Constraining the Polarized Gluon Distribution Through Di-jet Measurements at √s=500 GeV at STAR

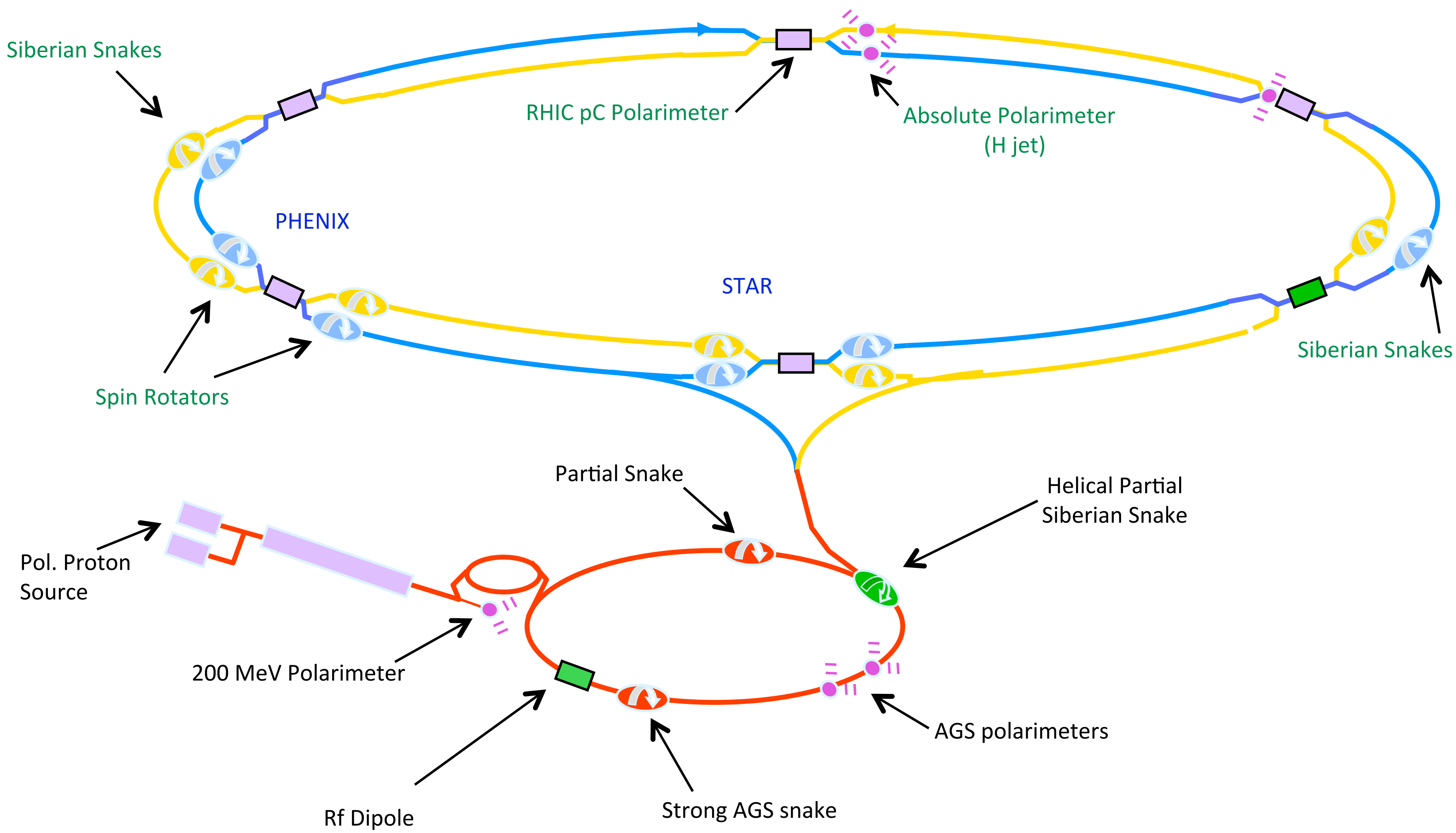
Daniel Olvitt

Temple University

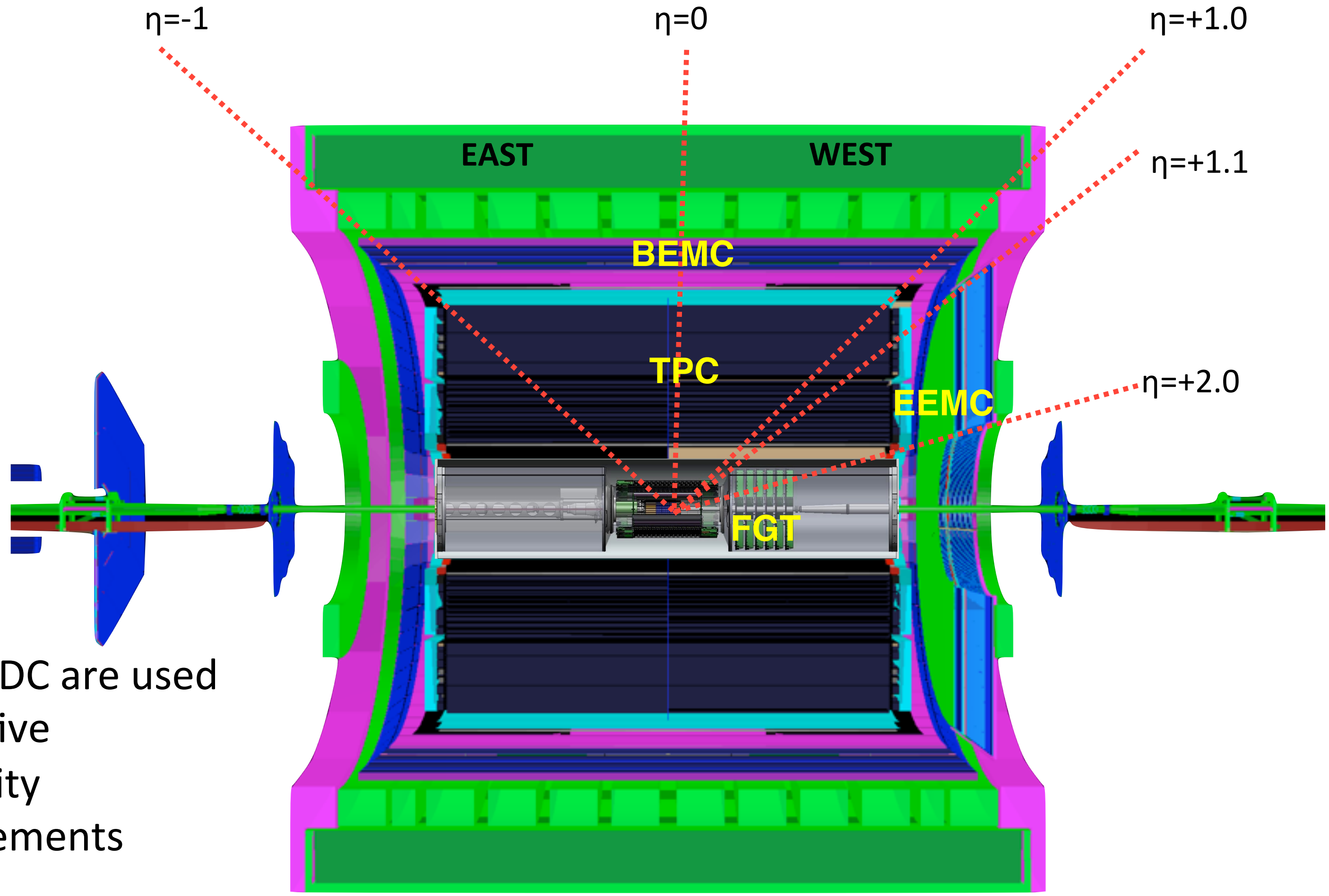
for the STAR Collaboration

