7th High Power Targetry Workshop
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Target system maintenance experience in hot cell at J-PARC

Hidetaka Kinoshita, Katsuhiro Haga, Tetsuya Kai,
Takashi Wakui, Hiroyuki Kogawa, Makoto Teshigawara,
Takashi Naoe, Hiroshi Takada

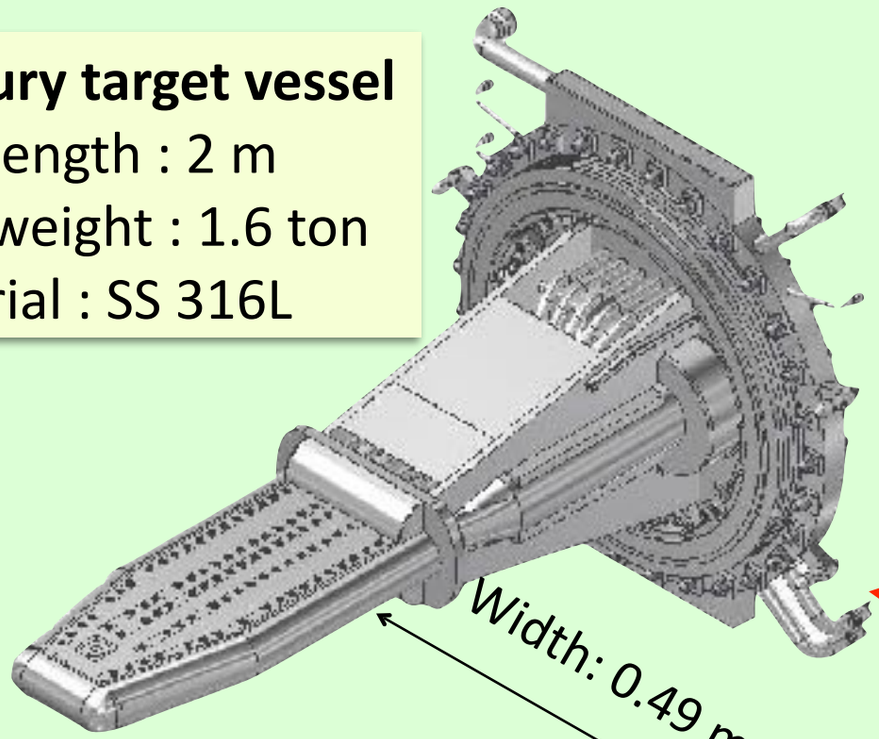
Neutron Source Section, Materials and Life Science Division,
J-PARC Center, Japan Atomic Energy Agency

Contents

- Mercury target for J-PARC spallation neutron source
- Hot cell design policy for liquid metal target
- Maintenance experience
- Improvements based on experience
- Summary

J-PARC 1MW spallation neutron source

Mercury target vessel
Total length : 2 m
Total weight : 1.6 ton
Material : SS 316L



Materials and Life science Facility (MLF)

Cryogenic hydrogen system

Helium vessel

Moderators

3 GeV 25 Hz
proton beams

Proton beam
window

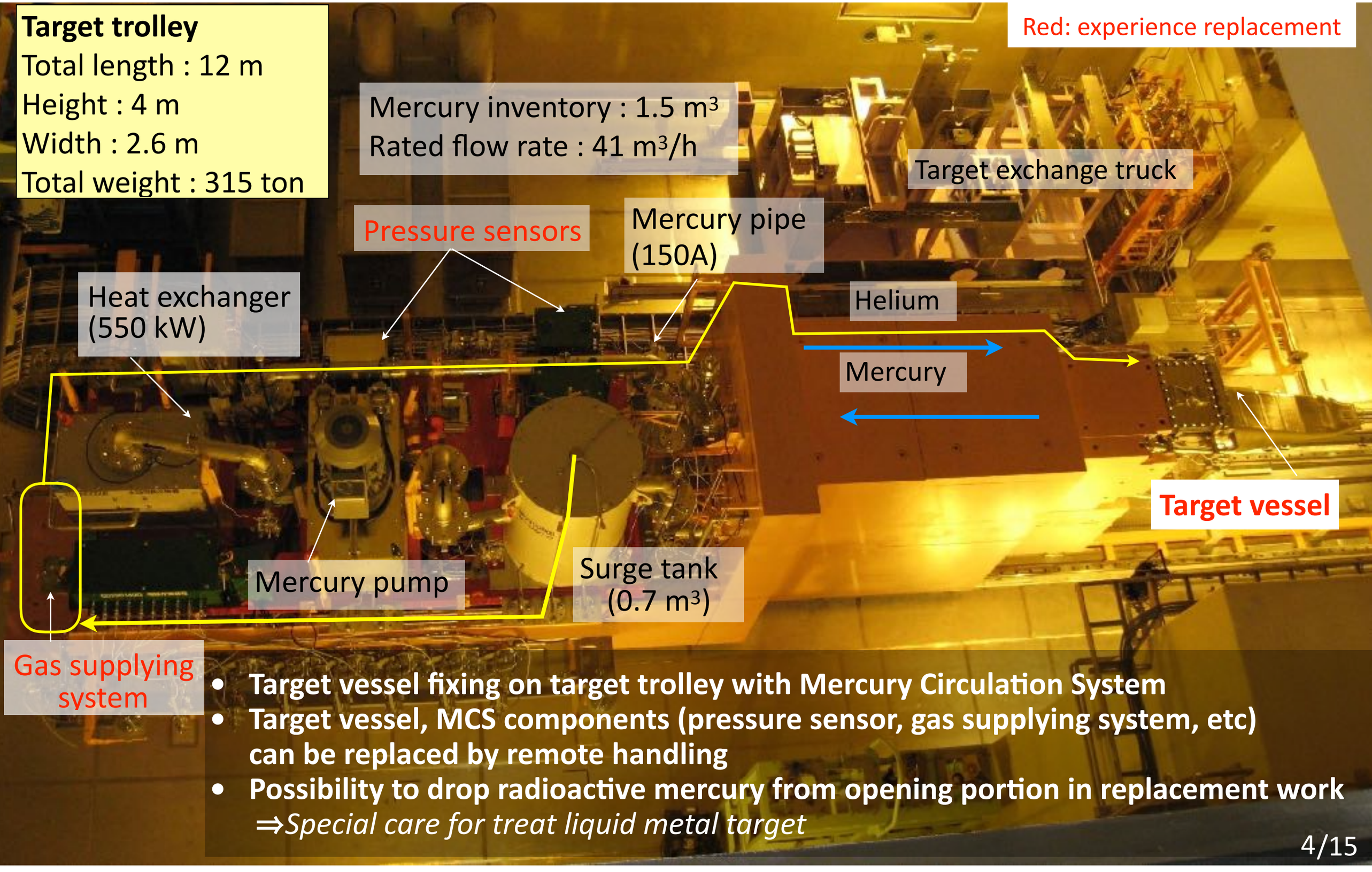
Mercury target vessel

Target trolley

Mercury circulation system

Neutron beam lines (23)

Mercury target and circulation system



- **Target vessel fixing on target trolley with Mercury Circulation System**
- **Target vessel, MCS components (pressure sensor, gas supplying system, etc) can be replaced by remote handling**
- **Possibility to drop radioactive mercury from opening portion in replacement work**
  ⇒*Special care for treat liquid metal target*

