Small-x Evolution of Unintegrated Gluon Distributions

Fabio Dominguez

Columbia University

QCD Evolution Workshop
April 8th, 2011.

Two Different Distributions

- Weizsäcker-Williams distribution
  - Explictly counts number of gluons in a physical gauge
- Fourier transform of dipole cross section
  - Widely used in k_t-factorized formulas for inclusive processes

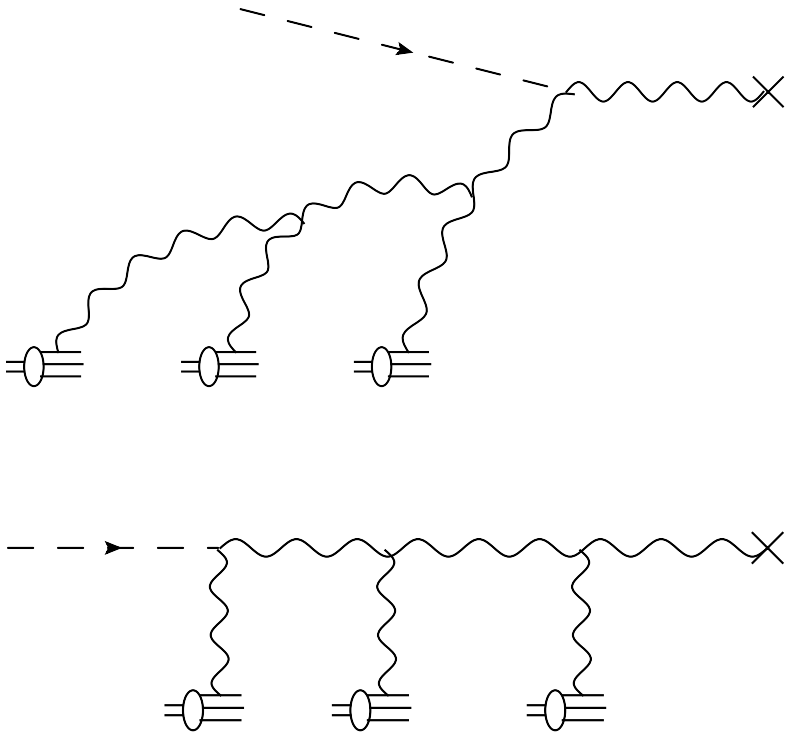
Dipole Distribution

- Inclusive gluon production
- Also appears in less inclusive measurements like $\gamma+$ Jet in pA collisions
- Evolution given by BK equation

Weizsäcker-Williams Distribution

Can be calculated in specific models

- McLerran-Venugopalan
- Kovchegov-Mueller

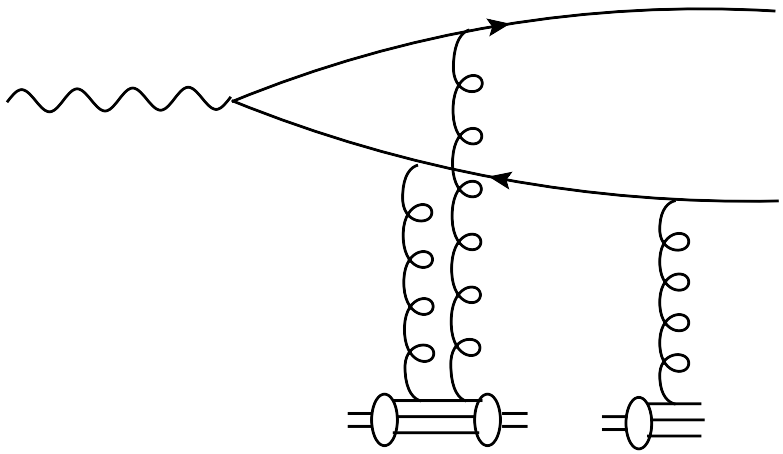


Weizsäcker-Williams Distribution From DIS

- No such colorless current available in the lab
- Consider two-jet events in DIS
- Make separation between quark and antiquark by taking correlation limit
- Singlet pair looks like a colorless object
- Octet pair looks like a gluon

