Online monitoring of beam intensity using current transformer at CRIB

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The industrial cooperation team in RNC is developing a method for wear diagnostics of industrial materials using RI beams as tracers in collaboration with SHIEI Ltd. and CNS.[1)] RI nuclei are implanted in the near surface of the machine parts within a depth of 10–100 μm, and its wear-loss is evaluated by the decrease in the measured radioactivity. Continuous γ-ray detection from the exterior of the machine enables real-time diagnostics of the wear in running machines.

In this technique, an intense low-energy RI beam with an intensity of 10^7–10^8 cps are produced at CRIB [2)] and implanted in a sample continuously for a few days in order to obtain the intended activation of a few hundred kBq. The stability of a RI beam irradiation needs to be monitored but it is too intense to monitor using a destructive detector and its energy loss in a detector disturbs the effective activation of a sample. Therefore, we examined the monitoring of the primary beam intensity detected nondestructively by a current transformer (CT) using a monitoring system that incorporates lock-in amplifiers (LIAs). The CT, called the E7 core monitor (E7CM), was developed for precise evaluation of the nuclear-reaction cross section at CRIB.[3)] The monitoring system using LIAs has been developed for stable operation of RIBF.[4)]

The schematic layout of CRIB and the examination setup are shown in Fig. 1. 5.0 MeV/nucleon ^{11}B beam accelerated by the AVF cyclotron was used. The beam-bunch signal detected by E7CM was fed to three LIAs via the three directional couplers in order to measure the three frequency components (1–3f, 1f: acceleration rf of 13.8 MHz) simultaneously, as shown in

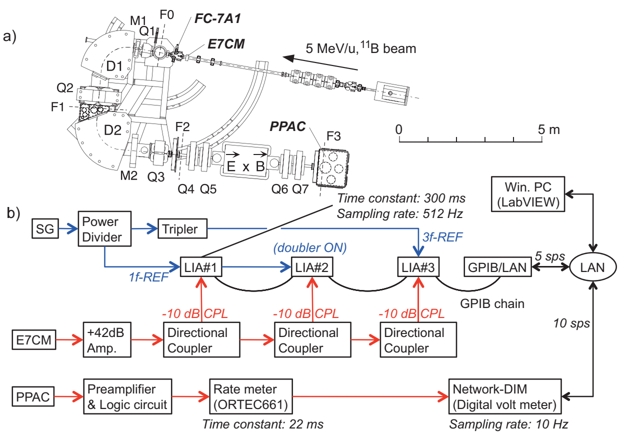

Fig. 1. Schematic layout of CRIB (a) and examination setup (b).

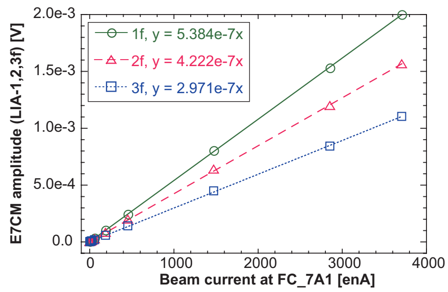

Fig. 2. Linearity between beam current detected by Faraday-cup 7A1 (FC-7A1) and E7CM amplitudes.

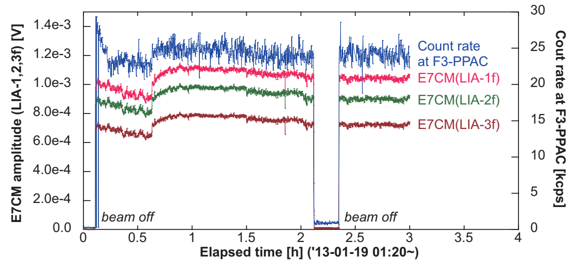

Fig. 3. Correlation between count-rate of secondary beam and E7CM amplitudes. The primary beam current was 1870–2100 enA.

Fig. 1b. A linearity of E7CM amplitudes to the beam current detected by Faraday-cup 7A1 is confirmed, as shown in Fig. 2. In addition, the correlation between E7CM amplitudes and the count-rate of the secondary beam detected by PPAC at F3 was observed, as shown in Fig. 3. For more precise comparison, however, we have to standardize the measurement condition such as time-constant and sampling-rate for the LIA and PPAC systems. At a beam current of 2850 enA, comparable to that of actual experiment, the S/N ratio of 1–3f was 770, 3990 and 1680, respectively. They are all acceptable values but it is favorable to monitor no less than the 2f component, because the origin of background is acceleration-rf and its reference signal, and thus, its 1f component has relatively large amplitude with some fluctuation. From these results, we can conclude that the E7CM and LIA system can fulfill a role for the beam-intensity monitoring.

References

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