Status of J-PARC Neutrino Project T2K (Tokai-to-Kamioka)

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(KEK)

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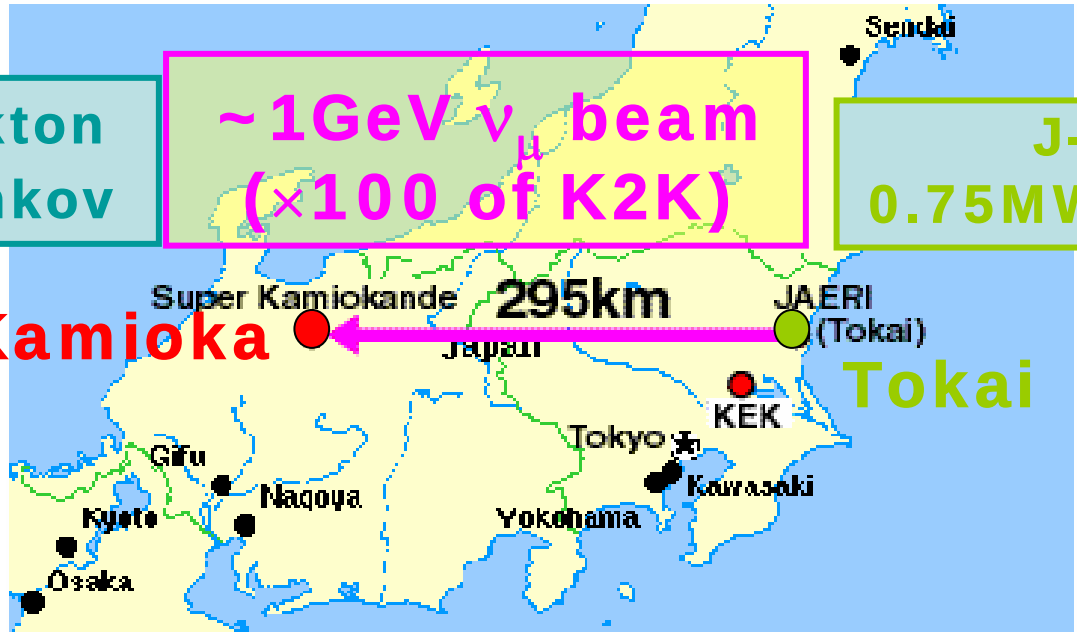
T2K experiment

Long baseline neutrino oscillation experiment from Tokai to Kamioka.

Super-K: 50 kton Water Cherenkov

~1GeV ν_μ beam (×100 of K2K)

J-PARC 0.75MW 50GeV PS



Phase2: Hyper-K

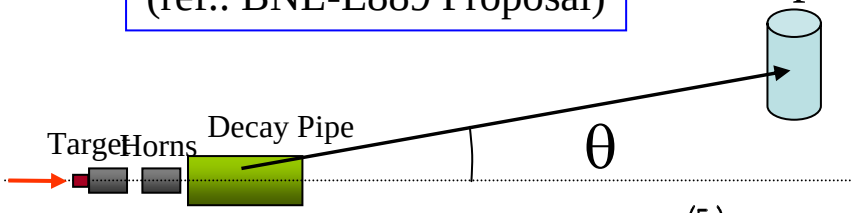
Phase2: 4 MW

Physics goals

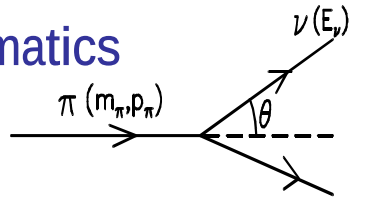
- **Discovery of $\nu_\mu \rightarrow \nu_e$ appearance**
- **Precise meas. of disappearance $\nu_\mu \rightarrow \nu_x$**
- **Discovery of CP violation (Phase2)**

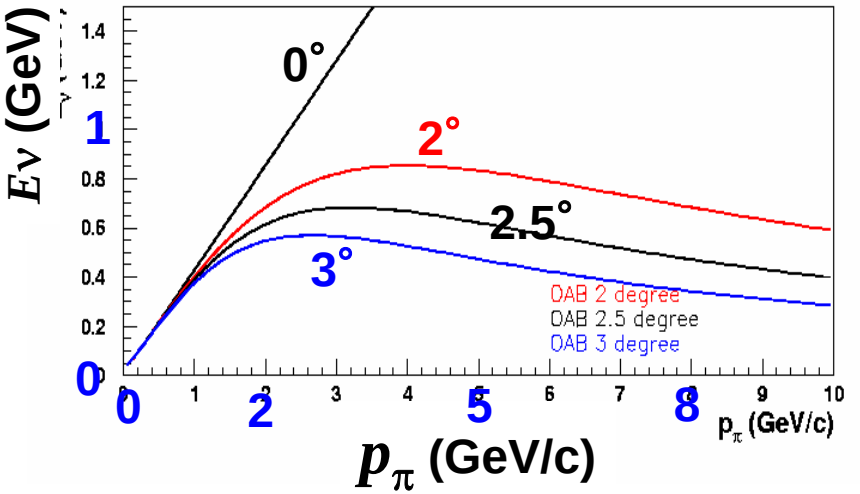
Narrow intense beam: Off-axis beam

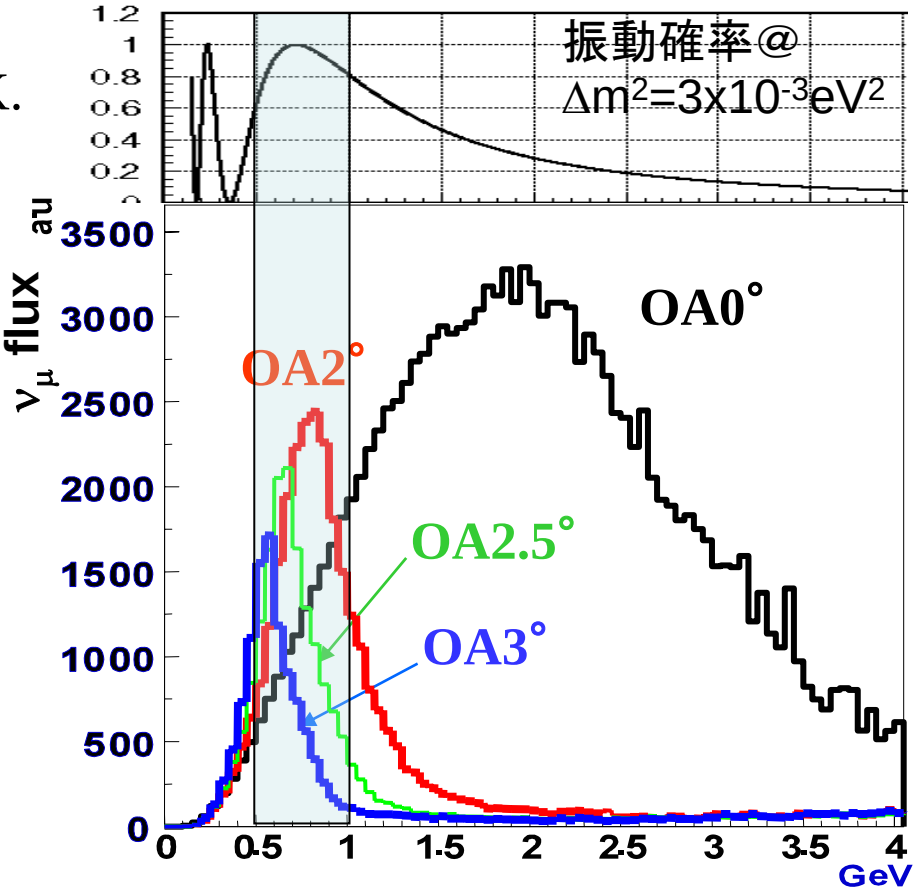
First Application
(ref.: BNL-E889 Proposal)



π decay Kinematics







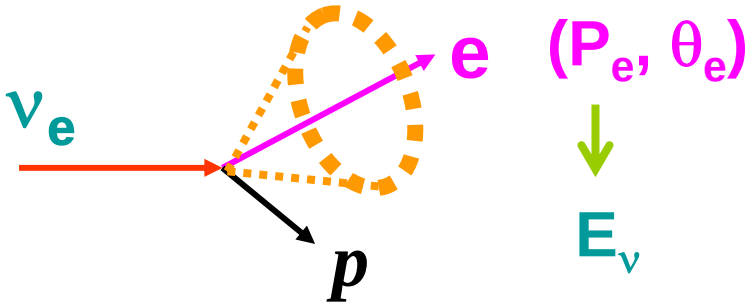
- Quasi Monochromatic Beam
- x 2~3 intense than NBB
- Tuned at oscillation maximum

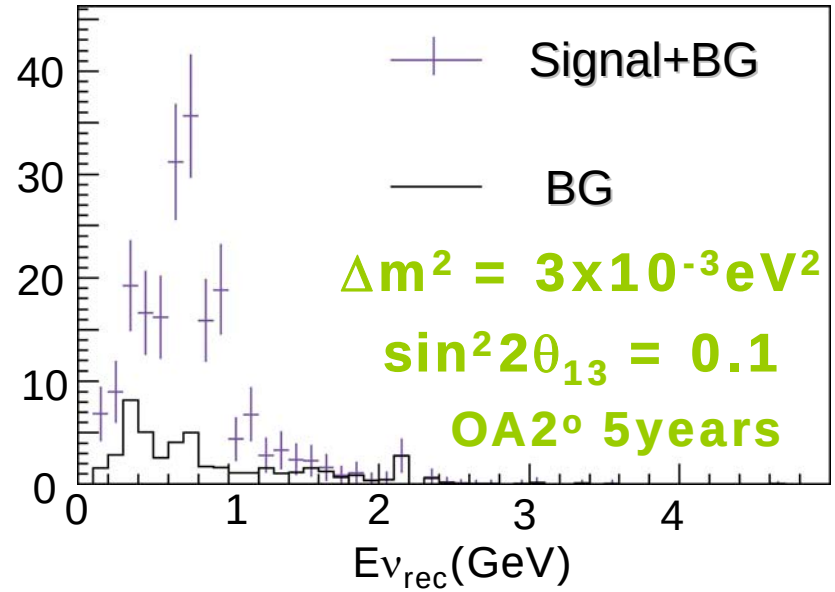
Statistics at SK
(OAB 2.5 deg, 1 yr, 22.5 kt)
~ 2200 ν_μ tot
~ 1600 ν_μ CC
ν_e ~0.4% at ν_μ peak

