Gluon Polarization and Inclusive Jet Measurements with ***STAR***

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for the
STAR **Collaboration**

Outline

- Introduction
- 2006 and 2009 measurements
- Looking ahead

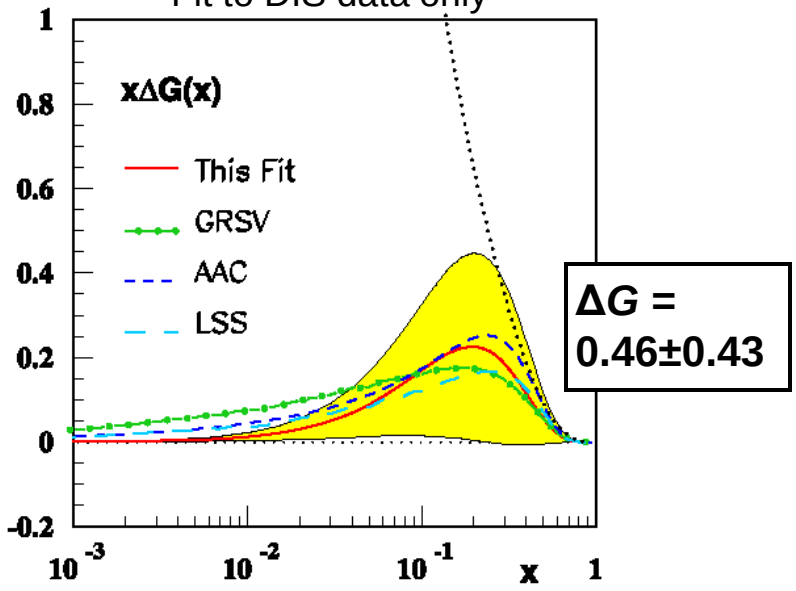
Partonic origin of the proton spin?

$$S_z = \frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + \langle L_z \rangle$$

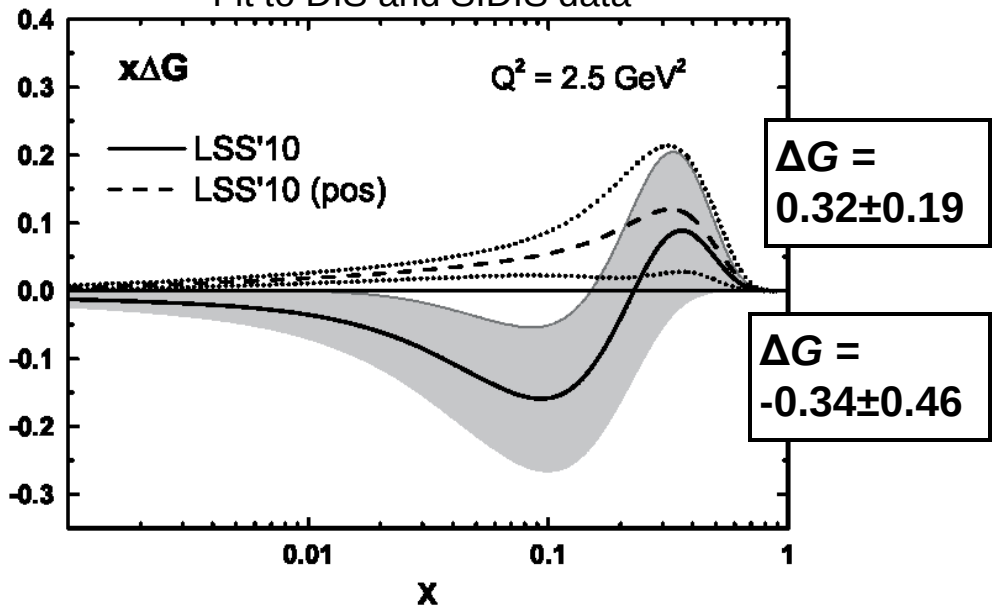
Polarized DIS: ~0.3

Poorly constrained by DIS

Blümlein & Böttcher, NPB 841, 205 (2010)
Fit to DIS data only



Leader et al, PRD 82, 114018 (2010)
Fit to DIS and SIDIS data



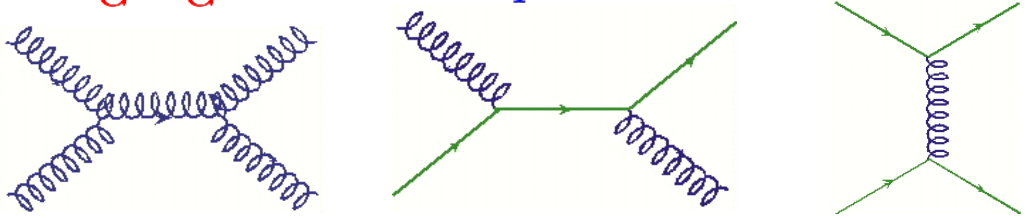
- Measuring the **gluon polarization distribution** is **a primary goal of the RHIC spin program**

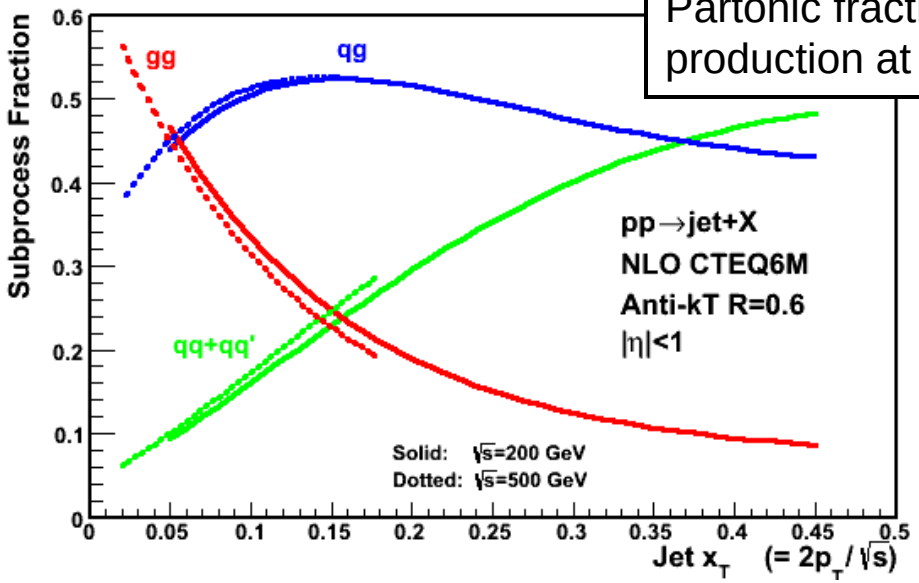
Exploring gluon polarization at RHIC

$$A_{LL} = \frac{\sigma^{++} - \sigma^{+-}}{\sigma^{++} + \sigma^{+-}} \propto \frac{\Delta f_a \Delta f_b}{f_a f_b} \hat{a}_{LL}$$

