T2K target

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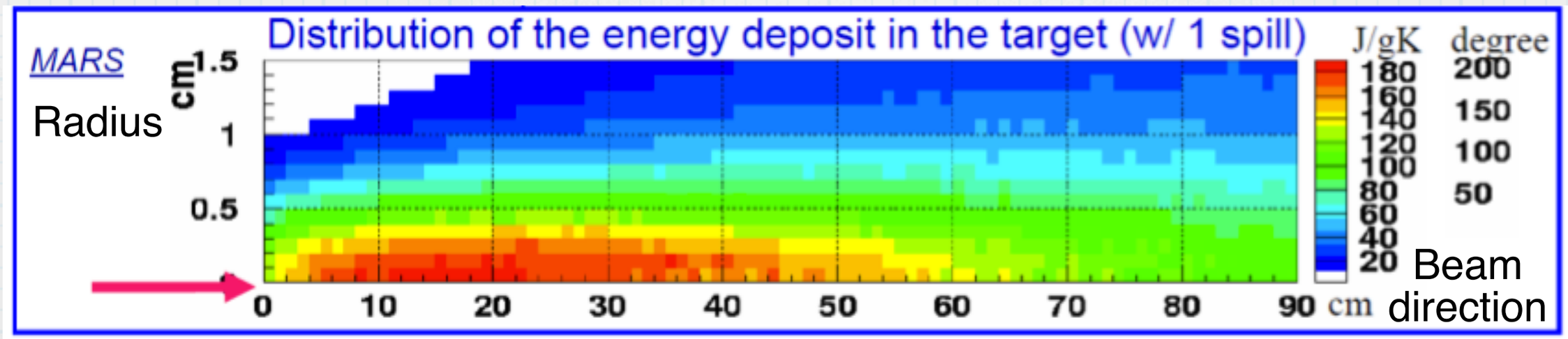
for
J-PARC neutrino construction group
T2K collaboration

Outline

- Overview of J-PARC ν-target
- Status of T2K target (after NBI2012 report)
  - Target replacement: No.1 → No.2
  - O_2 monitoring of cooling He
    - Reducing the oxidization is key of High-temperature graphite target.

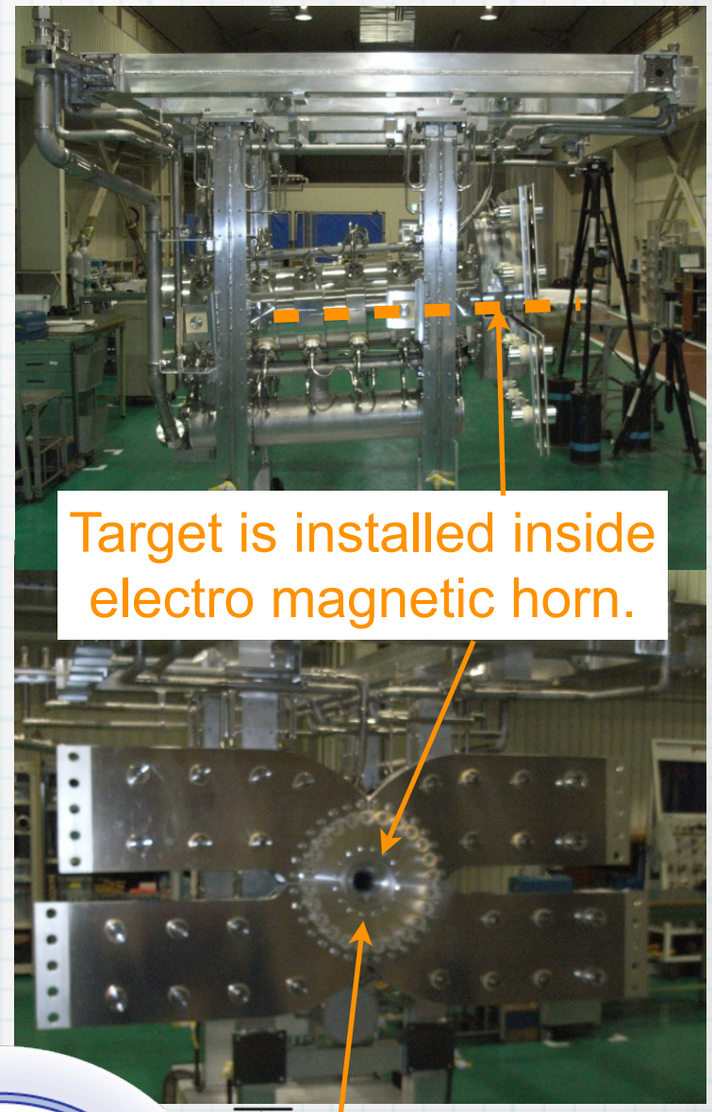
Thermal shock resistance of graphite target

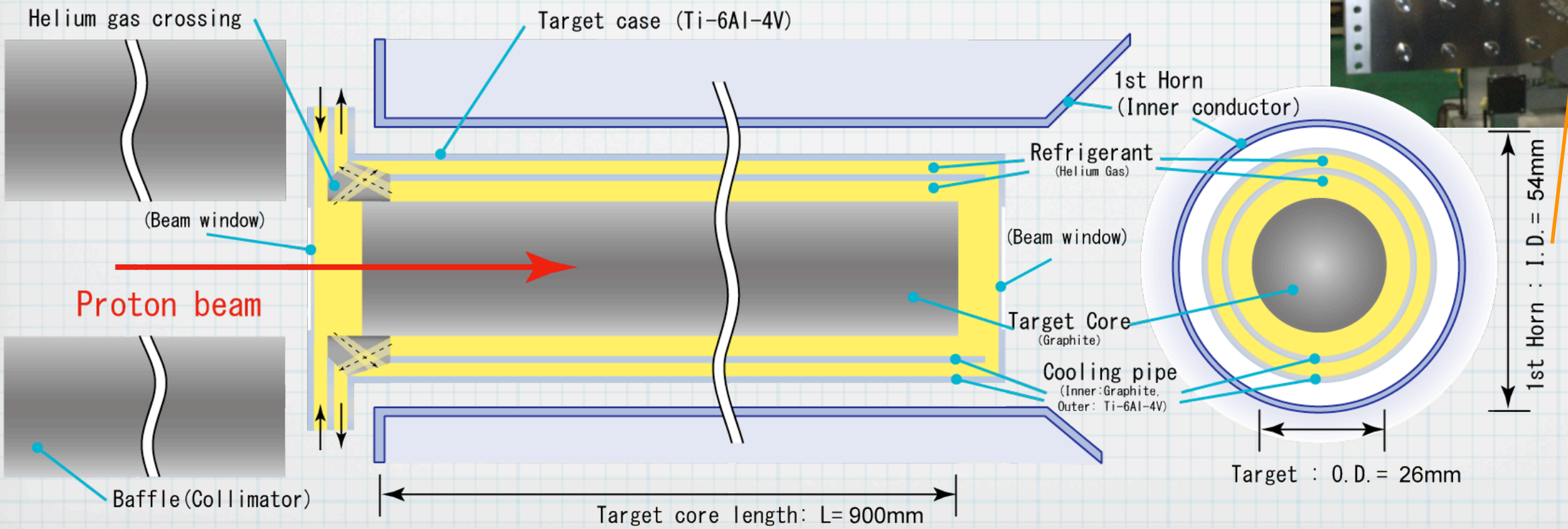
- Material : Isotropic graphite (IG-430 by Toyo. Tanso. Co. ltd.)
  - Tensile strength = 37.2MPa
  - Geometry: L = ~900mm (~$2\lambda_{int}$),φ=26mm (main part)
    (cf. proton beam size: $\sigma_x=\sigma_y$=4.2mm)
    ← Optimized to maximize the neutrino flux.
- Energy deposit: 41kJ/3.3×10^{14} proton (30GeV 1spill)
- Thermal shock : ΔT = 200K, σ_{eq} = 7.2MPa
  → Safety factor = 3.5 (including cyclic fatigue)
- Heat load: 19.6kW for 750kW beam



