Poster 24

Life cycle of the proton beam window in J-PARC MLF

– PBW replacement work in 2023 –

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Abstract

Materials and Life science experimental facility (MLF) in J-PARC is neutron and muon experimental facility in Japan. 3 GeV pulsed proton beam are injected to the spallation neutron target. The proton beam window (PBW) is the boundary wall between the vacuum space in the proton beam line and the helium atmosphere in the helium vessel where the neutron target is installed. Lifetime of the PBW is estimated to be 10 GWh and during this summer maintenance period, we finished 4th PBW replacement in MLF successfully.

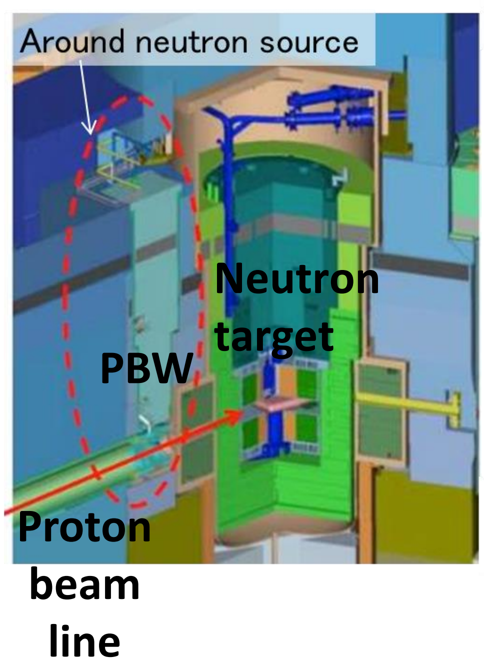
Purpose

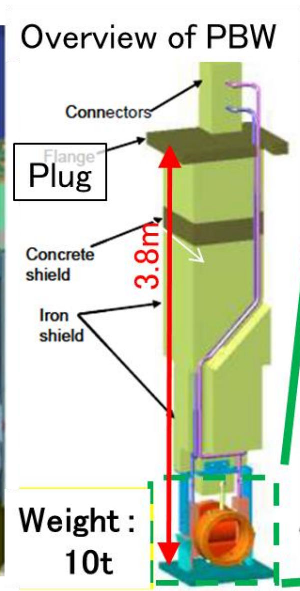
- Replace highly activated PBW #4 to new PBW #5.
- Reduction of radiation exposure risks during the replacement work.
  - internal exposure to under detection limit.
  - external exposure to lower than pre–evaluation value.

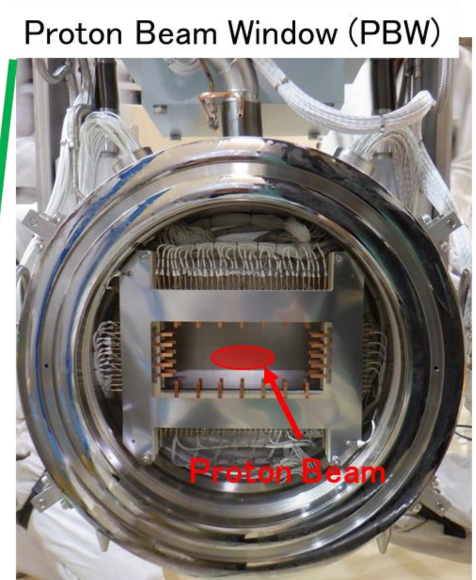
    (pre–evaluation is 60 μSv in 2023)