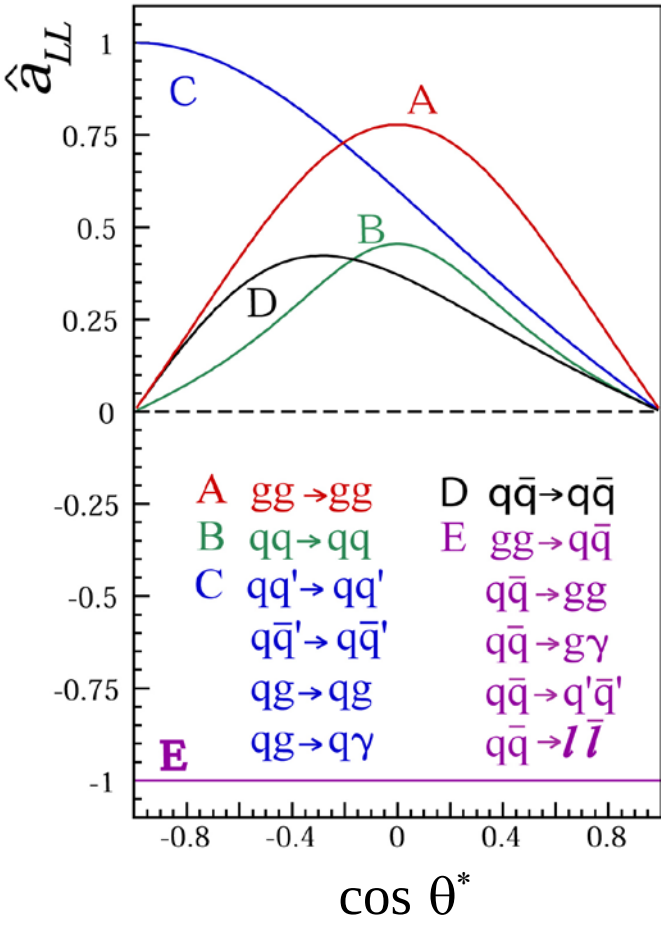
Δf: polarized parton distribution functions

$\frac{\Delta G}{G}\frac{\Delta G}{G}$ $\frac{\Delta q}{q}\frac{\Delta G}{G}$ $\frac{\Delta q}{q}\frac{\Delta q}{q}$





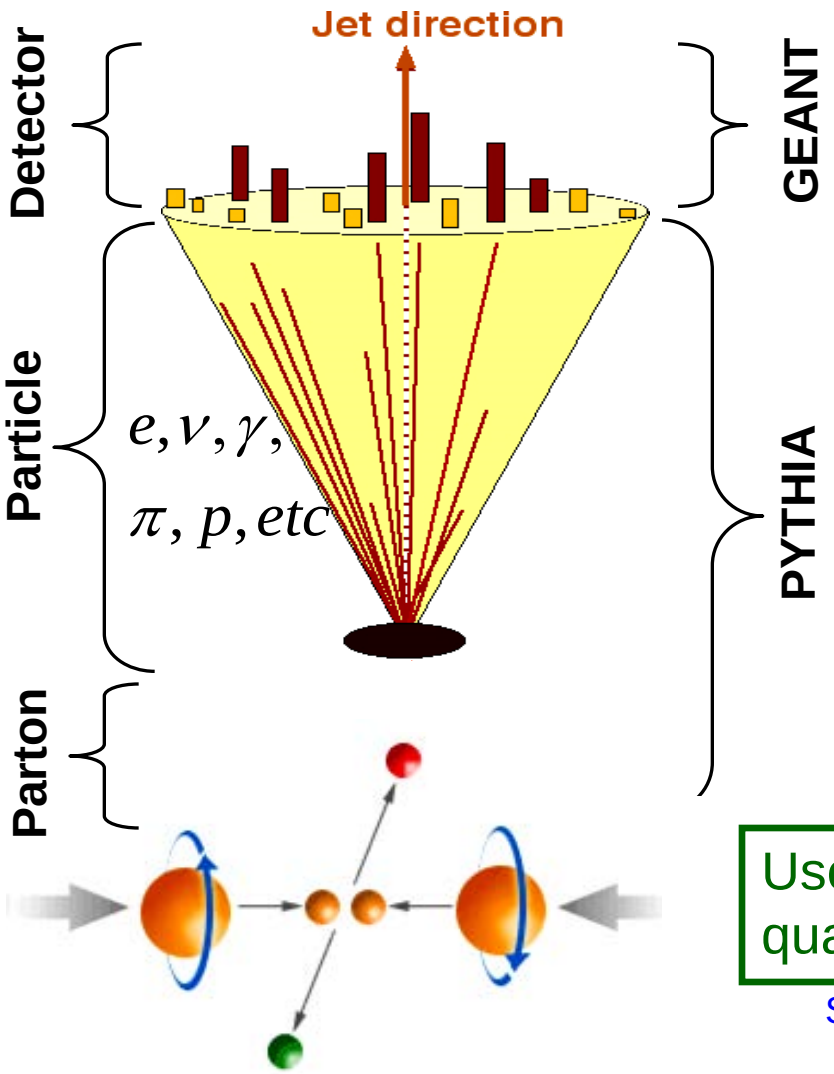
Partonic fractions in jet production at RHIC



For most RHIC kinematics, ***gg*** and ***qg*** dominate, making A_{LL} **for jets sensitive to gluon polarization.**

Jet reconstruction in ***STAR***

Data jets **MC jets**



For 2006 data

Midpoint cone algorithm

Adapted from Tevatron II - hep-ex/0005012

- Seed energy = 0.5 GeV
- Cone radius R = 0.7 in η-φ space
- Split/merge fraction f = 0.5

For 2009 data and beyond

Anti-k_T algorithm

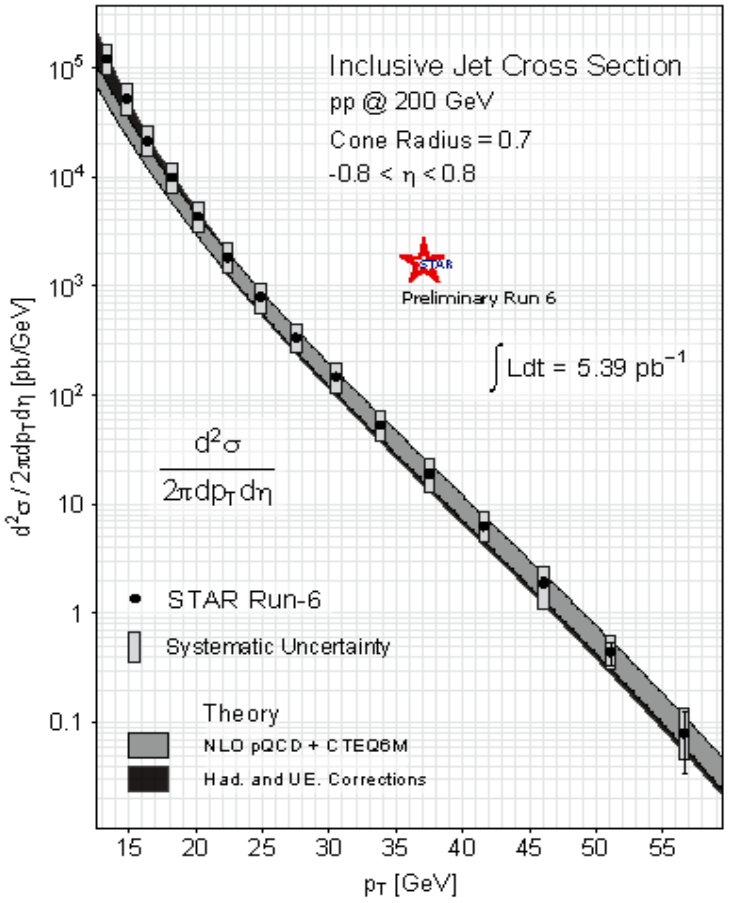
Cacciari, Salam, and Soyez, JHEP 0804, 063

