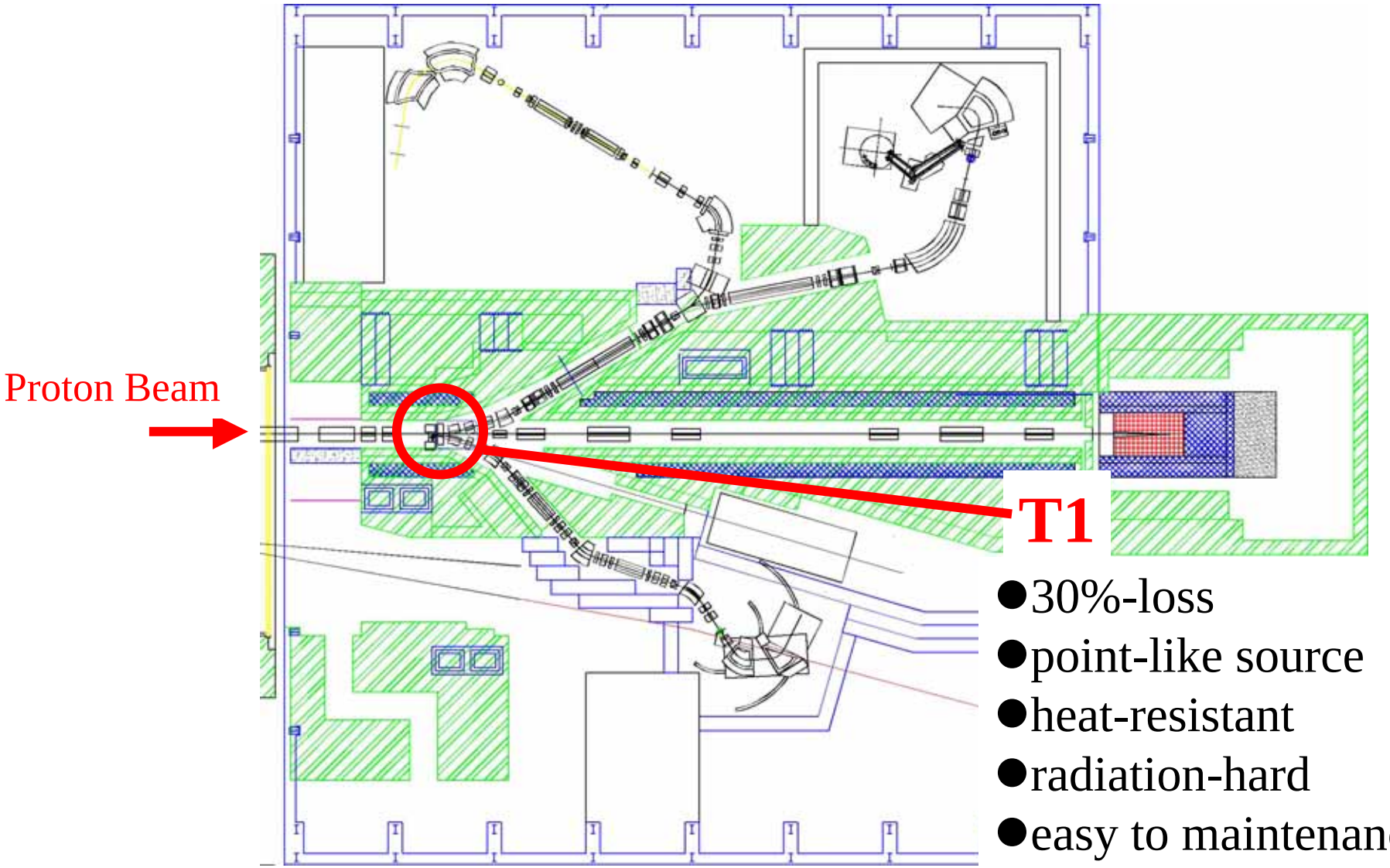
Production Target and Upstream End of Secondary Beam Lines

Hitoshi Takahashi

KEK, Institute of Particle and Nuclear Studies

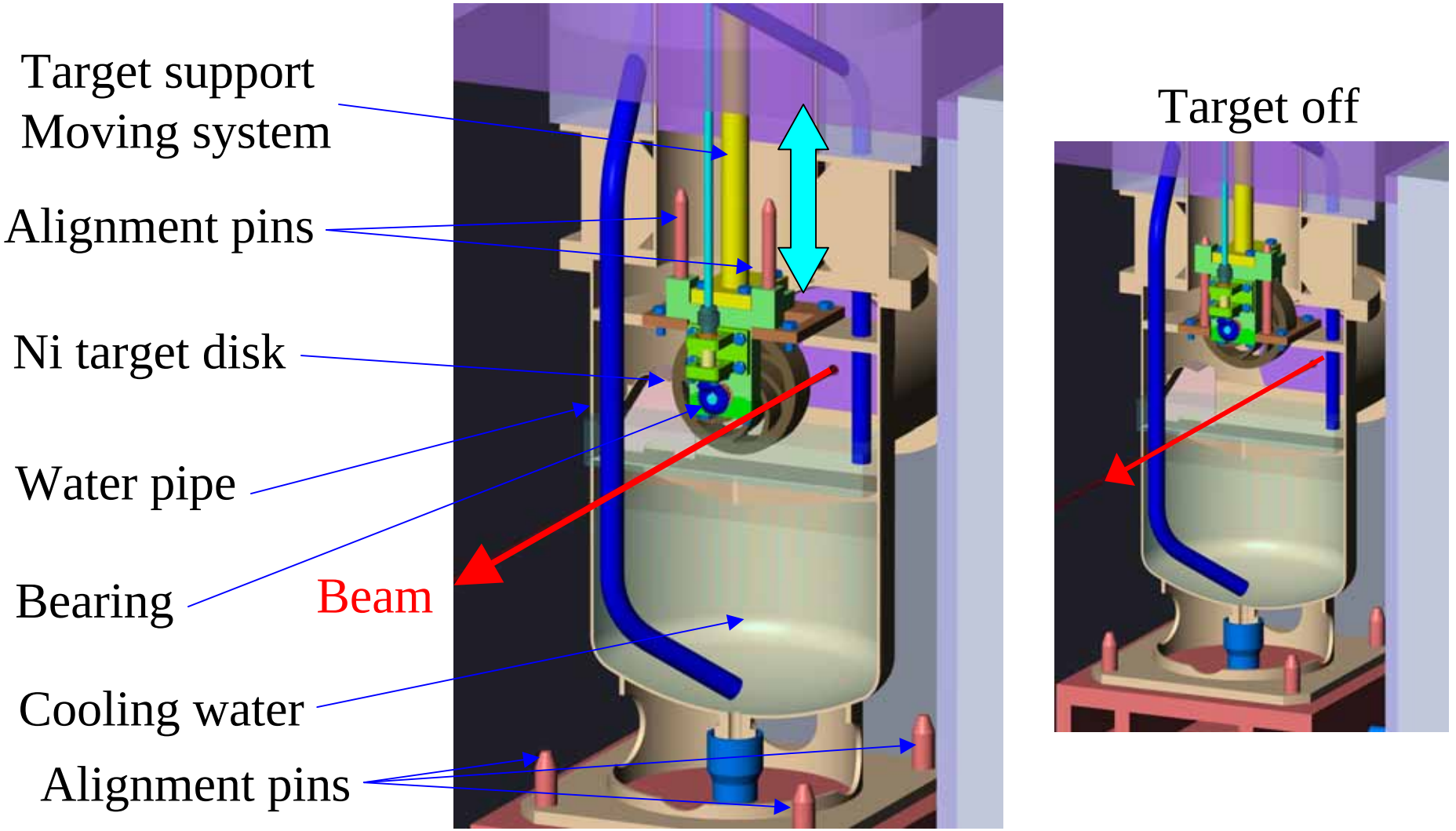
- T1 Target
  - Specifications
  - Thermal Analysis
  - R&D using Proto Type
  - Maintenance Scenario
- Vacuum Chamber
  - Conceptual Design
  - Magnet Operation in Vacuum

The Only Production Target in Phase 1 of J-PARC



- 30%-loss
- point-like source
- heat-resistant
- radiation-hard
- easy to maintenance

