New Measurement of $\frac{\Delta G}{G}$ *at COMPASS From Open Charm Events*

Florent Robinet
CEA, Saclay
on behalf of the COMPASS collaboration

The Nucleon Structure

The nucleon spin can be decomposed on its constituents : quarks and gluons

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

$\Delta\Sigma$ measurements shows that the quark spin has a small contribution to the nucleon spin

(COMPASS, HERMES, SMC, EMC, SLAC)

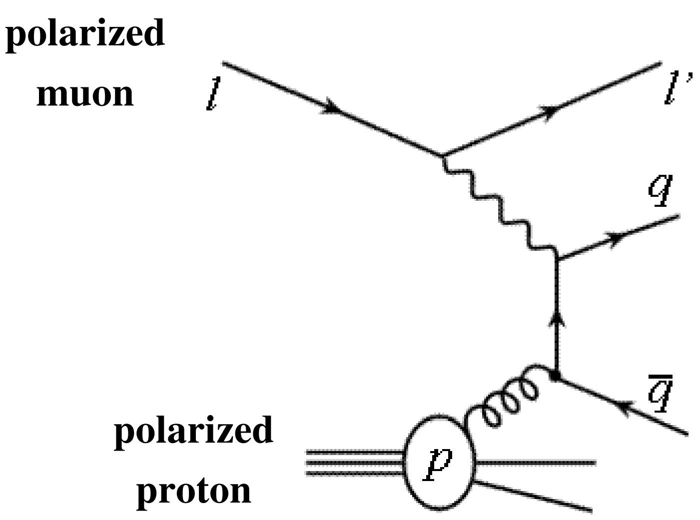
⇒ Gluons ?

ΔG : 2 motivations for its measurement

- How much does it contribute to the nucleon spin ?
- If it is large (~2-3) it could explain why $\Delta\Sigma$ was found small (axial anomaly)

Probing the Gluons in the Nucleon

Polarized Photon-Gluon Fusion Process (PGF) ⇒ Spin Asymmetries



How to tag PGF ?

- **Production of high-p_T hadrons**

  see Marcin Stolarski's talk

  (u, d, s, c quarks) ; hard scale : p_T

  high statistics

  background processes

- **Production of charm mesons**

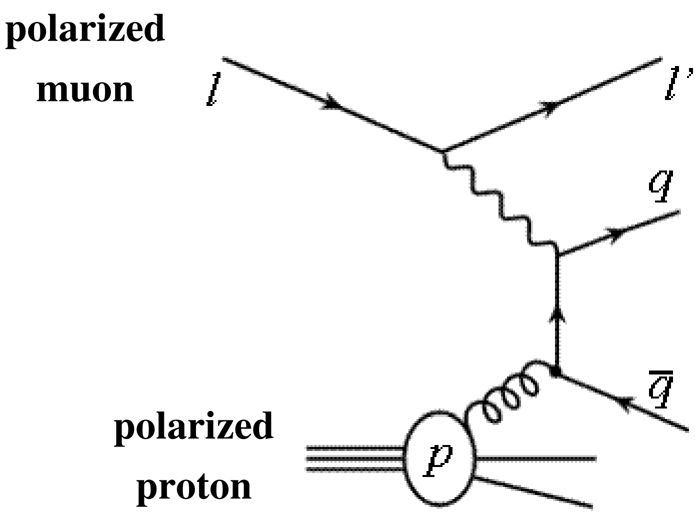
  (c quarks only) ; hard scale : m_{charm}

  no physical background

  low statistics

Probing the Gluons through Open Charm

Photon-Gluon Fusion Process (PGF)

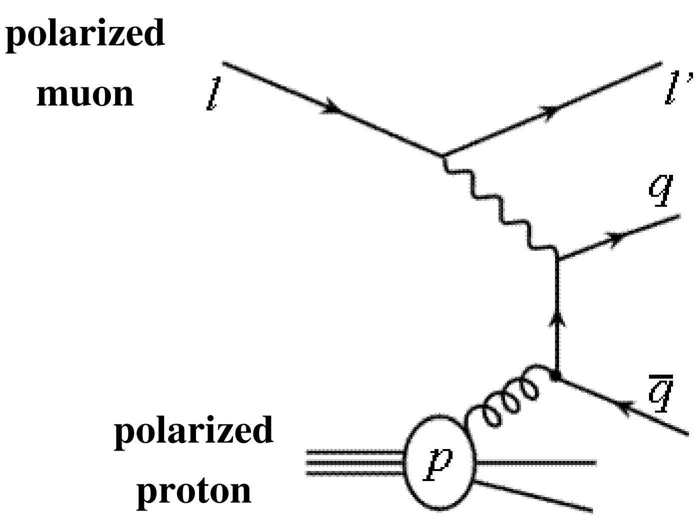


$D^0 \Rightarrow K\pi$ (D^0 channel)

$D^* \Rightarrow D^0 \pi_{soft} \Rightarrow K\pi\, \pi_{soft}$ (D^* channel)

Probing the Gluons through Open Charm

Photon-Gluon Fusion Process (PGF)



$D^0 \Rightarrow K\pi$ (D^0 channel)

$D^* \Rightarrow D^0 \pi_{soft} \Rightarrow K\pi\,\pi_{soft}$ (D* channel)

$\Rightarrow$ Kπ invariant mass : Signal centered on the D^0 mass

Selection to reduce the combinatorial background:

- Kinematical cuts (z_D, D^0 decay angle, π momentum)
- RICH PID
  - K and π are identified
  - electrons are rejected from the π_{soft} sample

For D*, cut on the 3-body mass

The COMPASS Experiment

Muon Beam :

