Upgrade of particle selection system for Rare RI Ring experiments

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We developed a particle selection system for Rare RI Ring experiments. This system selects particles to be injected into R3 using the flight time and energy loss ($\varDelta E$) information obtained at F3 in the BigRIPS focal plane. In the early stage of development,[1)] the signals from detectors were processed using the standard NIM modules with a processing time of at least 60 ns. Because it is necessary to transmit the trigger signal to the kicker magnets as soon as possible, we developed dedicated modules with the particle-selection function. A conceptual circuit diagram is shown in Fig. 1. Because these modules are placed at F3, they are remote-controlled through the ethernet communication. The signal processor consists of two types of modules. One is for particle selection (module A). This processes the raw signals related to the flight time and energy loss information.

Each particle arrives at a certain time relative to the RF Phase. The module A applies coincidence or veto logic with time window created by the RF signal and controls the output signal rate by adjusting the dead time of the module. Therefore, the particle is temporally separated and the output rate is appropriately adjusted. The module A has a window-type discrimination function and can select a certain pulse height signal depending on the energy loss. In combination with both functions, in principle, it is possible to select a single isotope. The required processing time is approximately 15 ns. The other module (module B) combines OR-logic with the signals from two or more types of module A. Because module A can control the rate of output signal in the given time window, it is possible to control the abundance of isotopes to be injected into R3. The processing time required in module B is also approximately 15 ns. Furthermore, module B can limit the total rate of the output signal and adjust the delay of the signal used as the excitation trigger for the kicker magnets.

We practically used the modules in the R3 experiments in fall 2018.[2,3)] The target nuclei chosen in the experiments were the neutron-rich Ni and Pd isotopes. In these experiments, a 2 mm-thick plastic scintillation detector was installed additionally at F3 to get $\varDelta E$ information for particle selection. Figure 2 (a) shows a typical particle-identification (PID) plot and ^{77}Ga has the highest abundance. The abundance of other isotopes could be increased by selectively getting rid of the Ga events, as shown in Fig. 2 (b), where ^{76}Zn is the measure component. We increased the purity of nuclei in the more neutron-rich side by shifting the time window and adjusting the output rate. Their purities can be higher than that of ^{77}Ga, as shown in Fig. 2 (c). Owing to this system, we successeded in the mass measurement of neutron-rich nuclei. This system is useful not only for R3 experiments but also other experiments on exotic nuclei.

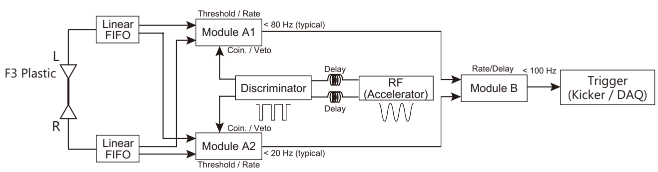

Fig. 1. Conceptual circuit diagram for particle selection and abundance tuning. Frequency of the output signal is adjustable.

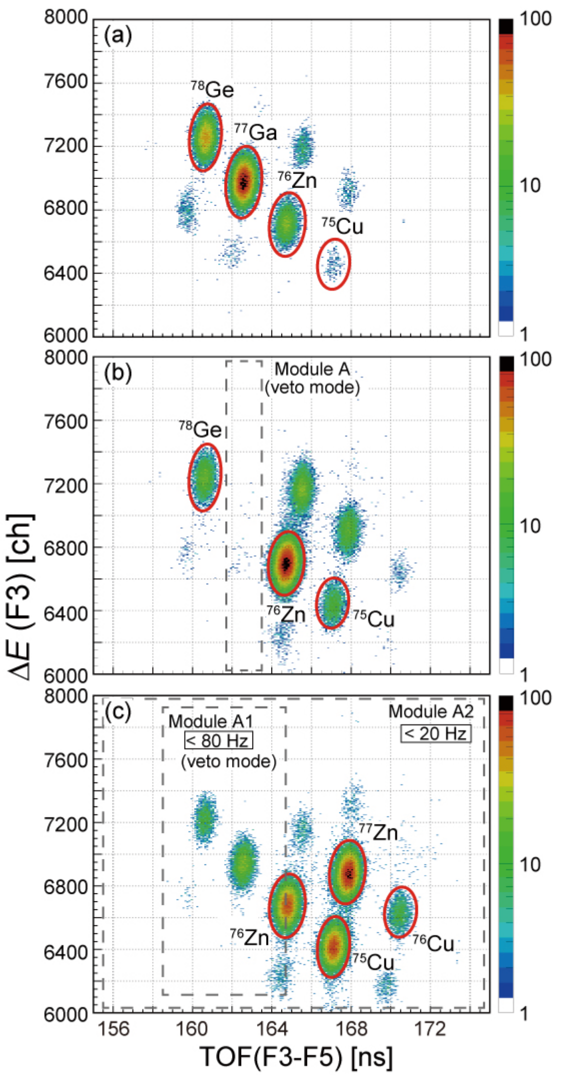

Fig. 2. (a) Typical PID plot of the secondary particles with TOF and $\varDelta E$. (b) Ga isotope was ridded by the selection system. (c) Typical example of abundance control. Broken-lines show the time window and frequency of the output rate set by each module A.

References

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2) A. Ozawa *et al.*, in this report.
3) S. Naimi *et al.*, in this report.

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