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# Measurement of $\frac{\Delta G}{G}$ in the Open Charm channel at COMPASS

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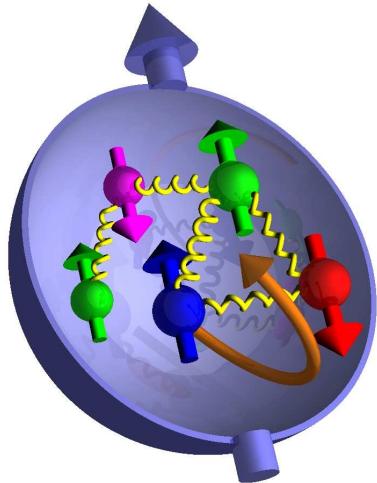


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on behalf of the COMPASS Collaboration



- ➊ Spin Structure & Measurement
- ➋ COMPASS Experiment
- ➌  $\frac{\Delta G}{G}$  in Open Charm
- ➍ Systematics
- ➎ Conclusion

# *Spin Structure of the Nucleon*



## Nucleon:

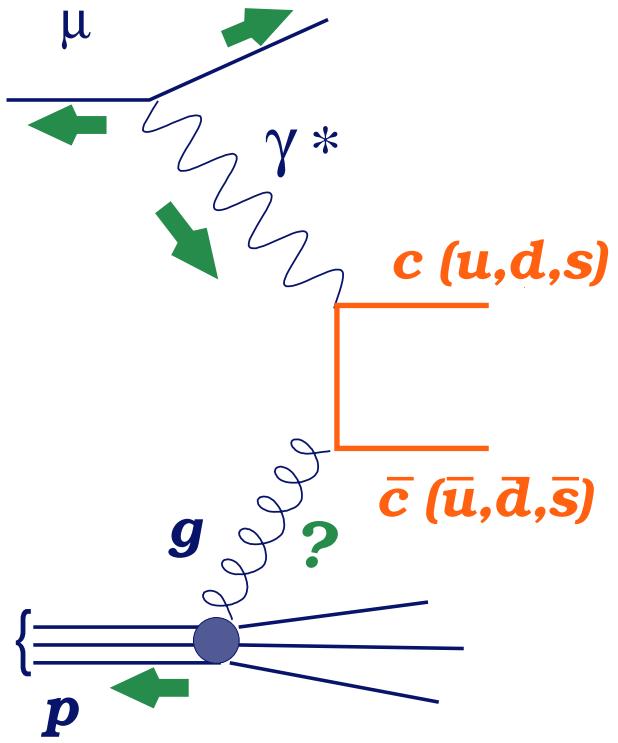
- ⌚ composition: quarks, gluons
- ⌚ spin:  $\frac{1}{2}$  → spin composition?

$$\langle \mathbf{S}_z^N \rangle = \frac{1}{2} = \frac{1}{2} \Delta \Sigma + \Delta G + \langle L_z \rangle$$

- ⌚ quark contribution:
  - ⌚ measured  $\Delta \Sigma$  smaller than predicted
  - ⌚ does not explain total nucleon spin
- ⌚ **How about the gluon contribution?**



