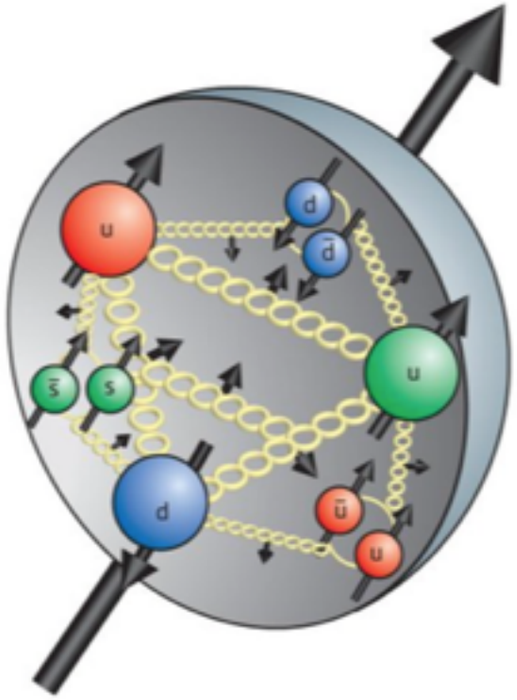
Stony Brook University

PHENIX

Direct Photon Production and Gluon Polarization Measurements in Proton-Proton Collisions at PHENIX



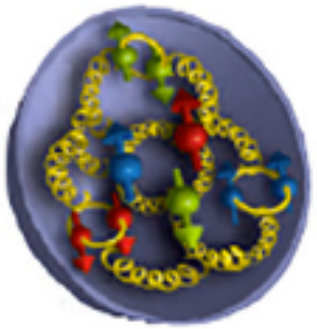
Nils Feege for the
PHENIX Collaboration

How does QCD give rise to the overall nucleon spin?

½ =

→ ~ 30%

+



→

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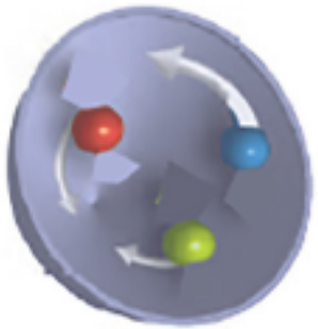
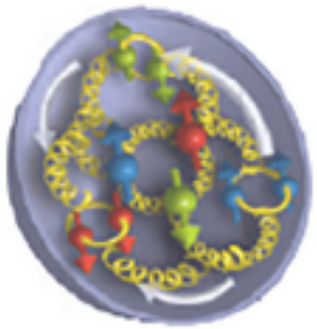
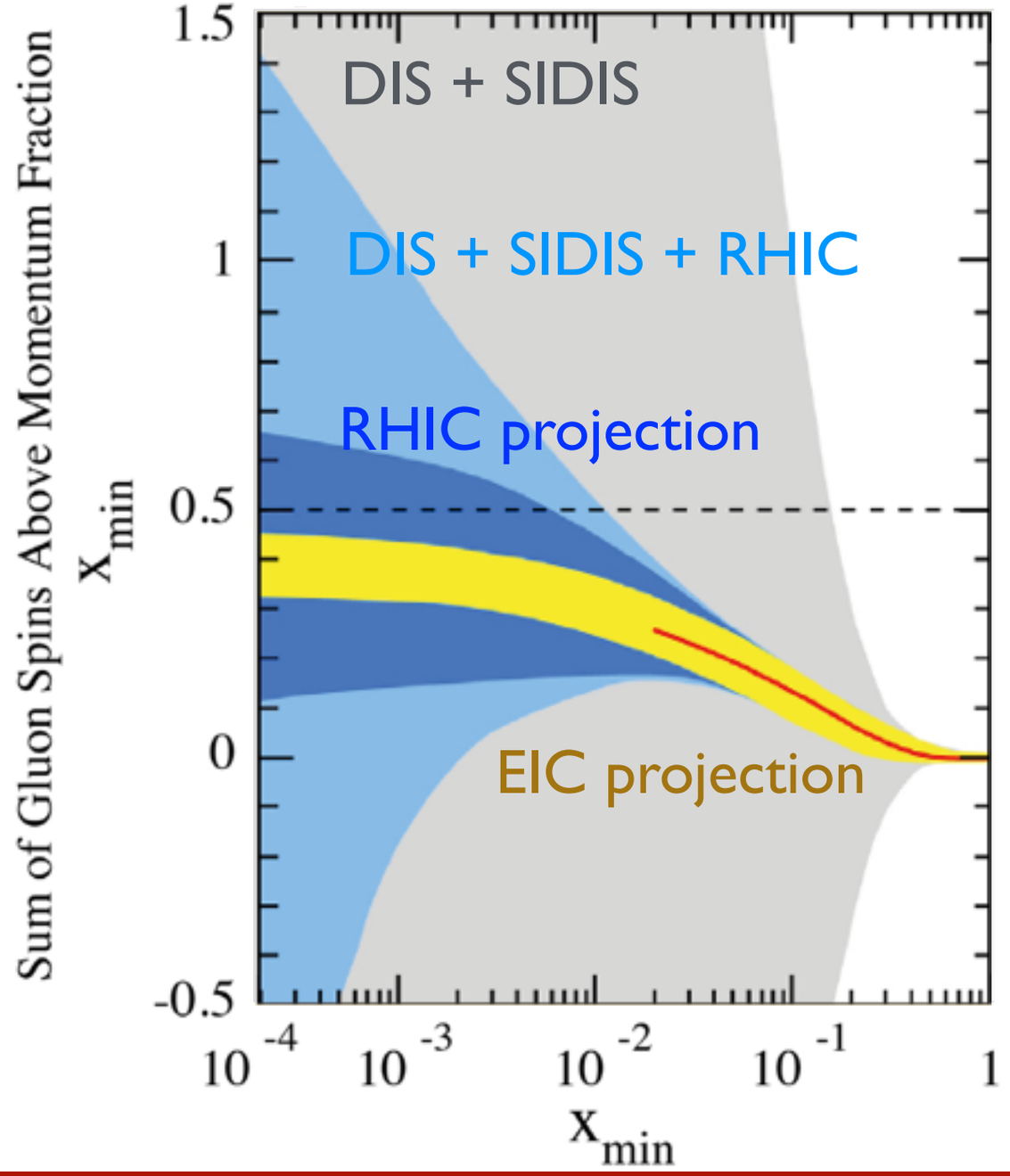
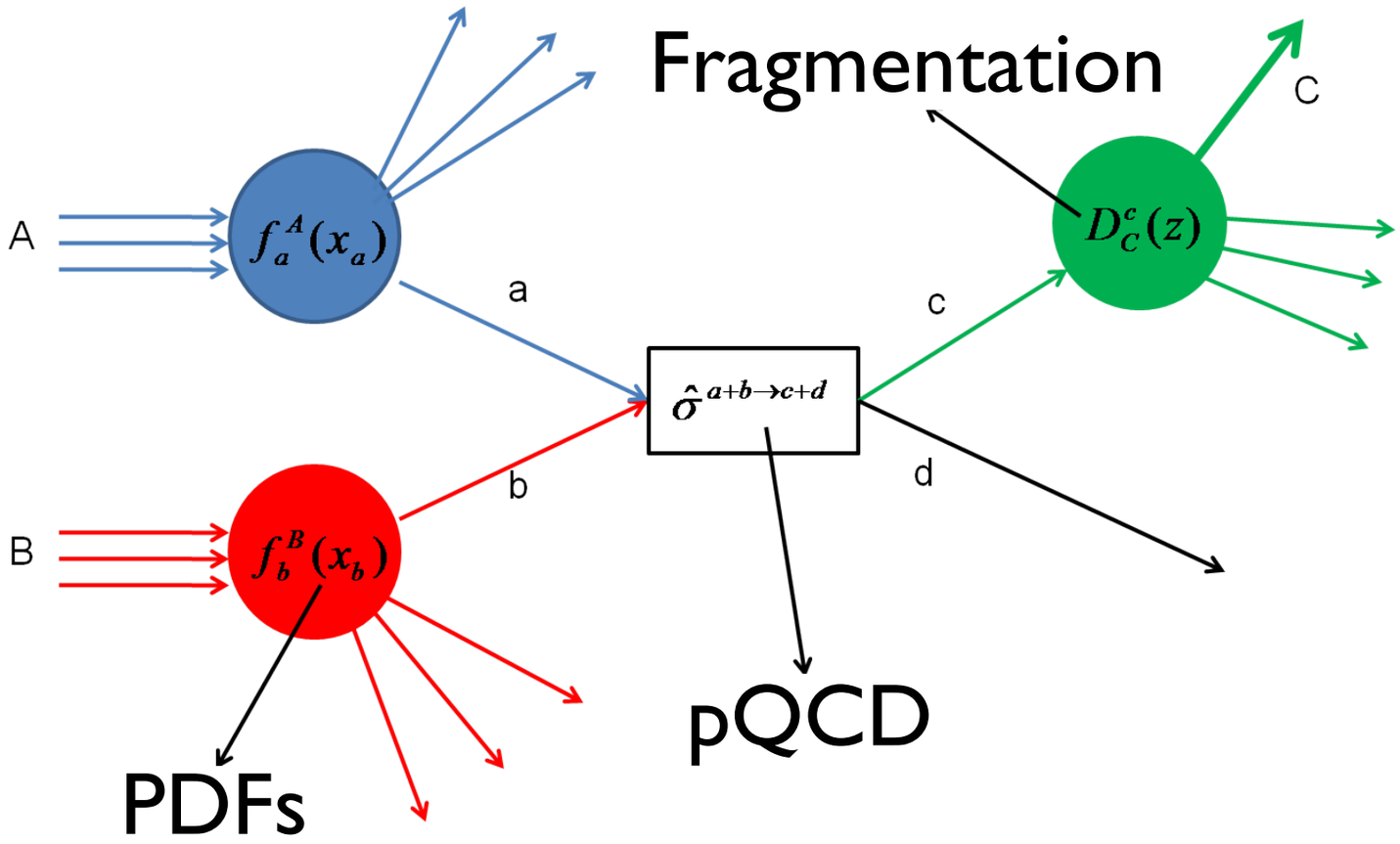
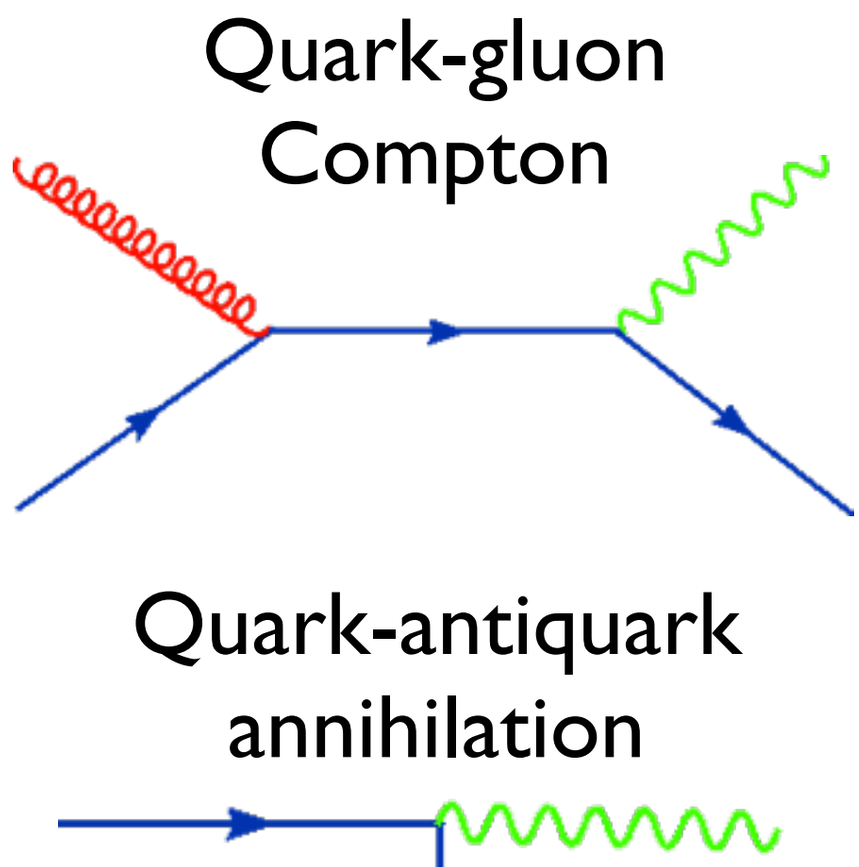






