Study of the N_c-dependence of TMD's initial condition for JIMWLK evolution

Based on hep-ph:2603.15243

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33rd International Workshop on Deep Inelastic Scattering and Related Subjects (DIS2026)
Bologna, Italy, from May 4 to May 8, 2026

Overview

Motivations

- TMD distributions and phenomenology.
- Evolution and the large N_c limit.

Operators and the Gaussian approximation

- Operator definitions and relation to irreps.
- IC in the Gaussian approximation.
- TMDs and sum rules for $SU(N_c)$ at $N_c \in \{2, 3\}$.

Numerical evaluation - To be or not to be N_c-scaling

- Scaling parameters for values of N_c.
- Results for the IC of Ω's.
- Results for the IC of TMD distributions.

Outlooks

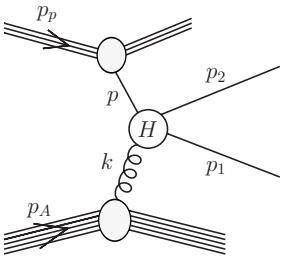


Figure: Inclusive forward di-jet production in p+A collision, figure from [Marquet-Petreska-Roiesnel 2016].

In the TMD factorization, one can write the formula for forward dijet production [Marquet-Petreska-Roiesnel 2016] [Kotko-Kutak-Marquet-Petreska-Sapeta 2015] [Dominguez-Marquet-Xiao-Yuan 2011] as :

$$\frac{d\sigma^{pA\to \text{dijets}+X}}{dy_1 dy_2 d^2p_{1t} d^2p_{2t}} = \frac{\alpha_s^2}{(x_1 x_2 s)^2} \sum_{a,c,d} x_1 f_{a/p}(x_1,\mu^2) \sum_i H^{(i)}_{ag\to cd}(z,P_t)\ \mathcal{F}^{(i)}_{ag}(x_2,k_t) \frac{1}{1+\delta_{cd}}\,, \quad (1)$$

...

Motivations - Evolution and the large N_c limit

Consider the dipole operator

$$\hat{S}_{\underline{x}\underline{y}} = \frac{1}{N_c}\mathrm{tr}\left(V_{\underline{x}}V_{\underline{y}}^{\dagger}\right), \qquad V_{\underline{x}} = P\exp\left\{ig\int_{-\infty}^{\infty} dt\ \alpha^a(t,\underline{x})t_F^a\right\}, \qquad t = x^{\pm}, \quad \alpha = A^{\mp}. \tag{2}$$

Acting with JIMWLK hamiltonian on the dipole minus the rhs of the BK equation, introduces the following:

$$\Delta_{\underline{x},\underline{y};\underline{z}} = \langle \hat{S}_{\underline{x}\underline{z}}\hat{S}_{\underline{z}\underline{y}}\rangle - \langle \hat{S}_{\underline{x}\underline{z}}\rangle\langle \hat{S}_{\underline{z}\underline{y}}\rangle \tag{3}$$

Observations:

- Expected to be of the order $\mathcal{O}(1/N_c^2) \overset{N_c=3}{\longrightarrow} \mathcal{O}(10\%)$
- Observed to be of the order $\mathcal{O}(1\%)$ in numerical simulations instead!
  [Rummukainen-Weigert 2004] [Kovchegov-Kuokkanen-Rummukainen-Weigert 2009]
- Conclusion reached for any distributions that can be expressed out of the dipole expectation value $\langle \hat{S}_{\underline{x}\underline{y}}\rangle$ without large $1/N_c$ corrections.
- A related study has been performed in the context of the quadrupole operator.
  [Dumitru-Jalilian-Marian-Lappi-Schenke-Venugopalan 2011]
  and more recently [Lappi-Triantafyllopoulos 2026]

$\Rightarrow$ What about distributions with large $1/N_c$ corrections?

Operator's definitions

Following the nomenclature from [Marquet-Petreska-Roiesnel 2016] and [Bury-Kotko-Kutak 2019]
Quark - Gluon sector:

$$\hat{\mathcal{F}}_{qg}^{(1)}(\underline{x},\underline{y}) = \mathrm{tr}\left[(\partial_i V_{\underline{x}}^\dagger)(\partial_i V_{\underline{y}})\right] \tag{4a}$$

$$-N_c\,\hat{\mathcal{F}}_{qg}^{(2)}(\underline{x},\underline{y}) = \mathrm{tr}\left[(\partial V_{\underline{x}})V_{\underline{x}}^\dagger(\partial V_{\underline{y}})V_{\underline{y}}^\dagger\right]\mathrm{tr}\left[V_{\underline{y}}V_{\underline{x}}^\dagger\right] \tag{4b}$$

$$-\hat{\mathcal{F}}_{qg}^{(3)}(\underline{x},\underline{y}) = \mathrm{tr}\left[(\partial V_{\underline{x}})V_{\underline{x}}^\dagger\left[V_{\underline{y}}V_{\underline{x}}^\dagger\right](\partial V_{\underline{y}})V_{\underline{y}}^\dagger\right] \tag{4c}$$

