



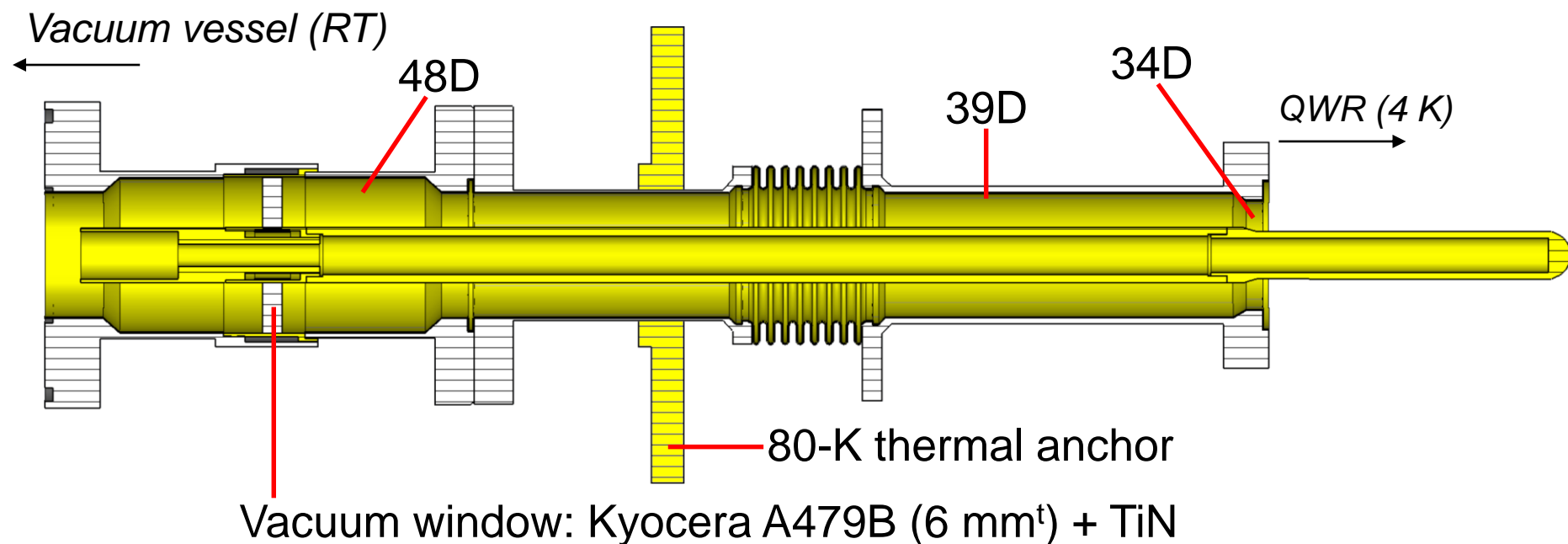
# Our experiences and troubles on FPCs for RIKEN QWR

OZEKI, Kazutaka  
RIKEN Nishina Center



# Basic specifications

- Disk-type single vacuum window
- Variable coupling
- Outer conductor: SS + 30  $\mu\text{m}^t$  Cu-plating
- Inner conductor: Cu pipe
- Connection with QWR: 34D
- Frequency: 73.0 MHz
- Assumed maximum RF power: 6 kW
- Mounted on QWR to off-center position



Delivery from manufacturer (MHI-MS)



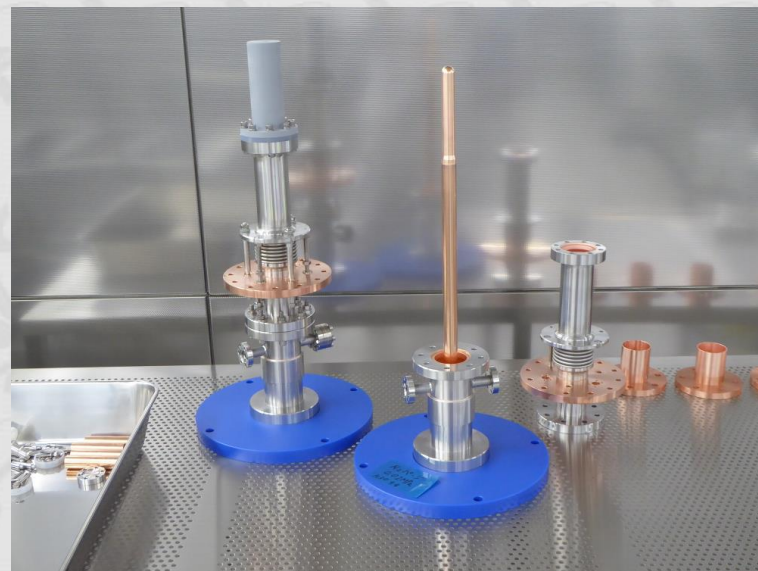
- 1) Disassembly
- 2) Ultrapure water rinsing (w/o supersonic wave)
- 3) Water removal using air-gun
- 4) Natural drying
- 5) Particle removal using ion-gun
- 6) Re-assembly
- 7) Mount of two FPCs on RF test stand
- 8) 120°C-baking of the system (1-2 day)
- 9) RF process
- 10) Dismount of FPCs from test stand



Mounted on QWR

All processes were performed in ISO-class 1 clean room.

