# Measurements of $\frac{\Delta G}{G}$ in COMPASS

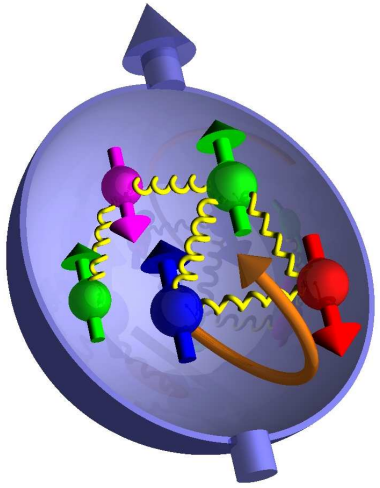

Susanne Koblitz,

Universität Mainz

on behalf of the COMPASS Collaboration


- Spin Structure & Measurement
- COMPASS Experiment
- $\frac{\Delta G}{G}$ in Open Charm
- Systematics
- Conclusion

# Spin Structure of the Nucleon



## Nucleon:

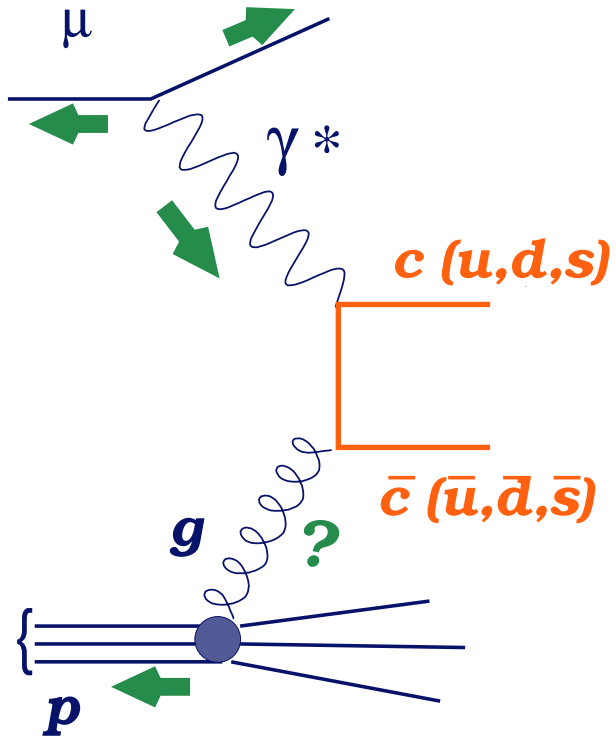
- composition: quarks, gluons
- spin: $\frac{1}{2}$ $\rightarrow$ spin composition?

$$< \mathbf{S_z^N} > = \mathbf{\frac{1}{2}} = \frac{1}{2}\Delta\Sigma + \Delta G + < L_Z >$$

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

# $\frac{\Delta G}{G}$ in COMPASS

## Photon-Gluon-Fusion




## PGF Tags:

- high $p_T$ hadron pairs
  - all quarks from PGF

  BUT competing processes

  $\Rightarrow$ difficult systematics
- **open charm**

$(\gamma^{\star} g) \rightarrow (c\bar{c}) \rightarrow D X \rightarrow (K\pi) X$

  - scale $\hat{\mathbf{s}} = \mathbf{4m_c^2}$
  - no physical background
  - challenge: **c**-quark tagging

