Inclusive Jet Production in Longitudinally Polarized *pp* Collisions at STAR

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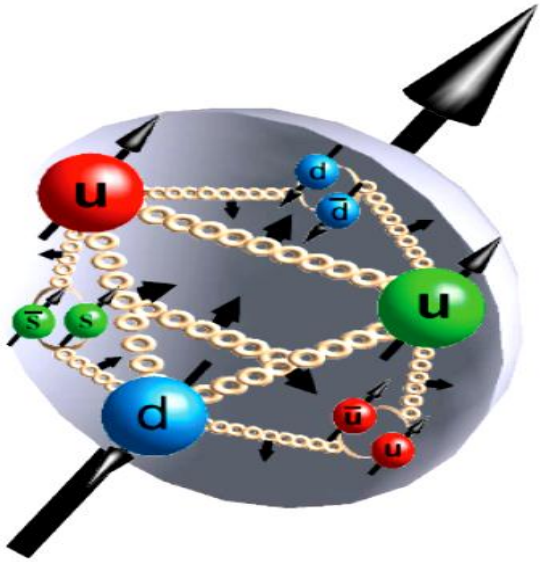
STAR

Proton Spin

Spin Helicity Sum Rule:

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



1. $\Delta\Sigma$: Quark polarization, about 0.3 measured by DIS.
2. ΔG: Gluon polarization, poorly determined by DIS.
3. L: Orbital angular moment of proton constituents, undetermined yet.

At STAR, polarized pp collisions allow unique access to gluon polarization.

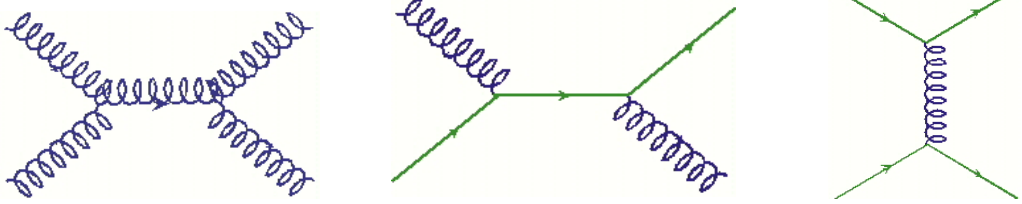
Inclusive Jet Double Spin Asymmetry– gluon contribution

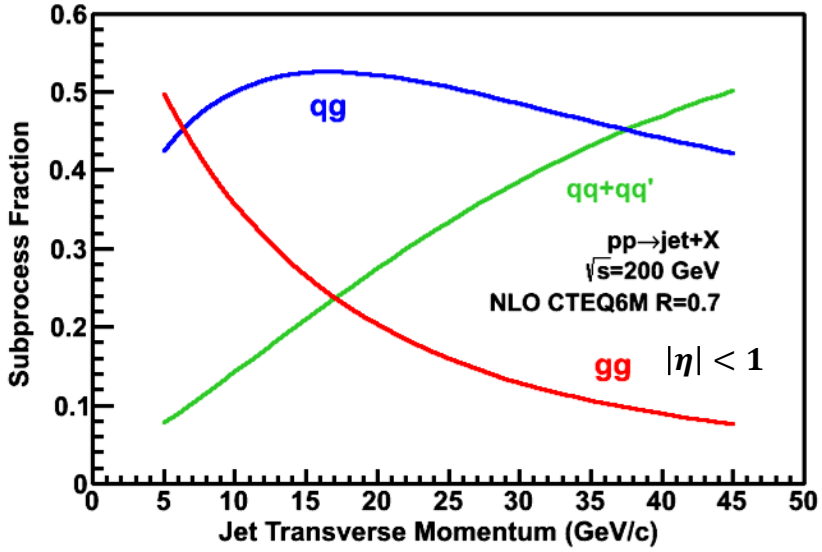
Inclusive jet A_{LL}:

