Matching Factors for Quasi-GPDs with Hybrid Renormalization

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LaMET Factorization Theorem

$$\tilde{q}(x,\Lambda,P_z)=\int\frac{dy}{|y|}Z\left(\frac{x}{y},\frac{\mu}{P_z},\frac{\Lambda}{P_z}\right)q(y,\mu)+\mathcal{O}\left(\frac{\Lambda^2_{\rm QCD}}{P_z^2},\frac{M^2}{P_z^2}\right)+....$$

- compensating the UV difference of quasi-PDF and PDF
- PDF in MS-bar, quasi-PDF in lattice spacing---lattice action dependence, slow convergence (linear divergence, Wilson line mass subtraction scheme, Ishikawa, Ma, Qiu, Yoshida; JWC, Ji, Zhang)

Non-perturbative renormalization (NPR)

Quark bilinear operators multiplicatively renormalized---

(1) Ratio scheme (same operator, different states, Radyushkin)

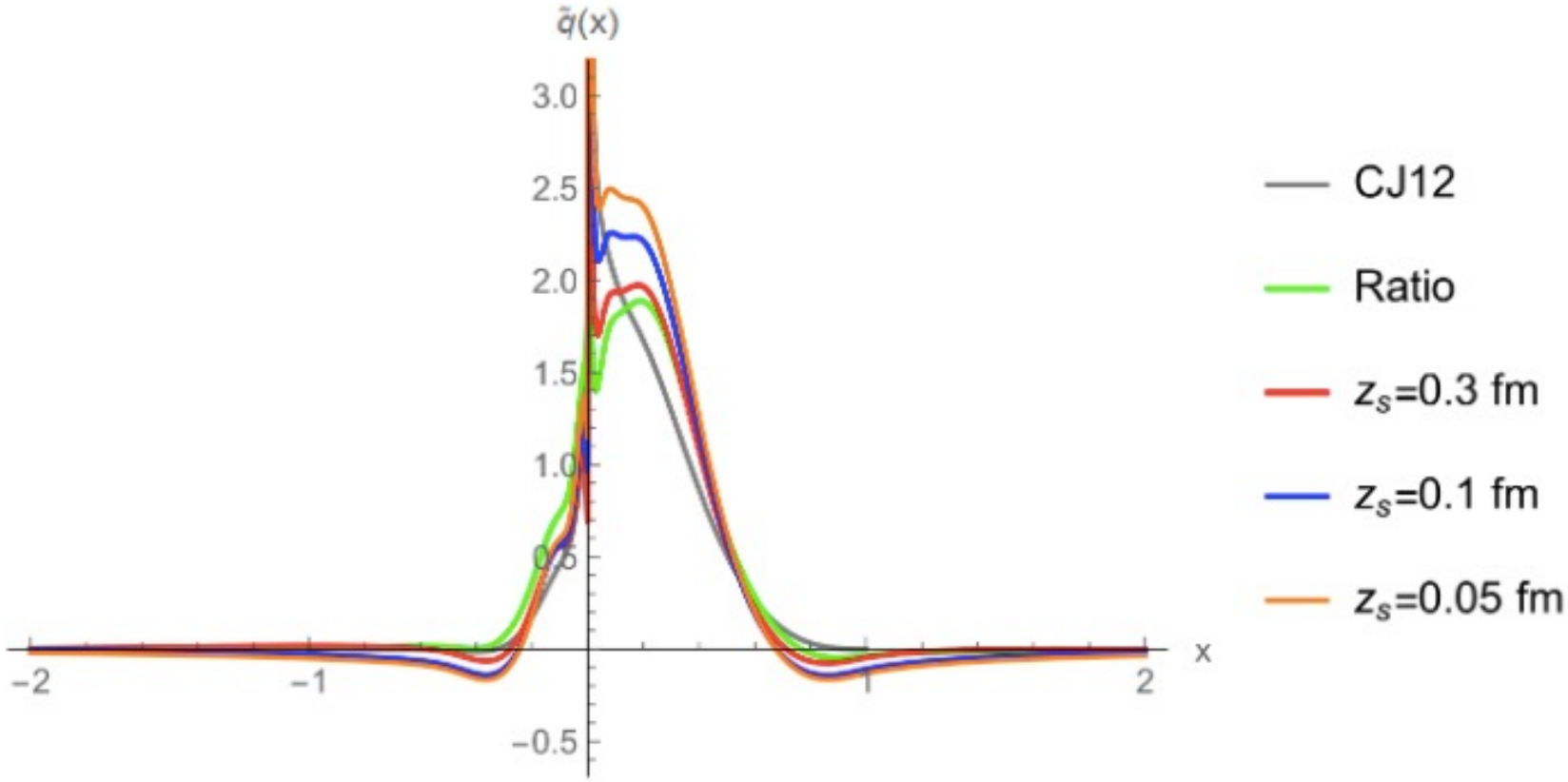
(2) RI/MOM (loop corrections removed at off shell momentum, Zhao & Stewart; Constantinou et al)

