Multiplicity Structure of Hadronic Final States in Diffractive DIS

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Abstract.
The charged particle multiplicity of the hadronic system X in deep-inelastic processes at HERA of the type $ep \to eXY$, where Y is dominantly a proton, is studied as a function of the invariant mass of the system X. H1 preliminary results on multiplicity moments, correlations between forward and backward hemispheres in the rest frame of X and the multiplicity distribution itself are compared with data from e^+e^- annihilations and hadron-hadron collisions and with Monte Carlo models. The long-range correlation between hadrons is larger in diffractive DIS than in e^+e^- annihilations, indicating that the colour connections between partons are more complex than those of a single colour string. This is in agreement with gluon-dominated models for diffraction.

MULTIPLICITIES AND CORRELATIONS

The different available pictures of diffraction range from so-called *quark dominated* processes, which lead to a final state parton configuration composed dominantly of a single quark-antiquark pair, to *gluon dominated* processes, which have more complex partonic configurations. Since the colour connections between partons are responsible for the long-range correlations between final state hadrons, one can try to discrimate between diffraction models by studying the multiplicity structure of the hadronic final state. For example, it has been shown that correlations between the number of particles produced in the forward and backward hemispheres reflect the variance in the number of colour strings between partons [1]. Results presented in this paper will be contrasted to data from e^+e^- annihilations, where the partonic final state consist dominantly of a single quark-antiquark pair.

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The correlation is reflected in the two-particle density $\rho_2(y_1, y_2)$, y being e.g. rapidity. Here, the measured observables are the probabilities, P_n, to have n charged particles in the final state. From this *multiplicity distribution* we can calculate the second factorial moment $\tilde{R}_2$, defined as

$$\tilde{R}_2 = \langle n(n-1) \rangle = \sum_n P_n n(n-1), \qquad (1)$$

which is directly linked to the two particle density through

$$\tilde{R}_2 = \int_\Delta \rho_2(y_1, y_2) dy_1 dy_2, \qquad (2)$$

where Δ is the considered region in rapidity. We will present results on the individual probabilities P_n, the average multiplicity $\langle n \rangle$, the dispersion $D = \sqrt{\langle n^2 \rangle - \langle n \rangle^2}$ and the normalized second factorial moment $R_2 = \tilde{R}_2 / \langle n \rangle^2$.

Long-range correlations can also be studied from the number of particles in the forward and backward hemispheres. These are defined in the $\gamma^* I\!P$ centre-of-mass system where the positive z-axis is given by the photon direction. Exploiting the relation between the dispersions for the full system X (D) and for the forward and backward hemispheres (D_F and D_B), one can define the correlation parameter ρ as

$$\rho = \frac{D^2 - D_F^2 - D_B^2}{2 D_F D_B}. \qquad (3)$$

This correlation parameter is, for symmetrical forward and backward hemispheres, equal to the (more conventional) slope b of the straight line fit to $\langle n_F \rangle$ as a function of n_B or $\langle n_B \rangle$ as a function of n_F [2,3].

EXPERIMENTAL RESULTS

A detailed description of the H1 detector [4] and the experimental procedure [5] can be found elsewhere.

The deep-inelastic kinematic variables (y_{Bj}, Q^2) are reconstructed from the scattered positron, detected in the Backward Electromagnetic Calorimeter. The diffractive kinematic variables ($x_{I\!P}$, M_X) are obtained from a combination of tracks and energy clusters, observed by the Central Tracker and the LAr Calorimeter. The final event sample consists of 3760 events, collected in 1994 and selected in the following kinematic region:

$$7.5 \text{ GeV}^2 < Q^2 < 100 \text{ GeV}^2 \ , \qquad x_{I\!P} < 0.025 \ ,$$
$$0.05 < y_{Bj} < 0.6 \ , \qquad M_X > 3 \text{ GeV} \ .$$

Charged particles are measured with the Central Tracker and only tracks which are successfully fitted to the primary event vertex contribute to the

