



# The Strange Quark Polarisation from Charged Kaon Production on Deuterons

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*On behalf of the COMPASS Collaboration*

# Contents

- Semi-inclusive spin asymmetries:

$$A^{\pi^+}(x) \quad A^{K^+}(x)$$

$$A^{\pi^-}(x) \quad A^{K^-}(x)$$

- LO extraction of polarised parton densities:

$$\Delta u_v(x) + \Delta d_v(x)$$

$$\Delta \bar{u}(x) + \Delta \bar{d}(x)$$

$$\Delta s(x) \equiv \Delta \bar{s}$$

- $\Delta s(x)$  from charged asymmetry  $A^{K^++K^-}$

- First moment of  $\Delta s$  vs. fragmentation functions

- Consistency of  $\Delta s$  from SIDIS and DIS.

## COMPASS 2002-2006 longitudinal SIDIS data

first flavour separation using particle ID

- $\mu^+$  beam             $E = 160 \text{ GeV}$              $P_B \approx 0.80$
- Pol. target             ${}^6\text{LiD}$              $P_T \approx 0.50$
- Hadron identification by RICH
- 2002-2004 data: previously used for
  - $g_1^d$  analysis            *Phys.Lett. B647 (2007) 8*
  - $\Delta u_v + \Delta d_v$  analysis    *Phys.Lett. B660 (2008) 458*
- 2006 data: **NEW** Polarised target and spectrometer upgraded

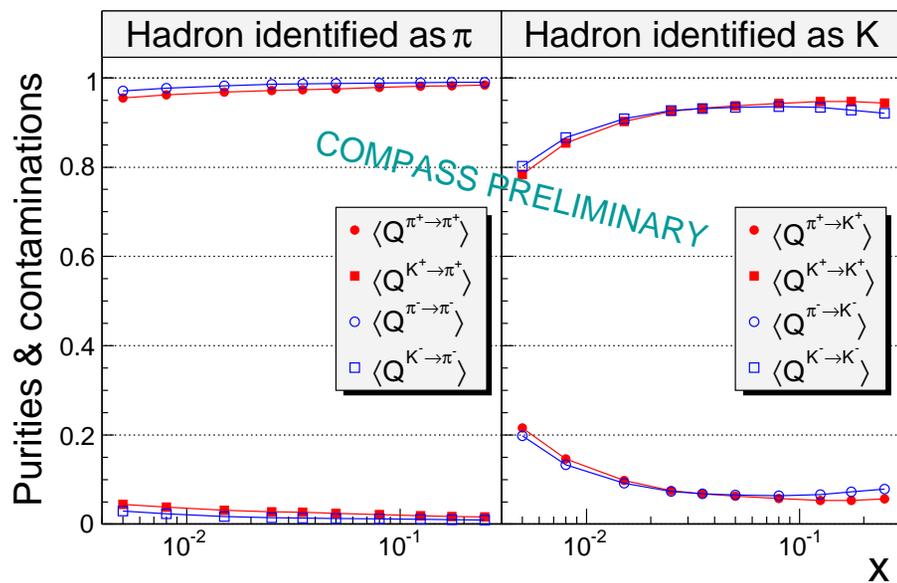
## Cuts and Statistics

- $\mu'$  selection
  - $Q^2 > 1 \text{ (GeV}/c)^2$  DIS
  - $0.1 < y < 0.9$
  - $x < 0.3$  SIDIS(sea  $q, \bar{q}$ )
- Hadrons
  - $0.2 < z < 0.85$  Current fragmentation
  - $10 < p < 50 \text{ GeV}/c$  RICH acceptance
  - RICH ID by likelihood cuts:
    1.  $\pi$  ID:  
 $LH_\pi > (LH_{bg}, LH_K, LH_p)$
    2.  $K$  ID:  
 $LH_K >$   
 $(1.24 \cdot LH_{bg}, 1.02 \cdot LH_\pi, LH_p)$

