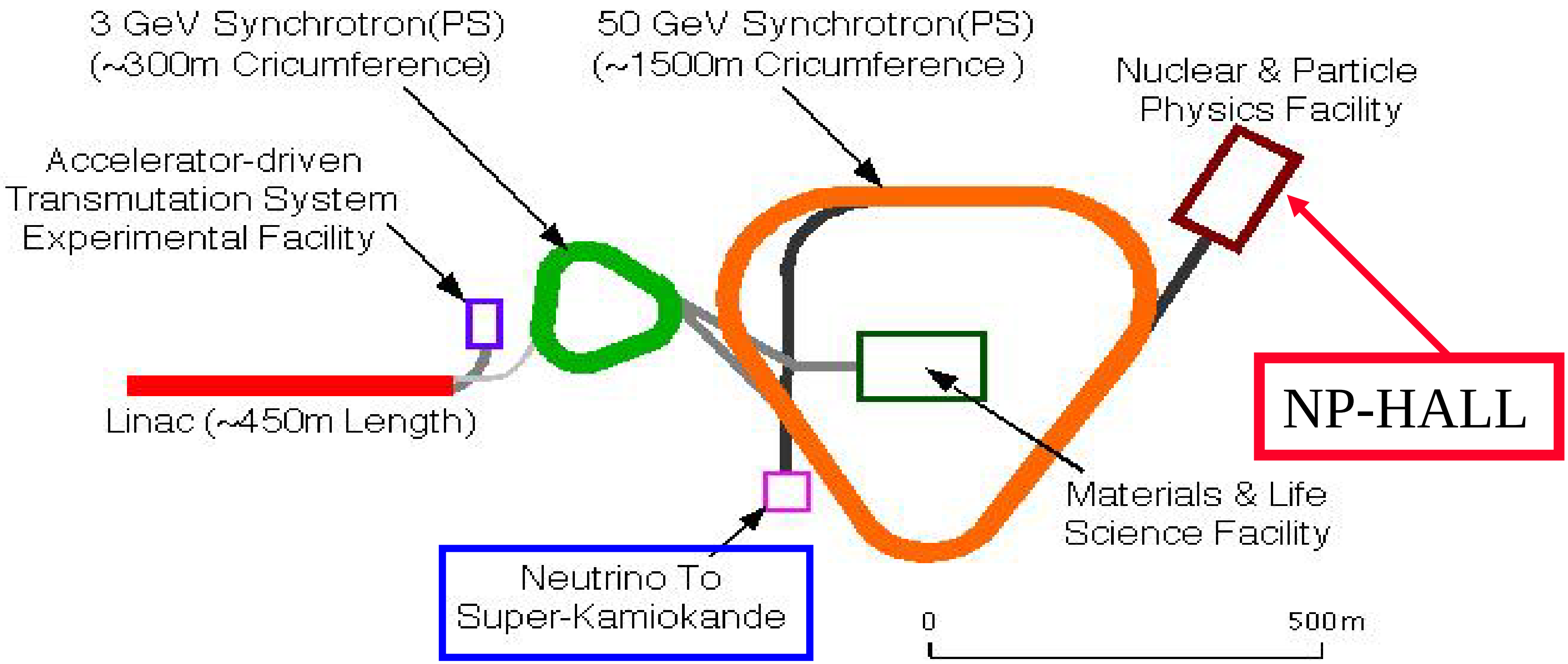
STATUS of the NP-HALL

K.H. Tanaka for NP Facility Construction Team



- NP-Hall: Experimental Hall for 50GeV-15 μA Slow Beam
  - The First (Only One?) ***KAON FACTORY*** in the World
- Neutrino Beam Facility (JHF-ν) : Long Baseline Experiment

STATUS of the J-PARC

Beam Profile of JHF-50GeV PS (Phase 1-)

- Beam Energy： 50GeV (30GeV)
- Beam Repetition: 3.4s
- External Beam Width： 0.7s (1.0s) **Slow Beam**
- Beam Intensity: 3.3×10^{14}ppp, 15μA
  (2×10^{14}ppp, 9μA)
  E_{Linac} = 400MeV (180MeV)
- Beam Power: 750kW (270kW)

Design Concept

JHF (50GeV) PS:

More than 100 times Higher Beam Power than the KEK (12GeV) PS.

- More than 100 times Higher Radiation Dose.
- More than 100 times Larger Heat Deposit.

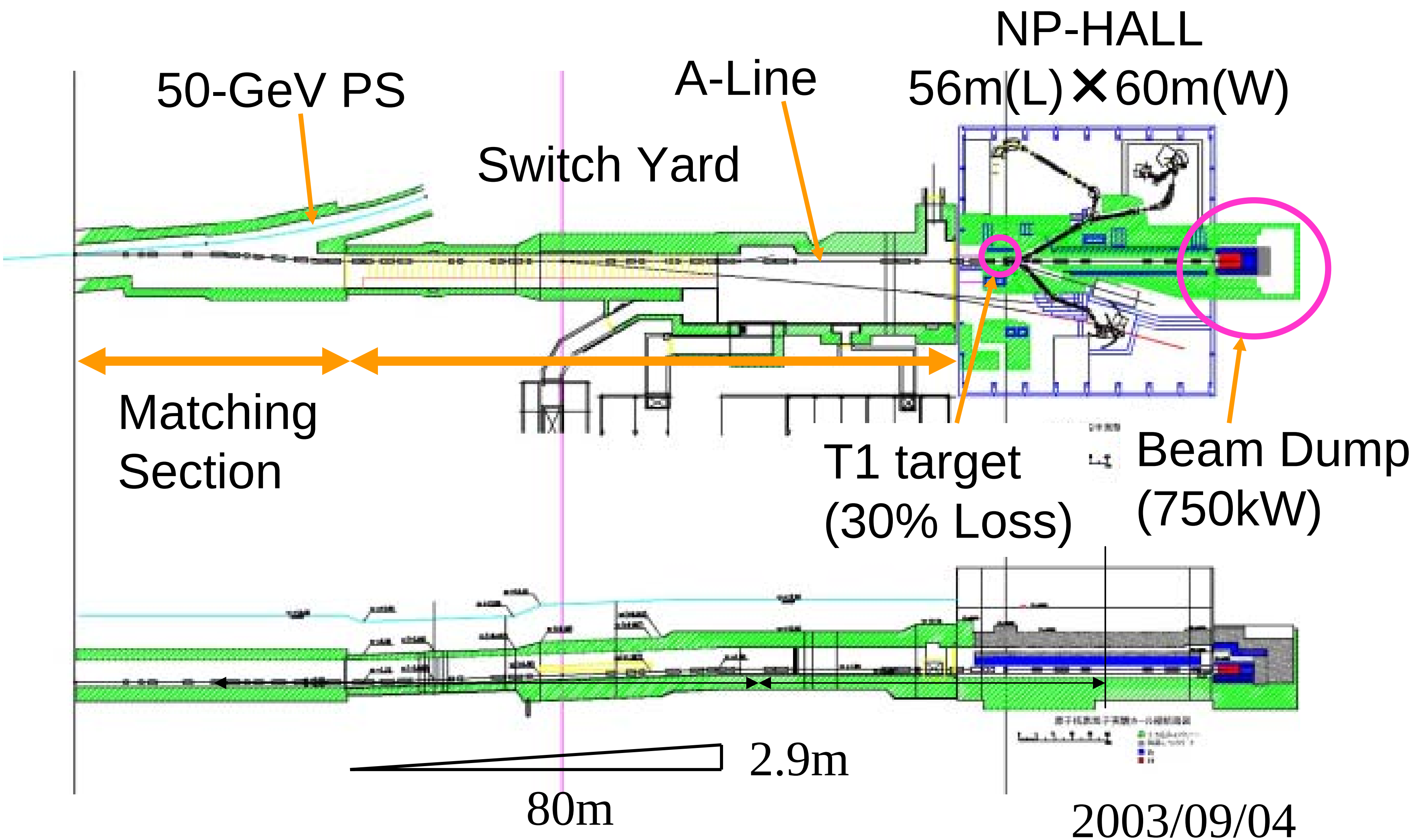
For the Stable Operation

- Tight/Enormous Radiation Shield.
- Radiation/Heat Resistant Beam Line Elements.
- Facility Design Oriented for the Maintenance.
  - Quick Disconnect Devices
  - Remote Handling Design/Tools

Progress in JFY 2003

- NP-Hall Design -> Imazato
- Optics of Primary Proton Beamline & Double Separated Kaon Beamline
- ***Radiation Resistant Beamline System*** for SY/ν-line & NP-Hall
- ***T1 Target*** & its Vicinity
- ***Beam Dump*** & its Moving

Slow Extraction Beam Line Facility (Phase I)



2003/09/04

Optical Parameters of SE Beam

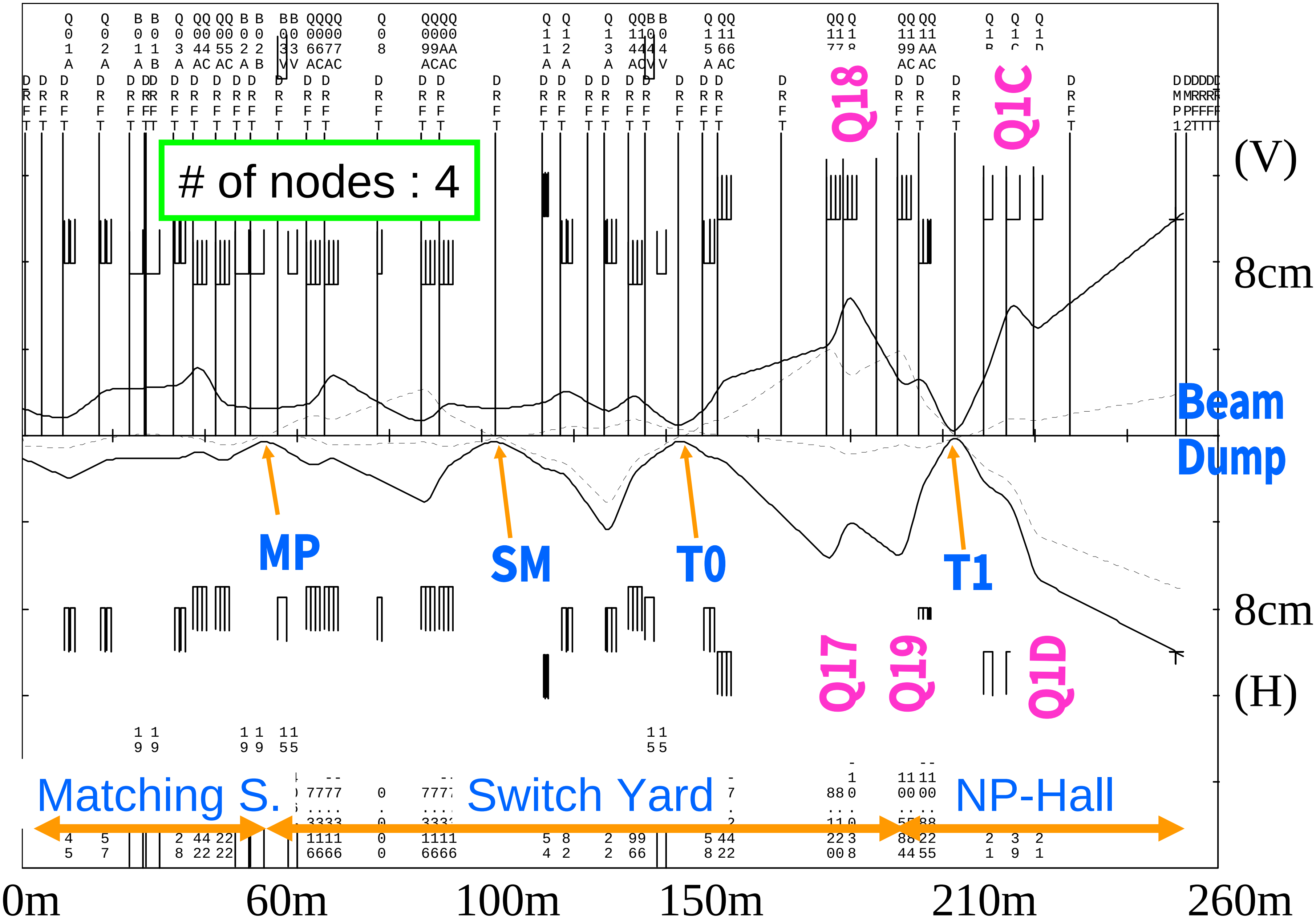
For 30 GeV from Tomizawa (2002.10.2)

Horizontal		Vertical	
ε_H (mm mr)	4.4π	ε_V (mm・mr)	10.4π
α_H	-2.21	α_V	1.133
β_H (m)	26.476	β_V (m)	16.629
dp/p (%)	0.31		
η(cm/%)	0.518		
η'(mr/%)	0.084		

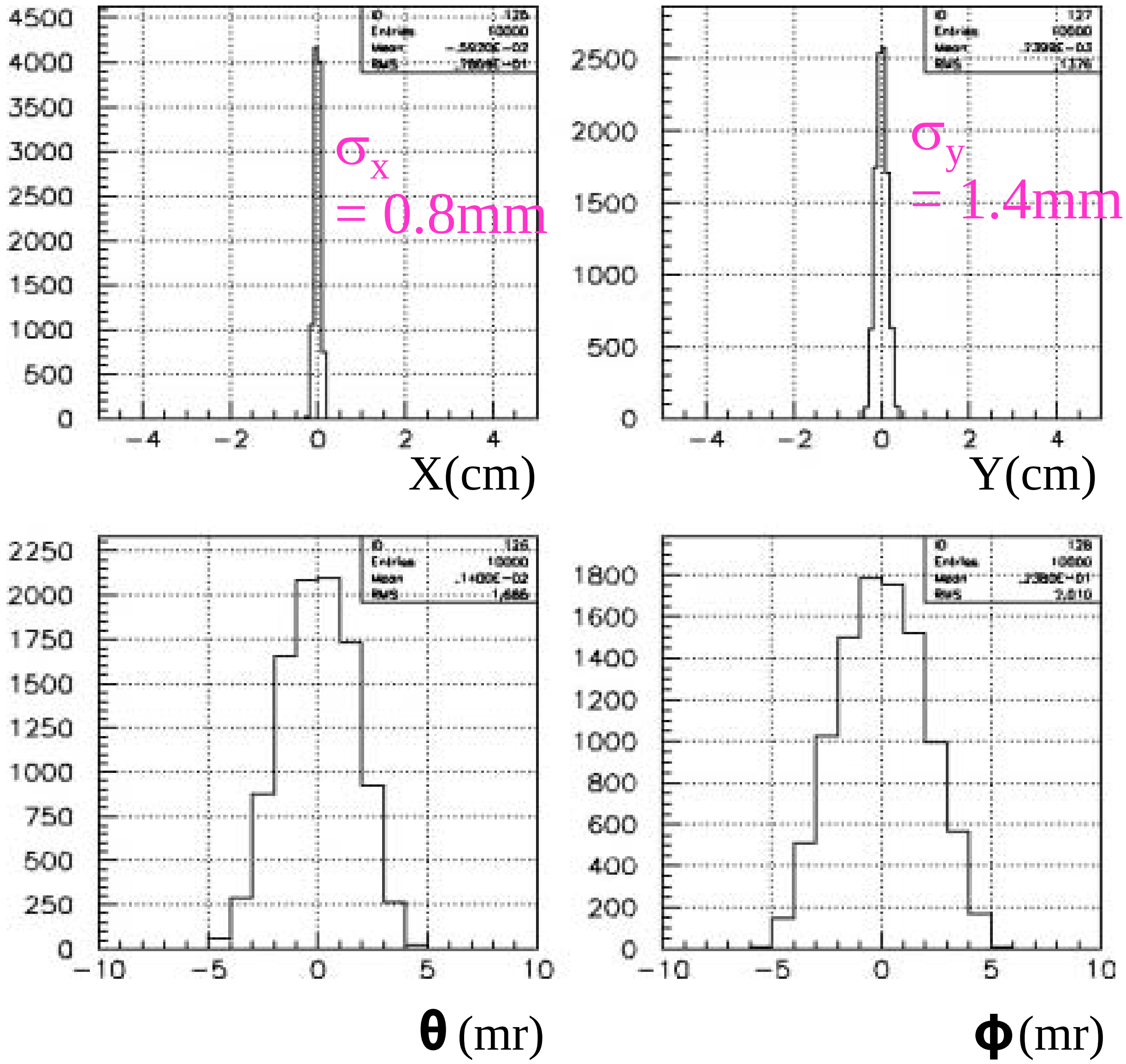
⇨ Emittance (50 GeV) ： $\varepsilon_H = 2.7\pi$, $\varepsilon_V = 6.3\pi$

Full Acceptance ： $\varepsilon_H = 10.3\pi$, $\varepsilon_V = 24.4\pi$ mm・mr

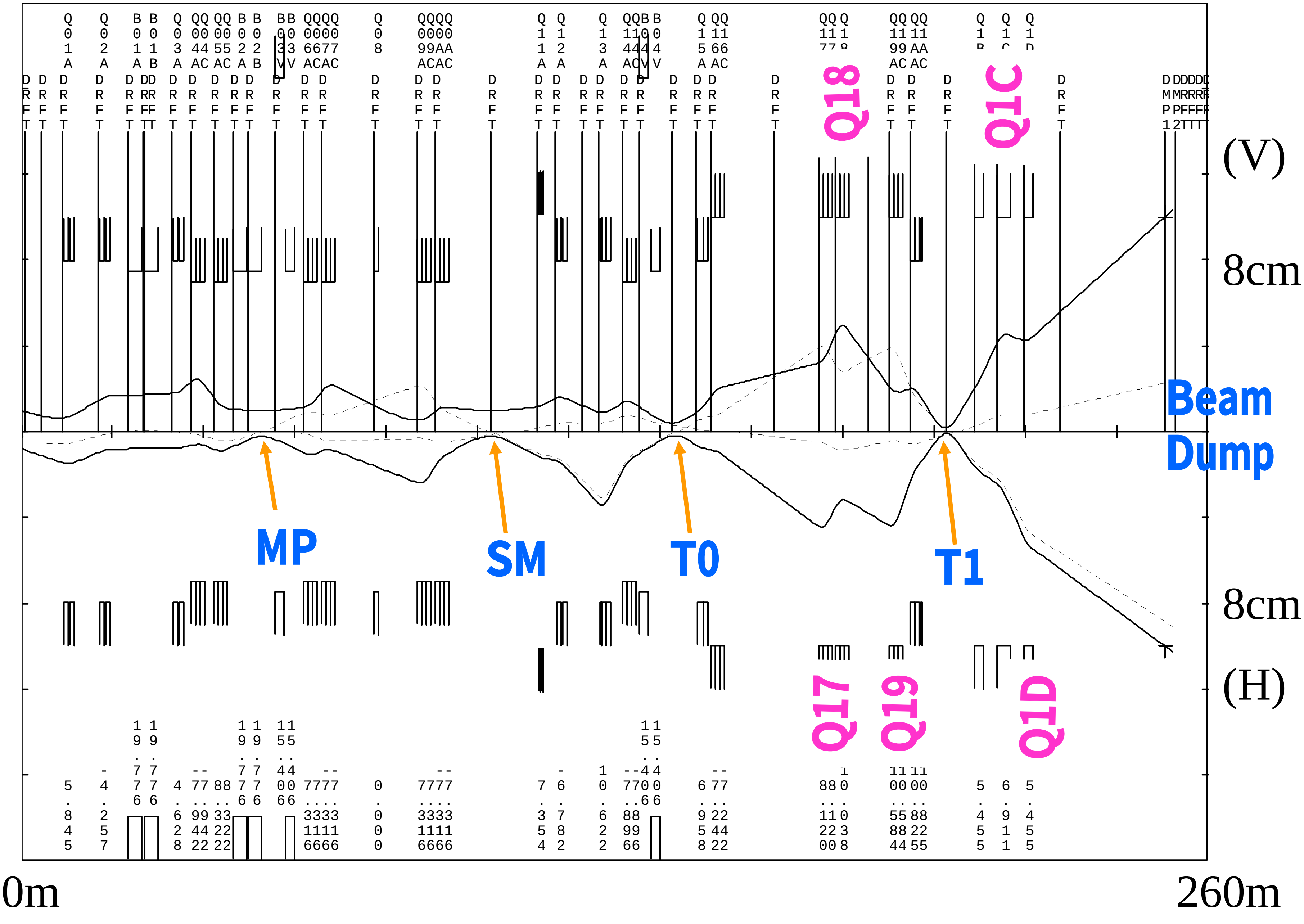
Beam Envelope (30 GeV SEB: $\varepsilon_H = 4.4\pi$ / $\varepsilon_V = 10.4\pi$ mm・mr)



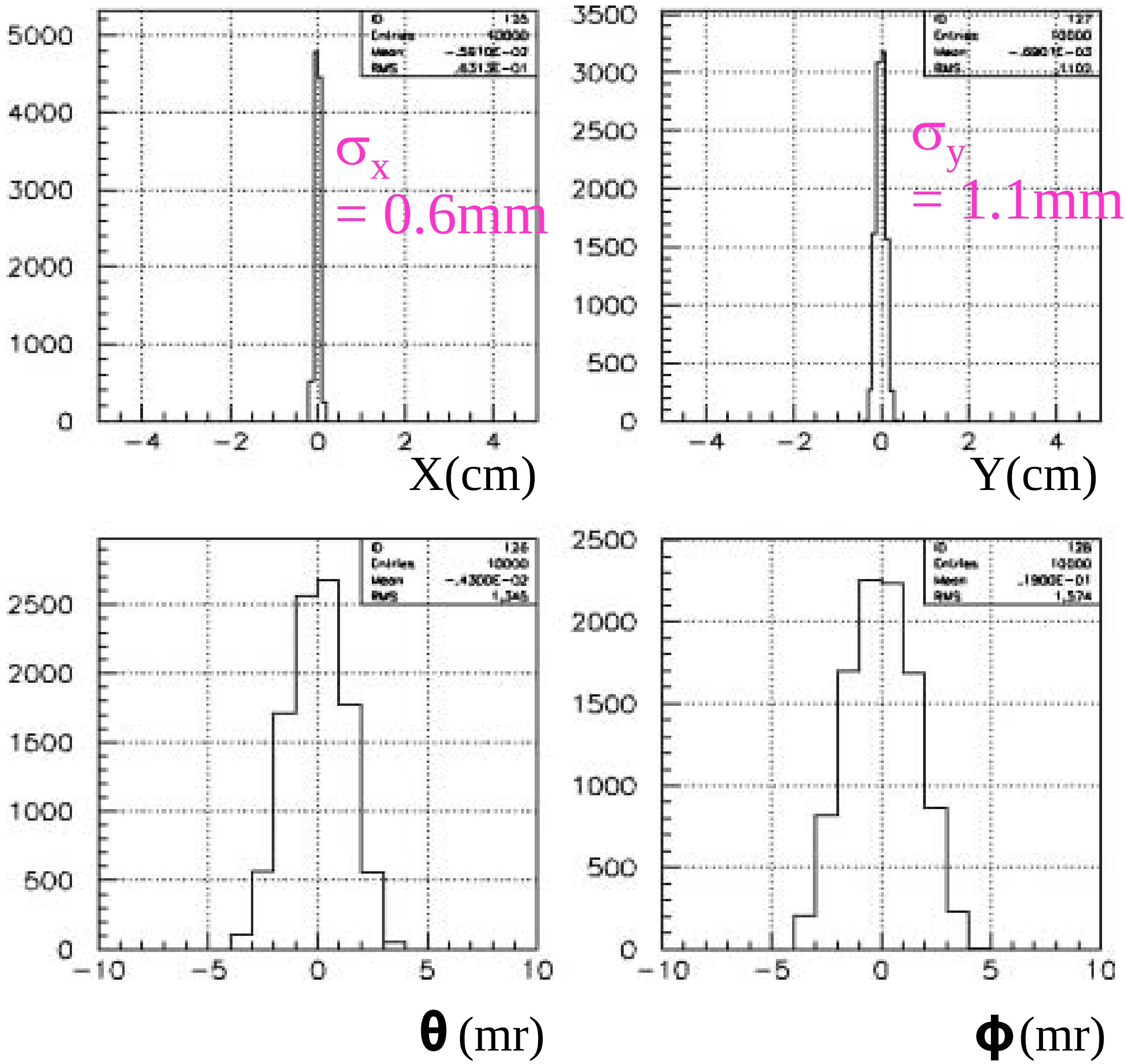
30-GeV Beam Profile@T1 (TURTLE)



