Gluon polarization measurements at COMPASS

F.-H. Heinsius *(Universität Freiburg)*

on behalf of the COMPASS collaboration

The COMPASS Collaboration

230 physicists
from 12 countries
28 institutes

Broad Physics Program

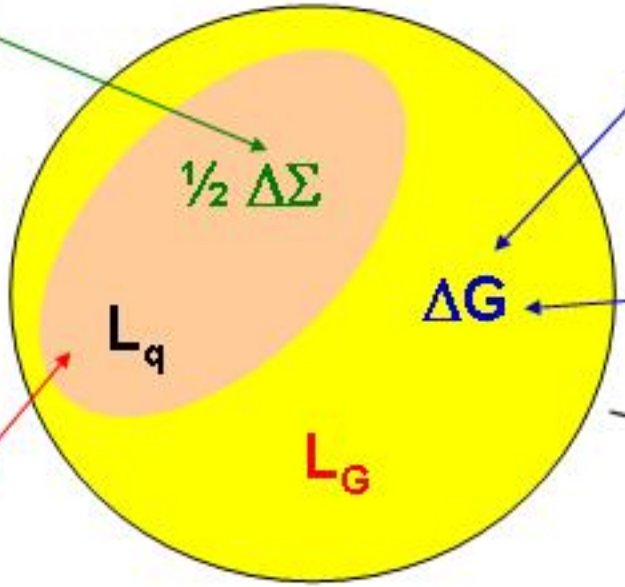
- $\Delta G/G$
- semi inclusive DIS
  - flavor dependent quark helicity density distributions Δq
  - transverse quark spin distribution function $h_1(x)$
  - polarised Λ fragmentation
  - vector mesons
- hadron spectroscopy with hadron beams

Spin of the Nucleon = ½ ħ

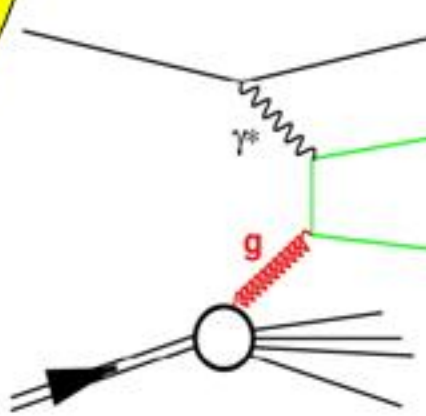
$$\Delta\Sigma = \Delta u + \Delta d + \Delta s + \Delta\bar{u} + \Delta\bar{d} + \Delta\bar{s}$$

DIS: $\Delta\Sigma \approx 0.3$ (CERN, SLAC, DESY)

QCD analysis of $g_1(x,Q^2)$



Photon gluon fusion

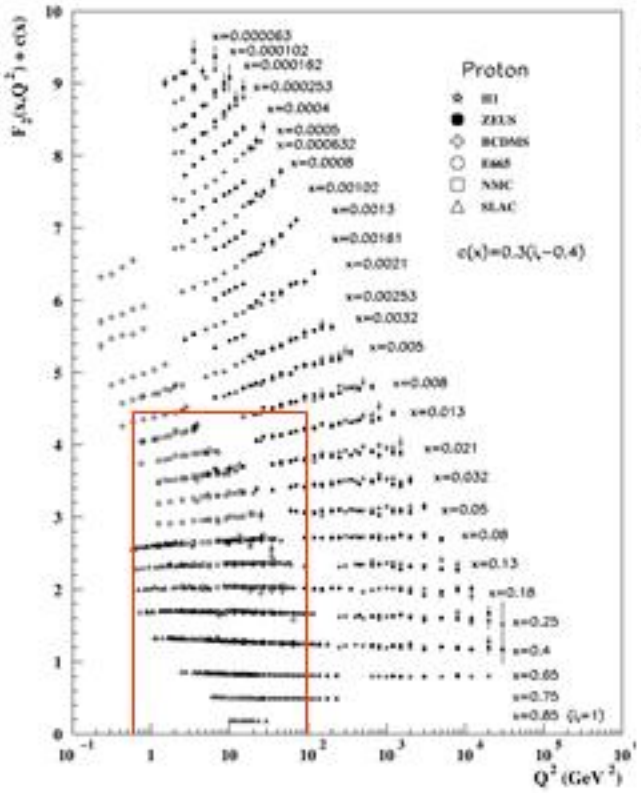


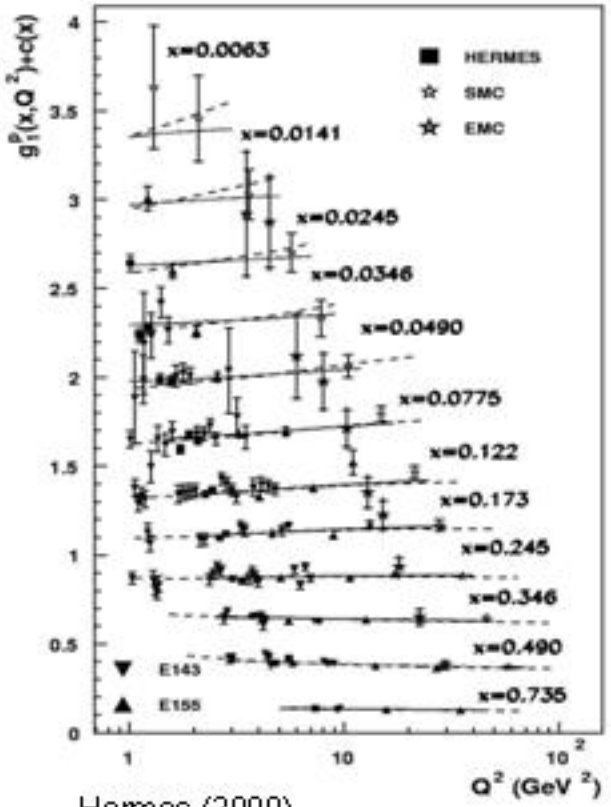
open charm

high-p_T

Measure generalized parton distributions

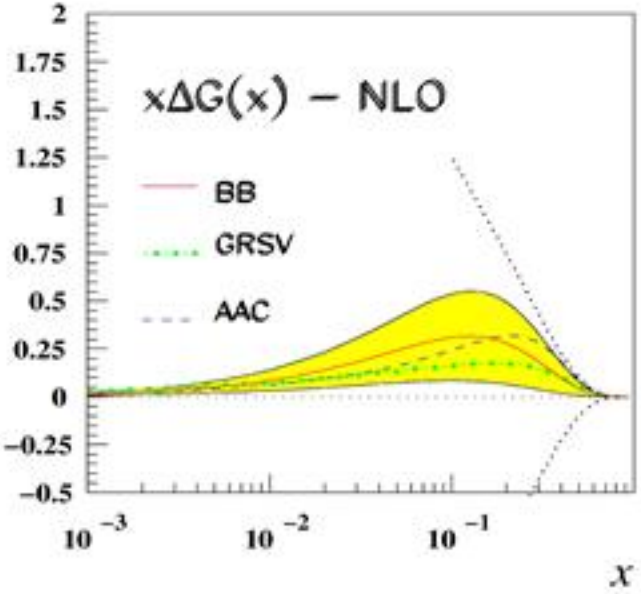
ΔG from QCD Analysis of g_1





Hermes (2000)

polarised gluon distribution from QCD fits:



Blümlein & Böttcher: fit to polarised data of EMC, E142, E143, E155, SMC, Hermes

Nucl. Phys. B636 (02) 225

Spin of the Nucleon = ½ ħ

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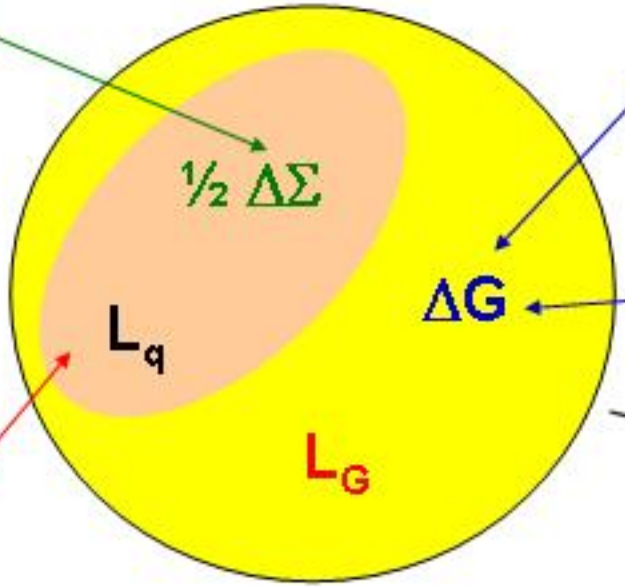
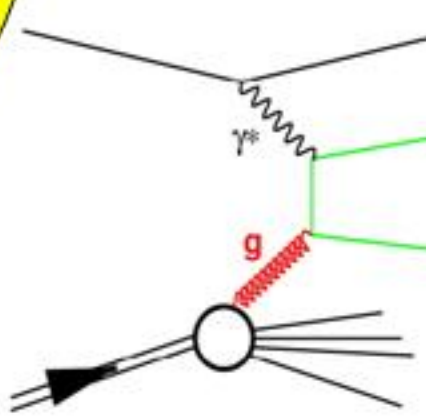


