JETS IN HOT AND DENSE QCD

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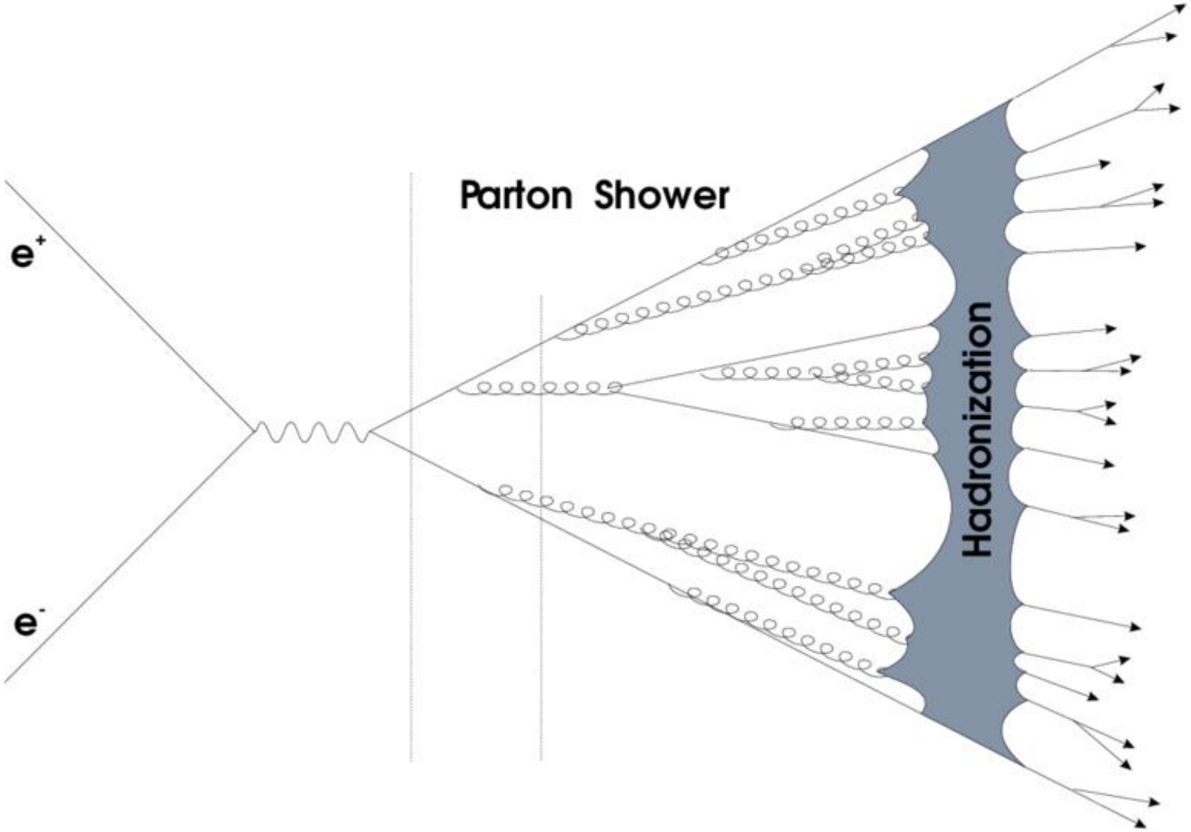
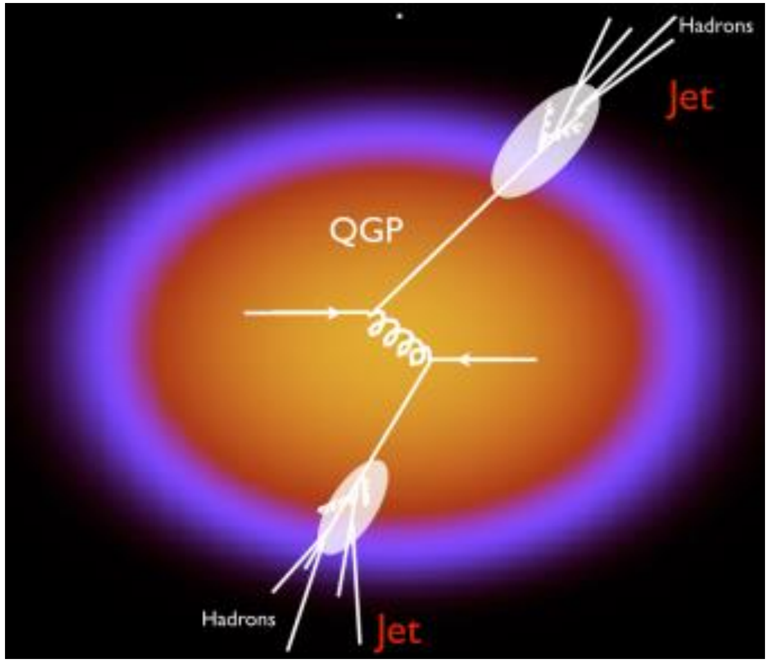
Assemblée Générale

GDR Groupement de recherche
QCD Chromodynamique quantique

The evolution of a jet can be viewed as a pattern of parton branchings.

