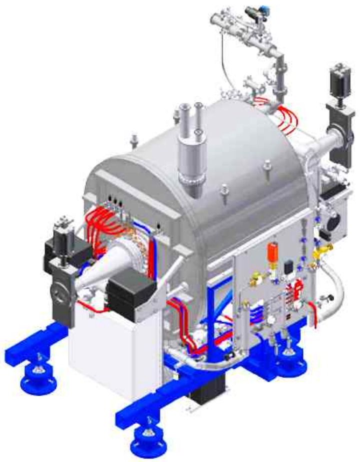
TTC2022 Aomori, TESLA Technology Collaboration

Machine Availability and Reliability of PLS-II at PAL

Younguk Sohn
Pohang Accelerator Lab., POSTECH



Oct 11-14, 2022

Abstract

3 SRF cryomodules have been operated since September, 2012 for the Pohang Light Source (PLS-II). They are the CESR-B type which were fabricated by the industry with the turn-key contract. For the less faults, the operation Vacc and RF power are about 60-70% of their specifications. There have been no severe problem in the coupler/window and cavity itself. But recently two vacuum leak events between cavity and He vessel were found, after 7.6 years' and 7 years' operation. Also at the beginning several years, we were suffered from the turbine troubles of He refrigerators.

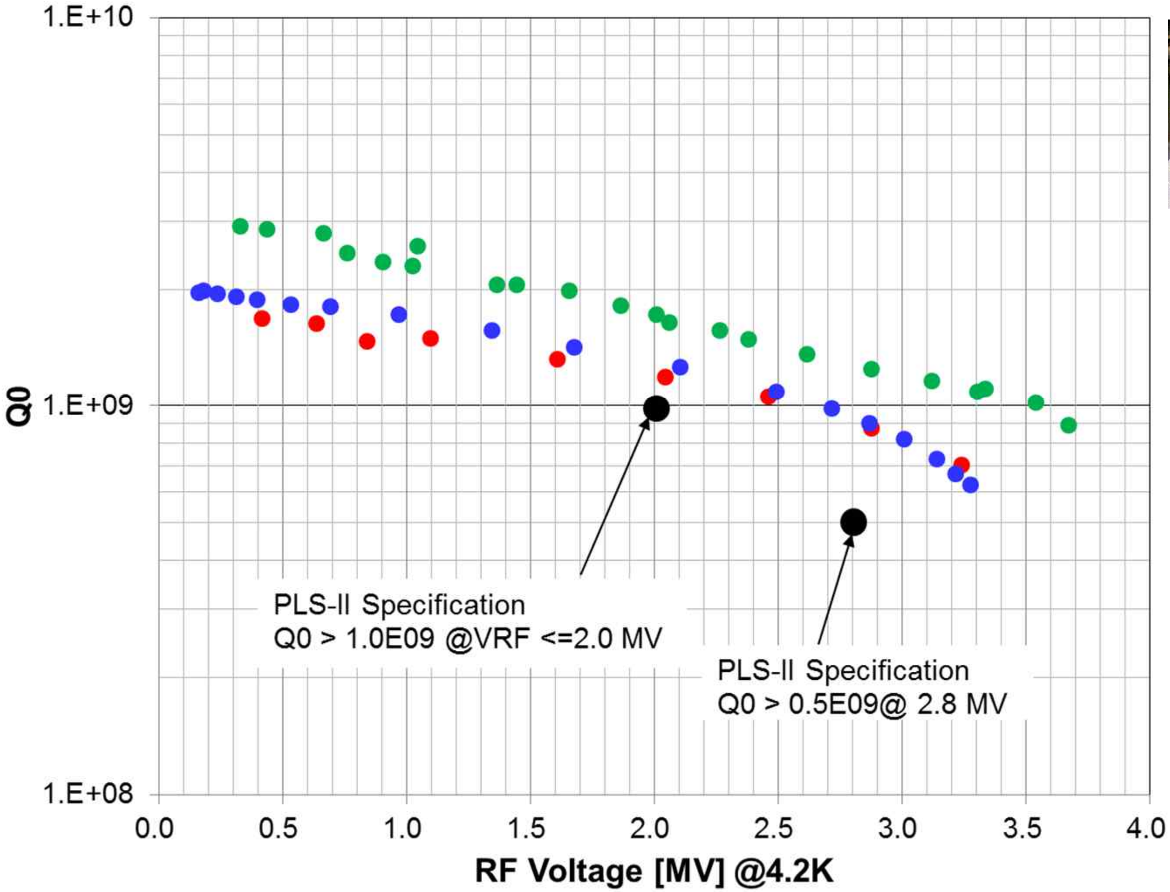
The fault statistics and analysis of SRF system at PLS-II are reported in the presentation

Parameters of PLS-II RF System

Parameters	Value
Energy [GeV]	3
Current [mA]	400
Emittance [nm-rad]	5.9
Beam loss power by synchrotron radiation [kW]	500
RF frequency [MHz]	499.973
No. of RF cavities	3
Accelerating voltage, Vacc [MV]	4.5
Vacc / cavity, [MV]	1.5
Klystron amplifier	3- 300 kW amp.
Cryogenic cooling capacity @4.5 K [W]	700

