Saturation effects in final states and total cross section due to CCFM with absorptive boundary

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Motivation

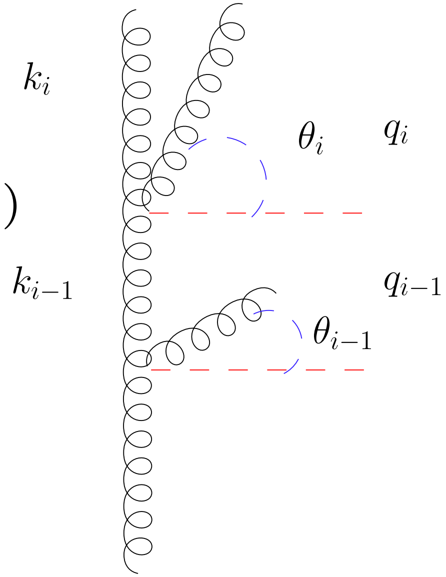
- HERA $\longrightarrow$ hints that at small fraction of proton momentum $x \sim 10^{-4}$ and low virtuality of the transverse momentum of the parton $\longrightarrow$ new kind of dynamics: BFKL growth? saturation?
- However, at HERA we cannot clearly see it. LHeC will probe gluon density at smaller proton momentum fraction.
- We know that NLO corrections to BFKL and for DGLAP are large.
- Important $\longrightarrow$ use BFKL $+$ DGLAP $\longrightarrow$ one is source of subleading corrections for the other. Compact way $\longrightarrow$ CCFM.
- Be prepared for description of dense partonic system $\longrightarrow$ possible saturation effects
- Monte Carlo approach allows us to study exclusive processes.
- CASCADE is MC in k_T factorisation approach where saturation -high density physics can be addressed

CCFM evolution equation

Strong ordering in angle of emitted gluons: $\theta_i \gg \theta_{i-1}$

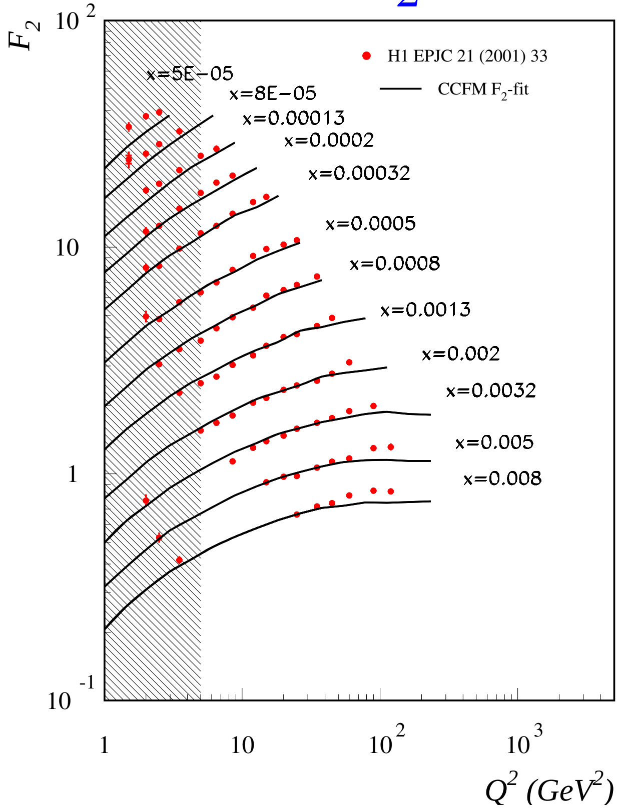
Integral equation:

$$xA(x, k_T, q) = xA_0(x, k_T, q) + K \otimes xA(x, k_T, q)$$



Contains information on angular distribution.
k_T transverse momentum of the most upper gluon q, factorization scale, $xA_0(x, k_T, q) \longleftarrow$ to be determined by fit. Implementation of CCFM in Monte Carlo $\longrightarrow$ CASCADE (Jung) $\longrightarrow$ exclusive, inclusive processes

F_2 from CCFM



- Good description
- However, at LHeC we go to smaller x...

