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

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Abstract

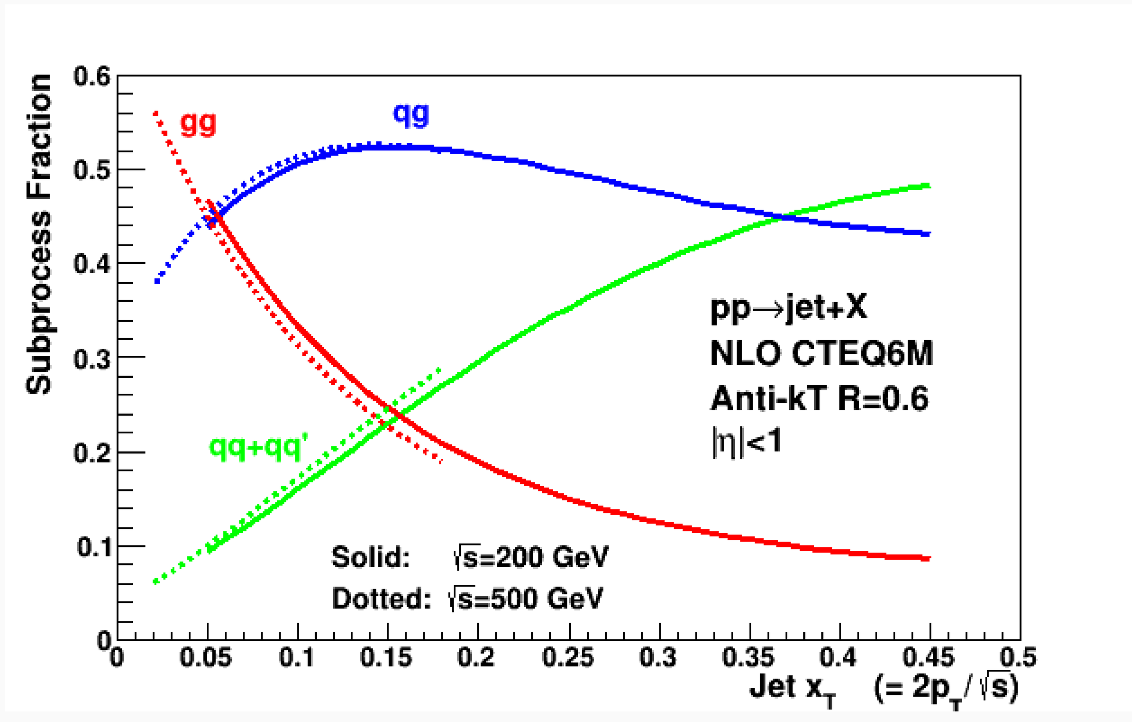
Jets, clusters of collimated particles produced in high energy proton-proton (pp) collisions, are an excellent tool to study the internal structure of the proton. According to perturbative QCD calculations, for center of mass energies of $\sqrt{s} = 200$ and 510 GeV at RHIC, jet production in the mid 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 $-1 < \eta < 2$, 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 poster, we will present the STAR preliminary results on mid pseudorapidity inclusive jet cross section measurements in pp collisions at $\sqrt{s} = 200$ and 510 GeV as well as the techniques used in this analysis. The latter includes determination of absolute luminosity, an off-axis cone underlying event correction to the jet transverse momentum, and an unfolding procedure to map the measured jet spectra to physical particle jet spectra.

Introduction

Partons from the hard QCD scatterings hadronize into clusters of collimated particles, called jets. In pQCD calculation, the cross section of jet production can be factorized into partonic scattering cross sections and parton distribution functions (PDFs):

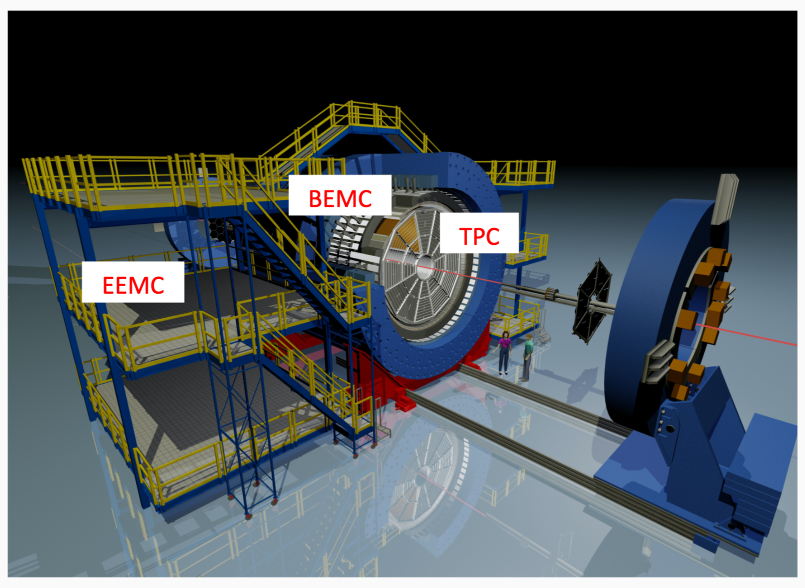
$$d\sigma \sim \Sigma_{a,b} f_a(x_a, Q^2) f_b(x_b, Q^2) \otimes d\hat{\sigma_{ab}}.$$