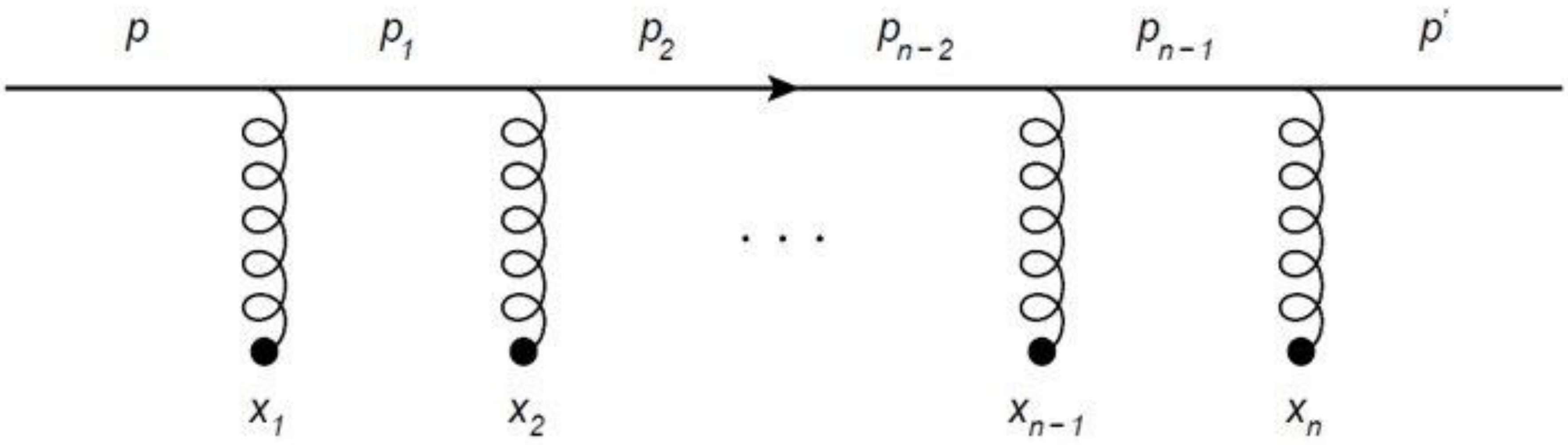
P. Abreu *et al.*, "A Measurement of α_s from the Scaling Violation in e^+e^- Annihilation", Phys.Lett. **B398** (1997) 194-206.





Gunther Roland, "Jet Experiments at LHC", *Jet Collaboration Symposium, Montreal, June 2015*.

How does an energetic parton traverse a dense medium?

