Recent Status of J-PARC Neutrino Beam-line

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for
J-PARC neutrino experimental facility

Outline

* Overview of J-PARC neutrino beam-line
* Beam operation history
* Recent status (troubles)
* Upgrade plans
* Summary

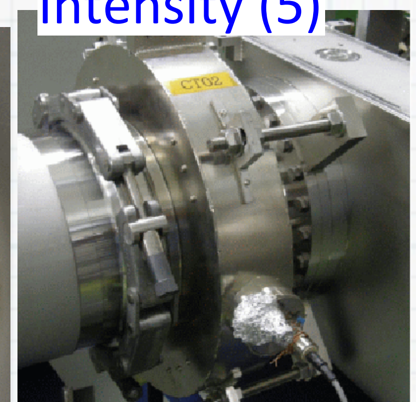
J-PARC neutrino primary beam-line

Beam monitors are install along the proton beam transport

Profile (19)

Position (21)

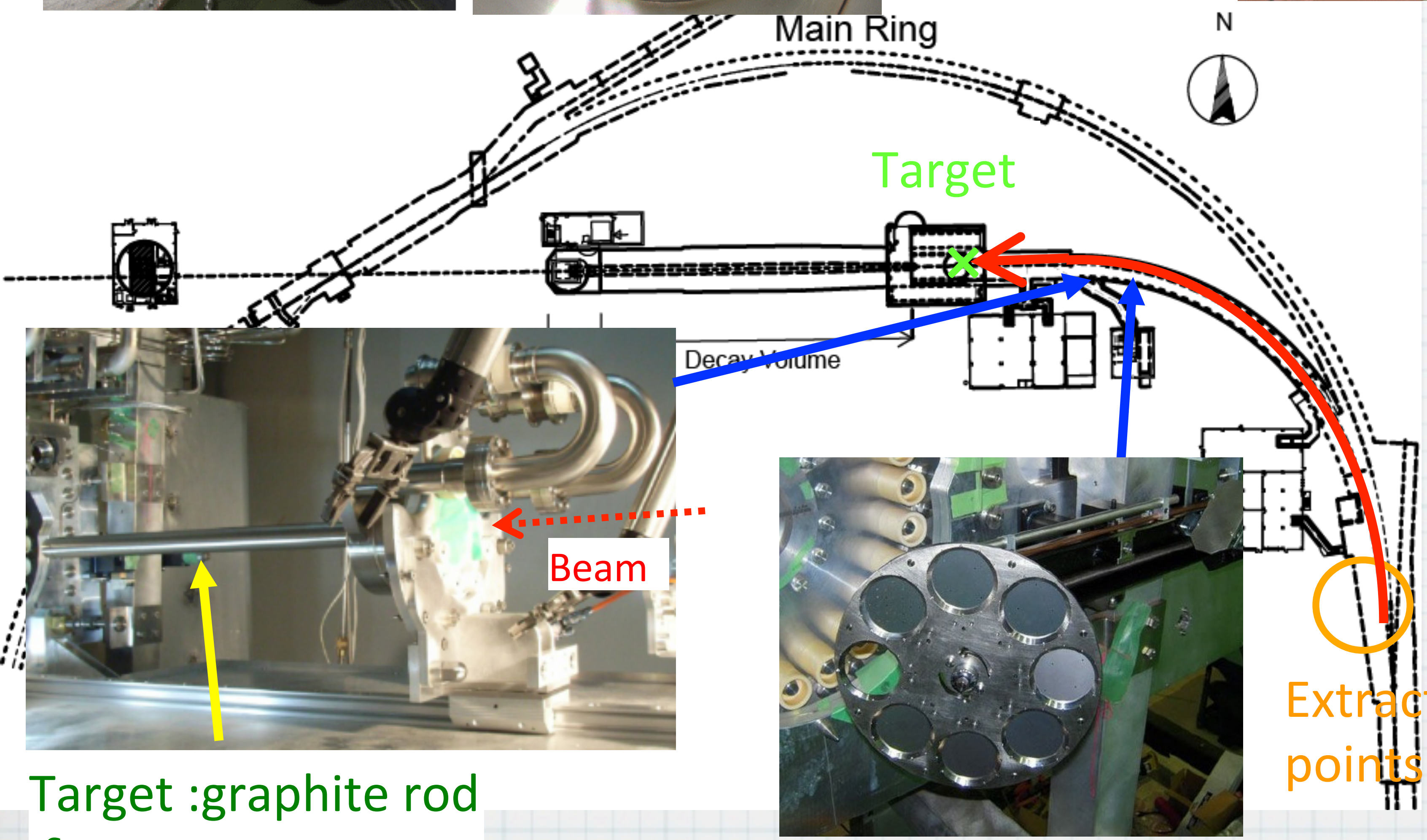
Intensity (5)



Beam loss (50)

