Diffractive dijets in $e\ p \to e'\ jet\ jet\ p$ reaction using GTMDs

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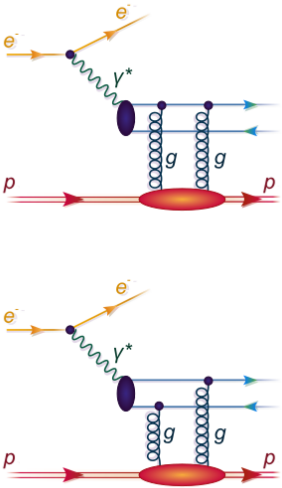
Supported by Polish National Science Center Grant UMO-2023/49/B/ST2/03665

Introduction

1. We calculate several differential distributions for diffractive dijets production in $ep \to e' \mathrm{jet}\,\mathrm{jet}\, p$ in the pQCD dipole approach using off diagonal unintegrated gluon distributions (GTMDs).
2. We concentrate on the contribution from exclusive $q\bar{q}$ dijets.
3. Our results, including experimental cuts, are below HERA data except for one GTMD; the mechanism contributes significantly to ZEUS but is negligible for H1.
4. The ZEUS data impose stricter constraints on GTMDs than the H1 data. Our calculations explain only a small part of the measured cross sections, suggesting additional contributions from pomeron remnants or the $q\bar{q}g$ component of the photon wave function.

B. Linek, M. Łuszczak, W. Schafer, A. Szczurek
Phys.Rev.D 110 (2024) 5, 054027

pQCD diagrams for exclusive diffractive dijet production



Diffractive photo production of $q\bar{q}$ in electron proton collisions

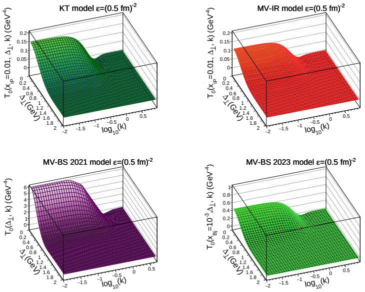
$$\frac{d\sigma^{ep}}{dydQ^2d\xi} = \frac{\alpha_{em}}{\pi y Q^2}\left[\left(1-y+\frac{y^2}{2}\right)\frac{d\sigma_T^{\gamma^* p}}{d\xi} + (1-y)\frac{d\sigma_L^{\gamma^* p}}{d\xi}\right].$$

$$\frac{d\sigma_T^{\gamma^* p}}{dzd^2\vec{P}_\perp d^2\vec{\Delta}_\perp} = 2N_c\alpha_{em}\sum_f e_f^2 \int d^2\vec{k}_\perp \int d^2\vec{k}_\perp^{\,\prime} T(Y,\vec{k}_\perp,\vec{\Delta}_\perp)T(Y,\vec{k}_\perp^{\,\prime},\vec{\Delta}_\perp)$$
$$\times \left\{\left(z^2+(1-z)^2\right)\left[\frac{(\vec{P}_\perp-\vec{k}_\perp)}{(\vec{P}_\perp-\vec{k}_\perp)^2+\epsilon^2} - \frac{\vec{P}_\perp}{P_\perp^2+\epsilon^2}\right]\cdot\left[\frac{(\vec{P}_\perp-\vec{k}_\perp^{\,\prime})}{(\vec{P}_\perp-\vec{k}_\perp^{\,\prime})^2+\epsilon^2} - \frac{\vec{P}_\perp}{P_\perp^2+\epsilon^2}\right]\right.$$
$$\left. + \; m_f^2\left[\frac{1}{(\vec{P}_\perp-\vec{k}_\perp)^2+\epsilon^2} - \frac{1}{P_\perp^2+\epsilon^2}\right]\cdot\left[\frac{1}{(\vec{P}_\perp-\vec{k}_\perp^{\,\prime})^2+\epsilon^2} - \frac{1}{P_\perp^2+\epsilon^2}\right]\right\},$$

