

# New COMPASS results on semi-inclusive polarised DIS



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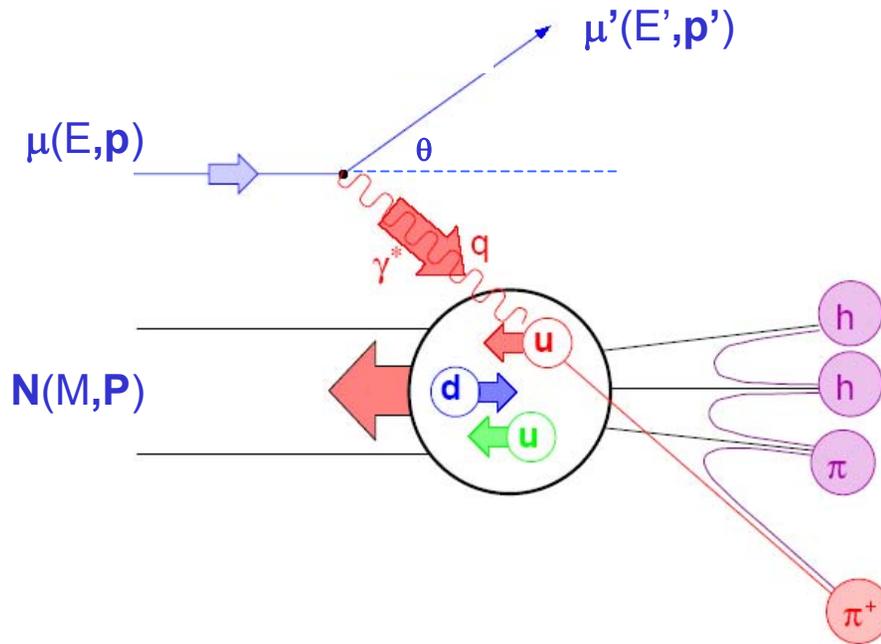
LIP - Lisboa

on behalf of the COMPASS Collaboration



- Semi-inclusive polarised deep inelastic scattering
- Polarised spin structure functions
- The strange quark polarisation

# Polarised Deep Inelastic Scattering



$$Q^2 = -q^2 = (k - k')^2$$

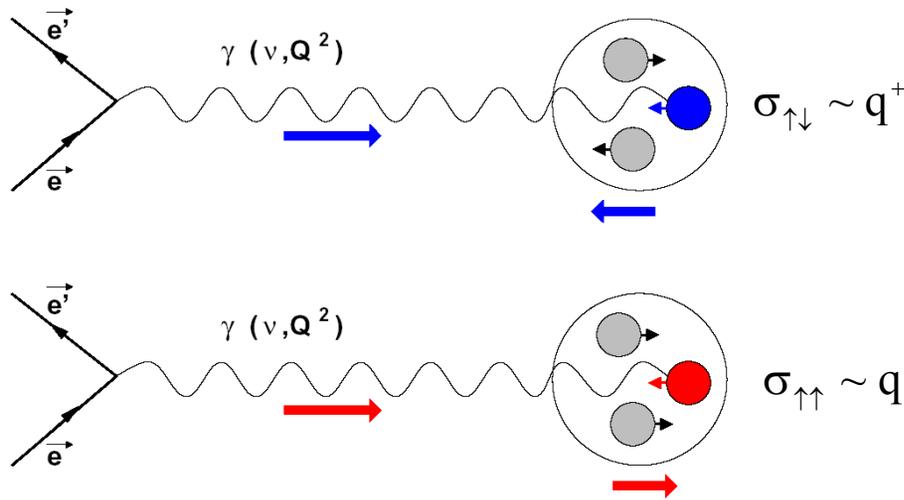
$$\nu = E - E'$$

$$x = Q^2/2M\nu$$

$$z = E_h/\nu$$

$$\frac{d^2\sigma}{d\Omega dE'} = \underbrace{c_1 F_1(x, Q^2) + c_2 F_2(x, Q^2)}_{\text{spin independent}} + \underbrace{c_3 g_1(x, Q^2) + c_4 g_2(x, Q^2)}_{\text{spin dependent}}$$

# Photon-nucleon Asymmetry



$$\Delta q(x) = q(x)^+ - q(x)^-$$

$$q(x) = q(x)^+ + q(x)^-$$

+ quark  $\uparrow\uparrow$  nucleon

- quark  $\uparrow\downarrow$  nucleon

Inclusive  
asymmetry

$$A_1(x, Q^2) = \frac{\sigma_{\uparrow\downarrow} - \sigma_{\uparrow\uparrow}}{\sigma_{\uparrow\downarrow} + \sigma_{\uparrow\uparrow}} \approx \frac{\sum_q e_q^2 \Delta q(x, Q^2)}{\sum_q e_q^2 q(x, Q^2)} = \frac{g_1(x, Q^2)}{F_1(x, Q^2)}$$

