Medium Induced Soft Gluon Distribution Inside a Jet

Fabio Dominguez
IPhT CEA-Saclay CNRS

In collaboration with Jean-Paul Blaizot, Edmond Iancu, and Yacine Mehtar-Tani

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Why soft gluons?

- Large asymmetry at the level of reconstructed jets
  - ✦ Hard emissions do not escape the jet cone
  - ✦ Fragmentation functions are found to be modified only at low momenta
  - ✦ No deflection observed

High medium modification of jet structure in low momentum modes

Single medium-induced gluon emission

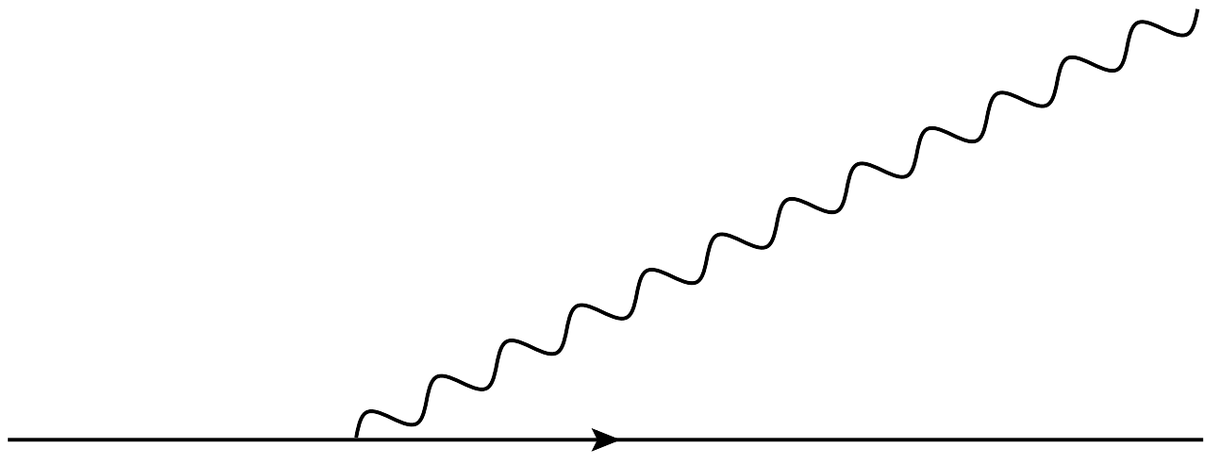
- BDMPS-Z formalism
  - Emitted gluons acquire transverse momenta through multiple scatterings with the medium

$$\omega \frac{dN}{d\omega} = \frac{C_F \alpha_s}{\pi} \sqrt{\frac{\hat{q} L^2}{\omega}} \propto \alpha_s \frac{L}{t_f} \qquad t_f = \sqrt{\frac{\omega}{\hat{q}}}$$

Soft emissions have short formation times*

Multiple emissions become important for: $\alpha_s \frac{L}{t_f} \sim 1$

Color structure of single emission in eikonal limit



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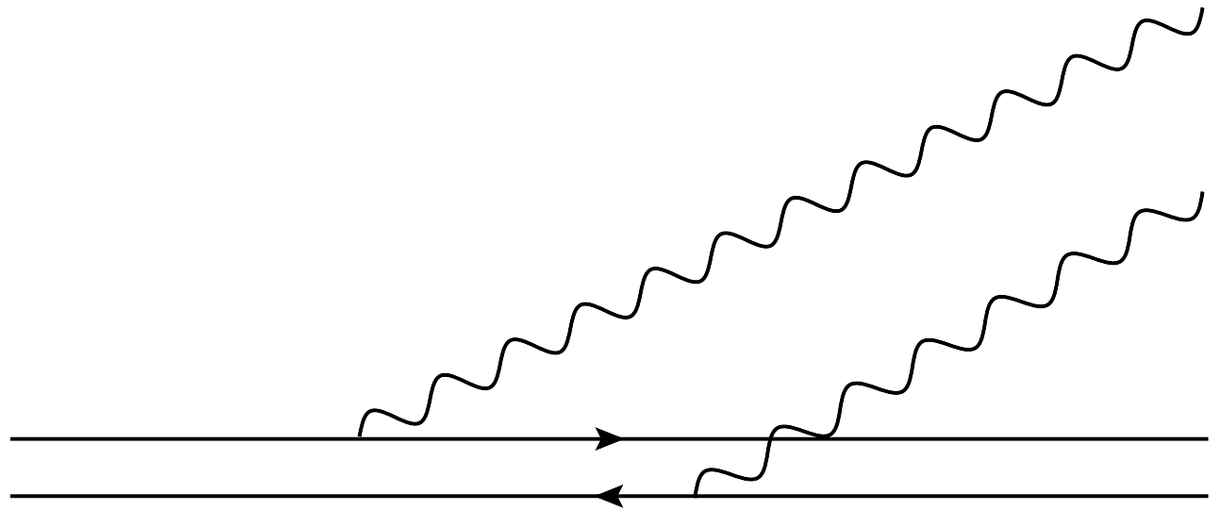

