AGK Rules in pQCD

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

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Content:

- Motivation, Introduction
- Foundation: basics in pQCD
- Rederive the AGK rules in pQCD
- A few new results
- Conclusions

Based upon:

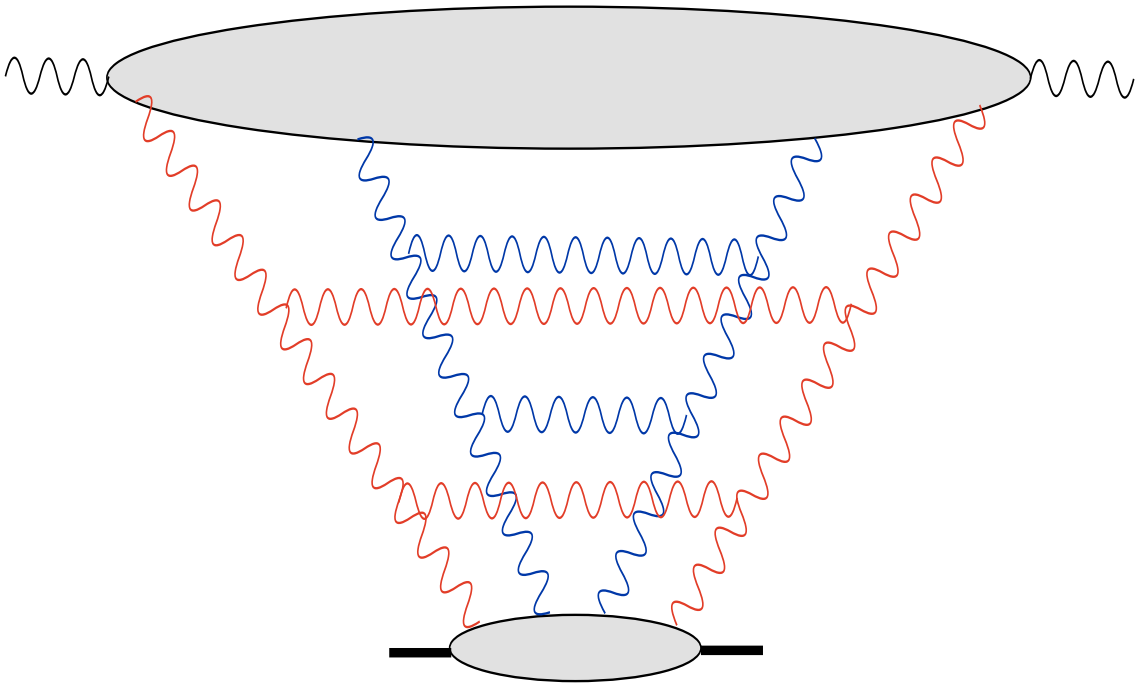
Abramovsky, Gribov, Kanchelli

JB, M.Ryskin
JB, M.Salvadore, G.P.Vacca

Motivation, Introduction

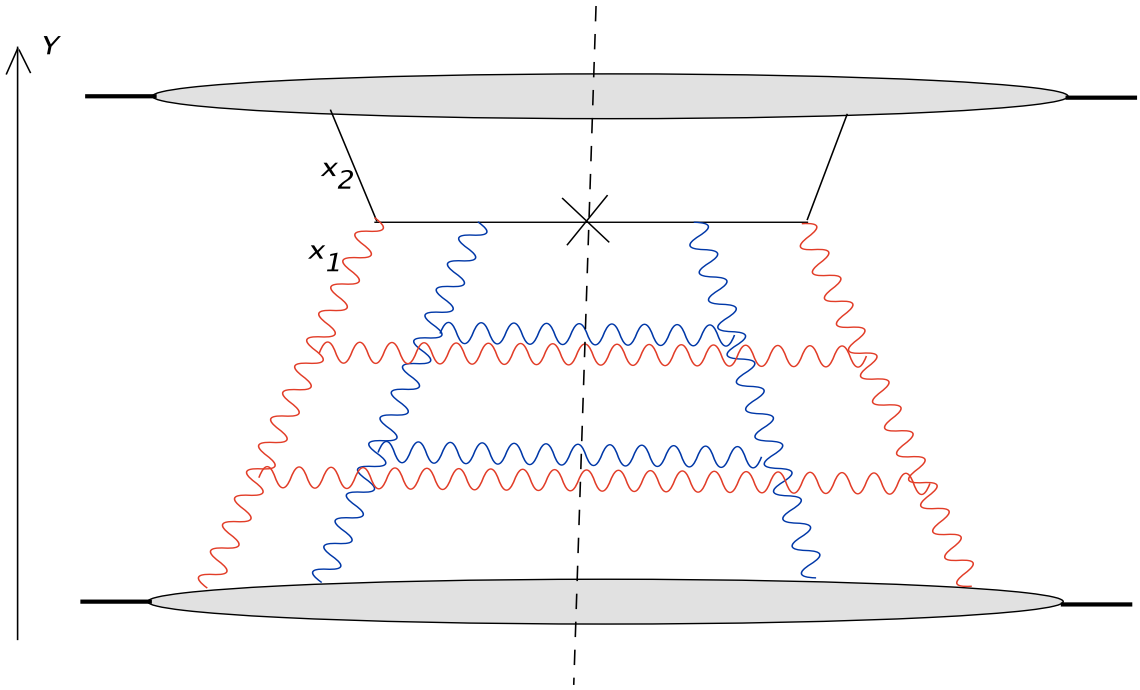
What is a key issue at HERA, may also be a central issue at the LHC:
multiple parton interactions