Gluon - Gluon sector:

$$N_c\hat{\mathcal{F}}_{gg}^{(1)}(\underline{x},\underline{y}) = \mathrm{tr}\left[(\partial_i V_{\underline{x}}^\dagger)(\partial_i V_{\underline{y}})\right]\mathrm{tr}\left[V_{\underline{x}}V_{\underline{y}}^\dagger\right] \tag{5a}$$

$$-N_c\hat{\mathcal{F}}_{gg}^{(2)}(\underline{x},\underline{y}) = \mathrm{tr}\left[(\partial_i V_{\underline{y}})V_{\underline{x}}^\dagger\right]\mathrm{tr}\left[(\partial_i V_{\underline{x}})V_{\underline{y}}^\dagger\right] \tag{5b}$$

$$-\hat{\mathcal{F}}_{gg}^{(3)}(\underline{x},\underline{y}) = \mathrm{tr}\left[(\partial_i V_{\underline{x}})V_{\underline{x}}^\dagger(\partial_i V_{\underline{y}})V_{\underline{y}}^\dagger\right] \tag{5c}$$

$$-\hat{\mathcal{F}}_{gg}^{(4)}(\underline{x},\underline{y}) = \mathrm{tr}\left[V_{\underline{x}}^\dagger(\partial_i V_{\underline{x}})V_{\underline{y}}^\dagger(\partial_i V_{\underline{y}})\right] \tag{5d}$$

$$-\hat{\mathcal{F}}_{gg}^{(5)}(\underline{x},\underline{y}) = \mathrm{tr}\left[V_{\underline{y}}V_{\underline{x}}^\dagger(\partial_i V_{\underline{y}})V_{\underline{y}}^\dagger V_{\underline{x}}V_{\underline{y}}^\dagger(\partial_i V_{\underline{x}})V_{\underline{x}}^\dagger\right] \tag{5e}$$

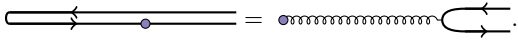
$$-N_c^2\hat{\mathcal{F}}_{gg}^{(6)}(\underline{x},\underline{y}) = \mathrm{tr}\left[(\partial_i V_{\underline{x}})V_{\underline{x}}^\dagger(\partial_i V_{\underline{y}})V_{\underline{y}}^\dagger\right]\mathrm{tr}\left[V_{\underline{x}}V_{\underline{y}}^\dagger\right]\mathrm{tr}\left[V_{\underline{y}}V_{\underline{x}}^\dagger\right] \tag{5f}$$

$$-N_c\hat{\mathcal{F}}_{gg}^{(7)}(\underline{x},\underline{y}) = \mathrm{tr}\left[V_{\underline{x}}V_{\underline{y}}^\dagger(\partial_i V_{\underline{x}})V_{\underline{x}}^\dagger(\partial_i V_{\underline{y}})V_{\underline{y}}^\dagger\right]\mathrm{tr}\left[V_{\underline{y}}V_{\underline{x}}^\dagger\right] \tag{5g}$$

Operator's definitions - Birdtracks

Introduce a birdtrack [Cvitanovic 2008] representation for WLs and (transverse) derivatives:

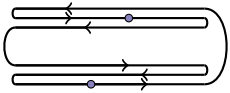
$$\mathcal{B}^i = (\partial^i V)V^\dagger = \quad = \quad . \tag{6}$$



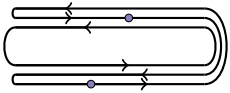
- Belongs to the adjoint irrep. Convenient to express forward staples.

Quark - Gluon sector:

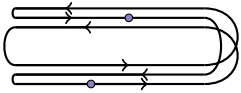
$$-\hat{\mathcal{F}}_{qg}^{(1)} = \tag{7a}$$



$$-N_c\,\hat{\mathcal{F}}_{qg}^{(2)} = \tag{7b}$$



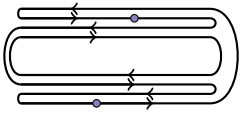
$$-\hat{\mathcal{F}}_{qg}^{(3)} = \tag{7c}$$

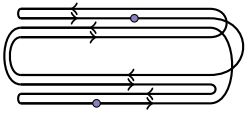


- Top lines are at position $\underline{x}$, bottom lines are at position $\underline{y}$.
- Left (resp. right) vertical lines are contractions of WLs at $\pm\infty$.

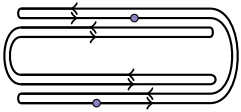
Gluon-Gluon sector

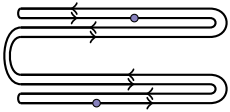
$$-N_c\hat{\mathcal{F}}_{gg}^{(1)} = \quad -N_c\hat{\mathcal{F}}_{gg}^{(2)} = \tag{8a}$$



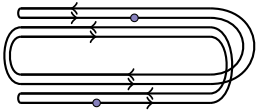


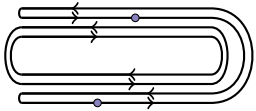
$$-N_c\hat{\mathcal{F}}_{gg}^{(3)} = \quad -\hat{\mathcal{F}}_{gg}^{(4)} = \tag{8b}$$



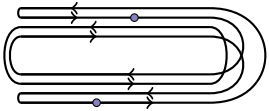


$$-\hat{\mathcal{F}}_{gg}^{(5)} = \quad -N_c^2\hat{\mathcal{F}}_{gg}^{(6)} = \tag{8c}$$





$$-N_c\hat{\mathcal{F}}_{gg}^{(7)} = \tag{8d}$$

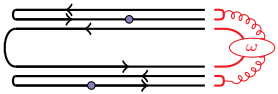


- Only seven out of all possible ways of contracting at $+\infty$ are of interest to us.

