Recent **COMPASS** spin physics results

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On behalf of the COMPASS collaboration

The COMPASS Collaboration

Broad Spin physics program:

○ Gluon Polarization $\Delta G/G$

  – Open Charm

  – High p_T, *cf.* K. Kurek

○ Inclusive DIS Asymmetry

○ Flavor separation using SIDIS

○ Transversity, *cf.* R.Webb

○ Diffractive vector mesons production *cf.* E.Burtin

○ Spin effects in Λ production

The Physics Case

- QCD fit of world Polarized DIS data (CERN, SLAC, HERMES, JLab)
  $\Rightarrow$
  - Valence well fixed.

  But. . .
  - Gluon largely undetermined.
- Inclusive DIS sensitive only to $\Delta q + \Delta\bar{q}$

$\Rightarrow$ Need for:
  - A direct measurement of $\Delta G/G$ $\leftrightarrow$ Open Charm, High p_T
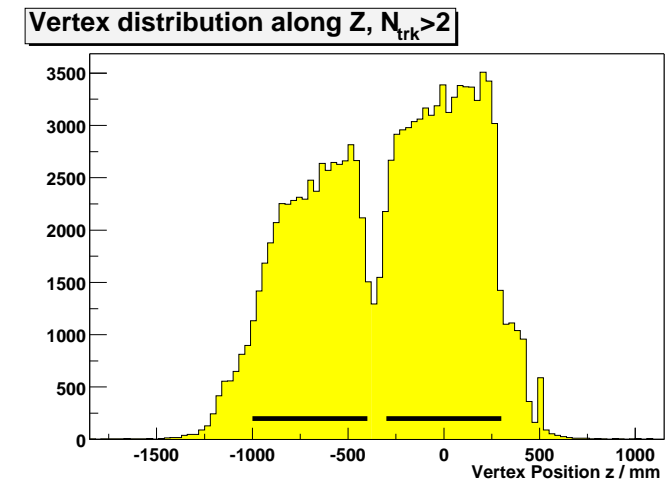 - Flavor separation $\leftrightarrow$ Semi-Inclusive DIS

  Also, for the extrapolation to $x \to 0$ in the computation of $\int g_1 dx$:
  - Data at small x