Hot cell design policy for J-PARC mercury target

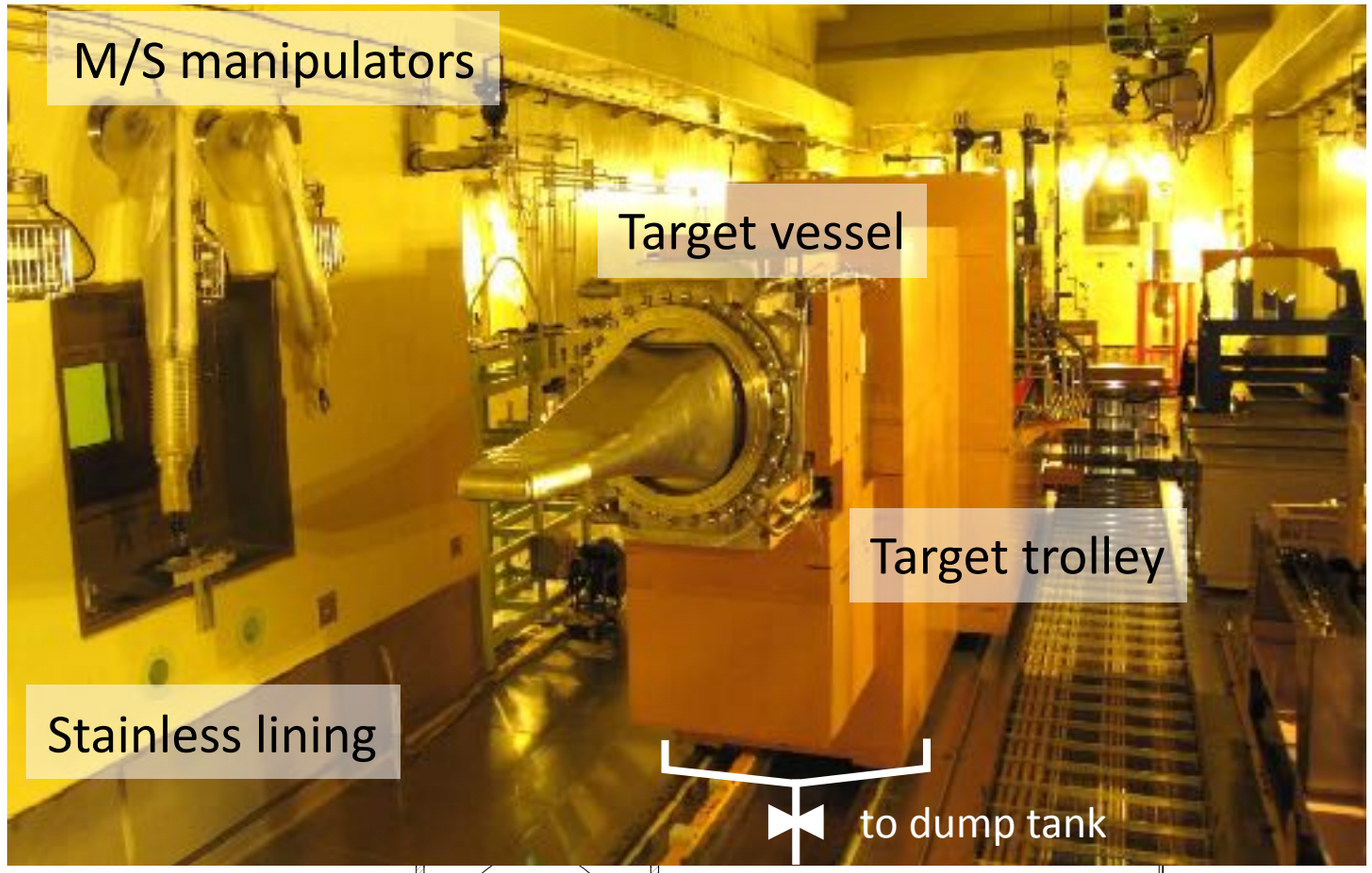
- **Mercury collectable structure, in case of mercury leak in hot cell**
  → Stainless lining floor and drain piping in hot cell and trolley

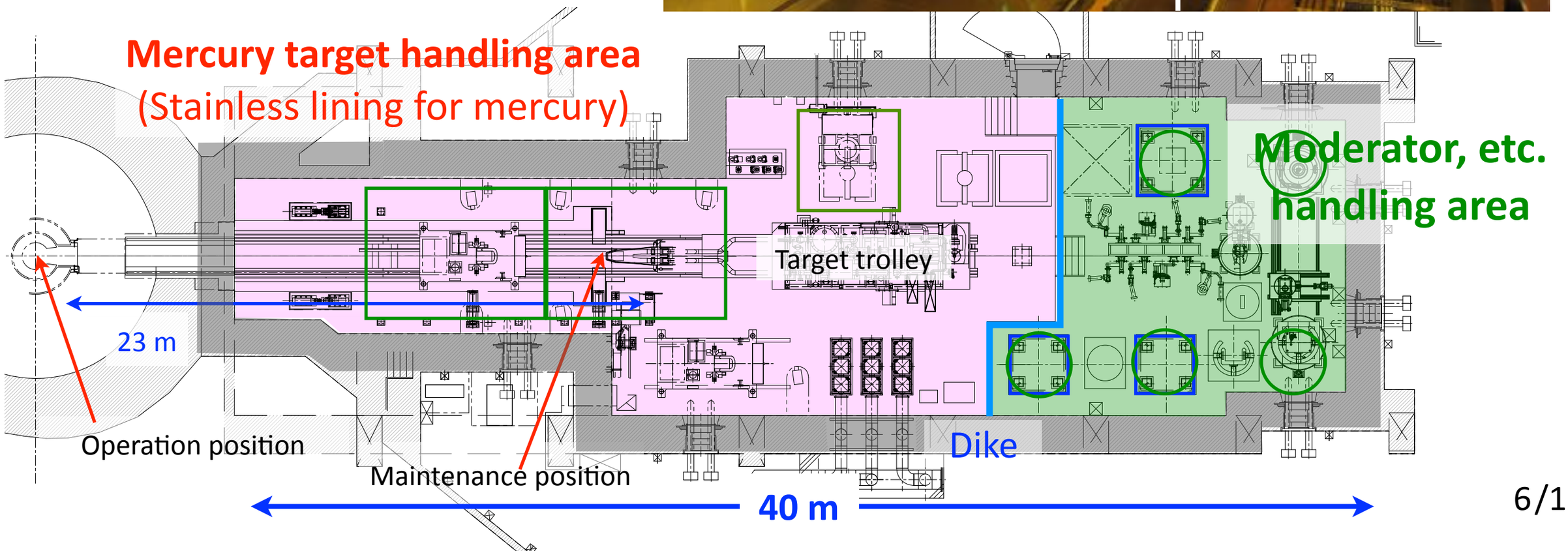
- **A few hands-on maintenance are necessary in hot cell**
  → Keep low-level contamination in hot cell

- **Control high-radioactive noble gas and tritium exhaust**
  → Off-gas processing system to filtering and decaying noble gas

Remote handling area in hot cell (1F)

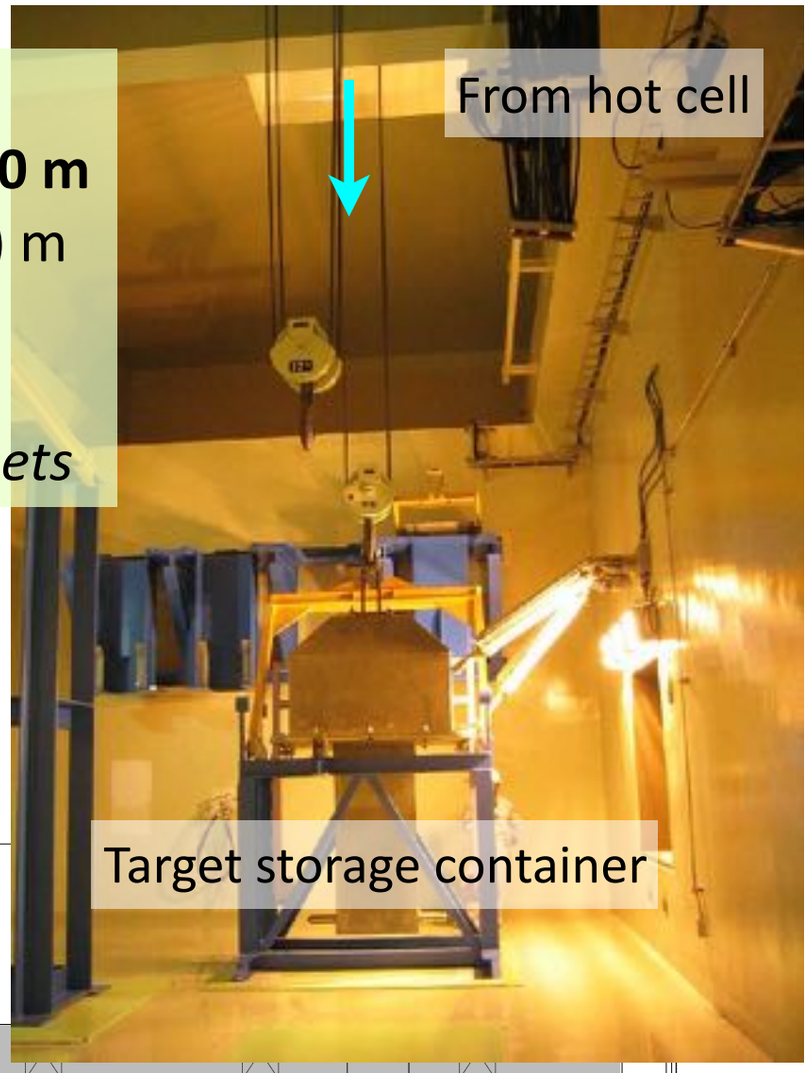
Hot cell (MLF 1F)
L : 40 m × W : 13 m × H : 12 m
Separate two area
Mercury area, moderator area
Ceiling hatch : 12×5 (2), 4×4 (1), 2.4×2.4 (5) m
Carry equipments into hot cell from high-bay
Floor hatch : 2.4×2.4 (3)
Carry used components into storage room/dry up room

