COMPASS (CERN-NA58) Overview

A. Magnon

CEA Saclay-DAPNIA/SPhN

COMPASS Collaboration

Longitudinally polarized muons   160 GeV/c
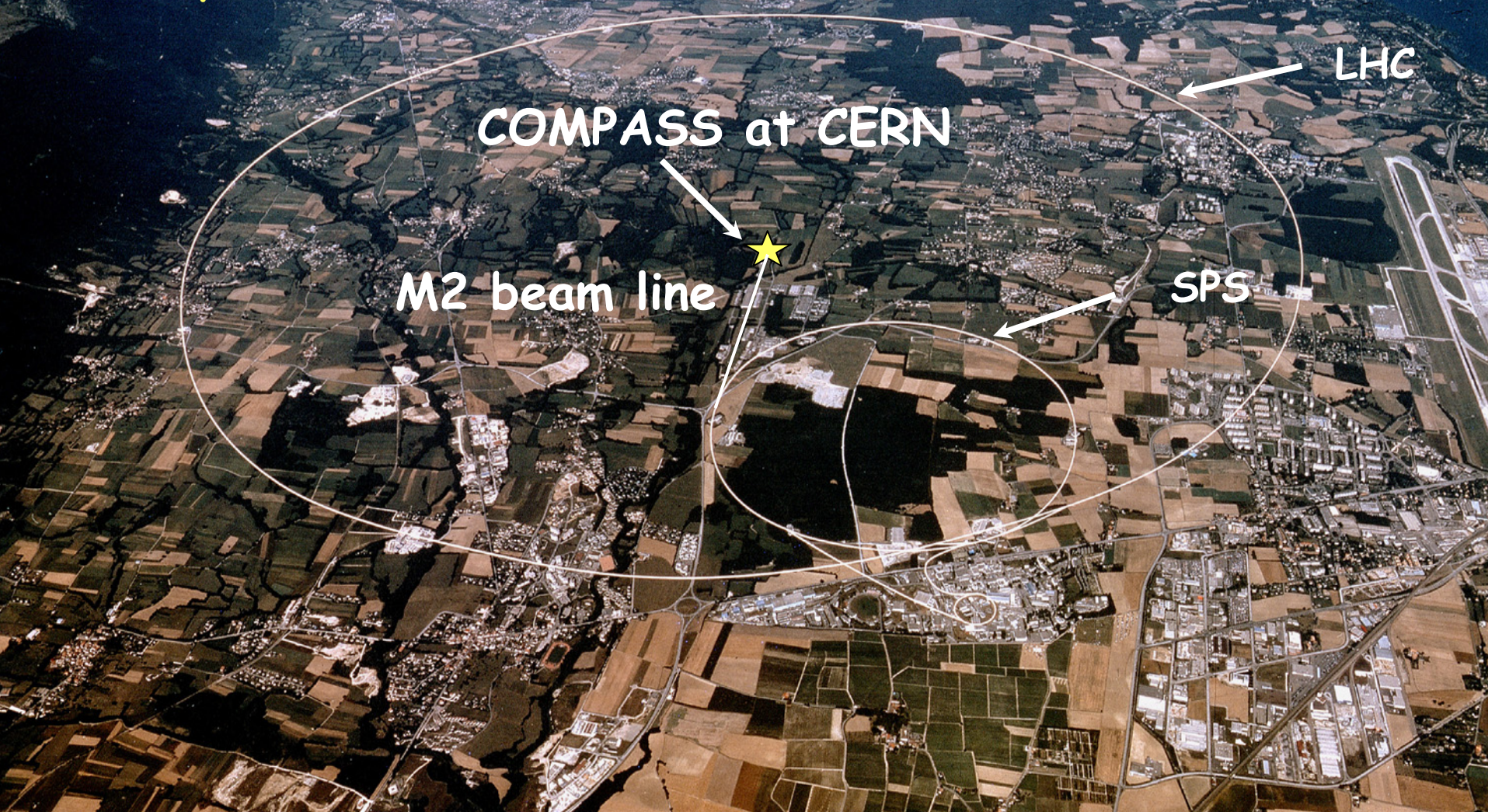2.10^8 μ/ spill (4.8s / 16.8s)
P_B= -80%
Longitudinally or transversely polarized deuteron target :
^{6}LiD $P_T \sim$ 50%
Luminosity: $\sim$ 5. 10^{32} cm^{-2}s^{-1}

LHC

COMPASS at CERN

M2 beam line

SPS

COMPASS Spectrometer

Trigger Hodoscopes

ECALs & HCALs

MWPCs

SM2

RICH

SM1

Drift Chambers

^{6}LiD target

μ Filters/Walls

50 m

Straws

160 GeV μ

Si

GEMs

Micromegas

SciFi

veto
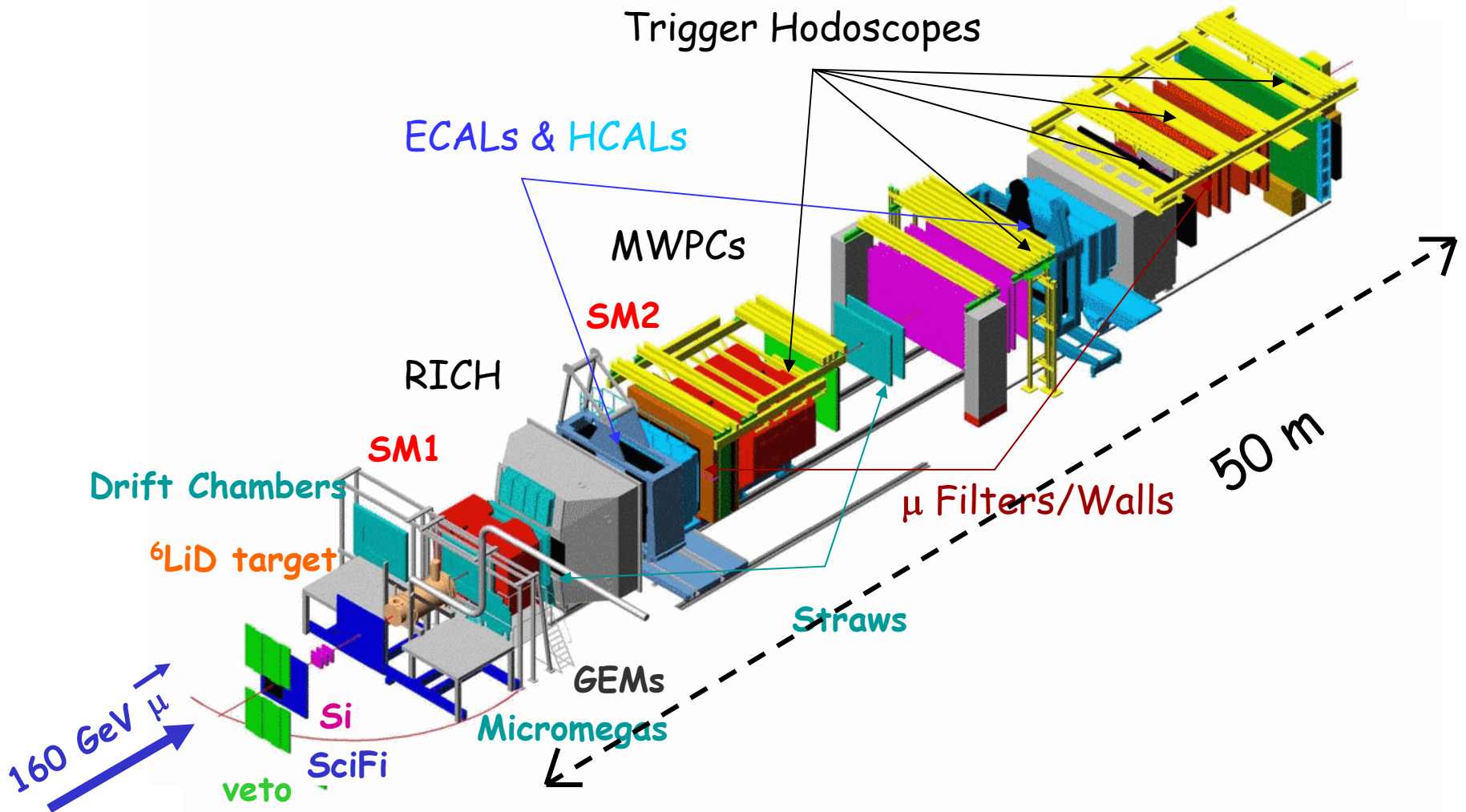
Physics Programmes

Muon beam programme

Polarised target (Long. & Transv.)

- Gluon contribution to nucleon spin
- Quark polarisation (g_1, $\Delta\Sigma$, Δq, flavor separation)
- Transversity
- Production of ρ, Φ, J/Ψ, Λ, ...

