Machine troubles during user-time in SPring-8

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SPring-8 accelerator div.

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SPring-8 is

Electron storage ring

8GeV 100mA life ~130hr for multi-bunch op.

Circumference 1436m

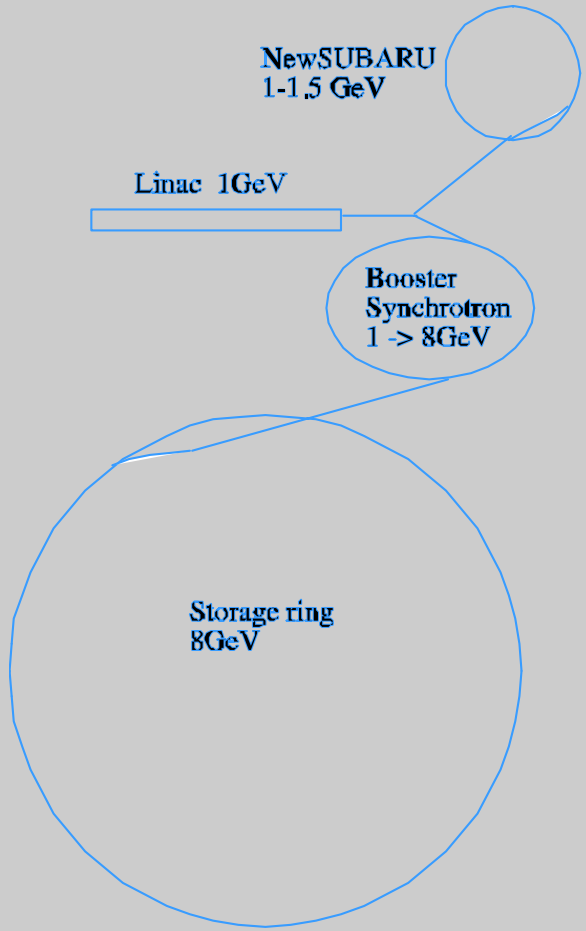
Emittance ~6nmrad

Coupling < 0.1%

Injector

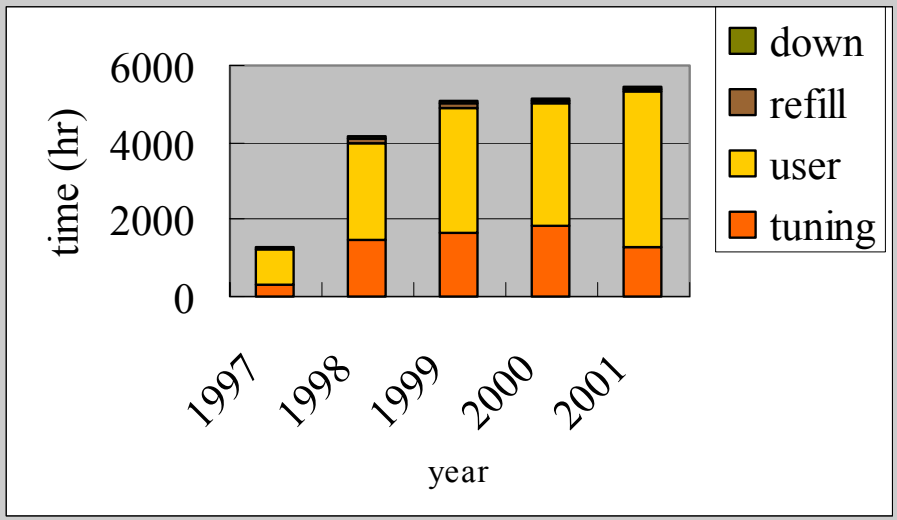
1GeV Linac

8GeV Booster Synchrotron



Operation statistics

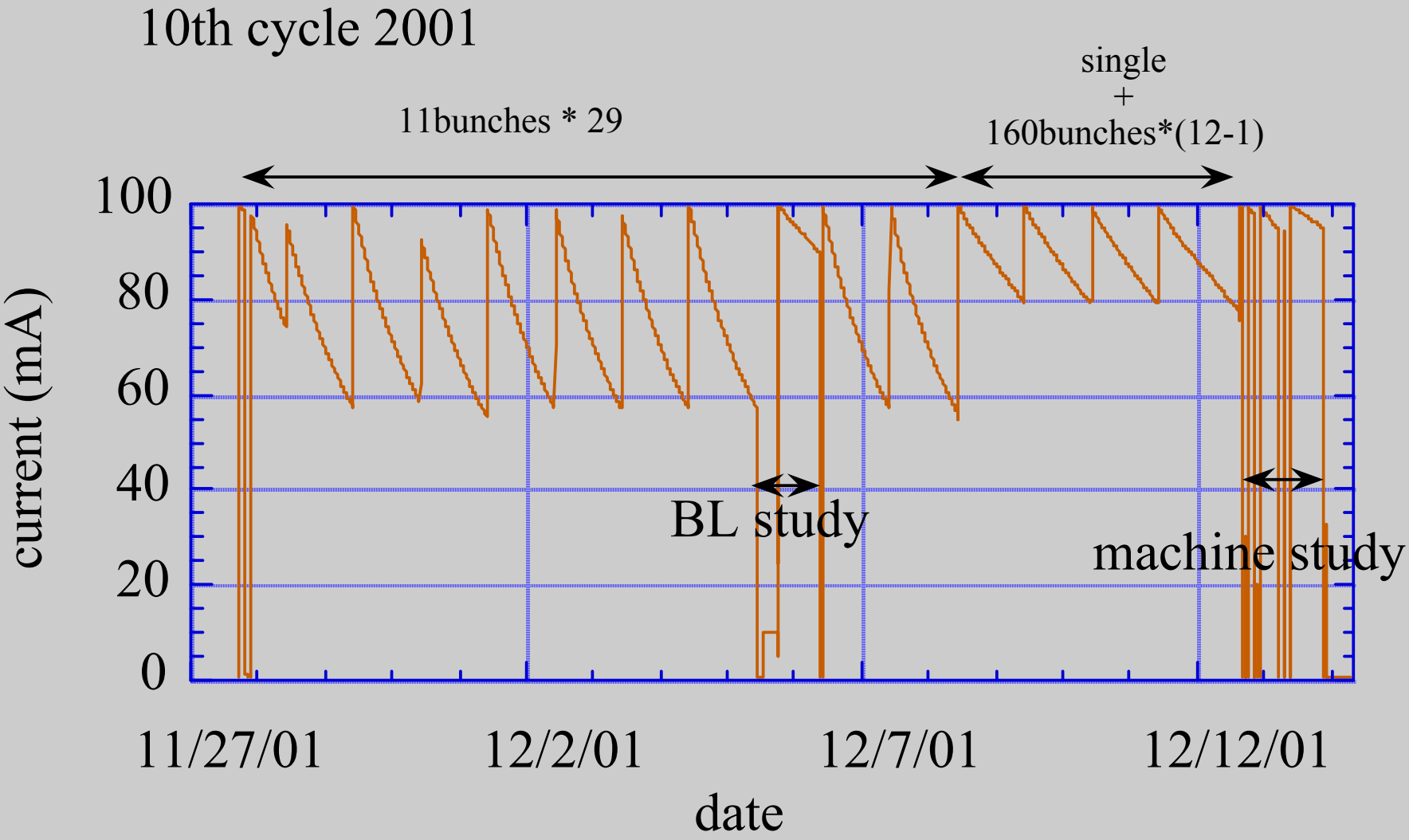
year	tuning	user	refill	down	total	
1997	304	906	50	26	1286	Commissioning
1998	1458	2512	110	110	4190	
1999	1624	3275	95	57	5052	Optics changed
2000	1815	3193	70	89	5168	Introducing LSS
2001	1277	4033	59	87	5456	



