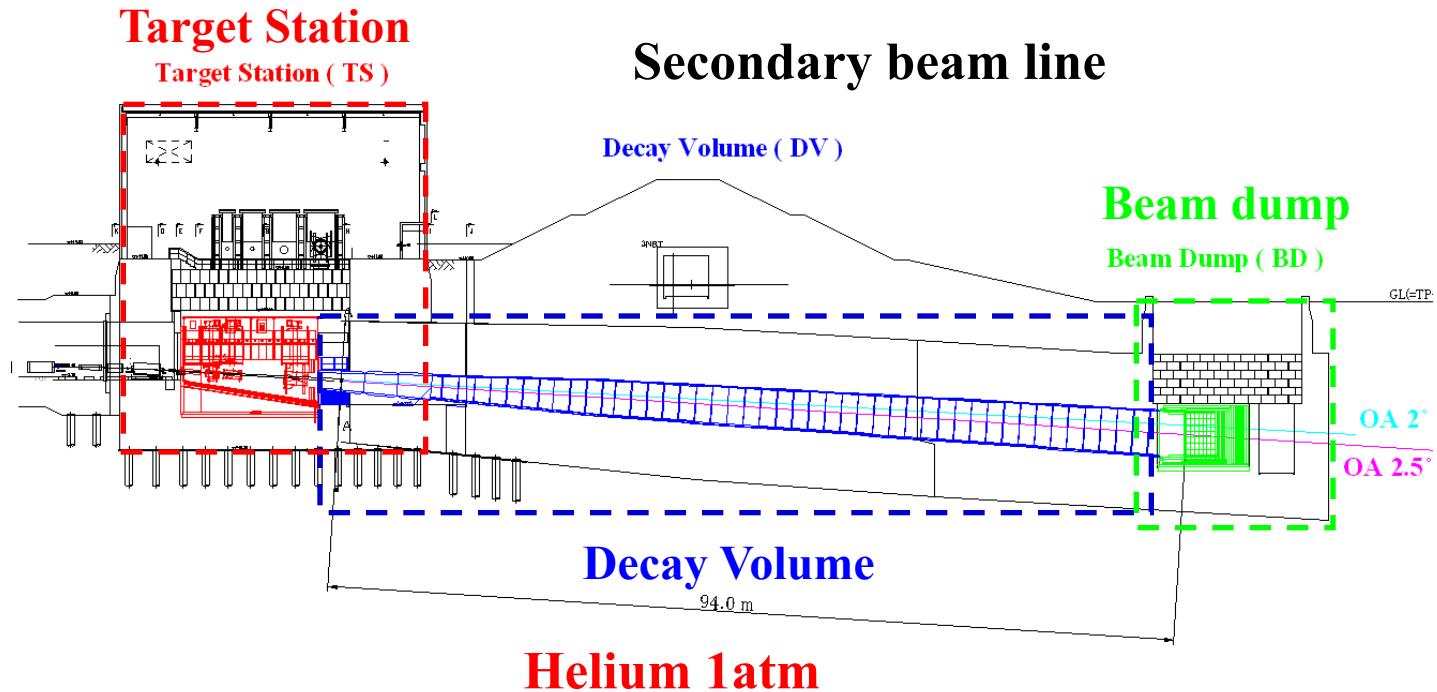


# **T2K Beam Window Replacement Work**

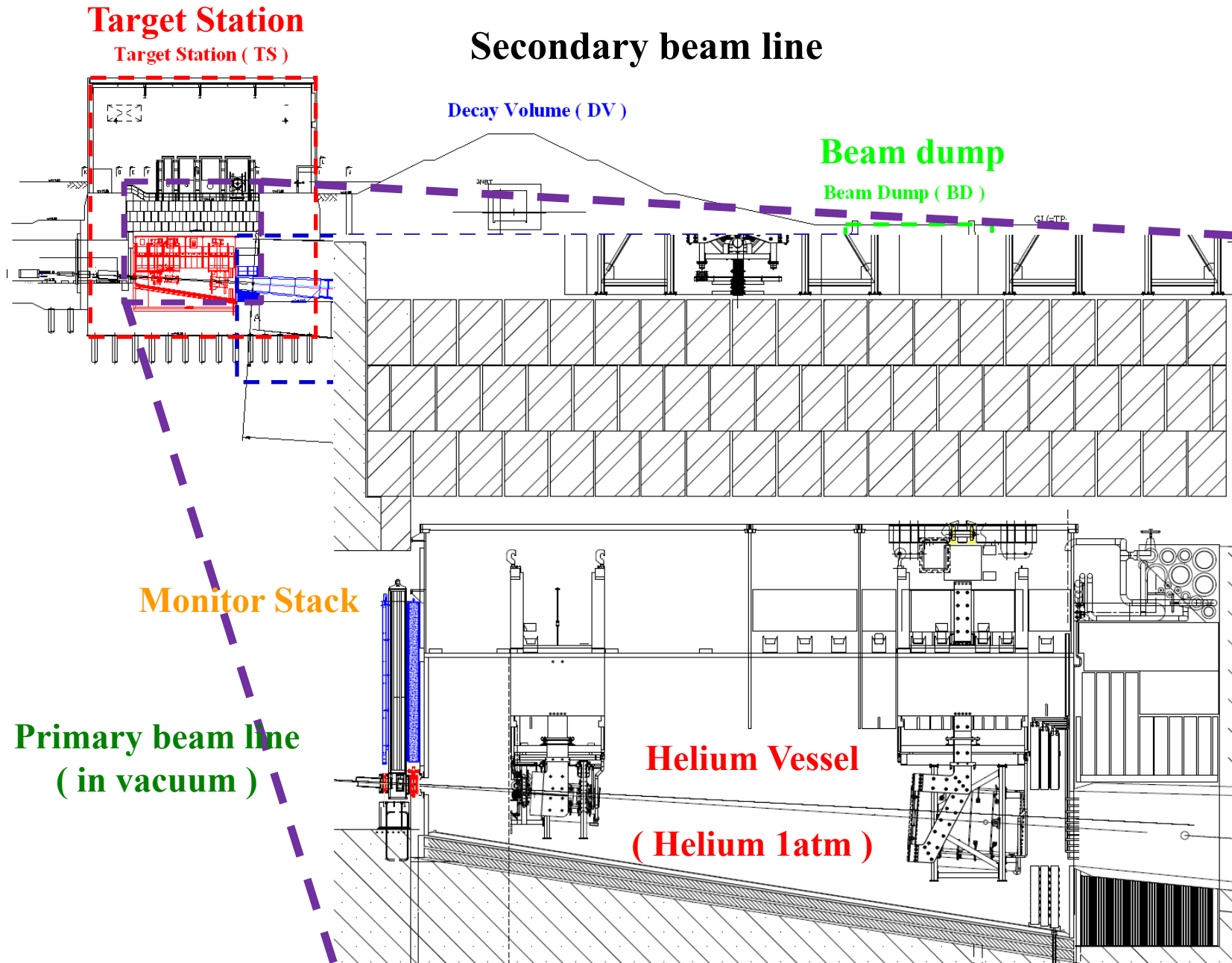
**2017.9.19  
KEK IPNS  
Tada**

# Beam window in T2K beam line



The components of the secondary beam line are in an integrated helium-tight vessel of the huge volume of the  $1500\text{m}^3$ .