Primary proton transport line

Super-conducting combined-function magnets

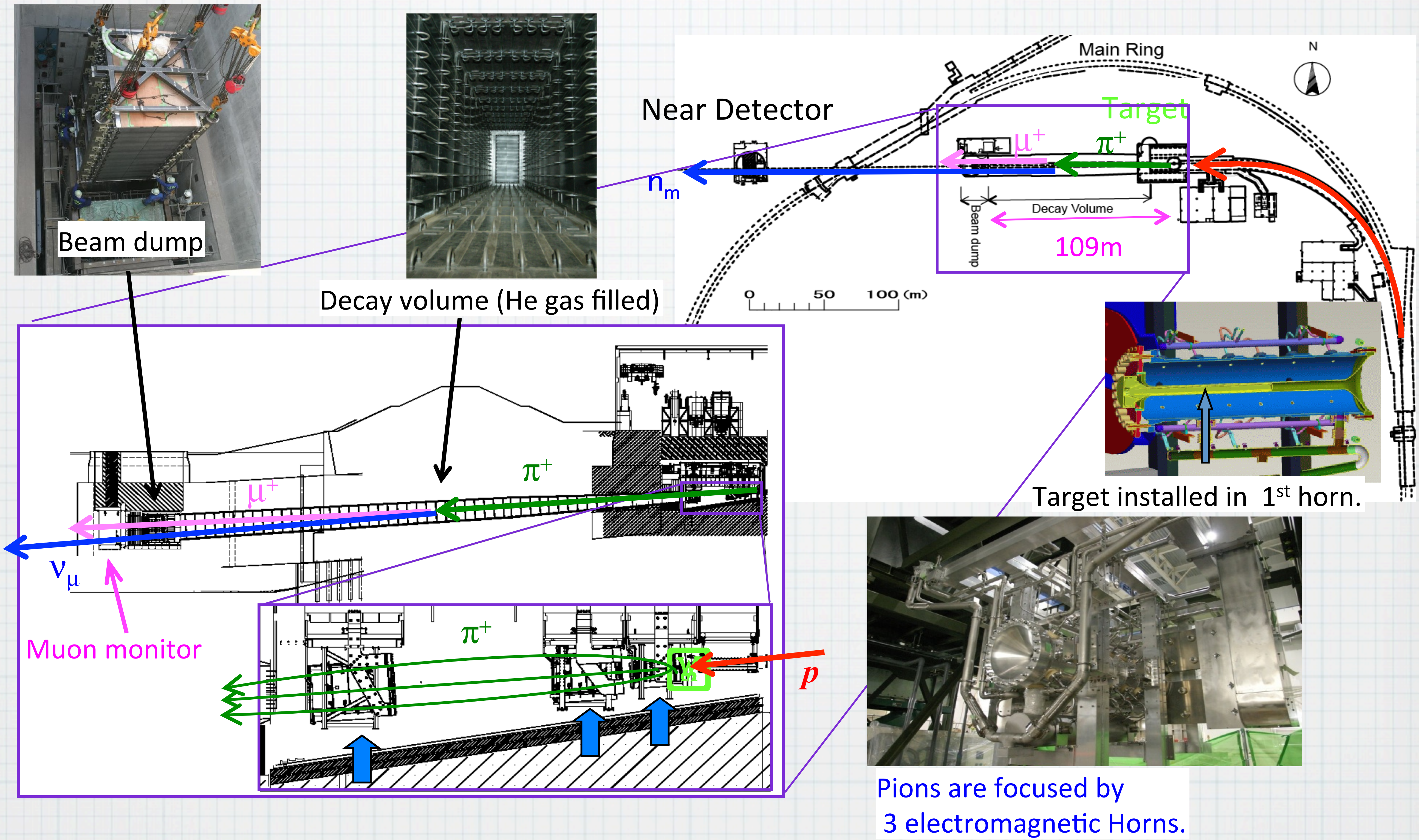


Target :graphite rod
f26mm,L=900mm

Optical Transition Radiation (OTR) Profile monitor

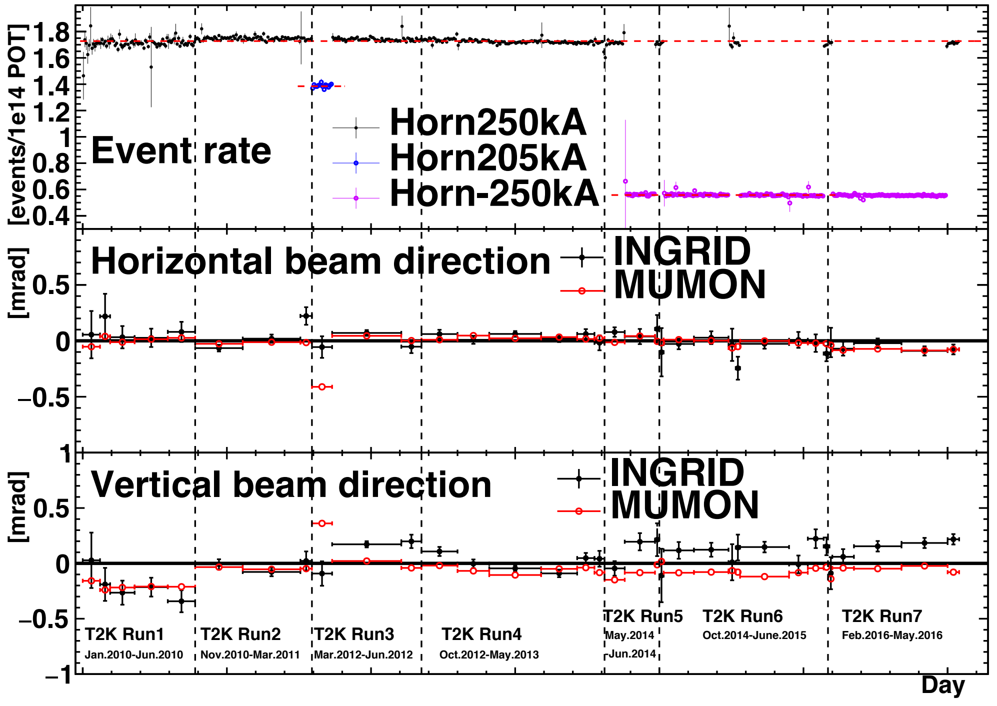
Normal-conducting magnets

J-PARC neutrino secondary beam-line

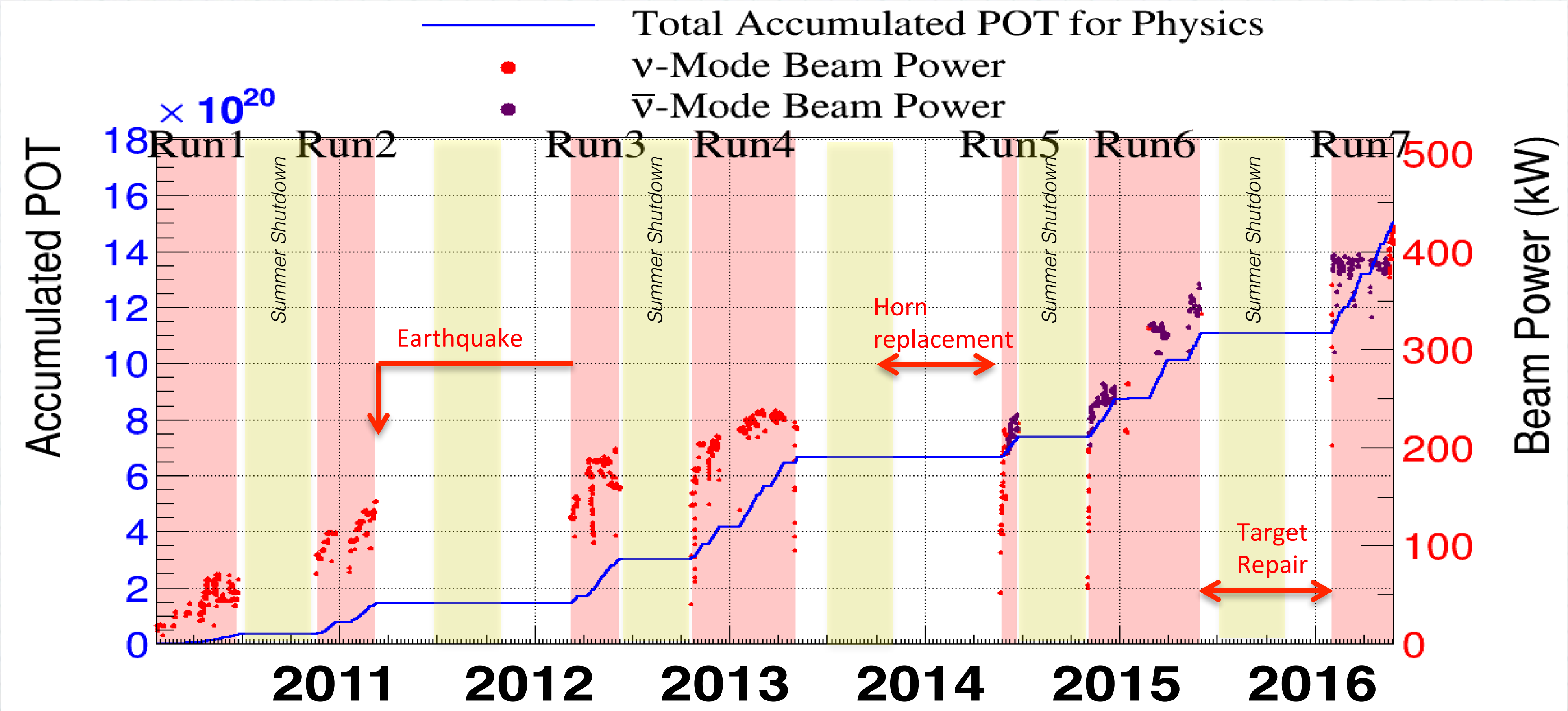


Operation history

- Beam quality is kept well.
  - Flux at ND/SK is estimated with ~10% uncertainty.
  - 425kW beam operation achieved.
    → 2.27×10^{14} p/pulse
    - 440kW trial is also performed.
- By 2016 May, 1.510×10^{21} POT is supplied for physics data for T2K.
  - ν-mode : 7.57×10^{20} + $\bar{\nu}$-mode : 7.53×10^{20}



- Beam operation for neutrino beam-line is resumed from Oct. 2016



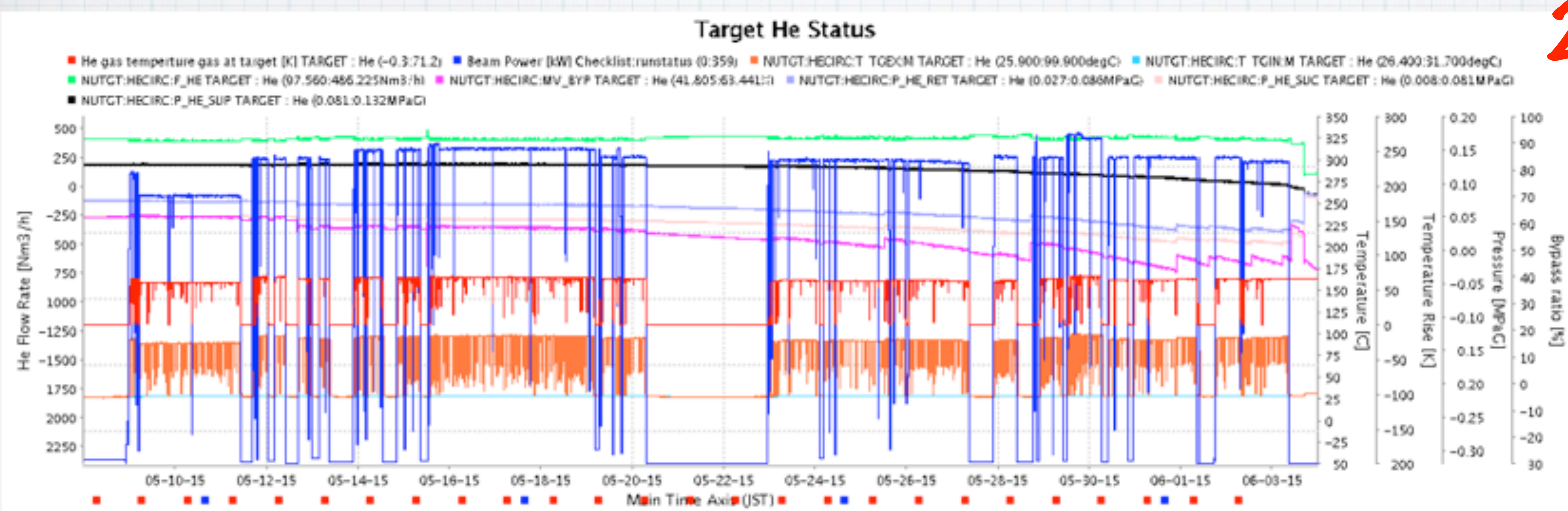
Big maintenance

* For secondary beam-line, it is necessary to open the concrete shields, He vessel by remote operation.
  * 2011: Inspection after the big earthquake.
  * 2014: Replacement of all three horns
    * Water-leak was happened at horn itself.
  * 2015: Target cooling He leak.
    * Inspection and repair was done.
    * OTR system also met the trouble.
  * 2016: No maintenance in He vessel.
    * Inspection of the outside of beam-window.