Photon gluon fusion



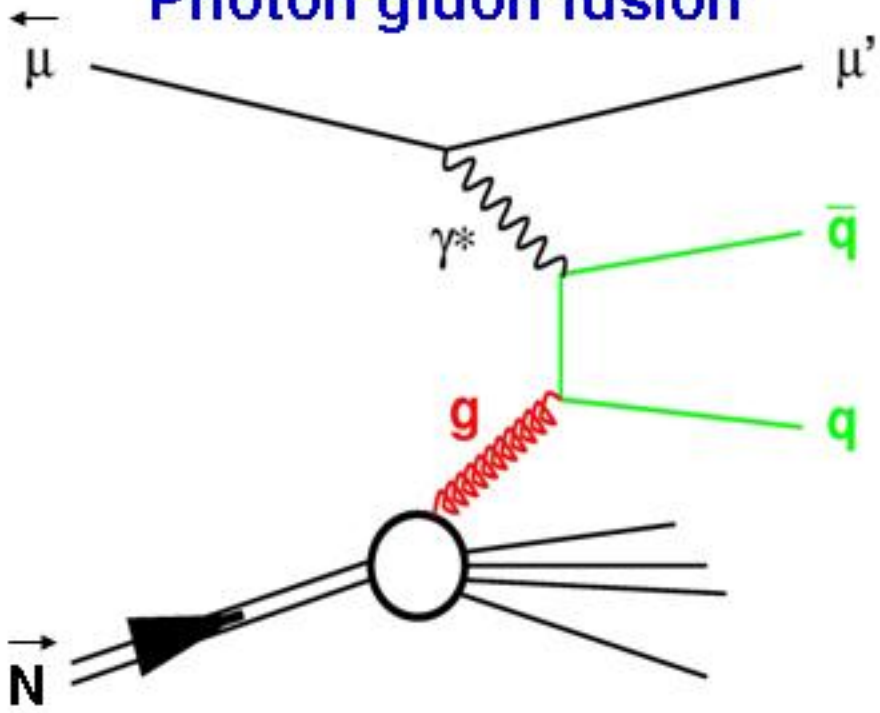
open charm

high-p_T

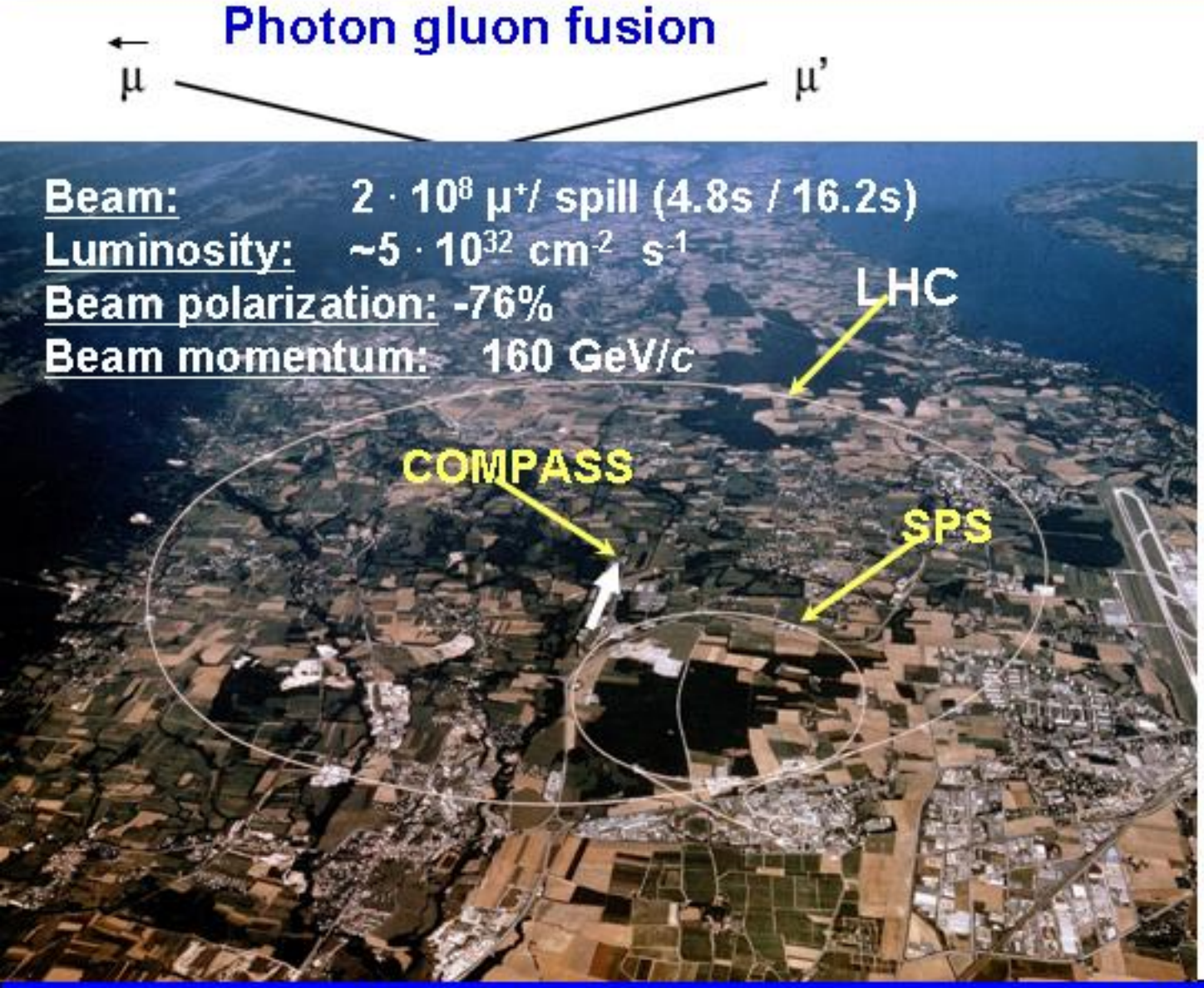
Measure generalized parton distributions