BUT low statistics

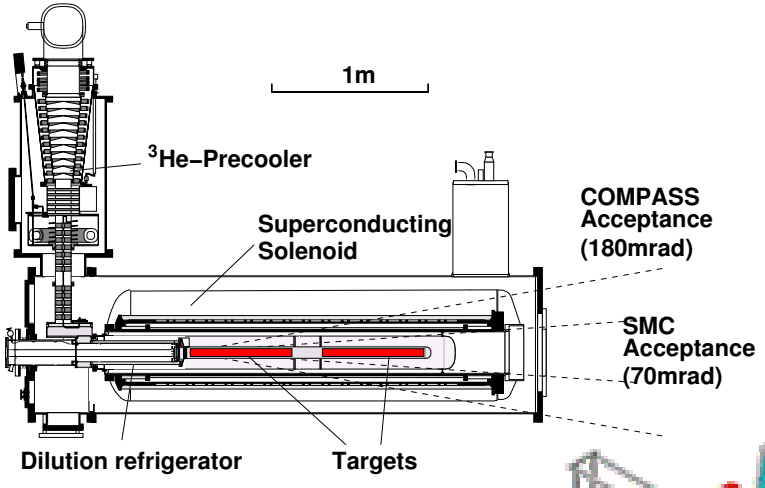
# COMPASS Detector

Target:

- $^6$LiD
- 2 cells (60 cm)
- $>$ 50% polarised

$\mu$ beam:

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



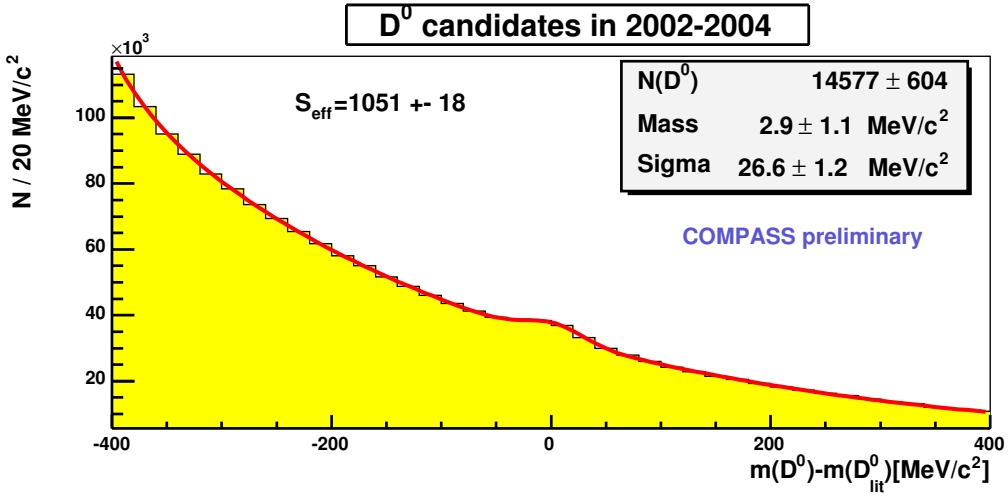


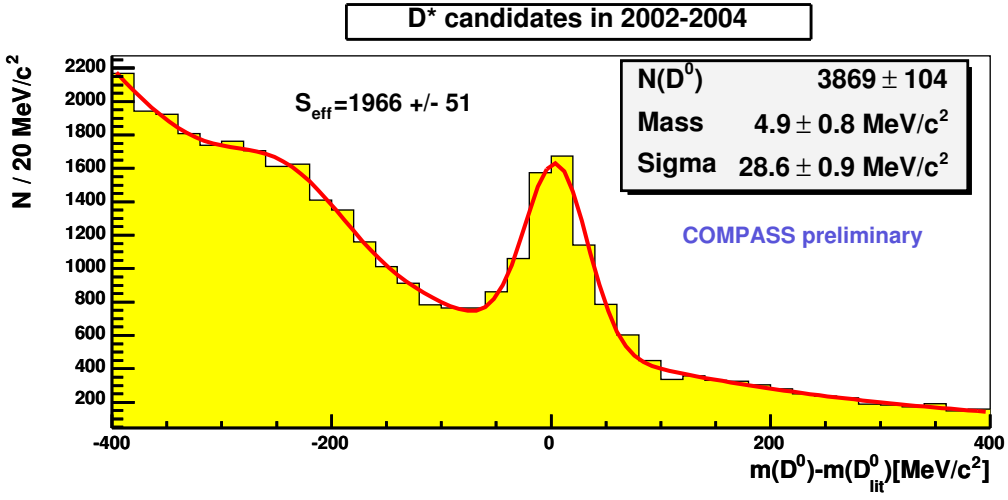


>300 Tracking planes:
Silicons
SciFi
GEMs
Micromegas
Drift Chambers
MWPC
Straws

# D Meson Reconstruction

- open charm tag: **reconstructed $D$-mesons**



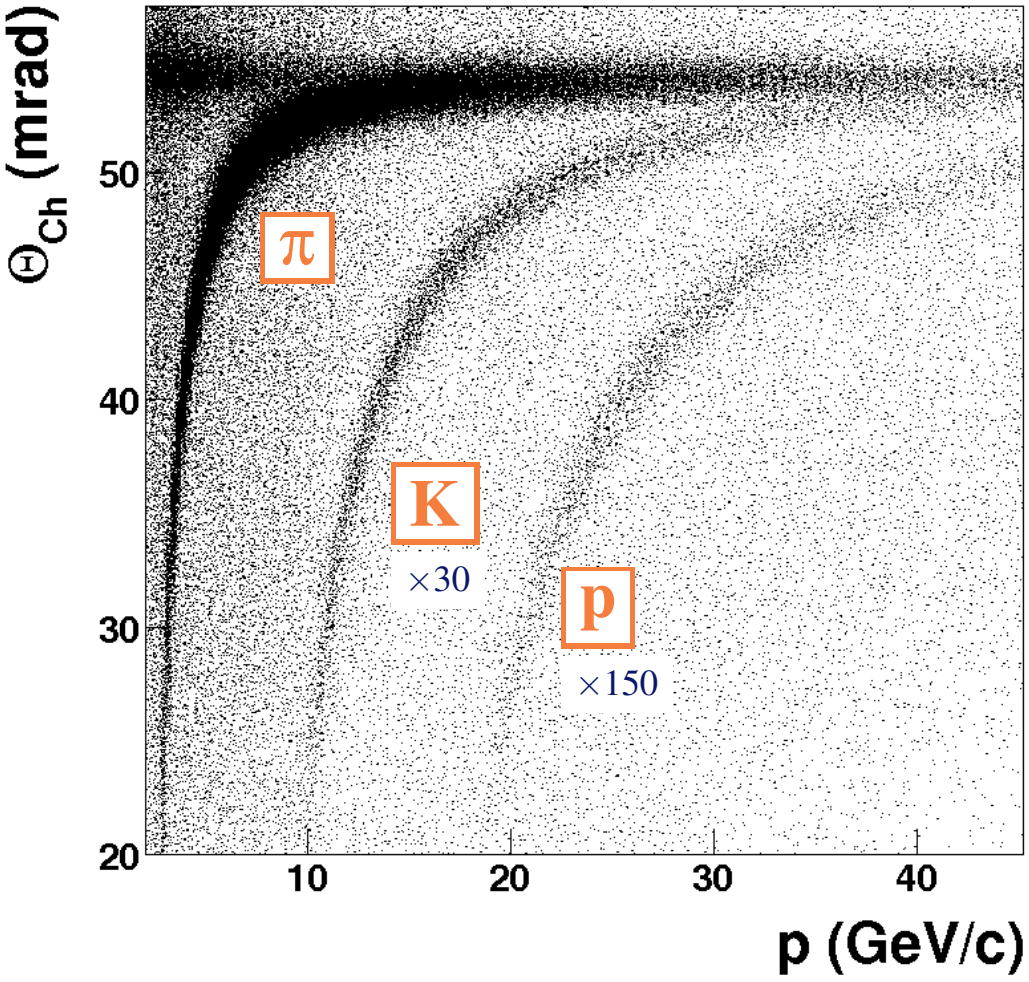

- thick target: no decay vertex
- track based reconstruction
- two channels:
  - $D^0 \rightarrow (K\pi)$, **no $D^\star$ tag**
  - $D^\star \rightarrow (K\pi)\pi_{slow}$
- **selection criteria:**
  - $D^0$ **kinematics:**
    - momentum fraction $z_{D^0} > 0.2 (0.2$
    - $D^0$ decay angle: $|cos\theta^\star|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

