UNIVERSITÄT BIELEFELD

Longitudinal structure of the initial state from 3+1D Glasma simulations

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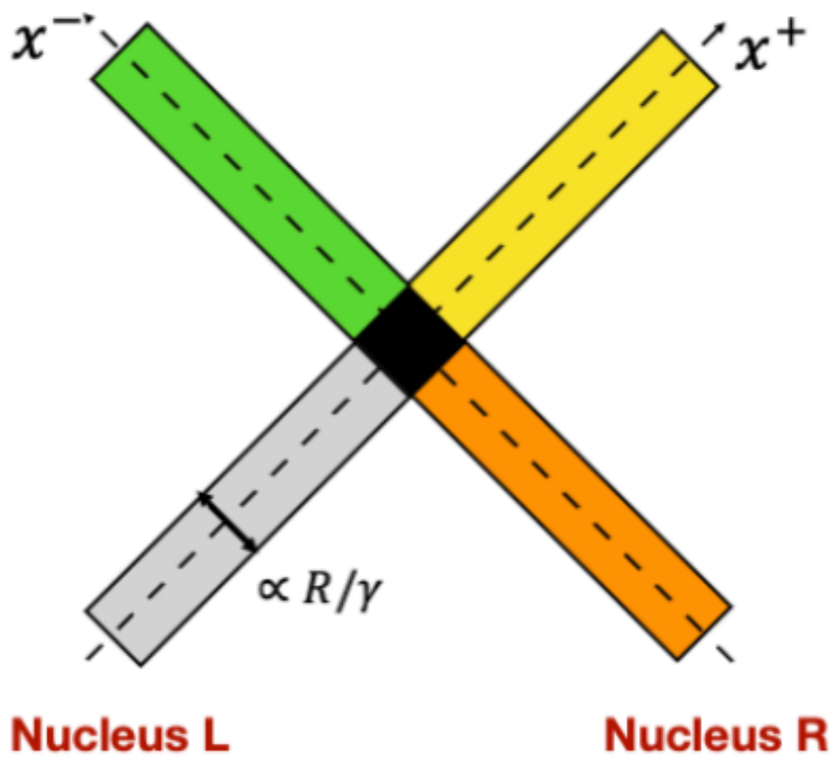
Motivation & Introduction

New measurements at RHIC and LHC indicates towards the presence of longitudinal dynamics arXiv:1503.01692 arXiv:1709.02301



Solve 3+1D classical Yang-Mills equations & evolution equations for eikonal currents, before, during and after the collision

Collision with (semi-) realistic charge distribution

Now in practice we employ a factorized ansatz for position and momentum dependence of the color charge distribution

$$\left\langle \rho^a(x)\rho^b(y)\right\rangle = \delta^{ab} T\left(\frac{x+y}{2}\right)\Gamma(x-y)$$

We determine the momentum dependence from TMDs in the dilute approximation (GBW model)

