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

Colin Bernet, on behalf of the COMPASS collaboration

CERN

25th April 2005

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

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The nucleon spin

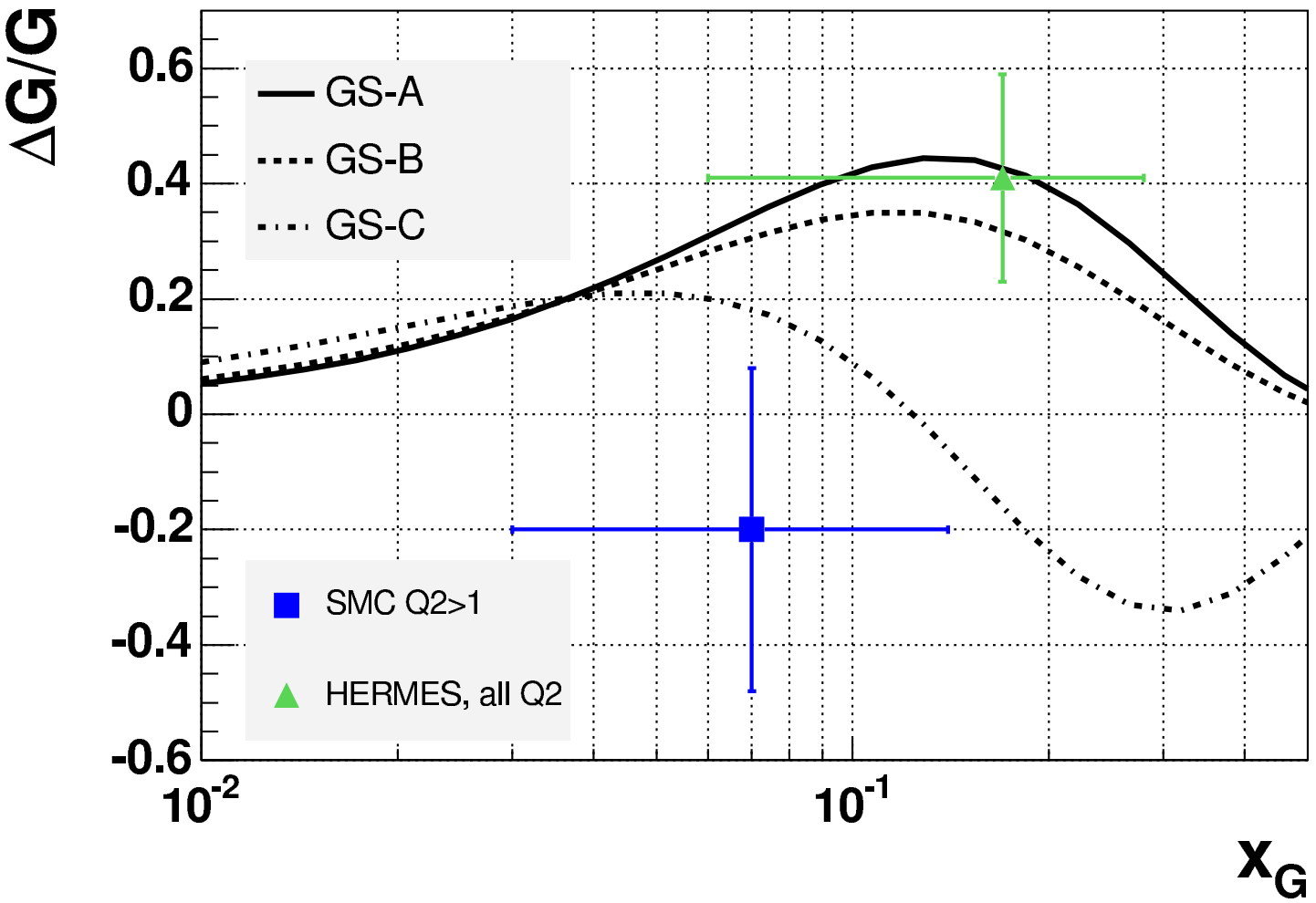
Angular momentum sum rule:

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

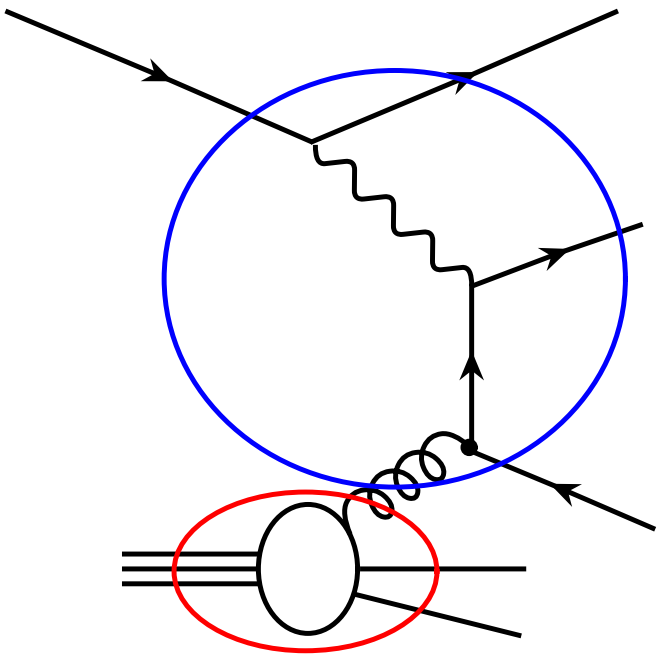
Access to the gluons spin ΔG:

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

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

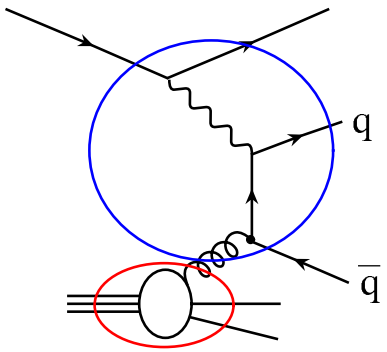


The photon-gluon fusion (pgf)



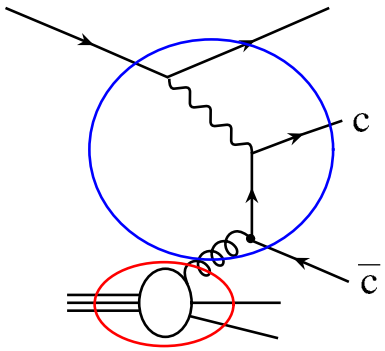
$$A_{pgf} \equiv \frac{\sigma_{pgf}^{\leftarrow\rightarrow} - \sigma_{pgf}^{\leftarrow\leftarrow}}{\sigma_{pgf}^{\leftarrow\rightarrow} + \sigma_{pgf}^{\leftarrow\leftarrow}} = \langle \hat{a}_{pgf} \rangle \frac{\Delta G}{G}$$

Selection of the photon-gluon fusion



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

Selection of the photon-gluon fusion



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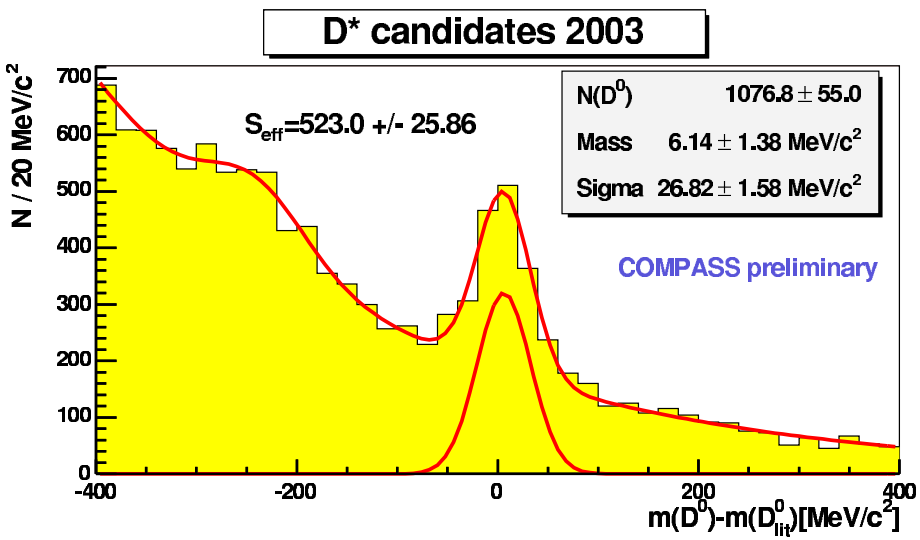
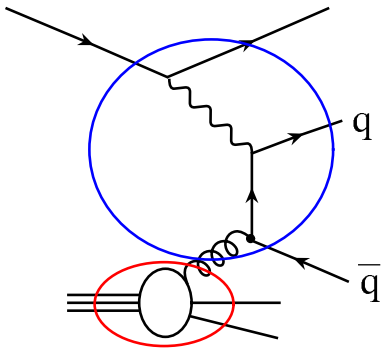
Charmed mesons



