Charged pi and K multiplicities from COMPASS

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On behalf of COMPASS Collaboration

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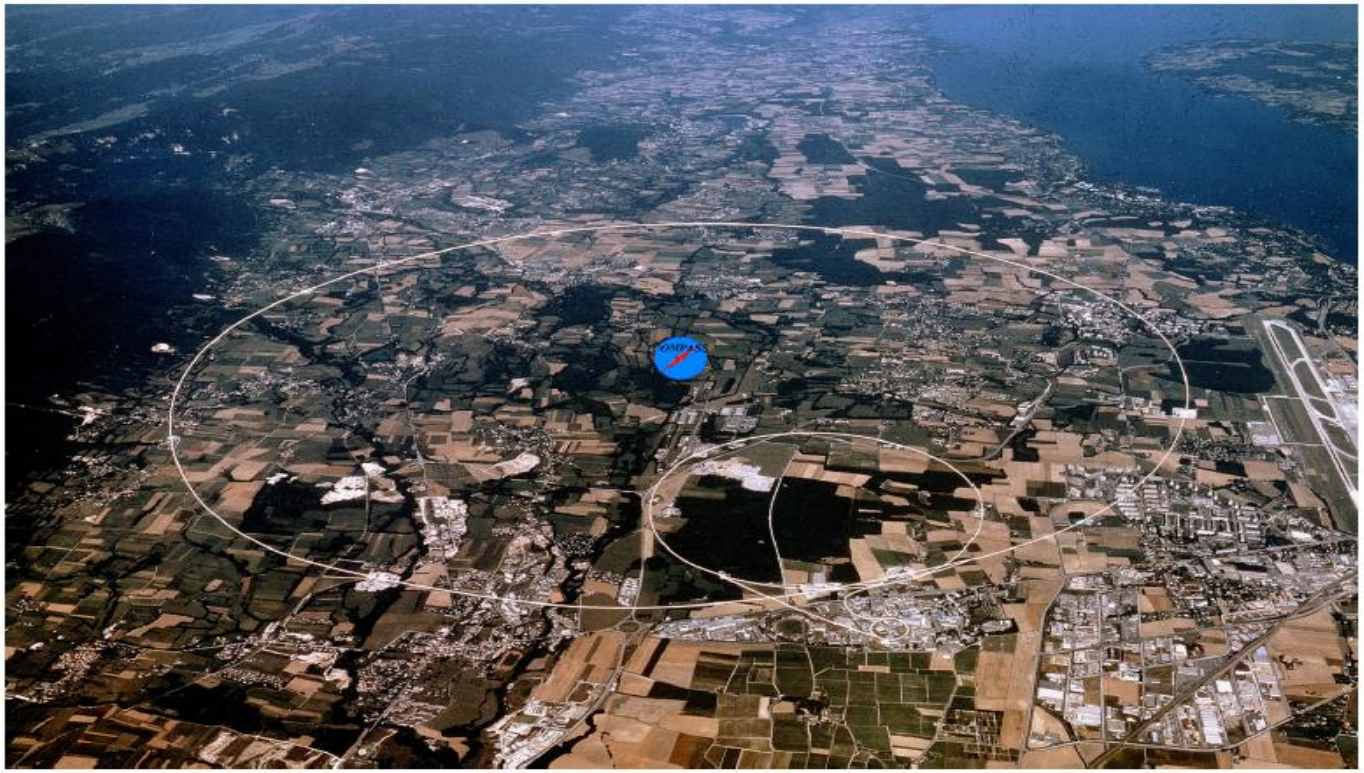
COmmon Muon Proton Apparatus for Structure and Spectroscopy



~240 physicists, 12 countries, 24 institutions

Fixed target experment, multi-purpose set-up.
Secondary ~200 GeV muon and hadron beams from CERN SPS
Various targets

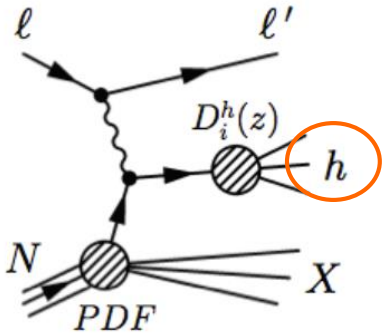
Quark Fragmentation Functions (FF)

FFs : - Non perturbative object; needed to describe various reactions

- Strange quark FF= **largest uncertainty in Δs extraction** from polarized SIDIS.