10 operation cycles in 2001
3 or 4 weeks/cycle

Injection:
once / day (multi-bunch op.)
twice / day (several bunch op.)

Example of stored current



No fault for 7 days + 6 days = 13 days (335hrs)

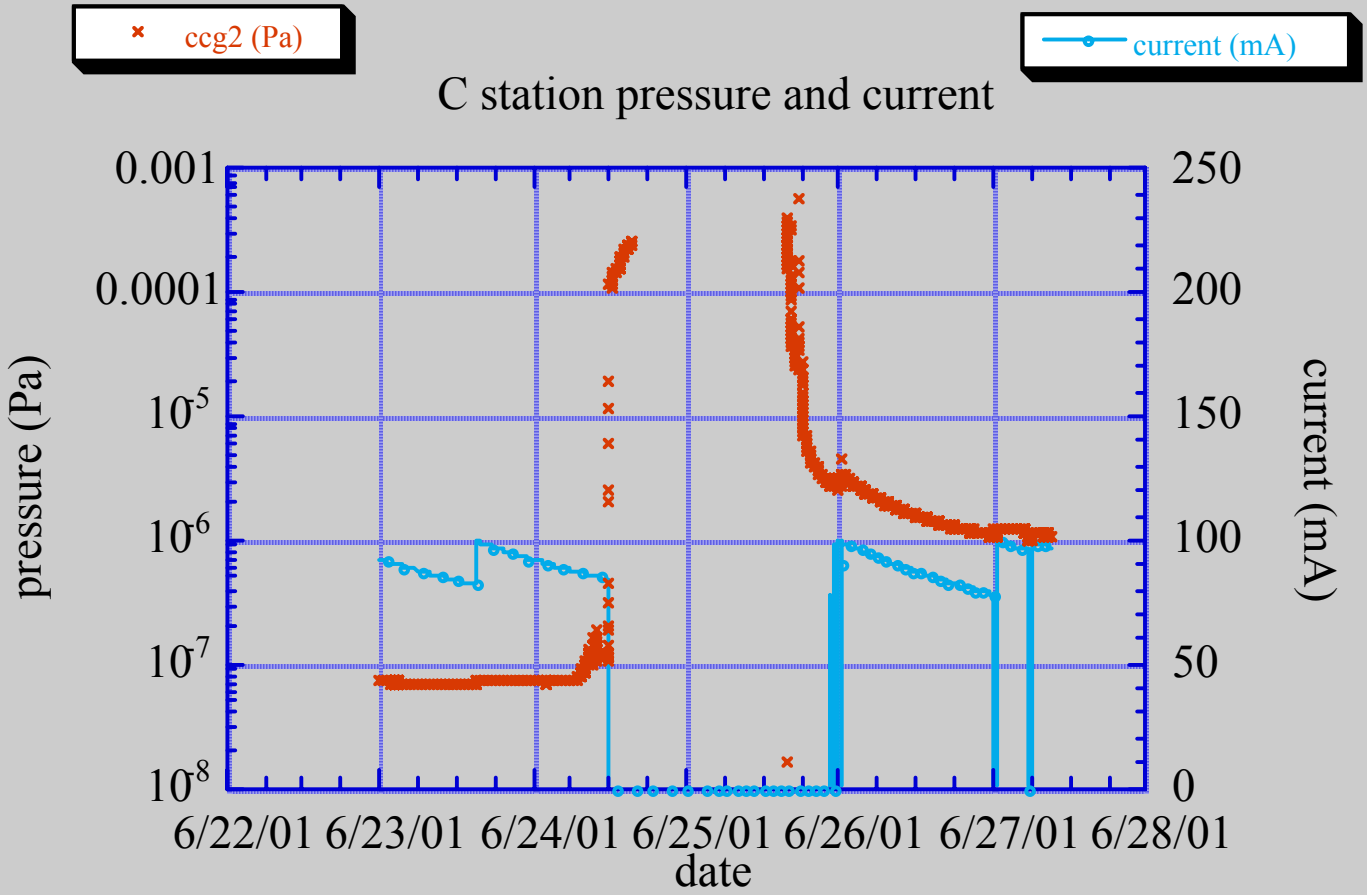
Troubles in 2001

type	failure	fault time(hr)
RF	14	44.7
magnet	10	16.7
beam line	11	10.7
safety	1	6.5
earthquake	1	2.7
lightening	1	1.2
other	5	3.6