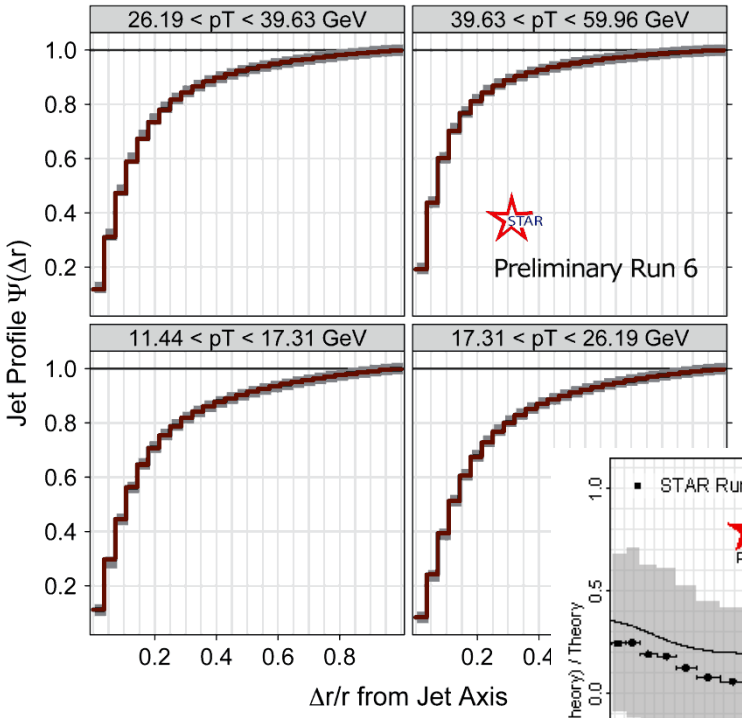
- R = 0.6

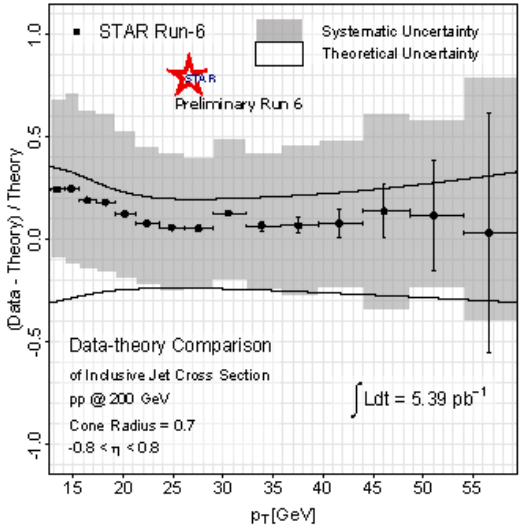
Use **PYTHIA** + **GEANT** to quantify detector response

Sjostrand, Mrenna, and Skands, JHEP 05, 026

Jet cross section from 2006 data

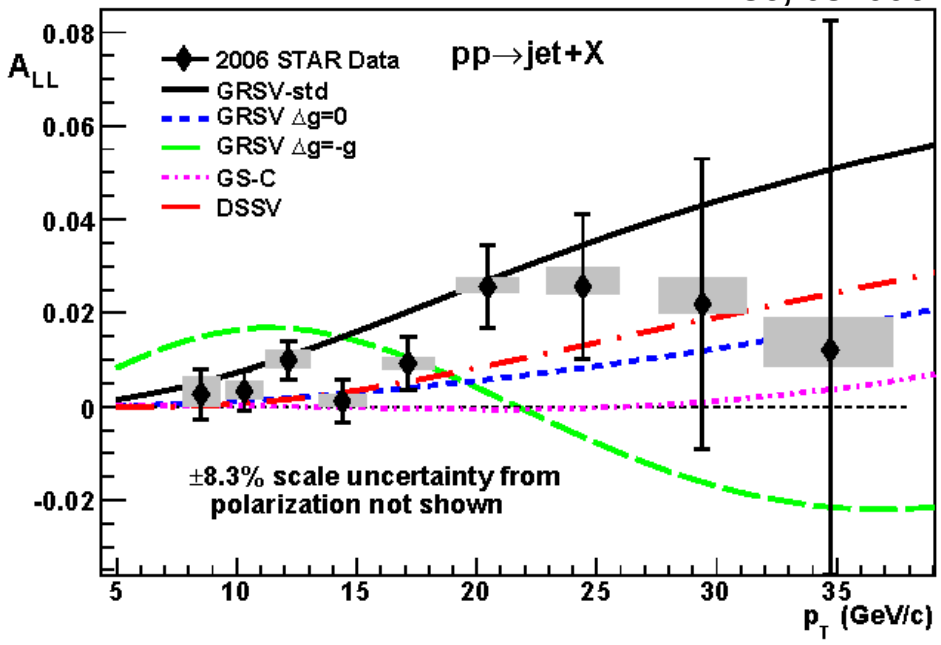


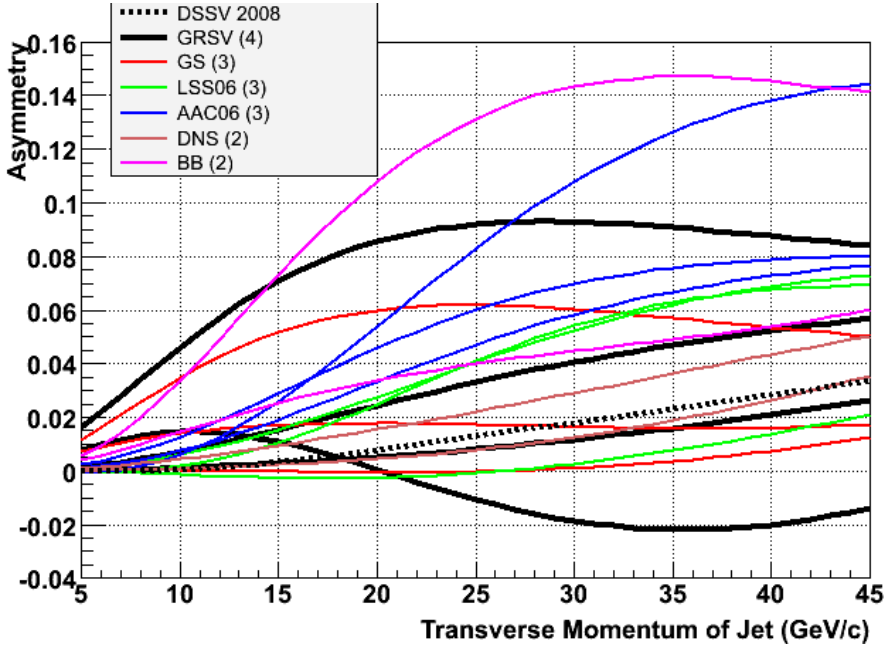




- Good agreement between data and simulation
- Good agreement with NLO pQCD calculation after hadronization and underlying event correction is applied
- Jet production is **well understood** at RHIC energies

