

PHOTOPRODUCTION OF DIJETS WITH HIGH TRANSVERSE MOMENTA AT HERA

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An analysis of dijet photoproduction in the region of photon virtualities $Q^2 < 1 \text{ GeV}^2$ with the H1 detector at the HERA electron proton collider is presented. The data correspond to an integrated luminosity of 66 pb^{-1} . Jets are defined with the inclusive k_{\perp} algorithm and a minimum transverse momentum of the leading jet of 25 GeV is required. Dijet cross sections are measured in direct and resolved photon enhanced regions separately. Longitudinal proton momentum fractions up to 0.7 are reached. The data compare well with predictions from Monte Carlo event generators based on leading order QCD and parton showers and with next-to-leading order QCD calculations corrected for hadronisation effects.

1. Introduction

The photoproduction of dijets with high transverse momenta at HERA can be calculated within perturbative Quantum Chromodynamics (pQCD) where the transverse momentum of jets provides the hard scale. Two contributions to the jet cross section can be distinguished: *direct processes* in which the photon itself enters the hard subprocess and *resolved processes* in which the photon fluctuates into partons of which one participates in the hard scatter. The hadronic structure of the proton and photon are described by their respective parton density functions (PDFs).

To test predictions of perturbative calculations and current PDF parametrisations the analysis¹ presented here investigates dijet production at very small Q^2 in positron proton interactions using the H1 detector at HERA. The transverse momentum (E_t) of the leading jet ranges between 25 and 80 GeV. The range of the photon momentum fraction carried by the parton participating in the hard interaction is $0.1 < x_{\gamma} < 1.0$. The proton momentum fraction carried by the interacting parton from the proton side is in the range of $0.05 < x_p < 0.7$.

Jets are reconstructed in the laboratory frame using the inclusive k_{\perp} algorithm.² The p_t -weighted recombination scheme is used in which the jets are considered massless and the separation parameter is set to 1. The jets are restricted to $-0.5 < \eta_{\text{jet}} < 2.75$ and only the two highest E_t jets are considered. Asymmetric cuts on the jets E_t are applied to avoid regions of phase space where the existing NLO QCD calculations suffer from an incomplete cancellation of infrared singularities. The leading jet is required to have $E_{t,\text{max}} > 25\text{GeV}$ and the other jet $E_{t,2\text{nd}} > 15\text{GeV}$.

2. QCD Models

The data are compared to Monte Carlo event generators based on leading order (LO) QCD and parton showers and to next-to-leading order (NLO) pQCD calculations with hadronisation corrections. The PYTHIA³ Monte Carlo program uses the Lund string model for hadronisation. Here the leading order parametrisation CTEQ5L⁴ for the proton PDFs and GRV-LO⁵ for the photon PDFs are used. The PYTHIA predictions need to be scaled up by a factor of 1.2 to describe the data. The HERWIG⁶ Monte Carlo, which uses the cluster model for hadronisation, is found to produce similar results to PYTHIA, but a scale factor of 1.55 is required to reproduce the total dijet cross section.

Parton level NLO QCD dijet cross sections are obtained using a program⁷ based on the subtraction method. In the calculation of the NLO cross sections the parametrisation CTEQ6M⁸ is chosen, the uncertainty is calculated from the 40 eigenvectors of the CTEQ6M PDFs. It varies from 4% at low x_p to 20% at high x_p . For the photon PDFs the GRV-HO⁵ parametrisation is used. Using instead the AFG-HO⁹ photon PDFs, differences of the order of 20% in the resolved enhanced region and of 10% in the direct enhanced region are seen¹⁰.

The renormalisation and the factorisation scale are set to the mean transverse momentum of the outgoing partons, on an event-by-event basis. The uncertainty on the NLO QCD predictions arising from a variation of the common scale by a factor two is found to vary between a few percent and almost $\pm 30\%$. The uncertainty from the PDFs is in general much smaller than the error from the scale uncertainty, except at large x_p where it grows to be about twice as big.

