DIJET RATES AT LOW x_B AND LOW Q^2

R. PÖSCHL
Universität Dortmund,Lehrstuhl für Experimentelle Physik V
44221 Dortmund, Germany
E-mail: poeschl@mail.desy.de

Dijet event rates, R_2, have been measured for deep inelastic ep scattering using data collected with the H1-Detector in the years 1996-1997 corresponding to an integrated luminosity of 22 pb^{-1}. R_2 is shown as a function of x_B and Q^2 in the kinematic region $10^{-4} < x_B < 10^{-2}$ and $5 < Q^2 < 100\,\mathrm{GeV}^2$. The data are confronted with next-to-leading order QCD calculations using two different choices of the renormalization scale μ_r^2 and assuming a point-like structure of the virtual photon. In addition the data are compared to NLO QCD calculations which include a resolved structure of the virtual photon. Finally, the dependence of the dijet rate on the transverse energy of the jets is shown and compared to theory.

1 Introduction

The study of jets in deep-inelastic ep scattering (DIS) at HERA provides a large phase space for testing perturbative QCD. The H1 collaboration has measured the fraction R_2 of dijet events in all DIS events as a function of the Bjorken variable x_B in different regions of the four-momentum transfer Q^2. For the selection of the inclusive DIS sample it was required that the inelasticity y lies between 0.1 and 0.7 and that the polar angle[a] of the scattered electron fulfills $156^o < \theta < 175^o$. To identify dijet events a jet search is then performed in the photon-proton center of mass frame using the inclusive k_t algorithm[1]. Dijet events must have at least two jets fulfilling the following criteria: the transverse energy $E_{t,jet}$ of each jet has to be at least 5 GeV and their pseudo-rapidity η as measured in the laboratory frame has to be between -1 and 2.5.

If NLO QCD is employed to confront theory with measurement the dependence of the theoretical prediction on the choice of the renormalization scale μ_r^2 is expected to be small. However, the correct choice of μ_r^2 remains a matter of concern especially at low x_B and low Q^2 where higher orders in the perturbation series might be of more importance. Concerning dijet events in DIS two evident scales are given by the nature of the process, one being the four-momentum transfer Q^2 providing the most naive choice for μ_r^2. The other possible scale for jet production is the transverse energy of the outgoing jets. The comparison of the H1 jet data with NLO predictions for these different scales is the main issue of this paper.

[a]Polar angles are defined w.r.t. the direction of the incoming proton

2 Comparison between data and theory

2.1 Comparison to NLO QCD calculations

The dijet rates are compared to NLO calculations using the DISENT[2] program which calculates the cross section for ep scattering to order $\mathcal{O}(\alpha_s^2)$ assuming the virtual photon to be point-like. To avoid infrared sensitivity of the predictions[3,4] the transverse energies of the jets are required to be $E_{t,jet1} > 7\,\mathrm{GeV}$, $E_{t,jet2} > 5\,\mathrm{GeV}$. The corresponding dijet rates are shown in figure 1. They in-

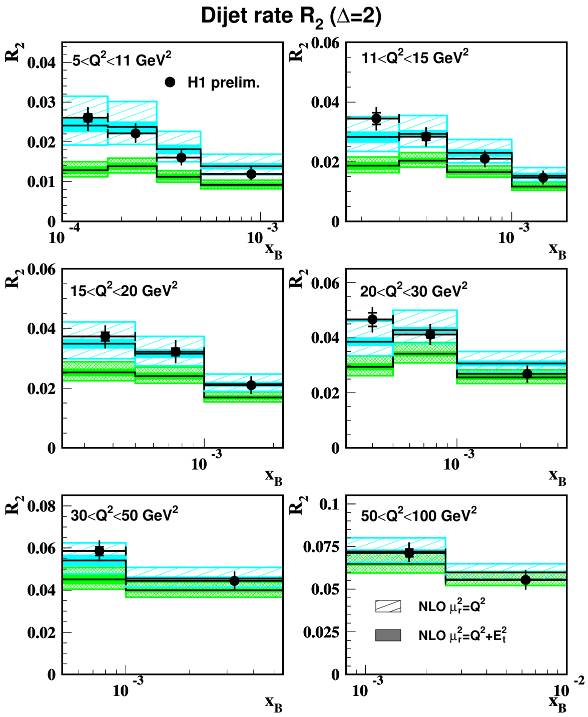

Figure 1: Dijet rate R_2 as a function of x_B in different bins of Q^2. The data are compared to NLO QCD calculations which have been corrected for hadronization effects. The full bands indicate the uncertainty from the hadronization corrections while the hatched band shows the total error adding hadronization corrections and scale uncertainties in quadrature.

