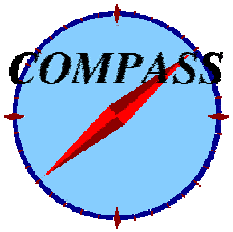


The COMPASS spin physics program

Stefano Panebianco (CEA/Saclay)

on behalf of the COMPASS Collaboration

XXXXth Rencontres de Moriond

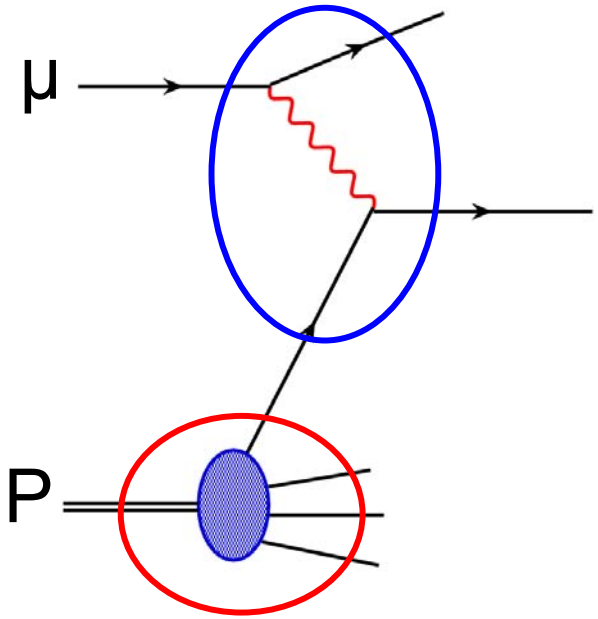
QCD and High Energy Hadronic Interactions

La Thuile, March 12th -19th 2005

Overview

- Spin structure of the nucleon
- Polarized quark PDF
- Gluon polarization
  - High p_t hadron pair leptoproduction
  - Open charm leptoproduction
- Transversity
- Conclusions

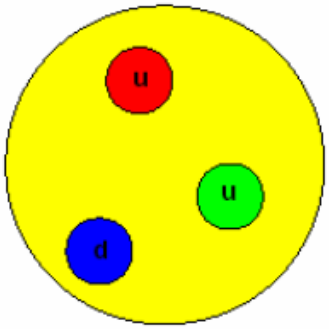
Nucleon parton distributions



- Unpolarized DIS :
  $q(x,Q^2)$ and $g(x,Q^2)$

- Here Polarized DIS :
  $\Delta q = q^{\uparrow\uparrow} - q^{\uparrow\downarrow}$, $\Delta G = g^{\uparrow\uparrow} - g^{\uparrow\downarrow}$

The spin of the nucleon

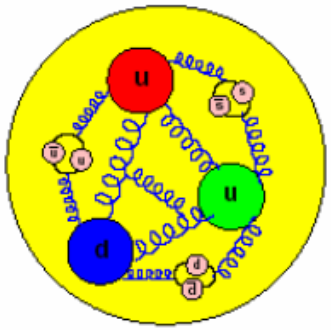


The theory (QM – EJ):

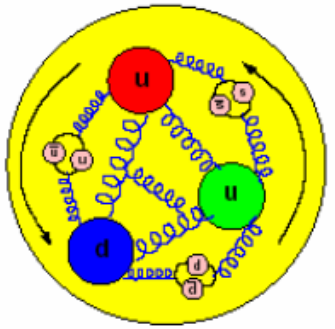
$$\Delta\Sigma = \Delta u + \Delta d + \Delta s \approx 0.6$$

EMC (1988):

$$\Delta\Sigma = 0.12 \pm 0.09 \pm 0.14$$



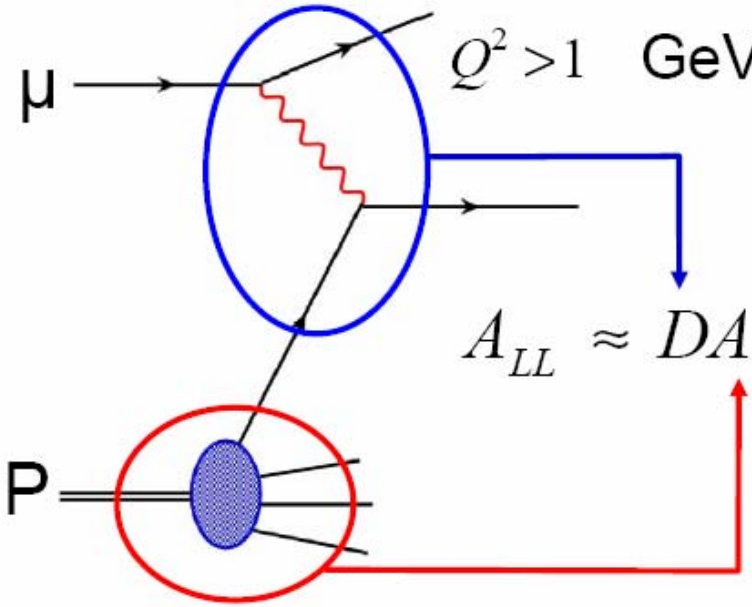
Gluons are important
In the polarized case



