

Transverse momentum of charged particles at low Q^2 at HERA

Anastasia Grebenyuk

on behalf of the H1 collaboration

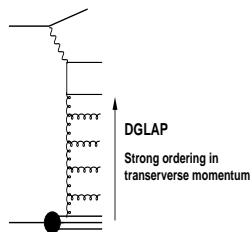
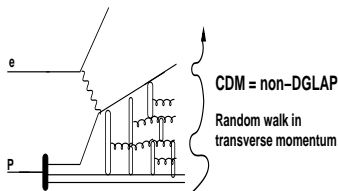
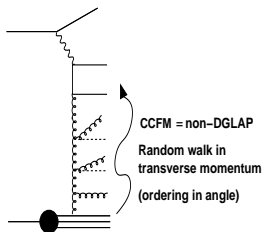
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Outline

- Introduction and motivation
- Analysis details
- Results
- Summary

Evolution equations

DGLAP
(RAPGAP)CDM (Color Dipole Model)
(DJANGOH)CCFM
(CASCADE)

DGLAP model $Q_0^2 \ll k_{T1}^2 \ll \dots \ll k_{Tn}^2 \ll Q^2$
DGLAP works when Q^2 is large, but x is not too small

beyond-DGLAP models (random walk in k_T)

- CDM (Color Dipole Model)
(not evolution equation, but gives BFKL-like final state)
works for small x and Q^2 is not large
- CCFM
Valid for both, small and large x

HFS as an access to the dynamics of the cascade

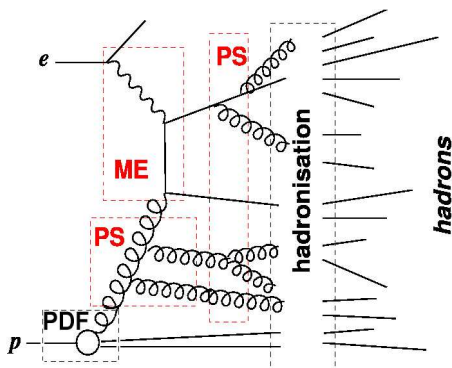
$F_2(x, Q^2)$ has little sensitivity to discriminate between DGLAP and beyond-DGLAP. Semi-inclusive measurements $ep \rightarrow e' hX$ are believed to possess higher discriminating power.

The observables for physics beyond DGLAP at HERA:

- Transverse energy flow
- Forward jets with $p_{Tjet}^2 \sim Q^2$
- Transverse momentum spectra:

Low p_T region:
hadronisation effects are expected to play a role.
Small sensitivity to different parton dynamic models.

Hadrons at large p_T :
disfavoured by the strong p_T ordering \rightarrow difference between different parton dynamics



Experimental setup and reconstruction

- HERA beam energies: $E_e = 27.6$ GeV, $E_p = 920$ GeV
- Data 2006e⁺: $L = 88.64$ pb⁻¹

- *Scattered electron*

Information from scattered positron (E'_e, θ'_e) and hadronic final state is used to reconstruct the kinematics:

$$Q_e^2 = 4E_e E'_e \cos^2 \frac{\theta'_e}{2}$$

$$y_{e\Sigma} = 2E_e \frac{\Sigma_h}{\Sigma^2}$$

$$\Sigma_h = \sum_h (E_h - p_{z,h}); \quad \Sigma = \Sigma_h + \Sigma_e$$

In this analysis:

$$5 < Q^2 < 100 \text{ GeV}^2, \quad 0.05 < y < 0.6$$

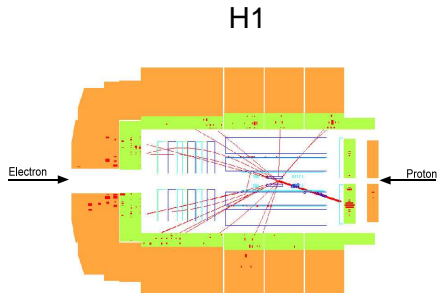
$$10^{-4} < x < 10^{-2}$$

- *For charged particles*

Extension to the forward region is performed.