ΔG/G at COMPASS

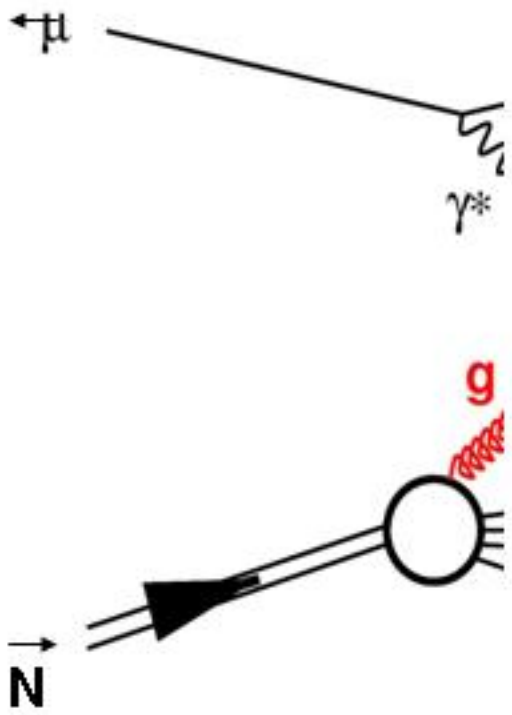
Photon gluon fusion



ΔG/G at COMPASS



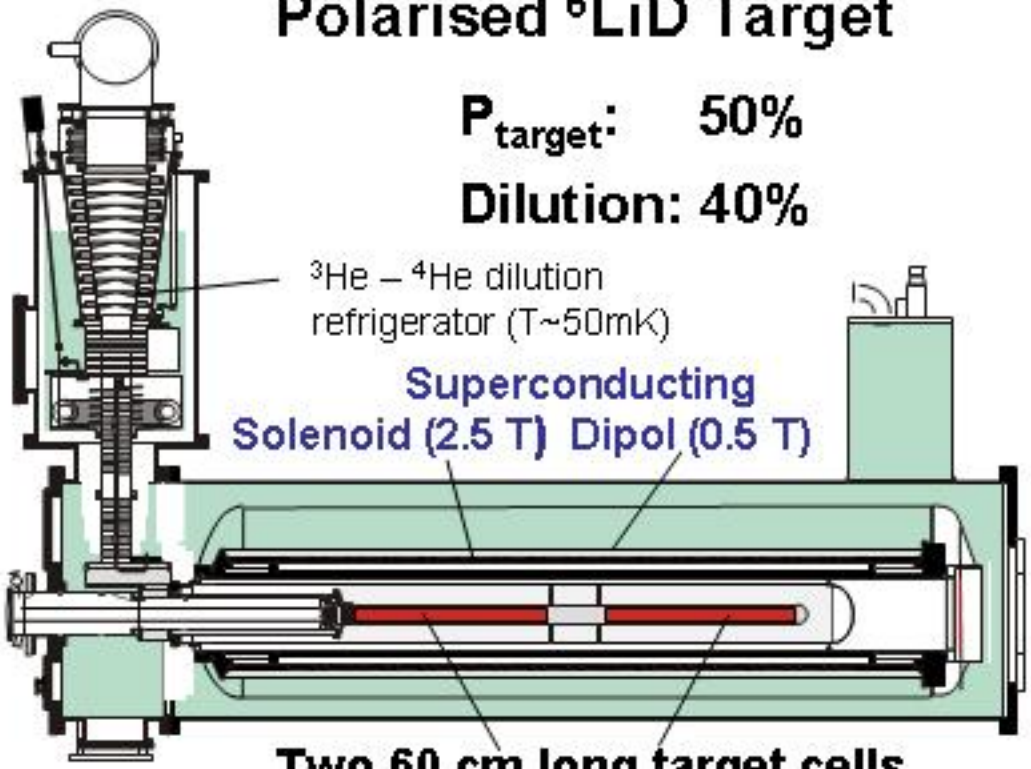
ΔG/G at COMPASS



Polarised ^{6}LiD Target

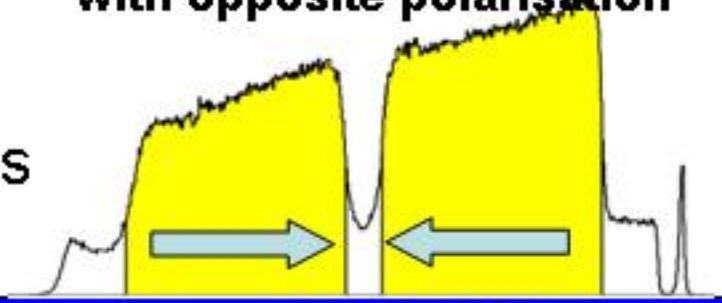
P_{target}: 50%

Dilution: 40%

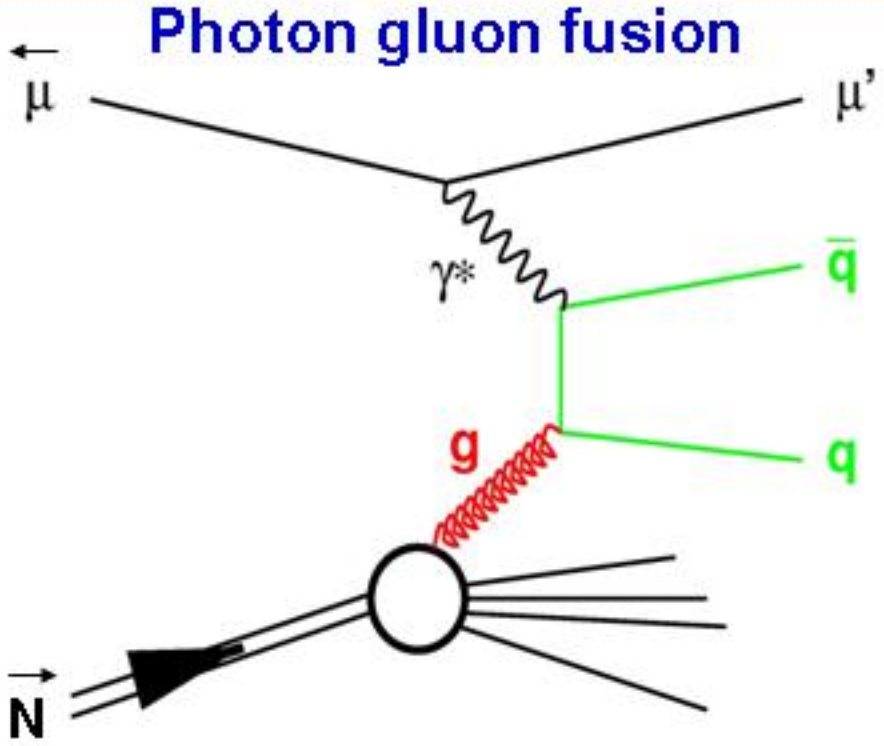


Two 60 cm long target cells with opposite polarisation

Reconstructed interaction vertices



ΔG/G at COMPASS



q = c cross section difference in charmed meson production

→ *theory well understood*

→ *experiment challenging*

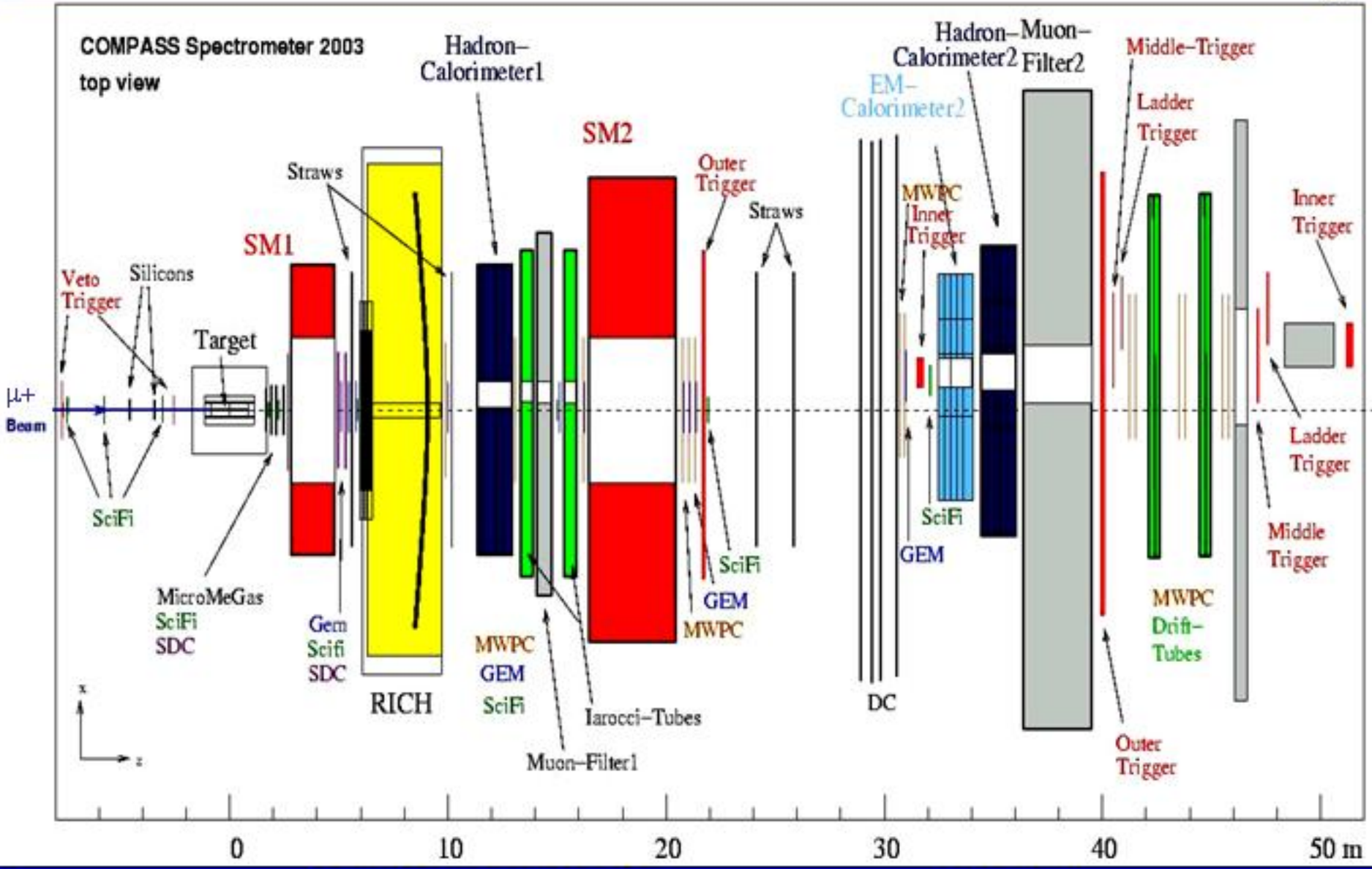
q = u,d,s cross section difference in 2+1 jet production.

