Rapidity gap distribution in diffractive deep-inelastic scattering: predictions for future EICs

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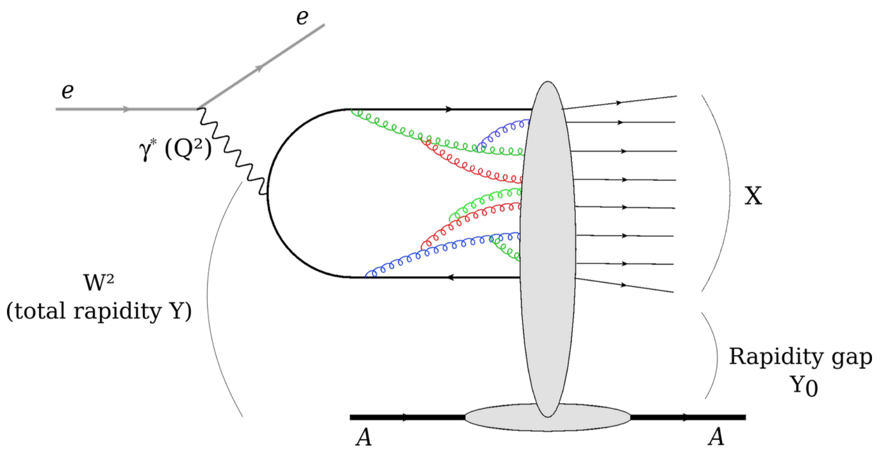
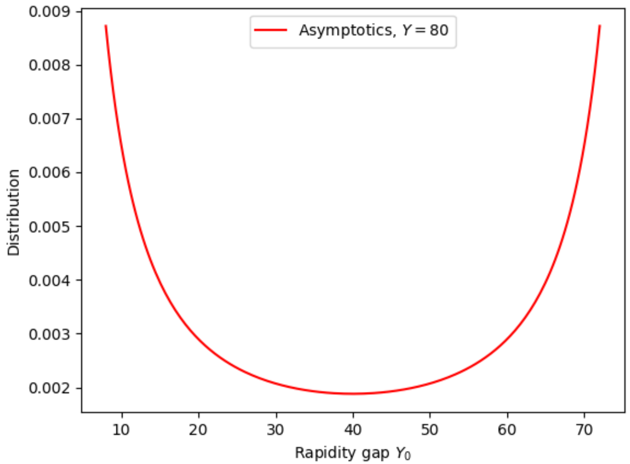
Objectives



Rapidity gap Y_0 ⟺ Angular gap in detectors



To analyze numerically the distribution of rapidity gaps in diffractive dissociation of a virtual photon off a large nucleus.

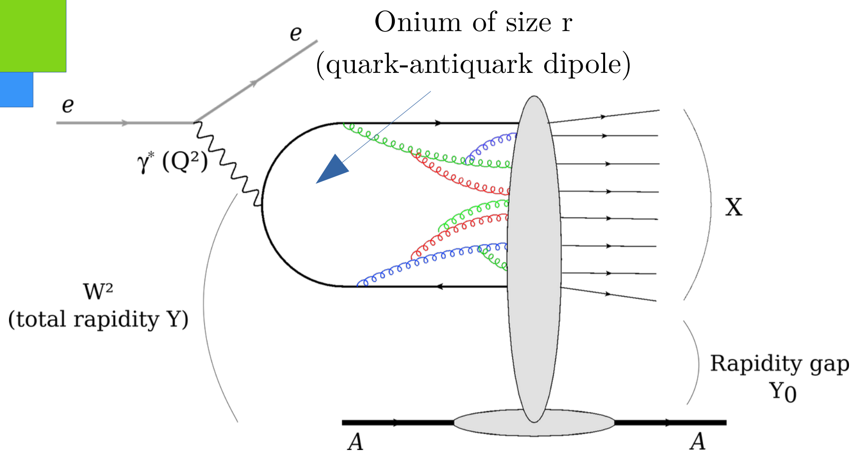
→ **Predictions for future EICs**

→ **Check of the applicability of the recently developed picture for diffractive dissociation.**

(see: *Mueller & Munier, PRD 98 (2018) 034021*;
ADL, Mueller & Munier (2021) arXiv:2103.10088; and
Munier's talk)

$$\textit{Asymptotic distribution} \sim \left[\frac{Y}{Y_0(Y-Y_0)}\right]^{3/2}$$

Color dipole formulation



- Diffractive cross-section with *minimal gap* Y_0:

$$\left(\frac{\sigma_{diff}}{\sigma_{tot}}\right)^{\gamma^* A}(Q^2, Y, Y_0) = \frac{\int d^2\underline{r} \int_0^1 dz \sum_{p=L,T;f} |\psi_p^f(\underline{r}, z, Q^2)|^2 \ [2N(\underline{r}, Y) - N_{in}(\underline{r}, Y, Y_0)]}{\int d^2\underline{r} \int_0^1 dz \sum_{p=L,T;f} |\psi_p^f(\underline{r}, z, Q^2)|^2 \ 2N(\underline{r}, Y)}$$

