Longitudinal Double-Spin Asymmetries for Di-jet Production at Intermediate Pseudorapidity in Polarized P+P Collisions at $\sqrt{s}$ = 200 GeV

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Abstract

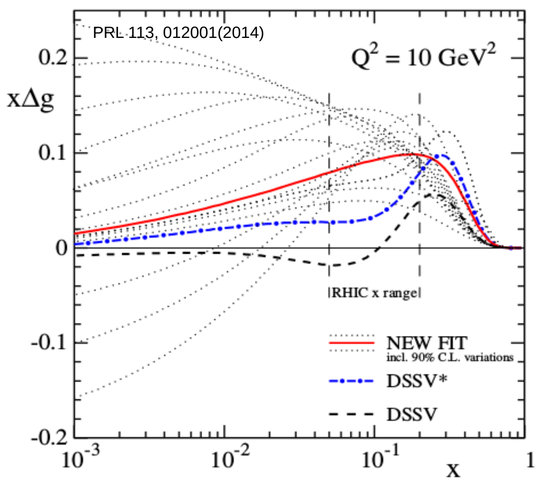
We present the first measurement of the longitudinal double spin asymmetry, A_{LL} for dijets with at least one jet reconstructed within the pseudorapidity range 0.8 < η < 1.8. The dijets were measured in polarized proton+proton collisions at a center-of-mass energy $\sqrt{s}$ = 200 GeV. Values for A_{LL} are determined for several distinct event topologies, defined by the jet pseudorapidities, and span a range of parton momentum fraction x down to x ~ 0.01. The measured asymmetries are found to be consistent with the predictions of global analyses that incorporate the results of previous RHIC measurements. They will provide important input in a previously poorly constrained region when included in future global analyses.

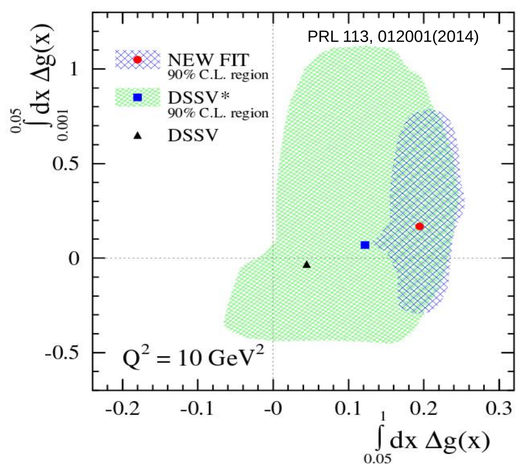
Motivation: Constraining ΔG

$$S = \frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L$$

Deep inelastic scattering measurements have found that the spin of the quarks (ΔΣ) account for ~30% of the total spin of the proton, the rest must come from gluon spin (ΔG) or orbital angular momentum (L) of the partons

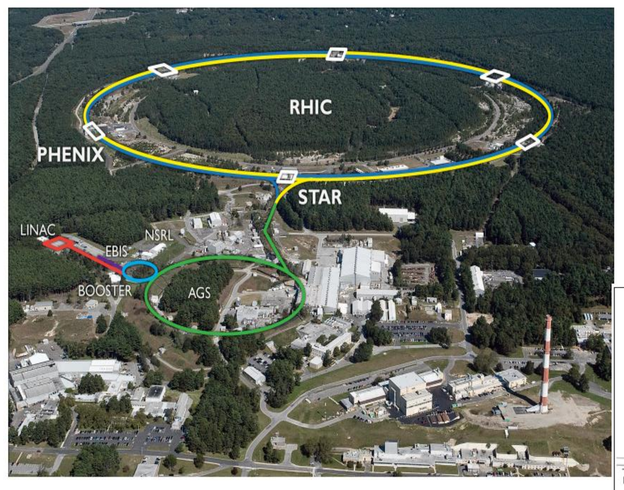
RHIC data have been added to the DSSV global analysis. Including the STAR 2009 inclusive jet results has shown, for the first time, a positive gluon polarization in our region of sensitivity





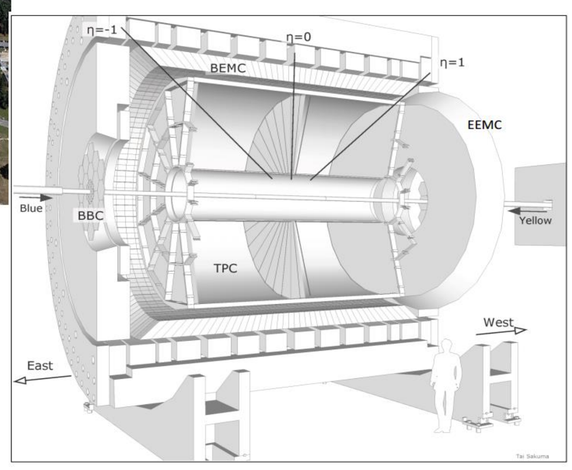
The low x behavior and shape of Δg(x) are still poorly constrained. Recent data will extend our reach in x using forward pion and jet results, and also using higher collision energies.

