Measurement of the vector analyzing power of $\vec{p}d$ elastic scattering at 0.5 GeV

S. Yaschenko[a], S. Barsov[b], S. Dymov[#], A. Kacharava[a], V. Komarov[c], A. Kulikov[c], I. Lehmann, G. Macharashvili[c,d], S. Merzliakov[c], A. Mussgiller, A. Petrus[c], D. Prasuhn, F. Rathmann, R. Schleichert, H. Seyfarth, H. Ströher, Yu. Uzikov[c,e], and B. Zalikhanov[c]

The first experiment with polarized beam at ANKE was carried out in September 2001. The main goal of the experiment was the measurement of the vector analyzing power of the deuteron break-up process $\vec{p}d \to ppn$ at a beam energy of 0.5 GeV. Another important task for this run was the development of a method to determine the beam polarization at ANKE. The EDDA detector [1] was used to obtain an unambiguous reference value for the proton beam polarization. Such a measurement is possible only at energies above 0.7 GeV at beam intensities below $5 \cdot 10^8$ stored protons. For these conditions a special procedure of measurement was developed [2] and the mean value of the beam polarization of $P_{beam} = 0.645 \pm 0.009$ was obtained. Polarization data with EDDA were recorded once or twice per day, thus, a method of continuous monitoring of the beam polarization using elastically and quasi-elastically scattered protons registered in the ANKE forward detector was established [2]. But for the measurement of the absolute value of the beam polarization at ANKE, it is necessary to use a process with known analyzing power that can be unambiguously separated from background processes. Here we describe the measurement of the vector analyzing power of a small angle $\vec{p}d$ elastic scattering.

Elastic $\vec{p}d$ scattering events were identified using the ANKE forward (FD) [2] and spectator (SpD) [3] detectors. The SpD consists of three layers of silicon detectors of varying thickness, 60 μm (first layer), 300 μm (second), and 5 mm (third). In Fig. 1a the energy loss in the first layer of the SpD vs the sum of energy losses in the first and second layers is shown for particles stopped in the second layer. From this correlation one can identify deuterons and protons, whereby $\vec{p}d$ elastic scattering events can be detected in coincidence between forward protons (in FD) and deuterons emitted sideways (in SpD). In Fig. 1b the deuteron energy in the SpD vs the polar angle of protons in the FD is plotted, indicating the strong correlation of the two–body kinematics. The angular interval of protons detected in the FD ($\theta_{lab} = 5.5°$ to $8.5°$) is defined by the SpD acceptance. In Fig. 1c the momentum distribution of protons detected in the FD in coincidence with deuterons in the SpD is shown (for $\theta_{lab} = 7°$ to $7.5°$). There is virtually no background. Overall, about $3 \cdot 10^5$ $\vec{p}d$ elastic scattering events were detected.

The vector analyzing power was determined from

$$A_y^p = \frac{1}{P} \cdot \frac{N_\uparrow - f N_\downarrow}{N_\uparrow + f N_\downarrow},$$

where P corresponds to the average beam polarization, $N_\uparrow$ ($N_\downarrow$) is the number of events scattered to the left ($\phi = 0$) with beam protons polarized $\uparrow$ ($\downarrow$), $f = L_\uparrow / L_\downarrow$ is the ratio of the luminosities for different orientations of the beam polarization. The ratio $f = 0.966 \pm 0.004$ was determined by counting protons from the inclusive reaction $\vec{p}d \to p + X$ at $\theta_{lab} \leq 0.5°$. In Fig.1d the angular dependence of the proton vector analyzing power A_y^p of $\vec{p}d$ elastic scattering is shown in comparison with other data at different energies, available from literature [4–6].

It should be noted, that the detection of $\vec{p}d$ elastic scattering events can be used for beam polarimetry at 796 MeV, where precise data on A_y^p exist in the angular range of the ANKE acceptance. In addition, it is possible to export a calibrated measurement of the beam polarization from 796 MeV to other energies, higher or lower, as shown in Ref. [7].

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[a] Universität Erlangen–Nürnberg, Germany
[b] PNPI, Gatchina, Russia
[#] PhD student from c
[c] JINR, Dubna, Russia
[d] HEPI, TSU, Tbilisi, Georgia
[e] Kazakh State University, Almaty, Kazakhstan

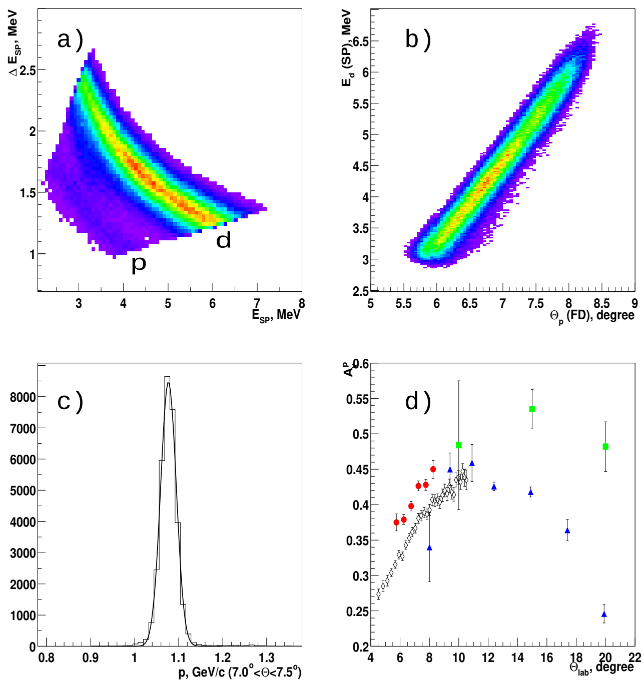

Fig. 1: a) Energy loss vs energy of particles stopped in the second layer of the SpD. b) Energy of deuterons stopped in the second layer of the SpD vs polar angle of forward protons. c) Proton momenta registered in the FD in coincidence with deuterons stopped in the second layer of the SpD. d) Comparison of the angular dependence of A_y^p of $\vec{p}d$ elastic scattering measured at ANKE (red circles) and other data at 544 MeV [4] (green squares), 796 MeV [5] (black diamonds), and 800 MeV [6] (blue triangles).