ASYMMETRY OF JET PRODUCTION IN $\vec{P}-\vec{P}$ COLLISIONS AT RHIC AND SIGN OF ΔG

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The jet production in $\vec{p}-\vec{p}$ collisions at high energies is studied. A possibility to discriminate the spin-dependent gluon distributions and to determine sign of ΔG is discussed. The predictions for the longitudinal asymmetry A_{LL} of the jet production in the $\vec{p}-\vec{p}$ collisions at RHIC energies have been made.

1 Introduction

Up to now, there exists neither a running experiment to directly measure the polarized gluon distribution nor does the variety of indirect analyses give a unique result. Hence there is no completely convincing argument on the shape and sign of $\Delta G(x,Q^2)$ yet, although a recent NLO analysis [1] clearly favors a positive sign. However, recent calculations in the context of a non–relativistic quark model and the bag model, respectively, [2] indicate that the integral over $\Delta G(x,Q^2)$ might be negative too. Both positive and negative values of the sign of $\Delta G(x,Q^2)$ were considered in [3]. The result of the DIS data analysis [4] on g_1^n strongly supports the conclusion that the sign of $\Delta G(x,Q^2)$ should be positive. The study of the asymmetry of jet and dijet production in $\vec{p}-\vec{p}$ collisions is more perspective for direct measuring of the $\Delta G/G$ [5].

2 Spin-Dependent Gluon Distribution

The 3 sets of spin-dependent parton distribution functions (PDF) [3] and [6] are used to calculate the jet asymmetry A_{LL}. First set is based on work of Altarelli and Stirling [6] and include a scenario with large gluon polarization Δg. Second and third ones have been obtained by the phenomenological method [3] including some constraints on the signs of valence and sea quark distributions, taking into account the axial gluon anomaly and utilizes results on integral quark contributions to the nucleon spin. It was shown in [7] that phenomenological method reproduces the main features of the NLO QCD Q^2-evolution of proton, deuteron and neutron structure function g_1. We shall denote $\Delta G^{>0}$ and $\Delta G^{<0}$ sets of spin-dependent PDF [3] with positive and negative sign of ΔG, respectively. Figure 1 shows the dependence of the ratio $\Delta G/G$ on x at $Q^2 = 100\ (GeV)^2$ for different gluon distributions (a) - [6], $\Delta G^{>0}$ [3] and (b) - $\Delta G^{>0}$, $\Delta G^{<0}$ [3].

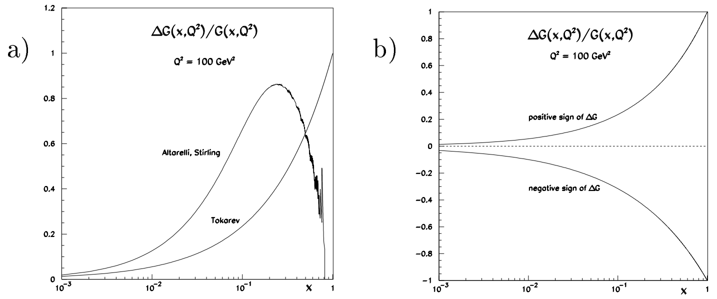

Figure 1: The ratio of polarized and unpolarized gluon distributions as a function of x at Q^2=100 GeV^2 for different parametrizations (a) - $\Delta G^{>0}$ [3], [6] and (b) - $\Delta G^{>0}$ [3], $\Delta G^{<0}$ [3].

3 Asymmetry of Jet Production

The double spin asymmetry A_{LL} of jet production in $\vec{p}-\vec{p}$ collisions is expressed via the difference of cross-sections (numbers of jets) for antiparallel ($\uparrow\downarrow$) and parallel ($\uparrow\uparrow$) spins of colliding protons. For study of jets asymmetry at STAR we have used the Monte Carlo code SPHINX [8]. Jets are defined in the two-dimensional (η, ϕ)-plane, η being pseudorapidity and ϕ the azimuthal angle. STAR detector covers $0 < \phi < 2\pi$ and $-1 < \eta < 2$. The expected segmentation $(\Delta\eta \times \Delta\phi = 0.1 \times 0.1)$ and resolution of the STAR Electromagnetic Calorimeter $\Delta E/E \simeq 0.16/\sqrt{E}$ were also taken into account. The values of jet-finder parameters were $E_{\perp}^{cell} = 1.5\ GeV$ and $R = \sqrt{\Delta\eta^2 + \Delta\phi^2} = 0.7$. Designed luminosity at RHIC, $\mathcal{L} = 8 \times 10^{31} cm^{-2} s^{-1}$ at $\sqrt{s} = 200\ GeV$ ($\mathcal{L} = 2 \times 10^{32} cm^{-2} s^{-1}$ at $\sqrt{s} = 500\ GeV$) and the polarization $P = 0.7$ of the beams were used in the calculations.

Figure 2(a) shows the dependence of A_{LL} on the jet transverse energy E_T at $\sqrt{s} = 200\ GeV$ for spin-dependent PDF's [6] and $\Delta G^{>0}$ [3]. The errors on all the figures are statistical only, based on the expected luminosity of RHIC and the properties of the STAR detector. The value A_{LL} for both set of PDF's is less than 5% at $E_T < 35\ GeV$. For $E_T > 35\ GeV$ the asymmetry calculated with PDF $\Delta G^{>0}$ increases with E_T.

