Mass measurements of neutron-rich isotopes in the vicinity of ^{54}Ca using the TOF–$B\rho$ technique

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The mass of an atomic nucleus is a fundamental quantity because it reflects the sum of all interactions within the nucleus. Mass measurements can directly probe changes in the shell structure in nuclei far from stability, which is called "shell evolution." The presence of subshell gaps at $N = 32$ and 34 around calcium isotopes has attracted much attention over recent years (for example, see Refs. 1–3). To investigate the shell evolution at $N = 32$ and 34, mass measurements of neutron-rich nuclei in the vicinity of ^{54}Ca were performed at the RIKEN RI Beam Factory.

The masses were measured using the TOF–$B\rho$ technique. The time-of-flight (TOF) of an ion was measured by a pair of diamond detectors with extremely high time resolutions. The dispersion-matched operation of the High-Resolution Beam Line and the SHARAQ spectrometer allowed high-precision measurements of the beam momenta. Details of the experimental setup are described in Ref. 4.

The reference nuclei with known masses used for mass calibration were $^{52-54}$Ca, $^{49,51-53}$K, $^{46-48}$Ar, $^{43-46}$Cl, ^{41,42}S, $^{38-42}$P, and $^{36-40}$Si. These nuclides have mass precisions in the literature of < 320 keV and do not have known long-lived ($T_{1/2} > 100$ ns) isomeric states. Masses were deduced by fitting with a fourth-order calibration function in TOF, the positions and angles at the focal planes F3 and S2, and the horizontal position at the dispersive focus S0, which is related to $B\rho$. Figure 1 shows the differences between the deduced m/q values and the values reported in the literature for the reference nuclei. Using the standard deviation of the data points, the systematic error in the mass determination was estimated to be 6.1 keV/q.

The deduced A/Q spectrum is presented in Fig. 2. In the present experiment, the achieved mass resolution was typically $\sim 1.0 \times 10^{-4}$ (σ). We measured 21 nuclides with unknown masses: $^{62-64}$V, $^{58-62}$Ti, $^{58-60}$Sc, $^{55-57}$Ca, ^{54}K, $^{50-52}$Ar, ^{48,49}Cl, and ^{46}S. The mass precisions for ^{55,56}Ca were evaluated to be less than 300 keV. Discussion regarding the deduced mass values is in progress.

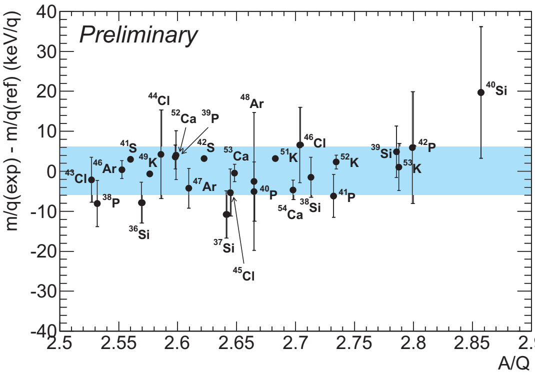

Fig. 1. Differences between the deduced and reference m/q values as a function of A/Q. The blue band indicates the region within the systematic error. Error bars represent the uncertainties in the reference values.

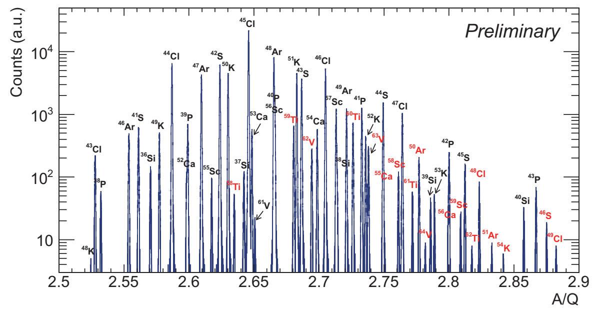

Fig. 2. A/Q spectrum deduced from the present experiment. Nuclides whose masses have not been measured previously are indicated with red letters.

References
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