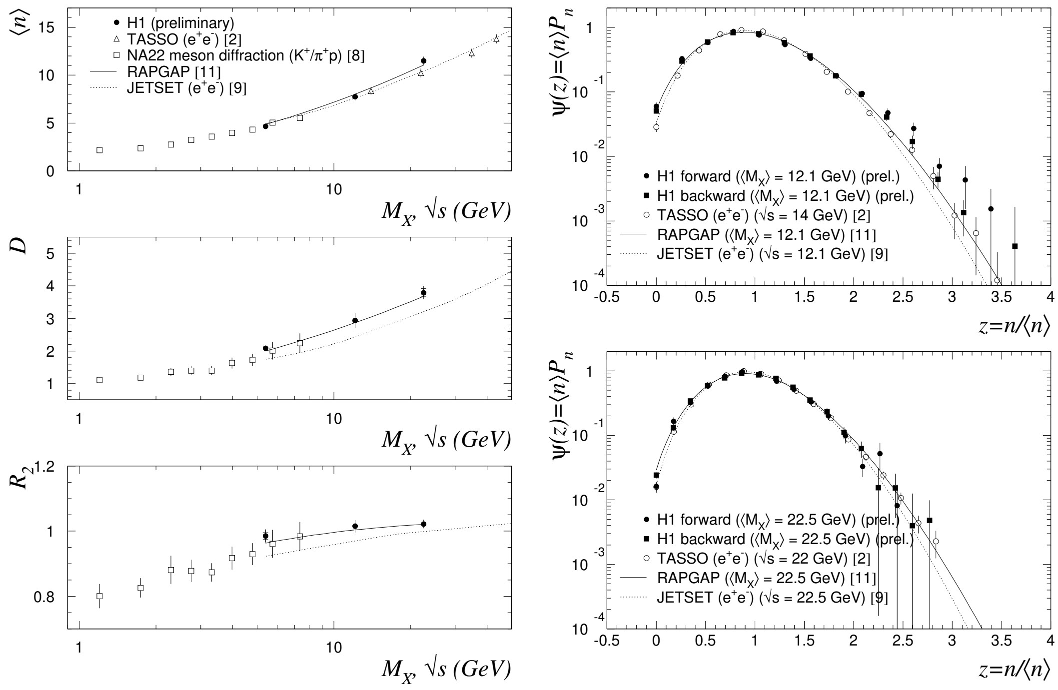

FIGURE 1. Full event multiplicity moments and single hemisphere KNO distributions.

multiplicity. The multiplicity distribution is then corrected with a matrix migration method based on Monte Carlo simulation [6,7]. The target remnant Y is always excluded from the multiplicity.

Figure 1 shows the multiplicity moments of the full system X as a function of the diffractive mass M_X (left). The H1 data points on the average multiplicity $\langle n \rangle$ are in agreement with lower-energy meson-diffraction points [8] and rise slightly faster than the e^+e^- annihilation data [2]. The dispersion D and second factorial moment R_2 for diffractive events in H1 are significantly larger than predicted by the JETSET Monte Carlo model [9]. This model adequately describes e^+e^- features relevant to this analysis and is used to represent e^+e^- data. The single hemisphere KNO distributions [10] (right) show the quantity $\psi(z) = \langle n \rangle P_n$ plotted as a function of the normalized multiplicity $z = n/\langle n \rangle$. The function $\psi(z)$ is expected, and has been observed, to become energy independent at large energies. Here, the KNO distributions are plotted for similar centre-of-mass energies in e^+e^- annihilation and H1 diffractive events, indicating a fair agreement, although the distribution is somewhat broader for the latter.

Figure 2 shows the rapidity spectrum (left). For high M_X a rapidity plateau develops. As is also the case for the multiplicity moments and the KNO distributions, the RAPGAP model [11], provides an adequate description of the data. RAPGAP events are generated using a hard gluon dominated partonic structure for the pomeron, obtained from inclusive measurements of diffraction in DIS [12]. The top right plot shows the parameter ρ (eq. 3), sensitive to the correlation between the forward and backward hemispheres. Although

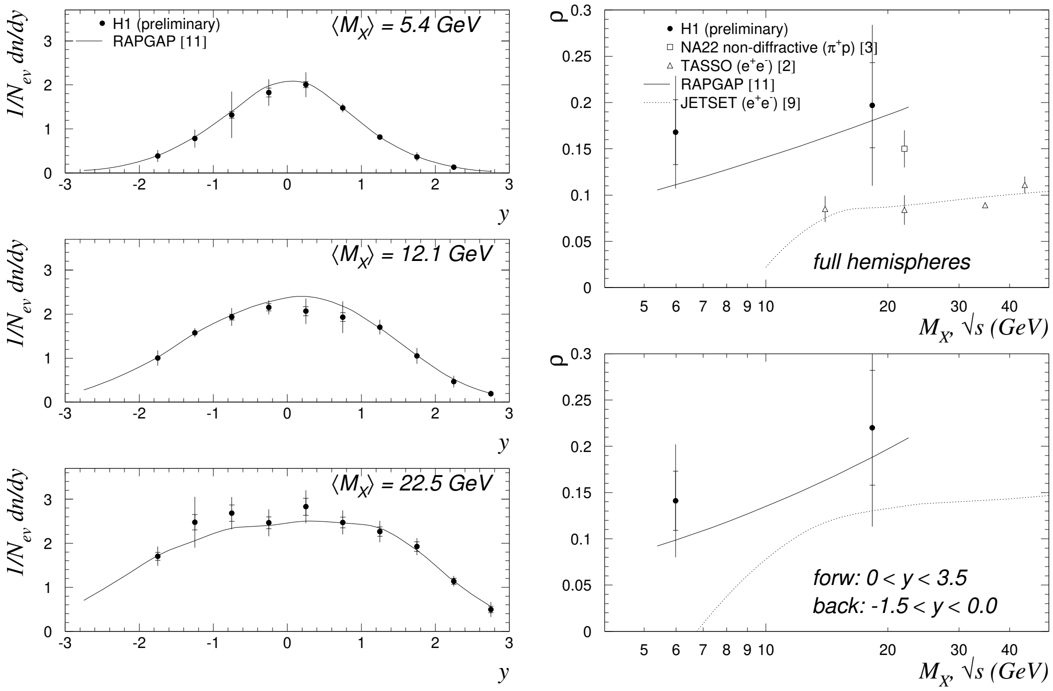

FIGURE 2. Rapidity spectra and forward-backward correlations.

the statistical and systematic errors are large, there is a tendency for stronger correlation in the H1 data when compared with e^+e^- results, as also seen in non-diffractive hadron-hadron collisions [3]. The lower plot supports this in a phase space region where the acceptance of the H1 detector is high everywhere.

In summary, these results provide evidence that the long-range correlations between hadrons are larger in diffractive DIS than in e^+e^- annihilations. This indicates that the colour connections between partons in the system X are more complex than those of a single colour string and is, therefore, in agreement with models with a gluon-dominated Pomeron.

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