Jets and α_s Measurements in DIS

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The inclusive, 2-jet and 3-jet jet cross sections at $5 < Q^2 < 100$ GeV^2 and the inclusive, 2-jet and 3-jet cross sections normalised to the NC DIS cross section at $150 < Q^2 < 15000$ GeV^2 are measured as function of Q^2 and P_T. The strong coupling is extracted.

1 Introduction

In contradiction to DIS cross section where α_s contributes indirectly (Fig. 1(a)), jet production cross sections directly depend on α_s through QCD Compton scattering (Fig. 1(b)) and boson-gluon fusion (Fig. 1(c)). This provides the possibility for an accurate determination of α_s from

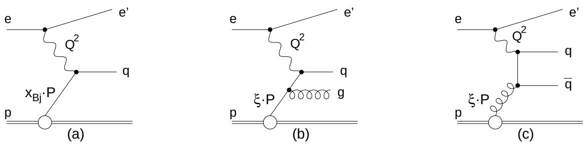

Figure 1: DIS at different order in α_s: (a) Born contribution, (b) QCD Compton scattering and (c) boson-gluon fusion

jet production data. The measurements are presented as both single and double differential cross sections in the variables Q^2 and jet transverse momentum P_T. The results agree well with NLO QCD calculations [1] corrected for hadronisation effects. The strong coupling α_s is extracted from a fit of the predictions to the data at low Q^2 ($5 < Q^2 < 100$ GeV^2) and at high Q^2 ($150 < Q^2 < 15000$ GeV^2). The running of α_s is tested in a wide range of μ_r.

2 Experimental methods and cross section measurements

The data presented in this paper were taken with the H1 detector at electron/positron and proton beam energies of 27.6 GeV and 920 GeV, respectively. The data samples were collected in 1999-2000 with an integrated luminosity of 43.5 pb^{-1} for low Q^2 and in 1999-2007 with an integrated luminosity of 395 pb^{-1} for high Q^2. The inelasticity y of the interaction is defined in the range $0.2 < y < 0.7$. Jets are defined with the inclusive k_t algorithm in the Breit frame. Cuts on the jet pseudorapidity η^L in the laboratory frame ($-1.0(-0.8) < \eta^L < 2.5(2.0)$ for low (high) Q^2) are applied to ensure that the jets are well contained within the acceptance of the calorimeter. To ensure the reliability of QCD predictions for the 2-jet and 3-jet sample [2], an additional cut on the invariant mass of the two leading jets ($M_{12} > 18(16)$ GeV for low (high)

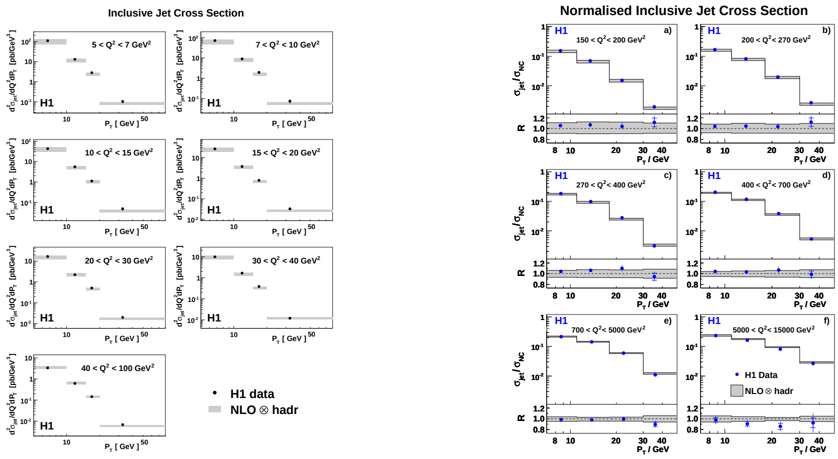

Figure 2: Inclusive (normalised) double differential jet cross sections as function of Q^2 and P_T compared with NLO QCD predictions corrected for hadronisation

