STUDY OF BEAM LOSS MEASUREMENT IN J-PARC LINAC

A. Miura#, S. Sato, T. Tomisawa, H. Sako, T. Morishita, H. Takahashi, A. Ueno, K. Hasegawa, H. Yoshikawa, JAEA/J-PARC, Tokai-mura, Ibaraki, JAPAN
Z. Igarashi, M. Ikegami, KEK, Tsukuba, Ibaraki, JAPAN

Abstract

Over hundred beam loss monitors (BLM) in the J-PARC LINAC have been used to measure the beam loss observed during the accelerator operation. Beam Loss dependence with beam current, particle number and chopping rate has been obtained. And characteristic beam loss obtained during beam bending operation. This paper focused on the topics of the beam loss records.

INTRODUCTION

The beam loss monitor (BLM) is the key device to observe the beam halo in accelerators. Over hundred BLMs provide a key role to make an alert system against the anomalous radiation problems at any points along the J-PARC LINAC. Typical tendencies of the beam loss were observed through operations. Current measurement system for beam loss, typical tendencies and characteristics are introduced in this paper.

BEAM LOSS MEASUREMENT IN J-PARC LINAC

Measurement Devices

An ionization chamber type of the beam loss monitor was employed, because it is easy to make and maintain, and it has an advantage by composing with only a passive components, that is a practically key issue for the detector under the radiation surroundings[1].

The high voltage supply is distributed along the LINAC and the voltage is partially controlled according to the beam energy concerned. A computer controlled threshold voltage is employed to indicate the radiation protection level and the signal amplitude comparator alerts the radiation interlock signal. Signal integrator shows the beam loss distribution along the LINAC and occasionally acquires the signal into the computer.

BLMs are installed in the following order in subsection of LINAC. 4 BLMs in (1) MEBT subsection, 53 BLMs in (2) DTL-SDTL subsection, 30 BLMs in (3) A0BT and 38 BLMs in (4) L3BT are installed. Totally over hundred BLMs can measure the beam loss through operations since 2004.

Beam Loss in LINAC

Beam loss measured at run 21 (Jan. 13., 2009) is shown in figure 1. This result shows a one of typical tendencies of beam loss which was obtained under operation with 181 MeV acceleration. In the SDTL subsection, radiation from SDTL cavities is usually observed (dotted circle in figure 1), because the detector has enough high sensitivity to measure the noise from another devices.

When the beam is injected to the 0 deg. dump (red line), radiation rate is higher than that obtained to 100 deg. dump (green line). It is thought that this is the direct beam reflection from the 0 deg. dump. The peak of the beam loss in L3BT subsection of 100 deg. dump is caused by another reason. This reason is considered after this section.

