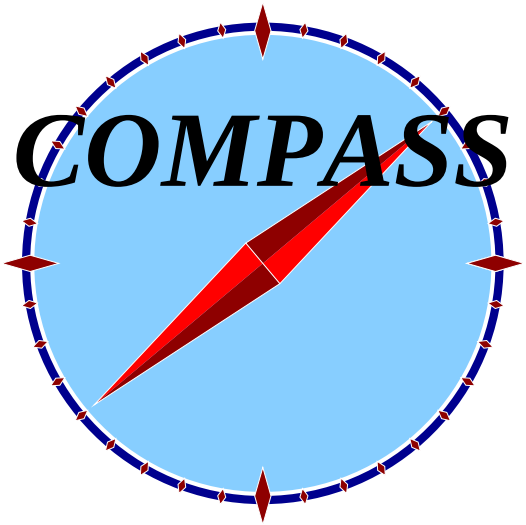
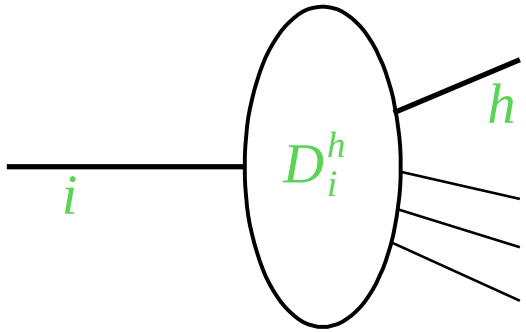
Single hadron multiplicities in SIDIS @ COMPASS



Yann Bedfer
Saclay - Irfu/SPhN
On behalf of the COMPASS collaboration

Fragmentation Functions

- Describe the collinear transition of a parton i
  into a hadron h carrying momentum fraction z.



- Non-perturbative but universal objects.
  Factorization : [PDF $\otimes$] parton-level X-section $\otimes$ FF
- pQCD predicts the scale dependence : $D_i^h(z, \mu^2)$
- Depend on $z =$ energy fraction carried by the hadron

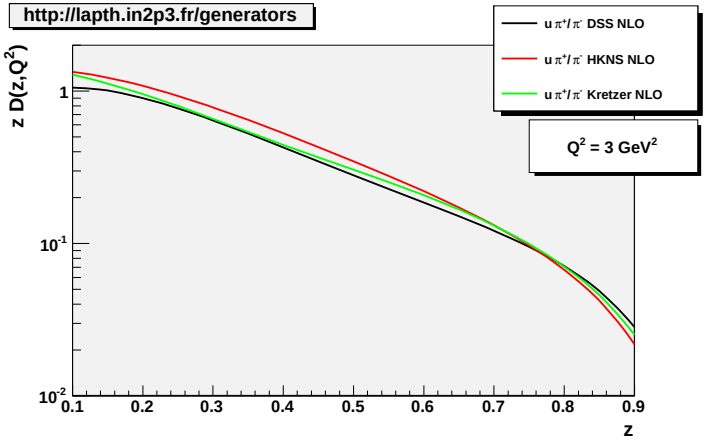
Importance of Inclusive Hadron Production

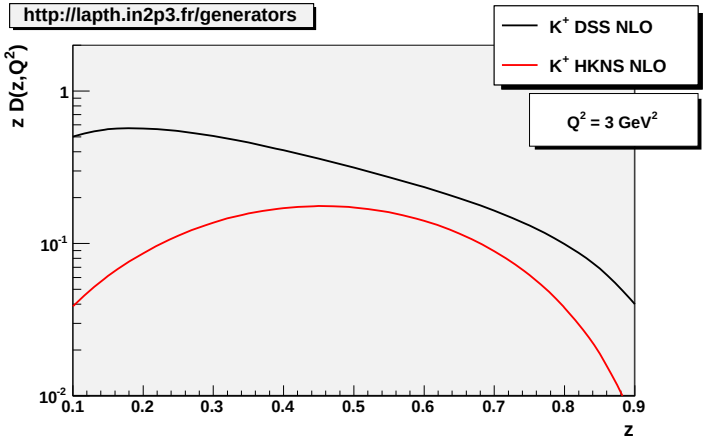
- High energy hadron collisions :
  - QGP *via* high p_T hadron suppression.
  - Control of Standard Model background processes
- Spin physics : Flavor separation of Polarized Parton Distributions
  - Polarized Gluon Distribution *via* High pT hadron production
    - In quasireal photoproduction $\vec{\gamma^*}\vec{N}$ @ COMPASS *cf. talk of Astrid Morreale*
    - In $\vec{p}\vec{p}$ @ RHIC
  - Polarized SIDIS @ HERMES, COMPASS, JLab.
    - Presently (*before W production @ RHIC*), only way to disentangle experimentally Δq from $\Delta\bar{q}$.
    - Polarized strangeness puzzle : Inclusive $\neq$ Semi-Inclusive DIS.
- e^+e^- SIA (*Single-Inclusive Annihilation*) :
  - Clean process : only non-perturbative piece = D_q^h
  - At $M_Z \Rightarrow$ sensitive to *Singlet* D_Σ^h
  - Some flavor tagging, but no distinguishing *favored* D_u^h from *unfavored* $D_{\bar{u}}^h$

Experimental Status of FF : Global Fits

- e^+e^- SIA only : $e.g.$ Kretzer (2000), HKNS (2007)
  $\Rightarrow$ Separation favored/unfavored via assumption : $D_{\bar{q}}^h = (1-z)D_q^h$
- $+= pp$: AKK (2008)
  Constrains D_g
- $+=$ SIDIS (HERMES preliminary) : DSS (2007)
  Flavor/charge separation $\Rightarrow$ $D_{\bar{q}}^h = (1-z)D_q^h$ disqualified
  Some tension in the K sector : Higher twist ? Or wrong sea PDFs ?
  pQCD scale evolution : $\mu^2 = Q^2 = 1 \div 3GeV \ll M_Z$

- Discrepancies in the K fragmentation :