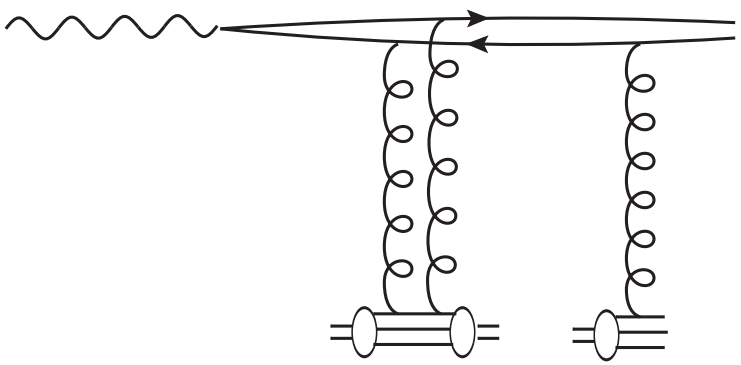
Weizsäcker-Williams Distribution From DIS

- No such colorless current available in the lab
- Consider two-jet events in DIS
- Make separation between quark and antiquark by taking correlation limit
- Singlet pair looks like a colorless object
- Octet pair looks like a gluon



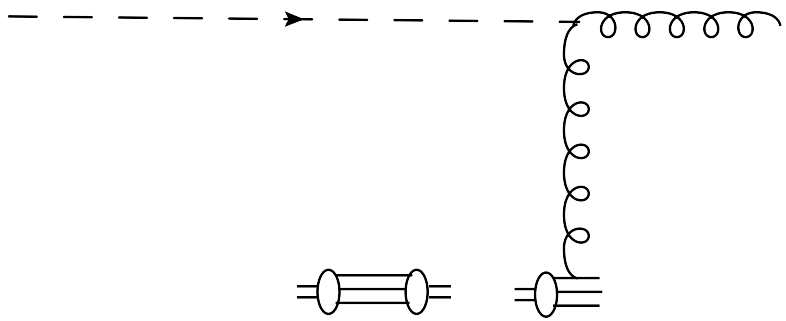
Weizsäcker-Williams Distribution From DIS

- No such colorless current available in the lab
- Consider two-jet events in DIS
- Make separation between quark and antiquark by taking correlation limit
- Singlet pair looks like a colorless object
- Octet pair looks like a gluon

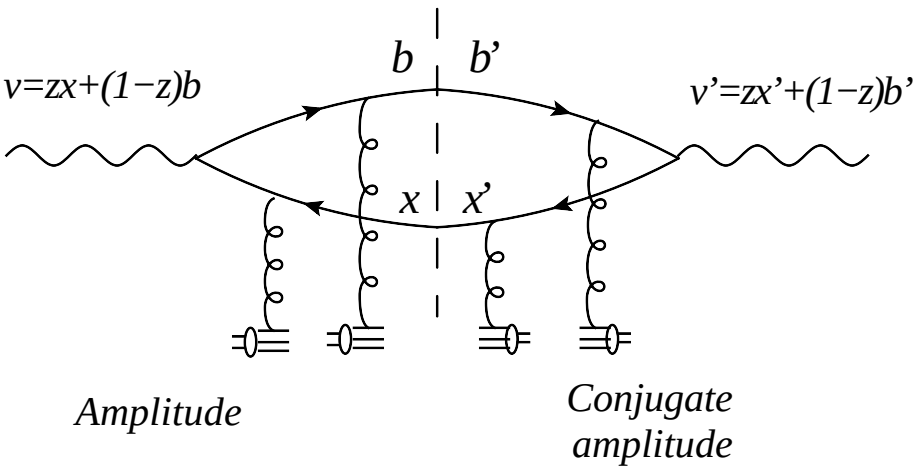


Weizsäcker-Williams Distribution From DIS

- No such colorless current available in the lab
- Consider two-jet events in DIS
- Make separation between quark and antiquark by taking correlation limit
- Singlet pair looks like a colorless object
- Octet pair looks like a gluon

