Status (critique) of TMD phenomenology

The phenomenological study of TMDs and their extraction from experimental data is reviewed, with attention to possible sources of uncertainties. The role of TMDs in different processes - SIDIS, e+e- and NN inclusive interactions - is discussed. Predictions and suggestions for Drell-Yan measurements are given.

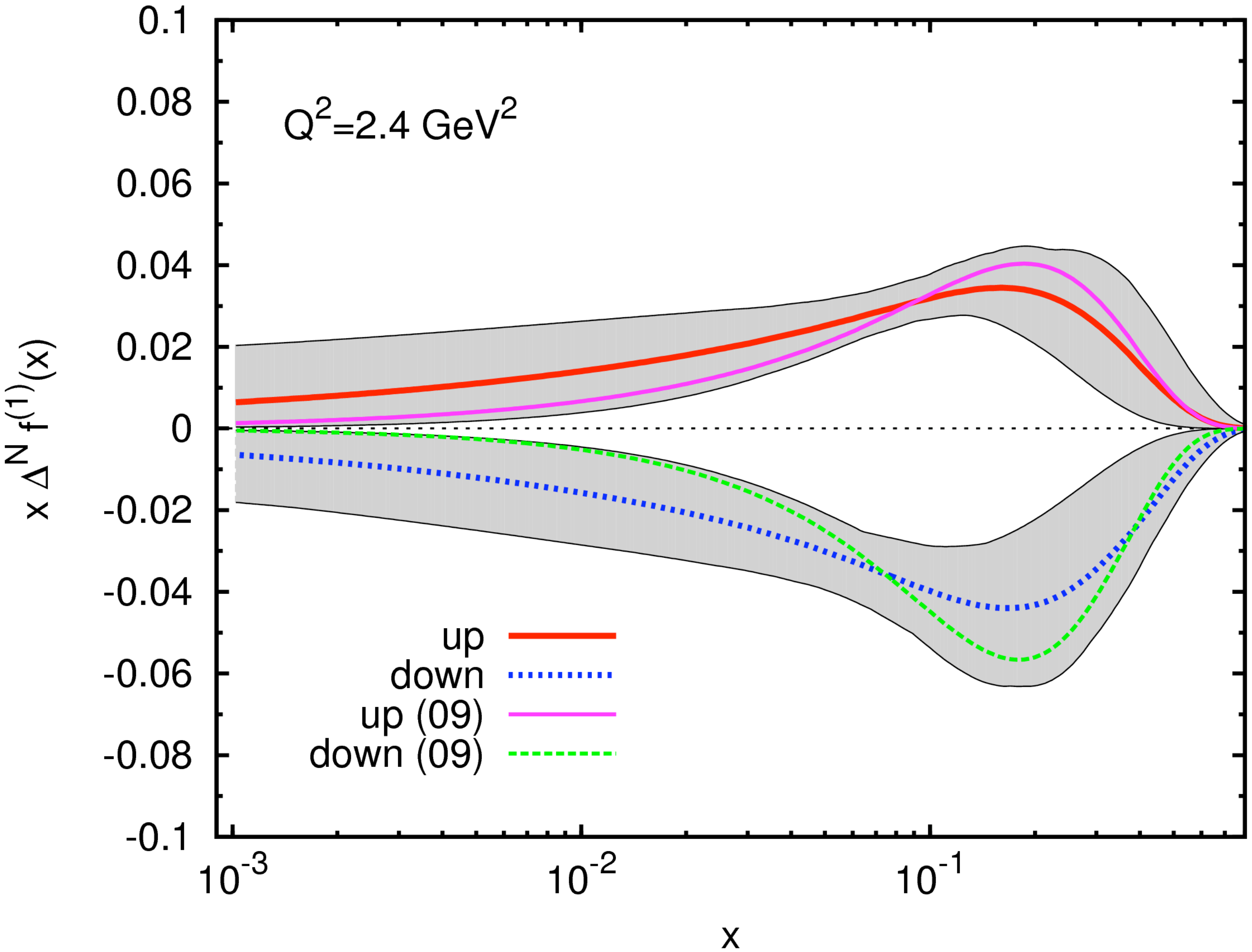
Opportunities for Drell-Yan Physics at RHIC
May 11-13, 2011, RIKEN BNL