Data exist from e^+e^- and pp reactions, but unsufficient and at too high Q^2

→ Measure hadron multiplicities in **SIDIS:** $\mu^+ d \rightarrow \mu^+ h^\pm X$ $h = \pi, K, p$



$z = E_h/(E_\mu - E_\mu')$

PDFs FFs

$$\frac{dM^h(x,Q^2,z)}{dz} \underset{\text{at LO}}{=} \frac{\sum_q e_q^2 f_q(x,Q^2) D_q^h(z,Q^2)}{\sum_q e_q^2 f_q(x,Q^2)}$$

PDFs depend on *x*, while FFs depend on *z*

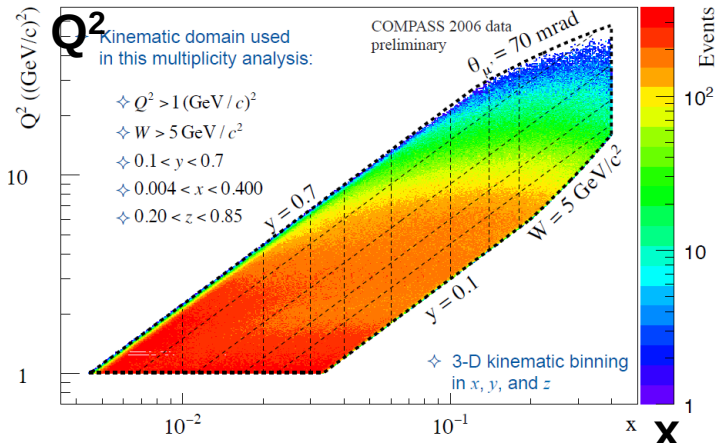
→ With kaons, access typically : $s(x,Q^2)$. $D_s^K(z,Q^2)$

Corrections for : acceptance, RICH purity & efficiency, radiative effects and vector meson contamination

Data obtained in a fine binning in x, z, Q^2

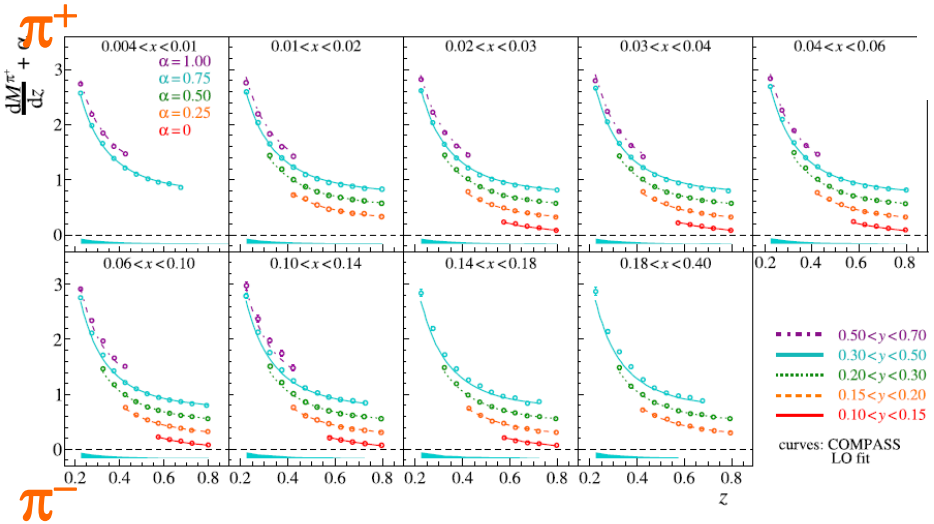
→ **π and *K* multiplicities constitute an input to global NLO QCD analyses to extract quark FFs,**

