Connection between DIS at small x and high energy pp collisions

Gösta Gustafson
coll. with Leif Lönnblad & Gabriela Miu
hep-ph/0209186 (PRD 69, 031020, 2003)

hh-coll.: Conventional collinear factoriz.

→ High $p_\perp$ jets

But: Minijet cross section diverges

$$\sigma_{jet} \sim \frac{1}{p_\perp^4}$$

Also total $E_\perp$ diverges.

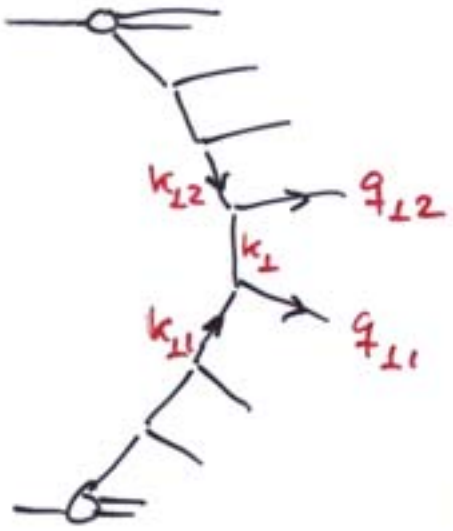
Cut off needed: Pythia fit to data ⇒

⇒ $p_{\perp 0} \sim 2$ GeV growing with energy.

Difficult to extrapolate to the high energies at LHC.

$k_\perp$ - factorization

cf talk by Szczurek



$k_\perp < k_{\perp 1}, k_{\perp 2}$ ⇒

Off shell ME does not blow up when $k_\perp \to 0$.

$k_\perp$ does not determine jet $q_\perp$.

⇒ total $E_\perp$ finite

$\sigma_{jet} > \sigma_{tot}$ ⇒ Several hard subcollisions in each event.

⇒ correlations important

Pedestal effect ⇒ hard coll. not indep

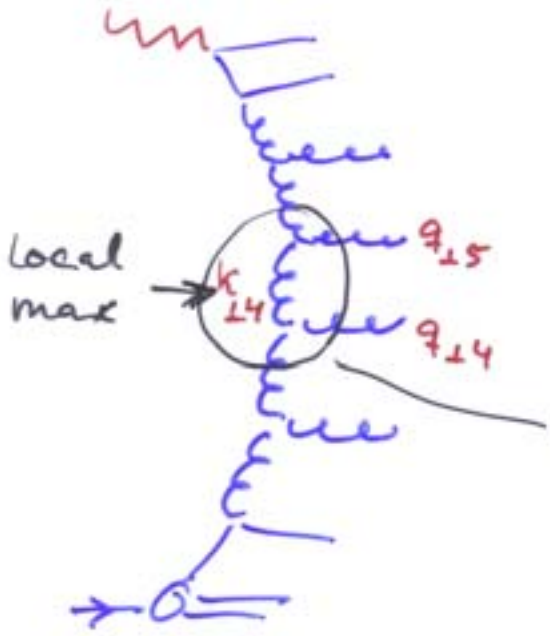
Impact parameter dependense:

central coll.: many minijets

peripherd coll.: few " "

How can DIS data improve predictions for hadronic collisions?

Small x: BFKL: Non-$k_\perp$-ordered parton chains important

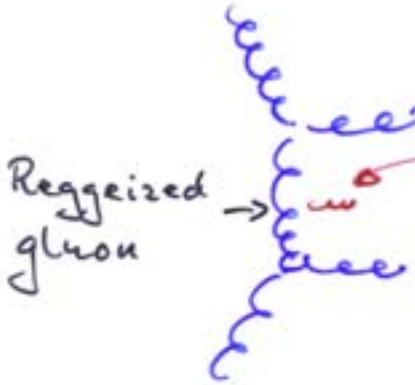


$q_{\perp 4} \approx k_{\perp 4} \approx q_{\perp 5}$

Single local max → Resolved photon interaction.

Several local maxima ⇒ Correlated hard subcoll.

BFKL integral eq. only inclusive



soft emissions compensated by virtual corrections

Do not contribute to parton distrn

But do " " a final state properties

Added with Sudakov form factors.