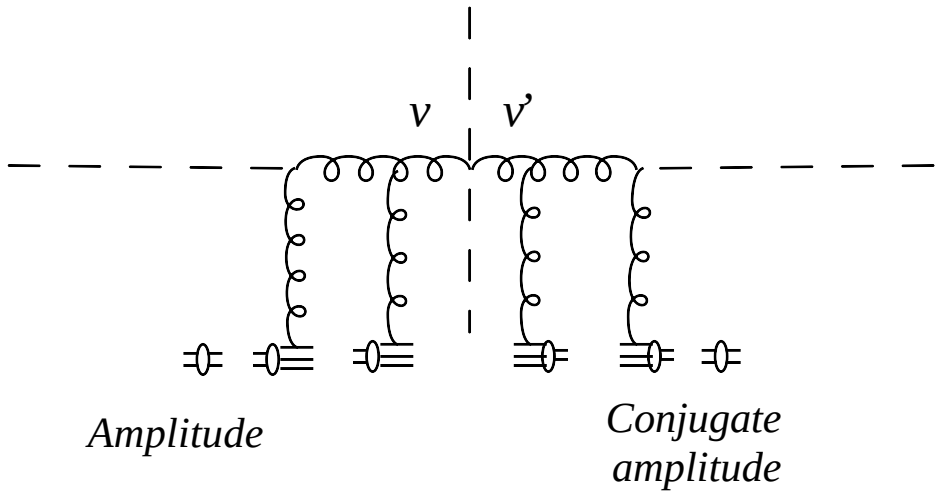


Dijet in DIS



$$\frac{d\sigma^{\gamma_T^* A\to q\bar{q}X}}{d^3k_1 d^3k_2} = N_c\alpha_{em}e_q^2\delta(p^+ - k_1^+ - k_2^+)\int \frac{d^2x}{(2\pi)^2}\frac{d^2x'}{(2\pi)^2}\frac{d^2b}{(2\pi)^2}\frac{d^2b'}{(2\pi)^2}$$
$$\times e^{-ik_{1\perp}\cdot(x-x')}e^{-ik_{2\perp}\cdot(b-b')}\sum \psi_T^*(x-b)\psi_T(x'-b')$$
$$\times \left[1 + Q_{x_g}(x,b;b',x') - S_{x_g}^{(2)}(x,b) - S_{x_g}^{(2)}(b',x')\right]$$

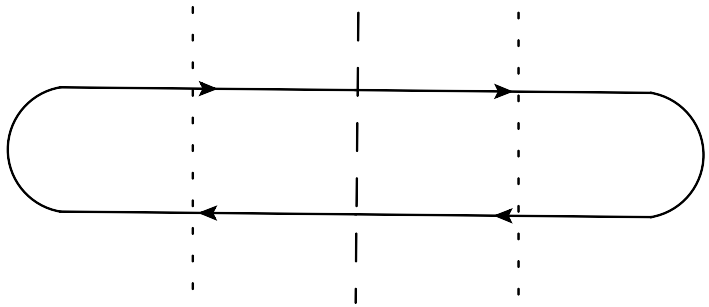
Dijet in DIS



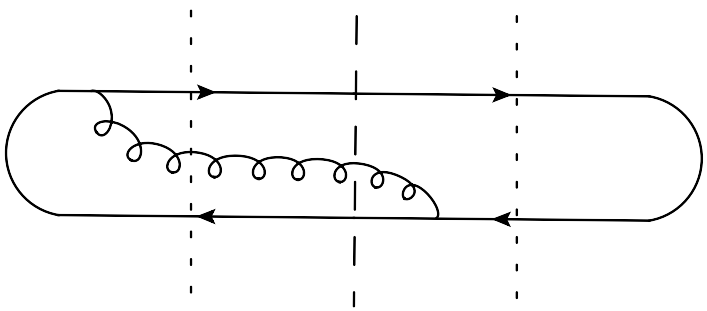
$$\frac{d\sigma^{\gamma_T^* A\to q\bar{q}+X}}{dy_1 dy_2 d^2P_\perp d^2q_\perp} = \delta(x_{\gamma^*}-1)x_g G^{(1)}(x_g,q_\perp)H_{\gamma_T^* g\to q\bar{q}}$$

