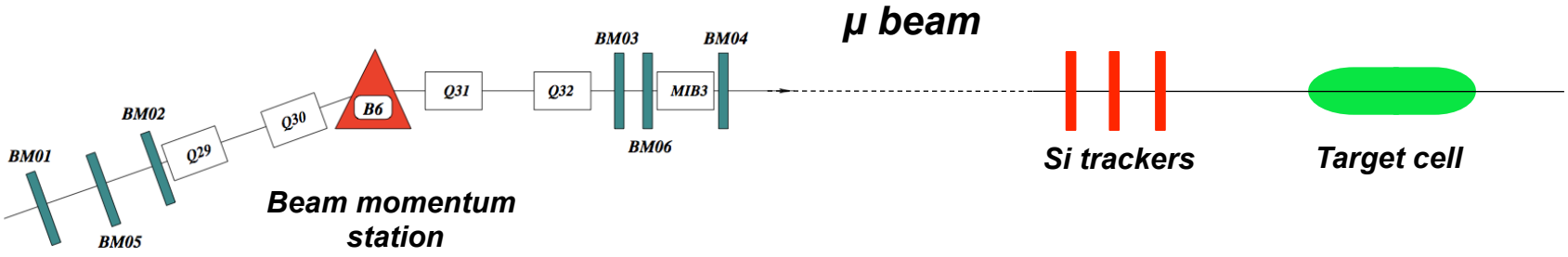
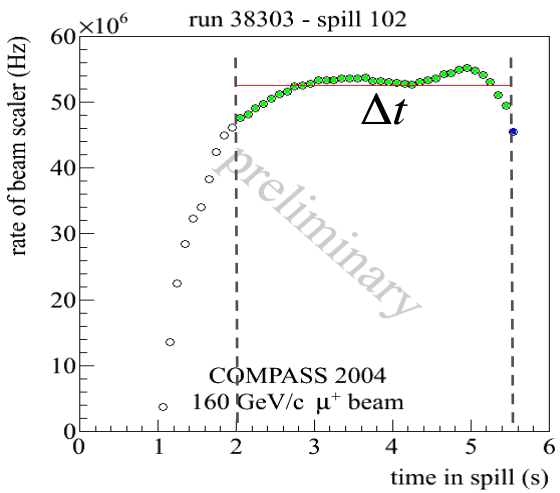
Hadron production cross section and multiplicities at COMPASS

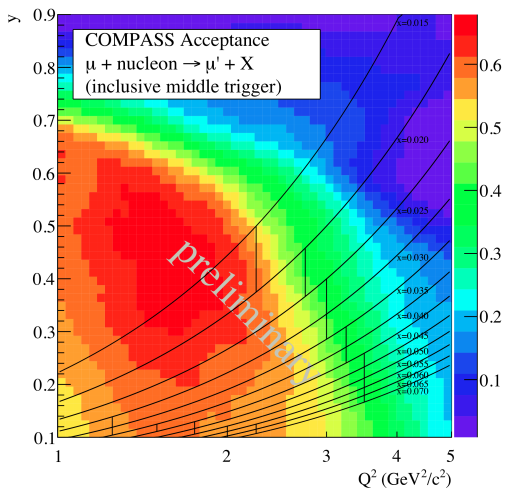
1. Absolute cross section measurements
2. $d\sigma/dp_T$ at low $Q^2 \rightarrow$ test of NLO pQCD
3. dN^h/dp_T^2 at high $Q^2 \rightarrow$ intrinsic $\langle k_T^2 \rangle$
4. $dN^{(h=K)}/dxdz \rightarrow D_s^K$ for Δs extraction
5. Conclusion

