# BEAM LOSS AND RESIDUAL DOSE AT 100KW USER OPERATION IN THE J-PARC ACCELERATOR

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Kazami Yamamoto

J-PARC Center

Accelerator Division

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- RCS loss and residual dose
- MR loss and residual dose
- Summary and answer for the question

# Linac residual dose distribution

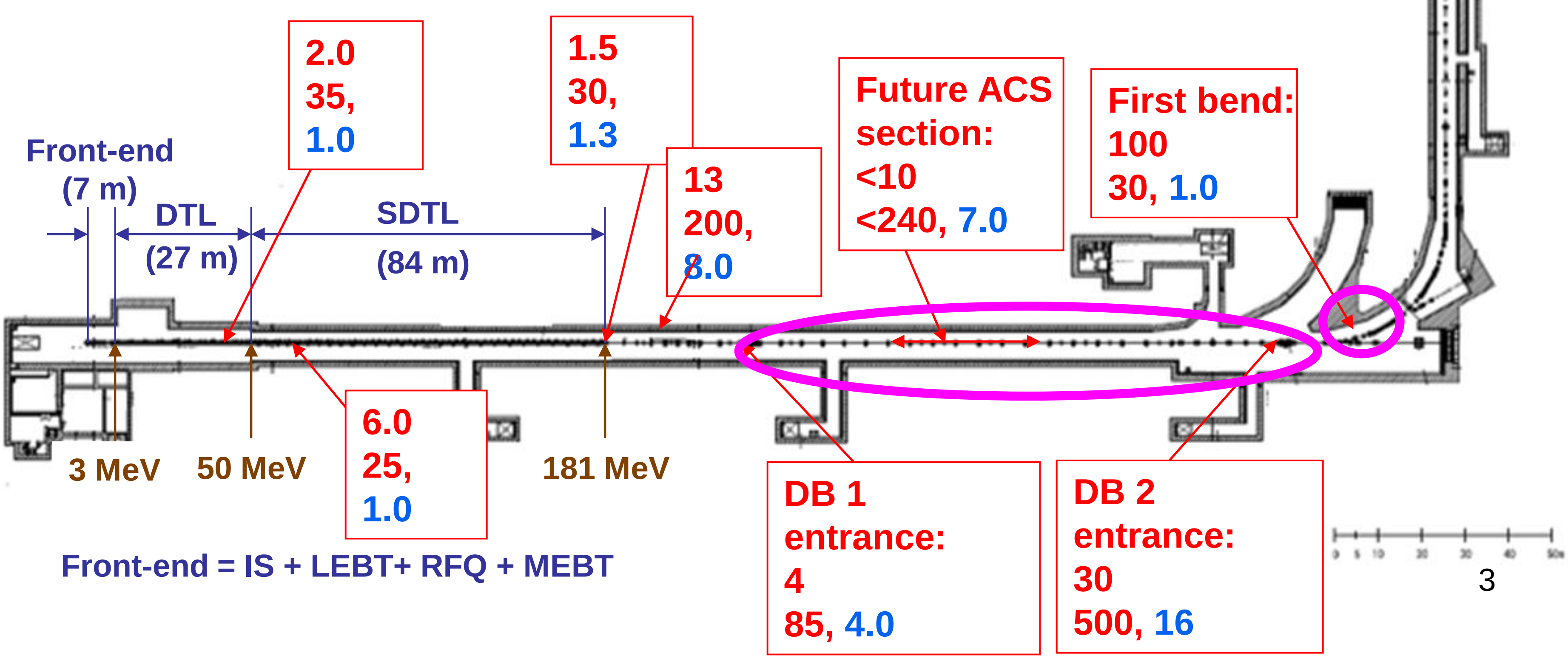
Residual radiation level after beam shutdown

- Top：6 hour after 4.5 kW operation (Dec. 2008)
- Bottom：5 hour after 120 kW operation (July. 2010)

