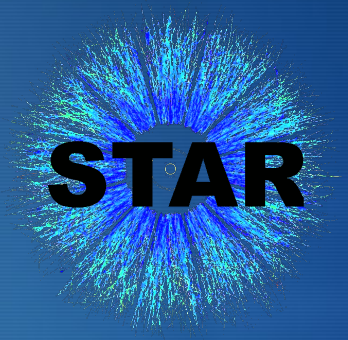


Probing Gluon Helicity with Dijets from √s = 510 GeV Polarized Proton Collisions at STAR

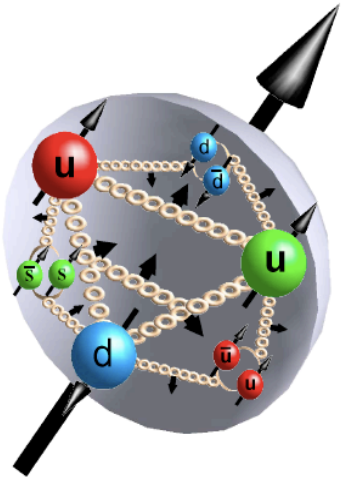
Suvarna Ramachandran

For the STAR Collaboration

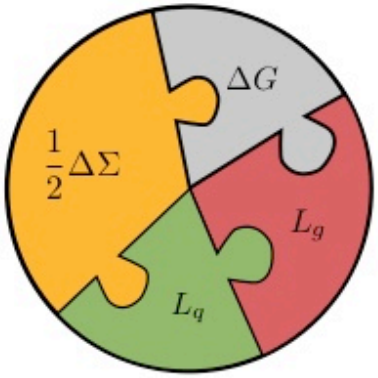
University of Kentucky

- Introduction and Motivation
- RHIC and STAR Detector
- Dijet Measurements at STAR
- Conclusion

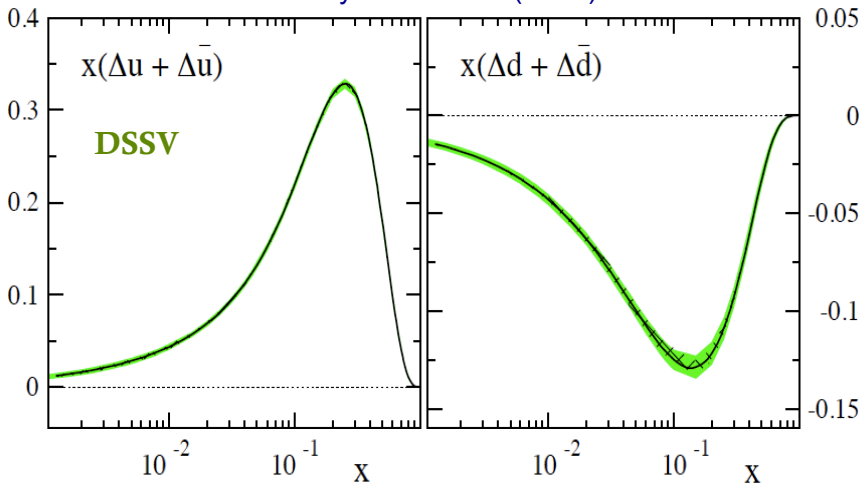
Spin of the Proton



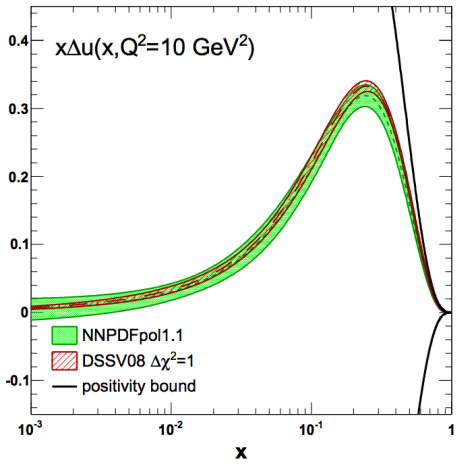
$$S_{PROTON} = \frac{\hbar}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L_q + L_g$$

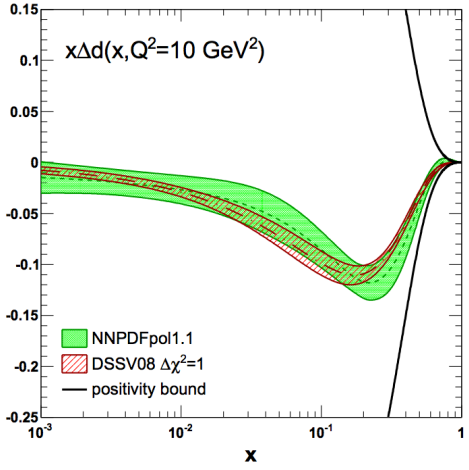


Phys. Rev. D80 (2009) 034030

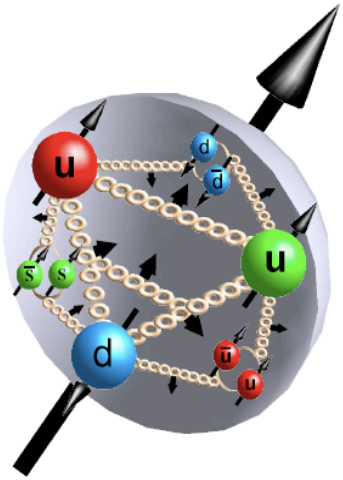


Nucl. Phys. B887 (2014) 276-308





Spin of the Proton



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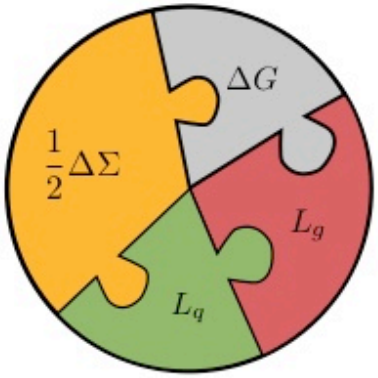
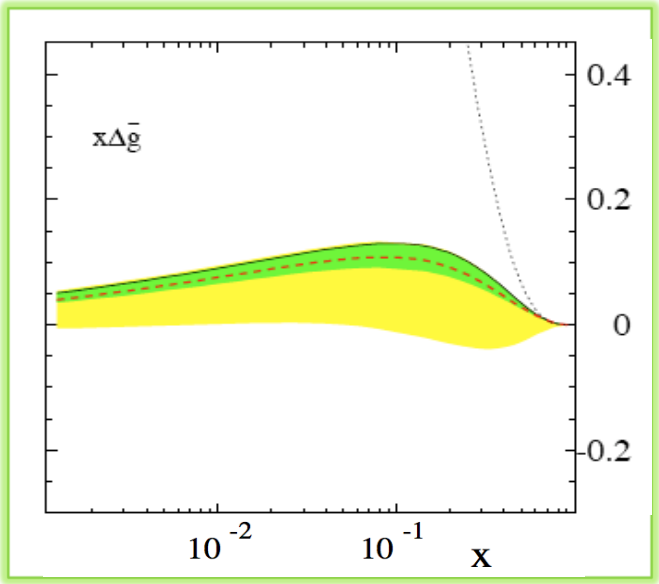
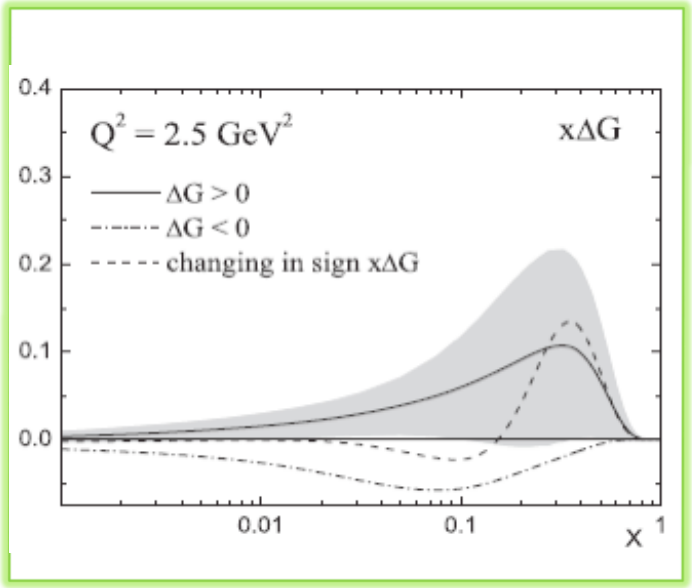


Phys. Rev. D71 094018 (2005)