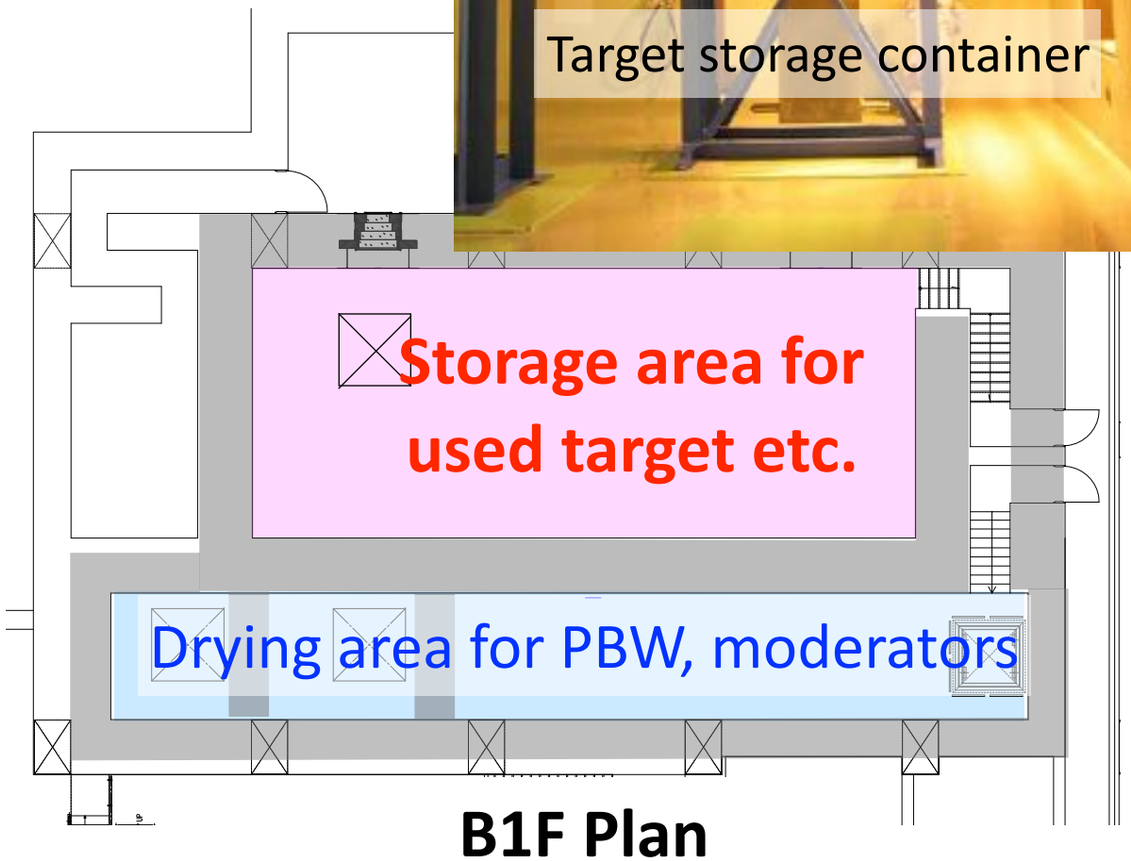




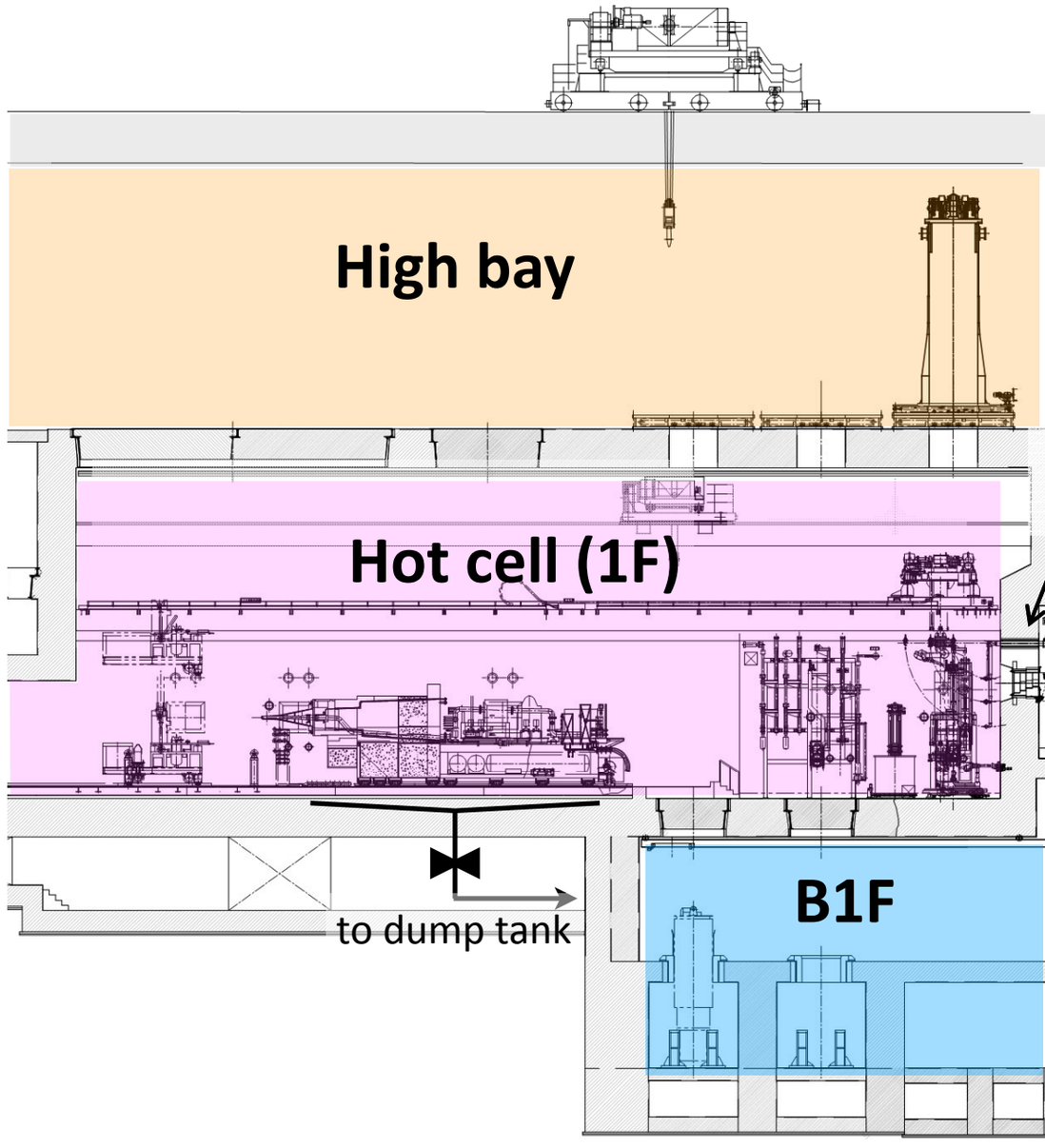
Storage room for used components

Storage room (MLF B1F)
L : 20 m × W : 8 m × H : 10 m
Ceiling hatch : 2.4×2.4 (1) m
In-cell crane 12 ton
M/S manipulator 2 pairs
Capacity:6~8 used targets



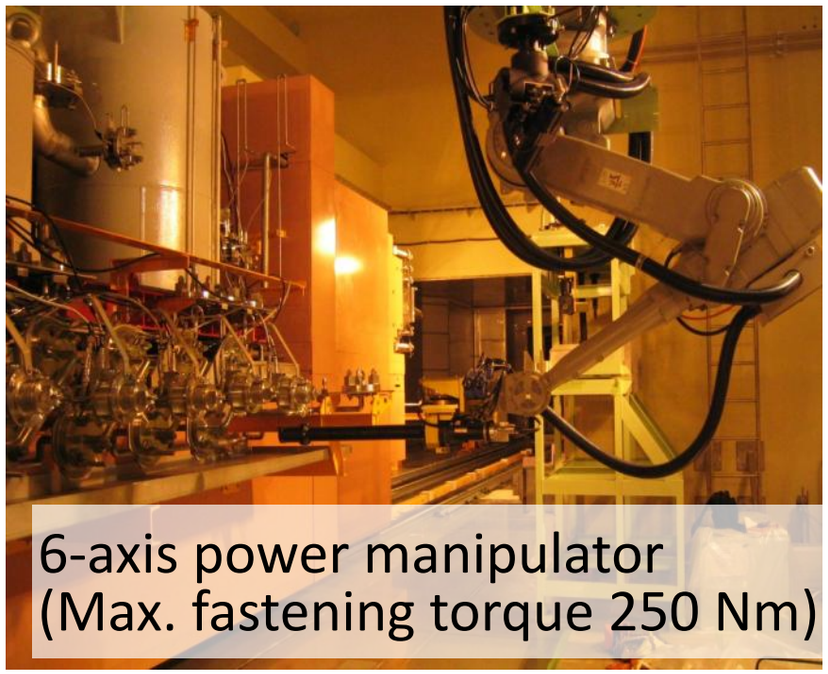


B1F Plan

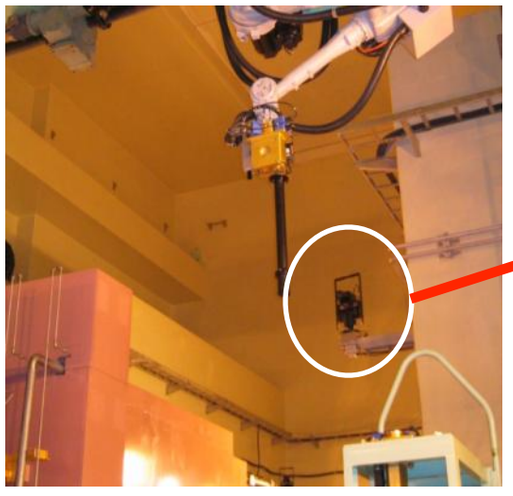


Sectional plan

Equipments for target vessel replacement



20ton crane: 1
M/S manipulator: 9 pairs
Power manipulator: 1
In-cell camera: 10
(target area)