CCFM-model interpolates between BFKL & DGLAP

Some soft emissions included in initial state rad. ⇒

Extra suppression from non-eikonal form factors

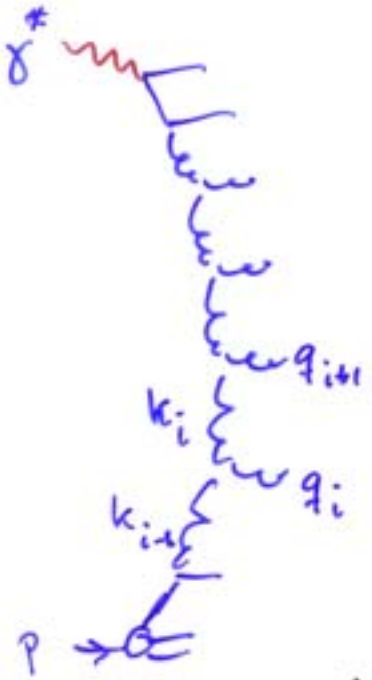
Linked Dipole Chain (LDC) model (Lund)

Reformulation and generaliz. of CCFM

Separation ISR - FSR more similar to BFKL formal

q final strad. if $q_1 < k_1$

⇒ ISR chain in LDC is symmetric photon end – proton end.



Leading order in $\ln 1/x$:

$$F \sim \sum_n \prod_i^n \int\int \frac{3\alpha_s}{\pi} \frac{dz_i}{z_i} \frac{dq_{\perp i}^2}{q_{\perp i}^2} \times$$

$$\times \theta(q_{\perp i} - \min(k_{\perp i}, k_{\perp i-1}))$$

$$q_{\perp i}^2 \approx \max(k_{\perp i}^2, k_{\perp i-1}^2)$$

$$\Rightarrow \frac{dq_{\perp i}^2}{q_{\perp i}^2} \approx \frac{dk_{\perp i}^2}{k_{\perp i}^2} \quad \text{except local max. or min.}$$

local max. $k_{\perp i}$ $\Rightarrow$ $\frac{dk_{\perp i}^2}{k_{\perp i}^4}$ hard subcoll.

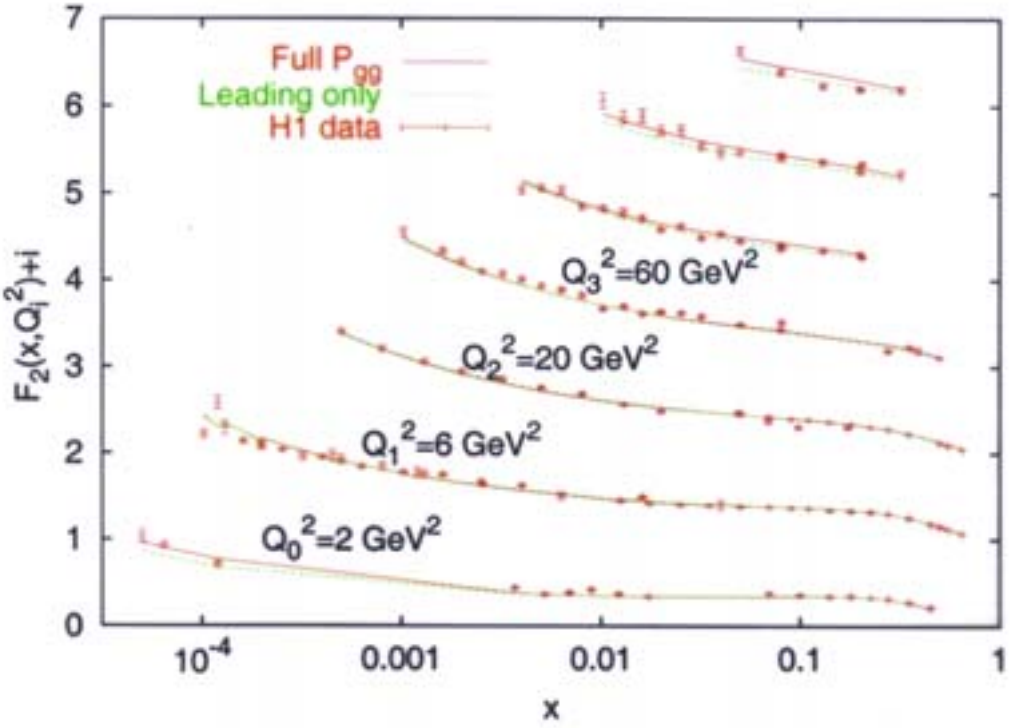
local min $k_{\perp i}$ $\Rightarrow$ $dk_{\perp i}^2$ no divergence (fig 2.)

