# Longitudinal Double-Spin Asymmetries for Forward Di-jet Production in Polarized pp Collisions at √s = 200 GeV

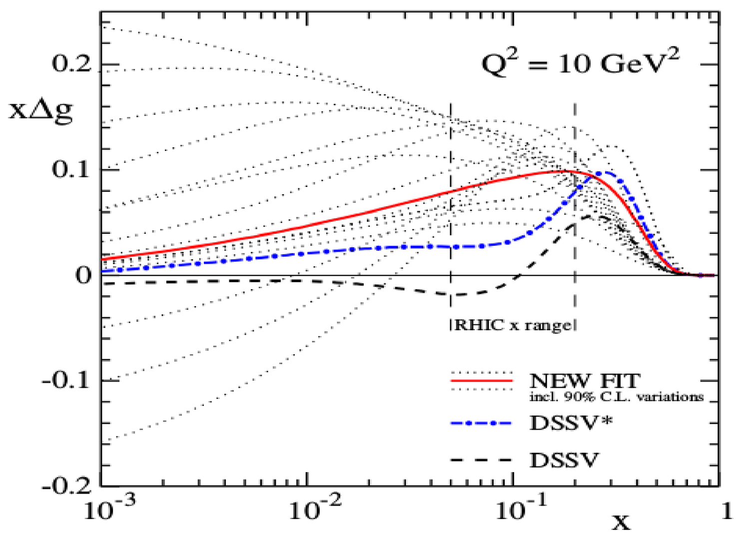
Ting Lin
Indiana University, for the STAR Collaboration

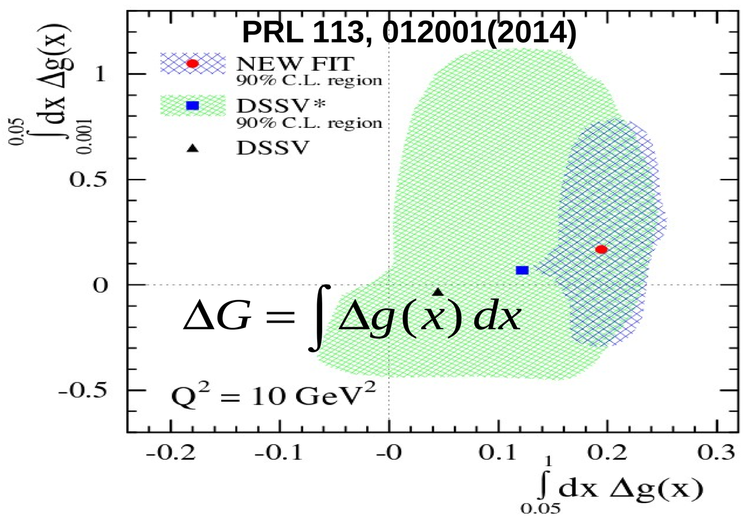
## Motivation: Constraining ΔG

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

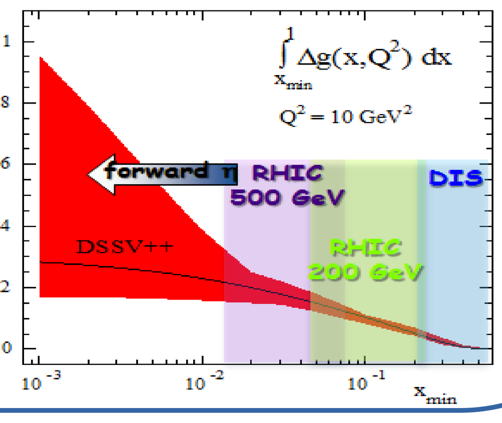
Deep inelastic scattering measurements have found that the spin of the quarks (ΔΣ) account for ~30% of the total spin of the proton, the rest must come from gluon spin (ΔG) or orbital angular momentum (L) of the partons

