Other Physics Opportunities in Future Drell-Yan Experiments

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Outline

- “Intrinsic sea-quarks” of the nucleons.
- Flavor dependence of the EMC effect.
- Equalities and inequalities in Drell-Yan azimuthal angular distributions.
- Flavor and *x*-dependence of quark intrinsic transverse momentum distributions.
- Drell-Yan and quarkonium duality.

Sea-quark flavor asymmetry and the "intrinsic" quark sea

In the 1980's, Brodsky et al. (BHPS) suggested the existence of "intrinsic" charm

$$|p\rangle = P_{3q}\,|uud\rangle + P_{5q}\,|uudQ\bar{Q}\rangle + \cdots\cdots$$

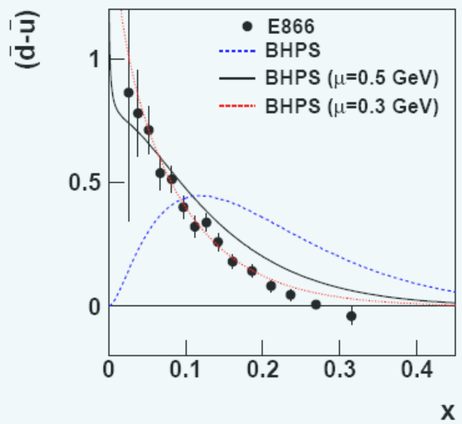
The $|uudc\bar{c}\rangle$ intrinsic-charm can contribute to charm-production at large x_F

No conclusive experimental evidence for intrinsic-charm so far

Are there experimental evidences for the intrinsic $|uudu\bar{u}\rangle, |uudd\bar{d}\rangle, |uuds\bar{s}\rangle$ 5-quark states ?

$$(P_{5q}^{uudQ\bar{Q}} \sim 1/m_Q^2)$$

Comparison between the $\bar{d}(x)-\bar{u}(x)$ data and the intrinsic 5-q model



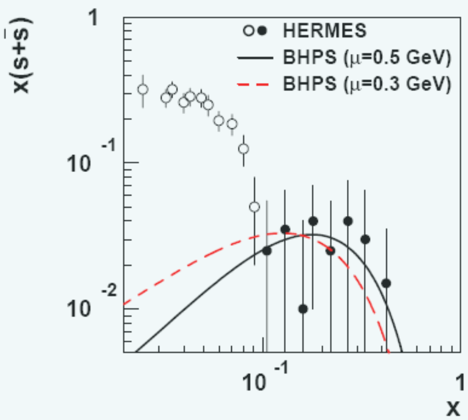
E866 data measured at $\langle Q^2 \rangle$ = 54 GeV^2

Need to evolve the 5-q model prediction from the initial scale μ to Q^2=54 GeV^2

(W. Chang and JCP arXiv:1102.5631, to appear in PRL)

$$P_5^{uudd\bar{d}} - P_5^{uudu\bar{u}} = \int_0^1 (\bar{d}(x) - \bar{u}(x))\,dx = 0.118$$

Comparison between the $s(x)+\bar{s}(x)$ data with the intrinsic 5-q model



$s(x)+\bar{s}(x)$ from HERMES kaon SIDIS data at $\langle Q^2\rangle = 2.5\ \mathrm{GeV}^2$

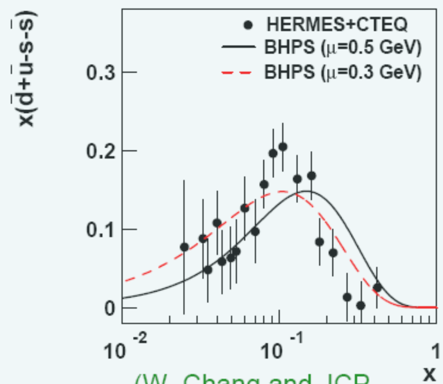
Two distinct shapes in the x distribution: extrinsic ($g \rightarrow s\bar{s}$) and intrinsic $uuds\bar{s}$ stat

