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

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on behalf of the H1 collaboration

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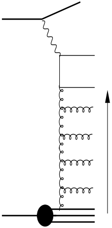
Outline

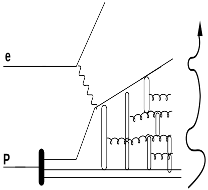
- Introduction and motivation
- Analysis details
- Results
- Summary

Evolution equations

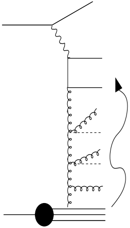
DGLAP
(RAPGAP)



CDM (Color Dipole Model)
(DJANGOH)



CCFM
(CASCADE)



DGLAP model $Q_0^2 \ll k_{T1}^2 \ll \cdots \ll k_{Tn}^2 \ll Q^2$
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

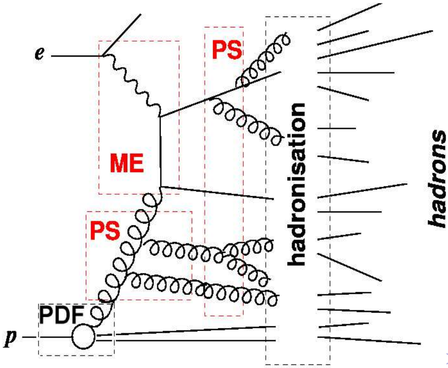
$F_2(x, Q^2)$ has little sensitivity to discriminate between DGLAP and beyond-DGLAP. Semi-inclusive measurements $ep \to e'hX$ are believed to possess higher discriminating power.

The observables for physics beyond DGLAP at HERA:

- Transverse energy flow
- Forward jets with $p^2_{Tjet} \sim Q^2$
- 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 → 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:

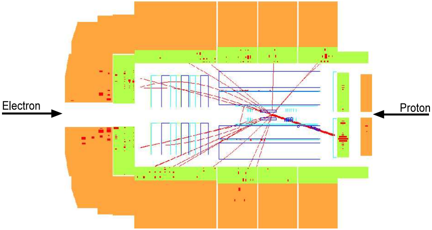
$$Q^2_e = 4E_eE'_e\cos^2\frac{\theta'_e}{2}$$
$$y_{e\Sigma} = 2E_e\frac{\Sigma_h}{\Sigma^2}$$

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

In this analysis:

$5 < Q^2 < 100$ GeV^2, $0.05 < y < 0.6$
$10^{-4} < x < 10^{-2}$

H1



- For *charged particles*

Extension to the forward region is performed.
Track selection:
$p_T > 0.15$ GeV, $10^\circ < \theta < 155^\circ$, (last preliminary results $20^\circ < \theta < 155^\circ$)

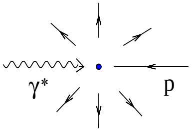
Reference frames

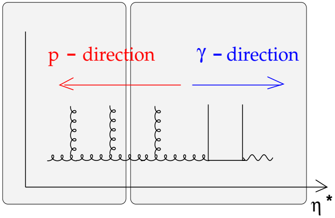
- Laboratory frame:

  $\eta = -\ln\tan(\frac{\theta}{2})$
  θ - with respect to proton direction
  $\eta > 0 \Leftrightarrow$ proton direction

- Hadronic centre-mass system (HCM):

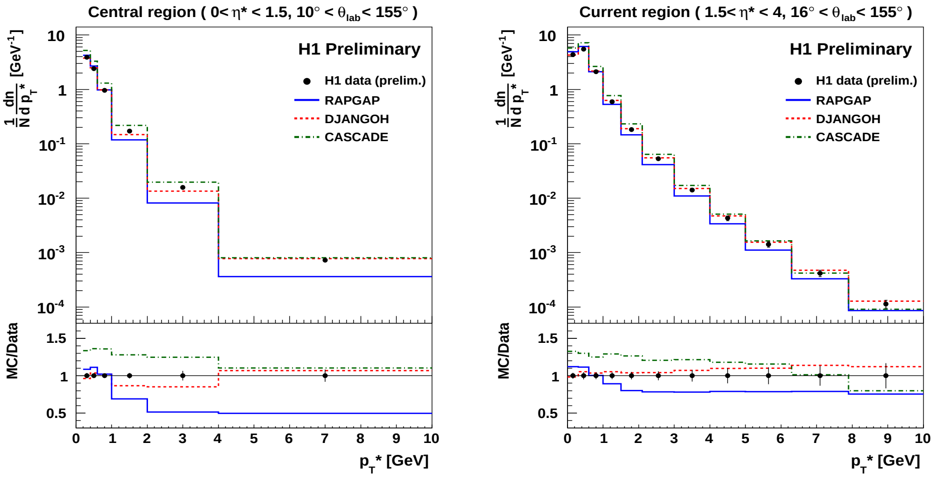
$\eta^* = -\ln\tan(\frac{\theta^*}{2})$
θ^* - with respect to virtual photon direction
$\eta^* < 0 \Leftrightarrow$ proton direction





