Charged Particle Production in the Current Fragmentation Region of the Breit Frame at HERA.

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Abstract. Data on the fragmentation function, invariant energy spectra and multiplicity distributions in the current quark hemisphere of the Breit frame from low x deep inelastic ep scattering are presented. The data are compared with results from e^+e^- collisions and fragmentation universality is tested.

INTRODUCTION

The hadronic final state in hard scattering processes is viewed to be the result of a hard scattering followed by a soft fragmentation process. For the former perturbative QCD can be applied, but for the latter generally phenomenological models are used. Recently progress has been made in understanding this process in the framework of the Modified Leading Log Approximation (MLLA) complemented with the assumption of Local Parton Hadron Duality (LPHD).

Earlier $e^+e^-$and ep experiments at lower energies have shown evidence for the universality of the fragmentation process. At HERA, the high center of mass (cms) energy of the ep collision, $\sqrt{s} = 300$ GeV, allows the study of fragmentation universality to higher energies to be extended.

In this analysis we confront new data on charged particles in deep inelastic ep scattering data, taken with the H1 experiment [1] in 1994, with e^+e^-data and predictions from MLLA + LPHD. The ep data, for $12 < Q^2 < 8000$ GeV^2 and $0.05 < y < 0.6$, are analysed in the Breit frame of reference. Previous studies at HERA with approximately six times less statistics [2,3] showed that particle production in the current quark hemisphere of the Breit frame in ep interactions is very similar to the one in a single hemisphere of an e^+e^-collision, when the equivalent of the cms energy E^* in e^+e^-, is taken to be Q for ep . More details on this analysis are given in [4].

FRAGMENTATION FUNCTION

The scaled hadronic momentum variable x_p is defined as $x_p = 2p/Q$ with p the hadron momentum. The fragmentation function for charged particles is the event normalized distribution $D(x_p, Q^2) = 1/N_{evts} \cdot dn/dx_p$. A new measurement of $D(x_p, Q^2)$ is shown in Fig. 1, as a function of Q, for different x_p bins, and compared with data from e^+e^-collisions. For these and the following figures the ep data are shown with statistical and systematical errors added in quadrature. In the region of overlap the $e^+e^-$and ep distributions agree well. Furthermore, strong scaling violation effects are clearly visible, i.e. the particle density increases with Q at low x_p and decreases at large x_p. Note that for the ep experiments at HERA, due to the large Q region covered, scaling violations can be established within one data sample. Such data can in future be used to extract the strong coupling constant α_s

CHARGED PARTICLE MULTIPLICITIES

The full multiplicity distribution is shown in so-called KNO form in Fig. 2. The upper figure shows that the distribution becomes more narrow as Q^2 decreases, hence showing clear violations of KNO scaling. The ep data at high Q^2 are similar to the e^+e^-data at high E^{*2}. The lower figure shows that the

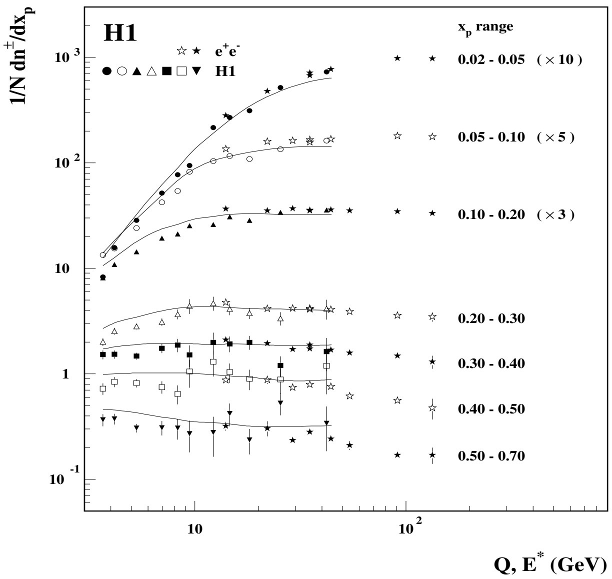

FIGURE 1. Fragmentation Function for the quark current hemisphere in ep and for e^+e^-(values divided by two). The curves are from an ep Monte Carlo calculation.

low Q^2 data deviate significantly from e^+e^-data. A better agreement can be obtained if cuts are applied which reduce LO QCD contributions, present in ep , but absent in e^+e^-, namely initial state QCD radiation and boson-gluon fusion. One possible cut to reduce the effect of these processes, as tested on Monte Carlo samples, is to remove events when the energy measured calorimetrically in the current hemisphere is low compared to the QPM expectation, and when the polar angle of the vectorial sum of these energy deposits with respect to the QPM expectation is large (for details see [4]). Fig. 2 shows that with these "flow selection" cuts the ep data become very similar to the e^+e^-data at comparable $Q^2(E^{*2})$. A similar observation is made for the average charged particle distribution $< n >$ [4].

