Transverse single spin asymmetry of the W production at RHIC

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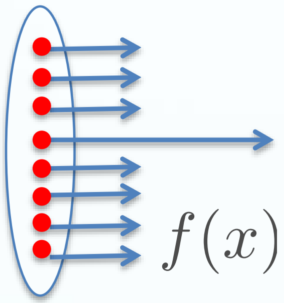
Outline

- Introduction
- TMD evolution
  - Framework
  - Coefficient functions
  - Y term
- Global analysis
  - Unpolarized TMDs
  - Sivers function
- Uncertainty on TMD evolution formalism
- Summary

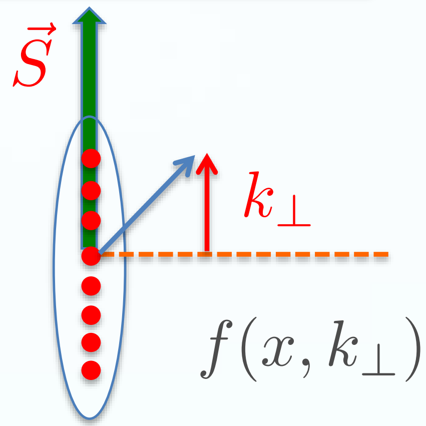
New structure of proton

- Transversely polarized scattering provides new structure of proton

Transverse Momentum Dependent parton distribution (TMDs)



$$p_a \approx x P_A$$



Longitudinal motion only

Longitudinal + transverse motion

- Sivers function: an asymmetric parton distribution in a transversely polarized nucleon (kt correlated with the spin of the nucleon)

$$f_{q/h^\uparrow}(x, \mathbf{k}_\perp, \vec{S}) \equiv f_{q/h}(x, k_\perp) - \frac{1}{M} f_{1T}^{\perp q}(x, k_\perp)\, \vec{S} \cdot (\hat{p} \times \mathbf{k}_\perp)$$

Spin-independent

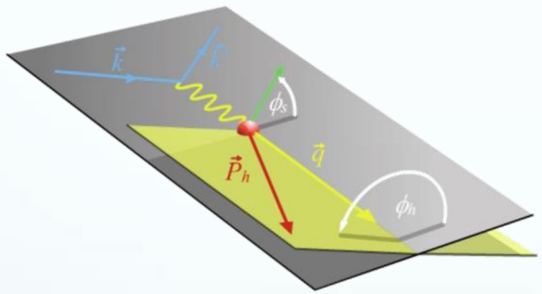
Spin-dependent

- Sign change:

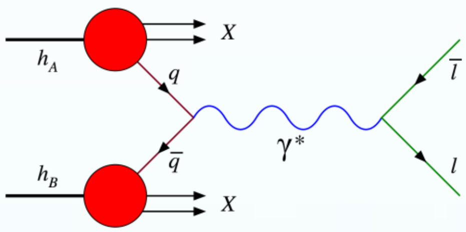
$$f_{1T}^{\perp,\mathrm{DIS}}(x, k_\perp) = - f_{1T}^{\perp,\mathrm{DY}}(x, k_\perp)$$

TMD work domain and experimental access

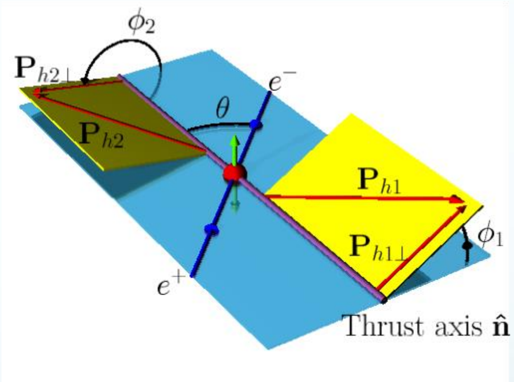
- TMD factorization works in the domain where there are two observed momenta in the process, such as SIDIS, DY, e+e-
- Q >> qt: Q is large to ensure the use of pQCD, qt is much smaller such that it is sensitive to parton’s transverse momentum



SIDIS
JLab 12, HERMES, COMPASS



Drell-Yan
COMPASS, Fermilab, RHIC

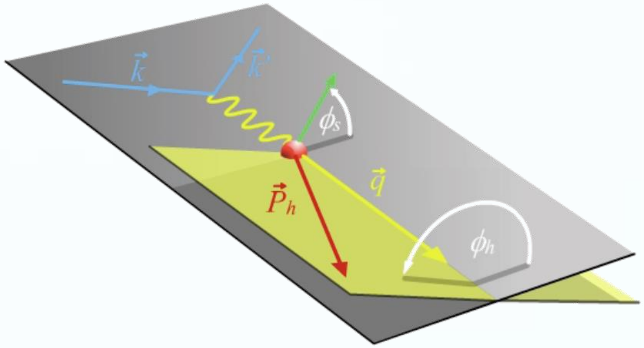


e^++e^-→h1+h2+X
Belle, BarBar

Sivers function from SIDIS

- Sivers asymmetry has been measured in semi-inclusive DIS (SIDIS) process: HERMES, COMPASS, JLab

$$\ell + p^{\uparrow} \to \ell' + \pi(p_T) + X$$



- Naïve QCD formalism for Sivers asymmetry

$$\frac{d\sigma}{dx_B\, dy\, dz_h\, d^2P_{h\perp}} \sim F_{UU} + |\mathbf{S}_\perp| \sin(\phi_h - \phi_s)\, F_{UT}^{\sin(\phi_h-\phi_s)}$$

$$F_{UT}^{\sin(\phi_h-\phi_s)} = -\sum_q e_q^2 \int d^2\mathbf{k}_\perp \frac{\hat{\mathbf{h}}\cdot\mathbf{k}_\perp}{M} f_{1T}^{\perp q}(x_B, k_\perp^2) D_{h/q}\left(z_h, \mathbf{p}_\perp^2\right) \delta^2\left(z_h\mathbf{k}_\perp + \mathbf{p}_\perp - \mathbf{P}_{h\perp}\right)$$

Gamberg, Kang, Prokudin, PRL, 2013

- Difficulties: Sivers functions (parton distributions) depend on the energy scale where they are probed

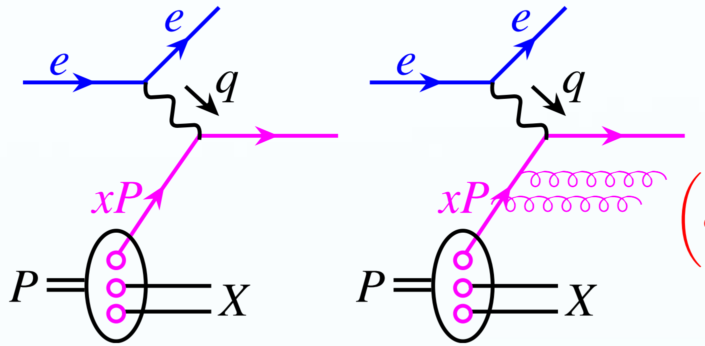
Energy dependence of TMDs

- Experiments operate in very different kinematic ranges
  - Typical hard scale Q is different: Q ~ 1 – 3 GeV in SIDIS, Q ~ 4 – 90 GeV for DY, W/Z in pp, Q ~ 3 – 10 GeV in e+e-
  - Also center-of-mass energy is different
- Such energy dependence (evolution) has to be taken into account for any reliable QCD description/prediction
- Both collinear PDFs and TMDs depend on the energy scale Q at which they are measured, such dependences are governed by QCD evolution equations

Collinear PDFs	TMDs
$F(x, Q)$	$F(x, k_\perp; Q)$

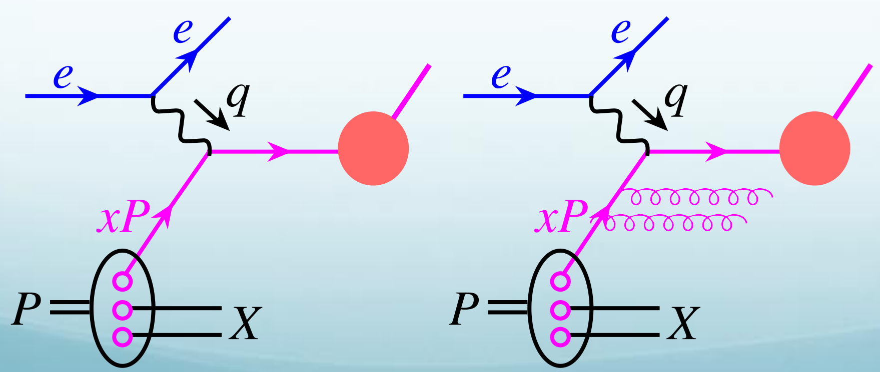
QCD evolution: meaning

- Evolution = include important perturbative corrections
  - DGLAP evolution of collinear PDFs: what it does is to resum the so-called single logarithms in the higher order perturbative calculations



$$\left(\alpha_s \ln \frac{Q^2}{\mu^2}\right)^n$$

- TMD factorization works in the situation where there are two observed momenta in the process, Q>>qt: what it does is to resum the so-called double logarithms in the higher order perturbative corrections



$$\left(\alpha_s \ln^2 \frac{Q^2}{q_T^2}\right)^n$$

Main difference between collinear and TMD evolution

- Collinear evolution (DGLAP): the evolution kernel is purely perturbative

$$\frac{\partial f_a(x,Q)}{\partial \ln Q^2} = \sum_b \int_z^1 \frac{dz}{z} P_{a\leftarrow b}\left(\frac{x}{z}, Q\right) f_b(z,Q)$$

$$f(x,Q_i) \longrightarrow R_{\rm coll}(x,Q_i,Q_f) \longrightarrow f(x,Q_f)$$

- TMD evolution: the evolution kernels are not. They contain non-perturbative component, which makes the evolution much more complicated but one can learn more
  - Kt can run into non-perturbative region

$$F(x,k_\perp;Q_i) \longrightarrow R_{\rm TMD}(x,k_\perp,Q_i,Q_f) \longrightarrow F(x,k_\perp;Q_f)$$

