Determination of the gluon polarisation

in ***COMPASS*** experiment @ CERN

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on behalf of the COMPASS collaboration

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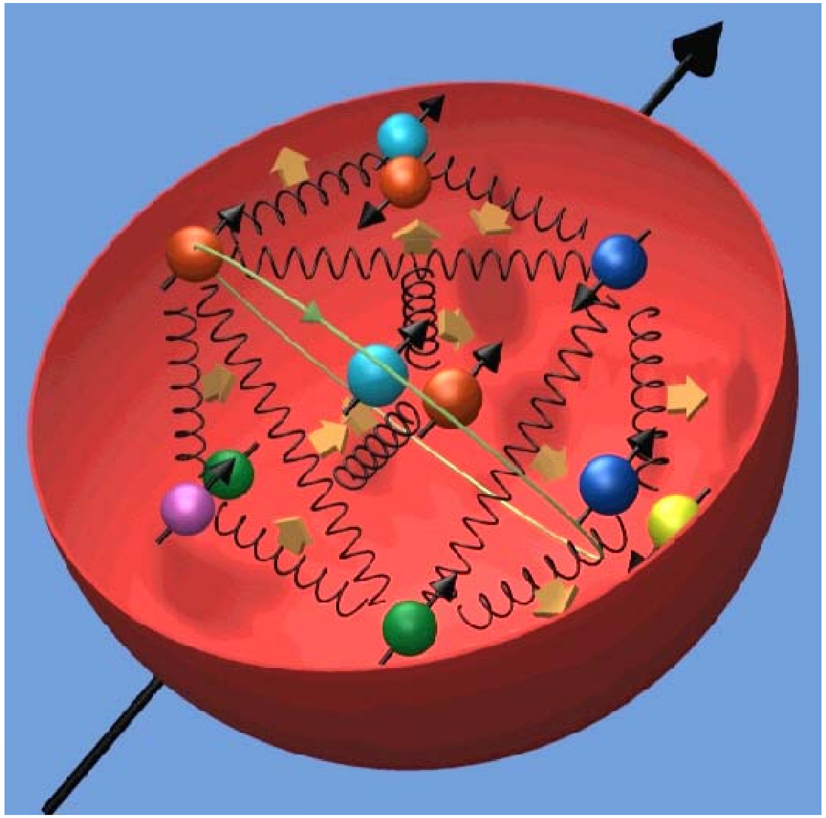
Nucleon spin structure



$$\frac{1}{2} = \Delta\Sigma + \Delta G + L_{q,g}$$

quarks

gluons

orbital momentum

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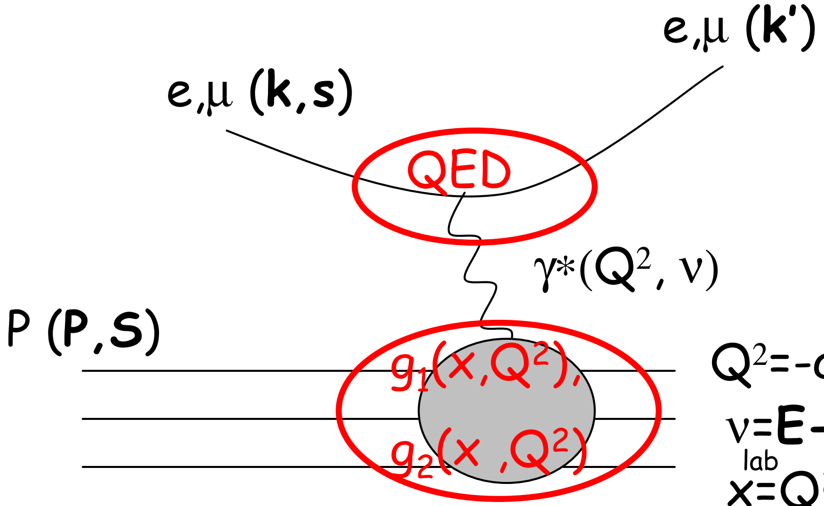
Quarks polarisation

Evaluated from the spin structure function $g_1(x)$ measured in Deep Inelastic Scattering of polarised lepton on the polarised nucleon :



Q^2=-q^2=-(**k**-**k'**)^2

ν=E-E'$_{lab}$

x=$Q^2/2M\nu$

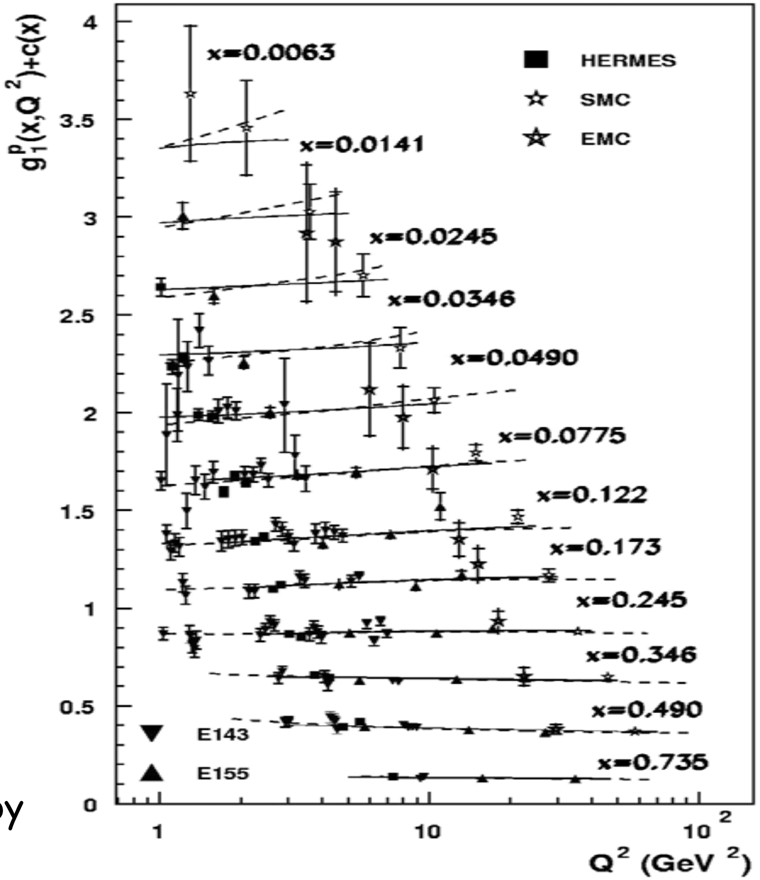
$$d\sigma_{\|} \propto g_1(x,Q^2), g_2(x,Q^2)$$

Assuming Quark Parton Model:

$$g_1(x,Q^2) = \frac{1}{2}\sum_{u,d,s} e_q^2 \Delta q(x,Q^2)$$

Proton momentum fraction carried by quark

$$\Delta q = q^{\rightarrow\Rightarrow} - q^{\leftarrow\Rightarrow}$$



$g_1(x,Q^2)$ world data (HERMES 2002)

