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Measurement of a transverse momentum of charged particles at low Q^2 with the H1 detector at HERA

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The electron-proton collider HERA allows for the study deep-inelastic scattering (DIS) at small Bjorken-x, ($x < 10^{-5}$). At small x, parton dynamics beyond DGLAP evolution is expected to become important. Charged particle spectra are measured in DIS at different x and Q^2 kinematic regions ($Q^2 > 5$ GeV^2) using data collected during HERA II running period. The measurements are compared to predictions from different Monte Carlos. It is shown that the region of small transverse momenta is primarily affected by the hadronisation process, whereas the region of large transverse momenta is mainly driven by perturbative parton radiation. The observed hardness of the transverse momentum spectra favors parton dynamics beyond DGLAP evolution.

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1. Introduction

In the region of small x at the HERA collider effects from non-p_T-ordered parton radiation might become visible. Inclusive measurement like the structure function $F_2(x,Q^2)$ cannot distinguish between DGLAP and beyond DGLAP parton radiation. A less inclusive measurement where, in addition to the scattered electron, charged hadrons are measured can perhaps be more sensitive. In [1] it has been proposed that a measurement of the transverse momentum spectrum of charged particles is sensitive to whether the partons are emitted in a p_T-ordered cascade (DGLAP) or in a unordered way (BFKL).

We present a measurement of charged particle transverse momenta as a function of x and Q^2, and compare it with predictions from different MC event generators [2]. In addition we discuss the question of the sensitivity to the hadronisation parameters.

2. Monte Carlo generators

Various Monte Carlo generators using different approaches to simulate the parton cascade are studied in present analysis: RAPGAP generator [3] based on leading log DGLAP parton showers; DJANGOH generator [4] based on Color Dipole Model (CDM), a description of parton emission which is similar to that of the BFKL evolution; CASCADE generator [5] based on the CCFM model, which unifies the BFKL and DGLAP approaches and requires angular ordering of the emitted quanta w.r.t the proton beam. In the CDM and the CCFM approaches the p_T of the emitted partons in a parton shower is not ordered w.r.t x, or the angle. All generators use the Lund string model [6] for hadronisation as it is implemented in PYTHIA, with parameters tuned by ALEPH collaboration to fit LEP data [7].

3. Event selection and reconstruction

The data taken in 2006 with a positron beam energy of 27.5 GeV and a proton beam energy of 920 GeV are used in the analysis. The analysed data set corresponds to an integrated luminosity of $L = 88.64\ \text{pb}^{-1}$. The SPACAL calorimeter was used to measure the energy of the scattered positron in the angular range of $155^o < \theta_e < 175^o$. The *phase space* of this analysis is defined by $5 < Q^2 < 100\ \text{GeV}^2$ and $0.05 < y < 0.6$.

Only tracks in the central tracking detector are used in this analysis. The reconstruction in the central region is based on the drift chambers, CJC1 and CJC2. The tracks are required to originate from the primary vertex and to lie within the central polar angular range of $20^o < \theta < 155^o$.

In order to provide a higher efficiency of the track reconstruction the transverse momentum of a track is required to be larger than 0.15 GeV.

4. Results

The data are corrected for detector effects, for QED radiation, as well as for the charged decay products of K^0_S, Λ and for other weakly decaying particles. The results are presented in the hadronic center of mass system (HCM), i.e. in the proton photon rest frame. The transverse momenta are

PoS(DIS 2010)109

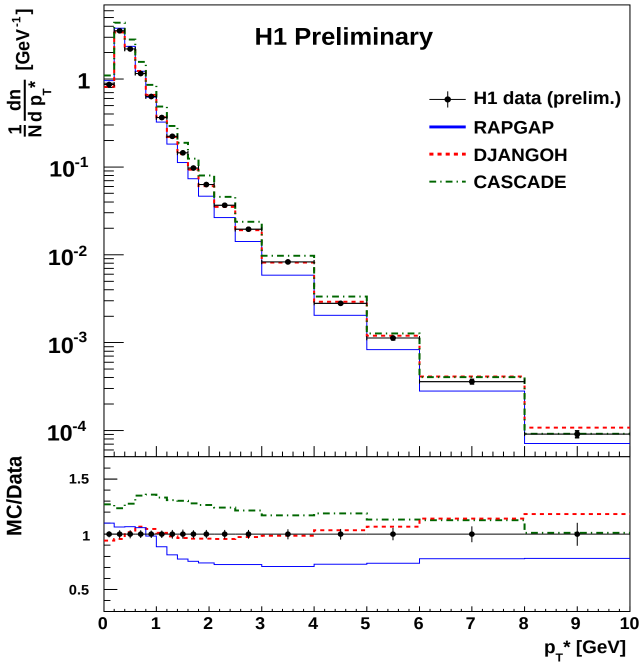

Figure 1: Measured p_T^* spectra and Monte Carlo predictions of charged particles in the central region of the pseudo-rapidity, $1.5 < \eta^* < 2.5$, in the hadronic center of mass system (HCM). Data are compared to RAPGAP, DJANGOH and CASCADE.

measured in the central pseudo-rapidity interval of $1.5 < \eta^* < 2.5$ [1]. All distributions shown are normalized to the total number of DIS events, satisfying the DIS phase space requirements of $5 < Q^2 < 100$ GeV^2 and $0.05 < y < 0.6$.

