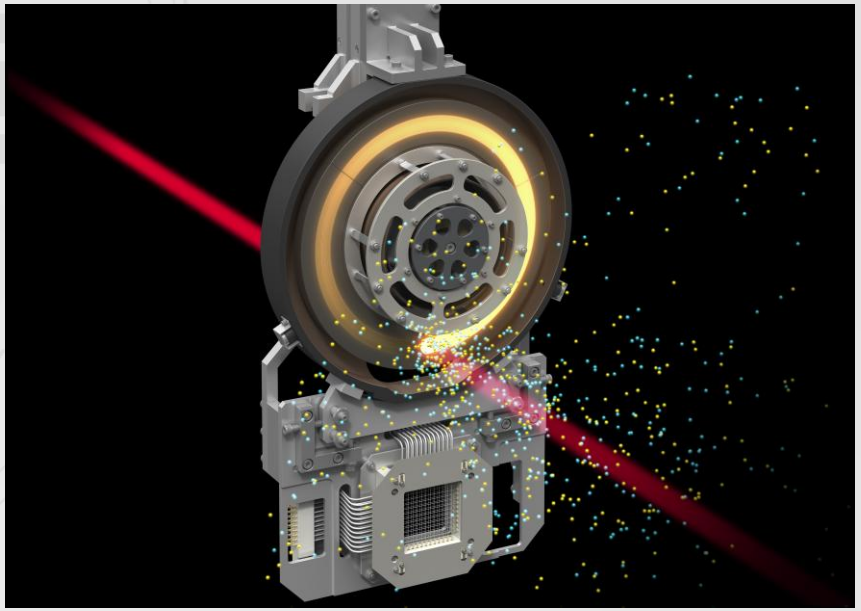
BRIDGE 2025 at Yayoi auditorium,
University of Tokyo on October 20, 2025.

MLF Muon target



KEK/J-PARC
Hikaru Sunagawa

Contents

1. Muon production target at MLF

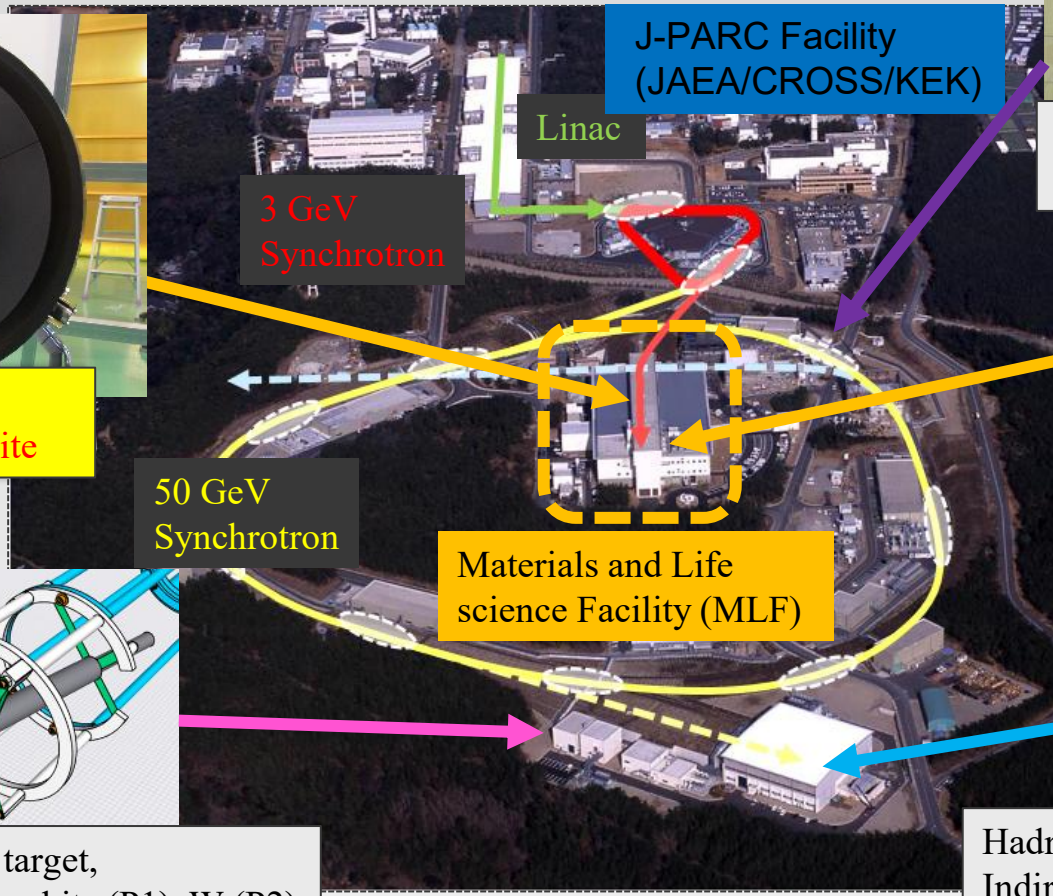
2. Challenges to achieve stable operation at 1MW

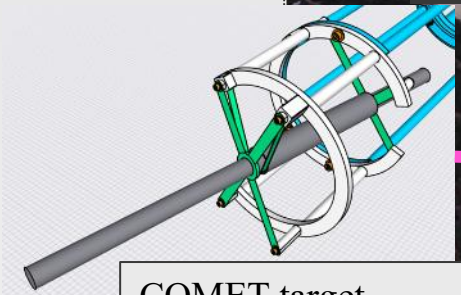
Various target at J-PARC

Muon target
Rotating, Graphite

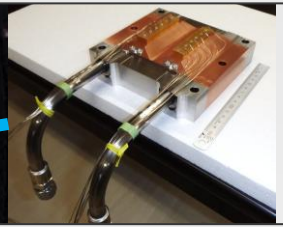
Neutrino target
He-gas-cooled, fixed, Graphite

Neutron target
Liquid metal, Mercury





COMET target,
Fixed, Graphite (P1), W (P2)