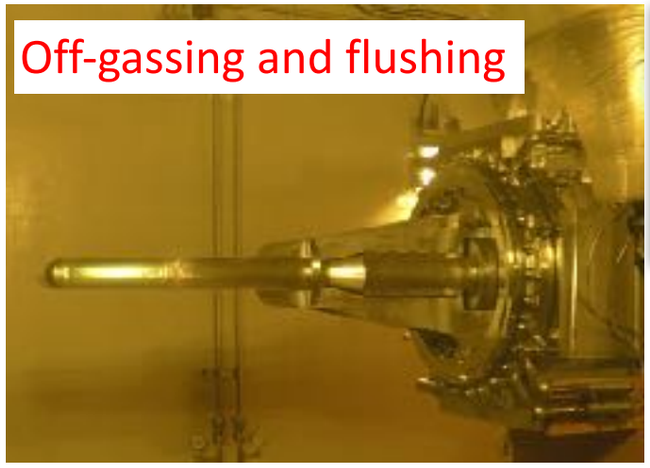
In-cell camera

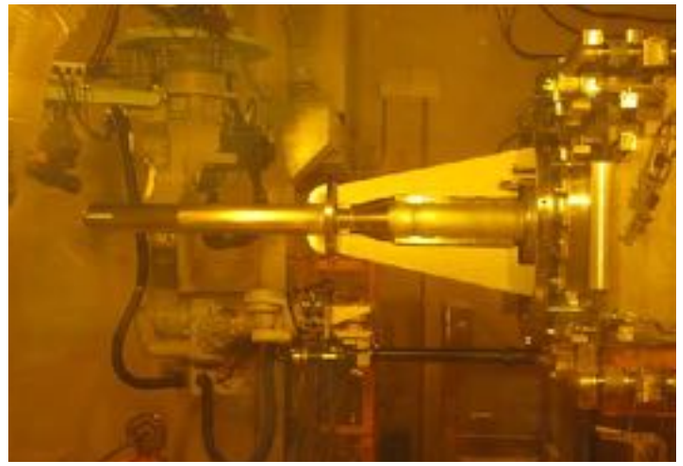
Video camera tube

Tools for power manipulator

- Target replace by remote handling using these equipments because used target has high-dose rate (ca.350 Sv/h)

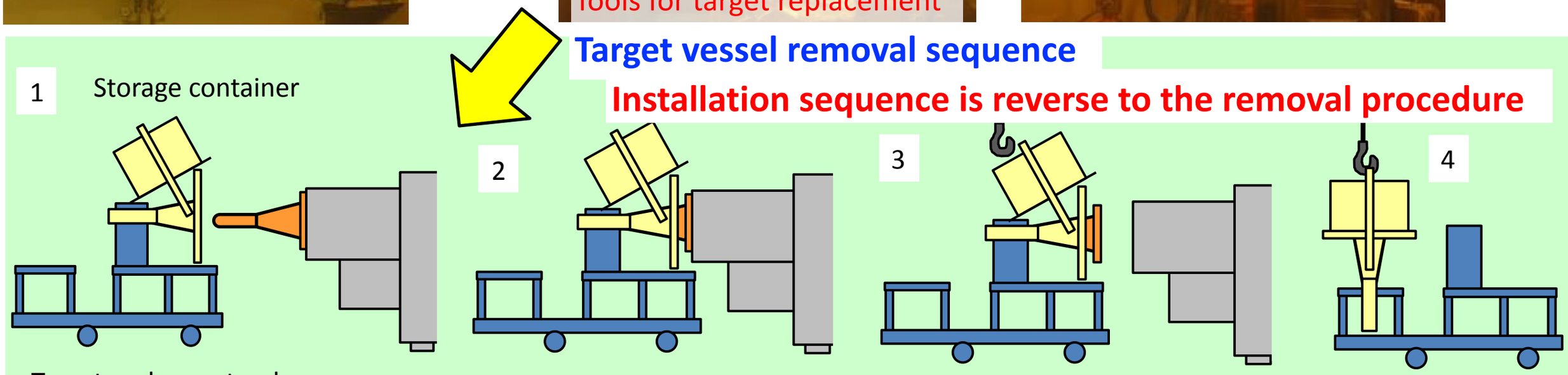
Outline of target vessel replacement





Target vessel removal sequence

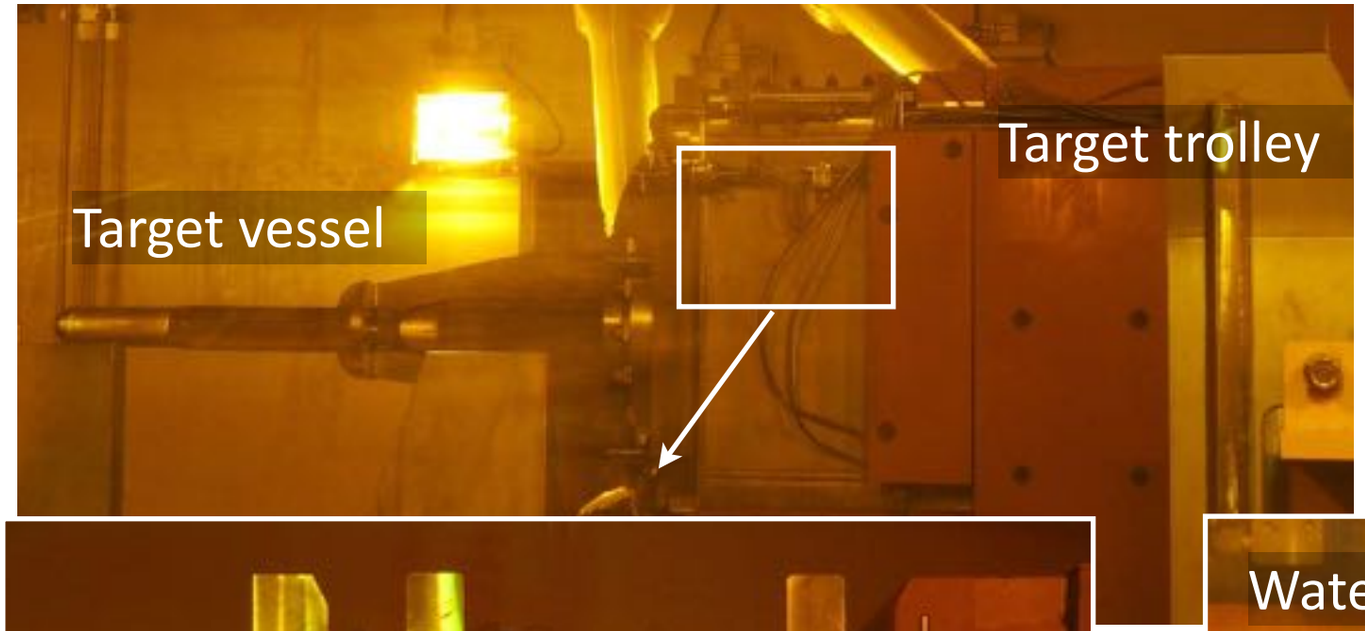
Installation sequence is reverse to the removal procedure