TMD evolution

$$F(x, k_\perp; Q)$$

- We have a TMD above measured at a scale Q. It is easier to deal in the Fourier transformed space (convolution → product)

$$F(x, b; Q) = \int d^2 k_\perp e^{-ik_\perp \cdot b} F(x, k_\perp; Q)$$

- In the small b region, one can then compute the evolution to this TMDs, which goes like

$$F(x, b; Q_f) = F(x, b; Q_i) \exp\left\{-\int_{Q_i}^{Q_f} \frac{d\mu}{\mu}\left(A \ln\frac{Q_f^2}{\mu^2} + B\right)\right\} \left(\frac{Q_f^2}{Q_i^2}\right)^{-\int_{c/b}^{Q_i} \frac{d\mu}{\mu} A}$$

$$A = \sum_{n=1} A^{(n)} \left(\frac{\alpha_s}{\pi}\right)^n, \qquad B = \sum_{n=1} B^{(n)} \left(\frac{\alpha_s}{\pi}\right)^n$$

CSS literatures
Kang, Xiao, Yuan, PRL 11, Aybat, Rogers, Collins, Qiu, 12, Aybat, Prokudin, Rogers, 12, Sun, Yuan, 13, Echevarria, Idilbi, Schafer, Scimemi, 13, Echevarria, Idilbi, Kang, Vitev, 14, …

Coefficient functions

- One might expand TMD at the initial scale Qi to collinear function

$$F(x_B, b; \mu, \zeta) = C(x_B/x, b, \mu, \zeta) \otimes F(x, \mu) \qquad C(x_B/x, b, \mu, \zeta) = \sum_{n=0} C^{(n)} \left(\frac{\alpha_s}{\pi}\right)^n$$

$$C^{(0)}_{q\leftarrow q'} = \delta_{qq'}\delta(1-z)$$

$$C^{(1)}_{q\leftarrow q'} = \delta_{qq'}\left[\frac{C_F}{2}(1-z) + \ln\left(\frac{\mu_b}{\mu}\right) P_{qq}(z) + C_F\delta(1-z)\left(-\ln^2\left(\frac{\mu_b}{\mu}\right) - \frac{3}{2}\ln\left(\frac{\mu_b}{\mu}\right) + \ln\left(\frac{\mu_b}{\mu}\right)\ln\frac{\zeta}{\mu^2}\right)\right]$$

CSS formalsims
Aybat, Rogers, 2011
Bacchetta, Prokudin, 2013

- This expansion suggests a “optimal” scale: standard CSS choice

$$\mu_b = c/b \qquad c = 2e^{-\gamma_E} \sim 1$$

$$F(x, b; Q) = C \otimes F(x, c/b) \exp\left\{-\int_{c/b}^{Q} \frac{d\mu}{\mu}\left(A \ln\frac{Q^2}{\mu^2} + B\right)\right\}$$

Coefficient for Sivers function

- Coefficient function for Sivers function is a bit more complicated

$$f_{1T}^{\perp q(\alpha)}(x,b;Q) = \frac{1}{M}\int d^2k_\perp\, e^{-ik_\perp\cdot b} k_\perp^\alpha f_{1T}^{\perp q}(x,k_\perp^2;Q),$$

$$f_{1T}^{\perp q(\alpha)}(x,b;Q)_{\rm DY} = \left(-\frac{i\,b^\alpha}{2}\right)\left[T_{q,F}(x,x,Q)+\cdots\right]$$

- The full expansion up to O(α_s) in the quark channel

$$f_{1T}^{\perp q(\alpha)}(x,b;\mu,\zeta)_{\rm DY} = \left(-\frac{i\,b^\alpha}{2}\right)\int_x^1\frac{dy}{y}\Bigg[T_{q,F}(y,y,\mu)\,\delta(1-z)+\frac{\alpha_s}{\pi}\ln\left(\frac{\mu_b}{\mu}\right)P_{qg\leftarrow qg}\otimes T_{q,F}(y,y,\mu)$$

$$-\frac{1}{4N_c}(1-z)\frac{\alpha_s}{\pi}T_{q,F}(y,y,\mu)$$

$$+T_{q,F}(y,y,\mu)C_F\frac{\alpha_s}{\pi}\delta(1-z)\left(-\ln^2\left(\frac{\mu_b}{\mu}\right)-\frac{3}{2}\ln\left(\frac{\mu_b}{\mu}\right)+\ln\left(\frac{\mu_b}{\mu}\right)\ln\frac{\zeta}{\mu^2}\right)\Bigg]$$

Kang, Xiao, Yuan, 11
Sun, Yuan, 13

Coefficient function in gluon channel

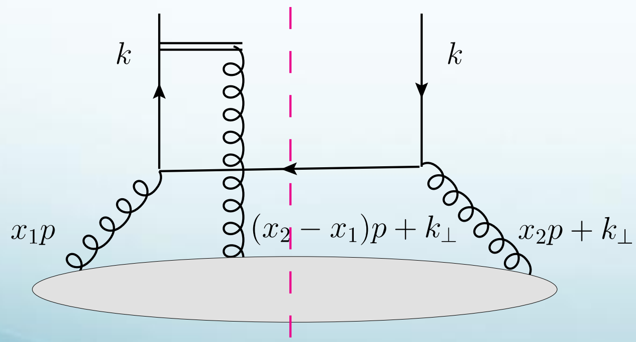
- From gluon correlation functions

Dai, Kang, Prokudin, Vitev, 14

$$f_{1T}^{\perp q(\alpha)}(x_B, b)_{\rm DY} = \left(-\frac{ib^\alpha}{2}\right)\int_{x_B}^1 \frac{dx}{x^2}\left\{C_{q\leftarrow g,1}(\hat{x})\left[O(x,x)+N(x,x)\right]+C_{q\leftarrow g,2}(\hat{x})\left[O(x,0)-N(x,0)\right]\right\},$$

$$C_{q\leftarrow g,1}(\hat{x}) = \frac{\alpha_s}{2\pi}\left[P_{q\leftarrow g}(\hat{x})\ln\left(\frac{\mu_b}{\mu}\right)+\frac{1}{2}\hat{x}(1-\hat{x})\right],$$

$$C_{q\leftarrow g,2}(\hat{x}) = \frac{\alpha_s}{2\pi}\left[P_{q\leftarrow g}(\hat{x})\ln\left(\frac{\mu_b}{\mu}\right)-\frac{1}{4}\left(1-6\hat{x}+6\hat{x}^2\right)\right].$$



So-called Y term

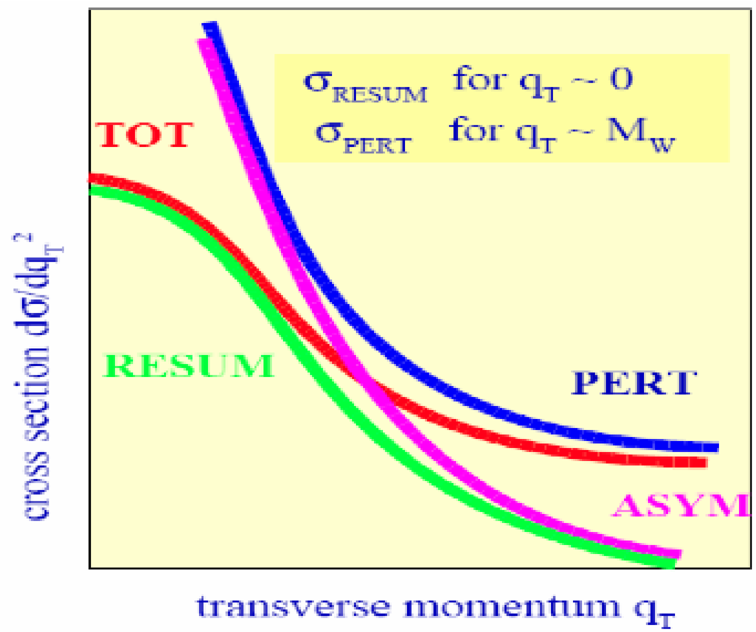
- What is the Y term?

$$d\sigma_{\rm SIDIS} = \sum_f \mathcal{H}_{f,\rm SIDIS}(Q) \otimes F_{f/H_1}(x, k_{1T}, Q) \otimes D_{H_2/f}(z, k_{2T}, Q) \quad + Y_{\rm SIDIS}$$

$$d\sigma_{\rm DY} = \sum_f \mathcal{H}_{f,\rm DY}(Q) \otimes F_{f/H_1}(x_1, k_{1T}, Q) \otimes F_{f/H_2}(x_2, k_{2T}, Q) \quad + Y_{\rm Drell-Yan}$$

$$d\sigma_{e^+e^-} = \sum_f \mathcal{H}_{f,e^+e^-}(Q) \otimes D_{H_1/\bar{f}}(z_1, k_{1T}, Q) \otimes D_{H_2/f}(z_2, k_{2T}, Q) \quad + Y_{e^+e^-}$$

$$\sigma_{\rm TOT} = \sigma_{\rm RESUM} + \sigma_{\rm PERT} - \sigma_{\rm ASYM}$$



$$Y = \sigma_{\rm pert,fixed\text{-}order} - \sigma_{\rm asym}$$

$$\sigma_{\rm asym} = \sigma_{\rm pert,fixed\text{-}order}\Big|_{p_\perp \ll Q}$$