# Particle Identification in the RICH

- RICH: $K/\pi$ separation up to $\sim 50\,\mathrm{GeV}/c$
- for $D$-mesons:
  - **kaon** identification
  - **pion:** kaon exclusion
- new method applied
  $\rightarrow$ **log-likelihood**

⊕ background parametrisation

⊕ number of photons in ring



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

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

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

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

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

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

- assume $A_B$ negligible

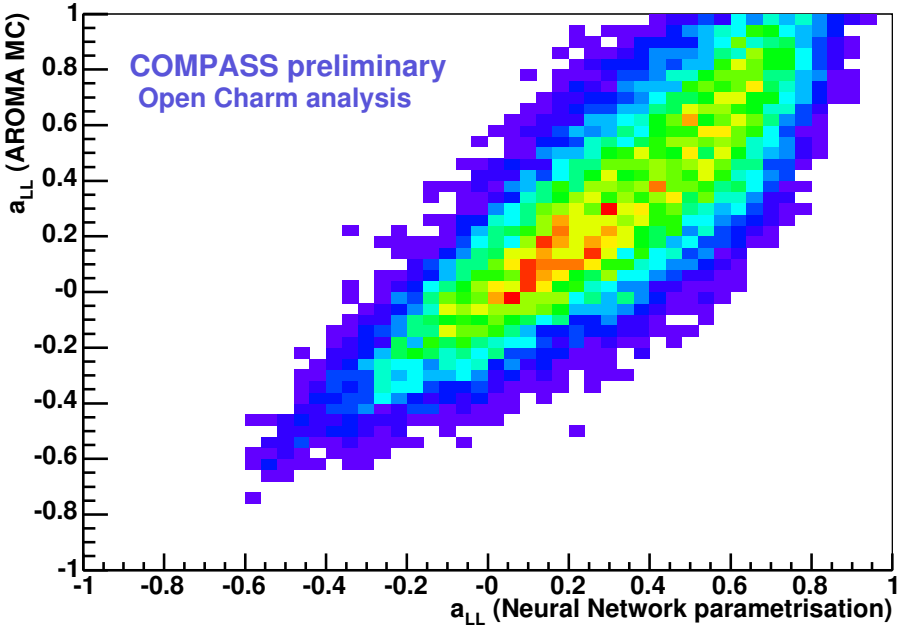
  $\Rightarrow$ solve for $\frac{\Delta G}{G}$ (2nd order equation)

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

# Analysing Power

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

$D$: Depolarisation factor




- hard scattering kinematics
- needs MC information
- MC (AROMA) vs Data: ✓
- calculated from: $y$, $Q^2$, $s$, $t$, $u$
- $\mathbf{a_{LL}}$ from **observables?**
- **neural network**
- parametrisation with:
  $y$, $Q^2$, $z_{D^0}$, $p_{T\,D^0}^{\gamma}$