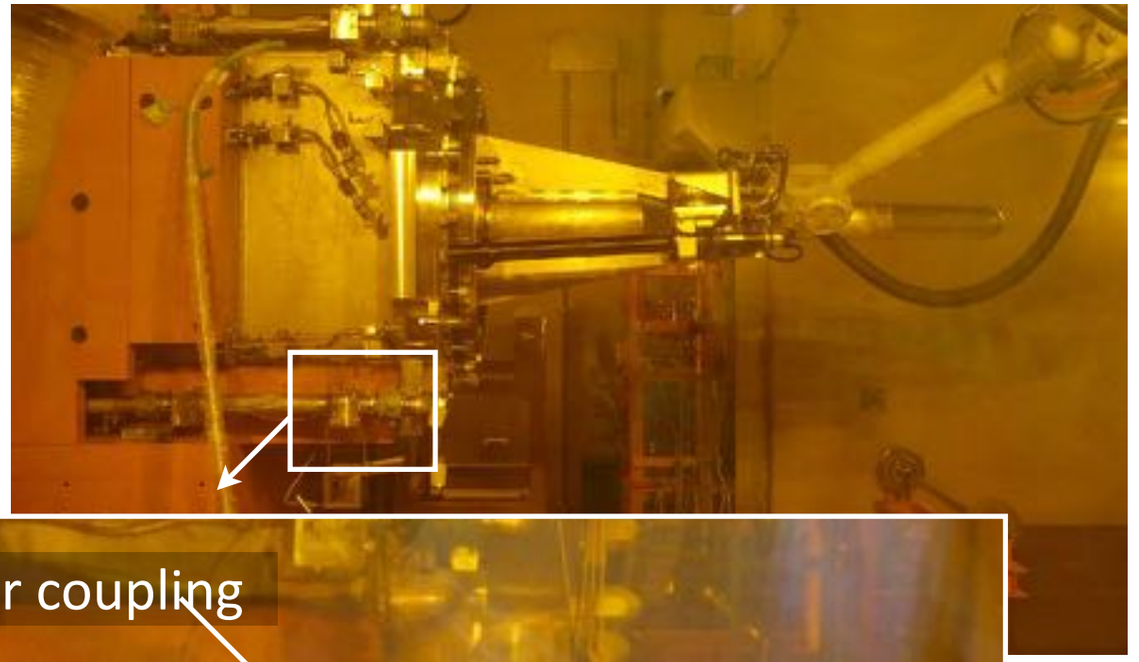


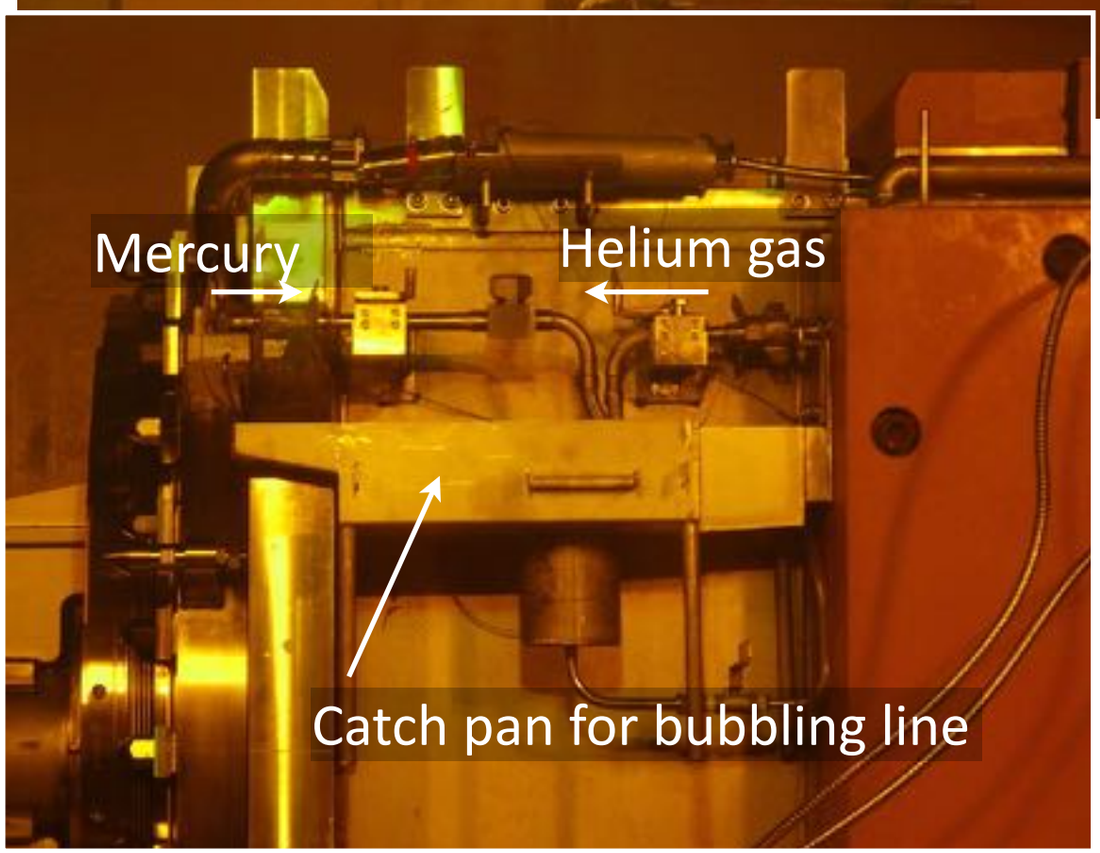
- Target exchange truck and storage container sets in front of target
- Remove bolts and H_2O, He, Hg pipings
- Insert target into storage container
- Separate target from target trolley
- Raise storage container and change to new target

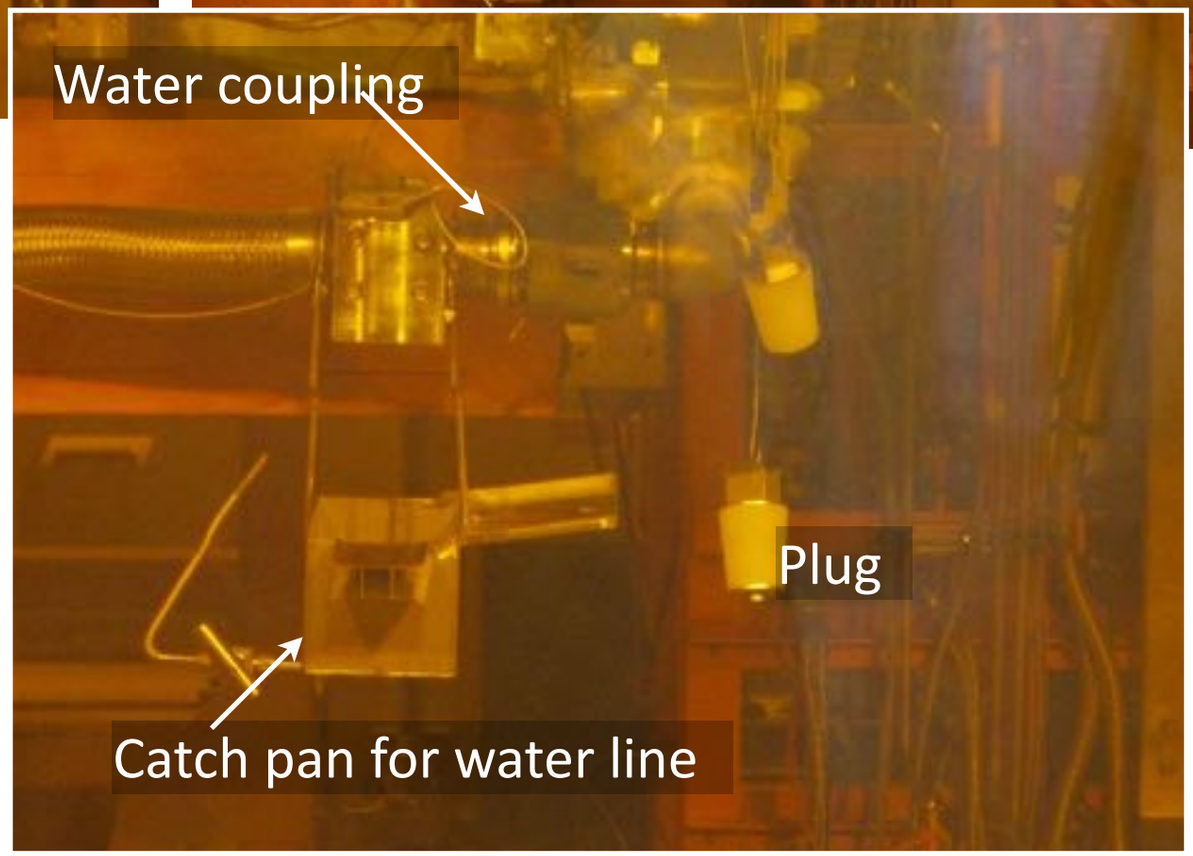
- Off-gassing and flushing inside mercury vessel and circulation system
- Dose rate of target vessel is ca. 350 Sv/h after 77 days operation
- 21 staff members involved for replacement work
- Actual result in 2017 was 20 working days (12 days for exclude off-gas processing)
  (Optimized replacement procedure, adopt new tools, increase worker skill)