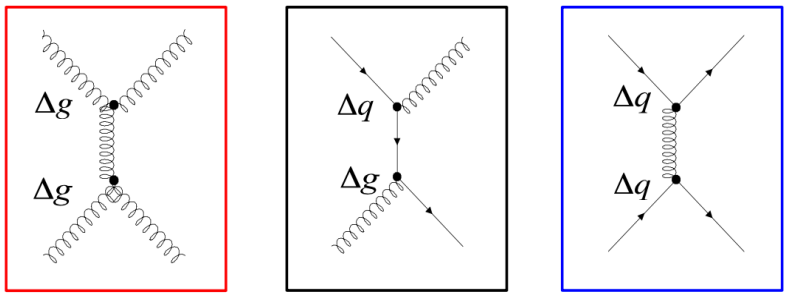


Phys. Rev. D75 074027 (2007)

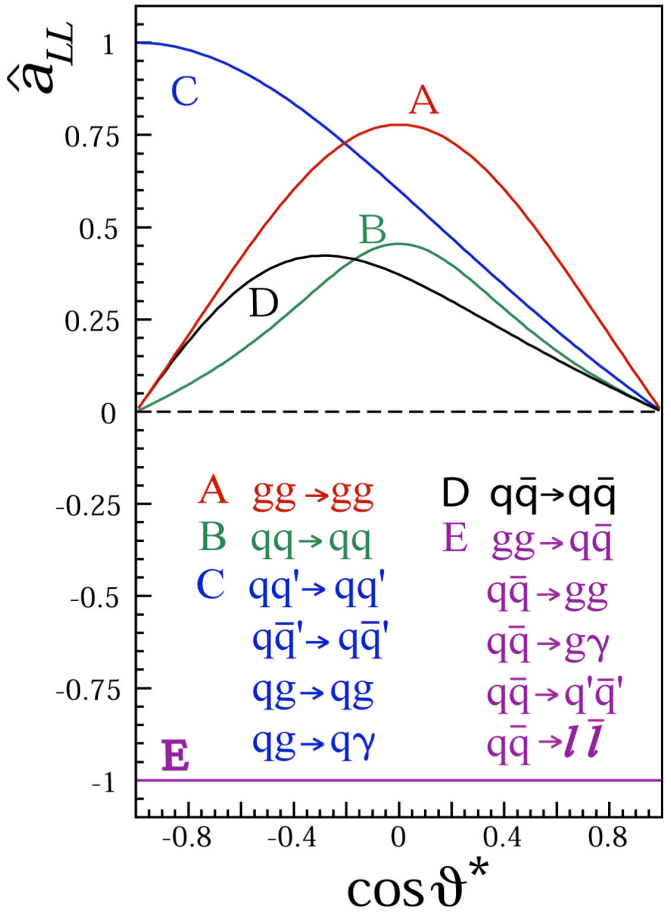


How do we access ΔG at a polarized proton collider?

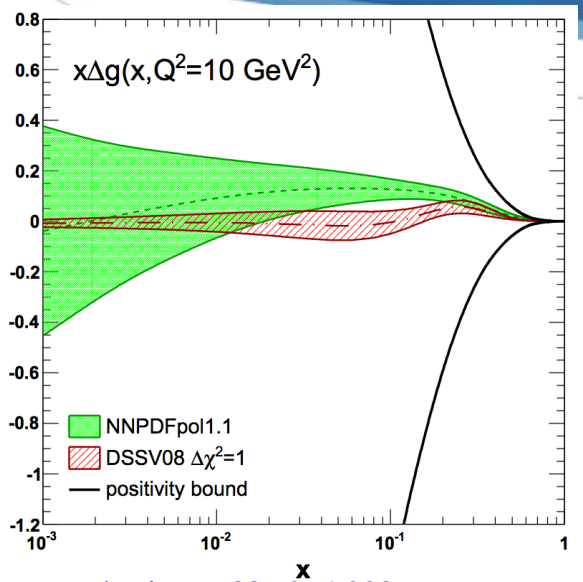
- Inclusive and Dijet Longitudinal Double Spin Asymmetry



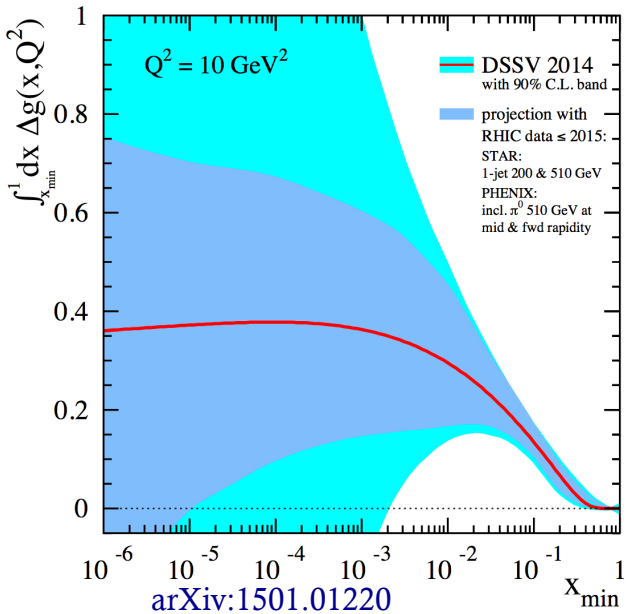
$$A_{LL} = \frac{\sigma^{++} - \sigma^{+-}}{\sigma^{++} + \sigma^{+-}} \propto \frac{\Delta f_a \Delta f_b}{f_a f_b} \hat{a}_{LL}$$