Operator's definitions - Relation to irreducible representations

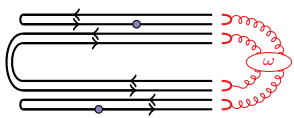
Introduce the following operators:

$$\hat{\Omega}^{\omega}_{qg} = 2 \times$$



(9)

$$\hat{\Omega}^{\omega}_{gg} = 4 \times$$



(10)

Irreducible representations (irreps) of interest are:

$$\hat{\Omega}^{\omega}_{qg}: \qquad 8 \otimes \bar{3} = 1\bar{5} \oplus 6 \oplus \bar{3} \tag{11}$$

$$\hat{\Omega}^{\omega}_{gg}: \qquad 8 \otimes 8 = 27 \oplus 0 \oplus (10 + \bar{10}) \oplus 8_s \oplus 8_a \oplus 1 \tag{12}$$

Remark:

- QG-sector, 3 irreps $\Leftrightarrow$ 3 TMD distributions.
- GG-sector: Full vector space at $+\infty$ has dimension 10 for $N_c > 3$.
  Combine $10 + \bar{10}$ (symmetry and charge).
  Focus only on hermitian part, ie drop the transitions $8_a \leftrightarrow 8_s$.
  Use Fierz identity at $-\infty$. Grand total of 7 contributions $\Leftrightarrow$ 7 TMD distributions.

Initial condition in the Gaussian approximation

Relate TMD distribution $\hat{\mathcal{F}}$ to irrep operators $\hat{\Omega}$:

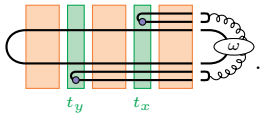
$$\hat{\mathcal{F}}_{ag} = M^{-1}_{ag} \cdot \hat{\Omega}_{ag} \quad \Longrightarrow \quad \mathcal{F}_{ag} = M^{-1}_{ag} \cdot \Omega_{ag}, \qquad a = \{q, g\}. \tag{13}$$

where M are matrices that only depend on N_c and are explicitly computed.

In the Gaussian approximation:

- Interaction involves only a two point function $\Gamma_{\underline{x}\underline{y}}$.
- Assume translation and rotation invariance: $\Gamma_r = \Gamma_{\underline{x}\underline{y}}\big|_{r=|\underline{x}-\underline{y}|}$.
- Interaction is instantaneous (i.e. Glauber gluons) $\longrightarrow$ $\langle \alpha(t_x)\alpha(t_y)\rangle \propto \delta(t_x - t_y)$.

$$\Omega_{qg} \equiv \langle \hat{\Omega}_{qg} \rangle^{(\text{Gaussian})} = 2 \times$$



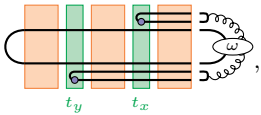
. (14)

- Orange: usual eikonal interaction $\langle \alpha_{\underline{u}} \alpha_{\underline{v}} \rangle$ $\longrightarrow$ Γ_r
- Green: involves either $\langle (\partial\alpha)_{\underline{u}} \alpha_{\underline{v}} \rangle$ or $\langle (\partial\alpha)_{\underline{u}} (\partial\alpha)_{\underline{v}} \rangle$ $\longrightarrow$ $\nabla^i_r \Gamma_r$ or $\nabla^2 \Gamma_r$.

And similar for the GG-sector.

Unequal time contribution

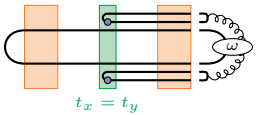
$$\Omega_{qg}^{(a)}\Big|_{t_x>t_y} = 2 \times$$



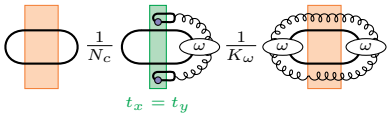
$$, \qquad \Omega_{qg}^{(a)} = \frac{N_c}{2} C_F (\nabla\Gamma_r)^2 \, e^{-C_F\Gamma_r} \, \delta_{\omega=\overline{3}} \tag{15}$$

Equal time contribution

$$\Omega_{qg}^{(b)} = 2 \times$$



$$= 2 \times$$



$$= -\frac{K_\omega}{2} (\nabla^2\Gamma_r) \, e^{-\frac{C_F + C_\omega}{2}\Gamma_r} \, \text{sinhc}\left[\frac{1}{2}(C_\omega - C_F)\Gamma_r\right] \tag{16a}$$

Remarks

- Two distinct cases: $\Omega_{ag}^{(a+b)}$ and $\Omega_{ag}^{(b)}$ depending on irrep ω
- Dependence on average and difference of charges: $\frac{1}{2}(C_\omega \pm C_F)$
- Similar expressions in the GG-sector (trade $C_F \leftrightarrow C_A$)

