

RF Related Issues Encountered during over 15years of Operation of SPring-8

Shigeki Sasaki,
SPring-8/JASRI

- 1. Outline of SPring-8**
- 2. Operation statistics**
- 3. Examples of troubles**
 - a) water leak from SR absorbers : 2001**
 - b) vacuum leak from a cavity : 2002**
 - c) water leak from cooling channel of klystron
output windows : 2010-2011**

SPring-8



SPring-8 storage ring parameter

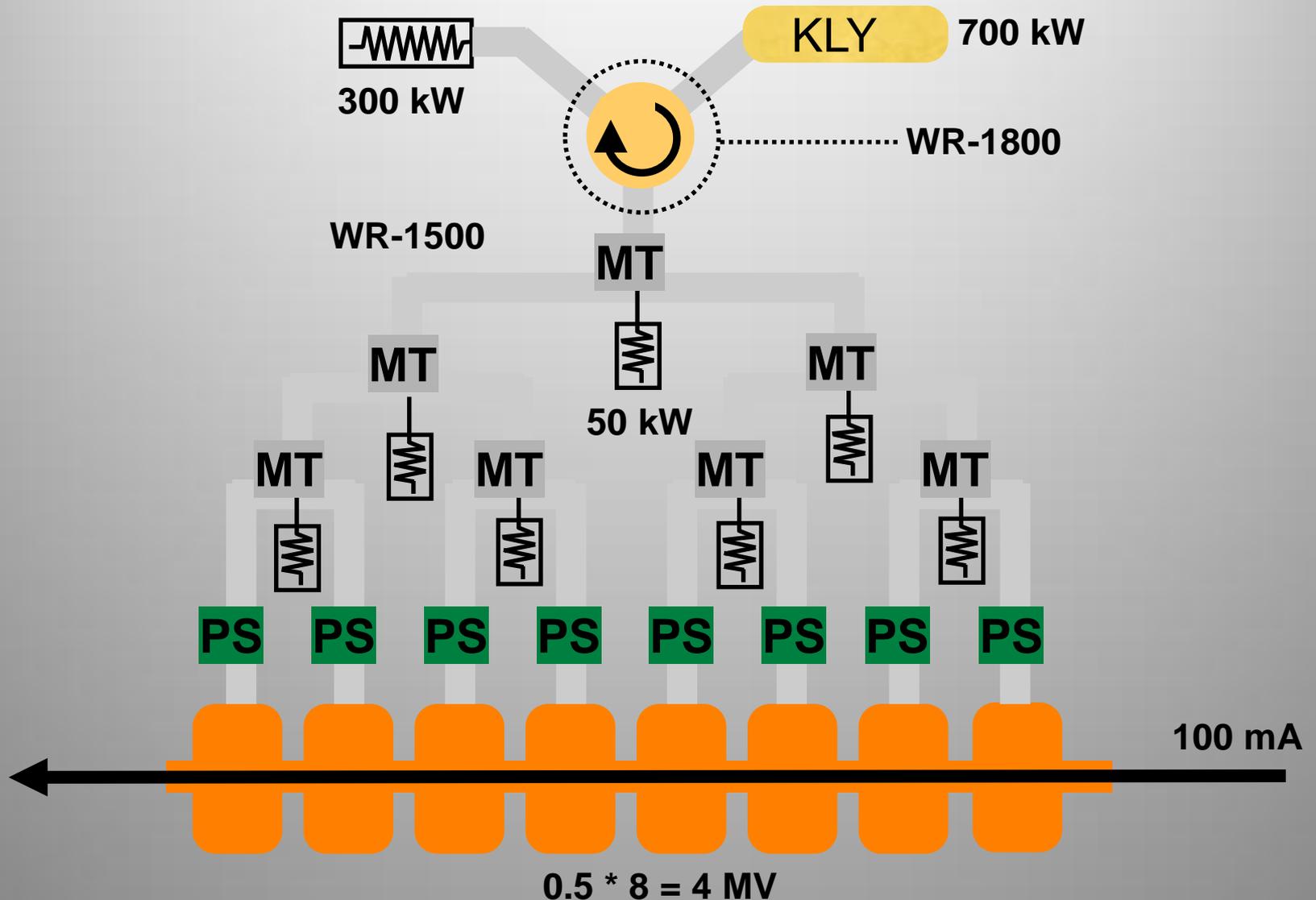
Energy	8GeV
Circumference	1436 m
Stored current	100 mA
Emittance	2.4 nm rad
Momentum compaction	1.7×10^{-4}
Energy spread	0.1%
Energy loss	8.9 MeV/turn (Bmag)
Harmonic number	2436
Cell configuration	36 normal DBA cell + 8 match. cell
Straight section	40 x 7 m + 4 x 30 m