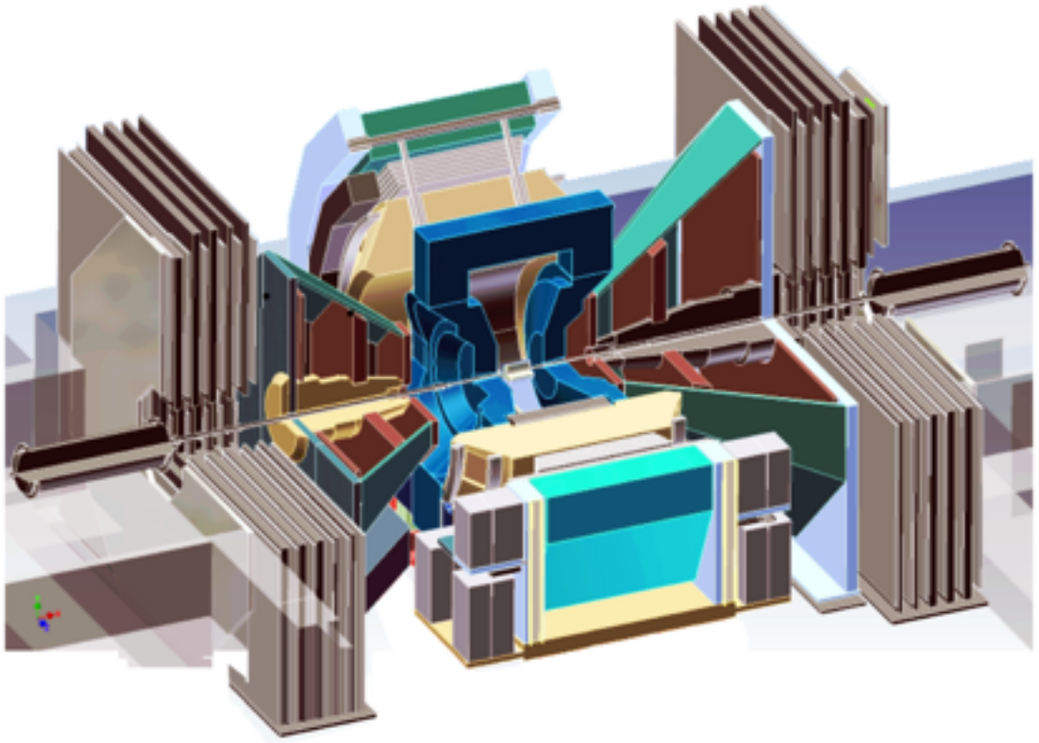
Probing the gluon polarization in protons with direct photons

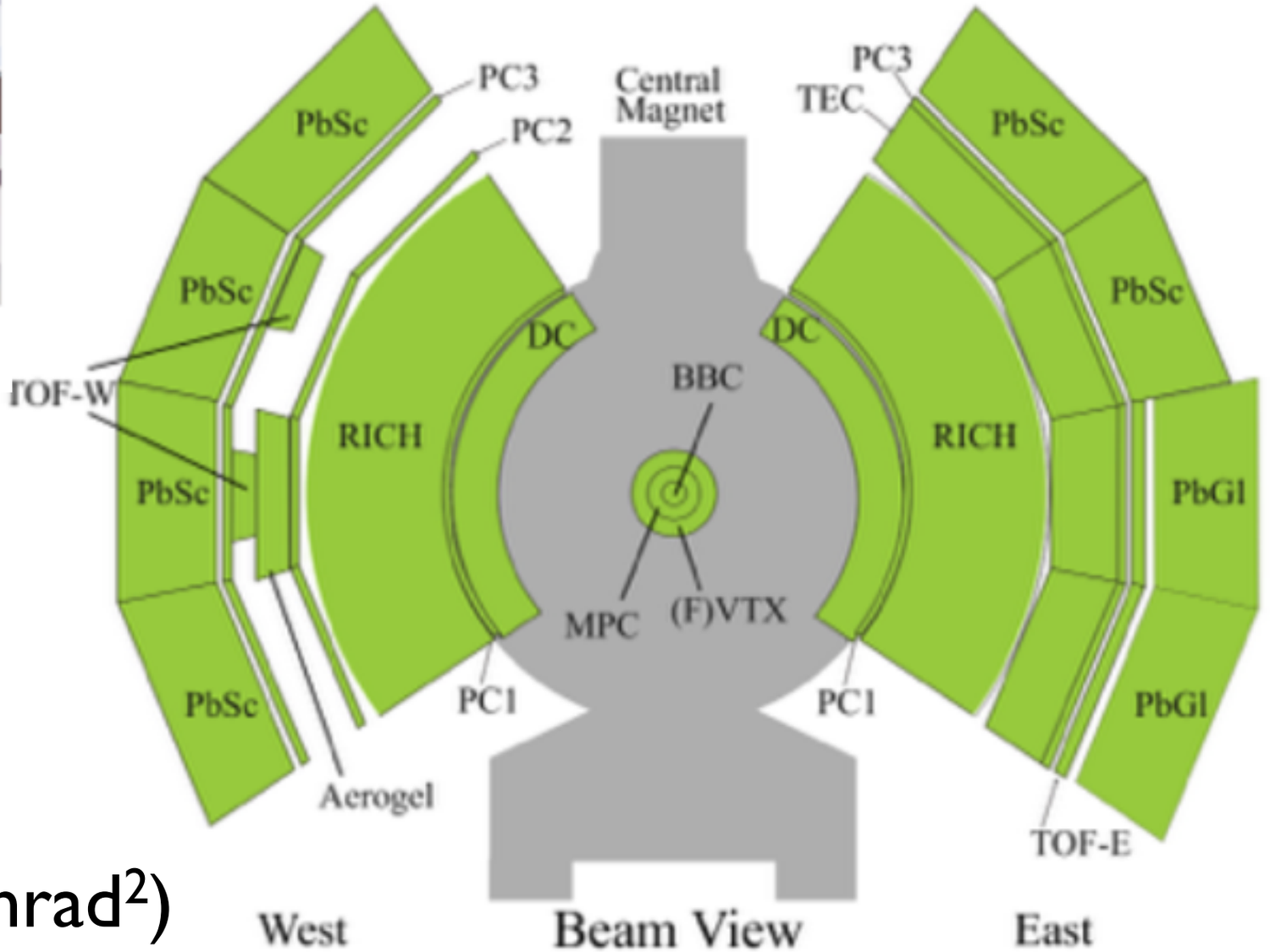




- No fragmentation ($D_c^h(z) = 1$)
- No final state color interaction
- Double spin asymmetry is linear in ΔG

The PHENIX experiment at RHIC





PbSc / PbGl Calorimeter:

- High p_T trigger
- $\sigma_E \approx 8\%/\sqrt{E}$
- Acceptance: $|\eta|<0.35$
- High granularity (10*10 mrad^2)