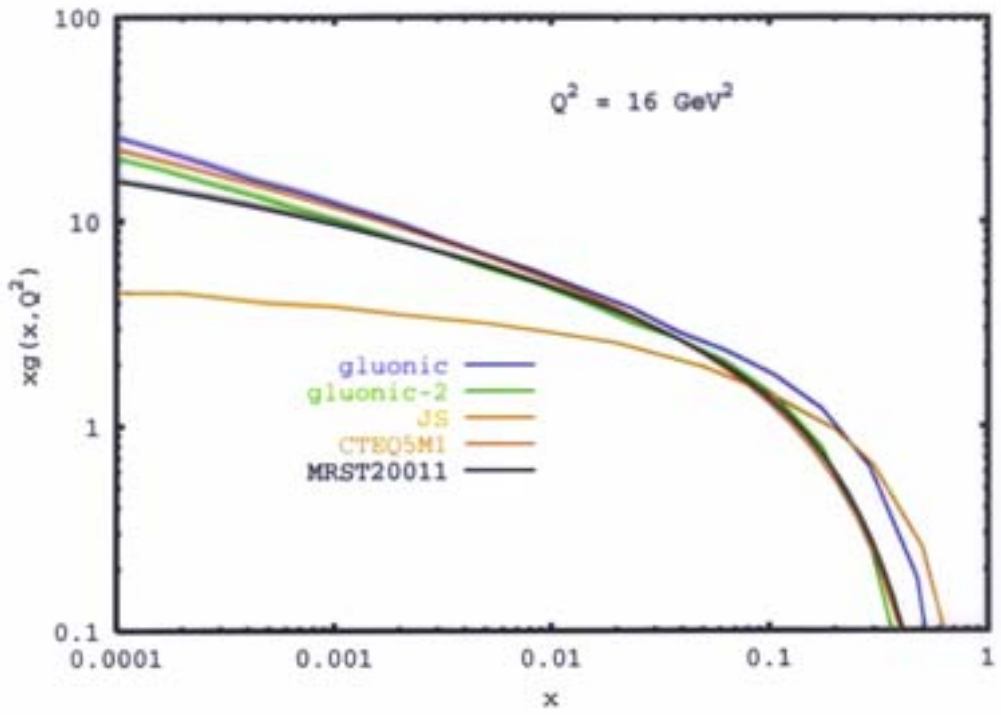
Symmetry ⇒ Also applicable to hh coll.

Fit to DIS ⇒ cross section for a chain in pp coll.

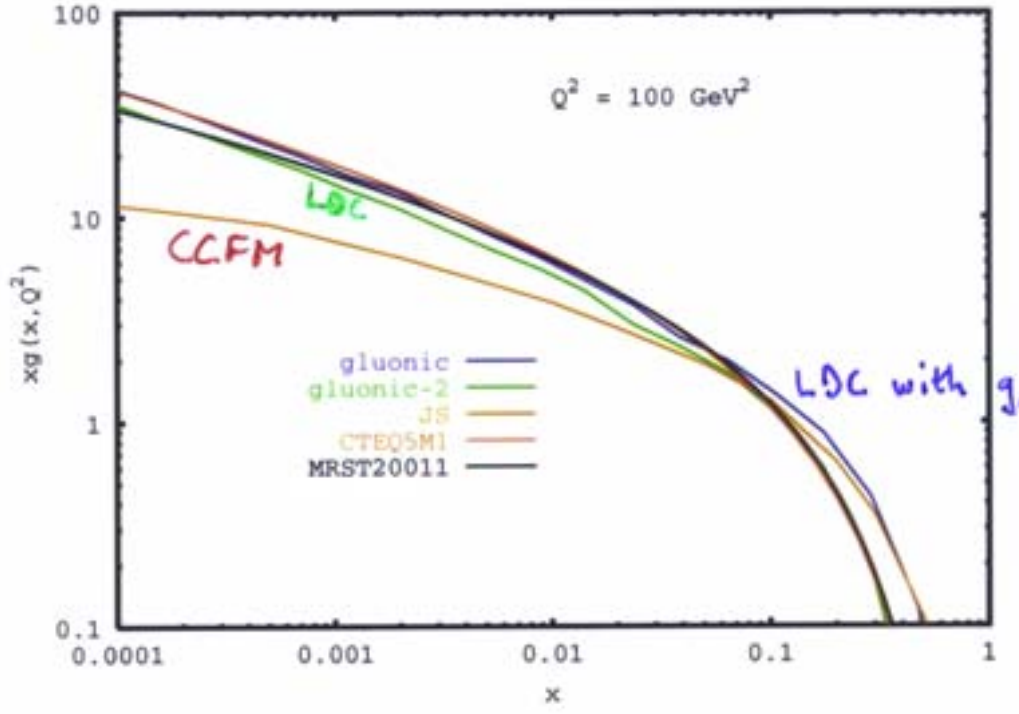
(possibly more than one hard subcoll.)