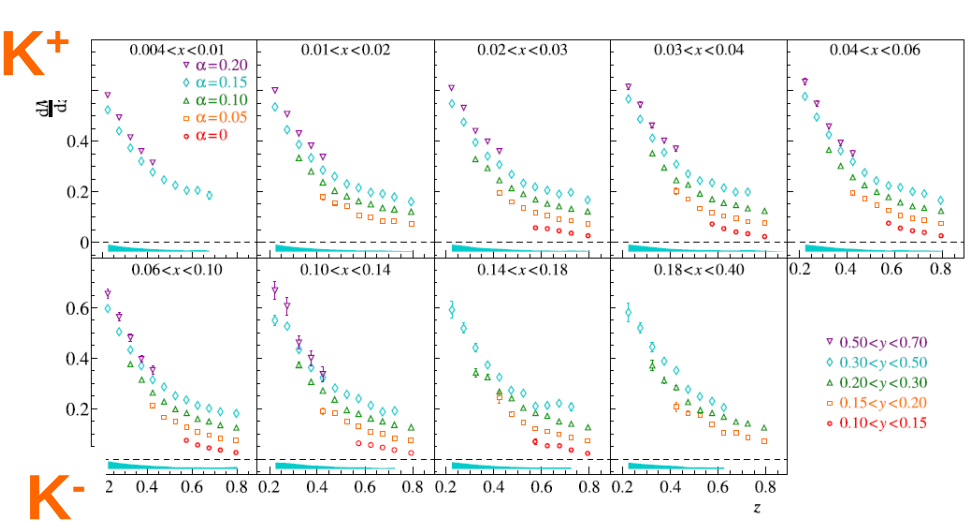
→ **Especially, *K* will constrain strangeness**