# Beam window in T2K beam line



# Beam window in T2K beam line

**Monitor Stack  
( in vacuum )**

**Shield**

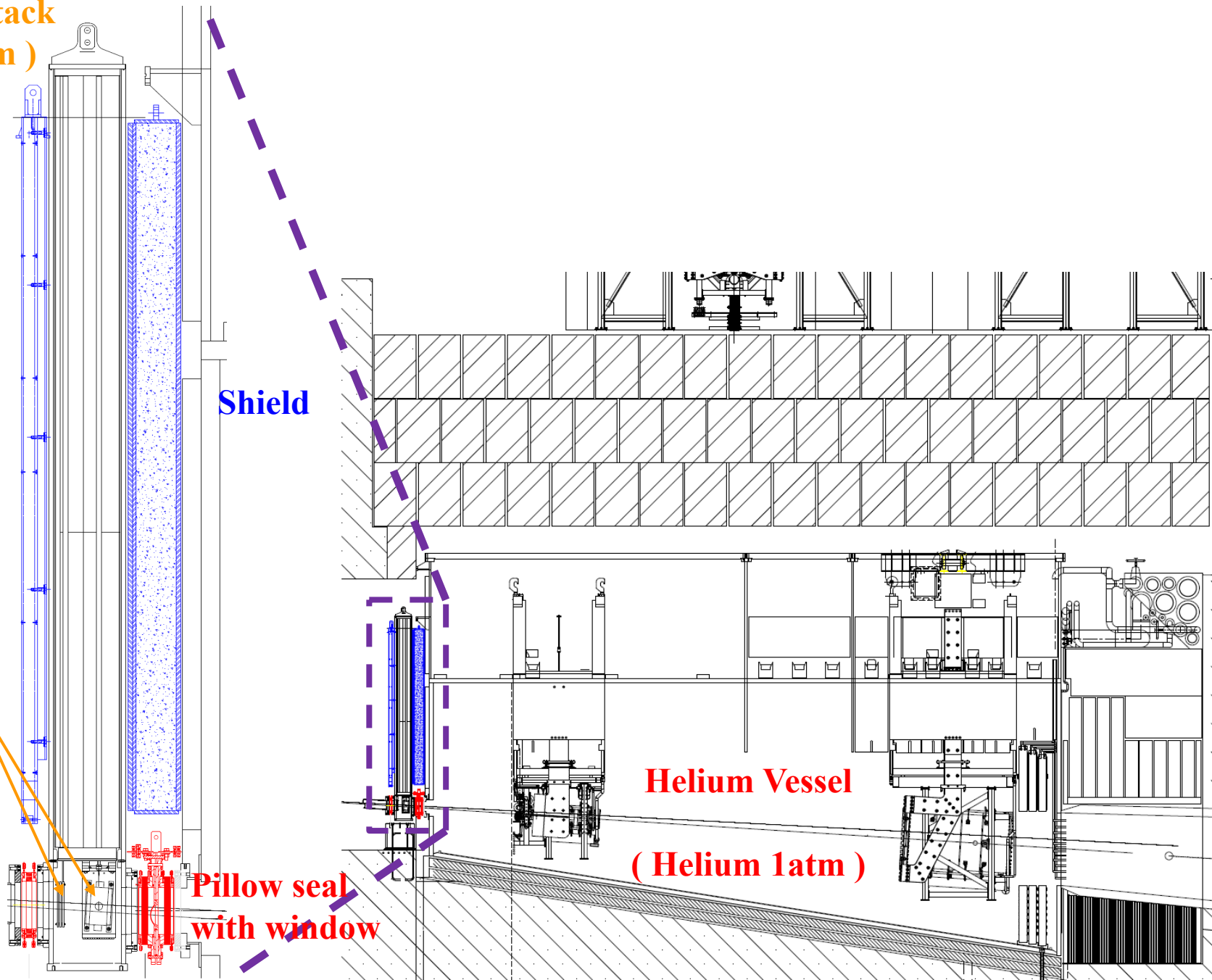
**Shield**

**Beam  
Monitor**

**Pillow seal  
without  
window**

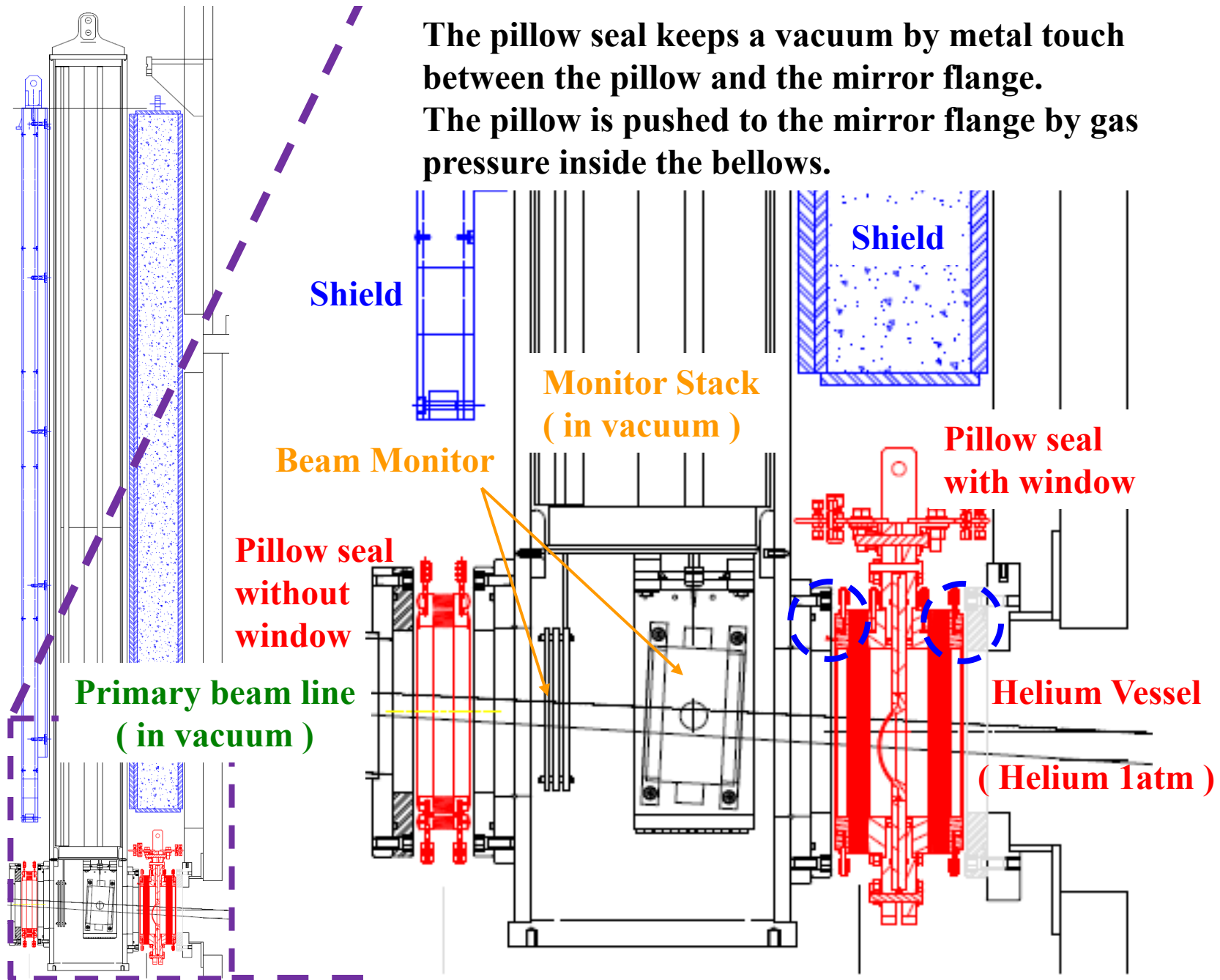
**Pillow seal  
with window**

**Helium Vessel  
( Helium 1atm )**

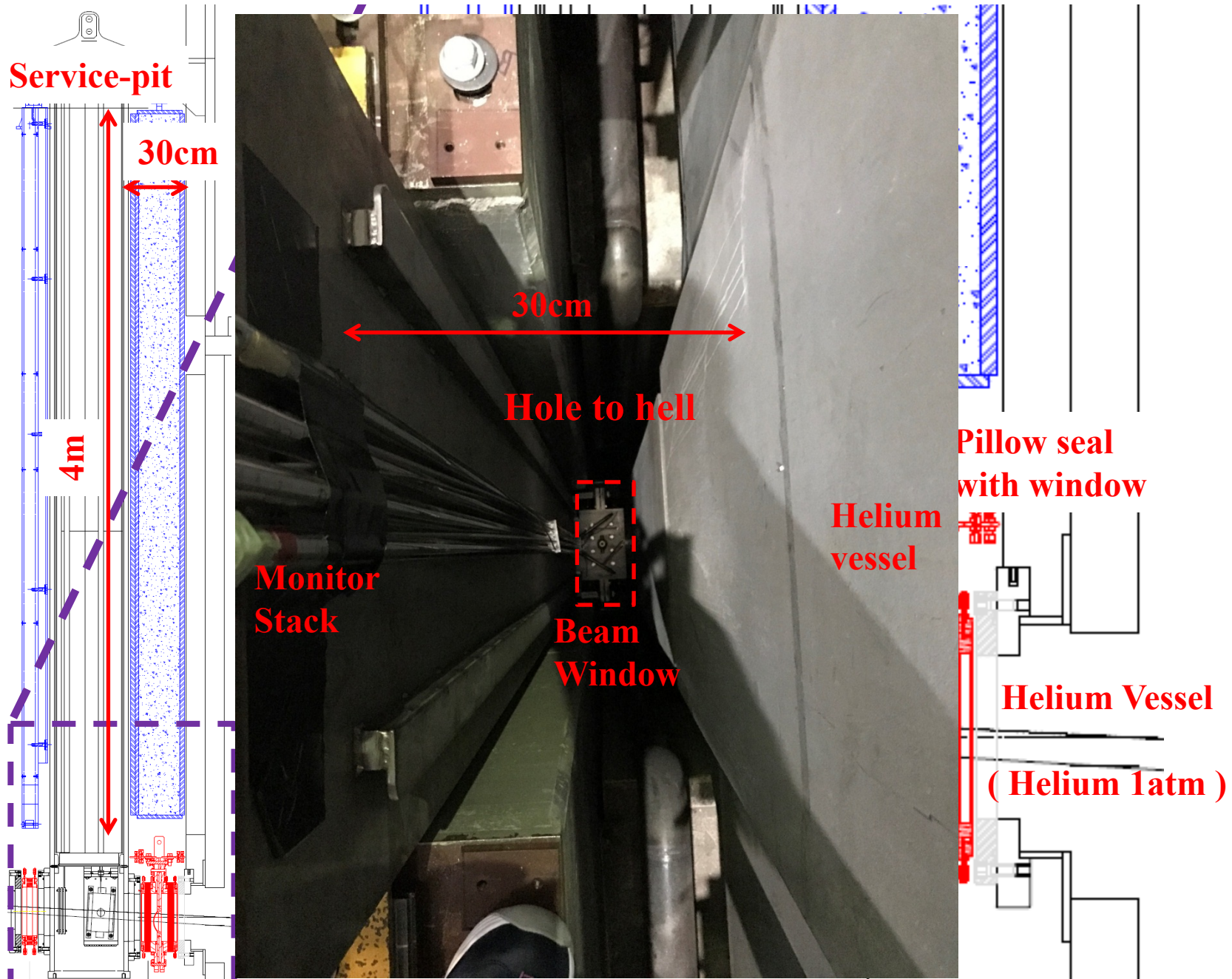




# Beam window in T2K beam line



# Beam window in T2K beam line



# Motivation for replacement work

**Ti-6Al-4V alloy**





# Motivation for replacement work

**Ti-6Al-4V alloy**



We have used the present beam window all the time since the T2K experiment started.

The present beam window have been exposed to  $2.2 \times 10^{21}$  protons.

**-> 1.8 DPA!!**

# Motivation for replacement work

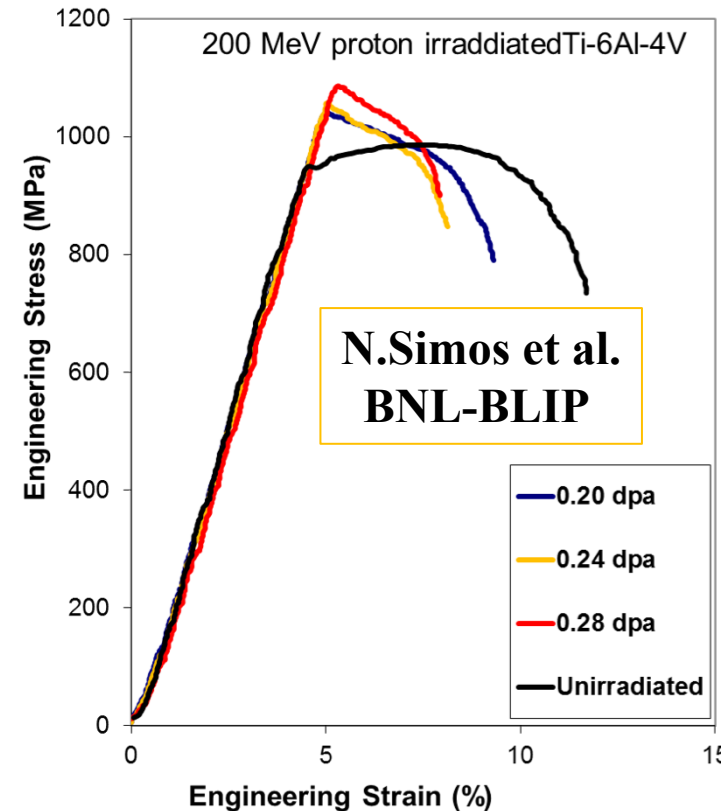
**Ti-6Al-4V alloy**



We have used the present beam window all the time since the T2K experiment started.

The present beam window have been exposed to  $2.2 \times 10^{21}$  protons.

**-> 1.8 DPA!!**



This value easily exceeds the reach of the data we have, so we can't guarantee safety of the beam window.

# Motivation for replacement work

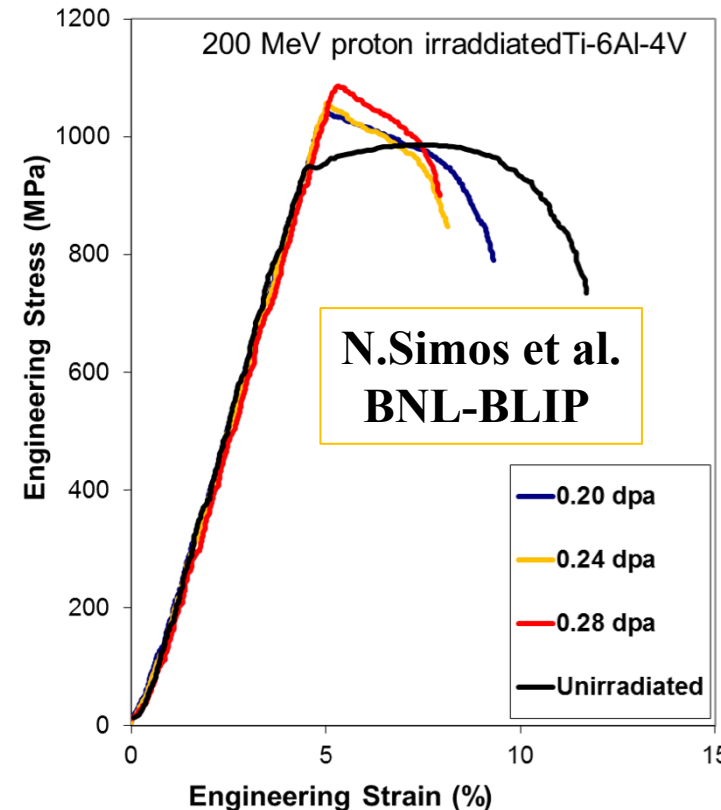
**Ti-6Al-4V alloy**



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The present beam window have been exposed to  $2.2 \times 10^{21}$  protons.

**-> 1.8 DPA!!**



This value easily exceeds the reach of the data we have, so we can't guarantee safety of the beam window.

**When the beam window rips, there is a possibility that the splinters of the window are scattered into the primary beam line and cause serious pollution.**



# Motivation for replacement work

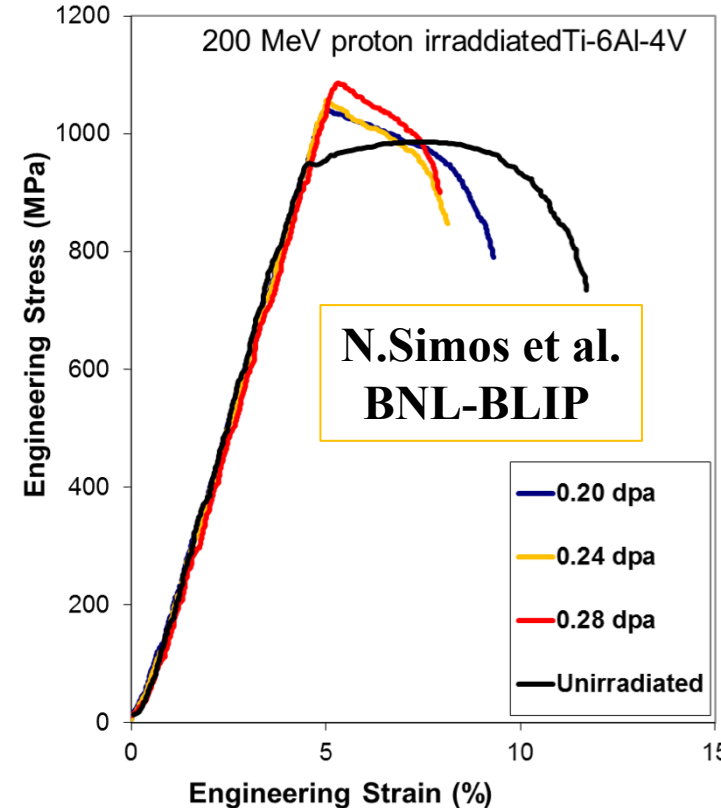
**Ti-6Al-4V alloy**



We have used the present beam window all the time since the T2K experiment started.

The present beam window have been exposed to  $2.2 \times 10^{21}$  protons.

**-> 1.8 DPA!!**

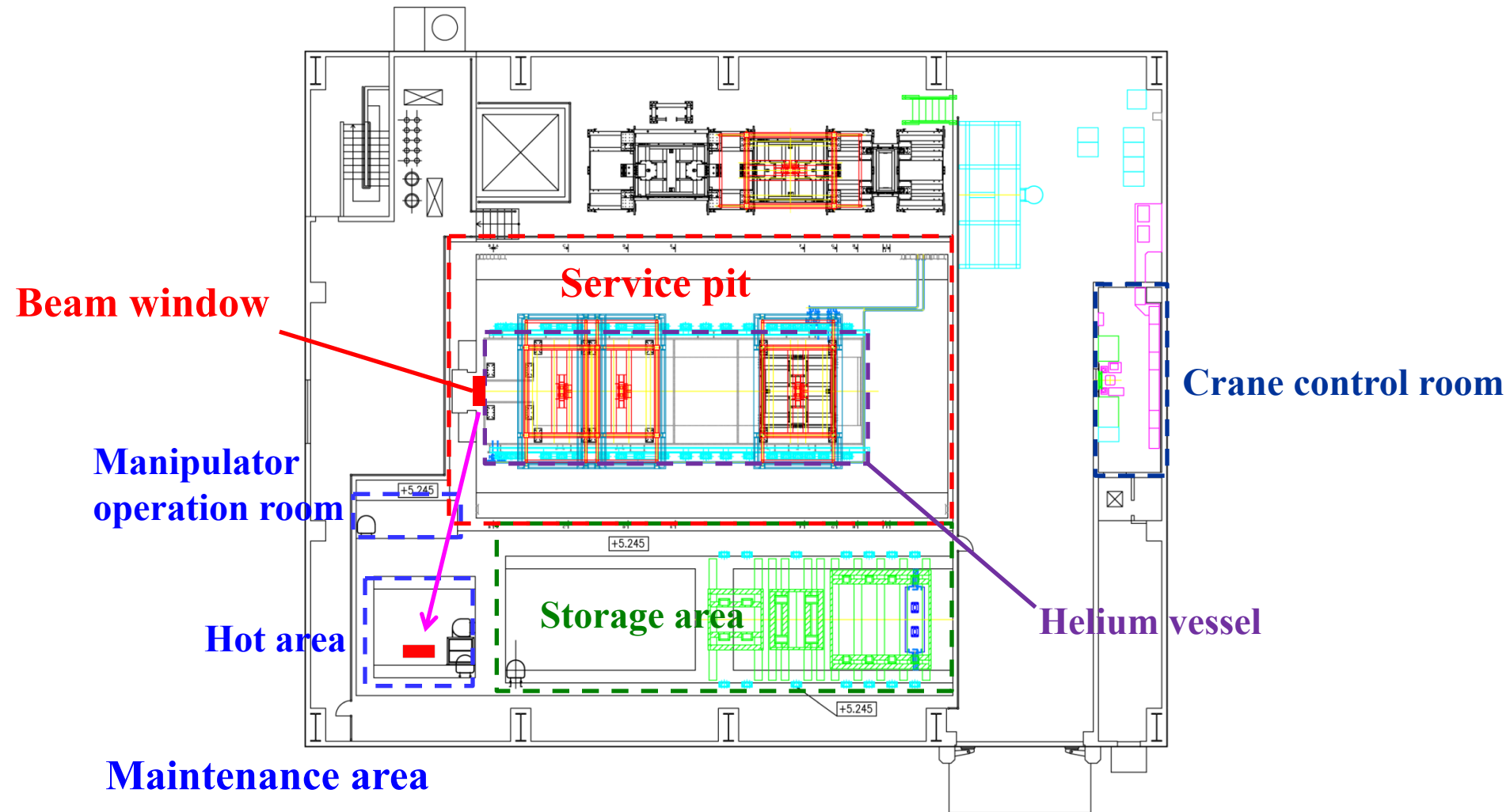


This value easily exceeds the reach of the data we have, so we can't guarantee safety of the beam window.

