Measurement of proton elastic scattering from ^{132}Sn at 300 MeV/nucleon in inverse kinematics

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The equation of state (EOS) of nuclear matter is expressed as the EOS of the symmetric nuclear matter and the symmetry energy. Particularly, the symmetry energy is important for understanding astrophysical phenomena, such as neutron stars. The EOS of symmetric nuclear matter is understood from previous experiments on stable nuclei, however there is much less understanding of the the symmetry energy. From many theoretical studies, it is known that the slope parameter of the symmetry energy is strongly correlated with neutron skin thickness, which is defined as the difference between the neutron and proton root-mean-square radii. In neutron-rich nuclei, the excess neutrons form a neutron skin structure. It is expected that this symmetry energy can be constrained by determining the neutron skin thickness from the neutron and proton density distributions.

We employed proton elastic scattering to extract neutron and proton density distributions. For stable nuclei, we have established a method to extract the proton and neutron density distributions using proton elastic scattering.[1)] To employ this method to unstable nuclei with large asymmetry, we started a new project to measure the elastic scattering of protons with RI beams (ESPRI) in inverse kinematics. We developed a recoil proton spectrometer (RPS), which consists of a 1-millimeter-thick solid hydrogen target (SHT[2)]), two multi-wire drift chambers (MWDCs), two plastic scintillators, and fourteen NaI rods. We measure the angle and energy of the recoil protons from the SHT using the RPS. We successfully performed ESPRI measurements for several light unstable nuclei.[3)]

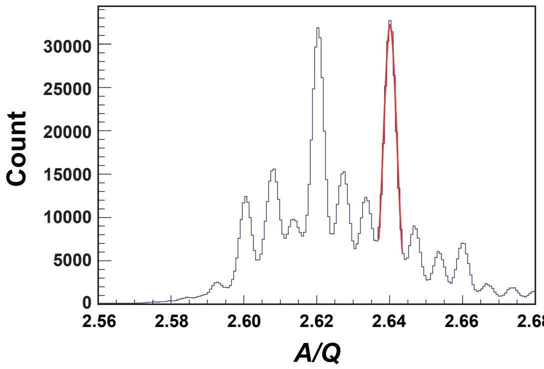

Fig. 1. A/Q spectrum of secondary beam including ^{132}Sn deduced from position and time-of-flight information at BigRIPS. The peak of ^{132}Sn is located at $A/Q = 2.64$ shown in red. The A/Q resolution in r.m.s is 0.058%.

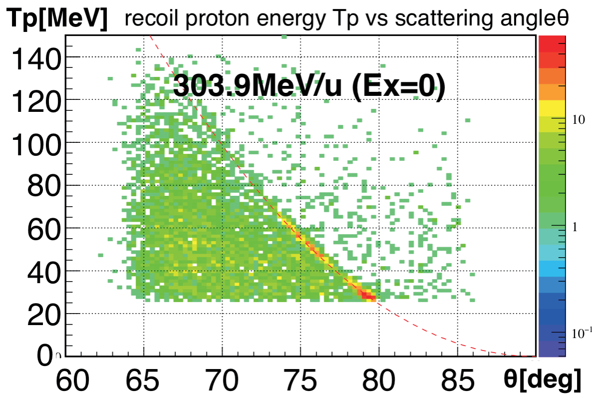

Fig. 2. Kinematical correlations of ^{132}Sn between scattering angles θ and kinematic energies of scattered protons T_p. The red dotted line indicates elastic scattering events between ^{132}Sn at 303.9 MeV/nucleon and protons.

^{132}Sn has a larger isospin asymmetry than ^{208}Pb, and is expected to have a thicker neutron skin thickness. In Novenver 2019, we performed proton elastic scattering from ^{132}Sn at 300 MeV/nucleon at the F12 area.[4)] The total beam rate was up to 600 kcps, and the purity of ^{132}Sn was 20%. The A/Q spectrum of the secondary beam including ^{132}Sn under high intensity is shown in Fig. 1. We identified elastic events of ^{132}Sn from the correlation of the kinematic energies and recoil angles of the scattered protons with NaI rods and MWDCs as shown in Fig. 2. Data analysis for deducing the excitation energy spectrum of ^{132}Sn and the angular distribution of the cross section is now in progress.

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