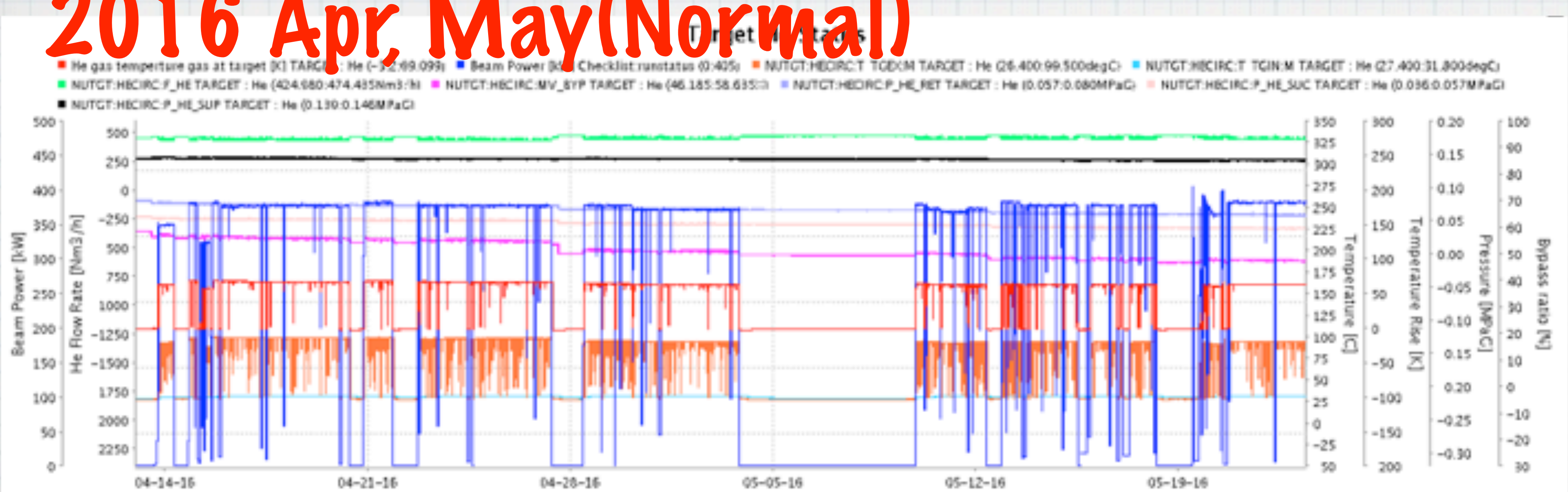
2015 Target He leak problem

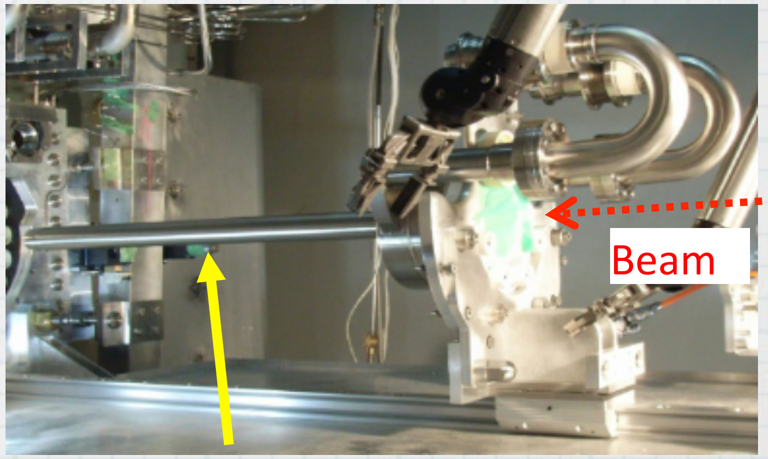
- Target: ~23kW heat load at 750kW → Cooled by He gas
    - In May 2015, Pressure of He gas become unstable.
    - ~ 10^{-1} Pa m^3/h (Requirement: ~ 10^{-3} Pa m^3/h)

