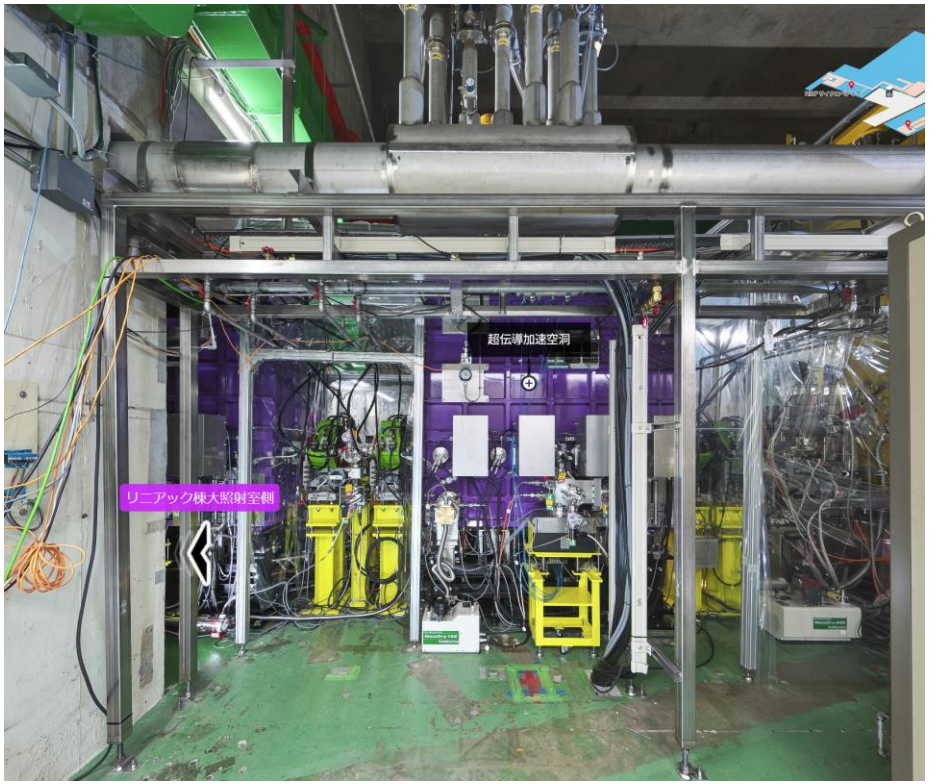
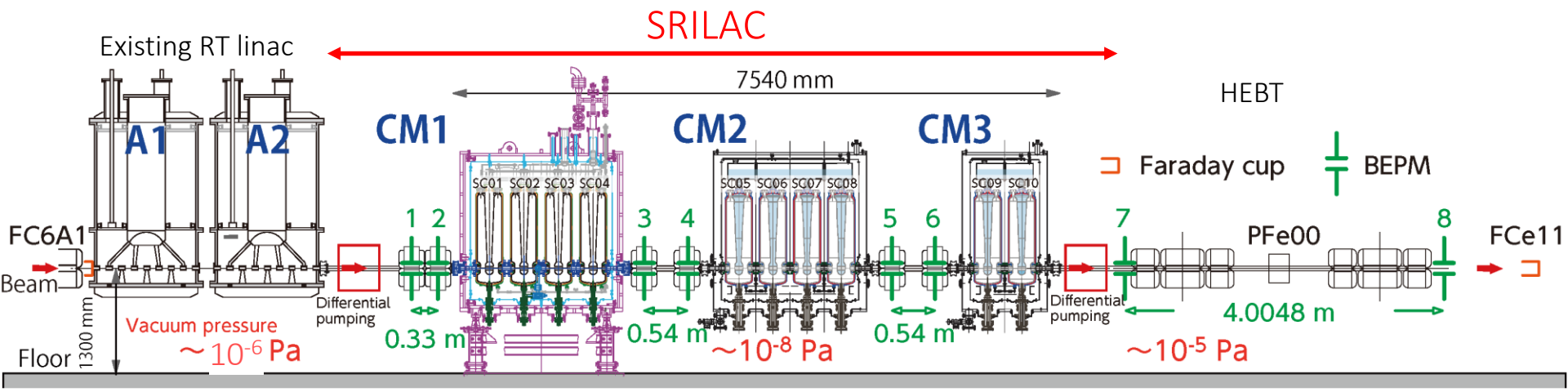
Contamination prevention measures when installing the SRILAC cryomodules to a 40-years-old dirty beam line