RF stations

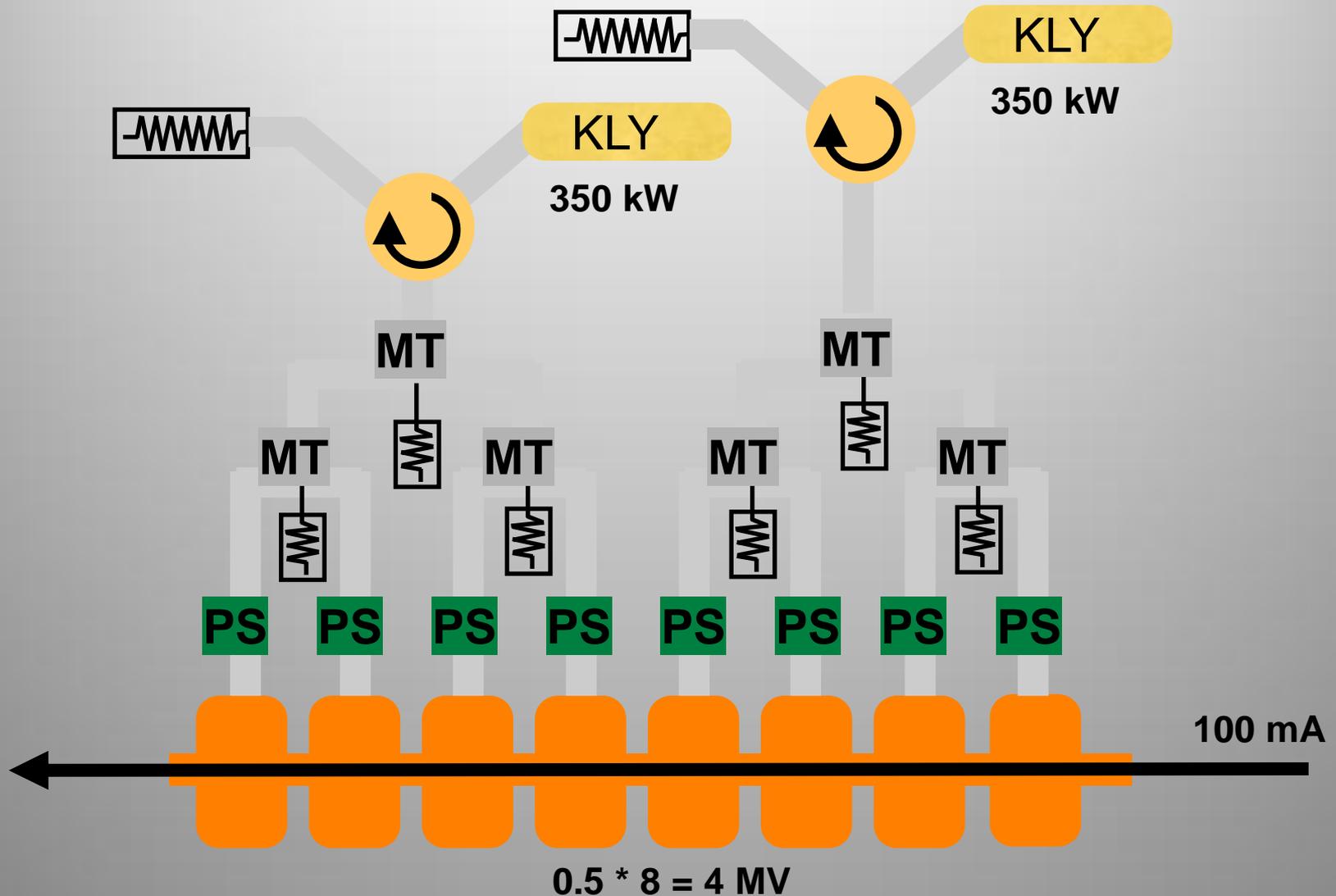


**Four RF systems in storage ring
named A-, B-, C- and D-station**

RF accelerating system 1



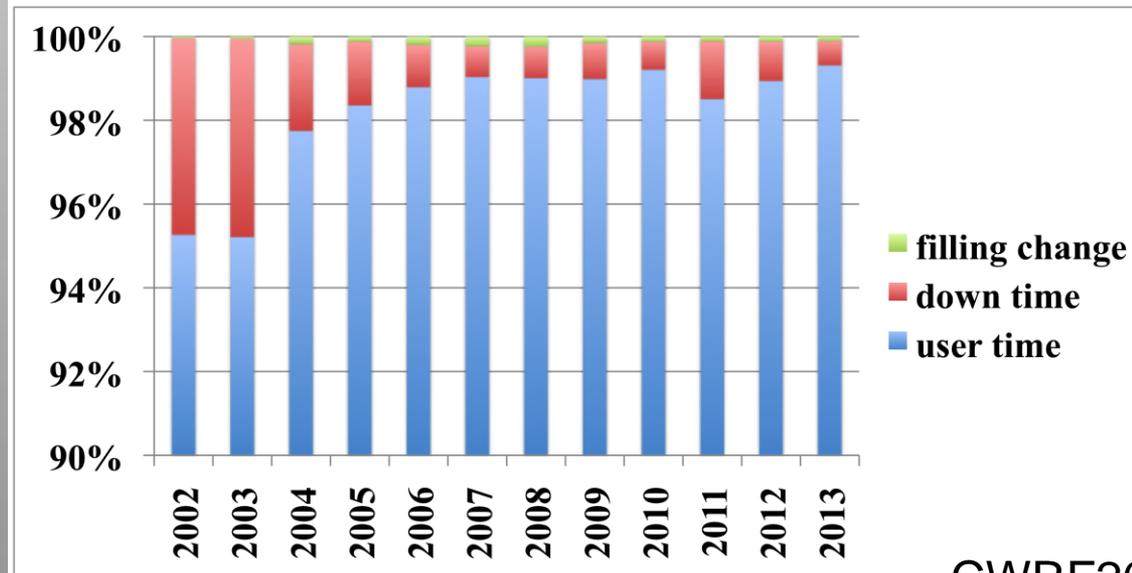
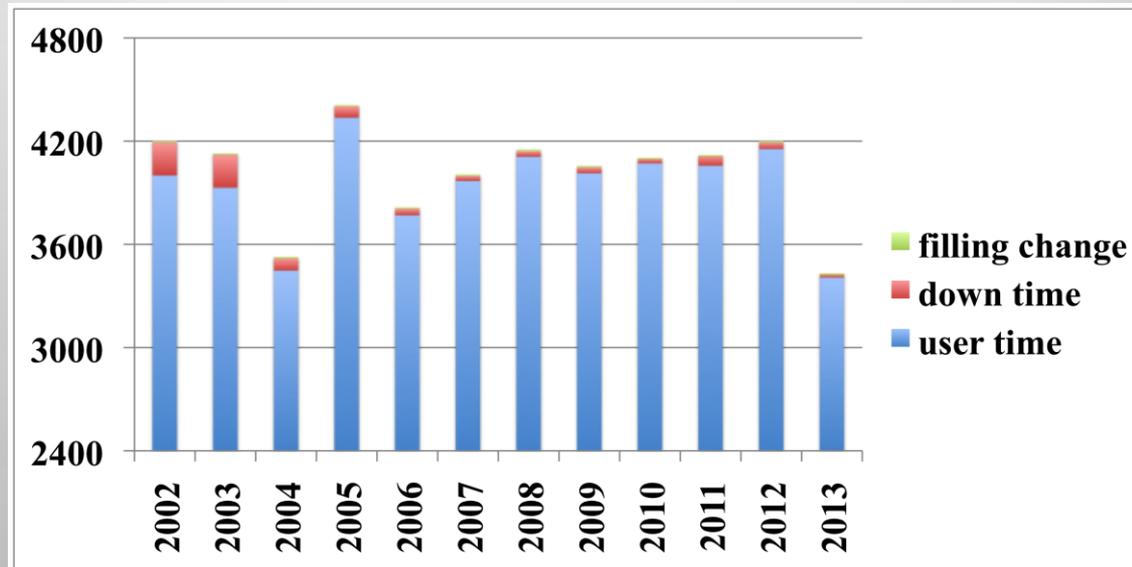
RF accelerating system 2



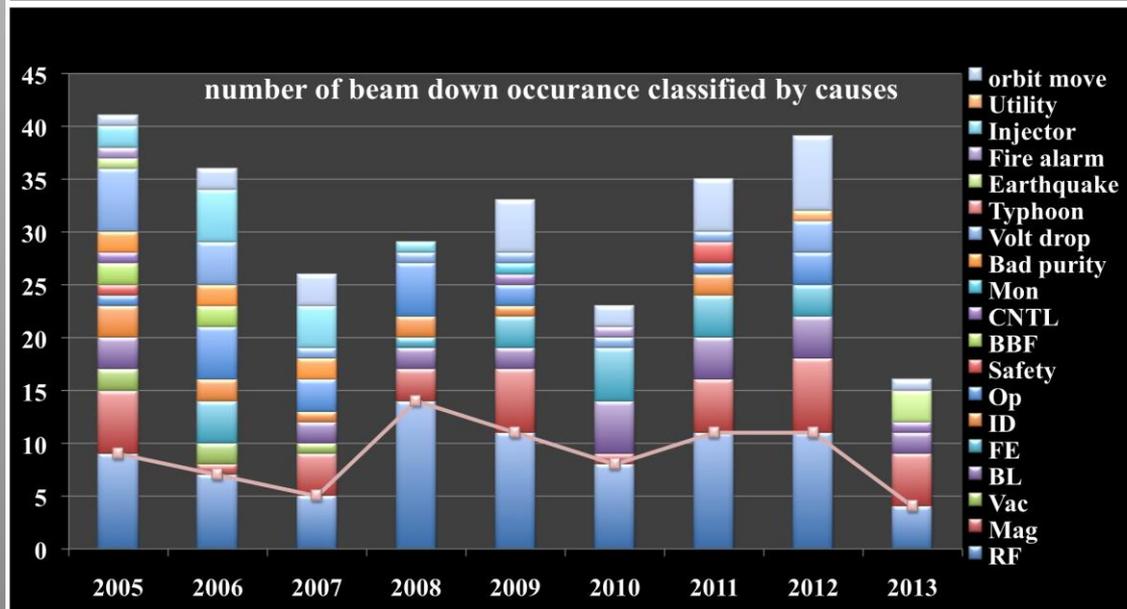
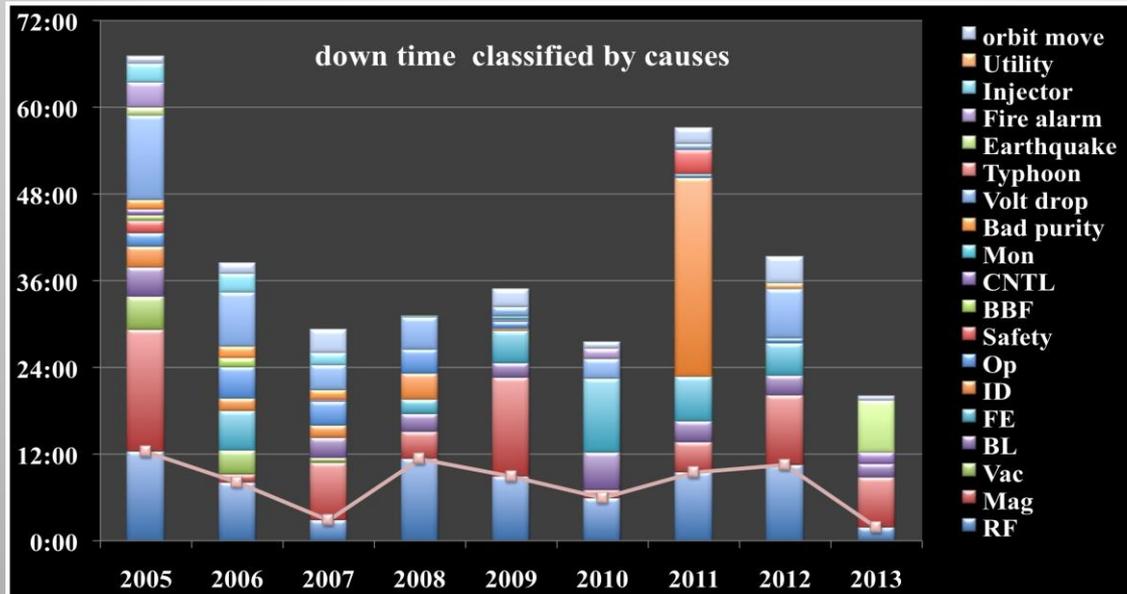
RF parameters