160 GeV

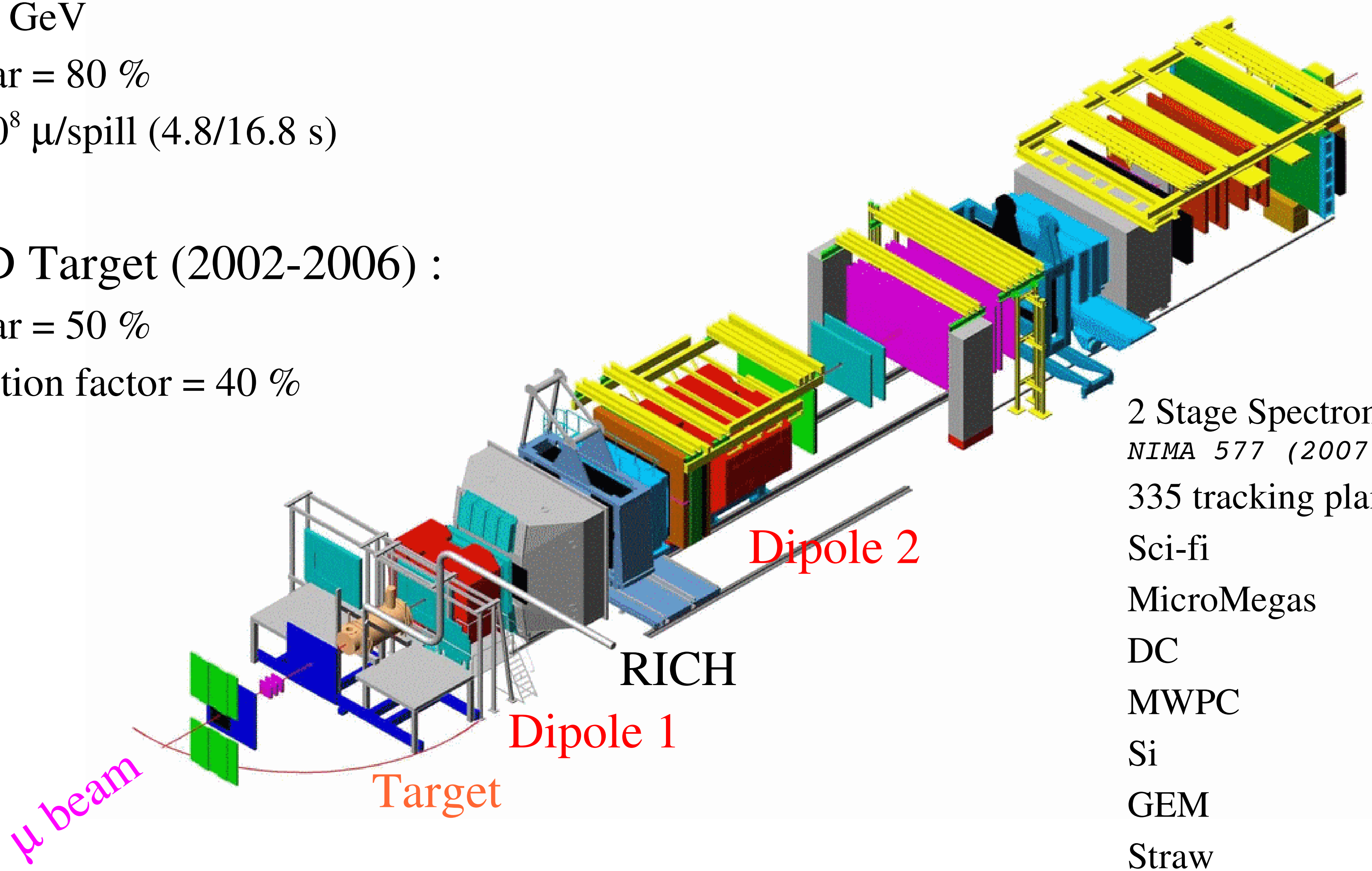
polar = 80 %

2.10^8 μ/spill (4.8/16.8 s)

LiD Target (2002-2006) :

polar = 50 %

dilution factor = 40 %



2 Stage Spectrometer

NIMA 577 (2007) 455

335 tracking planes :

Sci-fi

MicroMegas

DC

MWPC

Si

GEM

Straw

The COMPASS Experiment

Muon Beam :

160 G

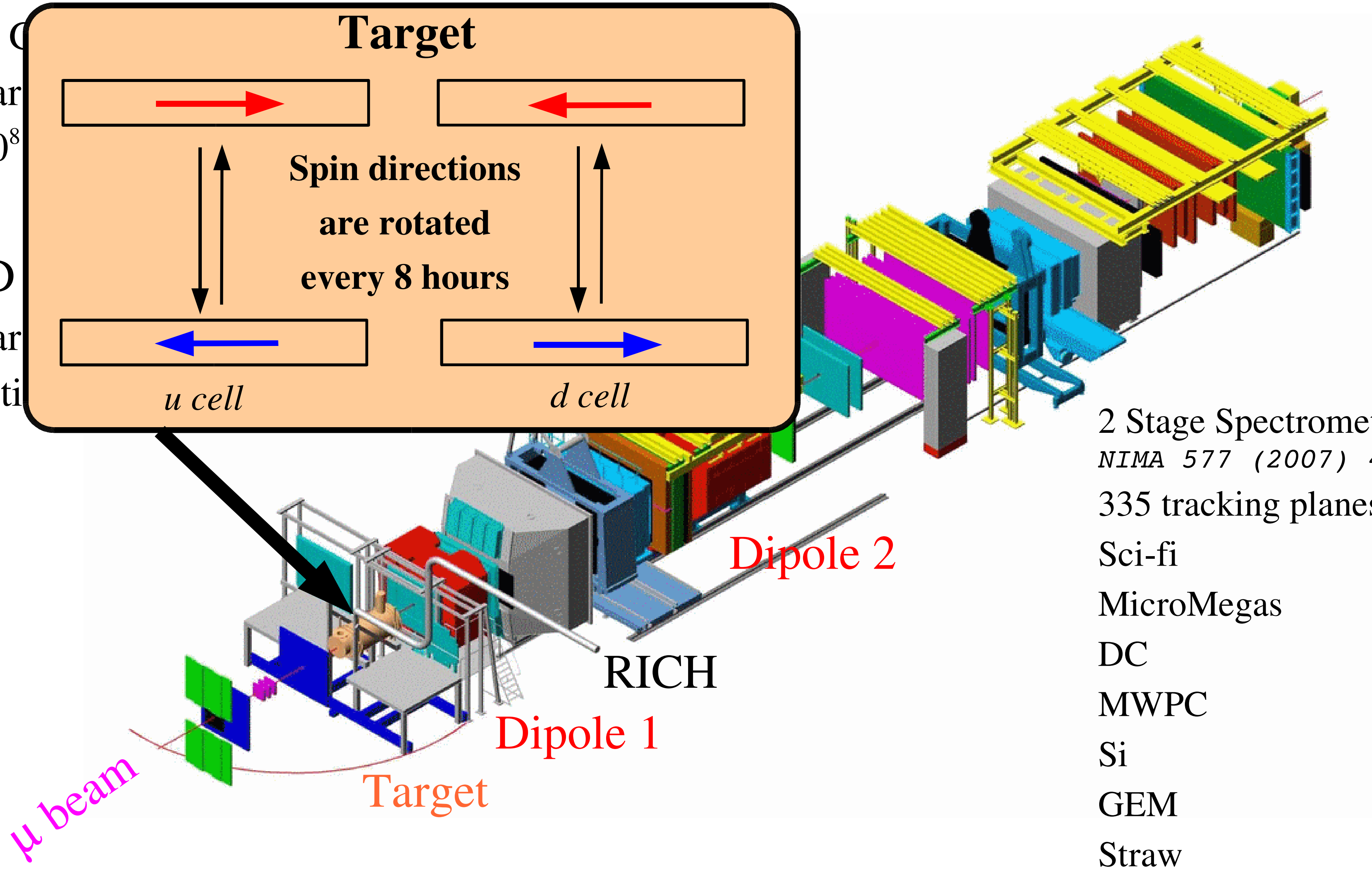
polar

2.10^8

LiD

polar

diluti



2 Stage Spectrometer

`NIMA 577 (2007) 455`

335 tracking planes :