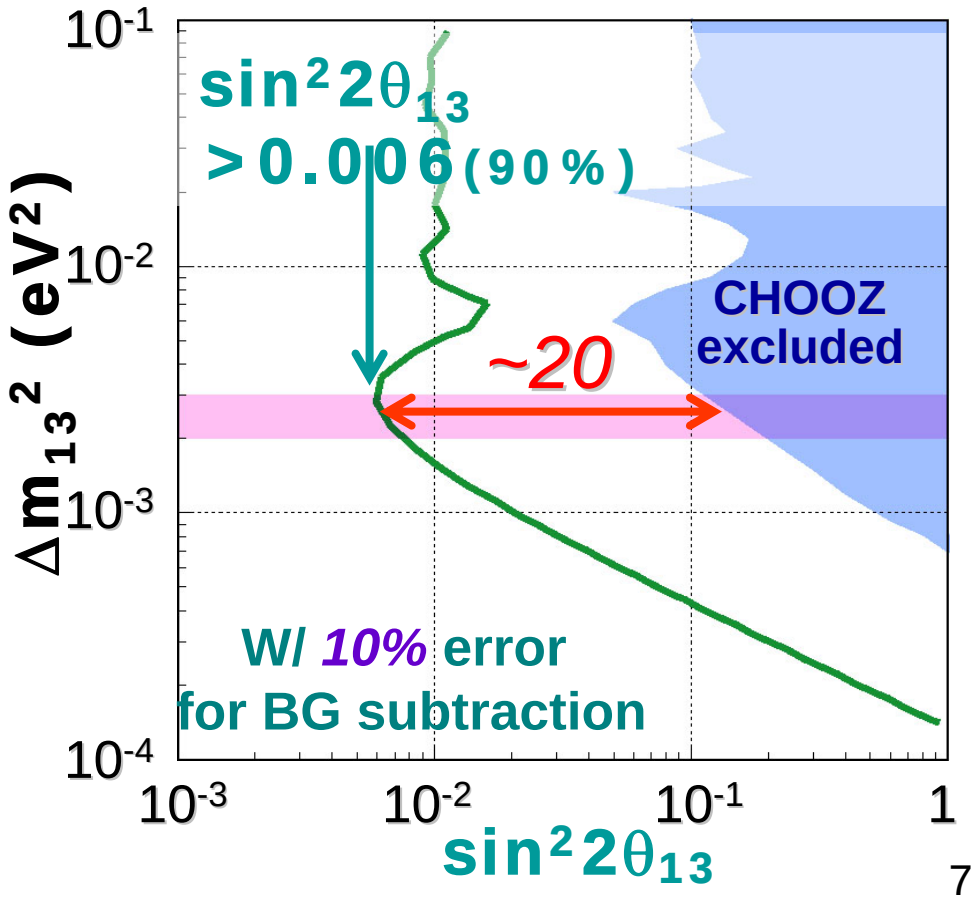
Sensitivity: ν_e appearance

Discovery of ν_e appearance (θ_{13},Δm_{13})

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

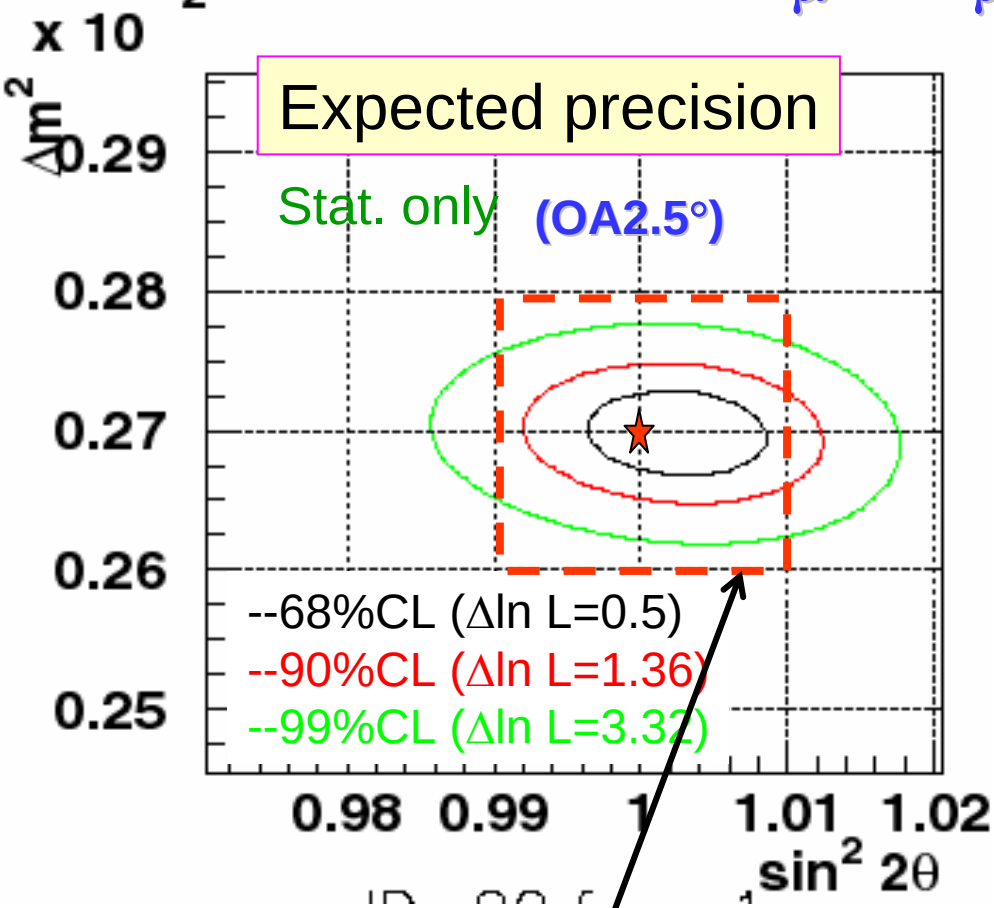






Assuming $\sin^2\theta_{23}$=0.5, δ=0, no matter

Sensitivity: $\nu_\mu \rightarrow \nu_\mu$ disappearance

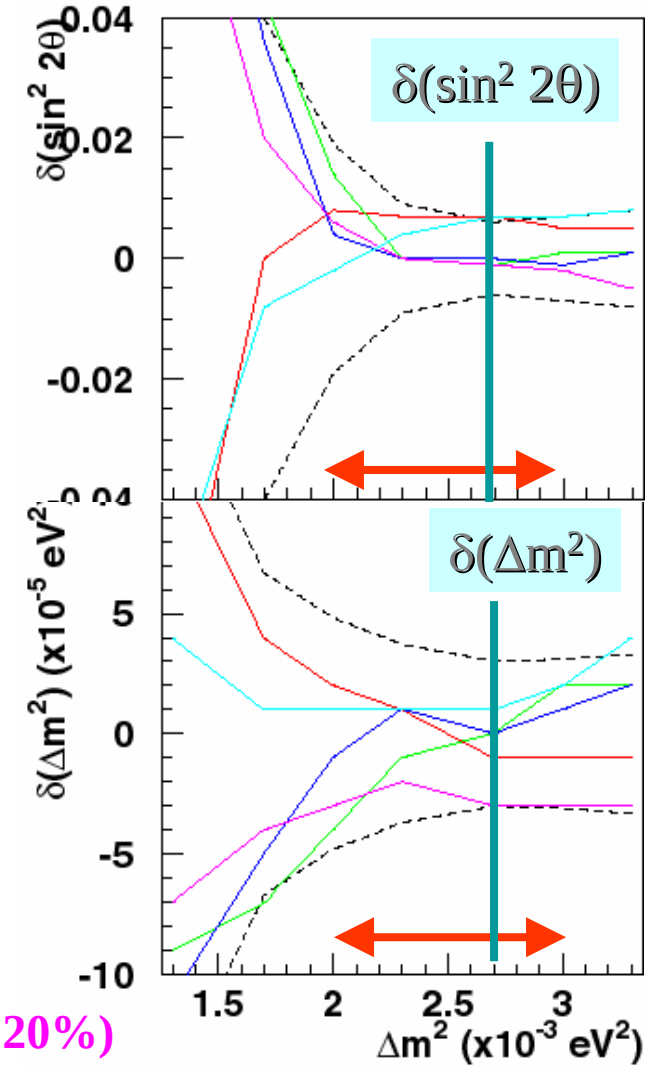


Goal

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

$\delta(\Delta m_{23}^2) \sim < 1 \times 10^{-4}$

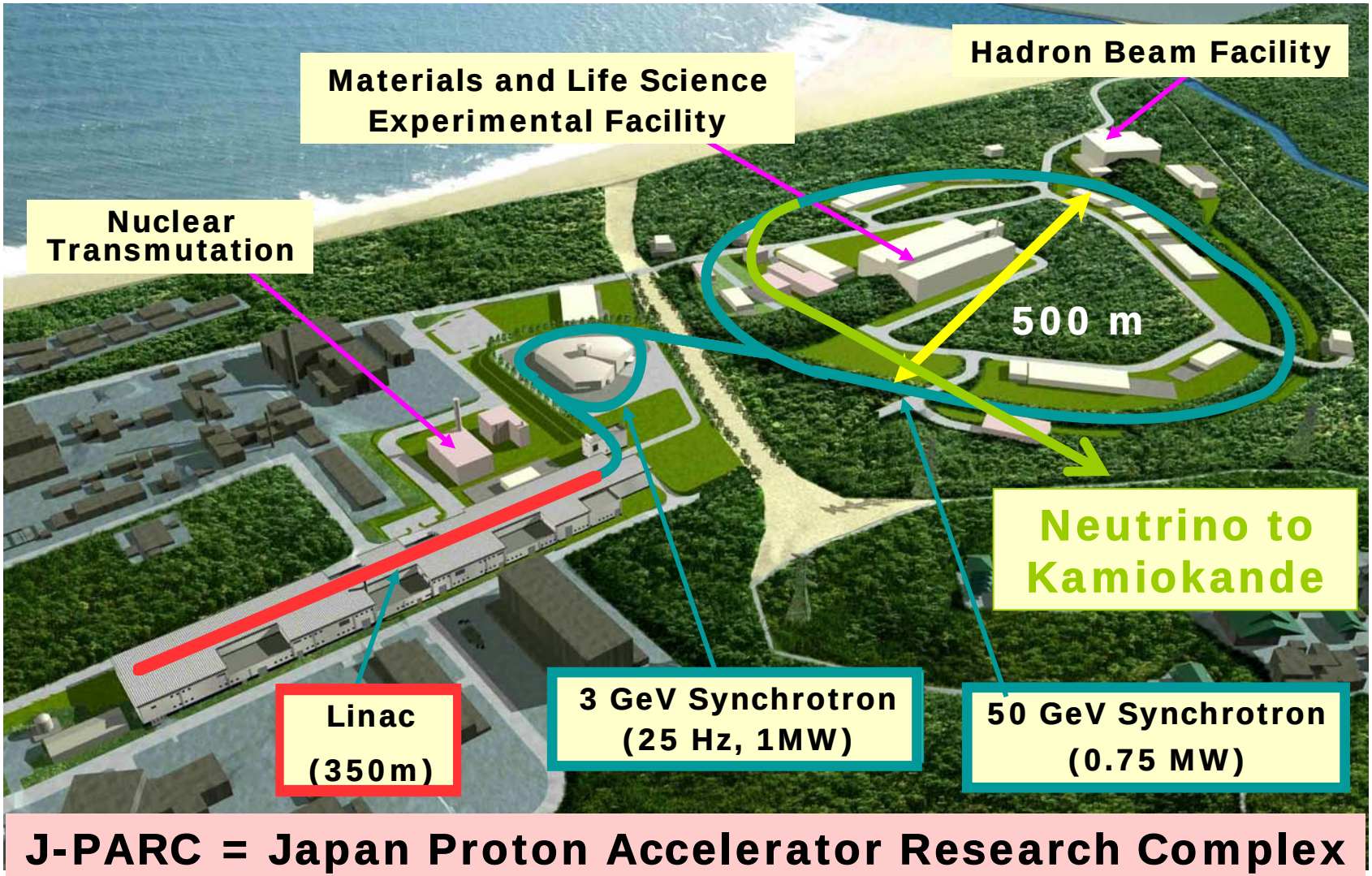
Effect of systematic error on param meas.