	Storage Ring	Booster
Beam current	100 mA	10 mA
Loss [MeV/turn]	8.9(B), 13.4 (B+ID)	12.3 (@8GeV)
RF stations	4	1
klystrons	5 x 1.2 MW	2 x 1.2 MW
frequency [MHz]	508.58 MHz	508.58 MHz
RF cavities	Single cell x 32	5 cell x 8
Va [MV]	16	18
Harmonic number	2436	672

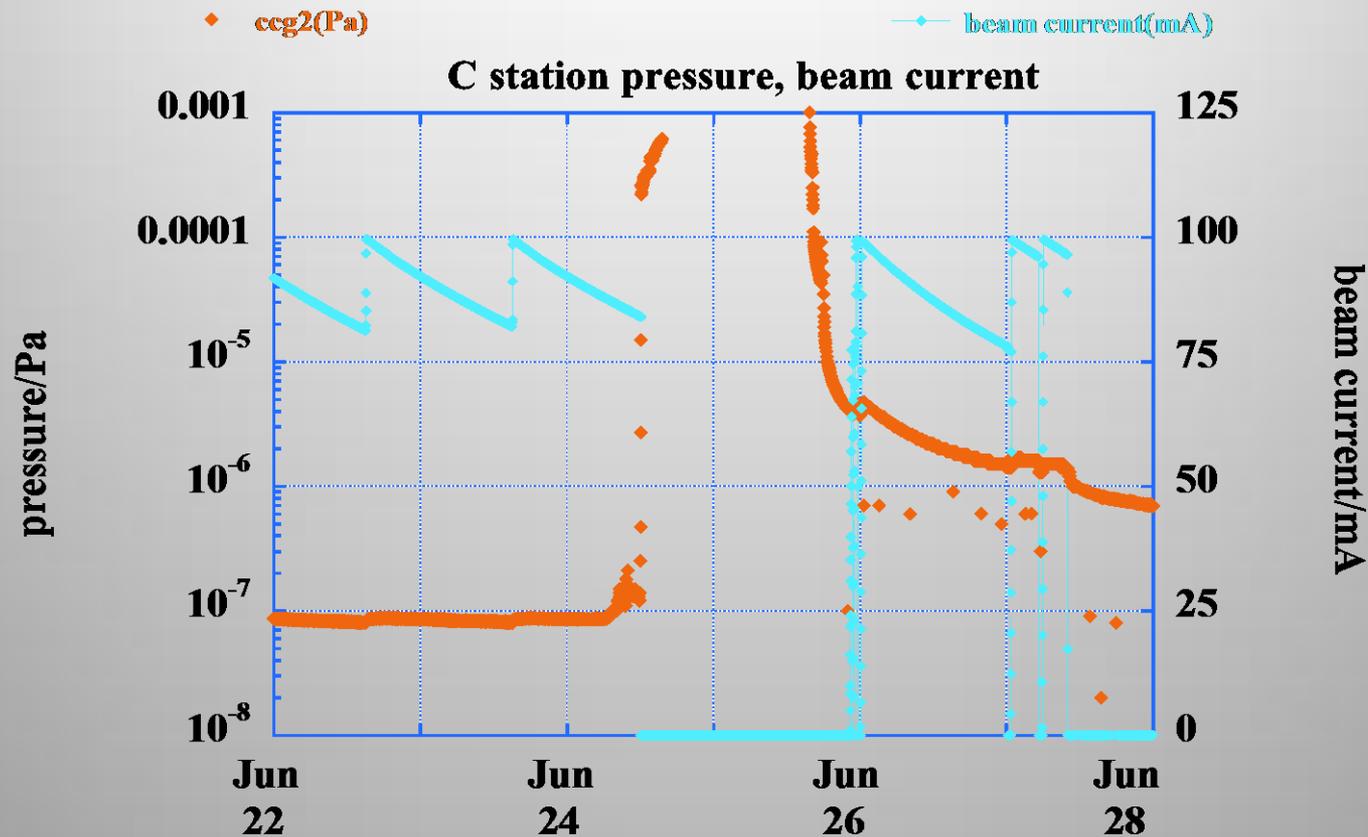
operation time and down time for recent 10 years



causes of down time



water leak into vacuum from SR absorbers in 2001

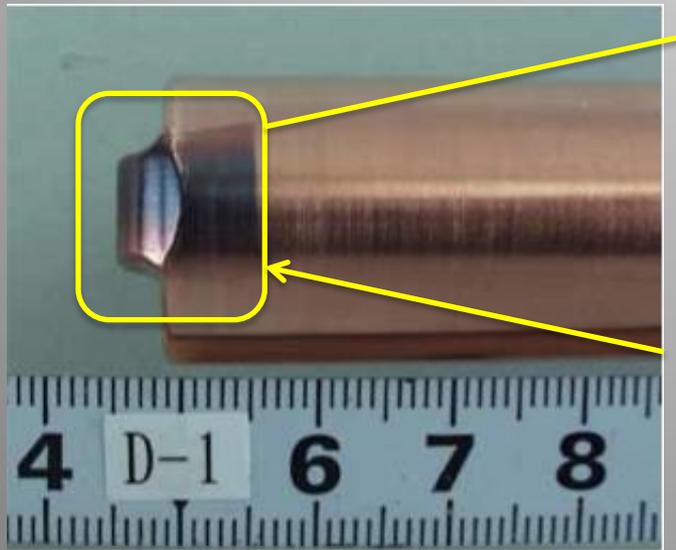


- sudden pressure rise → beam abort
- main component of the gas = H₂O
- water leak from absorber_2
- replace with spare
- 36 hour of down time