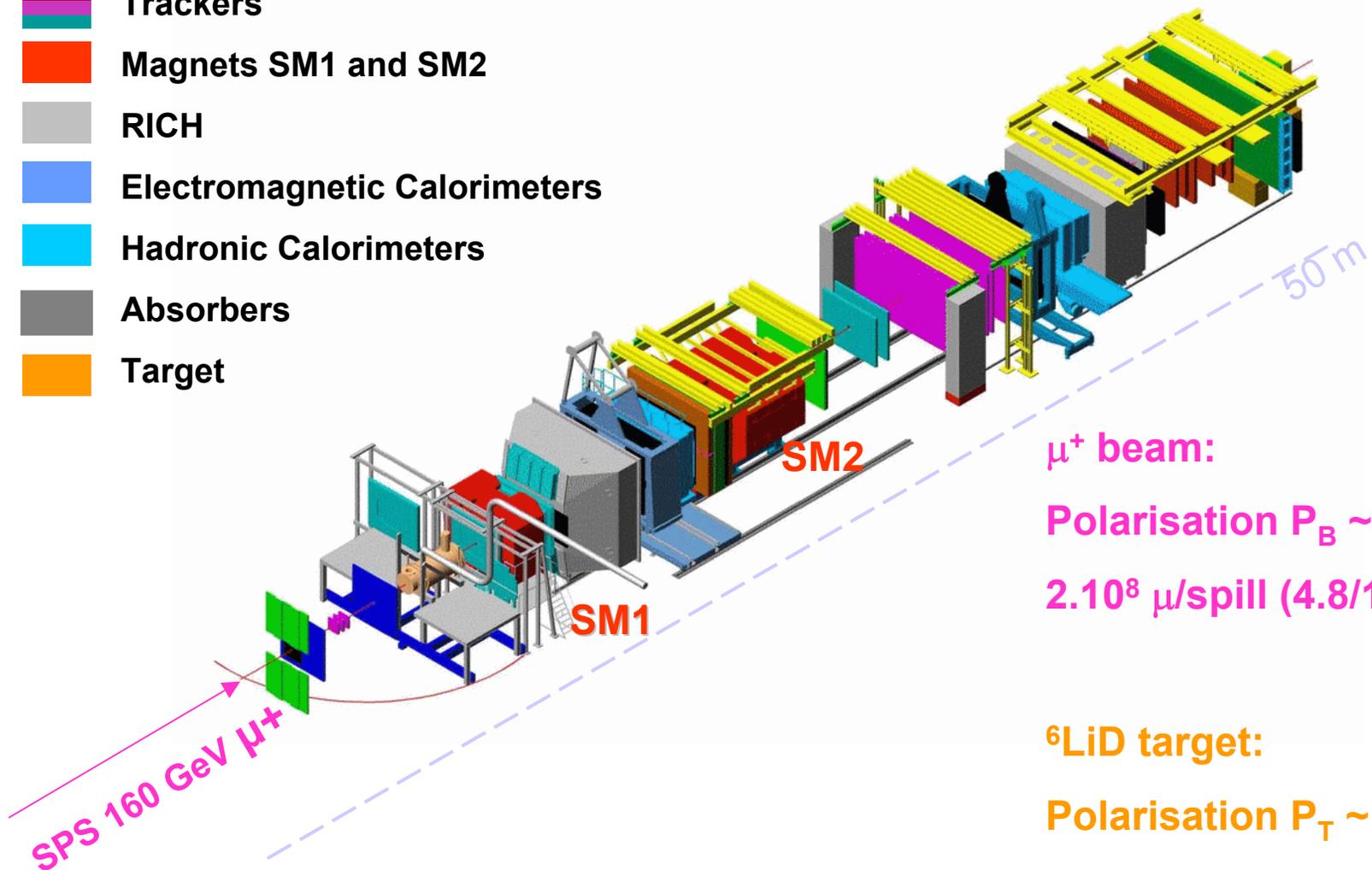
Semi-inclusive  
asymmetry

$$A_1^h(x, z, Q^2) = \frac{\sigma_{\uparrow\downarrow}^h - \sigma_{\uparrow\uparrow}^h}{\sigma_{\uparrow\downarrow}^h + \sigma_{\uparrow\uparrow}^h} \approx \frac{\sum_q e_q^2 \Delta q(x, Q^2) D_q^h(z, Q^2)}{\sum_q e_q^2 q(x, Q^2) D_q^h(z, Q^2)}$$

# The COMPASS Experiment

NIM A 577 (2007) 455

- Trackers
- Magnets SM1 and SM2
- RICH
- Electromagnetic Calorimeters
- Hadronic Calorimeters
- Absorbers
- Target



$\mu^+$  beam:  
Polarisation  $P_B \sim 80\%$   
 $2 \cdot 10^8 \mu/\text{spill}$  (4.8/16.8 s)

$^6\text{LiD}$  target:  
Polarisation  $P_T \sim 50\%$   
Dilution factor  $f \sim 40\%$

# Spectrometer Upgrade

Performed during SPS shutdown in 2005

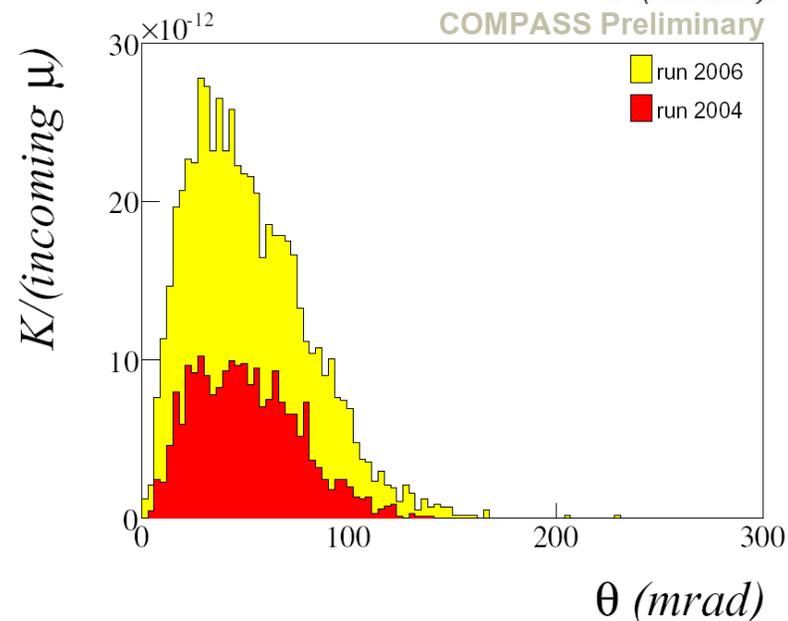
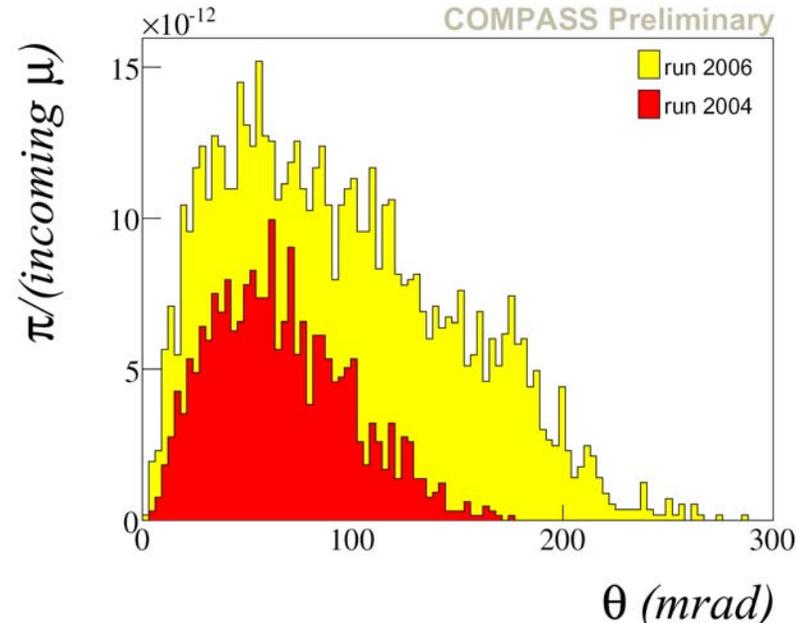
## POLARISED TARGET