In pp collisions at $\sqrt{s} = 200$ and 510 GeV, jets are sensitive to gluon PDF [1].



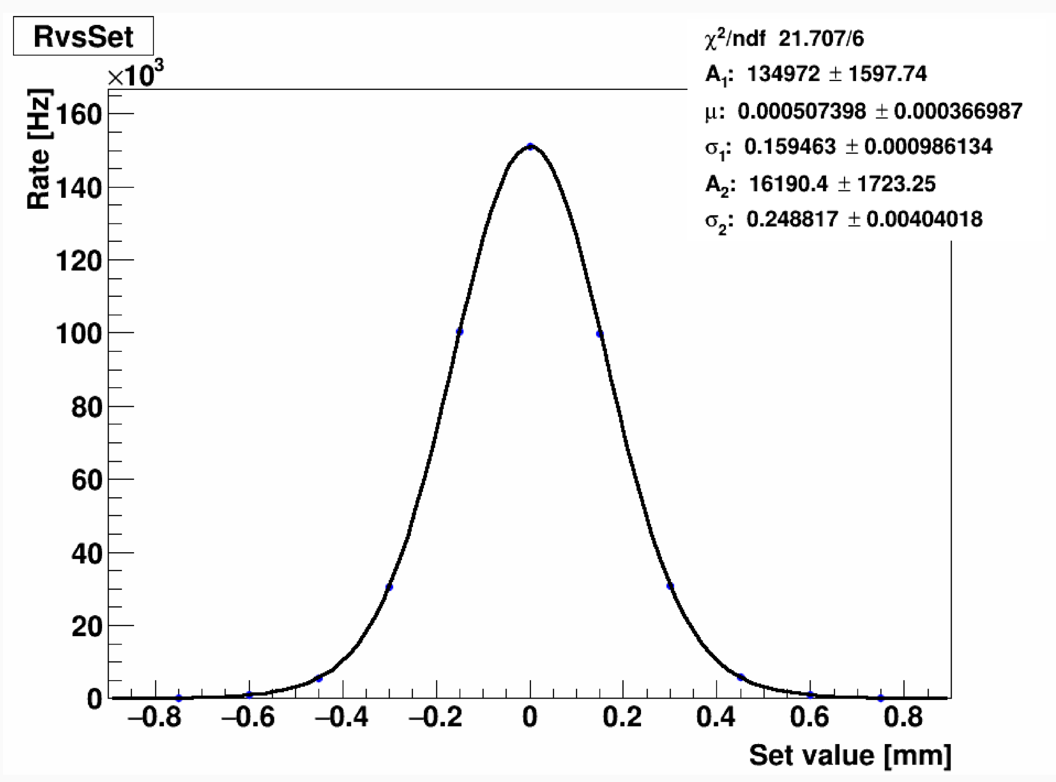
Experiment

The STAR subsystems relevant to this analysis cover full 2π in azimuth, ϕ, and various ranges in pseudorapidity, η: TPC, $|\eta| < 1.3$; B/E-EMC, $-1 < \eta < 2$; ZDC (not shown) monitors the sampled luminosity



