GLUON TMD OPPORTUNITIES WITH QUARKONIUM PRODUCTION AT A 2ND EIC DETECTOR

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UAH Madrid

1ST INTERNATIONAL WORKSHOP ON A 2ND DETECTOR FOR THE EIC

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Madrid UAH

talento cm Programa de atracción de talento investigador Comunidad de Madrid

ANIVERSARIO PATRIMONIO MUNDIAL

Gluon TMD PDFs: a largely unexplored territory

- Theory: different gauge-link structures...

  ...more diversified kind of modified universality!

- Pheno: golden channels for extraction

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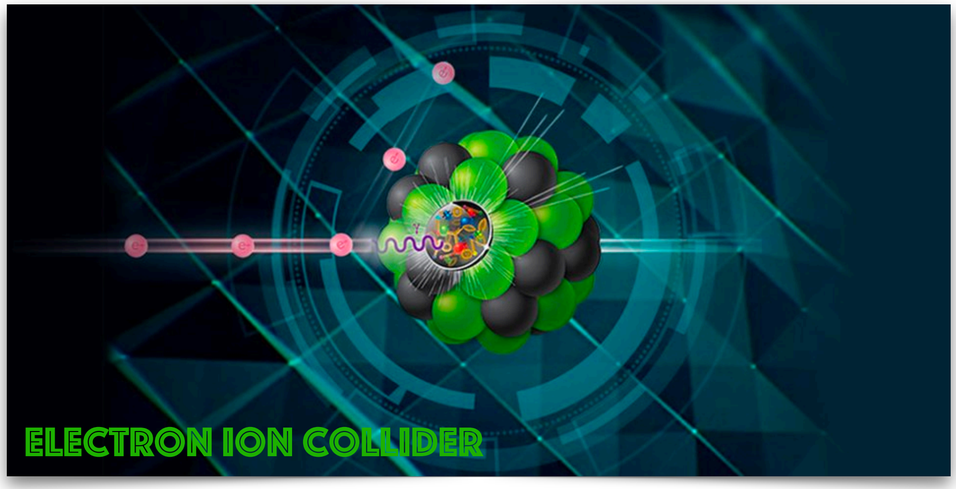

3D proton imaging

- Gluon TMD PDFs ⇒ core sector of EIC studies
- Need for a flexible model, suited to pheno

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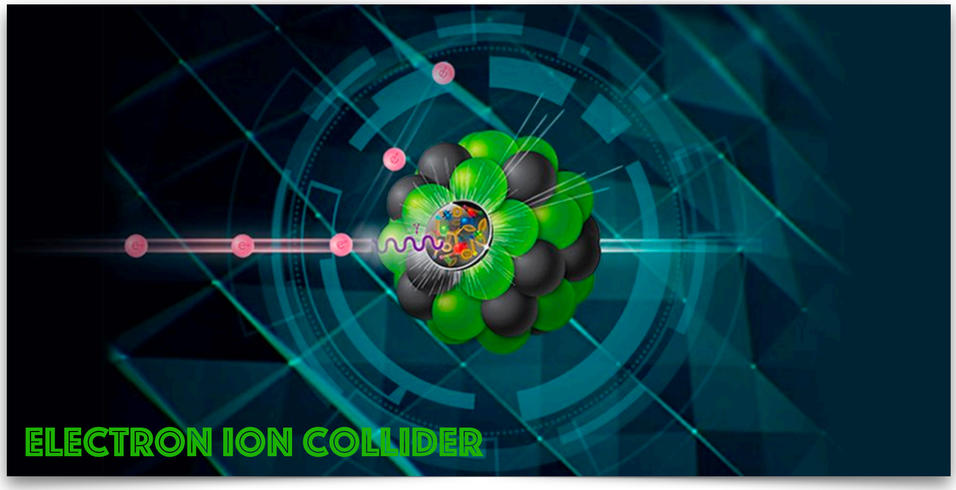


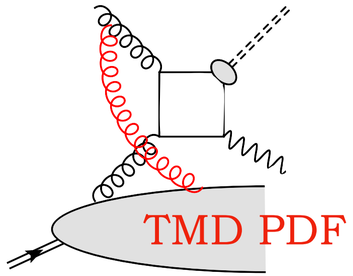
3D proton imaging

- Gluon TMD PDFs ⇒ core sector of EIC studies
- Need for a flexible model, suited to pheno
- Gluon and nucleon polarization at twist-2
- Window of opportunities also at a 2nd detector

Quarkonia: assets & challenges

Assets

Onia ⇒ clean channels of f-type gluon TMDs



Initial-state color flow ⇒ [– , –] gauge link

Sivers	$e\,p^{\uparrow} \to e'\,Q\,\overline{Q}\,X$ $e\,p^{\uparrow} \to e'\,j_1\,j_2\,X$
$f_{1T}^{\perp\,g\,[-,-]}$	√
$f_{1T}^{\perp\,g\,[+,-]}$	×

(overview) [D. Boer (2017)]

Boer-Mulders	$e\,p \to e'\,Q\,\overline{Q}\,X$ $e\,p \to e'\,j_1\,j_2\,X$
$h_1^{\perp\,g\,[-,-]}$(WW)	√
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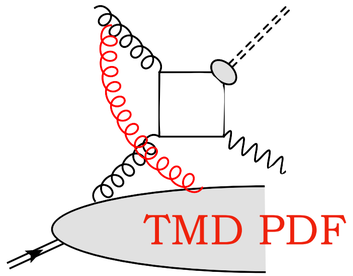

