Mass measurements of neutron-rich Ni isotopes in Rare-RI Ring II

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In spring 2021, we conducted an experiment at the Rare-RI Ring (R3) to measure the masses of neutron-rich Ni isotopes. Some of these nuclei were measured before at R3,[1)] but the mass values of ^{74}Ni and ^{76}Ni showed large systematic uncertainties. Since the top of the waveform in the previous kicker system is not flat, it causes a fluctuation of approximately 10% in the kick angle within an effective duration of 100 ns.[2)] Since the kick angle affects the orbit inside R3, this fluctuation was suspected to be a major source of systematic uncertainties. The kicker magnet system was successfully upgraded in the fall of 2020.[2)] For injection, a 100 ns flat top was realized, and the kick angle fluctuation is expected to be 1%. For ejection, a long flat top of approximately 400 ns was realized, enabling the extraction of all stored events in a single step.

The experimental setup was essentially the same as that in the previous experiments.[1)] A primary beam of ^{238}U accelerated in the Superconducting Ring cyclotron (SRC) to 345 MeV/nucleon impinged on a Be target with a thickness of 8 mm. Secondary beams, including ^{74}Ni isotopes, were produced via in-flight fission. We adjusted the thickness of degraders located at F1 and F2 in BigRIPS such that the beam energies of ^{76}Zn became approximately 150 MeV/nucleon, which was the proper energy for individual ion injection. Particle identification was performed up to F3 in BigRIPS.[1)] The plastic scintillator at F3 provided trigger signals for the kicker magnets to inject particles of interest into R3. To maintain the trigger rate of the kicker magnets within 80 Hz, we applied TOF-ΔE gates[3)] for the trigger signals. In this experiment, the momentum-dispersive focus was at F5 in BigRIPS. We placed two parallel-plate avalanche counters (PPACs) there to measure the beam momentum. At S0, the entrance of SHARAQ, we located a TOF counter,[4)] which provided the start signal of the TOF in R3. We also measured the TOFs of each particle between F3 and S0, which is used for β calibration. The particles injected into R3 were extracted after approximately 700 μs by using the same kicker magnets. After the extraction, the particle impinged on a plastic scintillator, which provided a stop signal for the TOF in R3; finally, it was stopped in a NaI scintillator.

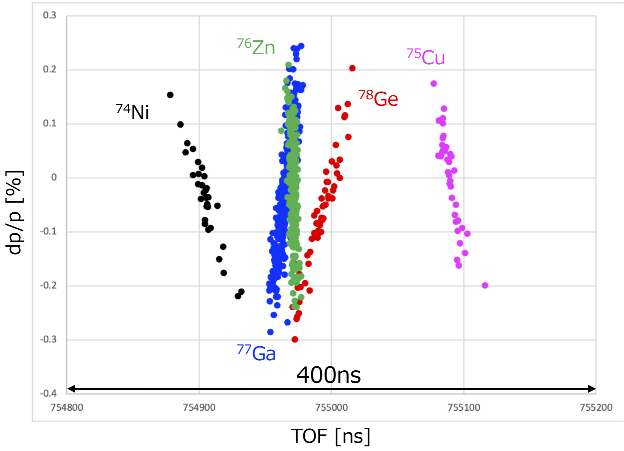

Fig. 1. TOF in R3 (ns) versus momentum difference (%) for extracted events in the experiment. Different colors show different species. All species are extracted within a time window of 400 ns.

In this experiment, we successfully extracted 5 species (^{78}Ge, ^{77}Ga, ^{76}Zn, ^{75}Cu, and ^{74}Ni). The isochronous optics of R3 was tuned using ^{76}Zn such that the width of the TOF in R3 was the narrowest for this nucleus. The observed momentum dependence of TOF in R3 in this experiment is shown in Fig. 1. All species were extracted within a time window of 400 ns. By careful tuning for trim coils, we achieved better isochronicity than in the previous experiment. To deduce the masses, the TOF in R3 should be corrected by the corresponding β or $B\rho$.

Data analysis is ongoing. At this moment, it is unclear whether the kicker upgrade affects the systematic uncertainties.

References

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