HERA: somewhere at low Q^2 and/or small x expect multiple interactions:

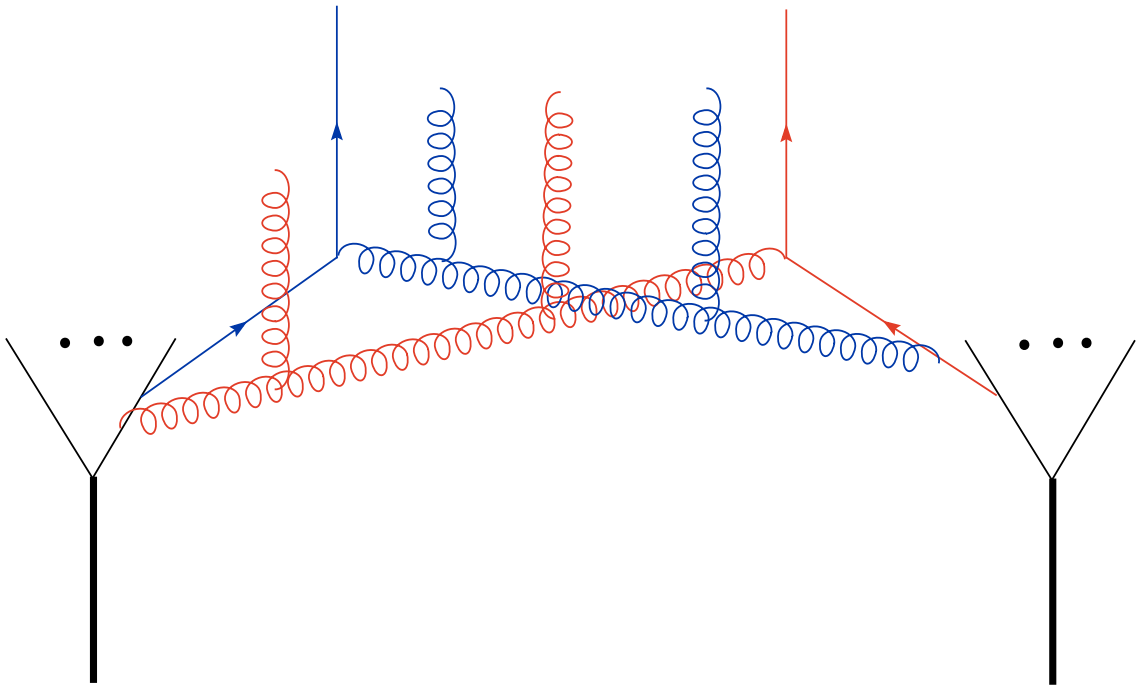


Related to higher twist, supression in $1/Q^2$ compensated by growth in $1/x$. 'Prove of existence' by observation of DIS diffraction.