RHIC

World’s first and only polarized proton collider



STAR Experiment



VPD & ZDC are used for relative luminosity measurements

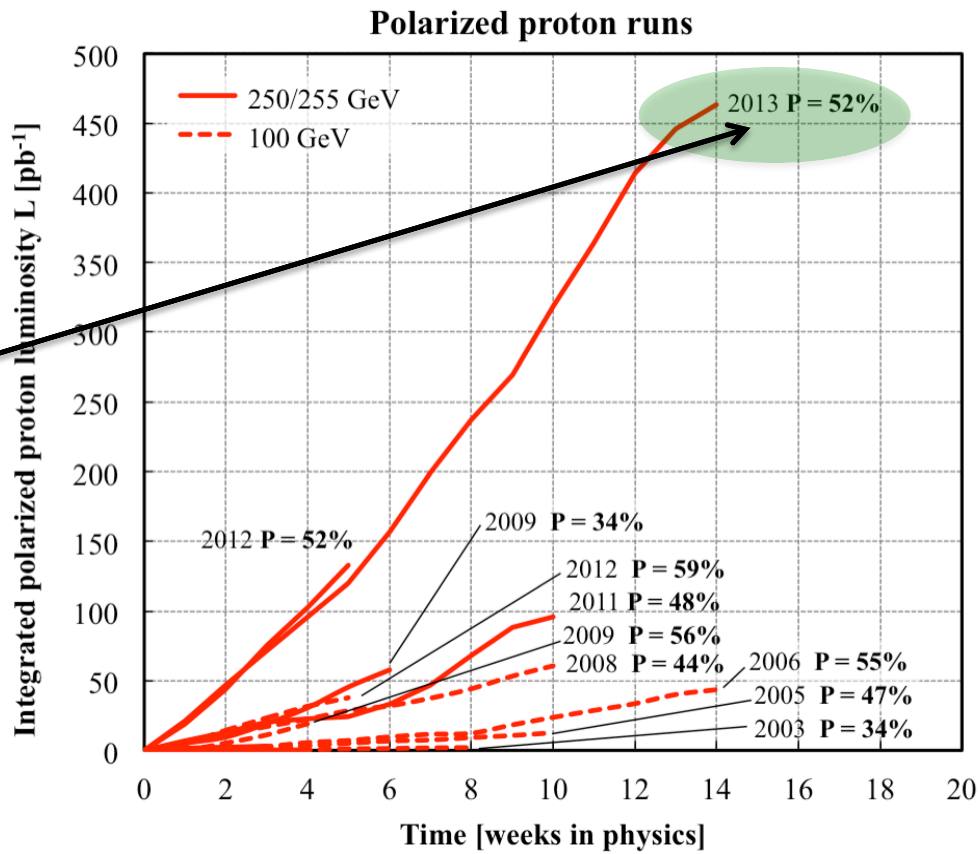
Energy Coverage
BEMC: $|\eta| \leq 1$
EEMC: $1.1 < \eta < 2$