Y terms are known in the literature

- DY Sivers asymmetry: spin-dependent cross section in the usual perturbative expansion

Ji, Qiu, Vogelsang, Yuan, 06

$$\frac{d^4\Delta\sigma(S_\perp)}{dQ^2dyd^2q_\perp} = \sigma_0\epsilon^{\alpha\beta}S_{\perp\alpha}q_{\perp\beta}\frac{\alpha_s}{2\pi^2}\int\frac{dx}{x}\frac{dx'}{x'}\sum_q e_q^2\left(H_q^s + H_q^h\right)\bar{q}(x')\delta(\hat{s}+\hat{t}+\hat{u}-Q^2)$$

$$H_q^s = \left[x\frac{\partial}{\partial x}T_F(x,x)\right]\frac{D_{q\bar{q}}^s}{-\hat{u}} + T_F(x,x)\frac{N_{q\bar{q}}^s}{-\hat{u}}$$

$$H_q^h = T_F(x-\bar{x}_g, x)\times\frac{(Q^2-\hat{t})^3+Q^2\hat{s}^2}{\hat{t}^2\hat{u}^2}\left[\frac{1}{2N_C}+C_F\frac{\hat{s}}{\hat{s}+\hat{u}}\right]$$

$$\bar{x}_g = -x\hat{t}/(Q^2-\hat{t})$$

- Key point: hard-pole contribution depends on the Qiu-Sterman function with two variables

Y term = pert - asy

- Asymptotic term: qt << Q

Ji, Qiu, Vogelsang, Yuan, 06

$$\frac{d^4\Delta\sigma^{q\bar{q}\to\gamma^* g}(S_\perp)}{dQ^2dyd^2q_\perp} = \sigma_0\,\epsilon^{\alpha\beta}S_{\perp\alpha}\,\frac{q_{\perp\beta}}{(q_\perp^2)^2}\,\frac{\alpha_s}{2\pi^2}\int\frac{dx}{x}\frac{dx'}{x'}\bar{q}(x')\left\{\delta(\xi_2-1)A+\delta(\xi_1-1)B\right\}$$

$$\begin{aligned}A =& \frac{1}{2N_C}\left\{\left[x\frac{\partial}{\partial x}T_F(x,x)\right](1+\xi_1^2)+T_F(x,x-\widehat{x}_g)\frac{1+\xi_1}{(1-\xi_1)_+}\right.\\ &\left.+T_F(x,x)\frac{(1-\xi_1)^2(2\xi_1+1)-2}{(1-\xi_1)_+}\right\}+C_FT_F(x,x-\widehat{x}_g)\frac{1+\xi_1}{(1-\xi_1)_+}\,,\\ B =& C_FT_F(x,x)\left[\frac{1+\xi_2^2}{(1-\xi_2)_+}+2\delta(\xi_2-1)\ln\frac{Q^2}{q_\perp^2}\right]\,,\end{aligned}$$

- In general, all spin-dependent Y term will depend on the twist-3 correlator T(x1,x2) with x1 =/= x2, how do we model them? Do we have enough data?

QCD evolution of TMDs – II

- Fourier transform back to the momentum space, one needs the whole b region (large b): need some non-perturbative extrapolation

$$F(x,k_\perp;Q)=\frac{1}{(2\pi)^2}\int d^2b e^{ik_\perp\cdot b}F(x,b;Q)$$
$$=\frac{1}{2\pi}\int_0^\infty db\, bJ_0(k_\perp b)F(x,b;Q)$$

- There are many different methods/proposals to deal with this nonperturbative part

Collins, Soper, Sterman 85, ResBos, Qiu, Zhang 99, Echevarria, Idilbi, Kang, Vitev, 14, Aidala, Field, Gamberg, Rogers, 14, Sun, Yuan 14, D'Alesio, Echevarria, Melis, Scimemi, 14 …

One of the approach

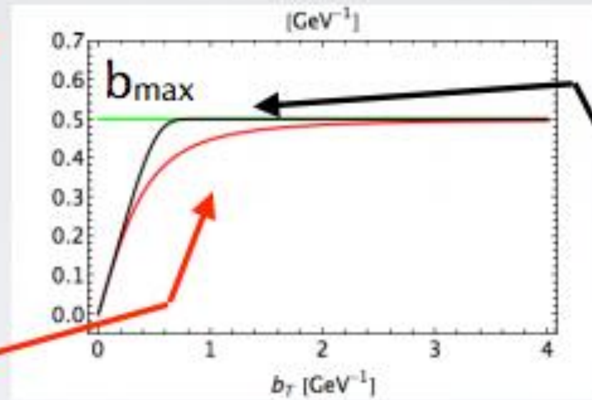
- Widely used prescription (Collins, Soper, Sterman)

$$F(x, b; Q_f) = F(x, b; Q_i) R^{\text{pert}}(b_*, Q_i, Q_f) \times \boxed{R^{NP}(b, Q_i, Q_f)}$$

b* prescription

$$\mu_b = \frac{2e^{-\gamma_E}}{b^*}$$

$$b^* = \frac{b_T}{\sqrt{1 + \frac{b_T^2}{b_{\max}^2}}}$$



exp prescription

$$\mu_b = \frac{2e^{-\gamma_E}}{b_T^\dagger}$$

$$b_T^\dagger = b_{\max} \left\{ 1 - \exp\left[-\frac{b_T^4}{b_{\max}^4} \right] \right\}^{\frac{1}{4}}$$

Radici, QCD evolution 2015 workshop

- Typical simple form for unpolarized PDFs and FFs

$$R^{\text{NP}}(Q, b) = \exp(-S^{\text{NP}})$$

$$S_{pdf}^{\text{NP}} = b^2 \left[g_1^{pdf} + \frac{g_2}{2} \ln(Q/Q_0) \right]$$

$$S_{ff}^{\text{NP}} = b^2 \left[g_1^{ff}/z^2 + \frac{g_2}{2} \ln(Q/Q_0) \right]$$

- Adjust the parameters to fit the unpolarized data

One slide to summarize TMD evolution

- QCD evolution of TMDs in Fourier space (solution of equation)

$$F(x,b;Q) \approx \boxed{C \otimes F(x,c/b^*)} \times \boxed{\exp\left\{-\int_{c/b^*}^{Q} \frac{d\mu}{\mu}\left(A \ln\frac{Q^2}{\mu^2} + B\right)\right\}} \times \boxed{\exp\left(-S_{\text{non-pert}}(b,Q)\right)}$$

Evolution of longitudinal/collinear part

Evolution of transverse part

- ✓ Non-perturbative part has to be fitted to experimental data
- ✓ The key ingredient is spin-independent

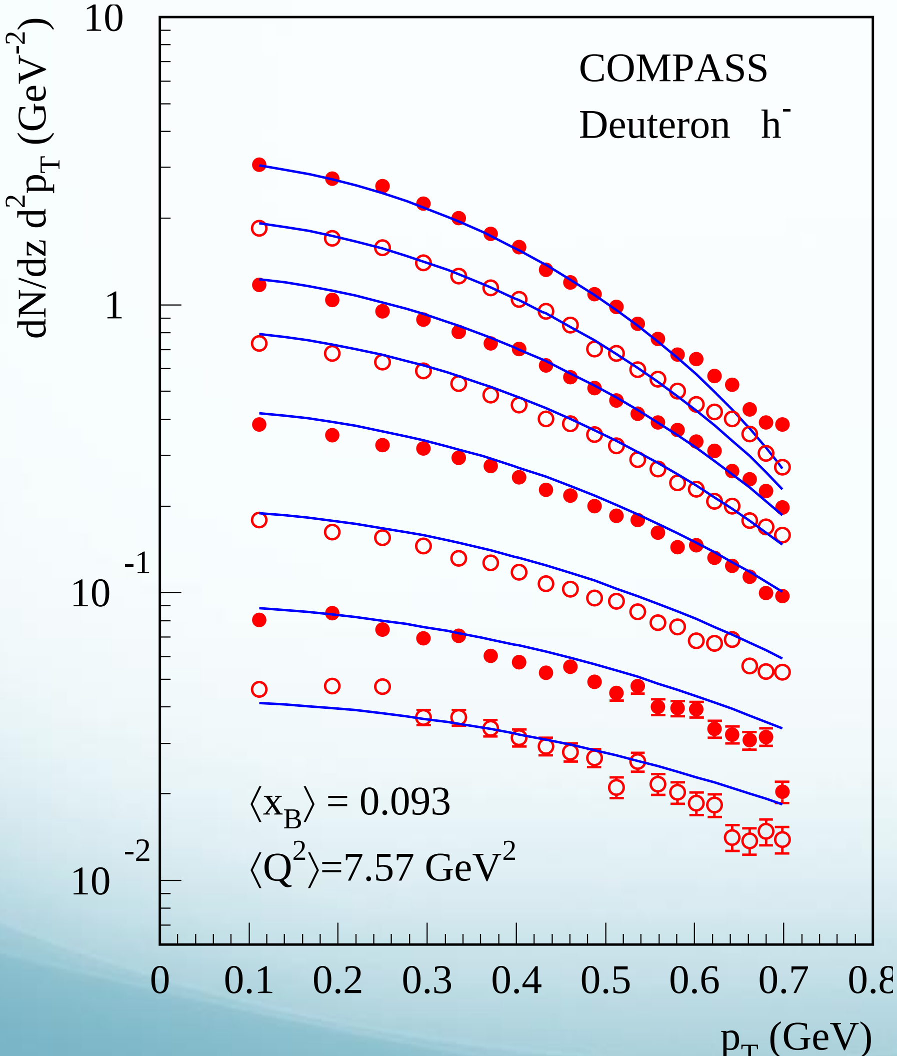
$$A = \sum_{n=1} A^{(n)} \left(\frac{\alpha_s}{\pi}\right)^n, \qquad B = \sum_{n=1} B^{(n)} \left(\frac{\alpha_s}{\pi}\right)^n$$

