Nov. 11th, 2010
@IPMU

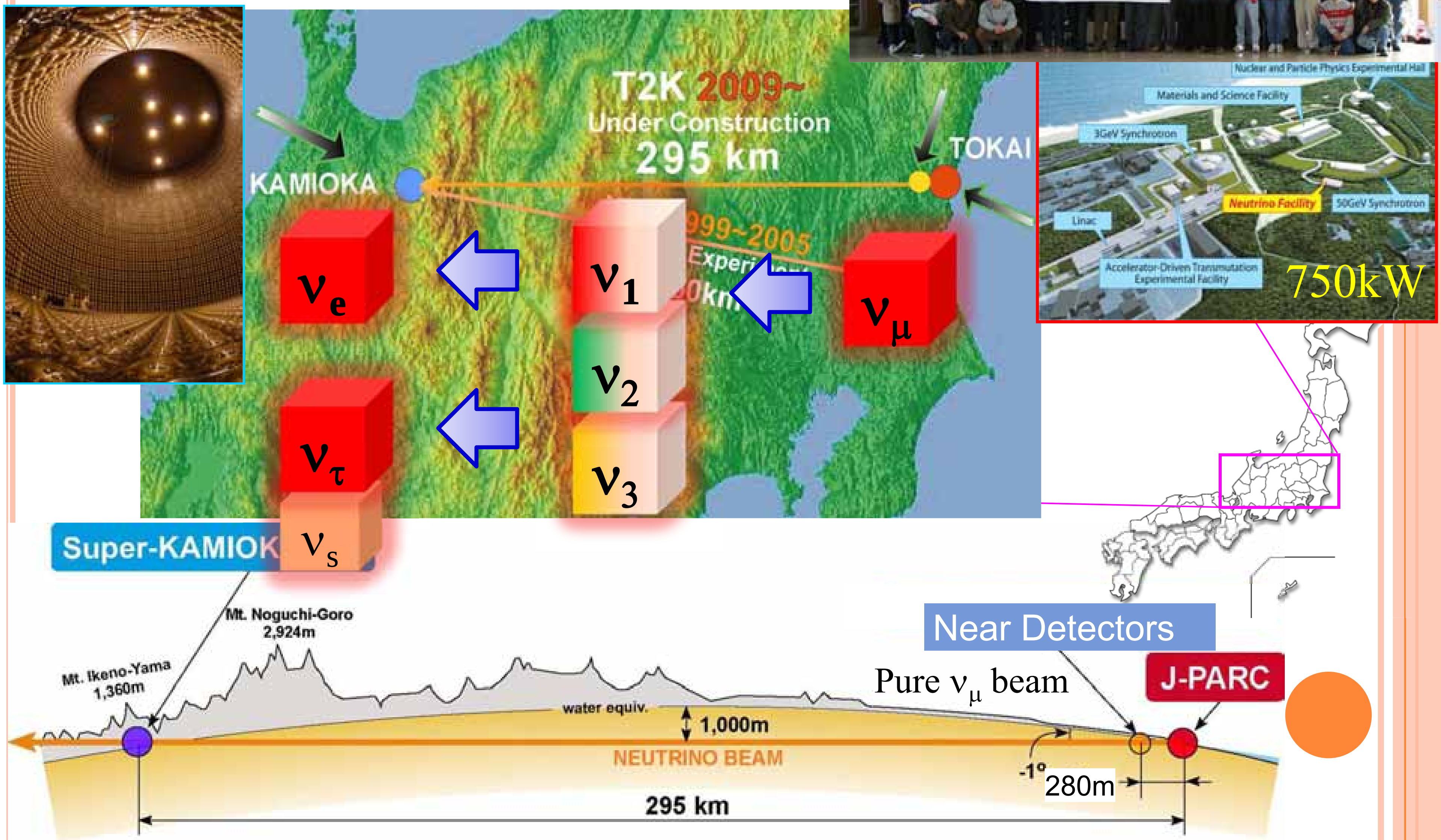
T2K and Beyond

T. Nakaya (Kyoto, IPMU)

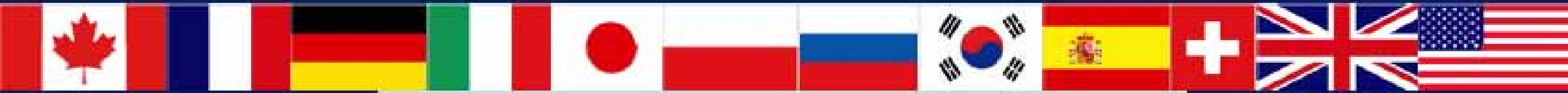
Outline

- Introduction to T2K
- Physics Sensitivity
- Experimental Overview
- T2K status
- Beyond

1. Introduction to T2K



The T2K Collaboration



~500 members, 62 institutes, 12 countries

Canada
TRIUMF
U. Alberta
U. B. Columbia
U. Regina
U. Toronto
U. Victoria
York U.

France
CEA Saclay
IPN Lyon
LLR E. Poly.
LPNHE Paris

Germany
U. Aachen

Italy
INFN, U. Roma
INFN, U. Napoli
INFN, U. Padova
INFN, U. Bari

Japan
Hiroshima U.
ICRR Kamioka
ICRR RCCN
KEK
Kobe U.
Kyoto U.
Miyagi U. Edu.
Osaka City U.
U. Tokyo

Poland
A. Soltan, Warsaw
H.Niewodniczanski, Cracow
T. U. Warsaw
U. Silesia, Katowice
U. Warsaw
U. Wroklaw

Russia
INR

S. Korea
N. U. Chonnam
U. Dongshin
U. Sejong
N. U. Seoul
U. Sungkyunkwan

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Liverpool U.
Oxford U.
Sheffield U.
Warwick U.
STFC/RAL
STFC/Daresbury

USA
Boston U.
B.N.L.
Colorado S. U.
Duke U.
Louisiana S. U.
Stony Brook U.
U. C. Irvine
U. Colorado
U. Pittsburgh
U. Rochester
U. Washington

BIRTH OF T2K

Letter of Intent:
A Long Baseline Neutrino Oscillation Experiment
using the JHF 50 GeV Proton-Synchrotron
and the Super-Kamiokande Detector

February 3, 2000

—V1.0—

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The JHF-Kamioka neutrino project

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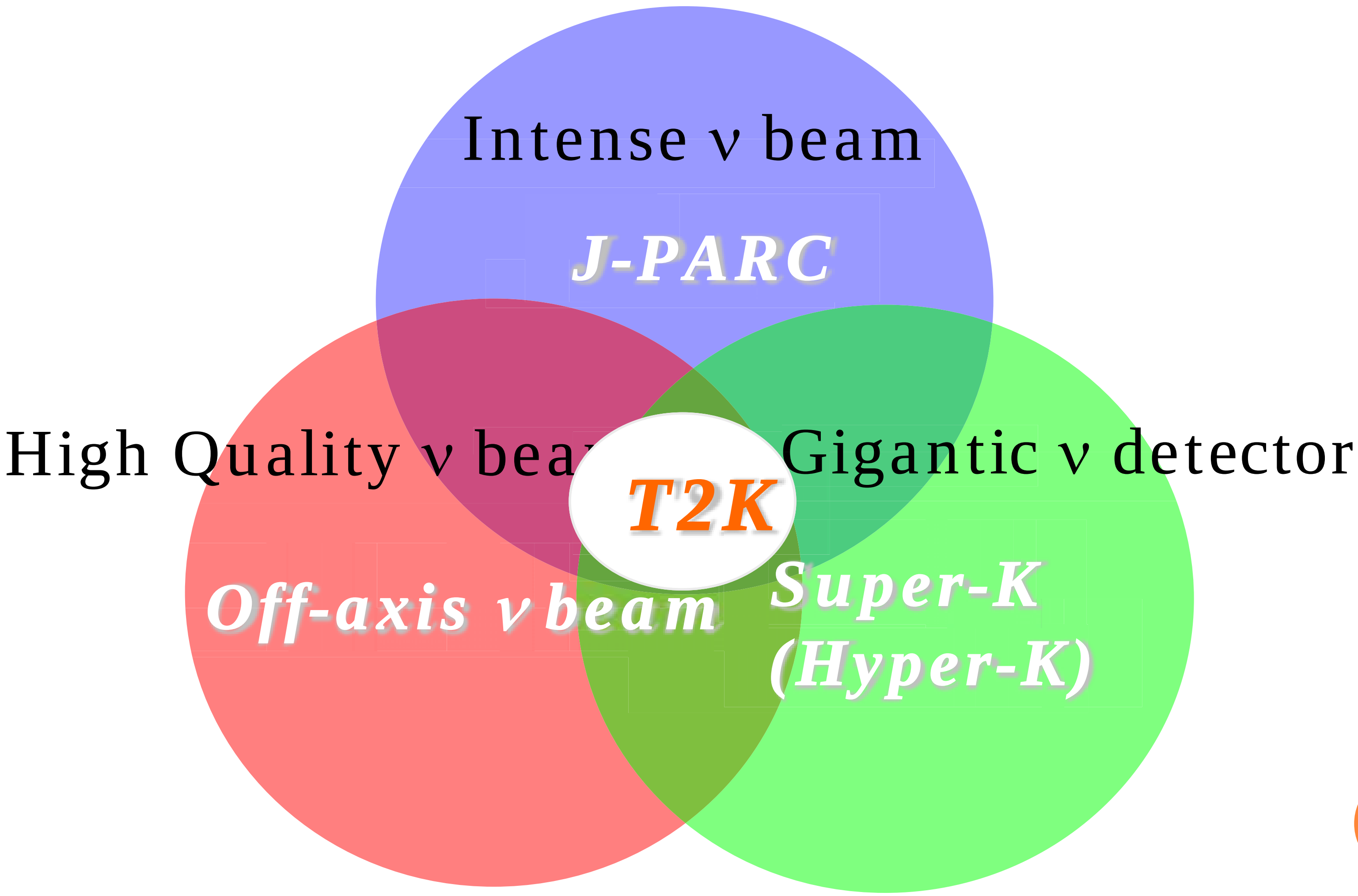
Abstract

The JHF-Kamioka neutrino project is a second generation long base line neutrino oscillation experiment that probes physics beyond the Standard Model by high precision measurements of

- **The JHF-Kamioka neutrino project.** hep-ex/0106019
  - *Citation: 690*

T2K Strategy



Mission of T2K

- **Discovery of ν_e appearance !**
  - A **new phenomenon**.
  - Complete the picture of **three generation mixing** scheme.
  - A window to study **CP violation** and mass-hierarchy.
- **Precision measurements of neutrino oscillation.**
  - Confirmation of standard neutrino oscillation scenario.

  => Precise determination of parameters?

  or

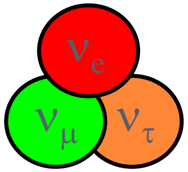
  => ***Probe new physics !***

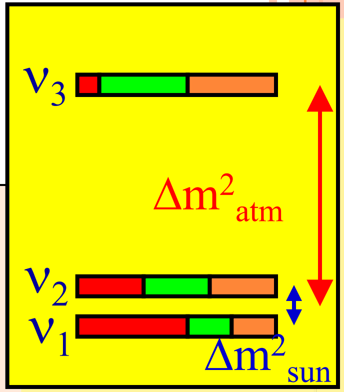
YOUR INTERESTS IN T2K

My personal guesses:

- When will T2K have the results?
- How is the J-PARC accelerator running?
- Is the option of anti-neutrino running?
- Does T2K have the sensitivity to the CP violation and the sign of Δm^2?
- What is the future upgrade (or successor) of T2K?

T2K Physics Sensitivity





Oscillation Probabilities when $\Delta m^2_{12} << \Delta m^2_{23} \approx \Delta m^2_{13}$

- θ_{23} : ν_μ disappearance

$$P_{\nu\mu\to\nu x} \approx 1 - \underbrace{\cos^4\theta_{13}}_{\sim 1} \cdot \sin^2 2\theta_{23} \cdot \sin^2\left(1.27\Delta m^2_{23} L / E_\nu\right)$$

common

- θ_{13}: ν_e appearance

$$P_{\nu\mu\to\nu e} \approx \underbrace{\sin^2\theta_{23}}_{\sim 0.5} \cdot \sin^2 2\theta_{13} \cdot \sin^2\left(1.27\Delta m^2_{23} L / E_\nu\right)$$

- δ : CP violation (T2K-beyond)

$$A_{CP} = \frac{P(\nu_\mu \to \nu_e) - P(\overline{\nu}_\mu \to \overline{\nu}_e)}{P(\nu_\mu \to \nu_e) + P(\overline{\nu}_\mu \to \overline{\nu}_e)} \cong \cdot$$

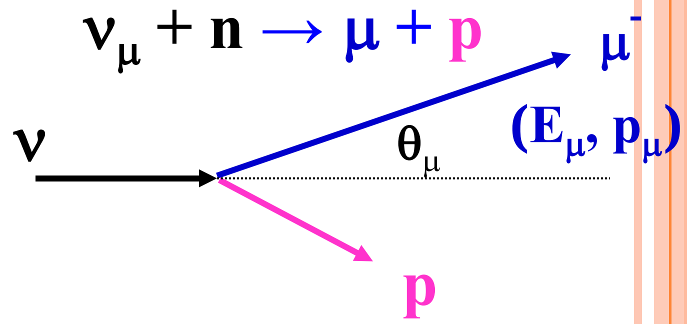
~0.18 ($\sin^2 2\theta_{13}$=0.1)
~0.58 ($\sin^2 2\theta_{13}$=0.01) $\cdot \sin\delta$

NOTE

- We are working to update the physics sensitivity based on the current experimental condition with data collected so far. However, they are not ready yet. So, I show the sensitivity in our proposal.
- We plan to have the first physics results soon (target: within JFY2010).

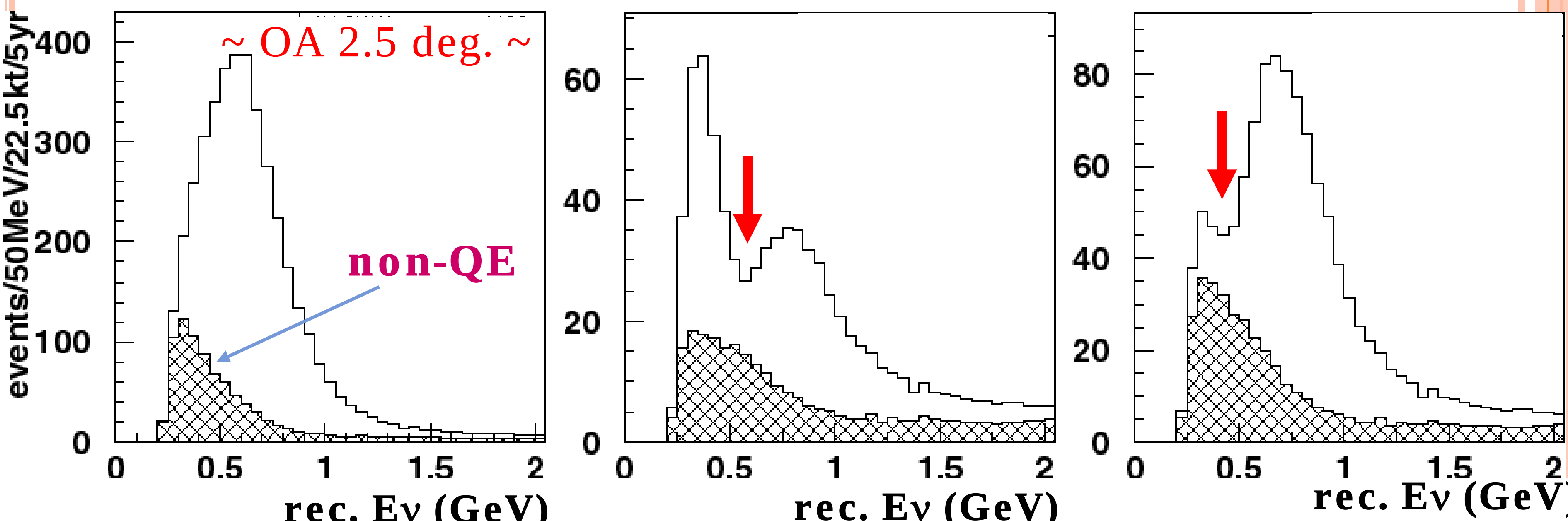
Measurement of θ_{23} , Δm_{23}^2

Use 1 ring μ-like events
(= **Quasi-Elastic** enhanced sample)
to reconstruct neutrino energy.



750kW 5 years

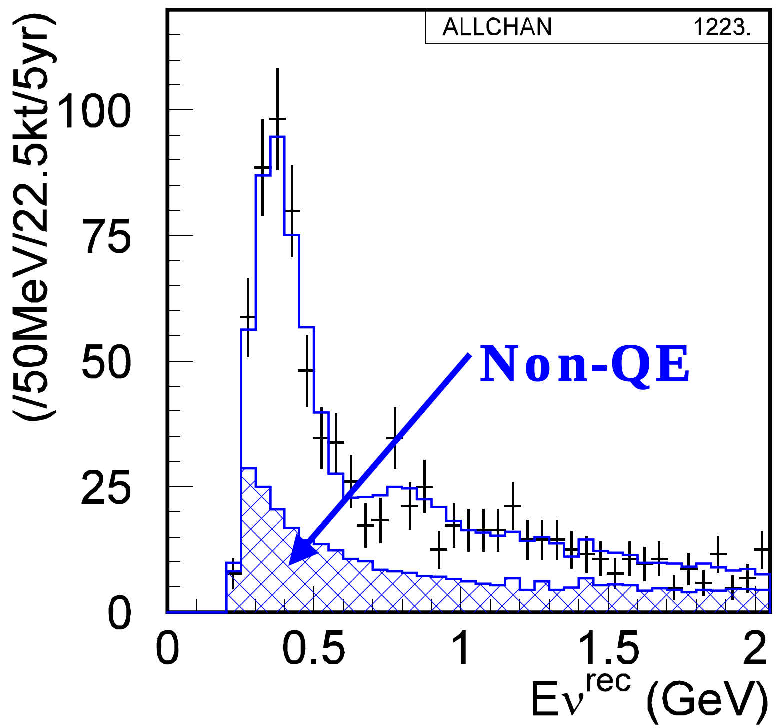
No oscillation **Δm^2= 2.5 x10^{-3} eV^2** **Δm^2= 2.0 x10^{-3} eV^2**



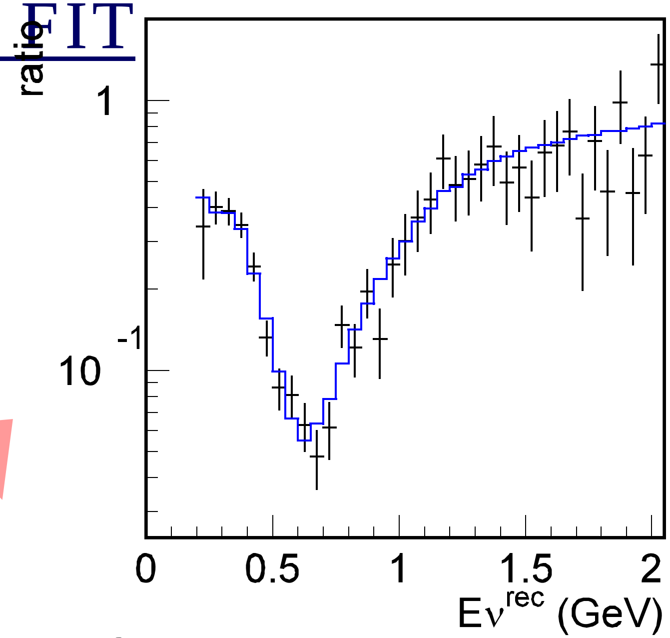
(assuming $\sin^2 2\theta_{23}$=1.0)

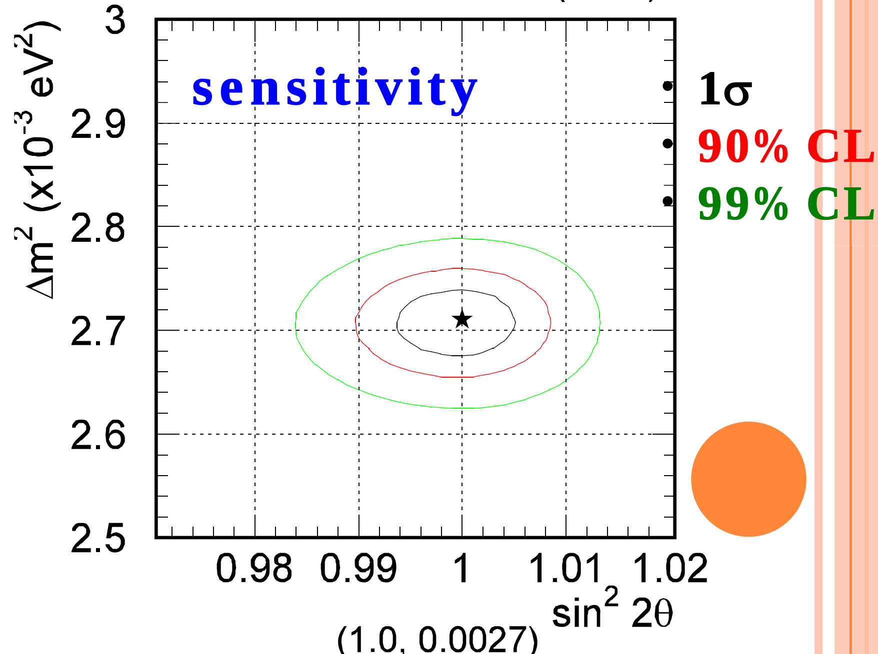
OSCILLATION PARAMETER FIT

Input:
$\sin^2 2\theta_{23} = 1.00$
$\Delta m^2 = 2.7 \times 10^{-3}\ eV^2$



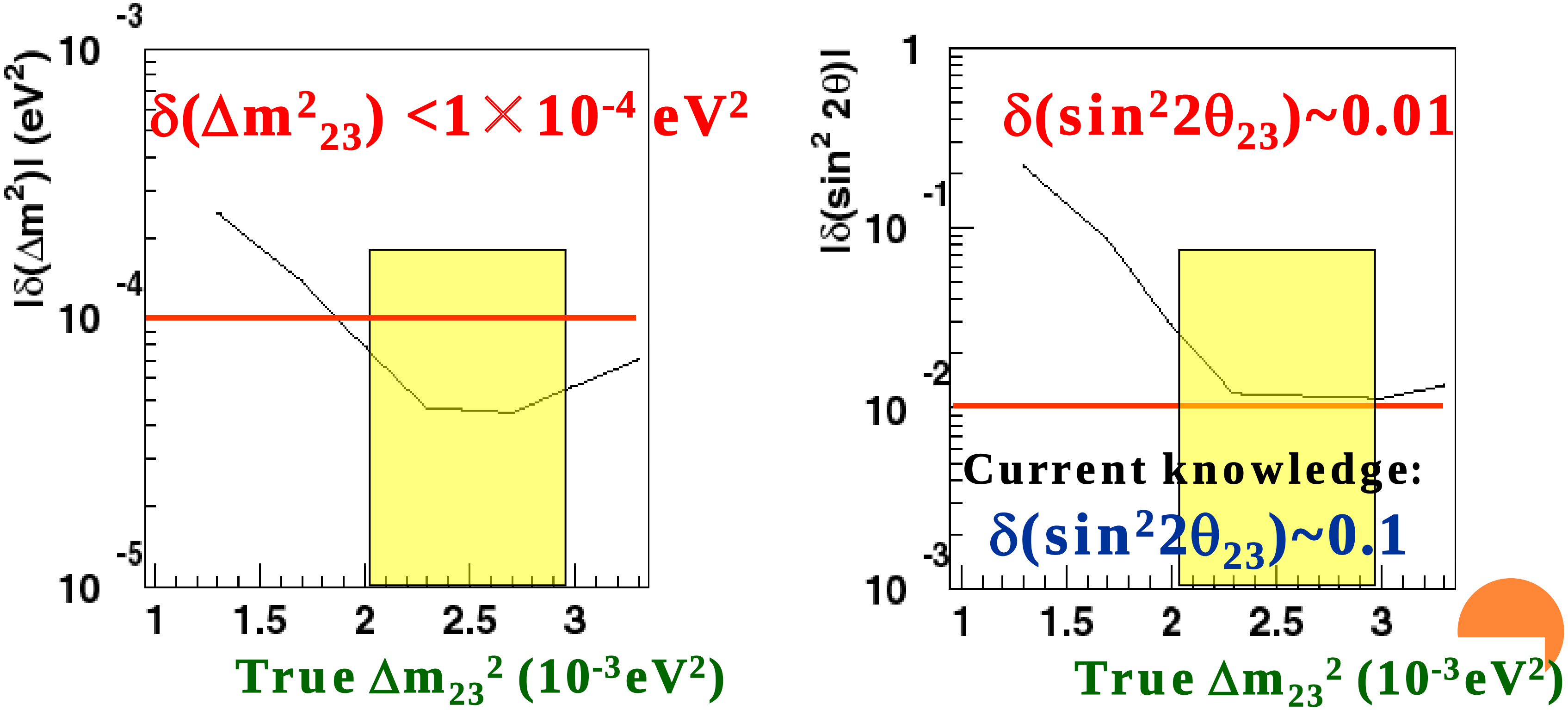
Ratio of E_ν to non-oscillation





T2K-I sensitivity with systematic errors

- normalization (5%)
- non-QE/QE ratio (5%)
- E scale (2%)
- Spectrum shape (20%)
- Spectrum width (5%)



θ_{13} measurement (ν_e appearance search)

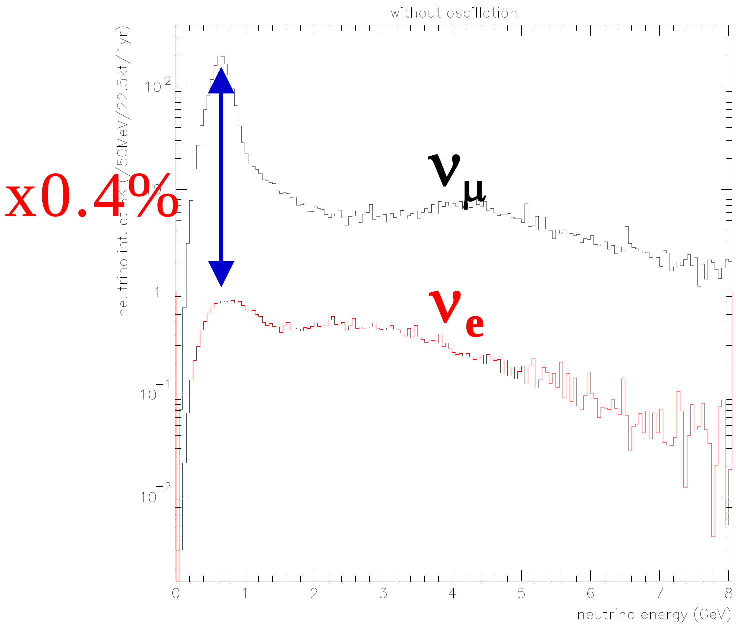
$\sin^2 2\theta_{23}=1$ and $\delta=0$ are assumed.

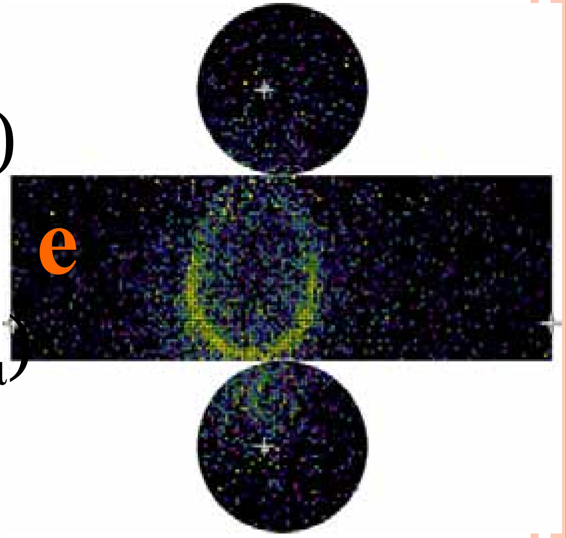
Signal:

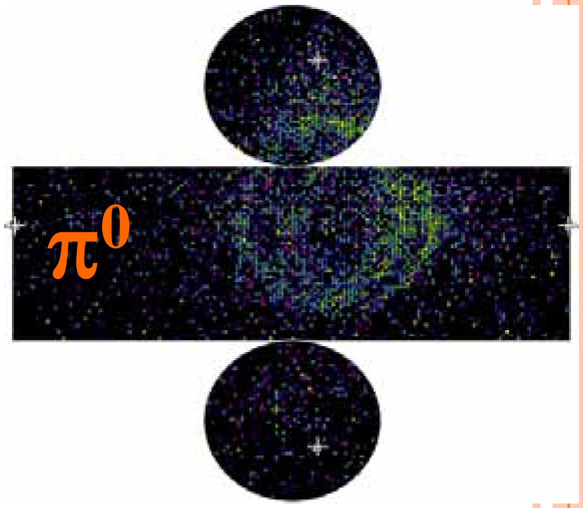
- 1ring e-like event (CC QE sample)

Background:

- beam ν_e contamination (0.4% of ν_μ)
- mis-reconstructed π^0 event



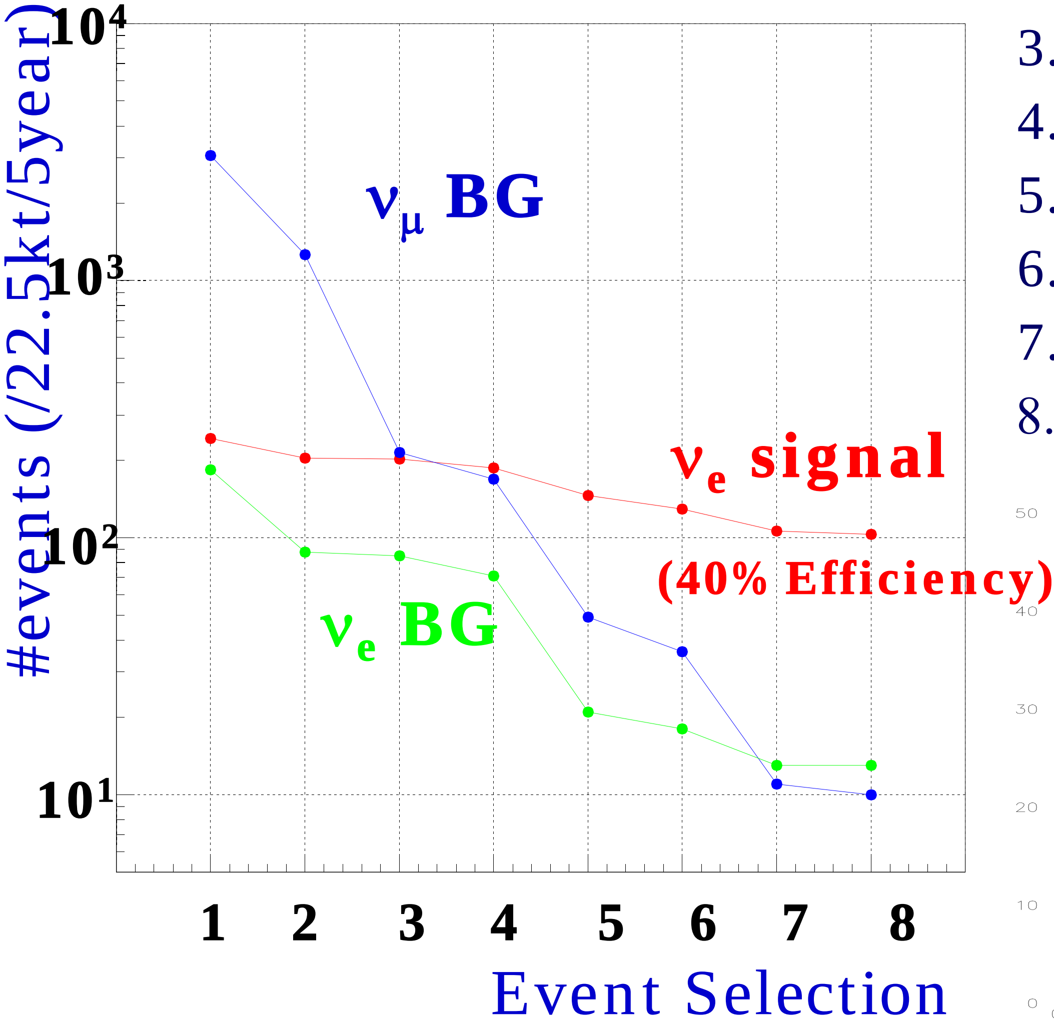


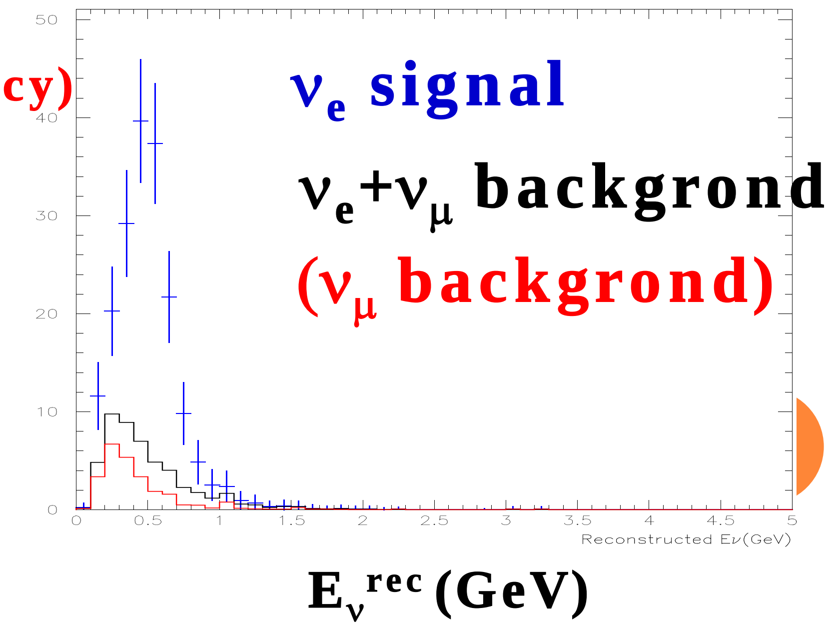


BACKGROUND SUPPRESSION

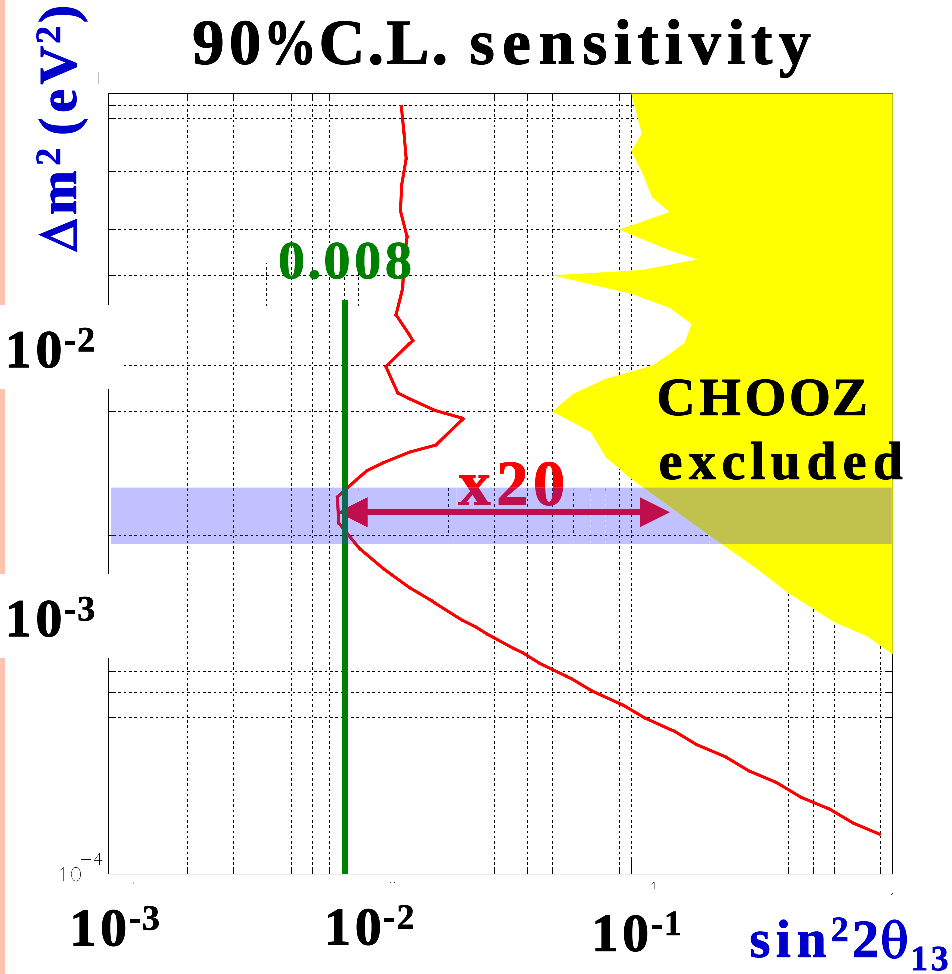
($\Delta M^2=2.5 \times 10^{-3} eV^2, \sin^2 2\Theta_{13}=0.1$)