Hadron beam programme

- Primakoff: π, K polarisabilities
- Exotics q-states, glue balls
- Double charmed hadrons
- Drell-Yann (project)

Muon beam, LH_2 target, proton recoil detector

- Generalized Parton Distributions (project ~ 2010)

2002 - 2006

- **2002   160 GeV $\vec{\mu}$ beam & ^{6}LiD Long/Transv polarisations**

- **2003   idem   (~ 80/20)**

- **2004   idem**

- **2004   hadron beam**

- **2005   NO SPS beam (Several upgrades)**

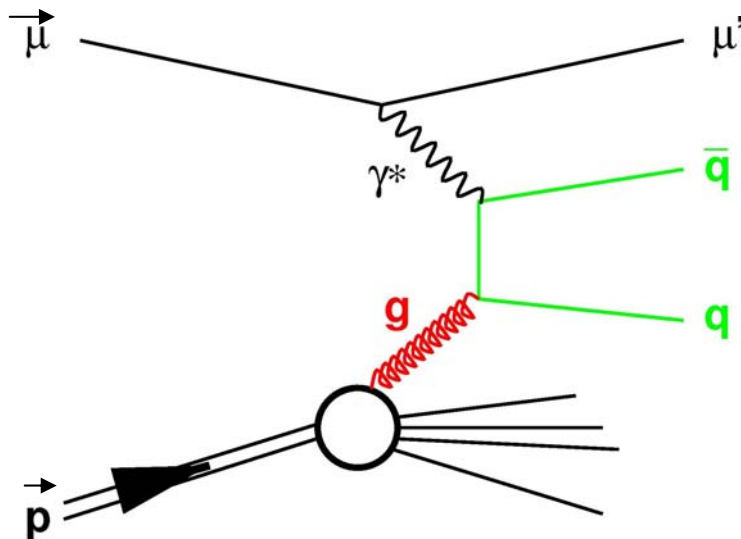- **2006   160 GeV $\vec{\mu}$ beam & ^{6}LiD Long/polarisation (plan)**

Physics Results Overview

- $\Delta G/G$ from production of high p_T hadron pairs

    & open charm

- g_1^D, new COMPASS NLO fit, a_0, Δ_s, $\Delta\Sigma$, ΔG

- Transversity: Collins, Sivers asymmetries

- (Λ Long. & Transv. Polarisations, ρ vector meson)

- Upgrades, prospects

$\Delta G/G$ from high p_T hadron pairs

Photon Gluon Fusion: $\gamma g \rightarrow q\bar{q}$

High p_T hadron pair $q\bar{q} \rightarrow hh$

Scale $\mu^2 = Q^2$ or Σp_T^2
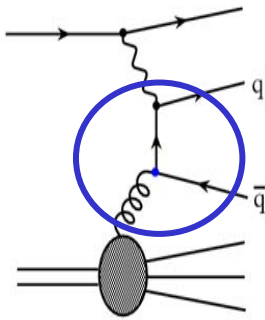
Large statistics

Physical background

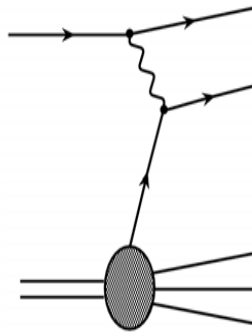2 cases: $Q^2 > 1$ (GeV/c)^2

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

$\Delta G/G$ from high p_T hadron pairs

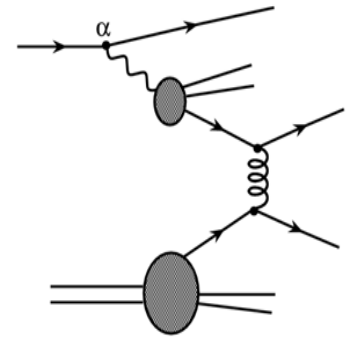$$A_{||} = R_{PGF} \times a_{LL}^{PGF} \times \frac{\Delta G}{G} + A_{Bkg}$$

Photon

Gluon

Fusion

Leading

Order
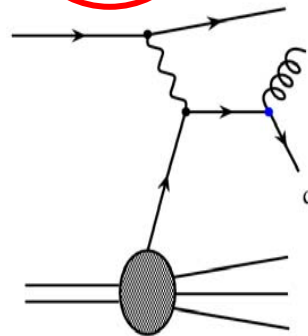
QCD compton

+

Resolved γ

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

a_{LL} : calculable partonic asymmetry

R_{PGF} : Monte Carlo is required to calculate R_{PGF}

$\Delta G/G$ from high p_T hadron pairs

Two high p_T hadrons, $p_T > 0.7$ GeV/c, $\Sigma p_T^2 > 2.5$ (Gev/c)2

$Q^2 < 1$ (GeV/c)^2 analysis - large statistics

- perturbative QCD scale from Σp_T^2

- **PHYTIA MC** used to evaluate RPGF (0.3) & physical Bkg, low p_T, resolved γ

- 2002 – 2004 data   **$Q^2 < 1$ (GeV/c)^2**

$\Delta G/G$ = 0.016 ± 0.058 (stat) ± 0.055 (syst)

@ $x_g \sim 0.085$, $\mu^2 = 3$ (GeV/c)^2

$\Delta G/G$ from high p_T hadron pairs

Two high p_T hadrons, p_T > 0.7 GeV/c, Σp_T^2 > 2.5 (Gev/c)2

Q^2 > 1 (GeV/c)^2 analysis - lower statistics

- perturbative QCD scale from Q^2,

- **LEPTO MC** used to evaluate RPGF (0.33) & physical Bkg

- 2002 – 2003 data   **Q^2 > 1 (GeV/c)^2**
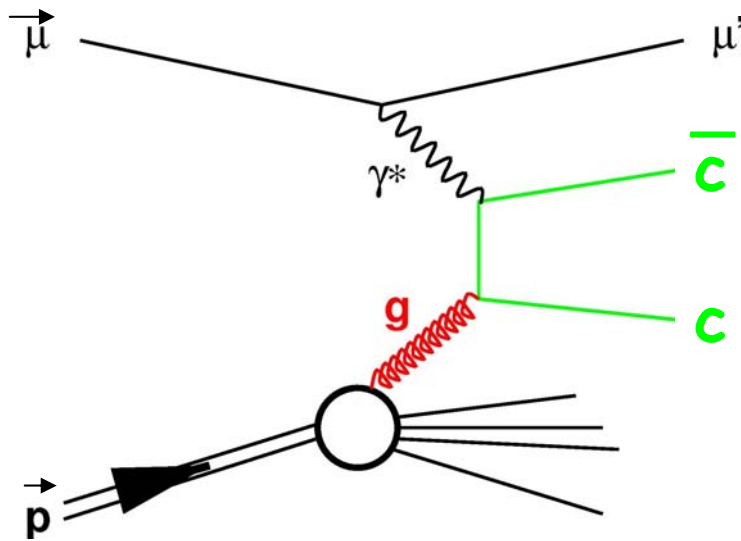
$\Delta G/G$ = 0.06 ± 0.31 (stat) ± 0.06 (syst)

@ x_g = 0.13 ± 0.08, μ^2 ~ 3 (GeV/c)^2

ΔG/G from open charm

Photon Gluon Fusion: $\gamma g \to c\bar{c}$

CHARM: $c \to D^0 \to K\pi$

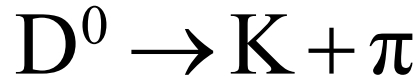Scale $\mu^2 = 4m_c^2$

Theory understood

$\sigma \sim 100$ nb, BR = 4%
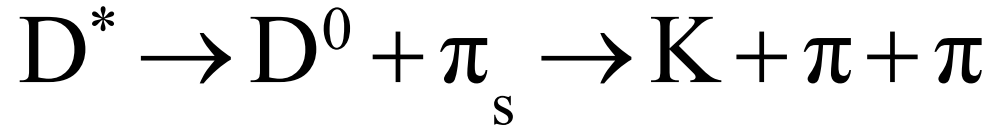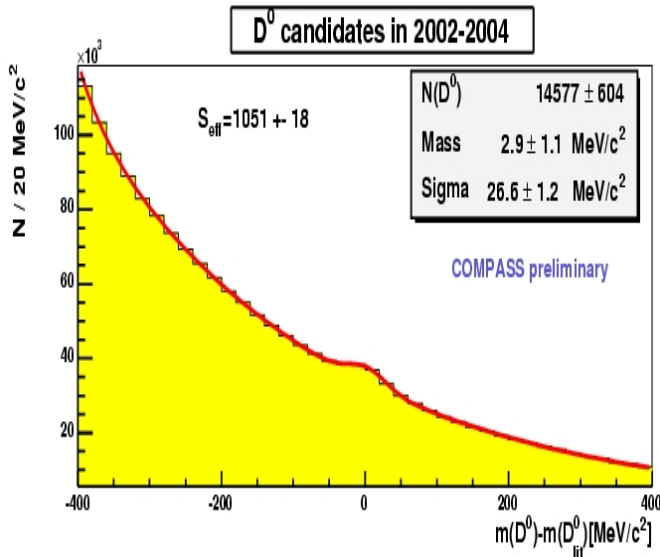
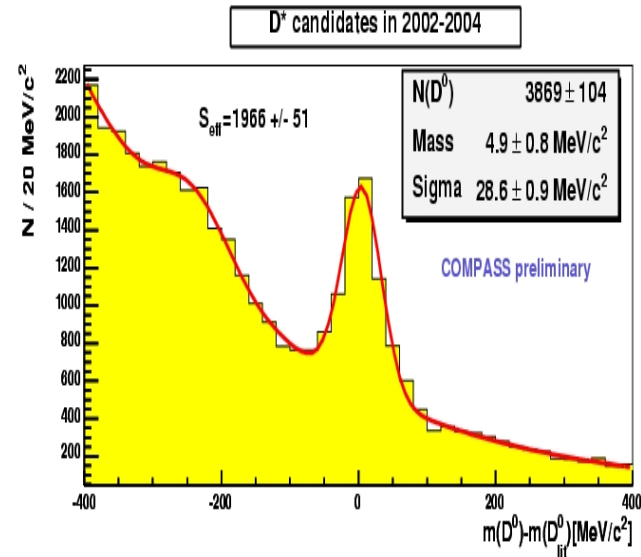Combinatorial background

Limited statistics

Challenging experiment.