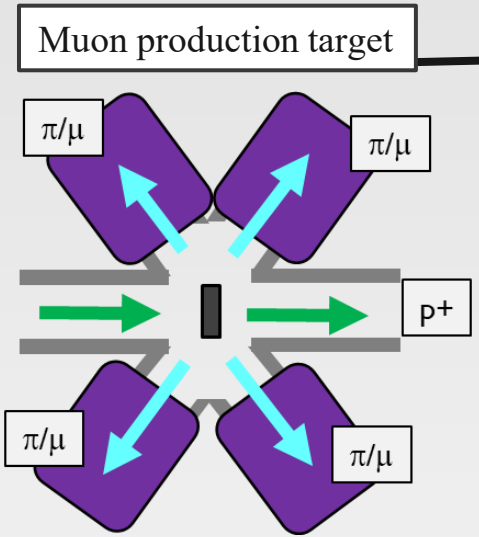


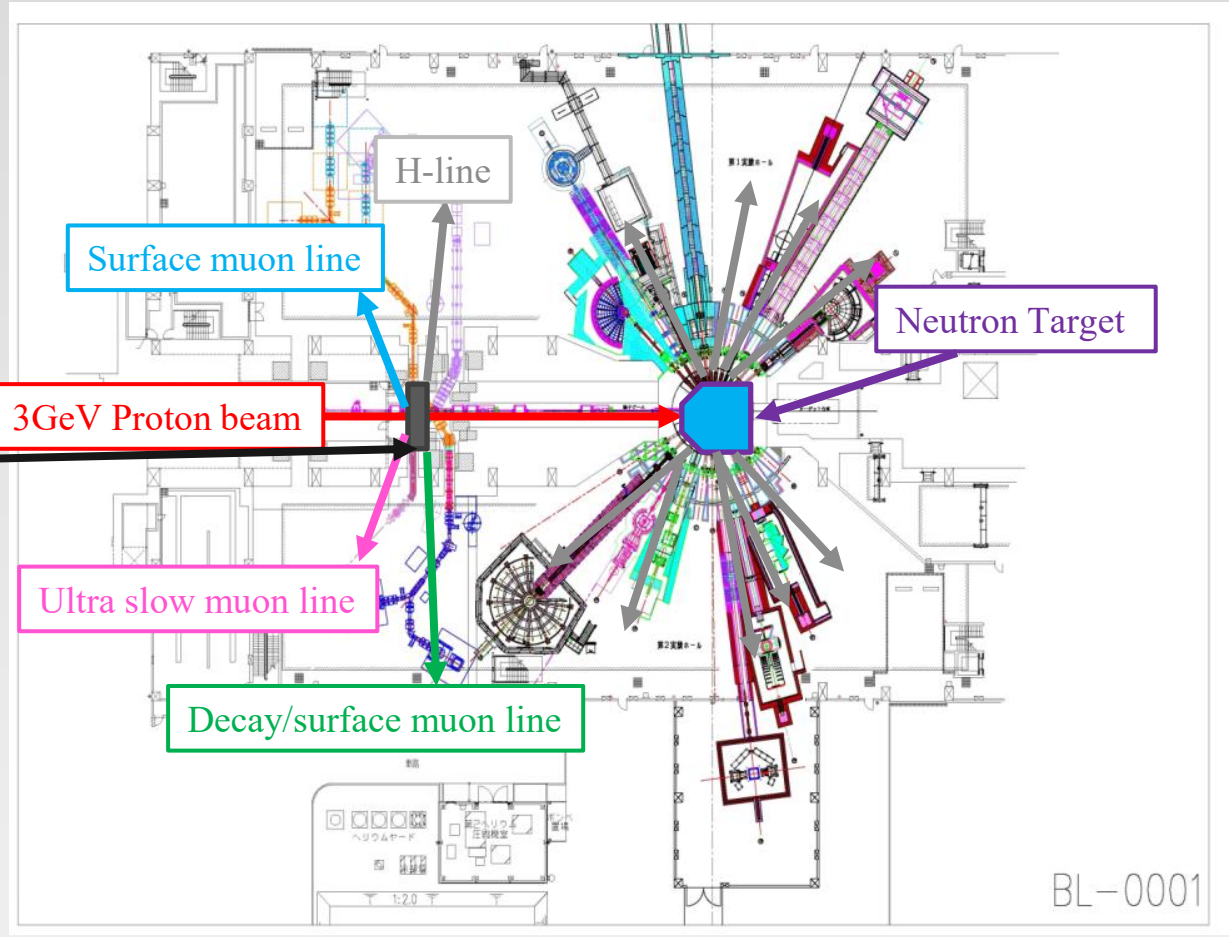
Hadron target
Indirect-water cooled, Fixed, Gold

Materials and Life science Facility (MLF)

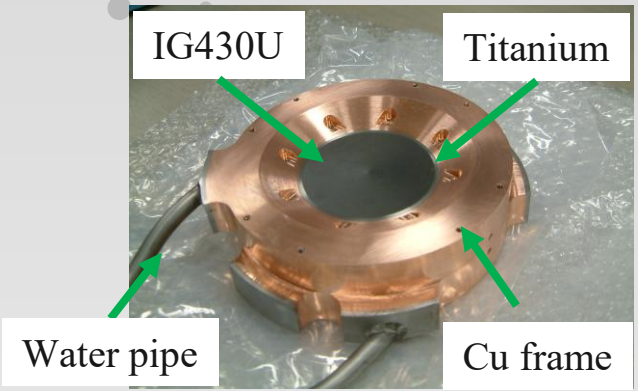
MLF : muon and neutron target.

Muon beam line
- Surface muon line (S-line)
- Decay/surface muon line (D-line)
- Ultra slow muon line (U-line)
- H-line





Muon production target at MLF

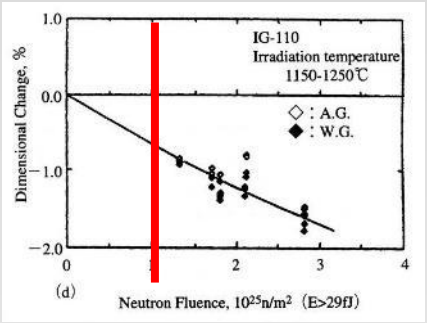


Muon fixed target (2008-2013)

Isotropic Graphite
(IG430U; Toyo Tanso Co., LTD.)
Thickness : 20 mm
Diameter : 70 mm
Fixed edge-cooling method

