Radiation monitoring for cycrotrons in RIBF

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Recently, we attempted to monitor the radiation due to beam loss in the RIBF using ionization chambers (ICs).[1] Usually, we investigate the radiation from the electrostatic deflection channels (EDC) at RRC and SRC. We input the alarm signal from these ICs to the beam interlock system (BIS).[2,3] However, four ring cyclotrons RRC, fRC, IRC, and SRC are used in the case of $^{238}U^{86+}$ beam acceleration. Hence, we installed the ICs near the EDC of fRC and IRC. Last year, we conducted tests by inputting the alarm signal from the IC signal near the EDC of the IRC. In this report, we attempted to input the alarm signal from the IC near the EDC of fRC to BIS.

We considered the alarm levels of the ICs by comparing the signals from the ICs with those from the thermocouples (TCs) set at the septum of RRC, IRC, and SRC.[2,3] Suppose that a beam deposits a 600 W heat at the septum electrode of the EDC. The temperature rise at the beam loss point is estimated to be 800°C based on a thermal analysis using the finite element method. At this moment, the temperature difference between the TC set at the nearest part where the beam was irradiated and the cooling water of the septum becomes 10°C. In contrast, the septum is made of Cu and its melting point is 1080°C. Therefore, the septum cannot be melted at these conditions. However, to protect against the risks of damage caused to the septum, the alarm level of the temperature difference of TCs was set to 10°C. Hence, we compared the temperature difference on the septum with the IC signal near the EDC of fRC in the user time (UT) of the $^{238}U^{86+}$ beam. The result is shown in Fig. 1. The data demonstrated little dispersion and we can obtain a calibration curve (red line), as shown in Fig. 1. From this curve, we can recognize that the voltage of the IC became approximately 0.55 V when the temperature difference became 10°C.

From October 16 to December 16, the $^{238}U^{86+}$ ion beam was accelerated to 345 MeV/nucleon. Usually, we collected the data of TCs and IC within 7–10 days from the beginning of the UT of RIBF. Based on this observation, we determined the alarm level of IC and set it to BIS, which is the time available between this experiment and the next. However, in this term, we could not find any vacant time to input the alarm signal to BIS. Thus, we compared the data when the BIS acted on the signal from the TCs set at EDC of fRC with the data of IC set near the EDC of fRC. We can then consider the propriety of the alarm level of the IC signal.

The IC signal from 0:00 to 5:00 on 12/3/2018 is shown in Fig. 2 as typical example data. From 2:08 to 2:50, BIS acted 20 times by the sudden temperature rising of EDC for the instability of electric field of fRC.

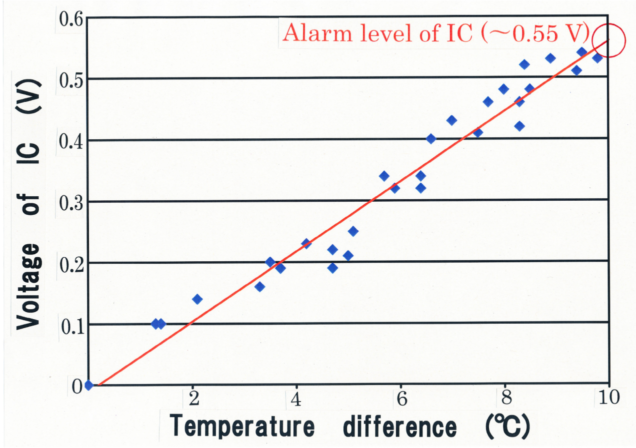

Fig. 1. Correlation of IC voltage and the temperature difference on the septum.

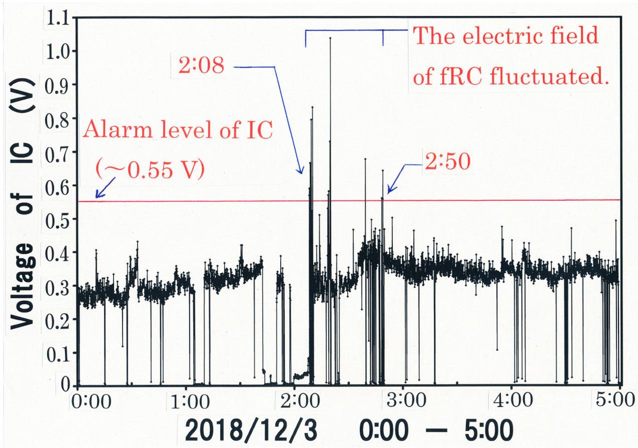

Fig. 2. Signals from the IC installed near the EDC of fRC.

During this term, the value of IC set near the EDC distributed from 0.56 to 1.05 V. Such phenomena were frequently observed on other days of this UT. On observing the IC signals when the BIS from TCs signals acted in this UT, the alarm level of IC described above is found to be reasonable.

We performed investigations by inputting the alarm signal to the BIS during the machine time of the $^{238}U^{86+}$ ion beam. However, we could not input the signal from the IC set near the EDC of fRC. Hence, we will investigate the alarm signal from fRC to BIS next time.

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References
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