No. of hadrons in  $10^6$

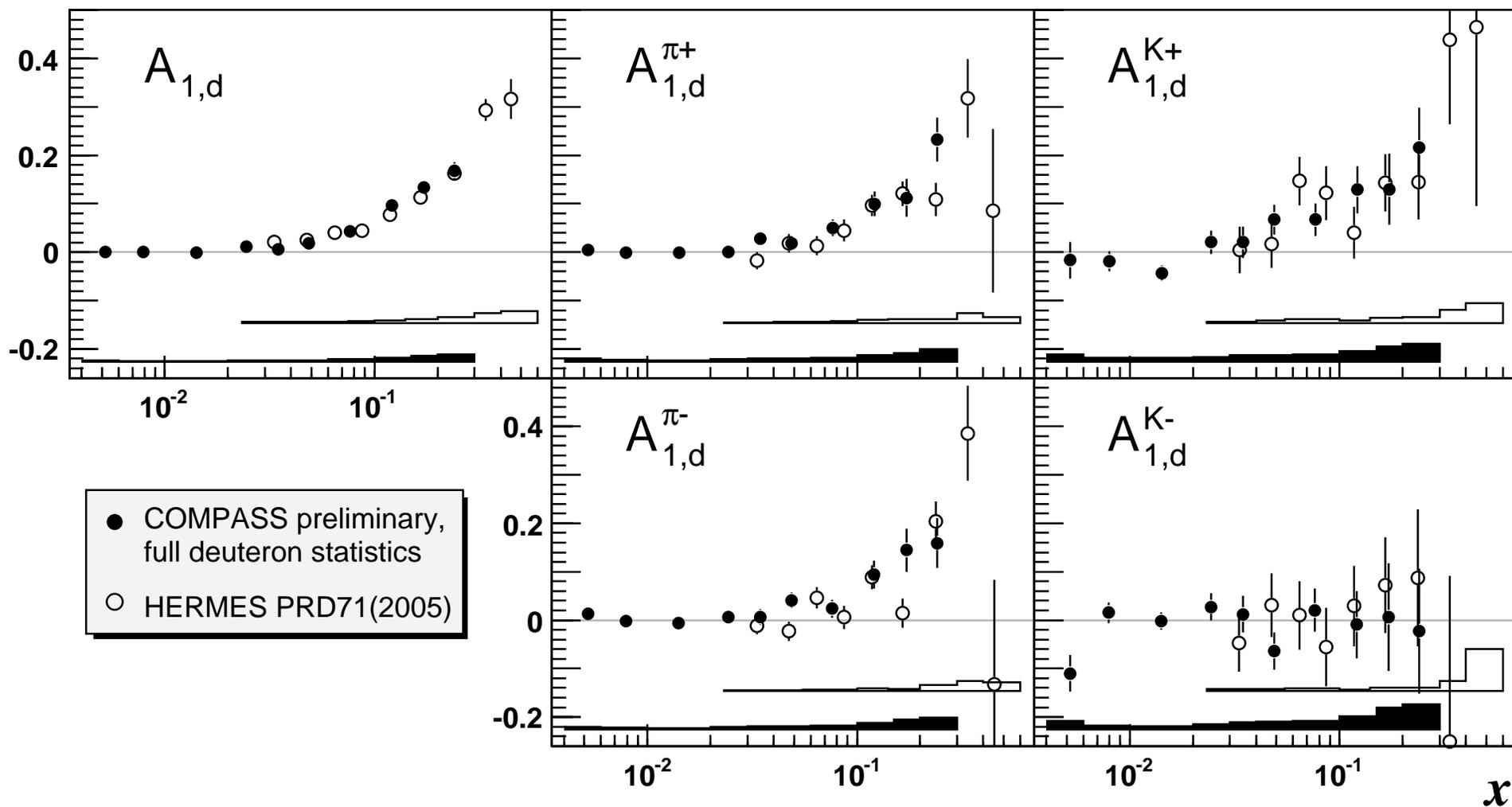
	+	-
$\pi$	23	21
$K$	4.8	3.3

## Purities/Contamination



- Quality of selected sample:  
 $Q^{i \rightarrow j}$  = fraction of part.  $i$  in  $j$  sample
- Reference samples:
  - $\pi^{+,-}$  from  $K^0$  decay
  - $K^{+,-}$  from  $\phi$  decay
- Unfolding procedure applied year by year, in bins of  $(p, \theta)$ .
- Effect on asymmetries is small.

# Asymmetries and comparison with HERMES



## Asymmetries (continued)

- General agreement in region of overlap
- Extension of measured  $x$  range down to  $x = 0.004$  (vs. 0.023)
- Statistical errors comparable in overlap region
- Estimated systematic errors in general comparable.