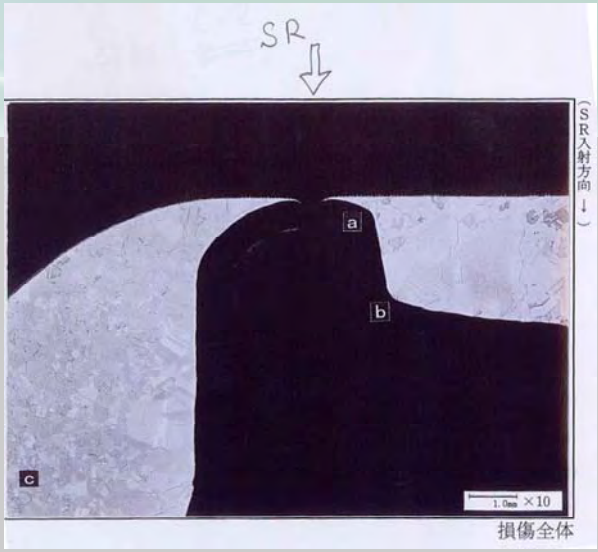
Total down time 87.1hrs ~2% to user time
Mean time between fault 58.4hrs

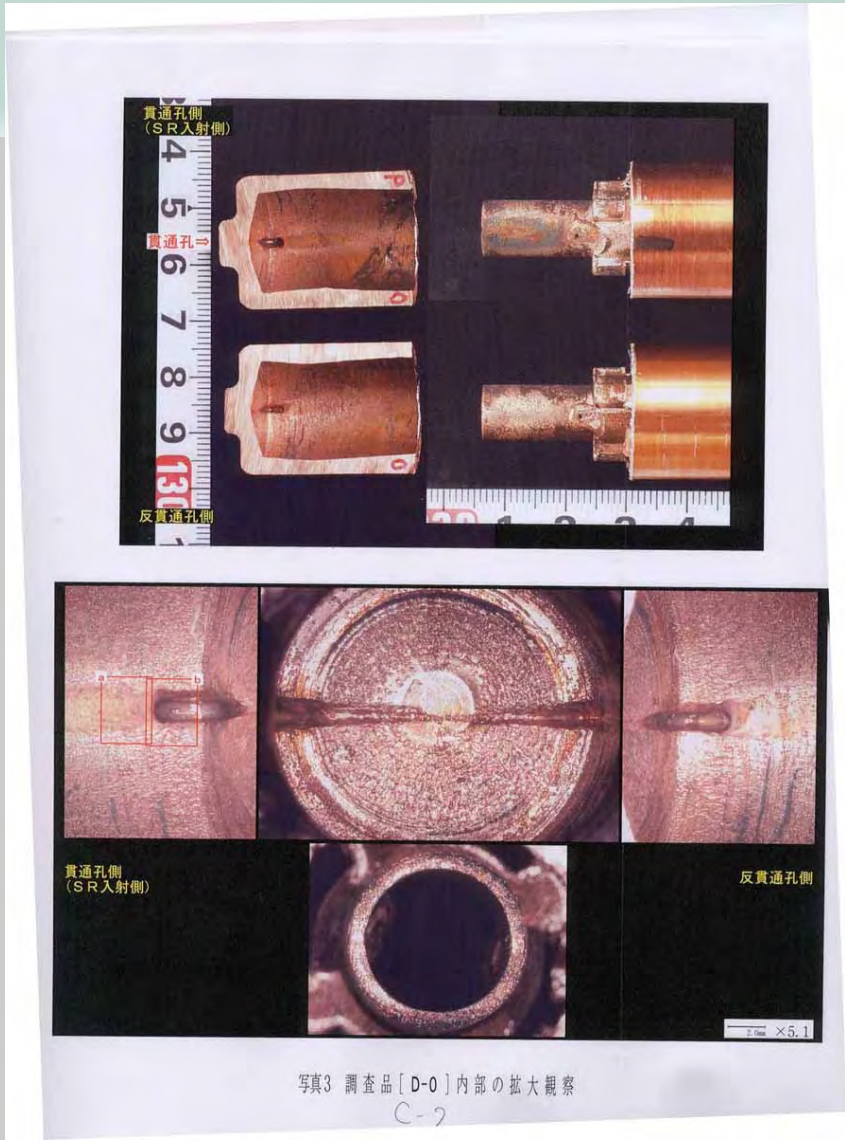
RF		Magbet		beamline	
arc	4	flow sw	6	rfbpm at ID	5
reflection	3	PS err	3	miss operation	1
kly vac	3	water leak from tube	1	vacuum leak	1
kly PS err	2			err in PLC for safety	1
kly over curr	1			air pressure down for GV	1
absorber	1			limit sw of door	1

Water leakage to vacuum from SR absorber of RF station



- Sudden pressure increase -> beam abort
- H_20 was dominant in gas components
- Found leak from absorber and Change to spare
- Down time: 36hr

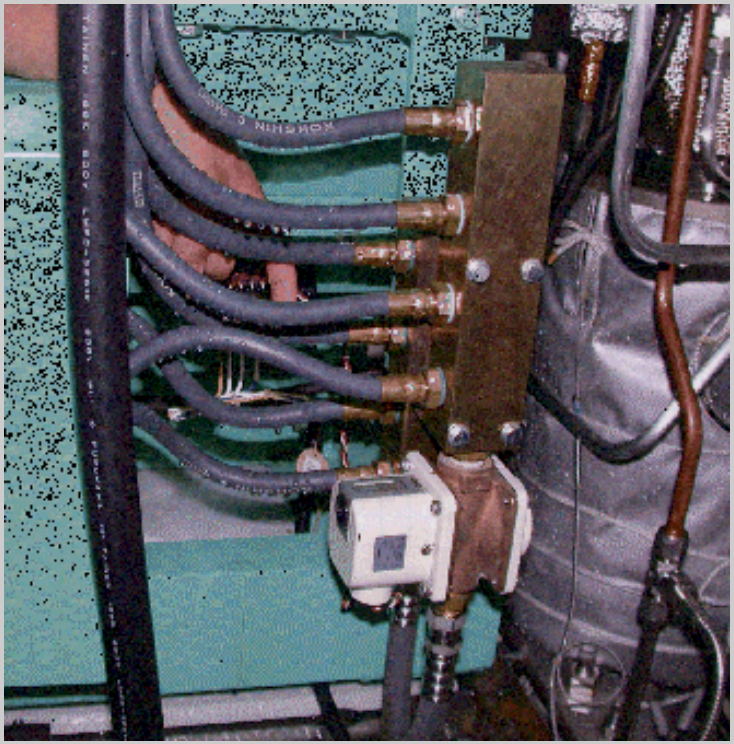




- OFHC+H_2O+SR
  -> corrosion

- Another leak at other station -> early start of summer shutdown
- Replace all absorbers
  at RF section
  with Newly designed absorbers