"The spin crisis"

experiment $$g_1 \rightarrow a_0 \overset{PM}{=} \Delta\Sigma = 0.14 \pm 0.17$$

Measured at CERN, SLAC, DESY

Result from SMC fit to proton world data
At $Q^2 = 5 GeV^2$ *Phys Lett B320 405 (1994)*

theory $$\Delta\Sigma = \Delta q \approx 0.6$$

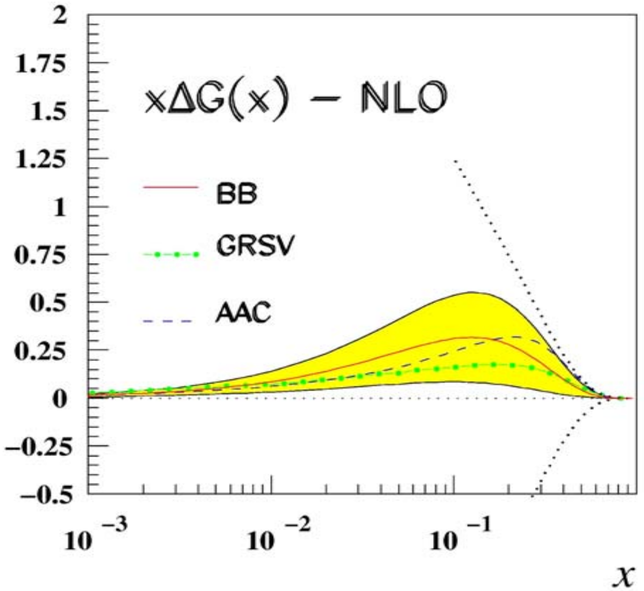
Ellis -Jaffe sum rule prediction

$$a_0 = \Delta\Sigma - \frac{3\alpha_s(Q^2)}{2\pi}\Delta G(Q^2)$$

According to triangle anomaly, there is no unambiguous way to separate the quark contribution and the anomalous gluonic contribution

Accesing gluon polarisation

From QCD evolution of $g_1(x)$ stucture function:



Fit to the $g_1(x,Q^2)$ world data, by Blümlein & Böttcher,

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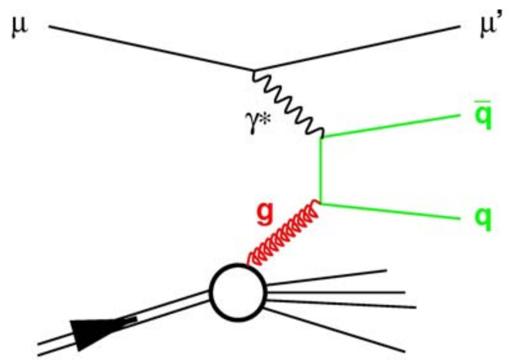
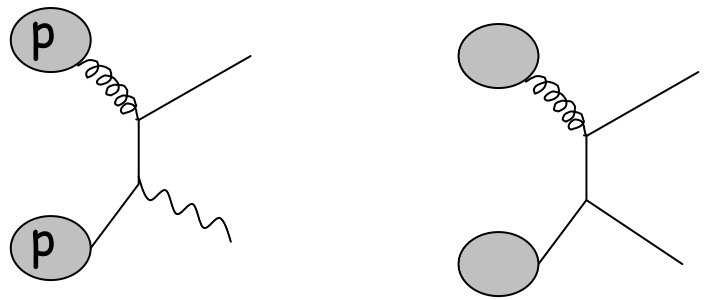
or from direct measurements

- Photon Gluon Fusion(SMC, HERMES,COMPASS)



- jets from polarised pp→2jets scattering (RHIC)

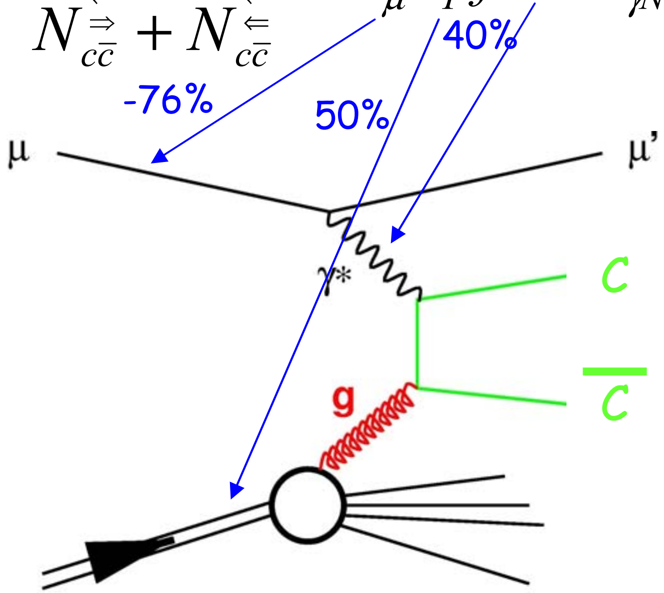


ΔG/G from open charm

$$A_{\gamma N}^{c\bar{c}} = \frac{\Delta\sigma^{\gamma N \to c\bar{c}X}}{\sigma^{\gamma N \to c\bar{c}X}} = \frac{\int d\hat{s}\, \Delta\sigma^{\mathrm{PGF}}(\hat{s})\,\Delta G(x_G,\hat{s})}{\int d\hat{s}\, \sigma^{\mathrm{PGF}}(\hat{s})\, G(x_G,\hat{s})} \approx \langle a_{LL} \rangle \left\langle \frac{\Delta G}{G} \right\rangle$$

$$\hat{s} = M_{c\bar{c}}^2$$

$$A_{LL} = \frac{N_{c\bar{c}}^{\overset{\leftarrow}{\Rightarrow}} - N_{c\bar{c}}^{\overset{\leftarrow}{\Leftarrow}}}{N_{c\bar{c}}^{\overset{\leftarrow}{\Rightarrow}} + N_{c\bar{c}}^{\overset{\leftarrow}{\Leftarrow}}} = P_\mu P_T f\, D\, A_{\gamma N}^{c\bar{c}}$$



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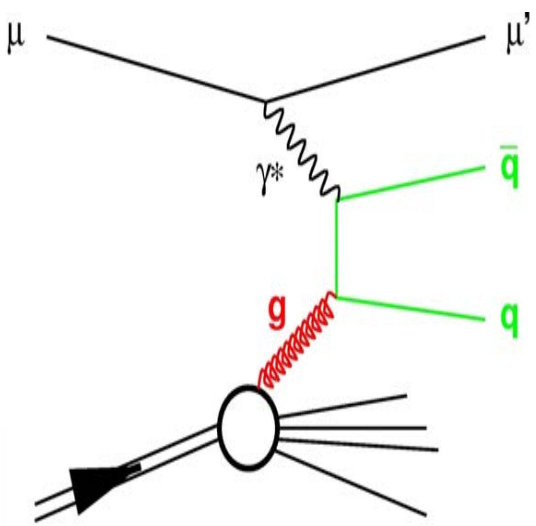
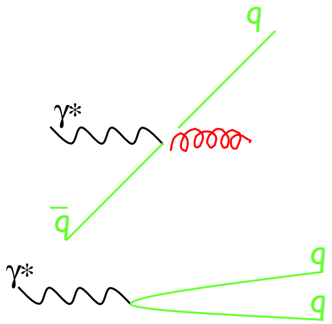
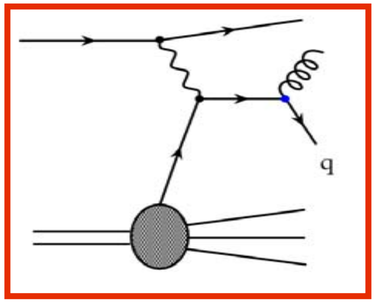
$\Delta G/G$ from high p_T hadrons

$$A^{\gamma^* d} = \frac{A_{LL}^{\mu N \to hh}}{D} \approx \left\langle \frac{\hat{a}_{LL}^{PGF}}{D} \right\rangle \left\langle \frac{\Delta G}{G} \right\rangle \frac{\sigma^{PGF}}{\sigma^{tot}} + \left\langle \frac{\hat{a}_{LL}^{Com}}{D} \right\rangle \left\langle \frac{\Delta q}{q} \right\rangle \frac{\sigma^{Com}}{\sigma^{tot}} + LO\,DIS$$

