

THE McDIPPER: A NOVEL SATURATION-BASED 3D INITIAL STATE MODEL FOR HEAVY ION COLLISIONS

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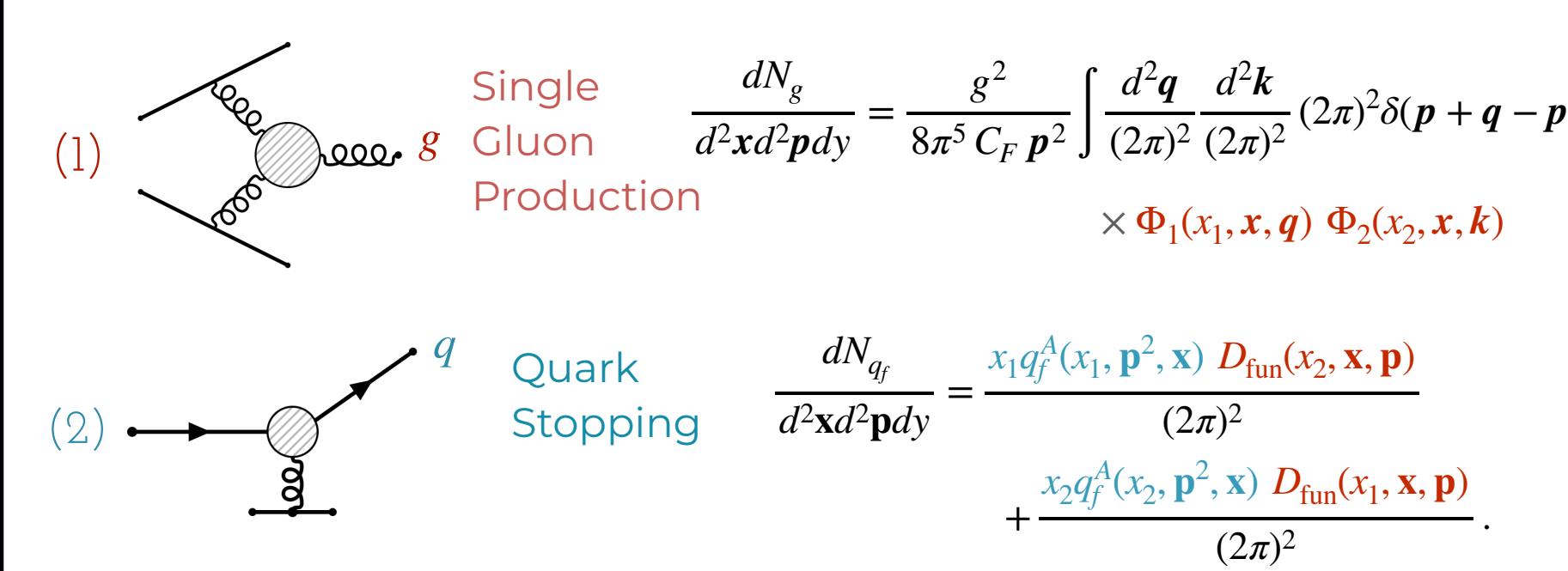
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MOTIVATION

- New experimental and theoretical insights towards the forward/backward rapidity window, e.g. longitudinal resolution and correlation of observables.
- Needed: A first-principles inspired framework to compute and compare Event-by-Event ICs in Heavy Ion Collisions

THE FRAMEWORK

- Use the dilute-dense approximation the Color Glass Condensate (CGC) Effective Field Theory (EFT) to compute charges and energy