Contamination control in hotcell



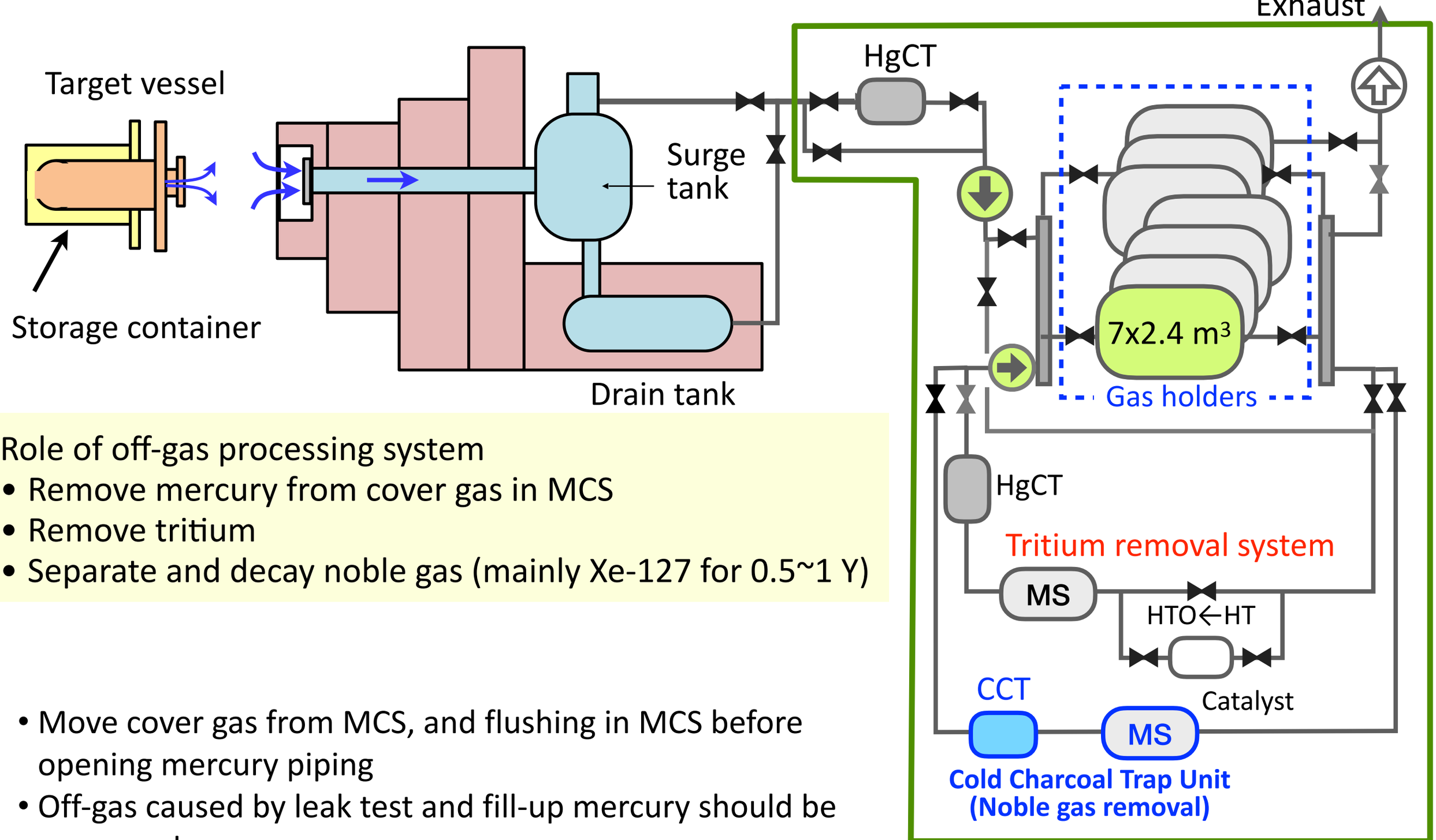






- Regularly inspection and maintenance work should be done in hot cell
- Catch pans are placed before removing mercury and water piping to contamination control of hot cell floor

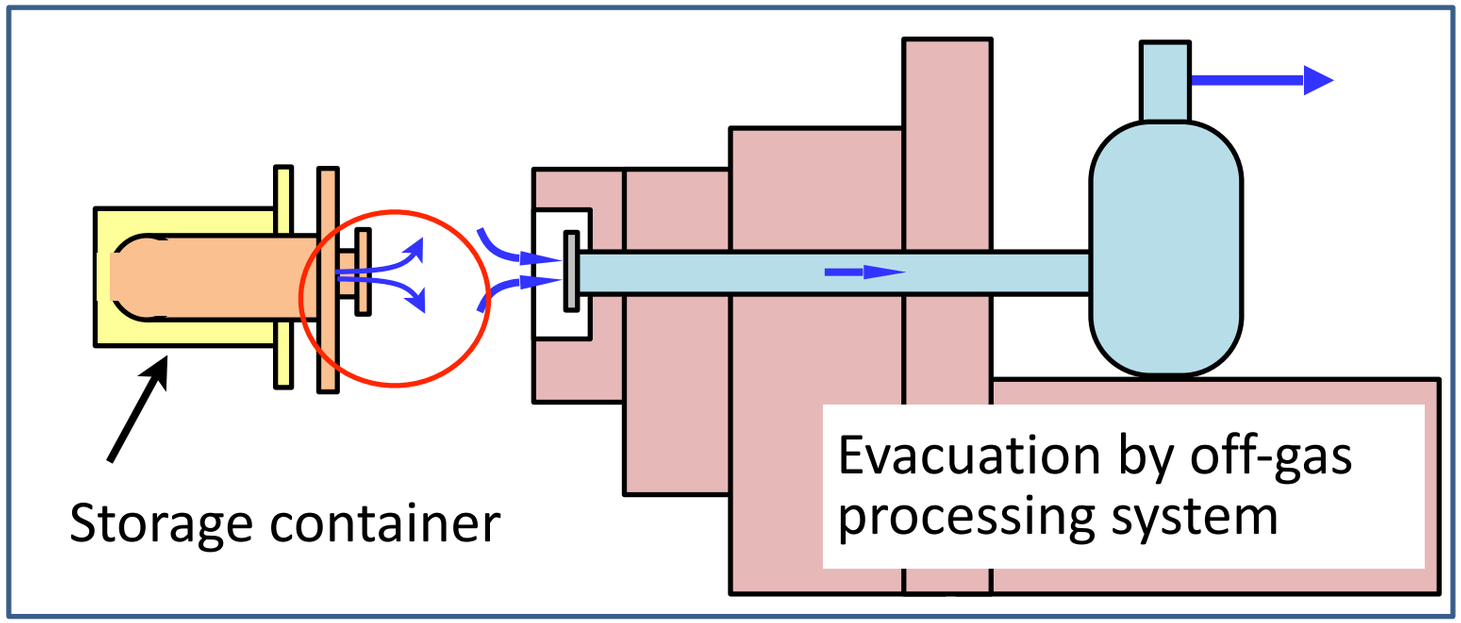
Off-gas processing system at J-PARC

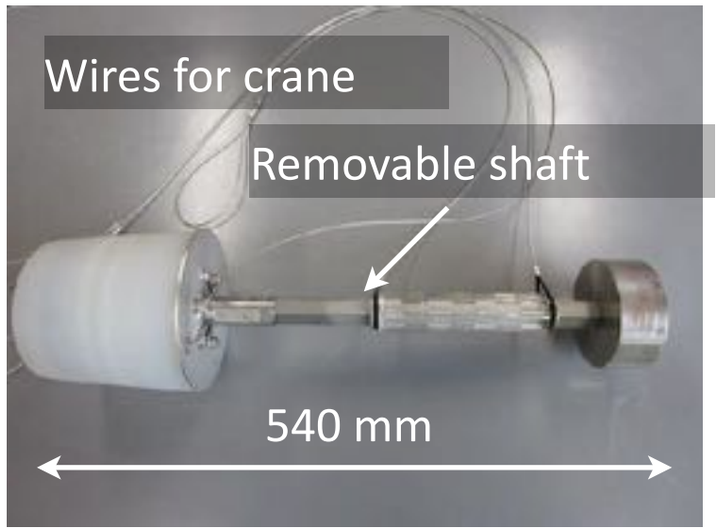


Role of off-gas processing system
- Remove mercury from cover gas in MCS
- Remove tritium
- Separate and decay noble gas (mainly Xe-127 for 0.5~1 Y)