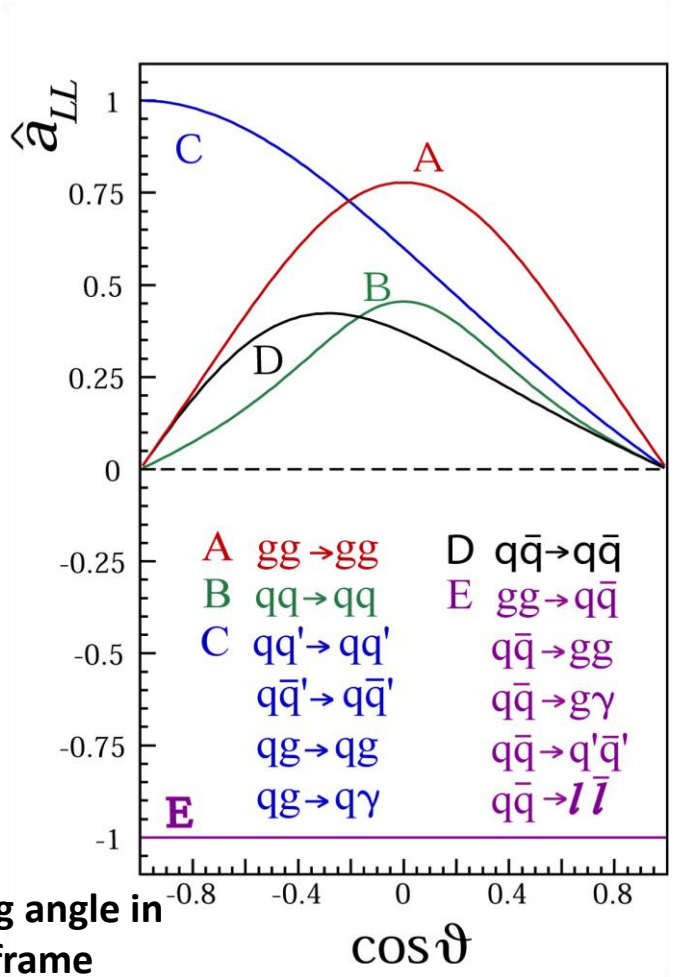
$$A_{LL} = \frac{\sigma^{++} - \sigma^{+-}}{\sigma^{++} + \sigma^{+-}} \propto \frac{\Delta f_a \Delta f_b}{f_a f_b} \hat{a}_{LL}$$

Δf: polarized parton distribution function.

