Finite Nc Corrections in the NLO BK Equation

Lappi, Mäntysaari, A. R.
[Phys. Rev. D 102 074027] (2020)

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Poster session flash talk

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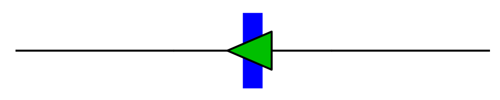
Wilson Line Correlators

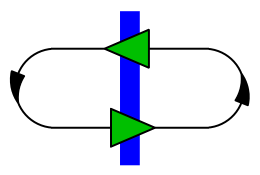
- Colour Glass Condensate effective field theory: small/moderate virtuality Q^2, small x_{Bj}
- Wilson lines are basic building blocks

$$U^\dagger_{\boldsymbol{x}} := P \exp\left\{ ig \int_{x^+} \alpha^a_{\boldsymbol{x}}(x^+) t^a \right\} \sim$$



- Enter cross sections explicitly within correlators $\langle \cdots \rangle$
- Evolution in rapidity of correlators governed by Balitsky Hierarchy $\Longleftrightarrow$ JIMWLK equation
- Infinite set of open equations – $\mathcal{O}(n)$ equation needs input from $\mathcal{O}(n+1)$
- First equation leads to BK equation for dipole

$$S^{(2)}_{\boldsymbol{x},\boldsymbol{y}} := \mathrm{tr}\left\{ U_{\boldsymbol{x}} U^\dagger_{\boldsymbol{y}} \right\} / N_{\mathrm{c}} \sim$$



- Can use large-N_{c} limit where expectation values factorise $\left\langle \mathrm{tr}\{\}\,\mathrm{tr}\{\} \right\rangle \to \left\langle \mathrm{tr}\{\} \right\rangle \left\langle \mathrm{tr}\{\} \right\rangle$, but we go beyond this

Next-to-leading Order Balitsky–Kovchegov Equation

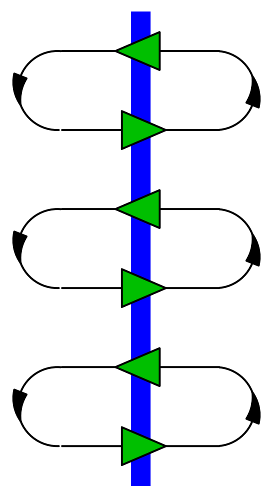
Balitsky, Chirilli [Nucl. Phys. B822:45-87 (2009)]

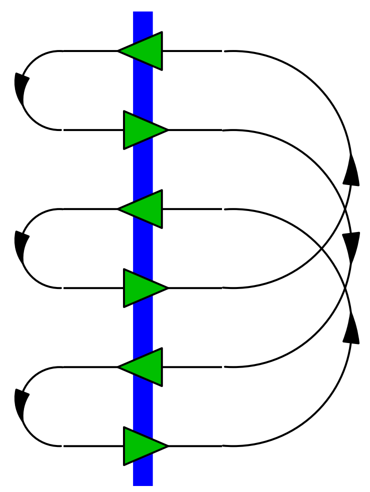
$$\partial_Y \left\langle S^{(2)}_{\boldsymbol{x},\boldsymbol{y}} \right\rangle = \frac{\alpha_s N_c}{2\pi^2} \int_{\boldsymbol{z}} K_1^{\mathsf{BC}} \langle D_1 \rangle + \frac{\alpha_s^2 N_c{}^2}{16\pi^4} \int_{\boldsymbol{z},\boldsymbol{z}'} \Big(K_{2,1} \langle D_{2,1} \rangle + K_{2,2} \langle D_{2,2} \rangle \Big) + \mathcal{O}(n_f)$$

$$\langle D_1 \rangle = \left\langle S^{(2)}_{\boldsymbol{x},\boldsymbol{z}} S^{(2)}_{\boldsymbol{z},\boldsymbol{y}} \right\rangle - \left\langle S^{(2)}_{\boldsymbol{x},\boldsymbol{y}} \right\rangle$$

$$\langle D_{2,2} \rangle = \left\langle S^{(2)}_{\boldsymbol{x},\boldsymbol{z}} S^{(2)}_{\boldsymbol{z},\boldsymbol{z}'} S^{(2)}_{\boldsymbol{z}',\boldsymbol{y}} \right\rangle - (z' \to z)$$

$$\langle D_{2,1} \rangle = \left\langle S^{(2)}_{\boldsymbol{x},\boldsymbol{z}} S^{(2)}_{\boldsymbol{z},\boldsymbol{z}'} S^{(2)}_{\boldsymbol{z}',\boldsymbol{y}} \right\rangle - \frac{1}{N_c{}^2} \left\langle S^{(6)}_{\boldsymbol{x},\boldsymbol{z},\boldsymbol{z}',\boldsymbol{y},\boldsymbol{z},\boldsymbol{z}'} \right\rangle$$