Absolute cross sections at COMPASS

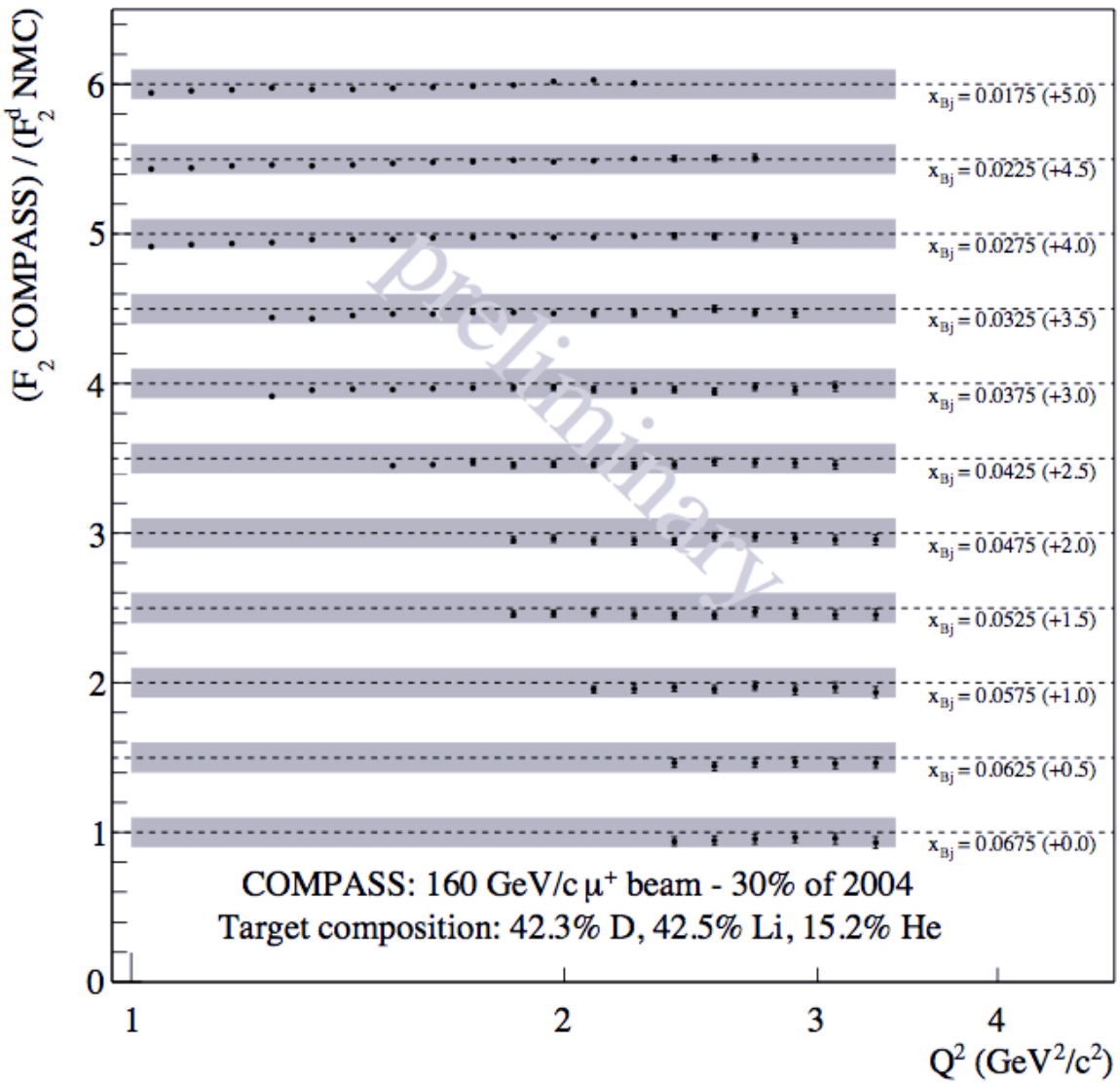


$$\sigma \propto \frac{N_{evts}}{Lumi.Acceptance} \quad ; \quad L = \Phi_{beam} . N_{target} \; ; \quad \Phi_{beam} = \frac{N_{beam\ tracks}}{\Delta t . N_{random}}$$



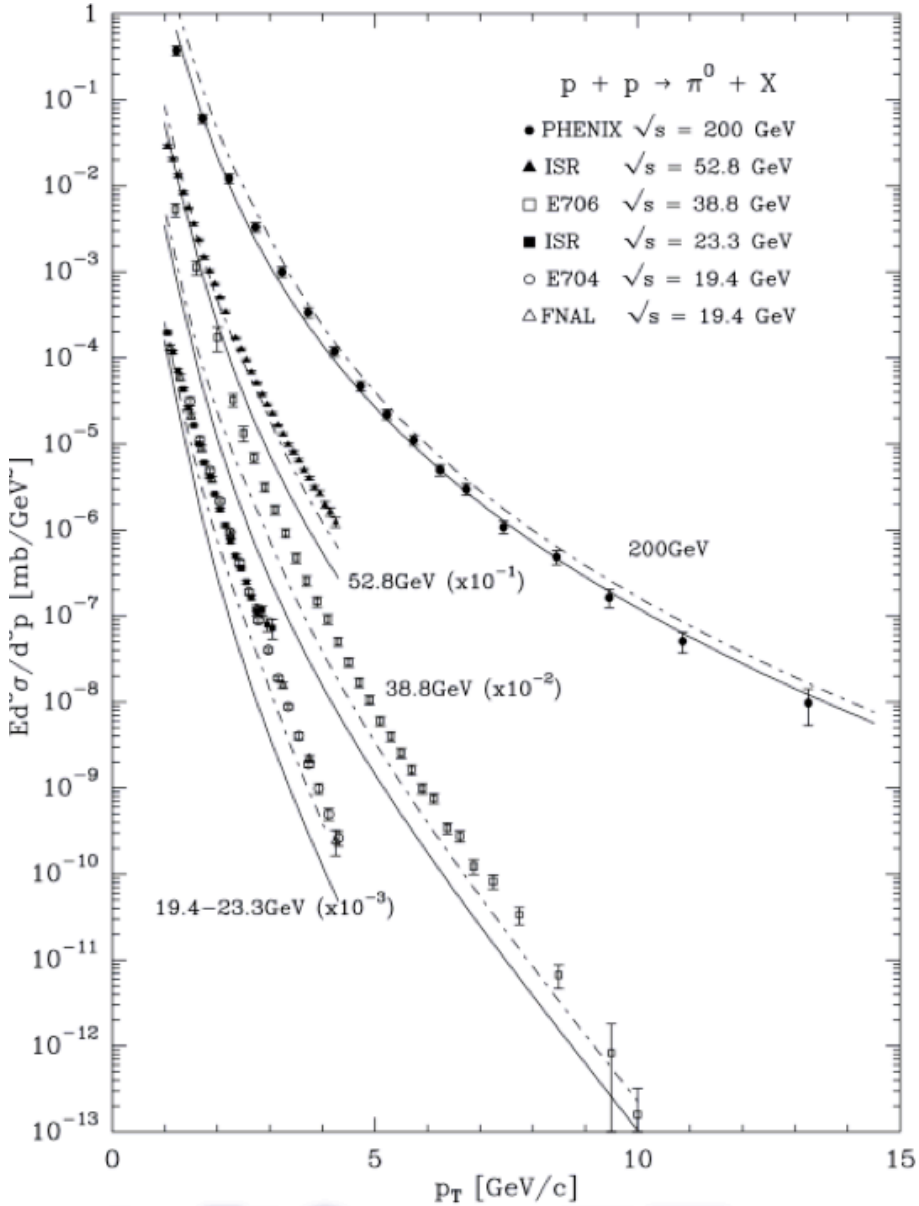


Cross section: determination of F_2



- determination of $F_2(x, Q^2)$
- part of 2004 LiD data
- one subtrigger
- Q^2 from 1 to 3 $(\mathrm{GeV}/c)^2$, $0.015 < x < 0.07$
- rather flat acceptance
- low rad. corr. $(y < 0.5)$
- shaded areas correpond to 10% luminosity error
- comparison to **NMC F_2 parametrisation**

Hadron production Xsection: test of pQCD



π^0 Cross-Sections at $\eta_{cm} = 0$ Experiment vs Theory

- $\sqrt{s}$=200 GeV (RHIC) Agreement
- $\sqrt{s}$=52.8 GeV (ISR) Agreement (scale dependent)
- $\sqrt{s}$=38.8 GeV (E706) Disagreement
- $\sqrt{s}$=19.4 GeV (FNAL/E704) Disagreement