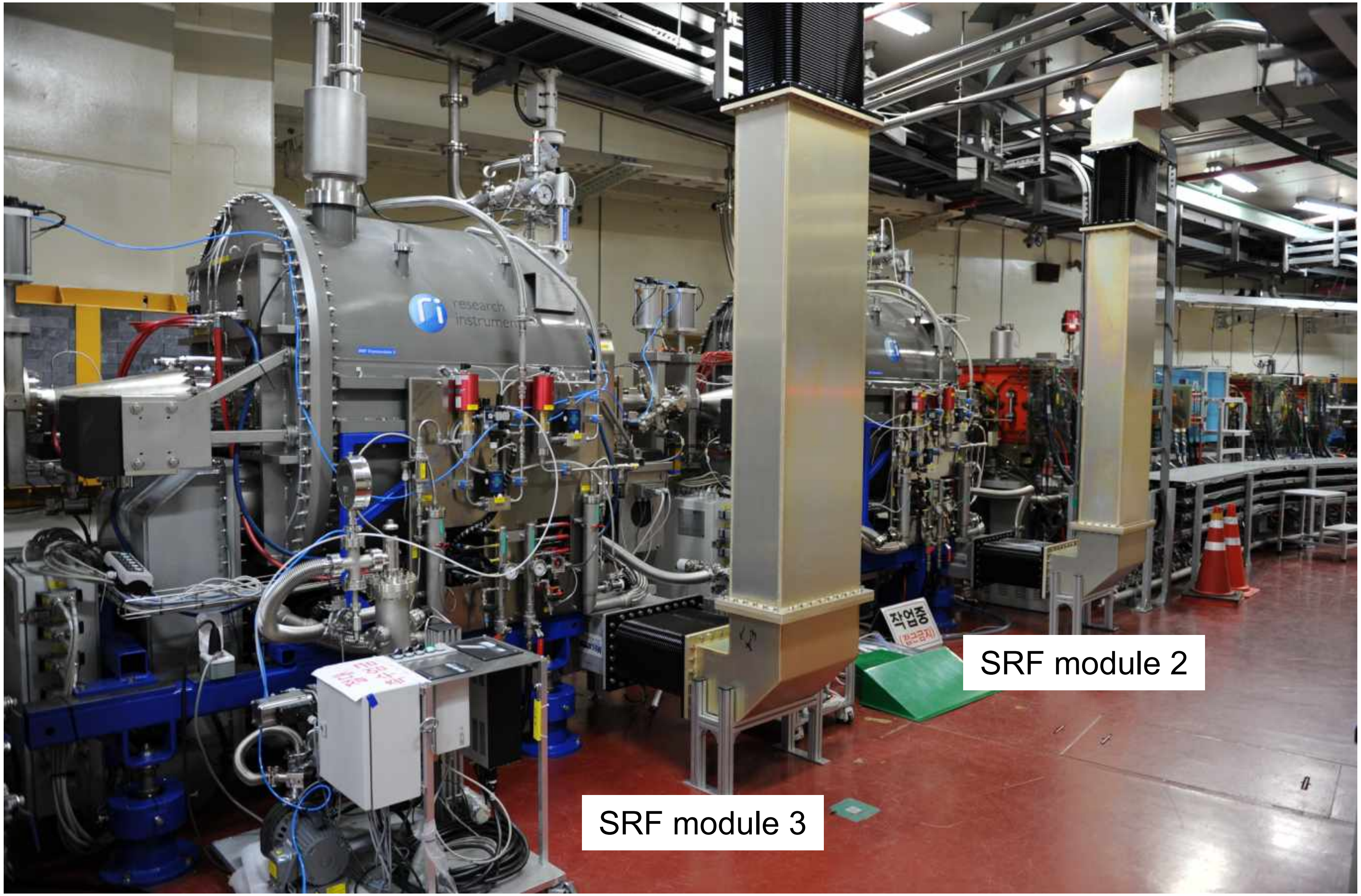
Accelerating Voltages @ Bare Cavity

(CESR-B cavities, operation voltage: 1.4 MV (4.7 MV/m)



2.0 MV = 6.7 MV/m
2.8 MV = 9.3 MV/m
1.4 MV = 4.7 MV/m

SRF Modules @Tunnel



Operation Parameters

- RF voltage, per unit: 1.4 MV (4.7 MV/m)
- Forward power through window (coupler), per unit: 140 ~ 190 kW CW
- Reflected power, per unit: < ~2 kW
- Vacuum pressure at window and cavity: ~ middle 10^{-10} mbar

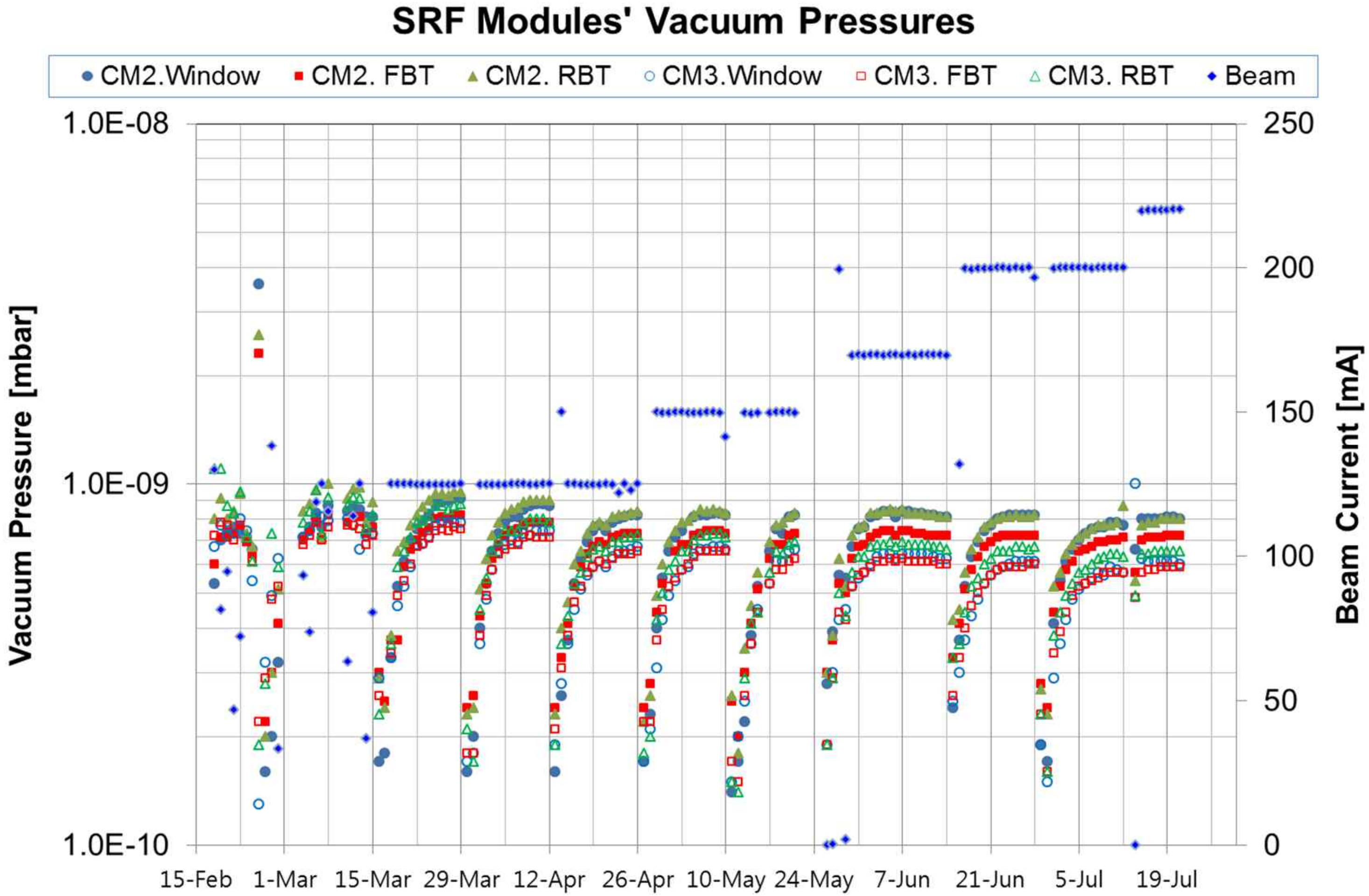
Operation Carrier of Each Module

	Year	Y-2012		Y-2013		Y-2014		Y2015		Y2016		Y-2017		Y2018		Y2019		Y-2020		Y2021		Y2022	
Status		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
CM1	Installation & commissioning																						
	Operation							8 years and 7 months															
	Out of service																						
CM2	Installation & commissioning																						
	Operation			9 years and 9 months																			
	Out of service																						
CM3	Installation & commissioning																						
	Operation		7 years																				
	Out of service																2 years & 4 months						

