J-PARC Neutrino Target Operation Status

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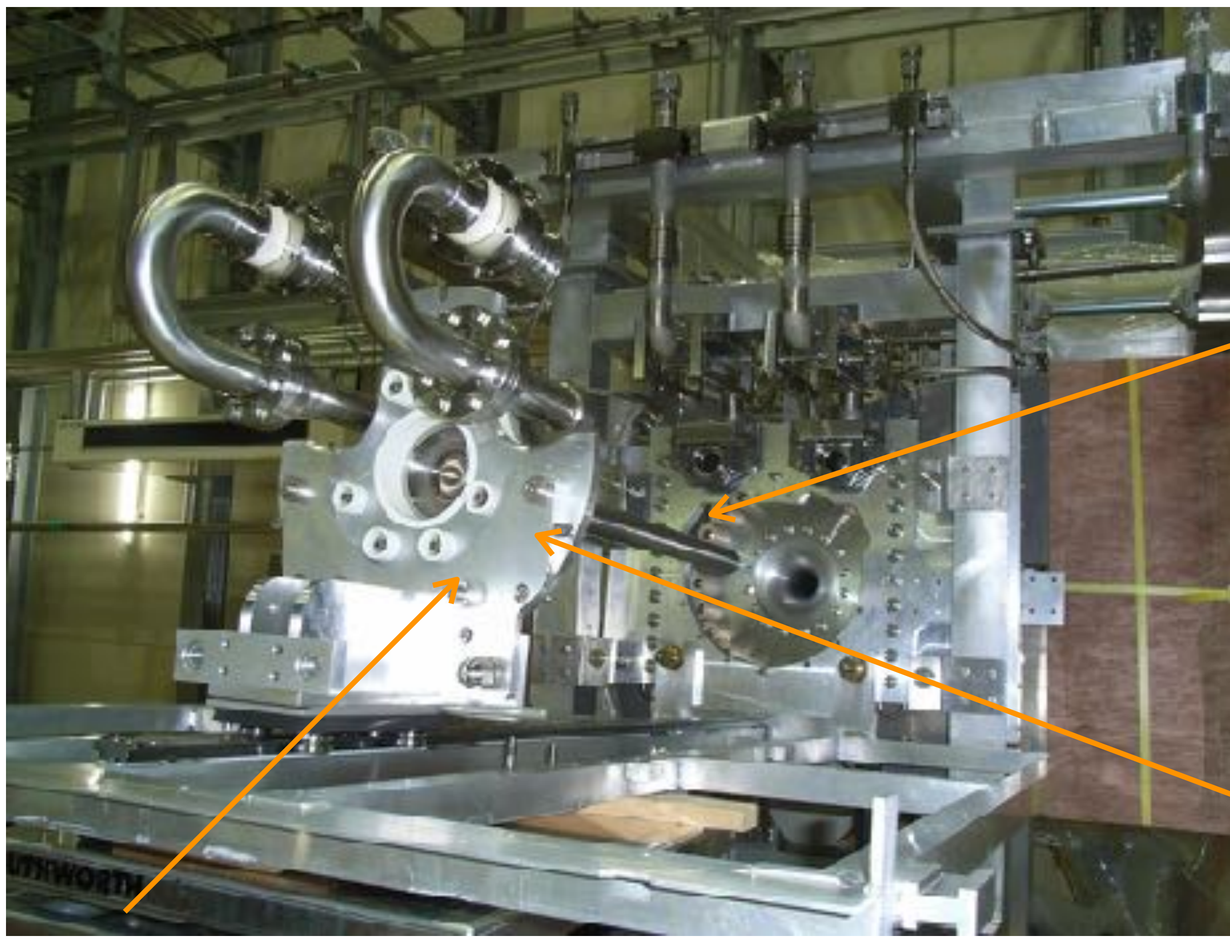
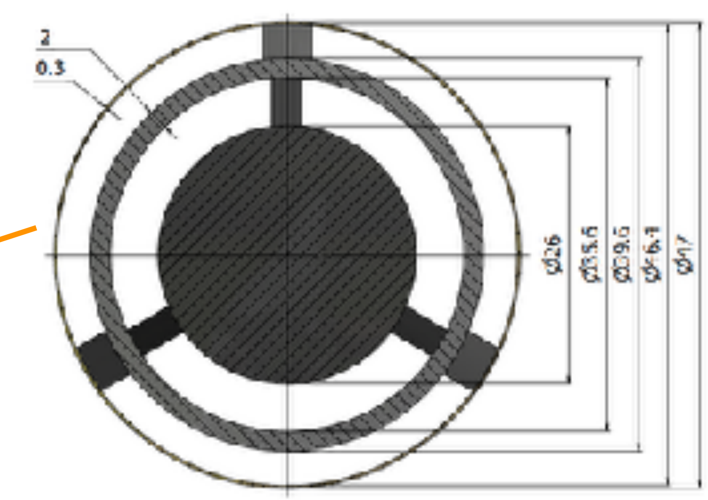
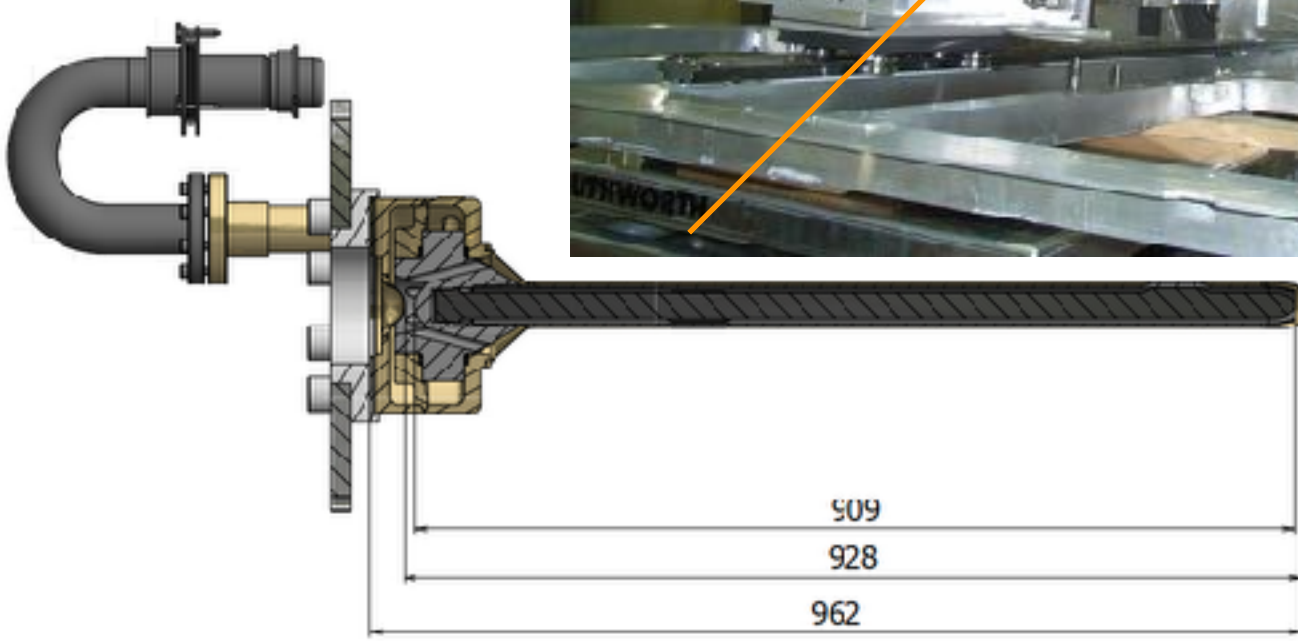
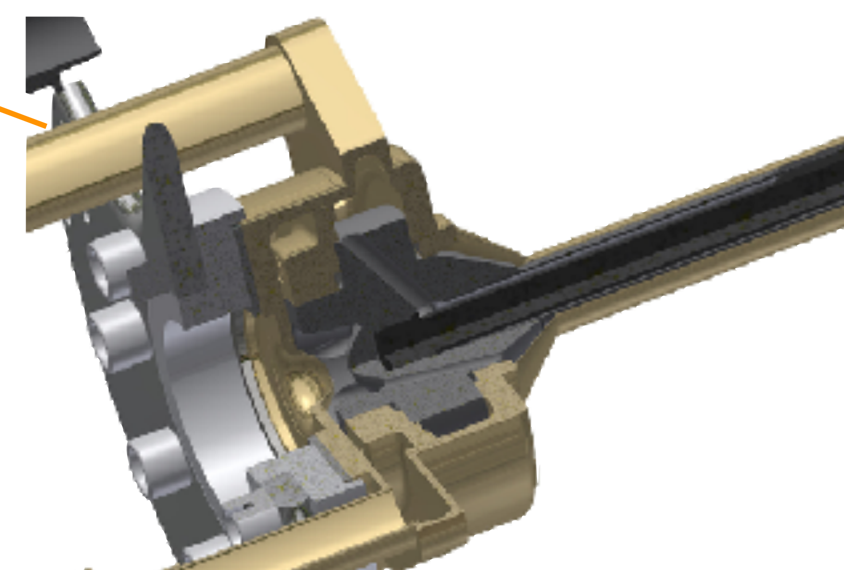
J-PARC neutrino target