Complete description:
orbital angular momenta

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

Deep inelastic scattering



detect scattered lepton only ⇒ inclusive

$$A_{LL} \approx DA_1 \approx D\frac{g_1}{F_1}$$

$$A_{LL} = D(A_1 + \eta A_2)$$

$$A_1 = \frac{g_1 - (4M^2x^2/Q^2)g_2}{F_1}$$

$$Q^2 = -q^2$$

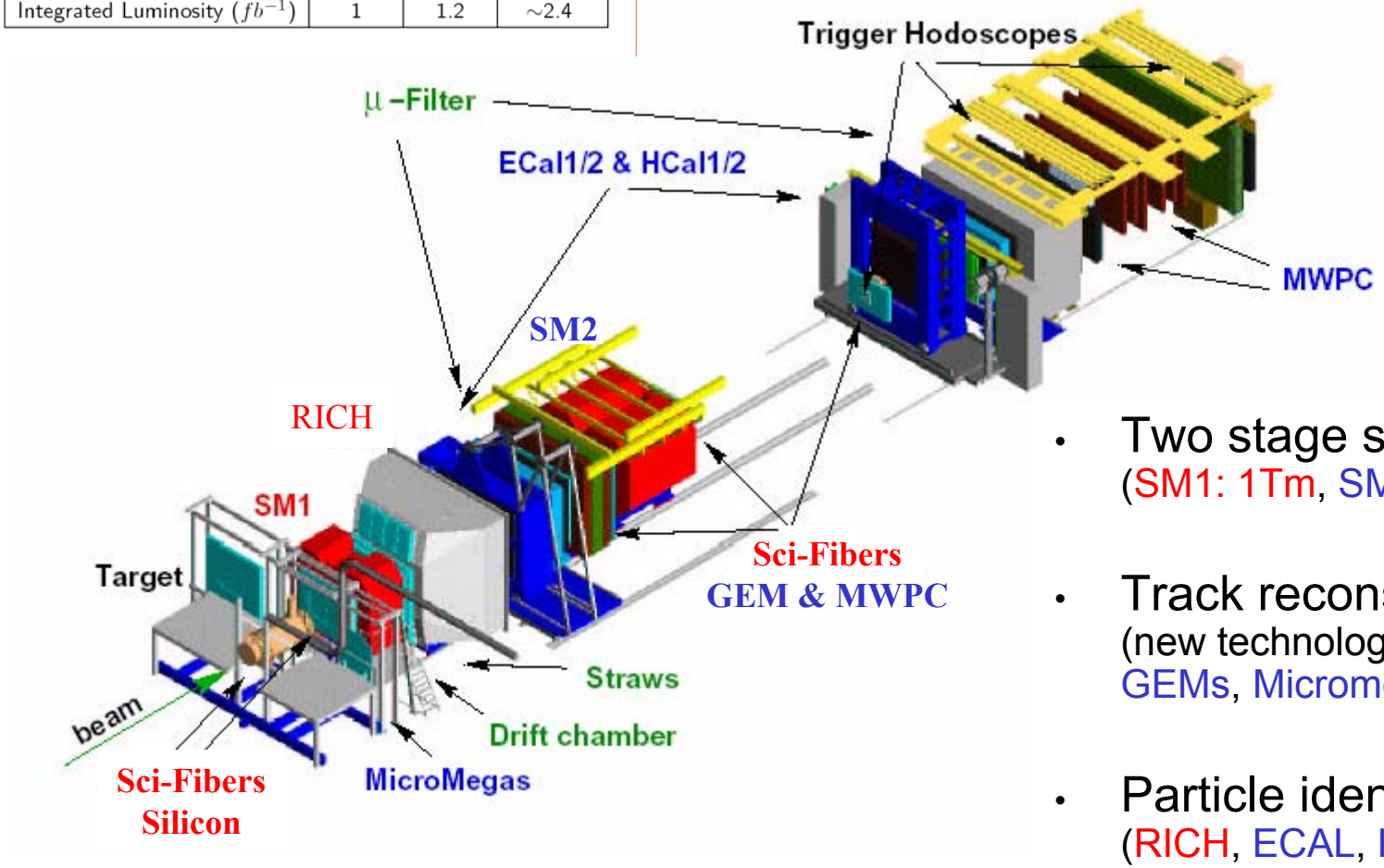
$$x_{bj} = \frac{Q^2}{2Pq}$$

$$\frac{d^2\sigma}{d\Omega dE} = \frac{\alpha^2 E'}{Q^2 E} L_{\mu\nu} W^{\mu\nu}$$

$$\sim \underbrace{c_1 F_1(x,Q^2) + c_2 F_2(x,Q^2)}_{\text{spin independent}} + \underbrace{c_3 g_1(x,Q^2) + c_4 g_2(x,Q^2)}_{\text{spin dependent}}$$