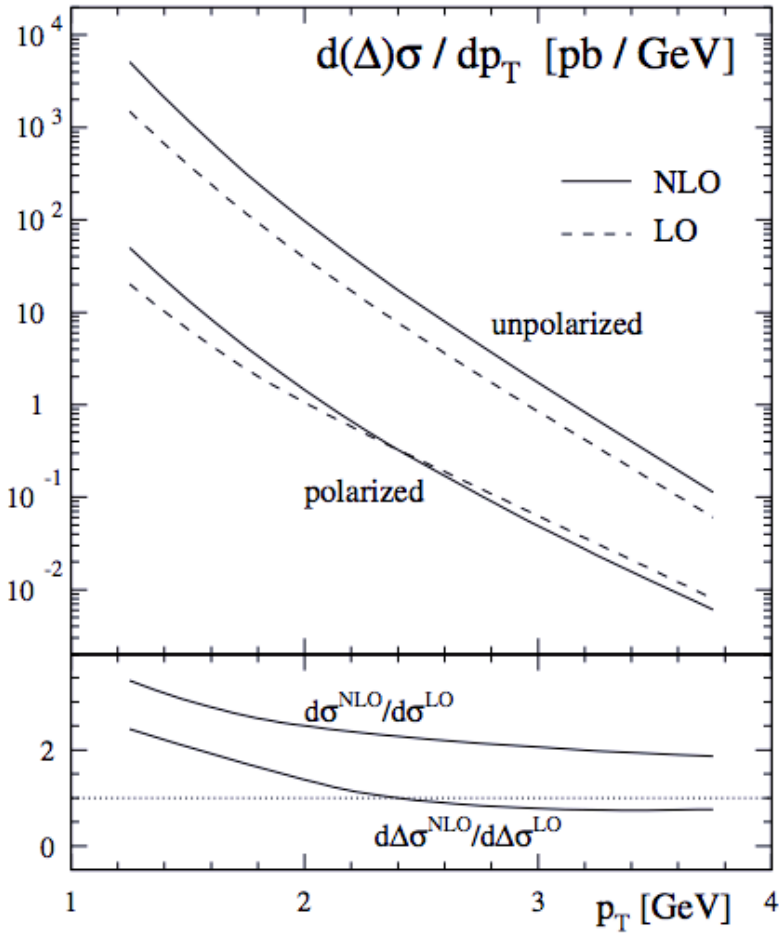
Disagreement at lower center of mass energies
Observed in p+p data

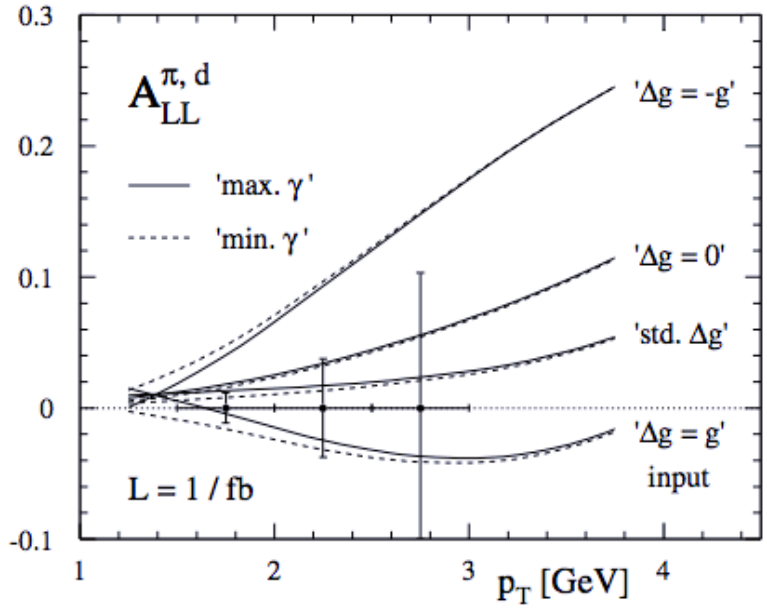
→Work needed to understand lower energies?

Bourrely et al, Eur.Phys.J.C36:371-374,2004

γ-production of hadrons at high $p_T \rightarrow \Delta G/G$

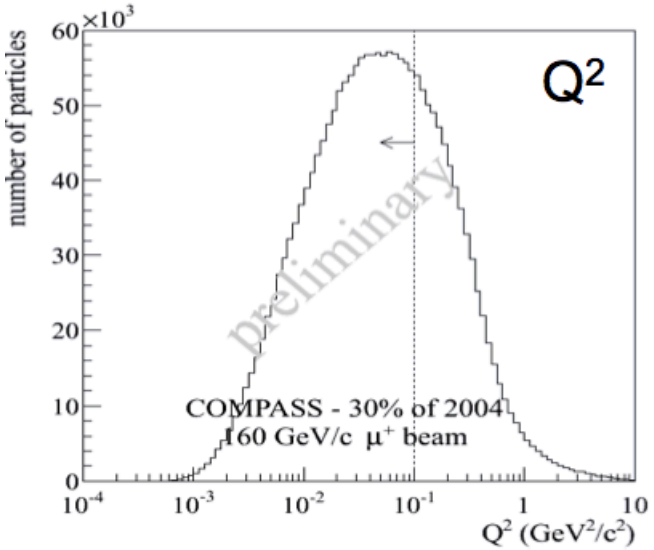
Projections by Jäger et al. for COMPASS with 1 fb^{-1}