- EMC FFs from SIDIS only, @ LO in pQCD

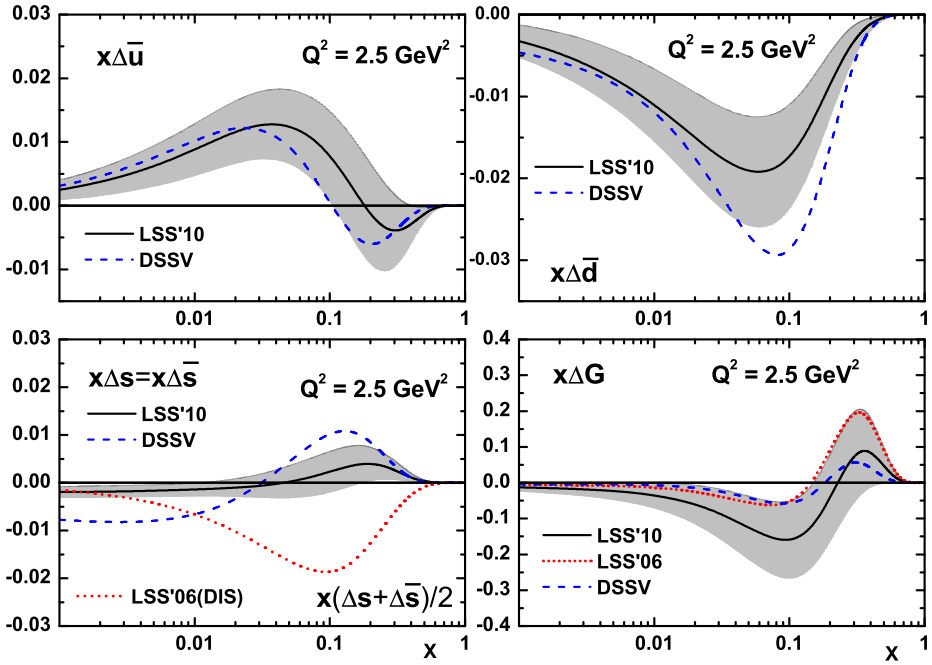
Why measure Fragmentation in COMPASS ?

- Data already available on clean enough isoscalar target LiD
  Nuclear effects expected to be small, *cf.* HERMES *NPB* ***780*** *(2007)* and *PRD* ***81*** *(2010)*
  Main Difficulty : Multiplicity $= \sigma^h_{SIDIS}/\sigma_{DIS}$ involve acceptance corrections

- Main incentive : Polarized Strange quark Δs puzzle
  - HERMES *PRL* ***92*** *2004* : SIDIS $\Rightarrow \Delta s \gtrsim 0$ while < 0 in inclusive DIS