Gaussian Approximation

Iancu, Leonidov, McLerran [Nucl.Phys. A692 (2001) 583-645]
Fujii [Nucl.Phys. A709 (2002) 236-250]
Dumitru, Dusling, Gelis, Jalilian-Marian, Lappi, Venugopalan [Phys.Lett. B697 (2011) 21-25]
Dusling, Mace, Venugopalan [Phys.Rev. D97 (2018) no.1, 016014]

- Go beyond large-N_c limit. Truncate infinite hierarchy of evolution equations
- Parametrise correlators according to

$$\partial_Y \left\langle \hat{\mathcal{O}} \right\rangle := -\frac{1}{2} \int_{\boldsymbol{uv}} G_{\boldsymbol{uv}}(Y) L^a_{\boldsymbol{u}} L^a_{\boldsymbol{v}} \hat{\mathcal{O}}$$

- Operate on $\mathcal{O}$ with Lie derivatives $L^a_{\boldsymbol{u}} L^a_{\boldsymbol{v}} \sim$ add gluon emission/absorption vertices
- We have found a non-trivial basis such that transition matrix block diagonalises

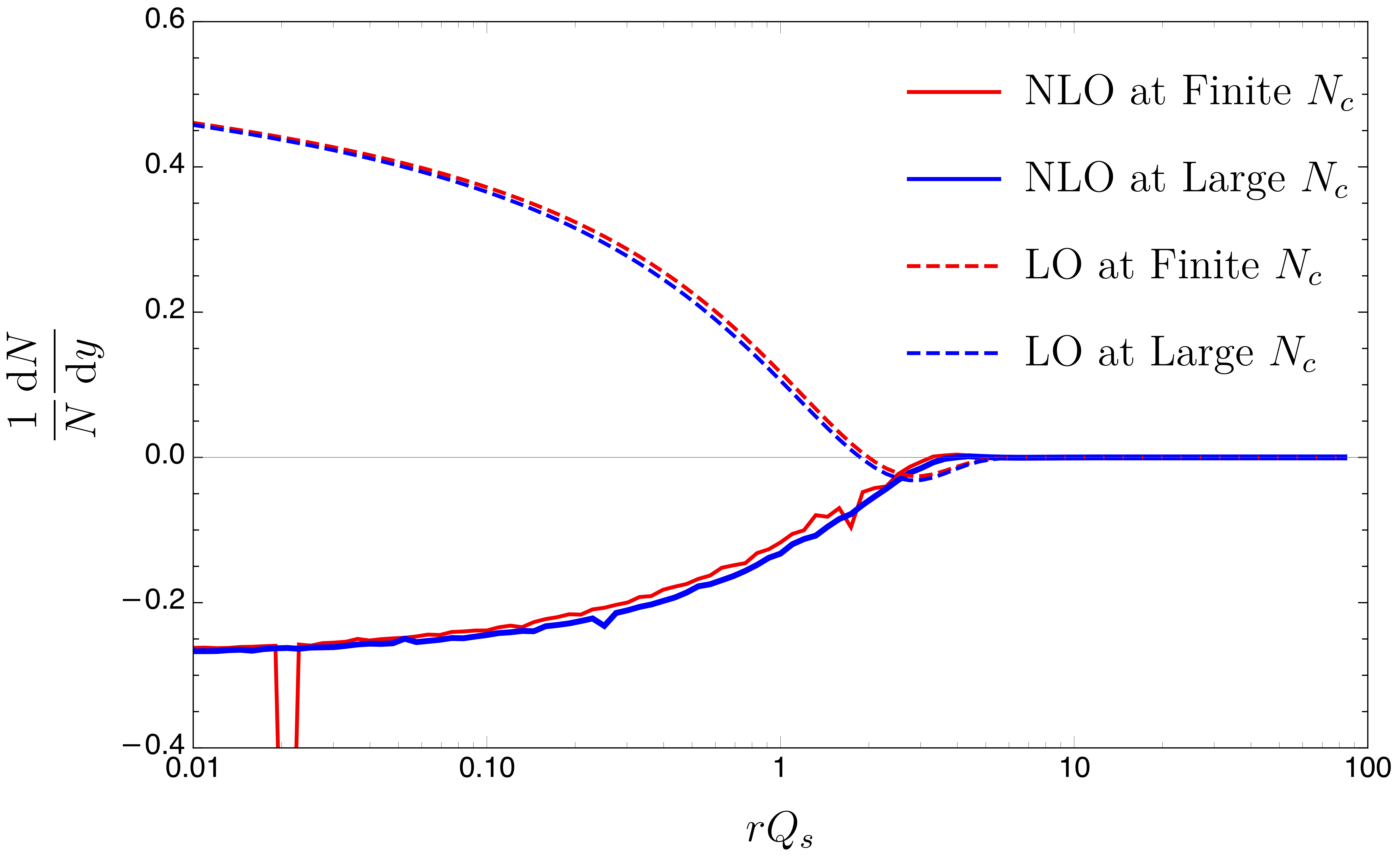
$$\lim_{\substack{\boldsymbol{u}\to\boldsymbol{z} \\ \boldsymbol{v}\to\boldsymbol{z}'}} \mathcal{M}(Y) = \begin{pmatrix} \mathcal{M}_1^{(3\times3)}(Y) & 0 & 0 \\ 0 & \mathcal{M}_2^{(2\times2)}(Y) & 0 \\ 0 & 0 & \mathcal{M}_3^{(1\times1)}(Y) \end{pmatrix}$$