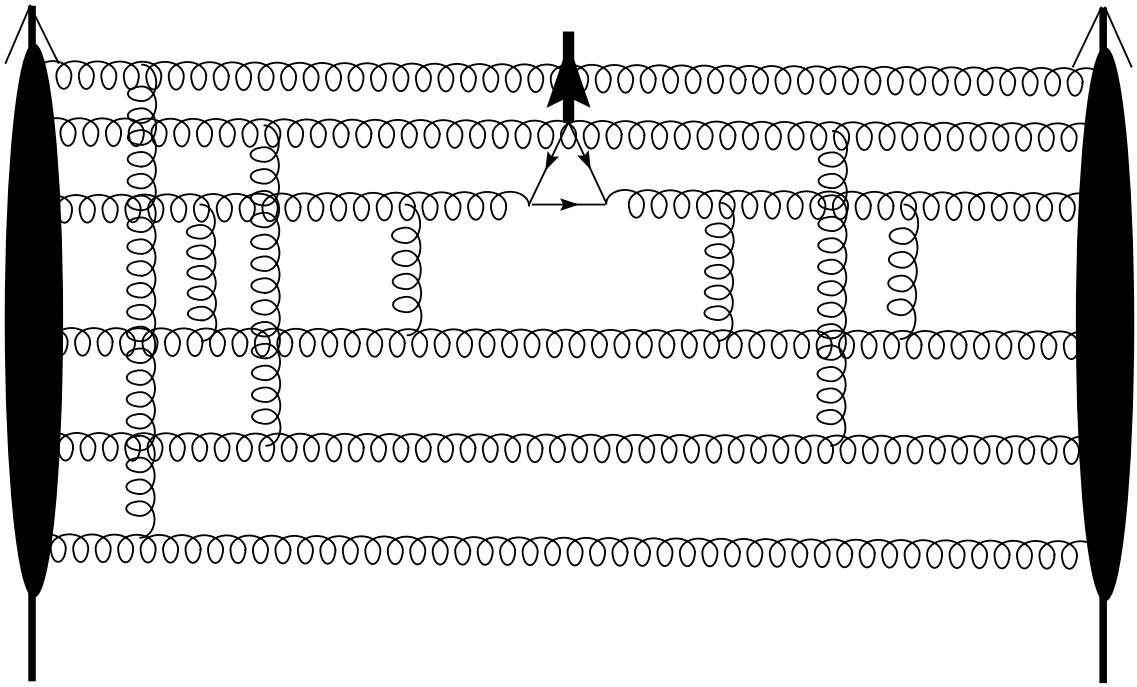
LHC: near the beam directions ($x_1 \ll x_2$)



QCD background of multi-jet final states:

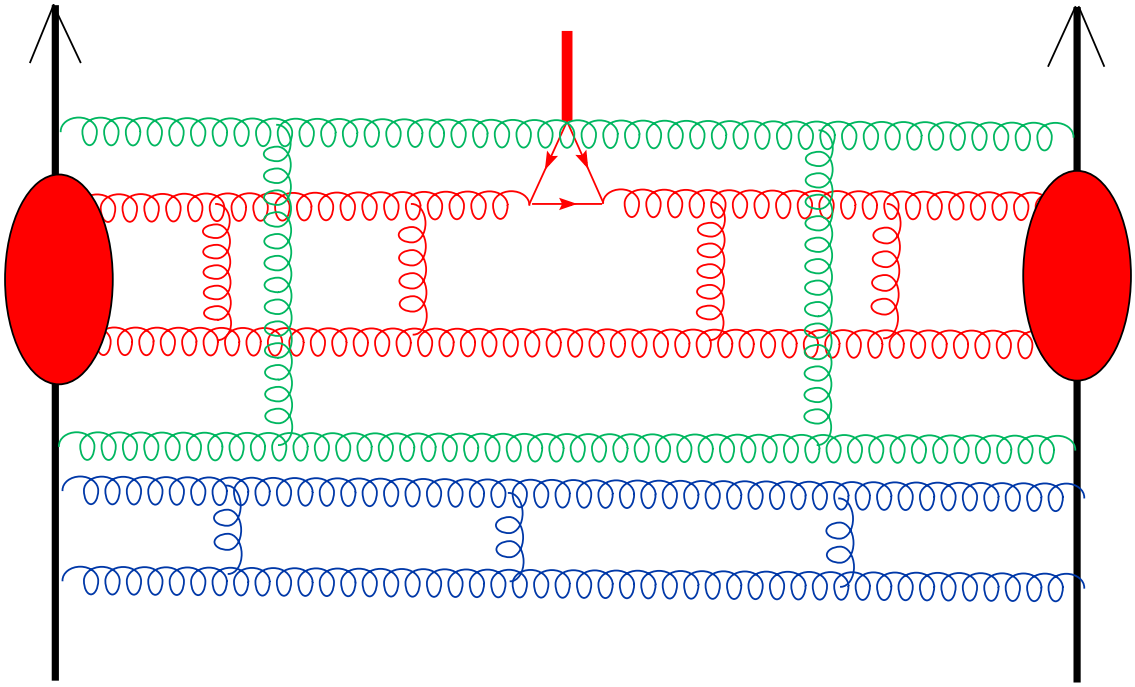


Long term hope: understand the structure of semihard diffractive events.