Vacuum leakage He vessel
to cavity during cooldown

- Warmed up to room temperature every years for maintenance of refrigerator
- For some years, un-planed warmed up by many reasons such as site blackouts, cryogenic problems, site utility maintenances, …
- Partial warmed up to 40K at beginning of each user-service term for vacuum improvement during the first 6 months operation after installation
- Regular partial warmup for every 5 user-services

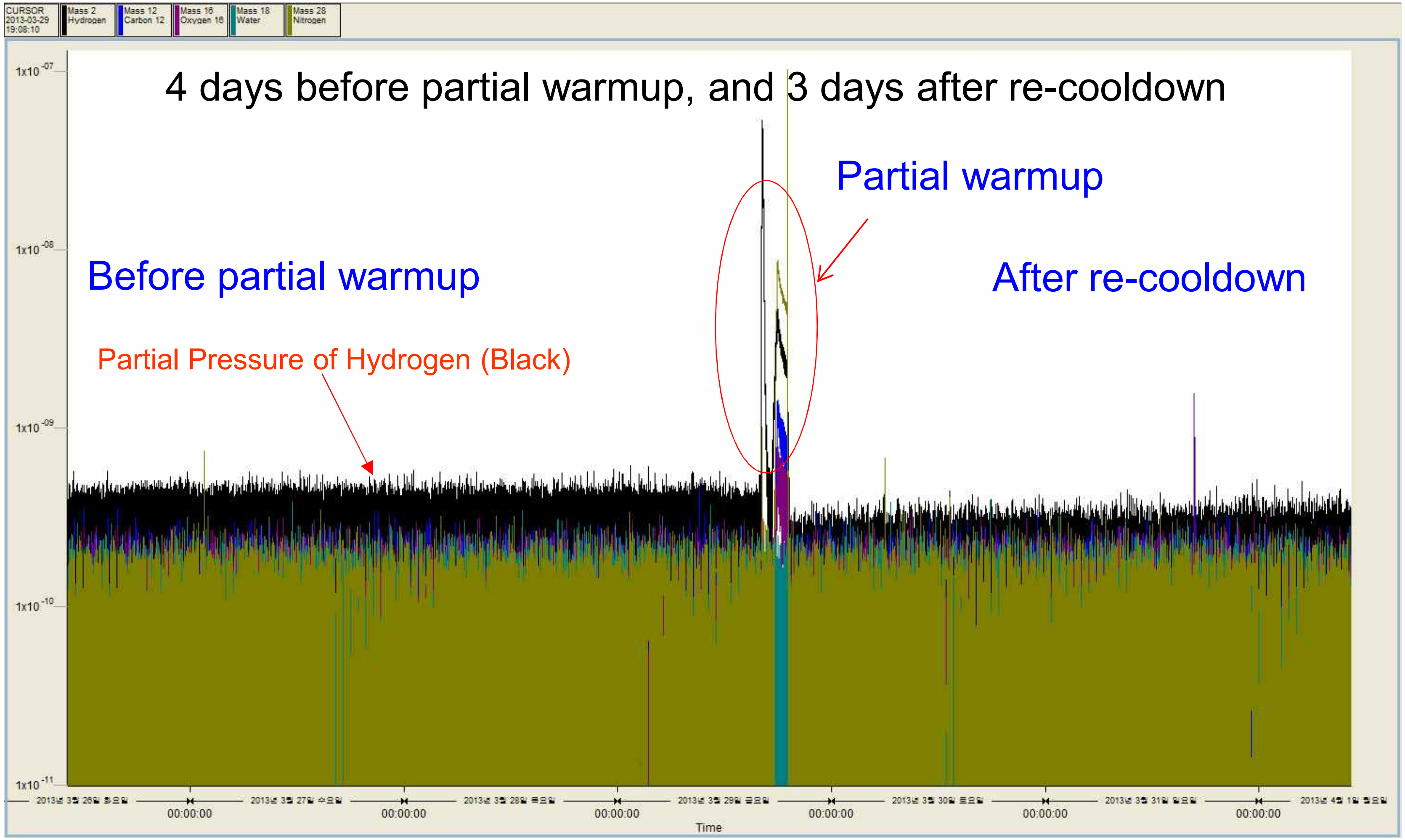
History of Partial Warmup (Feb.-Jul, 2013)



- Partial warming-up cavity up to 40K
- Threshold pressure vacuum bursts >1 x 10^9 mbar

