Saturation in pp collisions: the inclusive cross section in QCD

J.Bartels
II.Inst.f.Theor.Physik, Univ.Hamburg

CERN: HERA-LHC, May 28,2008

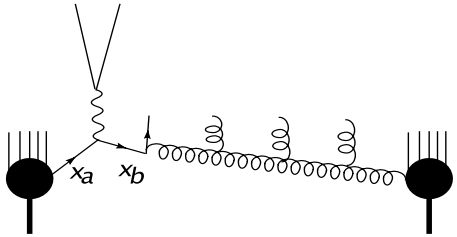
- Introduction
- Some details
- Results

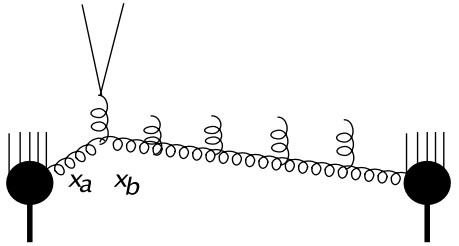
arXiv:0802.2702 [hep-ph] and accepted by JHEP,
in collaboration with G.P.Vacca and M.Salvadore

Introduction

Saturation first formulated (and seen?) in deep inelastic scattering.
In pp collision: where to search for saturation?

Most promising: Drell-Yan or inclusive jet production near the forward direction:

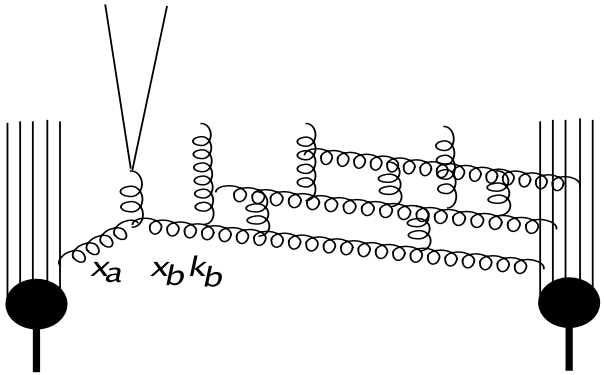




In collinear factorization:

$$d\sigma = \int dx_a dx_b f(x_a) \hat{\sigma}(x_a, x_b) f(x_b)$$

If there is saturation: much more complicated evolution to the right of the jet

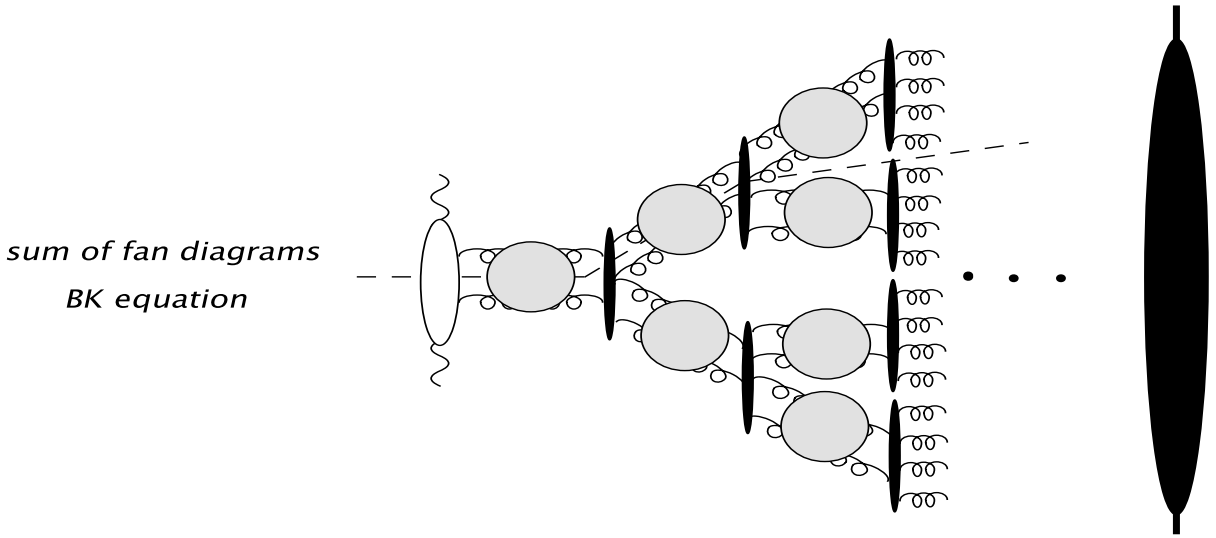


$$d\sigma = \int dx_a dx_b \int d^2k_b f(x_a)\hat{\sigma}(x_a, x_b, k_b)\tilde{f}(x_b, k_b)$$

What is the form of $\tilde{f}(x_b, k_b)$?
What are the evolution equations?