Selection of the photon-gluon fusion

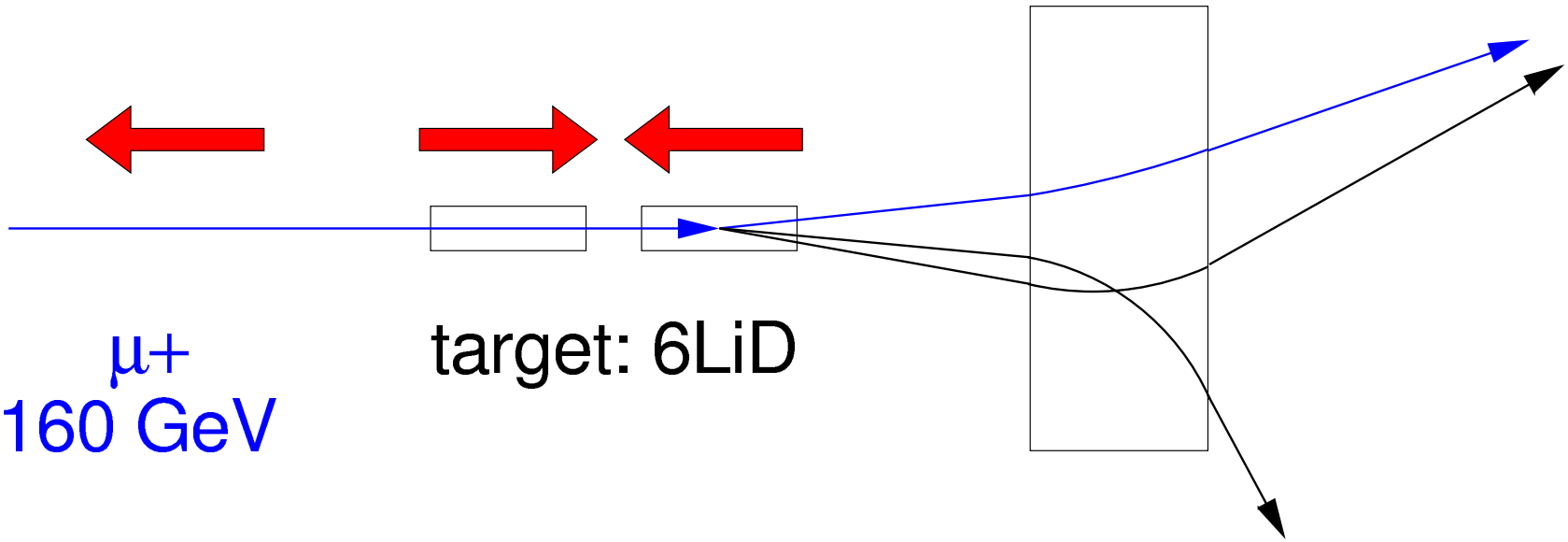


$$A_{\parallel} = R_{pgf} \langle \hat{a}_{pgf} \rangle \frac{\Delta G}{G} + \langle \textit{background asymmetry} \rangle$$

pair of p_T hadrons

- high statistics
- simulation necessary...

Experimental setup



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

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)

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

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

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

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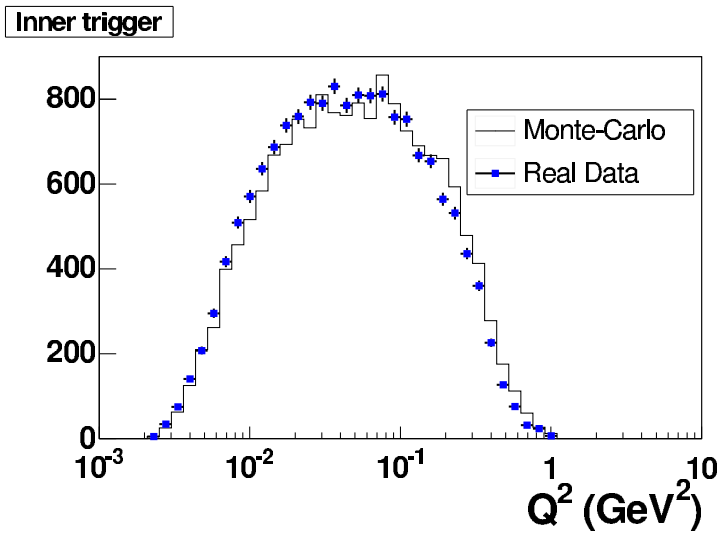
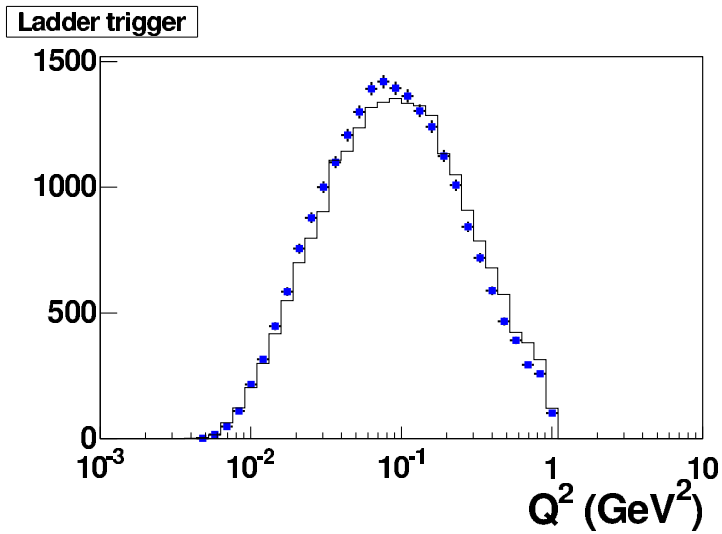
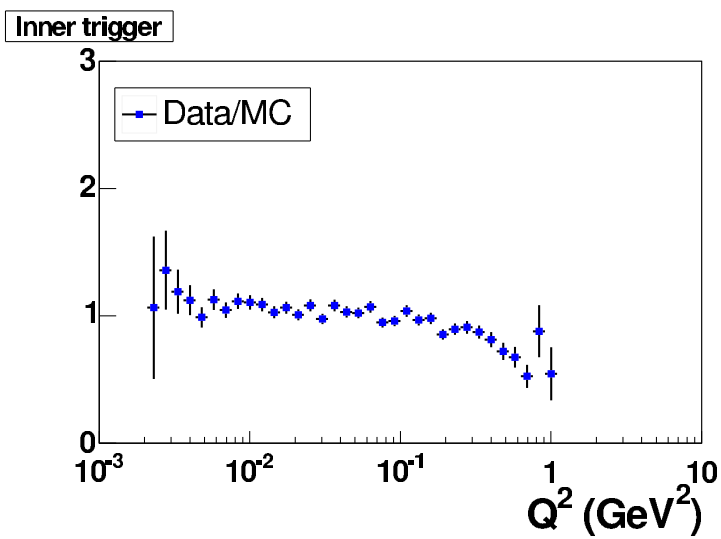
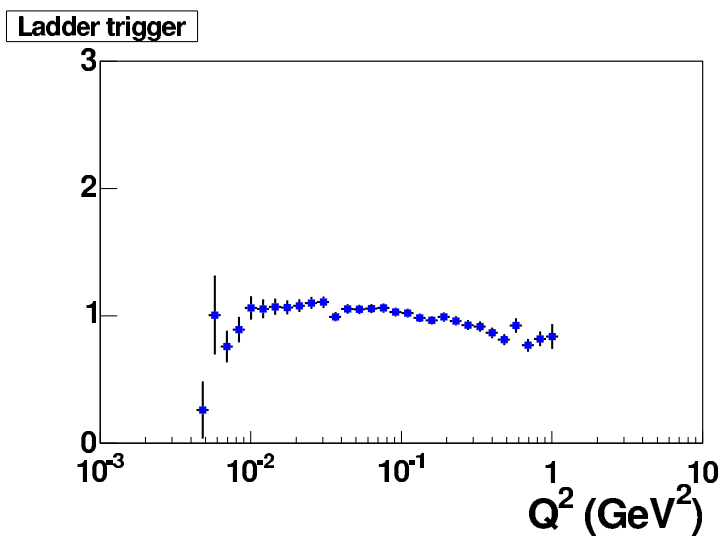
Data / Monte-Carlo comparisons: Q^2