### COMPASS systematics

$$P_B, P_T \rightarrow 5\% \text{ each}$$

$$f \rightarrow 2\%$$

$$D(R) \rightarrow 2 - 3\%$$

$$\text{"false asym"} \leq 0.4 \sigma_{stat}$$

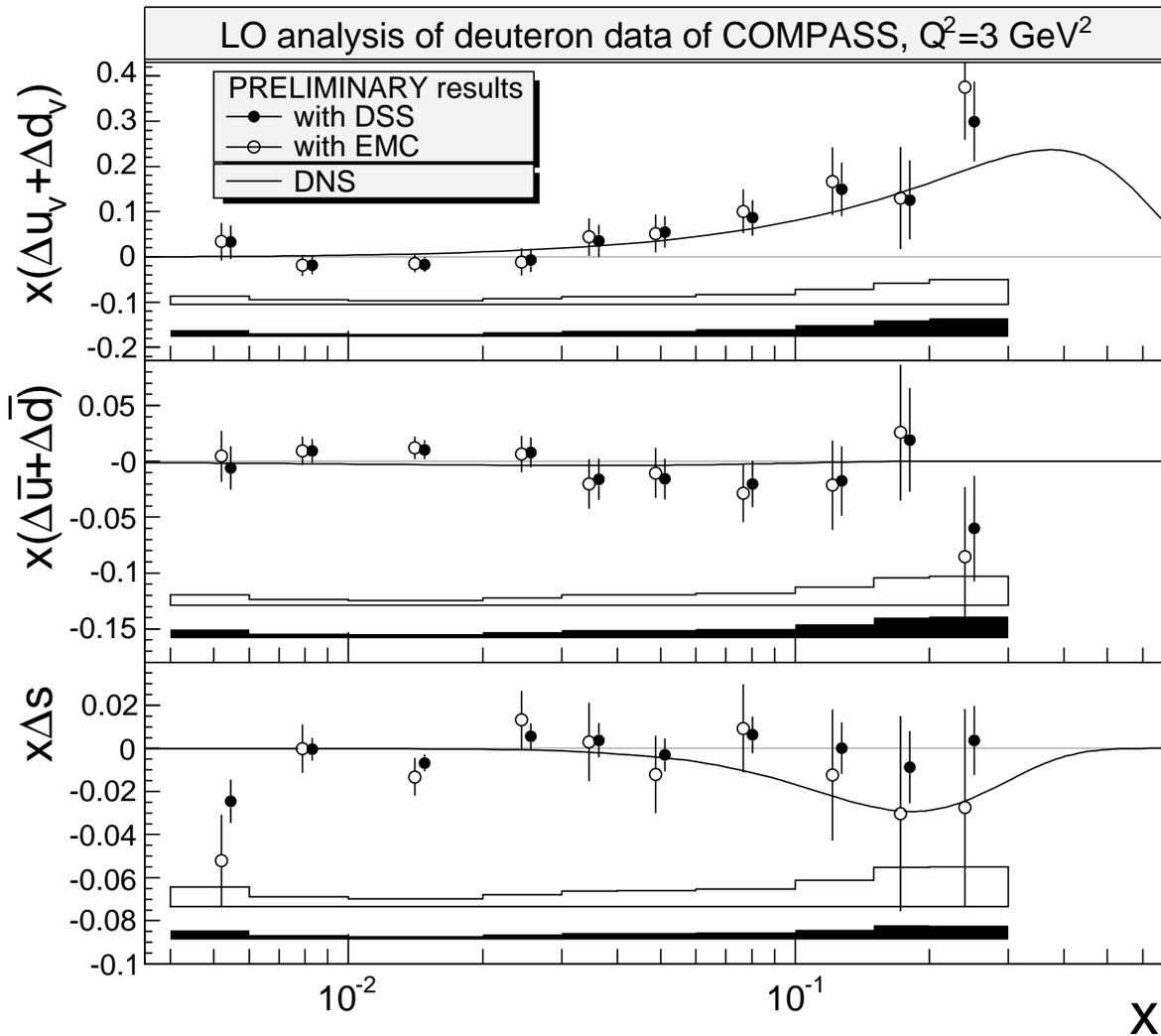
## LO Evaluation of polarized PDFs

$$\left( A_1, A_1^{\pi^+}, A_1^{\pi^-}, A_1^{K^+}, A_1^{K^-} \right) \rightarrow \left( \Delta u_v + \Delta d_v, \Delta \bar{u} + \Delta \bar{d}, \Delta s \right)$$

Least square fit in each  $x$  bin:

- Asymmetries assumed independent of  $Q^2$
- Unpolarised PDFs: MRST04 (LO)
- Integrated FFs  $\int_{0.2}^{0.85} D_q^h(z) dz$ :  
DSS (LO)  $\rightarrow$  recent analysis of world data (2007)
- For comparison: FFs from EMC (1989)
  - $D_u^{\pi^+, \pi^-}$  and  $D_u^{K^+, K^-}$  measured
  - $D_s^{K^+} = D_u^{\pi^+}$  assumed (in add. to charge conjugation and I-spin invariance and all unfavored FFs assumed to be equal)