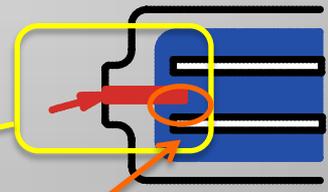
2001: Water leak from the absorbers for RF cavities to the vacuum area

SR lights pass the cooling channel and the chemical reactions with copper and the oxygen occurred, and the copper was eluted
Absorber wall thinned and finally the water leaked through holes

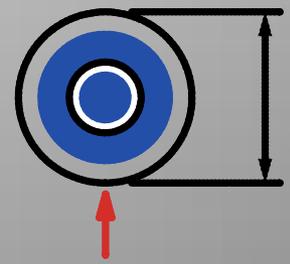
appearance of the



Irradiated area



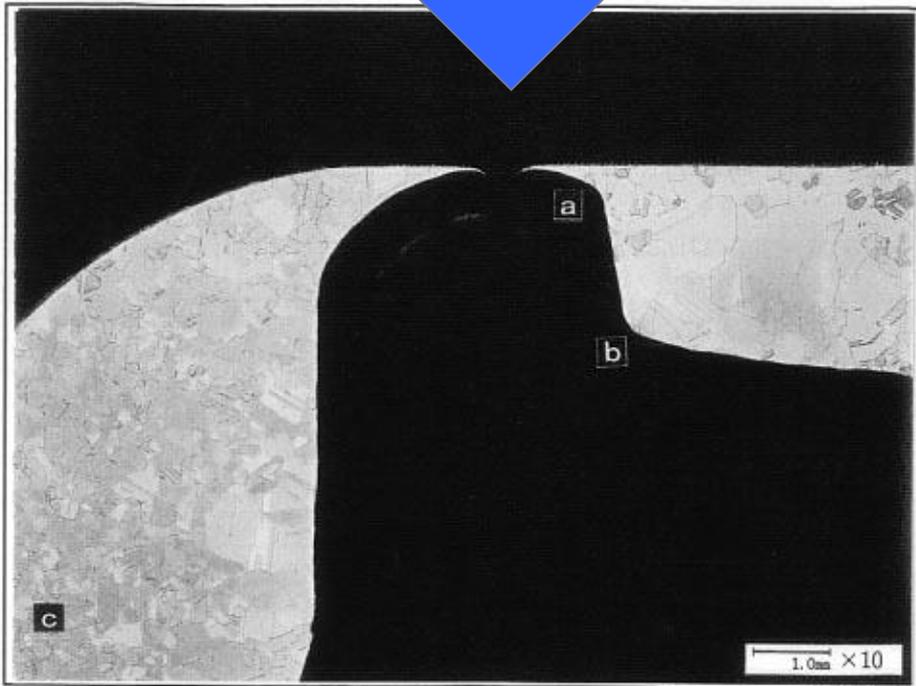
SR pass through the cooling water



absorber

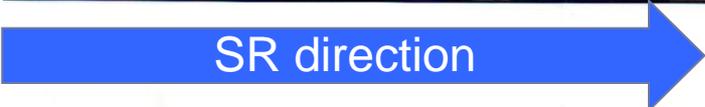
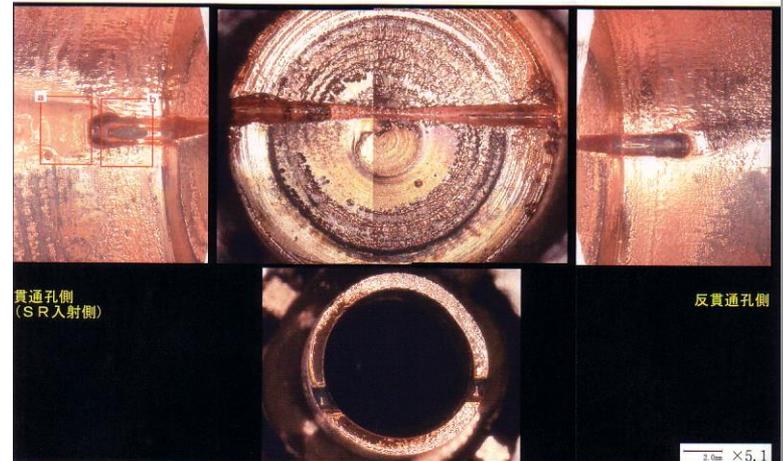
OFHC+H₂O+SR → corrosion?

Absorber No.	Power density
1(Cav#1-#2)	2.55kW/cm 2
2(Cav#3-#4)	1.60kW/cm 2
3(Cav#7-#8)	1.06kW/cm 2



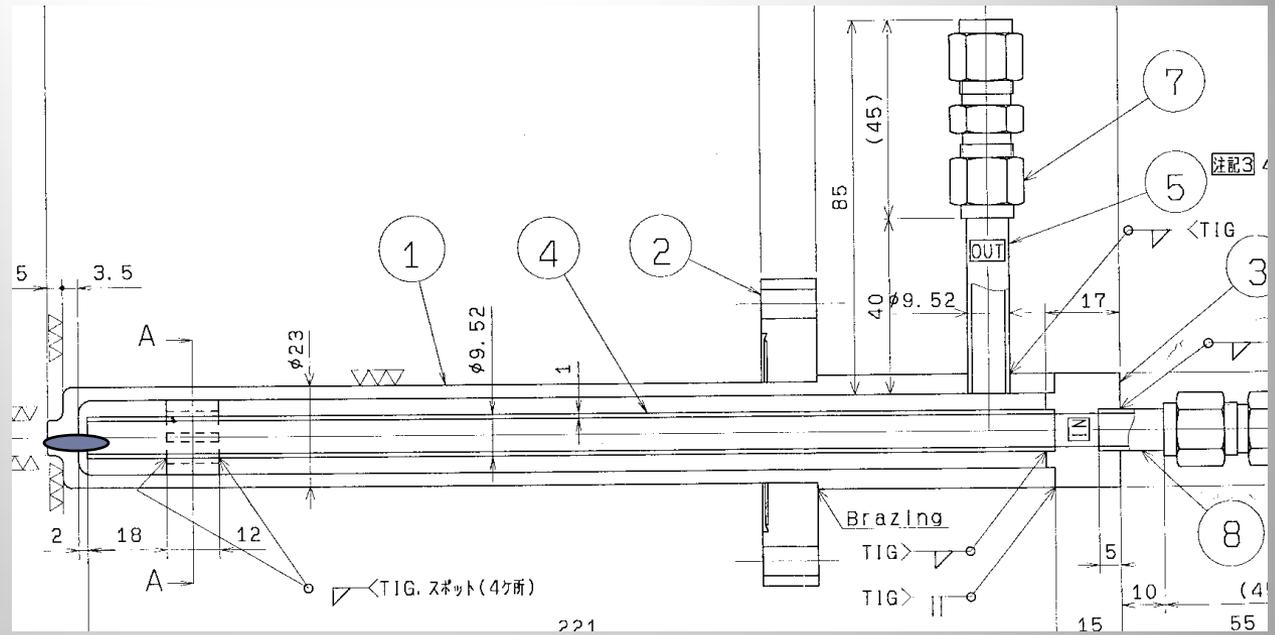
(SR入射方向↓)

