First Spectroscopic study of ^{56}Ca

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The first measurement of low-lying excited states of ^{56}Ca was performed as part of the third SEASTAR[1] (Shell Evolution And Search for Two-plus energies At the RIBF) campaign in May 2017. In a simple shell-model description, this nucleus has two neutrons in the $f_{5/2}$ orbital outside the closed (sub)-shell nucleus ^{54}Ca.[2] The location of its 2_1^+ energy gives a measurement of the difference between 0^+ and 2^+ two-body matrix elements in $\nu(f_{5/2})^2$, which is of importance to understand the nature of the very neutron-rich, potential closed (sub)-shell nucleus ^{60}Ca. Theoretical predictions of this energy level vary from 0.5 to 2 MeV; therefore, its experimental determination is desirable.

A ^{70}Zn beam accelerated to 345 MeV/nucleon impinged on a 10-mm thick ^{9}Be primary target with an average intensity of ∼160 pnA at the entrance of the BigRIPS separator to produce the radioactive secondary beam. BigRIPS was tuned to select and identify particles of interest via the measurement of Bρ, ΔE and ToF by using standard beamline detectors. The particle identification of BigRIPS is shown in Fig. 1. The average production rate of ^{57}Sc nuclei was 13.6 s^{-1}. To induce knock-out reactions populating low-lying states in ^{56}Ca, the secondary beam impinged

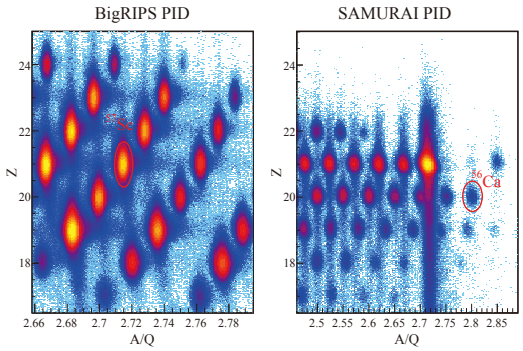

Fig. 1. BigRIPS particle identification (left) and SAMURAI particle identification for ^{57}Sc secondary beam (right). The ^{57}Sc$(p, 2p)^{56}$Ca channel is selected.

on the 150-mm-length LH2 target of the MINOS device.[3] The beam energy in front of the secondary target was measured to be ∼250 MeV/nucleon. The upgraded DALI2[4] array, which contains 226 NaI(Tl) detectors, was used to measure gamma rays emitted from the in-flight particles. The reaction residues were identified using the SAMURAI spectrometer.[5] The identification of the residues from the ^{57}Sc secondary beam is also shown in Fig. 1, from which the ^{56}Ca isotopes are selected.

Currently, the gamma-ray spectrum in coincidence with the ^{57}Sc$(p, 2p)^{56}$Ca reaction channel is under analysis. This preliminary energy spectrum shows a candidate peak of the $2_1^+ \rightarrow 0_1^+$ transition observed at an energy consistent with the aforementioned range of theoretical predictions. The spectra coincident with other reaction channels, which produce ^{56}Ca, are also under analysis.

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