Collins-Soper kernel from evenT generators

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PB meeting

Motivation

There is a lot of similarity between PB method and TMD factorization method. However, these approach are fundamentally different

TMD factorization

- Based on OPE aka TMD factorization theorem
- Theoretically well-defined components (in terms of operators)
- Universality (!)
- Valid in a corner of phase space $q_T \ll Q$
- Position space

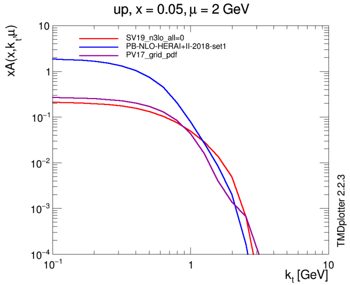
Parton branching

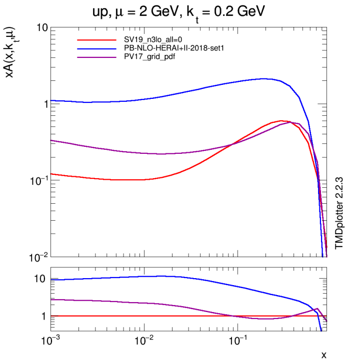
- Based on probabilistic interpretation of Feynman graphs
- No explicit definition of components
- Universality (?)
- Valid in a large area of phase space
- Momentum space

Main question

- How to compare elementary blocks of PB and TMD factorization?
  i.e. how to compare TMD distributions

Direct comparison is nonsense!



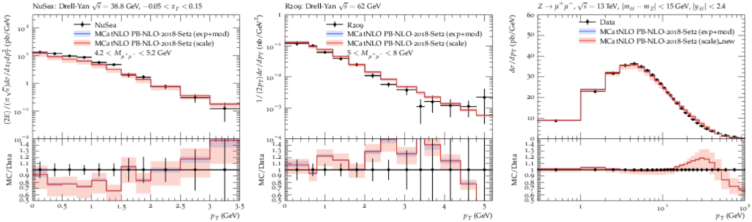


Most probably we compare different objects

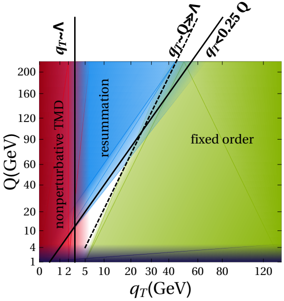
What-one-can-do (easily?) is to

extract and compare the NP evolution kernel (CS-kernel) from PB

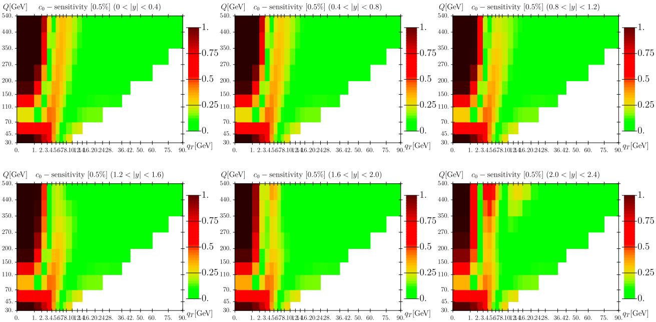
Non-perturbative physics from PB? → Yes, because it explains low-q_T



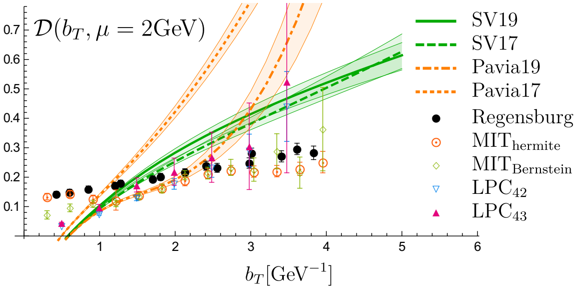
[A. Bermudez-Martinez, et al,2001.06488]