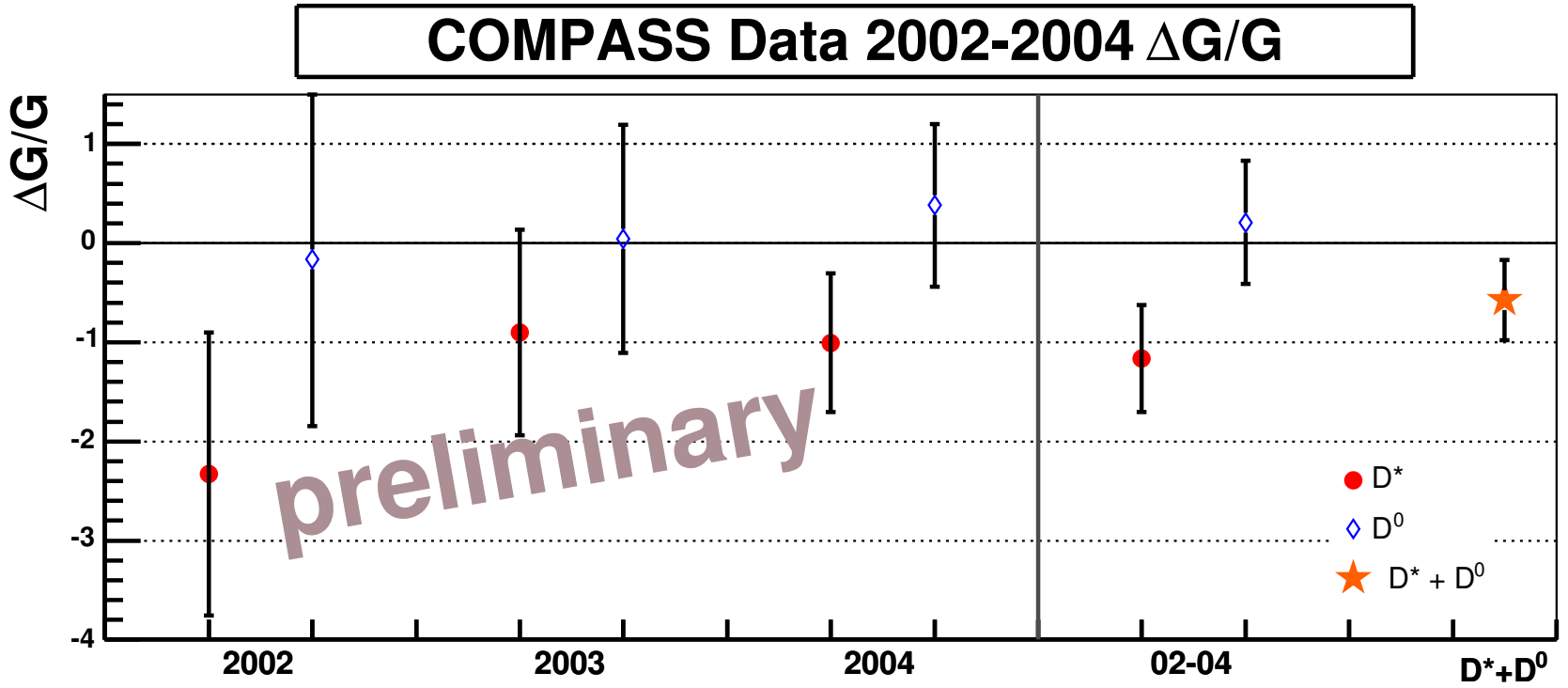
# Signal Purity


- 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

  $$\Rightarrow \sigma_{stat}\left(\frac{\Delta G}{G}\right) \propto 1/S_{\text{eff}}$$
- **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

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

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

# 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 instabilies (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!**