Conceptual design of J-PARC ν target

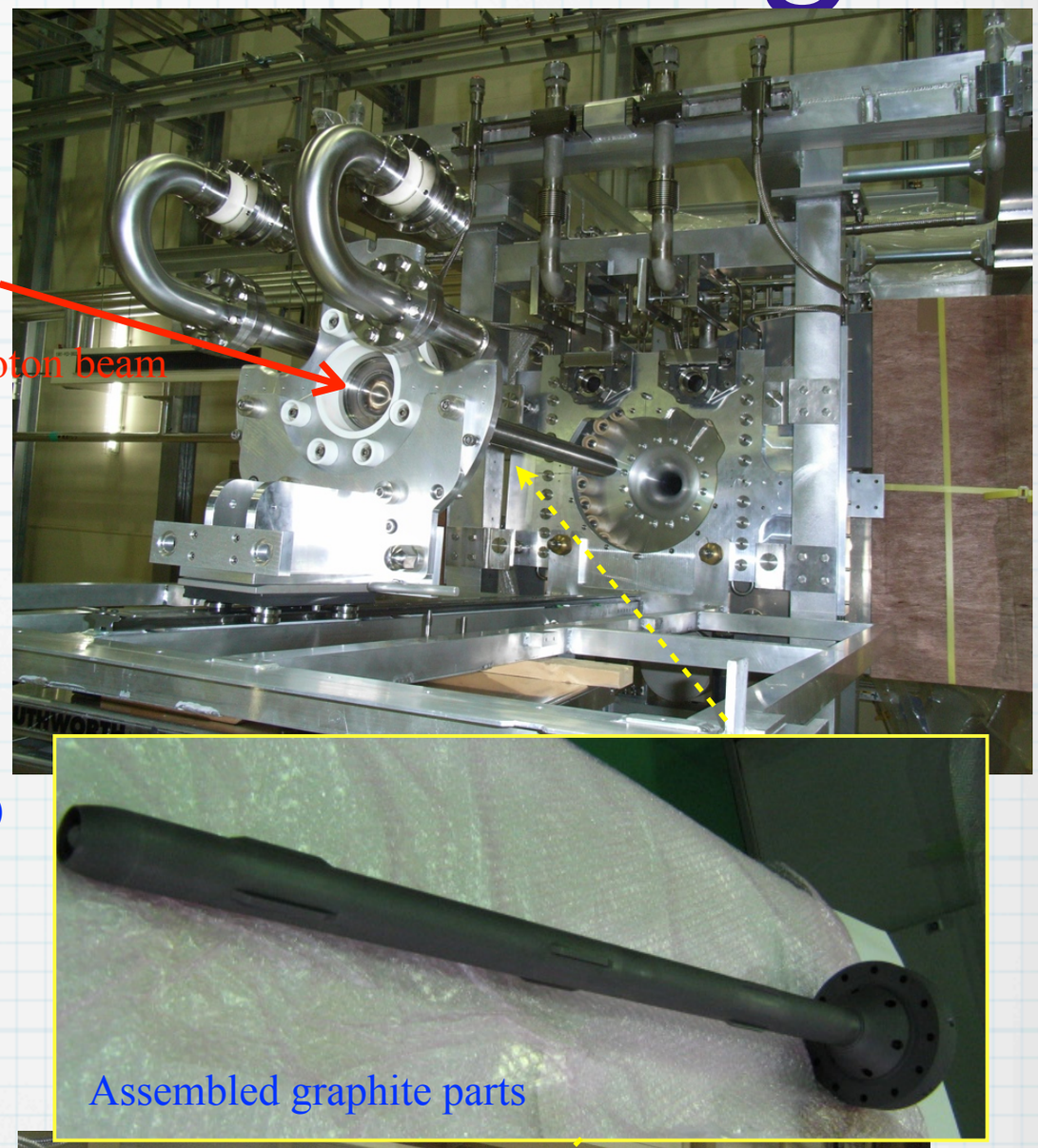
- Co-axial two cooling tube structure to enable the target to be detached from horn.
- Contained by He-tight case made of Ti-6Al-4V
  - t=0.3mm for beam-window part.
  - Target case become same electric potential due to AC-coupling: O(1kV)
    → Electric Insulation at support structure and He-tubes is necessary.
    → Connect to grand via high resistance (4MΩ) to avoid the charge-up.