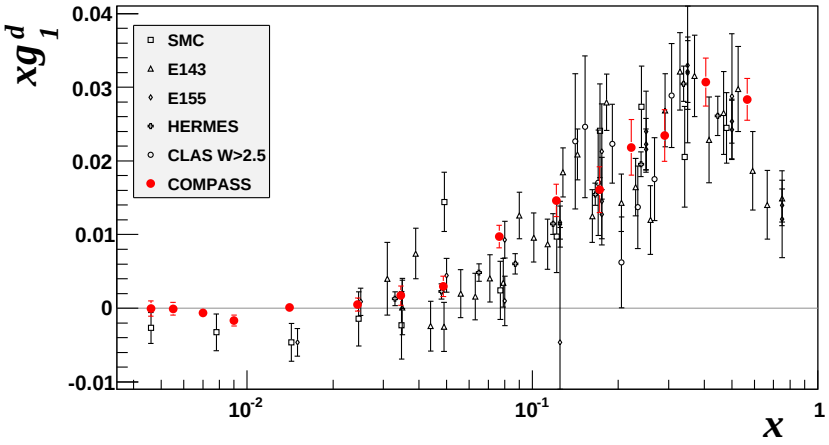
  - Confirmation by global fits

  DIS + SIDIS [+ RHIC] : DSSV, LSS10

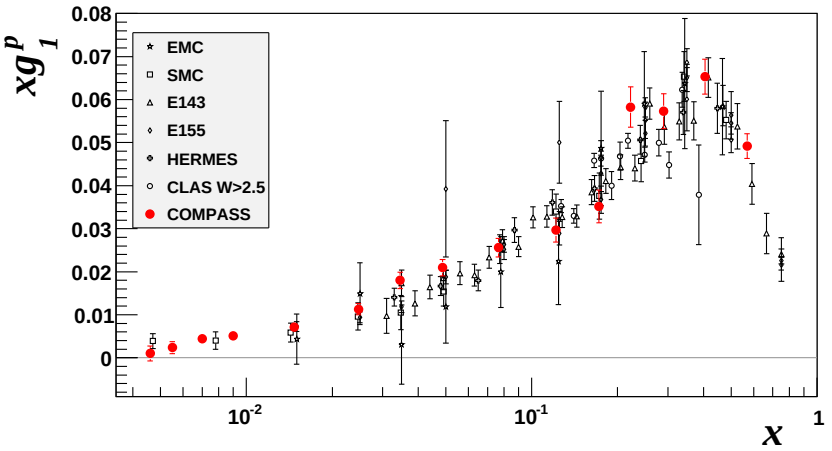


LSS, PRD ***82*** *(2010)*

Δs puzzle @ COMPASS : Inclusive DIS



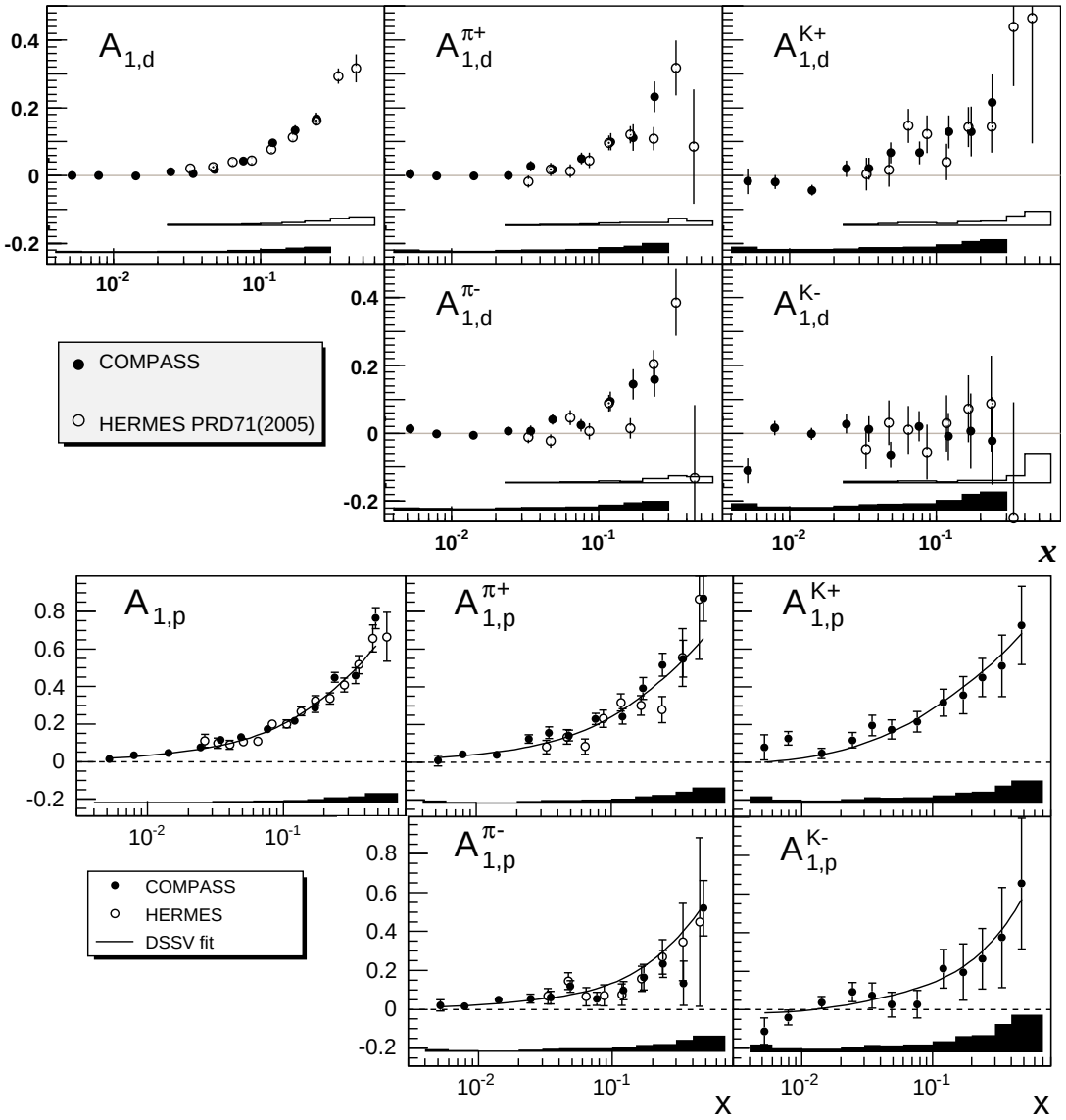
[2002,2004], ^6LiD target *PLB* ***647*** *(2007)*



2007, NH_3 target *PLB* ***690*** *(2010)*

- $g_1 \simeq A_{\parallel}/DF_1$ @ COMPASS $\sqrt{s}$
- $\int g_1^p(x,Q^2)dx = 1/6(1/2a_3 + 5/6a_8 + 2\Delta s(Q^2)$
  - Very solid measurement thanks to low x data
  - Main uncertainty : SU(3)$_f$ assumption
- Global NLO QCD fit, *e.g. : PLB* ***647*** *(2007)* :
  $\Delta s(Q^2 \to \infty) = -008 \pm 0.01(stat) \pm 0.02(syst)$
  $\Delta s(x) < 0$ for all x

Δs puzzle @ COMPASS : $A_1^h, h = \pi, K$ measurements



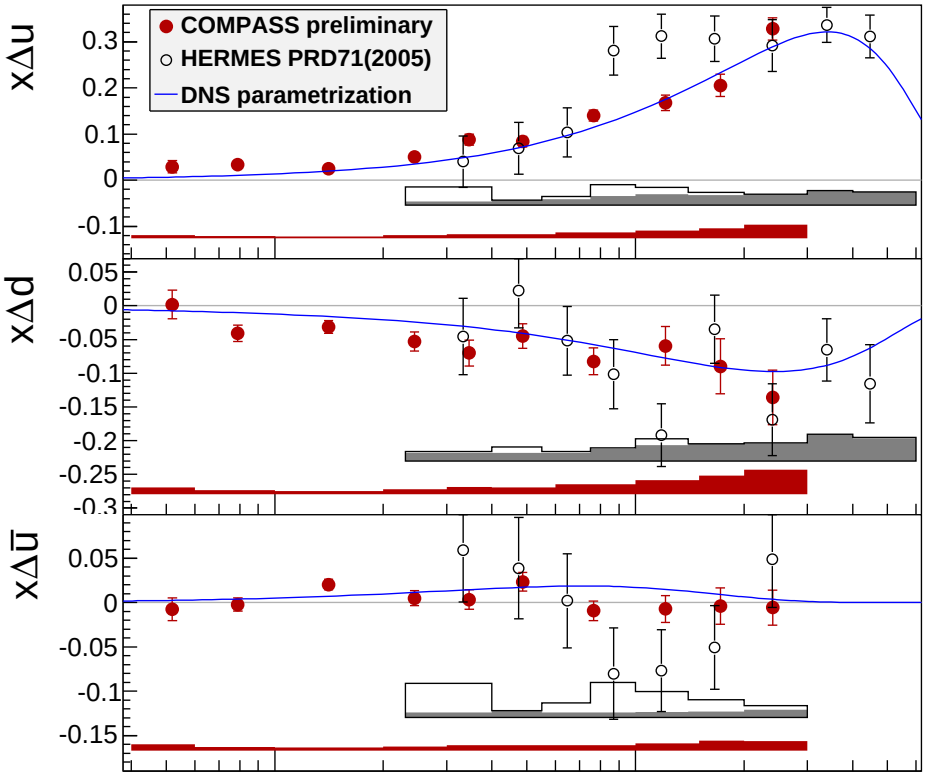
- [2002,2004], ${}^6LiD$ target
  PLB ***680*** *(2009)*

