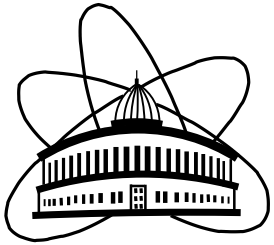

The strange quark polarisation from charged kaon production on deuteron from COMPASS

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Contents

- Semi-inclusive spin asymmetries:

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

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

- LO extraction of polarised parton densities:

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

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

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

- $\Delta s(x)$ from charged kaon asymmetry $A^{K^+ + K^-}$
- The first moment of Δs vs. fragmentation functions
- Consistency of Δs from SIDIS and DIS

Spin Puzzle

- Nucleon spin in QPM
  $\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L_z$
- Decomp. of quark contribution
  $\Delta\Sigma = \Delta u + \Delta\bar{u} + \Delta d + \Delta\bar{d} + \Delta s + \Delta\bar{s}$
- Determination of Δq via analysis of $g_1^{p,n,d}(x, Q^2)$
- "Spin crisis" (EMC, 1988)
- DIS experiments: SLAC, CERN, DESY, JLAB

Stat. quark model	$\Delta\Sigma = 1$
Relat. constituent-quark model	$\Delta\Sigma \approx 0.6$
Weak decay of barions ($J^P = \frac{1}{2}^+$)	$\Delta\Sigma = 0.58 \pm 0.03$ $\Delta s \equiv 0$
DIS experiment (EMC, 1988)	$\Delta\Sigma = 0.12 \pm 0.09 \pm 0.04$ $\Delta s = -0.19 \pm 0.03 \pm 0.04$
QCD analysis[a] of world data	$\Delta\Sigma = 0.30 \pm 0.01 \pm 0.02$ $\Delta s = -0.09 \pm 0.01 \pm 0.02$

[a] COMPASS Coll., Phys.Lett. B647 (2007) 8

COMPASS 2002 – 04 and 2006 longitudinal SIDIS data

first flavour separation using particle ID

- μ^+ beam $E = 160$ GeV $P_B \approx 0.80$ $I = 2 \cdot 10^8$ μ/spill
- Pol. target ^{6}LiD $P_T \approx 0.50$
- Hadron identification by RICH
- 2002 – 04 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

- μ' selection
  - ✓ $Q^2 > 1(\mathrm{GeV}/c)^2$ DIS
  - ✓ $0.1 < y < 0.9$
  - ✓ $x < 0.3$ SIDIS (sea quarks distributions become insignificant)
- Hadrons
  - ✓ $0.2 < z < 0.85$ Current fragmentation
  - ✓ $10 < p < 50$ GeV/c RICH acceptance
  - ✓ RICH ID by likelihood cuts:
    1. π ID:

$$LH_\pi > (LH_{bg}, LH_K, LH_p)$$

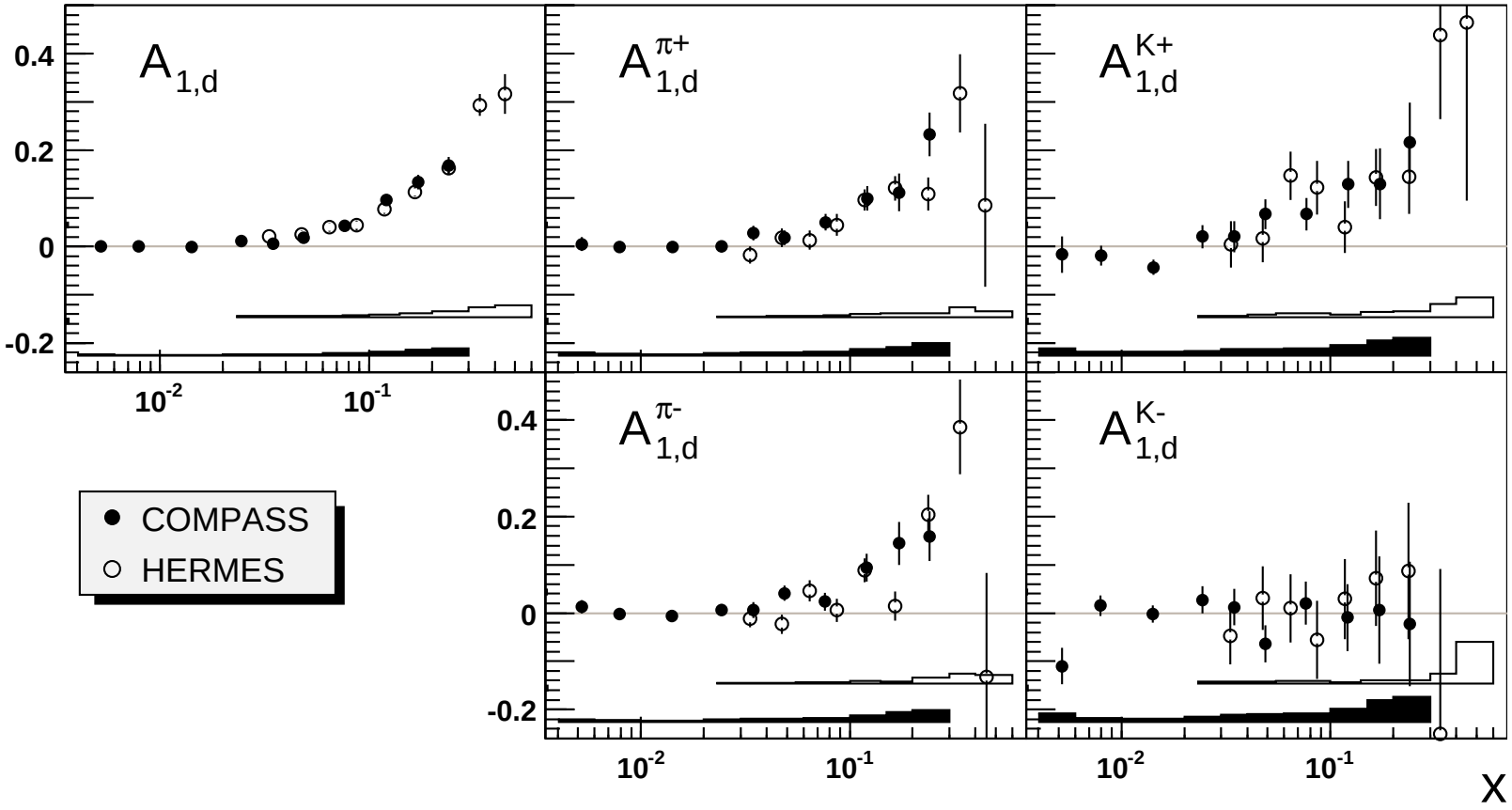
    2. K ID:

$$LH_K > (1.24 \cdot LH_{bg}, 1.02 \cdot LH_\pi, LH_p)$$

No. of hadrons, $\times 10^6$

	+	-
π	23	21
K	4.8	3.3

Asymmetries and comparison with HERMES



- 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

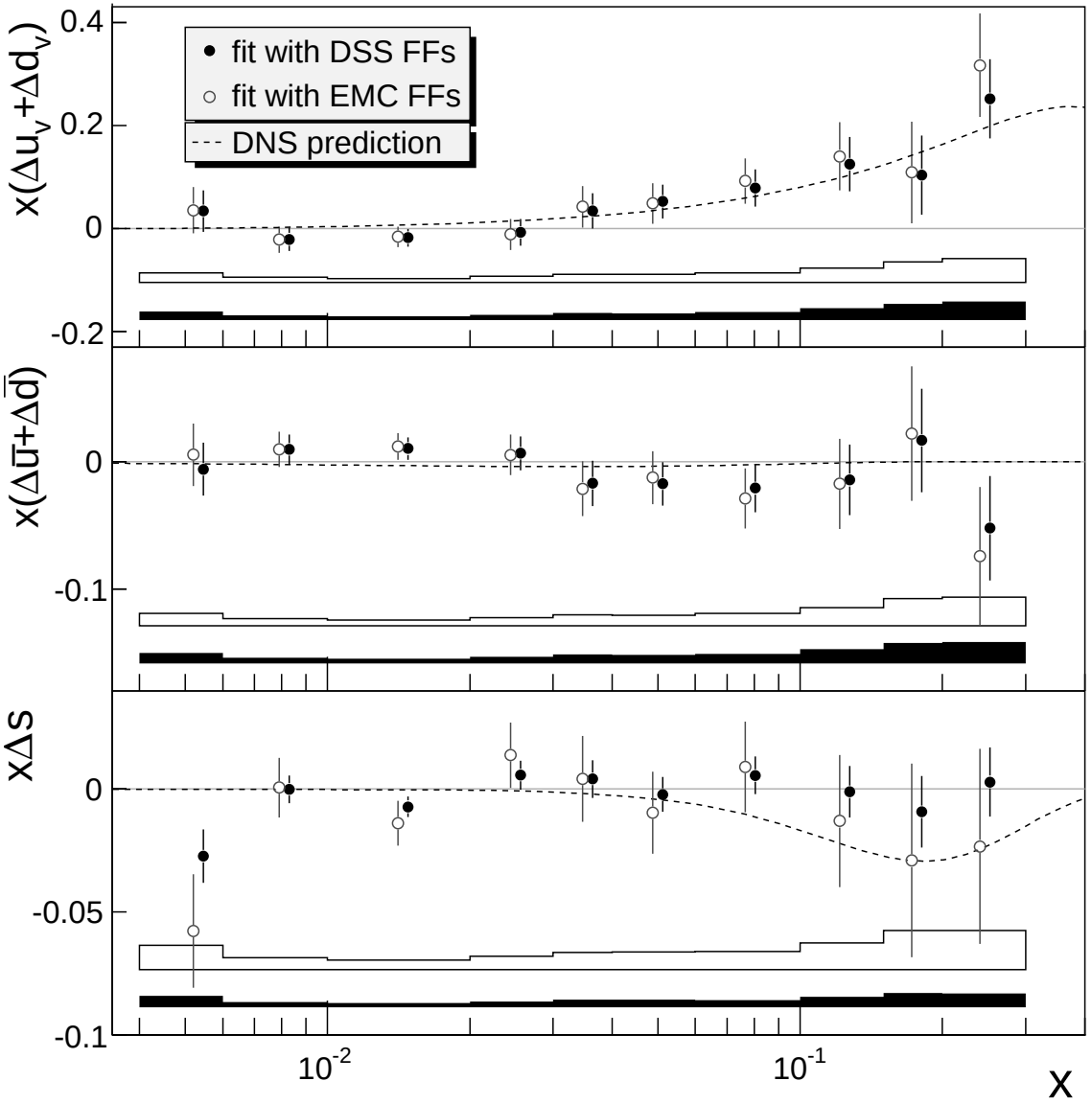
LO Evaluation of polarised PDFs

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

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
  - ✓ $D_{\bar{s}}^{K+} = D_u^{\pi+}$ 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 $Q^2 = 3(\mathrm{GeV}/c)^2$
- $\Delta u_v + \Delta d_v$: 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
- Δs: values and errors $2-3$ times larger with EMC FFs than with those of DSS

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

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

For comparison:

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

$\Delta s = -0.045 \pm 0.005 \pm 0.010$ COMPASS, from Γ_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:

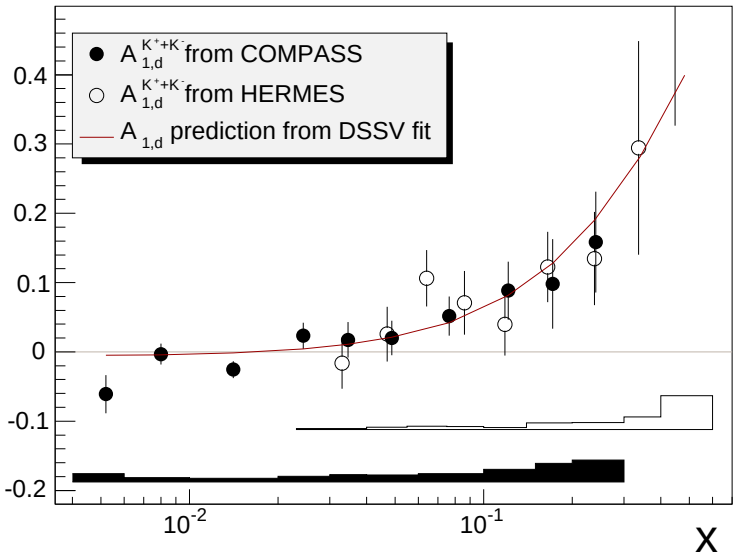
$$\boxed{R_{UF} = \frac{\int D_d^{K^+}(z)dz}{\int D_u^{K^+}(z)dz}} \quad \Leftrightarrow \quad \boxed{R_{SF} = \frac{\int D_{\bar{s}}^{K^+}(z)dz}{\int D_u^{K^+}(z)dz}}$$

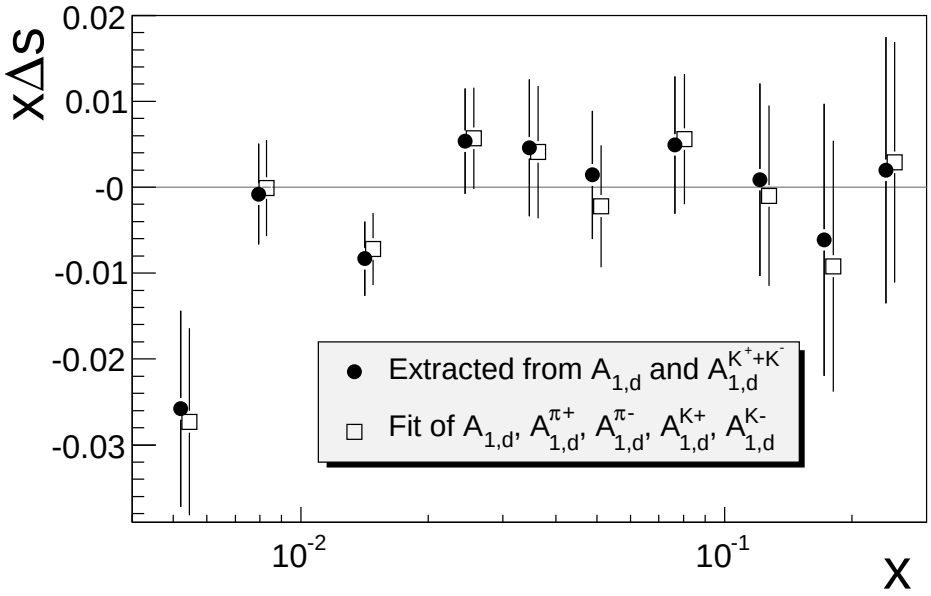
- $A^{K^+ + K^-}$ is very stable vs. changes of $\sigma^{K^-}/\sigma^{K^+}$ by $\pm 10\%$
- At $Q^2 = 3(\mathrm{GeV}/c)^2$, for the DSS FFs:

$$R_{UF} = 0.14 (\text{vs. EMC } 0.3)$$

$$R_{SF} = 6.6 (\text{vs. EMC } 4.4)$$

Δs from the charged kaon asymmetry



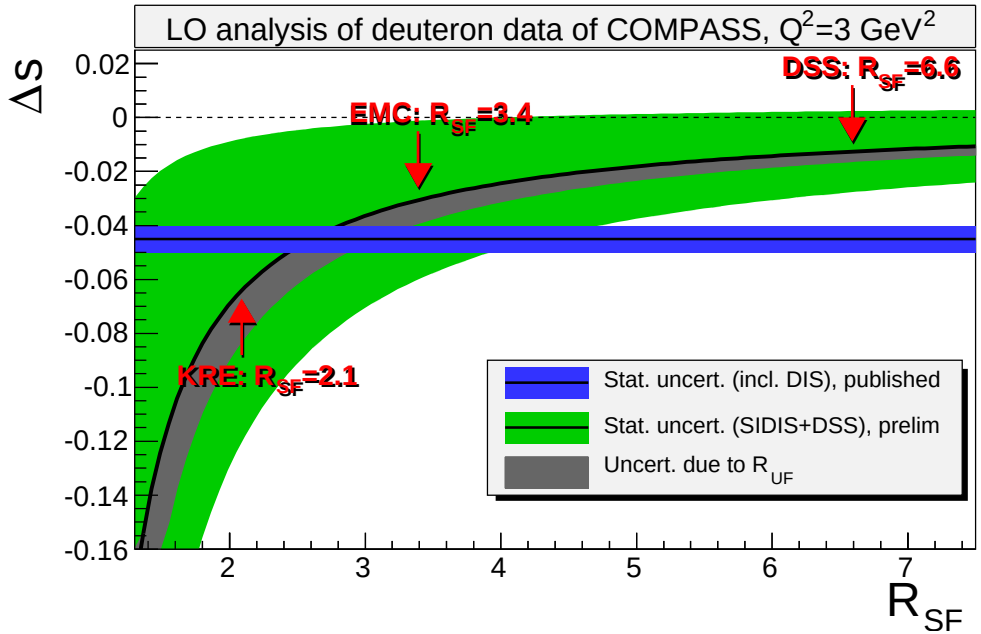


$$\frac{\Delta s}{s} = A_1^d + (A^{K^+ + K^-} - A_1^d)\frac{Q/s+\alpha}{\alpha - 0.8} \Leftarrow \alpha = \frac{2R_{UF}+2R_{SF}}{3R_{UF}+2}$$

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

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

First Moment Δs vs. R_{SF}

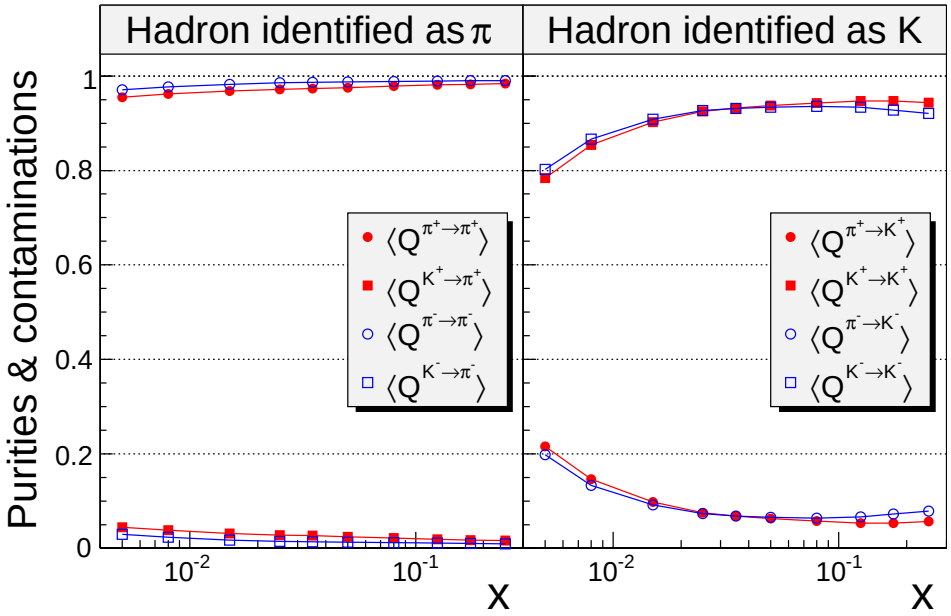


- Δs: strong dependence on R_{SF} (green) + minor dependence on R_{UF} (grey)
- $\int_{0.3}^{1} \Delta s(x)dx \leq 0.002$ (positivity condition)
- if $R_{SF} \geq 5$: $\Delta s(\text{SIDIS}) > \Delta s(\text{DIS}) \Rightarrow \Delta s(x) < 0$ for $x < 0.004$ (unmeasured), as in DSSV-NLO fit. However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