ΔG

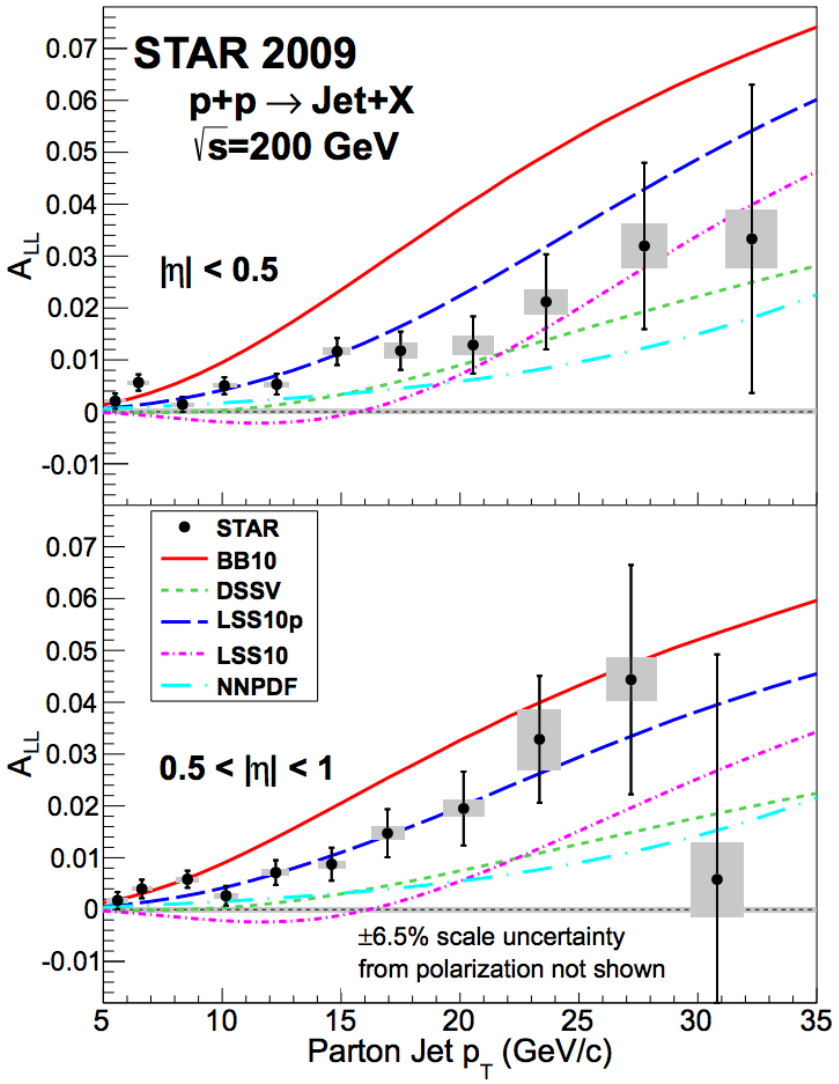


Nucl. Phys. B887 276-308



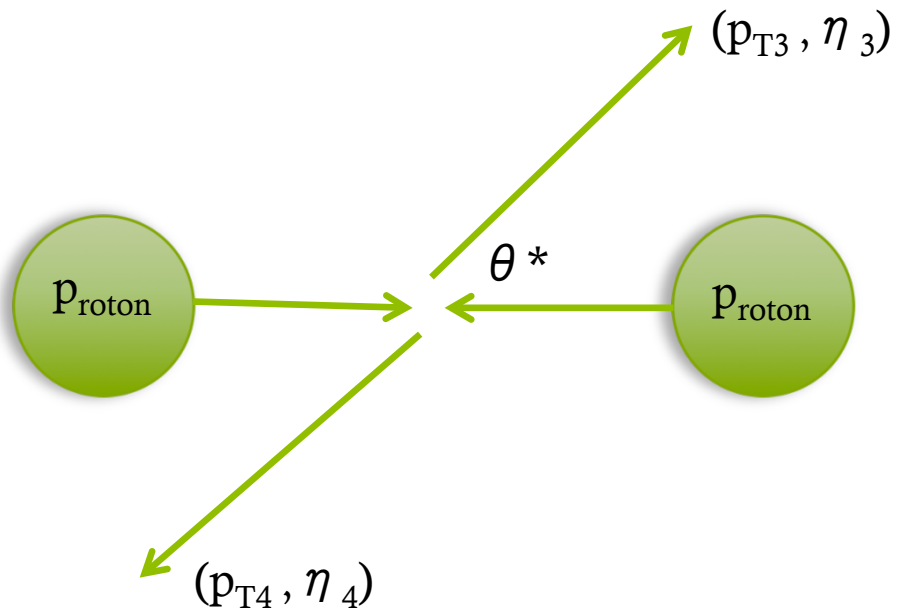
arXiv:1501.01220

Phys. Rev. Lett 115.092002



Dijets at 510 GeV

- Reconstructing dijets give access to initial partonic kinematics



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

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

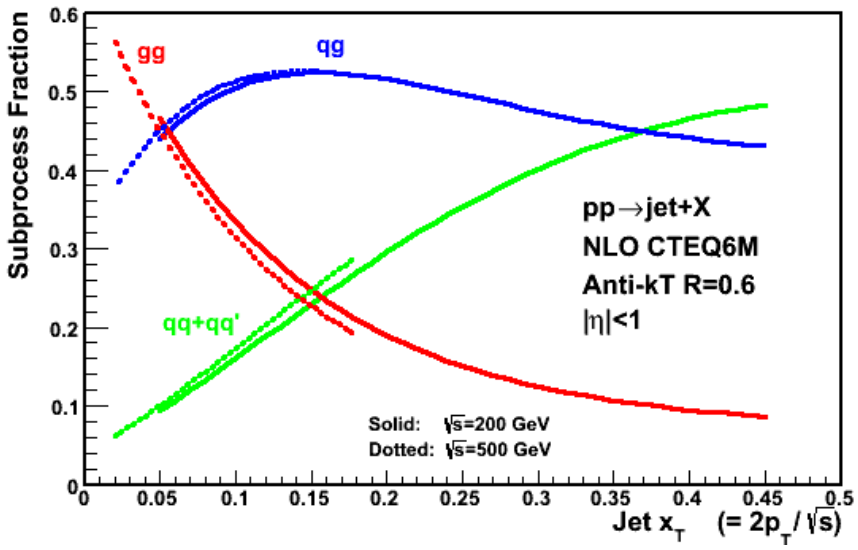
$$M = \sqrt{x_1 x_2 s}$$

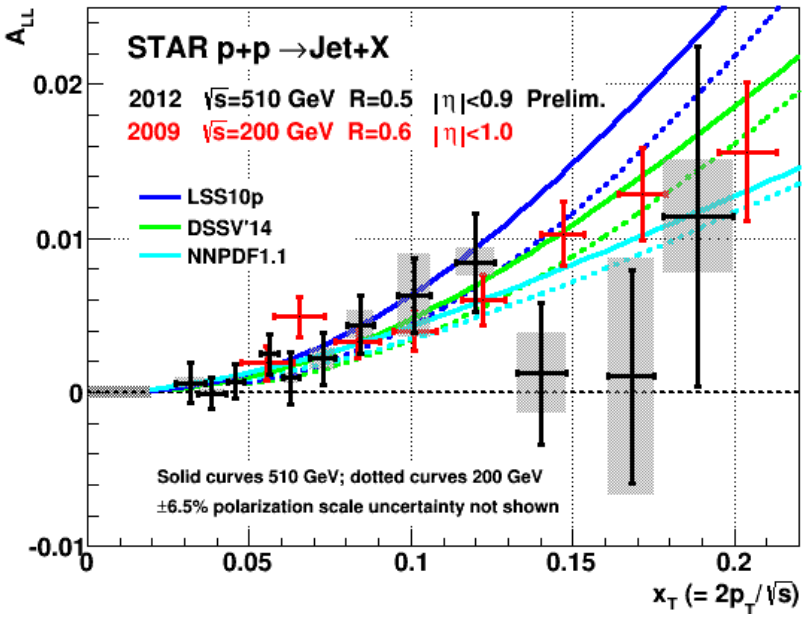
$$\eta_3 + \eta_4 = \ln\frac{x_1}{x_2}$$

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

Dijets at 510 GeV

- The dijet A_{LL} at 510 GeV is sensitive to lower x values, thus providing information on ΔG in a new kinematic regime