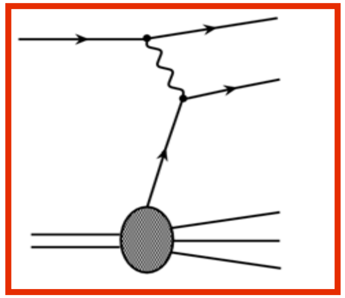


Photon Gluon Fusion



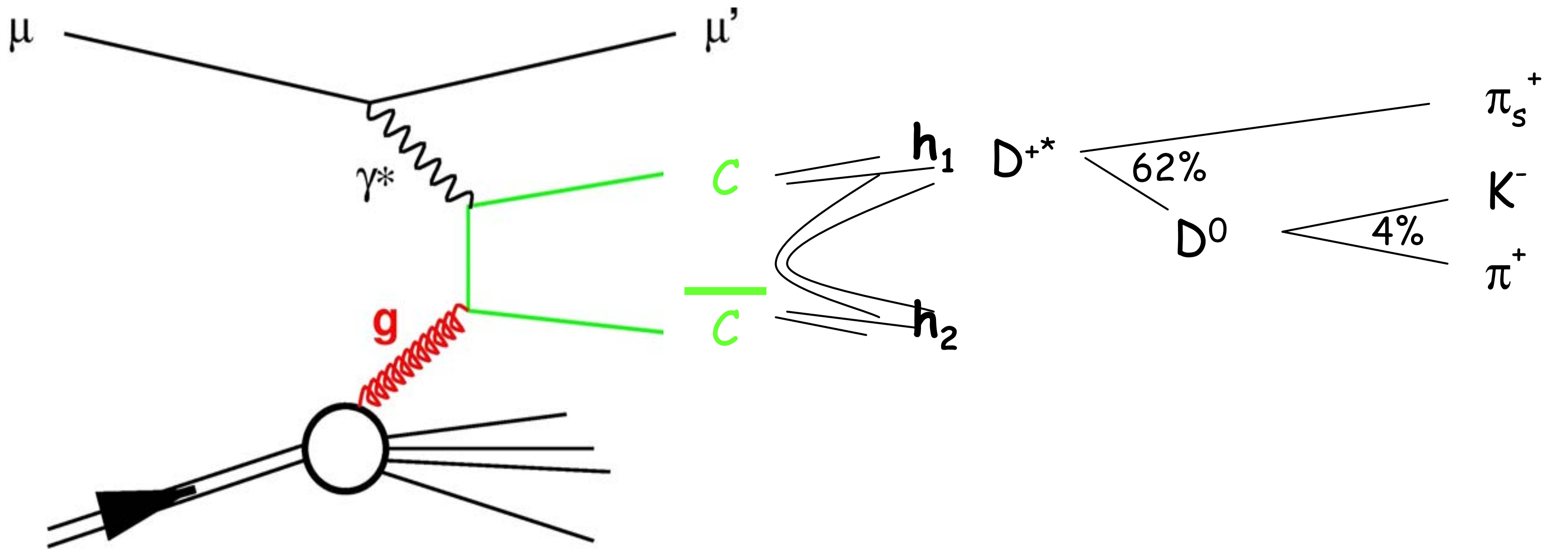


QCD-Compton



Leading Order

Photon Gluon Fusion



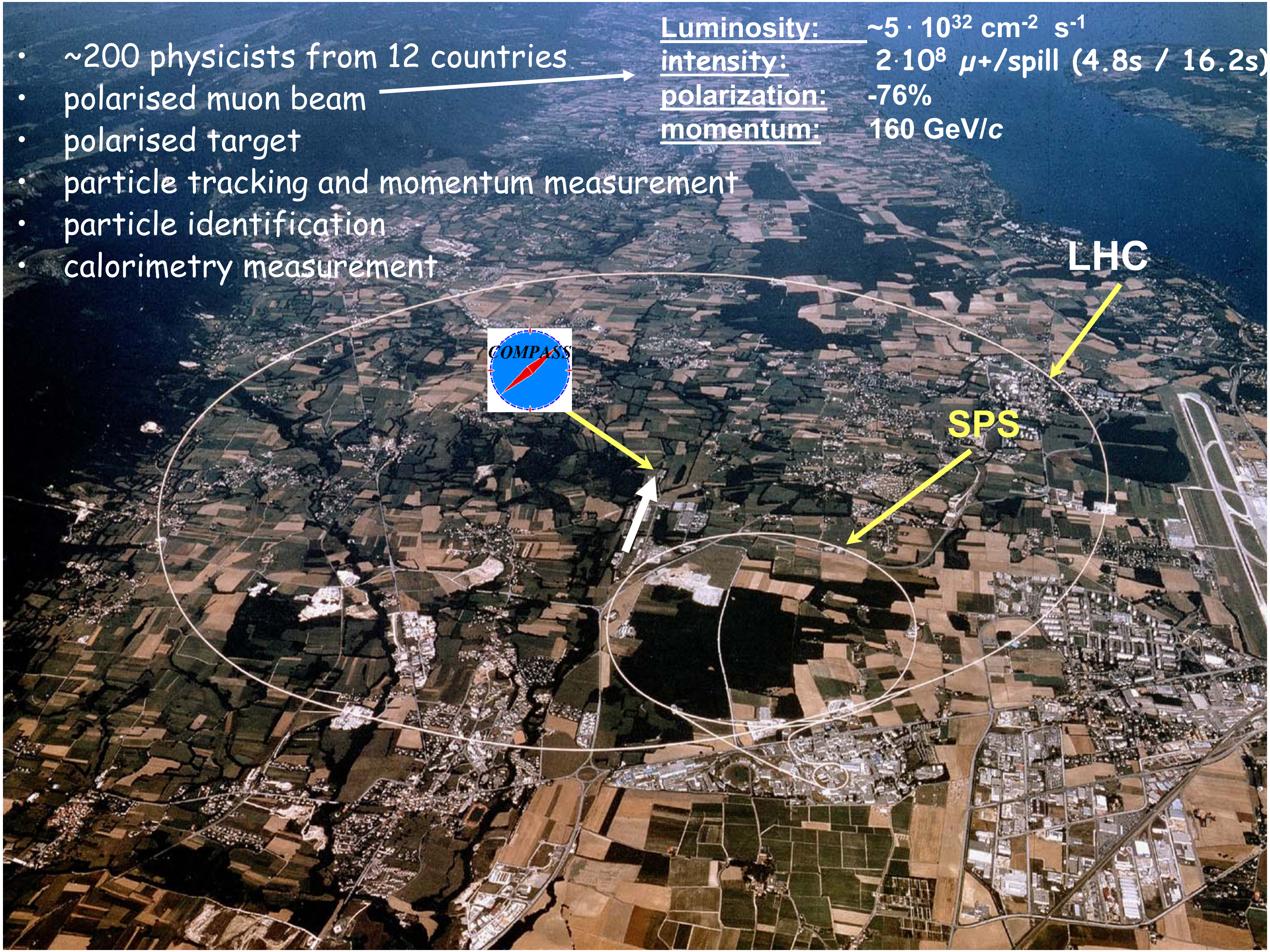
q=c, Open Charm Production

Looking for charged K and π

coming from D^0 and $D^{\pm *}$ decays

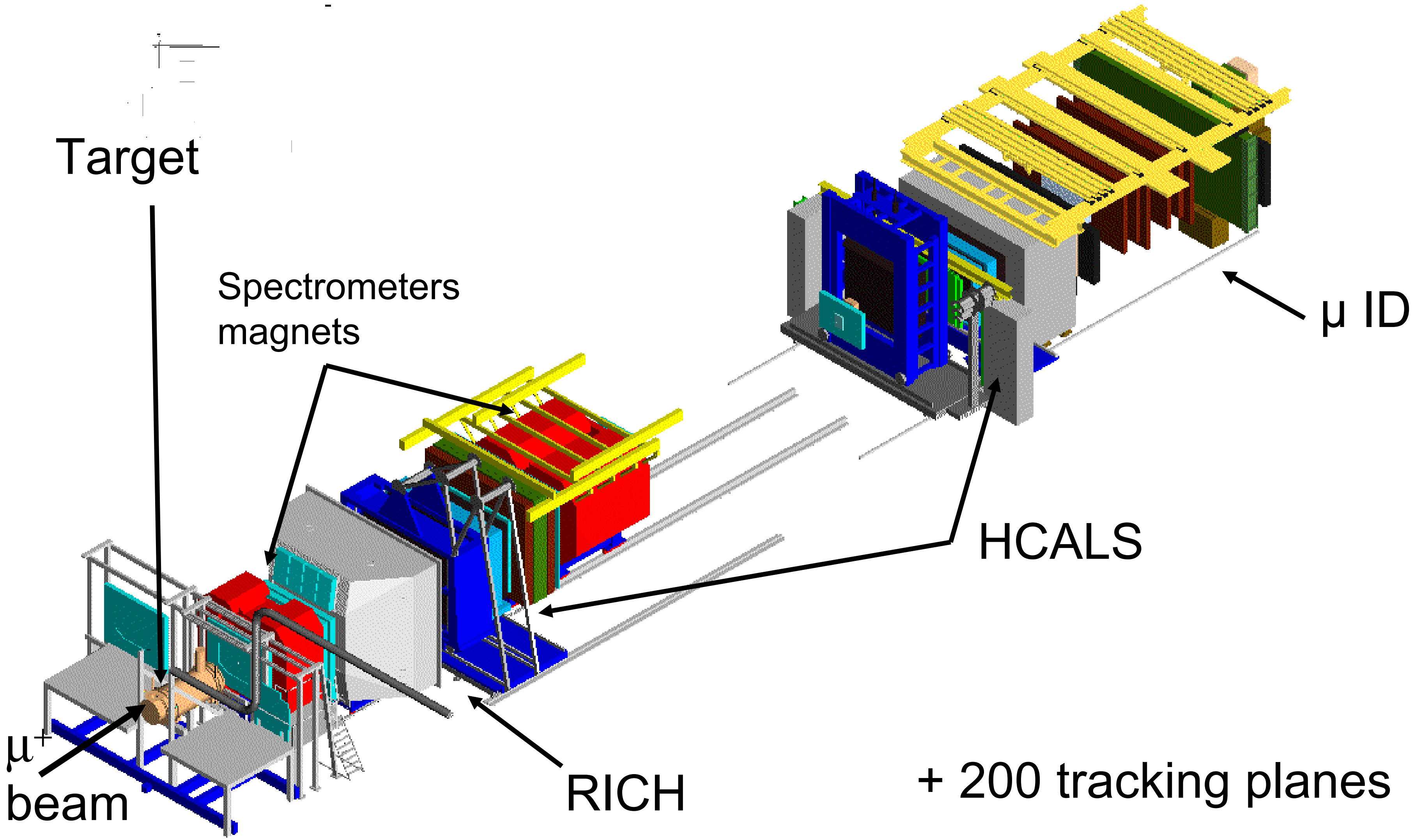
q =u,d,s,c at high p_T

Looking for high p_T hadron pairs



• ~200 physicists from 12 countries
• polarised muon beam
• polarised target
• particle tracking and momentum measurement
• particle identification
• calorimetry measurement
Luminosity: ~5 · 10^{32} cm^{-2} s^{-1}
intensity: 2·10^{8} μ+/spill (4.8s / 16.2s)
polarization: -76%
momentum: 160 GeV/c
COMPASS
LHC
SPS