F_2 Linked Dipole Chain MC





Integrated gluon distributions



LDC with $g_0 \propto (1-x)^4$ fixed

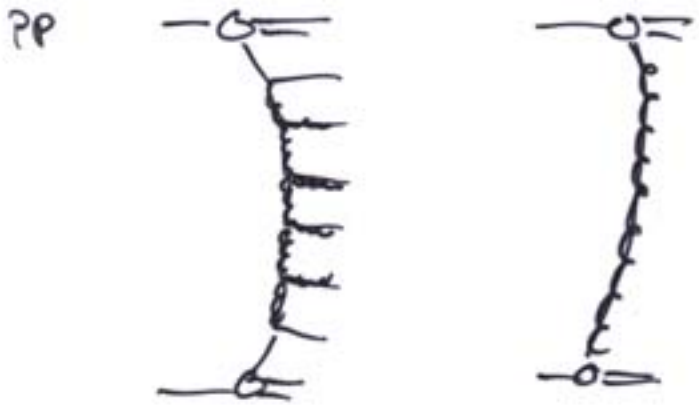
Lönnblad-Miu - GG JHEP '02

Potential problem

Fit to DIS : Running κ_s =>

=> Soft cutoff Q_0 needed.

Good fits to DIS data possible with different cuts if input distrib. $f_0(x, Q_0^2)$ is ajusted accordingly.



hard chain $q_i > Q_0$

soft chain $q_i < Q_0$

$Q_0^2 \nearrow \Rightarrow$ $\searrow$ $\nearrow$

Linked Dipole Chain model for hadronic coll.

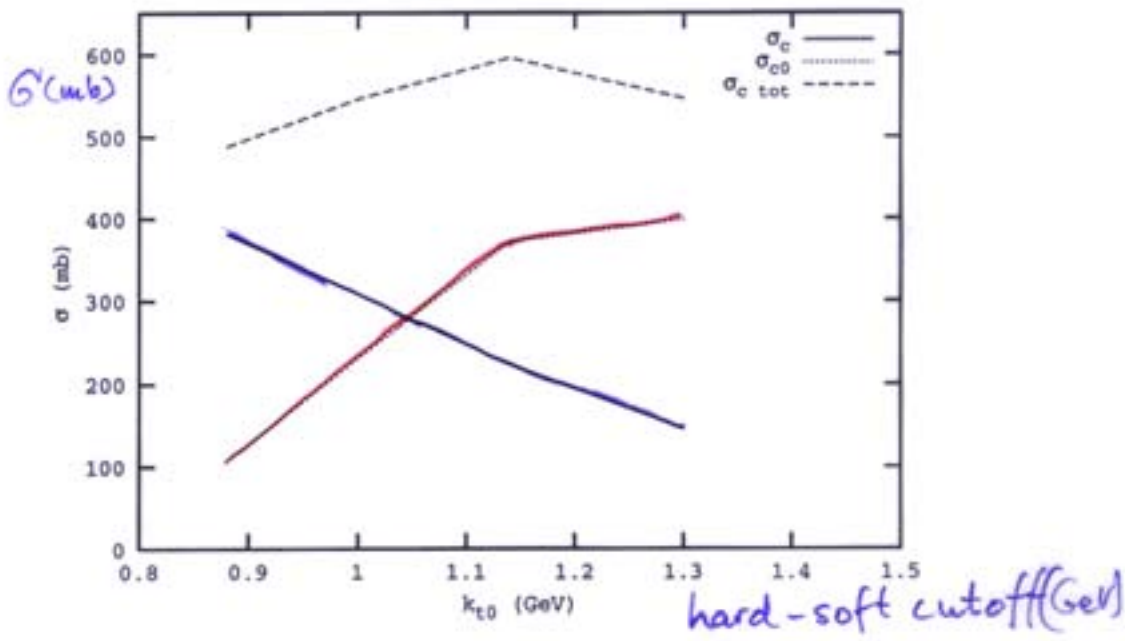
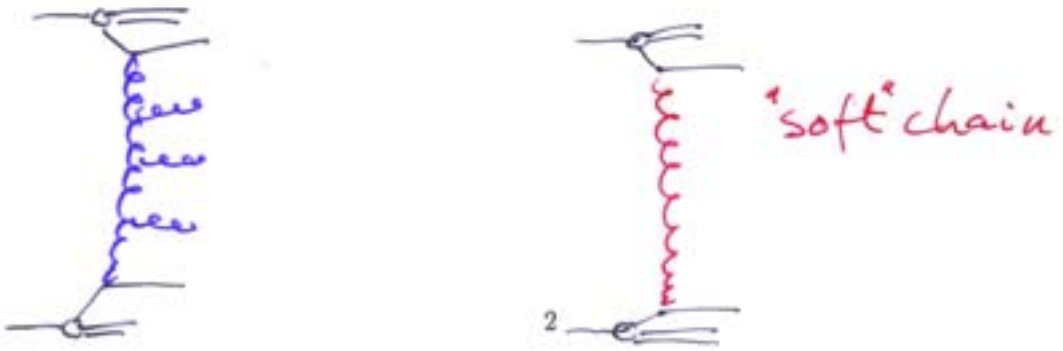