- Isotropic Graphite: ~90cm 26mmϕ cantilever
- Co-axial two pipes for He gas cooling and Ti-alloy container.
- Upstream structure for single-side He gas port.

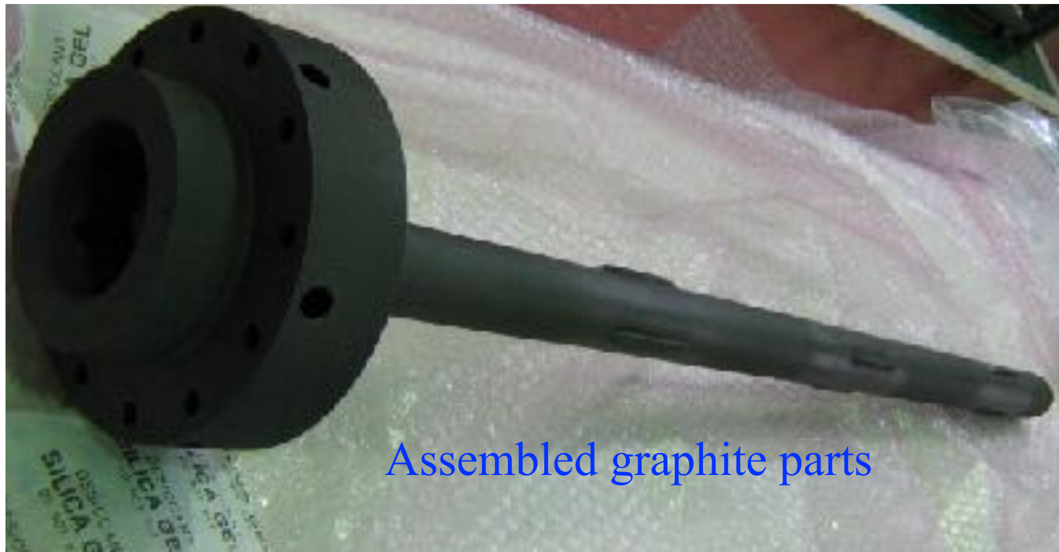


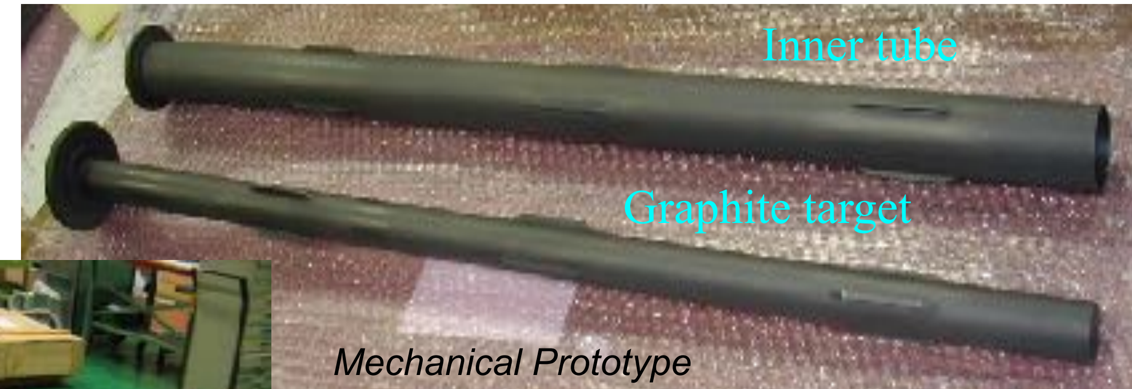






Components of J-PARC neutrino target


Assembled graphite parts




Assembled Ti-alloy tube

Downstream beam window


