Neutron-source Technical Advisory Committee

Target Station Structure

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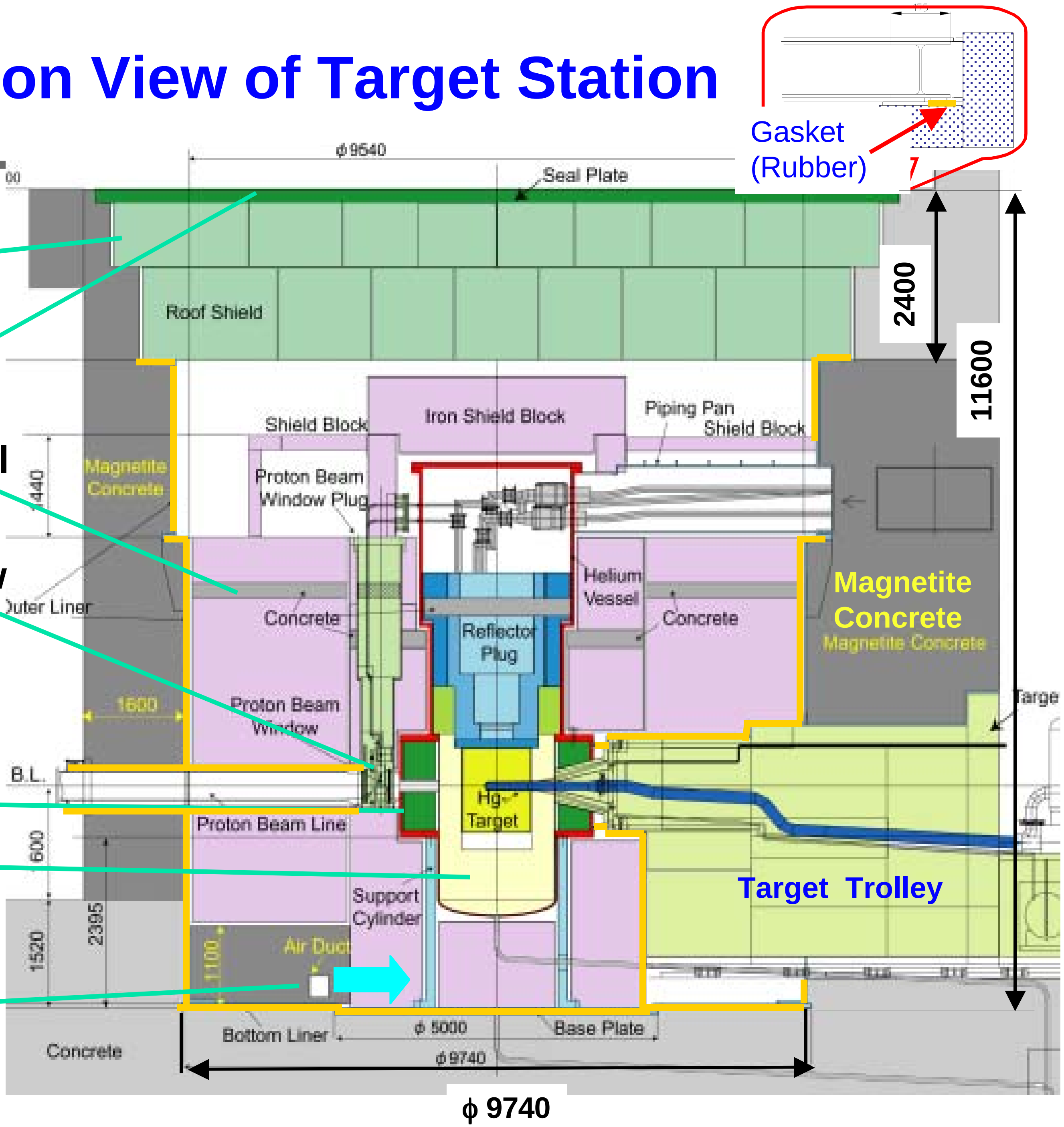
Elevation View of Target Station

- Thick roof shield without explicit metallic liners.
- Seal plate on the top.
- Concrete layer in steel shield.
- Proton beam window near vessel.

Water-Cooled Portion in Helium Vessel.
Middle section
Shielding around reflector

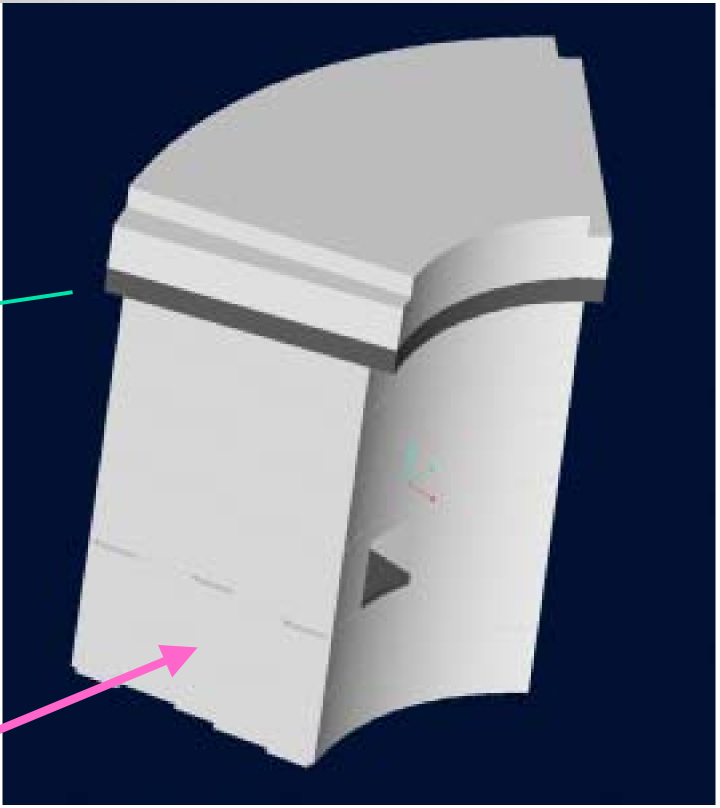
Dry air ventilation



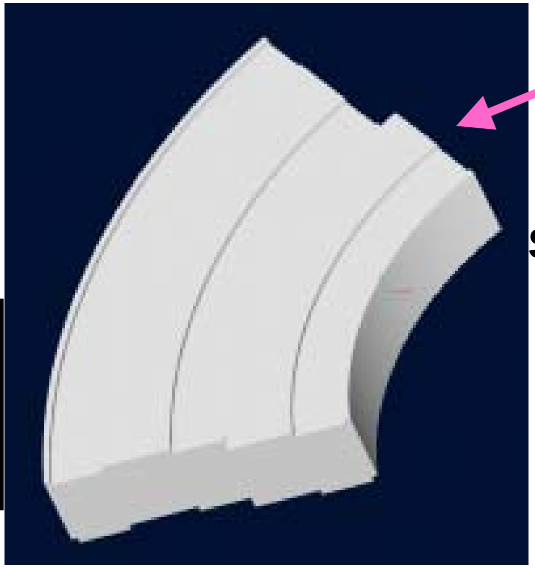
Shielding Block Structure

- Effective density : 7.6 g/cm³.
- Limited machining area for cost-saving.
- Concrete layer for effective shielding of low-energy neutrons.
- Weight : 50 tons /piece maximun

(Except for roof shield)



Shielding around Proton Beam Duct



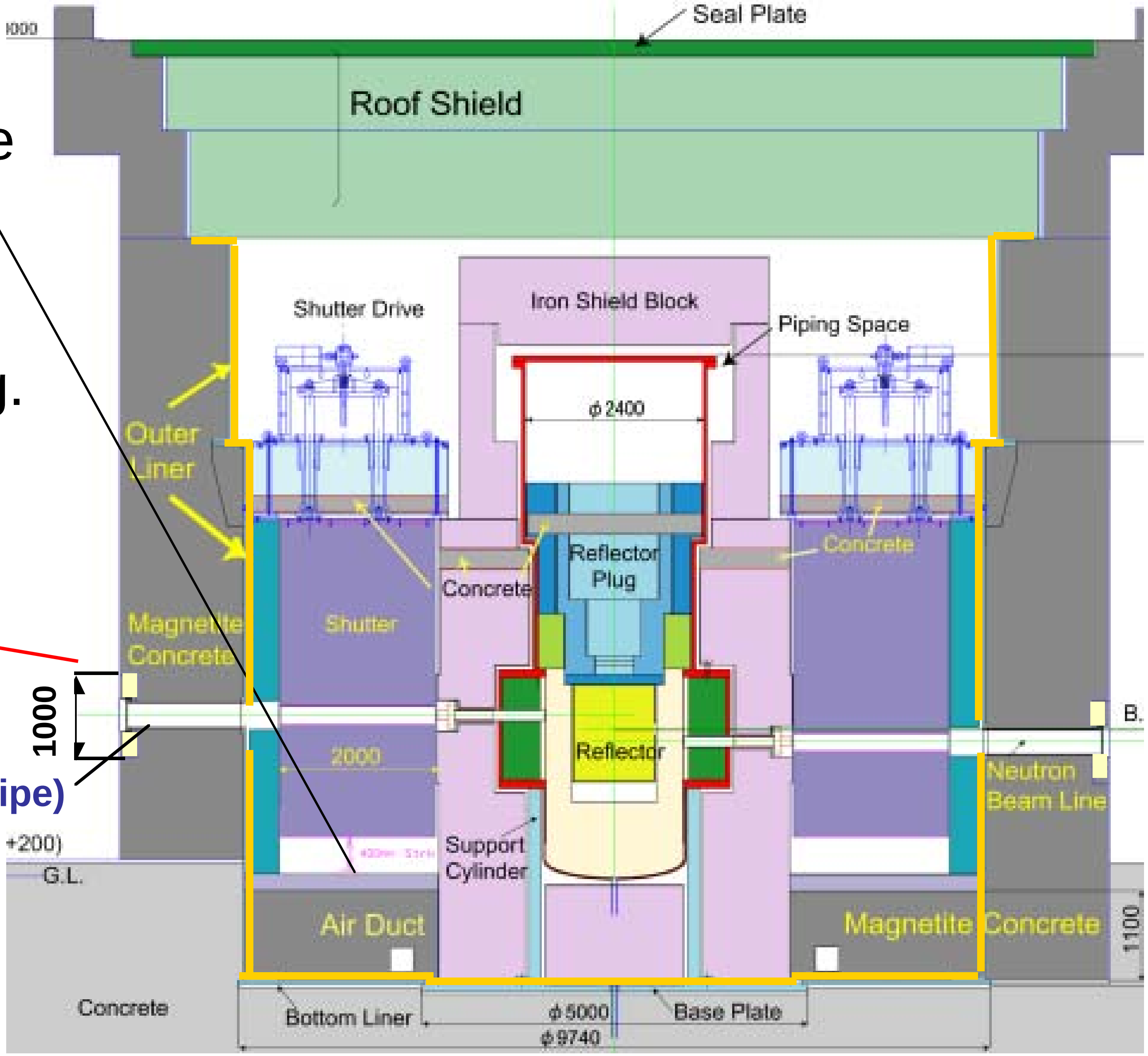
Gaps between shielding blocks and components : < 50 mm.