損傷全体



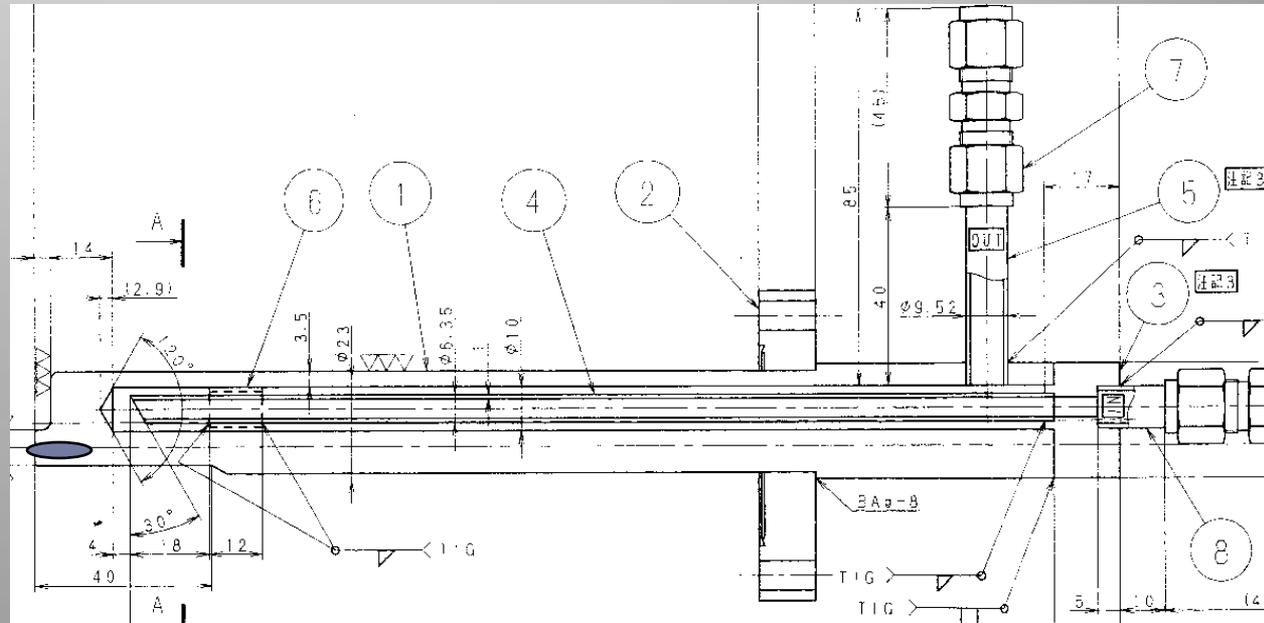
modified the desing
of the absorber

Old design



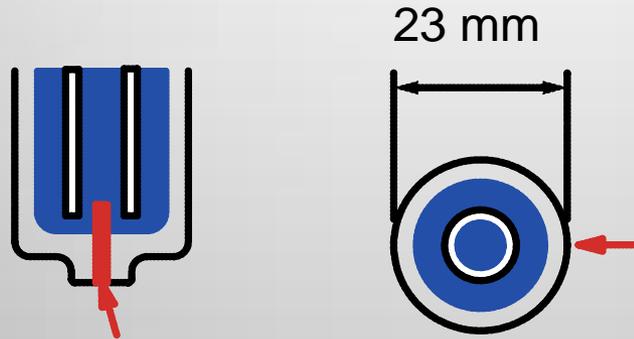
New design

cooling channel is apart
from the radiation point

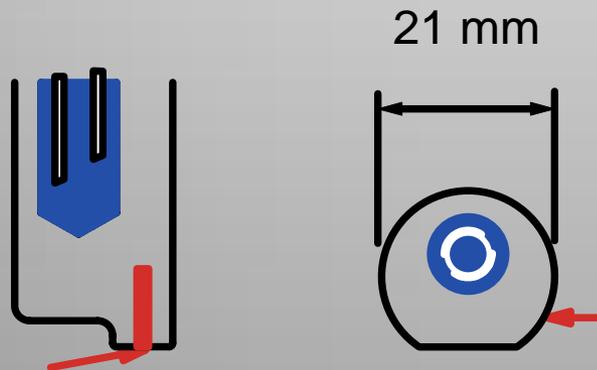


- Modify the structure of the absorber

Old type

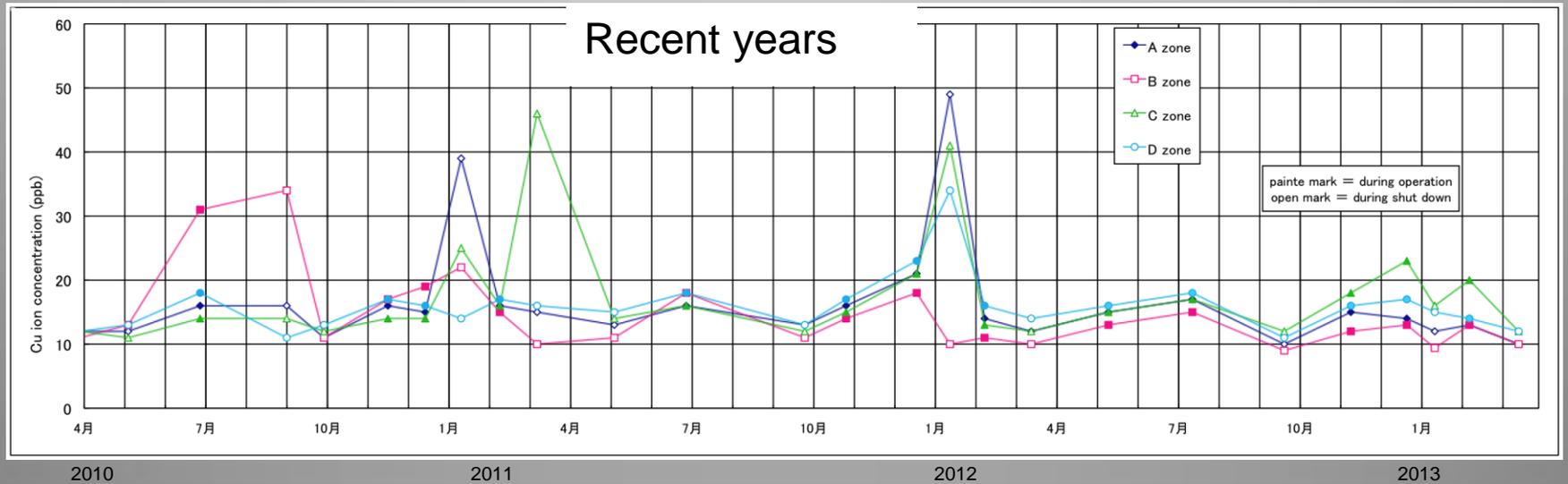
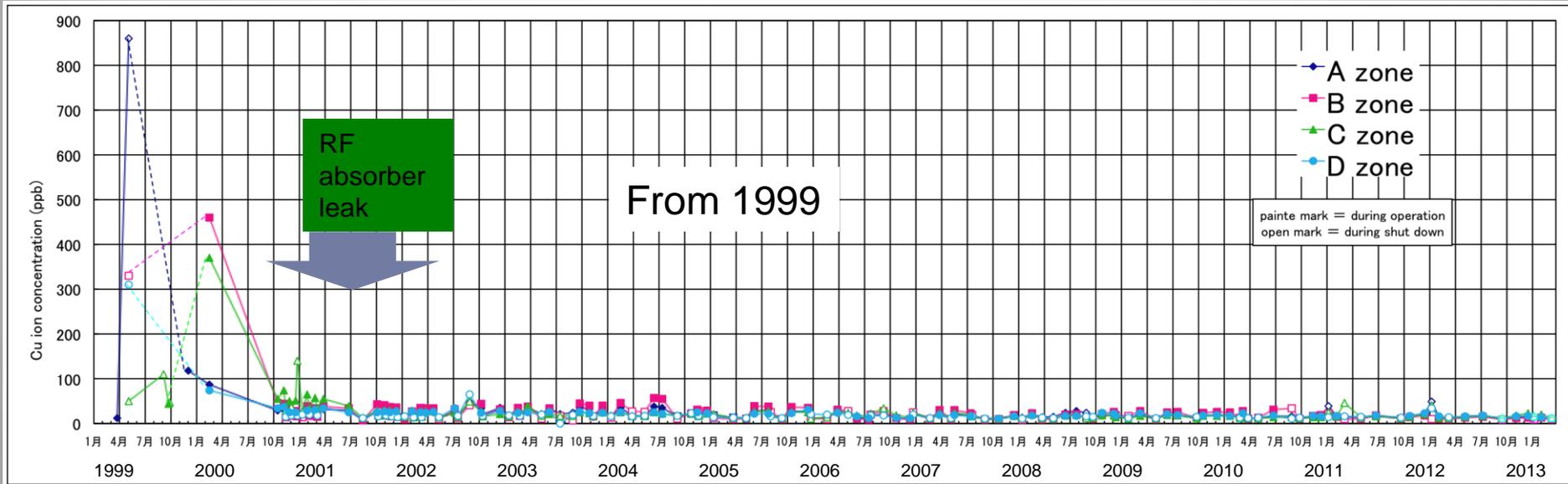