Water-cooled Rotating Disk



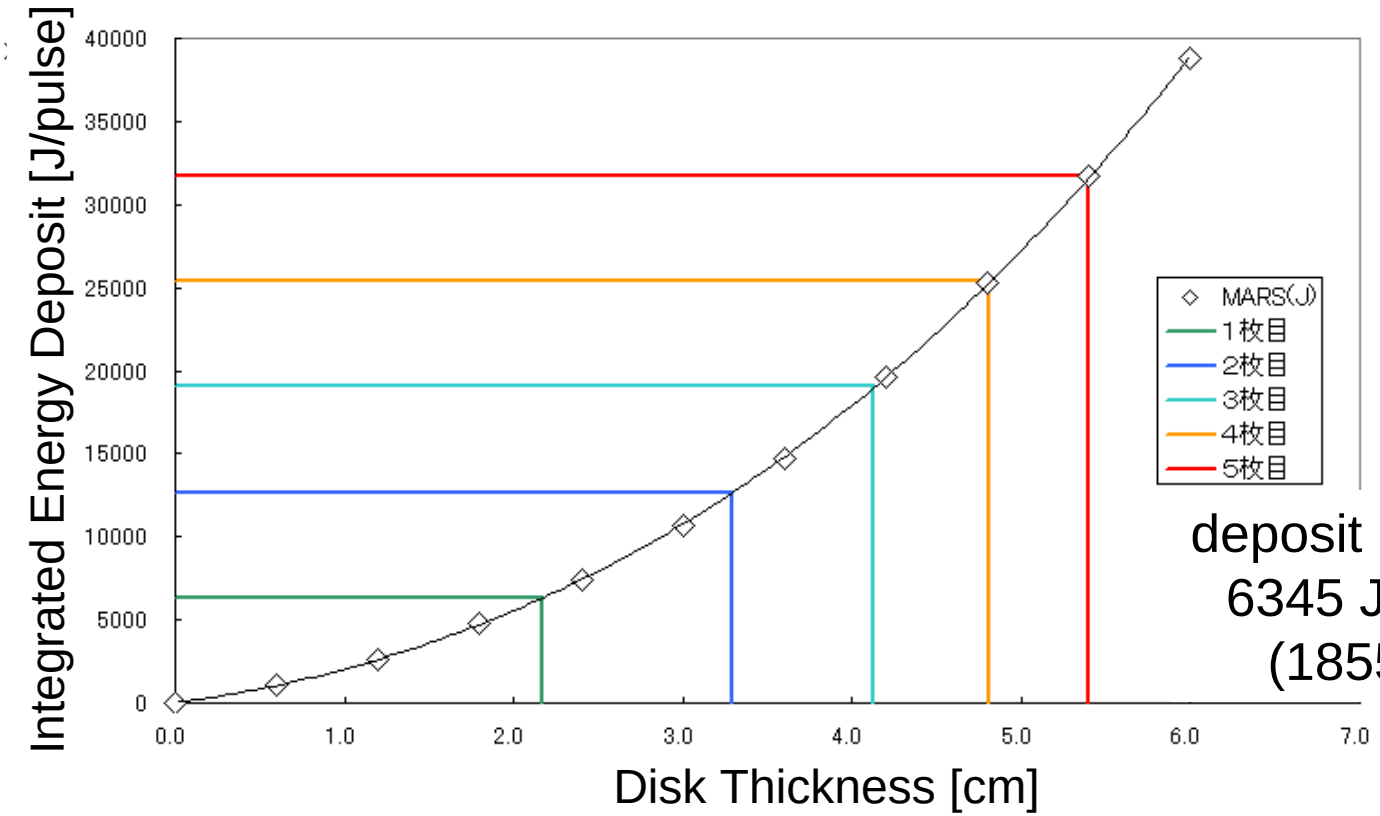
Specifications

- made of Nickel alloy
- 280 mmϕ in diameter
- total 54 mm in thickness
- divided to 5 disks
- gap of 3 mm between the disks
- 85 rpm (1 rotation per 0.7 sec)

Division of Target Disk

Higher energy deposit density in downstream disk
due to secondary particles

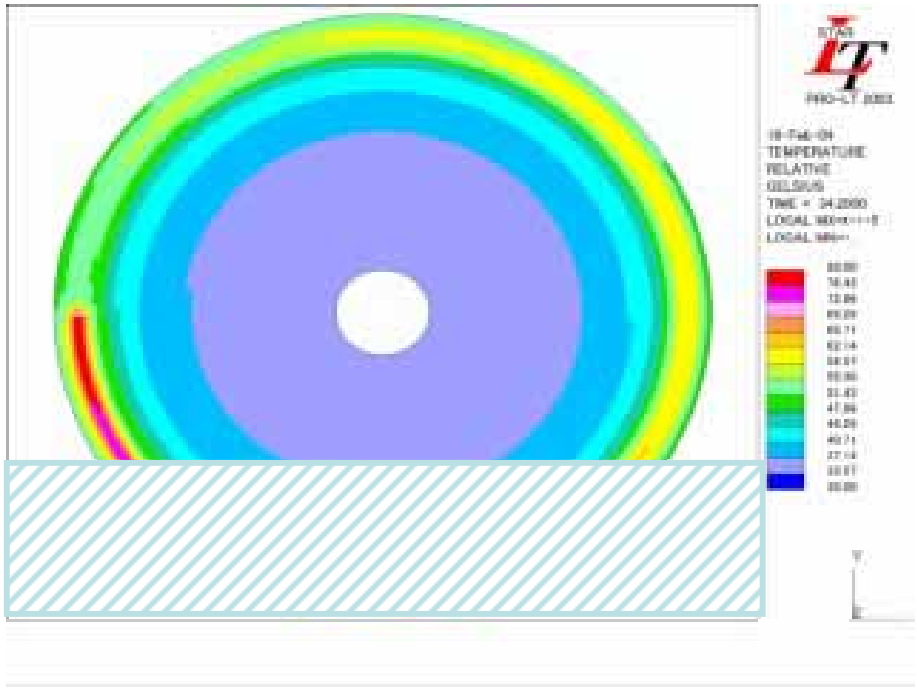
Divide a target disk so that
total energy deposit in each disk is equal



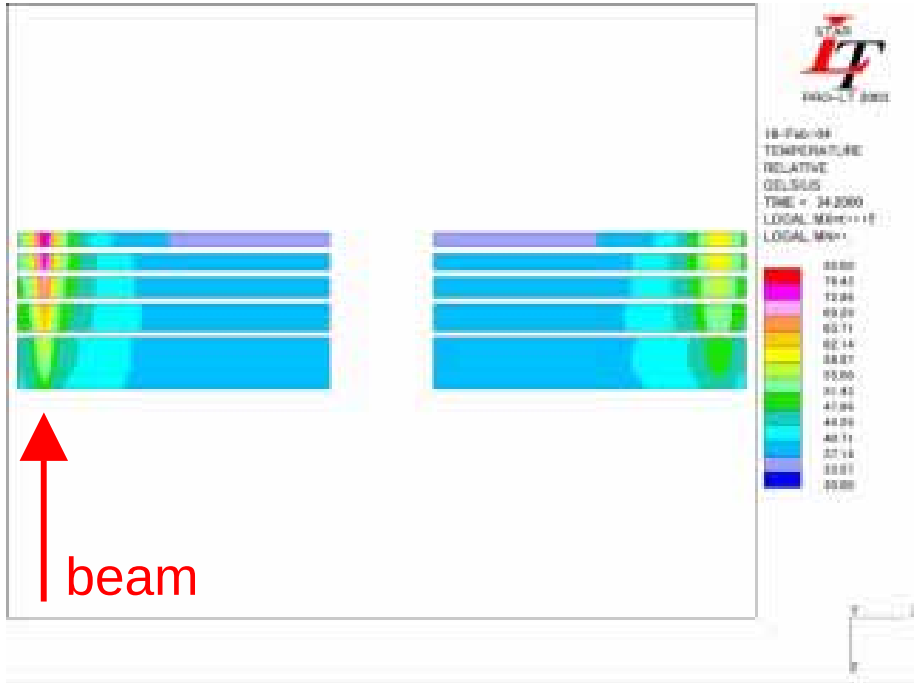
deposit per disk
6345 J/pulse
(1855 W)