Assume $x > 0.1$ data are from the intrinsic $uuds\bar{s}$ 5-quark state

(W. Chang and JCP arXiv:1102.5631, to appear in PRL)

$$P_5^{uuds\bar{s}} = 0.032$$

Comparison between the $\bar{u}(x)+\bar{d}(x)-s(x)-\bar{s}(x)$ data with the intrinsic 5-q model



$\bar{d}(x)+\bar{u}(x)$ from CTEQ6.6

$s(x)+\bar{s}(x)$ from HERMES

$$\int_0^1 (\bar{u}(x)+\bar{d}(x)-s(x)-\bar{s}(x))\,dx = P_5^{uudd\bar{d}} + P_5^{uudu\bar{u}} - 2P_5^{uuds\bar{s}}$$

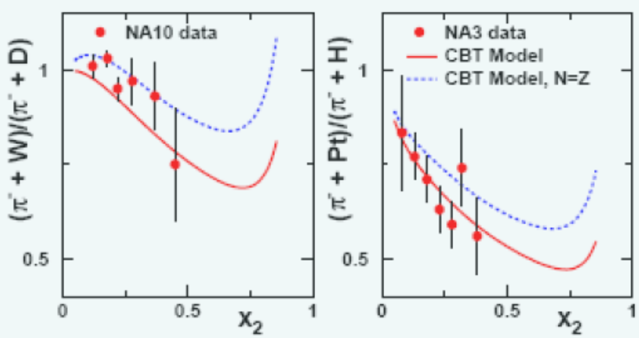
(W. Chang and JCP arXiv:1102.5631)

$$P_5^{uudd\bar{d}} = 0.248,\ P_5^{uudu\bar{u}} = 0.130,\ P_5^{uuds\bar{s}} = 0.032$$

Kaon-induced Drell-Yan could probe strange quark sea

Pion-induced Drell-Yan and the flavor-dependent EMC effect

$$\frac{\sigma^{DY}(\pi^- + A)}{\sigma^{DY}(\pi^- + D)} \approx \frac{u_A(x)}{u_D(x)}$$

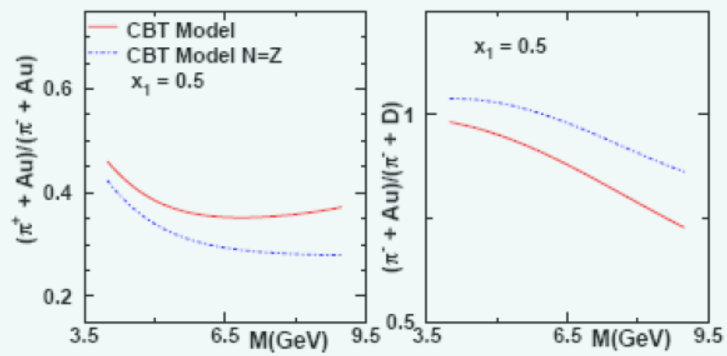


Red (blue) curves correspond to flavor-dependent (independent)

(Dutta, JCP, Cloet, Gaskell, arXiv: 1007.3916)

Pion-induced Drell-Yan and the flavor-dependent EMC effect

$$\frac{\sigma^{DY}(\pi^+ + A)}{\sigma^{DY}(\pi^- + A)} \approx \frac{d_A(x)}{4u_A(x)}; \qquad \frac{\sigma^{DY}(\pi^- + A)}{\sigma^{DY}(\pi^- + D)} \approx \frac{u_A(x)}{u_D(x)}$$