Section Through Shutters

- ●Magnetite concrete base for shutters.
- ●Flat top shutters.
- ●No shutter housing.
- ●No shutter support cylinder.

- **Small size alcove for beam line shield**

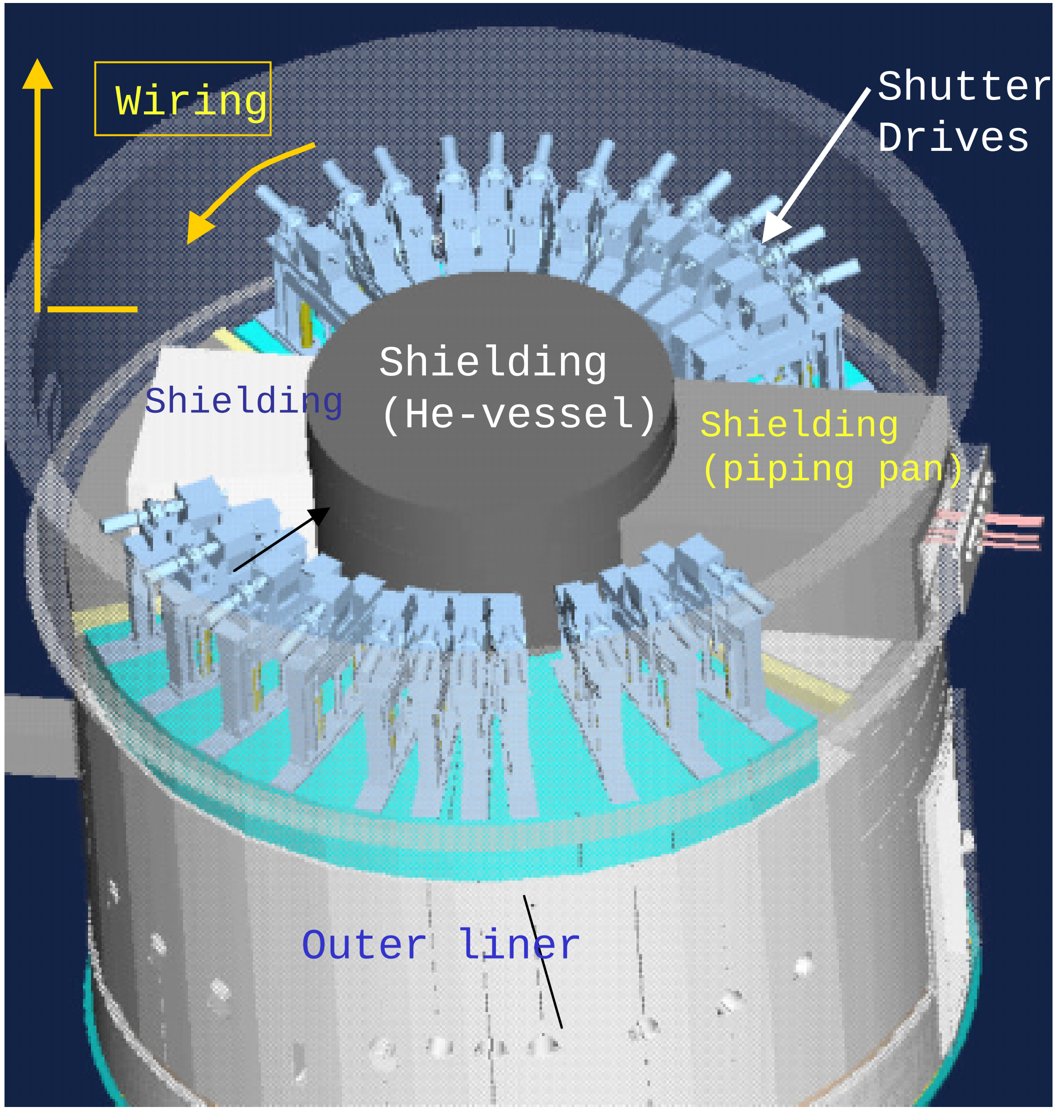
(duct: 300A pipe)



Total Weight :
- 4600 tons

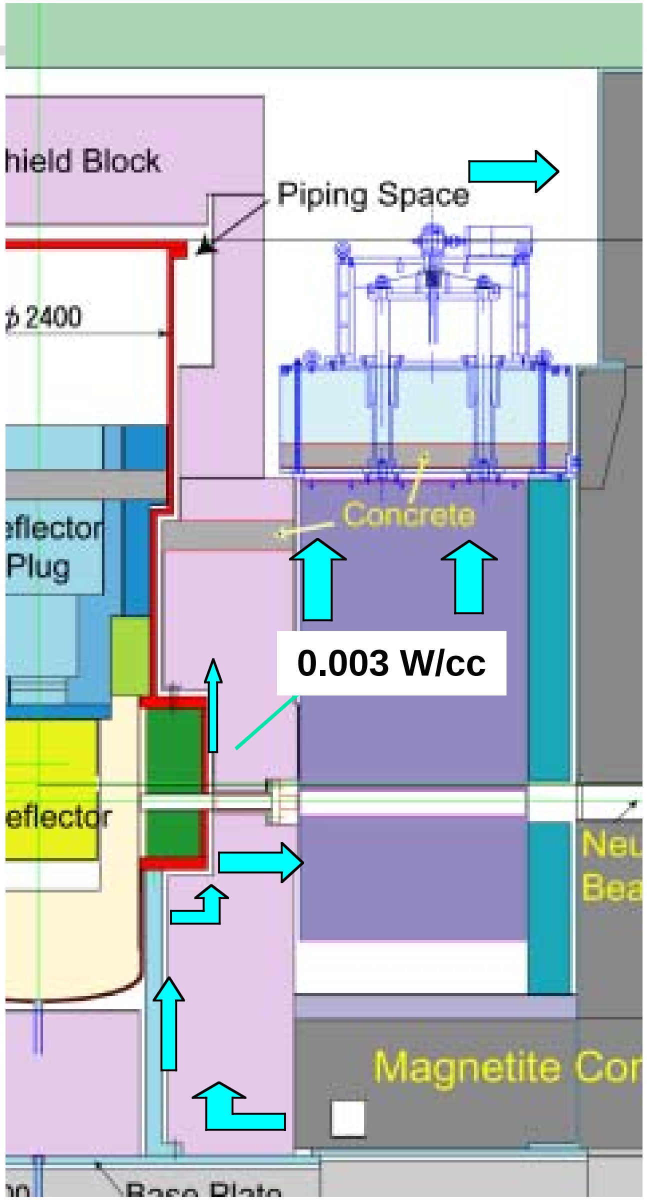
Shutter Drive Arrangement for 23 Beam-lines

- One shutter for each beam line.
  Irregular angular spacing
  Minimum 6.7° .
- Tight shutter drive arrangement
- Spaces between shutter drives : 20 mm minimum.
- Horizontal shutter adjustment within ±5mm.
- Tight maintenance space.
- Cabling and piping to the high bay.



Dry Air Ventilation Inside Target Station

- **Heat deposition around helium vessel : about 11 kW.**
- **Heat removal from shielding blocks around helium vessel.**



<u>Effects of dry air ventilation</u>

- **Reduce Tmax of concrete below 60℃**
- **Suppression of erosion due to NOx gas.**
- **Reduce ΔT at vessel insert flange.**

  Prevent bolts from loosing at flange.

Temperature Contour in Shielding around Helium Vessel

Conductivity of shielding blocks
: 2.4 W/m·K

Outer boundaries (air): 313K (40℃)

Forced Convection Heat Transfer by Air (50 W/m²·K)

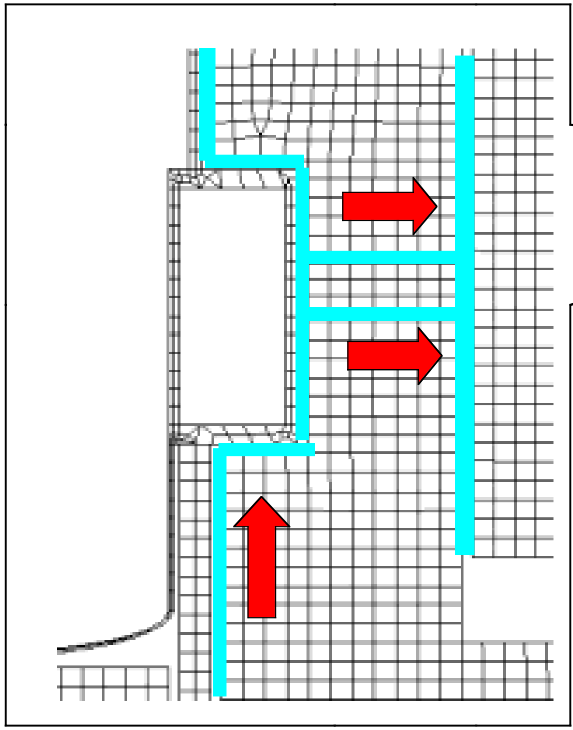
52℃ Max.