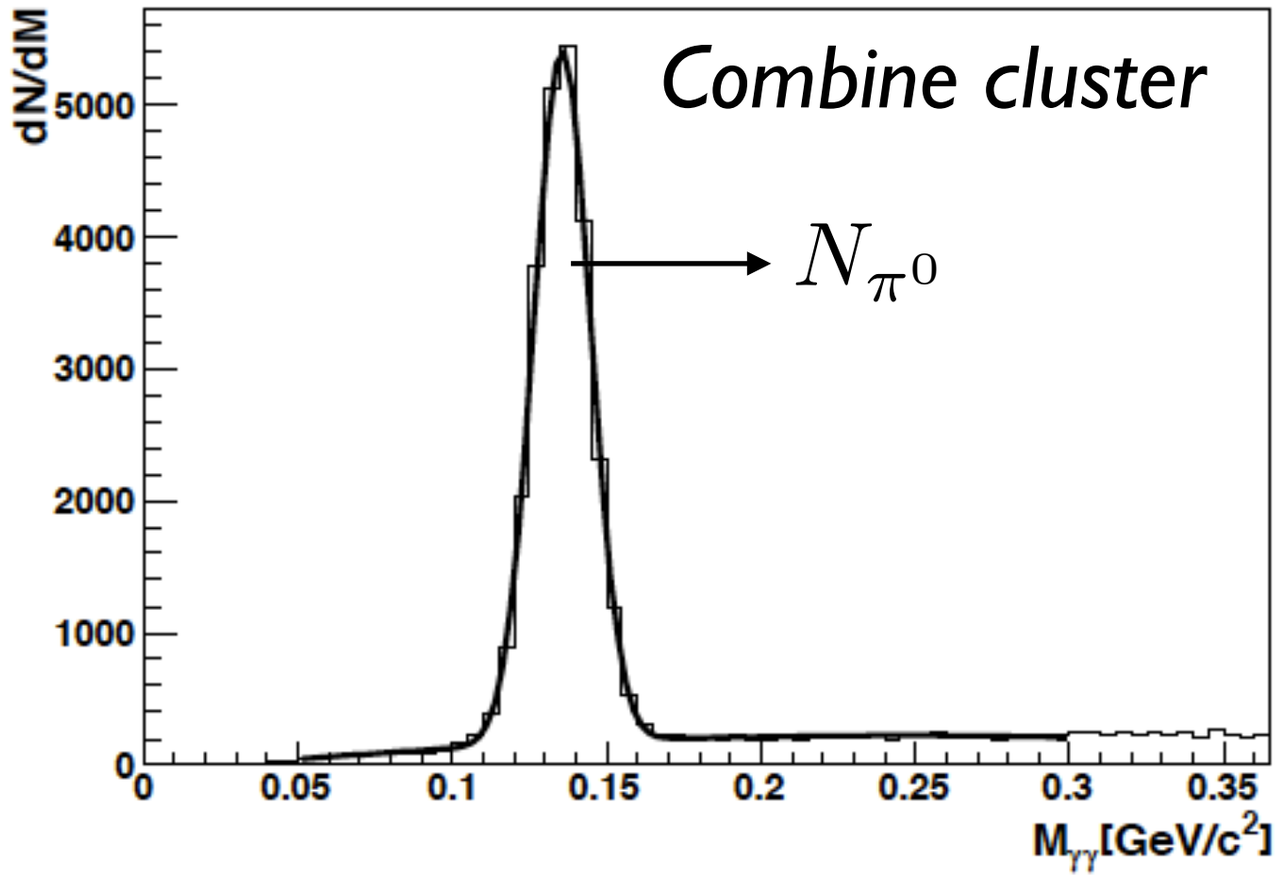
Counting direct photons

EMCal cluster
(pT > 5 GeV, TOF cut)

No charged track pointing to cluster

Shower shape agrees with single EM shower

N_{incl}

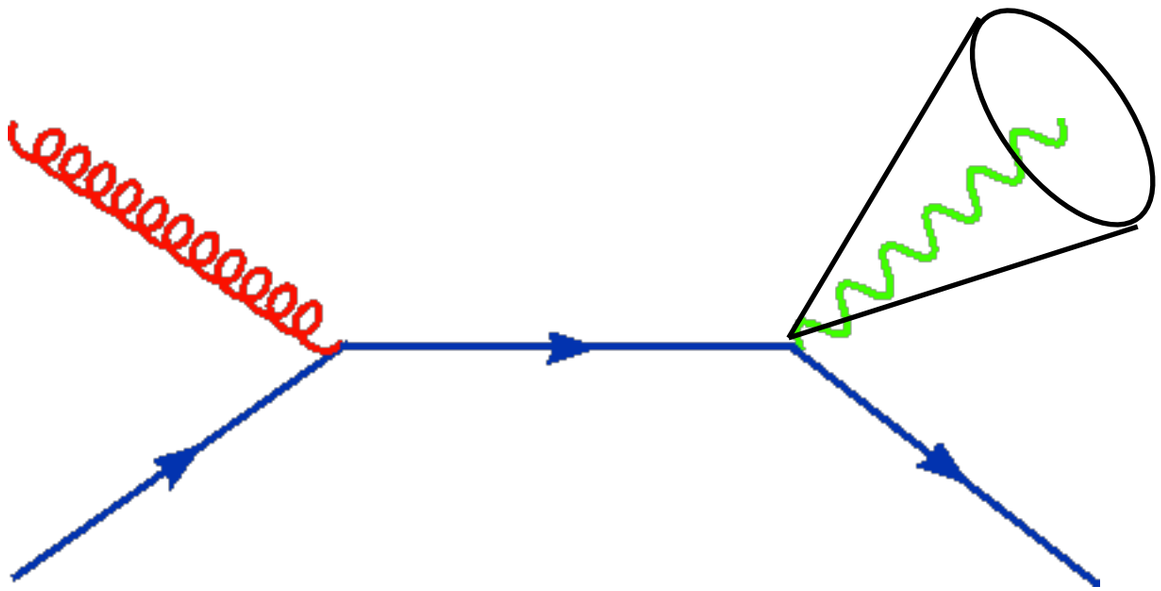


R: π^0 miss ratio (simulation)

A: heavier mesons / π^0 (branching ratios)

$$N_{dir\gamma} = N_{incl} - (1+R)(1+A)N_{\pi^0}$$

Improving the purity of the direct photon sample with an isolation cut



r = 0.5 rad

Requirement:

$$0.1 * E_{\gamma} > \sum E_{Neutral} + \sum P_{Charged}$$

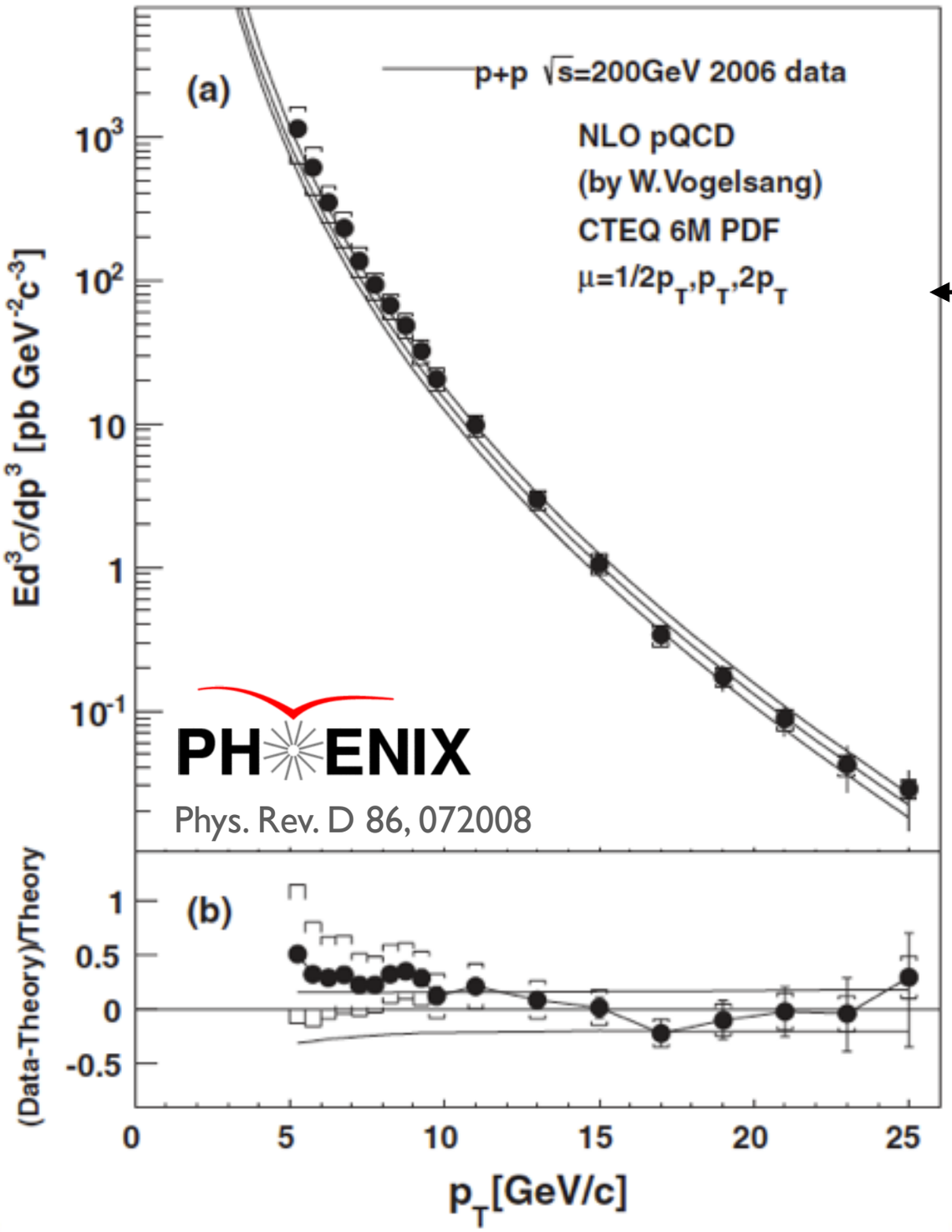
$n_{\pi^0}^{iso}$: asymmetric π^0 decays (check for partner photons)

$N_{\pi^0}^{Iso}$: isolated π^0s

A^{Iso} : heavy meson / π^0

$$N_{\mathrm{dir}}^{\mathrm{iso}} = N_{\mathrm{incl}}^{\mathrm{iso}} - (n_{\pi^0}^{\mathrm{iso}} + N_{\pi^0}^{\mathrm{iso}} R) - A^{\mathrm{iso}}(1+R)N_{\pi^0}^{\mathrm{iso}}$$

Does pQCD apply to our data?