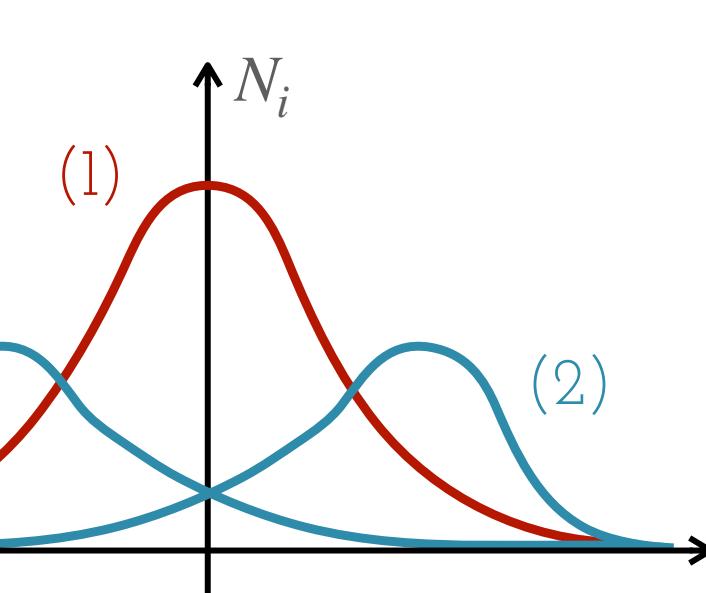


- Energy and charges are computed as moments of the single particle distributions:

$$\text{ENERGY} \quad (e\tau)_0 = \int d^2\mathbf{p} |\mathbf{p}| \left[K_g \frac{dN_g}{d^2\mathbf{x} d^2\mathbf{p} dy} + \sum_f \frac{dN_f}{d^2\mathbf{x} d^2\mathbf{p} dy} \right]_{y=\eta_s}$$

$$\text{BARYON CHARGE} \quad (B\tau)_0 = \sum_f B_f \int d^2\mathbf{p} \left[\frac{dN_f}{d^2\mathbf{x} d^2\mathbf{p} dy} - \frac{dN_{\bar{f}}}{d^2\mathbf{x} d^2\mathbf{p} dy} \right]_{y=\eta_s}$$