New type



SR pass through
the copper only region

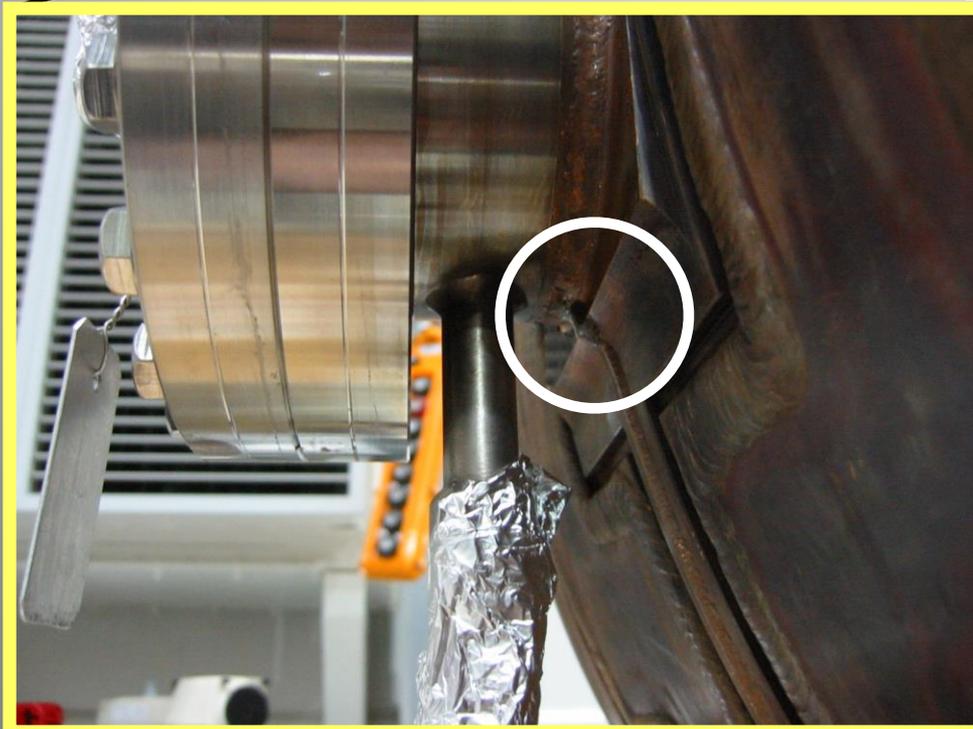
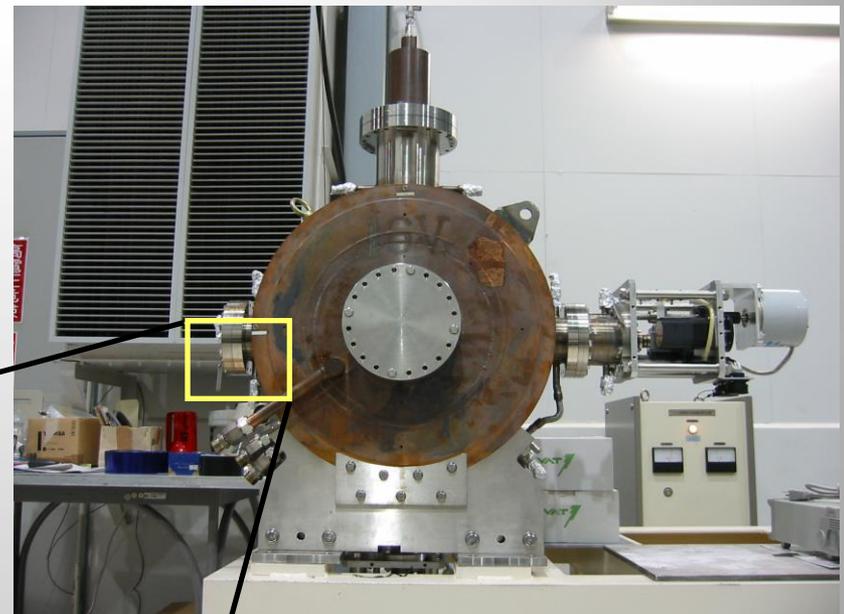
copper ion concentration in the cooling water



replacement of a cavity at Dst

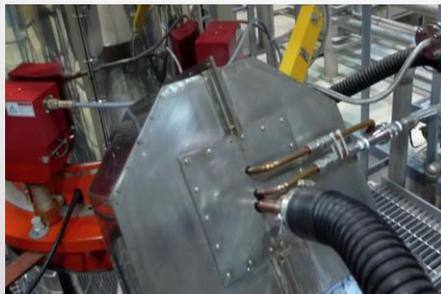
- vacuum leak from 3 cavities (electron beam welding type)
in the summer 2002 : temporary treatment with vac-seal
- manufacture 8 cavities with diffusion welding (- Jun 2003)
- High power test (Apr. – Jun. 2003)
- installation, tuning, putting into operation (Jul. – Aug. 2003)