Thermal Evolution

front view

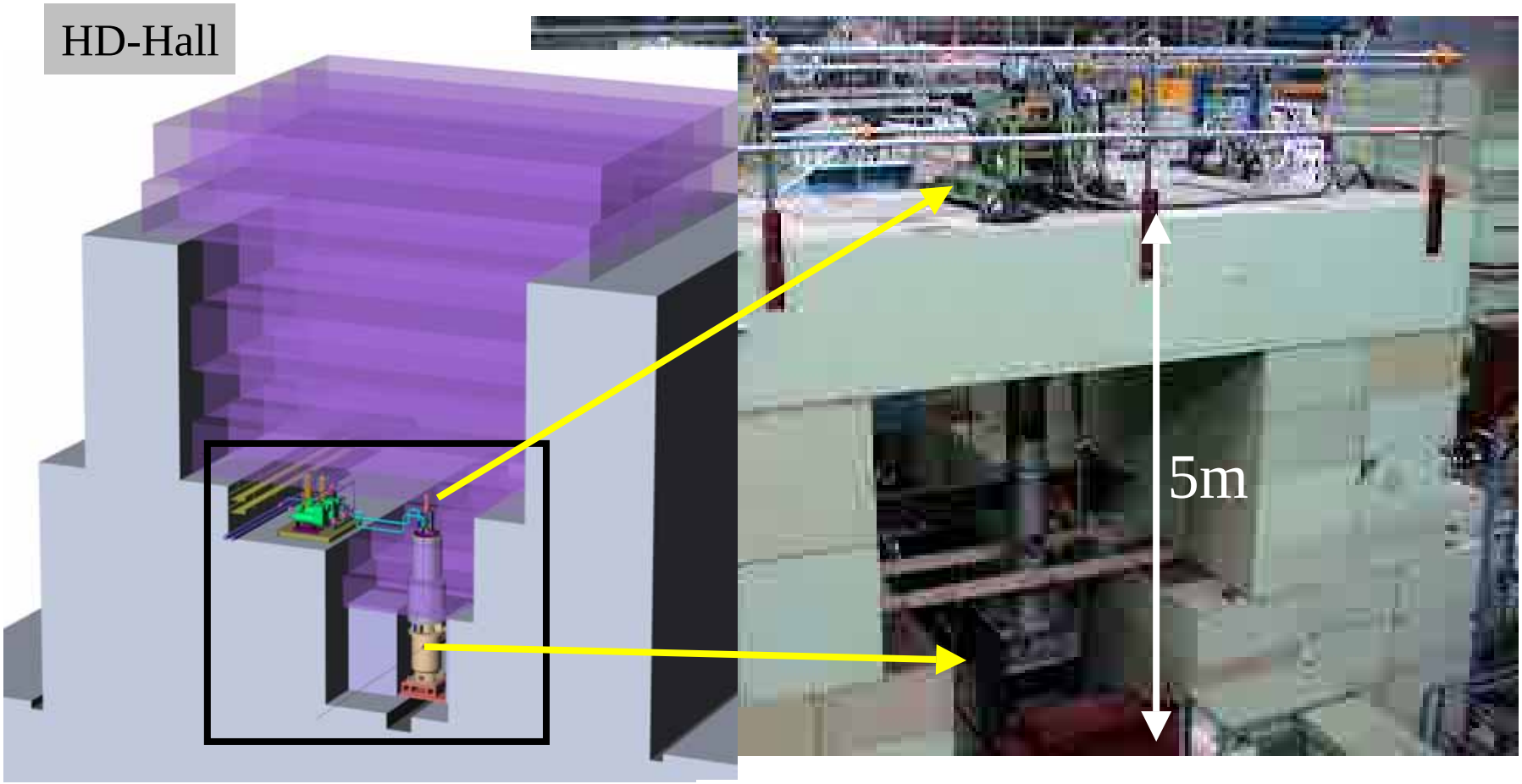


cross-sectional view



Max: about 80 ^{o}C

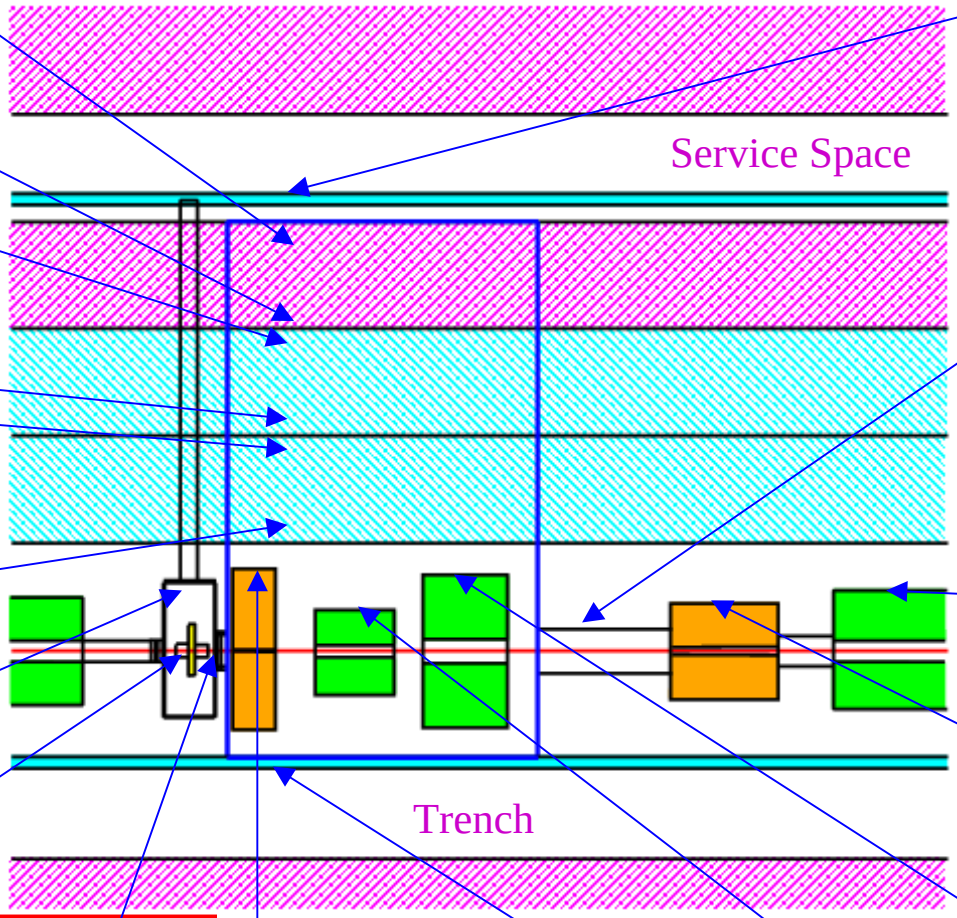
T1 Target Proto Type



Mock-up in East Counter Hall at KEK

Residual Dose

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



Concrete
7.9 μSv/h
0.03 μSv/h

Concrete
5.3 mSv/h
1.6 μSv/h

Iron
60 μSv/h
11 μSv/h

Iron
430 μSv/h
160 μSv/h

Iron
1.1 mSv/h
460 mSv/h

Iron
170 mSv/h
460 mSv/h

T1 Vessel
2.2 Sv/h
850 mSv/h

T1 Target
650 Sv/h
230 Sv/h