$\Delta G/G$ from open charm

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

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

untagged

tagged

ΔG/G from open charm

$$A_{LL} / D = \frac{S}{S+B} \times a_{LL} \times \frac{\Delta G}{G}(x_g)$$

a_{LL} calculated with help of Monte Carlo and parametrized by measured quantities, (Neural Network used.)
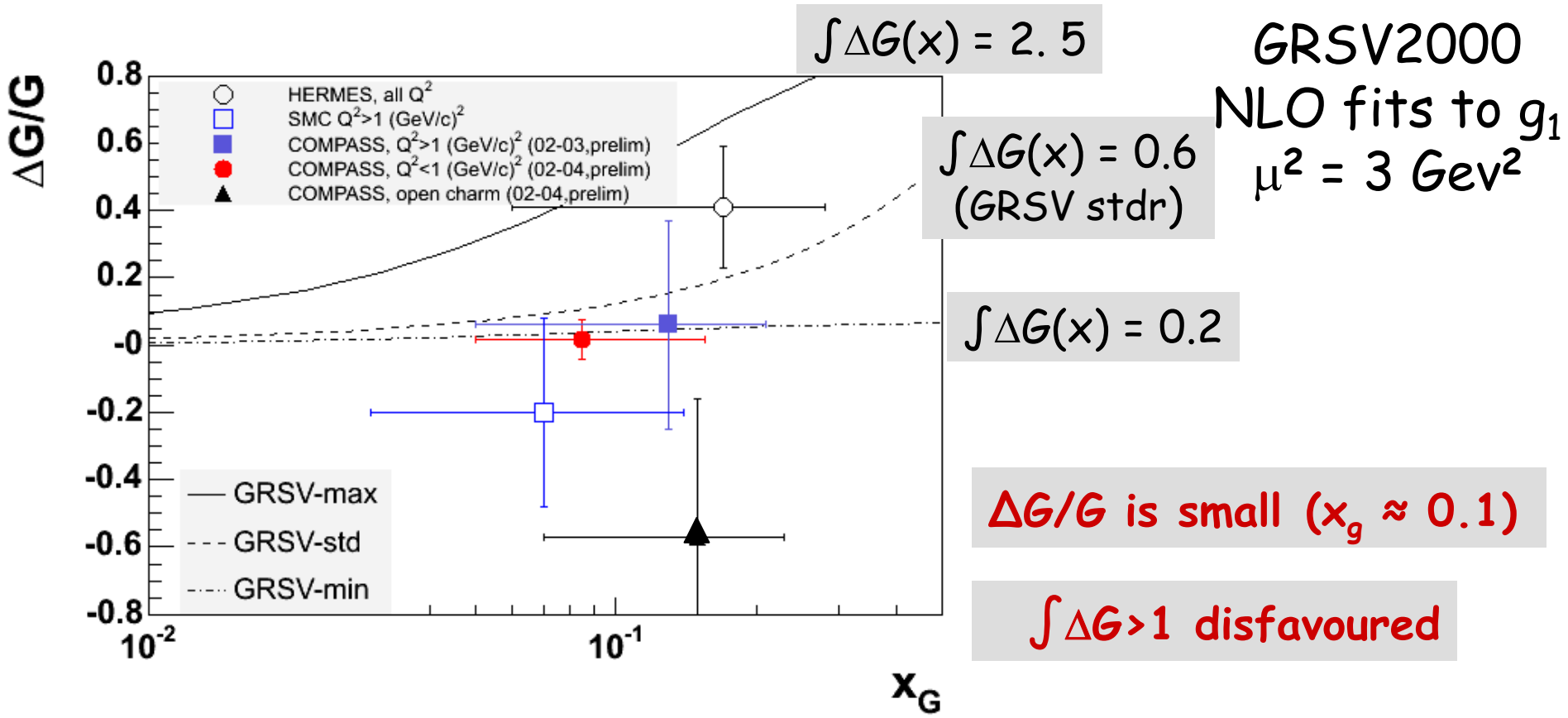
- 2002 – 2004 data D^0 + D*

Δ**G/G** = **-0.57** ± 0.41 (stat) ± (syst ≤ stat)

@ x_g ~ 0.15, μ^2 ~ 13 (GeV/c)^2

Direct measurements of ΔG/G

∫ΔG(x) = 2.5

∫ΔG(x) = 0.6
(GRSV stdr)

∫ΔG(x) = 0.2

GRSV2000
NLO fits to g_1
μ^2 = 3 Gev²

ΔG/G is small ($x_g \approx 0.1$)