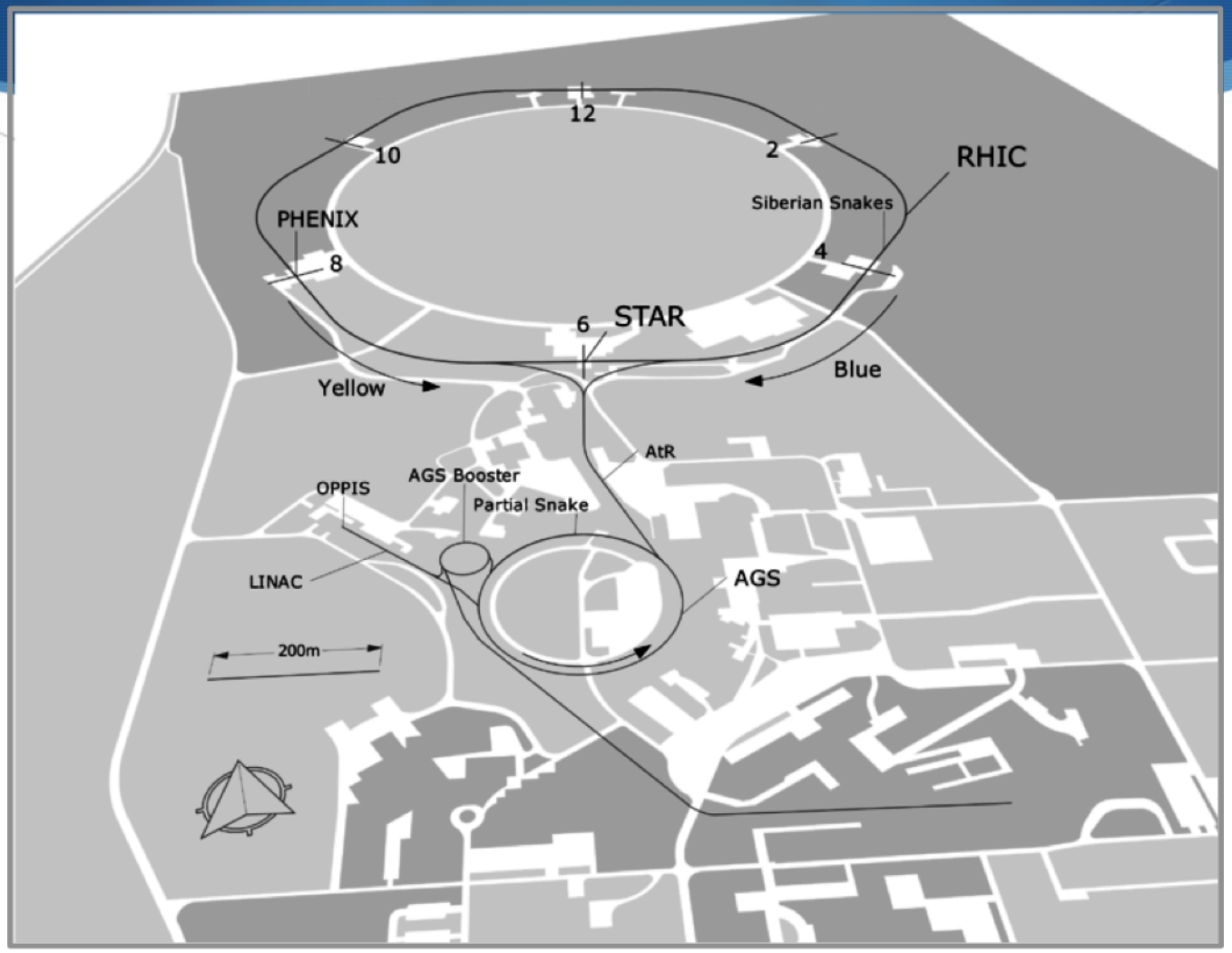




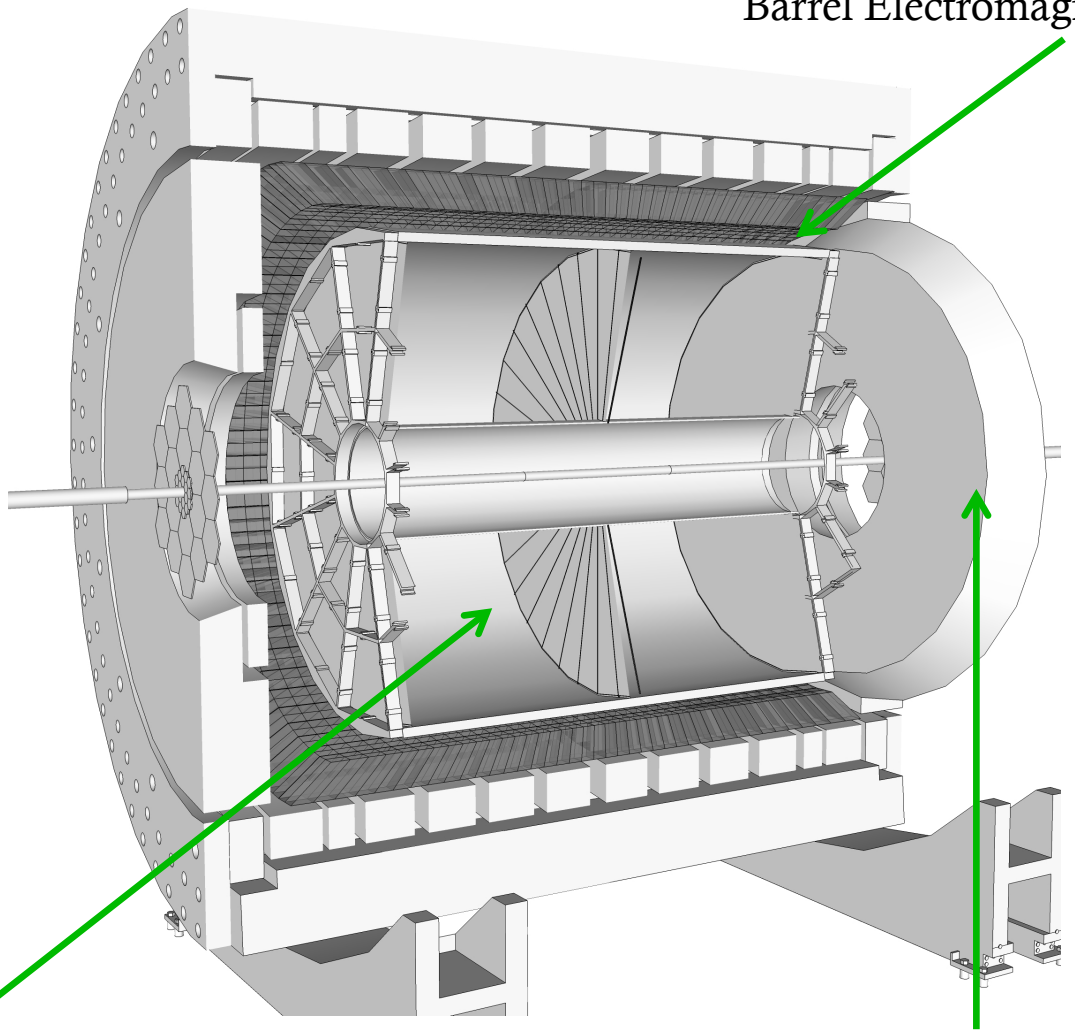
Jet p_T = 10 GeV → $x_T = 0.1$ ($\sqrt{s}$ = 200 GeV)
$x_T = 0.04$ ($\sqrt{s}$ = 500 GeV)

- Introduction and Motivation
- RHIC and STAR Detector
- Dijet Measurements at STAR
- Conclusion

Relativistic Heavy Ion Collider



Solenoidal Tracker At RHIC



- Introduction and Motivation
- RHIC and STAR Detector
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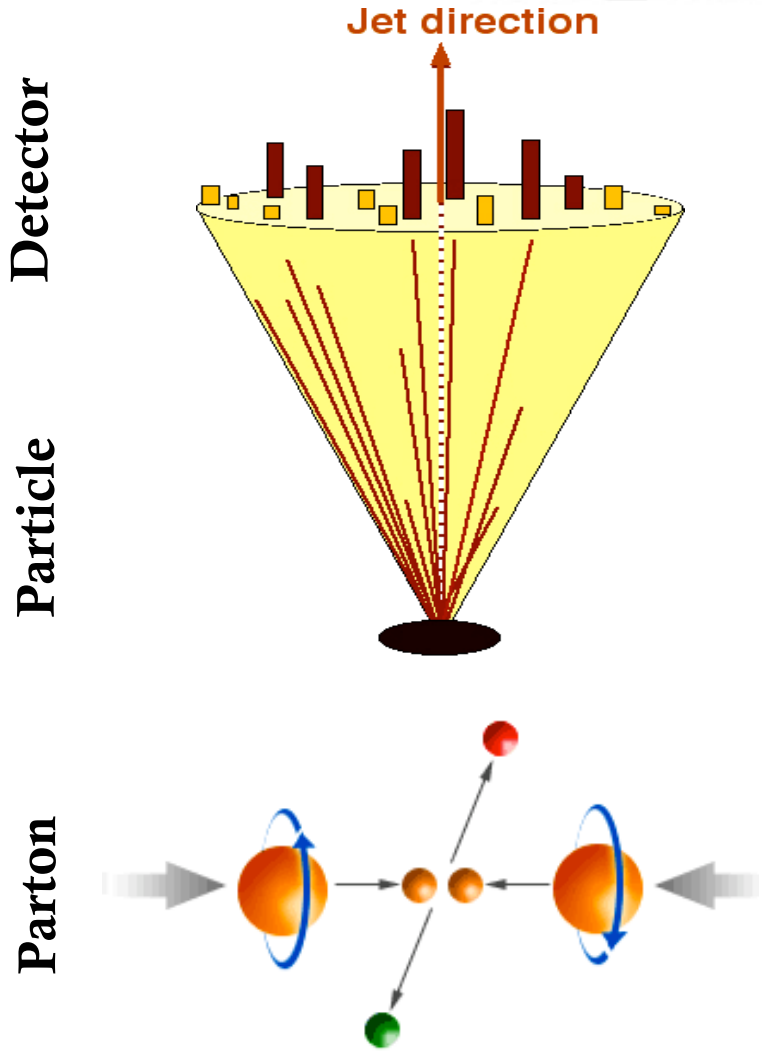
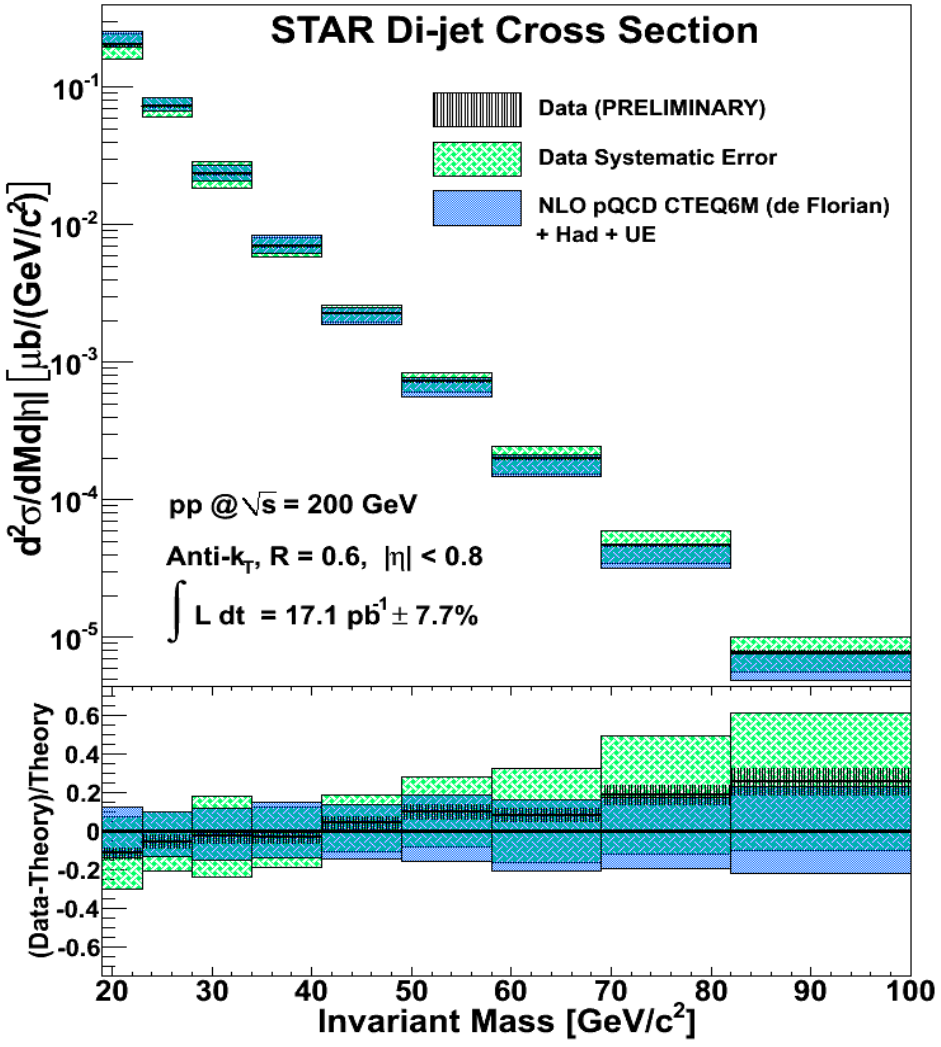
- Conclusion