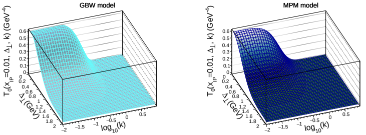
$$\frac{d\sigma_L^{\gamma^* p}}{dzd^2\vec{P}_\perp d^2\vec{\Delta}_\perp} = 2N_c\alpha_{em}4Q^2z^2(1-z)^2 \times \sum_f e_f^2 \int d^2\vec{k}_\perp \int d^2\vec{k}_\perp^{\,\prime} T(Y,\vec{k}_\perp,\vec{\Delta}_\perp)T(Y,\vec{k}_\perp^{\,\prime},\vec{\Delta}_\perp)$$
$$\times \left[\frac{1}{(\vec{P}_\perp-\vec{k}_\perp)^2+\epsilon^2} - \frac{1}{P_\perp^2+\epsilon^2}\right]\cdot\left[\frac{1}{(\vec{P}_\perp-\vec{k}_\perp^{\,\prime})^2+\epsilon^2} - \frac{1}{P_\perp^2+\epsilon^2} right\right],$$

GTMD is a representation of the diffraction amplitude in momentum space often used in the literature

- parametrizations based on the regularized Fourier transform of dipole amplitude: Kowalski –Teaney (KT) model, MV –IR model, MV –BS 2021 model, MV –BS 2023 model



- parametrizations of off-forward gluon density matrices for diagonal unintegrated gluon distribution compatible with the Golec-Biernat-Wüsthoff (GBW model), Moriggi-Paccini-Machado (MPM model)

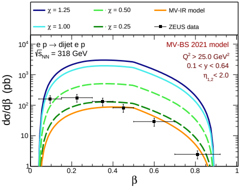


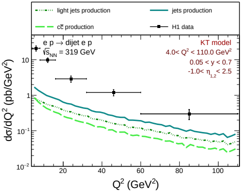
H1 and ZEUS kinematics

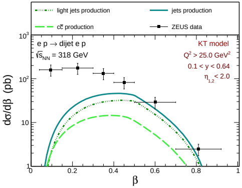
HERA cuts	
H1	*ZEUS*
$4 < Q^2 < 110\ GeV^2$	$Q^2 > 25\ GeV^2$
$x_{IP} < 0.1$	$x_{IP} < 0.01$
$0.05 < y < 0.7$	$0.1 < y < 0.64$
$-1 < \eta_{1,2} < 2.5$	$\eta_{1,2} < 2$
$p_{\perp 1} > 5\ GeV$	$p_{\perp 1,2} > 2\ GeV$
$p_{\perp 2} > 4\ GeV$	$M_{jj} > 5\ GeV$
$\lvert t \rvert < 1\ GeV^2$	$90 < W\gamma p < 250\ GeV$

GTMD approaches	H1 cuts, $\sigma(pb)$		
	light $q\bar{q}$	$ep \to c\bar{c}$	*no* $p_{\perp 1,2}$ *cuts*
GBW	26.35	19.91	10900.86
MPM	147.94	108.26	10151.00
KT	21.29	15.20	5957.65
$MV - IR$	243.20	155.21	11784.75
$MV - BS$ 2021	404.06	269.75	10999.73
$MV - BS$ 2023	288.34	189.74	6685.82
DATA	**254**		-

