

Results of Measurements of the Analyzing Powers for Polarized Neutrons on C , CH_2 and Cu Targets for Momenta Between 3 and 4.2 GeV/c.

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Abstract. The analyzing powers for neutron charge exchange $nA \rightarrow pX$ reactions on nuclei have been measured on C, CH₂ and Cu targets at incident neutron momenta 3.0 - 4.2 GeV/c by detecting one charged particle in forward direction. The polarized neutron measurements are the first of their kind. The experiment was performed using the Nuclotron accelerator in JINR Dubna, where polarized neutrons and protons were obtained from breakup of a polarized deuteron beam which has a maximum momentum of 13 GeV/c. The polarimeter ALPOM2 was used to obtain the analyzing power dependence on the transverse momentum of the final-state nucleon. These data have been used to estimate the figure of merit of a proposed experiment at Jefferson Laboratory to measure the recoiling neutron polarization in the quasi-elastic ${}^2H(e, e'n)$ reaction, which yields information on the charge and magnetic elastic form factors of the neutron.

1. Introduction

The proposal E12-07-109 [1] to measure the p/n polarization from the reaction ${}^2H(\vec{e}, e'p/n)$ up to momentum of p/n equal 8 GeV/c needs to have analyzing power A_y in dependence on solid scattering angle or its derivatives. This unique possibility takes place at the JINR NUCLOTRON. We are planning to measure A_y at the beam momenta of protons/neutrons up to 6.5 GeV/c. A part of this program is completed and we present the data on analyzing power for the nA interaction within the neutron momentum range 3.00 to 4.2 GeV/c.



2. Measurements

To obtain polarized proton/neutron beams we used the accelerated deuteron beam. After its interaction on the $T1$ target (see Fig.1), the secondary beams of protons/neutrons of half-momenta were directed to the $T2$ target. The $T1$ target was set at different locations to produce proton/neutron beams. The polarization transfer from deuteron to half-momentum nucleon is equal to 1. Spectra and φ -asymmetry of scattering on the $T2$ target were measured with the

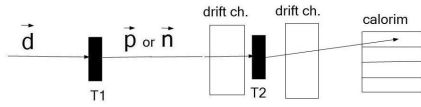


Figure 1. The scheme of the experiment.

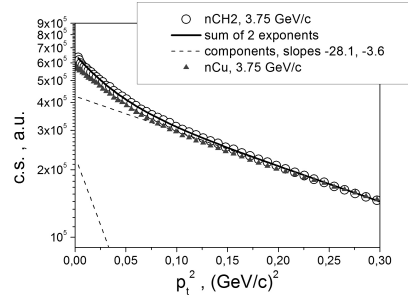


Figure 2. Spectra of the reaction $n + A \rightarrow p + X$.

help of drift chambers. For the neutron beam the average value of the directions of the secondary particles was assumed as direction of the incident particles. These values were monitored every 10 min of beam time.

To separate elastic and inelastic scattering on $T2$ information from the calorimeter was used. More details on the experiment can be found in [2].

3. Results

The results are presented as a function of the variable $p_t = p_{lab} \sin \theta$. For elastic scattering of equal mass particles we have $p_t^2 \simeq -t$, where t is a Mandelstam variable, which is good to the description of the elastic scattering spectra. Therefore, we present the obtained $n \rightarrow p$ spectra as a function of p_t^2 .

Part of the obtained results is shown in Fig.2. Firstly, one can see that A-dependence is not observed. Secondly, we see two distinct exponential slopes in the spectra behavior. Alike behavior of $p \rightarrow n$ spectra was observed in, for example, [3]. There, a sharper slope has been attributed to ρ -exchange, the other one – to π -exchange.

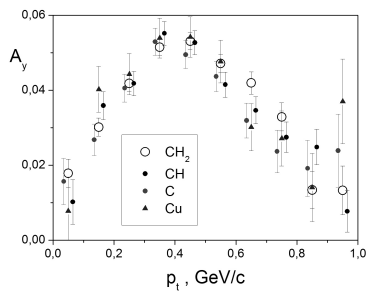


Figure 3. A-dependence of A_y in the reaction $n + A \rightarrow p + X$.

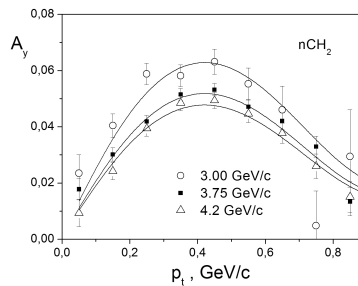


Figure 4. Momentum dependence of A_y in the reaction $n + A \rightarrow p + X$.

Following Ref. [4], the φ -asymmetry of the reaction with the vector polarized beam is:

$$N(p_t, \varphi, P) = N_0(p_t)[1 + A_y(p_t)P \cos \varphi], \quad -1 \leq P \leq 1 \quad (1)$$

where N_0 is yield on unpolarized beam, P is vertical polarization. For 2 values of polarization we have 2 Eqs.1, and so, we can exclude N_0 . The solution is given in [5].