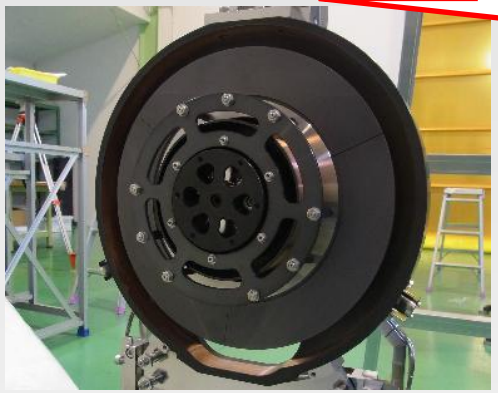
Irradiation by proton beam to graphite,
Lifetime; 0.5 year (@1MW)

1dpa



H. Matsuo, graphite1991 [No.150] 290-302

Change



Muon rotating target (2014~)

Rotating target, installed in 2014
Lifetime: Bearings
Aiming Lifetime: 10 years at 1 MW operation

1st target : 2014-2019 (Design mistake of shaft coupling)
2nd target : 2019~

Muon production rotating target

~3 m

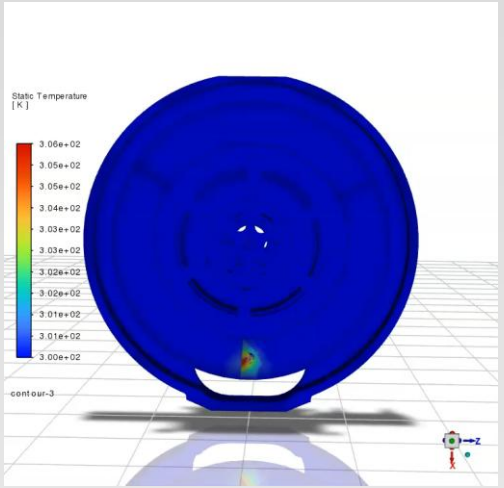
Target rod:
Up and down movement allows monitors and targets to be installed along the proton beam line.

Plug shield:
Shield radiation upward from the target, enabling component replacement above the target.

Graphite Target

Beam profile monitor

Graphite Target (IG430U)



- Shape (doughnut-shaped)
  - Outer diameter：336 mm
  - Inner diameter ：220 mm
  - Thickness ：20 mm
- Rotation speed : 15 rpm (0.25 Hz)
- Beam Size：14 mm (2σ)

Structure of rotating target

Motor & Magnet coupling

Transmitting rotational drive from air into the vacuum.
Replacement cycle: 2 years

Miter gear

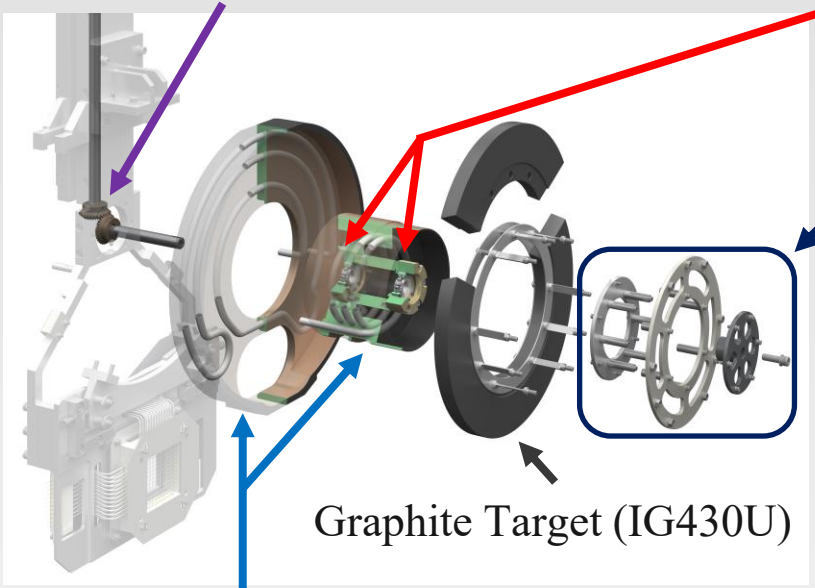
Transmit rotational drive at right angles.

Target shaft bearings (used at J-PARC and PSI)

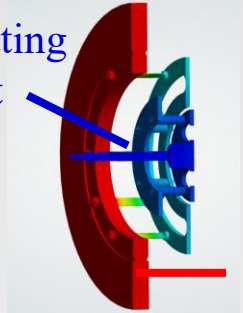
Separator (WS2)

By introducing solid lubricants (WS2) as separators, the lubricant quantity increases, thereby extending bearing's lifetime.

Expected lifetime : 10 years

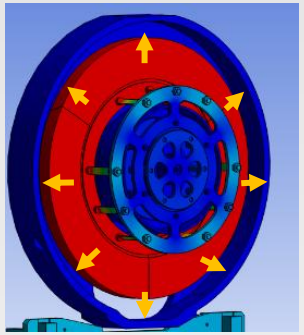


Inconel support



The design is longer distance to the bearing from high temperature target to increase thermal resistance.

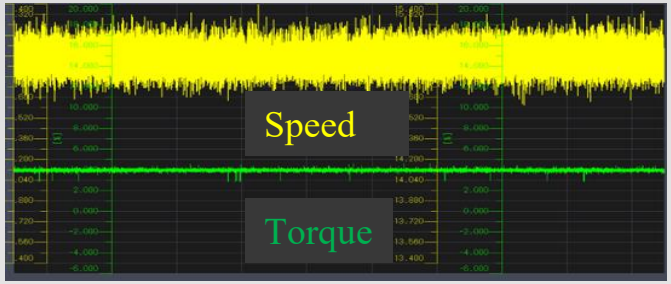
Cooling jacket & Cooling bearing box



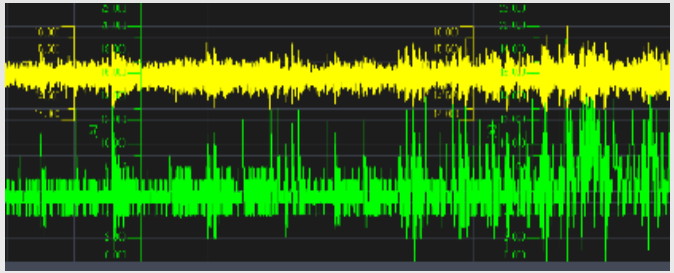
Thermal radiation cooling

Machine protect & Monitor systems

Motor speed & Torque monitor



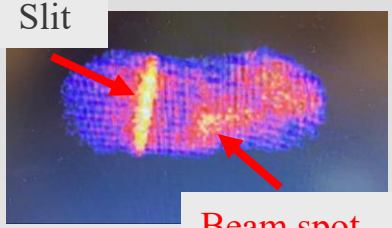
Normal



Abnormal

Detects excessive load and low speed to prevent machine failure.

