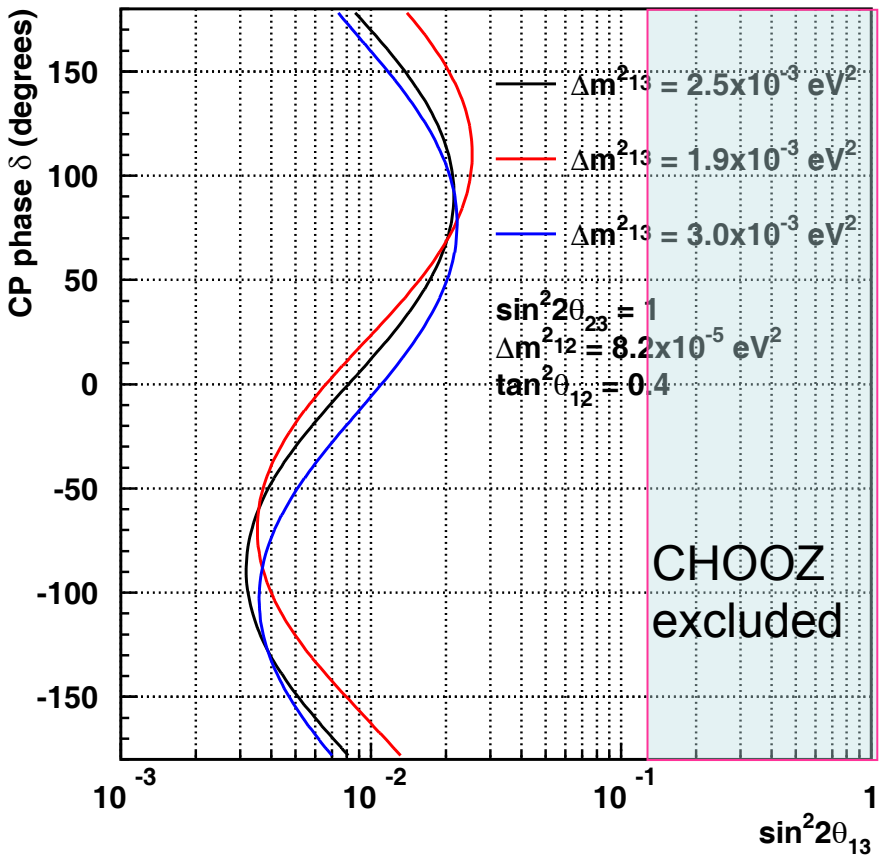




Assuming $\sin^2\theta_{23}=0.5$, $\delta=0$, no matter

$\sin^2 2\theta_{13}$	Background in Super-K			Signal	Signal + BG
	ν_μ	ν_e	total		
0.1	10	13	23	103	126
0.01				10	33

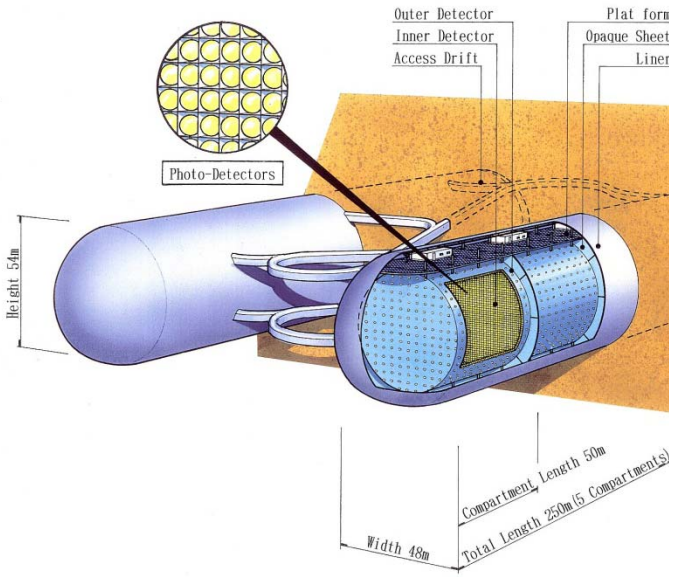
ν_e appearance sensitivity (as func of CP δ)

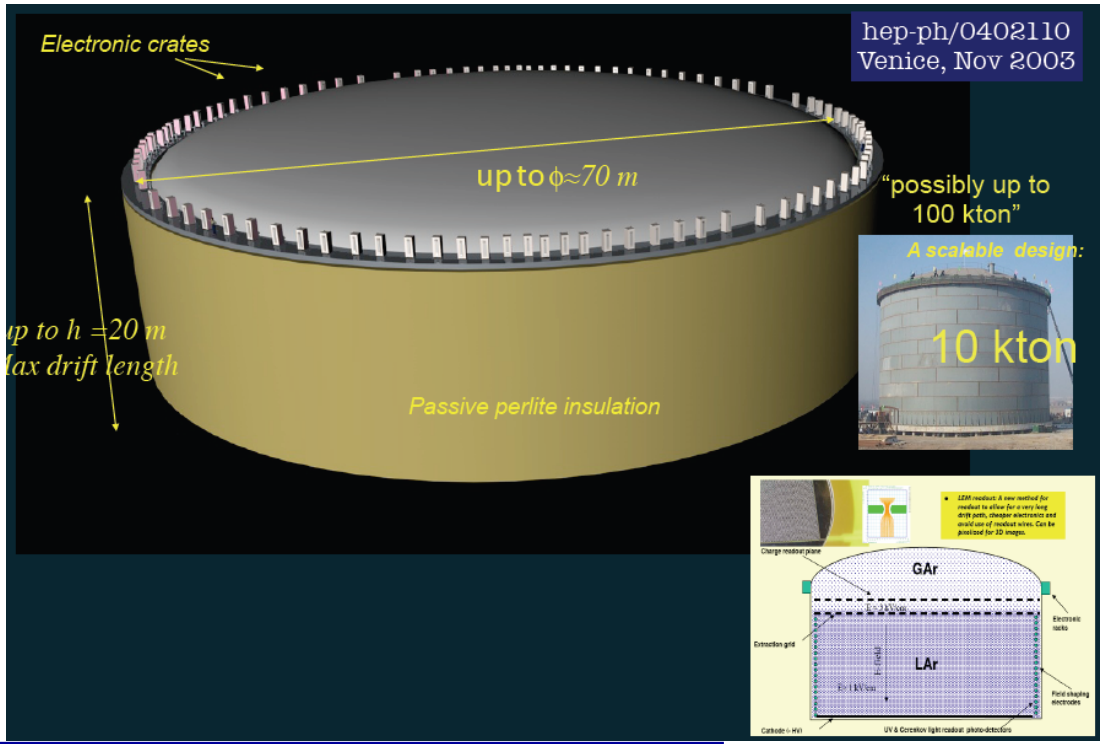


- **>10 times improvement for almost any δ**

Possible future extension

- **Beam power upgrade to Multi-MW**
- **New 100kt ~ Mt huge detector**





To explore

- **CP violation in neutrino sector**
- **Proton decay**

$\nu_\mu \rightarrow \nu_e$ appearance and CPV

$$P(\nu_\mu \to \nu_e) = 4C_{13}^2 S_{13}^2 S_{23}^2 \sin^2 \frac{\Delta m_{31}^2 L}{4E} \times \left(1 + \frac{2a}{\Delta m_{31}^2}\left(1 - 2S_{13}^2\right)\right)$$ Main

$$+8C_{13}^2 S_{12} S_{13} S_{23}(C_{12}C_{23}\cos\delta - S_{12}S_{13}S_{23}) \cos\frac{\Delta m_{32}^2 L}{4E} \sin\frac{\Delta m_{31}^2 L}{4E} \sin\frac{\Delta m_{21}^2 L}{4E}$$

$$-8C_{13}^2 C_{12}C_{23}S_{12}S_{13}S_{23}\sin\delta \sin\frac{\Delta m_{32}^2 L}{4E} \sin\frac{\Delta m_{31}^2 L}{4E} \sin\frac{\Delta m_{21}^2 L}{4E}$$ CP-odd

$$+4S_{12}^2 C_{13}^2 \left\{C_{12}^2 C_{23}^2 + S_{12}^2 S_{23}^2 S_{13}^2 - 2C_{12}C_{23}S_{12}S_{23}S_{13}\cos\delta\right\} \sin^2\frac{\Delta m_{21}^2 L}{4E}$$ Solar

$$-8C_{13}^2 S_{13}^2 S_{23}^2 \cos\frac{\Delta m_{32}^2 L}{4E} \sin\frac{\Delta m_{31}^2 L}{4E} \frac{aL}{4E}\left(1 - 2S_{13}^2\right)$$ Matter

$\delta \rightarrow -\delta$, $a \rightarrow -a$ for $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$

Matter eff.: $a = 7.56\times10^{-5}[\mathrm{eV}^2]\cdot\left(\frac{\rho}{[\mathrm{g/cm}^3]}\right)\cdot\left(\frac{E}{[\mathrm{GeV}]}\right)$

$$A_{CP} \equiv \frac{P - \bar{P}}{P + \bar{P}} \approx \frac{\Delta m_{12}^2 L}{E} \cdot \frac{\sin 2\theta_{12}}{\sin\theta_{13}} \cdot \sin\delta$$

$N(\nu_e) \propto \sin^2 2\theta_{13}$; $A_{CP} \propto \frac{1}{\sin\theta_{13}}$

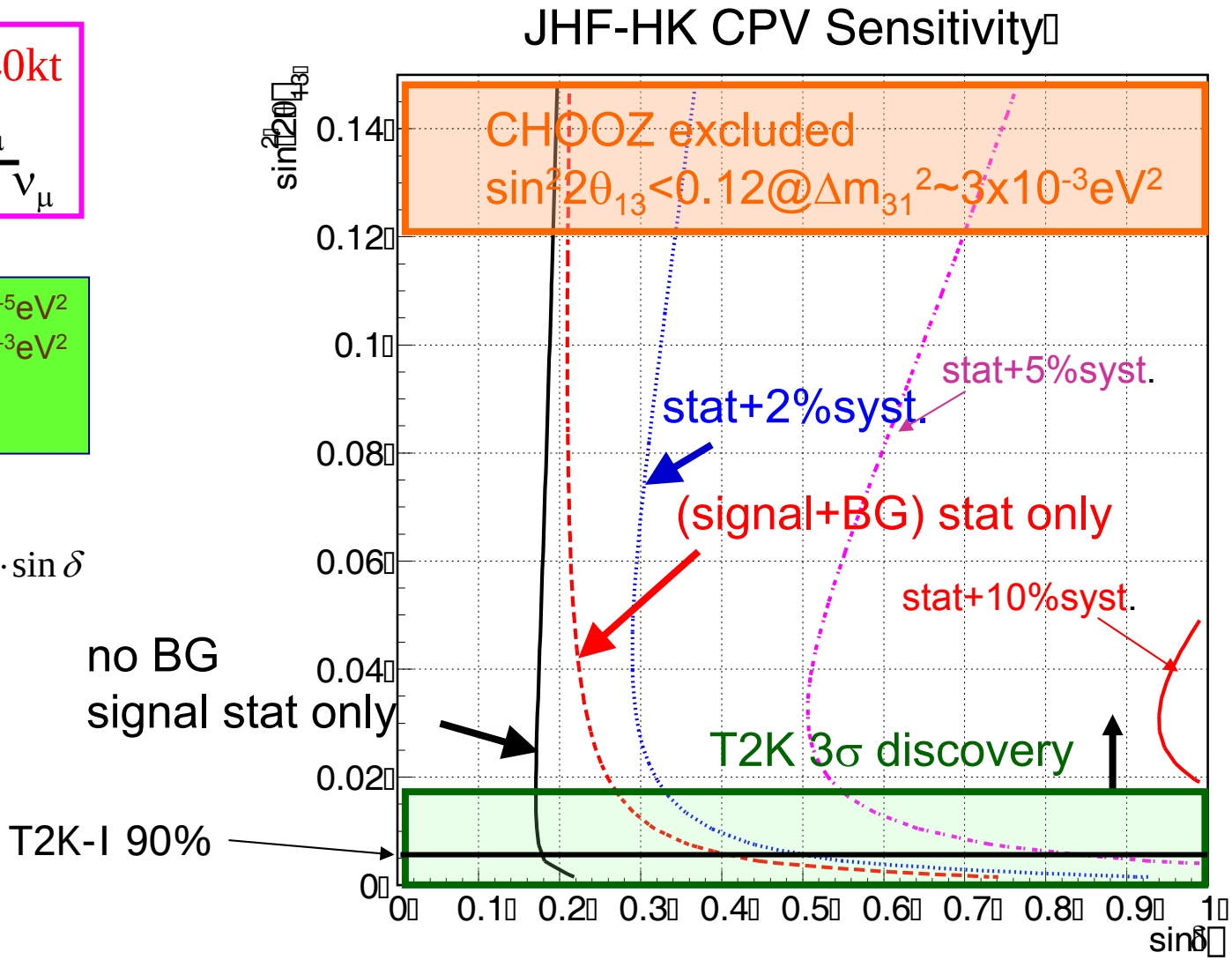
Size of θ_{13} critical !