When the beam window rips, there is a possibility that the splinters of the window are scattered into the primary beam line and cause serious pollution.

**→ We decided to replace the beam window before it breaks.**

# Top view of Target Station





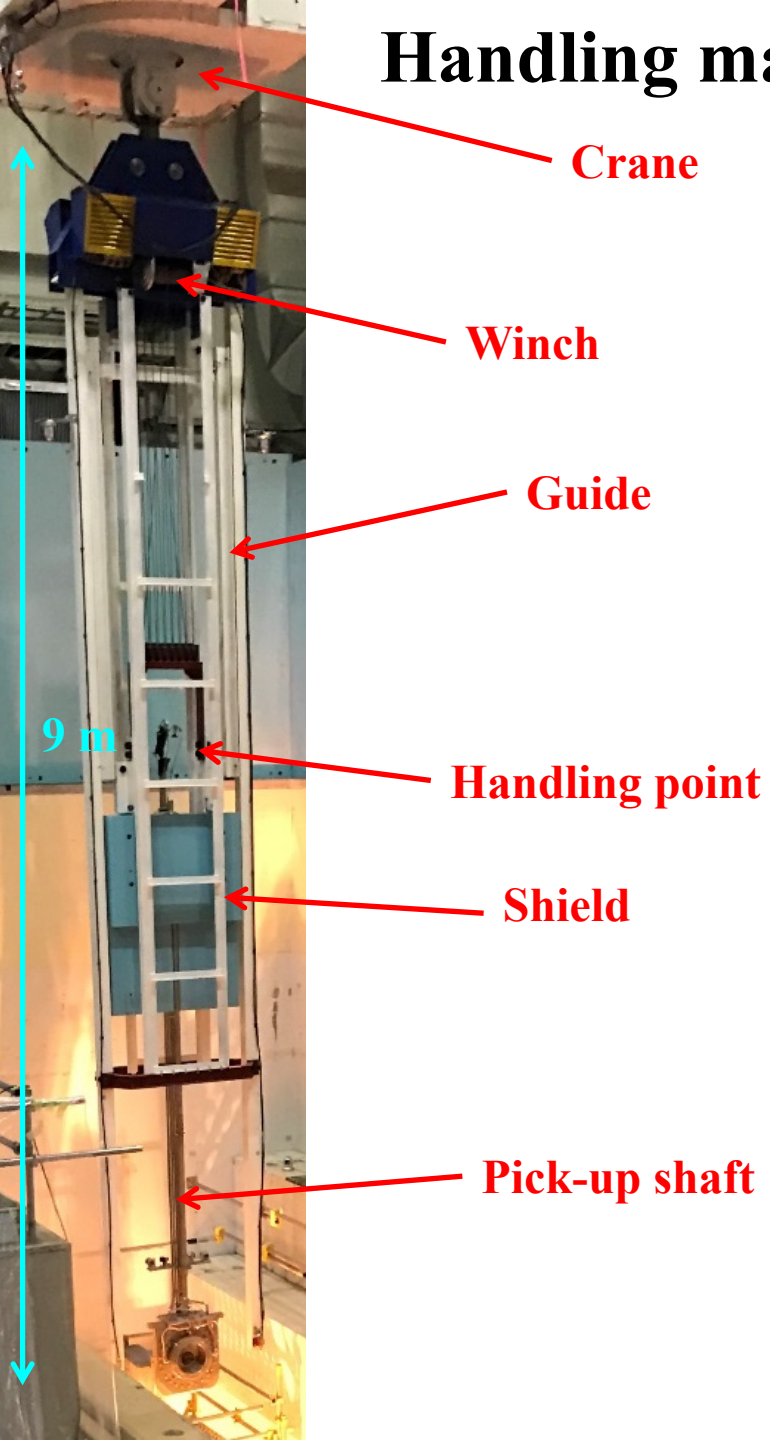
# **Procedure of the replacement for the beam window**

- 1) Pull the shield (above the beam window) out with handling machine**
- 2) Shorten the pillow seals and Pull the beam window out with handling machine**
- 3) Take the beam window to the maintenance area and put it into the casket with handling machine**
- 4) Clean the surface of the pillow seal flange with the cleaner**
- 5) Install the new beam window with handling machine and expand the pillow seals**
- 6) Install the shield above the beam window with handling machine**

# Procedure of the replacement for the beam window

- 1) Pull the shield (above the beam window) out with **handling machine**
- 2) Shorten the pillow seals and Pull the beam window out with **handling machine**
- 3) Take the beam window to the maintenance area and put it into the casket with **handling machine**
- 4) Clean the surface of the pillow seal flange with the cleaner
- 5) Install the new beam window with **handling machine** and expand the pillow seals
- 6) Install the shield above the beam window with **handling machine**

# Handling machine for beam window



**The handling machine is attached to crane, and it moves by crane horizontally.**

## Guide

# Shield

9 m

# Handling machine for beam window

**Crane**

The handling machine is attached to crane, and it moves by crane horizontally.

**Winch**

In vertical direction, it move by crane before the guide touch down the guide on the service-pit side, and it move by winch built in the handling machine after touch down.

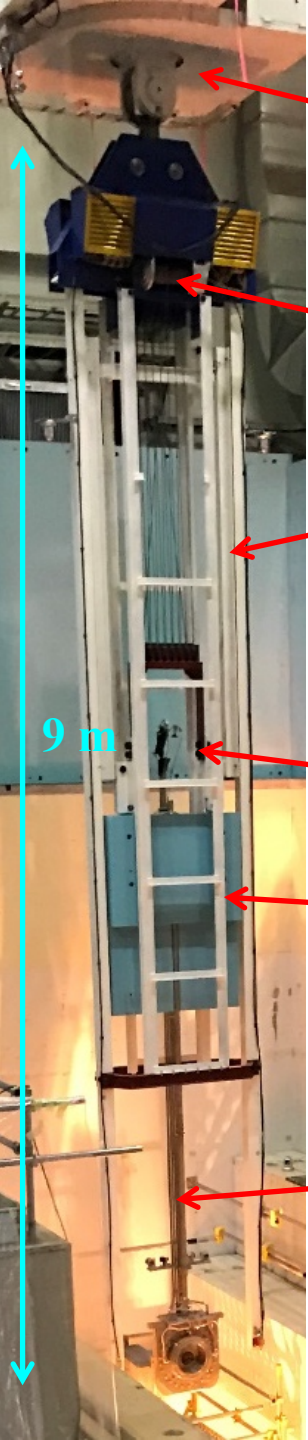
**Guide**

**Handling point**

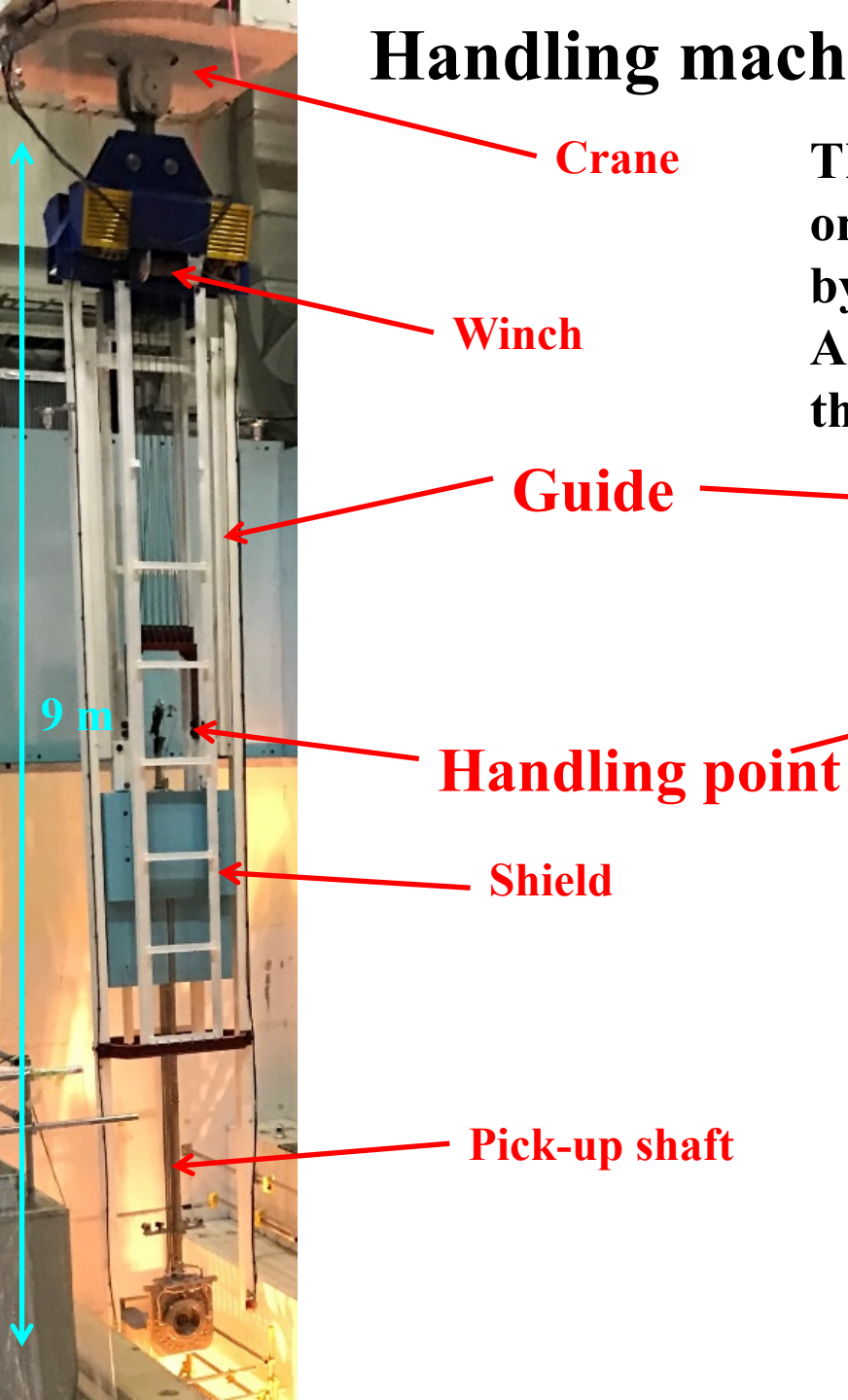
**Shield**

**Pick-up shaft**

9 m

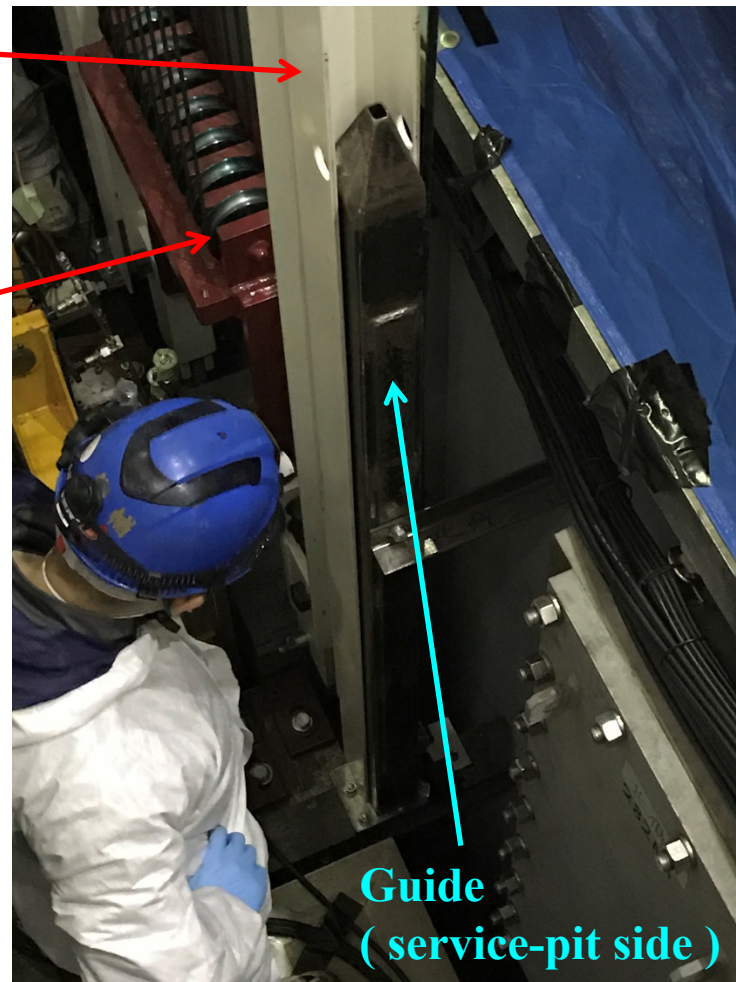


# Handling machine for beam window



The guide of handling machine fits the guide on the service-pit side or the maintenance side by outside.

