Power Corrections in DVCS

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We will need very high theory accuracy to access 3D structure on a quantitative level

— Power corrections are part of systematic errors
— Quark-gluon correlations are interesting on their own

- M. Defurne *et al.*, Nature Commun. **8**, no. 1, 1408 (2017)

  — Why Wandzura-Wilczek much too large for helicity flip?

- M. Hattawy *et al.* [CLAS Collaboration], Phys. Rev. Lett. **119**, no. 20, 202004 (2017)

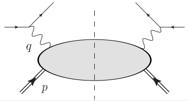
  — Why large nucleus mass does not spoil factorization?

- Higher twist and soft corrections beyond "kinematic" ones?

Ambiguity of the leading twist description

- **Planar vs. non-planar kinematics**

DIS

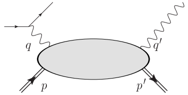


Define (p,q) as longitudinal plane:

$$\begin{aligned} p &= (p_0, \vec{0}_\perp, p_z) \\ q &= (q_0, \vec{0}_\perp, q_z) \end{aligned}$$

$\Rightarrow$ parton fraction = Bjorken x

DVCS



Many choices possible:

$$p = (p_0, \vec{0}_\perp, p_z), \quad q = (q_0, \vec{0}_\perp, q_z)$$

or

$$p + p' = (P_0, \vec{0}_\perp, P_z), \quad q = (q_0, \vec{0}_\perp, q_z)$$

etc.

$\Rightarrow$ parton fraction $2\xi = x_B[1 + \mathcal{O}\big(\frac{t}{Q^2}\big)]$,
$\&$ redefinition of helicity amplitudes

- **Ambiguity is resolved by adding "kinematic" power corrections t/Q^2, m^2/Q^2**
- **Why "kinematic": do not involve new nonperturbative input apart from usual GPDs**

helicity amplitudes in the "photon" frame

Braun, Manashov, Pirnay: PRD **86** (2012) 014003

$$\begin{aligned}\mathcal{A}_{\mu\nu}(q,q',p) &= i\int d^4x\, e^{-i(z_1 q - z_2 q')x}\langle p',s'|T\{J_\mu(z_1x)J_\nu(z_2x)\}|p,s\rangle \\ &= \varepsilon^+_\mu\varepsilon^-_\nu\,\mathcal{A}^{++} + \varepsilon^-_\mu\varepsilon^+_\nu\,\mathcal{A}^{--} + \varepsilon^0_\mu\varepsilon^-_\nu\,\mathcal{A}^{0+} \\ &+ \varepsilon^0_\mu\varepsilon^+_\nu\mathcal{A}^{0-} + \varepsilon^+_\mu\varepsilon^+_\nu\mathcal{A}^{+-} + \varepsilon^-_\mu\varepsilon^-_\nu\,\mathcal{A}^{-+} + q'_\nu\mathcal{A}^{(3)}_\mu\end{aligned}$$

for the calculation to the twist-4 accuracy one needs

- $\mathcal{A}^{++}, \mathcal{A}^{--}$: $1 + \frac{1}{Q^2}$
- $\mathcal{A}^{0+}, \mathcal{A}^{0-}$: $\frac{1}{Q}$ $\longleftarrow$ agree with existing results
- $\mathcal{A}^{-+}, \mathcal{A}^{+-}$: $\frac{1}{Q^2}$ $\longleftarrow$ straightforward

Main features:

- **Complete results available to t/Q^2, m^2/Q^2 accuracy**

  — translation and gauge invariance restored

  — factorization valid

  — correct threshold behavior $t \to t_{\min}$, $\xi \to 1$

  — correct dispersion relations

- **Two expansion parameters**

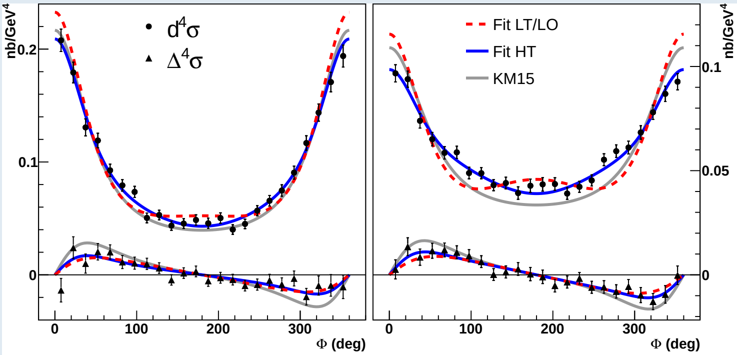
$$\frac{t}{Q^2}; \qquad \frac{t - t_{\min}}{Q^2}$$

- **Most of mass corrections absorbed in $t_{\min} = -4m^2\xi^2/(1-\xi^2)$; always overcompensated by finite-t corrections in the physical region**

- **Some extra m^2/Q^2 corrections for nucleon due to spinor algebra; disappear in certain CFF combinations and for scalar targets**

Large effects for the total cross section

M. Defurne *et al.*, Nature Commun. **8**, no. 1, 1408 (2017)



- $\mathcal{A}^{0\pm}$ too large?
- Flaw in the analysis? Twist-5? Genuine twist-3?
  — a pressing issue
- Twist-4 corrections generally on a 10% level

Coherent DVCS on nuclei

- **Target mass corrections**

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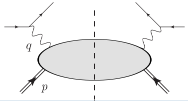


Nachtmann variable:

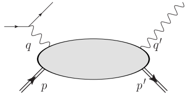
$$\xi \quad = \quad \frac{2x}{1+\sqrt{1+4x^2m^2/Q^2}}$$

On a nucleus

$$m \mapsto Am \qquad x \mapsto x/A$$

$\Rightarrow$ TMC unaffected

DVCS



Braun, Manashov, Pirnay: PRD **86** (2012) 014003

All twist-4 TMC are absorbed in

$$t_{\rm min} = -4m^2\xi^2/(1-\xi^2)$$

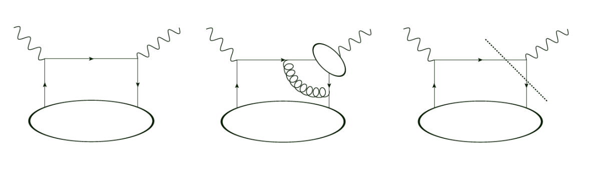
On a nucleus

$$m \mapsto Am \qquad \xi \mapsto \xi/A$$

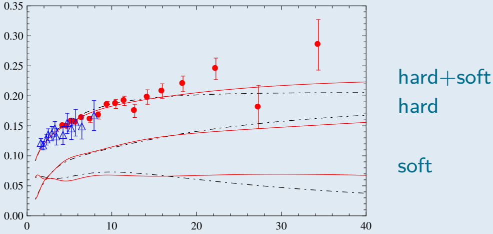
$\Rightarrow$ TMC unaffected

- **Extend to all twists?**
- **TMC and finite-t corrections are intertwined**

Soft corrections



-Example: $\pi\gamma^*\gamma$ S. S. Agaev *et al.*, Phys. Rev. D **83**, 054020 (2011)



- **Estimates possible:**
  — photon wave functions
  — dispersion relations and duality (LCSR)
- **Expect a small correction thanks to strong suppresion of GPDs at $x \to 1$**

"Genuine" higher twists (quark-gluon correlations)

- Twist-3 GPDS, "genuine" twist-3 corrections
  - **Potentially interesting, but want to see $g_2(x, Q^2)$**
- Twist-4 GPDS, "genuine" twist-4 corrections
  - **No reason to bother:**

    — Factorization broken

    — $\frac{|t|}{Q^2} \gg \frac{\Lambda^2_{\rm QCD}}{Q^2}$
- Soft corrections and vector meson electroproduction