Check: Cross section

$$E\frac{d^3\sigma}{dp^3} = \frac{1}{\mathcal{L}}\frac{1}{2\pi p_T}\frac{N_{\rm dir}}{\Delta p_T \Delta y}\frac{1}{\epsilon}\frac{1}{\epsilon_{bias}}$$

NLO pQCD calculations are consistent with data at $\sqrt{s} = 200GeV$

Ongoing: extension to $\sqrt{s} = 510GeV$

Preliminary A_{LL} results

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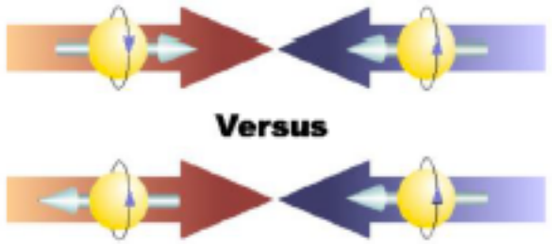
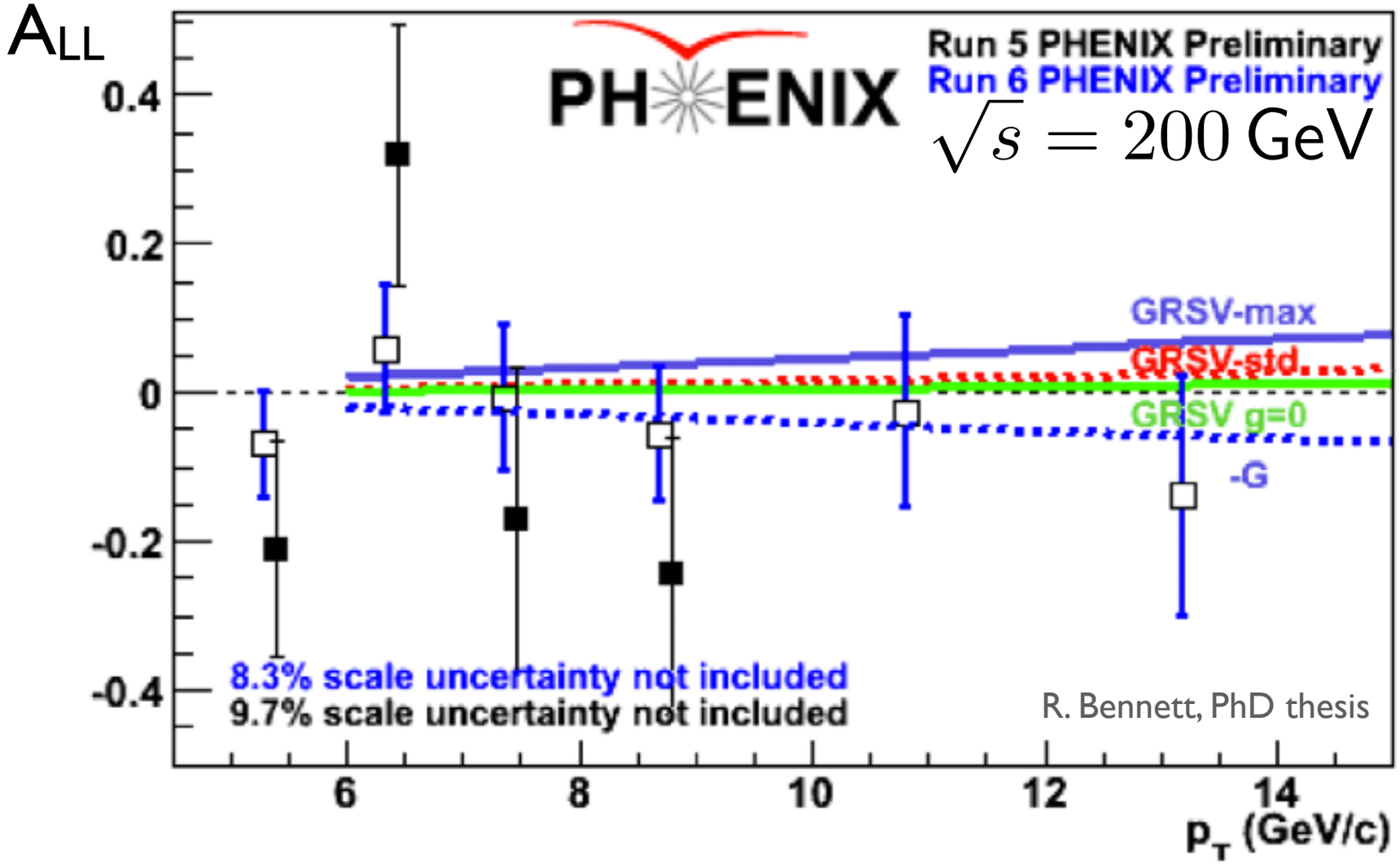