Sensitivity for CPV w/ Mt Water Черенков

4MW, 540kt
2yr for ν_μ
6~7yr for $\bar{\nu}_\mu$

Δm_{21}^2=6.9x10^{-5}eV^2
Δm_{32}^2=2.8x10^{-3}eV^2
θ_{12}=0.594
θ_{23}=π/4

$$A_{CP} \approx \frac{\Delta m_{12}^2}{4E_\nu} \cdot \frac{\sin 2\theta_{12}}{\sin \theta_{13}} \cdot \sin \delta$$



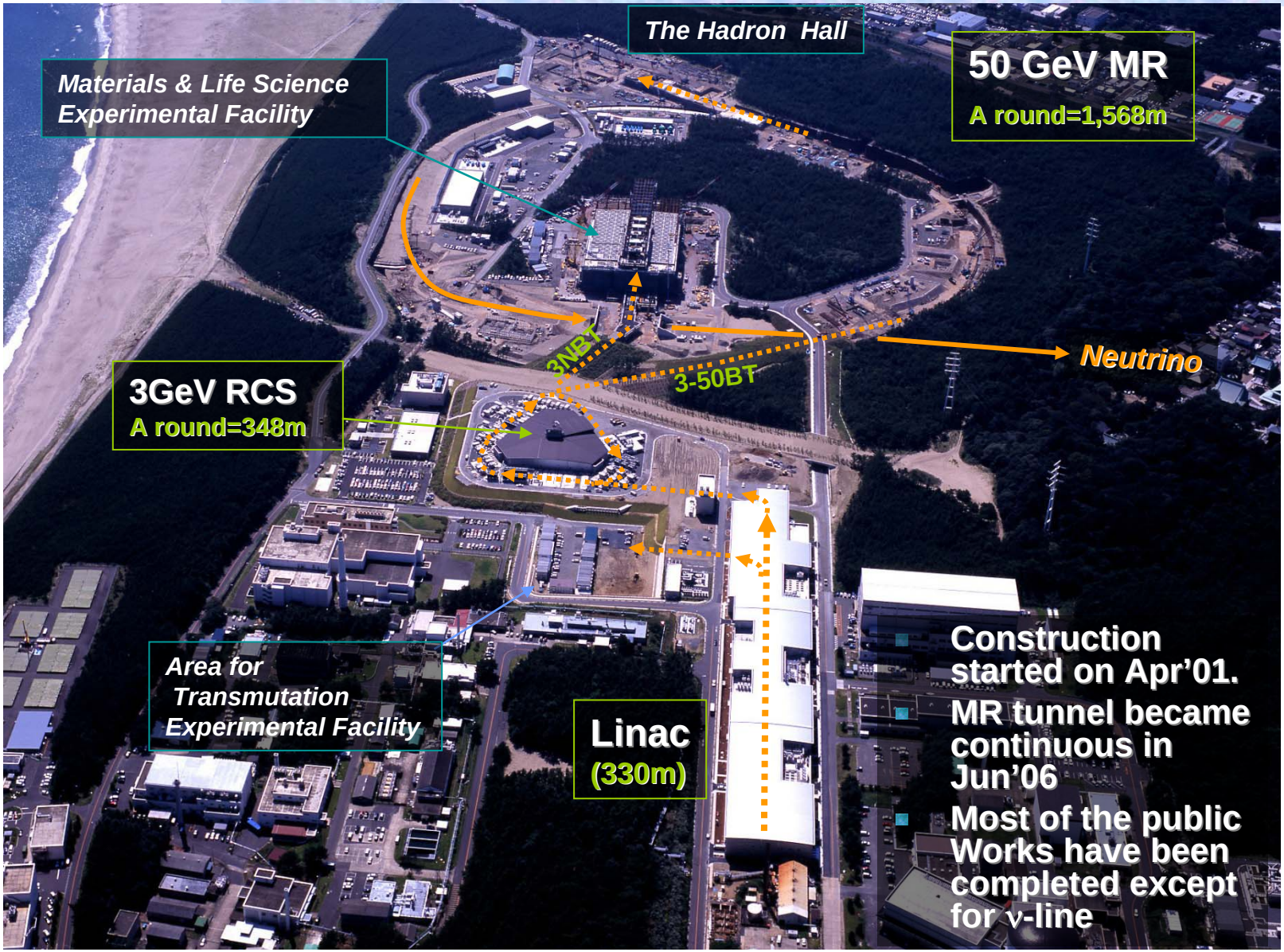
3σ CP sensitivity : $|\delta|>20^o$ for $\sin^2 2\theta_{13}>0.01$ with 2% syst.

Construction Status

Bird's-eye view

[As of Feb.2006]

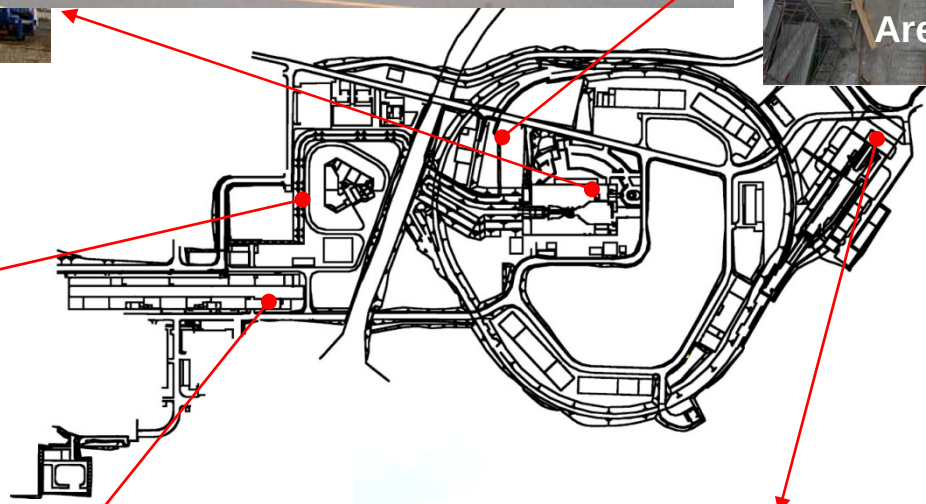
T.Ishida
(IPNS, KEK)




Materials & Life
Experimental Hall


Neutrino
Target
Area


3 GeV

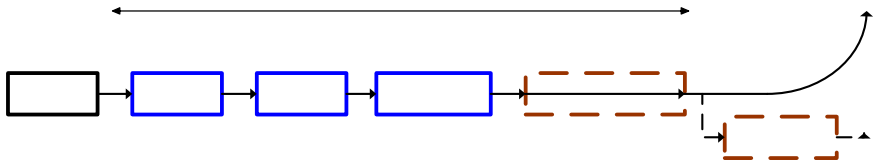



Linac


Hadron
Experimental Hall

Linac

T.Ishida
(IPNS, KEK)



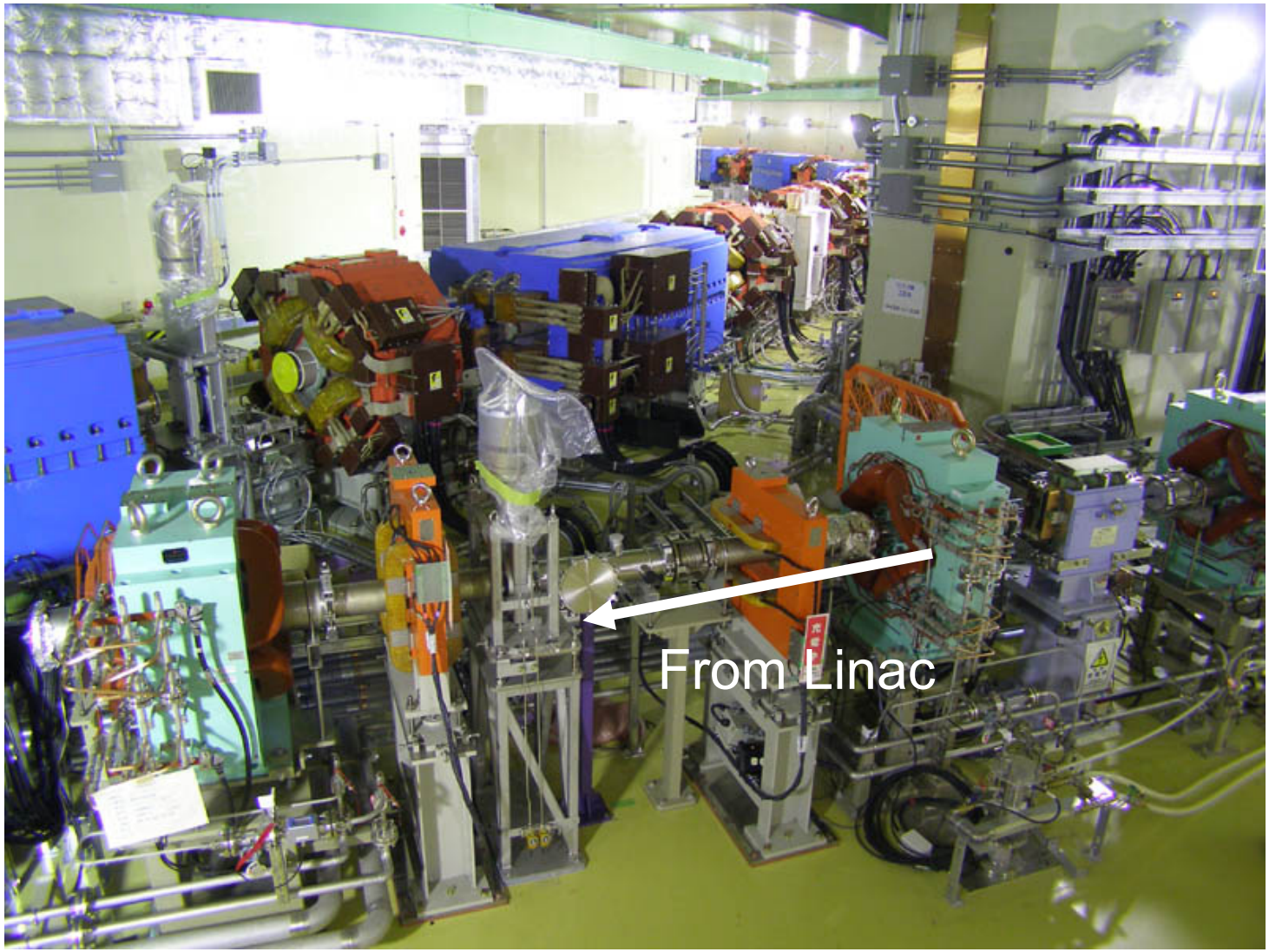
ACS: Annular ring Coupled Structure not installed on day-one
Peak current = 30mA@181MeV (50mA@400MeV)
Repetition 25Hz / Pulse Width 0.5ms

x 0.6

Linac beam on Jan. 24, 2007

Accelerated up to design energy of 181MeV

3 GeV Injection Area



3 GeV Ring

3 GeV RF Area

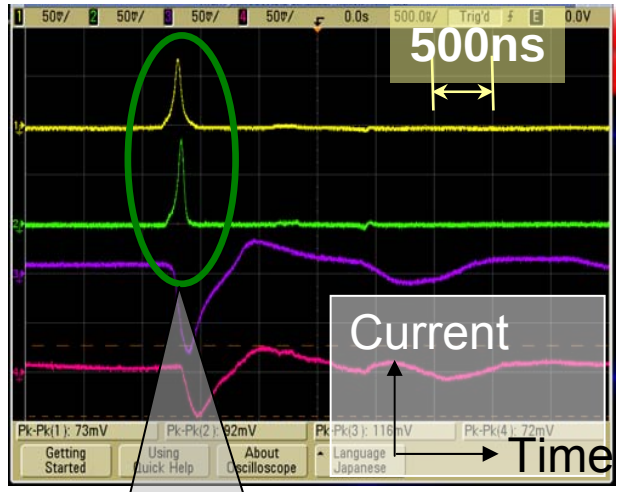
3 GeV Extraction Area

Acceleration and Extraction at 3 GeV

2007.10.31.14h03m23s

Beam Current inside the Ring

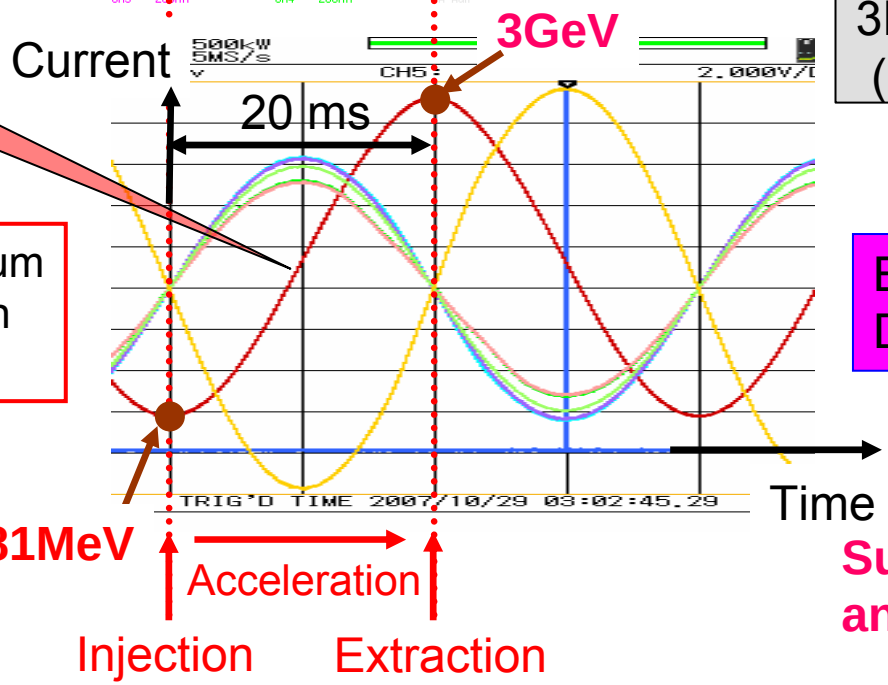
Beams remain inside the ring for 20 ms.



