Track distortion due to ion back flow in CAT-S at RIBF113: ^{132}Sn(d, d') measurement

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The equation of state (EoS) of nuclear matter not only governs the femto-scale quantum many-body system, namely nuclei, but also plays an important role in the structure of neutron stars and in supernova phenomena. In particular, the EoS of isospin asymmetric nuclear matter has attracted much interest from the viewpoint of the existence of heavy neutron stars. Although the asymmetric term of incompressibility, K_τ, can be a benchmark for various EoSs thanks to the direct accessibility via the measurements of isoscalar giant monopole resonances,[1)] the ambiguity of the K_τ is still larger than those of other EoS parameters. The measurement of deuterium inelastic scattering off ^{132}Sn was performed at RIBF in RIKEN, aiming at a more precise determination of the K_τ value.

An active target CAT-S has been employed for the measurement[2)] to measure the forward angle scattering, which is sensitive to the monopole transition, together with the backward angle scattering. A cocktail beam of ^{132}Sn, ^{133}Sb, and ^{134}Te having the total intensity of 3.2×10^5 particles per second bombarded the CAT-S filled with 0.4-atm pure deuterium gas. A set of three 400-μm thick THGEMs is used for the electron multiplication device in TPC of CAT-S. In this paper, we report the observed field distortion due to the injection of the high-intensity heavy-ion beam and its treatment in the tracking procedure.

There is a phenomena called ion back flow (IBF) where the ions produced in the THGEMs go back to the drift region through the hole of the THGEMs. The drift velocity of the ion is as slow as 0.01 cm/μs and a significant number of ions exists along the beam axis like a wall if the IBF rate is large. Since the geometrical configuration and voltage settings of THGEMs in RIBF113 were not optimized for the reduction of the IBF rate, the effect of space charge due to the ions is observed. This effect on the trajectory of recoil particle is observed in the vertex position dependence of the excitation energy (shown in the right panel of Fig. 1). because the position displacement along the beam axis changes the angle of trajectory. A locus around the excitation energy of zero corresponds to elastic scattering. Large deviations at the entrance ($Z = -50$) and exit ($Z = 50$) are clearly seen. The field distortion is estimated by using the finite element solver (FEniCS project) assuming a certain ion density along the beam axis in the active volume. The resultant position displacement between the electron generated point and the observed point are estimated by the simulation of electron transportation taking the estimated field distortion into account. Left panel of Fig. 1 shows the result with taking the position displacement into account in tracking procedure. In this procedure, the IBF rate of 32% is assumed. Now the locus of elastic scattering becomes straight and the effect of the IBF is compensated. The best estimator of the IBF rate can be obtained by comparing the widths of elastic peaks assuming various IBF rates.

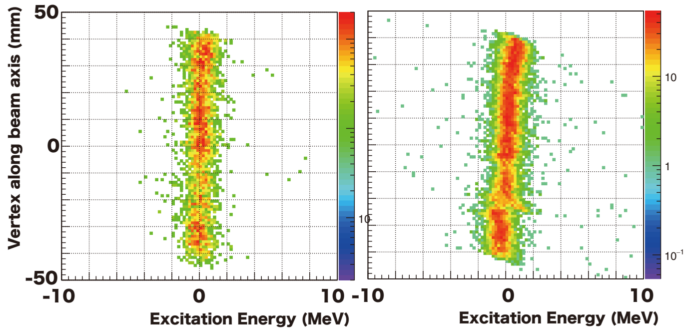

Fig. 1. Corrected (left) and uncorrected (right) correlation.

The excitation energy with beam particle identification is obtained and significant statistics is observed in the GMR energy region in excitation energy spectrum of each isotope. The analysis to finalize the excitation energy spectra at forward angle is ongoing and the further analysis for backward angle will be performed.

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