# Radiation monitoring in the RIBF using ionization chamber

M. Nakamura,*1 K. Yamada,*1 A. Uchiyama,*1 H. Okuno,*1 and M. Kase*1

In recent years, we have attempted to monitor radiation due to beam loss in the RIBF by using self-made ionization chambers (ICs)[1),2),3)] However, in the course of RIBF operations, a part of $^{238}U^{86+}$ ion beam accelerated at 345 MeV/nucleon struck the septum electrode of the electrostatic deflection channel (EDC) of RRC and the septum was damaged in December 2012. To avoid such serious damages, the part of septum where the ion beams can easily irradiate was cut off and molded to the "V-shaped" edge and many thermocouples (TCs) were set at the surface of the septum. Before the septum was damaged by the irradiation of ion beams and the consequent rise in temperature, these signals are input to BIS. However, the response time of these TCs are estimated in the order of few seconds. Furthermore, such results showed that the septum was damaged only when a part of the $^{238}U^{86+}$ beam hit the septum within $10^{-1}$ to 1 s. Hence, a faster signal for BIS with a response time of at least of the order of $10^{-1}$ s is required. On the other hand, the response time of IC can be estimated to the order of $10^{1}$ ms. The response time of the whole BIS is about 1～max. 25 ms. Accordingly, we can obtain the response time to the order of $10^{-1}$ s when the alarm signal from IC is used for BIS. Hence, we investigated to introduce the alarm signal from IC around the EDC of RRC into BIS in the case of $^{238}U^{86+}$ ion beam acceleration.

Usually, we input the alarm signal from IC near the EDC of SRC to BIS after the "calibration experiments"[1,2)]. In these experiments, the ion beams were attenuated from 1/100 to 1/10 and irradiated to the EDC for a fairly short time and IC voltages were measured. From these results, we can estimate the alarm levels of IC to BIS. However, it can be very dangerous to irradiate heavy-ion beams to the EDC of RRC because of a sudden increase in the temperature of the septum. Therefore, we can consider the alarm levels of IC from the signals of TCs set at the septum. When the temperature difference between the TC set at the upper part of the septum with the TC set at the beam-exit side of the septum (defined as "the maximum value of septum temperature rising") becomes 10℃, the alarm signal is input to BIS. Hence, we have compared the maximum value of septum temperature rising with the signal of IC set near the EDC of RRC in the machine time of the $^{238}U^{86+}$ beam. The result is shown in fig. 1. The data showed little dispersion and the calibration curve in fig. 1 can be drawn. From this curve, we can recognize that the voltage of IC became about 1.4 V when the maximum temperature rising of EDC reached 10℃, shown as red dotted line in fig. 1. Then we can decide the alarm level of IC for BIS for the $^{238}U^{86+}$ ion beam.

*1 RIKEN Nishina Center

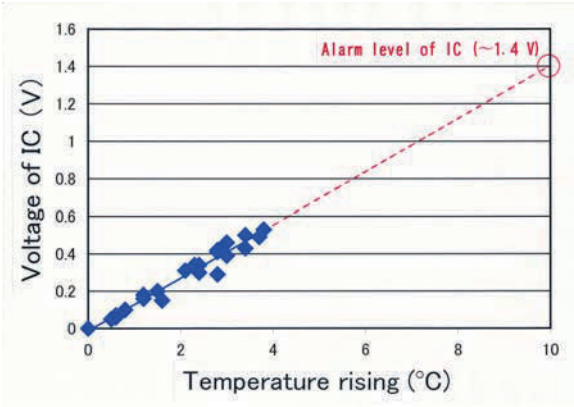


Fig. 1 Correlation of IC voltage and maximum value of septum temperature rising

We have input the alarm signal to BIS from April 28 to May 12 and from October 16 to November 14, 2014 when the $^{238}U^{86+}$ ion was accelerated at 345 MeV/nucleon. On May 5, the BIS by the alarm signal from IC acted and stopped the operations of RIBF. Fig. 2 shows the IC signal from May 5, 0:00 to 9:00. At 5:45, the signal suddenly rose up to 6.4 V and the alarm signal was sent to BIS. We could confirm that this signal reached BIS faster than the alarm signals from TCs set at EDC. After this signal, any alarm from IC did not reach BIS in the machine time of the $^{238}U^{86+}$ beam in 2014. The cause of this unusual signal shown in fig. 2 is unknown. In any case, as described above, we could confirm that the faster alarm signal to BIS can be input from the IC near the EDC of RRC. Thus, we investigated to input the alarm signal from IC in RRC to BIS each time heavy ions are accelerated, such as $^{238}U^{86+}$.

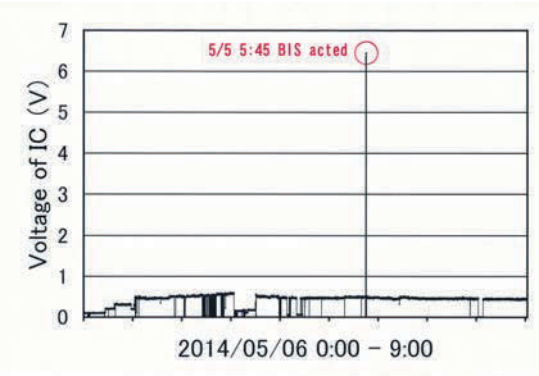


Fig. 2 Signal from the IC near EDC of RRC

References

1) M. Nakamura et al.: RIKEN Accel. Prog. Rep. 44, 293 (2011)
2) M. Nakamura et al.: RIKEN Accel. Prog. Rep. 45, 228 (2012)
3) M. Nakamura et al.: RIKEN Accel. Prog. Rep. 47, 310 (2014)