- Larger acceptance: 70  $\rightarrow$  180 mrad
- 2  $\rightarrow$  3 target cells for false asymmetries reduction

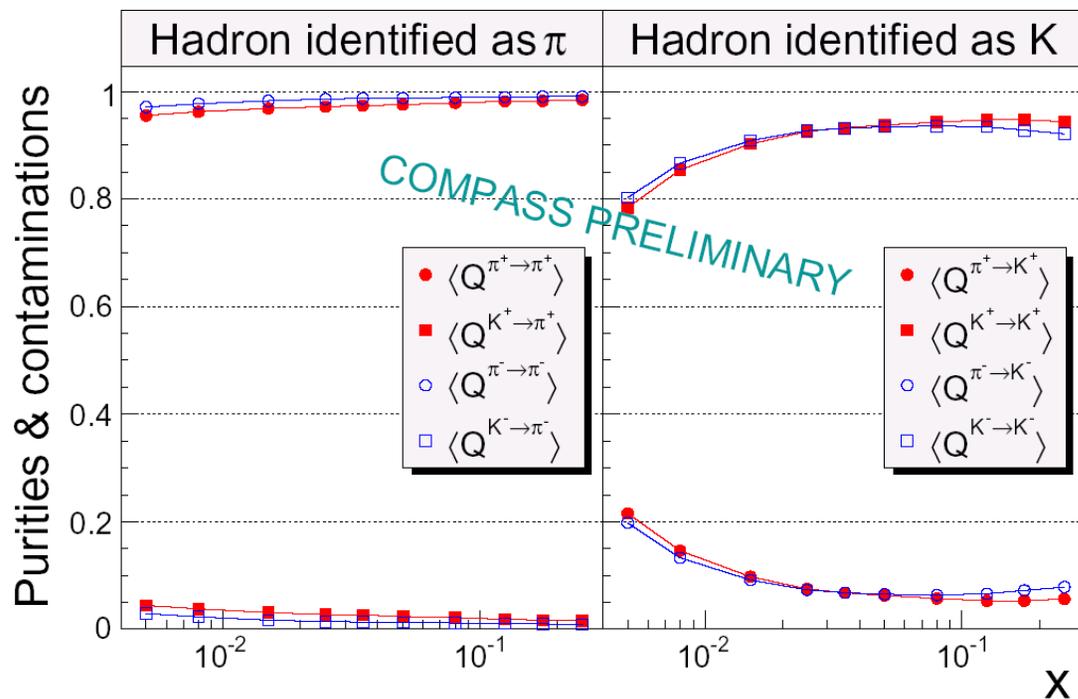
## RICH DETECTOR

- Central part replaced by MAPMTs  
 $\rightarrow$  Increase number of detected photons
- New readout system in the peripheral region

Improved resolution  $\rightarrow$   $\pi/K$  separation at  $2.5\sigma$   
up to 50 GeV/c

