

Introduction

oo
oo

The high p_T asymmetry

ooo

The PYTHIA simulation

ooo
oo

Systematics

o
oo

Result for $\frac{\Delta G}{G}$

ooooo

Recent measurement of $\frac{\Delta G}{G}$ at COMPASS

Colin Bernet, on behalf of the COMPASS collaboration

CERN

25th April 2005

Introduction

oo
oo

The high p_T asymmetry

ooo

The PYTHIA simulation

ooo
oo

Systematics

o
oo

Result for $\frac{\Delta G}{G}$

ooooo

Introduction

The nucleon spin

The photon-gluon fusion

The high p_T asymmetry

The PYTHIA simulation

Data / Monte-Carlo

Background processes

Systematics

Polarized structure of the *photon*

Tuning of the PYTHIA parameters

Result for $\frac{\Delta G}{G}$

$\frac{\Delta G}{G}$, 2002+2003

Introduction

oo
oo

The high p_T asymmetry

ooo

The PYTHIA simulation

ooo
oo

Systematics

o
oo

Result for $\frac{\Delta G}{G}$

ooooo

Introduction

The nucleon spin

The photon-gluon fusion

The high p_T asymmetry

The PYTHIA simulation

Data / Monte-Carlo

Background processes

Systematics

Polarized structure of the *photon*

Tuning of the PYTHIA parameters

Result for $\frac{\Delta G}{G}$

$\frac{\Delta G}{G}$, 2002+2003

Introduction

oo
oo

The high p_T asymmetry

ooo

The PYTHIA simulation

ooo
oo

Systematics

o
oo

Result for $\frac{\Delta G}{G}$

ooooo

Introduction

The nucleon spin

The photon-gluon fusion

The high p_T asymmetry

The PYTHIA simulation

Data / Monte-Carlo

Background processes

Systematics

Polarized structure of the *photon*

Tuning of the PYTHIA parameters

Result for $\frac{\Delta G}{G}$

$\frac{\Delta G}{G}$, 2002+2003

Introduction

oo
oo

The high p_T asymmetry

ooo

The PYTHIA simulation

ooo
oo

Systematics

o
oo

Result for $\frac{\Delta G}{G}$

ooooo

Introduction

The nucleon spin

The photon-gluon fusion

The high p_T asymmetry

The PYTHIA simulation

Data / Monte-Carlo

Background processes

Systematics

Polarized structure of the *photon*

Tuning of the PYTHIA parameters

Result for $\frac{\Delta G}{G}$

$\frac{\Delta G}{G}$, 2002+2003

Introduction

oo
oo

The high p_T asymmetry

ooo

The PYTHIA simulation

ooo
oo

Systematics

o
oo

Result for $\frac{\Delta G}{G}$

ooooo

Introduction

The nucleon spin

The photon-gluon fusion

The high p_T asymmetry

The PYTHIA simulation

Data / Monte-Carlo

Background processes

Systematics

Polarized structure of the *photon*

Tuning of the PYTHIA parameters

Result for $\frac{\Delta G}{G}$

$\frac{\Delta G}{G}$, 2002+2003

The nucleon spin

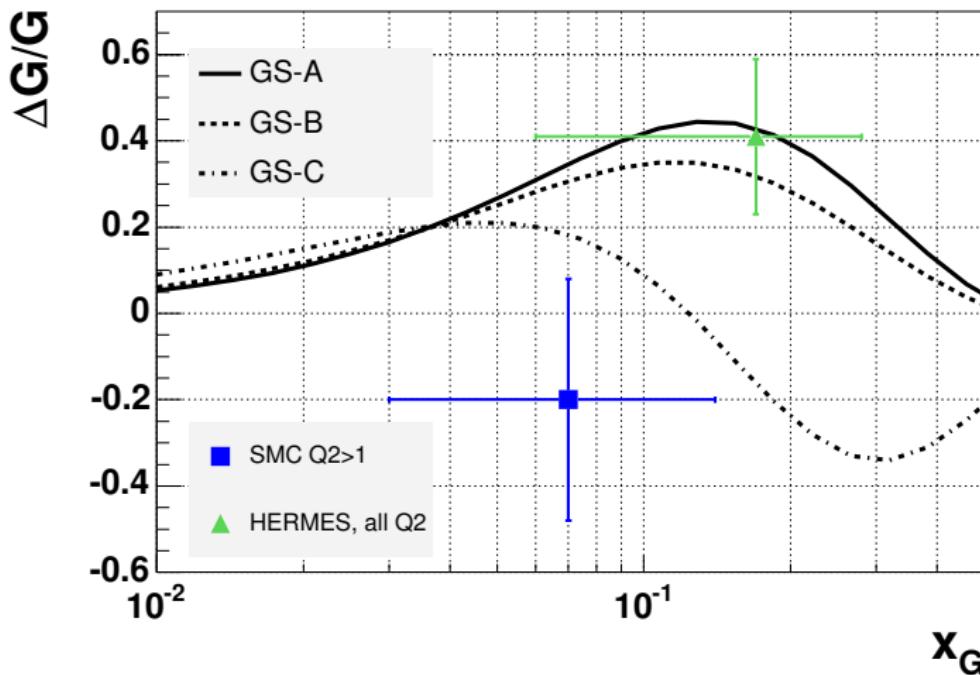
Angular momentum sum rule:

$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + (L_z^q + L_z^g)$$

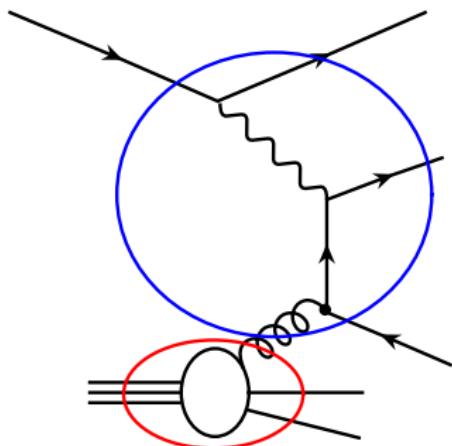
Access to the gluons spin ΔG :

- Q^2 evolution of g_1
fixed target experiments only → loose constraints
- direct measurements of $\frac{\Delta G}{G}(x_g)$.