Figure 2: *The cross section per chain in the LDC model as a function of the cutoff, $k^2_{\perp 0}$. The full line is the cross section for chains with at least on emission above the cutoff, the dotted line is for chains without emissions above the cutoff, and the dashed line is the sum of the two. Note that the input parton densities have been refitted for each value of $k^2_{\perp 0}$.*

Cross section for hard scatt chain



Total cross section for a chain

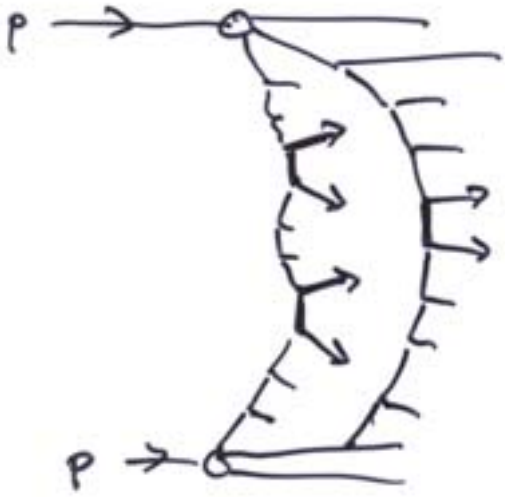
independent of the soft cutoff !!

$$\sigma_{chain} = \sigma_{hard\,chain} + \sigma_{soft\,chain}$$

fixed from DIS

Strong connection DIS - pp scatt.

Multiple interactions from 2 hard scatterings in the same chain and from more than one chain in a single event



Uncorrelated chains : Poisson distrib.

Pythia : b-dep. double Gaussian ~ Geometric distrib.