Then to continuum limit, lattice artifact gone (ChQCD (2012.05448): might not for RI/MOM)

Why Hybrid Renormalization?

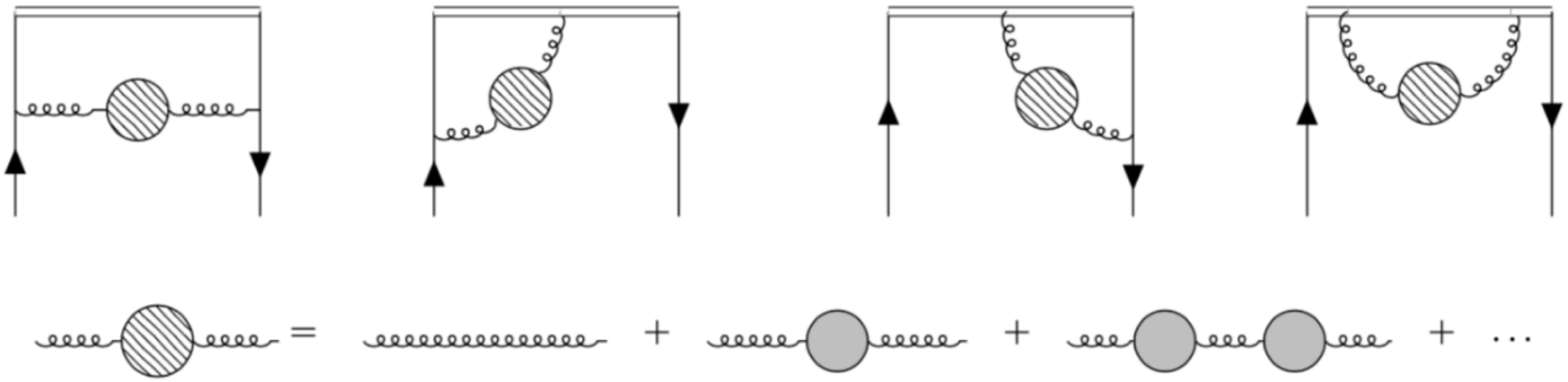
- NPR should not remove unquantified nonperturbative IR effect---not the case for ratio & RI/MOM schemes. Long (> Zs~0.3 fm) Wilson line op. renormalize by Wilson line mass subtraction scheme instead---Hybrid renormalization (X. Ji, Y. Liu, A. Schäfer, W. Wang, Y.B. Yang, J.H. Zhang, Y. Zhao, 2008.03886)
- Hybrid-ratio scheme preferred.

QPDF: Hybrid-Ratio to MS-bar Matching (Chien-Yu Chou, JWC, 2204.08343)



u-d in proton; Zs = 0.3 fm is close to infinity!