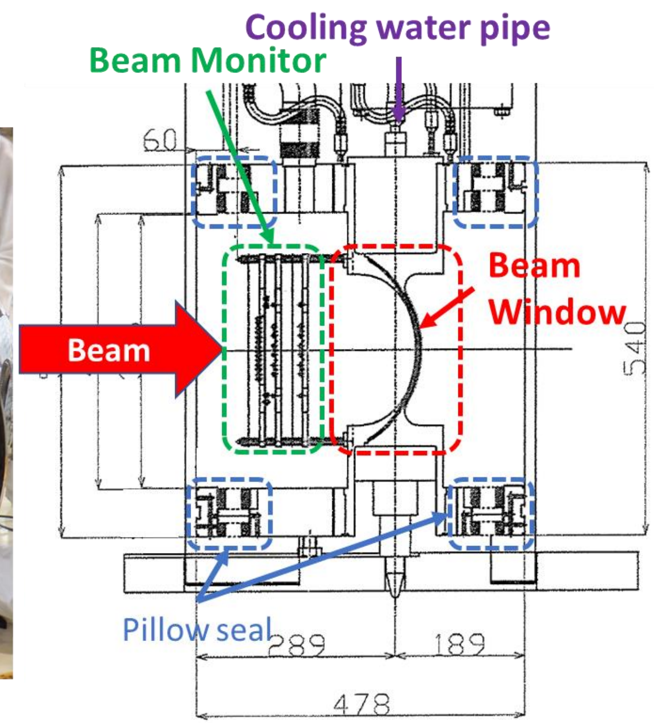
Proton Beam Window

・Boundary between Accelerator (Vacuum) and Neutron source (atmospheric pressure)
・Material: Al alloy (A5083). Double wall 2.5 mmt×2
・Cooling: Water cooling.
・Life time: 10 GWh (Replace every 2~3 years @ 1MW operation)
・Replacement work: Hands-on work and remote handling are required