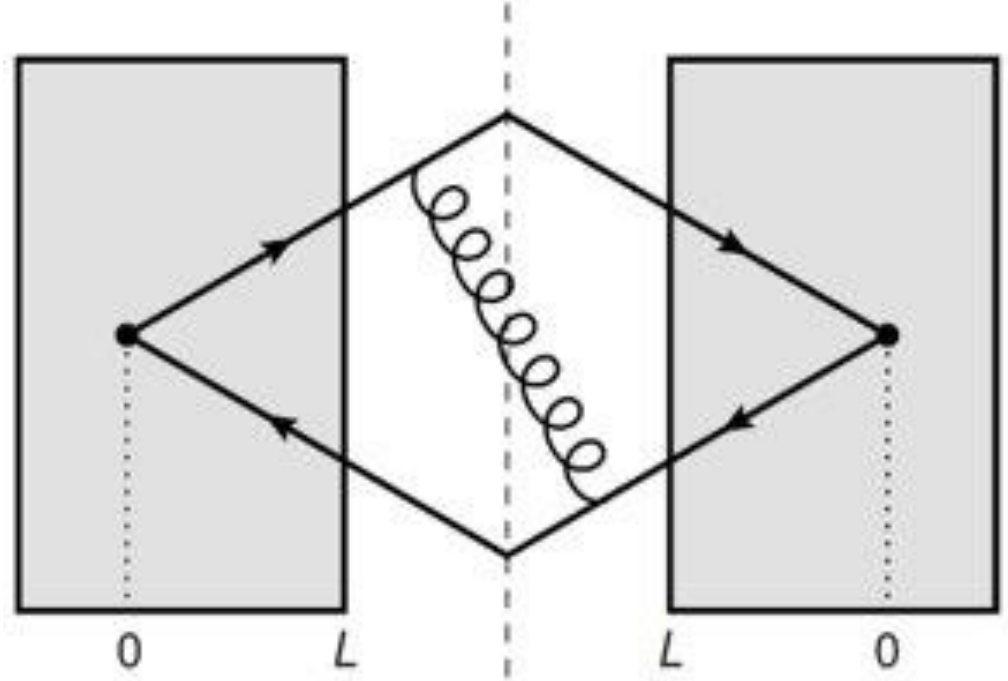


$$W(L^+, x_0^+; \boldsymbol{x}_\perp) = \mathcal{P} \exp \left[ig \int_{x_0^+}^{L^+} dx^+ \; A^-(x^+, \boldsymbol{x}_\perp) \right]$$

$$\mathcal{G}(L^+, \boldsymbol{x}_\perp; x_0^+, \boldsymbol{x}_{0\perp} | p^+) = \int_{\boldsymbol{r}_\perp(x_0^+)=\boldsymbol{x}_{0\perp}}^{\boldsymbol{r}_\perp(L^+)=\boldsymbol{x}_\perp} \mathcal{D}\boldsymbol{r}_\perp(\xi) \; \exp\left[i \frac{p^+}{2} \int_{x_0^+}^{L^+} d\xi \; \dot{\boldsymbol{r}}_\perp^2(\xi) \right] W(L^+, x_0^+; \boldsymbol{r}_\perp(\xi))$$

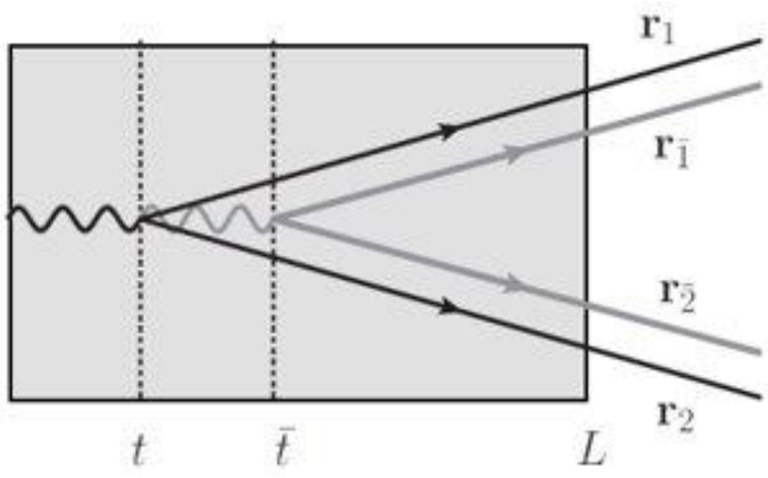
J. Casalderrey-Solana and C. A. Salgado, "Introductory lectures on jet quenching in heavy ion collisions", Acta Phys.Polon. B**38** (2007) 3731-3794 [arXiv:0712.3443 [hep-ph]].

A simple model of the jet cascade is the radiation pattern produced by a quark-antiquark *antenna*.



Y. Mehtar-Tani, C. A. Salgado and K. Tywoniuk, "Jets in QCD media: from color coherence to decoherence", JHEP **1204** (2012) 064 [arXiv:1112.5031 [hep-ph]].

- Medium-induced modifications from allowing a parton splitting to occur at a finite distance inside the medium.
- Subsequent parton branchings for a full-medium modified parton shower.



$$\frac{dN^{\rm med}}{dz d\theta} = \frac{dN^{\rm vac}}{dz d\theta}\left[1 + F_{\rm med}(z,\theta)\right]$$

TOTAL SPECTRUM

$$F_{\rm med} = 2\int_0^L \frac{d\bar{t}}{t_f}\cos\left(\frac{\bar{t}-t}{t_f}\right) S_{12}(\bar{t},t)Q(L,\bar{t}) - \sin\left(\frac{L-t}{t_f}\right) S_{12}(L,t)$$

$$S_{12}(\tau) = e^{-\frac{1}{12}\hat{q}\theta^2\tau^3}$$

$$Q(\tau_L,\tau) = e^{-\frac{1}{4}\hat{q}\xi\theta^2\tau_L\tau^2} + T(\tau)\int_{\bar{t}}^{L} ds\; e^{-\frac{1}{4}\hat{q}\xi\theta^2(L-s)\tau^2} e^{-\frac{1}{12}\hat{q}\theta^2[(s-\bar{t})^3+(s-t)^3-\tau^3]}$$