2015 May



2016 Apr, May(Normal)

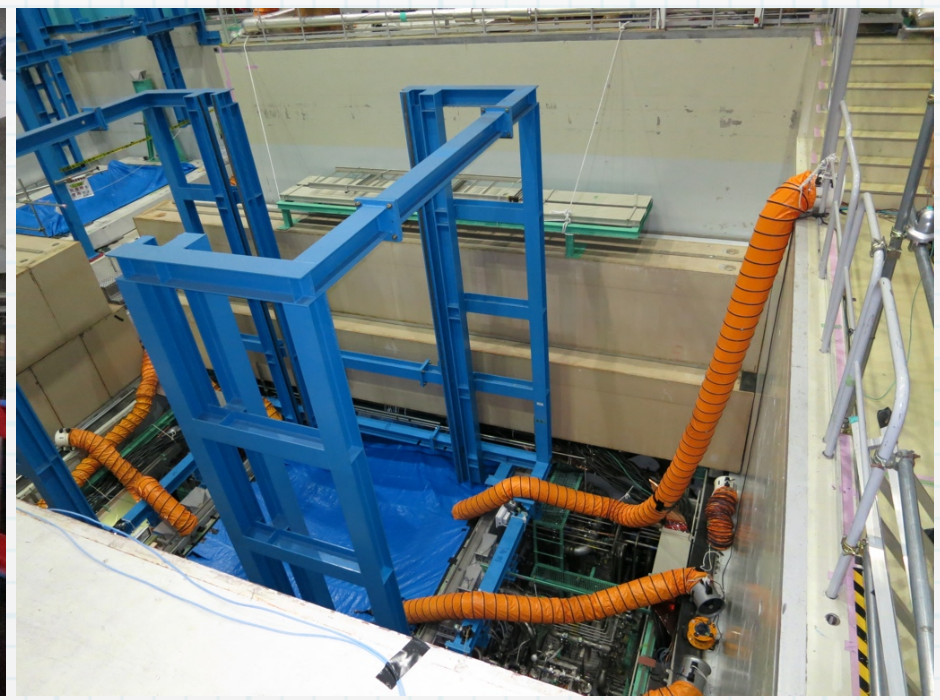


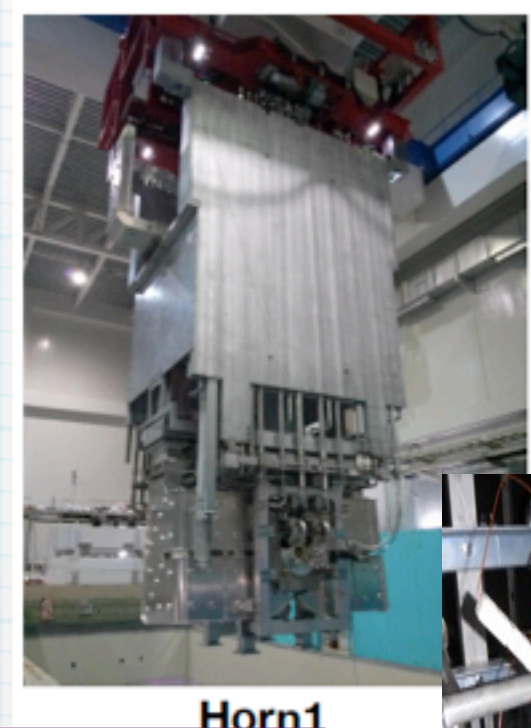


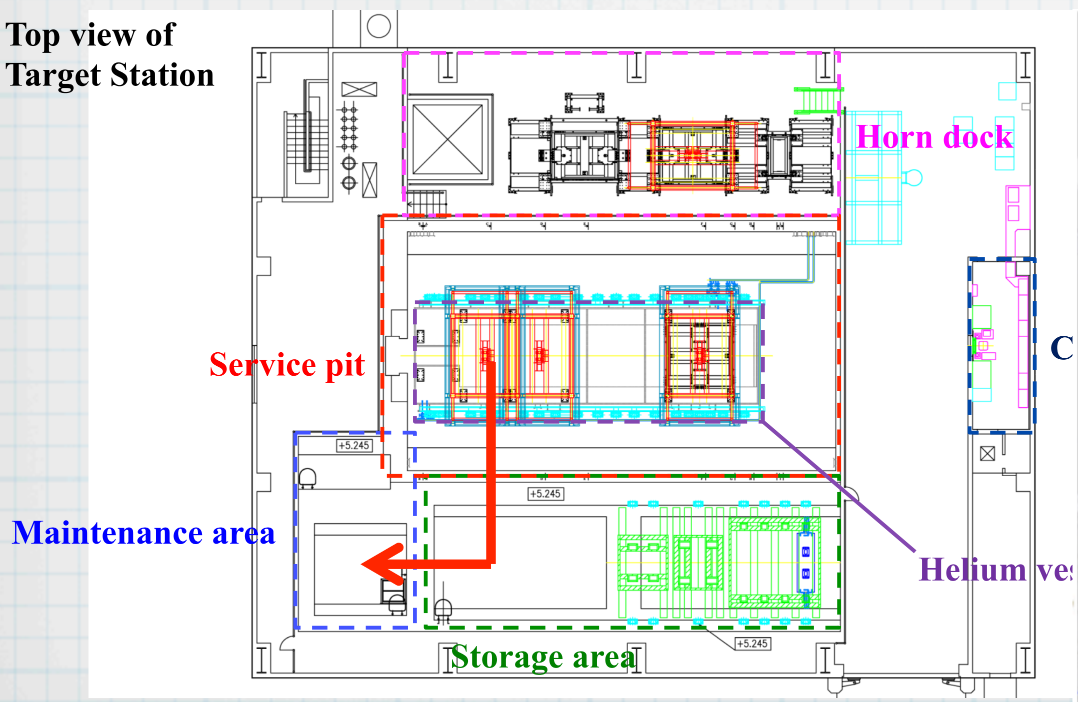
Target :graphite rod
φ26mm,L=900mm

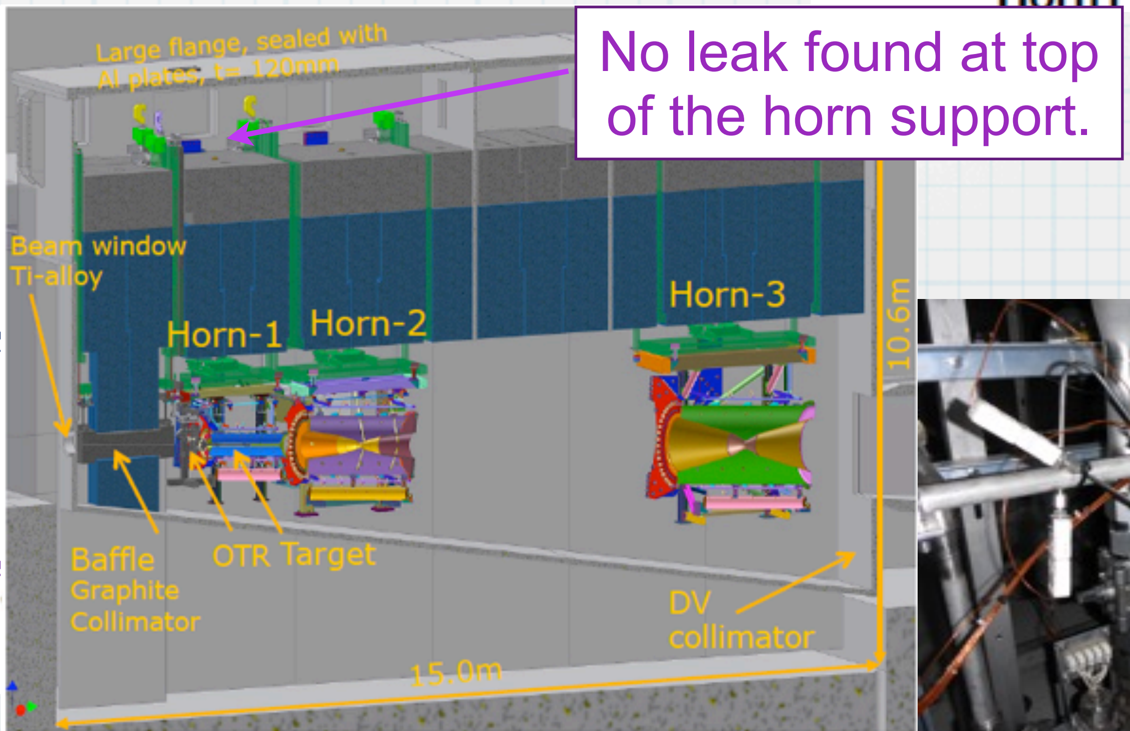
2015 Target He leak problem

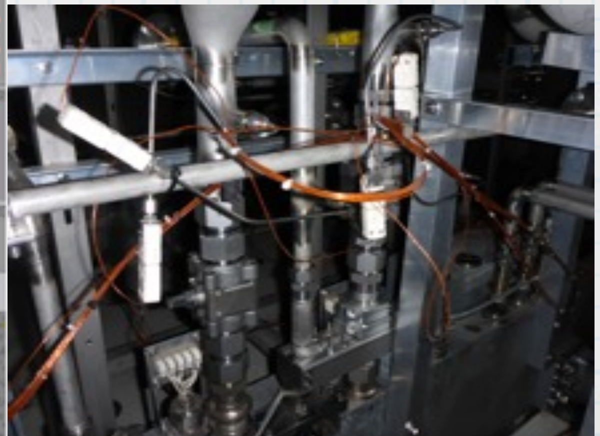
- There is no He leak found the He tubes outside TS He vessel, we have decided to open He vessel for further inspection.
- There is no leak at the top of horn module → Horn + target is transported to maint. area.





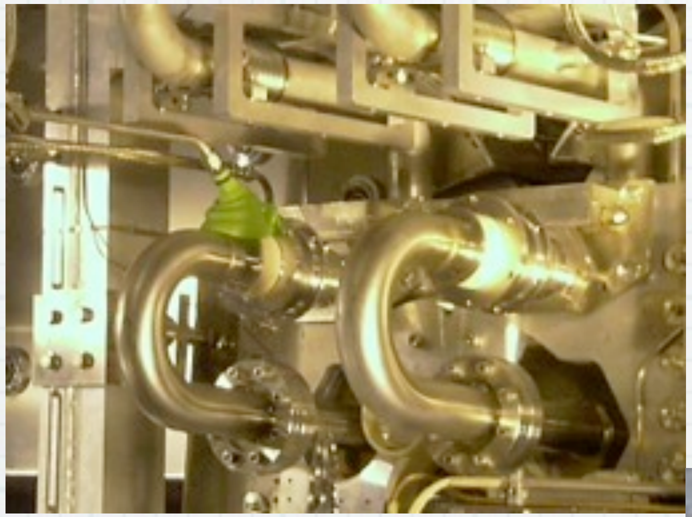


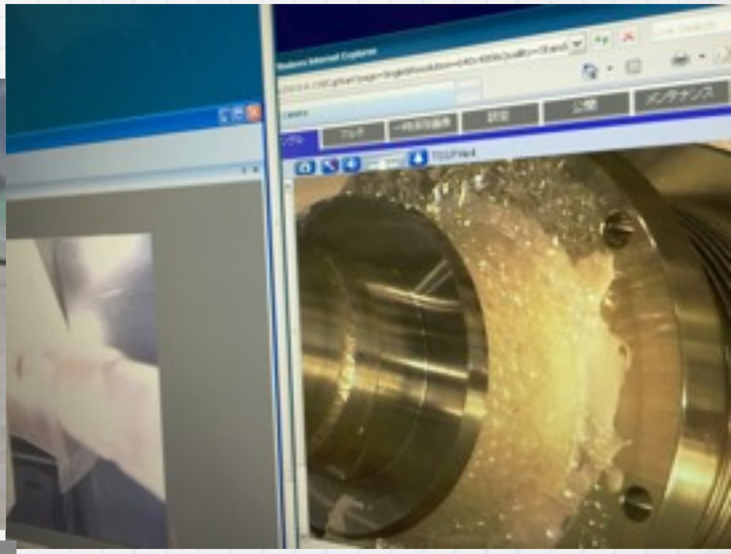


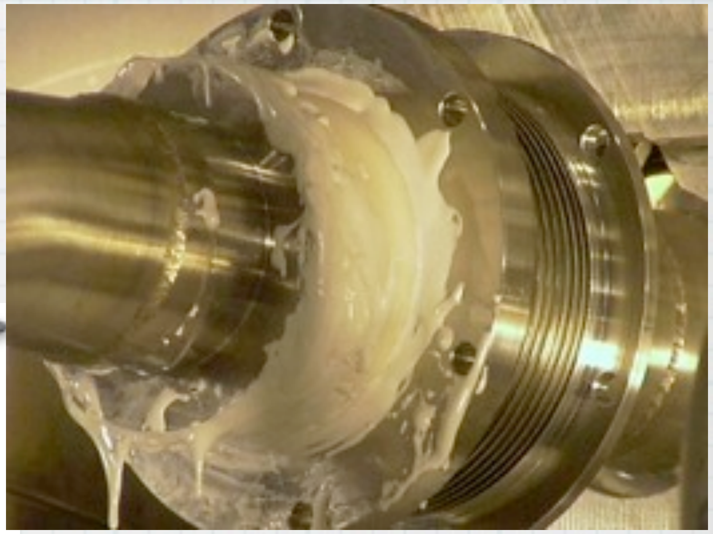


Target He-tube inspection at maintenance area

- At the maintenance area, the inspection by manipulator is performed.
  - Air is sampled by hand-pump and checked by handy gas detector.
    → He leak was found at ceramic break!
  - Fixing the leak by compound was tried.
    → We have confirmed that there is no other leak point.