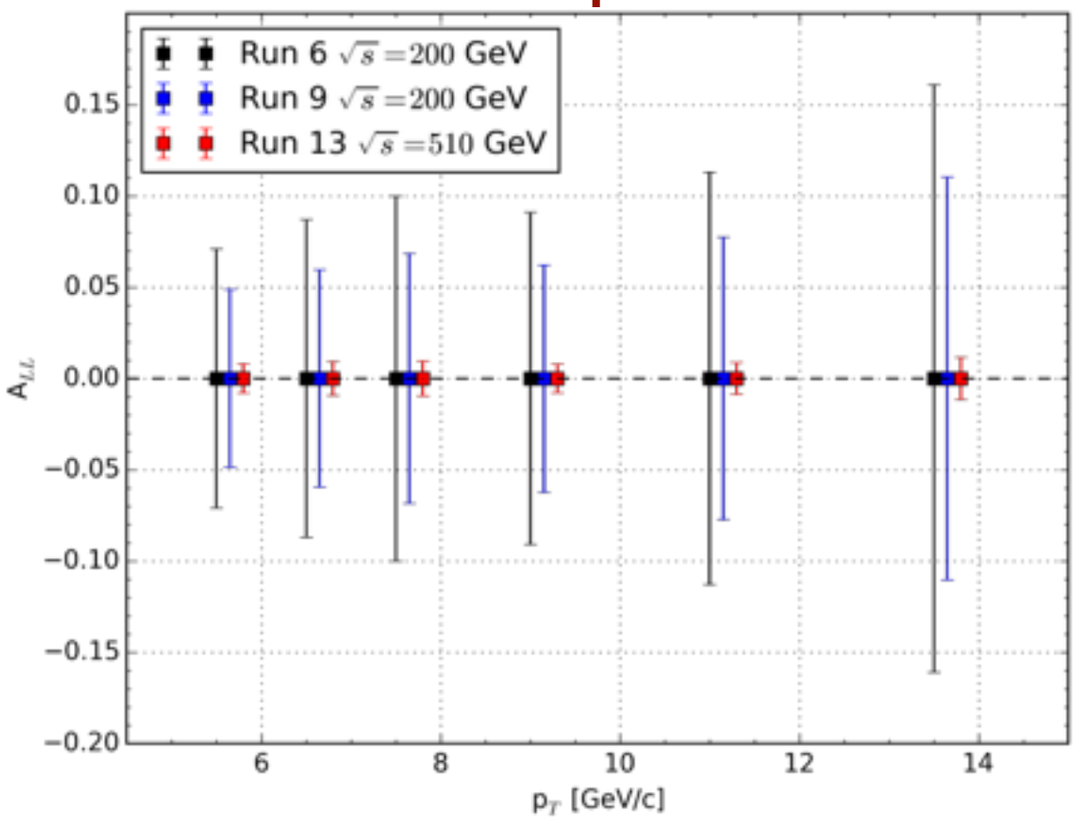
+-

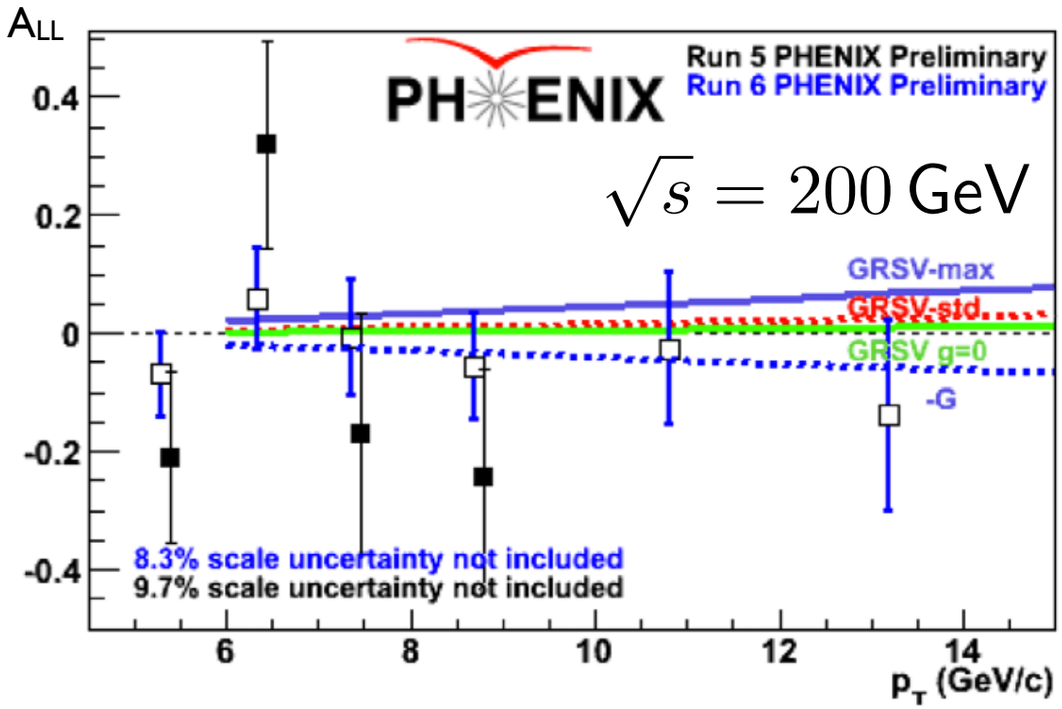
$$A_{LL} = \frac{1}{P_Y P_B} \frac{N^{++} - R N^{+-}}{N^{++} + R N^{+-}} \qquad R = \frac{L_{++}}{L_{+-}}$$



Future prospects of analyzing A_{LL}

Use more data:
Reduce uncertainties

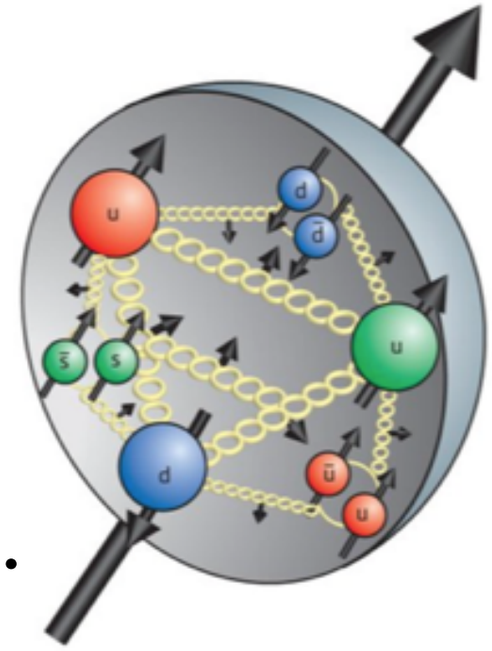




Data at $\sqrt{s} = 510$ GeV:
Access lower x

Improve constraints of Gluon Polarization in global fits

Summary



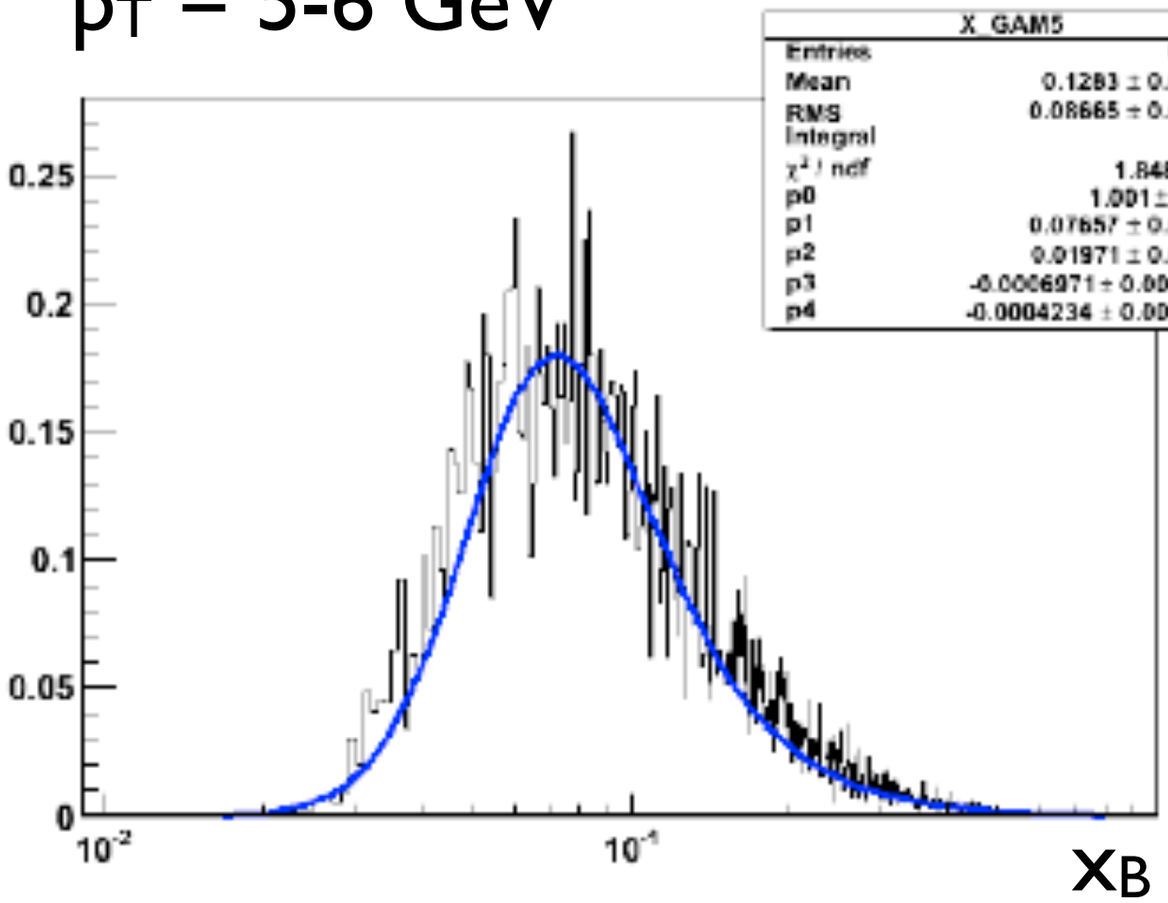
- Direct photons are the 'golden channel' to measure gluon polarization in polarized pp collisions at RHIC.
- Including more recorded data will considerably improve previous PHENIX results for A_{LL} measurement.
- The data recorded at 500 GeV will extend the lower limit of the probed x range.

Direct photon measurements will bring us closer to solving the nucleon spin puzzle.