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

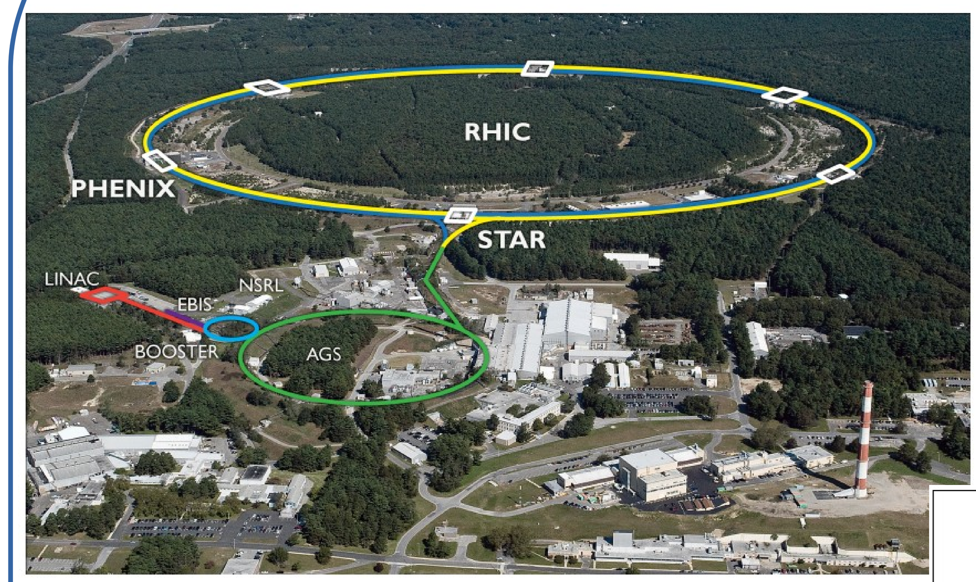


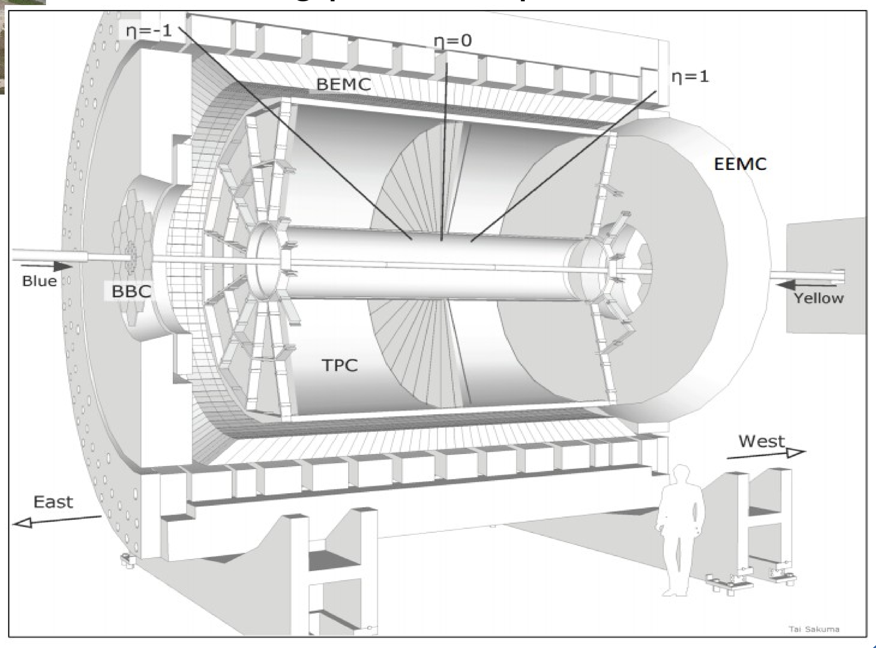

- The low x behavior and shape of Δg(x) are still poorly constrained. Recent data will extend our reach in x using forward pion and jet results, and also using higher collision energies.




## The Relativistic Heavy Ion Collider and STAR Detector

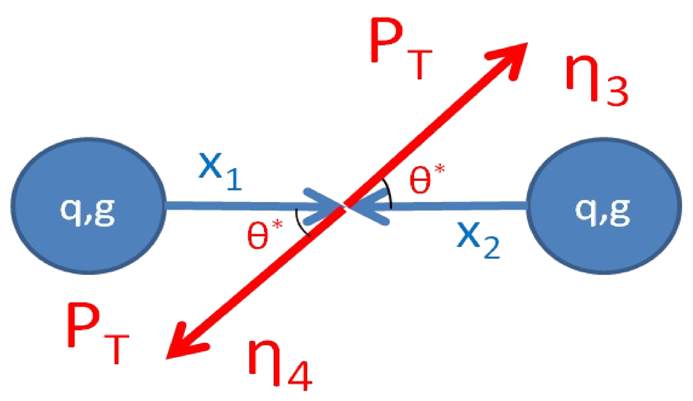



- The Relativistic Heavy Ion Collider (RHIC) is located at Brookhaven National Laboratory on Long Island
- Has the capability to accelerate many particle species to a wide range of energies
- World's first and only accelerator capable of colliding polarized protons