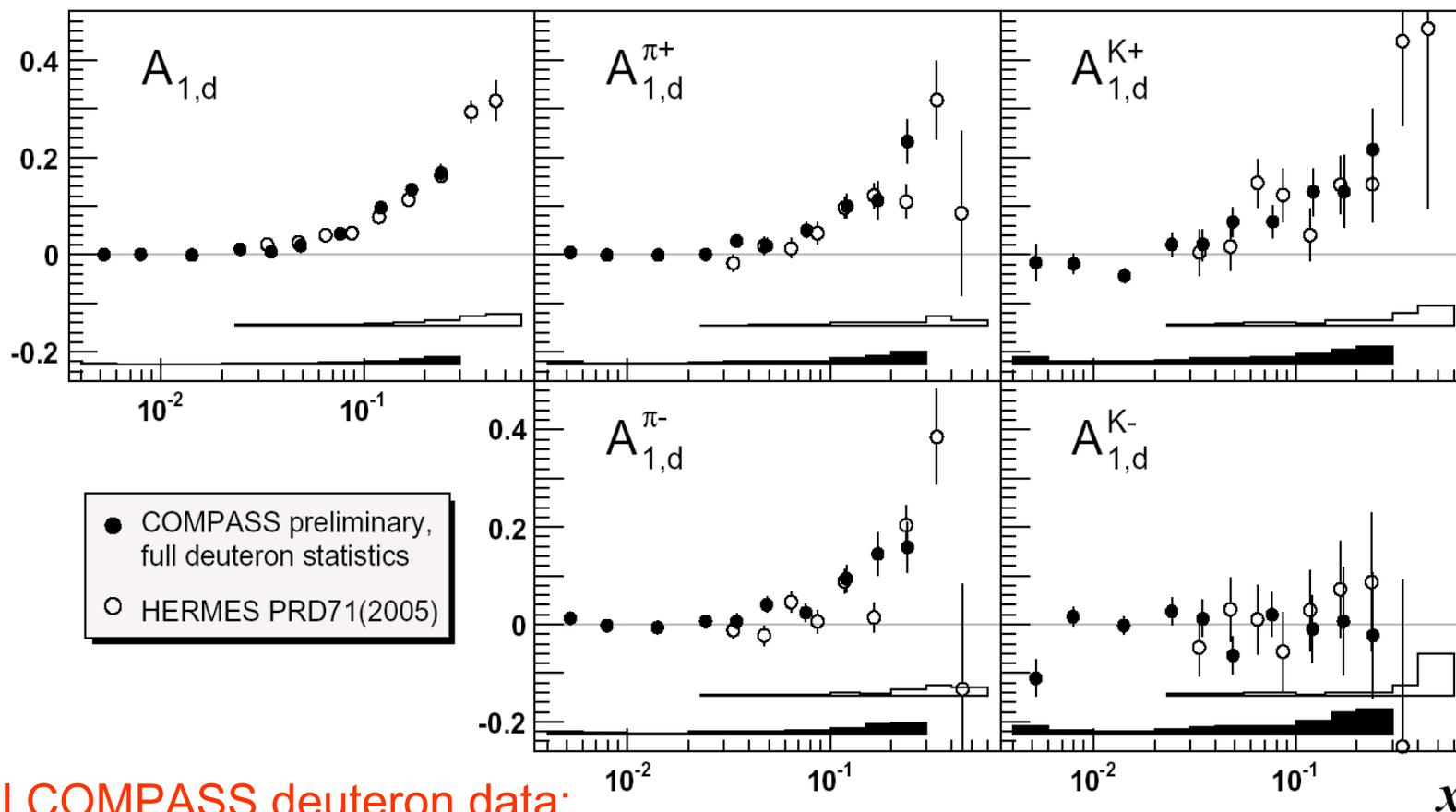


# Purities



- $Q^{t \rightarrow i}$  is the probability of a hadron, identified as type  $i$ , to be truly of type  $t$
- Unfolding method is applied in bins of momentum and polar angle  
 → effect on asymmetries is small

# Semi-inclusive Asymmetries



## Full COMPASS deuteron data:

- **Phase space:**  $Q^2 > 1(\text{GeV}/c)^2$ ,  $0.004 < x < 0.3$ ,  $10 < p < 50 \text{ GeV}/c$ ,  $0.2 < z < 0.85$
- **Statistics:**  $\pi^+ = 23 \cdot 10^6$ ,  $\pi^- = 21 \cdot 10^6$ ,  $K^+ = 4.8 \cdot 10^6$ ,  $K^- = 3.3 \cdot 10^6$
- **Systematics errors:**  $\delta \simeq 0.08A$  ( $\delta P_B$ ,  $\delta P_T$ ,  $\delta f$  and  $\delta D$ );  $\sigma_{false\ asym} < 0.4 \sigma_{stat}$

