Particle identification of light charged particle by SπRIT-TPC in Sn-Sn isotopic reactions

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The nuclear equation of state (EOS) is one of the most attractive subjects in nuclear physics and astrophysics. Intermediate energetic heavy ion collisions (HIC) with high isospin asymmetry provide us critical knowledge to constrain the density dependence of the symmetry energy, which contributes to the asymmetric nuclear EOS. Various types of models have predicted that the spectrum of π^-/π^+ from HIC has a high sensitivity to the symmetry energy;[1,2] however, the lack of experimental data and the model dependence are still a problem. At intermediate energies, since the π meson production is dominated by the decay of the Δ resonance state, which is excited from the inelastic nucleon-nucleon scattering, nucleon dynamics in the participant region indirectly influences the final yield of π mesons. Recent progress in calculations based on AMD shows that the cluster correlation alters the nucleon dynamics and has a considerable influence on the final yield of π^-/π^+ as well as the sensitivity of the symmetry energy.[3] Therefore, precise information on the cluster production in HIC is desired. In order to estimate the relative production rate of light clusters emitted from Sn-Sn reactions at 270 MeV per nucleon,[4] mass evaluation for the light charged particles is ongoing, which will be described in this report.

The SAMURAI Pion Reconstruction and Ion Tracker Time Projection Chamber[5] was placed into the gap of the SAMURAI dipole magnet at 0.5 T, which allows us to measure the energy deposit per unit length (dE/dx) and the magnetic rigidity of the charged particles individually. In order to calibrate dE/dx and to estimate the resolution of particle identification, the numerical mass is calculated as follows. The mean dE/dx for relativistic charged particles in a material is described well by the Bethe equation,[6] $-\langle dE/dx\rangle = f_{\mathrm{Bethe}}(\beta)$, where β is the velocity of the incident particle. Furthermore, $\beta^2 = (zR)^2/(m^2 + (zR)^2)$, where z is the charge, and R and m are the rigidity and mass, respectively. If the experimental locus of dE/dx and the rigidity for a certain particle species can be fit by $g(\beta) = a \times f_{\mathrm{Bethe}}(\beta) + b$ with fixed z and m (for an example of proton, $z = 1$ and $m = 938.272$ ... MeV/c^2), the empirical dE/dx calculator is obtained. Finally, by solving the equation

$$(dE/dx)_{\mathrm{measured}} - (a \times f_{\mathrm{Bethe}}(\beta) + b) = 0 \qquad (1)$$

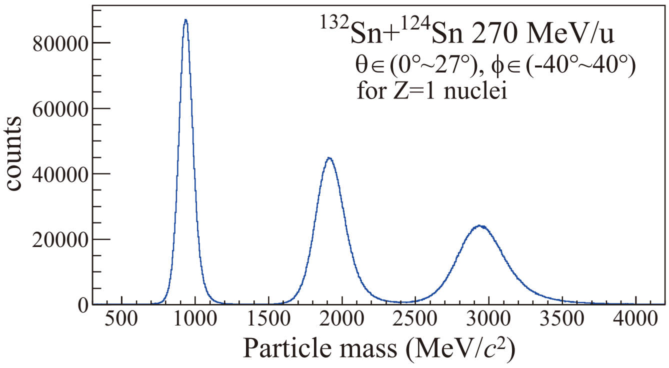

Fig. 1. Mass spectrum calculated from dE/dx and rigidity by using Eq. (1). θ and ϕ are polar and azimuthal angles in the laboratory frame, respectively.

in terms of mass with z for a certain particle and the obtained coefficients a and b, we can calculate the mass from the measured dE/dx and rigidity. Figure 1 shows the mass spectrum calculated by Eq. (1) for a restricted angle, where the coefficients a and b are obtained by fitting the proton locus of dE/dx and rigidity. The protons, deuterons, and tritons are well resolved, but the peak positions are slightly shifted for deuterons and tritons since only the proton locus is considered for the fitting.

In Ref. 6), a highly-skewed Landau distribution is introduced to calculate the energy loss, which considers the fluctuations of the energy loss during interactions with a thin absorber material. Investigation on the resolution using Landau formula is also ongoing.

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