Sci-fi

MicroMegas

DC

MWPC

Si

GEM

Straw

The 2006 Upgrades

- RICH Upgrades : MAPMT + faster electronics

  Faster (less pile-up)

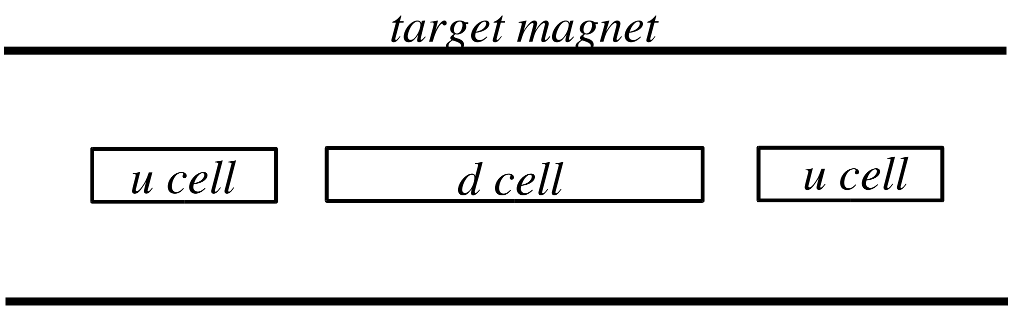
  More photons

  ⇒ **More D^0/μ, S/B improved**

- Larger Acceptance : 70 mrad ⇒ 180 mrad

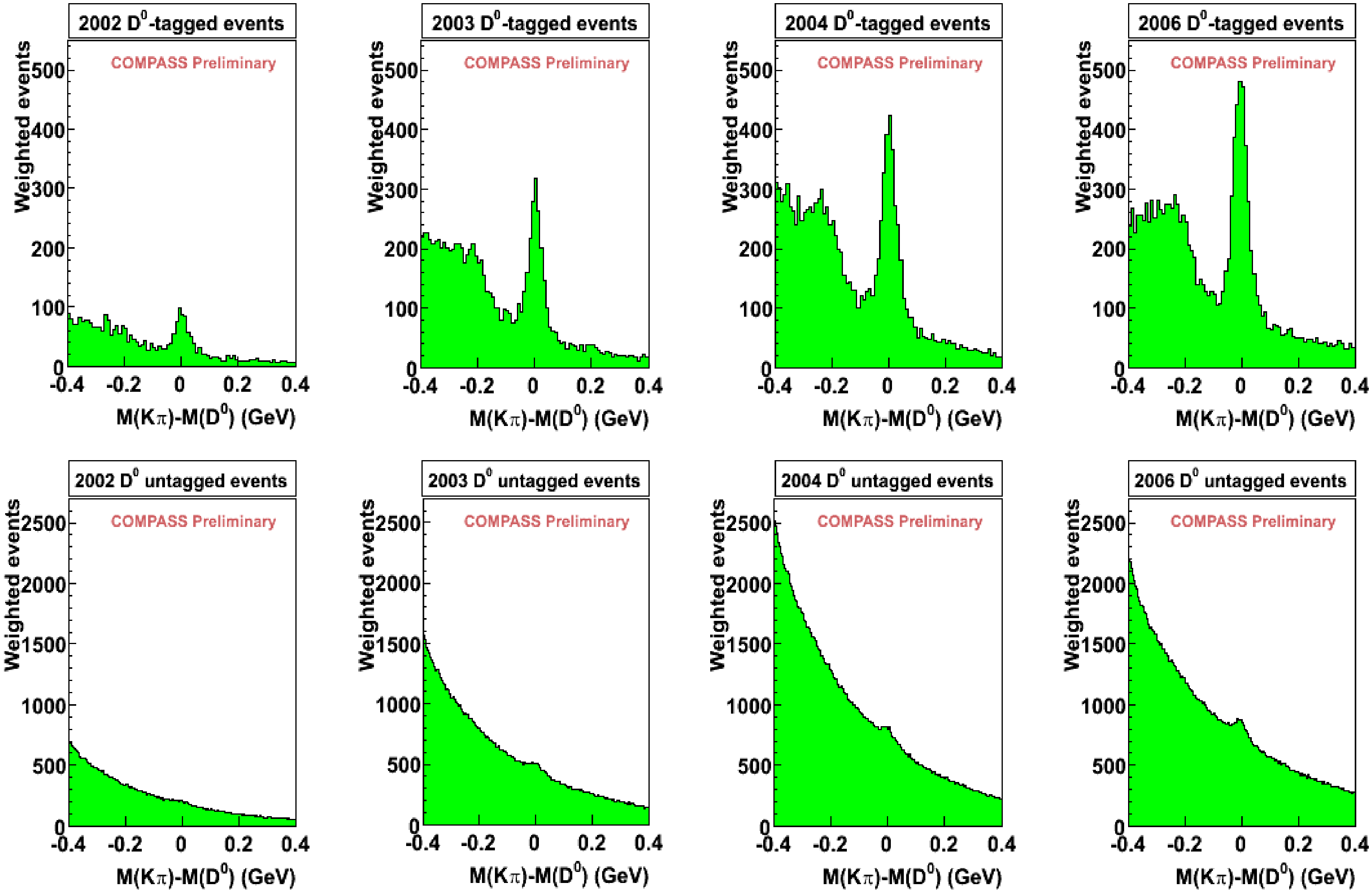
- 3-cells target ⇒ reduced false asymmetries

  u and *d cell* have the "same" acceptance



2002 – 2006 Campaign

All data with a deuterium target have been analyzed



TOTAL :

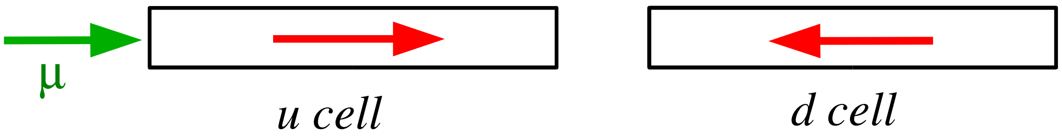
8675 D*

37398 D^0

Gluon Polarization

COMPASS

Target



$$\frac{\Delta G}{G} = \frac{1}{P_T P_\mu f \, a_{LL} \frac{S}{S+B}} \times \frac{\overset{\substack{\leftarrow \\ \rightarrow}}{N}_d - \overset{\substack{\rightarrow \\ \rightarrow}}{N}_u}{\overset{\substack{\leftarrow \\ \rightarrow}}{N}_d + \overset{\substack{\rightarrow \\ \rightarrow}}{N}_u}$$