Tracking Coverage
TPC: $|\eta| \leq 1.3$
FGT: $1 < \eta < 2$

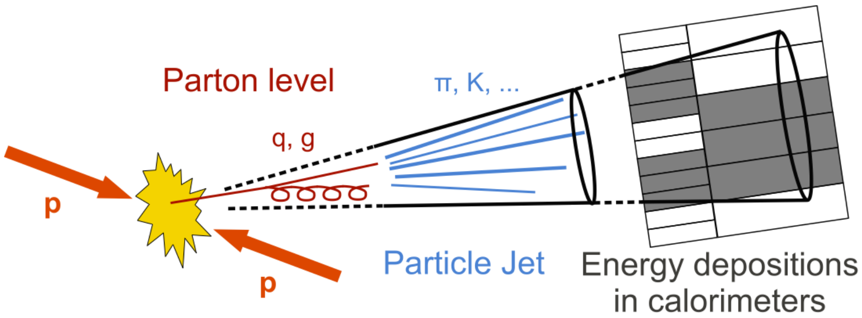
$$\eta = -ln\left(\tan\frac{\theta}{2}\right)$$

Data Collection at STAR

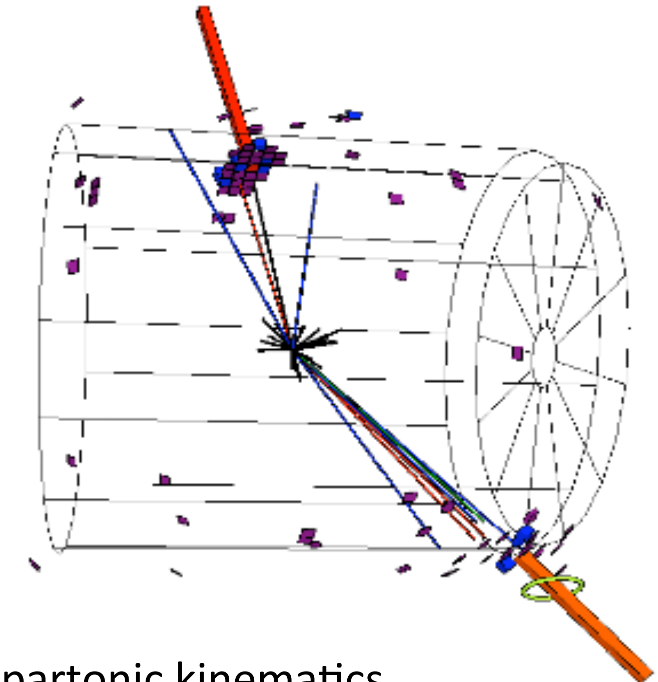
- Polarized p+p collisions
- In 2009, 2012, 2013 longitudinal production at √s=500 GeV
- 2013 collected the largest p-p data sample in the history of RHIC



Jet Definition



Parton: Jets contain gluons and quarks
Particle: Jets contain hadrons (pions, kaons, etc.)
Detector: Measure the tracking and energy of the jets



Di-jets give us access to the initial partonic kinematics

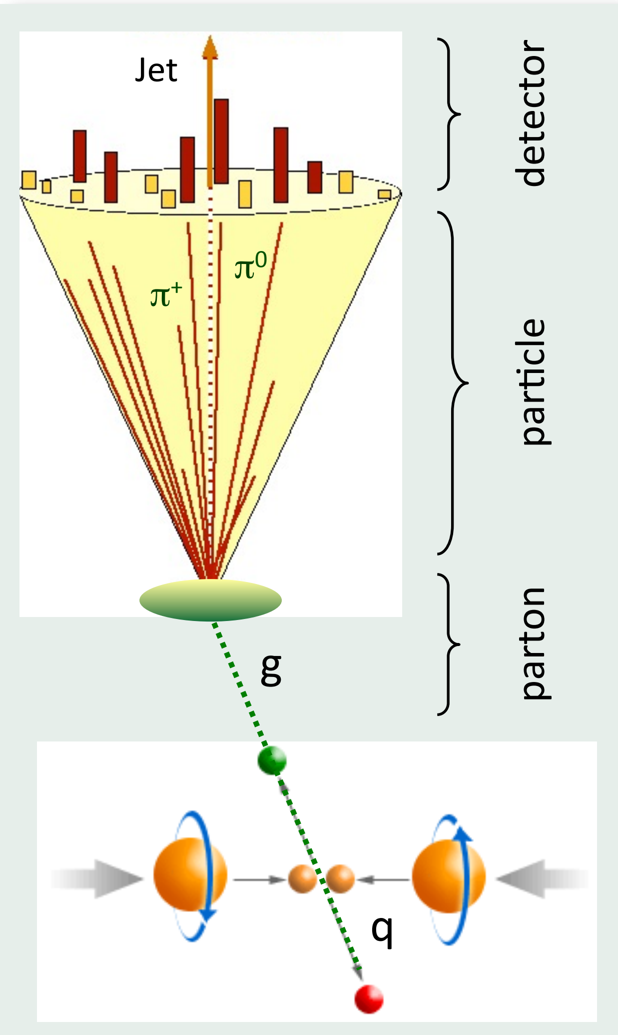
$$x_1 = \frac{2}{\sqrt{s}}\left(p_{T3}e^{\eta_3} + p_{T4}e^{\eta_4}\right)$$