Possible new effects

- CCFM is a linear $A(x, k_T, q) \sim x^{\beta}$
- Unitarity requirements $\longrightarrow$ $A(x, k_T, q)$ "less steep growth" e. g. $log(x)$$\longrightarrow$ saturation

Saturation sort of recombination of partons

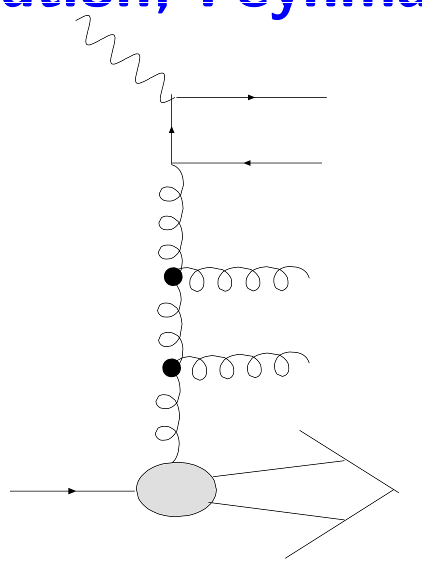
$\downarrow$

introduces part of unitarity corrections

$\downarrow$

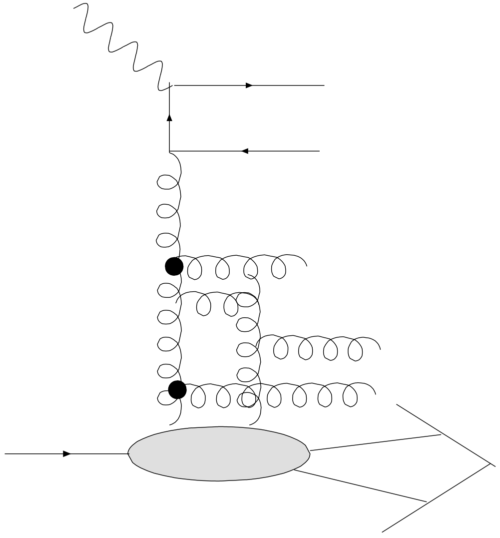
modeled by nonlinear evolution equations (Balitsky-Kovchegov, JIMWLK)

Saturation, Feynman diagrams and evolution equation



Leads to linear evolution equation

BFKL, CCFM,...