Kazunari Yamada, RIKEN Nishina Center

WG3, TTC2023, December 5th, 2023 @ Fermilab

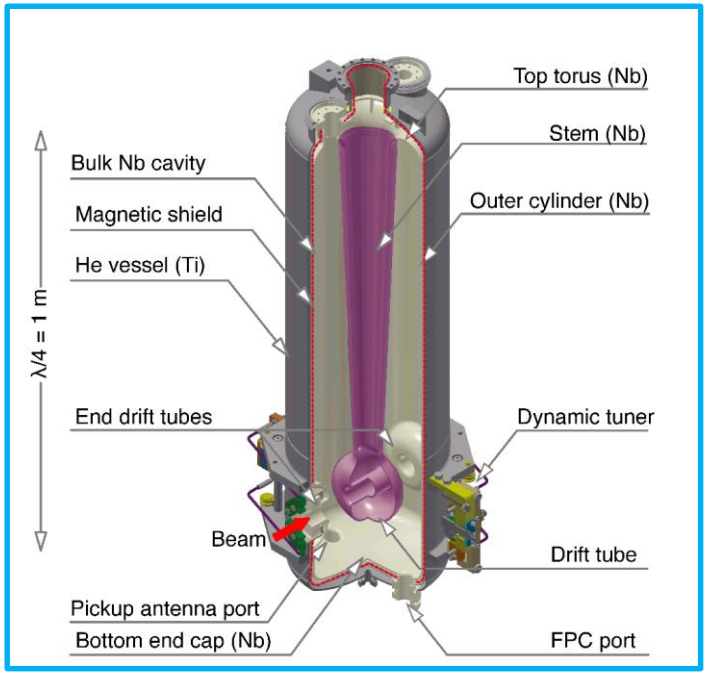
Overview of SRILAC



- CW heavy-ion linac at RIKEN Nishina Center
- 10 SC-QWRs arranged into 3 cryomodules
- 4.5 K operation
- RT Q-magnets are used as focusing elements
- Differential pumping systems
- Constructed by 2019
- First beam: Jan 28th, 2020

Design parameters of SC-QWR

Frequency [MHz]	73.0
Duty [%]	100
β_{opt}	0.078
Aperture [mm]	ϕ40
G [Ω]	22.4
R_{sh}/Q_0 [Ω]	579
Q_0	1.0×10^9
P_0 [W]	8
V_{acc} [MV] at E_{acc} = 6.75 MV/m, β = 0.078	2.16
E_{acc} [MV/m]	6.75
E_{peak}/E_{acc}	6.2
B_{peak}/E_{acc} [mT/(MV/m)]	9.6