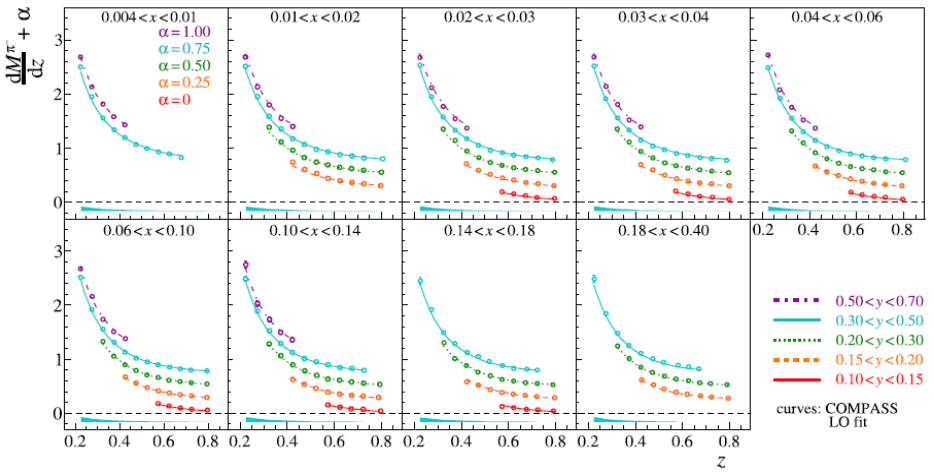


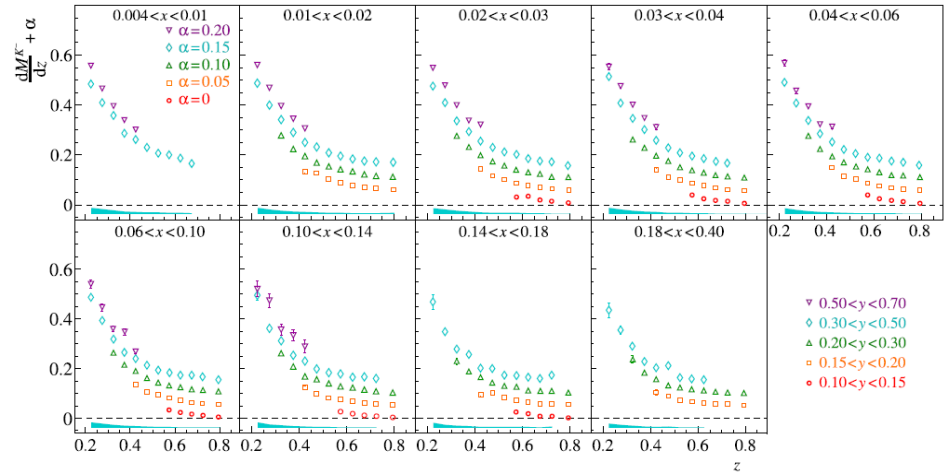
F. Kunne

COMPASS π and K multiplicities vs z in (x,y) bins









- More than 1200 points in total, various Q^2 staggered vertically for clarity
- Strong z dependance
- $M\pi^+ \sim M\pi^-$ and $MK^+ > MK^-$

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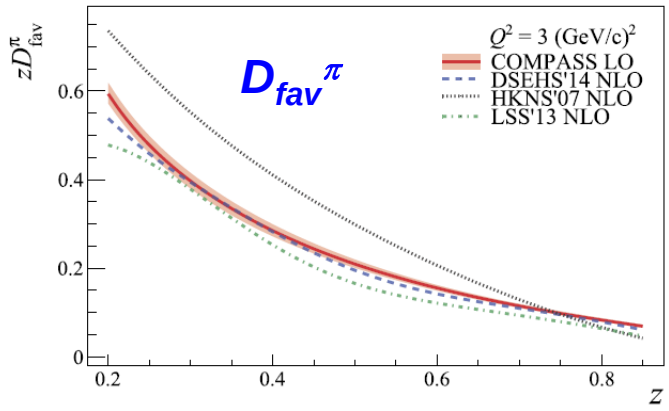
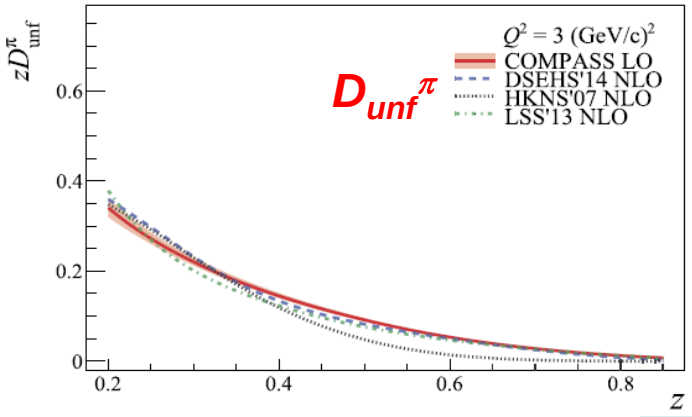
From multiplicities to quark Fragmentation functions

Pions Results from COMPASS LO fits assuming 2 independent FFs: D_{fav}^{π} D_{unf}^{π}





- As expected, $D_{fav}^{\pi} > D_{unf}^{\pi}$.
- COMPASS LO fit results ~agree with DSEHS and LSS NLO.