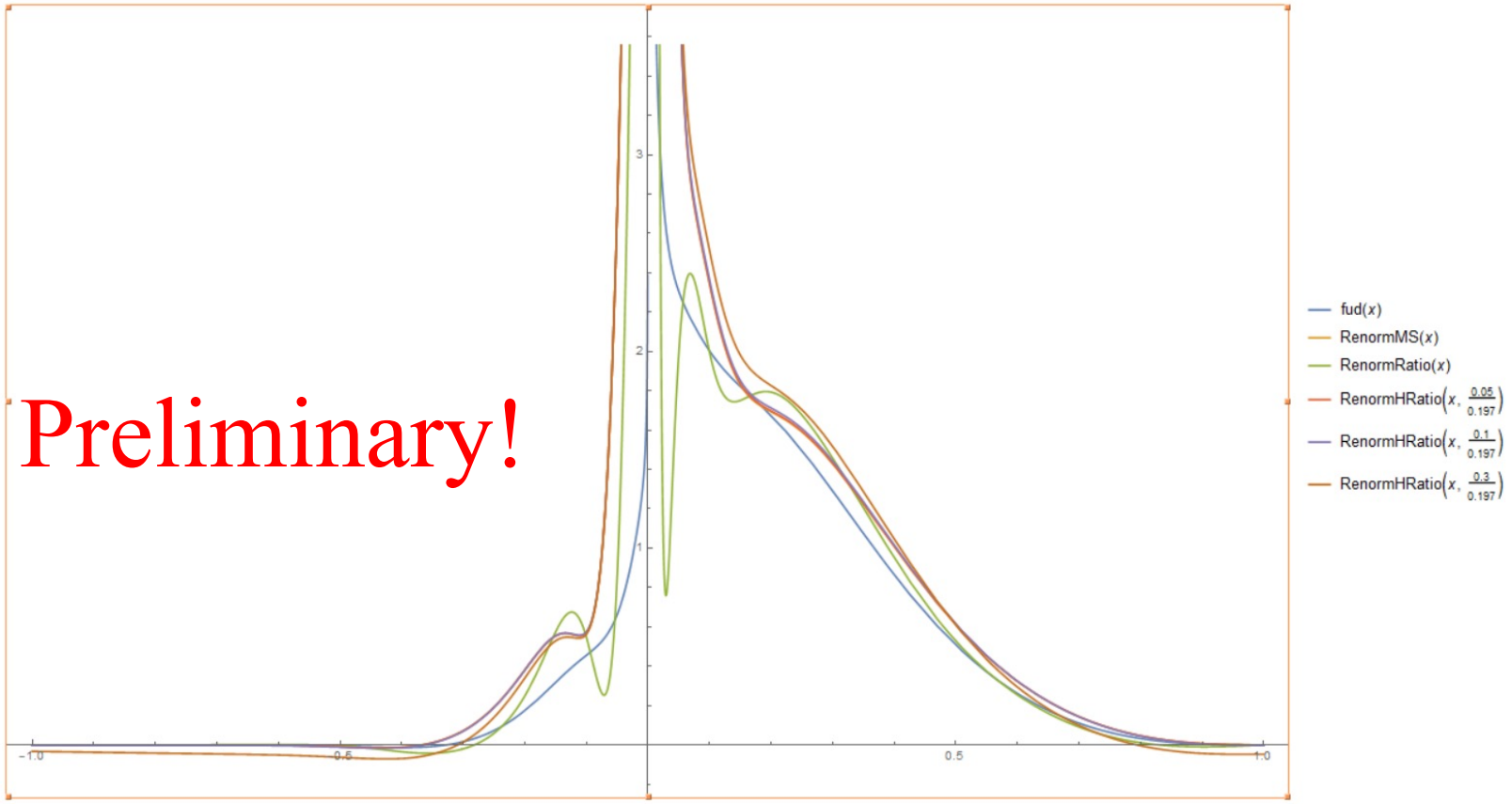
Renormalon in LaMET



Braun, Vladimirov and Zhang (1810.00048):
power correction $\mathcal{O}(\Lambda^2_{\rm QCD}/x^2P_z^2)$