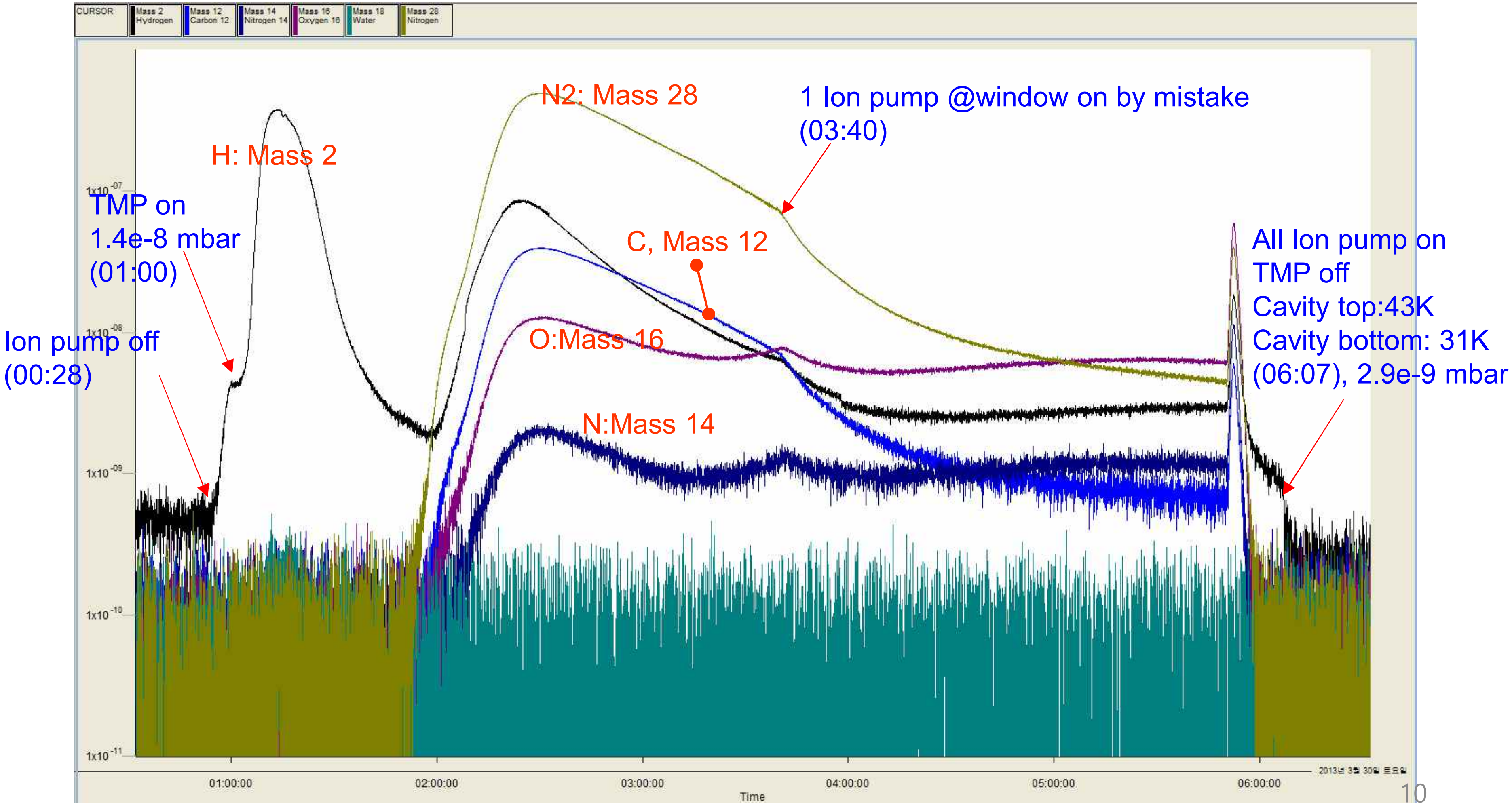
Partial Warmup & Cooldown

Mass-Spectrometer (RGA)