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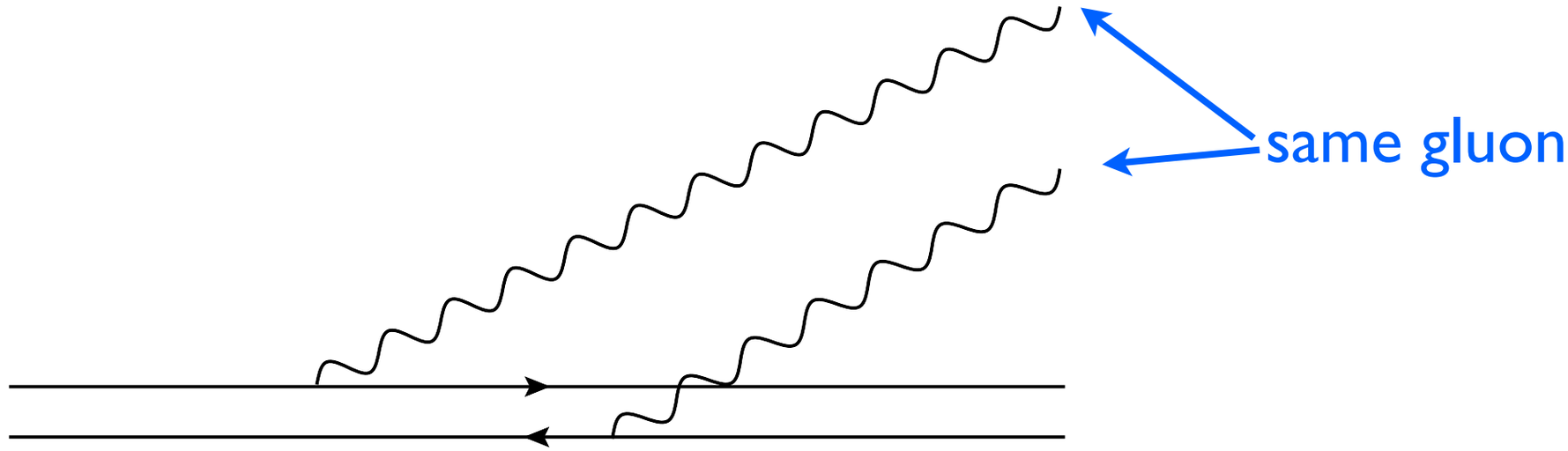

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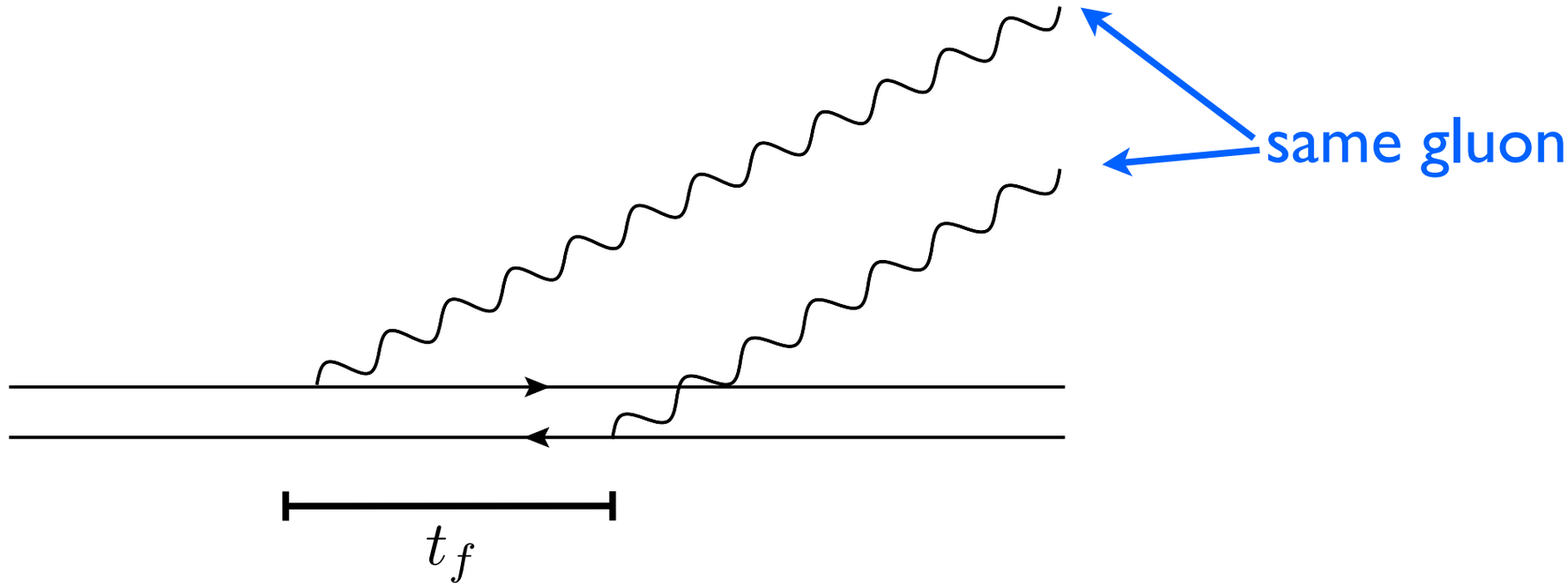