Hybrid-ratio renormalon ambiguity

w/ Yi-Xian Chen

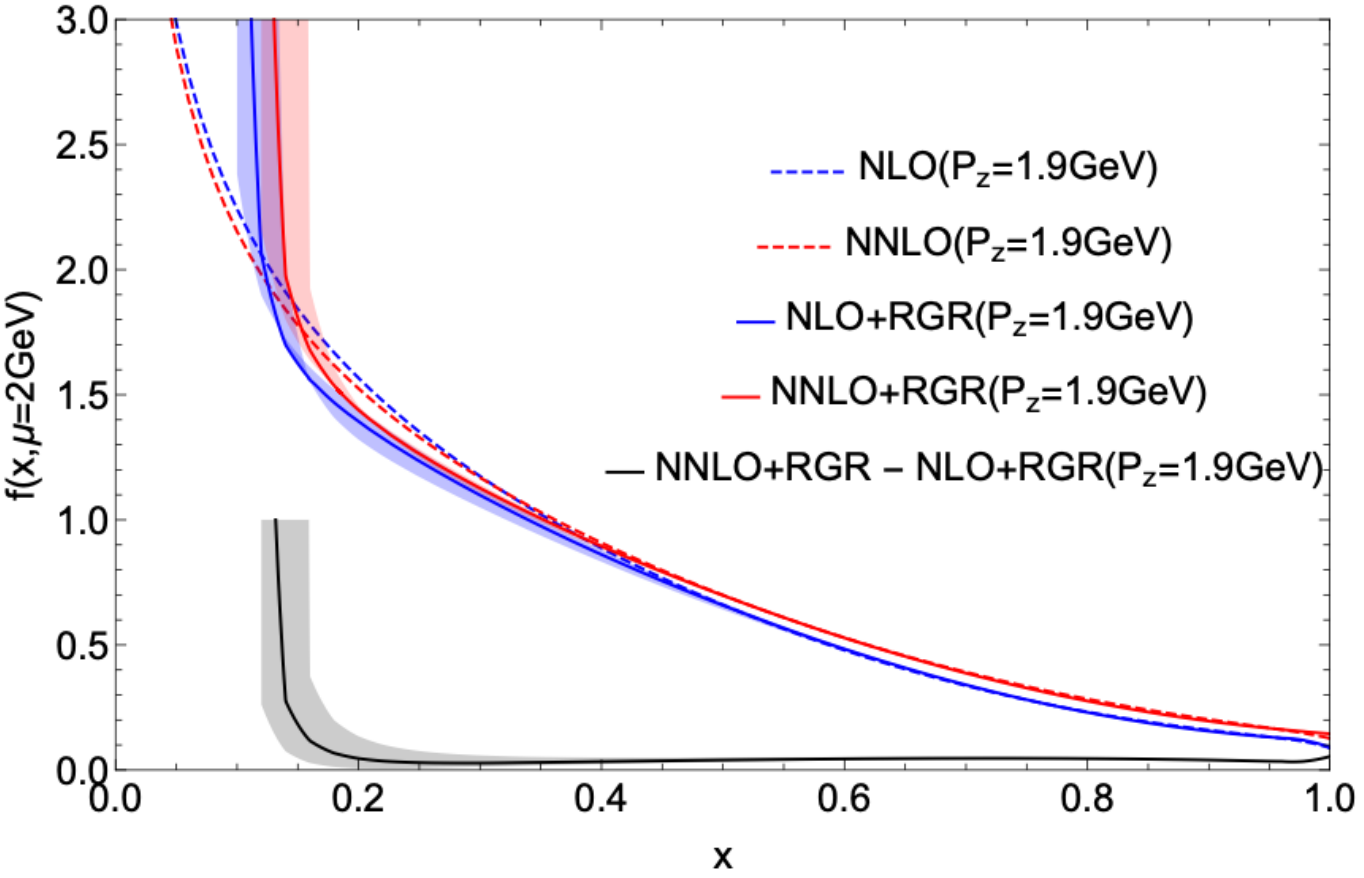


u-d in proton

Hybrid-ratio closer to MS-bar than ratio

--- Zs = 0.3 fm is close to zero!