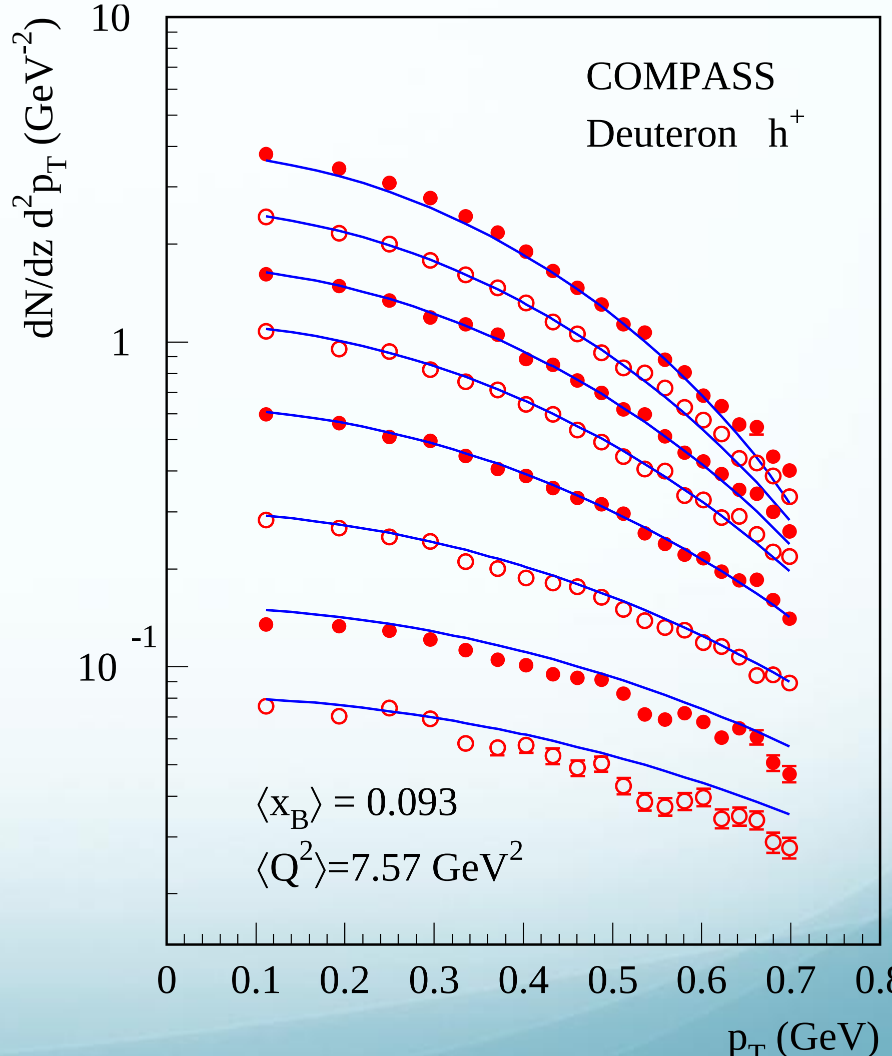
- Since the polarized scattering data is still limited kinematics, we can use unpolarized data to constrain/extract the key ingredient for the non-perturbative part

