FORWARD DI-JET PRODUCTION IN DILUTE-DENSE COLLISIONS

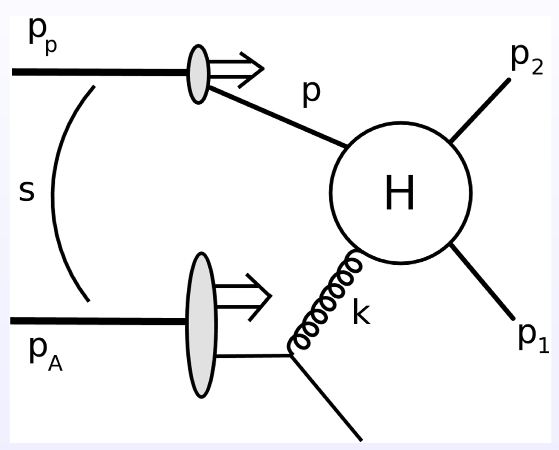
Elena Petreska

Centre de Physique Théorique, École Polytechnique, 91128 Palaiseau, France and Universidade de Santiago de Compostela, 15782 Santiago de Compostela, Spain

Collaboration with P. Kotko, K. Kutak, C. Marquet, S. Sapeta and A. van Hameren

MOTIVATION

UNIFICATION OF DIFFERENT THEORETICAL APPROACHES TO FORWARD DI-JET PRODUCTION



Three approaches:

Color Glass Condensate (CGC) at small-x

Saturation and multigluon distributions;

No k_t factorization.

High-Energy Factorization (HEF)

Region of validity: $Q_s \ll k_t \sim P_t$;

One k_t dependent gluon distribution for the small-x target;

Off-shell matrix elements.

Transverse Momentum Dependent Factorization (TMD)

Region of validity: $k_t \sim Q_s \ll P_t$;

Five k_t dependent gluon distributions for the small-x target;

On-shell hard factors.

RESULTS:

I. CONNECTION OF CGC AND HEF

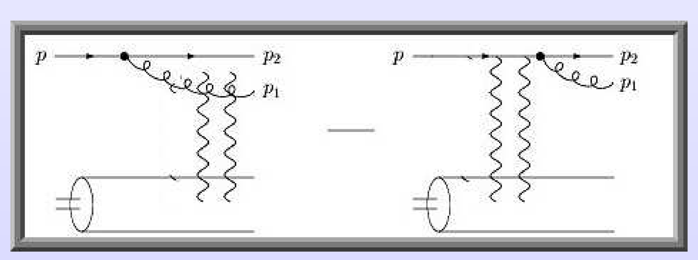
WE DIRECTLY SHOW THAT:

THE HIGH ENERGY FACTORIZATION FORMULA

$$\frac{d\sigma^{pA\to \text{dijets}+X}}{dy_1 dy_2 d^2p_{1t} d^2p_{2t}} = \frac{1}{16\pi^3(x_1x_2s)^2}\sum_{a,c,d} x_1 f_{a/p}(x_1,\mu^2)\,|\overline{\mathcal{M}_{ag^*\to cd}}|^2\mathcal{F}_{g/A}(x_2,k_t)\frac{1}{1+\delta_{cd}}$$

IS EQUIVALENT TO

THE COLOR GLASS CONDENSATE THEORY IN THE DILUTE TARGET LIMIT $Q_s \ll k_t \sim P_t$:



II. IMPROVED TMD FACTORIZATION

WE DERIVE AN IMPROVED TRANSVERSE MOMENTUM DEPENDENT FACTORIZATION FORMULA:

$$\frac{d\sigma^{pA\to \text{dijets}+X}}{d^2P_t d^2k_t dy_1 dy_2} = \frac{\alpha_s^2}{(x_1x_2s)^2}\sum_{a,c,d} x_1 f_{a/p}(x_1,\mu^2)\sum_{i=1}^{2} K^{(i)}_{ag\to cd}\Phi^{(i)}_{ag\to cd}(k_t)\,\frac{1}{1+\delta_{cd}}$$

IMPROVEMENTS:

INCLUDES ALL FINITE-N_c CORRECTIONS;

THREE NEW GLUON DISTRIBUTIONS;

ONLY TWO INDEPENDENT GLUON DISTRIBUTIONS PER CHANNEL.