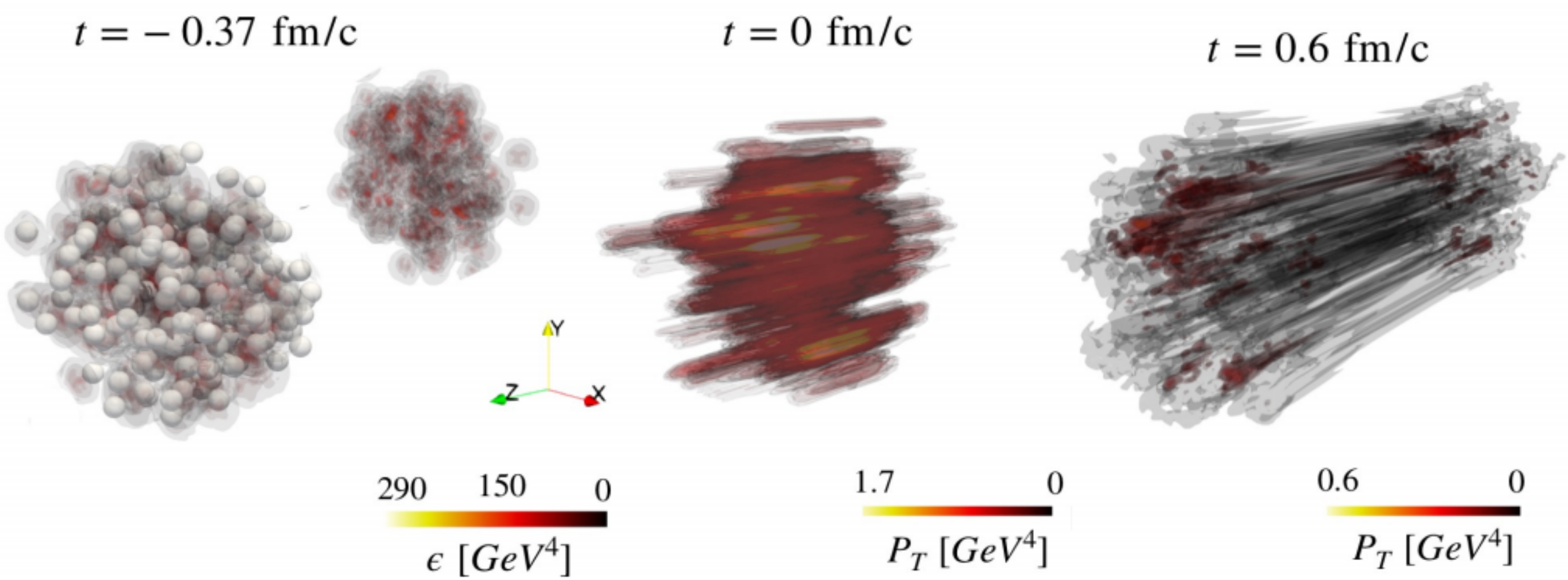
$$\tilde{\Gamma}(k_\perp, k_z) = \frac{8\pi}{g^2}\frac{N_c}{N_c^2-1}\frac{k_\perp^4}{Q_s^2(x_2)}\exp\left(-\frac{k_\perp^2}{Q_s^2(x_2)}\right)\Bigg|_{x_2=-\sqrt{2}k_z/\sqrt{s}_{NN}}$$