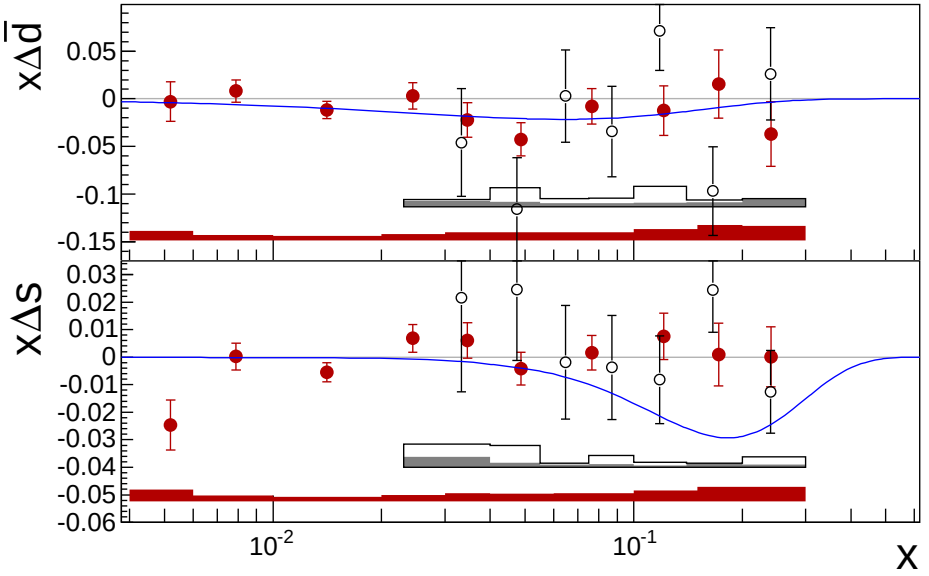
${}^6Li = {}^4He + d$

- 2007, NH_3 target
  PLB ***693*** *(2010)*
  $A_{1,p}^K$: 1st measurement ever.

Δs puzzle @ COMPASS : Flavor separation

- LO fit to COMPASS only data
- FF = DSS @ LO $\quad D_{fav} = D_u^{K^+}\ D_S = D_{\bar{s}}^{K^+}\ D_{unfav} = D_q^{K^+}, q = \bar{u}, d, \bar{d}, s$



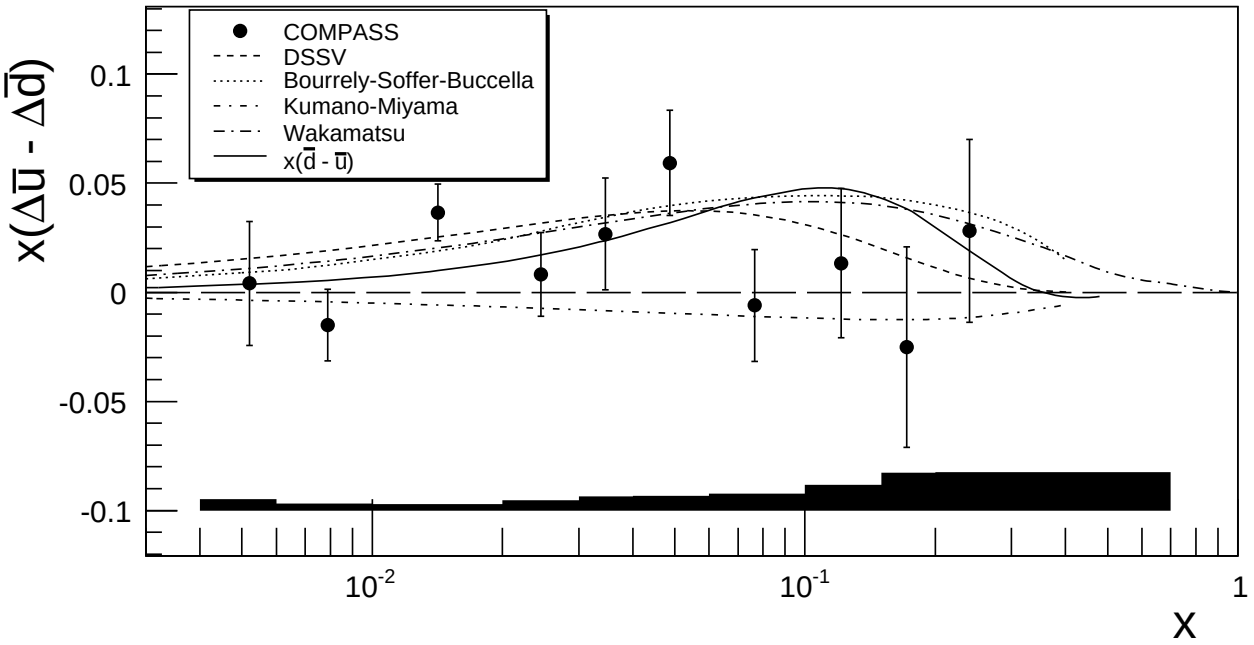


- *Caveat* :
  HERMES FF from LEPTO MC

$\Rightarrow$ Confirm $\Delta s \simeq 0$ in the range $0.008 < x < 0.3$, w/ improved precision
Otherwise compatibility w/ "conventional" Global Fits, *e.g.* DNS, and assumptions

Asymmetry of the polarized sea

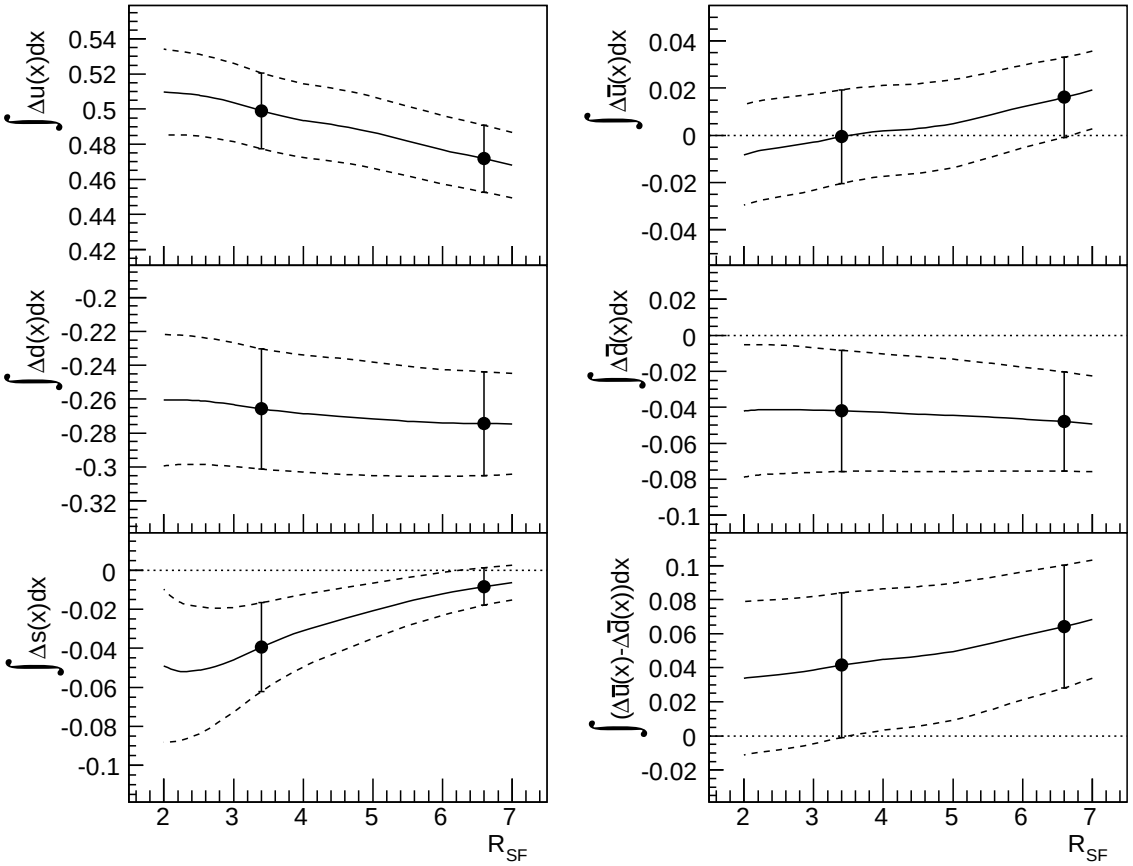
- In line w/ unpolarized case.
- Expecting $\Delta\bar{u} > 0, \Delta\bar{d} < 0$ based on Pauli principle