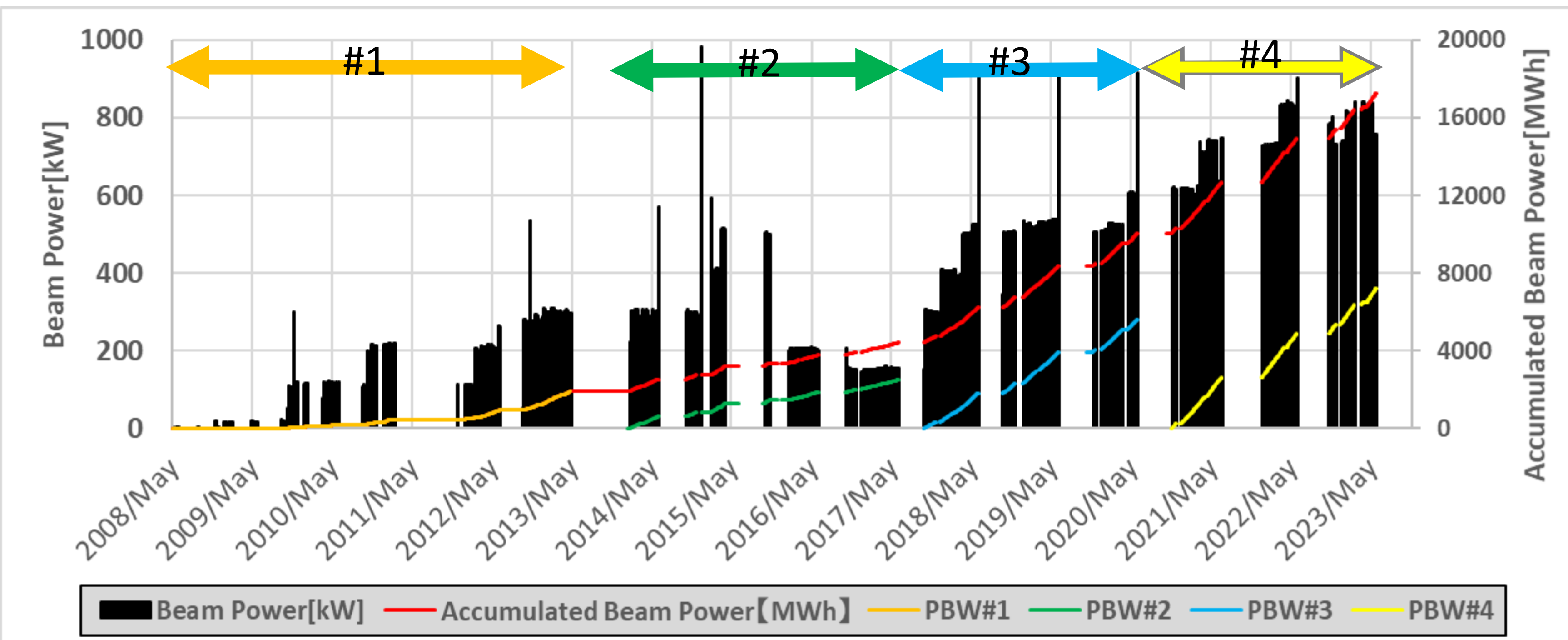






PBW operation history

PBW	Beam Power (MWh)	Operation period	Dose rate [mSv/h@50cm] (Cooling time)	Tritium density in water [Bq/cc]
#1	1917	2008 – 2013	-	
#2	2509	2014 – 2017	202 (1 month)	
#3	5630	2017 – 2020	570 (1 month)	1.3×10^5
#4	7180	2020 – 2023	538 (4 month)	2.1×10^5
#5		2023 -		



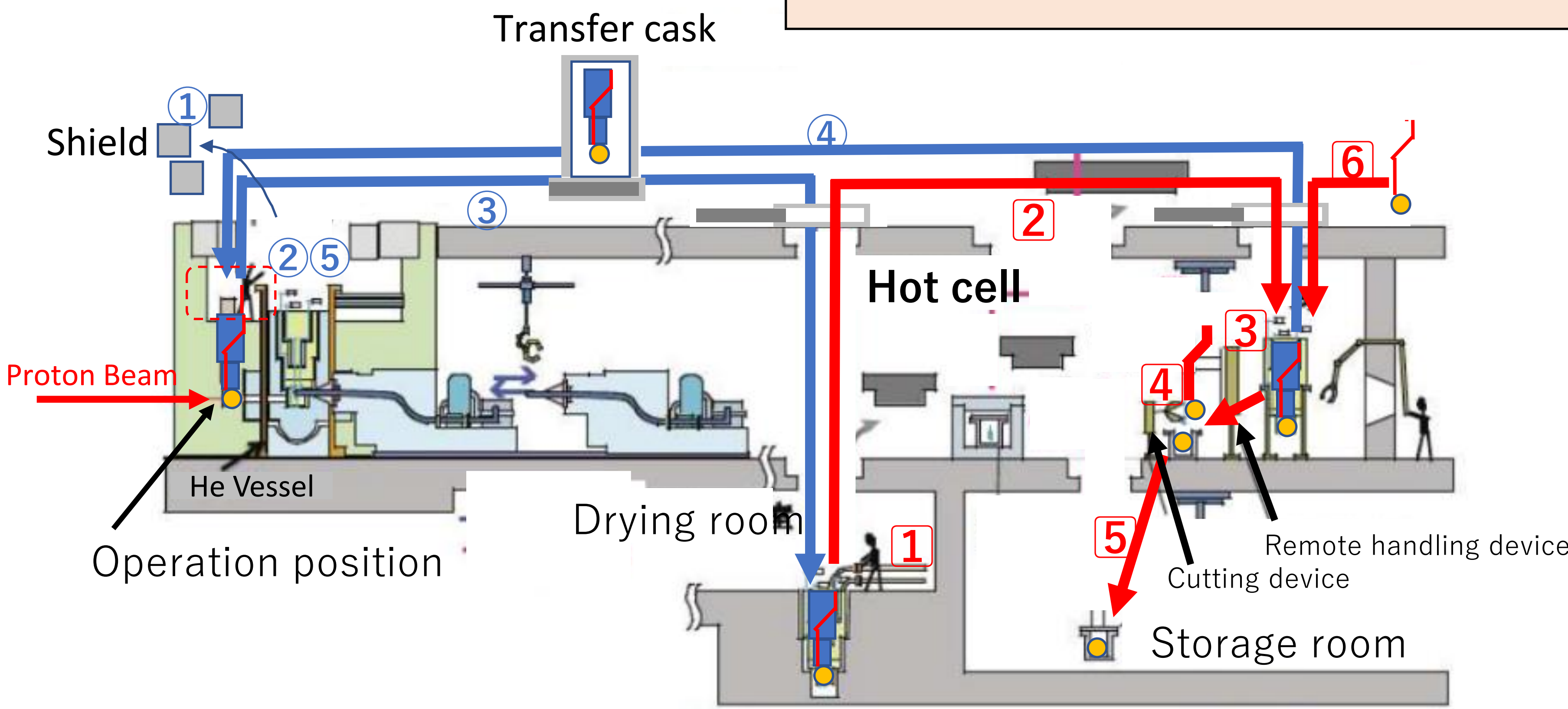
Outline of PBW replacement work

PBW Replace (In 2023, It took 7 days)

