Study of proton structure using $c\bar{c}$ correlation in ultraperipheral pA collisions

Barbara Linek[1,2]

In collaboration with Agnieszka Łuszczak, Marta Łuszczak,
Roman Pasechnik, Wolfgang Schäfer and Antoni Szczurek

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[1]Doctoral School of the University of Rzeszow, Poland [2]Institute of Physics, University of Rzeszow, Poland

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Introduction

- The diffractive production of high momentum particles provides information about, among other, unintegrated gluon distribution of the target.

- An example of above are Generalized transverse momentum distribution (GTMDs) which are derived from full transformation to the momentum space, the so-called Wigner distributions.

- In the region of small Bjorken$-x$ GTMDs are equivalent to dipole amplitude depending on the dipole size and impact parameter.

- GTMDs depend on the transverse momentum transfer and the transverse momentum of a parton in the proton or nucleus, including a dependence on the azimuthal angle between the two transverse vectors. It is therefore possible to distinguish so-called elliptic GTMD.

- Above azimuthal angle correlation refers to the dipole orientation with respect to the background color field of the target.

- It is possible to study the elliptic gluon distributions in diffractive reaction such as exclusive dijet production in ep collisions, pA and AA ultra-peripheral collisions (UPC) or exclusive $Q\bar{Q}$ photo-production in pA and AA UPC.

Introduction

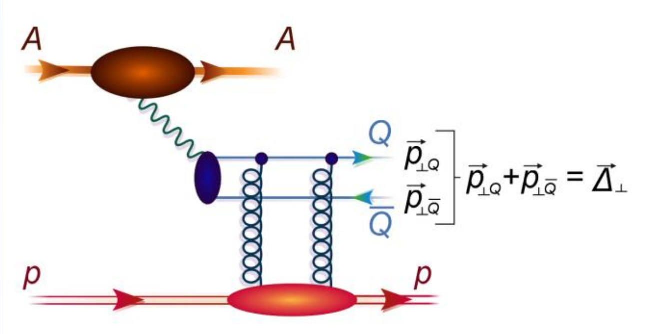
- This analysis concerns the exclusive production of $c\bar{c}$ pairs in proton-lead collisions at the LHC energy.

- The dominant reaction mechanism in mentioned collisions is the diffractive photo-production of the $c\bar{c}$ pair on a proton by a Weizsäcker-Williams photon emitted by the lead nucleus.

- One is interested in the angular correlation of the jet momentum $\vec{P}_\perp$ and the momentum transfer to the proton $\vec{\Delta}_\perp$ described as $cos\phi$.

- These correlations can be absorbed into the GTMD, in which would they correspond to the δ −function terms.

- At large jet momenta that correlations are expressed in term of the elliptic GTMD, while at lower $\vec{P}_\perp$ they are better understood as coming from the matrix element at finite $\vec{\Delta}_\perp$.

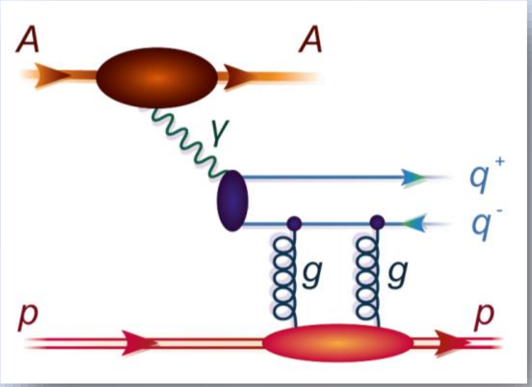


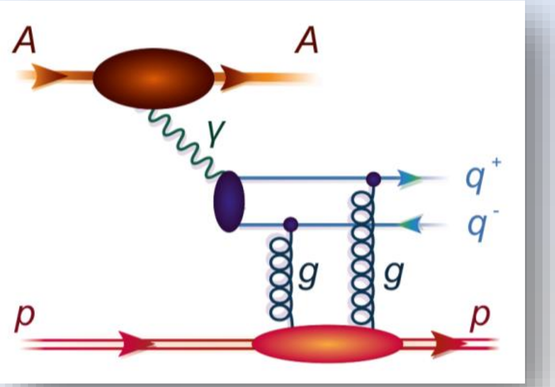
$$\vec{P}_\perp = \frac{1}{2}(\vec{p}_{\perp Q} - \vec{p}_{\perp \bar{Q}})$$

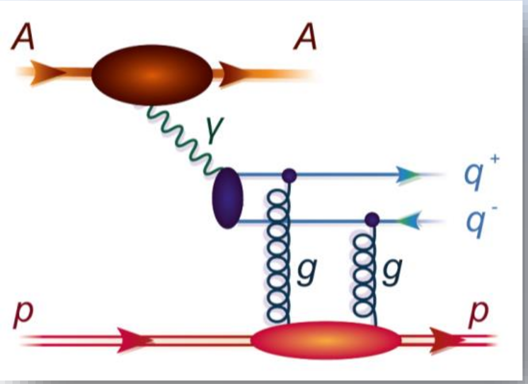
$$\vec{\Delta}_\perp = \vec{p}_{\perp Q} + \vec{p}_{\perp \bar{Q}}$$

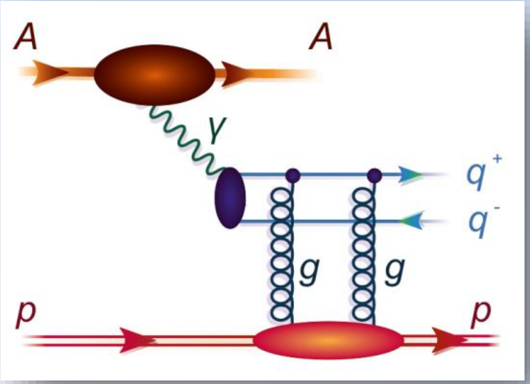
$$cos\phi = \frac{\vec{P}_\perp \cdot \vec{\Delta}_\perp}{P_\perp \Delta_\perp}$$

Diffractive photo-production of $Q\bar{Q}$ in proton-nucleus collisions









The cross section for the proton-nucleus reaction can be written as:

$$\frac{d\sigma(pA \to Q\bar{Q}pA; s)}{dx_Q dx_{\bar{Q}} d^2\vec{P}_\perp d^2\vec{\Delta}_\perp} = \frac{1}{x_Q + x_{\bar{Q}}} f_{\gamma/A}(x_Q + x_{\bar{Q}}) \frac{d\sigma(\gamma p \to Q\bar{Q}p; (x_Q + x_{\bar{Q}})s)}{dz d^2\vec{P}_\perp d^2\vec{\Delta}_\perp}$$

$$z = \frac{x_Q}{x_Q + x_{\bar{Q}}}$$

$$f_{\gamma/A}(x_A) = \frac{dN(x_A)}{dx_A} = \frac{2Z^2\alpha_{em}}{\pi x_A}\left[\xi_{jA} K_0(\xi_{jA}) K_1(\xi_{jA}) - \frac{\xi_{jA}^2}{2}\left(K_1^2(\xi_{jA}) - K_0^2(\xi_{jA})\right)\right]$$

$$\xi_{jA} = x_A m_p (R_j + R_A)$$

$$x_A = x_Q + x_{\bar{Q}}$$

Color dipole representation of the diffractive amplitude

In the color dipole approach to diffractive processes, the cross section for the $\gamma p \to Q\bar{Q}$ diffractive process is written as:

$$\frac{d\sigma(\gamma p \to Q\bar{Q}p; s_{\gamma p})}{dz d^2\vec{P}_\perp d^2\vec{\Delta}_\perp} = \bar{\sum_{\lambda_\gamma,\lambda,\bar{\lambda}}} \left| \int \frac{d^2\vec{b}_\perp d^2\vec{r}_\perp}{(2\pi)^2} e^{-i\vec{\Delta}_\perp\cdot\vec{b}_\perp} e^{-i\vec{P}_\perp\cdot\vec{r}_\perp} N(Y,\vec{r}_\perp,\vec{b}_\perp) \psi^{\gamma_\lambda}_{\lambda\bar{\lambda}}(z,\vec{r}_\perp) \right|^2$$

with the dipole scattering amplitude:

$$N(Y,\vec{r}_\perp,\vec{b}_\perp) = \int d^2\vec{q}_\perp d^2\vec{\kappa}_\perp f\left(Y, \frac{\vec{q}_\perp}{2} + \vec{\kappa}_\perp, \frac{\vec{q}_\perp}{2} - \vec{\kappa}_\perp\right) \exp[i\vec{q}_\perp \cdot \vec{b}_\perp]$$

$$\times \left\{ \exp\left[i\frac{1}{2}\vec{q}_\perp \cdot \vec{r}_\perp\right] + \exp\left[-i\frac{1}{2}\vec{q}_\perp \cdot \vec{r}_\perp\right] - \exp[i\vec{\kappa}_\perp \cdot \vec{r}_\perp] - \exp[-i\vec{\kappa}_\perp \cdot \vec{r}_\perp] \right\}$$

and the Light-Front wave function for the $\gamma \to Q\bar{Q}$ depends on the helicities of quarks $\lambda/2, \bar{\lambda}/2$ and photon λ_γ:

$$\psi^{\lambda_\gamma}_{\lambda\bar{\lambda}}(z,\vec{r}_\perp) = \frac{1}{\sqrt{4\pi z(1-z)}} \int \frac{d^2\vec{l}_\perp}{(2\pi)^2} e^{i\vec{r}_\perp\cdot\vec{l}_\perp} \psi^{\lambda_\gamma}_{\lambda\bar{\lambda}}(z,\vec{l}_\perp)$$

Color dipole representation of the diffractive amplitude

$$N(Y,\vec{r}_\perp,\vec{b}_\perp) = \int d^2\vec{q}_\perp d^2\vec{\kappa}_\perp f\left(Y,\frac{\vec{q}_\perp}{2}+\vec{\kappa}_\perp,\frac{\vec{q}_\perp}{2}-\vec{\kappa}_\perp\right)\exp[i\vec{q}_\perp\cdot\vec{b}_\perp]$$
$$\left\{\exp\left[i\frac{1}{2}\vec{q}_\perp\cdot\vec{r}_\perp\right]+\exp\left[-i\frac{1}{2}\vec{q}_\perp\cdot\vec{r}_\perp\right]-\exp[i\vec{\kappa}_\perp\cdot\vec{r}_\perp]-\exp[-i\vec{\kappa}_\perp\cdot\vec{r}_\perp]\right\}$$

- The dipole scattering amplitude depends on the "rapidity" $Y = \ln\left(\frac{x_0}{x_{\mathbb{P}}}\right), x_0 = 0.01$ and impact parameters of quark $\vec{b}_{\perp Q} = \vec{b}_\perp + \frac{\vec{r}_\perp}{2}$ and antiquark $\vec{b}_{\perp\bar{Q}} = \vec{b}_\perp - \frac{\vec{r}_\perp}{2}$.
- The unintegrated gluon density matrix is written as:

$$f\left(Y,\frac{\vec{q}_\perp}{2}+\vec{\kappa}_\perp,\frac{\vec{q}_\perp}{2}-\vec{\kappa}_\perp\right) = \frac{\alpha_s}{4\pi N_C}\frac{\mathcal{F}\left(x_{\mathbb{P}},\frac{\vec{q}_\perp}{2}+\vec{\kappa}_\perp,\frac{\vec{q}_\perp}{2}-\vec{\kappa}_\perp\right)}{\left(\frac{\vec{q}_\perp}{2}+\vec{\kappa}_\perp\right)^2\left(\frac{\vec{q}_\perp}{2}-\vec{\kappa}_\perp\right)^2}$$

Color dipole representation of the diffractive amplitude

The diffractive photo-production cross section is expressed in terms of amplitudes for the sum of quark helicities equal to zero or one:

$$\frac{d\sigma(\gamma p \to Q\bar{Q}p; s_{\gamma p})}{dz d^2\vec{P}_\perp d^2\vec{\Delta}_\perp} = e_f^2 \alpha_{em} 2N_C (2\pi)^2 \left\{ (z^2 + (1-z)^2) \left|\vec{\mathcal{M}}_0\right|^2 + m_Q^2 |\mathcal{M}_1|^2 \right\}$$

$$\vec{\mathcal{M}}_0(\vec{P}_\perp, \vec{\Delta}_\perp) = \int \frac{d^2\vec{k}_\perp}{(2\pi)^2} f\left(Y, \frac{\vec{\Delta}_\perp}{2} + \vec{k}_\perp, \frac{\vec{\Delta}_\perp}{2} - \vec{k}_\perp\right) \left\{ \frac{\vec{P}_\perp - \frac{\vec{\Delta}_\perp}{2}}{\left(\vec{P}_\perp - \frac{\vec{\Delta}_\perp}{2}\right)^2 + m_Q^2} + \frac{\vec{P}_\perp - \frac{\vec{\Delta}_\perp}{2}}{\left(\vec{P}_\perp + \frac{\vec{\Delta}_\perp}{2}\right)^2 + m_Q^2} - \frac{\vec{P}_\perp - \vec{k}_\perp}{\left(\vec{P}_\perp - \vec{k}_\perp\right)^2 + m_Q^2} - \frac{\vec{P}_\perp - \vec{k}_\perp}{\left(\vec{P}_\perp + \vec{k}_\perp\right)^2 + m_Q^2} \right\}$$

$$\mathcal{M}_1(\vec{P}_\perp, \vec{\Delta}_\perp) = \int \frac{d^2\vec{k}_\perp}{(2\pi)^2} f\left(Y, \frac{\vec{\Delta}_\perp}{2} + \vec{k}_\perp, \frac{\vec{\Delta}_\perp}{2} - \vec{k}_\perp\right) \left\{ \frac{1}{\left(\vec{P}_\perp - \frac{\vec{\Delta}_\perp}{2}\right)^2 + m_Q^2} + \frac{1}{\left(\vec{P}_\perp + \frac{\vec{\Delta}_\perp}{2}\right)^2 + m_Q^2} - \frac{1}{\left(\vec{P}_\perp - \vec{k}_\perp\right)^2 + m_Q^2} - \frac{1}{\left(\vec{P}_\perp + \vec{k}_\perp\right)^2 + m_Q^2} \right\}$$

Color dipole representation of the diffractive amplitude

Decomposing of the amplitudes allows to better understood azimuthal correlation:

$$\vec{\mathcal{M}}_0(\vec{P}_\perp,\vec{\Delta}_\perp) = \vec{\mathcal{J}}_0\left(\vec{P}_\perp,\frac{1}{2}\vec{\Delta}_\perp\right)C(Y,\vec{\Delta}_\perp) - \int\frac{d^2\vec{k}_\perp}{2\pi}\vec{\mathcal{J}}_0(\vec{P}_\perp,\vec{k}_\perp)f\left(Y,\frac{\vec{\Delta}_\perp}{2}+\vec{k}_\perp,\frac{\vec{\Delta}_\perp}{2}-\vec{k}_\perp\right)$$

$$\mathcal{M}_1(\vec{P}_\perp,\vec{\Delta}_\perp) = \mathcal{J}_1\left(\vec{P}_\perp,\frac{1}{2}\vec{\Delta}_\perp\right)C(Y,\vec{\Delta}_\perp) - \int\frac{d^2\vec{k}_\perp}{2\pi}\mathcal{J}_1(\vec{P}_\perp,\vec{k}_\perp)f\left(Y,\frac{\vec{\Delta}_\perp}{2}+\vec{k}_\perp,\frac{\vec{\Delta}_\perp}{2}-\vec{k}_\perp\right)$$

$$\vec{\mathcal{J}}_0(\vec{P}_\perp,\vec{q}_\perp) = \frac{\vec{P}_\perp-\vec{q}_\perp}{(\vec{P}_\perp-\vec{q}_\perp)^2+m_Q^2} + \frac{\vec{P}_\perp+\vec{q}_\perp}{(\vec{P}_\perp+\vec{q}_\perp)^2+m_Q^2} - \frac{2\vec{P}_\perp}{\vec{P}_\perp^2+m_Q^2}$$

$$\mathcal{J}_1(\vec{P}_\perp,\vec{q}_\perp) = \frac{1}{(\vec{P}_\perp-\vec{q}_\perp)^2+m_Q^2} + \frac{1}{(\vec{P}_\perp+\vec{q}_\perp)^2+m_Q^2} - \frac{2}{\vec{P}_\perp^2+m_Q^2}$$