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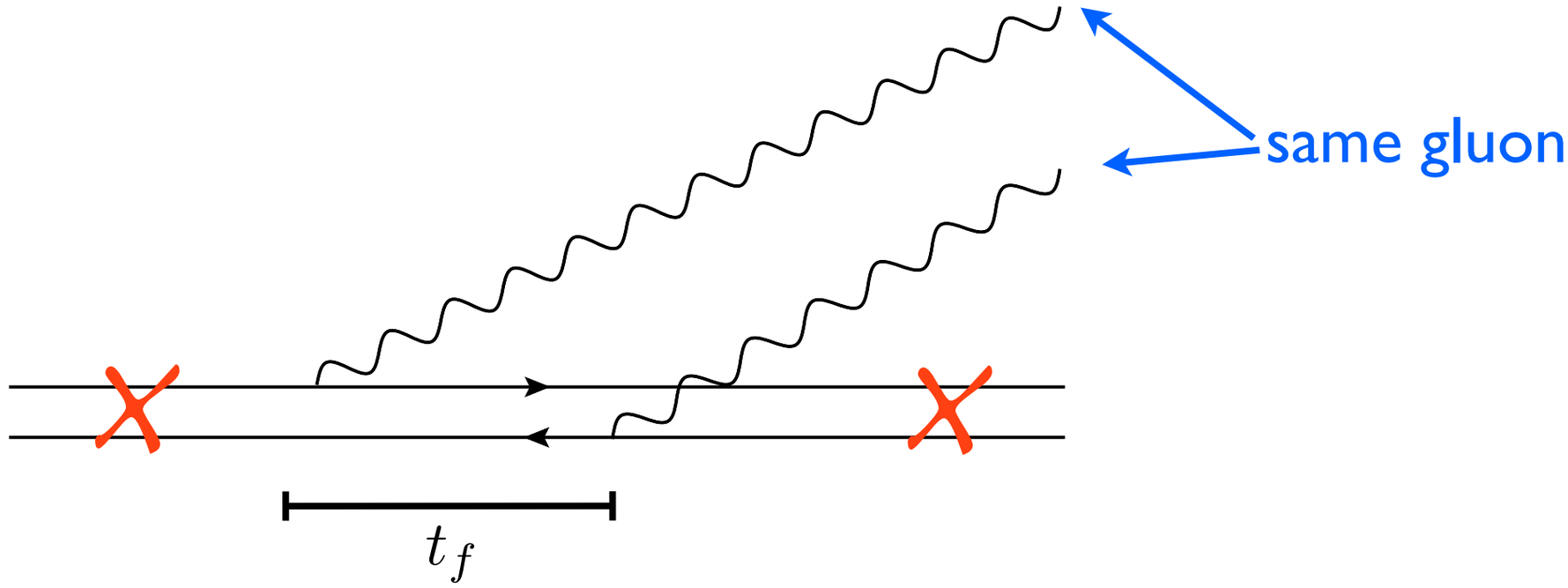

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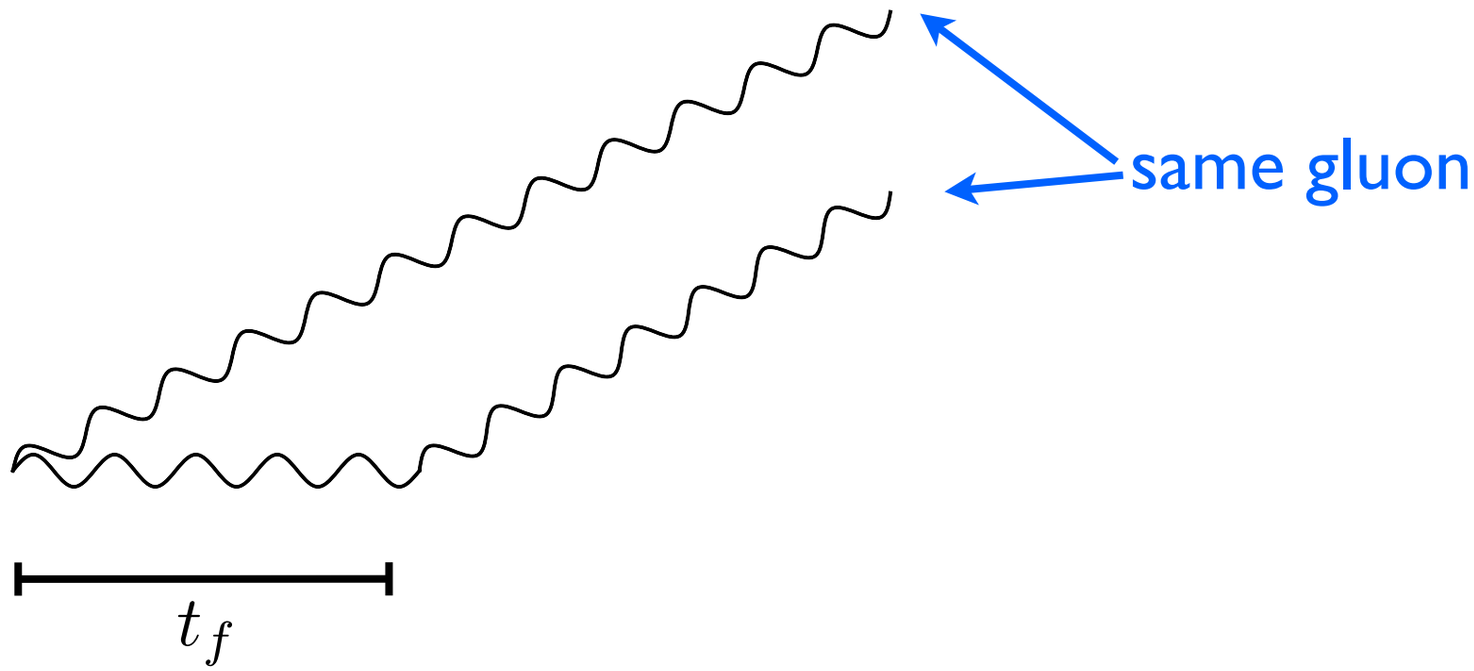