Observed sum rules

Irreps of interest are:

$$\hat{\Omega}^{\omega}_{qg}: \qquad 8 \otimes \bar{3} = 1\bar{5} \oplus 6 \oplus \bar{3} \tag{17}$$

$$\hat{\Omega}^{\omega}_{gg}: \qquad 8 \otimes 8 = 27 \oplus 0 \oplus (10 + \bar{10}) \oplus 8_s \oplus 8_a \oplus 1 \tag{18}$$

At $N_c = 3$, there is no irrep $\omega = 0$ in the decomposition $8 \otimes 8$. Thus there are only 6 linearly independent contributions. It yields the sum rule for the TMD's:

$$\left[\frac{3}{2}\hat{\mathcal{F}}^{(1)}_{gg} + \frac{3}{2}\hat{\mathcal{F}}^{(2)}_{gg} - \frac{1}{4}\hat{\mathcal{F}}^{(3)}_{gg} - \frac{1}{4}\hat{\mathcal{F}}^{(4)}_{gg} - \frac{1}{4}\hat{\mathcal{F}}^{(5)}_{gg} - \frac{9}{4}\hat{\mathcal{F}}^{(6)}_{gg} + \frac{3}{2}\hat{\mathcal{F}}^{(7)}_{gg}\right]_{N_c=3} = 0 \tag{19}$$

At $N_c = 2$, there is no irrep $\omega = 6$ in the decomposition $8 \otimes \bar{3}$, and no irrep $10 + \bar{10}$ nor $8s$ in the decomposition $8 \otimes 8$.

$$\left[2\hat{\mathcal{F}}^{(2)}_{qg} - \hat{\mathcal{F}}^{(3)}_{qg} - \hat{\mathcal{F}}^{(1)}_{qg}\right]_{N_c=2} = 0 \tag{20}$$

$$\left[\hat{\mathcal{F}}^{(3+4)}_{gg} - 2\hat{\mathcal{F}}^{(1+2)}_{gg}\right]_{N_c=2} = 0 \tag{21}$$

$$\left[4\hat{\mathcal{F}}^{(6)}_{gg} - \hat{\mathcal{F}}^{(3)}_{gg} - \hat{\mathcal{F}}^{(5)}_{gg} + 2\hat{\mathcal{F}}^{(2)}_{gg} - 2\hat{\mathcal{F}}^{(1)}_{gg}\right]_{N_c=2} = 0 \tag{22}$$

One realization

On a torus of length L discretized into a grid of N^2 points $\hat{x}$, a WL at the grid node $\hat{x}$ reads

$$V(\hat{x}) = \prod_{n=1}^{\text{erg}} e^{i\, A_n^a(\hat{x}) t^a}. \tag{23}$$

- "erg" chosen around ~ 200 where results become stable.

The field is obtained according to (Fourier acceleration)

$$A_n^a(\hat{x}) \equiv \text{Re}\ \frac{L}{2\pi} \frac{\mu}{\sqrt{\text{erg}}}\ \text{FFTW}_{2d} \left\{ \left[\hat{k}^2 + \left(\frac{m\, L}{2\pi} \right)^2 \right]^{-1} \nu_n^a(\hat{k}) \right\} (\hat{x}) \tag{24}$$

The noise $\nu_n^a(\underline{k})$, is a vector of $N_c^2 - 1$ components distributed according to

$$\mathcal{N}(x;\sigma) = \frac{1}{\sigma\sqrt{2\pi}}\ e^{-\frac{1}{2}\left(\frac{x}{\sigma}\right)^2}. \tag{25}$$

Thus, a realization is fully characterized by the set of parameters:

$$\{\text{erg}; N_c; N; L; m; \mu\} \tag{26}$$

Average over ensemble of realizations: $\langle \hat{\mathcal{O}} \rangle = \frac{1}{N_{rea}} \sum_{i=1}^{N_{rea}} \mathcal{O}[V_i]$

- A few realizations already give a good idea of the distribution

Numerical evaluation - the dipole and scaling factors

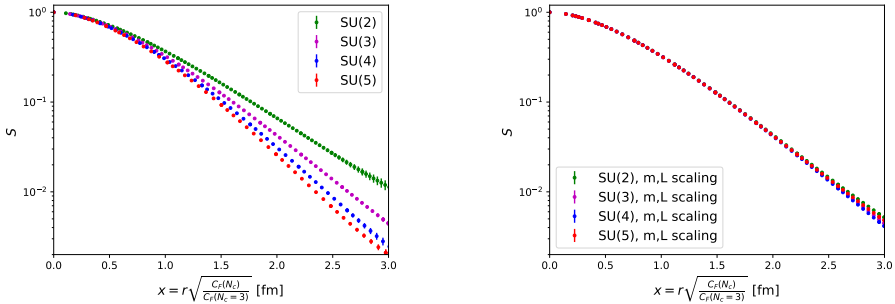


Figure: Dipole in the MV model obtained with (left panel) and without (right panel) scaling of the mass and volume. Simulation for $SU(3)$, $\mu = 0.7\text{fm}^{-1}, m = 0.2\text{fm}^{-1}, L = 100\text{fm}$.