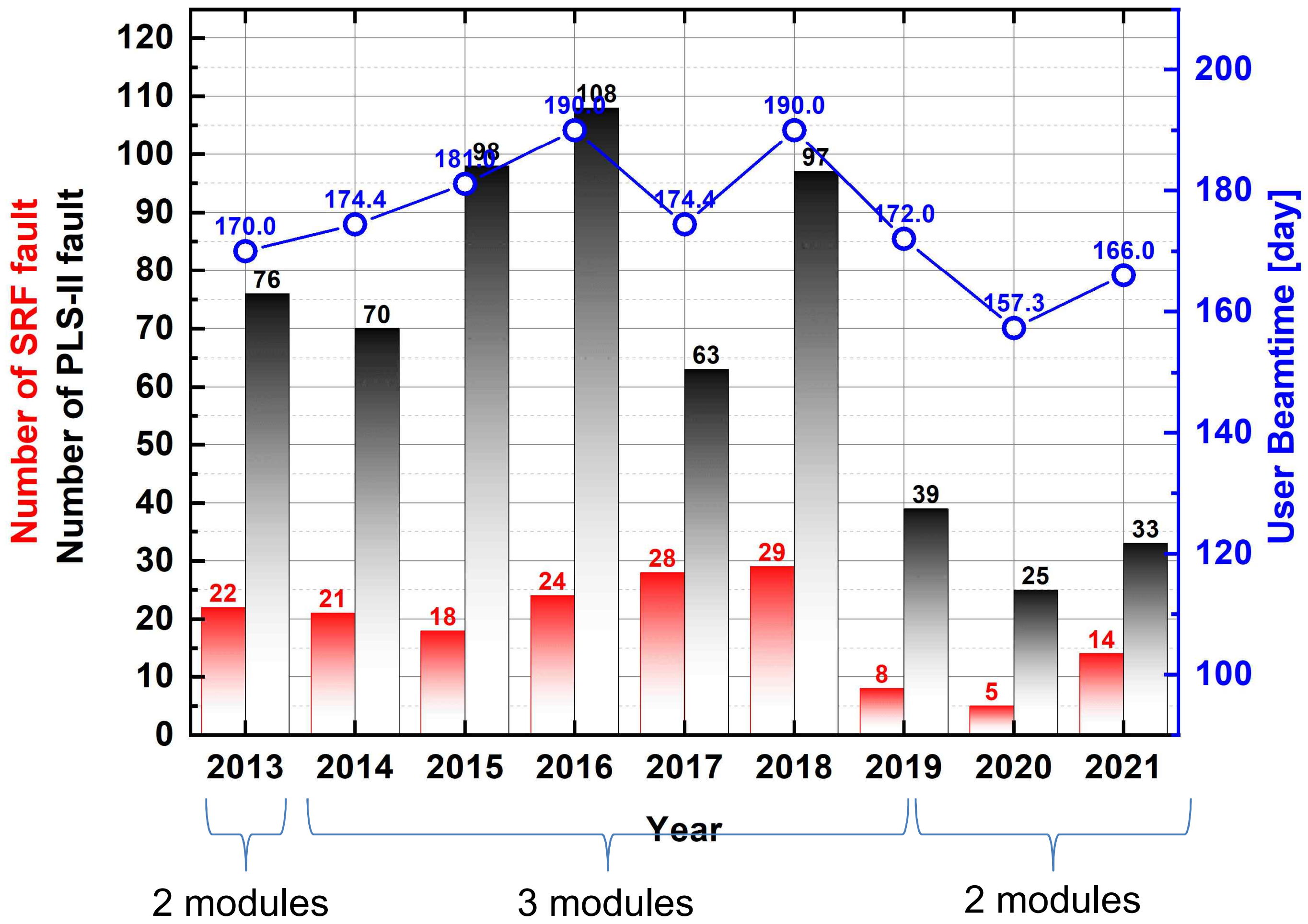
Partial Warmup & Cooldown

During partial warmup & cooldown with TMP operation

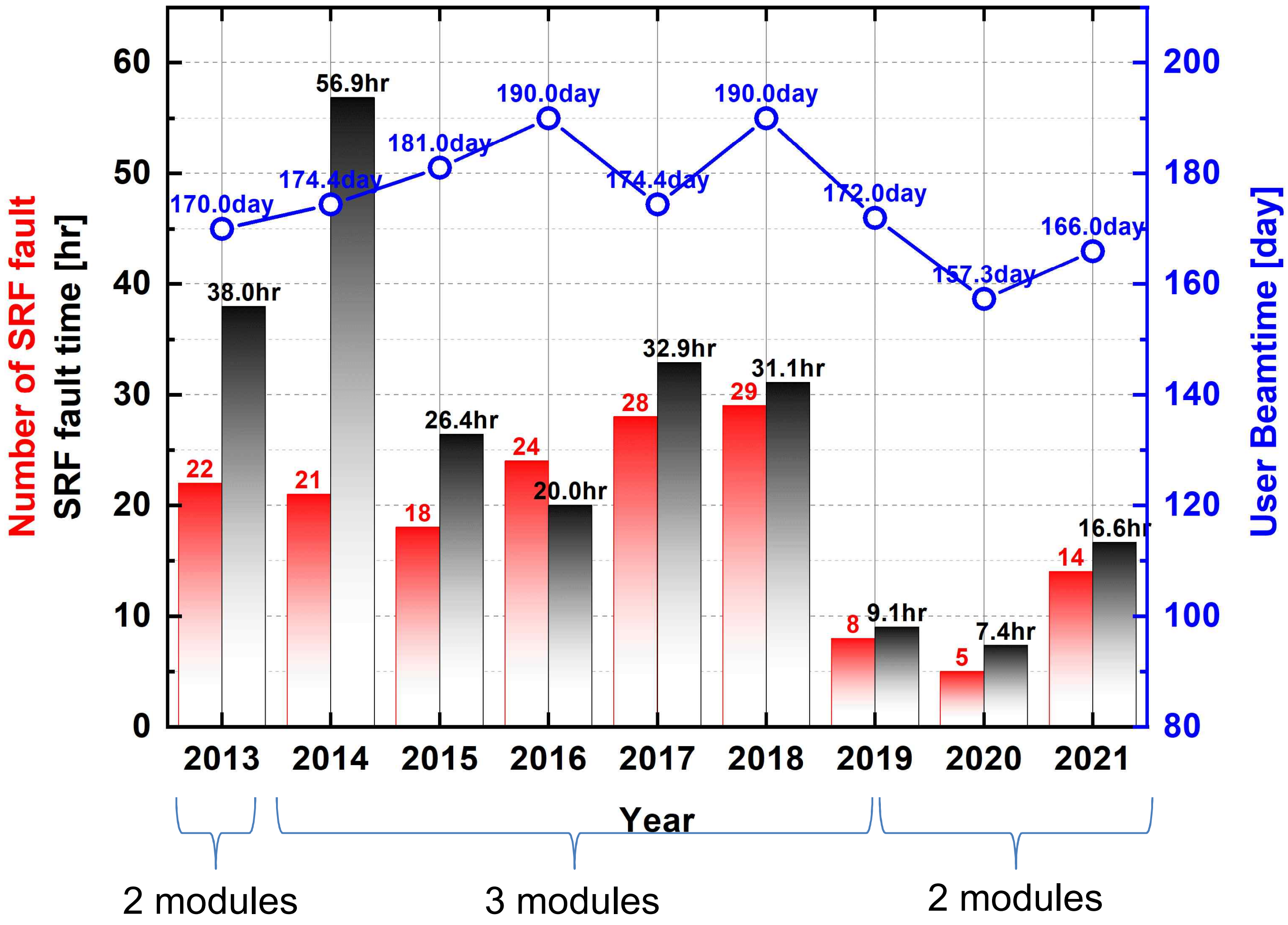


Number of SRF fault, SRF fault time

※ SRF includes all components of RF system such as cryomodule, cryogenics, HPRF, LLRF and control