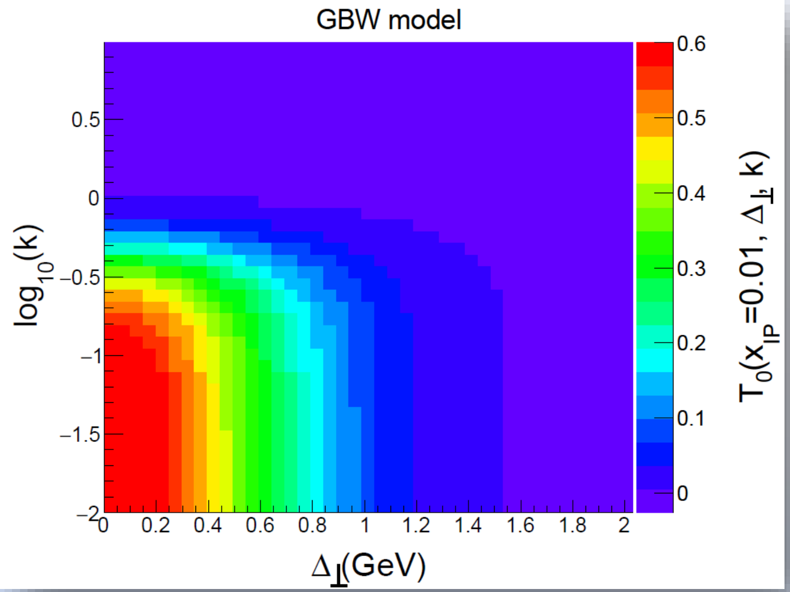
$$C(Y,\vec{\Delta}_\perp) = \int\frac{d^2\vec{k}_\perp}{(2\pi)^2}f\left(Y,\frac{\vec{\Delta}_\perp}{2}+\vec{k}_\perp,\frac{\vec{\Delta}_\perp}{2}-\vec{k}_\perp\right)$$

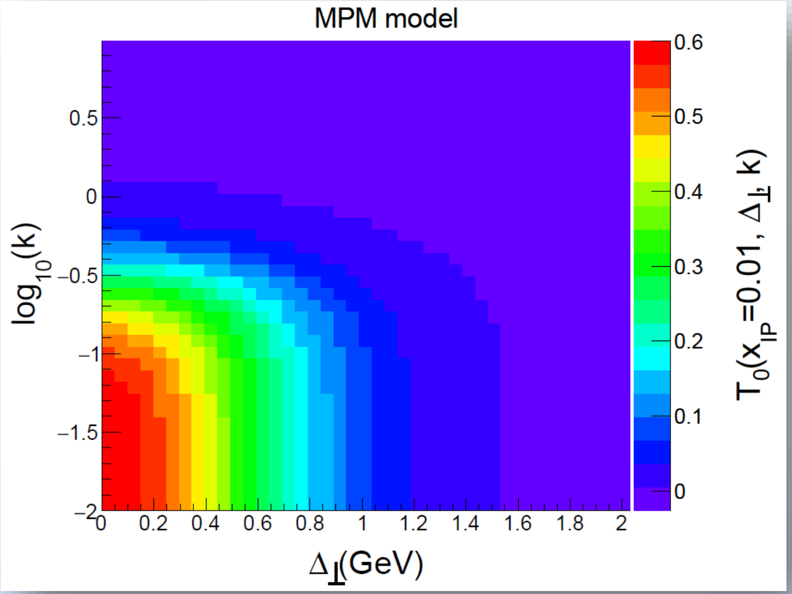
MPM and GBW parametrizations

Two different parametrization of the off-forward gluon density matrix were use in calculation:

$$f\left(Y,\frac{\vec{\Delta}_\perp}{2}+\vec{k}_\perp,\frac{\vec{\Delta}_\perp}{2}-\vec{k}_\perp\right)=\frac{\alpha_s}{4\pi N_C}\frac{\mathcal{F}(x_{\mathbb{P}},\vec{k}_\perp,-\vec{k}_\perp)}{\vec{k}_\perp^4}\exp\left[-\frac{1}{2}B\vec{\Delta}^2\right]$$

In both – the Golec–Biernat– Wüsthoff (GBW) model and the Moriggi–Peccini–Machado (MPM) model, the diffractive slope equals $B = 4\ GeV^{-2}$.





$$f\left(Y,\frac{\vec{q}_\perp}{2}+\vec{k}_\perp,\frac{\vec{q}_\perp}{2}-\vec{k}_\perp\right)\rightarrow\frac{1}{2}T(Y,\vec{k}_\perp,\vec{\Delta}_\perp)$$

Fourier transform of dipole amplitude

Gluon density matrix encodes the same information as the Fourier transform of the dipole amplitude , up to the term containing $\delta -$ function

$$f\left(Y,\frac{\vec{\Delta}_\perp}{2}+\vec{k}_\perp,\frac{\vec{\Delta}_\perp}{2}-\vec{k}_\perp\right)\rightarrow\frac{1}{2}T(Y,\vec{k}_\perp,\vec{\Delta}_\perp),\qquad T(Y,\vec{k}_\perp,\vec{\Delta}_\perp)=\int\frac{d^2\vec{b}_\perp}{(2\pi)^2}\frac{d^2\vec{r}_\perp}{(2\pi)^2}e^{-i\vec{\Delta}_\perp\cdot\vec{b}_\perp}e^{-i\vec{k}_\perp\cdot\vec{r}_\perp}N(Y,\vec{r}_\perp,\vec{b}_\perp)$$

which is clearly visible in the form

$$T(Y,\vec{k}_\perp,\vec{\Delta}_\perp)=C(Y,\vec{\Delta}_\perp)\left(\delta^2\left(\vec{k}_\perp-\frac{\vec{\Delta}_\perp}{2}\right)+\delta^2\left(\vec{k}_\perp+\frac{\vec{\Delta}_\perp}{2}\right)\right)-f\left(Y,\frac{\vec{\Delta}_\perp}{2}+\vec{k}_\perp,\frac{\vec{\Delta}_\perp}{2}-\vec{k}_\perp\right)-f\left(Y,\frac{\vec{\Delta}_\perp}{2}-\vec{k}_\perp,\frac{\vec{\Delta}_\perp}{2}+\vec{k}_\perp\right)$$

This transform is non-convergent, therefore it needs to be regularize by inserting a Gaussian cutoff function:

$$T(Y,\vec{k}_\perp,\vec{\Delta}_\perp)=\int\frac{d^2\vec{b}_\perp}{(2\pi)^2}\frac{d^2\vec{r}_\perp}{(2\pi)^2}e^{-i\vec{\Delta}_\perp\cdot\vec{b}_\perp}e^{-i\vec{k}_\perp\cdot\vec{r}_\perp}N(Y,\vec{r}_\perp,\vec{b}_\perp)\,e^{-\varepsilon r_\perp^2}$$

or, using $\delta -$ function with $\delta^2_\varepsilon(\vec{k}_\perp)=\frac{1}{4\pi\varepsilon}\exp\left(\frac{\vec{k}_\perp^2}{4\varepsilon}\right)$

$$T(Y,\vec{k}_\perp,\vec{\Delta}_\perp)=C(Y,\vec{\Delta}_\perp)\left(\delta^2_\varepsilon\left(\vec{k}_\perp-\frac{\vec{\Delta}_\perp}{2}\right)+\delta^2_\varepsilon\left(\vec{k}_\perp+\frac{\vec{\Delta}_\perp}{2}\right)\right)-f_\varepsilon\left(Y,\frac{\vec{\Delta}_\perp}{2}+\vec{k}_\perp,\frac{\vec{\Delta}_\perp}{2}-\vec{k}_\perp\right)-f_\varepsilon\left(Y,\frac{\vec{\Delta}_\perp}{2}-\vec{k}_\perp,\frac{\vec{\Delta}_\perp}{2}+\vec{k}_\perp\right)$$