Scaling in performed according to

$$\{r, L\} \longrightarrow \{r, L\}/\sqrt{C_F(N_c)/C_F(N_c=3)}, \tag{27a}$$

$$m \longrightarrow m\sqrt{C_F(N_c)/C_F(N_c=3)}. \tag{27b}$$

Fit of the right panel:

$$S_r = \exp\left\{-\frac{4}{3}\frac{\mu_{\text{fit}}^2}{m_{\text{fit}}^2}\left[1 - m_{\text{fit}}\, r\, K_1\left(m_{\text{fit}}\, r\right)\right]\right\}, \quad \mu_{\text{fit}} = 0.859\text{fm}^{-1}, \quad m_{\text{fit}} = 0.191\text{fm}^{-1}. \tag{28}$$

Numerical evaluation - Result for the Ω's

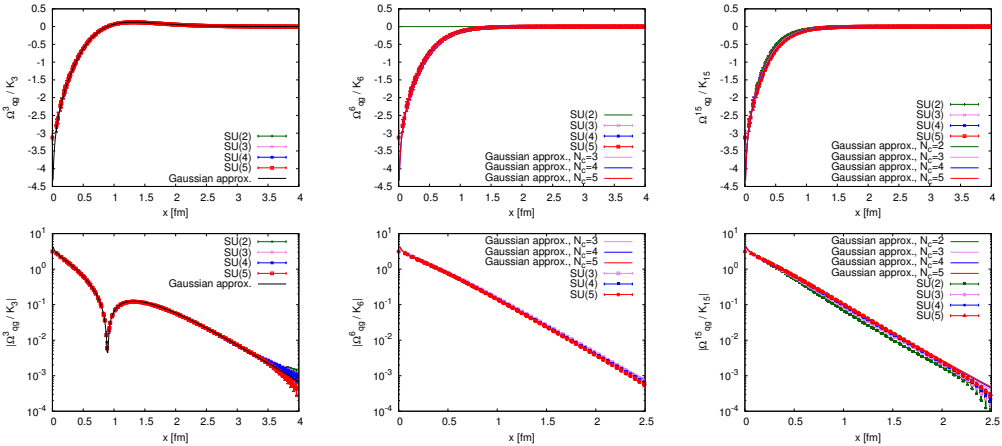


Figure: Dependence of $\Omega^{\omega}_{qg}/K_{\omega}$ on N_c. The Gaussian approximation is shown for each N_c with a continuous curve with color matching the color of the data.

- Exact scaling for Ω^3_{qg} (a single curve is thus shown)
- Slight deviation from scaling for $\Omega^{15/6}_{qg}$.
- Good agreement between numeric and Gaussian approximation.

Numerical evaluation - Result for the Ω's

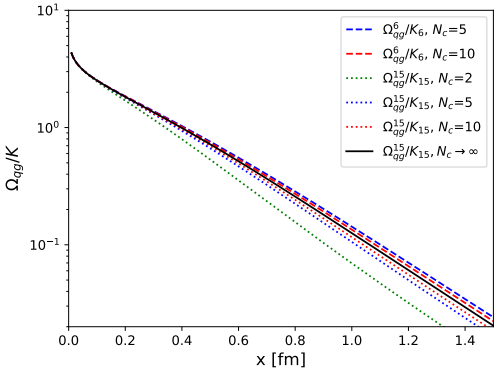


Figure: The comparison of $\Omega^{\omega}_{qg}/K_{\omega}$ for $\omega = \{\overline{15}, 6\}$ for various N_c using the Gaussian approximation.

- Mild breaking of N_c-scaling:
  $\rightarrow$ Impossibility to factorize both $C_F \pm C_{15/6}$ in $\Omega^{(b)}_{qg}$ into an N_c-indep combination.
- Large N_c limit: Same dimension $K_{15/6} \sim \mathcal{O}\left(\frac{1}{2}N_c^3\right)$ and charge $C_{15/6} \sim \mathcal{O}\left(\frac{3}{2}N_c\right)$.

Baseline: $N_c = 3$.

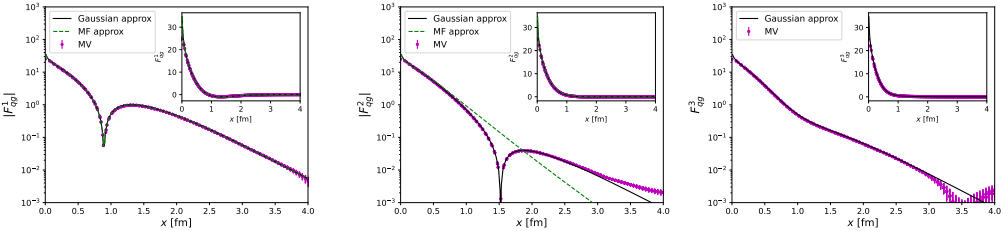


Figure: Evaluation of quark-gluon TMD distributions for $SU(3)$. The magenta data points are obtained from MV-model simulations. The black plain lines show the computed Gaussian approximations. The green dashed lines show results from [Caucal and al. 2025] where the mean-field approximation has been used. The MF curve for $\mathcal{F}_{qg}^{(1)}$ agrees with the Gaussian approximation and the data because of the exact scaling of this distribution.