## Polarised PDFs, FF from DSS and EMC



- Fixed  $Q^2 = 3 \text{ (GeV/c)}^2$
- $\Delta u_v + \Delta d_v$ : little or no effect from FFs; good agreement with DNS curve (as found in previous study of  $A^{h^+ - h^-}$ )
- $\Delta \bar{u} + \Delta \bar{d}$ : consistent with zero, little effect from FFs
- $\Delta s$ : values and errors 2-3 times larger with EMC FFs than with those of DSS

**First Moments at  $Q^2 = 3 \text{ (GeV}/c)^2$   
truncated to measured range  $0.004 < x < 0.3$**

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

For comparison:

$$\boxed{\Delta u_v + \Delta d_v = 0.26 \pm 0.07 \pm 0.04} \quad \text{COMPASS, from } A^{h^+ - h^-} \\ (Q^2 = 10 \text{ (GeV}/c)^2)$$

$$\boxed{\Delta s = -0.045 \pm 0.005 \pm 0.010} \quad \text{COMPASS, from } \Gamma_1^N, (0 < x < 1)$$

## Charged kaon asymmetry $A^{K^++K^-}$

$A^{K^++K^-}$  is a weighted average of  $A^{K^+}$  and  $A^{K^-}$ :

$$A^{K^++K^-} = \left[ \sigma^{K^+} A^{K^+} + \sigma^{K^-} A^{K^-} \right] / \left[ \sigma^{K^+} + \sigma^{K^-} \right]$$

- Ratio  $\sigma^{K^-} / \sigma^{K^+}$  from MRST04, LO and two ratios of FFs:

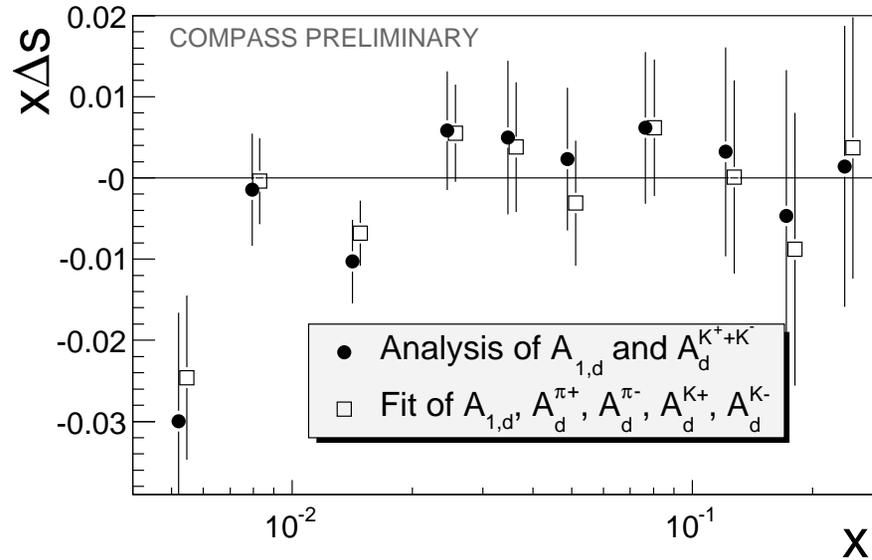
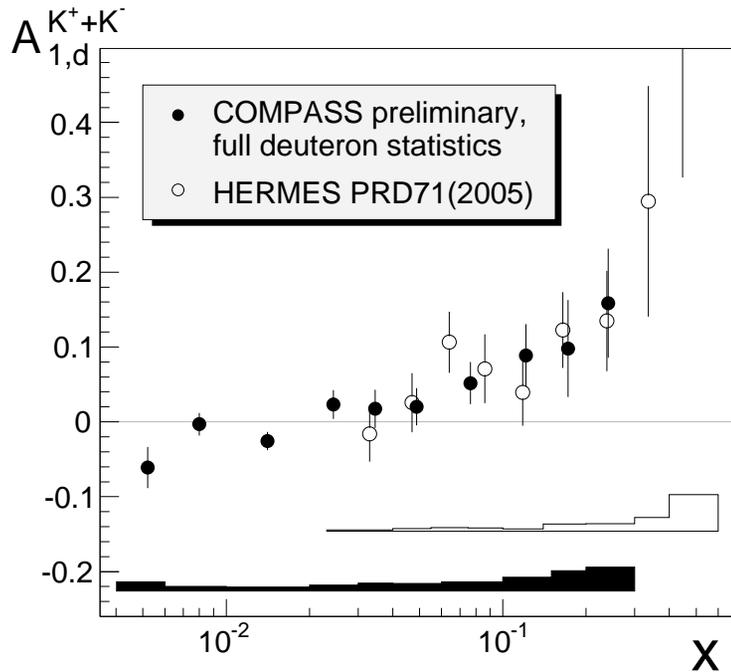
$$\boxed{R_{UF} = \frac{\int D_d^{K^+}(z) dz}{\int D_u^{K^+}(z) dz}} \quad \Leftrightarrow \quad \boxed{R_{SF} = \frac{\int D_{\bar{s}}^{K^+}(z) dz}{\int D_u^{K^+}(z) dz}}$$