Luminosity

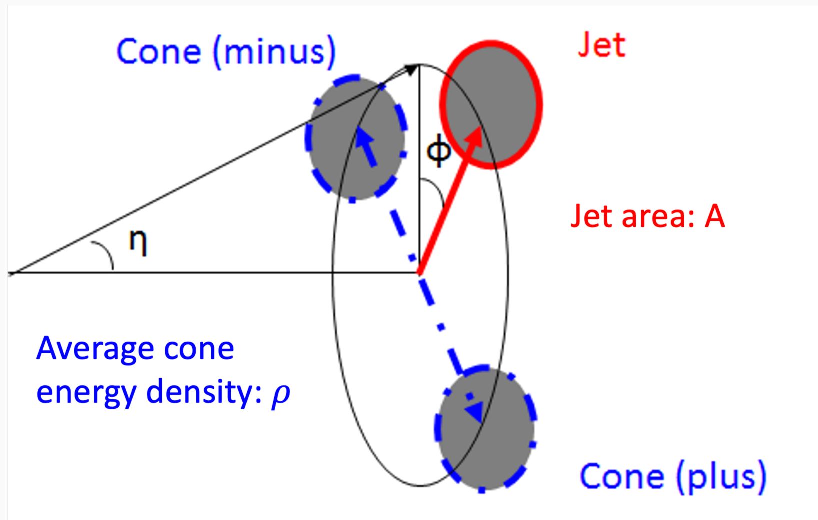
The transverse width of the colliding beams is determined from the vernier scans [2], where ZDC coincidence rate R_{ZDC} vs. beam displacement along a vertical axis is fitted with a double-Gaussian function $R_{ZDC} = A_1 e^{-\frac{1}{2}(\frac{x-\mu}{\sigma_1})^2} + A_2 e^{-\frac{1}{2}(\frac{x-\mu}{\sigma_2})^2}$.



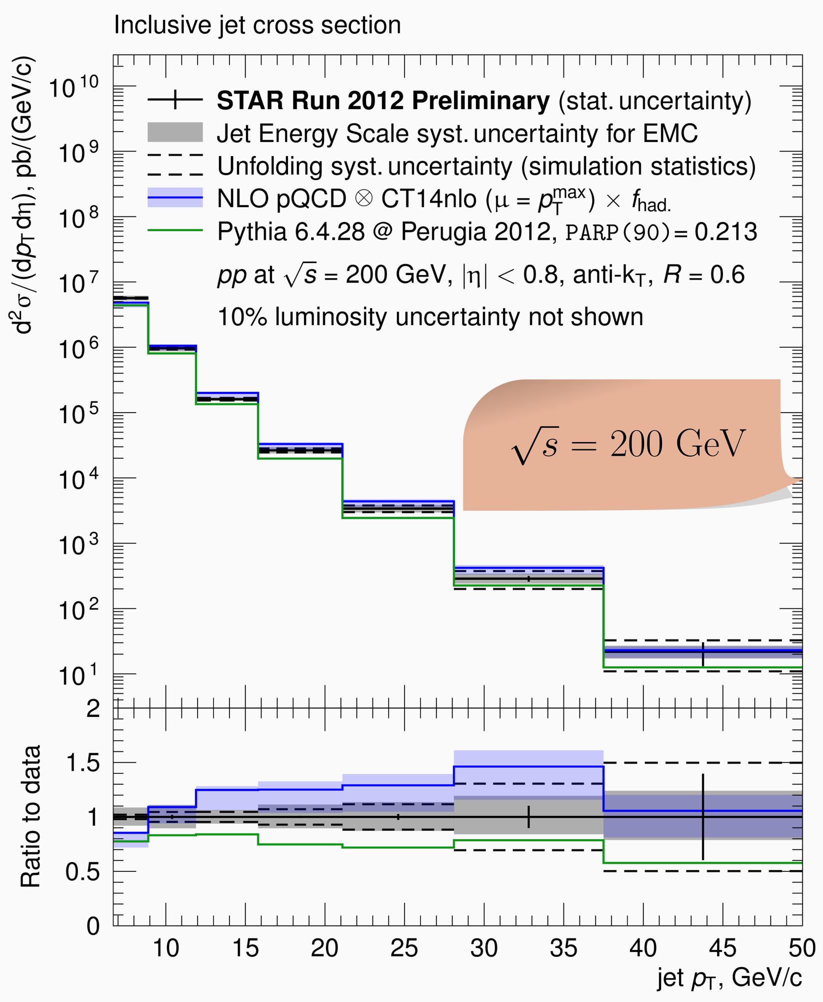
- An effective ZDC cross section σ^{eff}_{ZDC} is derived at the maximum beam overlap
- The sampled luminosity is calculated as $L = \int_{t_0}^{t_1} dt R_{ZDC}(t) \cdot \sigma^{eff}_{ZDC}$, where t is the time between the start t_0 and the end t_1 of data taking, corrected for the dead times from the trigger system and the data acquisition system