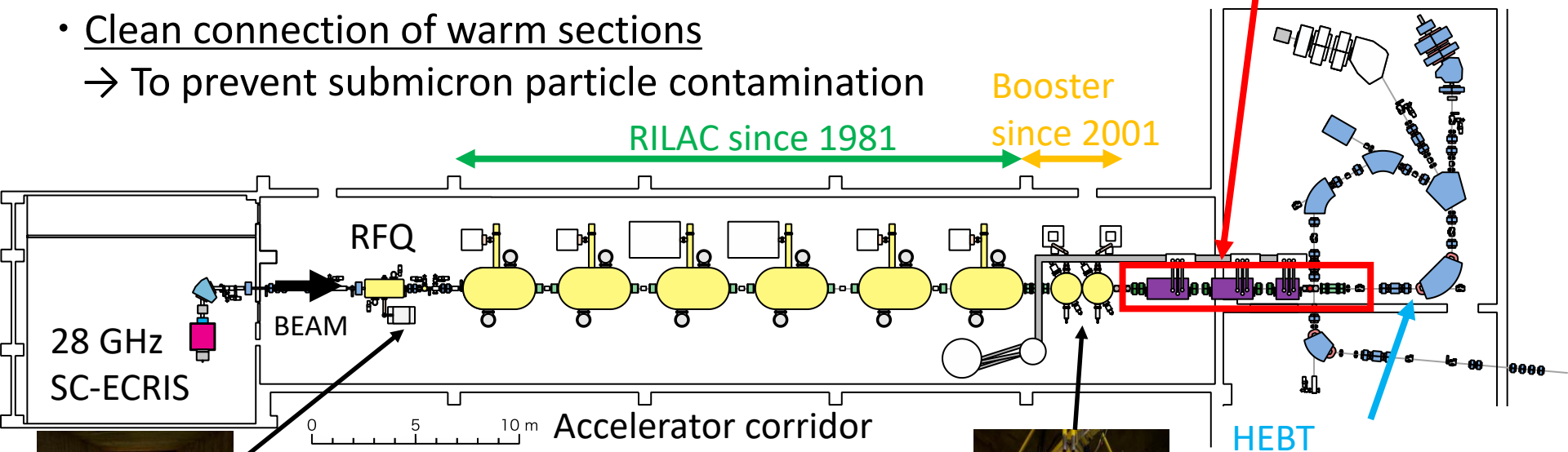


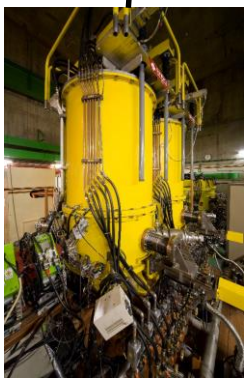
Installation of SRILAC cryomodules to existing beam line

Contamination prevention measures

- Reinforcement of vacuum pumps
- Differential pumping system
- Fast closing valves
- Cleaning of the existing beamline
  → Targeting coarse dust reduction
- Clean connection of warm sections
  → To prevent submicron particle contamination

New installation of SRILAC cryomodules & beamline in 2019





RIKEN Heavy-Ion Linac (RILAC) Facility

Cleaning of HEBT

Cleaning on site in radiation controlled area
for dipole magnets where the beam duct cannot be removed

・Inspection with fiber scope

・Alcohol wipes (Ethanol)

・Air blow – dust collector


Visible dusts are carefully
removed one by one viewing
with fiber scope


Performed by Japan environment research CO. LTD.