Vacuum Seal
30 Sv/h
11 Sv/h

Collimator
380 mSv/h
100 mSv/h

Iron Base
560 mSv/h
210 mSv/h

D1
530 mSv/h
270 mSv/h

Q1
62 mSv/h
33 mSv/h

Collimator
710 mSv/h
420 mSv/h

q1B
110 mSv/h
49 mSv/h

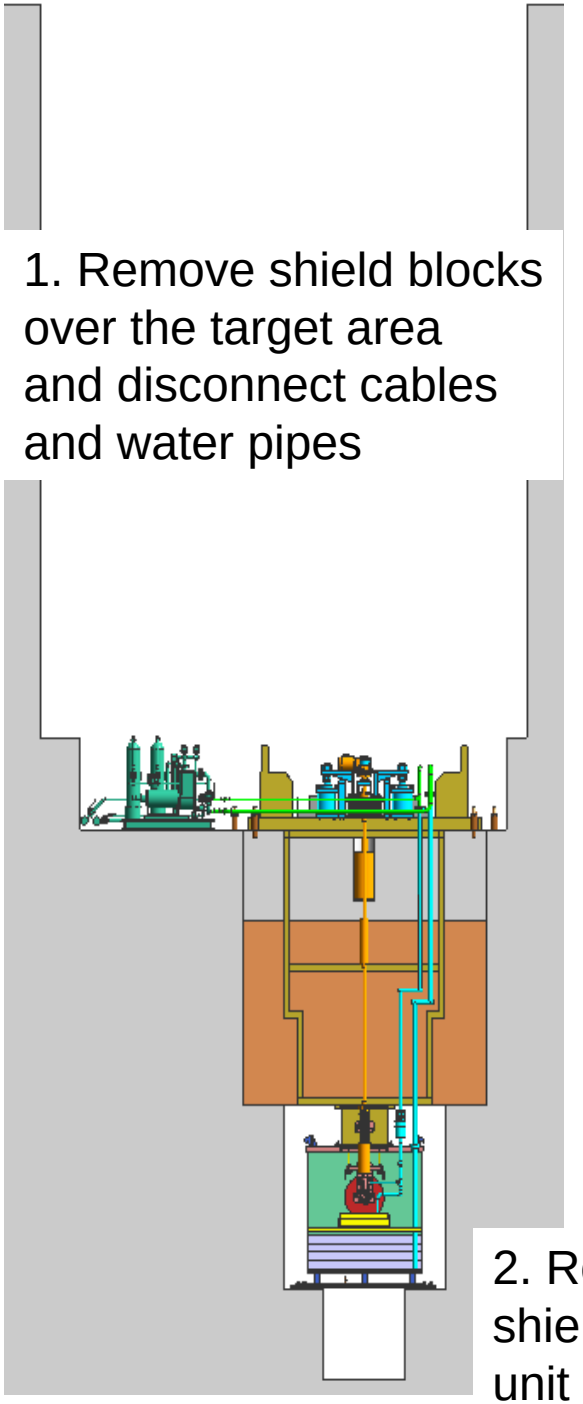
Vacuum Duct
SUS 3.2 Sv/h
1.2 Sv/h

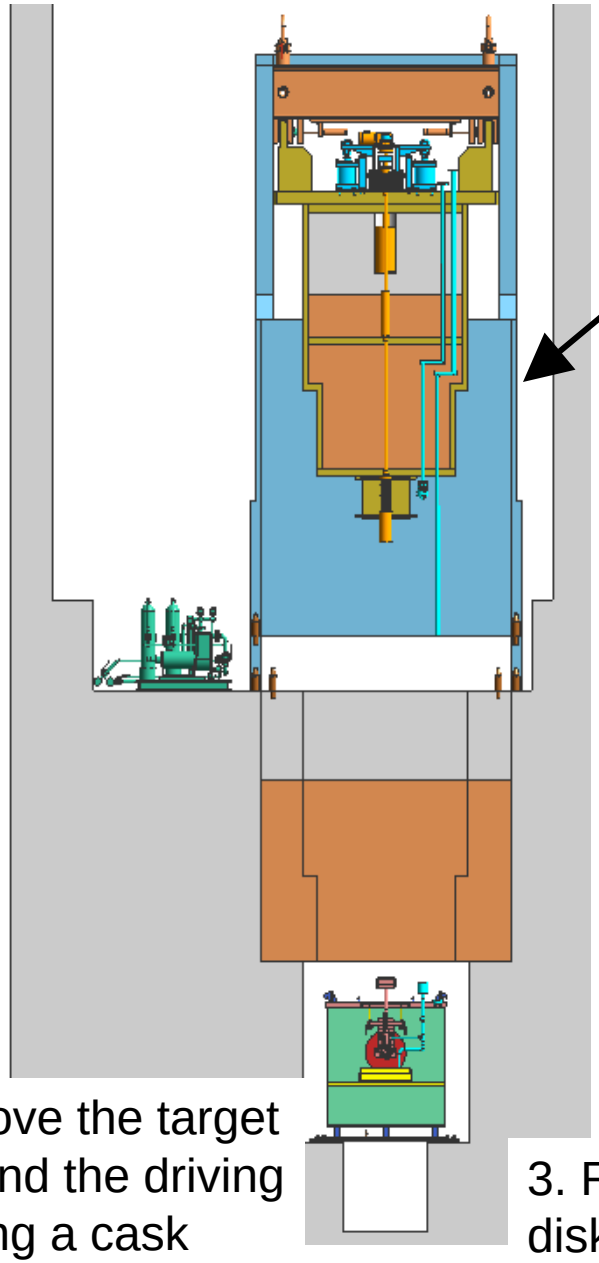
Ti 1.1 Sv/h
97 mSv/h

Water Pipe (SUS)
8.4 μSv/h
2.4 μSv/h

How To Exchange Disk

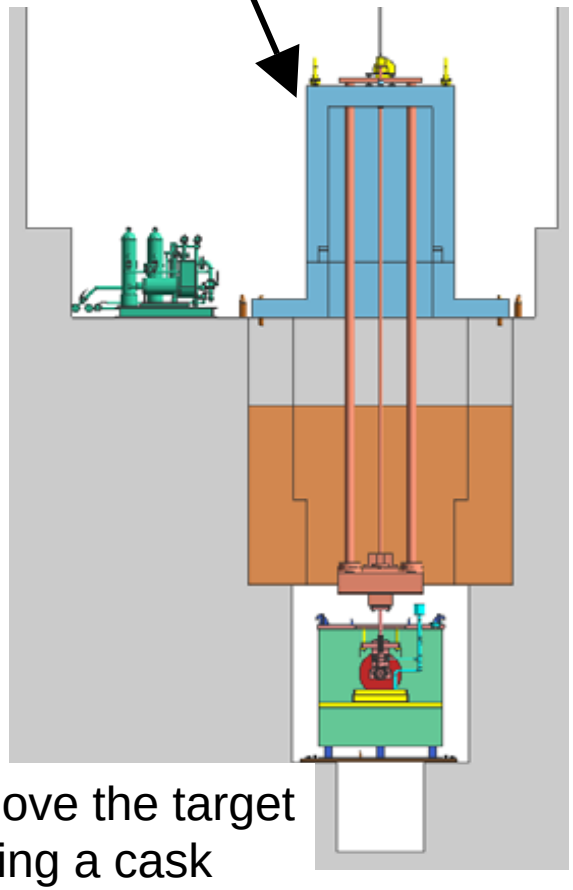
1. Remove shield blocks over the target area and disconnect cables and water pipes





