

Isolated photons at HERA

Ulrich Straumann (for the H1 and ZEUS collaborations)

Universität Zürich, Winterthurerstrasse 190, 8057 Zürich, Switzerland

E-mail: strauman@physik.uzh.ch

Abstract. This contribution describes two recent measurements of isolated photons appearing in photoproduction (measured by ZEUS) and deep inelastic scattering (measured by H1) at the ep collider HERA.

1. Introduction

Isolated photons with high transverse momentum in the final state are a sensitive probe of the dynamics of the hard sub-process, since they are largely insensitive to hadronisation and fragmentation and carry unaltered information of the hard scatter. Also, a good understanding of the Standard Model production mechanism of photons is especially important for new physics searches at hadron colliders, where new particle decays to photons have to be separated from the background induced by photons produced in the primary scattering processes.

2. Isolated photons in photoproduction

Events with isolated photons and at least one accompanying jet, are measured [1] by the ZEUS collaboration in the kinematical region of inelasticity $0.2 < y < 0.8$ and photon virtuality $Q^2 < 1 \text{ GeV}^2$.

In order to select events, each reconstructed jet is first classified as either a photon candidate or a hadronic jet. A photon-candidate jet is required to have no associated track and to be within the central tracking detector, $-0.74 < \eta^\gamma < 1.1$. For this jet, $E_{\text{EMC}}/E_{\text{tot}} > 0.9$ is required, where E_{EMC} is the energy reconstructed in the electromagnetic part of the calorimeter and E_{tot} is the total energy of this jet. A cut $E_T^\gamma > 5 \text{ GeV}$ is applied after correction for energy losses. Hadronic jets are selected in the kinematic range $E_T^{\text{jet}} > 6 \text{ GeV}$, $-1.6 < \eta^{\text{jet}} < 2.4$. If more than one jet fulfills these conditions, the jet with the highest E_T^{jet} is selected.

The identification of the photon makes use of the lower conversion probability for a single photon in the detector material compared to multi-photon events arising from neutral meson decays (π^0 , η , etc.). The number of charged particles in the barrel preshower detector (BPRES) [2] is thus expected to be smaller for isolated photons. The method is verified using deeply virtual Compton scattering events. In the data the γ candidates are fitted using a MC model with and without prompt photons, resulting in a number of events associated with a photon signal. The resulting differential cross section as functions of E_T and η for both the isolated photon candidates and for the accompanying jets are shown in Fig. 1.

The results are compared to two next-to-leading (NLO) order calculations, (KZ) [3] and (FGH) [4], as well as to a calculation based on k_T -factorisation with unintegrated quark and gluon densities of the proton and the photon, (LZ) [5]. All cross sections are corrected for

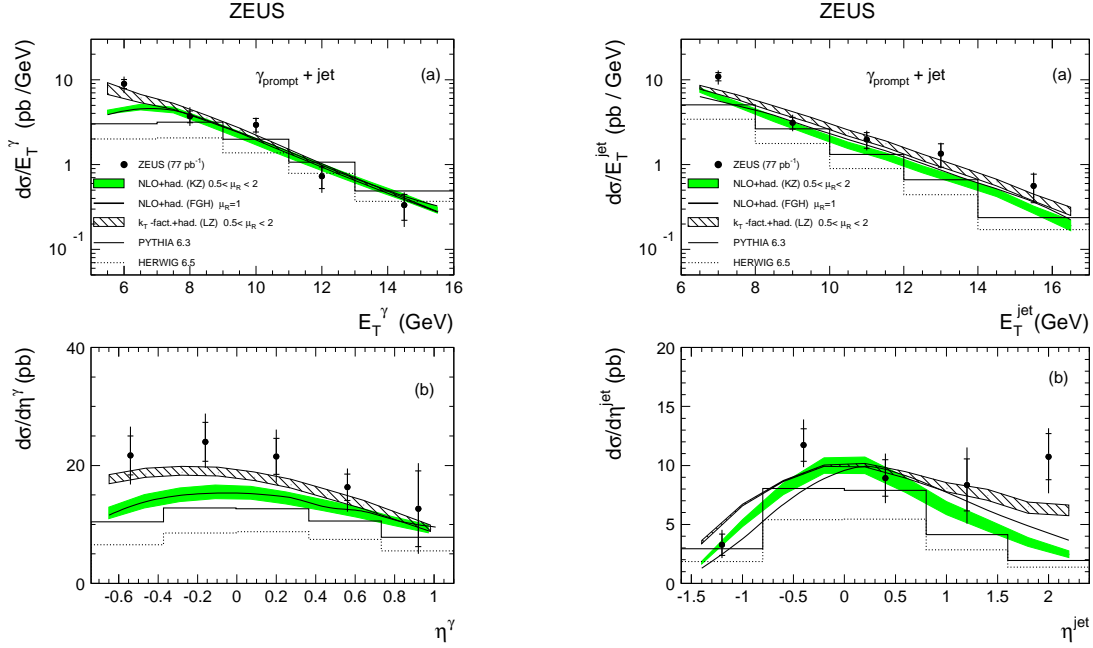


Figure 1. The differential γ +jet cross sections as functions of E_T and η of the prompt photon (left) and the jet (right). The data are compared to QCD calculations and MC models (see text). The shaded uncertainty bands correspond to a renormalisation scale variation by factors of 0.5 and 2.

hadronisation effects using a MC simulation. The comparison with the data shows, that the MC differential cross sections do not rise as steeply at low E_T^γ as the data. The KZ and FGH NLO predictions describe the data better, but still fail at low E_T^γ and in the forward jet region. The LZ prediction gives the best description. If the minimum transverse energy of the detected prompt photons $E_{T\min}^\gamma$ is increased from 5 GeV to 7 GeV (resulting in $E_{T\min}^\gamma > E_{T\min}^{\text{jet}}$), both the NLO QCD and the LZ predictions agree well with the data [1].