The NLO QCD predictions are compared to the data after a correction for hadronisation effects. The correction δ_{had} is determined from the Monte Carlo models and varies between 1% and 6%. Its uncertainty is determined

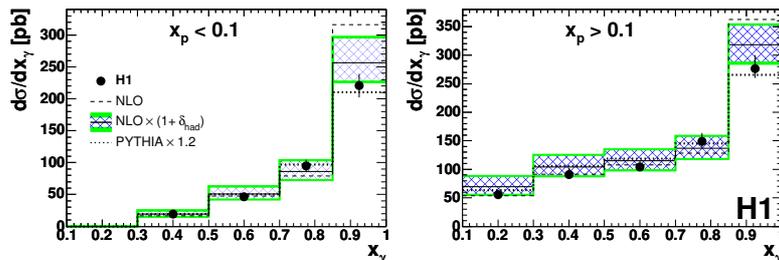


Figure 1. Cross sections as a function of x_γ in two regions in x_p for data, NLO QCD calculations with and without hadronisation corrections δ_{had} and for the PYTHIA Monte Carlo predictions scaled by a factor of 1.2. The inner band of the $\text{NLO} \times (1 + \delta_{\text{had}})$ result is the scale uncertainty, the outer band is the total uncertainty.

from the difference between the HERWIG and PYTHIA corrections and is in general smaller than the dominant theory uncertainty.

3. Results

The dijet cross section as a function of x_γ is shown in Fig. 1 in two regions of x_p . For $x_p < 0.1$ the fraction of events induced by gluons from the proton side is estimated to be about 70%. It decreases to 15% at the highest x_p reached in this analysis. Thus the two regions roughly distinguish between photon-gluon fusion ($x_p < 0.1$) and photon-quark scattering ($x_p > 0.1$). Over the entire range in x_γ and in both x_p regions the NLO QCD predictions agree with the data within uncertainties. The leading order Monte Carlo predictions also describe the data.

Figure 2 shows the cross section as a function of x_p . Here the measurement is made in two regions of x_γ ($x_\gamma > 0.8$ and $x_\gamma < 0.8$). In both regions the agreement of the NLO QCD predictions with the data is within 10% at low x_p . This is covered by the experimental uncertainties which are dominated by the hadronic energy scale uncertainty. The two other significant contributions to the experimental uncertainty are the model uncertainty (5% at low x_p) and the statistical uncertainty ($\approx 20\%$ in the highest x_p bin).

4. Conclusion

A new and more precise measurement of high E_t dijet photoproduction from the H1 Collaboration is presented. Differential cross sections are measured

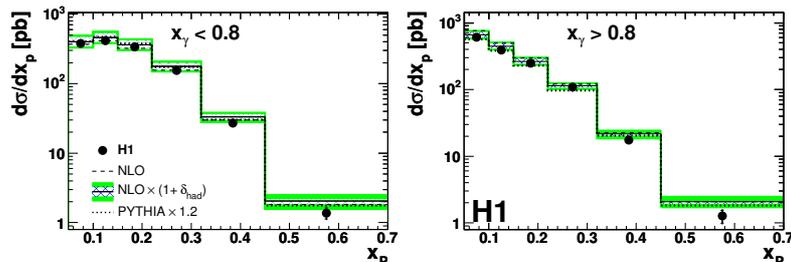


Figure 2. Cross sections as a function of x_p . The cross sections are shown separately for two regions in x_γ enhancing the resolved (left) or direct (right) photon contribution.

in two regions of the observable x_γ as a function of the longitudinal proton momentum fraction x_p . Both the NLO QCD calculation and the PYTHIA Monte Carlo simulation provide a reasonable description of the data.

The region of $x_\gamma > 0.8$ (direct photon enhanced region), in which the photon predominantly interacts directly with the proton, is particularly well suited to test proton structure as the photon structure plays no significant role there. At high $E_{t,\max}$ and large x_p the dominant theoretical uncertainty comes from the uncertainty of the proton parton density functions. The data in the region of $x_\gamma < 0.8$ (resolved photon enhanced region), where the photon mainly behaves like a hadronic object, may also provide additional constraints on the photon parton density functions.

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