Saturation effects in final states due to CCFM with absorptive boundary

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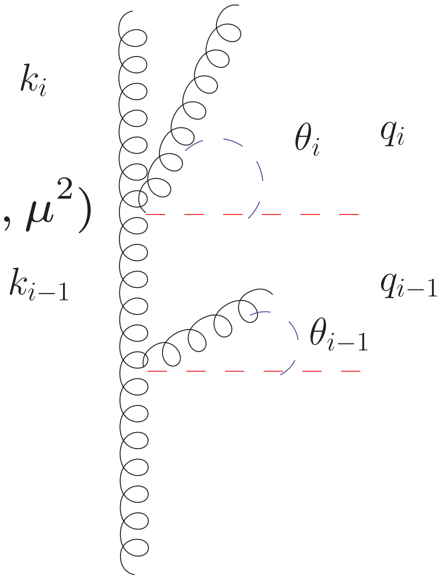
Motivation

- HERA → hints that at small fraction of proton momentum $x \sim 10^{-4}$ and low virtuality of the parton → new kind of dynamics: BFKL growth? saturation?
- However, at HERA we cannot clearly see it. In the future we will probe gluon density at smaller proton momentum fraction.
- We know that NLO corrections to BFKL and for DGLAP are large.
- Important → use BFKL + DGLAP → one is source of subleading corrections for the other. Compact way → CCFM.
- Be prepared for description of dense partonic system → possible saturation effects
- In k_T factorisation approach one can address problems of saturation.
- 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:

$$xA(x, k_T, \mu^2) = xA_0(x, k_T, \mu^2) + K \otimes xA(x, k_T, \mu^2)$$

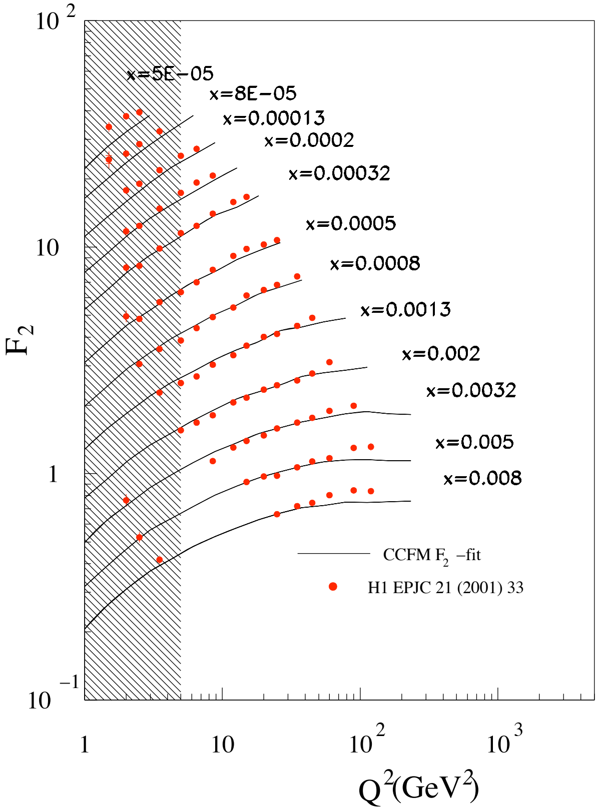
Contains information on angular distribution.

k_T transverse momentum of the most upper gluon μ, factorization scale, $xA_0(x, k_T, \mu^2) \longleftarrow$ to be determined by fit. Implementation of CCFM in Monte Carlo $\longrightarrow$ CASCADE (H.Jung)

F_2 from CCFM

$$F_2(x,Q^2) = \Phi(k_T^2) \otimes x A(x, k_T^2, Q^2)$$

- Good description
- However, at lower x...



Possible new effects

- CCFM is a linear $A(x, k_T, \mu^2) \sim x^\beta$
- Unitarity requirements $\rightarrow$ $A(x, k_T, \mu^2)$ "less steep growth" e. g. $log(x) \rightarrow$ saturation