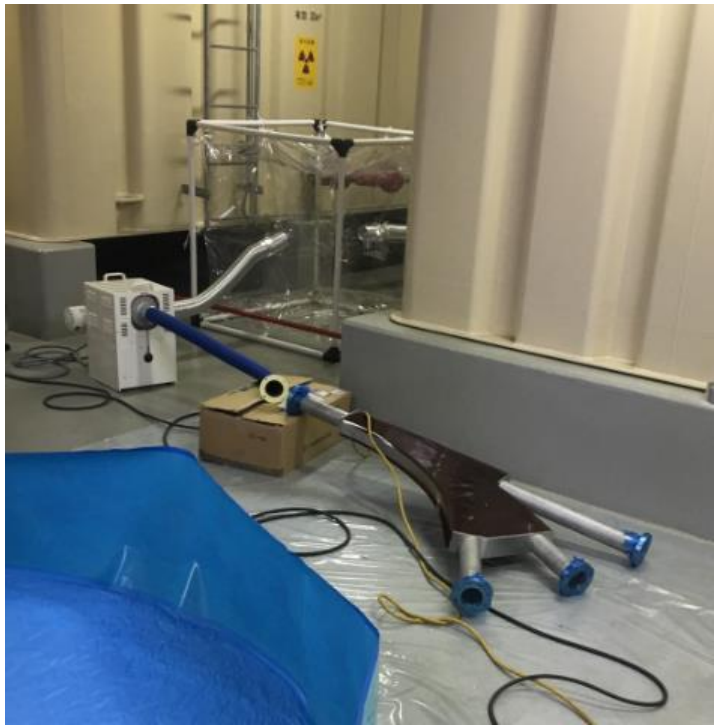
Pictures of contaminant in HEBT

Example for dipole beam duct

Cleaning of HEBT

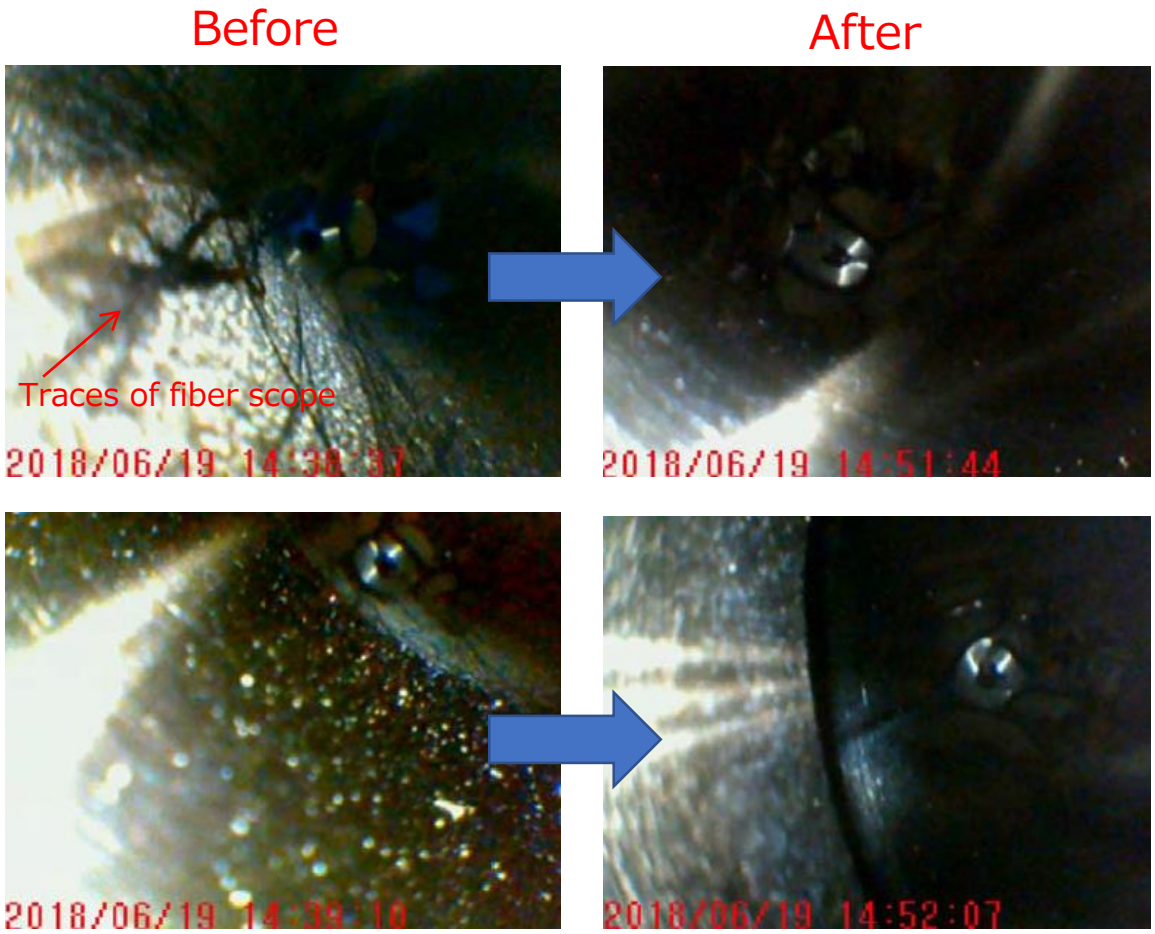
Cleaning for dipole magnets where the beam duct can be removed in other radiation controlled area at RIKEN