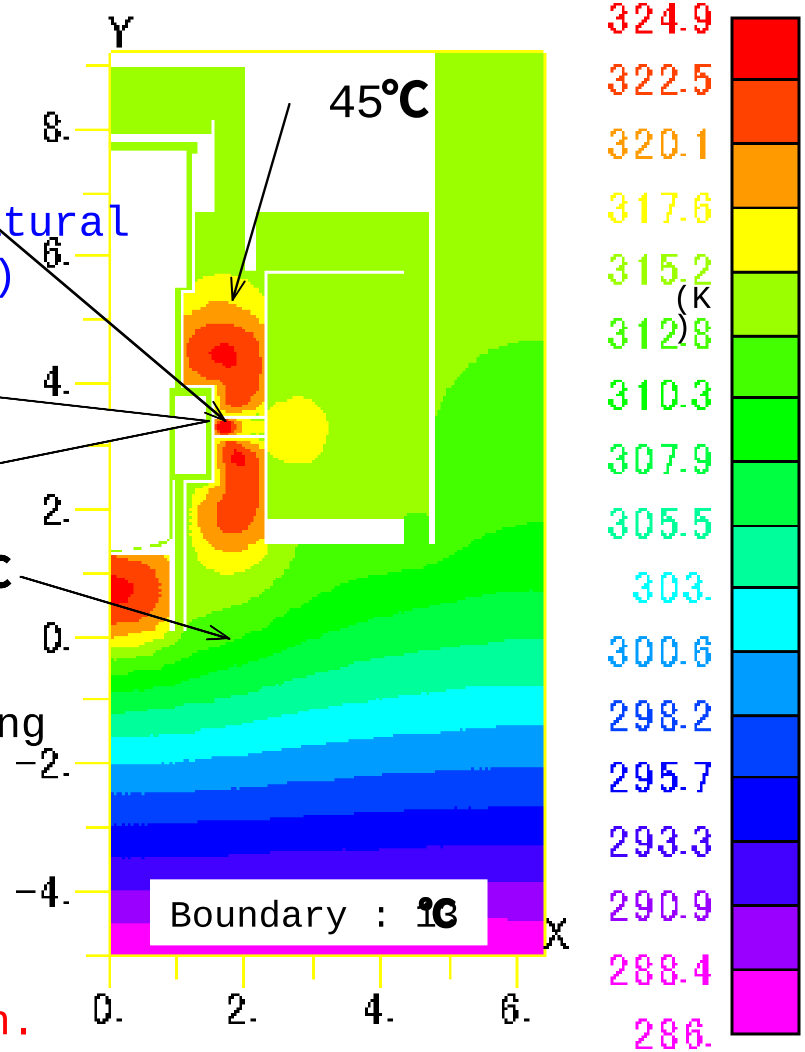
(88℃ @ Natural Convection)

45℃

38℃

Nuclear Heating
: 11 kW

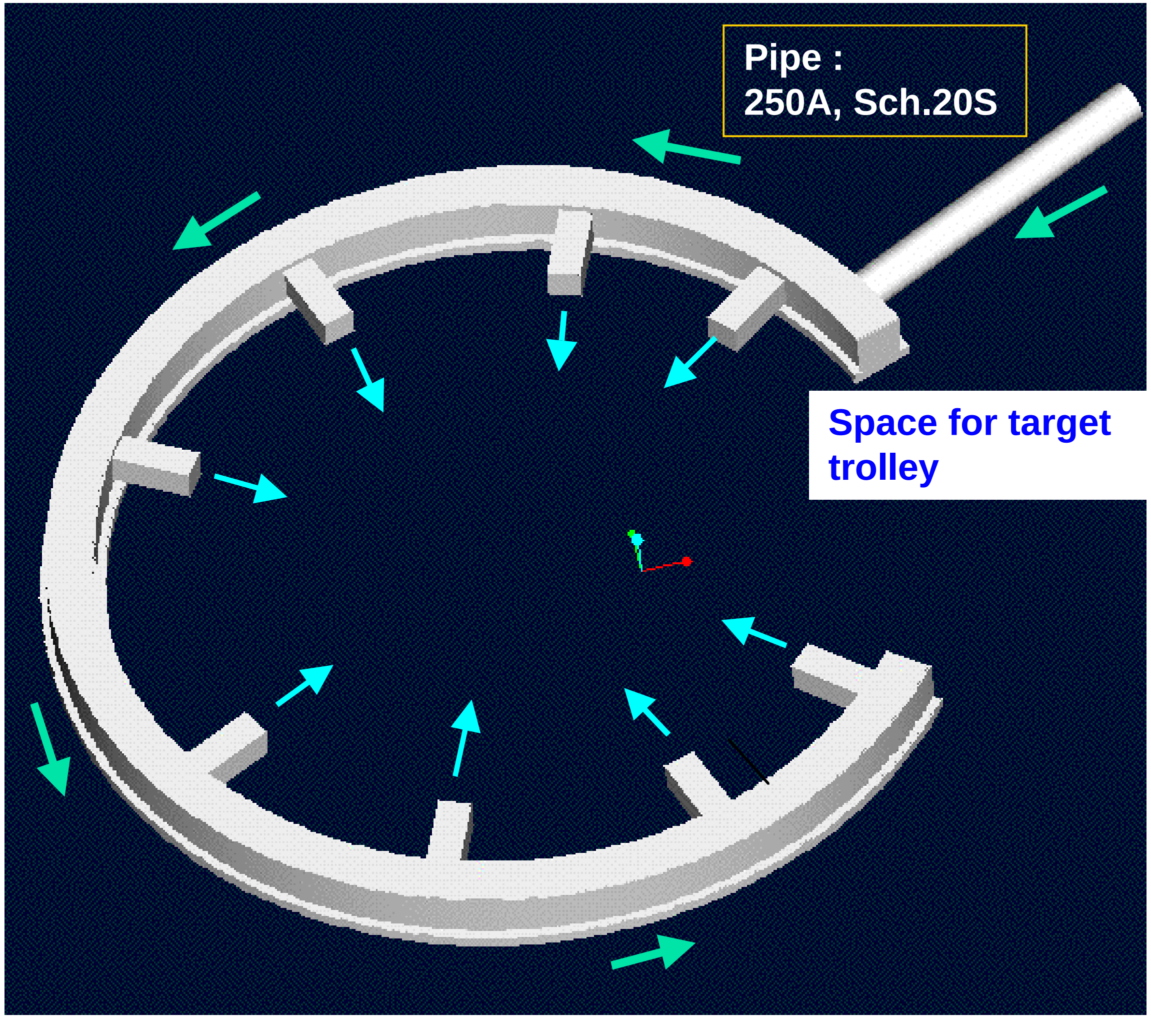




Flow channel is modeled in 2-dimension.

Dry Air Ventilation
-Conditions and Air Supply Duct Structure-

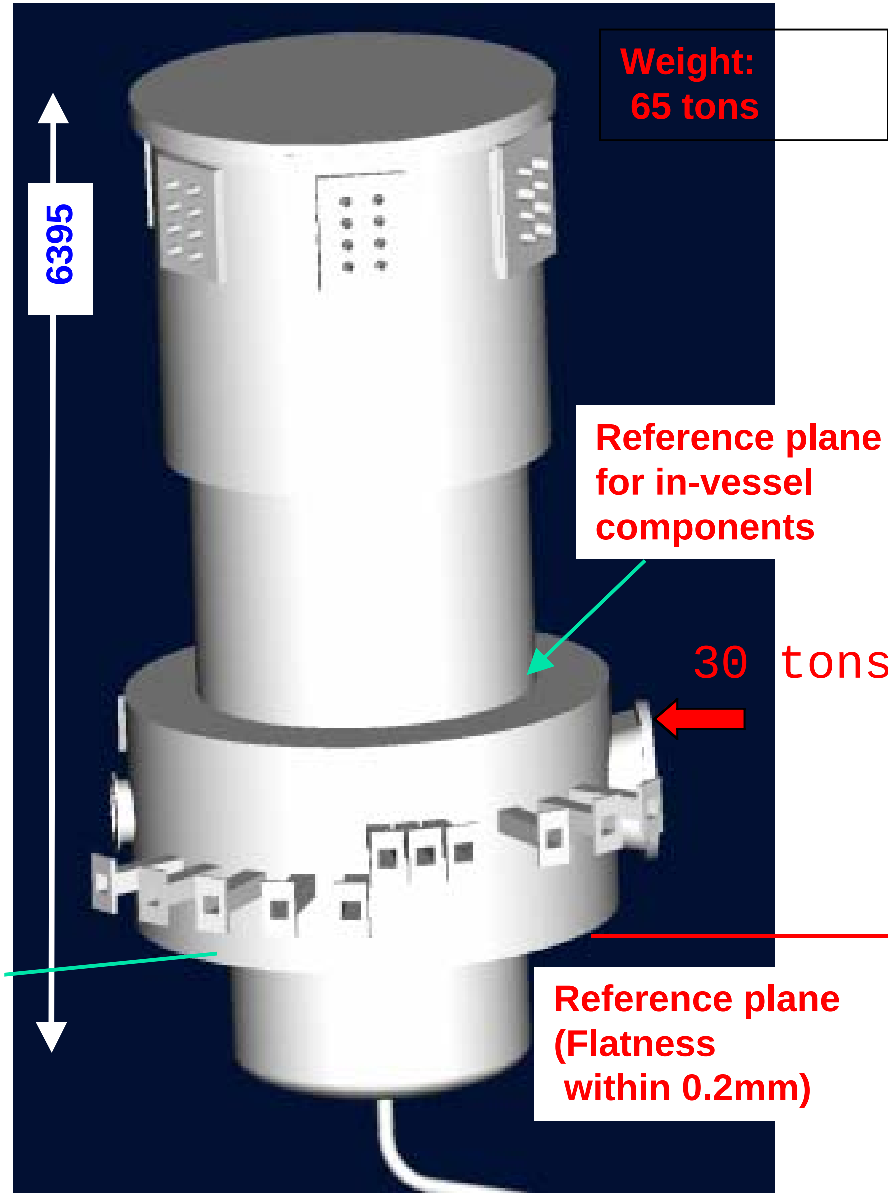
- Dry air supply from bottom of target station.
- Outlet temperature : 50°C.
- Inlet temperature : 35°C.
- Flow rate :   2400m^3/h.
- Flow velocity : 13.4 m/s.
- ΔP : 200 mmAq .



Supply duct (Type 304 SS)
300 x 300 mm, 4.5 t

Design of Helium Vessel

- **Water-cooled block region in middle section.**
- **Helium vessel on support cylinder : reference plane.**
- **Horizontal force by the target trolley: 30 tons.**
- **Vessel insert flange seal with metallic seals by a window handling device.**



Type-316 (LN) SS
Wall thickness : 50 mm

Earthquake Resistance Analyses of He-Vessel

- Analytical results of Displacement

- 3D shell model -

Acceleration X direction
(0.25G・・・47 tons)

Upper part of He-vessel
including iron shield at
maintenance
24 tons

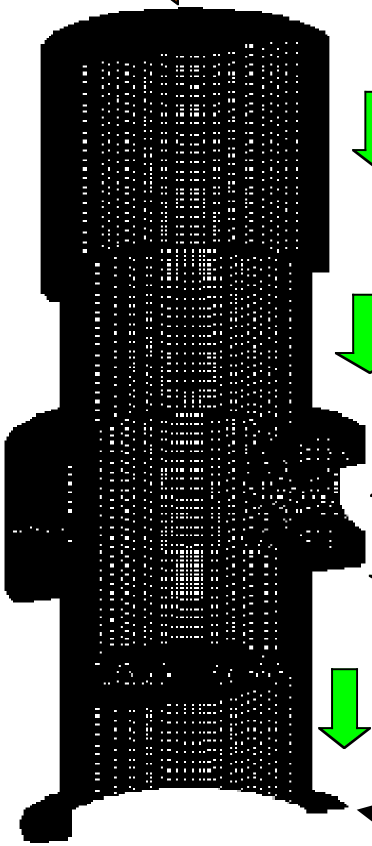
Cooled / Non-cooled
and Reflector
94 tons