- 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 $-1 < \eta < 2$

## Dijet Kinematics




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

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

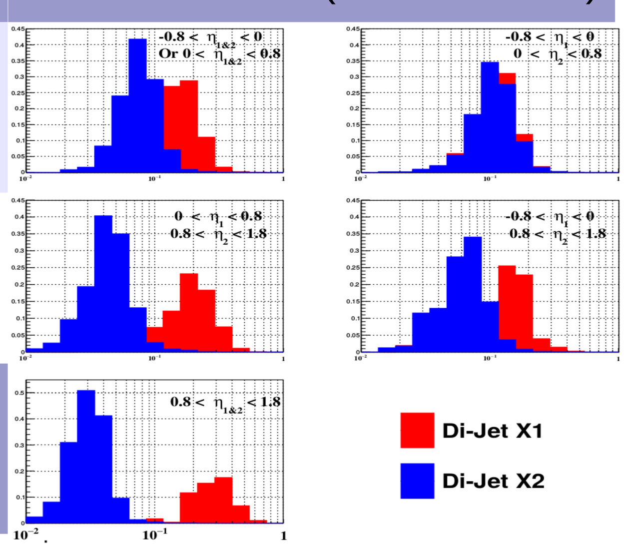
$$M = \sqrt{x_1 x_2 s}$$

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

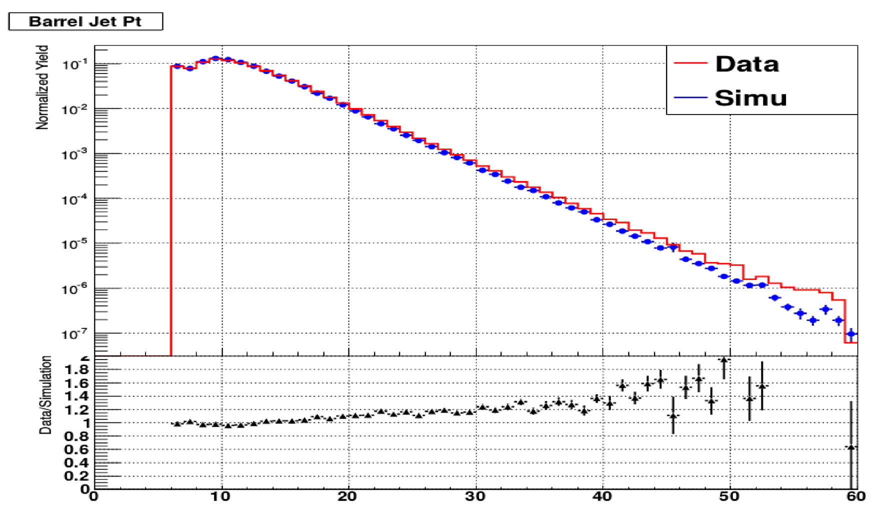
$$|\cos\theta^*| = \tanh\left|\frac{\eta_3 - \eta_4}{2}\right|$$

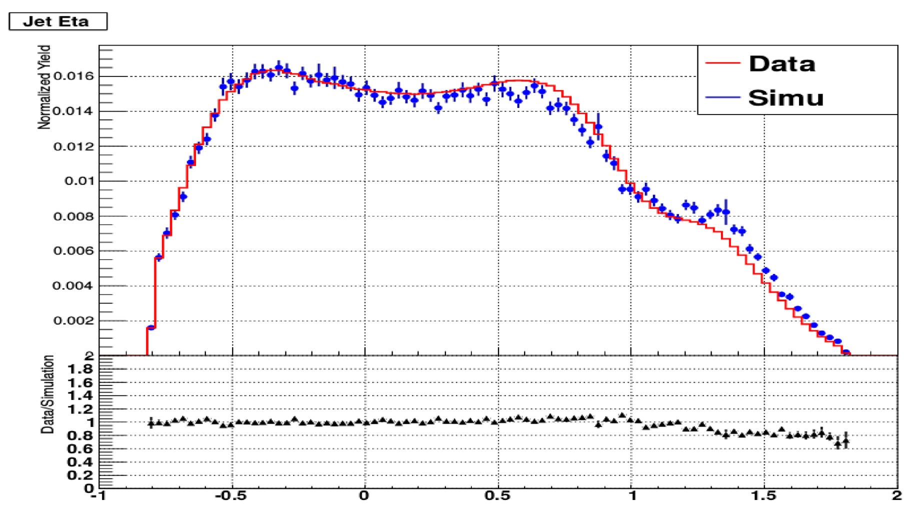
- Correlation measurements such as di-jets capture more information from the hard scattering – di-jet may place better constraints on the functional form of Δg(x,Q²)
- Forward rapidity jets arise from asymmetric partonic collisions and probe lower momentum gluons