Saturation sort of recombination of partons

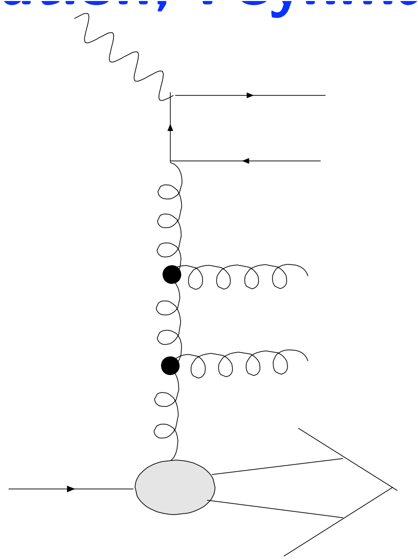
$\downarrow$

introduces part of unitarity corrections

$\downarrow$

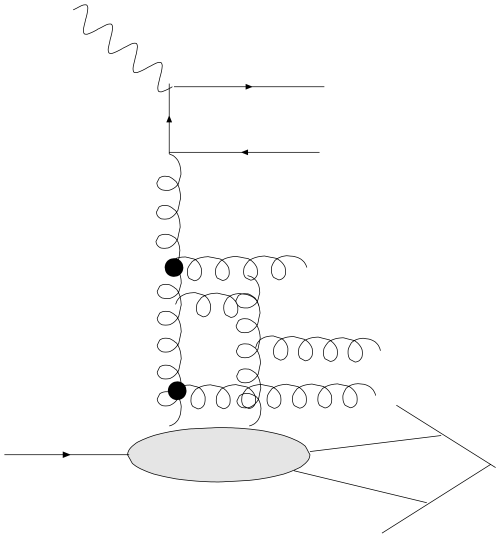
modeled by nonlinear evolution equations (Balitsky-Kovchegov, JIMWLK)

Saturation, Feynman diagrams and evolution equation



Leads to linear evolution equation

BFKL, CCFM,...

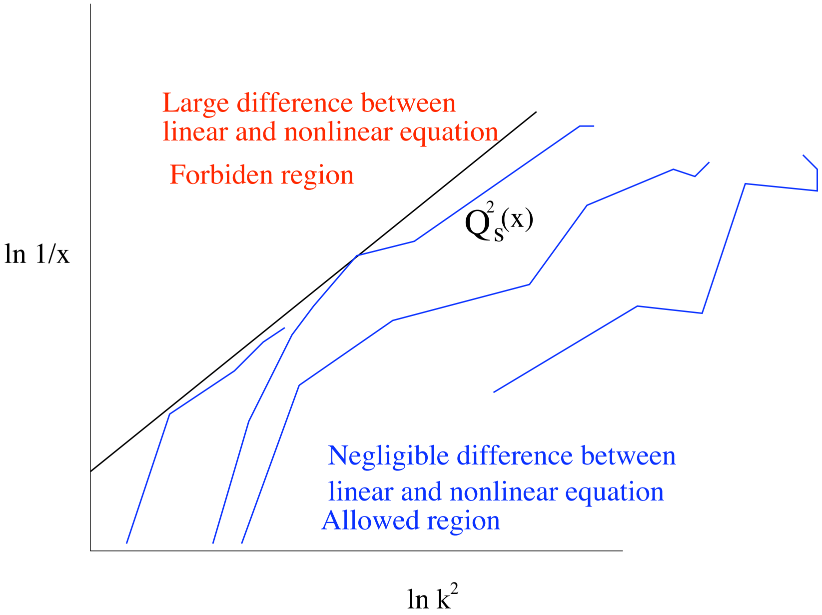


Leads to nonlinear evolution equatio

BK, GLR, GLRMQ

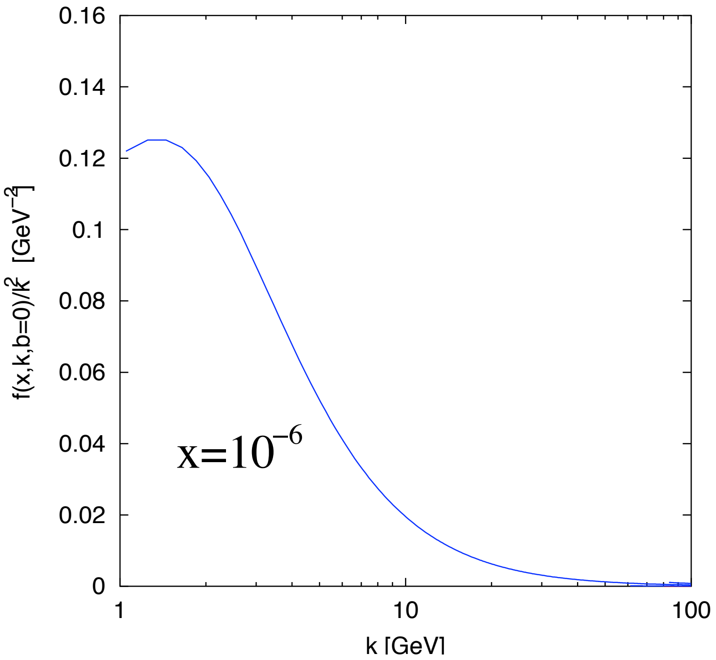
- Nonlinearity → saturation scale emerges Q_{sat}
- On solid grounds for nuclei, model for nucleon
- Leads to geometric scaling →$\sigma_{\gamma^* p}(x, Q^2) = \sigma_{\gamma^* p}(Q^2/Q_s^2)$