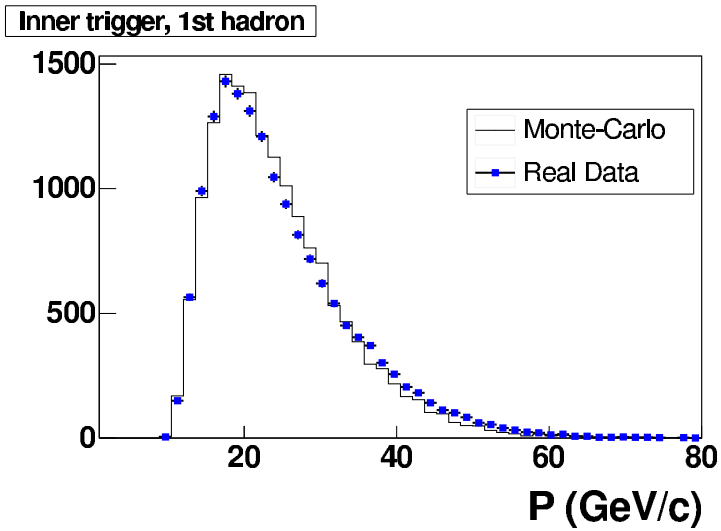


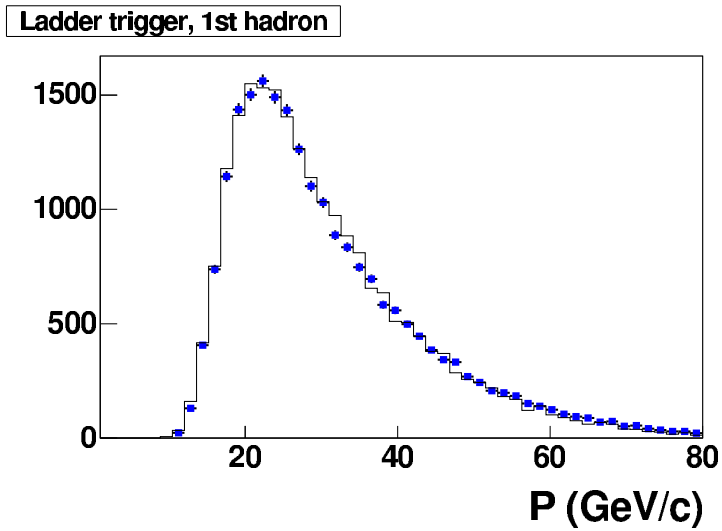


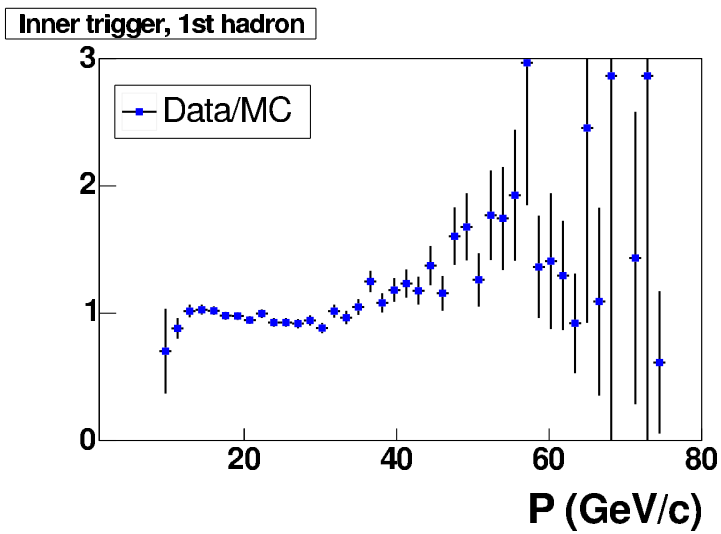


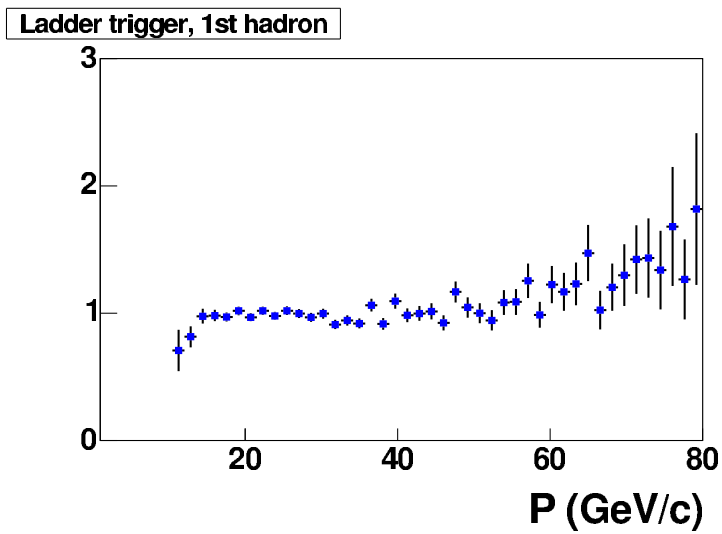


Data / Monte-Carlo comparisons: p first hadron

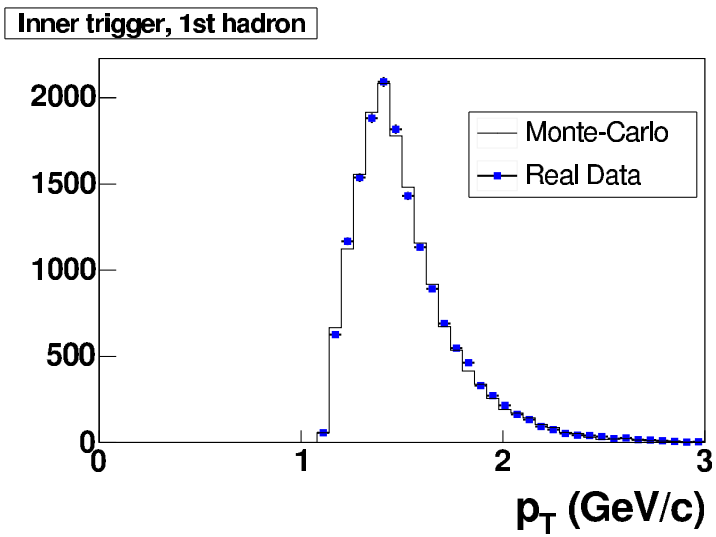


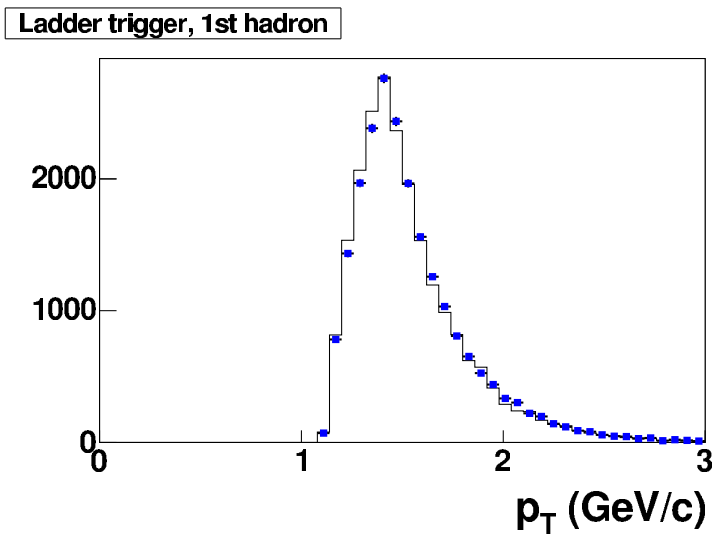


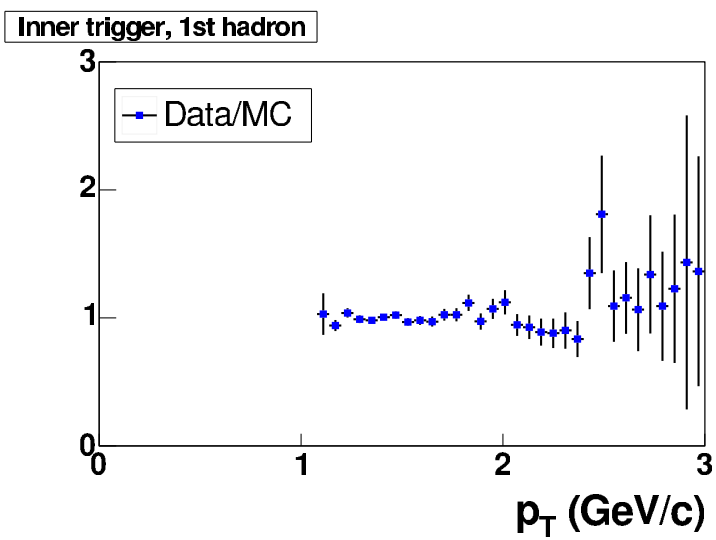


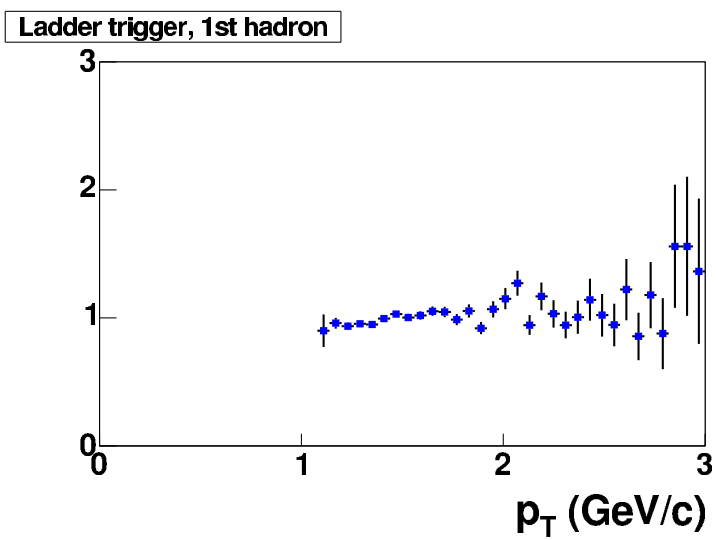