TMD evolution works: multiplicity distribution in SIDIS

- Comparison to COMPASS data

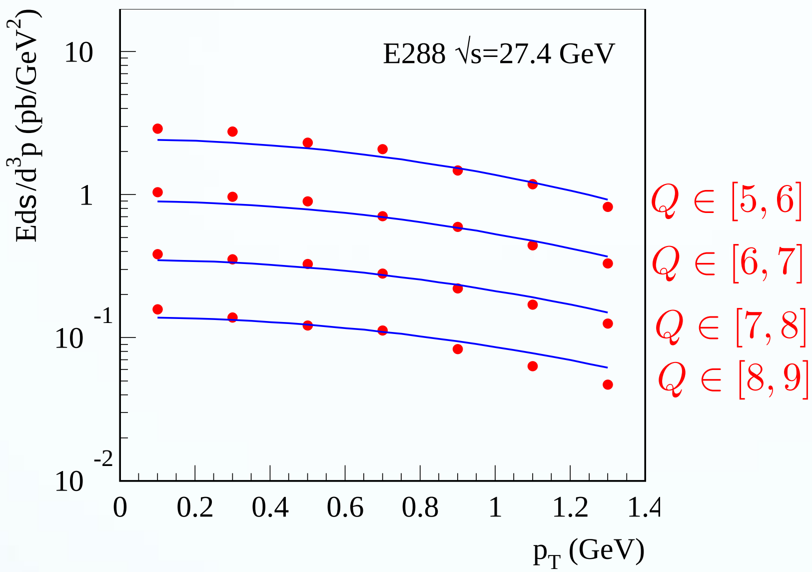
Echevarria, Idilbi, Kang, Vitev, 14

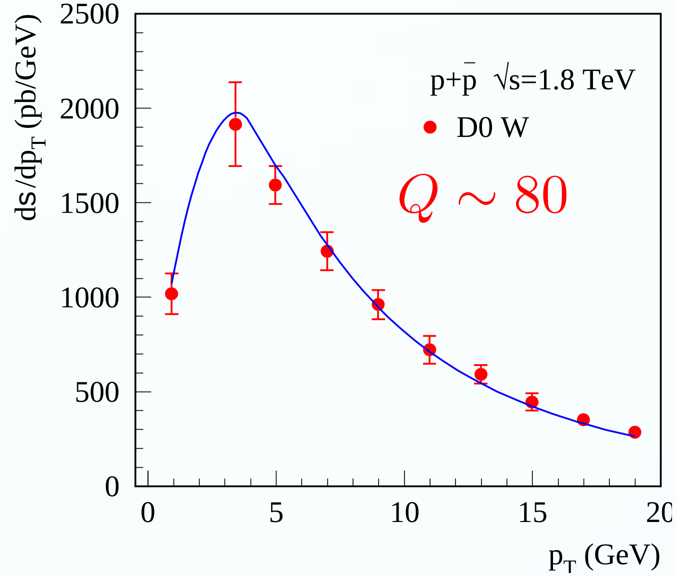


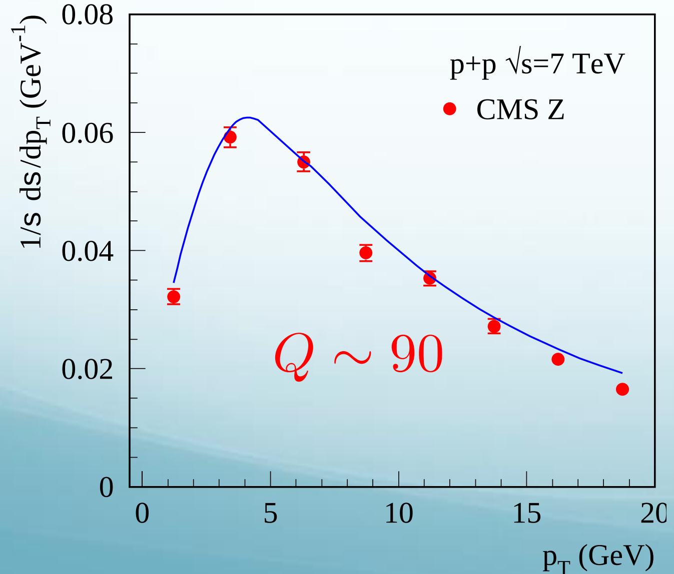


TMD evolution works: Drell-Yan and W/Z production

- Comparison with DY, W/Z pt distribution





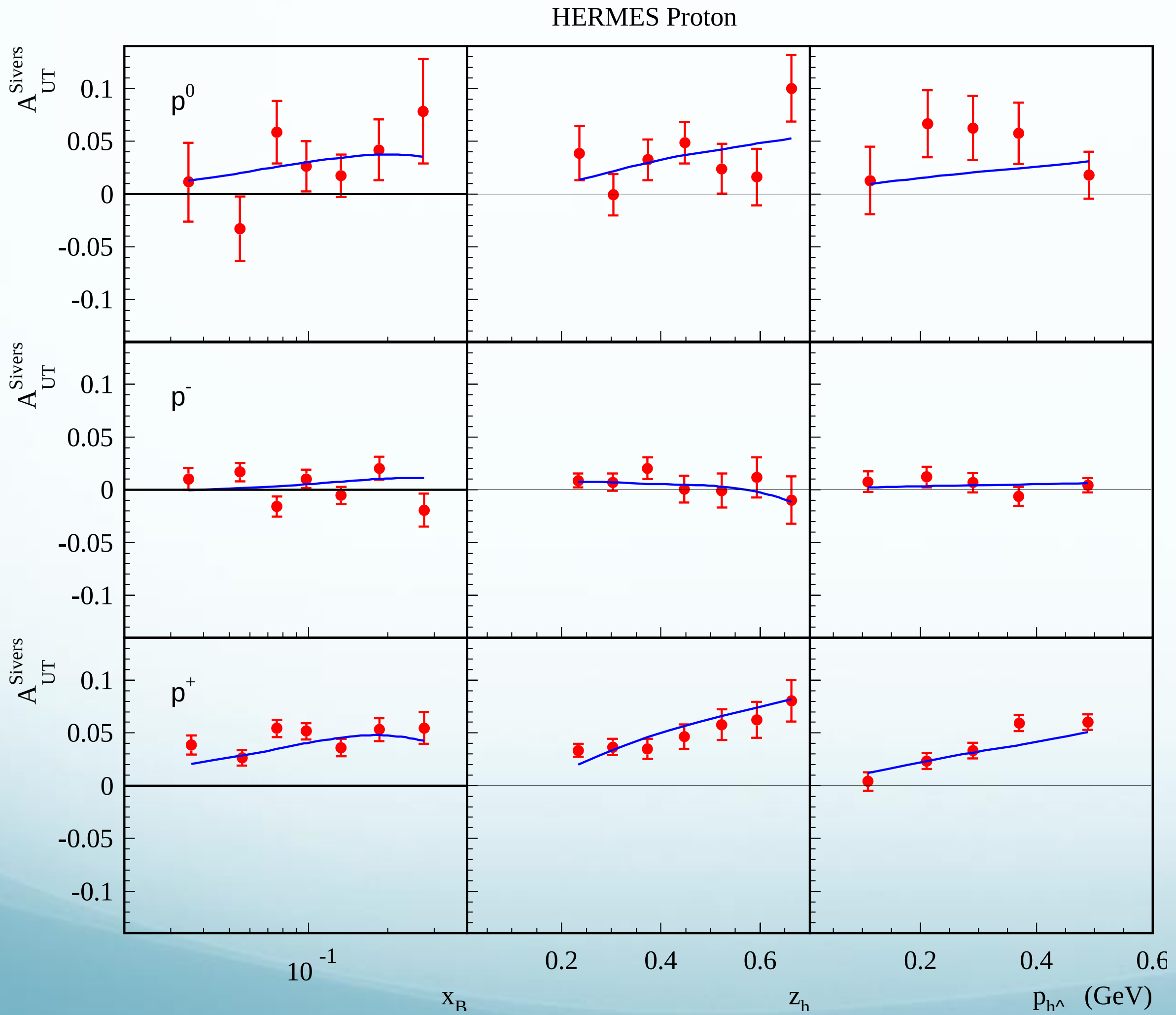


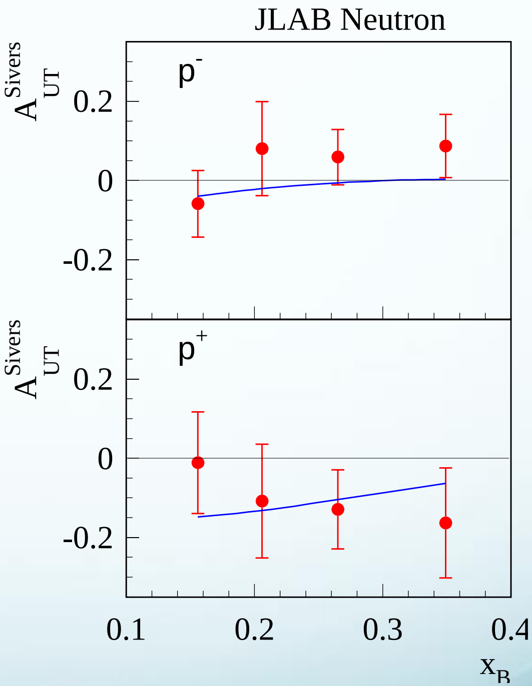
- Works for SIDIS, DY, and W/Z in all the energy ranges
- Make predictions for future JLab 12, COMPASS, Fermilab, RHIC experiments

Extract Sivers function with energy evolution

- Example of the fit: JLab, HERMES, COMPASS

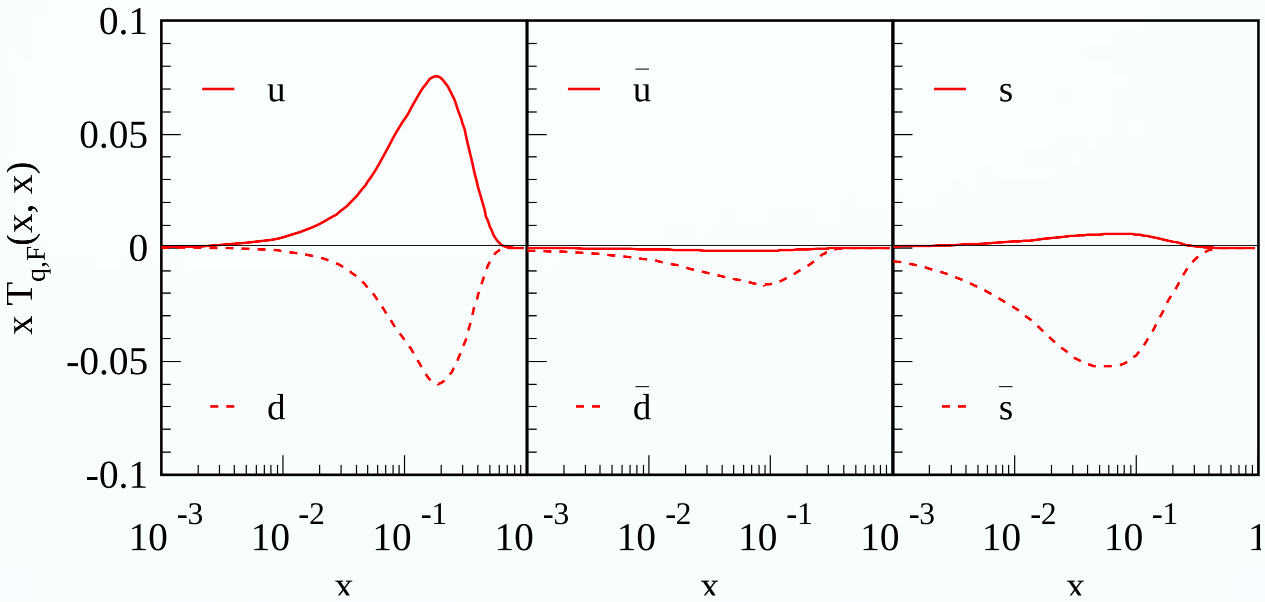
Echevarria, Idilbi, Kang, Vitev, 14





Extracted the collinear part of the Sivers function

- Chi2/d.o.f. = 1.3, the collinear part (twist-3 function) is plotted

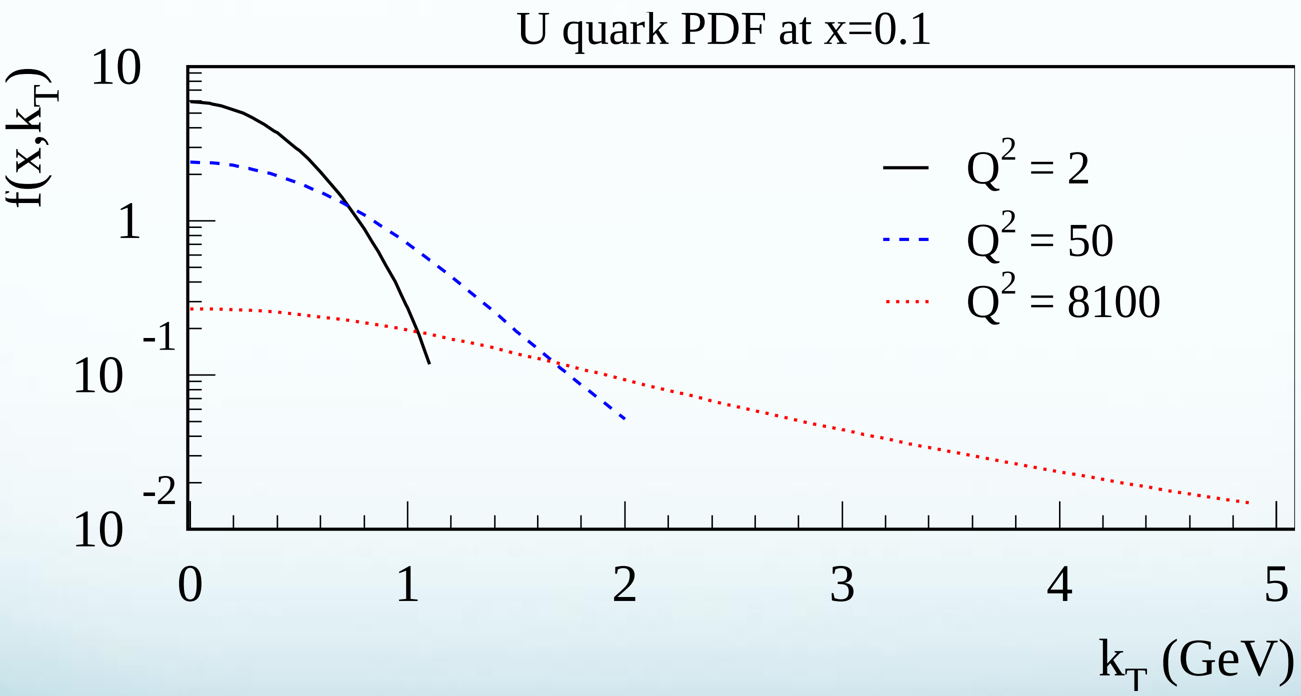


- Only u and d valence quark Sivers functions are constrained by the current data, all the sea quark Sivers functions are not constrained
  - If setting all sea quark Sivers functions vanishing, one still obtains similar chi2/d.o.f.
  - Our DY experiment E1039 is essential in determining the sea quark Sivers functions

Effect of QCD evolution

- What evolution does
  - Spread out the distribution to much larger kt
  - At low kt, the distribution decreases due to this spread