Beam Current Dependency

Difference of beam loss between beam current with 5.8

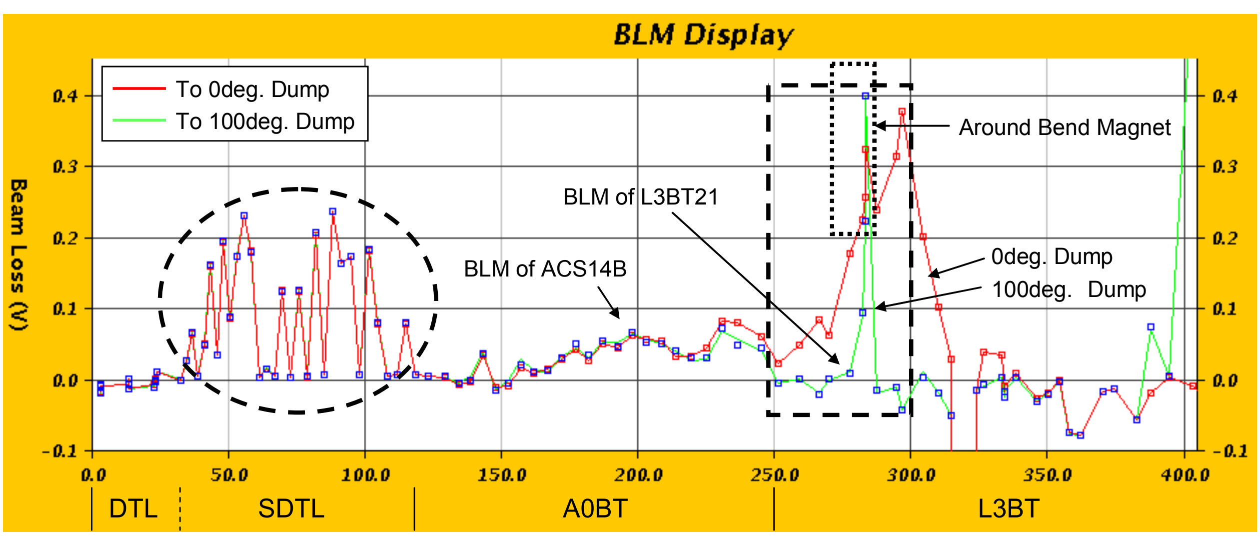
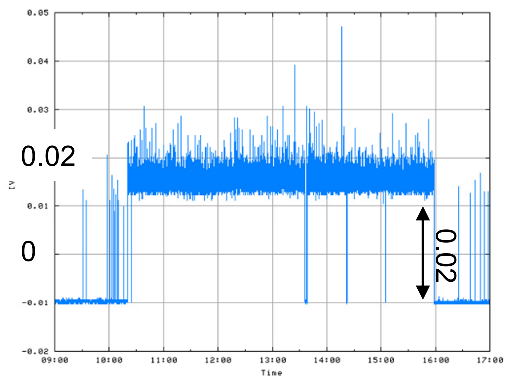


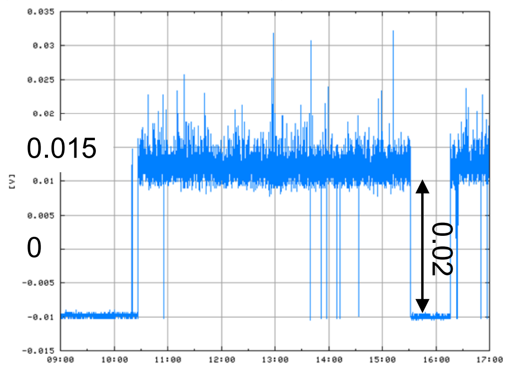
Figure 1: Beam Loss in J-PARC LINAC at Run 21 (Jan. 13., 2009)
Red line and green line show the loss at injection for 0 deg. dump and 100 deg. Dump respectively.

#miura.akihiko@jaea.go.jp

mA and that with 6.0mA is compared. Both operations were conducted with pulse width as 0.1ms, frequency as 8.3Hz, chop width 280 ns, 1 bunch and ~ 1.6 kW. Difference was observed by both BLMs at ACS14B and L3BT21. Both characteristics indicated that the beam loss level with 5.8 mA is 12 to 13 % higher than that with 6.0 mA.



(a) Beam Current: 5.8 mA (Run 17, Jun. 21, 2008)



(b) Beam Current: 6.0 mA (Run 18, Sep. 25, 2008)

Figure 2: Beam Loss Compared with Beam Current 5.8 mA and 6.0 mA.

Beam Loss Rate with Charged Particles

Difference of beam loss rate is compared with the beam with 0.4 ms pulse width and 0.1 ms. Number of charged particles with 0.4 ms pulse width is four time higher than those with 0.1 ms. Beam loss was measured at ACS14B and L3BT21 and measured pulse heights were compared.

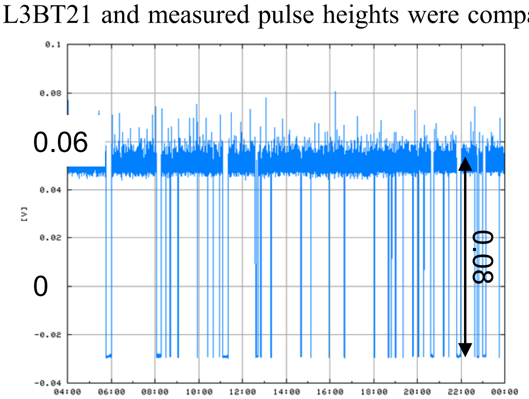


Figure 3: Beam Loss Rate Compared with Different Pulse width (compared with figure 2 (b)).