Data / Monte-Carlo comparisons: p_T first hadron

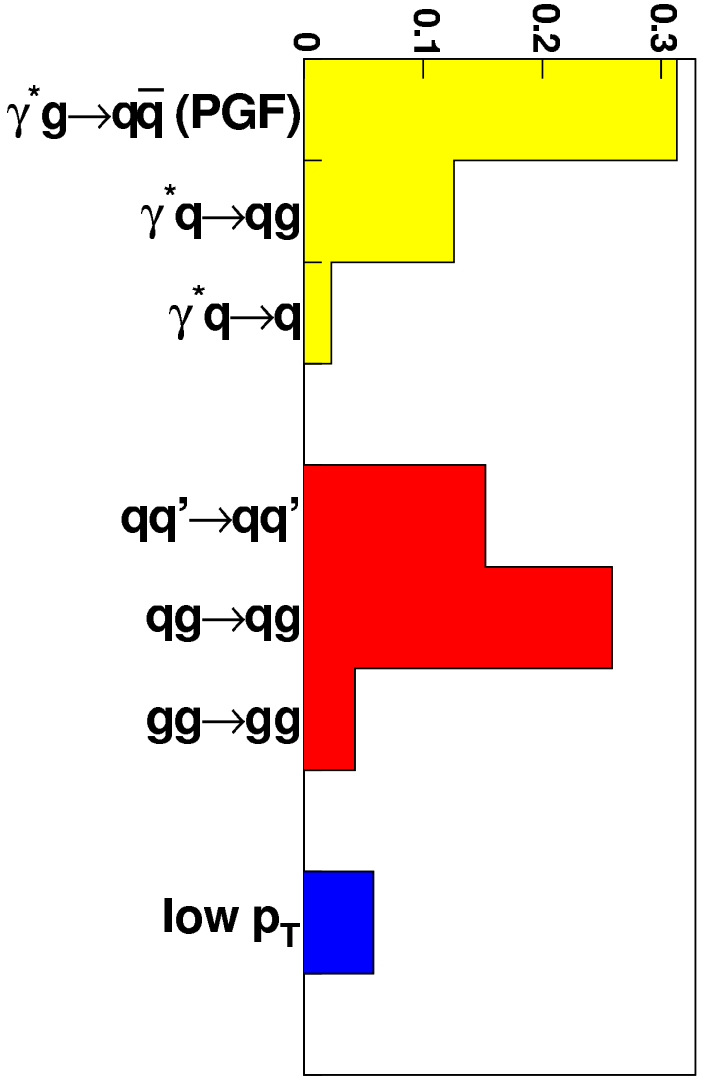


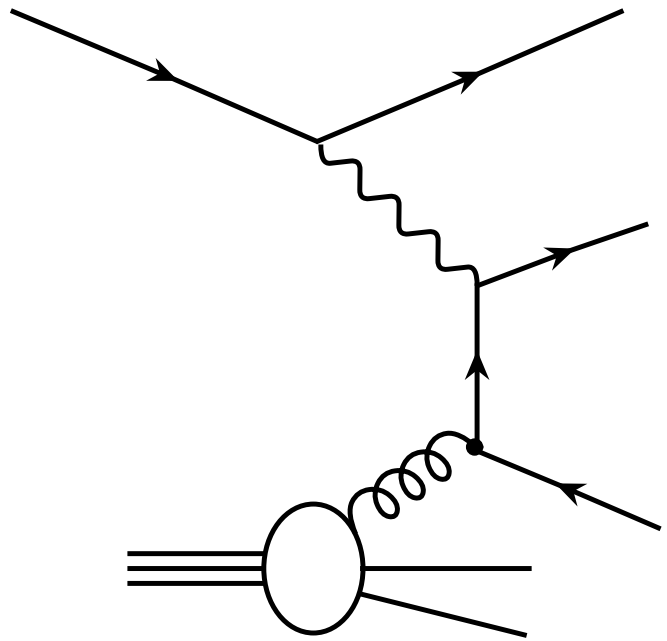






The PYTHIA subprocesses





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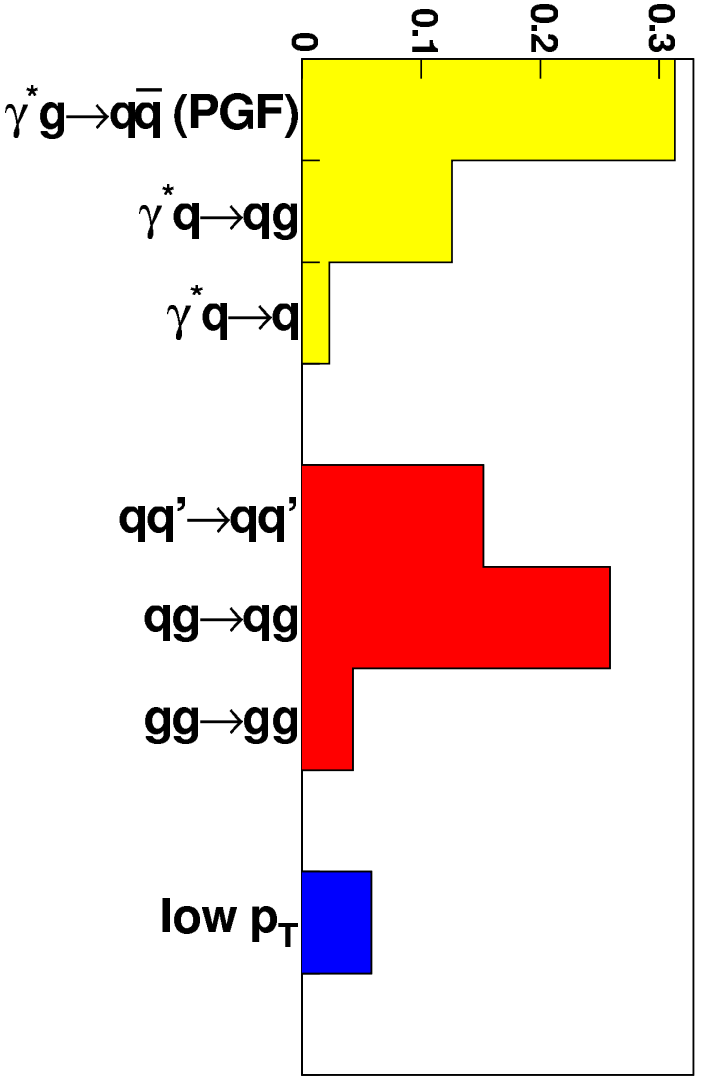

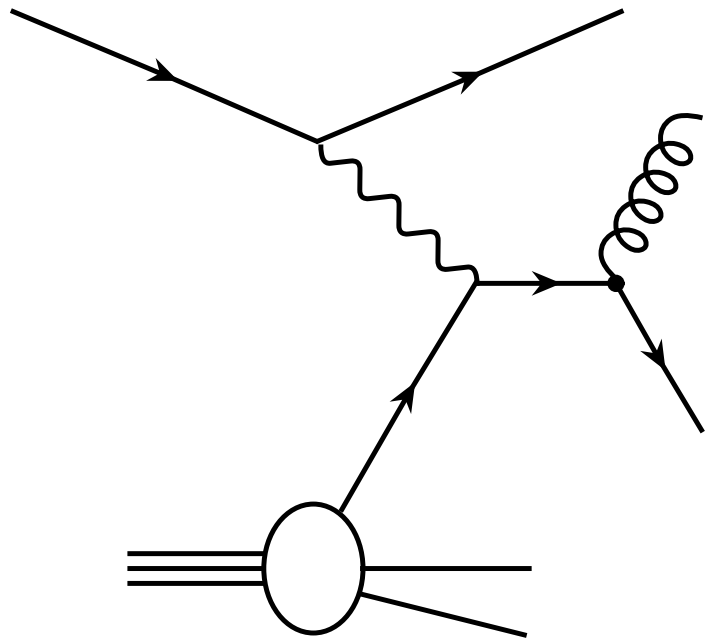

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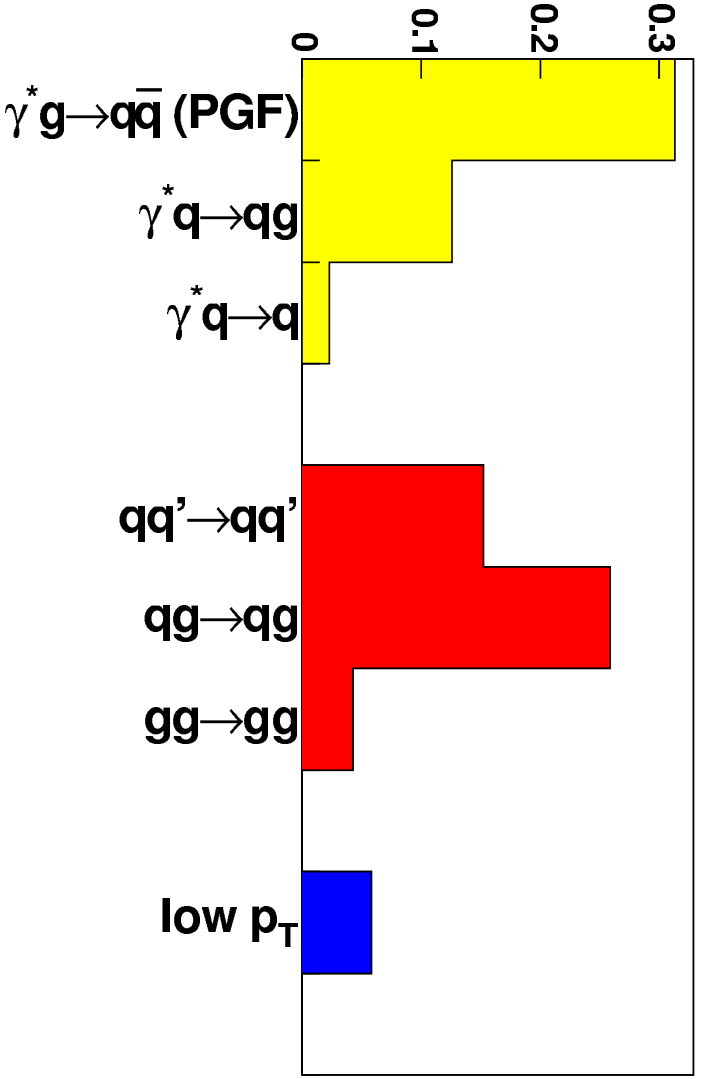