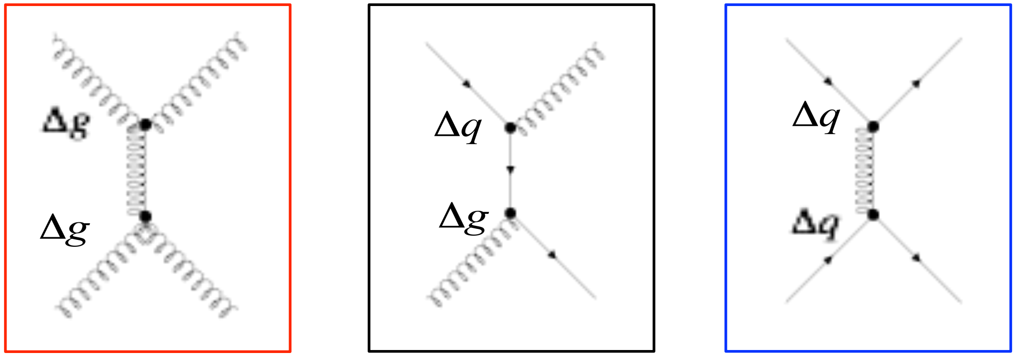
$$x_2 = \frac{2}{\sqrt{s}}\left(p_{T3}e^{-\eta_3} + p_{T4}e^{-\eta_4}\right)$$

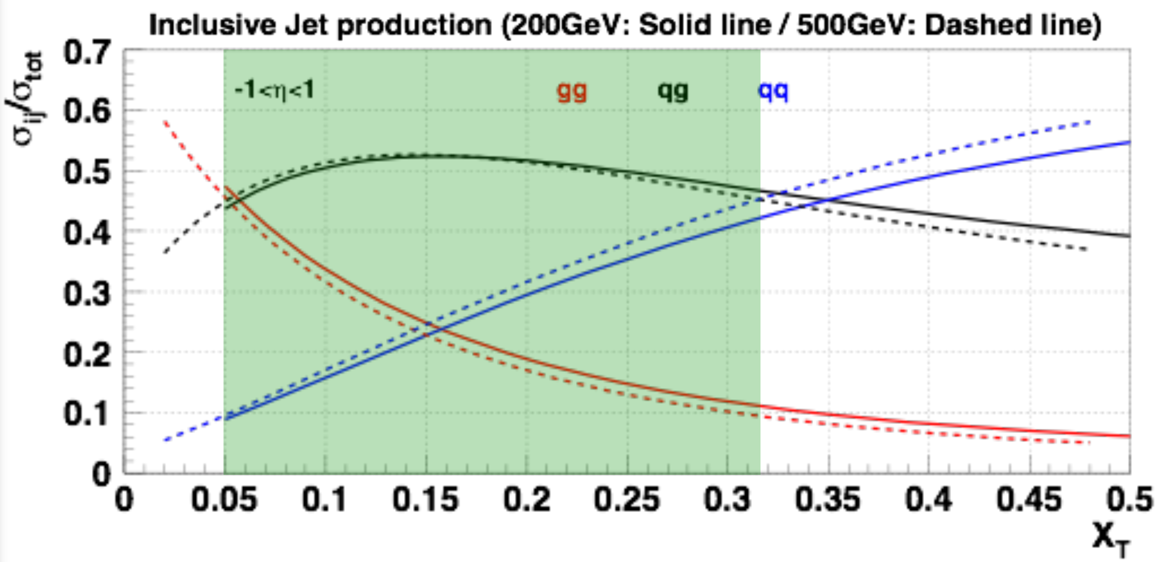
$$\eta = -ln\left(\tan\frac{\theta}{2}\right)$$