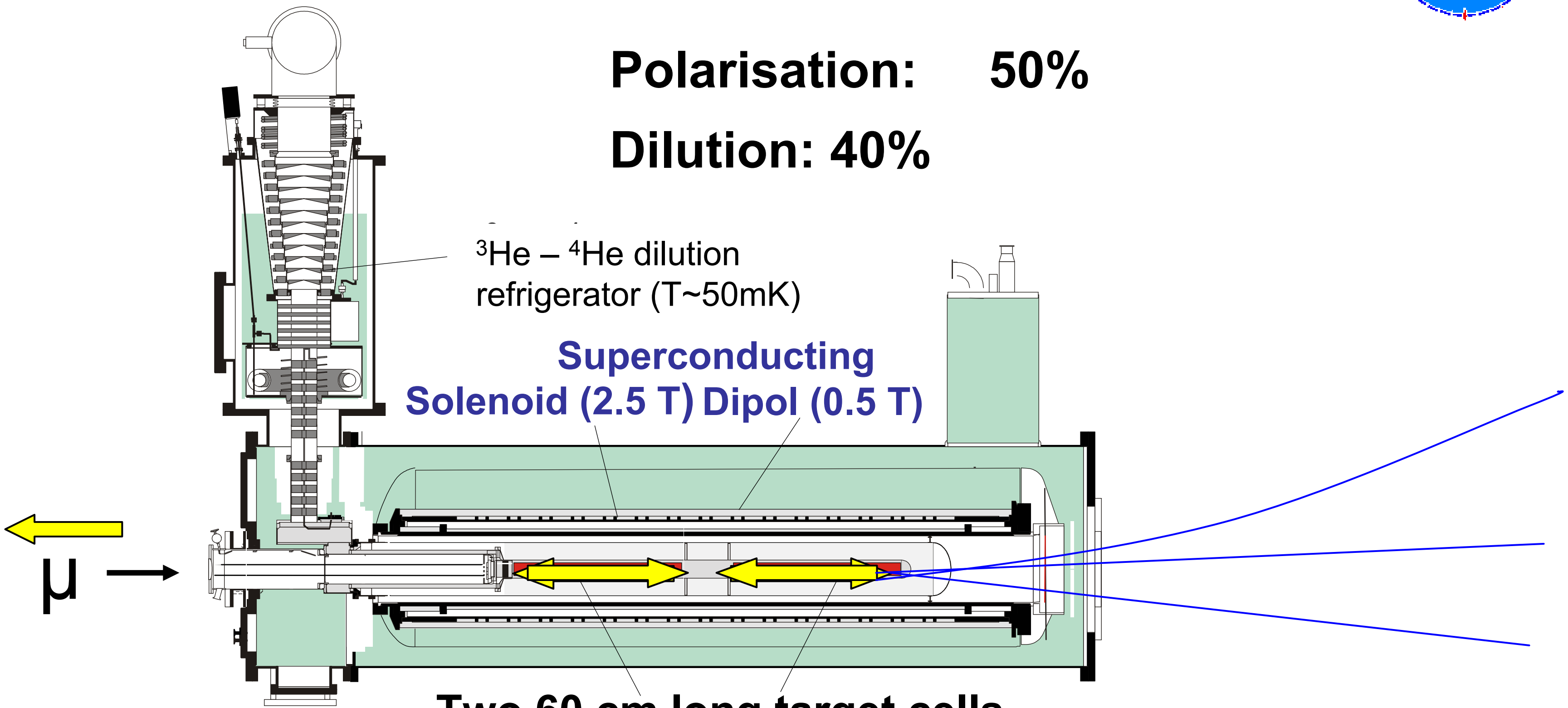
Experimental setup



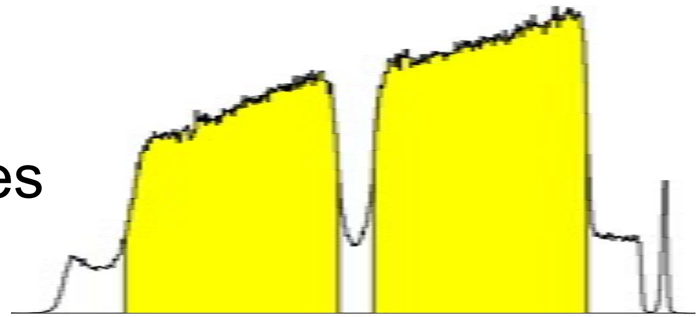
Polarised ^{6}LiD target

Polarisation: 50%

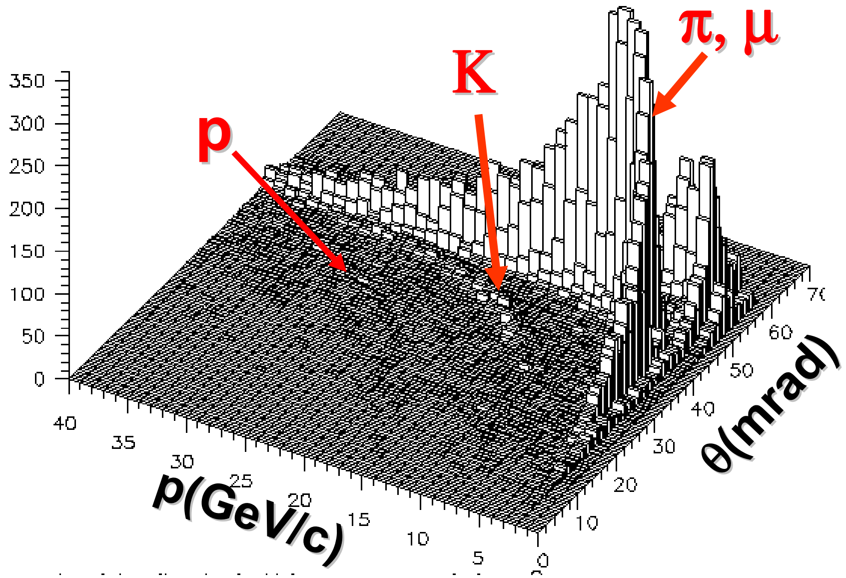
Dilution: 40%

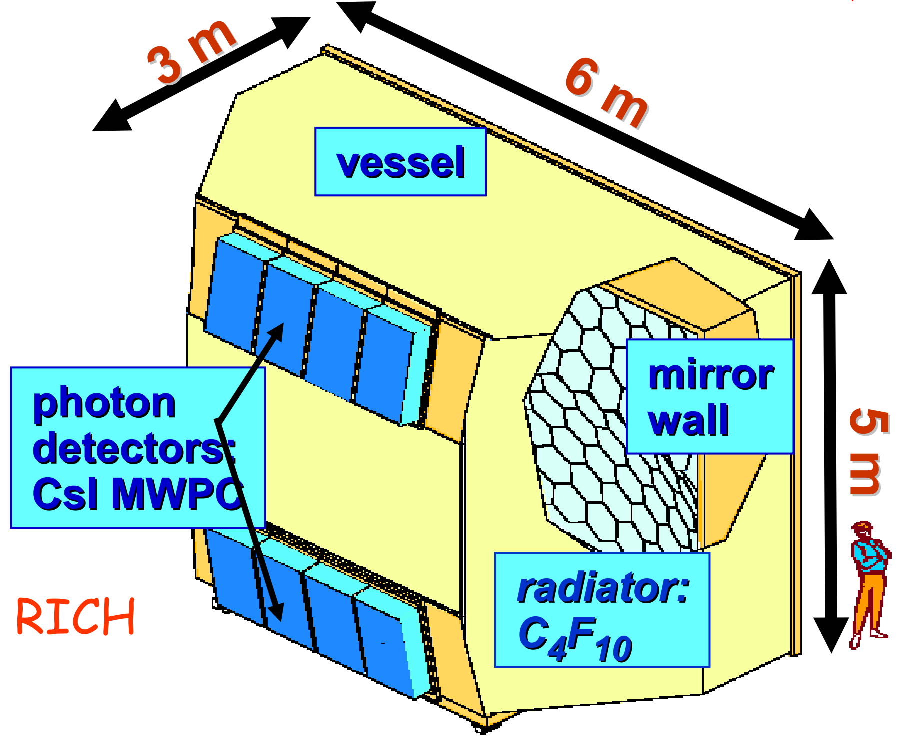


Reconstructed interaction vertices

