Present status of data analysis of commissioning experiment using exotic nuclei

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The Rare RI Ring[1)] is an isochronous storage ring constructed to measure the masses of short-lived rare nuclei using the time-of-flight (TOF) measurement method. In 2016, we performed a commissioning experiment using exotic nuclei with well-known masses[2)] to confirm the feasibility and principle of mass determination using the following equation:

$$\frac{m_1}{q} = \frac{m_0}{q}\frac{T_1}{T_0}\sqrt{\frac{1-\beta_1^2}{1-\left(\dfrac{T_1}{T_0}\beta_1\right)^2}}, \tag{1}$$

where $m_{0,1}/q$ denote the mass-to-charge ratio of the reference particle and particle of interest, respectively; $T_{0,1}$ are the revolution times of these particles; and β_1 is the velocity of the particle of interest. Because the isochronous condition is adjusted for the reference particle, isochronism is not fulfilled for the particles of interest. To evaluate masses of nuclei with non-isochronism, we correct their revolution time T_1 by the velocity measured upstream.

Exotic nuclei around ^{78}Ge were produced by in-flight fission of a 345 MeV/nucleon primary beam of ^{238}U on a 10-mm thick ^{9}Be target. We identified these nuclei before the F3 achromatic focus of BigRIPS. These nuclei were injected into the ring using the individual injection method with the fast kicker system.[3)] The isochronous magnetic field in the ring was adjusted for the reference particle ^{78}Ge with a precision of 5.4 ppm for a momentum spread of ± 0.3%.[4)] The exotic nuclei ^{79}As, ^{77}Ga, ^{76}Zn, and ^{75}Cu were successfully stored for about 0.7 ms and extracted from the ring. These particles, ^{79}As, ^{78}Ge, ^{77}Ga, ^{76}Zn, and ^{75}Cu, were circulated 1904 turns, 1880 turns, 1855 turns, 1828 turns, and 1801 turns, respectively. $T_{0,1}$ for each nuclei were deduced from the TOF between the S0 achromatic focus of SHARAQ and the ring exit ELC, and the turn number. β_1 was deduced from $B\rho$ and the TOF between the F3 achromatic focus of BigRIPS and S0.

Figure 1 shows the deviations of experimental m/q from their literature values listed in AME2016[5)] as a function of m/q. The mass accuracies preliminary obtained for ^{79}As, ^{77}Ga, ^{76}Zn, and ^{75}Cu were -2.2×10^{-5}, 1.9×10^{-5}, 2.5×10^{-5}, and 3.5×10^{-5}, respectively. The statistical uncertainty that is taken into account comes from measurements of T_0 ($\sim 10^{-6}$) and T_1 ($\sim 10^{-6\sim-5}$). Systematic uncertainty coming from β determination is of the order of about 10^{-5}.

A notable difference is observed between the experimental m/q and their literature values. The disagreement comes from the difference between the measured β_1 and in-ring β_1, which is due to the position-sensitive detector PPAC that was used at F6 for momentum tagging. Further analysis for correction of this effect is in progress. For future experiments, a position-sensitive detector with thin foil is needed to reduced the disagreement. Such a detector is now under development.[6,7)]

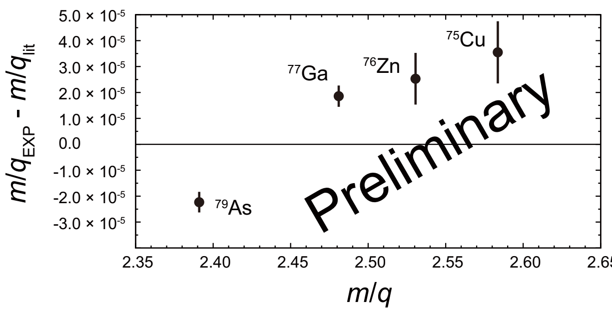

Fig. 1. Differences between the m/q values obtained in this analysis and the corresponding values from the literature.[5)] The error bars that are shown contain only statistical contributions.

References
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