FRAGMENTATION OF TENSOR POLARIZED DEUTERONS INTO CUMULATIVE PIONS

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The tensor analyzing power T_{20} of the reaction $\vec{d}A \to \pi^-(\theta = 0°)X$ was measured in the fragmentation of 9 GeV deuterons into pions with momenta from 3.5 to 5.3 GeV/c on hydrogen, beryllium and carbon targets. This momentum range corresponds to the region of cumulative pion production. The values of T_{20} were found to be small and consistent with positive values in contradiction with Impulse Approximation calculations based on the assumption of a direct mechanism of pion production ($NN \to NN\pi$). In addition, preliminary data on Ayy for pion production with high transverse momenta ($\theta = 135mr$) are presented.

The experiments performed on polarized deuteron beams at Saclay [1] and in Dubna [2] have shown that predictions for spin observables, based on Impulse Approximation (IA) calculations with standard two-component (S,D) deuteron wave functions (DWF), are confirmed only in the region of small internal momenta in the deuteron up to $k \simeq 0.25$ GeV/c. These deviations can be related to the manifestation of non-nucleonic degrees of freedom (NNDF) in the region of short range correlation (SRC) of a nucleon pair in the deuteron (deuteron core). A different character of the deviations for tensor analyzing powers in $A(d,p)X$ and $dp \to pd$ indicates that NNDF can manifest themselves in a high momentum part of DWF differently in different reactions. Thus it is highly desirable to compare of the behaviour of spin observables in a series of different reactions in order to identify the features of SRC in nuclei.

Another reaction to probe SRC is cumulative hadron production [3], i.e. the production of relativistic particles beyond the kinematical boundary for free NN interaction. Two alternative approaches were used to explain the mechanism of cumulative reactions. One is based on the hypothesis of the high momentum nucleon component in nuclei; the use of IA leads to the assumption of dominating the so-called direct mechanism when , for instance, in the $A(d,\pi)X$ reaction a cumulative pion is produced in the interaction of a high momentum nucleon in the deuteron with a target nucleon ($NN \to NN\pi$). The other approach is based on the consideration of SRC as multi-quark configurations. In this case, the cumulative pion is produced by hadronizing of a quark-spectator in the fragmentation of such a configuration [4].

One of the motivations to study T_{20} in the fragmentation of tensor polarized deuterons into cumulative pions was to verify the applicability of IA to this process. The calculations based on the direct mechanism [5] predict a similar $T_{20}(k)$-dependence in $\vec{d}A \to pX$ and $\vec{d}A \to \pi X$.

We present here the data on T_{20} vs two variables x_c and k_{min}. Cumulative number x_c is equal to a minimum effective number of nucleons which should take part in the collision to produce a cumulative particle [3]. In the framework of the direct mechanism, x_c can be related to internal momentum k which means that the cumulative pion of x_c must be produced on the nucleon of internal momentum $k \geq k_{min}(x_c)$.

The first measurement of T_{20} in cumulative pion production was performed with a carbon target [5]. Here, we report new data on the tensor analyzing power T_{20} in the reaction $\vec{d}A \to \pi^-(0°)X$ obtained with H-,Be-, and C-targets and Ayy-data for pion production with high transverse momenta in the reaction $\vec{d}Be \to \pi^-(135mr)X$. The value of T_{20} was determined by measuring the yield of pions ($N^{1,2}$) at two deuteron tensor polarizations ($p_{zz}^{1;2}$):
$T_{20} = 2\sqrt{2}(N^1 - N^2)/(N^1 p_{zz}^2 - N^2 p_{zz}^1)$.

The measurements were carried out using the setup described in [5]. At a fixed beam momentum of p_d=9.0 GeV/c the π^- momentum changed from 3.5 to 5.3 GeV/c at $\theta = 0$ and from 2.5 to 4.5 GeV/c at $\theta = 135mr$.

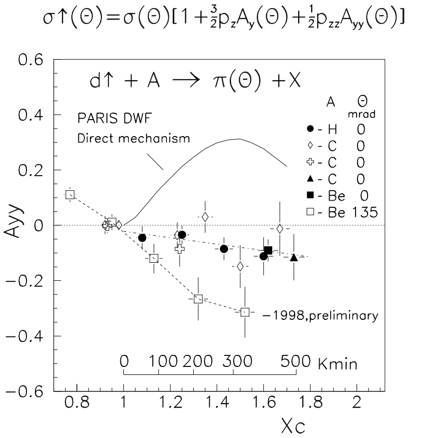

Figure 1: Ayy vs x_c and k_{min} for $\vec{d}A \to \pi^-(\theta)X$ in the fragmentation of 9 GeV deuterons on H-,Be-, and C-targets. The earlier data with C-target are marked by open diamond (π^-) and crosses (π^+).

Data at p_π=3.5, 4.0, 4.5 and 5.0 GeV/c were taken with the H-target. To check the A-dependence effect 5.0 GeV/c-point was repeated with the Be-target , and a point at 5.3 GeV/c was taken with the C-target (55 g/cm^2).

The new experimental results together with earlier data [5] are presented in Fig.1. The tensor analyzing powers are shown in the Cartesian form (Ayy) to combine the data for $\theta = 0$ and $135mr$ ($Ayy(0°) = -T_{20}/\sqrt{2}$). As shown in Fig.1, the Ayy of π^- is of negative sign. $Ayy(0°)$ is nearly zero at x_c=1.0 and decreases up to $\simeq -0.11$ at $x_c = 1.7$. $Ayy(135mr)$ demonstrates a more dramatic dependence on x_c reaching -0.3 at $x_c = 1.5$ ($p_T^{\pi} = 0.65$ GeV/c at this point). Comparing the new Ayy data obtained on H-,Be-, and C-targets , the A-dependence was found to be week.

The solid curve in Fig.1 shows the prediction of the direct production mechanism for $\vec{d}C \to \pi(0°)X$ calculated the Paris DWF [5]. These calculations fail to reproduce $T_{20}(x_c)$ in any part of the cumulative region ($x_c > 1$,$k_{min} > 0$) in contradiction with the T_{20}-behaviour in the $\vec{d}A \to p(0°)X$ where there is a quantitative agreement with IA calculations up to $k = 0.25$ GeV/c, as noted.

In conclusion:

The tensor analyzing power Ayy of the reaction $\vec{d}H(Be, C) \to \pi(0°)X$ at a deuteron momentum of 9 GeV/c and pion momenta from 3.0 to 5.3 GeV/c has been measured. As for the direct mechanism of pion production, this momentum region corresponds to internal momenta k up to $k \simeq$500 MeV/c. The sign of Ayy is opposite to that determined with the standard DWF assuming the direct mechanism. The above data show that the hypothesis of dominating the direct $NN \to NN\pi$ process is not appropriate in the fragmentation of deuterons into cumulative pions. Attention should be given to a quark scenario of cumulative particle formation considering the deuteron core as a multiquark configuration.

To make the comments on Ayy-data obtained at high p_T^{π}, the corresponding IA calculations for $\theta = 135mr$ have to be performed.

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