Ceramic insulator w/ resistor

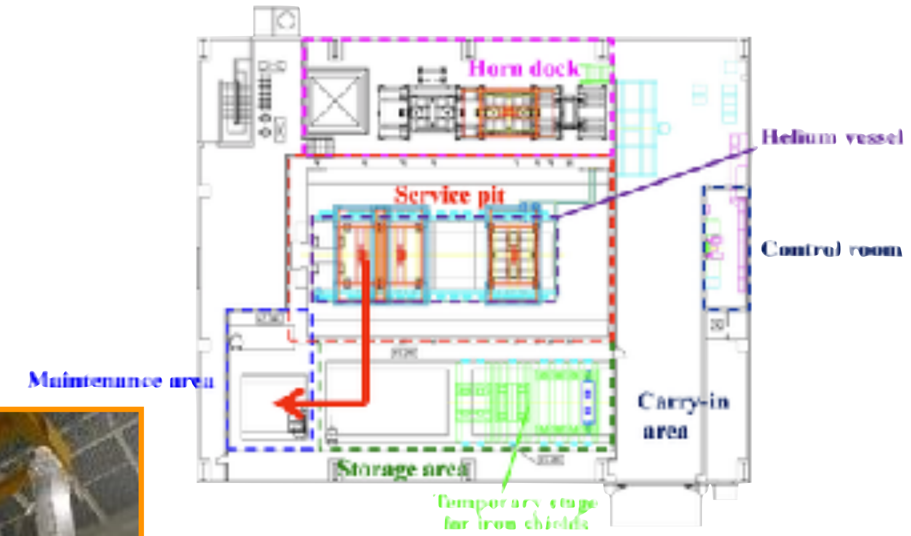

Upstream beam window

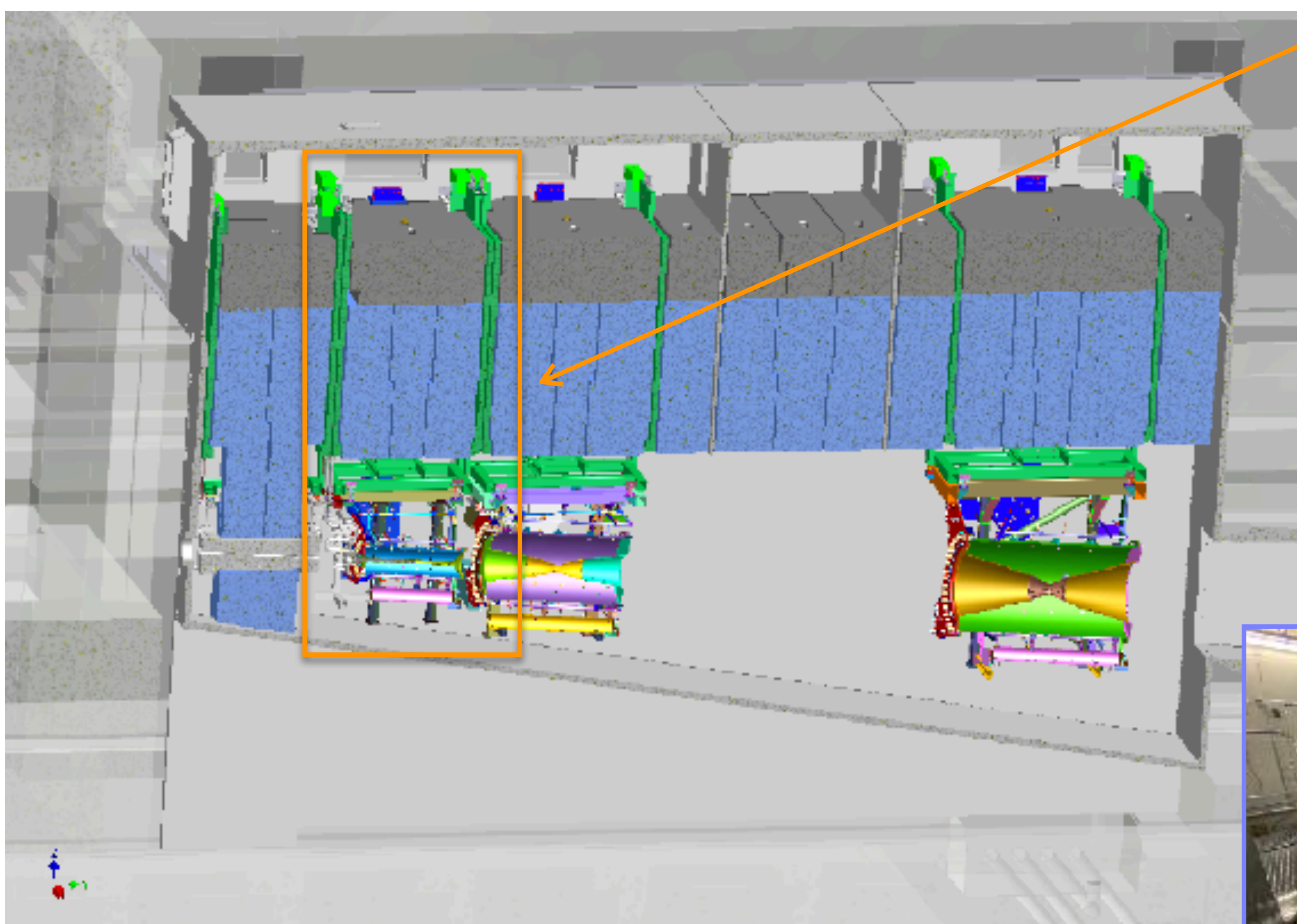
Pictures during assembly

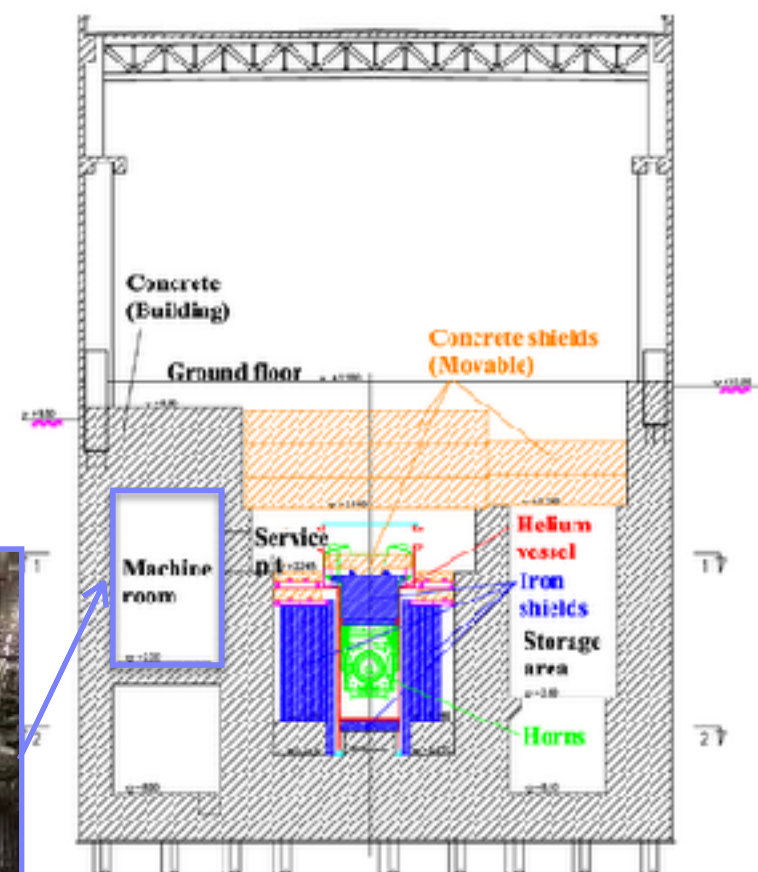
Outer tube (Ti-6Al-4V)
t = 0.3mm

Target position

- Target installed inside horn-1
- He compressor system for cooling is located at machine room besides TS-Vessel.