leak part of a
cavity



vacum leak from the joint part of
tuner port junction with electron
beam welding

2010-11: water leak from the cooling pipes of klystron output windows



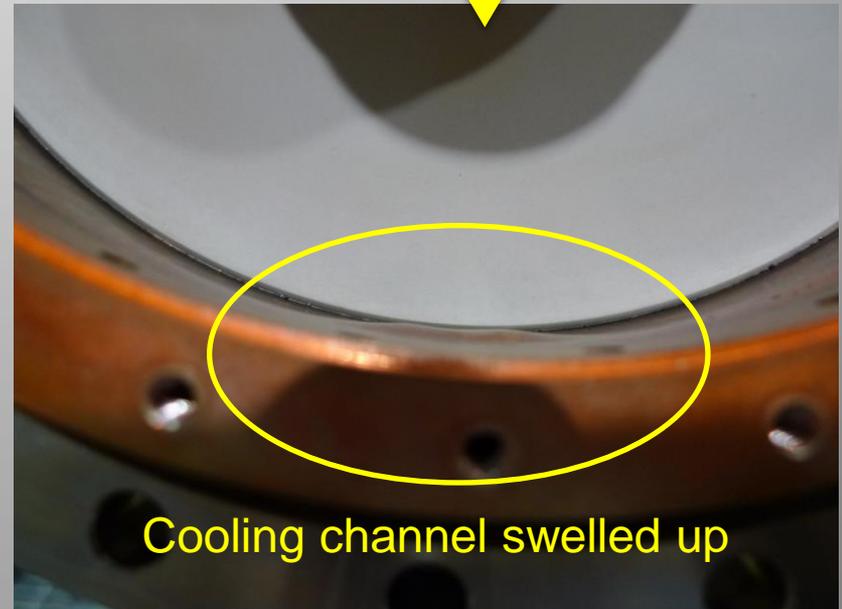
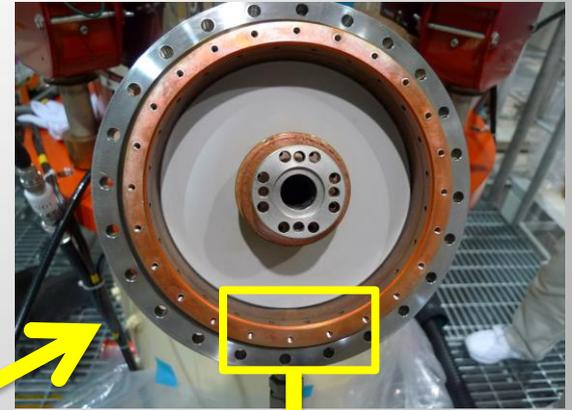
The water flow was more than necessary
(10L/min \rightarrow \approx 3.3m/s, \varnothing 8-mm pipe)
Water hit the pipe wall at the corner like point of
the piping configuration

The flow was lowered to the adequate level
($<$ 1.5m/s)

Some of the pipes were replaced
Klystrons were replace one by one

The water pipes were
replaced with angle joints
turning parts of the cooling

This part is hard to be repaired
Klystrons were replaced one by one, if the pipe
swellings were found before occurrence of leak



Aug.17, 2010: A pinhole was found at the output window of Bst klystron.

Aug. 20, 2010: Turbid water flowed from the cooling channel of the klystron when the cooling channel was disconnected for replacement of the klystron



possibility of oxidation during the shutdown
after the circulation of cooling water stopped

sampled water Feb.01, 2010

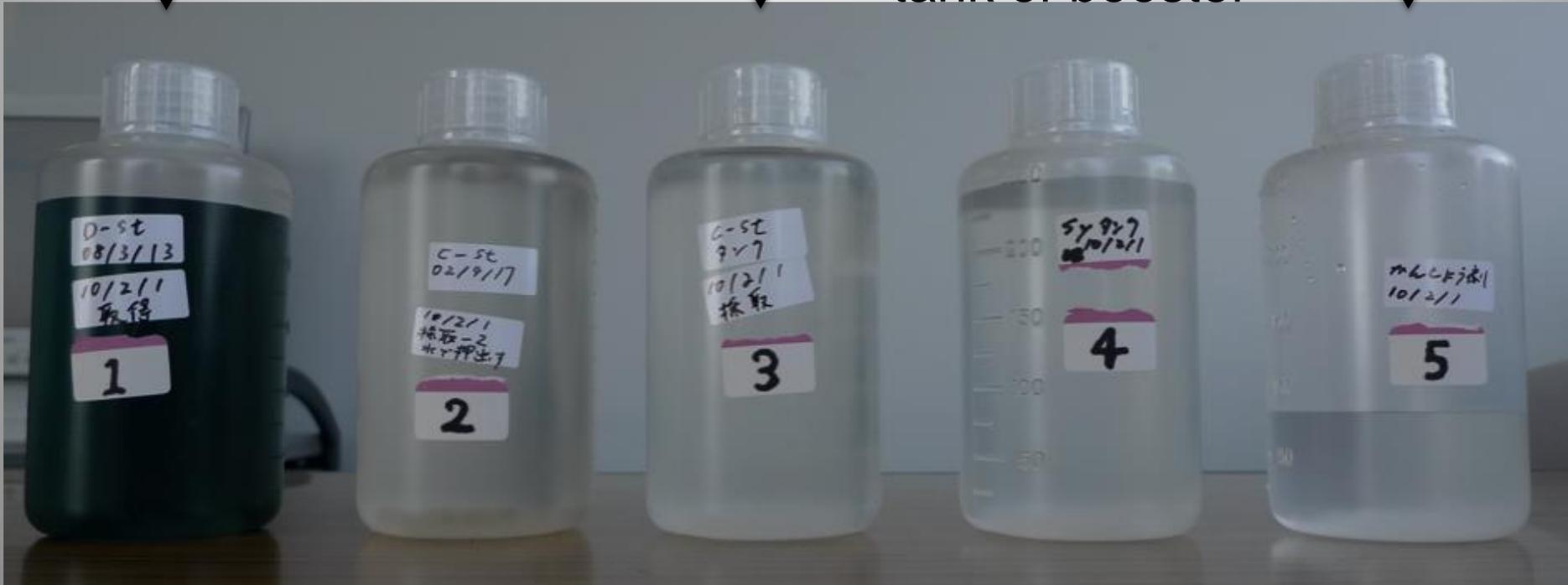
spare klystron
stocked from
Mar.13,2008

cooling water
tank of Cst

buffer solution
($\text{KH}_2\text{PO}_4 + \text{Na}_2\text{HPO}_4$)

stocked from
Sep.17, 2002

cooling water
tank of booster



water in tanks are clear.

water in one of stocked klystrons is suspended

does not depend on the period of storage

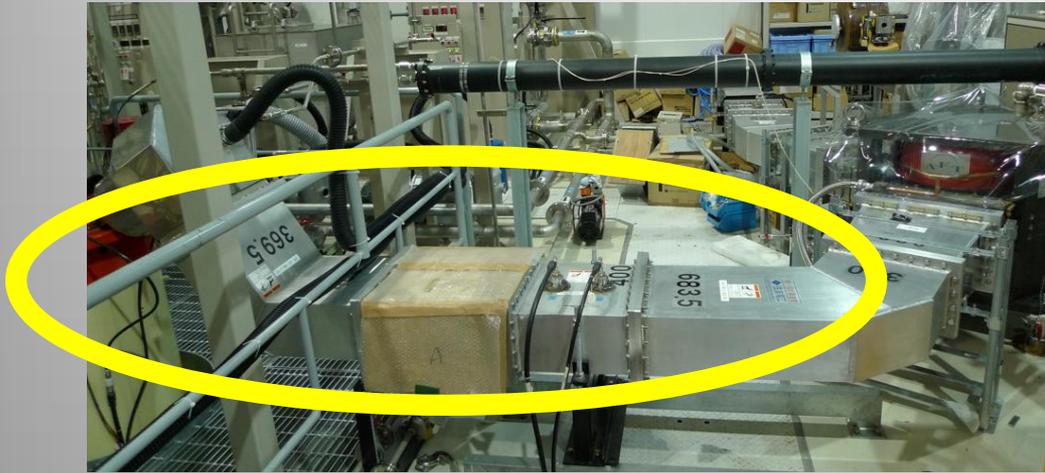
quantity of No1 sample water was small? air coexisted? was not filled with water?