- Complete the parton structure at leading twist $\leftrightarrow$ Transversity
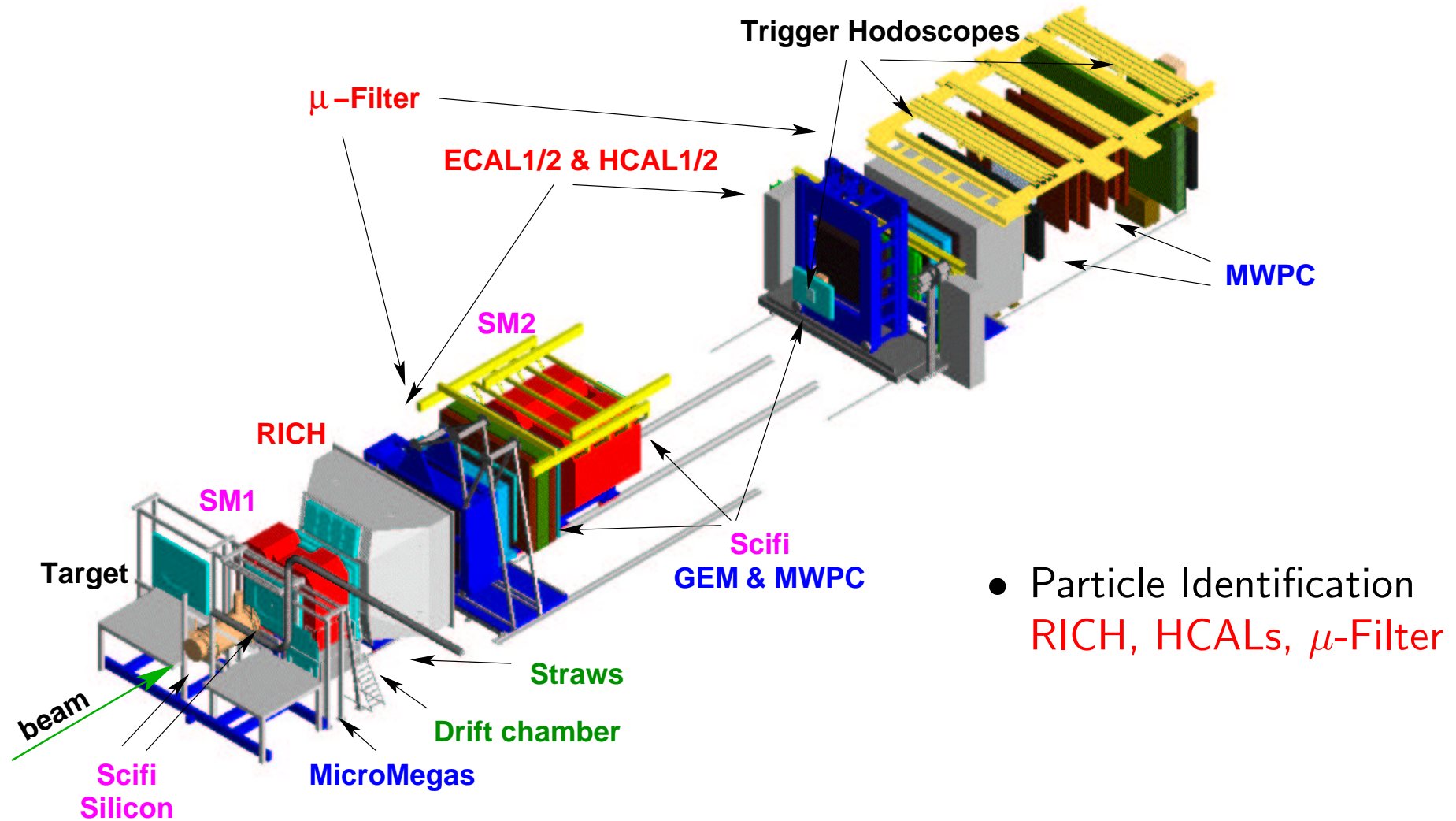
Experimental Essentials

- Polarized beam:
  - μ beam from π decay $\Rightarrow$ 76% polarization.
  - 5 times higher intensity w.r.t. to SMC. 160 GeV.
- Polarized target:
  - $^6LiD(\simeq 2d + 1\alpha)$ in He bath $\Rightarrow f \simeq 0.4$
  - 50 % polarization
- Control of fake asymmetries:
  - Two oppositely polarized target cells
  - Polarization reversal by field rotation every 8 hours
  - Polarization reversal by microwave reversal

Vertex distribution along Z, $N_{trk}>2$

$$A_{\gamma^*N} = \frac{1}{2} \quad \frac{1}{P_b D \times P_t f} \left(\frac{N_u - N_d}{N_u + N_d} - \frac{N_u' - N_d'}{N_u' + N_d'} \right)$$

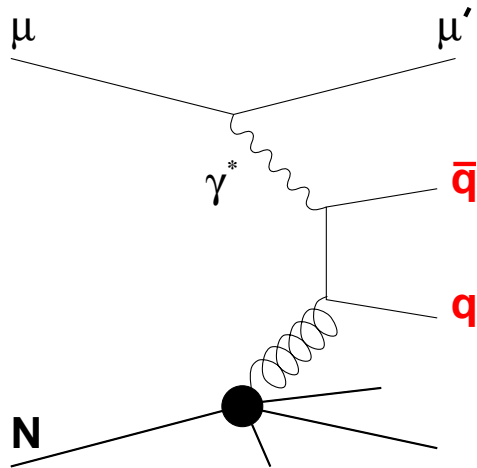# Essentials cont'd: The COMPASS Spectrometer!