Q^2) is applied. For the cross section extraction the experimental data is corrected for detector effects (resolution an efficiency) using Monte-Carlo event samples. The model uncertainties and the hadronic energy scale uncertainties are the dominant sources of experimental errors on the jet cross sections. The cross section normalisation to inclusive DIS data, applied to the high Q^2 data, allows to reduce systematic errors in most of the bins due to cancellation effects. Differential and double differential cross sections, corrected for detector and radiative effects are presented as function of Q^2 and P_T. Inclusive (normalised) double differential jet cross sections are presented in Fig.2 for low (high) Q^2. The band around the predictions shows the scale uncertainty of the NLO QCD calculations. In almost all the bins the scale uncertainty exceeds the total experimental error.

3 NLO QCD calculations. Strong coupling extraction

The data are compared with NLO QCD predictions, performed in the $\overline{\mathrm{MS}}$ scheme for five massless quark flavors. The parton level calculations are corrected for hadronisation effects. The PDFs of the proton are taken from the CTEQ6.5M set. The factorisation scale is chosen as $\mu_f = \sqrt{(Q^2 + P_T^2)/2}$ ($\mu_f = Q$) for low (high) Q^2. The renormalisation scale is chosen as $\mu_r = \sqrt{(Q^2 + P_T^2)/2}$. Varying the scales μ_f and μ_r by factors in the range 1/2 to 2, scale uncertainties up to 10% (30% at $P_T < 10$ GeV and 20% at $P_T > 20$ GeV) are observed for the data at high (low) Q^2. The uncertainties from PDFs and α_s are found to be small compared to these scale uncertainty. A fit of the (normalised) cross sections in bins of Q^2 and P_T to NLO predictions is performed, in order to extract α_s. The experimental errors and their correlations are taken into account using the Hesian method [3]. The results are consistent between different bins and combinations of bins. The same is true for combinations of inclusive, 2-jet or 3-jet measurements and for combining low and high Q^2 data. The theory error is estimated using the offset method, where the difference between α_s values obtained from fits under the variation of the theoretical uncertainties are studied.

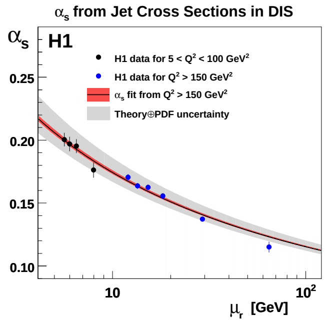

Figure 3: Comparison of $\alpha_s(\mu_r)$ values obtained by a fit in different bins to the two loop evolution.

4 Conclusion

Measurements of the inclusive, 2-jet and 3-jet (normalised) cross sections in the Breit frame in DIS with $0.2 < y < 0.7$ are presented for low (high) Q^2. Calculations in NLO QCD corrected for hadronisation effects agree well with single and double differential cross sections as functions of the jet transverse momentum P_T and the boson virtuality Q^2. It is observed that with a proper choice of the renormalisation scale, the theory is applicable for low P_T and low Q^2. The strong coupling $\alpha_s(M_Z)$ is extracted separately for low and high Q^2 as well as for both datasets together. The experimentally most precise determination of $\alpha_s(M_Z)$ is derived from a fit to the normalised jets cross sections at high Q^2 alone, as the normalisation leads to significant cancellations of systematic effects:

$$\alpha_s(M_z) = 0.1168 \pm 0.0007(\text{exp})^{+0.0046}_{-0.0030}(\text{th}) \pm 0.0016(\text{pdf})$$

Determination of $\alpha_s(M_Z)$ from a fit to the jets cross sections at low Q^2 alone gives:

$$\alpha_s(M_z) = 0.1160 \pm 0.0014(\text{exp})^{+0.0093}_{-0.0077}(\text{th}) \pm 0.0016(\text{pdf})$$

The combined fit of high and low Q^2 data has somewhat better experimental precision, but suffers from increased scale uncertainties. The running of α_s and the small experimental errors are visualised in Fig.3, where the measurements are displayed as a function of μ_r. It is remarkable that the total errors are essentially lower then theory prediction, hence setting a challenge for improved theoretical calculations.

References

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