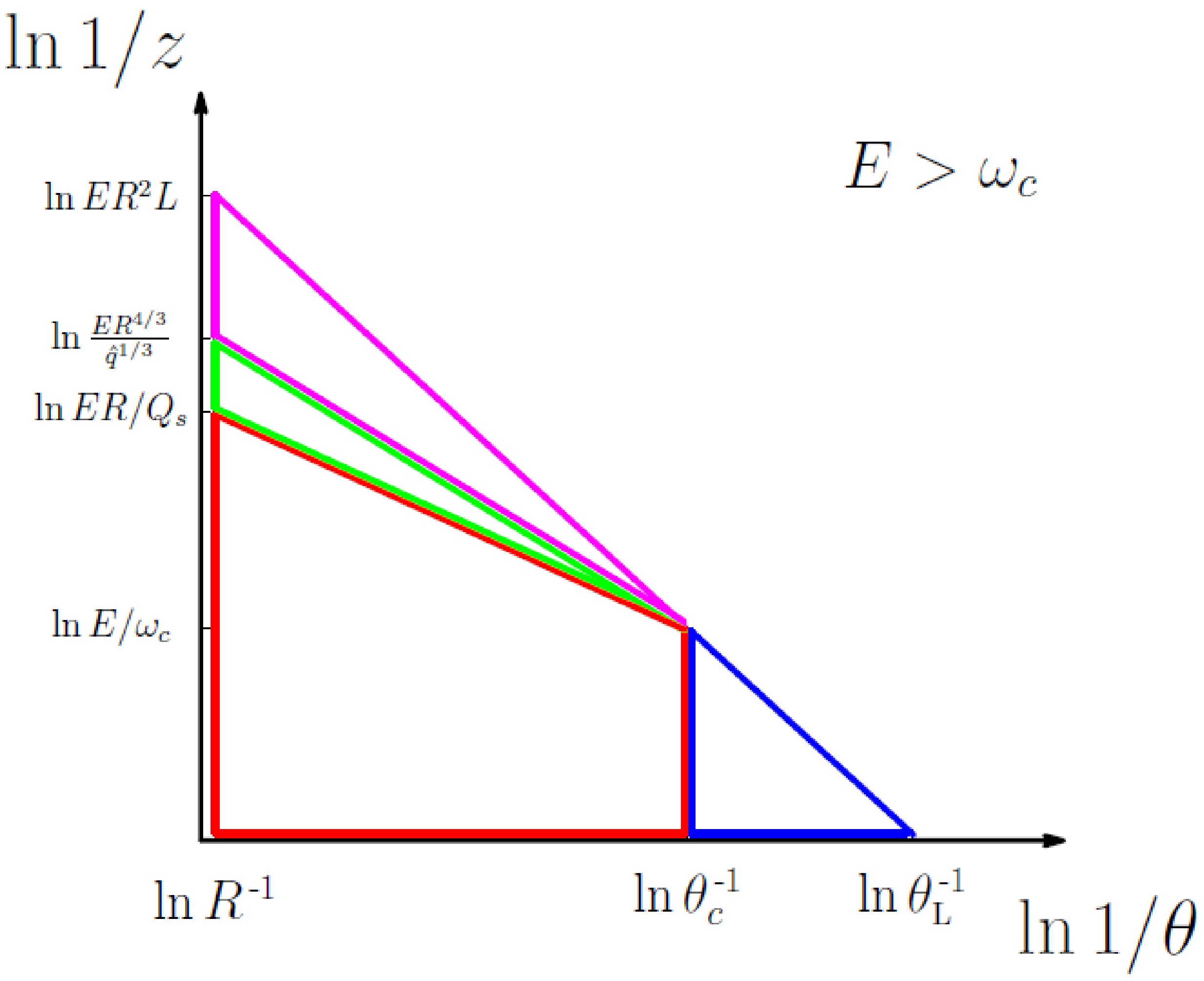
Dictating the color decoherence of the antenna.

$$t_d \sim \left(\frac{1}{\hat{q}\theta^2}\right)^{1/3}$$

$$t_{\rm broad} \sim \left(\frac{1}{\hat{q}\theta^2 L}\right)^{1/2}$$

The time-scale for medium-induced broadening.