Saturation and linear evolution equation



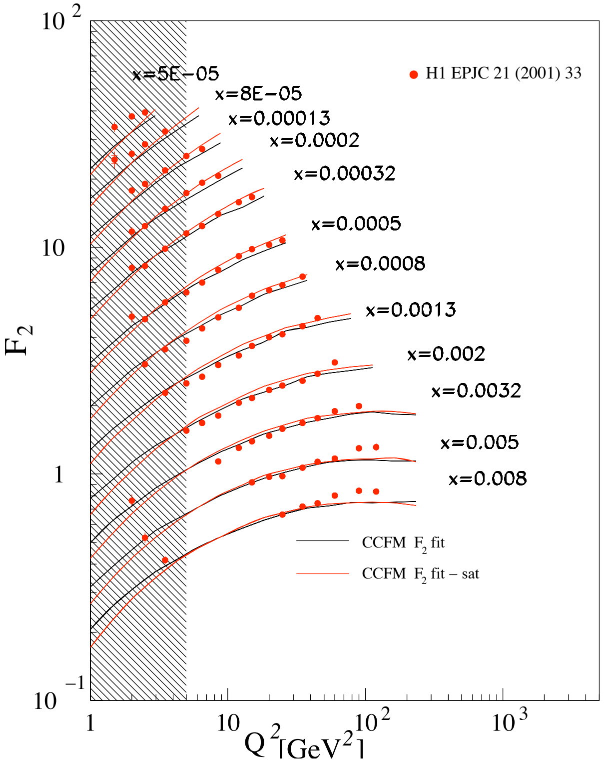
- One can require the amplitude coming from linear evolution equation (BFKL, CCFM) for some combination of gluon momentum and rapidity to be constant and close to unity → this defines saturation line in "linear approach" (Mueller, Trintafyllopoulos).
- Monte Carlo → it means that events that end up in saturated region are rejected
- At present we use GBW saturation line $Q_{sat} = Q_0(x_0/x)^{\frac{\lambda}{2}}$

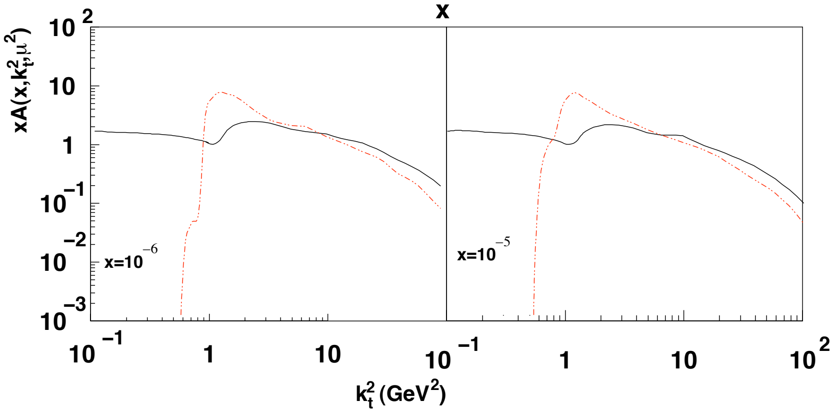
Example and lesson from BK for unintegrated gluon density