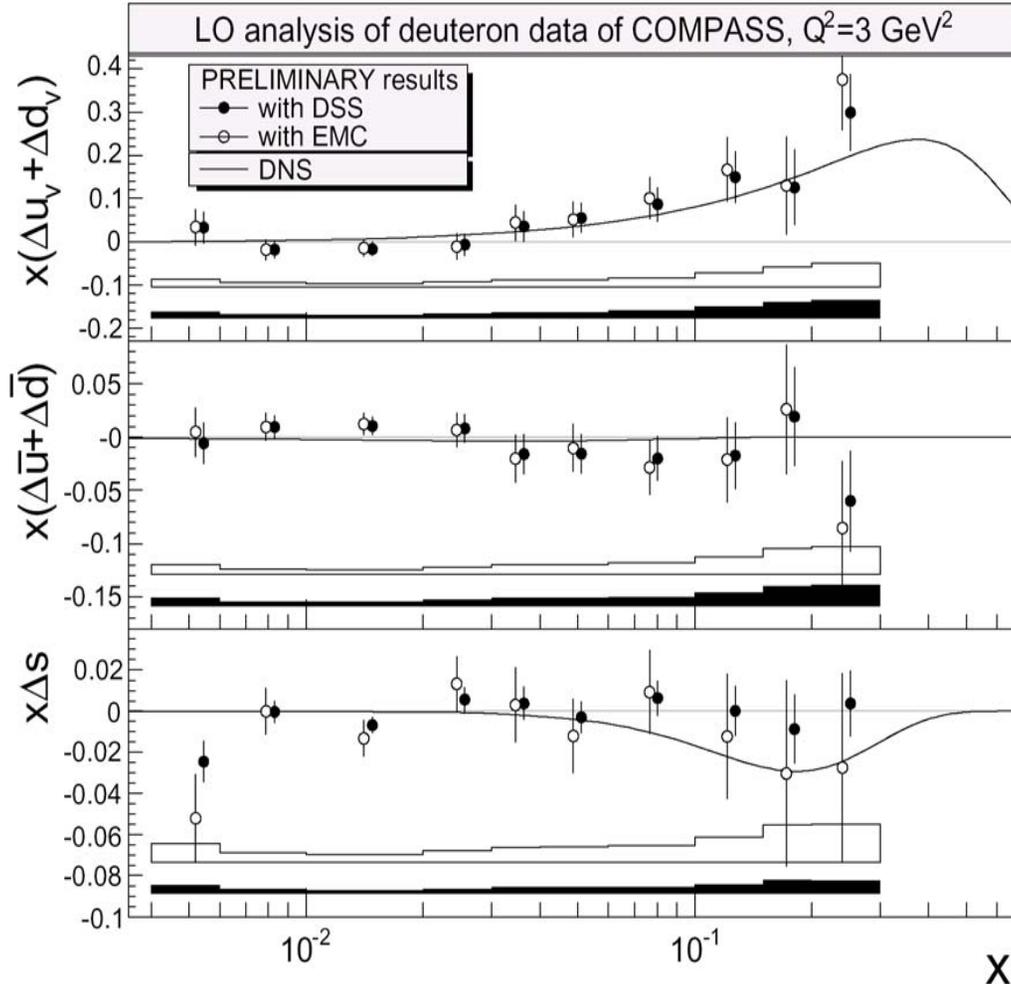
# Polarised PDFs

LO evaluation of  $\Delta u_v + \Delta d_v$ ,  $\Delta \bar{u} + \Delta \bar{d}$  and  $\Delta s$ :

- Asymmetries assumed to be independent on  $Q^2 \Rightarrow A_1^h(x, z) = \frac{\sum_q e_q^2 \Delta q(x) D_q^h(z)}{\sum_q e_q^2 q(x) D_q^h(z)}$
- $\Delta s \equiv \Delta \bar{s}$  assumed
- Unpolarised PDFs: MRST04
- Fragmentation functions:
  - ✓ DSS (global analysis of  $e^-e^+$ , SIDIS and p-p collisions)
  - ✓ From EMC  $D_u^{\pi^+, \pi^-}$  and  $D_u^{K^+, K^-}$  measurements. (For comparison only.  
 $D_{\bar{s}}^{K^+} = D_u^{\pi^+}$  assumed, in addition to charge conjugation and isospin symmetry. All unfavored FFs assumed to be equal.)

Least square fit in each x bin

# Polarised PDFs (cont.)



$\Delta u_v + \Delta d_v$ :

small sensitivity to different FFs; good agreement with DNS curve

$\Delta \bar{u} + \Delta \bar{d}$ :

compatible with 0; little effect from different FFs

$\Delta s$ :

statistical errors 2–3 times larger with EMC FFs

LO DNS analysis, based on KKP param. of FFs, includes all DIS  $g_1$  prior to **COMPASS** 2004 data and all SIDIS data from **SMC** and **HERMES**

# First Moments

## Full deuteron data – 2002-2006

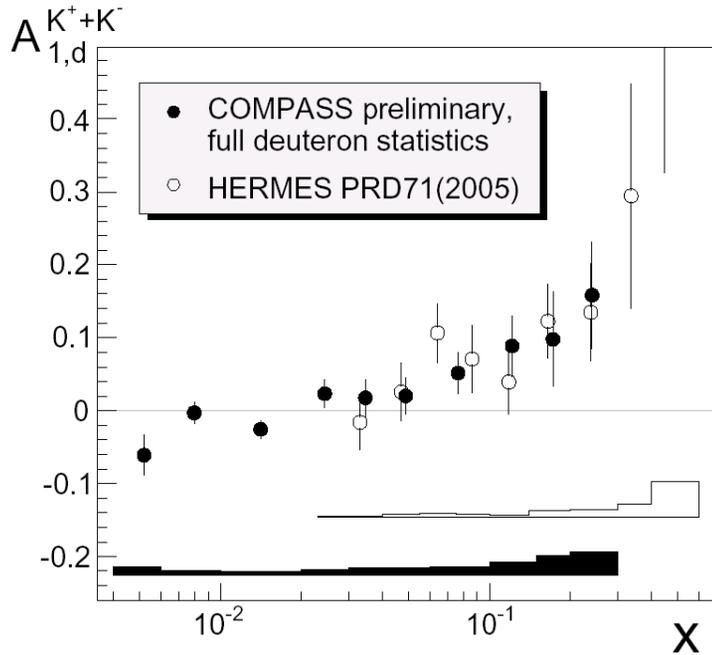
|                                   | FF's from <b>DSS</b>      |
|-----------------------------------|---------------------------|
| $\Delta u_v + \Delta d_v$         | $0.28 \pm 0.06 \pm 0.03$  |
| $\Delta \bar{u} + \Delta \bar{d}$ | $-0.03 \pm 0.03 \pm 0.01$ |
| $\Delta s \equiv \Delta \bar{s}$  | $-0.01 \pm 0.01 \pm 0.01$ |

- Truncated to measured range ( $0.004 < x < 0.3$ ), at  $Q^2 = 3$  (GeV/c)<sup>2</sup>
- $\int_{0.3}^1 \Delta s(x) dx \leq 0.002$  (positivity condition)

## From COMPASS 2002-2004 results:

- $\Delta u_v + \Delta d_v = 0.26 \pm 0.07 \pm 0.04$ , from  $A_1^{h^+h^-}$  approach (at  $Q^2 = 10$  (GeV/c)<sup>2</sup>)  
Phys. Lett. B 660 (2008) 458
- $\Delta s = -0.045 \pm 0.005 \pm 0.010$ , from  $\Gamma_1$  ( $0 < x < 1$ )  
Phys. Lett. B 647 (2007) 8