Infrared camera (development)



Infrared camera image

Photo from upstream of the beamline

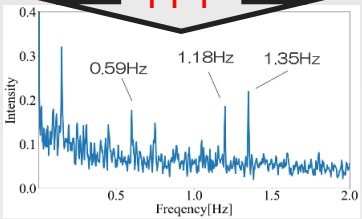
Observation with the infrared camera was successful.
But…radiation errors are the problem.

Now updating…

Torque vibration monitor (development)

Torque data

FFT



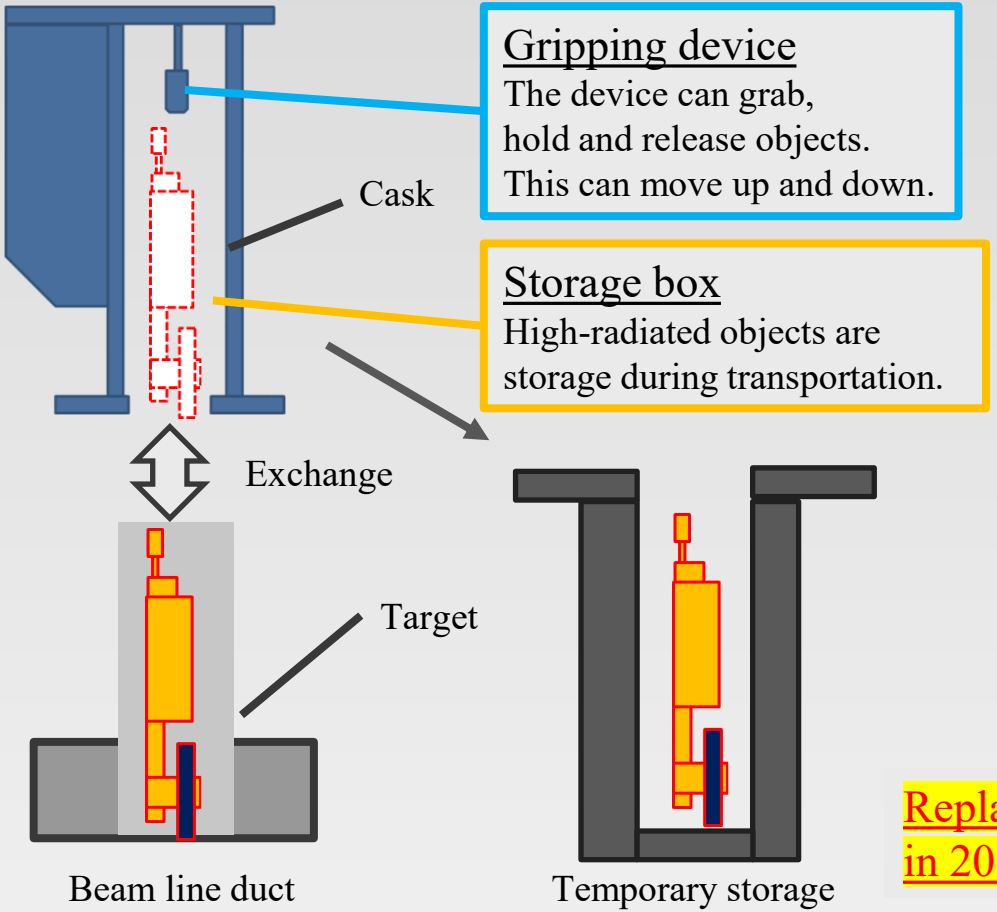
Bearing1 of Inner Shaft	Bearing2 of Inner Shaft	Bearing of Outor Rotor	Bearing of Target Shaft
0.155Hz	0.59Hz	0.995Hz	0.508Hz
1.36Hz	1.35Hz	1.966Hz	1.23Hz
0.39Hz	0.90Hz	1.534Hz	0.77Hz
0.31Hz	1.18Hz	1.99Hz	1.02Hz

Vibration components of the rotary feed-through bearings were confirmed from the torque data.→Fault prediction in the future.

Remote controlled target replacement.

• Over view of the cask

• view from below

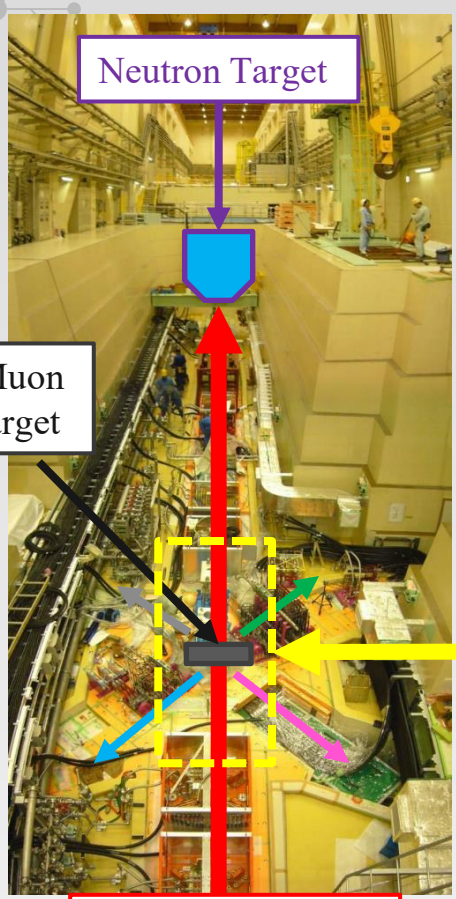


Gripping device
The device can grab,
hold and release objects.
This can move up and down.

Storage box
High-radiated objects are
storage during transportation.