- $A^{K^++K^-}$  is **very stable** vs. changes of  $\sigma^{K^-} / \sigma^{K^+}$  by factor (0.90 – 1.10).
- At  $Q^2 = 3 \text{ (GeV/c)}^2$ , for the DSS FFs:

$$R_{UF} = 0.14 \quad (\text{vs. EMC } 0.35)$$

$$R_{SF} = 6.6 \quad (\text{vs. EMC } 3.4)$$

## $\Delta_s$ from the charged kaon asymmetry

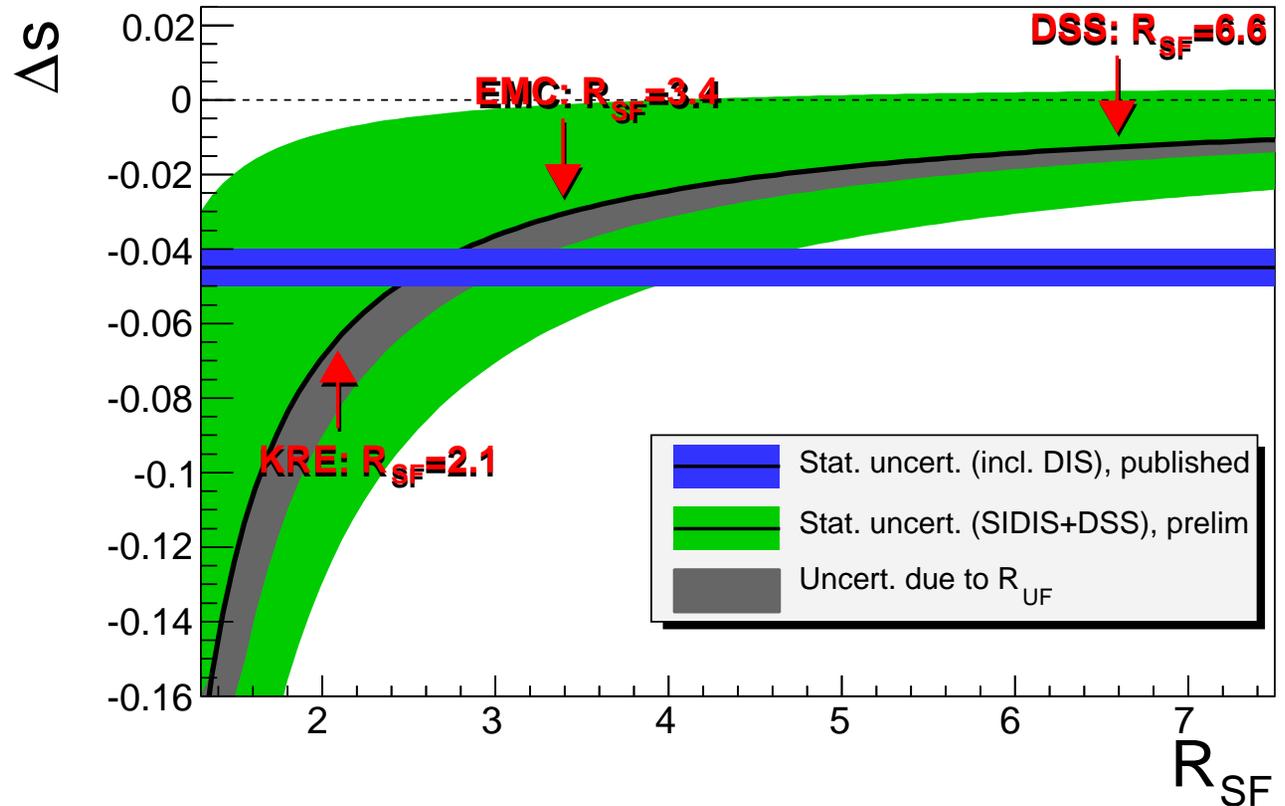


$$Q = u + \bar{u} + d + \bar{d}$$

$$\boxed{\frac{\Delta_s}{s} = A_1^d + (A^{K^+K^-} - A_1^d) \frac{Q/s + \alpha}{\alpha - 0.8}} \quad \Leftarrow \quad \alpha = \frac{2R_{UF} + 2R_{SF}}{3R_{UF} + 2}$$