- **Rapidity-gap distribution:** $\mathfrak{R}^{\gamma * A} = -\frac{\partial}{\partial Y_0}\left(\frac{\sigma_{diff}}{\sigma_{tot}}\right)^{\gamma^* A}$

- Balitsky-Kovchegov evolution of the *forward elastic amplitude* N and *inelastic cross-section* N_{in}:

$$\partial_Y \mathfrak{T}_r = \int_{r_1} K(r, r_1, r_2)\left[\mathfrak{T}_{r_1} + \mathfrak{T}_{r_2} - \mathfrak{T}_r - \mathfrak{T}_{r_1}\mathfrak{T}_{r_2}\right]$$

Kernel K:

+ Fixed coupling: $K^{fc} = \frac{\bar{\alpha}_s}{2\pi}\frac{r^2}{r_1^2 r_2^2}$

+ Running coupling:

$$K^{pd} = \frac{\bar{\alpha}_s(r^2)}{2\pi}\frac{r^2}{r_1^2 r_2^2} \quad \text{(parent dipole presc.)}$$

$$K^{Bal} = \frac{\bar{\alpha}_s(r^2)}{2\pi}\left[\frac{r^2}{r_1^2 r_2^2} + \frac{1}{r_1^2}\left(\frac{\bar{\alpha}_s(r_1^2)}{\bar{\alpha}_s(r_2^2)} - 1\right) + \frac{1}{r_2^2}\left(\frac{\bar{\alpha}_s(r_2^2)}{\bar{\alpha}_s(r_1^2)} - 1\right)\right] \quad \text{(Balitsky presc.)}$$

Initial conditions:

+ $N(r, Y=0) = 1 - \exp\left[-\frac{r^2 Q_A^2}{4}\ln\left(e + \frac{1}{r^2\Lambda_{QCD}^2}\right)\right]$

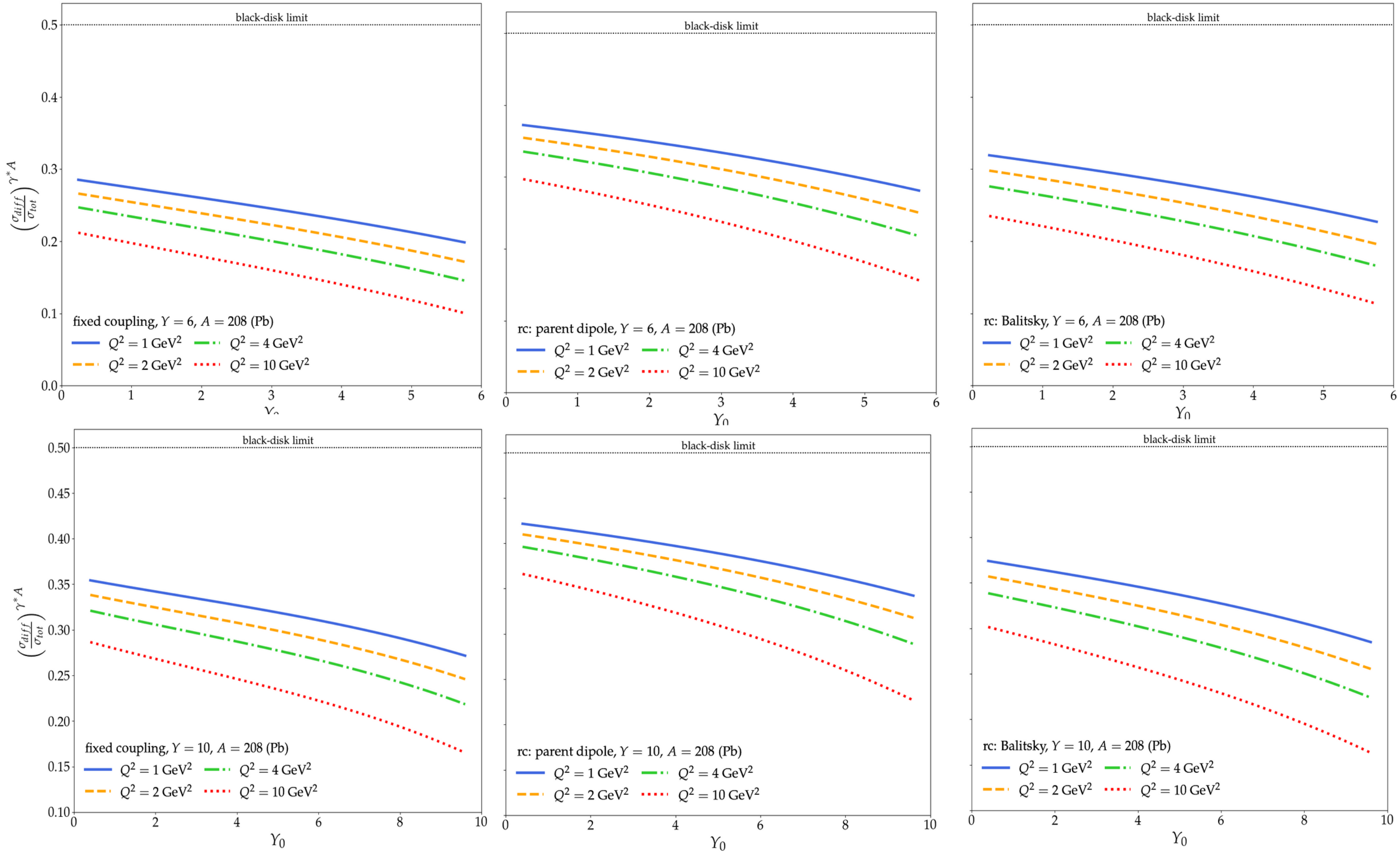
+ $N_{in}(r, Y=Y_0, Y_0) = 2N(r, Y_0) - N^2(r, Y_0)$