P_T : target polarization

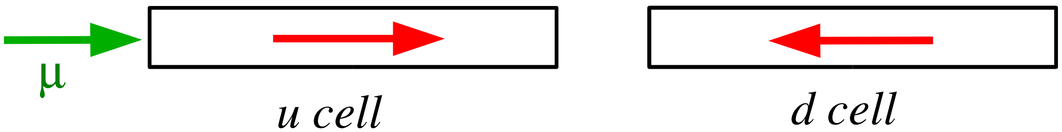
P_μ : beam polarization

f : dilution factor

a_{LL} : analyzing power

Gluon Polarization

Target



$$\frac{\Delta G}{G} = \frac{1}{P_T \, P_\mu \, f \, a_{LL} \, \frac{S}{S+B}} \times \frac{\overleftarrow{\overrightarrow{N}}_d - \overrightarrow{\overrightarrow{N}}_u}{\overleftarrow{\overrightarrow{N}}_d + \overrightarrow{\overrightarrow{N}}_u}$$

event weight w

P_T : target polarization

P_μ : beam polarization

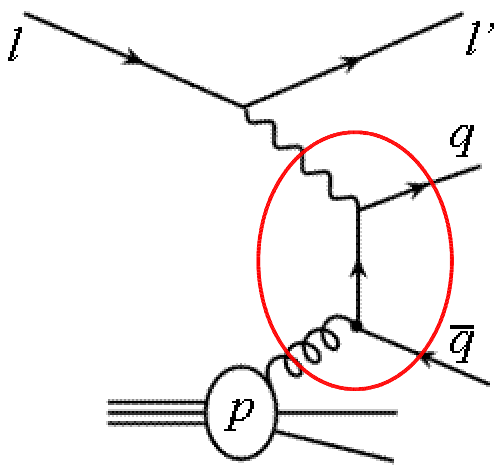
f : dilution factor

a_{LL} : analyzing power

$$\frac{\Delta G}{G} = \frac{1}{P_T} \times \frac{\sum \overleftarrow{\overrightarrow{w}}_d - \sum \overrightarrow{\overrightarrow{w}}_u}{\sum \overleftarrow{\overrightarrow{w}}_d^2 + \sum \overrightarrow{\overrightarrow{w}}_u^2}$$

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

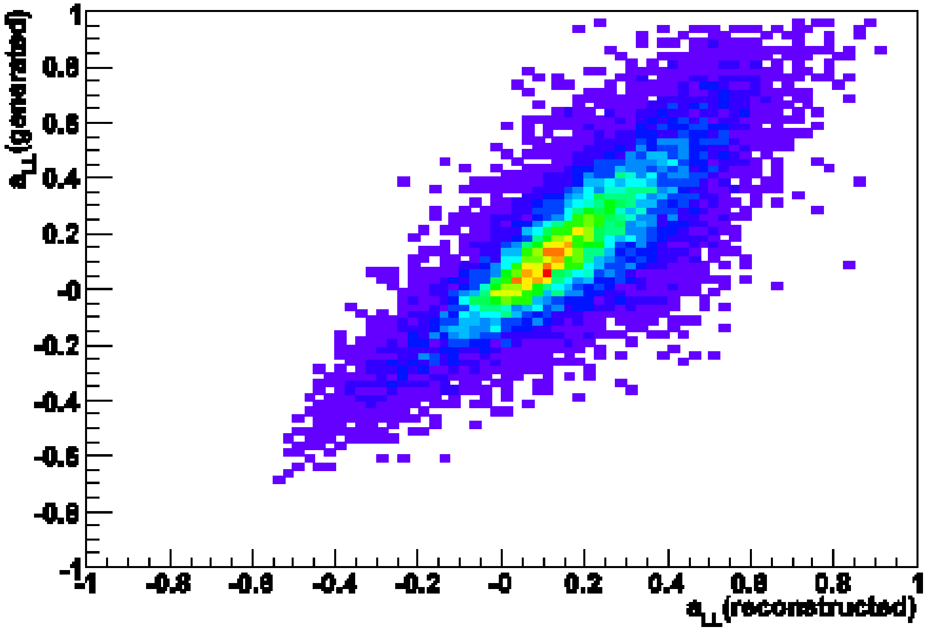
Analysing Power a_{LL}



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

To compute a_{LL}, one needs to know the full partonic kinematics

BUT, knowing the kinematics of one charm meson (D^0) is sufficient to have a rather good determination of the true a_{LL}.



a_{LL} is given by a Neural Network parameterization (LO)

MC studies : the reconstructed a_{LL} is strongly correlated with the real one

Signal Purity S/(S+B)

The signal purity gives the probability for an event to be a open charm

Old analysis : S/(S+B) was obtained from a fit on the mass spectra in a_{LL} bins:

$$\frac{S}{S+B} = f\left(M\left(K\pi\right)\right)$$

New **: S/(S+B) is parameterized (Σ) as a function of kinematical variables and the RICH response and is given event-by-event**

⇒ events with Σ close to 0 : high probability for being background

⇒ events with Σ close to 1 : high probability for being open charm

Event weight : $w = P_{\mu} f a_{LL} \Sigma$

Σ is built on the data only

Signal Purity : Σ - parameterization

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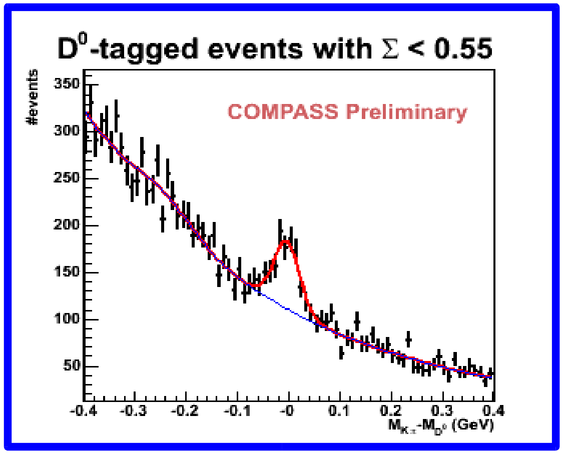
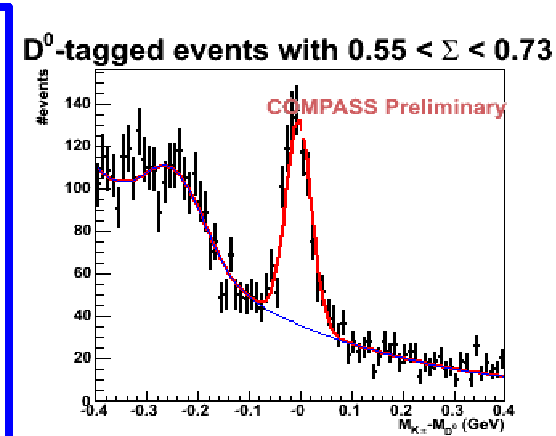
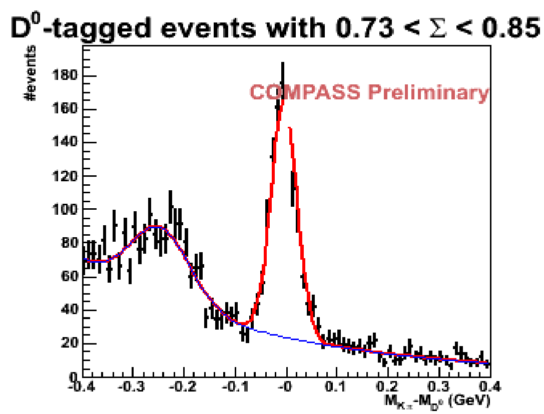
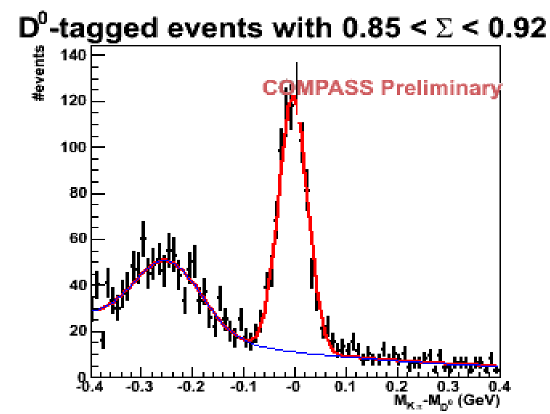
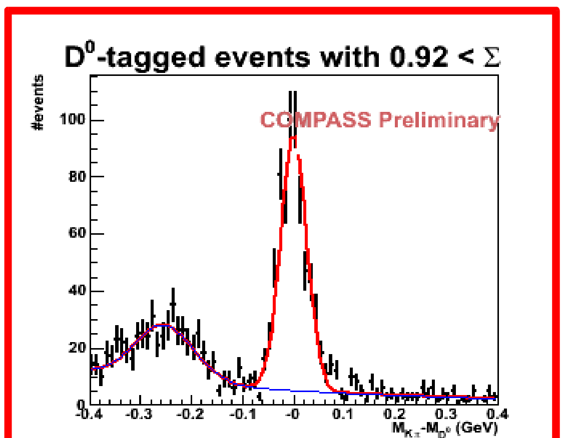
Events with a small Σ
(mostly background events)
⇒ small weight









