Improvement of kicker system for rare-RI ring

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The kicker system at the rare-RI ring (R3) facility has contributed to successful event-by-event measurements. Thus far, three kicker units have been utilized for injecting and ejecting particles using the same field waveform. However, this is not ideal because the top of waveform is not flat (see Fig. 1(a)). It causes an approximately 10% fluctuation in the kick angle within an effective injection duration of 100 ns. In addition, because the ejection duration is the same as the injection duration, it is impossible to eject all nuclides having different revolution times.[1)] In the following, we report a successful improvement in these issues by the addition of a kicker magnet.

Recent R3 experiments are conducted with an injection energy of around 165 MeV/nucleon. Revolution time at R3, which has a circumference of 60.35 m, is approximately 380 ns. It is necessary to make the magnetic field strength negligibly small when particles pass the kicker in the next revolution after injection. Hence, a flat-top with a duration of 100 ns is appropriate considering the fall time of the magnetic field. Furthermore, it is possible to eject all circulated particles in a single ejection duration by lengthening the flat-top to 380 ns or more.

The magnetic field shown in Fig. 1(a) is achieved by trial and error by adding a capacitor to suppress the reflections.[2)] In this study, two different types of magnetic field waveforms with and without this additional capacitor are produced. When passing through these two different fields, which are generated by two kicker units, a particle experiences a total magnetic field that has a flat-top (see Fig. 1(b)). Each kicker unit can generate a magnetic field twice within 0.7 ms. For injection, two kicker units are used, whereas for ejection, two additional kicker units are needed. To ensure a long flat-top ejection waveform, the delay between the firing of the first two kicker units and the additional two units is fixed to approximately 350 ns.

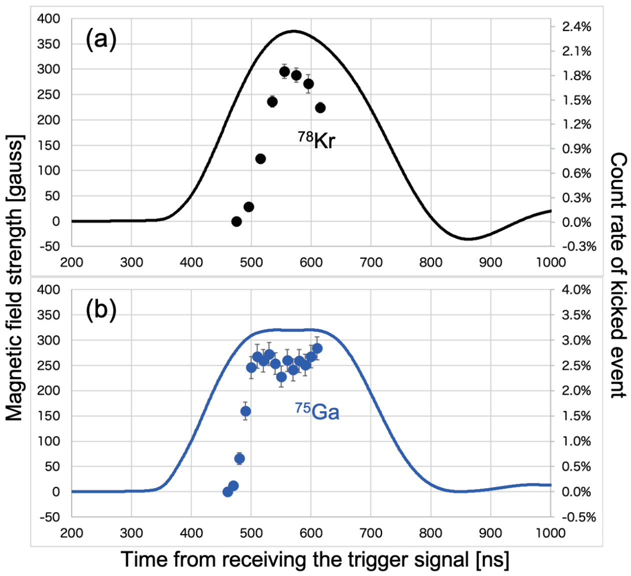

Fig. 1. Black line shows measured magnetic field, whereas blue line shows field experienced by particle (see text). Black and Blue dots indicate kicked events of ^{78}Kr and ^{75}Ga, respectively.

Blue dots in Fig. 1(b) indicate the kicked ^{75}Ga particles counted by a plastic scintillator with a width of 5 mm installed in the center orbit of the R3. This measurement was performed while changing the kicker trigger timing in 10 ns steps. It can be clearly seen that the count rate is constant compared with the ^{78}Kr case in the range of 100 ns, for which a flat-top has been realized. Kick angle fluctuation on the flat-top is expected to be 1%.

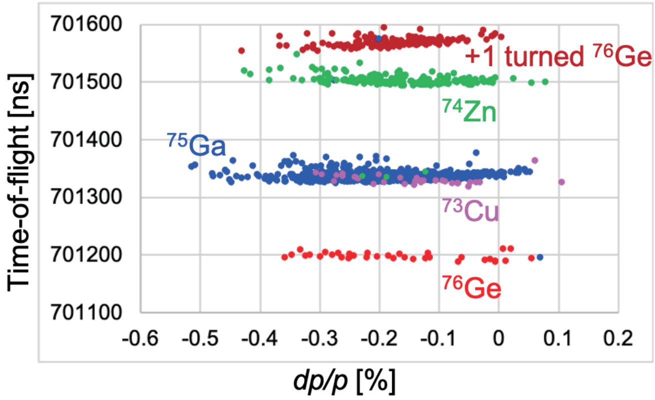

Fig. 2. Time-of-flights of ejected nuclides in single ejection as function of their momentum.

Figure 2 shows the measured flight times of the ejected nuclides as a function of momentum obtained from the position information of the PPAC at BigRIPS-F5. We succeeded in ejecting all injected nuclides in a single ejection. The events of ^{76}Ge that were not ejected in the first kick were ejected in the next kick. Thus, a long flat-top of approximately 400 ns was realized. Consequently, experimental efficiency became at least twice better than that achieved using the previous method, where different ejection timings were needed to eject all particles.

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