Water leakage from tube



Cooling water was leaked

from Q magnet

Down time 4.9hrs

Possible sources

*Growth of small cut

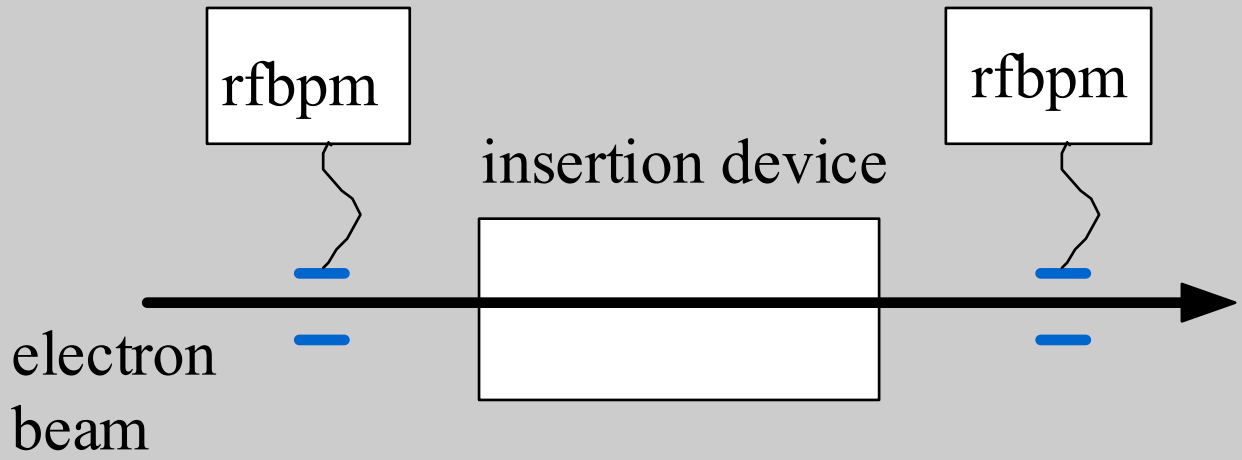
*Radiation damage

near injection point

greater than 10^6Gray for 3 years

radiation shield will be installed

rfbpm at ID section



- prevent SR irradiation of unexpected place

  window : 0.5mm (horizontal) 0.25mm (vertical)