Fourier transform of dipole amplitude

The matrix elements in terms of T −matrix are:

$$\vec{\mathcal{M}}_0 = \int \frac{d^2\vec{k}_\perp}{(2\pi)^2} T(Y,\vec{k}_\perp,\vec{\Delta}_\perp)\left\{\frac{\vec{P}_\perp - \vec{k}_\perp}{\left(\vec{P}_\perp - \vec{k}_\perp\right)^2 + m_Q^2} - \frac{\vec{P}_\perp}{\vec{P}_\perp^2 + m_Q^2}\right\}, \qquad \mathcal{M}_1 = \int \frac{d^2\vec{k}_\perp}{(2\pi)^2} T(Y,\vec{k}_\perp,\vec{\Delta}_\perp)\left\{\frac{1}{\left(\vec{P}_\perp - \vec{k}_\perp\right)^2 + m_Q^2} - \frac{1}{\vec{P}_\perp^2 + m_Q^2}\right\}$$

The leading dependence on dipole orientation is quantified by the elliptic part of the dipole amplitude in the Fourier expansion:

$$N\left(Y,\vec{r}_\perp,\vec{b}_\perp\right) = N_0(Y,r_\perp,b_\perp) + 2cos(2\phi_{br})N_\epsilon(Y,r_\perp,b_\perp) + \cdots$$

Therefore, the isotropic and elliptic parts of the dipole amplitude to GTMDs are translated by the appropriate Fourier-Bessel transforms:

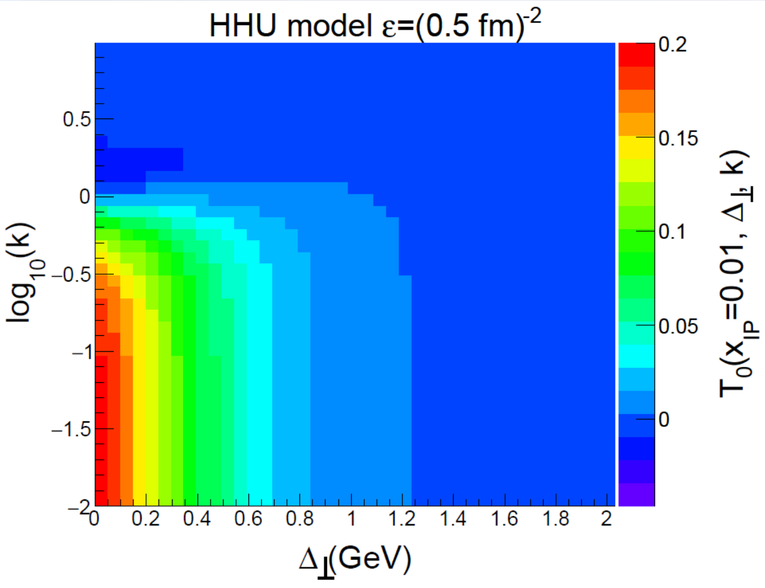
$$T_0(Y,k_\perp,\Delta_\perp) = \frac{1}{4\pi^2}\int_0^\infty b_\perp db_\perp J_0(\Delta_\perp \mathrm{b}_\perp)\int_0^\infty r_\perp dr_\perp J_0(k_\perp r_\perp)N_0(Y,r_\perp,b_\perp)\, e^{-\varepsilon_r r_\perp^2}$$

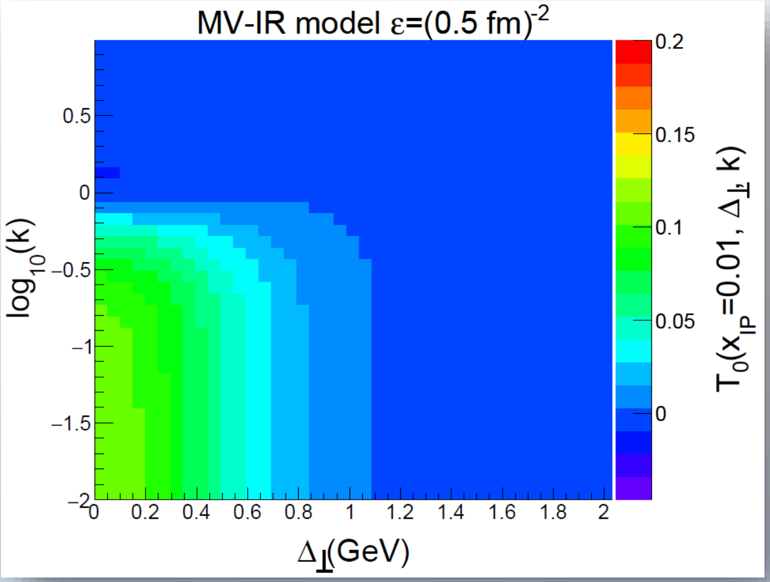
$$T_\epsilon(Y,k_\perp,\Delta_\perp) = \frac{1}{4\pi^2}\int_0^\infty b_\perp db_\perp J_2(\Delta_\perp \mathrm{b}_\perp)\int_0^\infty r_\perp dr_\perp J_2(k_\perp r_\perp)N_\epsilon(Y,r_\perp,b_\perp)\, e^{-\varepsilon_r r_\perp^2}$$

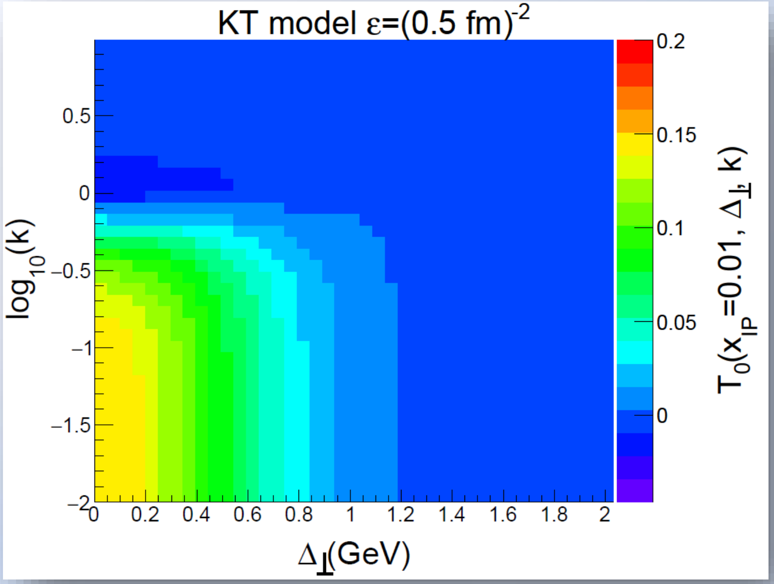
HHU, MV-IR and KT parametrizations

Parametrization based on the regularized Fourier transform of dipole amplitude are as follows:

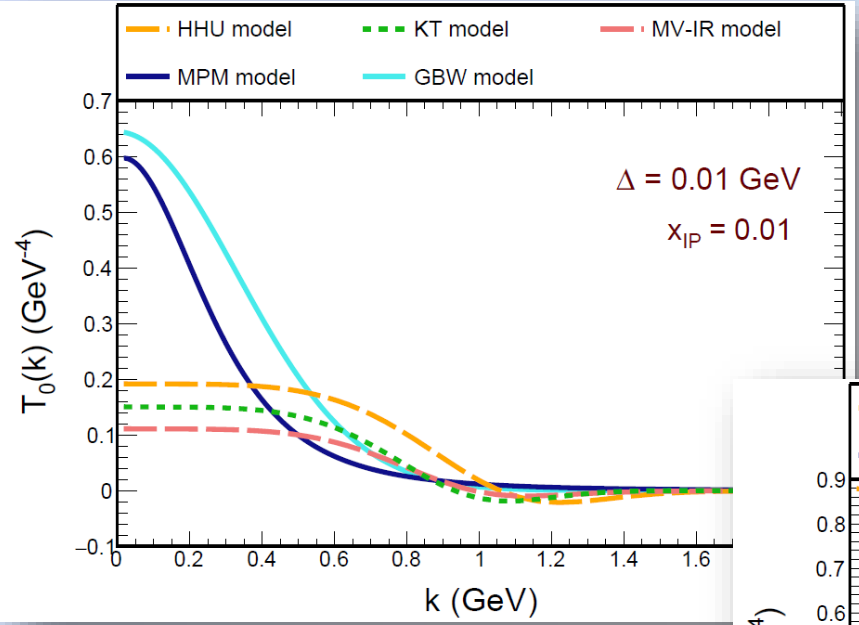
- **HHU model** numerically solving the Balitsky-Kovchegov equation for the dipole S −matrix;
- **The MV – IR model** based on the original effective McLerran-Venugopalan model independent of the Y, therefore we used formula including additional dependence: $T^{mod}_{MV-IR}(Y, \vec{k}_\perp, \vec{\Delta}_\perp) = T_{MV\_IR}(Y, k_\perp, \vec{\Delta}_\perp)e^{\lambda Y}$, $Y = \ln\left(\frac{0.01}{x_{\mathbb{P}}}\right)$, $\lambda = 0.277$;
- **The Kowalski – Teaney (KT) model** that has been adjusted to the proton structure function data but does not include dipole orientation effects;