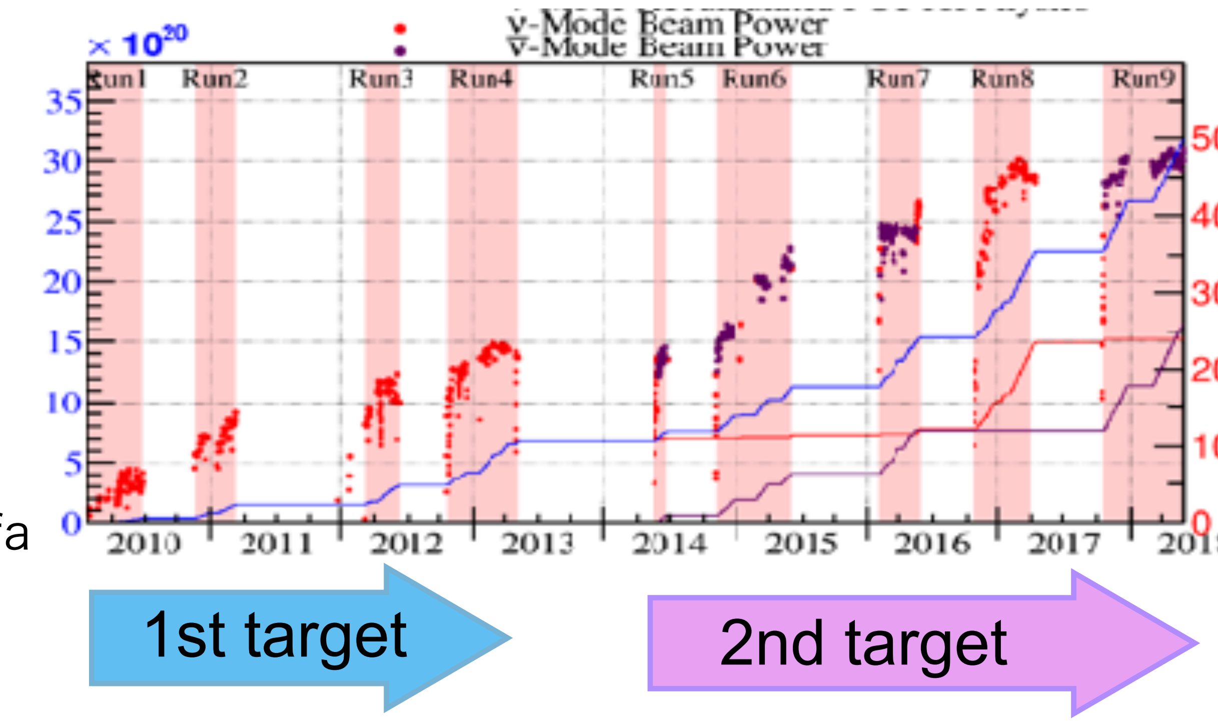


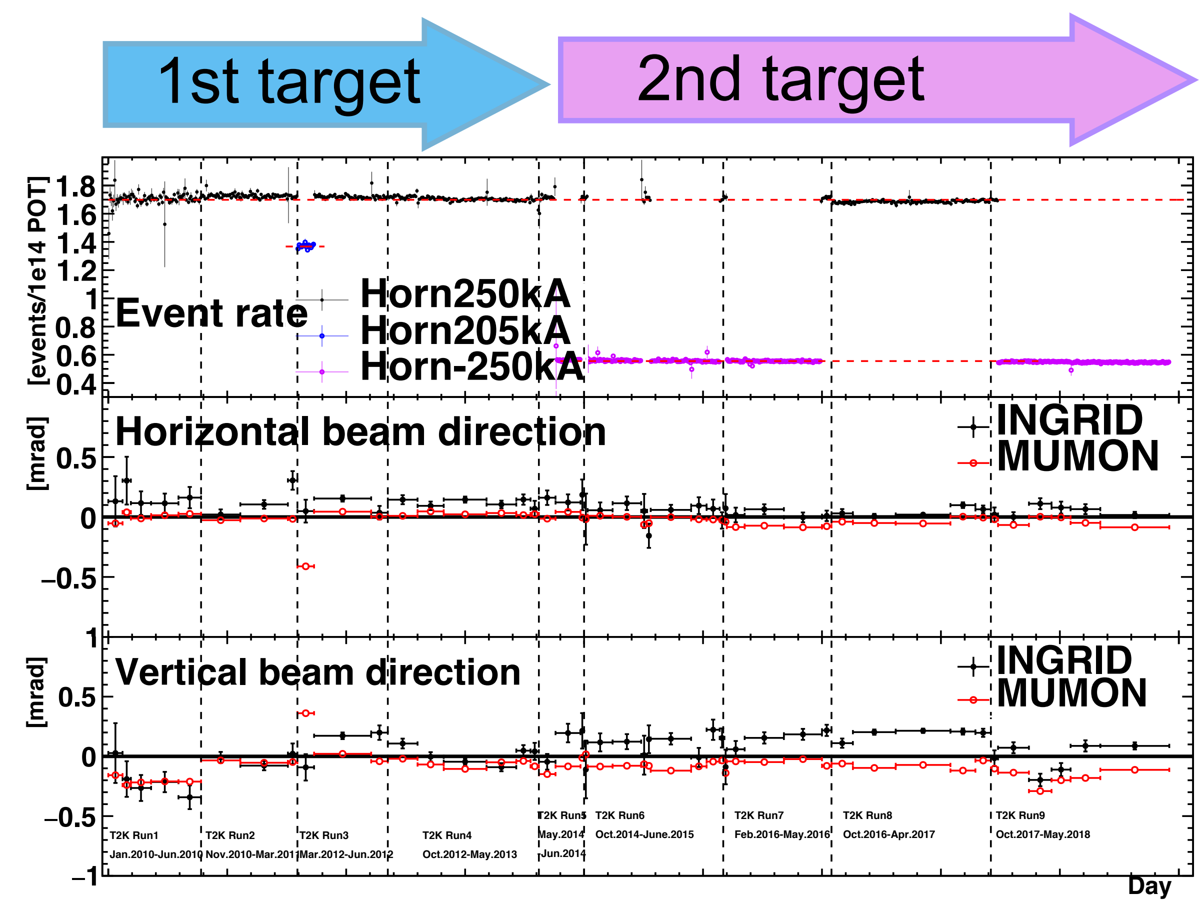


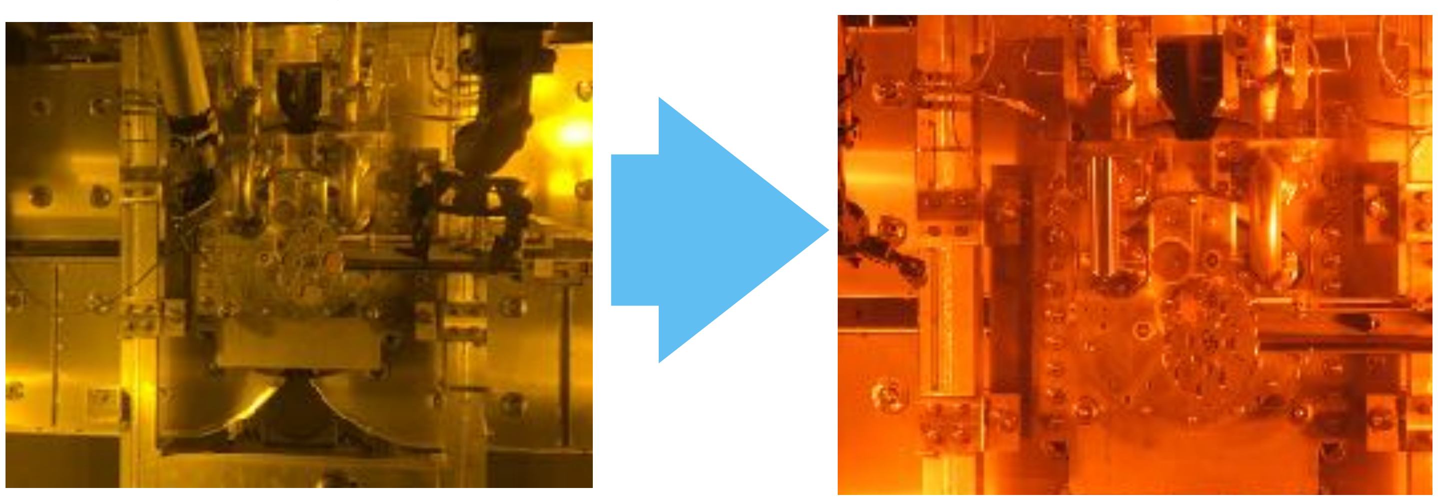


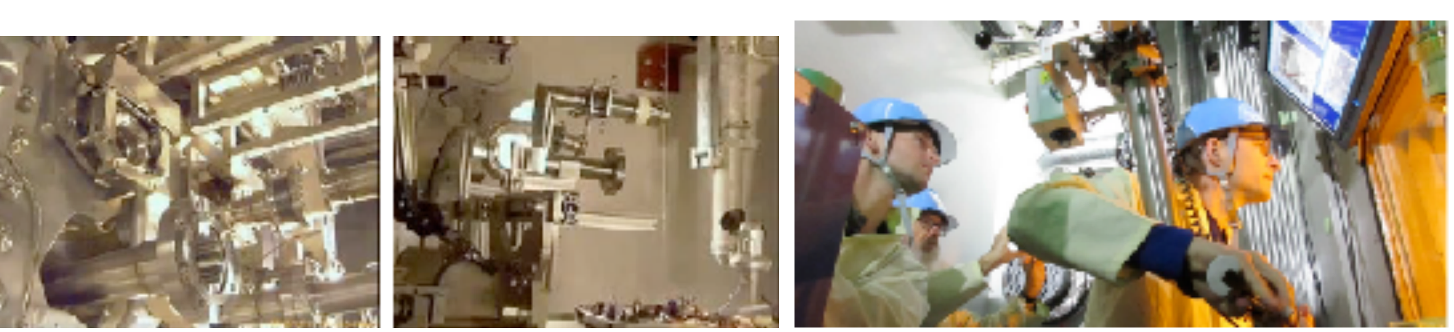
Target Operation History

- 1st target (2009 Apr. ~ 2013 May) : 0.67×10[21] POT:
  - Max beam power ~230kW
  - No significant trouble, but replaced when Horn-1 replaced.
- 2nd target (2014 May ~): 2.49×10[21] POT so far
  - Max beam power ~490kW
  - Normalized neutrino event rate (INGRID) is stable so fa
  - He leak happed at “ceramic break”
    → Fixed in 2015 by remote maintenance
- 3rd target is produced by RAL.
  - It will be installed into Horn-1 Ver.3 in next year.
  - 3rd target + Horn-1 Ver.3 will be used from 2022~.