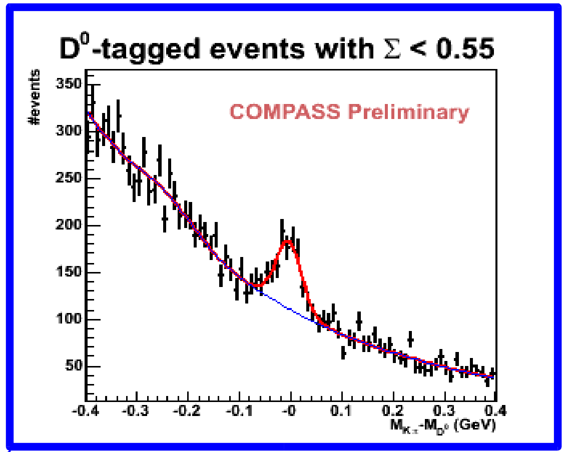


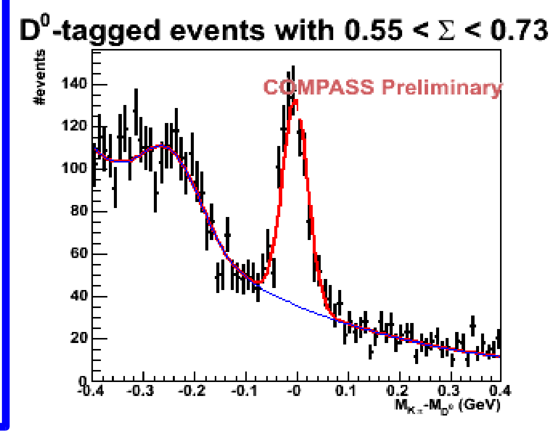
Events with a large Σ
(mostly signal events)
⇒ large weight

Signal Purity : Σ - parameterization

COMPASS

Events with a small Σ
(mostly background events)
⇒ small weight

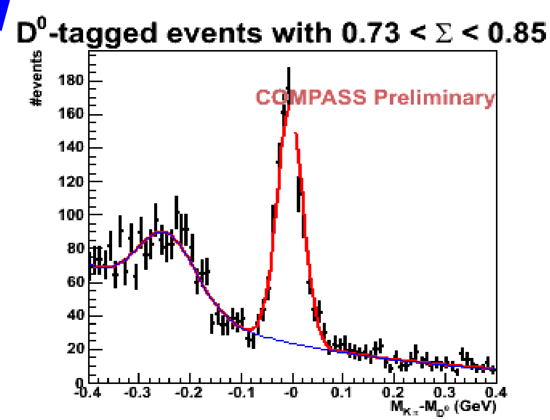


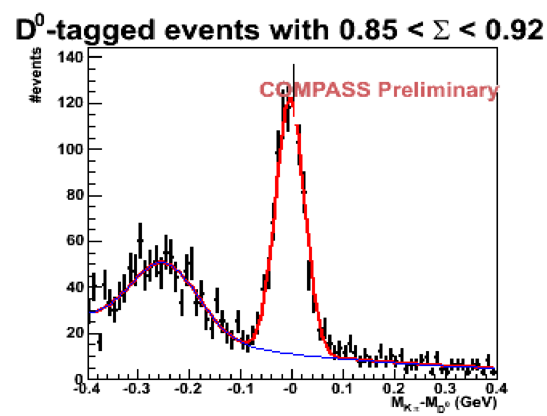


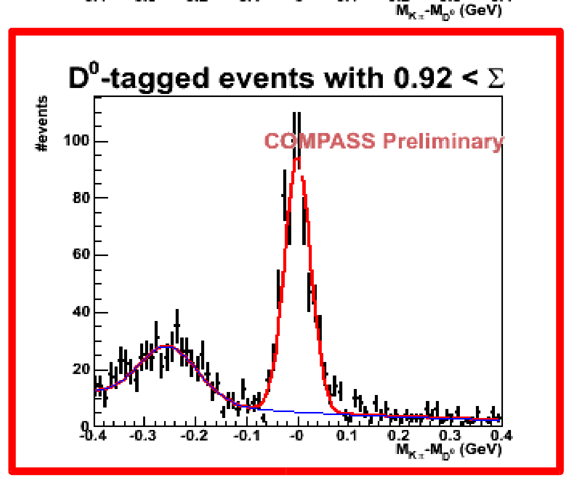
With Σ in the weight, the cuts can be less strict :

Background events are added

Signal events are “saved”