  abort the stored beam within a few ms

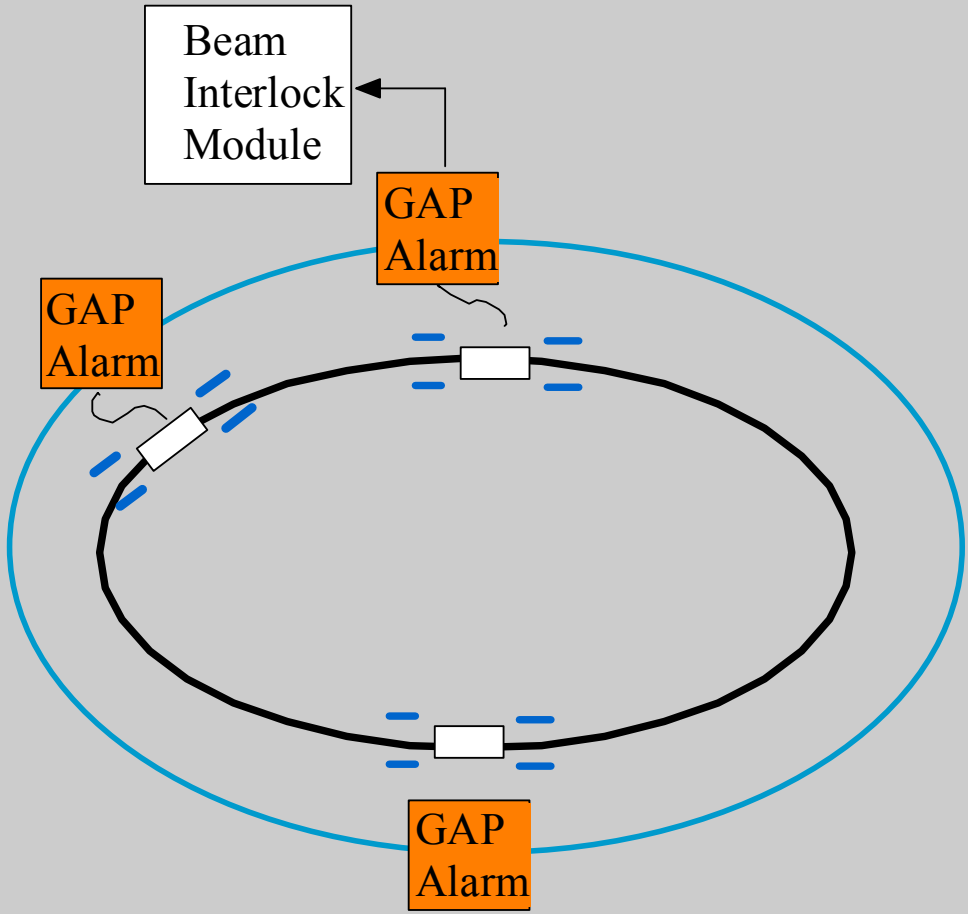
- Work well

  Earthquake

  Orbit drift induced by error in magnets

- 23 IDs are in operation
- Wide bandwidth of rfbpm

-> sensitive to noise



-> new system

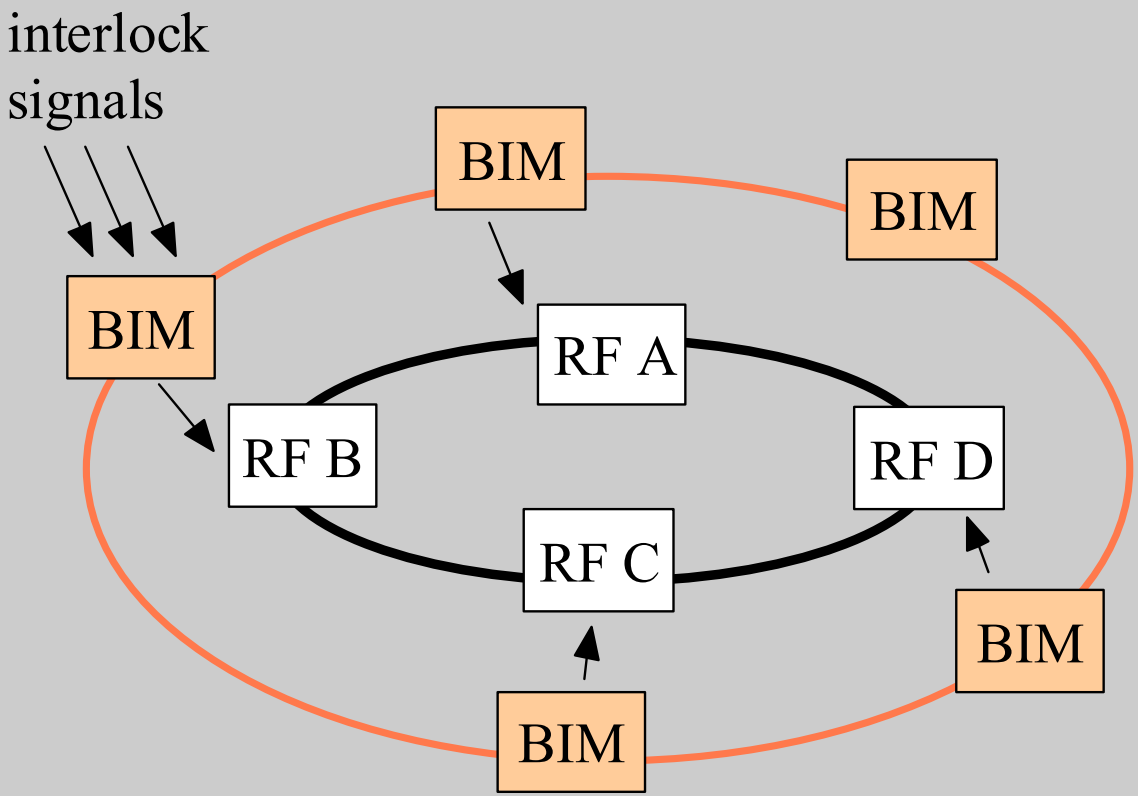
abort when 2 rfbpms fire

Interlock related to accelerator

- Beam Interlock Module (BIM)

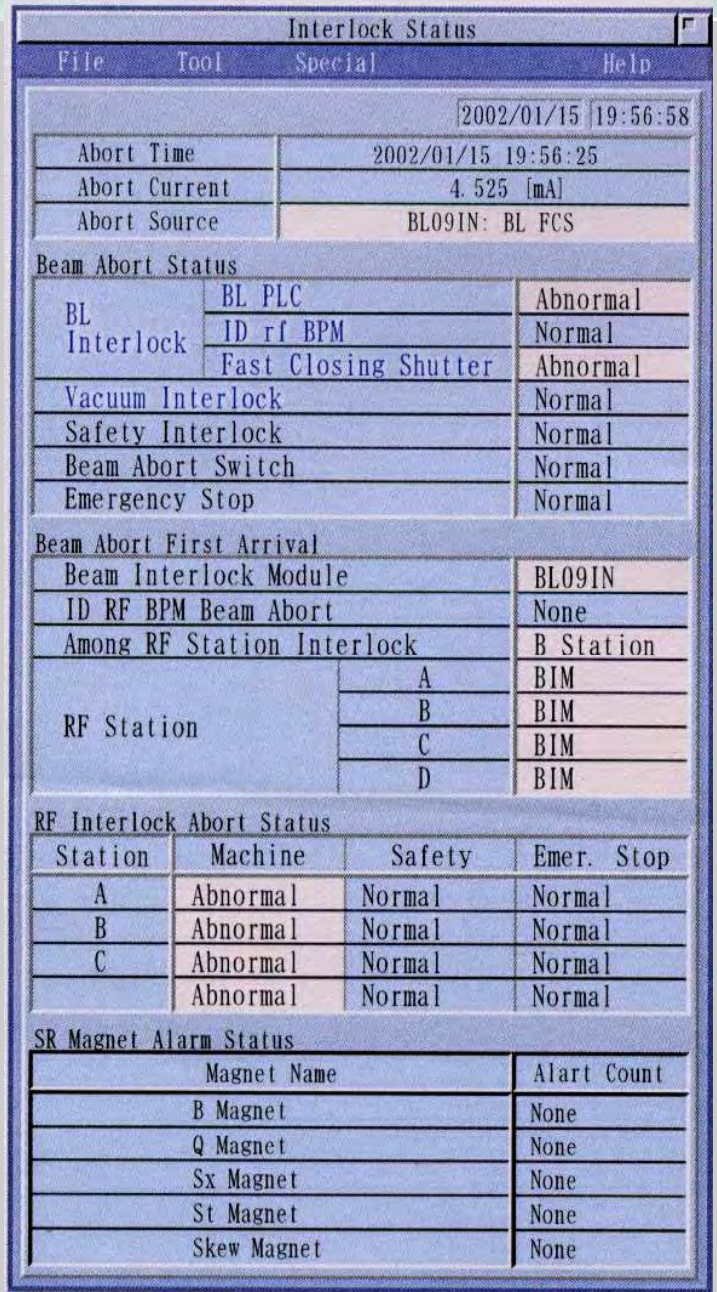
  transfer abort signal to RF stations to cut the power

  distinguish first arrival of interlock signal



Detection of abort source

- All data : saved in Data Base
- Loss of beam ->
  Voice alarm
- Possible source is presented
  in GUI
  Check the interlock signal
  Check which signal arrives first
- Confirmation & Reset interlock
- Restart beam operation



Delay in refill the beam

- Delay in refill was 8hrs in 2001

- Warm-up of injectors:30min before injection
- Linac

  Modulator (thyratron over current ...)
  pressure increase of waveguide or cavity
  Gun (burn out of cable of HV ...)
  Energy drift -> lead to loss of injected beam
  <- energy compensation system
  temperature stabilization of cooling water, waveguide
- Booster synchrotron