“KOACH” system by KOKEN-LTD.  
Report in detail by K. Yamada  
Feb. 06, WG4





# RF process (1)

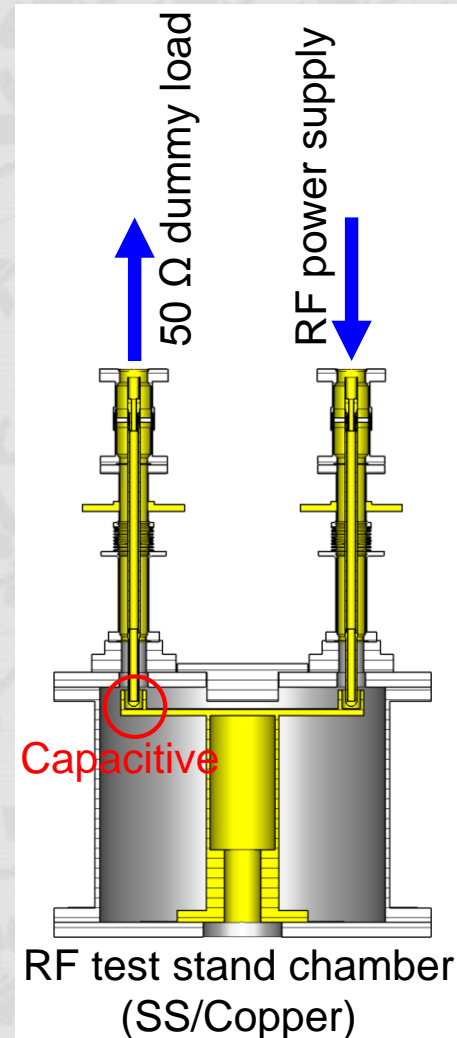
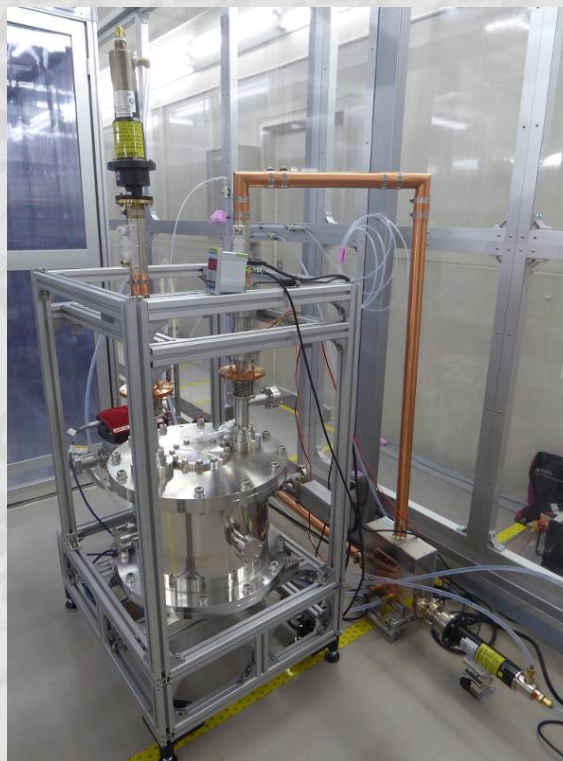
- Interlock
  - Vacuum (Vacuum gauge was mounted on test stand.)
  - Arc



View port

(Used for RF process only.  
Replaced to blank flange after RF process.)