Jet Reconstruction

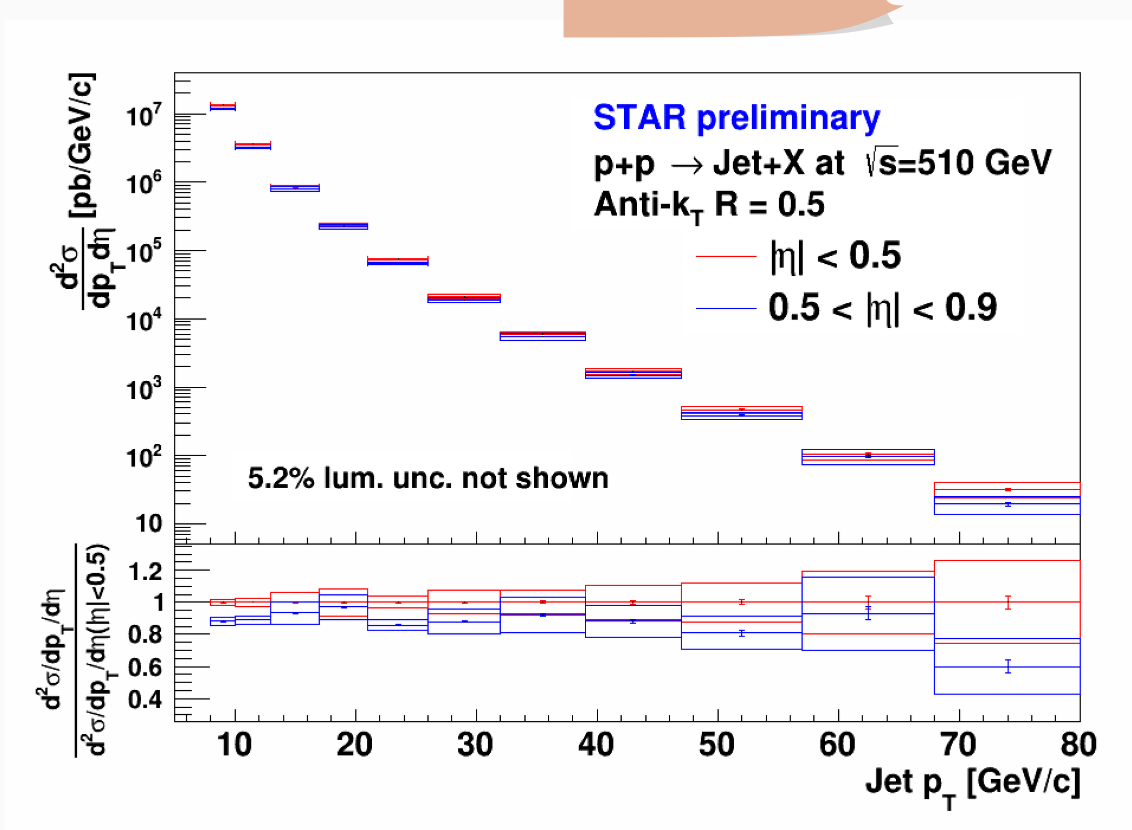
- Trigger: EMC based jet patch triggers. Each jet patch covers one unit in η and ϕ
- Jet finding: anti-k_T with $R = 0.6$ for $\sqrt{s} = 200$ GeV and $R = 0.5$ for $\sqrt{s} = 510$ GeV
- Underlying event correction: two off-axis cones centered at $\pm\frac{\pi}{2}$ away from the jet ϕ and the same jet η, $dp_T = \rho A$ [3]
- Unfolding to particle jet p_T spectrum : PYTHIA6+GEANT, response matrix inversion, predetermined p_T binning to minimize statistical fluctuations in the measured jet p_T spectrum



Results



$\sqrt{s} = 510$ GeV



- The fractions of fake jets, i.e. detector jets that are not matched to a particle jet in the simulation, and the jet-finding efficiencies due to the analysis cuts and the event triggering are taken into account
- The dominant systematic uncertainty comes from jet energy scale uncertainty, mainly contributed by EMC photonic calibration uncertainty, and EMC non-photonic response uncertainty
- STAR-tuned PYTHIA6 [3] under-predicates the data at $\sqrt{s} = 200$ GeV
- The 200 GeV results are below NLO pQCD calculation after hadronization corrections

Conclusion

In contrast to DIS experiments, pp collisions allow direct access to gluons inside the proton. The double-differential inclusive jet cross sections $\frac{d^2\sigma}{dp_T d\eta}$ vs. jet p_T are presented 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. The results are compared with predictions from the Monte-Carlo event generator, PYTHIA6, and the NLO pQCD calculation after hadronization corrections at $\sqrt{s} = 200$ GeV. A detailed study of the hadronization corrections at $\sqrt{s} = 510$ GeV as well as their impact on constraining the gluon PDFs in the proton will follow.

References

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[2] S. Van Der Meer, *ISR-PO/68-31, KEK 68-64* (1968).

[3] J. Adam et al., (STAR Collaboration) *Phys. Rev. D* **100** 052005 (2019).

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