  Large reflection from cavity

Conclusion

- Stable operation at SPring-8

  ex. No fault for 335hrs at 10th cycle ‘01 user time
- Some troubles & cure

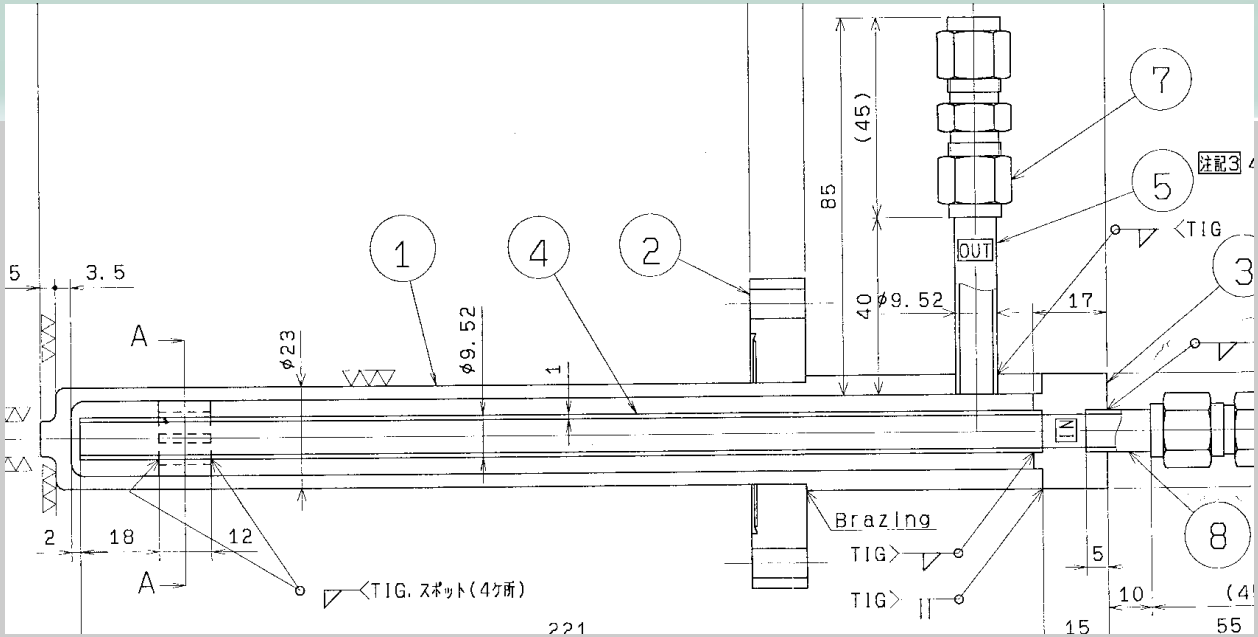
  leak from absorber at RF, water leak from tube of Mag, malfunction of rfbpm of ID . . .
- Detection of abort source