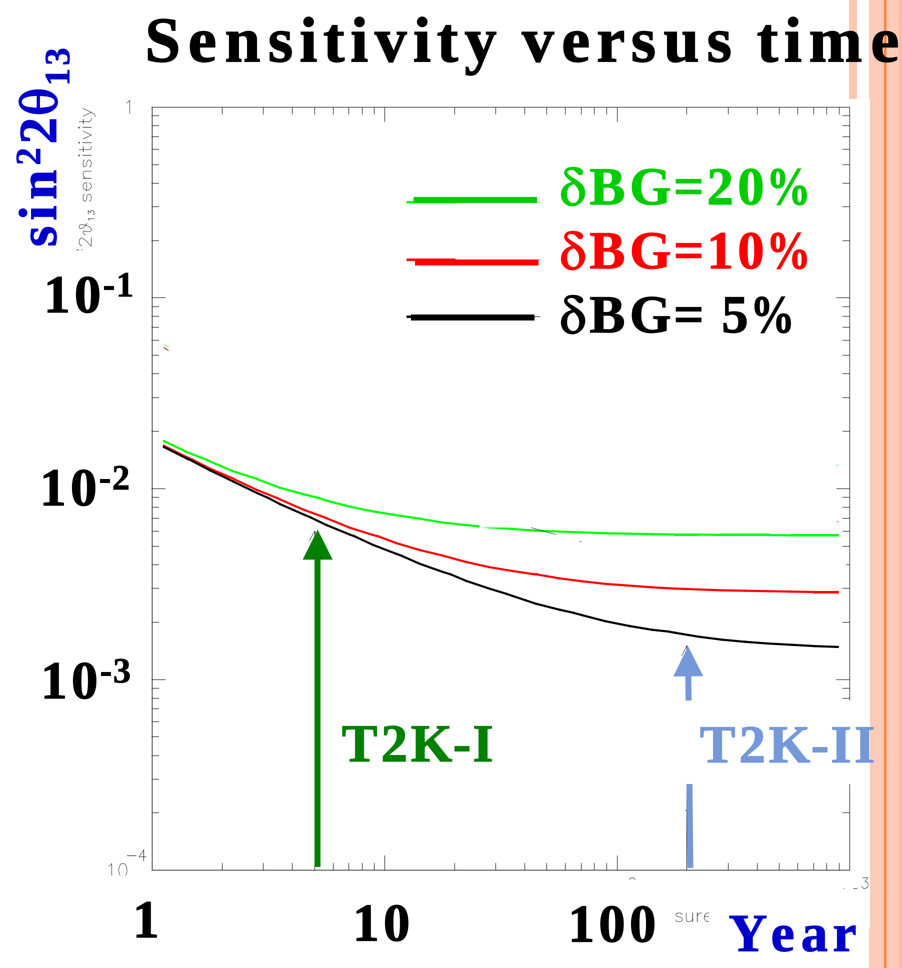
1. FCFV, $E_{vis.} > 100$MeV
2. single ring
3. e-like PID
4. no decay-electron
5. $0.35 < E_\nu^{rec} < 0.85$GeV
6. $\cos\theta_{\nu e} < 0.90$
7. $M_{\pi 0} < 100$MeV/c^2(π^0 fitter)
8. $\Delta L < 80$(π^0 fitter)





Θ_{13} Sensitivity (w/ ΔBG_{sys}=10%)

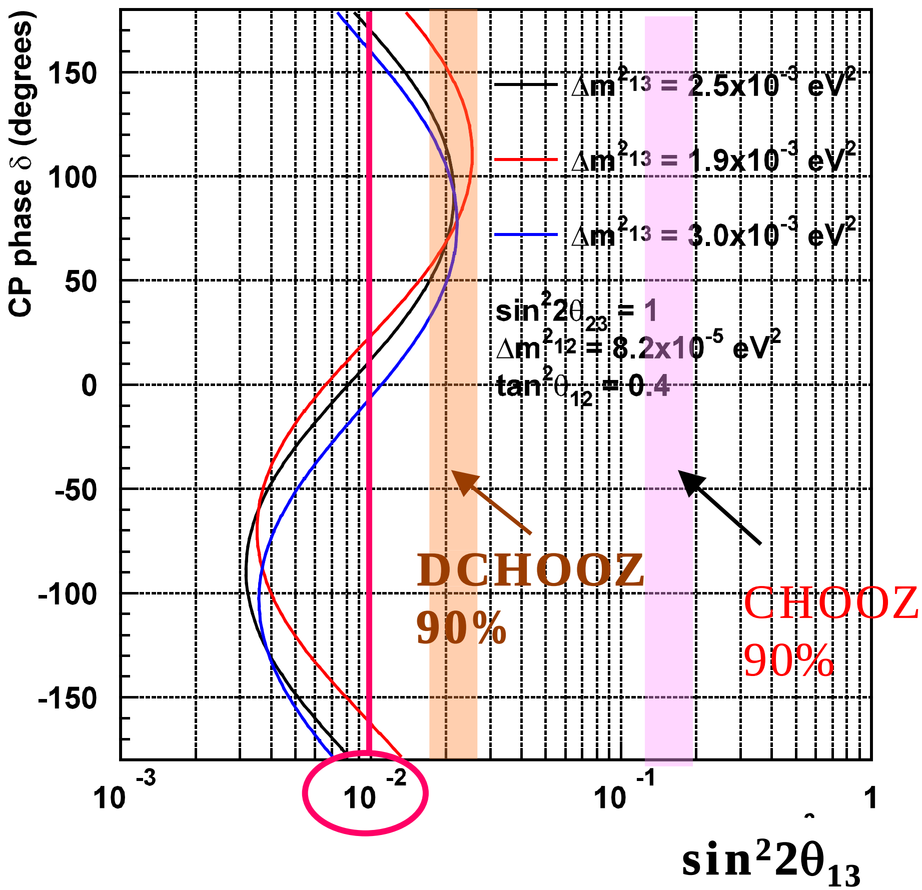


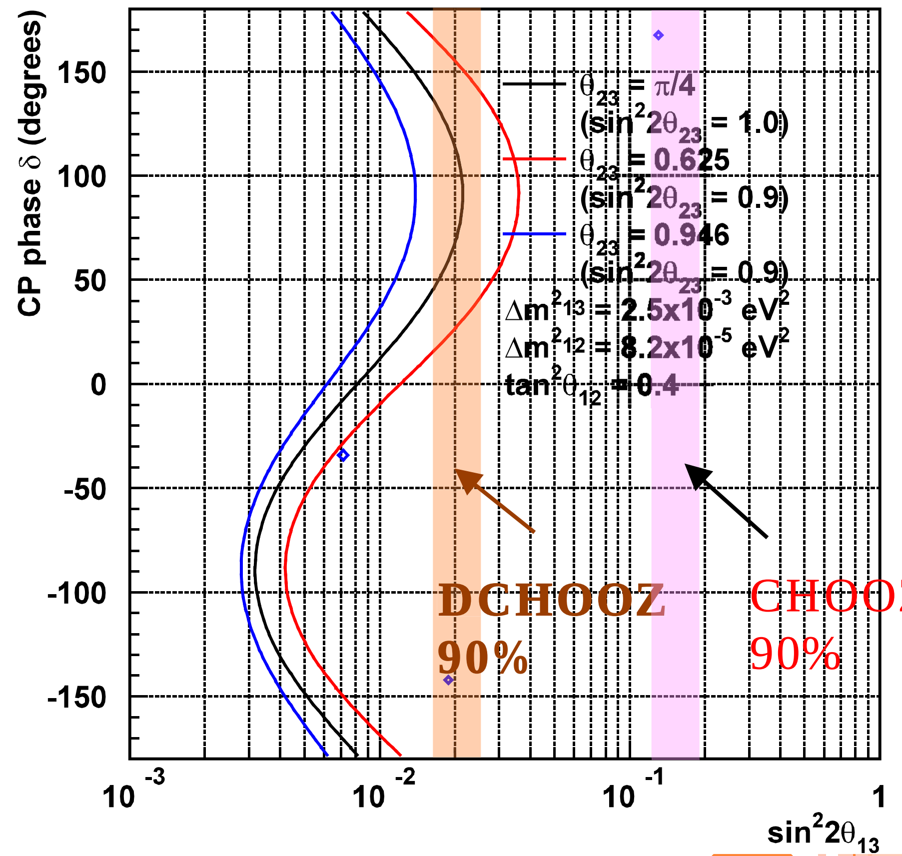


T2K Physics Sensitivity

ν_e appearance

(**Strong δ dependence**)

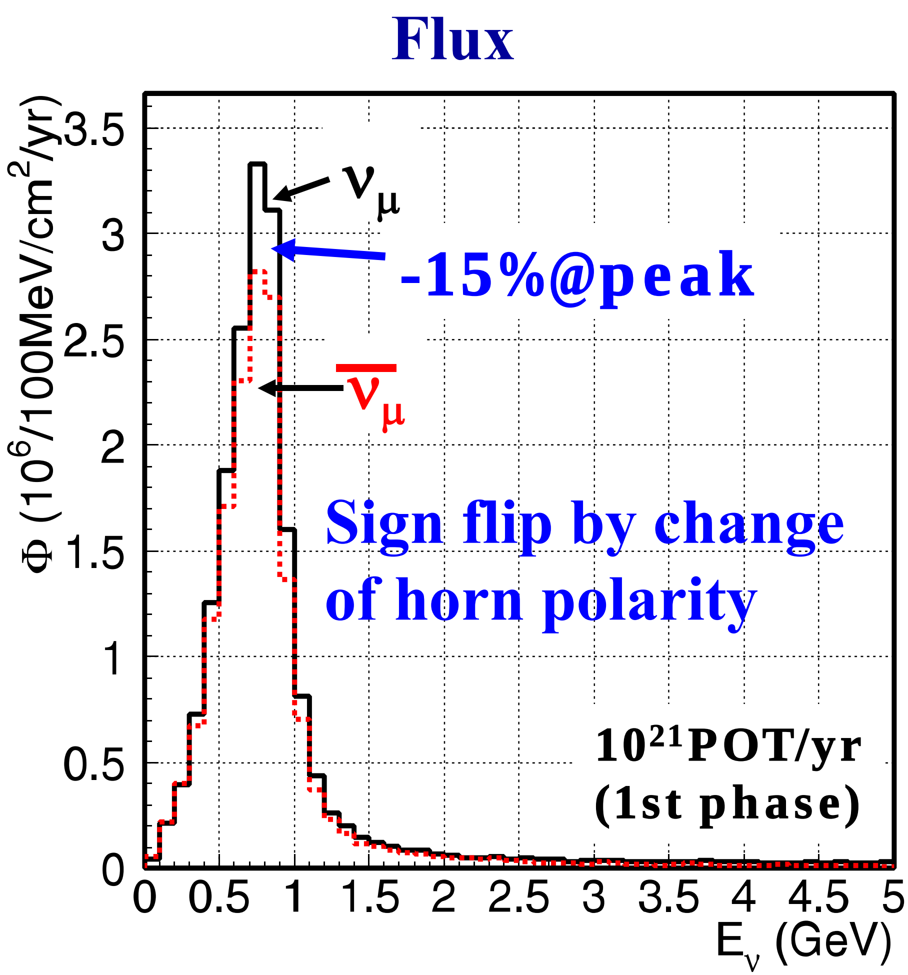


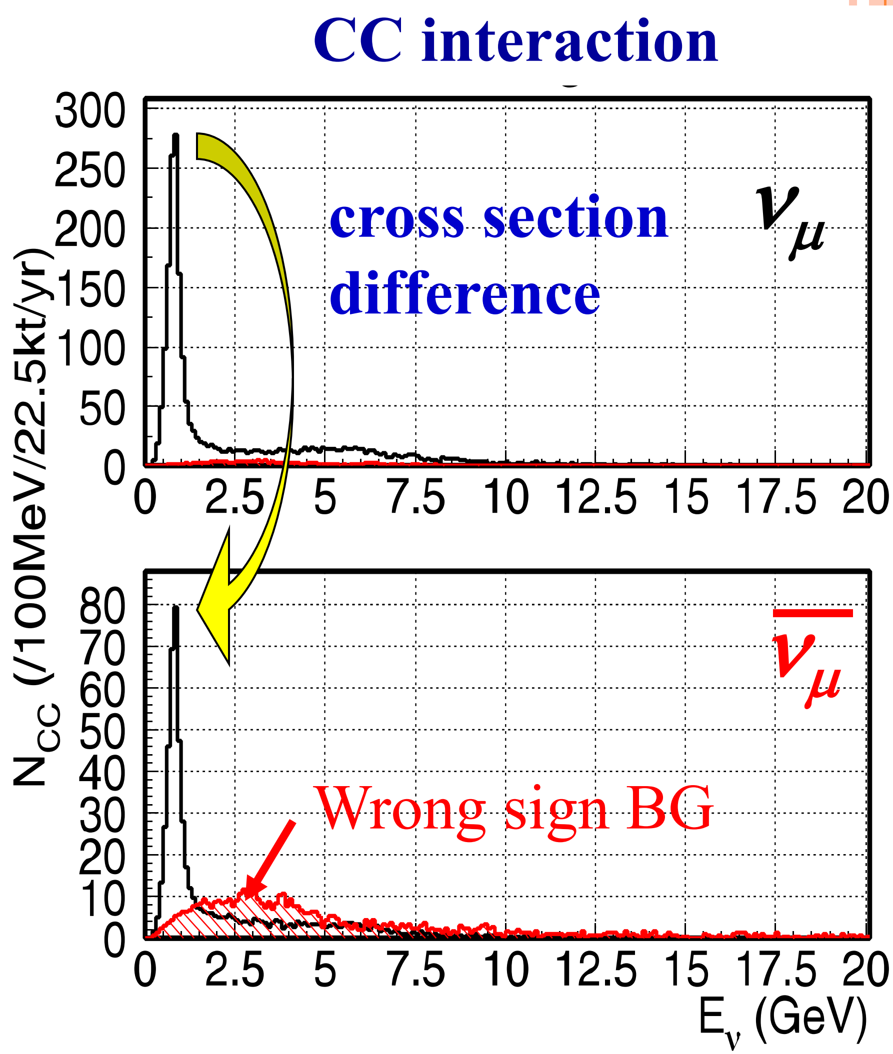


~10 times improvement from CHOOZ

CP VIOLATION STUDY $\bar{\nu}$ *beam is an option*

(Note: Old study with 2 off-axis)



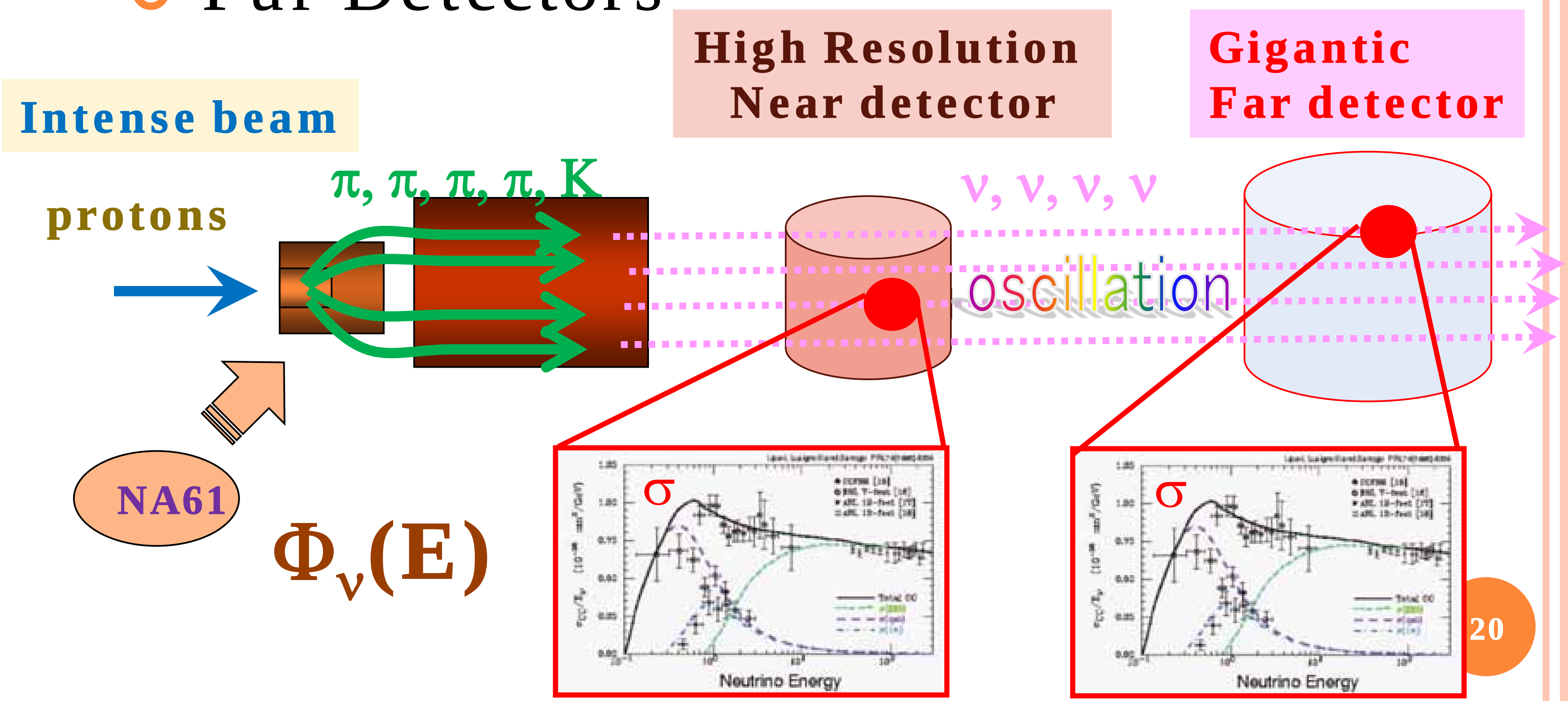


T2K Physics summary with future options

- Probe θ_{13} by looking for ν_e appearance.
- Precision measurements of θ_{23} and Δm^2_{23}.
- Search for sterile neutrinos by measuring the neutral current interactions.
- Look for the difference of between ν oscillation and $\bar{\nu}$.
  - CP violation (δ in the MNS matrix or new interactions)

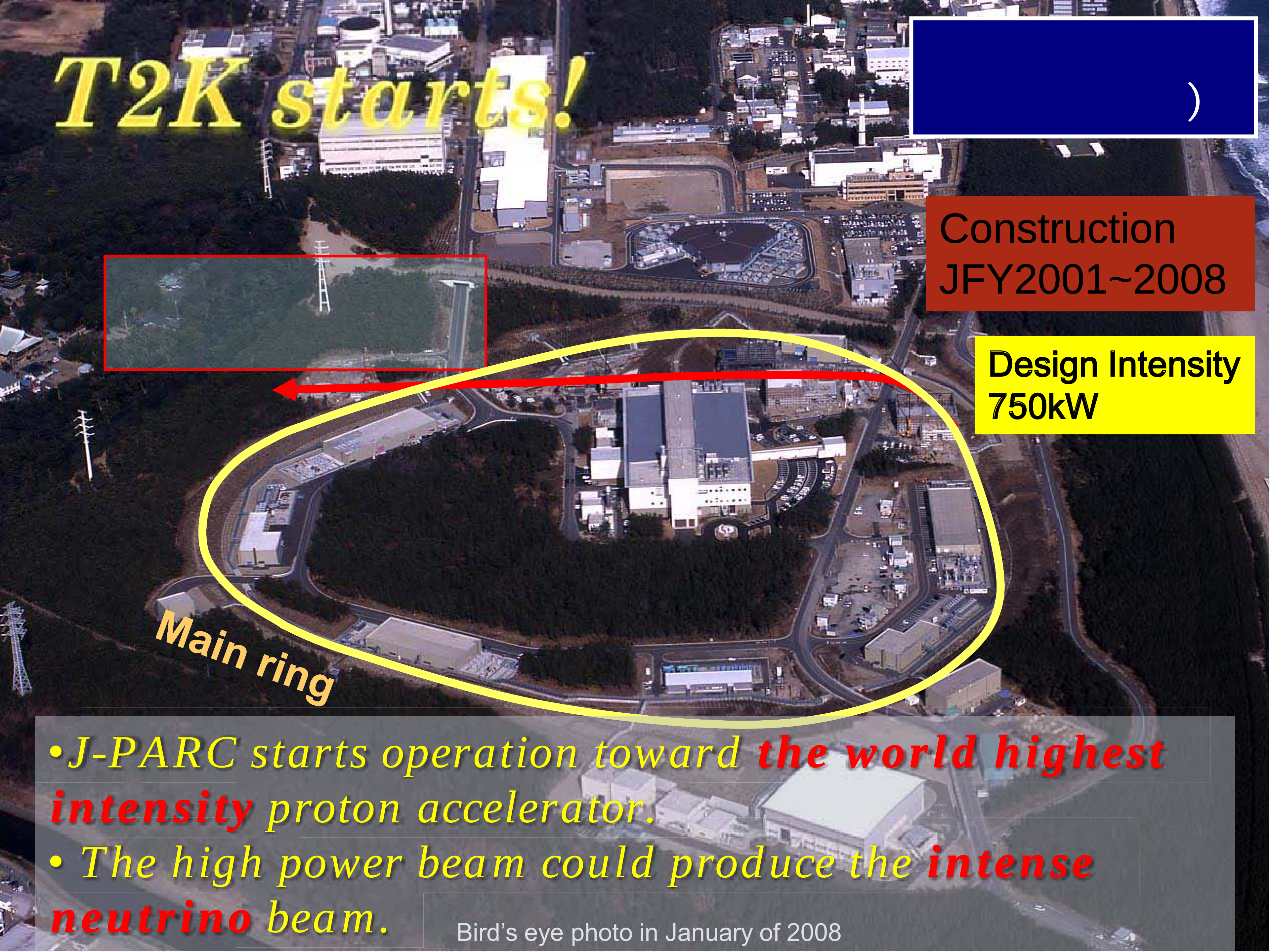
3. Experimental Overview

- Accelerator/Neutrino Beams
- Near Detectors
- Far Detectors



	T2K (construction: 2004~2010)
Accelerator	J-PARC MR 750kW (design) **New**
Neutrino Beam	2.5 degree off-axis E_{peak}~700MeV **New**
Near Detector	Fine-Segmented multi-type detectors w/ magnetic field (w/ water target) **New**
Far Detector	Water Cherenkov 50ktons (22.5 kt fiducial) 295km away
Near/Far extrapolation	Hadron production is measured by CERN NA61 **New**

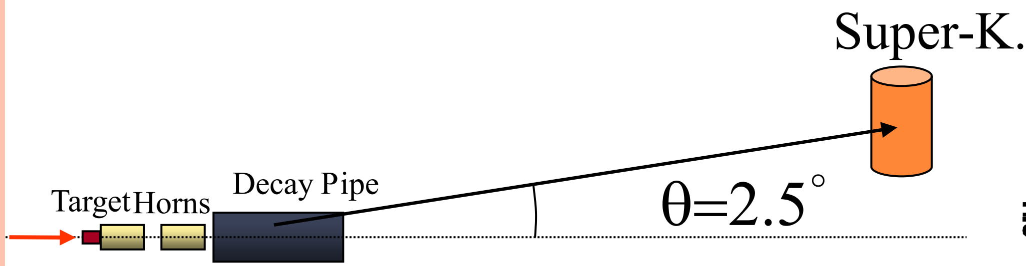
T2K starts!



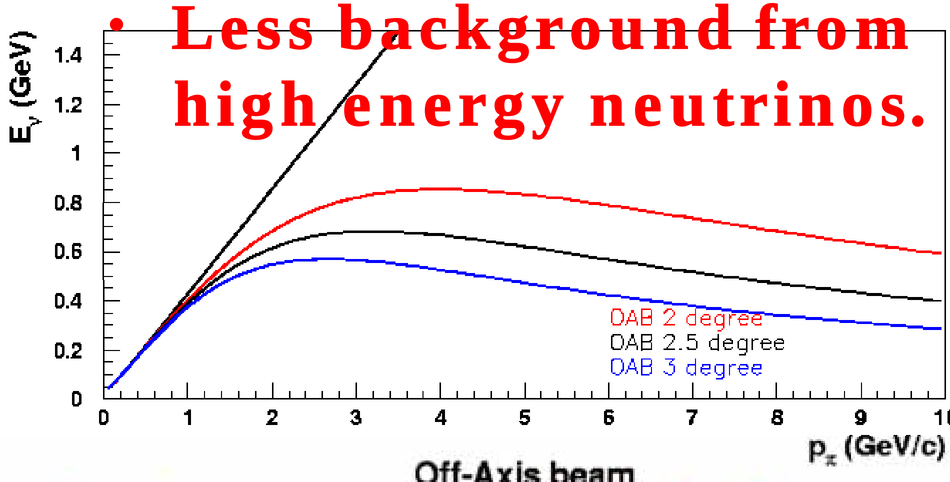
- *J-PARC starts operation toward* ***the world highest intensity*** *proton accelerator.*
- *The high power beam could produce the* ***intense neutrino*** *beam.*

Bird's eye photo in January of 2008

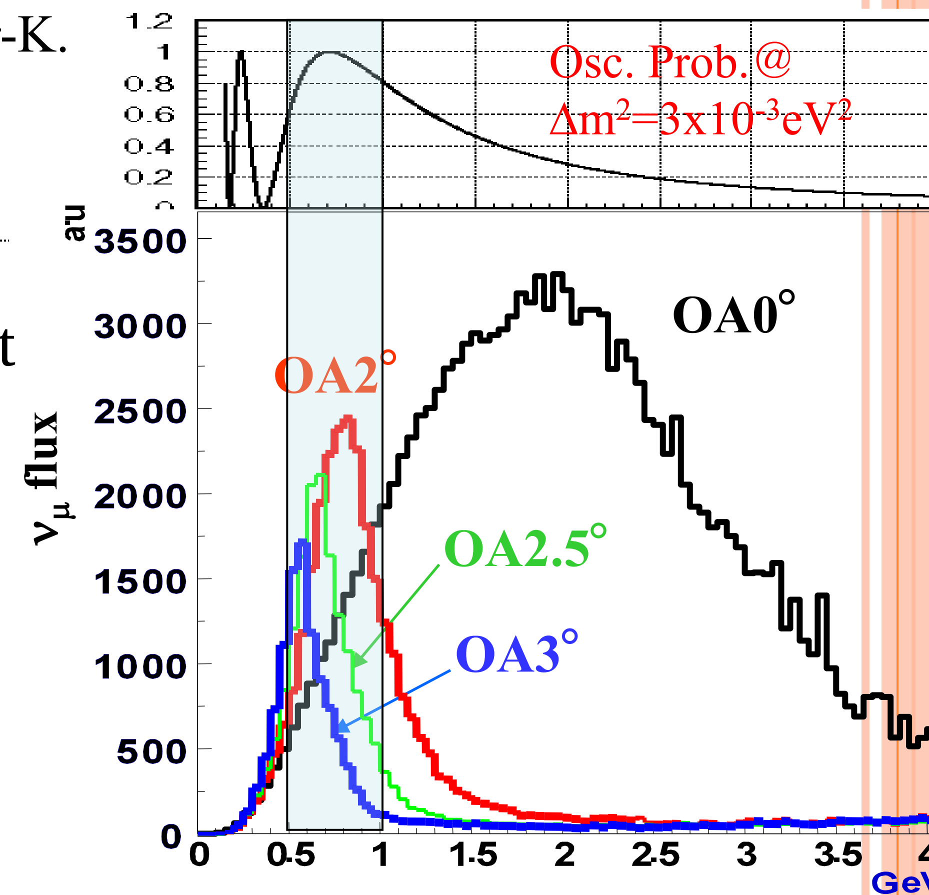
OFF-AXIS ν BEAM CONFIGURATION



- The ν beam energy is tuned at the oscillation maximum.
  - **Higher signal yield.**
  - **Less background from high energy neutrinos.**

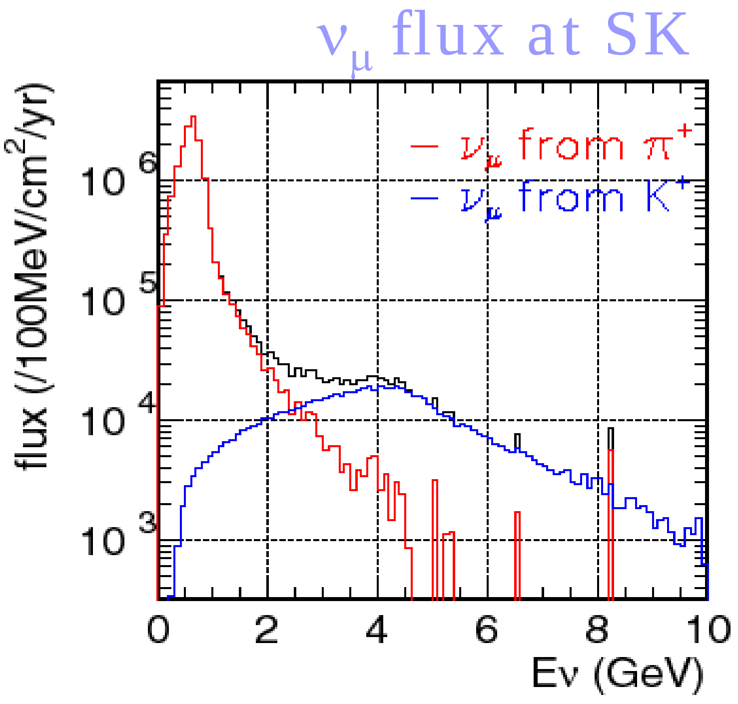


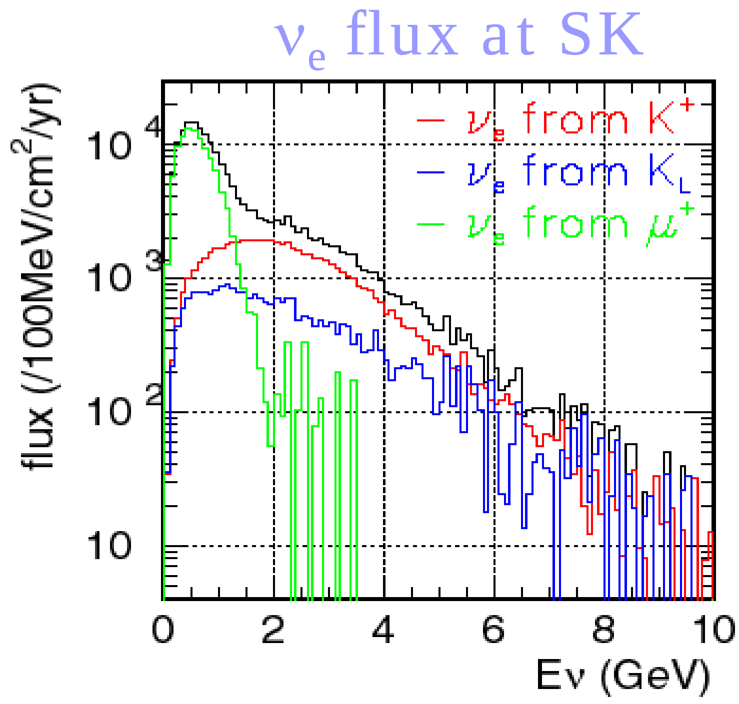
◆ **Quasi Monochromatic Beam**



Intense and high-quality neutrino beam

T2K Neutrino production mode

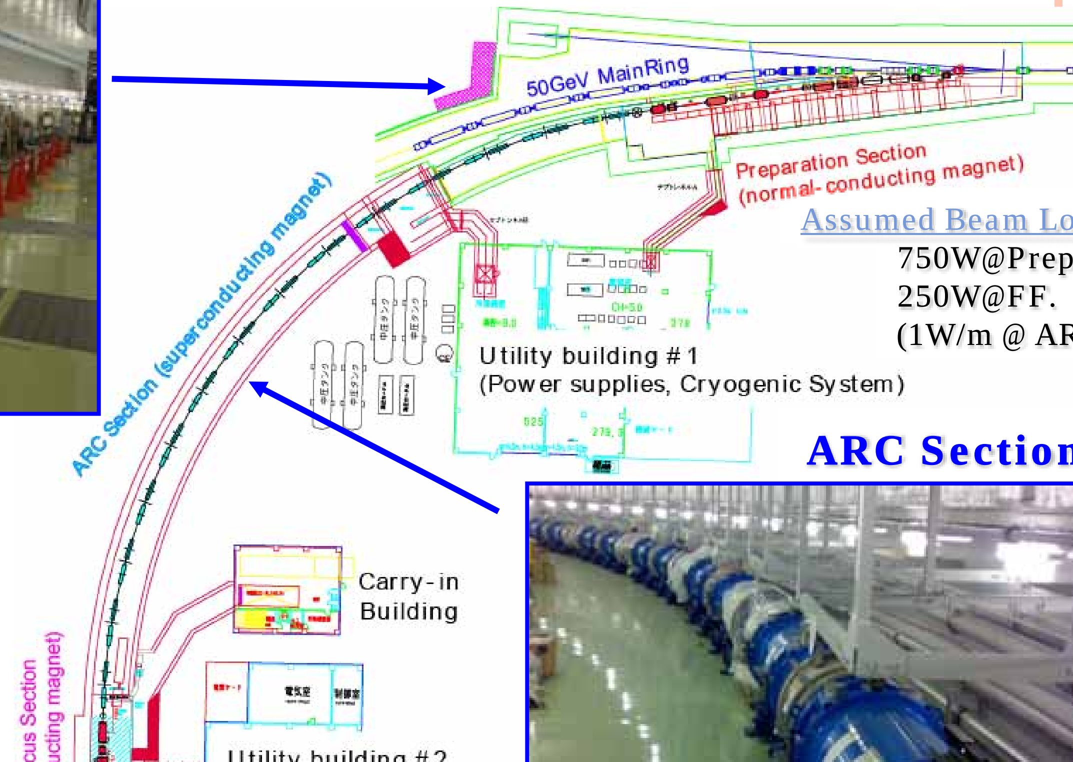




K / π = 0.052 @SK
= 0.047 @ND

K^+ / K_L / μ^+ = 32% / 14% / 54% @SK
= 29% / 13% / 59% @ND

PRIMARY BEAM-LINE



Preparation Section

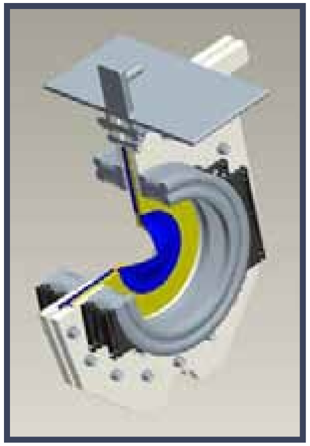
ARC Section

Final Focusing Section

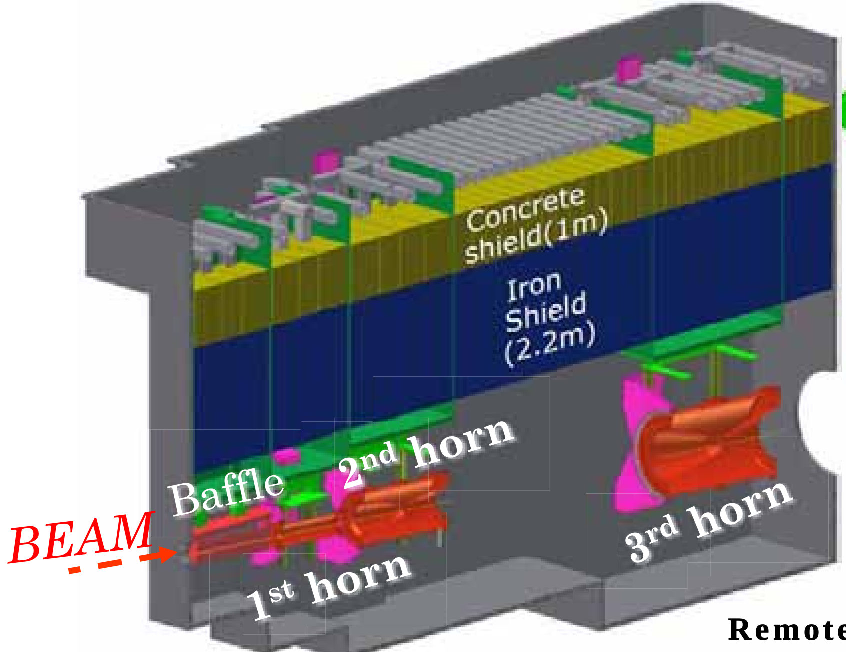
- Beam-line tunnel was completed in December 2006
- Installation finished in 2009