∫ΔG>1 disfavoured

LO high-p_T ΔG/G results shown with GRSV NLO fits to g_1

Consistent also with RHIC A_{LL} (π^0 channel) measurements

Also: C.Quintans session 2A

new: hep-ex/060938, CERN-PH-EP/2006-029
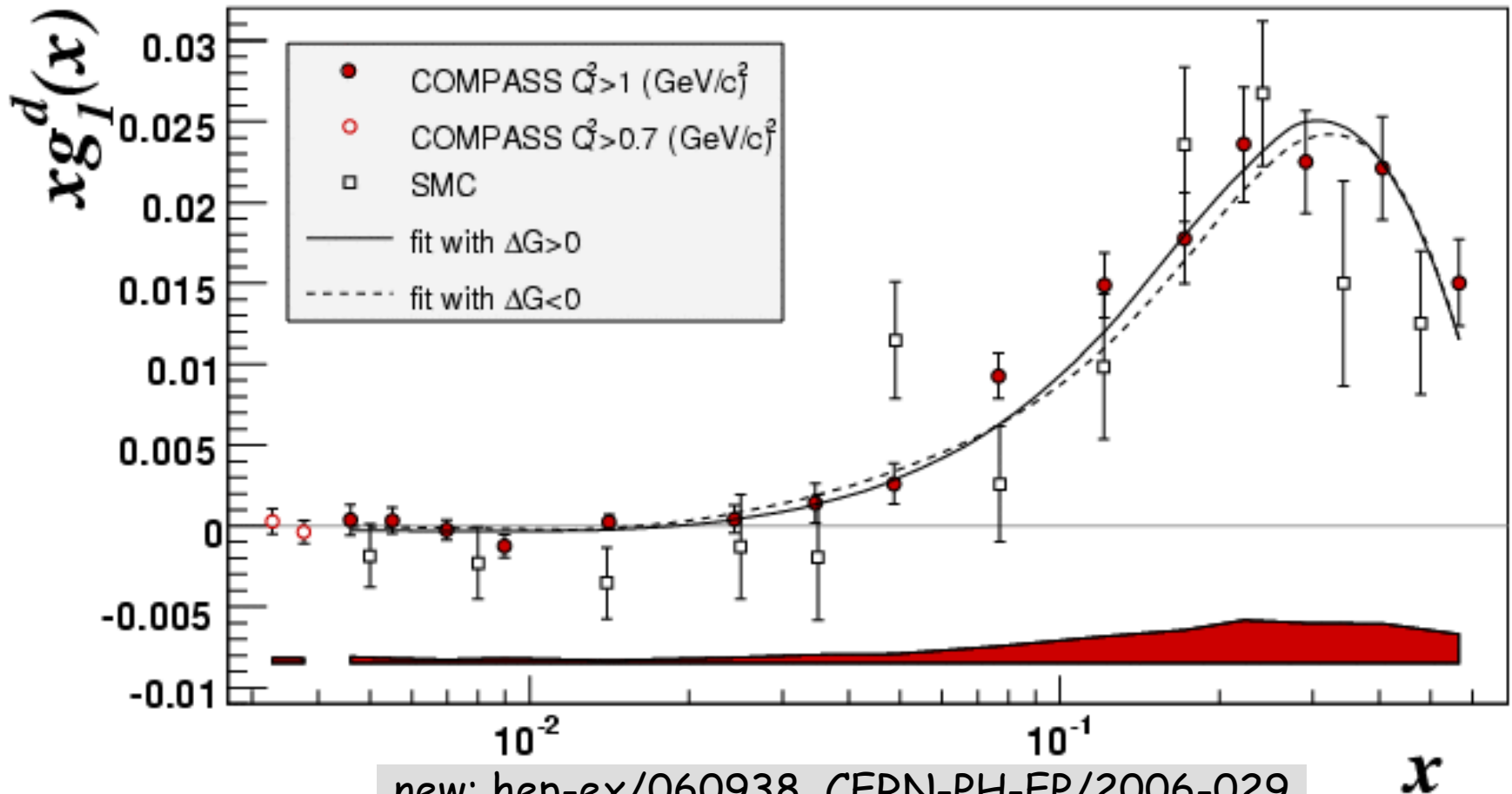
Also: I.Savin session 2A
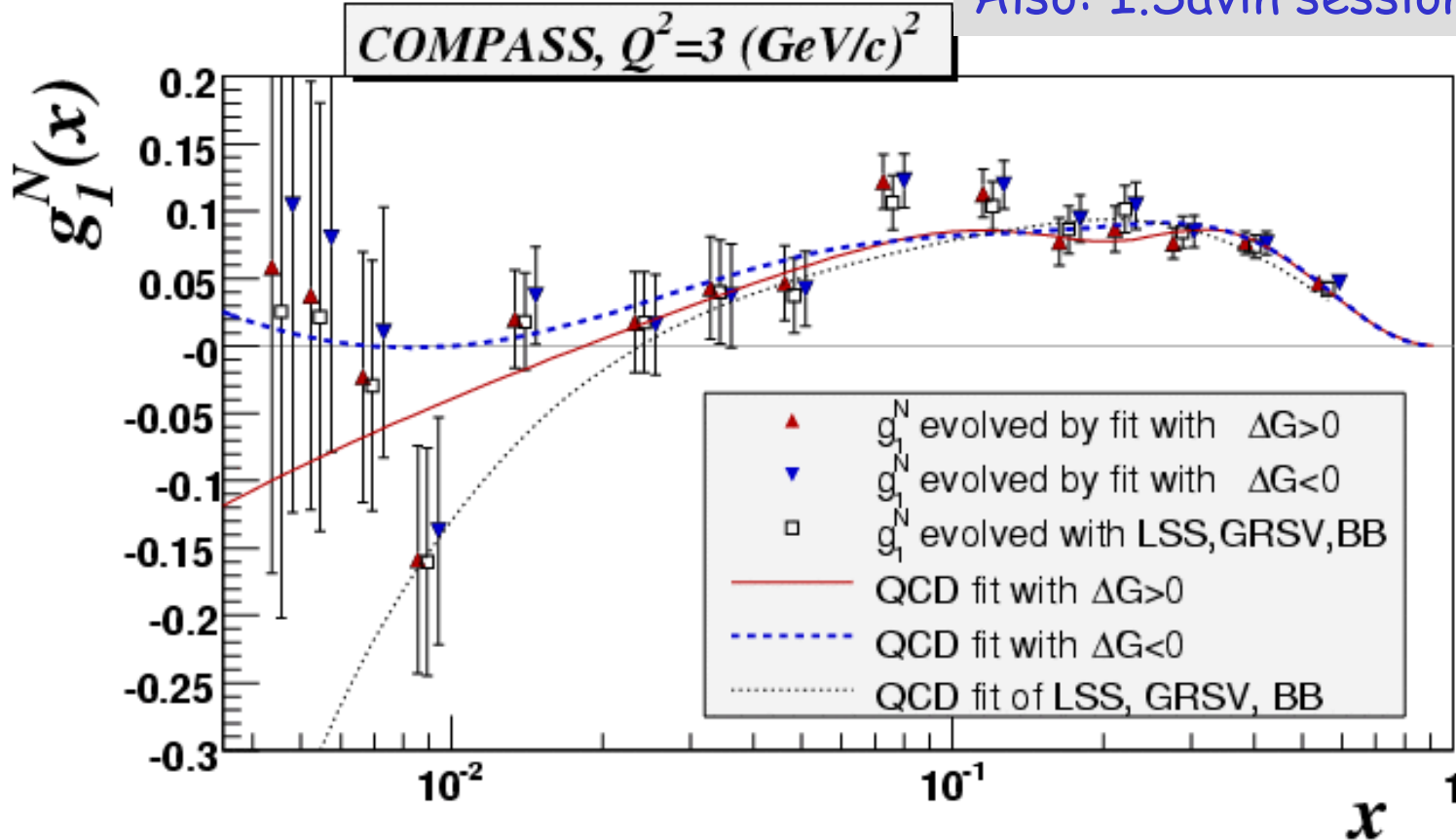
NLO fits to g_1^N world data (2006) & COMPASS

COMPASS g_1^D (2002-2004), NLO fit

NLO fit to world data (2006) & COMPASS, two equally

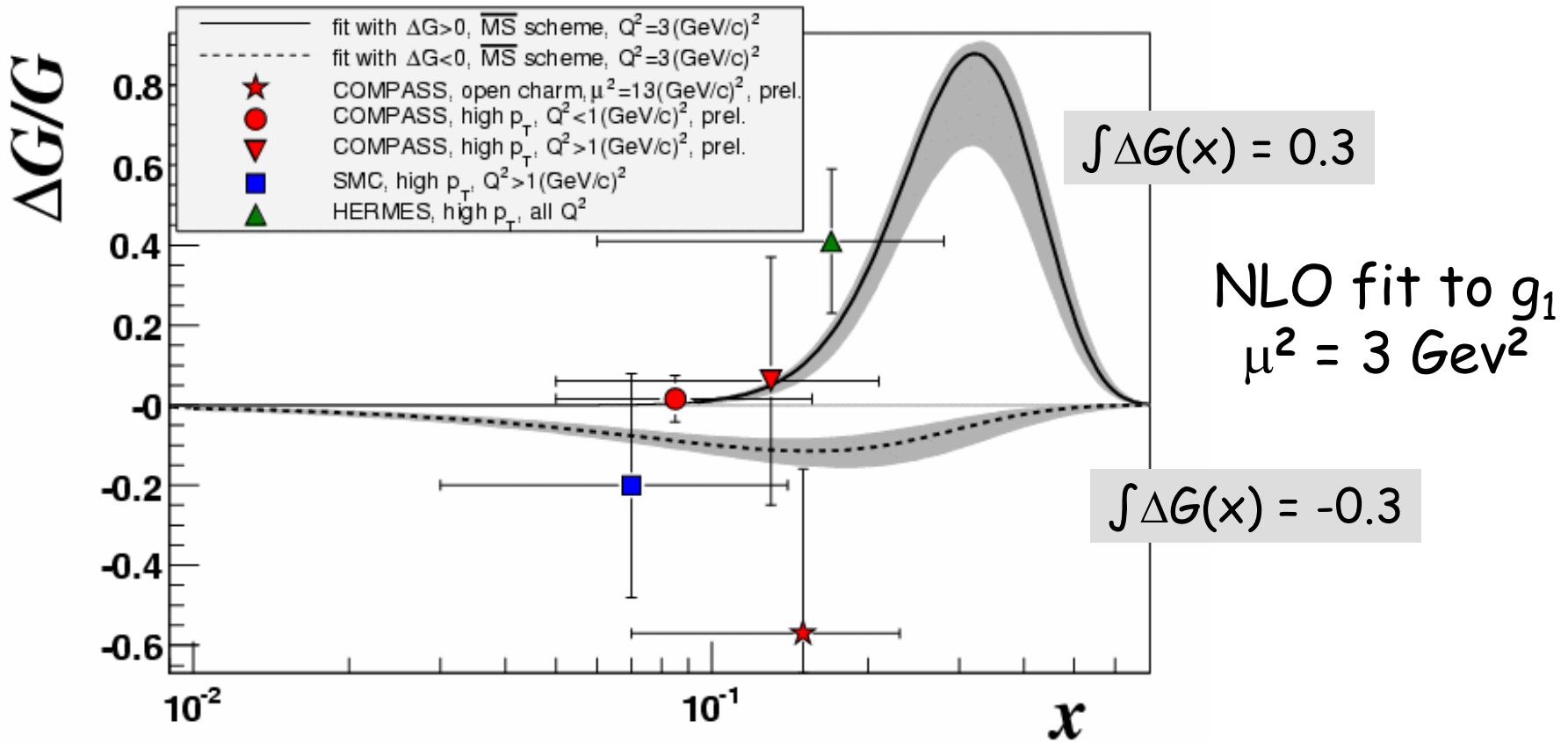probable solutions : $\Delta G > 0$ $\Delta G < 0$

- $\eta_{G\ (Q^2=3(GeV/c)^2)}$ = **+0.26** +0.04,-0.06   **-0.31** +0.10,-0.14

- $\eta_{\Sigma\ (Q^2=3(GeV/c)^2)}$ = **0.28** ± 0.01   **0.32** ± 0.01

COMPASS data alone :

- $a_{0\ (Q^2=3(GeV/c)^2)}$ = **0.35** ± 0.03 (stat) ± 0.05 (syst)

- $\Delta_s + \Delta_{\bar{s}\ (Q^2=3(GeV/c)^2)}$ = **-0.10** ± 0.01 (stat) ± 0.02 (syst)

Measurements of ΔG/G

∫ΔG(x) = 0.3

NLO fit to g_1
μ^2 = 3 Gev²

∫ΔG(x) = -0.3

LO high-p_T ΔG/G results shown with new NLO fits to g_1

Prospects

- $\Delta\Sigma \sim 0.2$ (before) $\Longrightarrow \sim 0.3$ (now)

- **Large ΔG less and less a likely candidate**

- Choose between two scenarios ?