The COMPASS spectrometer

	2002	2003	2004
Days	70	83	106
Integrated Luminosity (fb^{-1})	1	1.2	~2.4



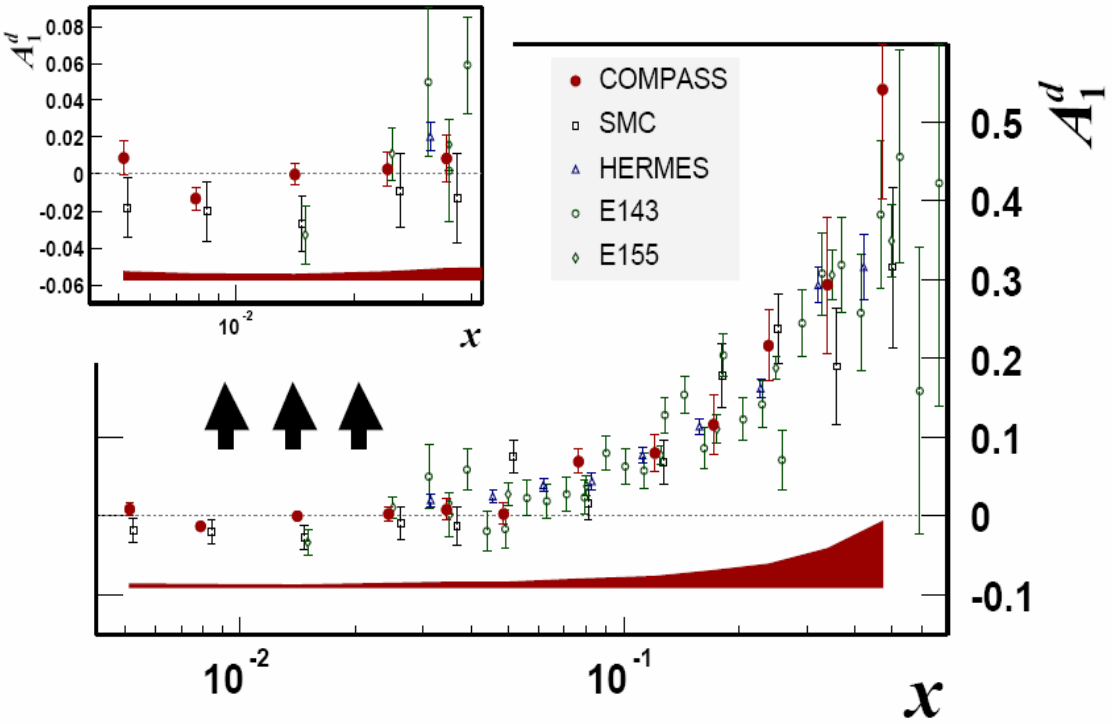
- Two stage spectrometer
  (SM1: 1Tm, SM2: 5.2 Tm)
- Track reconstruction
  (new technologies: Sci-Fibers, GEMs, Micromegas, straws)
- Particle identification
  (RICH, ECAL, HCALs, μFilters)

The inclusive asymmetry $A_1 \Longrightarrow \Delta q$

- γ-nucleon asymmetry:

$$A_1 = \frac{\Sigma e_q^2 (\Delta q + \Delta \bar{q})}{\Sigma e_q^2 (q + \bar{q})}$$

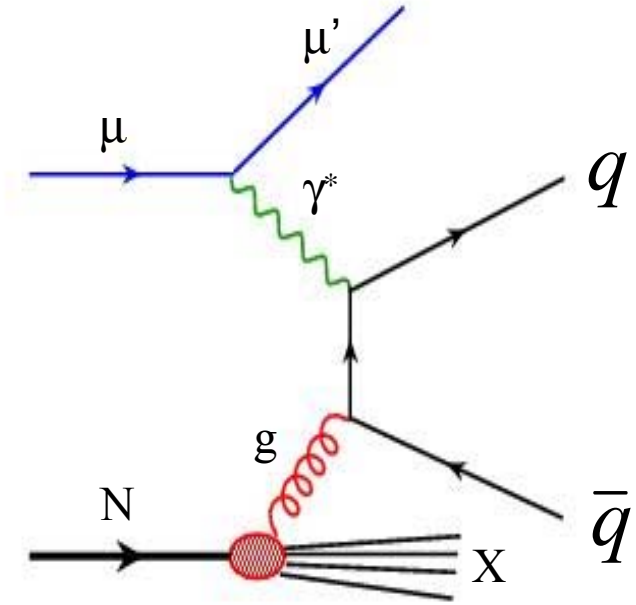
- COMPASS has:
  - high energy
  - high luminosity
  - high dilution factor for a solid state target
- $g_1 = A_1 F_1$
- Unique result in the low *x* region important to test QCD sum rules