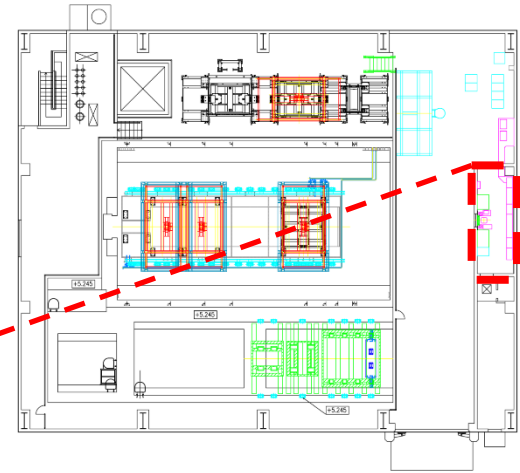
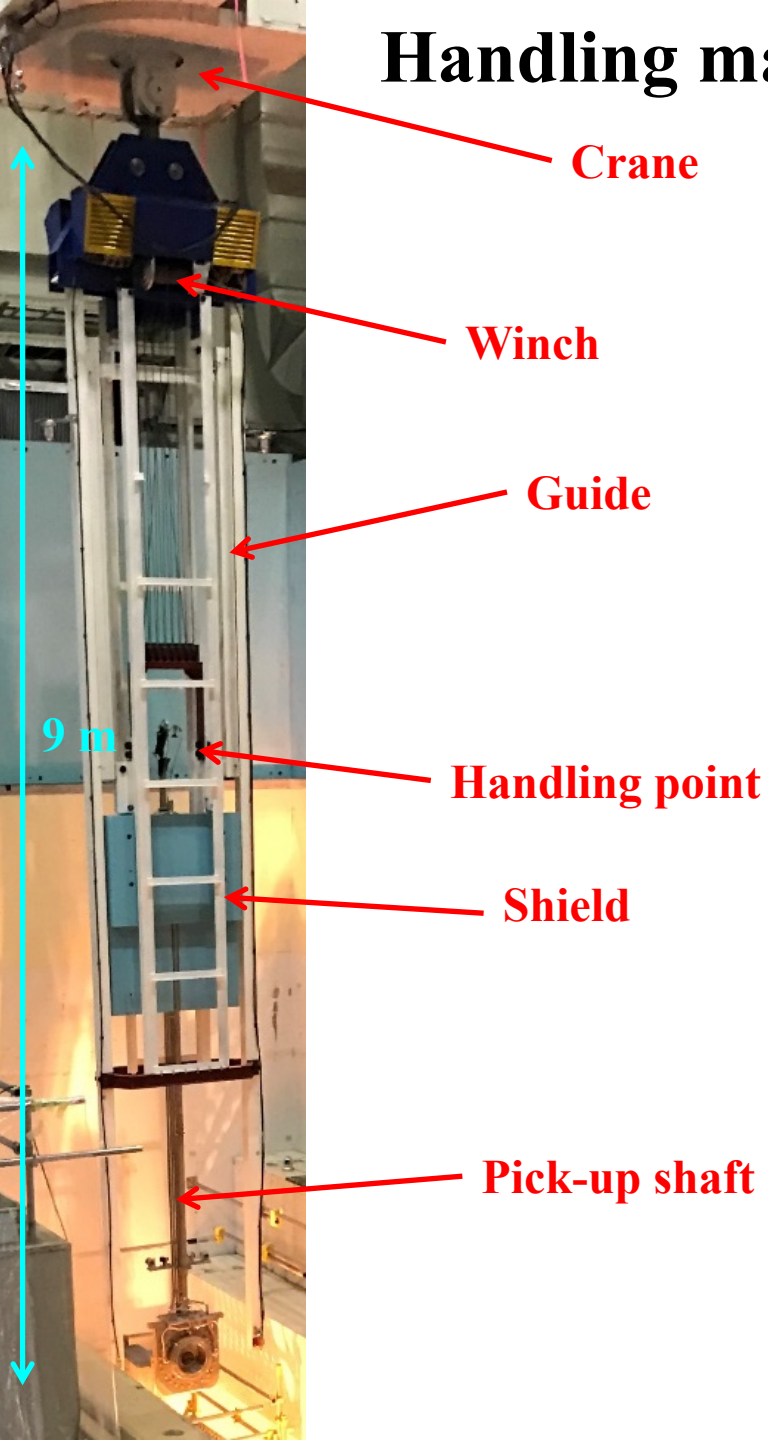
And the handling point moves along inside of the guide by the winch.







# Handling machine for beam window



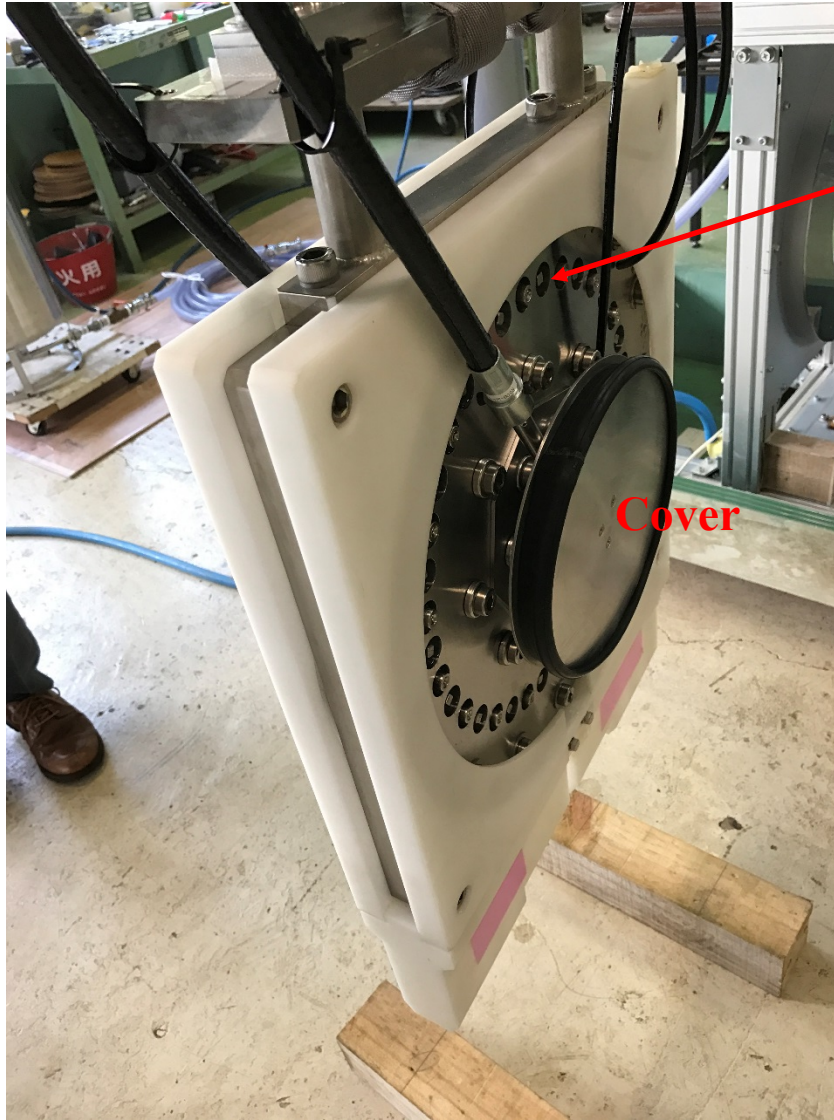


# **Procedure of the replacement for the beam window**

- 1) Pull the shield (above the beam window) out with handling machine**
- 2) Shorten the pillow seals and Pull the beam window out with handling machine**
- 3) Take the beam window to the maintenance area and put it into the casket with handling machine**
- 4) Clean the surface of the pillow seal flange with **the cleaner****
- 5) Install the new beam window with handling machine and expand the pillow seals**
- 6) Install the shield above the beam window with handling machine**

# Cleaner for mirror flange

It is the most important for the replacement work to keep clean the mirror flange of the pillow seal, so we developed the cleaner for the mirror flange. We use the cleaner when the mirror flanges are dirty.

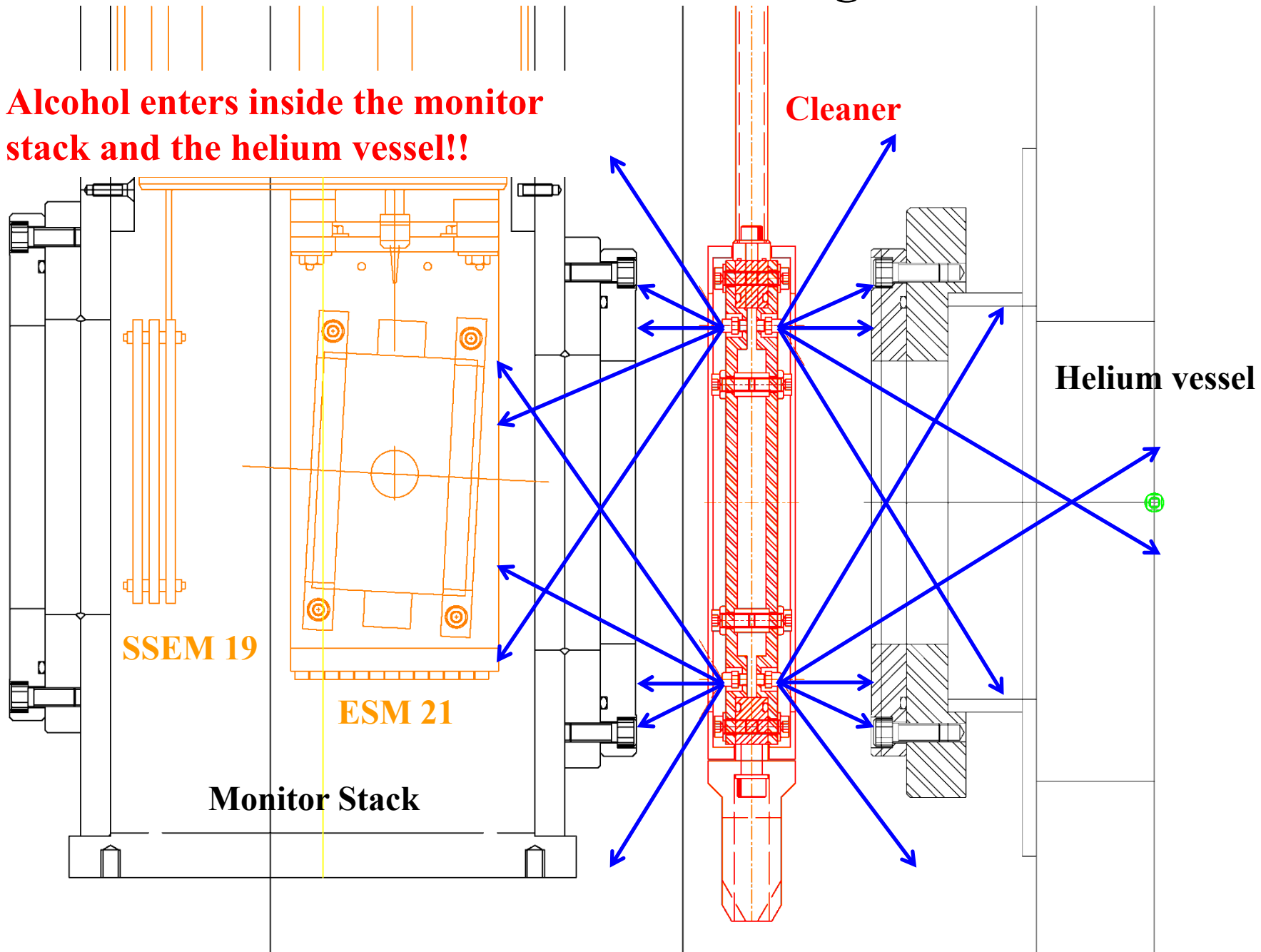


**Nozzles :**  
**Air or alcohol is sprayed here**

**Cover**

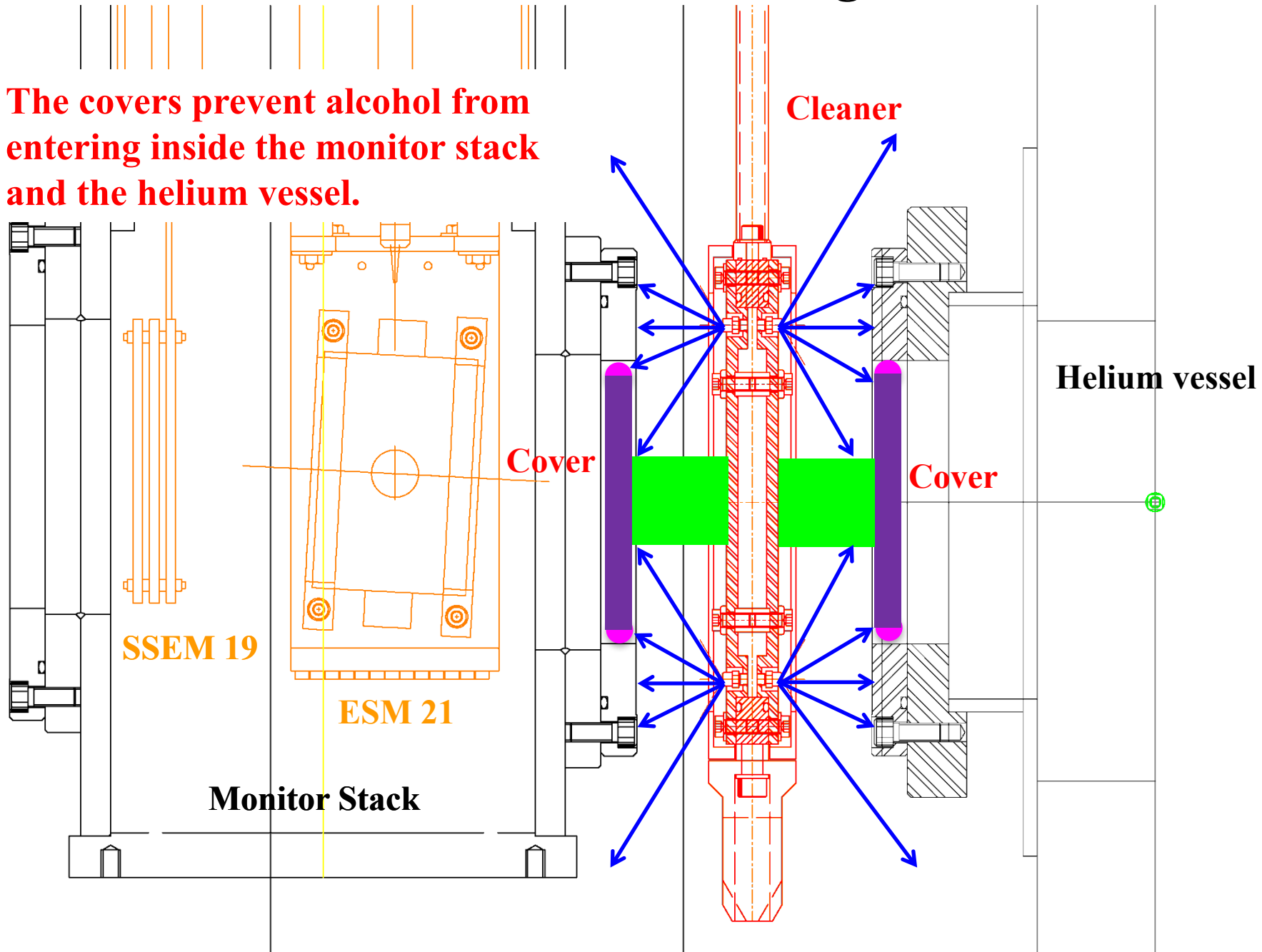
# Cleaner for mirror flange

**Alcohol enters inside the monitor stack and the helium vessel!!**



# Cleaner for mirror flange

The covers prevent alcohol from entering inside the monitor stack and the helium vessel.