## Photon-Gluon-Fusion



### PGF Tags:

- ⌚ high  $p_T$  hadron pairs

- ⌚ all quarks from PGF

BUT competing processes  
⇒ difficult systematics

- ⌚ open charm



- ⌚ scale  $\hat{s} = 4m_c^2$

- ⌚ no physical background

- ⌚ challenge: c-quark tagging

BUT low statistics

# COMPASS Detector

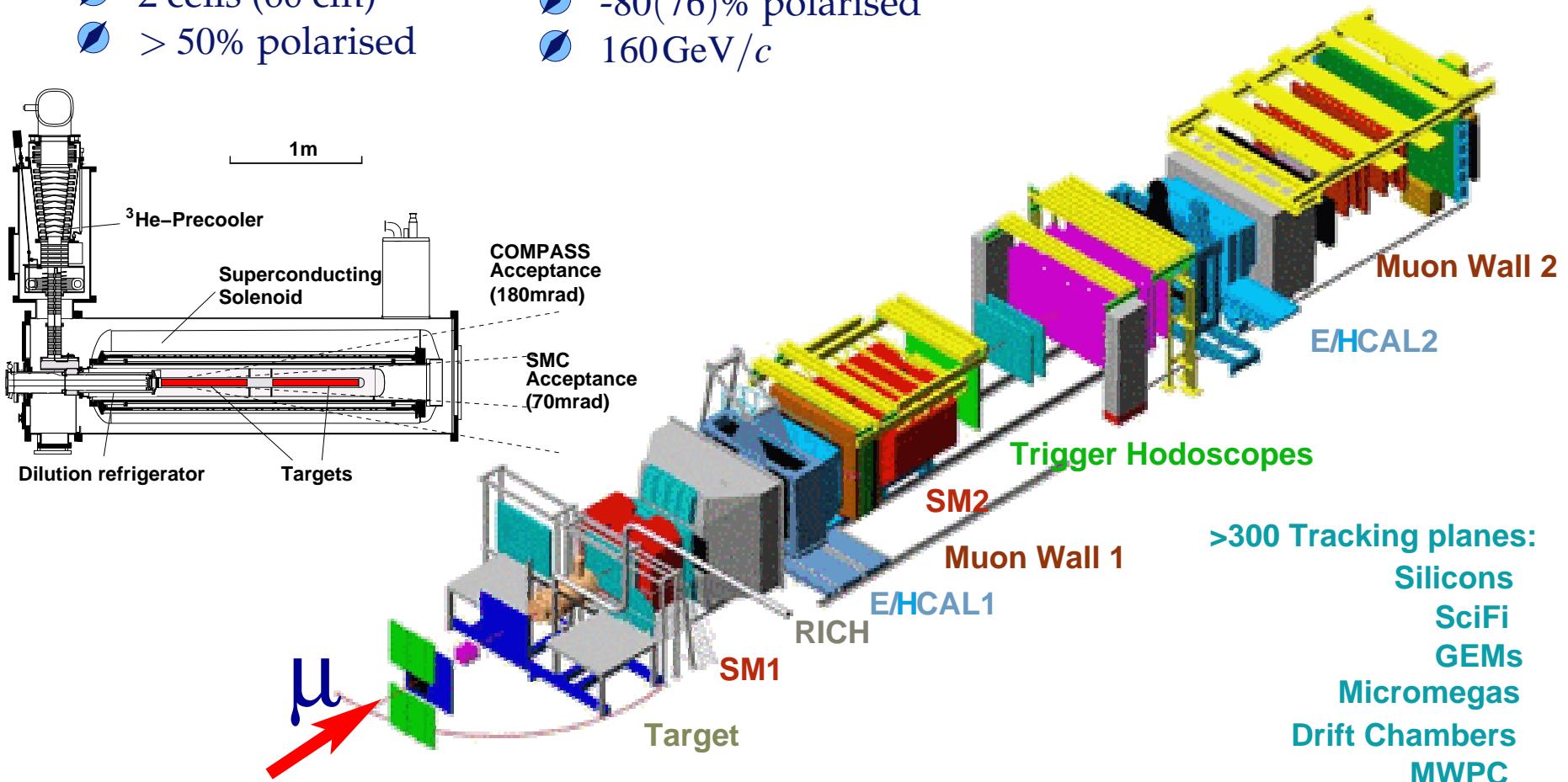


Target:

- ${}^6\text{LiD}$
- 2 cells (60 cm)
- > 50% polarised

$\mu$  beam:

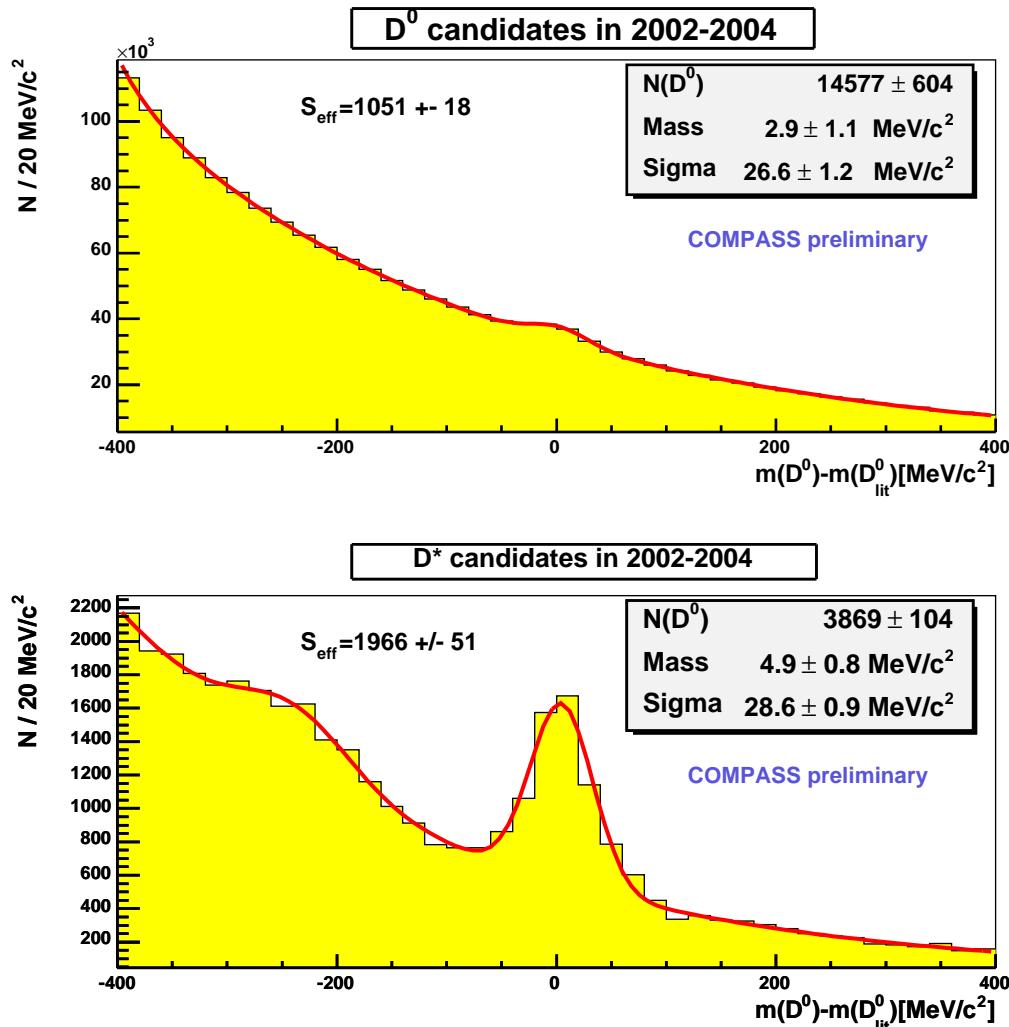
- $2 \cdot 10^8$  particles/spill(4.8s/16.8s)
- -80(76)% polarised
- 160 GeV/c