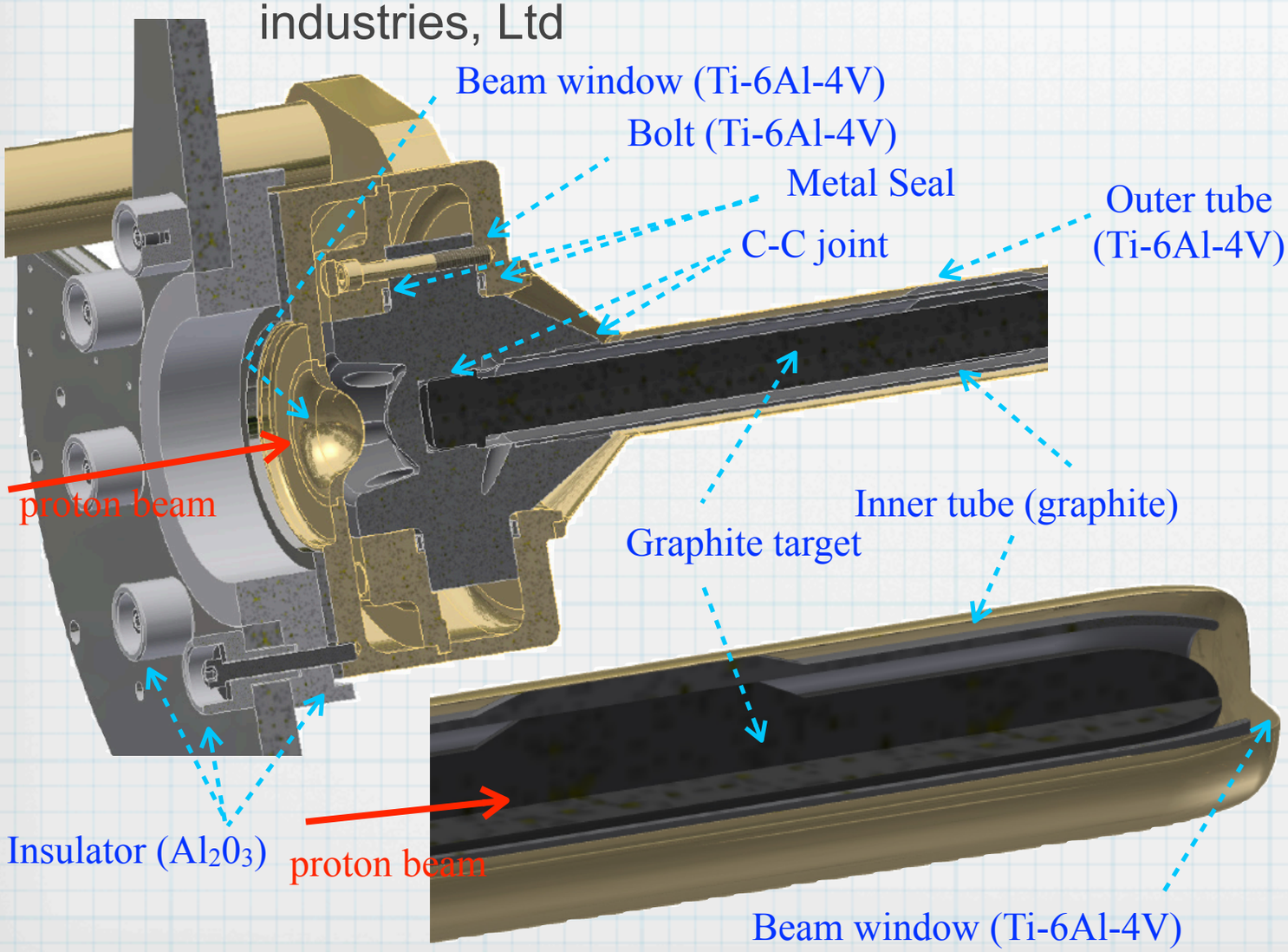


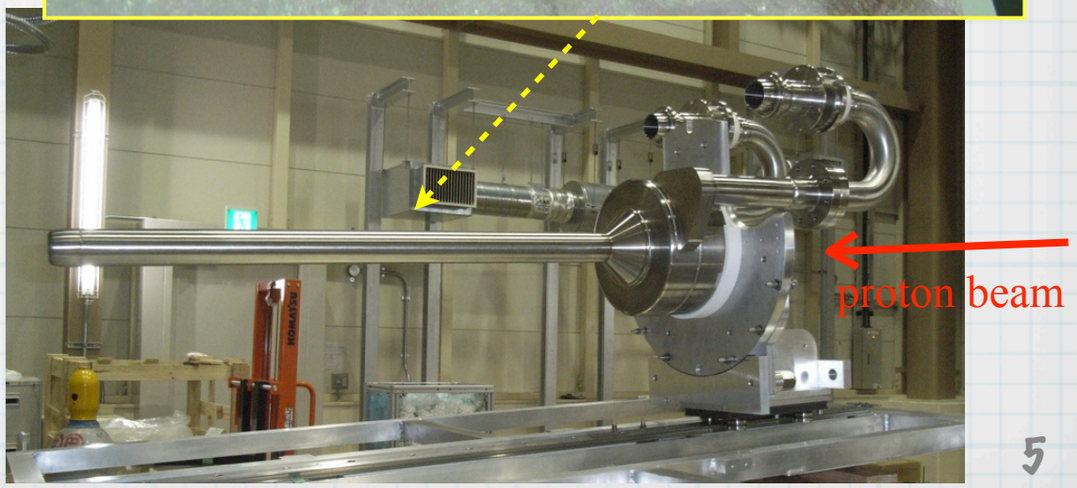


Mechanical structure of target

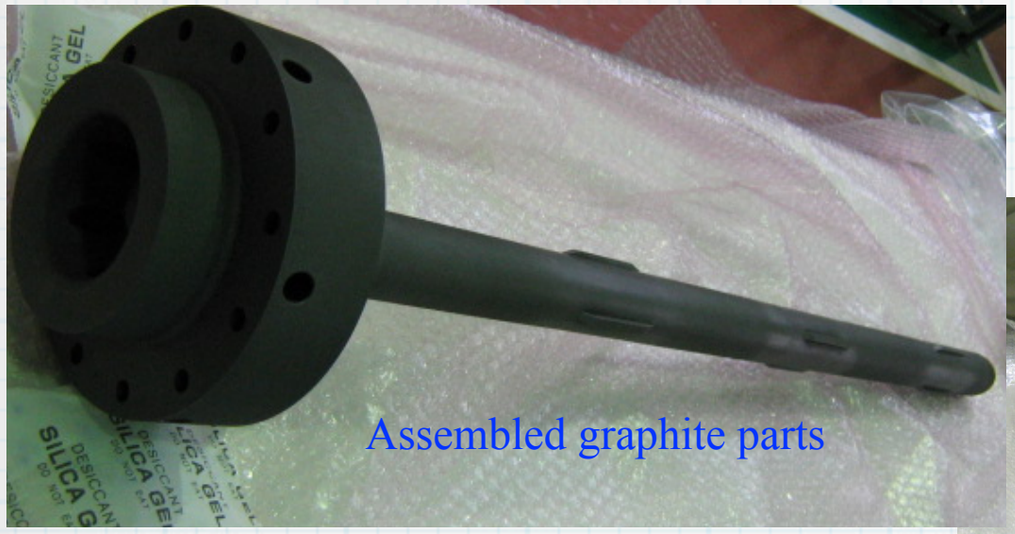
- Graphite-graphite bonding w/ thread structure
  - Spacer between cooling tube is unified to road/ tube part.
- Graphite-Ti alloy parts: fixed by bolts w/ low clamping force metal seal.
  - Metal Resilient Seal by Mitsubishi cable industries, Ltd