Pickup port

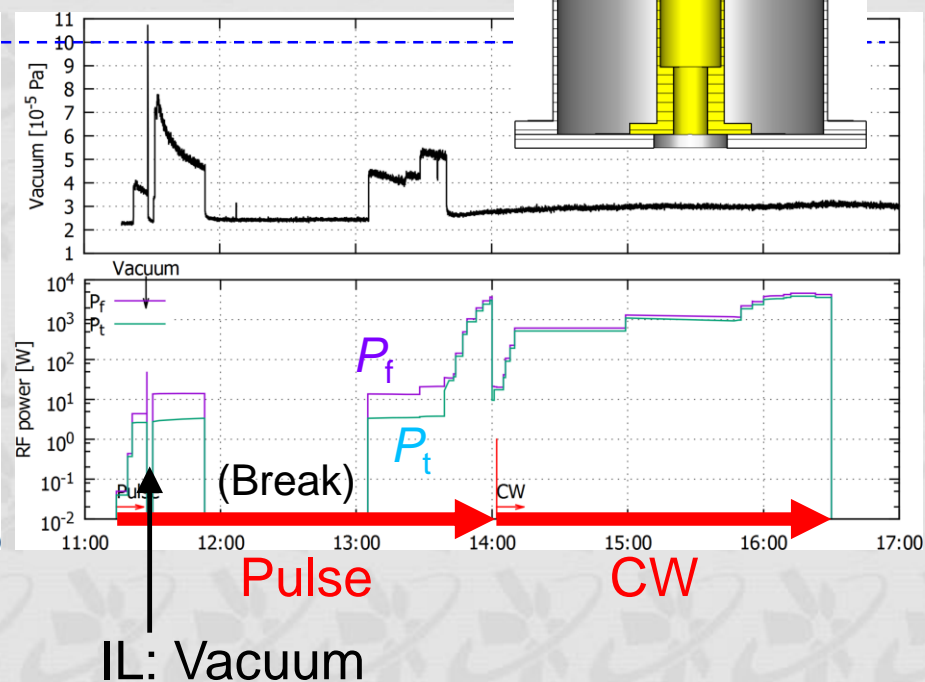
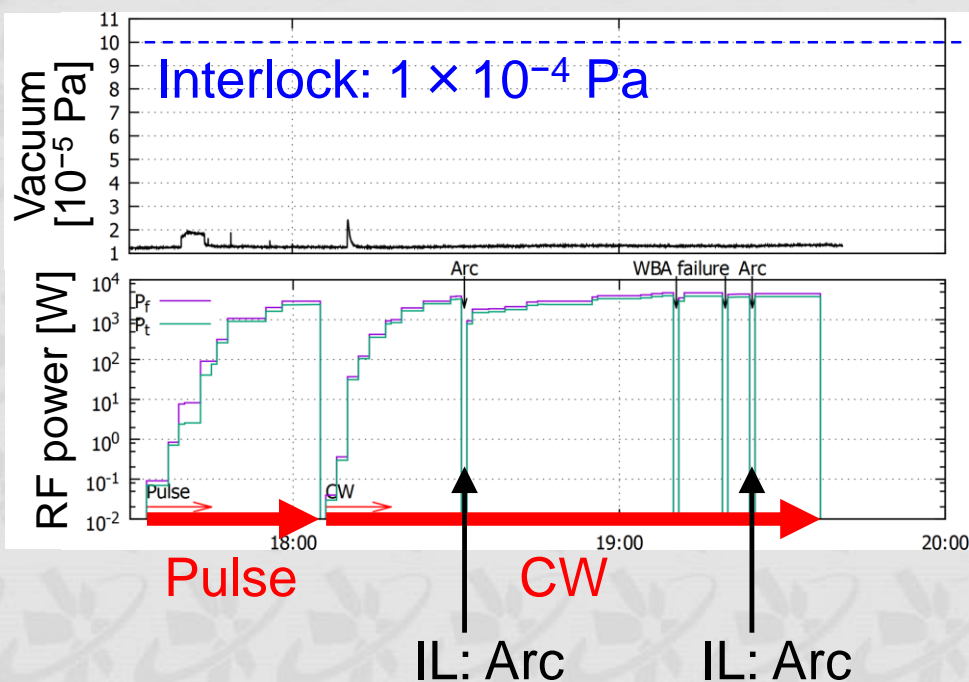
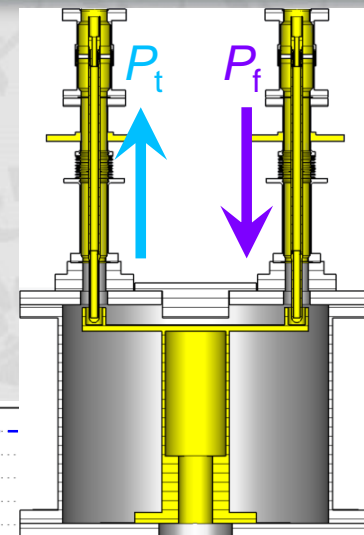


# RF process (2)

10 FPCs: 2 FPCs  $\times$  5 RF processes

Two examples of RF process logs

Pulse: Duty 50% (0.5 msec / 0.5 msec)



RF power seemed to be fed up to ~5 kW without any difficulties.

# Cryomodule

Mar. 2019: Assembly and installation  
of CMs were completed.

