Measurement of isochronism using ^{78}Kr beam for the Rare RI Ring

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We constructed a new storage ring based on the isochronous mass spectroscopy technique, named the "Rare RI Ring," to measure the masses of rare nuclei with high precision.[1)] An offline machine study using an α-source (^{241}Am) was performed last year. In the offline machine study, we succeeded in tuning the first-order isochronous field using trim coils.[2)]

In June 2015, the first beam commissioning of the Rare RI Ring was performed, where a ^{78}Kr beam at 345 MeV/nucleon was used. To perform an individual injection using a self-trigger signal from F3, the energy of ^{78}Kr beam was degraded to 168 MeV/nucleon by using a degrader.

First, we transported the beam to the ring with a dispersion matching at the center of kicker magnets in accordance with the optical calculations.[3)] After that, we injected ^{78}Kr particles individually using the fast-kicker system.[4)] After the individual injection was successful, we confirmed whether the particle was stored. We confirmed the periodic signals of the circulated particle through a foil detector, which was located on the closed orbit of the ring.[5)] Once the storage was confirmed, the extraction was performed. After removing the foil detector from the closed orbit, we succeeded in extracting the particles from the ring after about 700 μs.

Figure 1 shows the TOF of ^{78}Kr particles as a function of the momentum spread with different values of the radial gradient of the magnetic field $(\partial B/\partial r)/B_0$ and results of fitting with a quadratic function. From the fitting results, we found that the isochronous condition was changed according to the value of $(\partial B/\partial r)/B_0$. Furthermore, to evaluate the isochronism of the ring, the width of the TOF spectrum was extracted. Since the spectrum has a long tail due to higher-order isochronous field contributions in the ring, we fitted the spectrum using a Gaussian function with an exponential tail to evaluate the width that included the tail. Figure 2 shows the TOF spectrum and the result of fitting in the case of $(\partial B/\partial r)/B_0 = 0.279$ m^{-1}. The TOF width of $(\partial B/\partial r)/B_0 = 0.279$ m^{-1} was obtained about 12 ns in FWHM. Therefore, we found that the degree of isochronism achieved is about 1.9×10^{-5}. Thus, we were able to achieve a 10-ppm isochronism by adjusting the first-order isochronous field. Furthermore, we found that the optimum value would be slightly larger than 0.279 m^{-1} from these results.

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Since we succeeded in the first beam commissioning using a primary beam, we performed an experiment using a secondary beam in December 2015. In this experiment, we succeeded in extracting two kinds of RI produced from ^{48}Ca.[6)] In the near future, the Rare RI Ring will be able to measure the masses of exotic nuclei, which will have a significant impact on the understanding of the r-process.

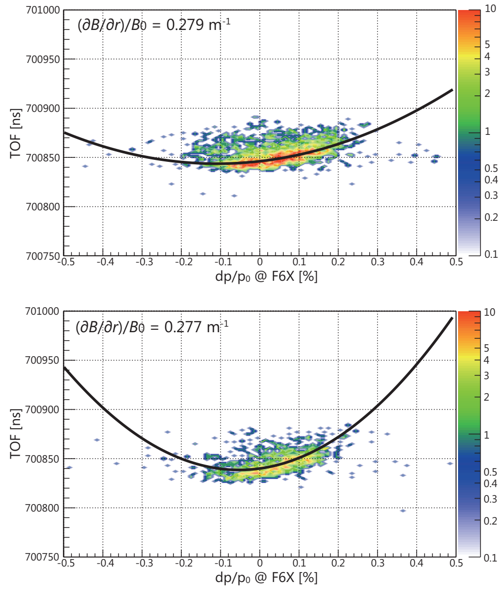

Fig. 1. TOF spectra as a function of the momentum spread with different values of the radial gradient of the magnetic field $(\partial B/\partial r)/B_0$. The solid lines show the results of fitting with a quadratic function.

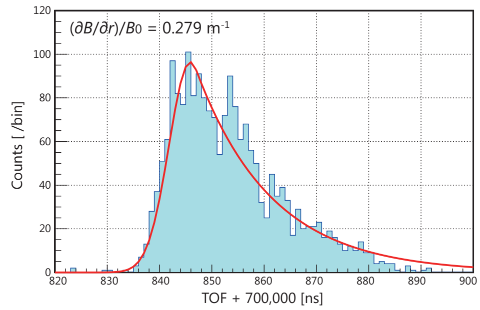

Fig. 2. TOF spectrum and the result of fitting using a Gaussian function with an exponential tail.

References
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