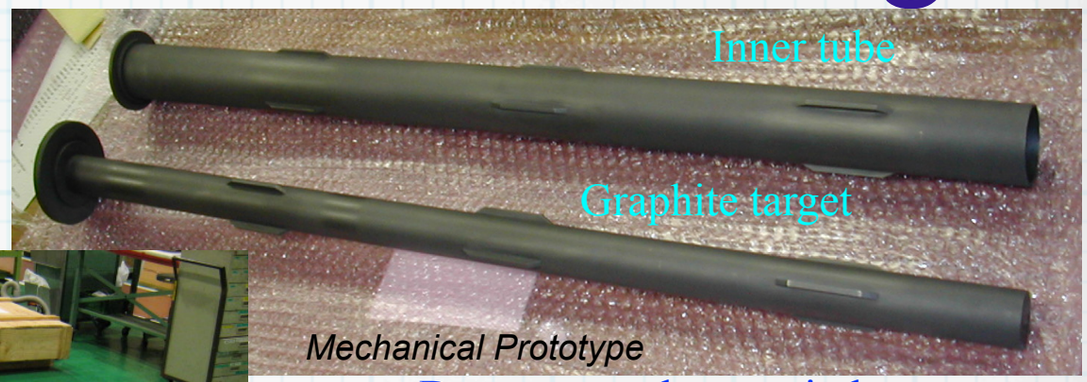




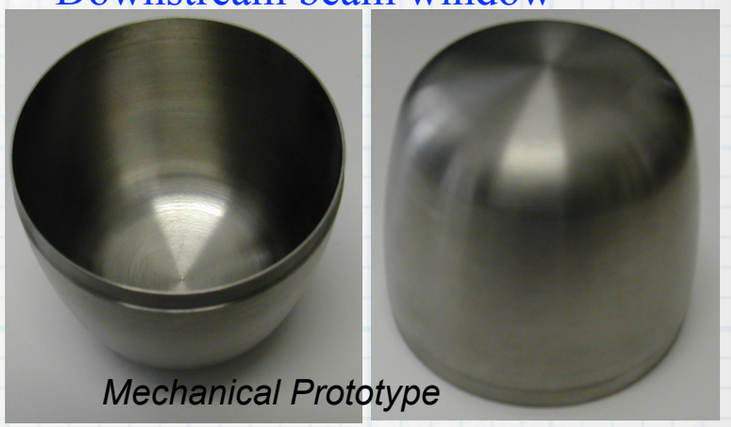
Components of J-PARC neutrino target



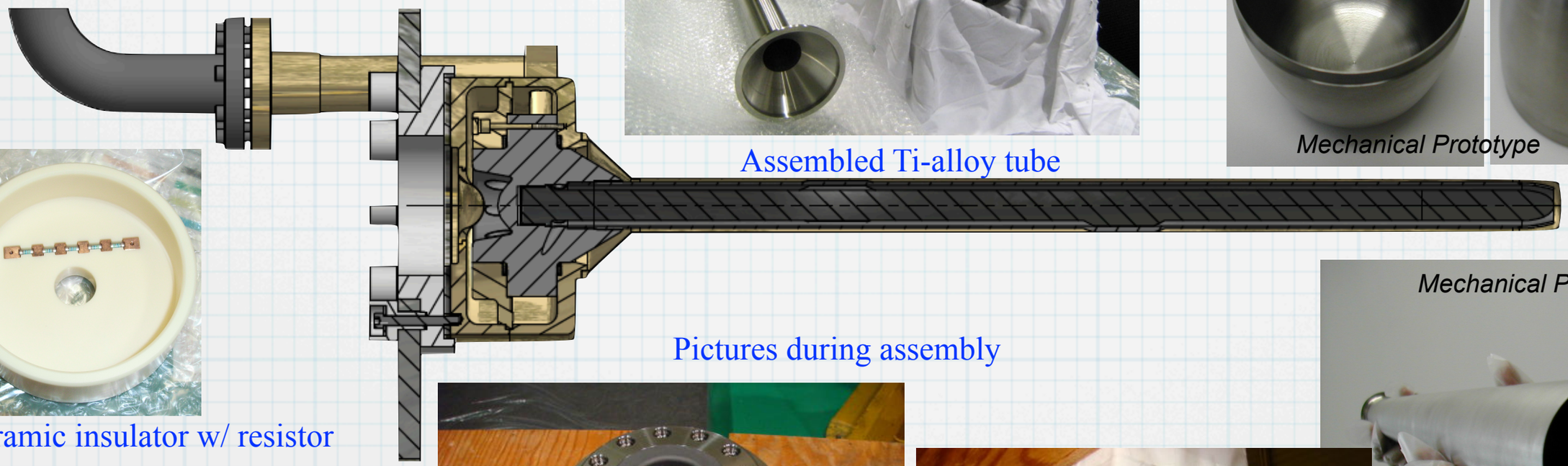
Assembled graphite parts



Downstream beam window



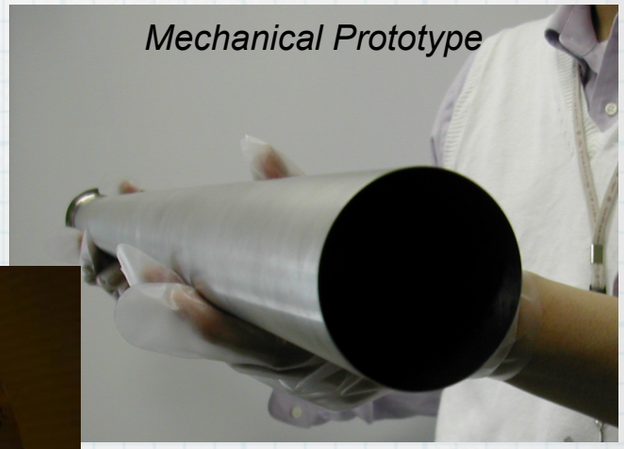
Assembled Ti-alloy tube



Pictures during assembly

Ceramic insulator w/ resistor

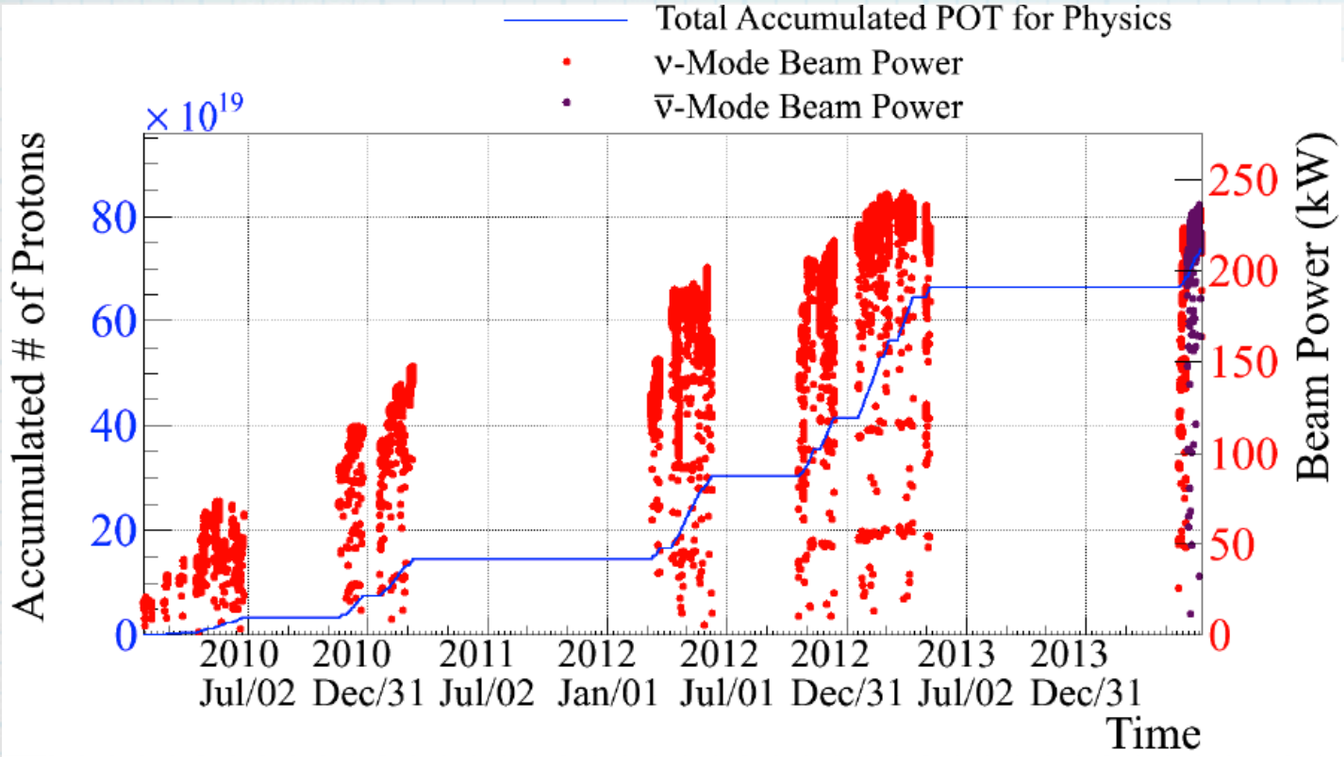
Upstream beam window



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

Operation status

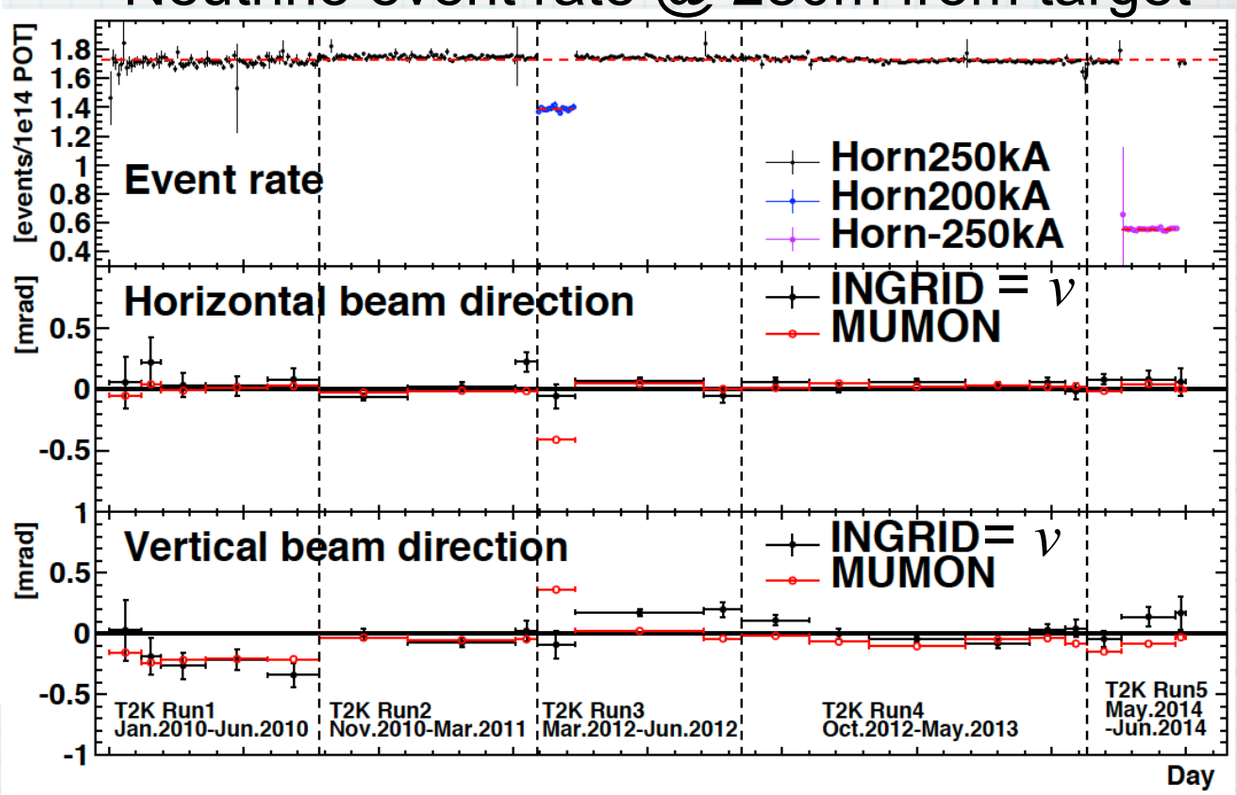
- First neutrino target: Apr. 2009 ~ May.2013: No significant trouble.
  - ~6.7×10^{20} POT: Max beam power ~230kW
    - CF. Much less than design beam power (750kW) / POT (~8×10^{21}).
  - Muon flux and Neutrino flux are stable.
  - The horns are replaced with improved during the shutdown in 2013-2014. Target (#1) is also replaced by 2nd one with same design.