Events with a large Σ
(mostly signal events)
⇒ large weight

Σ - Weighted Mass Spectra

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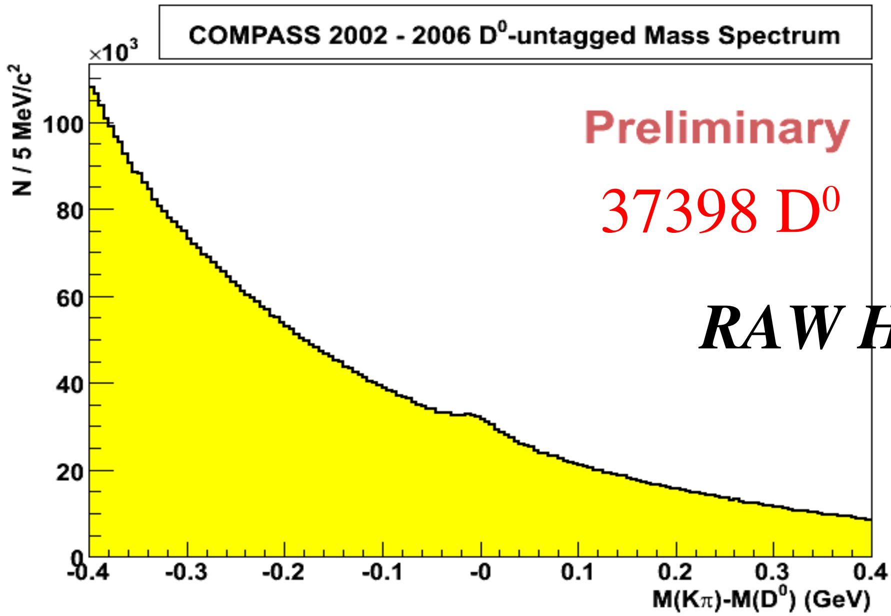
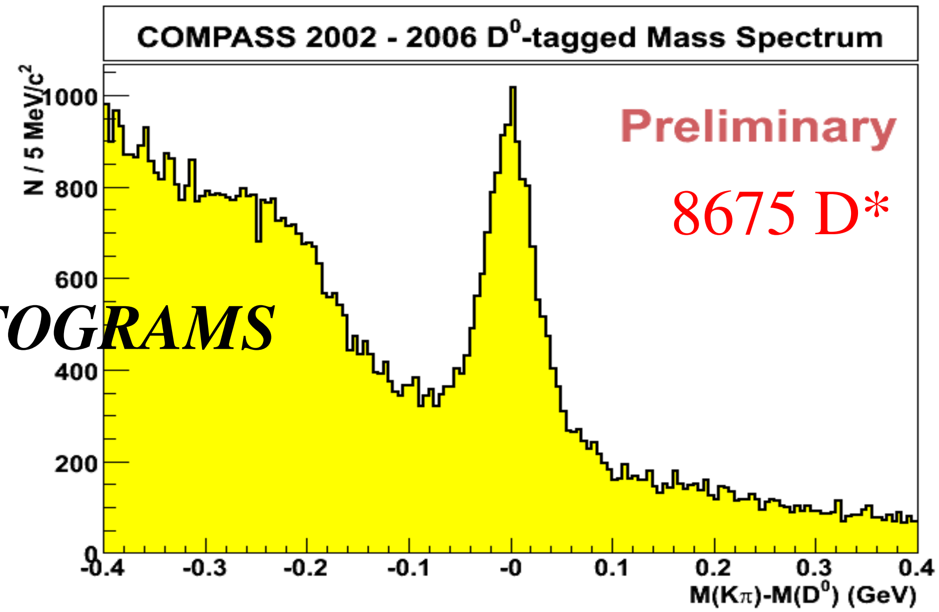
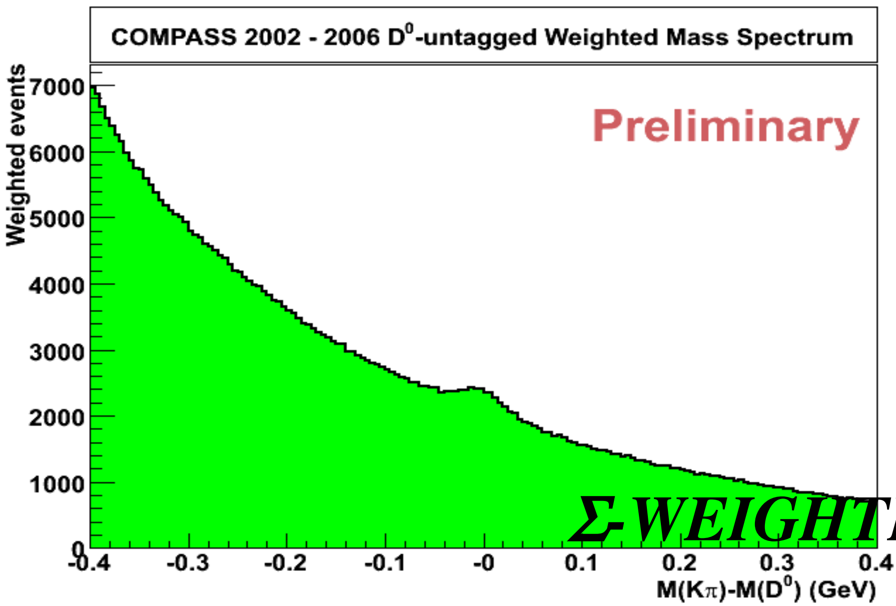
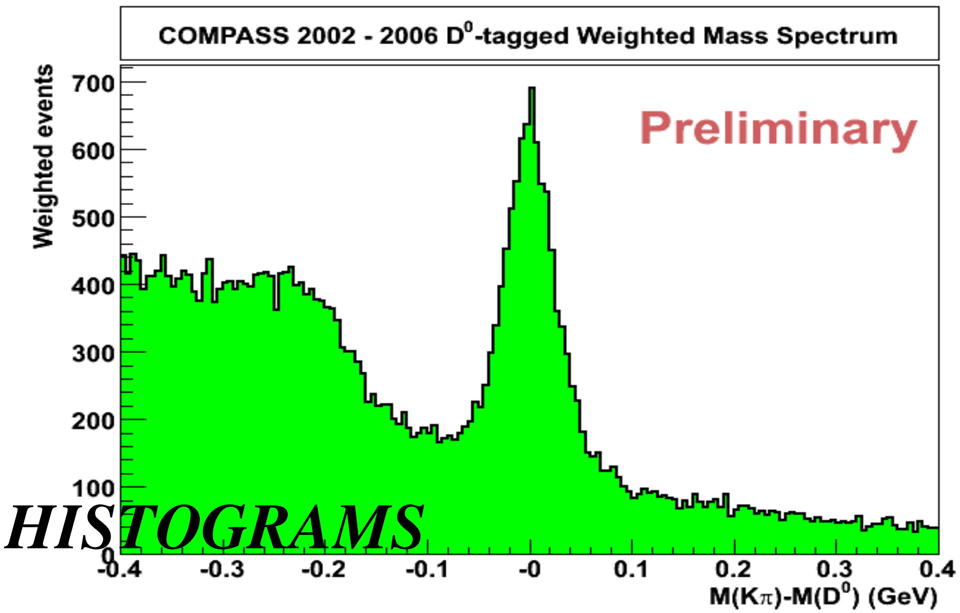




