Longitudinal Double Spin Asymmetry at Fixed centre of mass by Bag Model

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Abstract

In Longitudinal Polarized Proton Collisions, PHENIX is able to study the gluon spin contribution to the proton spin. A_{LL} results from 2005 and 2006 have been shown to constrain Δg. The longitudinal double spin asymmetry in polarized proton collisions at $\sqrt{s}$ = 200GeV is measured by PHENIX which is compared with our theoretical model of Thermodynamical Bag Model (TBM).

1. Introduction

Deep-inelastic Scattering (DIS) experiments with polarized leptons and polarized nucleons have found that the spin of quarks and antiquarks account for only 25% of the nucleon spin [1].The gluon helicity distribution and orbital angular momenta are thus essential to the understanding of nucleon spin. The Phenix experiment at the Relativistic Heavy Ion Collider (RHIC) studies the spin structure of the proton with longitudinally and transversely polarized proton collisions. With longitudinally polarized proton collisions, the gluon spin contribution to the spin of the proton (Δg) can be studied. By measuring the double spin asymmetry A_{LL} , both the sign and magnitude of Δg can be constrained.

In our present analysis, the measured longitudinal double spin asymmetry at fixed centre of mass energy [2] is compared with our evaluated values.

2. Bag Model

Nucleon [3] is considered to be in infinite momentum frame, in which quarks and gluons are treated as fermions and bosons respectively. The gauge-coupling constant between quarks and gluons varies with energy through"vaccum polarization" effects [4] as,

$$\alpha_s = \frac{4\pi}{\left(11-\frac{2N_f}{3}\right)\ln\left(\frac{Q^2}{\Lambda^2}\right)} \qquad (1)$$

The quark distribution $q(x)$ being a function of chemical potential 'μ' and temperature 'T' can be expressed as,

$$q(x) = \frac{6VM^2Tx}{4\pi^2}\ln\left[1+\exp\left\{\left(\frac{1}{T}\right)\left(\mu-\frac{Mx}{2}\right)\right\}\right] \qquad (2)$$

$q(x)dx$ is the probability of finding quark carrying the momentum fraction between x and $x+dx$ of the nucleon momentum. The volume of the bag increases with temperature. The Bjorken variable x governs the distribution function and the four momentum transfer (Q^2). These determine the invariant mass of the final hadronic state, which in turn measure the temperature T of the bag. This model remarkably explains the abundant experimental data of both polarized and unpolarized nucleon structure function and its asymmetries.

$$\Gamma_1^p(Q^2)-\Gamma_1^n(Q^2) = \frac{1}{6}\left\{\left(\frac{g_A}{g_V}\right)\left(1-\frac{\alpha_s(Q^2)}{\pi}\right)\right\} \qquad (3)$$

The spin dependent structure function $g_1^p(x,Q^2)$ and $g_1^n(x,Q^2)$ are evaluated by applying quark distribution in the Thermodynamical Bag Model ,while SMC[5] have evaluated the same by parametrization through QCD. The scaling violations are not appreciable and perceptible by the present experimental errors. This is in accordance with the results of [6], where the effect due to gluon polarization is analysed. This distribution satisfies the Bjorken sum rule [7].In the infinite momentum frame $q(x)dx$ gives the probability of finding a quark carrying the momentum fraction between x and $x+dx$ of the nucleon momentum and $u(x)$,$d(x)$ denotes the unpolarized up, down quark distributions in a bag.

3. Evaluation of longitudinal double spin asymmetry

A major goal of the RHIC spin program is to measure Δg through longitudinally polarized proton

collisions. In polarized proton collisions, we define the double spin asymmetry using the quark distribution as,

$$A_{LL} = D(A_1^P + \eta A_2^P) \qquad (4)$$

Where

$$A_1^P = \frac{g_1^P - \gamma^2 g_2^P}{F_1^P}$$

$$A_2^p = \frac{\gamma[g_1^p + g_2^p]}{F_1^p}$$

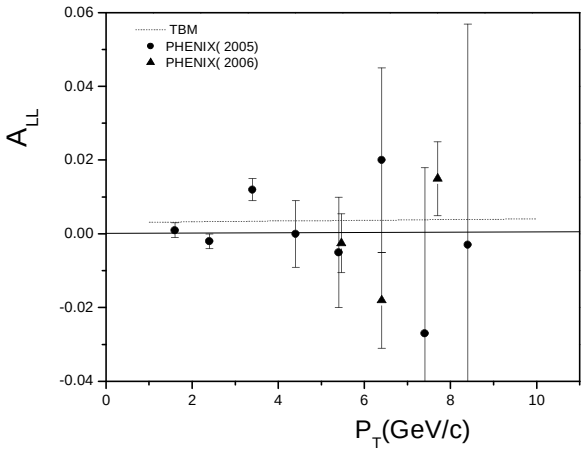

Fig 1: PHENIX results on A_{LL} at $\sqrt{s}$ = 200GeV is compared with our theoretical values (TBM).

Fig.1 shows A_{LL} versus P_T from 2005(Round circles) as well as high P_T data from 2006(square triangles) using a high P_T Photon filter [8].The Dashed curve Shows our theoretical evaluated values. The data in Fig. 1 cover an *x*-range of 0.07 to 0.2.When A_{LL} is measured for different center of mass energies; this x-range can be extended. Interpretation of this result requires that the data is described by perturbative Quantum ChromoDyanamics (pQCD).

4.Conclusions

The Polarization in longitudinally polarized proton collisions at RHIC in 2005 and 2006 have allowed PHENIX to constrain, ruling out maximal gluon polarization models, by measuring A_{LL} at $\sqrt{s}$ = 200GeV.This analysis is ongoing and upon completion, will allow further discussion of this A_{LL} result by comparing it with the pQCD calculations. Our theoretical model (TBM) calculations are in fair accuracy with the PHENIX data.

Reference

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