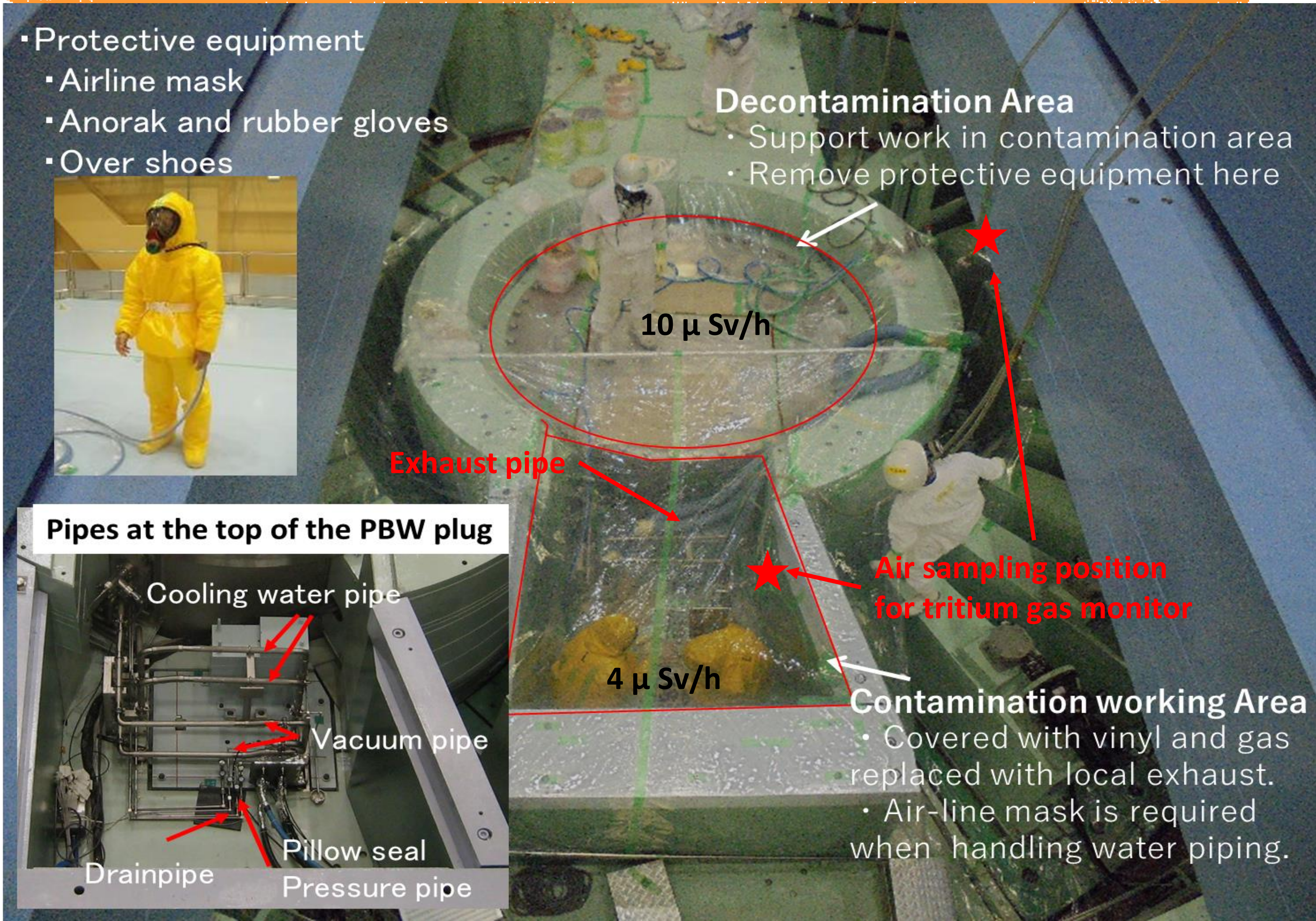
① Remove the upper shield
② Remove pipes by hands-on work
③ Move the used PBW to Drying room
④ Install new PBW to operation position
⑤ Connect pipes by hands-on, and seal check.