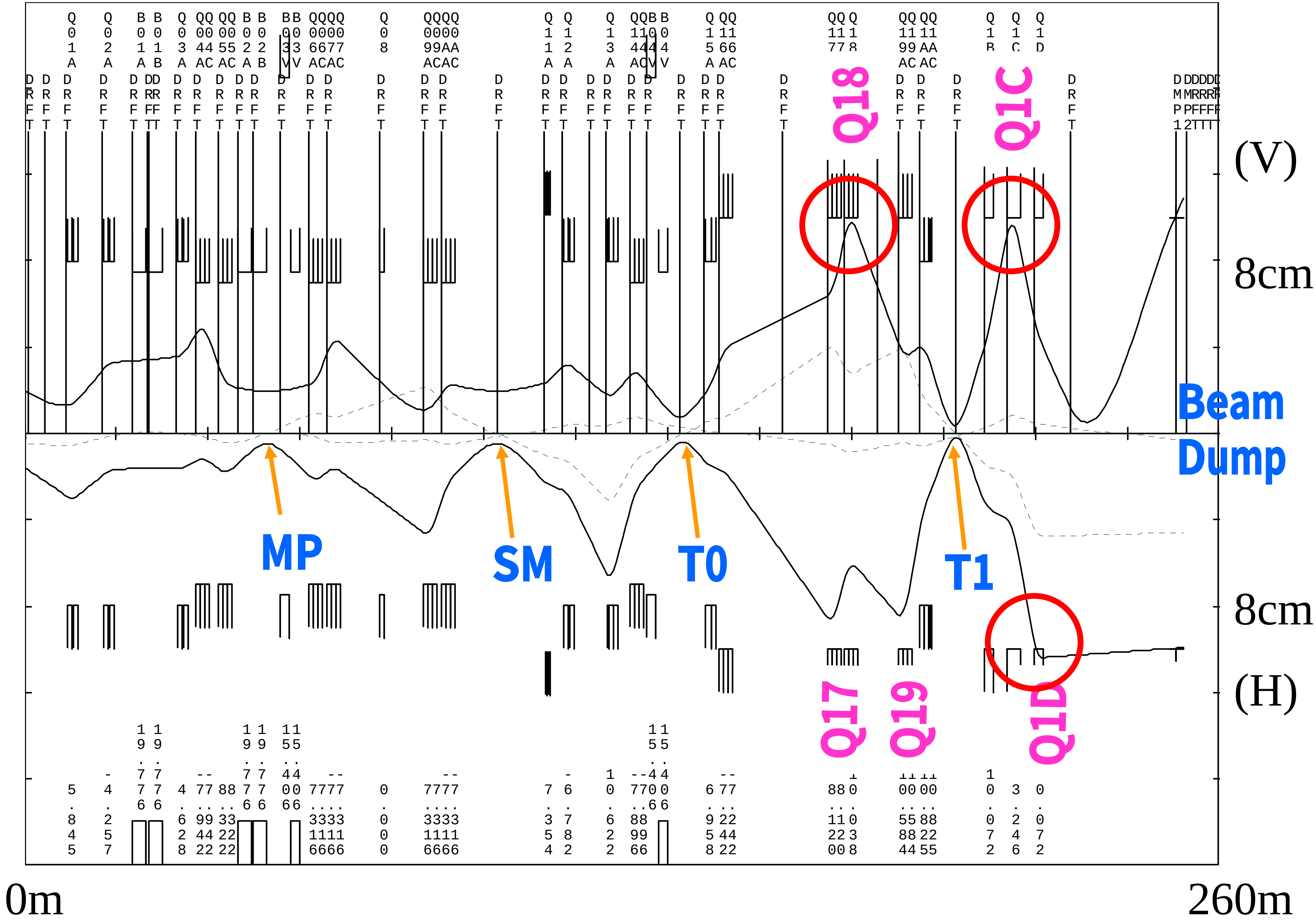
Beam Envelope (50 GeV SEB: $\varepsilon_H = 2.7\pi$ / $\varepsilon_V = 6.3\pi$ mm・mr)



50-GeV Beam Profile@T1 (TURTLE)



Beam Envelope(Full Acceptance: ε_H=10.3π /ε_V=24.4π mm･mr)



Summary of SEB

○SEB Optics

1) 4 nodes

- Focus at MP for tuning & monitoring
- Focus at SM (for future extension to the primary B-line)
- Focus at T0 (for future extension to the Test BL)
- Focus at T1 for Secondary Beam Lines

2) Defocus at the Beam Dump

3) Acceptable Beam Emittance: $\varepsilon_H = 10.3\pi$ / $\varepsilon_V = 24.4\pi$ mm・mr

Expected Emittance

$\varepsilon_H=4.4\pi$ / $\varepsilon_V=10.4\pi$ for 30-GeV SEB

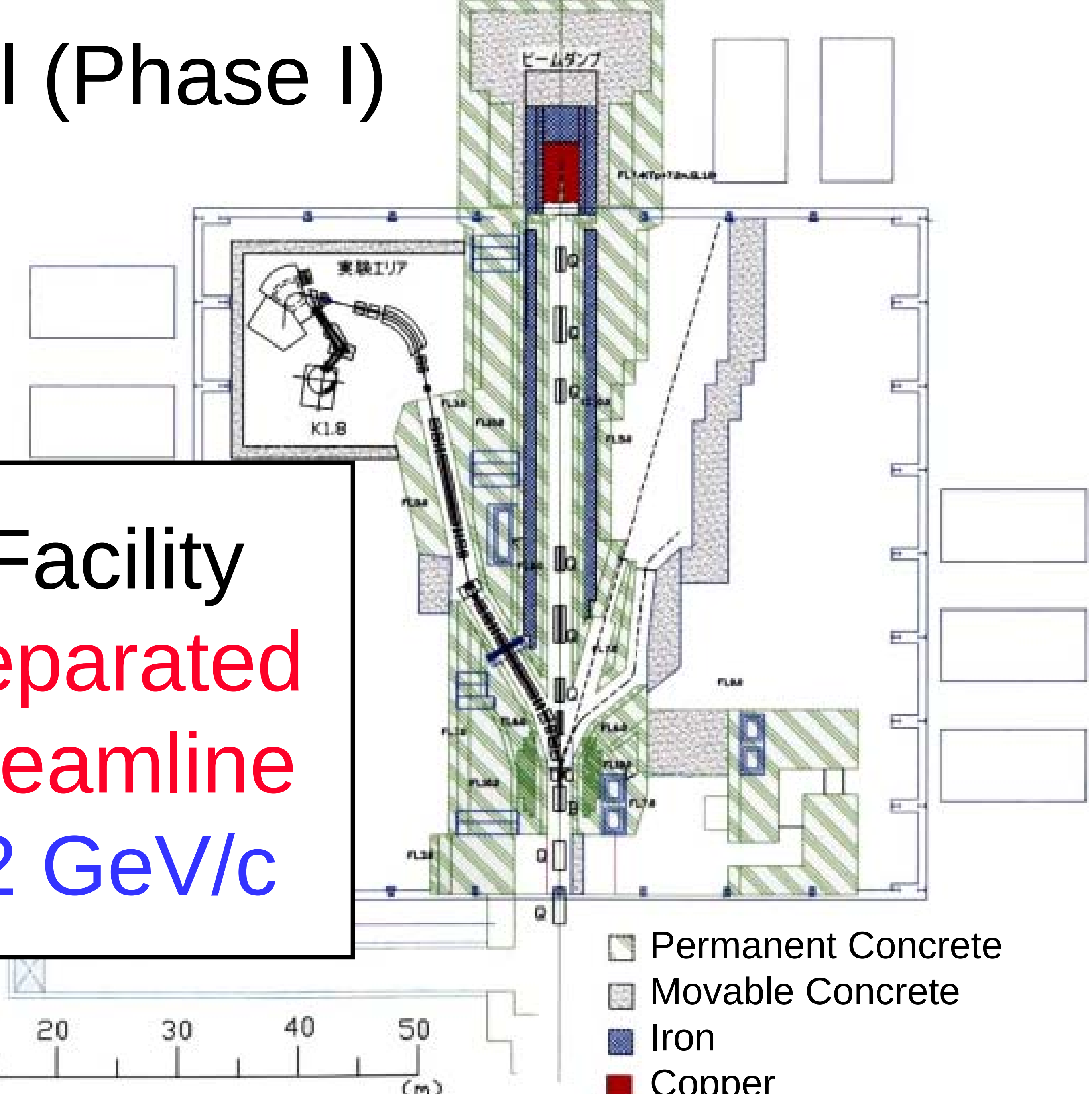
$\varepsilon_H=2.7\pi$ / $\varepsilon_V= 6.3\pi$ for 50-GeV SEB

○Beam Profile @ T1

$\sigma_x = 0.8$mm、$\sigma_y = 1.4$mm (30 GeV)

$\sigma_x = 0.6$mm、$\sigma_y = 1.1$mm (50 GeV)

NP Hall (Phase I)

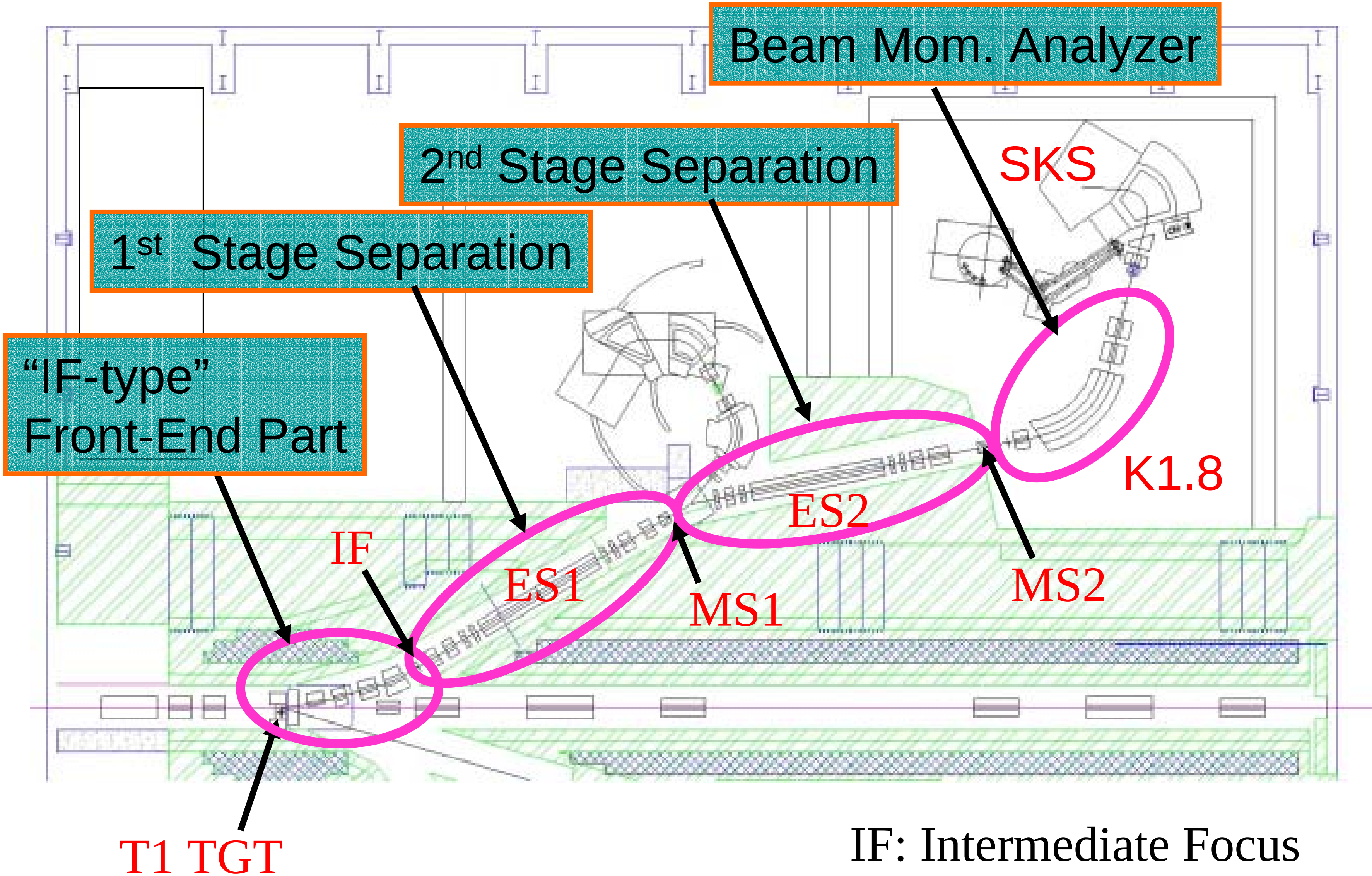


Main Facility

K1.8 Separated Kaon Beamline

P_{max} ~2 GeV/c

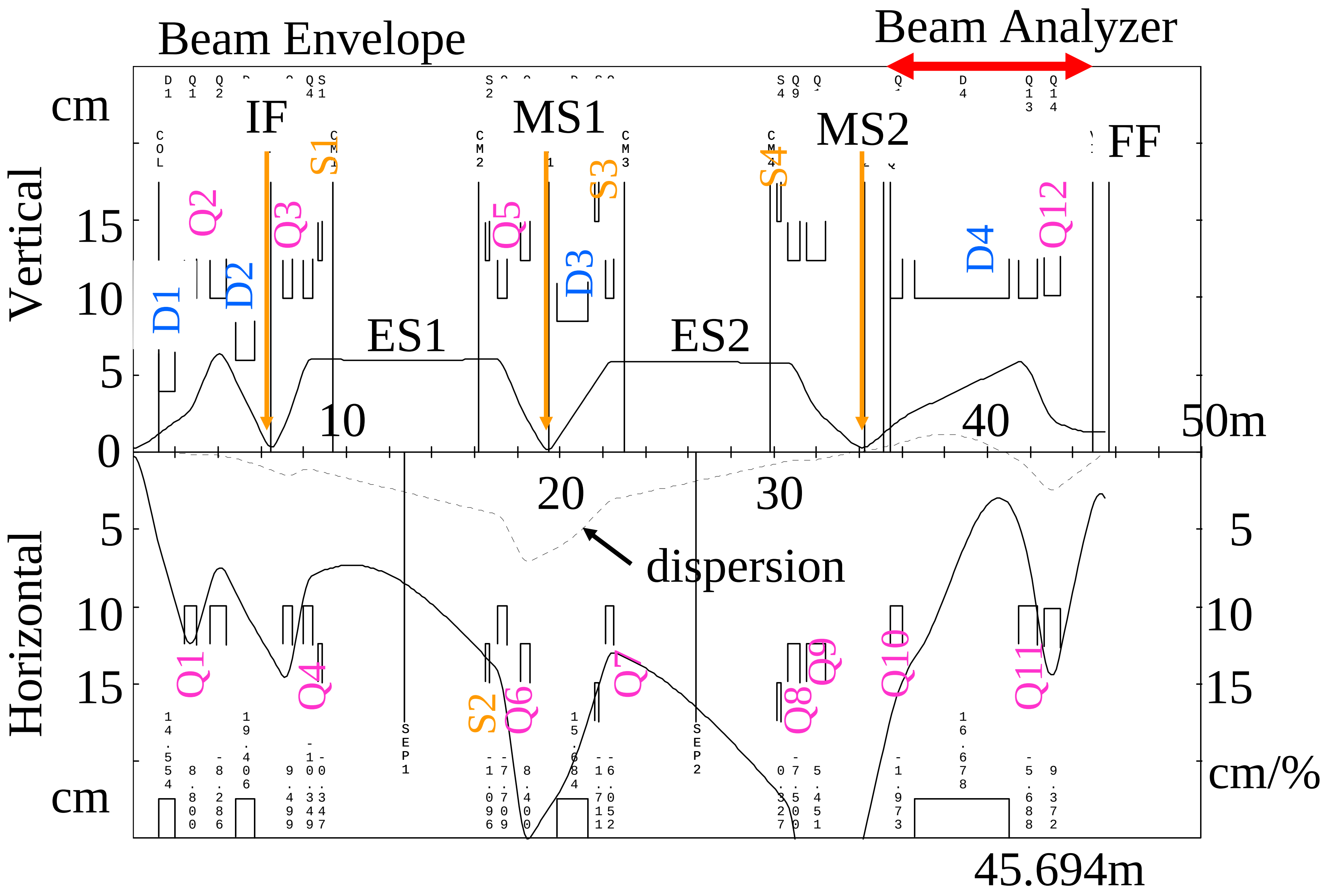
K1.8 Layout



IF: Intermediate Focus

“IF-Type” K1.8

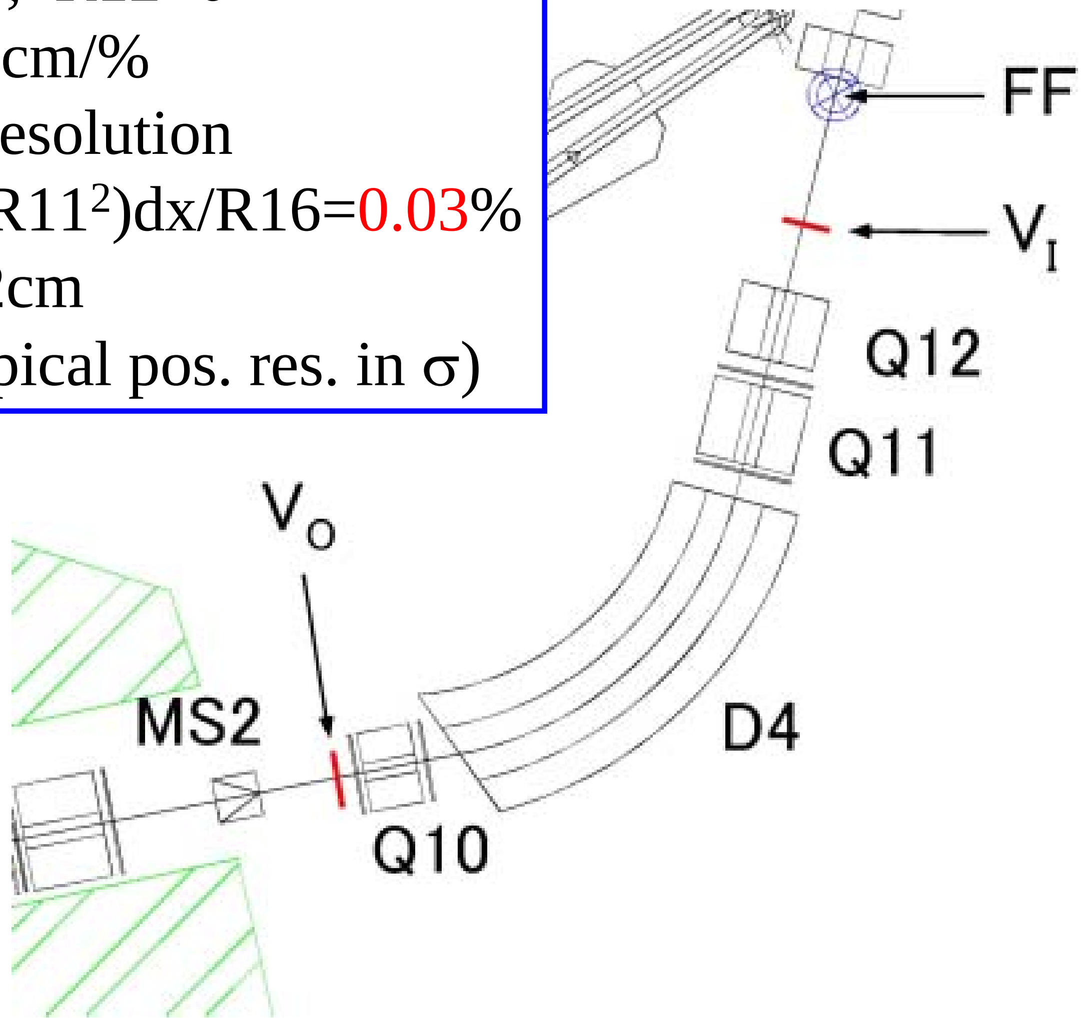
TRANSPORT(2nd Order)



Beam Momentum Analyzer

○ Beam Analyzer (Vo→Vi):
R11=-0.174, R12=0
R16=0.725 cm/%

○ 1st Order Resolution
$dp = \mathrm{sqrt}(1+R11^2)dx/R16 = 0.03\%$
for dx=0.02cm
(typical pos. res. in σ)



K1.8 Summary

○"IF-Type" "Double-Stage Separated" Beam Line with "Momentum Analyzer"

Total Length: 45.7m

K- intensity @ 1.8 GeV/c: 1.3×10^7ppp

K^-/π^-~infinite (Decay TURTLE 2nd Order)

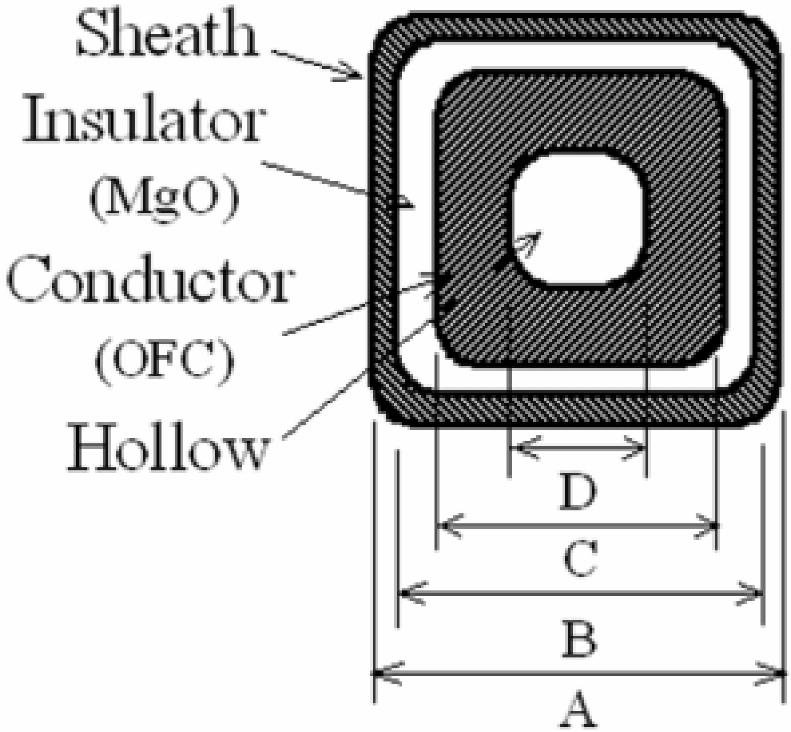
"cloud π" has yet to be estimated.