- High-pressure rinsing with ultra pure water
- Drying by hot air blower with HEPA filter



Pictures of contaminant in HEBT

Example for dipole beam duct

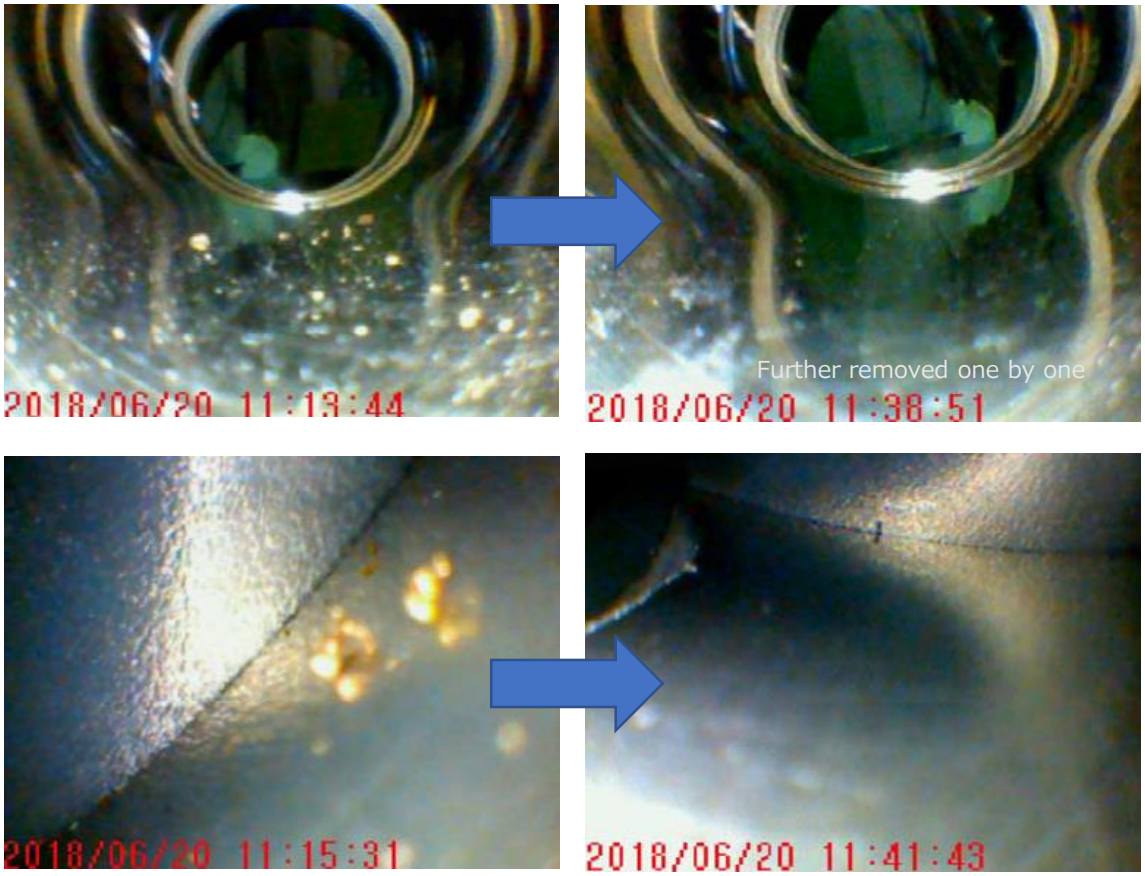


Pictures of contaminant in HEBT

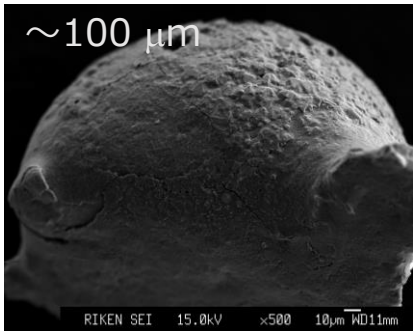
Example for diagnostic chamber

Before

After



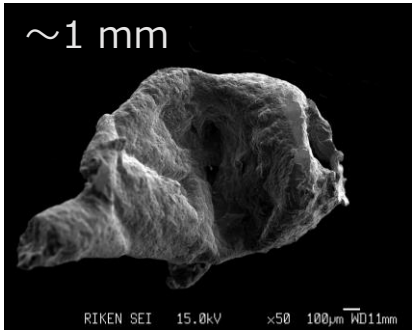