- Good agreement between data and both approximation at small separation.
- Deviation between approximation observed in the tail. Numerical simulation shown the validity of the mean-field approximation.

Numerical evaluation - Result for the TMD distributions

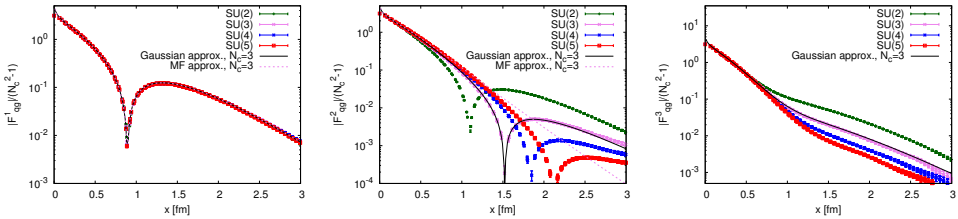


Figure: (N_c^2-1)-normalized quark-gluon TMD distributions for different values of N_c together with the Gaussian and mean-field approximations for $N_c = 3$.

- Exact scaling of $\mathcal{F}_{qg}^{(1)}/(N_c^2-1)$ which is equivalent to Ω_{qg}^3/K_3
- $\mathcal{F}_{qg}^{(2)}/(N_c^2-1)$ node depends on N_c, such that at $N_c \to \infty$ it *moves* toward $r \to \infty$.
- Clearly observe the N_c-ordering of the tails

$$\begin{pmatrix} \mathcal{F}_{qg}^{(1)} \\ \mathcal{F}_{qg}^{(2)} \\ \mathcal{F}_{qg}^{(3)} \end{pmatrix} = \begin{pmatrix} -\frac{N_c}{N_c^2-1} & 0 & 0 \\ -\frac{1}{N_c} & -\frac{1}{N_c} & -\frac{1}{N_c} \\ \frac{1}{2N_c} & \frac{1}{2} & -\frac{1}{2} \end{pmatrix} \cdot \begin{pmatrix} \Omega_{qg}^{\overline{3}} \\ \Omega_{qg}^{6} \\ \Omega_{qg}^{\overline{15}} \end{pmatrix} \tag{29}$$

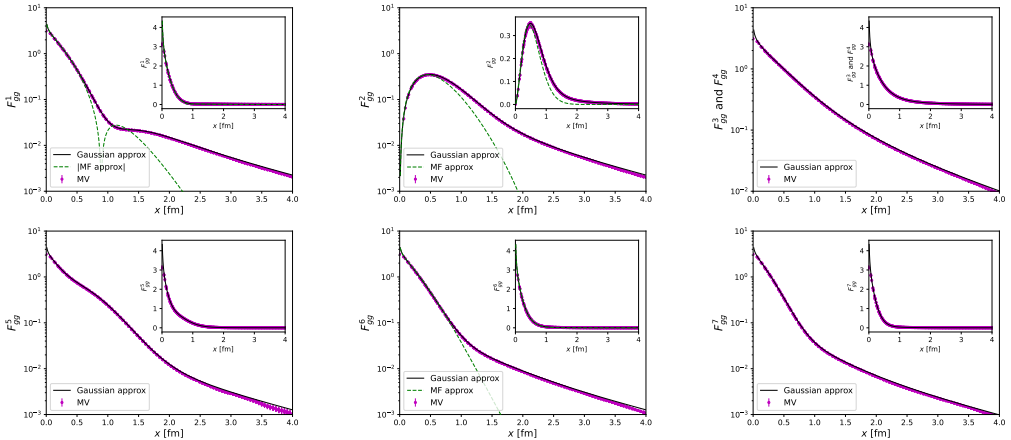


Figure: Evaluation of gluon-gluon TMD distributions for $SU(3)$. The magenta data points are obtained from MV-model simulations. The black plain lines show the computed Gaussian approximations. The green dashed lines show results from [Caucal and al. 2025] where the mean-field approximation has been used.

GG-sector

- The node appearing in $\mathcal{F}_{gg}^{(1)}$ if the MF approx is used is absent in the Gaussian approximation.
- Small separation agreement between simulation and MF / Gaussian approx is good.
- Tails are $1/N_c$ suppressed effect and thus cannot be obtained using MF.

Outlooks

Summary

- Initial condition for TMDs in the QG and GG sectors using numerical impl. of the MV model and analytic expr. in the Gaussian approximation.
- Tails of distribution well captured using the Gaussian approximation.
- Understanding of the behavior of those distributions in terms of irreps.
  Tails are from smallest charges: wide distribution but $1/N_c$ suppressed.
- Introduced $\Omega^{\omega}_{ag}/K_{\omega}$ showing N_c-scaling or mild deviation from N_c-scaling .
- Most of the N_c-scaling deviations in TMD's originates from the linear map with Ω's.
- Identified a sum rule for $N_c = 3$ valid in the GG-sector, following from the absence of the irrep $\omega = 0$ at $N_c = 3$.

Prospects

- Introduce the rapidity evolution using JIMWLK equation in the same range $N_c \in \{2, 3, 4, 5\}$.
- Can we still relate TMD's to the dipole using the Gaussian approx. after evolution?
- Does the deviations from $1/N_c$ features presented here persist after evolution?