Mauro Anselmino, Torino University & INFN

simple Sivers functions for u and d quarks are sufficient
to fit the available SIDIS data

large and very small x dependence not constrained by data

talk by A. Prokudin



new and previous extraction of u and d Sivers functions

S. Melis and A. Prokudin, preliminary results

Anselmino et al.
Eur. Phys. J. A39,89 (2009)

azimuthal modulations in TFR

(M.A, V. Barone, A. Kotzinian, PL B699 (2011) 108)

cross section for lepto-production of an unpolarized or spinless hadron in the TFR

$$\frac{\mathrm{d}\sigma^{\mathrm{TFR}}}{\mathrm{d}x_B\,\mathrm{d}y\,\mathrm{d}\zeta\,\mathrm{d}^2\boldsymbol{P}_{h\perp}\,\mathrm{d}\phi_S} = \frac{2\alpha_{\mathrm{em}}^2}{Q^2 y}\,\Bigg\{\left(1-y+\frac{y^2}{2}\right)$$
$$\times \sum_a e_a^2 \left[M(x_B,\zeta,\boldsymbol{P}_{h\perp}^2) - |\boldsymbol{S}_\perp|\,\frac{|\boldsymbol{P}_{h\perp}|}{m_h}\,M_T^h(x_B,\zeta,\boldsymbol{P}_{h\perp}^2)\sin(\phi_h-\phi_S)\right]$$
$$+\lambda_l\,y\left(1-\frac{y}{2}\right)\sum_a e_a^2\left[S_\parallel\,\Delta M_L(x_B,\zeta,\boldsymbol{P}_{h\perp}^2)\right.$$
$$\left.\left.+\;|\boldsymbol{S}_\perp|\,\frac{|\boldsymbol{P}_{h\perp}|}{m_h}\,\Delta M_T^h(x_B,\zeta,\boldsymbol{P}_{h\perp}^2)\,\cos(\phi_h-\phi_S)\right]\right\}\,.$$

possible Sivers-like azimuthal dependence from target fragmentation region

sign mismatch

(Kang, Qiu, Vogelsang, Yuan)

compare

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

as extracted from fitting A_N data, with that obtained by inserting in the the above relation the SIDIS extracted Sivers functions

similar magnitude, but opposite sign!

the same mismatch does not occurr adopting TMD factorization; the reason is that the hard scattering part in higher-twist factorization is negative

Cahn effect in unpolarized D-Y

M. Boglione, S. Melis, arXiv:1103.2084

access to $\langle k_\perp^2 \rangle$

$$\frac{d\sigma^{unp}}{d^4q\,d\Omega'} = \frac{\alpha^2}{6M^2 s}\sum_q e_q^2\, f^q_{a/A}(x_a)\, \bar{f}^q_{b/B}(x_b)\,\frac{e^{-q_T^2/\langle q_T^2\rangle}}{\pi\langle q_T^2\rangle}\left\{(1+\cos^2\theta') + \underbrace{\frac{q_T}{M}\,\frac{\langle k^2_{\perp a}\rangle - \langle k^2_{\perp b}\rangle}{\langle q_T^2\rangle}\sin 2\theta'\cos\phi'}_{\text{Cahn effect}}\right\}$$

$$\langle k^2_{\perp a}\rangle + \langle k^2_{\perp b}\rangle \equiv \langle q_T^2\rangle \qquad \boldsymbol{q}_T = \boldsymbol{k}_{\perp a} + \boldsymbol{k}_{\perp b}$$

$$f_{a/A}(x_a, k_{\perp a}) = f_{a/A}(x_a)\,\frac{e^{-k^2_{\perp a}/\langle k^2_{\perp a}\rangle}}{\pi\langle k^2_{\perp a}\rangle}$$