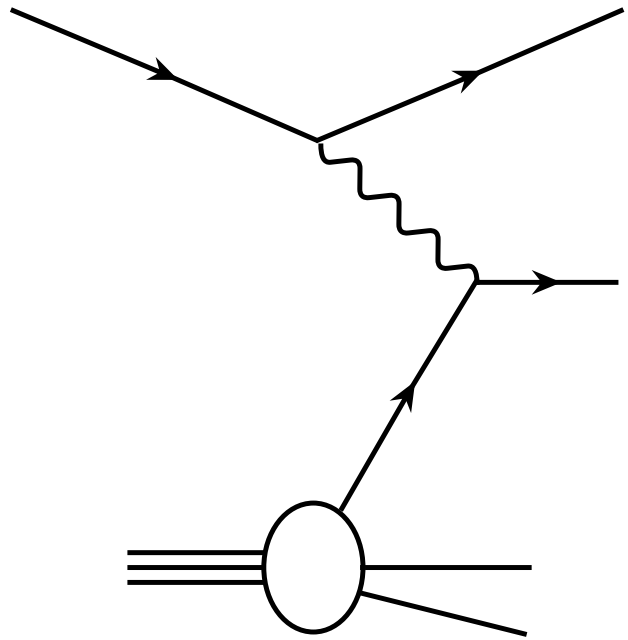

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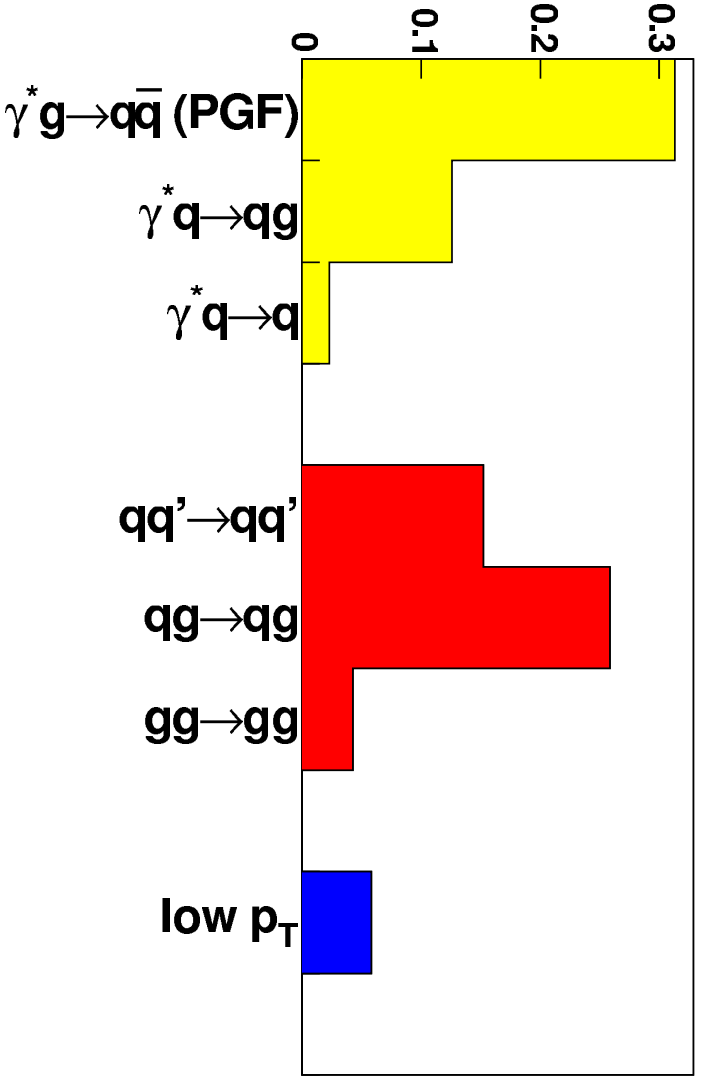

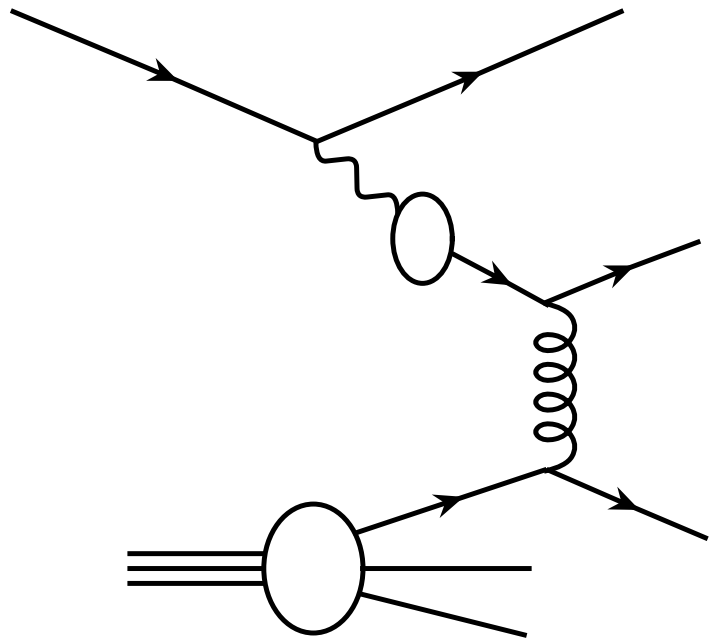

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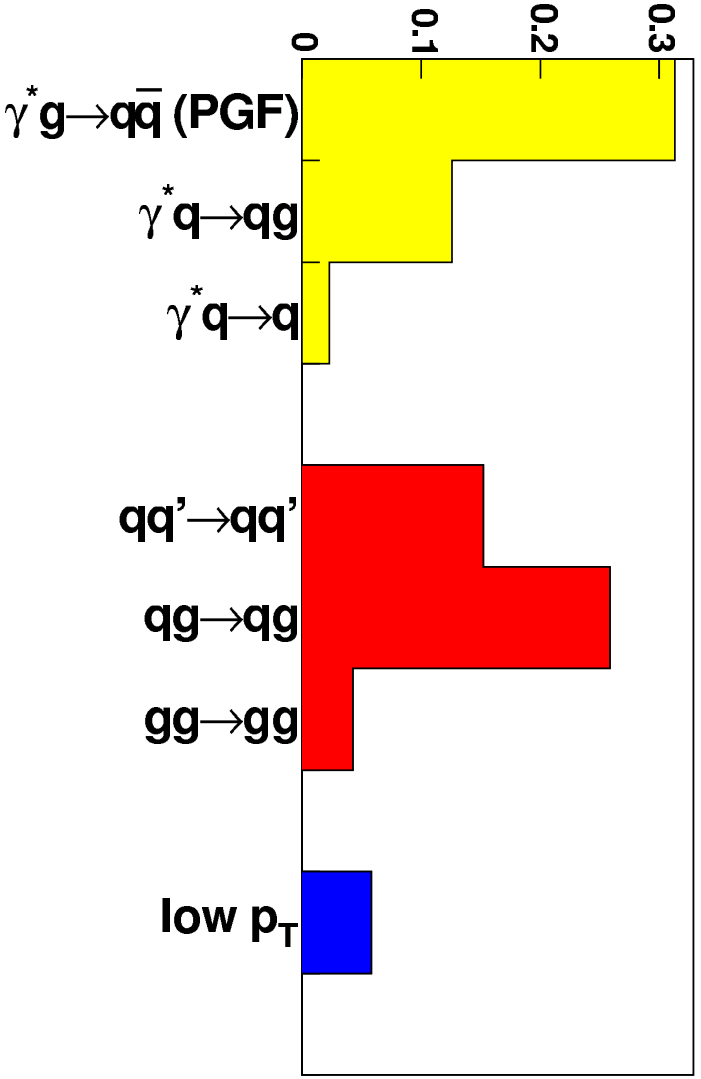

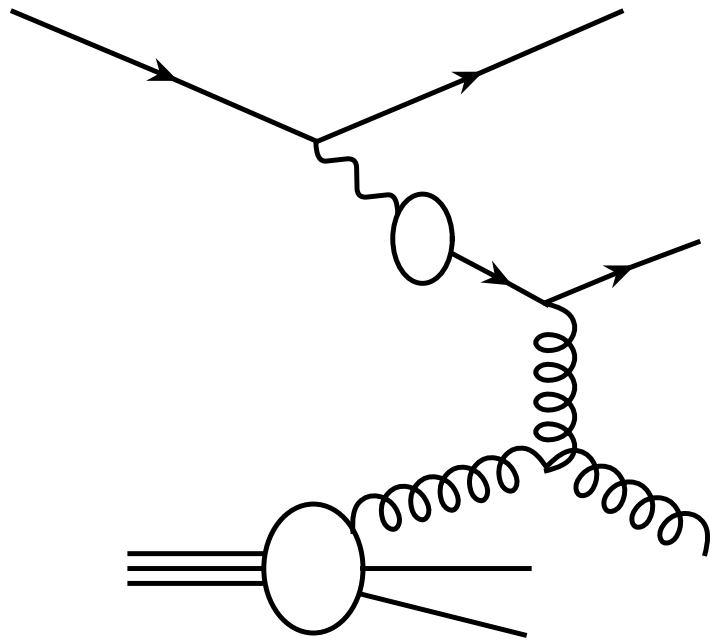

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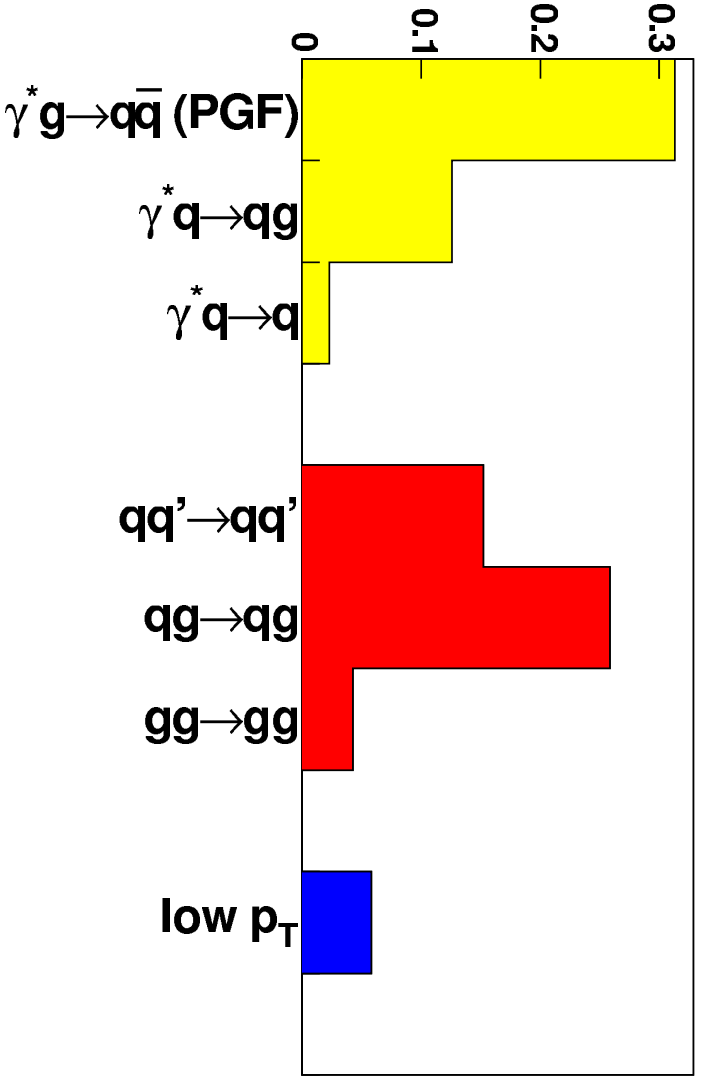