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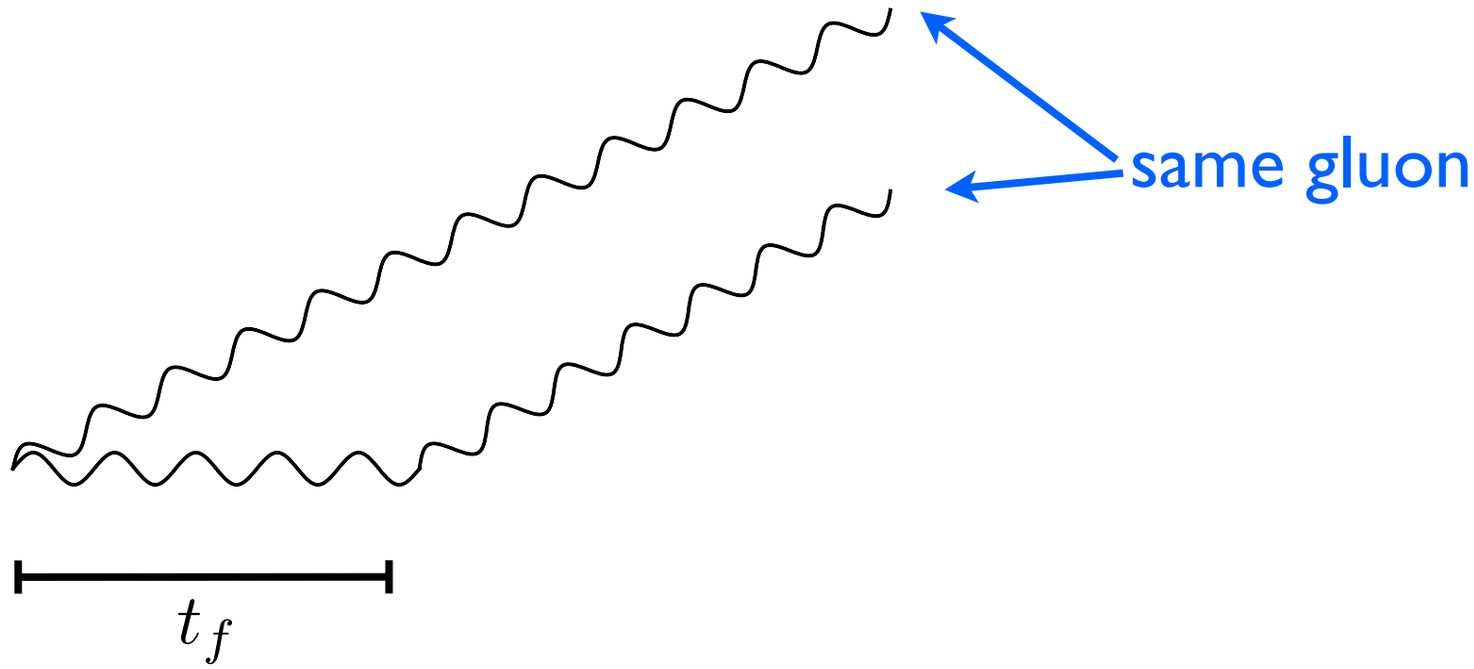


- System remains in a color singlet state at all times
- Singlet states with small transverse size can travel large distances