4.1 Transverse momenta of charged particle

The transverse momentum spectra (p_T^*) of charged particles are presented in Fig. 1. DJANGOH, based on CDM, describes the data fairy well for the whole p_T^* range, whereas RAPGAP is significantly below the data for $p_T^* > 1$ GeV. In contrast, CASCADE is above the data for almost the whole p_T^* range.

The transverse momentum spectra in different x and Q^2 bins are shown in Fig. 2 (the bin sizes are indicated on the plots). At large x and Q^2 ($Q^2 \sim 30$ GeV^2 and $x \sim 0.003$) both RAPGAP and DJANGOH provide a good description of the data. At small x and Q^2, where gluons dominate the proton structure, the DGLAP based RAPGAP predictions fall significantly below the data for $p_T^* > 1$ GeV. In contrast, DJANGOH gives a good description of the data over the full kinematic range, except for the lowest x and Q^2 bin for high p_T^* tail, where the model prediction is above the data.

The difference between the DGLAP model RAPGAP and the measurements might indicate that at small x more high p_T^* partons are produced.

[1] p_T^* and η^* refer to HCM system. $\eta^* = -\ln(\tan(\theta^*/2))$, where θ^* is the angle with respect to the virtual photon

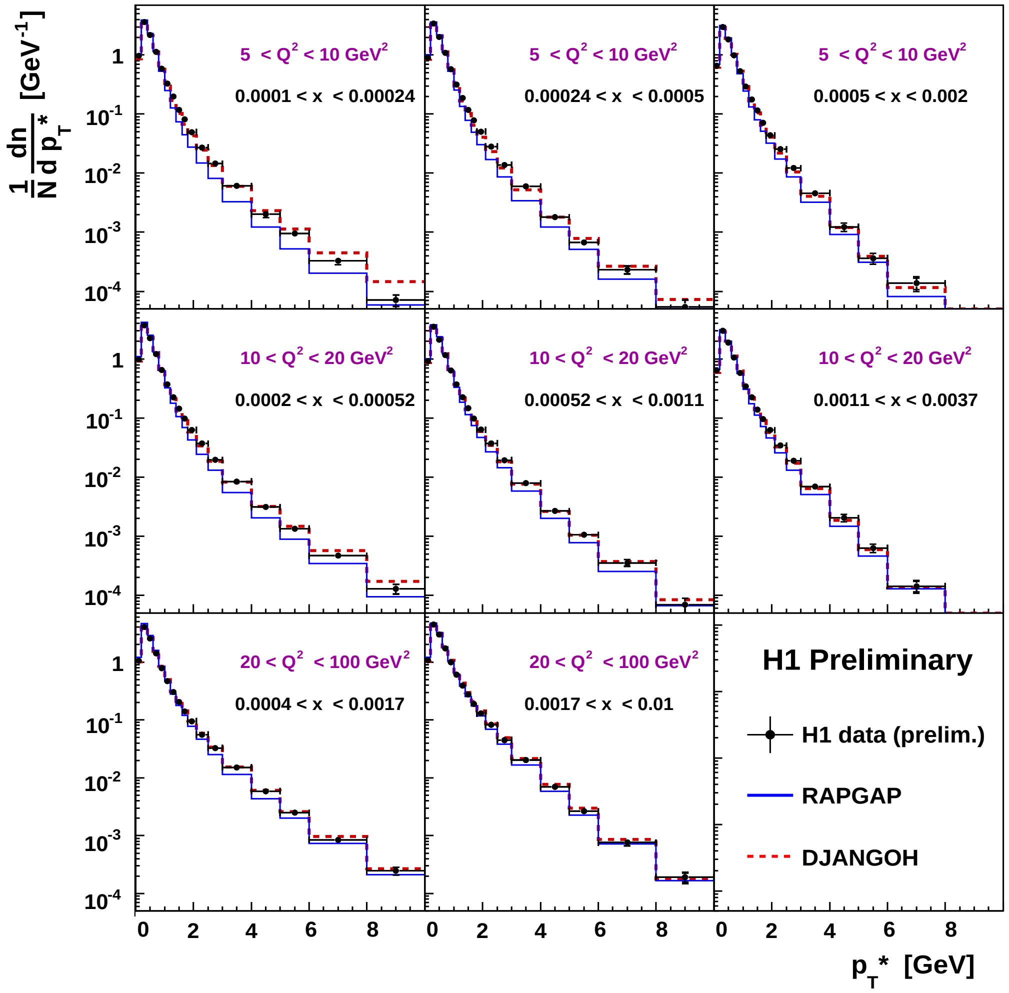

Figure 2: Measured p_T^* spectra of the charged particles in the central region of pseudo-rapidity, $1.5 < \eta^* < 2.5$, in the hadronic center of mass system (HCM), for 8 intervals of Q^2 and x_{Bj} . Data are compared to the RAPGAP and DJANGOH Monte Carlo predictions.

