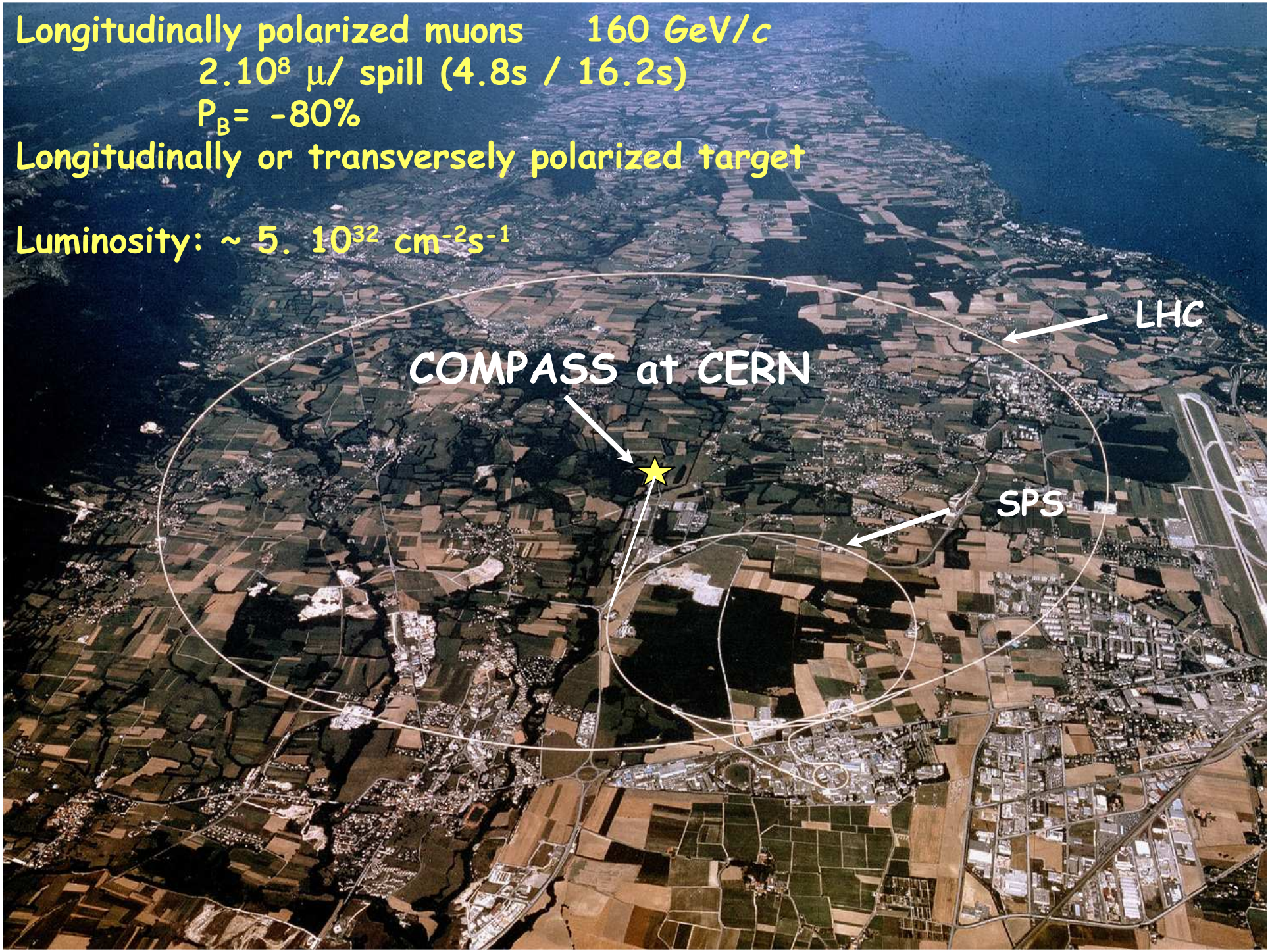
$\Delta g/g$ from Open Charm at COMPASS

F.Kunne – CEA Saclay, France
on behalf of the COMPASS collaboration

"SPIN 2008", Charlottesville VA, USA, October 6-11, 2008


Longitudinally polarized muons 160 GeV/c
2.10^8 μ/ spill (4.8s / 16.2s)
P_B = -80%
Longitudinally or transversely polarized target
Luminosity: ~ 5. 10^32 cm^-2 s^-1
COMPASS at CERN
LHC
SPS

COMPASS Collaboration at CERN

Common Muon and Proton Apparatus

for Structure and Spectroscopy

Czech Rep., France, Germany, India, Israel,
Italy, Japan, Poland, Portugal, Russia and CERN

Bielefeld, Bochum, Bonn, Burdwan and Calcutta, CERN, Dubna, Erlangen,
Freiburg, Lisbon, Mainz, Moscow, Munich, Prague, Protvino, Saclay,
Tel Aviv, Torino, Trieste, Warsaw, Yamagata

220 physicists, 26 institutes

COMPASS spin program 2002-2007

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

- $\Delta\Sigma$ measured small ~ 0.30
- Large ΔG would mask quark spin due to axial anomaly