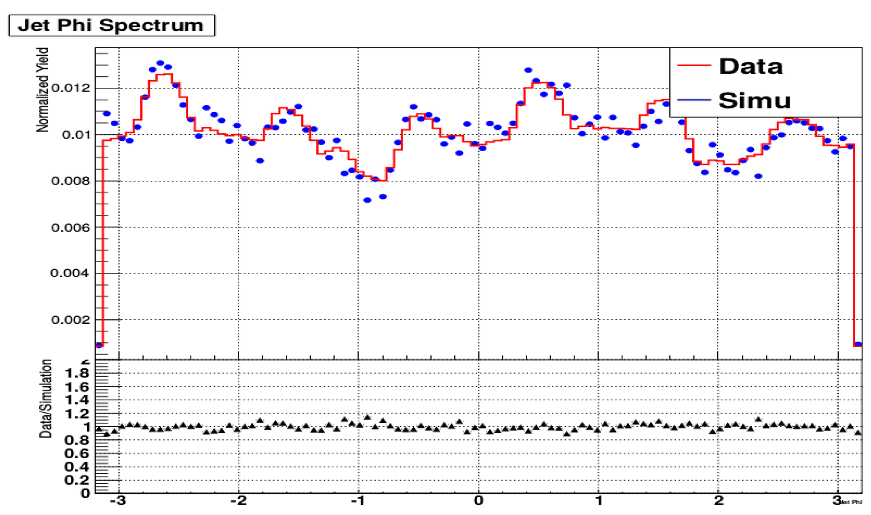
| Dijet Configuration | Minimum X1/X2 (√s = 200 GeV) |
|---|---|
| Barrel-Barrel | |
| Barrel-Endcap | |
| Endcap-Endcap | |