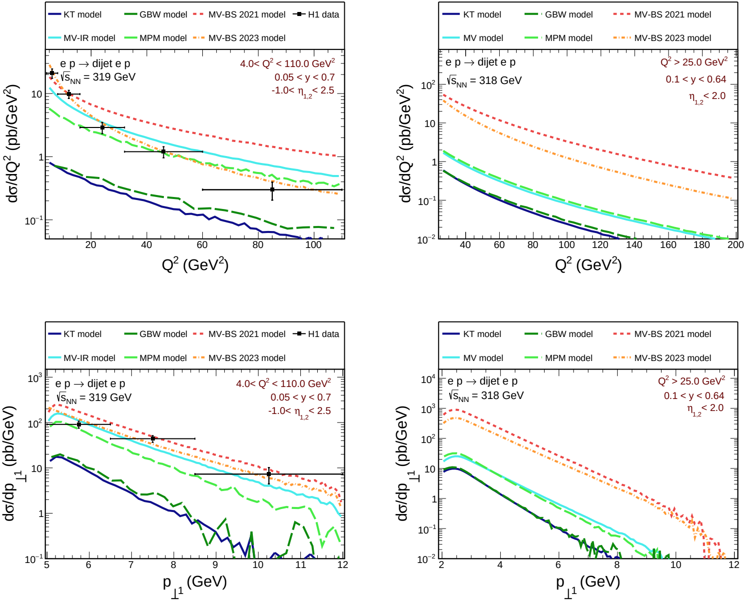
GTMD approaches	ZEUS cuts, $\sigma(pb)$		
	light $q\bar{q}$	$ep \to c\bar{c}$	*no* $p_{\perp 1,2}$ *cuts*
GBW	13.57	6.67	337.11
MPM	43.61	20.47	313.17
KT	12.57	5.67	52.60
$MV - IR$	37.83	17.62	91.18
$MV - BS$ 2021	1346.11	624.55	3117.95
$MV - BS$ 2023	732.15	348.40	1510.33
DATA	**72**		-







Numerical results



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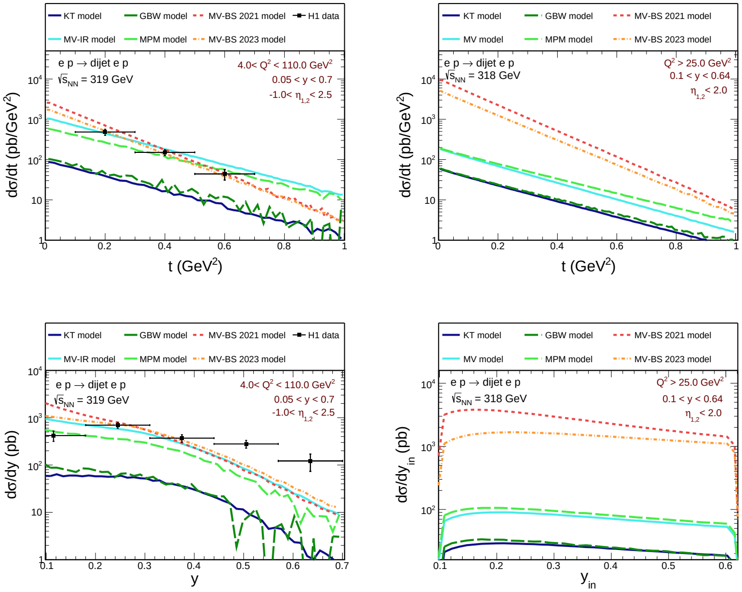

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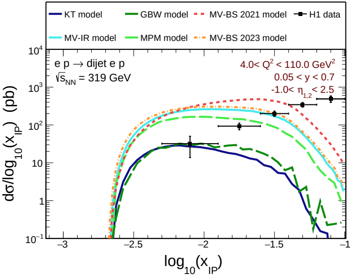