3NBT Beam Current (Extracted Beams)

Beam Loss

Magnetic Field

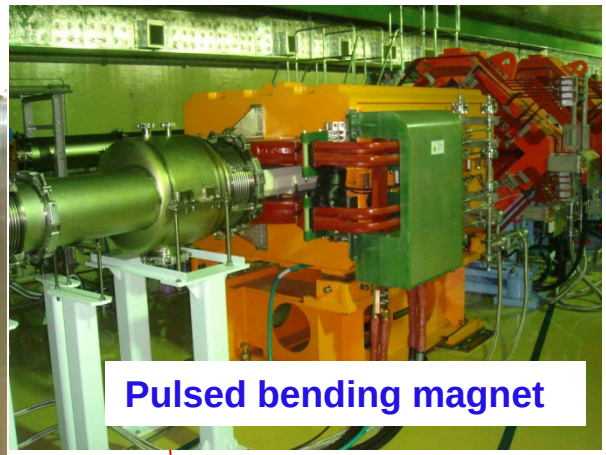


Injection at the minimum field and the extraction at the maximum field

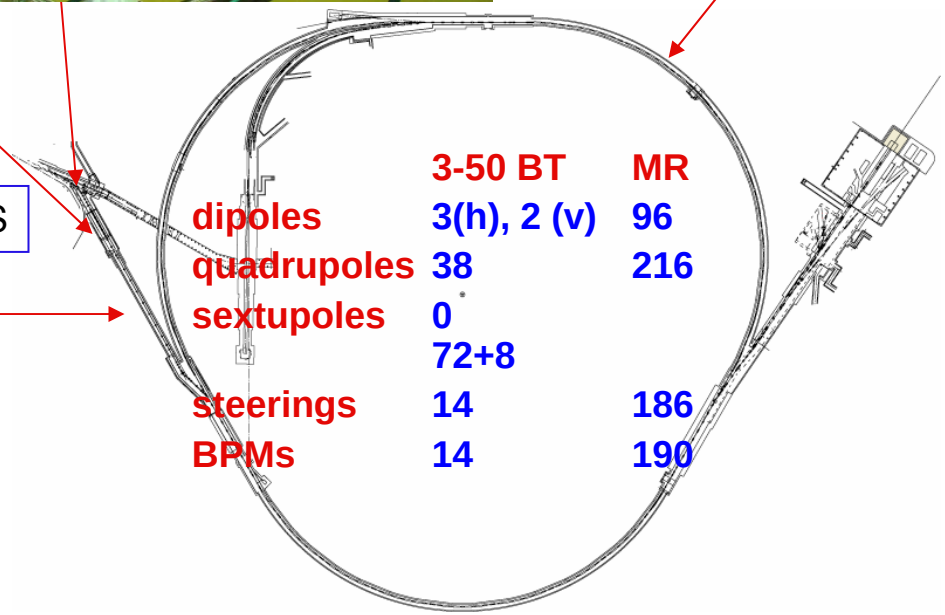
Beam Current Detected at 3NBT

Successful Acceleration and Extraction !!!

Construction status of 3-50BT and MR



RCS



	3-50 BT	MR
dipoles	3(h), 2 (v)	96
quadrupoles	38	216
sextupoles	0	
	72+8	
steerings	14	186
BPMs	14	190

Off-beam commissioning : Dec., 2007~
Beam commissioning : May, 2008~

Hadron Hall in August 2007

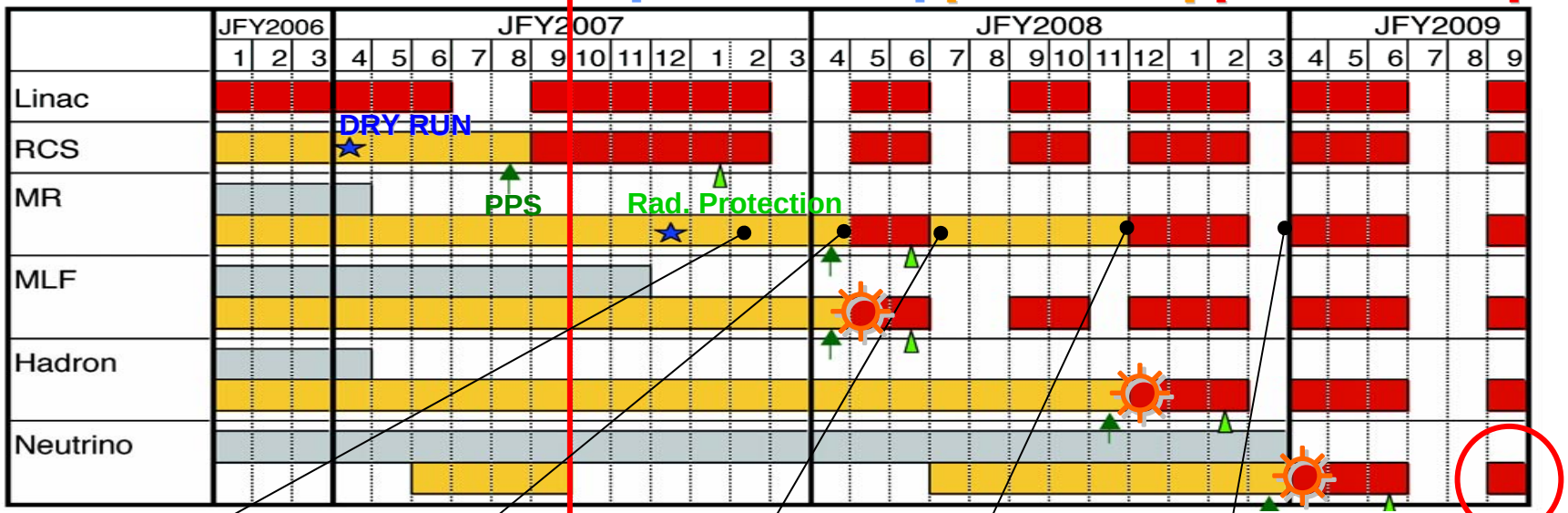
Hadron Hall

Commissioning Plan

T.Ishida
(IPNS, KEK)

Neutrino Facility at J-PARC

[CONSTRUCTION] [INSTALATION] [COMMISSIONING]



Install Fast Extraction Devices

STAGE-1: Establish Closed Orbit

Install Slow Extraction Devices

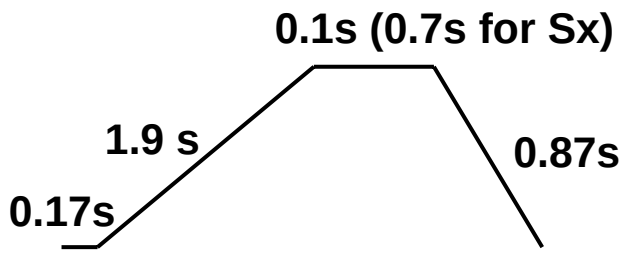
STAGE-2: Acceleration (30GeV)

STAGE-3: Fast Extraction

Asking Fx High Intensity Run

[Day-one Operation Parameters]

- 30GeV
- 6 bunches / h = 9 (kicker rise time problem)
- Rep. period: 3.04s for Fx (3.64s for Sx)



The Neutrino Beam-Line

Target-Horn System

Target Station

Preparation Section

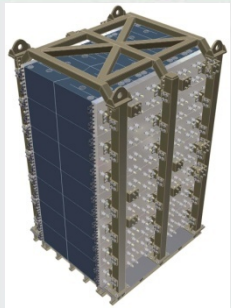
Muon
Monitoring Pit

Final
Focusing
Section

295km to
Super-Kamiokande

100m

Near Neutrino Detector



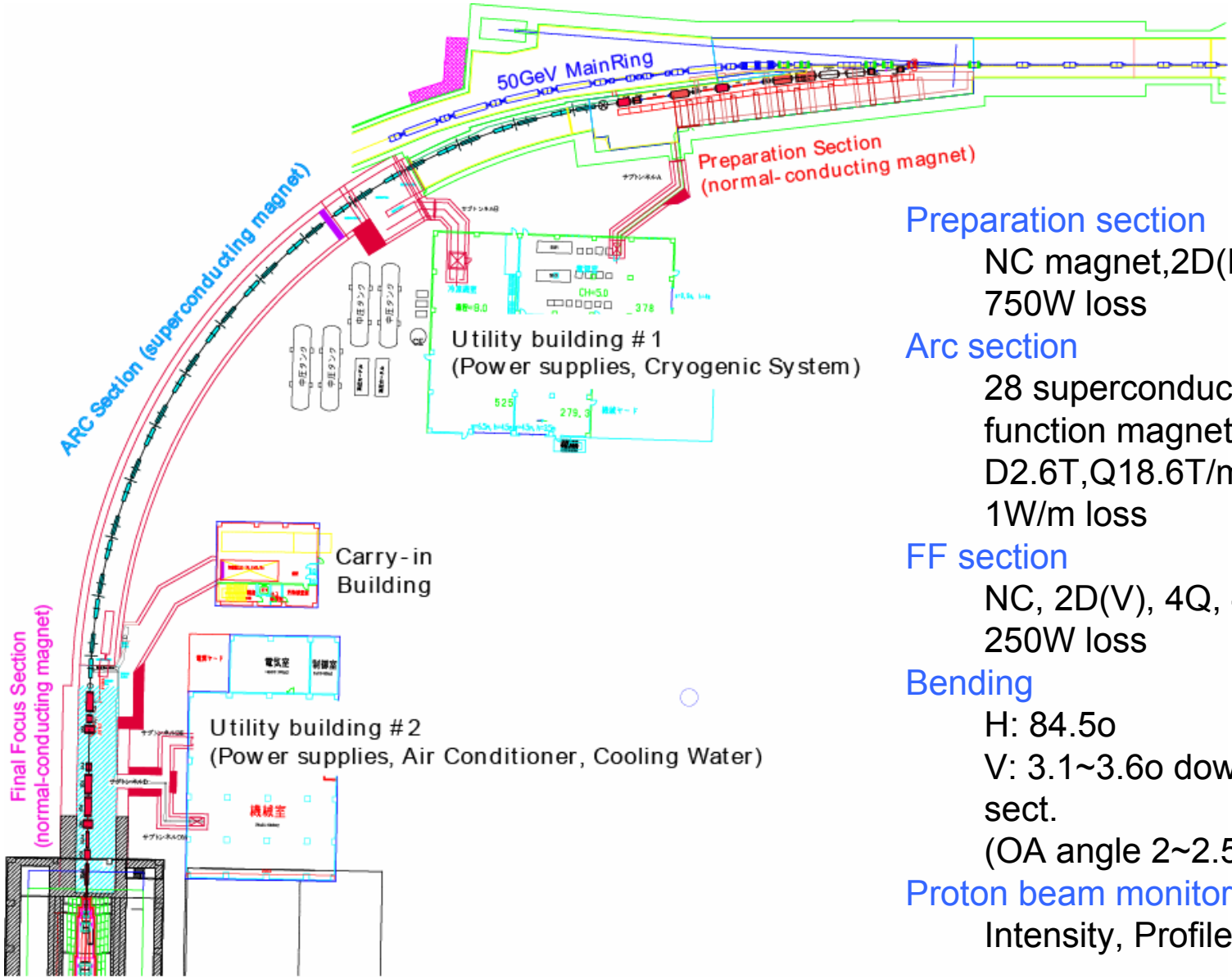
Beam Dump

Decay Volume

SCFM at ARC Section

Construction: Apr. 2004 ~ Mar. 2009 (5yrs)

Primary beam line



Preparation section

NC magnet,2D(H),5Q,4str
750W loss

Arc section

28 superconducting combined function magnets
D2.6T,Q18.6T/m, L=3.3m
1W/m loss

FF section

NC, 2D(V), 4Q, 4str
250W loss

Bending

H: 84.5o
V: 3.1~3.6o downward in FF sect.
(OA angle 2~2.5^{o})

Proton beam monitors

Intensity, Profile, Position, Loss

Tunnel for Primary Beam-line

Completed in Dec. 2006

Primary line components

- SC magnets
  - **23 (/28) mags, 9 (/14) "doublets" completed**
  - Up to 28 mags, 12 dblt's in FY2007 (by Mar.2008)
  - Corrector mags being fabricated at BNL
- Normal-conducting magnets
  - **11 mags in prep.section installed and aligned.**
  - Fabrication of FF mags in progress, inst. In 2008
- Misc.
  - Level meas. in progress to monitor ground sink.

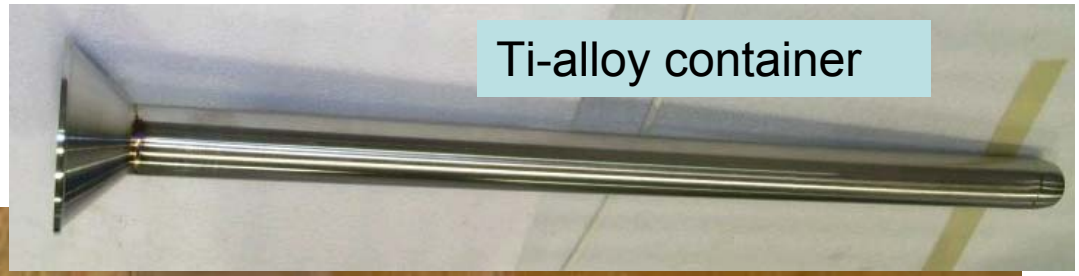
Level-measurement for the primary tunnelbein done.

