Radiation monitoring in the RIBF using ionization chambers

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In recent years, we attempted to monitor radiation due to beam loss at several important components in the RIBF by using self-made ionization chambers (ICs)[1)-5)]. Furthermore, we input an alarm signal from the IC to the RIBF beam interlock system (BIS)[5)]. The next focus of this study is the detection of the most suitable alarm level for acceleration operations. Firstly, we attempted to calibrate the alarm level by using an IC near the electrostatic deflection channel (EDC) of SRC[3)-5)]. In SRC operations, many ions, such as N, O, Ar, Ca, Zn, Xe, and U, were used. In the present study, we investigated beam-loss calibration for the N, O, Ca, and U beams. In this report, we summarize the results and consider the suitable alarm levels for the BIS.

The experimental conditions of IC measurements have been described in the previous papers[2),-4)]. When we attempted the calibrations, $^{18}O^{8+}$, $^{48}Ca^{20+}$, and $^{238}U^{86+}$ were accelerated at 345 MeV/nucleon, and only $^{14}N^{7+}$ was accelerated at 245 MeV/nucleon. The beam currents of these ions were less than about 300 enA. In the calibration tests, firstly, each ion beam current was attenuated to about 1/40 to 1/2 times the current under usual experimental conditions by using an attenuator. Subsequently, the EDC was irradiated by these attenuated ion beams for a fairly short time such that the EDC was never damaged. We measured the IC signal at this time. As a result, we could estimate the signal intensity when the beam loss was about 2.5% to 50%, and we could calibrate the IC signal for determining alarm levels.

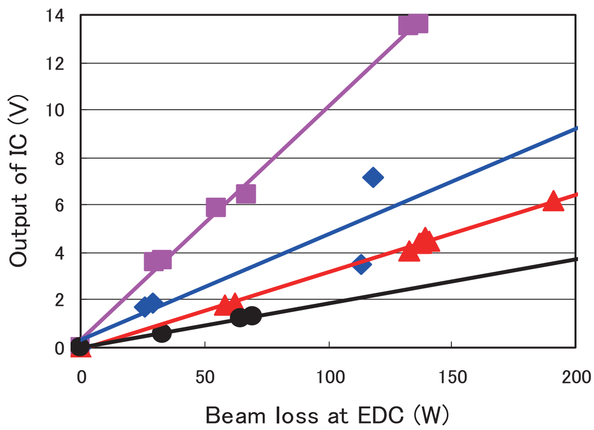

Fig. 1. The correlation between beam power loss and IC intensity.
blue rhombus: $^{14}N^{7+}$
pink square: $^{18}O^{8+}$
red triangle: $^{48}Ca^{20+}$
black circle: $^{238}U^{86+}$

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The results are shown in Fig. 1. The horizontal axis shows the beam power lost at the EDC. The vertical axis shows the output voltage of the IC. The calibration curves of $^{14}N^{7+}$, $^{18}O^{8+}$, $^{48}Ca^{20+}$, and $^{238}U^{86+}$ beams are drawn and compared with each other in the same figure.

The data of $^{18}O^{8+}$ and $^{48}Ca^{20+}$ beams showed little dispersion, and most of the data existed near the calibration curves. In the case of the $^{238}U^{86+}$ beam, we could collect only three data. However, the dispersion of the data was low, and a favorable calibration curve could be drawn. In the case of the $^{14}N^{7+}$ beam, we collected only four data at this stage, and the dispersion of the data was significant. Hence, the $^{14}N^{7+}$ beam should be studied further in the near future. Furthermore, among the calibration curves of $^{14}N^{7+}$, $^{18}O^{8+}$, $^{48}Ca^{20+}$, and $^{238}U^{86+}$ beams, the sharpest slope was observed for the calibration curve of the $^{18}O^{8+}$ beam. This result showed that the intensity of radiation caused by the $^{18}O^{7+}$ beam loss is the largest, at least in the present calibrations. Conversely, the calibration curve of the $^{238}U^{86+}$ beam showed the lowest slope, indicating that the intensity of radiation caused by the $^{238}U^{86+}$ beam loss is the smallest among these ion beams.

We investigated the alarm signal for the BIS using these data. In a previous paper[4)], we reported that problems with $^{48}Ca^{20+}$ ion beam in the EDC of SRC frequently occurred when the IC output had risen to about 4 V. On comparing the values in the previous paper with the values in Fig. 1, problems occurred in the EDC when the $^{48}Ca^{20+}$ beam loss at the EDC increased beyond about 130 W. The exact value of this threshold is still under investigation. Furthermore, the thresholds of the beam loss at which problems begin to occur in the EDC have to be studied for each ion. However, from these estimations, suitable alarm levels can be determined and input to the BIS.

At present, in addition to the elements estimated in this paper, Zn, Ar, and Xe ion beams were accelerated in the experiments using SRC. We plan to investigate the beam loss and alarm levels for these elements in the near future.

References

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