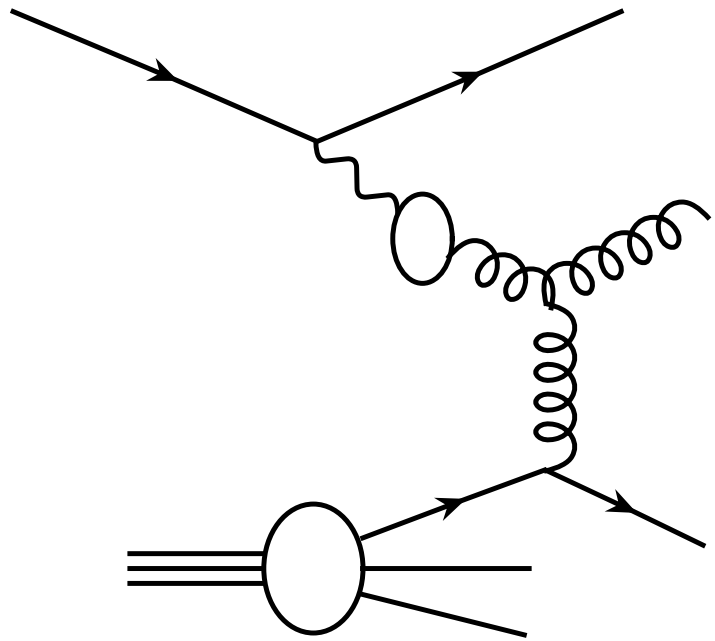

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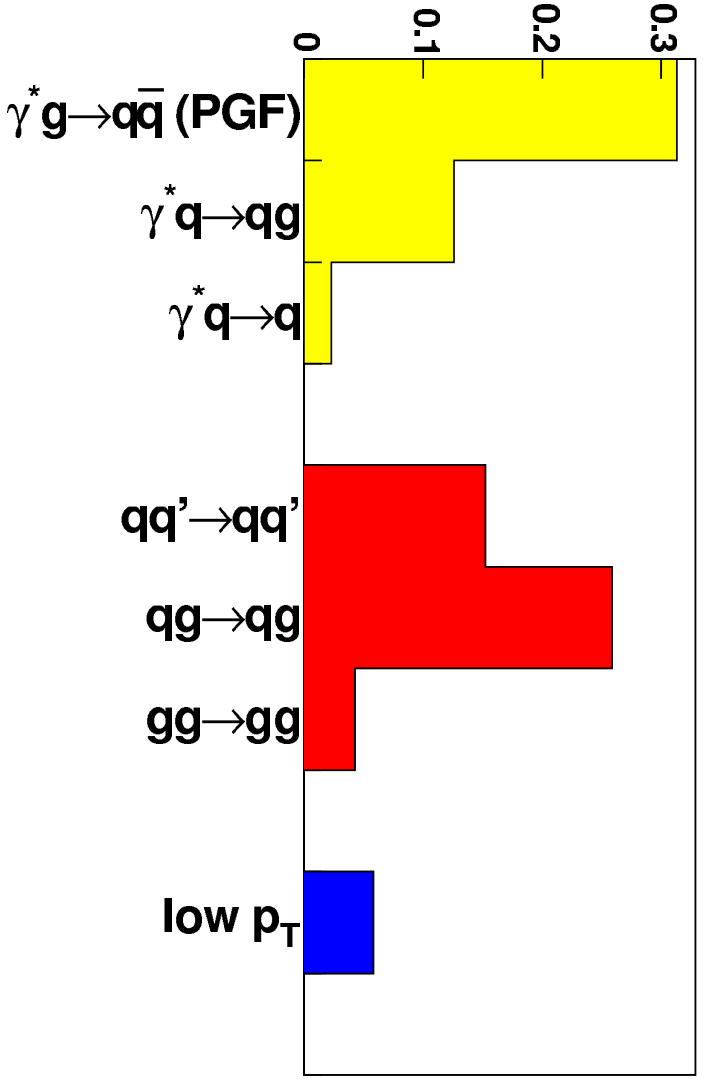
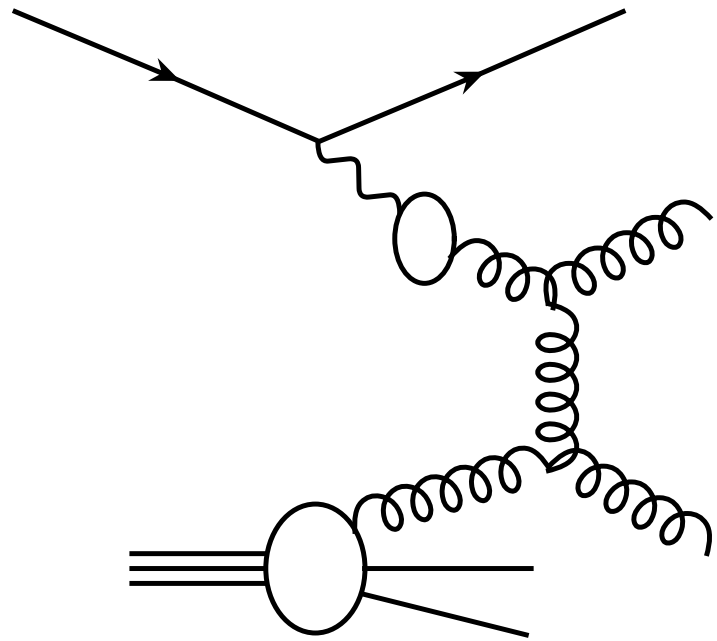
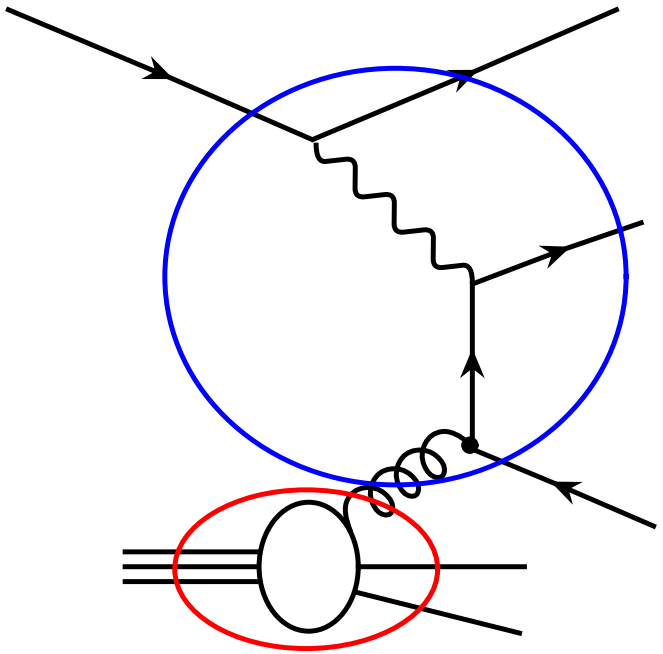


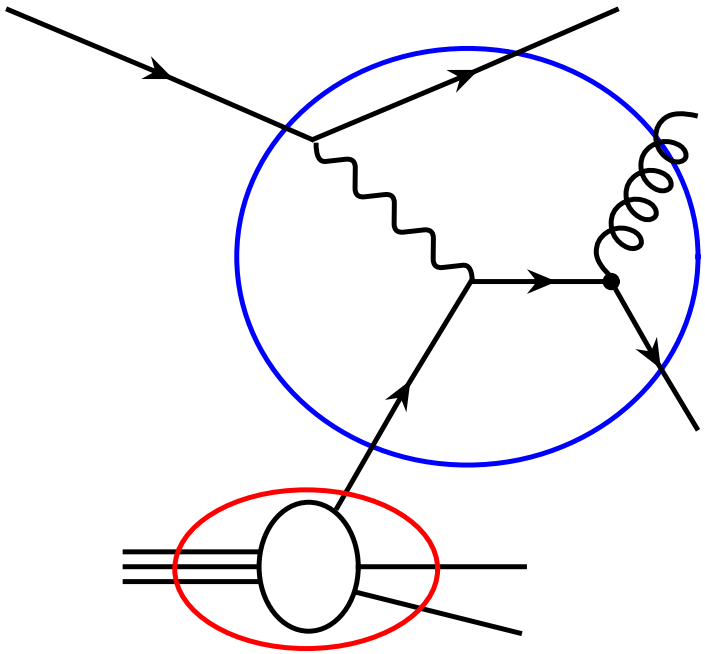


Contributions to the asymmetry



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

Contributions to the asymmetry



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

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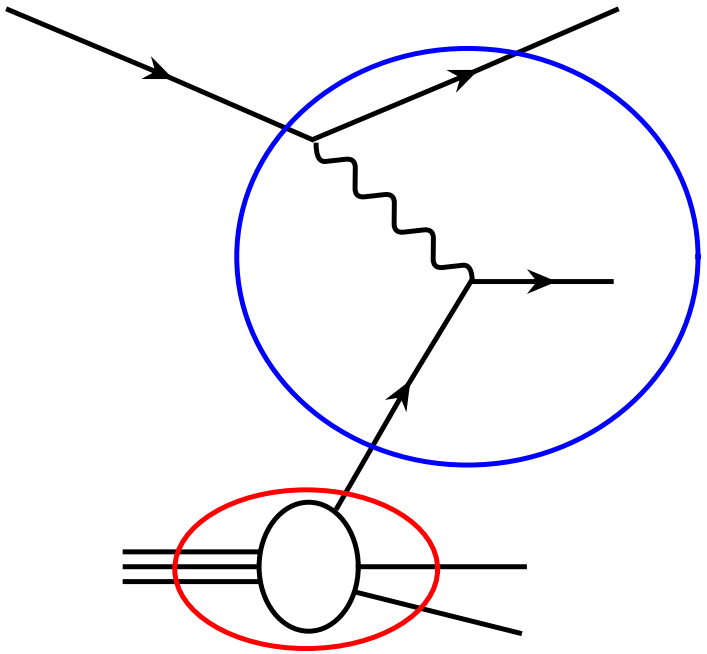