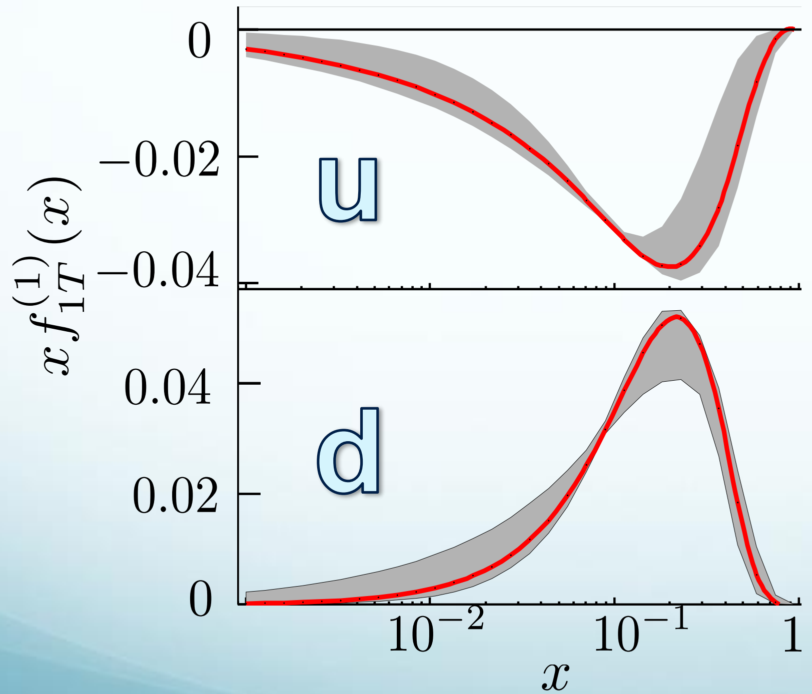
Based on Echevarria, Idilbi, Kang, Vitev, 14
See also similar plots at Kang, Prokudin, Sun, Yuan, 15

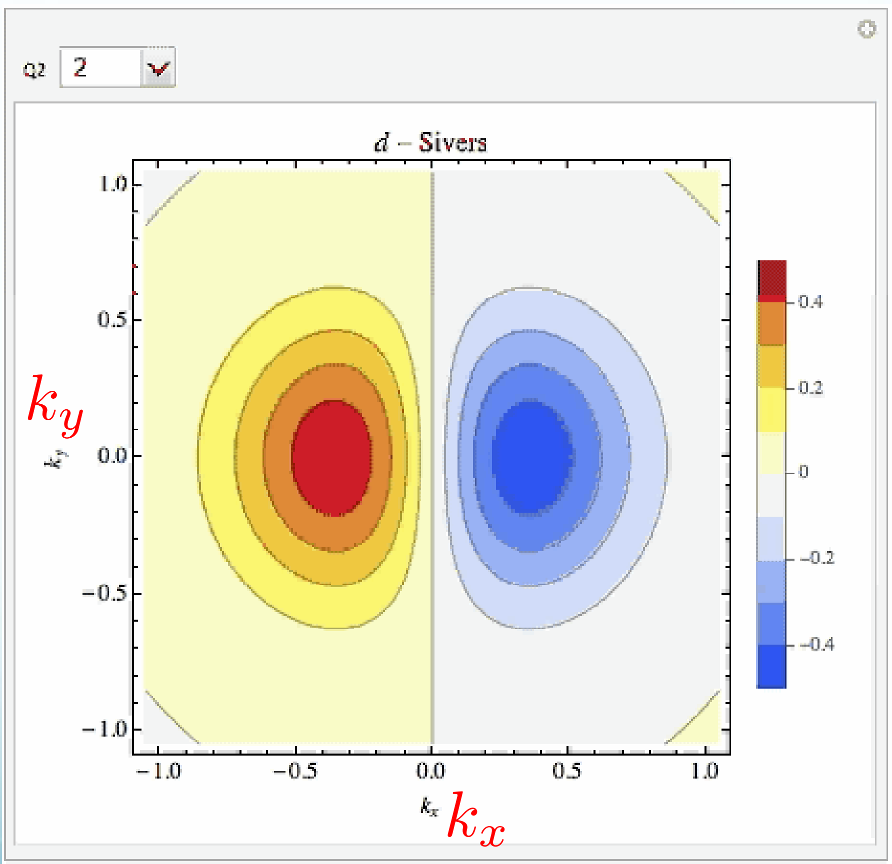


Effect of the evolution

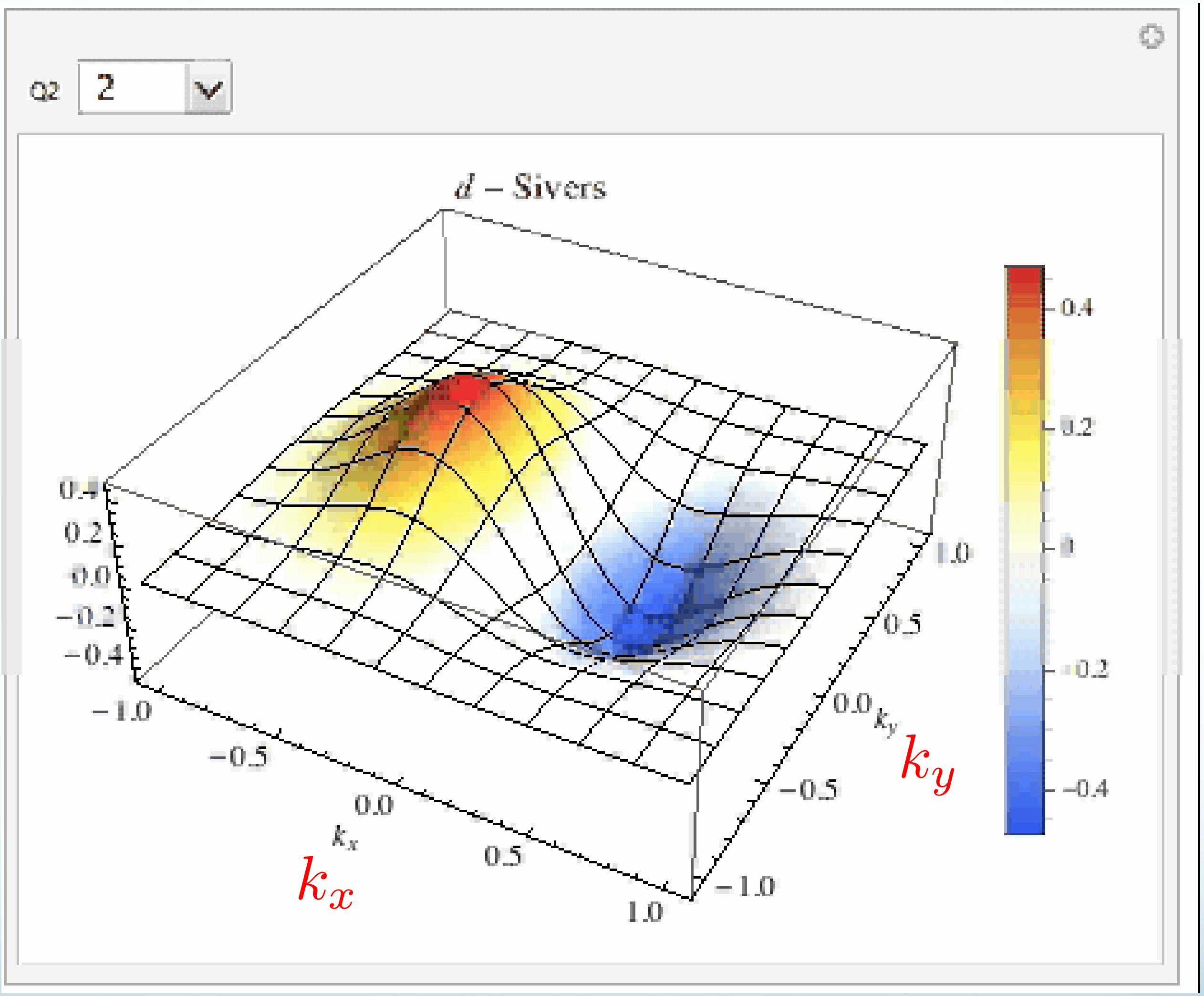
- Visualization of the Sivers effect for d quark
  - d quark Sivers is positive, and thus leads to more d quark moves to the left
  - Let us visualize how this shift changes as energy scale Q^2 changes: from 2 to 100 GeV^2

All visualizations are based on the results from Echevarria, Idilbi, Kang, Vitev, 14