(hep-ex/0501073, accepted Phys. Lett. B)

How to measure ΔG/G

Photon-Gluon Fusion (PGF)



$$A_{\mu N}^{PGF} = \langle a_{LL} \rangle \frac{\Delta G}{G}$$

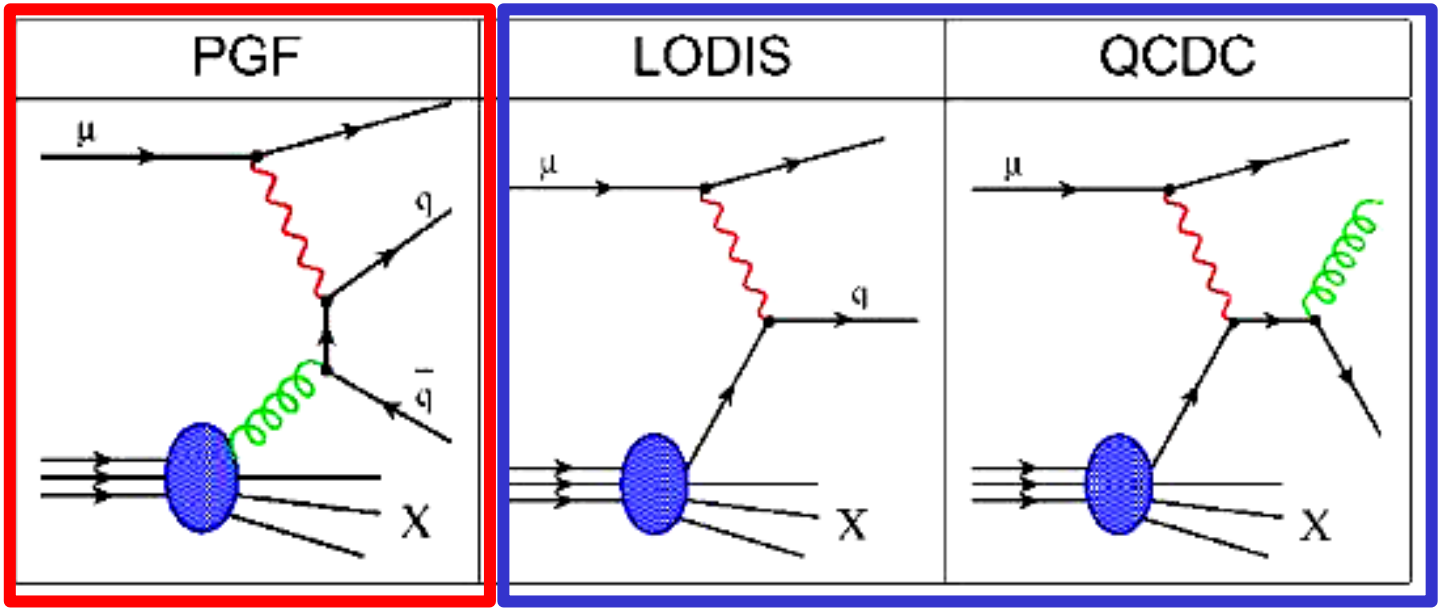
$$a_{LL} = \frac{\Delta\sigma_{\gamma g}^{c\bar{c}}}{\sigma_{\gamma g}^{c\bar{c}}}(y, \hat{s}, Q^2, \Phi)$$

Two tagging methods:

-High p_t hadron pairs

-Open charm

High p_t hadron pair production @ $Q^2>1$



$$A^{\mu N\to hhX} = \frac{\Delta G}{G}\left\langle \hat{a}_{LL}^{pgf}\right\rangle \frac{\sigma_{pgf}}{\sigma_{tot}} + A_1^d\left(\left\langle \hat{a}_{LL}^{LO}\right\rangle \frac{\sigma_{LO}}{\sigma_{tot}} + \left\langle \hat{a}_{LL}^{QCDC}\right\rangle \frac{\sigma_{QCDC}}{\sigma_{tot}}\right)$$