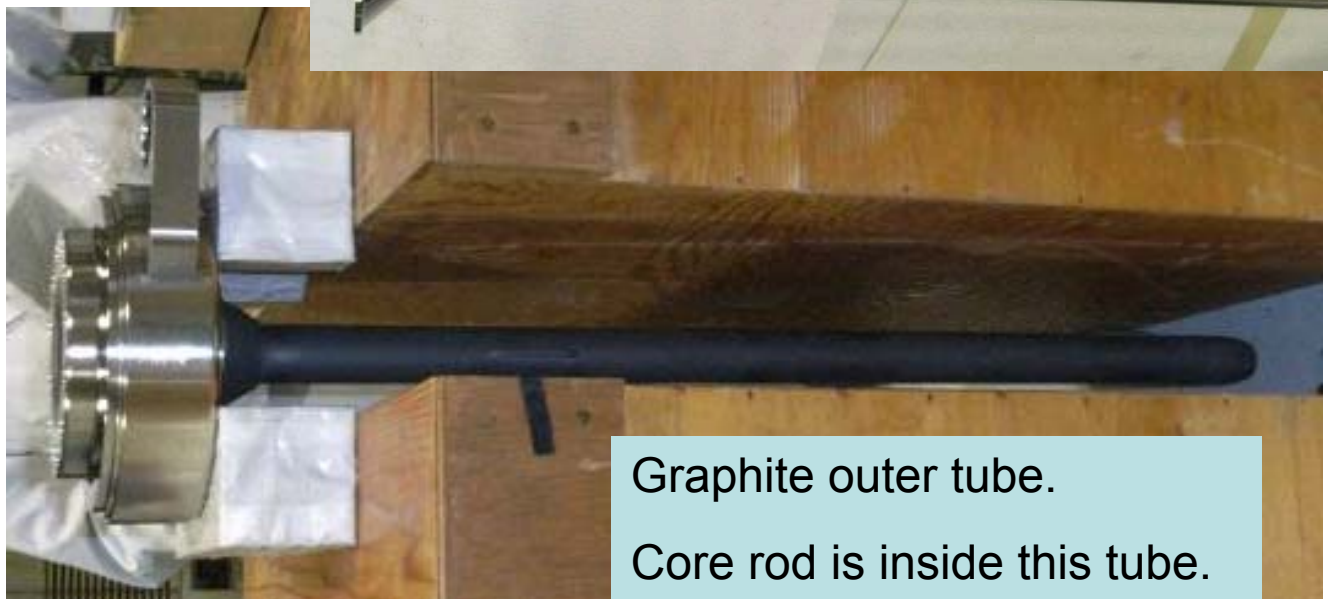
Delivery of superconducting magnet (doublet)

Preparation section

Target

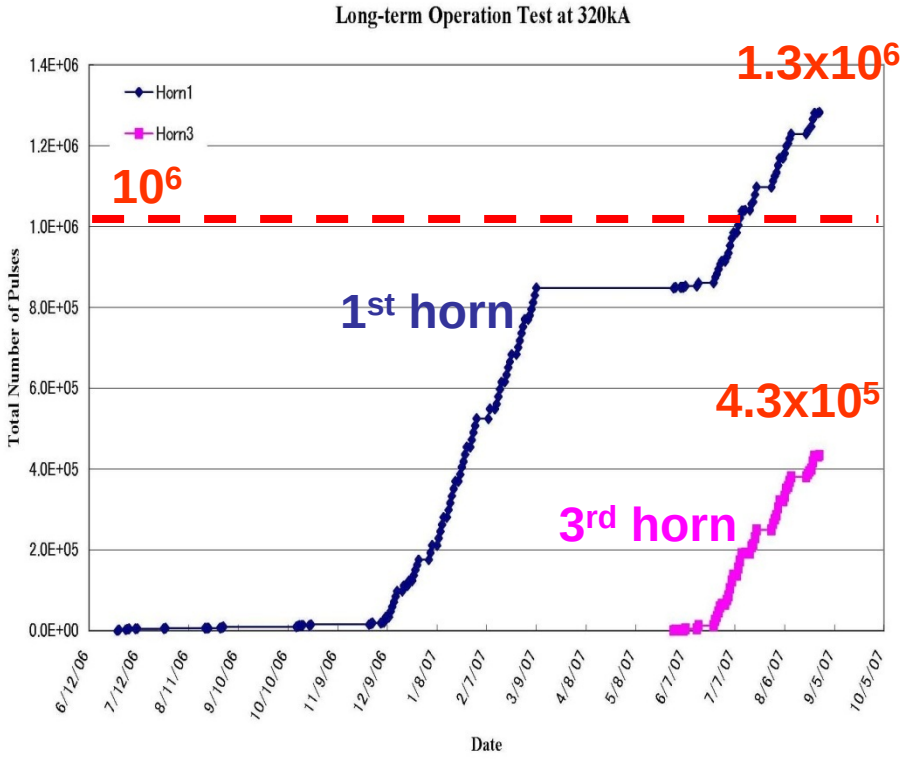
- Graphite 26mm(D)x900mm(L)
- Forced flow Helium gas cooling in Ti-alloy container
- Remotely exchangeable
- **Full-spec He flow test w/ mockup succeeded**
- **Day-1 target delivered.**
- Full-spec He-flow test w/ real target being prepared

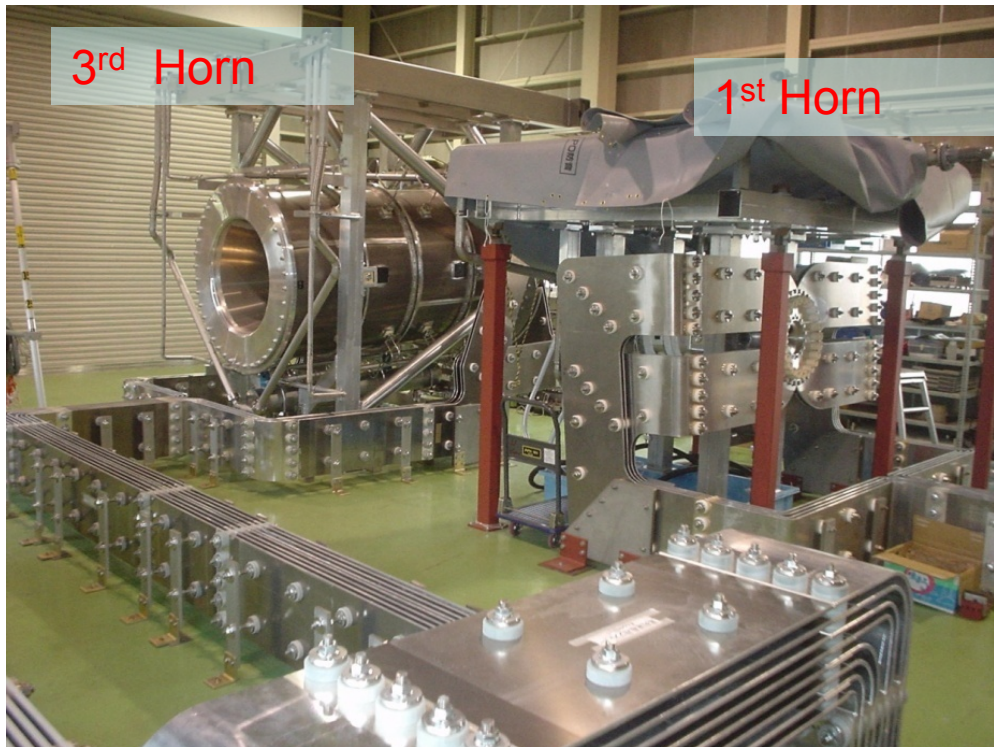




Electromagnetic horns

- Long term test at 320kA with 1st horn prototype and 3rd horn finished
  - Minor problems are indentified and being fixed before day-1.
- The 1st Horn for day-1 is under production, will be delivered in Mar.
- The 2nd Horn is under production in US, will be delivered in April.





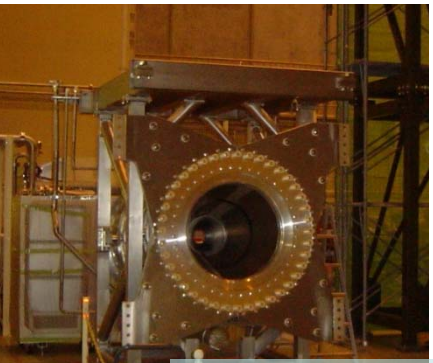
Full setup Test of Horn and Demonstration of its Remote Maintenance Scenario at Fuji, KEK

In preparation now.

The 320 kA operation is scheduled in February.

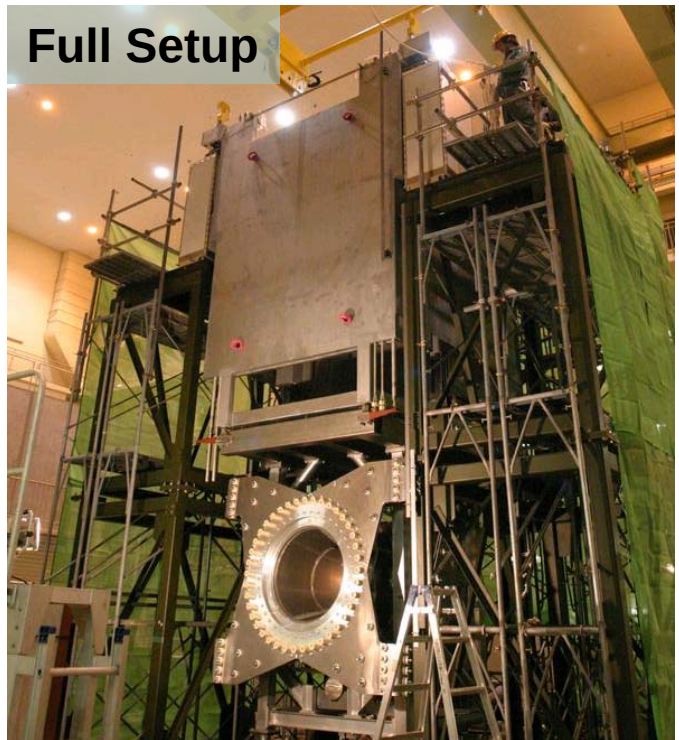
Necessary improvements are identified and being solved.

Support Module



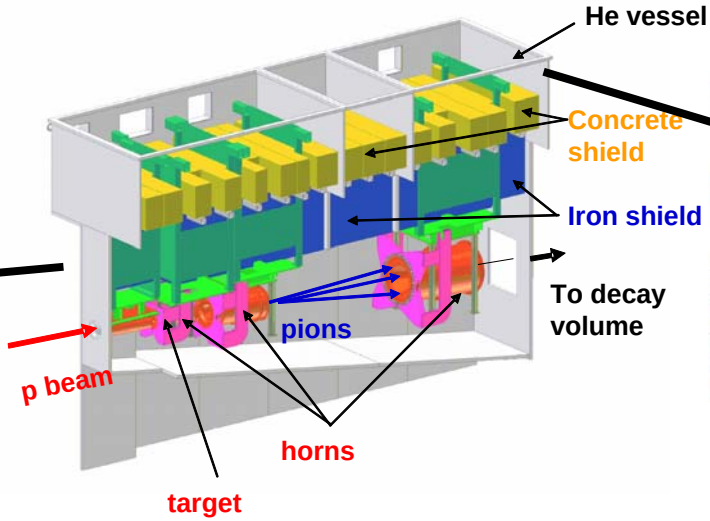
3rd Horn

Full Setup



Hung by remote sling tool

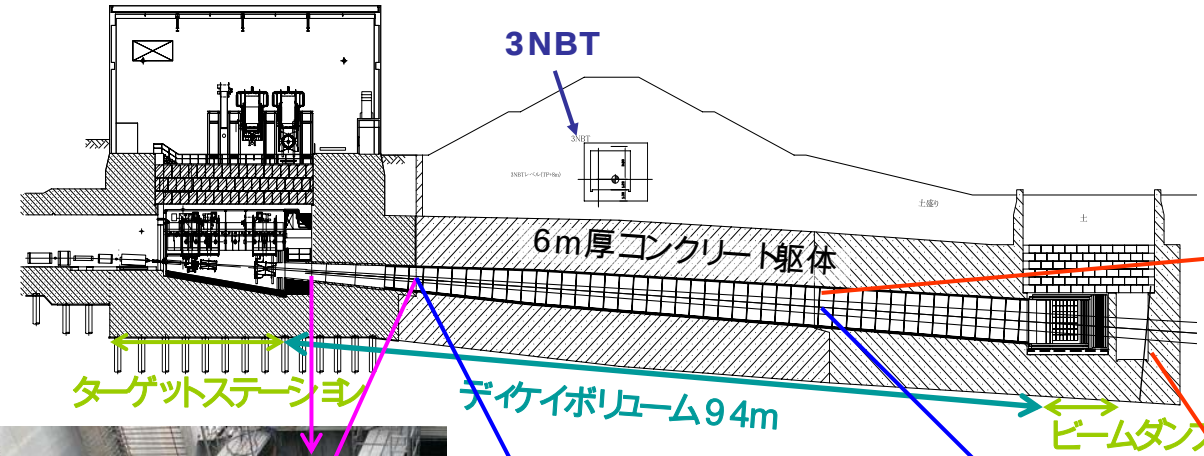
Target Station



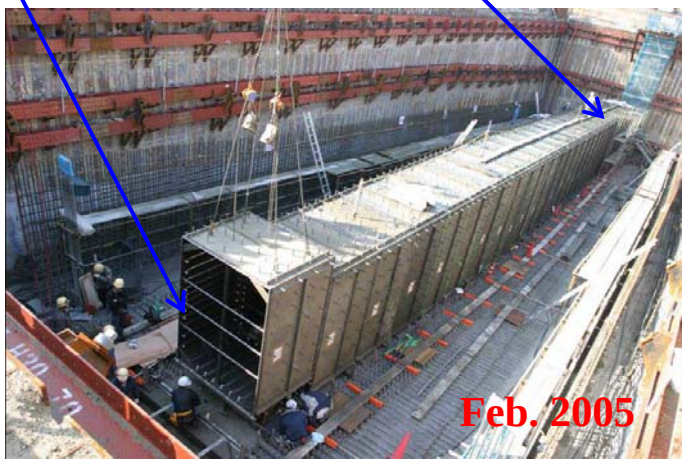
- Overcame water food problem during excavation in early 2007
- Installation of the helium vessel(~470ton, 1000m^3) finished, passed vacuum test in Nov. 2007 **as scheduled**
- Construction of surface building starts soon and will finish in June 2008.