Force from target
30 tons

Middle section
50 tons

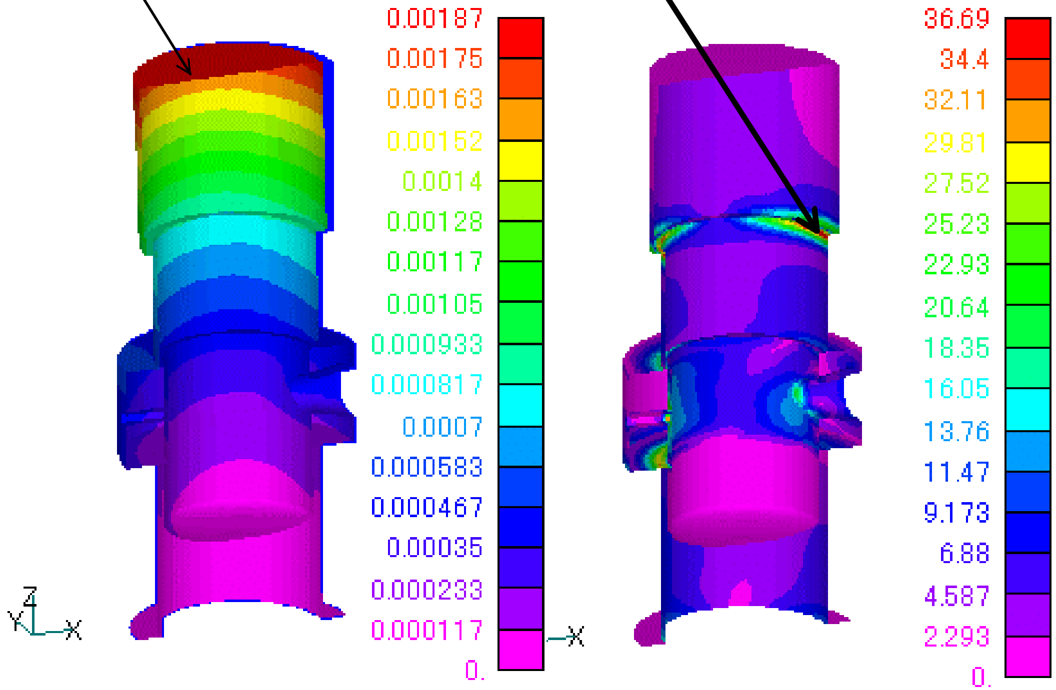
Support cylinder (m15)
19 tons

Bottom end is fixed.



Maximum Displacement
1.9 mm

Maximum σ VonMises
37 MPa

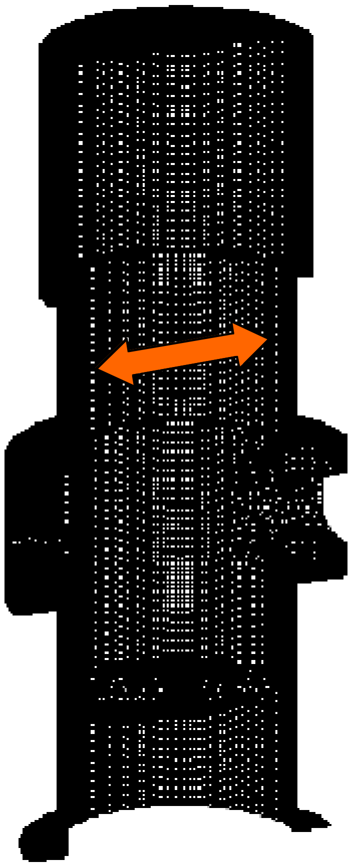


Material : type-316 SS
(E=190 GPa, ρ=80 kN/m³)
Allowable Stress : 172 MPa (1.5Sm)

Maximum Stress is less than design value.

Analysis of Displacement and Stress distribution on He-Vessel Caused by Internal Pressure

- 3D shell model -



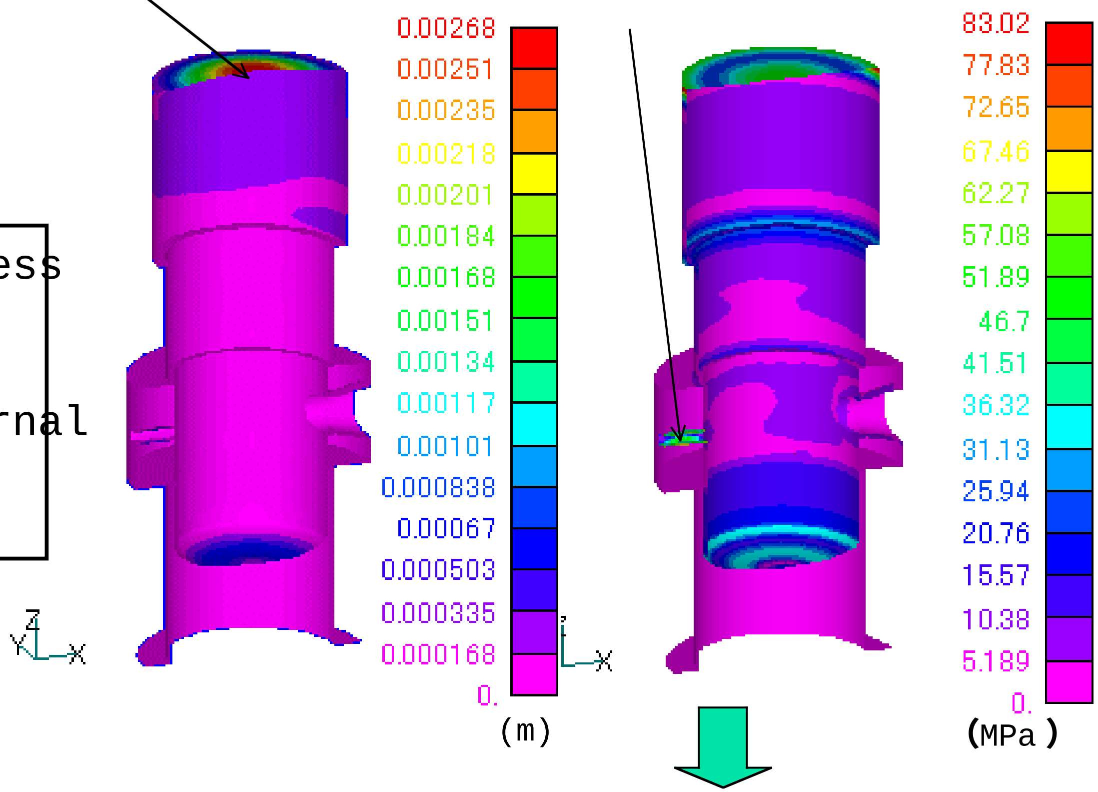
Wall thickness
: 50 mm

Design Internal pressure
: 0.3 MPa

- Analytical Results -

Maximum Displacement
2.7 mm

Maximum σ VonMises
83 MPa (@10mm t duct)



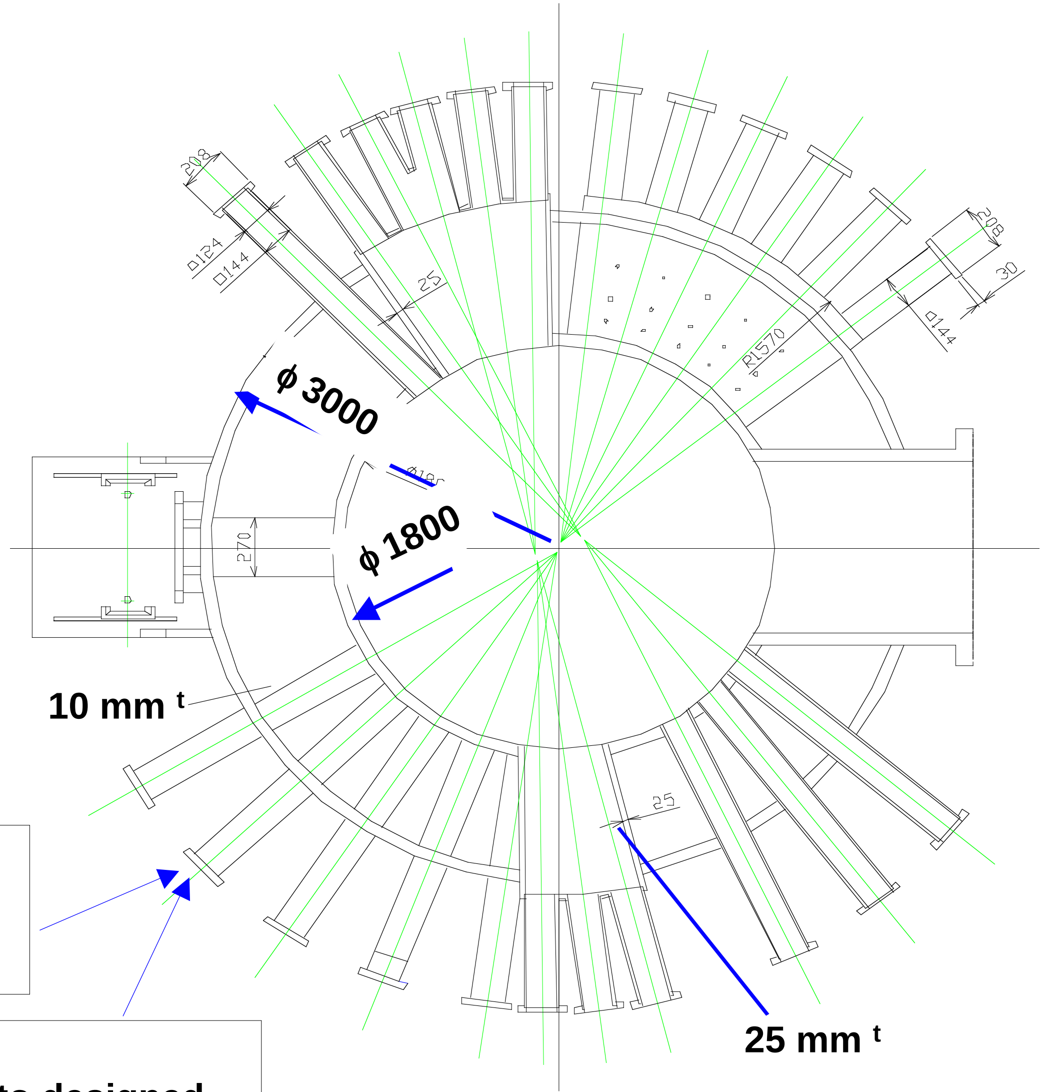
Material : Type-316 SS (E:190GPa)

Allowable Stress : 115MPa (Sm)

Maximum Stress is less than design value.

Middle Section Part of Helium Vessel
- Structure of Neutron Beam Ducts -

- Combination of single channel and multi-channel ducts for 23 beam extraction.
- Weld neutron beam ducts on type-316 SS container.
- Thickness of neutron beam ducts based on computer analysis.
- Accuracy of positioning pin and flatness of flange surface is important for seal.