$$p_{T1}^2 + p_{T2}^2 > 2.5\ \text{GeV}^2$$

to reduce LODIS

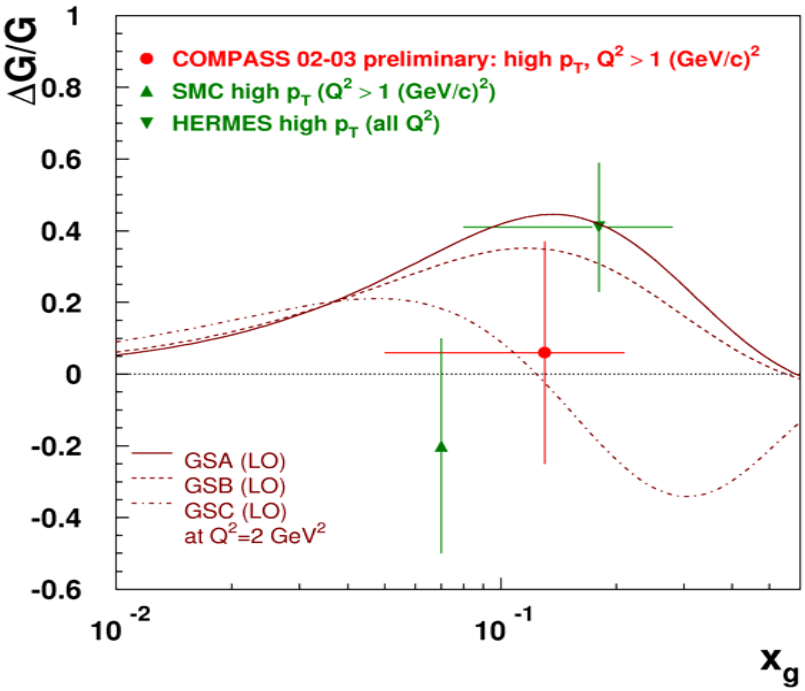
From Monte-Carlo

$\Delta G/G$ from high p_t hadron pair, $Q^2 > 1$

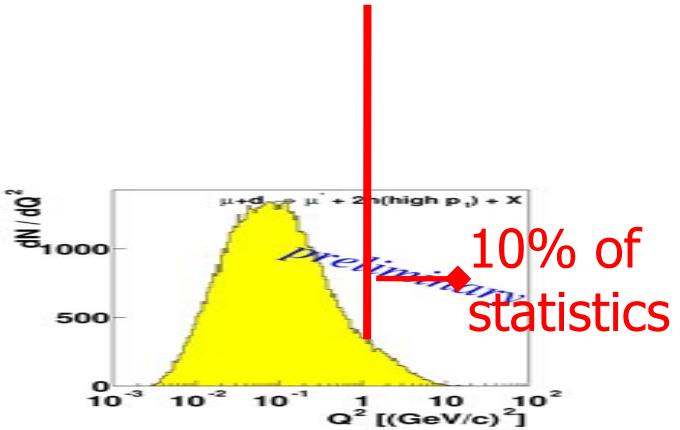
2002/2003 data:

$A_{||}/D = -0.015 \pm 0.080\ (stat.) \pm 0.013\ (syst.)$

$$\Delta G/G = 0.06 \pm 0.31_{stat.} \pm 0.06_{syst.}$$

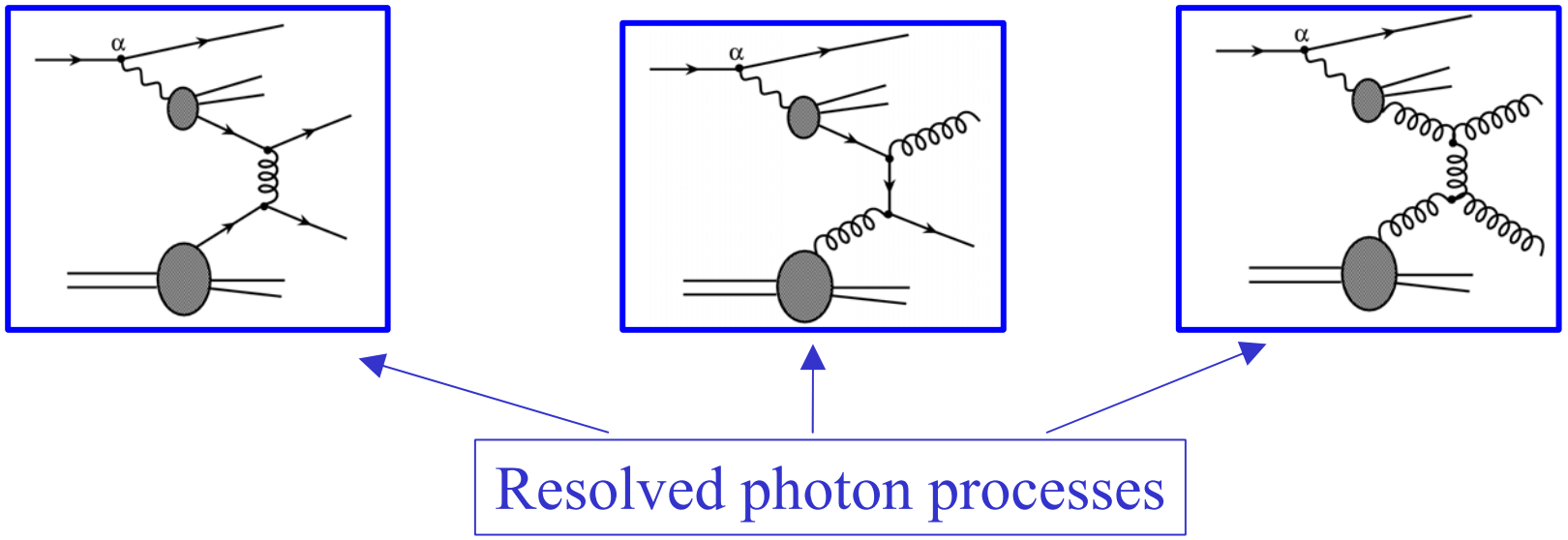


BUT...