Superimpose 3D MC-Glauber profile of spatial distribution of color charges

$$T(x,y,z) = \sum_{i=1}^{A} T_i(x,y,z)\ .$$

Effect of fluctuation at RHIC energies

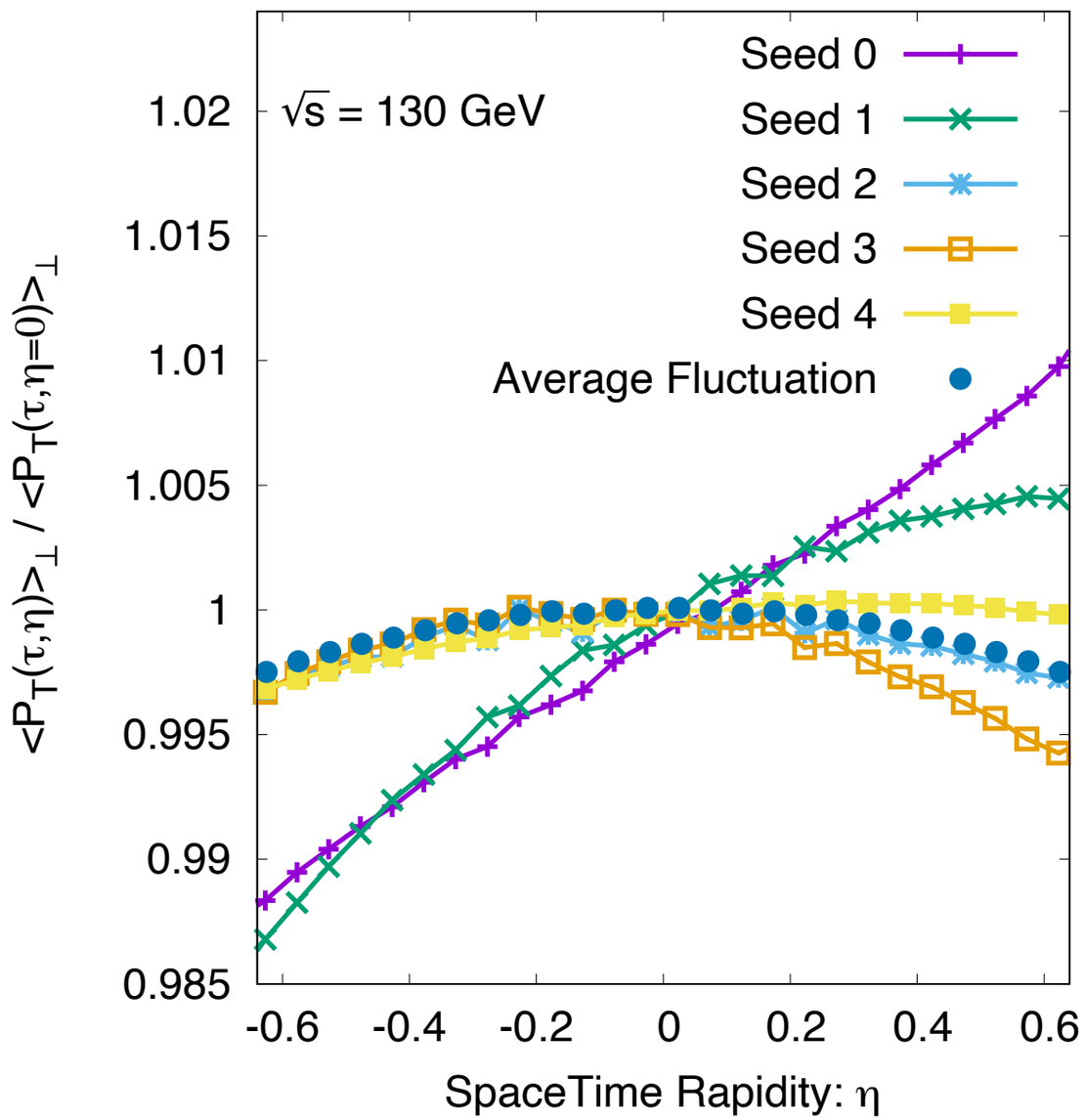
Before the collision | During the collision | After the collision