From single emission to multiple branchings

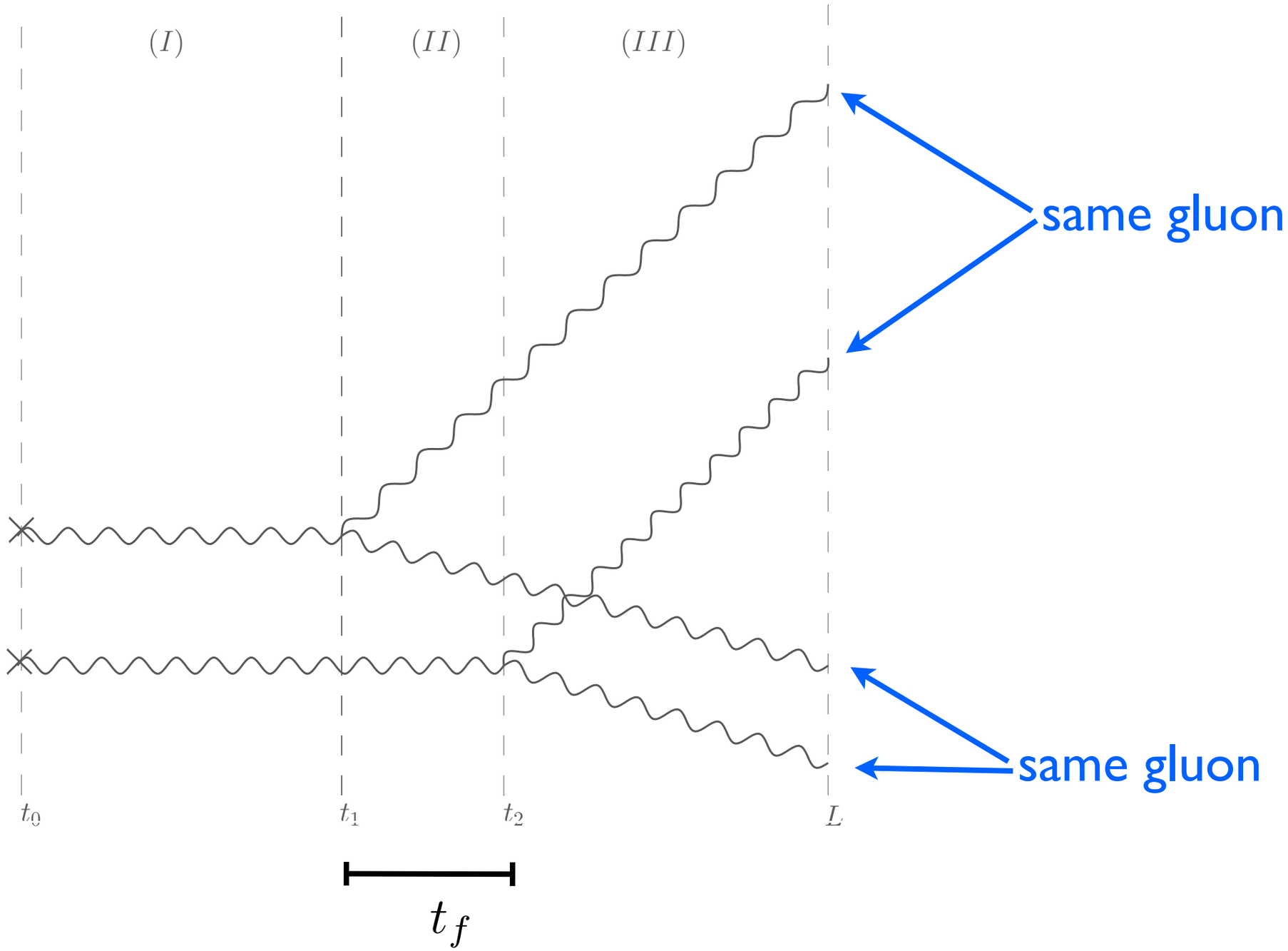
- Soft emissions not necessarily come from leading parton