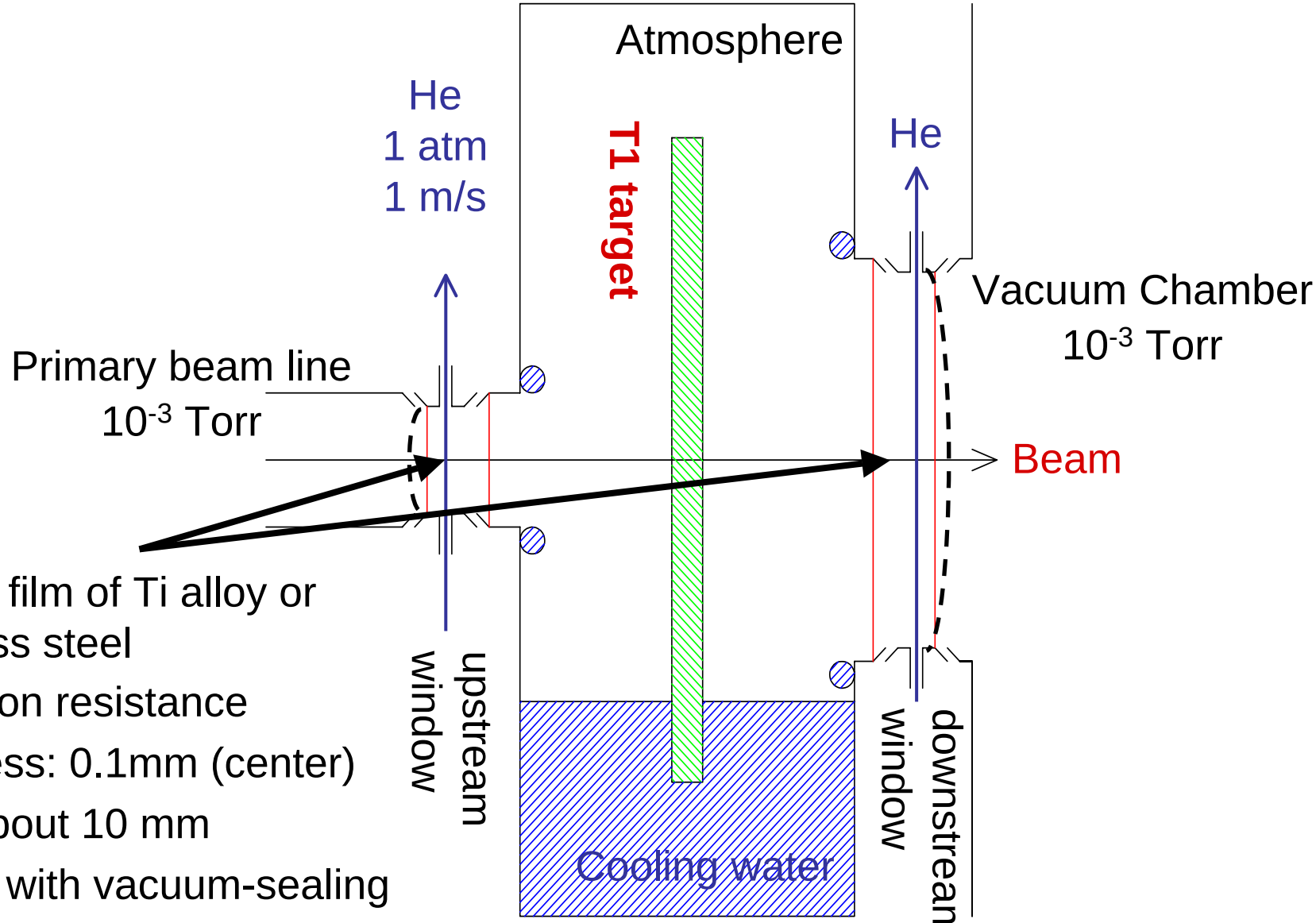
radiation-shielding cask

2. Remove the target shield and the driving unit using a cask



3. Remove the target disk using a cask

Beam Windows



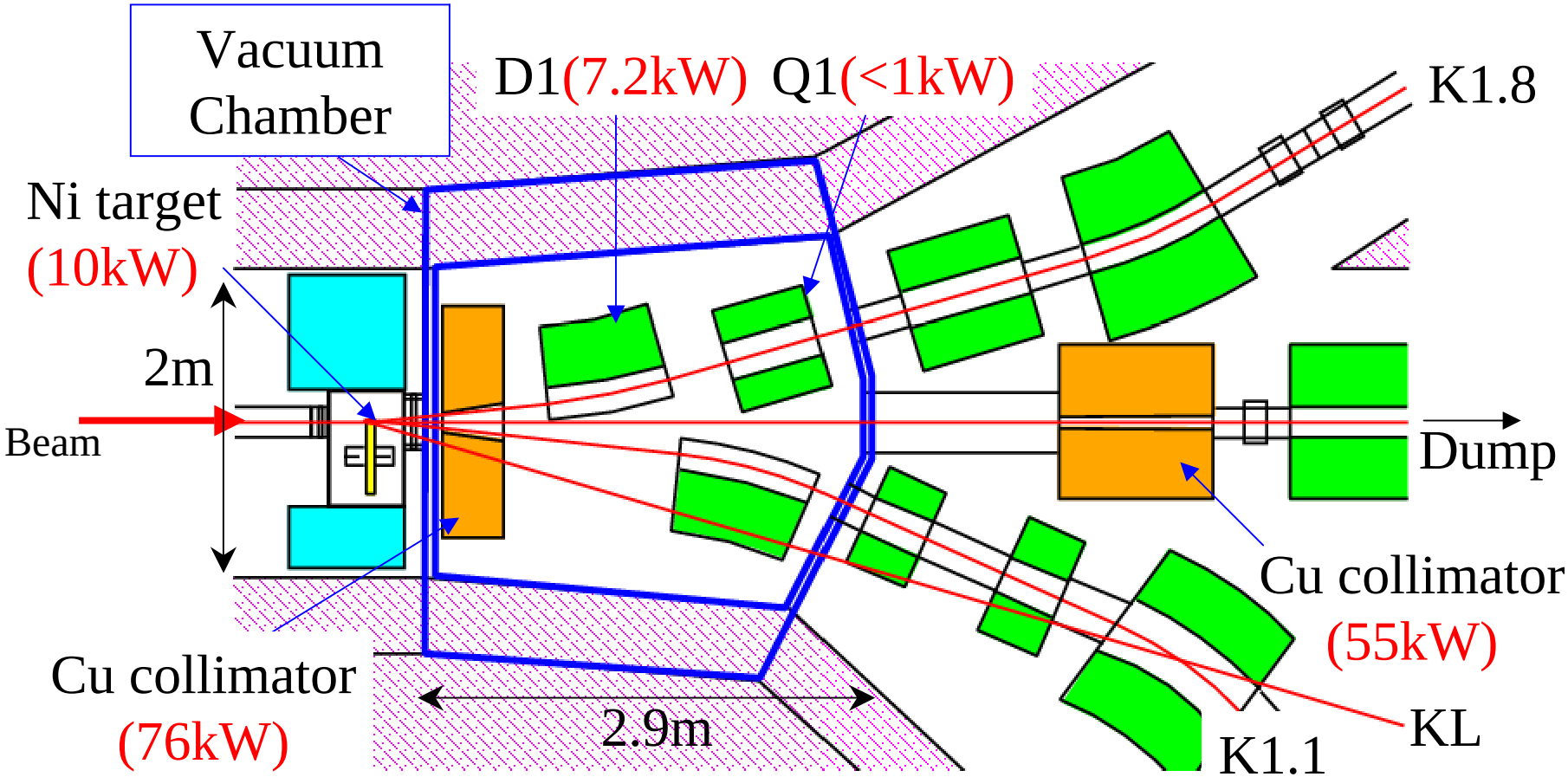
- double film of Ti alloy or stainless steel
- corrosion resistance
- thickness: 0.1mm (center)
- gap: about 10 mm
- unified with vacuum-sealing device

Downstream of T1 Target

How to solve 200kW Heat Problem?

Magnets → Upstream Collimator

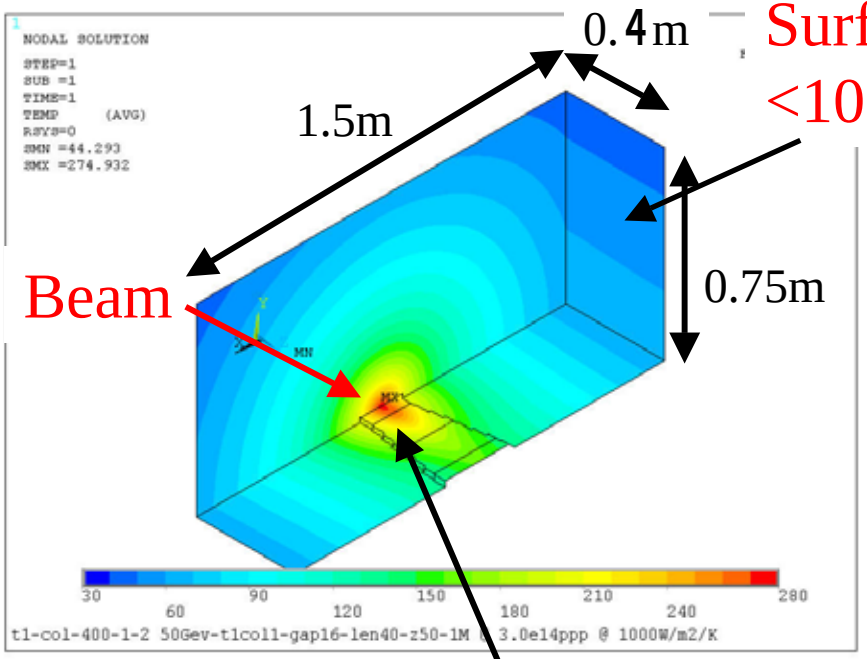
Beam Ducts → Big Vacuum Chamber instead of Ducts



Collimator

Thermal analysis using MARS and ANSYS

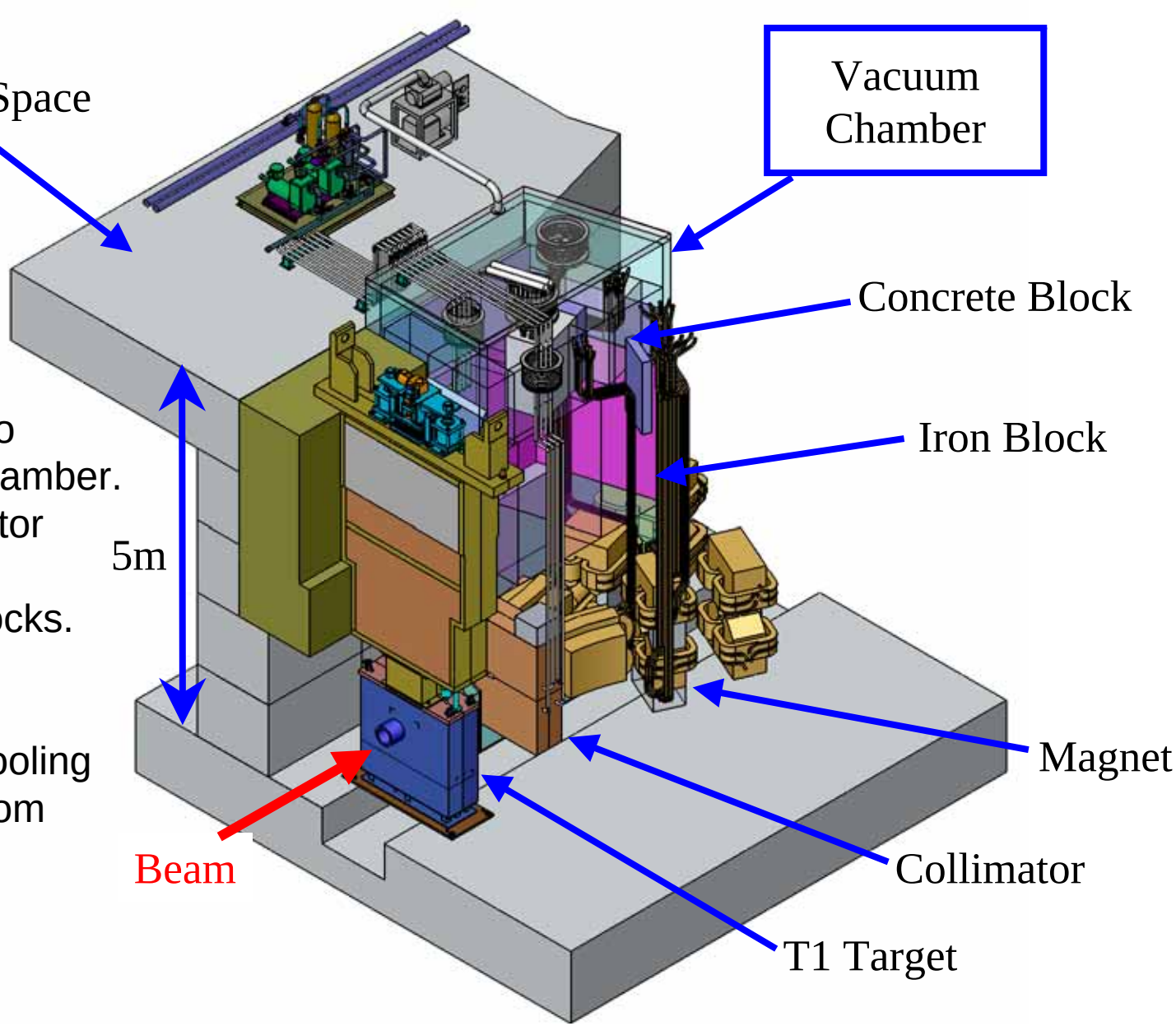
Cu collimator ($1.5m^H$ x $1.5m^W$ x $0.4m^T$)