Decay Volume

- 94m-L iron helium vessel cooled by water
- Middle part was constructed in 2005.
- Upstream part (20cm^t Iron) was installed&tested in Nov 2007 as scheduled
- Downstream parts will be finished by Aug. 2008.



Upstream part

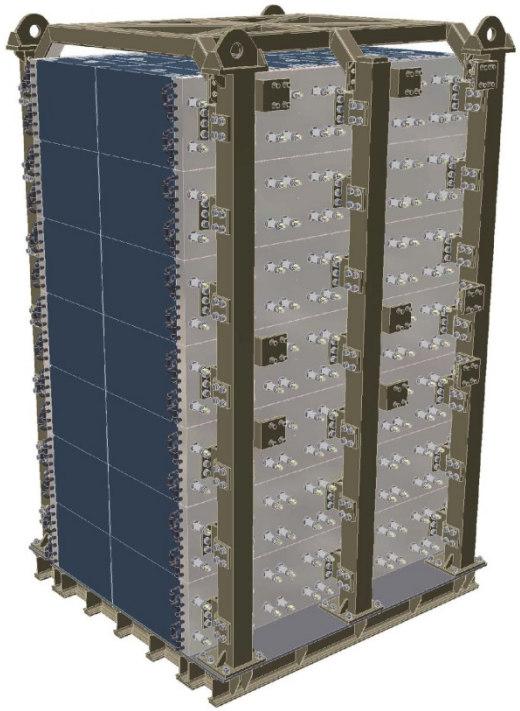


Middle part

Downstream part

Beam Dump

Beam dump



Prototype module

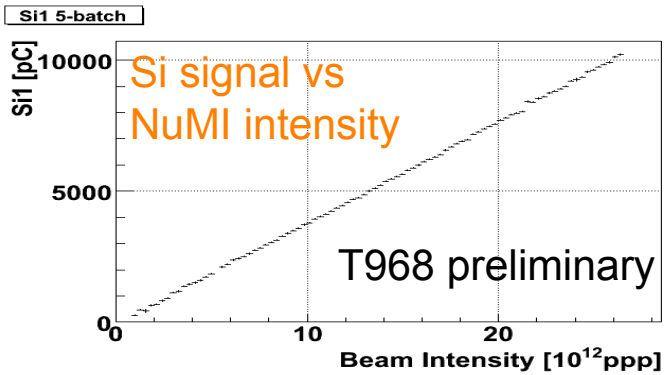
Module assembly

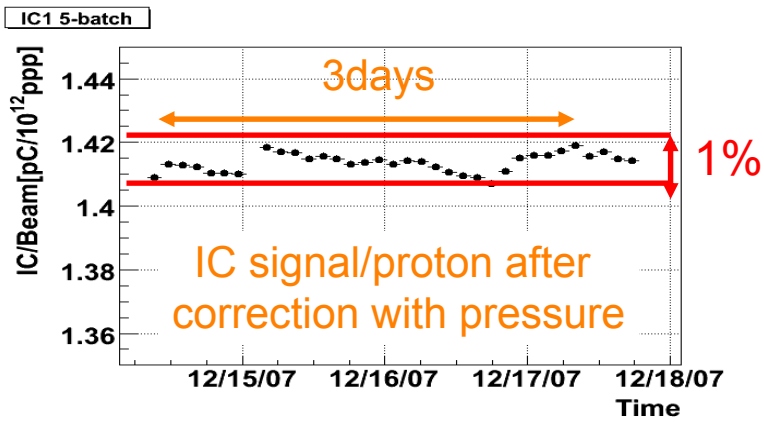
- 98 graphite blocks cooled by water-pipe embedded Al-casting block
- Layout of pipes & Al-casting method developed and established
- All parts are in production and will be ready by the end of Mar.2008
  - Graphite blocks being machined, ~1/4 delivered
  - First Al-cooling module delivery in Jan (out of 14)
  - Helium vessel iron plates (200mm^{t})
- Module assembly will be finished by the end of Mar.2008
- Installation from Aug. 2008

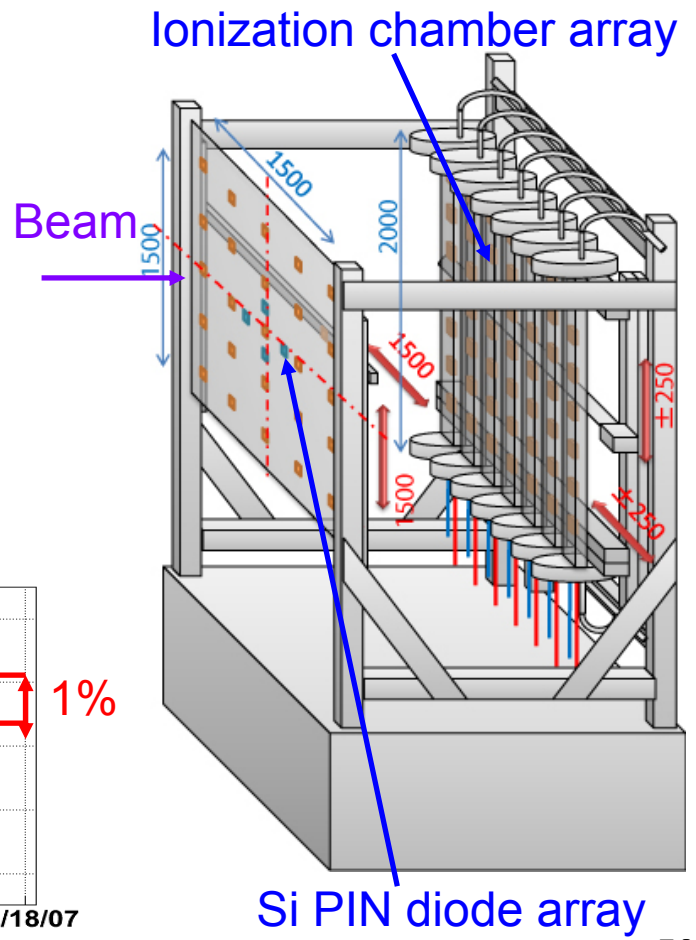
Muon Monitor

- Spill-by-spill monitor for the muon profile center (= beam direction)
- Long term test of prototype at FNAL/NuMI beamline (FNAL-T968 test exp.)
- Engineering design of detectors almost finished
- Design of the support structure ongoing
- Installation in fall-winter 2008

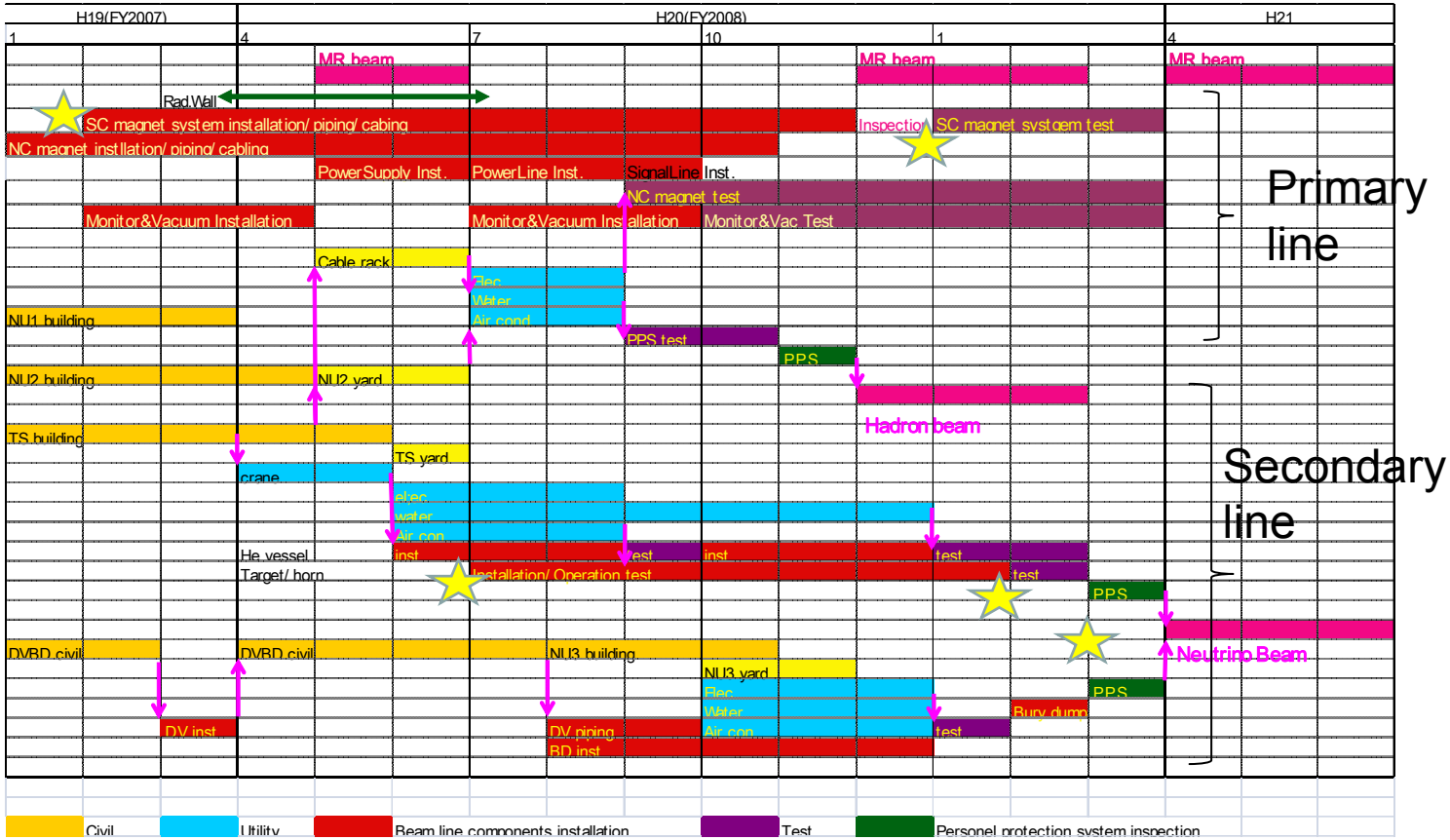
T2K prototype detectors installed behind NuMI/MINOS MUMON







Construction schedule

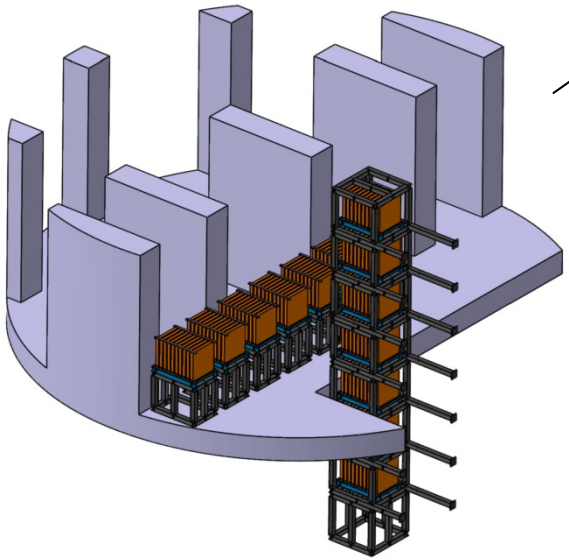


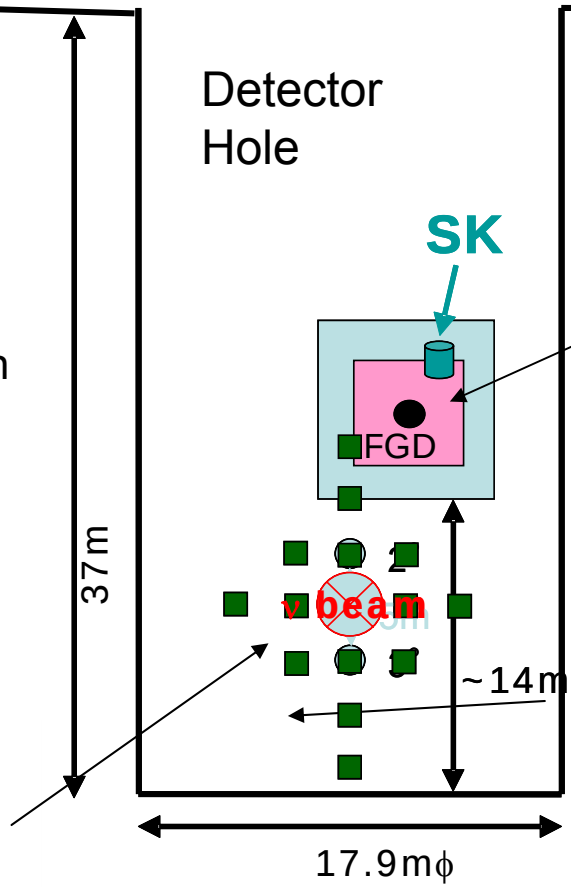
- Beam will start in April 2009, 15month from now.
- Installation of almost all components in 2008
  - SC magnets from Feb, Target/Horn from July,
  - SC/Horn in-situ ope. test from 2009, Intrlock inspection Mar. 2009