Stat. error

- norm (+5%)
- NQE (+5%)
- E_{SK} (+1%)
- beam shape (±20%)
- beam width (5%)

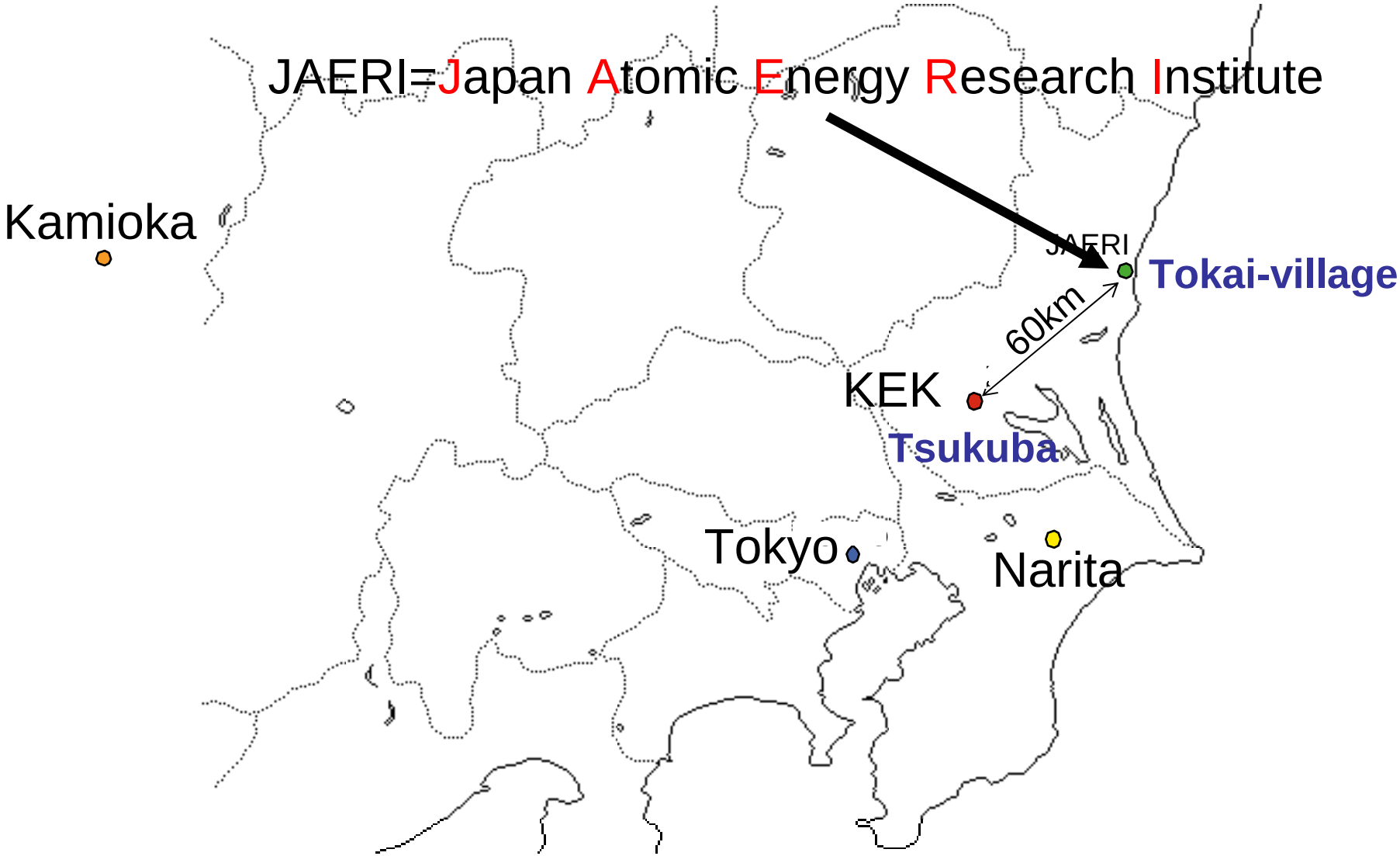
J-PARC Facility



J-PARC = Japan Proton Accelerator Research Complex

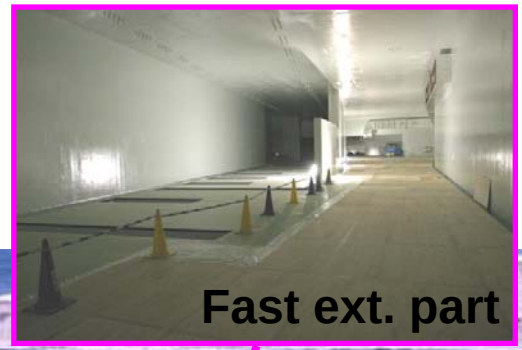
Joint Project between KEK and JAERI

Location of JAERI at Tokai-village



J-PARC status

- Buildings for LINAC and 3GeVPS finished.
- North-east part of tunnel for 50GeVPS finished.
- South-west part of tunnel will finish in FY2006.
- First beam on 50GeV PS in FY2008



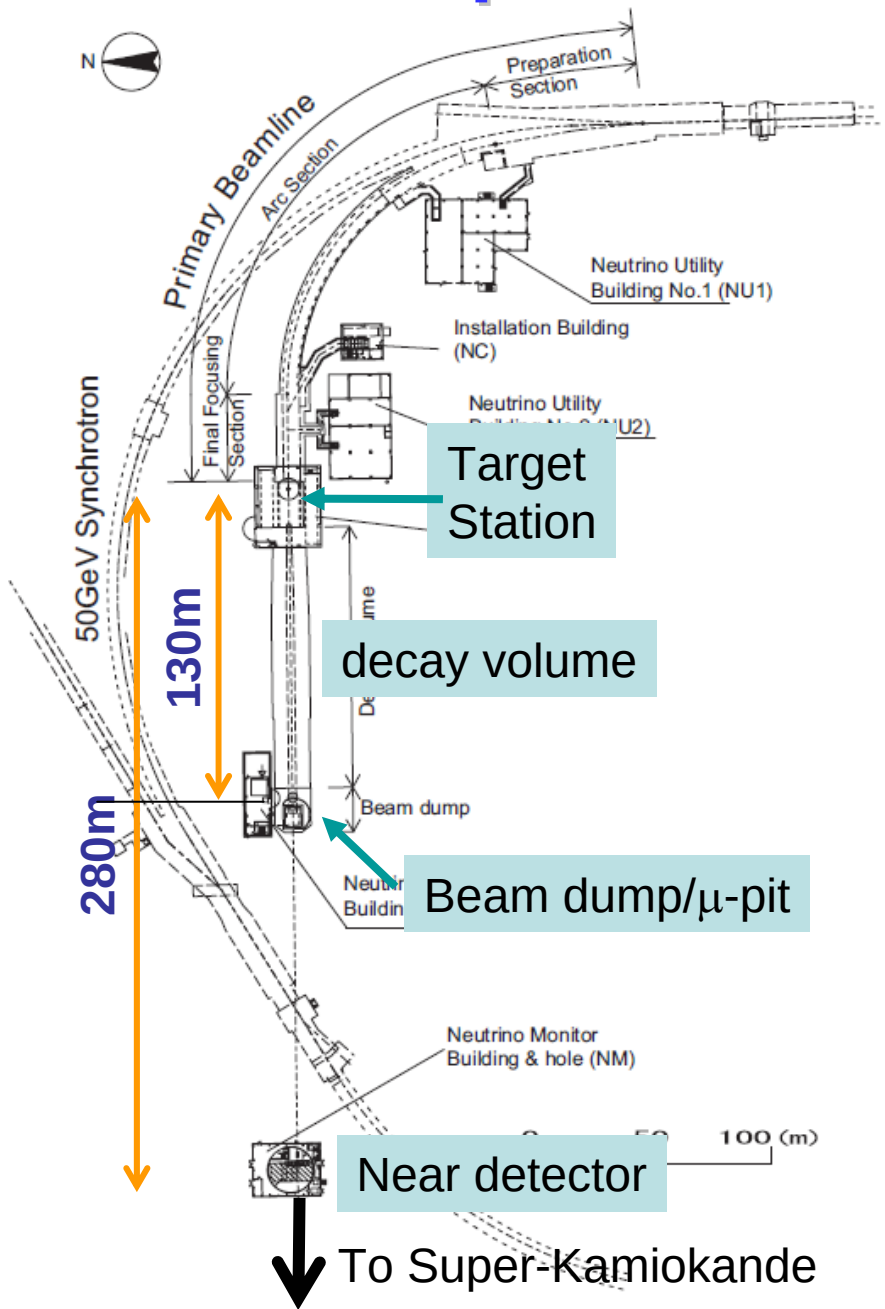
Neutrino Beam Line for T2K Experiment

Components

- Primary proton beam line
- Target/Horn system
- Decay pipe (130m)
- Beam dump
- muon monitors
- Near neutrino detector