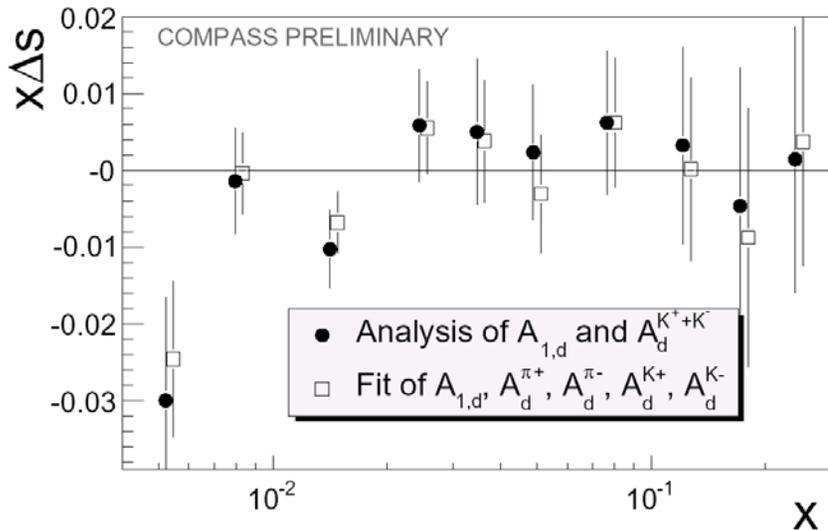
# $\Delta s$ from charged kaon asymmetry



$$\frac{\Delta s}{s} = A_1^d + \left( A_1^{K^+K^-} - A_1^d \right) \frac{Q/s + \alpha}{\alpha - 0.8}$$

$$\alpha = \frac{2R_{UF} + 2R_{SF}}{3R_{UF} + 2} \quad Q = u + \bar{u} + d + \bar{d}$$

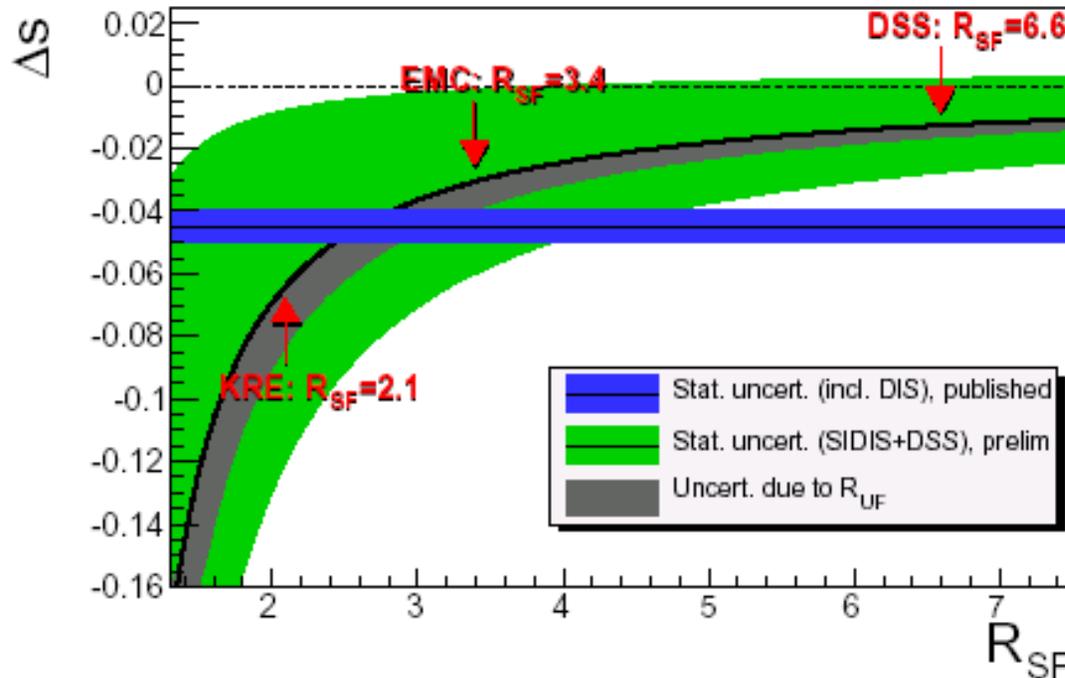
$$R_{UF} = \frac{\int D_d^{K^+}(z) dz}{\int D_u^{K^+}(z) dz} \quad R_{SF} = \frac{\int D_{\bar{s}}^{K^+}(z) dz}{\int D_u^{K^+}(z) dz}$$



if  $A_1^d = A^{K^+K^-} \Rightarrow \Delta s \geq 0$ , insensitive to FFs

if  $A^{K^+K^-} < 0$  (at low x)  $\Rightarrow \Delta s < 0$

# $\Delta s$ as a function of $R_{SF}$



$$R_{SF} = \frac{\int D_{\bar{s}}^{K^+}(z) dz}{\int D_u^{K^+}(z) dz}$$

$$R_{UF} = \frac{\int D_d^{K^+}(z) dz}{\int D_u^{K^+}(z) dz}$$

- $R_{UF}$  fixed at 0.14 from the DSS fragmentation functions
- Large statistical uncertainty due to  $R_{SF}$ ; slight dependence on  $R_{UF}$
- If  $R_{SF} \geq 5$ :  $\Delta S(\text{SIDIS}) > \Delta S(\text{DIS}) \Rightarrow \Delta S(x) < 0$  for  $x < 0.004$  (unmeasured), but  $2\sigma$  difference
- If  $R_{SF} \leq 4$ :  $A^{K^++K^-}$  becomes insensitive to  $\Delta s$  (small  $D_{\bar{s}}^{K^+}$ )