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Kaons Assuming 3 independent FFs: D_{fav}^{K} D_{unf}^{K} D_{str}^{K}

- LO fit not conclusive. Some difficulty in fitting high z data even at NLO (see later)
- Global NLO fit *DSS17*, half of data from COMPASS→ **Smaller D_{str}^{K}** than previously; also ongoing study of strange PDF and FF via iterative study *BSS arXiv:1708.01630*
- Some contrains on FFs from sum of K^+ and K^- multiplicities (see next slide)

Sum of *z* integrated multiplicities $\pi^+ + \pi^-$ & $K^+ + K^-$

For isoscalar target, simple dependence on FFs:

$$M^{\pi^+ + \pi^-} = (1 - \cancel{2S/(5Q+2S)})\, D_{fav} + D_{unf}$$

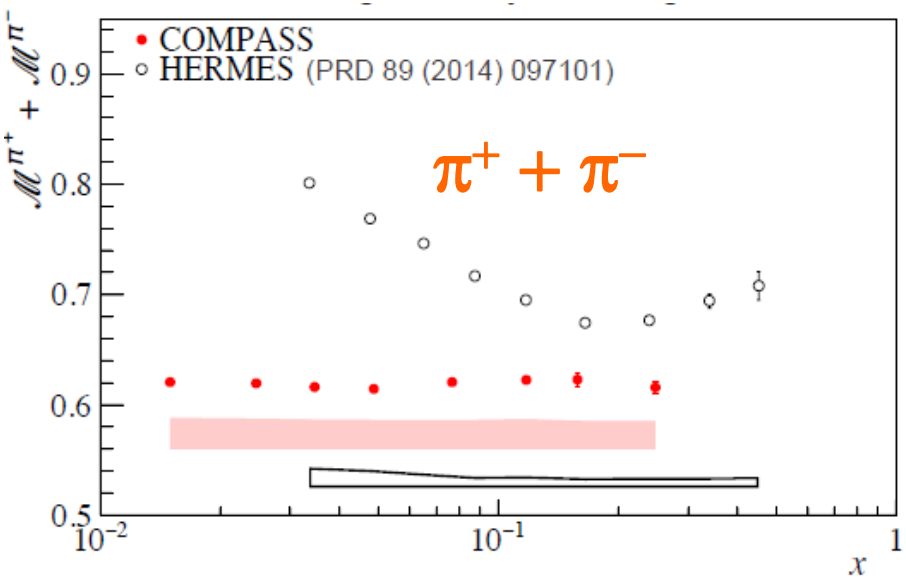
$$5M^{K^+ + K^-} = D_Q^K + S/Q\ D_S^K$$

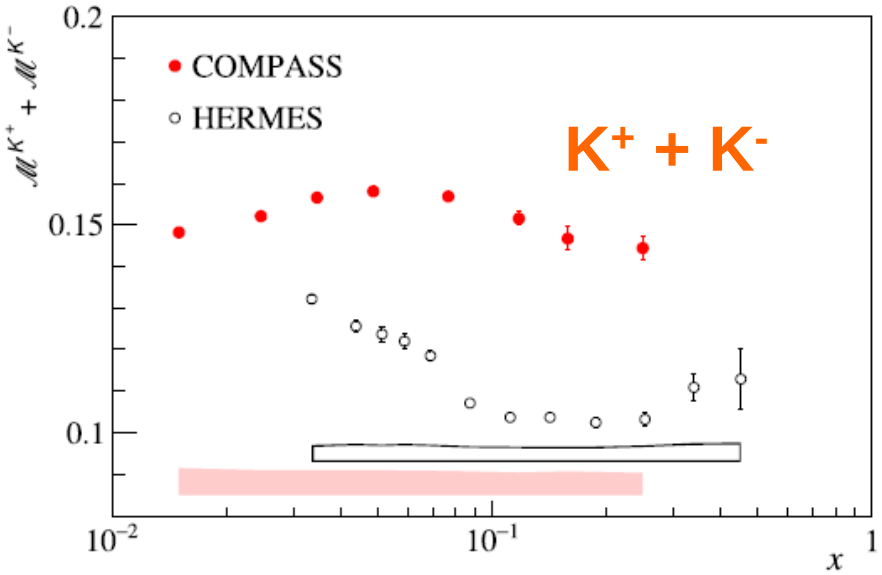
high x data ***low x data***

where:

$$Q = u + \bar{u} + d + \bar{d},$$
$$S = s + \bar{s}$$
$$D_Q^K = 4D_{fav}^K + 6D_{unf}^K$$