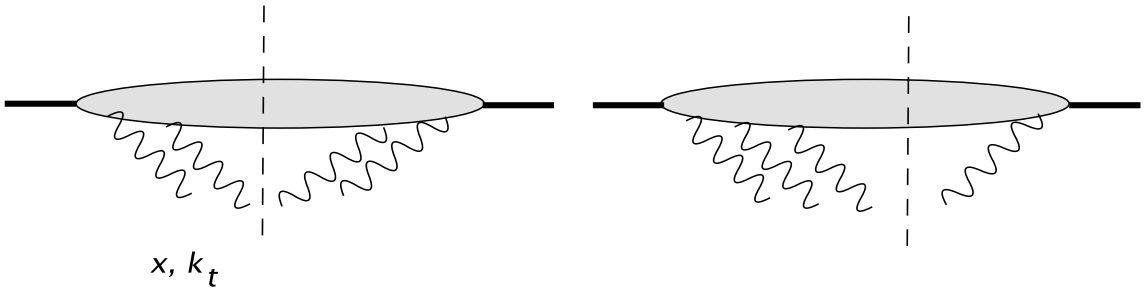
'Insert a hard scale into soft elastic scattering': how far does hardness spread out?

First step:



But there are clearly many more contributions.

Fundamental quantities: multiparton correlators



How big are they?

Theoretically not much studied (for k_t ordering: higher twist operators, but at small x twist not a good concept).

In DIS, photon side: hope to be able to calculate in pQCD (saturation models).

In pp scattering: couplings have to be modelled, look for guidance.

In the region of small x: constraints from AGK cutting rules.

'Multiparton correlators (finite x) have to obey cutting rules at small x'.

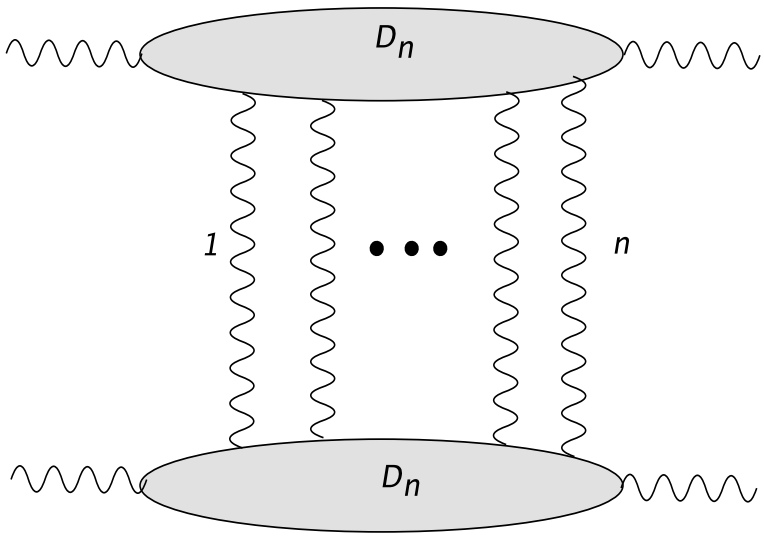
Basics in pQCD

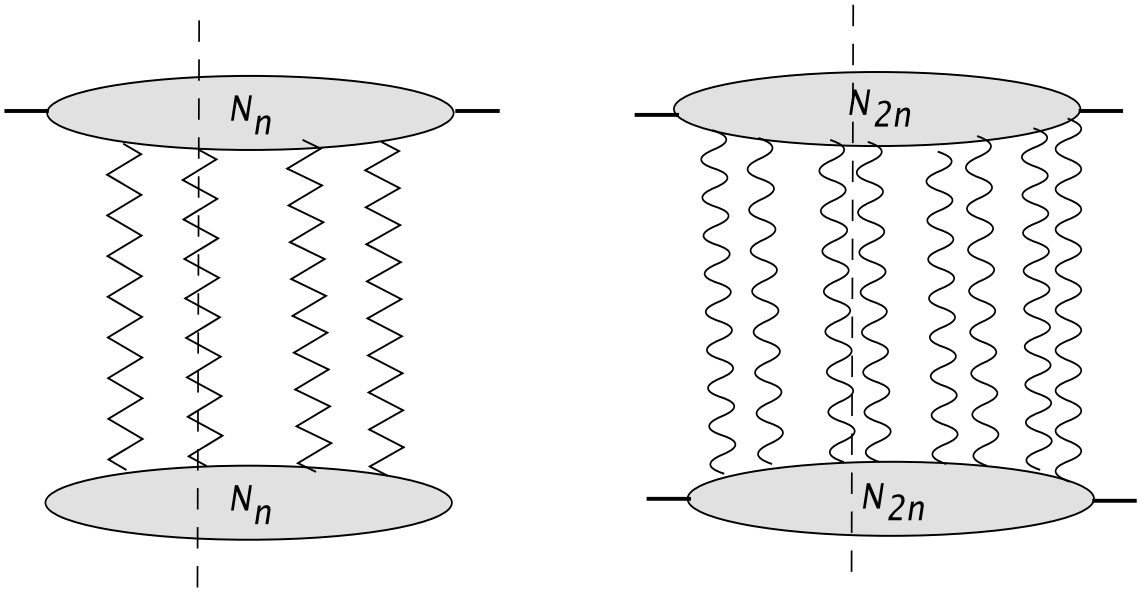
AGK cutting rules have been formlated in times before QCD.
No color degree of freedom.