STAR inclusive jet A_{LL} from 2006 data

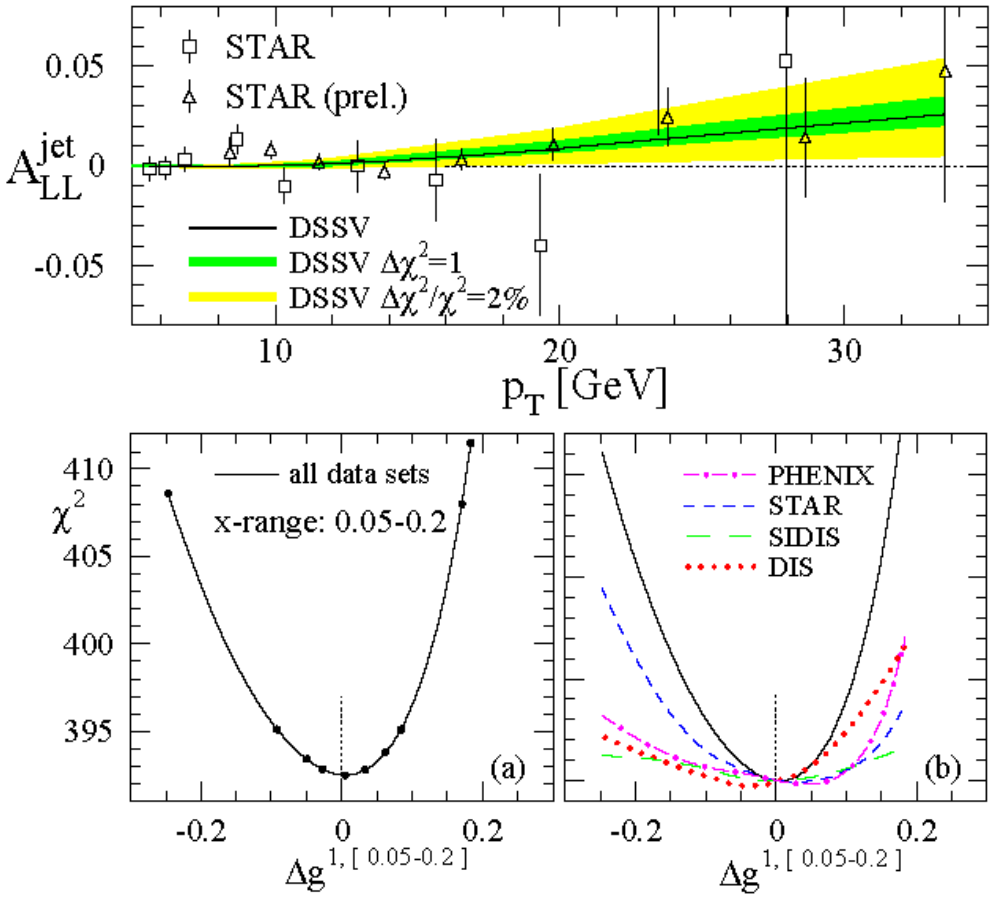


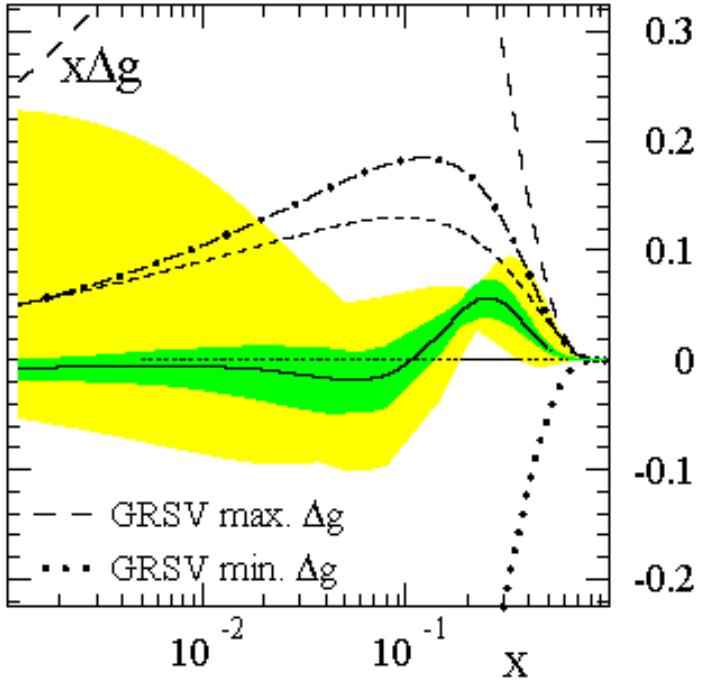


- ***STAR*** inclusive jet A_{LL} from 2006 excluded those scenarios that had a large gluon polarization within the accessible *x* region

DSSV – first global analysis with polarized jets

de Florian et al., PRL 101, 072001





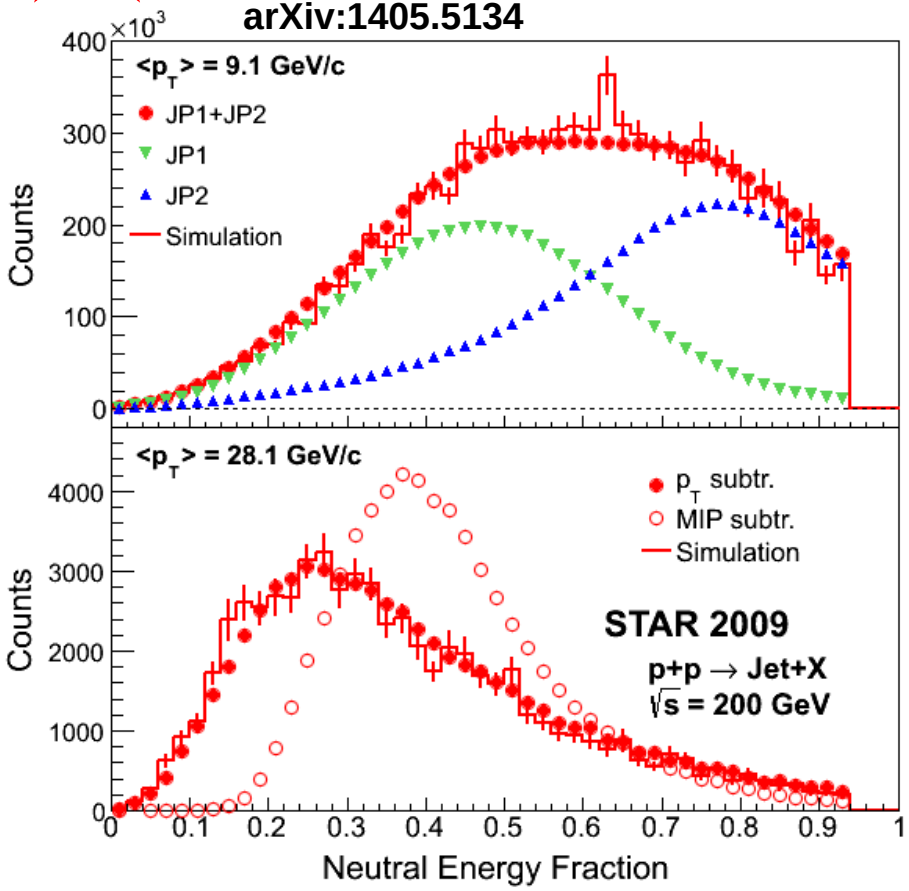
- The first global NLO analysis to include inclusive DIS, SIDIS, and RHIC pp data on an equal footing
- Found relatively small gluon polarization within the region $0.05 < x < 0.2$ that was sampled by the 2006 data