* Electric charge is obtained similarly, by using the correct U(1) charges

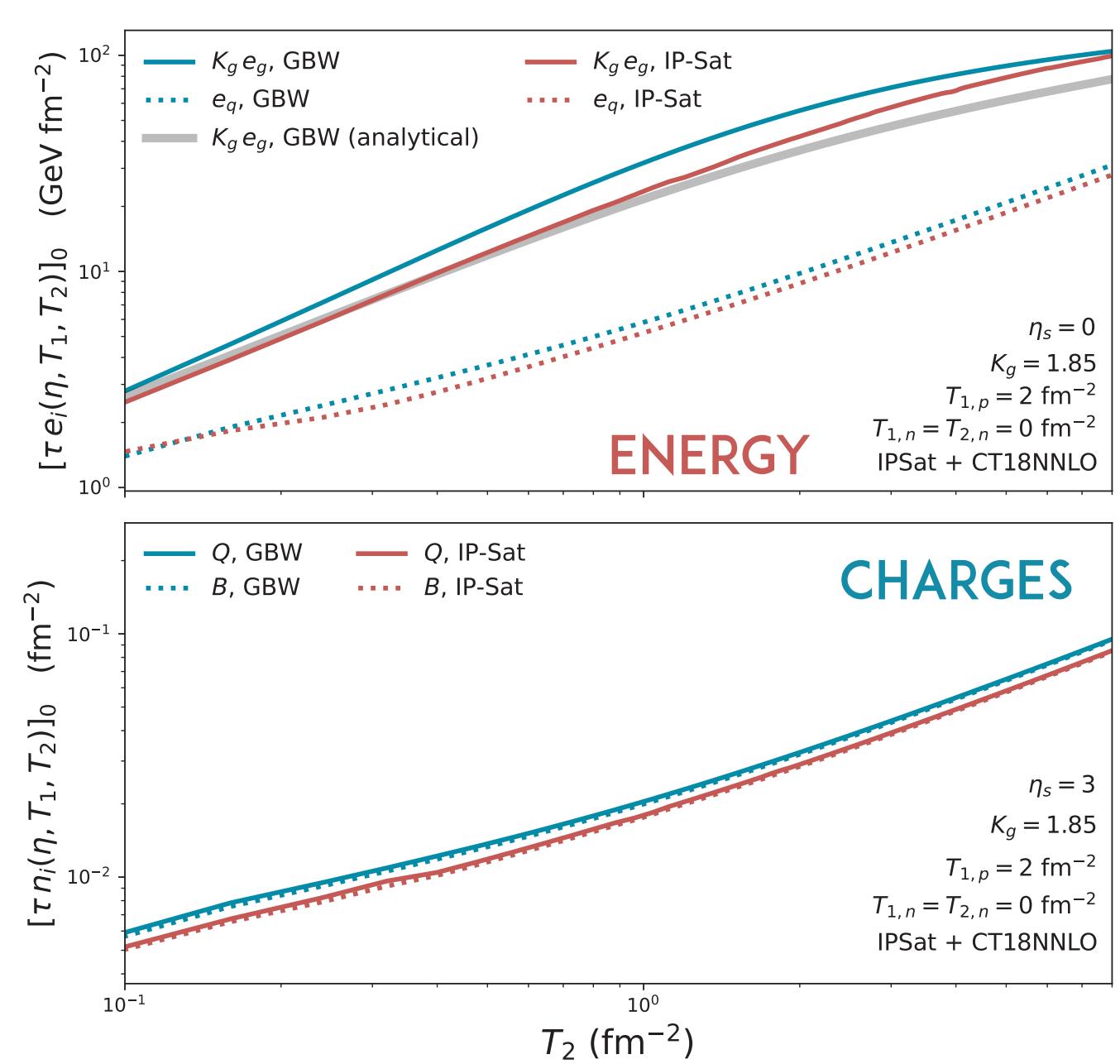


THE INPUT

- Low- x gluons: uGDFs $\rightarrow \Phi_i(x, r, \mathbf{q}) \sim q^2 D_{\text{adj}}(x, r, \mathbf{q})$
 - Dipoles: $\rightarrow D_{\text{adj}}(x, r, \mathbf{q}), D_{\text{fun}}(x, r, \mathbf{q})$
 - GBW, IP-Sat, MV...
 - High- x partons: $x_i q_f(x_i, \mathbf{p}^2)$
 - PDFs: \rightarrow Different PDF sets*.
- * Accessible in the McDIPPER through the LHAPDF library [2]

ANATOMY OF THE FRAMEWORK

- Charges are the basic building blocks in McDIPPER, $Q_i = Q_i(\eta_s, T_1, T_2)$, allow for comparison between models, *a priori* and *a posteriori*
- Non-boost invariant rapidity profiles arise naturally from the x -dependence of the input distributions (uGDFs, PDFs)
- Non-trivial nuclear thickness resolution from T-dependence of uGDFs (e.g. in IP-Sat) and PDF parton flux.



- McDIPPER enables PDF-dependence comparisons for the baryon-stopping.
- Overall normalization of gluon energy, K_g , treated as the only free parameter of the model, accounts for pert. corrections.
- Tune K_g using dE_1/dy in p+p min. bias collisions at $\sqrt{s_{NN}} = 5.02 \text{ TeV}$.

$$K_g = 1.25 \text{ [GBW]} \quad K_g = 1.85 \text{ [IP-Sat]}$$

► We have developed a 3D Initial state model using the principles of High Energy QCD, for all conserved charges.

► Non-trivial longitudinal resolution from the x-dependence of the input saturation model.

► This publicly available framework allows for mix-and-match of saturation models and collinear