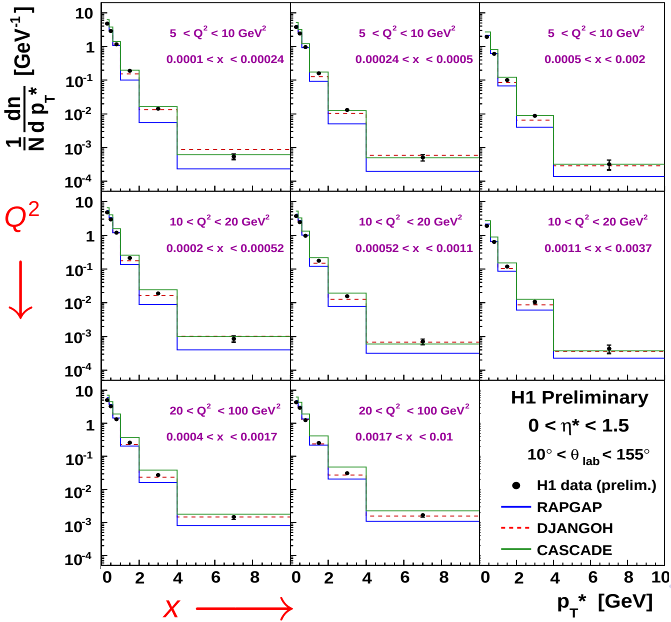
p_T^* distribution is studied in $0 < \eta^* < 1.5$ and $1.5 < \eta^* < 4$ region

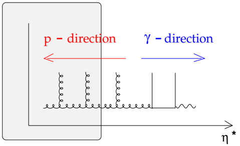
p_T^* spectra: DATA vs. DJANGOH/RAPGAP/CASCADE



- DJANGOH(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 hight p_T^*)

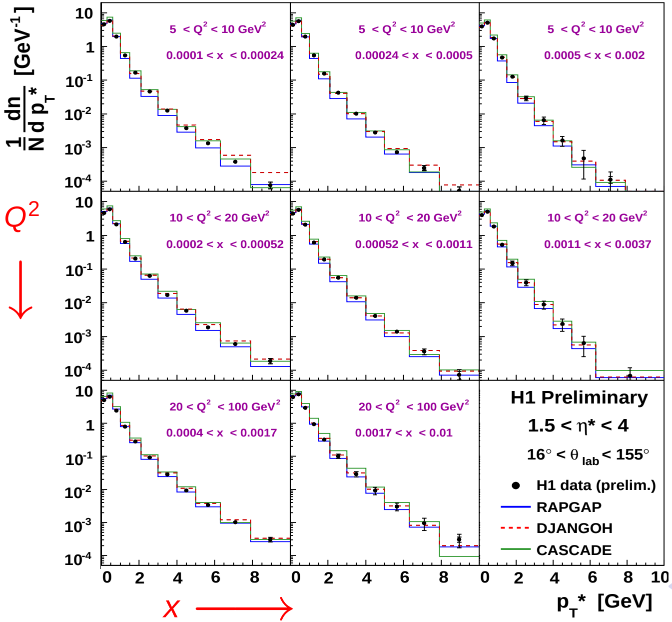
p_T^* distribution in bins of (x, Q^2); central region

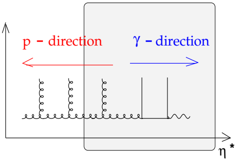




RAPGAP(DGLAP) is substantially below the data at lowest x and Q^2 region at large p_T^*