Conclusions

- 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 Δs is conditional on $R_{SF} = D_{\bar{s}}^{K^+}/D_u^{K^+}$ and comparison of SIDIS and DIS values of the first moment is still limited by statistics
- COMPASS Collaboration, "Flavor separation of helicity distributions from deep inelastic muon-deuteron scattering", hep-ex:0905.2828, submitted to PLB

Purities/Contamination



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

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

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

$$f \rightarrow 2\%$$

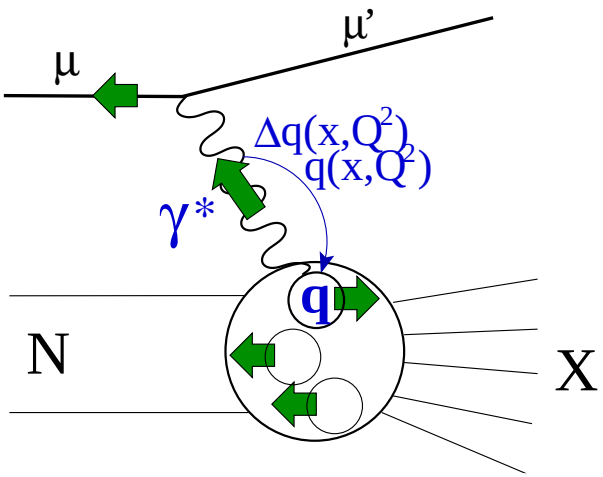
$$D(R) \rightarrow 2 - 3\%$$

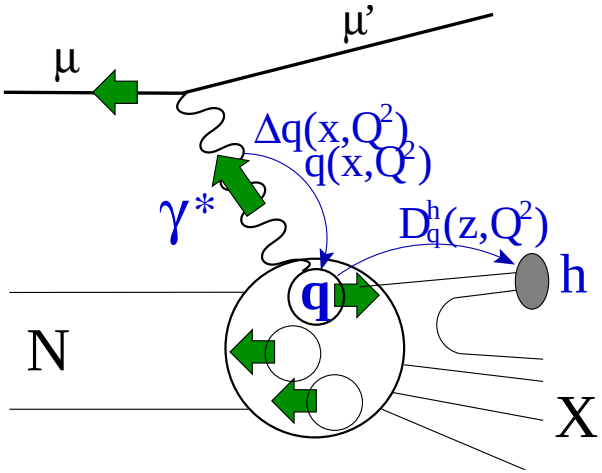
$$\text{“false asym.”} \leq 0.4\sigma_{stat}$$

Asymmetries (continued)

Inclusive DIS

- Detected particle: μ, μ'
- $A_1 = \frac{\sum_q e_q^2(\mathbf{\Delta q(x)+\Delta \bar{q}(x)})}{\sum_q e_q^2(q(x)+\bar{q}(x))}$
- only $\Delta q + \Delta \bar{q}$ can be measured





Semi-Inclusive DIS

- Detected particle: μ, μ', h, ...
- $A_1^h = \frac{\sum_q e_q^2(\mathbf{\Delta q(x) \int D_q^h dz+\Delta \bar{q}(x) \int D_{\bar{q}}^h dz})}{\sum_q e_q^2(q(x) \int D_q^h dz+\bar{q}(x) \int D_{\bar{q}}^h dz)}$
- $D_q^h \neq D_{\bar{q}}^h \Rightarrow$ quarks and anti-quarks separation