# Cleaner for mirror flange



# Cleaner for mirror flange



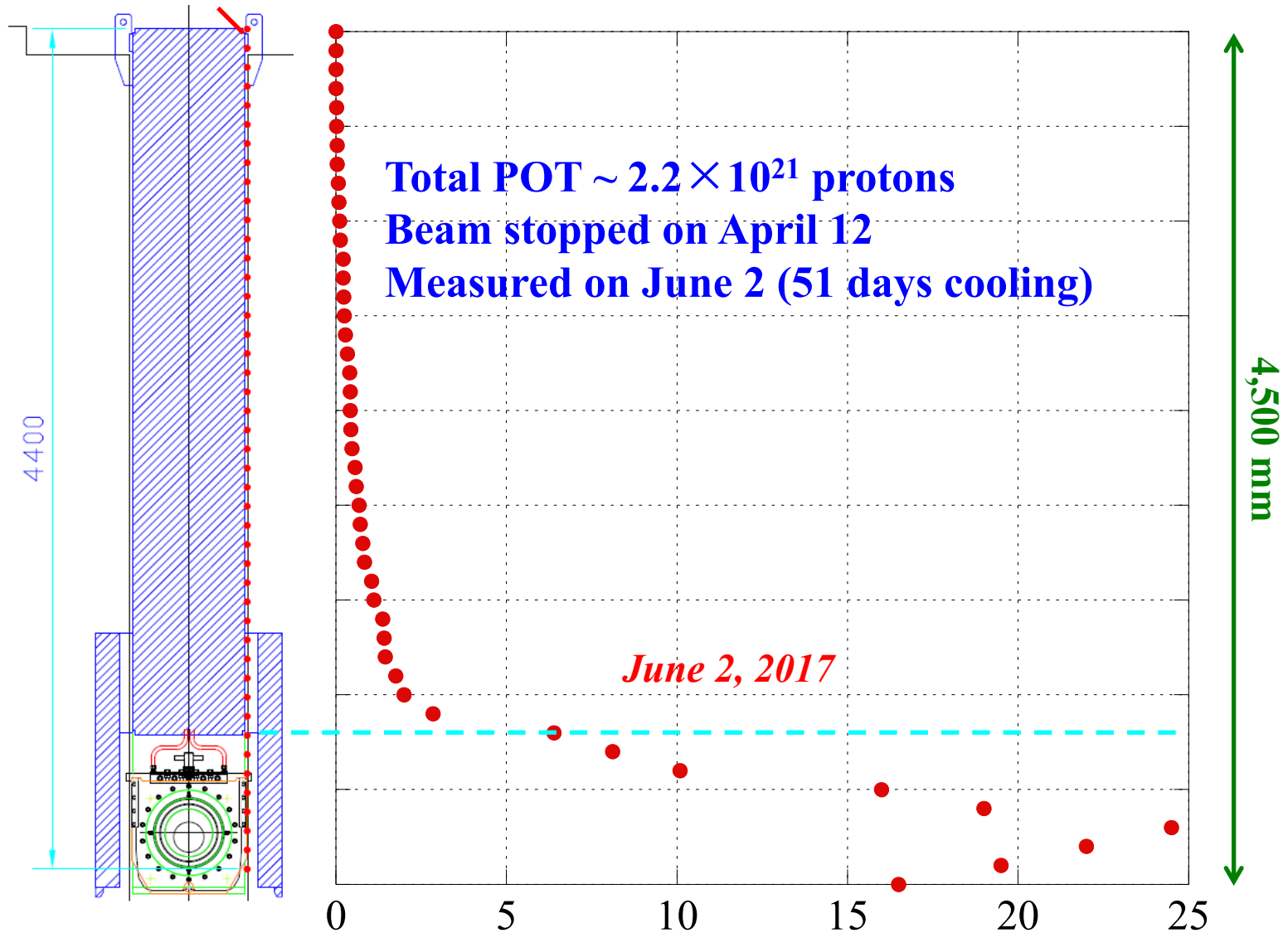
# **Procedure of the replacement for the beam window**

- 1) Pull the shield (above the beam window) out with handling machine**
- 2) Shorten the pillow seals and Pull the beam window out with handling machine**
- 3) Take the beam window to the maintenance area and put it into the casket with handling machine**
- 4) Clean the surface of the pillow seal flange with the cleaner**
- 5) Install the new beam window with handling machine and expand the pillow seals**
- 6) Install the shield above the beam window with handling machine**



# Radiation measurement before replacement work

Measured points

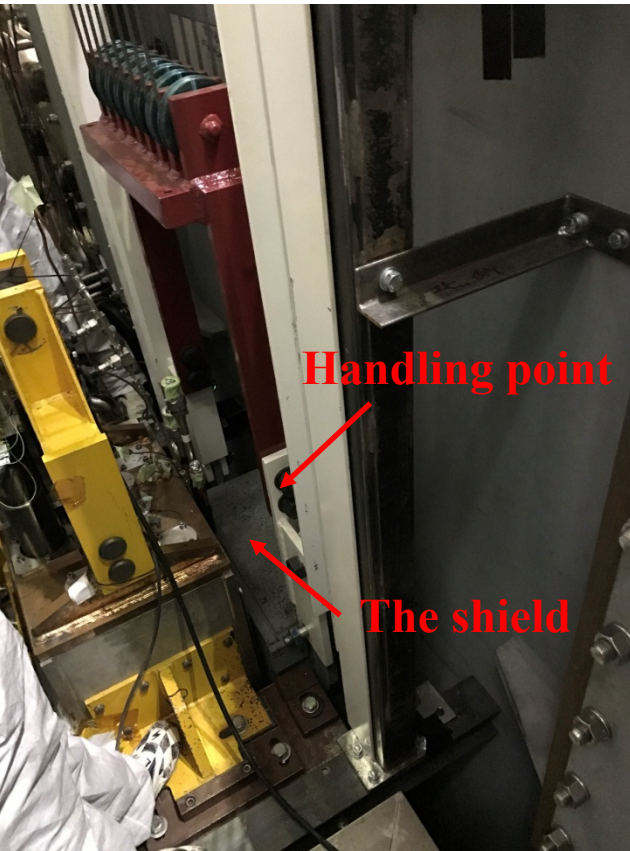




# Procedure of the replacement for the beam window

- 1) Pull the shield (above the beam window) out with handling machine**
- 2) Shorten the pillow seals and Pull the beam window out with handling machine
- 3) Take the beam window to the maintenance area and put it into the casket with handling machine
- 4) Clean the surface of the pillow seal flange with the cleaner
- 5) Install the new beam window with handling machine and expand the pillow seals
- 6) Install the shield above the beam window with handling machine

# Remove the shield from beam line **Aug. 18**



Pull the shield out with the handling machine **by remote**



Remove the shield to the maintenance area with the handling machine **by remote**



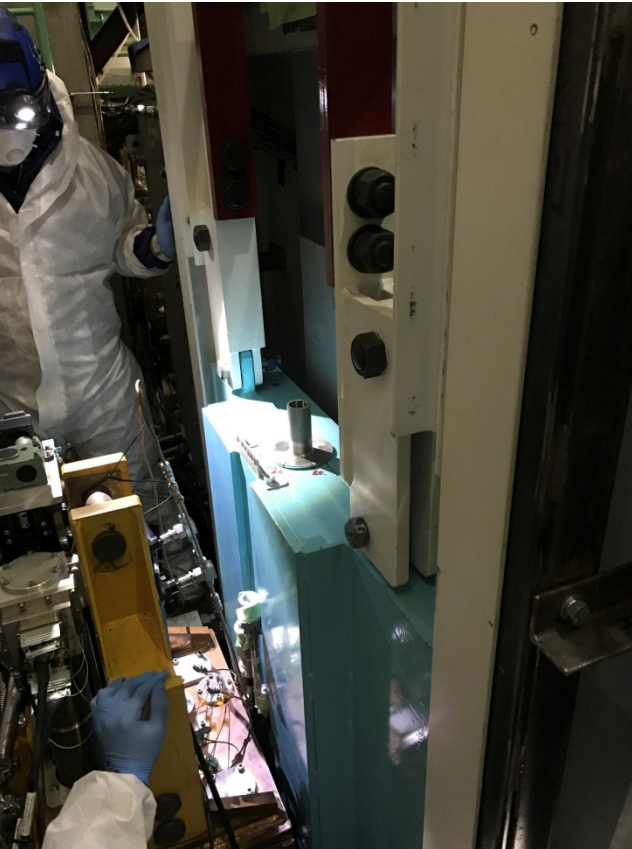
Connect the top of the shield above the beam window to the handling point of the handling machine **by hands**

# Procedure of the replacement for the beam window

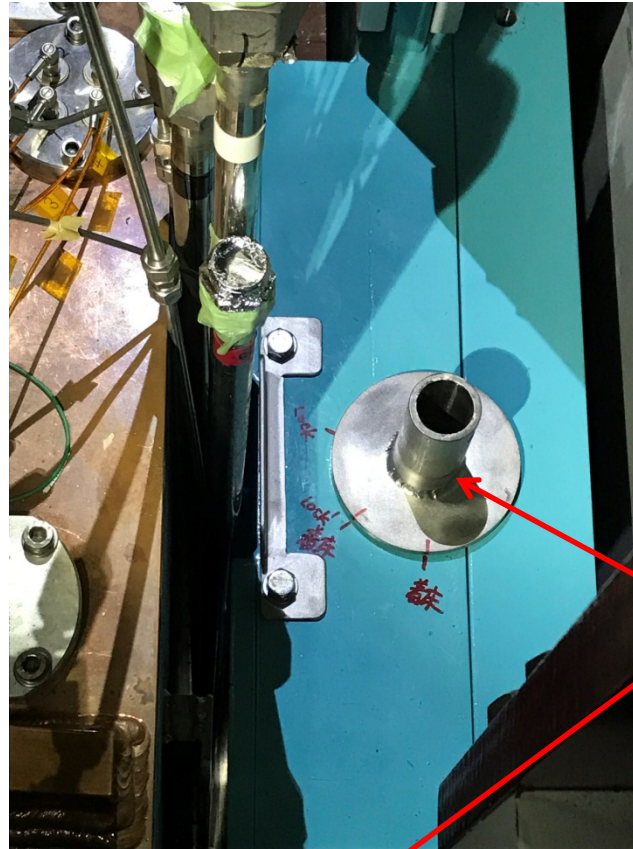
- 1) Pull the shield (above the beam window) out with handling machine
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- 3) Take the beam window to the maintenance area and put it into the casket with handling machine
- 4) Clean the surface of the pillow seal flange with the cleaner
- 5) Install the new beam window with handling machine and expand the pillow seals
- 6) Install the shield above the beam window with handling machine



# Pick-up the beam window **Aug. 22**

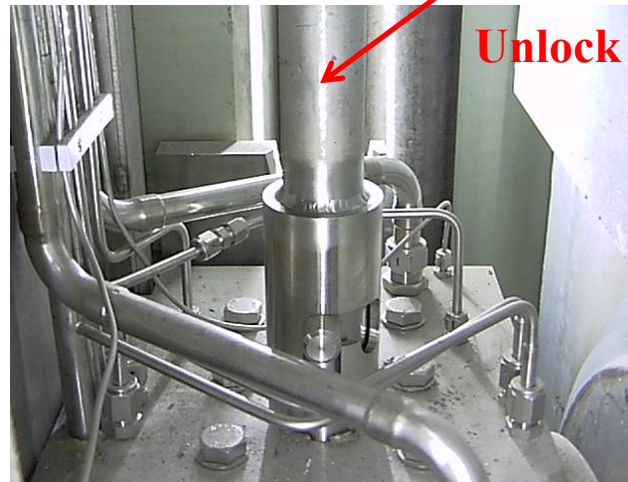


Set the handling machine  
above the beam window **by  
hand**

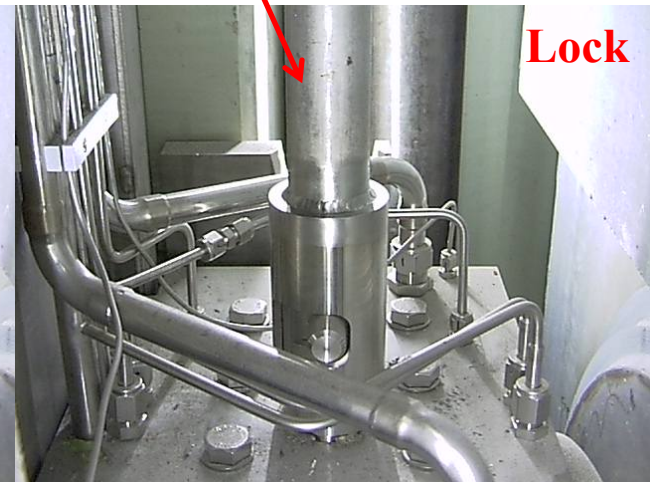


Rotate the pick-up shaft  
and lock the beam window  
**by hand** watching the top of  
the beam window ( the  
bottom of the shaft ) with  
camera