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



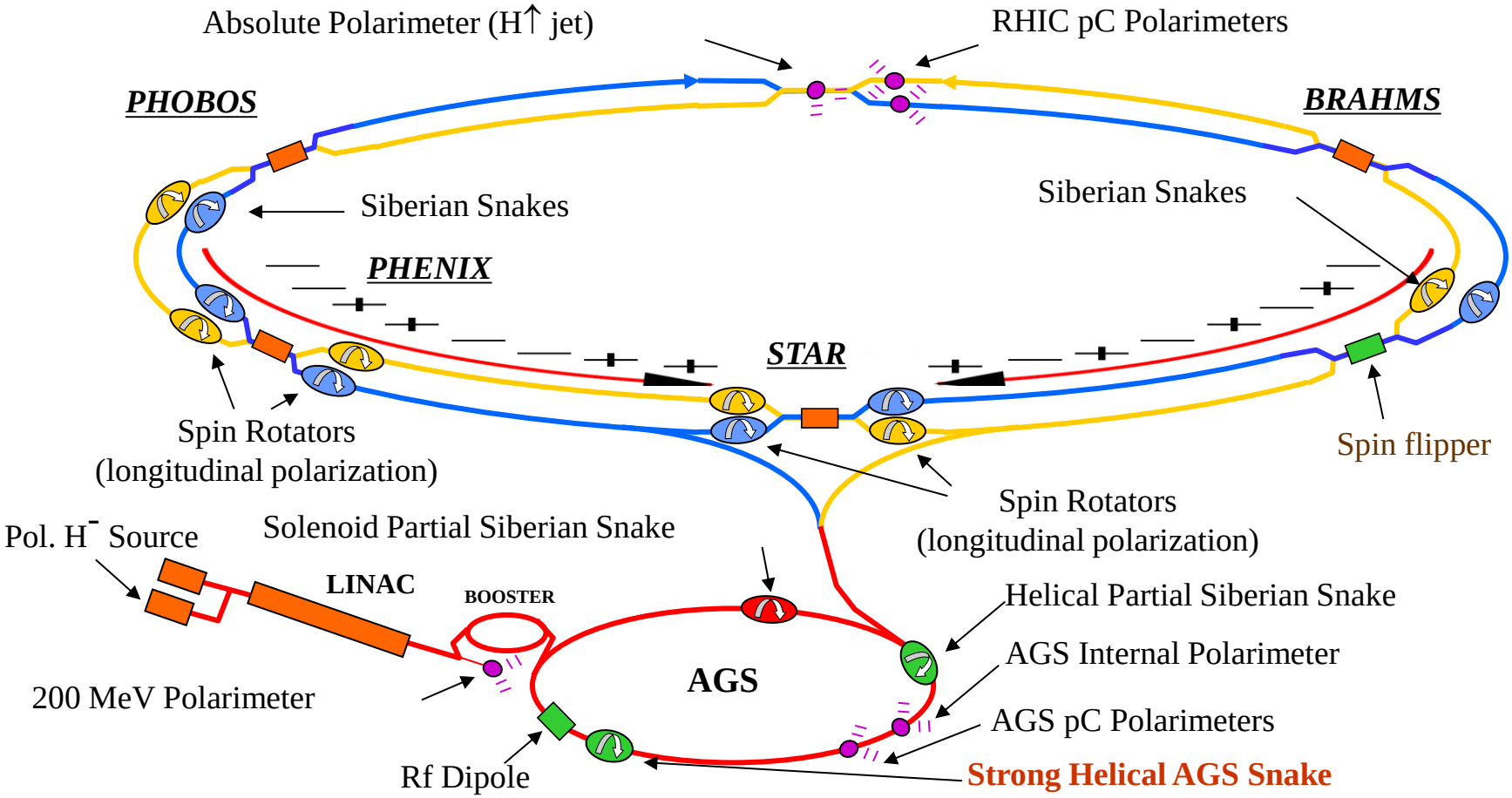




ϑ: scattering angle in the parton frame

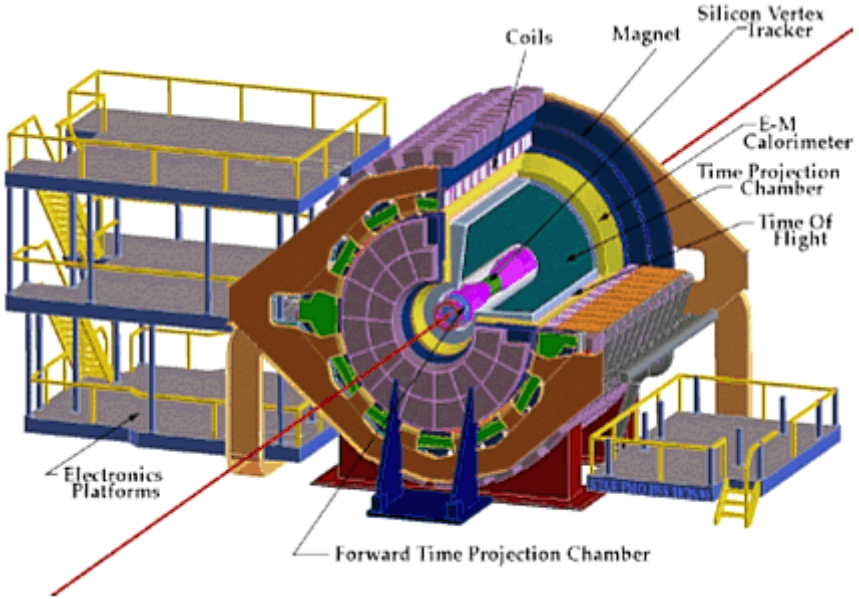
For most RHIC kinematics, **gg** and **qg** **dominate**, making A_{LL} for jets sensitive to **gluon polarization**.