Same as Leading Log Resummation!



Pion u-d valance quark PDF---Yushan Su, Jack Holligan, Xiangdong Ji, Fei Yao, Jian-Hui Zhang, Rui Zhang (2209.01236)

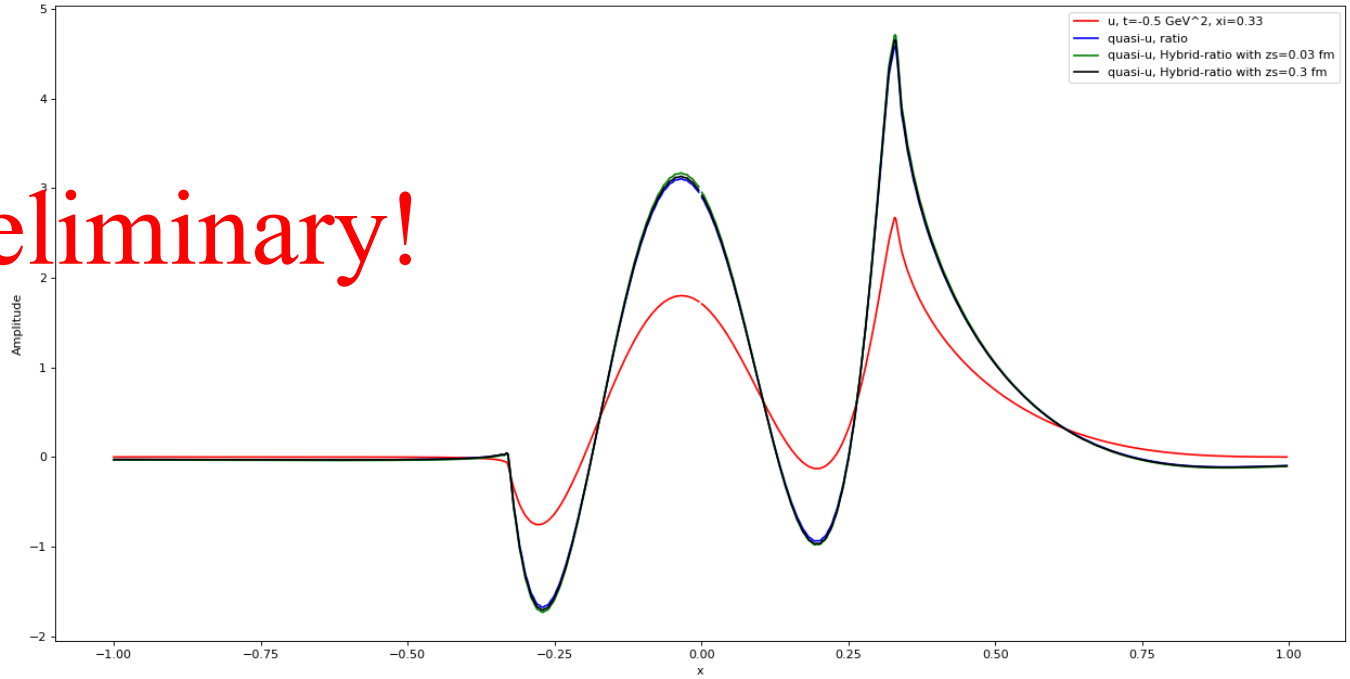
QGPDs in Hybrid-Ratio Scheme

- GPDs, depend on (x,xi,t)
- Hybrid-ratio kernel = ratio kernel (t independent) + Zs depend term (xi and t independent)
- xi = 0, Hybrid-ratio kernel = PDF kernel