○To be done (in Beam Optics)

1. Higher order (3rd order effect)
2. "cloud π" / "Scattered π"

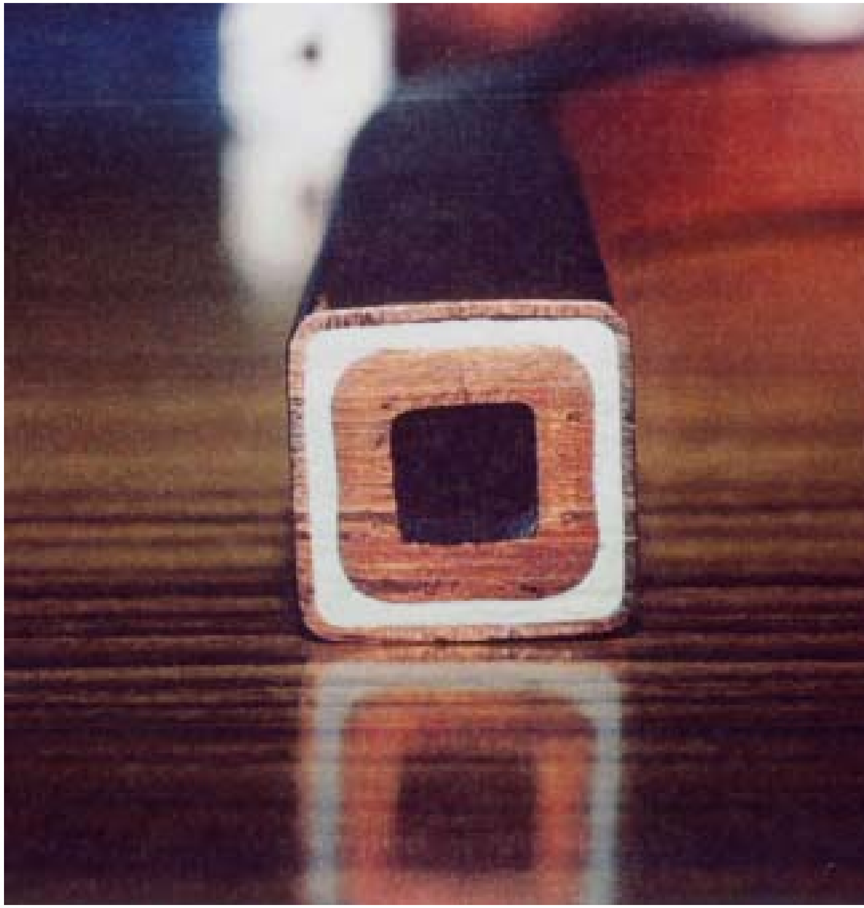
→GEANT

Mineral Insulation Cable

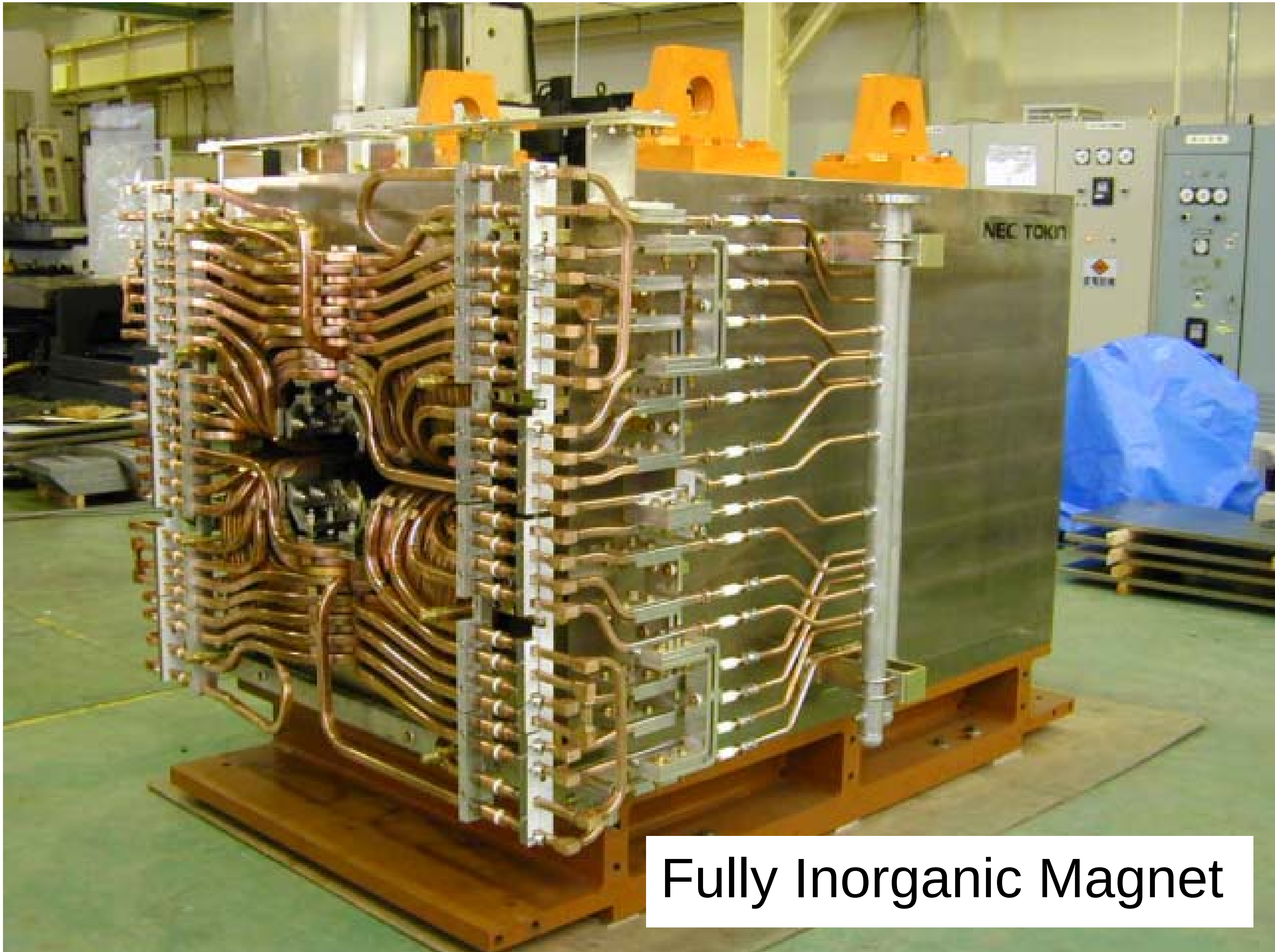


Nominal Current (A)	2000	2500	3000	1000*	2000*
Dimmensions (mm)					
A: Outward Size	20.0	23.8	28.0	18.0	14.0
B: Insulator Size	18.0	21.6	25.0	16.6	12.6
C: Conductor Size	14.6	18.0	20.0	13.2	9.2
D: Hollow Size	7.4	10.0	10.0	--	--
Cross Section (mm^2)					
Conductor	150.9	211.7	293.1	168.4	78.8
Insulator	117.7	153.2	227.4	106.6	79.4
Seath	73.4	95.3	150.6	47.8	36.6

* indicates Solid Conductor MICs. No hollow is in Cu conductor.



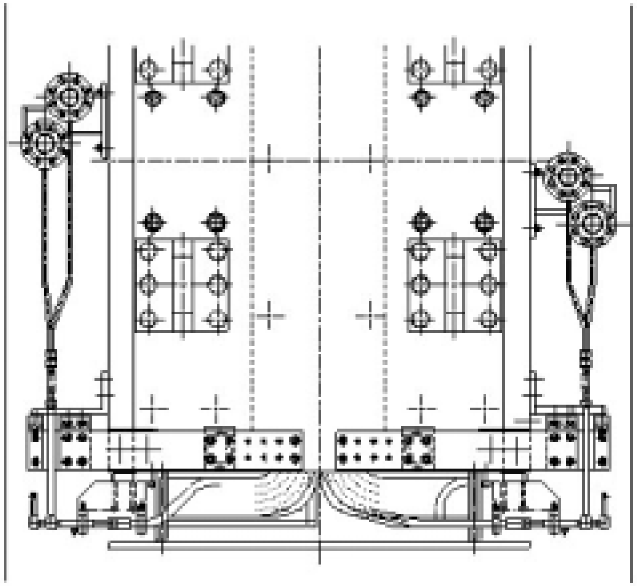
Construction of actual magnet Q440MIC



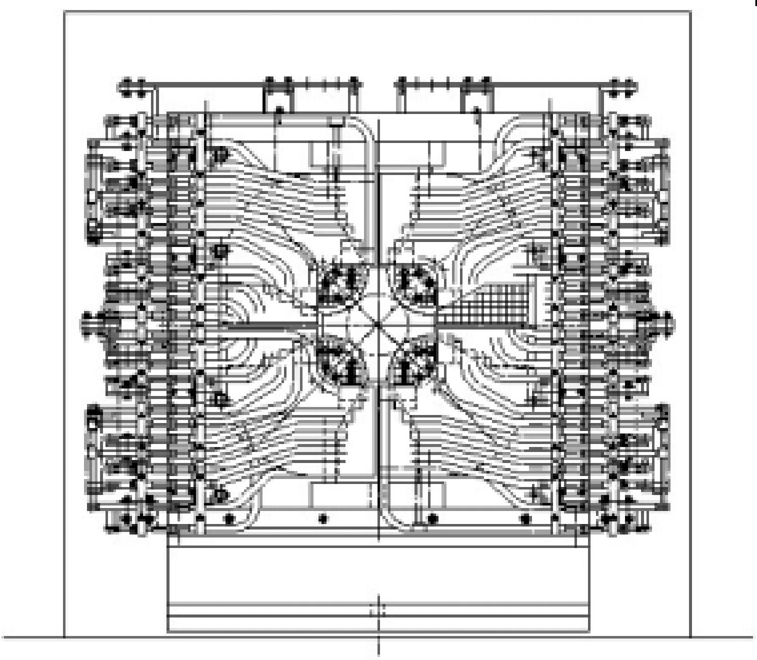
Fully Inorganic Magnet

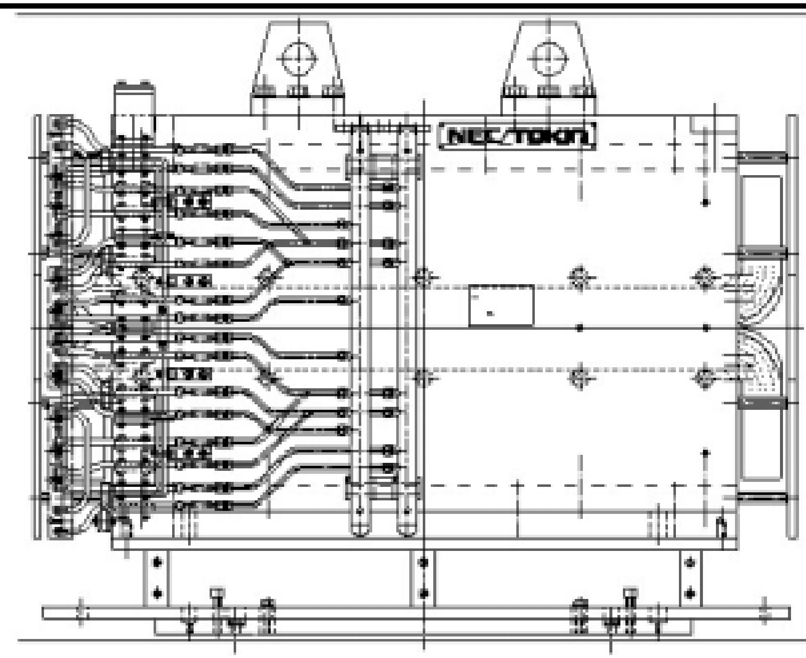
Construction of actual magnet

Q440MIC

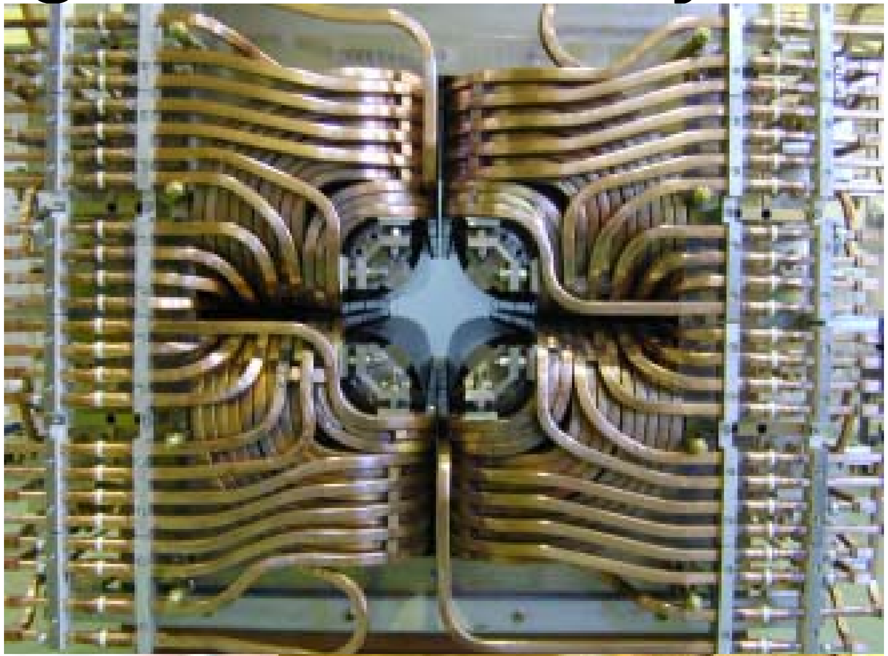


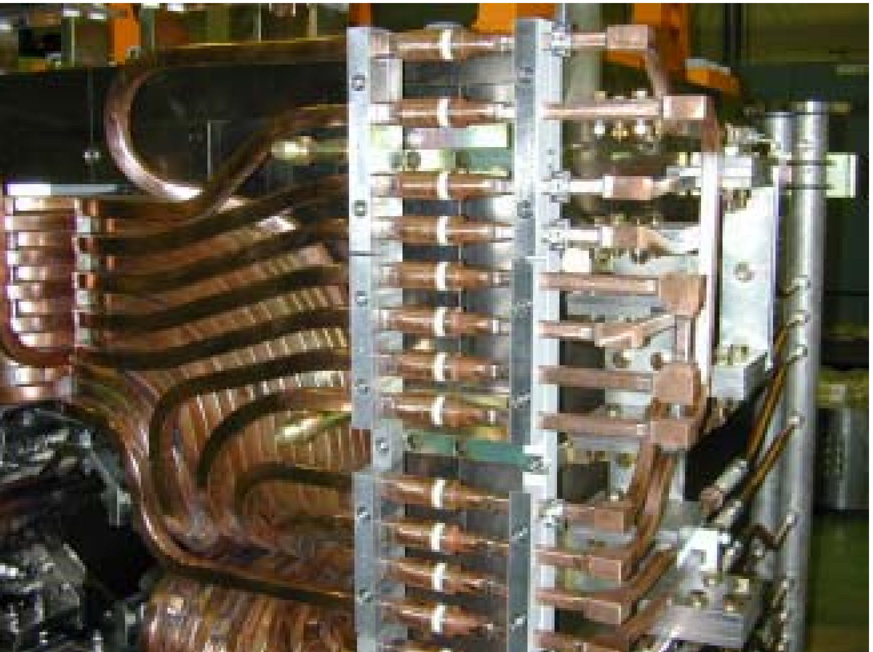
- 20cm bore diam., 200cm pole length
- 43T/pole, 1.3T@pole
- Nominal current/voltage=2200 A/200V
- Cooling water=290 L/min.@1MPa
- Cooling water Temp. rise=30 ℃
- Approximate Weight=33ton



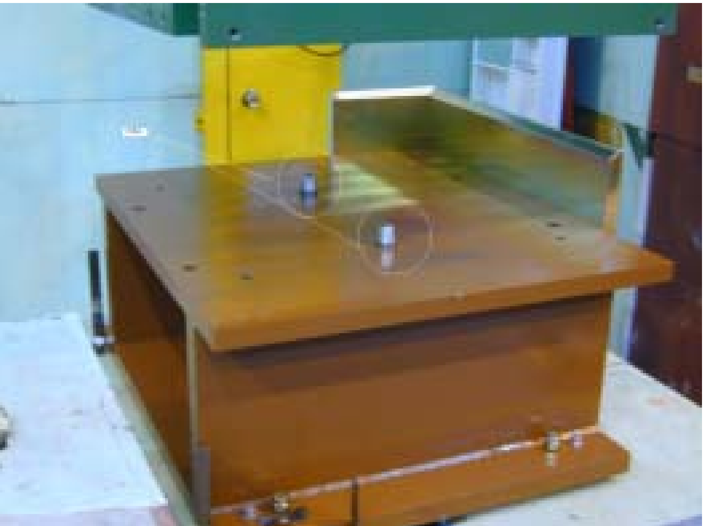


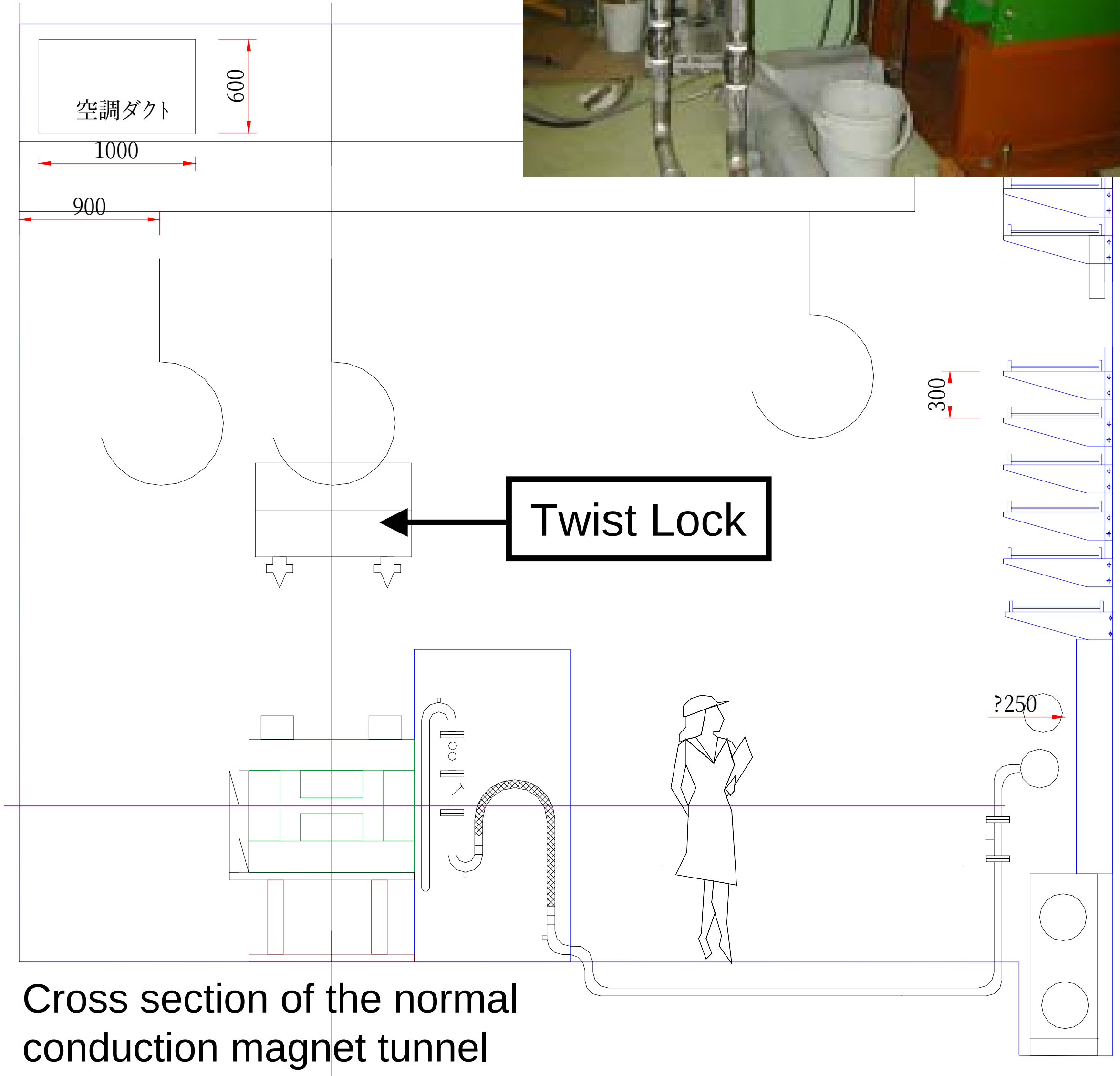
Q440MIC Magnet Assembly



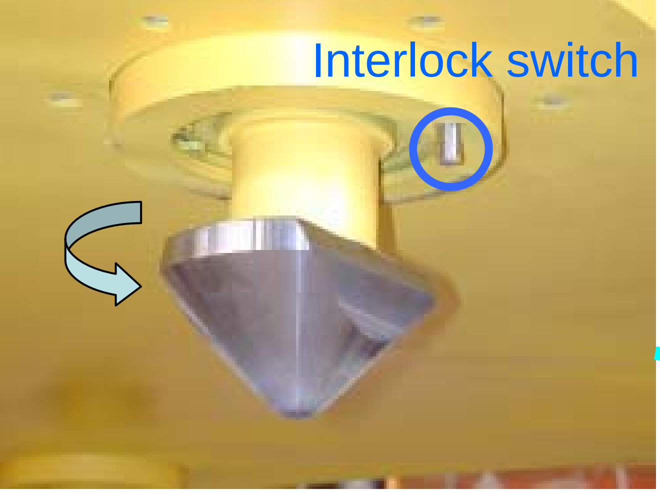


The development of "Twist-lock" (an automatic sling apparatus) for SY and ν-beam



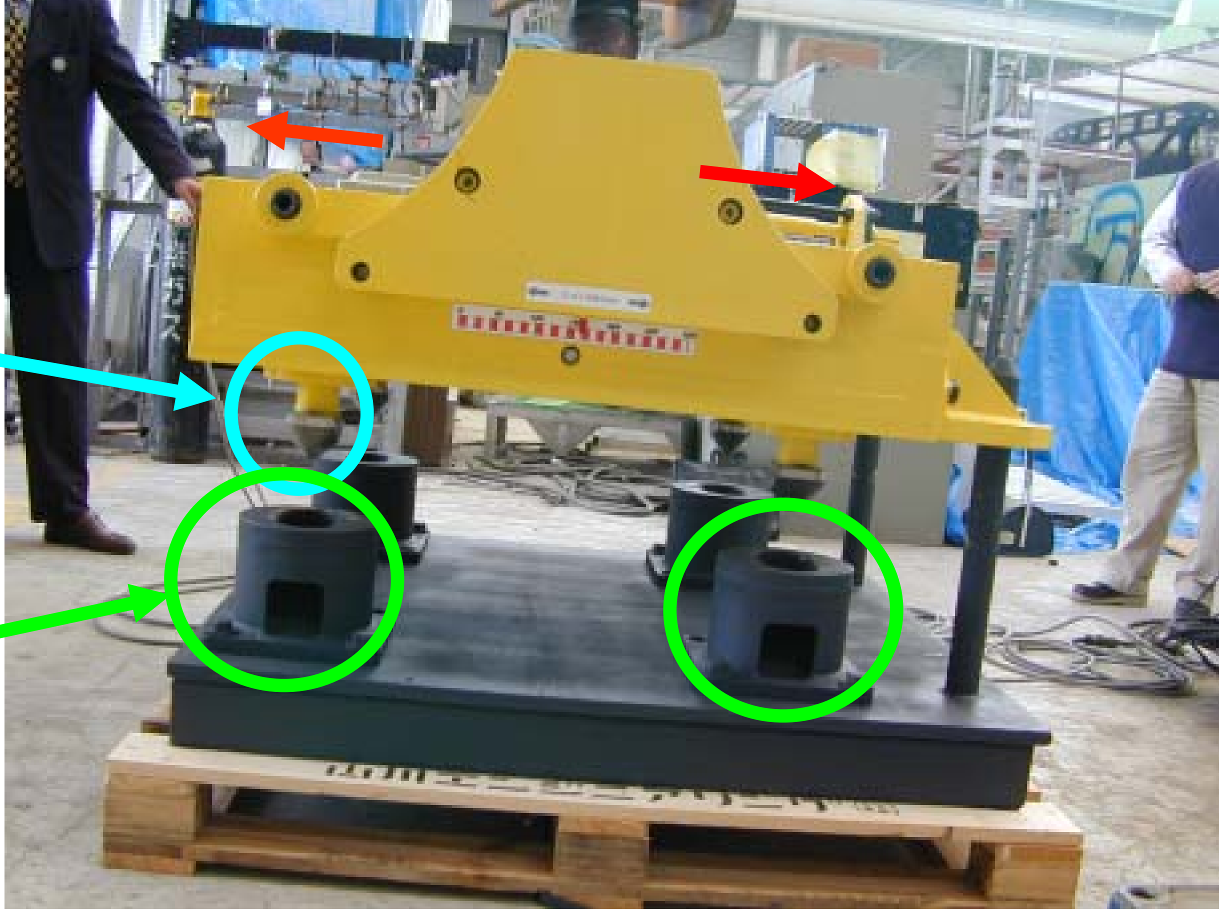


Cross section of the normal conduction magnet tunnel



Twist lock

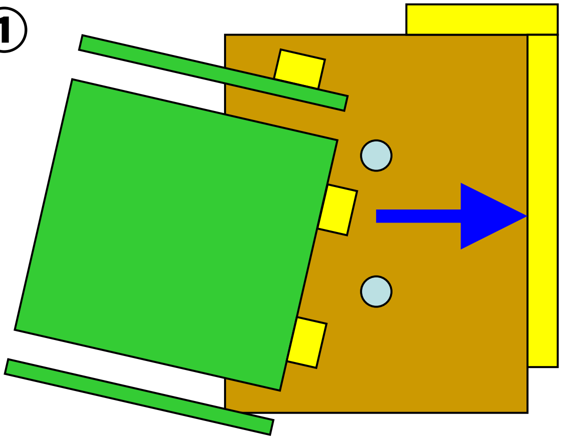
Corner fitting



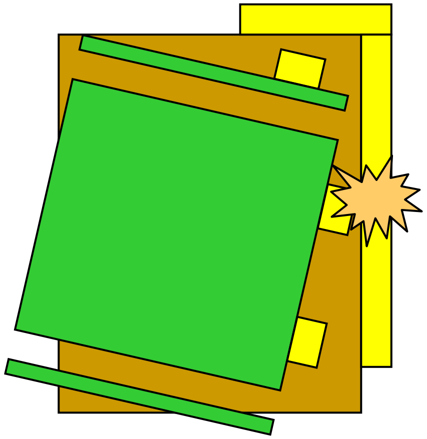
4 twist locks turned by the chain driven by the electric motor, simultaneously.