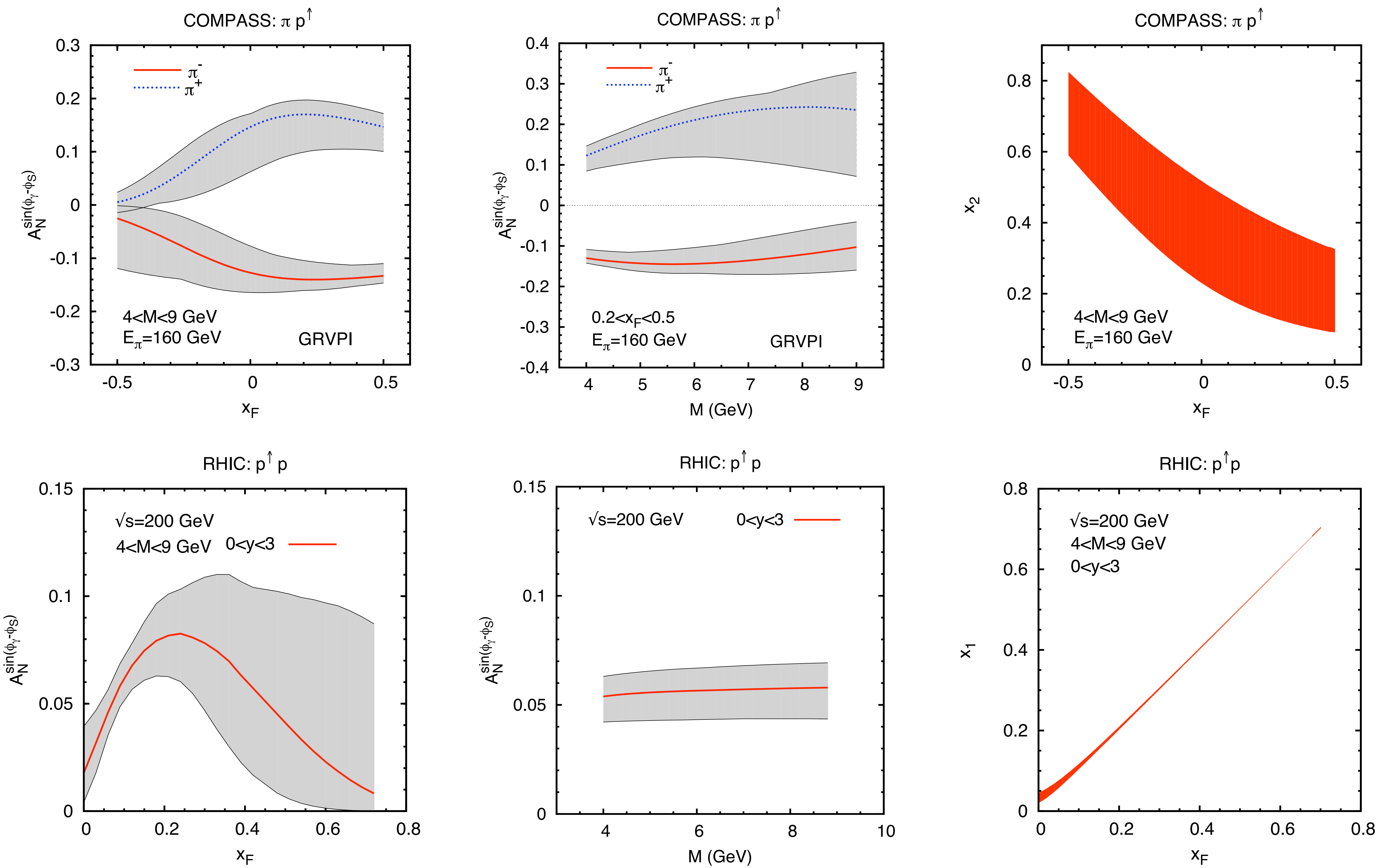
gaussian $k_\perp$ dependence

no effect if $\langle k^2_{\perp a}\rangle = \langle k^2_{\perp b}\rangle$

same conclusion holds for non gaussian distributions

Predictions for A_N

Sivers functions as extracted from SIDIS data, **with opposite sign**



M.A., M. Boglione, U. D'Alesio, S. Melis, F. Murgia, A. Prokudin, e-Print: arXiv:0901.3078