- $(A_1^d = A^{K^+K^-}) \implies \Delta_s \geq 0$ , insensitive to FFs
- At low  $x$ :  $(A^{K^+K^-} < 0) \implies \Delta_s < 0$

## First Moment $\Delta s$ vs. $R_{SF}$



- $\Delta s$ : **strong** dependence on  $R_{SF}$  (green) + **minor** dependence on  $R_{UF}$  (grey)
- $\int_{0.3}^1 \Delta s(x) dx \leq 0.002$  (positivity condition)
- If  $R_{SF} \geq 5$ :  $\Delta s(\text{SIDIS}) > \Delta s(\text{DIS}) \implies \Delta s(x) < 0$  for  $x < 0.004$  (unmeasured), as in DSSV-NLO fit. However difference **at most two**  $\sigma_{\text{stat}}$ .
- If  $R_{SF} \leq 4$ :  $A^{K^+K^-}$  becomes **insensitive** to  $\Delta s$  (small  $D_s^{K^+}$ )

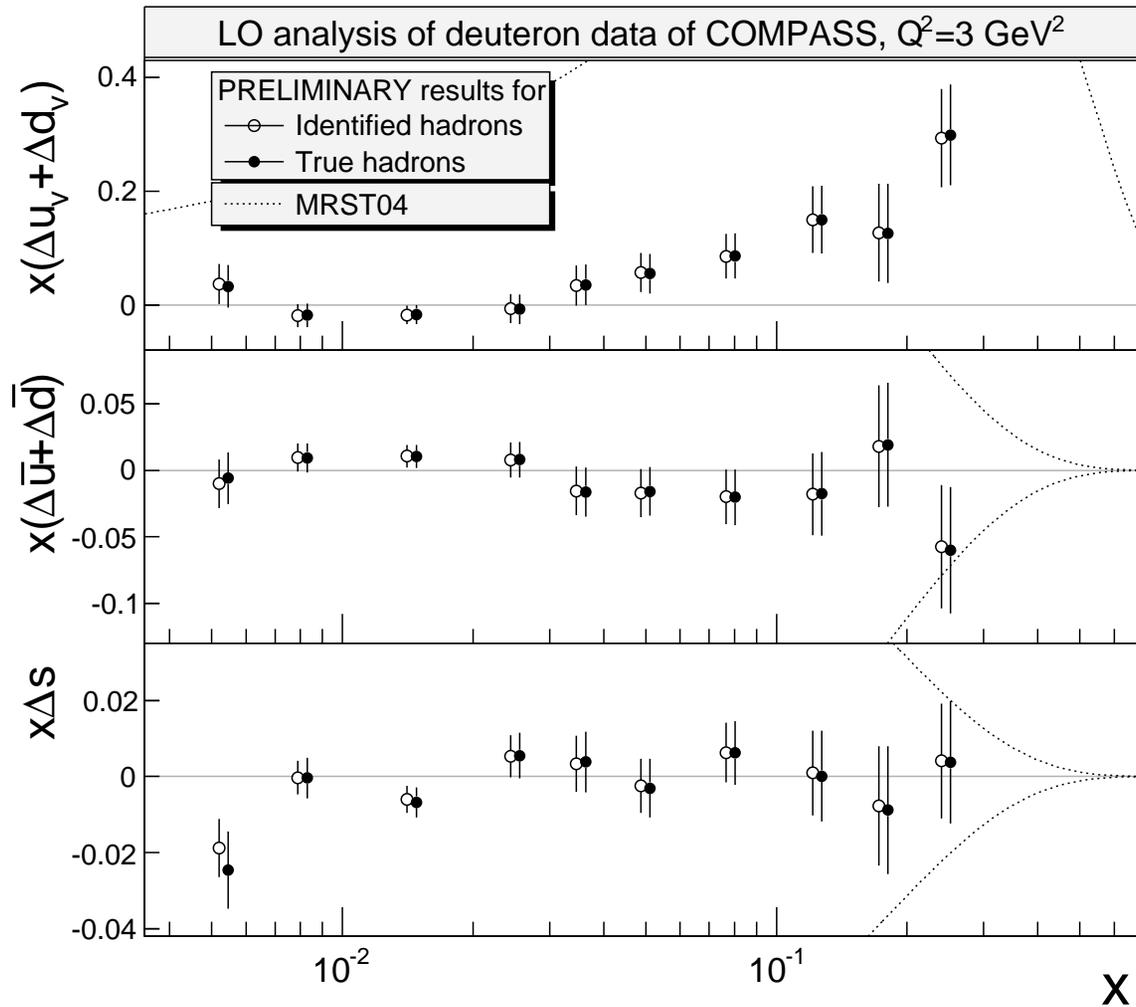