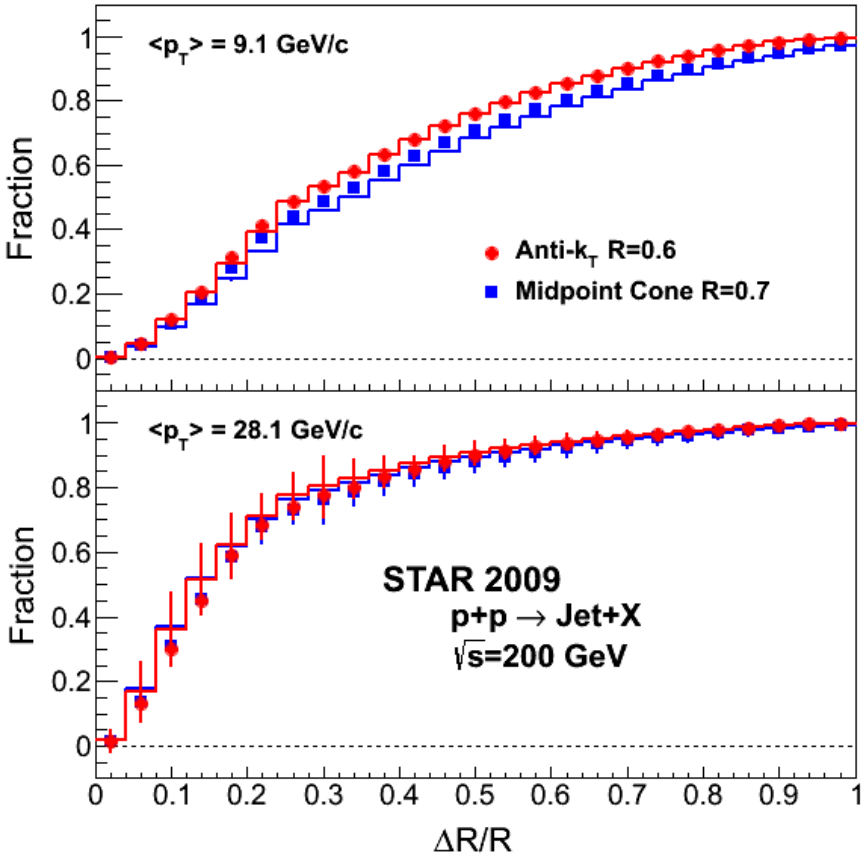
Improvements for 2009

- 2009 jet patch trigger upgrades
  - Overlapping jet patches and lower E_T threshold improve efficiency and reduce trigger bias
    - Net increase of 37% in jet acceptance
  - Remove beam-beam counter trigger requirement
    - Trigger more efficiently at high jet p_T
    - Measure non-collision background
- Increased trigger rate and reduced thresholds enabled by DAQ1000
- Sampled ~ 4 times the figure-of-merit relative to 2006
- Nearly **20-fold increase** in event statistics
- Improvements in jet reconstruction
  - Subtract 100% of track momentum from struck tower energy (2009) instead of MIP (2006)
  - Overall jet energy resolution improved from 23% to 18%
  - Switch from mid-point cone to anti-k_T

Understanding jets in the ***STAR*** detector

arXiv:1405.5134





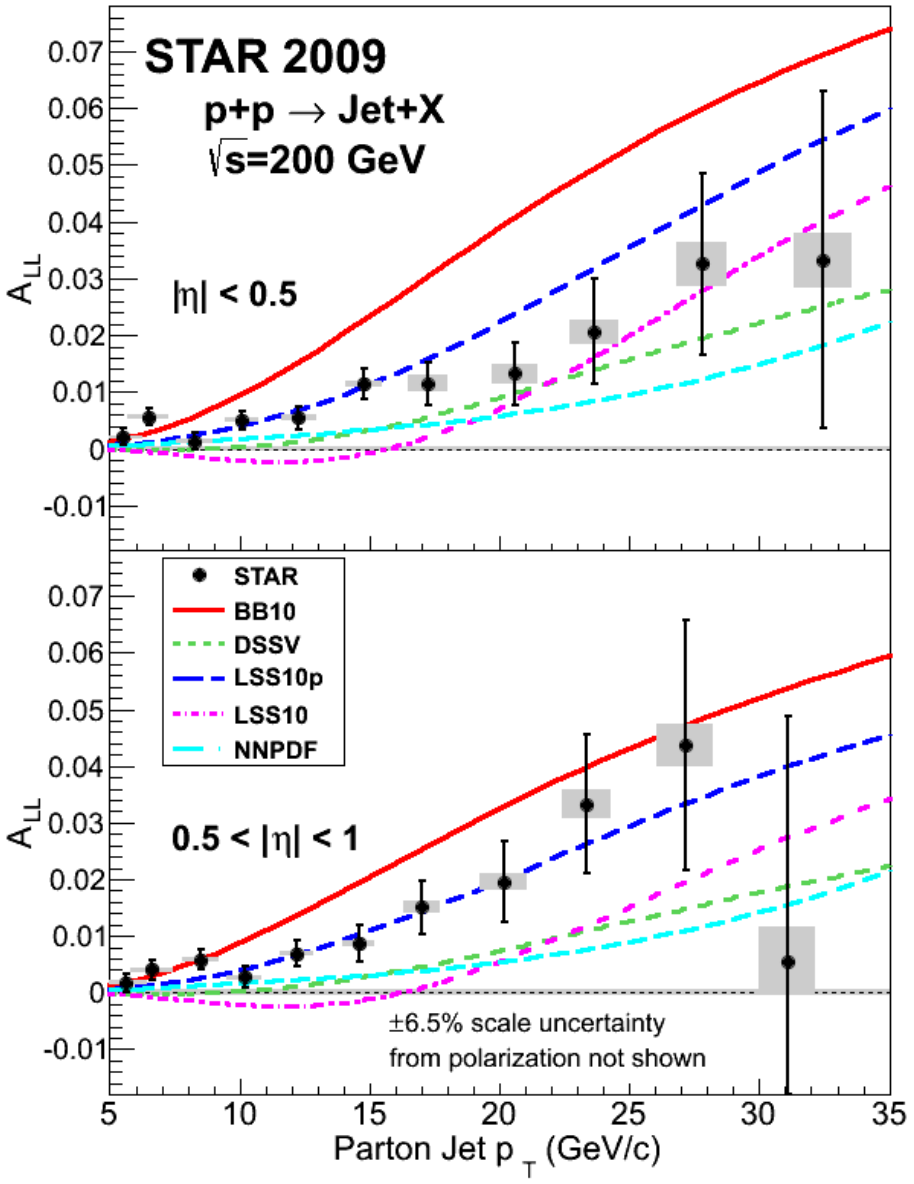
- Trigger preferentially selects events with large neutral fractions
- New hadronic correction reduces the bias