3. Isolated photons in deep inelastic scattering

Events with isolated photons in deep inelastic scattering have been measured [6] by the H1 collaboration within a kinematic region of $4 < Q^2 < 150 \text{ GeV}^2$ and $y > 0.05$. Background from elastic Compton scattering is suppressed by a cut on the invariant mass of the hadronic system $W_X > 50 \text{ GeV}$.

A photon candidate is identified by a cluster in the electromagnetic section of the H1 liquid argon calorimeter with a transverse energy $3 < E_T^\gamma < 10 \text{ GeV}$ and pseudo-rapidity $-1.2 < \eta^\gamma < 1.8$ and no track pointing to it. Jets with a transverse momentum of $P_T^{\text{jet}} > 2.5 \text{ GeV}$ and a pseudorapidity in the range $-2.0 < \eta^{\text{jet}} < 2.1$ are reconstructed using the k_T algorithm. To ensure isolation of the photon, $E_T^\gamma/E_T^{\text{photon-jet}} > 0.9$ is required, where the photon-jet is the jet containing the photon candidate. Hadronic jets are restricted to $-1.0 < \eta^{\text{jet}} < 2.1$. A shower shape analysis of the photon cluster makes use of the more narrow, symmetric and compact clusters created by single photons, which also start off slightly deeper in the calorimeter than multi-photon showers originating from neutral hadrons (π^0 , η , etc.). The contribution of photons and neutral hadrons in any analysis bin is determined by independent minimum- χ^2 fits of the simulated signal and background distributions to the data distribution.

The resulting differential cross sections are shown in Fig. 2 separately for events with a

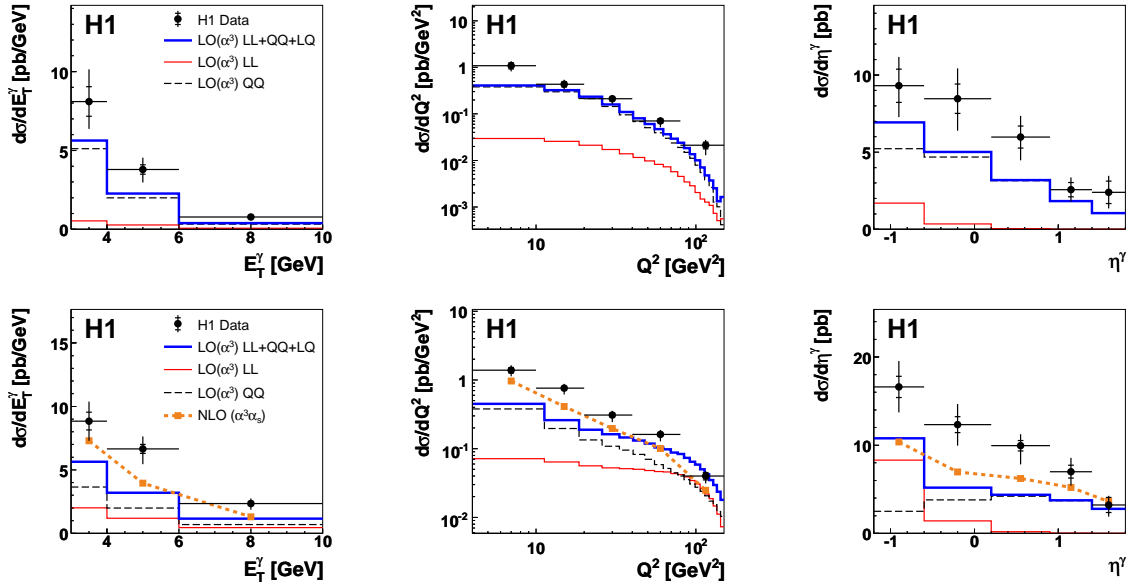


Figure 2. Isolated photon cross sections without (top) and with (bottom) additional reconstructed hadronic jets as a function of transverse energy E_T^γ , Q^2 and pseudorapidity η^γ for deep inelastic scattering events in the region of $4 < Q^2 < 150 \text{ GeV}^2$. The inner error bars on the data points indicate the statistical error, the full error bars contain in addition the systematic errors added in quadrature. The cross sections are compared with LO and NLO calculations.

photon and no hadronic jet (top) and with at least one jet (bottom). The uncertainty on the shower description gives the dominant contribution to the systematical error. A recent LO calculation [7, 8], $\mathcal{O}(\alpha^3\alpha_s^0)$, shows contributions from radiation from the quark (QQ) and the electron (LL) separately. The contribution from interference (LQ) is less than 3%. The predictions are corrected to hadron level, using the event generators PYTHIA and RAPGAP.

The LO calculation underestimates the cross sections in average by roughly 44%, most significantly at low Q^2 . The relative contribution of LL and QQ depends strongly on η^γ . The cut on W_X largely suppresses the LL contribution for the sample without jets.

The cross sections for events with additional jets are further compared to a NLO, $\mathcal{O}(\alpha^3\alpha_s^1)$, calculation [9] which is not available for the selection without jets. The shapes of the differential cross sections are better described, but the theory is still low in overall normalisation by more than 30%. The uncertainties of the NLO calculation are estimated by varying the renormalisation scales by a factor of two up and down. These uncertainties are below 3% and lower than uncertainties from the choice of the proton parton distributions and from the hadronisation corrections (11%).

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