PROCEEDINGS OF SCIENCE

Inclusive Jet Cross Section Measurements in pp Collisions at $\sqrt{s}$ = 200 and 510 GeV with STAR

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Jets, clusters of collimated particles produced in high energy proton-proton (pp) collisions, are an excellent tool to study the internal structure of the proton. According to perturbative QCD (pQCD) calculations, for center-of-mass energies of $\sqrt{s}$ = 200 and 510 GeV at RHIC, jet production in the mid pseudorapidity, $|\eta| < 1$, is dominated by quark-gluon and gluon-gluon scattering processes. These jets are sensitive to gluons in the proton with momentum fraction $0.01 < x < 0.5$. The STAR experiment has measured a series of jet double-spin asymmetries within the pseudorapidity region of $-1 < \eta < 2$, in longitudinally polarized pp collisions, to constrain the gluon helicity distribution function in the proton. Similarly, jet cross section measurements from unpolarized pp collisions are effective in constraining the unpolarized gluon distribution in the proton. In this proceeding, we will present the analysis techniques and the preliminary results of inclusive jet cross section measurements in pp collisions at $\sqrt{s}$ = 200 and 510 GeV.

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1. Introduction

Deep inelastic scattering (DIS) experiments have been successful in constraining the quark parton distribution functions (PDFs). Unlike DIS experiments, pp collisions allow direct access to the gluon PDFs through $2 \rightarrow 2$ hard scatterings such as qg and gg processes. The final-state particles fragmented from the scattered partons can be readily detected and clustered as jets using an algorithm such as anti-k_T [1]. At center-of-mass energies $\sqrt{s}$ = 200 and 510 GeV provided by RHIC, qg and gg processes dominate the jet production, as shown in Fig. 1 [1–3]. Therefore jet cross section measurements are sensitive to gluon PDFs and can be used to constrain them.

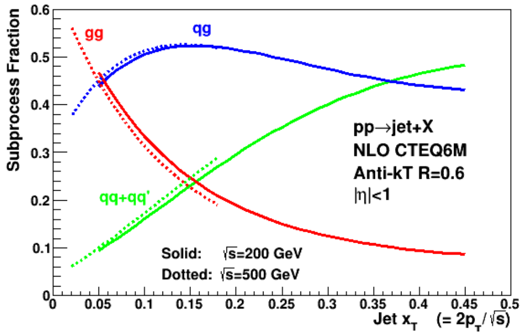

Figure 1: Fractions of jet production in gg (red), qg (blue) and qq (green) processes as a function of jet $x_T = \frac{2p_T}{\sqrt{s}}$ at $\sqrt{s}$ = 200 and 500 GeV [1–3].

2. Luminosity

Given the effective beam width in the transverse plane, h_x^{eff} and h_y^{eff}, the luminosity at the maximum overlap was expressed as $L_0 = \frac{N_1 N_2 f}{2\pi h_x^{eff} h_y^{eff}}$, where N_1, and N_2 were number of protons in the colliding bunches of the two beams, and f was the bunch crossing frequency. h_x^{eff} and h_y^{eff} were obtained from the change in the coincidence rate of the STAR Zero Degree Calorimeter (ZDC), R_{ZDC}, as a function of beam displacement, x_d, in either the horizontal or vertical direction, through the so-called vernier scans [4], as shown in Fig. 2. The effective total cross section seen by the ZDC was derived as, $\sigma_{ZDC}^{eff} = \frac{L_0}{R_{ZDC,max}}$. By monitoring the relative ZDC coincidence rate at a specific time t, $R_{ZDC}(t)$, the sampled luminosity was calculated as $L = \int dt R_{ZDC}(t) \cdot \sigma_{ZDC}^{eff}$, where $R_{ZDC}(t)$ was integrated over time when the analyzed data were taken.

3. Jet Reconstruction and Unfolding

Jets were reconstructed from charged tracks measured by the Time Projection Chamber (TPC) and energy deposits in the electromagnetic towers using the anti-k_T algorithm [1] provided by fastjet package [6]. At $\sqrt{s}$ = 200 GeV, jet parameter R was chosen to be 0.6 , while $R = 0.5$ was used at $\sqrt{s}$ = 510. The R parameter set the scale of the distance in $\eta - \phi$ space among particles in a jet. Smaller R was less sensitive to soft diffusion background created at higher $\sqrt{s}$. An off-axis cone

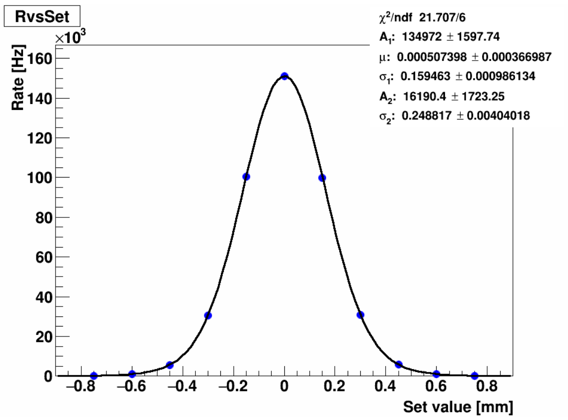

Figure 2: The accidental and multiple corrected [5] ZDC coincidence rate as a function of beam displacement was fitted with a double-Gaussian function, $R_{ZDC} = A_1 e^{-\frac{1}{2}(\frac{x_d-\mu}{\sigma_1})^2} + A_2 e^{-\frac{1}{2}(\frac{x_d-\mu}{\sigma_2})^2}$.

method was applied to the reconstructed jet transverse momentum p_T to correct for the contribution from underlying events [7].