Appendix

$$\hat{\mathcal{F}}_{ag} = M_{ag}^{-1} \cdot \hat{\Omega}_{ag} \quad \Longrightarrow \quad \mathcal{F}_{ag} = M_{ag}^{-1} \cdot \Omega_{ag}, \qquad a = \{q, g\}. \tag{30}$$

QG-sector

$$M_{qg}^{-1} = \begin{pmatrix} -\frac{N_c}{N_c^2-1} & 0 & 0 \\ -\frac{1}{N_c} & -\frac{1}{N_c} & -\frac{1}{N_c} \\ \frac{1}{2N_c} & \frac{1}{2} & -\frac{1}{2} \end{pmatrix} \tag{31}$$

GG-sector

$$M_{gg}^{-1} = \begin{pmatrix} -\frac{N_c^2-1}{N_c^2} & -\frac{1}{2} & -\frac{N_c^2-4}{2N_c^2} & 0 & 0 & 0 & -\frac{1}{N_c^2} \\ -\frac{N_c^2-1}{N_c^2} & \frac{1}{2} & -\frac{N_c^2-4}{2N_c^2} & 0 & 0 & 0 & -\frac{1}{N_c^2} \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 \\ -(N_c^2-1) & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 1 & -1 & 1 & -1 & -1 & 0 \\ -\frac{1}{N_c^2} & -\frac{1}{N_c^2} & -\frac{1}{N_c^2} & -\frac{1}{N_c^2} & -\frac{1}{N_c^2} & -\frac{1}{N_c^2} & -\frac{1}{N_c^2} \\ \frac{1}{N_c^2} & 0 & \frac{2}{N_c^2} & 0 & -\frac{1}{N_c} & \frac{1}{N_c} & -\frac{1}{N_c^2} \end{pmatrix} \tag{32}$$

Numerical evaluation - Result for the Ω's in the GG-sector

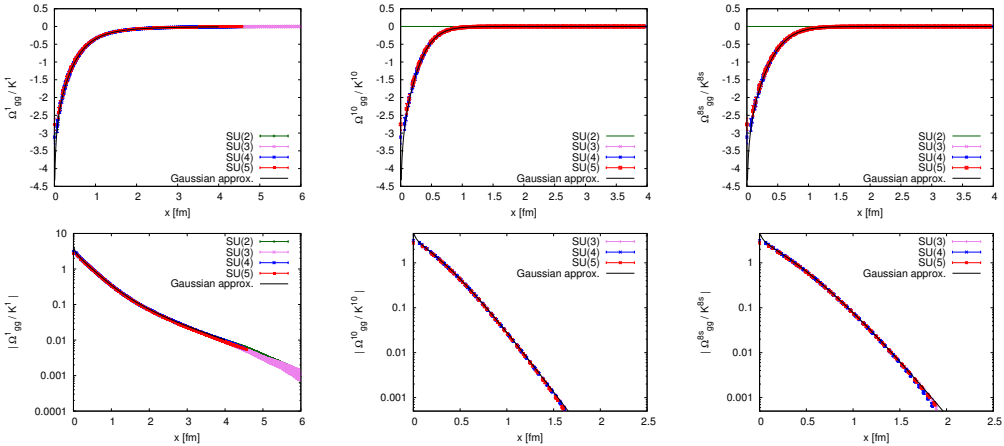


Figure: Dependence of $\Omega^{\omega}_{gg}/K_{\omega}$ on N_c for $\omega \in \{1, 10, 8s\}$. Additionally, the Gaussian approximation is shown with only one curve in black because of the scaling.

Numerical evaluation - Result for the Ω's in the GG-sector

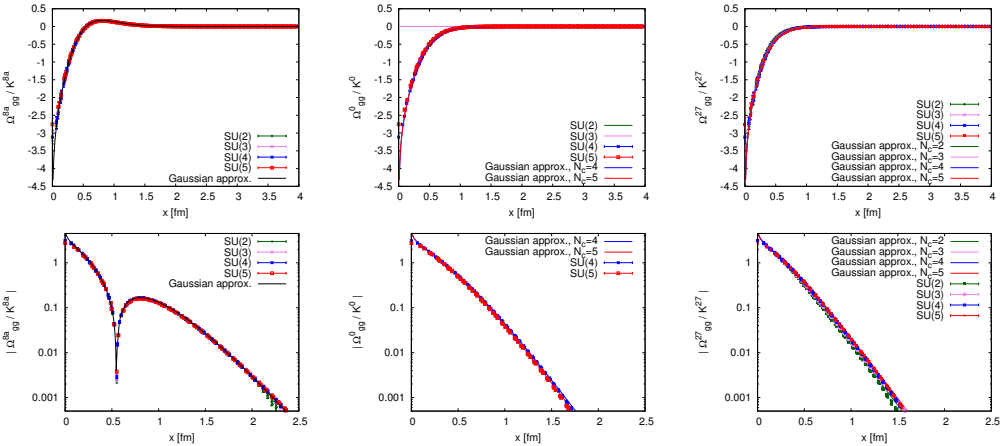


Figure: Dependence of $\Omega^{\omega}_{gg}/K_{\omega}$ on N_c for $\omega \in \{8a, 0, 27\}$. Additionally, the Gaussian approximation is shown for each N_c with a continuous curve with color matching the color of the data.