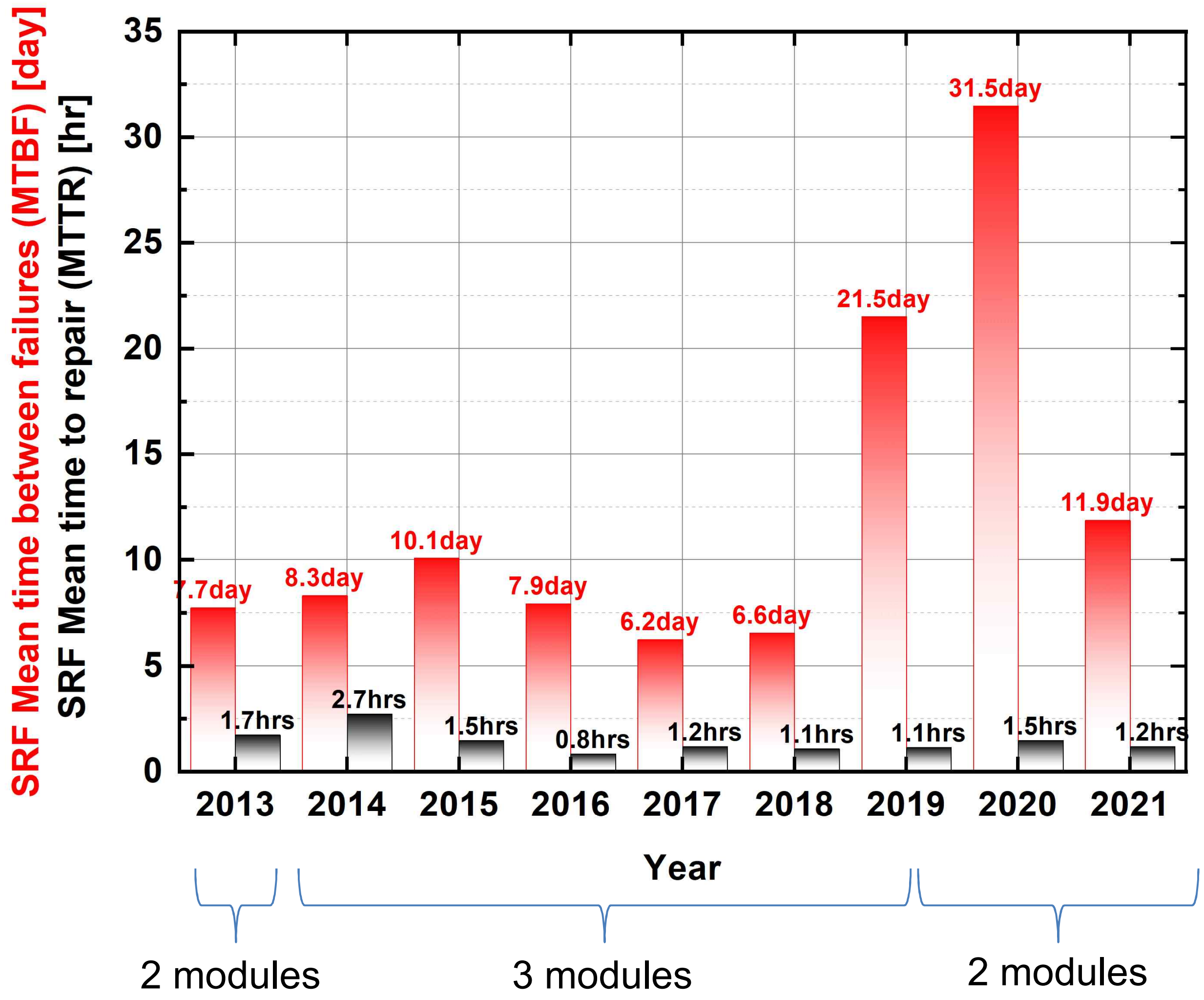


Number of SRF fault, SRF fault time

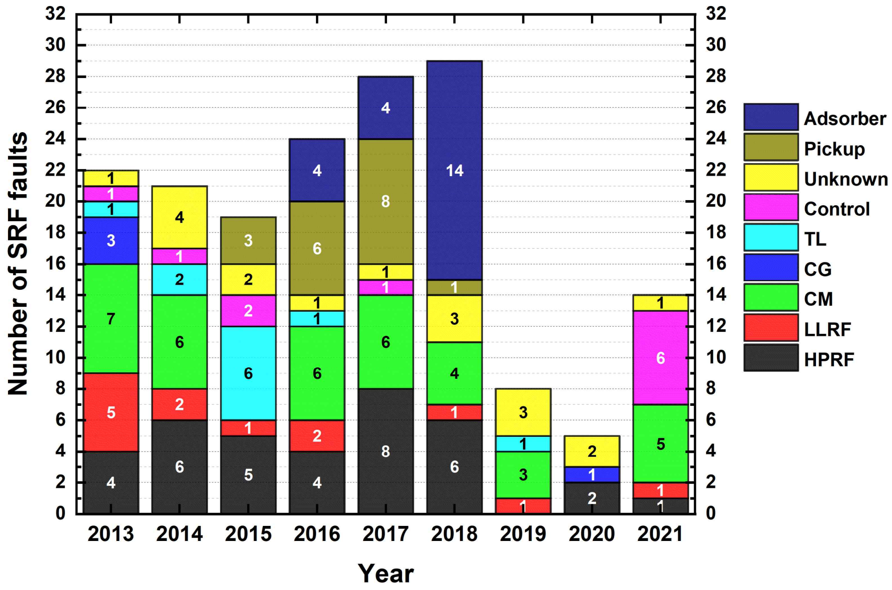


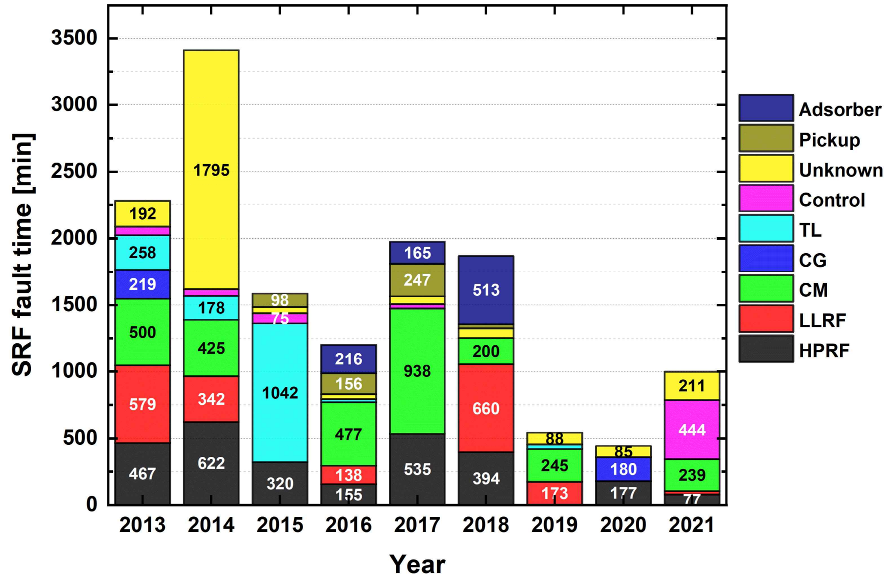
MTBF, MTTR from SRF System only

MTBF: mean time between failures, MTTR: mean time to repair



Faults for each RF Components





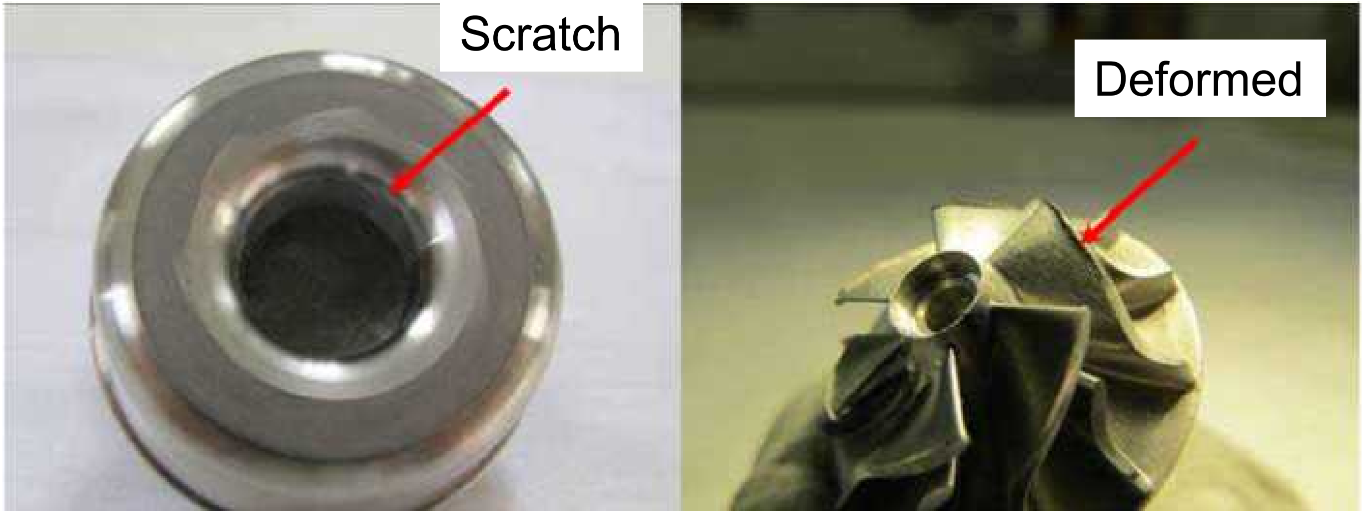
1) **Absorber** is the device installed in the coldbox of He refrigeration to remove impure gas from He gas. During absorber A working with every 12 days operation, the valves and vacuum pump manipulation makes He pressure disturbance at the high pressure line of cold box. It occasionally disturbs He pressure of module He vessel.
2) **Pickup** is the field pickup probe: with 5~8 user-service terms, condensed gases are expended abruptly then it makes vacuum pressure disturbance at CM3 only.
3) **TL** is the power transmission line including water load, circulator and RF switch.
4) **CG** is the He refrigerator including compressor, coldbox and He dewar

Severe Faults, Experienced

(more than 2 weeks downtime)