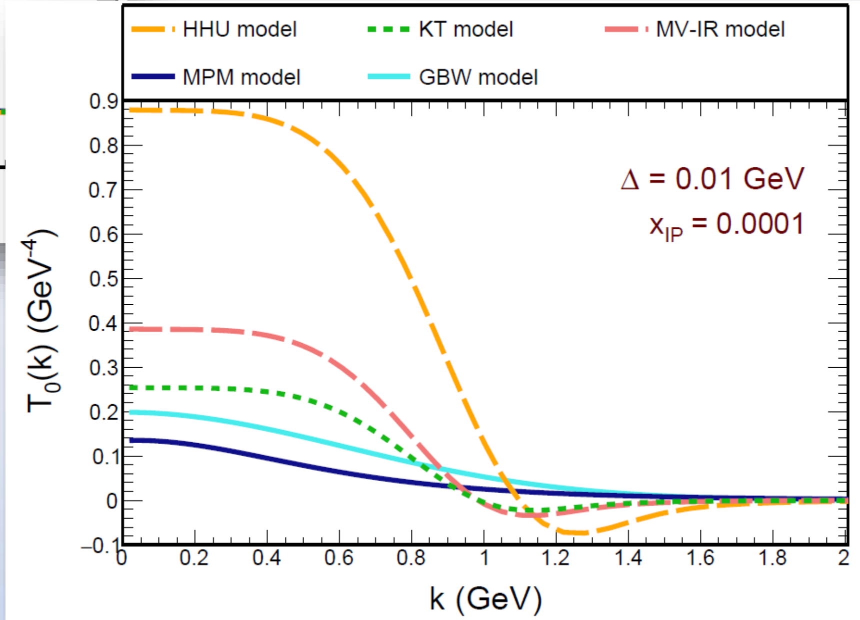






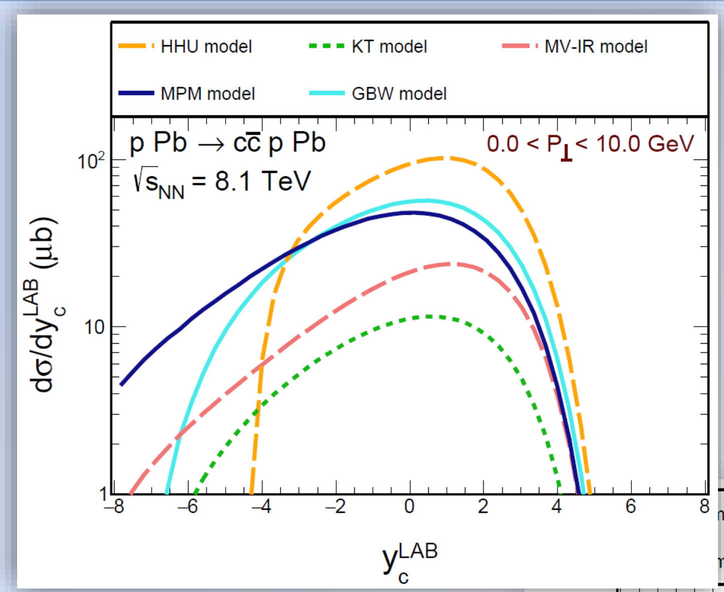
Different parametrizations of GTMD

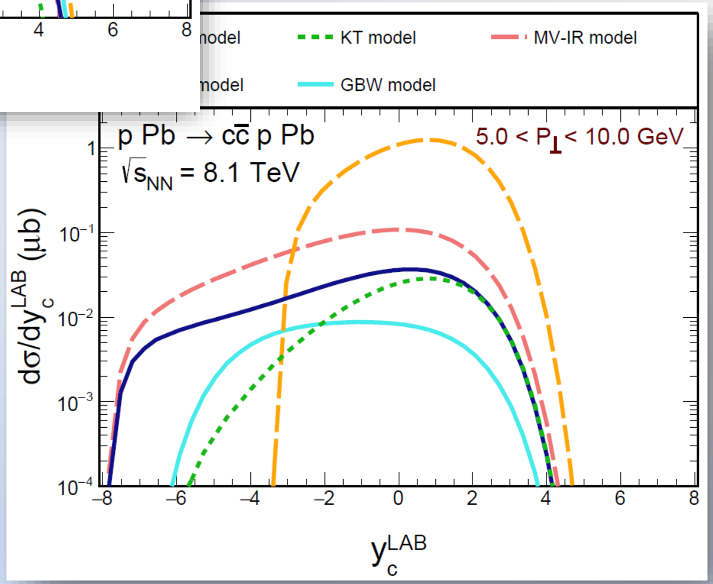


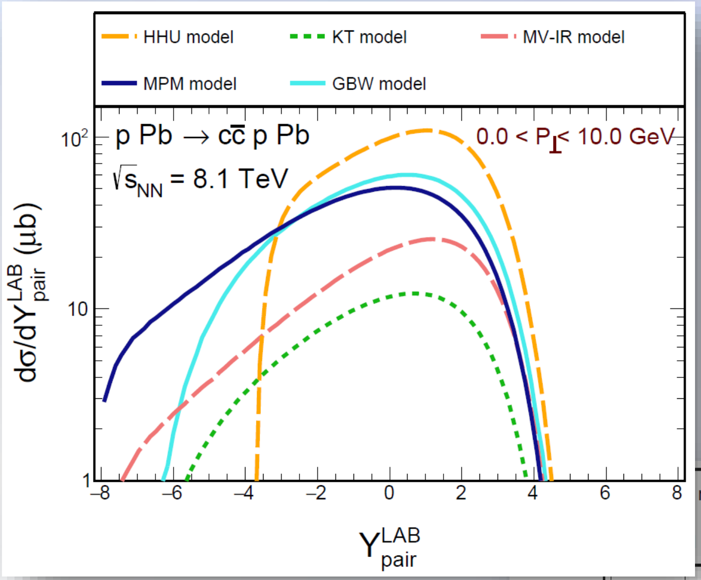


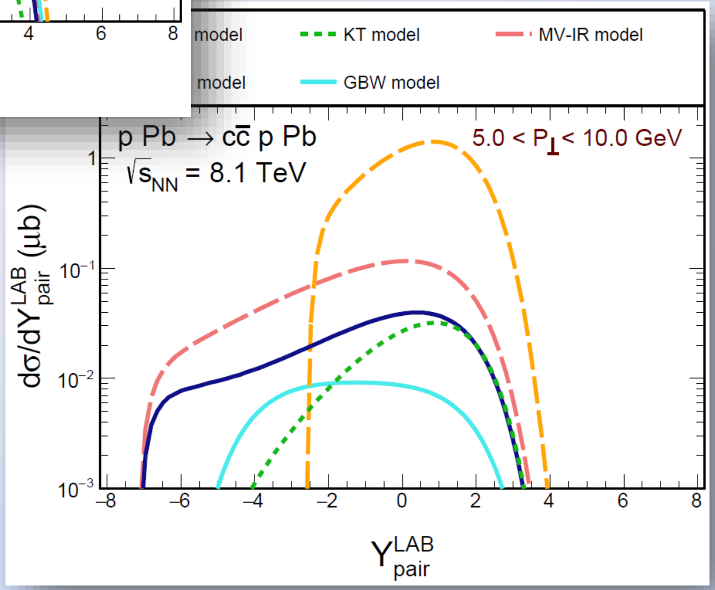
GTMD approaches	$\sigma\ (\mu b)$	$\sigma_{P_\perp > 5.0\ GeV}\ (\mu b)$
GBW	335.199	0.051
MPM	321.141	0.201
$\varepsilon = (0.5\ fm)^{-2}$		
HHU	520.691	4.573
KT	66.699	0.111
$MV-IR$	136.675	0.526
$\varepsilon = 1/2(0.5\ fm)^{-2}$		
HHU	743.41	4.348
KT	85.487	0.105
IR	169.561	0.510