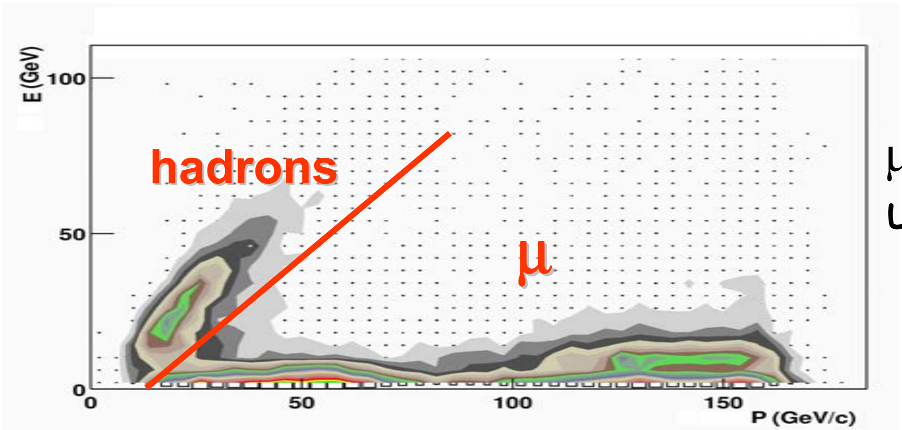


Particle identification



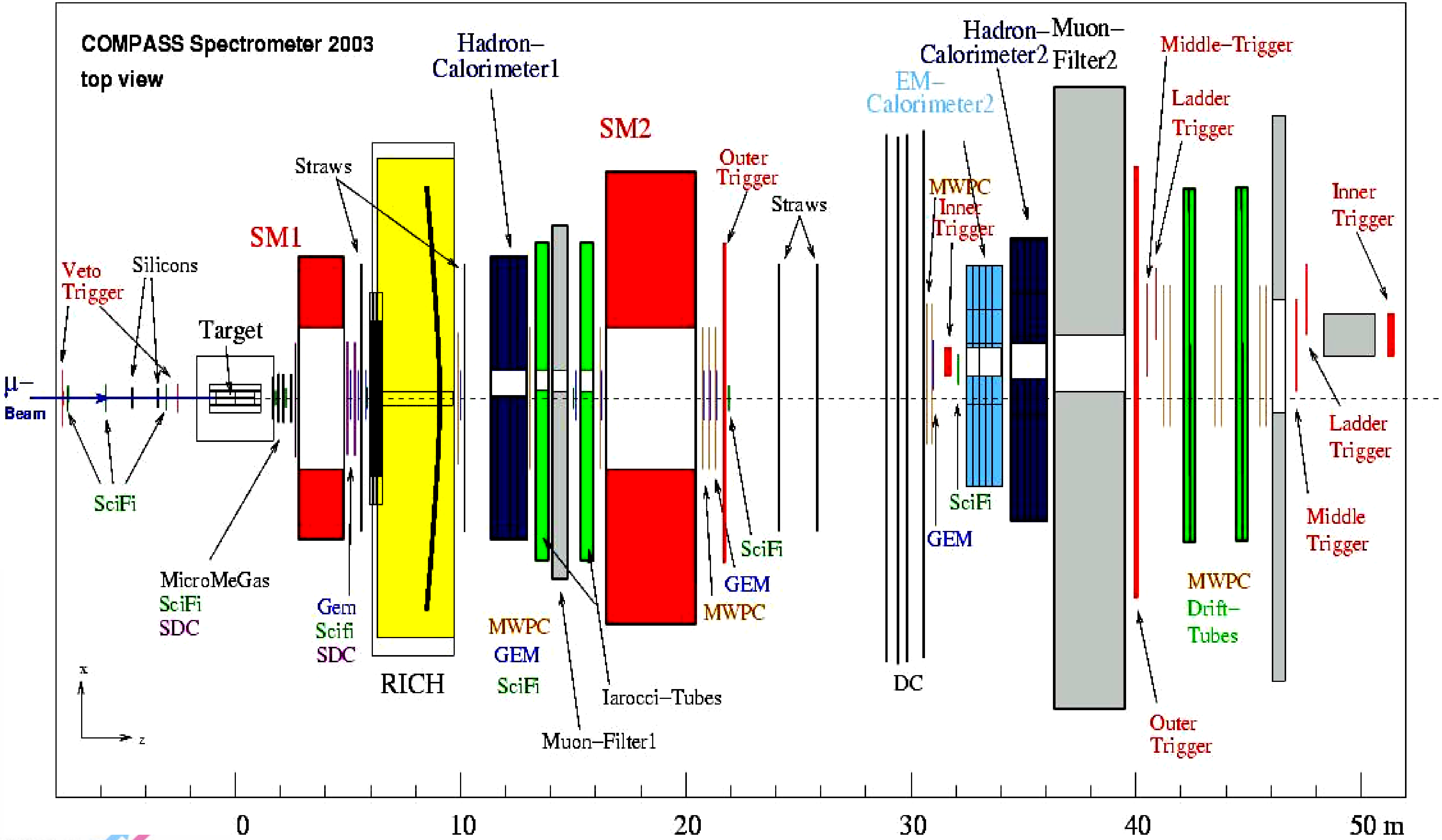


RICH

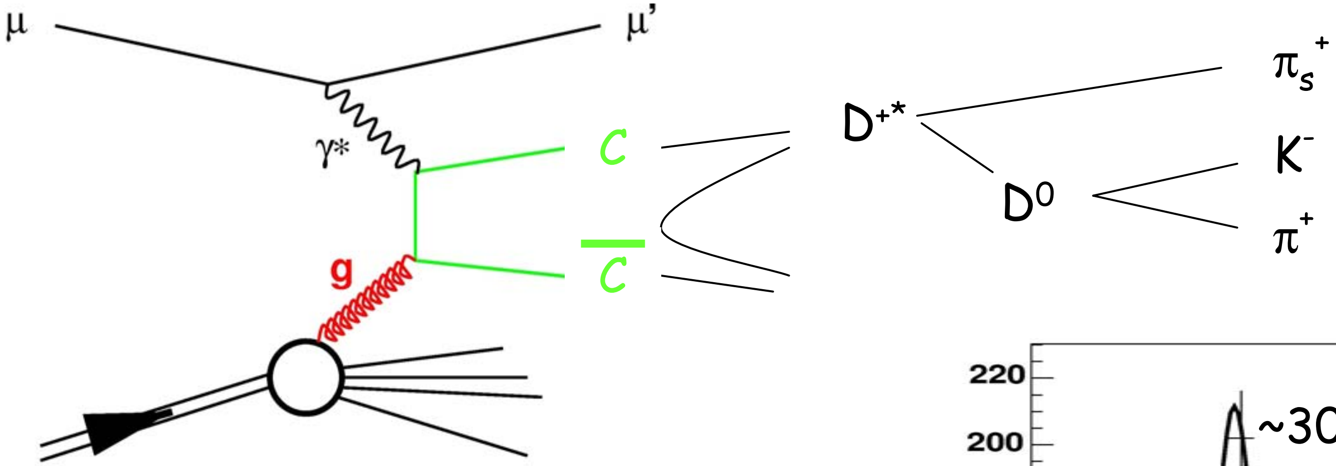


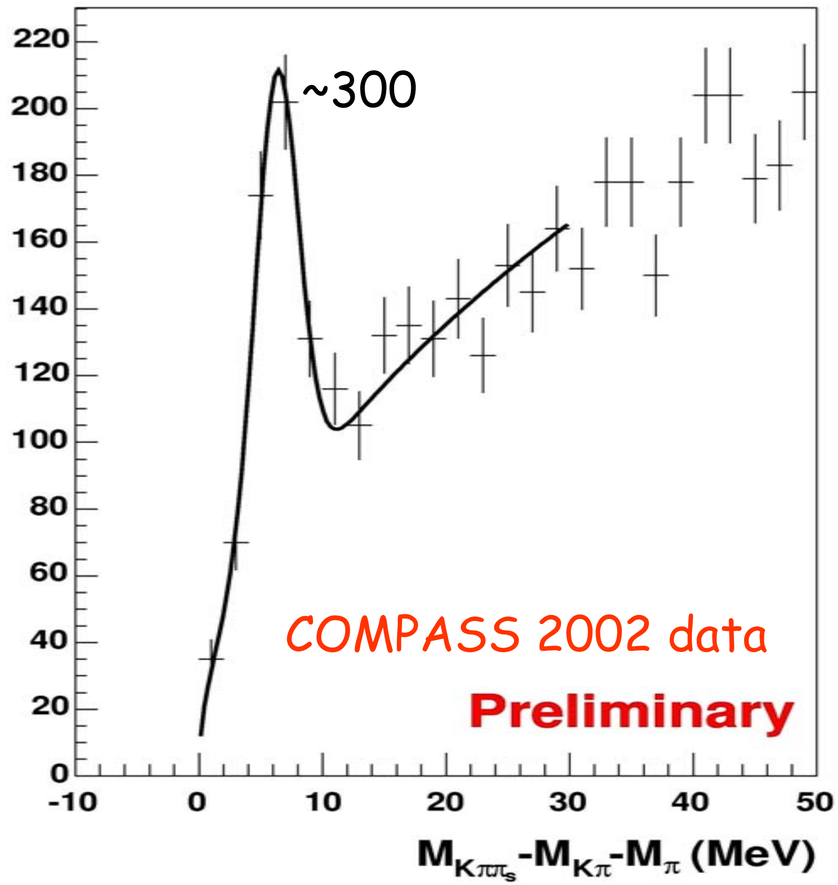
μ – hadron separation is also possible using hadron calorimeters