Analysis of water in klystrons

No.	Water sample	Detected metal ions					pH
		0.01 ~ 0.1ppm	0.1 ~ 1ppm	1 ~ 10ppm	10 ~ 100ppm	>100ppm	
①	D-st	B, Mg, W	Na, K, Ca, Mn, Zn, Cd	Fe, Ni	Cu	Mo	3.7
②	C-st	B, Na, Mg, K, Mn, Zn	Ca, Ni, Cu	Mo	—	—	6.3
③	C-st Tank	B, Cu	Ca, Ni, Mo	—	—	—	6.5
④	Booster Tank	B, Ni, Zn, Mo, Ag	Cu	—	—	—	6.1
⑤	Buffer solution	B, Ni, Rb, Cu, Mo	Cu	—	—	Na,K	7.6

- ① most oxidized; air coexistence affected ?
- ② the oxidation was small if filled with water?

Water leak from output port of a klystron (Ast No.2), in 2011



water stood whole the area of the wave guide

Apr/11 : Interlocks

Cathode voltage failure, anode over current, repeated klystron arcs

possibility of water leak from RF window, made appearance check without finding a leak halt operation of A-2 klystron



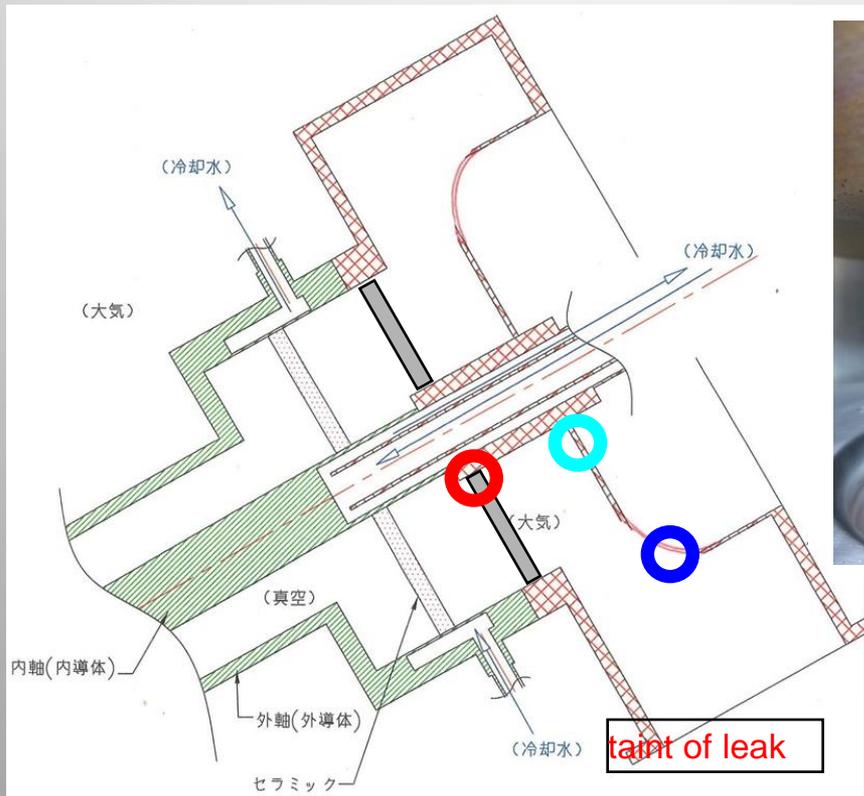
detected leak at the joint part of the circulator
a small step at the entrance of the circulator
→ circulator no exposure to water



Apr/20

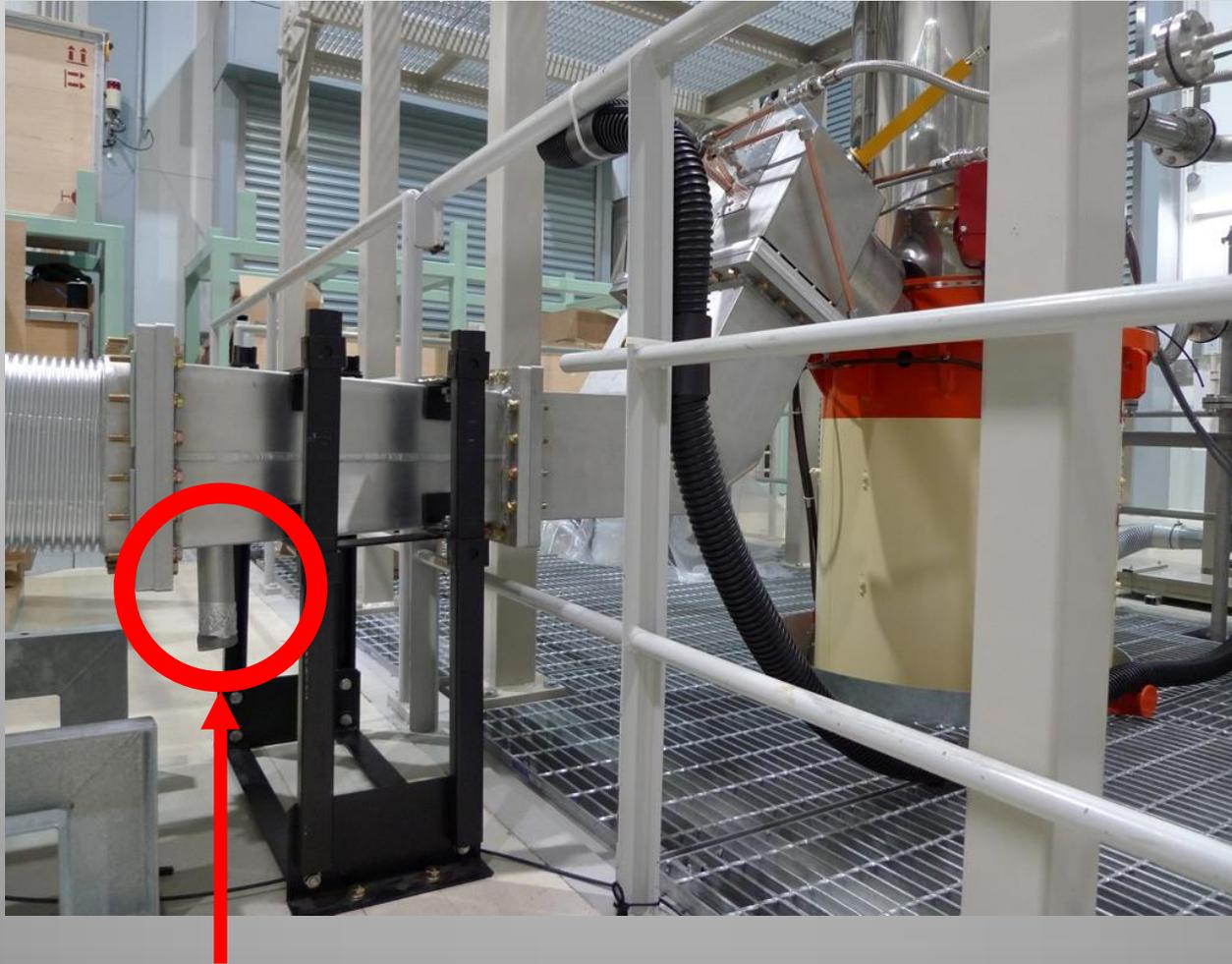
Water leak from waveguide connection part of the circulator

disconnect the wave guide and inspect inside
could not identify the leak source between the klystron and the circulator
stop supplying water to the window
→ stop leak
concluded leak from the output window part



Replace the klystron
brazing part of the inner conductor of the
coaxial structure

water leak detection port



add a port on the tapered wave guide (WR 1500 -1800) for detection of water leak

Summary:

a few comments learned from troubles

- careful design and control of the manufacturing process
 - Absorber water leak, Cavity vacuum leak
- Use under proper usage condition
 - Klystron output window water leak
- Inspection of and control of the cooling water quality