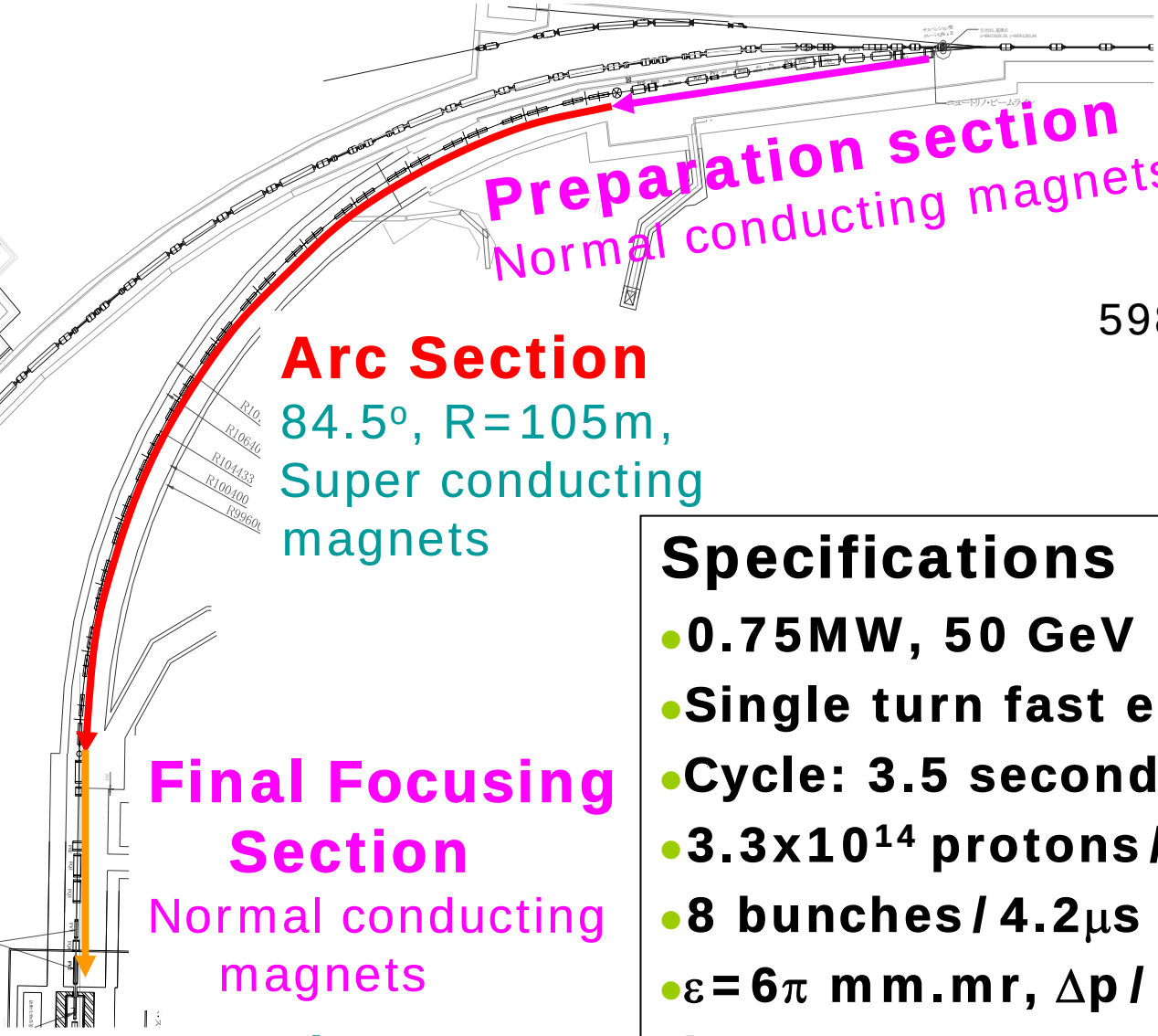
Special Features

- **Superconducting combined function magnets**
- **Off-axis beam**




Fast extraction part
Ring orbit
Fast ext. beam
3NBT
Decay Volume
(excavated)
Jan.28, 2005

Proton beam line

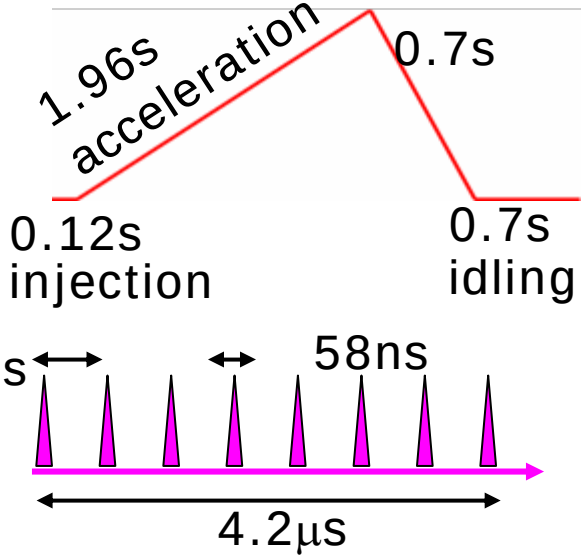


Preparation section
Normal conducting magnets

Arc Section
84.5°, R=105m,
Super conducting magnets

Final Focusing Section
Normal conducting magnets

Target station



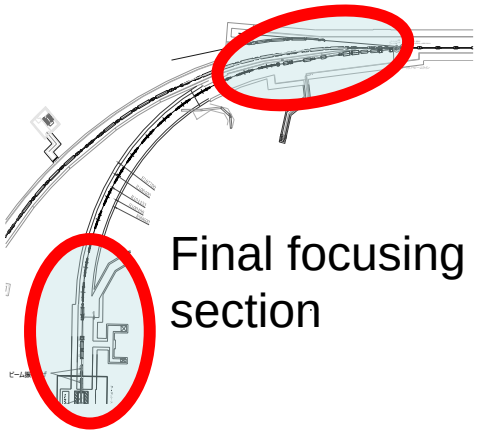
Specifications

- 0.75MW, 50 GeV (40GeV@t=0)
- Single turn fast extraction
- Cycle: 3.5 second
- 3.3×10^{14} protons/spill
- 8 bunches/4.2μs
- $\varepsilon = 6\pi$ mm.mr, $\Delta p/p = 0.31\%$
  ($\varepsilon = 7.5\pi$ mm.mr, $\Delta p/p = 0.36\%$@40GeV)

Normal conducting magnets

Tanaka-san's talk

Preparation section



Final focusing section

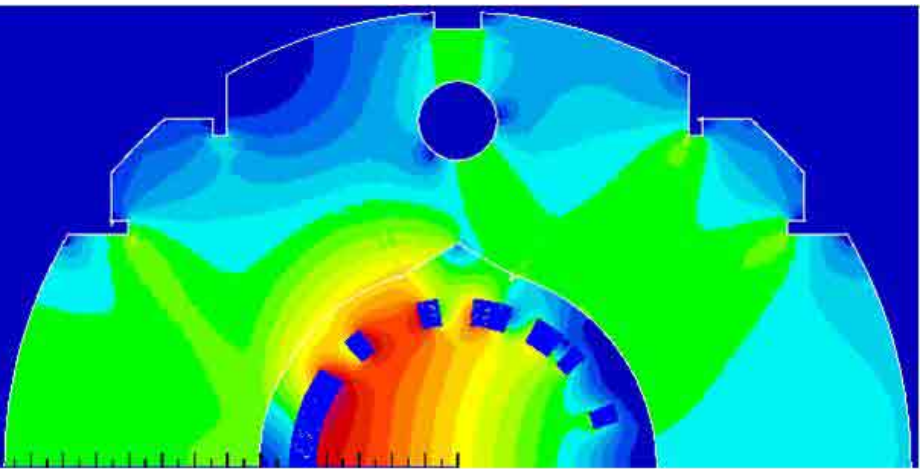
	Dipole	Quad.	Steer.	Total	(MIC)
Prep.	2(H)	5	3(H)+2(V)	12	(5)
FF	2(V)	4	2(H)+2(V)	10	(0?)
Total	4	9	9	22	(5?)

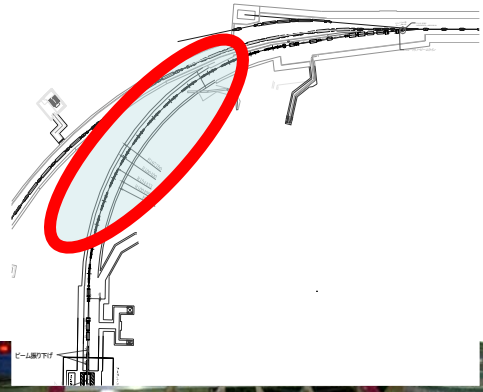
- 22 magnets in prep sect and FF sect.
  - Mineral Insulation Cable (MIC) for magnets > 1MGy/yr, Other: Polyimide insulation
  - At high radiation area, quick maintenance mechanism needed.
- Status
  - Development of quick maintenance system in progress as common technologies for ν and hadron facility
  - Engineering design with FEM done for preparation section
  - Started procurement of cables and irons for prep. sect.

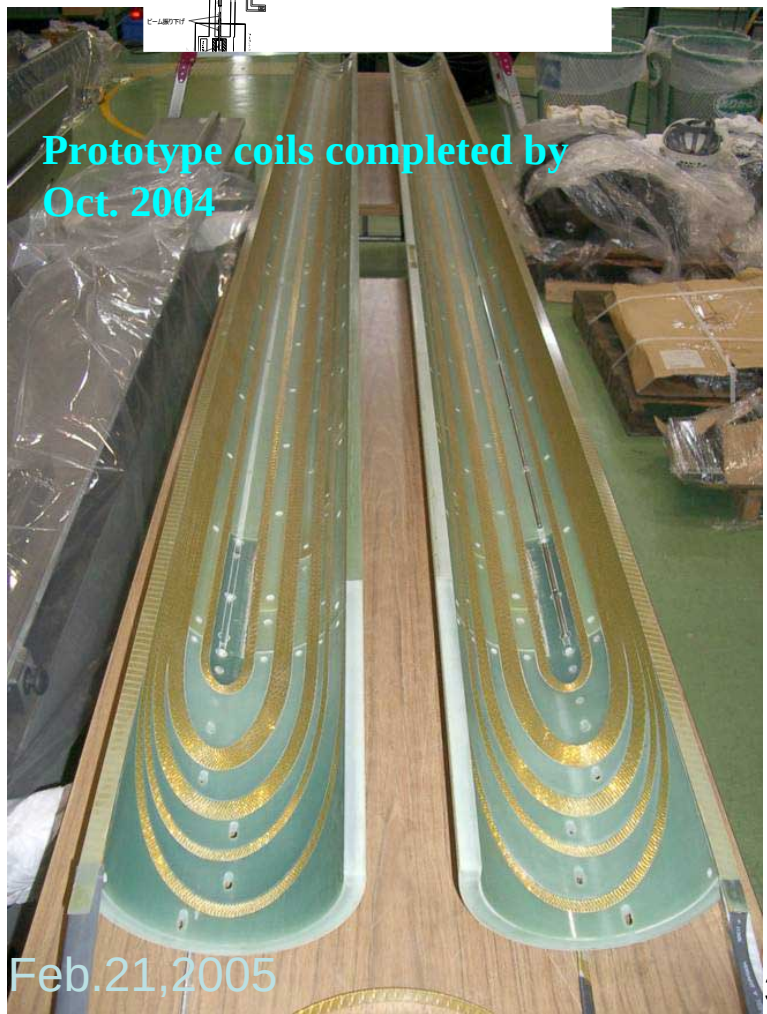
Superconducting magnets

T.Ogitsu, T.Nakamoto, et.al.,
Cryogenic Sci. Center, KEK

- Combined function magnets in arc part
  - Dipole Field: 2.587 T, Quad. Field: 18.62 T/m
  - Reduce cost while keeping large acceptance
  - Use common parts with LHC to reduce cost/risk
- First full size prototype completed
  - Cooled, current loaded
  - 7700A (ope. curr. @50GeV + 5%) achieved w/o any spontaneous quenching
- Contract for mass production made. Start fabrication soon