$\Delta\Sigma$	ΔG	L_q	L_g
½ = 1/2 × 0.3 + 0.35	+	0 +	0
½ = 1/2 × 0.3 + 0.0	+	0.35	

COMPASS/RHIC   **JLab/HERMES/COMPASS**

Transverse spin: Collins & Sivers asymmetries

$$A_{\Phi_{Coll}} = \frac{\Sigma_q e_q^2 \times \boxed{\Delta_T q} \times \boxed{\Delta_T^0 D_q^h}}{\Sigma_q e_q^2 \times q \times D_q^h}$$

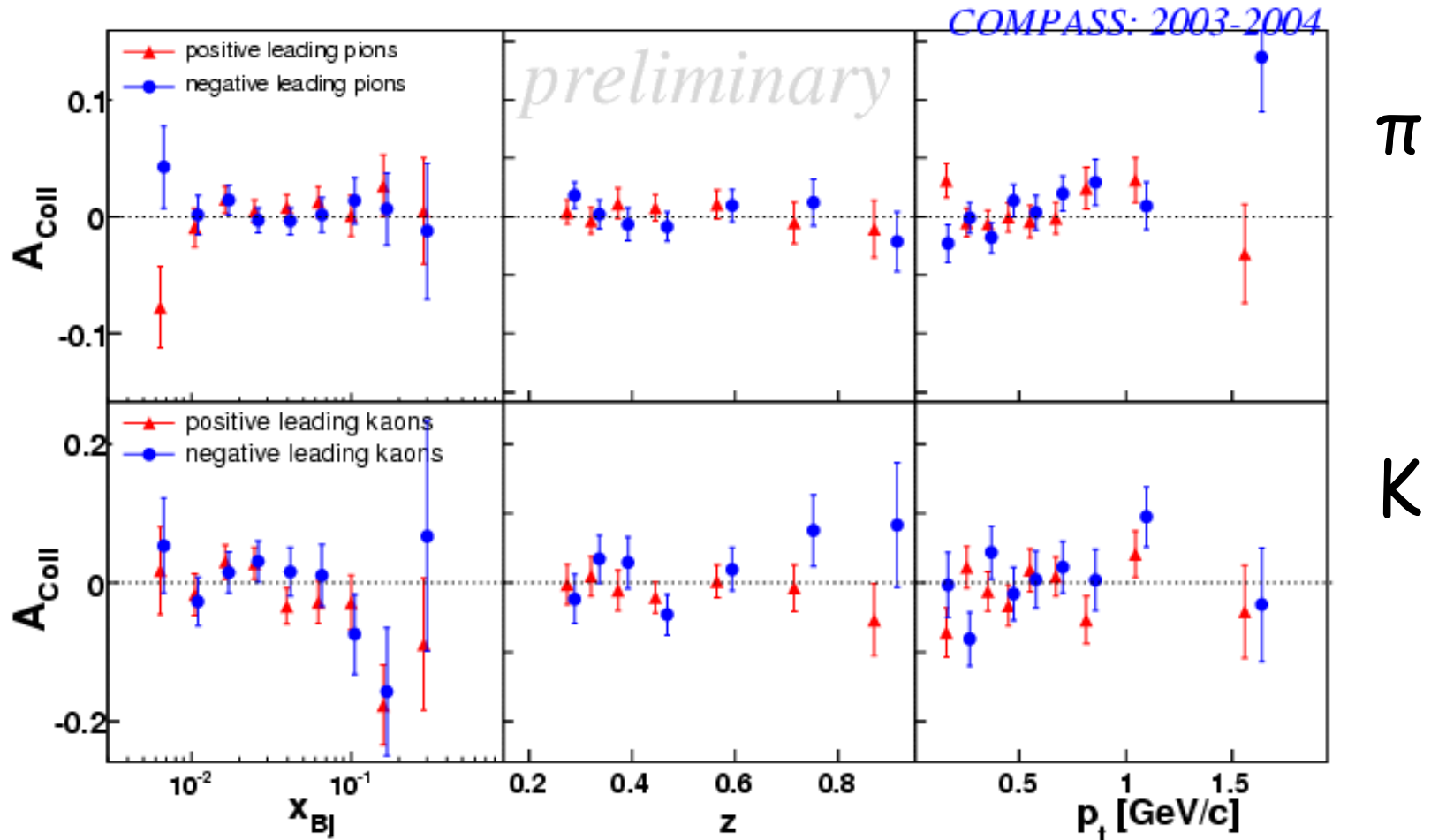spin dependent fragmention of transversely polarized quarks into hadrons

$$A_{\Phi_{Siv}} = \frac{\Sigma_q e_q^2 \times \boxed{\Delta_0^T q} \times D_q^h}{\Sigma_q e_q^2 \times q \times D_q^h}$$
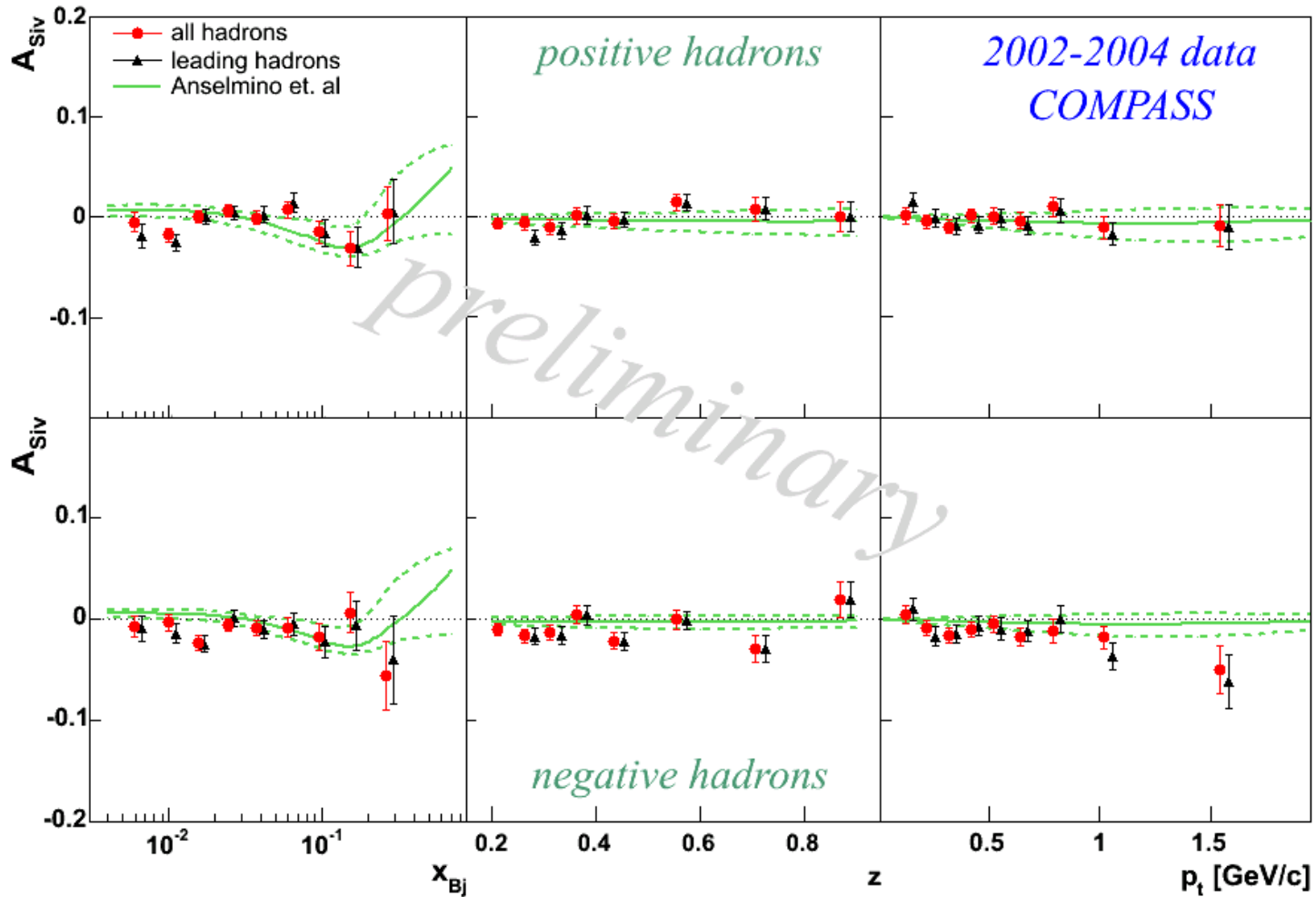
Intrinsic k_T dependence of the quark distribution

Also: F. Bradamante session 2B

COMPASS: 2003-2004

preliminary

π

K

positive leading pions
negative leading pions

positive leading kaons
negative leading kaons

A_{Siv} (deuteron)

Anselmino et. al hep-ph/0507181

More polarimeters for transvsersity:

- Two-hadrons T spin asymmetries (R. Joosten 2B)

- Λ & $\overline{\Lambda}$ T polarisations (A. Ferrero 2A)

Prospects:

- Precise transversity deuteron COMPASS

  data: hint for p & n cancellation for deuteron ?