Pin position accuracy :
within 2 mm with respect to designed beam line and flange surface.

Flange surface accuracy:
within 0.2 mm perpendicular to designed beam line, and the reference plane

Cross sectional view on proton beam plane

Analytical Results of Displacement and Stress Distribution on Neutron Beam Ducts on He-vessel

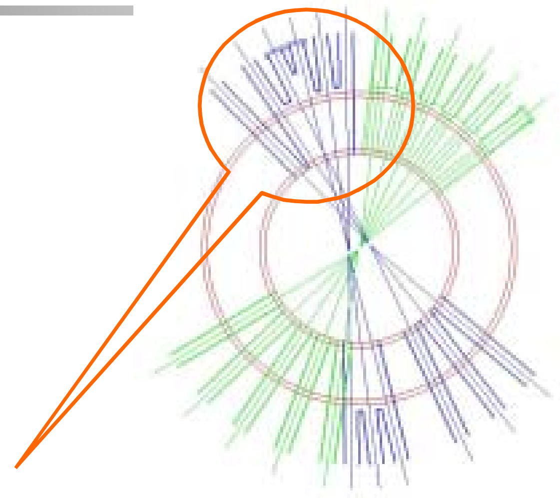
- 3D shell model -

Wall thickness : 25 mm

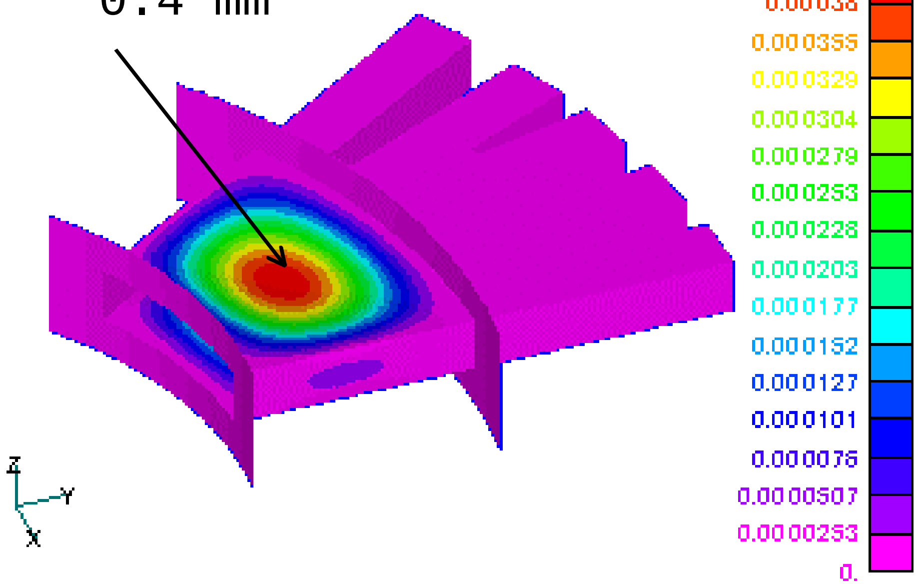
Design water pressure : 0.6 MPa

Material : type-316 SS (E=190 GPa)

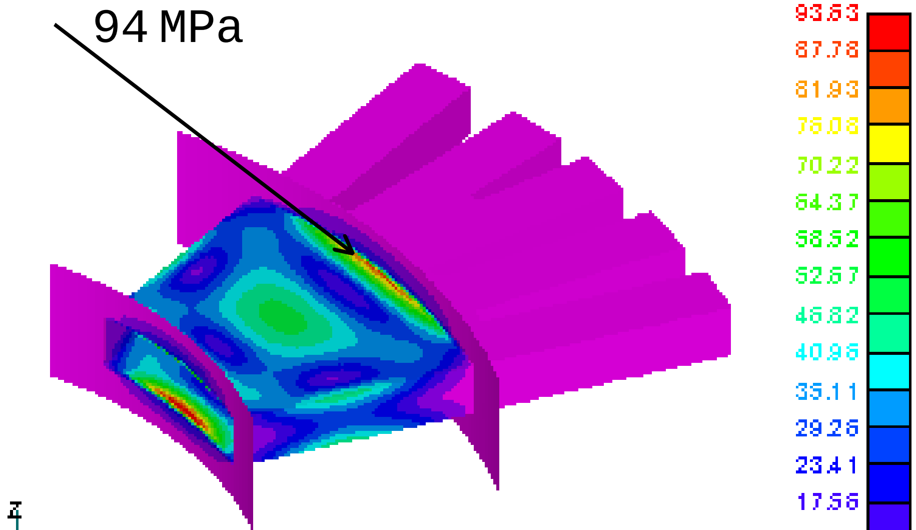
Allowable Stress : 172 MPa (1.5Sm)



Maximum Displacement
0.4 mm



Maximum σ VonMises
94 MPa



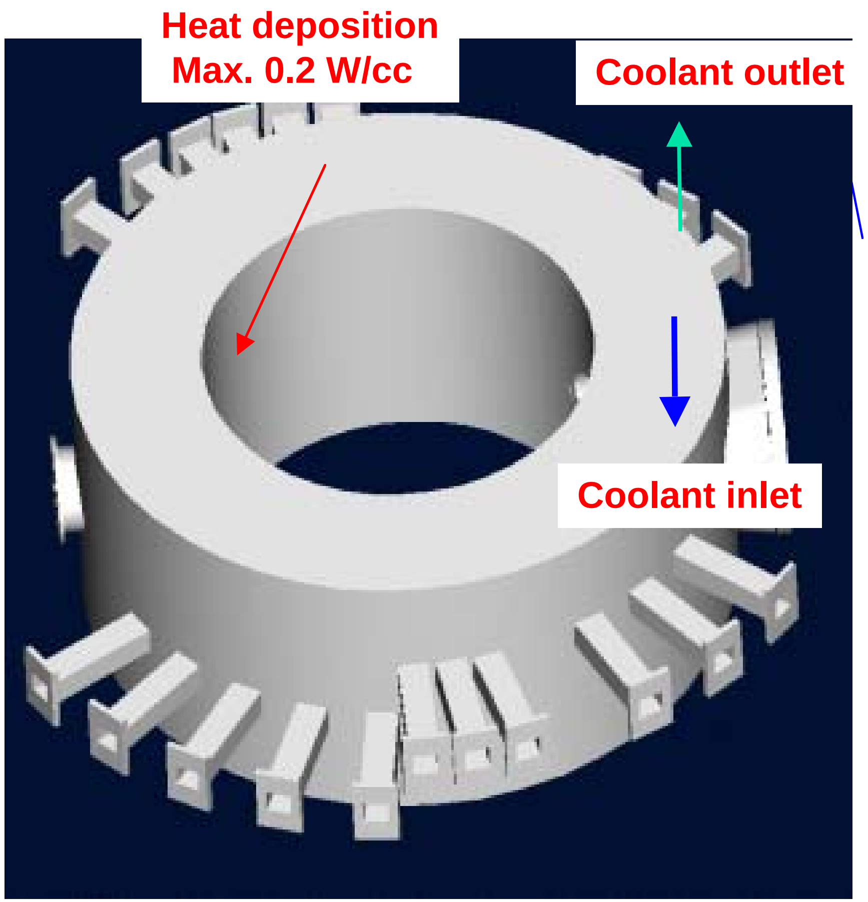
Maximum Stress is less than the design value.

Middle Section Part of Helium Vessel

Water-cooled block structure are under design

- Design conditions
  - Inner pressure : 0.3 MPa.
  - Inner pressure by water : 0.6 MPa.
  - Inlet temperature of water : 35°C.
  - Flow rate : less than 15 m^3/hr.
  - Total heat production : 30 kW.
  - Maximum power density : 0.2 W/cc.

- Design requirements
  - Maximum temperature of type-316 SS : less than 100°C.
  - Pressure drop through cooling channels : less than 0.2 MPa.