PBW cutting and storing (In 2022, It took 8 days)

1 Dry up water pipes of PBW
2 Move the used PBW to Hot cell
3 Remove PBW from Plug by remote handling
4 Cut pipes of PBW and store in cask
5 Store the cask to storage room
6 Install new PBW to plug



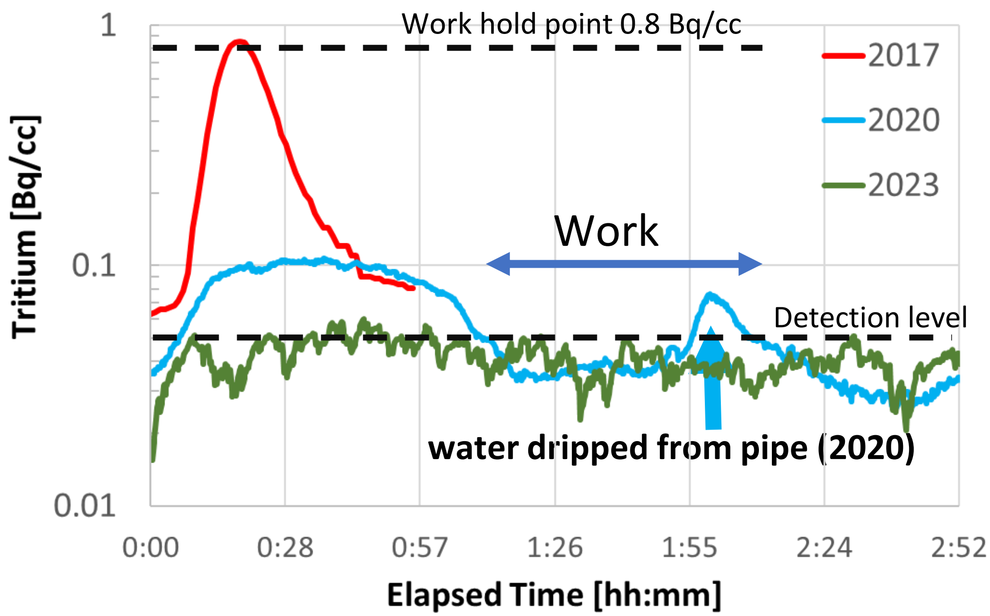
Working area above the PBW



Tritium concentration in the working space

Major tritium sources are He vessel, proton beam line and water in cooling pipe.
Tritium concentration above the PBW increased when pillow seal released and water dripped.
Radiation control team required to reduce worker's internal exposure as much as possible.
To reduce internal exposure, we use air-line mask, and local exhaust.
If possible, we wait for the tritium concentration in the air to decreases before starting the work.
The work hold point is decided to stop work when tritium concentration becomes high.