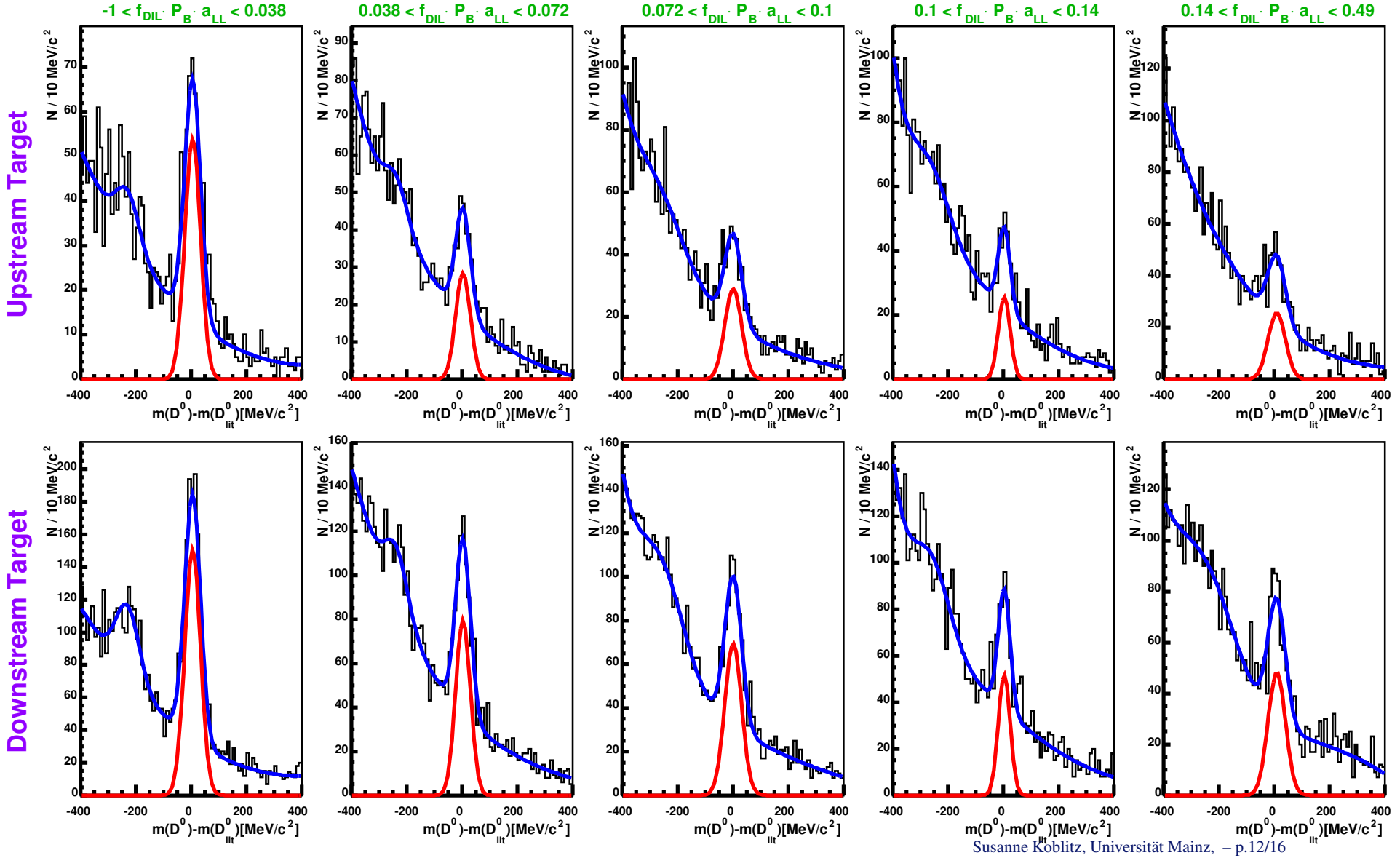
up to the level of statistical error

$\rightarrow$ **contribution estimated from statistical precision**

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

# Systematics: Example for Fit Function

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



# Systematics: Influence of Fit Function


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

$\rightarrow$ **contribution from fitting procedure**

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

# Systematics: other contributions

- background asymmetry:
  - no evidence found!(looser cuts, sidebands ...)
  - estimation of effect: added in $\frac{\Delta G}{G}$ determination

$$\delta(\Delta G/G)_{\mathrm{BA}} = 0.07$$

- Monte Carlo: modell dependency checked with:
  - different charm masses
  - different structure functions

$$\delta(\Delta G/G)_{\mathrm{MC}} = 0.05$$

- binning procedure:

$$\delta(\Delta G/G)_{\mathrm{MC}} = 0.04$$

- target polarisation (5%):

$$\delta(\Delta G/G)_{\mathrm{TP}} = 0.03$$

- beam polarisation (5%):