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

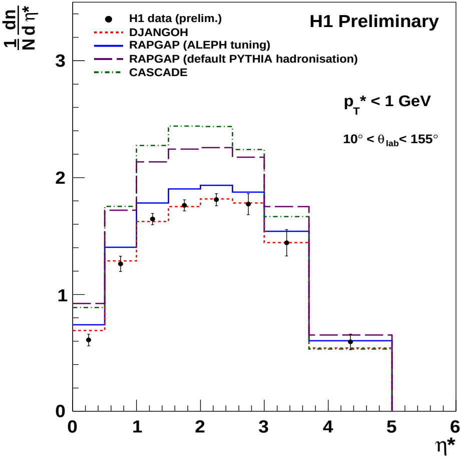




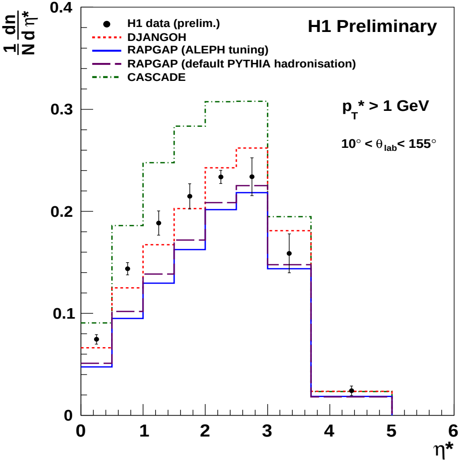
RAPGAP(DGLAP) provides better description of the data compared to the forward region

η^* - distributions

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



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



Strong sensitivity to hadronisation parameters.
Weak sensitivity to different parton dynamics.

Strong sensitivity to different parton dynamics.
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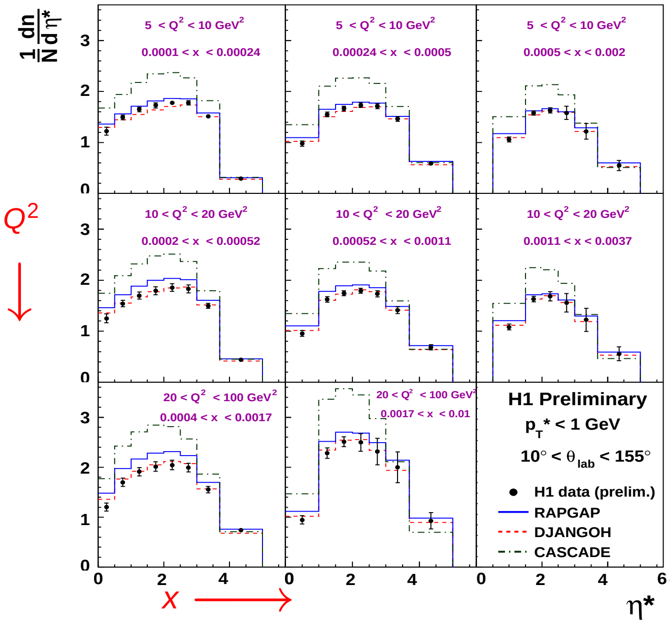
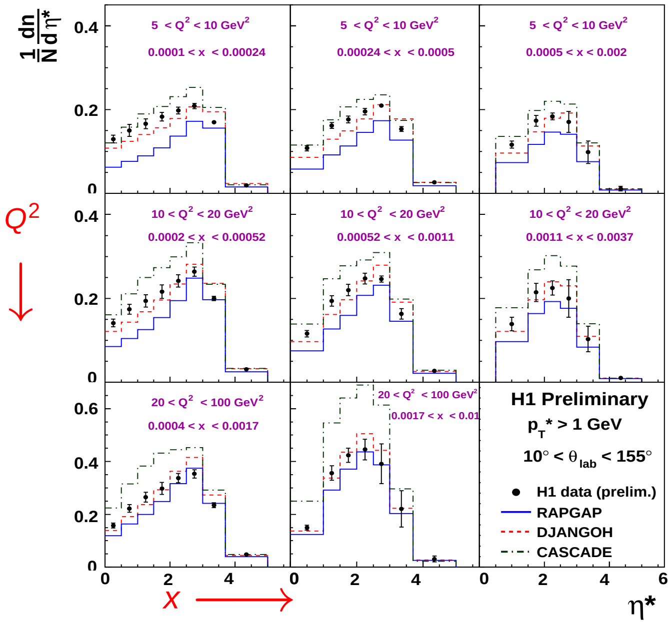
η^* distribution in bins of (x, Q^2) for $p_T^* < 1$ GeV



DJANGOH(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 DJANGOH(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
  - DJANGOH(CDM) is better than RAPGAP(DGLAP) in describing both, p_T^* and η^* measured spectra, especially at low x

$\rightarrow$ data are in favour of CDM (Colour Dipole Model) model