Analysis of particles by electron probe micro analyzer



Stainless steel

ZAF Metal

Element	Wt. (%)	Atom(%)
O	40.938	68.8388
Si	1.171	1.1219
Cr	19.564	10.1225
Fe	41.344	19.9168
Total	103.017	100.0000



Brass

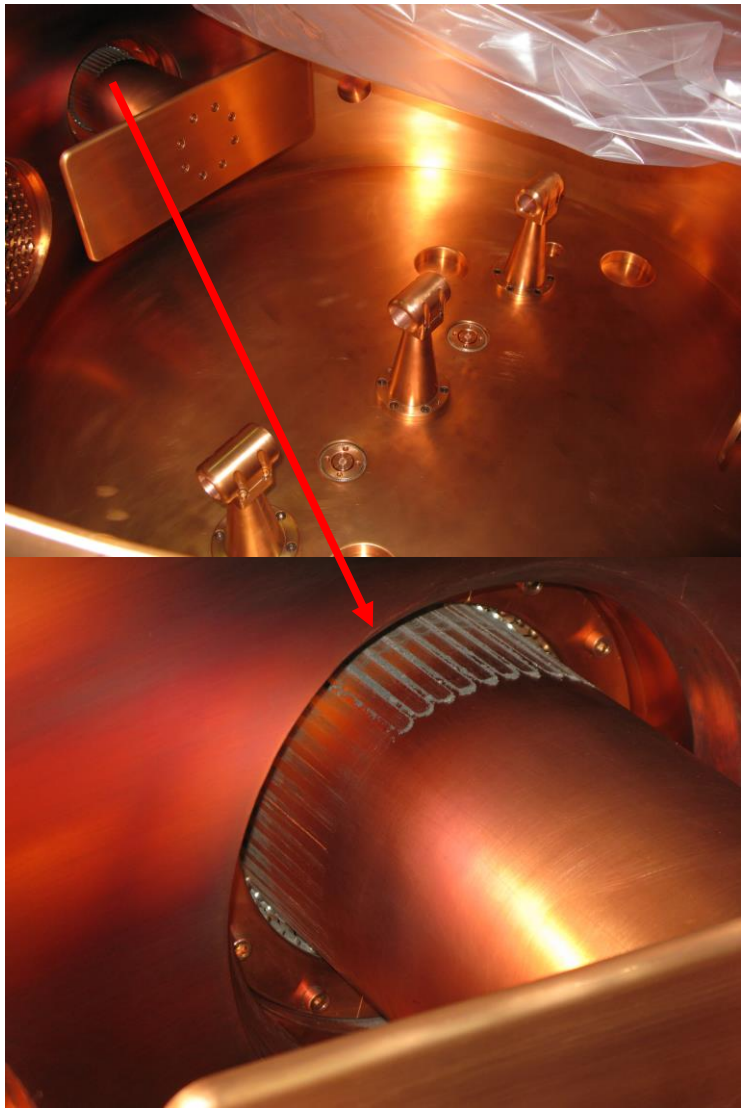
ZAF Metal

Element	Wt. (%)	Atom(%)
O	2.698	10.2162
Fe	1.919	2.0811
Cu	83.839	79.9209
Zn	8.397	7.7817
Total	96.853	100.0000