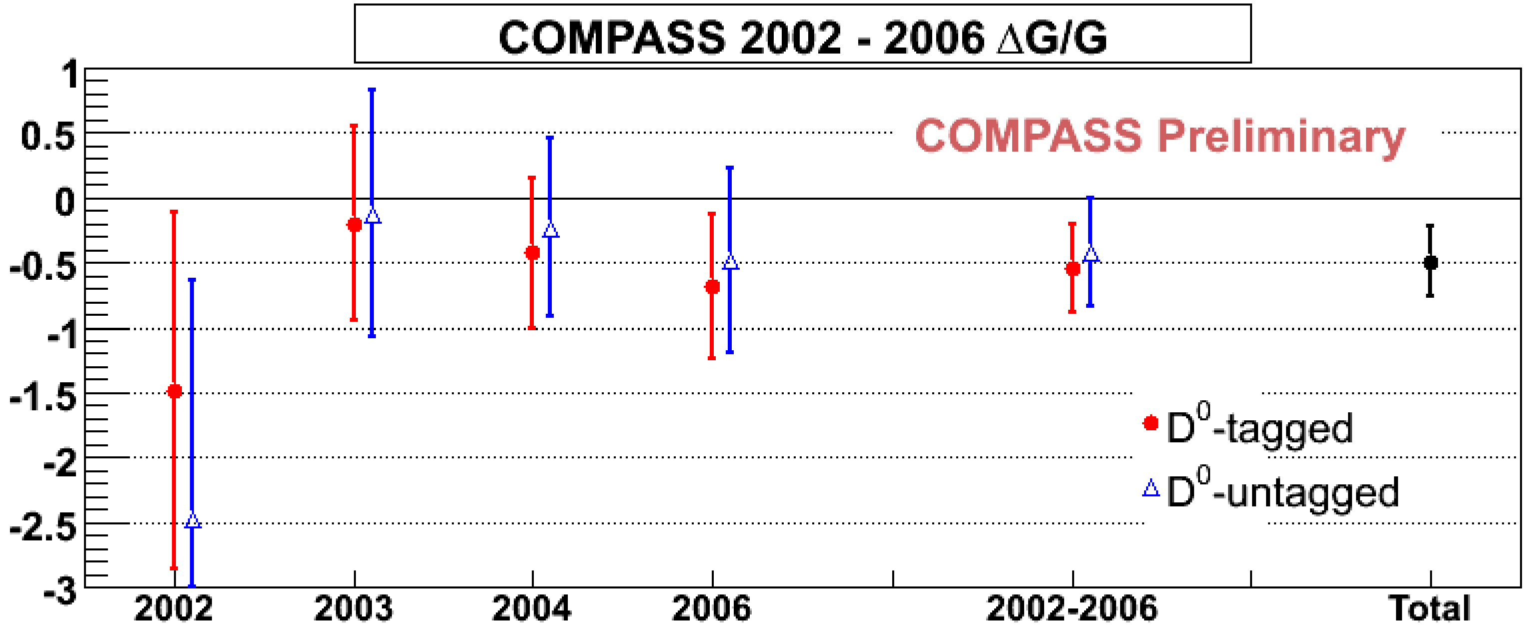
RAW HISTOGRAMS





Σ-WEIGHTED HISTOGRAMS

Preliminary Results (2002 - 2006)



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

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_{LL} (charm mass)	0.05	0.03
TOTAL	**0.11**	**0.07**

$$\langle x_g \rangle = 0.11^{+0.11}_{-0.05}$$

$$\langle \mu^2 \rangle = 13\, GeV^2$$

Conclusion

The new result of the ΔG/G measurement has been presented and reveals a significant statistical improvement in comparison to our previous release :

2002-2004 old analysis : $\Delta G/G = -0.47 \pm 0.44\,(stat) \pm 0.15\,(syst)$

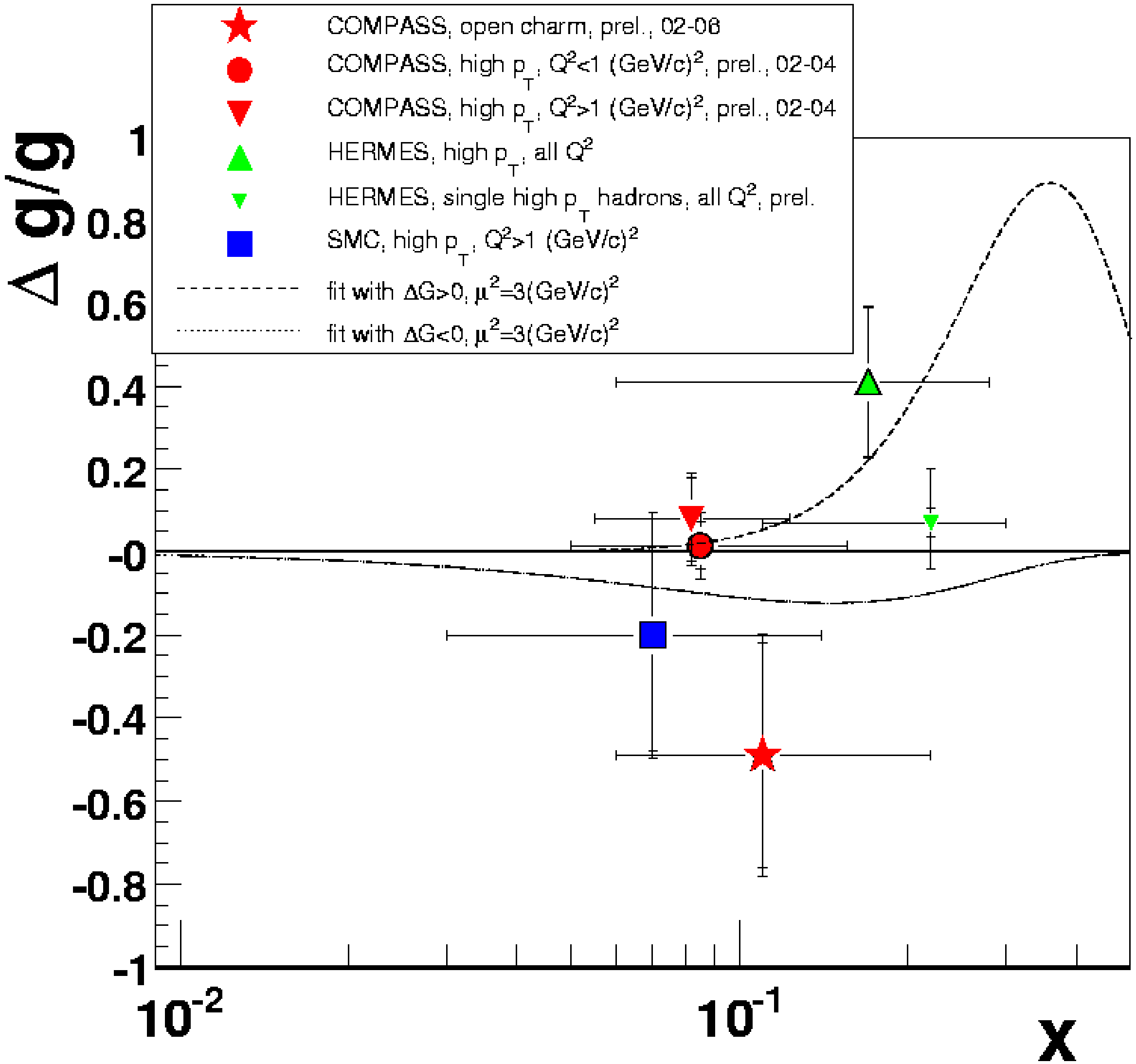
CERN-PH-EP/2008-002 hep-ex/0802.2160

2002-2006 new analysis : $\Delta G/G = -0.49 \pm 0.27\,(stat) \pm 0.11\,(syst)$

The reasons of this improvement are :