Direct measurements of $\frac{\Delta G}{G}$

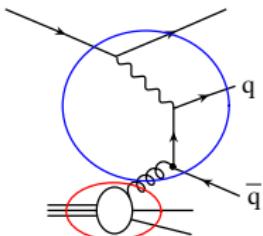


The photon-gluon fusion (pgf)



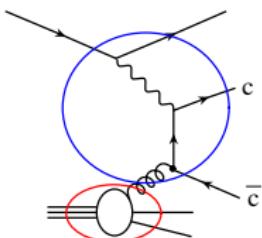
$$A_{pgf} \equiv \frac{\sigma_{pgf}^{\leftarrow\rightarrow} - \sigma_{pgf}^{\leftarrow\leftarrow}}{\sigma_{pgf}^{\leftarrow\rightarrow} + \sigma_{pgf}^{\leftarrow\leftarrow}}$$
$$= \langle \hat{a}_{pgf} \rangle \frac{\Delta G}{G}$$

Selection of the photon-gluon fusion



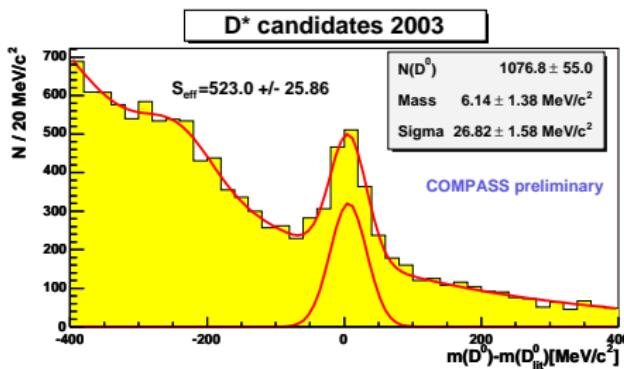
$$A_{\parallel} = R_{pgf} \langle \hat{a}_{pgf} \rangle \frac{\Delta G}{G} + \langle \text{background asymmetry} \rangle$$

Selection of the photon-gluon fusion

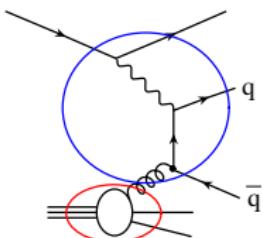


$$A_{\parallel} = R_{pgf} \langle \hat{a}_{pgf} \rangle \frac{\Delta G}{G} + \langle \text{background asymmetry} \rangle$$

Charmed mesons



Selection of the photon-gluon fusion



$$A_{||} = R_{pgf} \langle \hat{a}_{pgf} \rangle \frac{\Delta G}{G} + \langle \text{background asymmetry} \rangle$$

pair of p_T hadrons

- high statistics
- simulation necessary...

Introduction

○○
○○The high p_T asymmetry

●○○

The PYTHIA simulation

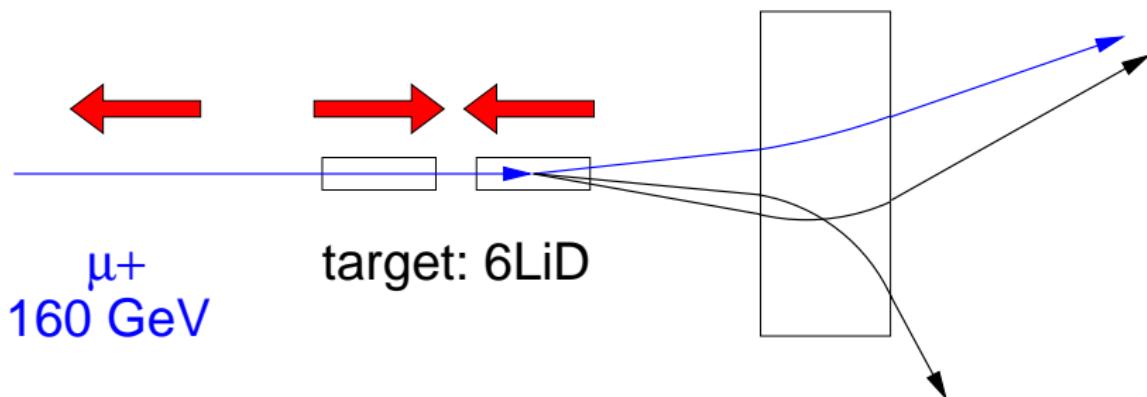
○○○
○○

Systematics

○
○○Result for $\frac{\Delta G}{G}$

○○○○○

Experimental setup



$$A_{||} \equiv \frac{\sigma^{\leftarrow\rightarrow} - \sigma^{\leftarrow\leftarrow}}{\sigma^{\leftarrow\rightarrow} + \sigma^{\leftarrow\leftarrow}}$$

Selection of high p_T events

- 2 hadrons with:

$$p_{T,1} \text{ and } p_{T,2} > 0.7 \text{ GeV}$$

$$p_{T,1}^2 + p_{T,2}^2 > 2.5 \text{ GeV}^2$$

$$z > 0.1$$

- $Q^2 < 1 \text{ GeV}^2$

The high p_T asymmetry (2002+2003)

$$A_{||} = R_{pgf} \langle \hat{a}_{pgf} \rangle \frac{\Delta G}{G} + \langle \text{background asymmetry} \rangle .$$

$$\frac{A_{||}}{D} = 0.002 \pm 0.019(\text{stat}) \pm 0.003(\text{exp.syst}).$$

$$= R_{pgf} \left\langle \frac{\hat{a}_{pgf}}{D} \right\rangle \frac{\Delta G}{G} + \left\langle \frac{\text{background asymmetry}}{D} \right\rangle .$$

The high p_T asymmetry (2002+2003)

$$A_{||} = R_{pgf} \langle \hat{a}_{pgf} \rangle \frac{\Delta G}{G} + \langle \text{background asymmetry} \rangle .$$

$$\frac{A_{||}}{D} = 0.002 \pm 0.019(\text{stat}) \pm 0.003(\text{exp.syst}).$$

$$= R_{pgf} \left\langle \frac{\hat{a}_{pgf}}{D} \right\rangle \frac{\Delta G}{G} + \left\langle \frac{\text{background asymmetry}}{D} \right\rangle .$$

The high p_T asymmetry (2002+2003)