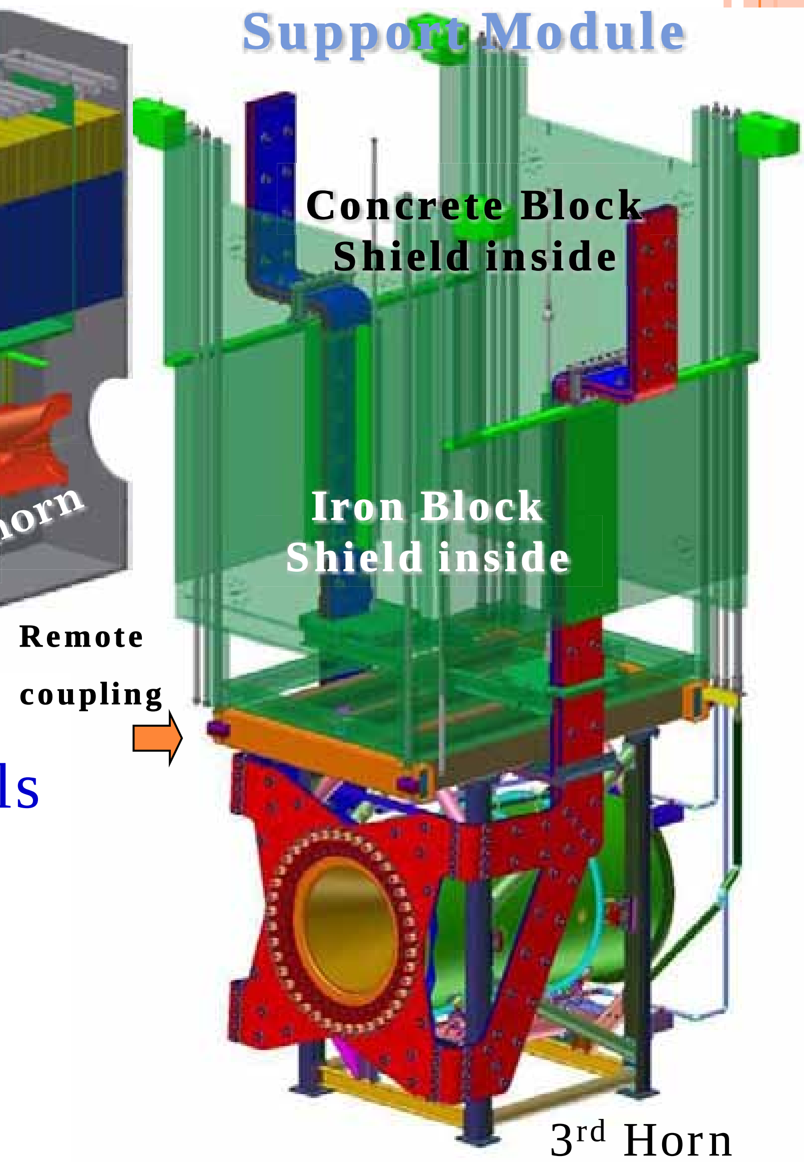
Target Station and horns

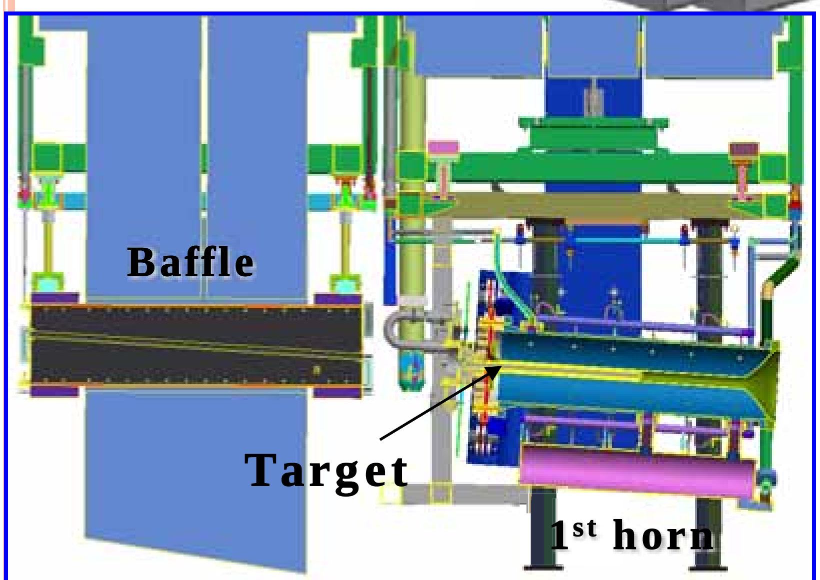
320kA current for the horn system



Beam Window
With pillow seal



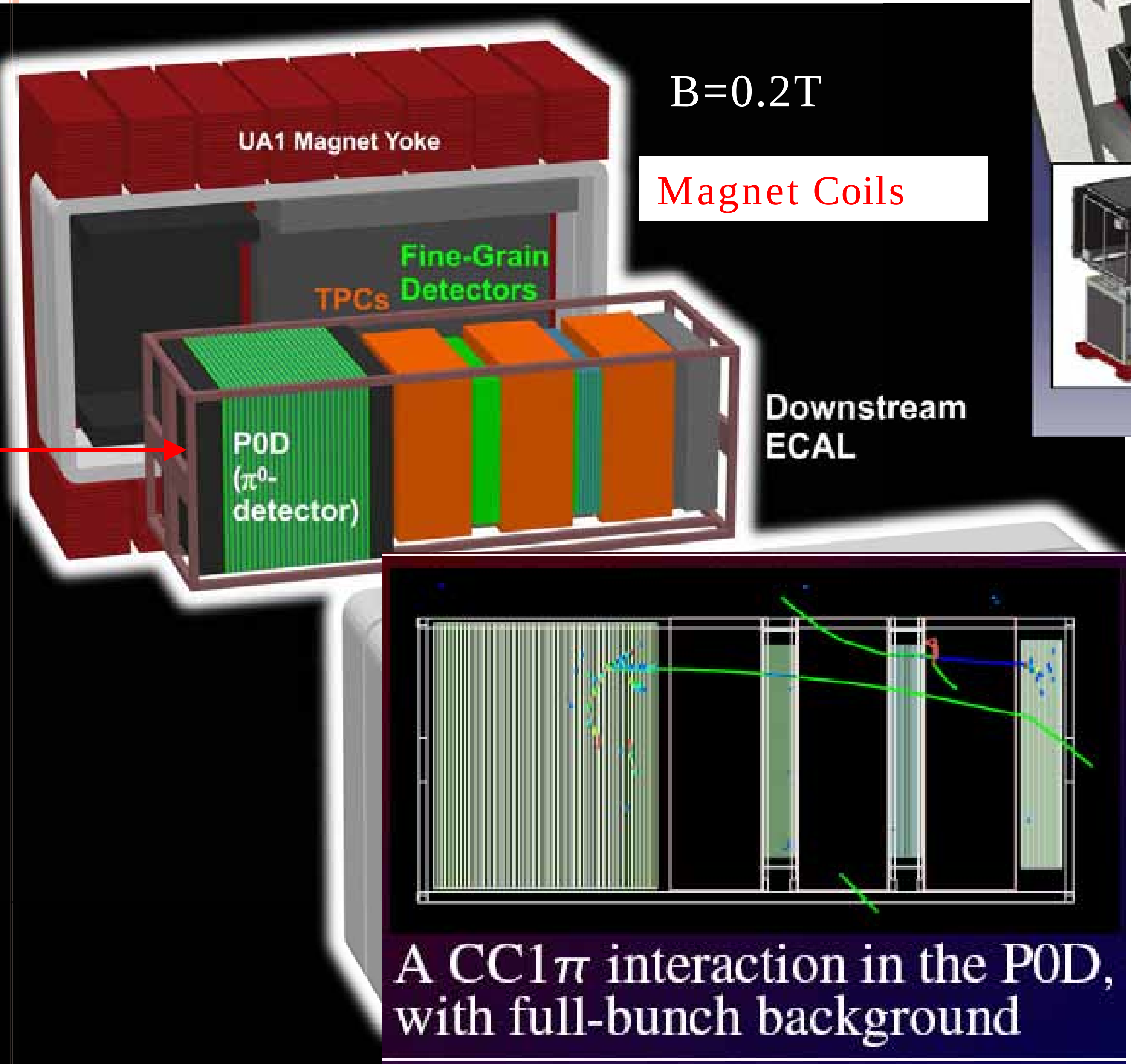


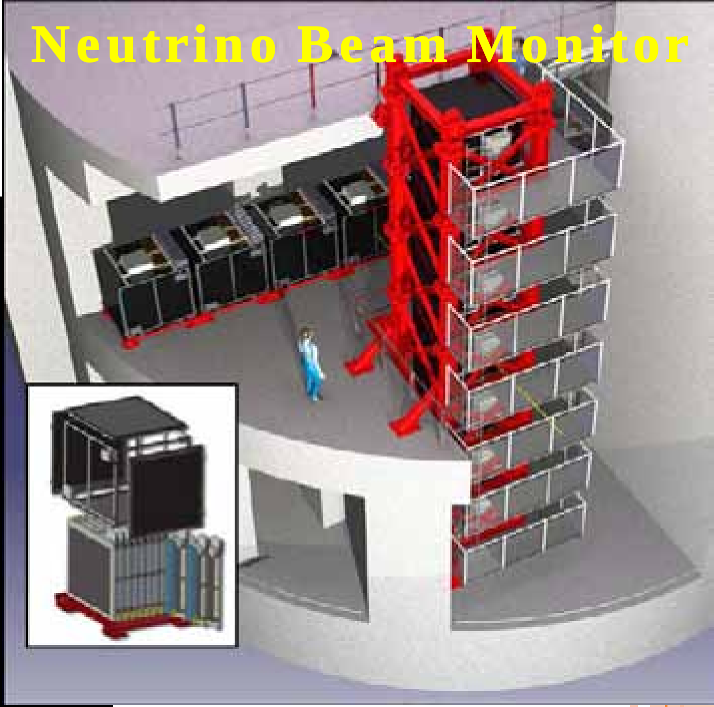


Huge
He vessels

ND280
(Near Neutrino Detectors)

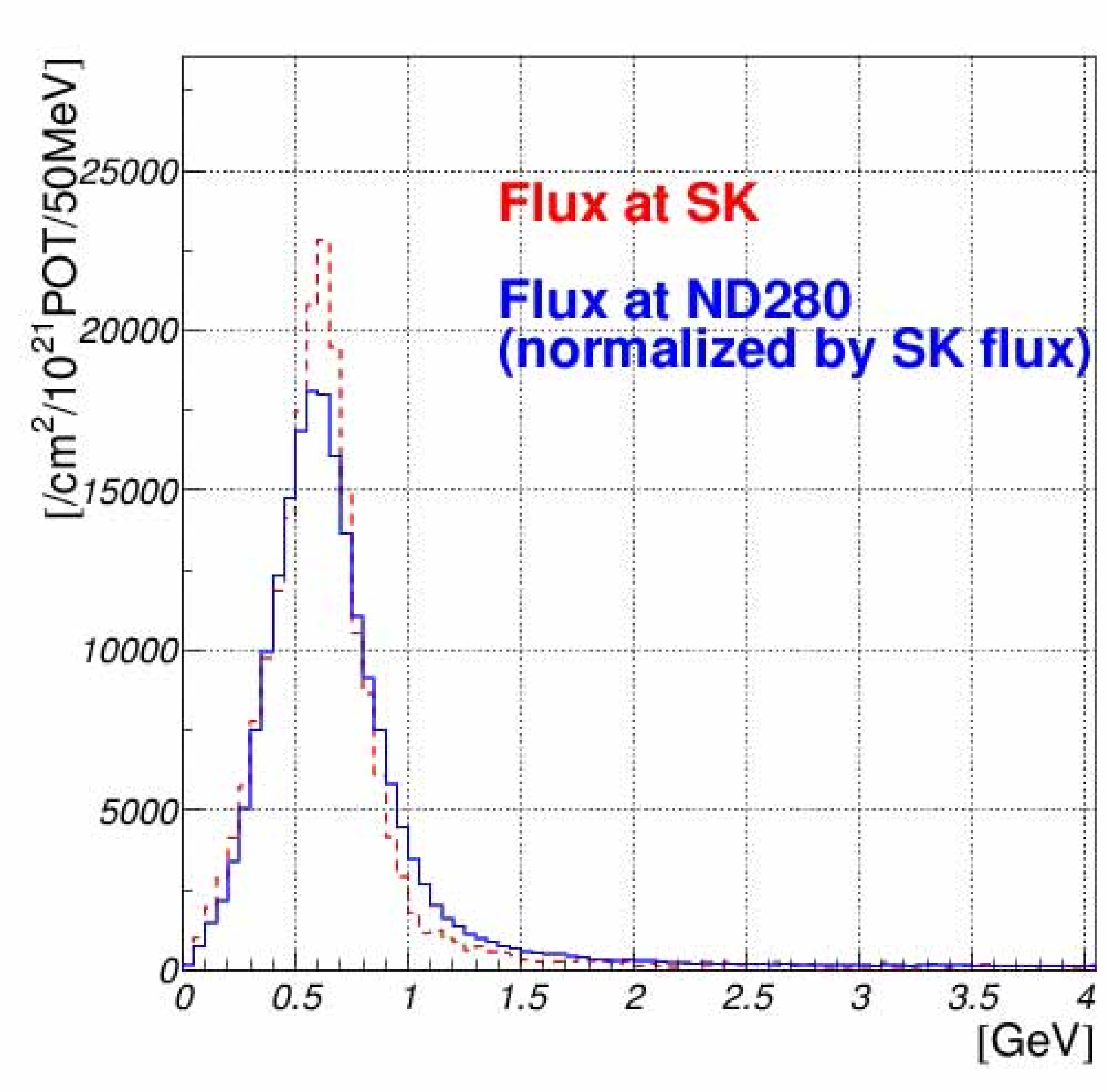
ND280 Off-axis





- Volume:
  - $3.5 \times 3.5 \times 7.0 m^3$
- **P0D:** π^0 Detector
- **FGD+TPC:** Charged Particle tracking
- **EM calorimeter**
- **Side-Muon-Range Detector**

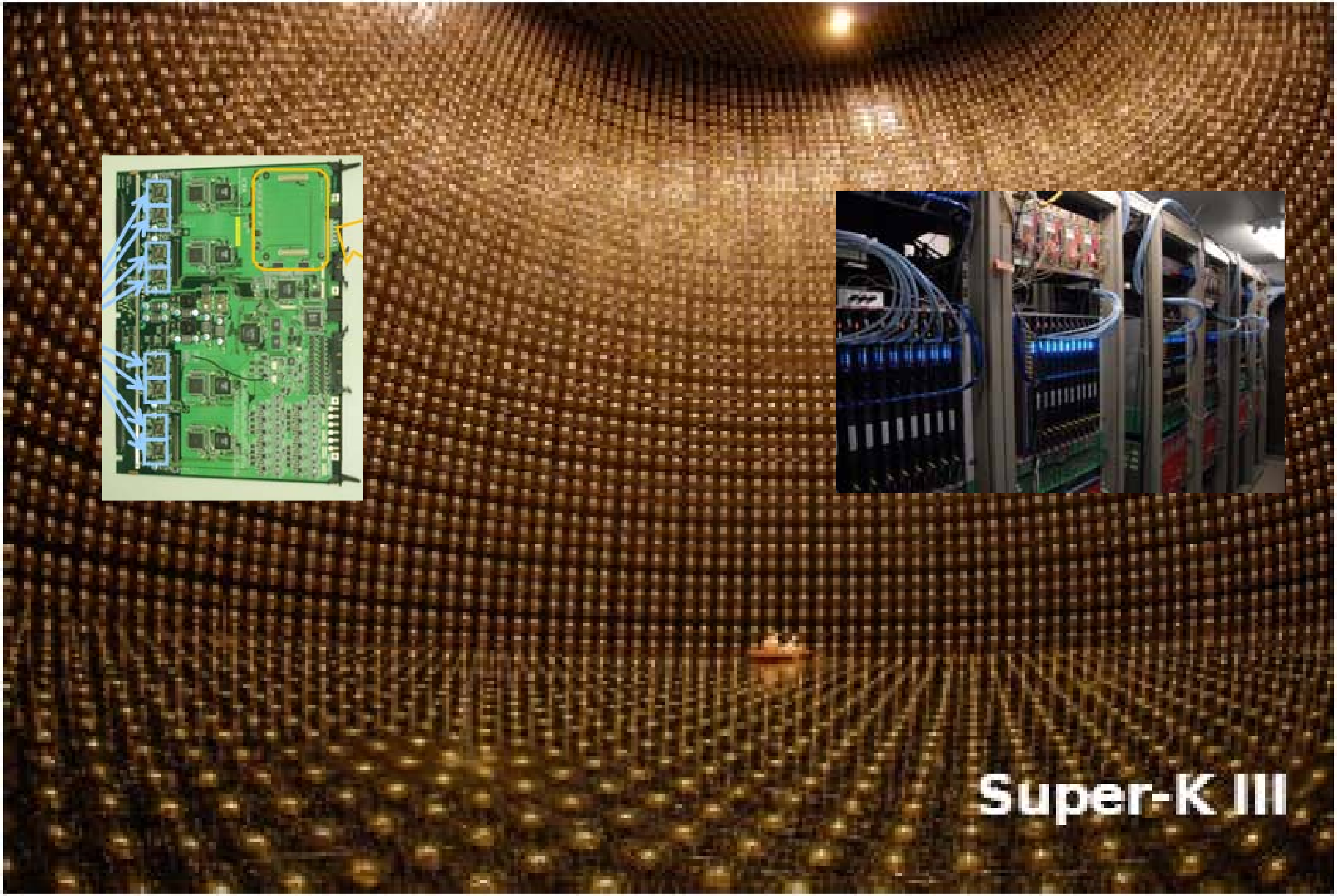
NEUTRINO BEAM SPECTRUM AT SK AND ND280



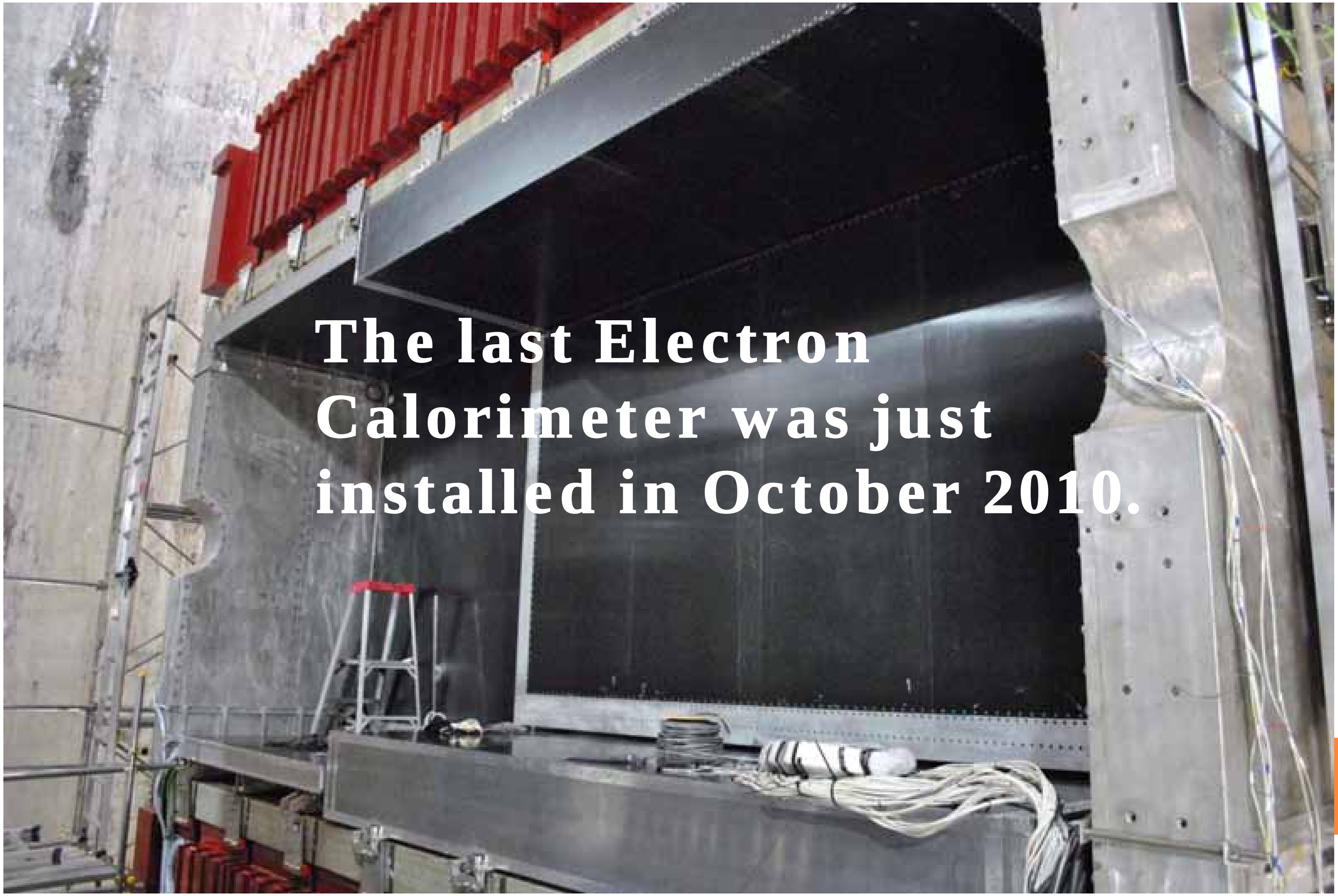
Off-axis Detector

- Measure ν_μ flux: <5%
- Measure ν_μ energy scale: <2%
- Measure intrinsic ν_e content of beam: <10%
- Measure non-CCQE backgrounds for both ν_μ disappearance and ν_e appearance: <10%
- Magnetic field, fine segmentation, excellent tracking
- Major international contributions
- High complexity and non-trivial integration

Far Detector: Super-Kamiokande IV

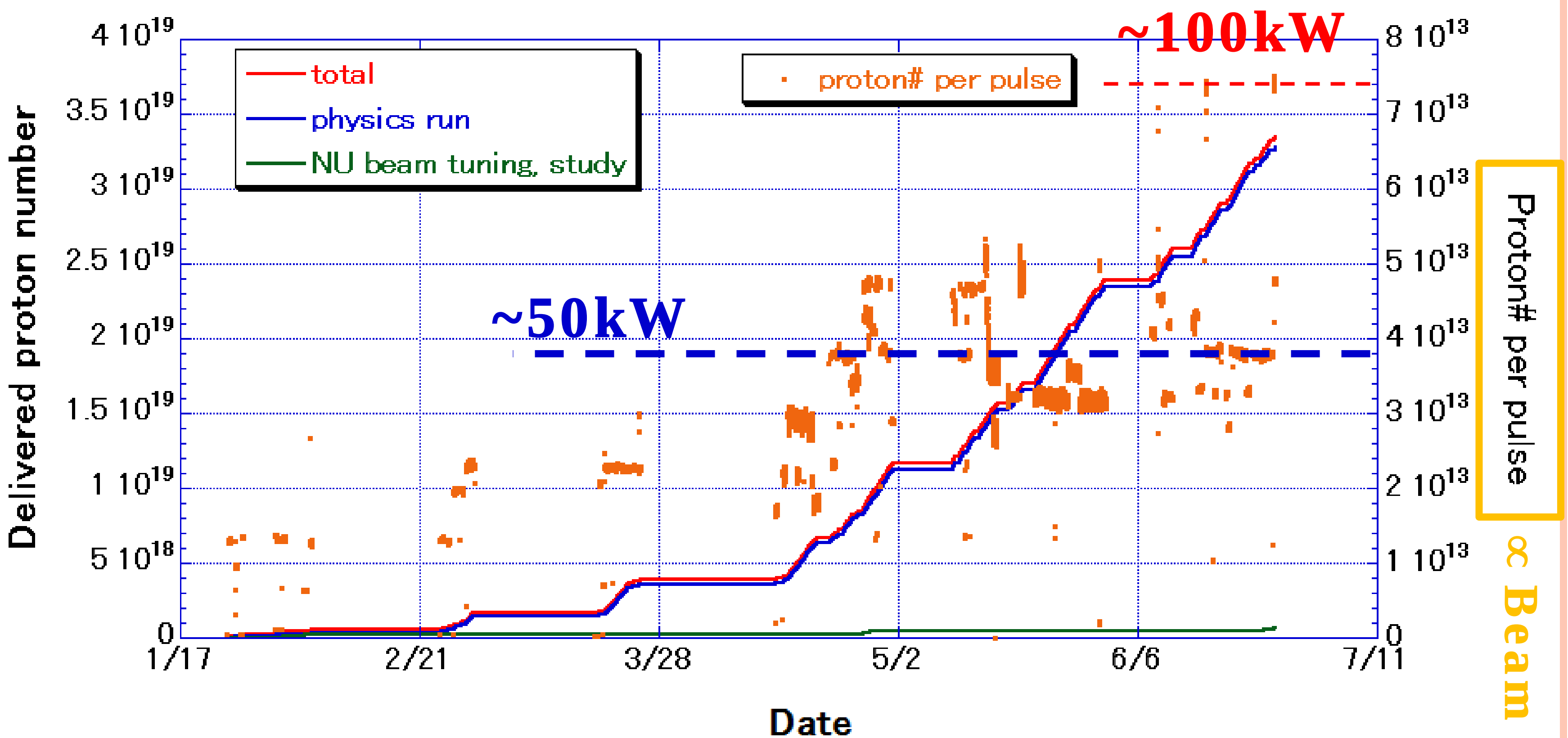


T2K CONSTRUCTION JUST FINISHED



T2K Status

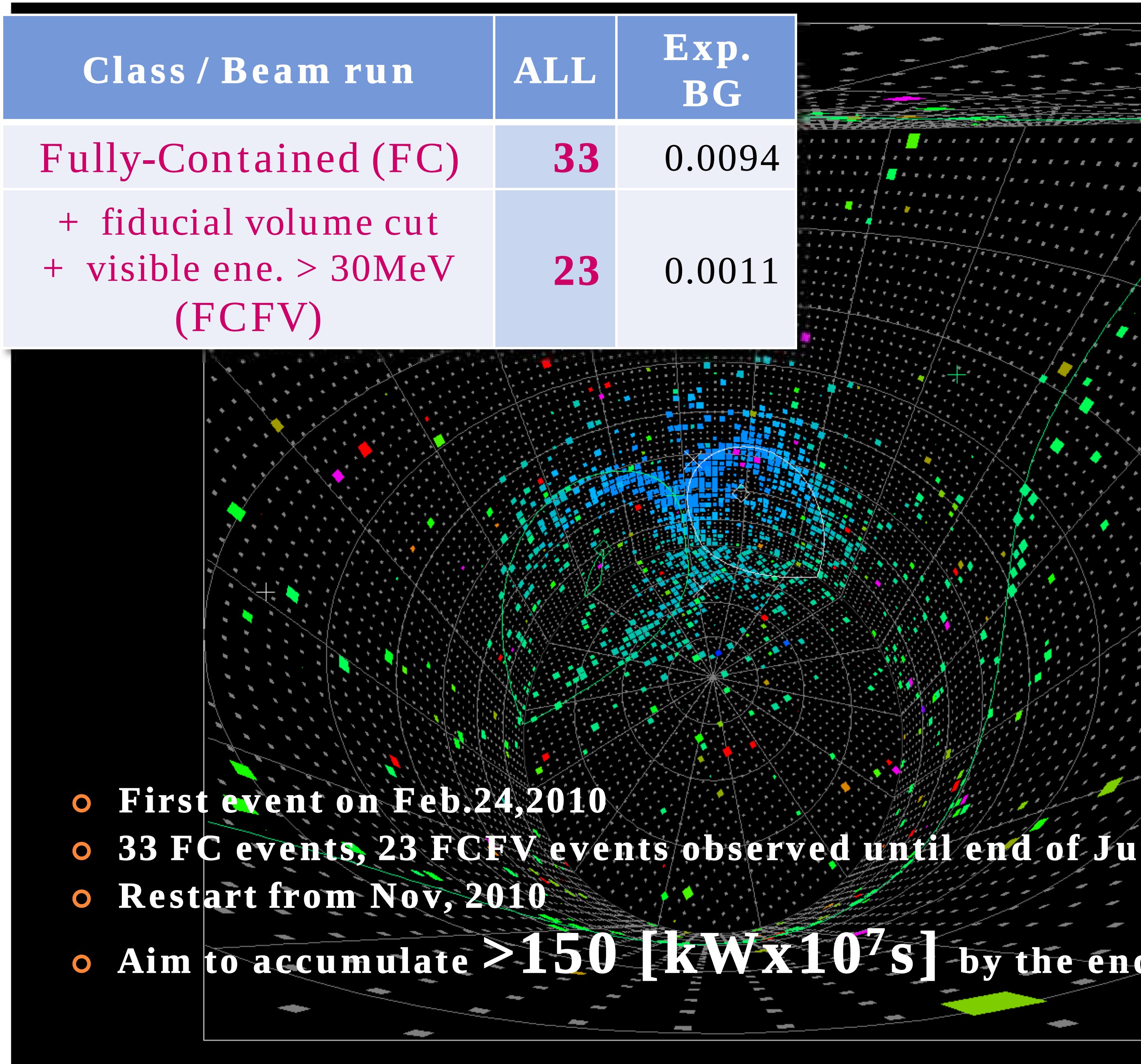
T2K Physics Run begins in 2010.

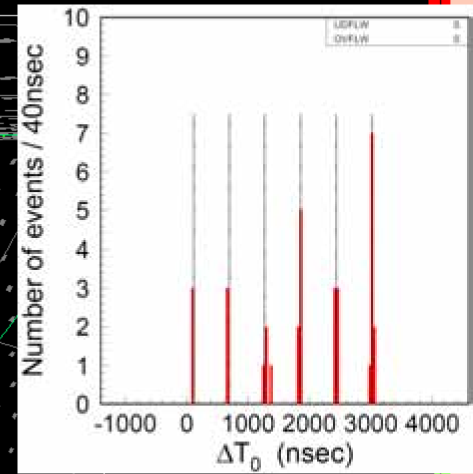


- Delivered POT: 3.35×10^{19} (3.28×10^{19} for physics)
- Continuous run @ ~50kW level
- Trial up to 100kW successful.

Observation at Super-Kamiokande

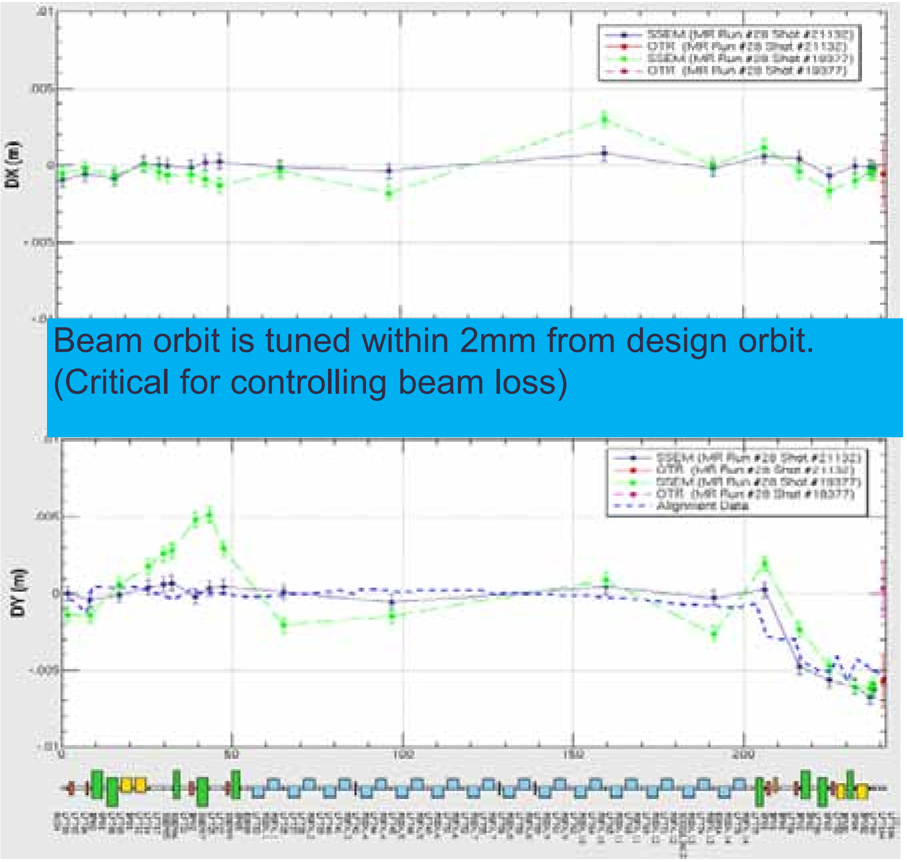
Class / Beam run	ALL	Exp. BG
Fully-Contained (FC)	**33**	0.0094
+ fiducial volume cut + visible ene. > 30MeV (FCFV)	**23**	0.0011



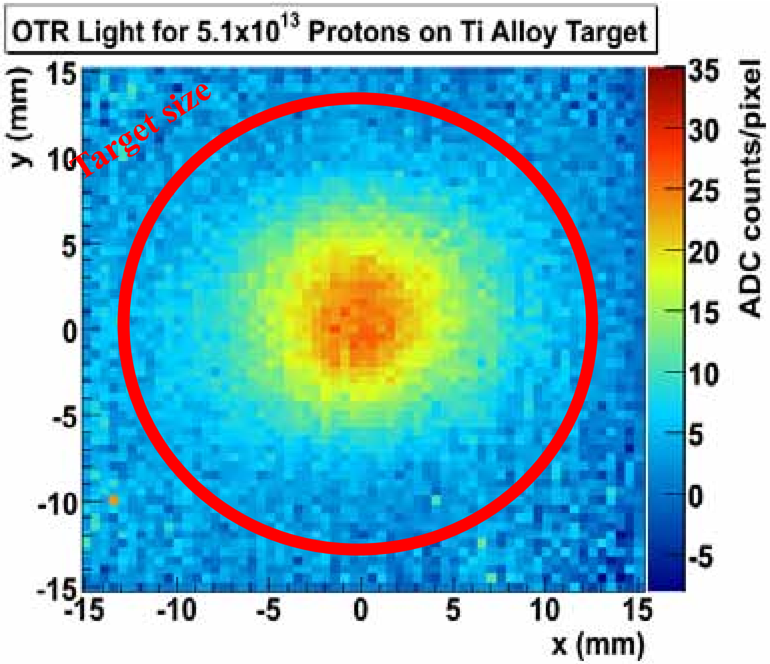


- First event on Feb.24,2010
- 33 FC events, 23 FCFV events observed until end of June
- Restart from Nov, 2010
- Aim to accumulate **>150 [kWx10^7s]** by the end of June 2011

FIRST NEUTRINO PHYSICS RUN: PRIMARY BEAM

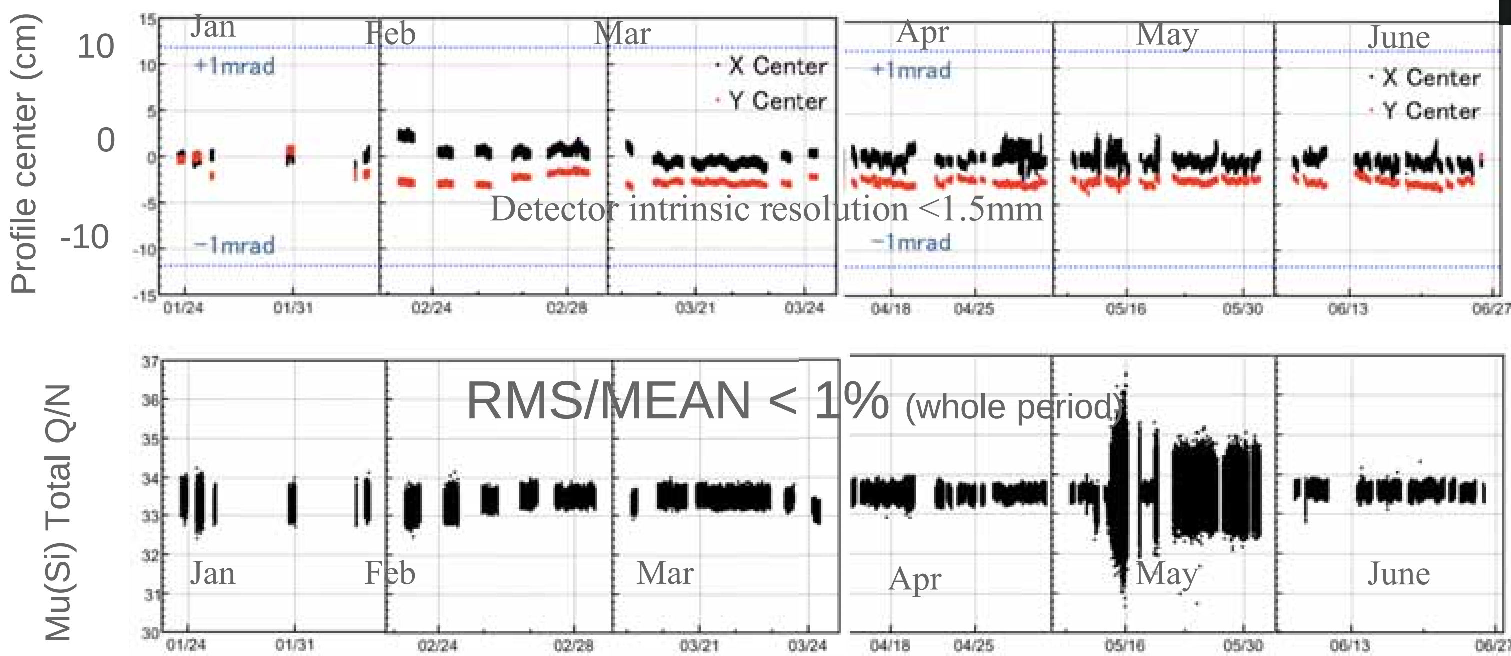


Beam orbit is tuned within 2mm from design orbit.
(Critical for controlling beam loss)



Optical transition radiation detector (OTR) immediately upstream of target:

First neutrino physics run: muon monitor



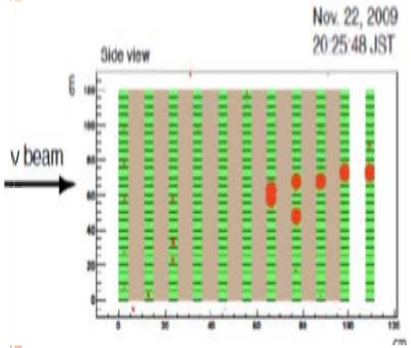
- Muon monitors:
  - Silicon detectors and ionization chambers downstream of hadron absorber
  - Additional emulsion detectors during commissioning runs
- Direction stable to <1 mrad
- Secondary/primary beam intensity ratio stable to 1%

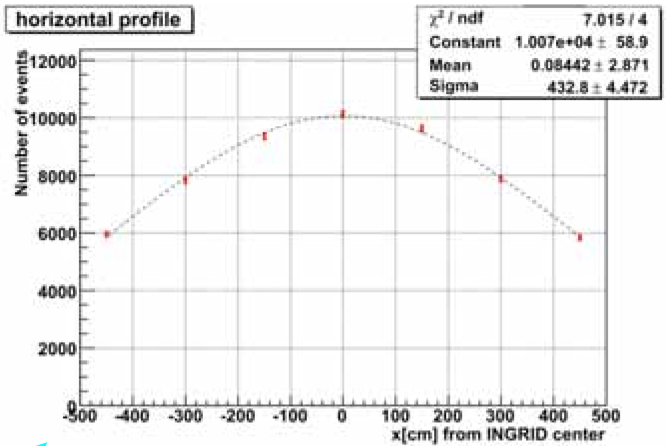
First Neutrino events in J-PARC

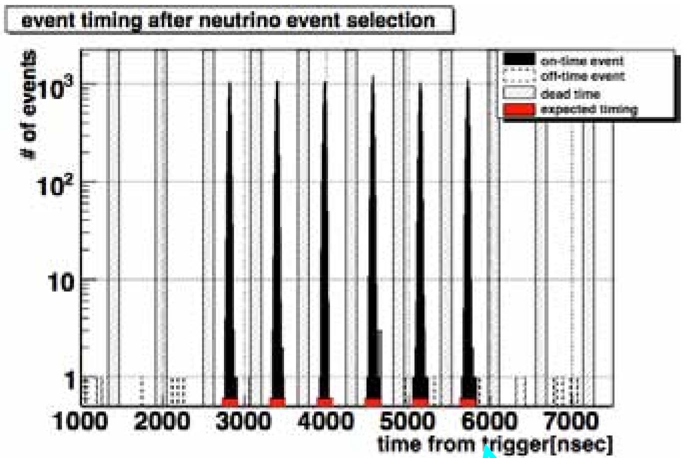
- Nov. 23rd, 2009.