Cleaning of booster cavity

By a vacuum cleaner and alcohol wipe

Rf contact scraped shavings (copper & silver)



Occasional cleaning after start of beam operation (2021)

Connection of warm sections in situ

Following clean connections were required

- Vacuum pumping stations of cryomodules (for beam vacuum)
- Slow leak and pumping system for clean work
- Beam ducts between cryomodules
- Beam ducts between cryomodule and differential pumping stations

CF flanges and SDC clean bolts were used for each connection in warm section (Beam ducts, vacuum pumping systems)

Slow leak and pumping system
using MFC & diffuser
→ Argon gas was used for pressurization

SDC clean bolt
(316L stainless steel + plasma surface hardening)
→ Low particle generation and anti-seizing

http://www.sdc-tanaka.co.jp/html/product-clean.html

Connection of vacuum pumping systems

Enclosed each section by local clean booth with standard aluminum frames and antistatic-vinyl sheets

One side of Stand KOACH pair was used for FFU

Open clean system ``KOACH''
https://www.koken-ltd.co.jp/english/product/clean/super/

KOACH C900-F (Stand KOACH)
ISO class 1 super clean area: W900 mm × H700 mm × L1800～2300 mm
→ One side of pair: L900～1800 mm

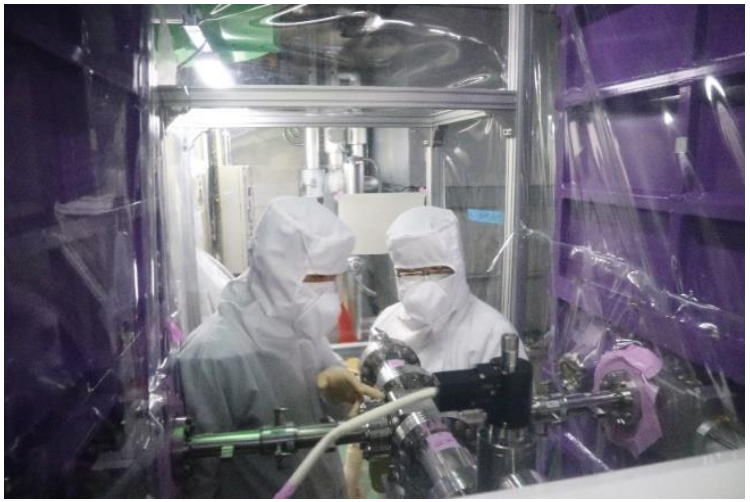
Connection of vacuum pumping assembly

Connection between differential pumping system and cryomodule

Connection of beam ducts and installation of Q magnets

Beam duct was connected before quadrupole magnets installation

Beam duct connection



Connection completed

Installation of lower half of Q-mag.

Mounting of upper half of Q-mag.