crease for decreasing x_B as expected, since the available phase space increases with the invariant mass of the hadronic final state $W^2 \approx \frac{Q^2}{x_B}$. In figure 1 the NLO QCD calculations, corrected for hadronization effects, are shown for

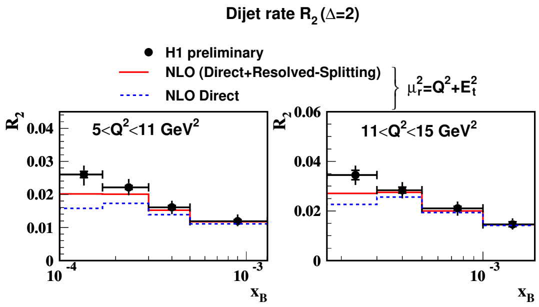

Figure 2: Dijet rate R_2 as a function of x_B for two Q^2 ranges. The data are compared to a NLO QCD calculation assuming a direct coupling of the virtual photon only (dashed line) and to a prediction which additionally includes a virtual photon structure (full line). All NLO QCD calculations are corrected for hadronization effects.

two choices of the renormalization scale, namely $\mu_r^2 = Q^2$ and $\mu_r^2 = Q^2 + E_t^2$. The factorization scale is set to $\mu_f^2 = Q^2$ and the CTEQ4M[5] parton densities are used for the proton. The theoretical predictions describe the data for $\mu_r^2 = Q^2$ with scale uncertainties up to 30%, if μ_r^2 is varied by a factor of 2. If $\mu_r^2 = Q^2 + E_t^2$ (where $E_t = (E_{t,jet1} + E_{t,jet2})/2$) is chosen, the NLO QCD calculations describe the data for large x_B and Q^2 only and clearly lie below the data for low x_B and low Q^2. In this case the scale uncertainties are considerably smaller and leave room for introducing additional contributions to jet production, for example processes where the virtual photon becomes resolved and acts as a source of partons.

2.2 Contributions from virtual photon structure?

In order to investigate a possible resolved contribution of the photon to dijet production, the data are compared to NLO QCD calculations using the program JETVIP[6]. For these studies the renormalization and factorization scale are set to $\mu_r^2 = \mu_f^2 = Q^2 + E_t^2$ and the SAS-1D[7] parton densities for the virtual photon are used. As shown in figure 2 the full calculation including all resolved and direct contributions leads to a better agreement with the data than a JETVIP calculation which only considers a point-like photon (NLO direct).

2.3 Dependence of R_2 on the transverse energy of the jets

To study the dijet rate as a function of the transverse energy of the jets the cut on $E_{t,jet1} > (5+\Delta)$ GeV is varied by introducing the parameter $\Delta \in [0, 7\ \mathrm{GeV}]$.

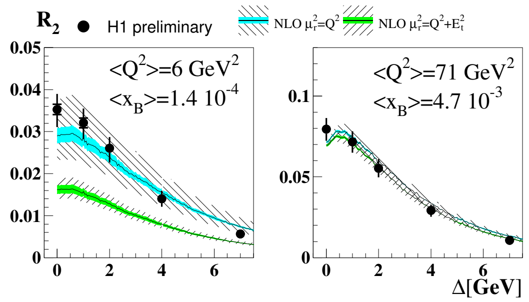

Figure 3: Dijet rate R_2 as a function of Δ in two different regions of Q^2 and x_B.

The measured R_2 as a function of Δ is presented in figure 3 for two bins in Q^2 and x_B. At large x_B and large Q^2 the NLO QCD calculations using DISENT perfectly describe the data for both choices of μ_r^2 and $\Delta \geq 1$ GeV, when staying away from the infrared sensitive region of the calculation. In the low x_B,Q^2 regime the predictions only describe the data when choosing $\mu_r^2 = Q^2$. For $\mu_r^2 = Q^2 + E_t^2$ a reasonable agreement between the prediction and the measurement is only observed for $\Delta = 7$ GeV which is equivalent to the requirement of large transverse energies of the jets. Finally it should be noted that the NLO calculations show a turnover between $\Delta = 0$ and $\Delta = 1$ GeV whereas the data continue to increase towards $\Delta = 0$. In this region resummed calculations are needed but not yet available. The presented measurements therefore provide an important reference for improved theoretical predictions.

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