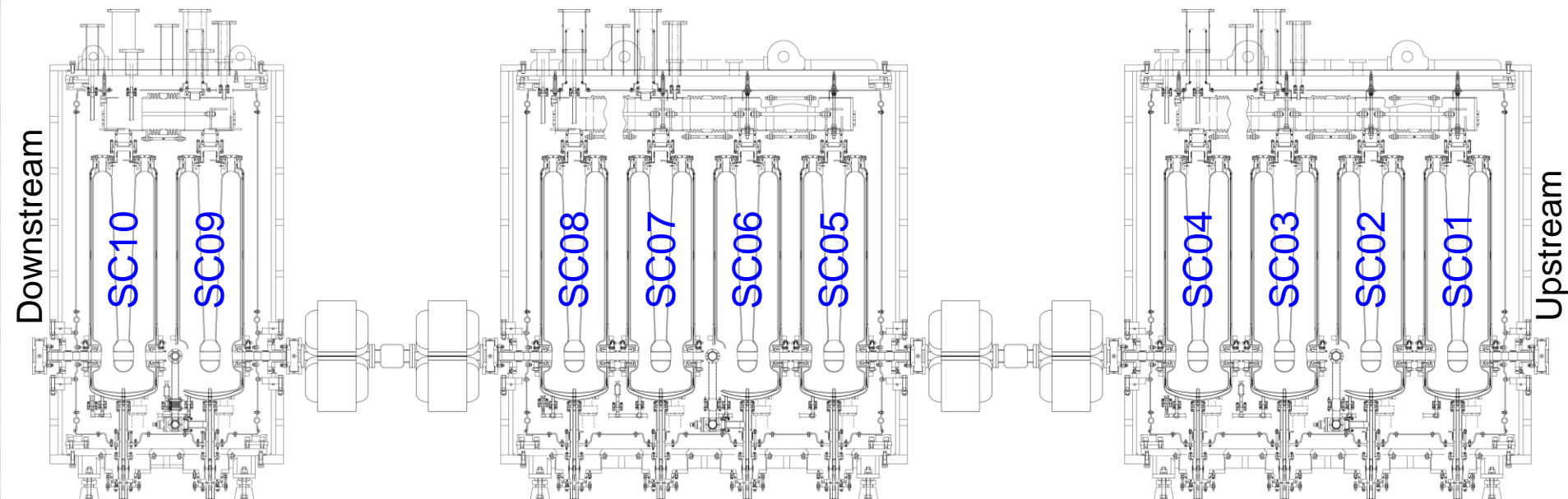
Sep. 2019: Evacuation of QWRs,  
cooling test of each CM was started.  
→ CMs were successfully cooled down.



CM#3

CM#2

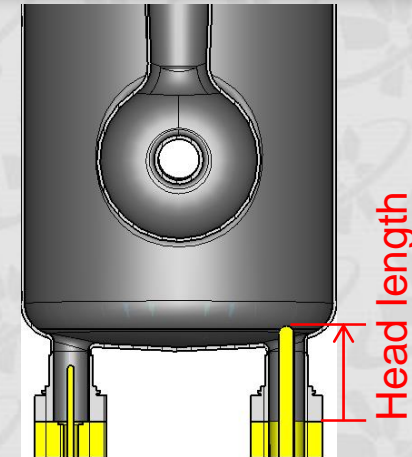
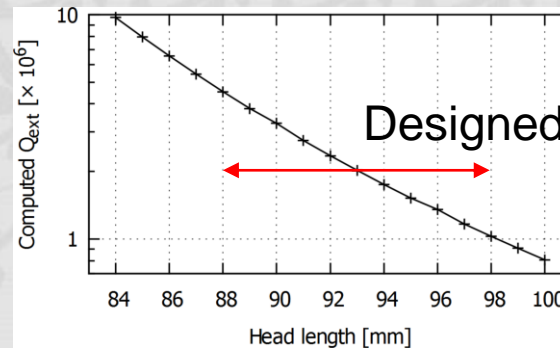
CM#1