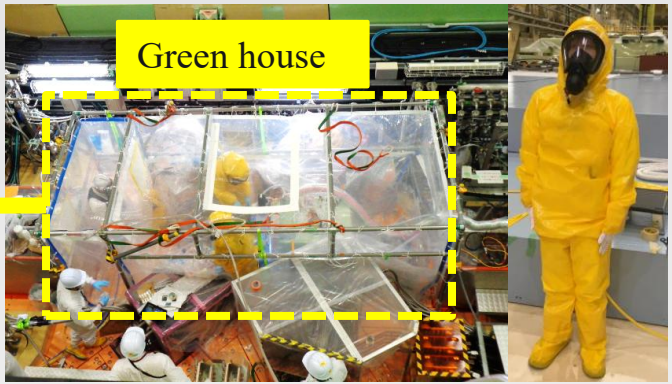
Replacement of target in 2019 was successful !

Maintenance



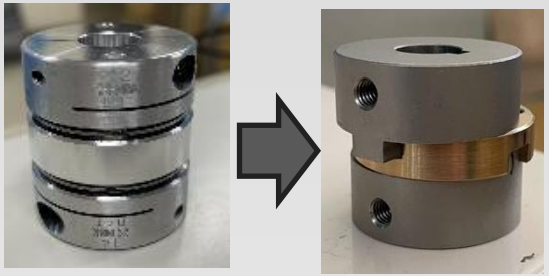
○Replacement of rotary feedthrough

The replacement work causes tritium within the duct to diffuse into the air, requiring reduced internal exposure for workers and prevention of contamination spread.



Maintenance in green house with anorak suits & airline mask.
→Workability is not good.

★Oldham couplings were introduced in 2022 (by S. Matoba)



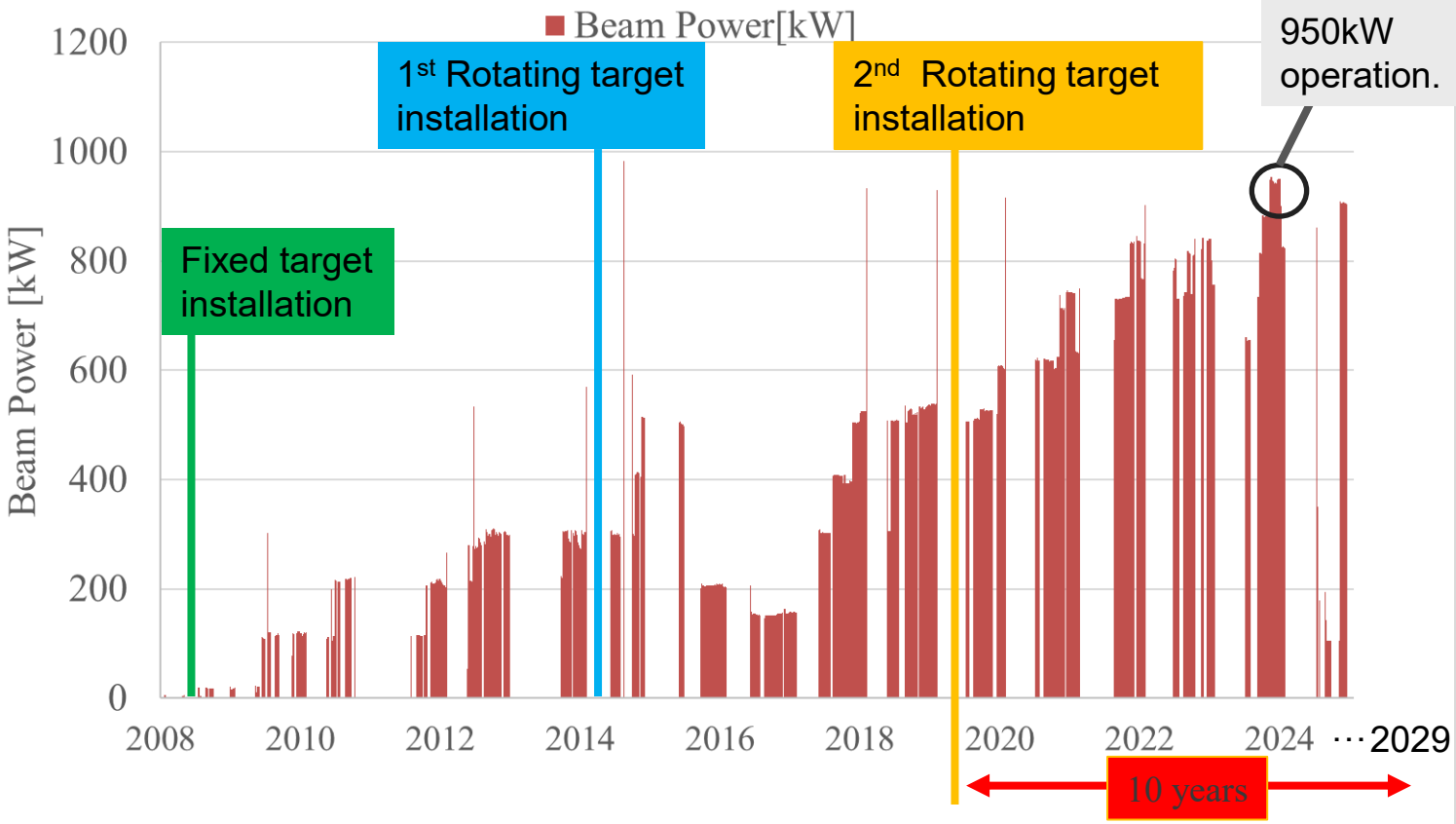
Desk type coupling Oldham coupling

Max. misalignment
0.25 mm → 0.6 mm

- Reducing the effects of eccentric conditions by misalignment.
- Shorter working times

The target rotated stably after replacement work in 2025.

History of muon production target operation



we believe it will continue to operate stably until 2029.

Contents

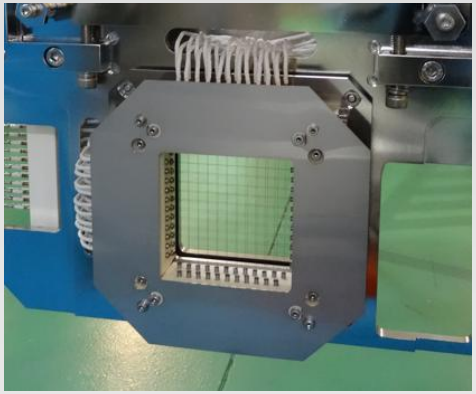
1. Muon Production target at MLF

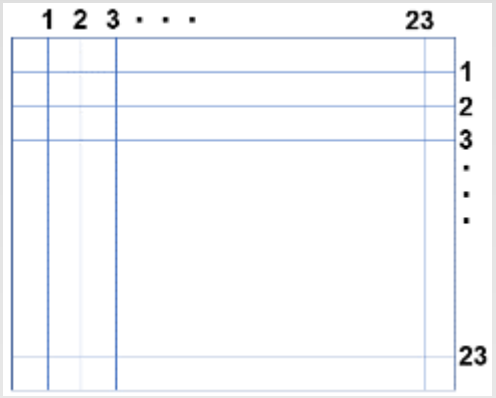
2. Challenges to achieve stable operation at 1MW
   - Beam profile monitor

Beam profile monitor

○Beam profile monitor

The beam profile monitor consists of 23 W-SiC wires in both the vertical and horizontal directions.