Quick alignment guide

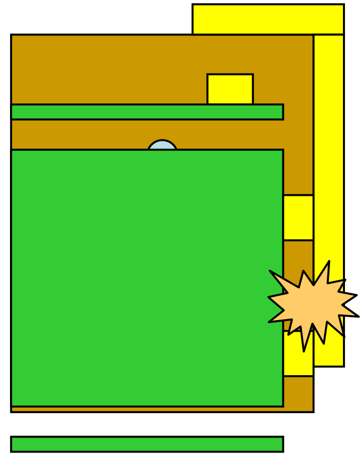
①



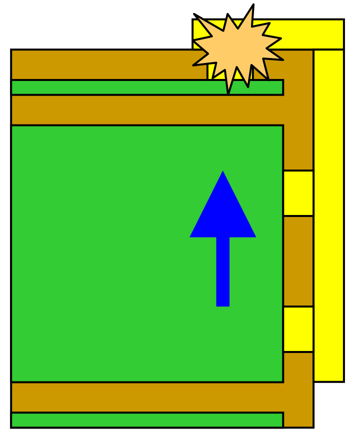
②

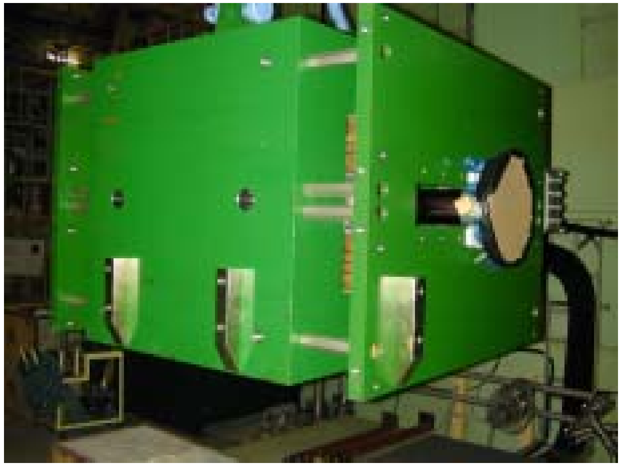


③

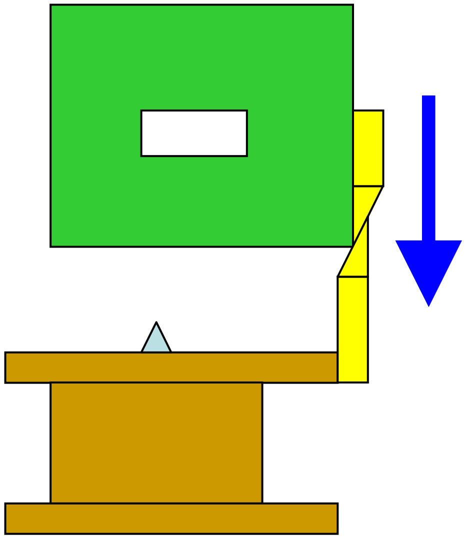


④

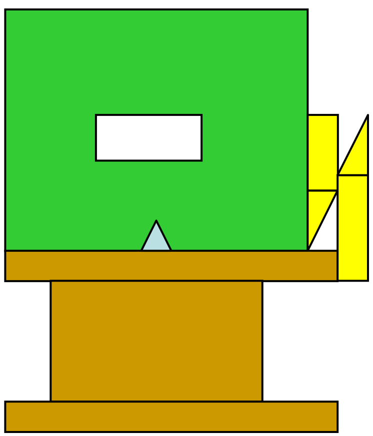




⑤

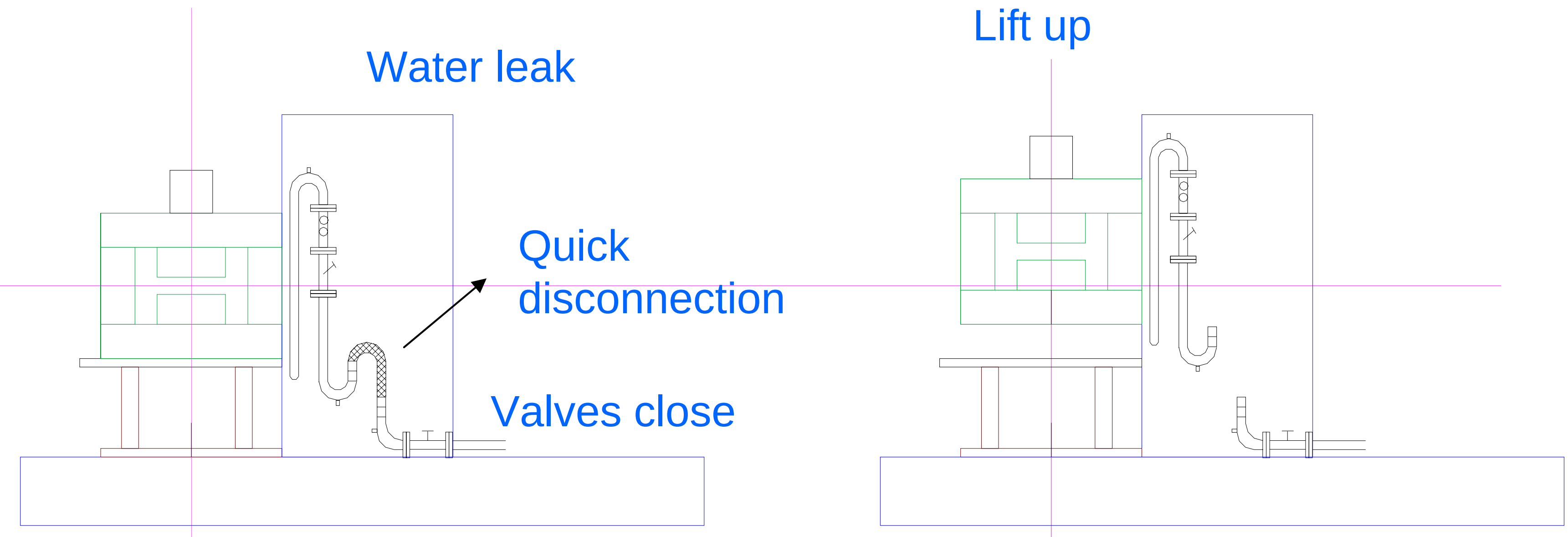


⑥



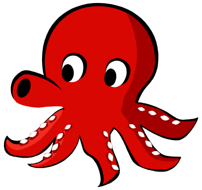
Connector of the cooling water

- Normal operation with 20 atm (2.0 MPa)
- Normal operation temperature : 15～80℃
- Pure water
- Two inch. Diameter
- Metal gasket
- The amount of leakage in case disconnection : 100ml/once
- The amount of time necessary for connection/disconnection by hand : 30sec/one circuit



Metal sealed lever coupler

- Using metal seal instead of rubber one
  - With 4 levers
  - Long lever
  - Fine tuning system for alignment



	H [mm]	T [mm]	material	Leakage test of Nitrogen with 3Mpa	Leakage test of Water with 3MPa
Metal hollow O-ring	2.4	0.25	SUS321 with silver coating	No leak	No leak
Metal C-ring	2.4		Inconel X75 with silver coating	Small leak	No leak
Metal E-ring	2.6		Inconel718 with silver coating	Small leak	No leak

“Drain trap” type

“Elephant nose” type

Mock up test will be done soon.

Water lock

Ball valves used for steam or viscous fluid piping on the market

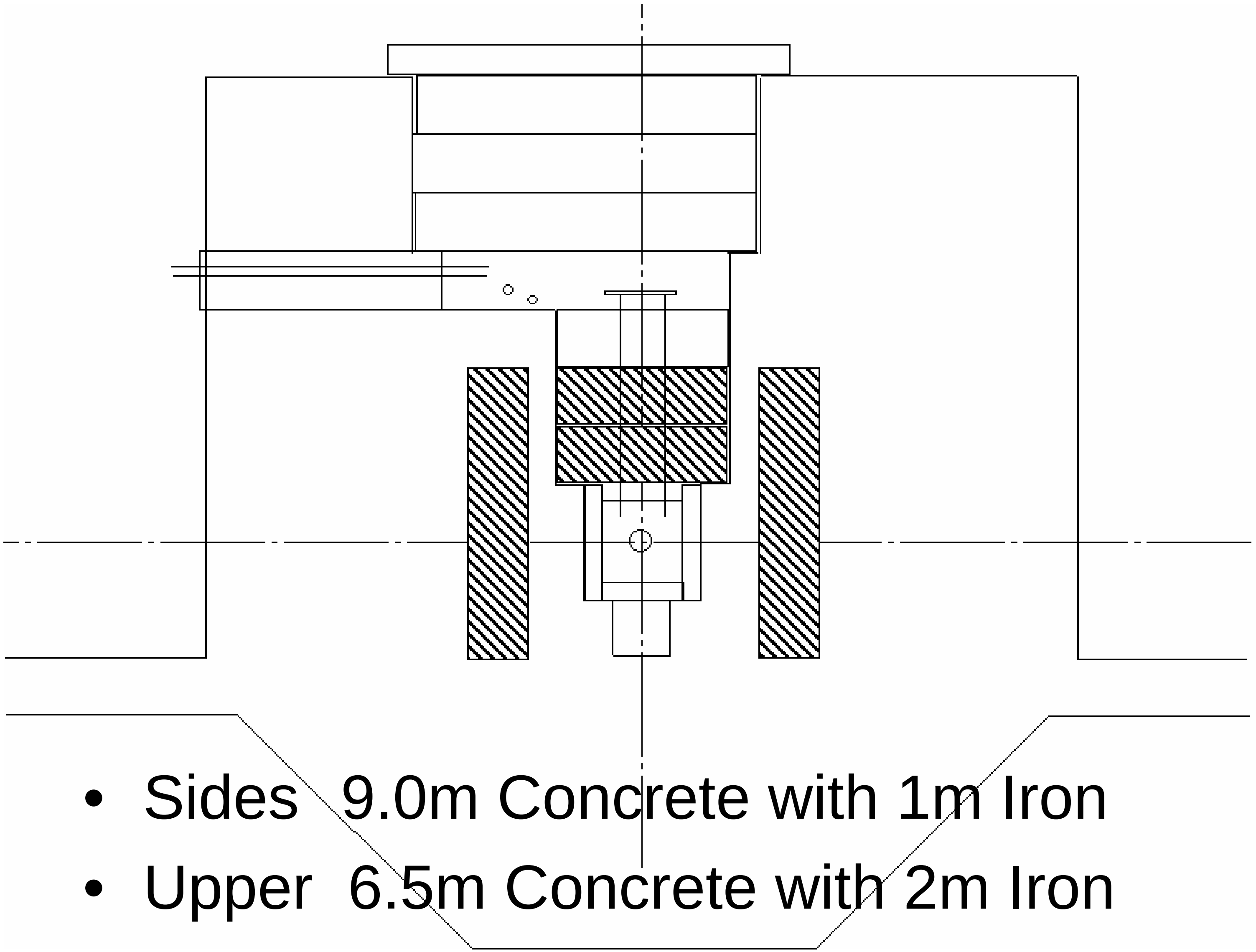
Gasket material : metal, graphite, asbestos

KITZ Ball valve

SY and ν line Summary

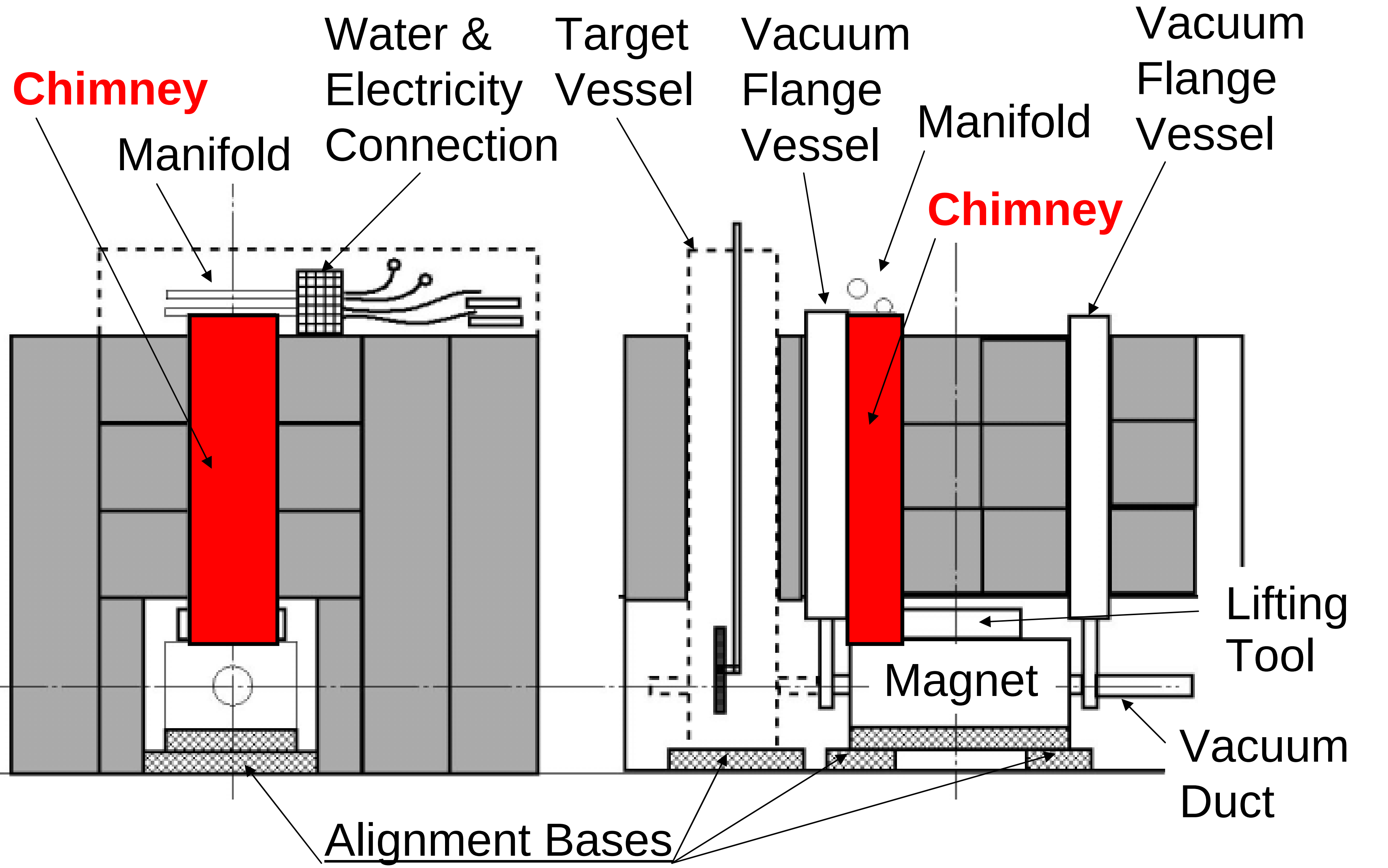
- The technology of radiation resistant magnets is established.
- Each tool for quick disconnection and quick installation will be establish soon.
- Total test will be performed at the mock up.

NP Facility: Cross-Section



- Sides 9.0m Concrete with 1m Iron
- Upper 6.5m Concrete with 2m Iron
- Lower 7.0m Concrete