Red: measured at the chamber surface

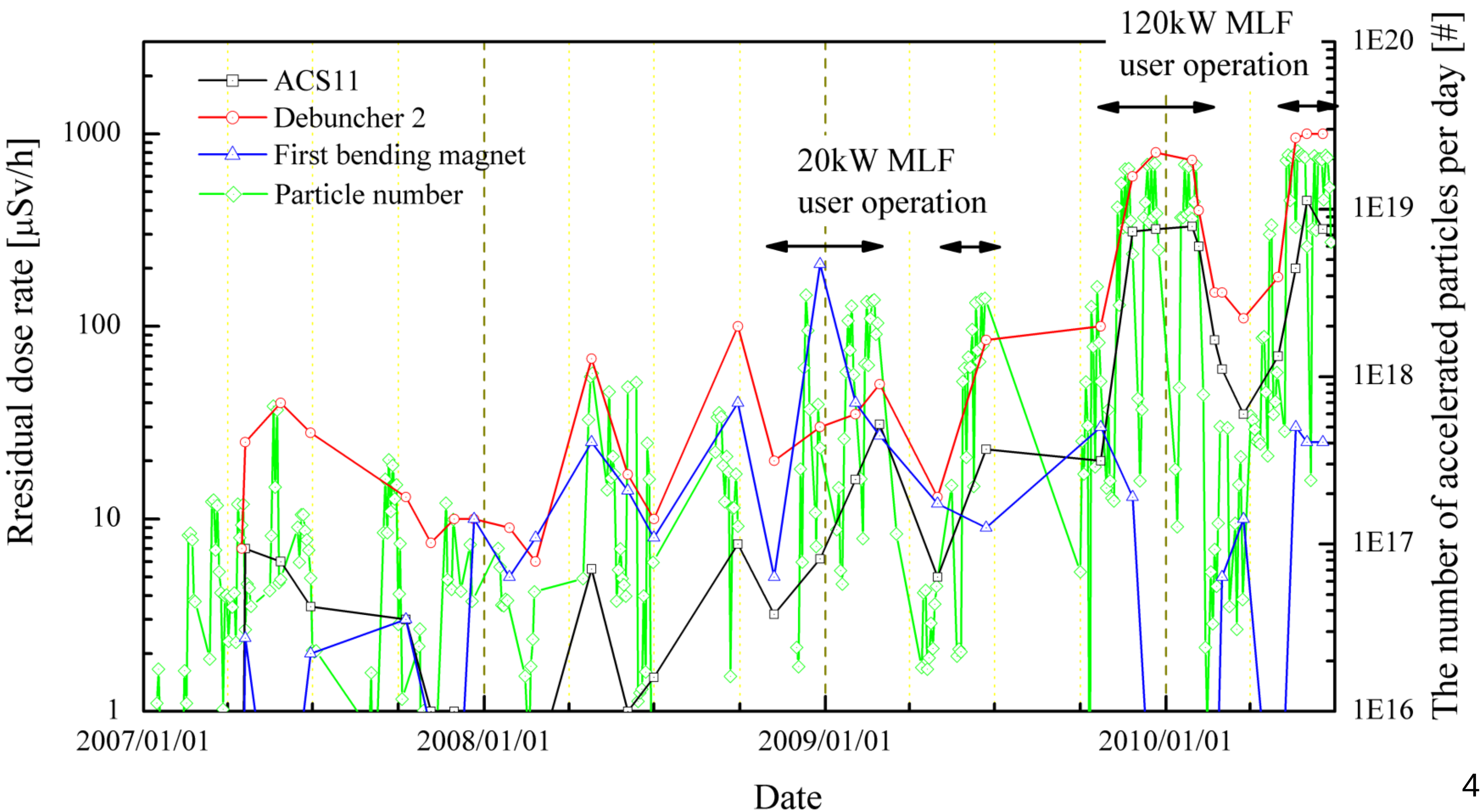
Blue: measured at 30 cm

Unit: μSv/h



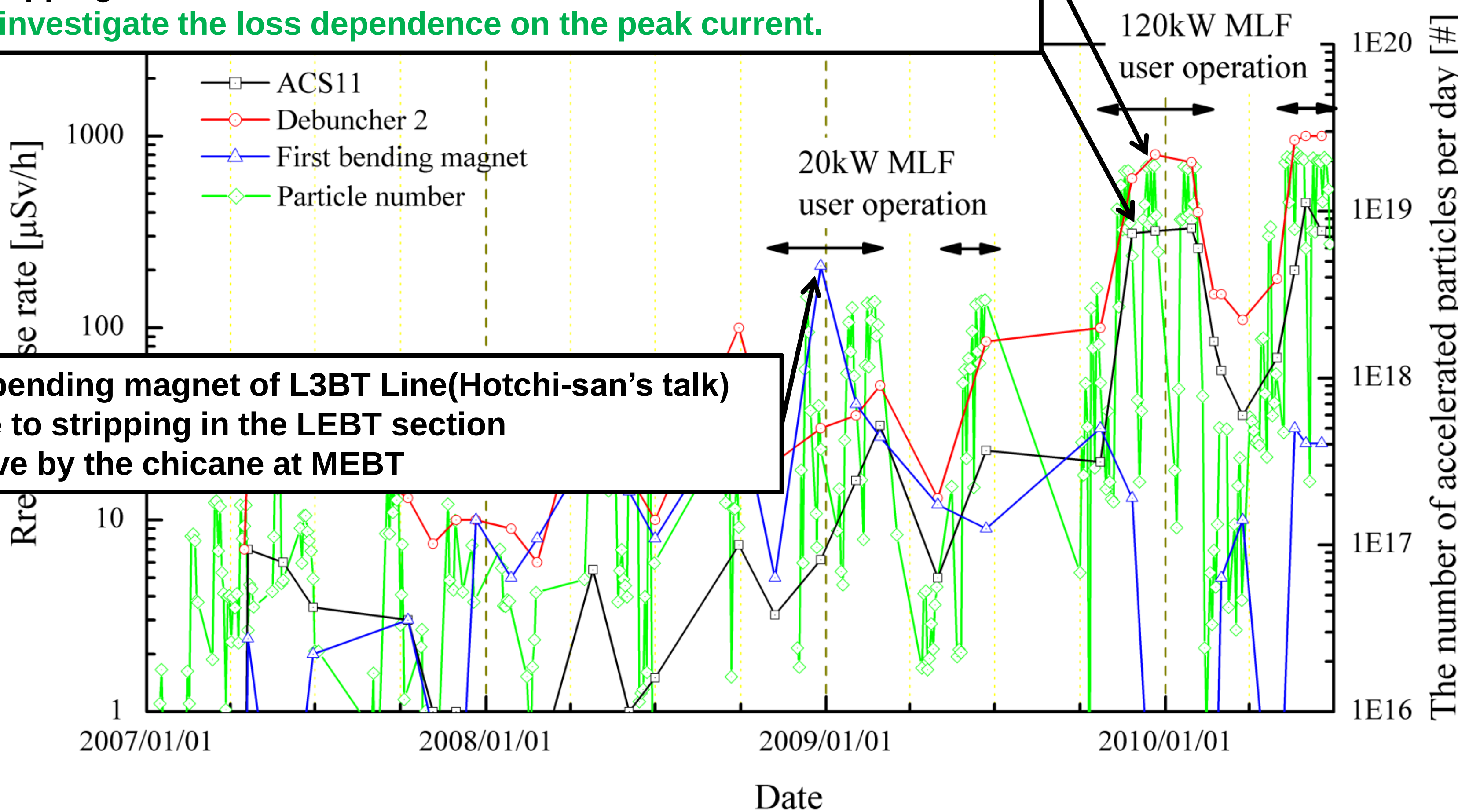

Front-end = IS + LEBT+ RFQ + MEBT

# Linac history of beam power and residual dose



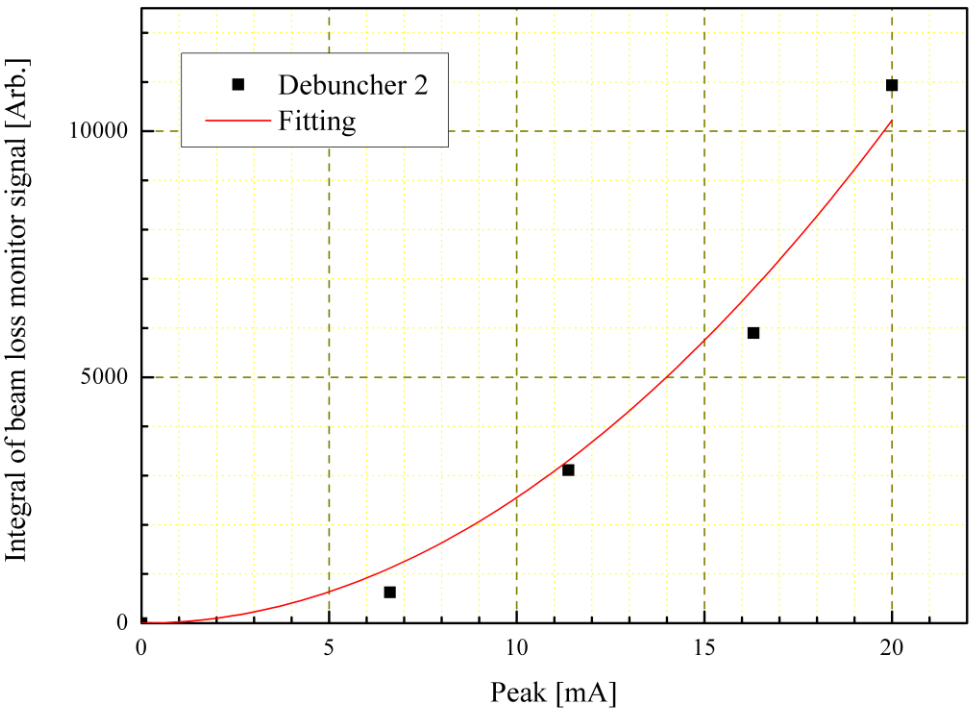
# Linac history of beam power and residual dose

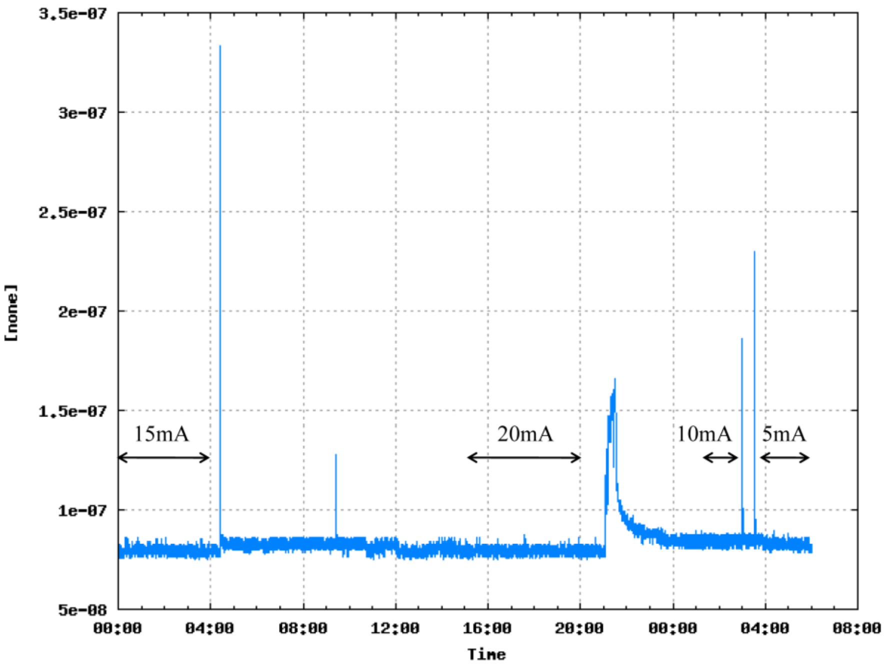
Regarding the loss widely distributed along the ACS section (Hotchi-san's talk)
→Previous study indicated these losses were concern with the residual gas stripping
→We investigate the loss dependence on the peak current.




First bending magnet of L3BT Line(Hotchi-san's talk)
→Due to stripping in the LEBT section
→Solve by the chicane at MEBT

# Peak current dependence




The pressure barely changed during this experiment.

If the loss was due to the stripping by the residual gas, it linearly depends on the peak current when the pressure was constant.