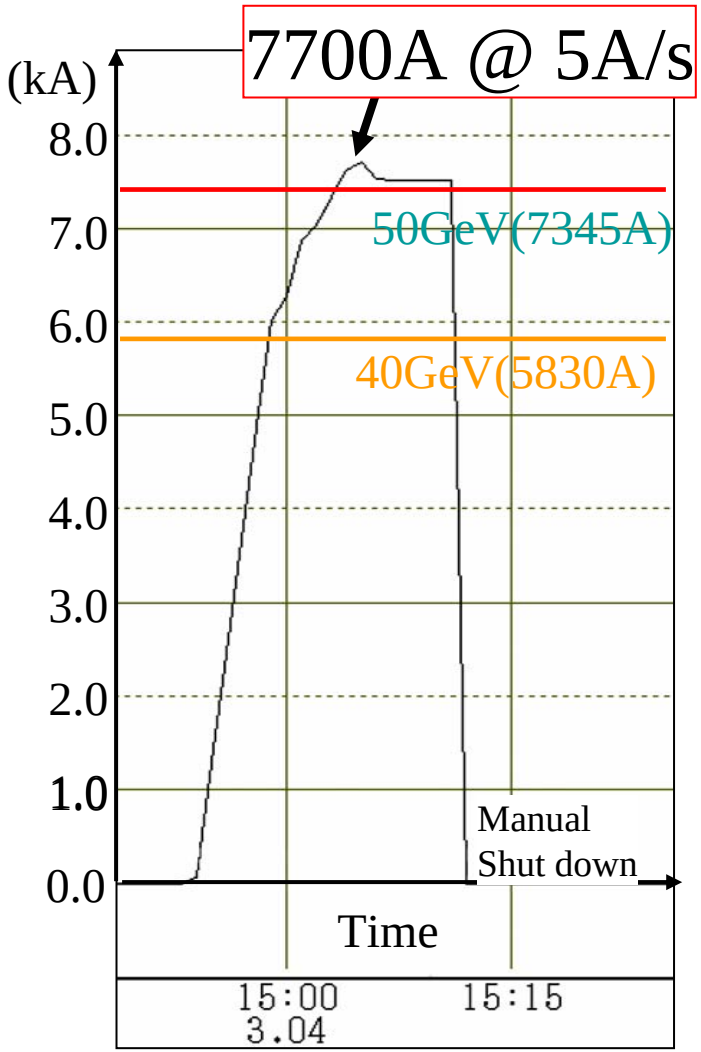


Shell Welding Completed (Dec21,04)

Vacuum Vessel from Spain

Put in vertical cryostat for cooling/current loading test (Feb.21,2005)