# Conclusions

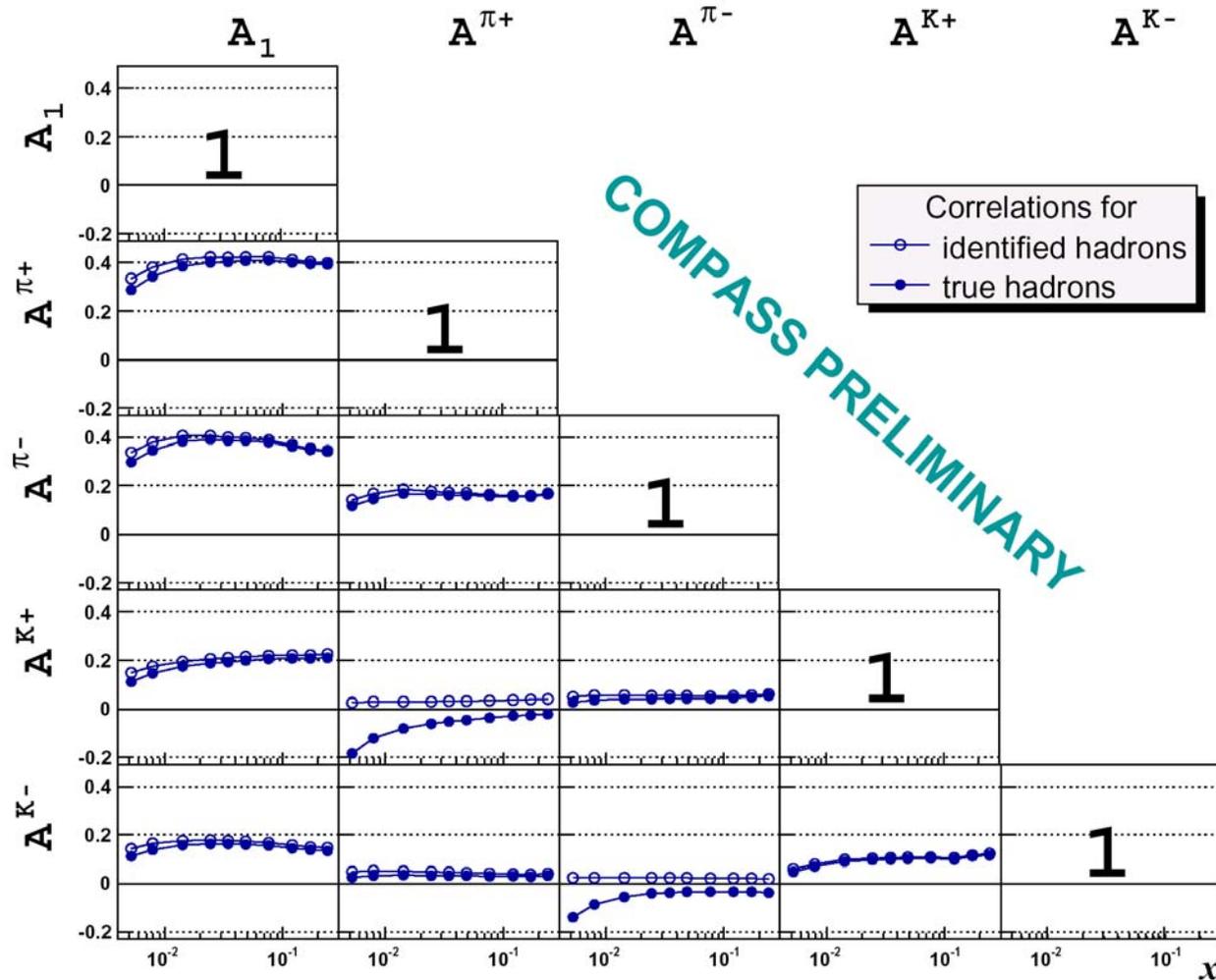
- COMPASS asymmetries for  $\pi^\pm$  and  $K^\pm$  from full deuteron data have been shown
- New evaluation of valence quark polarisations
- Sea polarisation is consistent with 0 over the measured range
- Strange quark polarisation strongly dependent on  $R_{SF}$ . Comparison between first moments of  $\Delta s$  from DIS and SIDIS limited by statistics

## Road Map

- Analysis of 2007 COMPASS proton data for flavour separation
- Extraction of  $R_{UF}$  and  $R_{SF}$  from COMPASS