Track selection:

$$p_T > 0.15 \text{ GeV}, \quad 10^\circ < \theta < 155^\circ, \quad (\text{last preliminary results } 20^\circ < \theta < 155^\circ)$$



Reference frames

- Laboratory frame:

$$\eta = -\ln \tan\left(\frac{\theta}{2}\right)$$

θ - with respect to proton direction

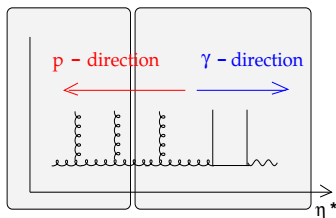
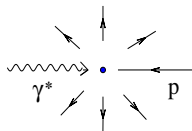
$\eta > 0 \Leftrightarrow$ proton direction

- Hadronic centre-mass system (HCM):

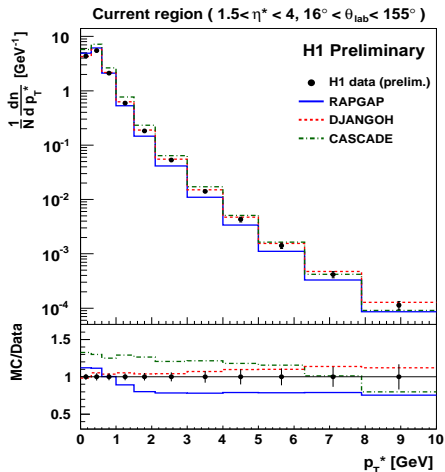
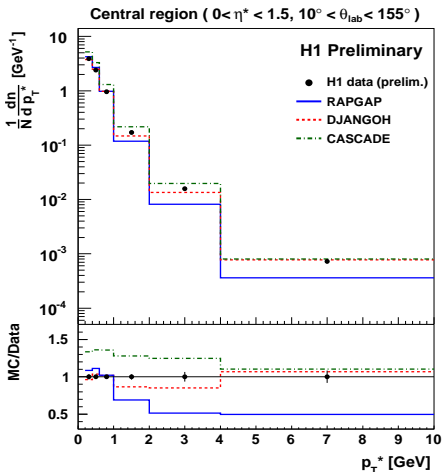
$$\eta^* = -\ln \tan\left(\frac{\theta^*}{2}\right)$$

θ^* - with respect to virtual photon direction

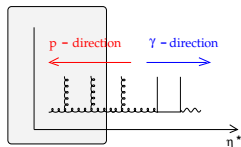
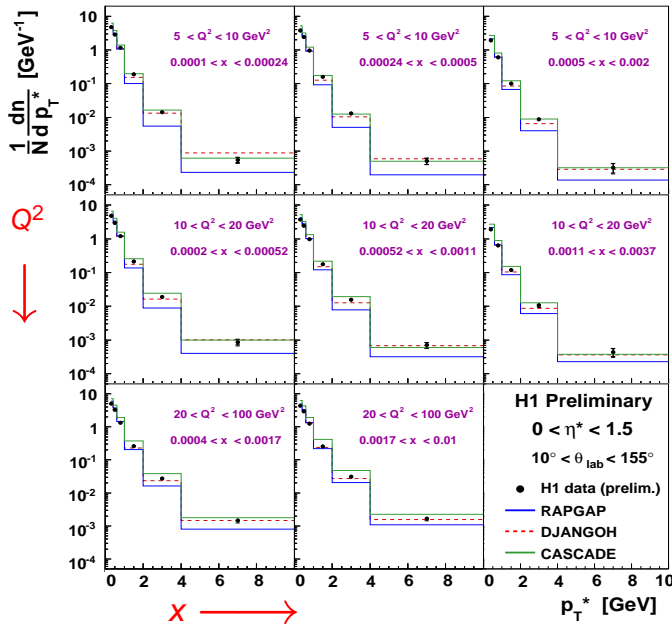
$\eta^* < 0 \Leftrightarrow$ proton direction