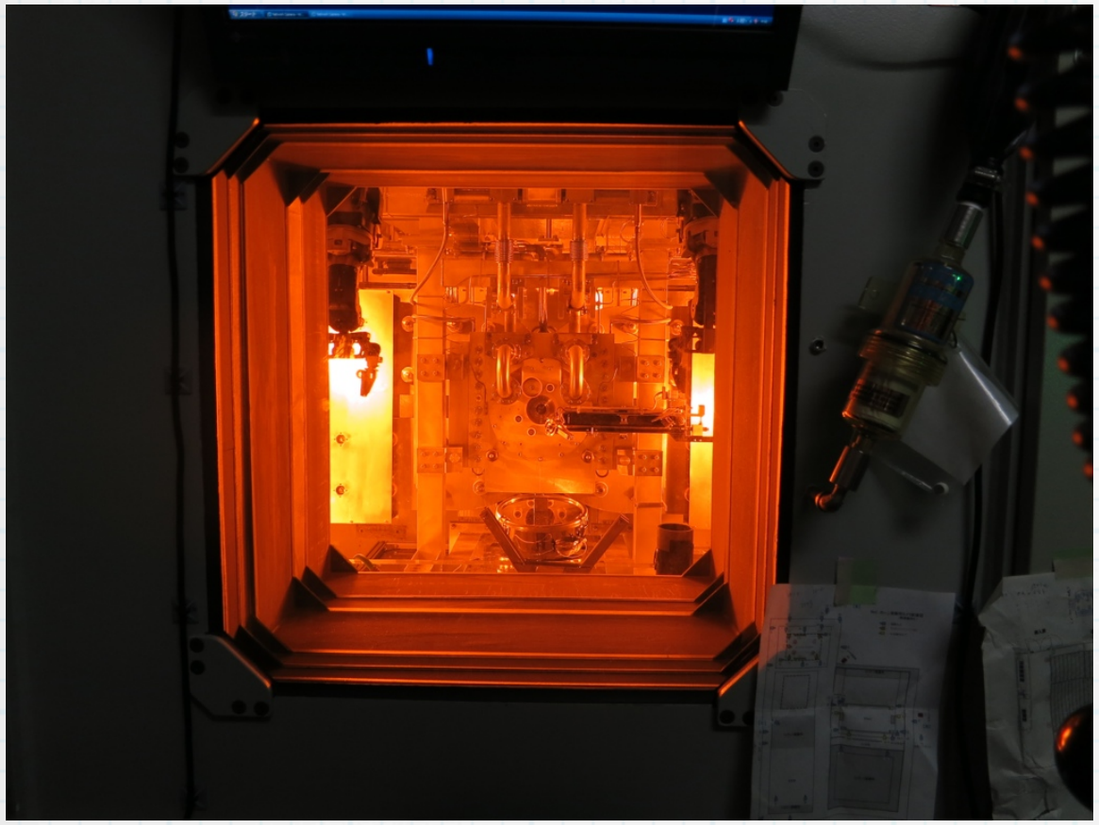
1st target

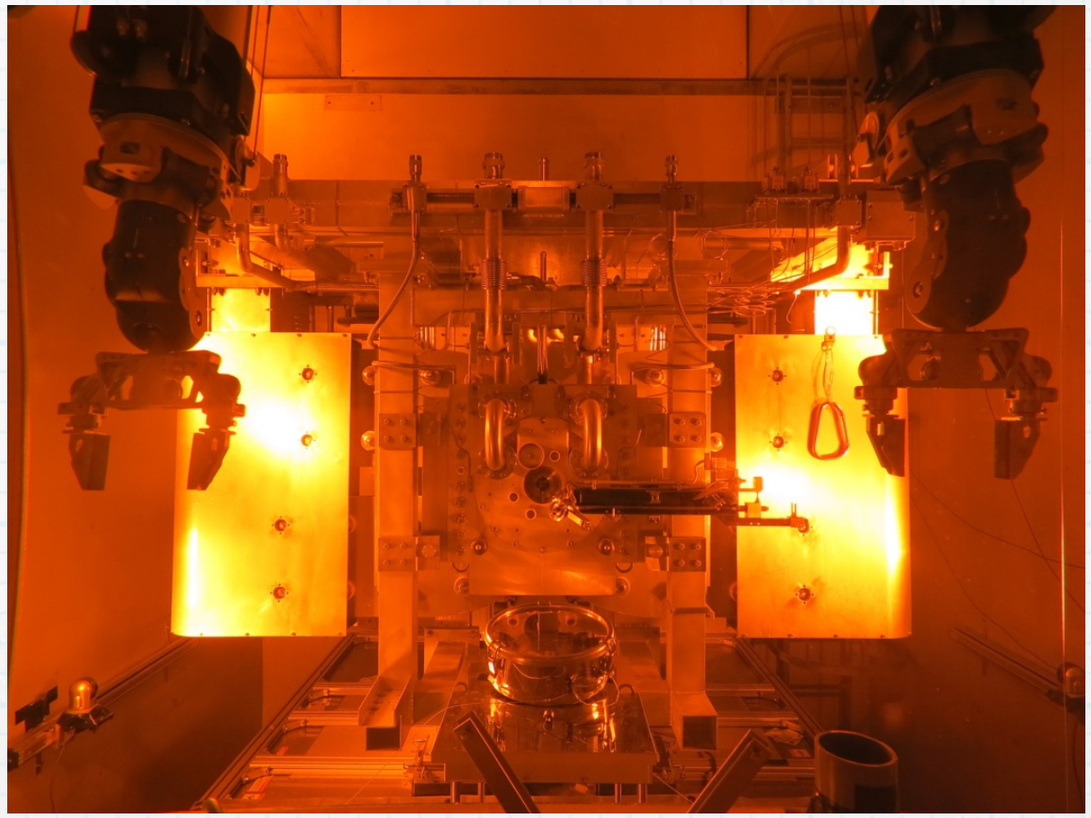
2nd target

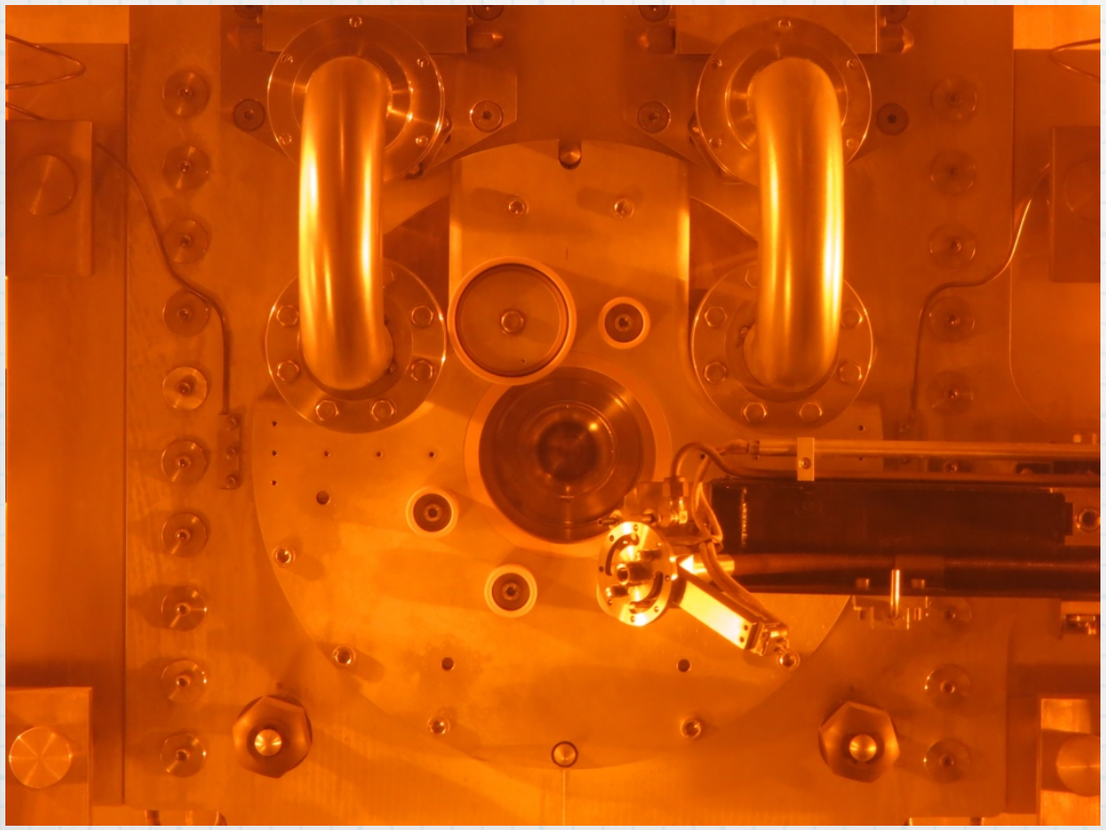
Neutrino event rate @ 280m from target

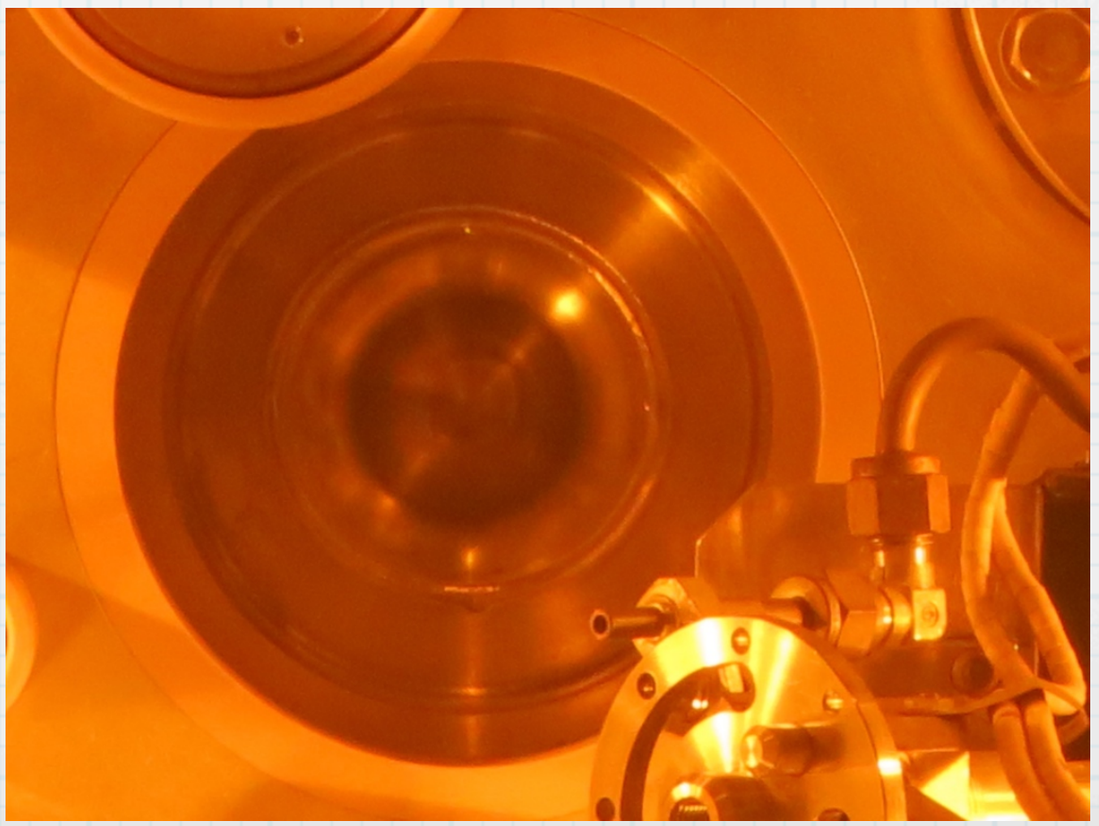


Pictures of T2K target #1 (used)