At high x, ~no *x* dependence expected





COMPASS pion data:

- **significantly below HERMES ones**
- **no x dependence**

(as in EMC h, but not shown here)

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COMPASS kaon data:

- **significantly above HERMES ones**
- **Indicate smaller D_S^K,and larger D_Q^K than previous NLO fits**

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Comments on corrections for QED radiative effects

In the paper of kaon multiplicities:
Muon yields (denominator): use TERAD
Kaon yields (numerator): use TERAD, excluding elastic and quasi-elastic tails.
But TERAD cannot account for a **z dependence**, and leads to an overestimate of the correction.

→ conservative approach: the correction is calculated for the two extreme cases, **no correction** and **full correction** to the number of kaons; half of the correction is applied to the multiplicities. This approach leads to an **overall correction between 1% and 7%** depending on kinematics.

Further ongoing work: use Djangoh which can account for z dependence:
- For muons, agreement Djangoh / TERAD within 3%
- For kaons, obtain a correction varying between 0 and 10% (dep. Kinematics) of the order of 5% in average.

Note that using RADGEN was excluded since it could not reproduce the photon spectrum observed in COMPASS

Summary

Pion and kaon multiplicities measured in semi-inclusive DIS:

- Produced the largest sample of kaon multiplicities to constrain FF (D_s^K).

- Large discrepancies between COMPASS and HERMES data:
up to 30-40% in the sum of z-integrated $MK^+ + MK^-$

Open questions

- **Discrepancy COMPASS / HERMES** also for pions, while extraction of FFs into pions looks solid.

- **Radiative corrections:** Further work from COMPASS using Djangoh points to slight change in multiplicities, will not change much COMPASS results.
  → Size of corrections for HERMES using Radgen?

- **Fitting kaon multiplicities.**

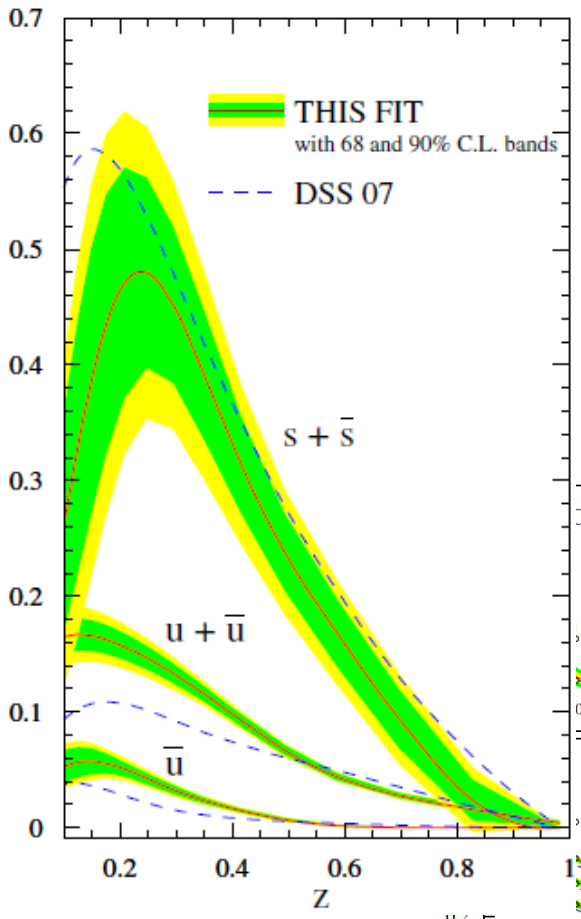
Problems in DSS approach (only fit with SIDIS HERMES and COMPASS):
- using 2 projections of HERMES data without taking into account correlations
- have to normalize the 2 projections in opposite directions
- still chi2 for HERMES data high
- have produced new fit « iterative » with PDFs and FFs, result not much different. → use NNPDF.