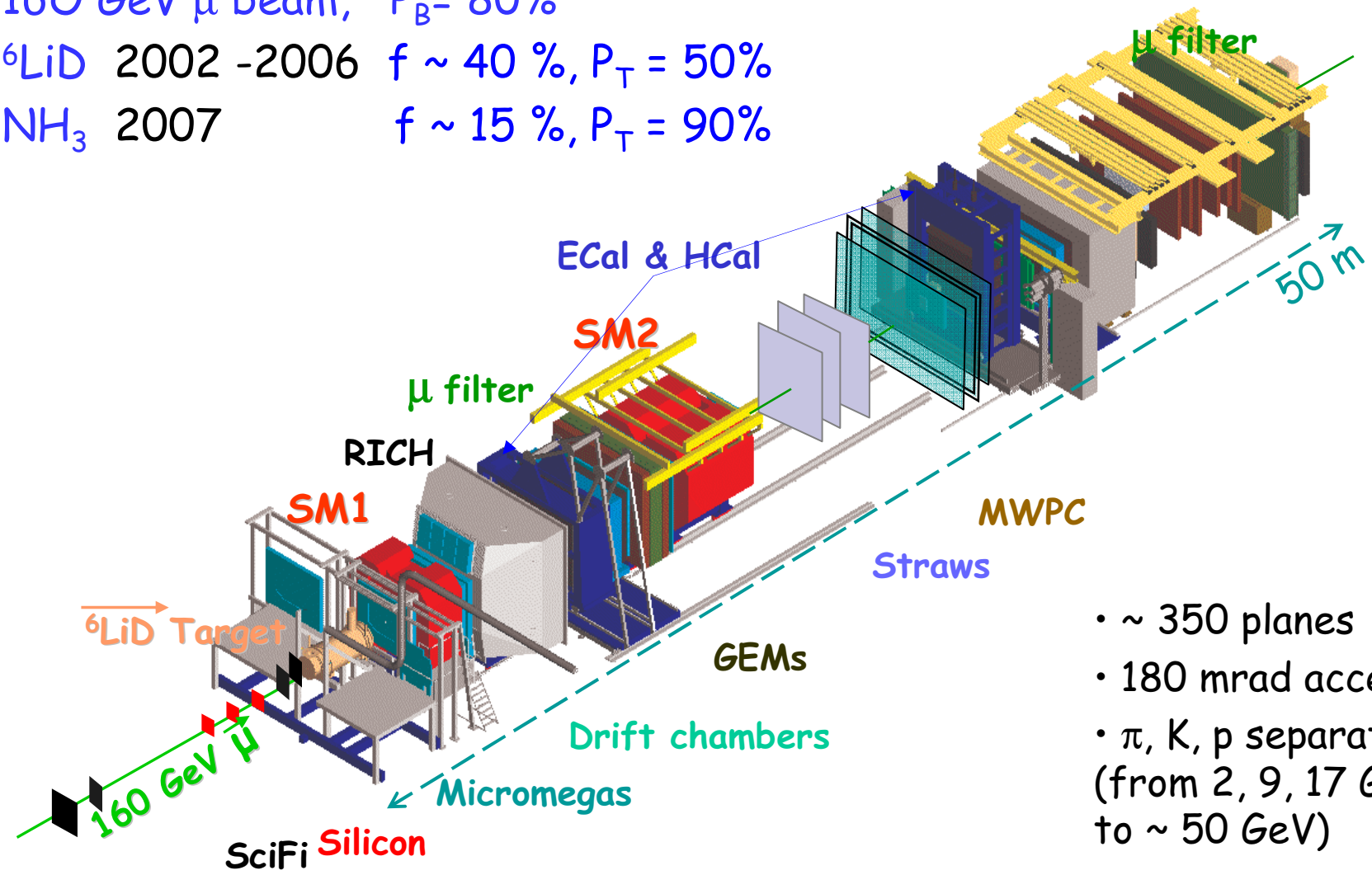
- Gluon polarization
  - Open Charm *this talk*
  - High p_T hadrons *see K. Kurek's talk*
- Quark polarization (g_1, $\Delta\Sigma$, Δq flavor decomposition)
  - Δs from SIDIS *see R. Windmolders's talk*
- Transversity and Transverse Momentum Distributions
  - Collins and Sivers Asymmetries *see H.Wollny's talk*
  - Lambda *see T.Negrini's talk*
- Meson production (ρ, ϕ, J/ψ, Λ, ...)

COMPASS

160 GeV μ beam, P_B= 80%

^{6}LiD 2002 -2006 f ~ 40 %, P_T = 50%

NH_3 2007 f ~ 15 %, P_T = 90%



- ~ 350 planes
- 180 mrad acceptance
- π, K, p separation (from 2, 9, 17 GeV up to ~ 50 GeV)

NIMA 577 (2007) 455

2006 Spectrometer upgrades

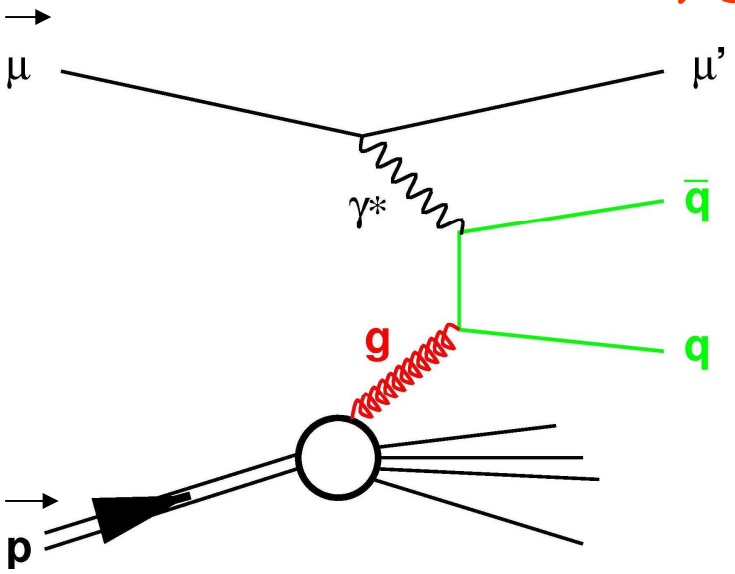
- Large acceptance target magnet: *70 → 180 mrad*
- 3 cell target : *reduce false asymmetries*
- RICH upgrade : *better PID*