- **Strong case for transversity proton data**
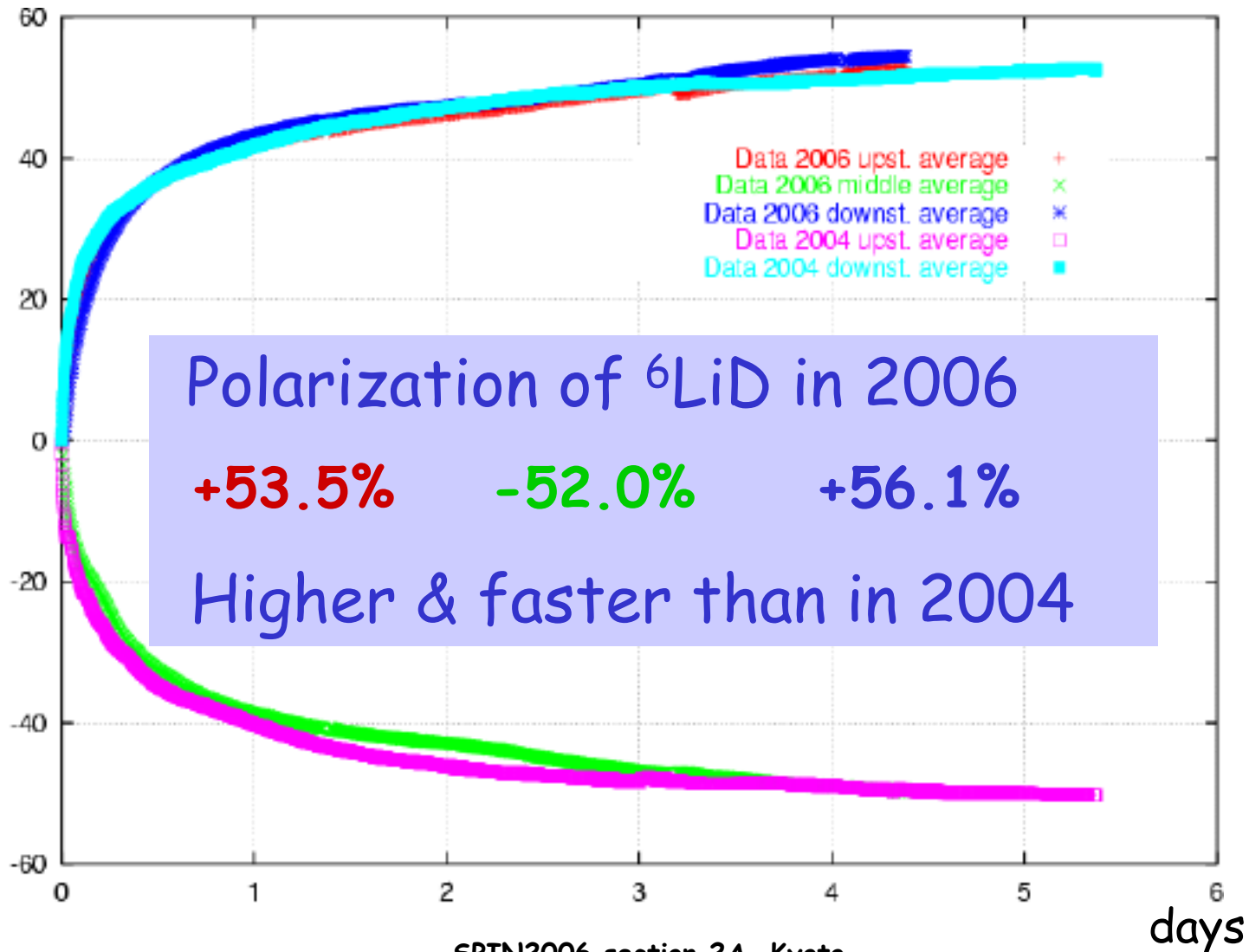
  with COMPASS in 2007.

Also: F.Gautheron session 9A

| + | - | - | + |

New COMPASS target magnet
-> 180 mrad
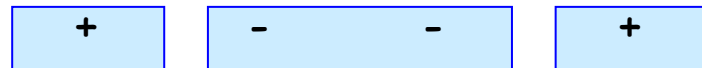
New 3-cell system & microwave cavity matched for larger acceptance, reduces false asymmetries

Polarized target performances

Polarization of ^{6}LiD in 2006

+53.5%   **-52.0%**   **+56.1%**

Higher & faster than in 2004

days
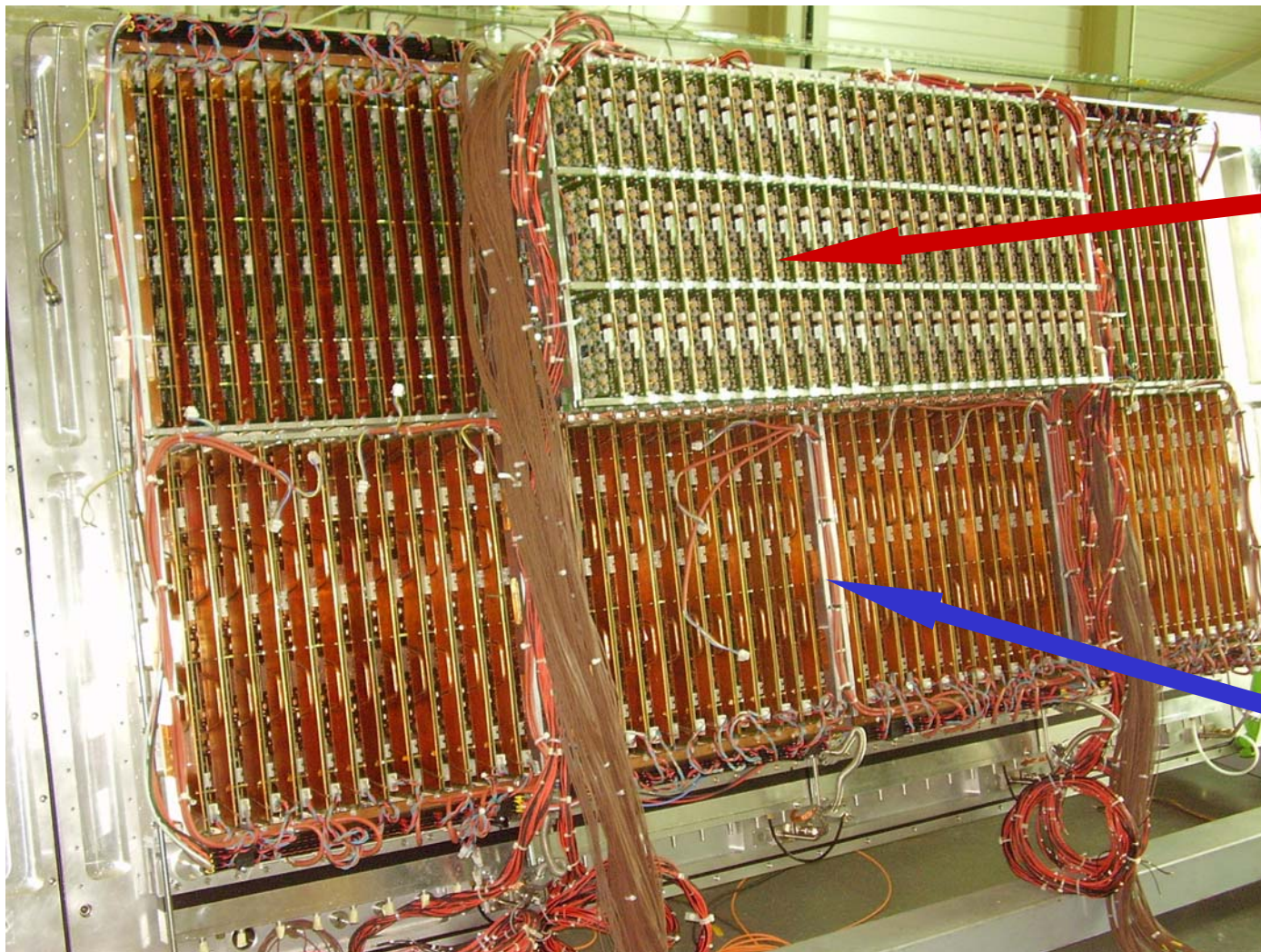
Lens system

+ MAPMTs

+ MAD4

+ F1

CsI MWPC

+ APV25S1

+ ADC

RICH-1 upgrade, MAPMTs "on-line"