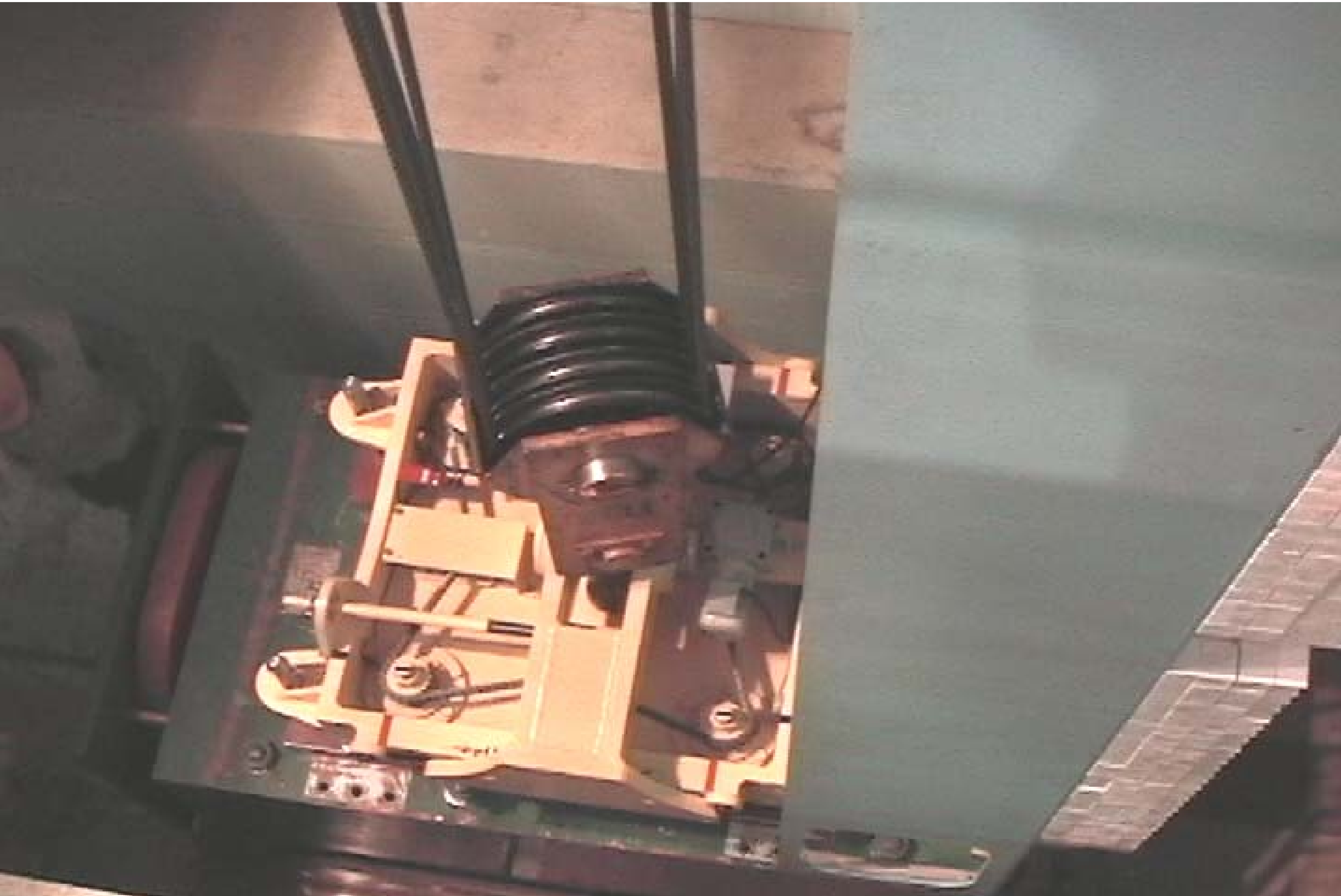
Chimney for NP-Hall Magnets



Chimney for NP-Hall Magnets

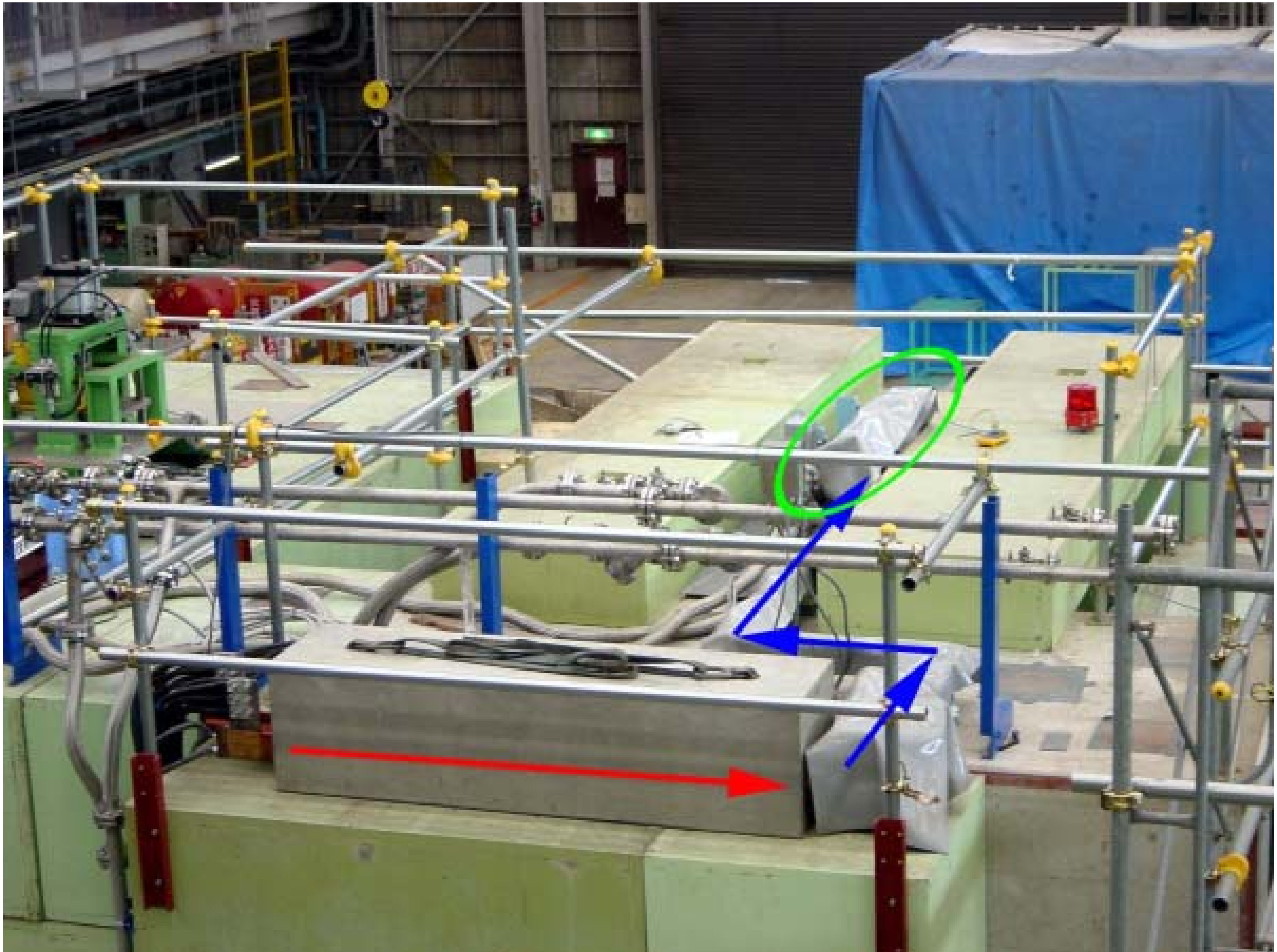
Magnet **Chimney** Prototype No. 0

Chimney for NP-Hall Magnets

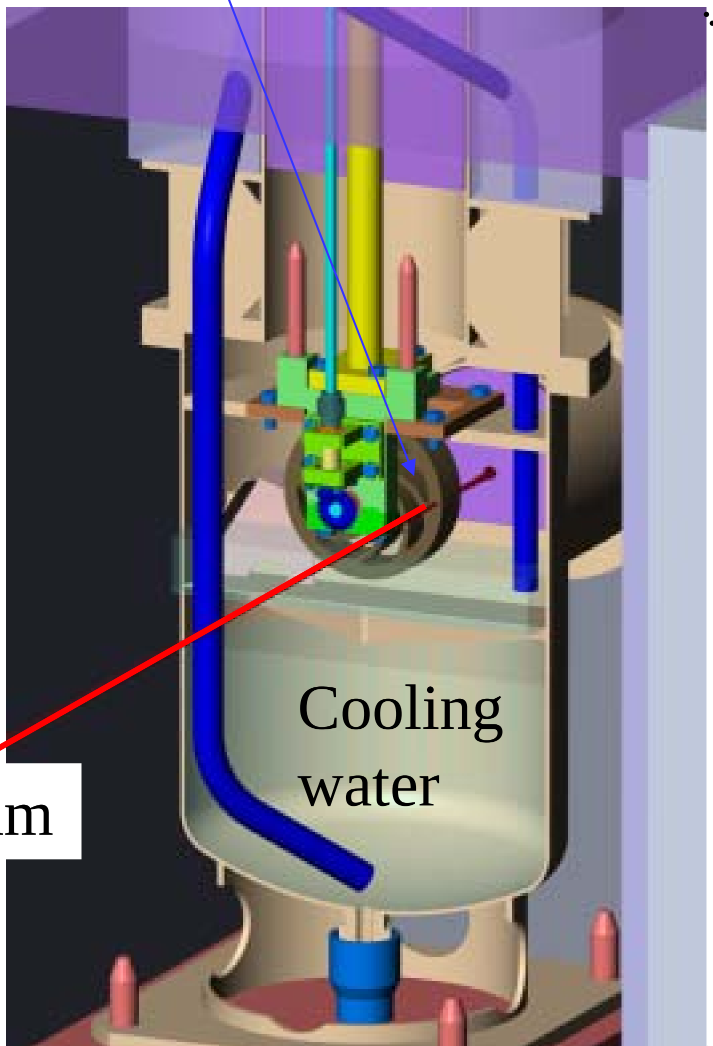


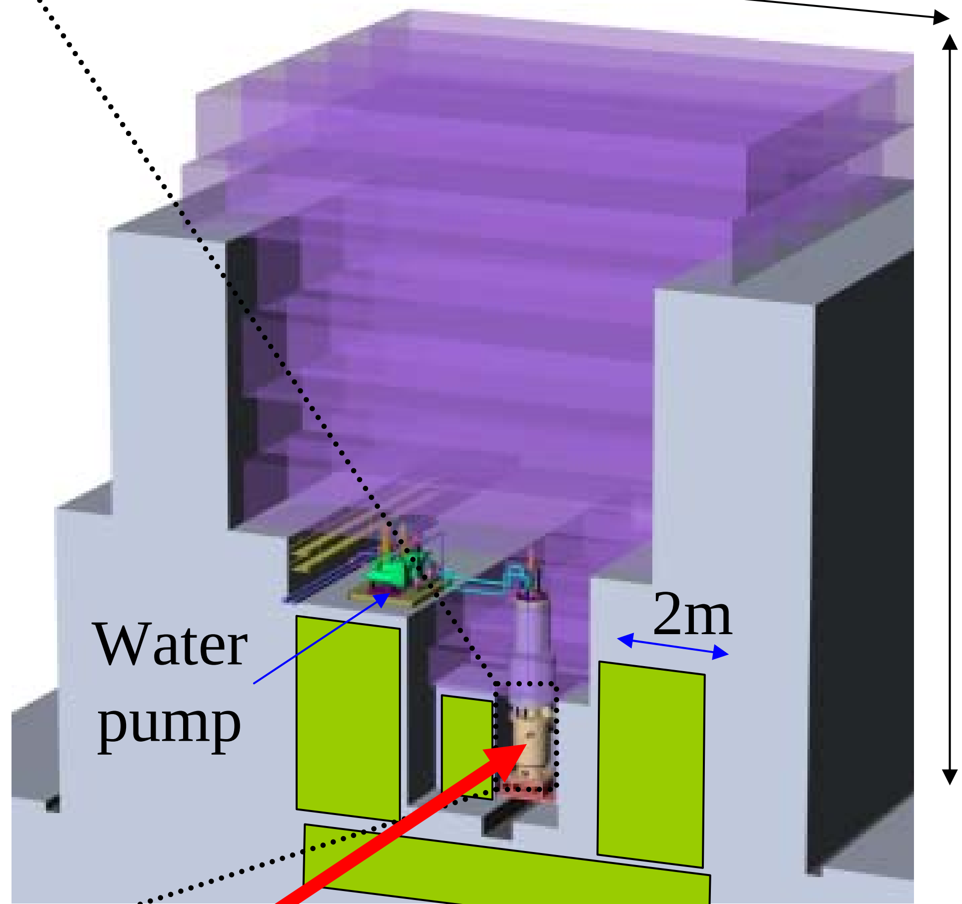
Water Cooled Penetrating Bus Duct + Bus Bar Cabling + Chimney

Total Operation Test at the Mock Up



T1 Target R&D I(by Yamanoi)

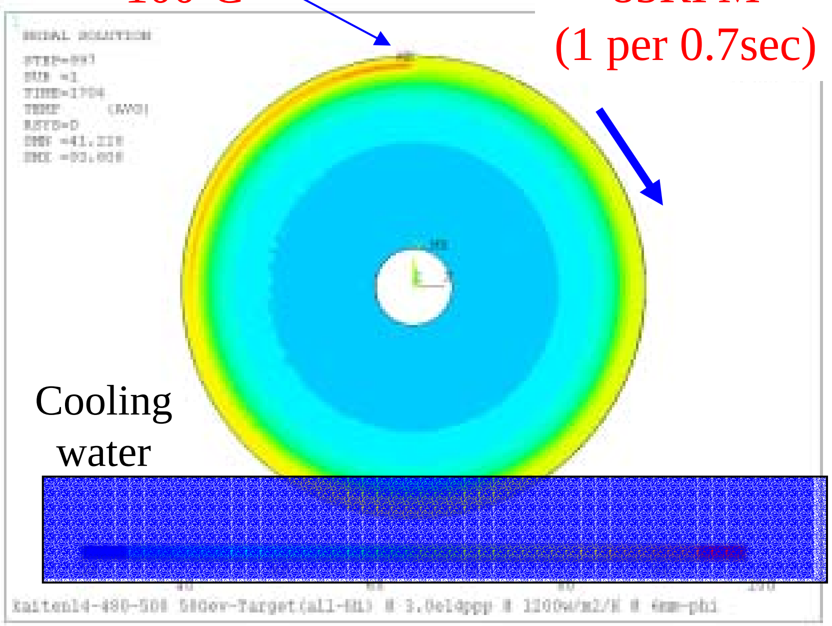




T1 Target R&D II

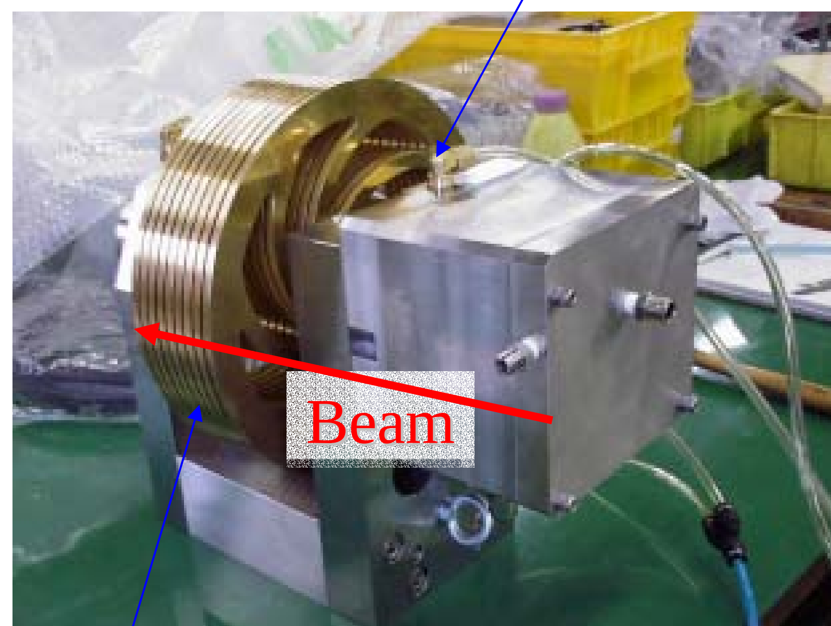
Rotating target and water cooling

Thermal evolution by ANSYS (M. Minakawa)



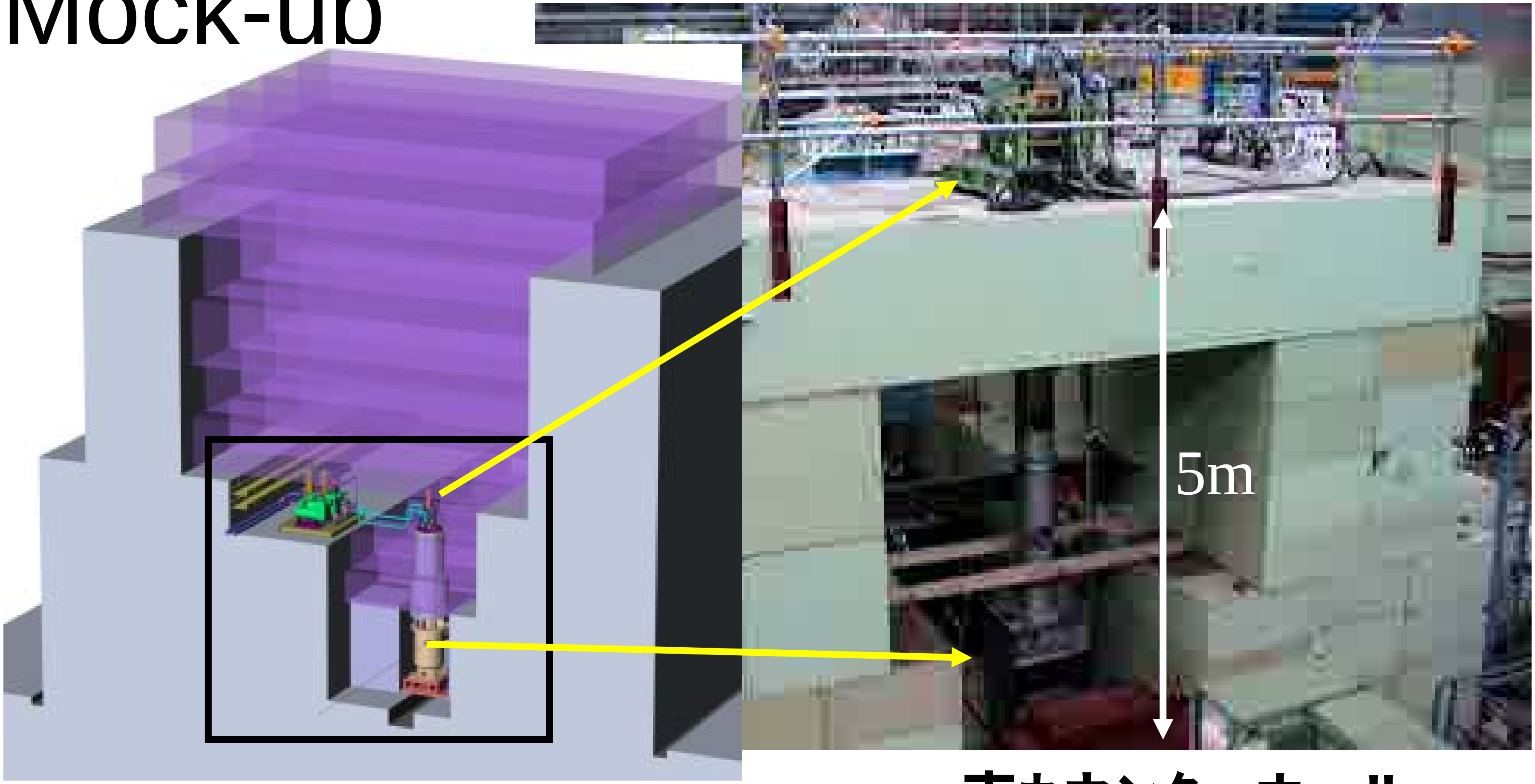
ϕ50cm x 6cm^t , Ni200

T1 prototype (Y. Yamanoi)



T1 Target Proto Type

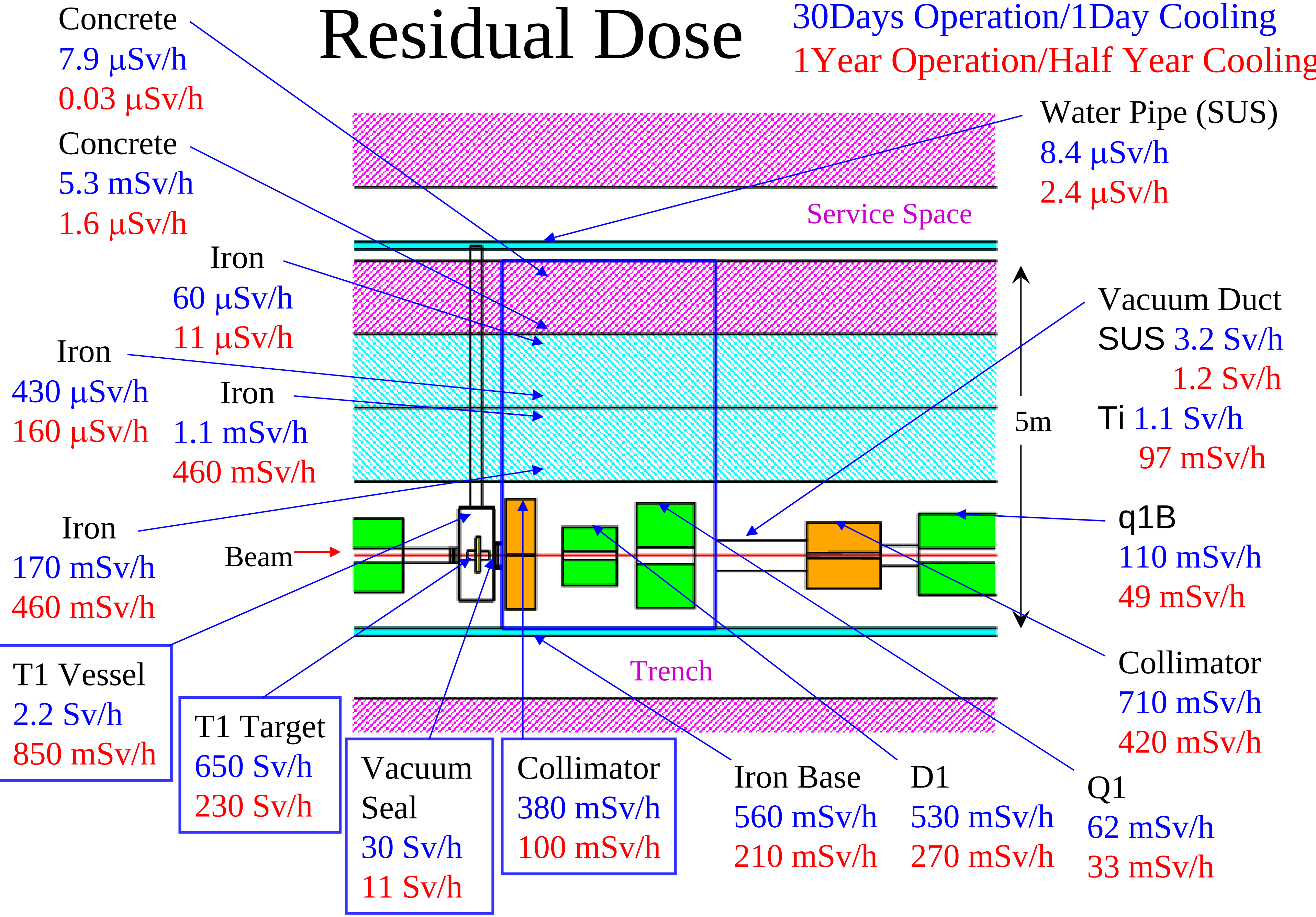
East Hall Mock-up



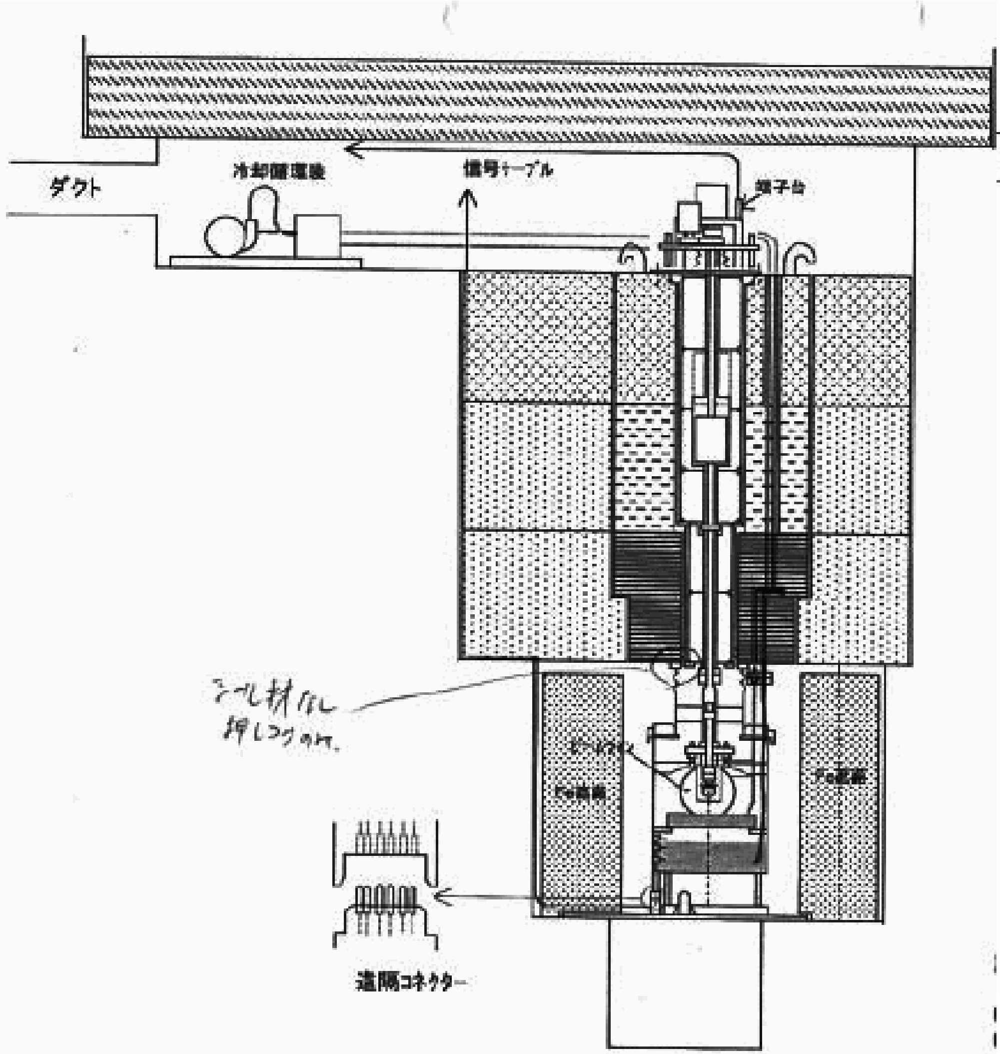
東カウンターホール

Residual Dose

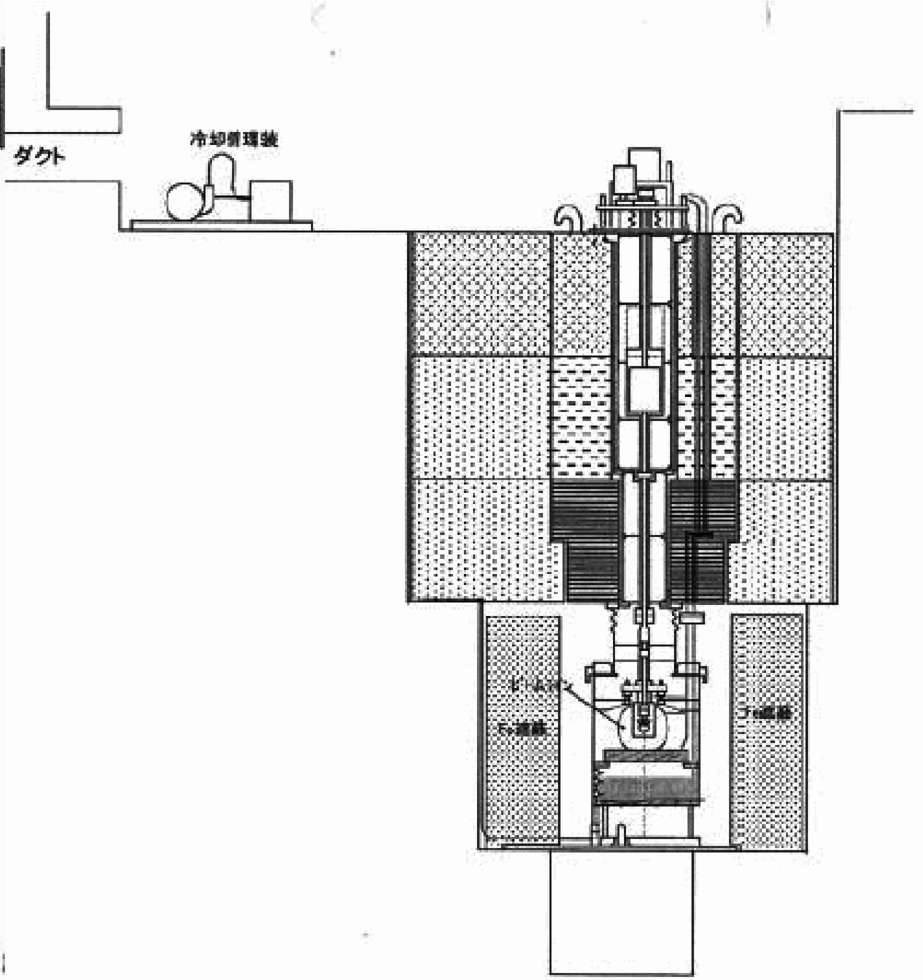
30Days Operation/1Day Cooling
1Year Operation/Half Year Cooling



T1 Maintenance Scenario(1)

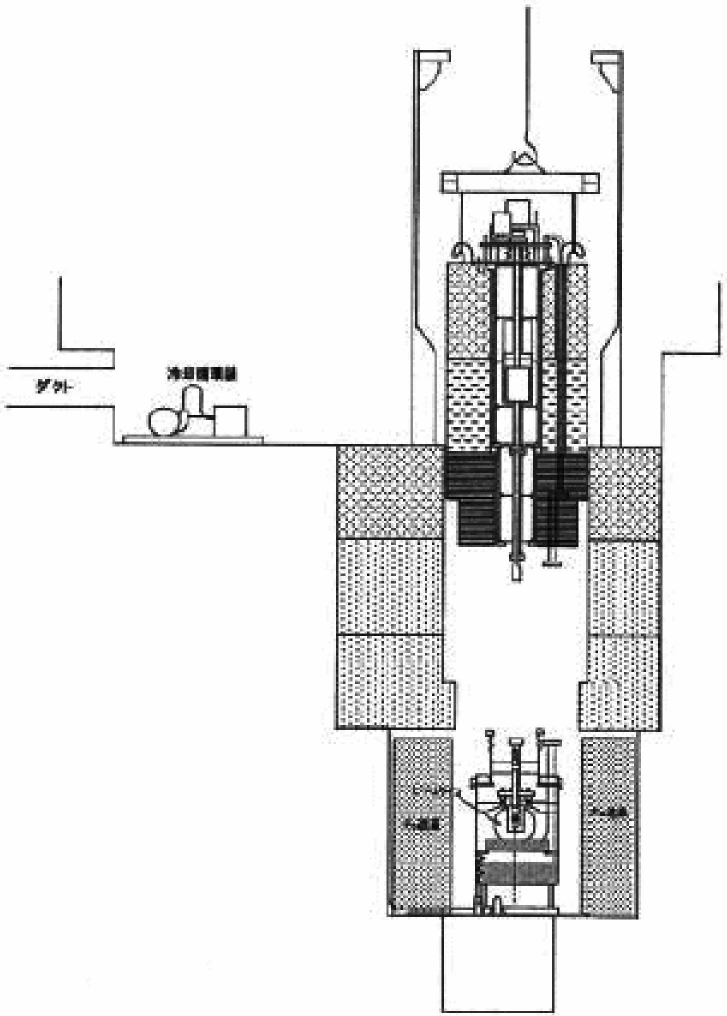


1,Initial Arrangements

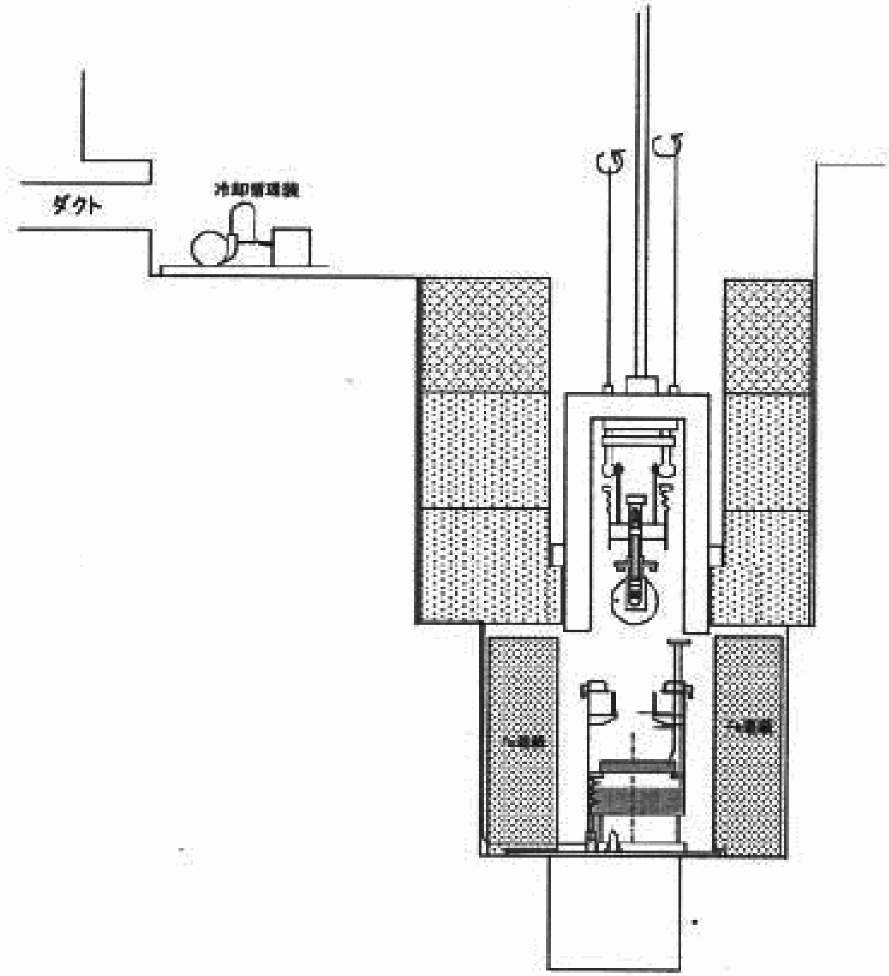


2, Open Service Space,
Remove Pipes etc.