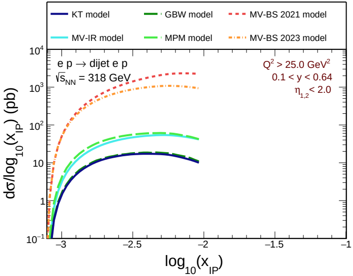

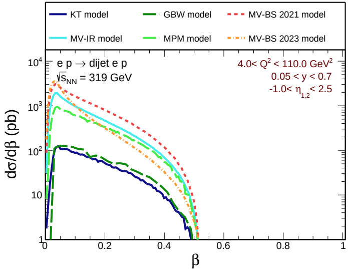

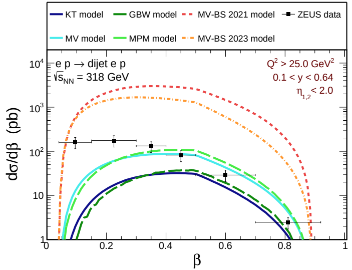

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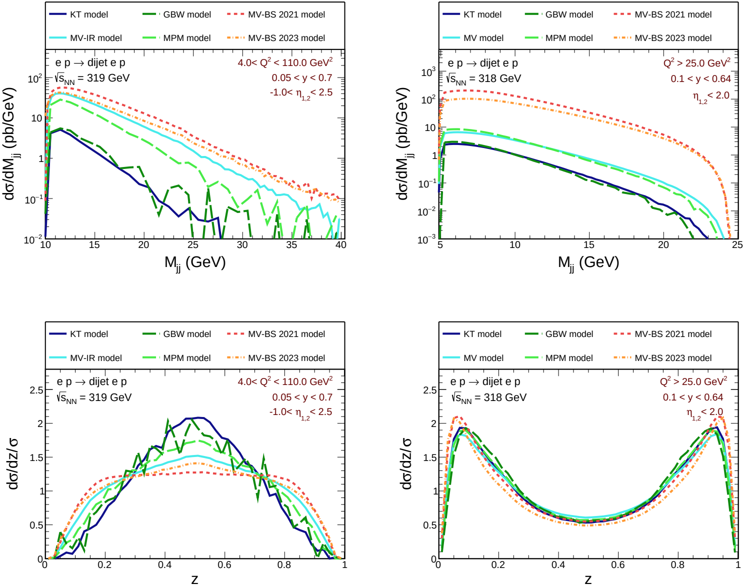

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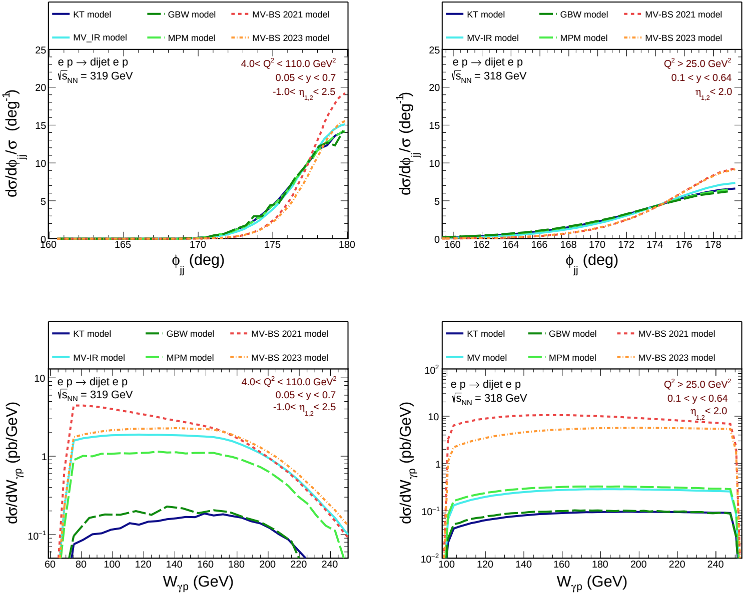