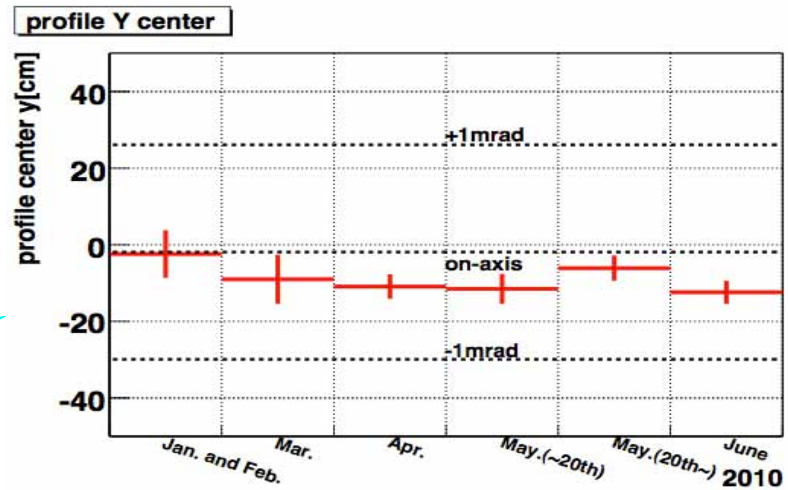
First neutrino physics run:
On-axis neutrino monitor (INGRID)

The first INGRID neutrino candidate



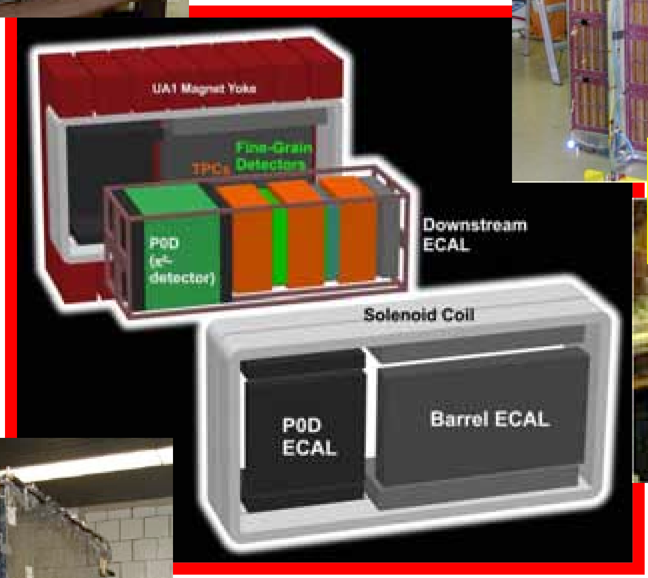






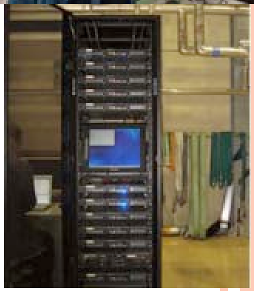
OFF-AXIS DETECTORS

FGD(Canada, Japan)

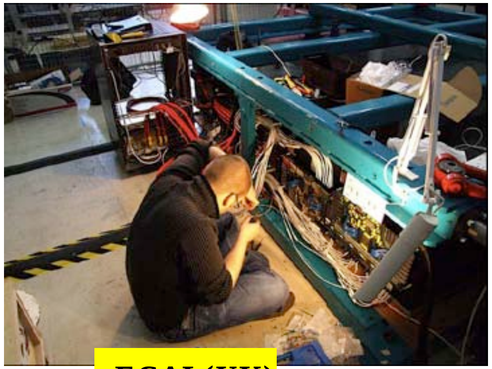


TPC(Canada/France, Spain, Swiss, Italy, German)

Elec(UK,Fr)



P0D(US)



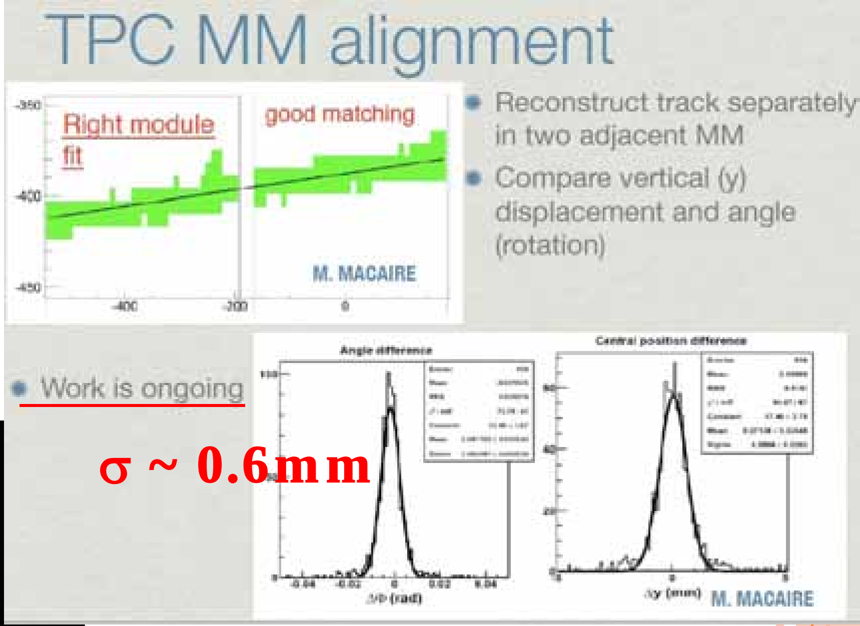
ECAL(UK)

SMRD(Jp,US,Pol,Rus)

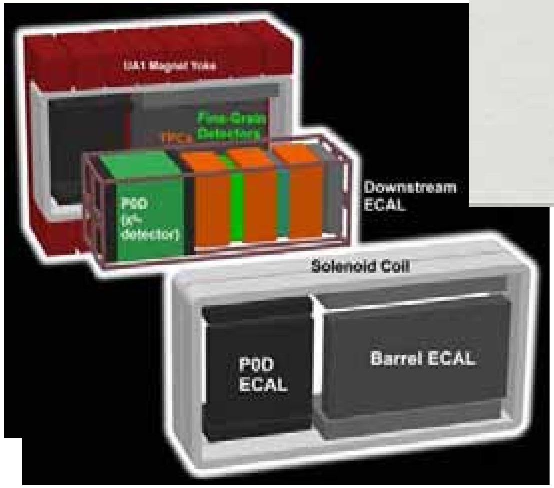
OFF-AXIS DETECTOR PERFORMANCES

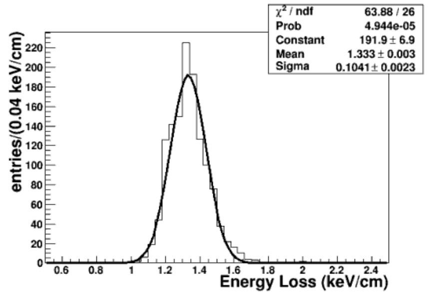
System	Channels	Bad chan.	Fraction
DSECAL	3400	11	0.3%
SMRD	4016	3	0.07%
P0D	10400	7	0.07%
INGRID	8360	8	0.1%
TPC	124416	12	0.01%
FGD	8448	55	0.7%

Very small number of bad channels

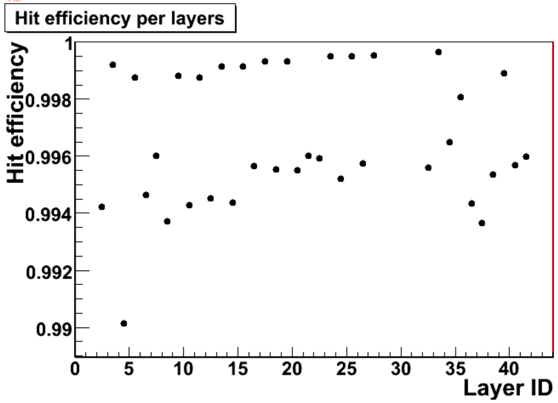


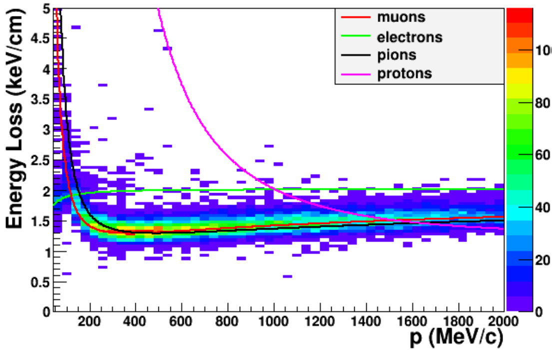
σ ~ 0.6mm

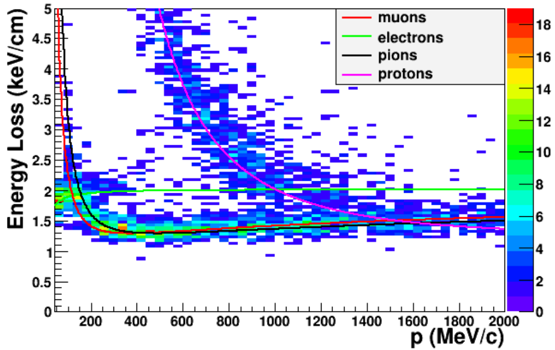




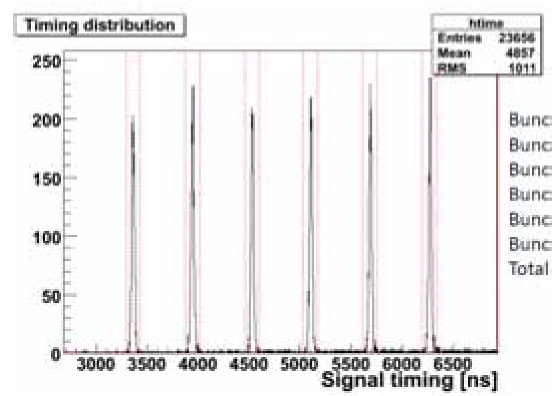
Hit Efficiencies >99%
For all layers (FGD)

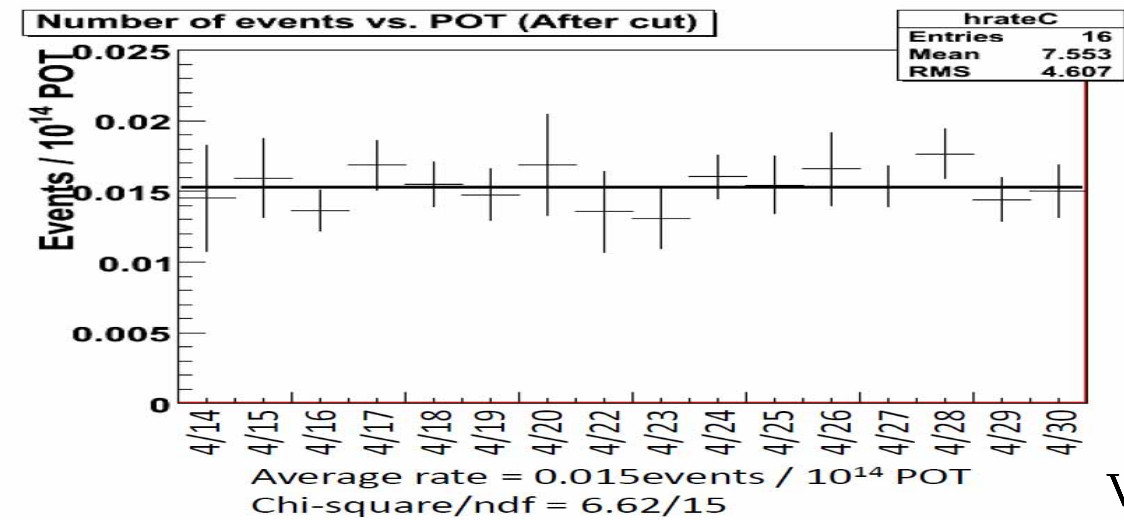


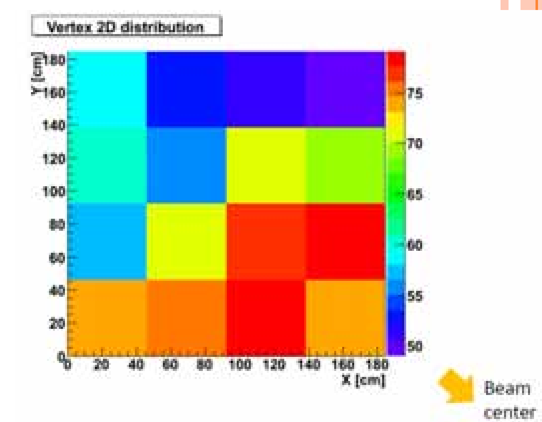




OFF-AXIS DETECTOR MEASUREMENTS

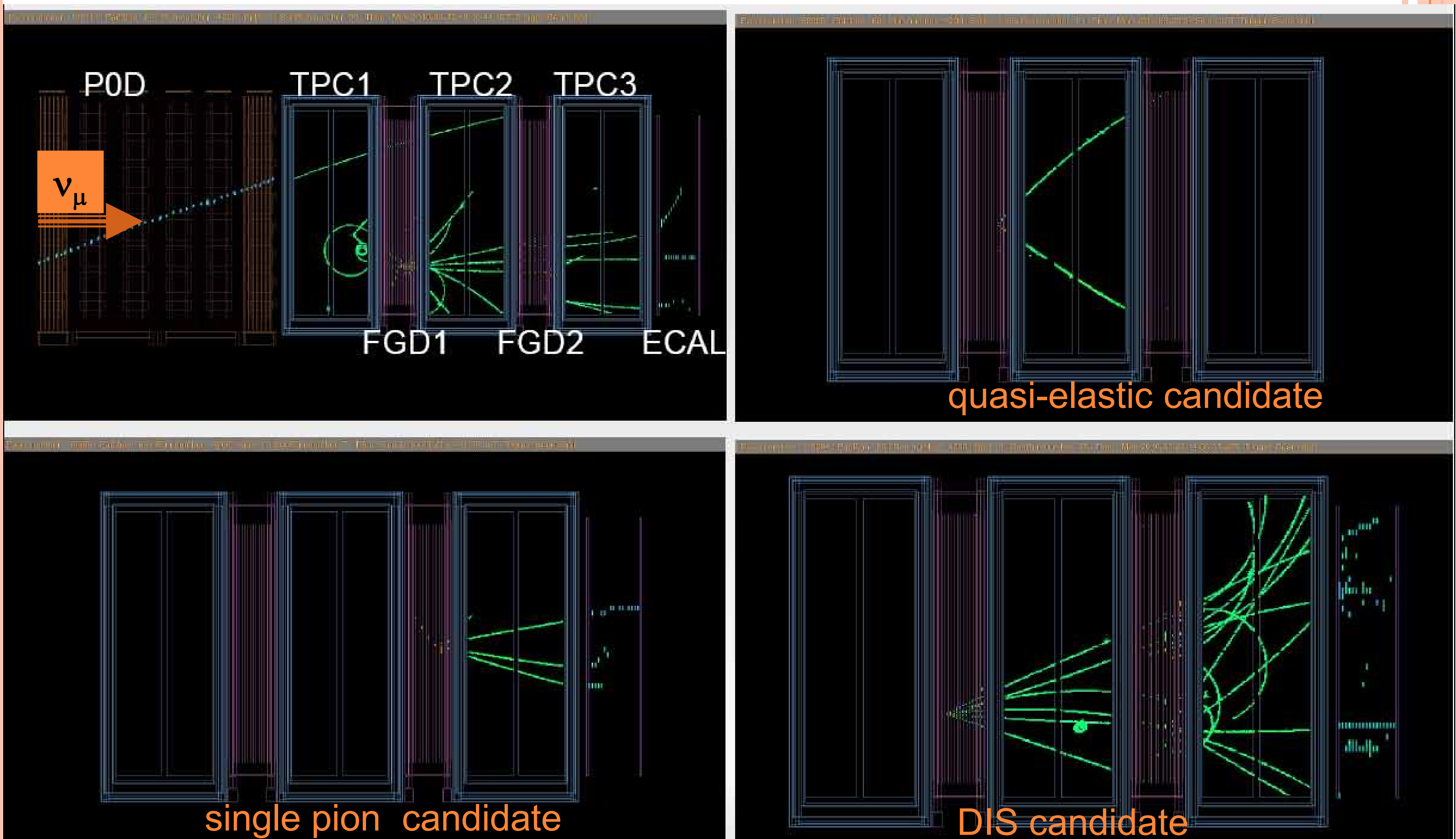






View from Downstream to Upstre

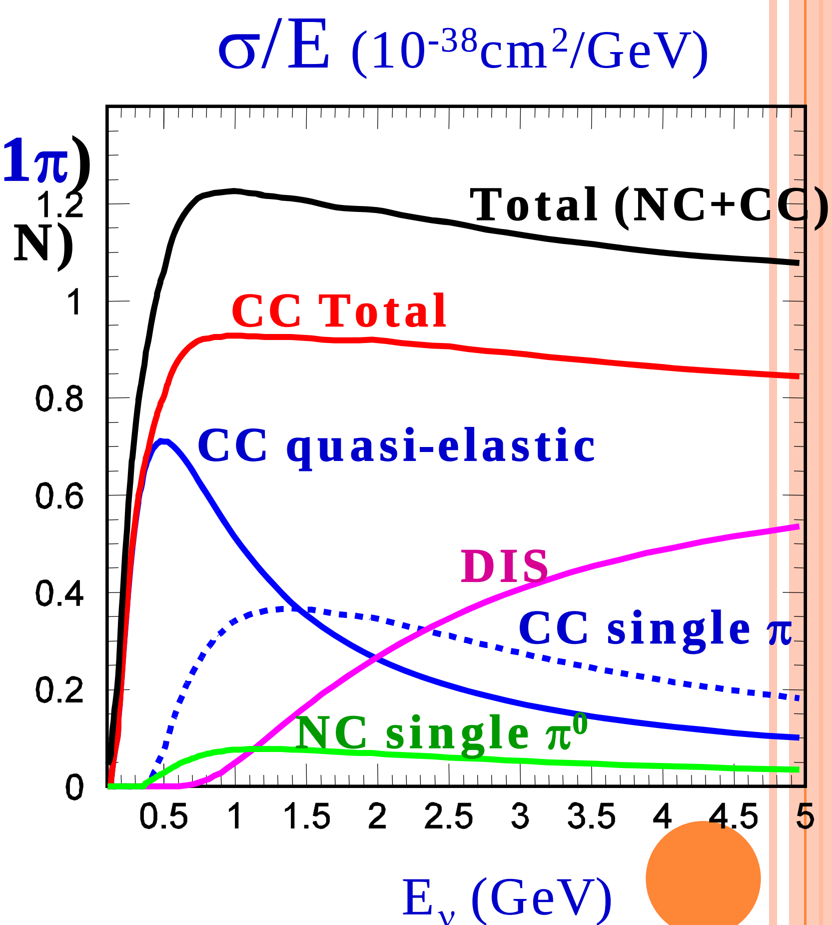
A few ND280 neutrino interaction candidates



Neutrino interactions in the T2K Energy (~1GeV)

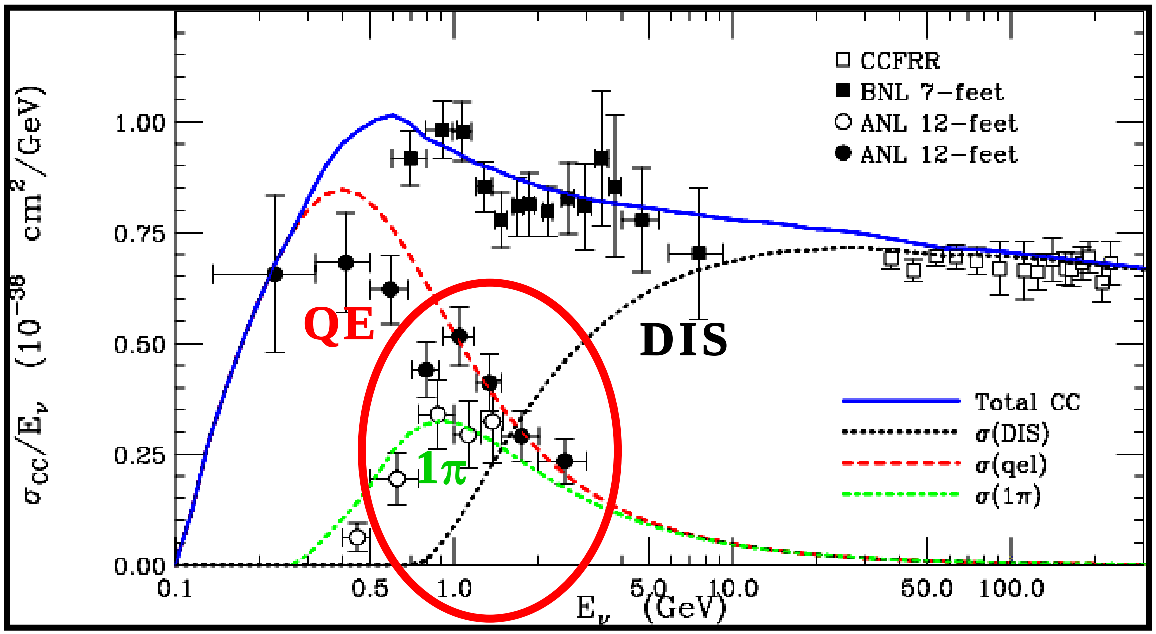
- **CC quasi elastic (CCQE)**
  - $\nu + n \rightarrow \mu^- + p$ (n in N)
- **CC (resonance) single π (CC-1π)**
  - $\nu + n(p) \rightarrow \mu^- + \pi^+ + p(n)$ (n,p in N)
- **DIS (Deep Inelastic Scattering)**
  - $\nu + N \rightarrow \mu^- + m\pi^{+,-,0} + N'$
- **CC coherent π**
  - $\nu + A \rightarrow \mu^- + \pi^+ + A$
- **NC**

+ Nuclear Effects



Existing Data (poor precision) ⇨ Measure them more precisely in T2K

σ_ν in this E range interesting:



MINOS, NuMI

K2K, NOvA

MiniBooNE, SciBooNE, T2K

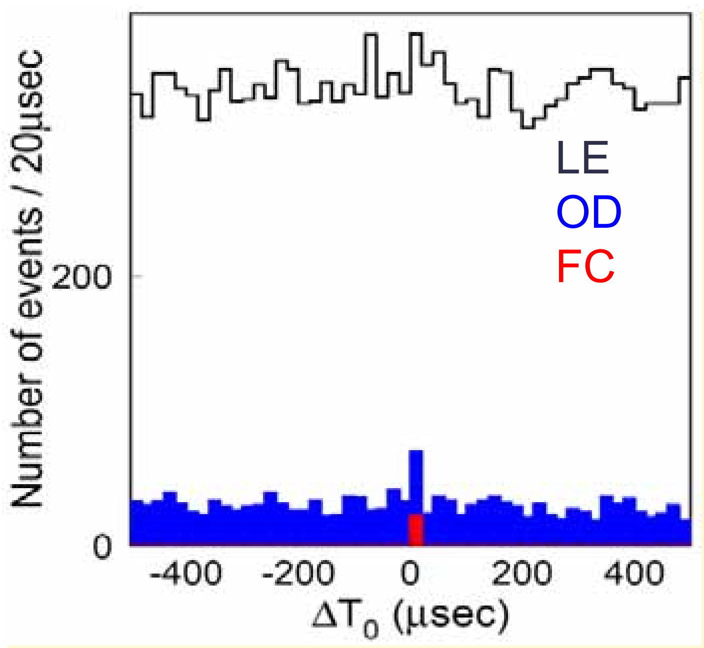
Super-K atmospheric ν

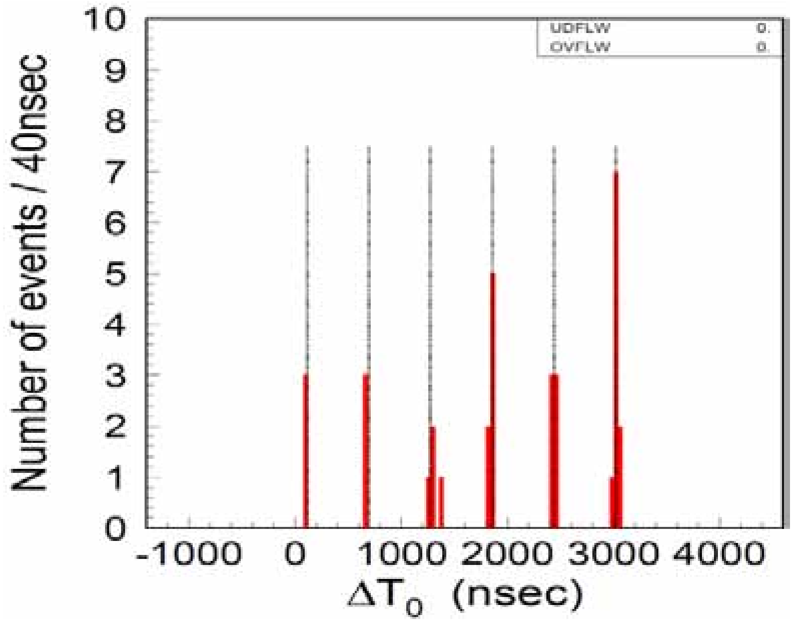
First neutrino physics run: Super-Kamiokande

- **J-PARC neutrino events selected by event timing using GPS**
- **SK analysis is very well established**
- **Event selection & cut values fixed before data collection for this run**

ν_μ	ν
μ	
	$\gamma\gamma$
	ν

First neutrino physics run: Super-Kamiokande

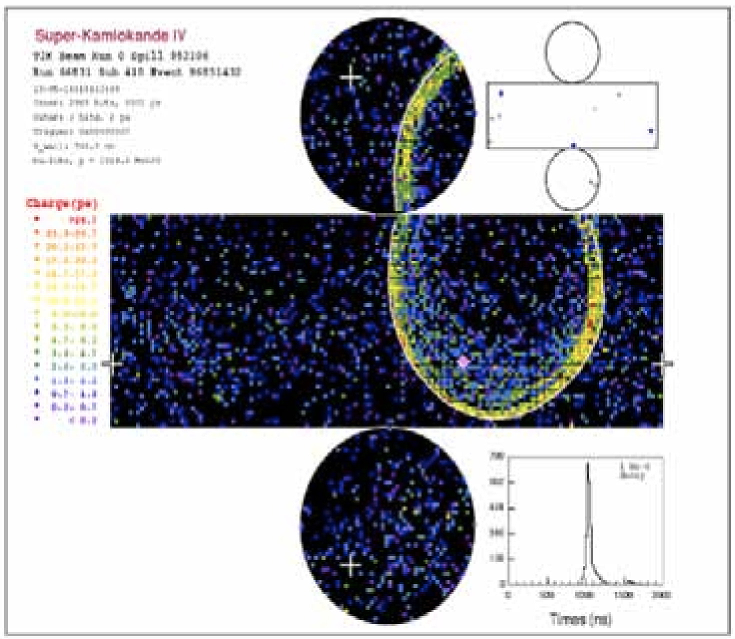




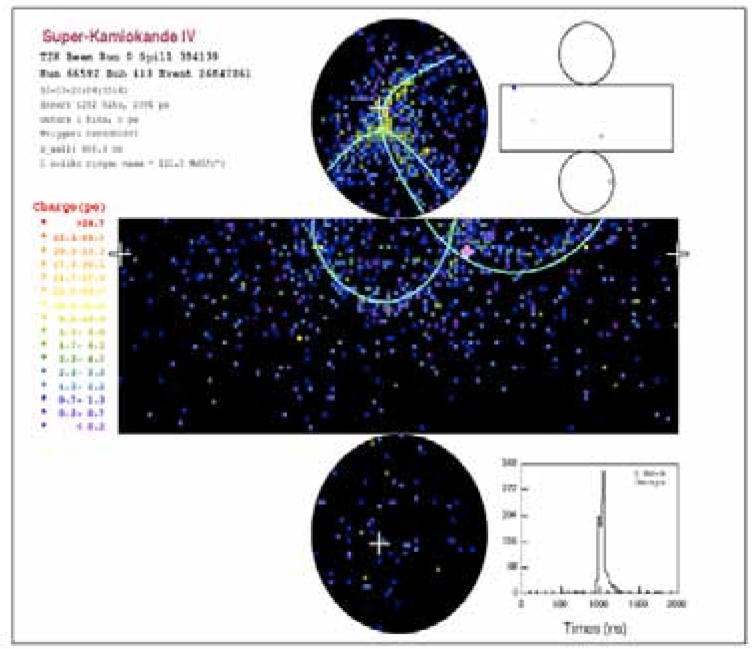
- Event time distribution clearly shows six-bunch beam structure
- 33 FC events and 23 are in the Fiducial Volume.
- Expected non-beam background: ~0.001 events

T2K NEUTRINO EVENTS

Single-ring μ-like event



Two-ring event

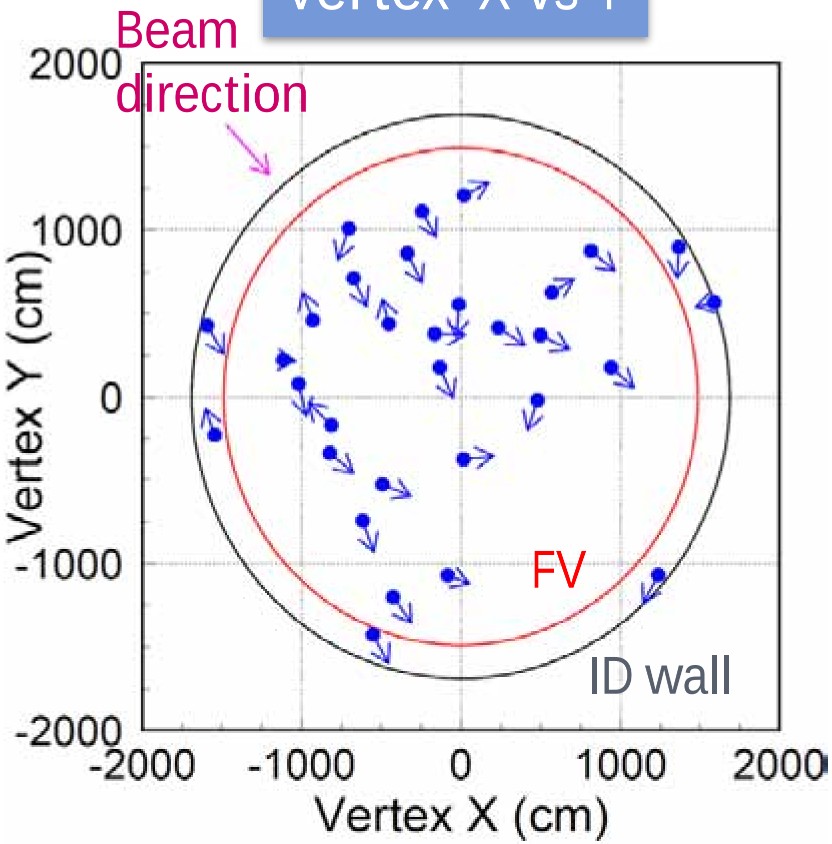


- Pink diamonds are placed on the wall in the beam direction starting from the reconstructed vertex.

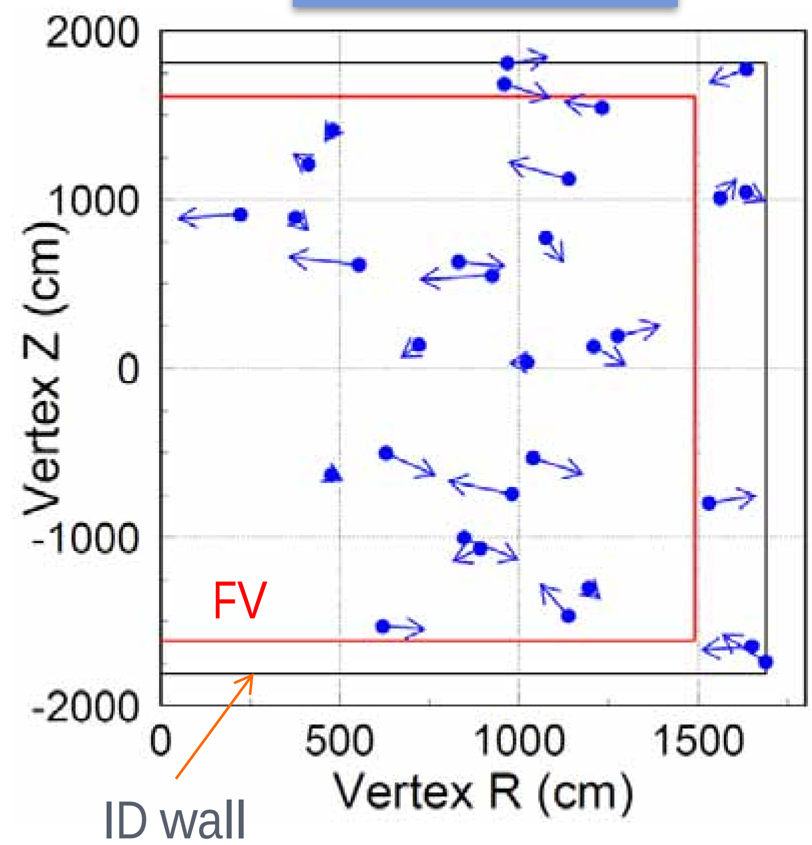
Vertex and direction
(FC, Evis>30MeV)

Points : Reconstructed event vertex
Arrow : 1st-ring direction

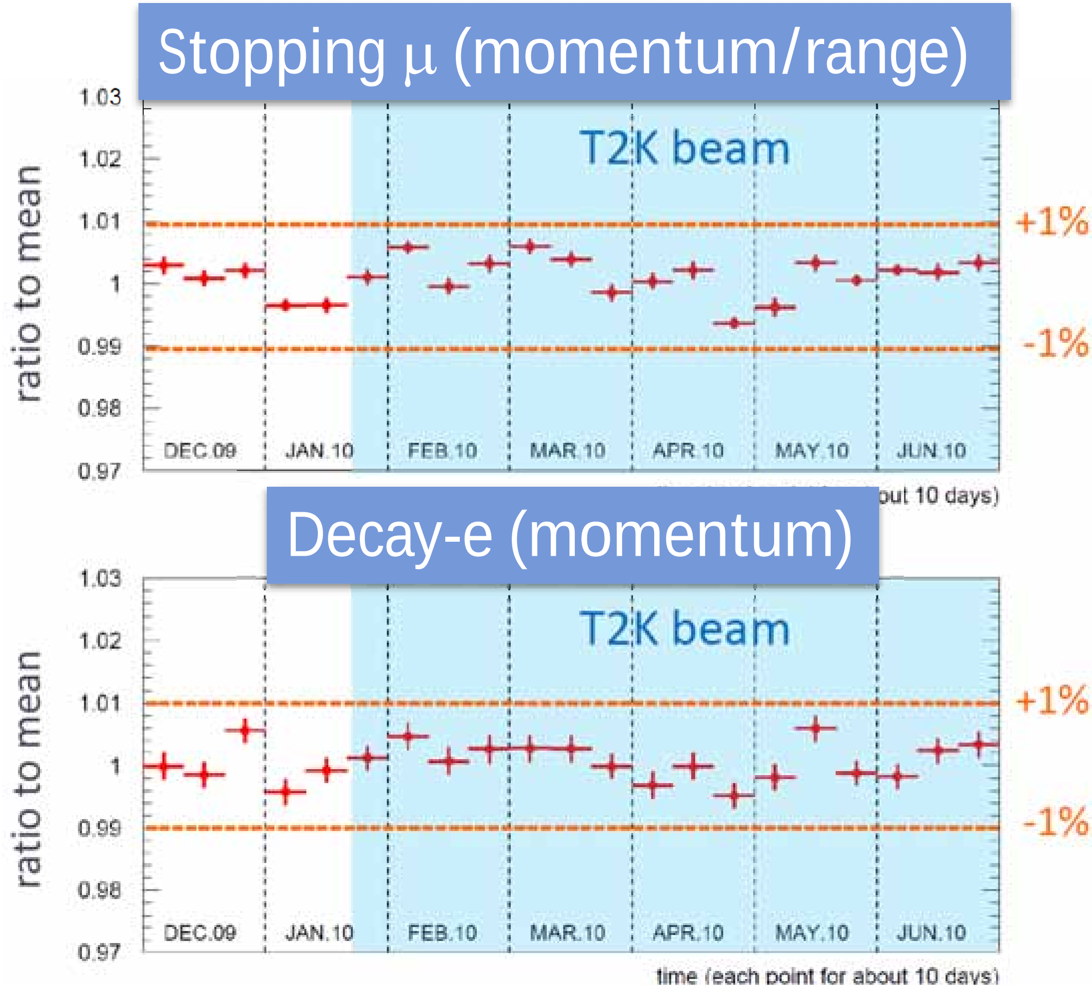
Vertex X vs Y



Vertex R vs Z



Super-K Energy scale stability for T2K data quality assuarance



RMS/MEAN
T2K period : 0.31%
(SK-IV all : 0.39%)

RMS/MEAN
T2K period : 0.28%
(SK-IV all : 0.45%)

Energy scale has been quite stable.