- Aperture size
  - H=±80mm (145mm)
  - V=±16mm (22mm)
- Acceptance
  - x=±50mrad
  - y=±20mrad
- 50cm away from T1

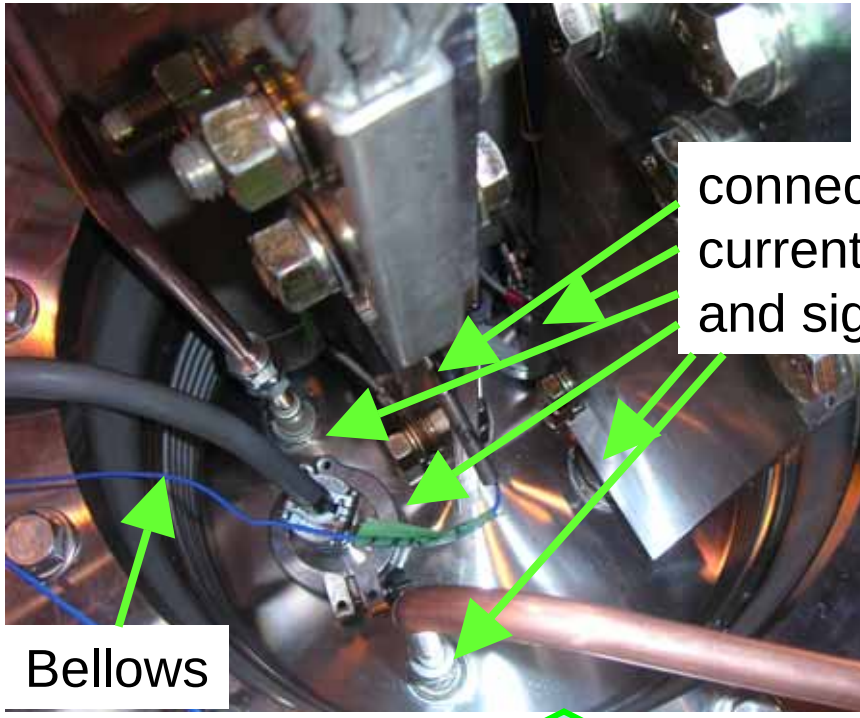
each side is cooled by 1000 $W/m^2/K$

Vacuum Chamber

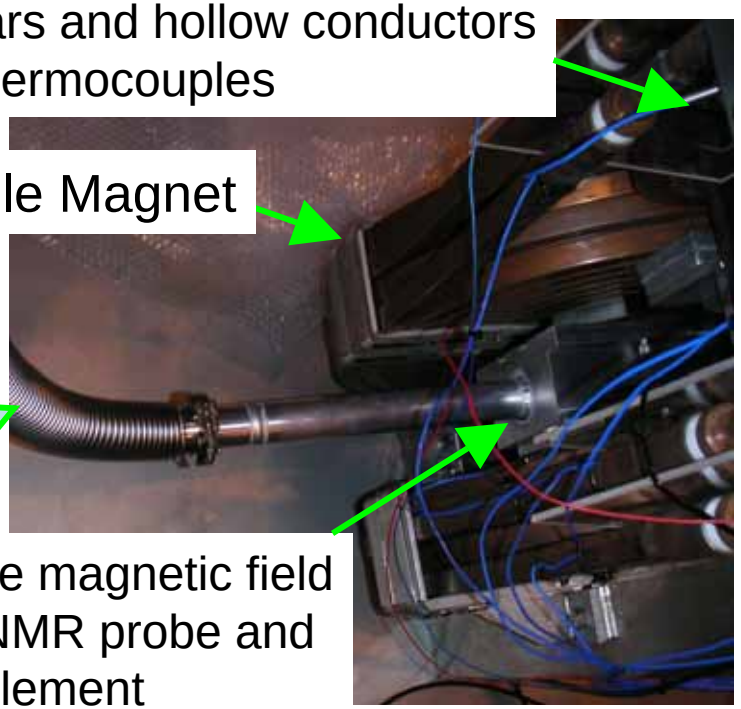


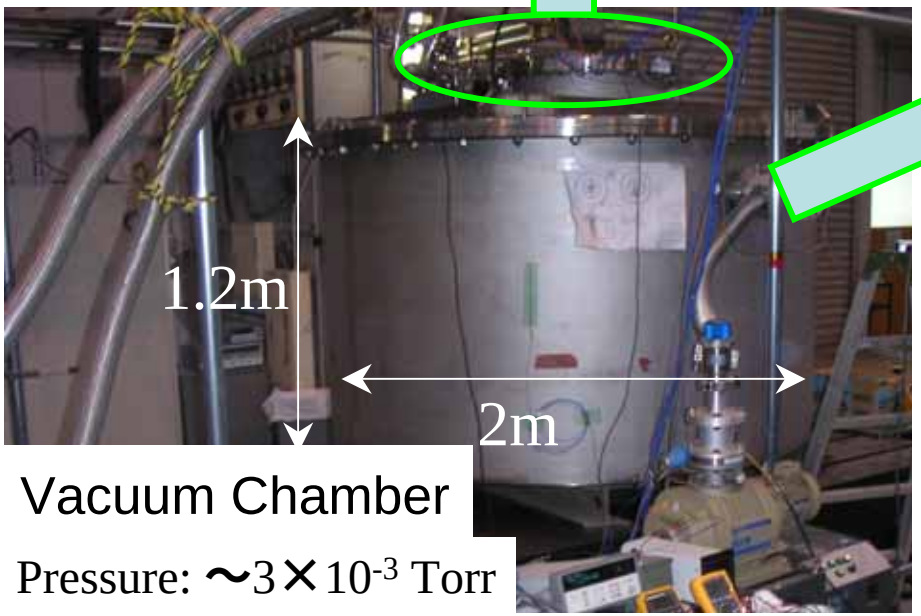
- Shield blocks are also inside the vacuum chamber.
- Each magnet/collimator has module structure unified with shield blocks.
- Chamber lid is at the service space level.
- Electric power and cooling water are provided from the service space.

Magnet in Vacuum



measure temperature of
bus bars and hollow conductors
with thermocouples





Magnet works in vacuum successfully with current of 3000A!