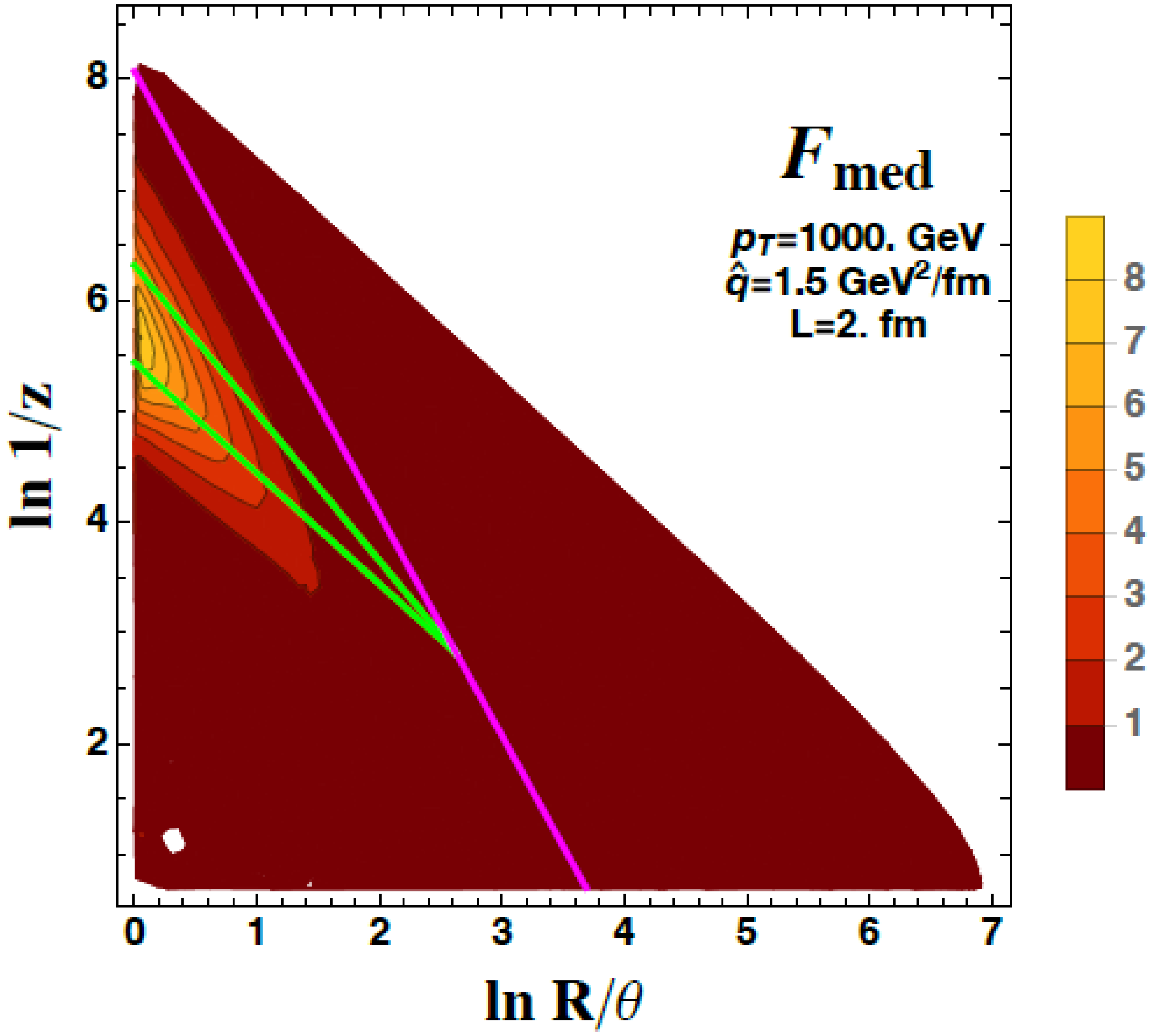
F. Domínguez, J. G. Milhano, C. A. Salgado, K. Tywoniuk, V. Vila, "Mapping collinear in-medium splittings", *Eur.Phys.J. C80* 2020 1,11 [arXiv:1907.03653 [hep-ph]].



F. Domínguez, J. G. Milhano, C. A. Salgado, K. Tywoniuk, V. Vila, "Mapping collinear in-medium splittings", *Eur.Phys.J.* *C80* 2020 1,11 [arXiv:1907.03653 [hep-ph]].