Main results: different cuts in multi-Pomeron exchange contribute to different final states.

In detail:
- inclusive cross section: counting rules for multiplicities.
- one, two jet inclusive cross sections: cancellations of Pomeron rescatterings
- no general argument for cut vertices, jet vertices etc.

How does this work in pQCD? Contact with collinear factorization.
All derived in $\gamma^*\gamma^*$ scattering:



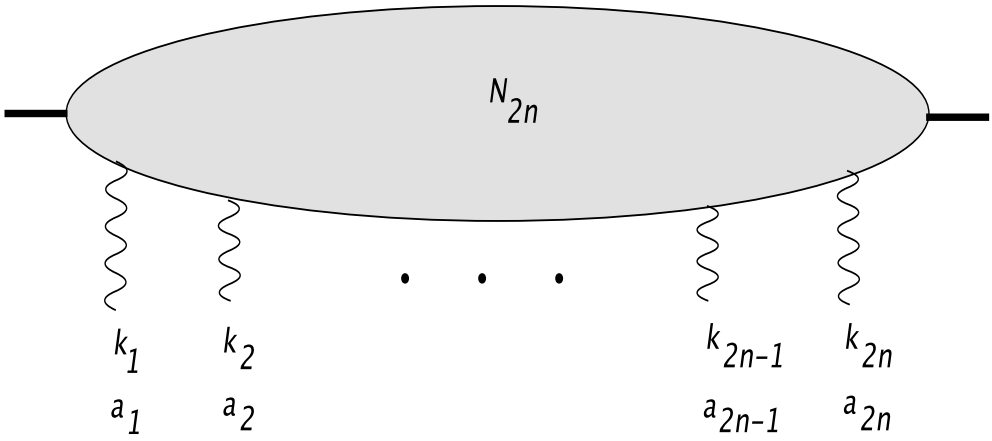


original AGK *AKG in pQCD*

Main ingredients of AGK:
1) symmetry of vertex function N_n under permutation of Pomerons
2) cut $=$ uncut

Analogous feature of pQCD:
1) symmetry of vertex function N_{2n} under permutations of gluons (bound states inside N_{2n}).
2) cut $=$ uncut

Example: eikonal ansatz

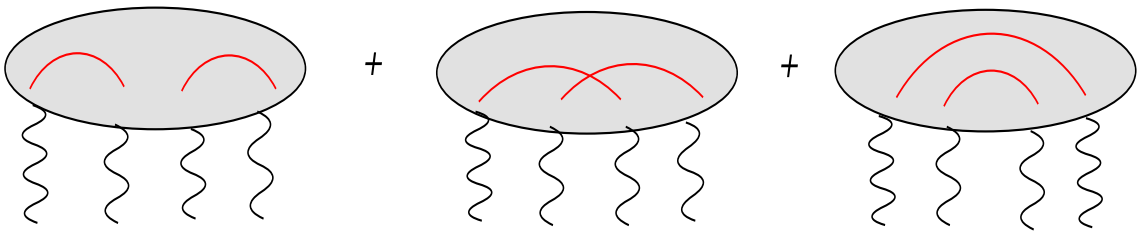


$$N^A_{2n}(\boldsymbol{k}_1, a_1; \ldots; \boldsymbol{k}_{2n}, a_{2n}; \omega) =$$

$$\frac{1}{\sqrt{(N_c^2-1)^n}}\Big(\phi^A(\boldsymbol{k}_1, \boldsymbol{k}_2; \omega_{12})\delta_{a_1 a_2}\cdot\ldots\cdot\phi^A(\boldsymbol{k}_{2n-1}, \boldsymbol{k}_{2n}; \omega_{2n-1,2n})\delta_{a_{2n-1}a_{2n}}$$

$$+ \sum_{Pairings}\Big) .$$

Symmetry requirements important in modelling multiparton correlators; color flow:



Consequences for coupling of color strings to proton remnants?

