

Gauge Links and TMD-Factorization

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I will provide a status overview of transverse momentum dependent factorization theorems, with an emphasis on evolution, universality/non-universality, and the issue of factorization breaking. I will start by reviewing the basic concepts of gauge links and the complications that arise when attempting to define parton correlation functions. I will also describe recent efforts to combine existing implementations of the Collins-Soper-Sterman evolution formalism with fixed scale fits of TMDs. The result is a set of TMD fits in transverse momentum space that include evolution. Emphasis will be placed on the relationship with more standard generalized parton model concepts. I will conclude with a discussion of our future plans to extend TMD phenomenology with evolution.

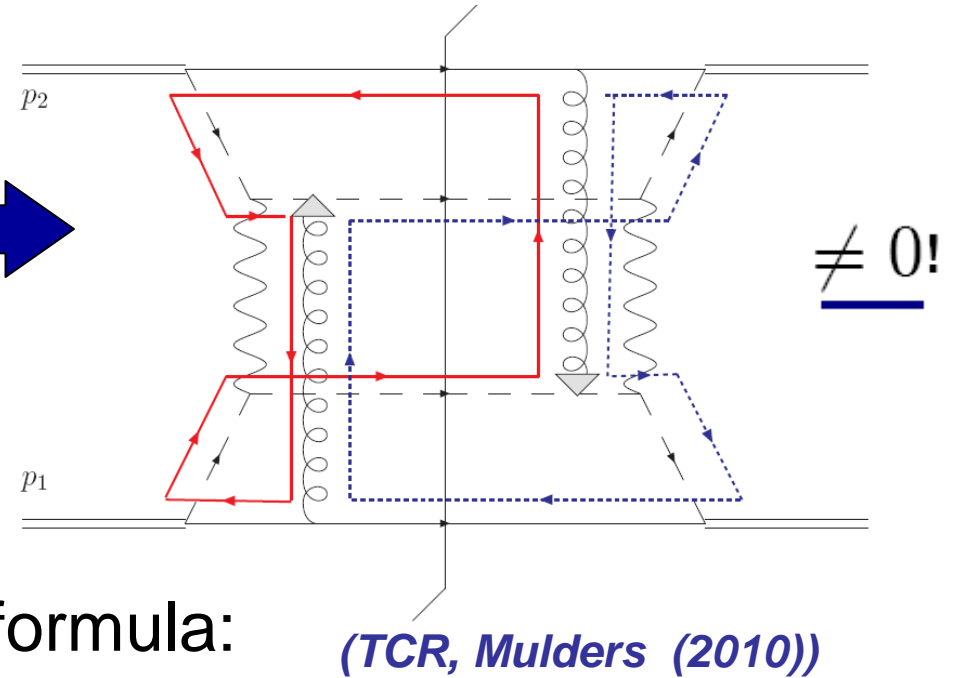
BNL Workshop on Drell-Yan Physics, May 11, 2011

Generalized TMD-factorization breaking:

- Gluons have color.

Actual color structure

Color Entanglement



- “generalized” factorization formula:

$$\mathcal{H} \times \left(\text{Diagram 1} \right) \times \left(\text{Diagram 2} \right) = \underline{0}$$

$\text{Tr}_C [t^a] = 0$

TMD-Factorization:

• Complications with defining TMDs:

- Divergences.
- Wilson lines / gauge links.
- Universality vs. non-universality.
- **Definitions dictated by requirements for factorization!**

• Processes:

- Semi-Inclusive deep inelastic scattering. ✓
- Drell-Yan. ✓
- e^+/e^- annihilation. ✓

~~$p + p \rightarrow h_1 + h_2 + X$!!~~

} Watch out for sign flips!

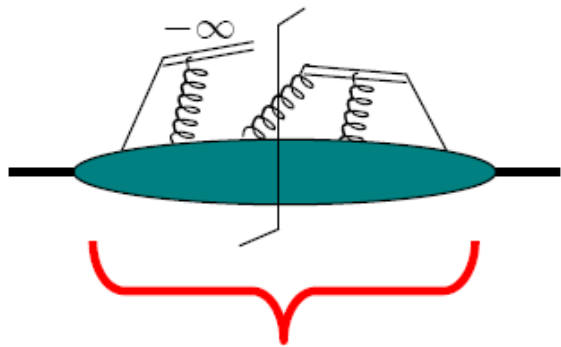
• Implementation and TMD phenomenology.