  MAPMTs in central region

  APV electronics in periphery

Δg/g measurement

Photon gluon fusion $\gamma g \to q\bar{q}$



• open charm $c \to D^0 \to K\,\pi$

pQCD scale $\mu^2 = 4(m_c^2 + p_T^2)$

Charm in final state signs PGF

no intrinsic charm

resolved γ small

Combinatorial background & limited statistics

Difficult experiment

• high p_T hadron pair $q\,\bar{q} \to h\,h$

pQCD scale $\mu^2 = Q^2$ or Σp_T^2

High statistics

Physical background

See K.Kurek's talk

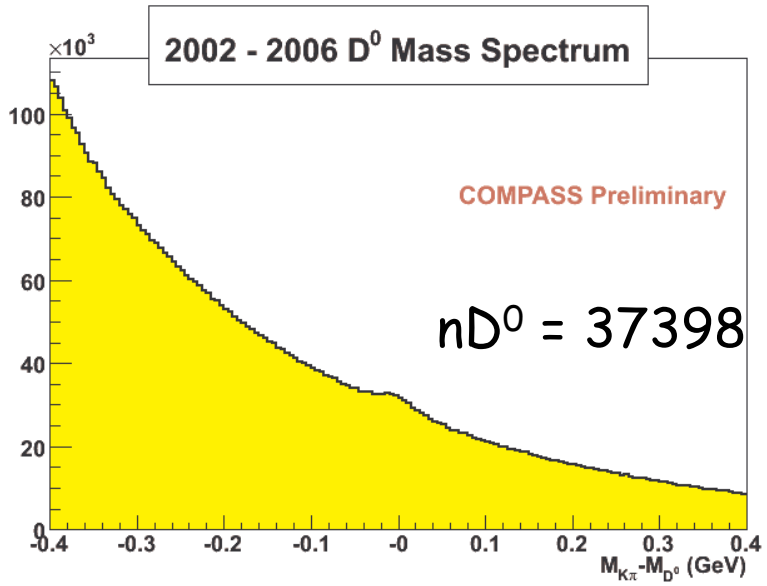
Open charm – D^0 and D^* events

Thick target, no D^0 vertex reconstruction

D^0 selection: *$K\pi$ invariant mass +*

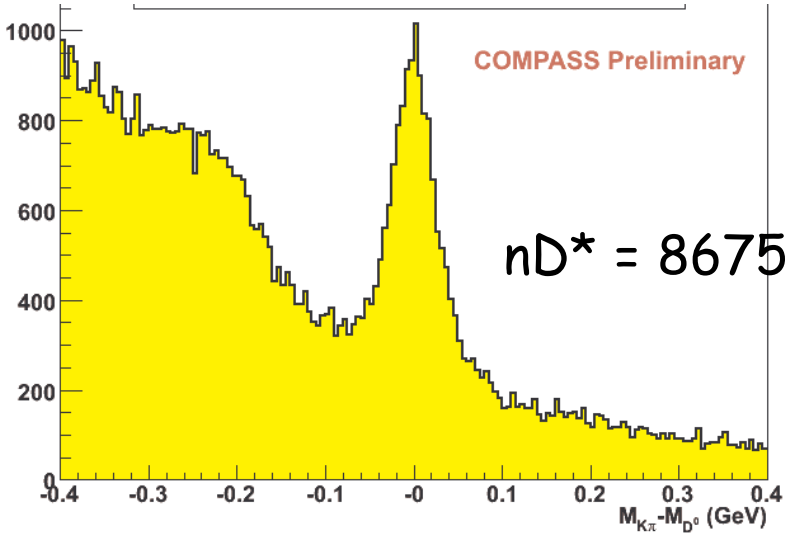
cuts on D^0 decay angle, momentum fraction $z(D^0)$ & RICH PID