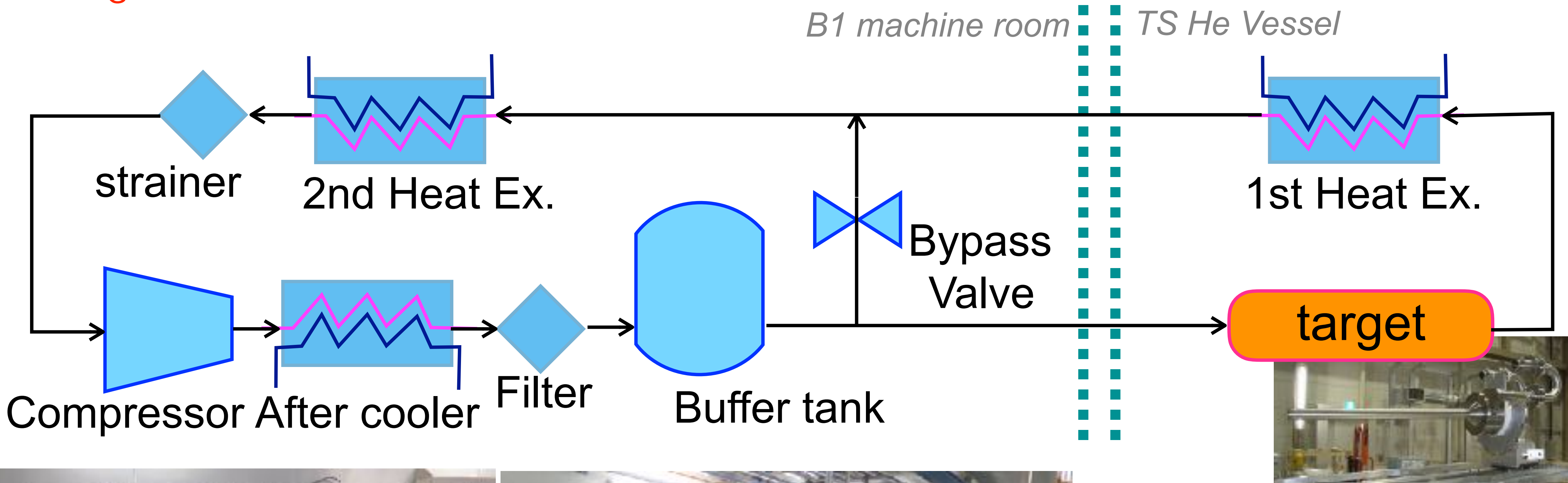


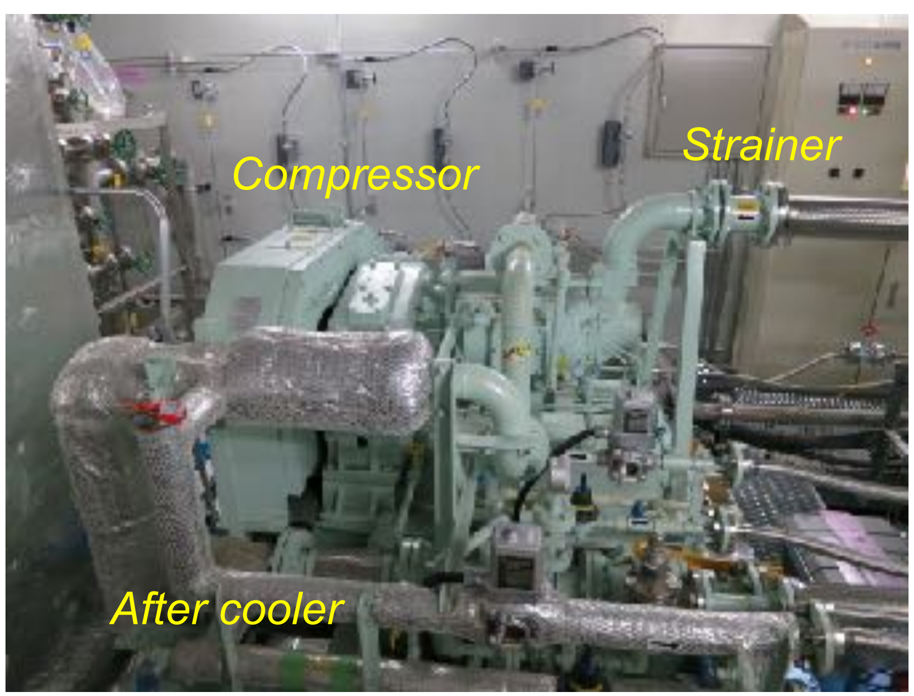


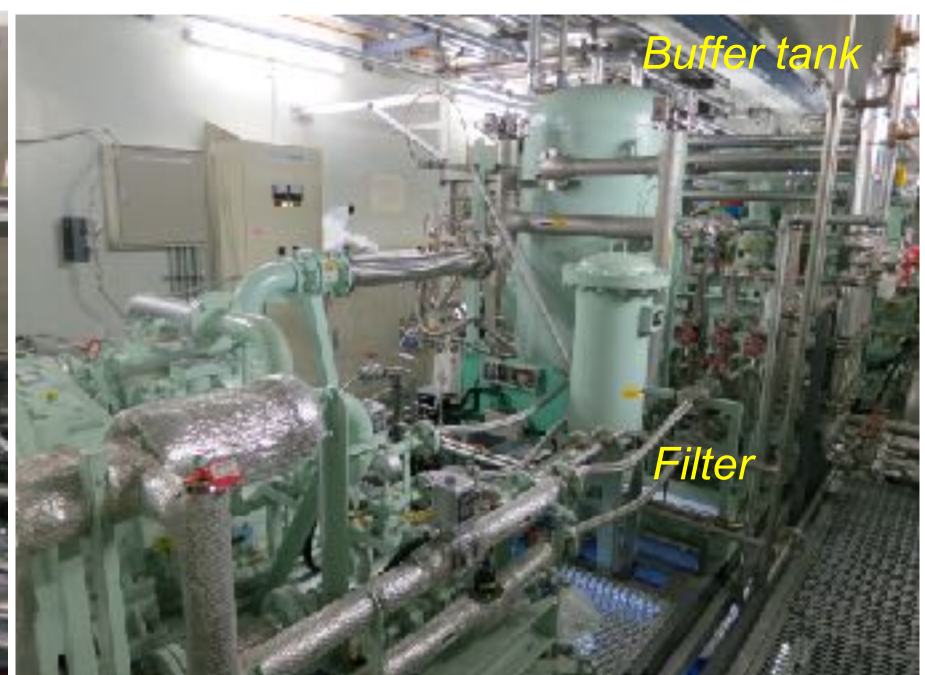


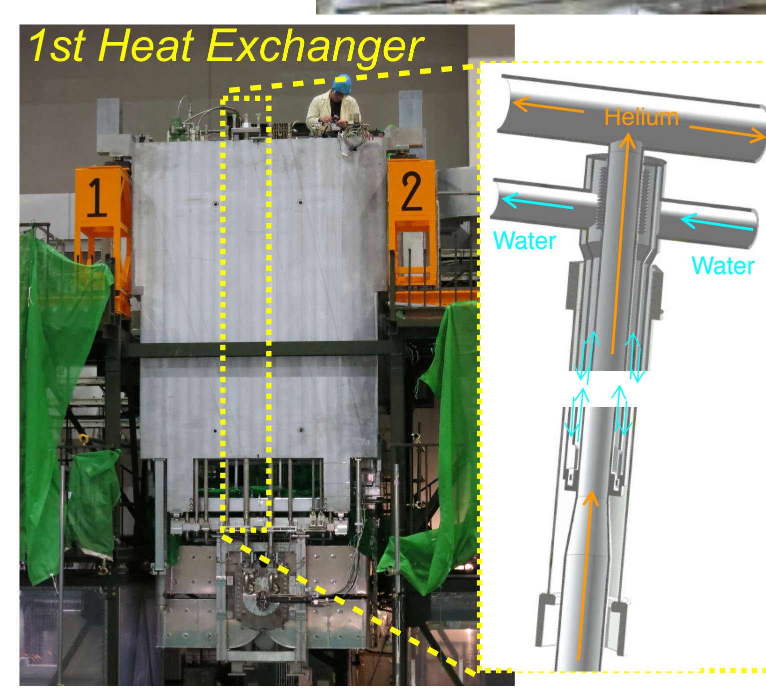
He compressor system

- Diagram of Main Target He loop
  - By-pass valve is adjusted to keep the pressure of He supply to target.
- Periodical radiation survey of filter and strainer is performed.
  - No significant excess above BG has been observed so far.



