Measurement for p–^{3}He elastic scattering with a 65 MeV polarized proton beam

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Abstract. We performed the measurement of the cross section and the proton analyzing power A_y for p–^{3}He elastic scattering with a 65 MeV polarized proton beam at Research Center for Nuclear Physics (RCNP), Osaka University. The proton analyzing power A_y data are compared with the theoretical calculations based on the nucleon–nucleon potential (INOY04).

Keywords: Three-nucleon forces, Few-nucleon scattering, Proton analyzing power A_y

1 Introduction

One of the most important topics of nuclear physics is to describe various nuclear phenomena based on the nucleon–nucleon (NN) interactions combined with the three–nucleon forces ($3N$Fs). $3N$Fs are key elements to understand various nuclear phenomena, e.g. binding energies of light mass nuclei [1] and equation of state of nuclear matter [2]. In order to study the dynamical aspects of $3N$Fs, such as momentum, spin, and iso-spin dependencies, few–nucleon scattering is a good probe. The first indication of the $3N$F effects in the few–nucleon scattering was found in the cross section minimum for deuteron–proton (dp) elastic scattering at intermediate energies ($E/A \gtrsim 65$ MeV) [3]. As an extension of the study of $3N$F effects in nucleon–deuteron scattering, we performed the measurement for the p–^{3}He scattering at 65 MeV. The motivation of this experiment is to explore

the $3N$F effects in four-nucleon scattering as well as to approach to the $3N$Fs with the channels of the total iso-spin $T = 3/2$.

2 Experiment

The measurement of p–^{3}He elastic scattering was performed in the west experimental hall of the RCNP cyclotron facility. Figure 1 shows the schematic view of the experimental setup. The polarized proton beams were provided by the High Intensity Polarized Ion Source and they were accelerated by the AVF cyclotron up to 65 MeV. After bombarding the ^{3}He gaseous target in the scattering chamber, the beams were stopped in the Faraday cup. The beam intensity was 20 – 100 nA. The polarization of the beam was measured by using the beam line polarimeter. The polarimetry was made by p–^{12}C elastic scattering. The typical beam polarizations were 45–55 % of the theoretical maximum values. In the experiment, the ^{3}He gaseous target was operated at the room temperature under the atmospheric pressure. The scattered particles were detected by the dE–E detectors which consisted of plastic and NaI(Tl) scintillators. The measured angles were 26.9°–170.1° in the center of mass system.

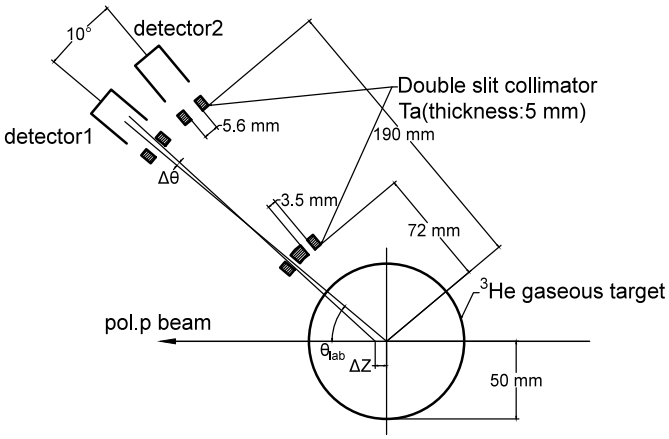

Fig. 1. Schematic view of the experimental setup

3 Results

Particle identification was made by using the correlation between the dE and E detectors. Figure 2 shows a two-dimensional plot of the light outputs of the dE and E detectors. The events from the p–^{3}He elastic scattering are clearly seen

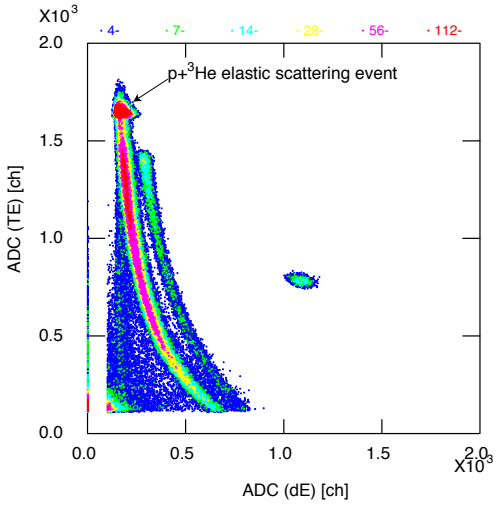

Fig. 2. Two-dimensional plot of the light outputs of the dE and E detectors.

around the highest ADC channels of the E detector. Time of flight information was also used for event selection.

As expressed in Eq. (1), the proton analyzing power A_y was extracted by using the beam polarization (p_y) and the difference of the yields (N) between the spin up and down modes (the subscripts "u" and "d" denote the spin–up and spin–down, respectively).

$$A_y^p = \frac{N^u - N^d}{N^d p_y^u + N^u p_y^d} \tag{1}$$

Figure 3 shows the experimental results of the proton analyzing power A_y as a function of the scattering angle in the center of mass system. Solid circles are the experimental data. Only the statistical errors are shown. The solid curve is the rigorous numerical four–nucleon calculations based on the realistic NN potential (INOY04 [4]) [5]. Statistical errors are less than 0.02 for all the measured data. The angular distribution of the experimental data has a moderate agreement with the theoretical calculation. However, the clear discrepancies are seen at the angles $\theta_{\mathrm{C.M.}} \sim 80°$ and $\theta_{\mathrm{C.M.}} \sim 140°$.

4 Summary

We performed the measurement of the cross section and proton analyzing power A_y for p–^{3}He elastic scattering using 65 MeV polarized proton beams. We obtained the experimental data in a wide angular range ($\theta_{\mathrm{C.M.}} = 26.9°$–$170.1°$). The experimental data are compared with the theoretical calculations based on

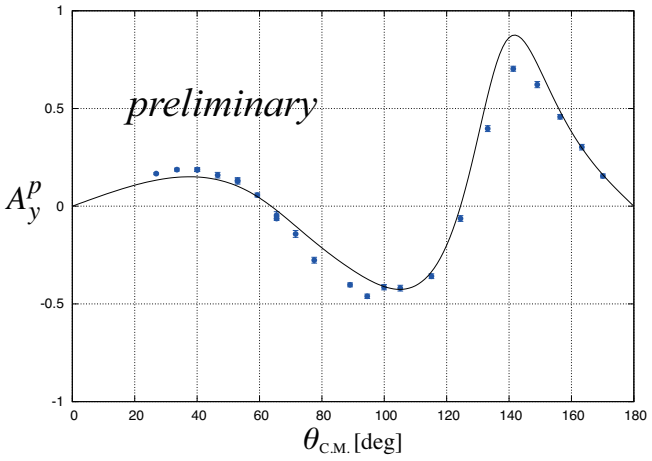

Fig. 3. Proton analyzing power A_y for the p–^{3}He elastic scattering at 65 MeV. The solid curve shows the theoretical calculation based on the INOY04 potential.

the INOY04 NN potential. Clear discrepancies between the data and the calculations are found at the angles where the proton analyzing power A_y takes minimum and maximum. The analysis of the cross section is in progress now.

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