Isochronous condition in Rare RI Ring

Y. Abe,[*1] Y. Yamaguchi,[*1] M. Wakasugi,[*1] D. Nagae,[*1] S. Naimi,[*1] S. Omika,[*1,*3] A. Ozawa,[*1,*2] F. Suzaki,[*1]
T. Uesaka,[*1] T. Yamaguchi,[*1,*2,*3] and for the Rare RI Ring collaboration

The Rare RI Ring (R3) is an isochronous storage ring used to measure masses of short-lived rare nuclei. The expected precision of the measured masses is of the order of 10^{-6}. The precision of the isochronism is one of the key issues regarding R3, because it directly determines the precision in mass determination for poor statistics, which are expected for rarely produced exotic nuclei. Two magnets at both ends of each sector are additionally equipped with ten trim coils to form the isochronous magnetic field with a precision of 1 ppm over a wide range of momentum values. The isochronism of the order of 1 ppm is realized by adjusting the currents of the trim coils.

In the third machine study, we used secondary beams around ^{78}Ge nuclei, and the isochronous condition was tuned to ^{78}Ge. Figure 1(a) shows the two-dimensional plot of events for ^{78}Ge, and the histogram of the revolution time (b). The isochronism was achieved as 5.4×10^{-6} in σ, within the momentum range of $\pm 0.3\%$.[1) The obtained isochronism has not yet reached to the target value of 1 ppm. As can be seen in Fig. 1(a), the revolution time is still slightly correlated to the momentum due to imperfections in the isochronous conditions.

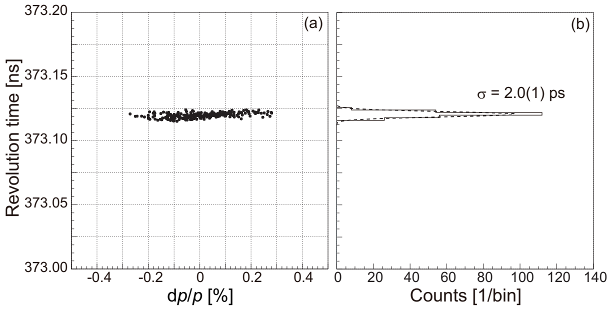

Fig. 1. Result of isochronism measurements in the third machine study. (a) Correlation(s) between revolution time and the momentum difference for ^{78}Ge. (b) Distribution of revolution time of ^{78}Ge with Gaussian fitting (broken line).

We performed a fourth machine study in November by using the same secondary beams to improve the isochronism. Figure 2 shows the results obtained after fine tuning the trim coils in this experiment. The isochronism was improved, and was achieved as 3.7×10^{-6} in σ. This seems to come from the instability of the main magnetic field in R3 caused by the instability of the power supply. In fact, the magnetic field measured using an NMR probe fluctuated within 8.5×10^{-6} of the full width during the measurements. We cannot see a strong correlation between the revolution time and the magnetic field; however, it would be necessary to reduce the fluctuation of the magnetic field to further improve the isochronism.

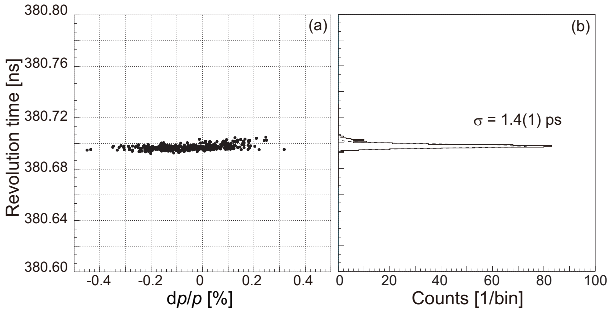

Fig. 2. Present result of isochronism. (a) Correlation(s) between revolution time and the momentum difference for ^{78}Ge. (b) Distribution of revolution time of ^{78}Ge with Gaussian fitting (broken line).

The above measurement time was about one hour. However, a longer time, such as several days, is necessary for mass measurements of exotic nuclei. Figure 3 shows the trends of the magnetic field, room temperature, and DCCT value of the main power supply during one day. These data were obtained four days after the magnets were excited. In order to measure the masses of exotic nuclei with high precision, it may be necessary to introduce technology to reduce the effect of this drift in the near future.

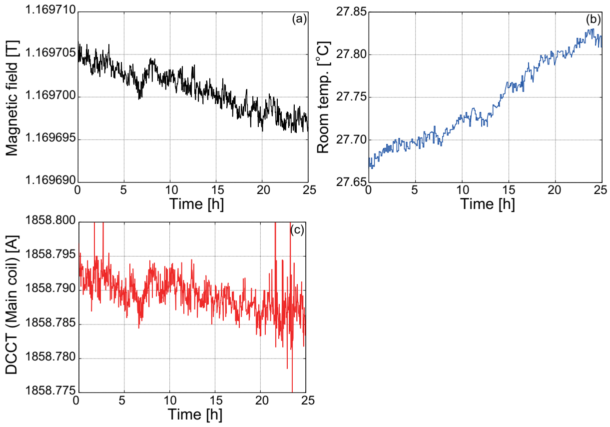

Fig. 3. Trend graphs obtained in one day; (a) Magnetic field measured by NMR probe. (b) Room temperature. (c) DCCT value of main power supply.

Reference

1) Y. Yamaguchi *et al.*, RIKEN Accel. Prog. Rep. **50**, 183 (2017).

[*1] RIKEN Nishina Center
[*2] Institute of Physics, University of Tsukuba
[*3] Department of Physics, Saitama University