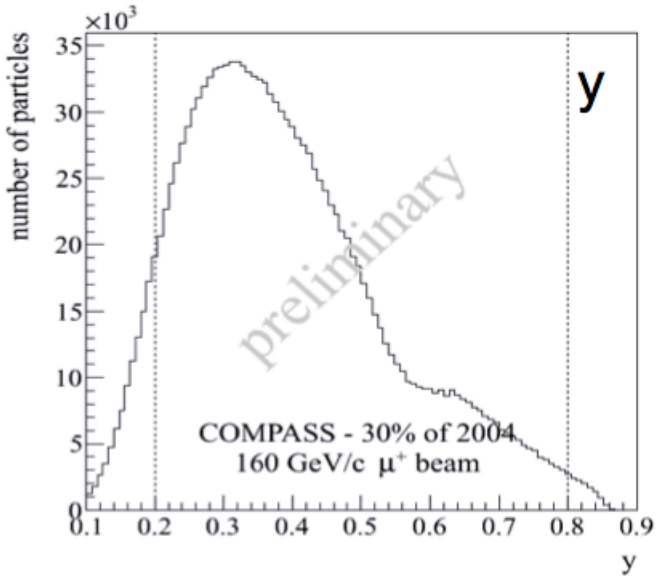


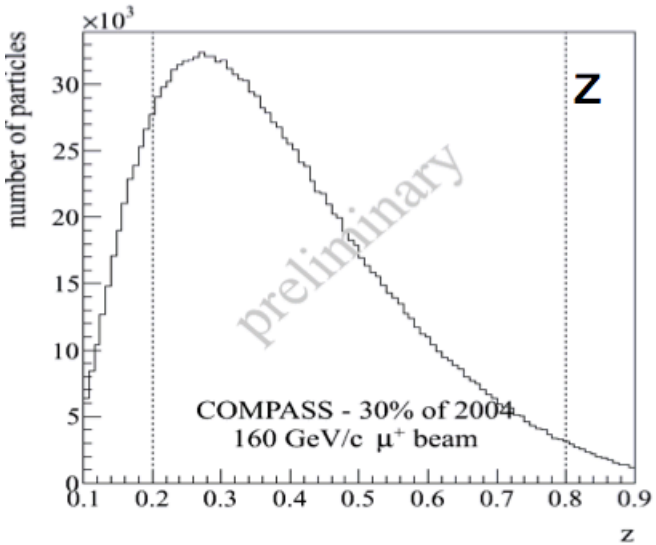


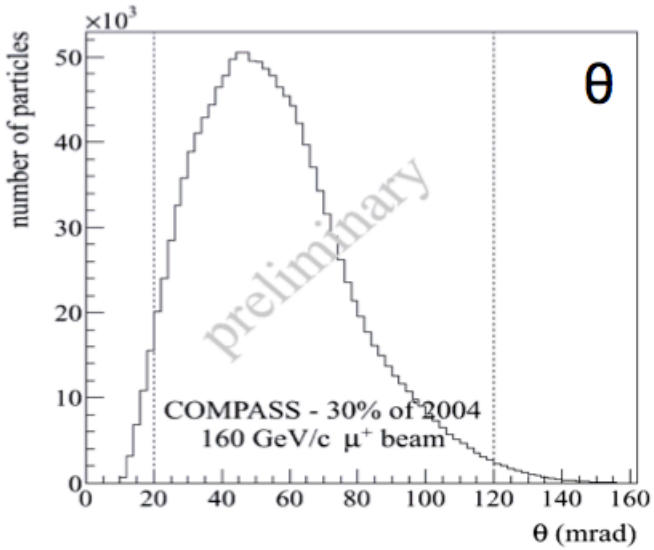
B. Jäger et al., Eur. Phys. J. C **44**, (2005) 533

Hadrons at high p_T : "acceptance"





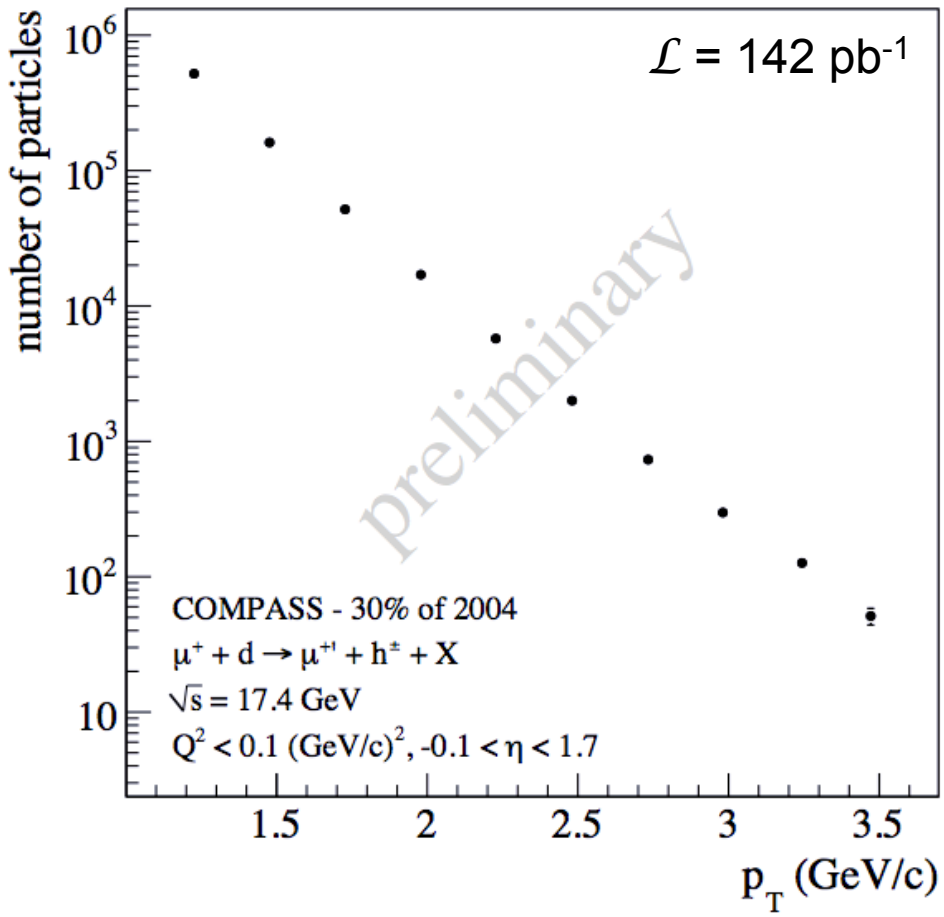




The kinematic cuts:

- Q2 < 0.1
- Y: From 0.2 to 0.8
- Z: 0.2~0.8
- θ (Scattering angle): 20 - 120mrad
  → translates to $-0.1 < \eta_{cm} < 1.7$
- pT >1 GeV/c