In COMPASS: Events with 2 hadrons with high p_T

→ *experiment easy*

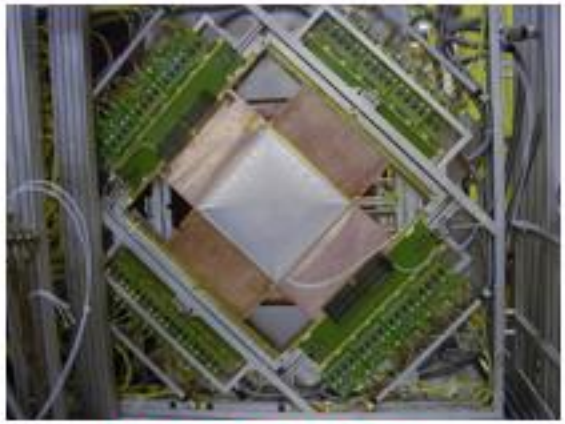
→ *theory difficult*

COMPASS Spectrometer 2003/04

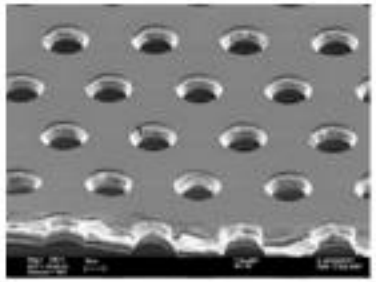


New Technologies for Tracking and Particle ID

Scintillating fiber trackers

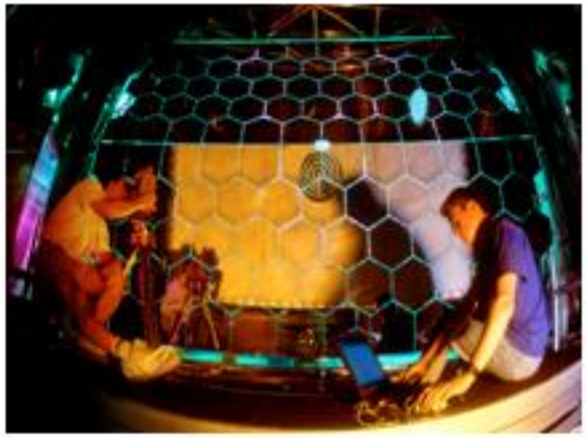


MicroMegas



GEM

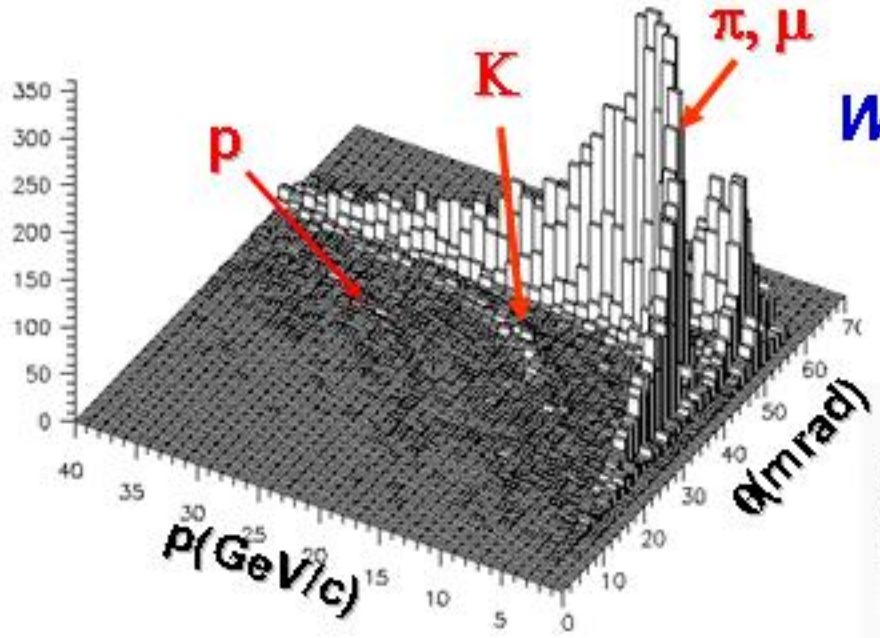
Large area drift detectors



RICH
CsI & MWPC readout
Radiator: C_4F_{10}

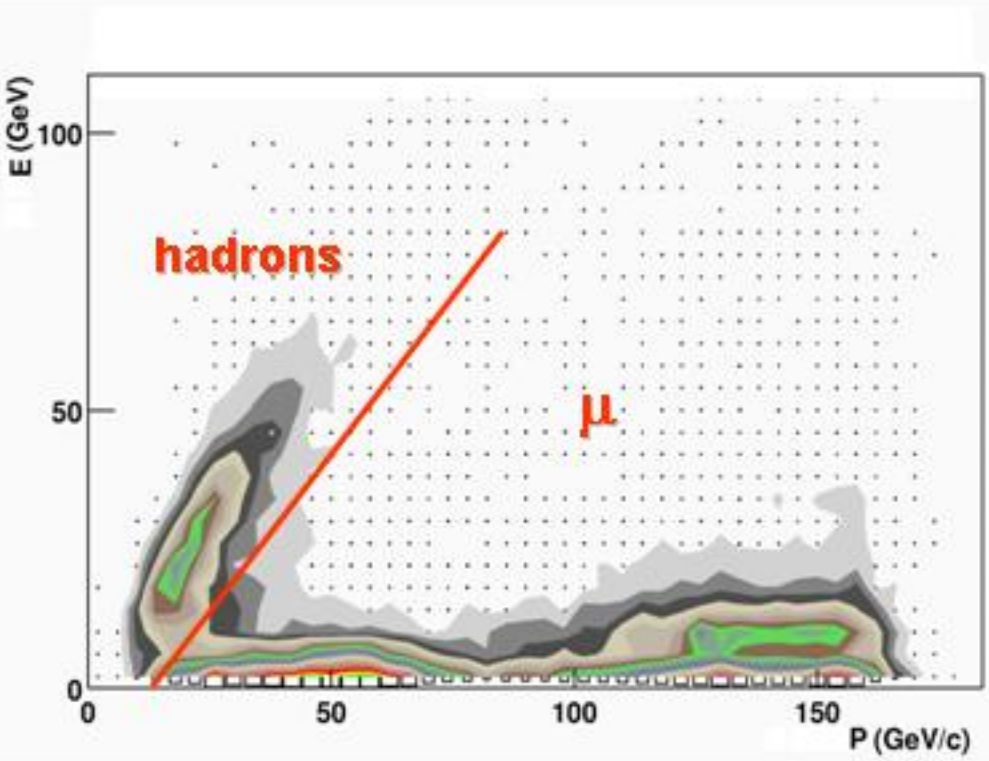
Readout electronics

Particle Identification



With RICH

and hadron calorimeters



Essential for reconstruction of D-Mesons

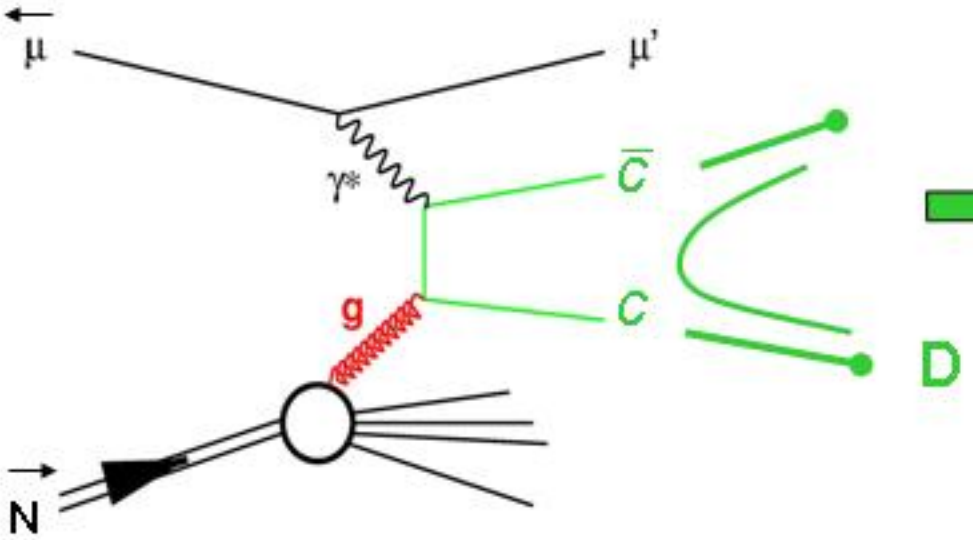
ΔG/G: Open Charm

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

$\Delta\sigma^{PGF}$ at NLO: Bojak, Stratmann NPB 540 (1999) 345; Contogouris *et al.*

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

Photon-Gluon Fusion



$$D^0 \to K^- \pi^+ \quad \text{(BR 4 \%)}$$

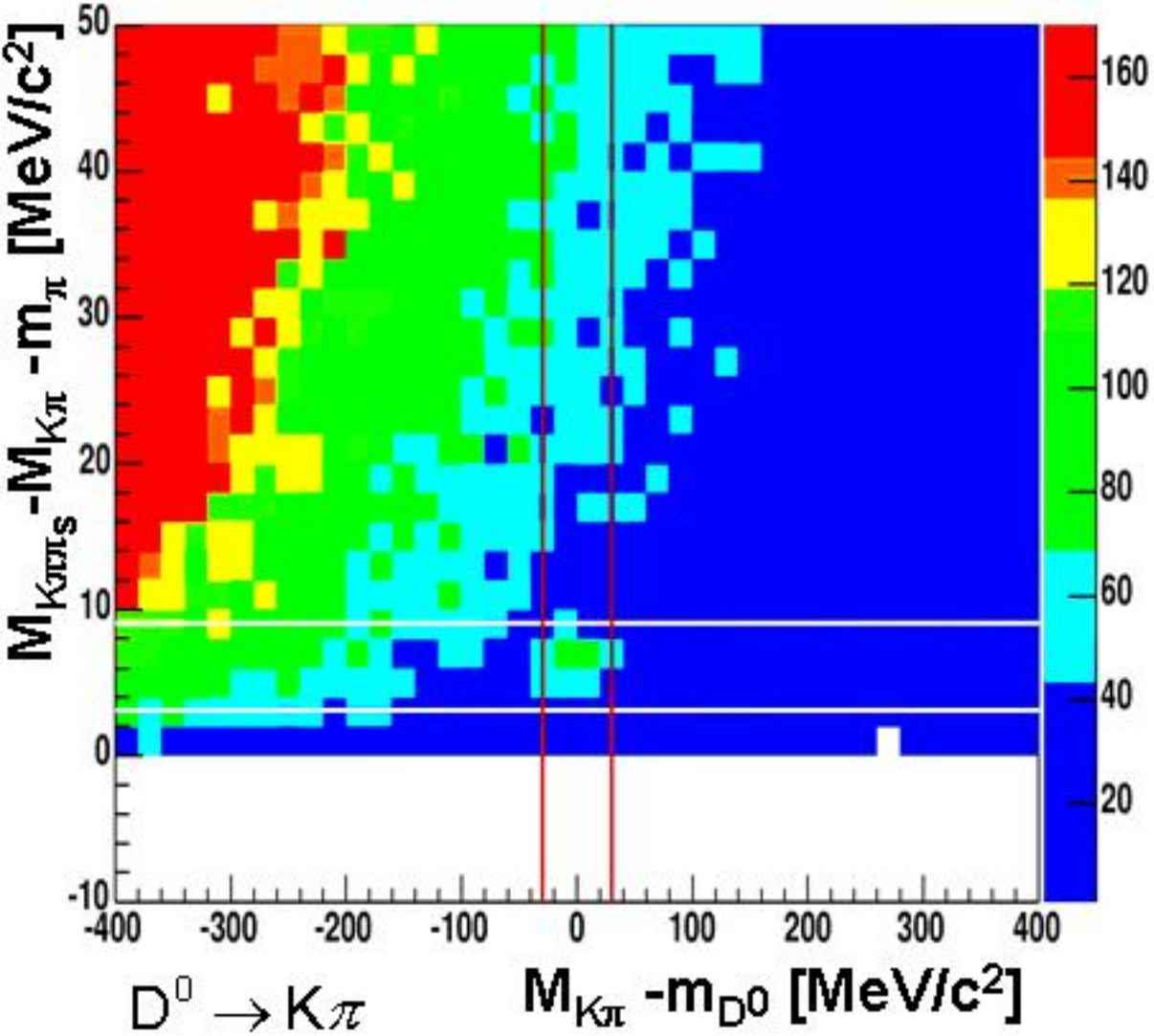
$$D^{*+} \to D^0 \pi^+ \to \left(K^- \pi^+\right) \pi^+$$

$$A_{raw} = \frac{N_{c\bar{c}}^{\overleftarrow{\Rightarrow}} - N_{c\bar{c}}^{\overleftarrow{\Leftarrow}}}{N_{c\bar{c}}^{\overleftarrow{\Rightarrow}} + N_{c\bar{c}}^{\overleftarrow{\Leftarrow}}} = P_\mu P_T f\, D\, A_{\mu N}^{c\bar{c}}$$

$P_\mu \approx -0.76$	$f \approx 0.4$
$P_T \approx 0.5$	$D(y)$

D* tagging: $D^* \longrightarrow D^0 \pi$

$D^* \rightarrow (K\pi)\pi$



Cuts:

$z_D > 0.2$

$|\cos \theta^*| < 0.85$

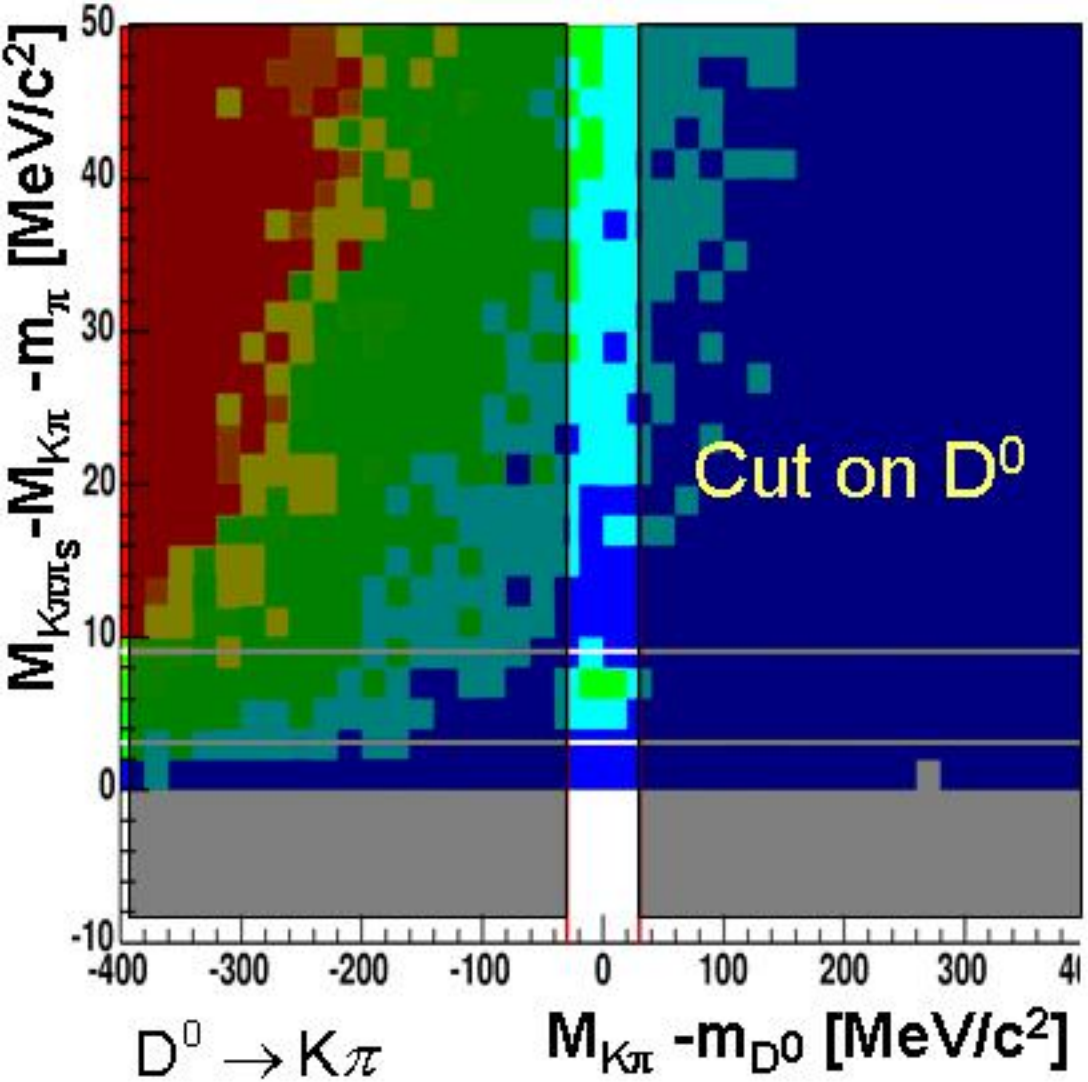
(Background)