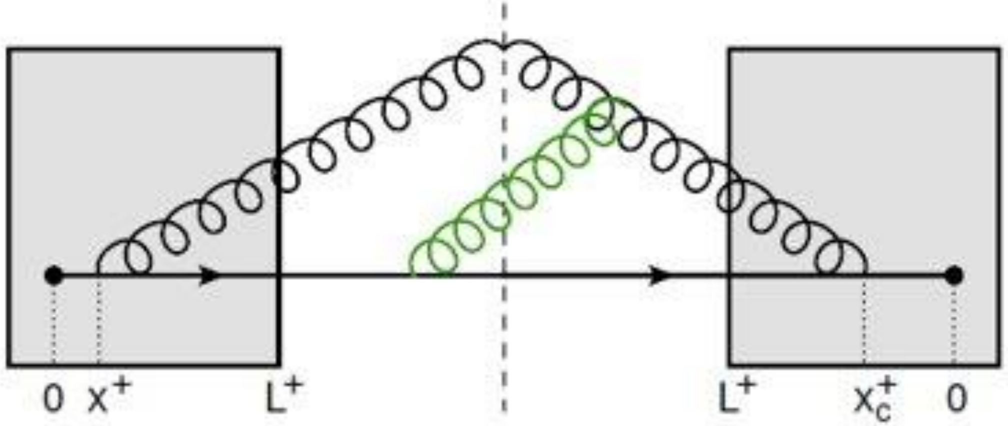
- The different order of the four competing time-scales correspond to the marked areas on the Lund plane.

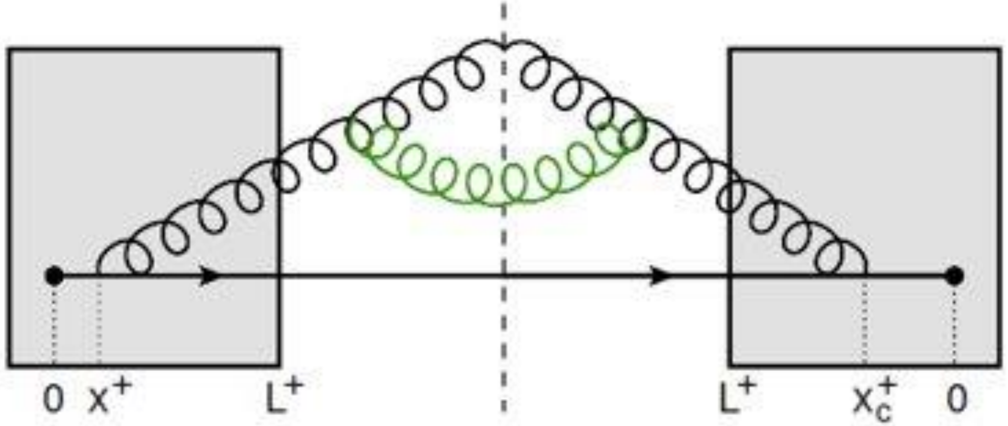
- Medium effects are expected to be visible within the areas (A.2) and (A.3).
- Regions (A.1) and (A.4) are regions of vacuum-like emissions.
- Medium effects are suppressed as the splitting occurs outside the medium.



F. Domínguez, J. G. Milhano, C. A. Salgado, K. Tywoniuk, V. Vila, "Mapping collinear in-medium splittings", *Eur.Phys.J. C80* 2020 1,11 [arXiv:1907.03653 [hep-ph]].

- In the region where vacuum-like emissions are expected to take place medium effects are negligible.
- The onset of medium modifications follow the line $t_f = t_d$, and they are more pronounced within the regime bounded by $t_{\rm broad} < t_f < t_d$.





$$\omega\omega' \frac{dI}{d^2\boldsymbol{k}\, d^2\boldsymbol{k}'\, d\omega\, d\omega'} = \frac{2C_F C_A \alpha_s^2}{(2\pi^2)\omega^2 \boldsymbol{k}'^2} \,\mathrm{Re}\Bigg[\int_{\boldsymbol{z}_\perp, \boldsymbol{z}'_\perp, x^+, x_c^+, \boldsymbol{y}_\perp} e^{i\boldsymbol{k}_\perp \cdot (\boldsymbol{z}'_\perp - \boldsymbol{z}_\perp)}$$
$$\times\, \partial_{\boldsymbol{x}_\perp} \cdot \partial_{\boldsymbol{x}'_\perp} \, \mathcal{K}(\boldsymbol{x}_\perp, \boldsymbol{y}_\perp)_{(x_c^+, x^+)} \, \mathcal{J}(\hat{\boldsymbol{r}}_{1x}, \hat{\boldsymbol{r}}_{1y})_{(L^+, x_c^+)}$$
$$\times\, \mathcal{J}(\hat{\boldsymbol{r}}_{2x}, \hat{\boldsymbol{r}}_{2y})_{(L^+, x_c^+)} \Bigg]_{\boldsymbol{x}_\perp = \boldsymbol{x}'_\perp = 0}$$

THE COMPUTED SPECTRUM

J. Barata, F. Domínguez, C. A. Salgado, V. Vila "A modified in-medium evolution equation with color coherence", arXiv:2101.12135 [hep-ph].