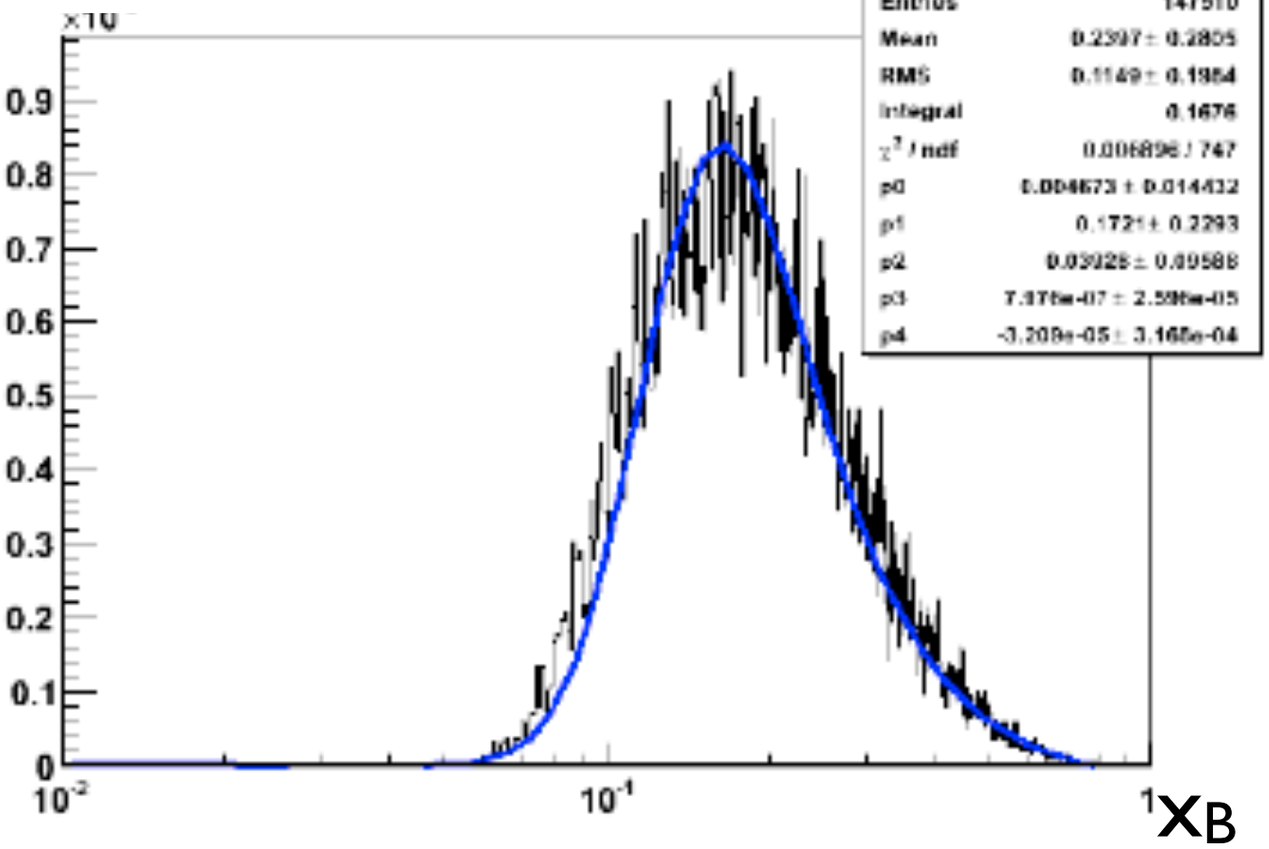
ADDITIONAL SLIDES

Accessed Bjorken-x range

p_T = 5-6 GeV



p_T = 12-15 GeV



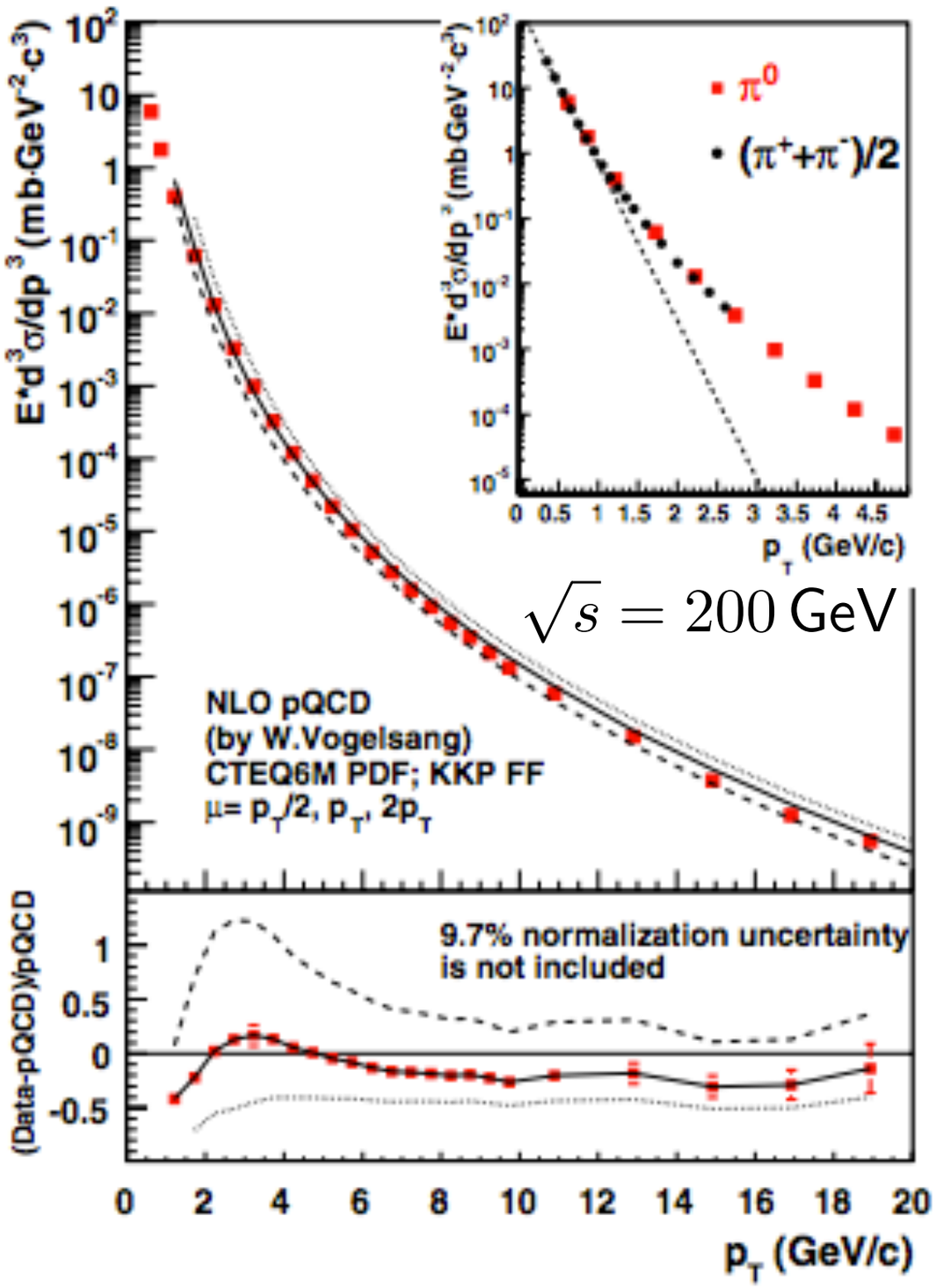
PHENIX Recored Luminosity

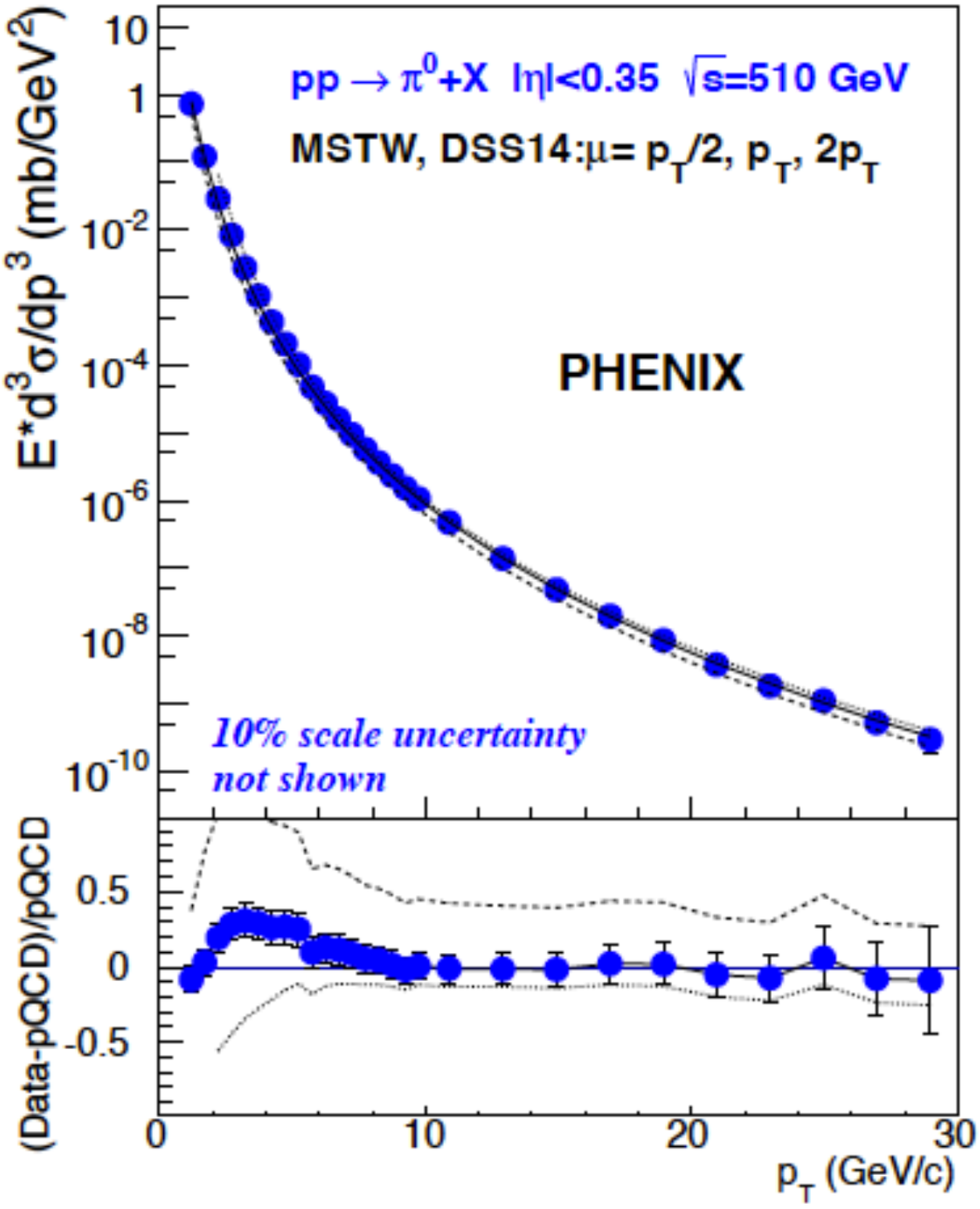
Year	$\sqrt{s}$ (GeV)	Recorded Luminosity for longitudinally polarized $p+p$ STAR	Recorded Luminosity for longitudinally polarized $p+p$ PHENIX	<P> in %
2006	62.4	-- pb^{-1}	0.08 pb^{-1}	48
	200	6.8 pb^{-1}	7.5 pb^{-1}	57
2009	200	25 pb^{-1}	16 pb^{-1}	55
	500	10 pb^{-1}	14 pb^{-1}	39
2011	500	12 pb^{-1}	18 pb^{-1}	48
2012	510	82 pb^{-1}	32 pb^{-1}	50/53
2013	510	300 pb^{-1}	155 pb^{-1}	50/53
2015	200	50 pb^{-1}	--	60

Table 3-1: Recorded luminosities for collisions of longitudinally polarized proton beams at the indicated center-of-mass energies for past RHIC runs since 2006. The PHENIX numbers are for |vtx| < 30cm. The bottom row reflects the STAR and PHENIX beam use request for 2015.

