Study 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 range, 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 ($\vec{P}_b$) was changing along Y-axis at every beam injection. The polarization value was measured by the EDDA polarimeter. Two Silicon Tracking Telescopes (STT) were installed at 3cm distance to the left and to 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].

Under the given experimental conditions the ANKE was operating as a single-arm polarimeter. So, the analyzing power (A_y) has to be derived from the asymmetry of counts corresponding to different orientations of $\vec{P}_b$. Such asymmetry is very sensitive to the relative normalization of counts measured in the experiment at different luminosity values. The normalization procedure was verified using the $\vec{p}d$ elastic scattering at all beam energies. In particular, at 0.8 GeV the angular dependence of asymmetry was found to be well coinciding with the dependence of analyzing power measured in [4]. Furthermore, the average beam polarization determined from this asymmetry very well agreed with the polarization measured by the EDDA polarimeter.

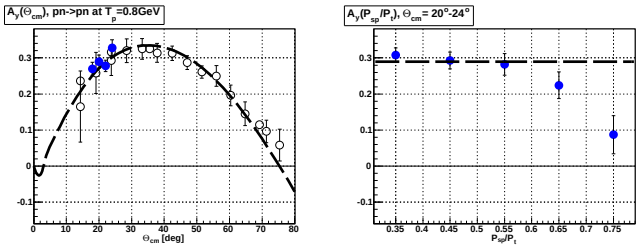

Fig. 1: The quasi-free $\vec{p}n$ elastic scattering at $T_p = 0.8$ GeV. **Left panel.** Open points represent the A_y from [5] versus Θ_{cm} angle. Blue solid points show the $A_y(\Theta_{cm})$ obtained at ANKE under conditions $P_{sp}/P_t < 0.5$ and $P_t > 0.2$ GeV/c. The SAID SP07 solution is shown by the dashed curve.
Right panel demonstrates the A_y measured at ANKE within the $\Theta_{cm} = 20^\circ - 24^\circ$ angular range as a function of the P_{sp}/P_t ratio. The dashed line indicates the $A_y(\Theta_{cm} = 22^\circ)$ predicted by SAID.

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 other experiments [5, 6, 7] where the A_y of quasi-free pn elastic scattering was measured detecting both scattered particles, at ANKE the fast scattered proton was detected in coincidence with the "spectator" proton. Due to the STT construction, the proton momentum must be larger than $70 MeV/c$ to be reconstructed. Since this introduced a low threshold on the P_{sp}/P_t ratio, a validity of the "spectator" model was tested. It was found that the model can be used at $P_{sp}/P_t < 0.5$ (Fig. 1) but the additional limitation of $P_t > 0.2 GeV/c$ turned to be necessary. The same restrictions on the P_{sp}/P_t ratio and the momentum transfer were derived from the analysis of quasi-free pp elastic scattering at 0.8 GeV.

Applying the determined limitations, the analyzing power was obtained for all other beam energies. It was found to be smoothly decreasing with increasing of beam energy. The results in Fig. 2 illustrate the scale of the dependence. Despite the different experimental approach, the ANKE results at 2.2 GeV are well consistent with data from [6, 7].

As it was mentioned, the data set on pn elastic scattering above 1.5 GeV beam energy is very poor. Therefore, it is not surprising that the SAID SP07 solution does not fit to experimental data in Fig. 2. But the SAID solution was recently revised involving in the fit new experimental data measured at WASA [8]. The new SAID solution [9] gives the prediction which quite well fits to our data at 1.6 GeV.

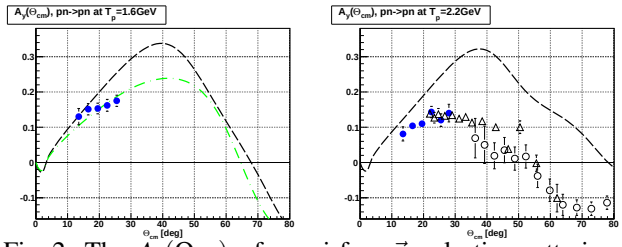

Fig. 2: The $A_y(\Theta_{cm})$ of quasi-free $\vec{p}n$ elastic scattering at 1.6 (left panel) and 2.2 GeV (right panel). Blue solid points show the A_y measured at ANKE. Open points represent results from [6, 7]. The SAID SP07 solutions are shown by dashed curves. The green dot-dashed curve represents the updated SAID solution at 1.6 GeV.

References:

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