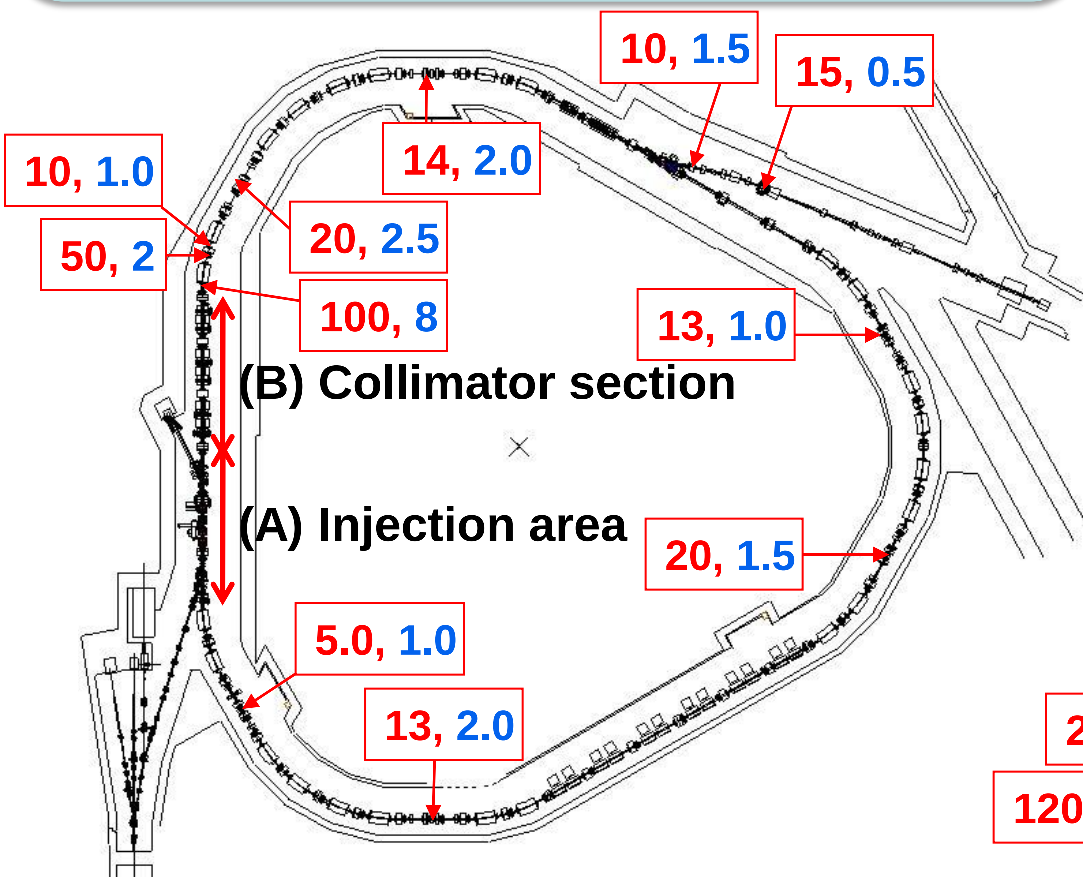
On the other hand, if the loss was due to the intra-beam stripping, it depends on the square of the peak current.

BLM signal seemed to depend on the square of the peak current.

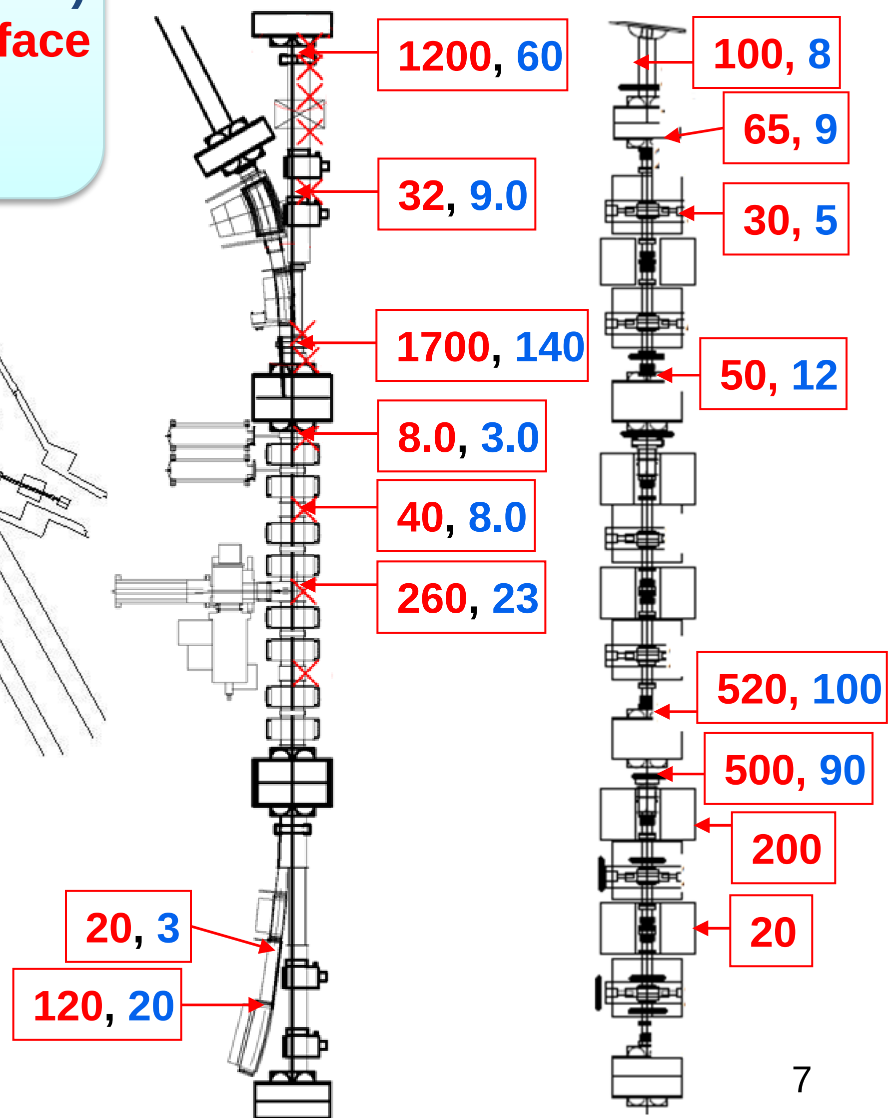
This result indicates that there is a possibility of the intra-beam stripping.

# RCS residual dose distribution

Residual radiation level after beam shutdown
- 5 hour after 120kW operation (July, 2009)
  - Red: measured at the chamber surface
  - Blue: measured at 30 cm
  - Unit: μSv/h