  identify the source within about 15min.
- Reliable => to satisfy user’s request

  reduction of down time

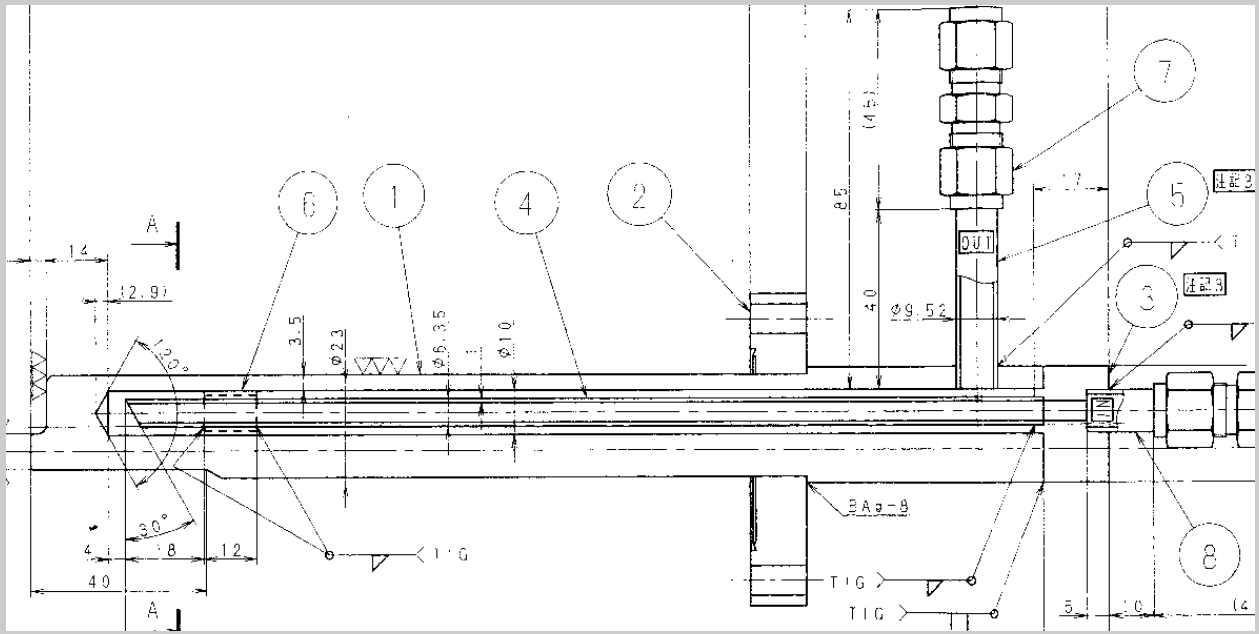
  stabilization of beam orbit

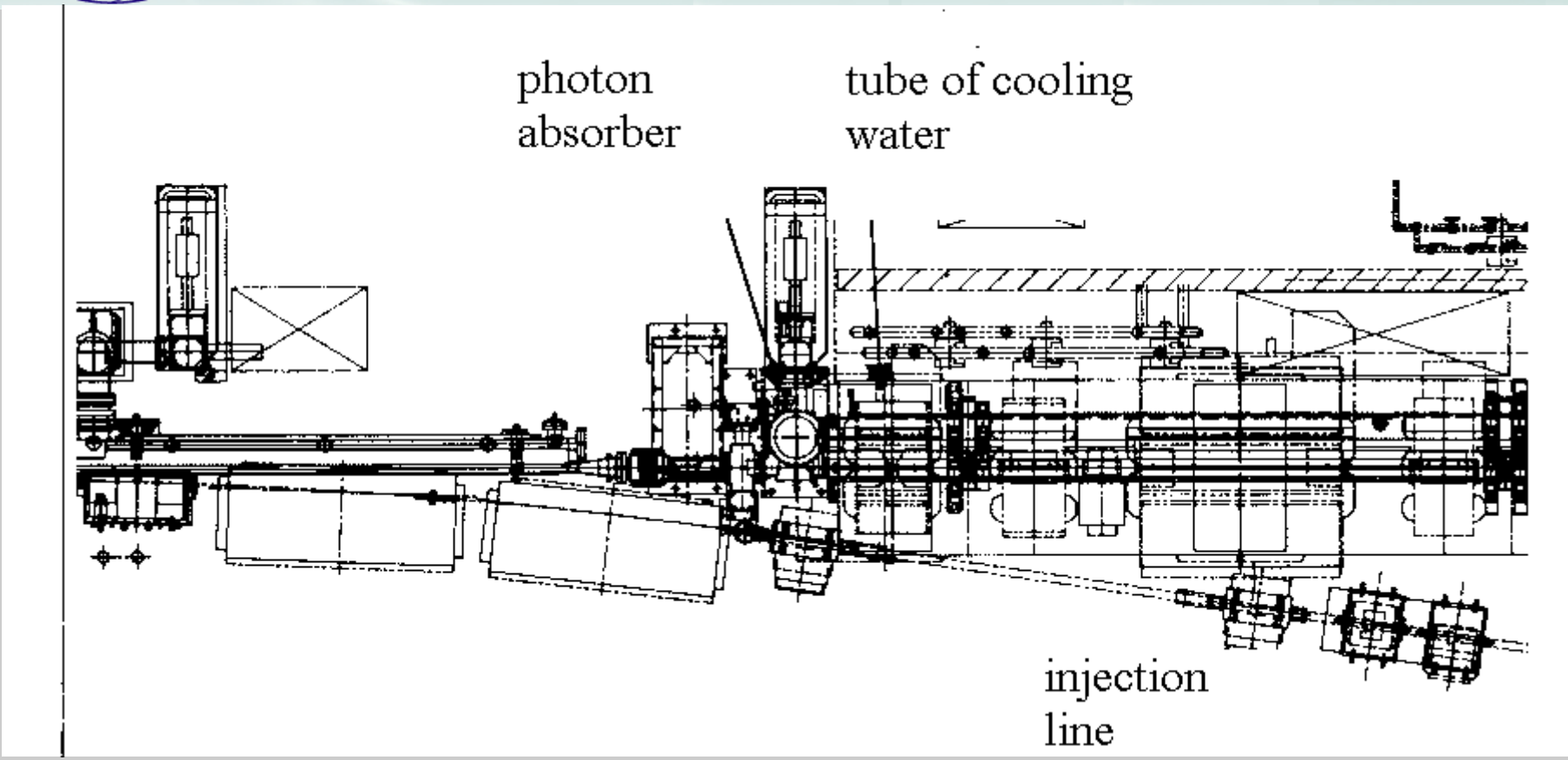
Old design



New design

cooling channel is off the radiation point





- Usually tubes are locate inner side of tunnel
- Near injection point there is no space so the tubing is located outer side

