arXiv:hep-ex/0007011v1 6 Jul 2000

HIGH E_T PHOTOPRODUCTION AND THE PHOTON STRUCTURE

M. WING
(On behalf of the H1 and ZEUS collaborations)
McGill University, Physics Department, 3600 University Street, Montreal, Canada, H3A 2T8
E-mail: wing@mail.desy.de

Dijet photoproduction results are presented from the H1 and ZEUS collaborations and compared to next-to-leading order pQCD calculations.

1 Introduction

The study of high transverse energy (E_T) dijet photoproduction provides both a test of pQCD and information on the structure of the photon. In events with jets of sufficiently high E_T, the contribution of non-perturbative effects, which are currently poorly understood, is suppressed. The effect of hadronisation is also reduced, allowing a more meaningful comparison of hadron-level data with parton-level next-to-leading-order (NLO) calculations. In the kinematic regime of the current measurements, the parton densities of the proton are well constrained, in contrast to the parton densities of the photon. The parameterisations currently fit F_2^γ data from e^+e^- experiments which do not well constrain the gluon density of the photon or the quark densities at high x_γ, the fraction of momentum of the photon carried by the struck parton.

In this paper, events with an almost real photon (virtuality, $Q^2 \approx 0$ GeV^2) containing at least two jets reconstructed using the k_T clustering algorithm [1] are analysed. Measurements of events with a virtual photon and with jets of lower E_T are discussed in detail elsewhere [2,3]. The H1 and ZEUS collaborations have analysed similar amounts of luminosity; 36 pb^{-1} and 38 pb^{-1} respectively, allowing measurements up to $E_T^{\rm jet} \sim 90$ GeV. Improvements in the understanding of pQCD for jet photoproduction has led to the agreement of many independent calculations to within $5-10\%$ [4,5].

2 Results

Cross sections as a function of the transverse momentum of the leading jet and the average transverse momentum of the two jets are shown in Fig. 1 compared to expectations from the PYTHIA Monte Carlo [6] program and an NLO calculation. The kinematic regime is shown in Fig. 1 where the leading jet was required to have $P_T^{\rm jet1} > 25$ GeV. The transverse momentum of the jet falls by three orders of magnitude up to values of ~ 90 GeV. The cross section measurements are well described by the pQCD calculation in both shape and normalisation.

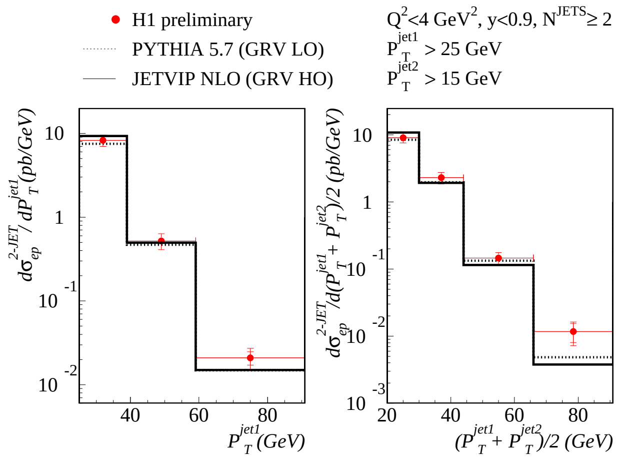

Figure 1: Cross section measurements in transverse momentum of the leading jet, $P_T^{\rm jet1}$ and the average transverse momentum of the two leading jets, $(P_T^{\rm jet1} + P_T^{\rm jet1})/2$ compared to expectations.

As the pQCD calculations describe the measurements at very high values of transverse energy, lowering the energy and considering other quantities provides a test of the current photon parton density functions (PDF's). It has already been demonstrated that at forward regions of pseudorapidity of the jet, $\eta^{\rm jet}$, the NLO calculations underestimate the data for all choices of photon PDF [4,7]. Requiring that $x_\gamma^{\rm obs}$, the fraction of the photon's energy participating in the production of the two highest energy jets;

$$x_\gamma^{\rm obs} = \frac{\sum_{\rm jet1,2} E_T^{\rm jet} e^{-\eta^{\rm jet}}}{2yE_e}, \tag{1}$$

where yE_e is the initial photon energy, satisfies $x_\gamma^{\rm obs} > 0.75$, enhances the direct photon component of the cross section. The NLO calculations were shown to agree with the data in this region justifying the validity of the calculations and indicating that the discrepancy when no $x_\gamma^{\rm obs}$ cut is applied arises due to the inadequacies of the photon PDF's.

This was investigated further by considering the cross section in $x_\gamma^{\rm obs}$. The measured cross sections in $x_\gamma^{\rm obs}$ for increasing slices in transverse energy of the leading jet are shown in Fig. 2 compared to an NLO calculation using the AFG-HO [8] photon PDF. The measured data clearly lie up to $50-60\%$ above the pQCD calculation for low values of $x_\gamma^{\rm obs}$ and the trend is maintained up to high values of $E_T^{\rm jet1}$.