RM01P___2D_SingleEvtPhotView_10nsTimeCut
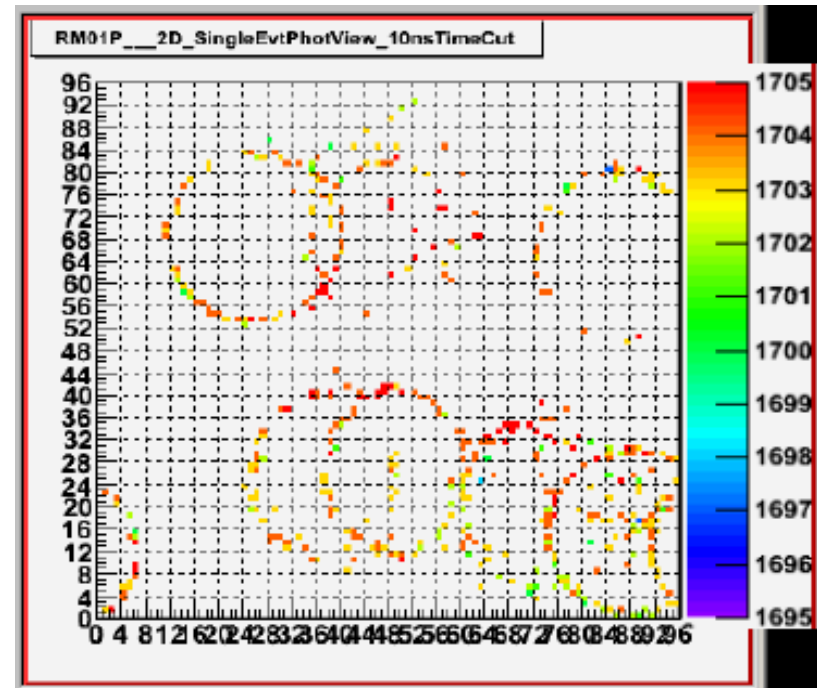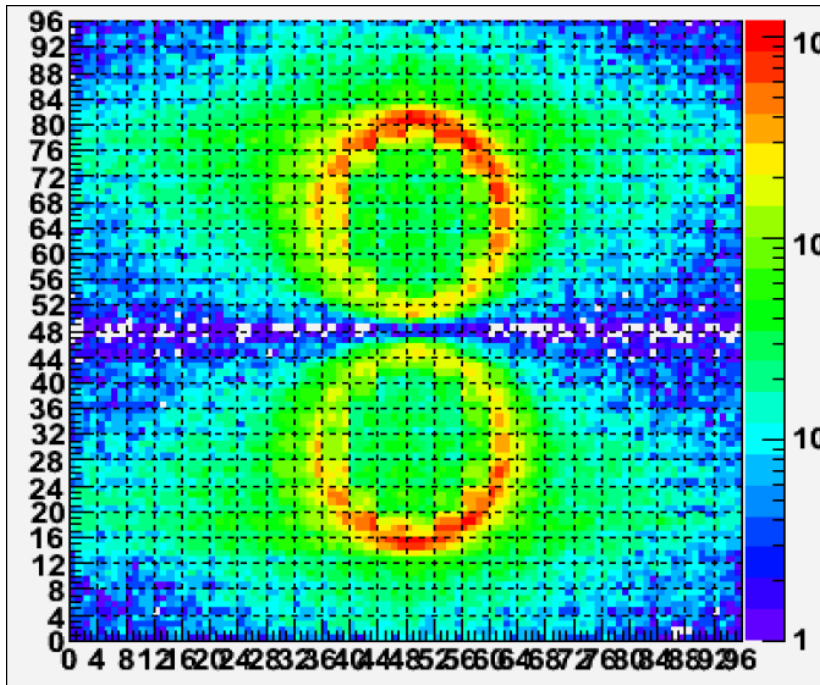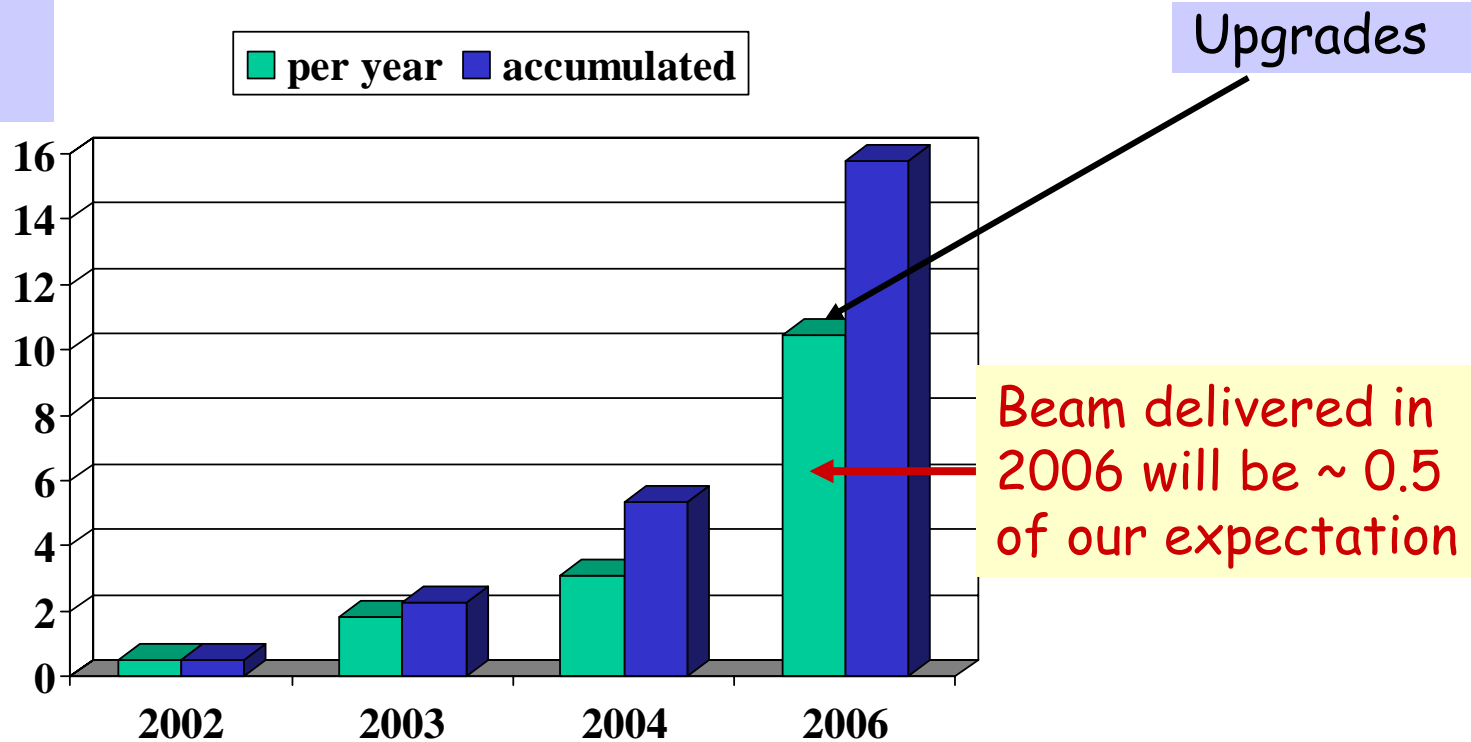

Very promising results !

- Precise timing

- **High photon statistics**
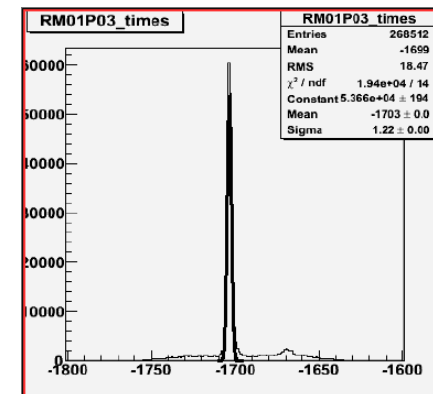
FoM for ΔG/G from open charm

$$1/\sigma(\Delta G/G)^{1/2}$$

$$= \text{FoM}$$

Upgrades

Beam delivered in 2006 will be ~ 0.5 of our expectation

- In 2006, apparatus will have reached optimum performances allowing us to make the most productive use of SPS beam

Prospects

- Proton target

  with Transverse polarisation (planned in 2007)

  with Longitudinal polarisation   (beyond 2007)

  SIDIS ⎤
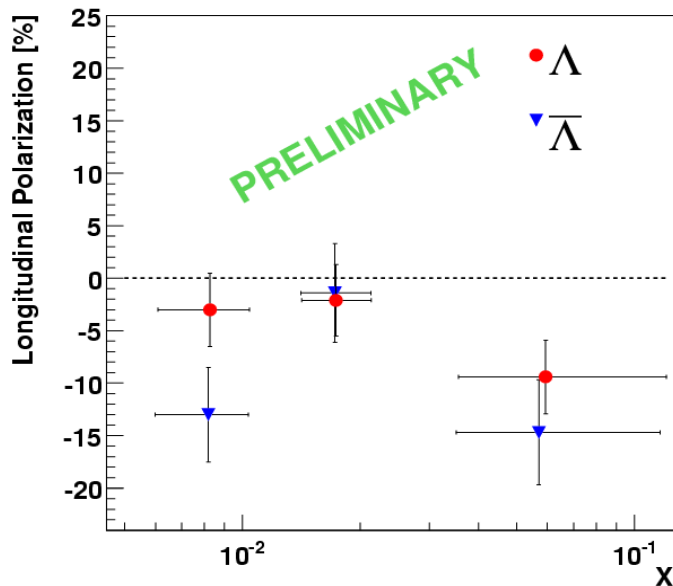 Particle ID ⎦ Flavor separation
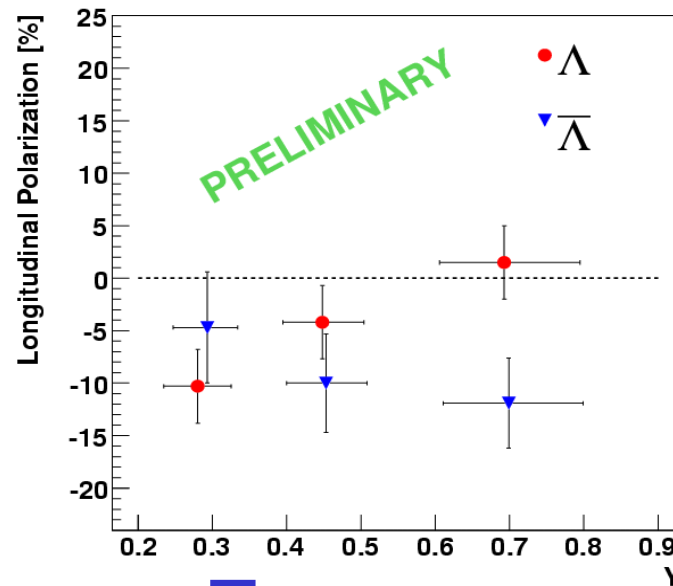
  Revisiting Bjorken SR ?