- the new 2006 data
- new data production (improved tracking)
- the Σ-parameterization in the event weighting
- a new cut for the D* channel : electron rejected from the soft pion sample

Conclusion



- Small ΔG values are preferred
- The new charm point is negative but compatible with zero.

Improvements are expected :

- 2007 data
- Improvements of the analysis

Background Asymmetry (2002 – 2006 data)

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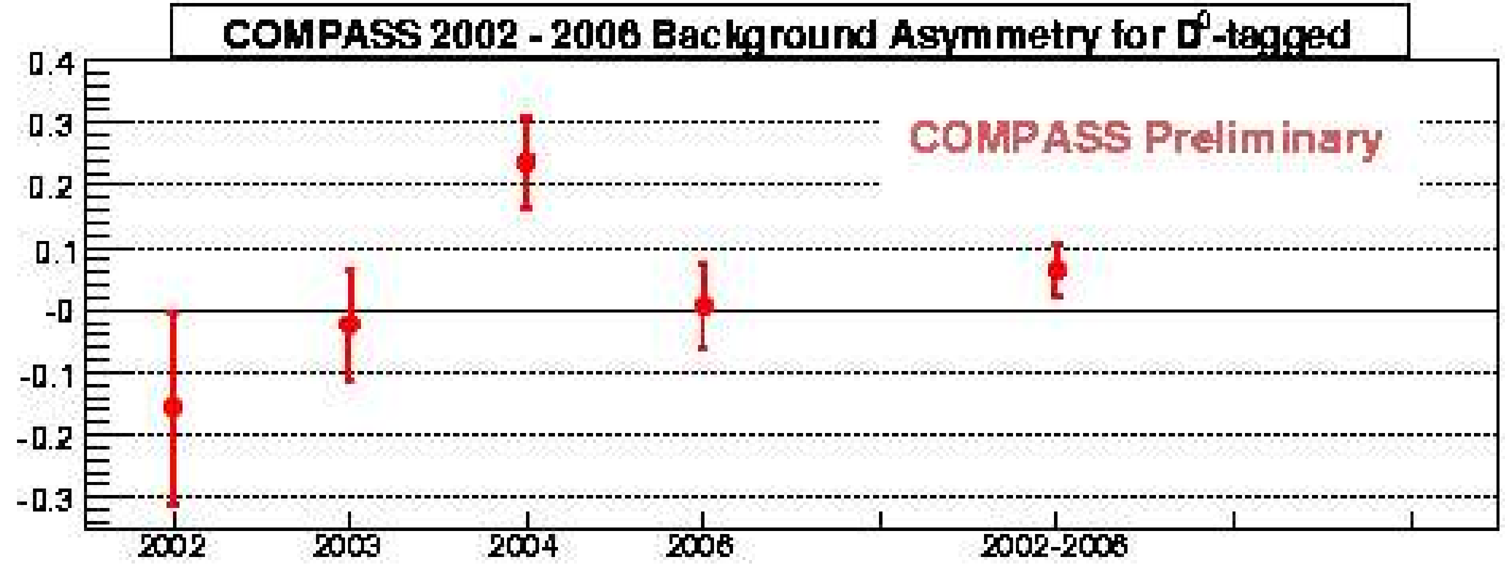

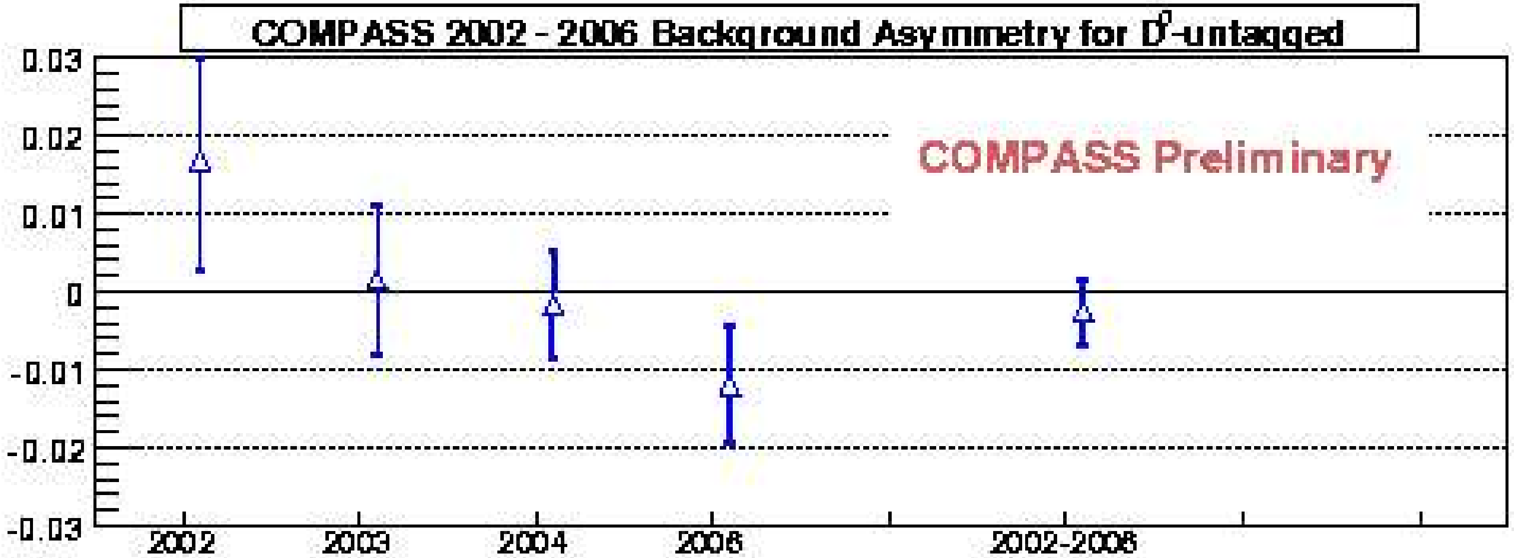

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2006 D^0 events in Σ bins