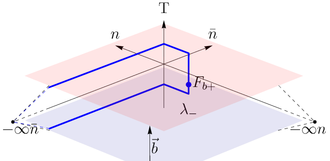
Sensitivity to NP-evolution parameters (here in kinematics of LHC)



All below $q_T < 5 - 10$GeV is sensitive to NP evolution



- CS-kernel is fundamental QCD observable. It parametrizes the vacuum expectation of the Wilson loop with insertion of $F_{\mu\nu}$ [AV, Phys.Rev.Lett. 125 (2020) 19, 192002]
- One can extract various NP QCD parameters from it: e.g. G_2, σ
- **So far, there is no agreement between extractions!**



How to extract?.. Proposal similar to lattice extractions.

$$\frac{d\sigma}{dQ^2 dy d^2\mathbf{q}_T^2} = \frac{\alpha_{em}^2(Q)\sigma_0}{Q^2}|C_V|^2(Q)\sum_f e_q^f \int \frac{db}{2\pi} bJ_0(bq_T)R[Q \to (\mu,\zeta)]^2 f_{1,f}(x_1,b,\mu,\zeta)f_{1,\bar{f}}$$

1. Hankel Transform of cross-section

$$\Sigma(b,Q,y,s) = \int_0^\infty dq_T q_T J_0(bq_T)\frac{d\sigma}{dQ^2 dy d^2\mathbf{q}_T^2} \quad (1)$$

2. Make a ratio at same $\{s$,y(could be integral),$b\}$ at different Q's

$$\frac{\Sigma(b,Q_1,y,s)}{\Sigma(b,Q_2,y,s)} = \frac{\alpha_{em}^2(Q_1)}{\alpha_{em}^2(Q_2)}\frac{Q_2^2}{Q_1^2}\frac{|C_V|^2(Q_1)}{|C_V|^2(Q_2)}\frac{R[Q_1 \to (\mu,\zeta)]^2}{R[Q_2 \to (\mu,\zeta)]^2} \quad (2)$$

   - $|C_V|^2(Q)$ is know up to α_s^3
   - (μ,ζ) independent
   - Set $(\mu,\zeta) = (Q_2, Q_2^2)$

3. Compute

$$R[Q_1 \to (Q_2,Q_2^2)]^2 = \frac{\alpha_{em}^2(Q_2)}{\alpha_{em}^2(Q_1)}\frac{Q_1^2}{Q_2^2}\frac{|C_V|^2(Q_2)}{|C_V|^2(Q_1)}\frac{\Sigma(b,Q_1,y,s)}{\Sigma(b,Q_2,y,s)} \quad (3)$$

$$= \exp\left(\int_{Q_2^2}^{Q_1^2}\frac{d\mu^2}{\mu^2}\gamma_F(\mu,Q_1) - \mathcal{D}(b,Q_2)\ln\left(\frac{Q_1^2}{Q_2^2}\right)\right)$$

$$\mathcal{D}(b,Q_2) = \frac{\int_{Q_2^2}^{Q_1^2} \frac{d\mu^2}{\mu^2}\gamma_F(\mu,Q_1) - \ln\left(\frac{\alpha_{em}^2(Q_2)}{\alpha_{em}^2(Q_1)}\frac{Q_1^2}{Q_2^2}\frac{|C_V|^2(Q_2)}{|C_V|^2(Q_1)}\frac{\Sigma(b,Q_1,y,s)}{\Sigma(b,Q_2,y,s)}\right)}{\ln Q_1^2 - \ln Q_2^2} \tag{4}$$

Attention! Possible sign-mistakes

To make such computation one needs

- Fine binning in q_T for $q_T < 5 - 10$GeV Smaller q_T = larger b
- Fine bin in Q Smaller bin = smaller uncertainty
- Y-bins are unimportant (could be fully integrated) different Y-bins should give same result