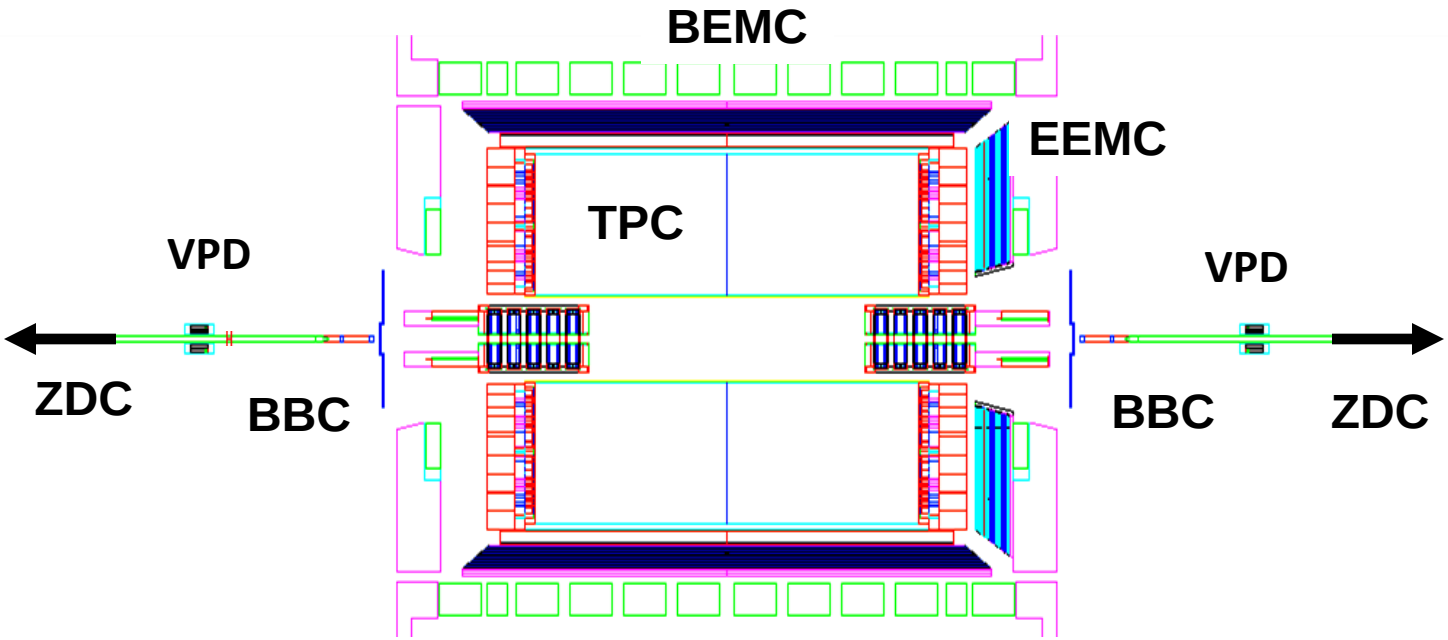
Experimental Setup – RHIC



1. ***Spin varies from rf bucket to rf bucket (9.4 MHz)***
2. ***Spin pattern changes from fill to fill***
3. ***Spin rotators provide choice of spin orientation***
4. ***Billions of spin reversals during a fill with little depolarization***