T1 Maintenance Scenario(2)

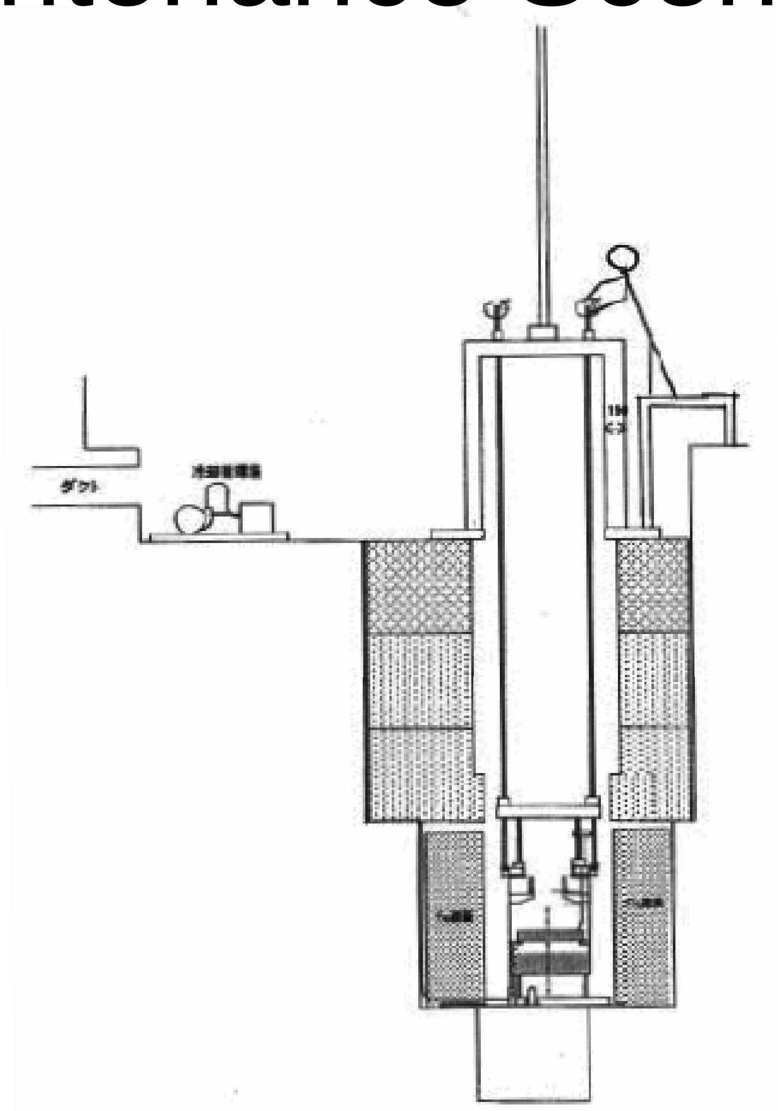


3, Remove Upper
Parts with Shields



4, Remove Target Disk

T1 Maintenance Scenario(3)



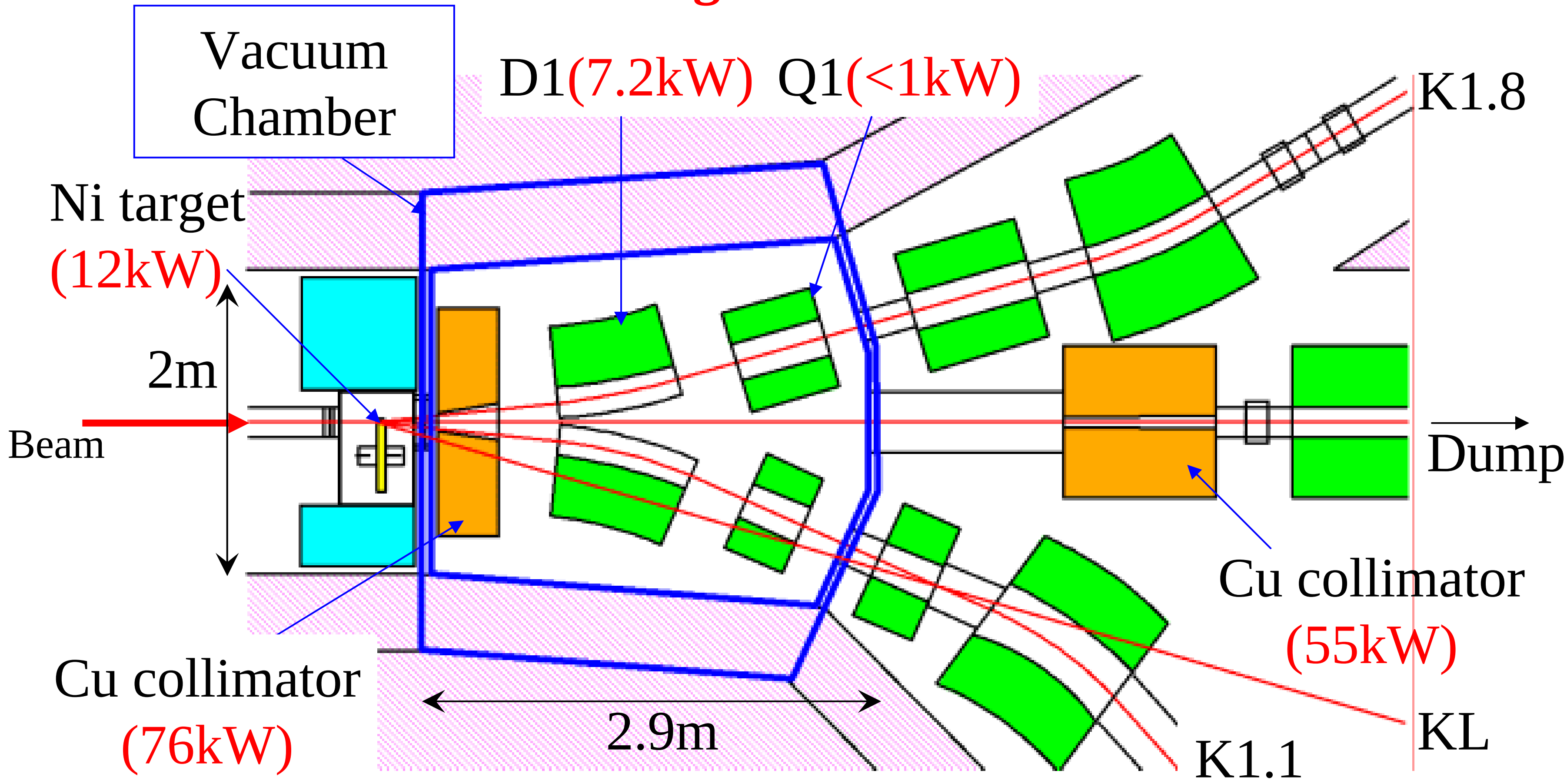
6, Remove Target Tank

Downstream of Target

How to solve 200kW Hear Problem?

Magnets→ Upstream Collimator

Beam Ducts → Big Vacuum Chamber instear of Ducts

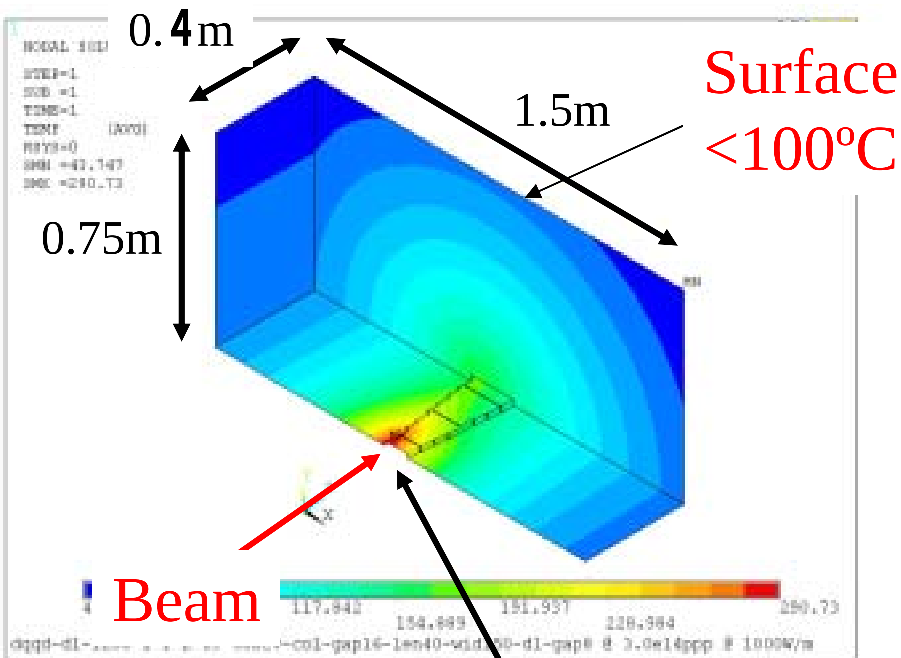


Collimator

Heat Calculation by MARS+ANSYS (Takahashi, Minakawa)

Calculation in Vacua

Cu collimator ($1.5m^H$ x $1.5m^W$ x $0.4m^T$)



- Aperture size
  - H=±60mm (120mm)
  - V=±16mm (22mm)
- Acceptance
  - x=±50mrad
  - y=±20mrad
- 50cm away from T1

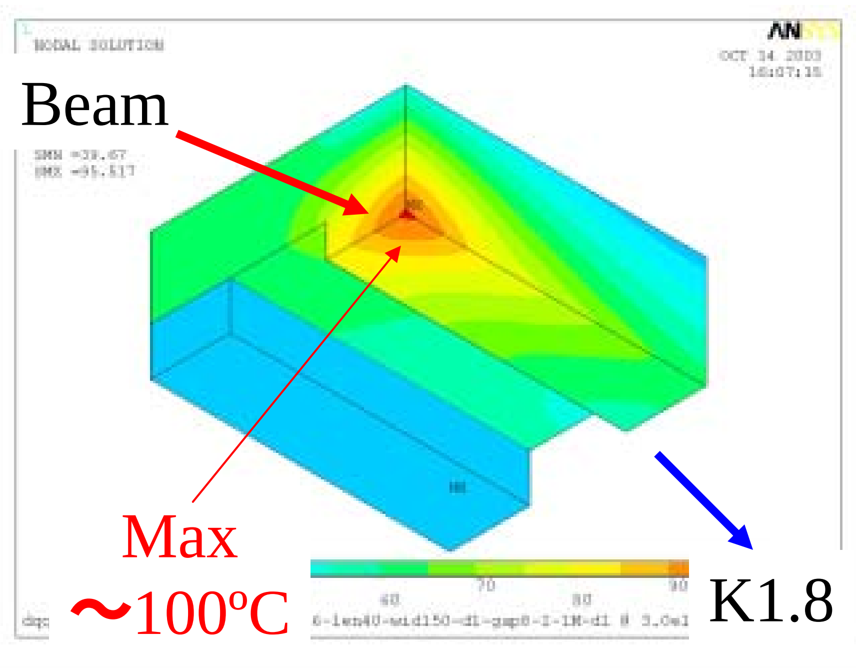
Radiation Rate = 0.85

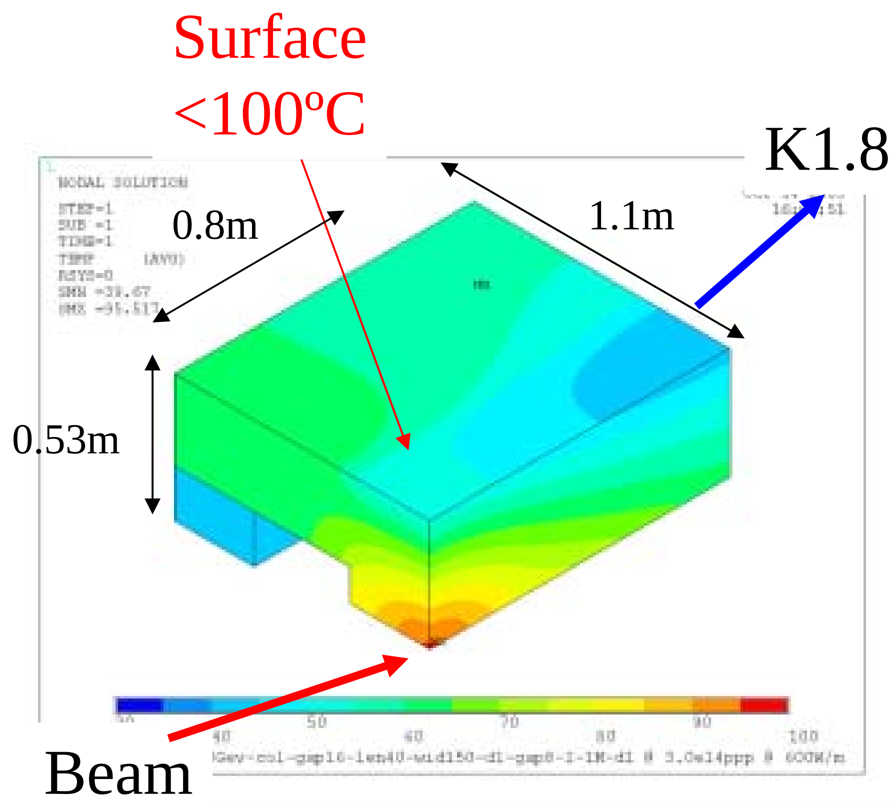
Water Cooling with 1000 $W/m^2/K$

K1.8 D1 Magnet

Heat Calculation by MARS+ANSYS **(Takahashi, Minakawa)**

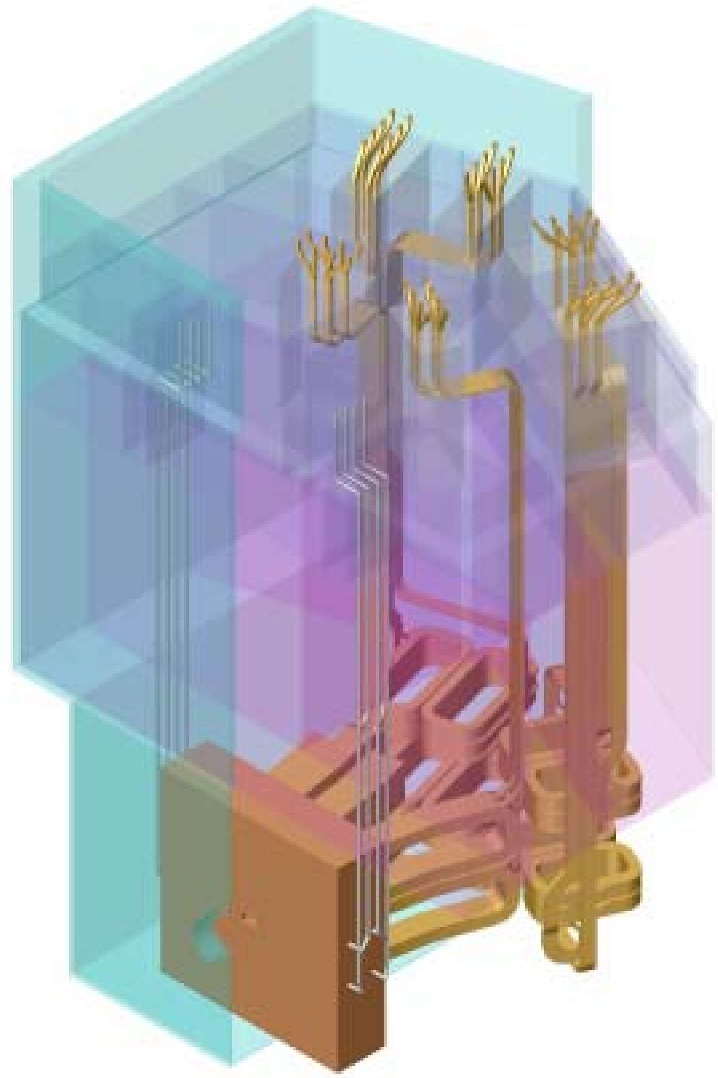
Calculation in Vacua

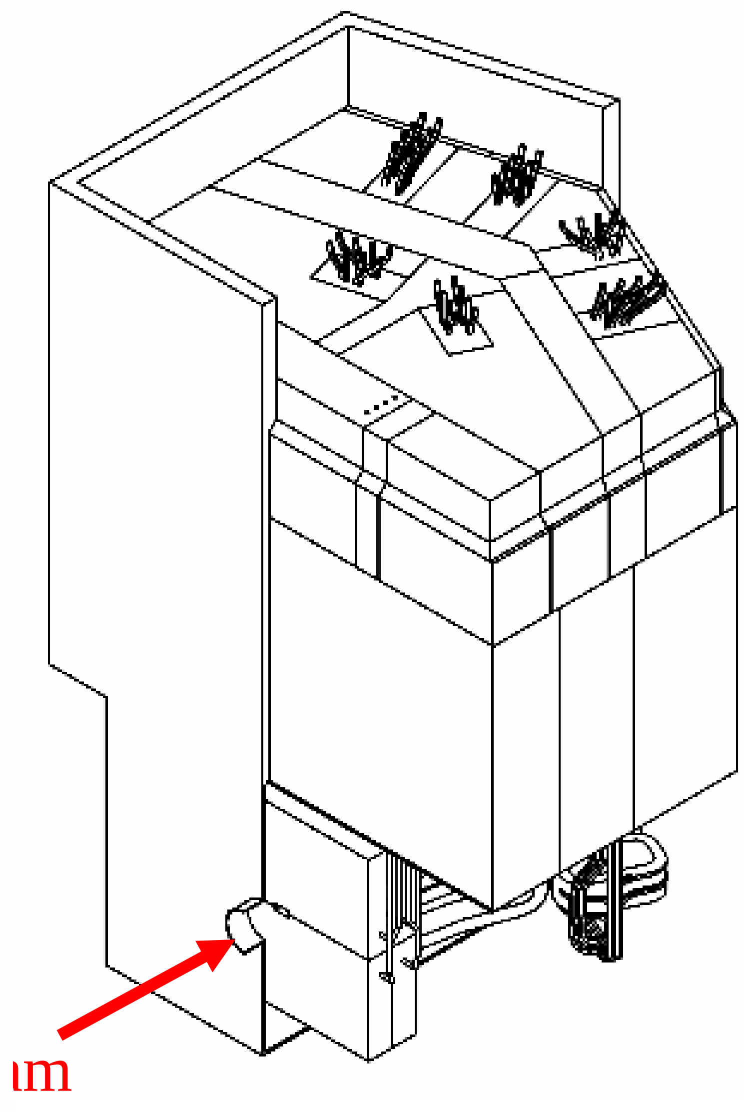




Water Cooling with 600 W/m^2/K at
Upper/Lower Surfaces and Side of Return Yoke only

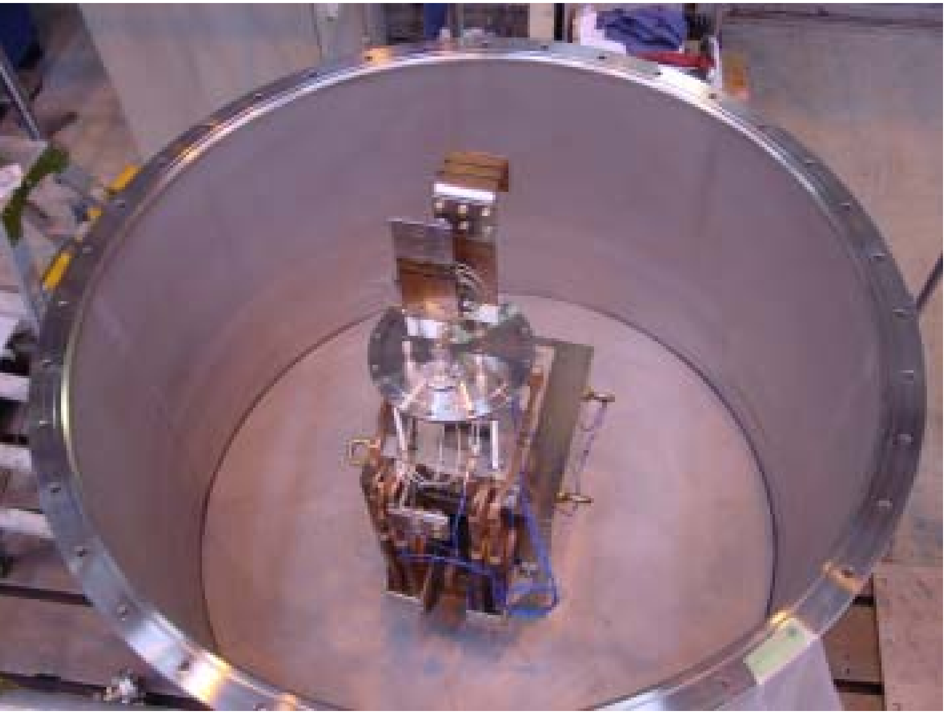
Vacuum Chamber





Magnet Operation in Vacuum

Dipole Magnet



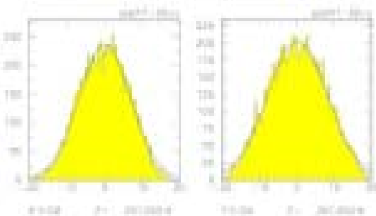
Vacuum Chamber

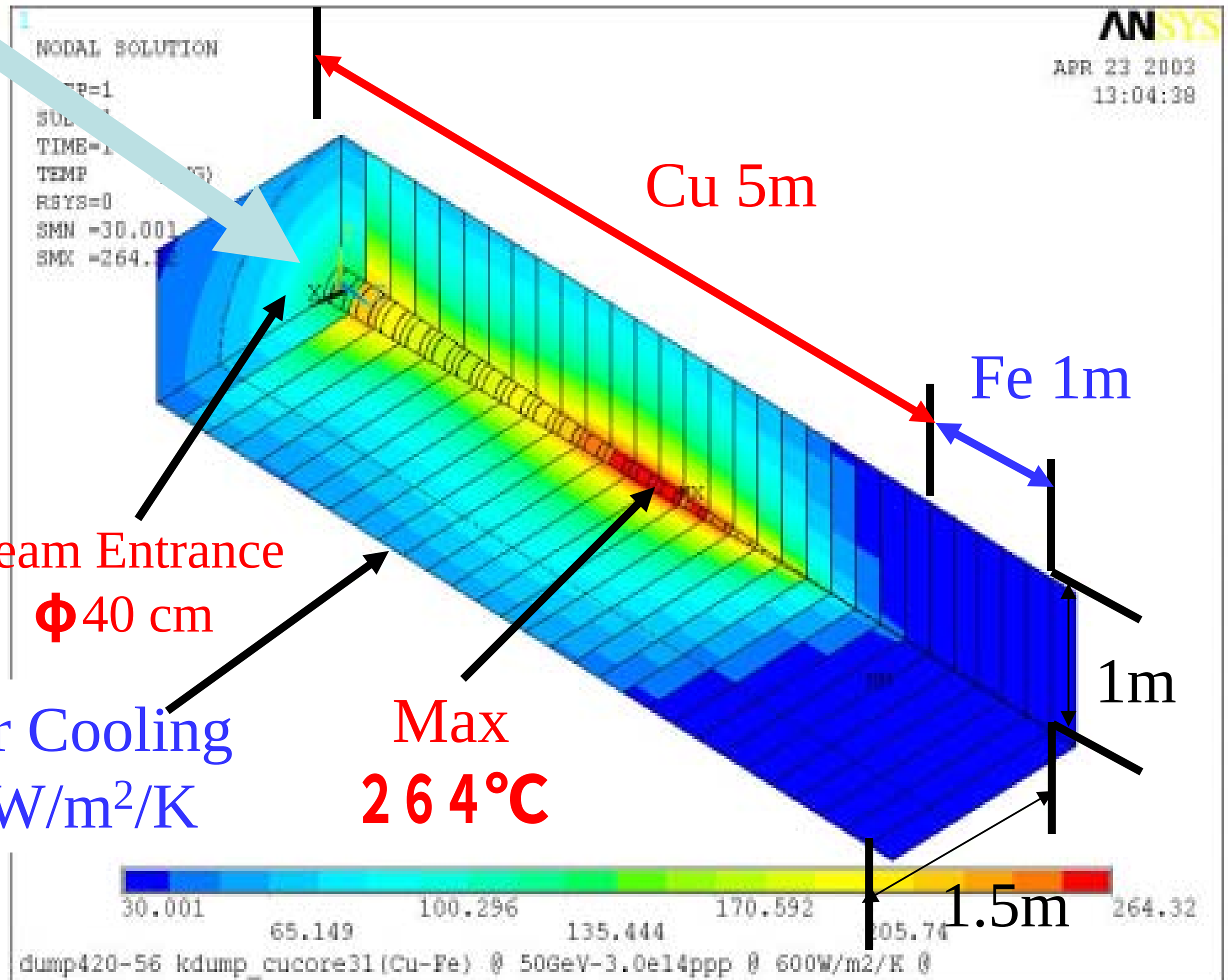
真空度：～3×10^{-3} Torr

Heat analysis by MARS & ANSYS
(calculated by Y. SATO & M. MINAKAWA)