1,2: Incoming
3,4: Outgoing

Access to Gluons at STAR

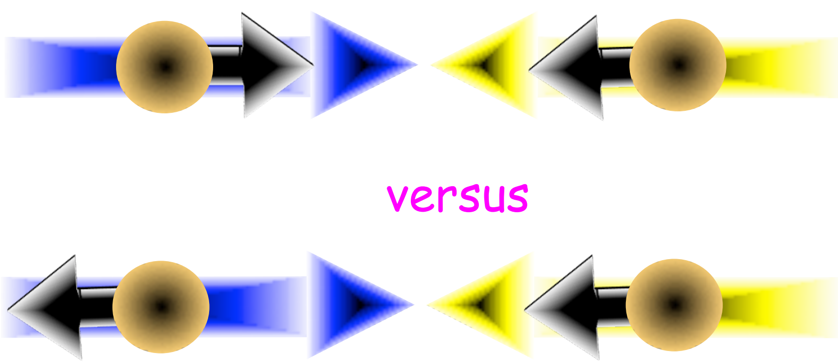


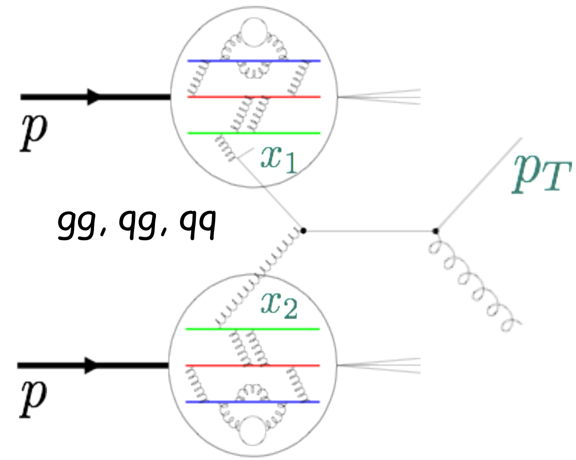




$$x_T = \frac{2p_T}{\sqrt{s}}$$ (x value at η = 0)

Access to ΔG





Di-Jet production

$$A_{LL} = \frac{\sigma^{++} - \sigma^{+-}}{\sigma^{++} + \sigma^{+-}} = \frac{1}{P_1 P_2} \frac{N^{++} - RN^{+-}}{N^{++} + RN^{+-}} \propto \frac{\Delta f_a \Delta f_b}{f_a f_b} a_{LL}$$