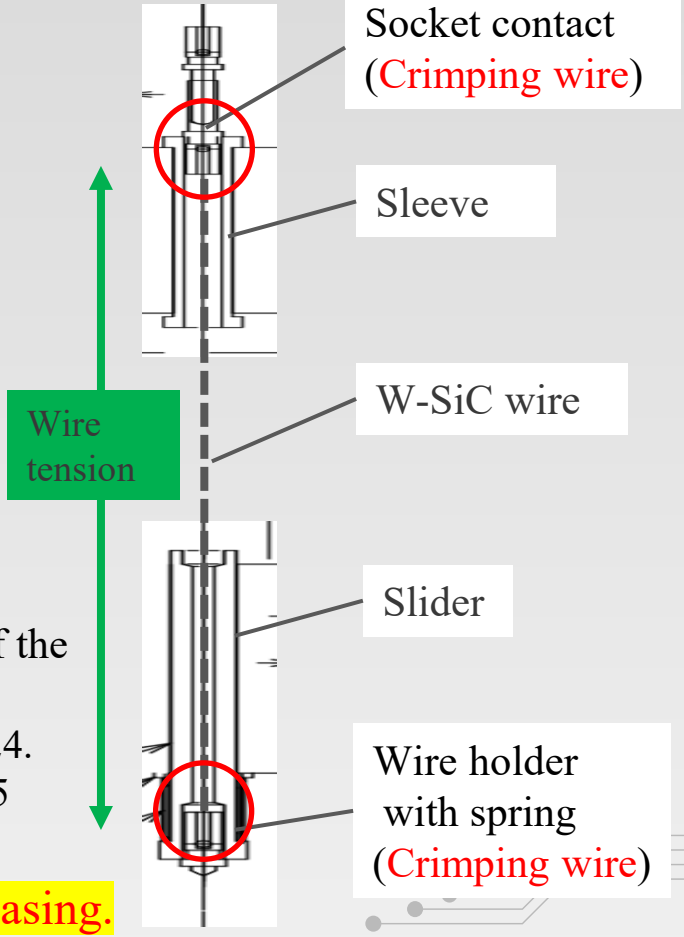


But…

a failure of the beam profile monitor located at the bottom of the target was found during 840 kW operation in 2024.

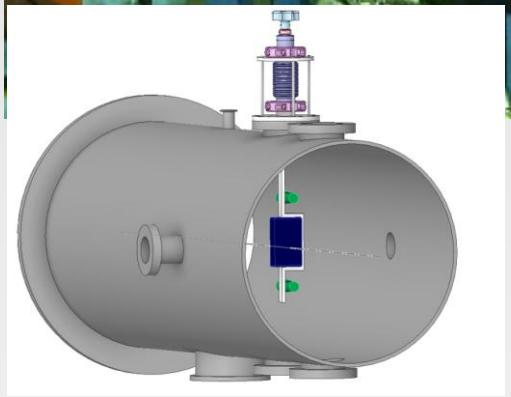
- Signals of No.12-14 vertical wire is not monitored in May 2024.
- Signals of No.11-16 vertical wire is not monitored in Feb 2025

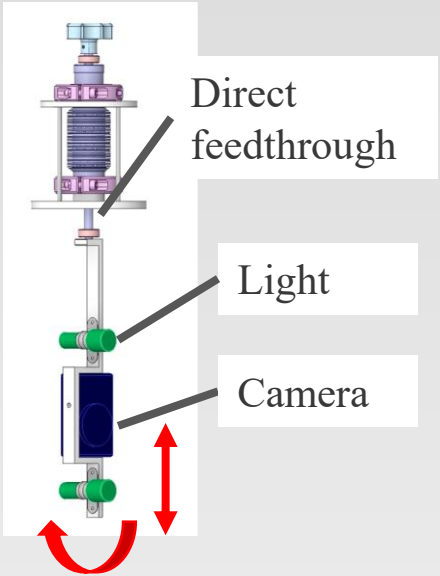
The wires that cannot be monitored is gradually increasing.



Beam profile monitor

○Photography from upstream of the beamline





○Camera insertion jig
Adjustable for up/down, rotation, and angle.

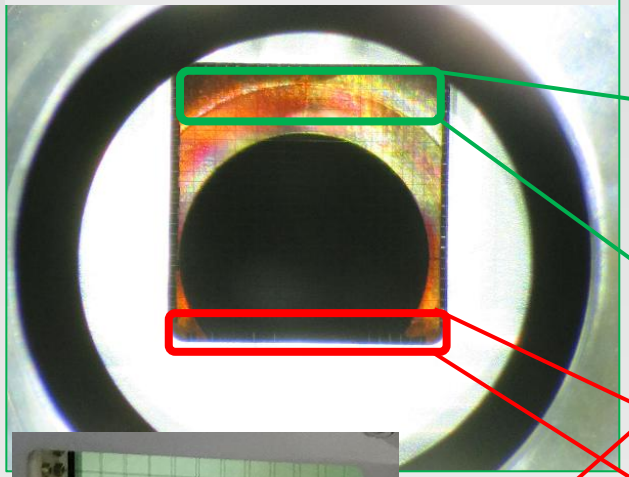
○Grove Box
Isolation of tritium diffusing when the beam duct port is open

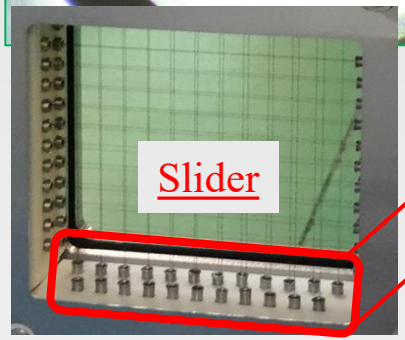
We successfully captured images.