- Particle Identification
  RICH, HCALs, μ-Filter

Data

- Data taking

	2002	2003	2004
Days	70	83	106
Integrated Luminosity (fb^{-1})	1	1.2	~2.4

- Analysed (preliminarily): 2002 and 2003 $\Rightarrow \sim 1/2$ of collected data

$\Delta G/G$: Photon Gluon Fusion

μ   μ′

γ* $\bar{\mathbf{q}}$

$\mathbf{q}$

N

q = c: Open Charm production
○ Triggered by PGF at LO
(neglecting Intrinsic Charm)
⇒ Theory Golden Channel

○ Experimentally difficult

○ pQCD scale set by $\hat{s} > 4m_c^2$

q = u,d,s,c: High p_T hadrons
○ Competing LO-DIS, QCD-Compton and
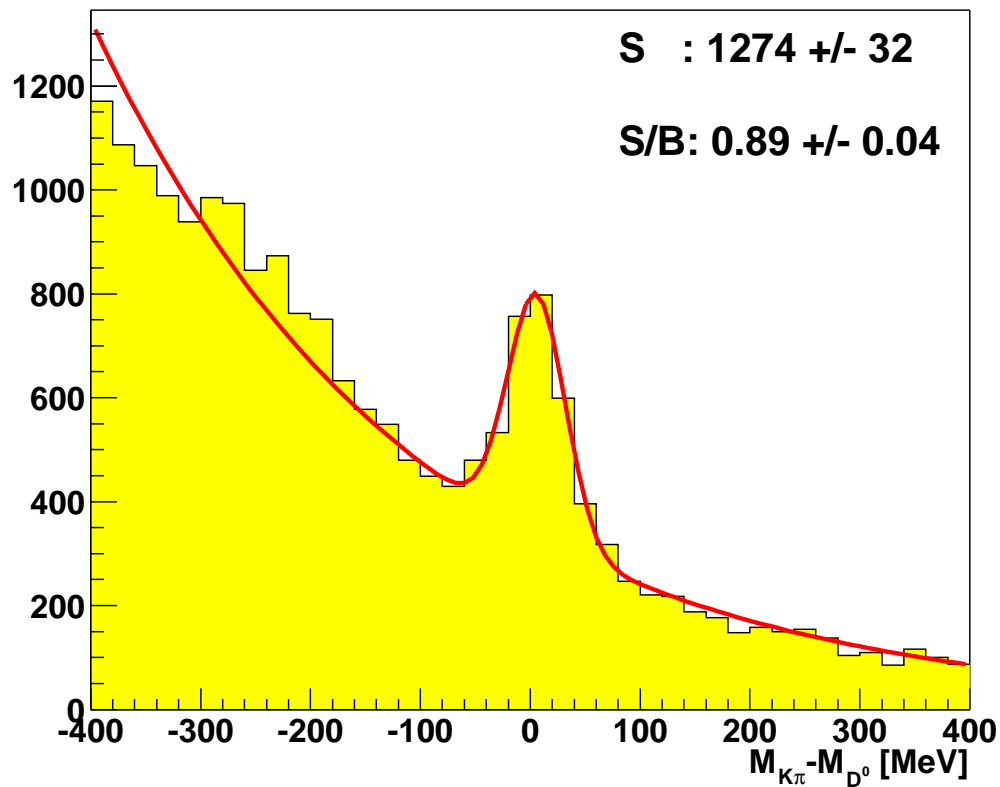resolved photon processes.
⇒ Theoretical uncertainties, $cf.$
K.Kurek's talk

○ Higher statistics

○ pQCD scale set by p_T

⇒ Explore all Q^2

Open Charm: D^o Reconstruction

- $D^o \to K\pi$
- Thick target
  $\Rightarrow$ No Charm decay vertex reconstruction

K/pi Invariant Mass (2003)

S   : 1274 +/- 32

S/B: 0.89 +/- 0.04

$M_{K\pi}$-M_{D^o} [MeV]

- Favorable case: D^o from D^*
  - 1/3 of D^o's
  - $D^* \to D^o\pi \to K\pi\pi$

  - D^* tagging by cut on 3-body invariant mass

$\Delta G/G$ *via* **Open Charm**

1.

$$\Delta G/G = \frac{1}{P_T P_b f} \ \frac{1}{\langle a_{LL} \rangle} \ \frac{N^{\uparrow\downarrow} - N^{\uparrow\uparrow}}{N^{\uparrow\downarrow} + N^{\uparrow\uparrow}}$$

2.