Yield for all hadrons at high p_T

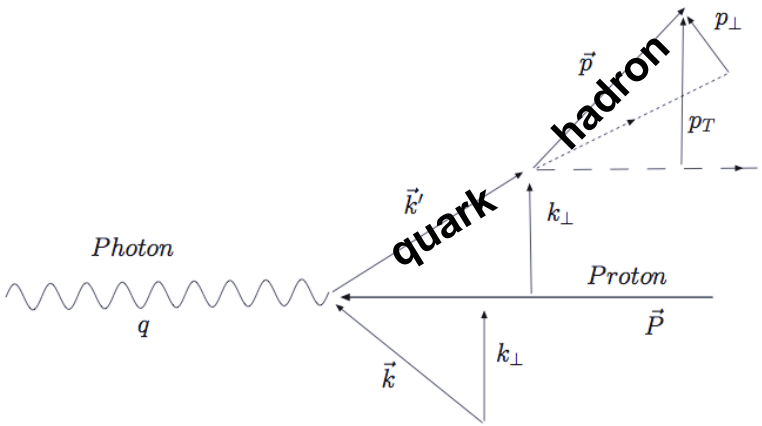


MC simulations of possible backgrounds at high p_T still underway

SIDIS: hadron transverse distributions

At $O(k_\perp/Q^2)$, SIDIS X section:

$$\frac{d^5\sigma^{\mu P\to\mu'+h+X}}{dx_{Bj}dQ^2dzd^2\vec{p}_T} \approx \sum_q e_q^2 \int d^2\vec{k}_\perp f_q(x_{Bj},k_\perp)\frac{d\hat{\sigma}^{\mu q\to\mu q}}{dQ^2}D_q^h(z,\vec{p}_\perp)$$



Asumming gaussian $k_\perp$ and $p_\perp$ dependence:

$$f_q(x,k_\perp) = f_q(x)\frac{1}{\pi\langle k_\perp^2\rangle}e^{-k_\perp^2/\langle k_\perp^2\rangle}$$

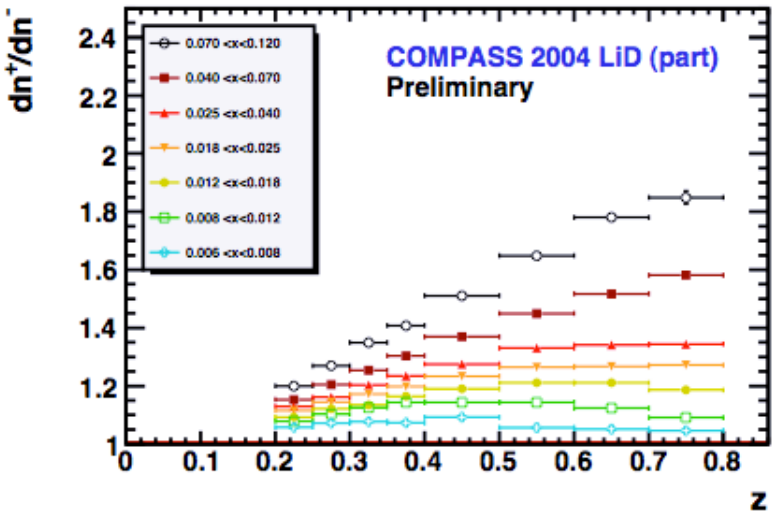
$$D_q^h(z,\vec{p}_\perp) = D_q^h(z)\frac{1}{\pi\langle p_\perp^2\rangle}e^{-p_\perp^2/\langle p_\perp^2\rangle}$$

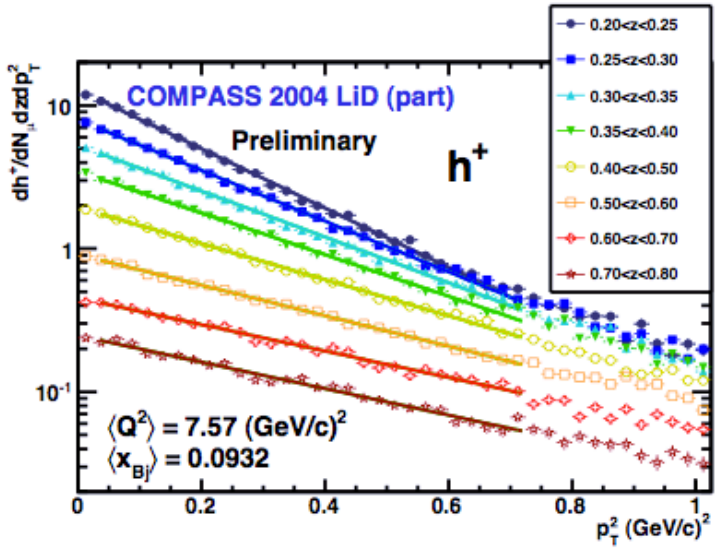
$$\longrightarrow \quad \frac{d^4\sigma^{\mu P\to\mu+h+X}}{dx_{Bj}dQ^2dzdp_T^2} \propto \sum_q e_q^2 f_q(x_{Bj})D_q^h(z)\frac{e^{-p_T^2/\langle p_T^2\rangle}}{\pi\langle p_T^2\rangle}$$

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

Hadron p_T^2 distributions

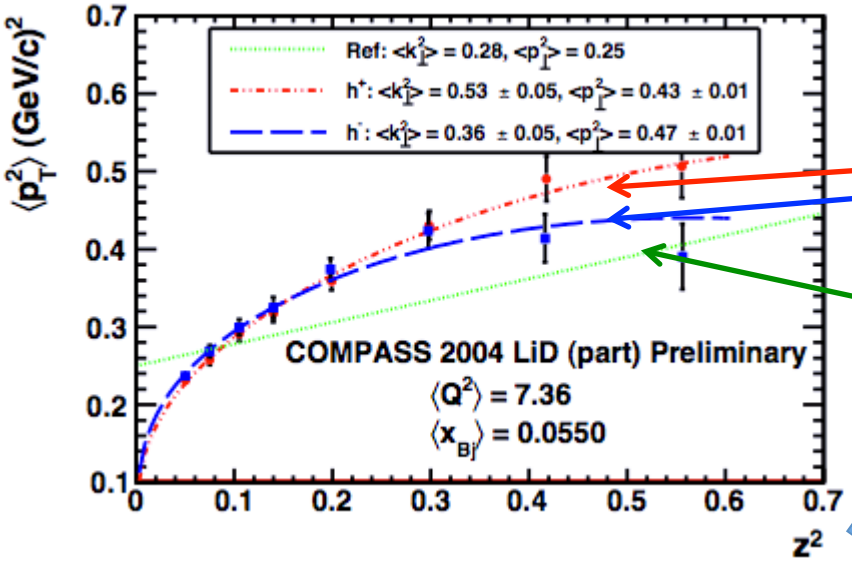
Using the $e^{-p_T^2/\langle p_T^2 \rangle}$ dependence of the cross section and the relation we fit the p_T^2 distributions with a Gaussian to get $\langle p_T^2 \rangle$.





The fits are limited to small p_T^2 in order to stay away from pQCD where the model is known to fail.