Tritium concentration in air above the PBW after pillow seal released



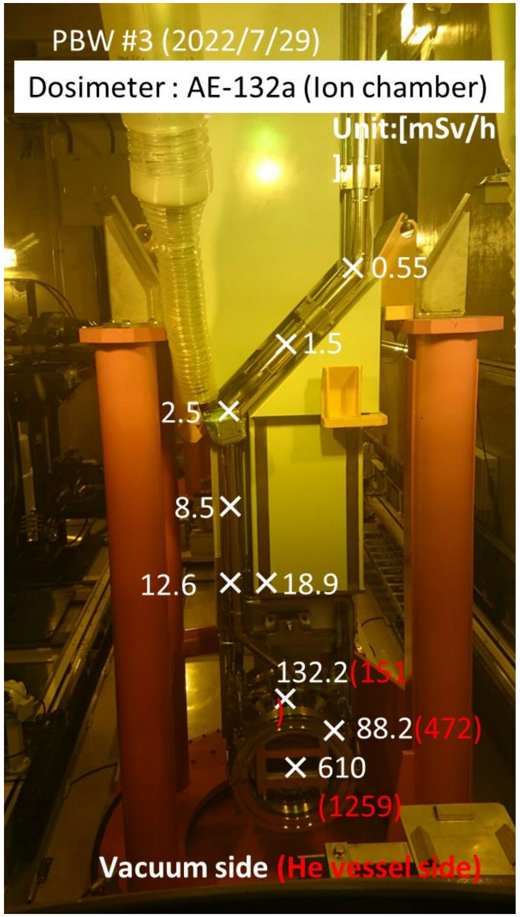
2017: After pillow seal released, tritium density over PBW was increased around **1 Bq/cc**

2020: Gas in **helium vessel** was replaced before the work. And the vessel exhaust system was running.
Tritium density over PBW was up to **0.1 Bq/cc.**
When the water dripped from the pipe, tritium density was increased to 0.07 Bq/cc.

2023: Gas in the **helium vessel** and **proton beam line** were replaced a few times before PBW replacement. Tritium density was increased up to **0.06 Bq/cc.**

Radiation dose from PBW #3

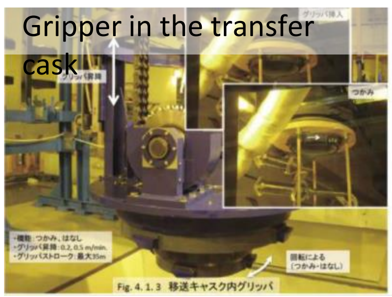
Used PBW has high radiation dose more than 1 Sv/h around PBW body. We transport PBW with shielded transfer cask which has iron shield of 30 cm thick. The surface dose of the transfer cask is a few µSv/h with the used PBW in it, making it safe to transport.



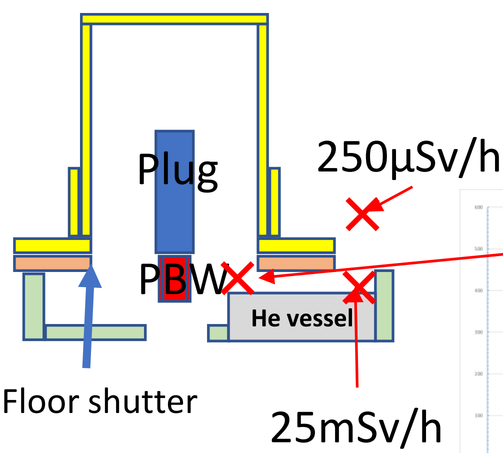
Dose during lifting up the PBW from operation position

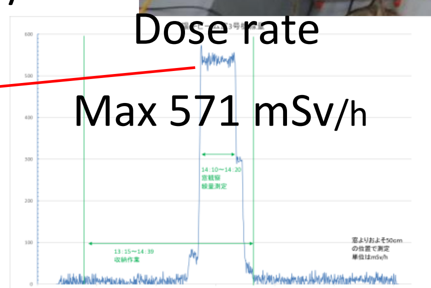
PBW is highly activated. We use shielded transfer cask to lift up from operation position. When the PBW is same height as the top of He vessel, dose rate above the He vessel becomes the highest. However, with the shield of the transfer cask, dose above the top shield is only a few µSv/h. After storing the PBW into the cask and closing the bottom hatch, we can access to the top of He vessel.