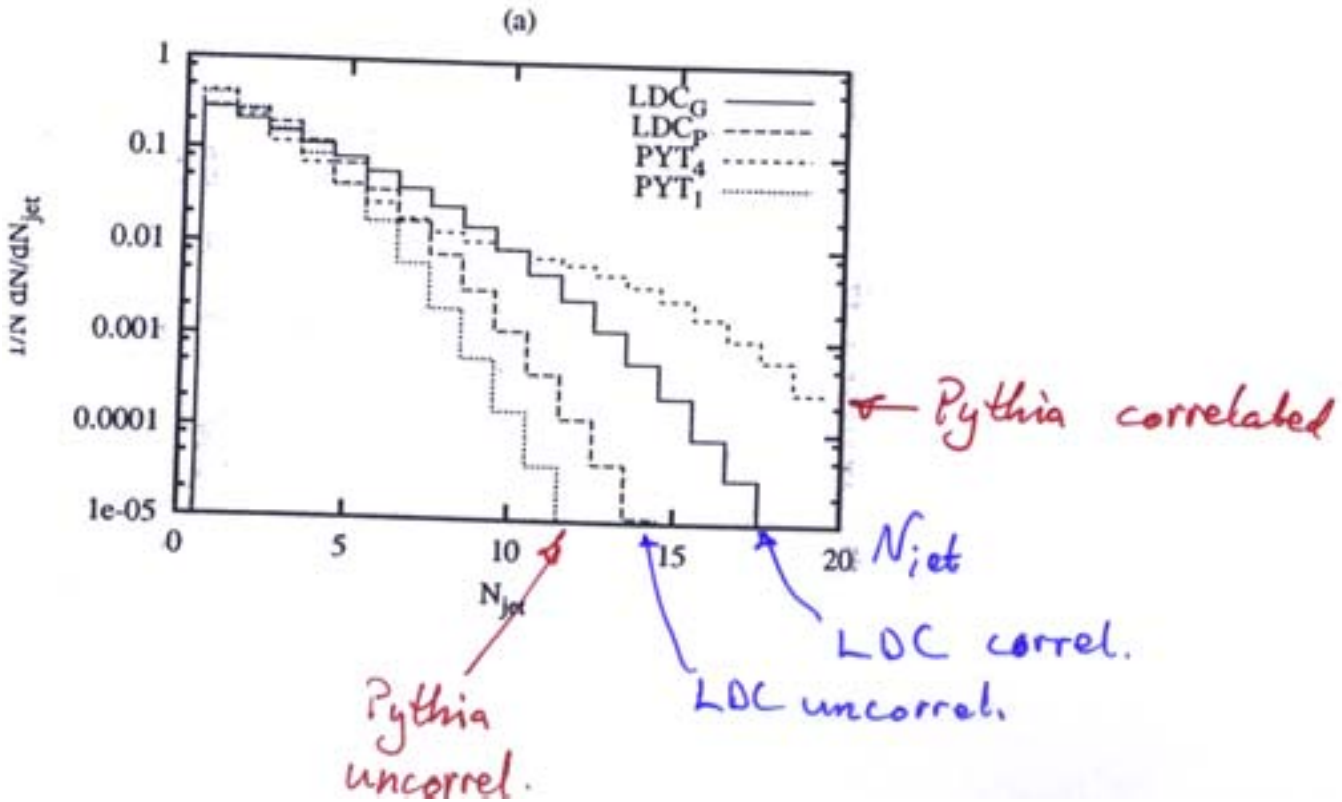
but tail reduced by energy conserv.

($\langle n_{ch} \rangle \sim 14 \rightarrow \sim 7$)

Prel. results. Hadroniz. not included
(dep. on colour connection)

$\sqrt{s} = 1.8$ TeV

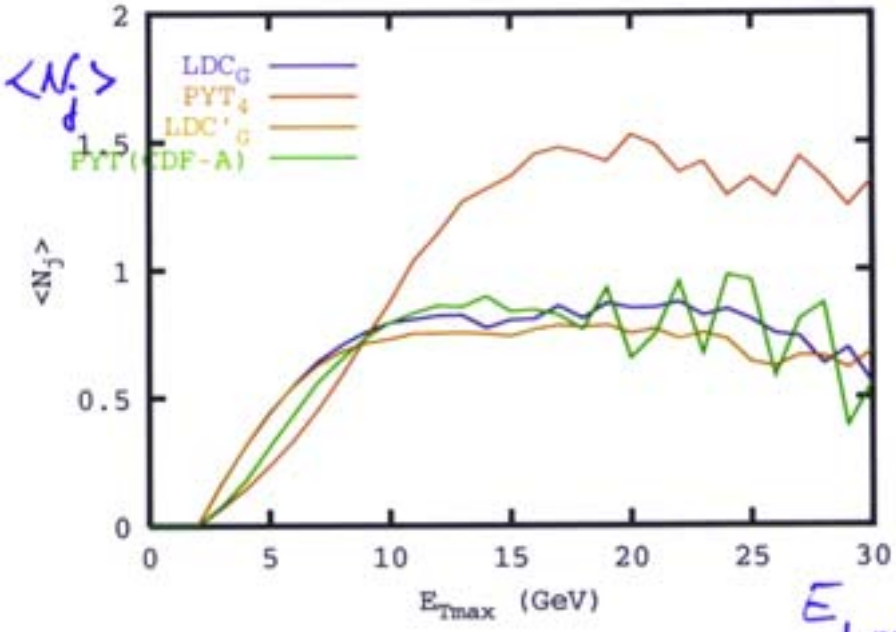
Minijets in $|\eta| < 2.5$ in events with $E_{\perp max} > 10$ GeV



Cutoff dependence

Pedestal effect: #jets in minimum azim.