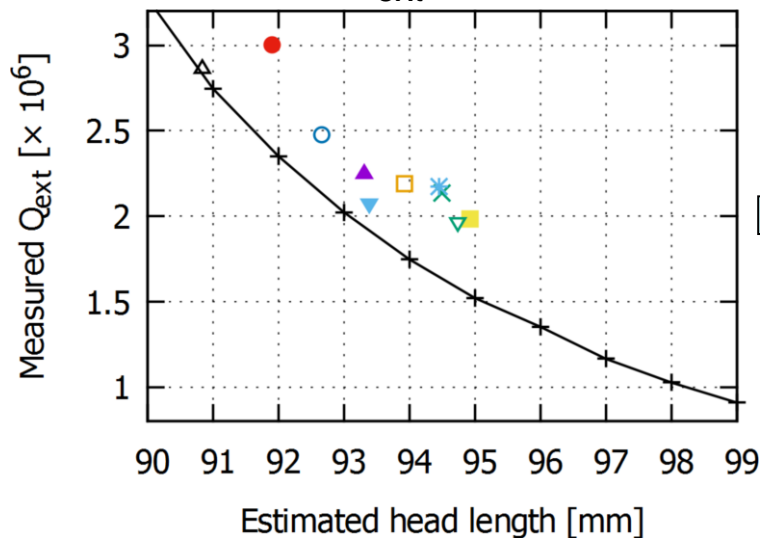
# $Q_{\text{ext}}$ adjustment

$Q_{\text{ext}}$  computed by CST MWS

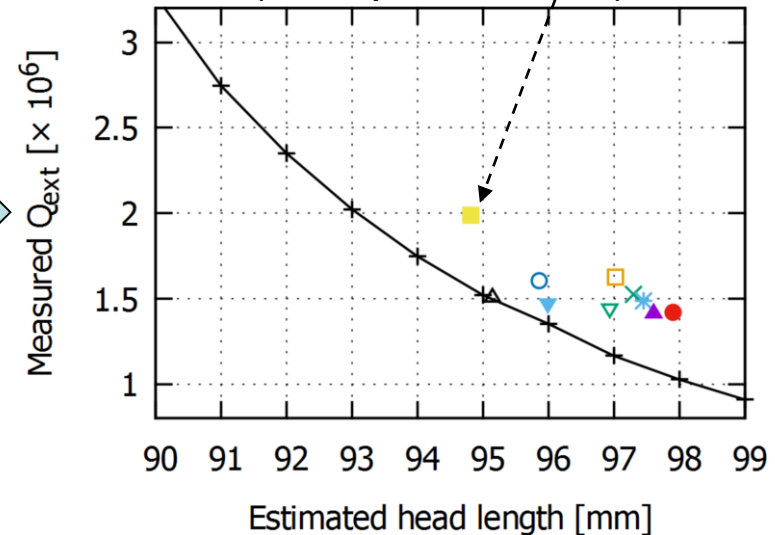


$Q_{\text{ext}}$  is adjustable while CM is cooled down.

Measured  $Q_{\text{ext}}$  @ initial setting



Adjusted to  $Q_{\text{ext}} \sim 1.5 \times 10^6$   
(Except for SC04)



- (CST) —+—
- SC01 ×
  - SC02 \*
  - SC03 □
  - SC04 ■
  - SC05 ○
  - SC06 ●
  - SC07 △
  - SC08 ▲
  - SC09 ▽
  - SC10 ▼

# Trouble: Vacuum leakage (1)

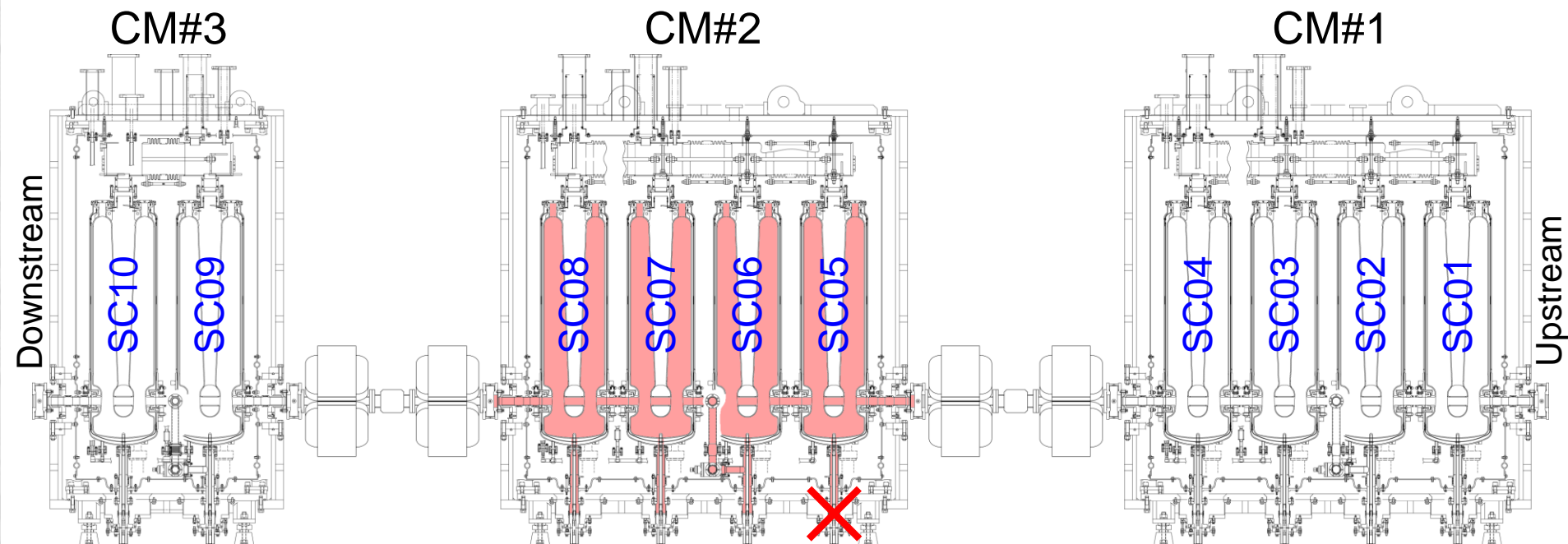
Nov. 2019 (After 2 months of evacuation)

Vacuum leakage

@ vacuum window of FPC mounted on SC05.