$$D^0 \rightarrow K + \pi$$



$$D^* \rightarrow D^0 + \pi_s \rightarrow K + \pi + \pi_s$$

D* tagging : cut on 3body invariant mass

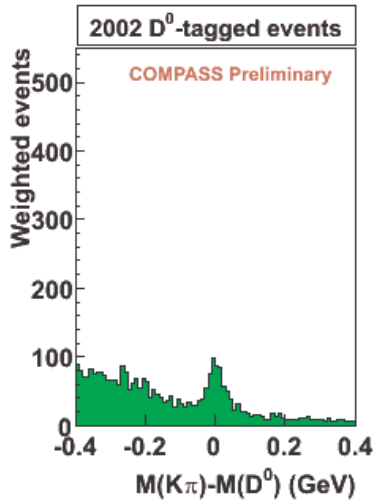
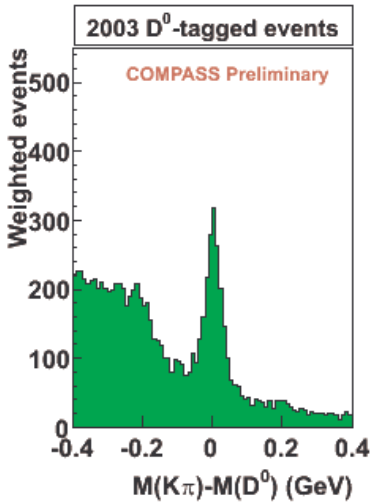
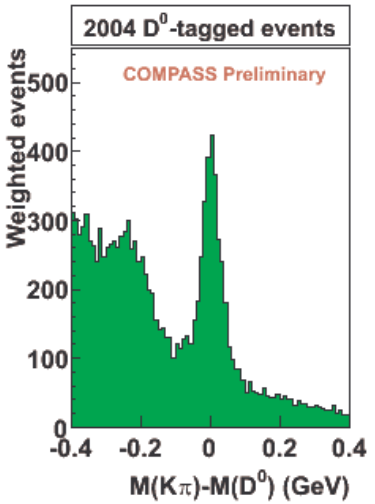
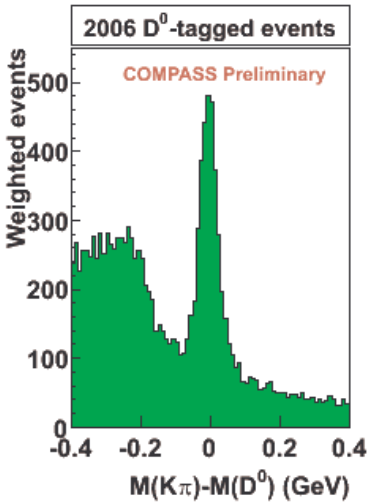
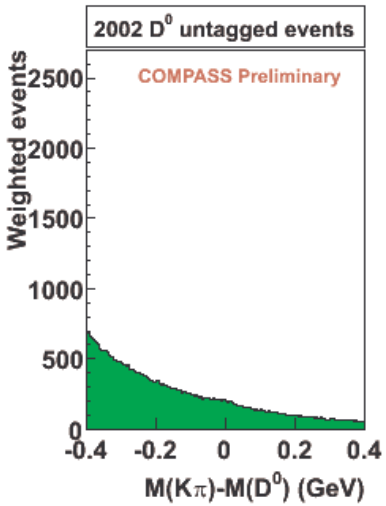
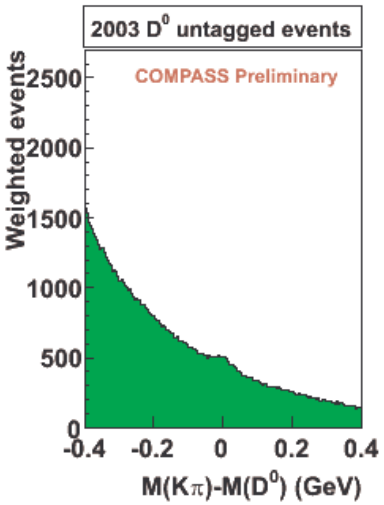
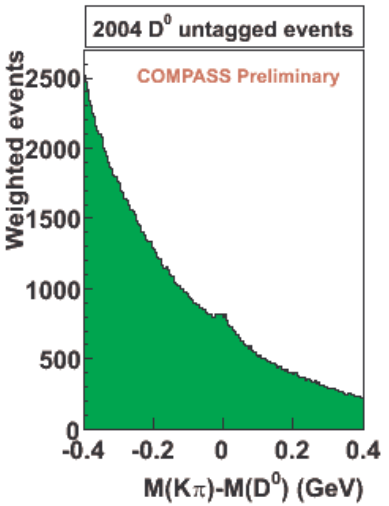
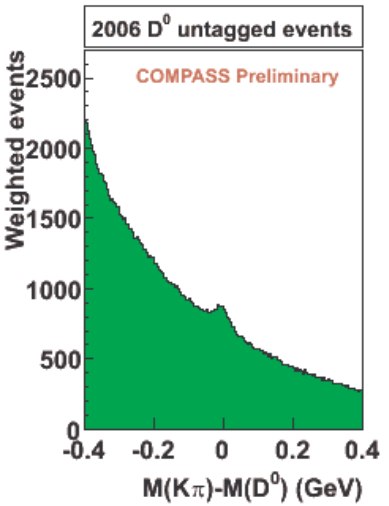


$$\delta\left(\frac{\Delta g}{g}\right) \propto 1\Big/\sqrt{\frac{S}{S+B}\times S}$$

- Use D0 and D* samples
- Additional bump not yet used $D^0 \rightarrow K + \pi + \pi_0$

Open charm signal – per year

Kπ invariant mass. *(weighted events- see next slide)*

	2002	2003	2004	2006
	0.43 fb $^{-1}$	0.58 fb $^{-1}$	0.92 fb $^{-1}$	0.85 fb $^{-1}$
D*				
D0				

Towards γ*N asymmetries

$$A_{\exp} = P_B P_T f \left[R_{PGF}\, D A^{\gamma N \to D X} + (1 - R_{PGF}) A_{bkg} \right]$$

$$\frac{1}{P_T} \frac{\sum w^{\leftarrow\Rightarrow} - \sum w^{\leftarrow\Rightarrow}}{\sum w^{\leftarrow\Rightarrow} + \sum w^{\leftarrow\Rightarrow}} = A^{\gamma N} \qquad w = f\, P_B \frac{S}{S+B} D$$

Weighting brings significant improvement due to large variations of D and $R_{PGF}=S/(S+B)$ in phase-space

Statistical gain : $1 + \dfrac{\sigma_w^2}{\langle w \rangle^2}$

S/(S+B) weighting

- S/(S+B) probability for an event to be PGF.