(A) Injection area (B) Collimator section



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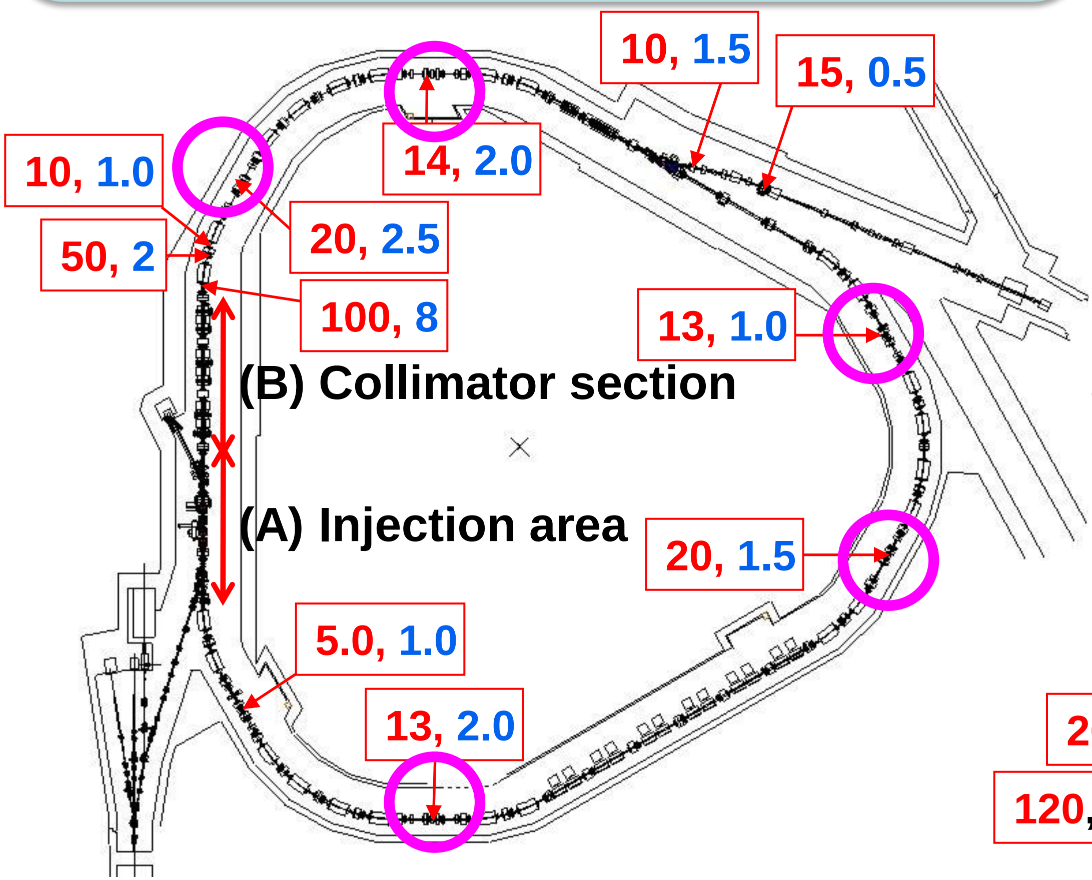
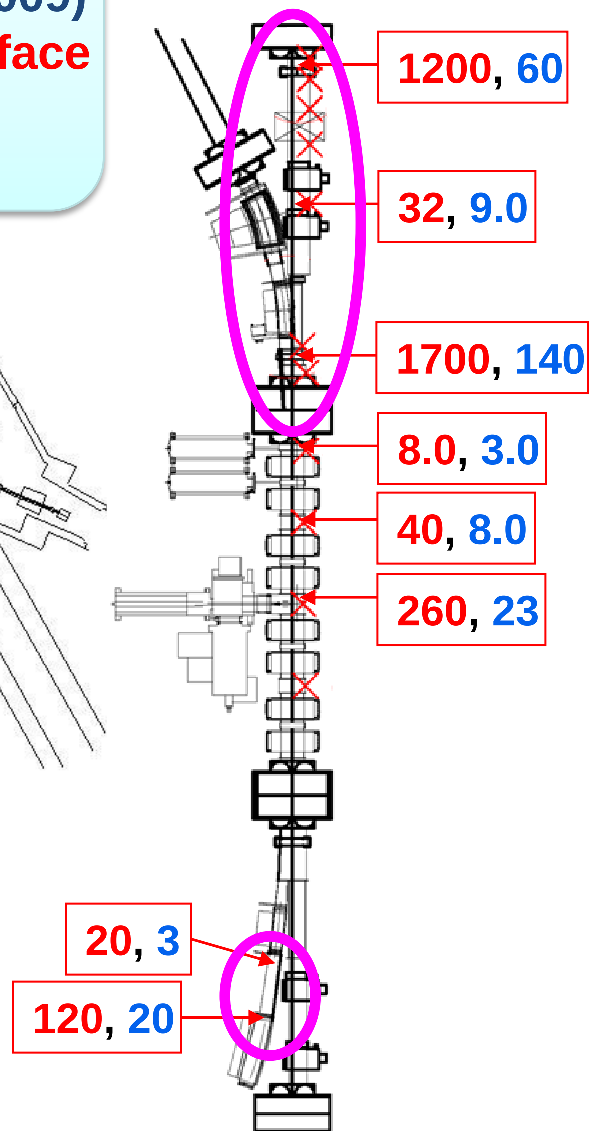
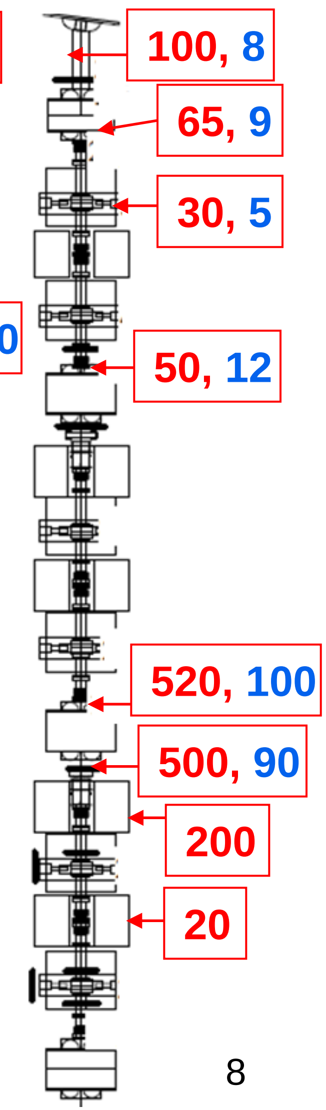