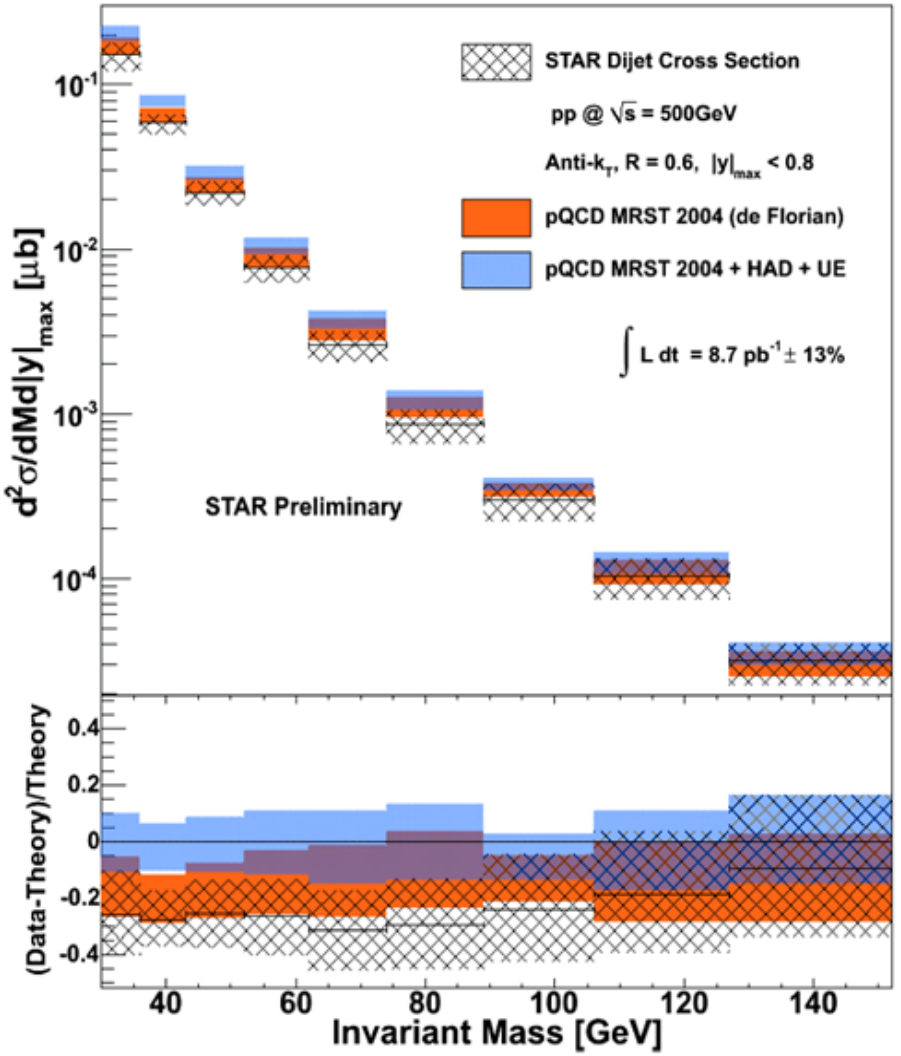
Jet Reconstruction at STAR



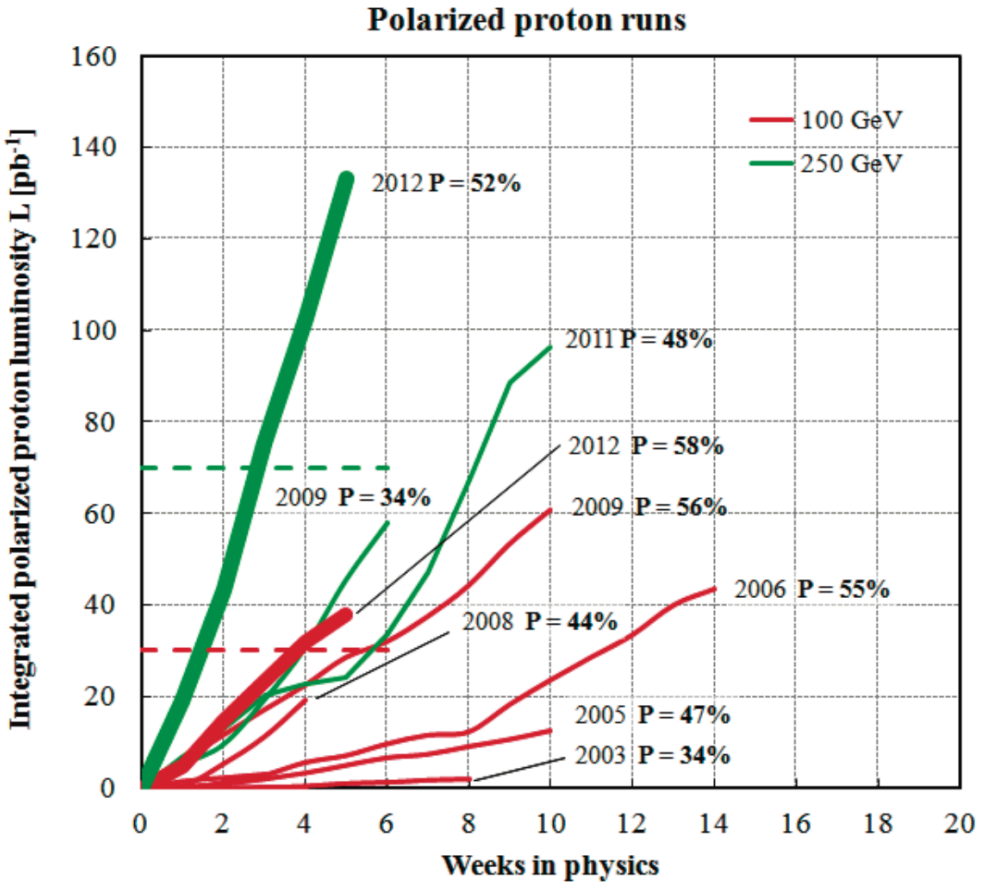
- Anti k_T algorithm *JHEP 0804 (2008) 063*
  - Sequential clustering algorithm
  - Infrared and collinear safe by design
- 2012 pp 510 GeV analysis
  - Anti k_T algorithm
  - R = 0.5
- Triggers used in this analysis:
  - Jet Patch Triggers: JP0, JP1, JP2