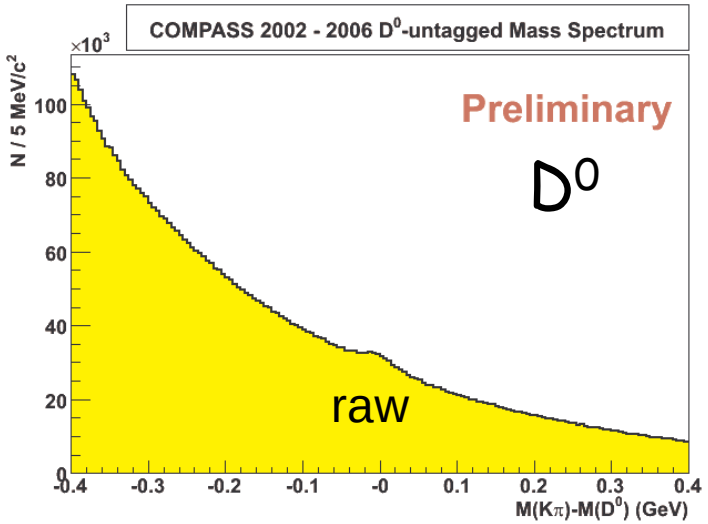
Parameterized as function of kinematics & RICH response.
Given event by event

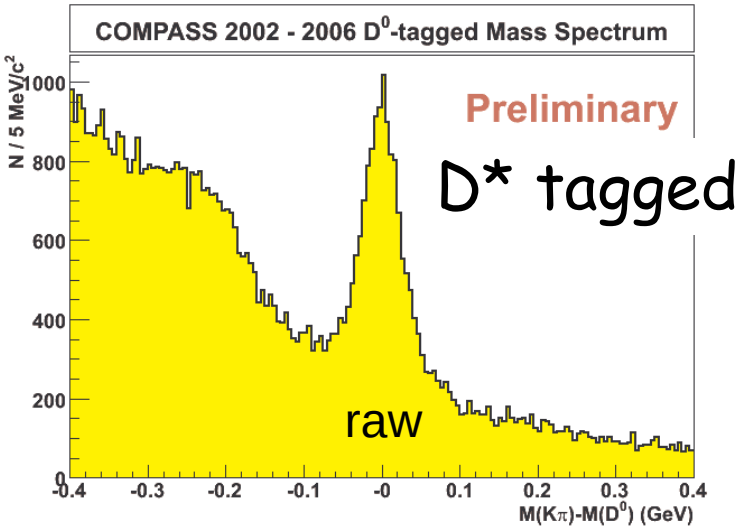
- Event weight with 10 variables built on data only

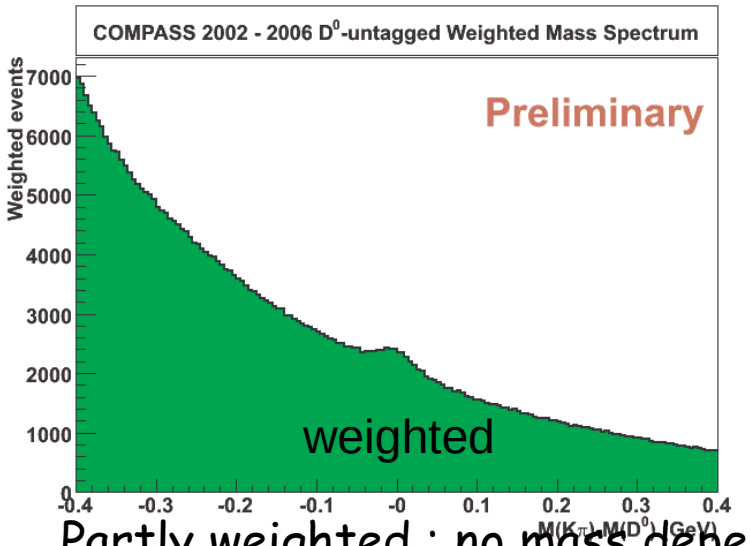
- Gain from S/(S+B) weighting :

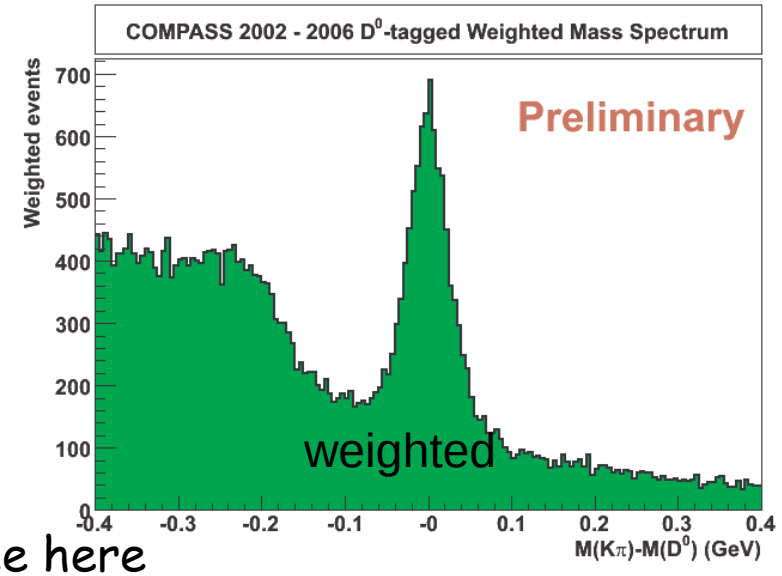
  +45% for D^0 and 15% for D*

Invariant mass of Kπ pairs - S/(S+B) weighting









Partly weighted : no mass dependence here

γ^*N asymmetries - results

- From data only, determine $A^{\gamma^*N \to DX}$
- Asymmetries $A^{\gamma^*N \to DX}$ calculated in (5 p_T bins) x (3 E_D bins)
  Bins chosen such that dispersion in a_{LL}/D is small
  Dependence on kinematic factors y, D,... is also weak.
  → in each bin, acceptance ~ constant

p_T bins (GeV/c)
0 – 0.3
0.3- 0.7
0.7 – 1
1 – 1.5
> 1.5

Asymmetries*, which are model independent :