Unpol. QGPD H

w/ Yi-Xian Chen, Chien-Yu Chou

Preliminary!



u quark in proton; t=-0.5 GeV^2, xi =0.33

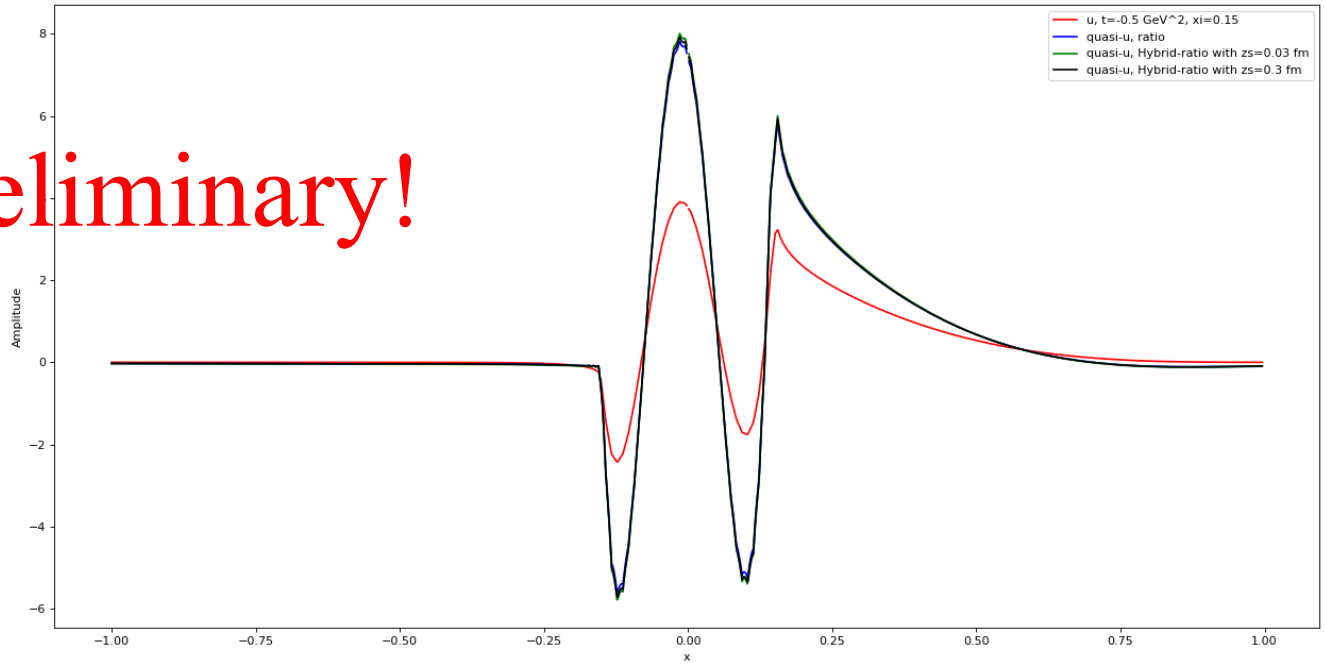
Zs = 0.3 fm is close to infinity!

GPD model: Yuxun Guo, Xiangdong Ji, M. Gabriel Santiago, Kyle Shiells, Jinghong Yang (2302.07279)

Unpol. QGPD H

w/ Yi-Xian Chen, Chien-Yu Chou

Preliminary!



u quark in proton; t=-0.5 GeV^2, xi =0.15

Zs = 0.3 fm is close to infinity!

GPD model: Yuxun Guo, Xiangdong Ji, M. Gabriel Santiago, Kyle Shiells, Jinghong Yang (2302.07279)

Summary

Hybrid-ratio scheme

(a) Renormalon ambiguity in PDF close to MS-bar scheme (Zs = 0.3 fm is close to zero). Bubble sum same as leading log resummation

(b) QGPD close to ratio scheme (Zs = 0.3 fm is close to infinity)