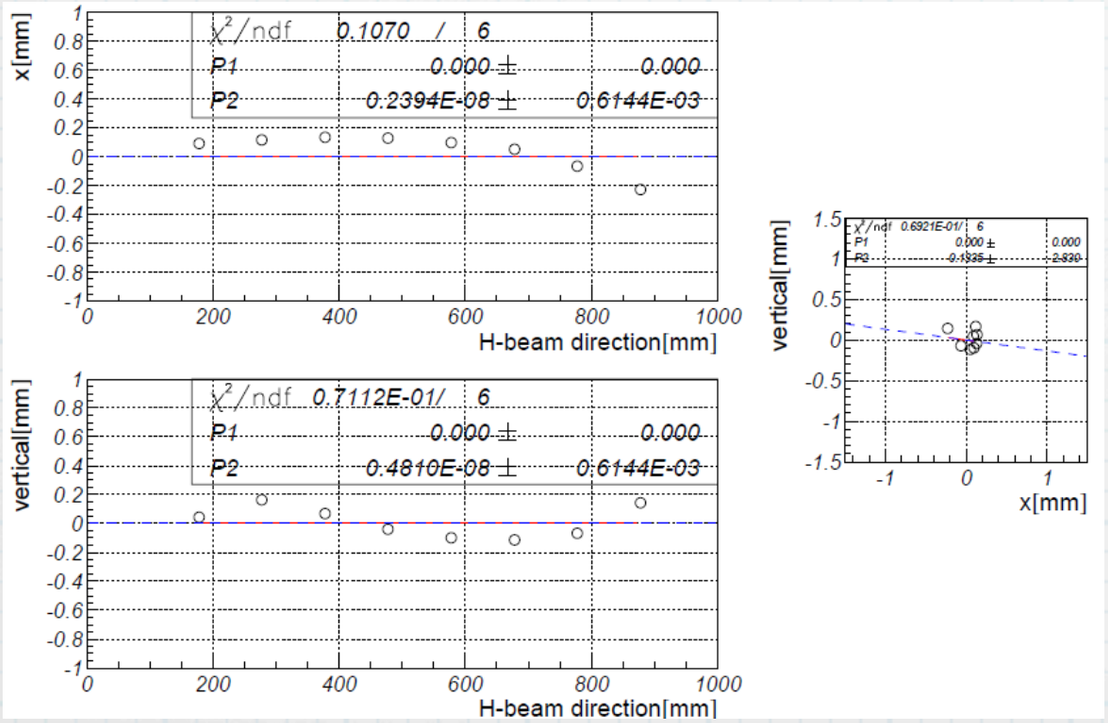


T2K target #2 (2014 May ~)

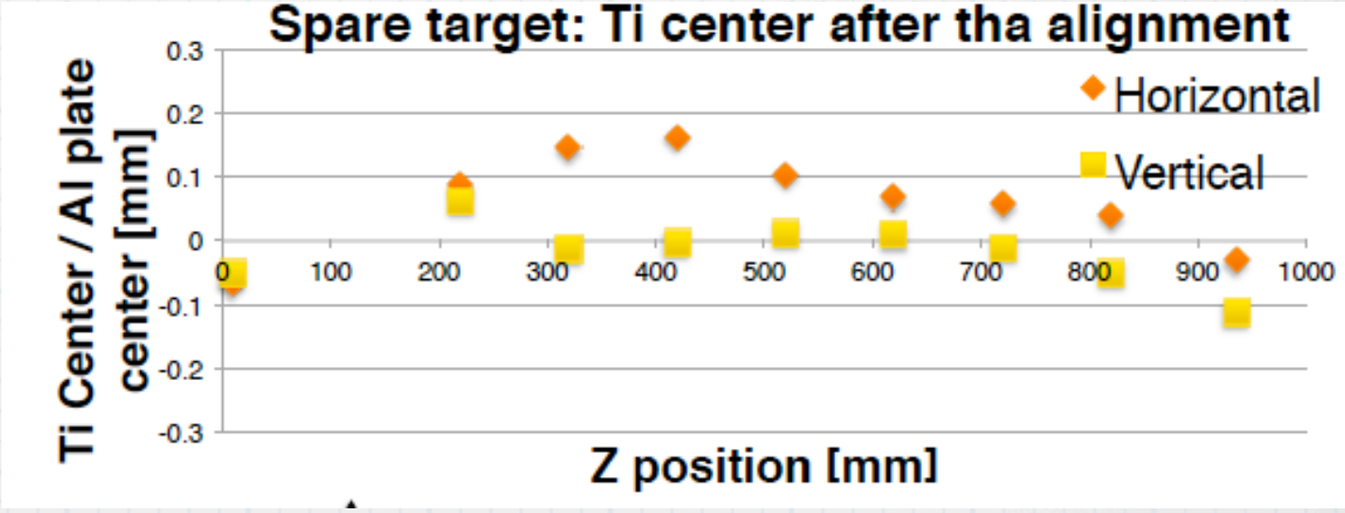
- Same design as T2K target #1
- The machining precision is improved:
  - Perpendicularity w.r.t front surface, straightness
  - By C-C bonding/purification process with alignment jigs