**Pick-up shaft**



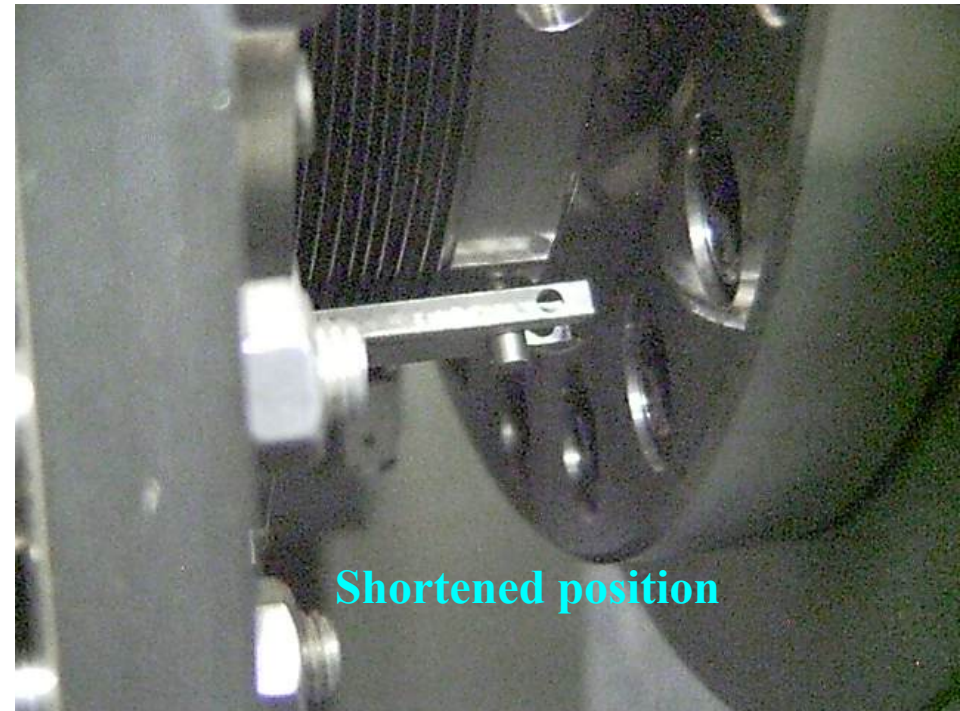
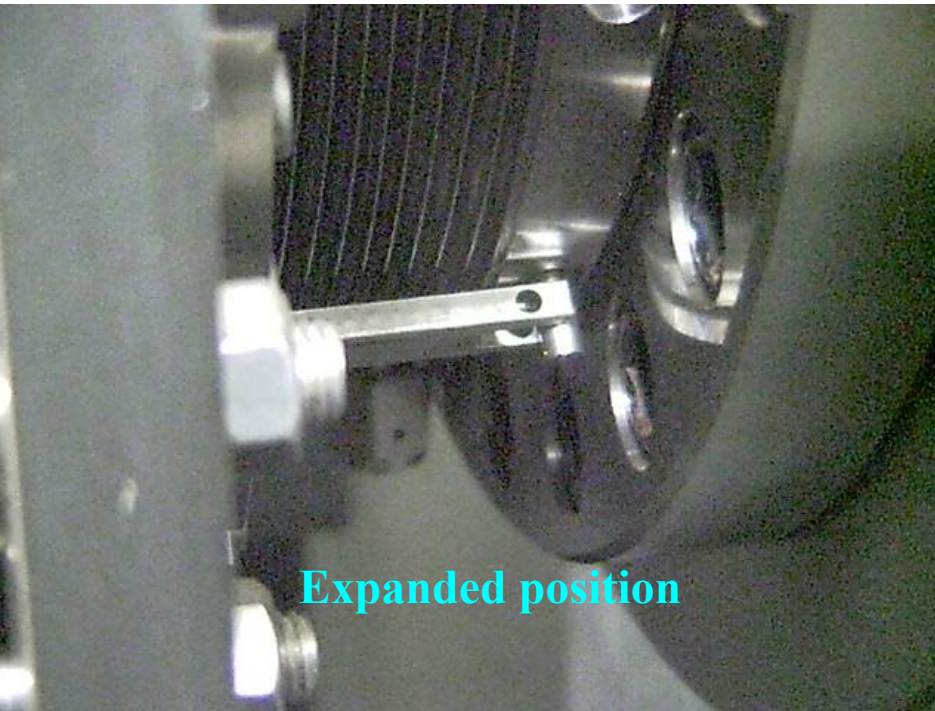
**Unlock**



**Lock**

Camera views

## Shorten the pillow seals **Aug. 22**



**Decrease the pressure of the pillow seal line under atmospheric pressure watching the motion of the pillows with a camera**



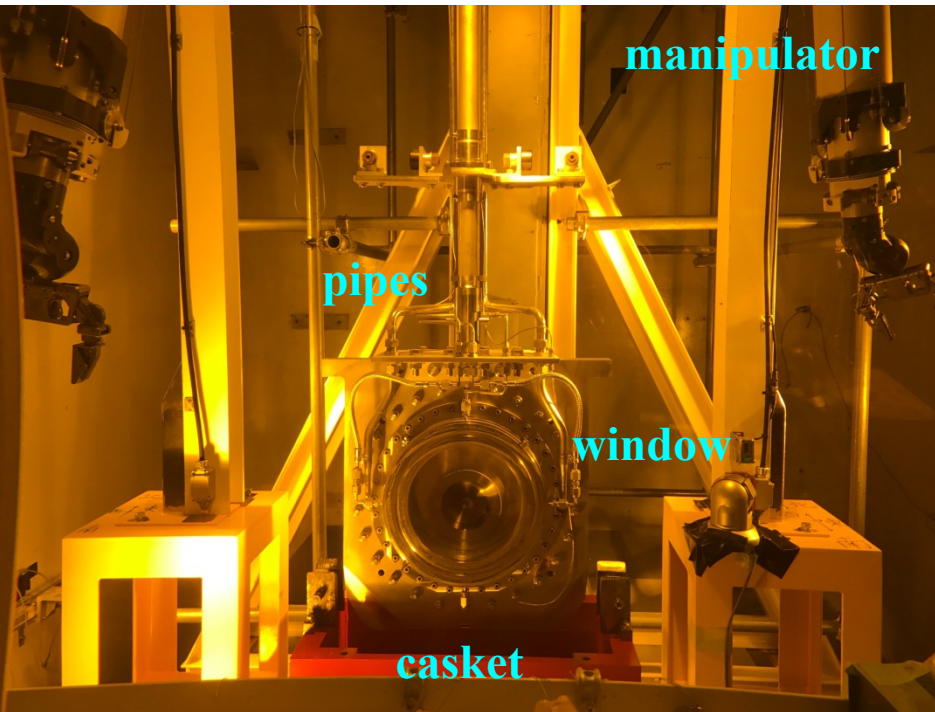
**Remove the beam window from the beam line**  
**and take it to the maintenance area Aug. 22**  
**×50 times speed**



# Procedure of the replacement for the beam window

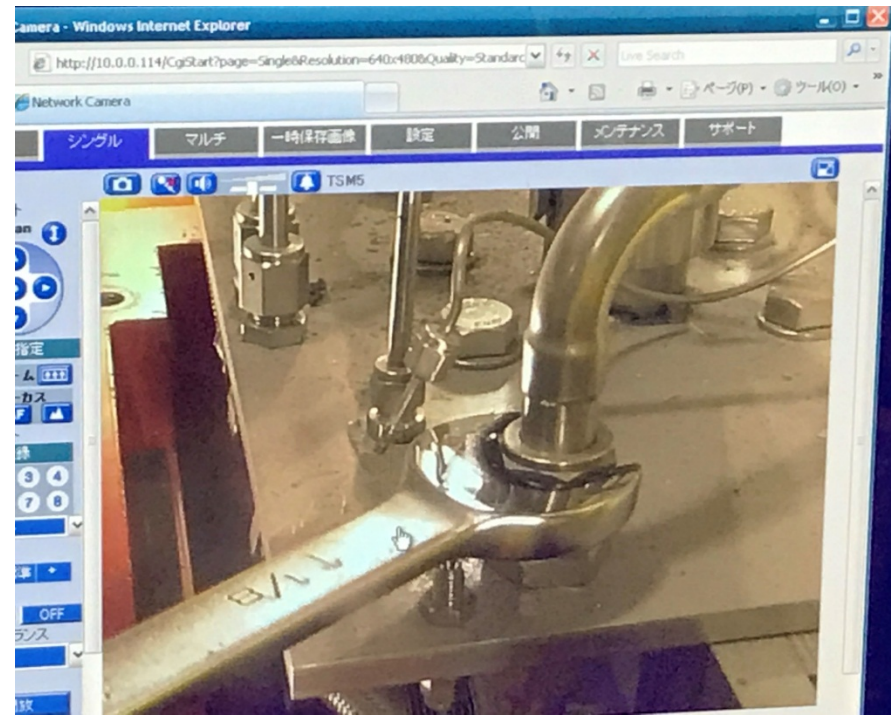
- 1) Pull the shield (above the beam window) out with handling machine
- 2) Shorten the pillow seals and Pull the beam window out with handling machine
- 3) Take the beam window to the maintenance area and put it into the casket with handling machine**
- 4) Clean the surface of the pillow seal flange with the cleaner
- 5) Install the new beam window with handling machine and expand the pillow seals
- 6) Install the shield above the beam window with handling machine

# Remove the pipes from the beam window **Aug. 22**



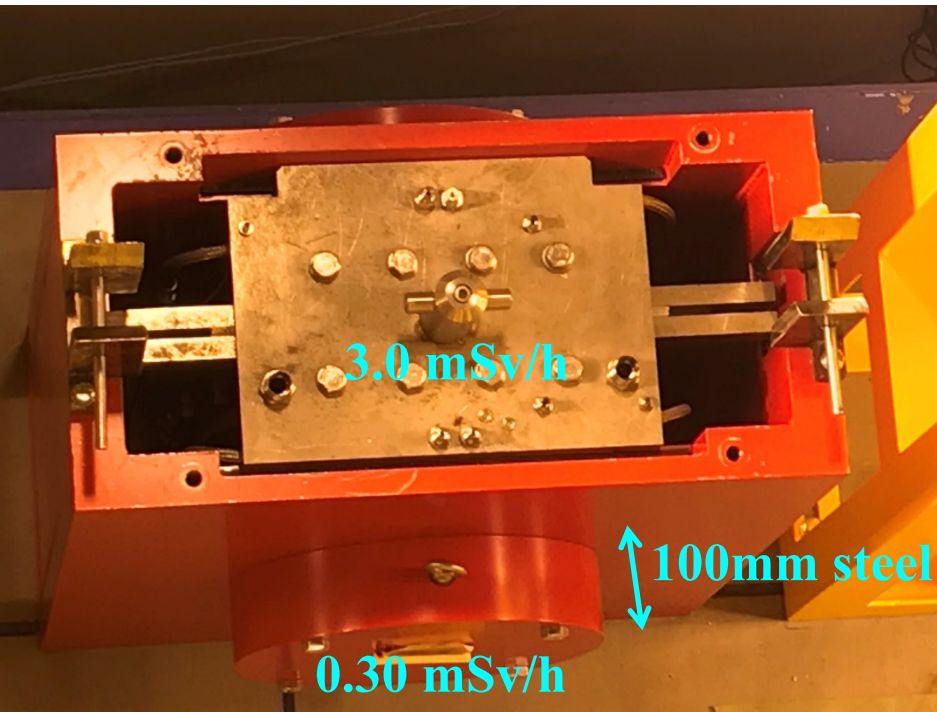
**Beam window in the maintenance area  
( through the lead glass )**

**Remove the pipes from the beam window  
with the manipulators  
( camera view )**

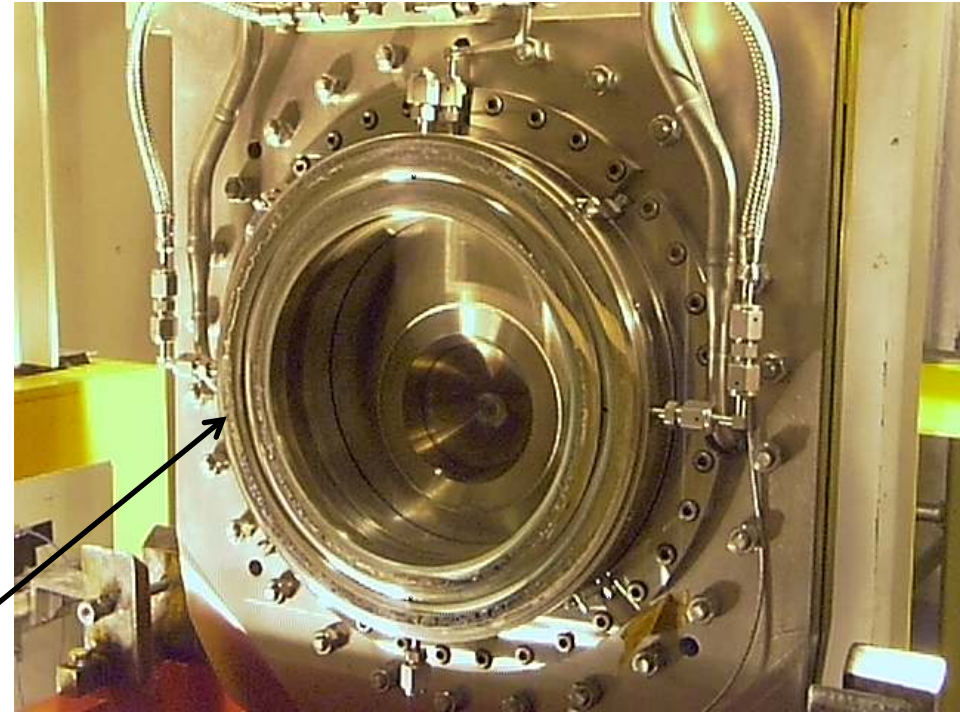
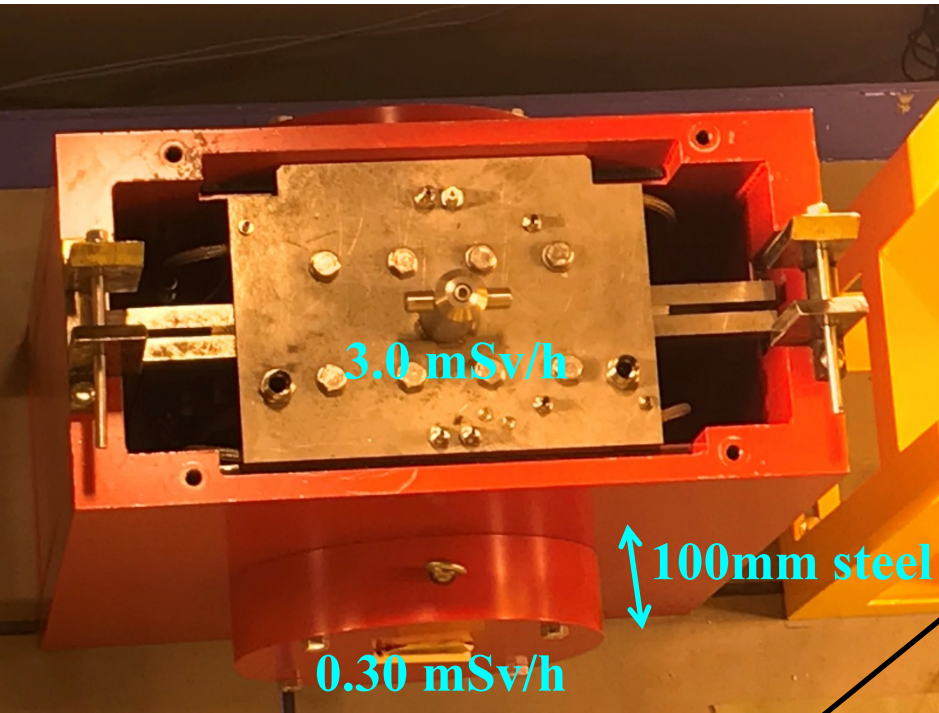