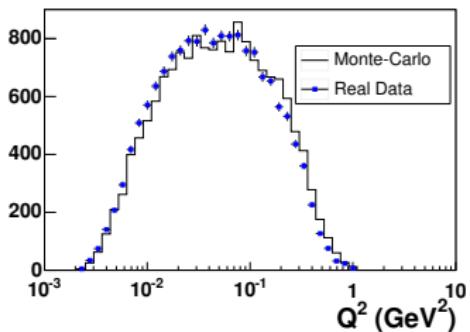
$$A_{||} = R_{pgf} \langle \hat{a}_{pgf} \rangle \frac{\Delta G}{G} + \langle \text{background asymmetry} \rangle.$$

$$\frac{A_{||}}{D} = 0.002 \pm 0.019(\text{stat}) \pm 0.003(\text{exp.syst}).$$

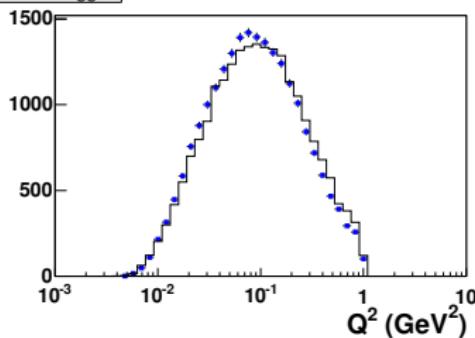
$$= R_{pgf} \left\langle \frac{\hat{a}_{pgf}}{D} \right\rangle \frac{\Delta G}{G} + \left\langle \frac{\text{background asymmetry}}{D} \right\rangle.$$

Data / Monte-Carlo comparisons: Q^2

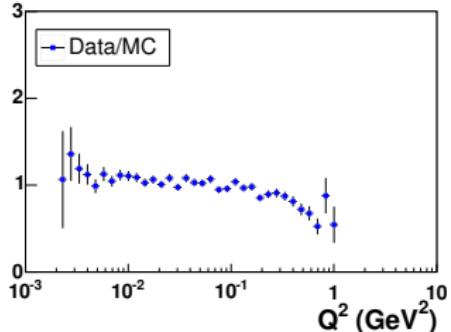
Inner trigger



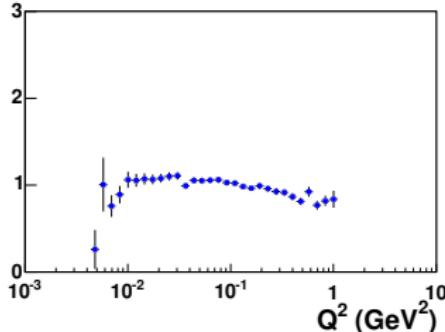
Ladder trigger



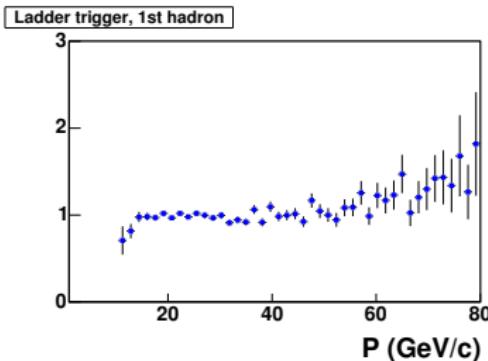
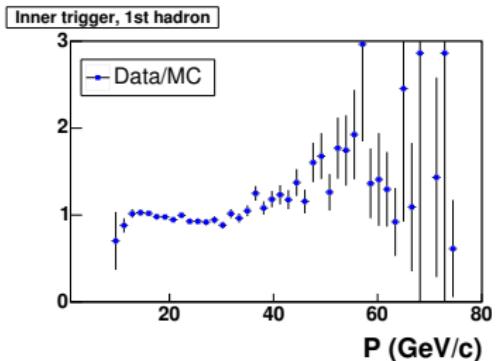
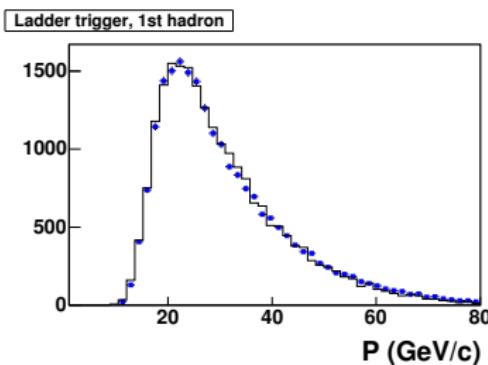
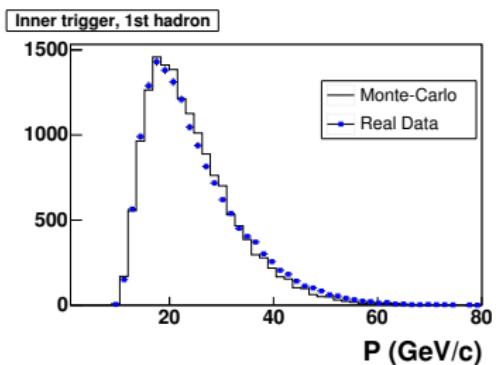
Inner trigger