The decoherence parameter naturally enters into the basic skeleton as a correction of the splitting kernel.

$$\mathcal{K}'(\mathbf{Q}, z, p_0^+; L-t, t) \equiv \mathcal{K}(\mathbf{Q}, z, p_0^+; t) \times \Delta_{med}(\mathbf{Q}, z, p_0^+; L-t)\,,$$

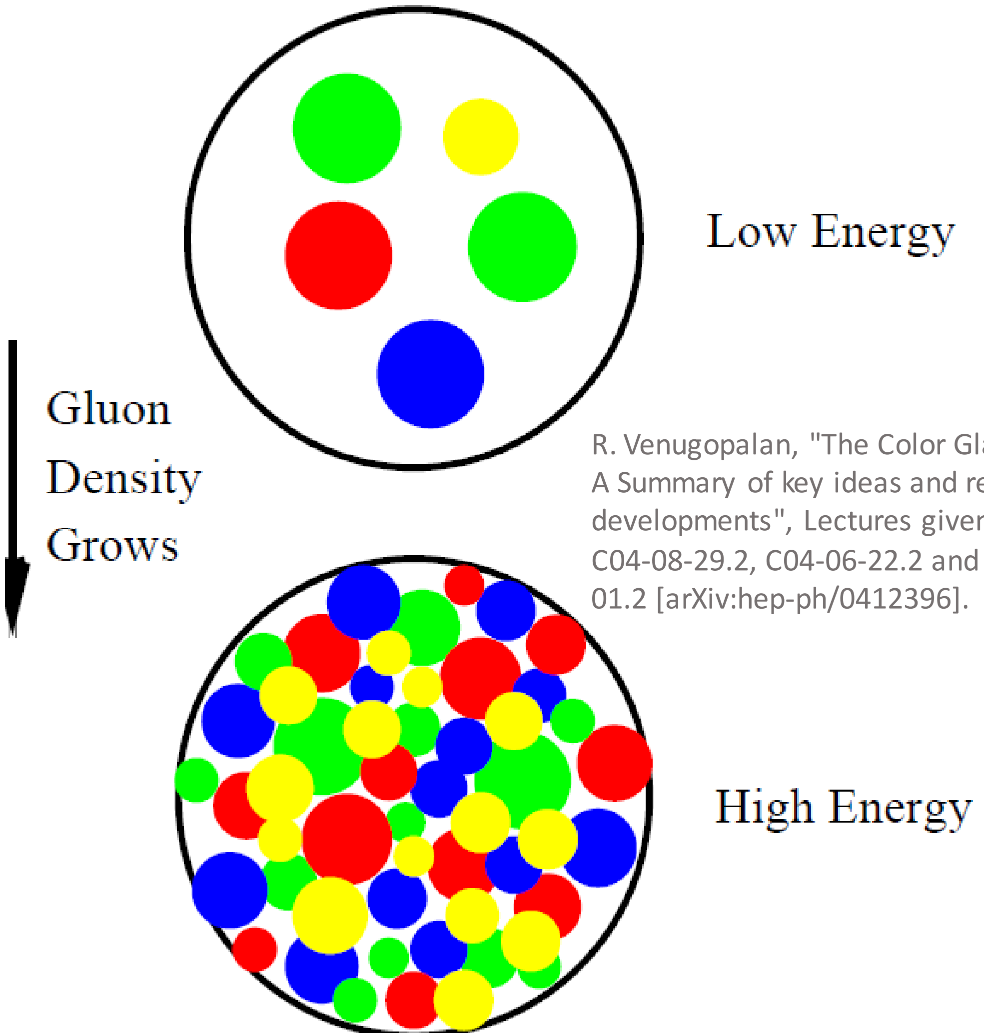
$$\Delta_{med}(\mathbf{Q}, z, p_0^+; L-t) = 1 - \exp\left(-\frac{\hat{q}}{12}\theta^2(\mathbf{Q}, z, p_0^+)(L-t)^3\right)\,,$$

$$\theta(\mathbf{Q}, z, p_0^+) = \left|\frac{\mathbf{Q}}{z(1-z)p_0^+}\right|\,.$$