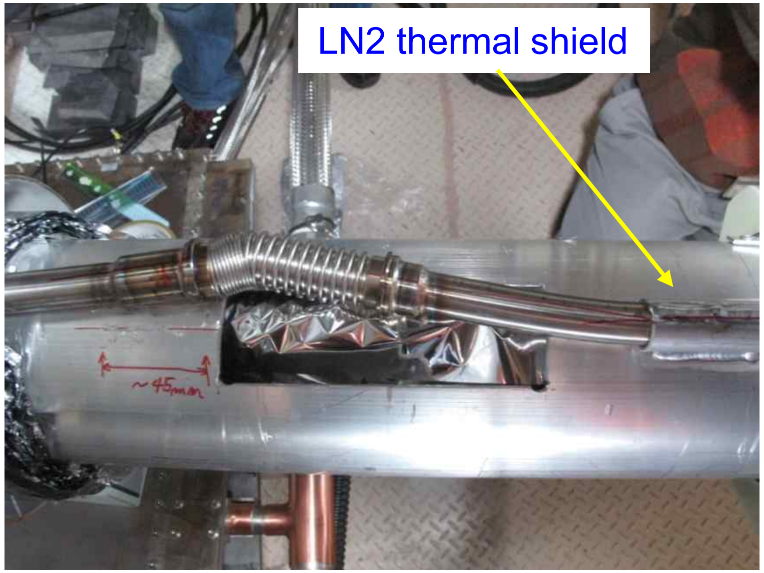
1) Blocking particle filter in LHe supply line during the 1st trying to cooldown cryomodules
2) Stoppage of expansion turbine in cold box during cavity cooling after planed maintenance: 26 Jan., 2014 (20 days' out of service), 14 Feb, and 24 Mar., 2017(45 days out of service) maybe impurity makes turbine jamming, but unknow cause and no pre-detected symptoms by system monitoring.
3) Tearing out of LN2 supply tube (bellows) of MCTL during cavity cooling: 19 Feb. - Mar. 26, 2014 (28 days' loss of beamtime), mis-design of section bellows and mis-selection of bellow type (blade guide)
4) Vacuum leakage between He vessel and cavity: CM3 – Sep. 2029, CM1 – Sep. 2022, maybe fatigue of indium sealing through the frequent thermal cycle and aging, resulted to reduced beam current, ordered spare module.

