Primary beam intensity calibration method using charge-states distribution

D. S. Ahn,[*1] H. Suzuki,[*1] N. Fukuda,[*1] Y. Shimizu,[*1] H. Takeda,[*1] K. Yoshida,[*1] Y. Yanagisawa,[*1] N. Inabe,[*1] and T. Kubo[*2,*1]

The primary beam intensity is an important quantity for experiments to obtain the production cross-sections and rates of radioactive isotopes and monitoring the stability of beam during the experiment. The primary beam intensity is determined using a triple coincidence (3-coin) monitor[1)] by detecting light charged particles recoiling out of the production target in the BigRIPS, as shown in Fig. 1. The advantage of this system is the nondestructive method and its availabillity at all times during the experiment but the calibration for 3-coin monitor is needed and depends on the combination of beams, targets, and beam energy.

The direct measurement of Faraday cup (FC) read-out is used for the calibration of the 3-coin monitor. The size of FC at the BigRIPS is small owing to the space limitation in the production target chamber, causing escape of the secondary electrons from the FC, even if the electric suppressor is applied. Consequentially, the read-out of FC gives a larger current in cases of heavy-ion primary beams. Therefore, the determination of FC calibration factor (FCF) is quite important to obtain absolute primary beam intensity. In this report, the calibration method of the primary beam intensity for FC using a charge-states distribution of the primary beam is reported.

Figure 2 shows the flow chart for the calibration method of the primary beam intensity for a $^{238}U^{86+}$ beam case. In principle, the beam current can be determined by counting the number of incident ions. The primary beam is irradiated to the target and measures the charge-states distribution after the target. The total number of incident ions is obtained from the number of one arbitrary charge-state and its ratio to the total. A 1 mm Be target is used to measure the charge-states distribution of ^{238}U at 345 MeV/nucleon (such a thin target is preferable to reduce the possible backgrounds of fission fragments). In the experiment, each charge-state was set to the central axis in each time. The relative yield

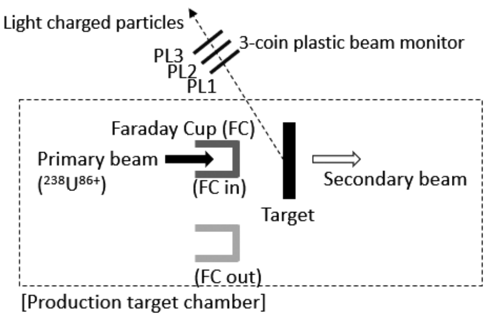

Fig. 1. Schematic view of the primary beam monitoring system at the production target chamber.

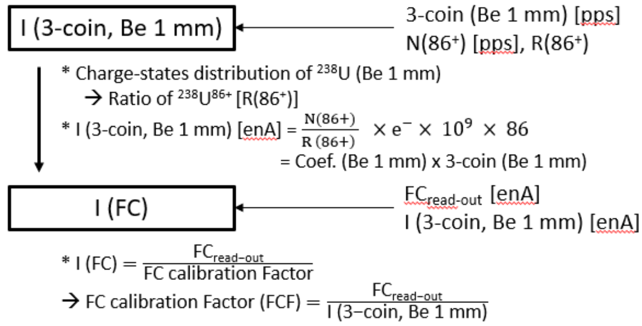

Fig. 2. Flow chart for the calibration method of the primary beam intensity.

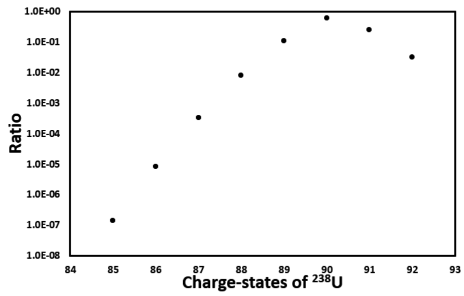

Fig. 3. Experimental charge-states distribution of ^{238}U after 1 mm Be target.

for the neighboring ionic charge-state was obtained with PPACs at F1 or plastic scintillator at F2 and it as normalized with the total number of counts. Figure 3 shows the charge-state distribution of ^{238}U after 1 mm Be target in the range from 92^+ to 85^+. The number of 86^+ charge-states, $N(86^+)$, and its ratio, $R(86^+)$, after the 1 mm Be target were deduced and the sum of ratio was nomarlized with 1. The intensity of the primary beam cannot be measured directly with the BigRIPS detectors because it has a significantly higher rate. The countable count rate of $N(86^+)$ was used to deduce the primary beam intensity whose ratio $R(86^+)$ was 8.2×10^{-6}. The number of 86^+ charge-state was $\sim 10^{4\sim 5}$ Hz with the full beam intensity (50∼100 pnA in a U beam case). Thus, we obtained the beam intensity by the 3-coin monitor, I(3-coin, Be 1 mm).

Consequentially, the FC calibration factor [FCF] was deduced by comparing the read-out of FC [$FC_{\text{read-out}}$] and I(3-coin, Be 1 mm), the average value of FCF is 3.2 in the $^{238}U^{86+}$ beam case. Similar types of calibration were performed in different primary beam cases. The average values of FCF are 1.7, 1.55, and 1.3 for a $^{124}Xe^{54+}$, $^{78}Kr^{36+}$, and $^{70}Zn^{30+}$ beam at 345 MeV/nucleon, respectively. The FCF is assumed to be 1.0 in the $^{48}Ca^{20+}$ and $^{18}O^{8+}$ beam cases.

*1 RIKEN Nishina Center
*2 FRIB/NSCL, Michigan State University

Reference

1) Y. Yamaguchi *et al.*, RIKEN Accel. Prog. Rep. **42**, 161 (2009).