$\Delta G/G$ from high p_t hadron pair, all Q^2

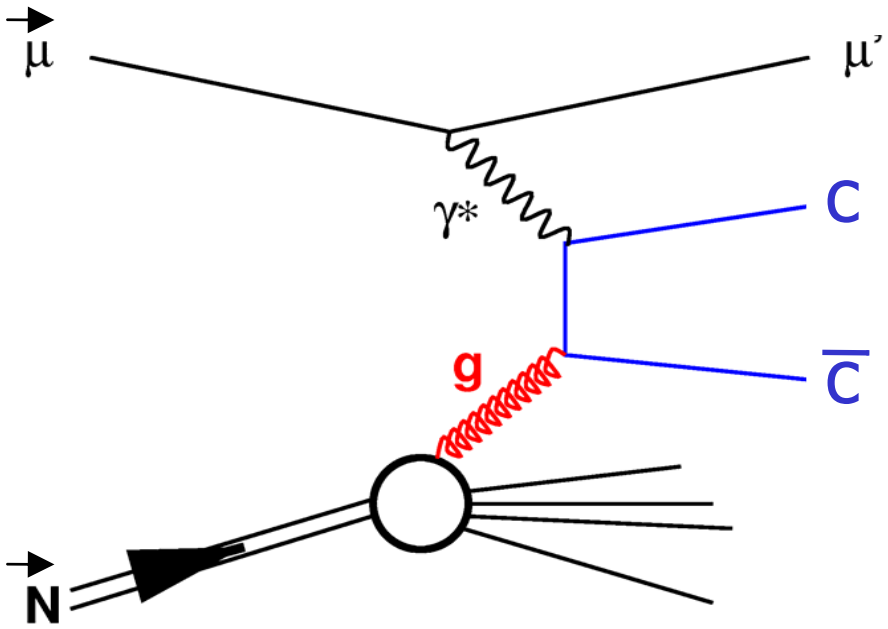
At $Q^2 < 1$ ⟹ additional background



High statistics

Projection for 2002-2004 data (all Q^2) ➡ $\delta(\Delta G/G) = 0.05$

ΔG/G from open charm

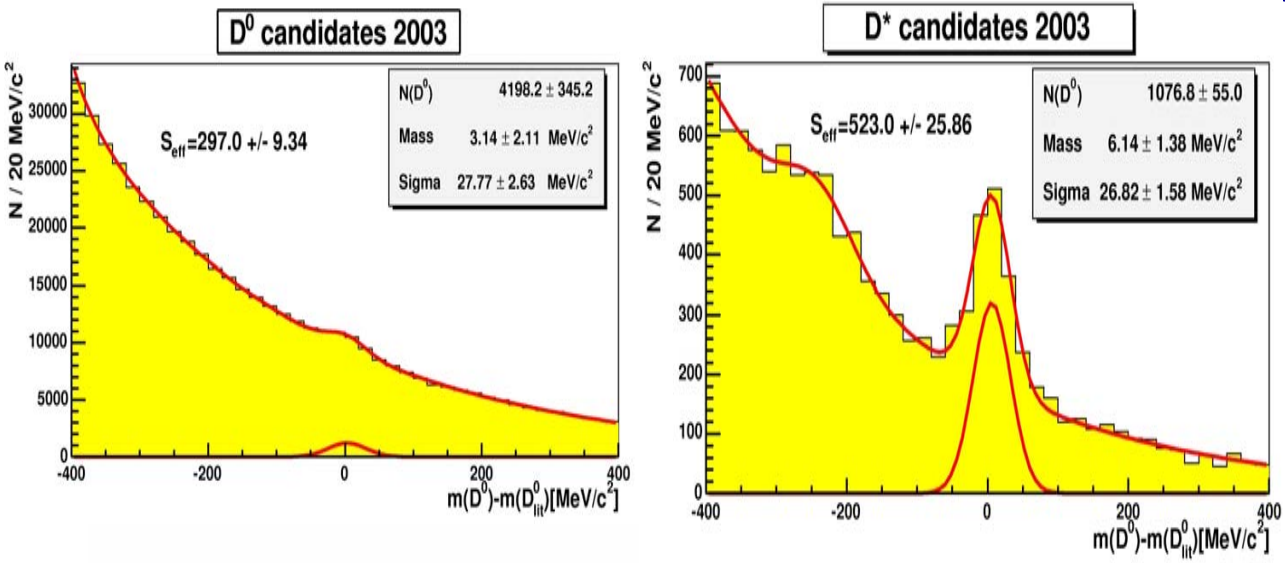


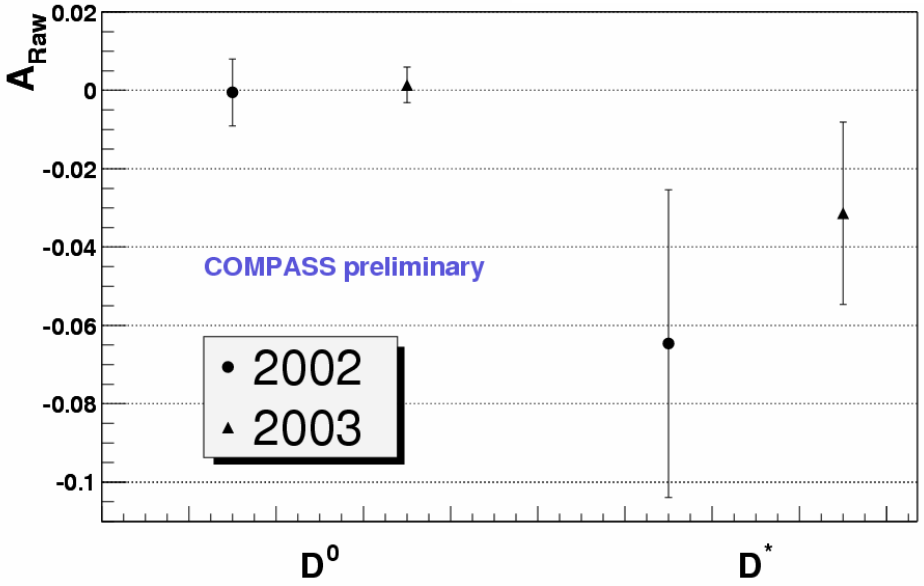
$D^0 \rightarrow K^- \pi^+$ (BR 4%)

$D^{*+} \rightarrow D^0 \pi^+ + \text{c.c.}$

$$A_{\gamma N}^{c\bar{c}} = \langle a_{LL} \rangle \frac{\Delta G}{G}$$

Open charm raw asymmetry



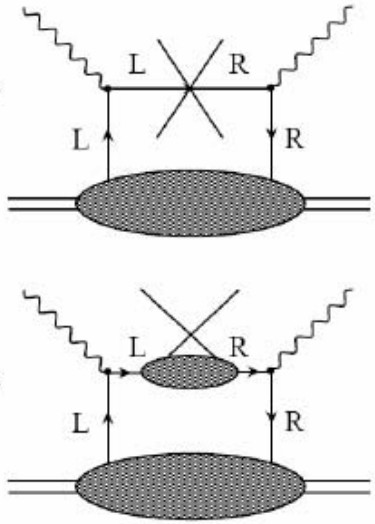


$$A_{Raw}^{m} = \frac{N_m^{\uparrow\downarrow} - N_m^{\uparrow\uparrow}}{N_m^{\uparrow\downarrow} + N_m^{\uparrow\uparrow}} = \frac{S}{S+B}\langle P_\mu P_T f a_{LL}\rangle \frac{\Delta G}{G}$$

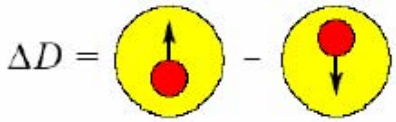
S. Panebianco

Measurement of the quark transversity

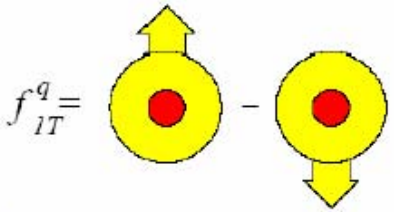
- Transversity is the third PDF of the quark: helicity flip of a transversely polarised quarks in a transversely polarised nucleon.
- It cannot be measured in inclusive DIS as quark helicity must flip → Semi inclusif DIS



- Measure polarisation of struck quark, e.g. by measuring azimuthal asymetries of produced hadrons ⟹ Collins effect



- Another asymetry can come from unpolarised quarks with transverse momentum ⟹ Sivers effect