$$x_g G^{(1)}(x_g,q_\perp) = -\frac{2}{\alpha_S}\int \frac{d^2v}{(2\pi)^2}\frac{d^2v'}{(2\pi)^2}\, e^{-iq_\perp\cdot(v-v')} \times \left\langle \mathrm{Tr}\left[\partial_i U(v)\right] U^\dagger(v')\left[\partial_i U(v')\right] U^\dagger(v)\right\rangle_{x_g}$$

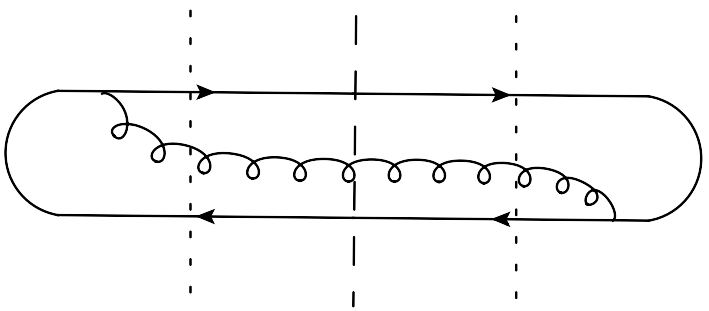
Quadrupole Evolution



- Soft gluon can create a new dipole

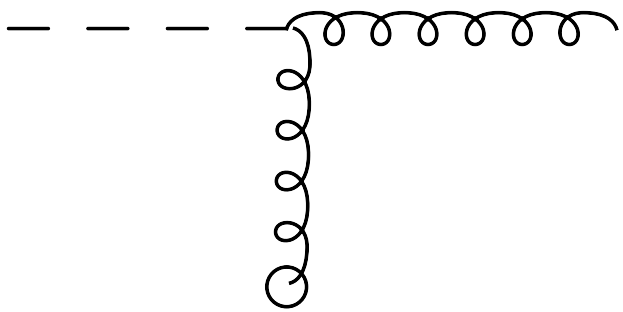


- Soft gluon can split quadrupole into two dipoles

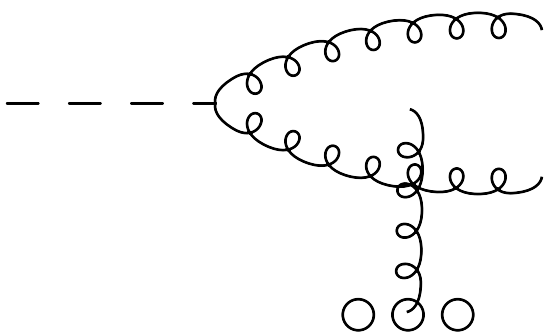


Weizsäcker-Williams Evolution

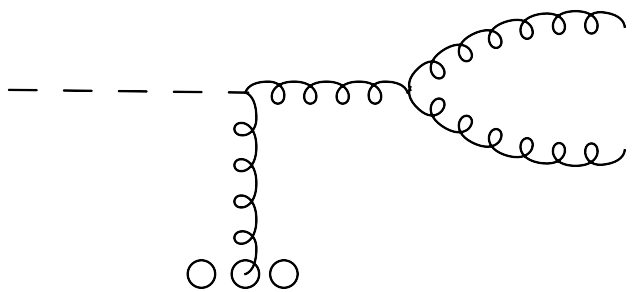
Effective vertex



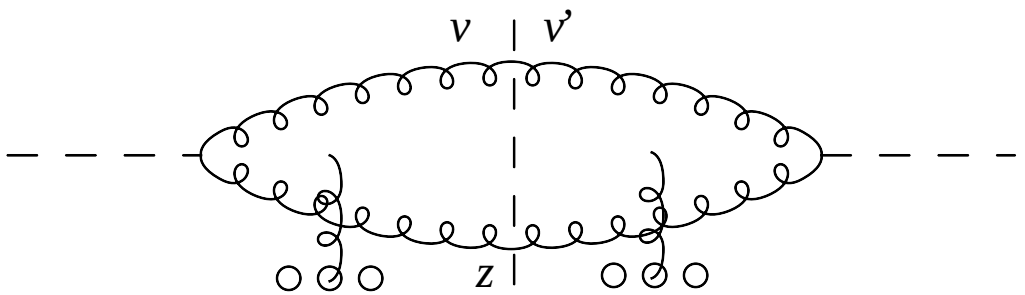
- Early emission



- Late emission

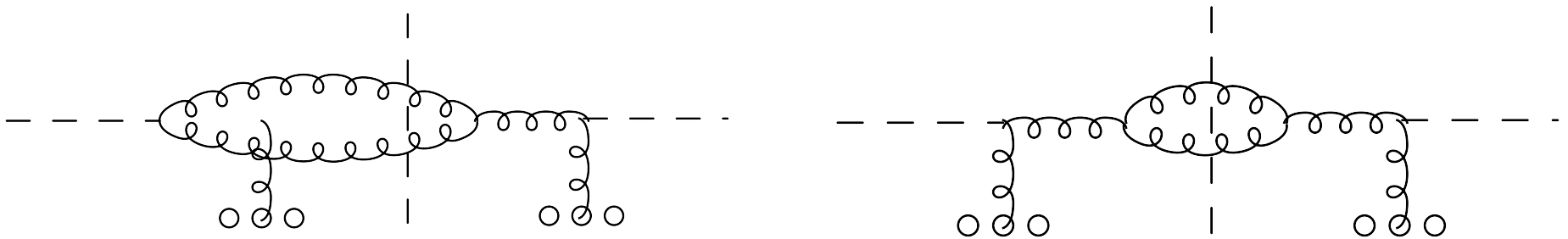


Early Emissions Only