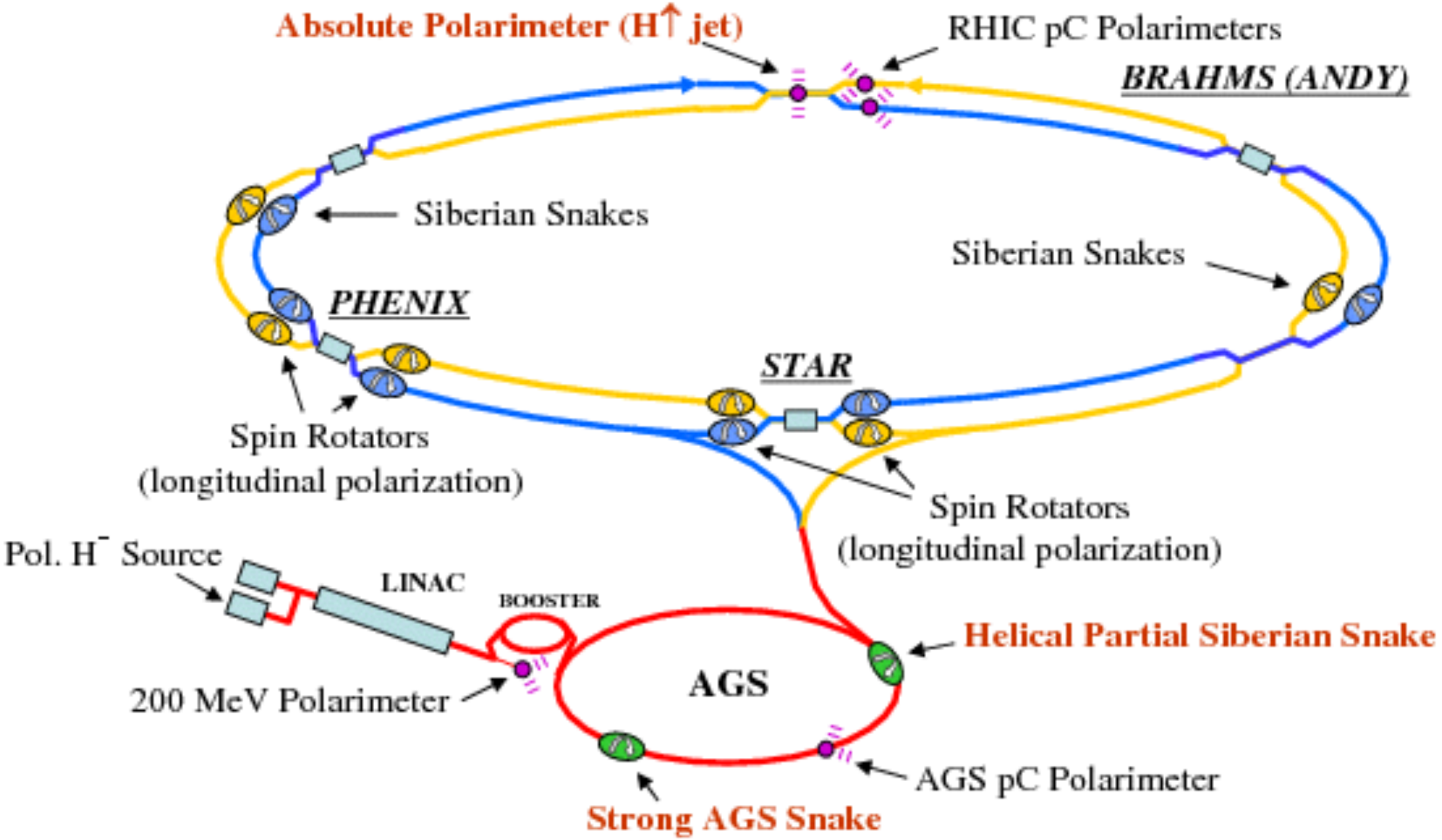
The RHIC Spin Program: Achievements and Opportunities (1/2015)