An Example of the Dump Core ¼ Model Calculation

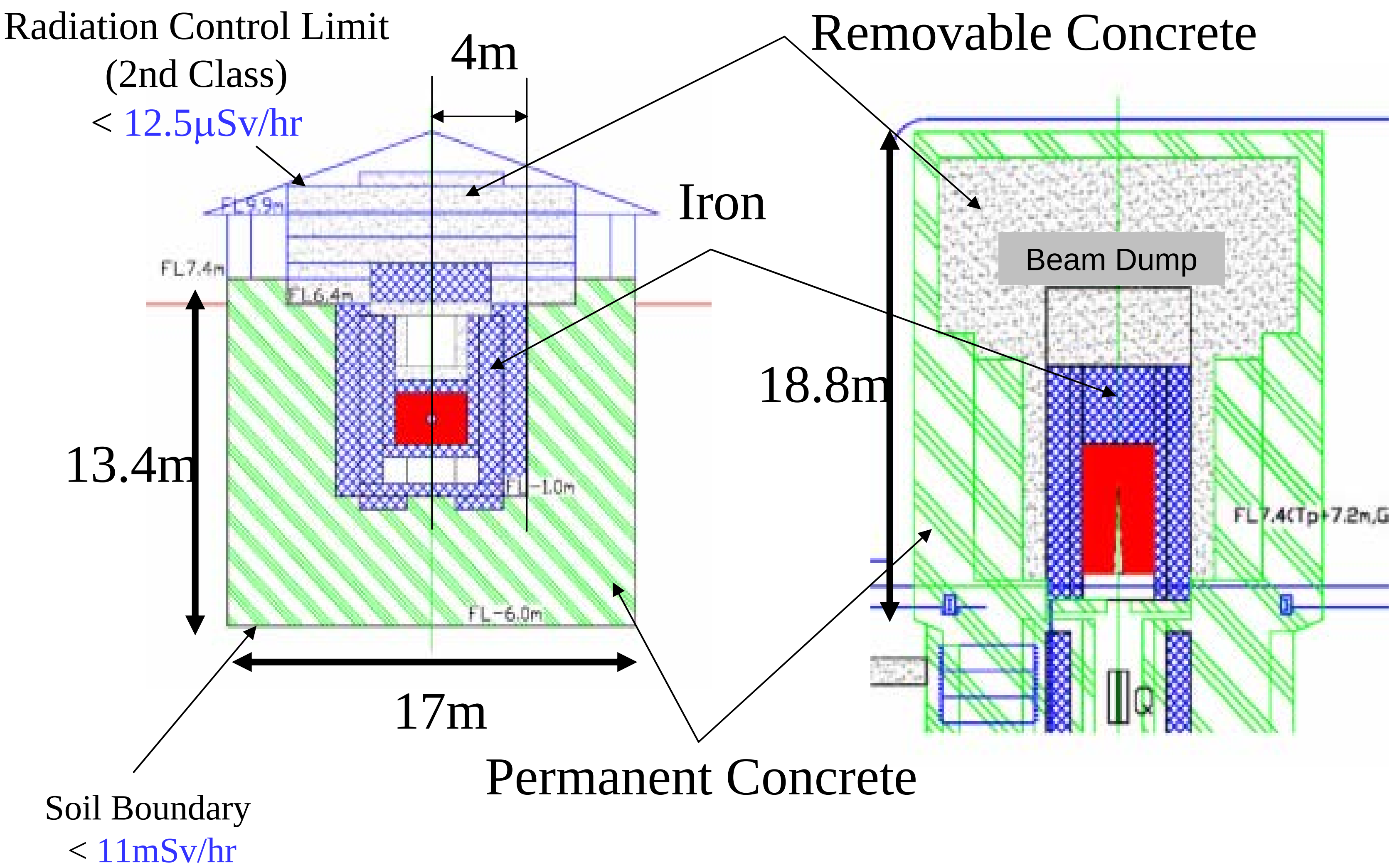
Proton beam
50GeV-15μA
(750kW)
ϕ40cm





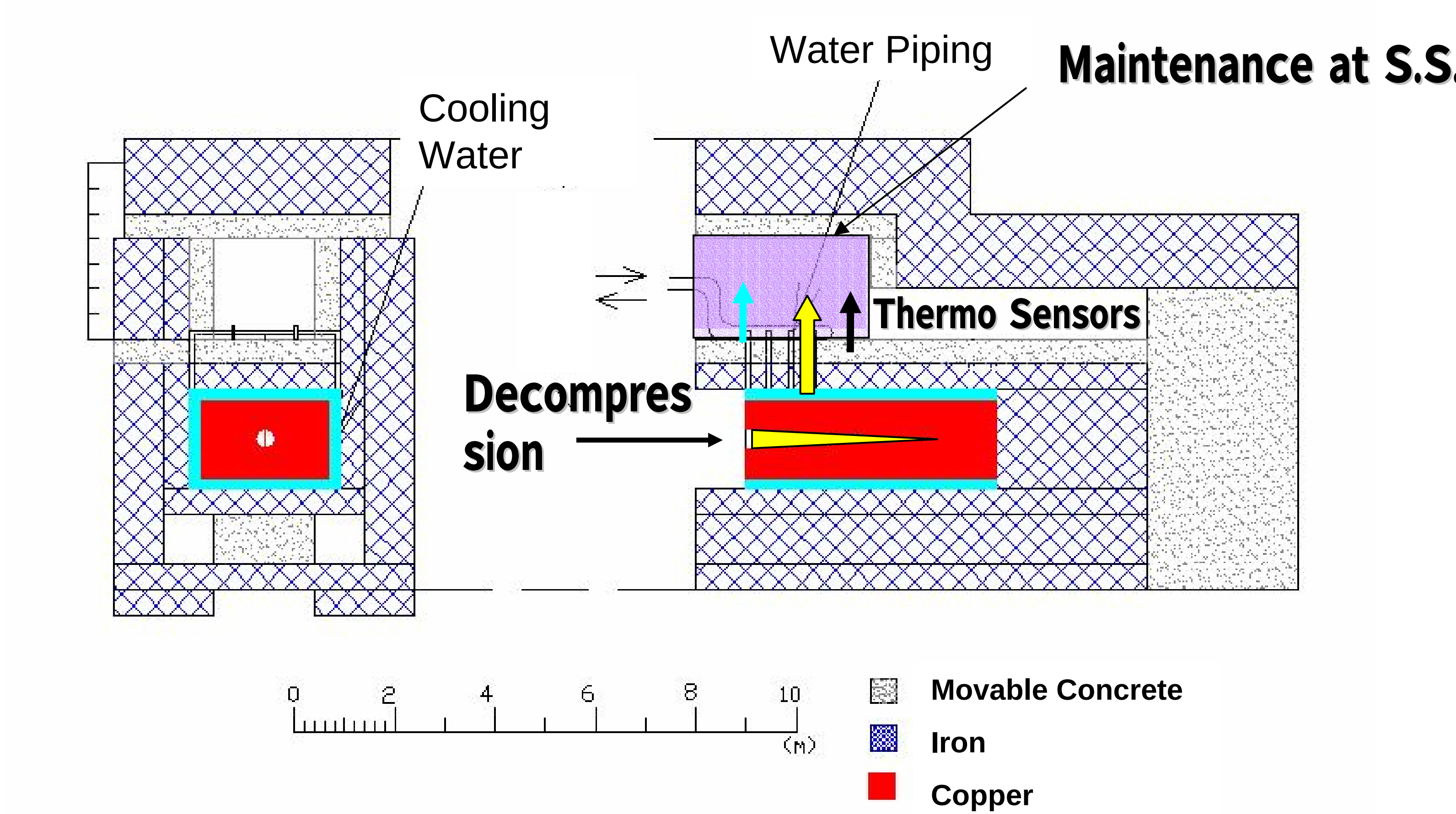
OFC
ρ =8.9[g/cm³]
Thermal
Conductivity
390 [W/m/K]

Structure

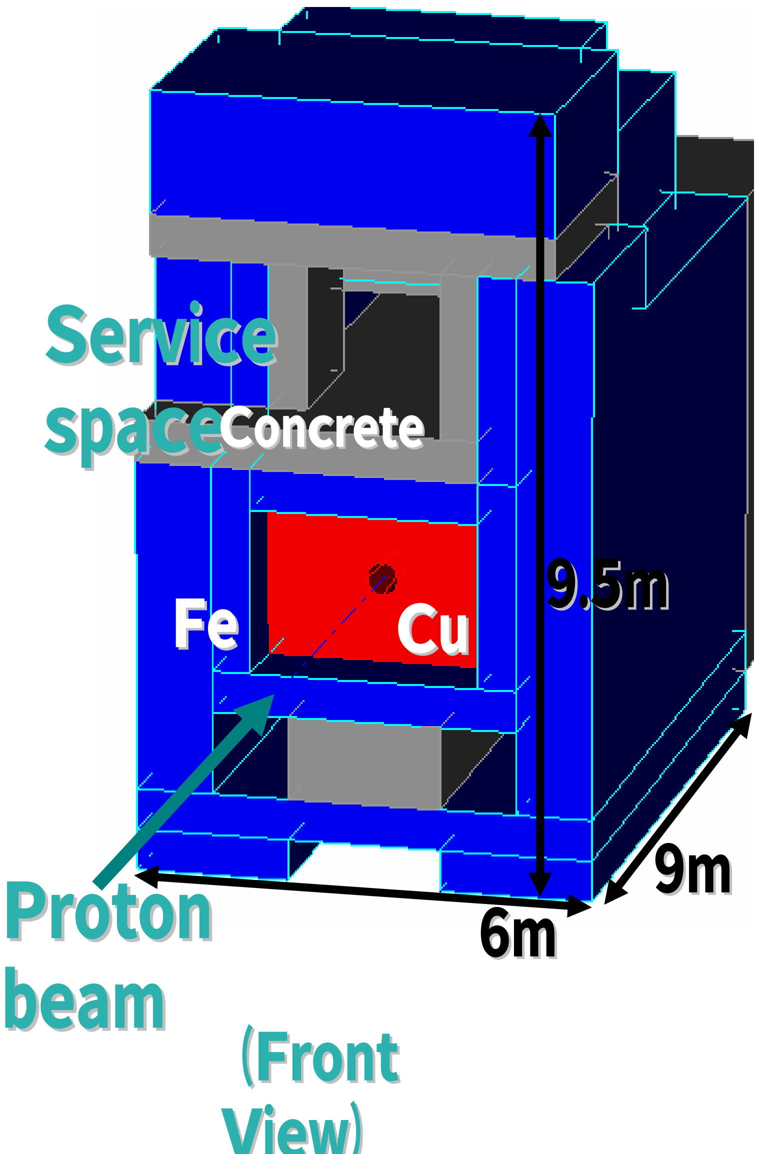

Radiation Control Limit
(2nd Class)
< 12.5μSv/hr
4m
Removable Concrete
Iron
Beam Dump
FL9.9m
FL7.4m
FL6.4m
FL-1.0m
FL-6.0m
13.4m
18.8m
17m
Permanent Concrete
Soil Boundary
< 11mSv/hr

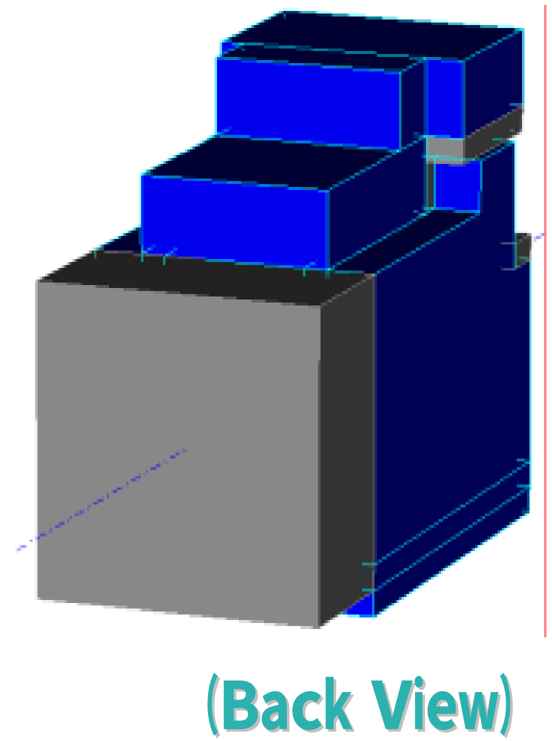
Maintenance/Operation Scenario

- Core Part should be Maintenance Free
- Cooling Water from Service Space(S.S.).
- Reduce the air Pressure in the Taper.
- Beam Stop at High Temp and/or Imbalance Temp. Distribution.



How to build





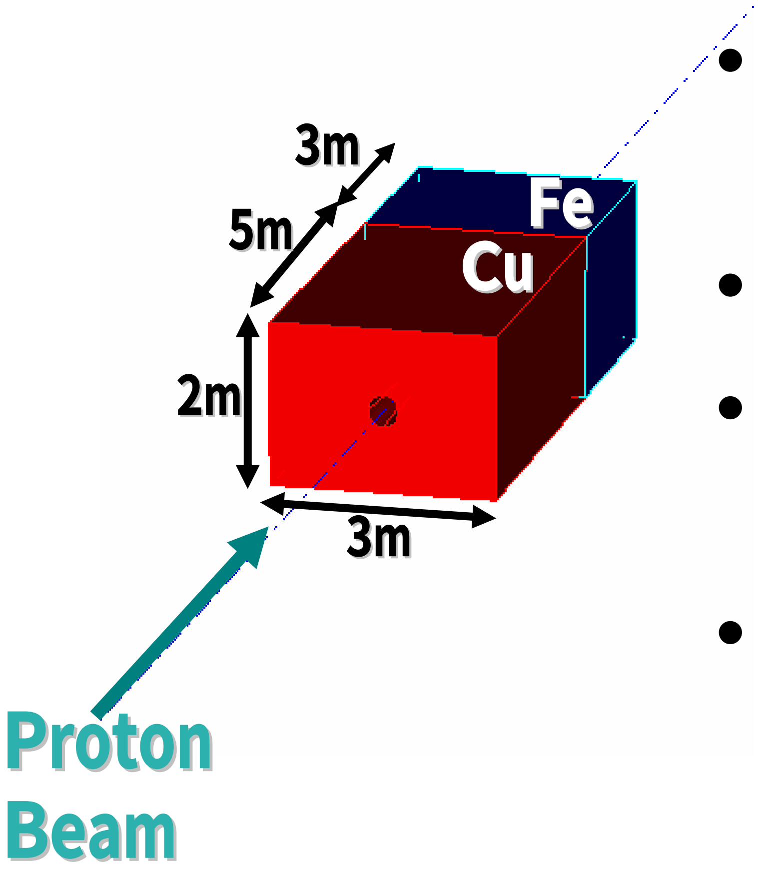
Core: Copper

High Thermal Conductivity.

Maintenance

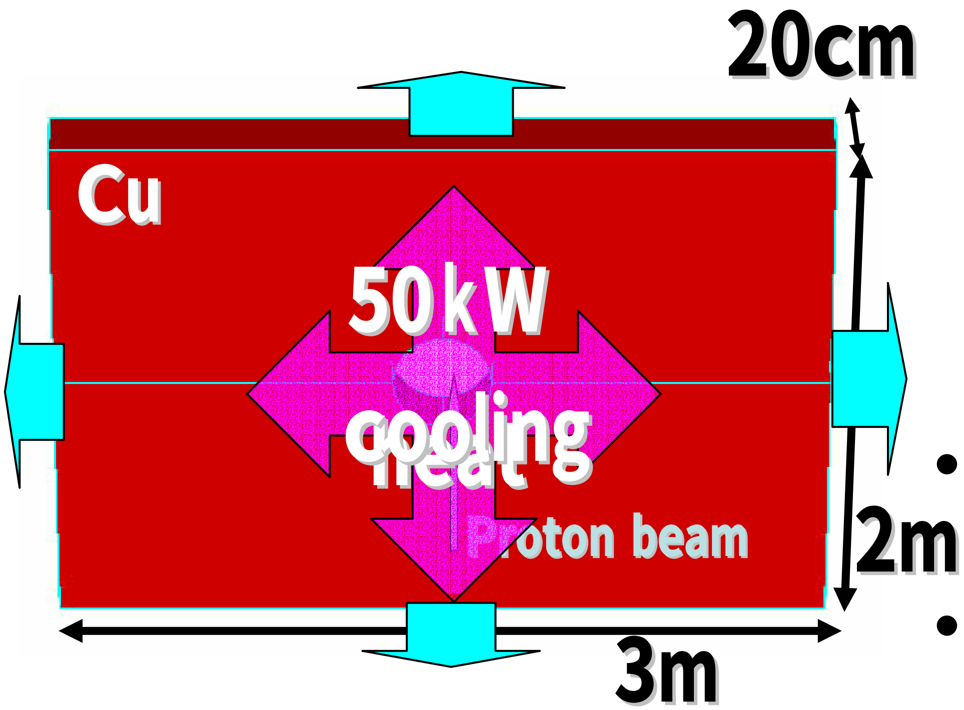
Service Space Structure.

Core Part of Beam Dump (1)



- Copper：2x3x5m (~270ton)
- Iron：2x3x3m^3 (~140ton)
- Tapered Hole at the Center
- Decompression of Air in the Tapered Hole.

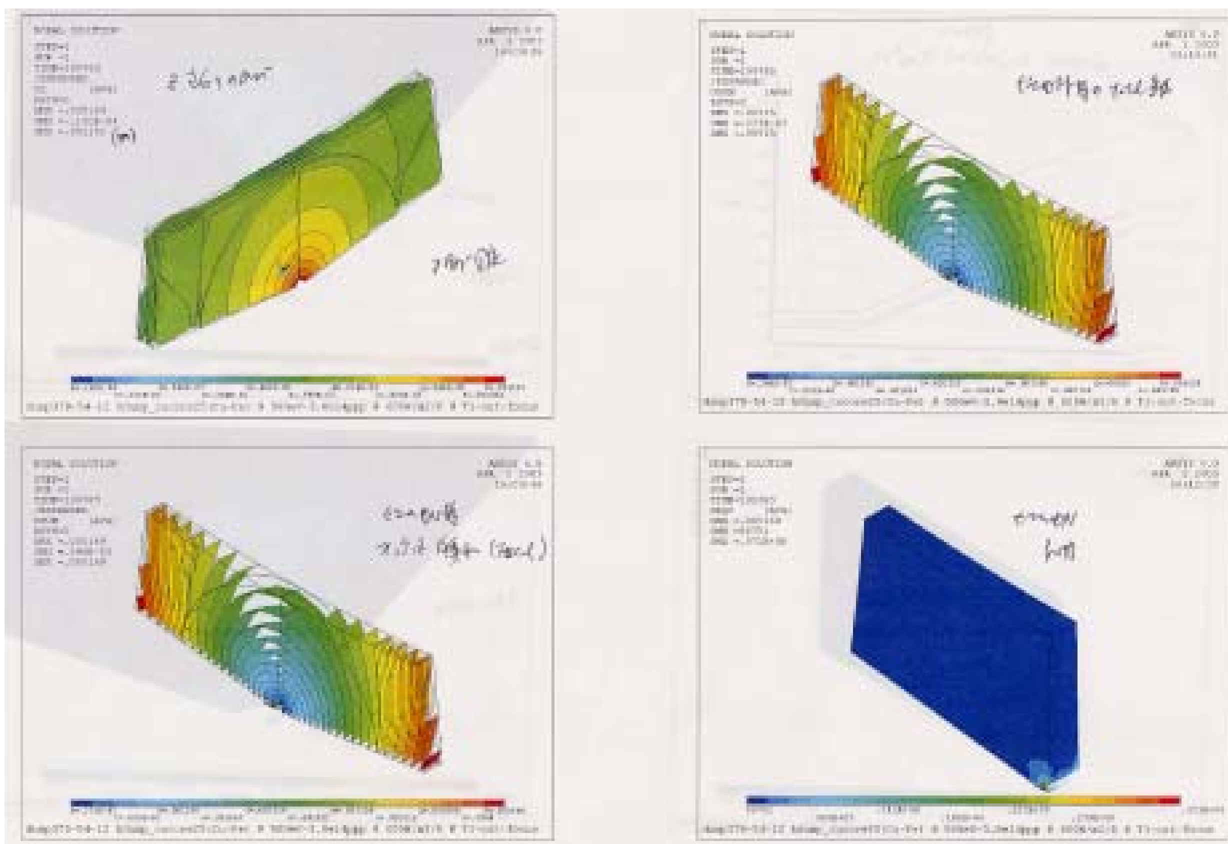
Core Part of Beam Dump (2)



- Max. Copper Cake Size available in Japan
  - 0.62m^{W} x 0.23m^{T} x 6.0m^{L} 8t Hitach
  - 1.07m^{W} x 0.18m^{T} x 6.4m^{L} 11t Furukawa
  - 1.05m^{W} x 0.26m^{T} x 4.0m^{L} 9t Mitsubishi
- Heat Dissipation to the Radial Direction.
- Low Residual Radiation at the Surface.
- Low H_3 Production in the Cooling Water.

Heat Stress Analysis (preliminary)

- Max. Stress should be less than 50MPa (Copper’s max Stress).
- Accumulated Stress by Machine Trouble is under study.



ANSYS
by M. Minakawa

Cooling test

- 3 Cooling Methods
  - Al Spraying
    - SUS Tube, No Water Leak
    - Indirect Cooling,
  - BTA(Gun Drilling)
    - Direct Cooling, Good Heat Removal,
    - Straight Line, Water Connection (Leak?)
  - FSW(Friction Stir Welding)
  - EBW(Electron Beam Welding)
    - Direct Cooling, Good Heat Removal, Curved Line,
    - Water Connection (Leak?)