# D Meson Reconstruction



## ⌚ open charm tag: reconstructed D-mesons

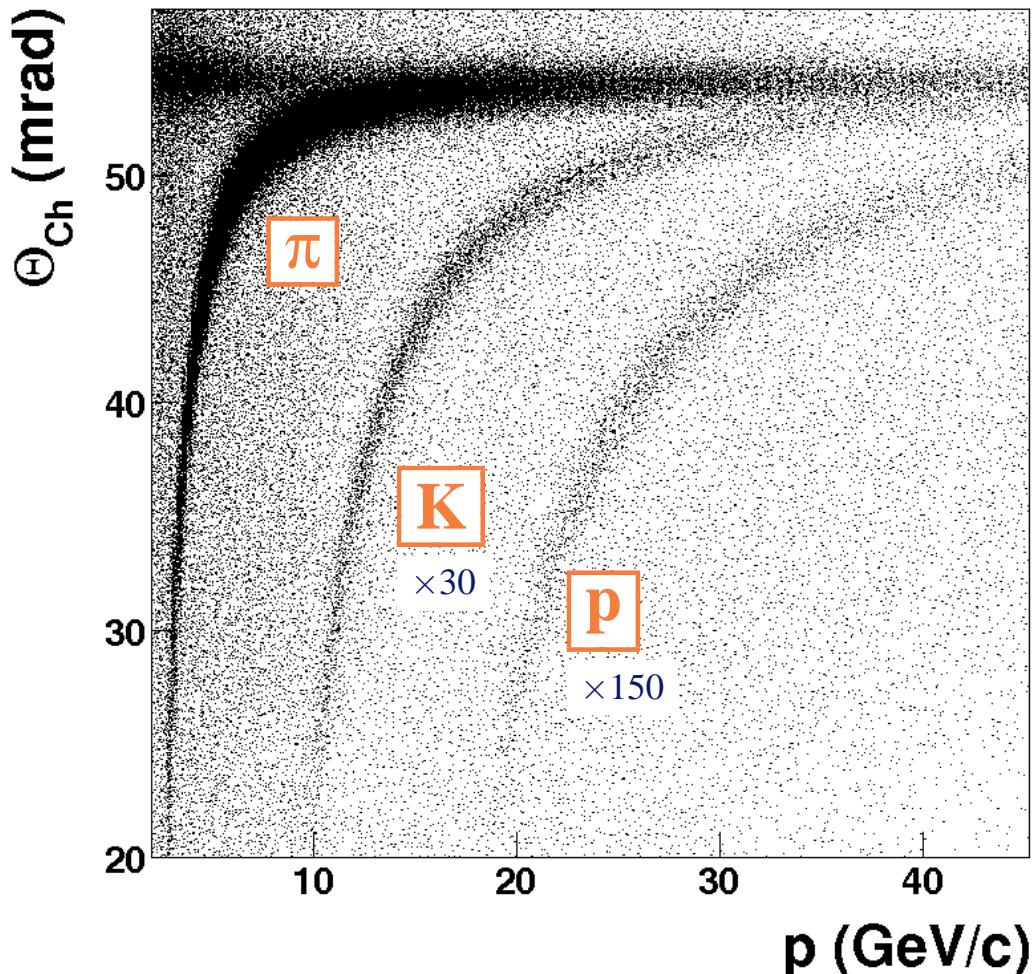


- ⌚ thick target: no decay vertex
- ⌚ track based reconstruction
- ⌚ two channels:
  - ⌚  $D^0 \rightarrow (K\pi)$ , no  $D^*$  tag
  - ⌚  $D^* \rightarrow (K\pi)\pi_{slow}$
- ⌚ selection criteria:
  - ⌚ **D<sup>0</sup> kinematics:**
    - ⌚ momentum fraction  $z_{D^0} > 0.2(0.25)$
    - ⌚  $D^0$  decay angle:  $|\cos\theta^*| < 0.85(0.5)$
  - ⌚ **D<sup>\*</sup> tag:** mass difference  $\delta m$   
 $3.1 \text{ MeV}/c^2 < \delta m - m_\pi < 9.1 \text{ MeV}/c^2$
  - ⌚ **PID (next slide)**

# Particle Identification in the RICH



- ➊ RICH:  $K/\pi$  separation up to  $\sim 50 \text{ GeV}/c$
- ➋ for  $D$ -mesons:
  - ➌ **kaon identification**
  - ➍ **pion:** kaon exclusion
- ➎ new method applied  
→ **log-likelihood**
- ➏ background parametrisation
- ➐ number of photons in ring



# Determination of $\frac{\Delta G}{G}$



$$N_{u,d} = \mathbf{a} \Phi n (\sigma_{PGF} + \sigma_B) (1 + P_T P_B f(\mathbf{a}_{LL} \frac{\sigma_{PGF}}{\sigma_{PGF} + \sigma_B} \frac{\Delta G}{G} + a_{LL}^B \frac{\sigma_B}{\sigma_{PGF} + \sigma_B} A_B))$$

- ⌚ 4 counting rates: 2 cells  $\times$  2 configurations

→ look at **double ratio**:  $\delta = \frac{N_u \cdot N'_d}{N'_u \cdot N_d}$

- ⌚ flux normalisation: same flux for both cells  $\rightarrow \frac{\Phi n_u \cdot \Phi' n_d}{\Phi' n_u \cdot \Phi n_d} = 1$

- ⌚ assume: stable acceptance ratio:  $\frac{a_u \cdot a'_d}{a_d \cdot a'_u} = 1$

- ⌚ assume  $A_B$  negligible

⇒ solve for  $\frac{\Delta G}{G}$  (2nd order equation)