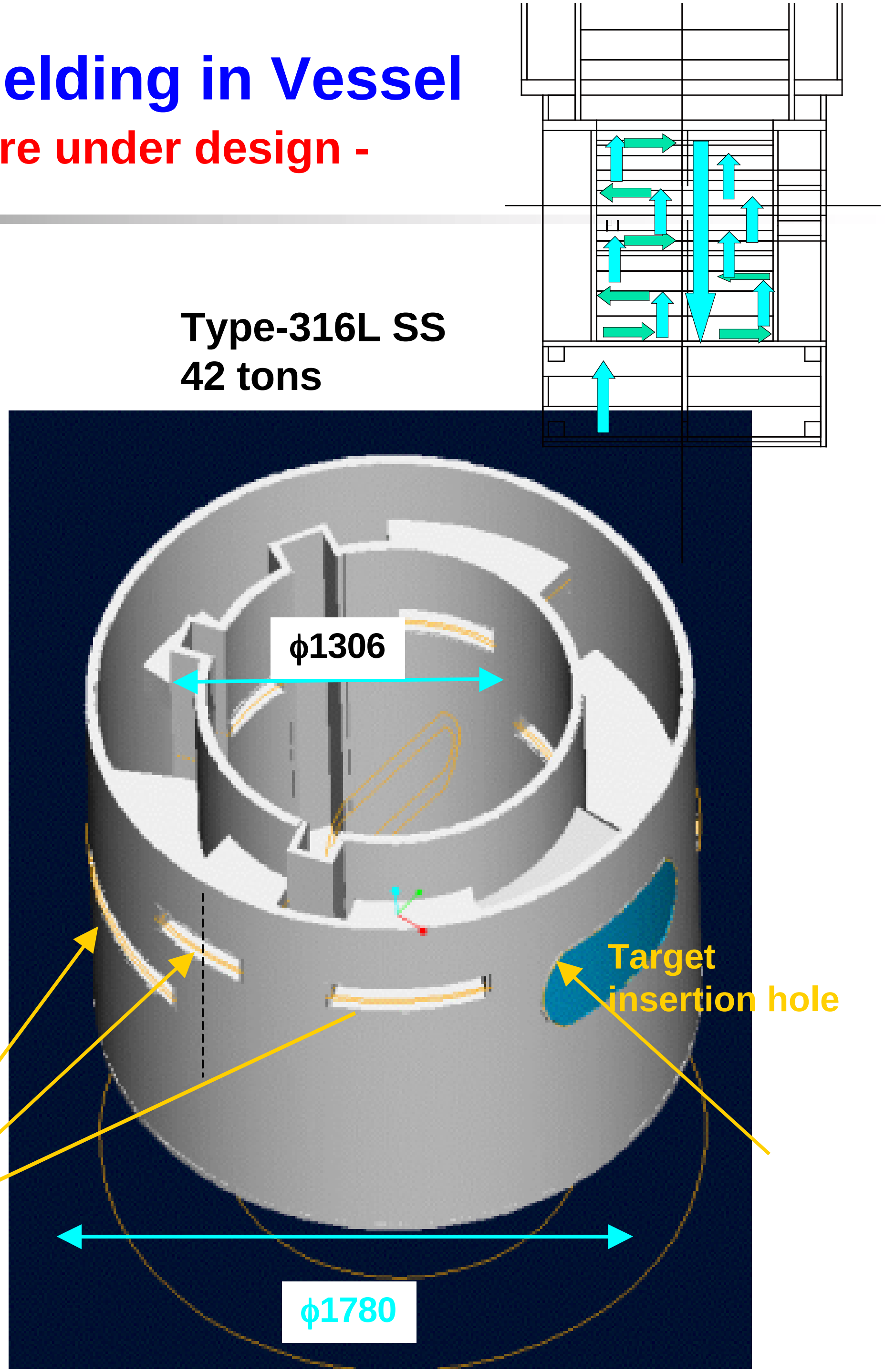


Water-Cooled SS Shielding in Vessel

- Water-cooled SS blocks are under design -

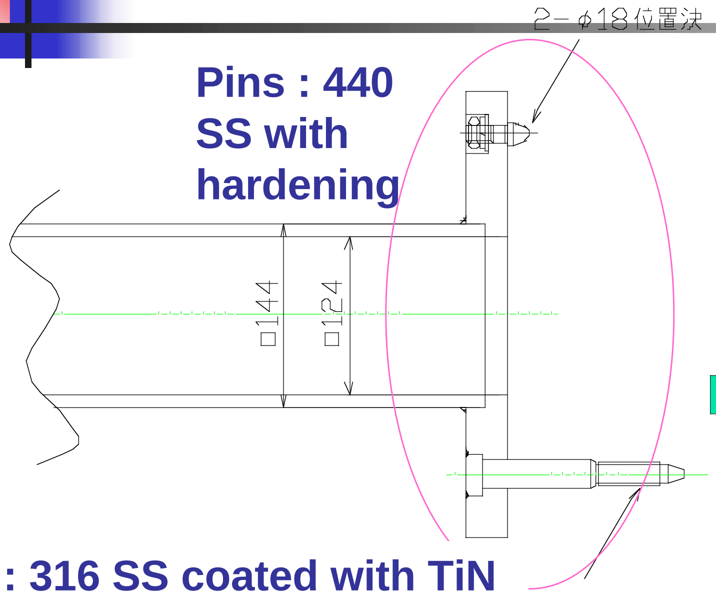
- **Design conditions**
  - Inner pressure by water : 0.6 MPa.
  - Inlet temperature of water : 35°C.
  - Flow rate : less than 15 m^3/hr.
  - Total heat production : 120 kW.
  - Maximum power density : 0.8. W/cc at vicinity of proton beam incident duct.

- **Design requirements**
  - Maximum temperature of type-316 SS : less than 100°C.
  - Pressure drop through cooling channels : less than 0.2 MPa.



Neutron beam extraction holes

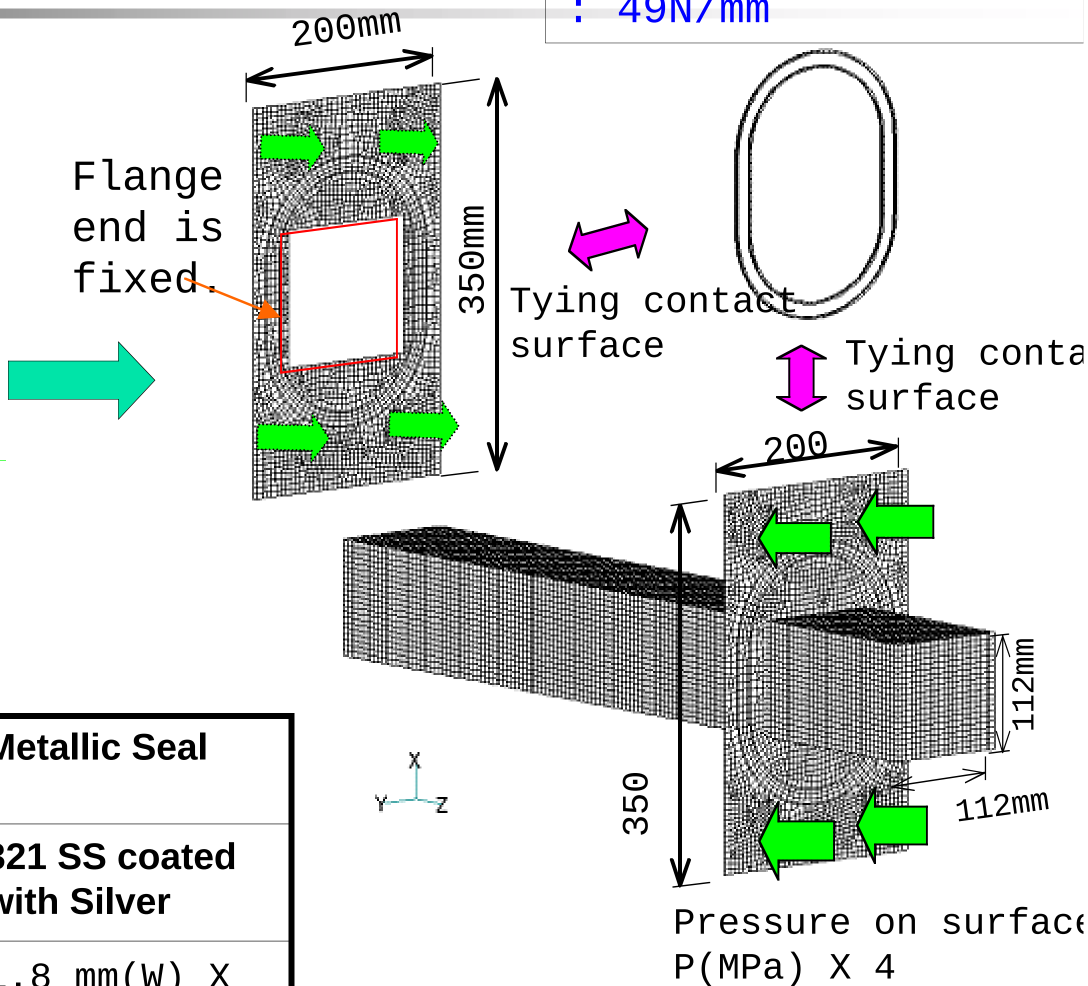
Metallic Seal of Neutron Beam Duct Flange



Bolts : 316 SS coated with TiN

Bolts are not replaceable.

Required Force for Se
: 49N/mm

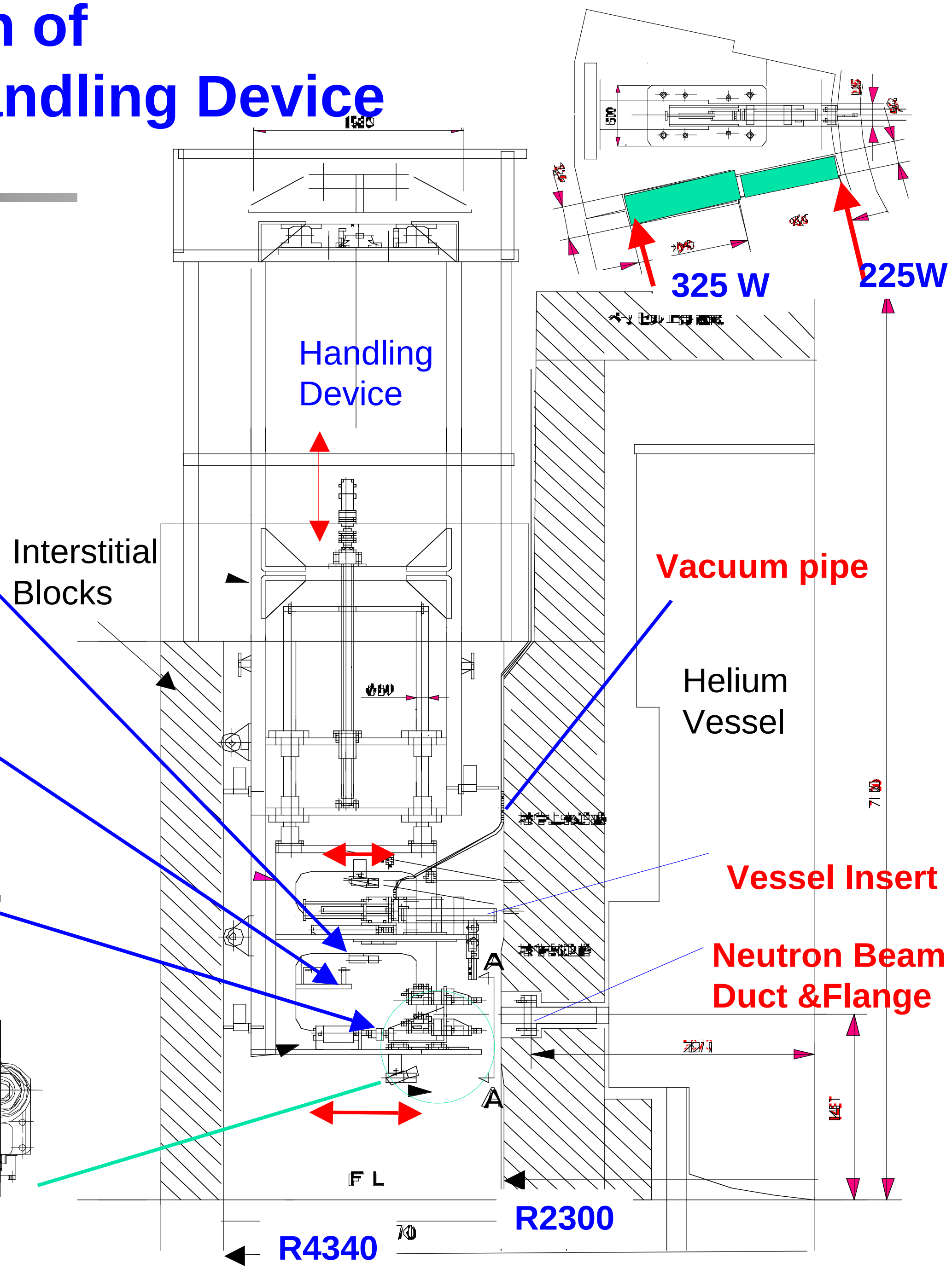


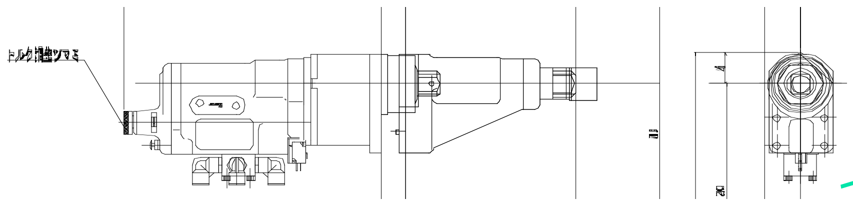
	Beam duct flange	Vessel insert flange	Metallic Seal
Material	316 SS	Al-alloy (A5083)	321 SS coated with Silver
Thickness	30 mm	75 mm	1.8 mm(W) X 2.4 mm(H)
Young's Modulus	190 GPa	65 Gpa	0.17 GPa

Required Pressure : 77 MPa
(Force : 2.0 tons for M18 bolt)

Conceptual Design of Vessel Window Handling Device

- **Move vessel insert to the beam level through the shutter cave by this device.**
- **Insertion and removal of vessel insert by a pneumatic plunger.**
- **Positioning of vessel insert with respect to the flange by a camera.**
- **CCD camera at initial installation.**
- **Attachment of vessel insert by fastening 4 nuts with nut-runners.**





Sketch of nut-runner

Vessel Window Handling Device -Critical Subjects -

- **Validation test at a factory of the contractor :**
  Use a test stand with the same flanges as those of He-vessel.

