Isomeric-to-ground state ratio of ^{128}Sn measured by Rare RI Ring

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The excitation energy of the isomeric state and the isomeric-to-ground state ratios are very important to understand the nuclear structure and reactions. Direct mass measurement can be used for measuring the excitation energy of the long-lived isomeric state and determining the isomeric-to-ground state ratio simultaneously. Rare RI Ring (R3) is an isochronous mass spectrometer in RIBF. The principle of the mass measurement at R3 is described by the following equation:

$$\frac{m_1}{q_1}=\frac{m_0}{q_0}\frac{T_1^{corr}}{T_0}=\frac{m_0}{q_0}\frac{1}{T_0}T_1\sqrt{1+\frac{1-\left(\frac{T_0}{T_1}\right)^2}{\left(\frac{m_0/q_0}{B\rho_1}c\right)^2}},\qquad(1)$$

wherec T_1 and T_0 are the time-of-flight (TOF) of the nucleus of interest and reference nucleus, respectively, and $B\rho_1$ is the magnet rigidity of the nucleus of interest.[1)] The unknown mass m_1 is determined relative to the mass of the isochronous reference nucleus m_0. Bρ tagging is performed at the momentum-dispersive focal plane F5 of BigRIPS by measuring the horizontal position with two parallel-plate avalanche counters (PPACs). The TOF of the nuclei in R3 was measured using the E-MCP detector[2)] at S0 of SHARAQ and a plastic scintillator placed behind R3.

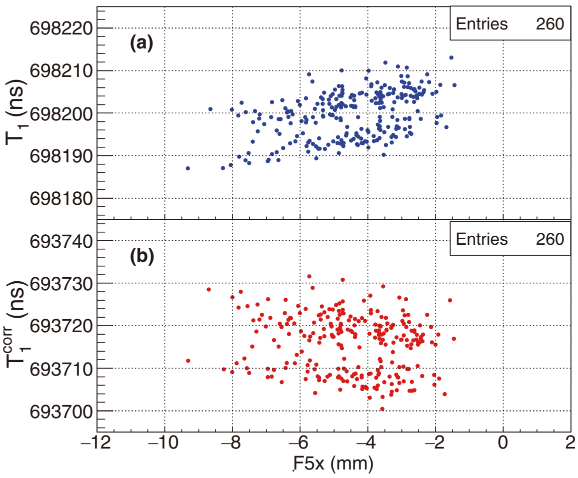

Fig. 1. (a), (b) Correlations between T_1 and T_1^{corr}, respectively, and the F5 position for ^{128}Sn.

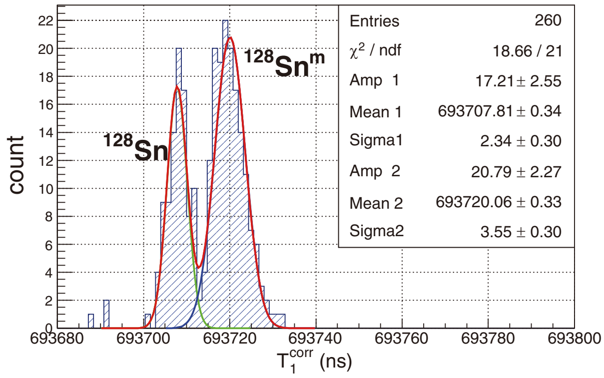

Fig. 2. T_1^{corr} spectrum of ^{128}Sn; two Gaussian functions were used to fit the histogram.

In the autumn of 2018, the first mass measurement campaign was conducted at R3. To measure the mass of ^{125}Ag and ^{124}Pd, 3 neighbor isotones, ^{126}Cd, ^{127}In, and ^{128}Sn, were injected in R3 as reference nuclei to determine the mean Bρ value of R3.[3)] The first isomeric state of ^{128}Sn, the excitation energy and half-life of which are about 2091.5 keV and 6.5 s,[5)] respectively, was produced and observed during this experiment. The TOF in R3 for each particle was normalized to the same turn numbers[4)] to determine T_1. The correlation between the T_1 of ^{128}Sn and the F5 position is shown in Fig. 1(a). After event-wise correction with Bρ, T_1^{corr}'s dependence on the F5 position is shown in Fig. 1(b). The isomeric state and ground state of ^{128}Sn can be well resolved in the spectrum of T_1^{corr}, as shown in Fig. 2. The left peak is the ground state of ^{128}Sn, and the right one is the isomeric state. A function composed of the sum of two Gaussian functions was used to fit this spectrum.

The mass resolving power of R3 can be given by

$$R=m/\Delta m=T_1^{corr}/\Delta T_1^{corr},\qquad(2)$$

which is derived from Eq. (1). The full width at half maximum of the achieved mass resolving power is about 125,000 from the ground-state peak. The isomeric-to-ground state ratio for ^{128}Sn is 1.8(4), which is determined by the integral values' ratio of the fitting functions.

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