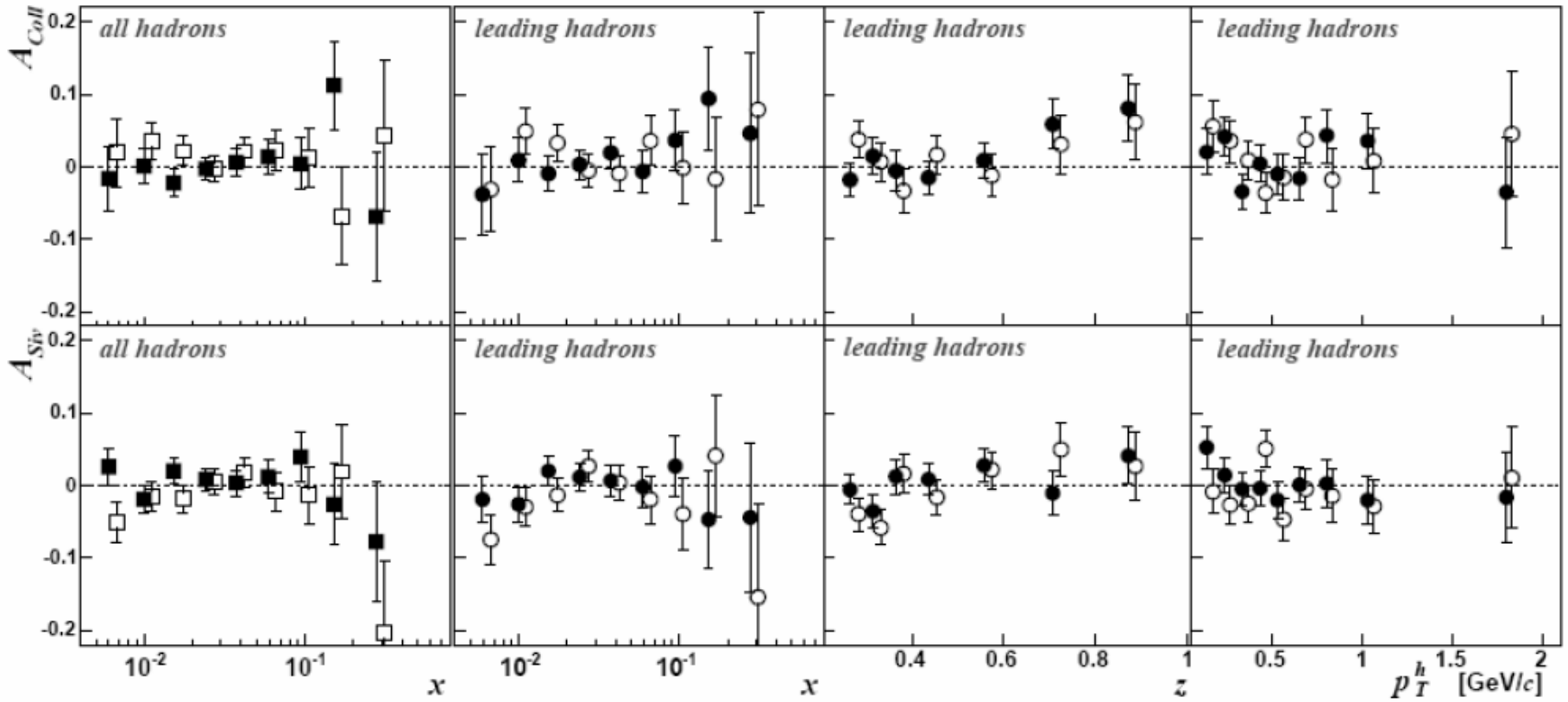


Collins and Sivers asymmetries

(hep-ex/0503002)

$$A_T^h \sim \ldots \boxed{\sin(\phi+\phi_s-\pi)} \frac{\sum_i e_i^2 \Delta_T q_i(x) \Delta D_{q_i}^h(z)}{\sum_i e_i^2 q_i(x) D_{q_i}^h(z)} \quad \text{Collins–Effect}$$

$$+\ldots \boxed{\sin(\phi-\phi_s)} \frac{\sum_i e_i^2 f_{1T}^{\perp i}(x) D_{q_i}^h(z)}{\sum_i e_i^2 q_i(x) D_{q_i}^h(z)} \quad \text{Sivers–Effect}$$



Conclusions

- COMPASS is very well contributing to the understanding of the nucleon structure
- High precision inclusive asymmetry measurement in the low x region
- COMPASS first measurement of $\Delta G/G$ from high p_t
- Unique possibility to measure $\Delta G/G$ from open charm
- Big effort in searching signals of transversity
- More results to come very soon on
  - $\Delta G/G$ from high p_t (all Q^2)
  - $\Delta G/G$ from open charm
- We look forward a long and successful beam time in 2006