Compared with the pulse height of figure 2 (b) and figure 3, figure 2 (b) was obtained with 0.1 ms pulse width and figure 3 was obtained with 0.4 ms pulse width, both beam heights per pulse width are agreed.

Chopping Rate Dependence on Beam Loss

Chopping rate dependence on beam loss is shown in figure 4. These data were obtained at ACS14B and L3BT21 under operation with beam injection for 0 deg. dump. When the beam is chopped to 1/4 or 1/8, beam energy is decreased from 1.6 kW to 0.4 kW or 0.2 kW respectively. But, in this operation no chopping mode and 1/4 chopping mode were operated with 1.0 Hz, but 1/8 chopping mode was with 25 Hz. Then, 1/8 chopping mode had operated with 5kW. Above operation modes are listed below.

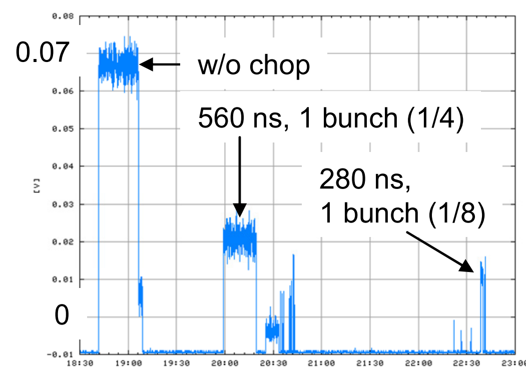
w/o chop: 5.5 mA, 0.1 ms, 1 Hz, ~1.6 kW

1/4 chop mode: 5.5 mA, 0.1 ms, 1 Hz, 560ns, ~0.4 kW

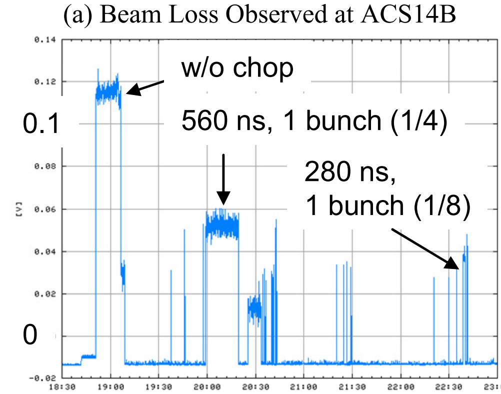
1/8 chop mode: 5.5 mA, 0.1 ms, 25 Hz, 280ns, ~5.0 kW

When the beam is chopped to 1/4, if the heights of beam loss were compared, about 1/4 beam loss becomes 1/4 to half. This value is higher than estimated beam loss. When the beam is chopped to 1/8, beam loss is almost same as the beam loss at 1/4 mode.

Compared with the difference of the measurement position, every beam loss peak of ACS14B is higher than that of L3BT21. When the beam was injected to 0 deg. dump, reflection occurred at the dump. Then the higher beam loss was observed.



(a) Beam Loss Observed at ACS14B



(b) Beam Loss Observed at L3BT21

Figure 4: Chopping Rate Dependence on Beam Loss (Run 20, Dec. 21, 2008).

Beam Loss at Bend Magnet

The beam loss peak is remarkably observed in L3BT subsection when the beam is bended by magnets (see figure 1). In order to clarify the cause of the beam loss, additional monitors were installed around the bend magnets (figure 5). And residual radiation at the surface of the bend magnet was measured after operation.