Results

Kinematics accessible at BNL-EIC and LHeC:

- Rapidity: $Y = 6, 10$ ($x \approx 2\text{x}10^{-3}$, $5\text{x}10^{-5}$, resp.)
- Photon virtuality: $Q^2 = 1 - 10$ GeV^2

Results (1/3): Rate of diffractive events



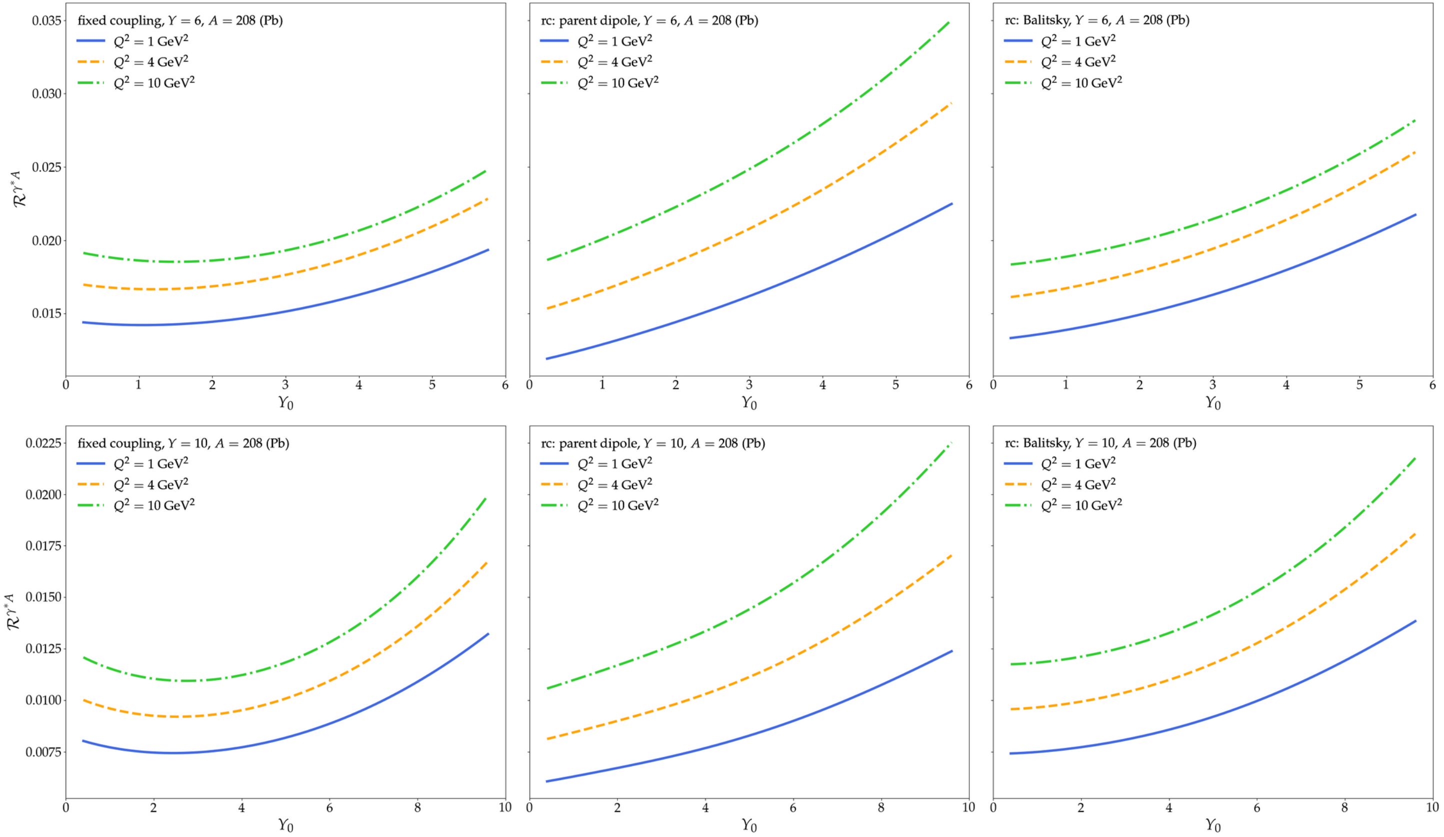
Diffractive cross section:

$$\left(\frac{\sigma_{diff}}{\sigma_{tot}}\right)^{\gamma^* A}(Q^2, Y, Y_0)$$

Y_0: minimal rapidity gap

Diffractive events account for a significant ratio!

Results (2/3): Rapidity-gap distributions

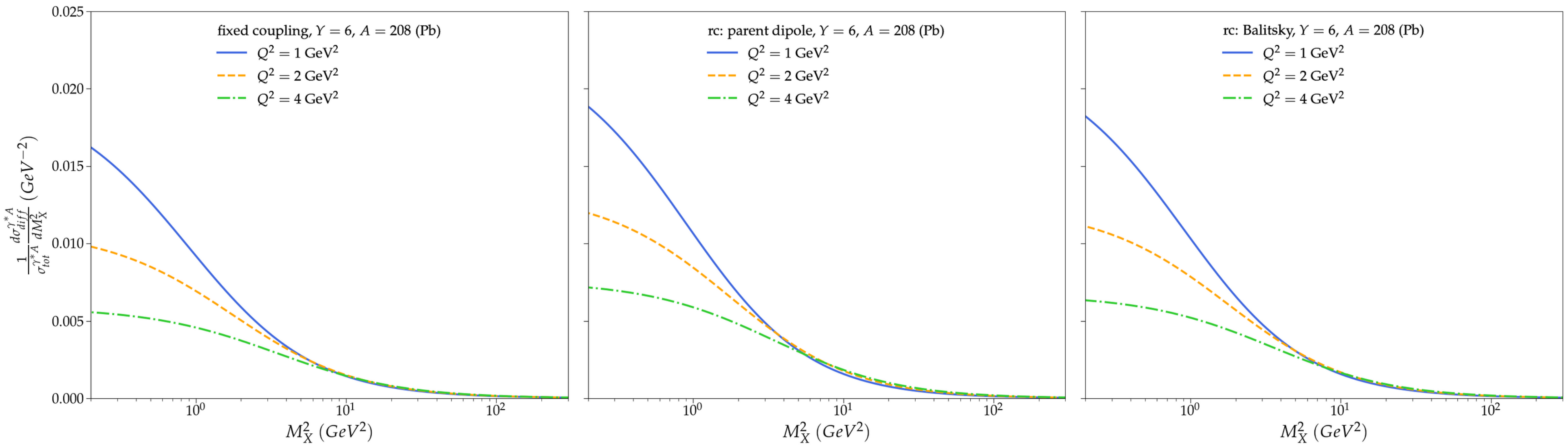


$$\mathfrak{R}^{\gamma^* A} = -\frac{\partial}{\partial Y_0}\left(\frac{\sigma_{diff}}{\sigma_{tot}}\right)^{\gamma^* A}$$

(Y_0: rapidity gap)

- Distributions with running coupling rather different from with fixed coupling
- Fixed-coupling distributions reflect the prediction of the partonic model (hammock shape), more obvious at higher rapidities.

Results (3/3): Diffractive mass spectra



$$\frac{1}{\sigma_{tot}^{\gamma^* A}} \frac{d\sigma_{diff}^{\gamma^* A}}{dM_X^2} = \frac{\mathcal{R}^{\gamma^* A}}{M_X^2 + Q^2}$$

- Low-mass dominates over high-mass.
- High-mass regime slightly enhanced at higher Q^2.
- Low-mass regime suppressed at higher Q^2.

Conclusions

- Diffractive events contribute significantly in considered kinematics at EICs.

- Fixed coupling and running coupling equations lead to different distributions.

- Distribution rather insensitive to running coupling prescription.

- Fixed coupling distributions reflect the partonic model for diffractive dissociation.

  $\rightarrow$ Measurement of rapidity-gap distribution at future EICs is relevant for the microscopic understanding of diffractive dissociation!

THANK YOU FOR ATTENTION!