Ladder trigger

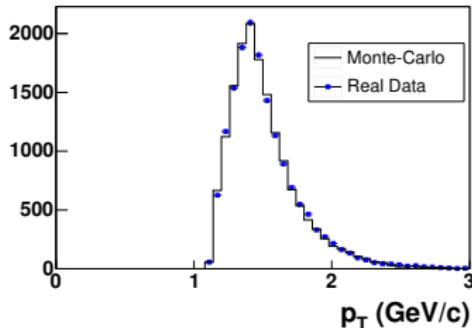


Data / Monte-Carlo comparisons: p first hadron

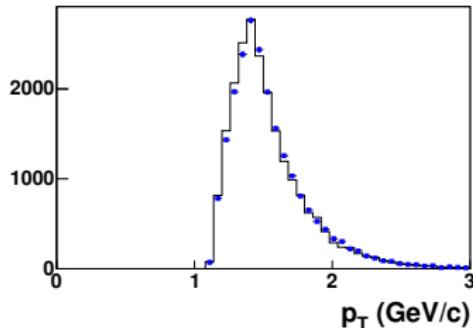


Data / Monte-Carlo comparisons: p_T first hadron

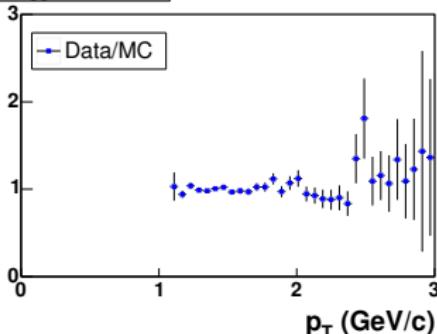
Inner trigger, 1st hadron



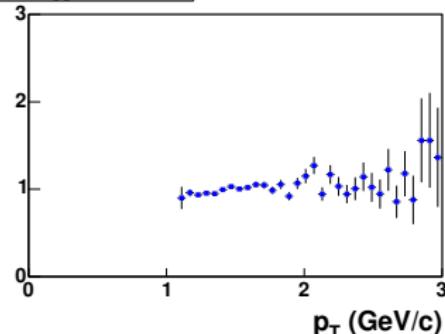
Ladder trigger, 1st hadron



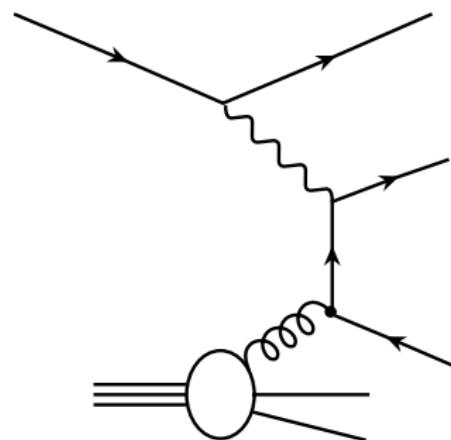
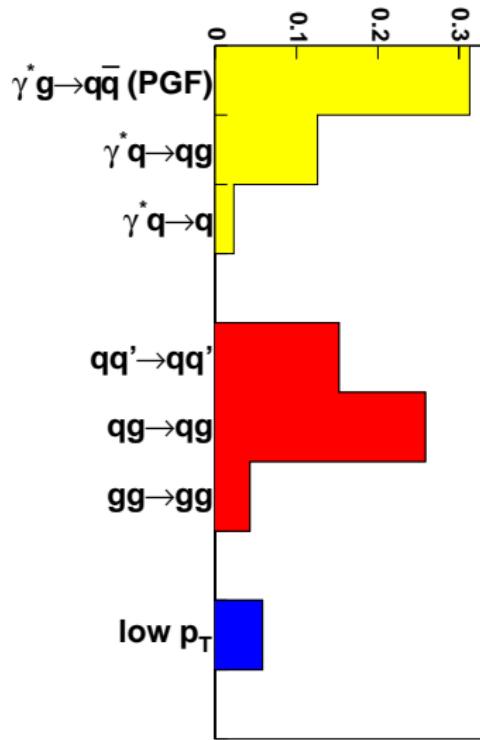
Inner trigger, 1st hadron



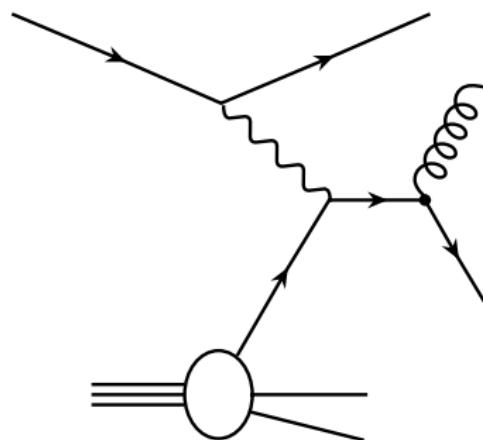
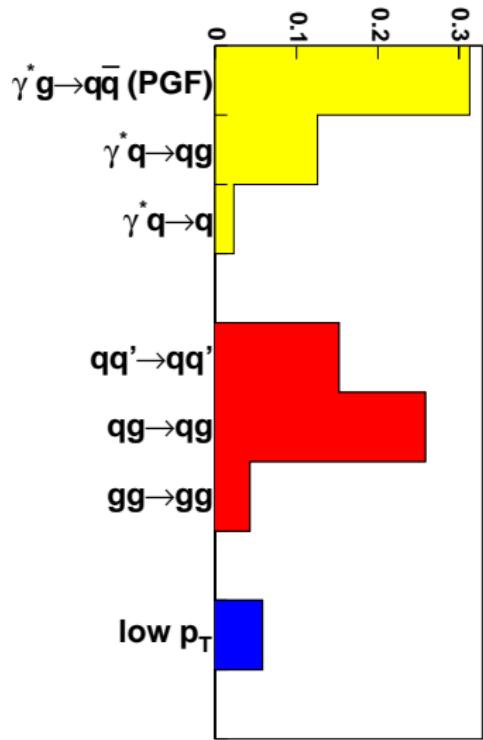
Ladder trigger, 1st hadron



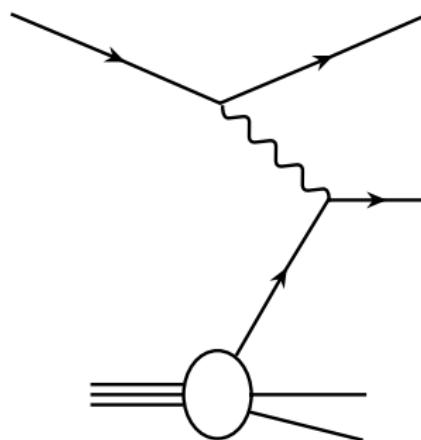
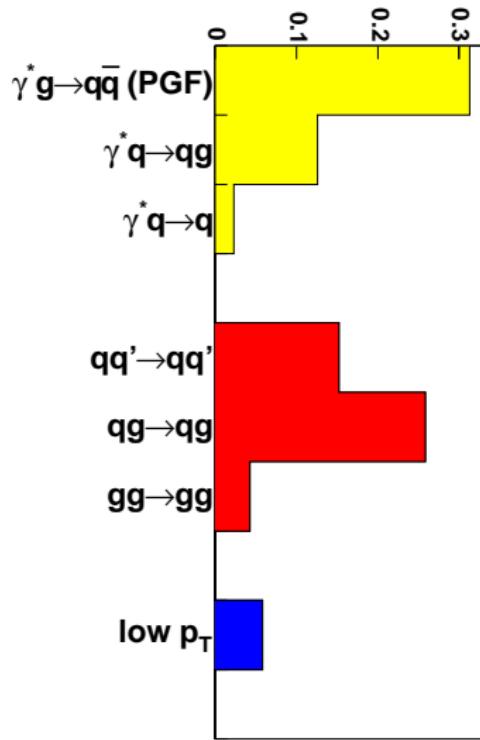
The PYTHIA subprocesses