1.8 TeV $|\eta|<2.5$



LDCMC $k_{\perp 0}$:

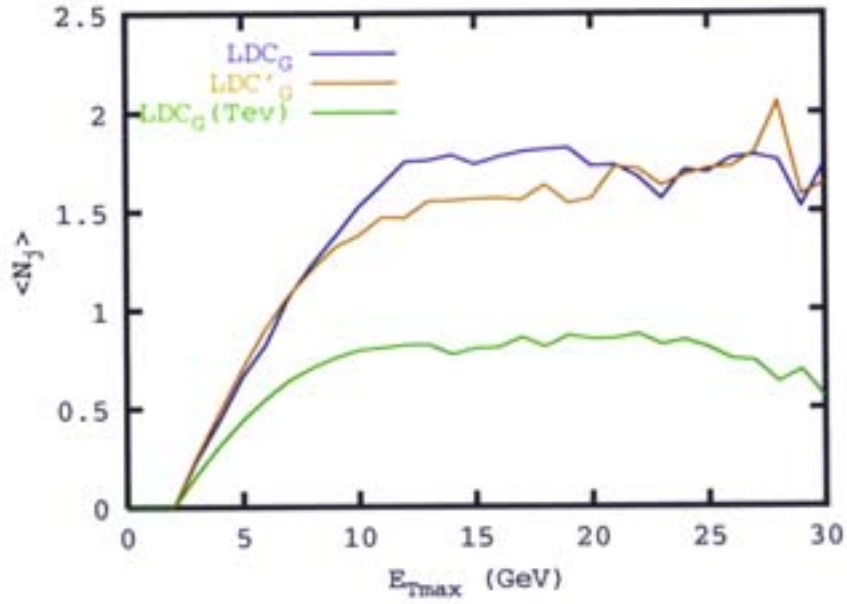
0.99 GeV→ 1.3 GeV

PYTHIA:

Default→CDF-A

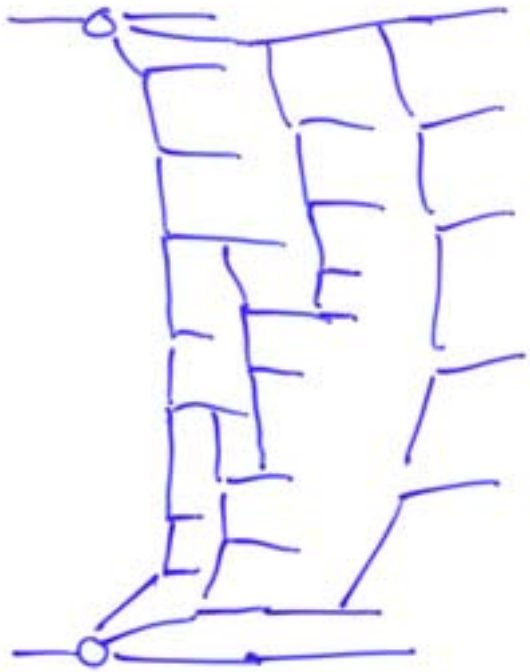
↑ CDF tune

LHC?



LDCMC $k_{\perp 0}$:
$0.99 \rightarrow 1.3$ GeV

Unitarization and saturation



$$\sigma_{chain} \propto s^{\lambda}$$

$$\langle n_{chain} \rangle \propto \frac{s^{\lambda}}{\sigma_{tot}}$$

The chains join at one end at the same rate as they multiply at the other.

Work on saturation and diffraction in progress.

Conclusions

- New way of describing final states in hadronic collisions uses $k_\perp$-factorization (LDC)
- Cutoff independent underlying event and pedestal effect
- Everything predicted from fit to DIS F_2

Future:

- Colour connections between mult. chains must be improved
- Studies of correlations, saturation and diffraction in progress