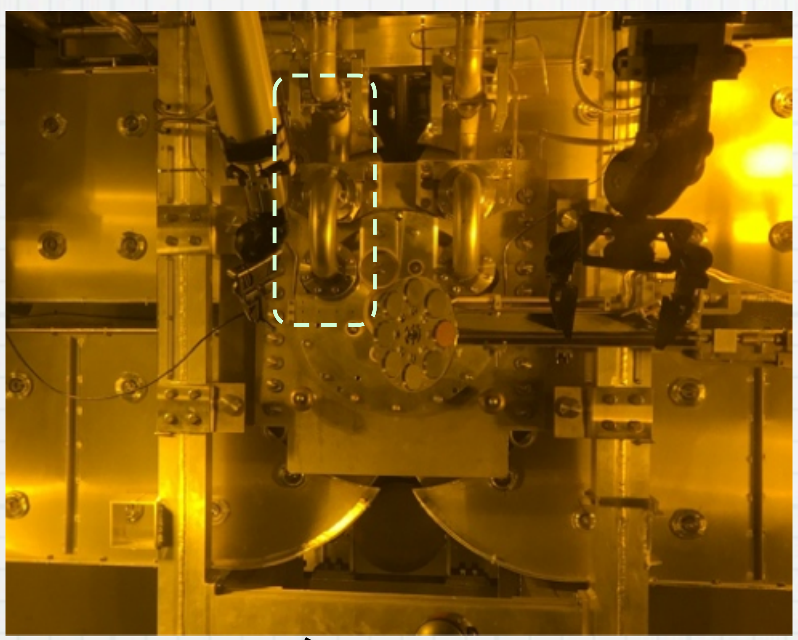


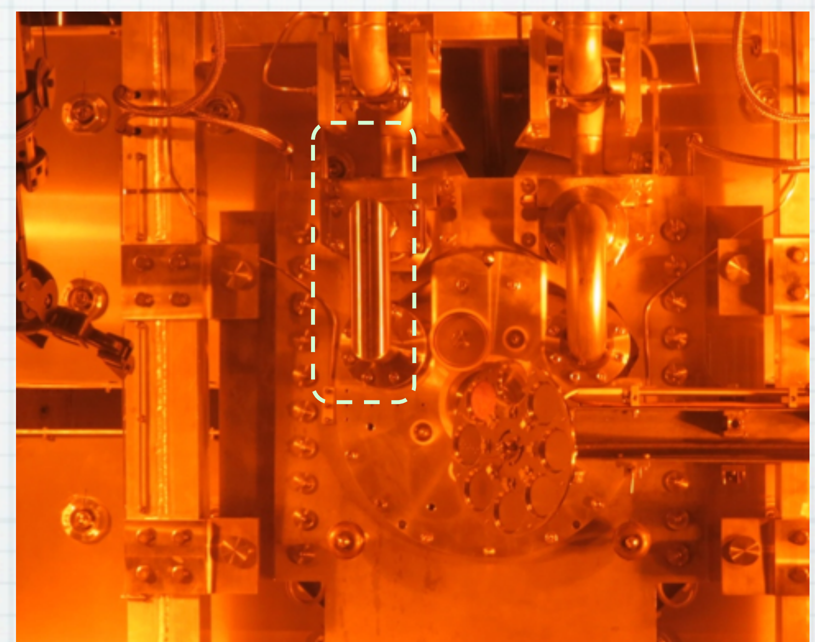


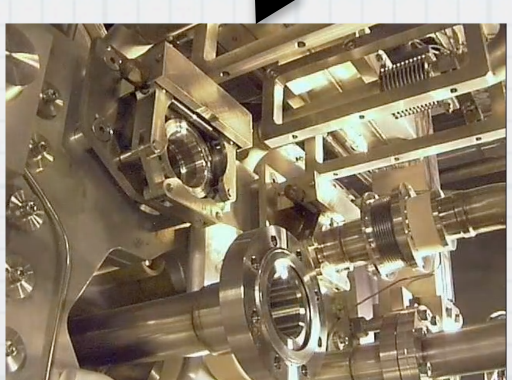


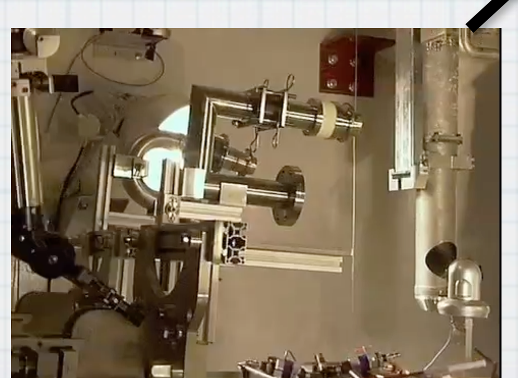
Replacement of the He tube

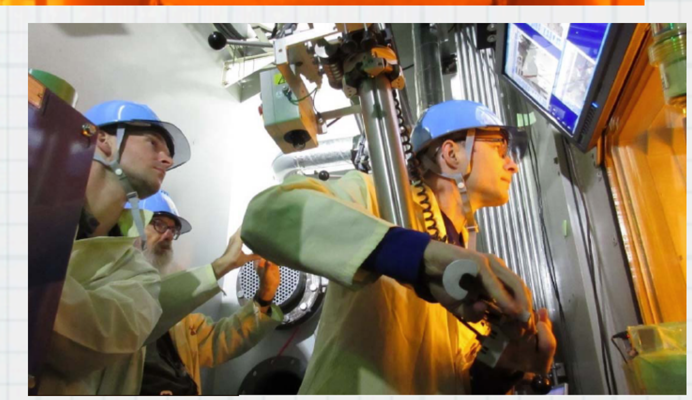
* Improved He tube with ceramic break and the remote exchange tools are prepared by RAL and KEK. The exchange work is done by the corroboration among RAL, TRIUMF and KEK.
* Distortion of U-shape part made by cold working may be cause of the trouble → C-shape with miter joint (welding) is adopted.