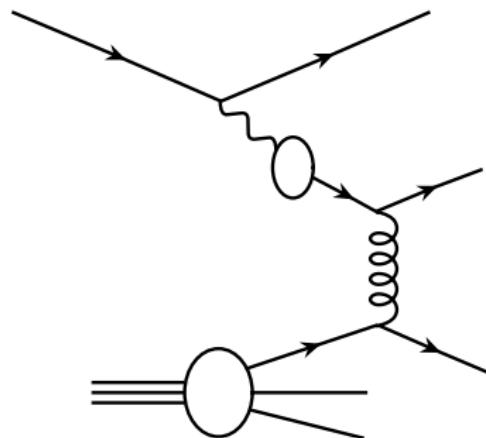
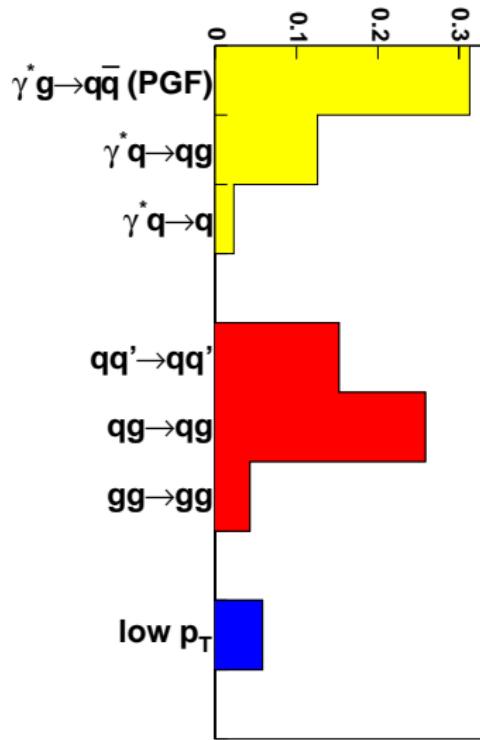
The PYTHIA subprocesses



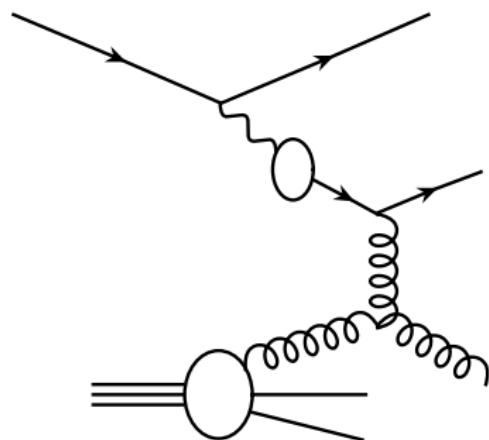
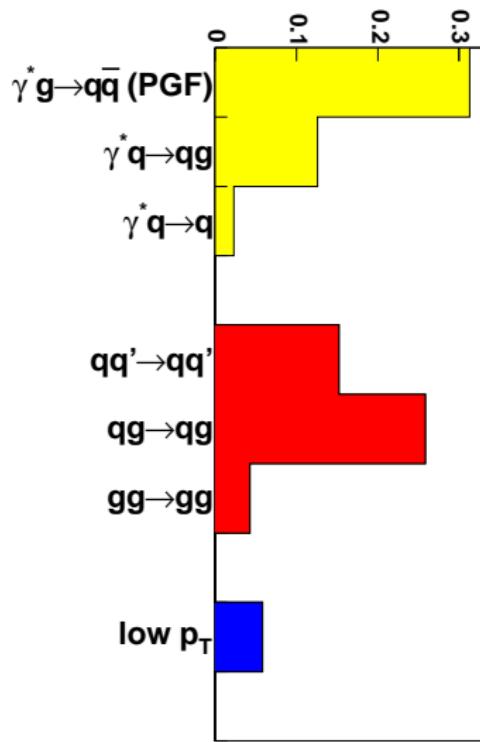
The PYTHIA subprocesses



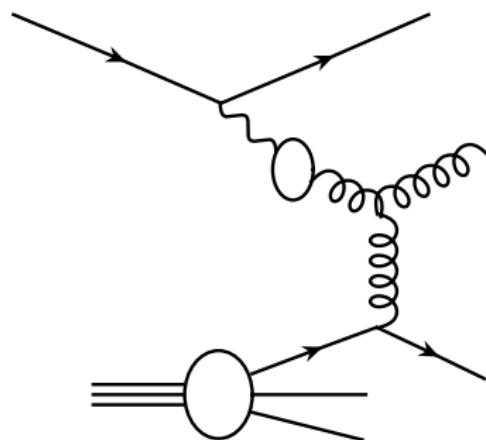
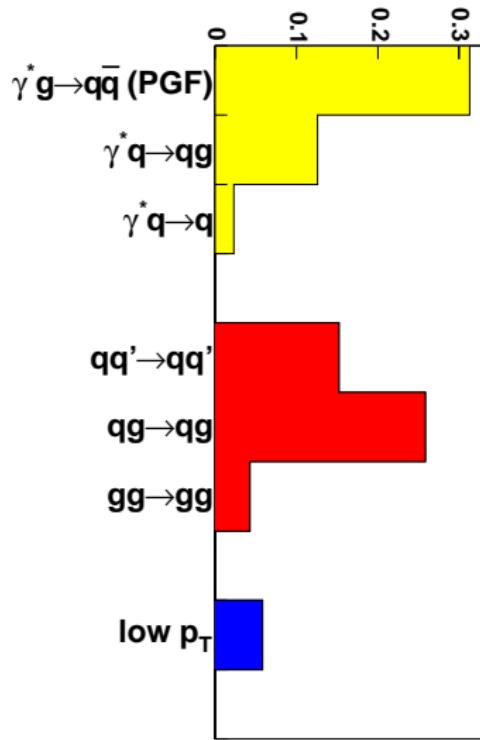
The PYTHIA subprocesses



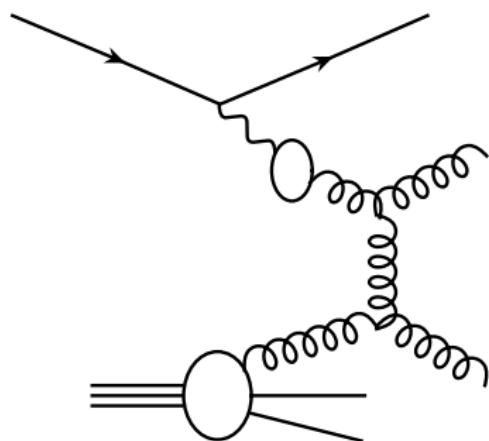
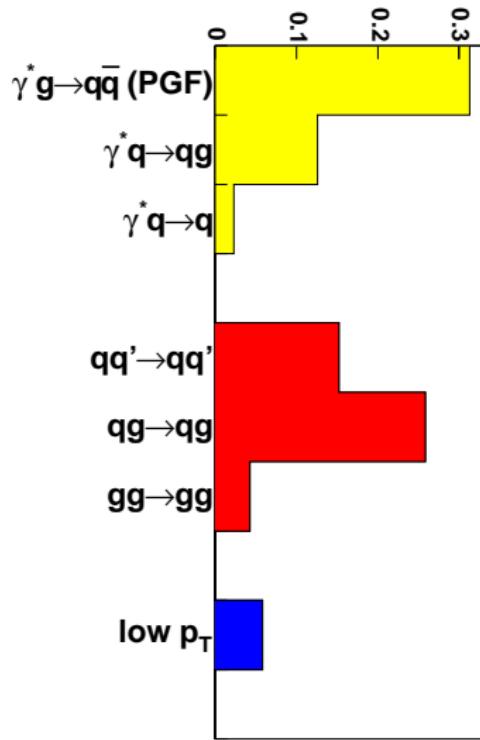
The PYTHIA subprocesses