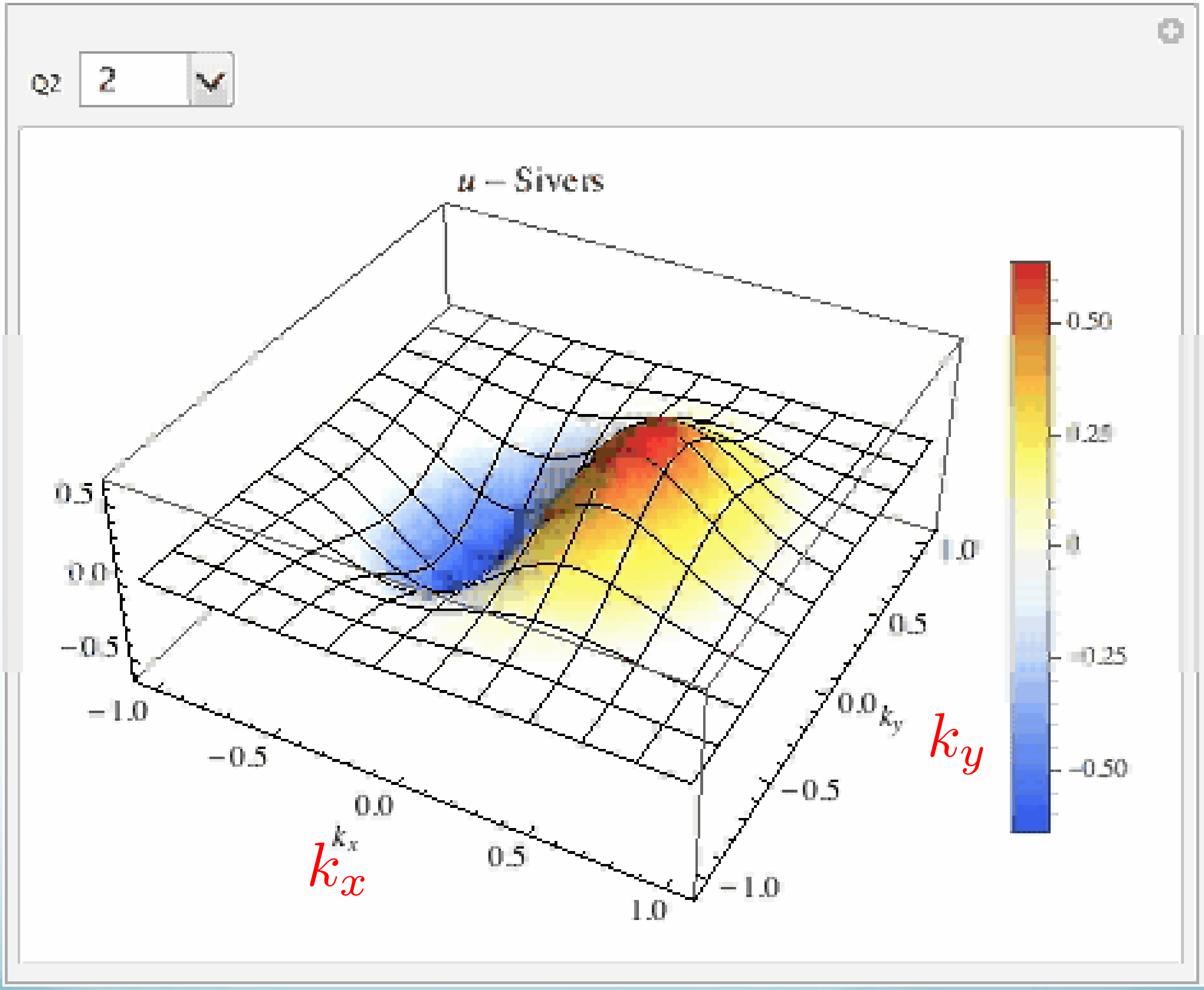




3D view: d quark

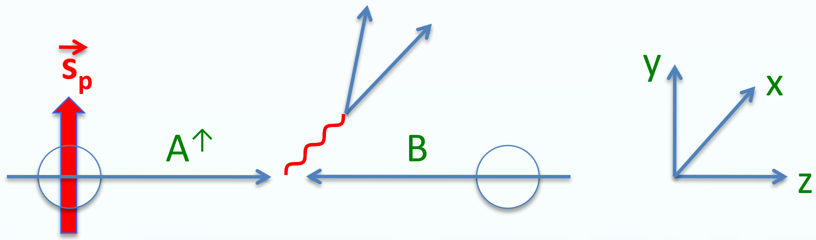


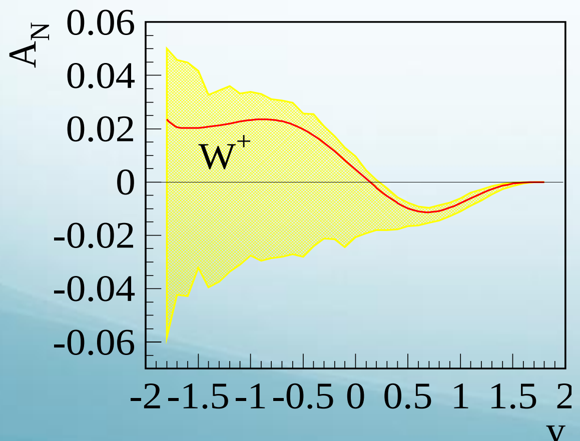
3D view: u quark

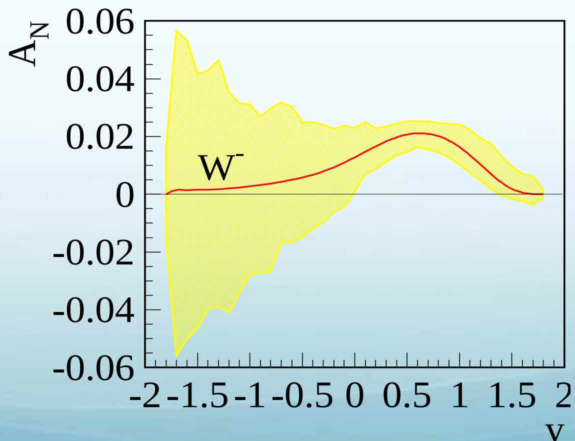


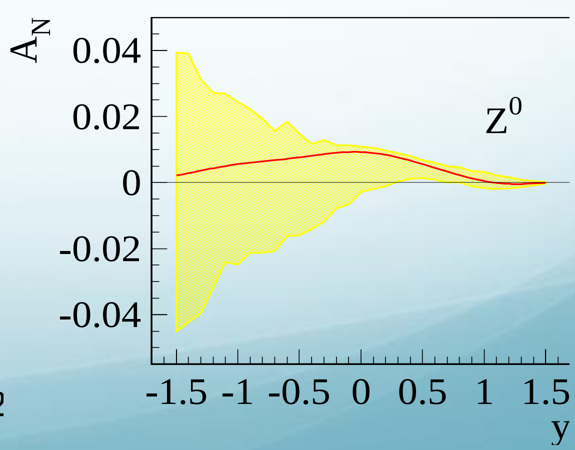
Sign change and predictions for W/Z

- Sivers effect: still need DY/W/Z to verify the sign change, thus fully understand the mechanism of the SSAs
- Reverse the sign of Sivers function from SIDIS, make predictions for W/Z at 510 GeV RHIC energy
  - Note: sea quark Sivers functions are not constrained from the current data, so the backward rapidity region has large uncertainty