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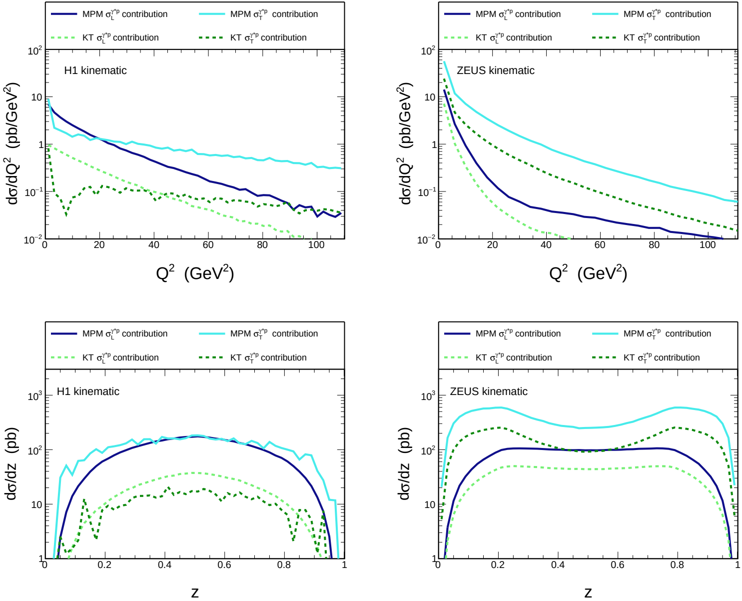
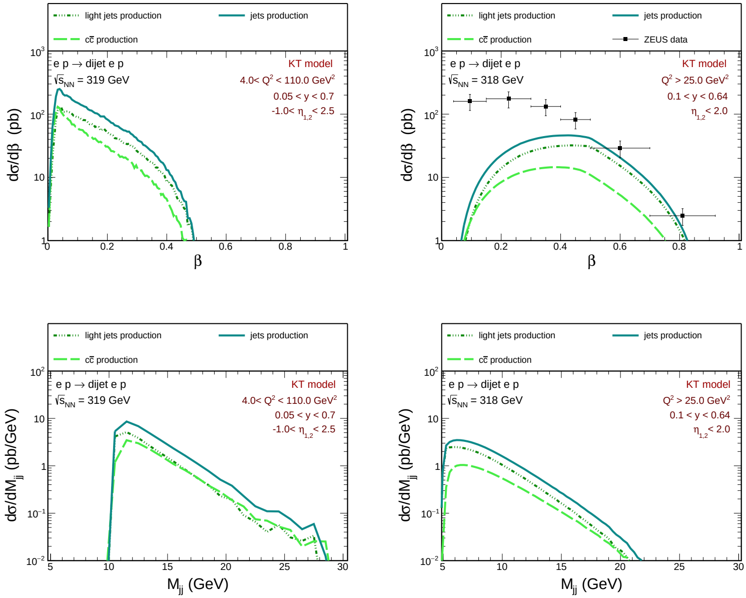


Numerical results



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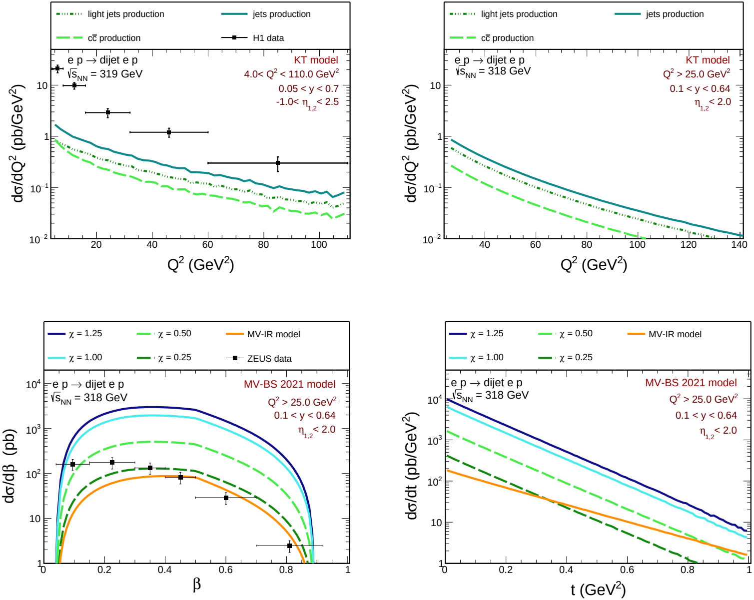

Conclusions

- Several differential distributions for the diffractive photo-production of dijets in $ep \to e' jjp$ reaction at LHC energies have been presented
- Models based on the Fourier transform of the dipole matrices were regularized by an extra factor that leads to rather large uncertainties as far as normalization of the cross section is concerned
- Special attention has been paid to azimuthal correlations However, the found correlations result only from geometric dependencies, hence they may cause erroneous interpretations
- The MV BS, MPM and MV IR GTMDs models reasonably well describe many observables for the H1 kinematics, but fail to describe distributions in X_{IP}distribution and strongly overshoot the cross section differential in β for the ZEUS kinematics
- Predictions for the EIC kinematics are also presented, which are quite similar to the H1 kinematics due to similar cuts. However, the much higher luminosity of the new accelerator will contribute to a much more accurate fit of the models used to the experimental data, which will, of course, also require taking into account other processes.