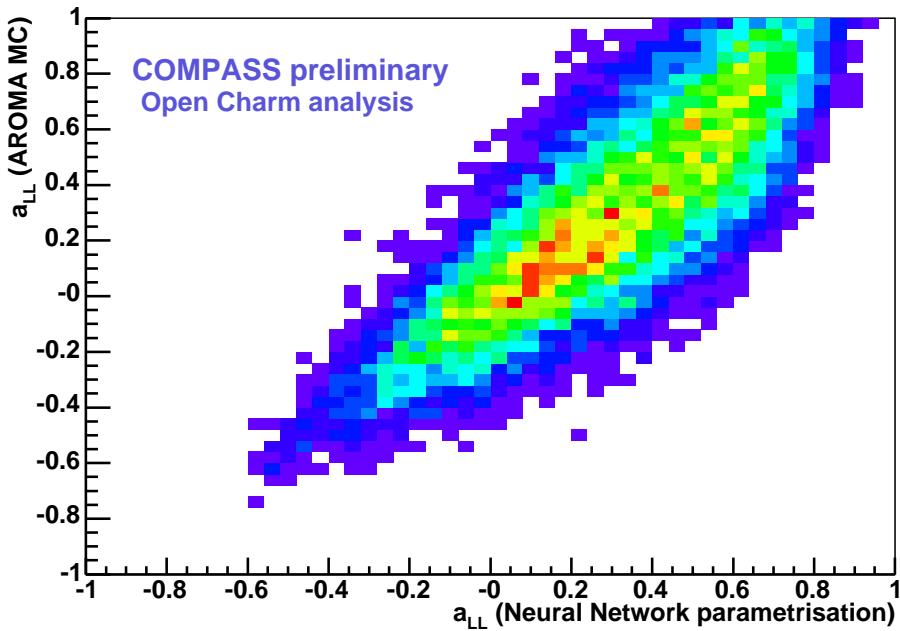
- ⌚ needed inputs:
  - ⌚ polarisations & dilution factor ✓
  - ⌚ analysing power & signal purity

# Analysing Power



PGF events:  $\frac{A_{||}}{D} = \frac{\int d\hat{s} \Delta\sigma^{PGF}(\hat{s}) \Delta G(x_g, \hat{s})}{\int d\hat{s} \sigma^{PGF}(\hat{s}) G(x_g, \hat{s})} \approx \langle a_{LL} \rangle \frac{\Delta G}{G}$

D: Depolarisation factor



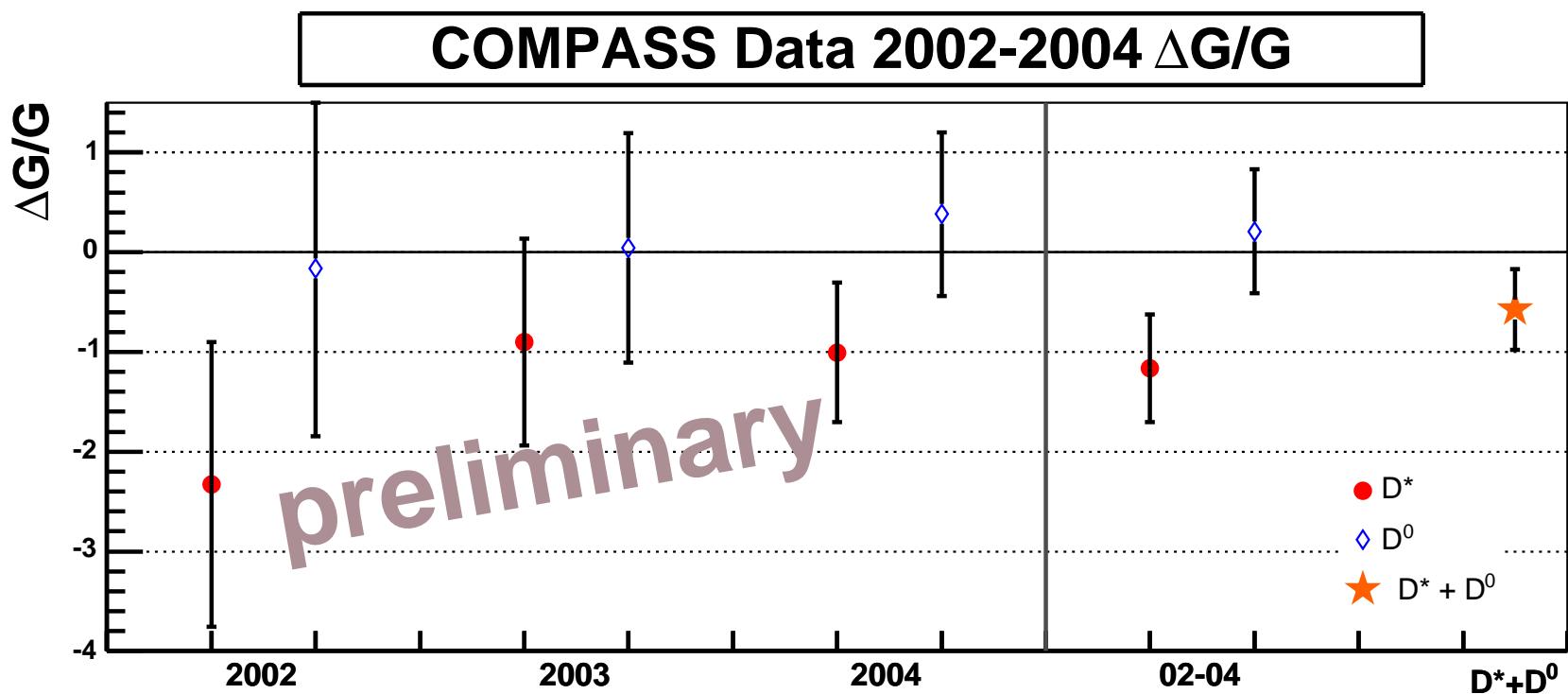
- ➊ hard scattering kinematics
- ➋ needs MC information
- ➌ MC (AROMA) vs Data: ✓
- ➍ calculated from:  $y, Q^2, s, t, u$
- ➎ **a<sub>LL</sub> from observables?**
- ➏ **neural network**
- ➐ parametrisation with:  
 $y, Q^2, z_{D^0}, p_T^\gamma D^0$