Distributions in y_c and Y_{pair}







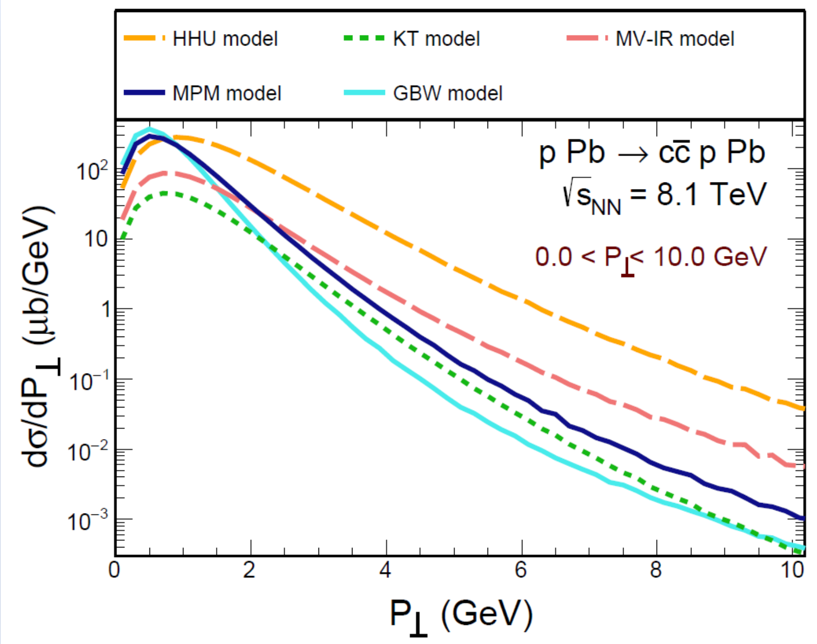


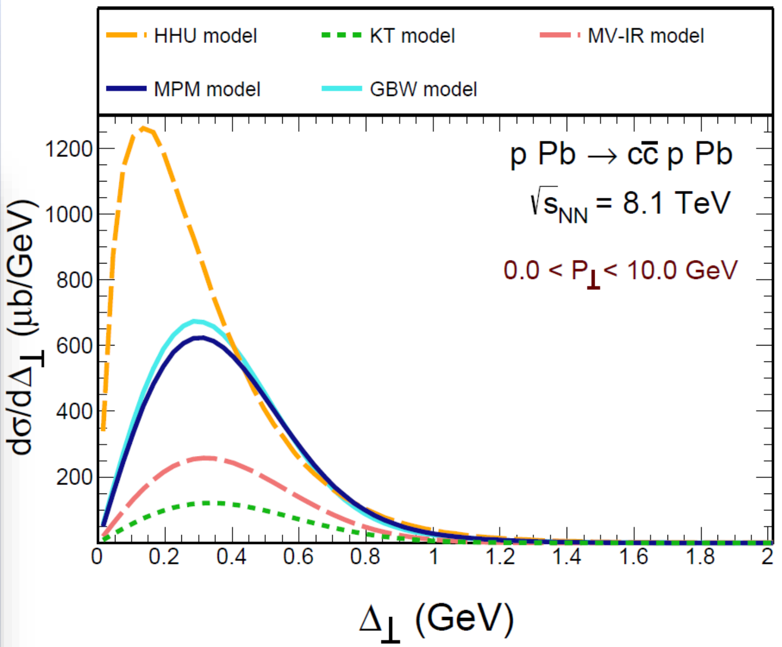
$$y_{Q,\bar{Q}}^{LAB} = y_{Q,\bar{Q}} + \frac{1}{2}\log\left(\frac{Z}{A}\right)$$

$$Y_{pair} = \frac{1}{2}\log\left(\frac{x_A}{x_B}\right) = \log\left(\frac{x_A\sqrt{s}}{M_\perp}\right)$$

$$Y_{pair}^{LAB} = Y_{pair} + \frac{1}{2}\log\left(\frac{Z}{A}\right)$$

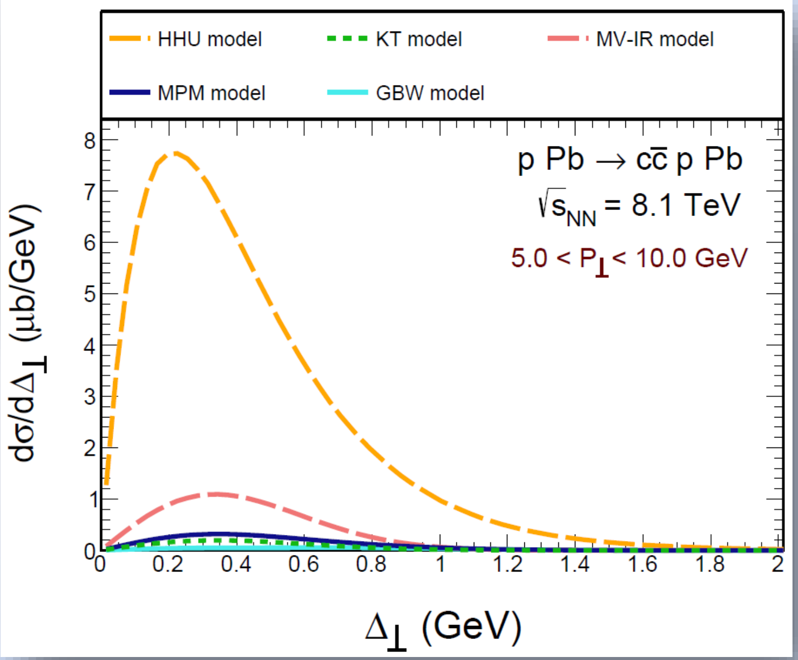
Distributions in $\Delta_\perp$ and $P_\perp$



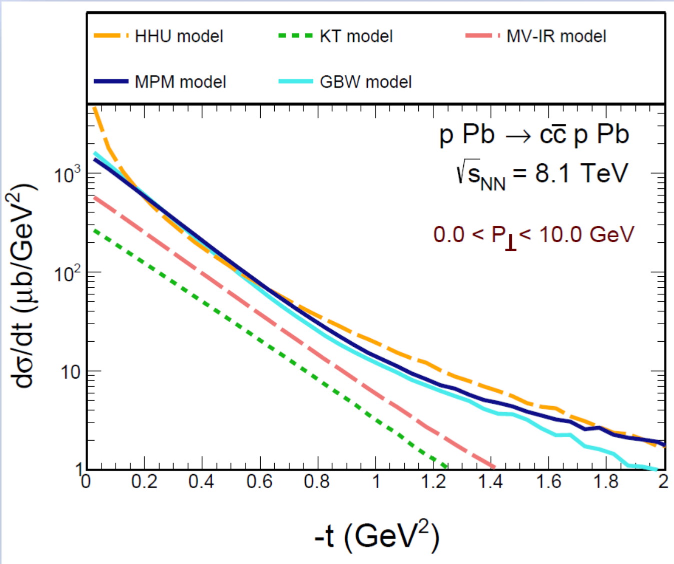


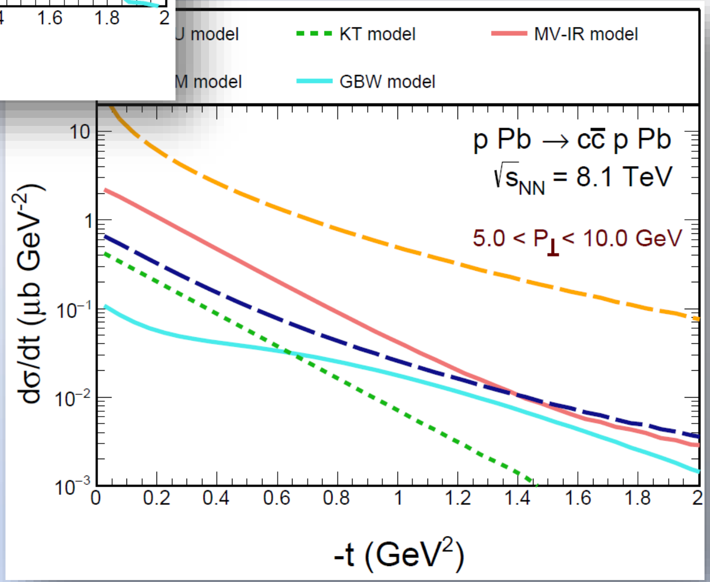
$$\vec{P}_\perp = \frac{1}{2}(\vec{p}_{\perp Q} - \vec{p}_{\perp \bar{Q}})$$