- can be included in world data NLO analysis *(g_1 + RHIC+ charm)* to constrain $\Delta g(x)$
- may allow for extraction of $\langle \Delta g/g \rangle$ at NLO from COMPASS charm data alone *in progress at COMPASS*

* available on request

Extraction of $\Delta g/g$ at LO

- Model independent asymmetries were extracted <u>from data only</u>

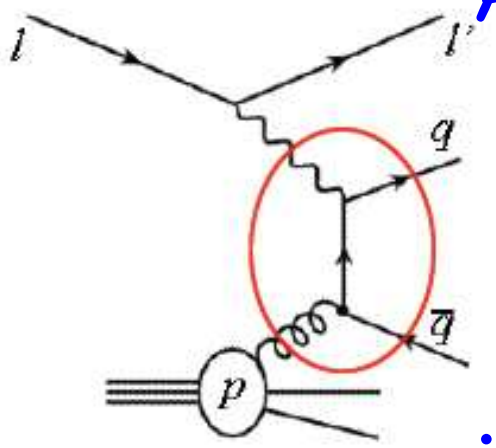
$$A_{\exp} = P_B P_T f\left[R_{PGF} DA^{\gamma N \to DX} + (1 - R_{PGF}) A_{bkg}\right]$$

- $\frac{\Delta g}{g}$ can be extracted using a_{LL}^{PGF} calculated at LO :

$$A_{\exp} = P_B P_T f\left[R_{PGF}\, a_{LL}^{PGF} \frac{\Delta g}{g} + (1 - R_{PGF}) A_{bkg}\right]$$

similar analysis, but with weight $w = f\, P_B \frac{S}{S+B} a_{LL}$

Analyzing power – a_{LL}



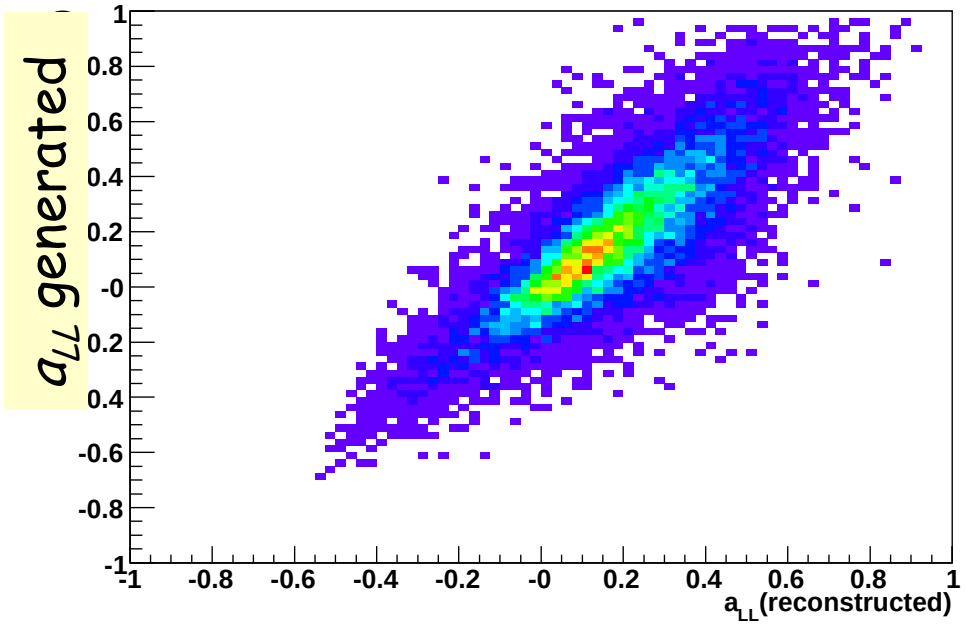
$$a_{LL} = \frac{\Delta\sigma^{PGF}}{\sigma^{PGF}}\left(y, Q^2, x_g, z_c, \phi\right)$$ at LO

- Would need full partonic kinematics to compute a_{LL}
- Already good reconstruction from one D meson only:

a_{LL} from Neural Network trained on MC (AROMA): input variables : Q^2, x_{bj}, y, p_T, z_D