Turbine Troubles

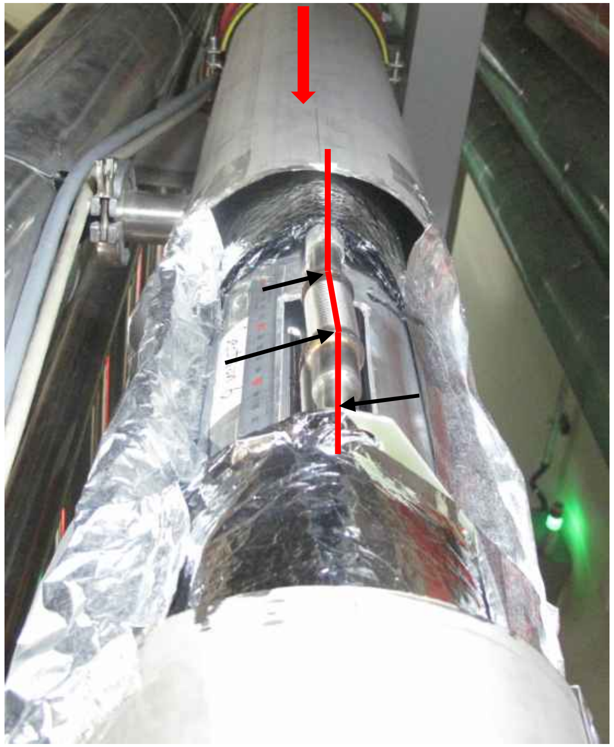


Contact marks between turbine wheel and exhaust turbine diffuser

Damaged Bellows

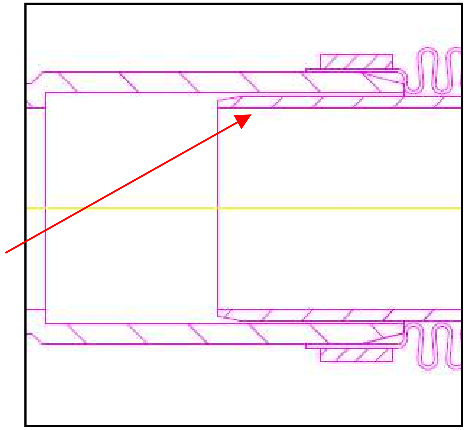


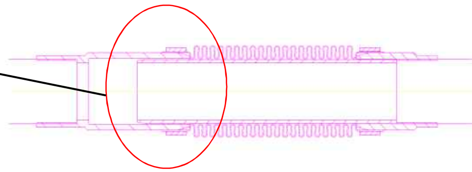
Teared bellows @ MCTL Section 8



Deformed bellows @ MCTL Section 6

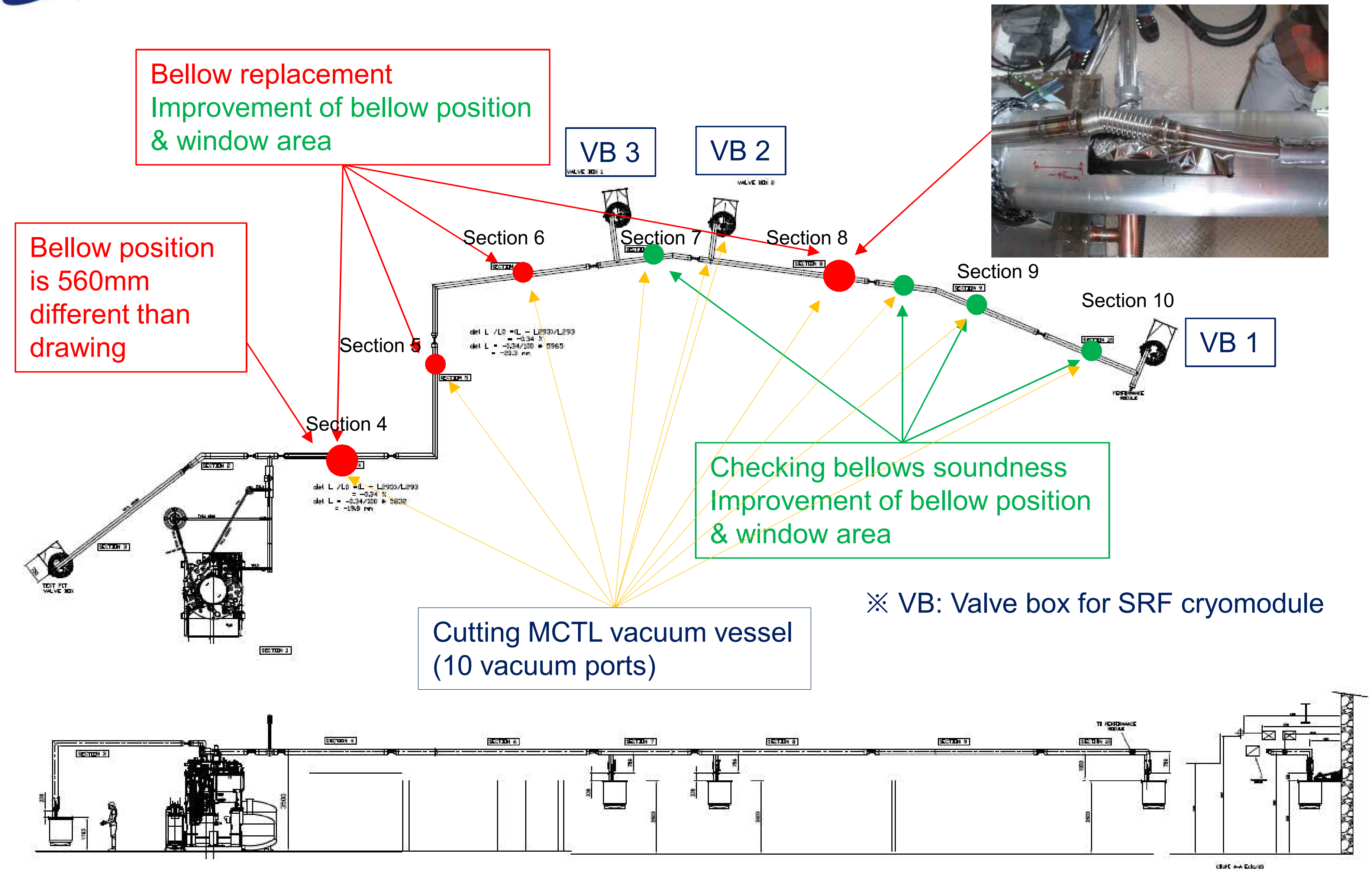
Guide blade





End type of bellow

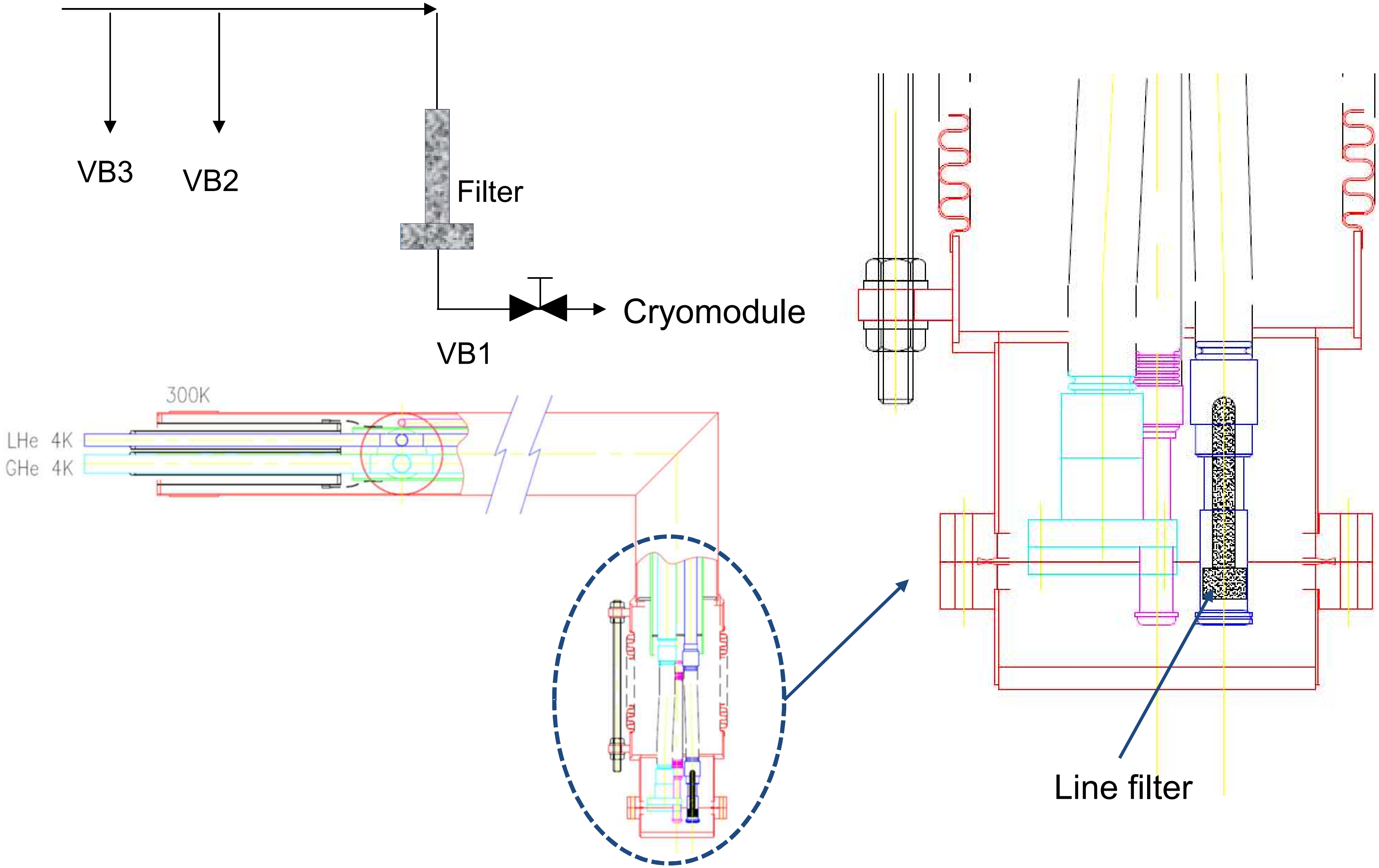
Repair of LN2 Lines



※ VB: Valve box for SRF cryomodule

Blocking Particle Filter in LHe Supply Line

LHe supplying line in MCTL



Discussion

1) How frequently a cold box and compressor should be maintained for the keep their performance ?
2) Whether the skipping some procedures (sequences) to resume coldbox operation would be recommended, after safe stop of turbine (just few minutes ~ few hours) due to the facility troubles such as site blackout, losses of cooling water and pneumatic air ?
3) Is it possible for a large volume of LHe dewar to keep cavity cold (not over 50K) for the long idle standby, ? and recommendable ?
4) Is there any special idea to detect the possibility of turbine stoppage ?

   (We monitor turbine speeds, pressure disturbances around turbines and He impurity of several positions of warm and cold parts)
5) Life time of ceramic window ?
6) Calibration of field pickup, how frequently ?
7) Necessity of dual refrigerators, worthwhile ?

END