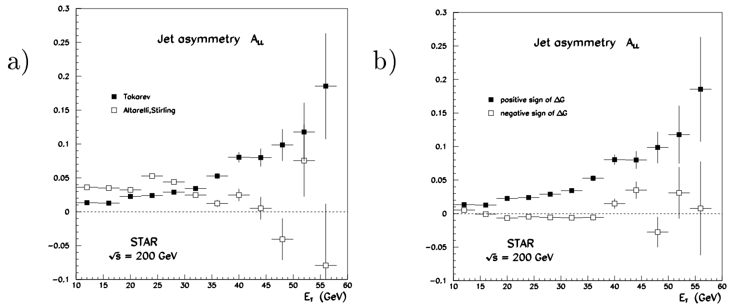

Figure 2: Asymmetry of jet production A_{LL} in $\vec{p}-\vec{p}$ collisions at $\sqrt{s} = 200$ GeV for different sets of spin-dependent PDFs (a) - $\Delta G^{>0}$ [3], [6] and (b) - $\Delta G^{>0}$ [3], $\Delta G^{<0}$ [3] as a function of jet transverse energy E_T.

We can consider 3 characteristic regions on the Figure 2(a). In the low E_T region ($E_T < 20$ GeV) the asymmetry A_{LL}^{Al-St} obtained with parametrization [6] is larger than the asymmetry A_{LL}^{Tok} obtained with parametrization $\Delta G^{>0}$ [3]. The ratio $\Delta G/G$ for PDF's [6] is larger than $\Delta G/G$ calculated with PDF $\Delta G^{>0}$ [3] at low x (Fig.1a), so the behaviour of the asymmetry A_{LL} is reasonable. In the range $20 < E_T < 40$ GeV the asymmetry A_{LL}^{Al-St} decreases and A_{LL}^{Tok} increases. Here, the main contribution comes from $q-g$ scattering, so the difference of the Δq parametrizations in [3] and [6] becomes equally important as ΔG. The ratio $\Delta G/G$ for parametrization [6] decreases with x at $x > 0.2$ which results in the decreasing of asymmetry value A_{LL}. For $E_T > 40$ GeV the asymmetry $A_{LL}^{Al-St} \simeq 0$ and A_{LL}^{Tok} increases with E_T and reaches (15-20)% at $E_T > 50$ GeV. The main contribution comes from $q-q$ scattering, so the resulting asymmetries reflect the difference between the spin-dependent quark distributions. Figure 2(b) shows the dependence of A_{LL} on E_T at $\sqrt{s} = 200$ GeV for PDF's with different sign of gluon distributions, $\Delta G^{>0}$ and $\Delta G^{<0}$ [3]. The asymmetry calculated with PDF $\Delta G^{>0}$ increases with E_T, while the asymmetry calculated with PDF $\Delta G^{<0}$ is practically equal to zero in the whole region. The dependence of A_{LL} on E_T at $\sqrt{s} = 500$ GeV for spin-dependent PDF's $\Delta G^{>0}$ and $\Delta G^{<0}$ [3] are presented in Figure 3(a). In the low E_T region ($E_T < 30$ GeV) the values of the asymmetry A_{LL} are the same for both positive and negative sign of ΔG. It is due to the dominant contribution of $g-g$ scattering and the factor $\Delta G/G$ enter twice the formula for asymmetry. For $30 < E_T < 65$ GeV, there is a clear difference between asymmetry values for positive and negative sign of ΔG. The results obtained with the parametrization [6] are presented in Figure 3(b). Analysis of the Fig. 3 allows us to conclude that the information about ΔG could be extracted from the experimental data on jet asymmetry.

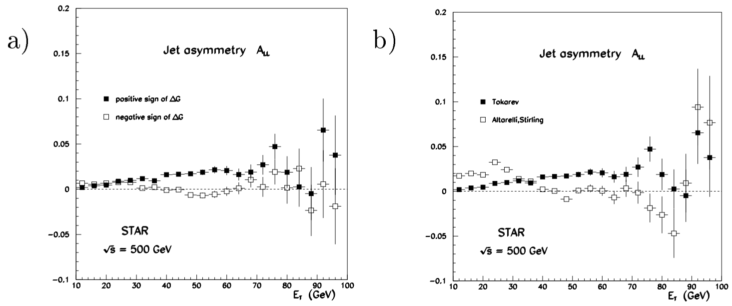

Figure 3: Asymmetry of jet production A_{LL} in $\vec{p}-\vec{p}$ collisions at $\sqrt{s} = 500$ GeV for different sets of spin-dependent PDFs (a) - $\Delta G^{>0}$ [3], $\Delta G^{<0}$ [3] and (b) - $\Delta G^{>0}$ [3], [6] as a function of jet transverse energy E_T.

4 Conclusions

The asymmetry of jet production A_{LL} in $\vec{p}-\vec{p}$ collisions at RHIC energies was studied. The Monte Carlo study of A_{LL} dependence on jet transverse energy E_T for different parametrization of ΔG was performed. The parameters of the STAR EMC detector were taken into account. The asymmetry is sensitive to Δq at high E_T values and reaches (15-20)% for $E_T > 50\ GeV$. It was found that the value of A_{LL} is less than 5% for $E_T < 30\ GeV$. In the region $30 < E_T < 50\ GeV$, the asymmetry A_{LL} is especialy sensitive to the sign and shape of the $\Delta G(x, Q^2)$.

References

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