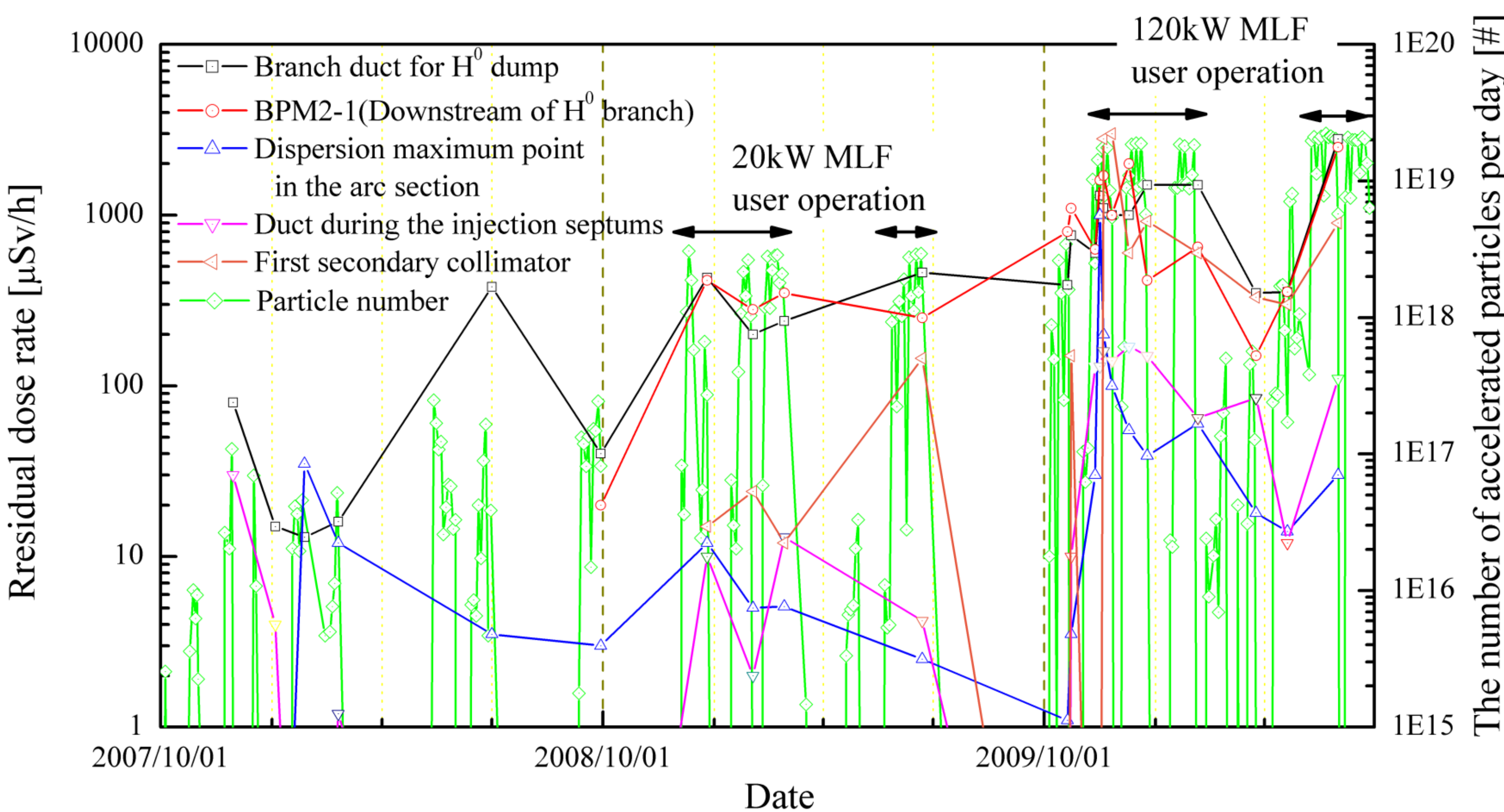

(A) Injection area




(B) Collimator section



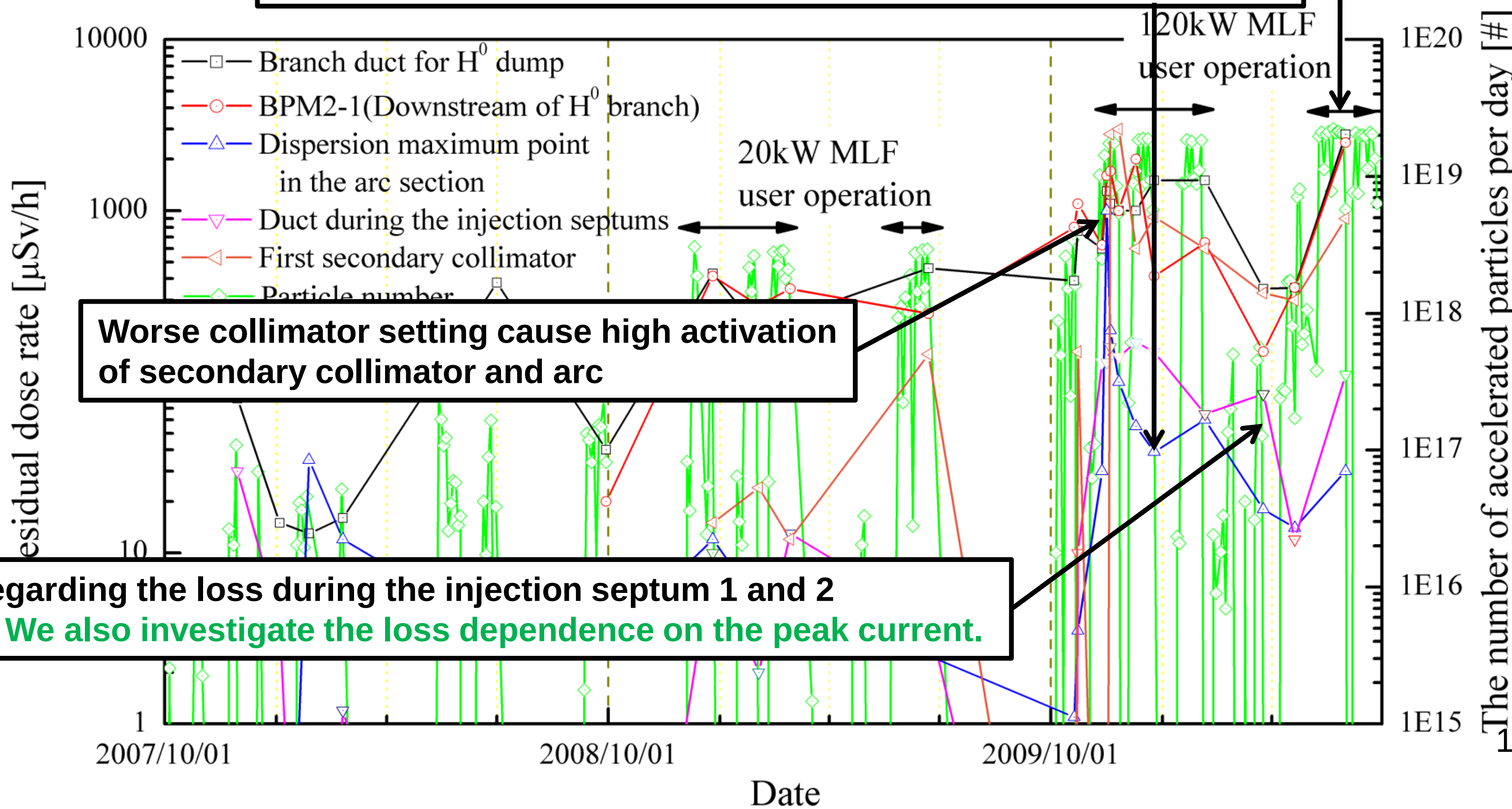
# RCS history of beam power and residual dose



# RCS history of beam power and

Branch duct of H0 dump line and downstream BPM (Hotchi-san and Saha-san's talk)
→ Due to foil scattering
→ Solve by the minimized foil and additional collimator installation.

Dispersion maximum point (Hotchi-san's talk)
→ Due to insufficient chromatic correction.
→ Solve by the AC sextupole power supply

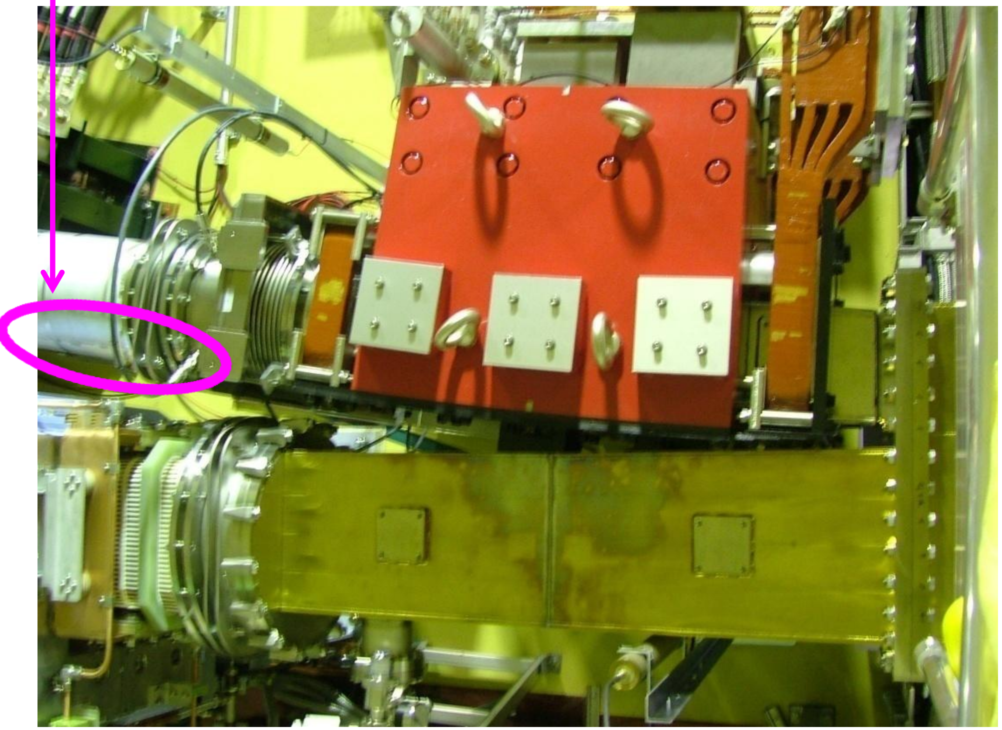


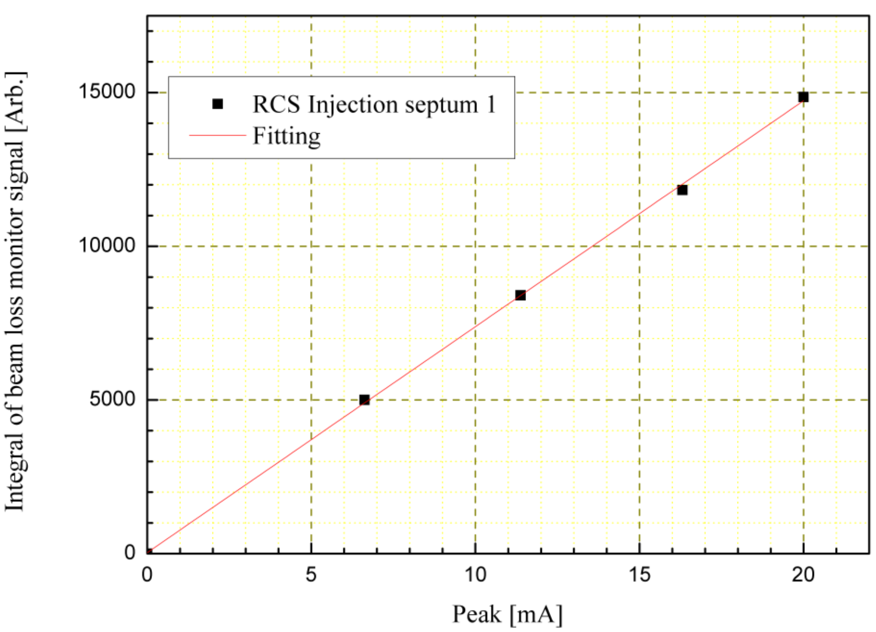

Worse collimator setting cause high activation of secondary collimator and arc

Regarding the loss during the injection septum 1 and 2
→ We also investigate the loss dependence on the peak current.

# Peak current dependence

The residual dose could be observed only at the opposite direction of the injection (H-) beam orbit of the chamber.
We considered that the beam loss was probably caused by the charge exchanged particles which was similar to the linac case.
However, loss signal indicated that the loss at the injection septum depends linearly on the peak current.
This result was quite different from the linac case.





# Comparison of the residual dose near the foil between SNS and J-PARC

The highest activation point is different between SNS ring and J-PARC RCS.
In the SNS, highest activation point is a foil chamber(about 8mSv/h@30cm and 15mSv/h on contact)
In the J-PARC, the dose rate of foil chamber is less(about 23μSv/h@30cm and 260μSv/h on contact)

The ratio of beam power is about 10, but ratio of the residual dose is more than 100!

We calculated the neutron flux from the foil by GEANT4, and it indicated that SNS case makes 4 times more neutrons than J-PARC case.
（Some pion also produced but mainly neutron）
It depends on the foil thickness and Injection energy.
(350μg/cm$^2$,1GeV for SNS and 200μg/cm$^2$,181MeV for J-PARC).

