$W^{+/-}$, Z^0-Asymmetry Predictions

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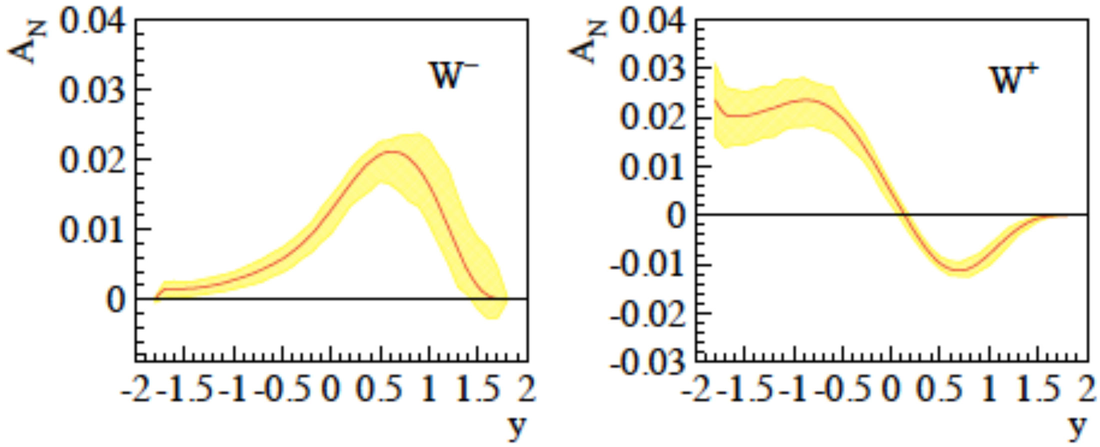
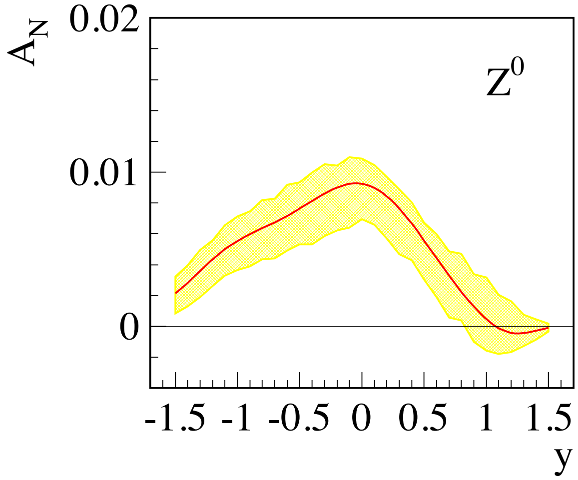
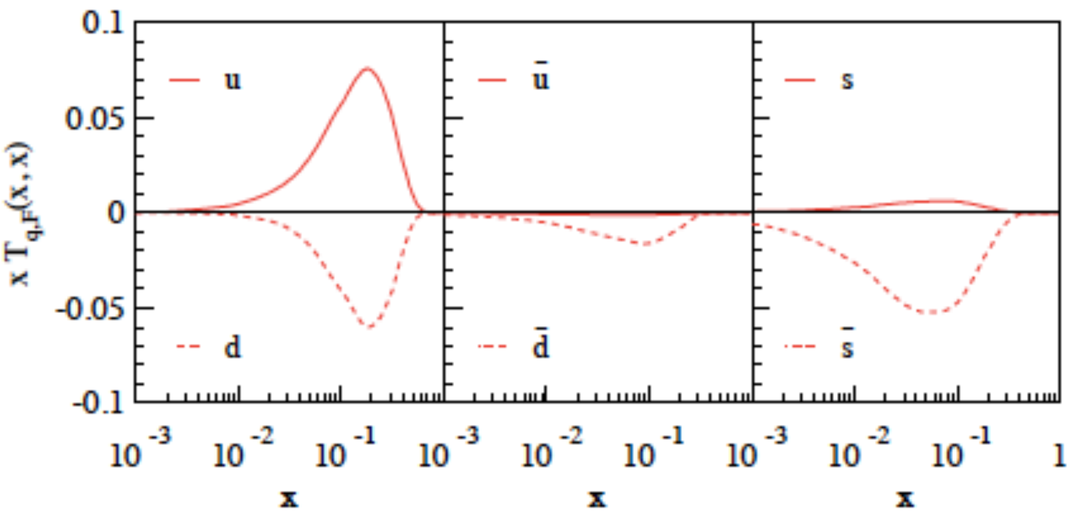
1. Asymmetry predictions from arXiv:1401.5078