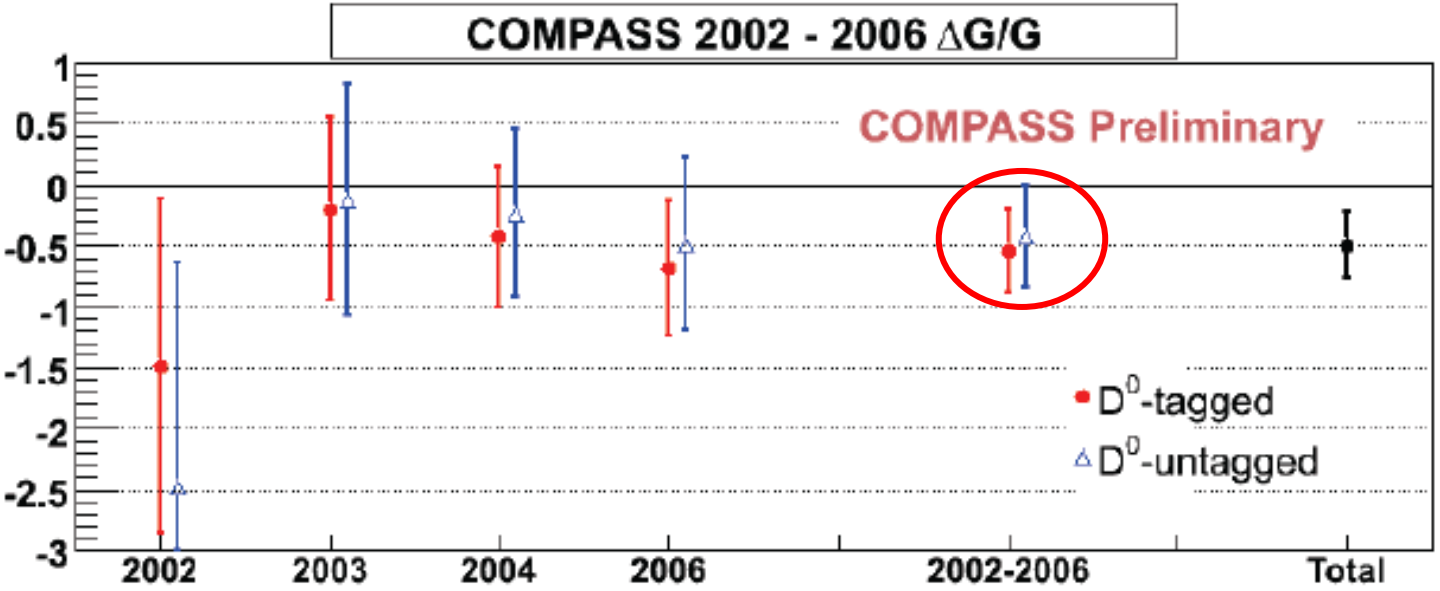
- 82% correlation NN/MC

- very large dispersion of values, even change of sign: weighting essential



a_{LL} reconstructed

Open charm : D^0 + D* Result



$\Delta G/G = -0.49 \pm 0.27\ (stat) \pm 0.11\ (syst)$

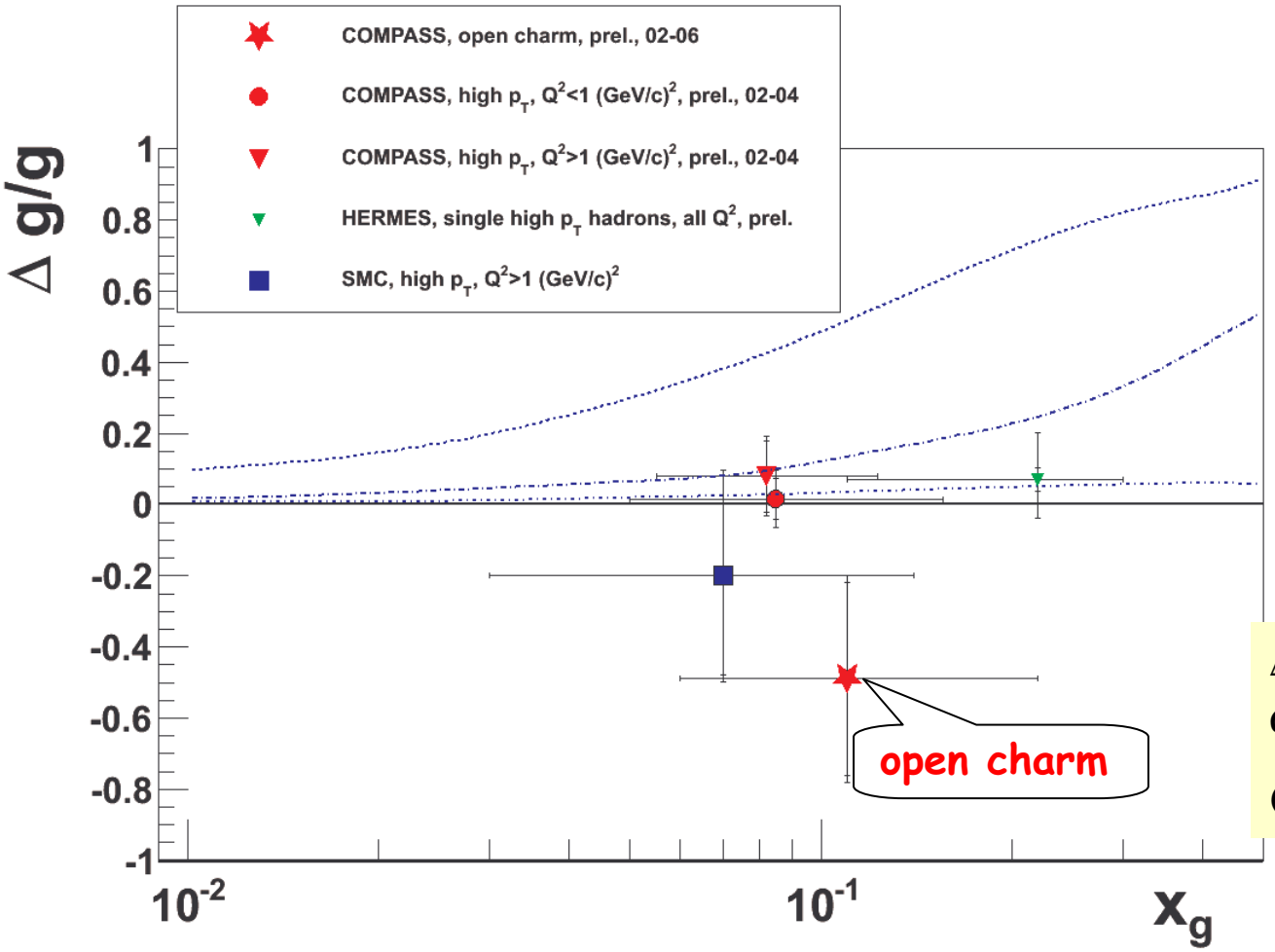
Systematics :