III. UNIFYING FORMULA

WE DERIVE A UNIFYING TRANSVERSE MOMENTUM DEPENDENT FACTORIZATION FORMULA

THE NEW FORMULA IS VALID FOR AN ARBITRARY VALUE OF THE MOMENTUM IMBALANCE OF THE JETS, k_t

$$\frac{d\sigma^{pA\to \text{dijets}+X}}{d^2P_t d^2k_t dy_1 dy_2} = \frac{\alpha_s^2}{(x_1x_2s)^2}\sum_{a,c,d} x_1 f_{a/p}(x_1,\mu^2)\sum_{i=1}^{2} K^{(i)}_{ag^*\to cd}(k_t)\Phi^{(i)}_{ag\to cd}(k_t)\,\frac{1}{1+\delta_{cd}}$$

IMPROVEMENTS:

THE MATRIX ELEMENTS ARE OFF-SHELL:

We derive k_t-dependent matrix elements for TMD factorization with two independent methods:

Standard Feynman diagrams technique;

Helicity method for color-ordered amplitudes.

The matrix elements in the new formula are:

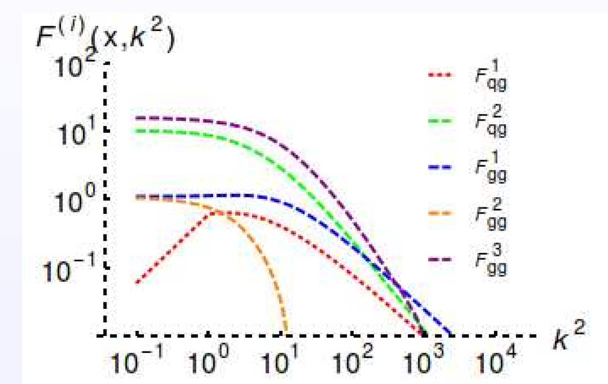
i	1	2
$K^{(i)}_{gg^*\to gg}$	$\frac{N_c}{C_F}\frac{\left(\bar{s}^4+\bar{t}^4+\bar{u}^4\right)\left(\bar{u}\hat{u}+\bar{t}\hat{t}\right)}{\bar{t}\hat{t}\bar{u}\hat{u}\bar{s}\hat{s}}$	$-\frac{N_c}{2C_F}\frac{\left(\bar{s}^4+\bar{t}^4+\bar{u}^4\right)\left(\bar{u}\hat{u}+\bar{t}\hat{t}-\bar{s}\hat{s}\right)}{\bar{t}\hat{t}\bar{u}\hat{u}\bar{s}\hat{s}}$
$K^{(i)}_{gg^*\to q\bar{q}}$	$\frac{1}{2N_c}\frac{\left(\bar{t}^2+\bar{u}^2\right)\left(\bar{u}\hat{u}+\bar{t}\hat{t}\right)}{\bar{s}\hat{s}\hat{t}\hat{u}}$	$\frac{1}{4N_c^2C_F}\frac{\left(\bar{t}^2+\bar{u}^2\right)\left(\bar{u}\hat{u}+\bar{t}\hat{t}-\bar{s}\hat{s}\right)}{\bar{s}\hat{s}\hat{t}\hat{u}}$
$K^{(i)}_{qg^*\to qg}$	$-\frac{\bar{u}\left(\bar{s}^2+\bar{u}^2\right)}{2\bar{t}\hat{t}\hat{s}}\left(1+\frac{\bar{s}\hat{s}-\bar{t}\hat{t}}{N_c^2\,\bar{u}\hat{u}}\right)$	$-\frac{C_F}{N_c}\frac{\bar{s}\left(\bar{s}^2+\bar{u}^2\right)}{\bar{t}\hat{t}\hat{u}}$