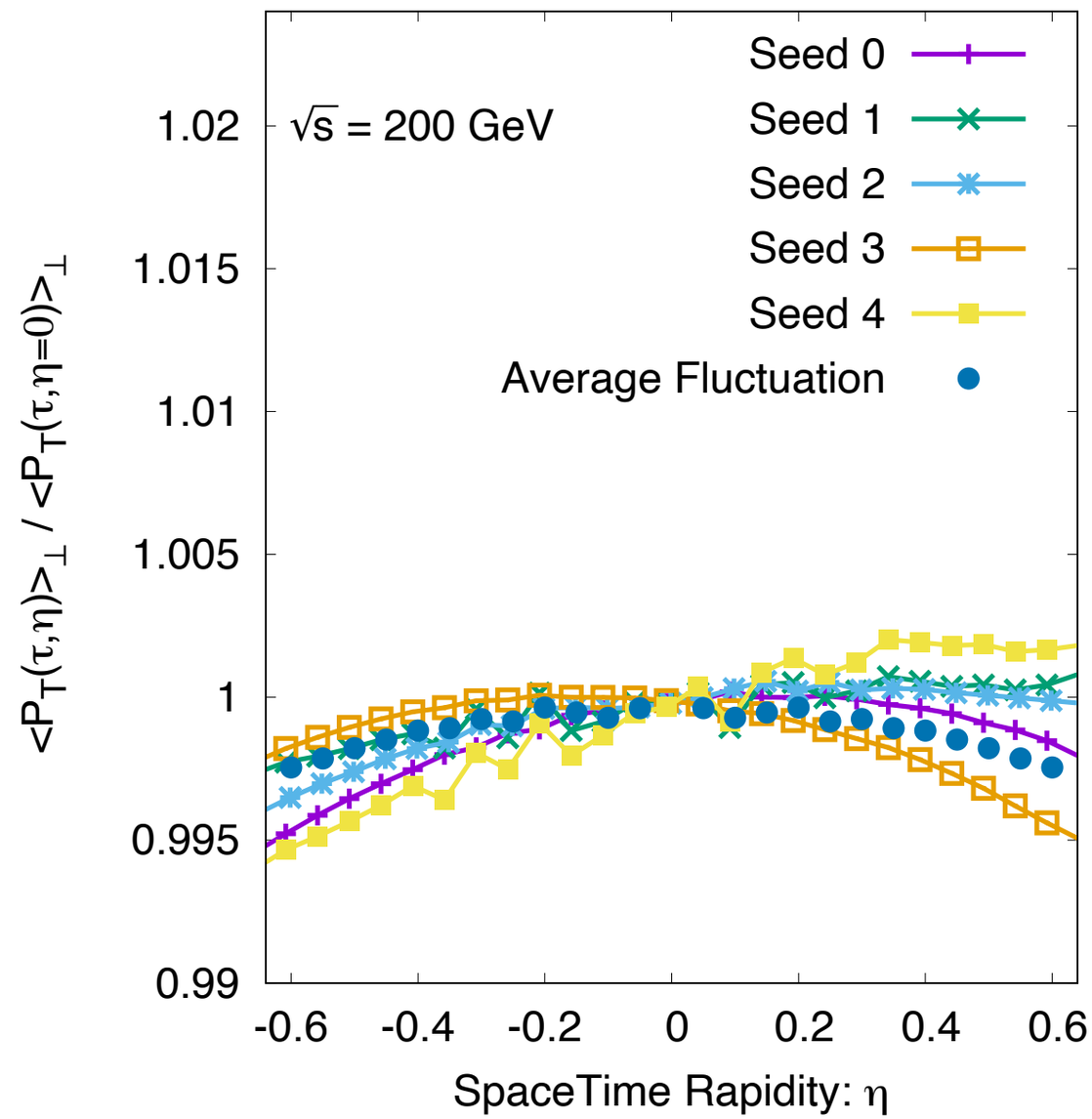


Au-Au collision at $\sqrt{s} = 200$ GeV

Inhomogeneity emerge mostly due to the fact that different nucleons control energy deposition at different space-time positions

Effect of fluctuation at RHIC energies





Fixed $\tau \simeq 0.75$ fm/c

Fluctuation relatively small $\leq 1\,\%$ and decreases with increasing $\sqrt{s}$

Decorrelation of n-th order anisotropic flow

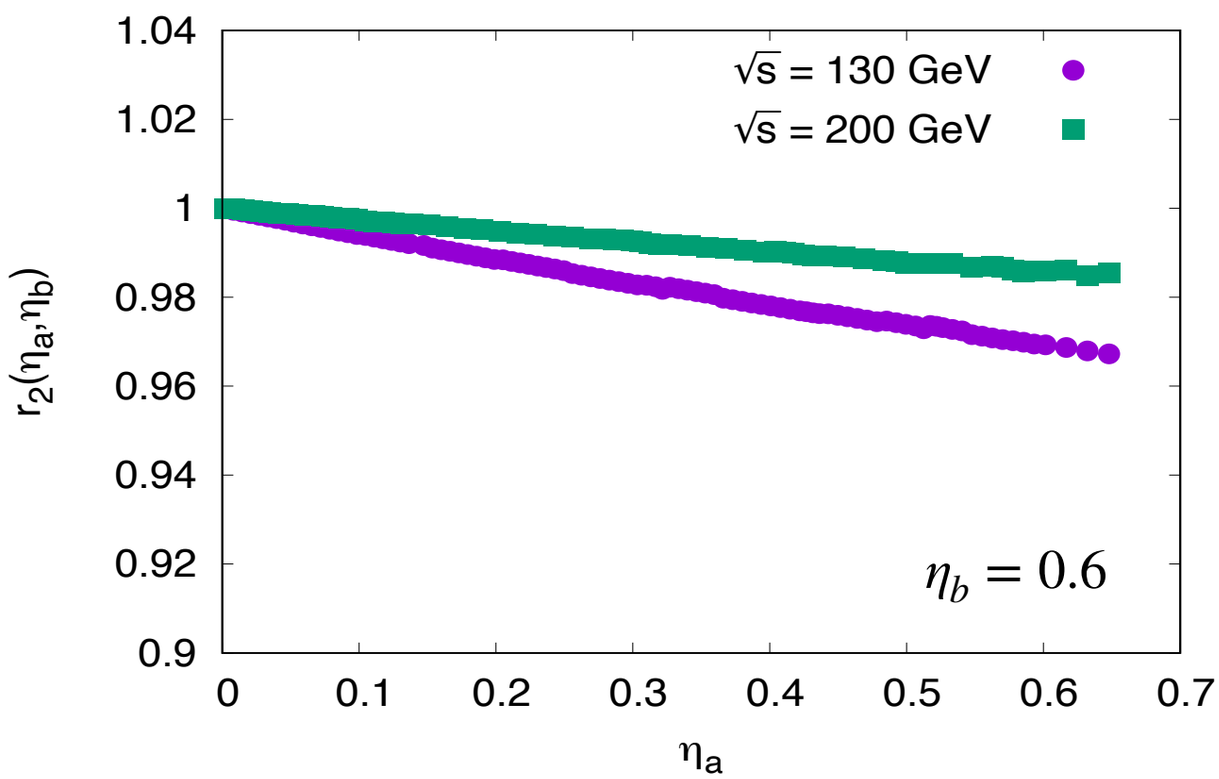
Characterise overall decorrelation using forward-backward ratio