- Anti-k_T algorithm is less sensitive to backgrounds from underlying event and pile-up contributions

- Monte Carlo simulations provide a **very good description of the data**

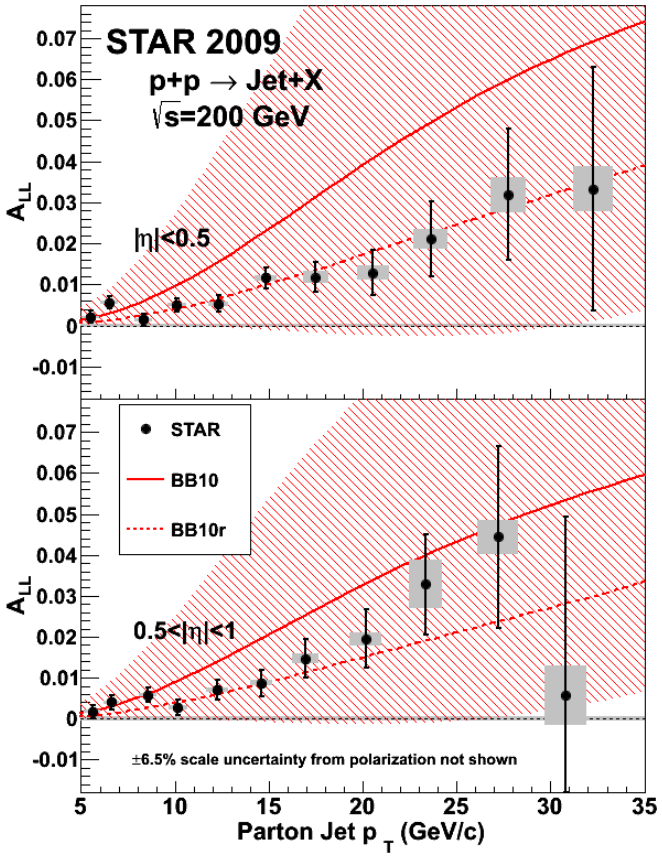
STAR inclusive jet A_{LL} from 2009 data

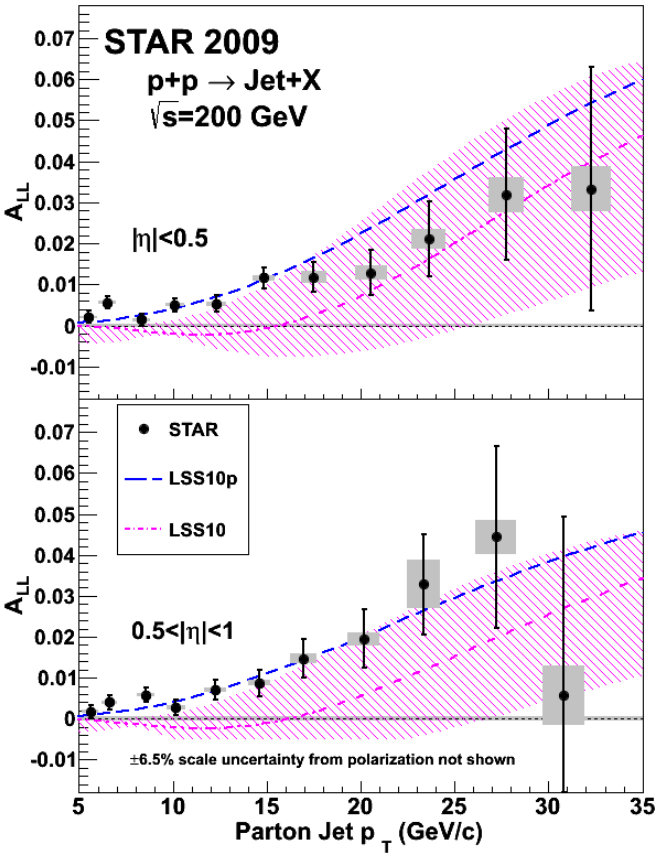
arXiv:1405.5134



- 2009 ***STAR*** inclusive jet A_{LL} measurements are a factor of 3 (high-p_T) to >4 (low-p_T) more precise than 2006
- A_{LL} falls in the middle among several recent polarized PDF fit predictions
- A_{LL} is somewhat larger than predictions from the 2008 DSSV fit
  - Points toward **positive Δg** in the accessible *x* region