Reminder: saturation in DIS total cross section, BK equation:

$$\sigma_{tot}^{\gamma^* p} = \int dz |\psi|^2 \sigma_{q\bar{q}} = \Phi \otimes f(x,k)$$

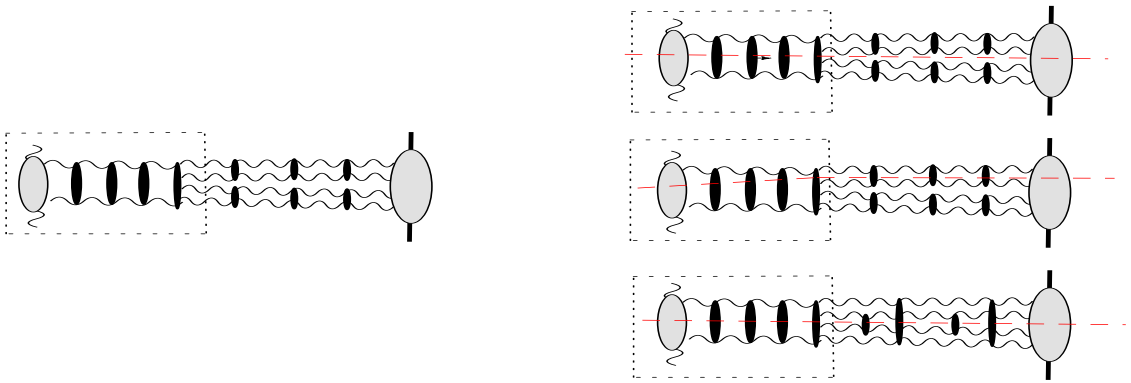


As often in inclusive quantities: enormous cancellations and simplifications.
What happens if we 'open' the total cross section,
ask for a single jet inclusive cross section?
Earlier work by Kovchegov et al.; Braun; Blaizot et al.; Kovner et al.

Some details

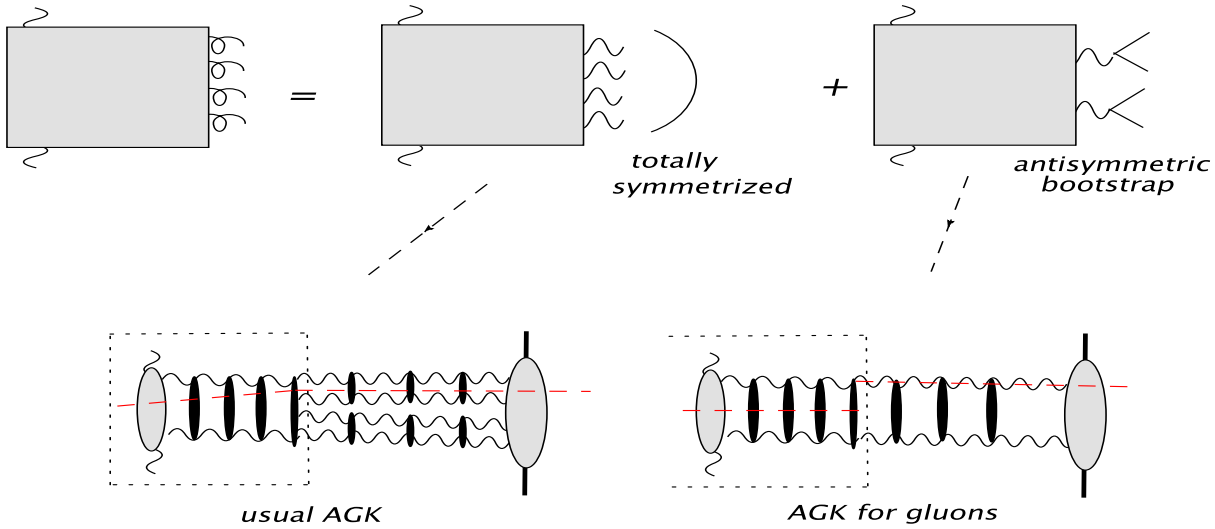
Compute the inclusive cross section from unitarity sums (=imaginary part),
study scattering on two independent targets (nucleus)
$\longrightarrow$ elastic scattering of a virtual photon on deuteron.