Extracted p_T^2 and $k_\perp^2$

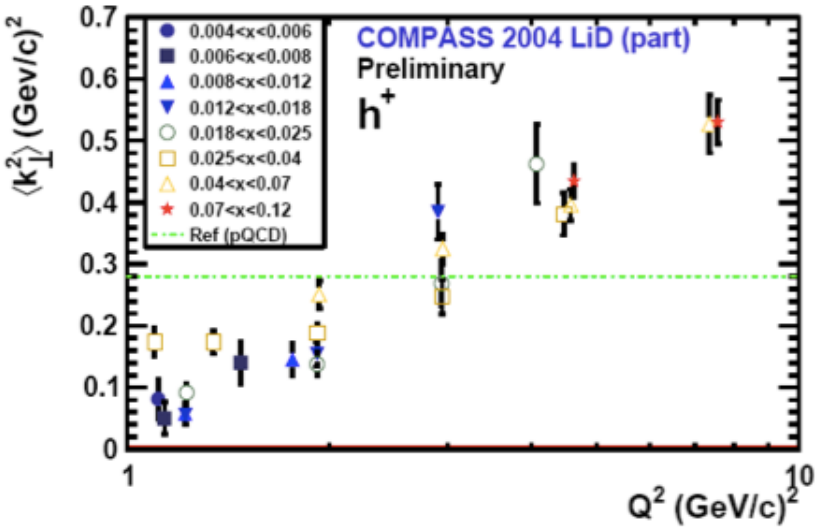


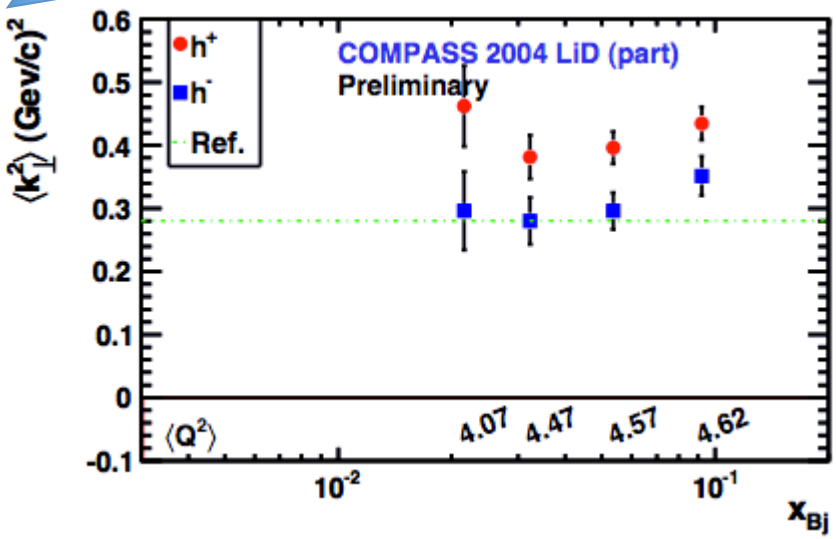
$$\langle p_T^2 \rangle = z^\alpha (1-z)^\beta \langle p_\perp^2 \rangle + z^2 \langle k_\perp^2 \rangle.$$

α=0.5; β=1.5

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

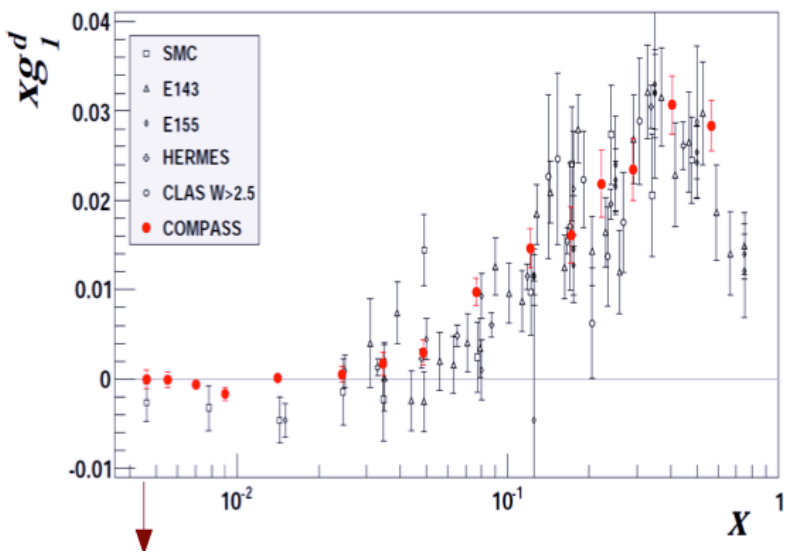
$\langle k_\perp^2 \rangle$(h+) ≈ $\langle k_\perp^2 \rangle$(h-) + 0.1 (GeV/c)²





Polarized strange quark distribution: DIS

$$A_1(x,Q^2) = \frac{\sigma_{\uparrow\downarrow}-\sigma_{\uparrow\uparrow}}{\sigma_{\uparrow\downarrow}+\sigma_{\uparrow\uparrow}} \approx \frac{\sum_q e_q^2 \Delta q(x,Q^2)}{\sum_q e_q^2 q(x,Q^2)} = \frac{g_1(x,Q^2)2x(1+R)}{F_2(x,Q^2)}$$

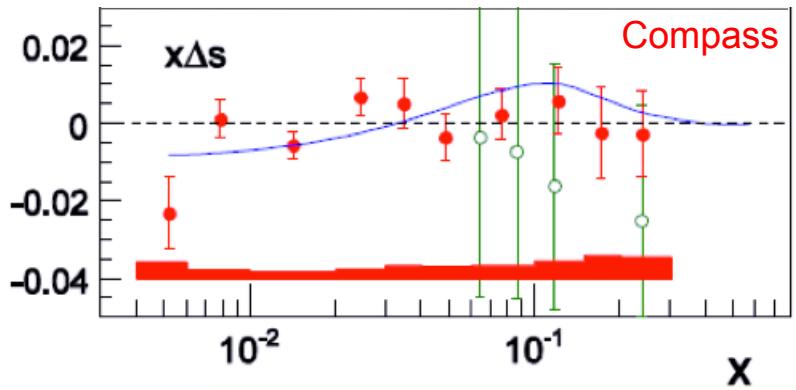


NLO QCD fits to g_1 (p,d, He^3)
PLB 647(2007)8

$$(\Delta s + \Delta \bar{s}) = \frac{1}{3}(\Delta\Sigma^{\overline{MS}} - a_8) = -0.08 \pm 0.01(\mathbf{stat}) \pm 0.02(\mathbf{syst})$$