## Data – Simulation Comparison

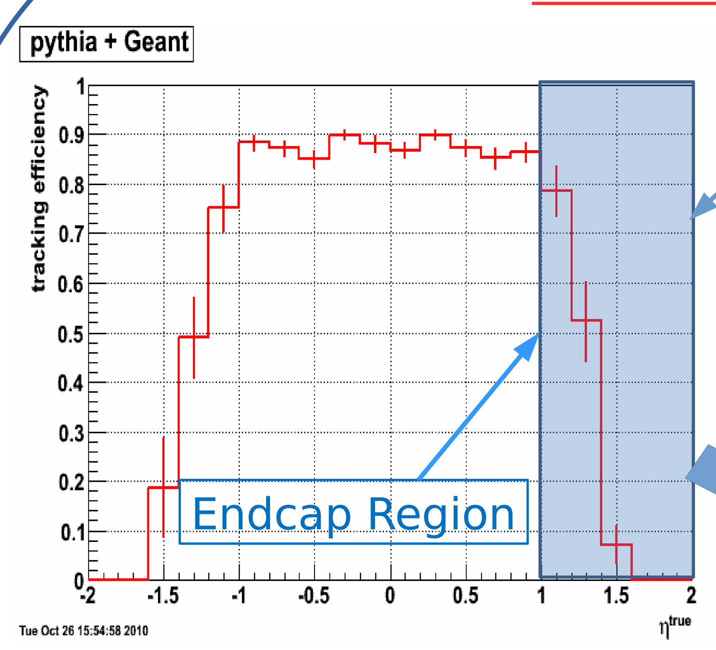


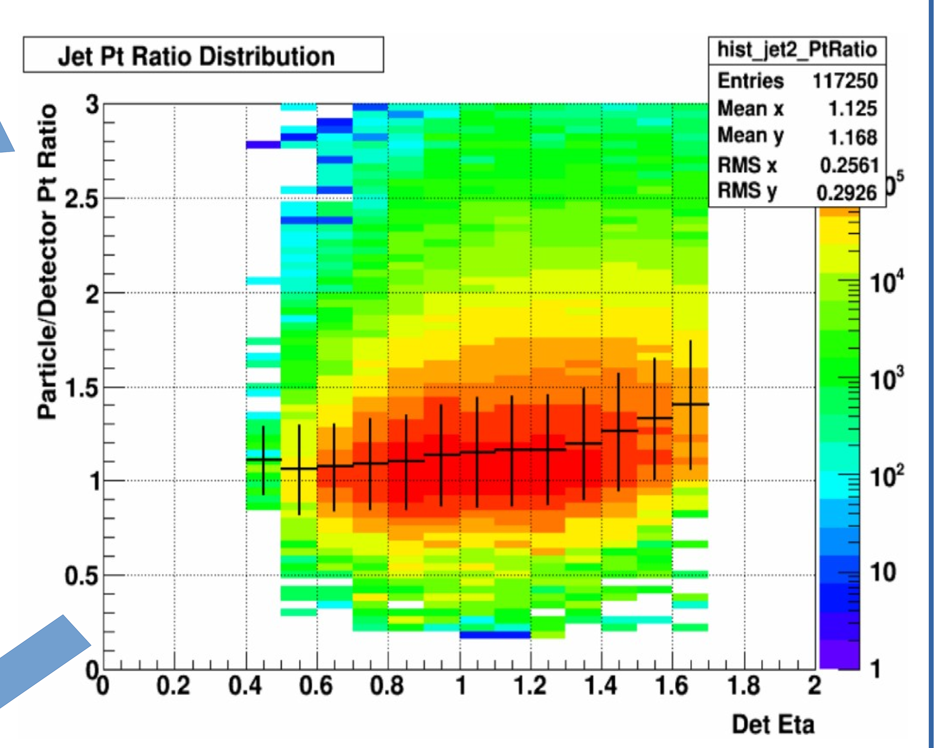

- Simulation events created using PYTHIA and embedded into Zero-Bias data and then run through a STAR detector response model based on GEANT 3
- In general, we see good agreement between Run 9 data and simulation for single jet kinematic quantities

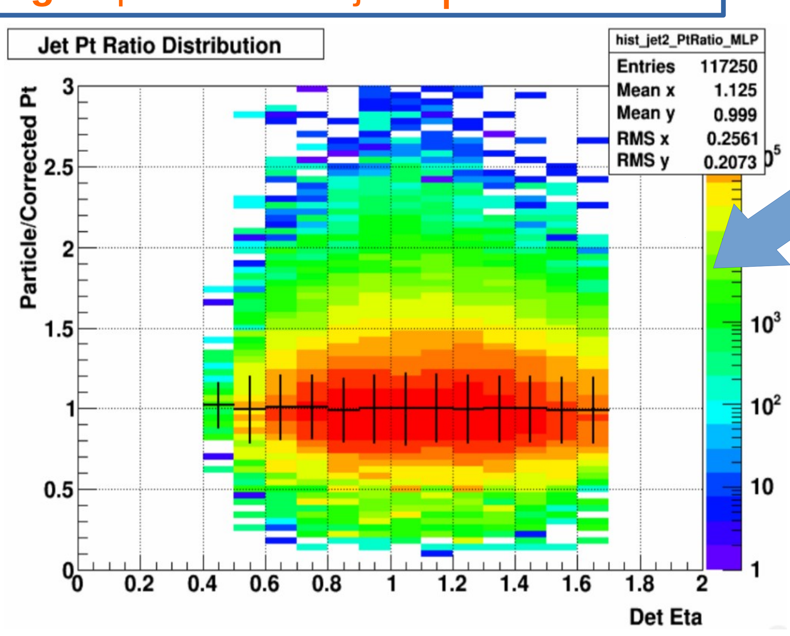
## Challenges and Methods




- TPC efficiency decreases in forward region
- Fewer tracks means reconstructed jets will have lower $P_T$ on average
- Inaccurate $P_T$ reconstruction skews extraction of initial state parton 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 $P_T$