Center position of the target tube

T2K target No.1 H: -0.25 ~ +0.2mm
V: -0.15 ~ +0.2mm



T2K target No.2 H: -0.05 ~ +0.2mm
V: -0.15 ~ +0.1mm

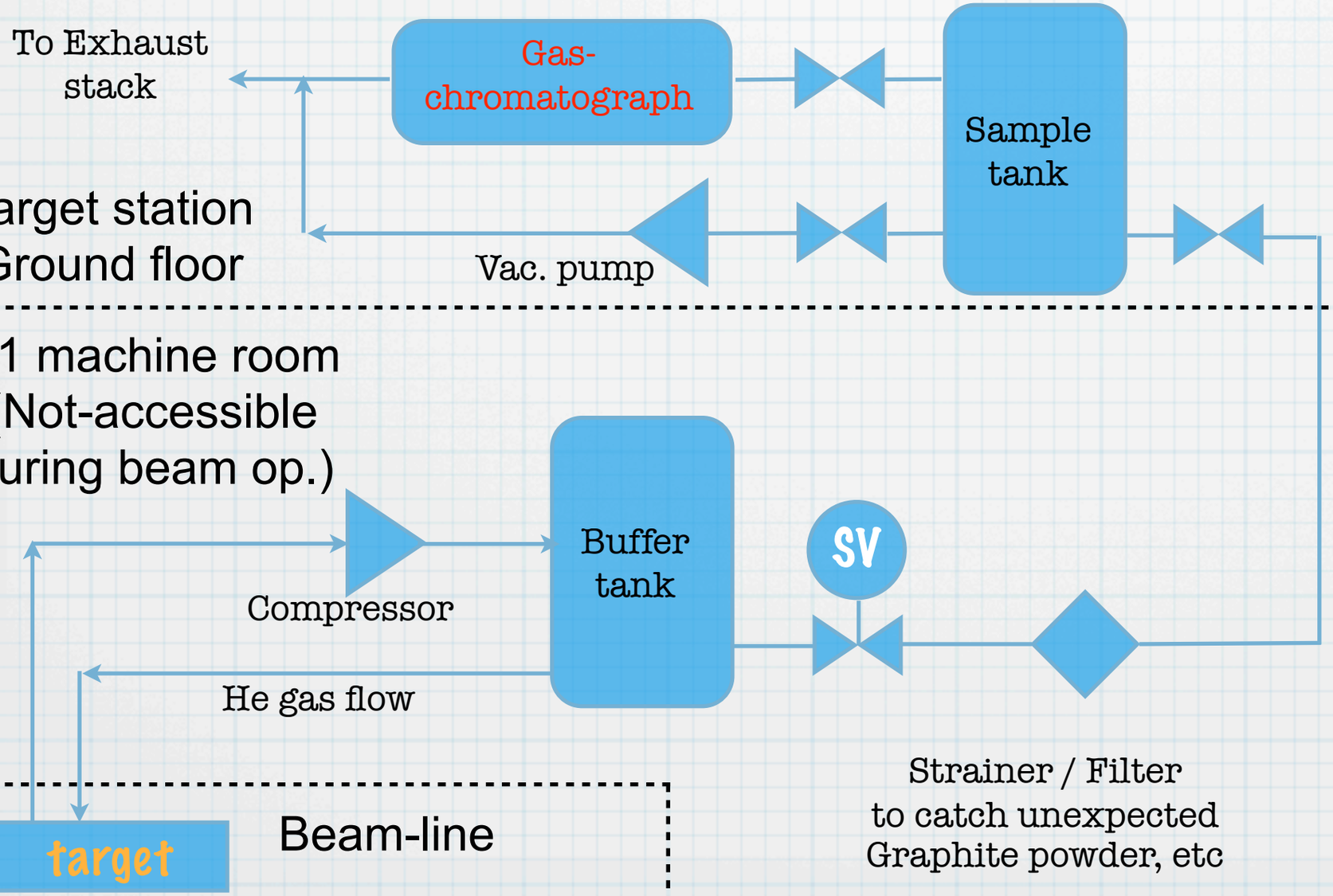


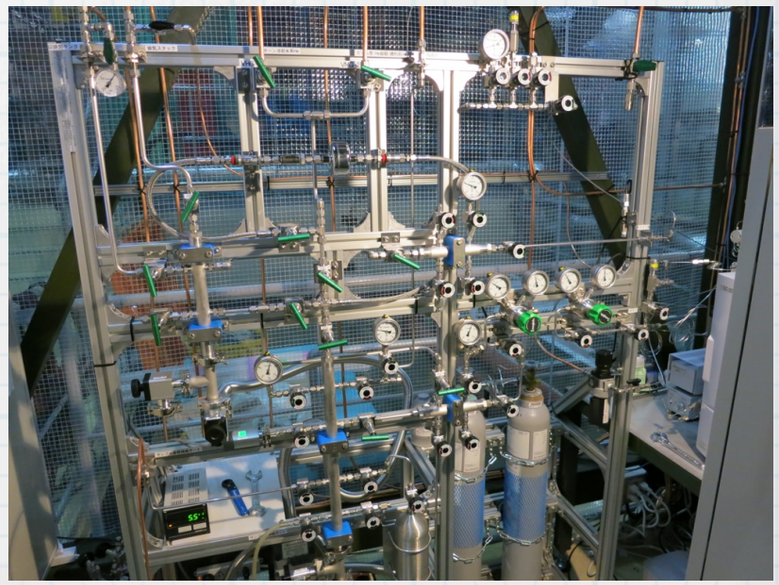
Recent works for T2K target

- O_2 monitoring
- The lifetime of graphite target w/ He cooling is limited by the oxidization.
- He purity is important.
- Oxidization speed and Tensile strength after oxidization was measured.
- $O_2 < 100$ ppm is our goal so that the T2K graphite target can survive for 5 years.

O_2 monitoring

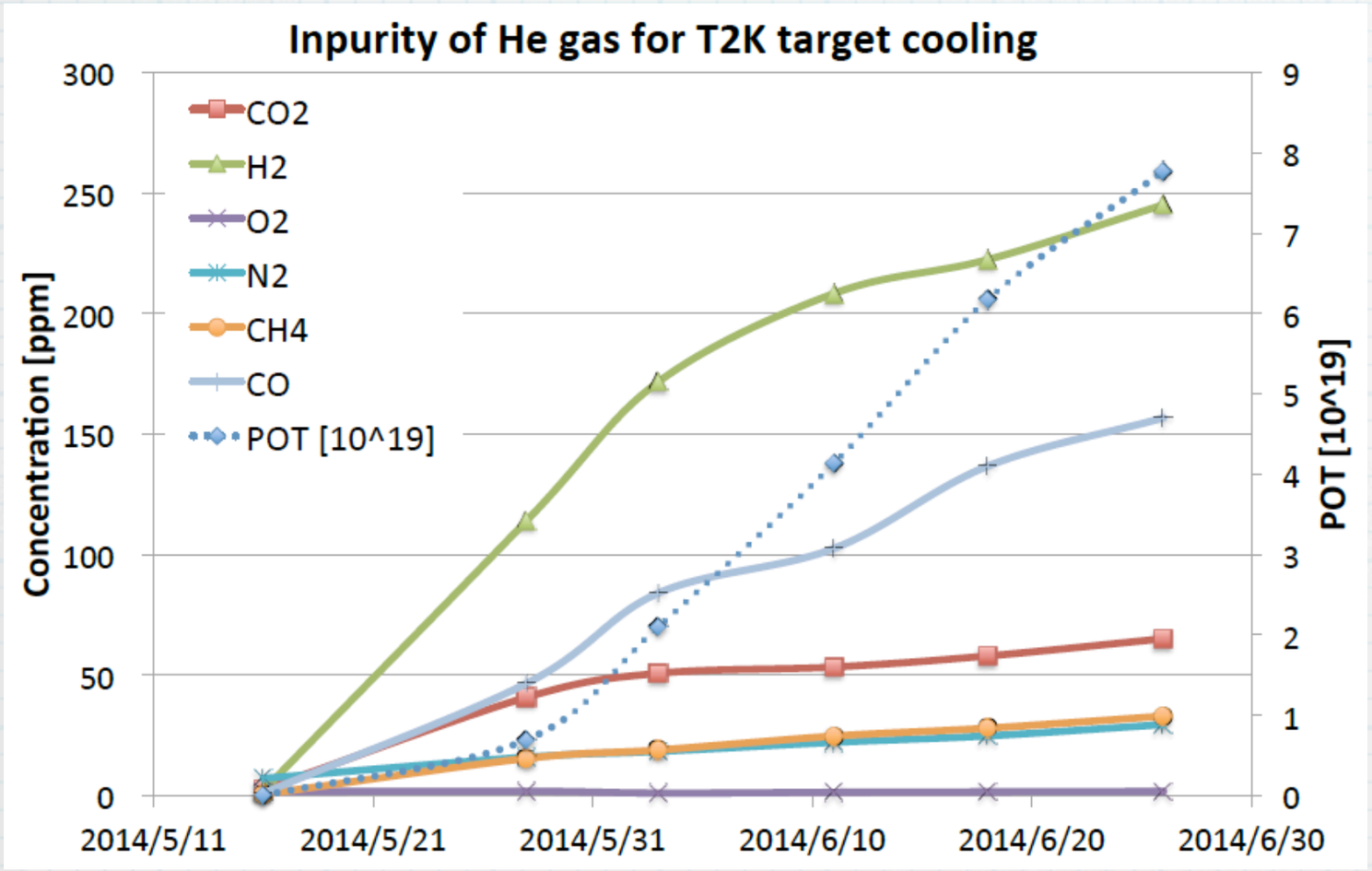
- Gas-chromatography system with the gas-sampling system w/ remote operation is constructed.
  - O_2, CO, CO_2, H_2, CH_4 can be detected: 1 ppm ~ 10000 ppm
  - Not only for target He-line, but other He-lines.





Measured He purity

- T2K Tun-5 (5/16-6/26): 7.8×10^{19} POT (include beam-tuning run.)
  - T2K target No.2 is used.
- Concentration of O_2 is kept <100 [ppm], but ....
  - Increase of CO, CO_2 is observed.