Polarized strange quark distribution: SIDIS

$$A_1^{h\,(p/d)}(x,z,Q^2) \approx \frac{\sum_q e_q^2 \Delta q(x,Q^2) D_q^h(z,Q^2)}{\sum_q e_q^2 q(x,Q^2) D_q^h(z,Q^2)}$$



Unpolarized PDF: MRST04
F.F: DSS parametrization, $\Delta s = \Delta \bar{s}$

PLB 693(2010)227

$$\Delta s(\mathbf{SIDIS}) = -0.01 \pm 0.01(\mathbf{stat}) \pm 0.01(\mathbf{syst}) \quad @ \quad 0.003 < x < 0.3$$

SIDIS Δs sensitivity to D_q^K F.F.

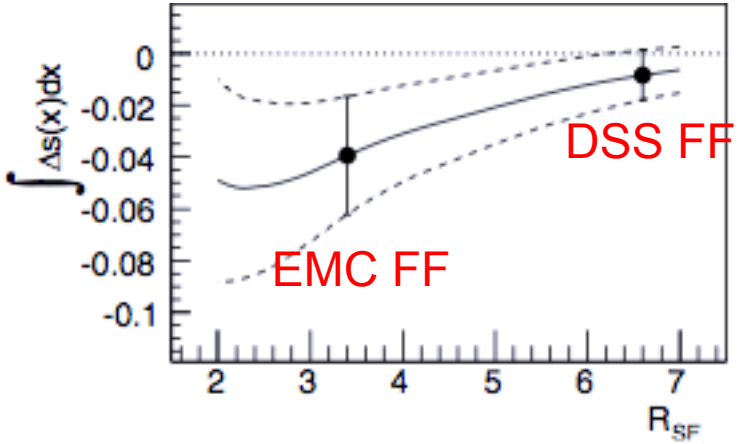
PLB 693(2010)227 (Compass)

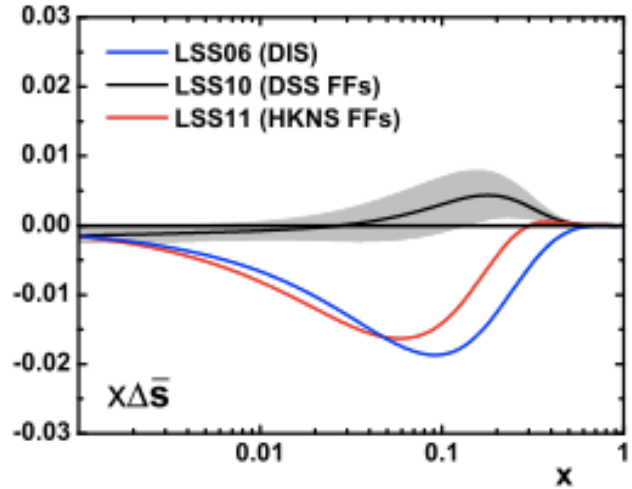
- $K^{\pm}$ asymmetries from deuteron data

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

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

- $R_{UF} = \frac{\int D_d^{K^+}(z)\mathrm{d}z}{\int D_u^{K^+}(z)\mathrm{d}z}$, $R_{SF} = \frac{\int D_{\bar{s}}^{K^+}(z)\mathrm{d}z}{\int D_u^{K^+}(z)\mathrm{d}z}$





LSS: ArXiv:1103.5979

Large sensitivity of Δs to « strange to favoured » FF ratio
→ try to extract R_{SF} from Kaon multiplicities

D_s^K/D_u^K from hadron multiplicities

Attempt to fit FFs from M^{K^+}, M^{K^-} in several bins of x

$$M^{K^{+,-}}(x,z) = \frac{\sum_q e_q^2 \left[q(x) D_q^{K^{+,-}}(z) + \bar{q}(x) D_{\bar{q}}^{K^{+,-}}(z) \right]}{\sum_q e_q^2 \left[q(x) + \bar{q}(x) \right]} \quad (1)$$

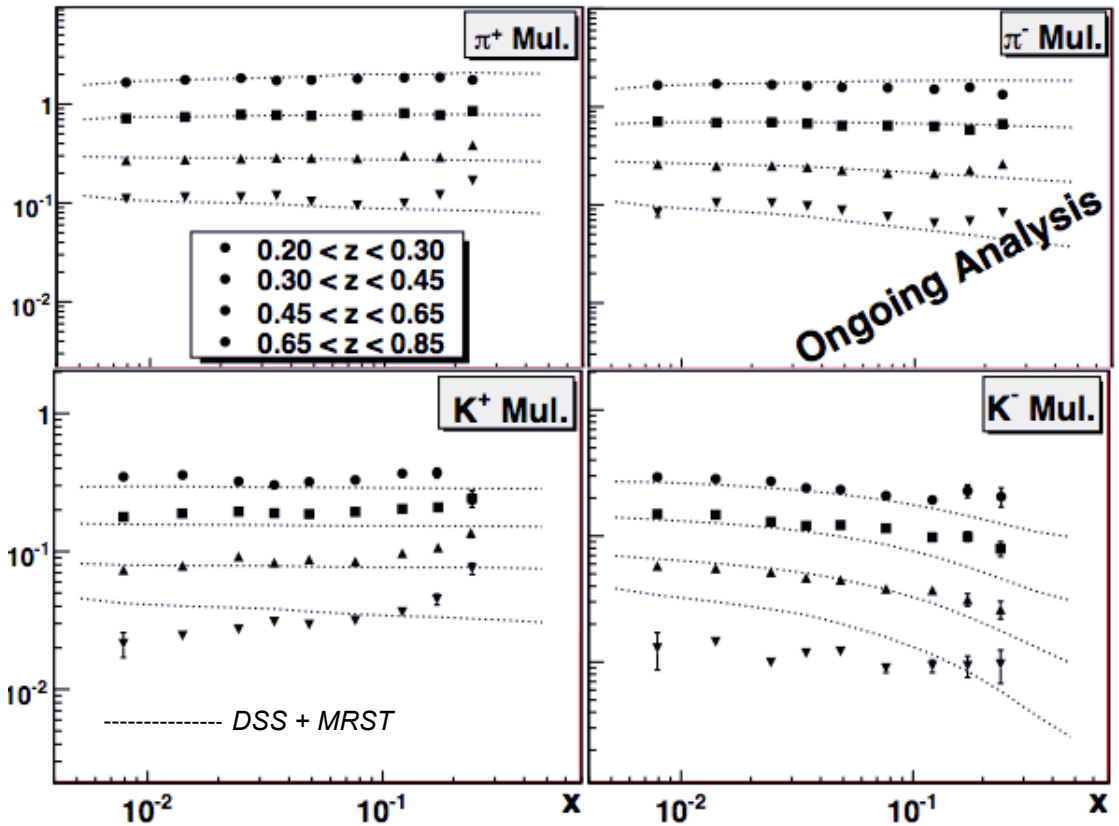
Not possible, because $D_q^K = D_q^K(z,Q^2)$, and thus depend on x