Experimental – STAR Detector

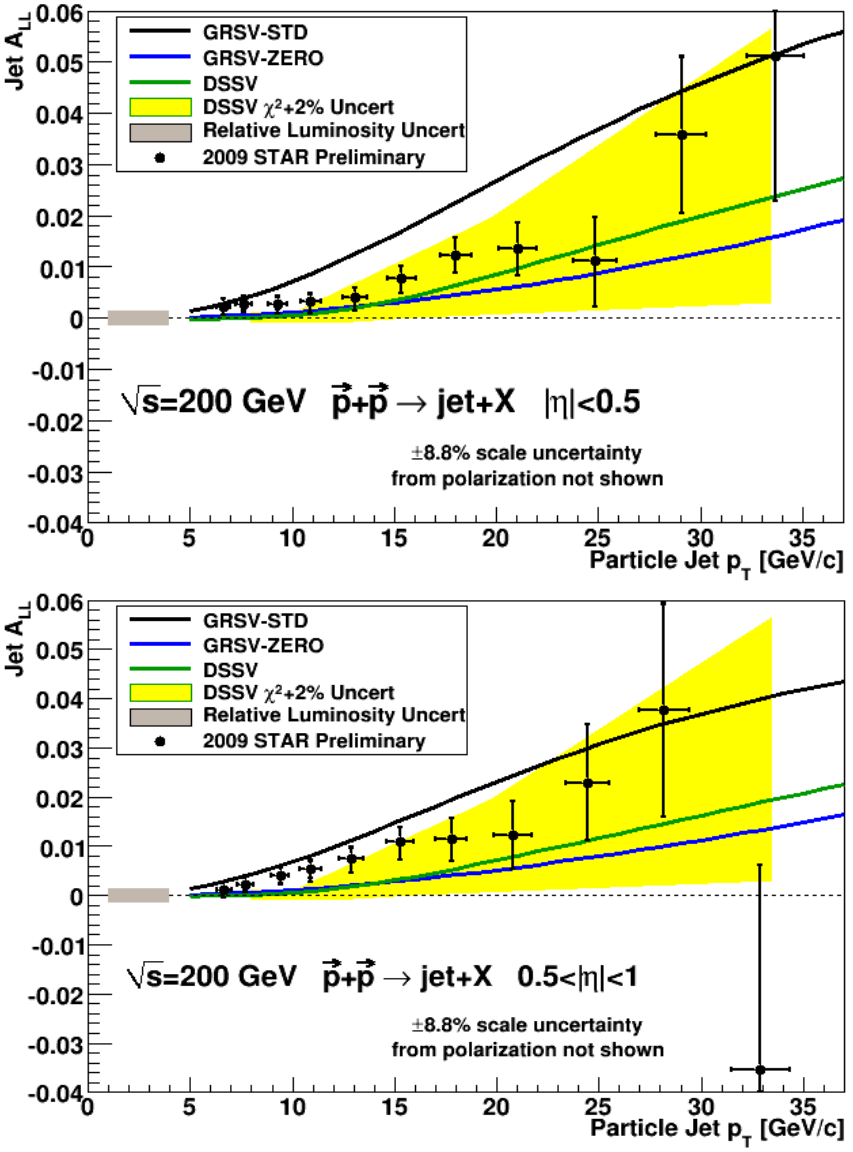




STAR 2009 200 GeV inclusive jet A_{LL} result

STAR preliminary

Inclusive jet A_{LL} in mid- and forward- pseudo-rapidity



STAR 2009 run:

Integrated luminosity: ~ 20 pb^{-1}

Beam polarization: ~ 58%

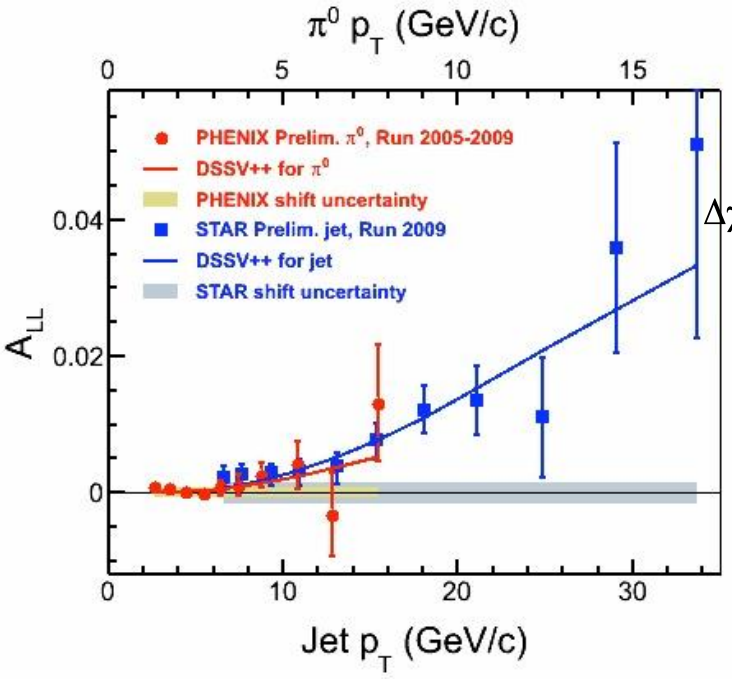
Jet reconstruction:

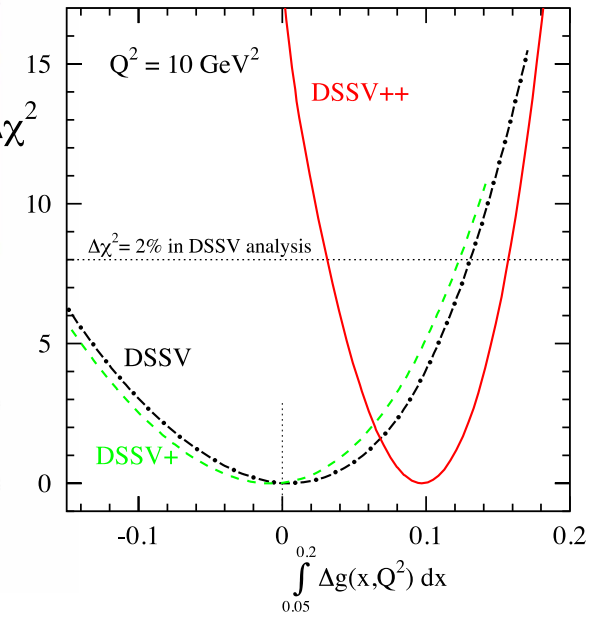
1. subtract track momentum from tower energy
2. jet energy resolution 18%
3. mid-point cone algorithm with cone radius 0.7
4. ($anti-k_T$ jet-finding algorithm with cone radius 0.6 for final result)

