

## Radiation monitoring for cyclotrons in RIBF

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In recent years, we attempted to monitor radiation due to beam loss in the RIBF by using ionization chambers (ICs). Thus far, we were able to perform simultaneous measurements of beam loss at several important components at RRC and SRC.<sup>1)</sup> Especially, we investigated the radiation from the electrostatic diffraction channel (EDC) at RRC and SRC. Furthermore, we successfully input the alarm signal from these ICs to the beam interlock system (BIS).<sup>2,3)</sup> On the other hand, the case of the  $^{238}\text{U}^{86+}$  beam, for example, RRC, fRC, IRC and SRC are used. Hence, in this time, we newly installed the ICs near the EDC of fRC and IRC. We report here our recent attempt to monitor the beam loss at the EDC of RRC, fRC, IRC and SRC simultaneously.

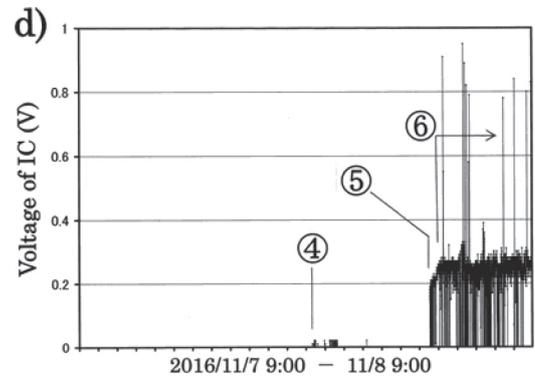
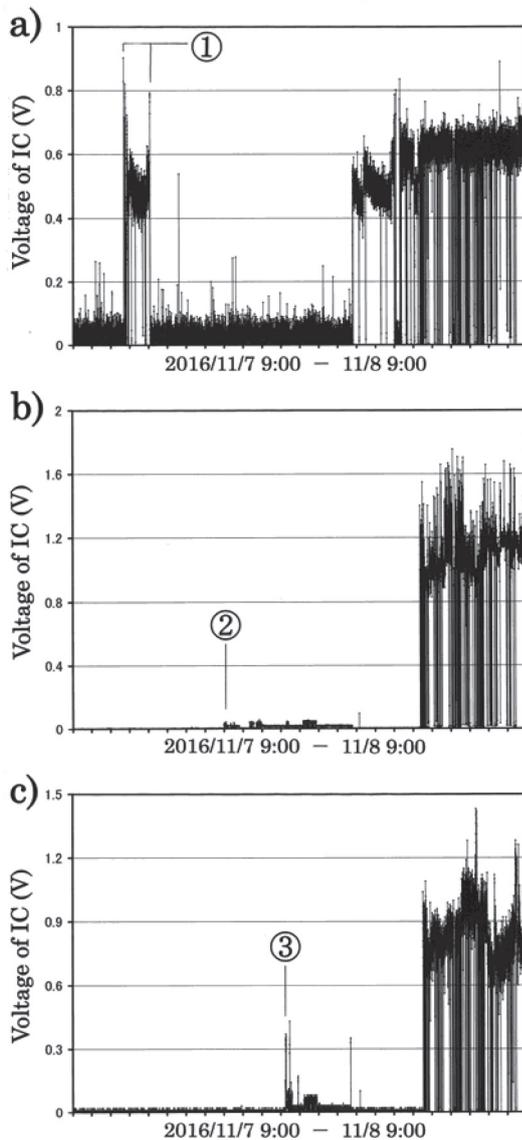


Fig. 1. Signals from ICs installed near the EDCs in RIBF  
a) EDC of RRC b) EDC of fRC c) EDC of IRC d) EDC of SRC.

From October 11 to November 11, the  $^{238}\text{U}^{86+}$  beam was accelerated to 345 MeV/nucleon. The measured signals from 9:00 on 11/7/2016 to 9:00 on 11/8/2016 are shown in Fig. 1 a) – d), as the examples. In Fig. 1 a), we observed some noise around the baseline. The cause of the noise is unknown. However, we consider that this signal reflected the operating conditions of RRC well.

In these figures, the main occurrences are shown by ① – ⑥. These events are listed as follows.

- ① At 11:45 on 11/7, the beam reached RRC. After 13:10, the beam was reduced and RRC was adjusted.
- ② At 17:00 on 11/7, the reduced beam was transported to fRC and fRC adjustment was started.
- ③ At 19:00 on 11/7, the beam was transported to IRC and IRC adjustment was started.
- ④ At 21:00 on 11/7, the beam was transported to SRC and SRC was adjusted until 22:00.
- ⑤ At 3:00 on 11/8, the beam irradiation from SRC was started.
- ⑥ At 3:40 on 11/8, SRC adjustment for “High intensity beam tuning” was started.

We could confirm that these four ICs signals reflected the RIBF operations from 9:00 on 11/7 to 9:00 on 11/8. By observing the signals of ICs from 10/11/2016 to 11/11/2016, we also verified that these signals corresponded to the conditions of RIBF operations quite well.

In this experiment, we performed simultaneous measurements of beam loss near the EDC of RRC, fRC, IRC and SRC. We can use the signals of these four ICs to monitor the RIBF operations and adjust each EDC for ensuring the best conditions.

### 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. **48**, 237 (2015)

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