2009 Dijet Cross Section Results





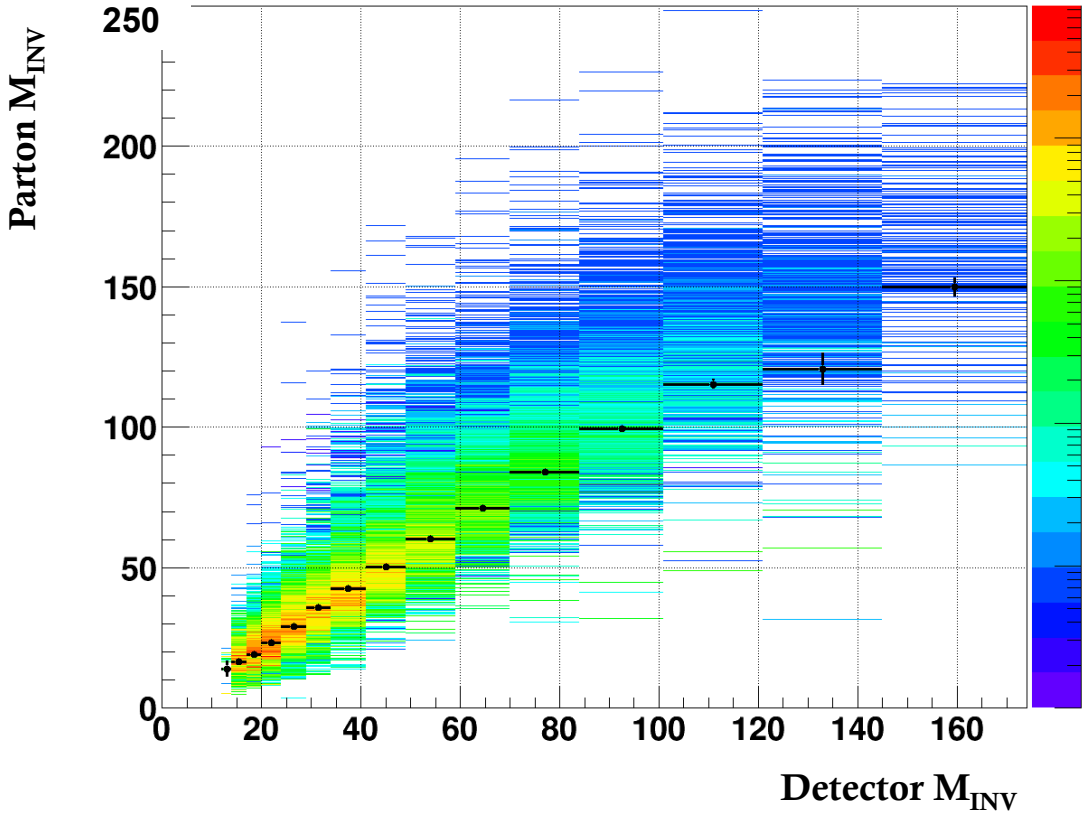
2012 pp 510 GeV Run



Analysis cuts

- Asymmetric p_T cut (8,6 GeV)
- Opening angle cut
- Geometric trigger condition (at least one jet)
- -0.8 >physics > 0.8
- $-0.7 > \eta_{\text{Detector}} > 0.9$
- Neutral Energy fraction, $R_T < 0.95$

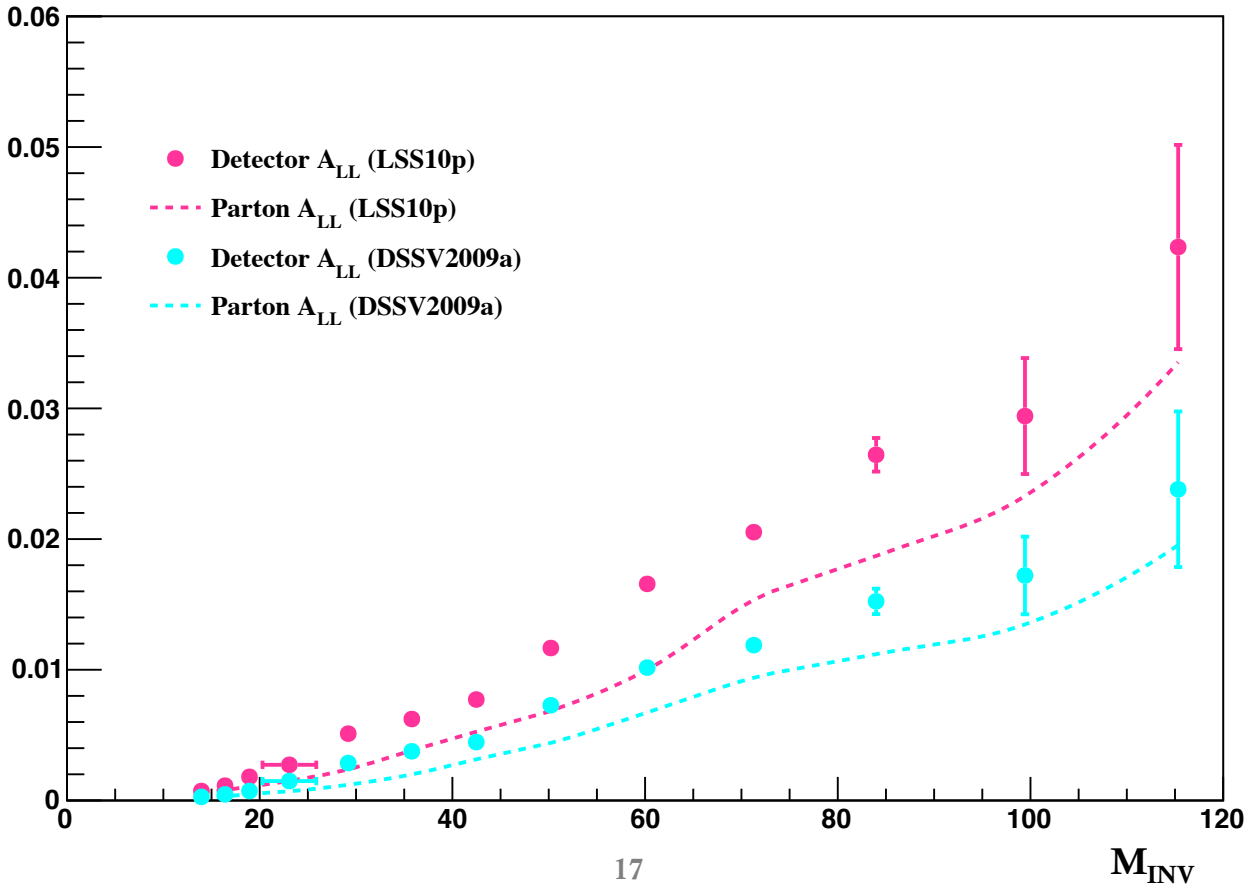
Jet Energy Scale corrections



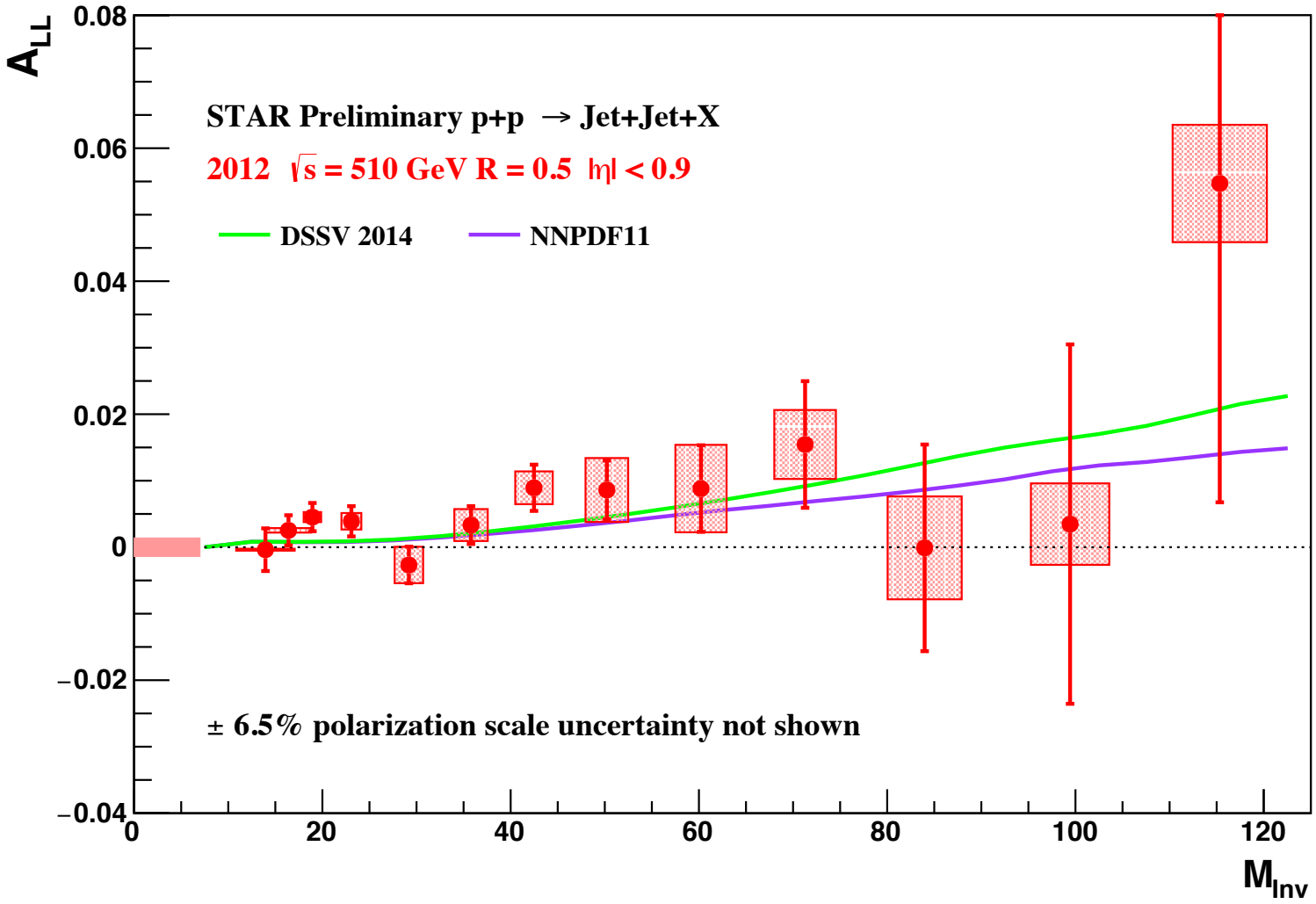
- The systematic error on the reconstructed dijet M_{INV} is due to the jet energy scale uncertainty
  - Includes contributions from BEMC calibration and tracking efficiency uncertainty.