$\sim 10^{-7}$  Pa  $\rightarrow$   $\sim 10^0$  Pa

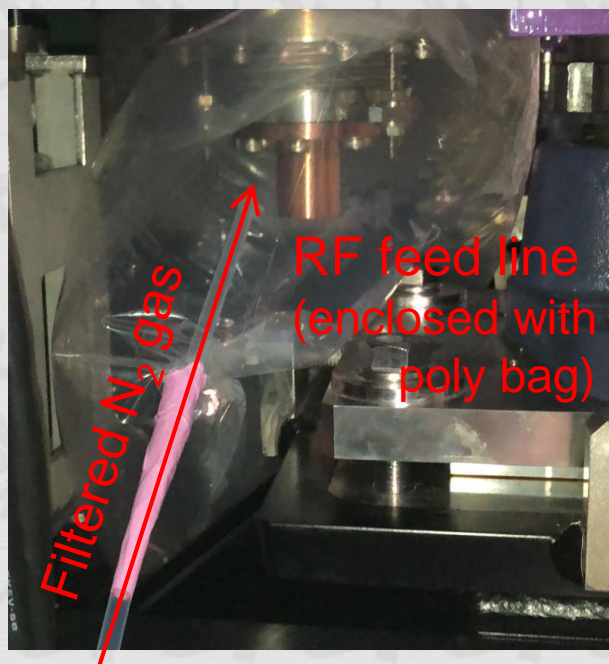
- During warm-up process after cooling test.



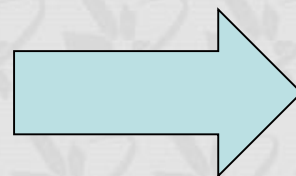


## Trouble: Vacuum leakage (2)

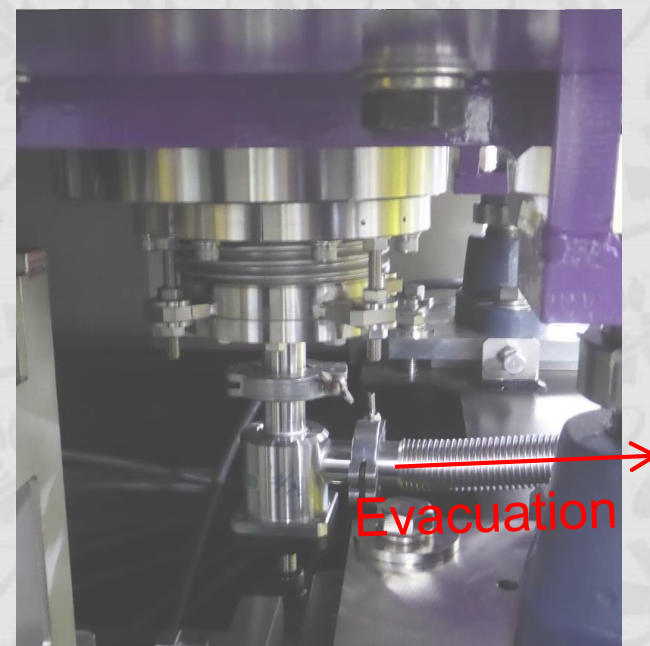
First aid to prevent  
air leak in.



Preparation of  
evacuation  
flange



Evacuation from air-side  
of the vacuum window.



Cavity vacuum has restored to  
almost same level as CM#1 &3.

Cavity vacuum (@ 4 K)