# Conclusions and Prospects

- **First COMPASS SIDIS asymmetries for  $\pi^\pm$  and  $K^\pm$  on complete deuteron data sample**
- New evaluation of  $\Delta u_v + \Delta d_v$
- $\Delta \bar{u}(x) + \Delta \bar{d}(x) \approx 0$  over measured range
- **Evaluation of  $\Delta s$  is conditional** on  $R_{SF} = D_{\bar{s}}^{K^+} / D_u^{K^+}$  and comparison of SIDIS and DIS values of first moment is still limited by statistics

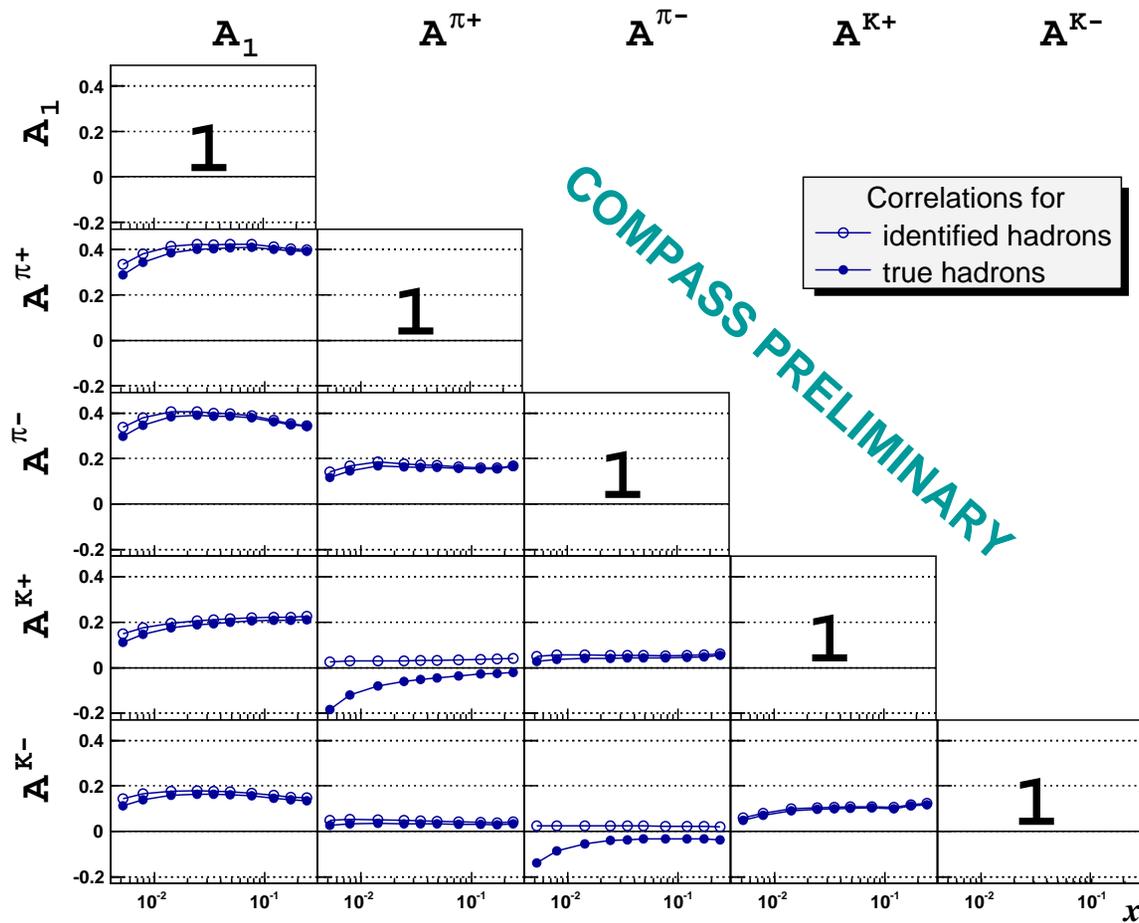
## FUTURE

- Use of 2007 proton data for  $\Delta u, \Delta d$  separation
- Extraction of  $R_{UF}$  and  $R_{SF}$  from COMPASS data on  $\sigma^{K^-} / \sigma^{K^+}$  (needs detailed MC study of acceptance effects)