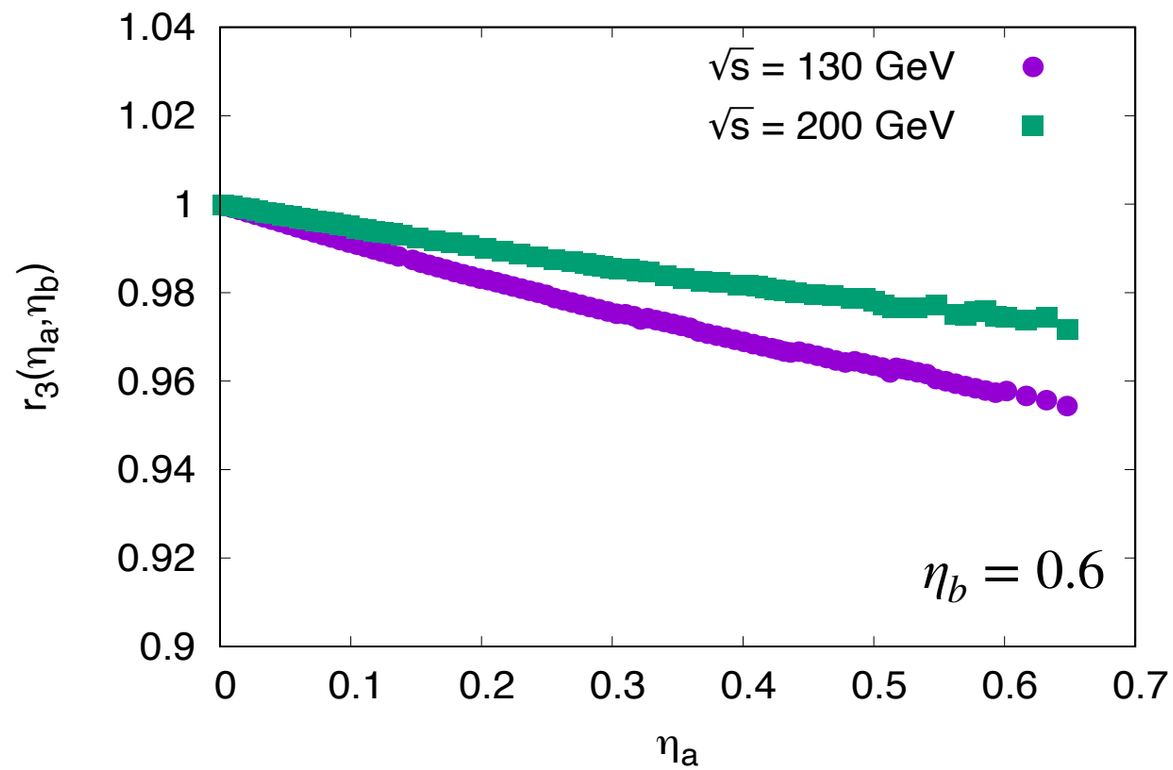
$$r_n(\eta_a, \eta_b) = \frac{\langle \mathrm{Re}[\boldsymbol{\epsilon}_n(-\eta_a) \cdot \boldsymbol{\epsilon}_n^*(\eta_b)] \rangle}{\langle \mathrm{Re}[\boldsymbol{\epsilon}_n(\eta_a) \cdot \boldsymbol{\epsilon}_n^*(\eta_b)] \rangle}$$

Using initial state $\boldsymbol{\varepsilon}_n$

CMS Collaboration PRC 92, 034911 (2015)

Simultaneous description of r_2 and r_3 for central collision





Strong decorrelation at lower energies

Conclusion & Outlook

Developed a framework to describe 3D profiles of initial energy deposition using CGC.

Successful results from numerical simulations; additional analytic insights highly desirable

So far focused on longitudinal profiles of initial state energy deposition; also interesting to explore early time non-equilibrium dynamics

Thank you...

Backup: 3+1D Glasma simulations

1. Sample 3D distribution of color charges $\rho(x^{\pm}, x_{\perp})$ in each half boxes.

2. Solve for Weizsäcker-Williams fields (WW) of the incoming nuclei.

3. Evolve gauge fields and corresponding conjugate momenta according to the discretised 3+1D YM

$$[D_{\mu}, F^{\mu\nu}] = J^{\nu}$$

4. Evolve eikonal currents according to continuity equation.

$$[D_{\mu}, J^{\mu}] = 0$$

5. Solve 3. and 4. simultaneously to simulate early time dynamics of collision in 3+1D

Rigorous derivation of initial condition that successfully conserves Gauss Law.