# Signal Purity



- signal purity:  $\frac{S}{S+B}$  taken from fit to spectra
- analysing power  $\leftrightarrow$  signal purity anticorrelated  
 $\Rightarrow$  **subdivide sample into bins of  $a_{LL}$  for fit**
- weight events with  $\frac{S}{S+B}$  in  $\frac{\Delta G}{G}$  determination  
 $\Rightarrow \sigma_{stat}(\frac{\Delta G}{G}) \propto 1/S_{\text{eff}}$
- Effective signal:**  $S_{\text{eff}} = \int \frac{S(m)}{S(m)+B(m)} dm$
- $\frac{\Delta G}{G}$  determination
  - use weighted events  $\rightarrow$  optimises  $\sigma_{stat}$
  - calculated  $\frac{\Delta G}{G}$  for each year / channel separately  $\rightarrow$  minimise  $\sigma_{syst}$

# $\frac{\Delta G}{G}$ from Open Charm (preliminary)



Preliminary Result from COMPASS 2002-2004 data

$$\frac{\Delta G}{G} = -0.57 \pm 0.41$$

$$\mu^2 \sim 13 \text{ (GeV}/c)^2, x_G \sim 0.15$$

# Systematics: False Asymmetries



- False Asymmetry: non physical asymmetry from unstable acceptance:  $\frac{a_u \cdot a'_d}{a_d \cdot a'_u} \neq 1$
- studied possible FAs from instabilities (in full mass range)
  - spectrometer geometry (particle angles)
  - momentum ranges of outgoing particles
  - time of day
  - microwave settings (target setting)
  - target cell (acceptance)

no effect seen!