PHENIX π^0 Cross Section

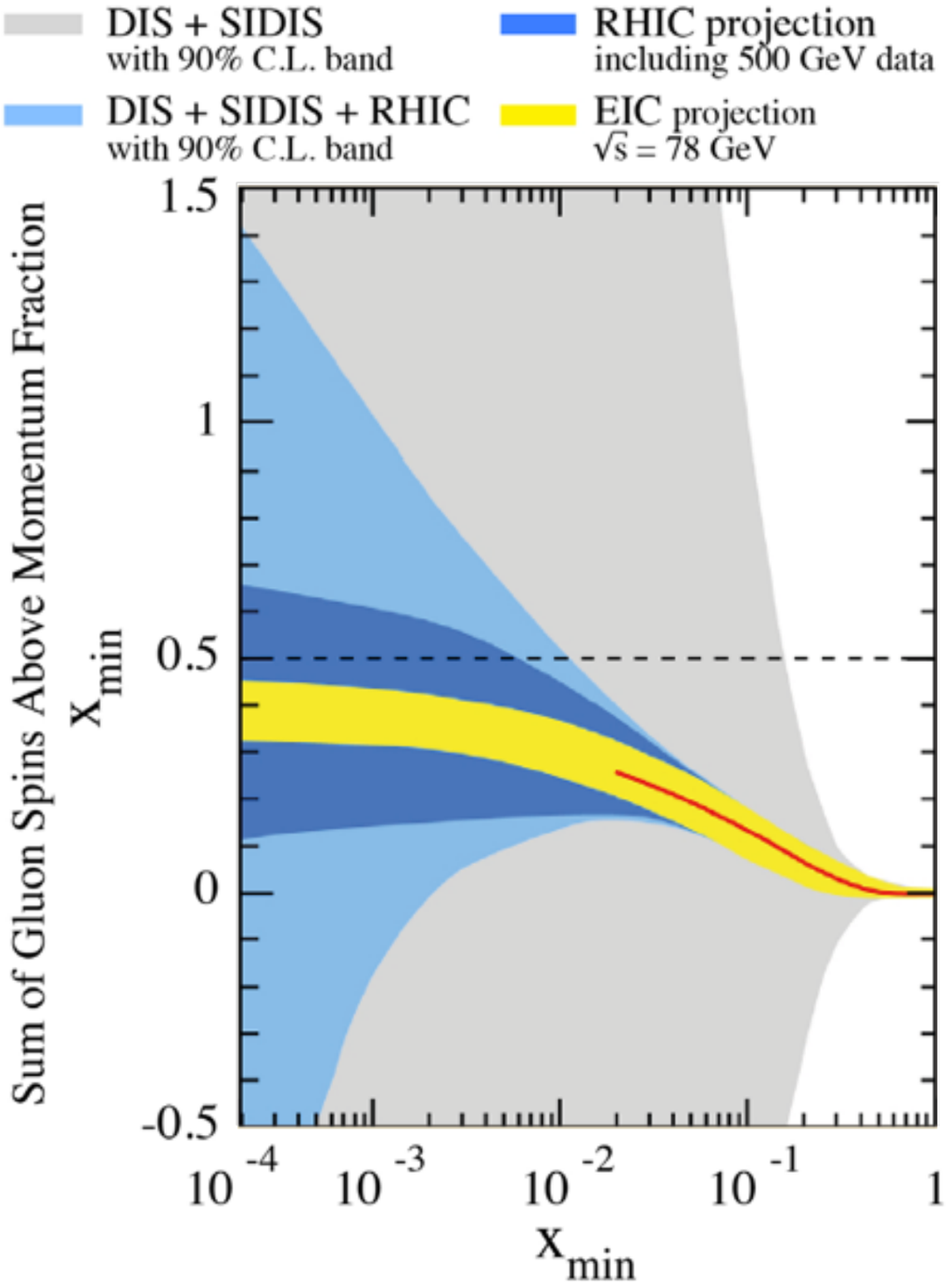


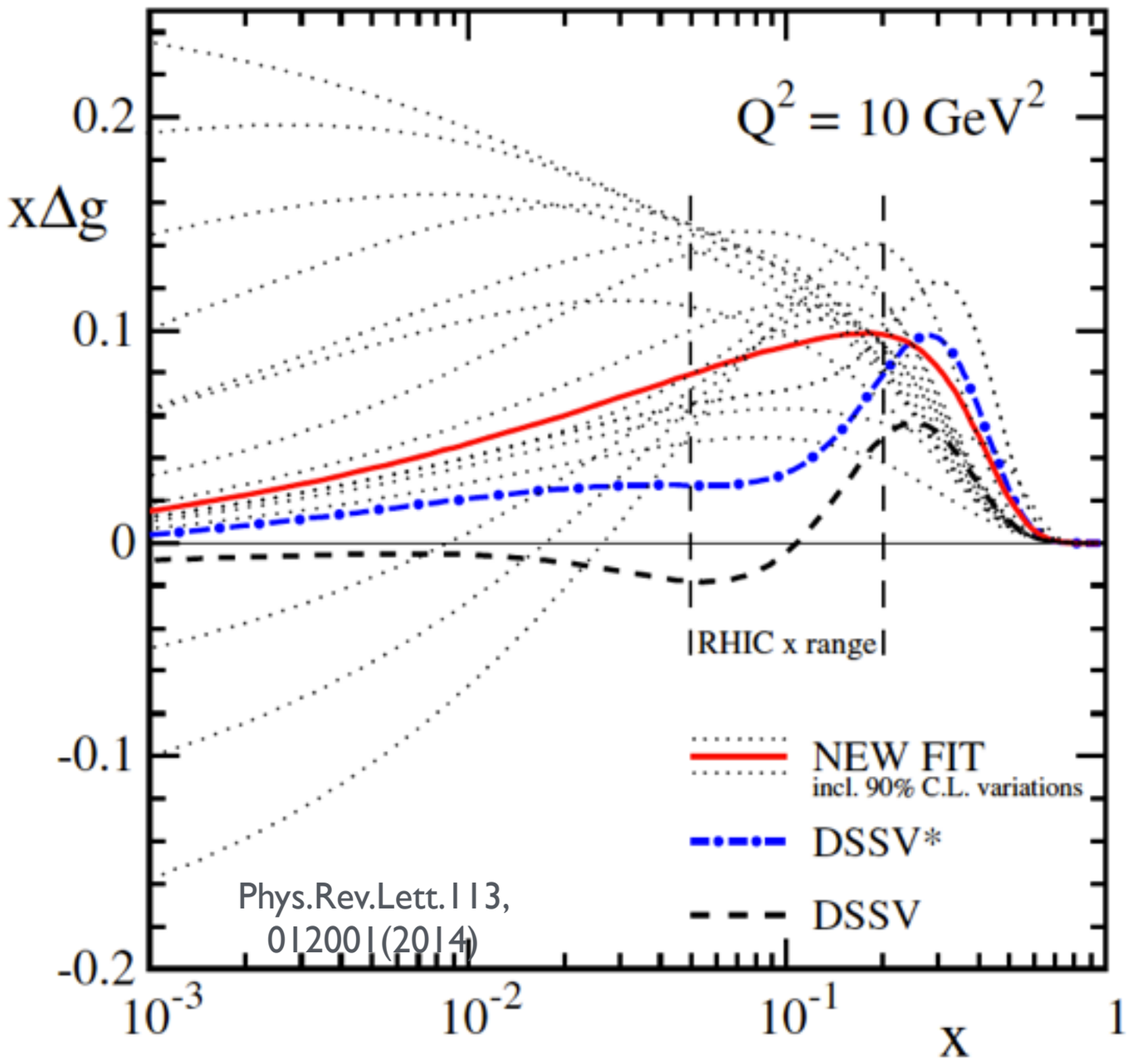


The Relativistic Heavy Ion Collider



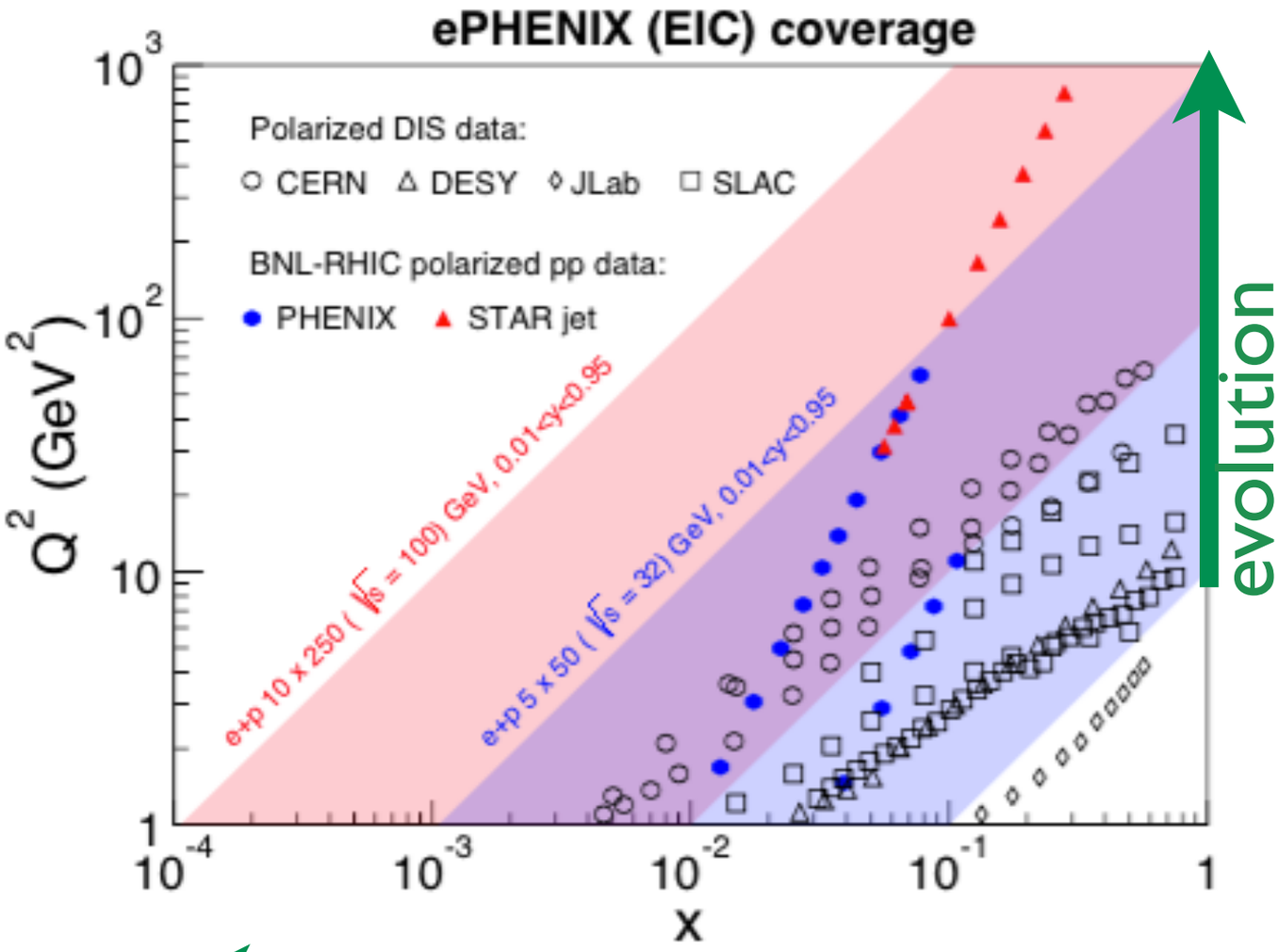
Our current knowledge about ΔG





Proton Spin Structure at the EIC

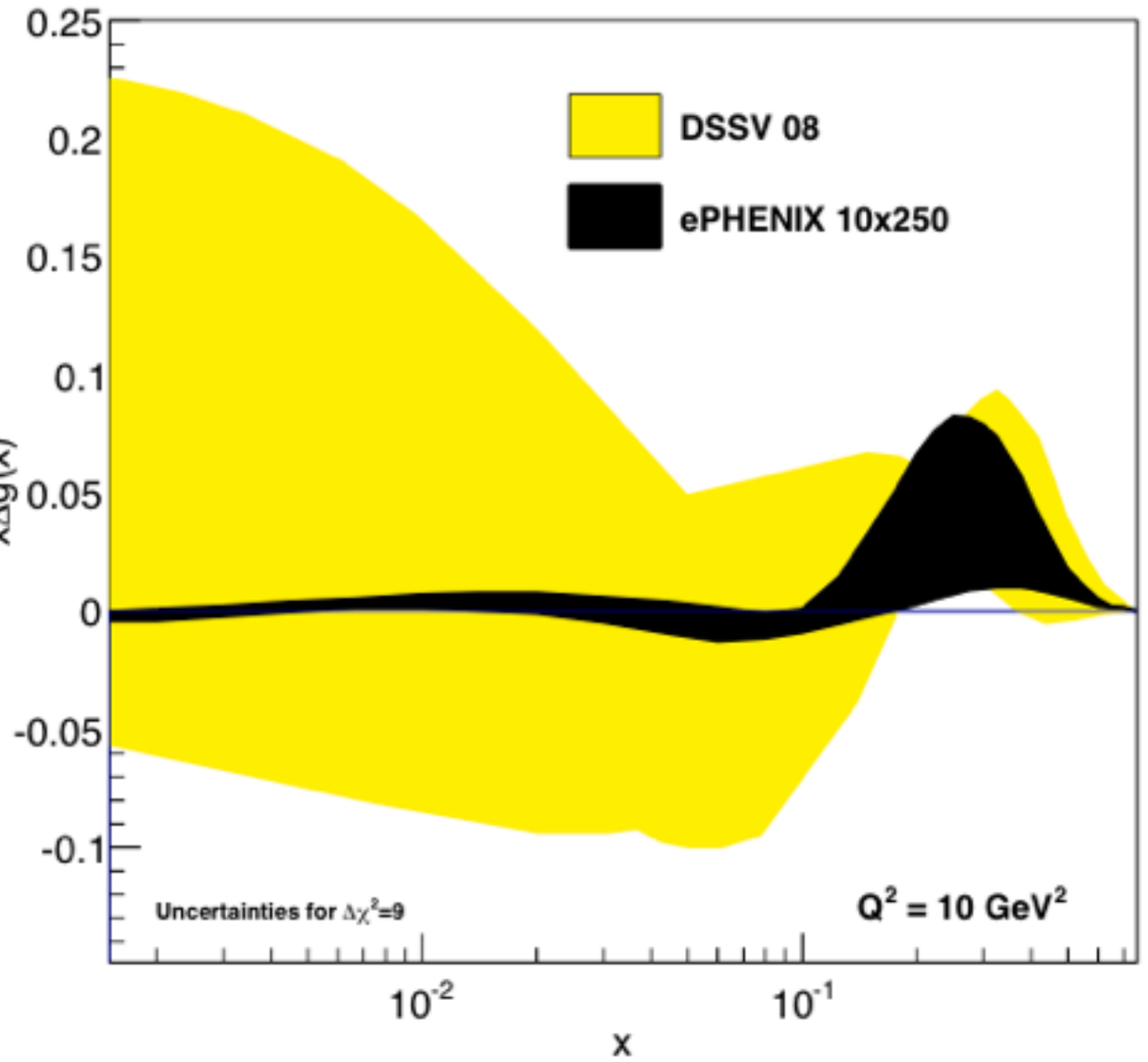
$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + L_q + \Delta G + L_g$$



valence to low-x physics

PHYTHIA generator and ePHENIX acceptance/efficiencies

10 fb^{-1} at 10GeV×250GeV



arXiv:1402.1209v1