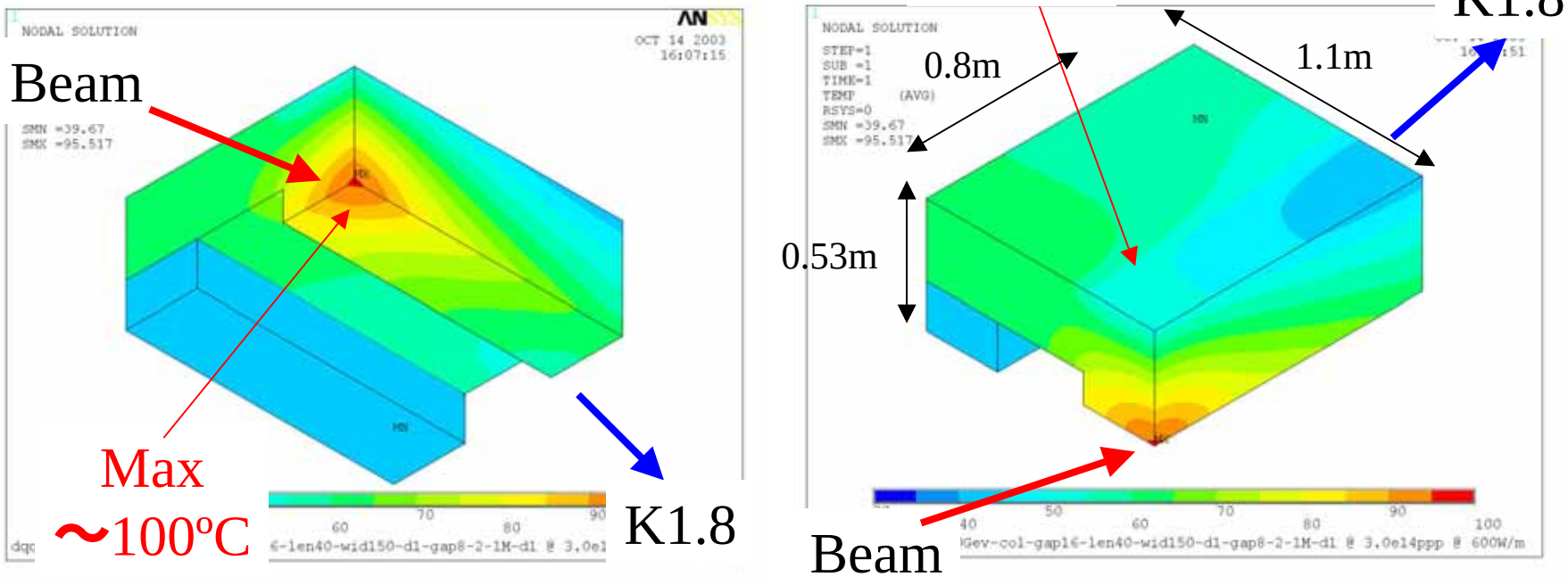
Next Plan

- Make T1 proto-type #2
- R&D for water-cooling system
- Detailed design of vacuum chamber
  - Mechanical and thermal analysis
  - Maintenance scenario
- Construct vacuum-chamber mock-up

Appendix

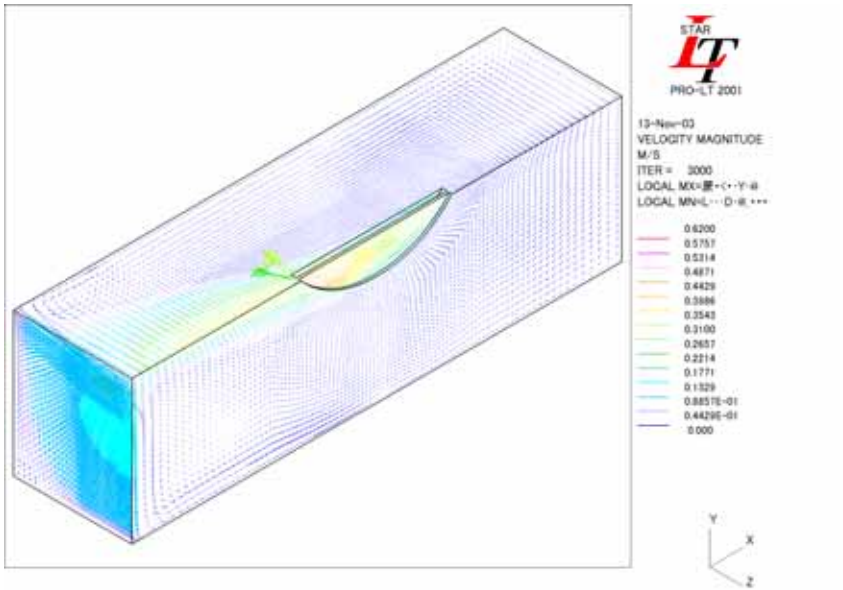
K1.8 D1 Magnet

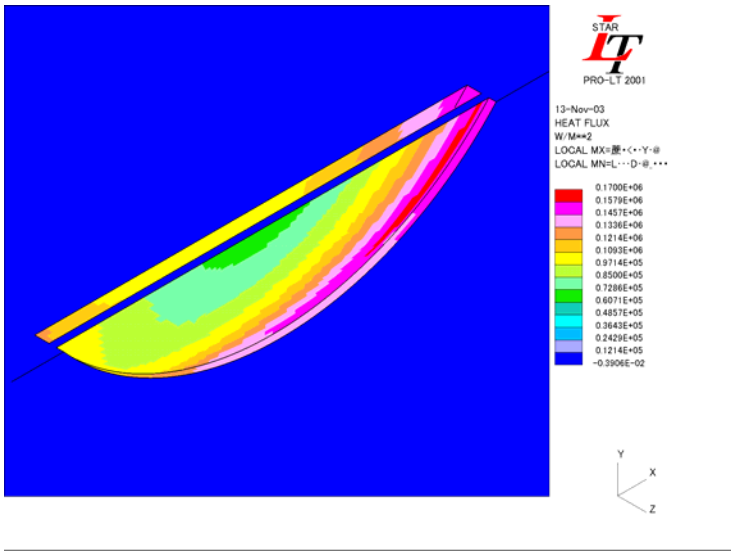
Thermal analysis using MARS and ANSYS



Yoke is cooled by 600 W/m^2/K

Thermal Convection of Disk Surface





解析コード: **流体解析プログラム** STAR-LT 2001
使用要素タイプ: **6面体要素**
境界条件: **全て標的ディスク壁面を60℃固定**
流体モデル: **非圧縮性流体、乱流モデル→k-ε モデル**

近似式
K= {3423−0.6908×(d−d0)−7.206×(h−h0)} × {(0.7895×v+0.1573)}

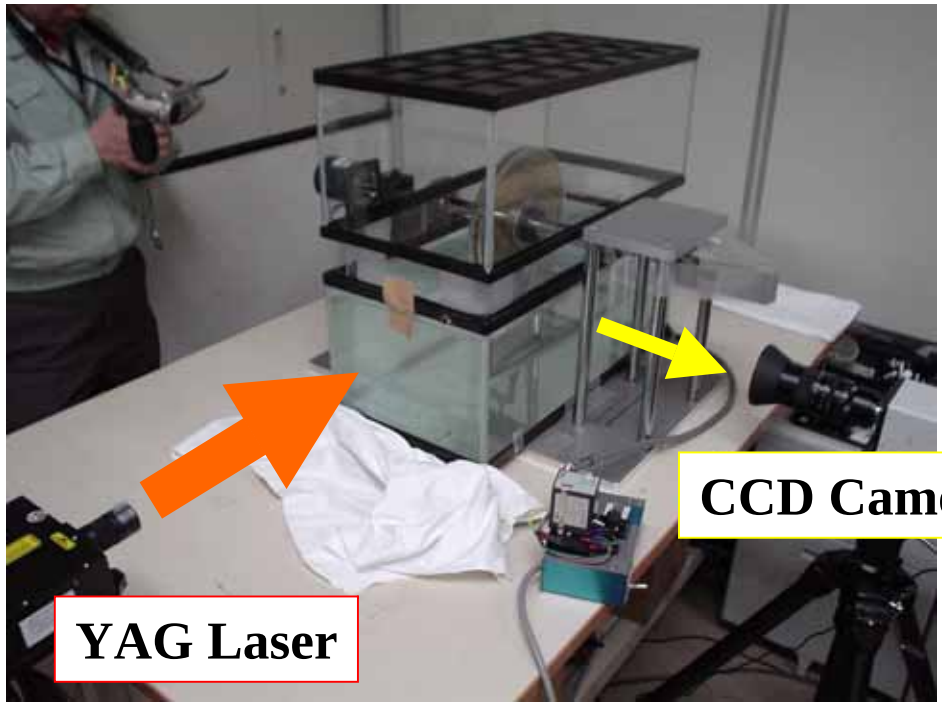
K:**平均熱伝達率** d:**ディスク径** (mm) 、h:**水没深さ**(mm)、v:**外周速度**(m/s)
基準設計値 d0=360mm、h0=40mm、v0=1.07m/s