Physics Sensitivity of this run

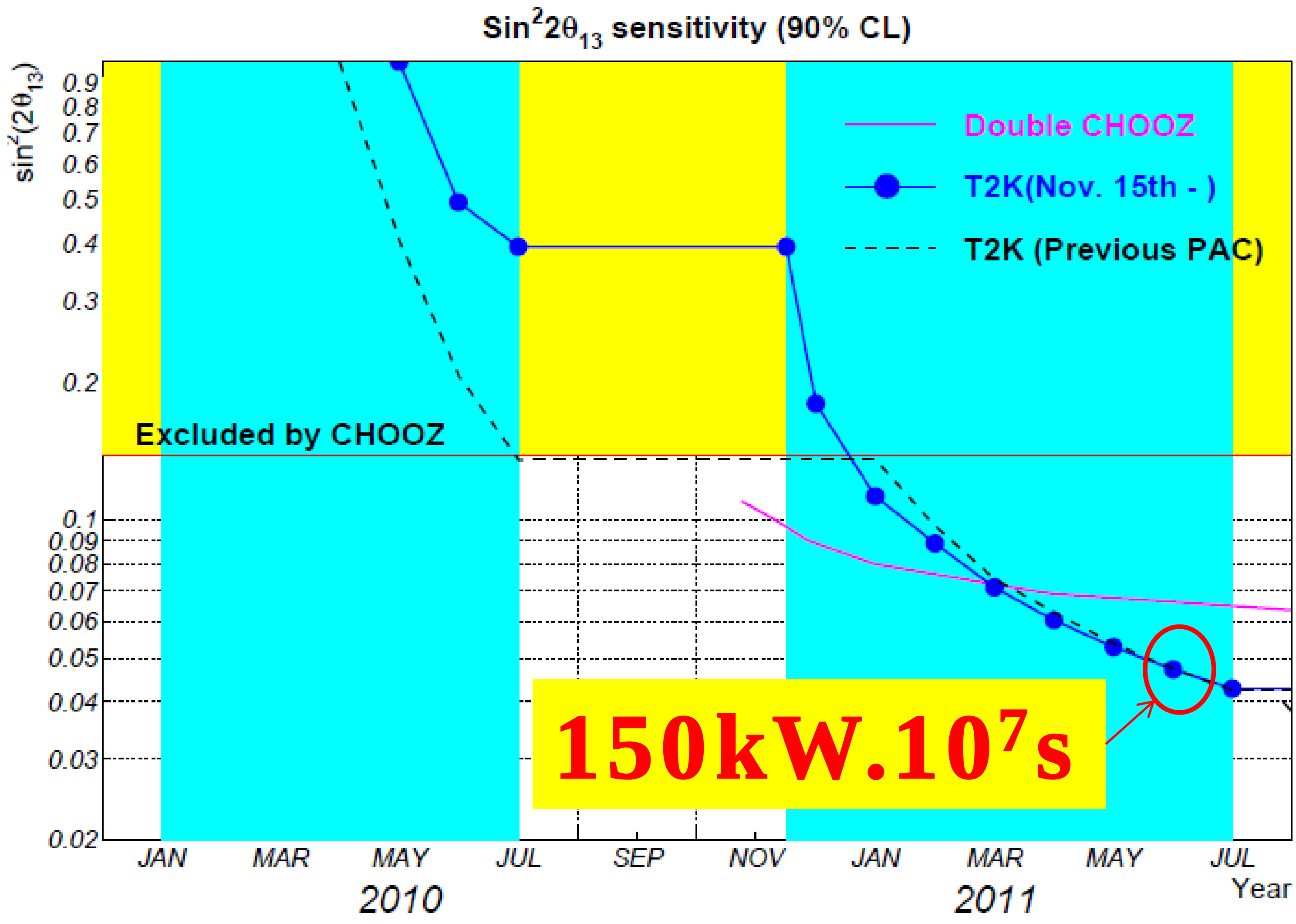
- Physics analysis with the 3.23 E19 POT data is under processed and will be shown soon.
  - Measurements of muon neutrino disappearance
    - **Sensitive to $\sin^2 2\theta_{23}$ and Δm^2_{23}**
  - Search for electron neutrino appearance
    - **Sensitive to $\sin^2 2\theta_{13}$**
- Appealing features
  - High quality data with the off-axis beam to study neutrino oscillations.
    - **Expect the similar sensitivity as that of K2K**

Near term improvement

- The beam power of 2010 Jan.-June run was limited to 50kW by the fast-extraction kicker problem.
  - Fixed during this summer maintenance.
  - 100kW operation was tested and is successful.
- T2K will start running from the next week.
  - 6 bunch → 8 bunch (33% more protons)
  - Acceleration Cycle: 3.64s → 3.2s (14% more protons)

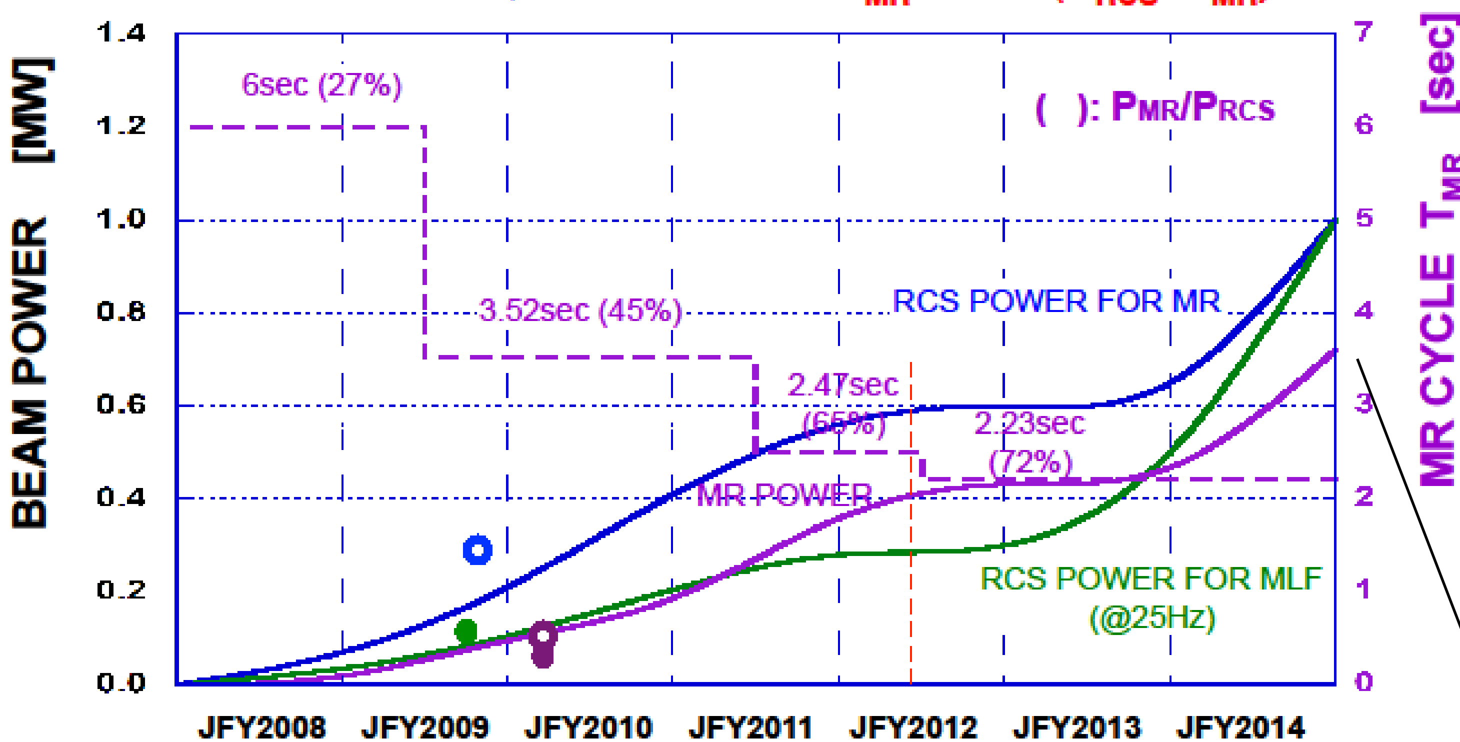
  ⇨ **150kW operation is feasible.**

Short term goal toward 2011



Power upgrade plan of RCS and MR(FX)

For 8 bunches, 30 GeV at MR: $P_{MR}=1.6 \times (P_{RCS}/ T_{MR})$



3-50BT collimator shields,
RF (1st HH), FX kickers

Ring collimator shields, RF (6th F, 2nd HH), Inj. Sep 1

ACS Installation in JFY2012
400 MeV injection in the RCS

RF (3rd HH), Inj. Sep 2, FX Septa,

750kW
in 2014

Beyond

T2K Beyond

Study Symmetry Violation between ν and $\bar{\nu}$

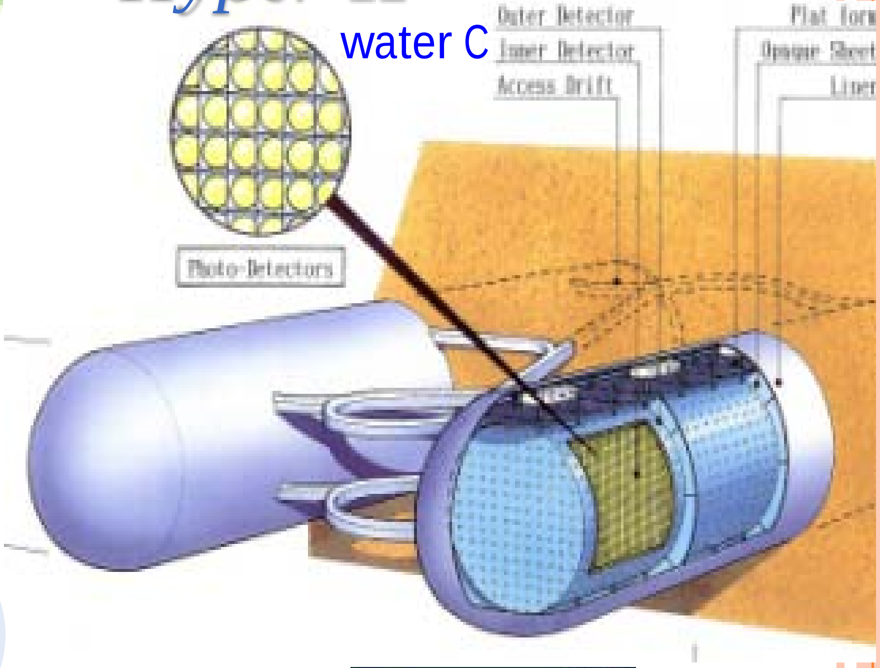
J-PARC Upgrade
KEK Roadmap
→1.7MW

Best Optimization

Huge ν detector
- Water Cherenkov
- Lq. Ar TPC

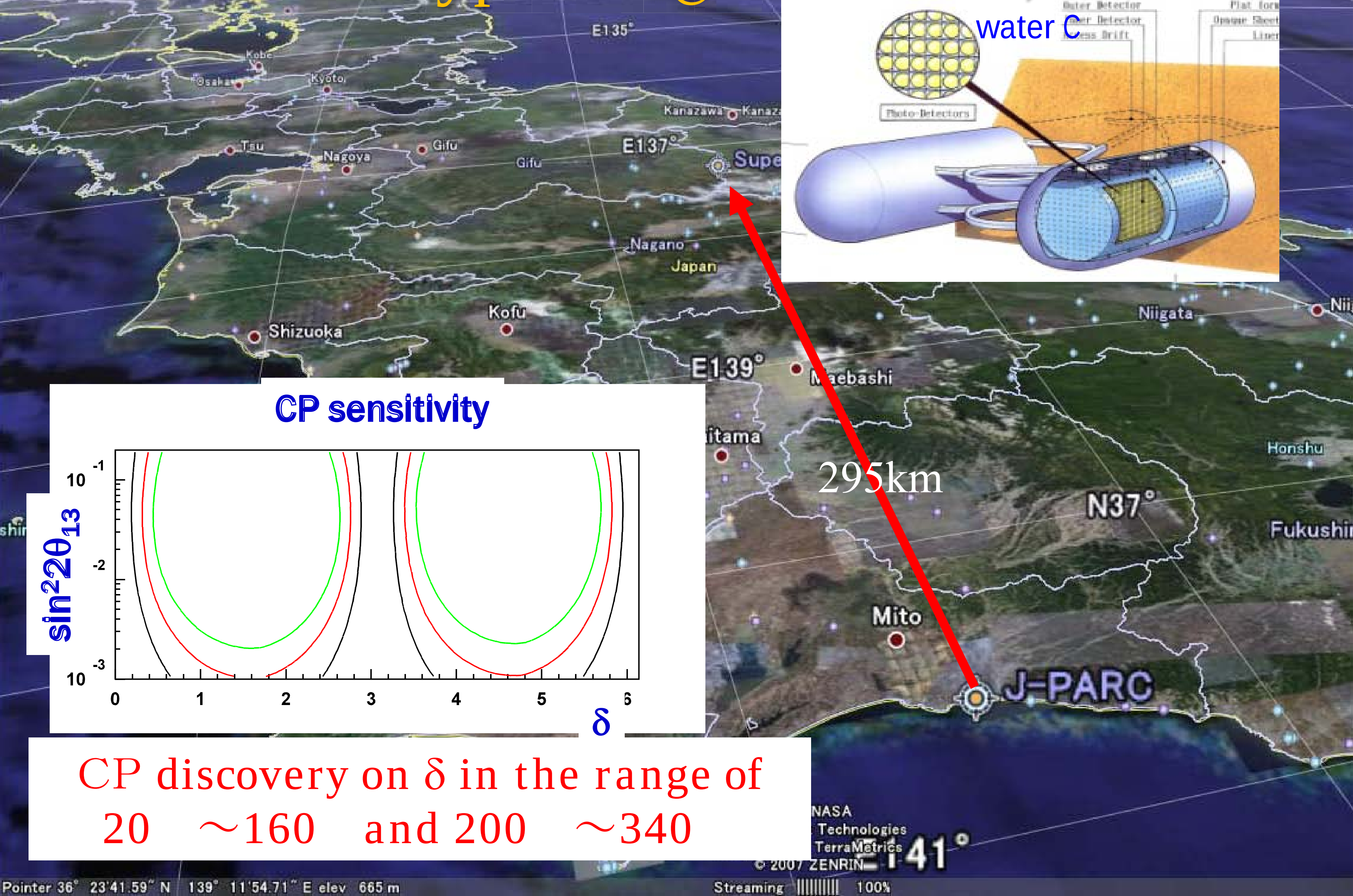
O(~100k)ton

Hyper-K



GUT
Proton Decay

Scenario 1（Hyper-K @ Kamioka）

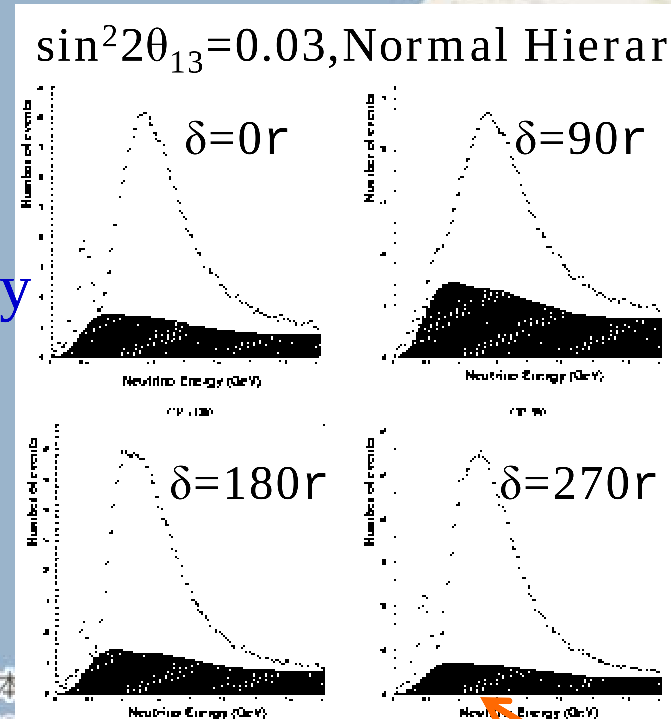


CP discovery on δ in the range of
20 ～160 and 200 ～340

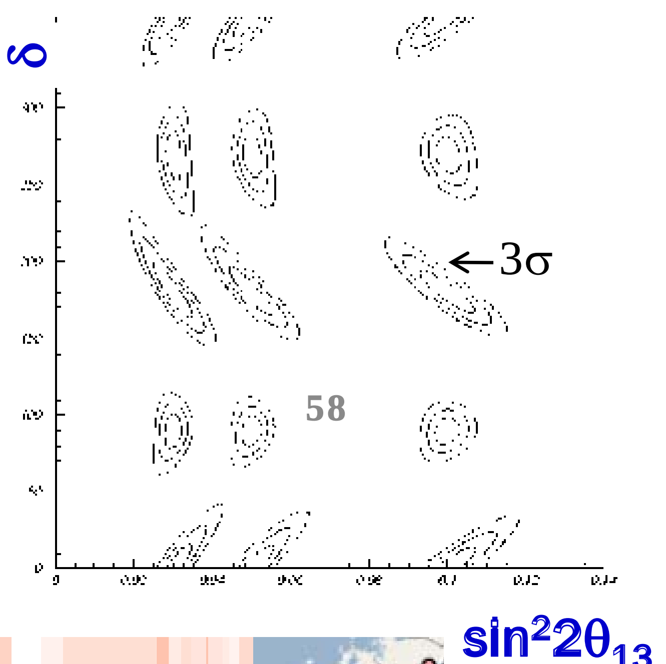
Scenario 2

- 100kton Lq. Ar TPC @ 658km
- ν beam only
- Sensitivity to the mass hierarchy

ν_e Spectrum



CP Measurement Potential



NP08, arXiv:0804.2111

YOUR INTERESTS IN T2K

My personal guesses:

- When will T2K have the results?
  - First results with the similar sensitivity as K2K will come soon.
  - In 2011, the sensitivity will be improved to be $\sin^2 2\theta_{13}$~0.05.
  - After 2011, the sensitivity will be further improved.
- How is the J-PARC accelerator running?
  - Expect the operation with150kW or higher in 2010-2011.
  - Aim the design intensity of 750kW.
- Is it the option of anti-neutrino running?
  - Technically feasible. The physics case should be studied and reviewed by PAC.
- Does T2K have the sensitivity to the CP violation and the sign of Δm^2?
  - The probability of ν_e appearance has the strong CP dependence, but do not have the sensitivity to the sign of Δm^2 with 300km baseline
- What is the future upgrade (or successor) of T2K?
  - J-PARC proton beam power upgrade
  - A Huge Far Detector to probe the proton decay and the ν CP violation.


NNN10
11th International Workshop on
Next Generation Nucleon
Decay and Neutrino Detectors
December 13-16, 2010, Toyama, Japan
Proton Decay
High Intensity ν beams
Supernova Neutrinos
Solar Neutrinos
Atmospheric Neutrinos
Reactor Neutrinos
Large Detectors R&D
Steering Committee
C.K. Jung
T. Kajita
S. Katsanevas
Program Advisory Committee
V.Barger
J.F.Beacom
S.B.Kim
Y.K.Kim
M.Lindner
M.Mezzetto
H.Murayama
K.Nishikawa
A.Rubbia
N.P.Samios
K.Sato
H.W.Sobel
N.Spooner
A.Suzuki
B.Svoboda
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M.Zito
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T.Nakaya
H.Suzuki
Y.Suzuki
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Secretary
M.Takamatsu
Email:nnn2010@km.icrr.u-tokyo.ac.jp
URL:http://www-sk.icrr.u-tokyo.ac.jp/NNN10
ICRR


The XXV International Conference on Neutrino Physics and Astrophysics
NEUTRINO 2012
June 3-9 2012 Kyoto, Japan
June 3, Kyoto University Clock Tower Centennial Hall
June 4-9, Kyoto TERRSA
http://neu2012.kek.jp/
Hosted by
The Science Council of Japan (plan)
The Physical Society of Japan
Co-hosted by
Kamioka Observatory, Institute for Cosmic Ray Research (ICRR),University of Tokyo
Kyoto University
High Energy Accelerator Research Organization (KEK)
International Advisory Committee
Local Organizing Committee

BACKUP
-T2K -

Status of J-PARC

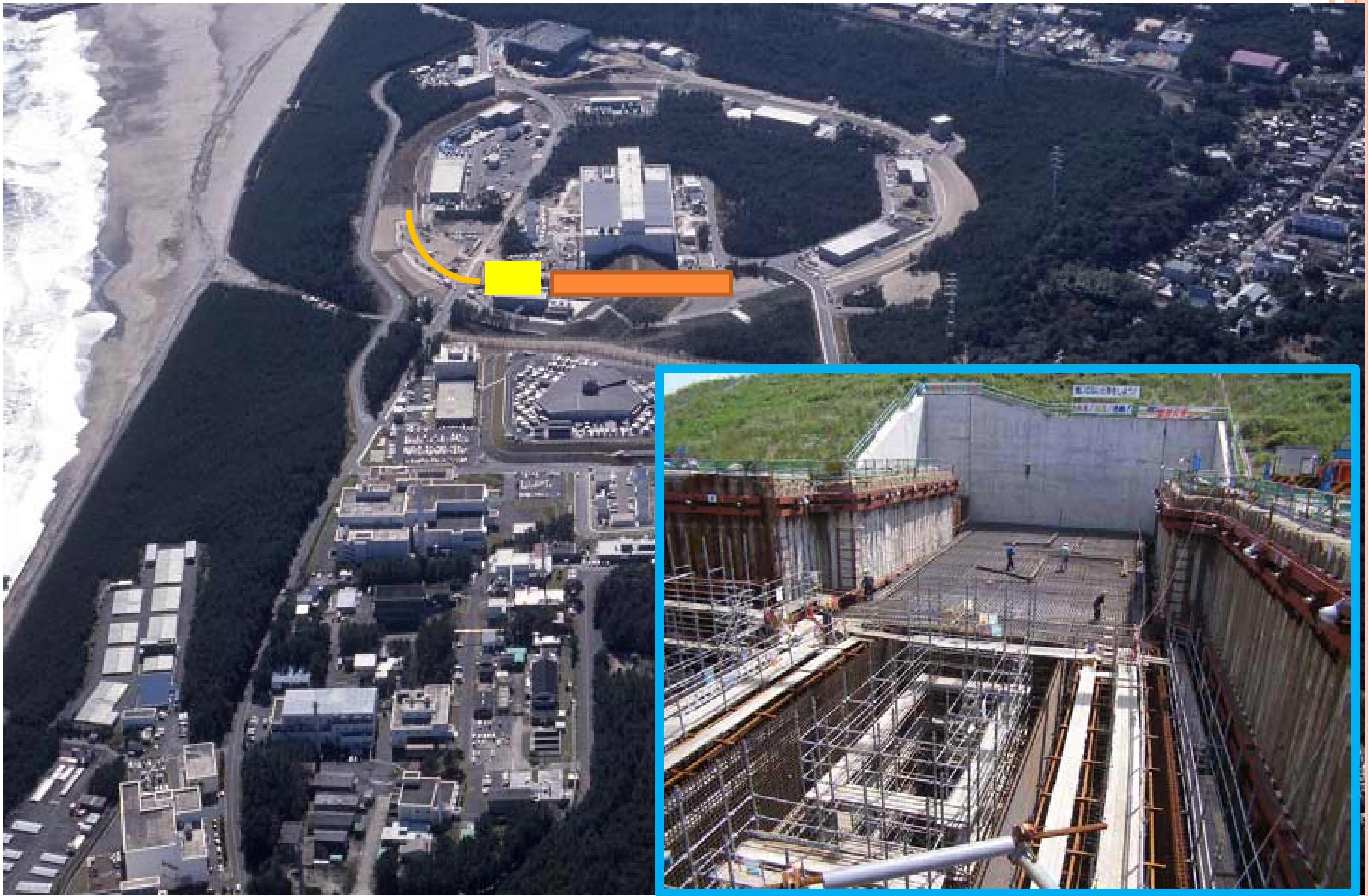
MR commissioning May, Jun, Dec~ in 2008

3 GeV RCS beam commissioning succeeded in Nov. 2007

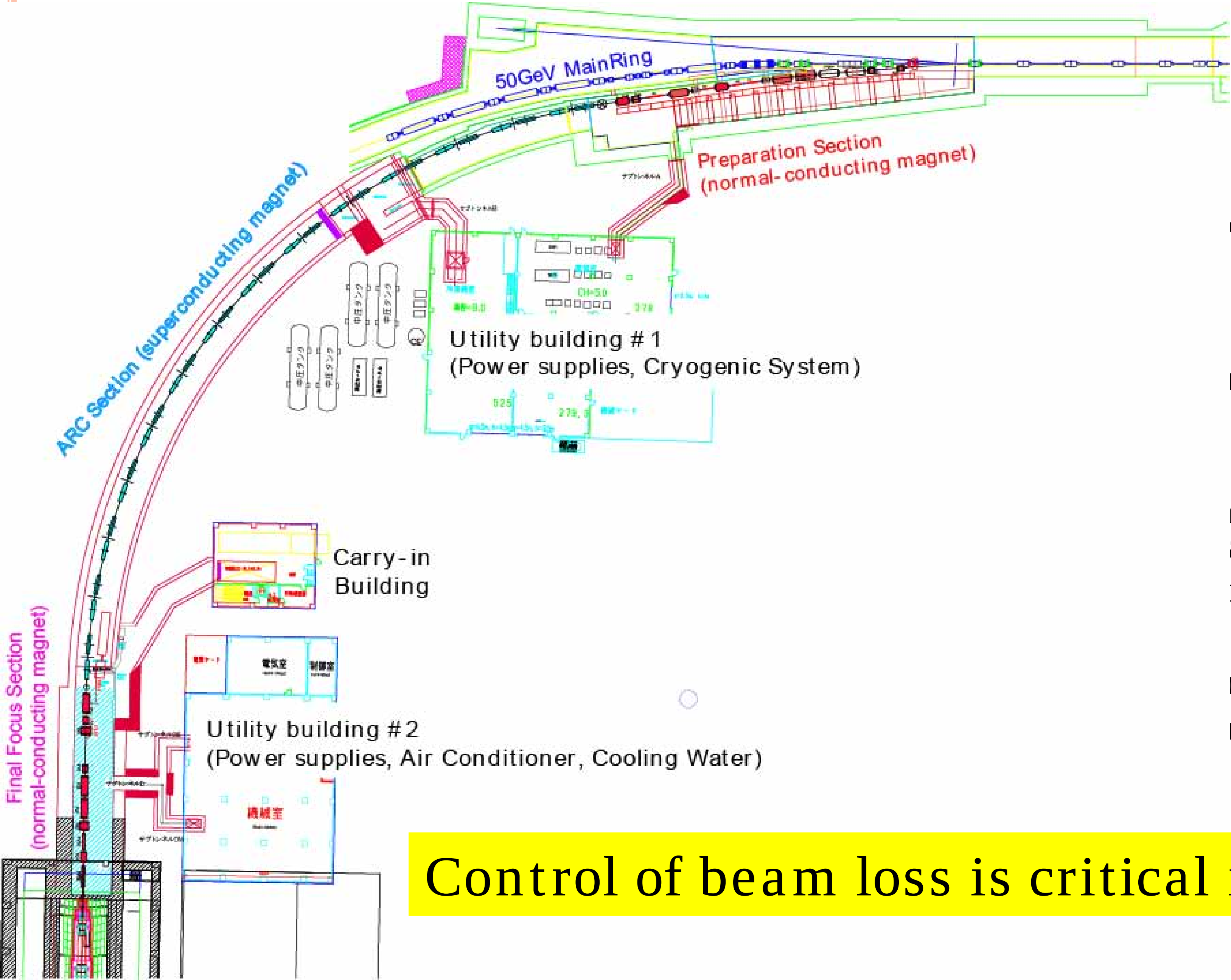
Linac succeeded in 181 MeV acceleration in Jan. 2007

3.1 ニュートリノビーム/J-PARC

3.1 ニュートリノビーム/J-PARC



3.1 ニュートリノビーム/J-PARC



agnets

bined
application)
m

on
agnets

Control of beam loss is critical issue

Superconducting magnets

Primary line components (1)

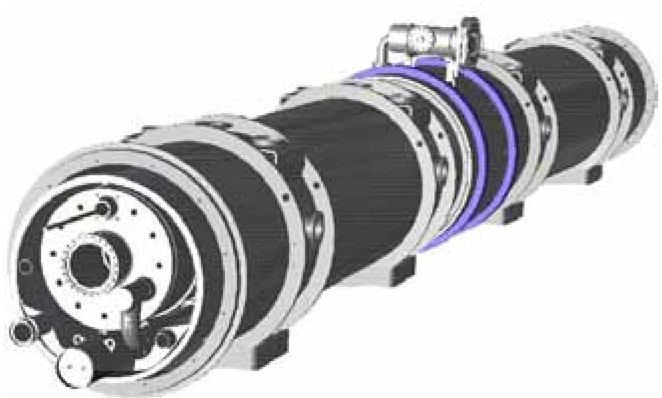
- 26 (/28) mags, 11 (/14) “doublets” completed
- 6 doublets already installed in the tunnel
- Up to 28 mags, 12 dblt’s in FY2007 (by Mar.2008)
- 4 corrector mags are produced by BNL. 2 are delivered to KEK, 2 more being fabricated
- Magnet safety system (MSS) by Saclay
  - Hardware being constructed almost on time (Delivery to KEK in June)

Correctors

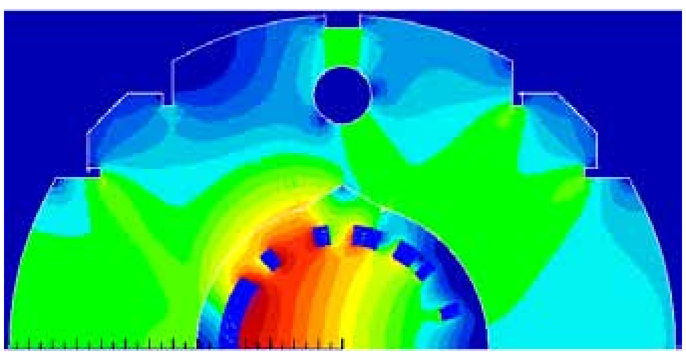
MSS

Superconducting magnets (doublet) in Tunnel

Superconducting Magnets



Two magnets in cryostat “doublet”
14 doublets + 2 spare doublets
+ 4 corrector magnets by BNL



SCFM : Superconducting Combined Function Magnet
D: 2.6 T, Q: 18.6 T/m, Length: 3.3m, Current: 7,345A@ 50GeV

- 11 doublets in beam-line, Cryogenics installation on time.
- Entire system will be completed by December 2008

PRIMARY LINE COMPON

Normal-conducting magnets

- **11 mags in prep.section installed and aligned.**
- Installation of FF magnets starts in March 2008.

Misc.

- Installation of vacuum components / beam plug started.
- Level meas. in progress to monitor ground sink.

PROTON BEAM MONITO

Position: 20 x ESMs

Profile: 19 x SSEM s

Intensity: 5x CTs

- **Being assembled**
- **Installation started in prep sect**

ESM

CT

Loss: 50 x Ionization chambers

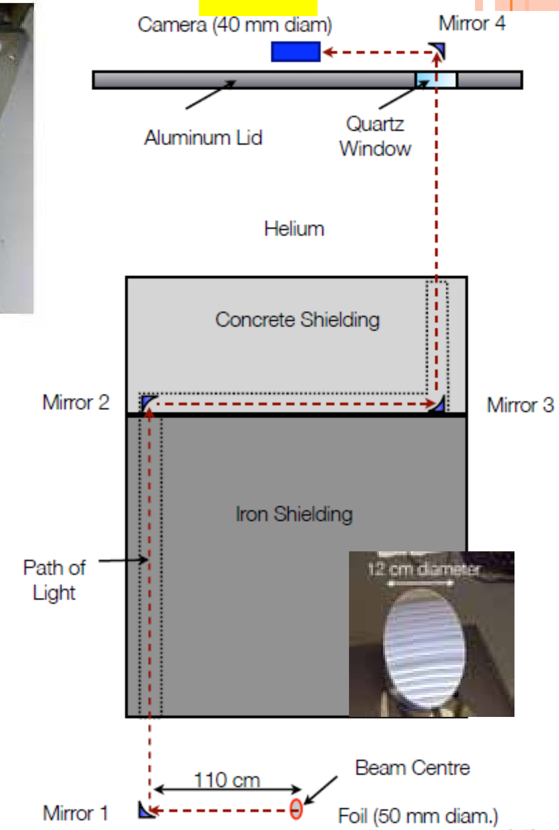
- **Twenty monitors are purchased in this FY**

SSEM

OTR detector (provided by Canada)

- Provide all-time profile just in front of target
- **Mirrors, rad-hard camera delivered**
- Manufacturing, assembling in progress

OTR

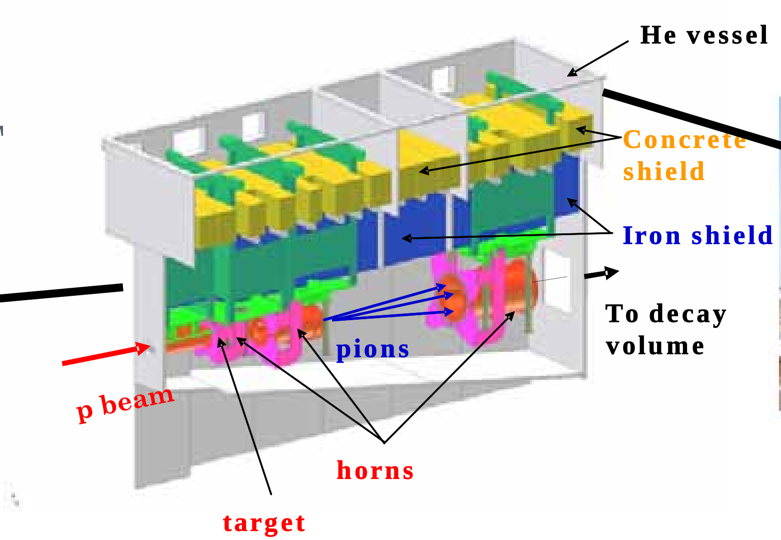


Electronics

- FADC for CT/ESM being produced by US
- FADC for SSEM prepared by Korea

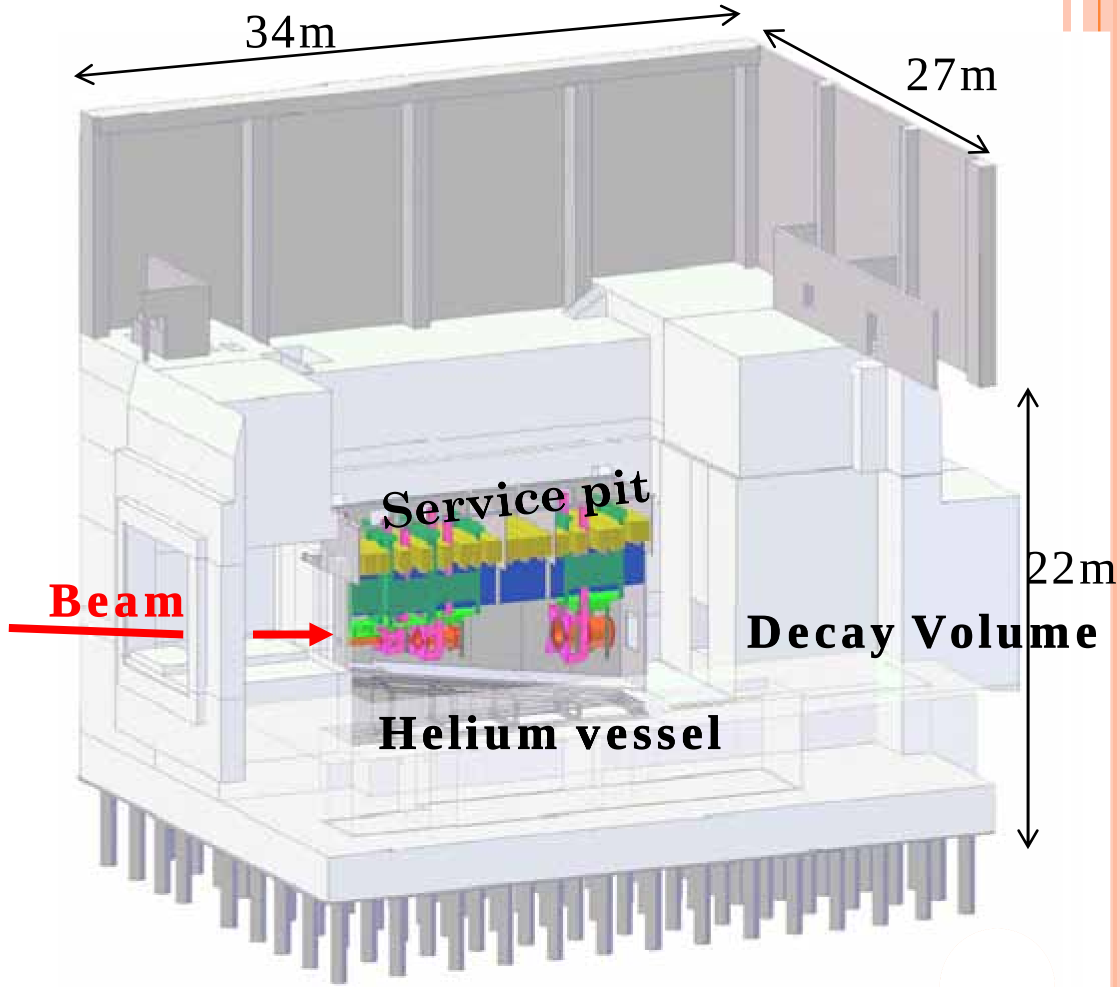
Installed monitor chamber

T



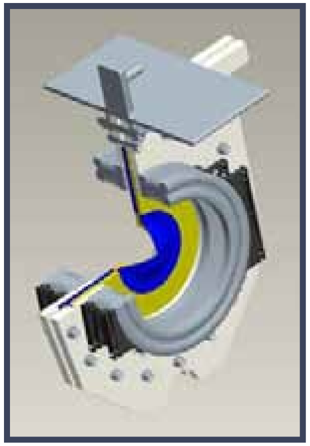
- Overcame water food problem during excavation in early 2007
- Installation of the helium vessel(~470ton, 1000m^3) finished, passed vacuum test in Nov. 2007 **as scheduled**
- Construction of surface building starts soon and will finish in June 2008.