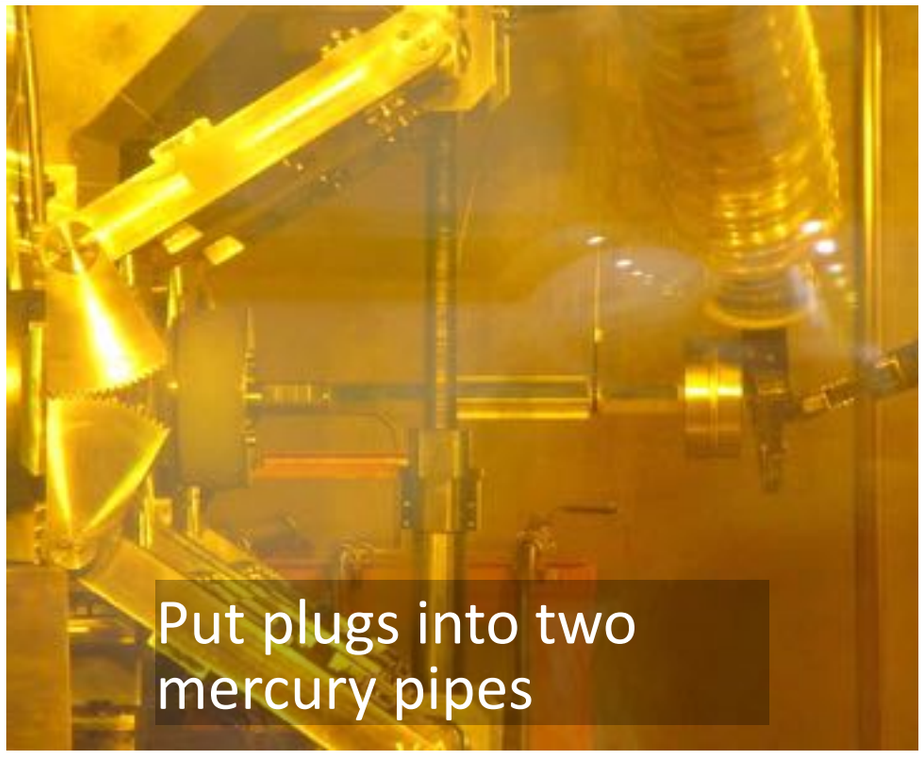
- Move cover gas from MCS, and flushing in MCS before opening mercury piping
- Off-gas caused by leak test and fill-up mercury should be processed
- Evacuate gas from MCS to off-gas processing system to make flow when MCS piping is opening (Airflow control)

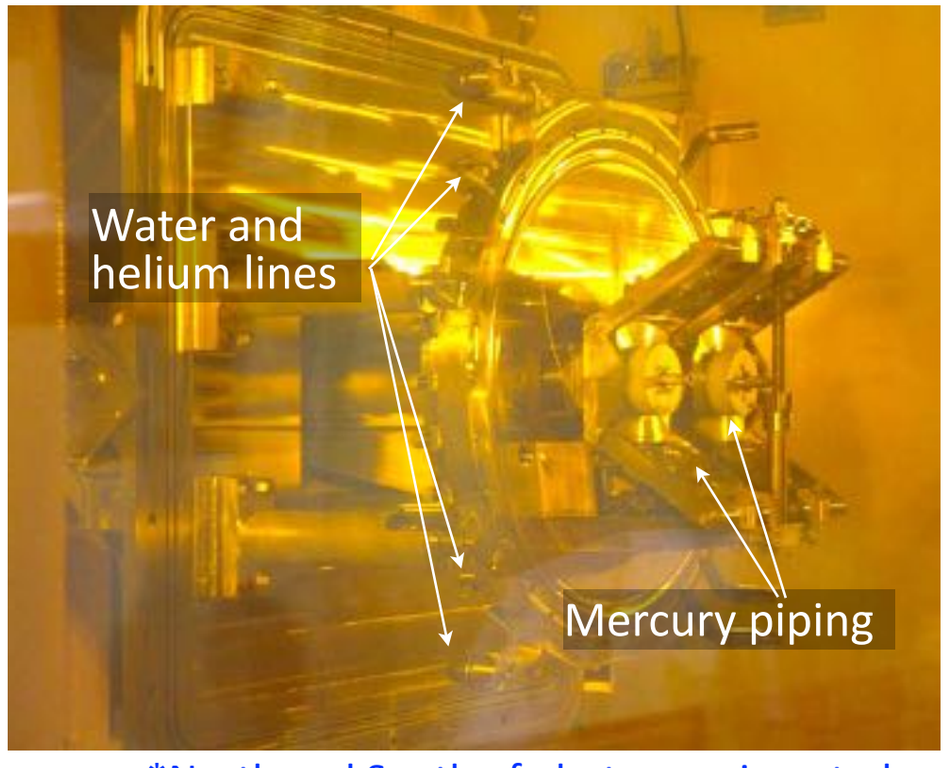
Measures to reduce tritium release





Silicone rubber plug





*North and South of photos are inverted

- Plugs made of silicon rubber was inserted into mercury pipe by MSM with crane
- Evacuation of mercury piping was continued until new target vessel was installed
- Tritium release is reduced to <15% by adopting air flow control and plugs

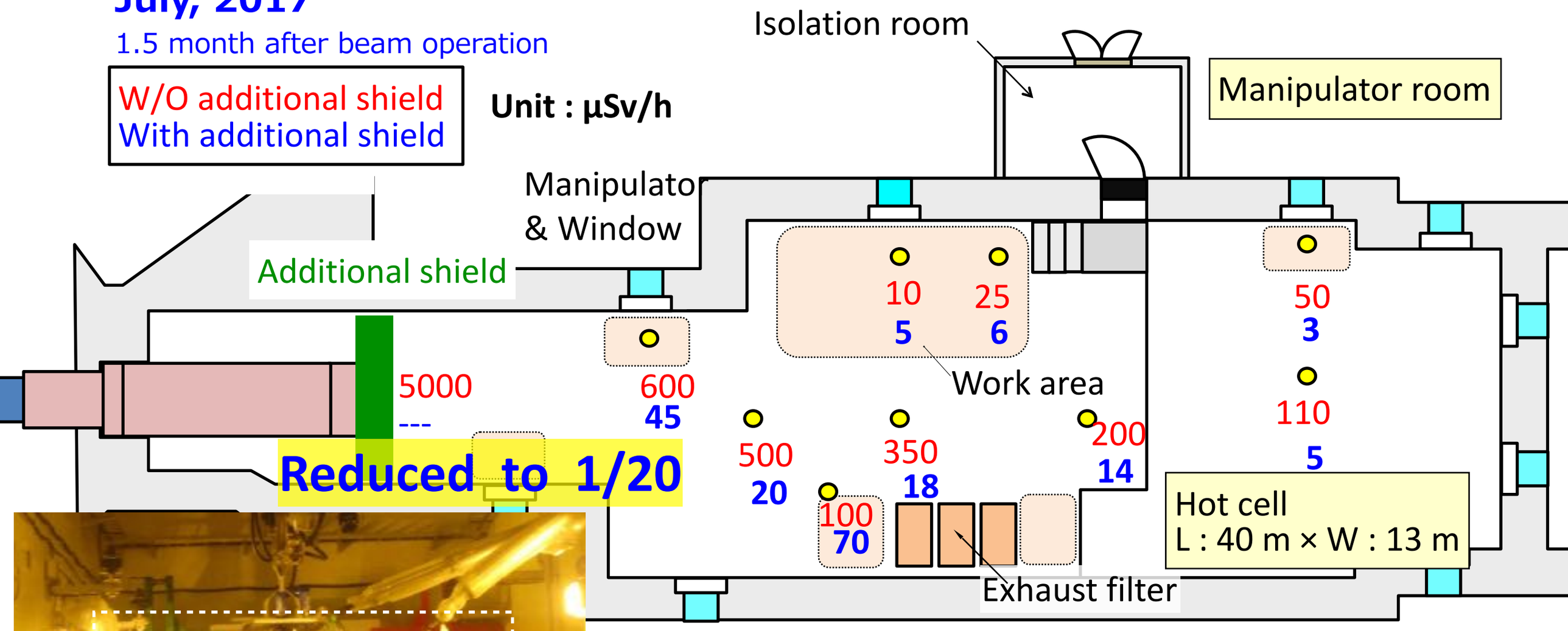
Additional shield for in-cell maintenance