# Comparison of the residual dose near the foil between SNS and J-PARC(con't)

SNS :The hit number of proton per 1 sec is
1e14(ppp of 1MW operation)) * 10(The average number of foil hits) * 60(repetition) = 6e16

J-PARC: the hit number of proton per 1 sec is
1e13 (ppp of 120kW operation)* 9(The average number of foil hits) * 25(repetition) = 2.25e15

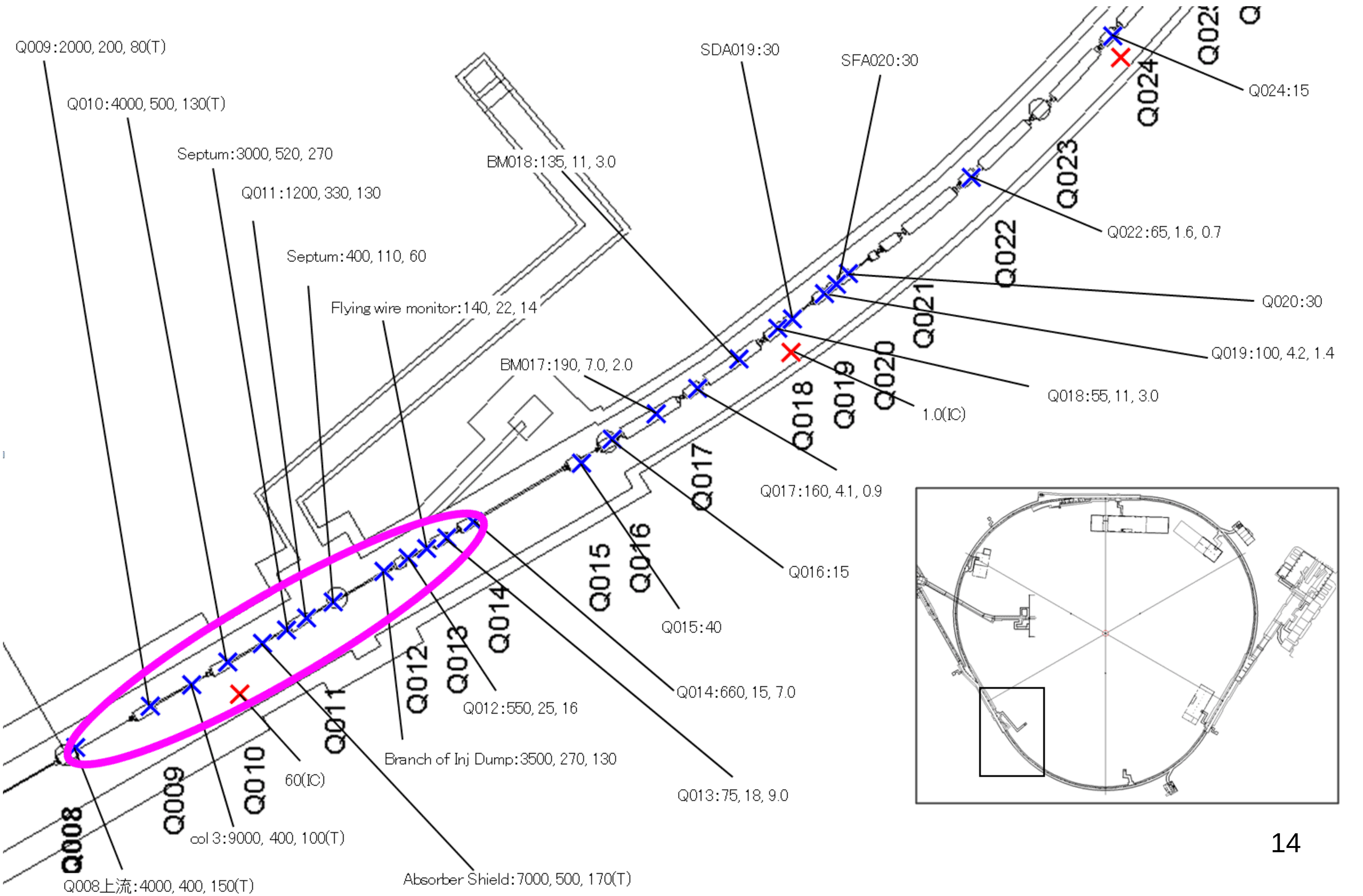
If we multiply the hit number of SNS by the ratio of produced neutron number, 4,
We can get the relative neutron flux of SNS as 2.4e17
and the relative neutron flux of J-PARC RCS as 2.25e15

→almost same as the ratio of the residual dose on contact.

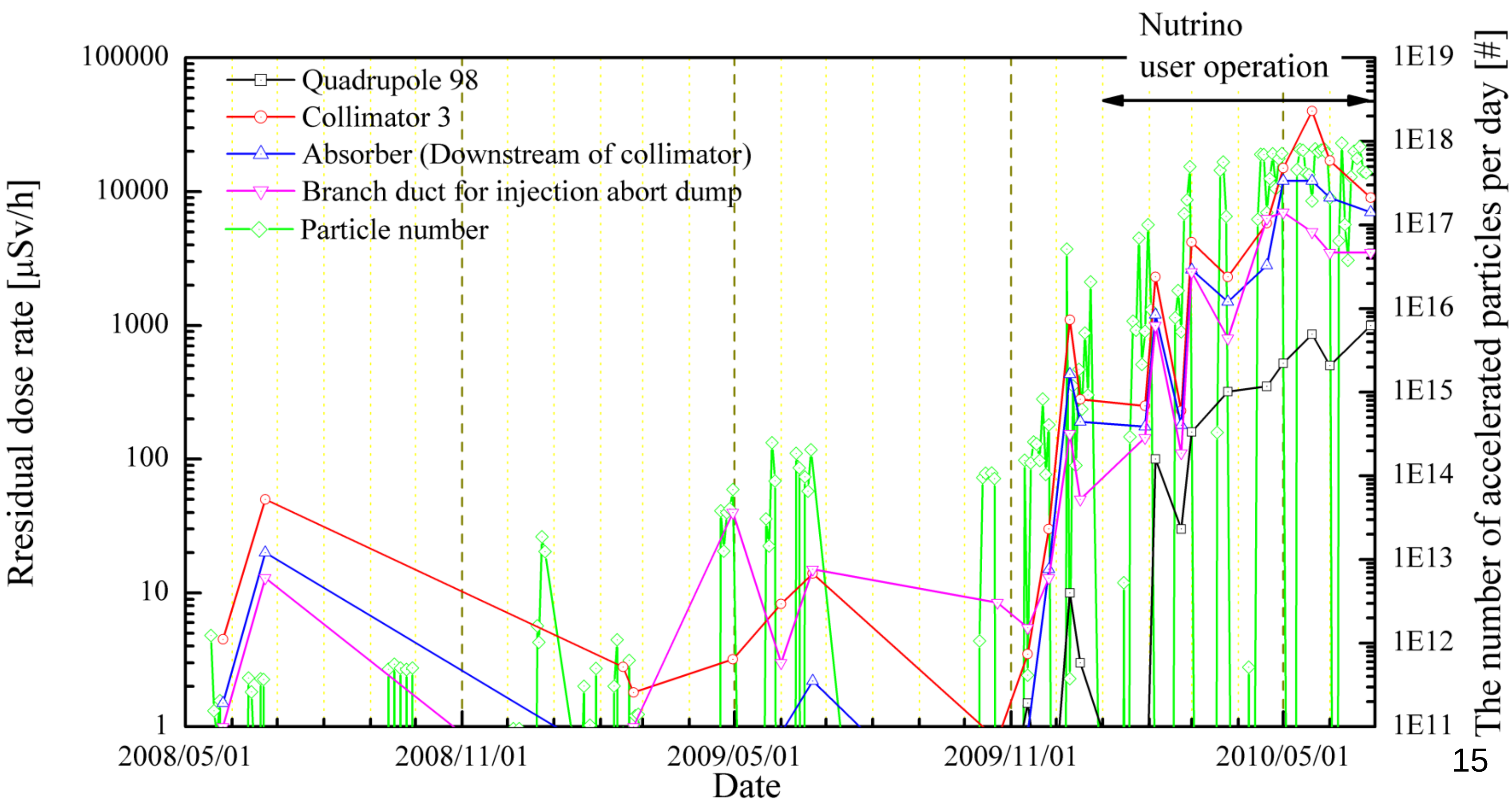
Regarding the residual dose @30cm, J-PARC foil chamber is covered with the injection bump magnets and it seems like a radiation shielding.

So the ratio of the residual dose @30cm becomes more than 100.