Target Station

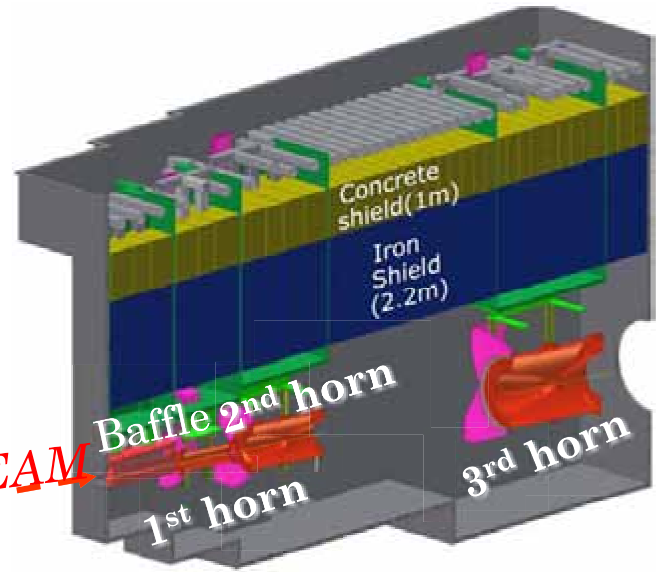


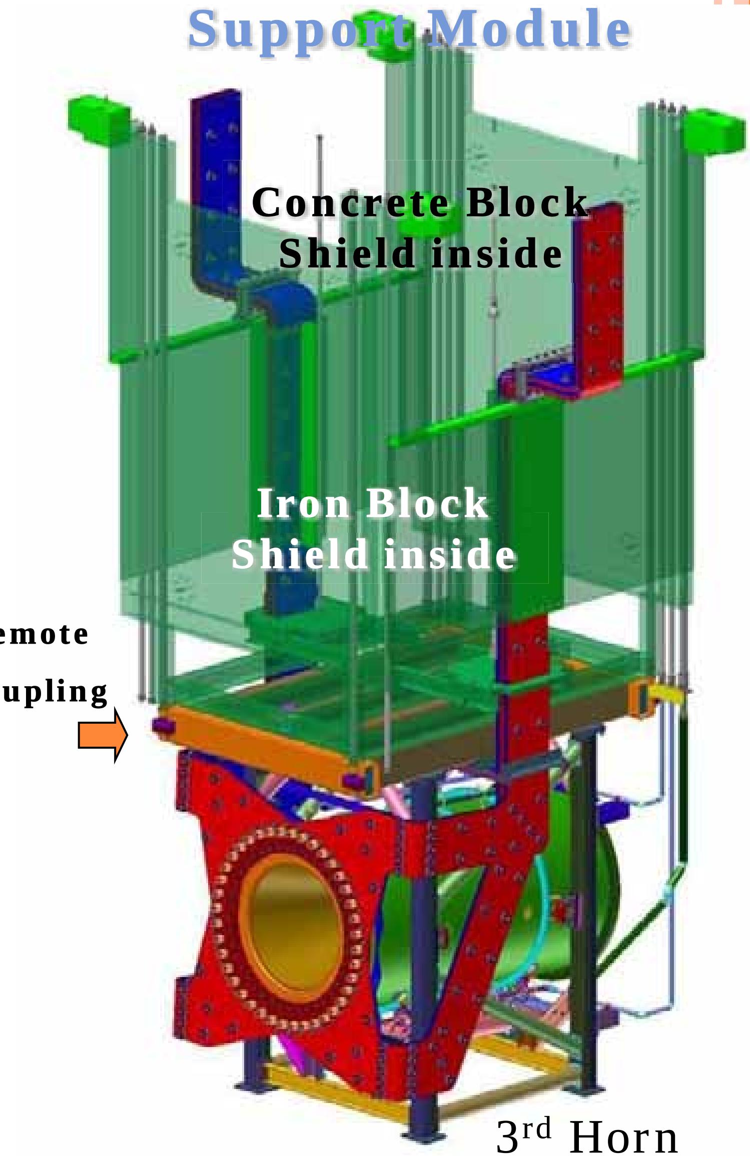
- 40t crane for remone maintenance installed on March '08
- Construction of the building to be completed in June 200

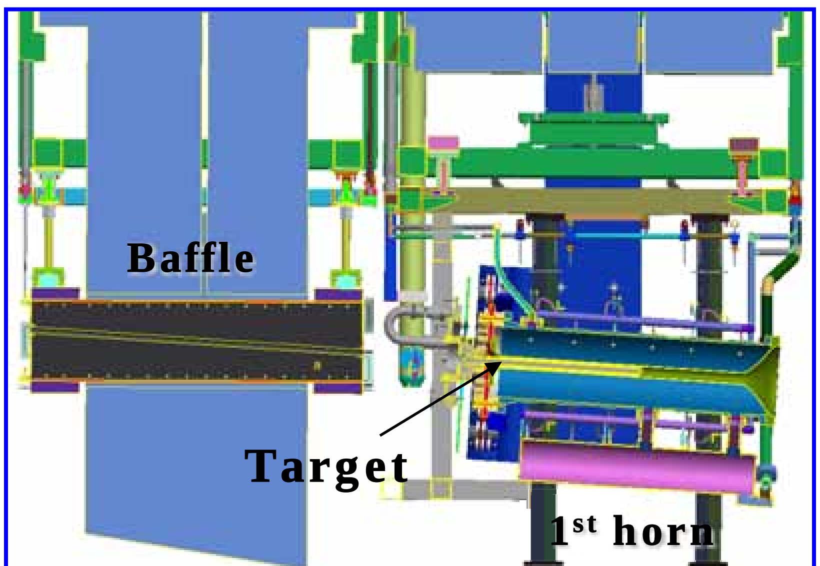
APPARATUS IN THE TS VESSEL

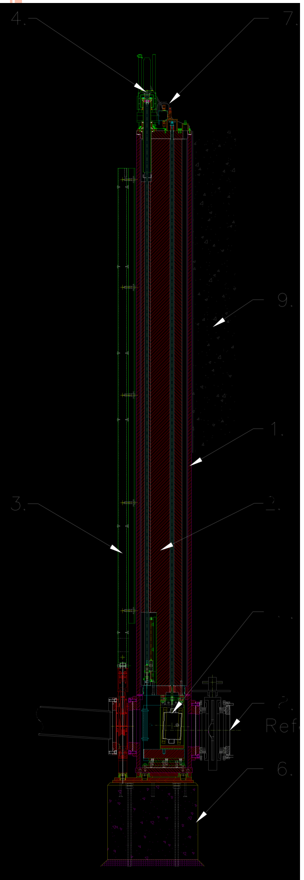


Beam Window
With pillow seal





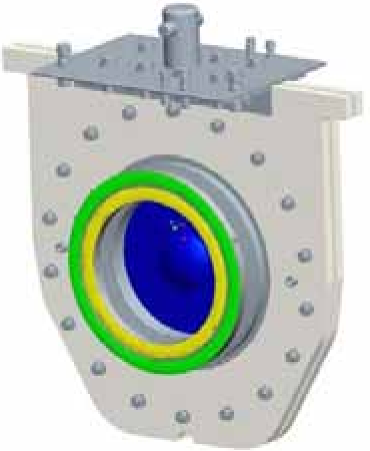




Downstream dome Upstream dome

Downstream plate Upstream plate

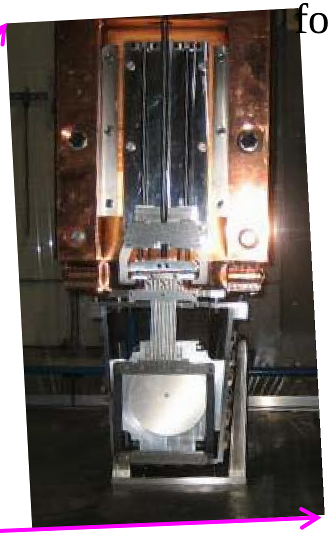
Pillow seal flange for window



Beam window @RAL

Monitor chamber @TRIUMF

Mockup monitor

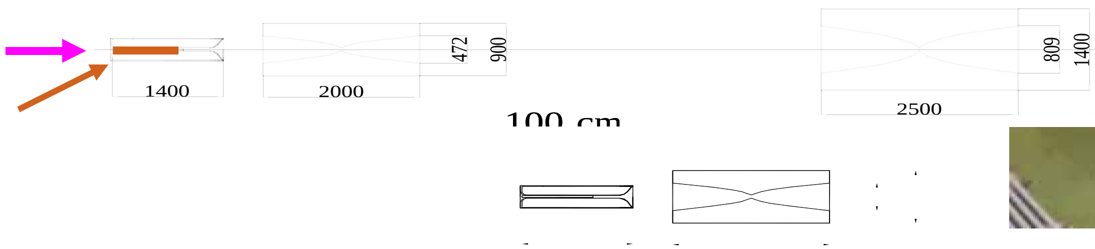


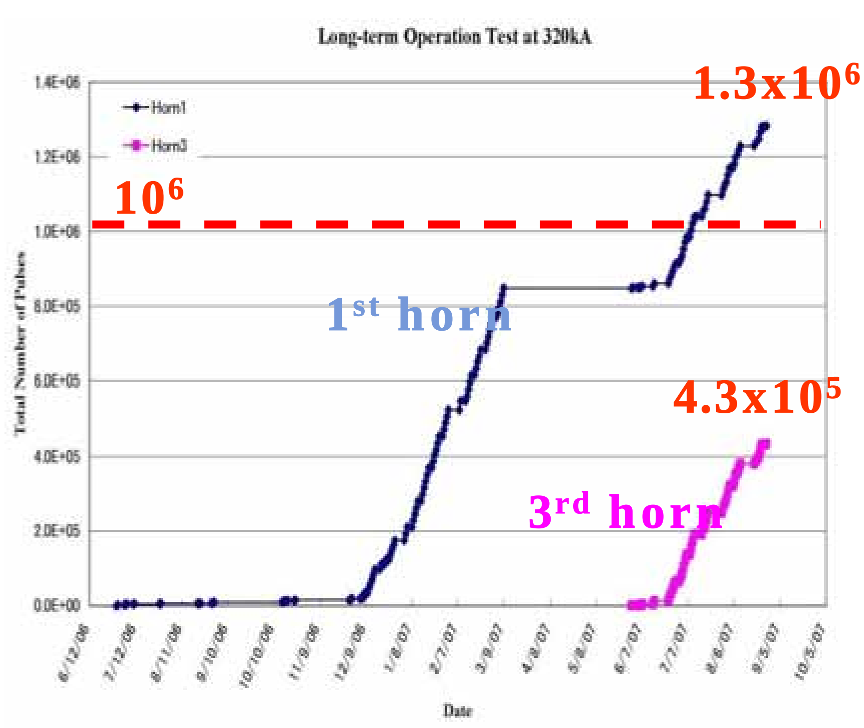
Pillow seal flange for monitor chamber

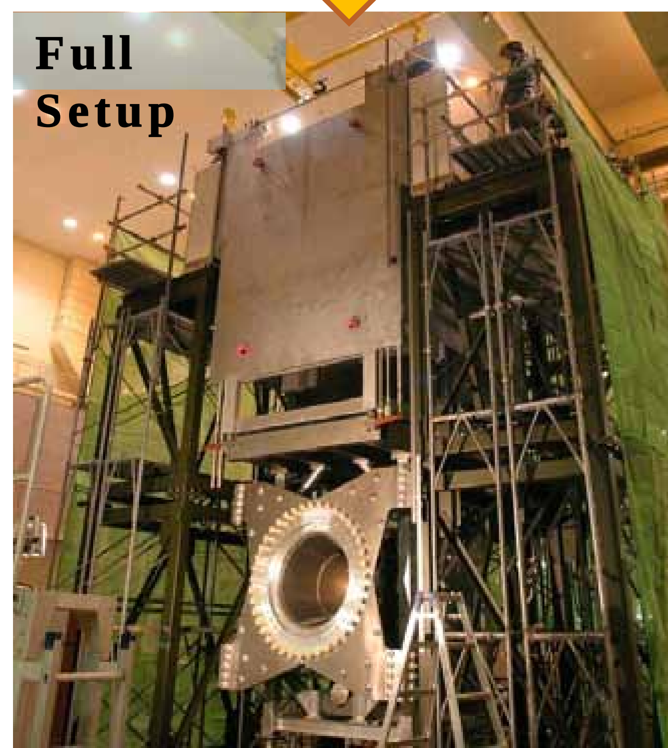
Beam window and monitor chamber are under assembly at RAL/TRIUMF and will be installed into TS from July 2008.

電磁ホーン(π収束装置)

- 3 ホーンシステム
  - 320kA運転で長期試験







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

In preparation now.

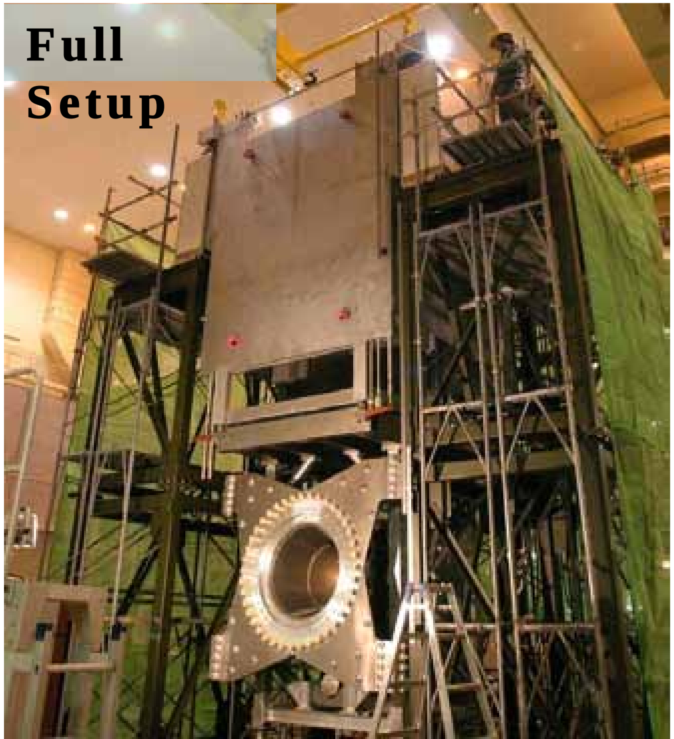
The 320 kA test operation soon.

Necessary improvements are identified and being solved.

Support Module

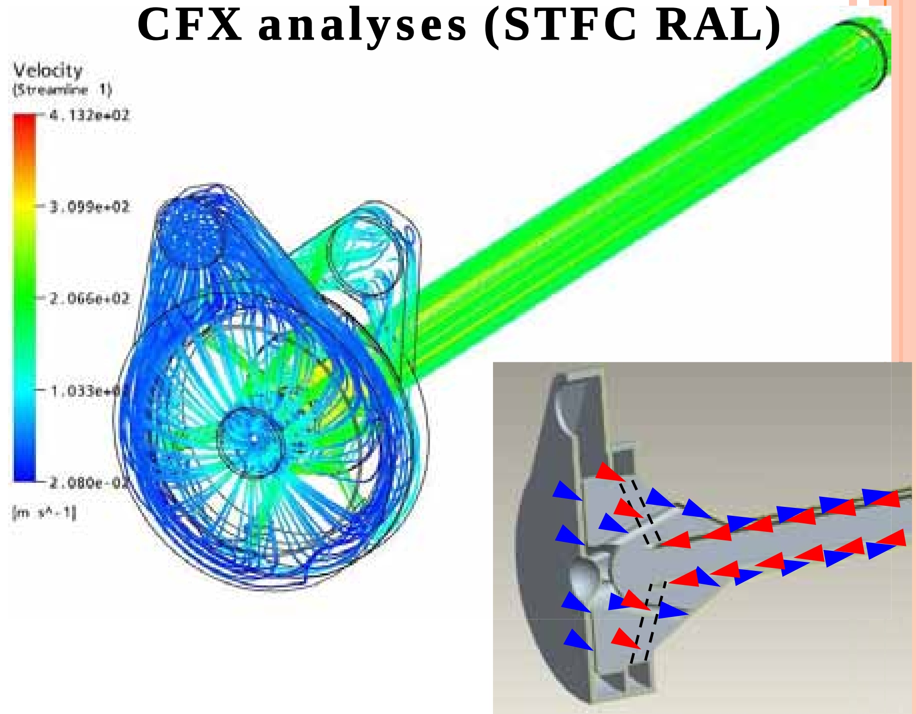
3rd Horn

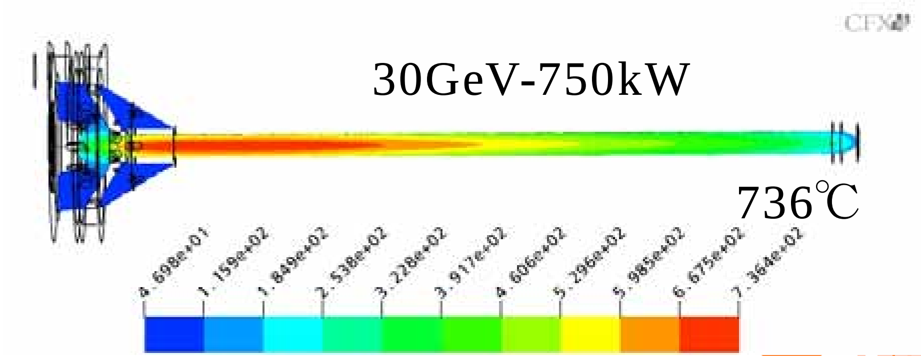
Full Setup



Hung by remote sling tool

TARGET



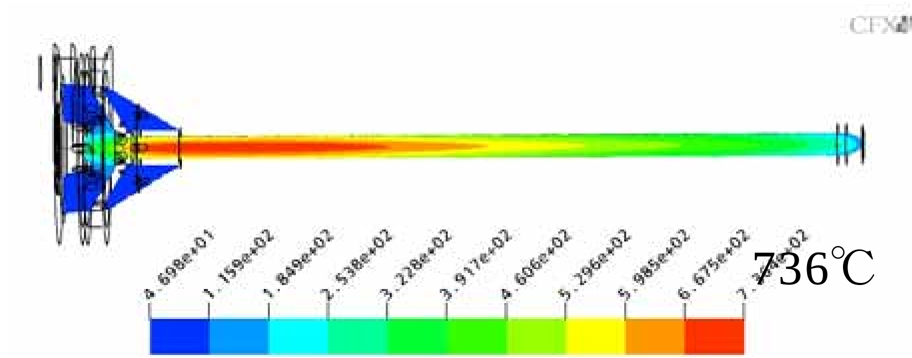


- Full prototype delivered in Dec. '07
- He gas flow test, achieve 650Nm^3/h (200m/s)

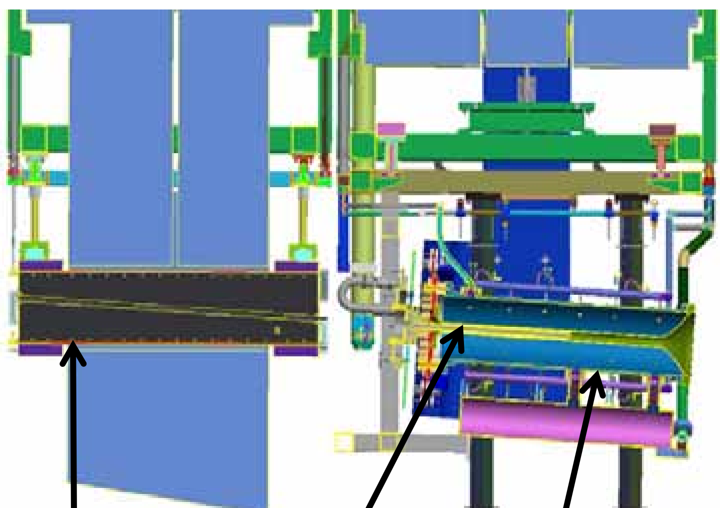
ΔT~200K ~7MPa(Tensile 27MPa)

標的

- グラファイト:
  - 26mm(D)x900mm(L)
- ヘリウム冷却



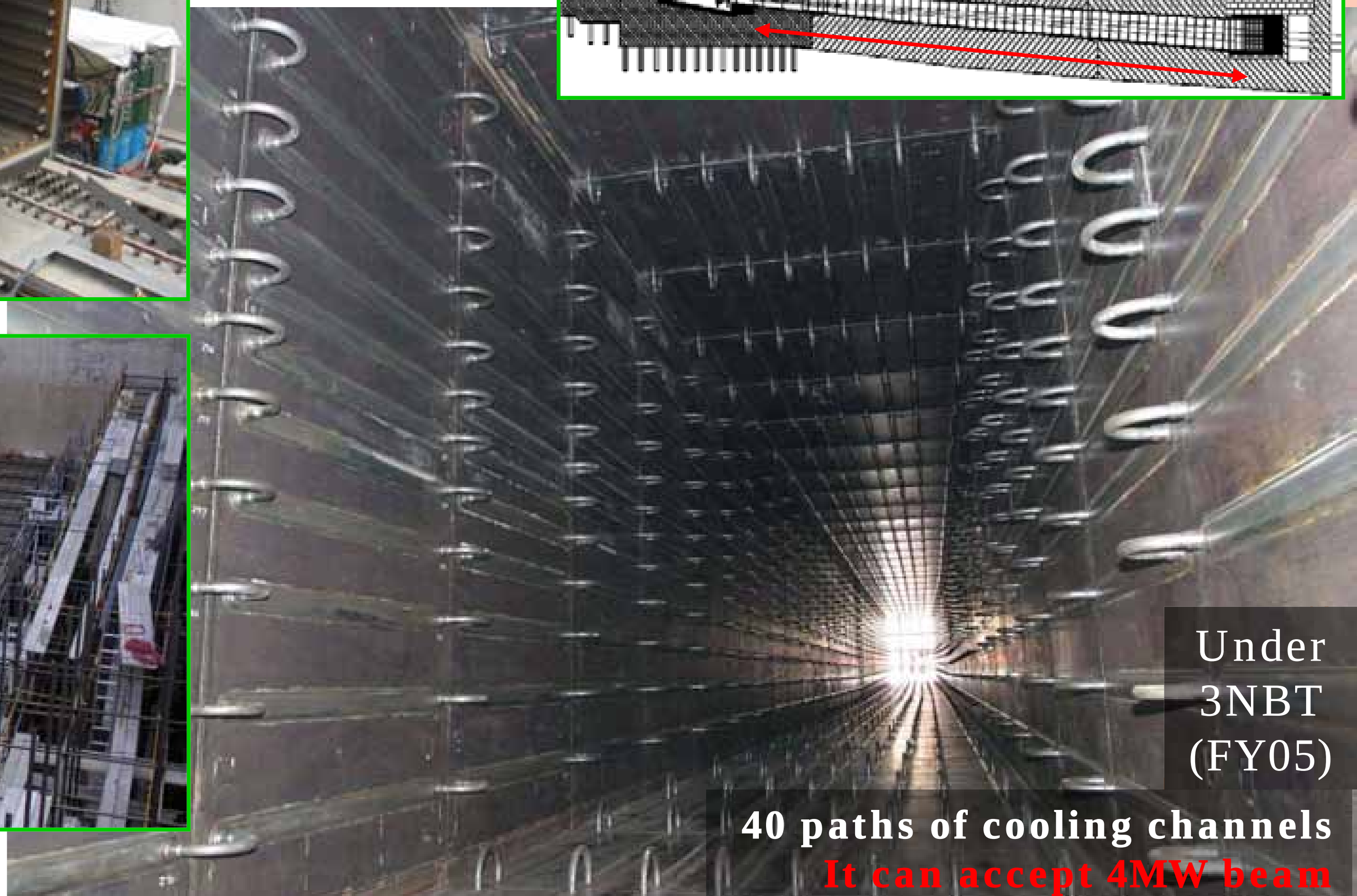
ΔT~200K ~7MPa(Tensile 27MPa)

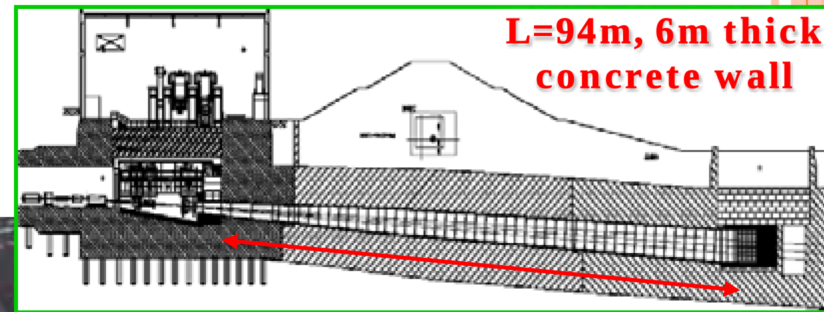


Baffle (RAL)　Target　1st horn

DECAY VOLUME

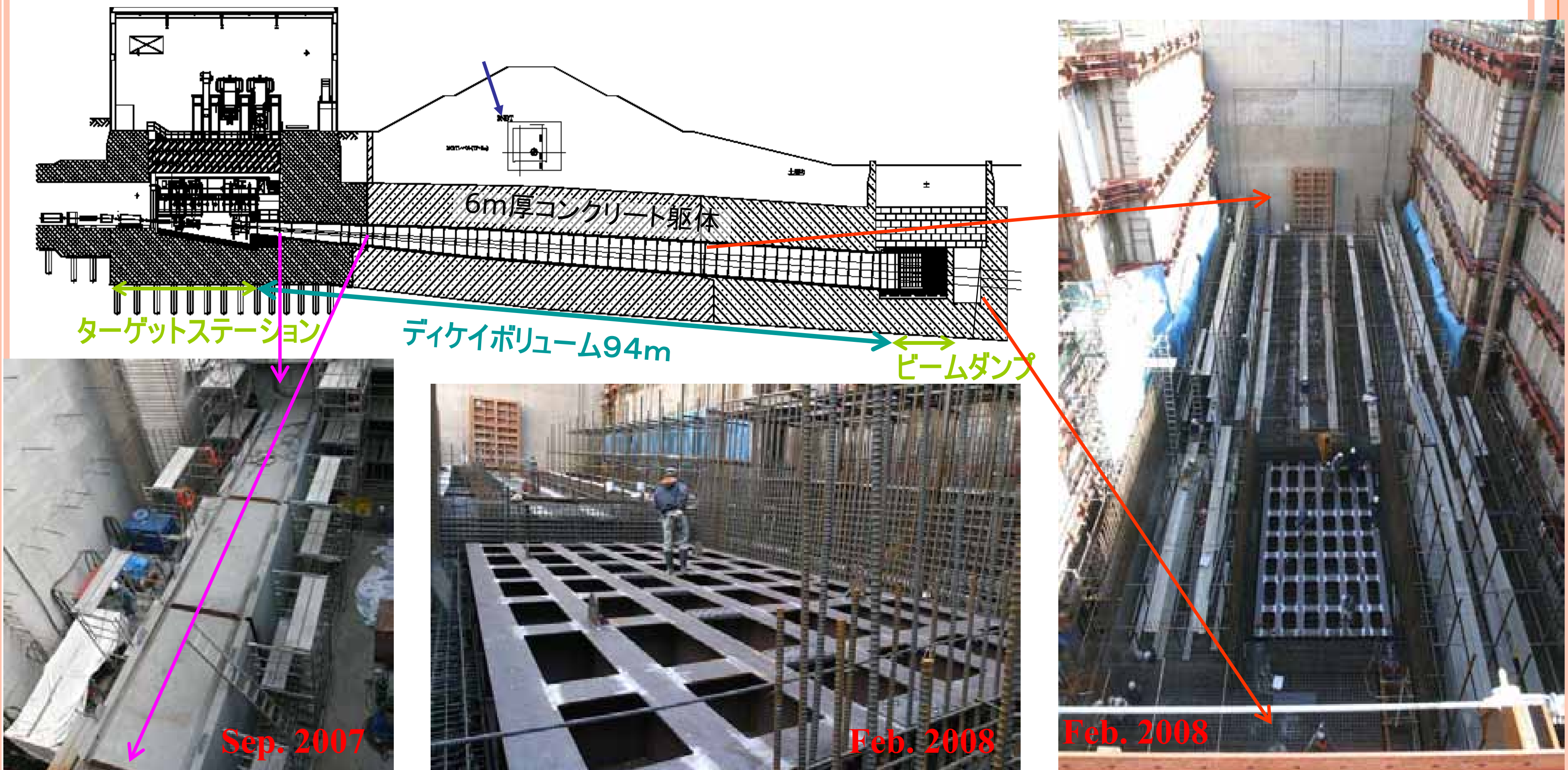
2008/03/07





Decay Volume

- Upstream part (20cm^t Iron) was installed & tested in Nov 2007.
- Anchor frame for BD core was embedded in concrete in Feb. 2008.
- Civil construction of downstream part will be finished by Aug.
- Construction of He vessel:
  for DV: just started, for BD: will start in Aug. 2008.



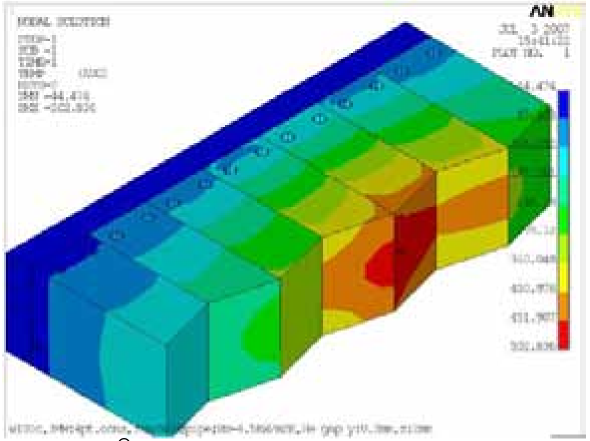
Upstream part

Anchor frame for BD core

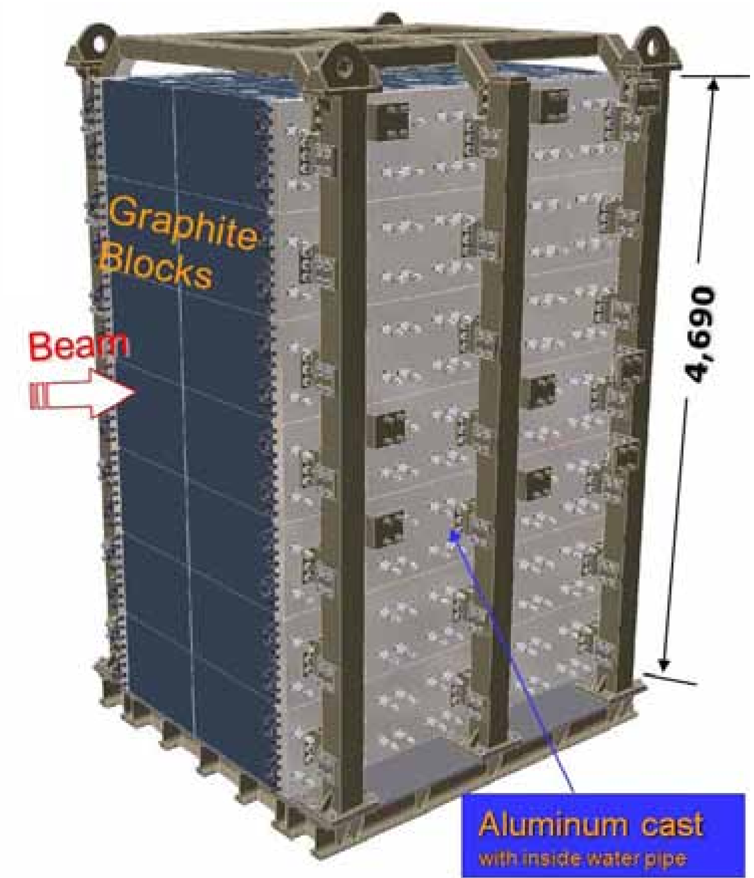
Downstream part

ビームダンプ

- 98 グラファイトブロック
- Core will be Installed into He vessel in Oct/Nov 2008.