- Saturation scale emerges
- Universal shape for fixed impact parameter

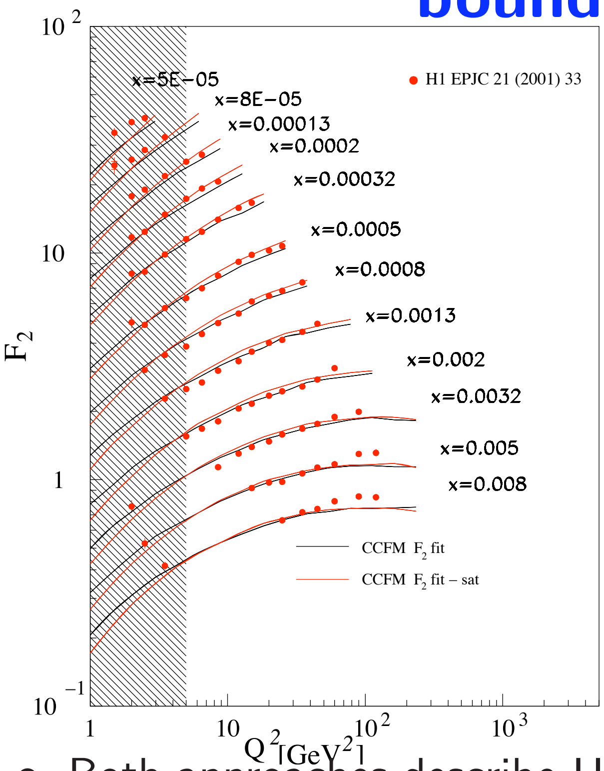
F_2 and gluon density from CCFM with absorptive boundary - preliminary results

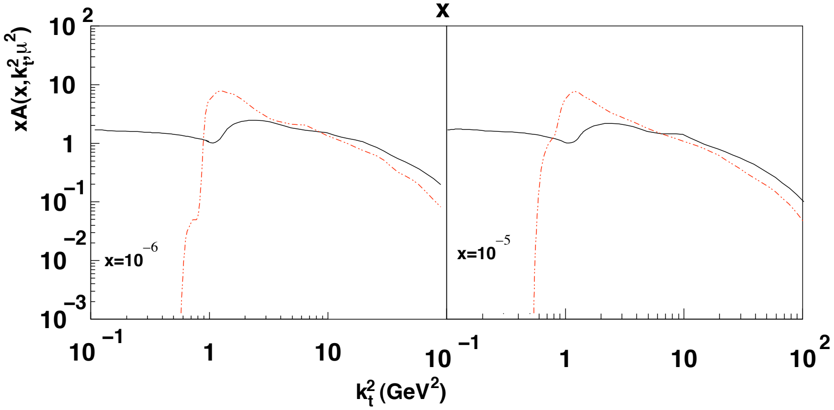




Parameters→ $xA_0(x,k^2) = Nx^{\alpha}(1-x)^4 e^{(k^2-k_0^2)/\mu}$, $Q_{sat} = Q_0(x_0/x)^{\lambda/2}$

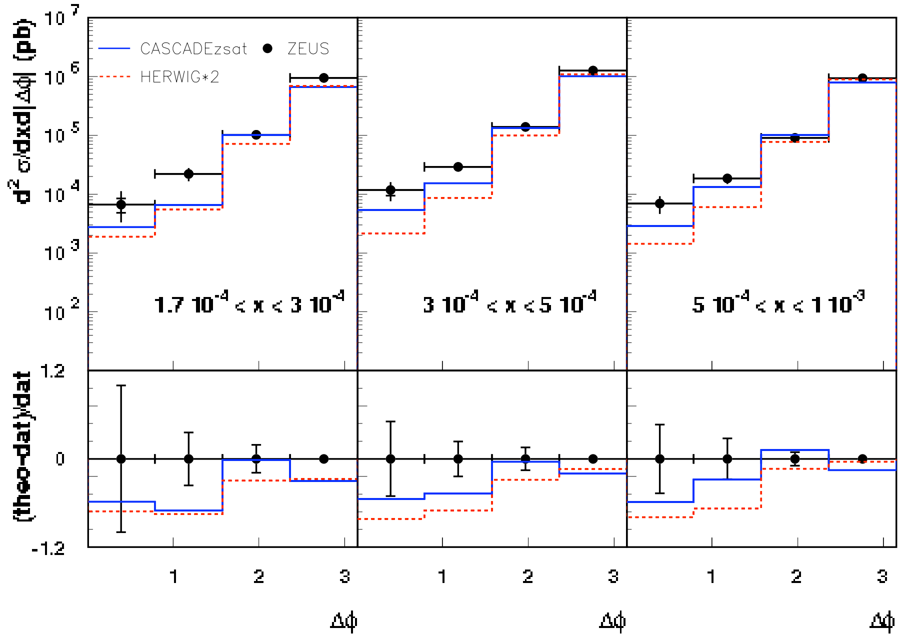
F_2 and gluon density from CCFM with absorptive boundary - preliminary results