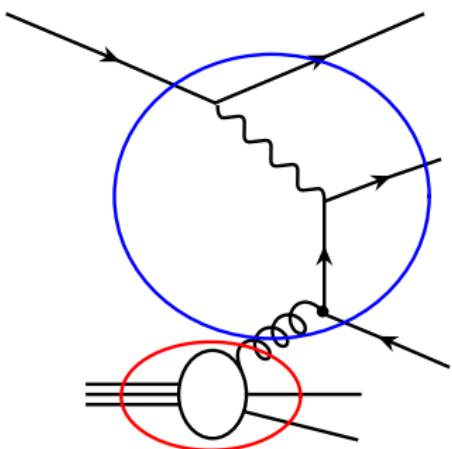
The PYTHIA subprocesses



The PYTHIA subprocesses

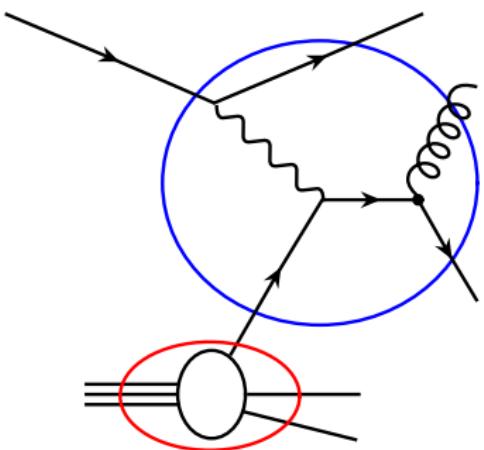


Contributions to the asymmetry



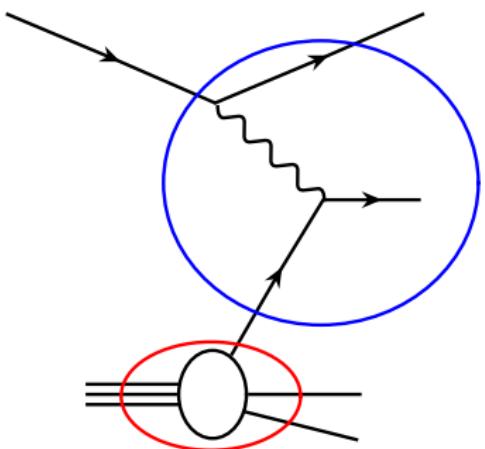
$$\frac{A_{\parallel}}{D} = R_{pgf} \left\langle \frac{\hat{a}_{pgf}}{D} \right\rangle \left(\frac{\Delta G}{G} \right)^d$$

Contributions to the asymmetry



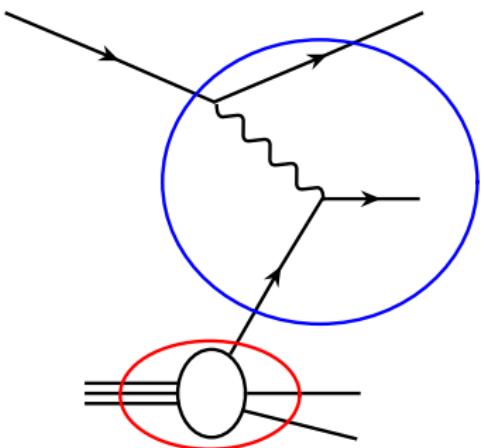
$$\frac{A_{\parallel}}{D} = R_{pgf} \left\langle \frac{\hat{a}_{pgf}}{D} \right\rangle \left(\frac{\Delta G}{G} \right)^d + R_{qcdc} \left\langle \frac{\hat{a}_{qcdc}}{D} \right\rangle \left(\frac{\Delta q}{q} \right)^d$$

Contributions to the asymmetry



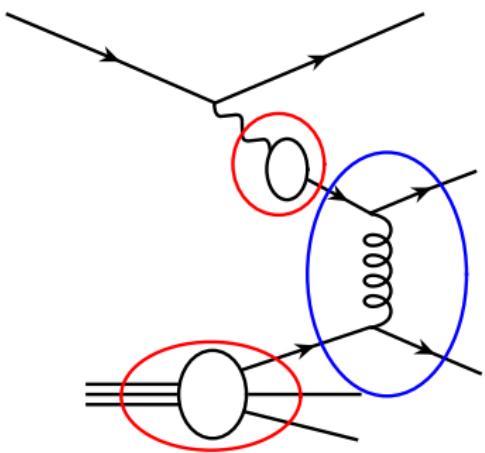
$$\begin{aligned} \frac{A_{\parallel}}{D} = & R_{pgf} \left\langle \frac{\hat{a}_{pgf}}{D} \right\rangle \left(\frac{\Delta G}{G} \right)^d \\ & + R_{qcdc} \left\langle \frac{\hat{a}_{qcdc}}{D} \right\rangle \left(\frac{\Delta q}{q} \right)^d \\ & + R_{lodis} \left\langle \frac{\hat{a}_{lodis}}{D} \right\rangle \left(\frac{\Delta q}{q} \right)^d \end{aligned}$$

Contributions to the asymmetry



$$\frac{A_{\parallel}}{D} = R_{pgf} \left\langle \frac{\hat{a}_{pgf}}{D} \right\rangle \left(\frac{\Delta G}{G} \right)^d + R_{qcdc} \left\langle \frac{\hat{a}_{qcdc}}{D} \right\rangle \left(\frac{\Delta q}{q} \right)^d$$

Contributions to the asymmetry

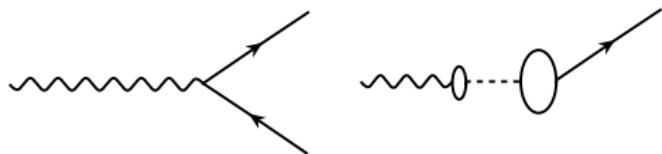


$$\frac{A_{\parallel}}{D} = R_{pgf} \left\langle \frac{\hat{a}_{pgf}}{D} \right\rangle \left(\frac{\Delta G}{G} \right)^d + R_{qcdc} \left\langle \frac{\hat{a}_{qcdc}}{D} \right\rangle \left(\frac{\Delta q}{q} \right)^d$$

$$+ R_{qq'} \left\langle \hat{a}_{qq'} \right\rangle \left(\frac{\Delta q}{q} \right)^d \left(\frac{\Delta q'}{q'} \right)^\gamma$$

+ ...