Tracking detectors

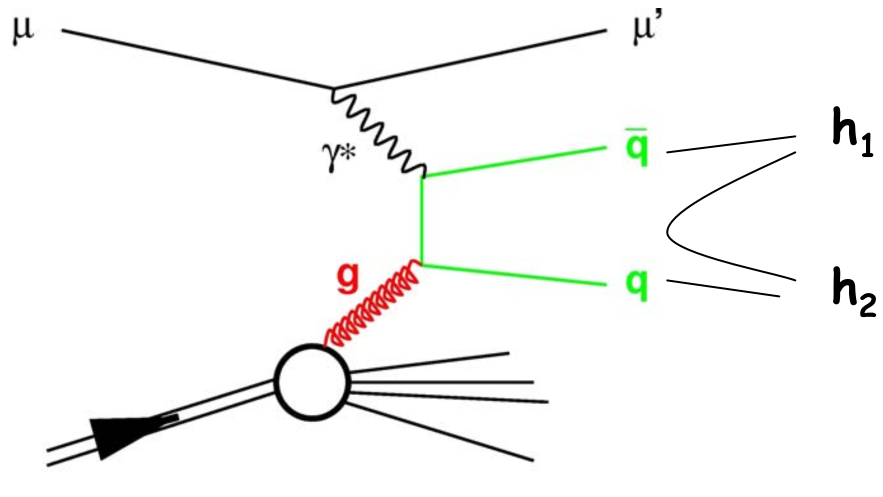


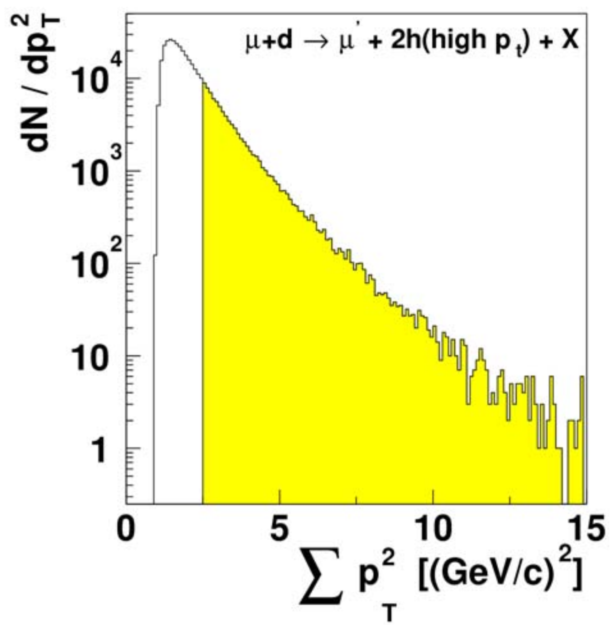
Open charm – selection in COMPASS





High p_T hadrons- selection



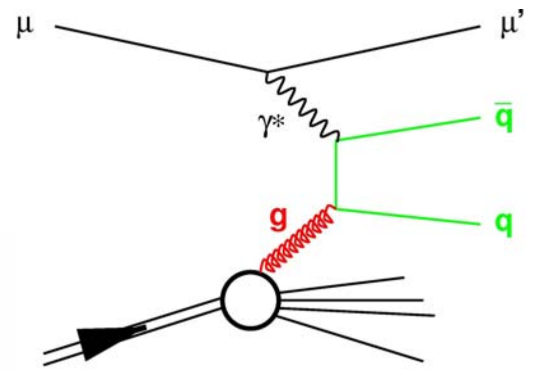


- Current fragmentation
  - $x_F > 0.1$
  - $z > 0.1$
- 2 high p_T hadrons
  - $p_T > 0.7$ GeV/c
  - $p_{T1}^2 + p_{T2}^2 > 2.5$ (GeV/c)^2
  - $m(h_1 h_2) > 1.5$ GeV/c^2

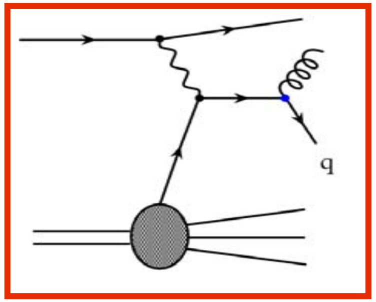
$\Delta G/G$ from high p_T hadrons

$$A^{\gamma^* d} = \frac{A_{LL}^{\mu N \to hh}}{D} \approx \left\langle \frac{\hat{a}_{LL}^{PGF}}{D} \right\rangle \left\langle \frac{\Delta G}{G} \right\rangle \frac{\sigma^{PGF}}{\sigma^{tot}} + \left\langle \frac{\hat{a}_{LL}^{Com}}{D} \right\rangle \left\langle \frac{\Delta q}{q} \right\rangle \frac{\sigma^{Com}}{\sigma^{tot}} + LO\,DIS$$

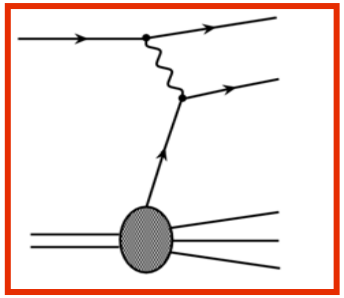
$$\frac{A_{LL}^{\mu N \to hh}}{D} = -0.065 \pm 0.036(stat.) \pm 0.01(syst.)$$