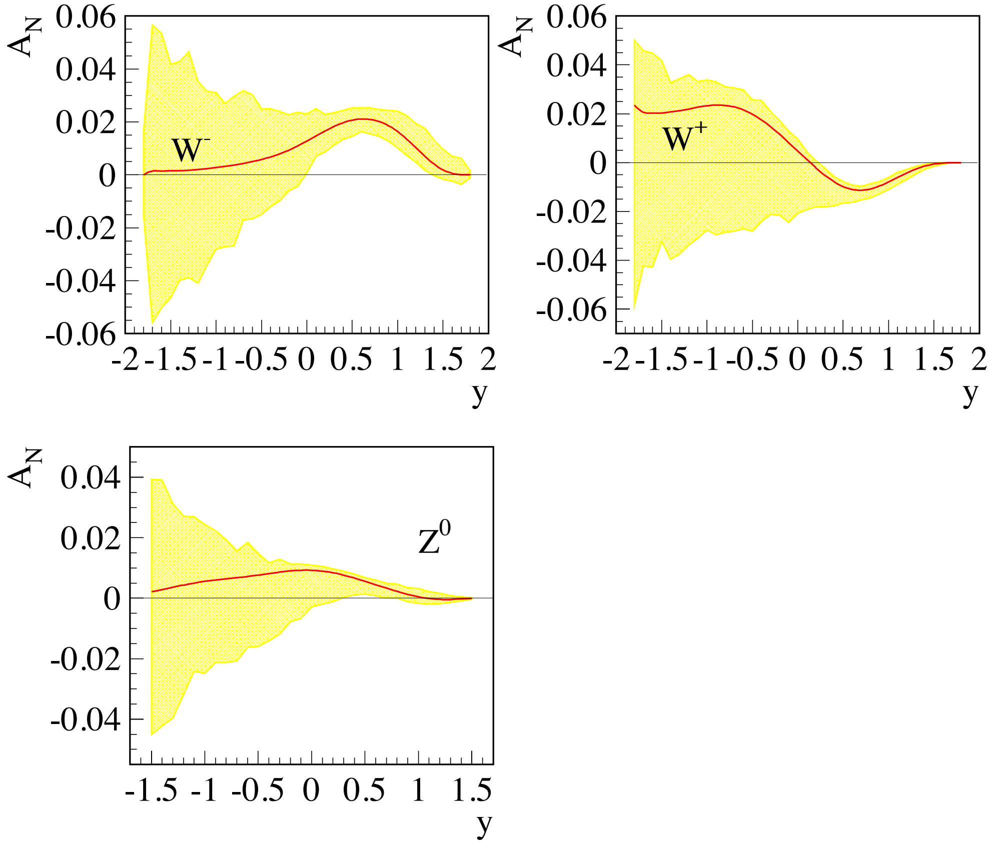
Below the asymmetries as originally calculated in Z. Kang et al. The sivers fct. is extracted from the SIDIS data, such the constrain to the sea-quarks is minimal.







ZhangBo was nice enough to develop a mechanism to allow for prediction with the positivity bound in the Twist-3-formalism. This procedure is described on the last page.



I think this shows that high precision A_N for $W^{+/-}$ and Z^0 can make a very nice impact on the Sivers fct. for sea-quarks. Zhangbo promised also to send us new calculations for direct photons in the next days.

Error band for W/Z Sivers asymmetry

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Explain a little bit on the positivity bound we used in the plots.

As I explained in the email, when we use the TMD evolution method closer to the traditional Collins-Soper-Sterman (CSS) method, it is not so easy to impose the usual positivity bound on the Sivers function. In our recent paper [1], we did use this method. As you can see from Eqs. (12) - (14) of Ref. [1], we expand the usual TMDs in terms of the corresponding Collinear functions: e.g., the Sivers function is expanded in terms of Qiu-Sterman function $T_{q,F}(x,x)$. In other words, the final formalism does not contain the TMD any more (only the collinear functions remain in the cross sections, see, e.g., Eq. (41) for Sivers asymmetry in SIDIS.

Nevertheless, it is still better to have something similar such that we could at least assess the uncertainty introduced by the sea quark Sivers functions: to be able to use the formalism in Ref. [1], apparently we need to derive something for Qiu-Sterman function $T_{q,F}(x,x)$. To do that, realize

$$T_{q,F}(x,x) = -\int d^2k_\perp \frac{|k_\perp|^2}{M} f_{1T}^{\perp,q}(x,k_\perp^2)|_{\rm SIDIS}. \tag{1}$$

Positivity bound for quark Sivers function is given by

$$\left|\frac{k_\perp}{M} f_{1T}^{\perp,q}(x,k_\perp^2)\right| \leq q(x,k_\perp^2) \tag{2}$$

Let us assume

$$q(x,k_\perp^2) = q(x)\frac{1}{\pi\langle k_\perp^2\rangle} e^{-k_\perp^2/\langle k_\perp^2\rangle} \tag{3}$$

Plug Eqs. (2) and (3) into (1), we could derive

$$|T_{q,F}(x,x)| \leq q(x)\cdot\frac{\sqrt{\pi\langle k_\perp^2\rangle}}{2} \tag{4}$$

We would hope this equation holds true for any hard scale Q. Since $\langle k_\perp^2\rangle$ will increase (due to TMD evolution), the stringent constraint certainly comes from the initial scale Q_0. In our paper [1], at HERMES initial scale $Q_0^2 \approx 2.4$ GeV, we have $\langle k_\perp^2\rangle_{Q_0} = 0.38$ GeV^2. If we plug this in, we have

$$|T_{q,F}(x,x)| \leq q(x)\cdot 0.55 \text{ GeV} \tag{5}$$

This is the positivity bound I actually used in the uncertainty plots for W/Z asymmetries.

[1] M. G. Echevarria, A. Idilbi, Z. -B. Kang and I. Vitev, Phys. Rev. D **89**, 074013 (2014) [arXiv:1401.5078 [hep-ph]].