$10 < p_K < 35$ GeV/c

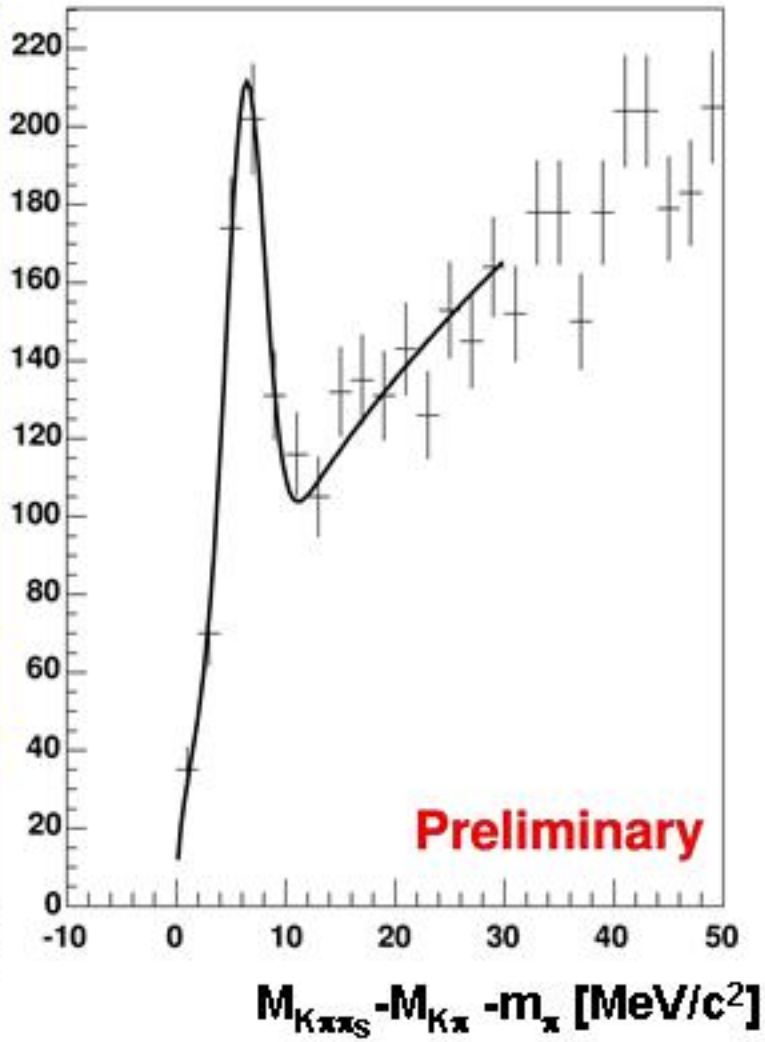
(RICH PID)

D* tagging: $D^* \longrightarrow D^0 \pi$

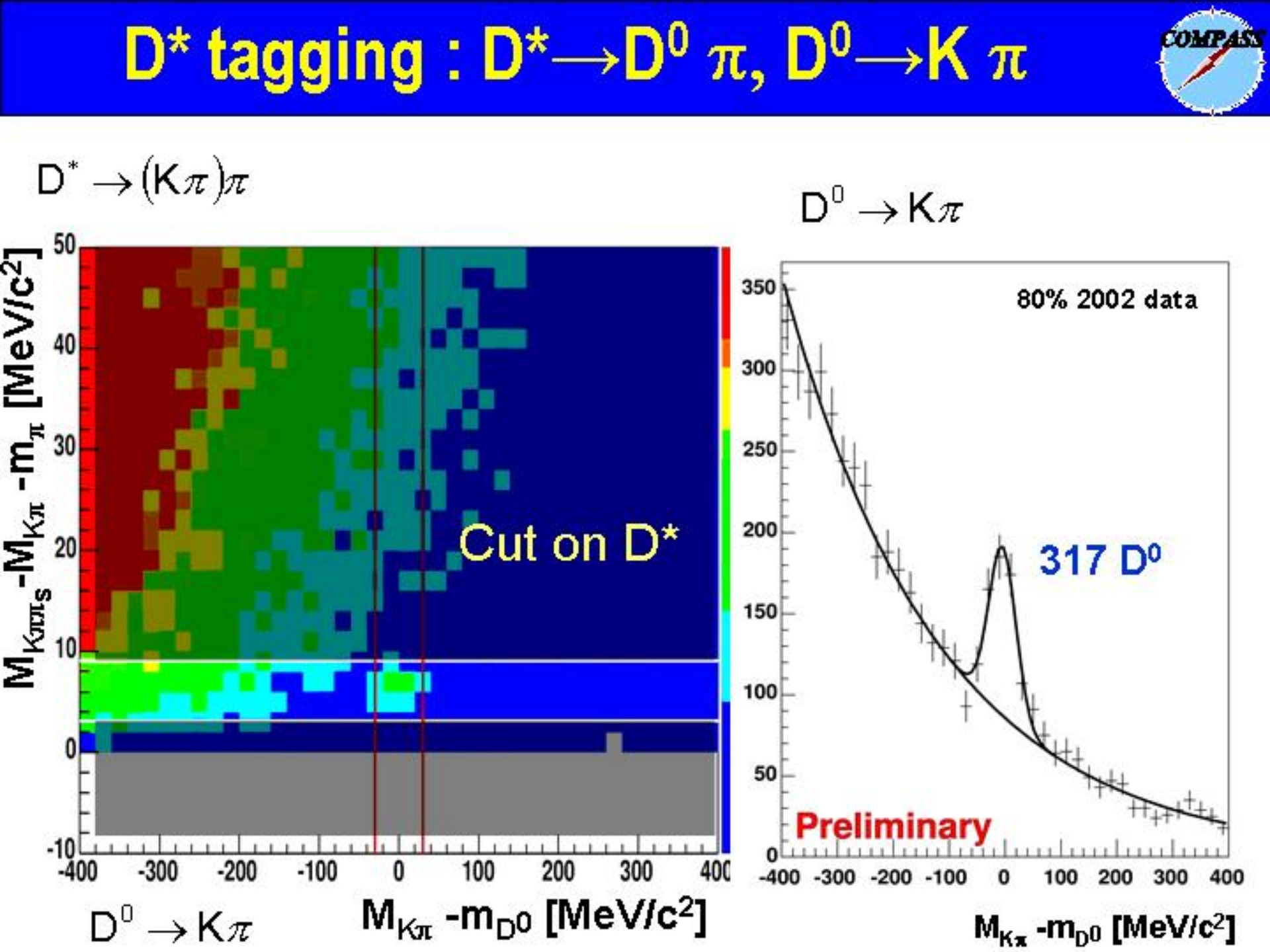
$D^* \rightarrow (K\pi)\pi$



$D^* \rightarrow (K\pi)\pi$



D* tagging : $D^* \longrightarrow D^0 \pi$, $D^0 \longrightarrow K \pi$



ΔG/G: Prospects from Open Charm

- First reconstruction of charmed mesons with polarised target and beam

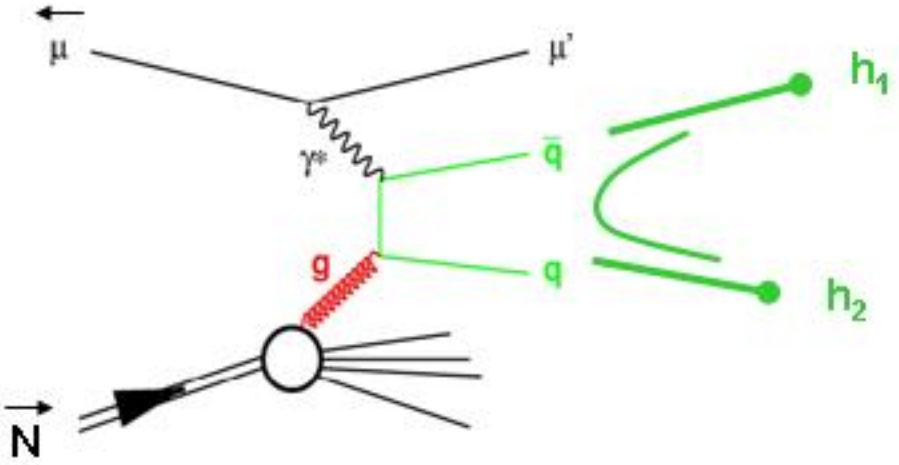
- Very challenging because
  - vertex reconstruction inside massive target
  - event rate small compared to background

- Improvements
  - gains in 2003 and 2004 spectrometer performance
  - double beam time in 2004
  - better beam reconstruction
  - several improvements in reconstruction algorithms and analysis methods

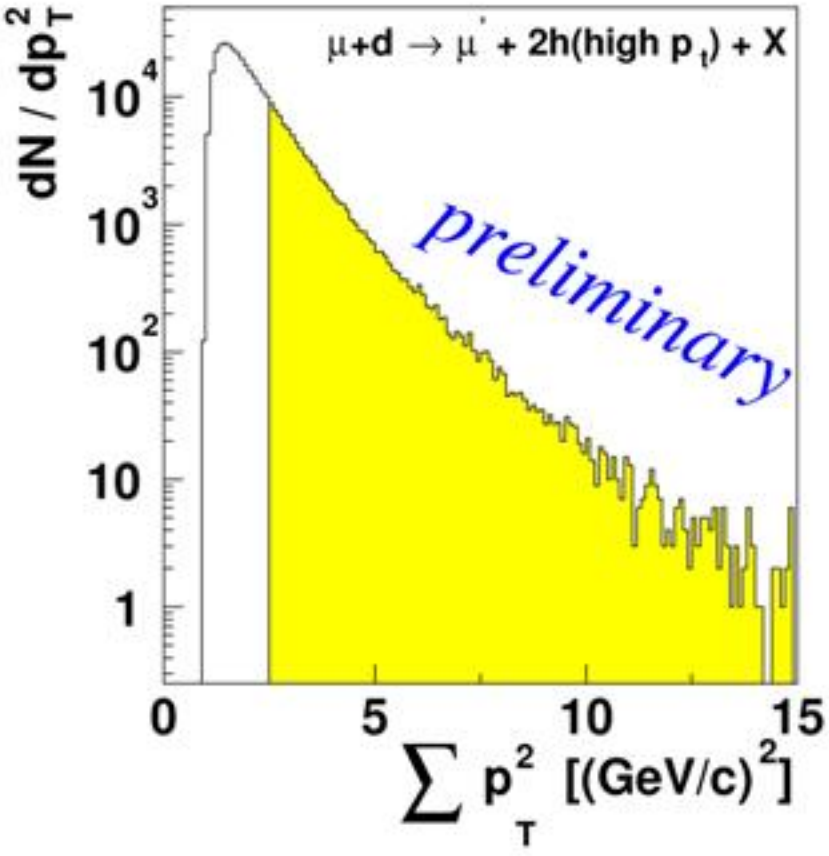
→ Projected error on ΔG/G from 2002-2004 data: 0.24