Photon Gluon Fusion



QCD-Compton

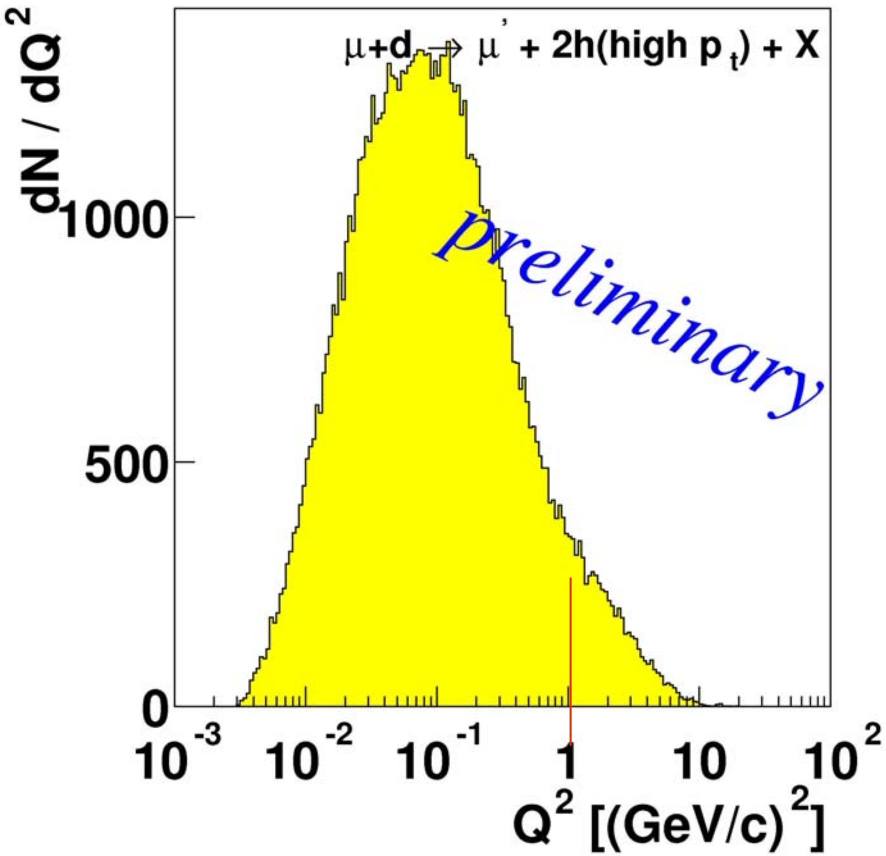


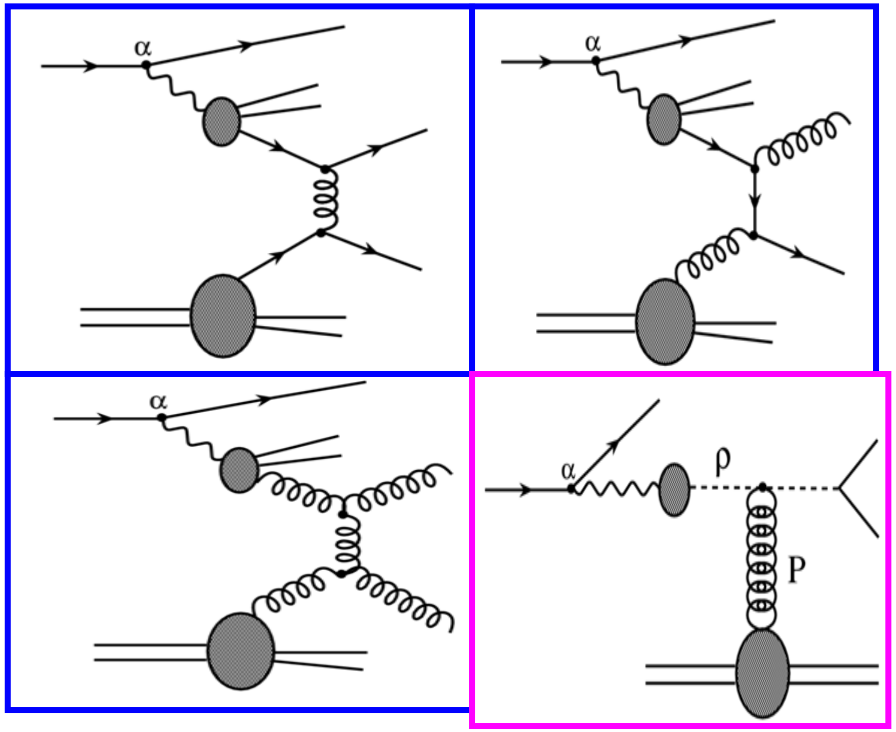
Leading Order

fractions of cross section determined by Monte Carlo

$\hat{a}_{LL}^{PGF} \approx -1$ and $\hat{a}_{LL}^{Com} \approx 0.5$

Additional background for $Q^2<1(GeV^2)$





Resolved Photon

VMD - Pomeron

$\Delta G/G$ at COMPASS -present status

Open charm

- Theoretically clean $\Delta G/G$ extraction, experiment challenging because of difficulty of the charm reconstruction in the large target.
- We are able to reconstruct charmed mesons.
- We are still collecting the data.
- Projected error on $\Delta G/G$ from 2002-2004 data: 0.24

High p_T hadron pairs

- Experimental signature easy, background subprocesses extraction based on Monte Carlo
- Measured asymmetry from 2002 data: $A^{\gamma^* d} = -0.065 \pm 0.036_{stat.} \pm 0.010_{syst.}$
- + 2003, 2004 $\rightarrow$ stat. < 0.018
- Up to now systematic error contains only studies on false asymmetries due to target or spectrometer effects

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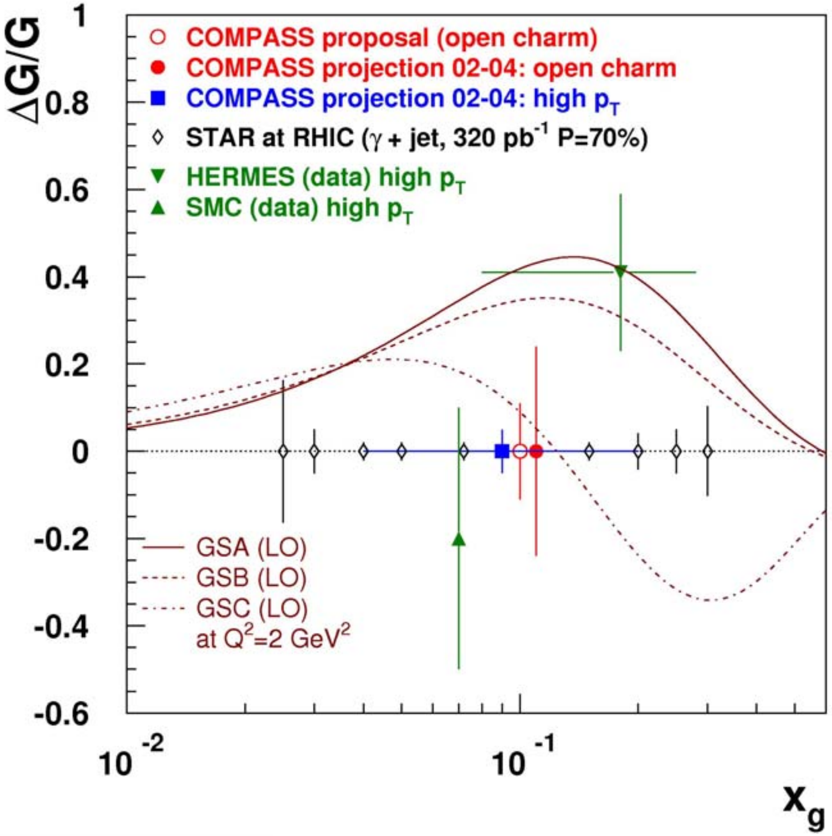
SUMMARY



$$\frac{1}{2} = \Delta\Sigma + \Delta G + L_{q,\,g}$$

- Quarks spin distribution is known.
- Gluon spin contribution is going to be measured soon in different processes.
- Orbital momentum components of the spin → next generation experiments.
- Nucleon spin puzzle is still very exciting subject.