up to the level of statistical error

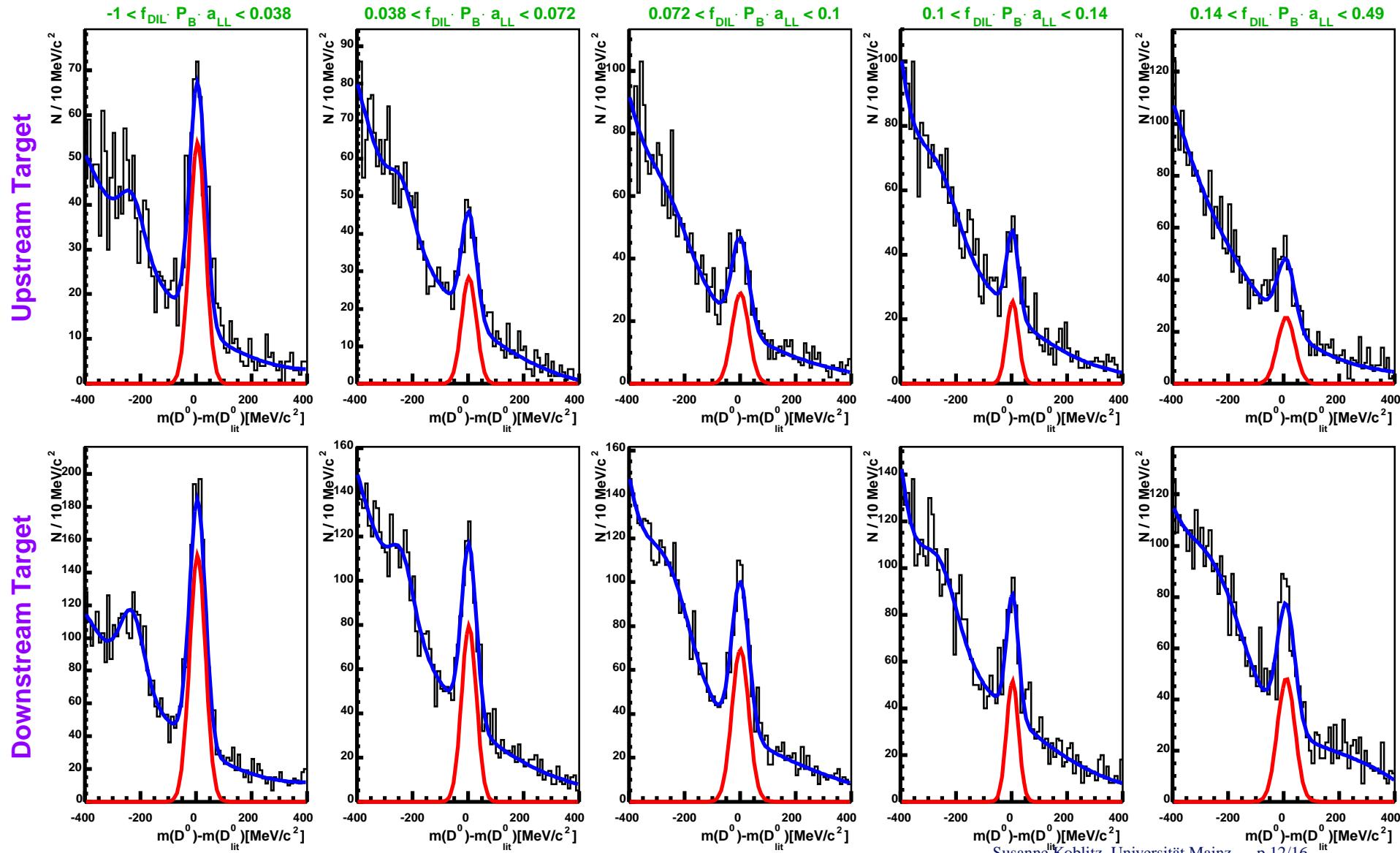
→ contribution estimated from statistical precision

$$\delta \left( \frac{\Delta G}{G} \right)_{\text{FA}} = 0.10$$

# Systematics: Example for Fit Function



## Systematics Studies: fit to spectra of D\* candidates (COMPASS Preliminary)



# Systematics: Influence of Fit Function



- ➊ result of fit to spectra used for signal purity
- ➋ several choices for fit:
  - ➌ function for background description
  - ➌ binning
  - ➌ minimization
  - ➌ fixed parameters (function shapes)
- ➌ for systematics: perform fits with different settings  
look at spreading of  $\frac{\Delta G}{G}$   
→ **contribution from fitting procedure**