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$\eta_{c,b}$ ⇒ LHC complementarity, TMD factorization

$$\frac{d\sigma}{dq_T} \sim$$

at low transverse momentum for (pseudo)scalar state

$$\sim \mathcal{C}[\, f_1^{g/A}\ f_1^{g/B}\,] \pm \mathcal{C}[\, h_1^{\perp g/A}\ h_1^{\perp g/B}\,]$$

unpolarized gluons — **lin. polarized** gluons

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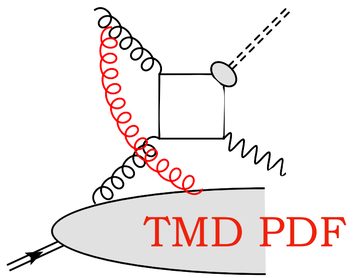

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Challenges

Precision TMD ⇔ production mechanism(s)

(production mechanisms, LHC) [J.-P. Lansberg (2020)]

Color Evaporation Model

$(Q\bar{Q})$ decorrelated from onium, semi-soft gluon emissions

Overshoots data at large p_T

Color Singlet Model

$(Q\bar{Q})$ to onium, no gluon emissions

Fails at large p_T, improves at NLO

NRQCD and Color Octet

Higher Fock states, soft gluon emissions

Problems at low p_T, fails on polarization

Quarkonia & Gluon TMDs: a path toward precision

TMD & shape functions

- NRQCD ⇒ double expansion: $\alpha_s \oplus v$
- NRQCD ⇒ $\mathrm{d}\sigma(|\mathcal{Q}\rangle) \propto \mathscr{H} \otimes \mathrm{LDME}$

$$|\mathcal{Q}\rangle = \mathcal{O}(1)\,|Q\bar{Q}[^3S_1^{(1)}]\rangle + \mathcal{O}(v)\,|Q\bar{Q}[^3P_J^{(8)}g]\rangle + \mathcal{O}(v^2)\,|Q\bar{Q}[^1S_0^{(8)}g]\rangle + \mathcal{O}(v^2)\,|Q\bar{Q}[^3S_1^{(1,8)}gg]\rangle + \mathcal{O}(v^2)\,|Q\bar{Q}[^3D_J^{(1,8)}gg]\rangle + \dots .$$

S-wave quarkonium wave function

- TMD ⇒ from LDMEs to shape functions (ShFs)
- 2 mechanisms: bound state + soft-gluon

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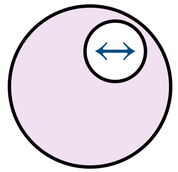
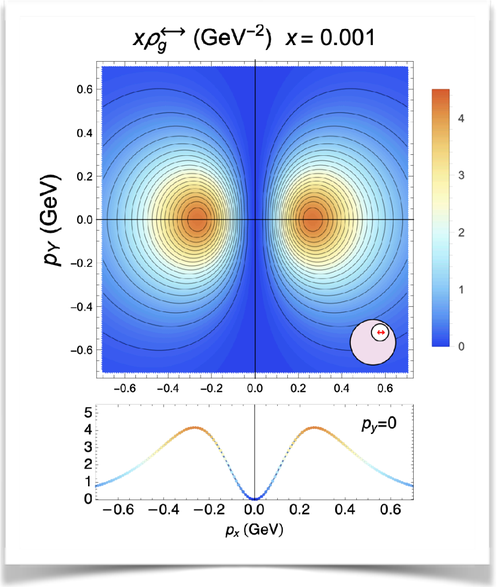
3D proton imaging: LHC & EIC



EIC, LHCb, FT@LHC

Boer-Mulders



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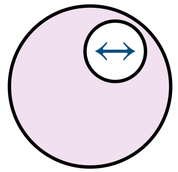

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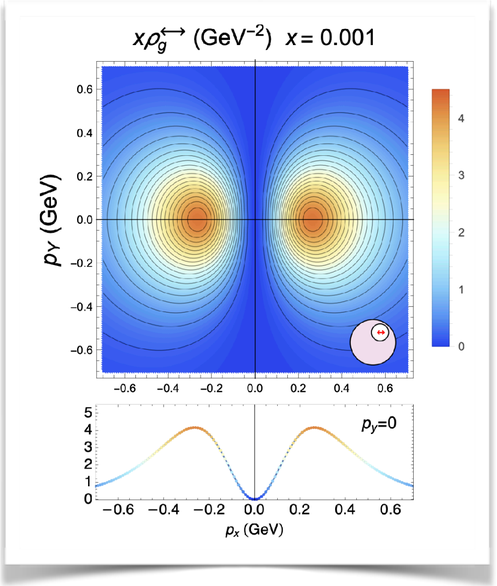
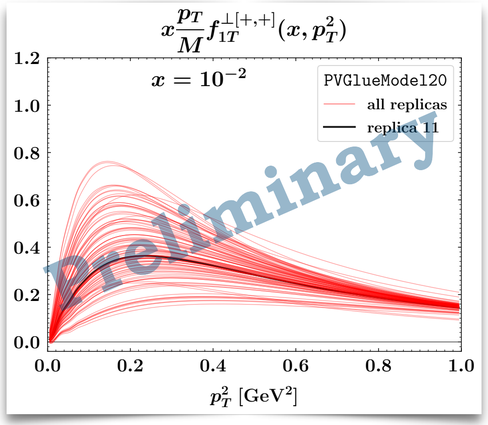
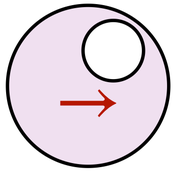


[A. Bacchetta, F.G. C., M. Radici, P. Taels (2020)]
[A. Bacchetta, F.G. C., M. Radici (to appear)]





EIC, LHCspin

Sivers

A path toward precision