Application of electrostatic pickups for beam current monitoring using double-integration technique at RIBF

R. Koyama,[*1,*2] T. Watanabe,[*2] H. Haba,[*2] and A. Kamoshida[*3]

We have successfully developed a method to estimate beam current by double-integrating the signals from electrostatic pickups, such as a phase probe (PP) and beam energy and position monitor (BEPM). The double-integrated beam current and the beam energy measured using PP or BEPM are used to ensure the specified values in some experiments, including synthesizing super-heavy elements or producing radioisotopes. Furthermore, it was confirmed that the double-integrated beam current is more effective as a non-destructive beam current monitor for accelerator tuning during the beam supply to experiments than the conventional method using lock-in amplifiers (LIA).[1)]

As shown in Fig. 1, the procedure to obtain a double-integrated beam current is as follows:

1. Obtain waveform (b) by integrating the pickup signal (a) acquired using an oscilloscope.
2. Estimate the background level (c) by interpolating the area between the left and right sides of the peak region of the waveform (b).
3. Obtain the integrated waveform (d) by subtracting the background (c) from the waveform (b).
4. Calculate the area by integrating the waveform (d) and convert it to beam current using first-order calibration, referencing the beam current from the Faraday cup (FC) nearest to the relevant pickup. We refer to this as "double-integrated beam current."

We examined the consistency between the beam current measured using the double-integration technique and that measured by a Faraday cup (FC) under various conditions.[2)] Figure 2 shows a comparison while the isochronism of the AVF cyclotron is slightly disrupted, leading to changes in both the extracted beam intensity and its waveform. Under all conditions, the double-integrated beam current (legend name: Integral) closely matches the FC beam current (legend name: FC). We speculate that the significant differences in LIA amplitudes (legend name: LIA-1f–3f) result from variations in the relative strengths of frequency components caused by changes in the beam waveform.

Figure 3 shows a comparison of the extracted beam intensity from SRC, which was gradually increased from 3000 nA for FC-G01 during the accelerator tuning process for the uranium beam time in the fall of 2024. Throughout this tuning and subsequent beamtime, the double-integrated beam current obtained using PP-G01 was more consistent with the FC beam current than other methods.

For more details and other comparisons, see Ref. 2).

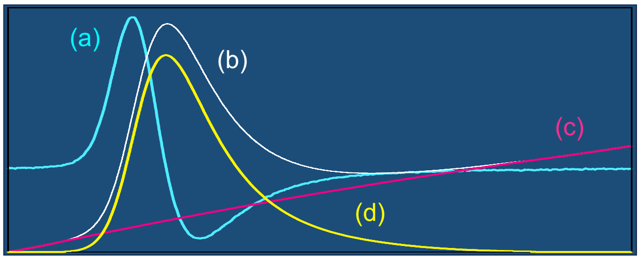

Fig. 1. Waveform processing of the pickup signal to obtain the "double-integrated" beam current.

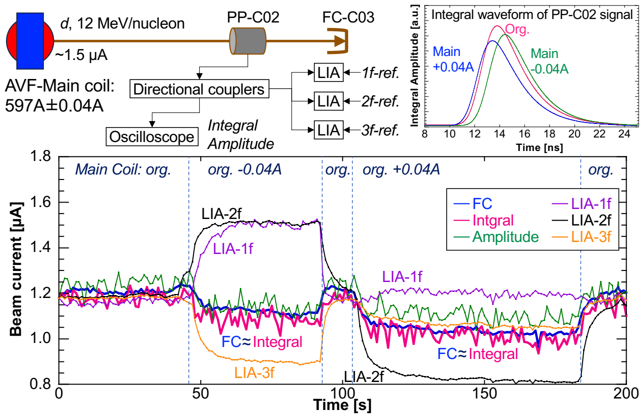

Fig. 2. Beam current comparison under conditions where the isochronism of the AVF is slightly disrupted.

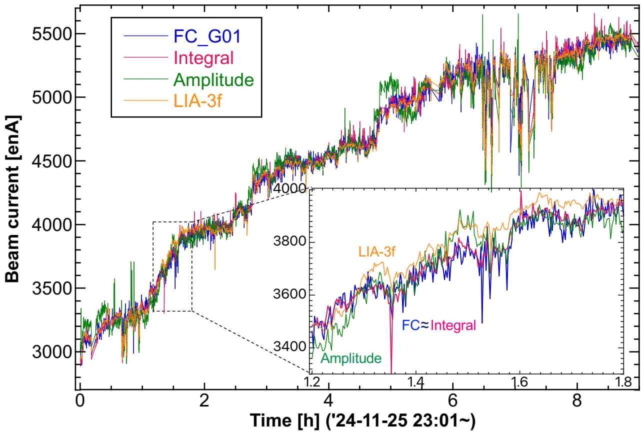

Fig. 3. Comparison of the extracted beam current from SRC during the accelerator tuning process.

References

1) R. Koyama *et al.*, Nucl. Instrum. Methods Phys. Res. A **729**, 788 (2013).
2) R. Koyama *et al.*, Proc. of PASJ2024, (Yamagata, Japan, July 31–August 3, 2024), THOT03, pp. 89–93.

*1 SHI Accelerator Service Ltd.
*2 RIKEN Nishina Center
*3 National Instruments Japan Corp.

DOI:10.34448/RIKEN.APR.58-130