$$\delta \left( \frac{\Delta G}{G} \right)_{\text{fit}} = 0.09$$

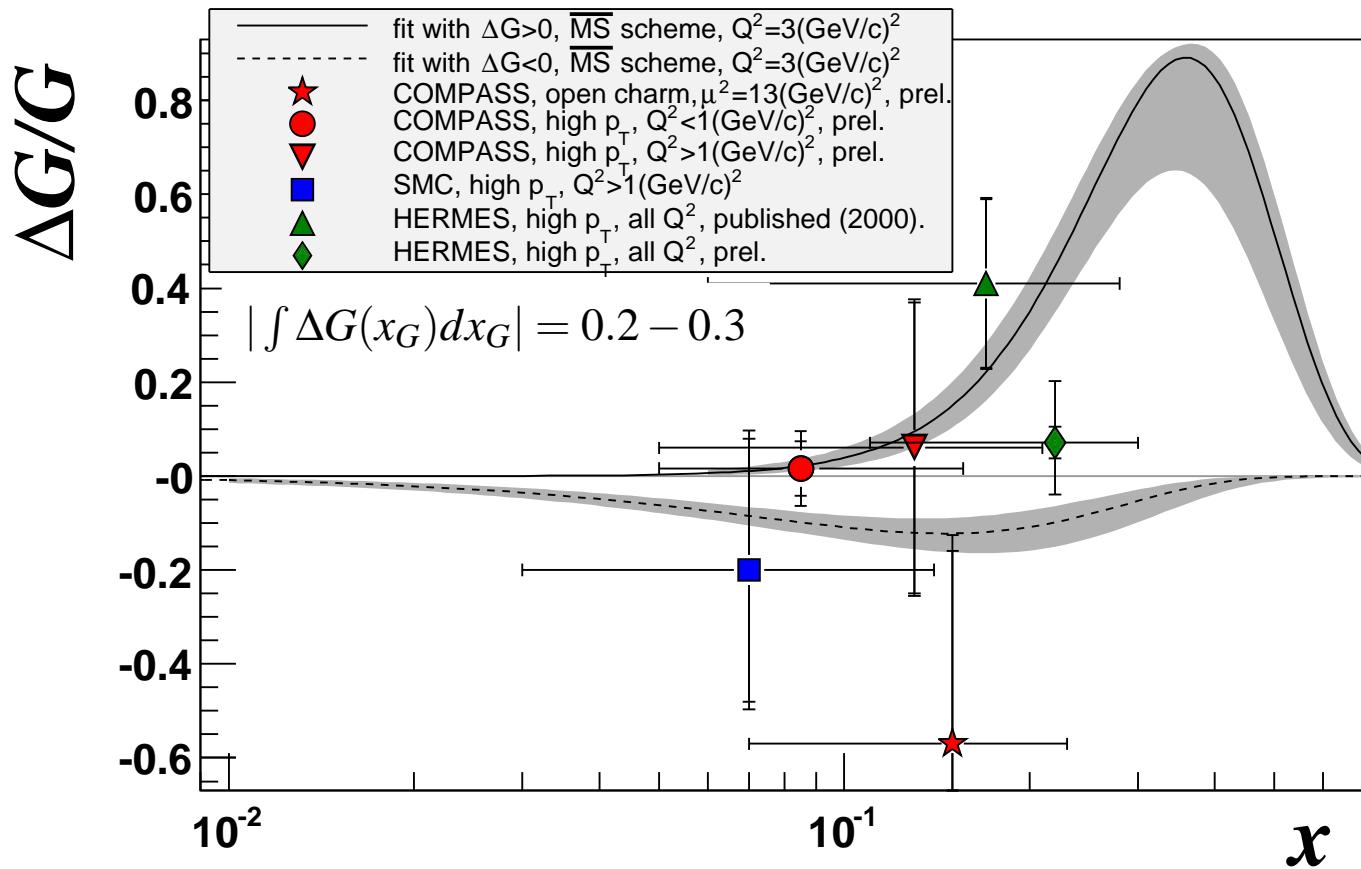
# Systematics: other contributions



- ➊ background asymmetry:
  - ➊ no evidence found!(looser cuts, sidebands ...)
  - ➋ estimation of effect: added in  $\frac{\Delta G}{G}$  determination  $\delta(\Delta G/G)_{\text{BA}} = 0.07$
- ➋ Monte Carlo: model dependency checked with:
  - ➊ different charm masses  $\delta(\Delta G/G)_{\text{MC}} = 0.05$
  - ➋ different structure functions
- ➌ binning procedure:  $\delta(\Delta G/G)_{\text{MC}} = 0.04$
- ➍ target polarisation (5%):  $\delta(\Delta G/G)_{\text{TP}} = 0.03$
- ➎ beam polarisation (5%):  $\delta(\Delta G/G)_{\text{BP}} = 0.03$
- ➏ dilution factor (5%):  $\delta(\Delta G/G)_{\text{DF}} = 0.03$

$$\delta \left( \frac{\Delta G}{G} \text{ syst.} \right) = 0.17$$

# Conclusion



- ➊ small  $\int \Delta G dx_G$  preferred
- ➋ spin puzzle not yet solved!

# Conclusion

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- ➊ addition of 2004: significant improvement in statistics
- ➋ systematical uncertainty relatively small
- ➌ 2006 data: improvements from hardware upgrades expected
  - ➍ larger acceptance: magnet + tracking
  - ➎ RICH upgrade
- ➏ analysis started!