Put the beam window into the casket **Aug. 22**



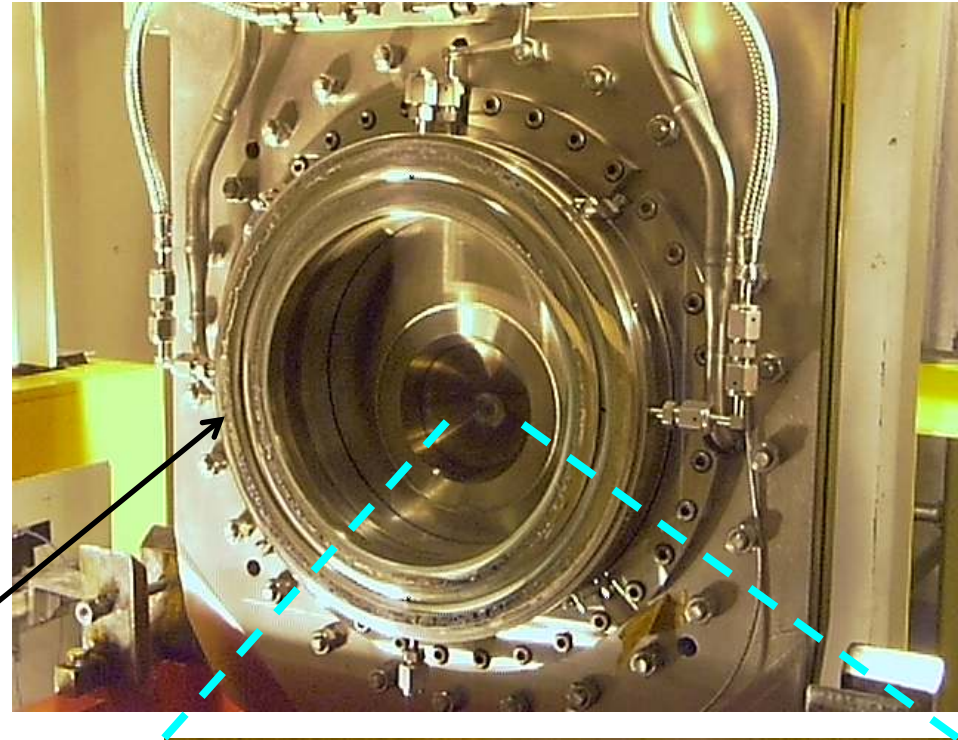
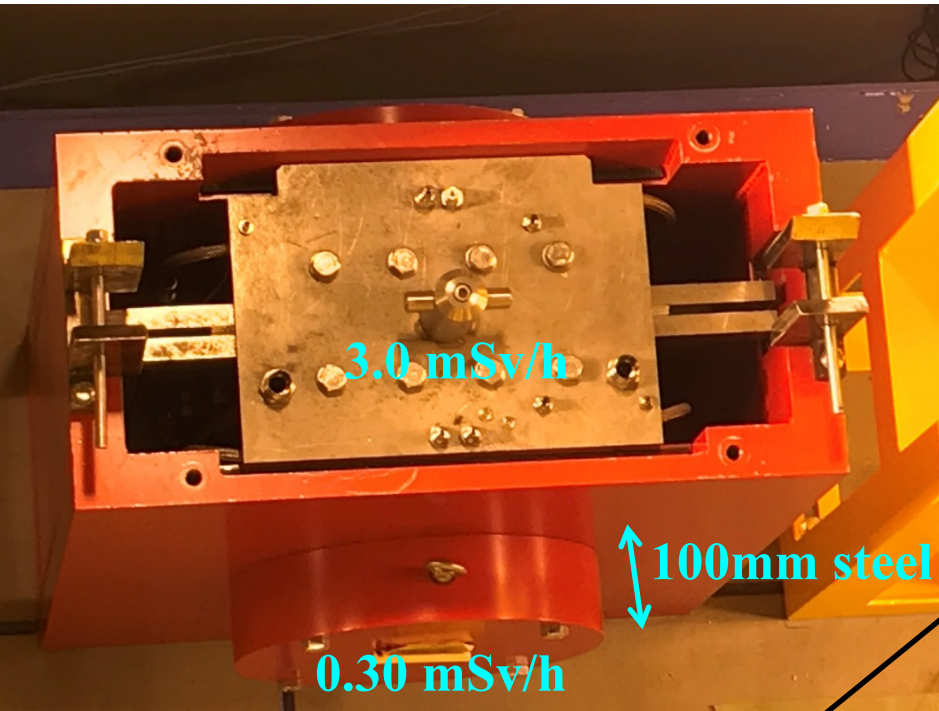
# Put the beam window into the casket **Aug. 22**



**Pillow seal is deformed, so it is impossible to reuse the old beam window.**



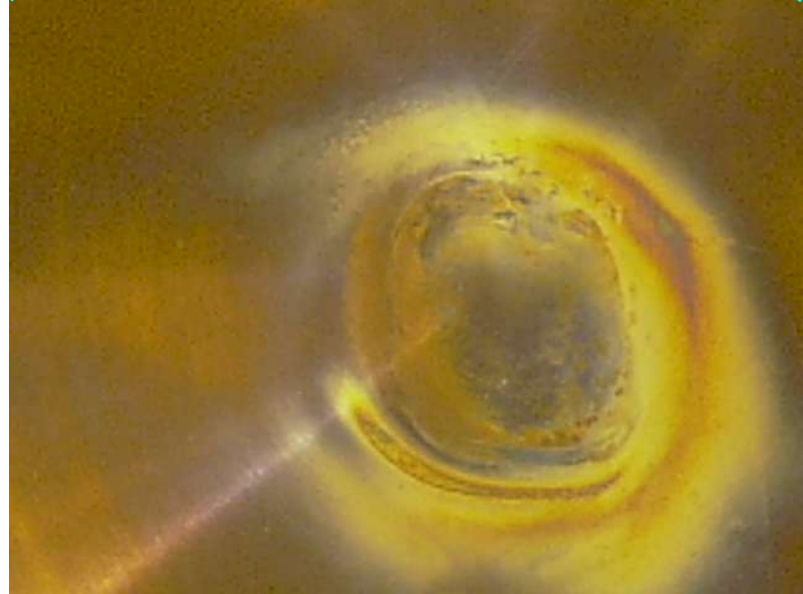
# Put the beam window into the casket **Aug. 22**



Pillow seal is deformed, so it is impossible to reuse the old beam window.

The beam window is damaged.  
**It is correct to replace it this year!!**

We have to investigate what happens to this part.

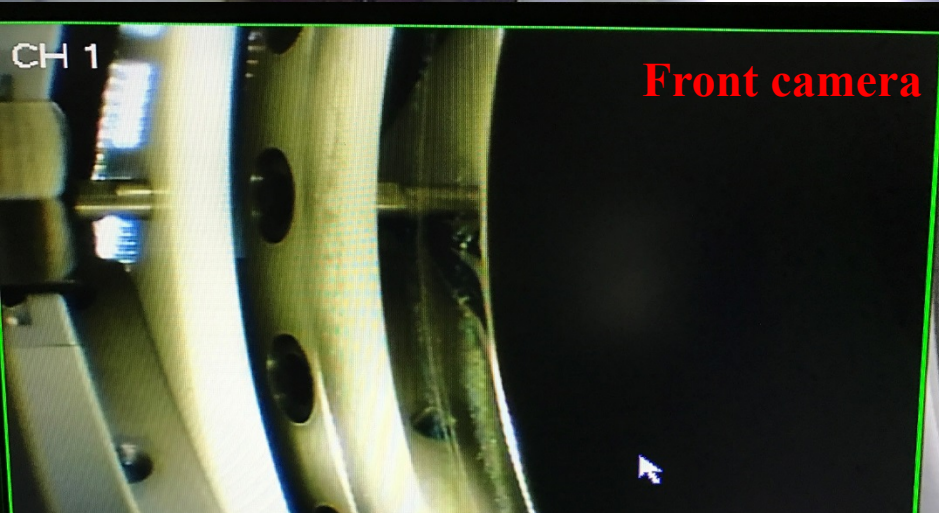
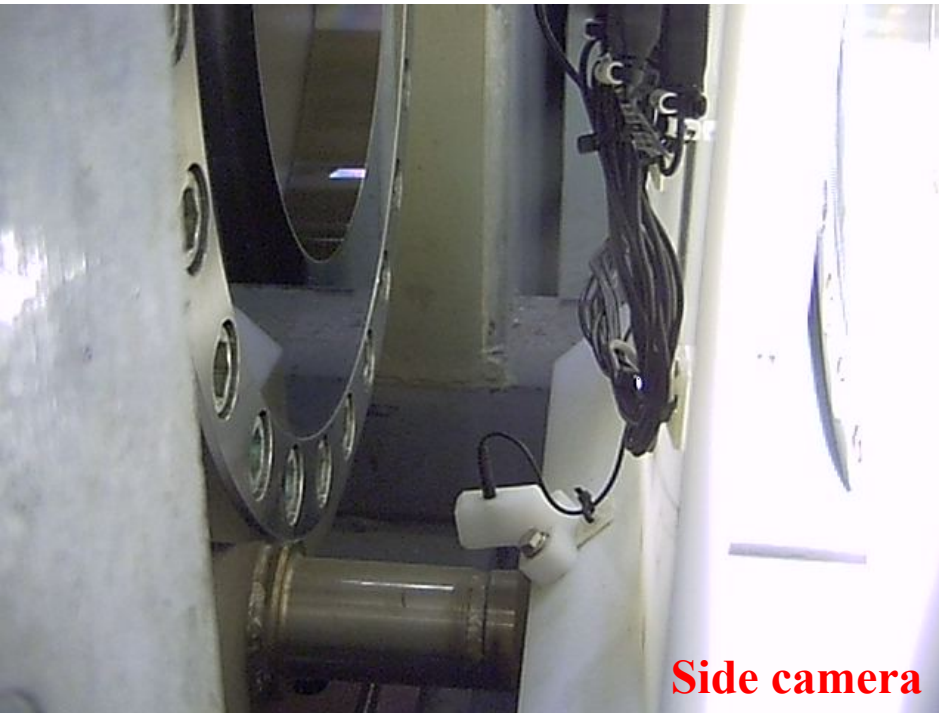


# Procedure of the replacement for the beam window

- 1) Pull the shield (above the beam window) out with handling machine
- 2) Shorten the pillow seals and Pull the beam window out with handling machine
- 3) Take the beam window to the maintenance area and put it into the casket with handling machine
- 4) Clean the surface of the pillow seal flange with the cleaner**
- 5) Install the new beam window with handling machine and expand the pillow seals
- 6) Install the shield above the beam window with handling machine



# Watch the mirror flanges with camera **Aug. 22**



**Mirror flanges were very clean and had no scratch.**



# Procedure of the replacement for the beam window

- 1) Pull the shield (above the beam window) out with handling machine
- 2) Shorten the pillow seals and Pull the beam window out with handling machine
- 3) Take the beam window to the maintenance area and put it into the casket with handling machine

**4) Clean the surface of the pillow seal flange with the cleaner**

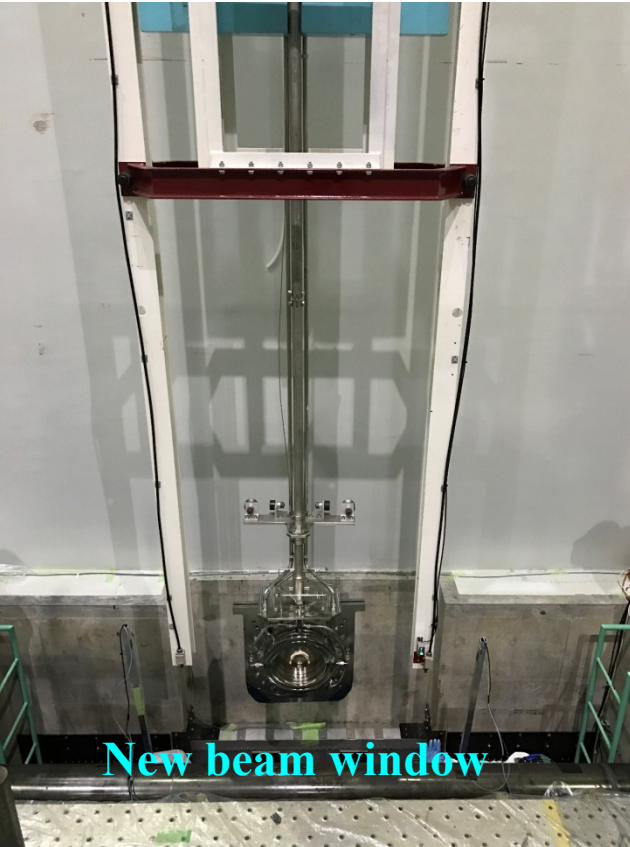
**We skipped this process, because the mirror flanges are very clean.** he pillow seals

- 6) Install the shield above the beam window with handling machine

# Procedure of the replacement for the beam window

- 1) Pull the shield (above the beam window) out with handling machine
- 2) Shorten the pillow seals and Pull the beam window out with handling machine
- 3) Take the beam window to the maintenance area and put it into the casket with handling machine
- 4) Clean the surface of the pillow seal flange with the cleaner
- 5) Install the new beam window with handling machine and expand the pillow seals**
- 6) Install the shield above the beam window with handling machine

# Install the new beam window into the beam line **Aug. 23**



We can work near the beam window because the new one is not irradiated.

Camera view



But it is necessary to watch the camera near the beam line.