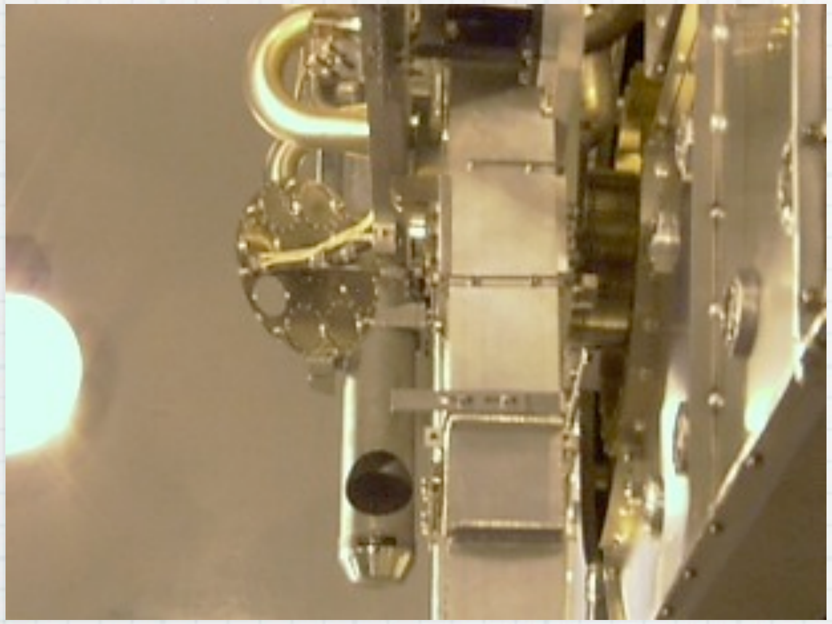


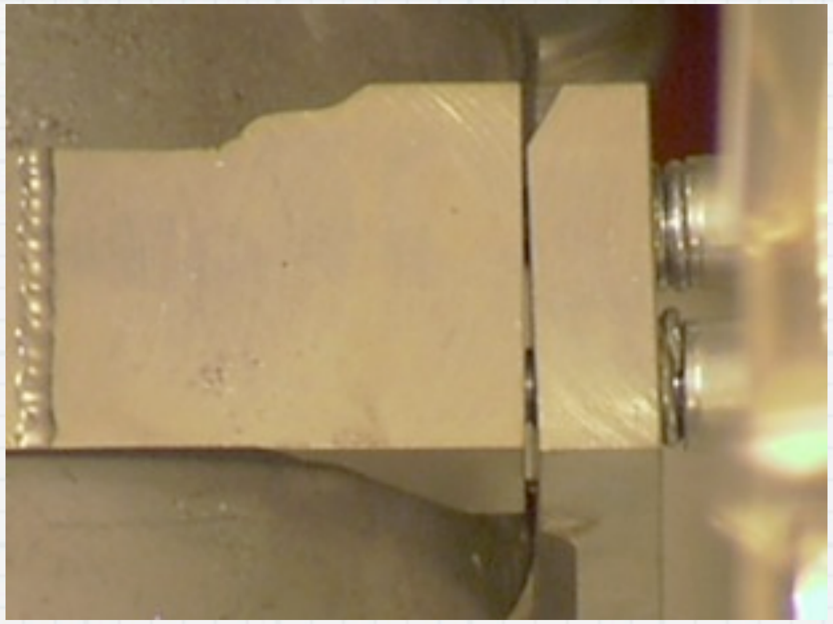


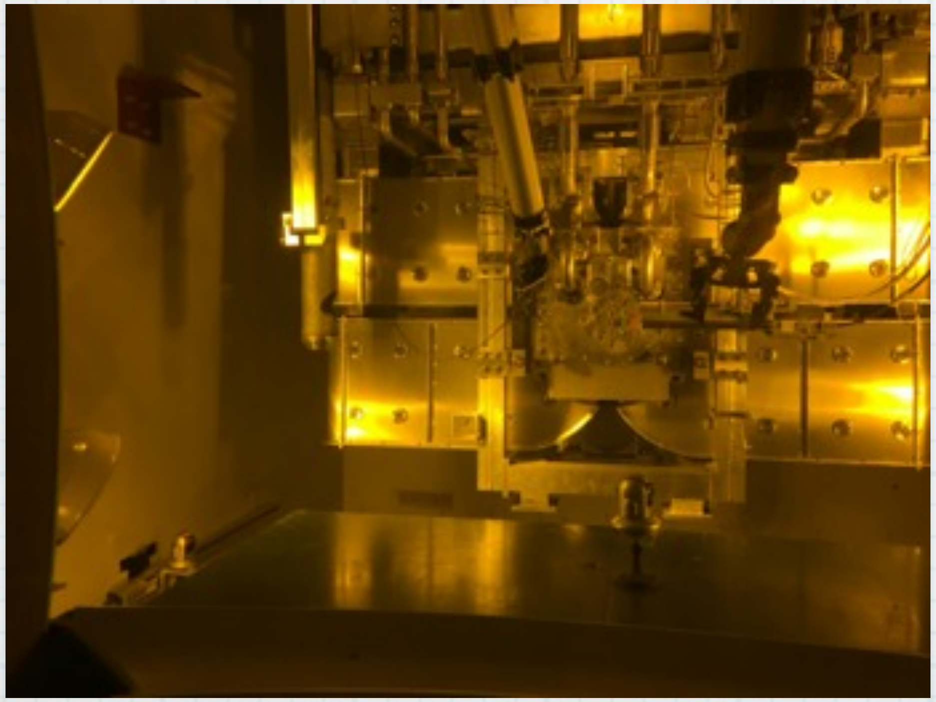
Replaced by manipulators at the maintenance area

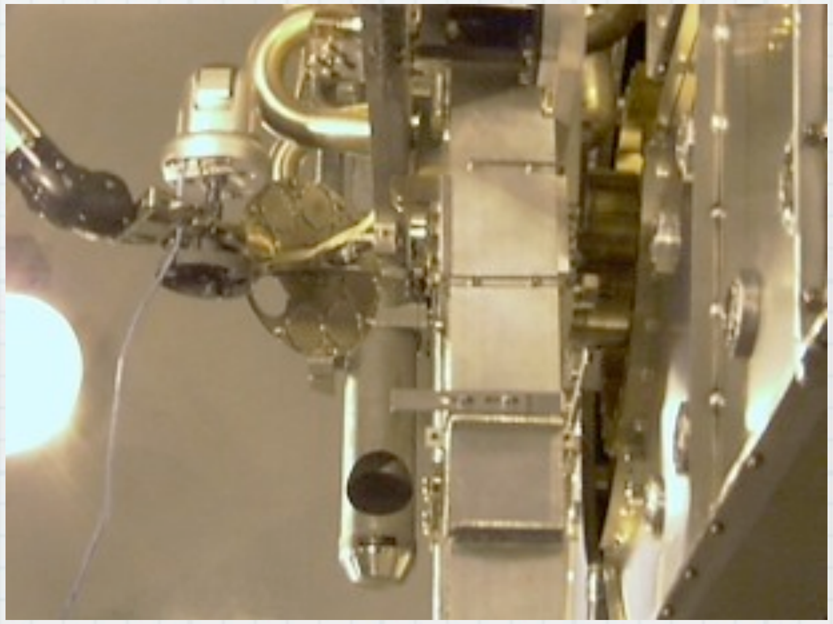
OTR inspection

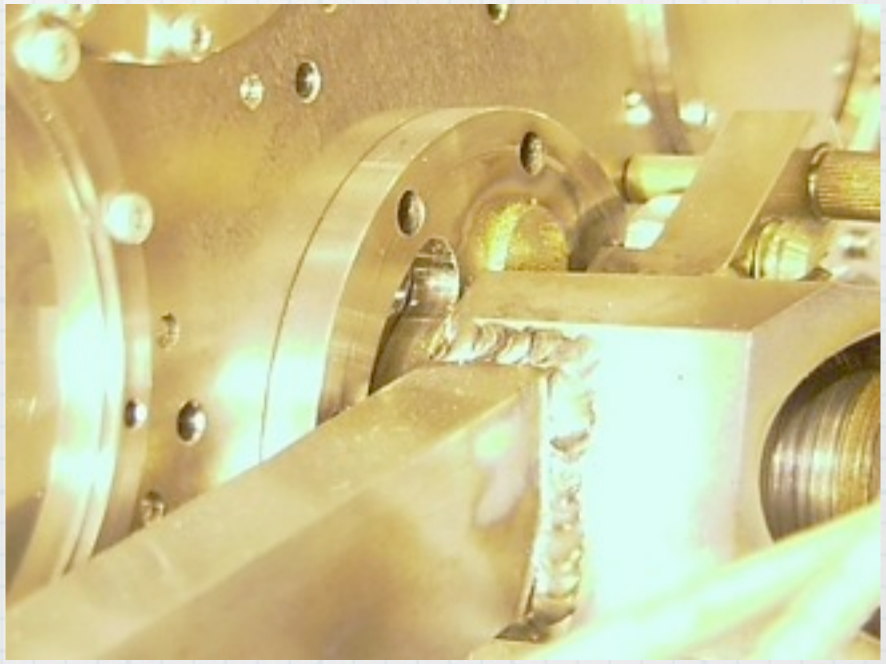
* OTR system: Mirror alignment check
* Trouble in the disk rotation: Required torque become large.
  It can not to be rotated by remote controlled motor.
  → Now we are using 1 Ti foil.