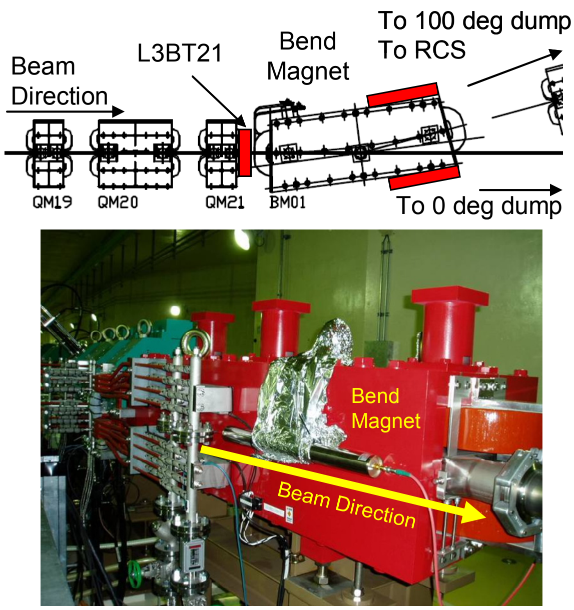


Figure 5: BLM installed at Bend Magnets.

In figure 1, beam loss at right side of the bend magnet (lower side in figure 5) is always higher than that at left side (upper side). Figure 6 also indicates the same situation. Total current of right side due to beam loss is remarkably high to that of left side. This fact suggest that residual H+ particles in beam bunch are bended to opposite side from 100 deg. dump when the negative ions are bended to 100 deg. dump.

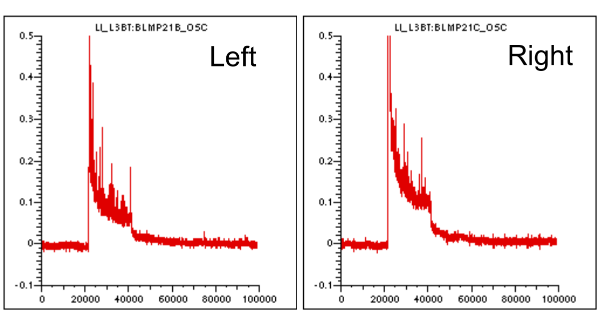


Figure 6: Beam Loss Measured around the Bend Magnet.

Residual radiation at the several points of the bend magnet was measured after operation. Measured points are illustrated in figure 7.

Highest residual radiation was always measured at the point B, because the point B is the opposite position to designed orbit for bended beam. All beam loss data around the bend magnet indicated that there remained H+ particles and they were bended by magnets as the H- particles.

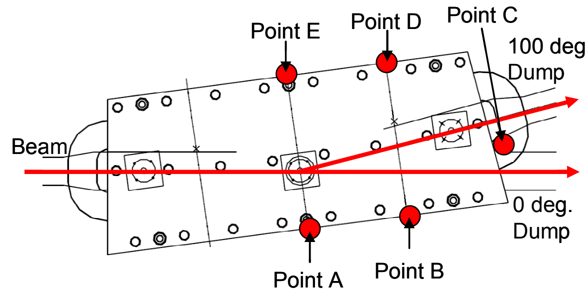


Figure 7: Points for Residual Radiation on Bend Magnet.

Table 1: Residual Radiation on the Bend Magnet

Measurement point	A	B	C	D	E
After Run 19	75	210	100	10	13
Before Run20	33	75	55	4	8
After Run 20	50	67	80	6	12
After Run 21	47	70	60	4.5	6.5

Unit [μSv]

It is thought that H+ particles are generated at the frontend of the LINAC. Essential countermeasure of such high beam loss at the bend magnet is removing the H+ particles during the early stage of the acceleration in LINAC. We are discussing the H+ removal using scraper in MEBT subsection. Currently this is very effective to decrease the beam loss at bend magnet. After some operations are experienced to collect beam loss data, effect by above will be introduced.

SUMMARY

Over hundred beam loss monitors (BLM) in the J-PARC LINAC have been used to measure the beam loss observed during the accelerator operation. As the results, beam loss dependence with beam current is slightly observed. Also, the particle number and chopping rate have not strong dependence on beam loss. Operational records and residual radiation explained the existence of H+ ions in the accelerated beam. When the beam is bended by bend magnet, residual H+ ions in beam bunch are bended like H- particles. The bended H+ ions cause the beam loss by radiation. Countermeasures of such high beam loss at bend magnet are currently discussed.

REFERENNCES

[1] Y. Yamazaki, eds. *Accelerator Technical Design Report for J-PARC*, KEK Report 2002-13.