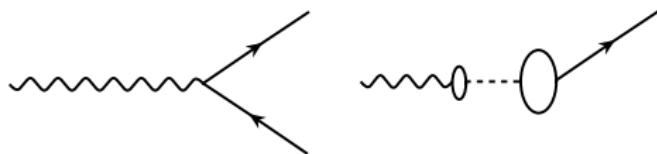
Quarks polarization in the photon $\left(\frac{\Delta q}{q}\right)^\gamma$



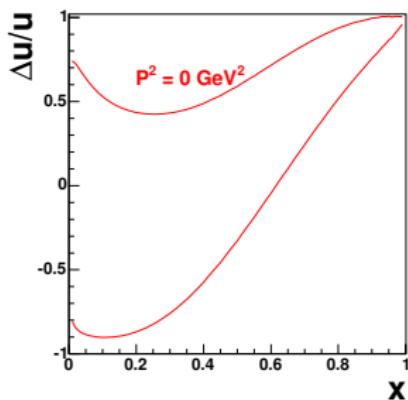
$$\Delta q^\gamma = \Delta q_{q\bar{q}}^\gamma + \Delta q_{VMD}^\gamma$$

- $\Delta q_{q\bar{q}}^\gamma$: QED+QCD
- min and max scenarios:
 $-q_{VMD}^\gamma \leq \Delta q_{VMD}^\gamma \leq q_{VMD}^\gamma$

Quarks polarization in the photon $\left(\frac{\Delta q}{q}\right)^\gamma$



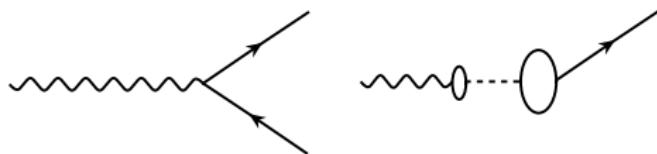
$$\Delta q^\gamma = \Delta q_{q\bar{q}}^\gamma + \Delta q_{VMD}^\gamma$$



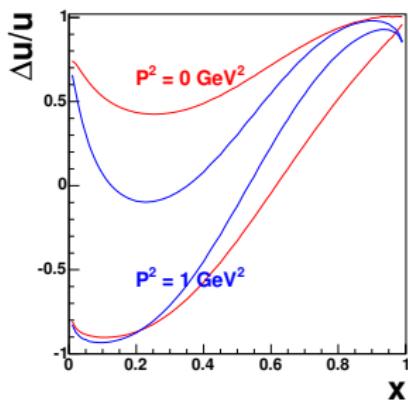
- $\Delta q_{q\bar{q}}^\gamma$: QED+QCD
- min and max scenarios:
 $-q_{VMD}^\gamma \leq \Delta q_{VMD}^\gamma \leq q_{VMD}^\gamma$

(Glück, Reya, Sieg)

Quarks polarization in the photon $\left(\frac{\Delta q}{q}\right)^\gamma$



$$\Delta q^\gamma = \Delta q_{q\bar{q}}^\gamma + \Delta q_{VMD}^\gamma$$



- $\Delta q_{q\bar{q}}^\gamma$: QED+QCD
- min and max scenarios:
 $-q_{VMD}^\gamma \leq \Delta q_{VMD}^\gamma \leq q_{VMD}^\gamma$

(Glück, Reya, Sieg)

Systematic error associated to the Monte-Carlo

$$\frac{A_{||}}{D} = 0.002 \pm 0.019(stat) \pm 0.003(exp.syst).$$

$$= R_{pgf} \left\langle \frac{\hat{a}_{pgf}}{D} \right\rangle \frac{\Delta G}{G} + \left\langle \frac{background\ asymmetry}{D} \right\rangle.$$

Scan of the PYTHIA parameters

- related to NLO:
 - Renormalization/factorization scale,
 - “Parton Showers”.
- acting on p_T :
 - parton fragmentation,
 - primordial transverse momentum of the partons in the nucleon and in the photon.

Systematic error associated to the Monte-Carlo

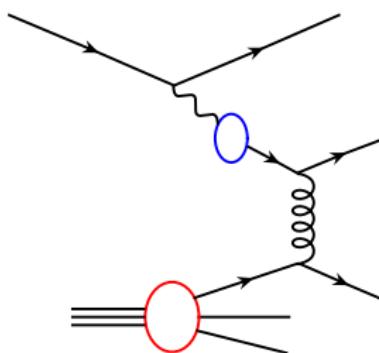
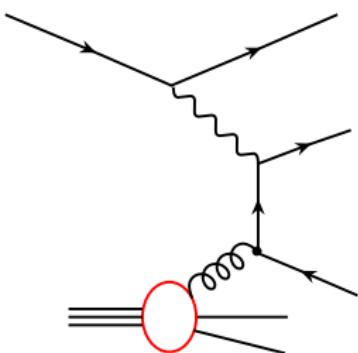
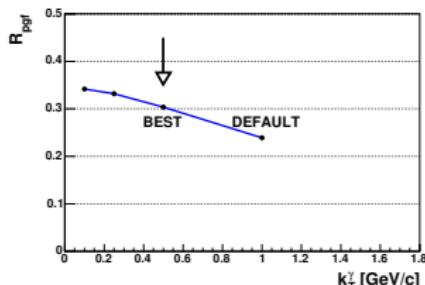
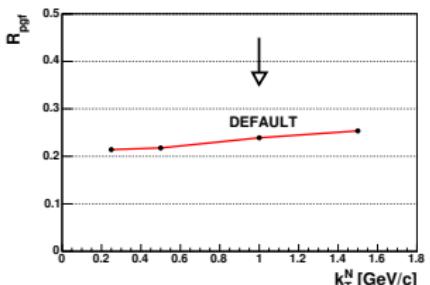
$$\frac{A_{||}}{D} = 0.002 \pm 0.019(stat) \pm 0.003(exp.syst).$$

$$= R_{pgf} \left\langle \frac{\hat{a}_{pgf}}{D} \right\rangle \frac{\Delta G}{G} + \left\langle \frac{background\ asymmetry}{D} \right\rangle.$$

Scan of the PYTHIA parameters

- related to NLO:
 - Renormalization/factorization scale,
 - “Parton Showers”.
- acting on p_T :
 - parton fragmentation,
 - primordial transverse momentum of the partons in the nucleon and in the photon.