Rederive results of AGK in pQCD

Derive in pQCD the same counting rules as in AGK paper.

a) Inclusive cross section: k cut pomerons inside n Pomerons:

$$F_k^n \propto (-1)^{n-1-k} \frac{n!}{k!(n-k)!}, \qquad k = 0, ..., n-1$$

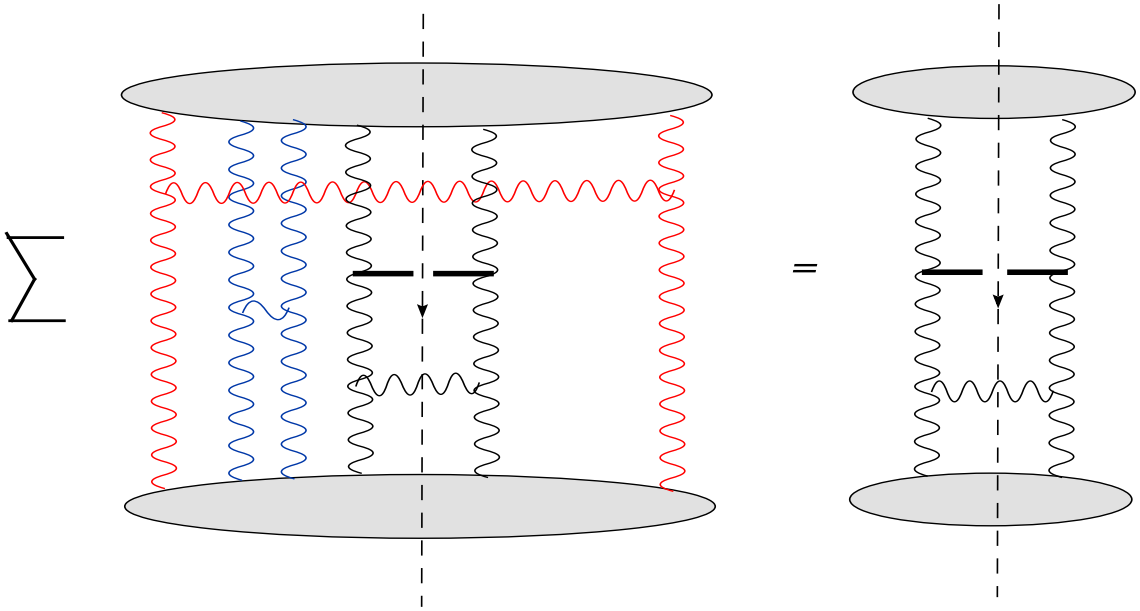
for the probability of finding k cut Pomerons among n Pomerons.

If you want to sum over n: need model, e.g. the eikonal coupling:

$$P(s, \vec{b}) = \frac{[\Omega(s, \vec{b})]^k}{k!} e^{-\Omega(s,\vec{b})}$$

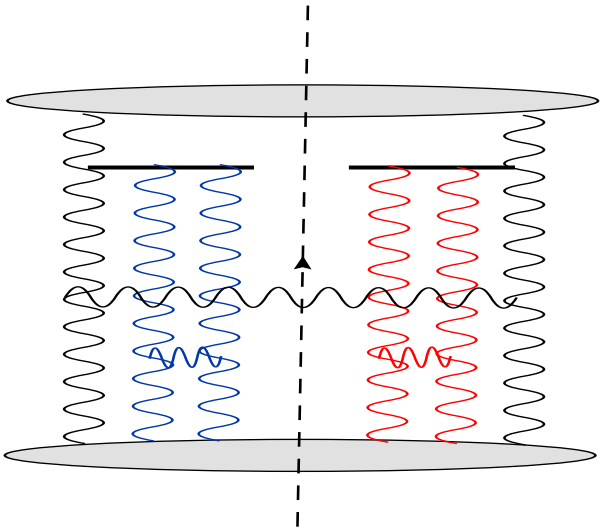
for the probability of finding k cut BFKL Pomerons any number of exchanged Pomerons.