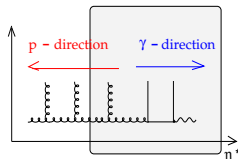
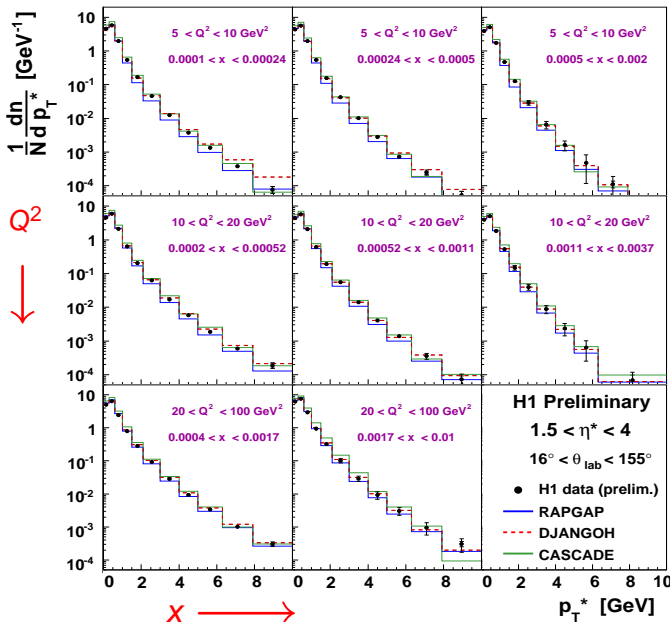
p_T^* distribution is studied in $0 < \eta^* < 1.5$ and $1.5 < \eta^* < 4$ region

p_T^* spectra: DATA vs. DJANGO/RAPGAP/CASCADE

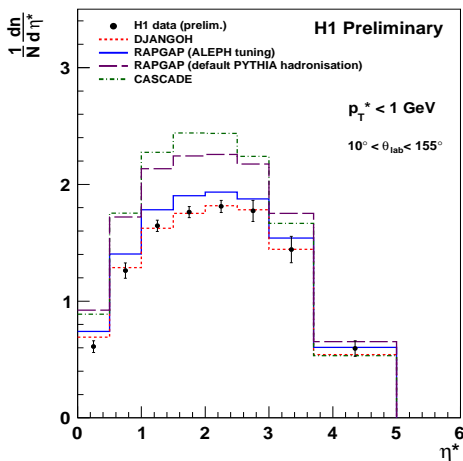
- DJANGO(CDM) describes new data for whole p_T^* spectra
- RAPGAP(DGLAP) is below the data for $p_T^* > 1$ GeV (especially in the forward region)
- In contrast, CASCADE(CCFM) is systematically above the data (except high p_T^*)

p_T^* distribution in bins of (x, Q^2) ; central region

RAPGAP(DGLAP) is substantially below the data at lowest x and Q^2 region at large p_T^*

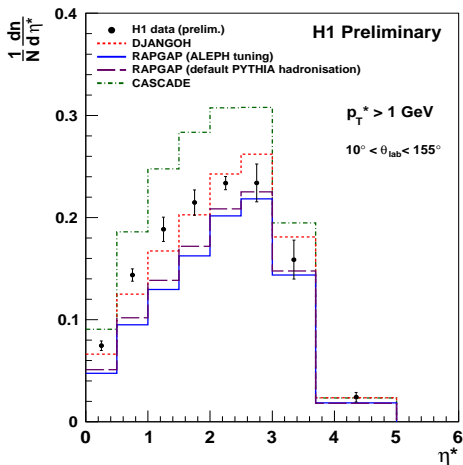
p_T^* distribution in bins of (x, Q^2) ; current region region

RAPGAP(DGLAP)
 provides better
 description of the data
 compared to the
 forward region

η^* - distributionsCharged particles with $p_T^* < 1$ GeV:

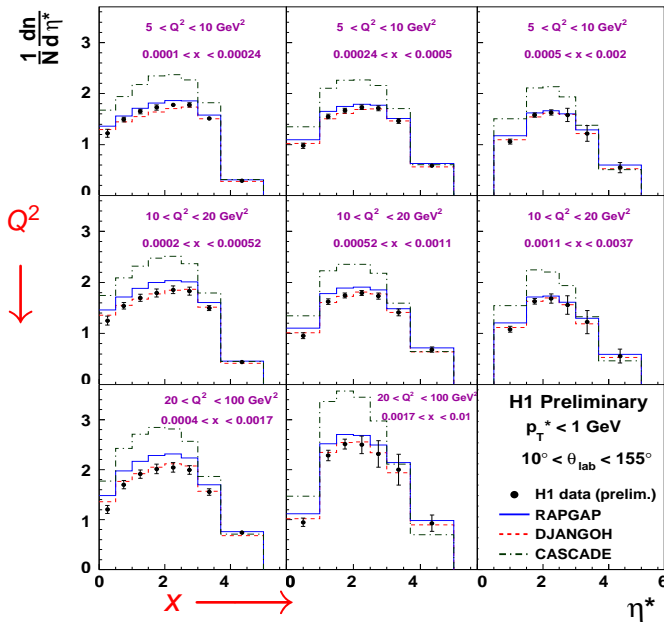
Strong sensitivity to hadronisation parameters.

Weak sensitivity to different parton dynamics.

Charged particles with $p_T^* > 1$ GeV:

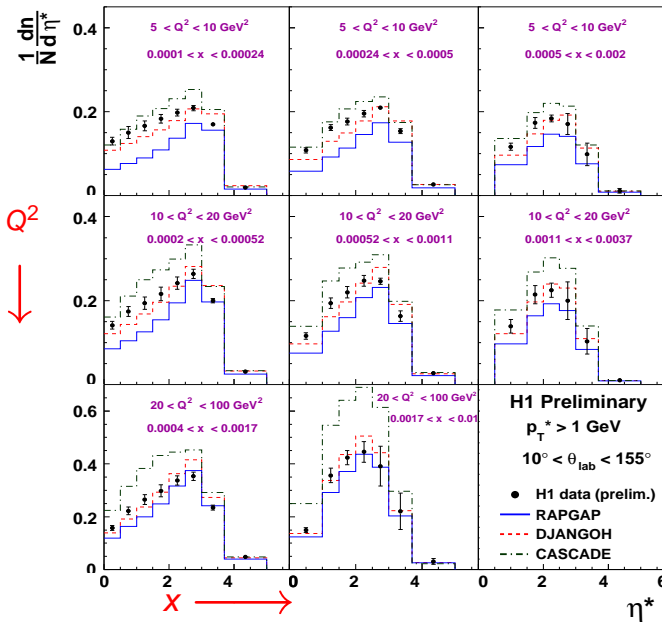
Strong sensitivity to different parton dynamics.

Weak sensitivity to hadronisation parameters.

η^* distribution in bins of (x, Q^2) for $p_T^* < 1$ GeV

DJANGO(CDM) provides reasonable description of the data for all (x, Q^2) -bins. RAPGAP(DGLAP) is slightly above the data for lowest x .

η^* distribution in bins of (x, Q^2) for $p_T^* > 1$ GeV;



RAPGAP(DGLAP) is below the data for almost all (x, Q^2) -bins. The difference is more pronounced in proton direction ($\eta^* < 2$)

Summary

- Transverse momenta and rapidity spectra were measured with H1 detector at HERA (2006 e^+p data)
 - Low p_T^* region ($p_T^* < 1$ GeV):
 - Sensitivity to the fragmentation parameters
 - Both RAPGAP(DGLAP) and DJANGO(CDM) provide reasonable description of the data for both p_T^* and η^* distributions
 - Hard p_T^* region ($p_T^* > 1$ GeV):
 - Sensitivity to the different parton dynamic models
 - DJANGO(CDM) is better than RAPGAP(DGLAP) in describing both, p_T^* and η^* measured spectra, especially at low x
- data are in favour of CDM (Colour Dipole Model) model