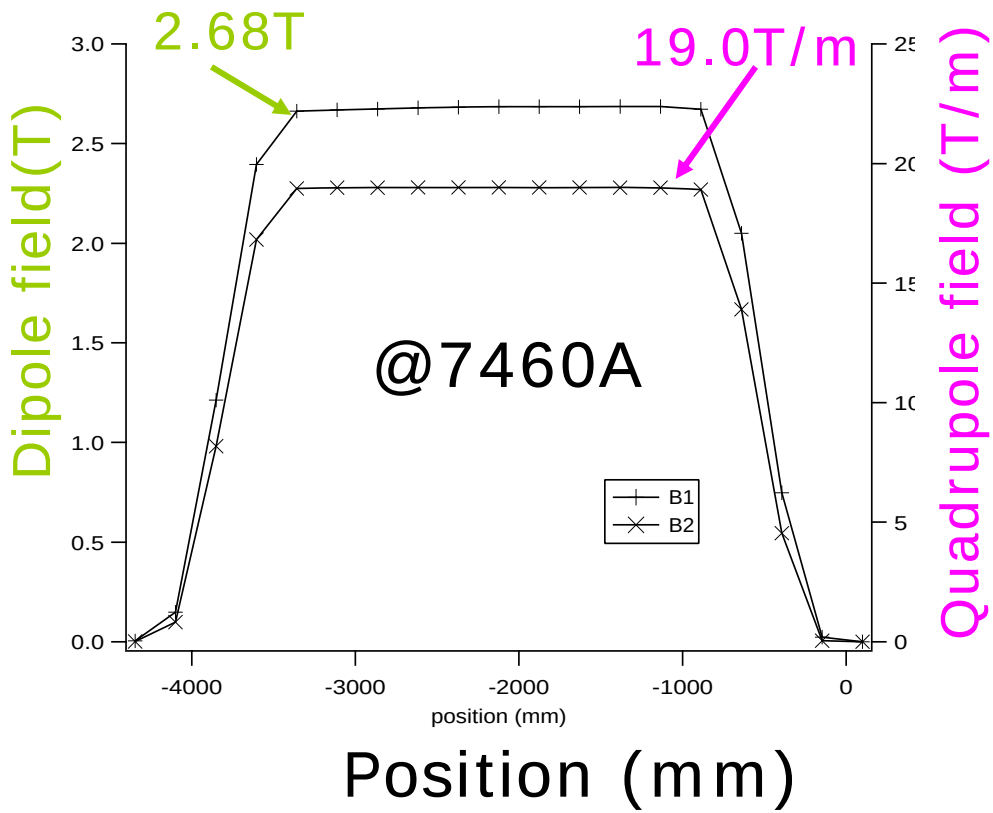
Superconducting magnet



Prototype magnet worked

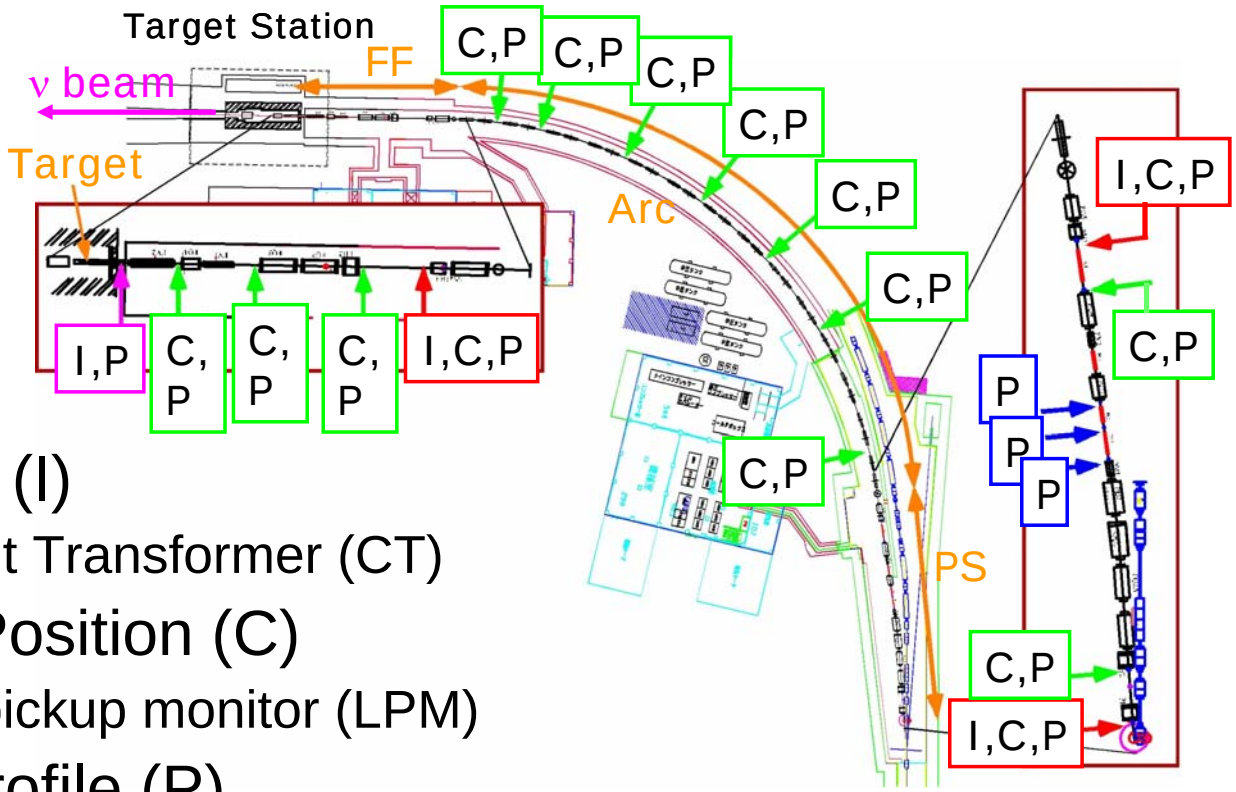
- **as designed**
- **without quench**

Another "proof model" worked



Beam monitors

Hayato-san's talk

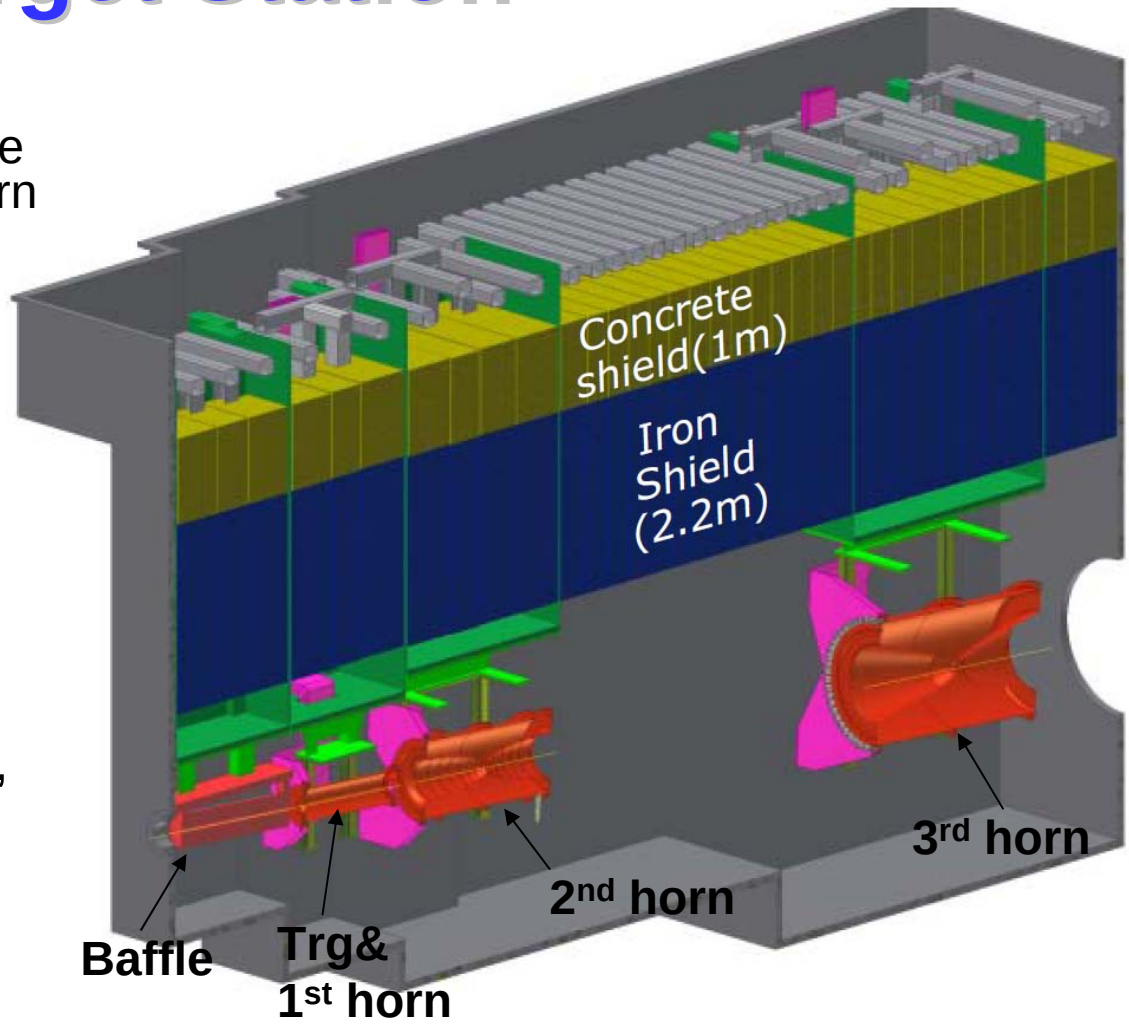


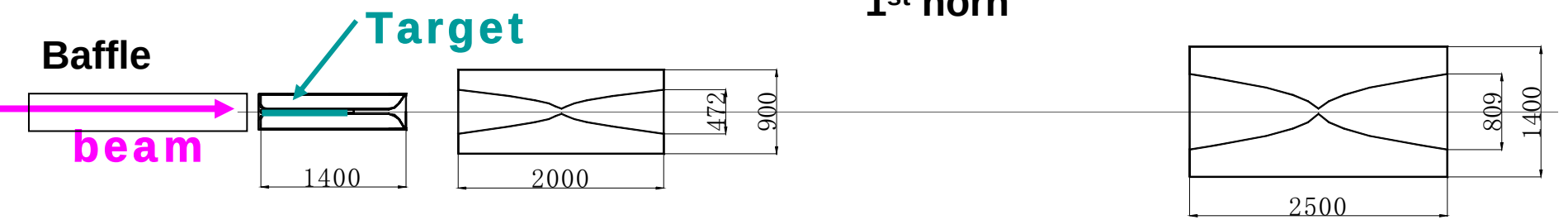
- Intensity (I)
  - Current Transformer (CT)
- Center Position (C)
  - Loop pickup monitor (LPM)
- Beam Profile (P)
  - Segmented Secondary Emission Monitor (SSEM)
- Loss monitor
  - Ionization Chamber
- Prototype made, tested with K2K fast beam
- Started final engineering design

Target Station

Nakadaira-san's talk

- Accommodate
  - Baffle: Graphite, 32mmϕ hole x 1.7m long to protect 1st horn
  - Target
  - 3 Horns
- Area filled with Helium gas
  - reduce Tritium, NOx production
- Highly radio-activated
  - ~1Sv/h,
  - Need remote-controlled maintenance system
- Need cooling (Helium vessel, radiation shield,..)





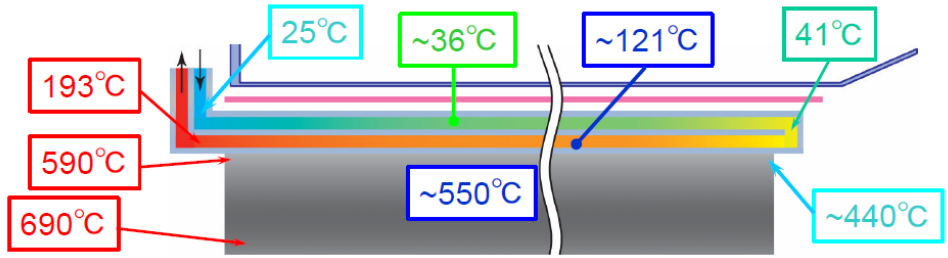
Target

➔ Nakadaira-san's talk

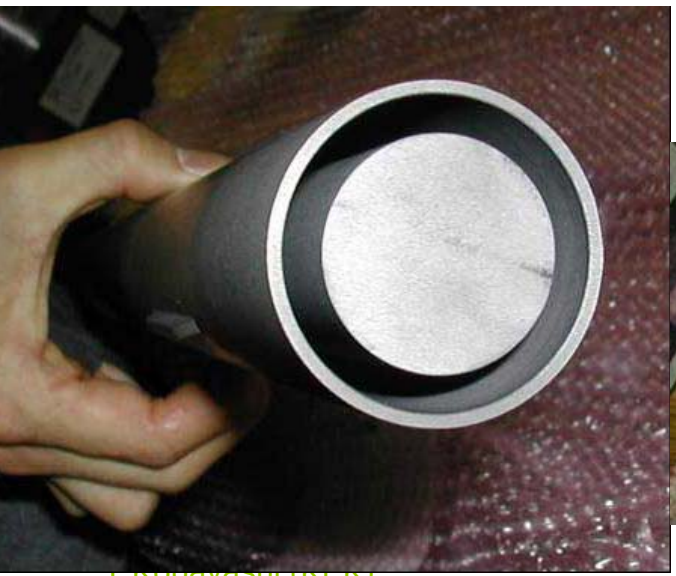
- Carbon Graphite: 30mm(D)x900mm(L), 2 interaction length (70% int.)
- Energy deposit: 58kJ/spill (~20kW)
- Equivalent stress (ΔT~200K) ~ 7MPa (<Tensile strength of 37MPa)
- Cooled at outer surface

R&D and Design Status

- Helium cooling method designed
- Prototype of Graphite target made
  - Feasibility of machining proved
- Radiation damage of Graphite tested

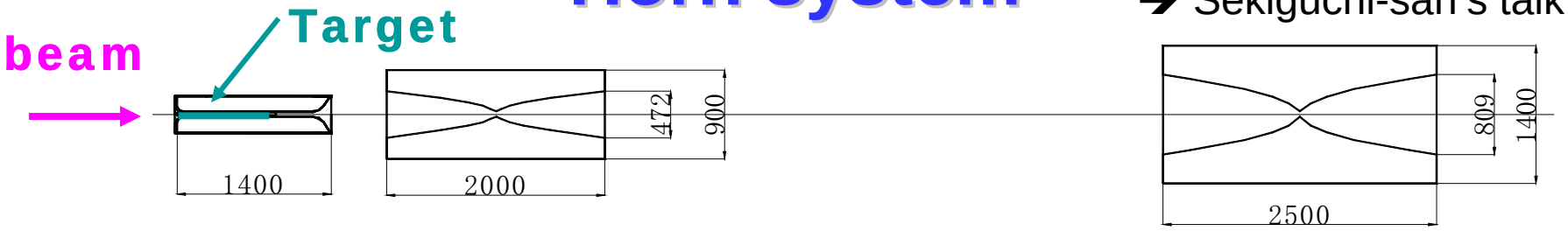


Prototype production



Horn system

➔ Sekiguchi-san's talk



1st Horn 2nd Horn

3rd Horn

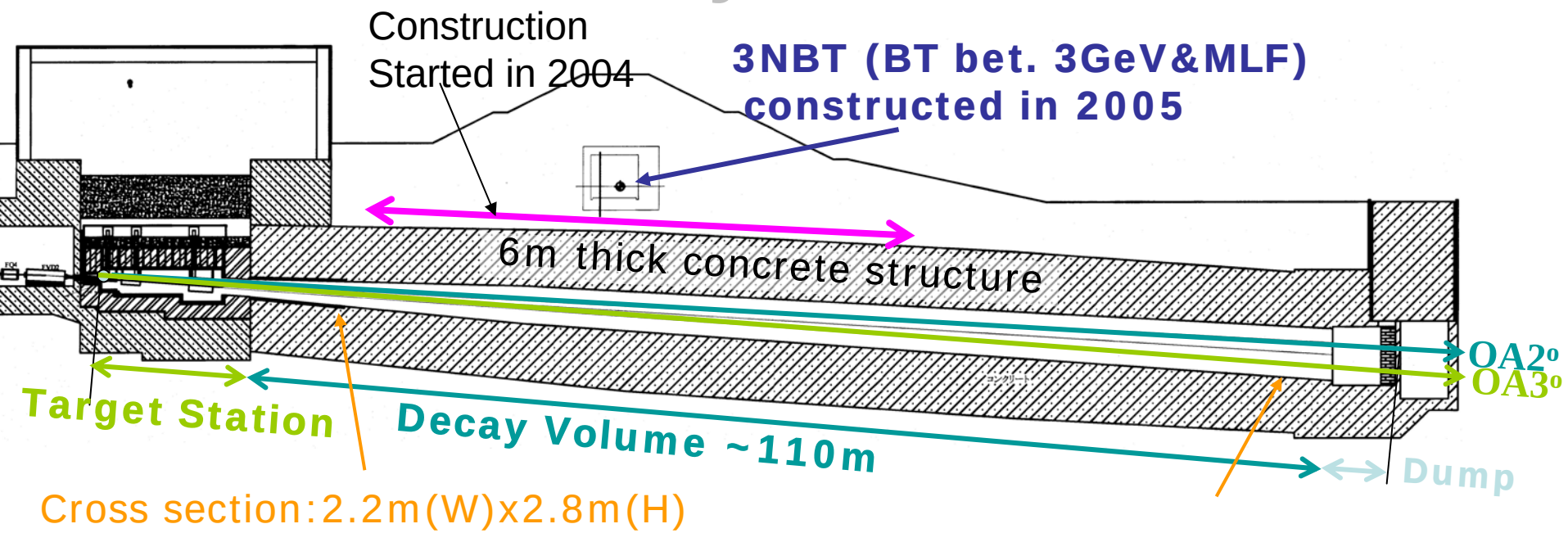
- Field shape optimization completed.
- 320kA pulsed current operation
- Prototype horns are made
  - 1st horn inner/outer conductor
  - 3rd horn inner conductor
- Preparing for pulsing test

