A MEASUREMENT OF α_s FROM DIFFERENTIAL JET RATES

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A measurement of the strong coupling constant α_s from differential jet rates in deep inelastic electron proton scattering is presented. The measurement is based on an event sample recorded in 1994 with the H1 detector at HERA. The differential (2+1) jet rate is reconstructed with the JADE jet algorithm as a function of the resolution parameter. Hadronisation and detector effects are corrected. The phase space is restricted to minimize uncertainties in the jet reconstruction. The measurement is compared to the NLO prediction of PROJET and α_s is extracted.

1 The observable y_2

The (2+1) jet rate reconstructed with the JADE jet algorithm depends on the jet resolution parameter y_{cut}. For each event a $y_{cut} \equiv y_2$ can be found where the number of jets flips from (2+1) to (1+1). It describes the minimum invariant mass squared that is built by all possible pairs of the (2+1) jets, normalised by the total invariant mass squared of the hadronic final state W^2 and neglecting the invariant mass of the jets itself. The y_2 distribution is identical with the differential (2+1) jetrate $1/\sigma_{tot}\ d\sigma_{2+1}/dy_{cut}$, if the contribution of events with (3+1) jets can be neglected [1]. Here σ_{tot} is the total DIS cross section for the kinematic range considered.

The quantity y_2 offers the opportunity to study hadronisation and detector effects on the basis of single simulated events, as it can be calculated for the parton jets and for the reconstructed jets. Hence the resolution of y_2 can be taken into account at the correction of the measured y_2 distribution for these effects.

2 QCD calculation and models

The cross section for events with (2+1) parton jets in DIS can be calculated by the program PROJET [2] to order α_s^2. Feynman diagrams with $2+1$ and $3+1$ massless partons in the final state are taken into account. One recombination step is applied to build (2+1) massless parton jets from (3+1) massless partons.

The Monte Carlo generator LEPTO [3] in combination with the simulation of the H1 detector describes the measured jet distribution reasonably well [1]. It is based on the QCD matrix element to the order α_s, parton showers in the leading logarithm approximation and the Lund string hadronisation. It is used to correct the data for hadronisation and detector effects, such that they can be compared with the prediction of PROJET.

The parton showers in LEPTO are a model for higher order parton radiation. Applying the jet algorithm on the partons after the radiation of parton showers, multiple recombination steps are necessary to build (2+1) parton jets. The difference to the prediction of the matrix element alone gives a hint for the influence of the recombination effects at higher order parton radiation. Since there is only one recombination step and no parton showers in PROJET, the influence of the parton showers on the parton jets in LEPTO present an uncertainty for the correction of the data.

Figure 1 a shows the z_p distribution for (2+1) parton jets with $y_{cut} = 0.02$ before and after parton showers in LEPTO. The biggest influence of the parton showers appears at low z_p. By applying the cut $z_p > 0.1$ this influence can be suppressed. The remaining effect of the parton showers is strongly dependent on the event kinematics, as it can be seen in figure 1 b. Restricting the kinematic region to $Q^2 > 200\mathrm{GeV}^2$ and $\Theta_{Quark} < 100°$ the influence of the parton showers is small. Here Θ_{quark} is the the angle of the scattered quark in the quark parton model with respect to the proton direction.

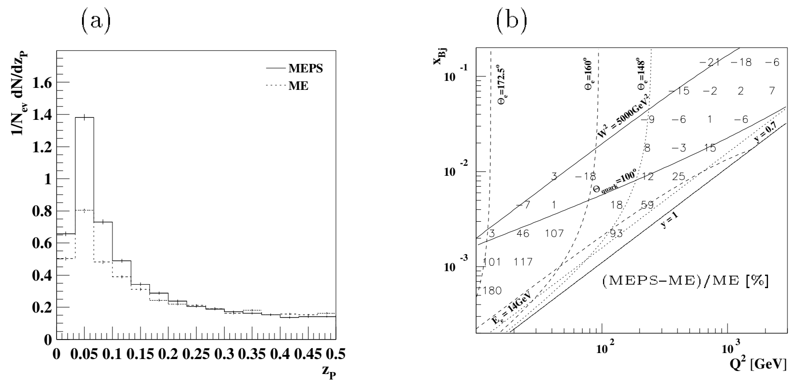

Figure 1: z_p distribution from the matrix element (ME) and ME plus parton showers (MEPS) at $y_{cut} = 0.02$ (a). The relative difference between MEPS and ME after the cut $z_p > 0.1$ as a function of the event kinematic (b). The lines in (b) represent the selection cuts for DIS events.

These cuts are applied to the H1 data to keep the uncertainty at the correction due to parton showers small. To account for the limited z_p resolution the cut is rised to $z_p > 0.15$.

3 Unfolding the data

As the resolution for y_2 estimated from LEPTO gives an RMS of 0.02 an unfolding method [4], which uses a correction matrix and suppresses oscillating solutions, is applied to correct the data. With the given statistic of 187 events after all cuts in combination with the resolution of y_2, the corrected differential jet rate can be expressed in two independent bins. The result is shown in figure 2 in comparison with the prediction of PROJET.

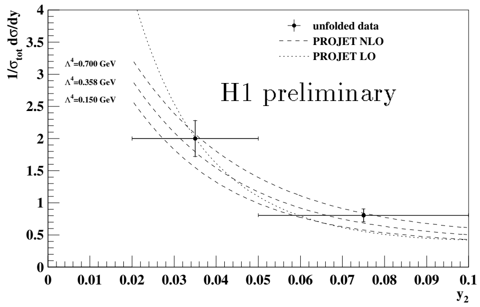

Figure 2: Unfolded data in comparison with the prediction of PROJET in LO and NLO for different values of Λ. The errors are statistical only

4 Determination of α_s and systematical errors

Using the NLO prediction of PROJET, α_s is extracted for each bin in y_2. To estimate systematical uncertainties the cuts, calibration constants and the scales have been varied and different parton densities have been used. The largest experimental uncertainty is the calibration of the calorimeters for hadrons and the largest theoretical error is the renormalisation scale dependence. The uncertainties for the lower y_2 bin are much larger than for the higher one. Thus we considered the value $\alpha_s = 0.128 \pm 0.010(\text{stat.}) \pm 0.012(\text{syst.})$ from the high y_2 bin as the main result, within the framework of PROJET.

References

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