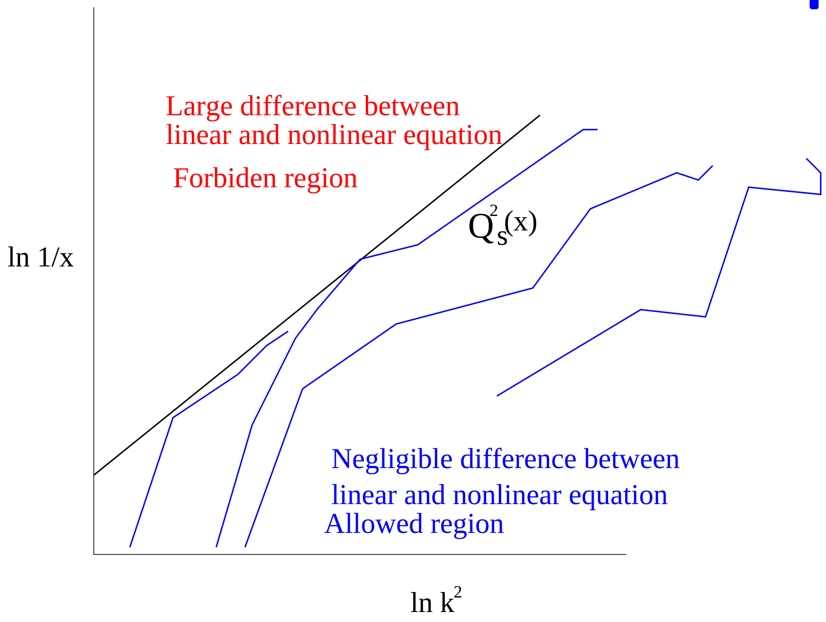


Leads to nonlinear evolution equatior

BK, GLR, GLRMQ

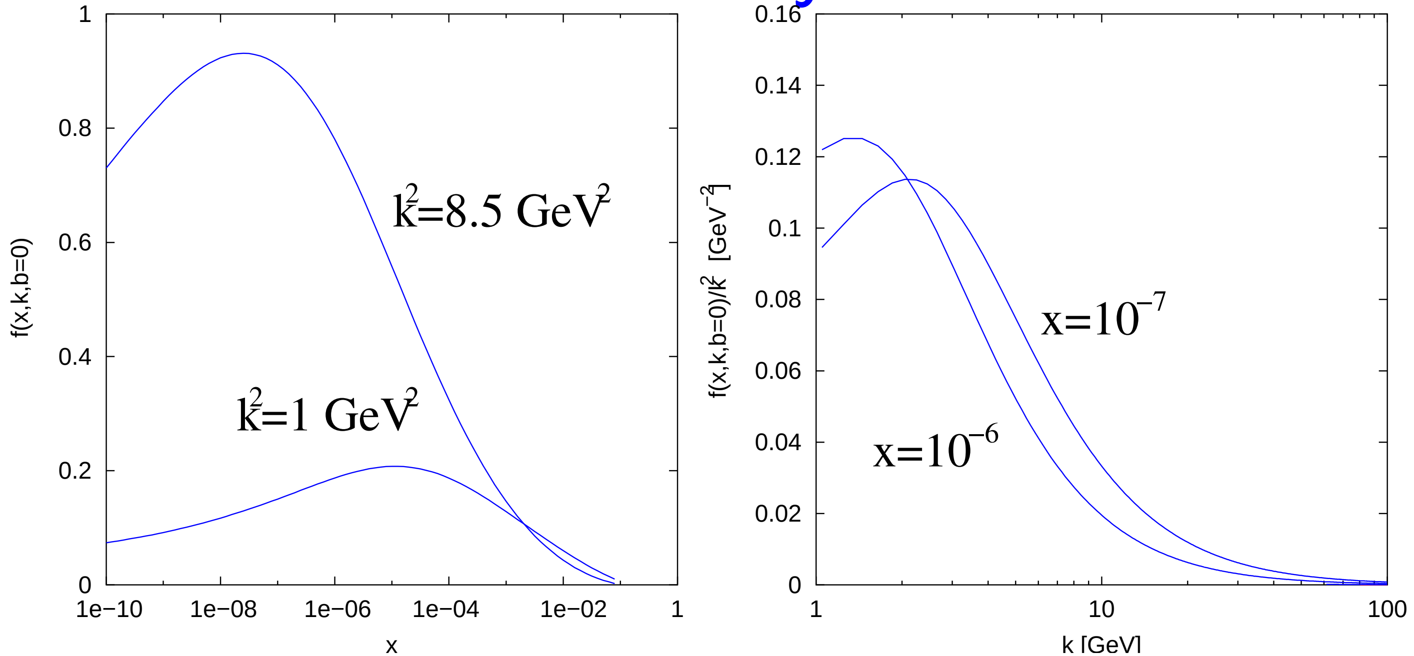
- Nonlinearity $\longrightarrow$ saturation scale emerges Q_{sat}
- On solid grounds for nuclei, model for nucleon
- Leads to geometric scaling $\longrightarrow \sigma_{\gamma^* p}(x, Q^2) = \sigma_{\gamma^* p}(Q^2/Q_s^2)$ (Golec-Biernat, Kwieciński, Staśto)