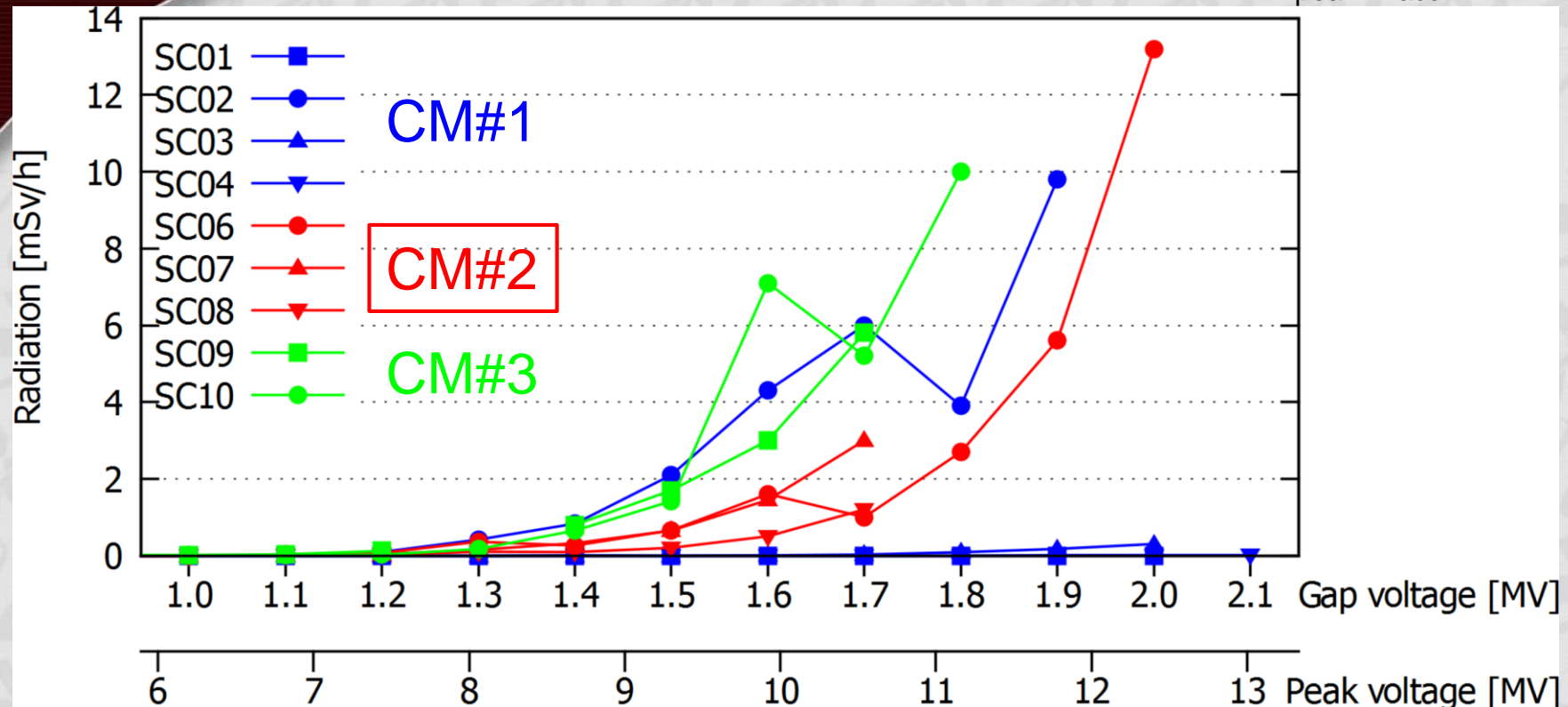
CM#1:  $2.5 \times 10^{-8}$  Pa

**CM#2:  $4.0 \times 10^{-8}$  Pa**

CM#3:  $2.4 \times 10^{-8}$  Pa

# Effects on other QWRs in CM#2

$$E_{\text{peak}}/E_{\text{acc}} = 6.2$$





# Summary

- 10 FPCs were produced for RIKEN QWRs.
- Processes for FPCs seemed to have completed without any troubles.

## ————— After assembly and installation of CMs —————

- $Q_{\text{ext}}$  was adjusted to  $\sim 1.5 \times 10^6$ .
- Leakage from vacuum window of one of the FPCs.
  - First aid to prevent air leak in.
  - Evacuation from air-side of the vacuum window.
- Not so serious effects on other QWRs in same CM.
  - Contaminants were trapped in cryogenic FPC itself and connected QWR?

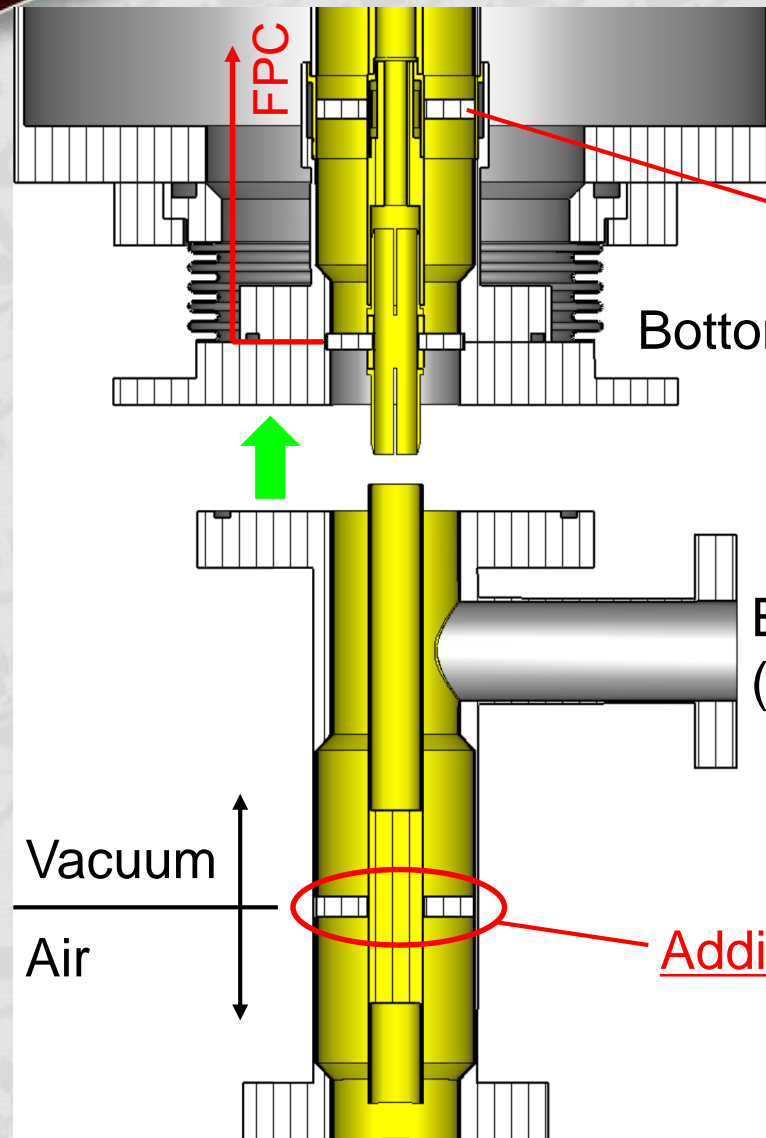
Beam energy required for experiments is achievable with 9 QWRs.  
Preparations for commissioning were proceeded.