Trigger Bias Studies

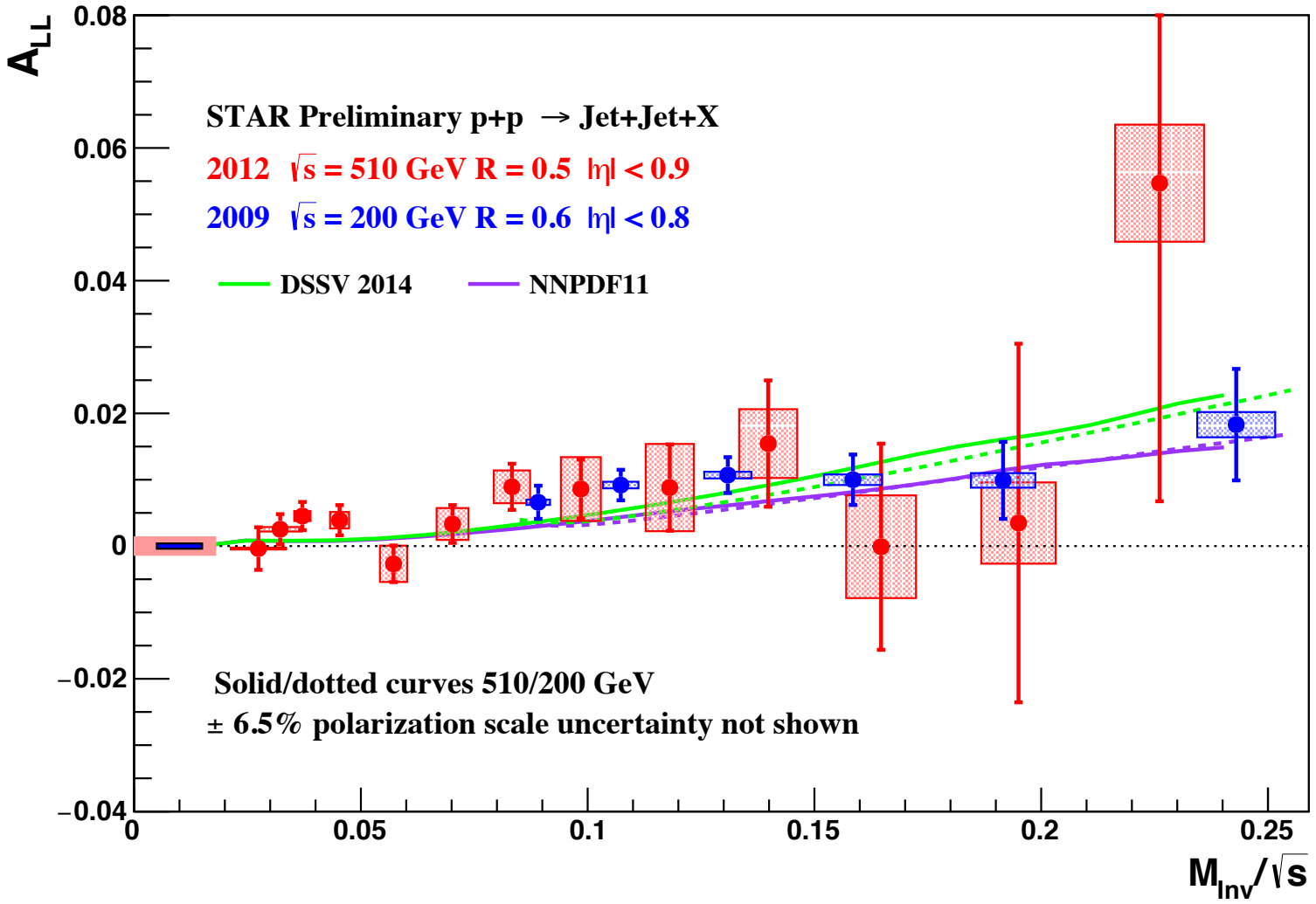
- The bias of the jet patch triggers towards a quark jet vs. a gluon jet
  - Sub-process fractions in the events are affected, and the "expected" asymmetry changes



Dijet A_{LL}


A_LL
0.08
0.06
0.04
0.02
0
−0.02
−0.04
0
20
40
60
80
100
120
M_Inv
STAR Preliminary p+p → Jet+Jet+X
2012 √s = 510 GeV R = 0.5 |η| < 0.9
DSSV 2014
NNPDF11
± 6.5% polarization scale uncertainty not shown

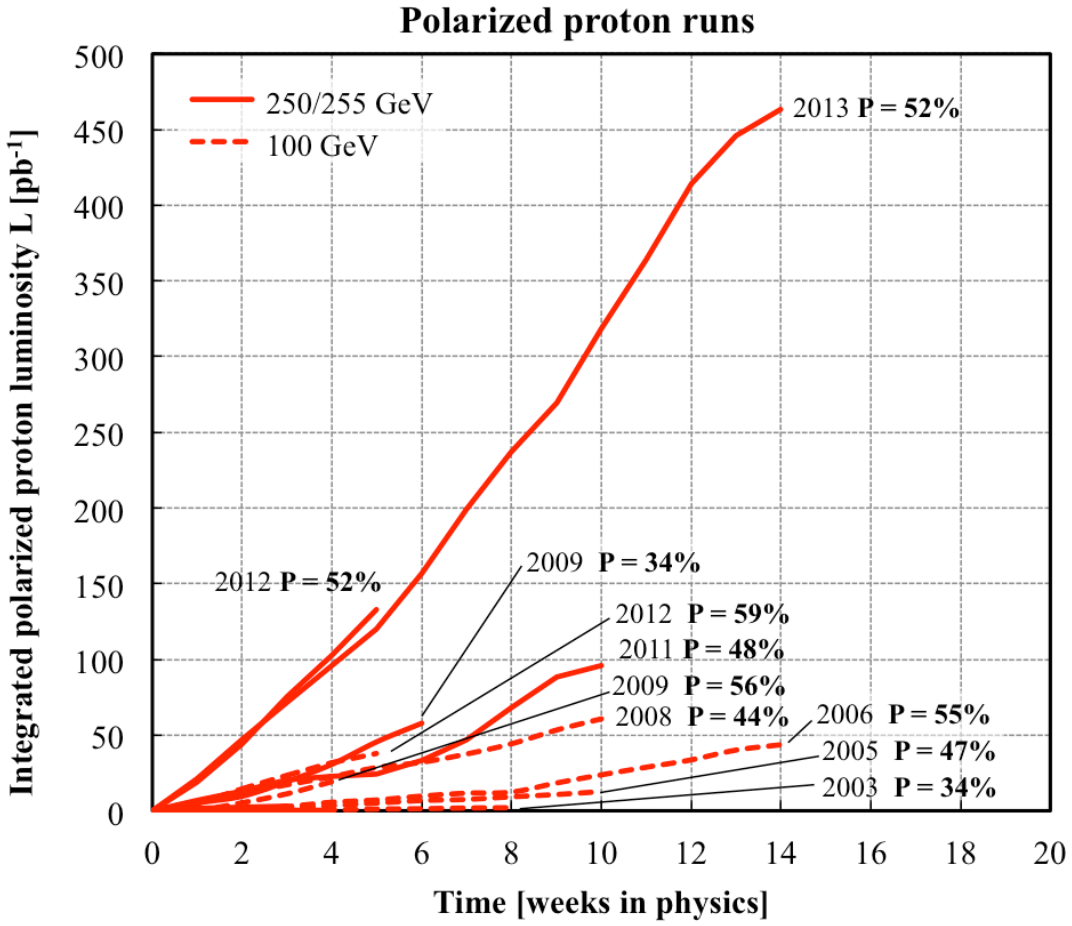
Dijet A_{LL}


A_LL
0.08
0.06
0.04
0.02
0
−0.02
−0.04
0
0.05
0.1
0.15
0.2
0.25
M_Inv/√s
STAR Preliminary p+p → Jet+Jet+X
2012 √s = 510 GeV R = 0.5 |η| < 0.9
2009 √s = 200 GeV R = 0.6 |η| < 0.8
DSSV 2014
NNPDF11
Solid/dotted curves 510/200 GeV
± 6.5% polarization scale uncertainty not shown