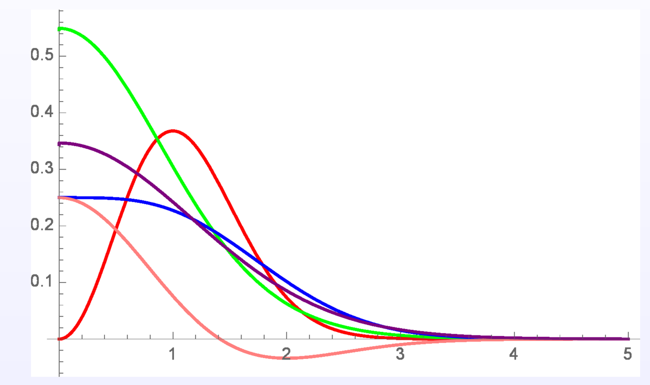
THE NEW FORMULA ENCOMPASSES ALL THE REGIMES OF VALIDITY OF THE DIFFERENT FORMALISMS

IV. PHENOMENOLOGY

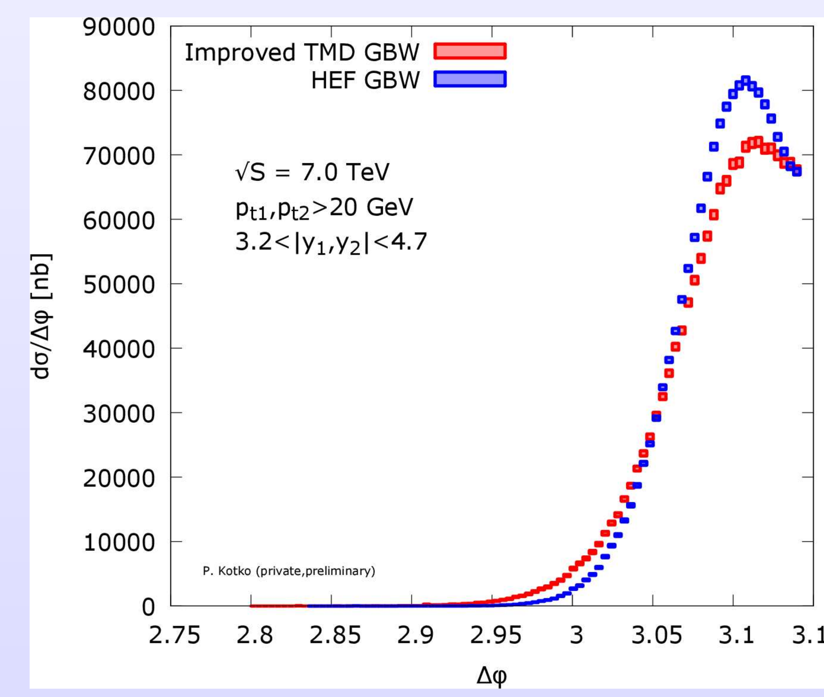
WE CALCULATE THE TMD GLUON DISTRIBUTIONS THAT ENTER IN THE UNIFYING FORMULA WITH

Kutak-Sapeta non-linear evolution: AND Golec-Biernat-Wusthoff model:





AZIMUTHAL CORRELATIONS IN FORWARD DI-JET PRODUCTION WITH THE UNIFYING FORMULA:



We observe a suppression in the correlation limit and an increase in the decorrelation sector in comparison to HEF.

SUMMARY

- We derive the High-Energy Factorization formula from CGC in the dilute target limit;
- We extend the TMD factorization formula to finite N_c and we write it with two k_t dependent gluon distributions per channel;
- We derive an improved TMD factorization that unifies the different k_t regimes.

Acknowledgments

We thank the Japan Society for the Promotion of Science (JSPS) for the travel support through the Japan-France Integrated Action Program (SAKURA). We thank Quark Matter 2015 for the Fellowship for young participants.

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