  Relax eikonal approximation

- Determine the role of interferences

  Relation between decoherence time and formation time

Structure of gluon branching



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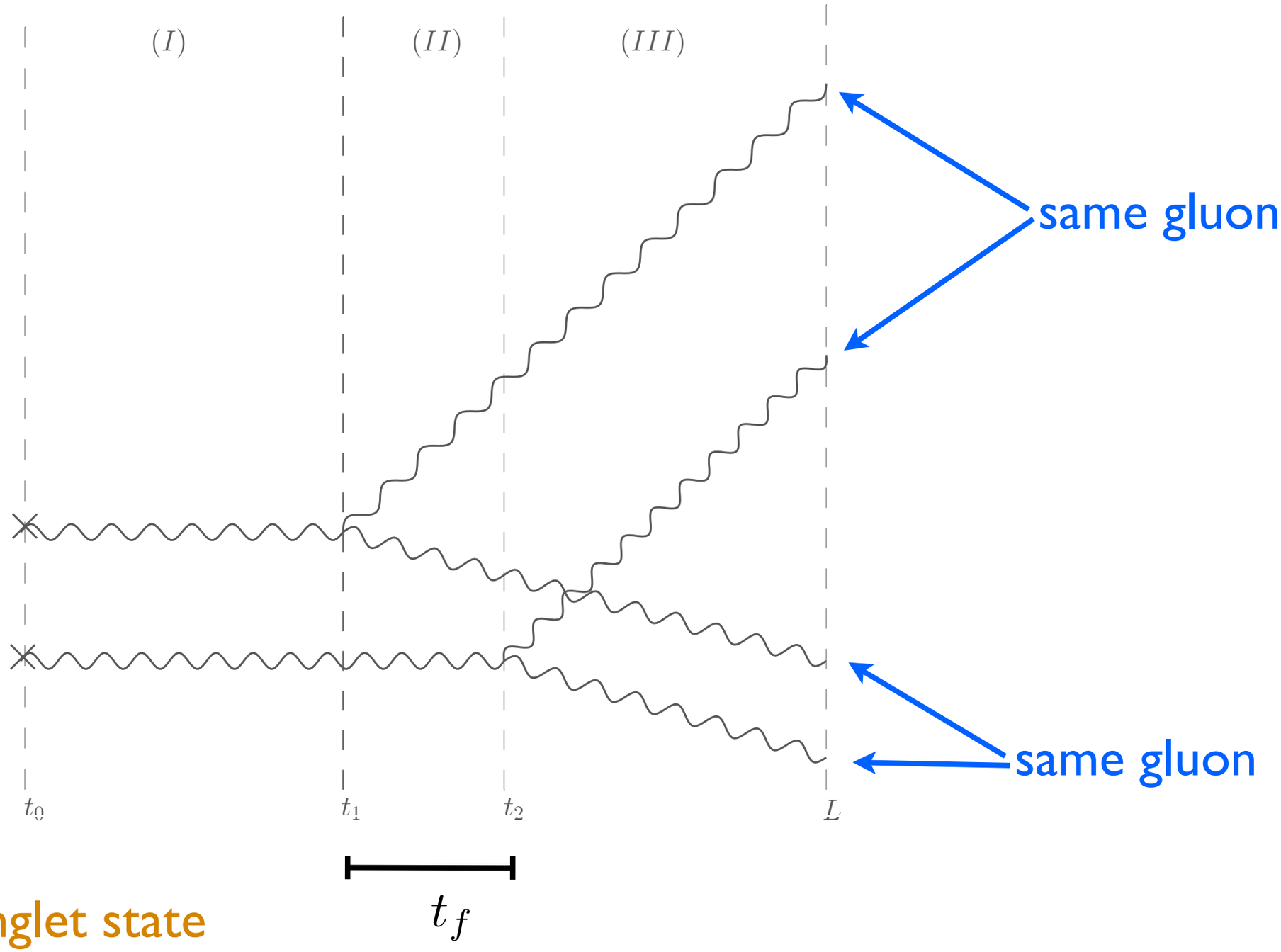
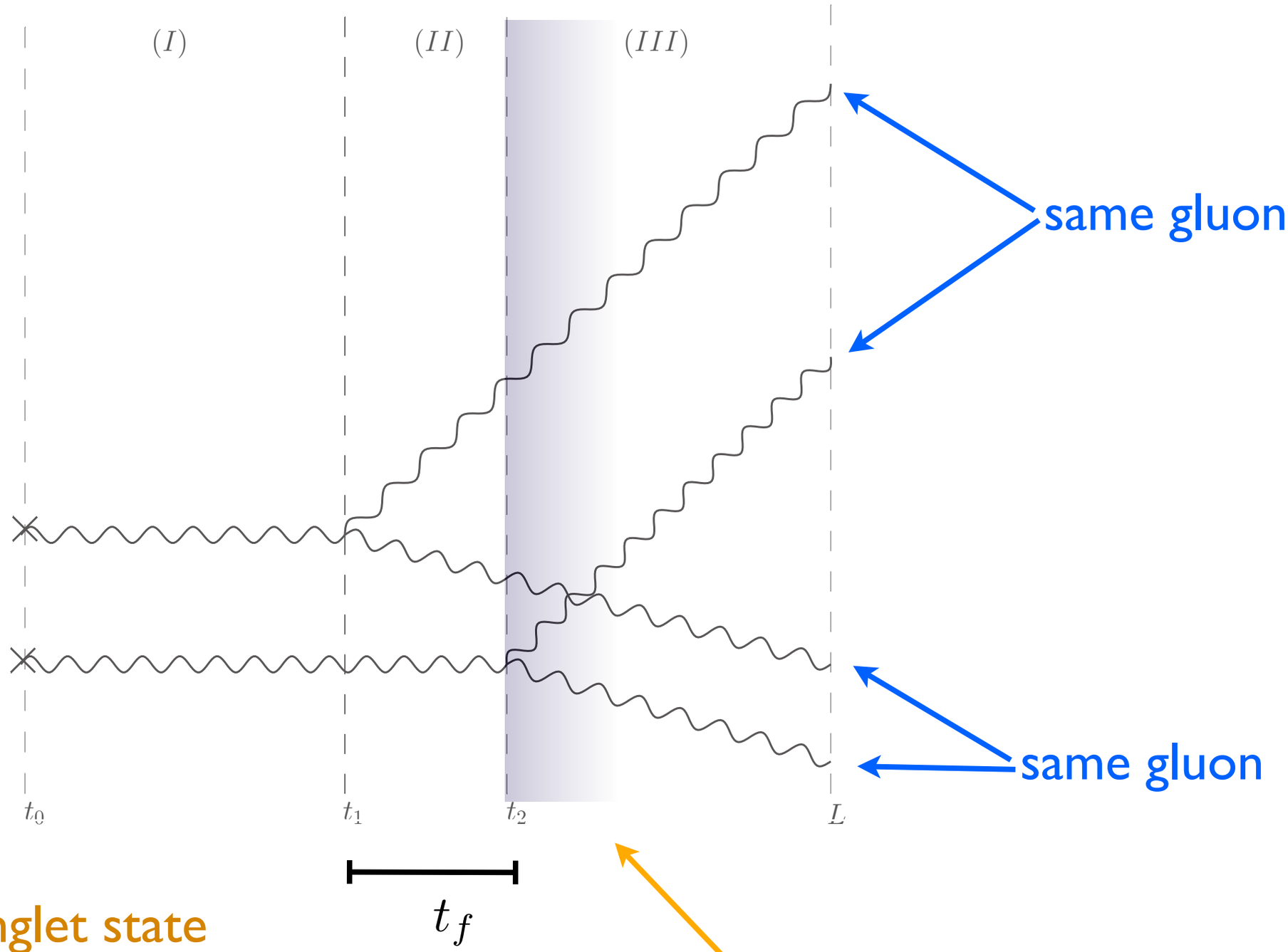