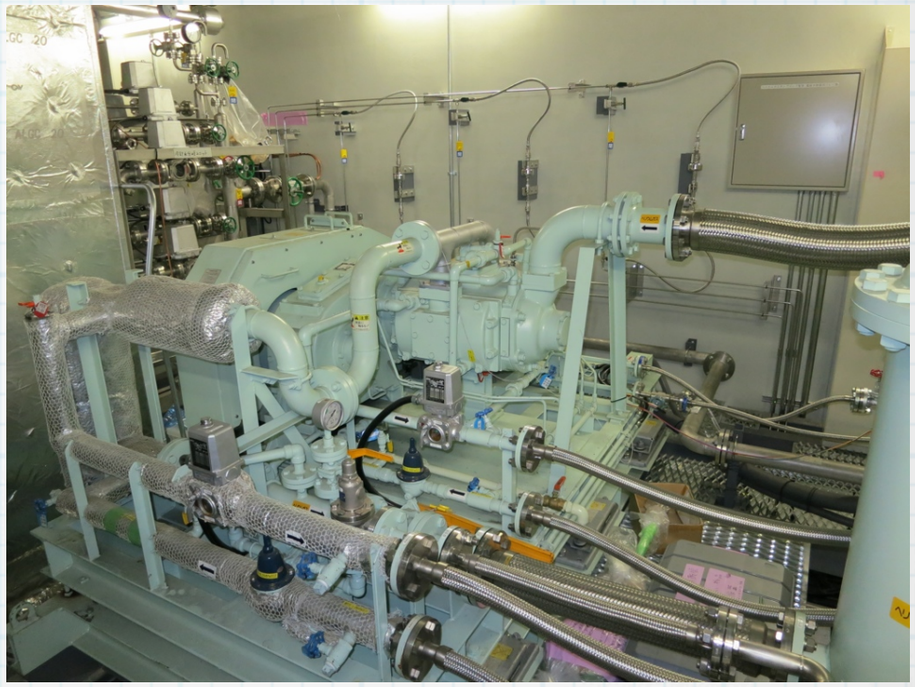


	5/16	5/26
POT	0	7.8×10^{19}
O_2 [ppm]	1.7	1.8
CO [ppm]	1.0	156.7
CO_2 [ppm]	2.6	65.1
N_2 [ppm]	7.2	29.5
H_2 [ppm]	2.0	245.1
CH_4 [ppm]	0.6	33.0

Measured He purity (Cont'd)

- Two plausible possibility of O_2 contamination.

1. Air leak at the seal of shaft of He compressor.
   - Air-leak rate that is estimated from N_2 concentration is less than CO, CO_2 production rate.
2. He includes H_2O contamination at the beginning.
   - O_2 produced due to H_2O decomposition?
     H_2O contamination is not measured yet.
     - cf. Tritium measurement result after 7.8×10^{19} POT received.
       → HTO=36.1[Bq/L], HT=8.8[Bq/L]

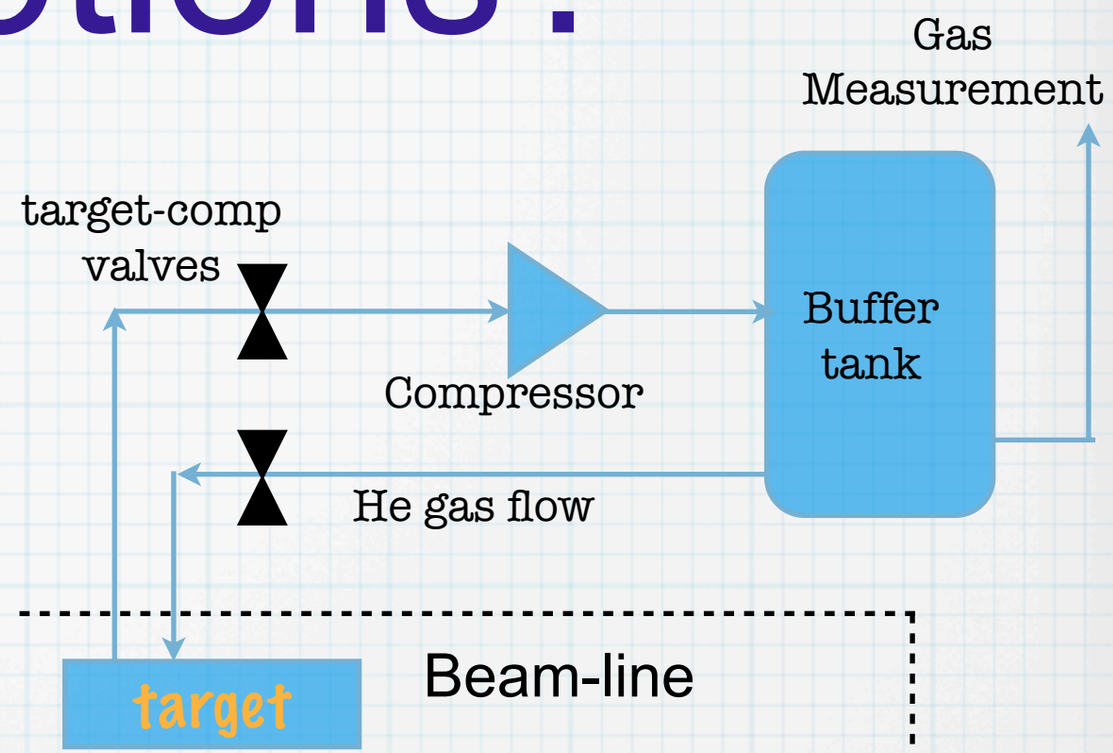


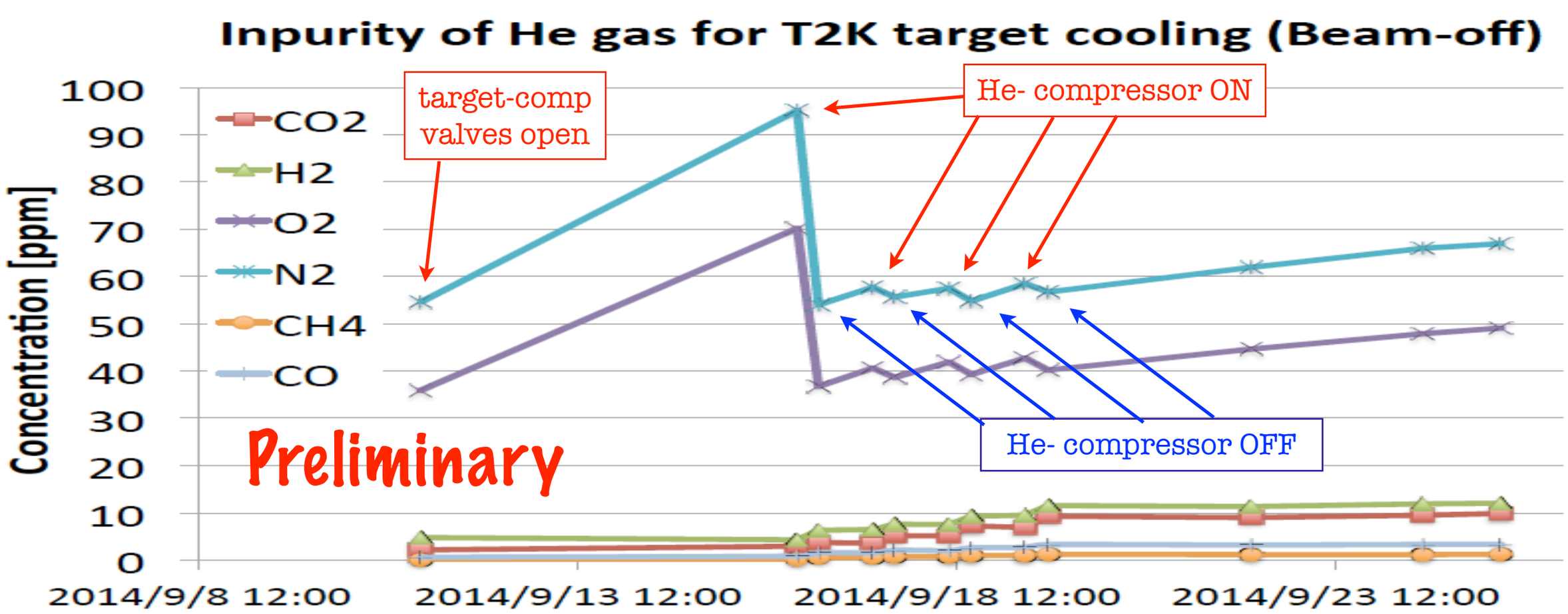
- Other possibility:
  - Some amount of O_2 is adsorbed by the target graphite?
  - Is there the source of CO, CO_2 other than target?
    ← CO, CO_2 production rate is not fully correlated with beam power (target temperature.)
    - One possibility is the oxidization of graphite parts of compressor used for lubricant.

- Countermeasures
  - Adding the filter for He compressor system: Installation work is in progress.
    - We plan to use commercial products: "Super Clean Gas-filter" by Scientific Glass Technology, Ltd.
      Filter capacity (catalog values): H_2O = 1.8 [g/unit], O2 = 500[mL], CHx = 7[g/unit]
  - Flow the He gas around the He compressor shaft.

O2 adsorptions?

- Under investigation
- Data during Beam off shows the contamination changes due to ...
  - Target graphite is exist, or not.
  - Compressor is on or off.
- If it is true, it is better to design so that the target case can be evacuated to remove the adsorbed O_2.





Summary

- Overview of T2K target is introduced.
- 1st target was used for ~6.7×10^{20} POT(Max beam power ~230kW) without no significant trouble.
- From May. 2014, 2nd target is used.
  - Same design w/ good assembly accuracy.
- O_2 monitoring system is constructed in 2013.
  - Oxidization of graphite is monitored.
  - Improvement to reduce O_2 contamination is in progress.