3rd horn outer conductor

1st horn outer conductor

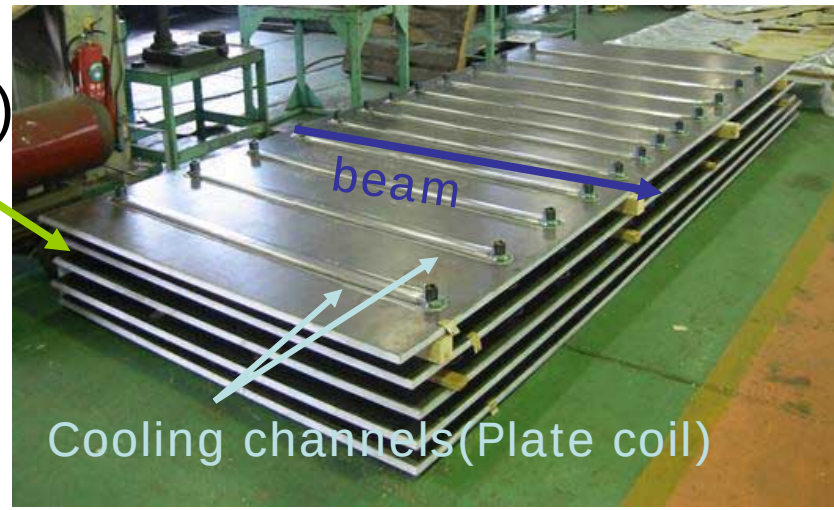
1st horn inner conductor

Decay Volume



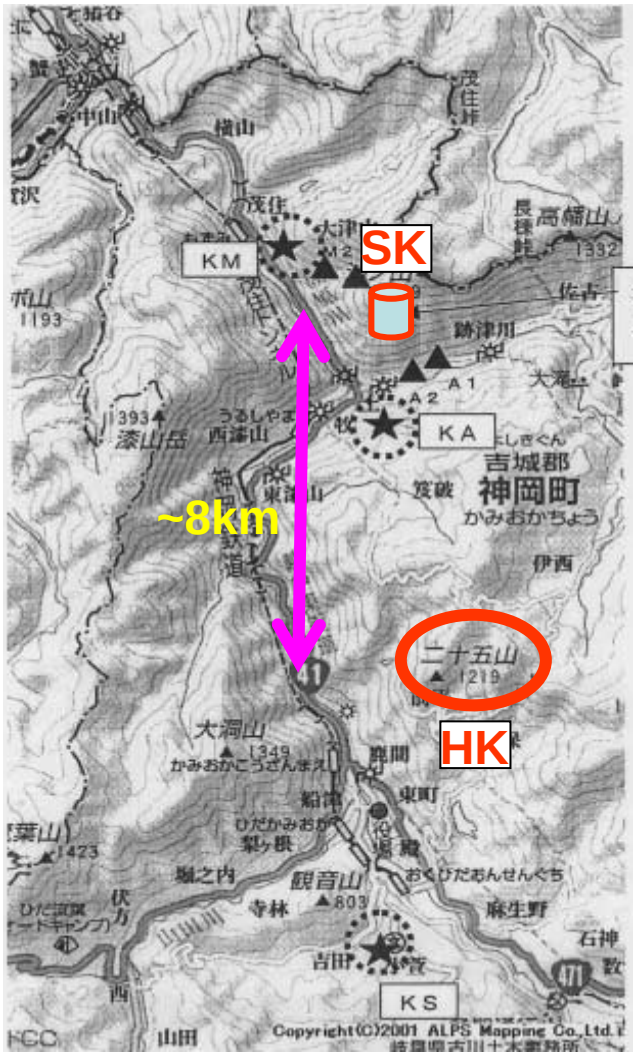
- Cover Off Axis angle : 2º~3º
- Square box shape made with water cooled iron plates (T<60ºC)
- Filled by 1atm Helium gas
- 50m part crossing w/ 3NBT completed.
- Remaining part in 2007&2008

3.0m(W)x4.6m(H)



Common decay pipe for SK/HK covering 2~3 deg OA angle

Candidate site for HK



Beam eye

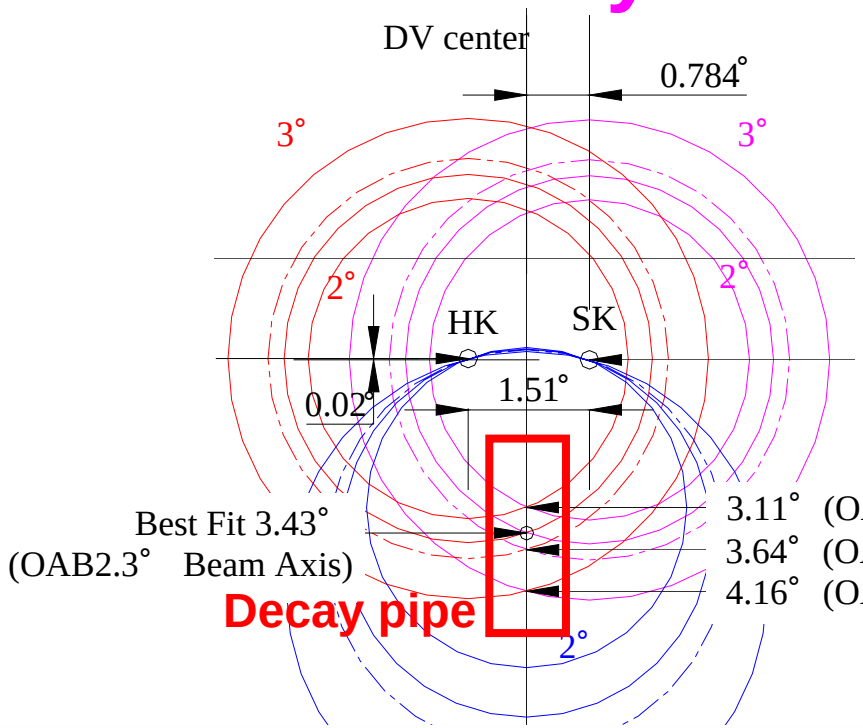


表 3.1: E_ν at the oscillation maximum for the baseline length of 295km and corresponding off-axis angle.

Δm^2	2.04	2.18	2.75	3.17	3.28
$[10^{-3}eV^2]$	(90% A.R.)	(80% A.R.)	(best fit)	(80% A.R)	(90 % A.R)
$E_\nu[GeV]$	0.487	0.520	0.656	0.756	0.782
OA angle[deg.]	3.1	3.0	2.4	2.1	2.0

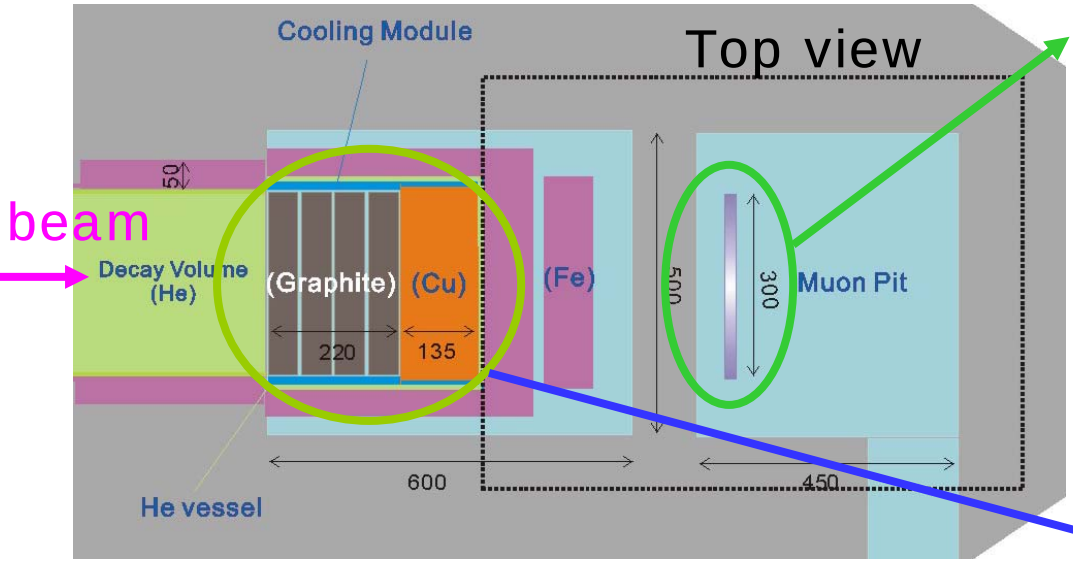
Cover this region

Civil construction of DV

Beam dump & Muon monitor

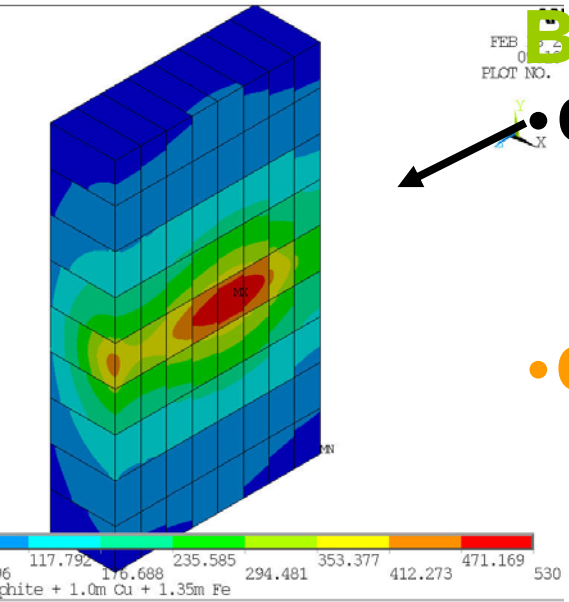
Ishida-san's talk

Kurosawa-san's talk



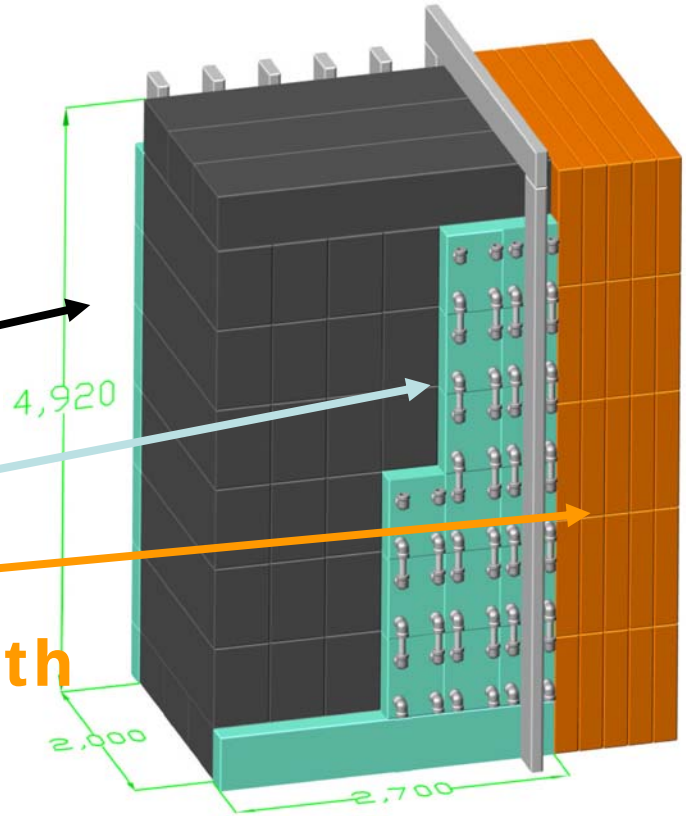
Muon monitors

- spill-by-spill monitor of beam direction / intensity
- Ionization chambers
- Silicon or Diamond Detectors