Source	D^0	D*
Beam polar	0.025	0.025
Target polar	0.025	0.025
Dil. Fact.	0.025	0.025
False asymmetry	0.05	0.05
Signal extraction (Σ)	0.07	0.01
a_{11} (charm mass)	0.05	0.03
TOTAL	**0.11**	**0.07**

$$\langle x_g \rangle = 0.11^{+0.11}_{-0.05}$$
$$\langle \mu^2 \rangle = 13\,GeV^2$$

Submitted to Phys. lett. B

$\Delta g/g$ direct measurements



GRSV, ΔG

max, 2.5

std, 0.6

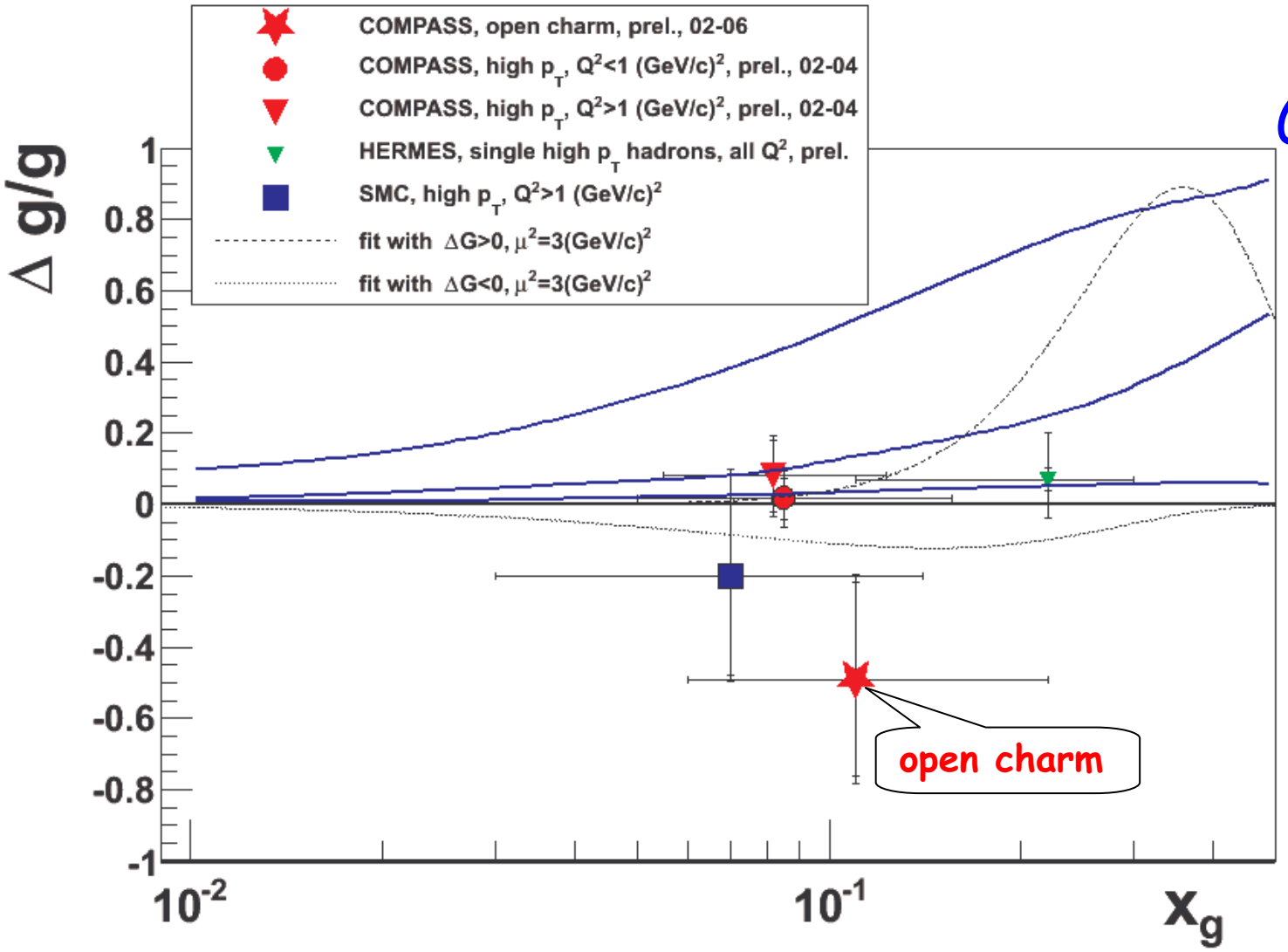
min, 0.2

$\Delta g/g$ calculated at LO

QCD fits at NLO

$\langle \Delta g/g \rangle$, LO extraction at $\langle x_g \rangle = 0.11$, prefers negative value, but still less than 2σ away from 0

Δ g/g direct measurements



GRSV, ΔG

max, 2.5

std, 0.6

min, 0.2

COMPASS QCD fits

$|\Delta G| \sim 0.3$

Conclusion and outlook for the charm channel

- Significant improvement for $\Delta g/g$ from open charm :
  - *adding 2006 data (increased acceptance &improved PID)*
  - *using S/B weighting and improved reconstruction*

- $\langle \Delta g/g \rangle$ from charm, LO extraction at $\langle x_g \rangle = 0.11$ prefers negative value, but still less than 2σ away from 0.

- Asymmetries $A^{\gamma N \to D0}$ in (P_T, E_D) bins, independent of models:
  - can be included in world data NLO analysis
  - may allow for $\langle \Delta g/g \rangle$ extraction at NLO

  in progress at COMPASS

- More statistics to come: *2007 p data & $D^0 \to K\pi\pi^0$*