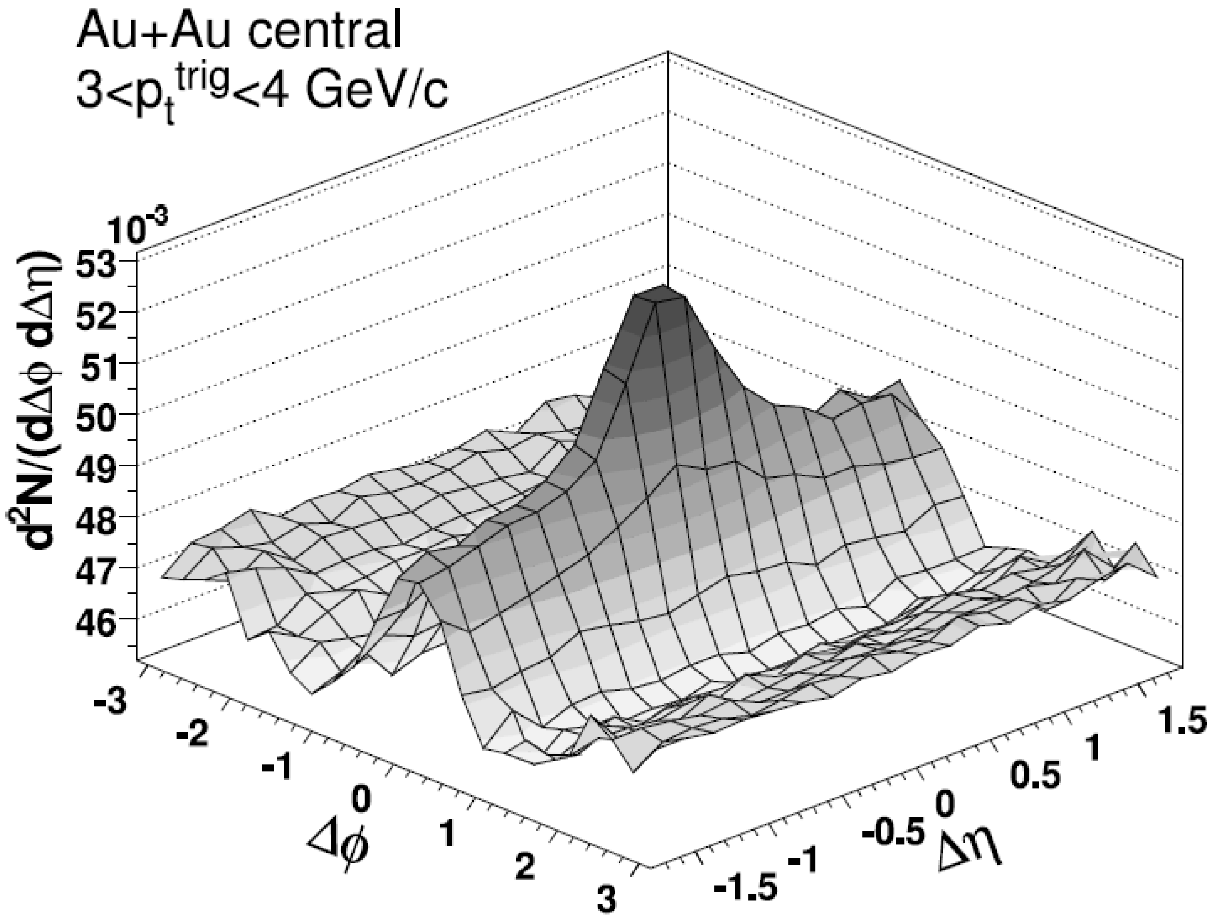
COHERENCE-MODIFIED KERNEL

This allows us to build a coherence-modified evolution equation for the single gluon distribution that can be compared with the totally decoherent one.

J. Barata, F. Domínguez, C. A. Salgado, V. Vila "A modified in-medium evolution equation with color coherence", arXiv:2101.12135 [hep-ph].



R. Venugopalan, "The Color Glass Condensate: A Summary of key ideas and recent developments", Lectures given at Conferences C04-08-29.2, C04-06-22.2 and C04-06-01.2 [arXiv:hep-ph/0412396].



B. I. Abelev *et al.* [STAR Collaboration], "Long range rapidity correlations and jet production in high energy nuclear collisions", *Phys.Rev.* C**80**, 064912 (2009) [arXiv:0909.0191 [nucl-ex]].

THANK YOU VERY MUCH FOR YOUR ATTENTION!

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