4.2 Rapidity distribution

The charged particle multiplicity as a function of pseudorapidity is shown in Fig. 3. As argued in [8], hadronisation effects should be relevant only at small p_T, while parton radiation should manifest itself in the tail in the p_T distribution. In order to test this idea the rapidity distributions were measured for $p_T^* < 1$ GeV and for $p_T^* > 1$ GeV, separately.

In addition to the RAPGAP distributions with parameters tuned by ALEPH to fit LEP data, the RAPGAP distributions with default PYTHIA fragmentation parameters are shown in Fig. 3. Significant differences between these two models are seen in the soft p_T^* region, while for particles with the harder transverse momenta this discrepancy is much smaller. Comparing predictions from generators with different QCD scenarios for parton cascades, one can see the largest difference for $p_T^* > 1$ GeV, while for $p_T^* < 1$ GeV both RAPGAP and DJANGOH reasonably describe the data.

direction, i.e. to the positive z^* direction

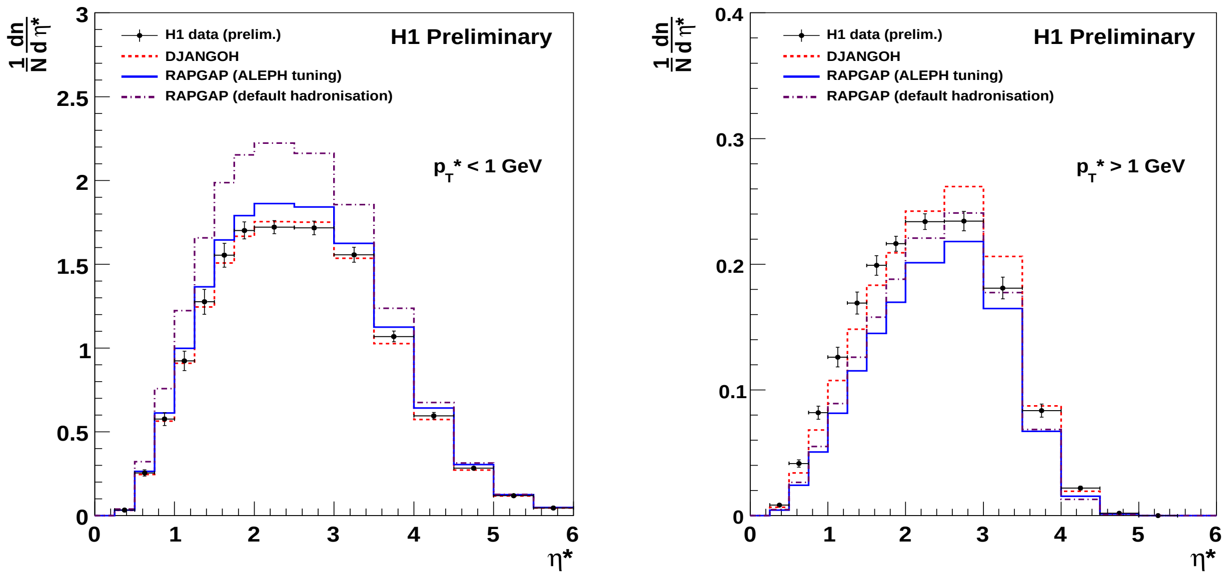

Figure 3: Measured η^* and Monte Carlo predictions for the charged particles in the hadronic center of mass system.

5. Conclusion

Hadronic final states in DIS have been studied by measuring the transverse momentum and rapidity spectra of charged particles with the H1 detector at HERA. The measured transverse momentum spectra are presented as a function of x and Q^2 in the region of the pseudo-rapidity of $1.5 < \eta^* < 2.5$. The measurements are compared to predictions from different parton dynamics models (DGLAP, CDM and CCFM). The data are shown to be in favour of CDM, while the DGLAP models are below the data in hard momentum region ($p_T^* > 1$ GeV) and for smaller x and Q^2.

It has been shown that at small p_T^* hadronisation effects are important, whereas at large p_T^* the parton radiation mechanism dominates.

References

[1] M. Kuhlen, A new method to probe the low x parton dynamics at HERA, hep-ph/9606246

[2] Slides:
$http://indico.cern.ch/contributionDisplay.py?sessionId=6\&contribId=151\&confId=86184$

[3] H. Jung, Comp. Phys. Commun. 86(1995) 147

[4] K. Charchula, G.A. Schuler, H. Spiesberger, Comp. Phys. Commun. 81(1994) 381

[5] H. Jung, Comp. Phys. Commun. 143(2002) 100

[6] B. Andersson, G. Gustafson, G. Ingelman, T. Sjostrand, Phys. Rept. 97(1983) 31

[7] I. G. Knowles et al., Workshop on Physics at LEP2, v.2, Geneva, Switzerland, 2 - 3 Nov 1995, p.103

[8] M. Kuhlen, QCD and the Hadronic Final State in Deep Inelastic Scattering at HERA, hep-ph/9712505