  ○ a_{LL} varies largely over kinematical domain, even changing sign

  ○ So does Signal over Background

$\Rightarrow$ Event by event weighting:

$$\Delta G/G = \frac{1}{P_T P_b f} \ \frac{\sum_i^{\uparrow\downarrow} w_i - \sum_i^{\uparrow\uparrow} w_i}{\sum_i^{\uparrow\downarrow} w_i^2 + \sum_i^{\uparrow\uparrow} w_i^2} \qquad\qquad w_i = \frac{\langle a_{LL} \rangle_i}{(1 + B/S)_i}$$
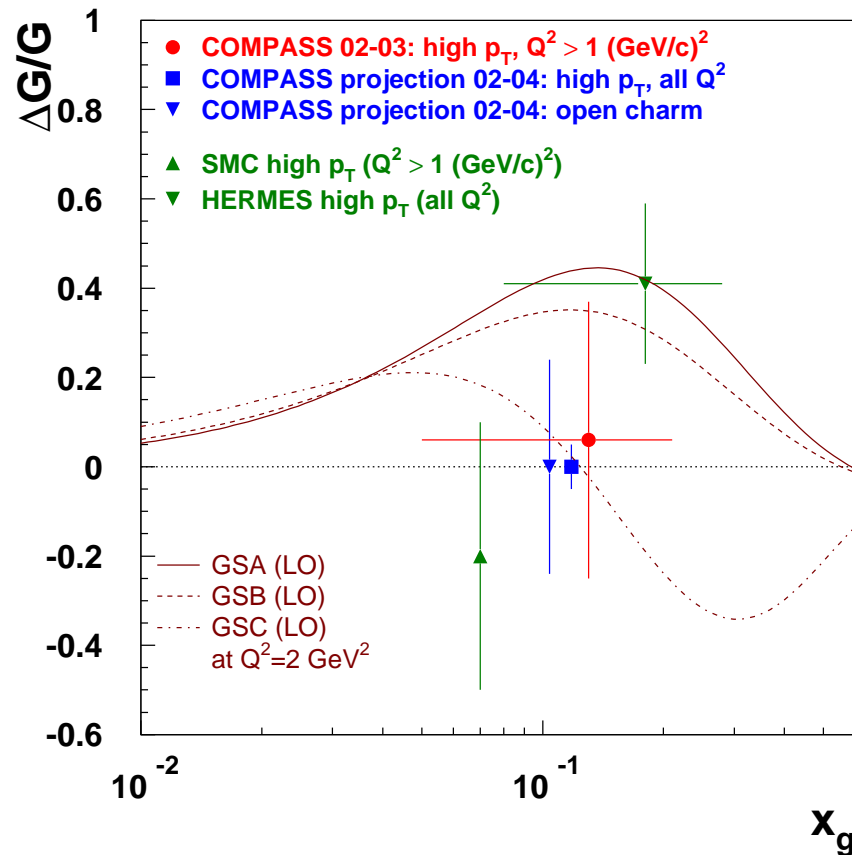
- With full [2002,2004] statistics
- D^o with AND without D^* tagging

$$\Rightarrow \qquad \boxed{\delta(\Delta G/G) = 0.24}$$

$\Rightarrow$ Take more data. . .

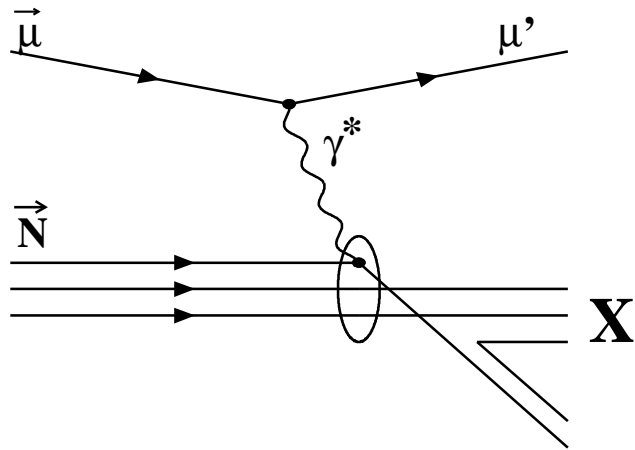# $\Delta G/G$: Result and Expectations

- Open Charm:
  $\delta(\Delta G/G) = 0.24$

- High p_T hadrons pairs
  - $Q^2 > 1$ ($\sim 1/2$ of data)