- **Critical subjects needed for test :**
  - **Handling of inserts using a pneumatic cylinder.**
  - **Seal performance using real double metallic seals.**
  - **Vacuum pipe loading from flange to top of shielding blocks.**

  etc.

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Validation tests at contractors' factory.

- **Use helium vessel's flange.**
- **Neutron beam shutter system.**
  Set-up and movement of the handling device in shutter caves.

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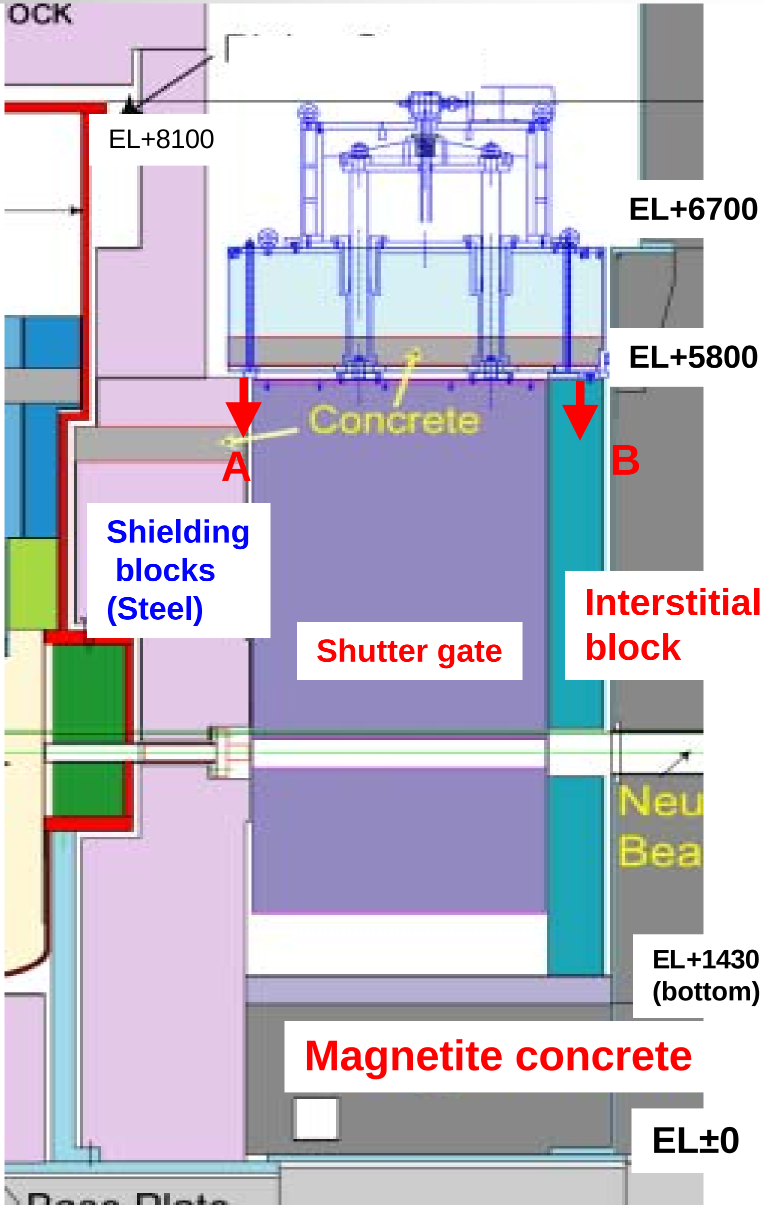
Installation of vessel inserts at Material Life Science Facility.

Neutron Beam Shutter System Structural Design

- **Shutter gate : rigid connection by two guide rods.**
- **Shutter weight support by inner shielding blocks and interstitial blocks.**
- **Shielding block horizontal level adjustment : accuracy less than 1/1000.**
- **Limitation of upper level of shutter drive : 8110 mm from bottom of base plate.**

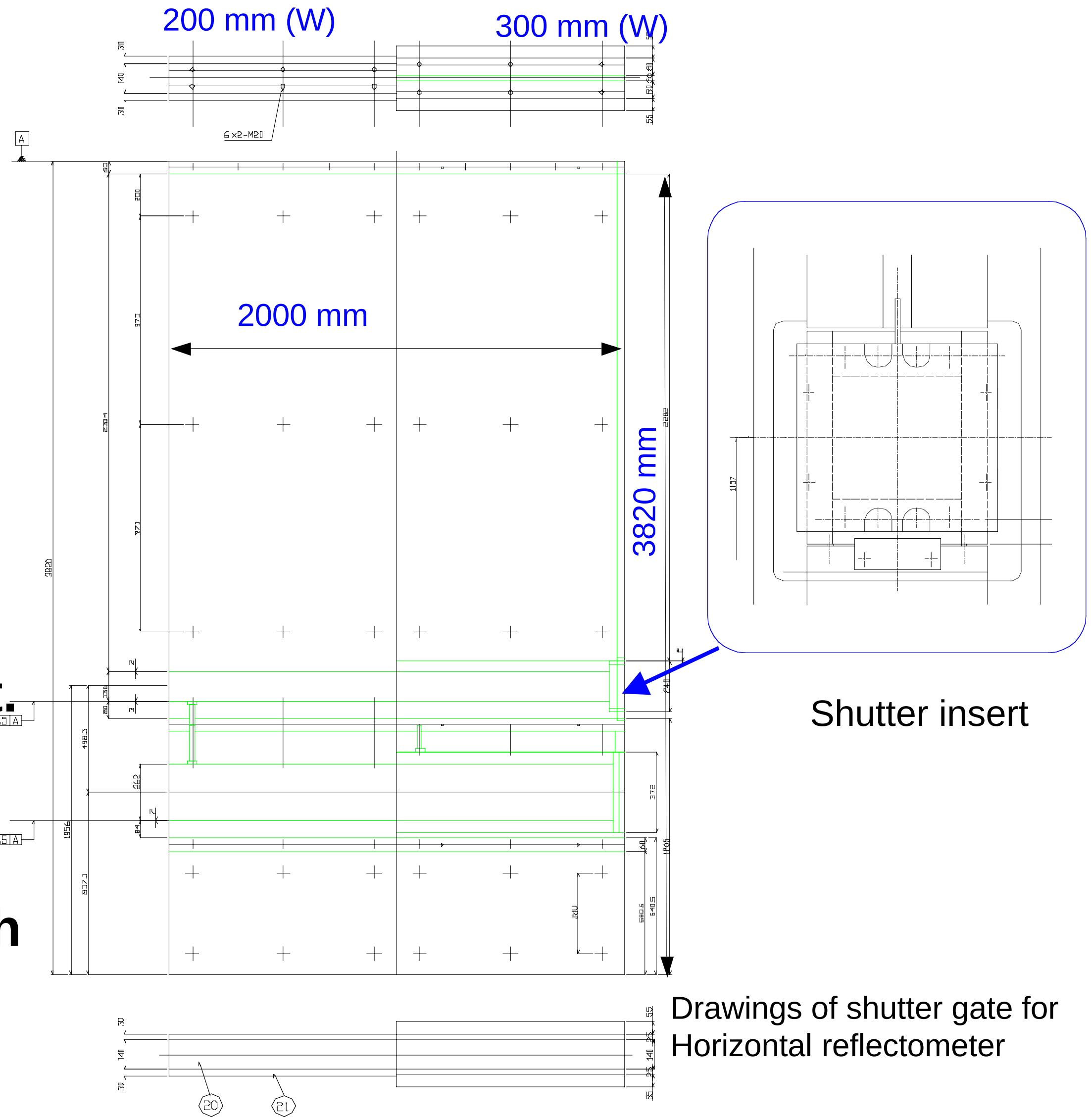


Level change by thermal expansion : 0.7 - 1.2 mm difference between A and B.

This does not cause serious problem to drive shutter gates.

Shutter Gates and Inserts

- **Shutter gate has a neutron extraction hole for a shutter insert.**
- **Shutter gate for horizontal reflectometer has two holes.**
- **Level accuracy of extraction hole: within 1/1000 with respect to top plane of gate.**
- **No special alignment mechanism for shutter insert.**
- **Access to insert from downstream side of the gate.**
- **Vacuum pipe connection with insert.**