- Use existing fixed-scale fits / no evolution.
- Use existing “old fashion” implementation of Collins-Soper-Sterman formalism.
- **Full TMD formalism, including evolution.**

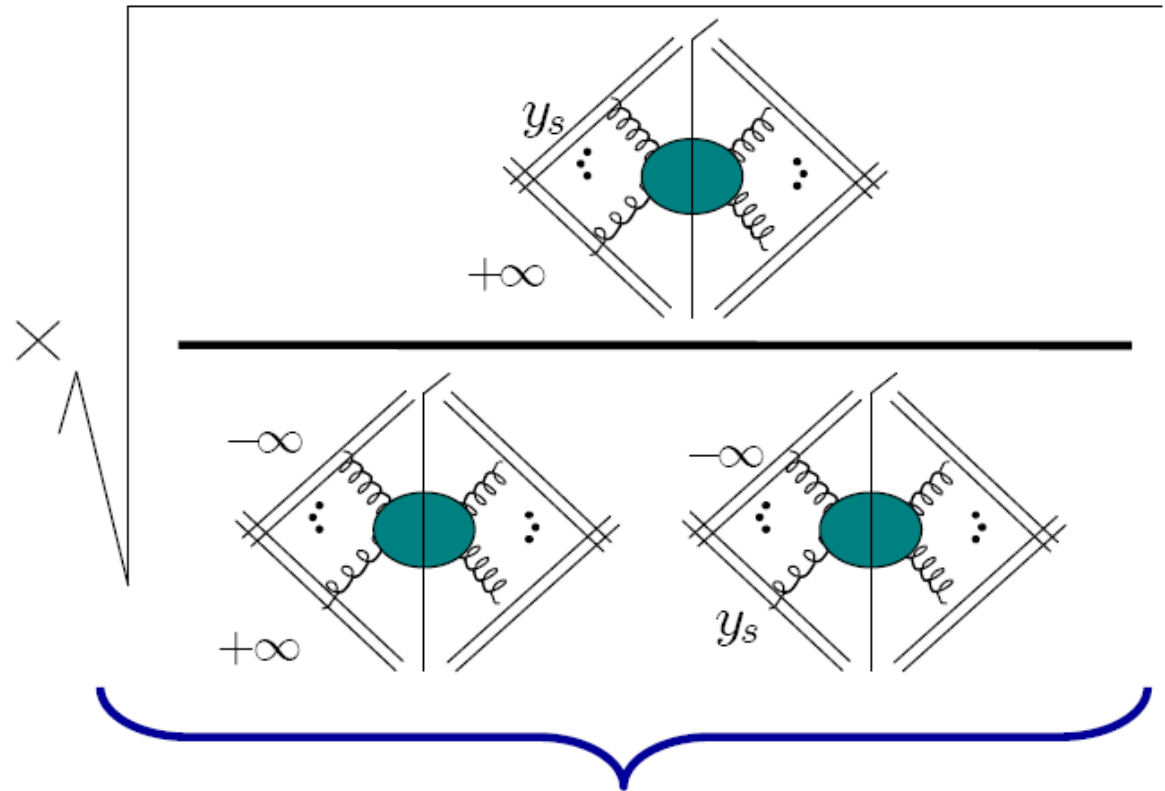
(New Collins Definitions)

TMD PDF, Complete Definition:

$$F_{f/P}(x, b; \mu; \zeta_F) =$$



“Unsubtracted”



Implements Subtractions/Cancellations

From *Foundations of Perturbative QCD*, J.C. Collins,
(See also, Collins, TMD 2010 Trento Workshop)

Current Strategy:

- Use evolution to combine existing fits into unified/global fits that include evolution.