$\Rightarrow$ Lack of significance

Sensitivity to FF

- $R_{SF} = \int D_S dz / \int D_{fav} dz, \qquad R_{UF} = \int D_{unfav} dz / \int D_{fav} dz$



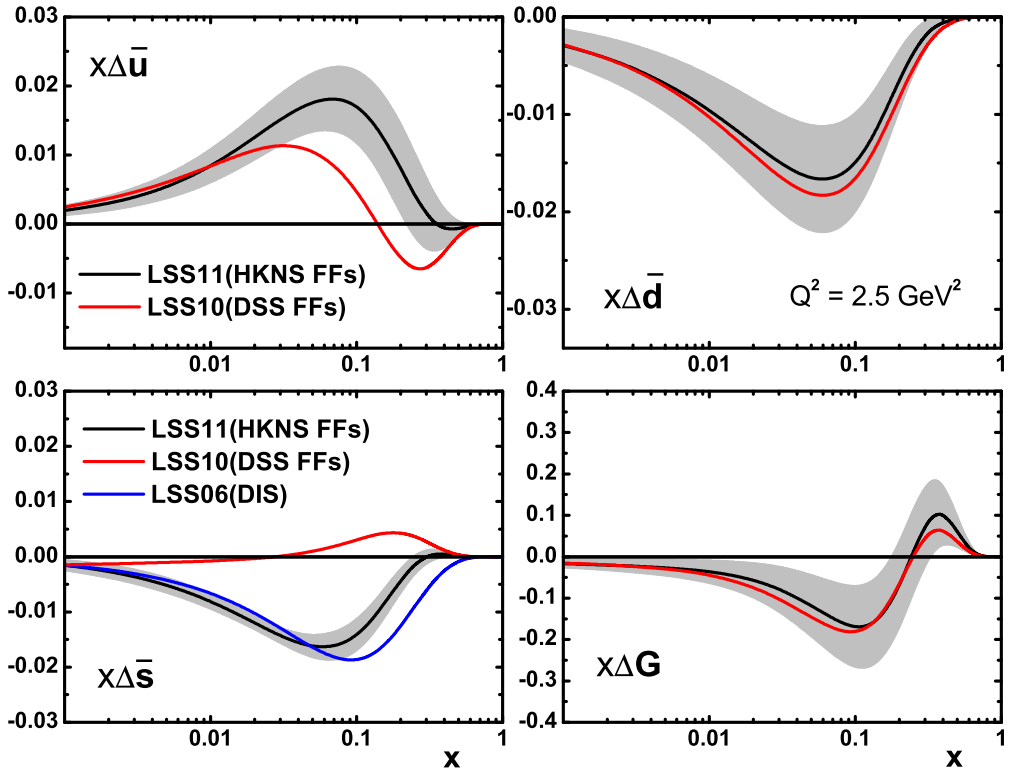
- R_{SF} : DSS ↘ EMC

while R_{UF} *varied opposite so as to to keep* $K^+ \sim const$

- Large change for Δs and $\delta\Delta s$

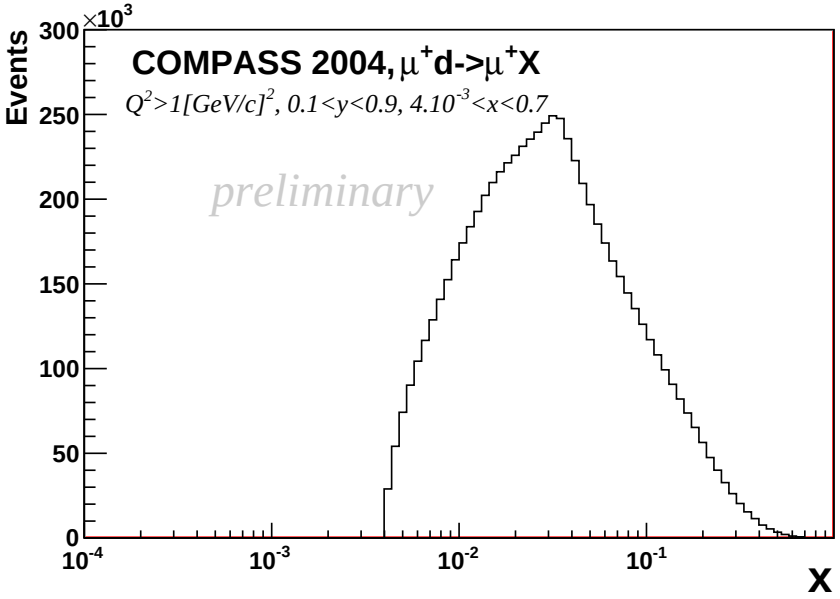
Sensitivity to FF : LSS11

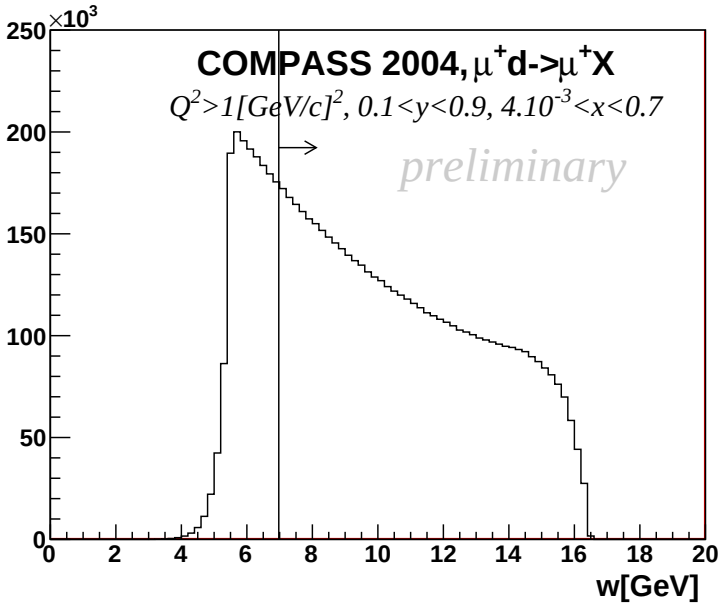
- Using HKNS instead of DSS



