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PHOTON STRUCTURE FROM HERA*

Stephen Maxfield

On behalf of the H1 and ZEUS Collaborations

Dept. of Physics, University of Liverpool
Oxford Street, Liverpool L69 7ZE, UK

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Some recent measurements of real and virtual photon structure at HERA are reviewed. The cross section for dijet events in photoproduction is compared to NLO QCD calculations. In low Q^2 DIS, the production of dijets is shown to be sensitive to the structure of longitudinally polarised photons and the Q^2 evolution modified in charm-enriched events.

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1. Introduction

Measurements of dijet production in photoproduction and low Q^2 Deep Inelastic Scattering (DIS) supply constraints on the parton density functions (pdf's) of real and virtual photons respectively as well as tests of perturbative QCD. This is because the jets can be produced in resolved photon interactions where the photon has fluctuated into a system of partons one of which undergoes a hard scattering with a parton from the proton. In effect the proton beam acts as a source of coloured partons which probe of the structure of the target photon. They do this at a scale determined by the transverse energy, $E_{\rm T}$ of the jets. The cross section for the process can be written as a convolution of photon fluxes, parton densities for the photon and proton and matrix elements for the parton–parton scattering:

$$\sigma \sim f_{\gamma^{*k}|e} \otimes \mathrm{pdf}^{\gamma,k} \otimes \mathrm{pdf}^{\mathrm{proton}} \otimes M_{ij}\,.$$

Of the various components, the photon fluxes, $f_{\gamma^{*k}|e}$, $k = \mathrm{T,L}$, are determined from QED, the matrix elements have been calculated up to NLO in perturbative QCD and parton densities in the proton have been measured

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to high precision from deep inelastic scattering data. Parton densities for quasi-real photons have been obtained from global fits to measurements of the photon structure function F_2^γ taken at several different scales in $e\gamma$ DIS (two photon) processes at e^+e^- colliders.

I will try to summarise the current status of photon structure measurements made at HERA concentrating on the more recent dijet cross section measurements made by ZEUS and H1. The analyses are presented individually and in more detail elsewhere in these proceedings [1]. Single-inclusive jet cross sections are also useful in this context but I will not discuss them here.

2. Real photon structure

H1 and Zeus have completed similar measurements of the high E_{T} dijet cross section in photoproduction [2]. The H1 measurement is based on an integrated luminosity of 34.9 pb^{-1} with inelasticity in the range $0.1 < y < 0.9$. A $\mathrm{k_t}$ algorithm [3] was used to find jets. Selected events contain at least two jets in the range $-0.5 < \eta < 2.5$ with asymmetric cuts on their transverse energy, $E_{\mathrm{T}}^{\mathrm{jet1}} > 25\,\mathrm{GeV}$ and $E_{\mathrm{T}}^{\mathrm{jet2}} > 15\,\mathrm{GeV}$. The measured cross sections are compared with next-to-leading order QCD calculations [4]. Effects of hadronisation are estimated with leading order simulations (HERWIG 5.9 [5] and PYTHIA 5.7 [6]). The calculations use GRV-HO and AFG-HO densities for the photon and CTEQ5M densities for the proton.

The ZEUS measurement was made using slightly different inelasticity ranges (134 GeV $< W_{\gamma p} <$ 277 GeV) and the jets were limited to $-1.0 < \eta < 2.4$ with $E_{\mathrm{T}}^{\mathrm{jet1}} > 14\,\mathrm{GeV}$ and $E_{\mathrm{T}}^{\mathrm{jet2}} > 11\,\mathrm{GeV}$. Comparisons are again made to the NLO calculations of Frixione *et al.*, corrected for hadronisation effects using HERWIG 6.1 (and PYTHIA 6.1).

The NLO matrix elements can be tested by looking at the distribution of the cosine of the centre of mass scattering angle, $\cos\theta^* = \tanh(\Delta\eta/2)$. This is controlled by the propagator: necessarily a quark in direct photon interactions and dominantly a gluon in resolved processes. Enriched samples of the two types of process can be obtained by selecting events according to the value of:

$$x_{\gamma,\mathrm{jets}} \equiv \frac{E_{\mathrm{T,jet1}}\mathrm{e}^{-\eta_{\mathrm{jet1}}} + E_{\mathrm{T,jet2}}\mathrm{e}^{-\eta_{\mathrm{jet2}}}}{2yE_{\mathrm{ebeam}}} \tag{1}$$

which $\to 1$ in direct events. A cut on the dijet mass is needed to avoid distortion of the distributions by phase space effects. Within the experimental and theoretical uncertainties, the NLO calculations give a good description of the distributions indicating that the dynamics of the dijet production mechanism are understood.