$$N = \frac{\sigma}{L}, R = \frac{L^{++}}{L^{+-}}$$

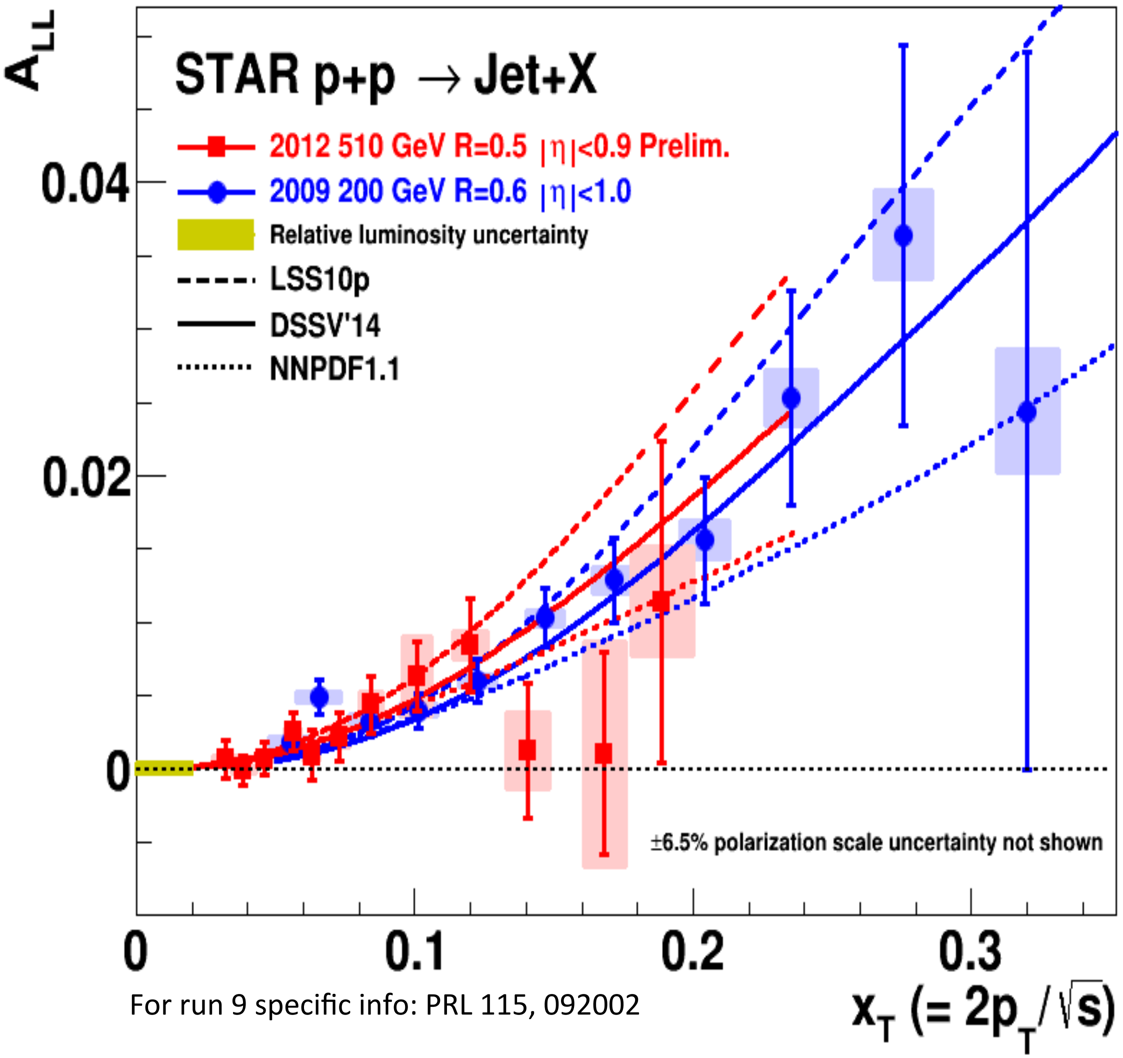
For Jets Only

Experiment

Theory

Recent Inclusive Results

arXiv:1512.05400

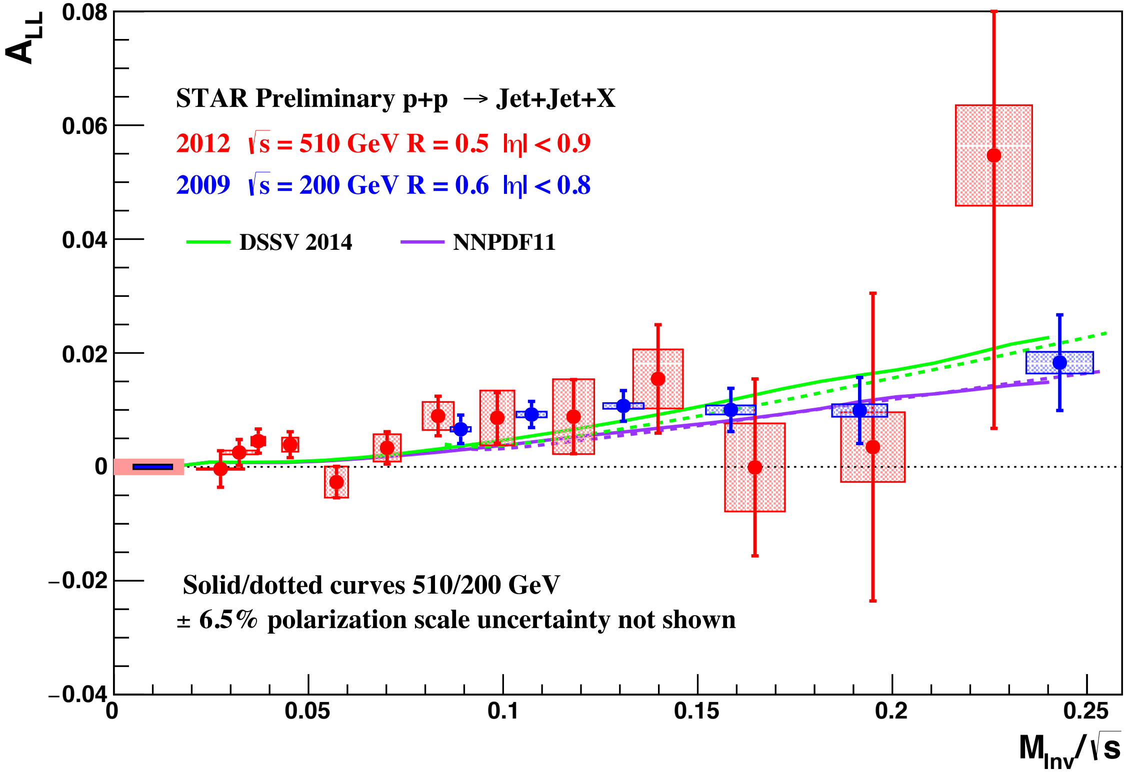


For run 9 specific info: PRL 115, 092002

- Run 9 A_{LL} measurement (200GeV) and Run 12 A_{LL} measurement (510GeV) are in good agreement in x_T overlap region
- To further constrain the measurement the large Run 13(510 GeV) data sample will be leveraged
- Run 13 collected ~3 times the luminosity of run 12

Recent Di-jet Results

arXiv:1608.01332



- Run 9 A_{LL} measurement (200GeV) and Run 12 A_{LL} measurement (510GeV) are in good agreement
- To further constrain ΔG, the Run 13(510 GeV) data sample will reduce the statistical error bars
- Both results show a trend to a positive A_{LL}
- Run 13 collected ~3 times the luminosity of run 12
- The run 13 data will have the largest impact $0.02 \leq x \leq 0.05$

RHIC Impact on Global Analyses

- Inclusion of the 2009 RHIC data greatly reduced the uncertainty on ΔG for the DSSV group for $x \geq 0.05$

- DSSV – New Fit Δg(x)

$$\Delta G = \int_{0.05}^{1} \Delta g(x, Q^2 = 10GeV^2) = 0.20^{+0.06}_{-0.07}(90\%C.L.)$$