Numerical evaluation - Result for the Ω's in the GG-sector

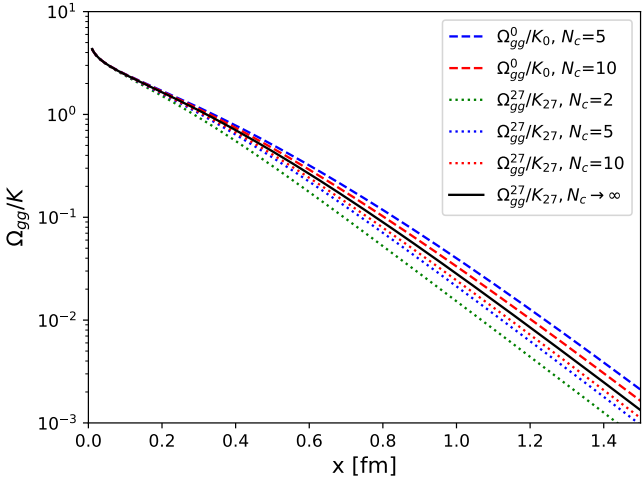


Figure: The comparison of $\Omega^{\omega}_{gg}/K_{\omega}$ for $\omega = \{27, 0\}$ for various N_c using the Gaussian approximation. Both sets of data converge to a common limit: $\lim_{N_c\to\infty} \Omega^{27}_{gg}(\mathrm{x})/K_{27} = \beta_{27}(\mathrm{x}) = \lim_{\mathrm{N_c}\to\infty} \Omega^{0}_{\mathrm{gg}}(\mathrm{x})/\mathrm{K}_0 = \beta_0(\mathrm{x})$.

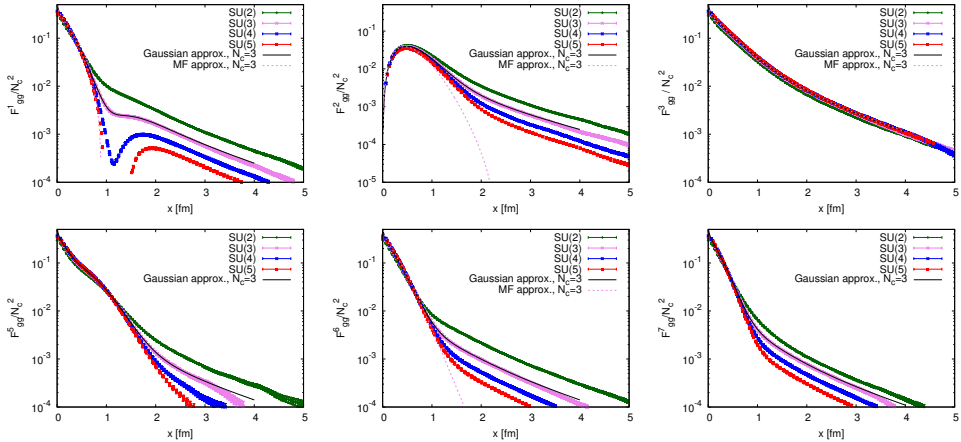


Figure: N_c^2-normalized gluon-gluon TMD distributions for the MV model for different values of N_c together with the Gaussian and mean-field approximations for $N_c = 3$ [**?**]. All TMD distributions show the scaling expected from Eq. (**??**) and the convergence towards the mean-field approximation is of $\mathcal{O}(1/N_c^2)$. For $\mathcal{F}_{gg}^{(3)}/N_c^2$ all curves lie on top of each other due to exact scaling.

Teaser: Evolution and Gaussian approximation

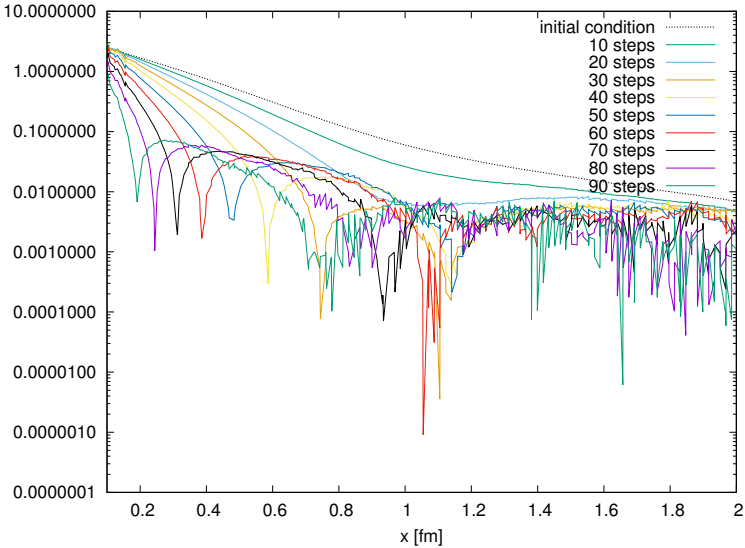


Figure: Very preliminary: Evolution of F^3_{QG} for $SU(3)$ - Breaking of the Gaussian approximation