The Partonic Structure of the Quasi-Real Photon

J.H. Vossebeld (On behalf of ZEUS and H1)

NIKHEF, P.O. Box 41882, 1009 DB Amsterdam, The Netherlands
E-mail: `vossebeld@nikhef.nl`

Abstract

New measurements of dijet photoproduction at HERA provide information on the gluon density in the photon and on its quark densities at high x_γ and high factorisation scales.

1. Introduction‡

In dijet photoproduction two event classes are distinguished: direct events, in which the photon couples directly to a parton in the proton, and resolved events, in which the photon acts as a source of partons, one of which scatters off a parton in the proton. Resolved processes are sensitive to the partonic structure of the photon. Experimentally direct and resolved events can be separated using x_γ^{obs} $(= x_{\gamma,jets})$, the fractional momentum of the photon participating in the hard scatter, defined as: $x_\gamma^{obs} = (E_{T\,1}^{jet} e^{-\eta_1^{jet}} + E_{T\,2}^{jet} e^{-\eta_2^{jet}})/2yE_e$, where y is the fractional momentum of the incoming positron transferred to the photon.

2. Measurement of the gluon density in the photon

H1 has measured the dijet photoproduction cross section as a function of $x_{\gamma,jets}$, using $7.2\,\mathrm{pb}^{-1}$ of data collected in 1996. From this measurement the gluon density in the photon is extracted, using the *single effective subprocess* approximation [1], in which the cross section factorises in an effective scattering process and effective parton densities in the proton and the photon, defined by: $f_{eff} = \sum_i^{n_f}(q_i + \bar{q}_i) + \frac{9}{4}g$, where n_f is the number of active quark flavours.

Jets are reconstructed using a cone algorithm with cone radius $R = 0.7$. The sensitivity to multiple interaction effects is reduced by subtracting pedestals from the transverse momenta of jets. A kinematic region is selected satisfying: $-0.5 < \eta^{jets} < 2.5$, $P_T^{jets} > 6$ GeV, $|\eta_1^{jet} - \eta_2^{jet}| < 1$, $0.5 < y < 0.7$ and $Q^2 < 0.01$ GeV^2.

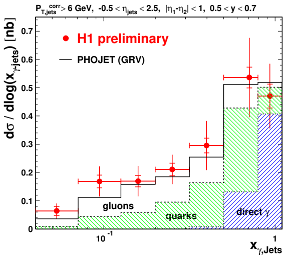

Figure 1. Dijet cross section as a function of $x_{\gamma,jets}$ compared to the PHOJET Monte Carlo, using the GRV parametrisation of the photon structure.

In figure 1 the cross section is compared to the PHOJET [2] Monte Carlo, using the GRV [3] parametrisation for the photon structure. Direct events and resolved events due to quarks and gluons in the photon are shown separately. At low $x_{\gamma,jets}$ a clear sensitivity of the cross section to the gluon content of the photon can be observed.

After unfolding to the parton level, the effective parton density in the photon is determined from the ratio between the cross sections in data and Monte Carlo. Quark densities, as given by GRV, which agree with existing F_2^γ data [6], are subtracted to obtain the gluon density. The effective parton density and the gluon density, shown in the figures 2a and 2b, are compared to the GRV [3] and

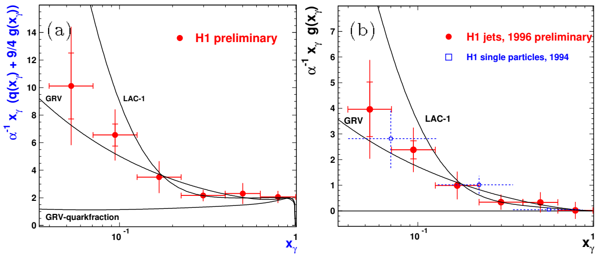

Figure 2. The effective parton density (a) and the gluon density (b) in the photon compared to GRV and LAC1. The open squares in figure (b) were determined in a measurement [5] of the charged particle cross section in photoproduction.

---

‡ The results discussed here have also been described in the papers 157ad and 540, submitted to this conference.

LAC1 [4] densities. The gluon density rises at low x_γ and favours the low GRV gluon density. Figure 2b also shows results obtained from a measurement of the charged particle cross section in photoproduction [5].

3. Measurement of dijet photoproduction at high transverse energies

ZEUS has measured the dijet cross section as a function of the highest transverse jet energy and the jet pseudorapidities, using 38 pb^{-1} of data collected in 1996 and 1997. A kinematic region is selected where: $-1 < \eta_{1,2}^{jet} < 2$, $E_{T\,1}^{jet} > 14$ GeV, $E_{T\,2}^{jet} > 11$ GeV, $0.20 < y < 0.85$ and $Q^2 < 1$ GeV^2. Jets are reconstructed using a k_T clustering algorithm [7] in the inclusive mode [8].