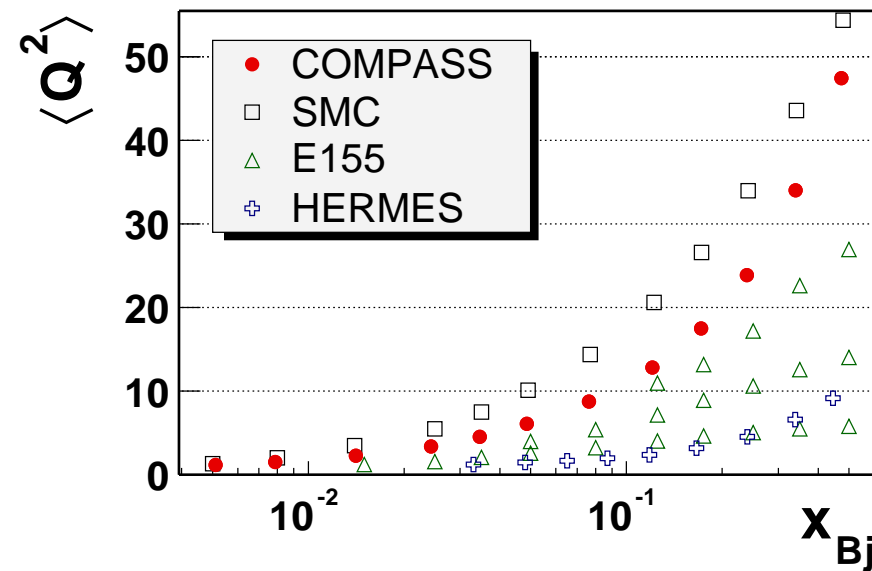 $$\Delta G/G = 0.06 \pm 0.31 \pm 0.06$$
  $$x_g = 0.13 \pm 0.08 RMS$$

  - Adding 2004 data, All Q^2
    $\Rightarrow \delta(\Delta G/G) = .05$

- Single high p_T hadron analysis in progress.

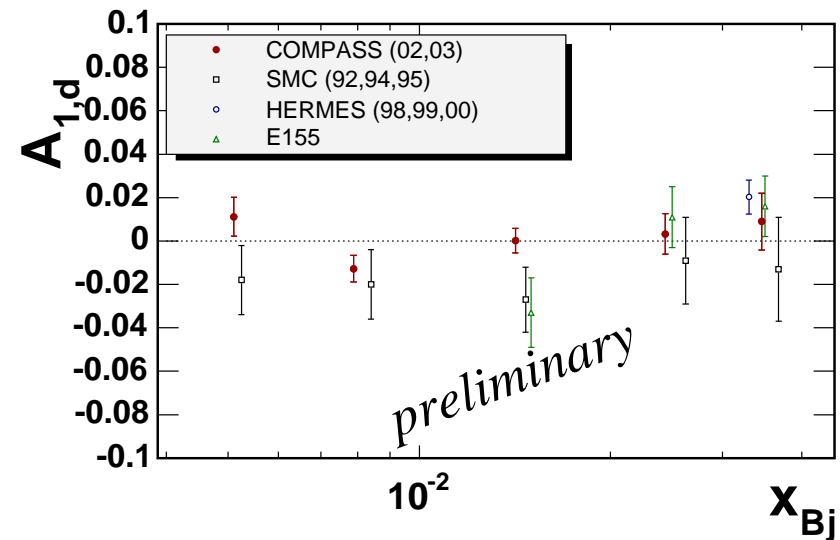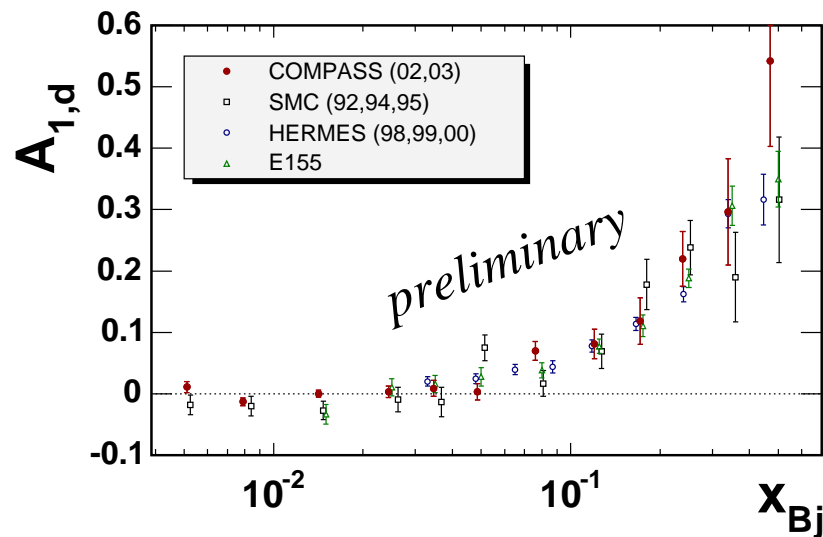# Inclusive A_1^d