6-point correlators

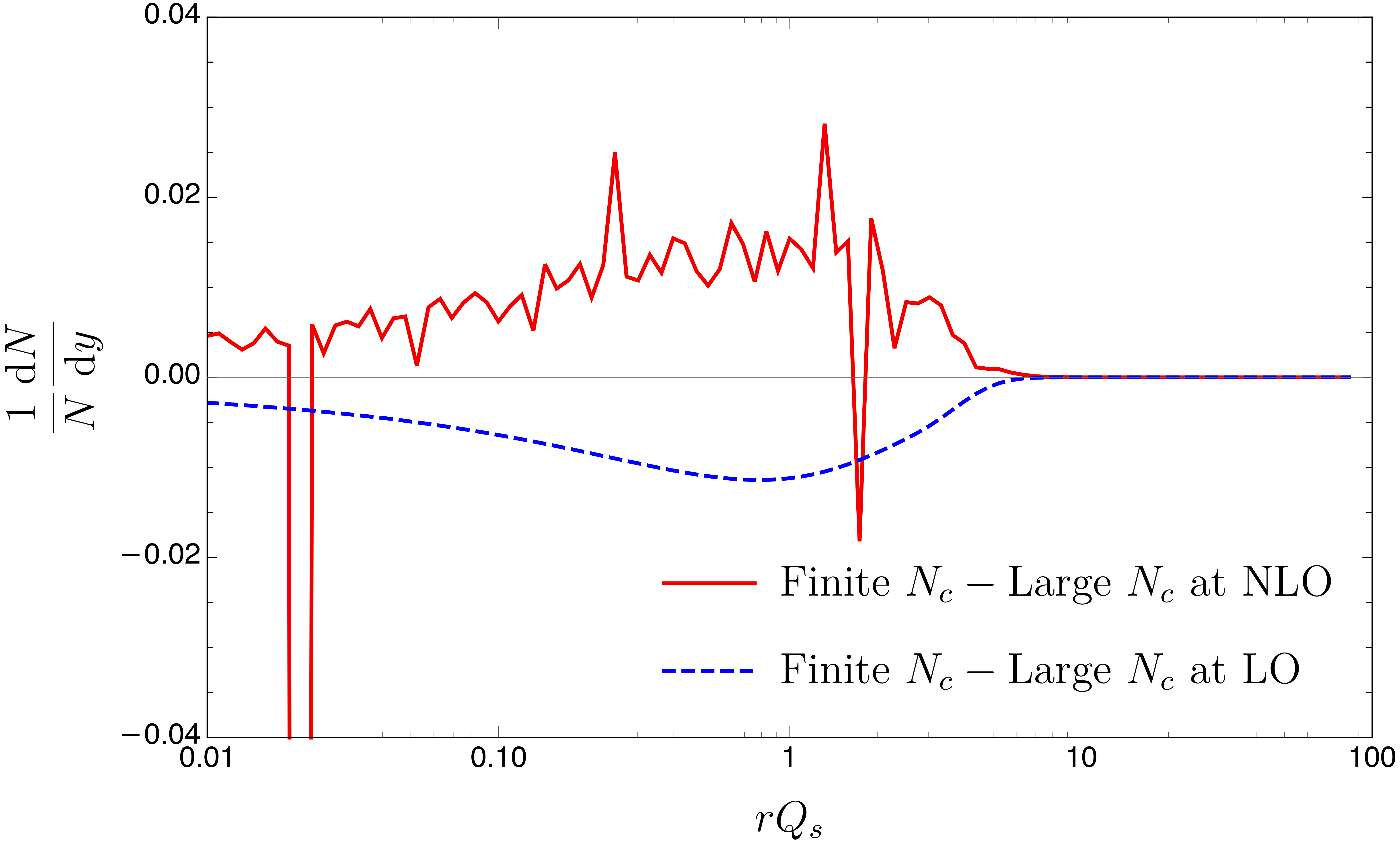
4-point correlator

2-point correlator

Numerical Results 1/2



Numerical Results 2/2



Conclusion: Naive expectation a priori is finite-N_c corrections at NLO are $1/{N_\mathrm{c}}^2 \sim \mathcal{O}(10\%)$.

Numerics show much smaller correction $\sim \mathcal{O}(1\%)$!

Thank you for watching!