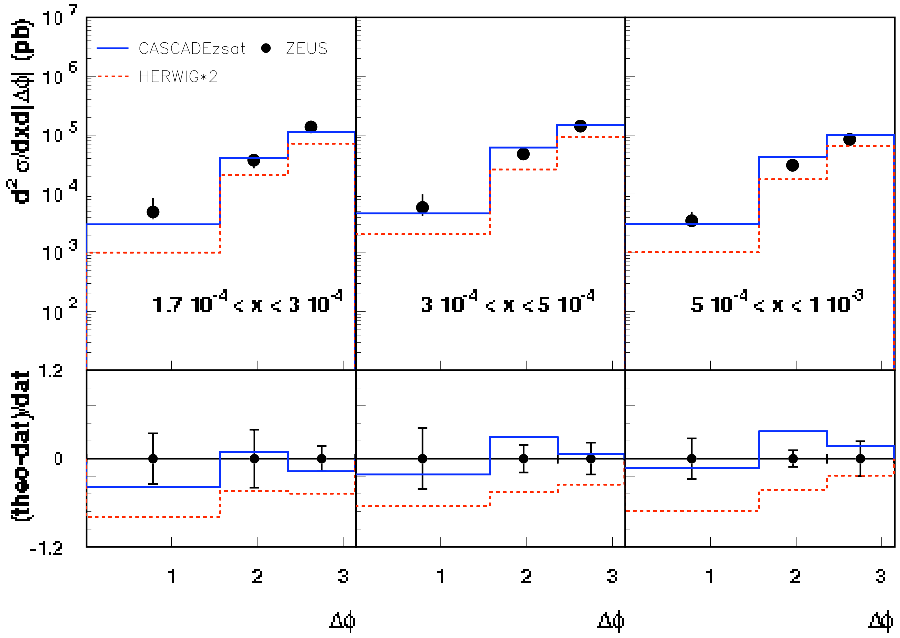




- Both approaches describe HERA data equally well. However, gluon densities are different...
- Possible implications for exclusive directly sensitive to k_T observables...

Angular distribution of jets in DIS

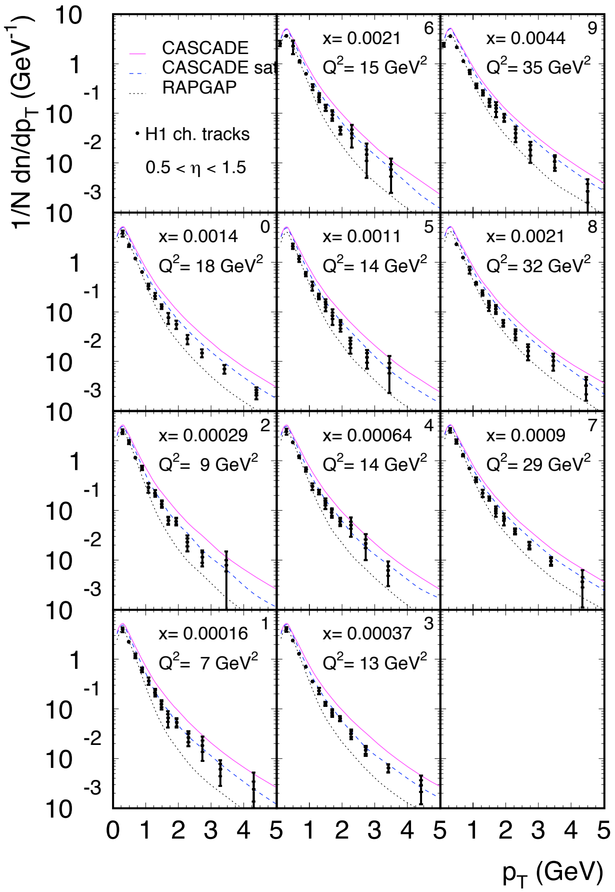




- left figure → dijets
- right figure → three jets

Distribution of charged particles

Data → desy96-215-1



Conclusions and outlook

- We addressed successfully saturation issues within CCFM Monte Carlo approach
- We obtained reasonable description of F_2 data
- We have description of exclusive observables with saturation
- We studied DIS but we can also adress hadron-hadron questions.

- Impact parameter issues
- Various scenarios for input distribution