(S.M. Aybat, TCR (2011))

– PDFs:

- Start with DY:

(Landry et al, (2003); Konychev, Nadolsky (2006)) (BLNY)

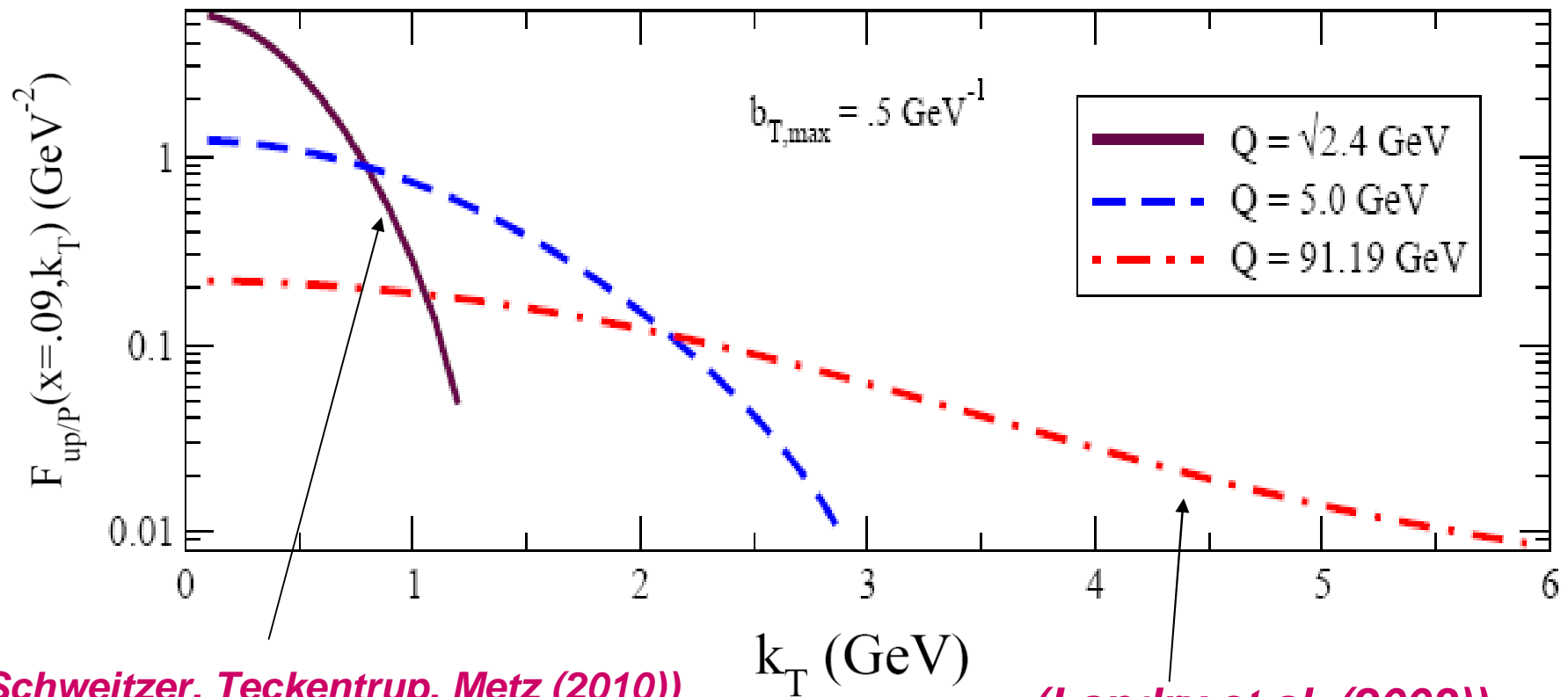
- Modify to match to SIDIS:

(Schweitzer, Teckentrup, Metz (2010)) (STM)

- Can supply explicit, evolved TMD PDF fit.

Evolving TMD PDFs

Up Quark TMD PDF, $x = .09$



(Schweitzer, Teckentrup, Metz (2010))
(SIDIS)

(Landry et al, (2003))
(Drell-Yan)