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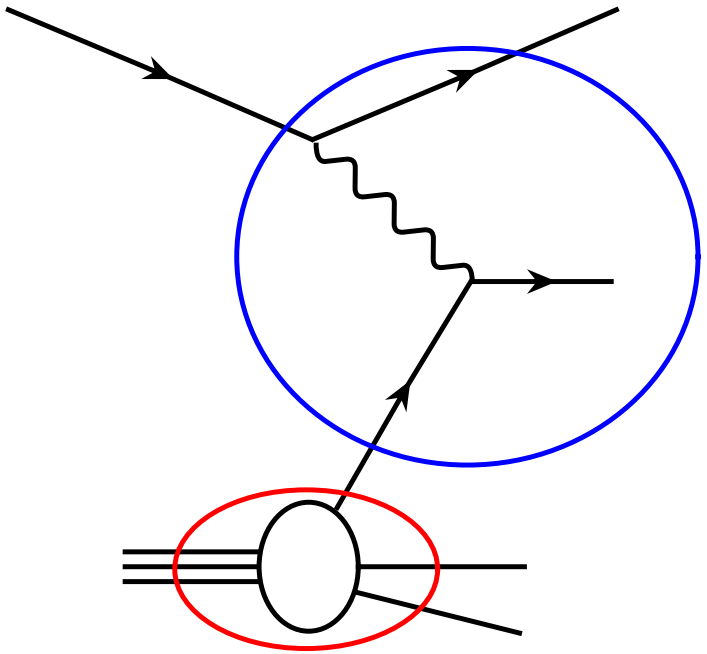

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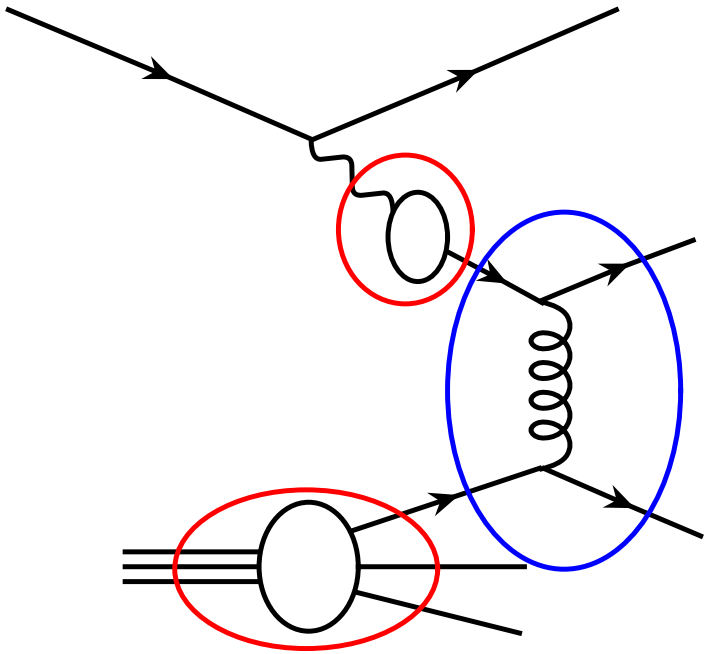

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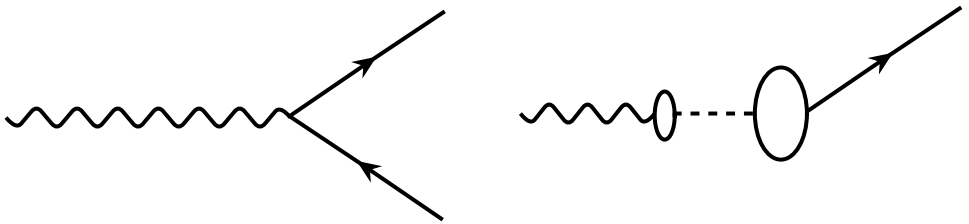
$$+ R_{qcdc}\left\langle \frac{\hat{a}_{qcdc}}{D} \right\rangle \left(\frac{\Delta q}{q}\right)^{d}$$

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

$$+ \ldots$$

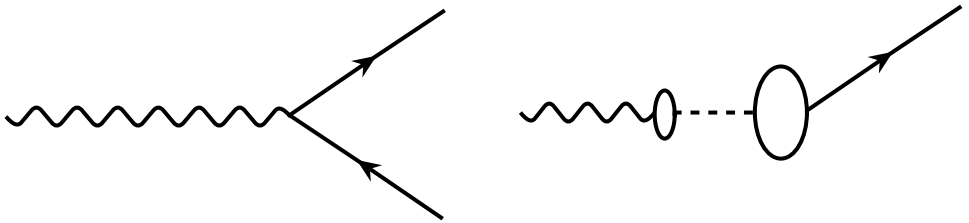
Quarks polarization in the photon $\left(\frac{\Delta q}{q}\right)^{\gamma}$



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

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

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



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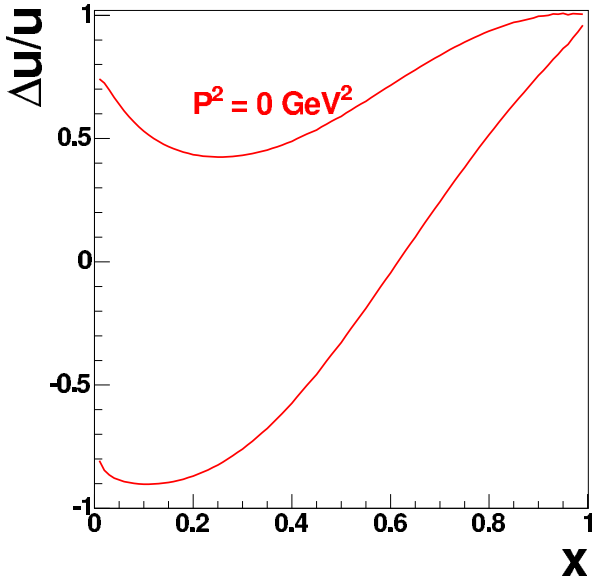

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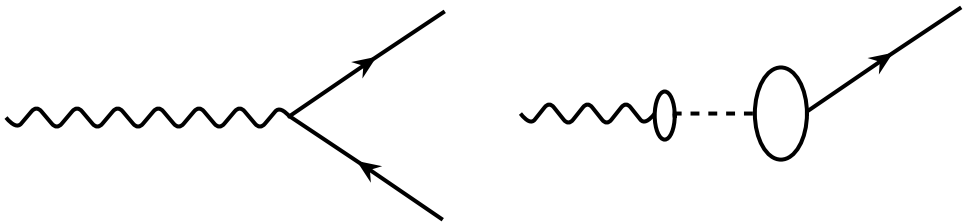
(Glück, Reya, Sieg)

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



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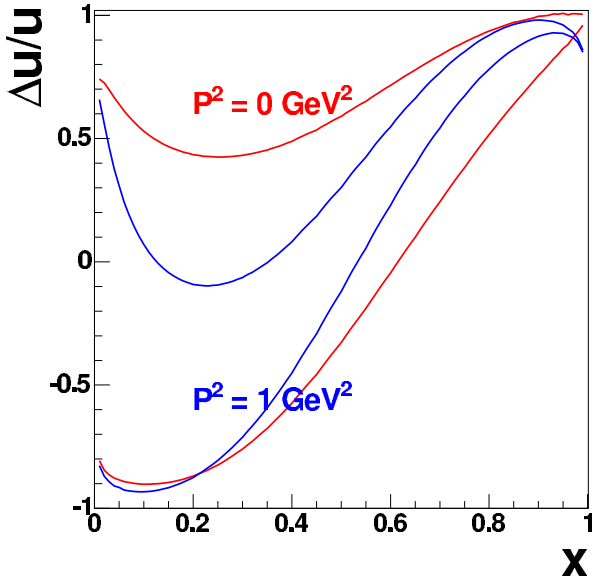

- $\Delta q^{\gamma}_{q\bar{q}}$: QED+QCD
- min and max scenarios:
  $-q^{\gamma}_{VMD} \leq \Delta q^{\gamma}_{VMD} \leq q^{\gamma}_{VMD}$

(Glück, Reya, Sieg)

Systematic error associated to the Monte-Carlo

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

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

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.