The A -dependence of the analyzing power is shown in Fig.3. One can see that no sizeable dependence is observed.

The dependence of the analyzing power on the beam momentum is shown in Fig.4.

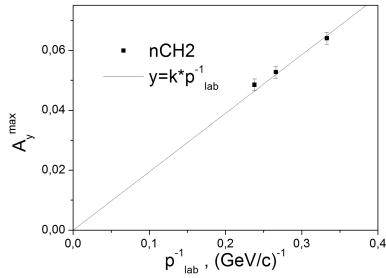


Figure 5. Dependence of A_y^{max} on neutron beam momentum.

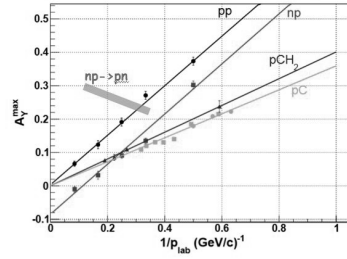


Figure 6. Dependence of A_y^{max} on proton beam momentum.

We can remark here that the positions of maxima of A_y coincide. The dependence of the values of maxima on the beam momentum is shown in Fig.5. We see that these value are proportional to p_{lab}^{-1} . A similar behavior in the $p \rightarrow p$ reaction was observed in [5] and other experiments (see Fig.6).

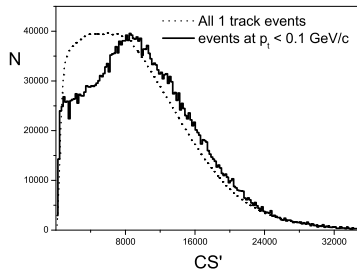


Figure 7. CS' distributions.

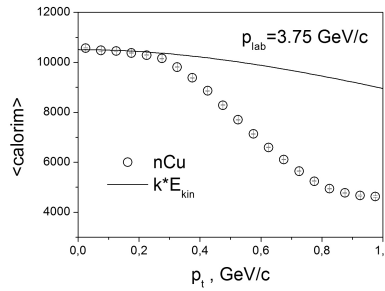


Figure 8. Average CS vs p_t .

The polarization measurement error is described by the following formula:

$$\Delta P = \frac{1}{\mathcal{F}} \sqrt{\frac{2}{N_{inc}}}, \quad (2)$$

where N_{inc} is the number of incident particles, \mathcal{F} is the figure of merit. \mathcal{F} is connected to analyzing power, differential cross section and target thickness by

$$\mathcal{F}^2 = N_{nucl} \int_{p_t} \frac{d\sigma}{dp_t} A_y^2(p_t) dp_t, \quad (3)$$

where N_{nucl} is the number of nuclei in the target.

Let us consider now, how the calorimeter may improve \mathcal{F} . The distribution of given values, $CS' = CS * E_{kin}(0)/E_{kin}(p_t)$, where CS is calorimeter signals, is shown in Fig.7. Also, it is shown the same distribution, but at $p_t < 0.1$ GeV/c (normalized), where events are certainly elastic. The average CS vs p_t is shown in Fig.8. We expect, for elastic scattered events these values are proportional to $E_{kin} = f(p_t, p_{lab})$. We see such a behavior at $p_t < 0.3$ GeV/c. At higher values of p_t the average CS are sizeable less due to contribution of inelastic scattering with small A_y . It is seen from Fig.9 that larger values of A_y correspond to larger values of CS .

Subdividing all events on 3 slices along CS' , we can construct

$$\mathcal{F}_c^2 = \sum_{i=1}^3 \mathcal{F}_i^2, \quad (4)$$

where i is the slice number, \mathcal{F}_i^2 is Eq.3 for i -th slice. In Fig.10 it is seen that such an approach improves figure of merit.

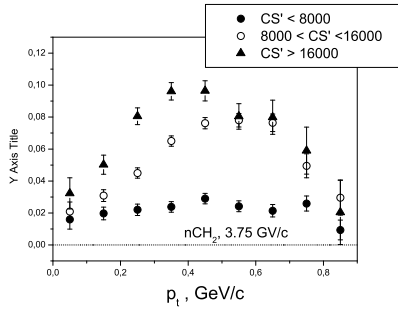


Figure 9. A_y vs p_t for 3 regions of CS' .

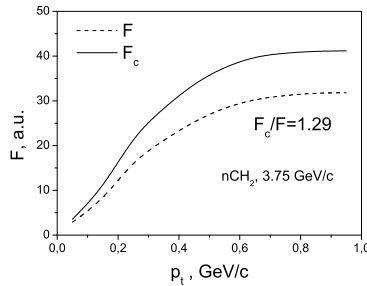


Figure 10. Figure of Merit vs acceptance of the setup.

For the track reconstruction via the drift chambers, the description of the spectra and obtaining of A_y , the soft [6, 7] was used.

Acknowledgments

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