Beam profile monitor

○Observation from upstream of beamline.

Photo of profile monitor taken from upstream of beamline in 2025.





Some wire (No.2,4,6,8) (downstream side) are missing.

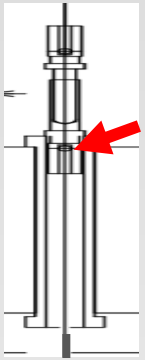
No.17-23 wire is visible.

Several wires towards the right of the center are missing. (No.11-16)

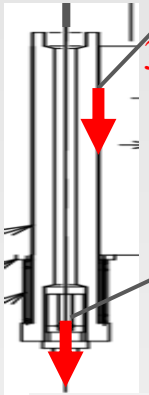
The slider is down.

The wire has come loose from the top, It suggests a bias in the pattern of wire detachment.

Why the slider is down ?

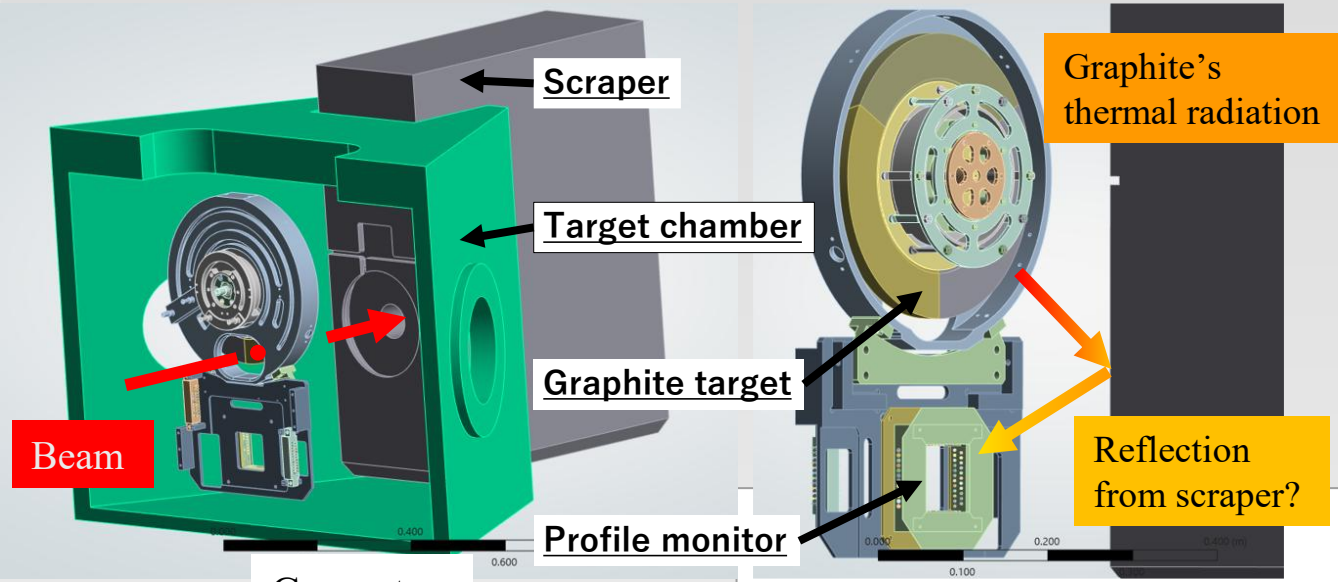


1. The wire came loose at the climped section at the socket contact.



Beam profile monitor

○Reserch of thermal radiation efficient by ANSYS.



Geometry

Constraint

・Heat generation

Using the heat deposit was estimated by PHITS simulation.

・Emissivity

Target and assembly(Black bodied) : ε=0.8

Other metal : ε=0.2

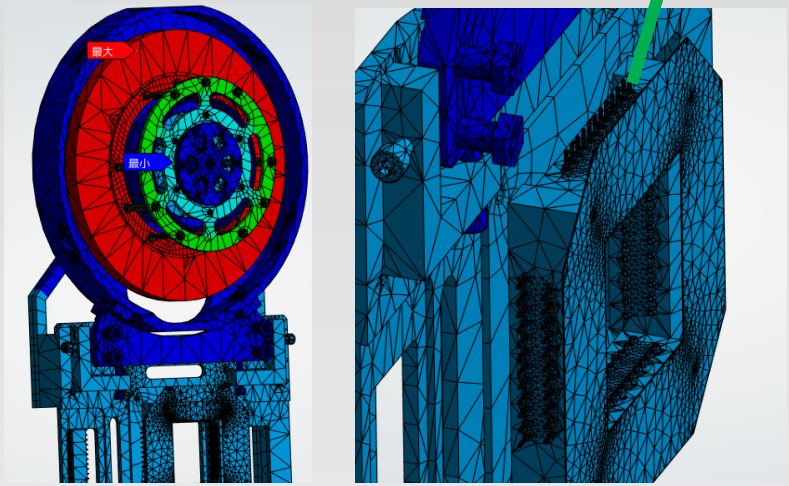
Ceramic (Al_2O_3) : ε=0.5

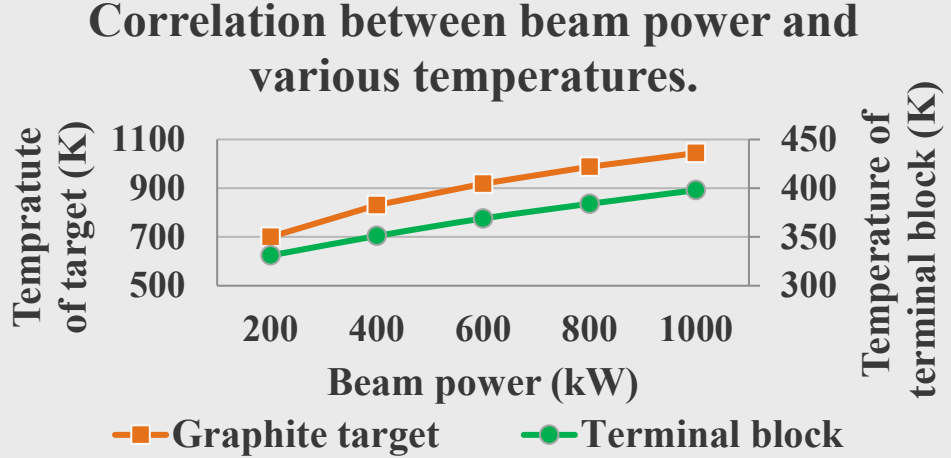
	Internal_heat_generation (W/mm^3) on 1MW
Graphite target (IG-430)	3.4E-3
Electrode guard at upper stream (SUS304)	3.89E-5
Electrode guard at down stream (SUS304)	6.58E-5
Terminal block (Al_2O_3)	3.08E-5
Profile monitor mounting plate (SUS304)	3.9E-5

We first suspected thermal effects and calculated the temperatures around the profile monitor by ANSYS.