ΔG/G: Pairs of High p_T Hadrons

Photon Gluon Fusion



- 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
  - $m(h_1h_2) > 1.5$ GeV/c^2



COMPASS Result

$$A^{\gamma^* d} = \frac{1}{2 P_T \, f D P_B} \left[\frac{N_1^{\Leftarrow} - N_2^{\Leftarrow}}{N_1^{\Leftarrow} + N_2^{\Leftarrow}} + \frac{N_2^{\Leftarrow} - N_1^{\Leftarrow}}{N_2^{\Leftarrow} + N_1^{\Leftarrow}} \right]$$

two target cells, opposite polarisation,
polarisation flipped every 8 hours

Asymmetry in production of hadron pairs with high p_T:

$$A^{\gamma^* d} = -0.065 \pm 0.036_{stat.} \pm 0.010_{syst.}$$

2002 data

up to now systematic error contains only studies on
false asymmetries due to target or spectrometer effects

Improvements:

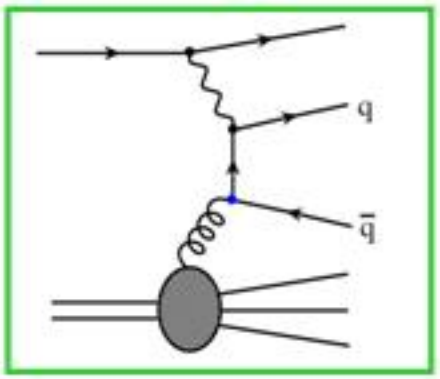
- 2003 and expected 2004 data will give a factor of 4 more data
- better reconstruction algorithm

How to get ΔG/G

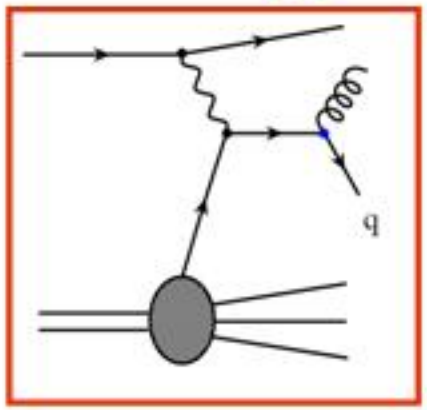
$$\hat{a}_{LL}^{PGF} \approx -1 \text{ and } \hat{a}_{LL}^{Com} \approx 0.5$$

fractions of cross section determined by Monte Carlo

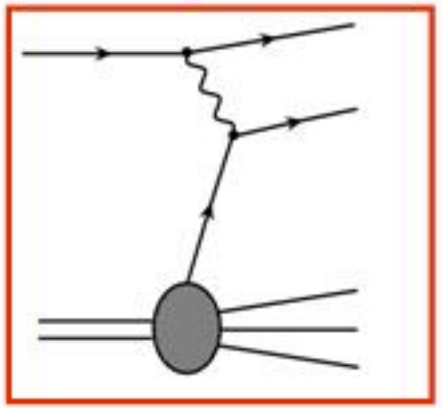
$$A^{\gamma^* d} = \frac{A_{LL}^{\mu N \to hh}}{D} \approx \left\langle \frac{\hat{a}_{LL}^{PGF}}{D} \right\rangle \left\langle \frac{\Delta G}{G} \right\rangle \frac{\sigma^{PGF}}{\sigma^{tot}} + \left\langle \frac{\hat{a}_{LL}^{Com}}{D} \right\rangle \left\langle \frac{\Delta q}{q} \right\rangle \frac{\sigma^{Com}}{\sigma^{tot}}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



Photon Gluon Fusion

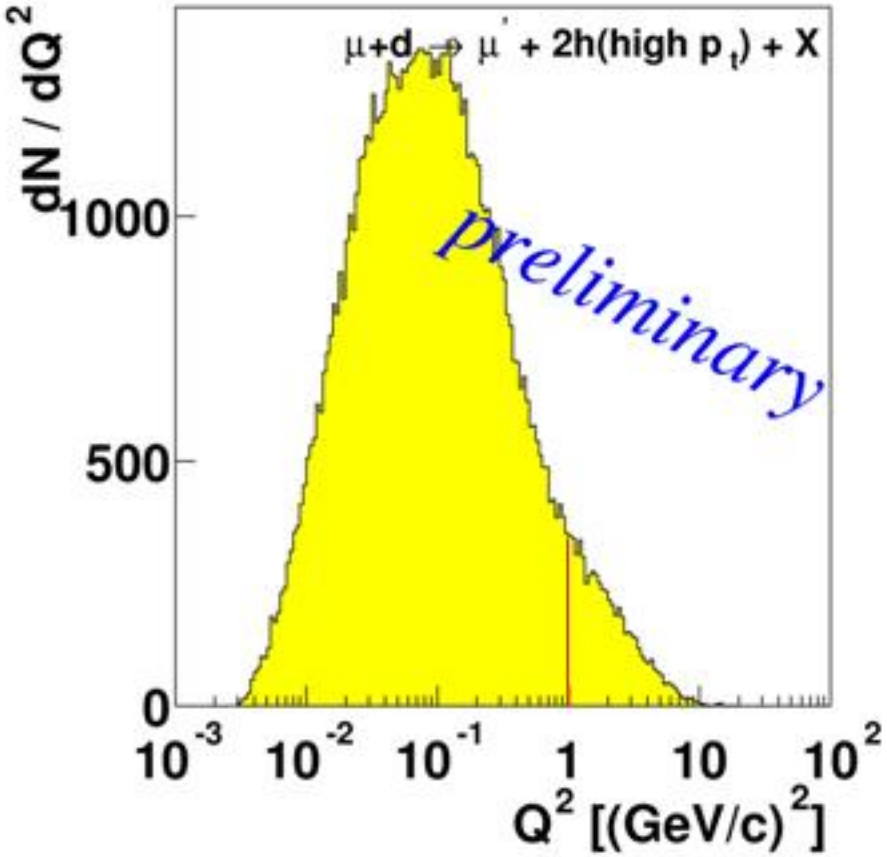


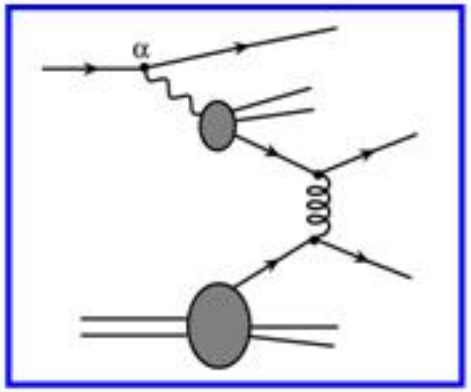
QCD-Compton

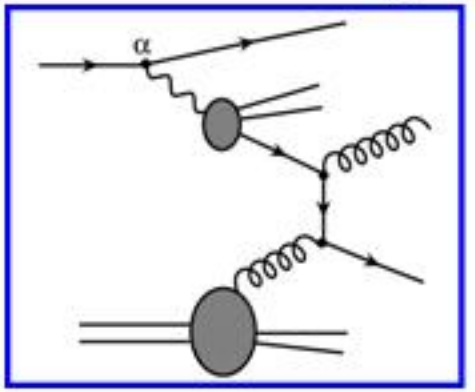


Leading Order

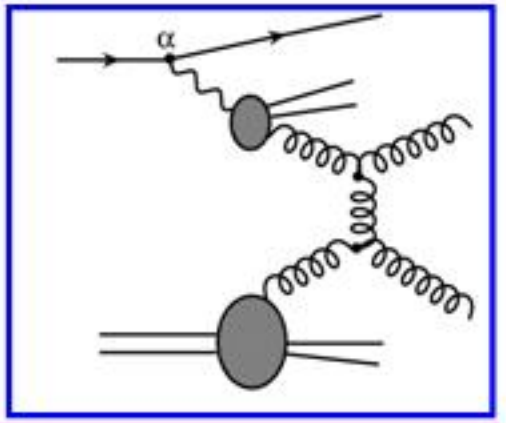
Additional Background



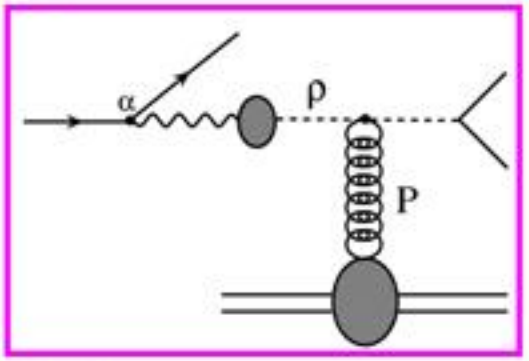




Resolved Photon



Relevant for
$Q^2<1$ (GeV/c)^2



VMD - Pomeron

Next Steps in high-p_T Analysis

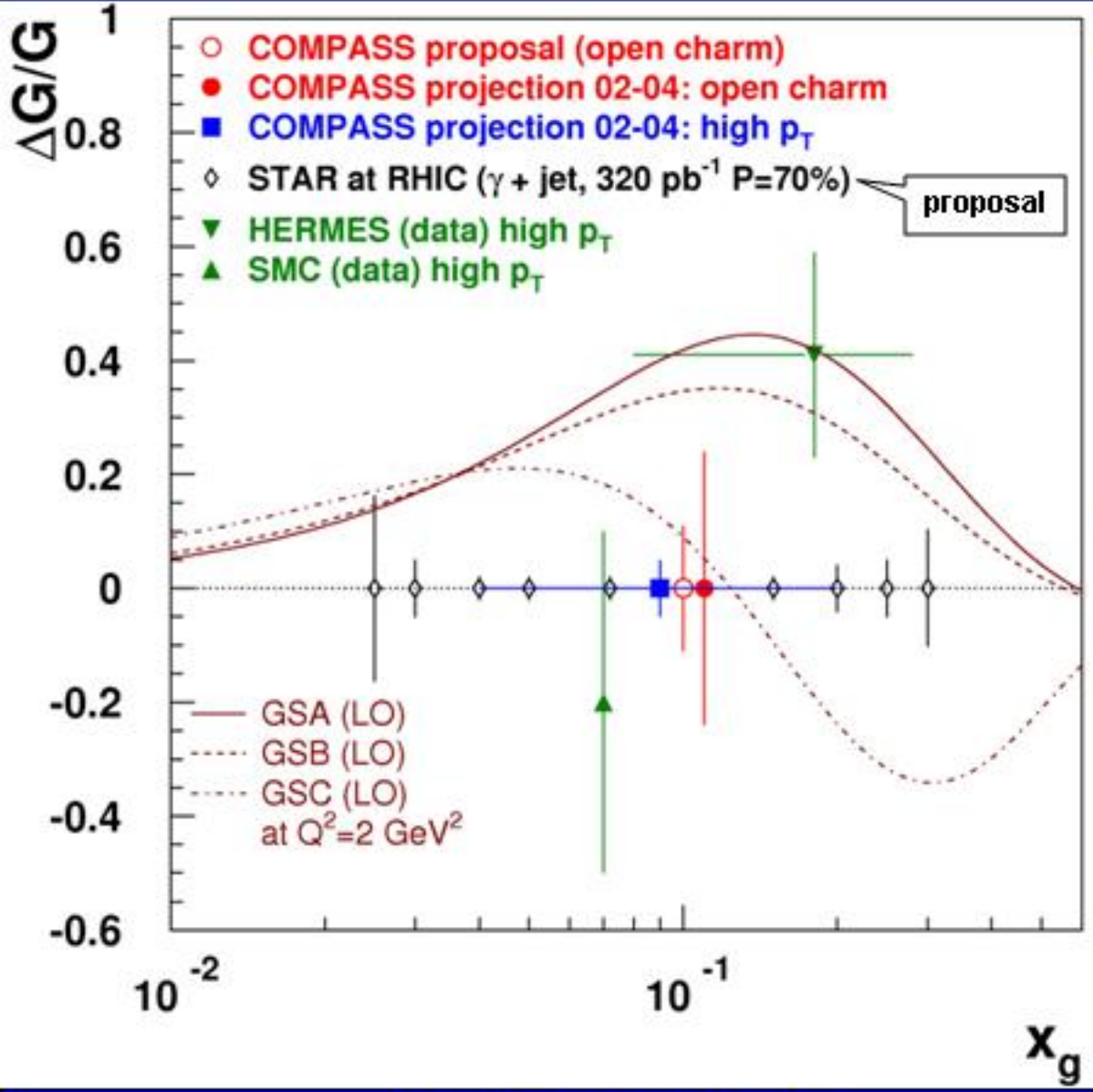
Monte Carlo studies are in progress:

- *PYTHIA*
  - simulates all processes
  - PYTHIA used in HERMES analysis (Q^2 unmeasured)
- *LEPTO*
  - simulates PGF, QCD-Compton and LO DIS
  - LEPTO used in SMC analysis ($Q^2>1$ (GeV/c)^2 selected)

- Projected error on $\Delta G/G$ for 2002-2004 data (assuming fraction of PGF events is ¼):

  0.05 [0.16 for $Q^2>1$ (GeV/c)^2]

Expected error on $\Delta G/G$



COMPASS Summary

First glance at open charm PGF with polarised target and beam

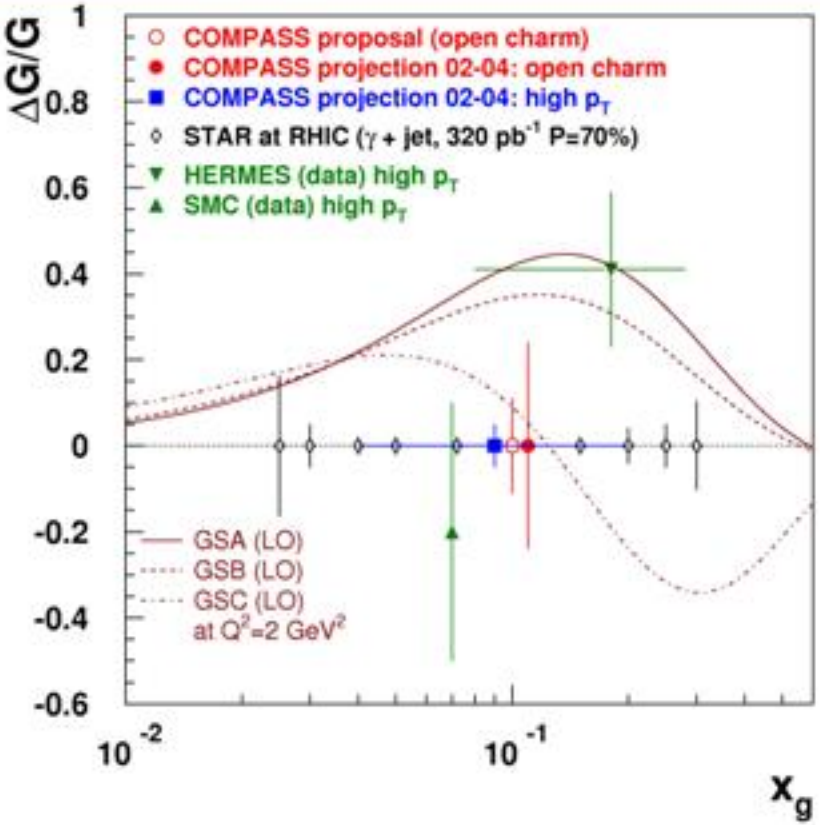
Good perspectives for ΔG from high-p_T hadron pairs

More COMPASS physics

- Inclusive and semi-inclusive asymmetries *M. Leberig*
- Transverse asymmetry A_{UT} for charged pions *H. Fischer*

End of Talk

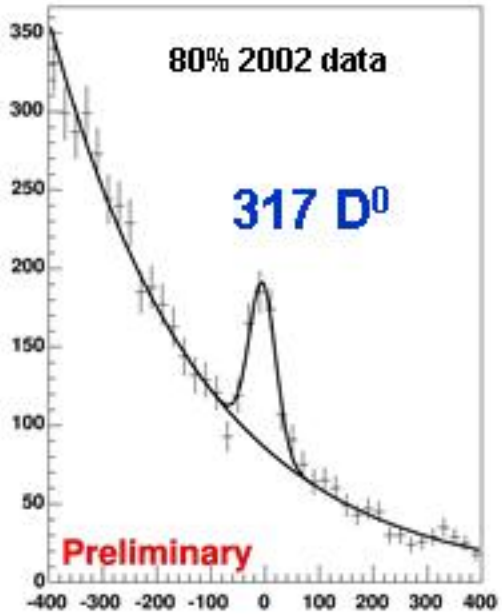
ΔG/G at COMPASS



Open charm

First reconstruction of charmed mesons with polarised target and beam:

$D^0 \to K\pi$ tagged by $D^* \to (K\pi)\pi$

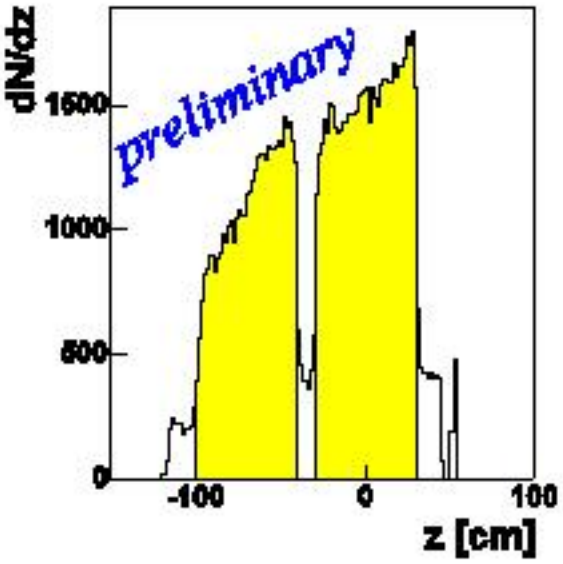


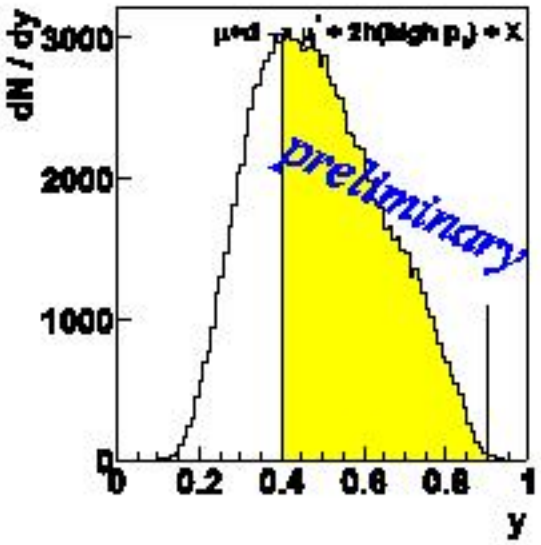
High p_T hadron pairs

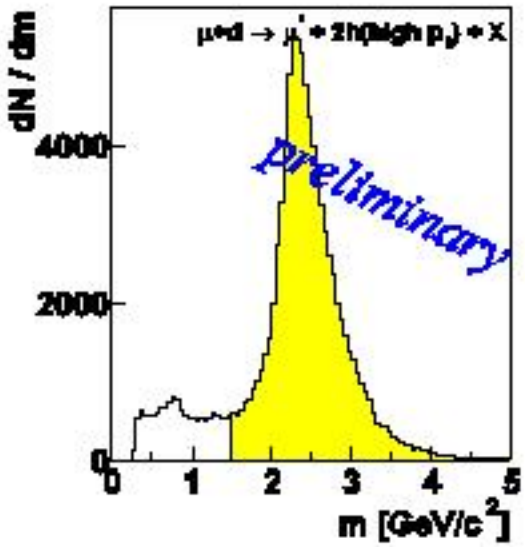
Measured asymmetry from 2002 data:

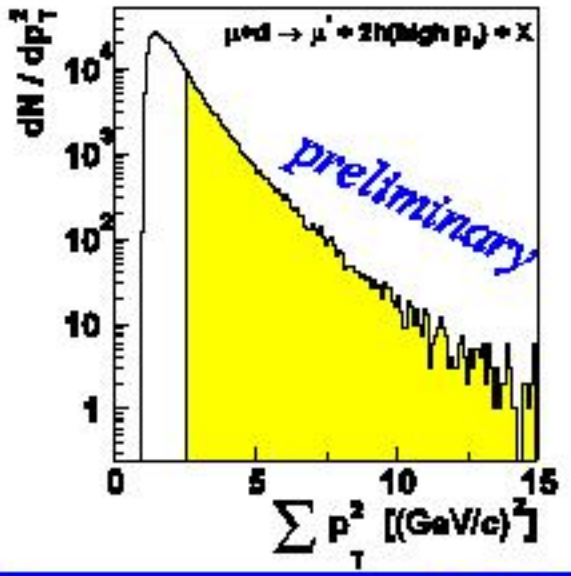
$$A_{LL}^{d} = -0.065 \pm 0.036_{stat.} \pm 0.010_{syst.}$$