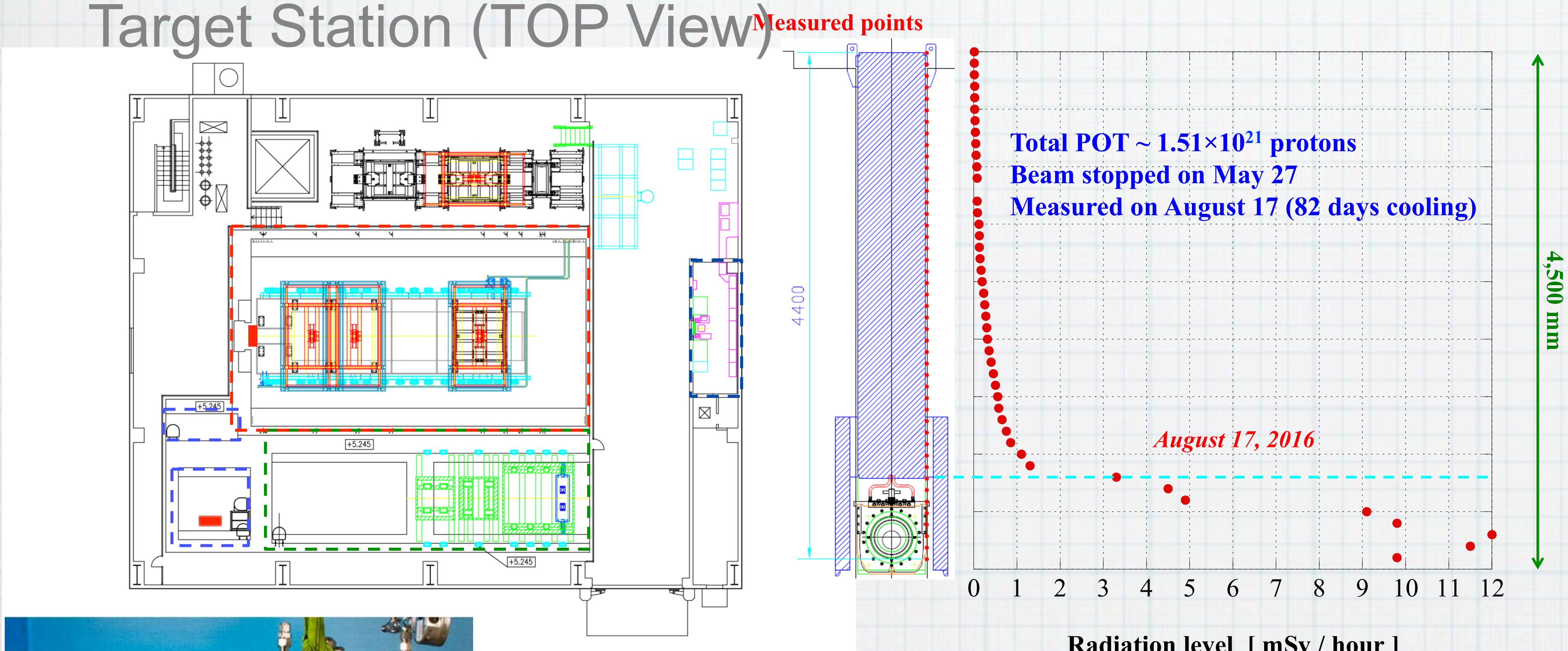




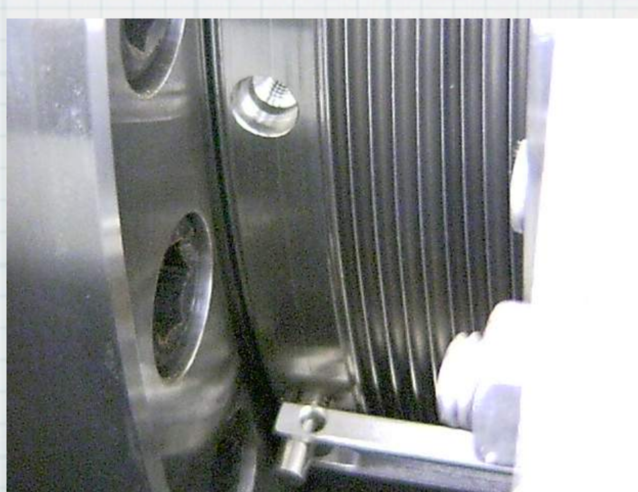
Beam window inspection

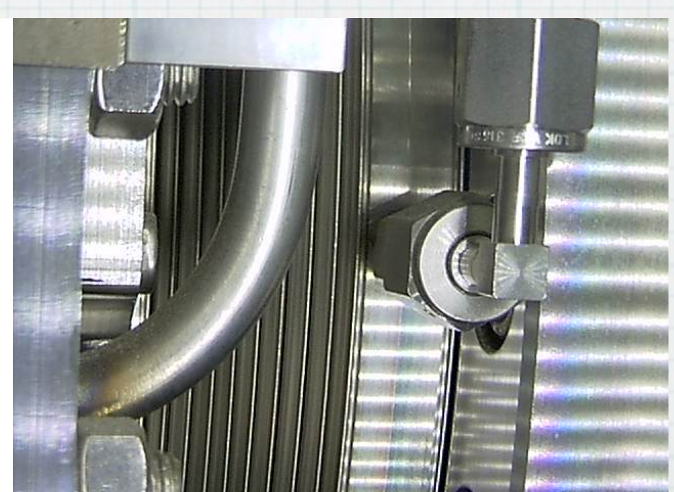
- In 2016, we have checked the beam window by removing the upper shields to check what kind of work is necessary for exchanging with spares.
  - "Pillow seal" used for Vacuum / He-gas requires the very good surface condition. We have to consider the method to clean up, if necessary.

Target Station (TOP View)



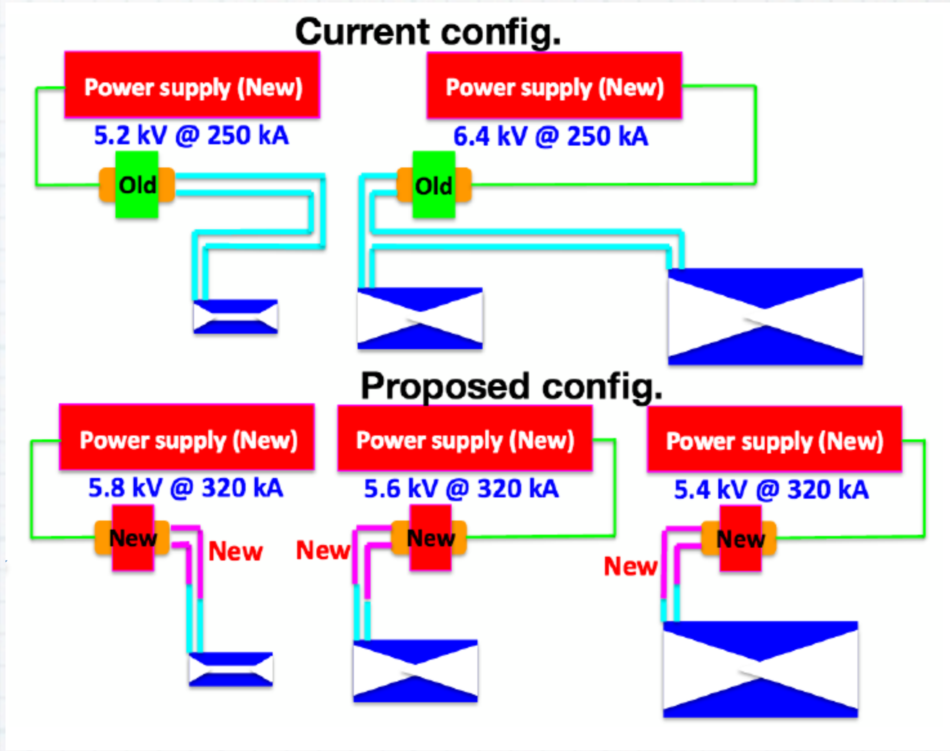
In 2016 →

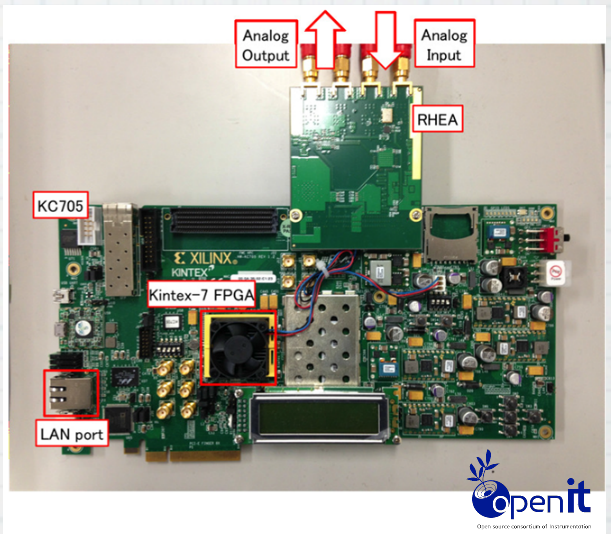


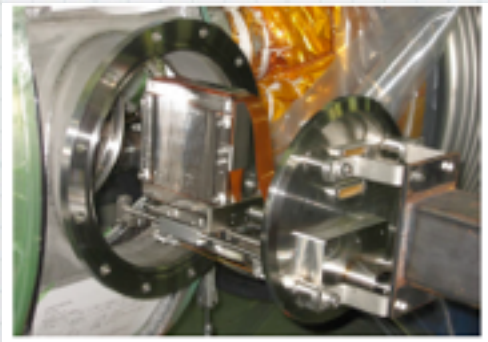


To achieve 750 kW p-beam operation

* Upgrade the beam-line for 1Hz operation.
  * Horns : 2 PS + 2 old trans. + 3 horns
    → 3 PS + 3 new trans. + 3horns.
    * Currently used pulse transformers are produced for 250kA operation for K2K in ‘90s.
    * New pulse transformers for 320kA is under design.
      → ~10% improvement for ν flux / POT is also expected.
  * DAQ for beam monitors.
  * Beam interlock system.
    → The module that issues the fast Inhibit signal using the beam monitor outputs processed by FPGA.







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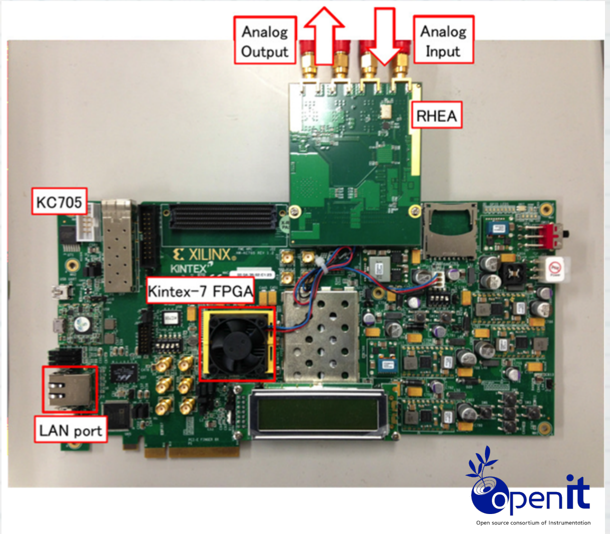