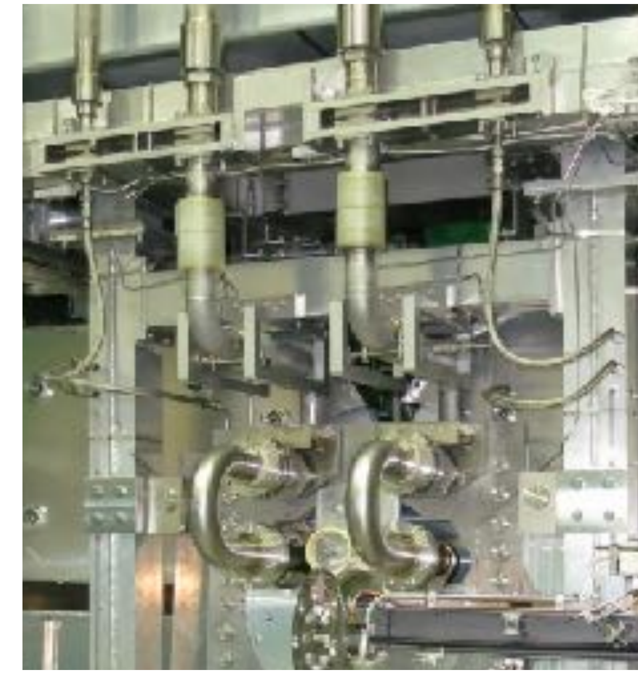




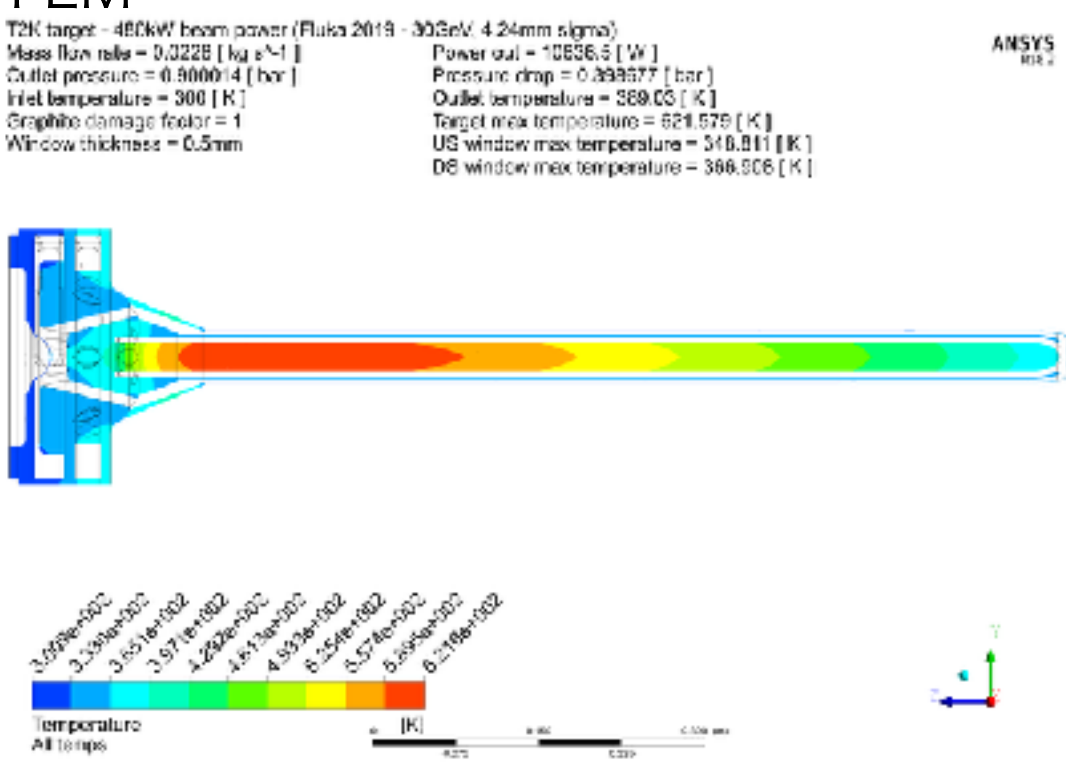


He gas measurement

- He gas temperature at Target inlet and outlet was measured.
  - 490kW beam, He flow ~25 [g/s] → ΔT (He) ~72K
- Latest simulation with FLUKA & ANSYS by M. Fitton (RAL)
  - 480kW beam, He flow 23 [g/s] → ΔT (He) ~89K
- **No large discrepancy**, considering the condition difference and the temperature measuring point.



FEM

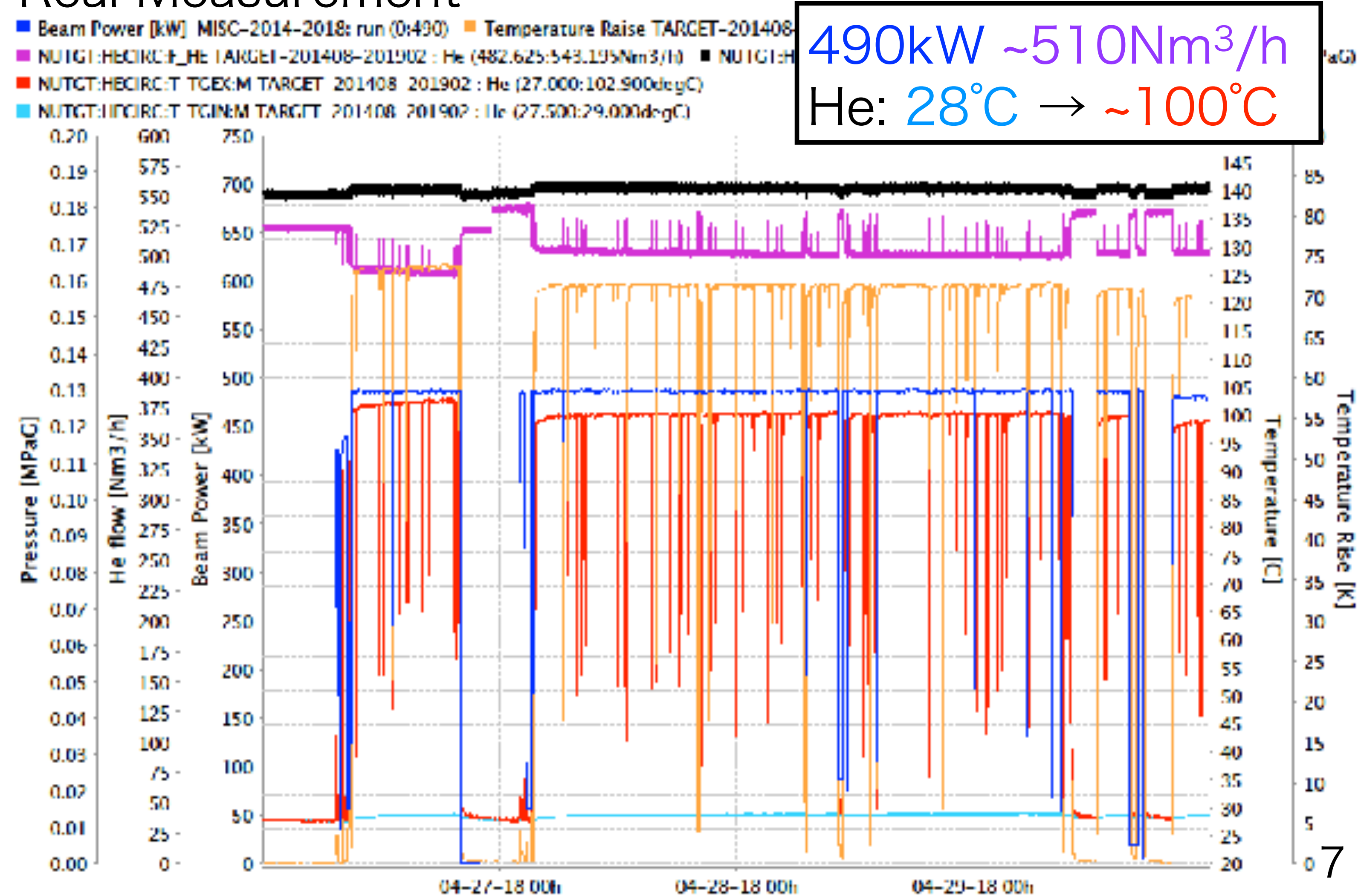


480kW 22.8[g/s] No. Rad. damage

He: 300K→ 389K

Graphite: 622K max.