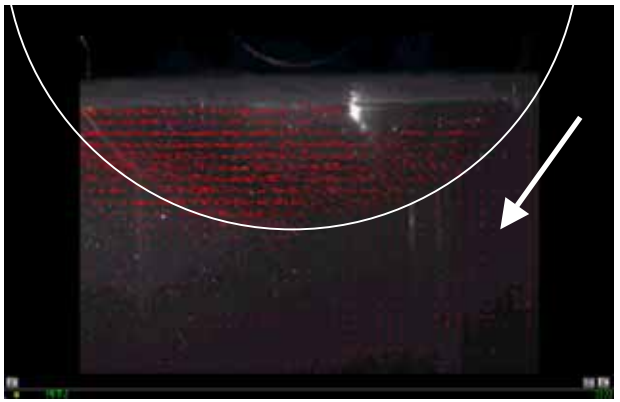
Tritium

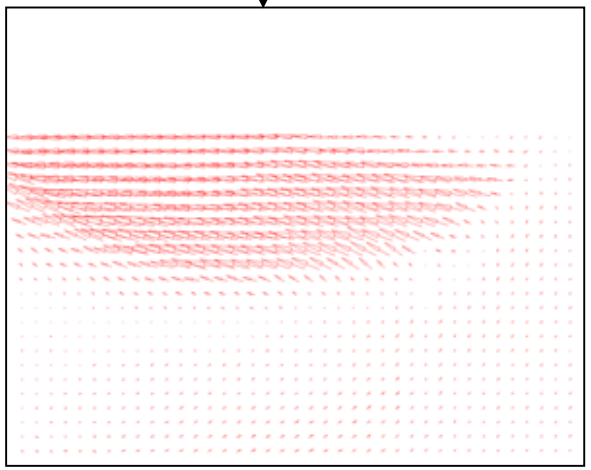
Estimated tritium density in 30t water
after 30-days operation with 15μA beam

	Phase 1 (30 GeV)	Phase 2 (50 GeV)
Collimator#1	1.0 Bq/cc	1.3 Bq/cc
Collimator#2	11 Bq/cc	16 Bq/cc
K1.8D1 coil	7.9 Bq/cc	11 Bq/cc
K1.8D1 yoke	2.1 Bq/cc	2.5 Bq/cc

Particle Image Velocimetry



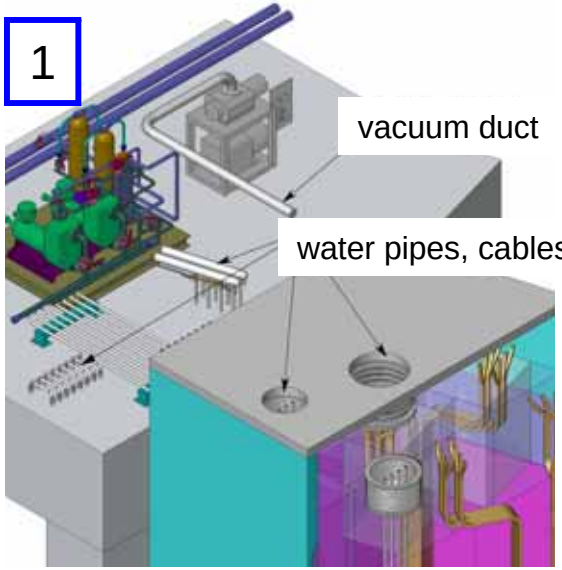




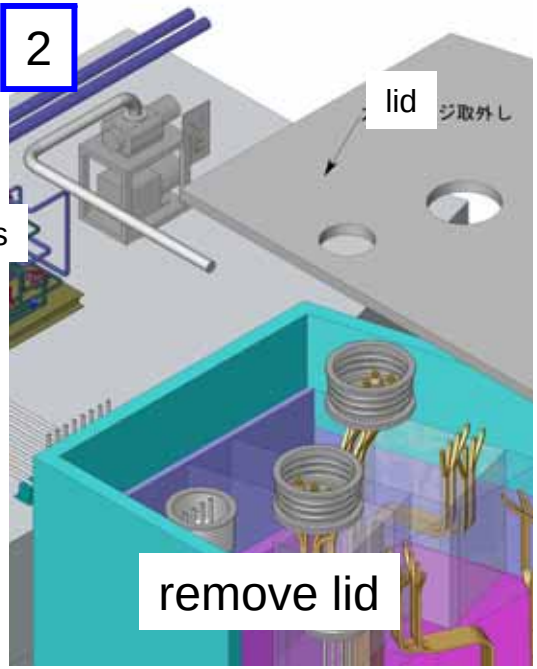
Disk：240 mm$^{\phi}$, 6 mm^{t},
acryl disk, gap, metal disk, gap, acryl disk
YAG laser：beam size 3 mm$^{\phi}$, 7 ns,
oscillated like sheet by 30 Hz
CCD camera：1008x1018 pixels, pixel □9 μm、
shutter 1/10000 s

Maintenance Scenario

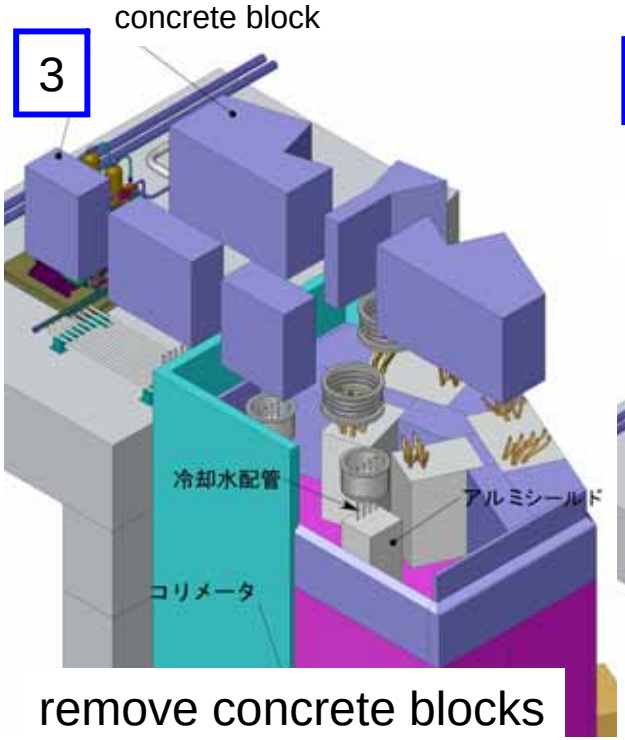
How to exchange collimator



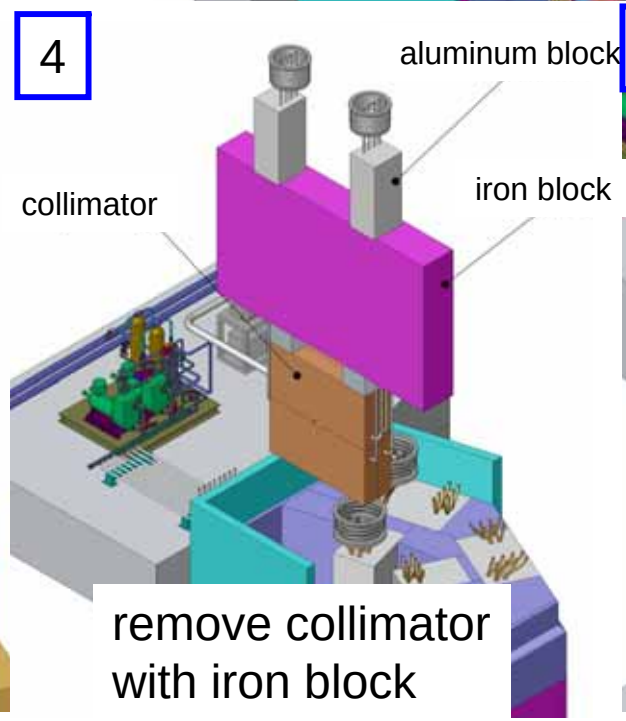
disconnect cables, pipes



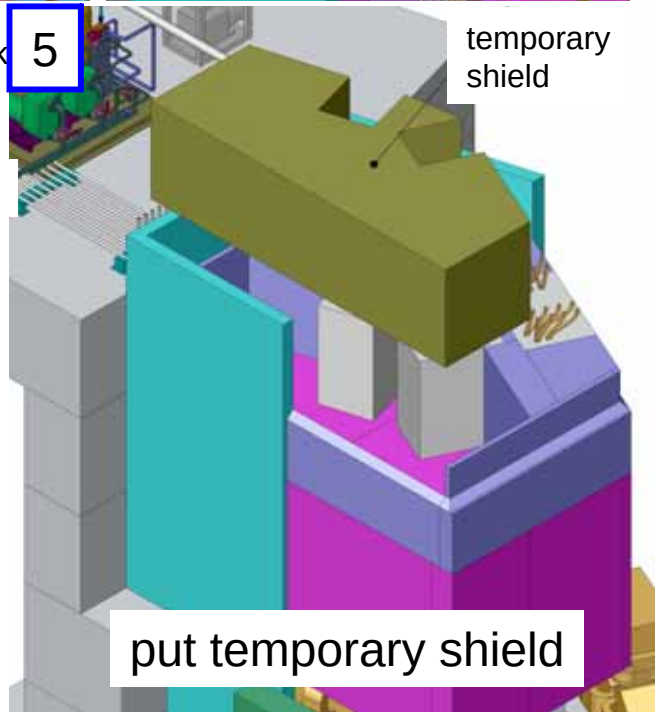
remove lid



remove concrete blocks



remove collimator with iron block



put temporary shield

Alignment Test with Dummy Cask