INVARIANT ENERGY SPECTRA

Fig. 3 shows the invariant charged particle energy spectra. Here $E = \sqrt{Q_0^2 + p^2}$ with $Q_0^2 = 270$ MeV^2. In the MLLA approach Q_0^2 can be considered as a cut-off mass for the parton shower. The prediction of MLLA + LPHD is that at low momentum values these spectra become nearly independent of the energy of the parent hadron [5]. In the upper plots the data at low Q^2 are shown with (full circles) and without (open circles) the "flow selection" cut. The low Q^2 data with the cut and the high Q^2 data are in agreement with

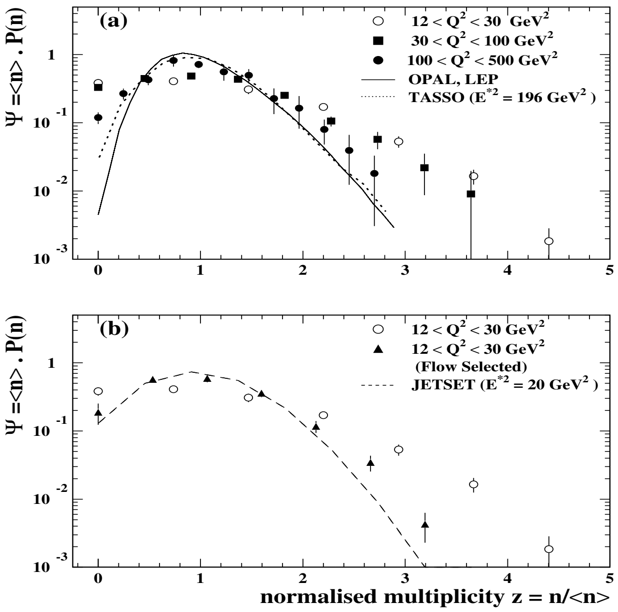

FIGURE 2. The charged multiplicity distribution in KNO variables for the current hemisphere in ep and single hemisphere (data or Monte Carlo calculation) for e^+e^-.

the MLLA + LPHD expectations of a common limit at small E, while the low Q^2 data without the cut deviate from these expectations. The figure also shows the effect of a running α_s (full line) and constant α_s (dashed line). A comparison with predictions for e^+e^-collisions (curves) shows further that the low momentum limit of these spectra is very similar in $e^+e^-$and ep collisions.

In conclusion, new ep data on the fragmentation function are presented which show clear scaling violations. Multiplicity distributions and invariant energy spectra have been compared with results from e^+e^-. Within the present accuracy of the data, quark fragmentation universality in $e^+e^-$and ep processes is observed, when care is taken for the difference resulting from QCD processes in ep which have no analogon in e^+e^-.

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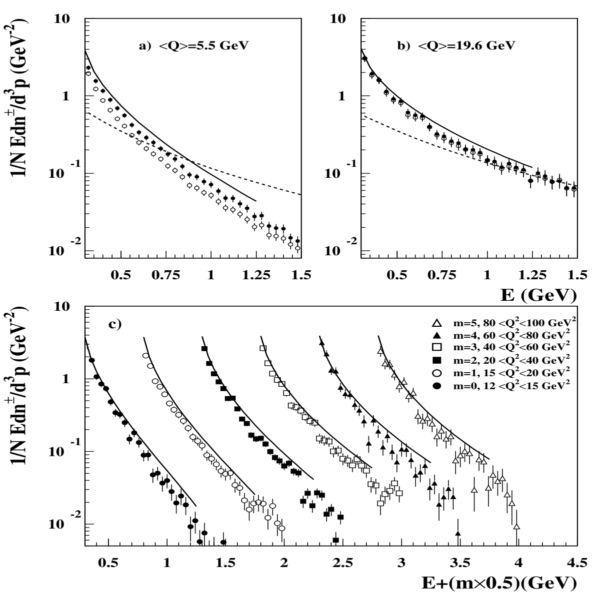

FIGURE 3. The invariant charged hadron energy spectrum for the quark current hemisphere in ep, compared with MLLA+LPHD predictions. The dashed lines in the top figures are for a non-running coupling constant α_s, contrary to the solid lines.