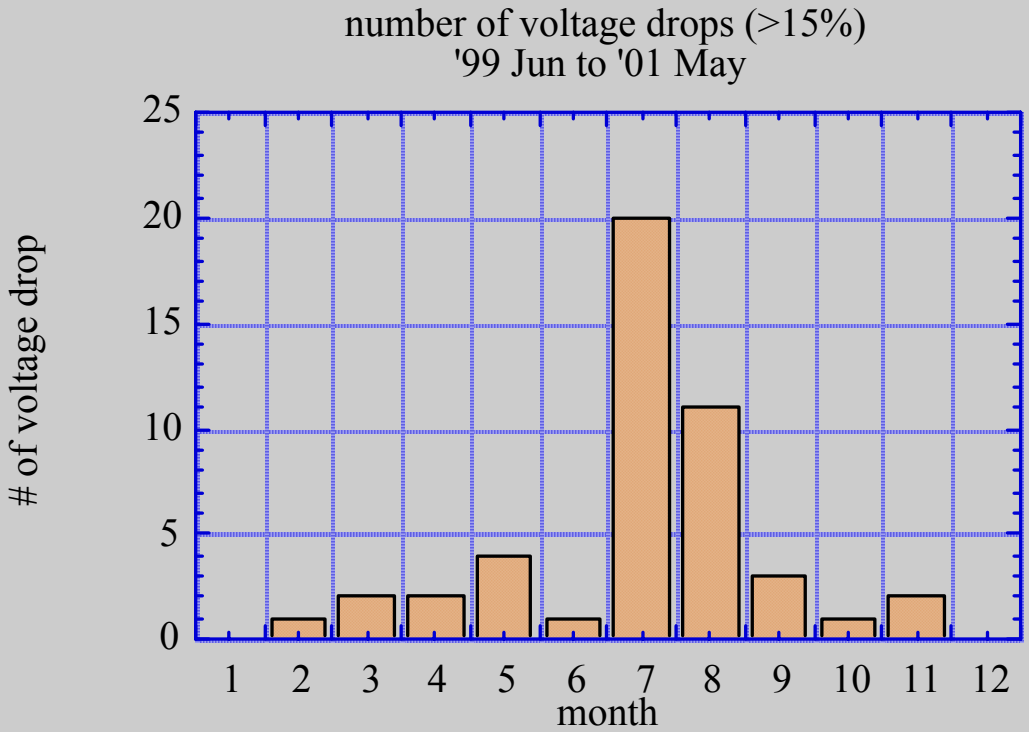
Voltage drop of power line

- Voltage drop

  < 15% ==> No trouble

  > 15% ==> fault in Q PS, cooling pump …

- lightning to electric cable of power company



summer shutdown

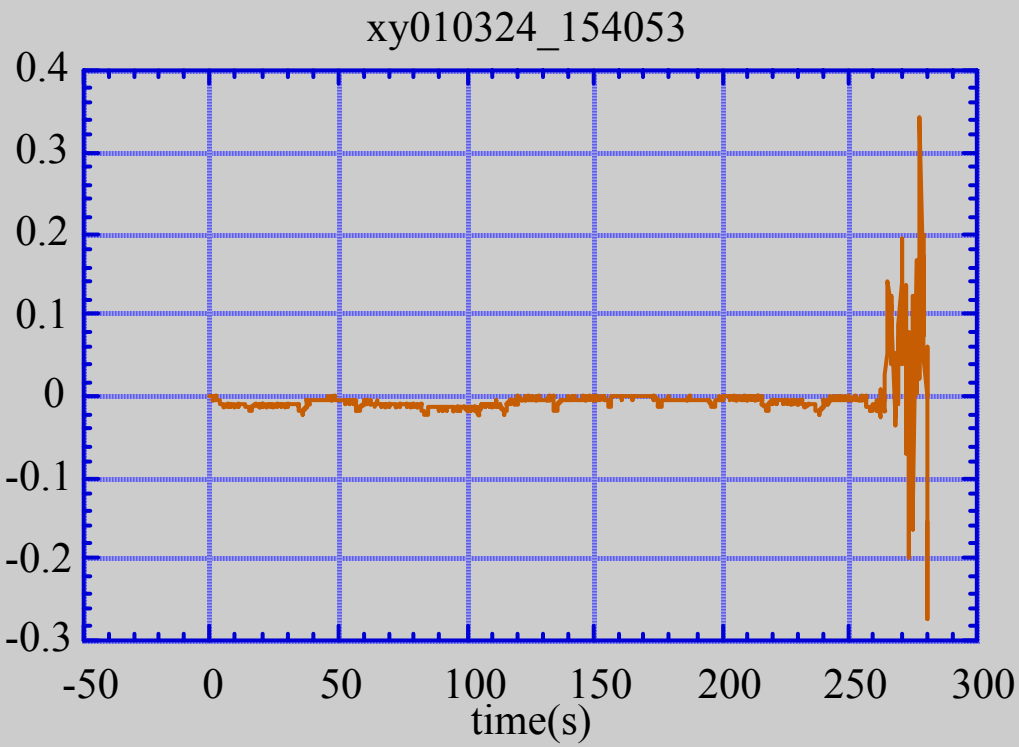
Jul. - Aug.

Down time

‘00 : 2 times 5.0hr

‘01 : once 1.2hr

Earthquake



Ground motion ->

change in circumference

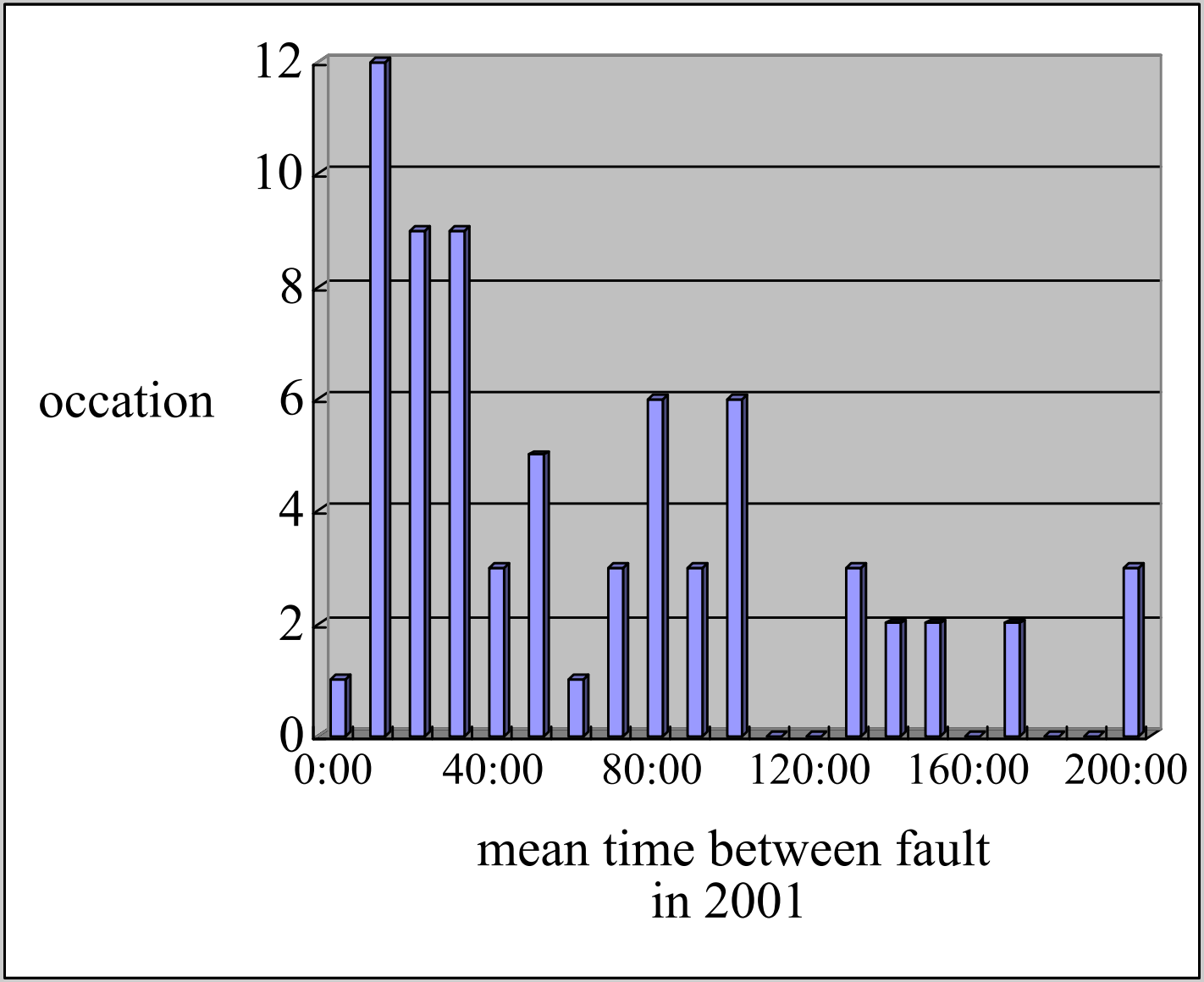
misalignment of magnets

Horizontal beam oscillation

-> abort by rfbpm @ ID

Down time

‘99 May20	1hr	south east of Hyogo	M3.4	
‘00 Oct06	3.2hr	west of Tottori	M7.1	
‘00 Nov16	1hr	New Ireland	M8	(No beam abort)
‘01 Mar24	2.7hr	Geiyo	M6.4	


occation
12
10
8
6
4
2
0
0:00
40:00
80:00
120:00
160:00
200:00
mean time between fault
in 2001