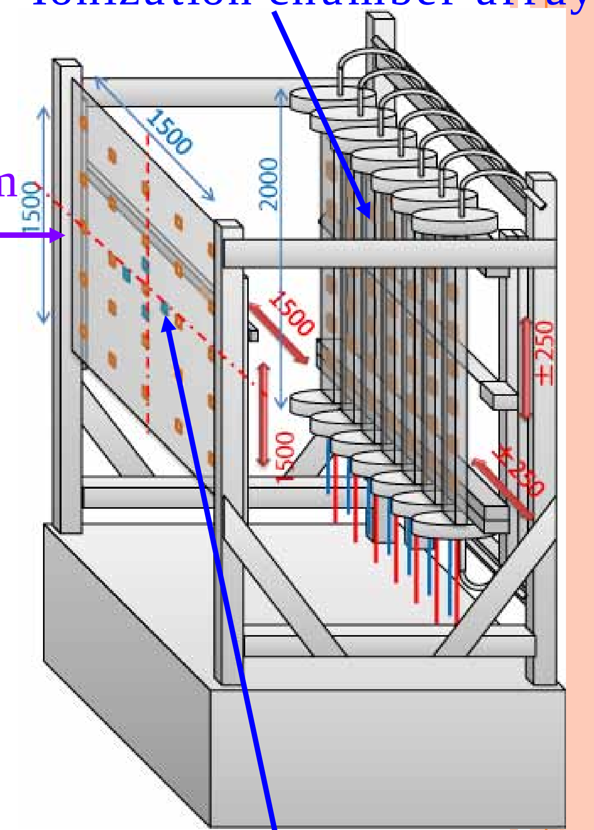
500℃ with 3MW
[Assuming phase-I target]

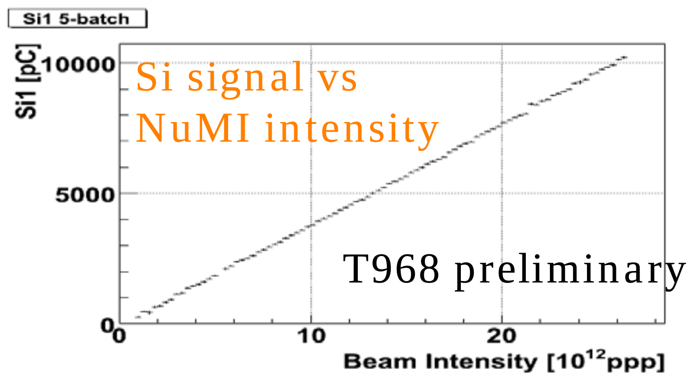


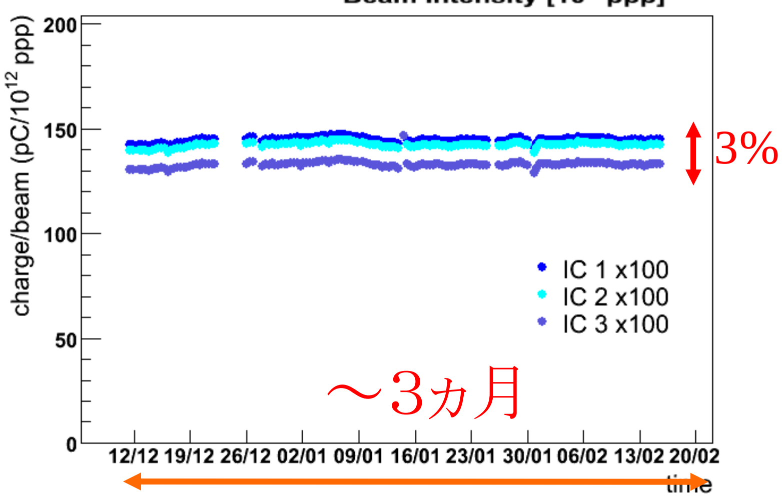
1st assembled module

ミューオンモニター

- パルス毎にニュートリノビームをモニター
  - 強度、方向、プロファイル
- フェルミ研T968として、NuMIビームラインでプロトタイプの長期試験中
- 2008年冬に設置予定。







NuMI/MINOSに設置されたT2K-ミューオンモニター試作機

26pZj:15:45〜

- ☐ 松岡
- ☐ 久保

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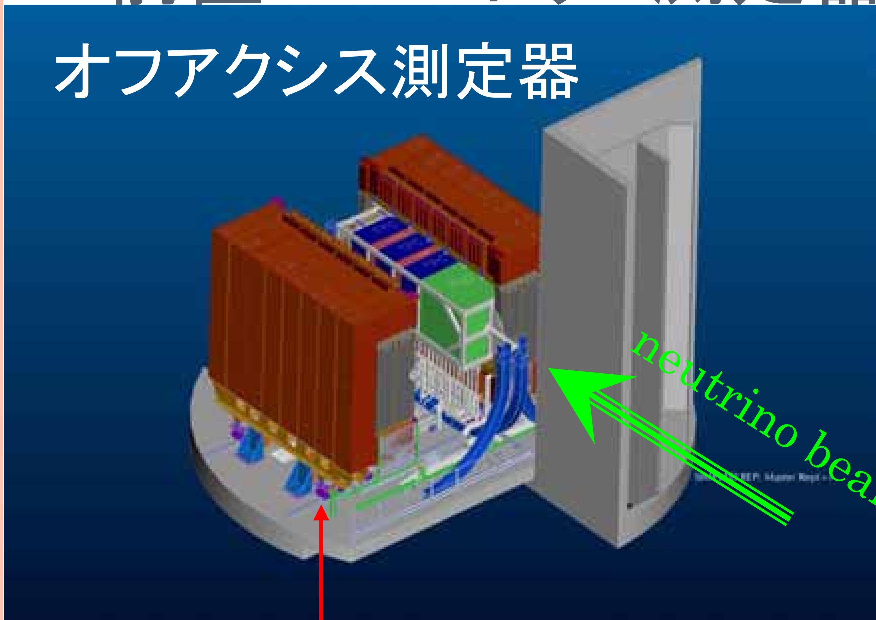
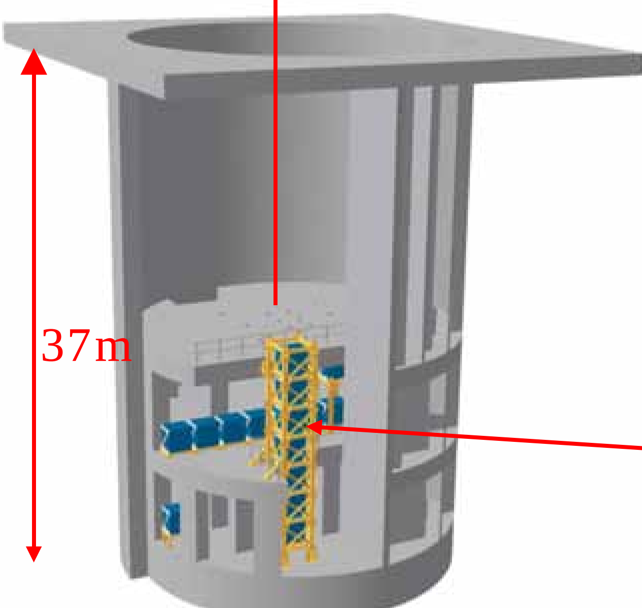
Summary of Status

	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 are starting as scheduled

前置ニュートリノ測定器: ND280



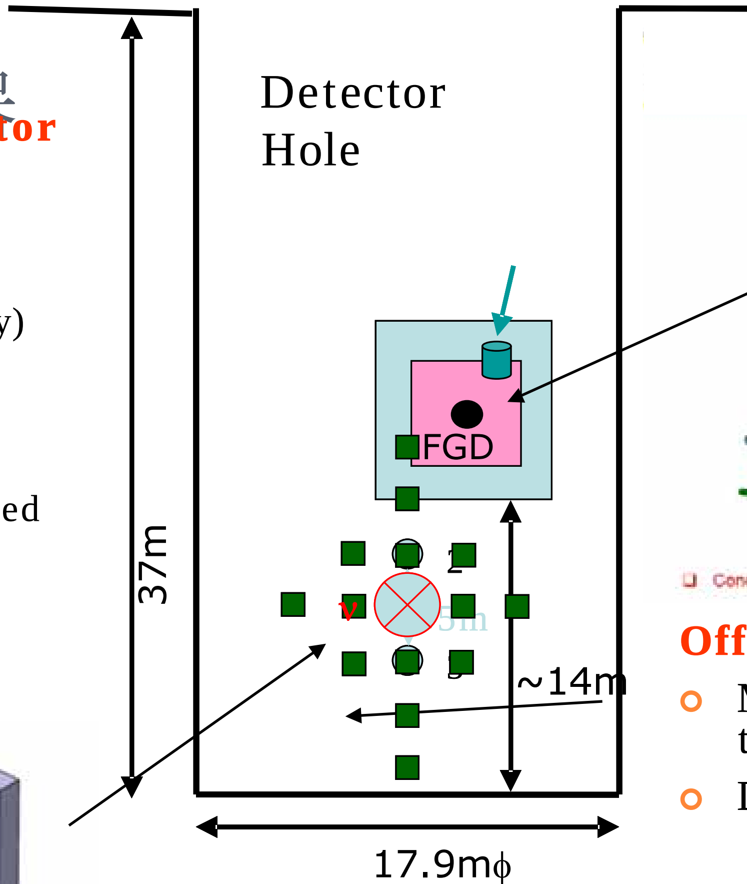


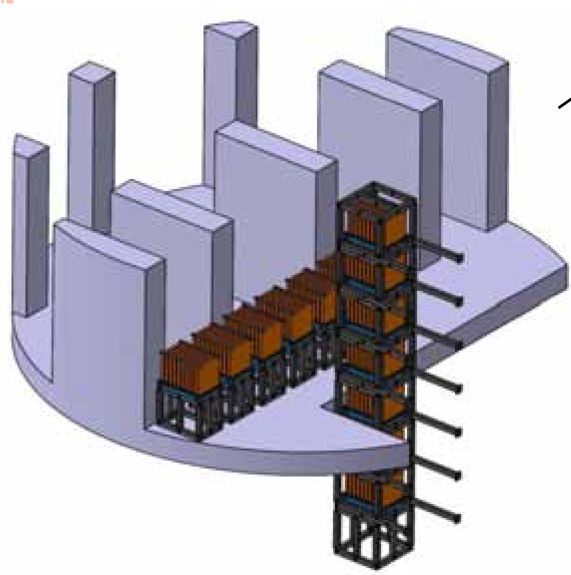
ニュートリノモニター:
INGRID

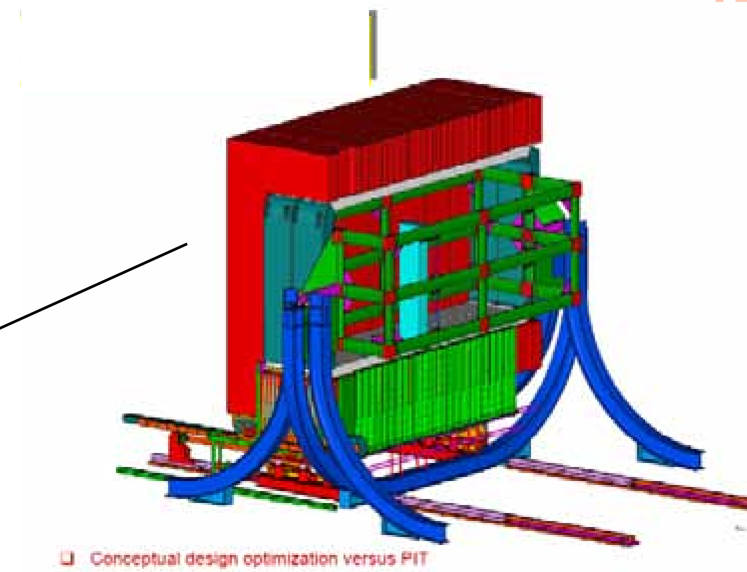
前置測定器

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

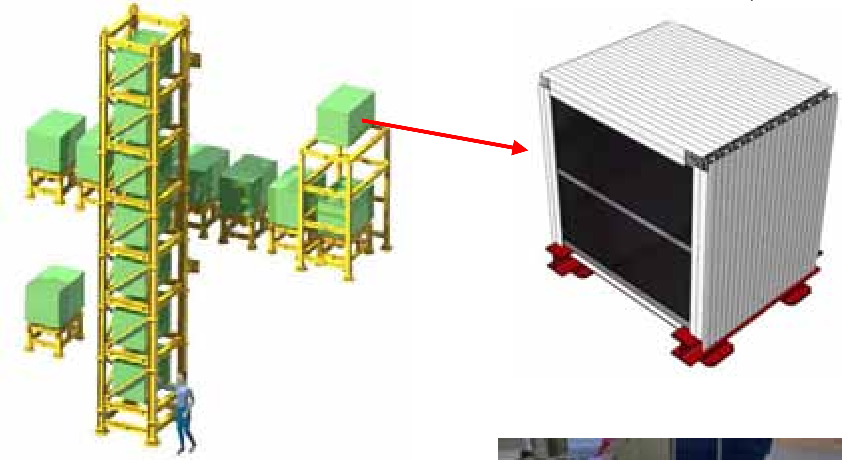
Off-axis Detector

- Measure ν_μ flux: <5%
- Measure ν_μ energy scale: <2%
- Measure intrinsic ν_e content of beam: <10%
- Measure non-CCQE backgrounds for both ν_μ disappearance and ν_e appearance: <10%
- Magnetic field, fine segmentation, excellent tracking
- Major non-Japanese contributions
- High complexity and non-trivial integration

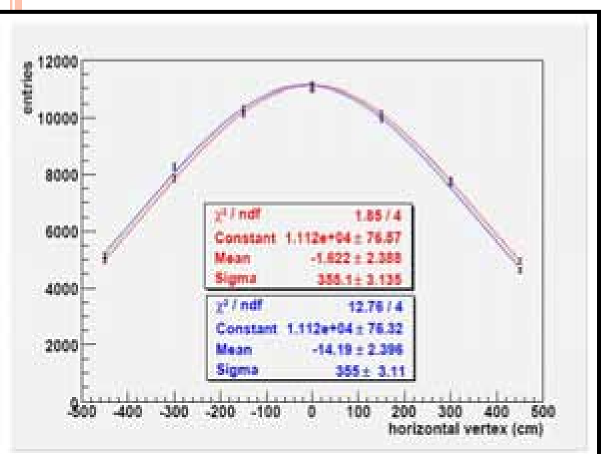
280M DETECTOR HOLE CONSTRUCTION

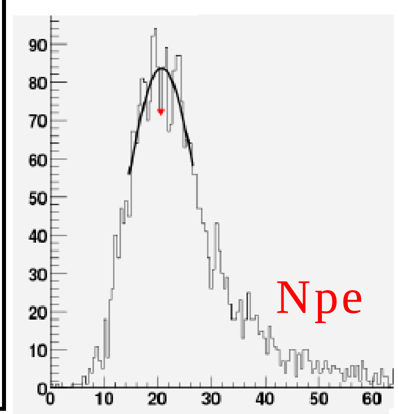
- 17.5m-ϕ x 33.5m deep hole excavation finished in Jan 2009
- Underground floors being constructed.
- UA1 magnet installation Apr-Jun, 2008
- **Construction is on schedule**

INGRID: ニュートリノビームモニター

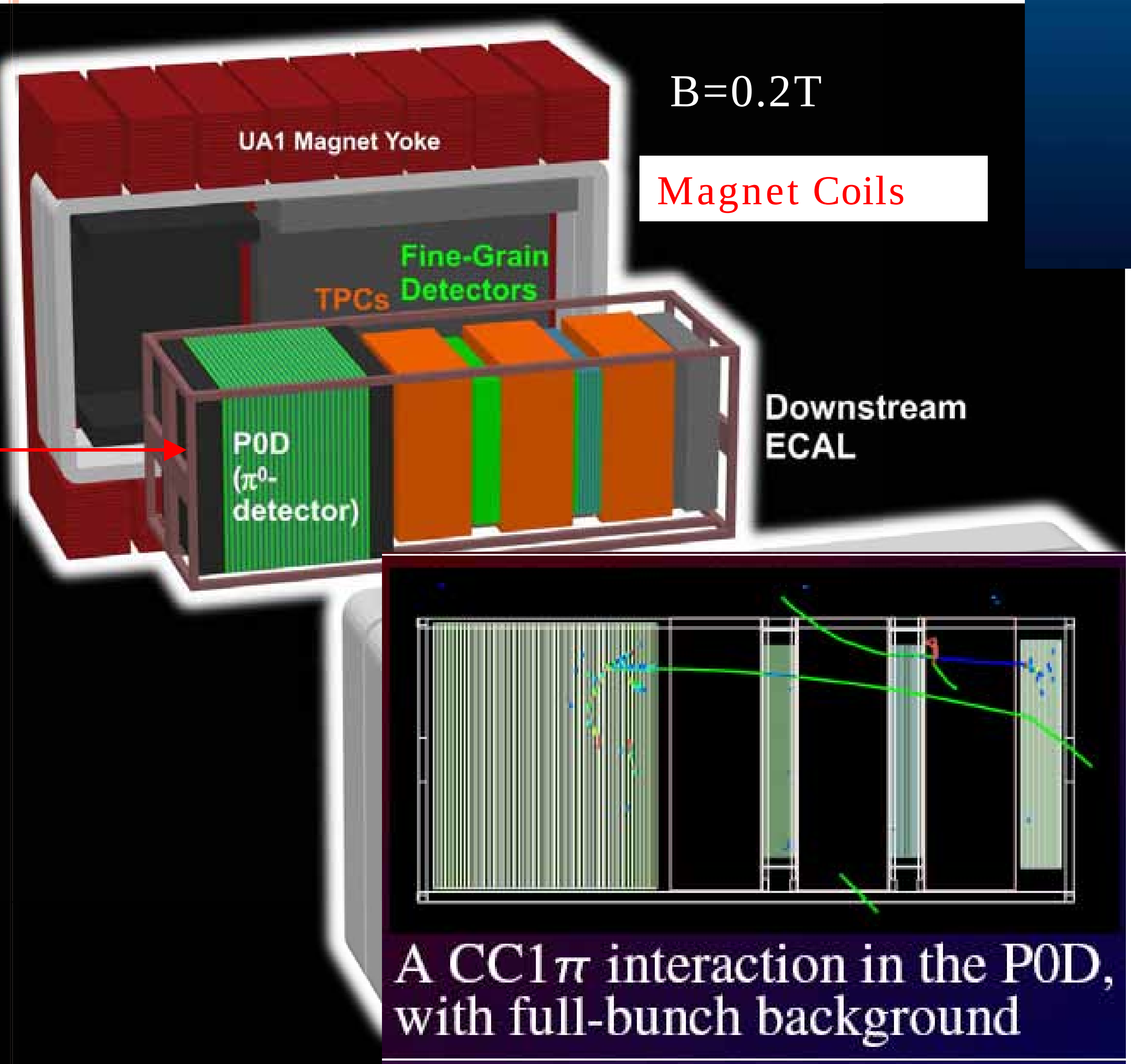


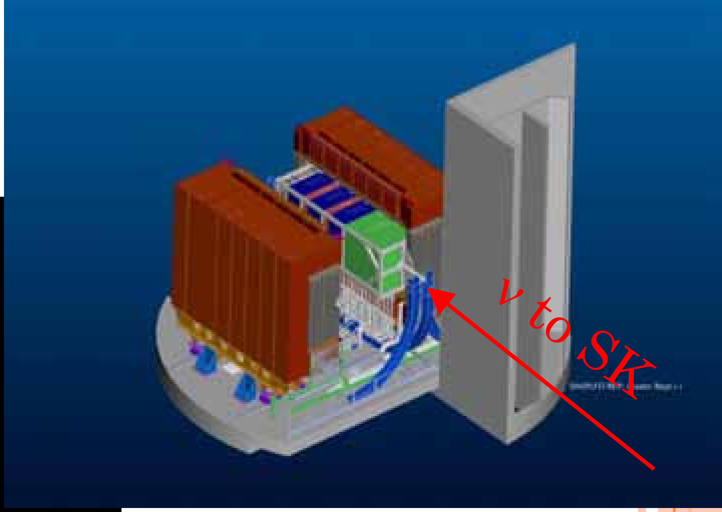
- 7+7+2モジュール
  - 10,000事象/モジュール/日
  - ニュートリノ強度、ビーム方向、スペクトル安定性をモニター
- 120×5×1cm³シンチレータ
  - 約10,000本
  - 波長変換ファイバー読出し
  - 光測定器:浜フォトMPPC
  - 平均光量: ～15p.e./cm
- 2009年4月測定開始





オフアクシス測定器

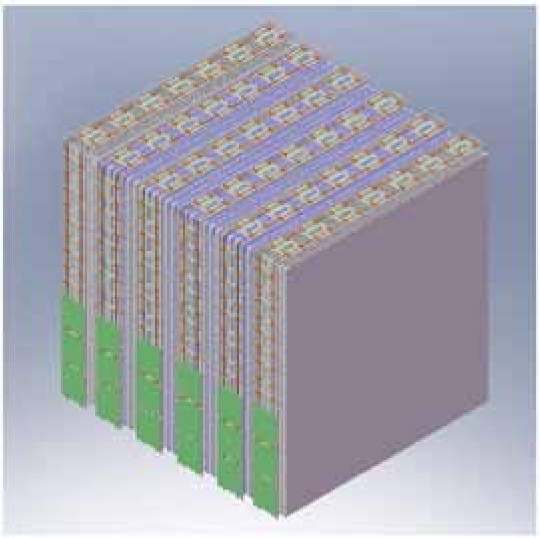




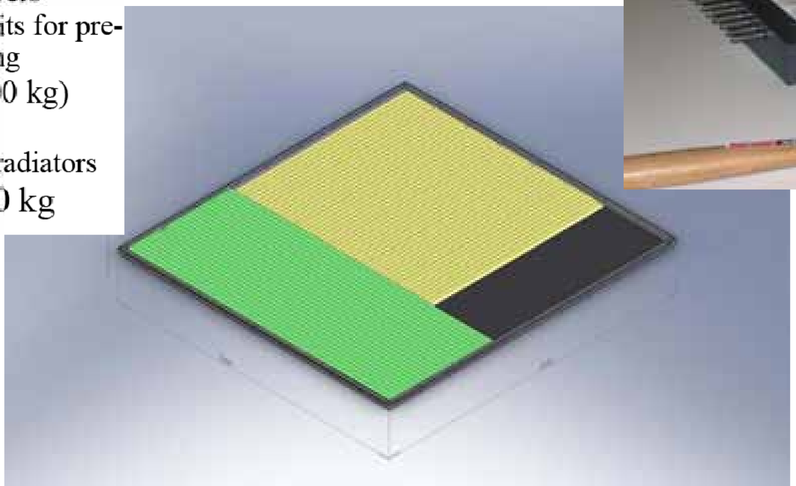
- 測定器容量:
  - $3.5\times3.5\times7.0\mathrm{m}^3$
- P0D π^0 測定器
- FGD+TPC:
  - 荷電カレント反応測定
- 電磁カロリメータ
- サイドミューオン飛程測定器

P0D

- Scintillator bars – lead/brass sandwich – water targets. Mass: 17.6ton total, 2.9ton water
- Optimized for NC π^0 production measurements
- Runs with/without water: C/H_2O scaling
- 17,000 NC $1\pi^0$ events/year in water
- MINERVA bars, WLS fibres, MPPCs, TRIP-t electronics
- Construction: May-December 2008

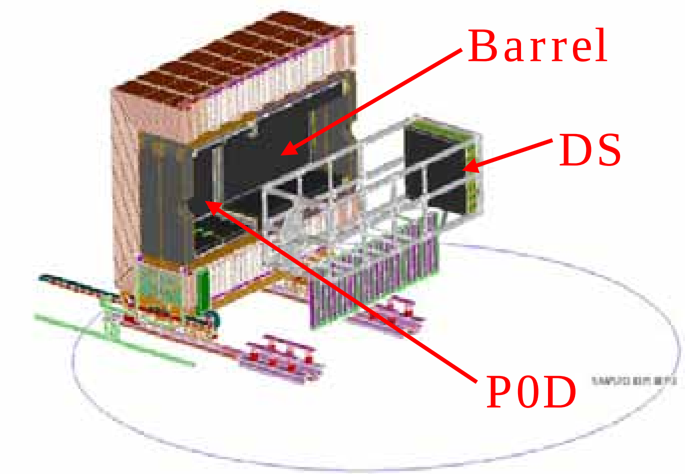


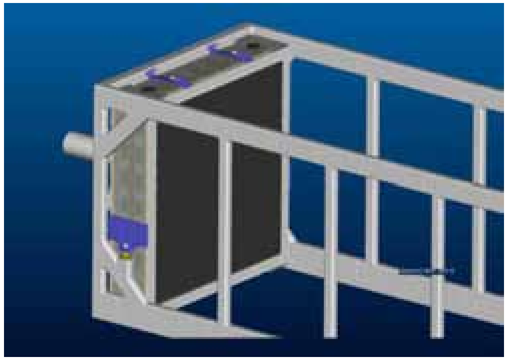
- 3 Super-PØDules
  - Upstream ECAL (3200 kg)
    - 7 PØDules
    - 7 4mm-thick lead radiators
  - Target (11000 kg)
    - 2857.3 kg water
    - 26 PØDules
    - 25 1.6mm brass radiators
    - 25 Water target layers
    - Split into 2 sub-units for pre-installation handling
  - Central ECAL (3200 kg)
    - 7 PØDules
    - 7 4mm-thick lead radiators
- Total Mass is 17600 kg

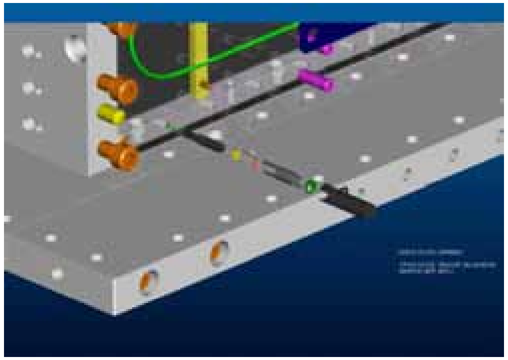


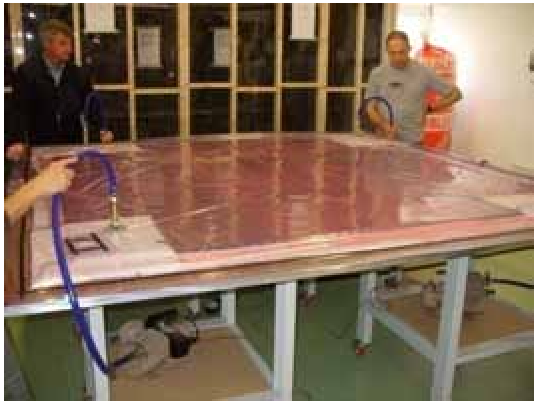
ECAL

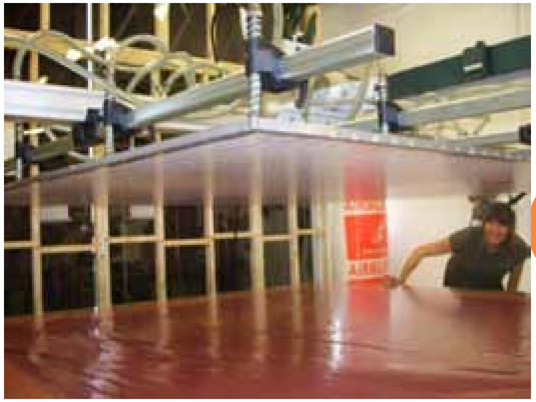
- Reconstruct π^0, identify $e/\mu/\pi$
- Lead-scintillator sampling calorimeter
- 4cm x 1cm scintillator, WLS fibre, MPPCs, TRIP-t readout
- 32 layers, 1.75mm Pb, $10X_0$
- DS ECAL ready for installation summer 2009; Barrel in 2010





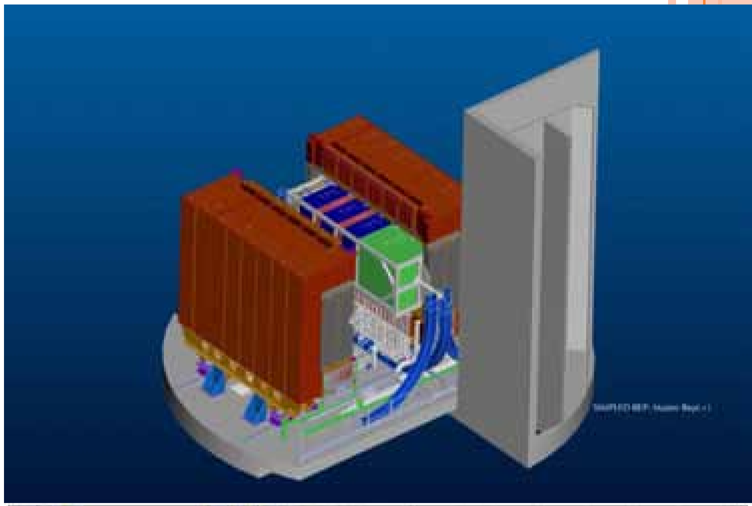


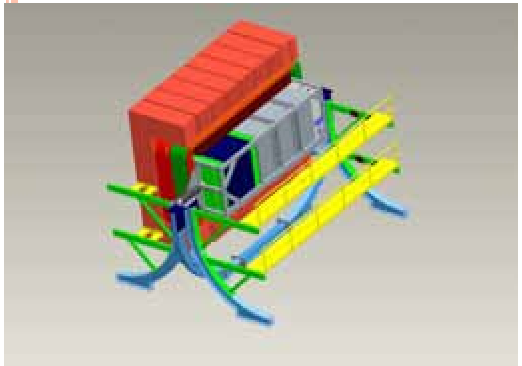


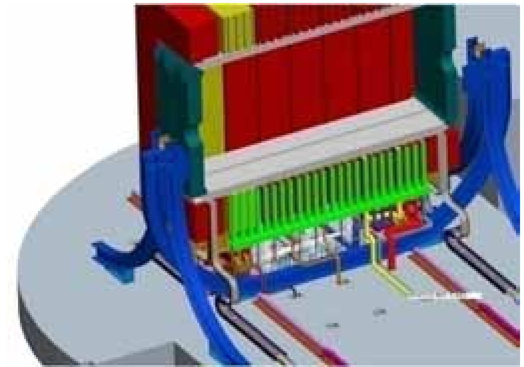


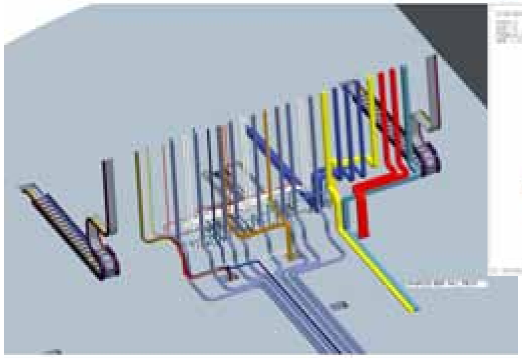
Integration

- Complex dependencies and interactions in space and time
- Technical Board, installation co-ordinators
- Central 3-D pit description, including services routing
- Central project file
- Seismic studies
- Environmental studies (temperature, humidity)







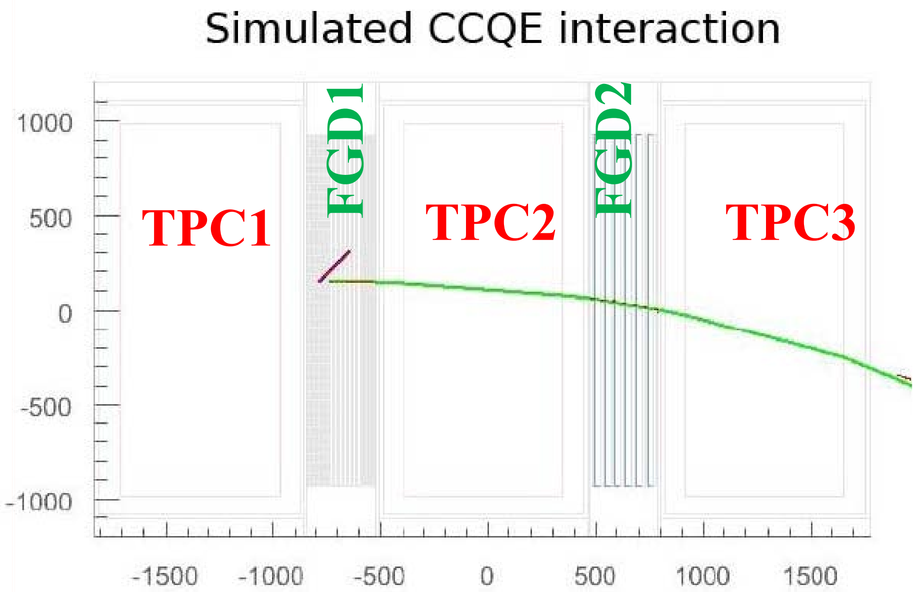


UA1 MAGNET

- UA1実験のダイポールマグネットをCERNより輸送。
  - J－PARCに設置終了
- TPCと組み合わせて運動量測定
  - 0.2Tで運転
  - 高精度＋大立体角で荷電粒子測定。

Fine Grain Detectors

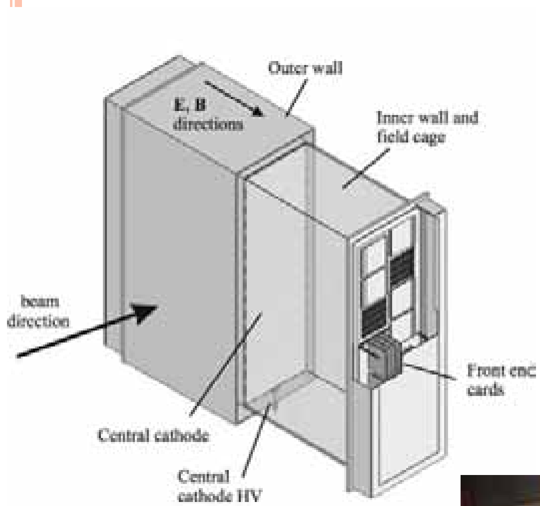
- ニュートリノバーテックス測定器
- 1cm x 1cm シンチレータ, 波長変換ファイバー＋MPPC
- 2009年夏にインストール

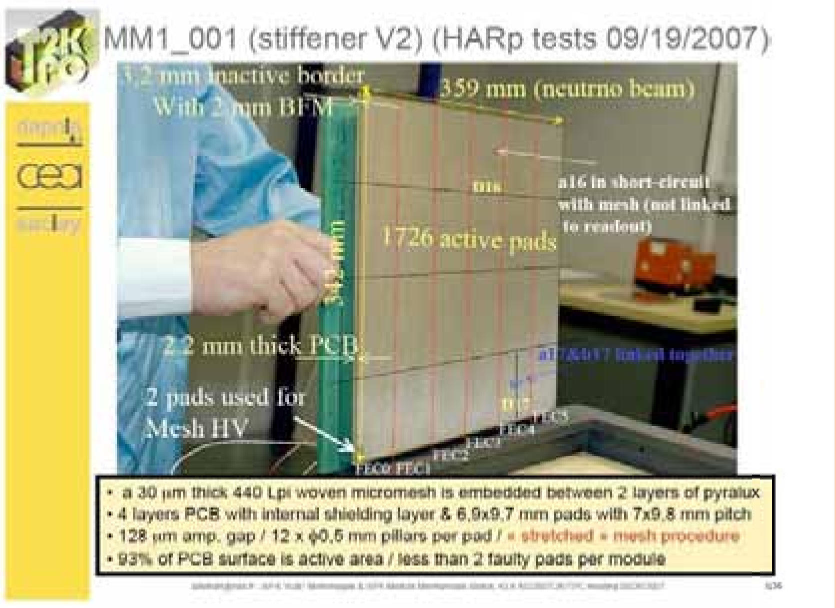


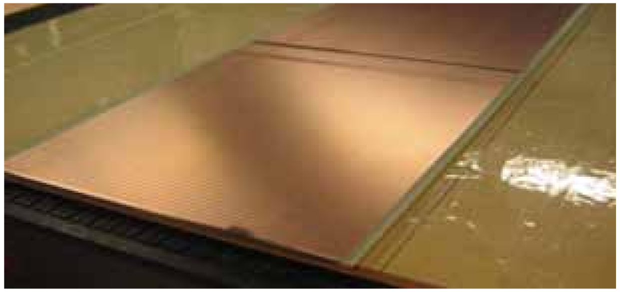
Tracker volume

TPC

- 3TPC, MicroMegas 読み出し (8mm × 8mm パッドサイズ)
- 10% 運動量分解能 (p<1GeV/c), ~10% dE/dx 分解能
- MicroMegas試作機はCERNでテスト。=>　生産開始へ！
- 2009年夏に2台のTPCを設置予定。

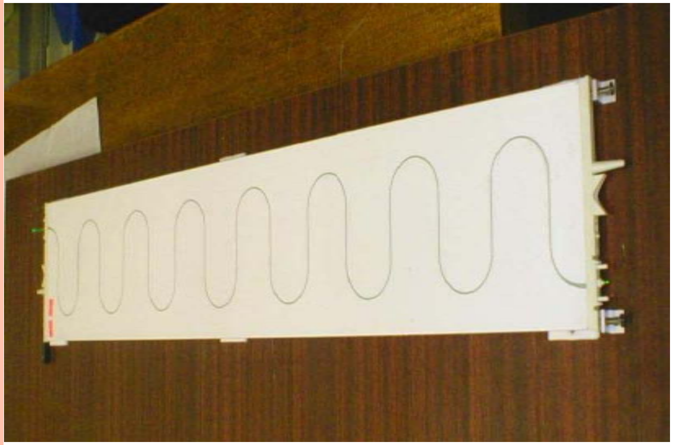
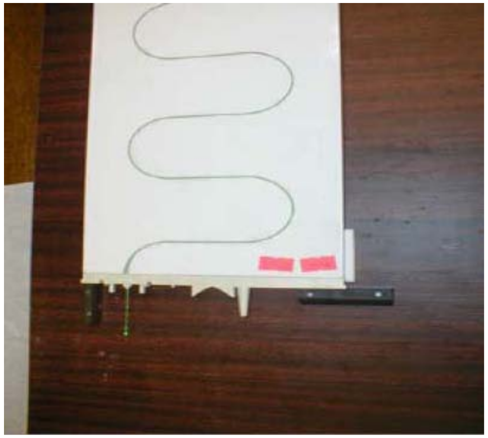






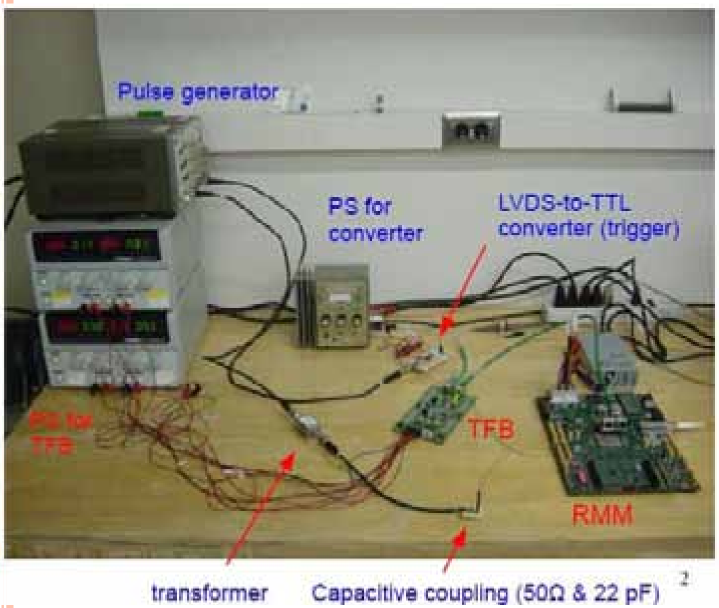
Side Muon Range Detector

- 磁石ヨークのギャップ(1.7cm厚)にシンチレータ挿入。
  - 7mm厚シンチレータ – 波長変換ファイバー＋MPPC
- ミューオン検出、外部からの事象のVETO、宇宙線トリガー

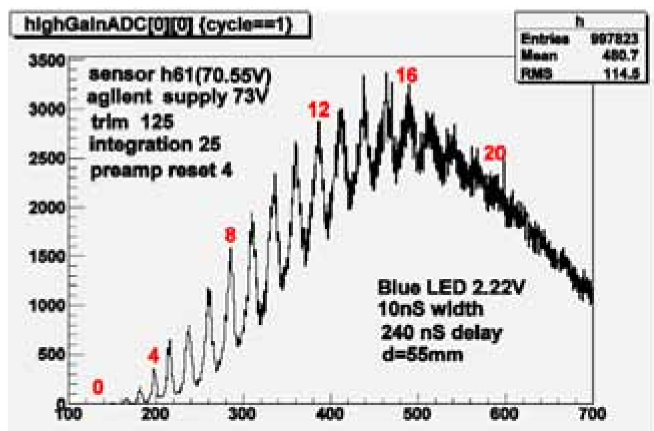




READOUT ELECTRONICS

- Two solutions for Front End Electronics:
  - UK system using FNAL TRIP-t chip: INGRID, P0D, ECAL, SMRD
  - French system using Saclay AFTER chip: FGD, TPC
- Prototypes for both systems operational
- Back End Boards and DAQ system by RAL (common to all)
- Slow Control: MIDAS (TRIUMF)