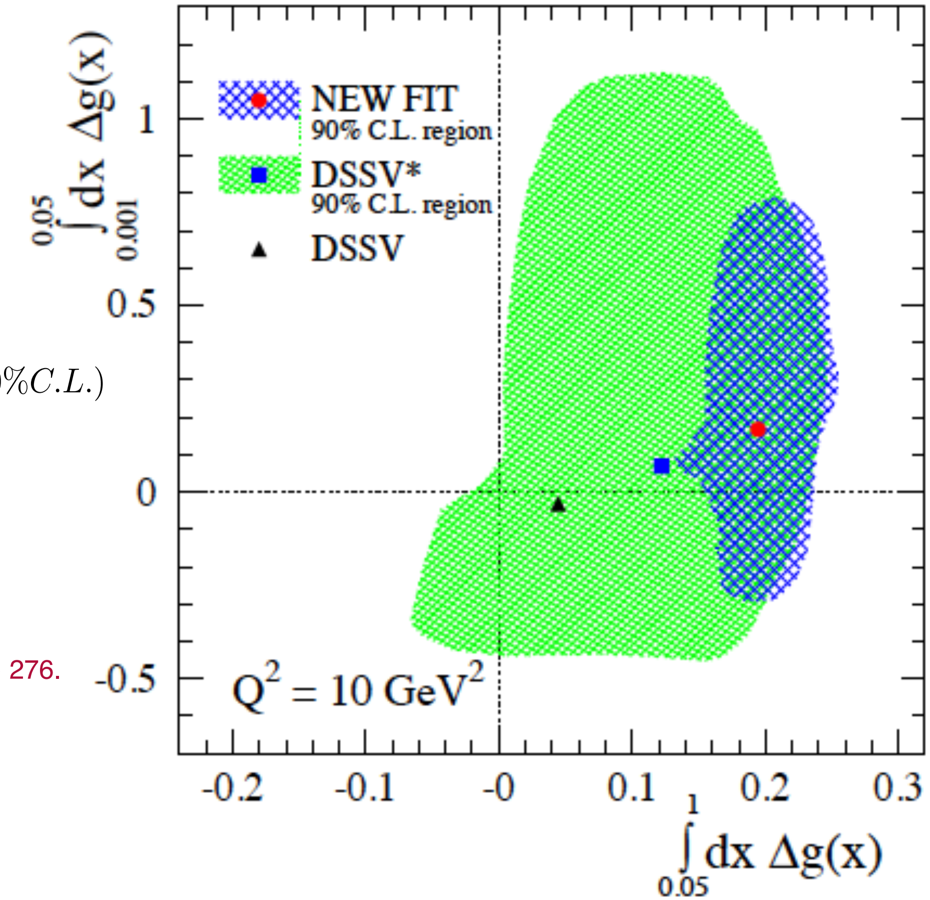
- An independent analysis by NNPDF shows similar results

$$0.23^{+0.07}_{-0.07} \text{ for } 0.05 < x < 0.5$$

E. R. Nocera et al., Nucl. Phys. B887 (2014) 276.

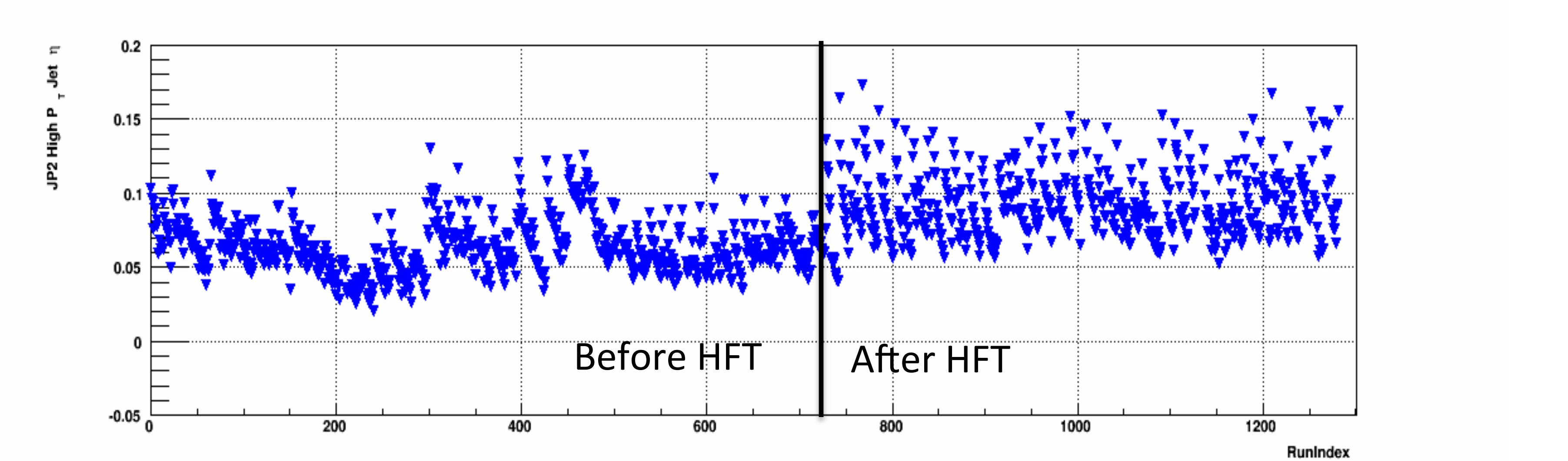
- Large 2013 data sample will provide better constraints at lower Bjorken x

