Time-of-Flight mass measurements of neutron-rich Ca isotopes beyond $N = 34$

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The nuclear mass is one of the fundamental quantities used in investigating nuclear structure properties such as shell closures and new magic numbers. The neutron numbers of 32 and 34 have been theoretically suggested to be candidates of new magic numbers in the Ca isotopes[1)]. Recently, the prominent shell closure at $N = 32$ was established by measurements of the massses of ^{53}Ca and ^{54}Ca[2)]. Moreover, the excitation energy of the 2_1^+ state in ^{54}Ca was reported[3)], and the result suggests the existence of an $N = 34$ shell closure in ^{54}Ca. For establishment of the closed-shell nature of ^{54}Ca, mass measurements of the Ca isotopes beyond $N = 34$ are essential. The present work aims at studying the nuclear shell evolution at $N = 32$ and 34 by direct mass measurements of neutron-rich nuclei in the vicinity of ^{54}Ca.

We performed the nuclear mass measurement at the RIKEN RI Beam Factory using the SHARAQ spectrometer. The masses were measured directly by the TOF-$B\rho$ technique. The experimental setup is presented in detail by Kobayashi *et al.*[4)].

Here, current status of the data analysis is described. We analyzed the data taken by diamond detectors, which were employed for timing measurement. Time resolution was estimated to be 12 ps (σ), which is a much better value than that in the previous measurement using ^{12}N beams at 320 AMeV[5)]. This improvement of the time resolution can be interpreted in terms of the energy deposit in the diamond detector, which was ∼60–100 MeV (∼10 MeV) in the present (previous) experiment.

The mass to charge ratio (A/Q) was reconstructed by the $B\rho$ value from the beam tracking with up to fourth-order aberrations, and calibrated by using the reference nuclei such as $^{53-54}$Ca, $^{49,51-52}$K, $^{46-47}$Ar, $^{43-46}$Cl, $^{41-42}$S, $^{39-42}$P, and ^{38}Si. Figure 1 shows an A/Q spectrum for one of the reference isotopes, ^{54}Ca. The relative mass resolution of ∼1/8000 (σ) has been achieved for $Z \sim 20$ nuclei. The total yield of ^{55}Ca, which is one of the target nuclei, is several thousands. It is expected that the mass of ^{55}Ca can be deduced with the precision of $\sim 3 \times 10^{-6}$.

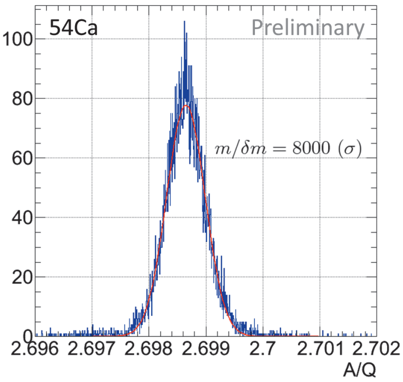

Fig. 1. A/Q spectrum for a reference nucleus, ^{54}Ca.

At present, energy loss in a PPAC, which was used for the $B\rho$ measurement, has not been considered in the mass calibration. It will be included in the fitting to reduce the residuals of the calibration. Further analysis is in progress.

References
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