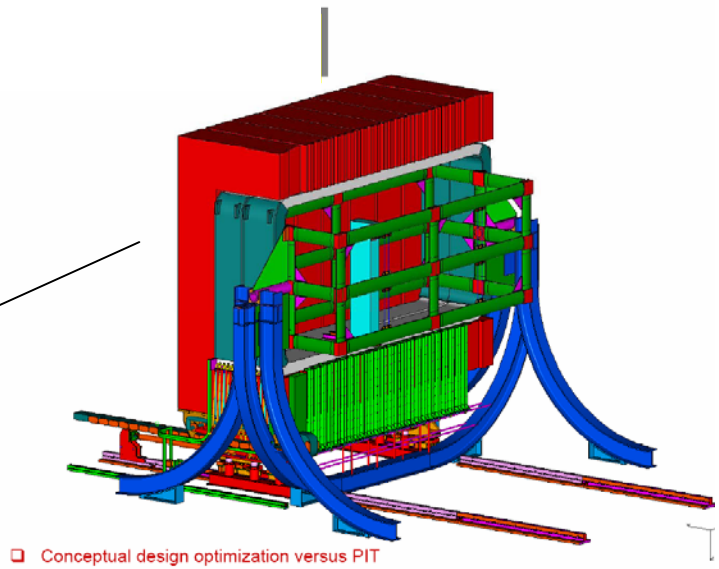
Near Neutrino Detectors @ 280m

On-axis neutrino moitor

- Monitor
  - Profile
  - Direction
  - Intensity (& Energy)
- Iron-Scintillator sandwich detector
  - 1mx1mx10cm Iron
  - 1.25cm thick extruded Scinti.
  - New Photo-Sensor (MPPC/SiPM)







Off-axis detector

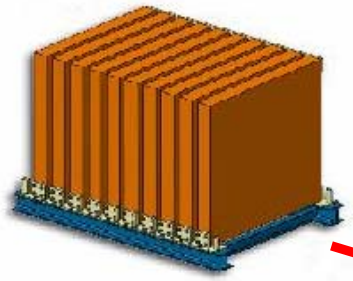
- Measurement of ν flux and σ in the SK direction.
- Detector components.
  - UA1 magnet (0.2T)
  - TPC
  - Fine-Grained Scintillator detector (FGD)
  - Lead/Scintillator tracking detector for π^0
  - Electromagnetic Calorimeter
  - Muon Range Detector in mag
- Key technologies
  - Photo-sensor, Micromegas

Progress on 280m Hall

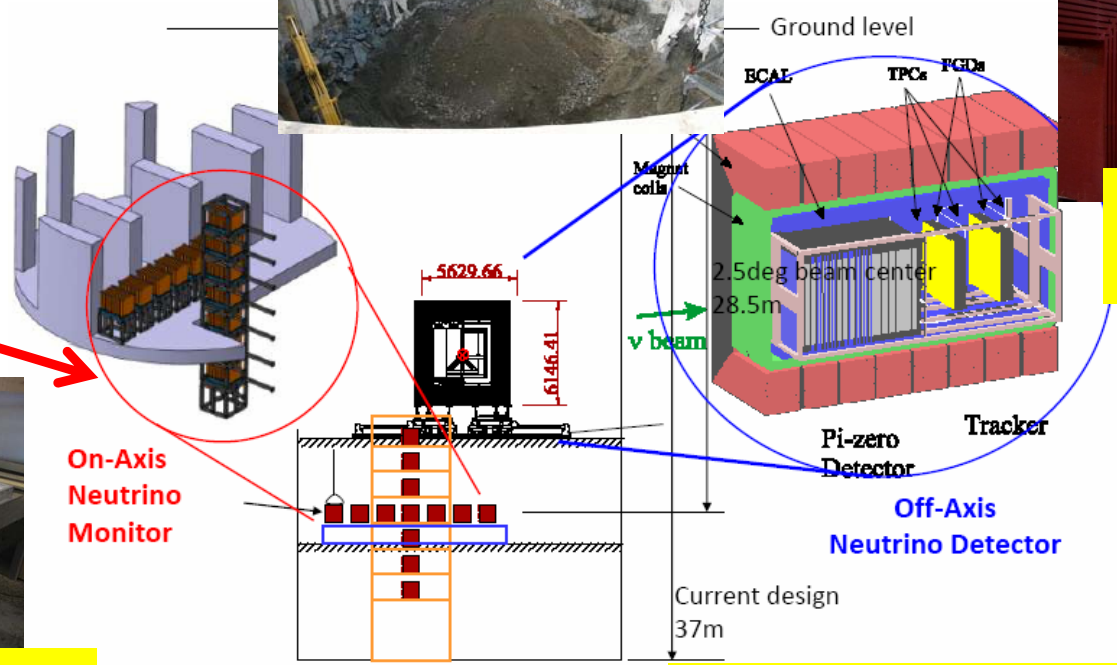
Status of 280m Near Detectors

On-axis detector
(INGRID)

Iron+Scibar
Sandwich



UA1 magnet
being shipped
Installed in Apr-Jun.2008



In production, ready in Apr.2009

FGD

All are in production

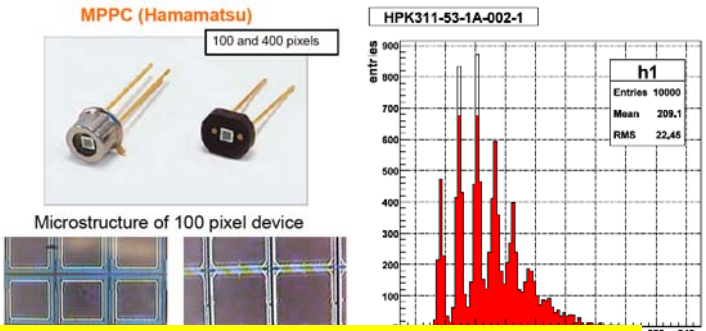
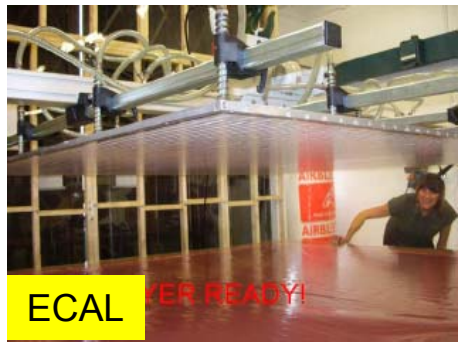


Photo-sensor (~60k ch) in production

TPC

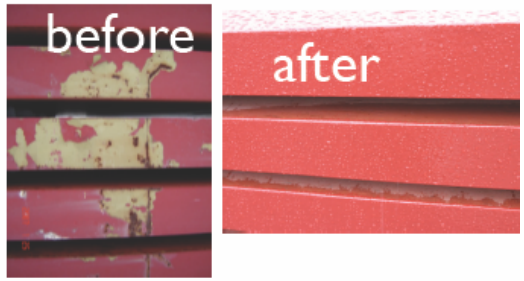


ECAL

FGD

UA1 magnet (donation from CERN)

C refurbishing (spring 2007)



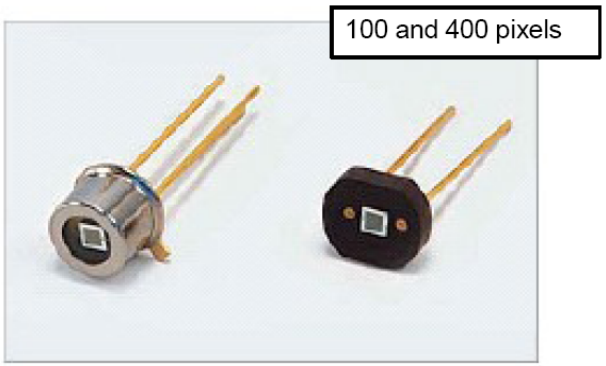
- **Refurbishing done**
- **Shipping started**
- **Installation during Apr~Jun., 2008**

Novel photosensor

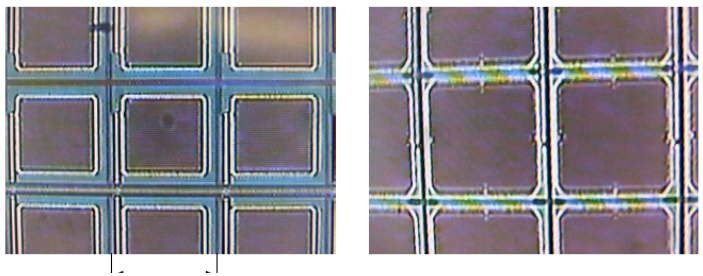
- Multi-pixel Geiger mode avalanche photodiode
  - Can be used in magnetic field
  - High gain ~(5-7)x10^5, high photon detection efficiency ~30-35% for green light
- Used in INGRID, FGD, P0D, SMRD, ECAL
  - In total ~60,000 channel
  - Key component
- R&D finished, mass-production started

T2K will use 1.3x1.3 mm^2 667 pixel MPPC produced by Hamamtsu

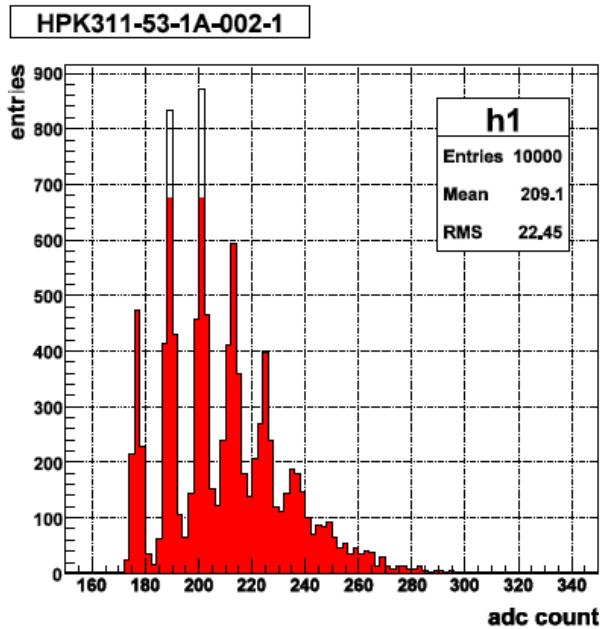
MPPC (Hamamatsu)



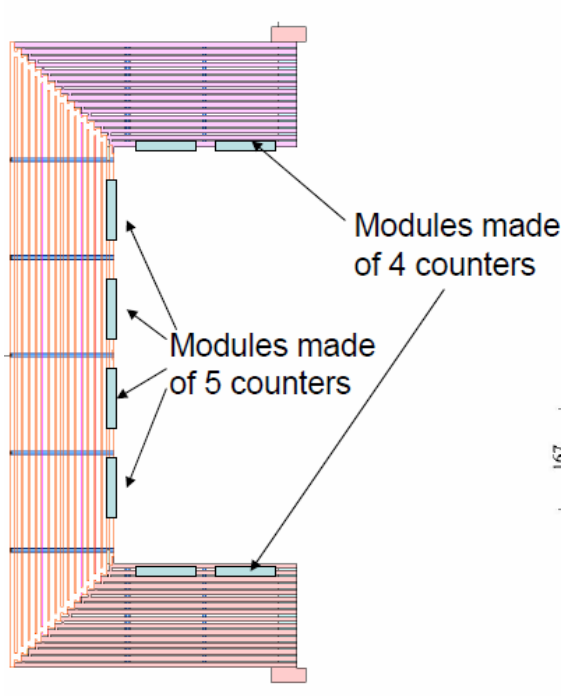
Microstructure of 100 pixel device



new design



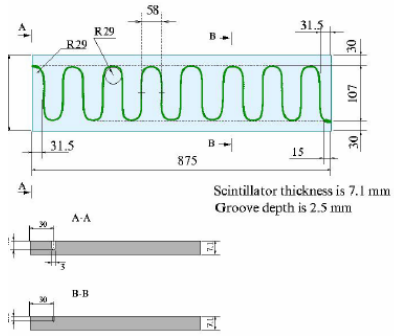
Side Muon Range Detector (SMRD)

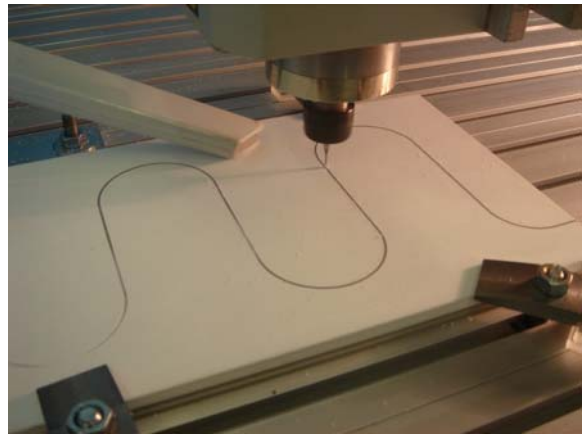


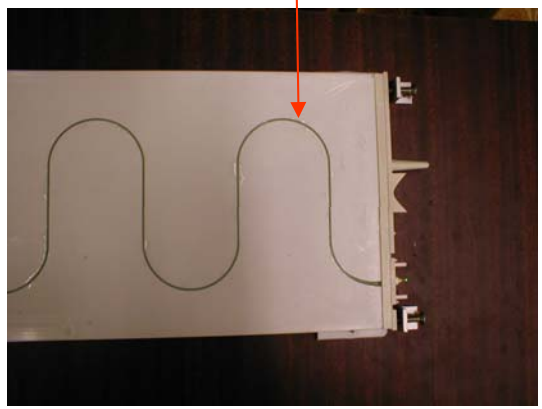
Total horizontal counters: 768
Dimensions: **870 x167 x 7 mm3**