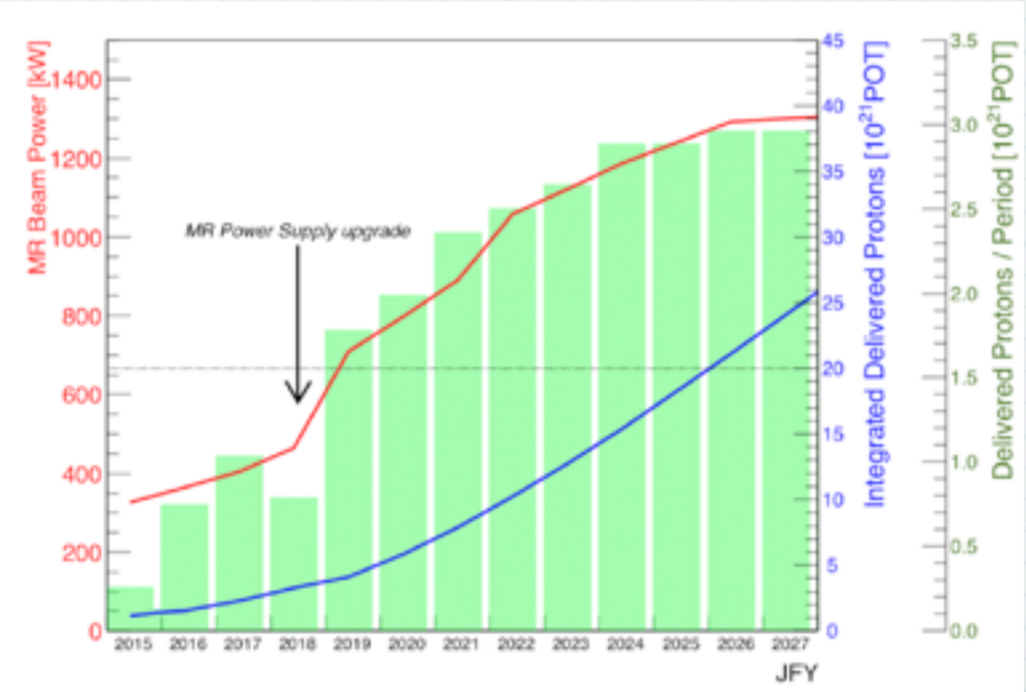
Future plans

- The T2K experiment submitted the proposal of extended data accumulation up to 2×10^{22} POT to J-PARC PAC in June 2016.
  - PAC recommended the Stage-1 status in July 2016.
    - Cf. J-PARC has 2-stage approval.
      - Stage-1 status: Physics interest is recognized.
      - Stage-2 approval: Green signal for execution.
  - ~1.3MW beam power is expected.
- New short base line experiment E62 (NuPrism) got stage-1 status, too.
- The J-PARC upgrade for the future long base-line neutrino experiment using Hyper-K is recognized as KEK Project-implementation-plan (PIP) with high priority.

J-PARC MR-FX beam power upgrade strategy

	Achieved (User beam)	Mid-term plan	Long-term plan
Protons/pulse	2.2×10^{14}	2.2×10^{14}	3.2×10^{14}
Repetition cycle	2.48 s	1.3 s	1.16 s
Beam power	420kW	800kW	1.3MW

↑ Protons / pulse required to achieve original design intensity (750kW) has been achieved.

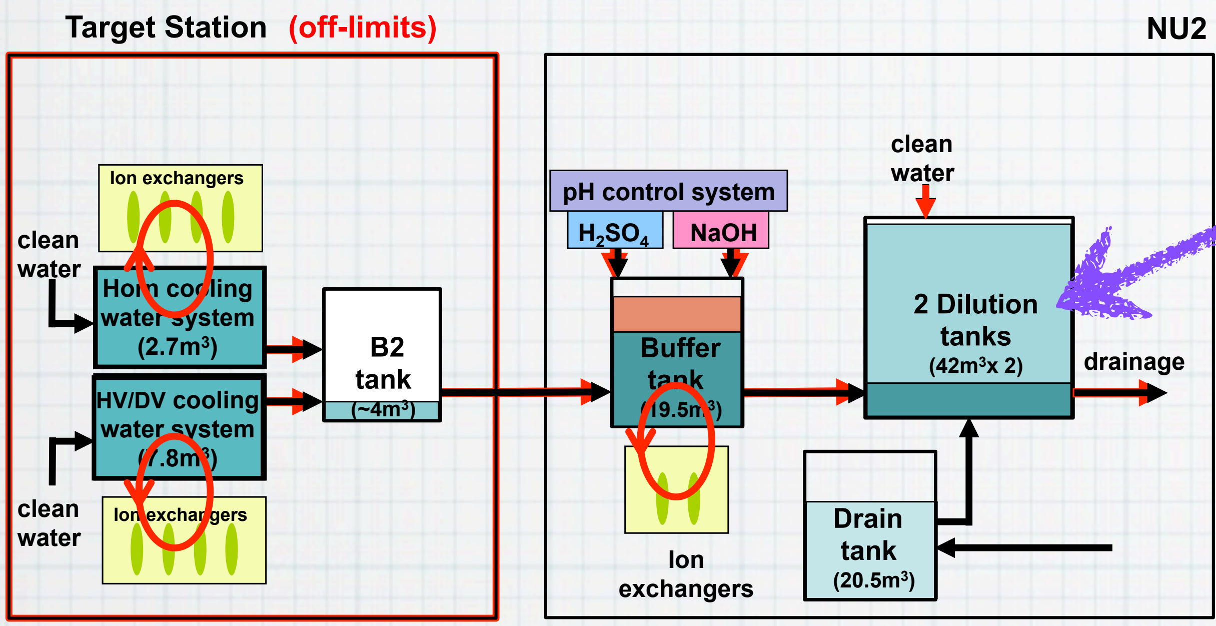


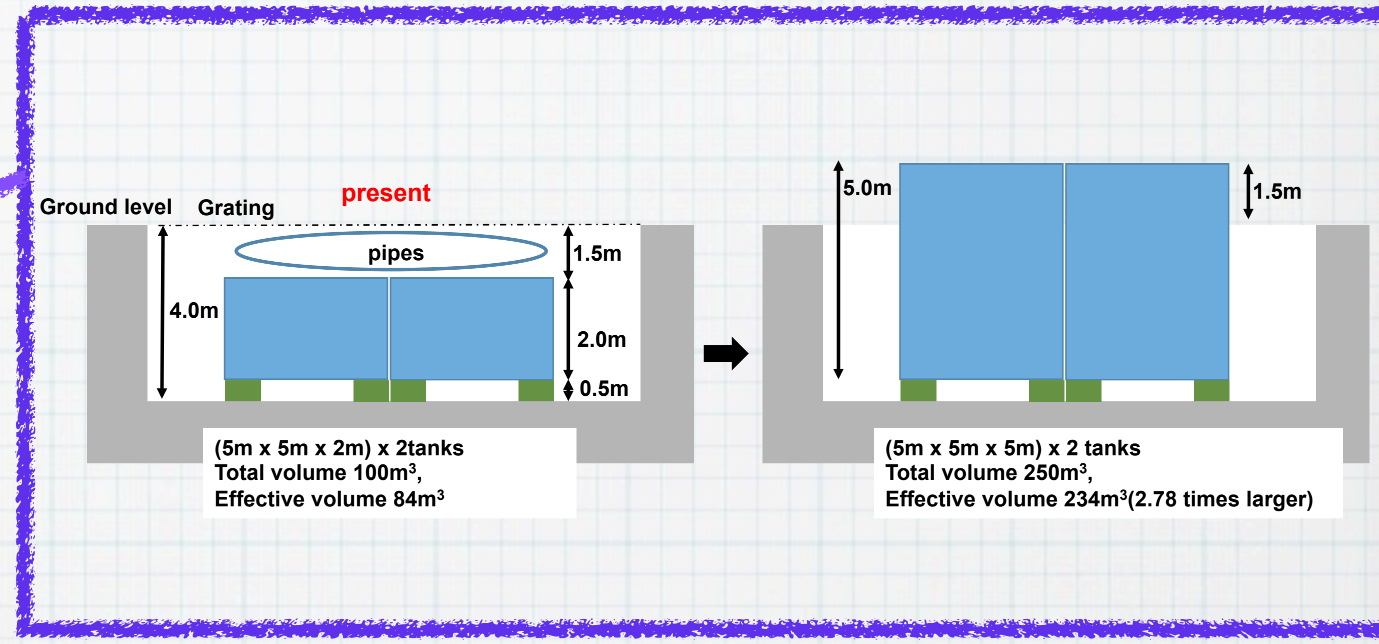
To do list for >1MW beam power

* Reinforce the radiation shield of the Target Station.
* Enlarge the processing capacity of the radioactive waste (activated cooling water, etc.)
    * See next slide
* Reinforce the cooling capability of target, electromagnetic horns, TS He vessel, Decay Volume, and beam-dump.
* Enlarge the aperture of the magnet for upstream part of primary proton transport (if necessary).
* Primary beam monitors that cause less beam-loss.
* Sophistication of remote maintenance procedure for activated equipment.

Reinforcement of Radio-activated water treatment

- Target station (TS + Upstream of DV) : Plans in JFY2018





- NU3 (Downstream of DV + BD) : Started from JFY2015~
  - Transport activated water to the facility of JAEA with tank track.

Summary

* J-PARC Neutrino beam-line met the troubles in target system in 2015. It was fixed by remote operation.
* In 2016 beam time, there is no severe trouble that takes long maintenance period.
  * No trouble in 440kW trial.
* There are several work to achieve ~1Hz operation and >1MW beam.
  * We plan to do the upgrade work that requires long shutdown in JFY2018 during the J-PARC MR power supply upgrade as much as possible.