Multiplicity Measurement : Event Selection

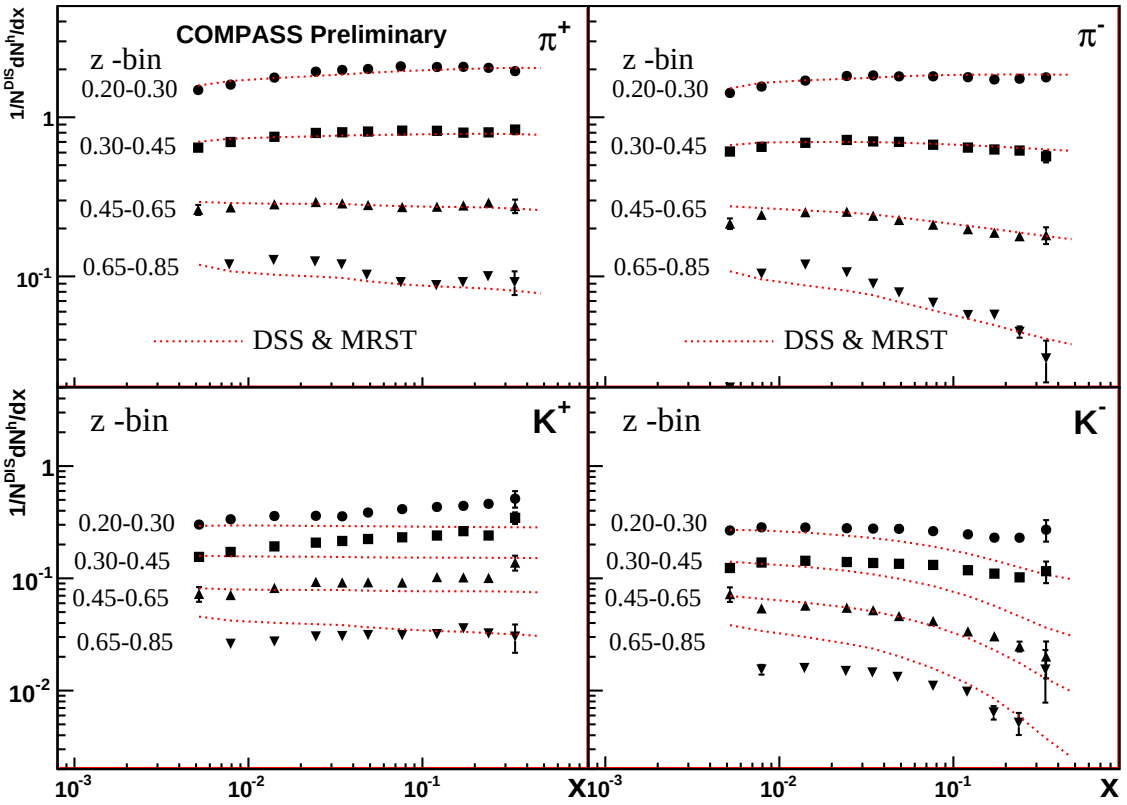
- Event selection :
  - Inclusive DIS trigger
  - $Q^2 > 1, \;\; 0.1 < y < 0.9 \;\; 0.004 < x < 0.7$
  - PID by COMPASS RICH imposes $P_K > 10\,GeV$
    $\Rightarrow \quad W > 7\,GeV$





- Radiative corrections via PYTHIA + RADGEN

Multiplicities in bin of x and z



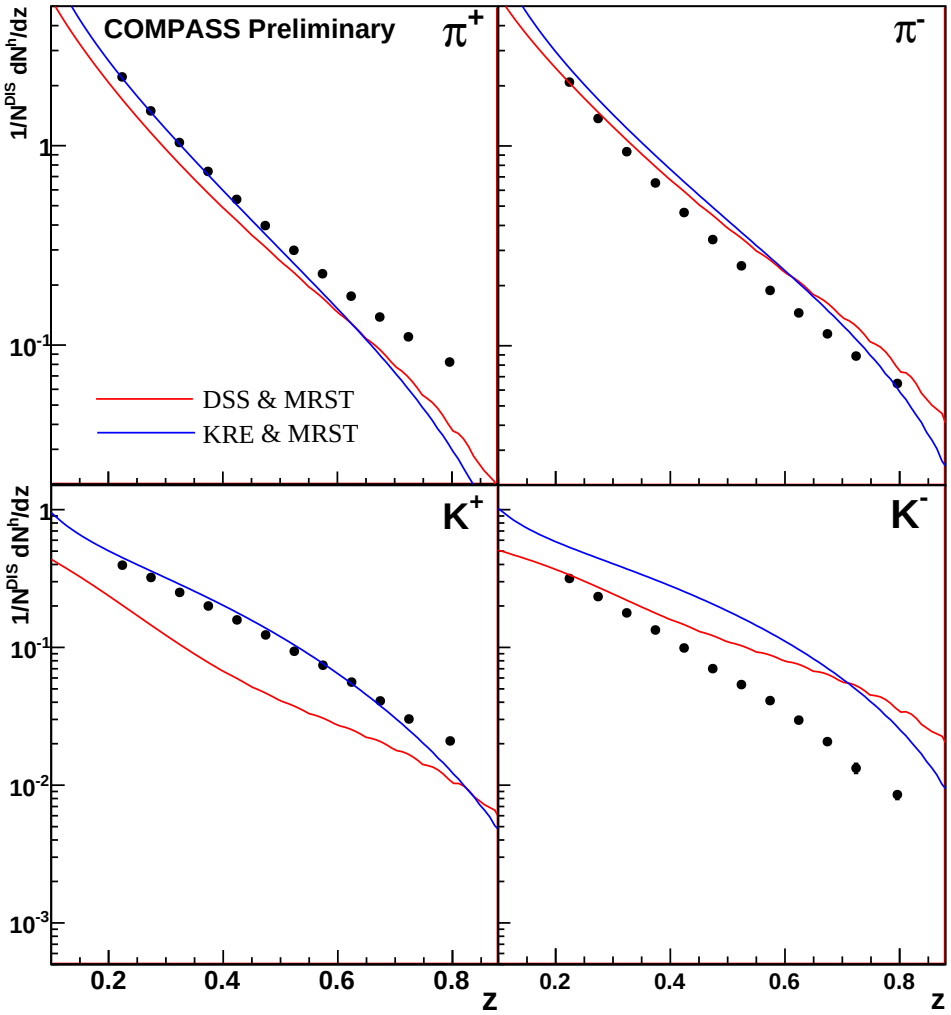
MRST04 LO $\times$ DSS LO
calculated @ (x, z) w/ $\langle Q^2 \rangle$
(*Curves to guide the eye*)