Relativistic Heavy Ion Collider and STAR Detector

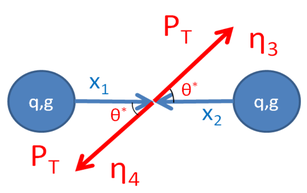


- The Relativistic Heavy Ion ollider(RHIC) is located at Brookhaven National Laboratory on Long Island
- Has the capability to accelerate many particle species to a wide range of energies
- World's first and only accelerator capable of colliding polarized protons

- The Solenoidal Tracker at RHIC (STAR) is a large solid angle detector with charged particle tracking and electromagnetic calorimetry
- Tracking is accomplished with a Time Projection Chamber (TPC)
- Electromagnetic calorimetry provided by BEMC & EEMC and extends from -1 < η < 2



Dijet Kinematics



$$x_1 = \frac{1}{\sqrt{s}}\left(p_{T3}e^{\eta_3} + p_{T4}e^{\eta_4}\right)$$

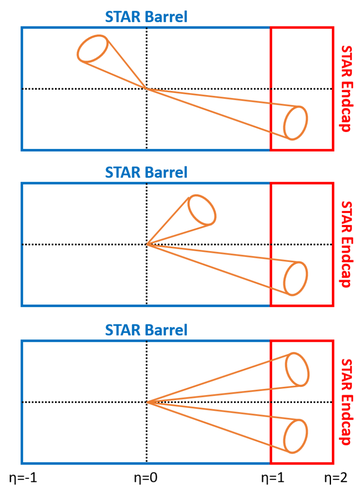
$$x_2 = \frac{1}{\sqrt{s}}\left(p_{T3}e^{-\eta_3} + p_{T4}e^{-\eta_4}\right)$$

$$M = \sqrt{x_1 x_2 s}$$

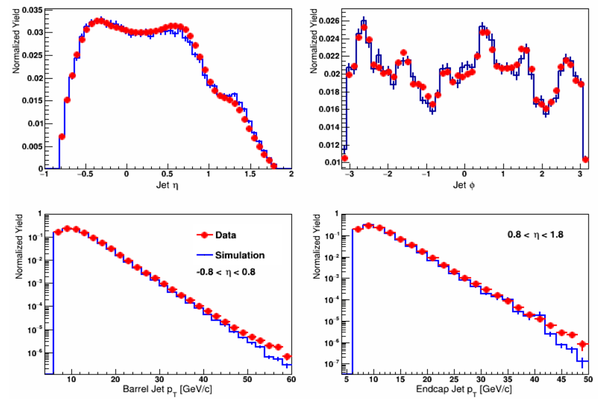
$$\eta_3 + \eta_4 = \ln\frac{x_1}{x_2}$$

$$|\cos\theta^*| = \tanh\left|\frac{\eta_3 - \eta_4}{2}\right|$$

- Correlation measurements such as dijets capture more information from the hard scattering and provide a more direct link to the initial kinematics than inclusive probes
- Leading order expressions show how different jet configurations are sensitive to different kinematic values
- Di-jets may place better constraints on the functional form of Δg(x,Q^2)

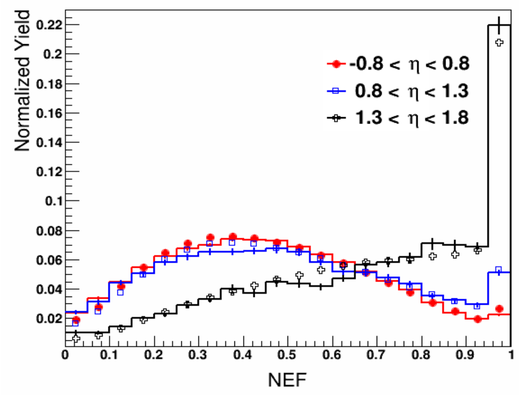


Data-Simulation Comparison

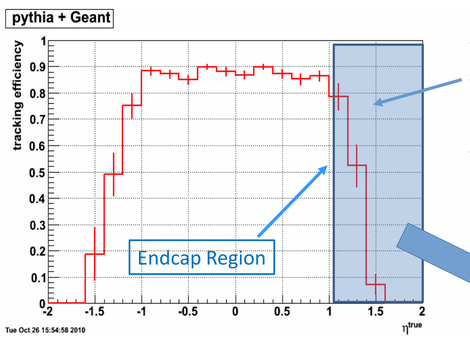


- In general, we see good agreement between 2009 data and simulation for single jet kinematic quantities

- Simulation events created using PYTHIA which run through a STAR detector response model based on GEANT 3, and then embedded into Zero-Bias data

