Measurements of the $\vec{p}n$ quasi-free elastic scattering at ANKE*

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As discussed in [1], the nucleon-nucleon interaction amplitudes extracted by the phase-shift analysis are of general importance for study of any hadronic process at intermediate energies. The significant contribution to a small angle domain of the *np* elastic scattering has been done at ANKE during last years by measuring the interaction of deuteron beam with the hydrogen target [2]. However, in this case the beam energy is limited by 1.15 GeV/nucleon. To approach the higher energy domain, where data are very scarce, measurements were performed at ANKE using the polarized proton beam and unpolarized deuterium cluster target.

The data have been taken at 6 proton beam energies of 0.8, 1.6, 1.8, 2.0, 2.2 and 2.4 GeV. The orientation of beam polarization along Y-axis was changing every 3 minutes. The value of polarization was measured by the EDDA polarimeter. Two Silicon Tracking Telescopes were installed at 3cm distance to the left and the right from the deuterium target to detect low energetic particles in coincidence with fast particles going into the ANKE Forward detector (Fd). The missing mass technique and the asymmetric Fd acceptance were exploited for identification of the quasi-free *NN* elastic scattering as described in [3]. It must be noted that other data on the *pd* [4] and quasi-free *NN* elastic scattering [5], which can be used for comparison with our results, exist at $T_p =$ 0.8 GeV only.

Under the given experimental conditions, one has to derive polarization observable from the simple asymmetry of counts corresponding to different orientations of the beam polarization. Such asymmetry is very sensitive to the relative normalization of counts measured, in fact, at different luminosity and different beam polarization values. Taking into account the significant discrepancy between the analyzing power for the quasi-free $\vec{p}n$ elastic scattering obtained at ANKE and the $A_y^n(\Theta_{cm})$ from [5], which was mentioned in our previous report [3], a new normalization procedure was developed. It was verified by the $\vec{p}d$ elastic scattering. The angular dependence of asymmetry well coincides with the angular dependence of the analyzing power $A_y(\Theta_{cm})$ measured in [4]. (Fig. 1) Furthermore, the average beam polarization value determined from the asymmetry is of **0.501+/-0.001(stat)** which is in a good agreement with the polarization measured by the EDDA polarimeter (**0.4890+/-0.0003(stat)+/-0.015(sys)**) as well as with our previous value (**0.513+/-0.001(stat)**).

However, the $A_y^n(\Theta_{cm})$ derived from the same set of data was still found to be about 30% smaller than the analyzing power published in [5] (Fig. 2, left panel). As follows from Fig. 2 (the right panel), the observed discrepancy seems to be related to different ways of the *pn* elastic scattering identification used in these two experiments. The quasi-free scenario is generally assumed to be realized when the momentum transfer from a beam particle to a scattered one (P_t) is large enough as compared with the "spectator" particle momentum (P_{sp}). In contrast to [5] where both scattered particles (proton and neutron) were detected, at ANKE we have detected the "spectator" proton in coincidence with the scattered proton. Since in our case the "spectator" proton momentum can only be reconstructed when $P_{sp} > 70MeV/c$, the $P_{sp}/P_t > 0.3$ at the 0.8 GeV beam energy. Nevertheless, the fact that at $P_{sp}/P_t < 0.4$ the $A_y^n(\Theta_{cm})$ measured at ANKE gets close to the expected value gives a good basis for the further analysis of data taken at higher beam energies.

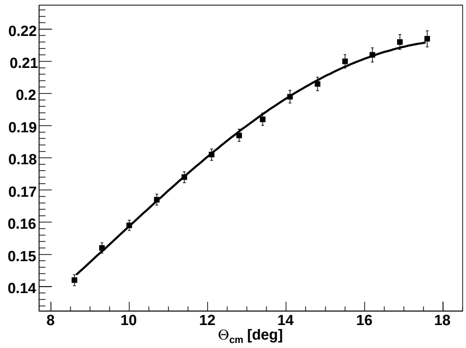

Fig. 1: The $\vec{p}d$ elastic scattering asymmetry (points) versus Θ_{cm} angle is shown together with the $A_y(\Theta_{cm})$ from [4] (line) scaled with the only parameter equal to the average beam polarization at $T_p = 0.8$ GeV.

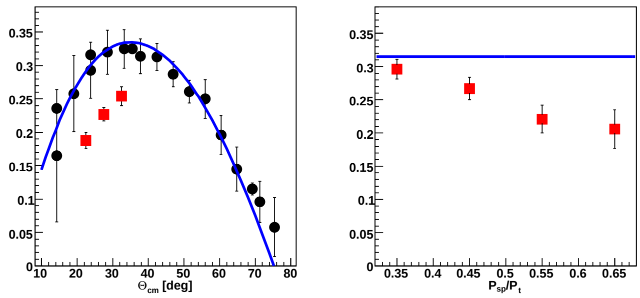

Fig. 2: The quasi-free $\vec{p}n$ elastic scattering at $T_p = 0.8$ GeV. **Left panel** represents the $A_y^n(\Theta_{cm})$ from [5] (black points) versus Θ_{cm} angle. Red squares show the $A_y^n(\Theta_{cm})$ measured at ANKE. In this case data are averaged over full available P_{sp}/P_t range. The current SAID solution is shown by the solid line.
Right panel demonstrates the A_y^n measured at ANKE within the $\Theta_{cm} = 25° - 30°$ angular range as a function of the P_{sp}/P_t ratio. Here, the solid line indicates the $A_y^n(\Theta_{cm} = 27.5°)$ predicted by SAID.

References:

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