The work by *Nour Makke and Elena Zemlyanichkina*

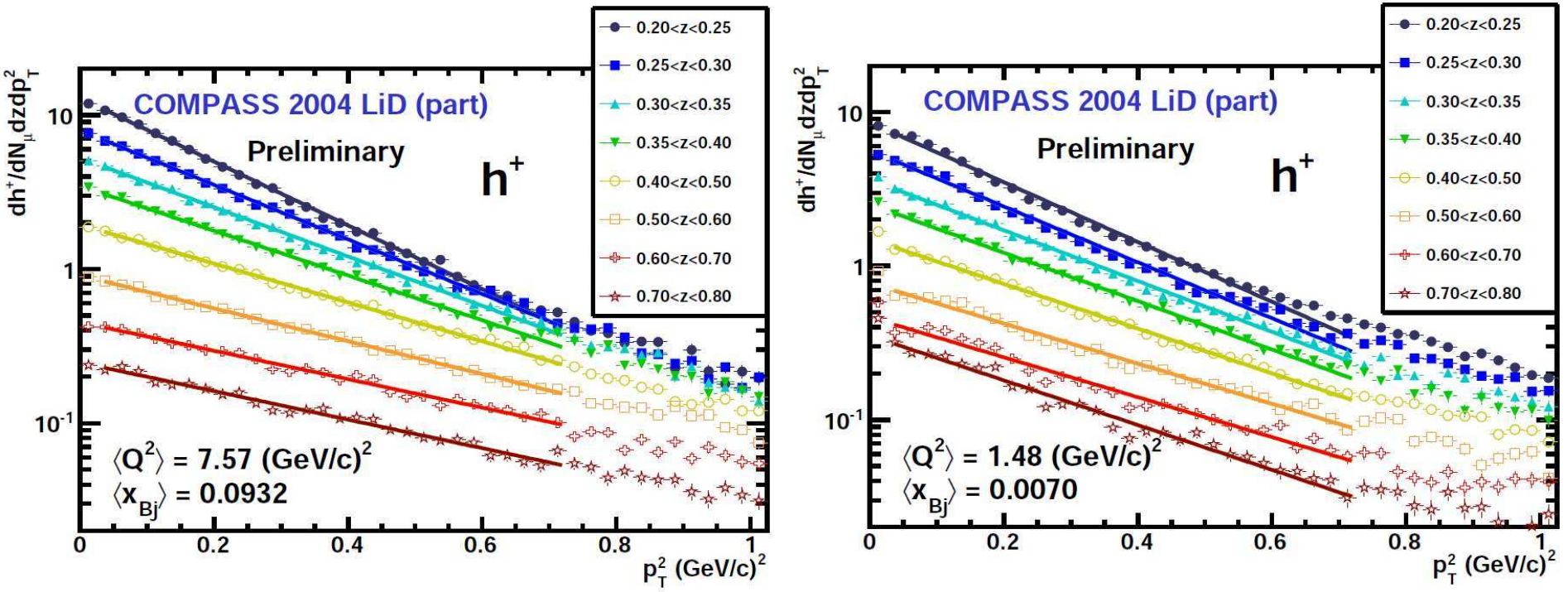
$\Rightarrow$ Good agreement for $\pi^{\pm}$, except at large z
$\Rightarrow$ Large deviations for $K^{\pm}$

- Model uncertainty :
  LO, unpolarized $s(x)$ distribution, higher twist ?