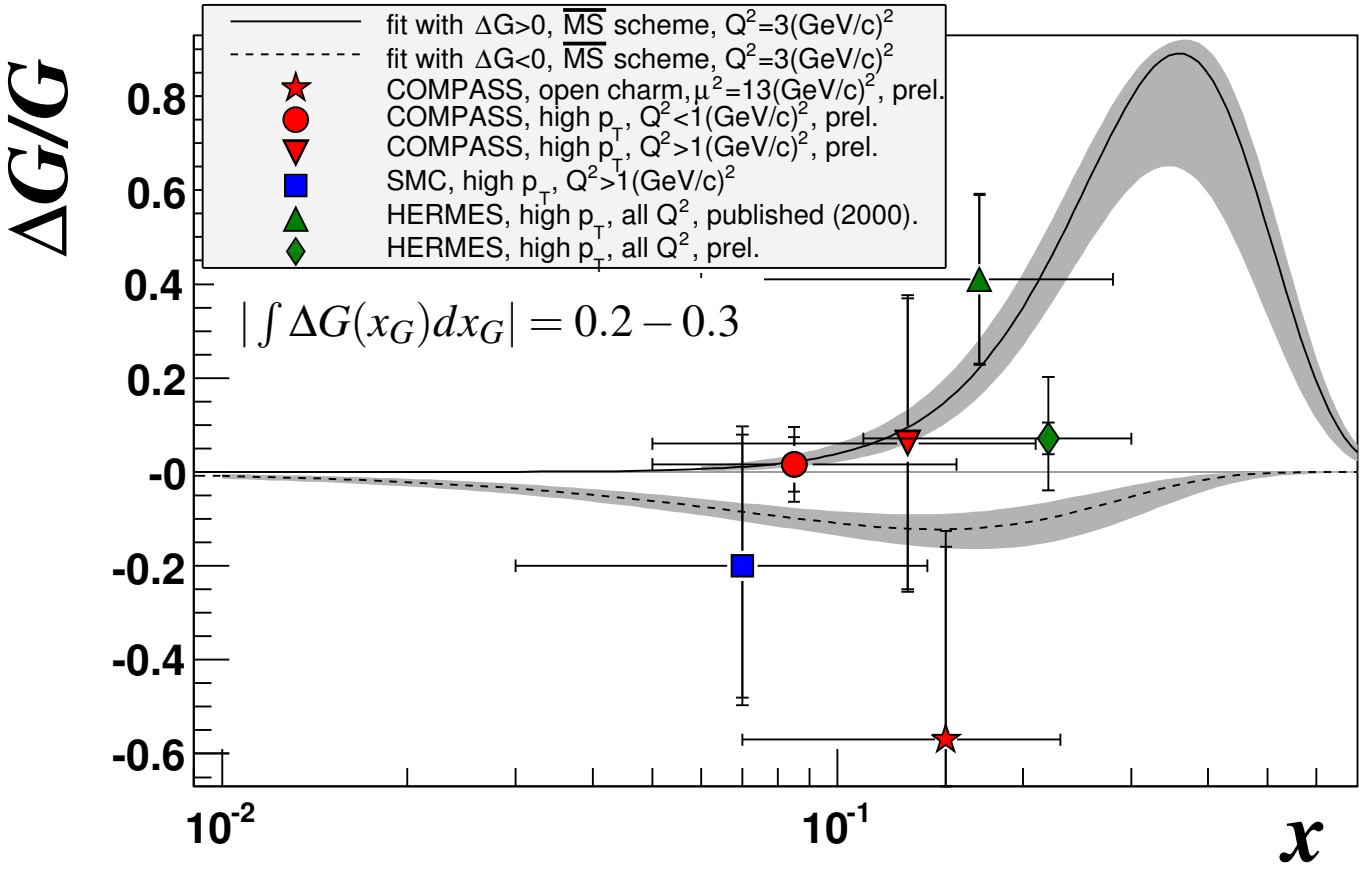
$$\delta(\Delta G/G)_{\mathrm{BP}} = 0.03$$

- dilution factor (5%):

$$\delta(\Delta G/G)_{\mathrm{DF}} = 0.03$$

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

# Conclusion




- small $\int \Delta G dx_G$ prefered
- spin puzzle not yet solved!

# Conclusion


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