Development of Particle identification method of high-intensity secondary beams at BigRIPS

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Recent development of accelerators enables us to utilize high-intensity primary beams and resultant high-intensity secondary beams at RIBF. Available intensity of the secondary beam becomes more than 10^5 cps at BigRIPS. However, when we apply the standard particle identification method of TOF-$B\rho$-ΔE for such high-intensity beams, in particular around Z=50 beams, two problems arise.

One serious problem is that the resolution of ΔE becomes worse due to the pile up of the slow signal from the ionization chamber, thereby reducing the resolution of atomic number. The other problem is the radiation damage of plastic scintillators that are used to measure the TOF. In addition to these problems, the PPAC had larger discharge probability with the high-intensity beams than that with the low-intensity beams. In this paper, we report a new particle identification method using detectors with high radiation hardness and fast time response at BigRIPS, in order to resolve this problem and identify the high-intensity secondary beams.

We propose the new particle identification method of TOF-$B\rho$-$B\rho$, where ΔE is not measured directly. An energy degrader is placed at the dispersive second focus (F5) and the energy loss at the degrader is indirectly used for the extraction of atomic number. Assuming that mass number and charge do not change at the degrader, the energy loss at F5 is expressed by $\Delta E = (\gamma_{35}-1)Am_u-(\gamma_{57}-1)Am_u = cZ(\frac{B\rho_{35}}{\beta_{35}}-\frac{B\rho_{57}}{\beta_{57}})$. Combining this expression with the Bethe-Bloch formula for the energy loss, $\Delta E \sim d\frac{Z^2}{\beta_{35}^2}$, where d is the thickness of the degrader, and assuming that the ion is fully stripped, namely $Q = Z$, the atomic number can be obtained as,

$$Z = C(\frac{B\rho_{35}}{\beta_{35}} - \frac{B\rho_{57}}{\beta_{57}})\frac{\beta_{35}^2}{d}. \quad (1)$$

In order to overcome the difficulty of radiation damage and discharge, plastic scintillators and PPACs are replaced with diamond detectors[1)] and low-pressure multi-wire drift chambers[2)] (LP-MWDC), respectively.

The test experiment was performed using a ^{132}Sn beam at incident energies of 100 and 200 MeV/u. The typical intensity was 1×10^6 cps and the maximum intensity was 3.4×10^6 cps. Figure 1 shows the correlation between the atomic numbers deduced using the new method and the standard method, which are shown by the horizontal and vertical axes, respectively. There is a clear correspondence of two values, which validates that the new method extracts the correct atomic number. Figure 2(a) shows the plot for particle identification with a low-intensity beam (less than 10^3 cps). Vertical and horizontal axes show the atomic number and mass-to-charge ratio, respectively. Figure 2(b) shows the same plot with the high-intensity beams (about 10^6 cps). Efficiency seems worse for the high-intensity beams, which may be caused by wrong position deduction of LP-MWDC, which will be recovered by further analysis.

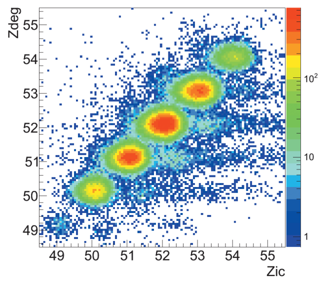
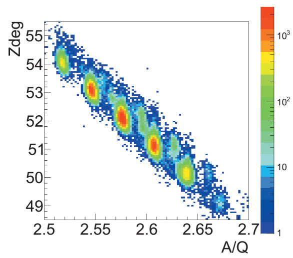
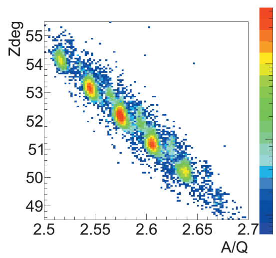


Fig. 1.: Correlation between the atomic numbers deduced using the new method (Zdeg) and the standard method (Zic).



(a) 10^4 cps.



(b) 10^6 cps.

Fig. 2.: Correlation between the atomic number and the mass-to-charge ratio.

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References

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