D. deFlorian et al., Phys. Rev. Lett. 113 (2014) 012001.



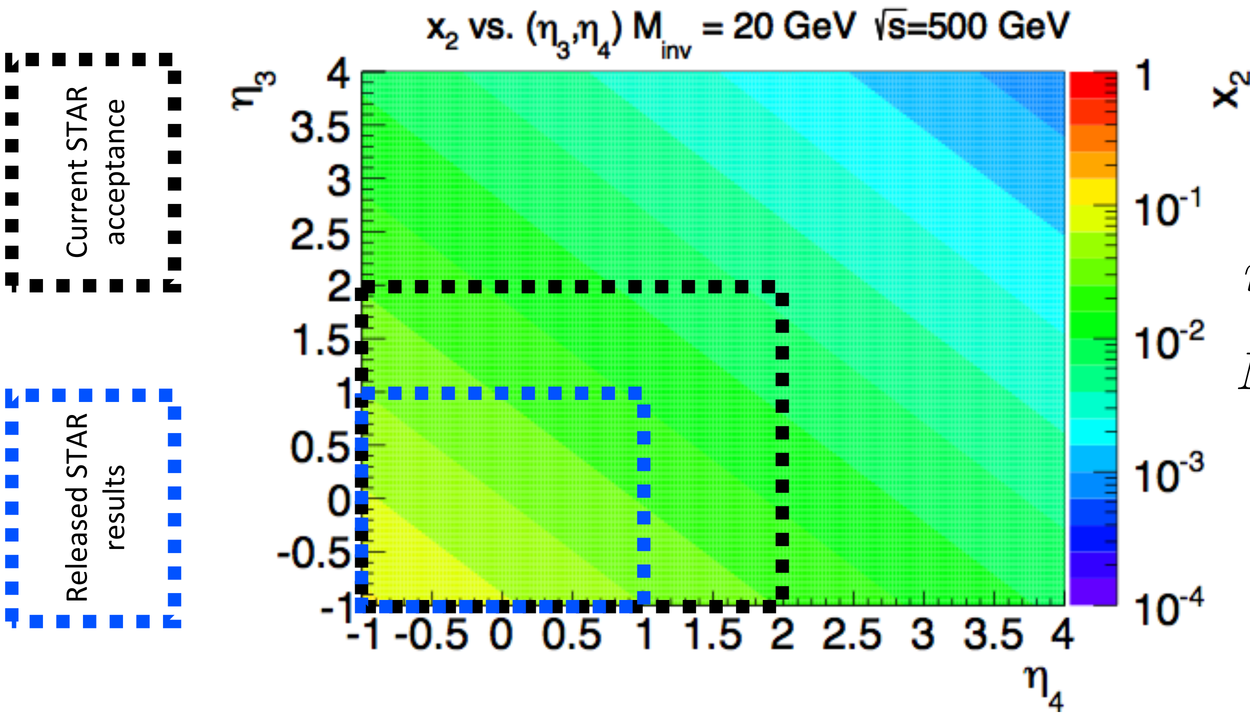
DSSV: Original global analysis (first RHIC results, Run 5&6)
DSSV*: New COMPASS inclusive and semi-inclusive results
DSSV – NEW FIT: Now includes RHIC Run 9 data, strong impact of Δg(x)

2013 Status



- Part way through the run in 2013 the Heavy Flavor Tracker (HFT) was partially installed on the east side ($\eta < 0$) of STAR
- There is a "jump" in average η after the partial installation of the Heavy Flavor Tracker (HFT)
- It was determined that the cause of the "jump" was a tracking effect
- A new tracking method was tested
  - Showed greater tracking efficiency
  - The dependencies were still present in both tracking codes

Going Forward in η



For more info on the FCS and forward upgrade: STAR Note SN0605

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

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

- By extending our acceptance forward in η it would allow us to probe as far down as 10^{-3} in x with both jets far forward in η
- Forward hadronic calorimeter would be an ideal tool to accomplish this measurement at larger values of η

Summary

- STAR has continued to take advantage of the highly polarized proton beams at RHIC allowing the development of a strong jet/di-jet program

- Jet and di-jet measurements allow us to measure the gluon polarization function
  - 2009 STAR results at 200 GeV made a strong impact in reducing uncertainty in RHIC range ($0.05 \leq x \leq 0.2$)
  - Di-jet measurements will allow one to constrain the shape of Δg
  - Further reduce the uncertainty at lower Bjorken x with the 2013 data collected at 510 GeV

- Future forward upgrade of the STAR instrumentation would give STAR the unique ability to probe as low as 10^{-3} in Bjorken x, long before an EIC would turn on