Measurement of proton elastic scattering from ^{136}Xe at 200 and 300 MeV/nucleon

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The Measurement of Elastic Scattering Anytime anywhere any-beam (MESA) project, which is part of the Transformative Research Innovation Platform of RIKEN platforms (TRIP), is aiming to measure proton elastic scattering of various nuclei and determine the global optical potentials.[1] Proton elastic scattering is one of the most precise probes to determine the proton and neutron density distributions in the nuclei, which play an important role in studying the equation of state of the nuclear matter.

The proton elastic scattering of medium heavy nuclei; ^{86}Kr,[2] ^{44}Ti[3] and ^{50}Ca[4] was performed (TRIP23-01 and TRIP24-01-01) for the MESA project. We focused on ^{136}Xe as one of the benchmark nuclei in the heavy region. The measurement of elastic scattering of protons from ^{136}Xe was performed at F12 in November 2024 (TRIP24-01-02). In this experiment, a 345 MeV/nucleon ^{136}Xe beam was decelerated to 200 and 300 MeV/nucleon and selected by its charge state using BigRIPS, and then transported to F12 at a high rate of about 600 kcps. Because of the high intensity of the beam, the standard detectors were moved out after measuring the beam profile. The DELTA[5] and ESPRI[6] detector systems were employed to detect recoil protons. The 50 μm thick polyethylene target and 1 mm thick solid hydrogen target were used for DELTA and ESPRI, respectively. The setup of the detectors at F12 was similar to that of the TRIP24-01-01 experiment.[3,4]

While the data analysis is ongoing, we show online-analysis results in this article. Figure 1 shows the kinematical correlation between the recoil angles and proton energies obtained by the ESPRI device. Elastic events are visible in the shade between $\theta_{\rm lab} = 74°$ and 81°. The plots for particle identification (PID) are shown in Figs. 2(a) and 2(b). Figure 2(a) shows the correlation between the deposited energies in 300 μm thick Si strip detector and GAGG(Ce) calorimeter. We also employed the pulse shape analysis of GAGG(Ce) calorimeter for PID.[7] Figure 2(b) shows the result of this new method. The ΔE-E method works well in the low energy region, whereas the method using the pulse shape analysis can separate the proton and deuteron loci in the higher energy region.

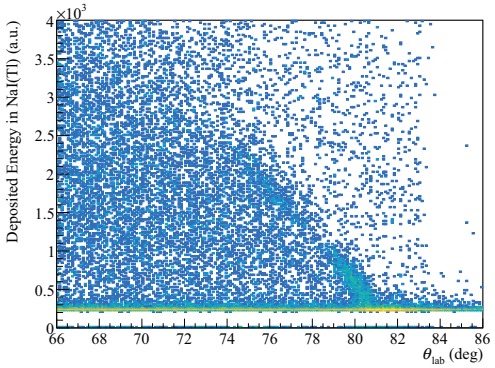
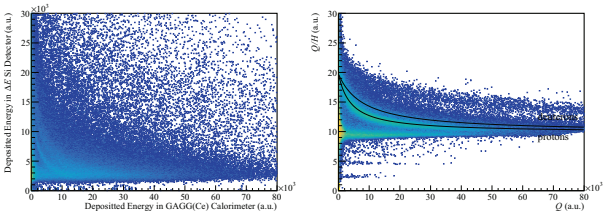


Fig. 1. Kinematical correlation between recoil angles and proton energies measured by NaI(Tl) calorimeters of the ESPRI device. The locus of elastic protons can be seen by a shade at higher angles.



(a) (b)

Fig. 2. PID plots of DELTA. (a) Correlation between the deposited energies in ΔE Si detector and GAGG(Ce) calorimeter. In the low energy region, the loci of the protons and deuteron are visibly separated. (b) PID plot obtained using the pulse shape analysis method.[7] The horizontal and vertical axes indicate the integrated charge of the signal, Q, and the charge divided by the pulse height, H, respectively. Lines represent the proton and deuteron loci predicted by the response function depending on AZ^2.

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