Total vertical counters: 1060
Dimensions: **870 x175 x 7 mm3**

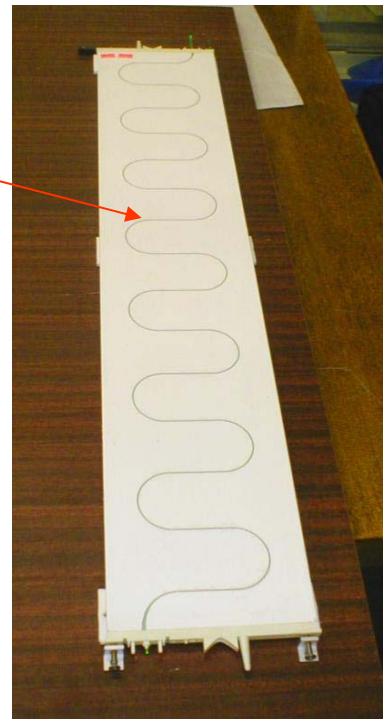
Total counters: ~2000
(including spares)







fiber

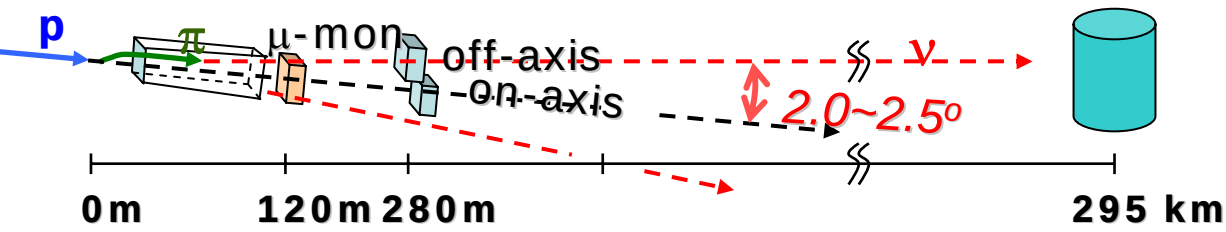


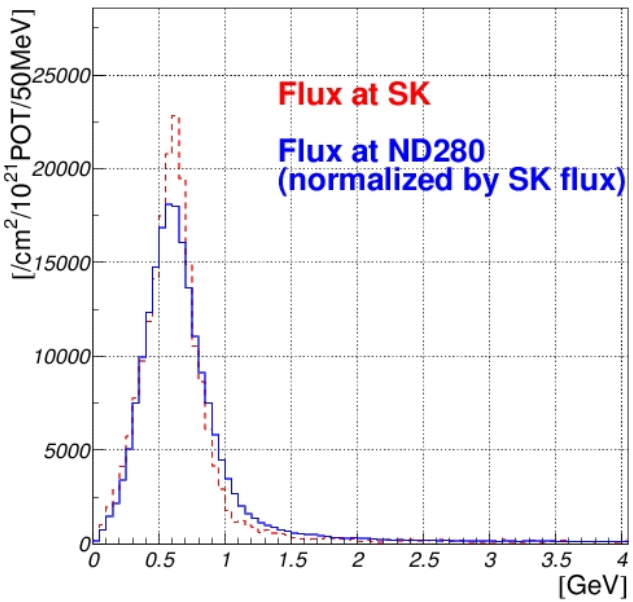
Summary

- Working very hard to keep schedule
  - Both civil and equipments
  - Almost all beam line components will be installed in FY2008
- Beam commissioning will start in Apr. 2009
  - w/ completed beamline, MUMON, On-axis detector
- Off-axis detector will be ready by 2009 fall run
  - except for a part of ECAL
- Aim to obtain 1st physics result from 100kWx10^7sec beam operation in 2010
- Workshop to discuss future neutrino experiments with J-PARC (http://j-parc.jp/NP08/)
  - Mar. 5~7, 2008 near J-PARC (Mito-city, Ibaraki, Japan)
  - **YOU ARE WELCOME**

Backup slides

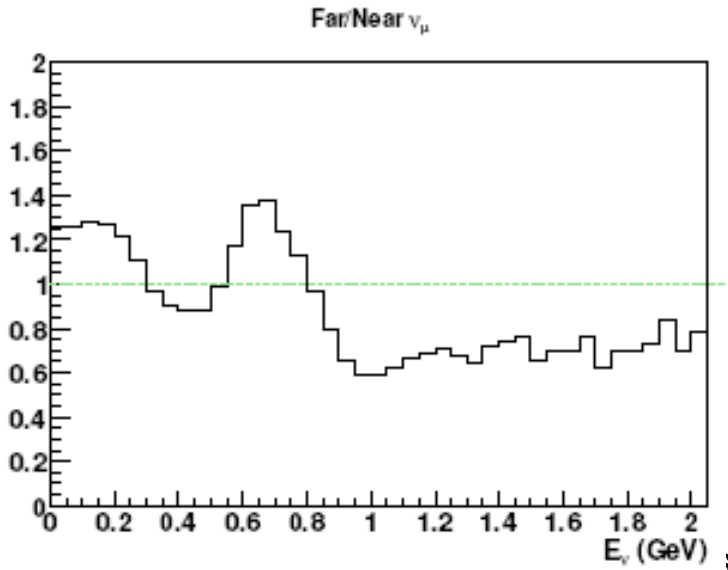
Experimental Setup





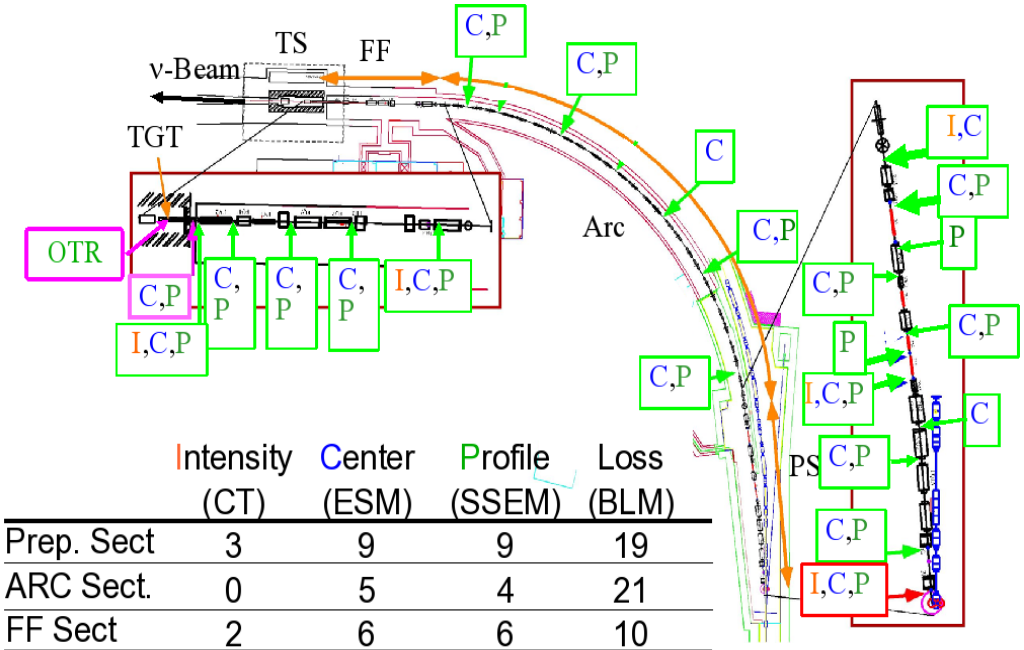
- **Muon monitors @ ~140m**
  - Fast (spill-by-spill) monitoring of beam direction/intensity
- **Near detector @280m**
  - On-axis
    - Monitor Intensity and direction (profile)
  - Off-axis
    - Flux/spectrum/νe
- **Far detector @ 295km**
  - **Super-Kamiokande (50kt)**

- **Neutrino spectrum at Far is different from Off-axis**

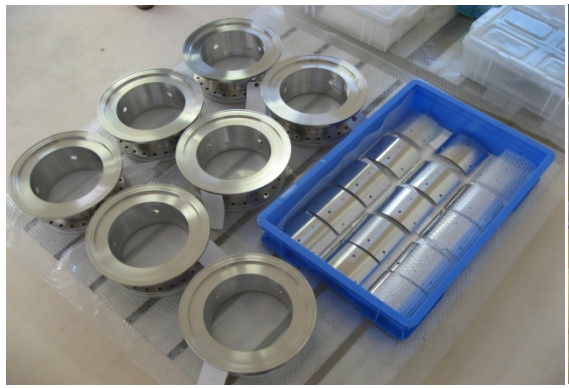


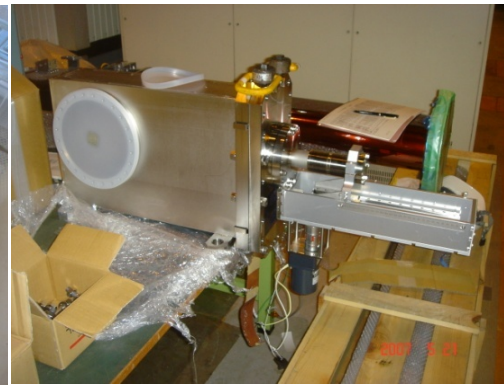
Proton beam monitors

- Position: ESM
  - 9 prep ESMs delivered
  - ARC ESMs being manufactued
- Profile: SSEM
  - Chambers and Moving mechanisms for Prep SSEMs delivered, installation in this FY.
  - Chambers and Moving mechanisms for SC part will be manufactured soon
  - SSEM sensor will be assembled/installed in the next FY
- Intensity: CT
  - Final design fixed
  - All parts are ordered
  - Prep CTs will be assembled/installed in this FY
- Loss: Ionization chamber
  - Commercially available (used by J-PARC acc group)
  - Layout/configuration fixed
  - Twenty monitors are purchased in this FY



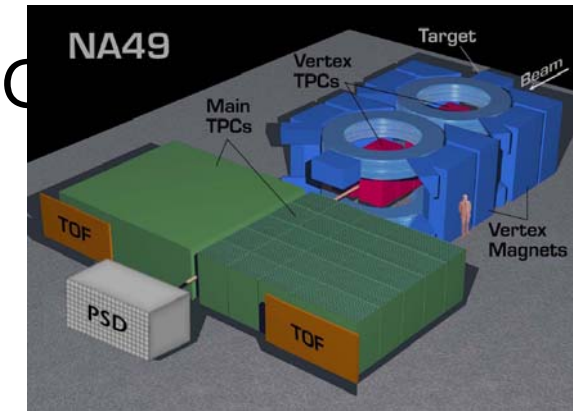
	Intensity (CT)	Center (ESM)	Profile (SSEM)	Loss (BLM)
Prep. Sect	3	9	9	19
ARC Sect.	0	5	4	21
FF Sect	2	6	6	10



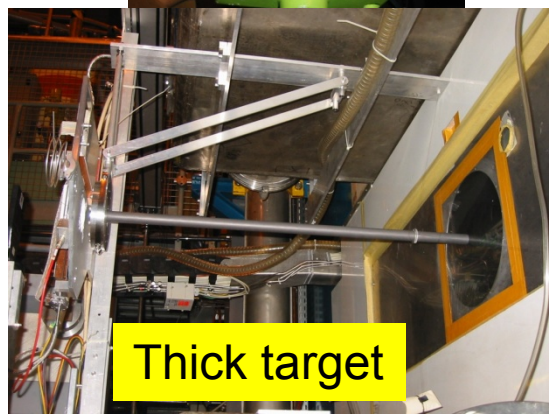


Hadron production measurements at CERN-SPS NA61 (SHINE) experiment

- Measure hadron (π/K) production from C
  - to predict
    - Near and far energy spectra (<2~3%)
    - Near to far spectrum extrapolation (<2~3%)
    - ν_e contami. (from K, μ) (<2~3%)



- **First data taking successfully finished in 2007 (1month)**
  - Beam: 30GeV proton
  - Thin target (2cm^t 4%int):~ 500k int.
  - Replica target (90cm, 80%int): ~180k int.
    - (Goal: 1M int. for both)
  - Intense analysis started



- Measurements in 2008 planned
  - DAQ rate: ~1Hz→ ~100Hz

➔ Marek's talk

Goal of NA61 for T2K

- ν_μ Far/Near ratio shape ~< 2~3%
- ν_e Far/Near ratio R(<1GeV), R(>1GeV) ~2~3%

	T2K goal	Error from F/N ratio	
		w/o NA61	w/ NA61
$\delta(N_{bg})$ for ν_e app.	10%	15%	<4%
$\delta(\sin^2 2\theta_{23})$	1%	1.5~3%	0.5%
$\delta(\Delta m_{23}^2)[10^{-4}eV^2]$	1	0.5~1	0.15