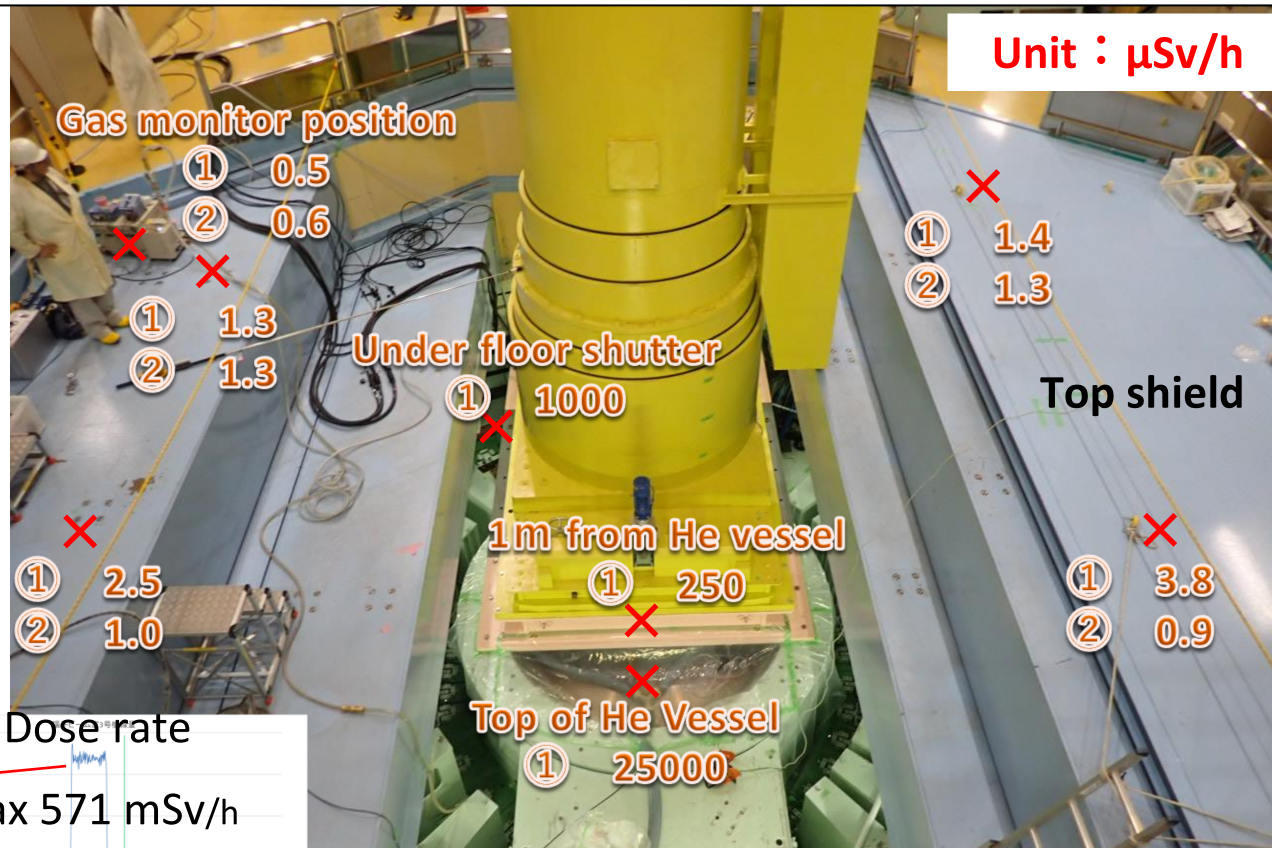
Dosimeter
- GG-105J（Proportional counter)
- GT-104J（Teletecta）



PBW position of ①







① PBW is same height as the top of He vessel.
② PBW is stored in transfer cask.

Results

PBW #4 was successfully replaced to PBW #5 on schedule.
The radiation exposure (both of internal and external) of workers was below the detection limit.
Tritium concentration above the PBW was the lowest compared with the past replacement works when the pillow seal released.

Issue

The lifetime of 10 GWh has been conservatively estimated based on post-irradiation examination (PIE) at the Swiss Spallation Neutron Source (SINQ), Paul Scherrer Institute (PSI) and should be investigated by PIE for the PBW of MLF to avoid lack of storage space. However, it is difficult to perform PIE at MLF and other facilities in JAEA due to allowable contamination level of Hot-cell and regulation in Japan, respectively.
Thus, similar examination using heavy ion beam is underway.