Figure 3 shows the cross section as a function of the highest transverse jet energy in various regions of the jet pseudorapidities, compared to NLO QCD calculations [9] using the AFG-HO [10] parametrisation of the photon structure. The cross section was measured for the full data sample and for a direct-enriched sample with $x_\gamma^{obs} > 0.75$. In general, data and theory agree, with the exception of the forward region, to be discussed below, where the data lie above the predictions.

The cross section as a function of the jet pseudorapidities (figure 4) was determined for thresholds on the highest transverse jet energy, ranging from 14 GeV to 29 GeV. To obtain a better correlation between the jet pseudorapidities and x_γ, the measurement was restricted to a kinematic region with: $0.50 < y < 0.85$. For the direct-enriched sample ($x_\gamma^{obs} > 0.75$) the data agree with NLO QCD. For the full x_γ^{obs} range, however, at forward and central pseudorapidities, the cross sections lie above the calculations. This difference remains up to high transverse energies.

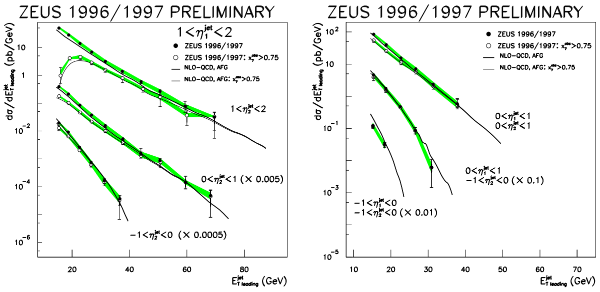

Figure 3. Dijet cross section as a function of the highest transverse jet energy, in various regions of the jet pseudorapidities, for the full x_γ^{obs} range and for $x_\gamma^{obs} > 0.75$, compared to NLO QCD. Thick error bars represent the statistical uncertainty and thin error bars the systematic and statistical uncertainties added in quadrature. The shaded band represents the energy scale uncertainty.

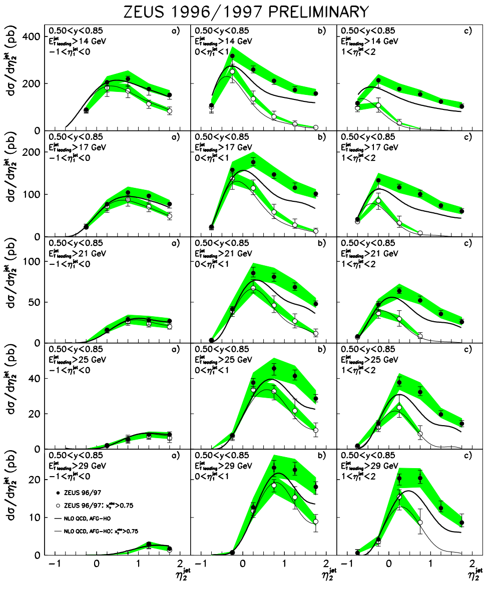

Figure 4. Dijet cross sections as a function of the jet pseudorapidities, for $0.50 < y < 0.85$ and for different thresholds on the transverse energy of the leading jet, compared to NLO QCD.

Various theoretical uncertainties, that can affect the comparison between data and theory, were studied and found to be small (see also [11]). Therefore the observed discrepancies, which are also present when other parametrisations of the photon structure are compared to, suggest that available parametrisations of the photon structure are too low in the region of high x_γ and high factorisation scales.

4. Summary

Both HERA experiments, ZEUS and H1, have produced new results on the partonic structure of the photon. These data are complementary to F_2^γ data from e^+e^- experiments, and should be included in QCD fits used to determine parametrisations of the parton densities in the photon.

References

[1] B.L. Combridge and C.J. Maxwell, *Nucl. Phys.* B **239**, 429 (1984).
[2] R. Engel, *Z. Phys.* C **66**, 203 (1995).
[3] M. Glück et al., *Phys. Rev.* D **46**, 1973 (1992).
[4] H. Abramowicz et al., *Phys. Lett.* B **269**, 458 (1991).
[5] H1 collab., DESY-98-148, submitted to *Eur. Phys. J.*.
[6] G. Cowan, these proceedings.
[7] S. Catani et al., *Nucl. Phys.* B **406**, 187 (1993).
[8] S.D. Ellis and D.E. Soper, *Phys. Rev.* D **48**, 3160 (1993).
[9] S. Frixione, *Nucl. Phys.* B **507**, 295 (1997).
[10] P. Aurenche et al., *Z. Phys.* C **64**, 621 (1994).
[11] ZEUS Collab., DESY-99-057, Submitted to *Eur. Phys. J.*.