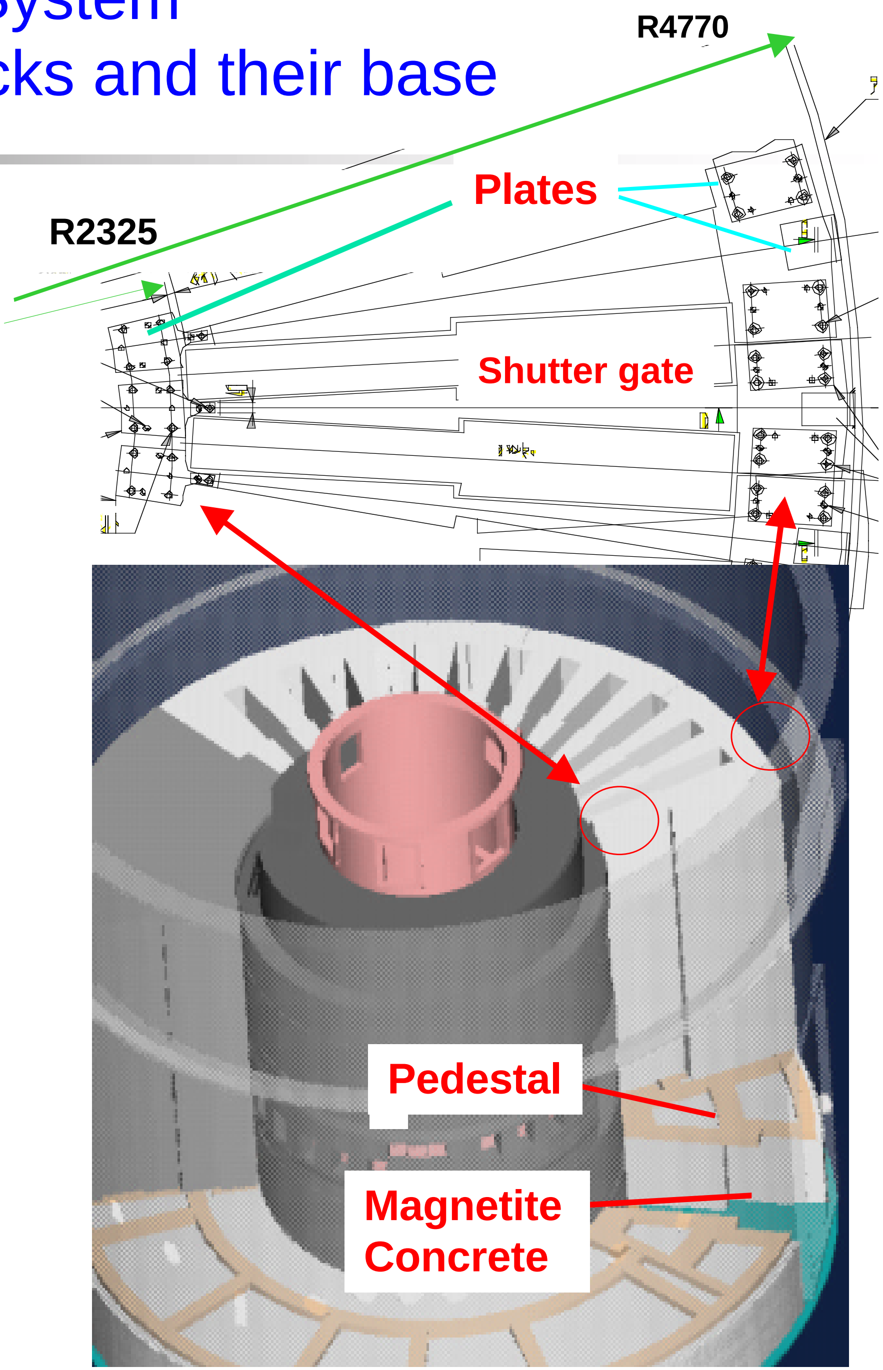


Shutter insert

Drawings of shutter gate for Horizontal reflectometer

Neutron Beam Shutter System
Design of Interstitial blocks and their base

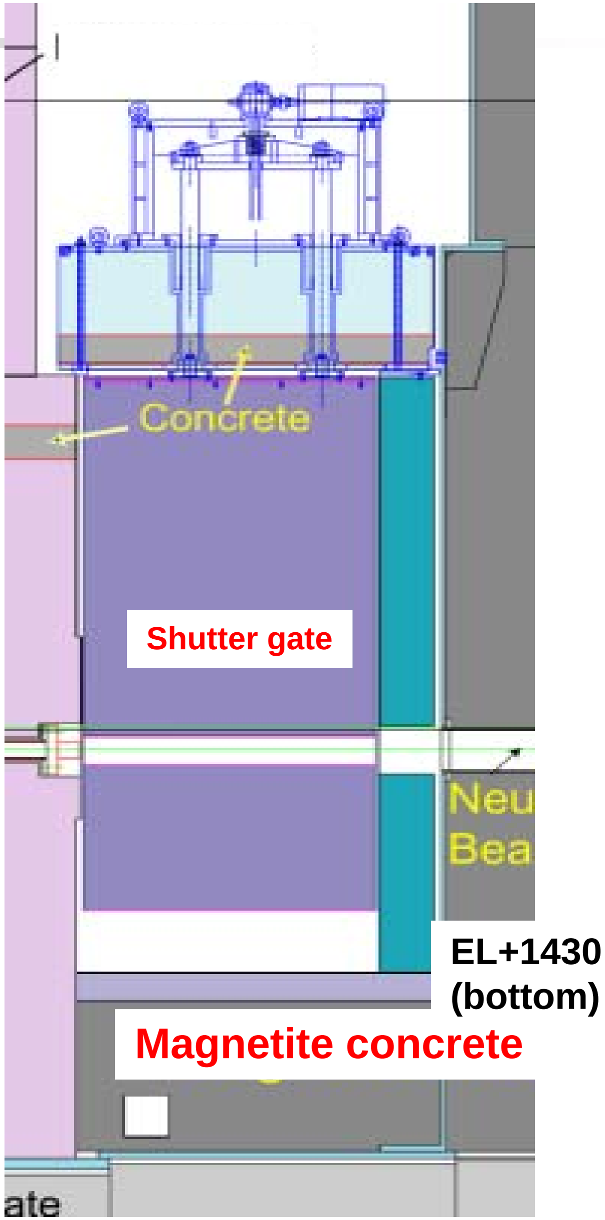
- **Nominal gaps between shutter gates and interstitial blocks :**
  - **20 mm in beam line direction**
  - **12.5 mm to sideward.**
- **Interstitial blocks with positioning pins and keys.**
- **Pedestals on the magnetite concrete base for Interstitial block set-up .**
- **Interstitial block connections**
  - **Inner shielding blocks**
  - **neighboring blocks**
  - **Outer-liner**



Shutter Motion Specifications

- Shutter stroke : 400 mm
  50 mm margin for lower and upper directions
- Electrical motor drive mechanism
- Elapsed time to open/close: less than 1 minute
- Reproduceability accuracy of shutter positioning is 0.5 mm.
- Neutron beam line is close as shutter gate is at the lowest position.

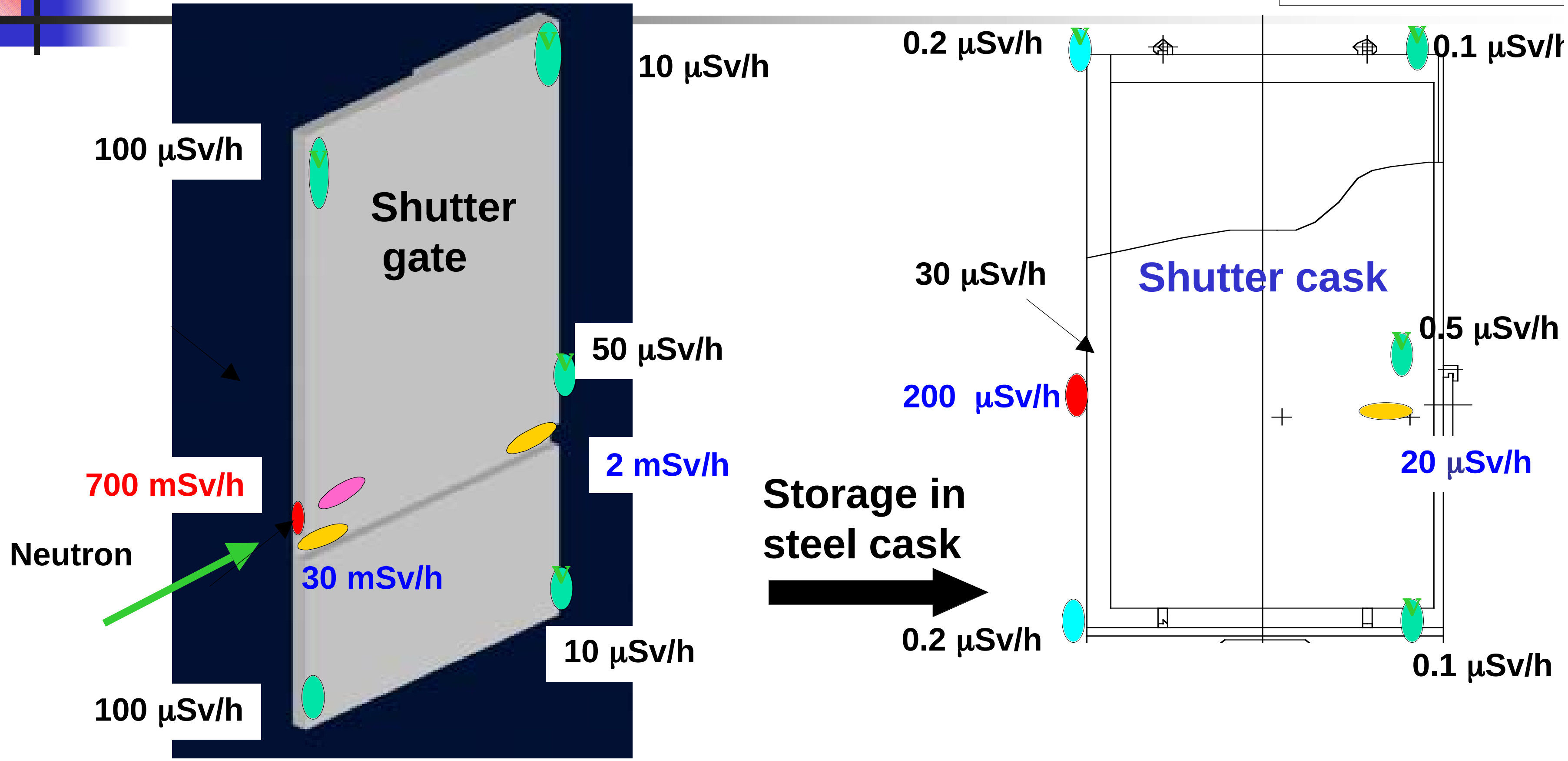
  Shutter gate for reflectometer close at 120 mm from the lowest position
- Positioning sensors
  - Rotary encorder
  - Mechanical switches

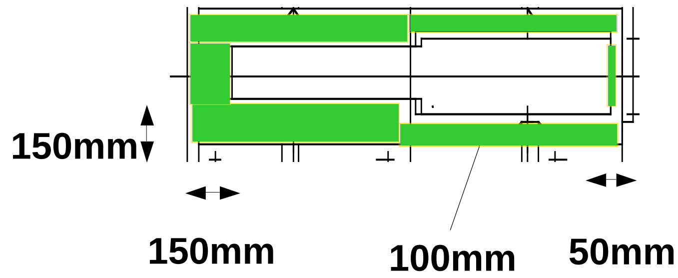


Shutter Gate Maintenance Concept

- Estimated Dose Rate at contact (Just after shut-down) -

Major source nuclide : Fe-59





- Highly irradiated spot on upstream side.
- Need to wait for decay of Na-24.

Shutter Gate Maintenance Concept

1. Remove Shutter drive
2. Remove Shielding block
3. Connection rod to two guide rods
4. Shutter cask set-up with pedestal
5. Lift shutter gate into cask by crane
6. Move cask

Subjects to study

- Detaills on pedestal set-up
- Guide ?