Only one singlet state
available for three-gluon state

Structure of gluon branching



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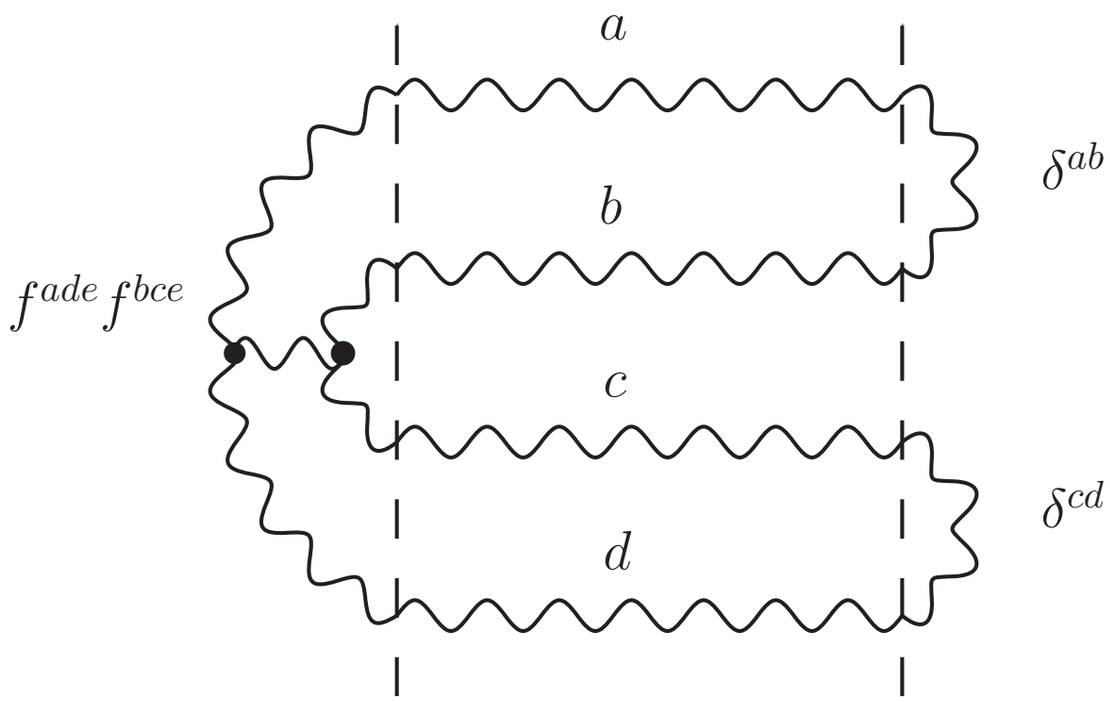
Factorization of two-gluon propagation



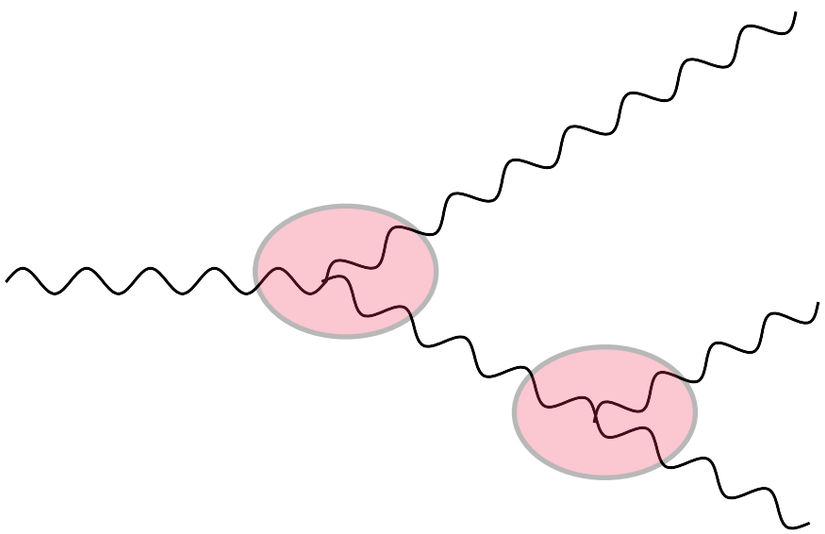
- For large number of colors, the medium average can be explicitly performed and the point of the transition singled out