Multiplicities *vs.* z



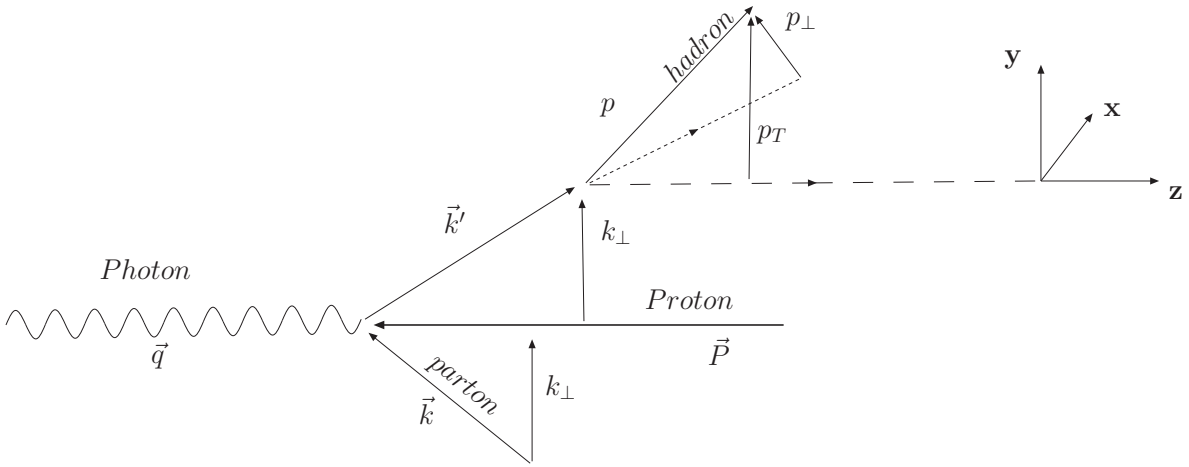
Multiplicities *vs.* p_T^2

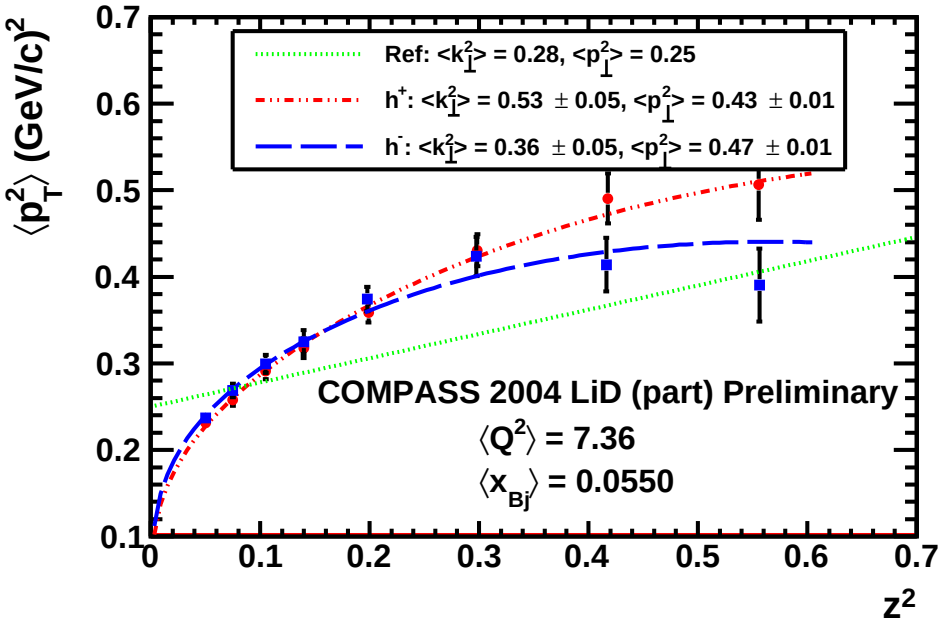


- Fit w/ $e^{-p_T^2/\langle p_T^2\rangle}$
- Restricted p_T range : avoid NLO pQCD processes.

Work by J.F. Rajotte and Nour Makke

p_T in terms of parton $k_\perp$ and fragmentation $p_\perp$





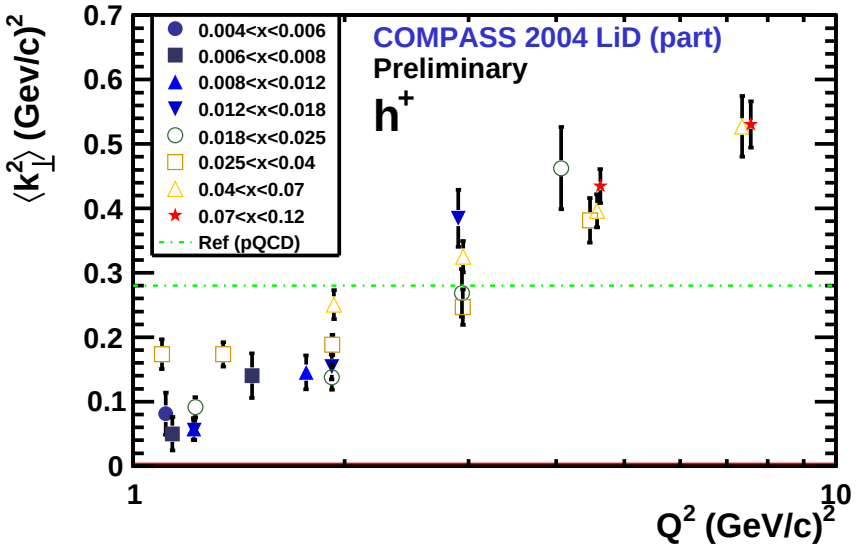
$$\langle p_T^2 \rangle = \langle p_\perp^2 \rangle + z^2 \langle k_\perp^2 \rangle$$

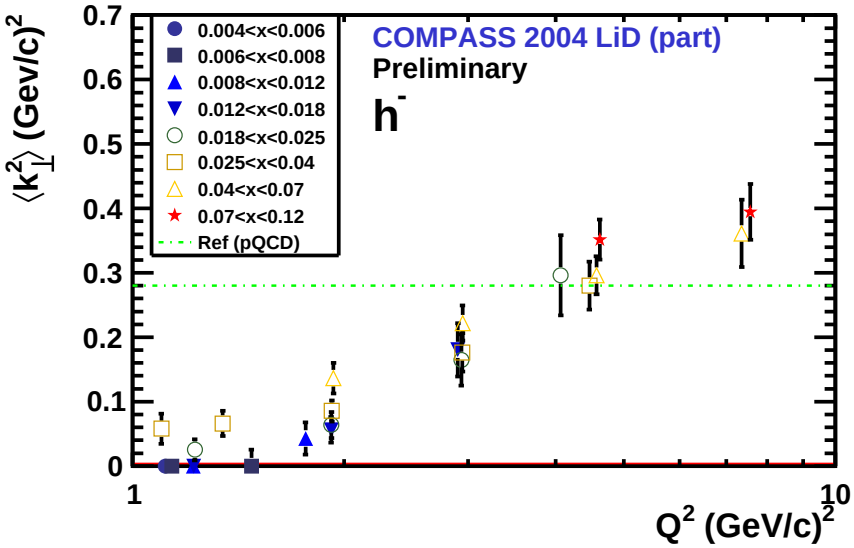
Anselmino et al., PRD ***71****, 2005*

$$\langle p_T^2 \rangle = z^\alpha (1-z)^\beta \langle p_\perp^2 \rangle + z^2 \langle k_\perp^2 \rangle$$

$$\alpha = 0.5, \beta = 0.4$$

$k_\perp$ as a function of kinematics





- $\langle k_\perp^2 \rangle$ increases w/ Q^2
- $\langle k_\perp^2 \rangle$ for h^+ higher than for h^-

Outlook

- COMPASS multiplicities to be included in next DSS global fit.
  - Provide data at lower x and higher Q^2

  $\Rightarrow$ Better constrain D^K

  $\Rightarrow$ Confirm $D_{\bar{s}}^{K^+} \gg$?

  - *Also Final HERMES et e^+e^- from Belle/BaBar*

- Extract FF at LO in pQCD from COMPASS data alone

- More precision on A_1^p from 2011 data

- 2012 DVCS test run on a proton target

  $\Rightarrow$ Multiplicity data complementing those on isoscalar LiD target.