Real Measurement



490kW ~510Nm³/h

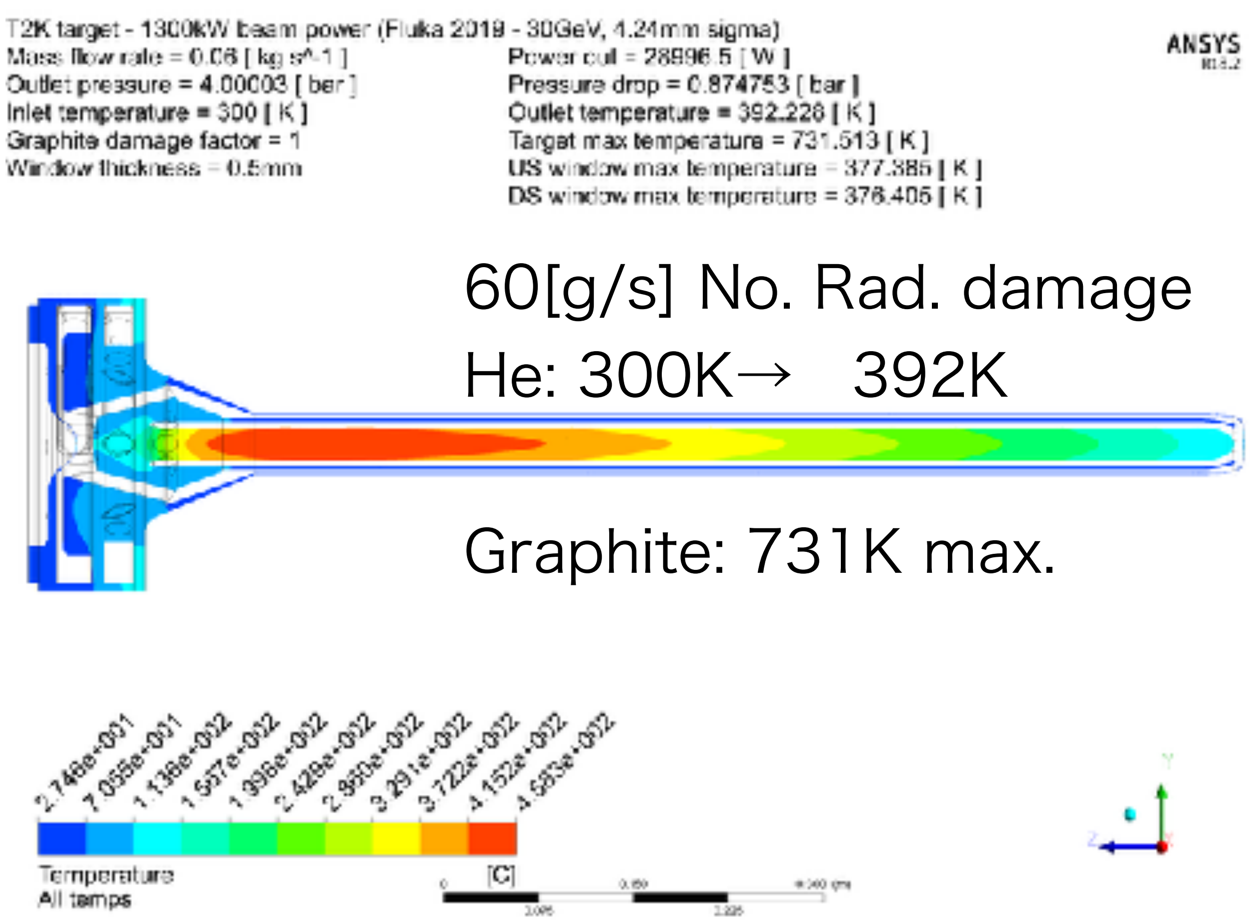
He: 28℃ → ~100℃

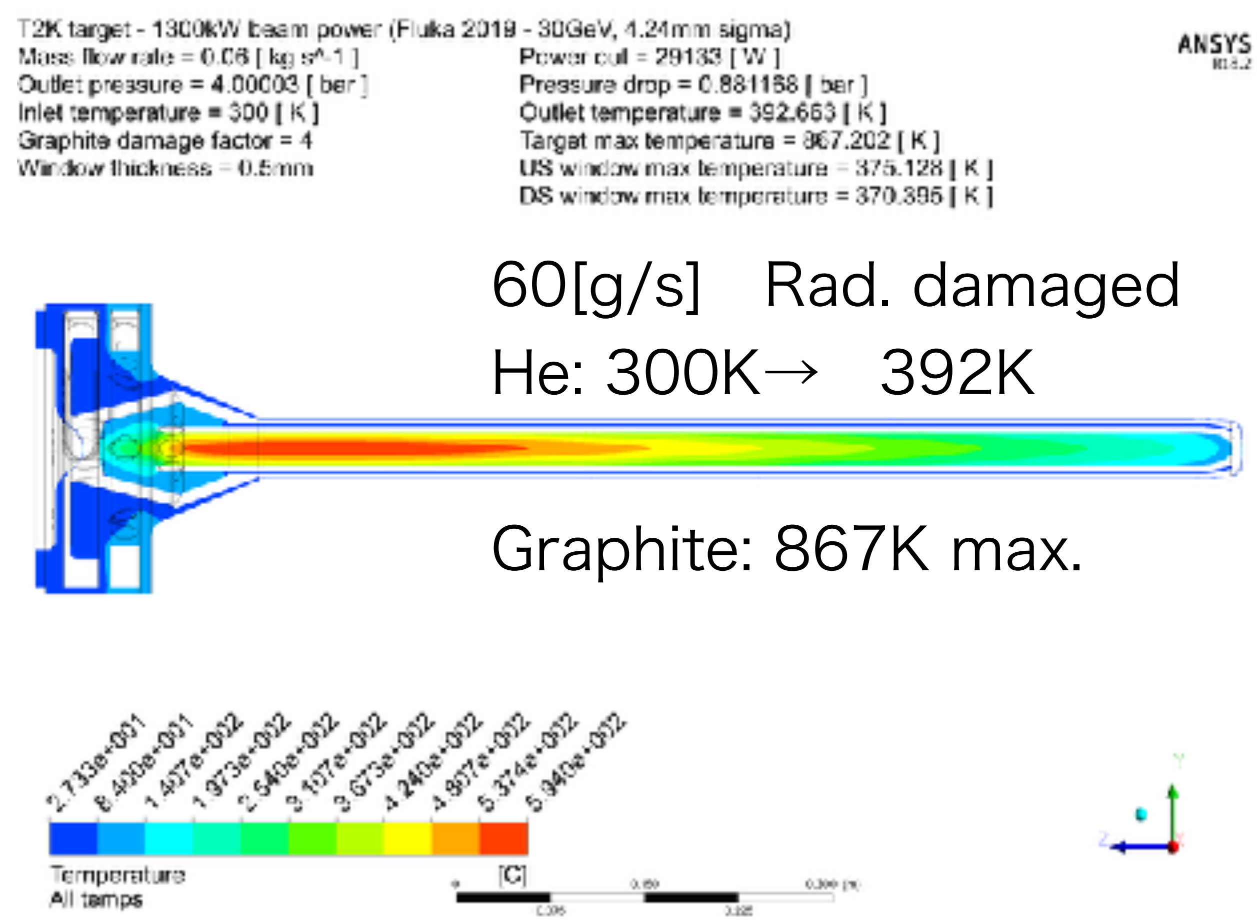
He gas cooling for 1.3MW

- He cooling simulation for 1.3MW beam is also performed with FLUKA & ANSYS (M. Fitton ,RAL)
  - Requirements: graphite temperature ≲ 700℃
  - He gas temperature ≲ 200℃
- To satisfy these requirements for 1.3MW, flow rate should be increased: 32[g/s] → 60 [g/s]