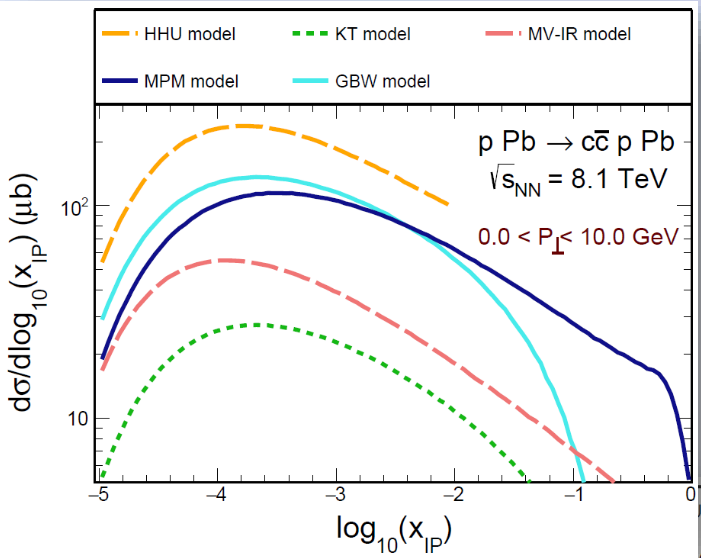
$$\vec{\Delta}_\perp = \vec{p}_{\perp Q} + \vec{p}_{\perp \bar{Q}}$$

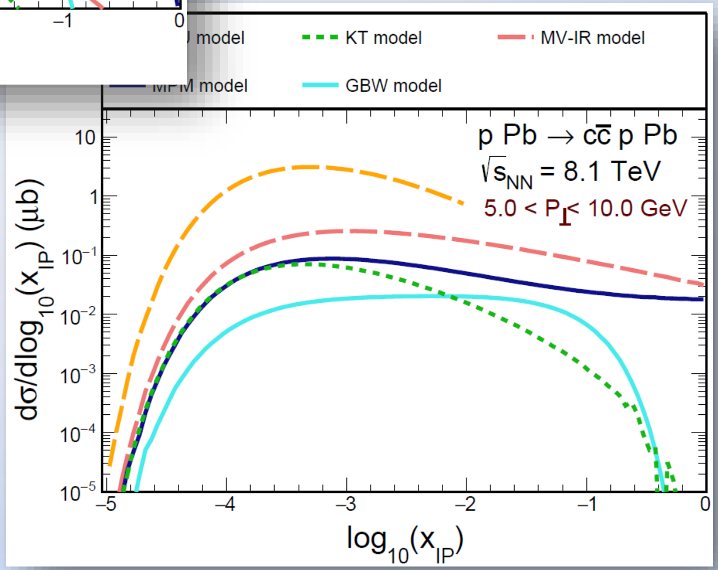


Distributions in $-t$ and $\log_{10}(x_{\mathbb{P}})$







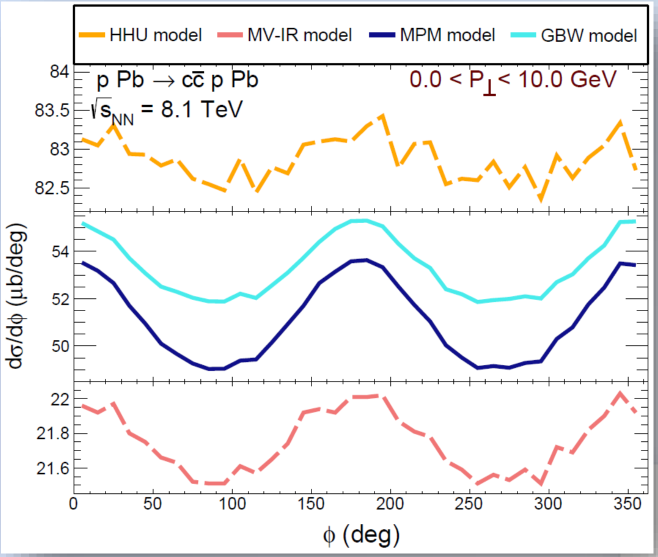


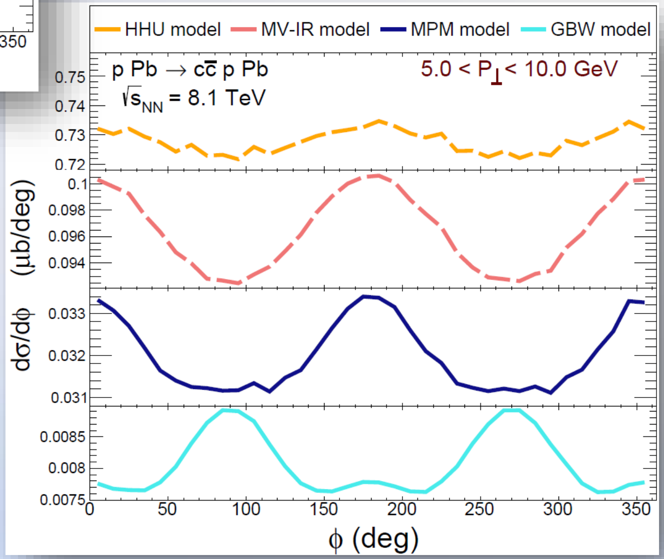
$$t = -\frac{\Delta_{\perp}^2 + x_{\mathbb{P}}^2 m_p^2}{1 - x_{\mathbb{P}}}$$

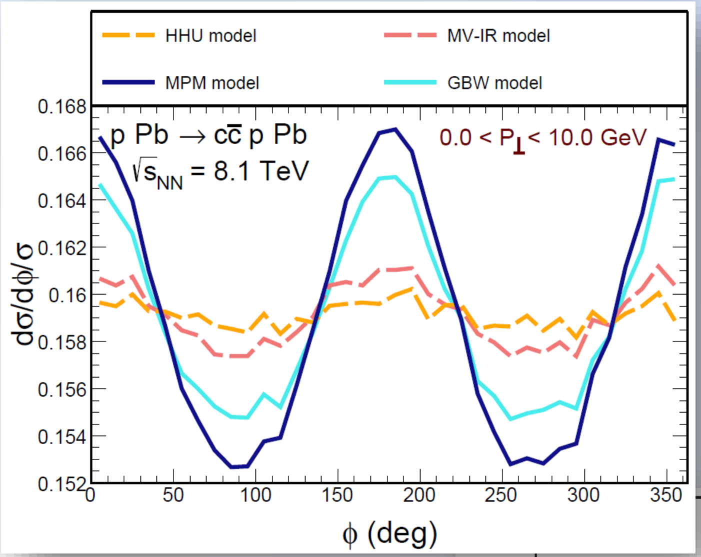
$$x_{\mathbb{P}} \equiv x_B = \frac{M_{\perp}^2}{s_{\gamma p}} = \frac{M_{\perp}^2}{x_A s}$$