Additional slides

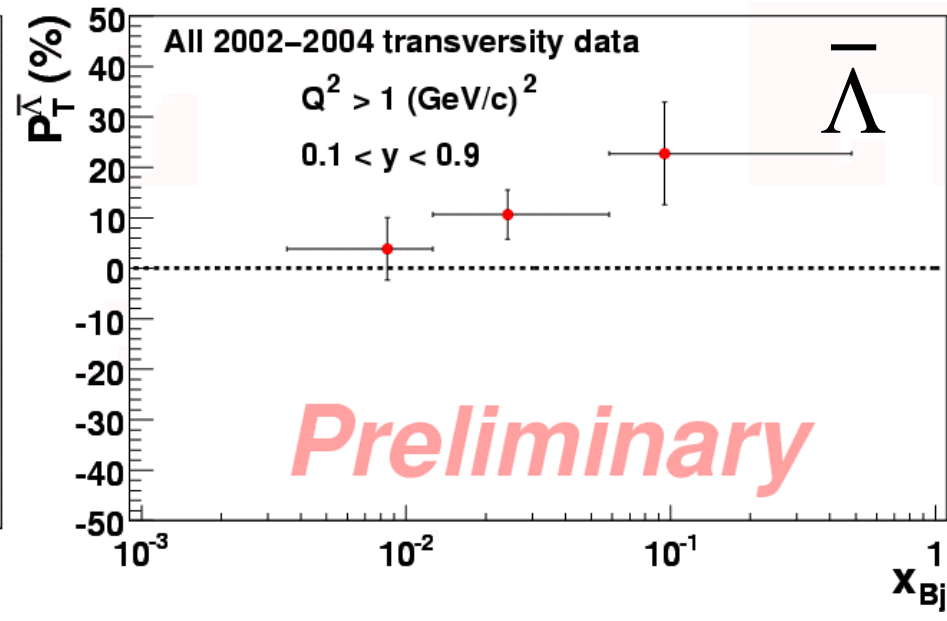# Longitudinal Λ & $\bar{\Lambda}$ polarisations
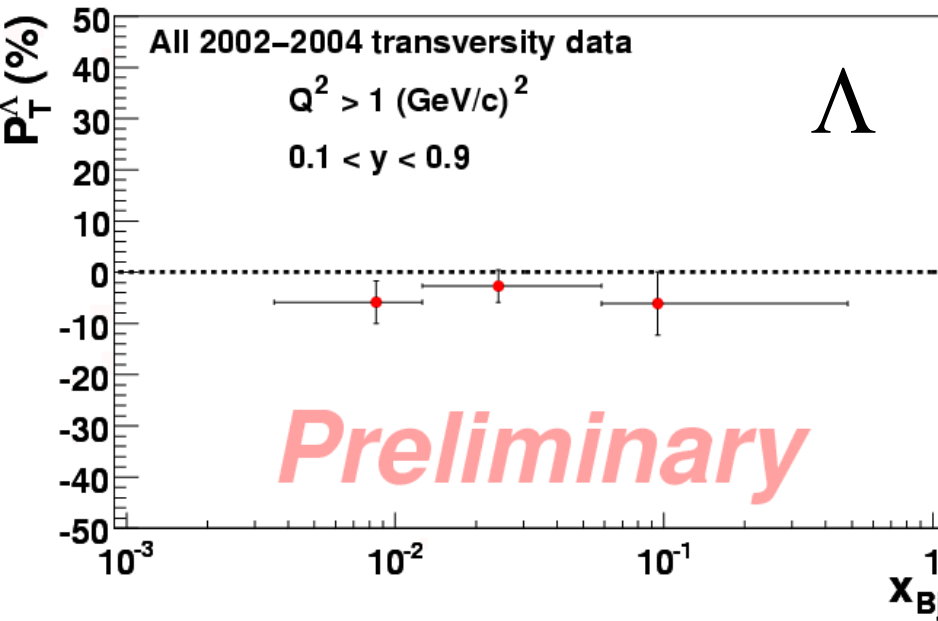

- Statistics of ~ 31000 Λ and ~ 18000 $\bar{\Lambda}$ from 2003 data

- 2004 data will at least double statistics

- Access to s and $\bar{s}$ quarks, also Δs ? Need dedicated studies
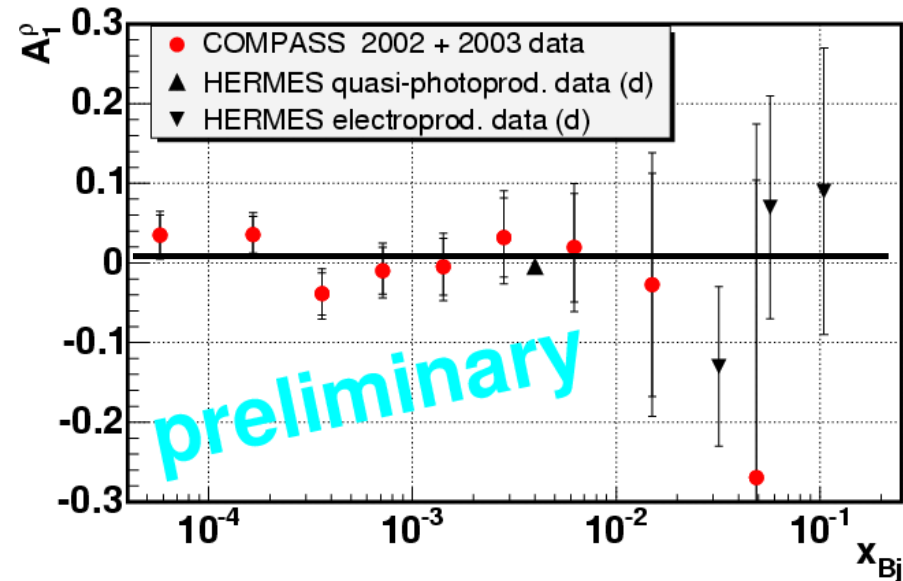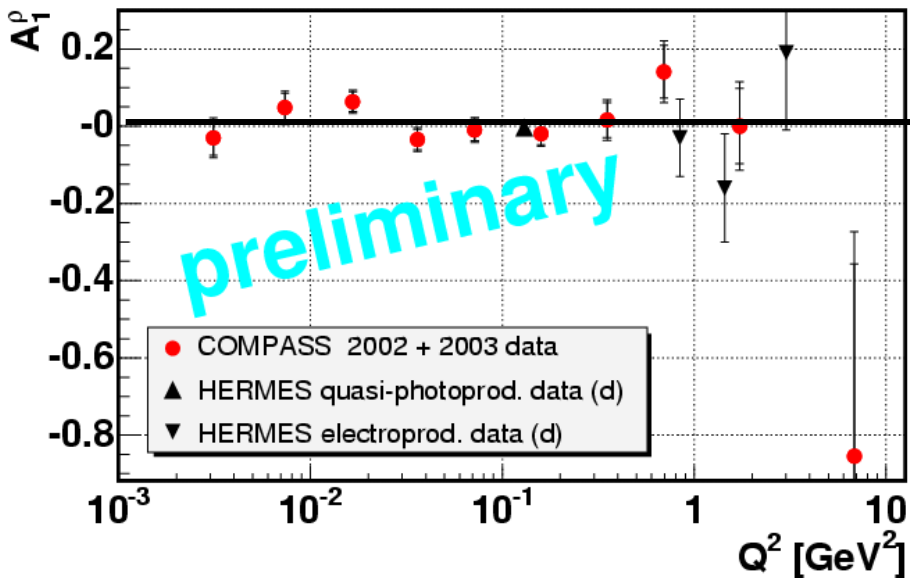
  with Monte Carlo

Also: M. Sapozhnikov session 2A

Also: A. Ferrero session 2A

$$P_T^\Lambda = f\, P_T\, D\, \frac{\sum_q e_q^2 \times \Delta_T q \times \Delta D_q^\Lambda}{\sum_q e_q^2 \times q \times D_q^\Lambda}$$

Hard exclusive ρ^0 meson production

- Large statistics on diffractive production of $\rho, \phi, J/\Psi$

- Large x, Q^2 range

- Measure spin density matrix elements and L-double spin asymmetries

- A_1 for ρ^0 compatible with zero, more data needed