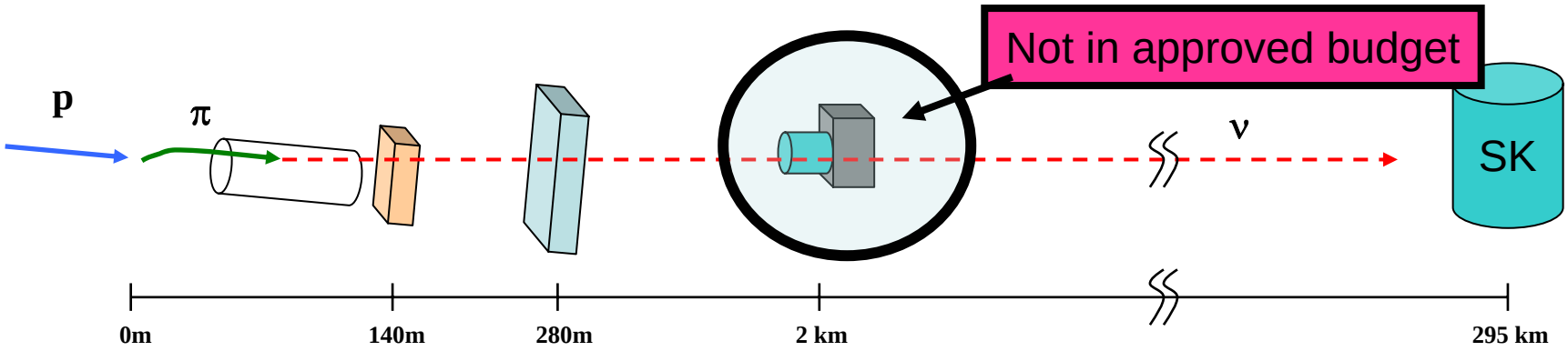


Beam dump

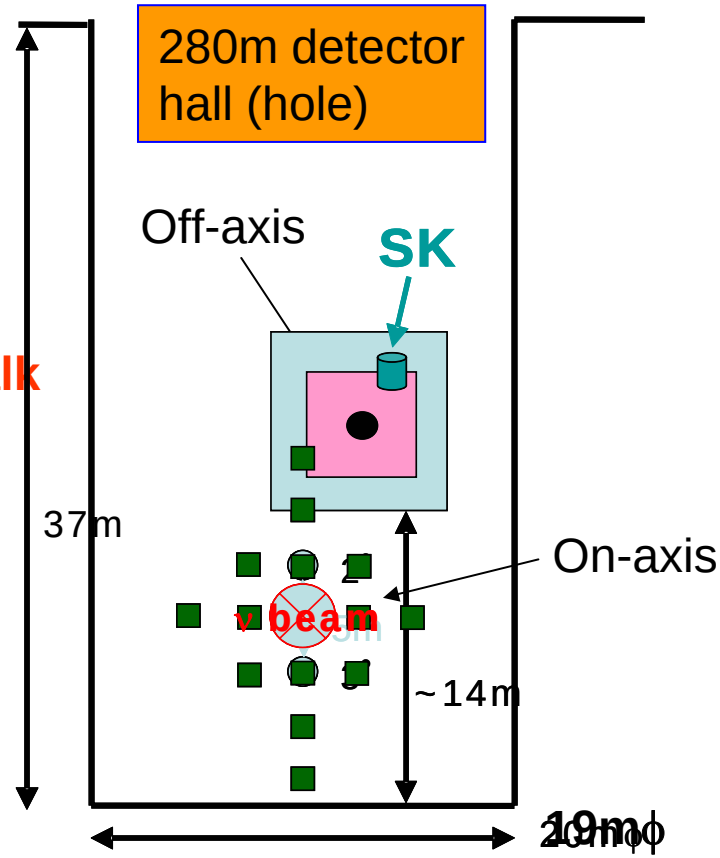
- Graphite blocks with cooling modules
- Copper blocks with cooling path



Neutrino Detectors



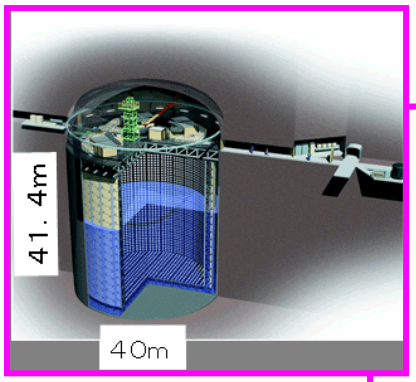
- **First near detectors @280m**
  - 2 detectors: On/Off-axes
  - On-axis: intensity/direction
    - Grid type detectors **Kurimoto-san's talk**
  - Off-axis: Flux/spect./νint/νe
    - UA1 magnet + TPC **Hiraide-san's talk**
- **Second near detector @ ~2km**
  - **Not in the approved budget**

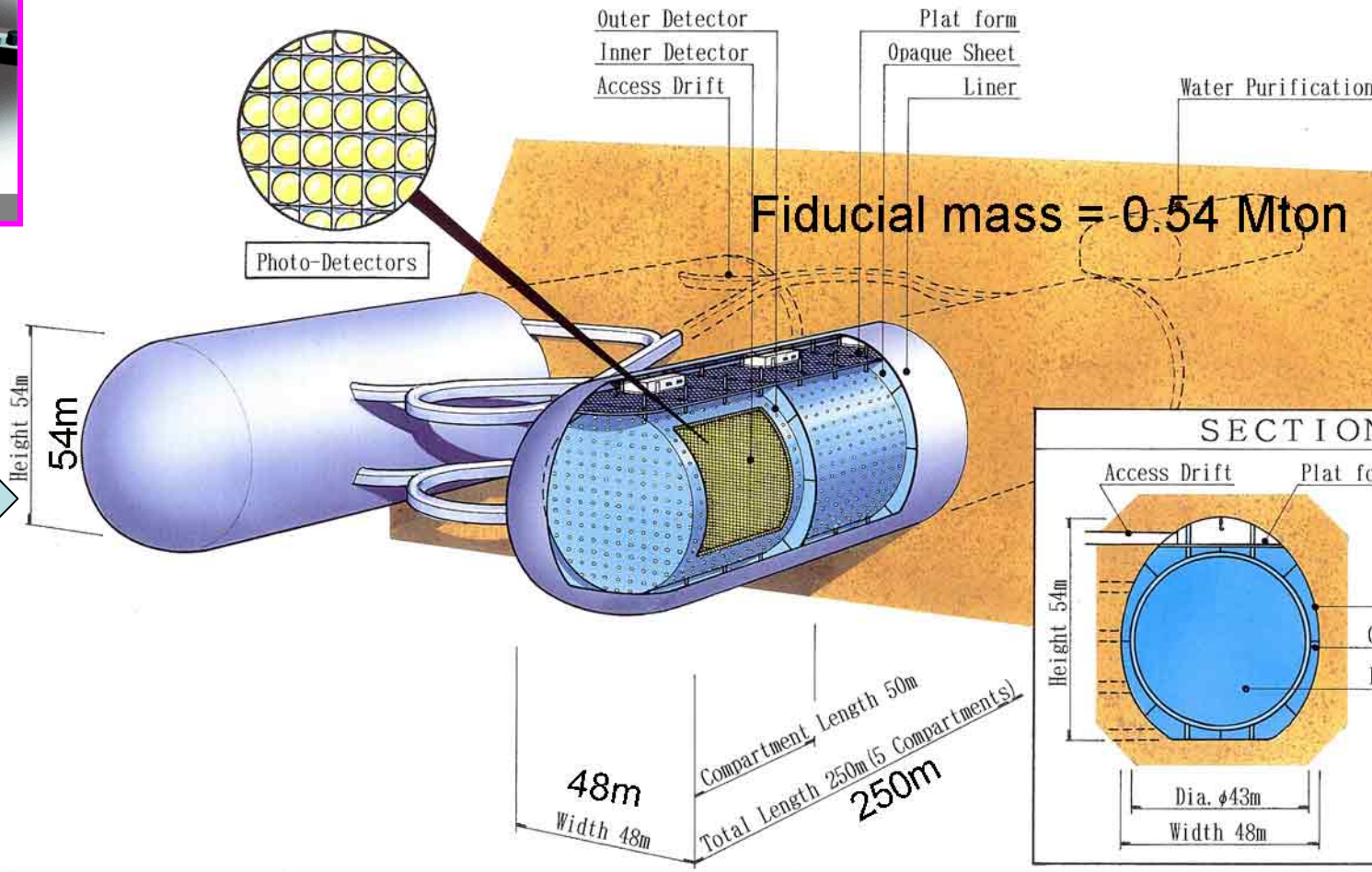


Far Detectors

1st Phase (2009~, ≥5yrs)
Super-Kamiokande(22.5kt)

2nd Phase (201x~?)
Hyper-Kamiokande(~540kt)





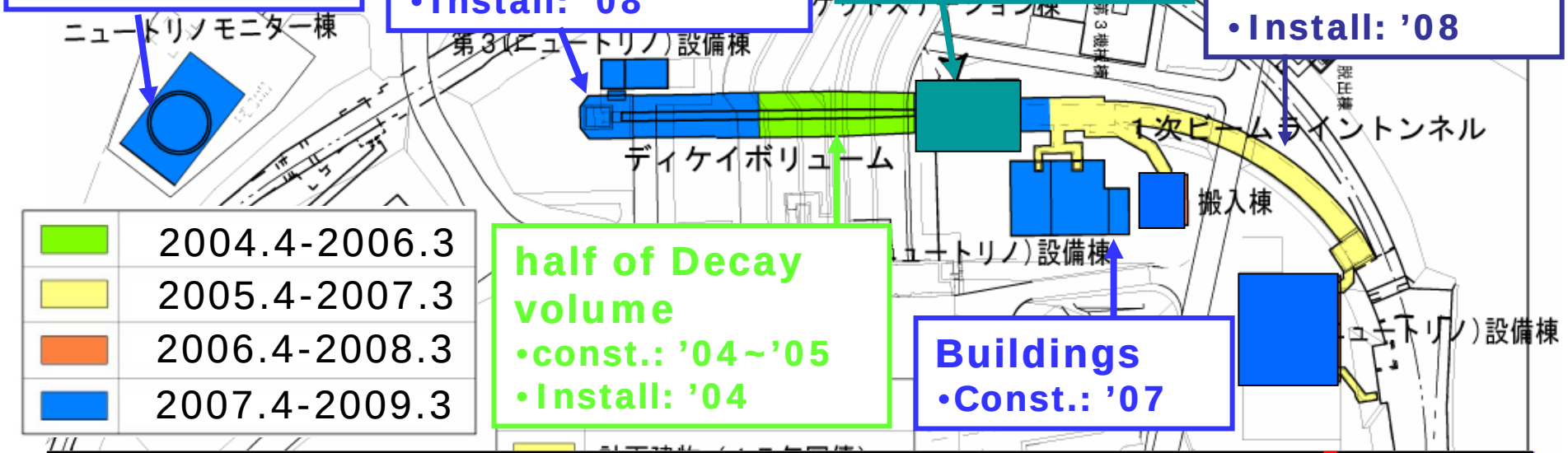
Schedule of ν beam line

Near detector
- const.: '07~'08
- Install: '08

Beam dump & half of Decay vol.
- const.: '07~'08
- Install: '08

Target station
- const.: '06~'07
- Install: '08

Proton beam line
- const.: '05~'06
- Install: '08



half of Decay volume
- const.: '04~'05
- Install: '04

Buildings
- Const.: '07

	2004				2005				2006				2007				2008				2009			
	1st yr				2nd yr				3rd yr				4th yr				Last yr				H21			
	4	7	10	1	4	7	10	1	4	7	10	1	4	7	10	1	4	7	10	1	4	7	10	1
Decay Volume I																								
Primary Beam Tunnel																								
1st Util. Build.(NU1)																								
Installation Build.(NC)																								
TS (underground)																								
TS building																								
TS instrumentation/ test operation																								

Start experiment

Summary

- T2K Experiment
  - High intensity superbeam experiment
  - Off-axis beam
  - Primary goal: Discovery of ν_e appearance
- Neutrino beam facility
  - Construction started in April 2004
- Intensive R&D and design work of beam line components
- Start experiment in 2009

See coming talks for technical detail of each component