- **D_s^K** : We now have at hand a large set of kaon data and need to conclude on FF to finalize result on $\Delta s(x)$.

Backup slides

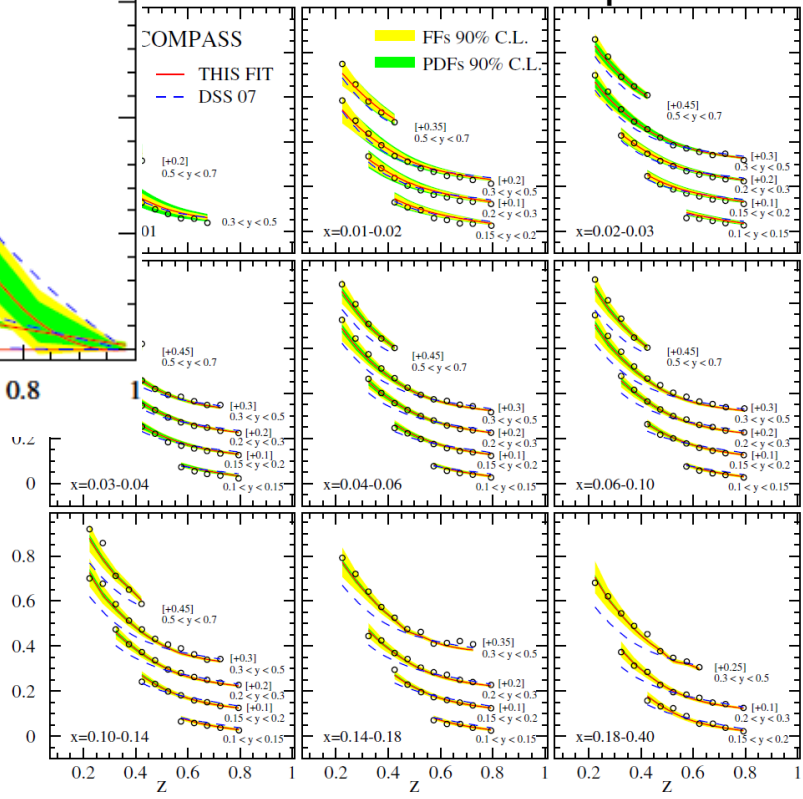
Strange quark FF. DEHSS global fit of kaon data

Experiment	Data type	$\mathcal{N}_i$	# data in fit	χ^2
Tpc [38]	Inclusive	1.003	12	13.4
Sld [35]	Inclusive	1.014	18	17.2
	uds tag	1.014	10	31.5
	c tag	1.014	10	21.3
	b tag	1.014	10	11.9
Aleph [32]	Inclusive	1.026	13	29.7
Delphi [33]	Inclusive	1.000	12	6.9
	uds tag	1.000	12	13.1
	b tag	1.000	12	11.0
Opal [39]	*u* tag	0.778	5	9.6
	d tag	0.778	5	7.7
	s tag	0.778	5	23.4
	c tag	0.778	5	42.5
	b tag	0.778	5	16.9
BABAR [19]	Inclusive	1.077	45	30.6
Belle [20]	Inclusive	0.996	78	15.6
Hermes [21]	K^+ (p) Q^2	0.843	36	61.9
	K^- (p) Q^2	0.843	36	29.6
	K^+ (p) x	1.135	36	75.8
	K^- (p) x	1.135	36	42.1
	K^+ (d) Q^2	0.845	36	44.7
	K^- (d) Q^2	0.845	36	41.9
	K^+ (d) x	1.095	36	48.9
	K^- (d) x	1.095	36	44.4
Compass [24]	K^+ (d)	0.996	309	285.8
	K^- (d)	0.996	309	265.1
Star [26]	$K^+,K^-/K^+$	1.088	16	7.6
Alice [25] 2.76 TeV	K/π	0.985	15	21.6
Total			1194	1271.7



DEHSS, PRD95, 094019 (2017)

COMPASS K+ multiplicities



- Half of entries from COMPASS
- D_s^K smaller than in DSS07

	s tag	0.778	5	23.4
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Simultaneous study of PDF and FF 1/2

Borsa, Sassot & Stratmann arXiv:1708.01630v

Iterative procedure; fitting SIDIS charged kaon multiplicities from COMPASS and HERMES.