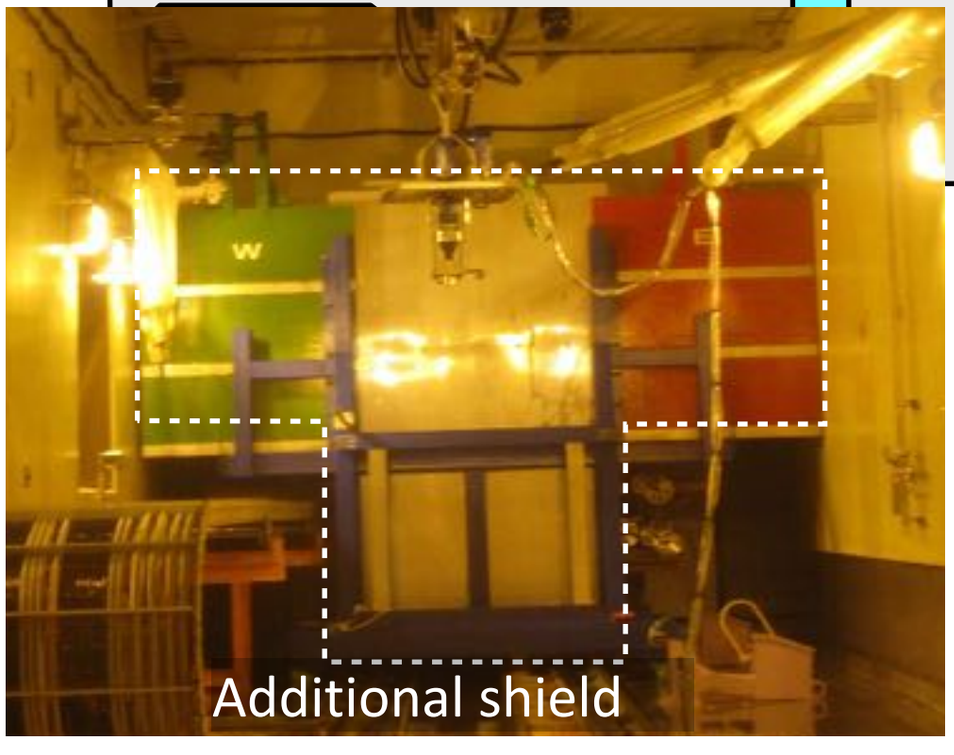
July, 2017

1.5 month after beam operation

W/O additional shield
With additional shield

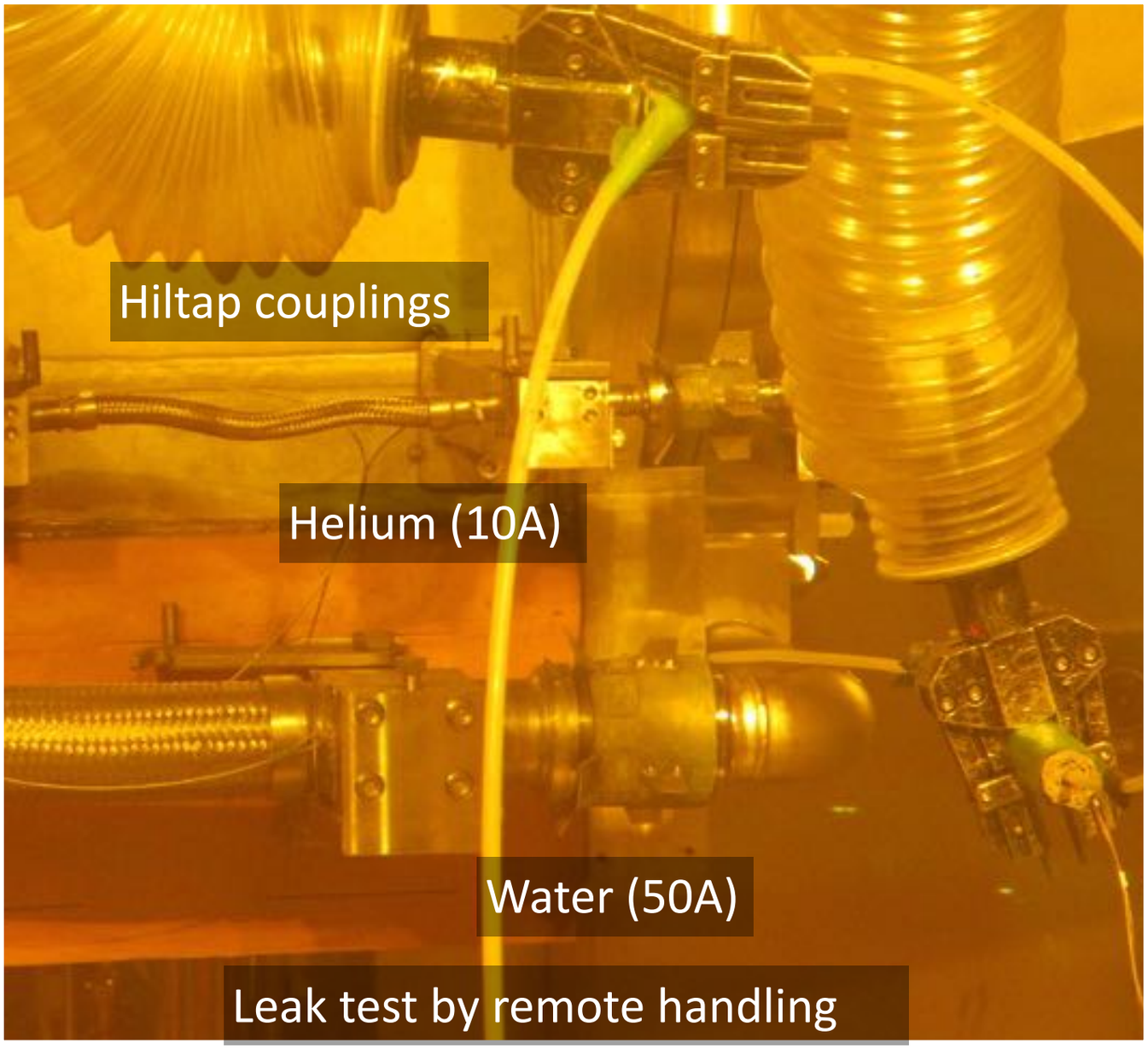
Unit : μSv/h

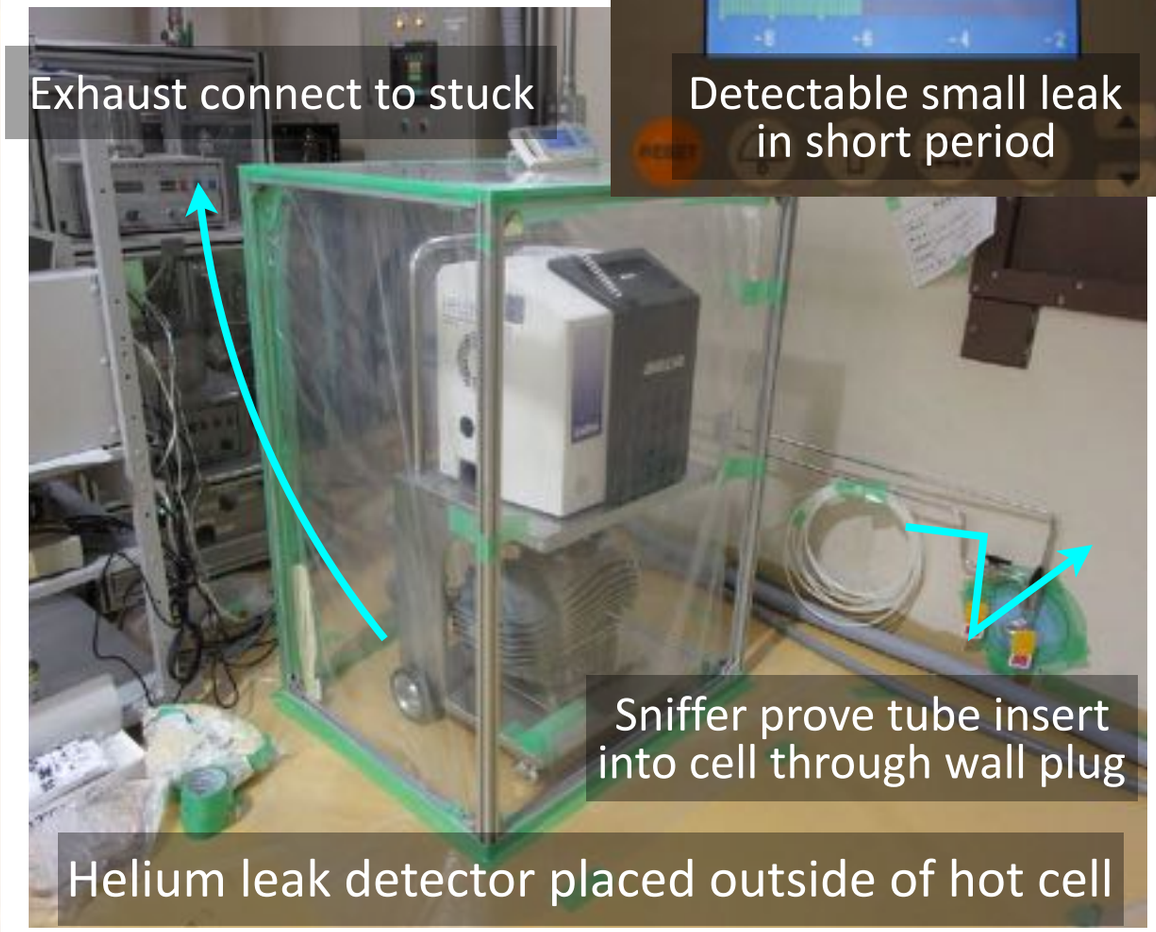




- Need regularly in-cell work for preparation of target cutting and crane inspection, etc
- Dose rate in hot cell is increased after draining mercury
  Spallation products (Osmium, etc.) attached inside mercury pipe may increase dose rate

Sniffer helium leak test by remote handling





- Takes long time for detecting small leakage by pressure change method (1 month for 10^{-6} Pa·m^3/s)
- Impossible to detect leak location in the system with multiple test section
- Adoption of sniffer leak test with remote handling for reducing test time

Summary

- Introduced hot cell design policy for the J-PARC liquid mercury target: mercury collectable structure, frequently enter in hot cell, noble gas and tritium control
- Measures to reduce tritium release by air flow control with off-gas processing system made a fine performance for the safety target replacement
- Improvements learned from 10 years operation experience were introduced