- **Kinematics:**
  - E_μ 160 GeV
  - $Q^2 > 1$ GeV^2
  - $0.1 < y < 0.9$
    $\Rightarrow x_{min} = 0.003$
    - Hermes: $x_{min} = 0.02$
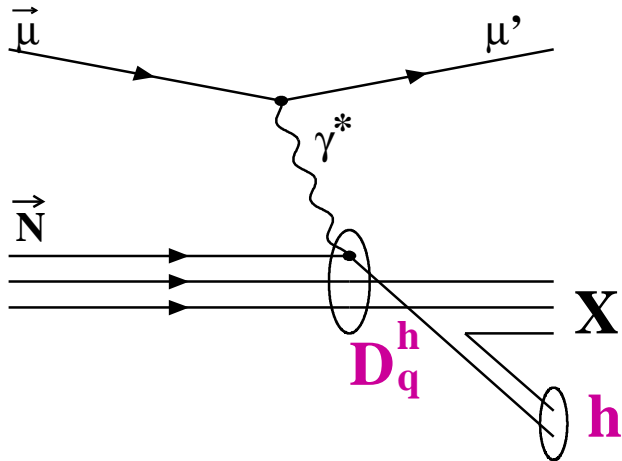   - SLAC: $x_{min} = 0.01$

Asymmetry A_1^d

- Good agreement with published results at high x
- Systematic errors under study (smaller than statistical ones)

- High precision data at small x

Flavor Separation *via* SIDIS

- Hard $\gamma^* q$ interaction and soft q hadronization factorize

$$N^h(x,z) \propto \sum_q e_q^2 \left(q(x) \int D_q^h dz + \bar{q}(x) \int D_{\bar{q}}^h dz \right)$$