Saturation and linear evolution equation



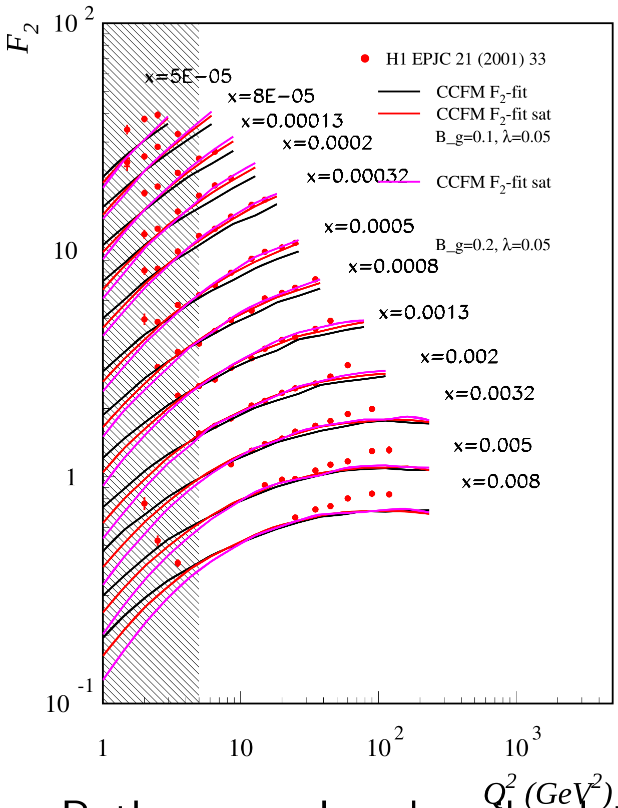
- One can require the amplitude coming from linear evolution equation (BFKL, CCFM) for some combination of gluon momentum and rapidity to be constant and close to unity $\longrightarrow$ this defines saturation line in "linear approach" (Mueller, Trintafyllopoulos).
- Monte Carlo $\longrightarrow$ it means that events that end up in saturated region are rejected

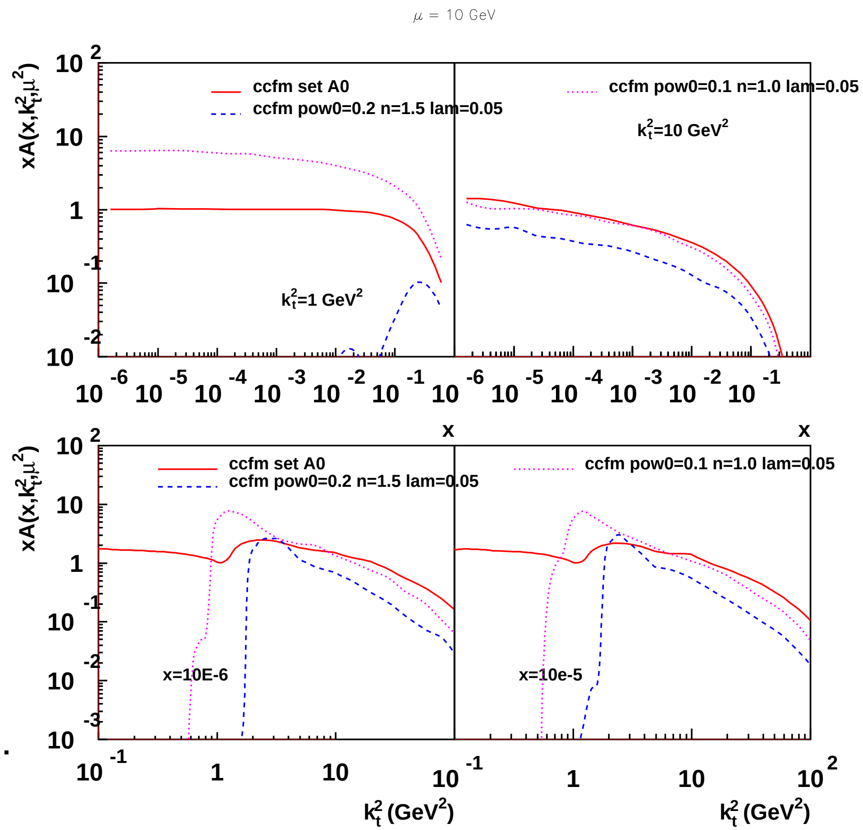
Example and lesson from BK for unintegrated gluon density