Concluding on NNPDF3.0 PDF set for s(x).

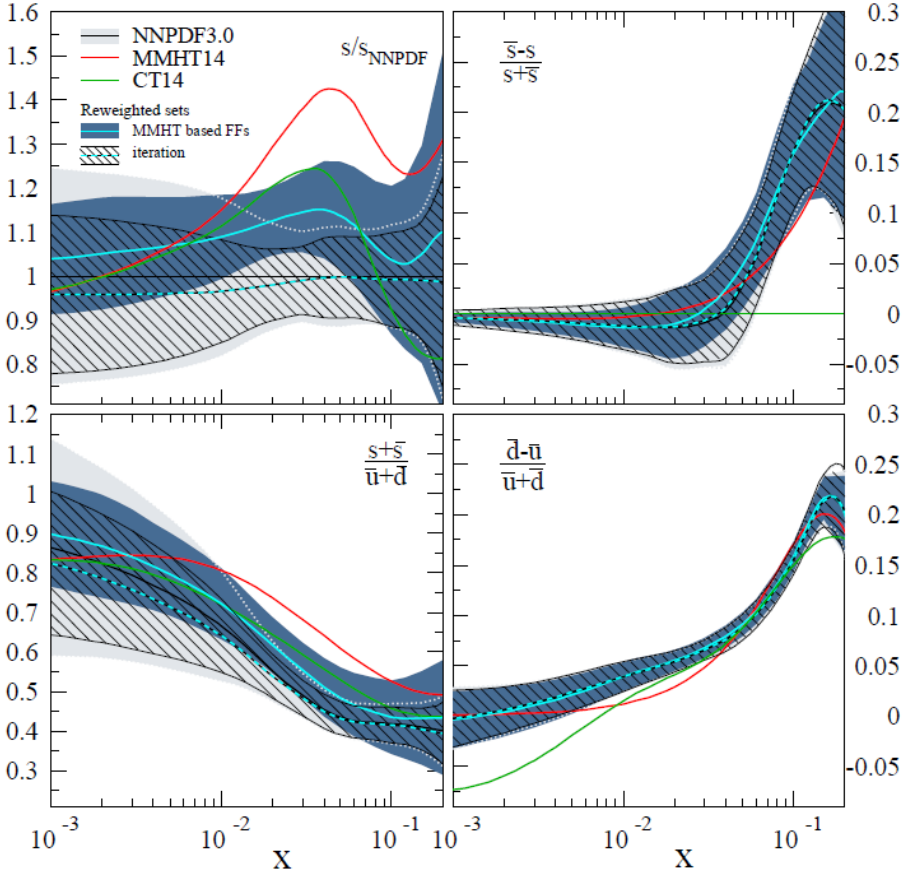

FIG. 5: Reweighting of the strange quark distribution (upper left panel) and for the PDF combinations sensitive to charge (upper right panel) and flavor (lower panels) symmetry breaking using the DSS 17 set of kaon FFs that is based on the MMHT 14 set of PDFs; see text. The dashed light blue and black lines and the hatched areas represent the results of one iteration of the reweighting procedure and the corresponding uncertainty bands, respectively; see text. All results are shown at a scale of $Q^2 = 5\,\mathrm{GeV}^2$.

Simultaneous study of PDF and FF 2/2

From R.Sassot, talk at INT sept.2017
Borsa, Sassot & Stratmann arXiv:1708.01630v