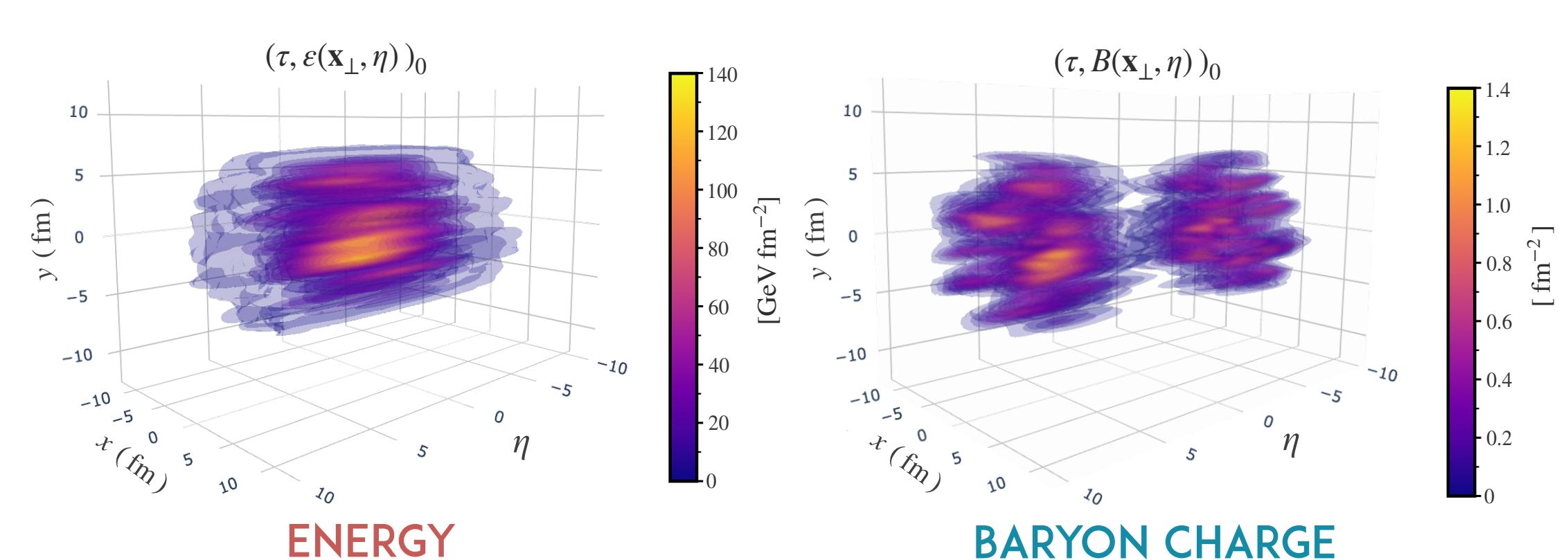
► Systematically improvable: Fluctuations, NLO processes, EIC physics...

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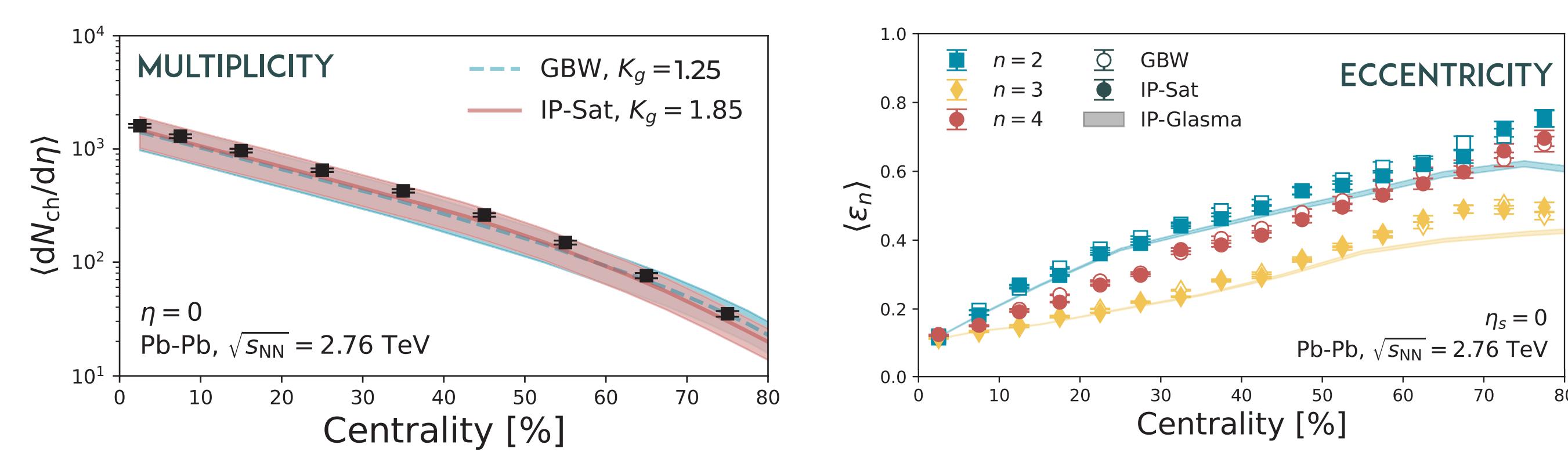