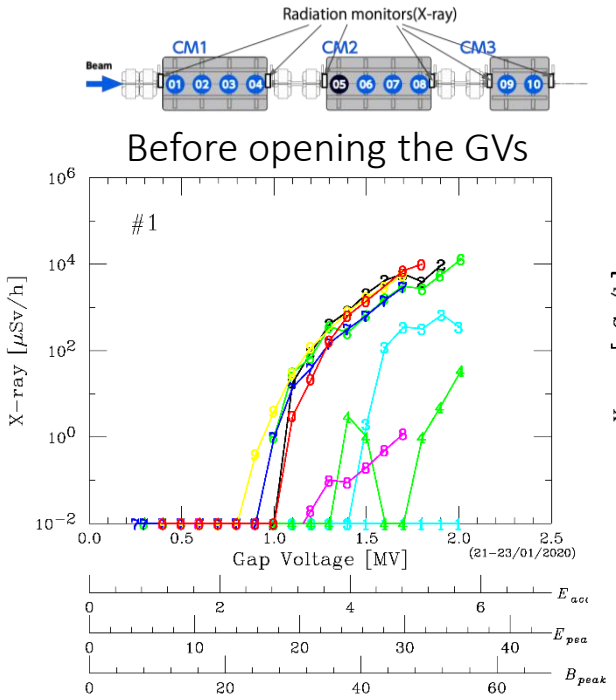
Degree of contamination

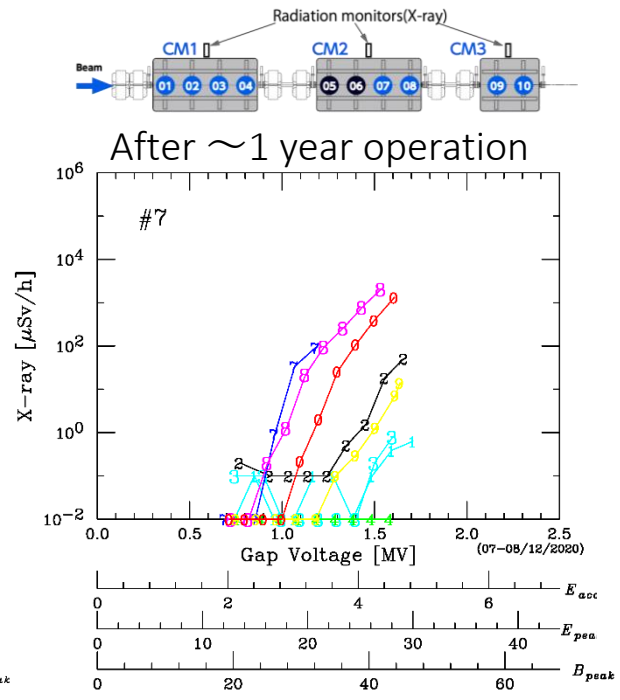
・Degradation of CM2 performance is mainly due to an impact of SC06 coupler-window-break

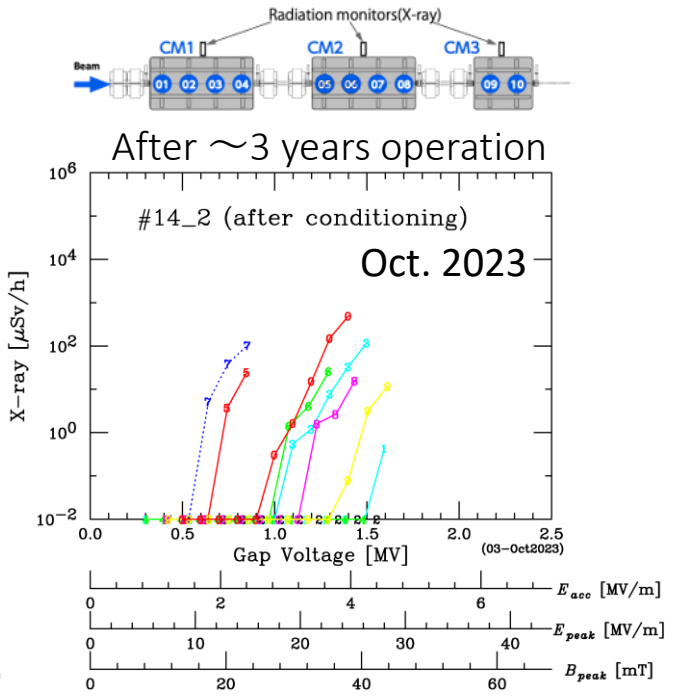
・No significant performance degradation of CM1 and CM3 was observed after the connection of warm sections

・X-ray emissions were gradually increasing in the CM1 and CM3 with operation, however, the performance degradation has been recovered by a pulse conditioning so far

・It seems to be preventing the contamination of metallic coarse particles from old beam line







Summary

Three cryomodules of the SRILAC were installed in the 40-years-old dirty beam line

Cleaning of existing beam line and clean connection using a local clean booth were performed

The contamination of coarse particles could have been prevented by cleaning the existing beam line