Systematics: k_T^N et k_T^γ



Introduction

○○
○○The high p_T asymmetry

○○○

The PYTHIA simulation

○○○
○○

Systematics

○
○○Result for $\frac{\Delta G}{G}$

●○○○○

$\frac{\Delta G}{G}$, 2002+2003

$$\left(\frac{\Delta G}{G}\right)_{min} = 0.016 \pm 0.068(stat) \pm 0.011(exp.syst) \pm 0.018(MC.syst)$$

$$\left(\frac{\Delta G}{G}\right)_{max} = 0.031 \pm 0.089(stat) \pm 0.014(exp.syst) \pm 0.052(MC.syst)$$

$$\frac{\Delta G}{G} = 0.024 \pm 0.089(stat.) \pm 0.057(syst.).$$

Introduction

○○
○○The high p_T asymmetry

○○○

The PYTHIA simulation

○○○
○○

Systematics

○
○○Result for $\frac{\Delta G}{G}$

●○○○○

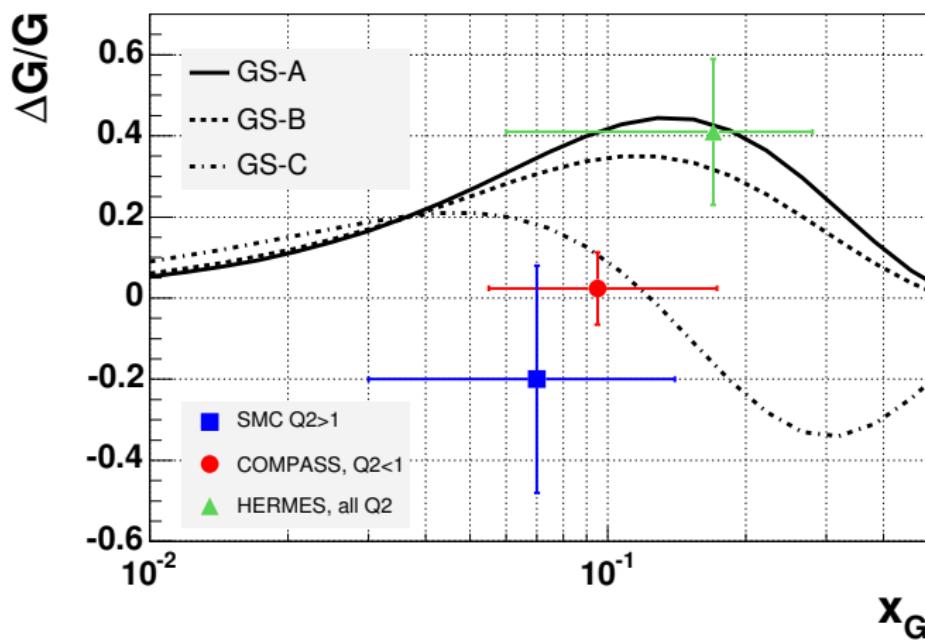
$\frac{\Delta G}{G}$, 2002+2003

$$\left(\frac{\Delta G}{G}\right)_{min} = 0.016 \pm 0.068(stat) \pm 0.011(exp.syst) \pm 0.018(MC.syst)$$

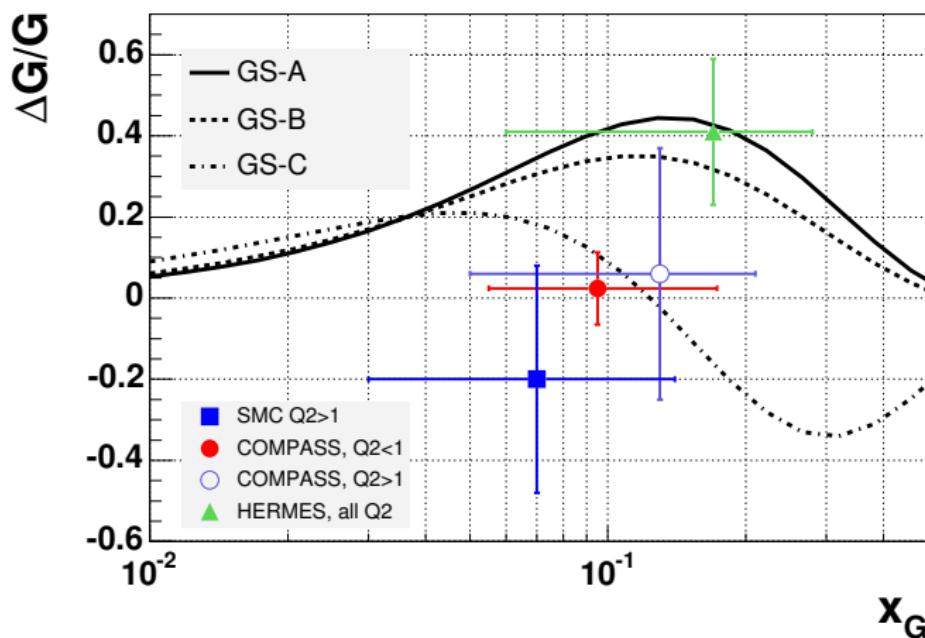
$$\left(\frac{\Delta G}{G}\right)_{max} = 0.031 \pm 0.089(stat) \pm 0.014(exp.syst) \pm 0.052(MC.syst)$$

$$\frac{\Delta G}{G} = 0.024 \pm 0.089(stat.) \pm 0.057(syst.).$$

2002+2003 data



2002+2003 data



Conclusion

2002+2003 data, $Q^2 < 1 \text{ GeV}^2$

$$\frac{\Delta G}{G} = 0.024 \pm 0.089(\text{stat.}) \pm 0.057(\text{syst.}).$$

- either ΔG is small,
- either $\Delta G/G$ has to cross 0 around $x_G = 0.1$.

Outlook

- Including 2004 data:
 - $Q^2 < 1 \text{ GeV}^2$: $\delta(\Delta G/G) = 0.065$
 - $Q^2 > 1 \text{ GeV}^2$: $\delta(\Delta G/G) = 0.22$
- Open charm: $\Delta G/G$ will be presented soon.