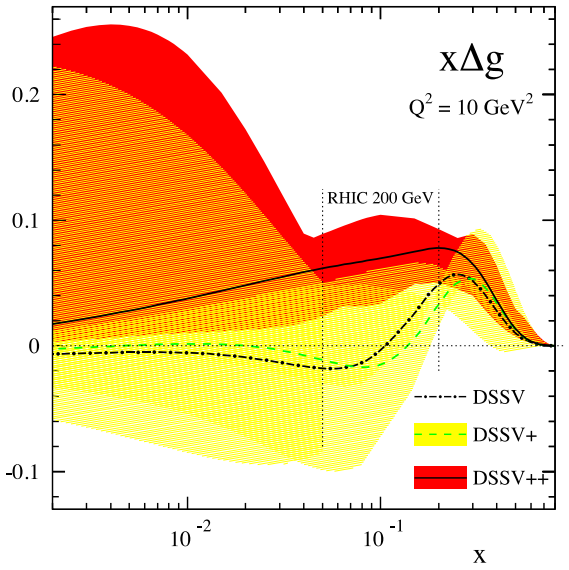
Implication – global analysis with 2009 RHIC data

arXiv:1304.0079

Special thanks to the DSSV group!







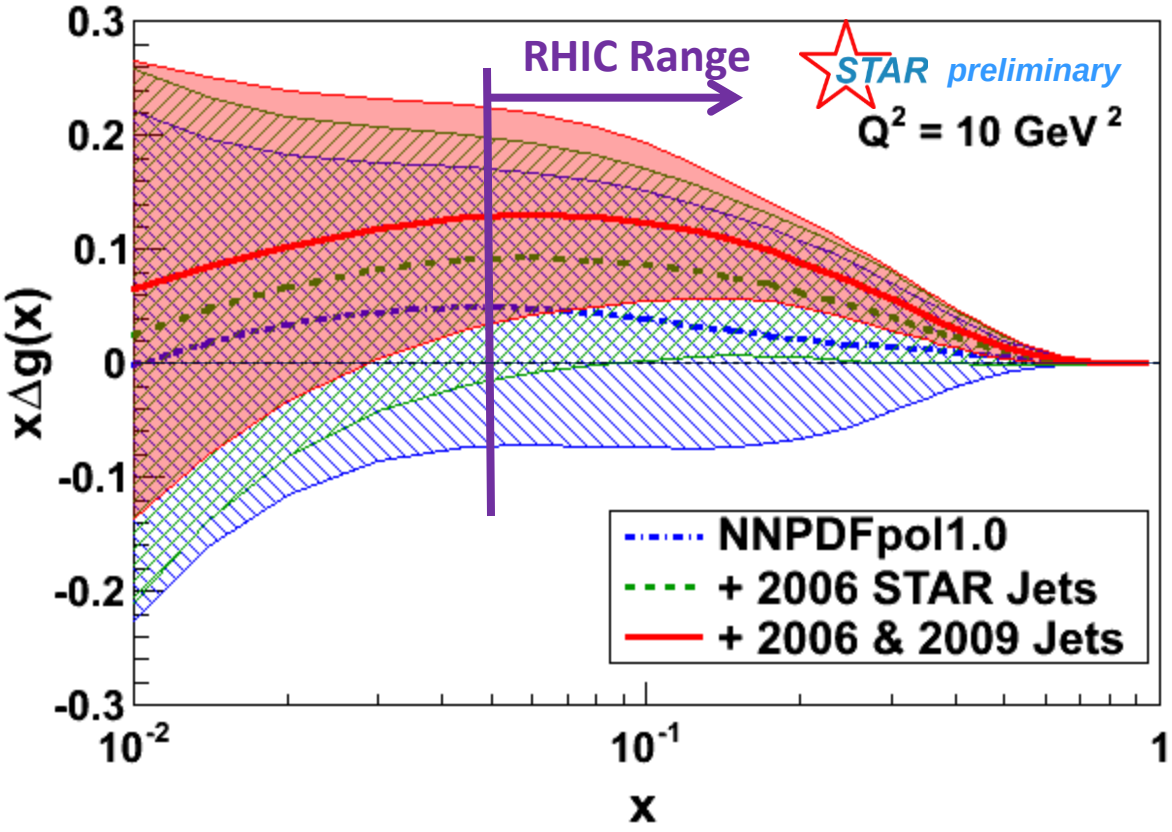
- **DSSV++,** a new preliminary global analysis from the DSSV group that includes the 2009 RHIC A_{LL} data (STAR inclusive jets and PHENIX π^0's) shows

$$\int_{0.05}^{0.2} \Delta g(x, Q^2 = 10\ GeV^2)dx = 0.10^{+0.06}_{-0.07}$$

- First experimental evidence of **non-zero Δg(x)** in RHIC range ($0.05 \le x \le 0.2$)

Implication – NNPDFpol1.0 calculation

To evaluate the implications of the STAR inclusive jet A_{LL} results, have included them in NNPDFpol 1.0 using the recommended prescription (reweighting).