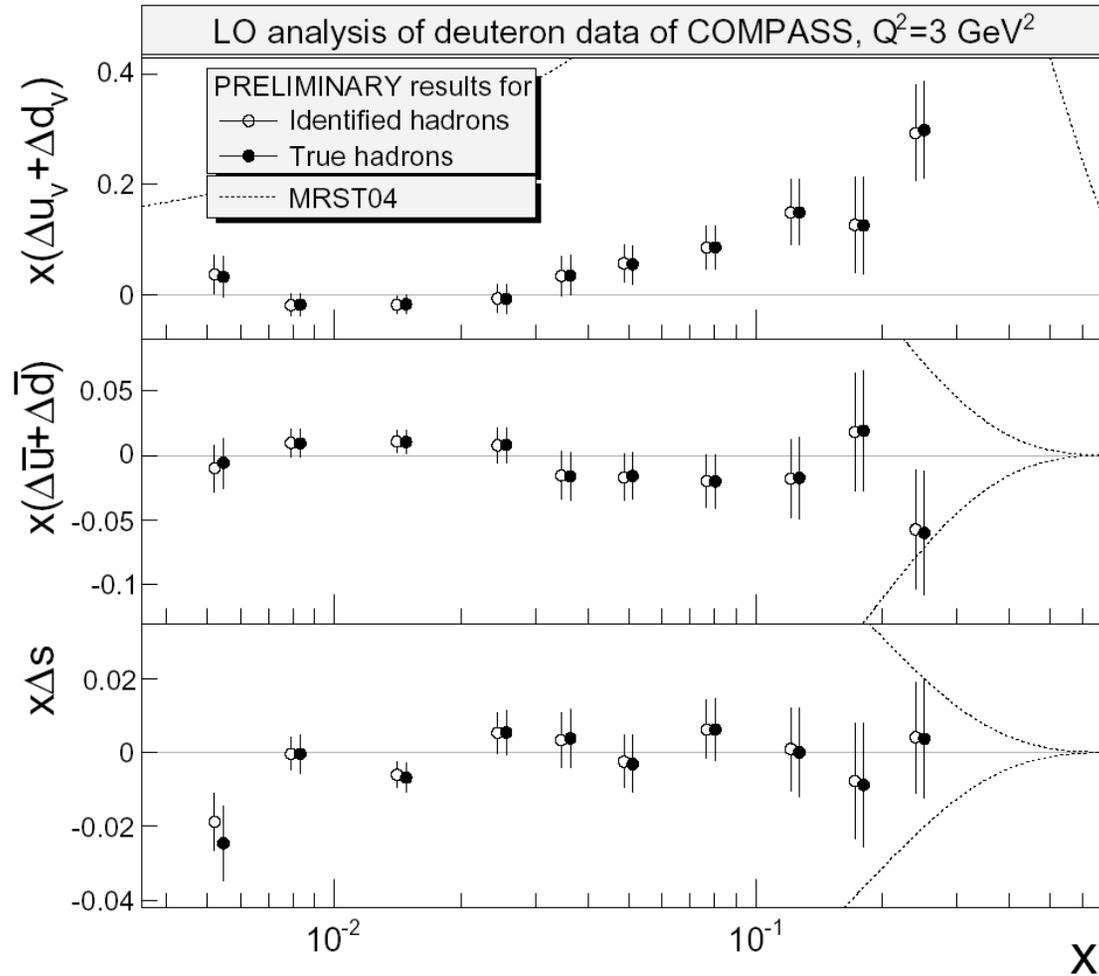
# Spares

# Correlations

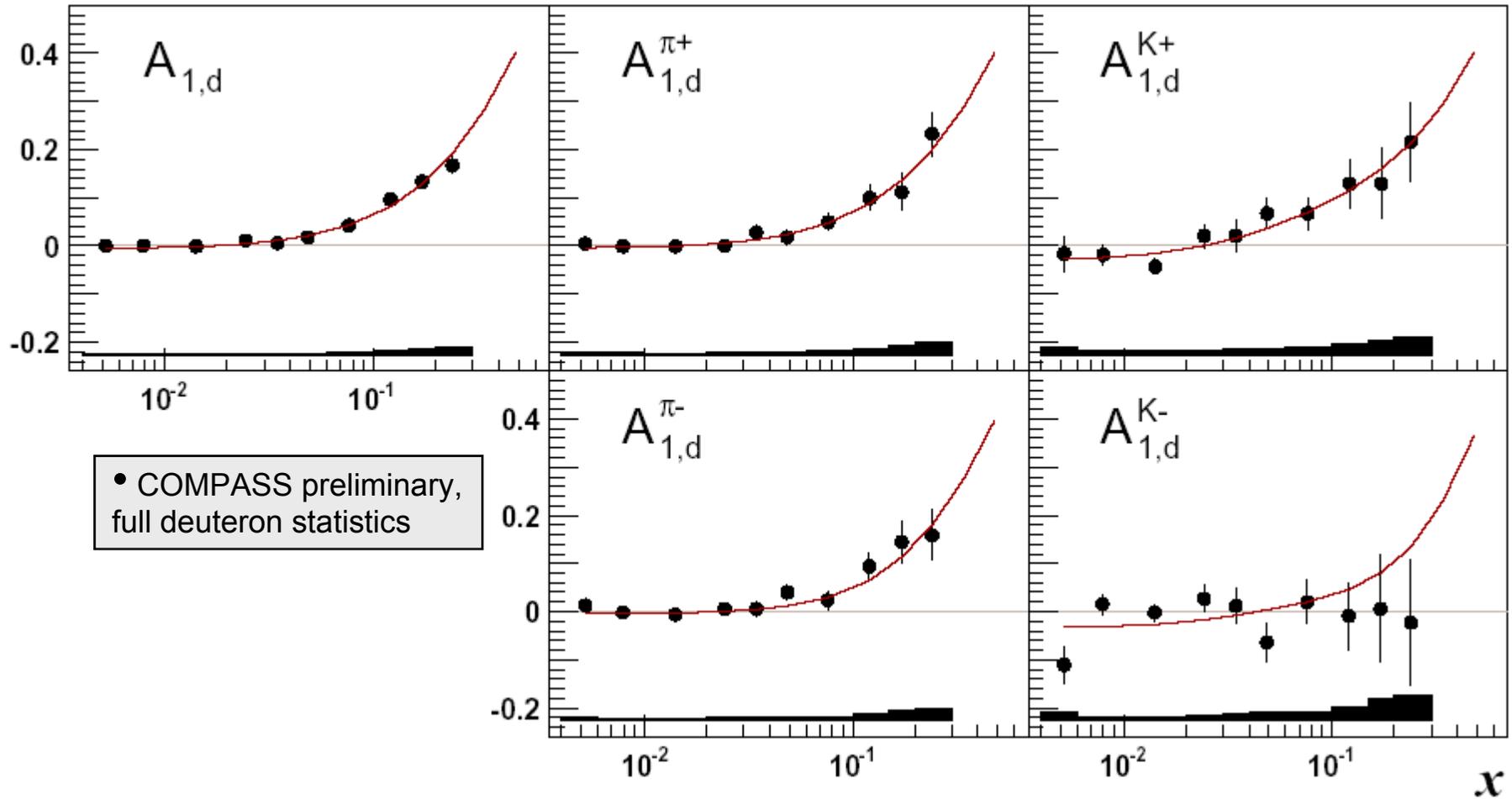


Asymmetry correlation matrices, before and after unfolding

# PDFs before and after unfolding



# Semi-inclusive Asymmetries



Curves are NLO predictions from DSSV Group (D. De Florian, R. Sassot, M. Stratmann and W. Vogelsang)