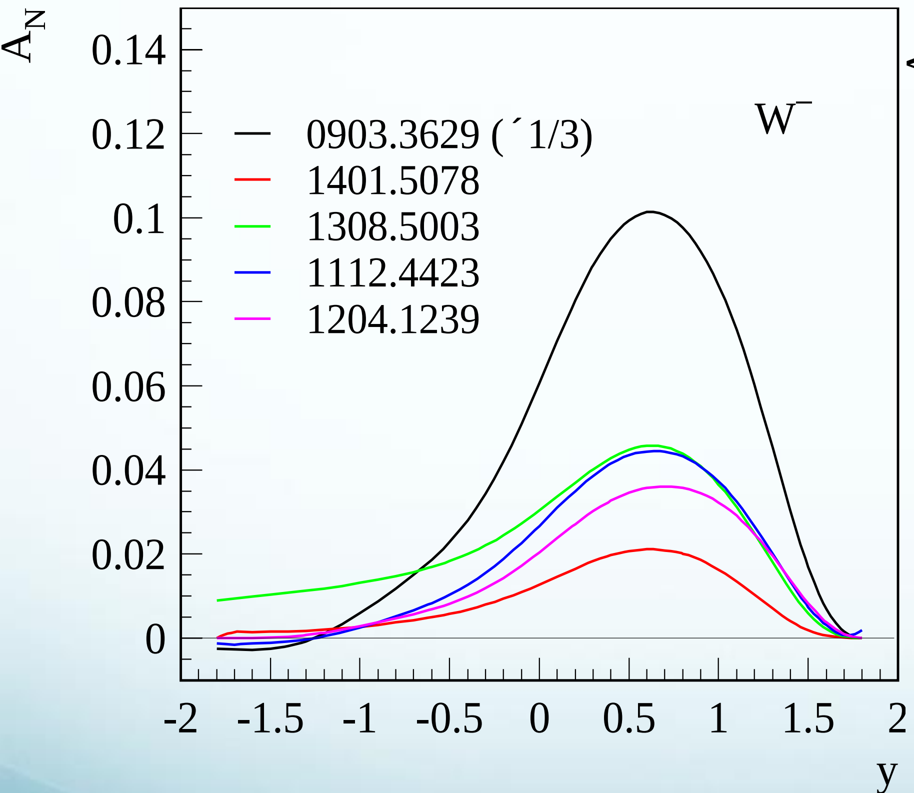


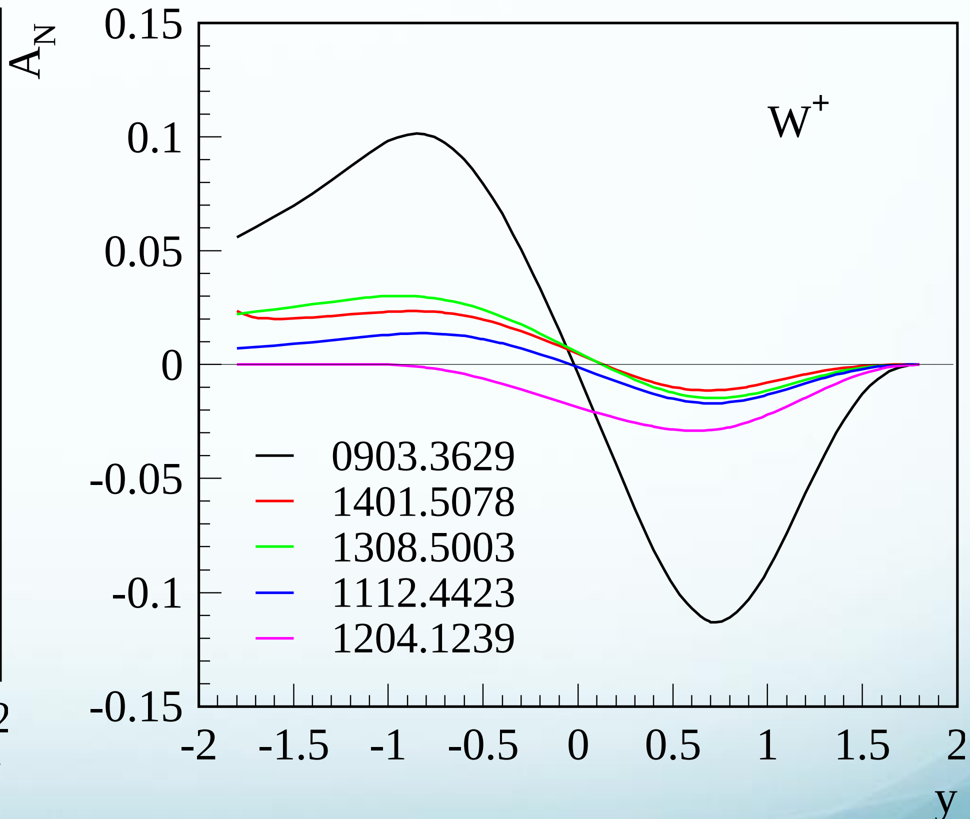




Uncertainty in the evolution formalism

- Even the evolution formalism itself has large room to improve – non-perturbative Sudakov needs further improvement





Further improvement

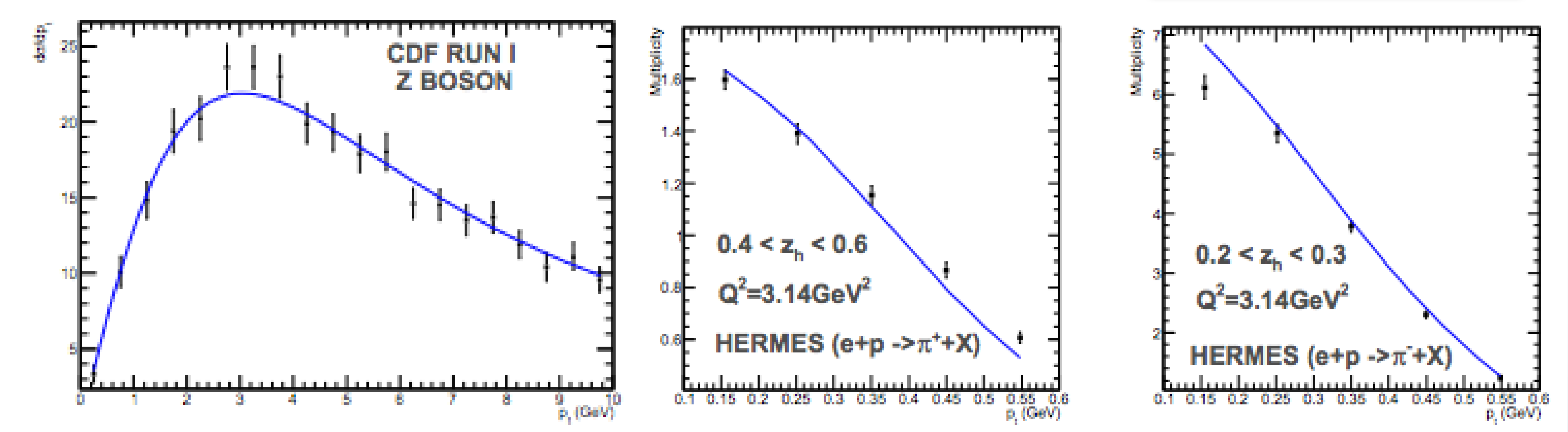
- A new fit with DY and SIDIS

Sun, Isaacson, Yuan, Yuan, 1406.3073
Aidala, Field, Gamberg, Rogers, 1401.2654

$$\exp\left[-g_2 b^2 \ln(Q/Q_0) + \cdots\right]$$

$$\exp\left[-g_2 \boxed{\ln(b/b^*)} \ln(Q/Q_0) + \cdots\right]$$

$$\boxed{\frac{1}{2}\ln\left(1+\frac{b^2}{b_{\max}^2}\right)}$$



- Seems rather well for SIDIS multiplicity, though requires additional K factor ~ 2 for multiplicity distribution
  - Maybe it is good enough for asymmetry?

No fully satisfactory fit of both SIDIS and DY yet

- Several different groups are trying to perform the fitting within the similar b*-type prescription
  - One could fit either SIDIS successfully or DY successfully, but not both

Boglione, D'Alesio, Echevarria, Kang, Melis, Rogers, Qiu…

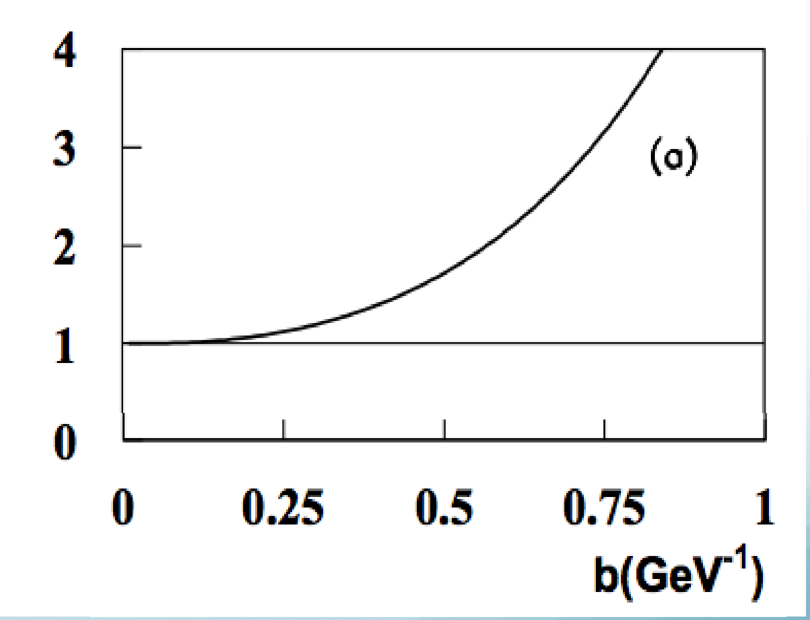
- Maybe b*-prescription has intrinsic problem
  - Significantly change even in the perturbative region

Qiu, Zhang, 01

Ratio $\tilde{W}(b_*, Q, x_A, x_B)/\tilde{W}(b, Q, x_A, x_B)$

Ratio of DY cross section (integrand before b-integration) with b*-prescription and without

$$Q = M_z \quad \sqrt{S} = 1.8\ \mathrm{TeV}$$



- Large Y term in the TMD region?

Stay tuned

W measurements might give even more

- Generic formalism for W cross sections

Huang, Kang, 15

$$\frac{d\sigma}{dy d^2q_\perp} \sim (-g_{\mu\nu} + \frac{q_\mu q_\nu}{M_W^2}) W^{\mu\nu} \propto \int d^2k_{a\perp} d^2k_{b\perp} \delta^2(q_\perp - k_{a\perp} - k_{b\perp})$$
$$\times \, \mathrm{Tr}\left[\gamma^\mu(1-\gamma^5)\Phi^q(x_a, k_{a\perp}, S_a)\gamma^\nu(1-\gamma^5)\bar{\Phi}^q(x_b, k_{b\perp}, S_b)\right]$$

$$\Phi^{q\,[\gamma^+]} = f_1^q(x_a, \vec{k}_{aT}^2) - \frac{\epsilon_T^{ij} k_{aT}^i S_{aT}^j}{M_a} f_{1T}^{\perp q}(x_a, \vec{k}_{aT}^2),$$
$$\Phi^{q\,[\gamma^+\gamma_5]} = S_{aL}\, g_{1L}^q(x_a, \vec{k}_{aT}^2) + \frac{\vec{k}_{aT}\cdot\vec{S}_{aT}}{M_a} g_{1T}^q(x_a, \vec{k}_{aT}^2),$$
$$\Phi^{q\,[i\sigma^{i+}\gamma_5]} = S_{aT}^i\, h_1^q(x_a, \vec{k}_{aT}^2) + \frac{k_{aT}^i(\vec{k}_{aT}\cdot\vec{S}_{aT}) - \frac{1}{2}\vec{k}_{aT}^2 S_{aT}^i}{M_a^2} h_{1T}^{\perp q}(x_a, \vec{k}_{aT}^2)$$
$$+ S_{aL} \frac{k_{aT}^i}{M_a} h_{1L}^{\perp q}(x_a, \vec{k}_{aT}^2) + \frac{\epsilon_T^{ij} k_{aT}^j}{M_a} h_1^{\perp q}(x_a, \vec{k}_{aT}^2).$$

- Besides the Sivers function, there should be more things we can study and learn (those should also be very interesting)

Summary

- Great progress on TMD evolution and global analysis
- Lots of work are still needed in the future to improve the TMD formalism
  - Still no successful simultaneous description of both SIDIS and DY unpolarized data
  - It is better to present the cross section instead of asymmetry/multiplicity distribution, need those with absolute cross section, not ratios!!!
  - Need to understand how to implement Y term in the polarized cross sections
- Transverse W program at RHIC should provide us such important information
  - Sign change
  - TMD evolution
  - Other TMDs

Thank you!