b) Another famous AGK result: cancellations in inclusive jet cross sections

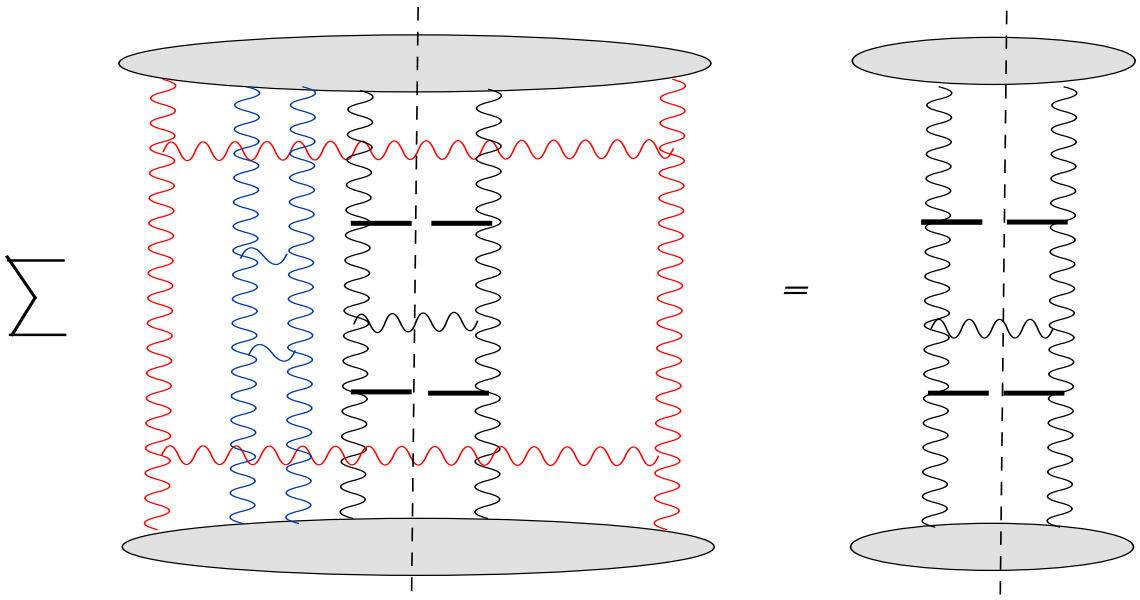


Works in pQCD. Includes soft rescattering. Agrees with QCD factorization theorems.

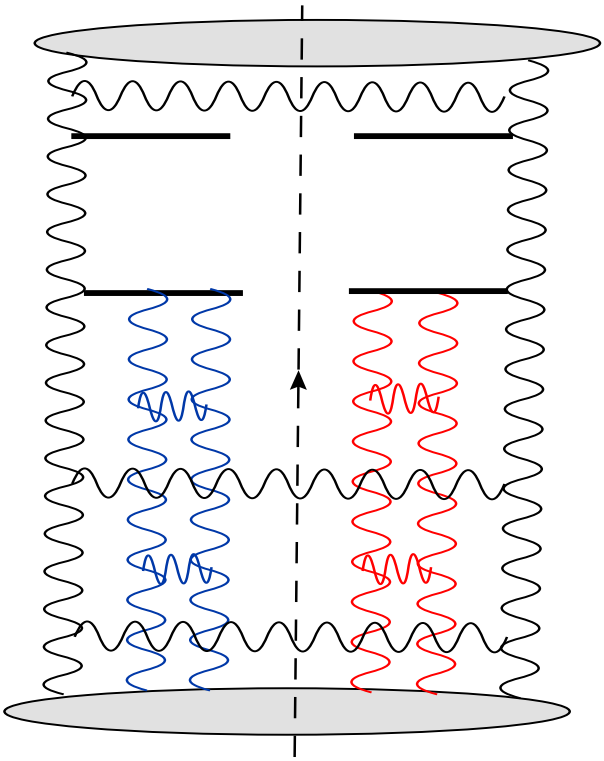
But: possible rescattering effects between jet and one of the projectiles:



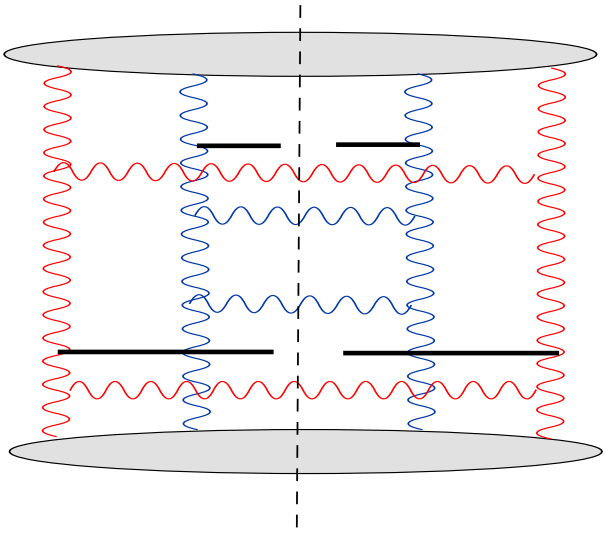
The same in double inclusive cross sections:



But there are rescattering effects between jet and projectile, e.g.