# MR residual dose distribution



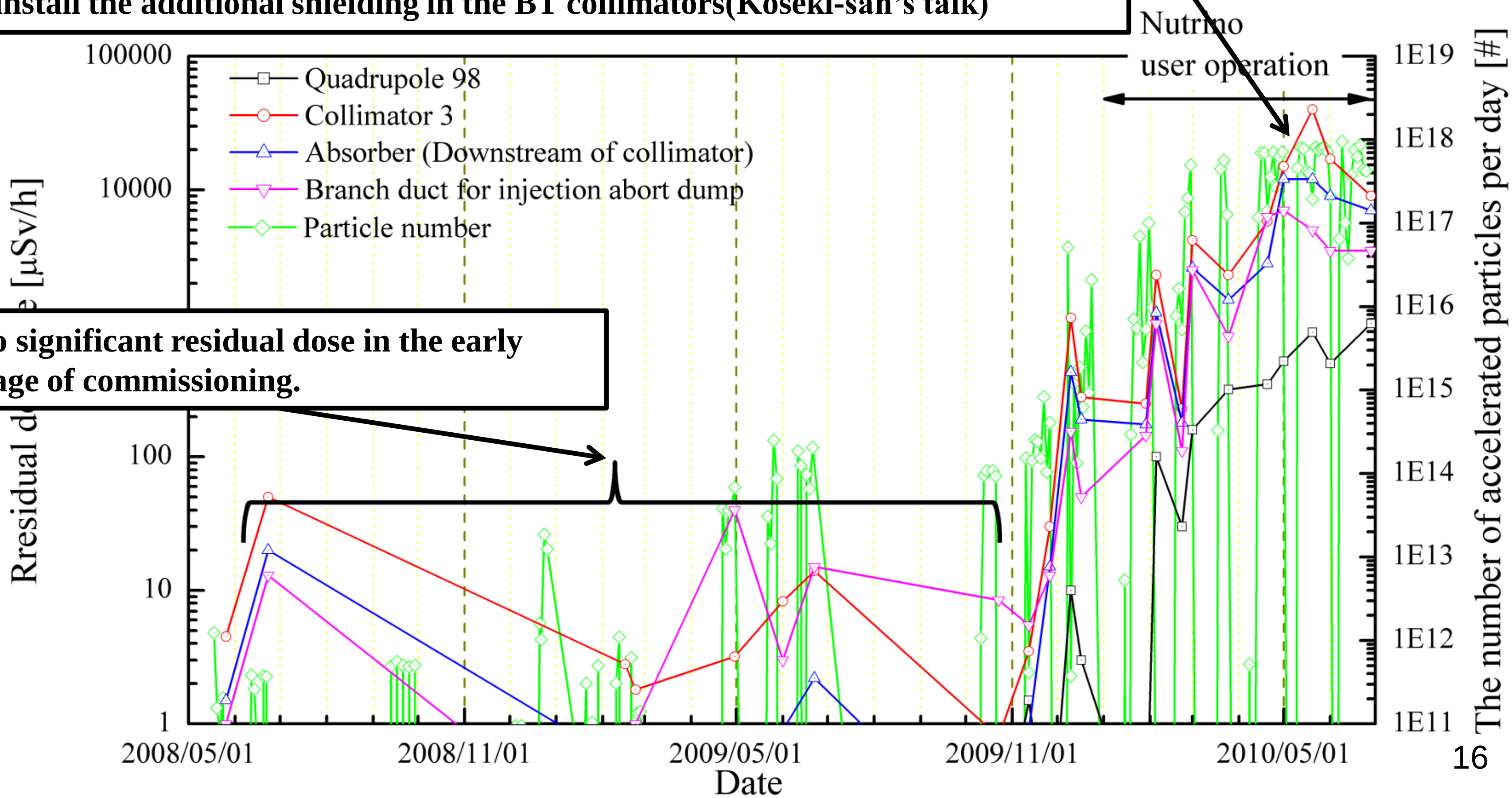
# MR history of beam power and residual dose



# MR history of beam power and

**The collimator section and the branch duct of injection abort dump have had higher dose rate since start of user operation for T2K experiment.**
**→Due to insufficient halo removal at BT collimators and narrower aperture of the branch duct of the injection abort dump**
**→ To replace the branch duct of injection abort dump with a wider one and to install the additional shielding in the BT collimators(Koseki-san's talk)**

**No significant residual dose in the early stage of commissioning.**



# Summary

- Linac:

-Widely distributed loss along the ACS section

->Awaiting solution

- RCS:

-Loss at the downstream of the injection point caused by the foil scattering

->taking measures

-Loss at the dispersion maximum points in the arc section due to insufficient chromatic correction

->taking measures

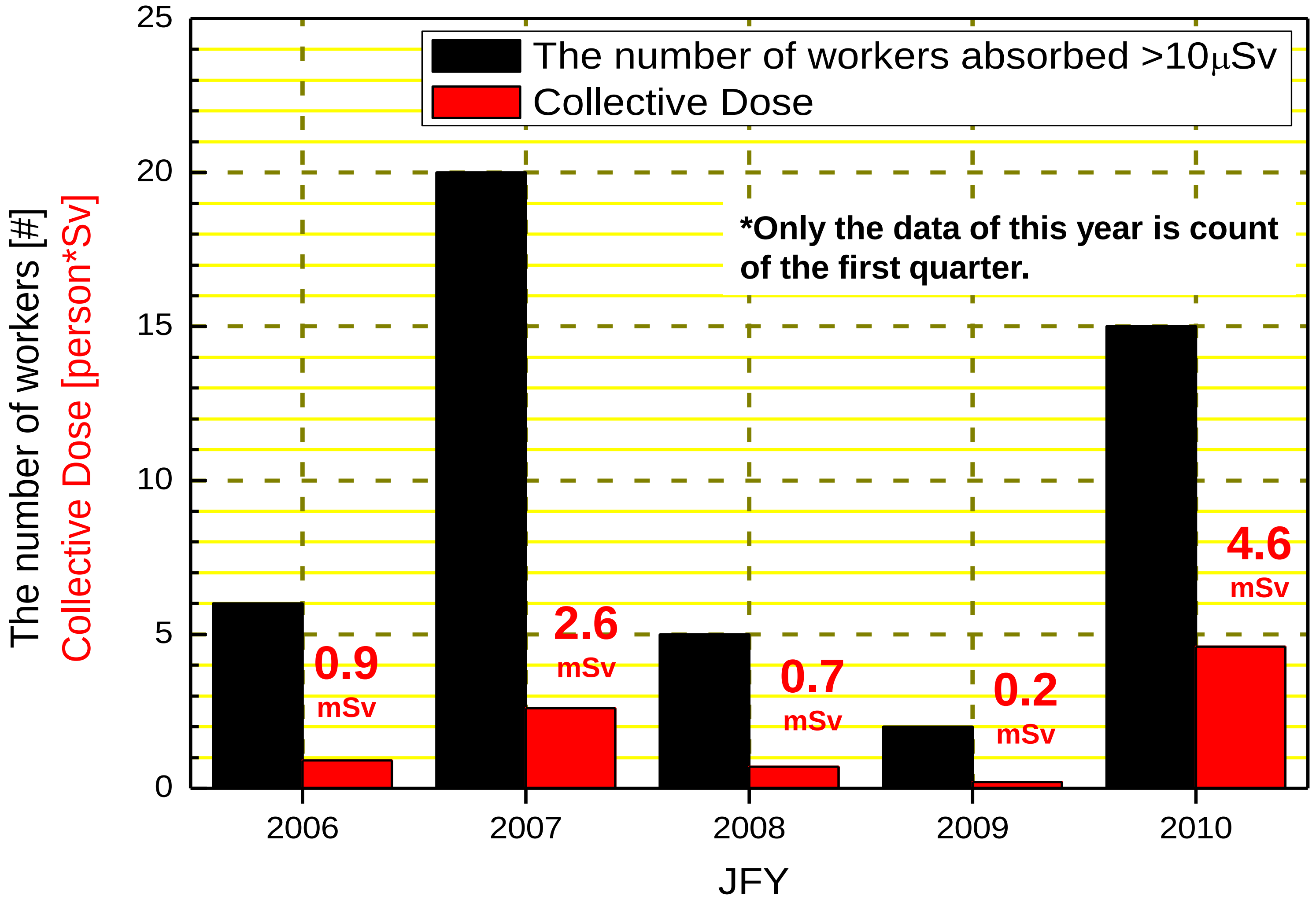
-Loss during the injection septums->Awaiting solution

- MR:

-Loss at the collimator section->taking measures

# Beam loss

## Q- what are the work-force annual dose ?



# Beam loss

## Q- what are the work-force annual dose ?

Dose of fist quarter of this year in J-PARC

| Area | The number of worker who was absorbed > 10μSv | Collective dose | Maximum dose per |
|---|---|---|---|
| MR | 2 | 0.5 Person･mSv | 0.3 mSv |
| HD | 12 | 4.0 Person･mSv | 0.9 mSv |
| NU | 1 | 0.1 Person･mSv | 0.1 mSv |

*Only the data of this year is count of the first quarter.

Dose of accelerator member was negligible!

# Beam loss

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Dose of accelerator member was negligible!

# MPS

Q- what are the machine protection requirements, with respect to beam shut-down?