OBSERVABLES

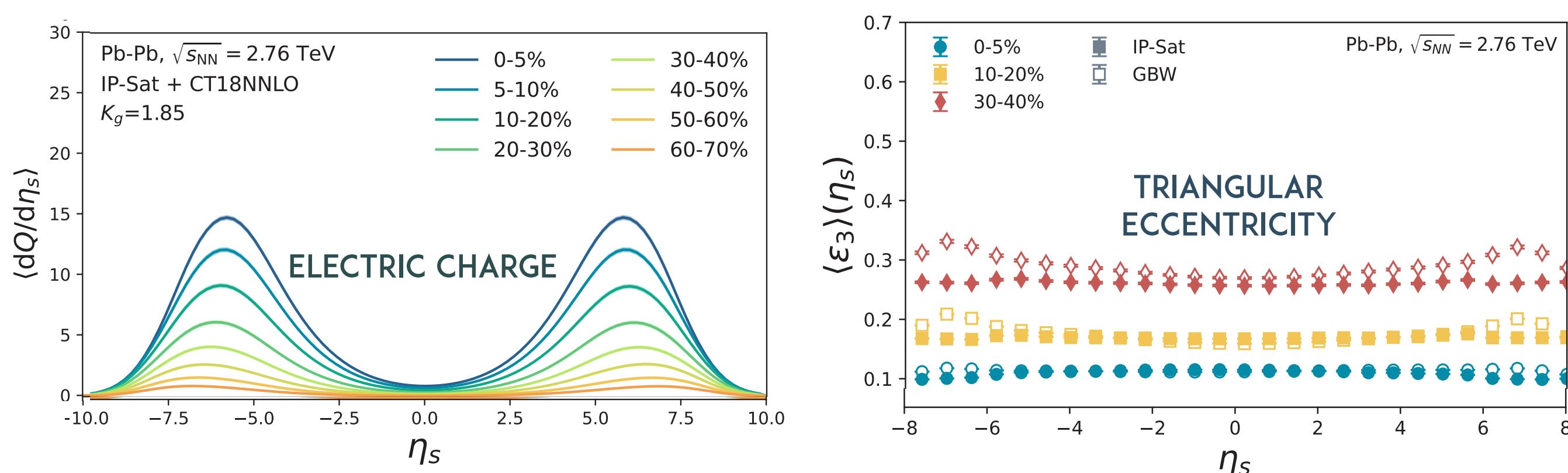
- Combine precomputed energy and charges (in terms of η_s, T_1, T_2) with MC-Glauber sampling to produce rapidity resolved event-by-event fluctuations



- Check: Good agreement with experimental data for charged particle multiplicity. Agreement with eccentricities for the successful midrapidity IP-Glasma model.