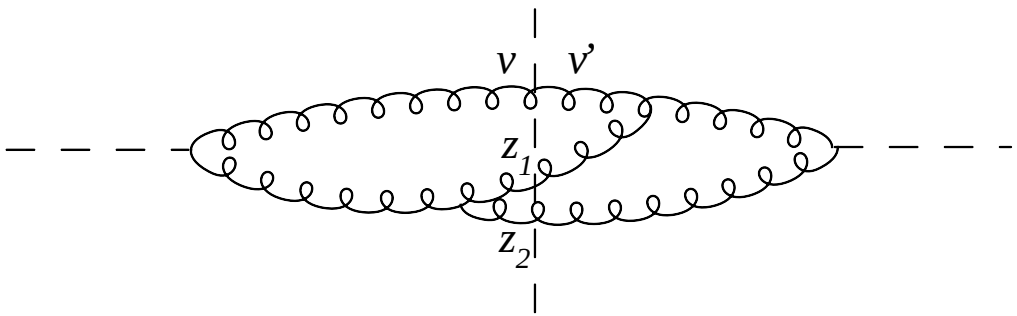
- Can be written in terms of dipole scattering only
- At the quadrupole level this corresponds to picking only the terms where the quadrupole splits into two dipoles

Late Emissions - First Step



- Virtual corrections have to be included too
- Complete cancelation at leading twist
- Lots of cancelations in different momentum regions. Not when softer gluon has a transverse momentum close to saturation scale

Quadrupole Comes Back



- For large N_c we get a quadrupole and two dipoles
- Large growth of the wavefunction
- Not clear it should give a small contribution

Conclusion

- Further insight into quadrupole evolution is needed
- Asymptotic limits seem to be dominated by dipole evolution