with Fragmentation functions:
$$D_q^h(z), \; z = E_h/E_{\gamma^*}$$

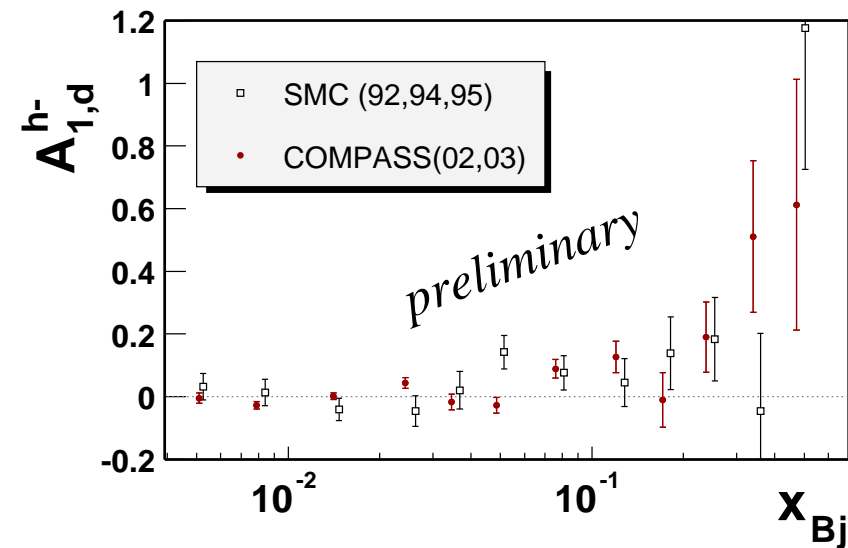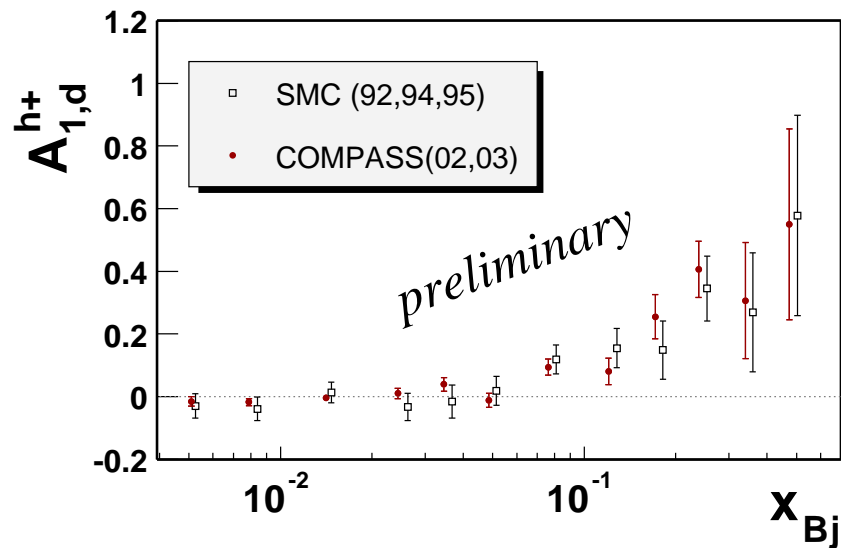- $z > 0.2$ to ensure current fragmentation

$\Rightarrow$ Asymmetries

$$A_1^h = \frac{\sigma_h^{\uparrow\downarrow} - \sigma_h^{\uparrow\uparrow}}{\sigma_h^{\uparrow\downarrow} + \sigma_h^{\uparrow\uparrow}} = \frac{\sum_q e_q^2 \left(\Delta q(x) \int D_q^h dz + \Delta\bar{q}(x) \int D_{\bar{q}}^h dz \right)}{\sum_q e_q^2 \left(q(x) \int D_q^h dz + \bar{q}(x) \int D_{\bar{q}}^h dz \right)}$$

with $D_{\bar{q}}^h \neq D_q^h$ allow flavor separation.

- Isoscalar, d, target $\Rightarrow \vec{\Delta q} = \left(\Delta u + \Delta d, \Delta\bar{u} + \Delta\bar{d}, \Delta s = \Delta\bar{s} \right)$

Semi-Inclusive Asymmetries

- Asymmetries to be measured: $\vec{A}_1^d = \left(A_1, A_1^{h^+}, A_1^{h^-}, A_1^{K^+}, A_1^{K^-}, A_1^{K_s^o} \right)$

- Fragmentation Functions:
  - EMC: $D_u^{\pi^+}$, $D_{\bar{u}}^{\pi^+}$, $D_u^{K^+}$, $D_{\bar{u}}^{K^+}$, D_u^p, $D_{\bar{u}}^p$
  - MC (Pythia): $D_q^{K_s^o}$

- First asymmetry measurements:

Conclusions

- 3 years of data taking. Analysis in progress.

- First physics results bearing on $\sim 1/2$ of the collected data.

- $\Delta G/G$:

  - $$\Delta G/G = 0.06 \pm 0.31 \pm 0.06$$
    $$x_g = 0.13 \pm 0.08 RMS$$

  - Better precision in 2005.