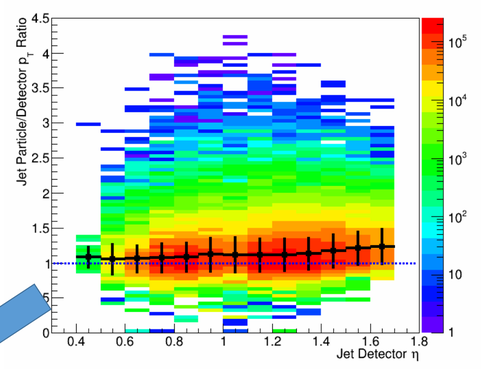


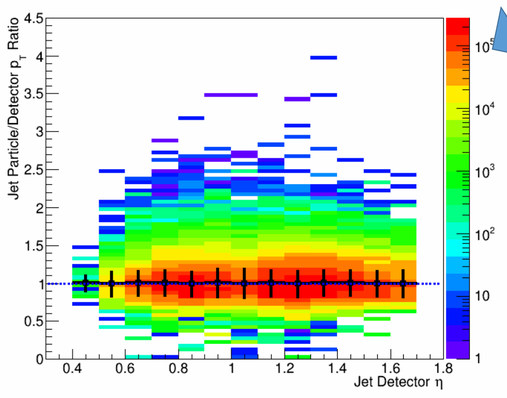
Challenges and Methods

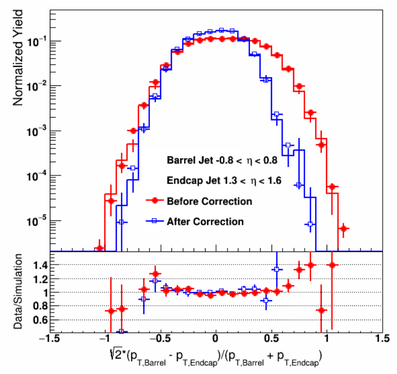


- TPC efficiency decreases in forward region
- Fewer tracks means reconstructed jets will have lower P_T and jet mass on average
- Inaccurate P_T reconstruction skews extraction of partonic momenta

Machine Learning: Multilayer Perceptron(MLP)
Variables: Endcap jet detector level P_T , detector eta, neutral fraction; Barrel jet P_T
Target: particle level jet P_T





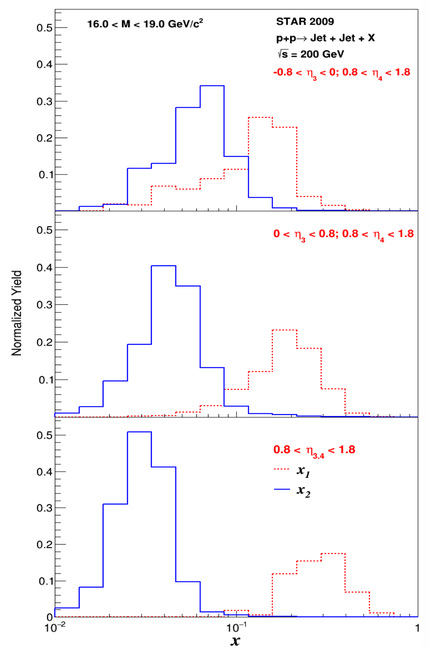


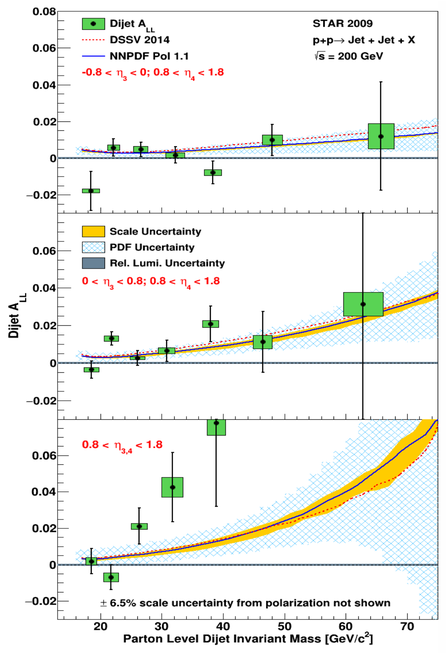
- Barrel and Endcap jets are separately corrected in P_T and mass using similar methods
- Di-Jet invariant masses are calculated using the shifted jet transverse momentum and mass from machine learning

Dijet Longitudinal Double-Spin Asymmetries

$$A_{LL} = \frac{\sigma^{++} - \sigma^{+-}}{\sigma^{++} + \sigma^{+-}} = \frac{1}{P_Y P_B}\frac{N^{++} - rN^{+-}}{N^{++} + rN^{+-}}$$

P_Y *and* P_B are the measured polarizations of the Yellow and Blue beams, N's are the dijet yields from proton beam bunches with equal and opposite helicity configuration while r is the relative luminosity.





Summary

- The first measurement of the di-jet A_{LL}at intermediate pseudorapidity is presented, which is in good agreement with recent theory prediction, and should provide new and tighter constraints on gluon helicity distribution Δg(x), especially at lower x;
- With the increased statistics from 2012 and 2013 at √s = 510 GeV, STAR data will help to further constrain the value and shape of Δg(x) at lower Bjorken-x.

References

[1] D. de Florian, R. Sassot, M. Stratmann and W. Vogelsang, Phys. Rev. Lett. 113, 012001 (2014).
[2] Ting Lin, Doctoral Dissertation, Indiana University (2017).
[3] J. Adam et al. [STAR Collaboration], arXiv:hepex/1805.09742.

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