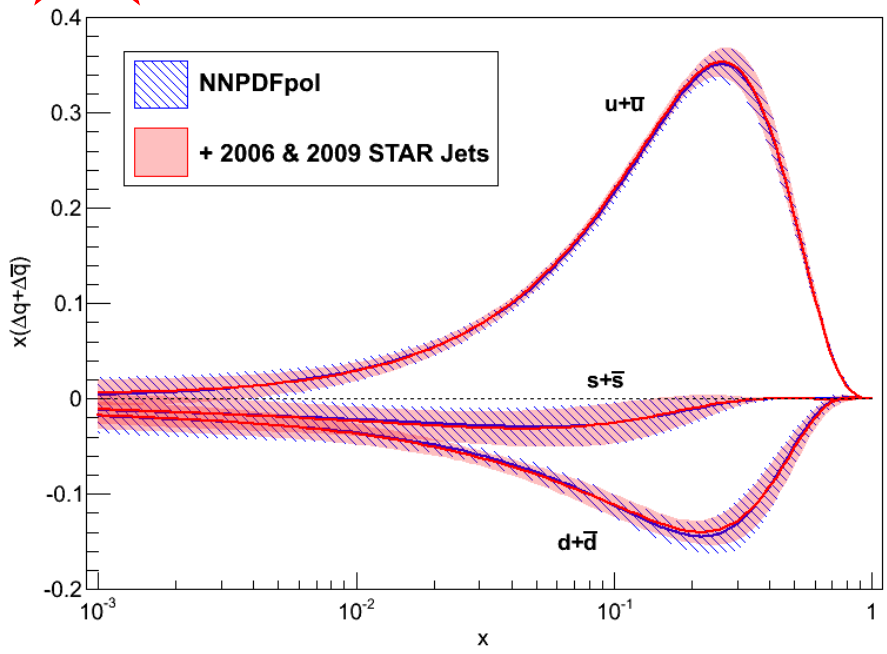
BB and LSS model uncertainties

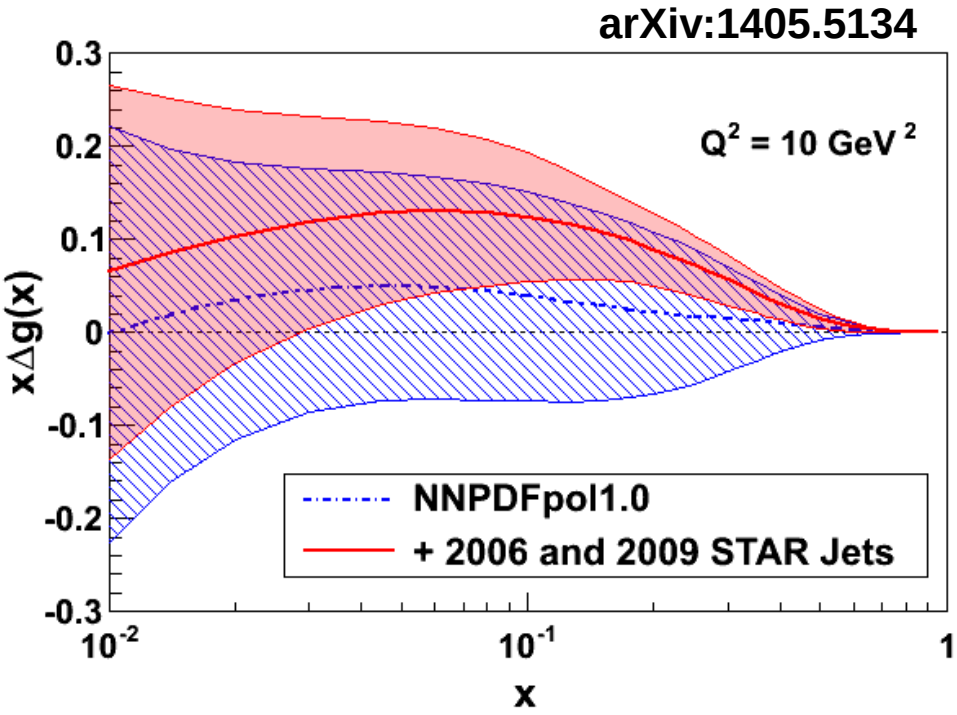




- Results are well within the quoted BB10 uncertainties
  - Can **reduce inclusive jet χ^2 from 89 to 18** while increasing the DIS data χ^2 by less than 0.03% (0.36 in 1537, "BB10r")
- Results fall outside the quoted LSS10 uncertainties for p_T <~ 12 GeV/c
  - Very strong preference for LSS10p (χ^2=22.5) over LSS10 (χ^2=57)

Implications for polarized parton distributions

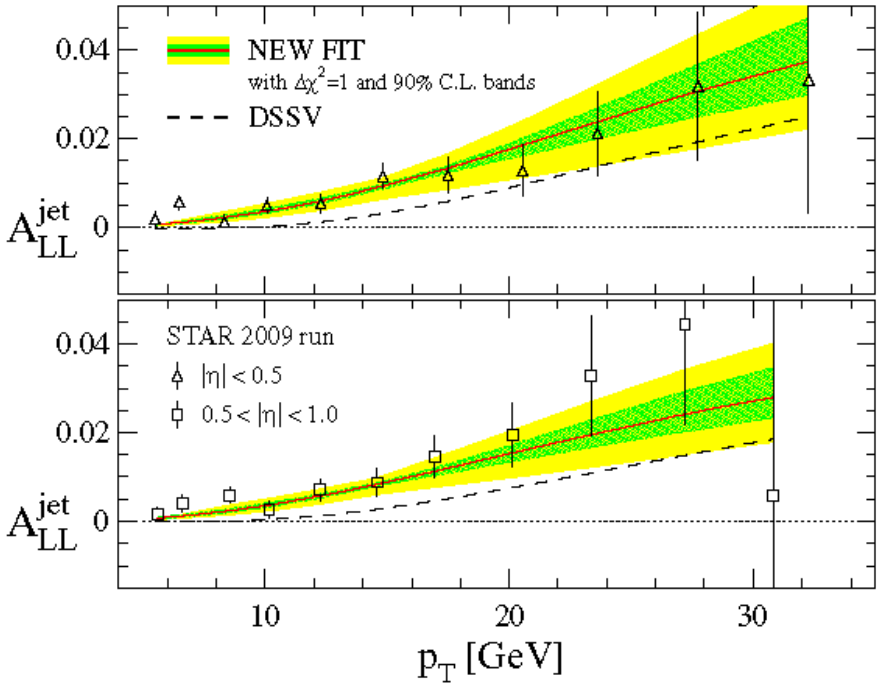




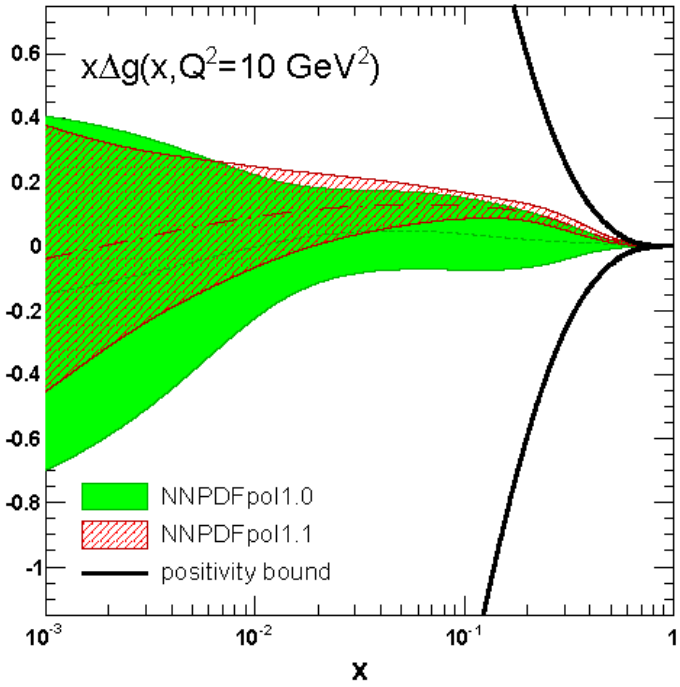
- NNPDF has developed a reweighting procedure to include new data without needing to redo the entire fit
- Impact of adding ***STAR*** jet A_{LL} results to NNPDFpol1.0
  - Polarized quark and anti-quark distributions: no change
  - Polarized gluon distribution: substantial increase in the central value and decrease in the uncertainties