TFB system in US lab

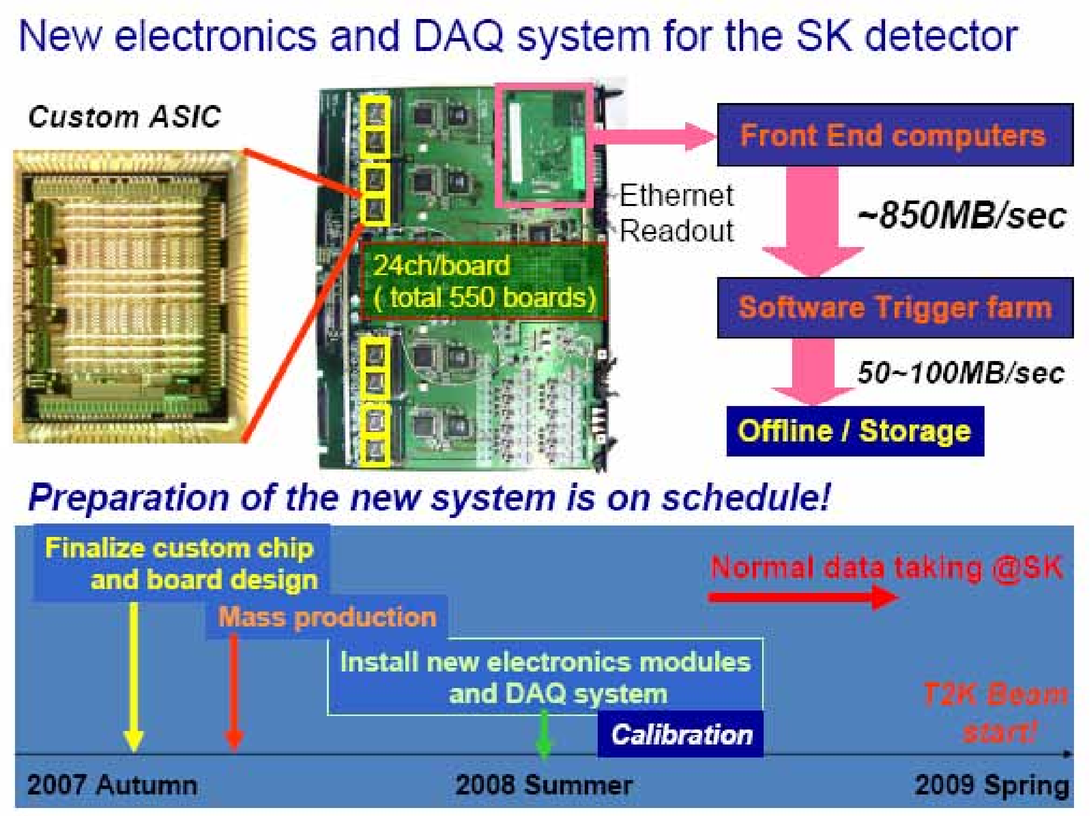


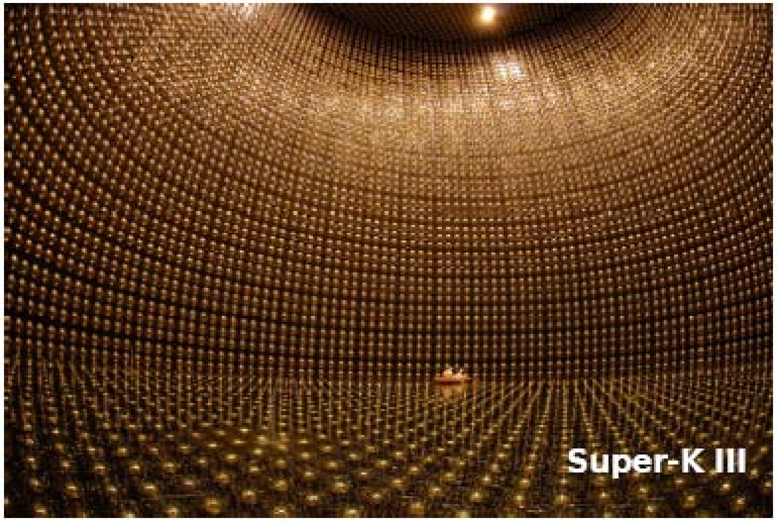
MPPC spectrum with prototype TFB, BEB, and DAQ

AFTER chip and card

SUPERKAMIOKANDE

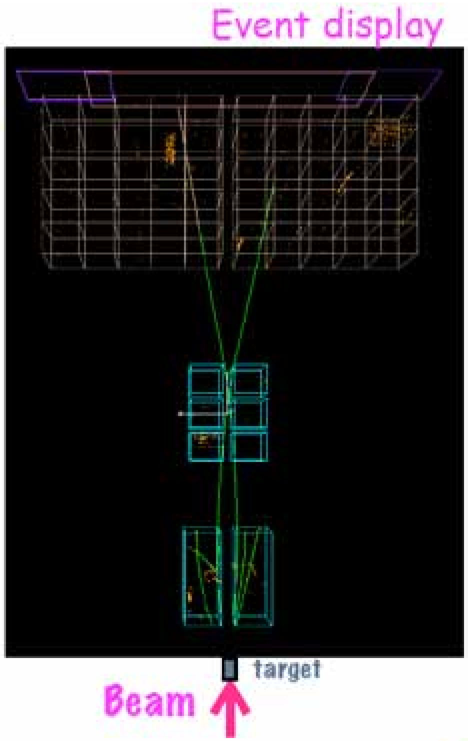
- Refitted SuperK, major next upgrade: electronics (higher dynamic range – faster – no dead time – stability >10 years)
- Installation starting September 2008
- New Online, spill time information transferred from J-PARC over private line, allow to flag and record ±500μs around each spill
- Reconstruction and simulation will be adapted

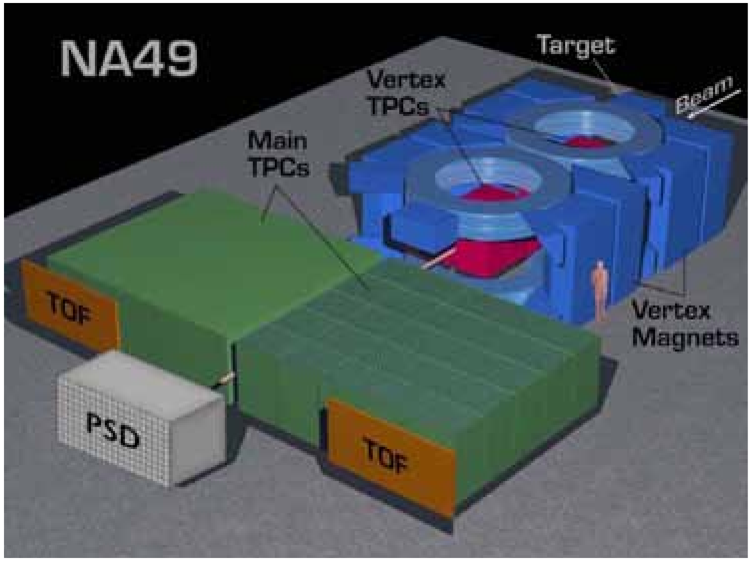


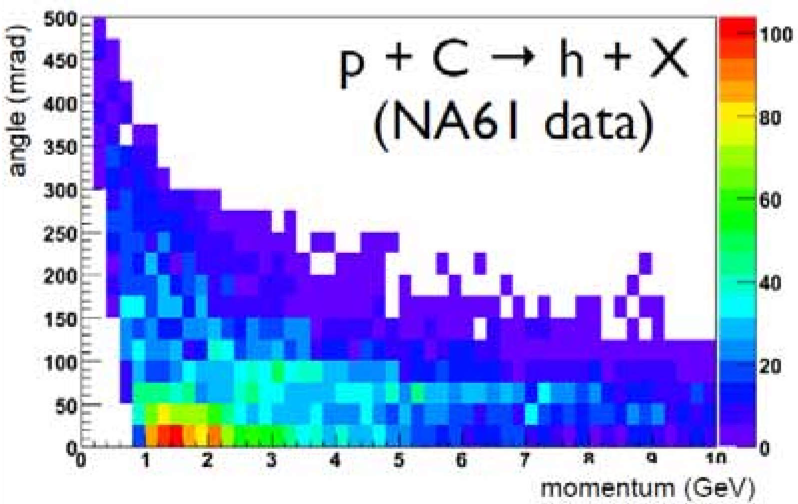


CERN-SPS NA61 (SHINE) EXPERIMENT

- Measure π/K prod. from Graphite target 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 in Oct., 2007 (1month)**
  - Beam: 30GeV proton
  - Thin target (2cm^t 4%int):~ 500k int.
  - Replica target (90cm, 80%int): ~180k int.
- Measurements in 2008 planned



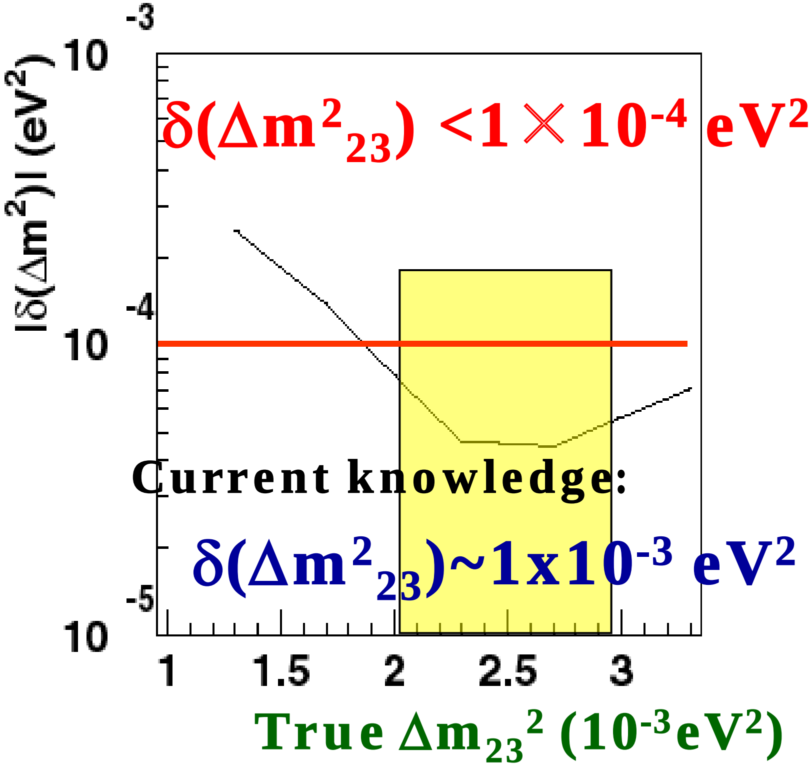


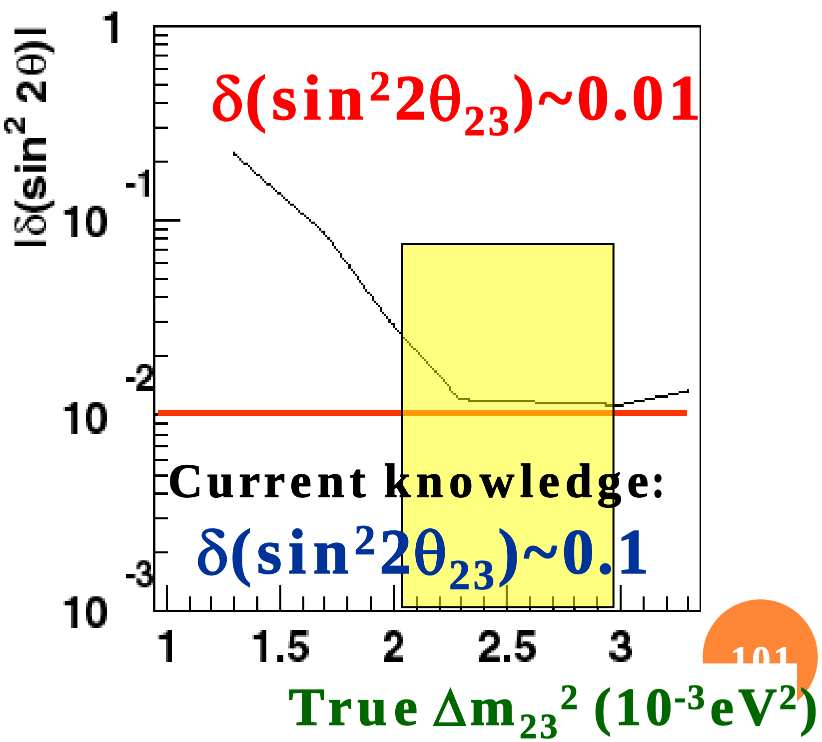


First look of data
(PID, acceptance not corrected)

T2K-I sensitivity with systematic errors

normalization	(5%)
non-qe/qe ratio	(5%)
E scale	(2%)
Spectrum shape	(20%)
Spectrum width	(5%)





FUTURE PROSPECTS IN A FEW-YEAR SCALE

- We are requesting 100kW operation of MR for more than 10^7s(several months) to the accelerator group before 2010 summer shutdown
  - This is vitally important, in order to get the 1st result with enough impact.

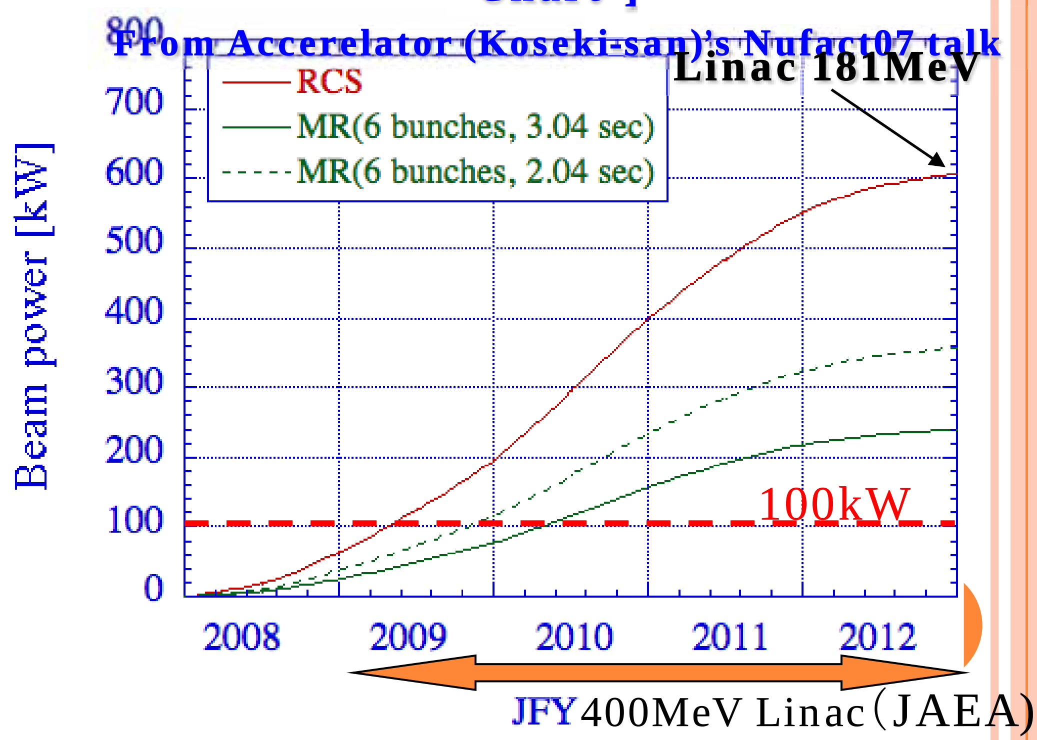
To achieve the request, to inclease rep. rate is a preferable solution, without significant hardware upgrades:

Cycle: 3.04→2.04sec, 30GeV

- Acc1.9 →1.1sec
- Reset 0.87 →0.67sec

- # of bunches to be recovered from 6 to 8 (design).
- Nominal beam power: 30GeV-9uA (270kW), to be achieved in JFY2012 or earlier.

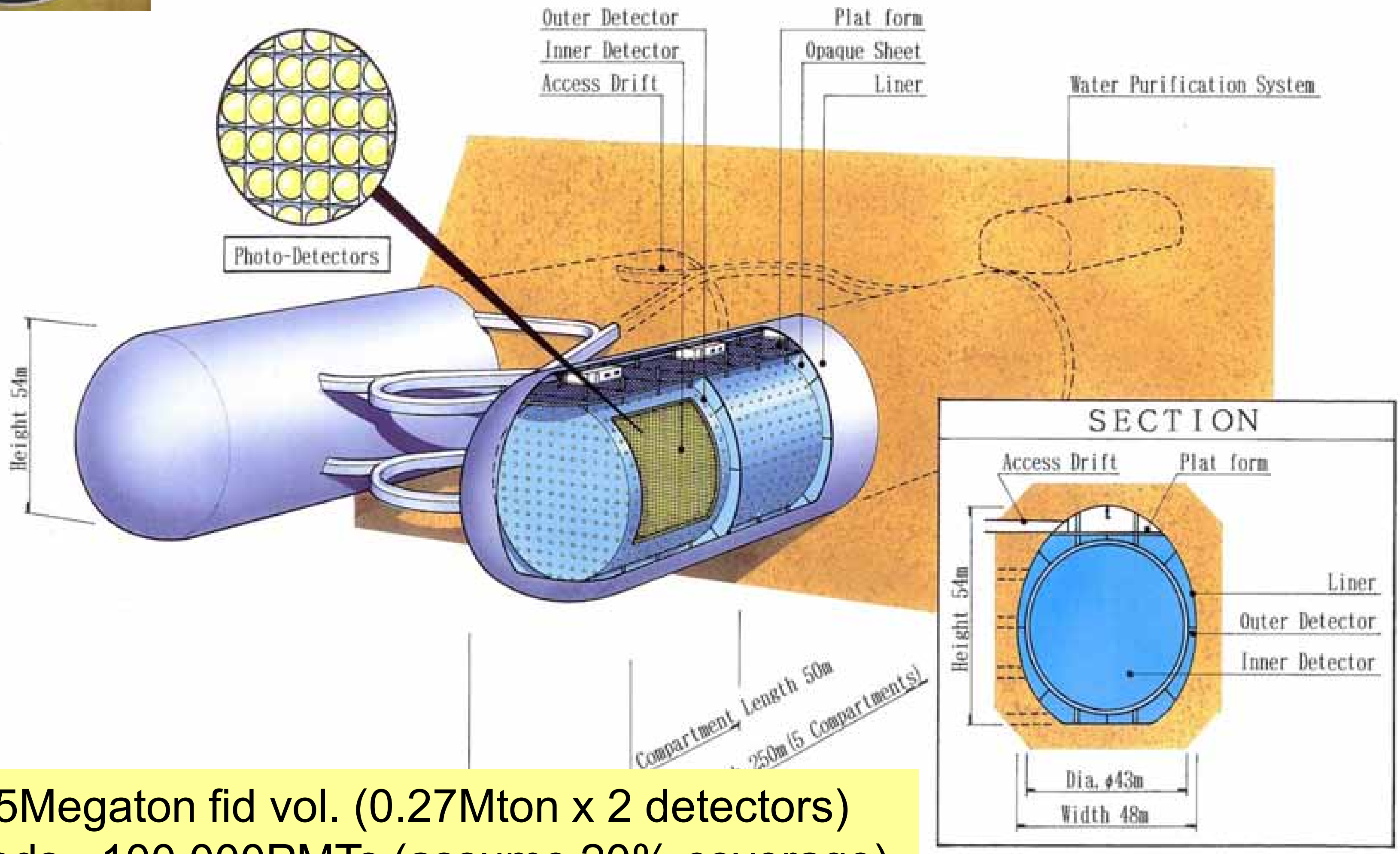
[J-PARC Director's order: "Nagamiya Chart"]



POWER UPGRADE FOR FUTURE PROJECTS

- Future projects to investigate Lepton sector CPV / neutrino mass hierarchy
  - Key components: J-PARC power upgrade (750kW→**MW) & massive far detector(s)
  - Proton decay
  - Intensive discussion is being started to prepare the best proposal towards 2012.
- Need continuing upgrades for accelerator components for the purpose.
  - For Linac: 181MeV → 400MeV with ACS Installation
    - Just after completion of J-PARC: Apr.'09 ~
    - 4 year (3 year in case R&D in 2008 goes smoothly)
  - For RCS/MR RF: Improvement for the magnetic alloy cut core
    - To achieve the high field acceleration as designed (25kV/m)
    - To improve procuction process / Water → Oil (paraffin) cooling
    - This will further increase the rep. rete
  - For MR Fx kicker:
    - To improve slow rise time 1.6us→1.1us (#b 6→8)
    - Without causing discharge
  - 30GeV →40(50)GeV energy boot-up
- MR intensity upgrade scenario
  - Increasing repetition rate (cycle=3.04 to 1.92sec)
  - Reduce harmonic number of RCS from 2 to 1
    - 1x8 injections instead of 2x4: Almost twice of beam injected to MR.
  - KEK roadmap: 1.66MW
- We will learn a lot more by the successful operation of the neutrino beam-line !

Hyper-Kamiokande

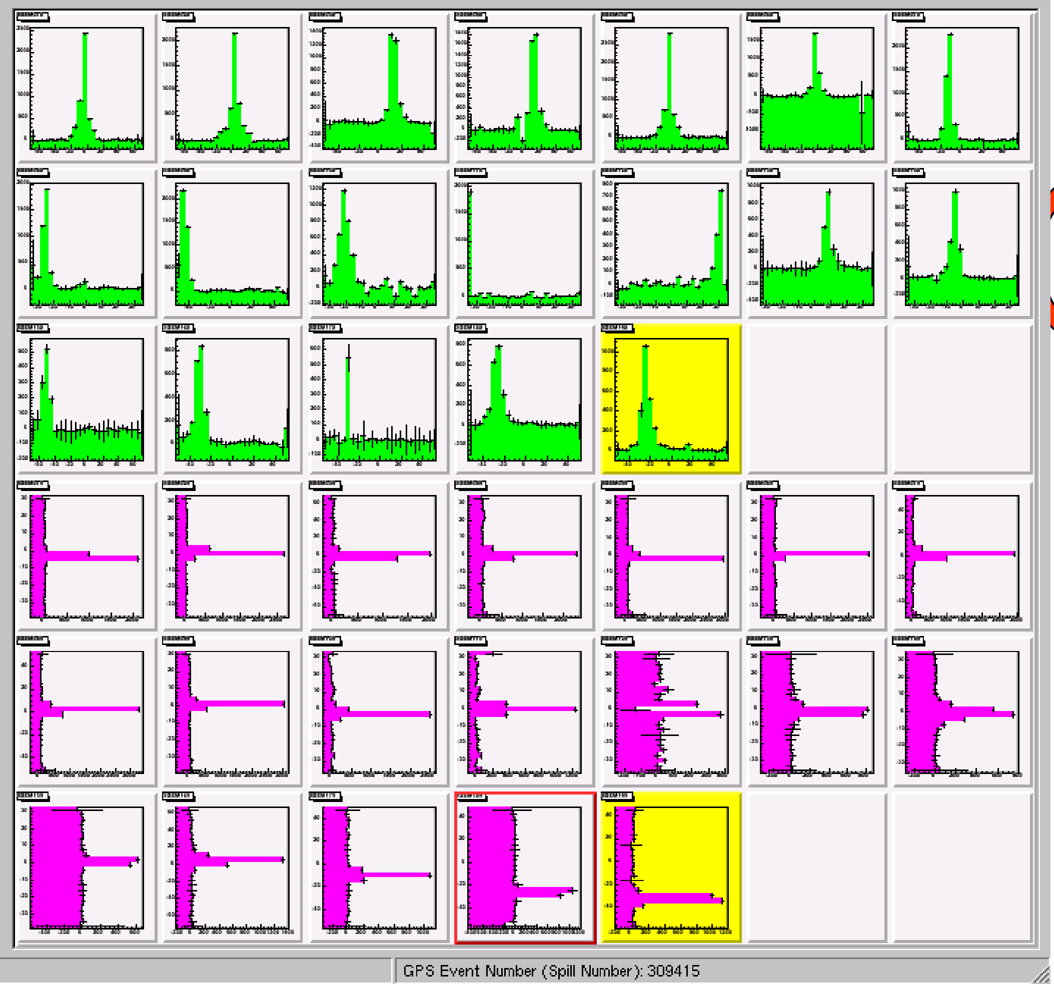


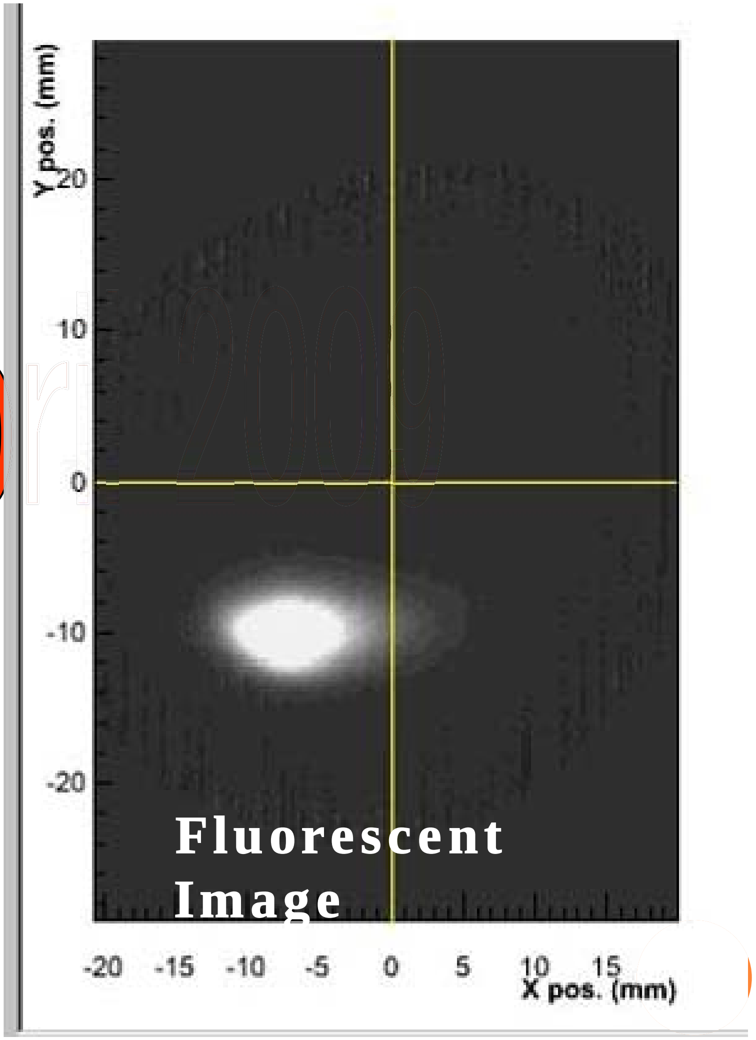
~0.5Megaton fid vol. (0.27Mton x 2 detectors)
Needs ~100,000PMTs (assume 20% coverage)

First shot of the proton beam

SSEM

(Segmented Secondary Emission Monitor)



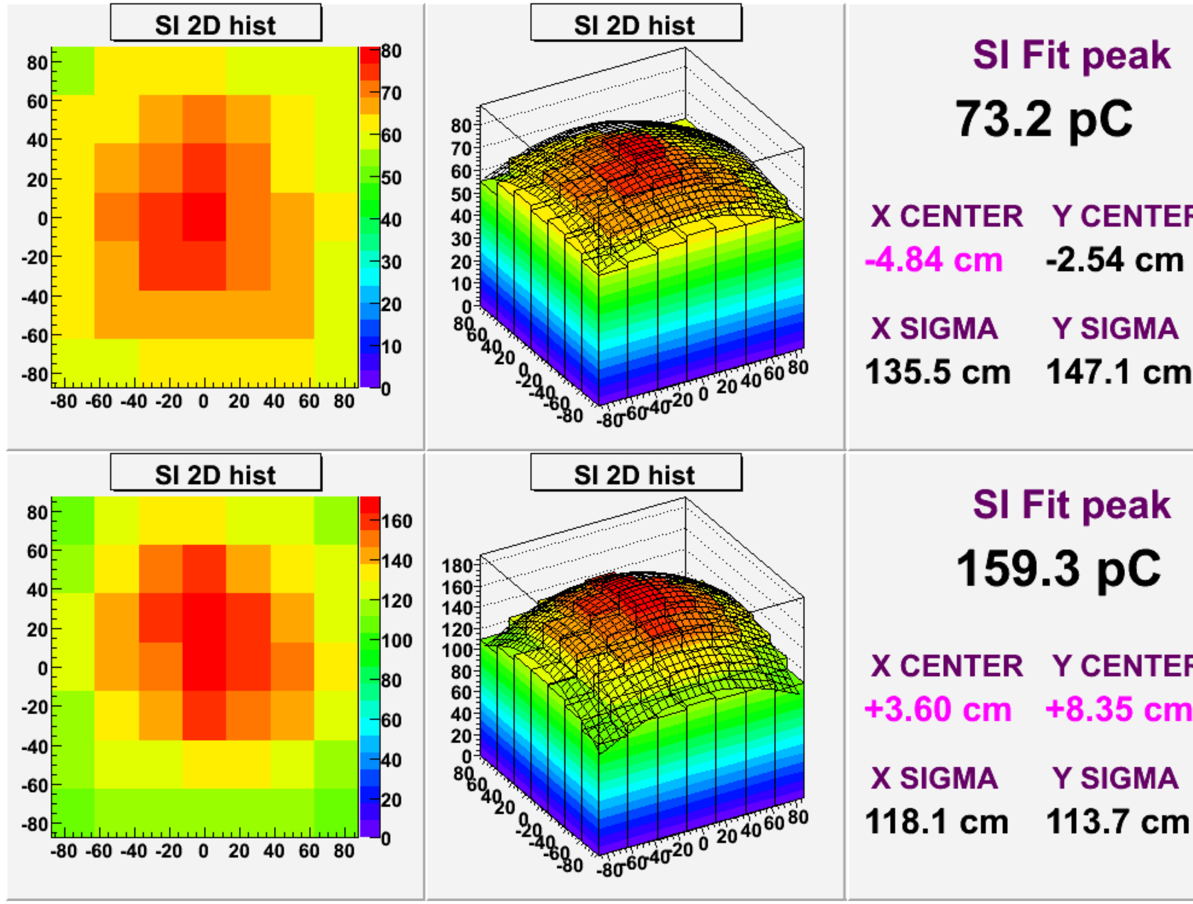


Fluorescent Image

Horn focusing: Muon Monitor Signal

Horn off

Horn on

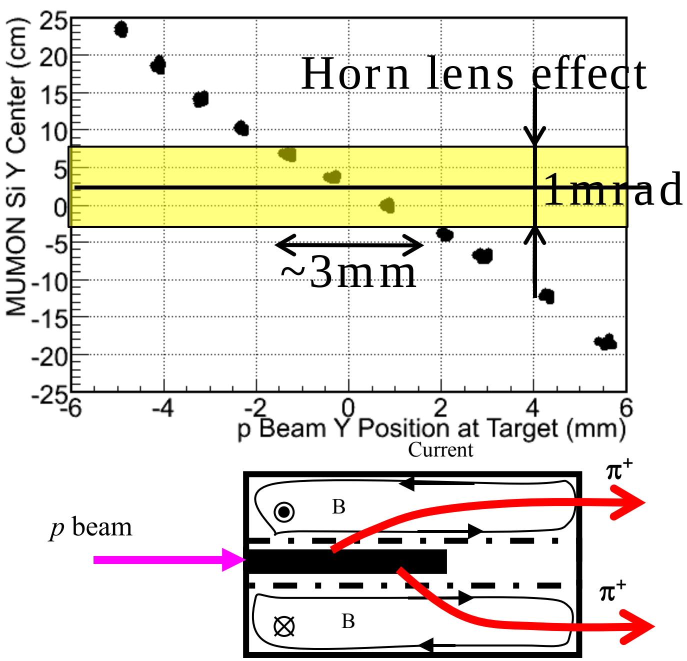


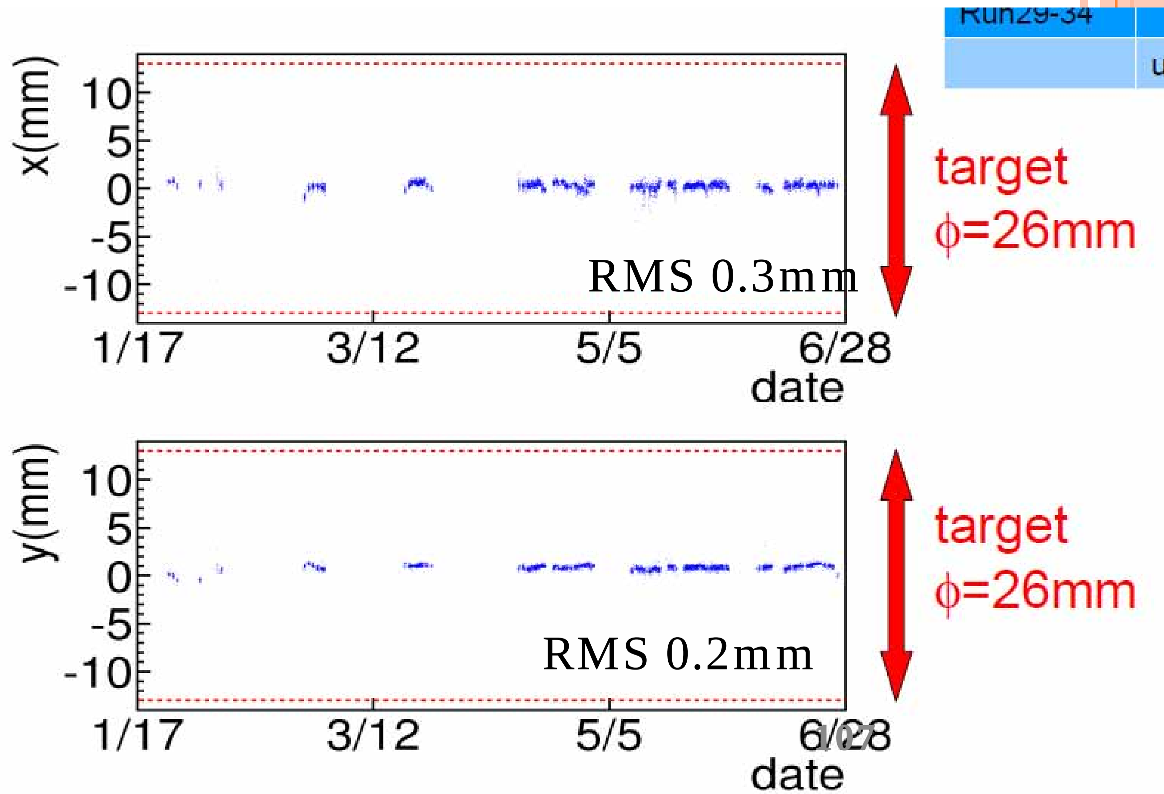
MUMON Silicon PIN photodiode array

Proton beam quality and stability

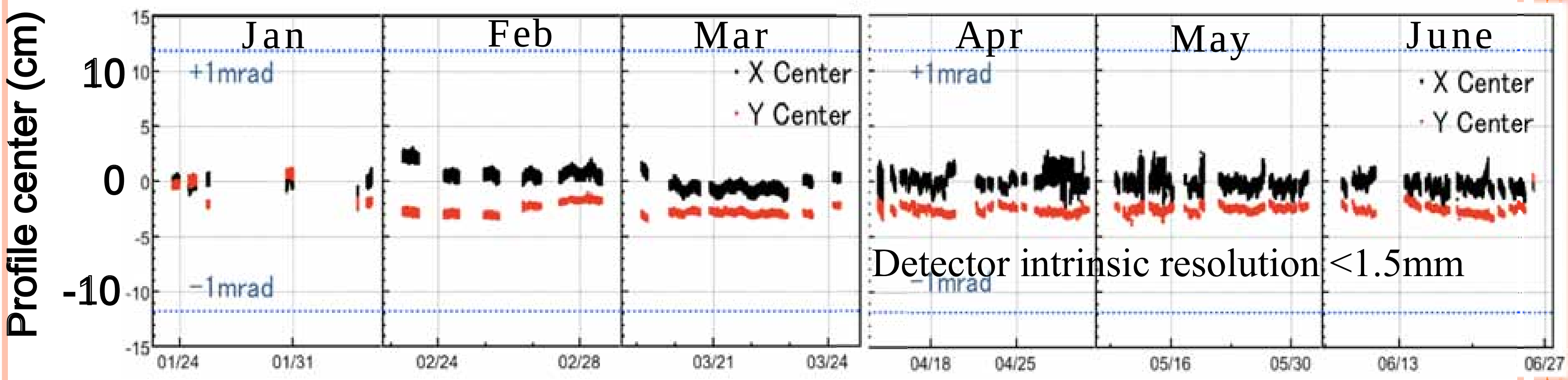
- Beam position on target have to be controlled < 1mm
  - To control direction of secondary beam within 1mrad
  - To avoid destroying the target from non uniform thermal stress on target (at higher power)
- Succeeded to control <1mm during long term operation

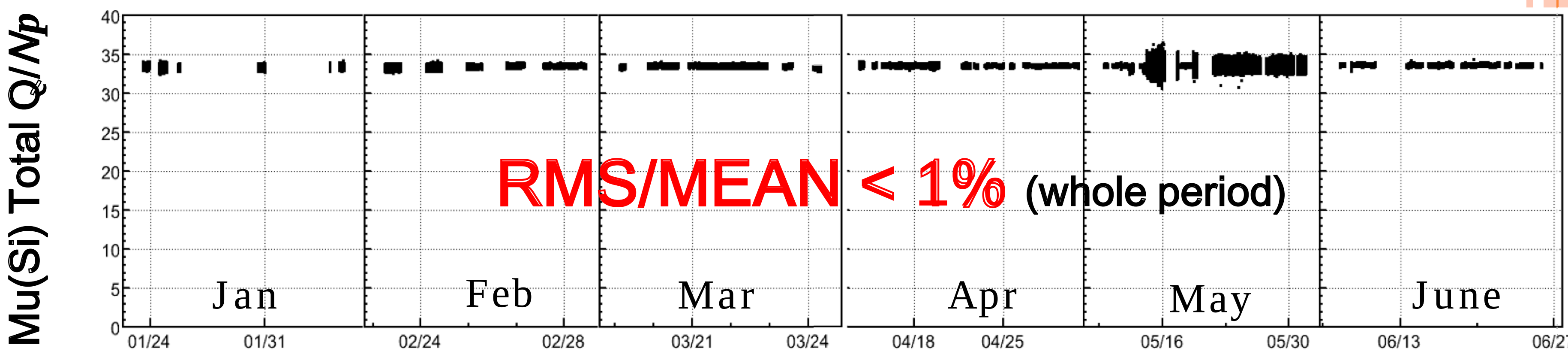
Correlation btw p beam position on target vs MUMON center





Secondary beam quality & stability (MUMON)





- Beam direction is controlled well within 1mrad
- Secondary beam intensity stable within 1%
  - (reflects stability of targeting, horn focusing, etc)
- Stable well within our physics requirements