Aluminum Spraying Test

- Al Spraying Models

✧No Trench

✧With Brazing

✧Half Triangle

✧With Brazing

✧Half U

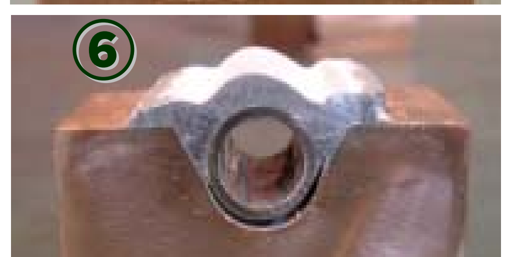
✧With Brazing

✧Full U

✧With Brazing

✧Full U

✧No Brazing

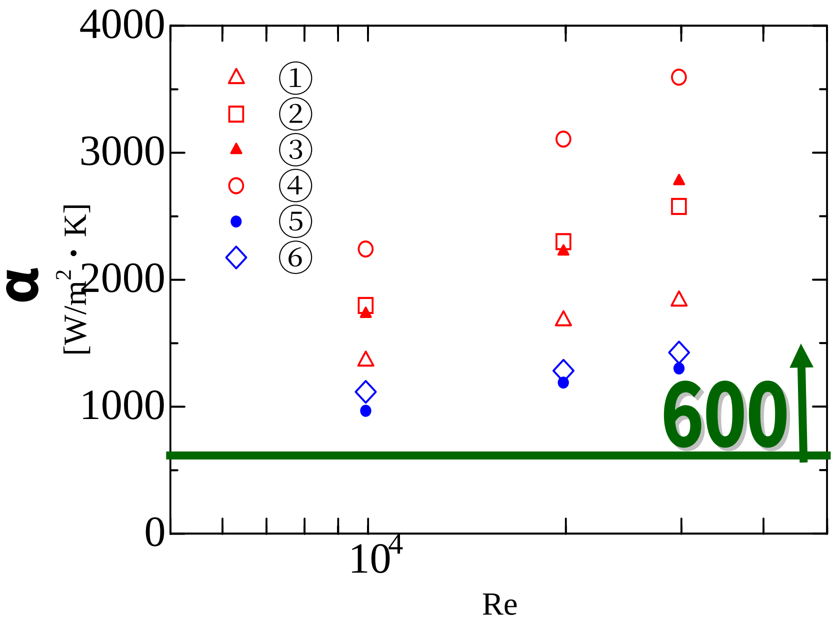


✧V (+ U)

✧No Brazing

Test results

- All the conditions tested achieved the 600[W/m^2•K].
- With Brazing: Much Better Thermal Conductivity
- No Brazing: Acceptable. But Perfect Spraying between Tube_&_Copper will give us Much Better Results!!



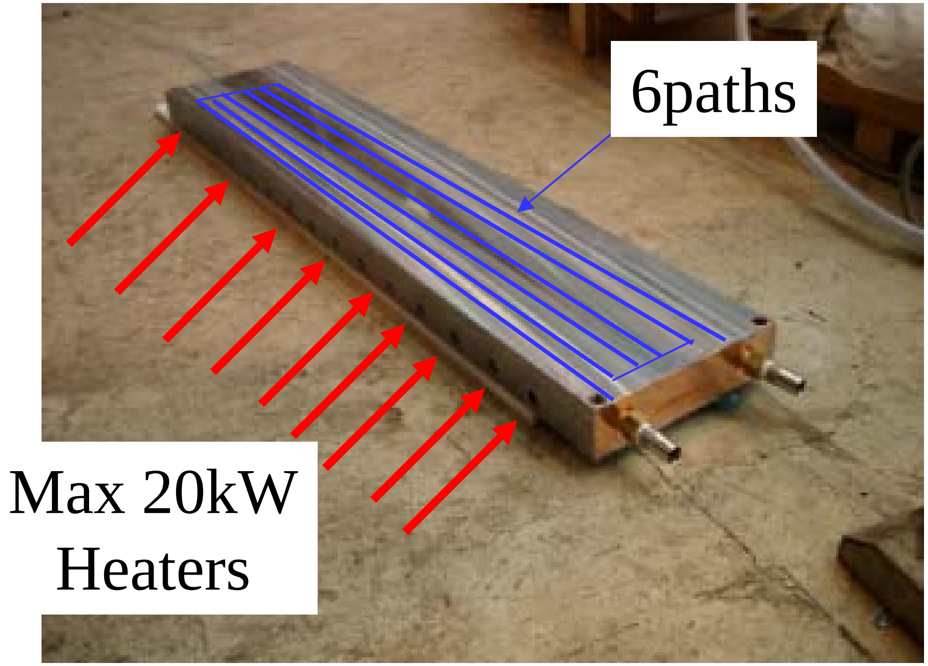
Flow Rate [l/min]	Velocity [m/s]	Re
5	0.93	9920
10	1.85	19842
15	2.75	29762

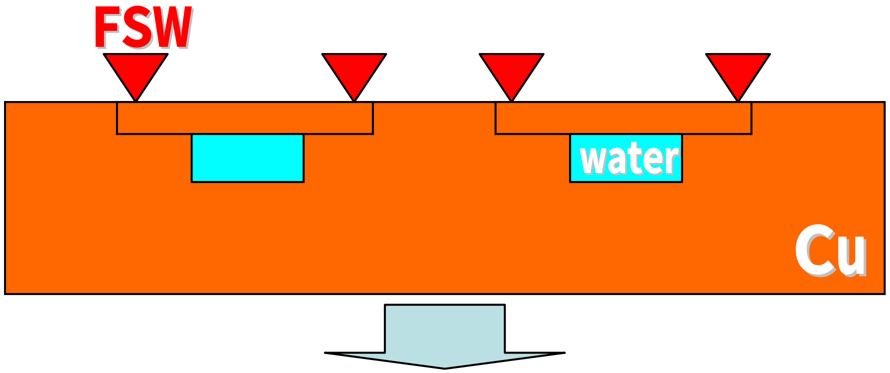
Direct Cooling Methods & Their Tests

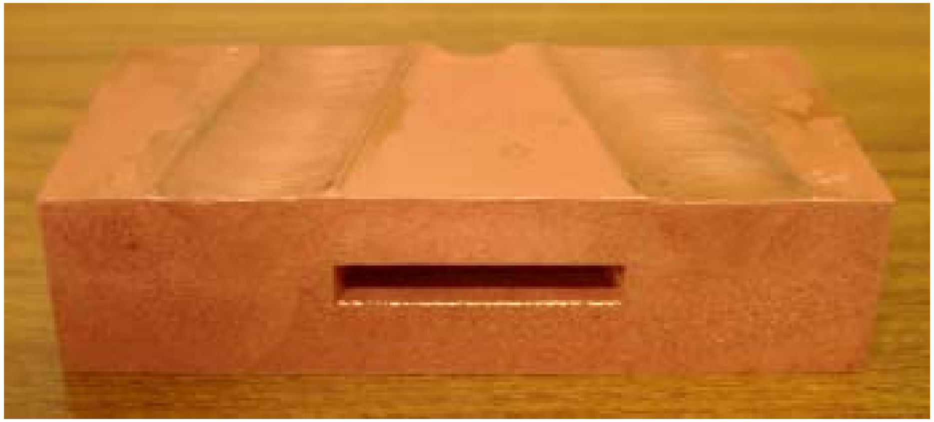
No Tube Water Cooling
At the copper Surface.

- FSW
- EBW
- BTA(Gun Drilling)

FSW Test Module



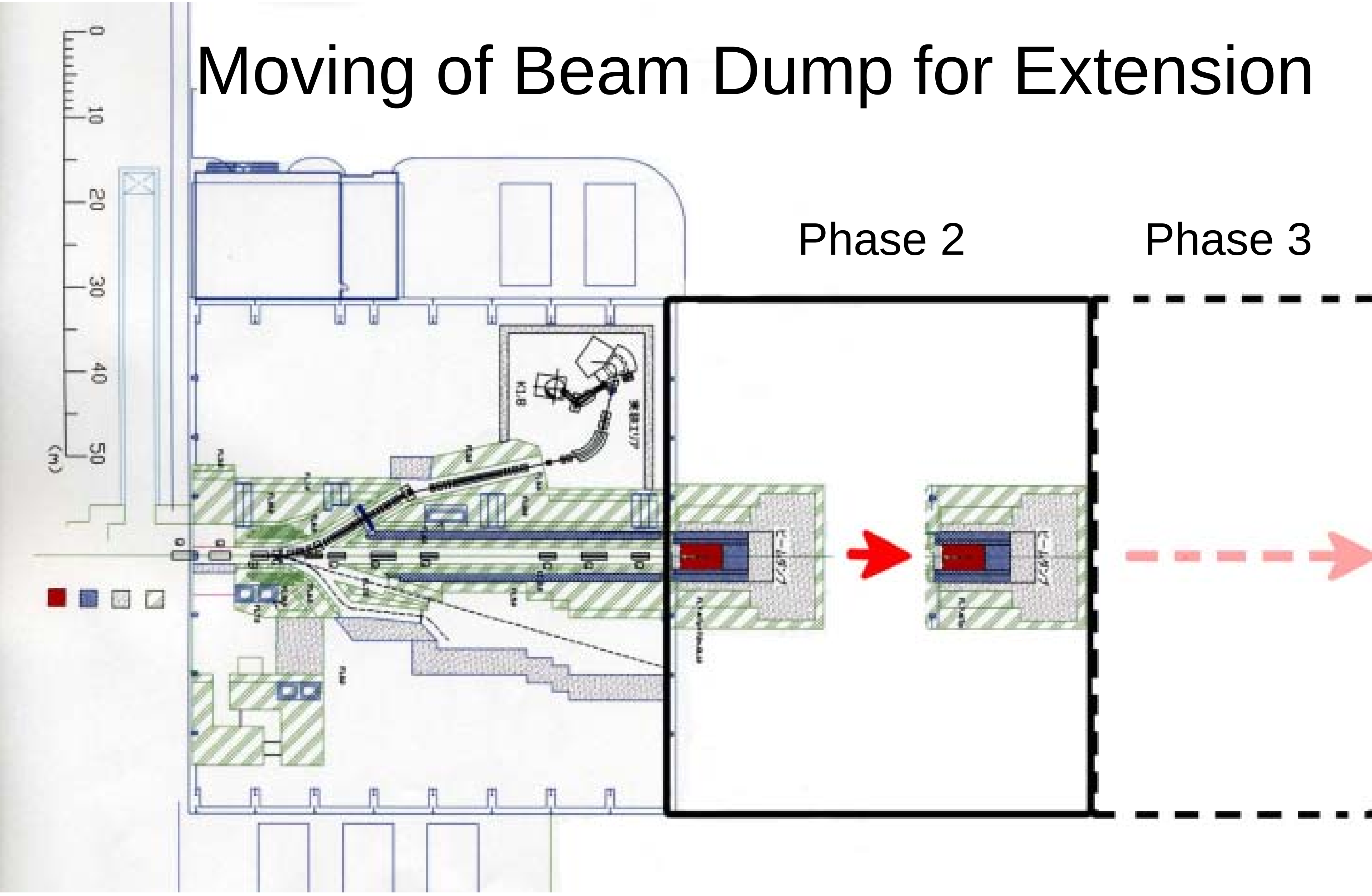




BTA
(Gun Drilling)
Sample

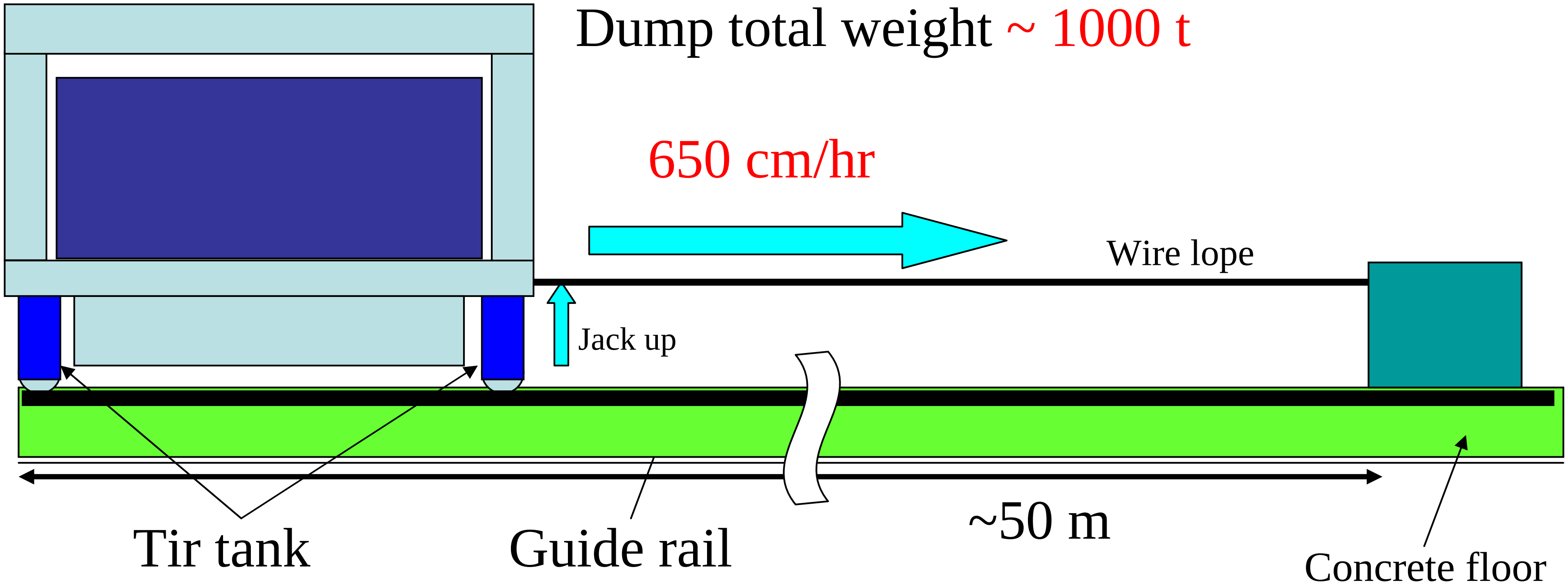
Heat
Removal
Test

Moving of Beam Dump for Extension



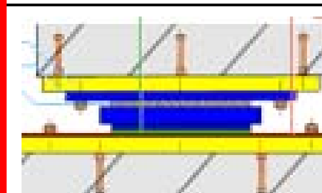
Beam dump must be moved for the future extension!

How to move it safely?



- Need to be balanced carefully
- Guarantee flatness of the floor

How to move

Methods	Advantage	Disadvantage	
Roller	◆Easy ◆Cheap	◆Manpower & Time ◆Unstable	
Linear Guide	◆Stable	◆Expensive	
Air Bearing	◆Low Friction	◆Motion Guide ◆Braking ◆Clean Floor	
Till Tank	◆Space Saving ◆Cheap?	◆Some Guide for Linear Motion	
Sliding Shoe	◆Manpower Saving ◆Easy Installation	◆Organic Material for Shoe	

Moving scheme and Radiation

End of Phase 1 Experiments

Beam Stop

↓

One or Half Year Cooling

↓

New Expanded Building
Removal of Radiation Shields
Water Pipe etc. Removal

↓

MOVING!

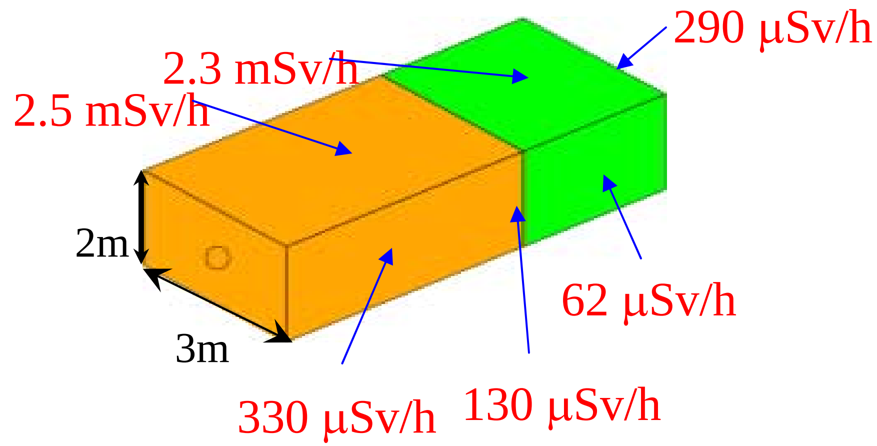
↓

Dump Reconstruction

↓

Experiments Re-Start

- Residual Radiation after 1 Year Operation/Half Year Cooling at the Core Surfaces
- 500mm Iron will be Left at the Core Surfaces: Less Radiation for Work Places

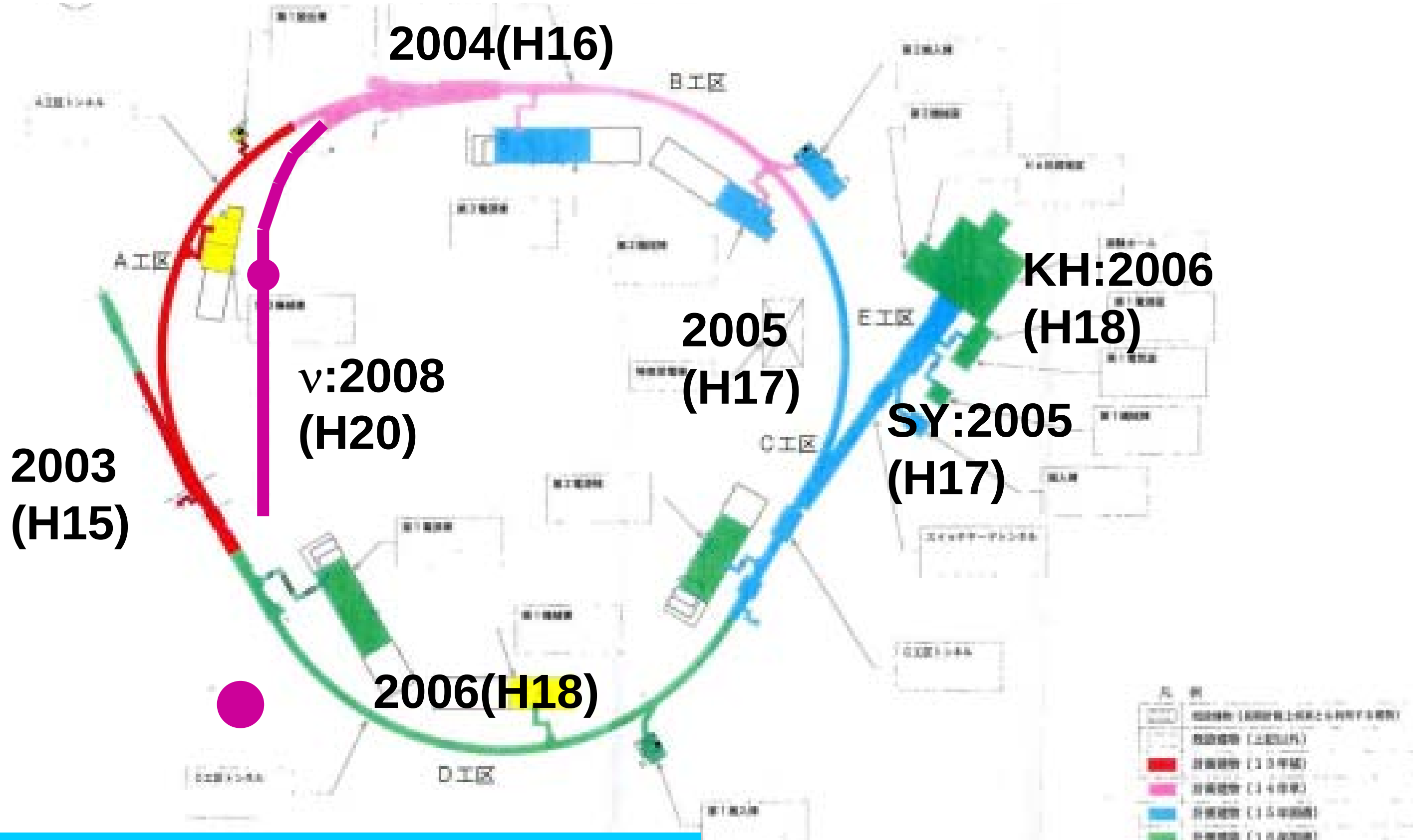


Summary & Status

- Beam Design
  - Almost Completed
- High Intensity Beam Handling System
  - Almost Ready.
- Most Serious Parts,

  i.e. Target and Beam Dump
  - Final Stage of Design/R&D.

Construction Schedule



Magnets etc. at ＳＹ：2006(H18)

Magnets etc. at NP-Hall：2007(H19)

The first Beam to NP-Hall：2008(H20)?

ν-Beam：2009(H21)

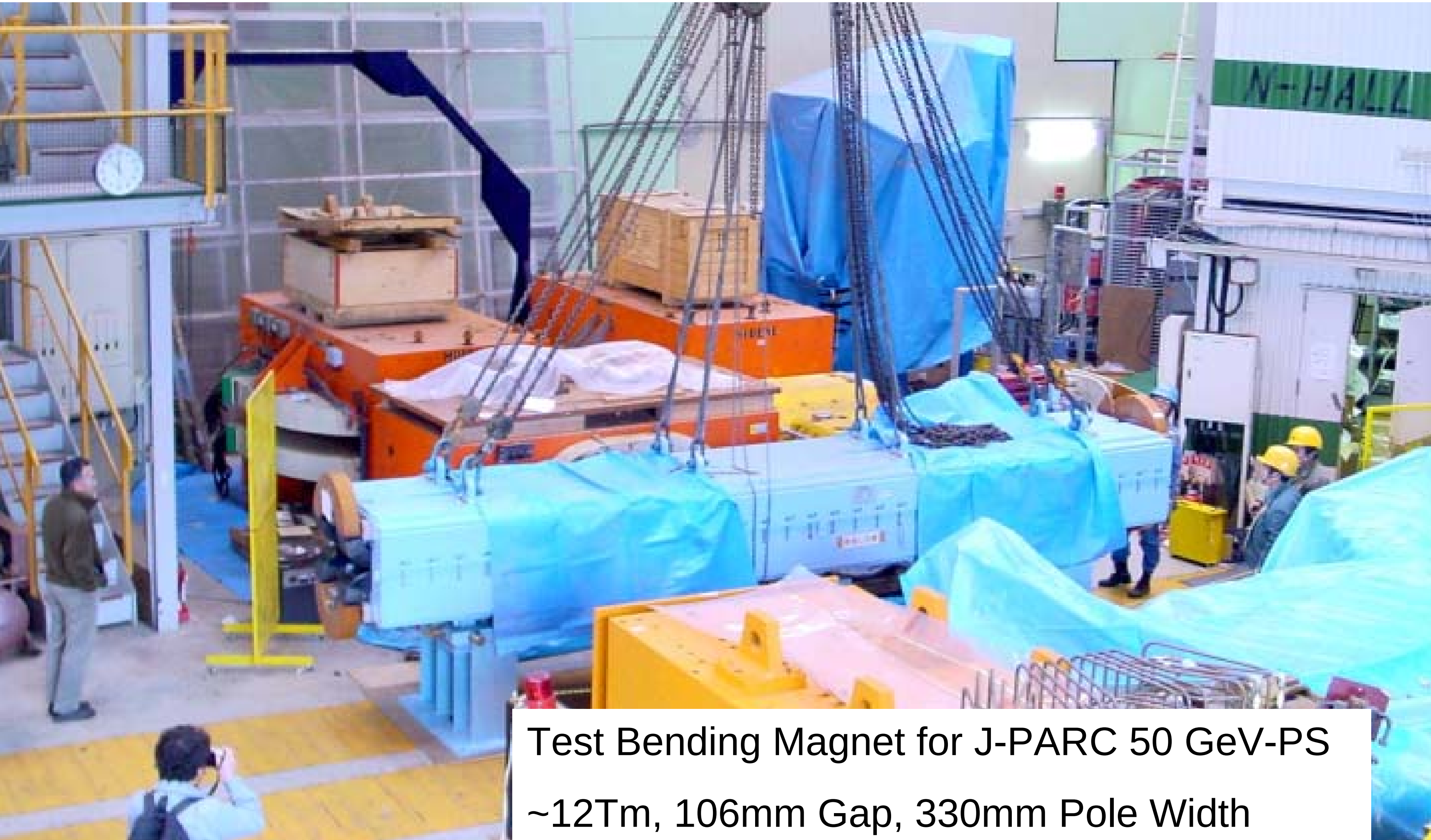
Dates of Remember

- January 2006: We can start SY settings
- January 2006: The most magnets should be ready
  - January 2005: We would like to start recycling magnets
  - January 2005: K2K should be shut down, ***please!***
    - Now March 2005: K2K shut down
    - Now June 2005: KEK-PS shut down
    - Till June 2005 the most of construction team should take care of the external beam lines of the KEK-PS.
- February 2007: We can start NP-Hall settings
- March 2008: The construction should be completed (officially)!

- Now the first beam will be October 2008?
- Anyway by the end of 2008?
- We are trying harder to reduce time/cost!

Magnet Collection Project

Our Latest Acquisition!



Test Bending Magnet for J-PARC 50 GeV-PS

~12Tm, 106mm Gap, 330mm Pole Width

Hadron Beam Sub-Group