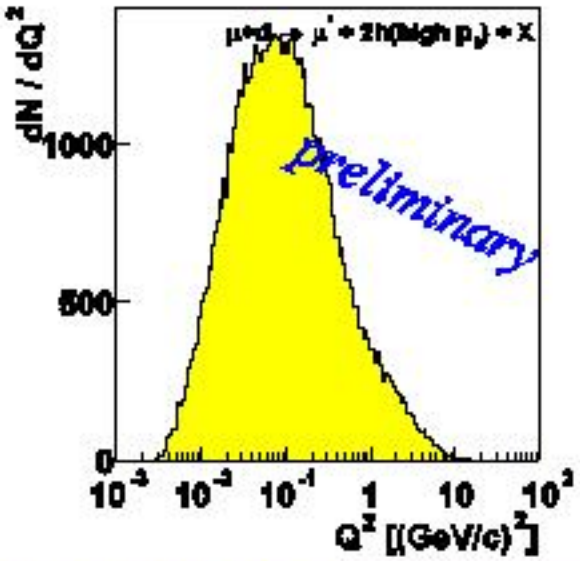
High p_T cuts


dN/dz
preliminary
z [cm]

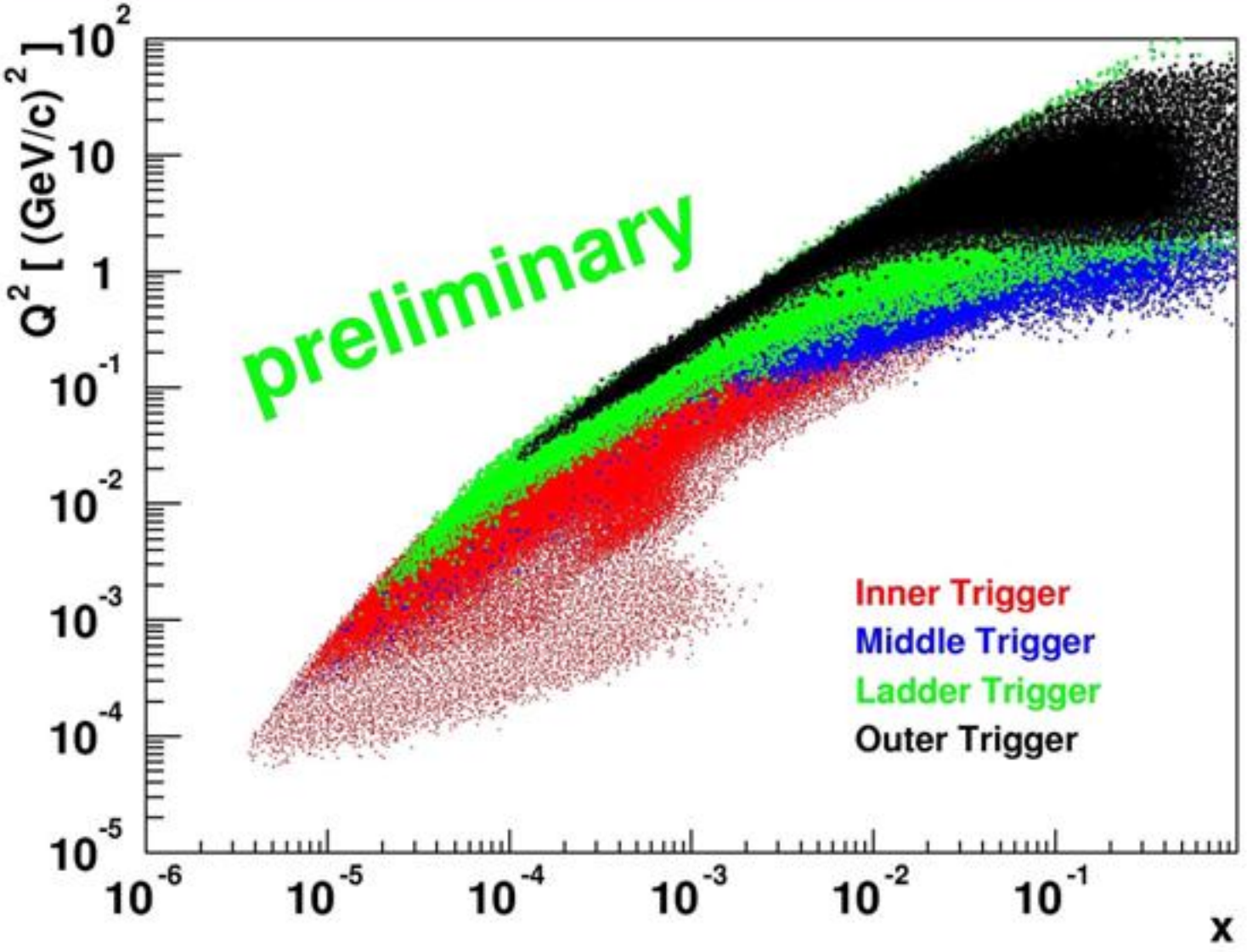

dN / dy
preliminary
y


dN / dm
preliminary
m [GeV/c²]

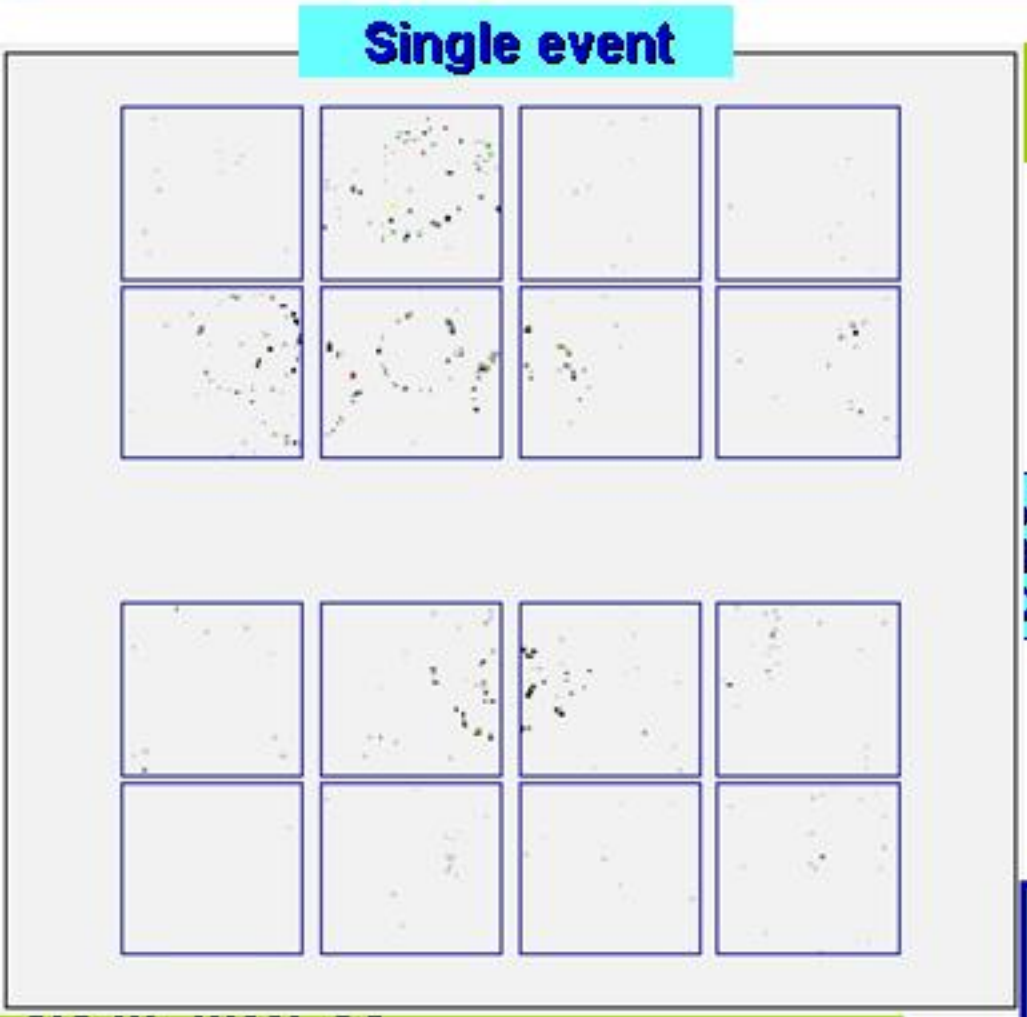

dN / dp²T
preliminary
Σ p²T [(GeV/c)²]

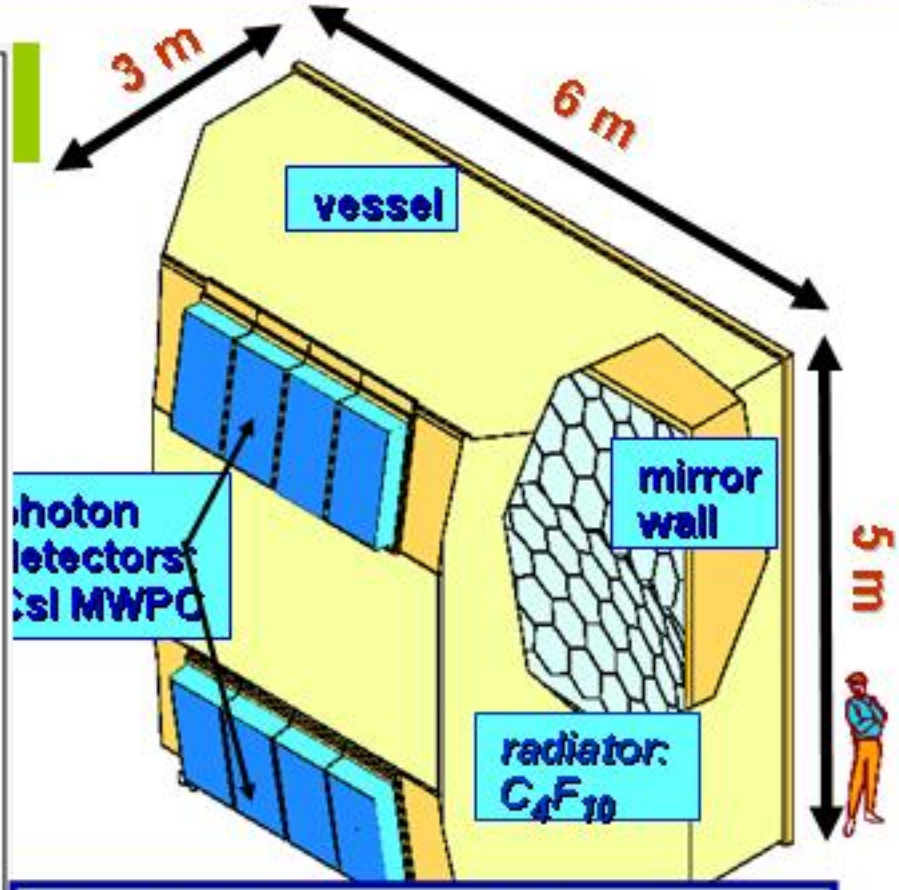

dN / dQ²
preliminary
Q² [(GeV/c)²]

COMPASS Acceptance



Ring Imaging CHerenkov Counter (RICH)





16 CsI Photocathodes

84,000 analog readout channels

single photon:	σ =1.2 mrad
ring:	σ =0.4 mrad
photons/ring	n ~14
3σ π/K sep.	up to 40 GeV/c