Original transverse momentum dependence of the transverse single spin asymmetries for very forward neutron production in inclusive triggered $p^{\uparrow} + p$ collisions at $\sqrt{s}$ = 200 GeV

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Abstract

Transverse single spin asymmetries (A_N's) are a useful probe to understand the production mechanism of particles such as neutrons, among others, in high energy particle collisions. We have for the first time extracted explicitly unfolded transverse momentum (p_T) dependent results of transverse single spin asymmetries for very forward neutron production in PHENIX RUN 15 inclusive triggered $p^{\uparrow} + p$ collisions at $\sqrt{s}$ = 200 GeV. As raw transverse momentum-dependent asymmetries were already initially extracted, we have performed an unfolding of the data because of the limited acceptance and resolution of the PHENIX Zero Degree Calorimeter (ZDC). Utilizing a boot-strap method for finding the optimal functional form of the true asymmetries in weighted Monte Carlo simulations, we were able to unfold the actual asymmetries and obtained their true transverse momentum dependence based on those smearing matrices. For the unfolding, spin dependent yields and smearing matrices were used that were two-dimensional in transverse momentum and azimuthal angle (φ). The overall unfolded A_N's as a function of true p_T show, within systematic uncertainties, a tendency to increase initially in magnitude while at higher p_T at most a moderate increase or even a decrease of asymmetries is favored. The p_T dependent asymmetries have been extracted via hadronic interactions using One Pion Exchange (OPE) Monte Carlo simulations based on a polynomial weight function of third order. According to OPE theoretical interpretations, A_N's arise from the interference between spin-flip and spin non-flip amplitudes. Since the pion exchange amplitude is fully spin-flip, A_N's are very sensitive to other spin parity 1^+ reggeon, $a_1(1260)$, exchange amplitudes even for very small amplitudes. These results will substantially contribute to theoretical understanding of forward neutron single spin asymmetries.