Instead:
-Extract R_{UF} and R_{SF} as a function of D_{fav}
-Search limits and/or optimal value of D_{fav}

$$M^{K+} \cdot f_2 = D_{fav} \left[4(val + sea) + (val + 6sea + 2s) R_{UF} + 2s R_{SF} \right]$$

$$M^{K-} \cdot f_2 = D_{fav} \left[4sea + (5val + 6sea + 2s) R_{UF} + 2s R_{SF} \right]$$

D_s^K/D_u^K from hadron multiplicities



- Data 2004 W31
- Range: $0.01 < x < 0.3$, $2.0 < Q^2 < 33$ GeV/c
- $K^{+,-}$ identified by RICH
- corrected for momentum cut ($10 < P < 50$ GeV/c)
- corrected for angular acceptance

Conclusions

•First absolute cross sections from COMPASS at 10% syst. level

•Unpolarized $d\sigma/dp_T$ at $Q2 < 0.1$ $(GeV/c)^2$

Test of NLO pQCD calculations at COMPASS energies

→ $\Delta G/G$ from single high p_T hadron asym. at $Q^2 < 1$ $(GeV/c)^2$

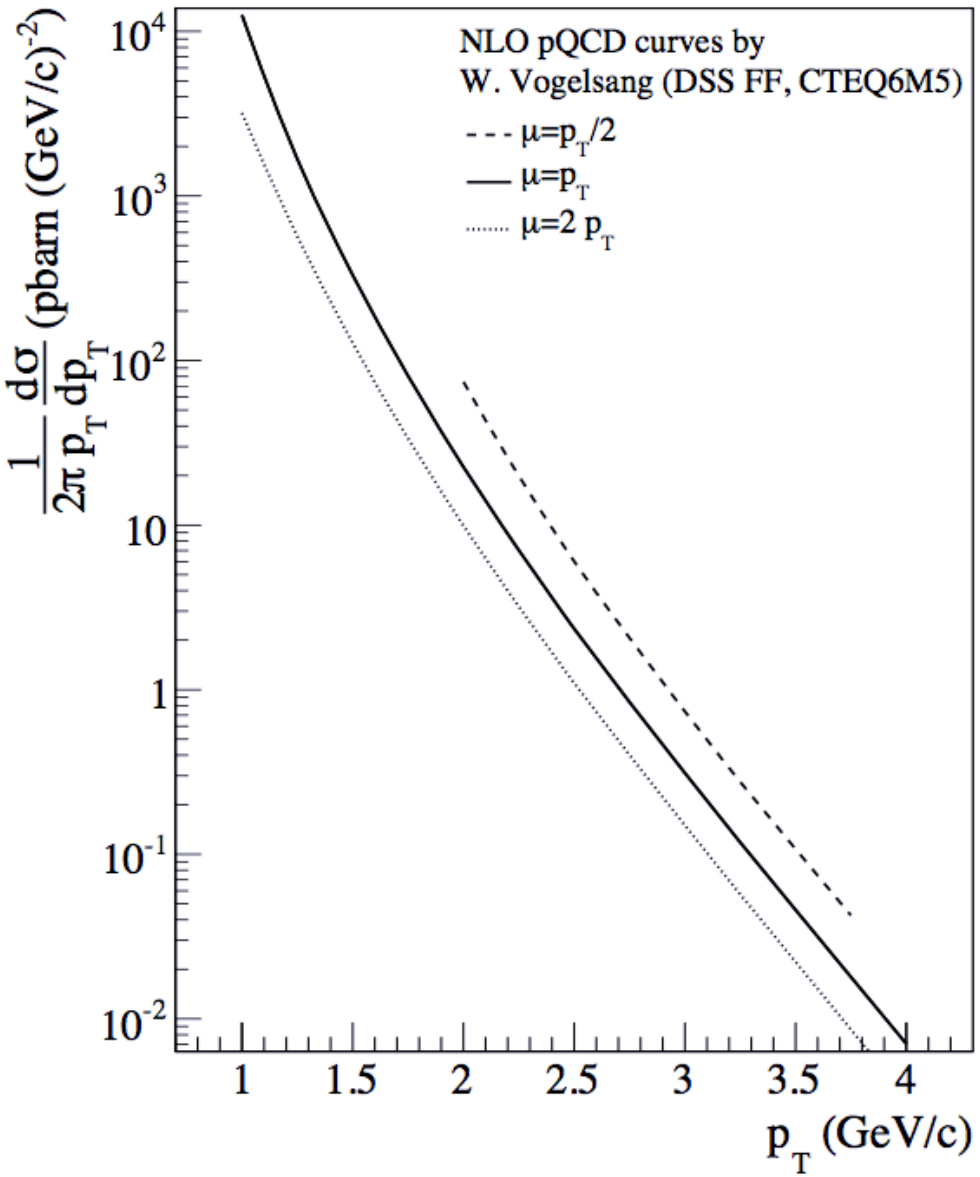
•p_T^2 distributions for hadron production over large z and Q^2 range:

$0.2 < z < 0.8$, 1 $(GeV/c)^2 < Q^2 < 33$ $(GeV/c)^2$

→ obtention of quark intrinsic transverse momentum $\langle k_\perp \rangle$

•Tentative extraction of $R_{SF}=D_s^K/D_u^K$ from K multiplicities

→ better constrain Δs obtained from SIDIS

Spares

NLO pQCD results for hadrons at high p_T