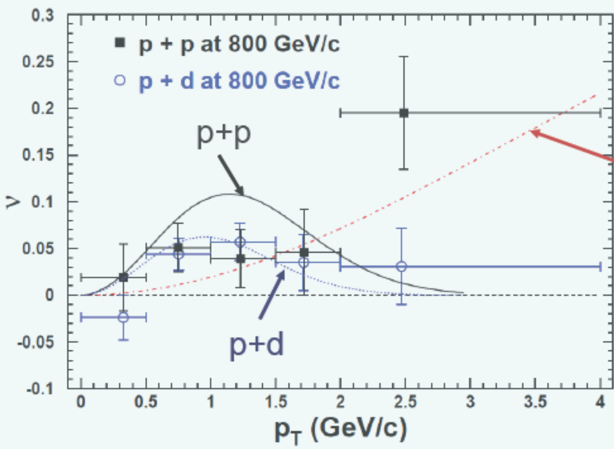


160 GeV pion beam

Future Drell-Yan data with pion beams could provide important new information

Results on cos2Φ Distribution in p+p Drell-Yan

L. Zhu, J.C. Peng, et al., PRL 102 (2009) 182001



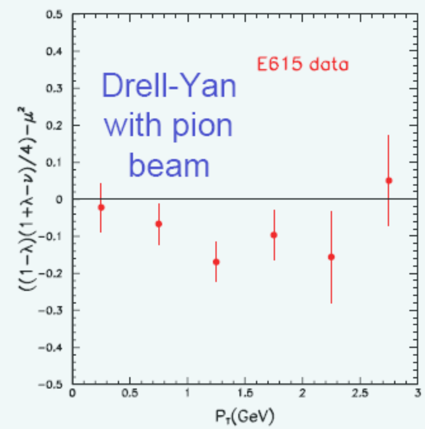
QCD
(Boer, Vogelsang; Berger, Qiu, Rodriguez-Pedraza)

Combined analysis of SIDIS and D-Y by Melis et al.

More data are anticipated from future DY exps.

Is the $\mu^2 \leq (1-\lambda)(1+\lambda-\nu)/4$ inequality valid?

$$(1-\lambda)(1+\lambda-\nu)/4-\mu^2 \geq 0?$$



The inequality appears to be violated!

(Teryaev and JCP)

Our knowledge of D-Y azimuthal angular dependence is still incomplete (New Drell-Yan data are essential)

What do we know about the quark and gluon transverse momentum distributions?

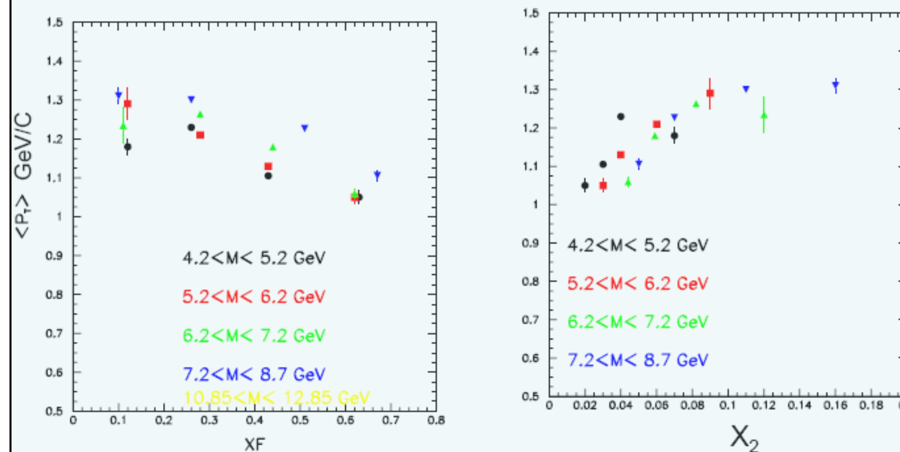
- Does the quark k_T distribution depend on x?
- Do valence quarks and sea quarks have different k_T distributions?
- Do u and d quarks have the same k_T distribution?
- Do nucleons and mesons have different quark k_T distribution?
- Do gluons have k_T distribution different from quarks?

• Important for extracting the TMD parton distribution

• Interesting physics in its own right

Possible x-dependent k_T-distributions

E866 p+d D-Y data (800 GeV beam)



$\langle p_T \rangle$ scale with x_2 ?

Analysis is ongoing. Future data at lower beam energies are essential