- BK predicts valence like unintegrated gluon density (Braun, Kwieciński, Kutak,..)
- Saturation scale emerges
- This depends on details of impact parameter dependence

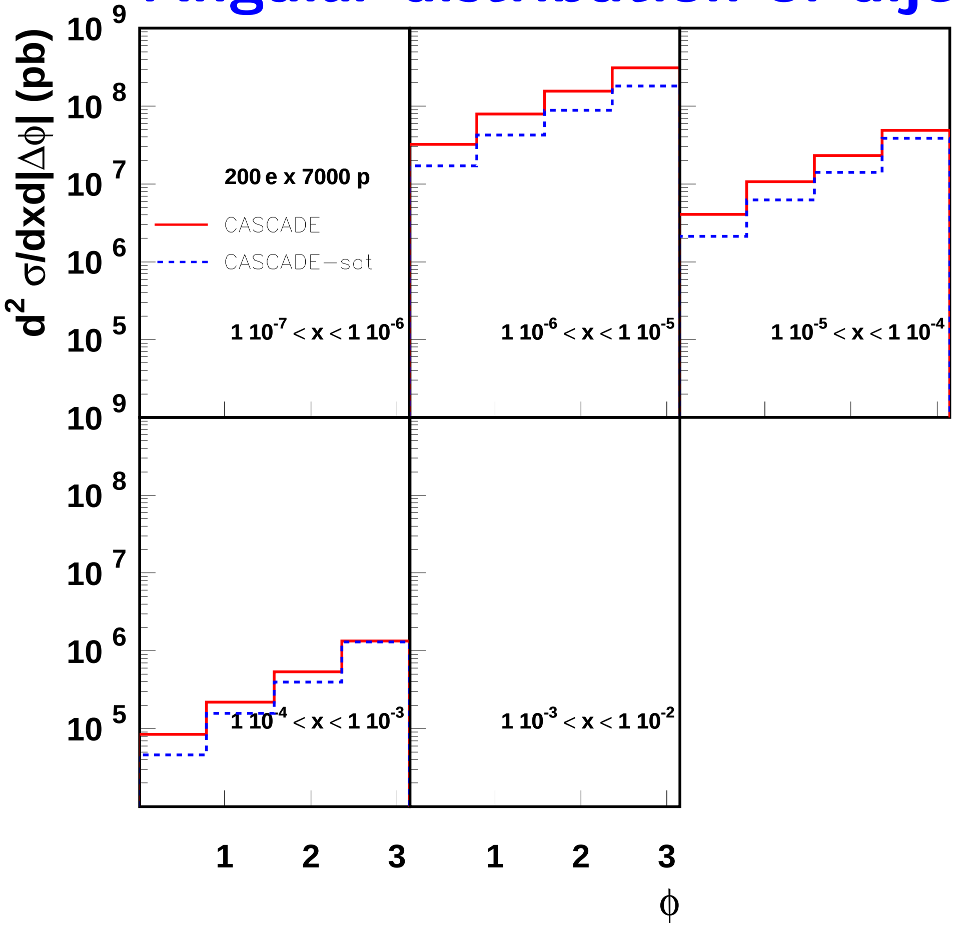
F_2 and gluon density from CCFM with absorptive boundary





- Both approaches describe data equally well.
- However, gluon densities are different...
- Possible implications for exclusive directly sensitive to k_T observables...

Angular distribution of dijets



- In back to back scenario for small x bin we see reduction of x-section

Conclusions and outlook

- We addressed succesfuly saturation issues within CCFM Monte Carlo approach
- We obtained reasonable description of F_2 data

- Impact parameter issues
- Various scenarios for imput distribution
- Even more precise fit