# Expand the pillow seal **Aug. 23**

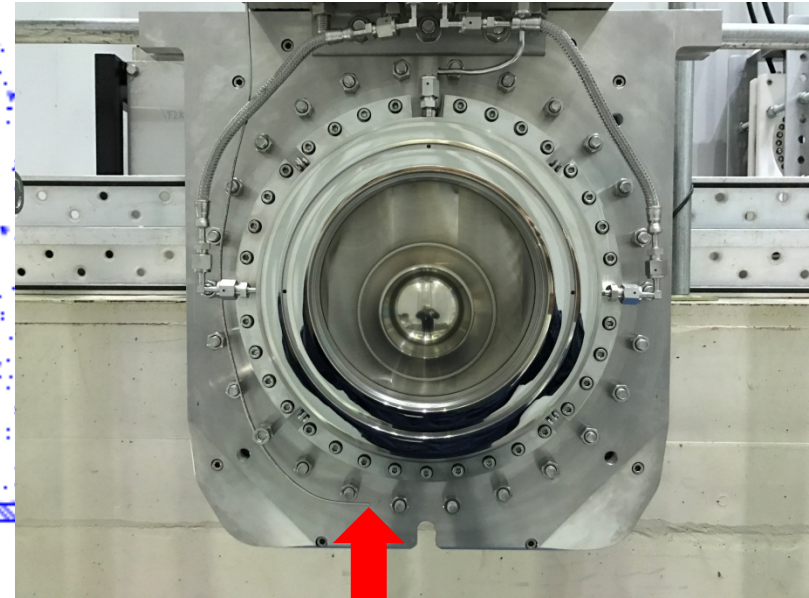
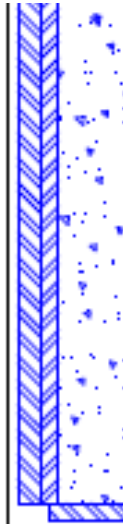
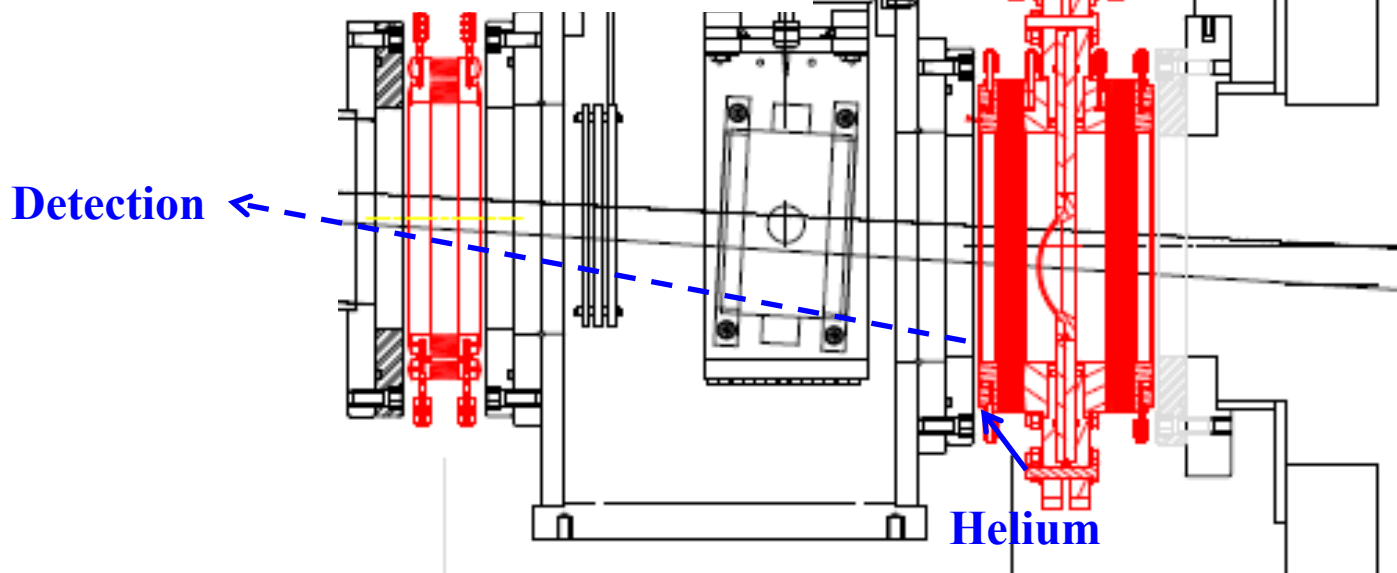




# Leak test **Aug. 25**



Helium gas was sprayed through the pipe for the leak test and the leak rate was detected with a helium leak detector in the primary beam line.

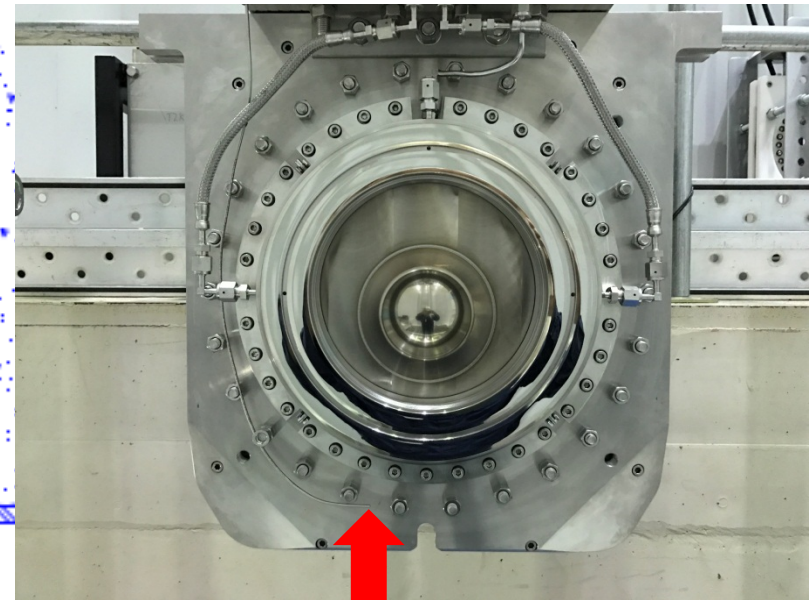
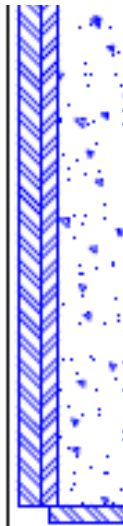
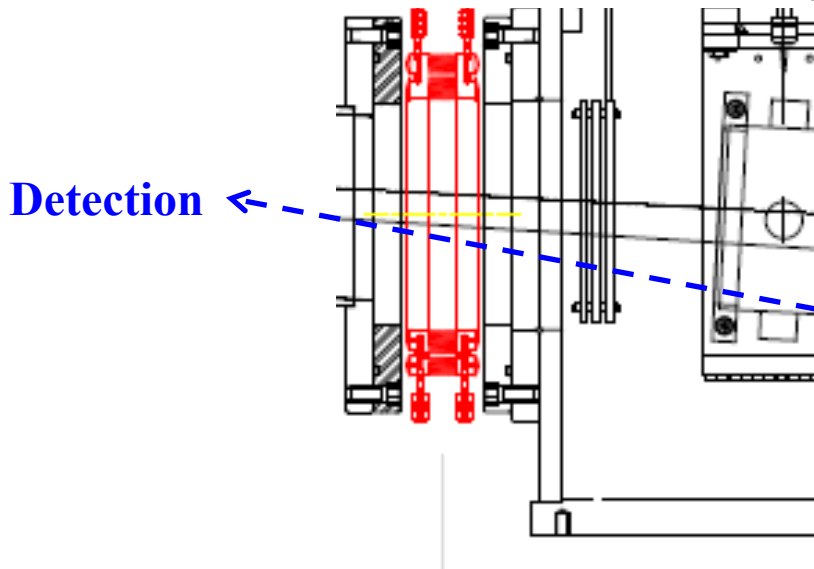


**Helium pipe for leak test**

# Leak test **Aug. 25**



Helium gas was sprayed through the pipe for the leak test and the leak rate was detected with a helium leak detector in the primary beam line.



**Helium pipe  
for leak test**

**Results :**

**Before replacement ( old window )**

**$1.8 \times 10^{-9} \text{ Pa m}^3 / \text{sec}$**

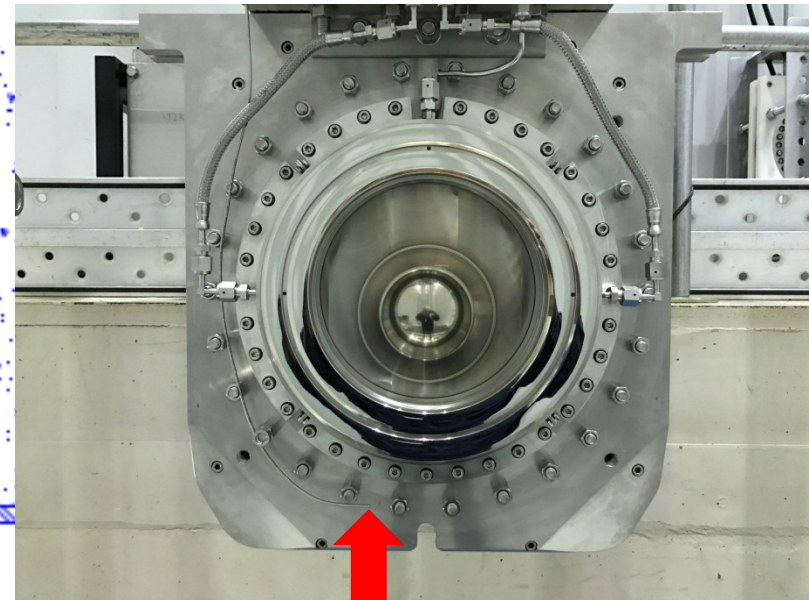
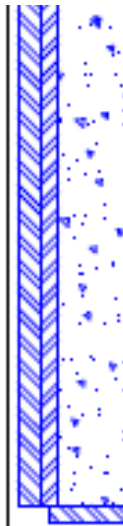
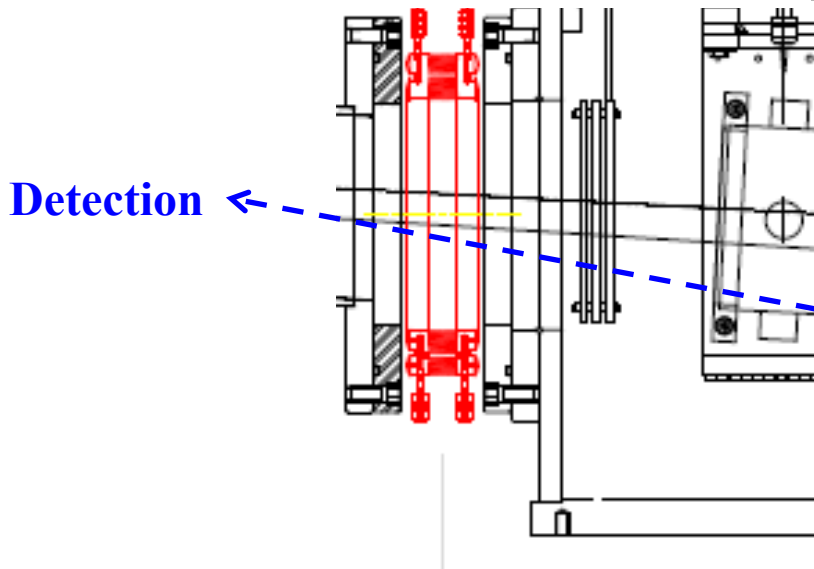
**After replacement ( new window )**



# Leak test **Aug. 25**



Helium gas was sprayed through the pipe for the leak test and the leak rate was detected with a helium leak detector in the primary beam line.



**Helium pipe  
for leak test**

**Results :**

**Before replacement ( old window )**

**$1.8 \times 10^{-9} \text{ Pa m}^3 / \text{sec}$**

**After replacement ( new window )**

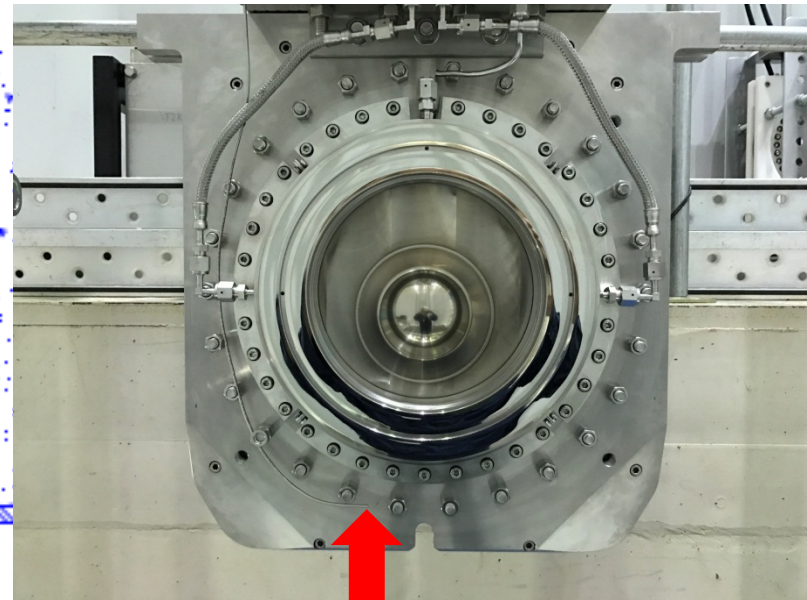
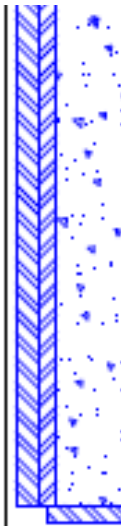
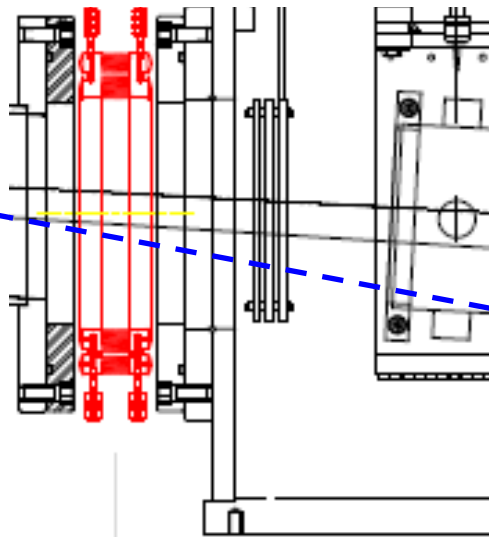
**$1.4 \times 10^{-9} \text{ Pa m}^3 / \text{sec}$**

# Leak test **Aug. 25**



Helium gas was sprayed through the pipe for the leak test and the leak rate was detected with a helium leak detector in the primary beam line.

Detection ←



**Helium pipe  
for leak test**

**Results :**

**Before replacement ( old window )**

**$1.8 \times 10^{-9} \text{ Pa m}^3 / \text{sec}$**

**After replacement ( new window )**

**$1.4 \times 10^{-9} \text{ Pa m}^3 / \text{sec}$**

**Replacement work was succeeded!!**



# Install the shield **Aug. 25**



**Install the shield above the beam window**



**Connect pipes**



**Take the shield from the maintenance area**

# Summary

**We replaced the beam window this summer.**

**The beam window was replaced successfully!!  
No serious trouble arose.**

**Keys of success are :**

**Using well-designed remote handling machines and working plan  
Sufficient preparations and rehearsals**



# Schematic diagram of the gas/vacuum system for window