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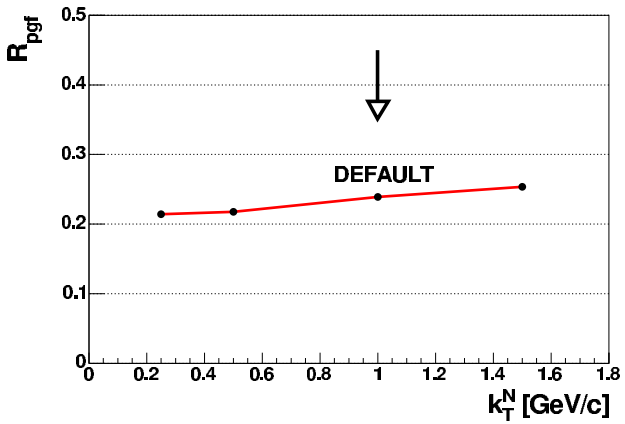
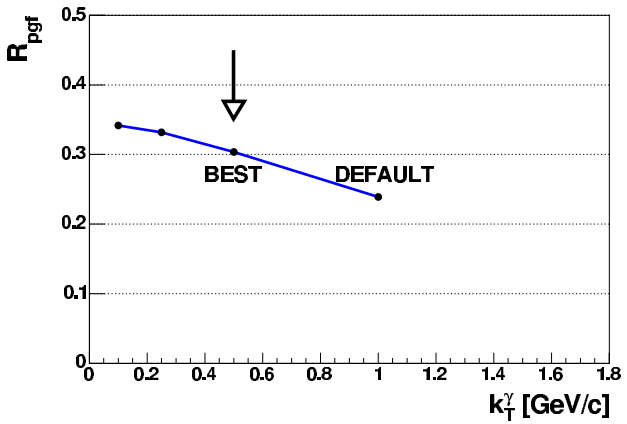
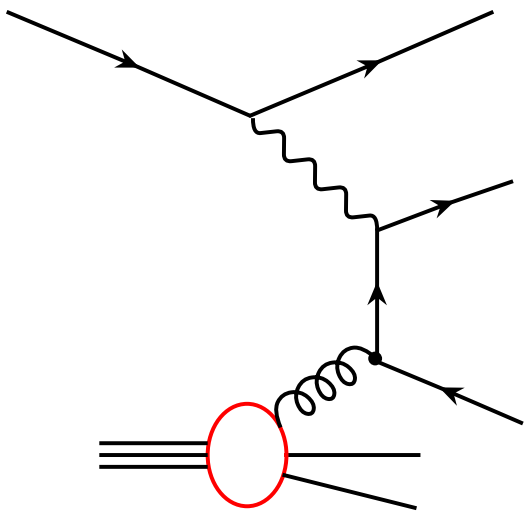
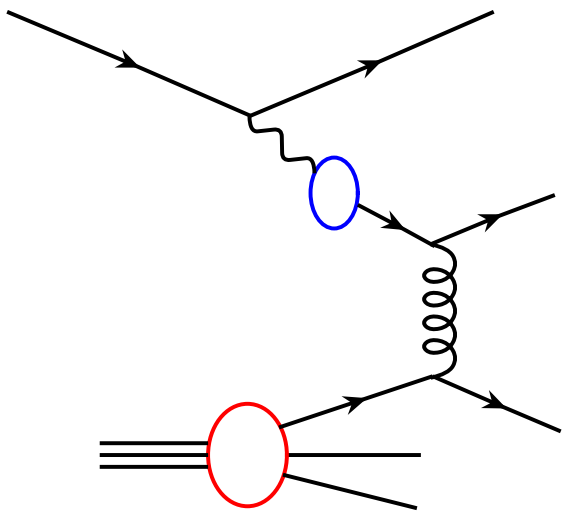
Systematics: k_T^N et k_T^γ









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

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

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

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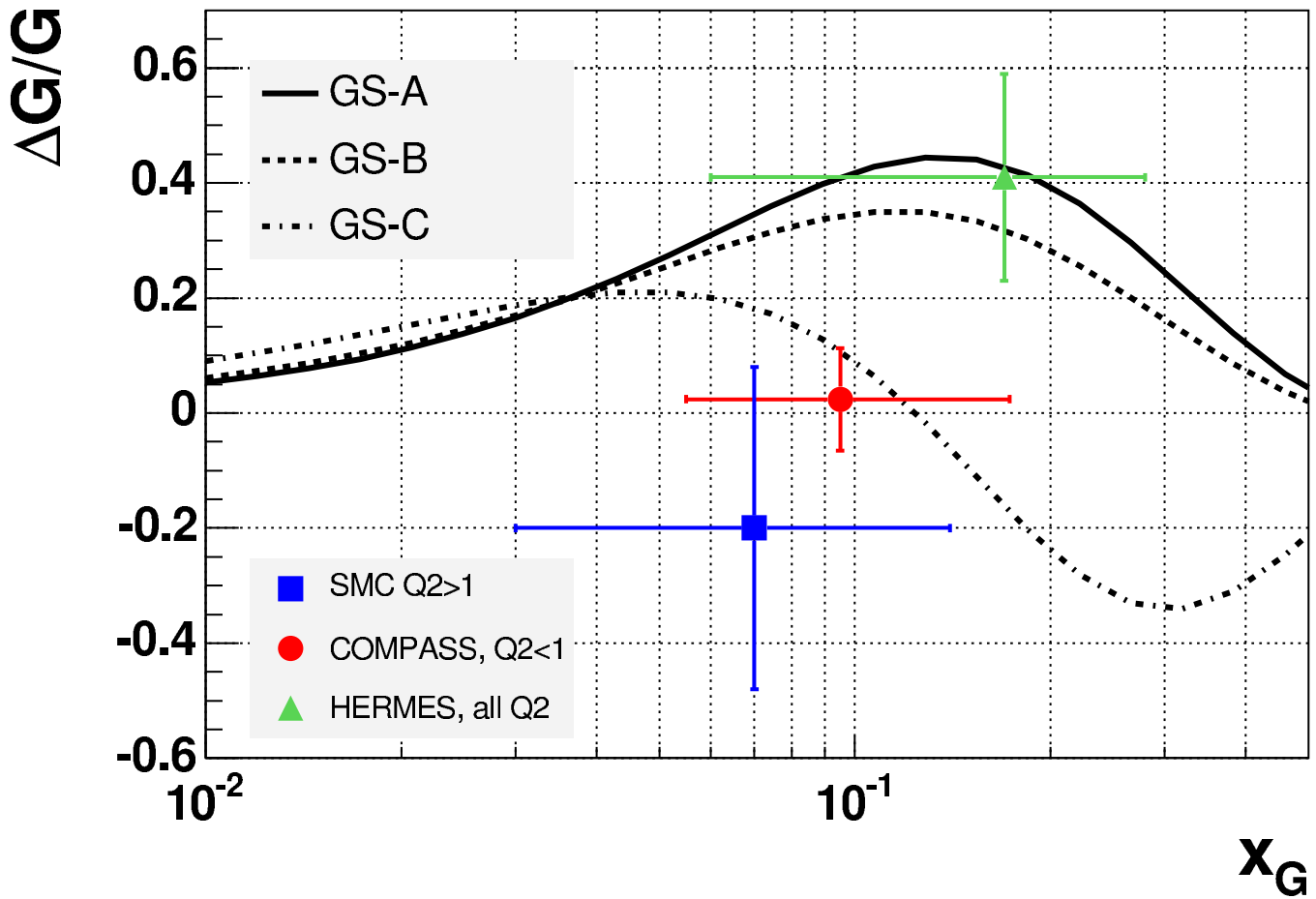
2002+2003 data



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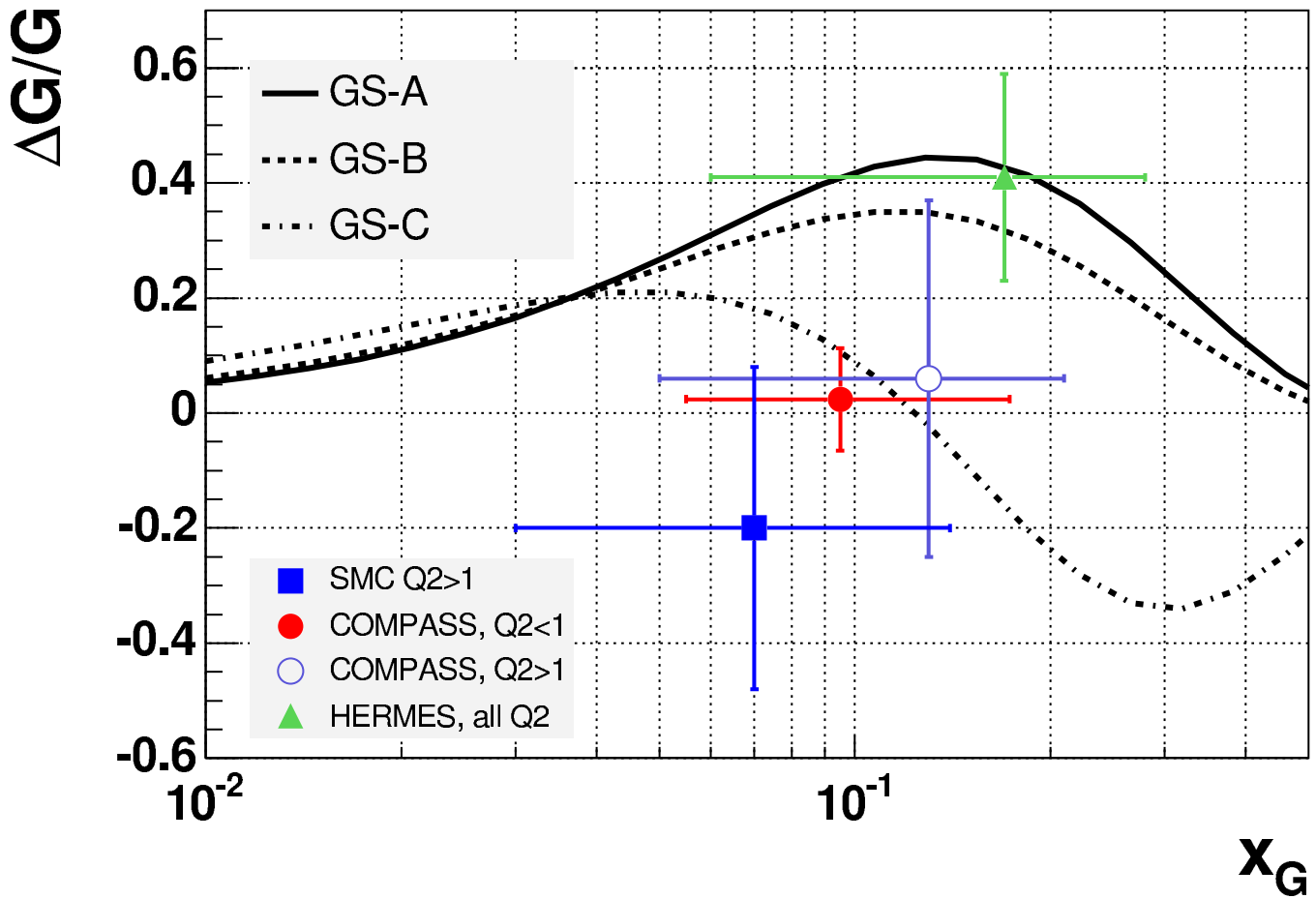

Conclusion

2002+2003 data, $Q^2 < 1$ GeV^2

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

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

Outlook

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