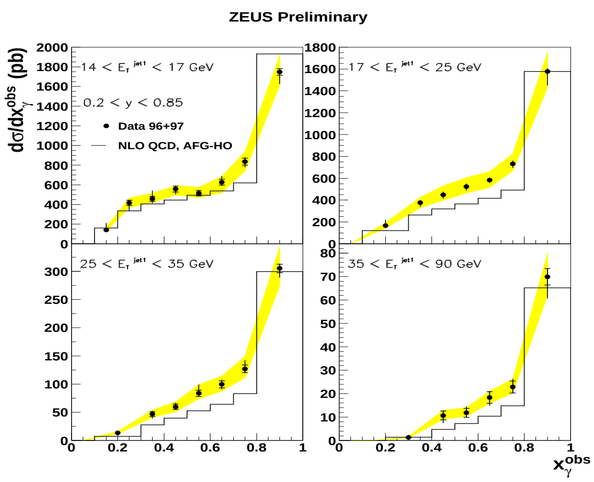

Figure 2: Cross section measurements in $x_\gamma^{\rm obs}$ in slices of $E_T^{\rm jet1}$. The jets were restricted to $-1 < \eta^{\rm jet} < 2$ and the events to the region $Q^2 < 1$ GeV^2 and $0.2 < y < 0.8$. The band around the points displays the error due to the uncertainty associated with the calorimeter energy scale.

Having established a region of phase space in which the data is not described by the pQCD calculations, further studies were made to ascertain if the problem lies with the calculation or the photon PDF. This was done by considering the cross section in $|\cos\theta^*|$, the angle between the dijet and beam axes in the dijet centre-of-mass system. This measurement directly tests the parton-parton dynamics of the hard sub-process and was performed in two regions of $x_\gamma^{\rm obs}$ ($x_\gamma^{\rm obs} < 0.75$ and $x_\gamma^{\rm obs} > 0.75$). Additional requirements were made to remove the biases in the distribution due to the $E_T^{\rm jet}$ and $\eta^{\rm jet}$ cuts. Cuts on the dijet invariant mass, $M_{jj} > 39$ GeV and the average pseudorapidity of the jets, $0 < \bar{\eta} < 1$, were made.

The cross section is shown in Fig. 3 compared to the absolute prediction and the shape of the NLO calculation. As has already been observed, the higher $x_\gamma^{\rm obs}$ region is well described and the lower $x_\gamma^{\rm obs}$ region poorly described in normalisation. However, the shape of the cross section for $x_\gamma^{\rm obs} < 0.75$ is well described by the NLO calculation indicating that the calculation describes

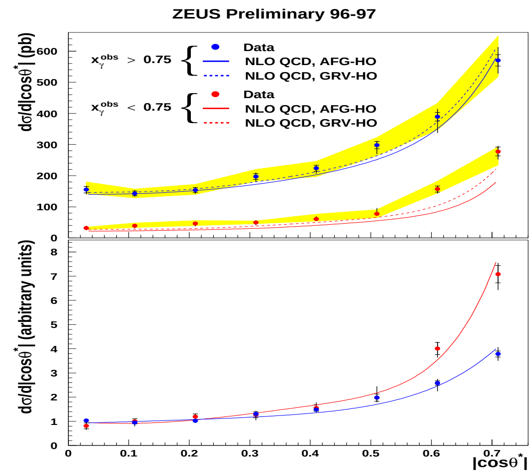

Figure 3: Cross section in $|\cos\theta^*|$ compared to NLO cross section predictions and shape where the distributions are normalised such that the integral of the first three bins is equal.

the parton-parton dynamics of the hard sub-process.

3 Conclusions

Dijet photoproduction has been measured up to $E_T^{\rm jet} \sim 90$ GeV and compared to pQCD calculations. Clear evidence is seen that the calculations give a good description of the scattering process. However, inadequacies in the current parameterisations of the photon PDFs are evident. The use of the data presented here in future fits would greatly improve our understanding of the photon PDF.

References

1. S. Catani et al., *Nucl. Phys.* B **406**, 187 (1993).
2. S. J. Maxfield, these proceedings.
3. ZEUS Collab., J. Breitweg et al., DESY00-017, accepted by *Phys. Lett.* B
4. ZEUS Collab., J.Breitweg et al., *Euro. Phys. J.* **C11**, 427 (1999).
5. S. Frixione, *Nucl. Phys.* B **507**, 295 (1997); S. Frixione and G. Ridolfi, *Nucl. Phys.* B **507**, 315 (1997); B. W. Harris, M. Klasen and J. Vossebeld, `hep-ph/9905348`; B. Pötter, `hep-ph/9911221`.
6. H.-U. Bengtsson and T.Sjöstrand, *Comp. Phys. Commun.* **46**, 43 (1987).
7. ZEUS Collab., Paper EPS-540, EPS conference, Tampere (1999).
8. P. Aurenche, J. Guillet and M. Fontannaz, *Z. Phys.* C **64**, 621 (1994).