- ~200k good recon'ed pion tracks give sufficient precision

Based on Ken Sakashita's MC Studies

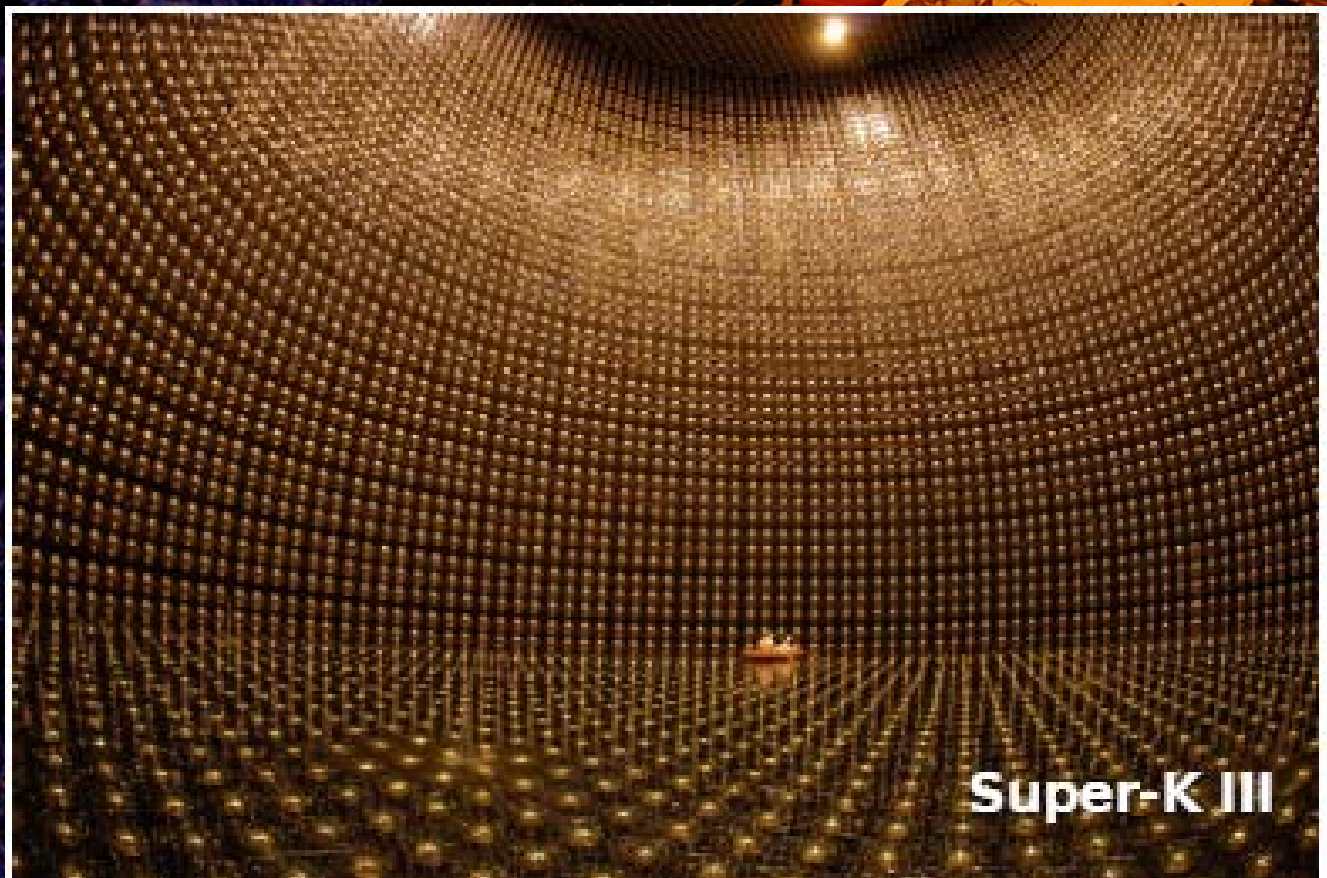
Summary of Status

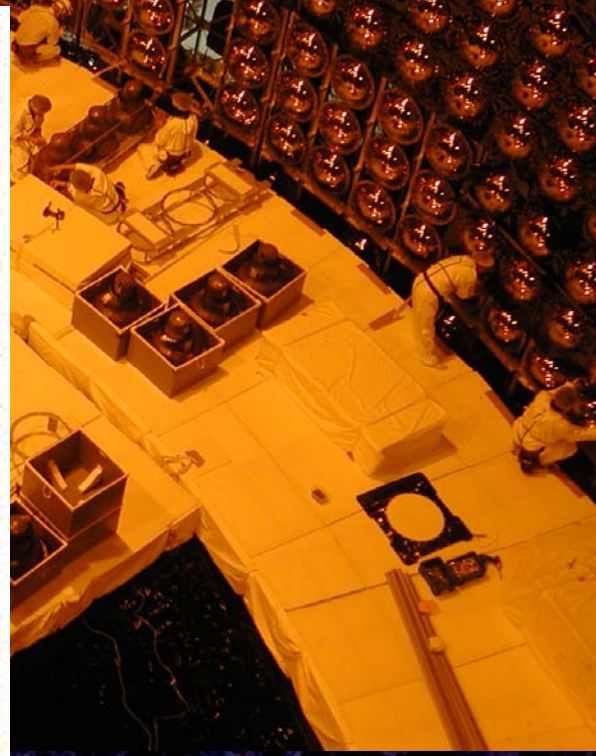
	Conceptual Design	Engineering Design	Real Production	Installation
Proton Beam monitor				Feb.~
Superconducting magnets				Feb~
Cryogenics				Apr~
Normal Conducting magnets				
Vacuum system				
Target				Aug.~
Horn				Aug.~
Target Station				
Beam Window				Jul~
Decay Volume				
Beam Dump				Aug~
Muon monitor				08/09

- All components are in production phase
- Installations is starting as scheduled

Completion of the MLF Building

Super Kamiokande Rebuild





Dave Wark
Imperial College/RAL

DAQ System Upgrade in SK

- ***Motivations***
  - ***Stable DAQ for the next 10 ~ 20 years***
    - long-life electronics
    - lower power dissipation
  - ***Good Data Quality***
    - wide charge dynamic range
    - low noise electronics
  - ***Dead Time Free DAQ***
    - high speed AD conversion & data transfer
    - "recoding all hits of PMTs"
    - no dead time for higher rate Supernova bursts
- **R&D of electronics & online is underway.**

SK data flow @ T2K era

DAQ Electronics

Frontend

Data Merger

Software Trigger

Reformat System

Storage

Offline Analysis

~840 MB/s

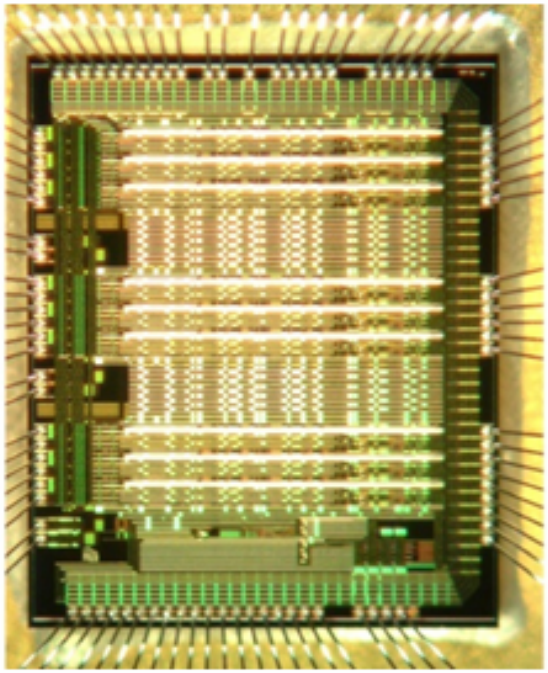
10~50MB/s (depend on analysis)

Collect ALL the hits,
Stamp GPS local timing
and send to Software Trigger

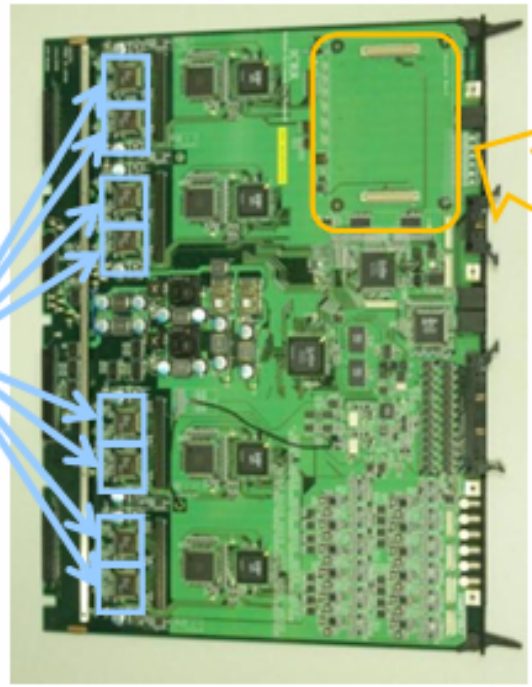
Apply 'Trigger' by software
- GPS based trigger for T2K
- Hitsum trigger for usual analysis
- Reconstructed vertex based trigger for the lower energy event analysis

Transfer and store reduced data

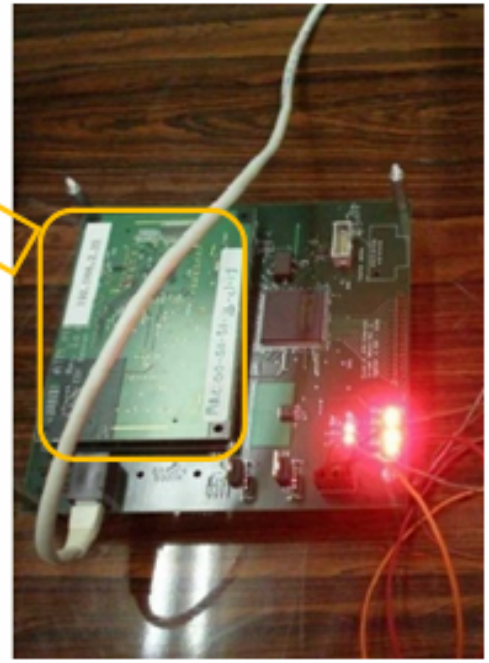
New Electronics Development in SK



QTC
(Charge to Time Converter)



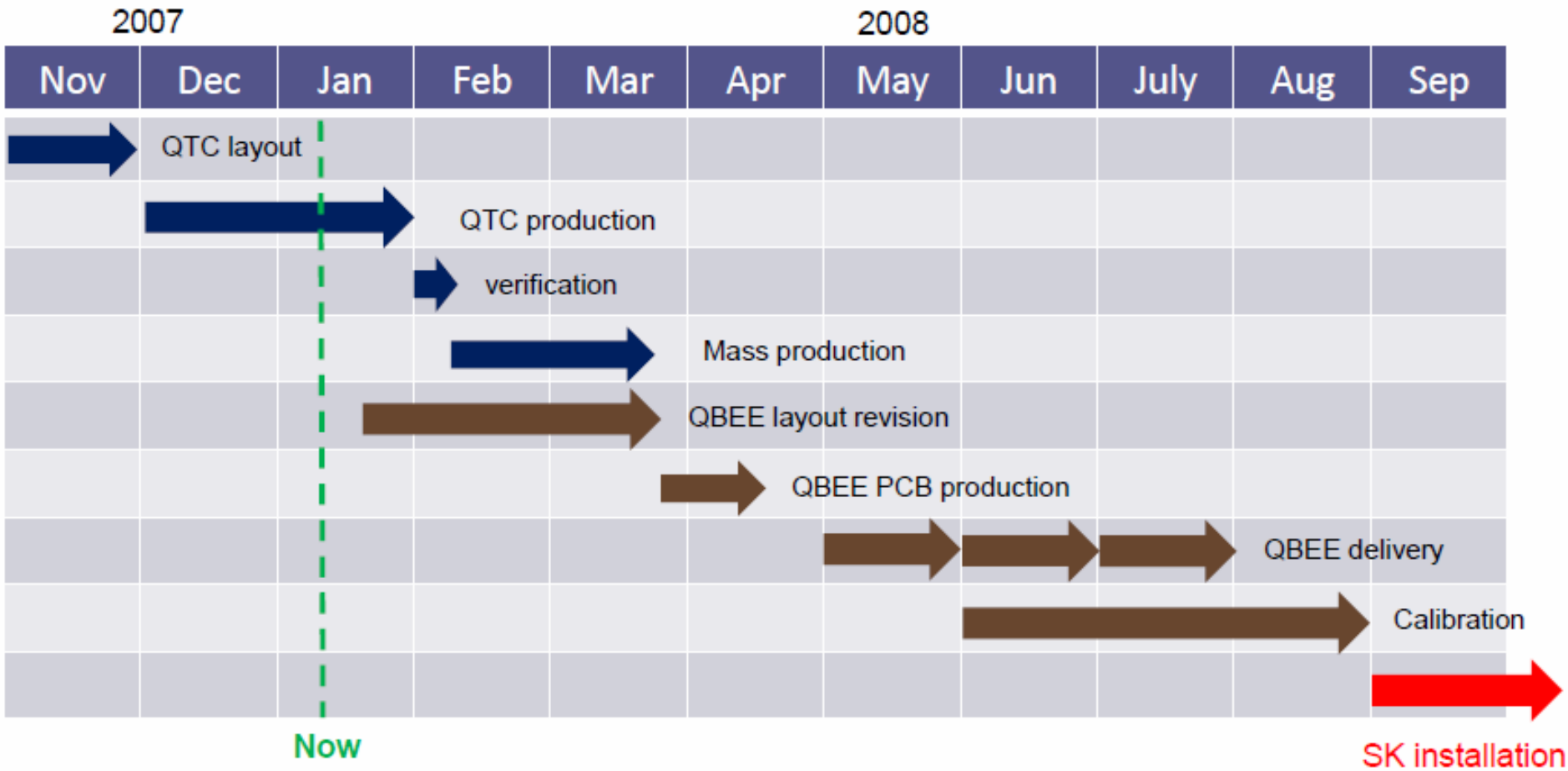
Front-End Board: Q-bee
= Qtc-based Electronics
with Ethernet



Readout Card for SiTCP
w/ Boston Univ.
& Uchida-san (Tokyo)

Clock & Trigger Generation & Distribution Modules

Schedule



QBEE will be delivered in May~July

SK installation from Sep. 2008
(three month delay from initial plan)