NNPDFpol1.0
arXiv:1303.7236

NNPDFpol1.0 with 2006 and 2009 combined STAR inclusive jet data shows apparent gluon contribution and reduced uncertainty for $x > 0.05$ and $Q^2 = 10\ GeV^2$

2012 inclusive jet A_{LL} analysis status

STAR 2012 run:

510 $\boldsymbol{GeV}$ longitudinally polarized proton-proton collisions with average **~ 55% polarization** and **integrated luminosity ~ 80** $\boldsymbol{pb^{-1}}$

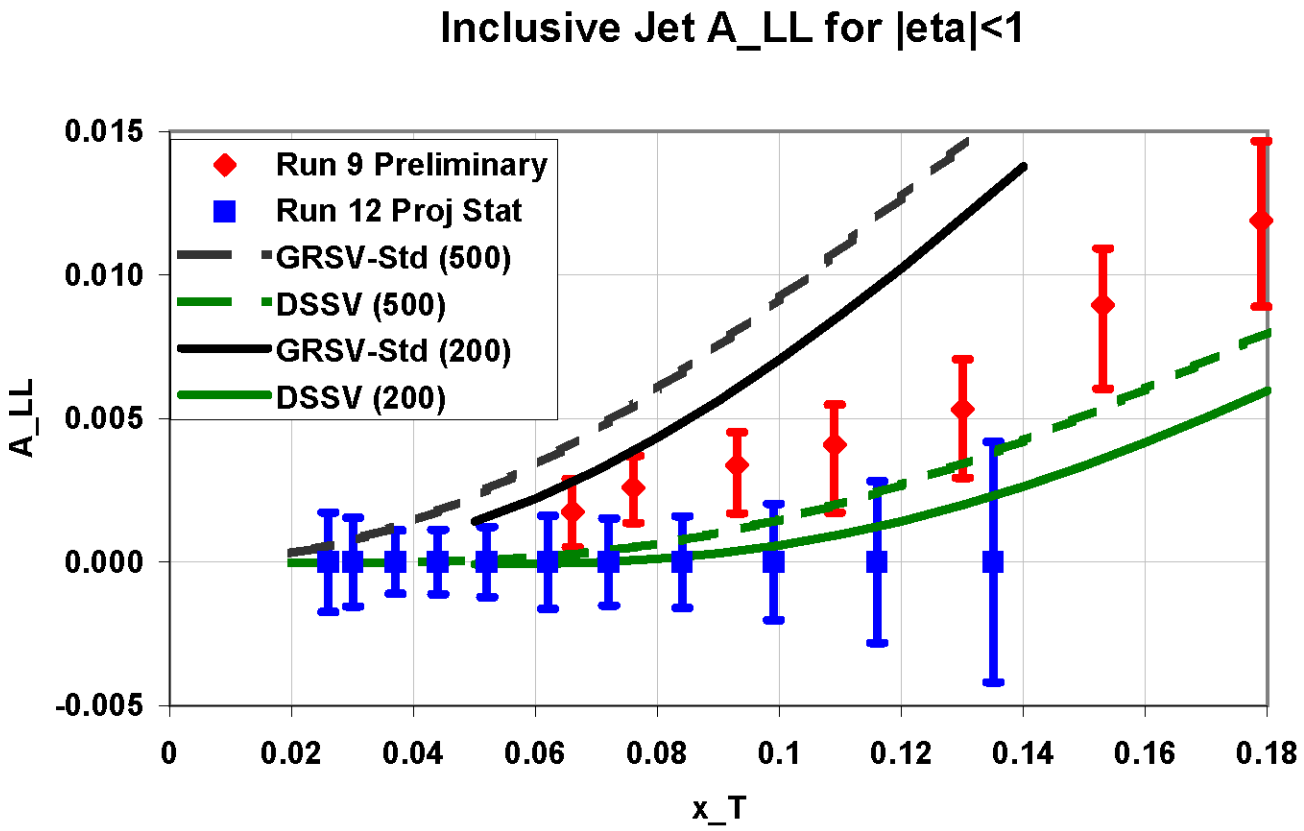
Recent progress:

Relative luminosity: Accidental and multiple corrected VPD (Vertex Position Detector) coincidence rate. The **uncertainty** is estimated to be about $\boldsymbol{2 \times 10^{-4}}$. This contributes about $\boldsymbol{4 \times 10^{-4}}$ to the **relative uncertainty** of **jet** $\boldsymbol{A_{LL}}$