Total cross section: there are three contributions (cuts). For large N_c:

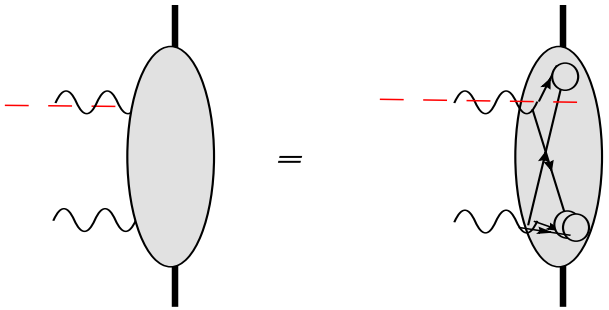


AGK: all boxes are equal (undependent of cut), definite phases, AGK counting rules.
Result: $+1\ -4\ +2\ =-1$

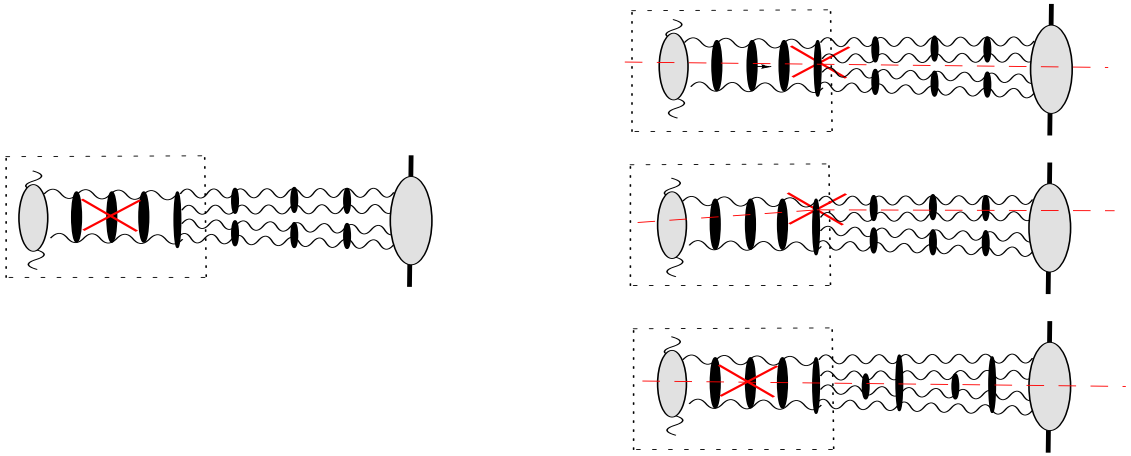
But: in QCD the gluon reggeizes. Different symmetry classes:



Need to seperate the two classes.
Reggeizing contributions lead to corrections inside the target.

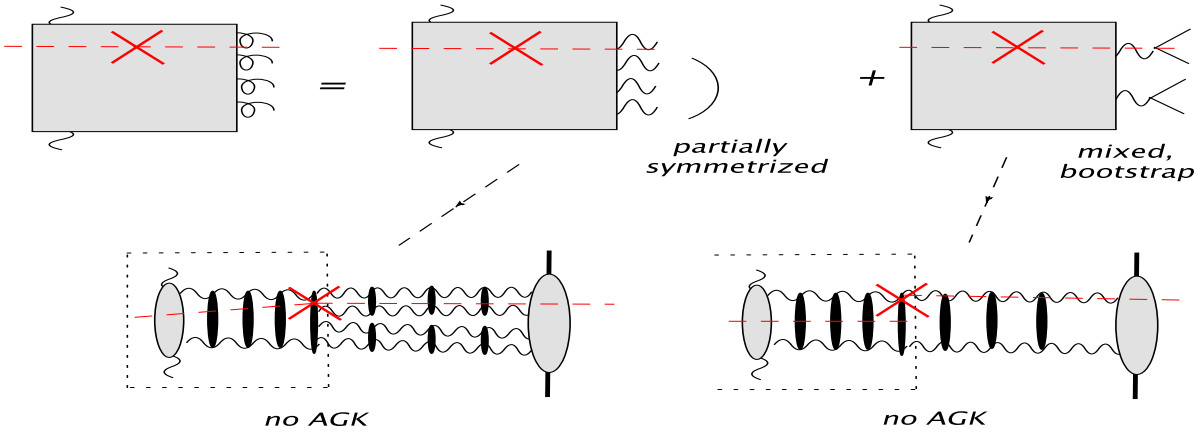


Now the 1-gluon inclusive cross section: much of the coherence is lost:

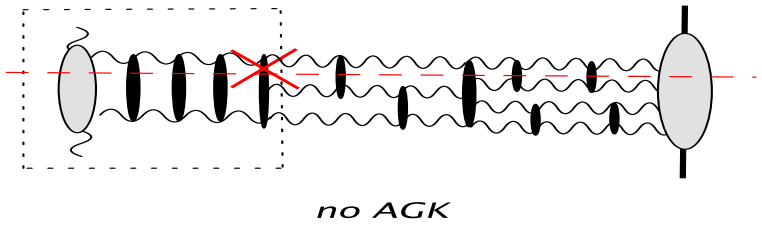


Boxed are no longer equal, depend upon location of produced gluon (jet).
Still the same phases as in total cross section, but no longer simple AGK counting rules.

Problem of reggeization persists:
symmetrization on both sides of the cutting line is required

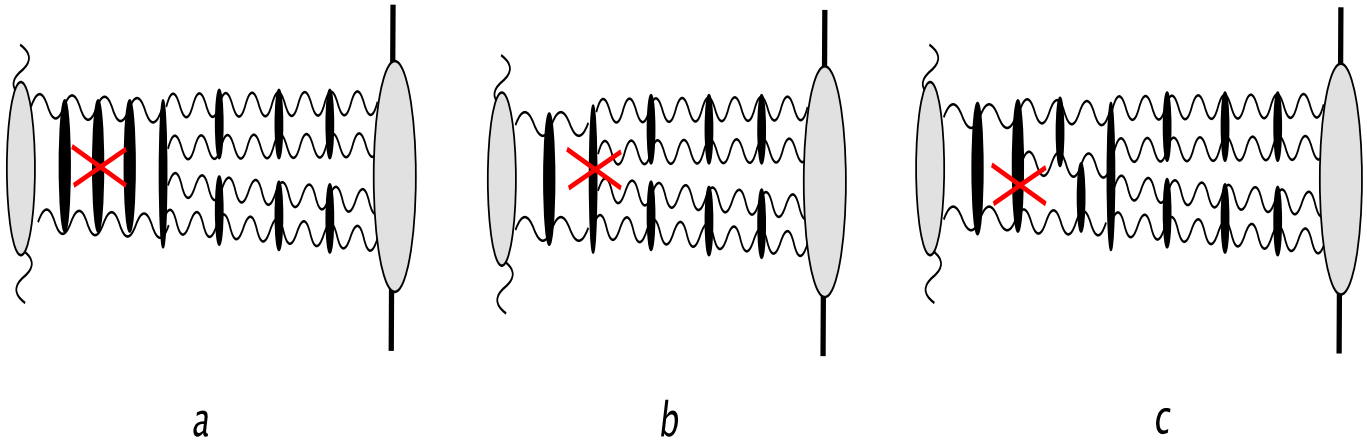


New piece appears:
three gluon correlator



Results

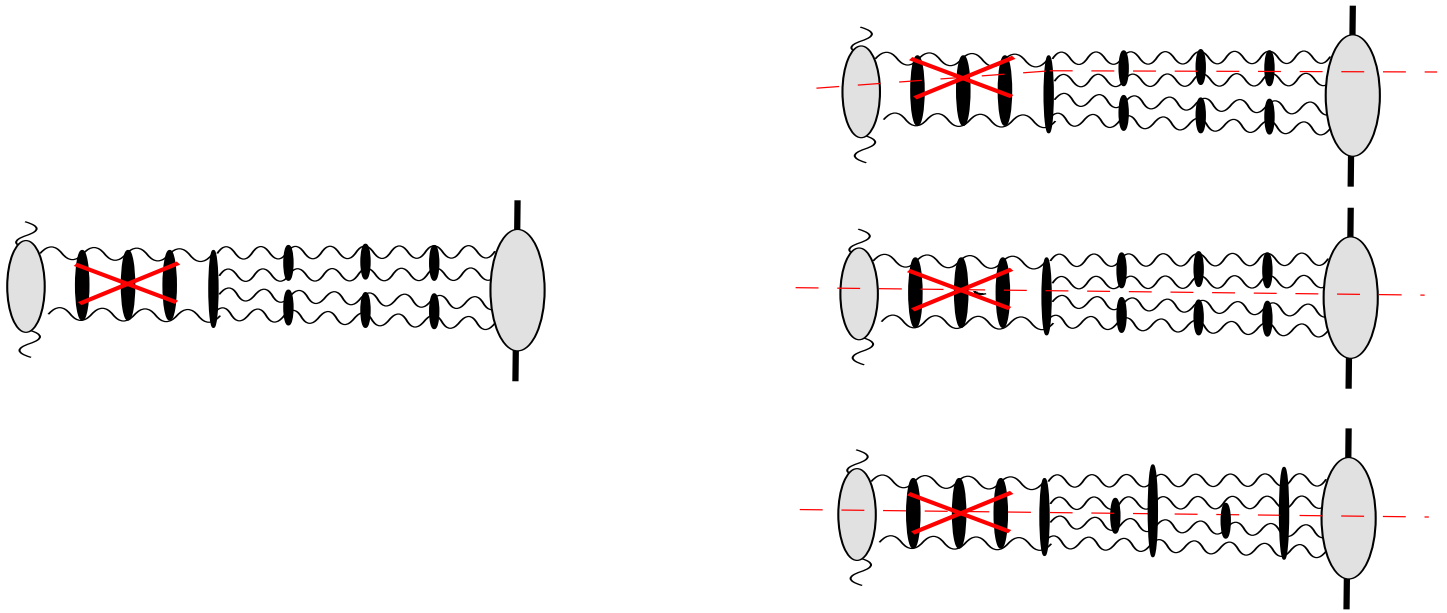
The inclusive cross section consists of several terms. For large N_c:



No emission from one of the two ladders: AGK counting rules.

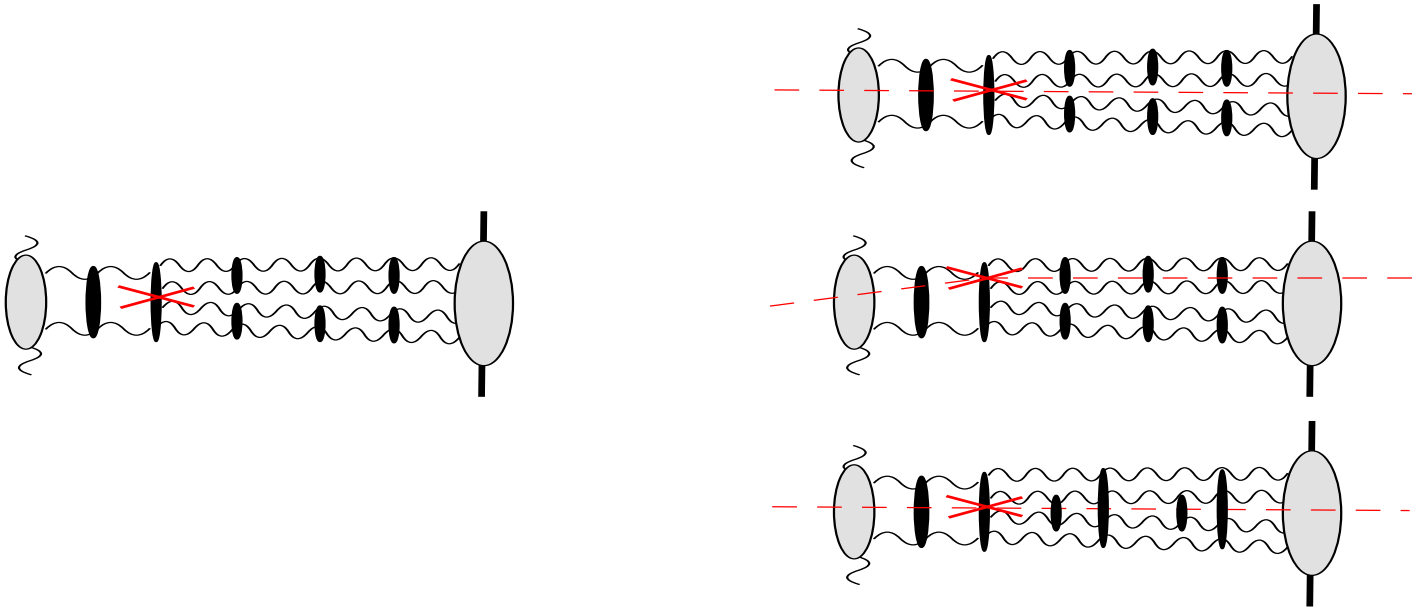
$$\frac{d\sigma}{d^2k dy} = f_2(k,y) \otimes V \otimes \Big[\phi_2(k, Y-y) + \phi_4(k_1, k_2, Y-y) + \phi_3(k_1, k_2, Y-y)\Big]$$