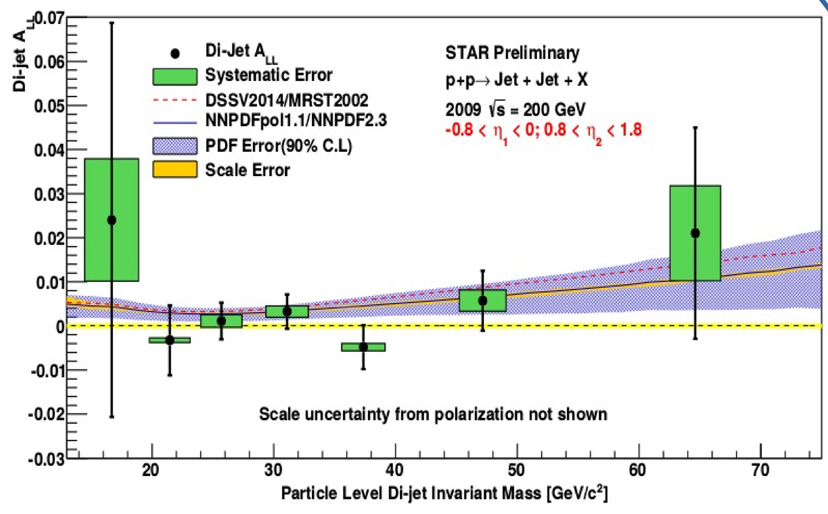


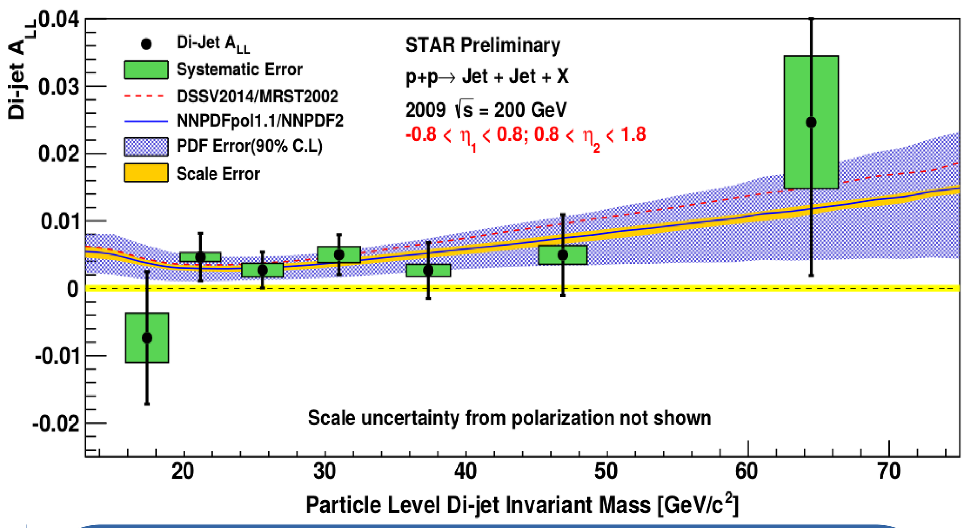



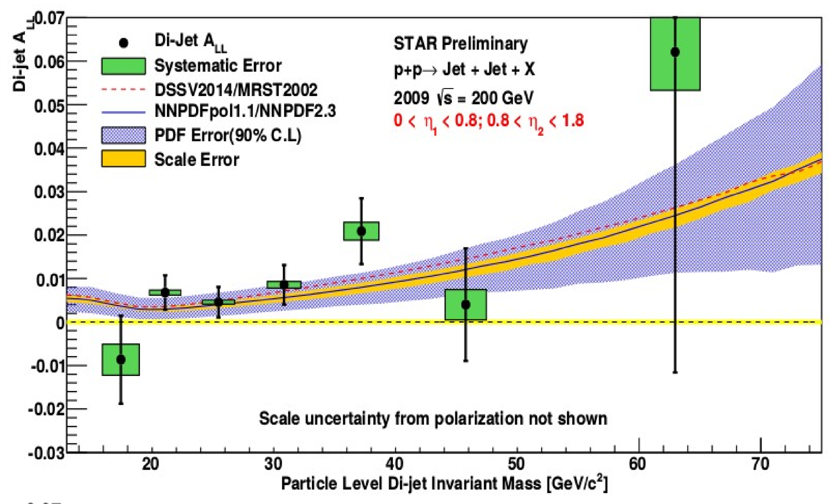

- **Supervised machine learning** regression algorithms make use of training events, for which the desired output is known, to determine an approximation of the underlying functional behavior defining the target value
- Toolkit for Multivariate Analysis (TMVA) [arXiv:physics/0703039]

## Di-Jet Asymmetry: Results and Conclusion

- 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
- Underlying events are studied in simulation and in data, and are included in the total systematic error




- 2009 forward di-jet double spin asymmetry is non-zero and positive over much of the kinematic region probed which is in qualitative agreement with recent theory prediction
- With the increased statistics from 2012 and 2013 at √s = 510 GeV, will help to better constrain the value and shape of Δg(x) at lower Bjorken-x.