  … He gas pressure will be increased: 0.2MPaG→0.5MPaG

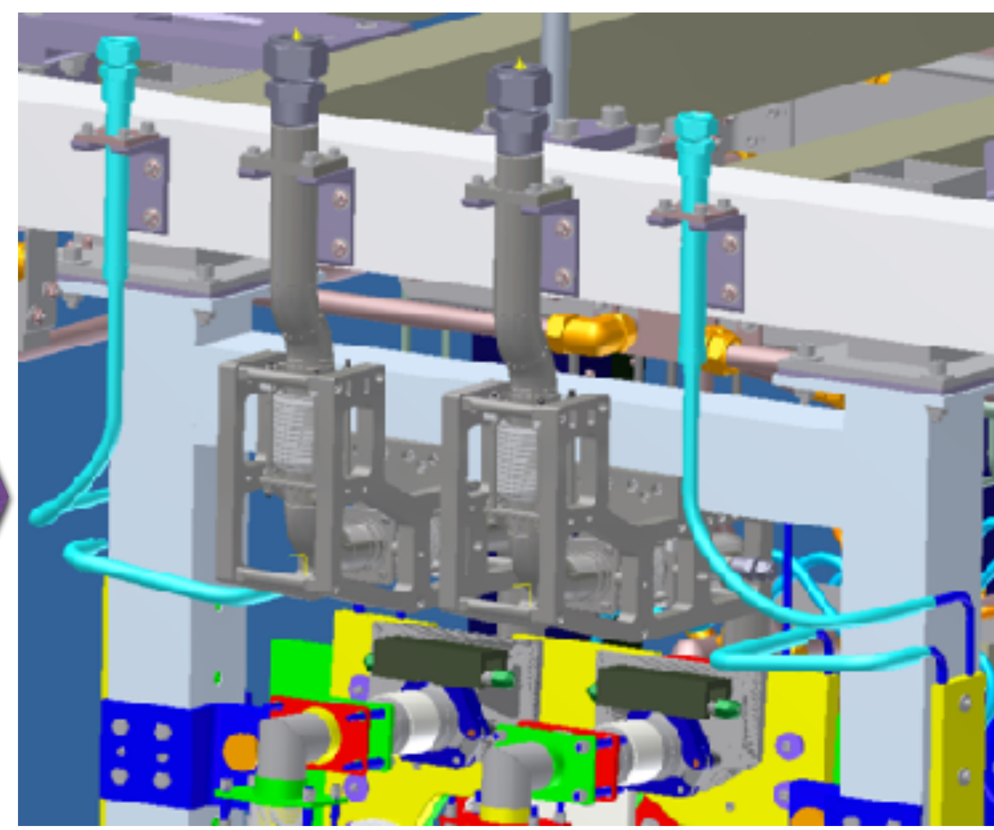
  → He gas system and should be upgraded.

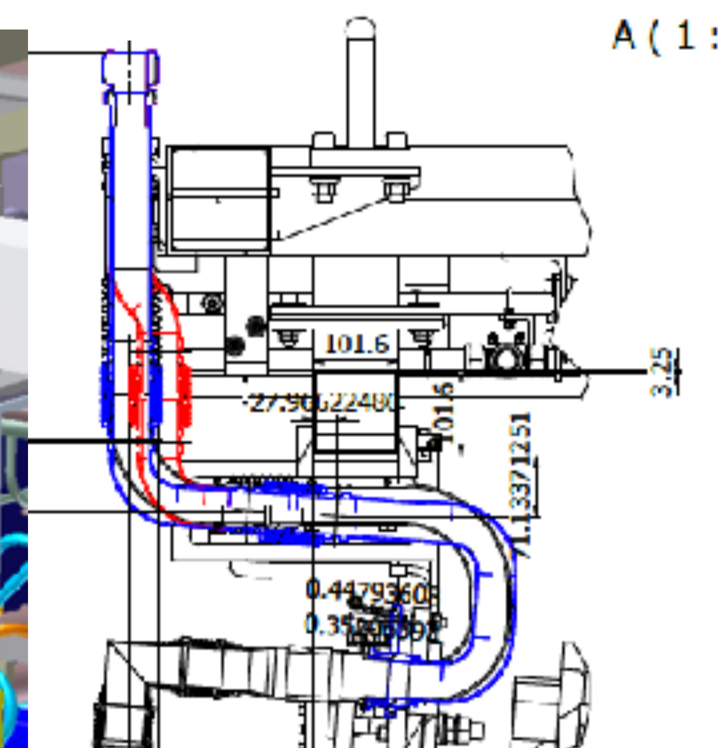




He system upgrade for 1.3MW

- Current system is designed for 0.2MPa He, and several parts has only 0.3MPa pressure resistance.
  → It should be replaced for 1.3MW operation.
- Bellows of He tubes on horn-1 frame should be updated.
  - The target He tube with 0.9MPa pressure resistance for Horn-1 Ver.3 is under construction.
    → Horn-1 ver3 become ready for 1.3MW beam.
- Detailed upgrade plan of He system will be presented by T. Matsubara.





Black: current
Red: modified

He gas sampling / impurity measurement

- Target He gas can be remotely sampled at TS ground floor for
  - Impurity measurement by gas-chromatography
    - O_2, CO, CO_2, H_2, CH_4, N_2
  - Tritium measurement
- He gas is sampled / exhausted thorough strainer and filter to avoid the emission of fragments from target system if it is exists.
  - Radiation survey of filter and strainer is always performed when He gas exhaust.
    → No excess w.r.t BG has been observed so far.

He measurement results

- Beam period: 2018 Mar. 9th ~ 2018 May. 30th.
  - Delivers beam: 5.6×10^{20} POT (~480kW)
  - He system is filled with fresh He gas in Mar. 5th.
- CO and CO_2 increase is observed: (caused by O2 contamination?)
  If we assume all target loss, ~0.1% mass reduction for 1×10^{21} POT.
  → Acceptable level, but it is better to improve.
- ~0.1% H^2 production, ~1[kBq/L] Tritium production for 1×10^{21} POT.
  But, the beam period by period fluctuation is large. Under investigation.

- It is desired to measure $H_2$0 contamination in He gas.

Impurity [ppm]	CO_2	H_2	O_2	N_2	CH_4	CO
2018/3/5	0	0	1	3	0	0
2018/5/31	118	489	0	26	41	371

[Bq/L]	^3H Total	(HTO)	(HT)
2018/3/5	n/a		
2018/5/31	543	(471)	(18)

Summary

- J-PARC neutrino target made of 90cm, 26mmϕ graphite that is cooled by He gas, and contained by Ti-alloy case.
- Currently used Target-2 has been exposed to proton beam (max. ~500kW) ~2.5×10^{21} POT, so far.
  - **No big trouble** after He-leak trouble (2015) is fixed.
  - Target-3 is produced by RAL and waiting for installation.
- Measured He gas temperature is comparable with the expectation with FLUKA+ ANSYS simulation.
- For 1.3MW beam power, He system upgrade (32g/s, 0.2MPa→60g/s, 0.5MPa) is necessary.
- CO and CO_2 in He gas are produced during beam operation. It is probably acceptable level at this moment.
- Production rates of H_2 gas and ^3H are obtained. Its period by period fluctuation is not yet under understood.