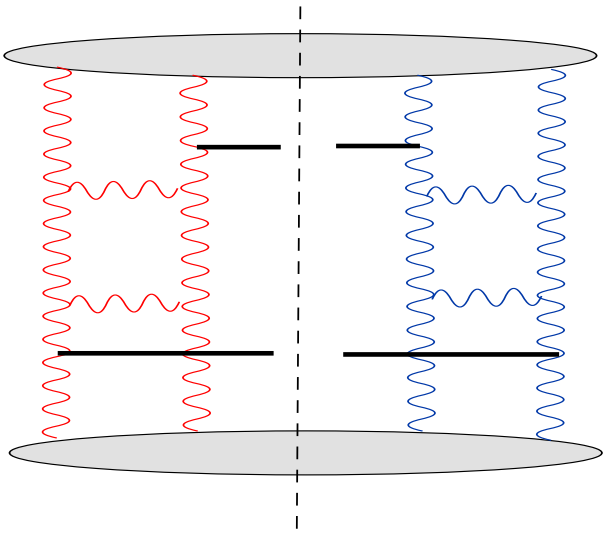


and a new contribution (Mueller-Navelet jets):



Energy dependence: double intercept, compared to single ladder cross section (Tevatron Data).

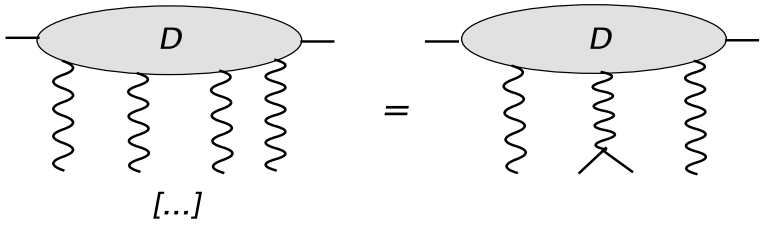
Interesting connection with hard color singlet exchange:



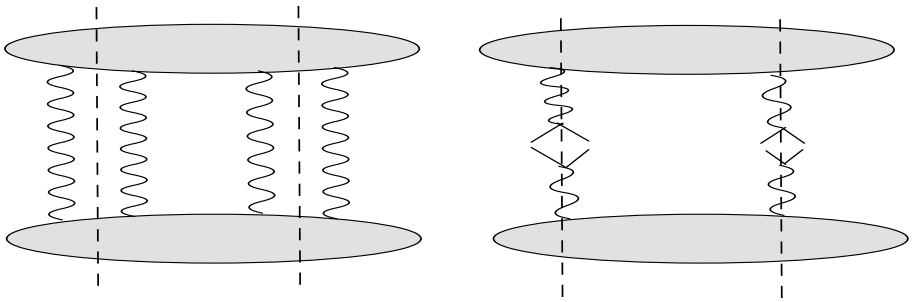
Needs to be worked out.

A few new results

There are more new results which could not be derived from the AGK paper.
a) Reggeization of the gluon. Explicit calculation shows that there exist new configurations, antisymmetric couplings to the projectile, e.g.



Leads to cut gluons , can be discussed in the framework of AGK cutting rules (odd signature reggeon):

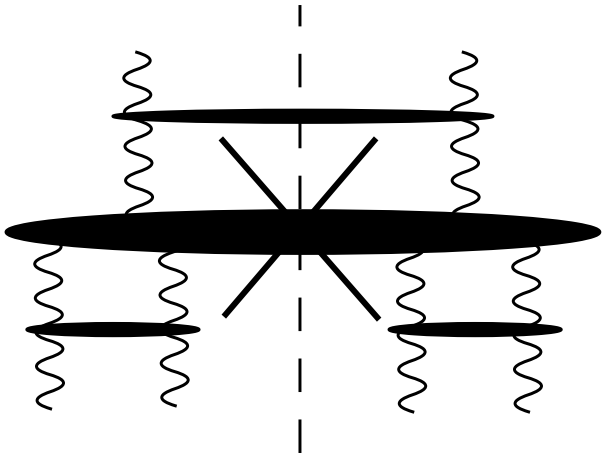


In many applications: higher order effect.
Unfortunately:
cannot be neglected in DIS (diffractive $q\bar{q}$ production),
and in the pp scattering (inclusive jet vertex at LHC):

naive AGK counting of Pomerons is not sufficient.

b) Cut vertices: no general cutting rules, but can be computed in pQCD.

Example: inclusive jet production: may violate the symmetry requirements, (see discussion above), therefore AGK might not be applicable between the jet vertex and the projectile. (→ (Kovchegov et al., Braun))



Outlook

What has been accomplished:

- rules for multiparton contributions at small x
- see how AGK works in pQCD
- there exist studies of multiple interactions (Lund, R.Field; not discussed in this talk)

What needs to be done:

- understand theory of multiparton correlators, connection with higher twist evolution etc.
- calculate multiparton - jet vertices
- need to know the size of the coupling functions N_n: more work on MC's, test out on HERA data (F_2, DIS diffraction).

Transport of HERA-results/expertise to LHC has been started, needs much more work.