On Jan. 28<sup>th</sup>, First beam was successfully accelerated using 9 QWRs.

Cause of FPC failure is unknown for now.

# We beg your advice: How can we recover SC05?



For instance,  
Additional vacuum window?  
(rough sketch)

Original vacuum window

Bottom part of CM

Evacuation port  
(ICF)

Vacuum

Air

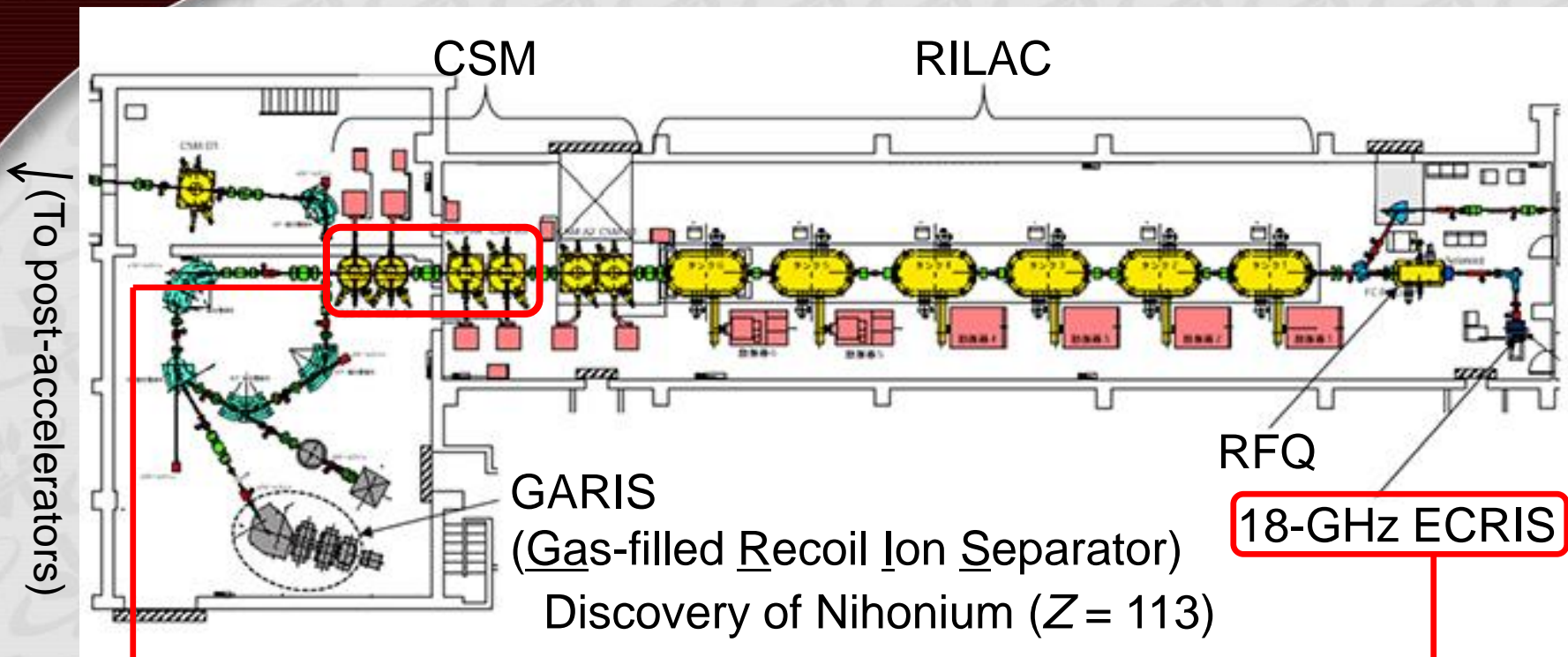
Additional vacuum window





# Background

## Overview of RILAC (RIKEN Heavy Ion Linear Accelerator)



Discovery of  $Z \geq 119$   
 Synthesis of RI medicines ( $^{211}\text{At}$ ) } Upgrade of RILAC

Replaced to 10 SC-QWRs.  
 (SRILAC, Superconducting RILAC)

Replaced to 28-GHz SC-ECRIS.

# Layout of CMs