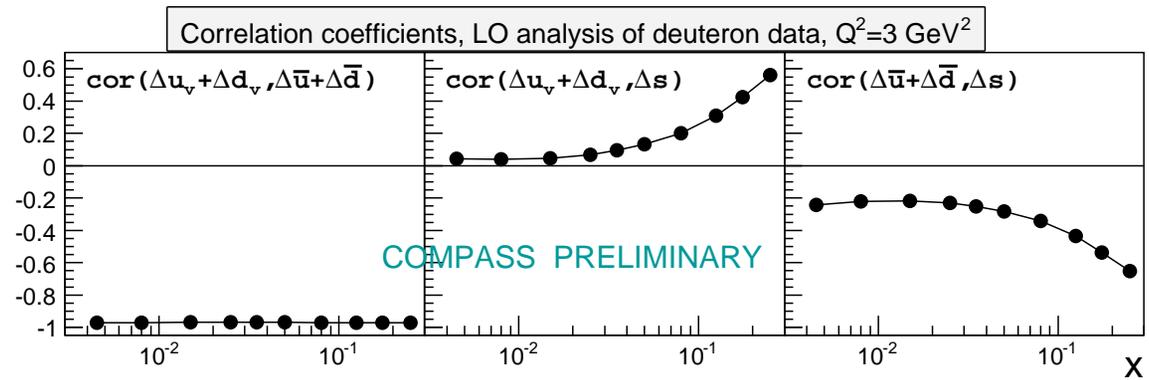
# Additional Plots



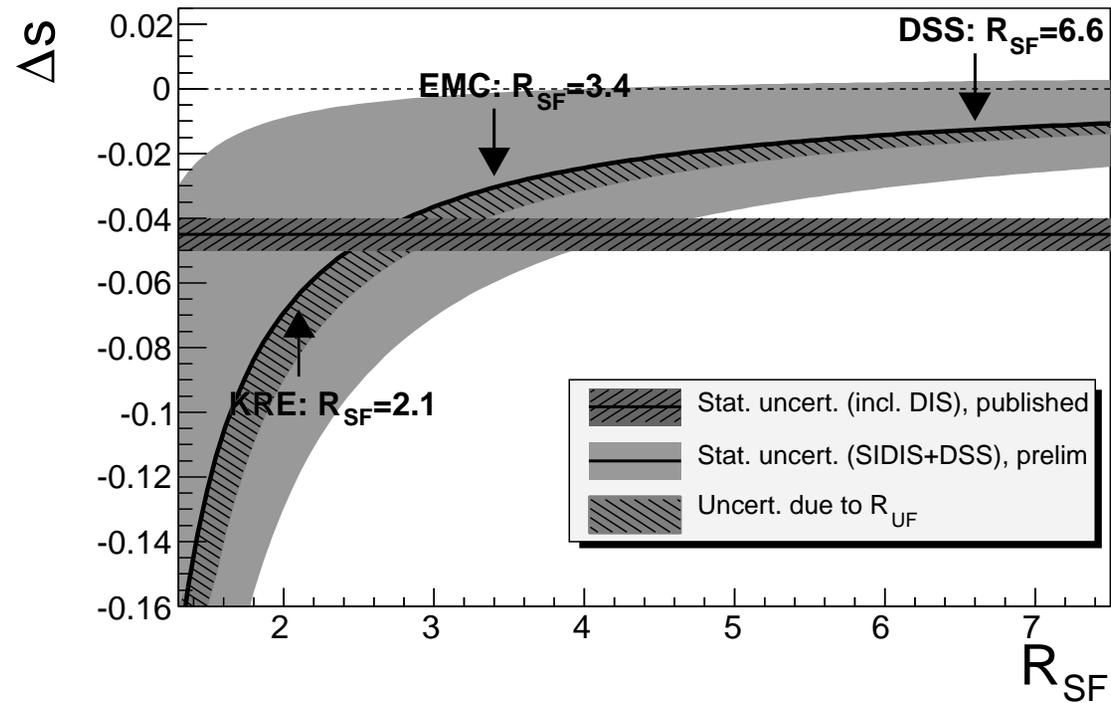
Polarised PDFs obtained in the least square fit of asymmetries in each bin of  $x$ . The difference between the two sets of points indicates the effect of the unfolding.



Initial and final (after unfolding) asymmetry correlation matrices for all data (**2002 - 2006**).



Correlation matrix of PDFs obtained in the fit with DSS parametrization.



Integral of  $\Delta s$  over the range of measurements, as a function of the ratio  $R_{SF}$  for  $R_{UF}$  fixed at 0.14 (black curve). The green area shows the statistical error and the grey band the effect of increasing  $R_{UF}$  to 0.35. The horizontal blue band shows the full moment of  $\Delta s$  as obtained from the value of  $\Gamma_1^N$  measured by COMPASS.