- The time scale for such a transition is given by the formation time

Consequences of short formation times

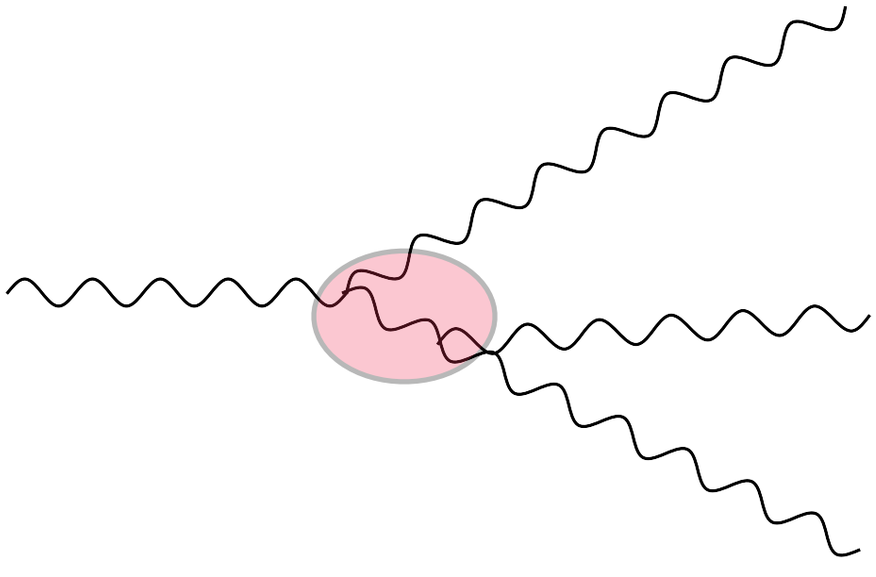
- Splitting process is semi-local
- Propagation of two-gluon system factorizes into independent propagation
- Overlapping emissions are suppressed by factors of $\frac{t_f}{L}$
- Interferences are a subleading effect

Interferences



$$\sim \left(\alpha_s \frac{L}{t_f}\right)^2$$

Independent emissions are enhanced by the medium length



$$\sim \alpha_s^2 \frac{L}{t_f}$$

Interferences II

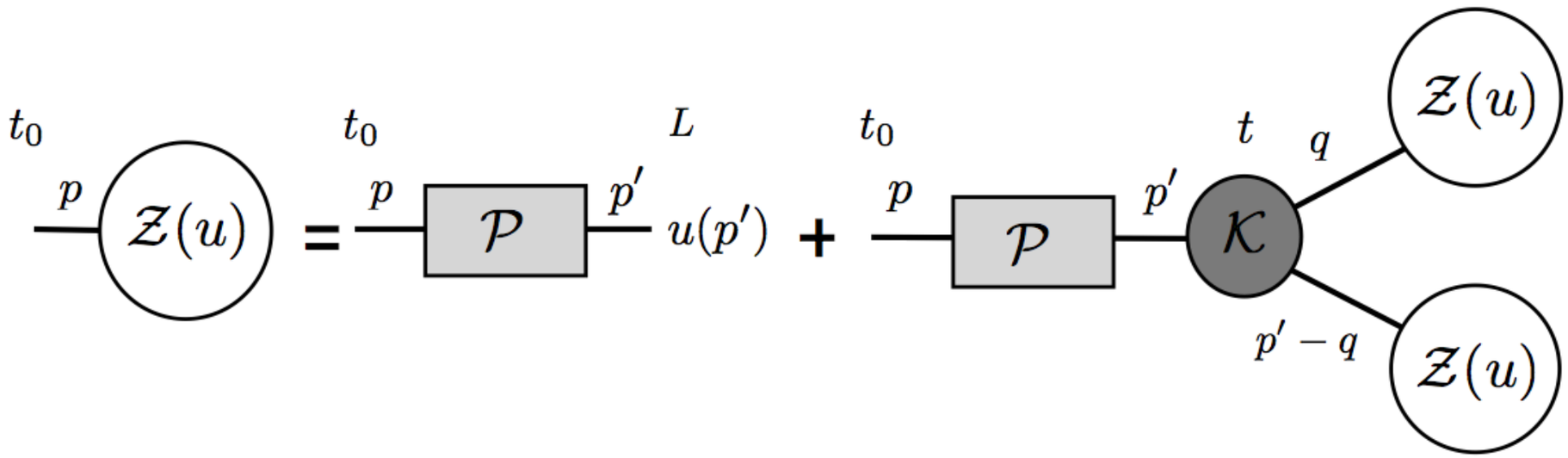
- Interferences between emissions from different sources are important only if they occur sufficiently close to previous splitting

Mehtar-Tani Friday 5D

- For dynamical case,

  decoherence time = formation time

Probabilistic picture



$$\mathcal{Z}(\mathbf{p}, L-t_0|u) = \Delta(p^+, L-t_0) \int \frac{d\mathbf{p}'}{(2\pi)^2}\, \mathcal{P}(\mathbf{p}'-\mathbf{p}, L-t_0)\, u(\mathbf{p}') + \alpha_s \int_{t_0}^{L} dt\, \Delta(p^+, t-t_0)$$

$$\times \int_0^1 \frac{dz}{z} \int \frac{d\mathbf{p}'}{(2\pi)^2} \mathcal{P}(\mathbf{p}'-\mathbf{p}, L-t_0) \int \frac{d\mathbf{q}}{(2\pi)^2}\, \mathcal{K}(\mathbf{q}-z\mathbf{p}'|z)\, \mathcal{Z}(\mathbf{q}, L-t|u)\, \mathcal{Z}(\mathbf{p}'-\mathbf{q}, L-t|u)$$

In-medium splitting kernel:

$$\mathcal{K}_g(\mathbf{q}, z) \approx \frac{2}{p^+} P_{gg}(z)\ \sin\left[\frac{\mathbf{q}^2}{2\mathbf{k}_{\mathrm{f}}^2}\right]\ \exp\left[-\frac{\mathbf{q}^2}{2\mathbf{k}_{\mathrm{f}}^2}\right]$$

Conclusion

- Two-gluon production factorizes in the limit of short formation times
- Interferences are unimportant for soft emissions
- Full medium-induced branching process can be set in a suitable way for MC implementation (generating functional)