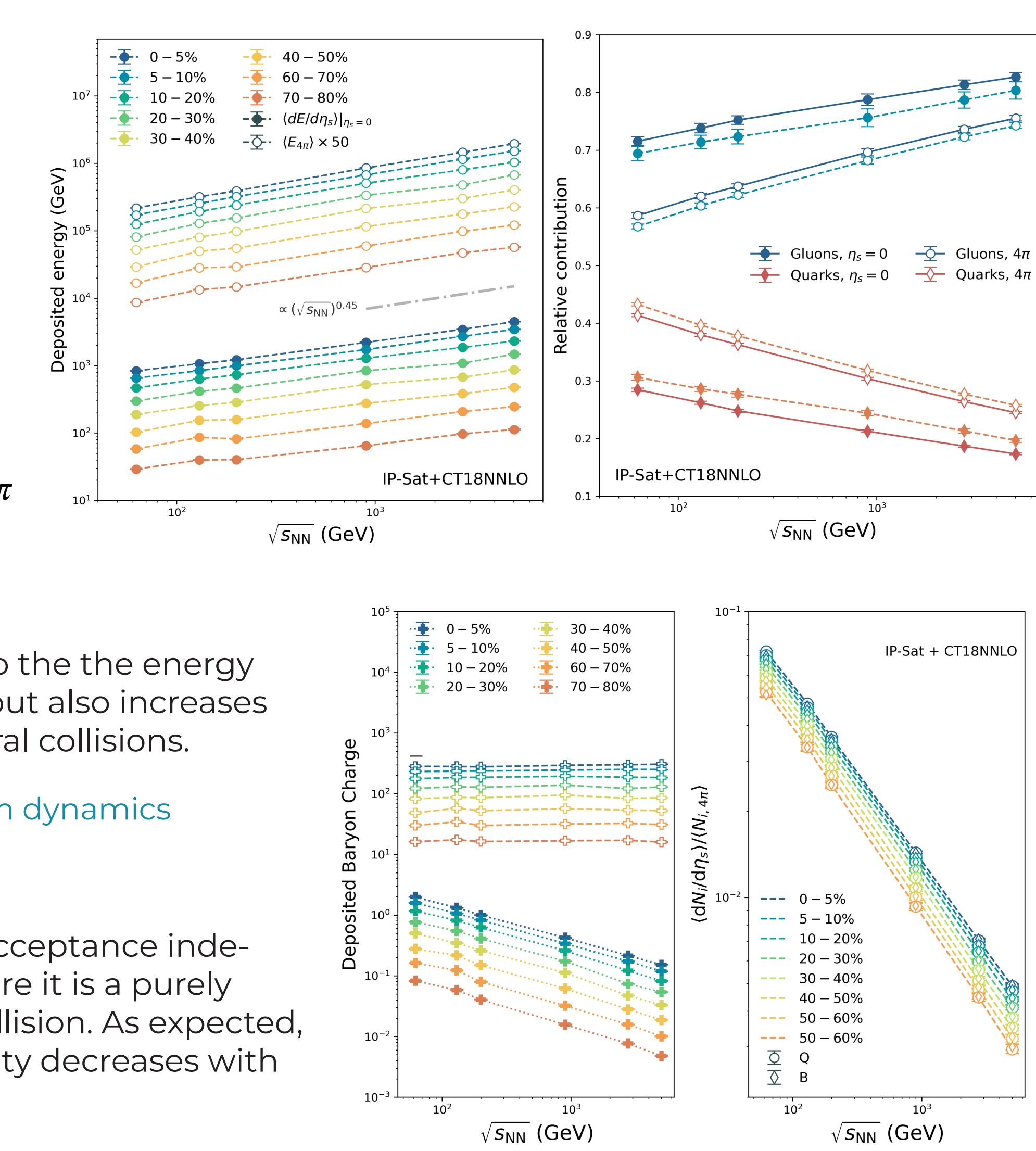


- Observables yields and correlations have a non-trivial rapidity resolution, resulting from the x-dependence of the input saturation models.



ENERGY AND CHARGE DEPOSITION

- Comparison of energy and charge deposition at $\eta_s = 0$ and the event-total, the 4π acceptance.
- Energy at midrapidity and 4π exhibit a similar power-law dependence of $\sqrt{s_{NN}}$.
- Quark relative contribution to the energy increases at lower energies, but also increases softly at larger more peripheral collisions.
- Relevant for pre-equilibrium dynamics and EM probe production!
- Charge deposition is at full acceptance independent of $\sqrt{s_{NN}}$, and therefore it is a purely geometrical aspect of the collision. As expected, charge deposition at midrapidity decreases with energy.



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