Particle selection using RF signal for Rare RI Ring experiments

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We commissioned the Rare RI Ring by using secondary beams around ^{78}Ge nuclei in November.[1)] The secondary beams were produced via the in-flight fission of a 345 MeV/nucleon ^{238}U primary beam with a ^{9}Be target. To inject rare RI to the ring reliably, a self-trigger injection method was adopted in the ring. In this method, the RI of interest itself generates a trigger signal for the injection kicker at F3. It is necessary to perform a particle identification (PID) before generating the trigger signals and to transmit the trigger signal to the fast kicker system[2)] as soon as possible. The PID is based on the TOF-$B\rho$-ΔE method, in which the time-of-flight (TOF), magnetic rigidity ($B\rho$), and energy loss (ΔE) are measured. In order to perform PID, the TOF between F2 and F3 using a plastic scintillation counter and the ΔE at F3 using an ionization chamber were measured, as shown in Fig. 1. An acceptable momentum window of the ring is $\pm 0.3\%$, which corresponds to the isotone region shown in the figure.

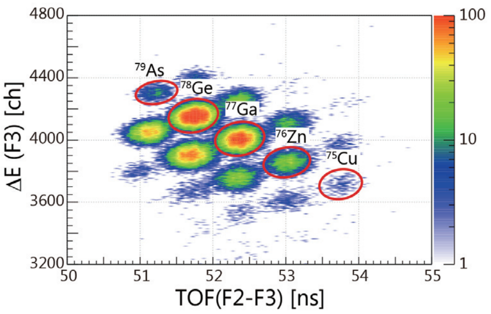

Fig. 1. PID plot of secondary particles with TOF and ΔE.

As can be seen from Fig. 1, the yield of nuclei on the neutron-rich side is very low. Because the purity of the neutron-rich nuclei is also low, the ratio included in the trigger signal, which was generated by the F3 plastic scintillation counter becomes lower. Because the maximum injection repetition frequency of the kicker system is 100 Hz, the measurement for such nuclei becomes time consuming. Therefore, we developed a new technique for restriction by TOF in order to efficiently measure such nuclei. We combined a radio frequency (RF) timing signal for accelerators with the trigger signal. This is because the timing of the RF signal and the arrival time of the RI beam have a certain time relationship so that only the RI arriving at a certain time can be used as a trigger signal by combining the RF signals. A conceptual diagram of the circuit is shown in Fig. 2. The adjustment of the particles to be restricted was carried out by changing the external delay in the circuit.

In the experiment, we demonstrated the technique. Figure 3 shows the difference in particles that generate trigger signals obtained when changing the external delay. When we changed the delay time every 2 ns, particles reaching at certain time do not participate in the trigger. By using this technique, for example, in the case of ^{75}Cu, we succeeded in improving the purity by more than one order of magnitude. From this result, it became possible to efficiently inject nuclei in the neutron-rich region. Moreover, this technique can be applied not only to the experiments of the Rare RI Ring but also to experiments in RI Beam Factory (RIBF). It is possible, for example, to acquire only event data of nuclides of interest.

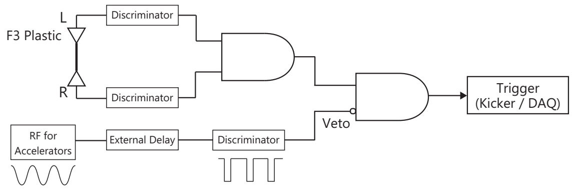

Fig. 2. Conceptual diagram of circuit for particle selection in generating trigger signal using RF signal for accelerators and timing signal at F3.

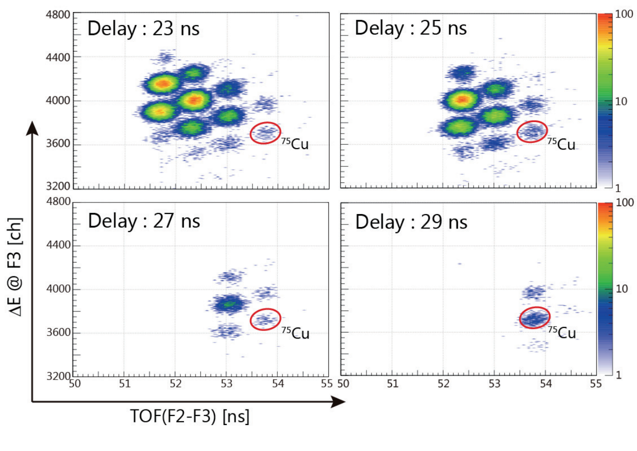

Fig. 3. Results of particle restriction using RF timing signal. The external delay time was different in each setting.

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References
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2) Y. Yamaguchi et al., Phys. Scr. **T166** 014056 (2015).