(a) 'normal contribution':



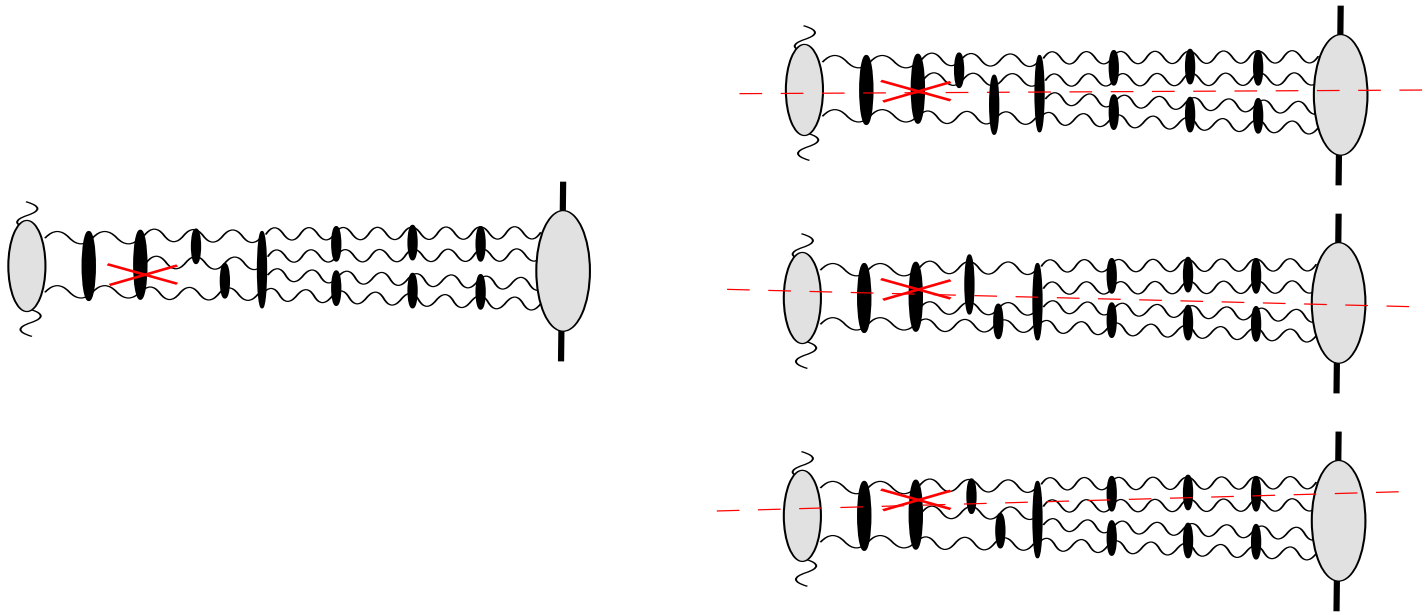
satisfies AGK rules, k_t factorization, obeys BK equation

(b) 'double Pomeron exchange':



Cannot satisfy AGK rules; generalized k_t factorization, BK-evolution for both Pomerons(?)

(c) new contribution: three gluon correlator.



No AGK rules,generalized k_t factorization, what type of evolution?

Conclusions

- Going from total cross section to single inclusive cross section destroys coherence.
- results for single inclusive cross section disagree with the earlier results (Braun, Kovchegov-Tuchin): the three gluon term is missing
- comparison difficult: need to translate our results (in the large-N_c limit) into configuration space.
- Double inclusive cross section: (known) AGK rules do not work
- evolution for inclusive cross section is not yet understood
- new contribution to multiple interactions

How relevant is all this for the search for saturation at the LHC:
Signals for saturation may be more subtle,
(e.g. HERA: geometric scaling, ratio of diffractive to total DIS cross section...)
need accurate predictions.