The reconstructed jets were unfolded to the physical particle jets by taking into account the fraction of unmatched detector jets, the response matrix, and the efficiency. The simulation was generated from the STAR tuned PYTHIA 6 event generator, and the GEANT3 detector simulator, and embedded into zero-bias real events, which were uncorrelated with any triggers [7]. The unfolding process was a simple matrix inversion, where the regularization was achieved by selecting the optimal number of jet p_T bins and their bin width to avoid statistical fluctuations.

4. Results

The double differential inclusive jet cross section $\frac{d^2\sigma}{dp_T d\eta}$ is presented as a function of jet p_T in $|\eta| < 0.8$ at $\sqrt{s}$ = 200 GeV and in $|\eta| < 0.5$ and $0.5 < |\eta| < 0.9$ at $\sqrt{s}$ = 510 GeV in Fig. 3. The systematic uncertainties include those from the electromagnetic calorimeter response to photons/electrons and hadrons, which is the dominant contribution, the TPC track momentum resolution, the TPC tracking efficiency, the unfolding bias, and the luminosity scale. At $\sqrt{s}$ = 200 GeV, the results are compared with PYTHIA 6 and pQCD calculations. The results are larger than the PYTHIA prediction across the jet p_T range, but their shapes are quite close. A hadronization correction is estimated from PYTHIA. With this applied to the NLO calculation [2] at the parton level, the 200 GeV results are below the NLO predictions with the CT14 NLO PDFs [8].

5. Conclusion

In summary, we reported the preliminary results of inclusive jet cross section at $\sqrt{s}$ = 200 and 510 GeV as a function of jet p_T in different η bins. The results will provide constraints to the unpolarized gluon PDFs at $0.01 < x < 0.5$. They will also provide normalizations for future fragmentation measurements at STAR. Complementary to data from the Tevatron and the LHC, they can be used to tune event generators, especially $\sqrt{s}$ dependent parameters. At $\sqrt{s}$ = 200 GeV,

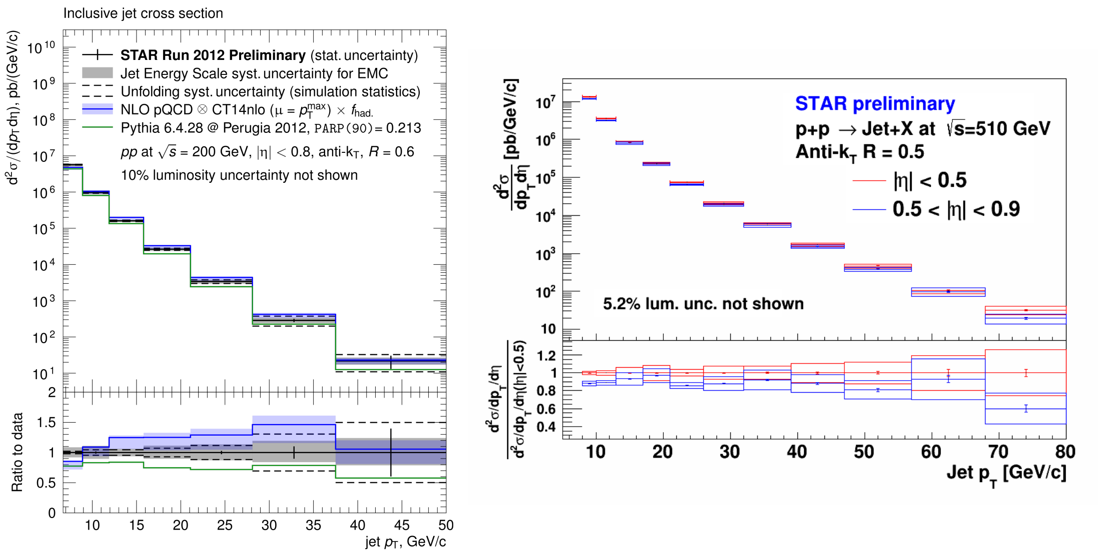

Figure 3: Preliminary results of double differential inclusive jet cross section, $\frac{d^2\sigma}{dp_T d\eta}$, at $\sqrt{s}$ = 200 (left) and 510 (right) GeV.

the jet cross section will serve as reference data to the same measurements in Au+Au collisions at STAR in order to study the properties of the quark-gluon plasma.

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