Conclusion

- RHIC's highly polarized proton beams have facilitated a robust spin program at STAR. The wide acceptance of the STAR detector is well suited for jet reconstruction.
- STAR inclusive jet measurements at $\sqrt{s}$ = 200 GeV have provided the first evidence of a significant polarized gluon distribution for $x > 0.05$
- By extending these measurements to higher $\sqrt{s}$, it is possible to constrain the $x < 0.05$ region. Dijet observables allow for reconstruction of the partonic kinematics at leading order.
- This contribution, which represents the first Dijet A_{LL} measurement at $\sqrt{s}$ = 510 GeV, agrees well with previous measurements at 200 GeV and theoretical NLO calculations.
- In 2013 STAR collected 3 times more data, of longitudinally polarized proton collisions at $\sqrt{s}$ = 510 GeV.

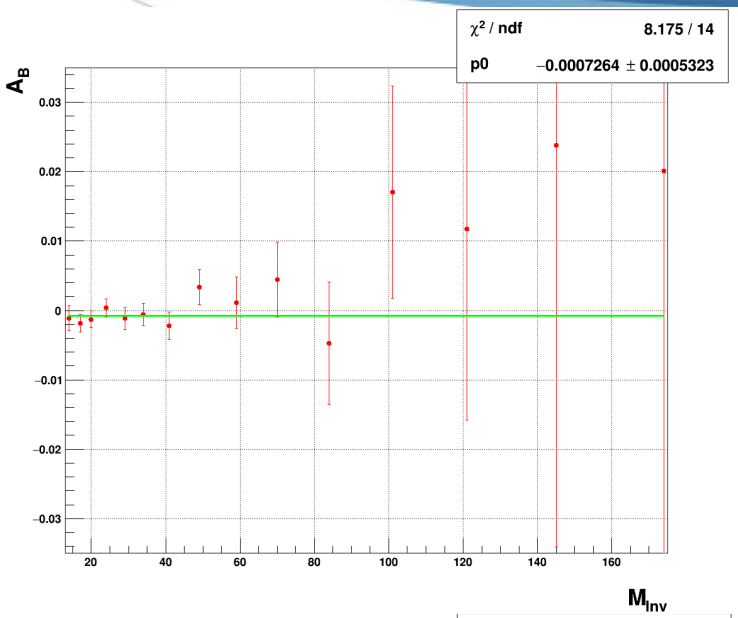
Stay Tuned!

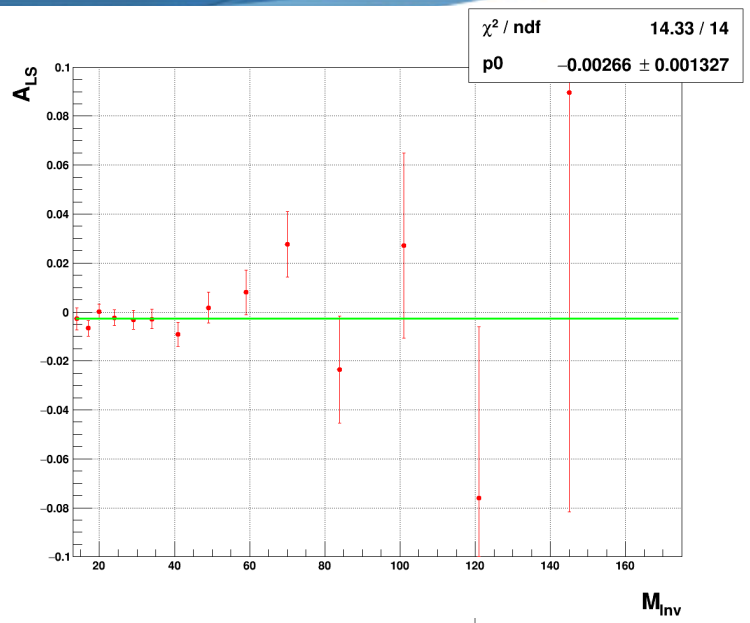


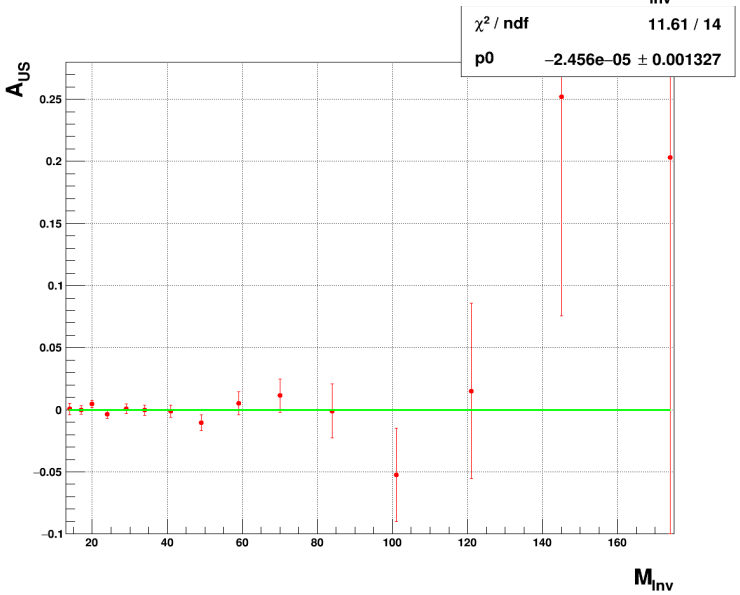
Thank You

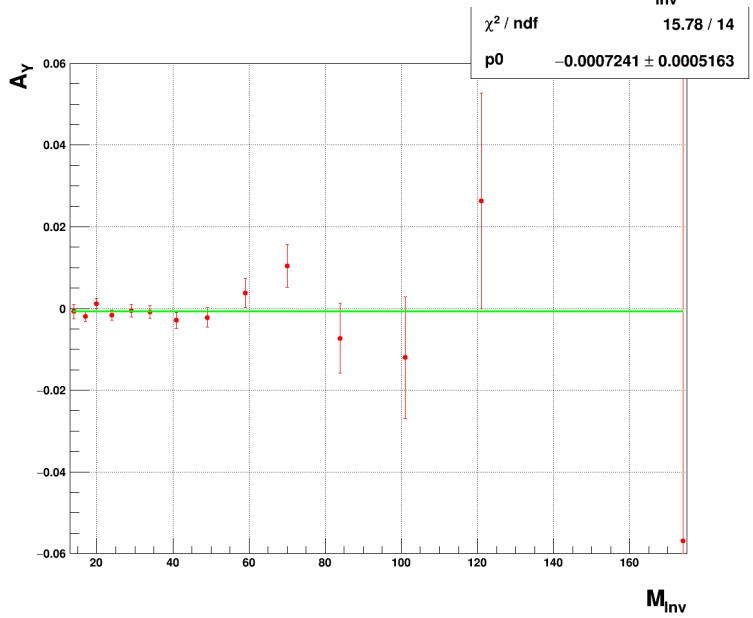
Back Up

False Asymmetries









Systematic Errors - Summary

Invariant Mass		Systematics	
Bin	Corrected	Trigger Bias	Jet Energy Scale
12-14	13.95	0.000143	3.1073
14-17	16.4	0.000338	2.4237
17-20	18.94	0.000755	0.9289
20-24	23.08	0.001240	1.0557
24-29	29.19	0.002736	1.5124
29-34	35.79	0.0024	1.7749
34-41	42.48	0.002466	1.9916
41-49	50.22	0.004806	2.2652
49-59	60.22	0.006574	2.7202
59-70	71.28	0.005186	3.2722
70-84	83.98	0.00774	3.9340
84-101	99.43	0.006125	4.1615
101-121	115.33	0.008823	5.0057

- Systematic error due to R3 uncertainty ~ 0.0004
- Residual Transverse Polarization – negligible
- Non collision background – negligible