Jet reconstruction:

1. $anti - k_T$ algorithm with cone radius 0.6
2. Run quality assurance under way

2012 inclusive jet A_{LL} projection



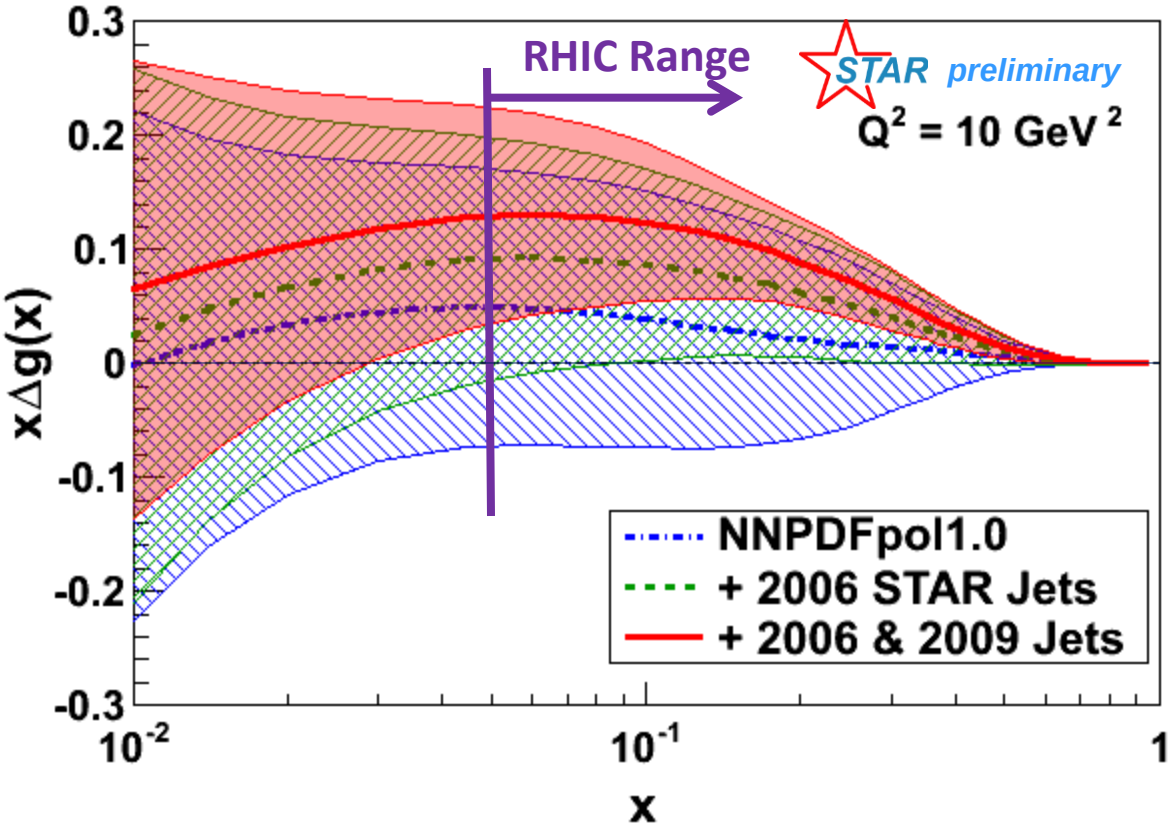
510 GeV extends precision inclusive jet A_{LL} measurements to x_T as low as 0.02

Conclusion

1. STAR 2009 inclusive jet data provide **significant constraints** on **gluon contribution** on proton spin.
2. First clear evidence of **non-zero gluon contribution** in the RHIC range.
3. STAR 2012 510 GeV allows to explore **gluon contribution** at even **lower** $x_T \sim 0.02$.
4. Inclusive jet $\boldsymbol{A_{LL}}$ results from the very **successful** 2012 proton-proton run will be coming soon.

Implication – NNPDFpol1.0 calculation

To evaluate the implications of the STAR inclusive jet A_{LL} results, have included them in NNPDFpol 1.0 using the recommended prescription (reweighting).



NNPDFpol1.0
arXiv:1303.7236
Uses EMC, SMC, SMClowx, COMPASS, HERMES97, HERMES, E143, and E154 data to determine polarized PDF.

NNPDFpol1.0 with 2006 and 2009 combined STAR inclusive jet data shows apparent gluon contribution and reduced uncertainty for $0.05 < x$ and $Q^2 = 10\ GeV^2$