$$\xi \approx 1 - x_{\mathbb{P}}$$

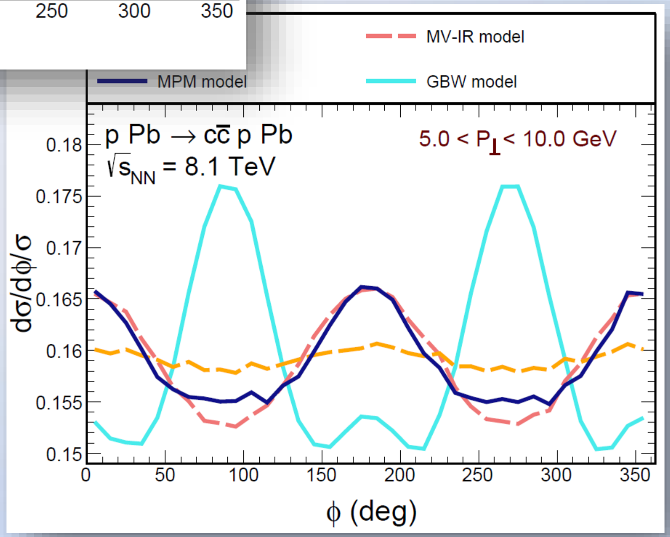
Distributions in ϕ







$$\cos\phi = \frac{\vec{P}_{\perp} \cdot \vec{\Delta}_{\perp}}{P_{\perp} \Delta_{\perp}}$$



Conclusions

- Several differential distributions for the diffractive photo-production of $c\bar{c}$ pair in $pA \to p(c\bar{c})A$ reaction at LHC energies have been presented.
- Models based on the Fourier transform of the dipole matrices was regularized by an extra factor that leads to rather large uncertainties as far as normalization of the cross section is concerned.
- The special attention has been paid to azimuthal correlations which were proposed in the literature to test the models of small$-x$ dynamics.
- The find azimuthal correlations turned out to be rather small.
- The modulations depends on the specific GTMD models used in analysis, therefore it is important to test them in actual measurements at the LHC.

Thank you for your attention

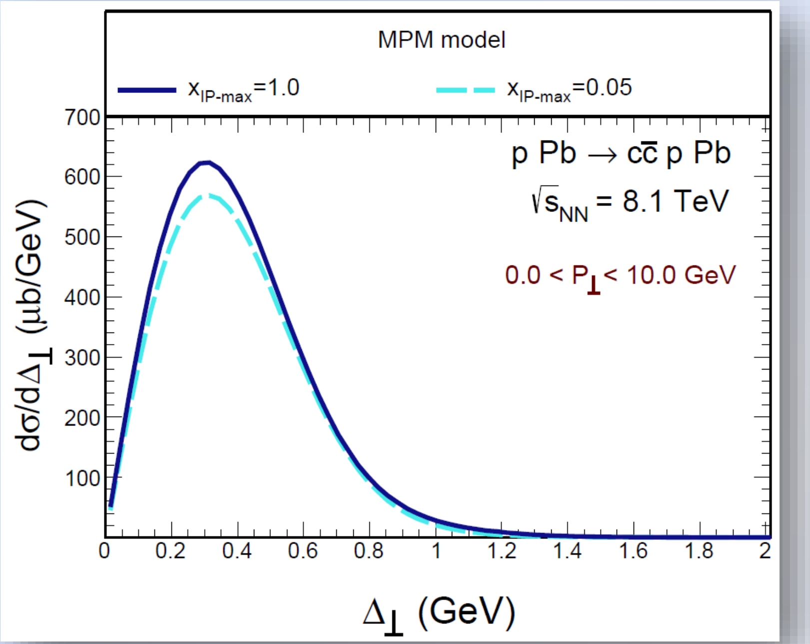
Additional slides

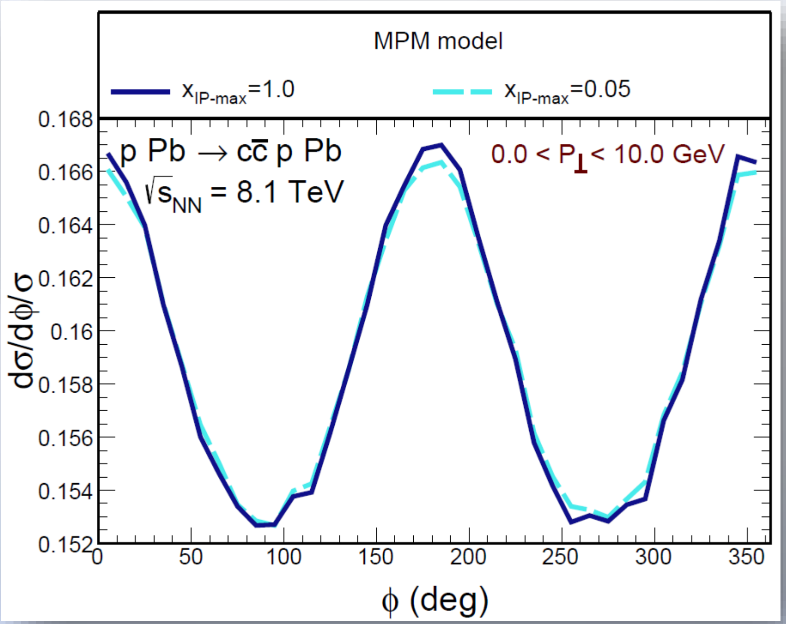
Small Bjorken-x range results

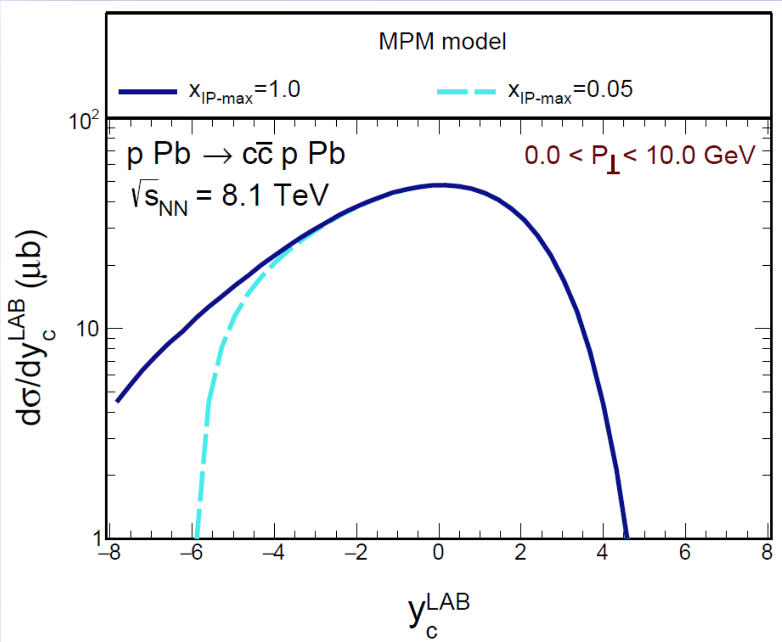
GTMD approaches	$\sigma(\mu b), 0 < P_T < 10GeV$	
	$0 < x_{IP} < 1.0$	$0 < x_{IP} < 0.02$
GBW	335.199	330.046
MPM	321.141	293.300
$\varepsilon = (0.5\ fm)^{-2}$		
HHU	520.691	520.691
KT	66.699	65.023
$MV - IR$	136.675	129.883
$\varepsilon = 1/2(0.5\ fm)^{-2}$		
HHU	743.411	743.411
KT	85.487	83.039
$MV - IR$	169.561	161.360

GTMD approaches	$\sigma(\mu b), 5 < P_T < 10GeV$	
	$0 < x_{IP} < 1.0$	$0 < x_{IP} < 0.02$
GBW	0.051	0.046
MPM	0.201	0.173
$\varepsilon = (0.5\ fm)^{-2}$		
HHU	4.573	4.573
KT	0.111	0.110
$MV - IR$	0.606	0.526
$\varepsilon = 1/2(0.5\ fm)^{-2}$		
HHU	4.348	4.348
KT	0.106	0.106
$MV - IR$	0.587	0.510

Small Bjorken-x range results







Small Bjorken-x range results