Linac, RCS

->MPS system stops the RF of RFQ before next beam(less than 20msec from the MPS signal)

->Practically MPS signal passes faster and beam is stopped in the middle of acceleration. But existing beam is accelerated and extracted.

MR

-> MPS system starts abort kicker and extract.

->Existing beam is aborted.

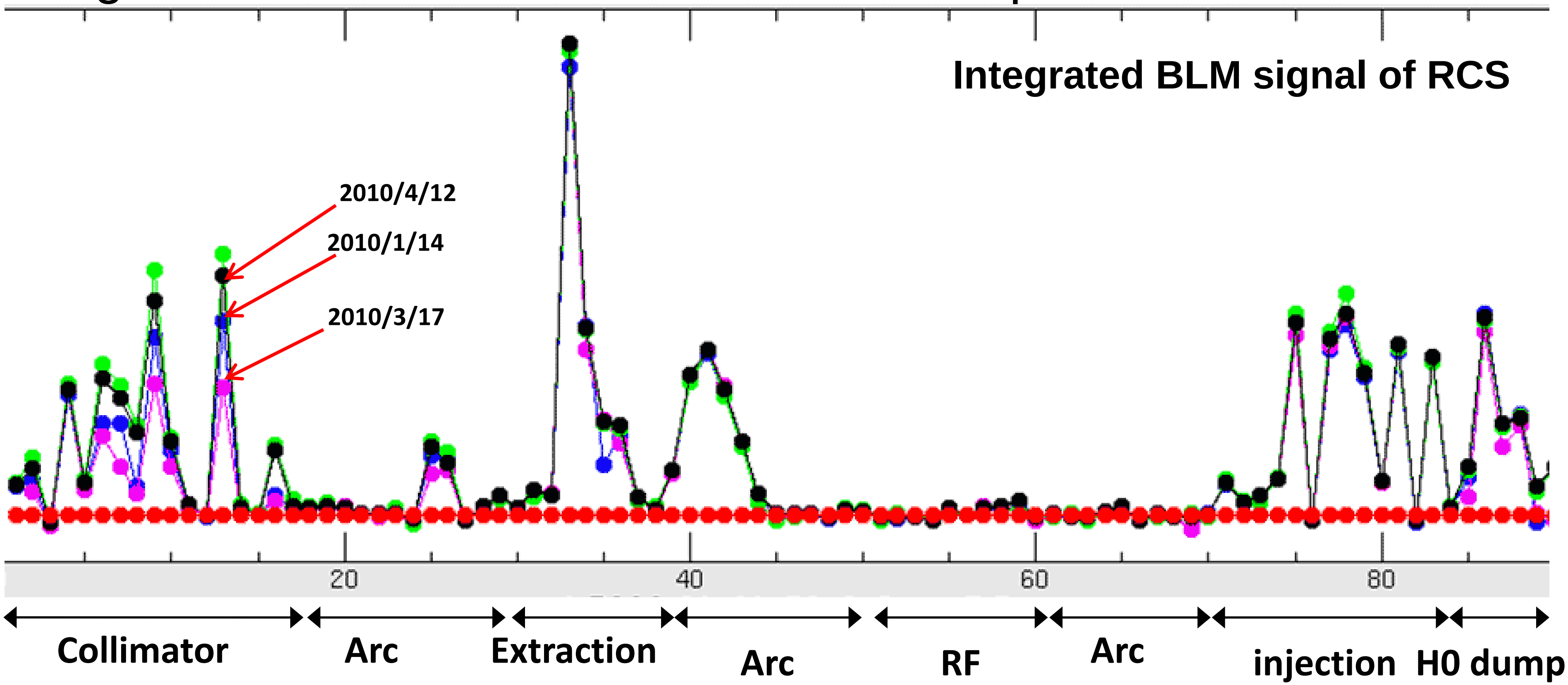
**So far, when MR alerted during supply for both facilities, supply for MLF is also stopped. In this summer, we improved MPS system. Now the only trigger, which extracts a beam from the ion source for MR, is shifted when MR alerted. This desynchronizes the only beam for MR with RF excitation timing of the linac and prevents the beam from accelerating. We can continue to provide a proton beam to MLF when MR alerted.**

# MPS

Q- how is control of residual activation dealt with? E.g. , the same system as above ?

Residual activation level is controlled by the MPS alert from BLM.

Limitation level of the BLM signal is decided by comparing BLM signal level with the residual dose after operation.

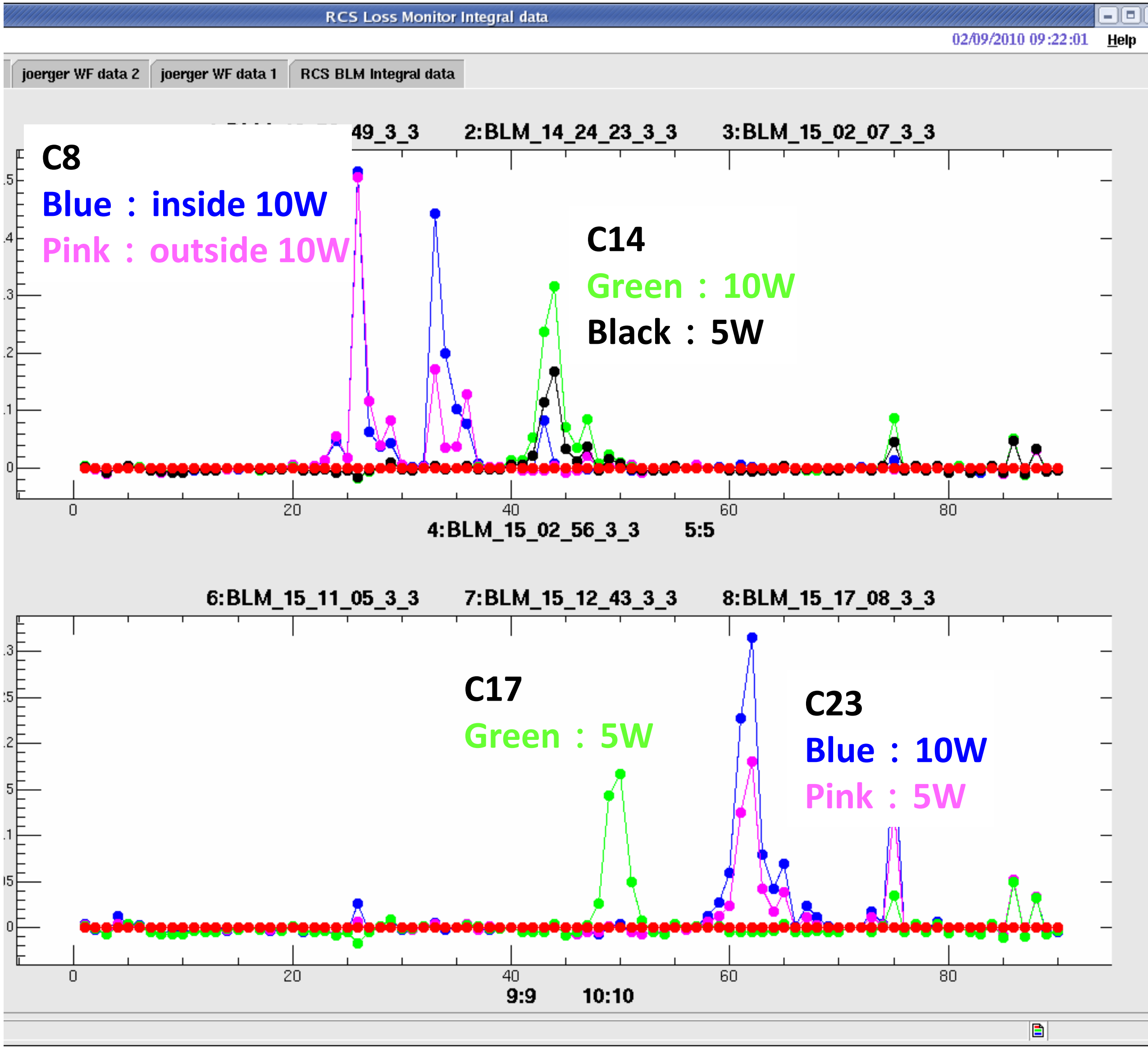


# MPS

## Q- how is control of residual activation dealt with? E.g. , the same system as above ? （Con’t)

**Limitation level is also decided by the study of intentionally loss. These are the response from BLM at dispersion maximum point. We made bump orbit by steering magnet and momentum offset.**

**Now we limited less than 1mSv/h on contact dose level after 10hours-1day cooling.**
**It seems severe but we plan a large-scale installation in order to recover the linac energy . So we should limited severely until it is finished.**



# *Thank you for your attention*