Two new polarized distribution fits

DSSV, PRL 113, 012001



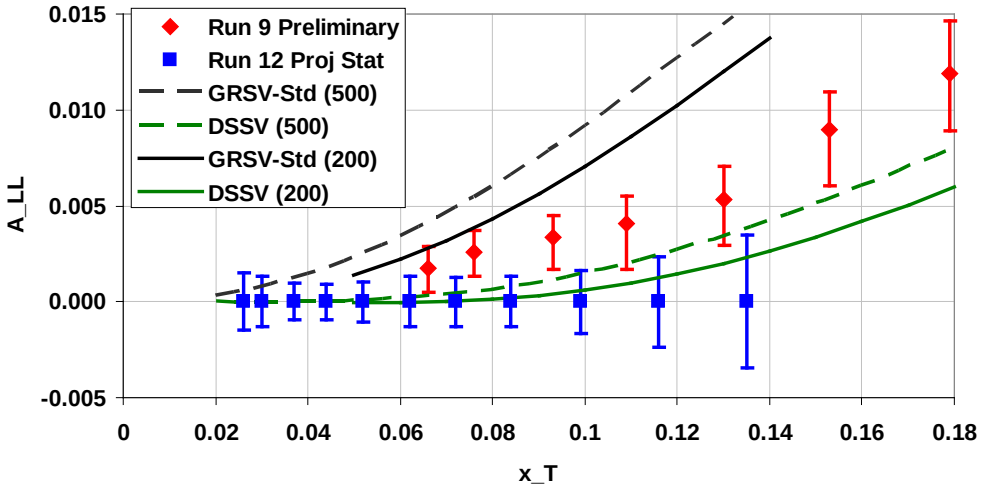
NNPDF, NPB 887, 276



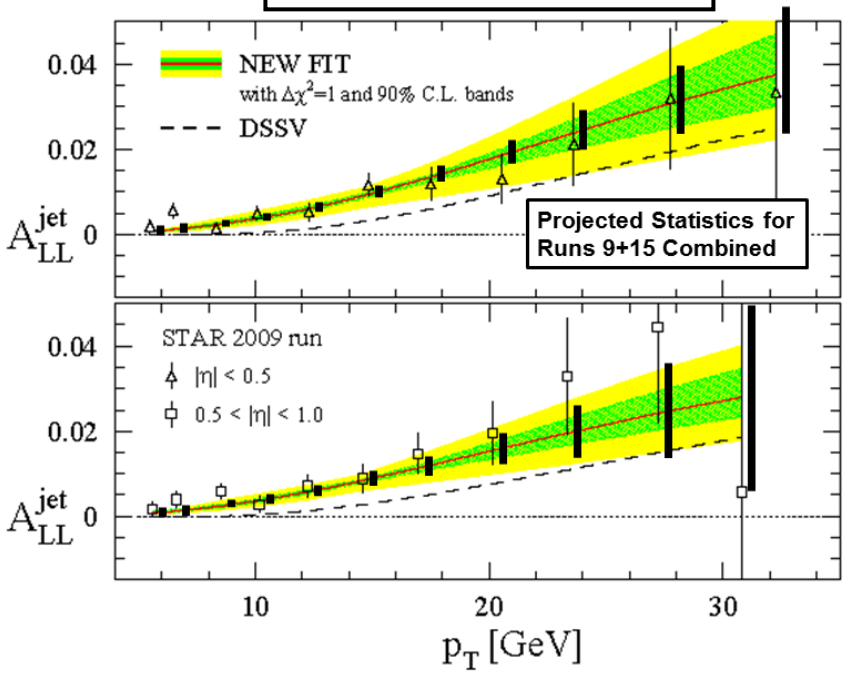
- Both DSSV and NNPDF have released new polarized PDF fits
- Both find **2009 *STAR* jet A_{LL} results provide significantly tighter constraints on gluon polarization** than previous measurements
- Both find **evidence for positive gluon polarization** in the region $x > 0.05$
  - **DSSV: $0.19^{+0.06}_{-0.05}$ at 90% c.l. for $0.05 < x$**
  - **NNPDF: 0.23 ± 0.07 for $0.05 < x < 0.5$**

Higher precision coming soon

510 GeV
2012 Projection

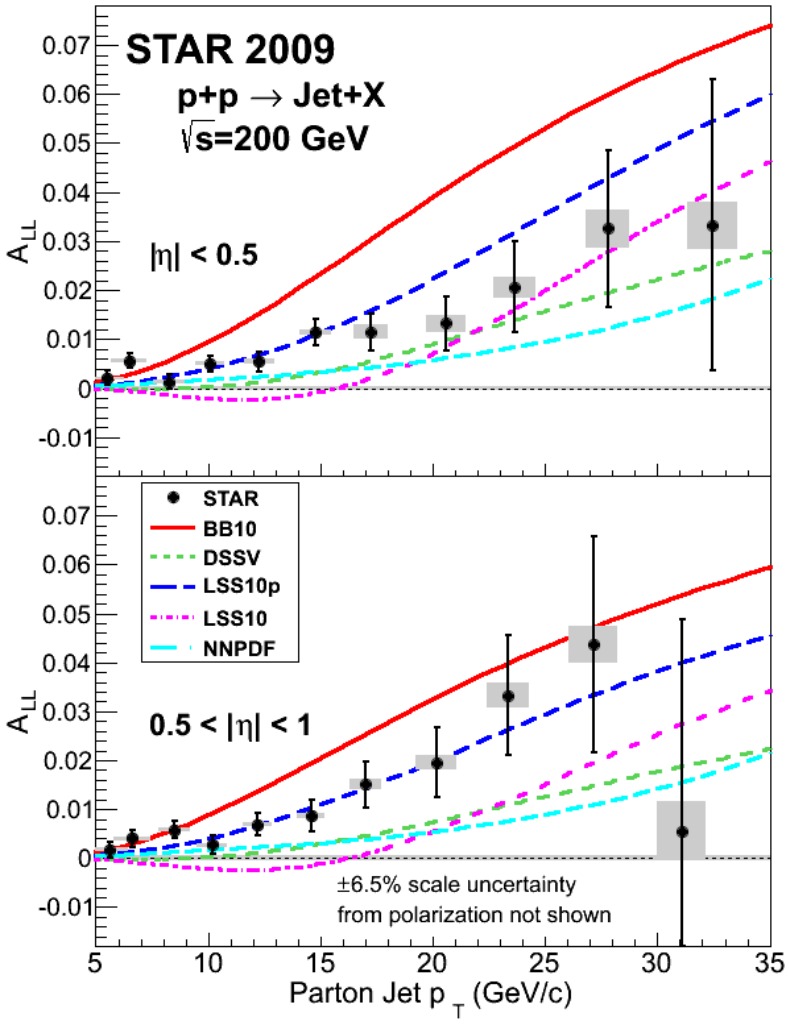


200 GeV
2009+15 Projection



- During 2012 ***STAR*** measured inclusive jet A_{LL} in **510 GeV collisions**
  - Higher beam energy provides sensitivity to smaller x_g
- ***STAR*** also anticipates **significant future reductions** in the uncertainties for **200 GeV collisions** relative to the 2009 results
  - Hope to record triple the existing 200 GeV data during the 2015 RHIC run

Conclusions



- ***STAR* 2009 inclusive jet A_{LL} results** provide the **first experimental evidence** for **positive gluon polarization** in the RHIC range
- **Several more results are coming soon**
  - First measurement of **inclusive jet A_{LL} at 510 GeV** (2012 data)
    - Preliminary results will be presented at SPIN 2014
  - Improved precision for **inclusive jet A_{LL} at 200 GeV** (2015 data)
- **Stay tuned!**