Beam profile monitor

○Result

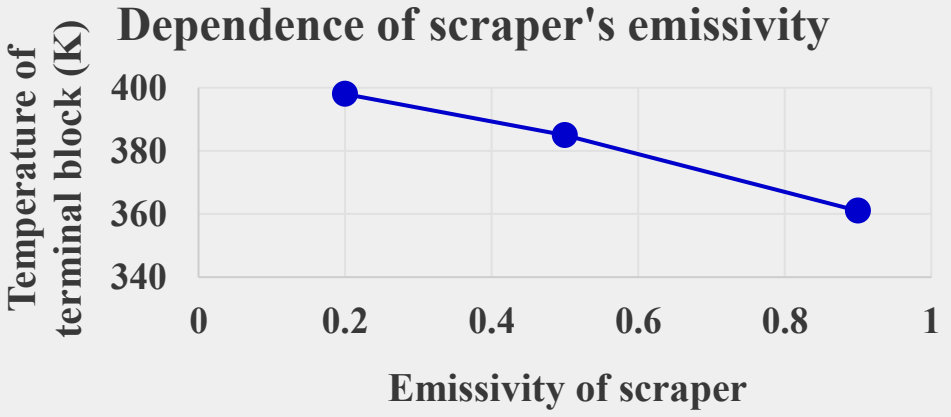




○The terminal block temperature increase with beam power, and may achieve 400K (The wire came loose at about 423K before another monitor) at 1MW.

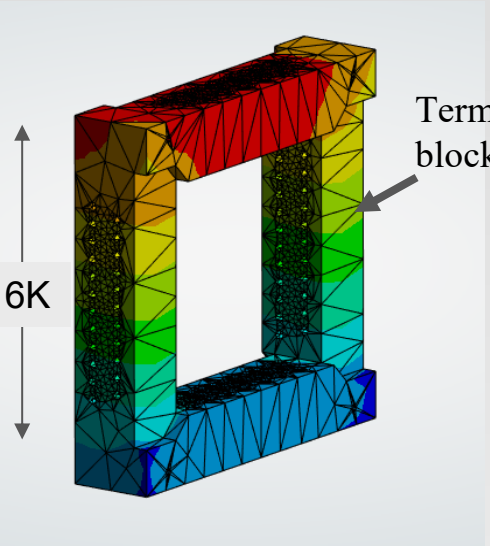
○The terminal block temperature is dependent on emissivity of scraper.

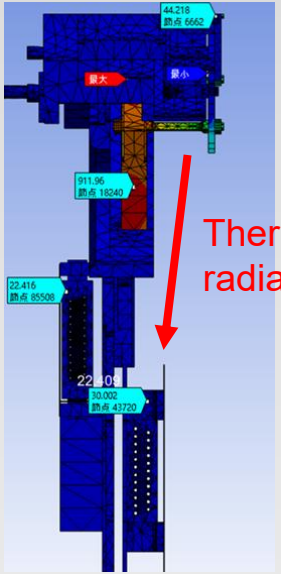
It indicated that the reflected thermal radiation by the scraper contributes to the monitor‘s temperature→Adding thermal shield?

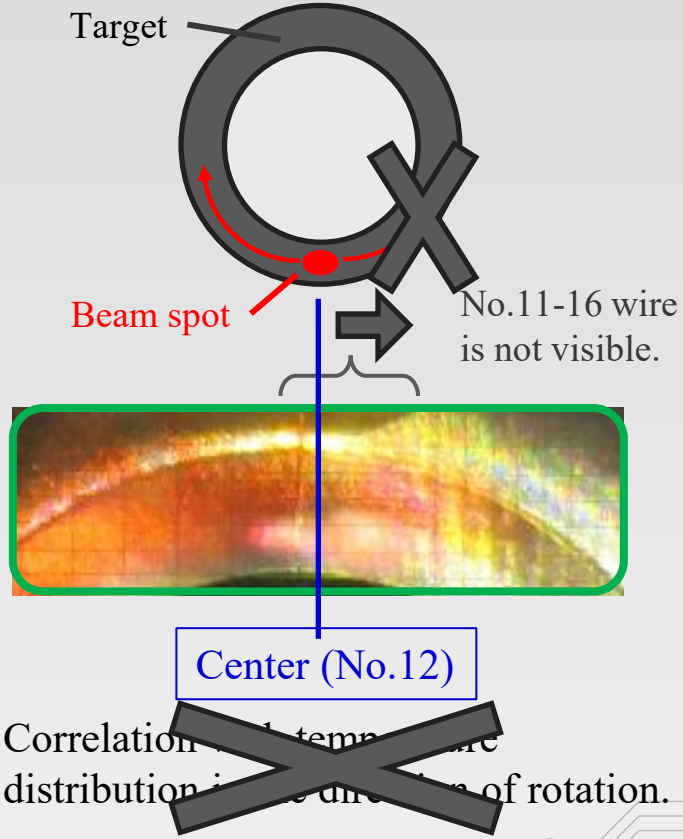


Beam profile monitor

Why does only the upper socket contact come loose?







Temperature distribution of terminal block indicates a difference of approximately 6K due to thermal radiation from the Inconel support. Although very small, the top tends to become higher. Furthermore, based on the heat deposit distribution calculated using PHITS, it is understood that the upper part of the profile monitor tends to higher temperatures.

Correlation [illegible] distribution [illegible] of rotation.

We continue to investigate

Summary

- The muon production target has continued stable operation with some trouble.

- The failure of the beam profile monitor may be due to thermal effects, and analysis and investigation are ongoing.

Thank you for your attention.

Muon target maintenance team