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MEASUREMENT OF SINGLE INCLUSIVE HIGH e_{T} JET CROSS-SECTIONS IN PHOTOPRODUCTION AT HERA*

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Inclusive jet cross-sections for the reaction $e^+p \to \mathrm{jet} + X$ for $Q^2 < 1$ GeV^2 and photon-proton energies in the interval $95 \leq W \leq 285$ GeV have been measured. Jets with transverse energies $E_{\mathrm{T}}^{\mathrm{jet}} > 21$ GeV in the pseudorapidity range $-1 \leq \eta^{\mathrm{jet}} \leq 2.5$ are searched for using the inclusive k_{T} cluster algorithm in the laboratory frame. Cross-sections as a function of η^{jet} and $E_{\mathrm{T}}^{\mathrm{jet}}$ are compared with NLO QCD calculations using different sets of photon parton density functions as input. The cross-sections are in good agreement with NLO QCD up to the highest measured values of $E_{\mathrm{T}}^{\mathrm{jet}} = 75$ GeV.

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1. Introduction

At HERA, the collisions of protons with quasi-real photons emitted from the incoming electrons can result in the production of jets with high transverse momentum $E_{\mathrm{T}}^{\mathrm{jet}}$. Measurement of the inclusive cross section for such a process has two motivations. Firstly, at high $E_{\mathrm{T}}^{\mathrm{jet}}$, where non-perturbative effects are less influential, jet cross-sections directly reflect the underlying parton dynamics of the photon-proton collision. Therefore, $E_{\mathrm{T}}^{\mathrm{jet}}$ spectra measurements offer a means of testing the validity of QCD predictions. Secondly, quasi-real photons may develop hadronic structure, which is probed by the partons in proton. As the proton parton density functions (PDF) are

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well constrained by F_2^p DIS measurements, measurements of pseudorapidity[1] distribution $d\sigma/d\eta^{\rm jet}$ allow the probing of photon structure at higher scales than those reached at e^+e^- colliders and provide complementary information to that obtained from *e.g.* dijet analysis.

In this paper, measurements of differential jet cross-sections as a function of the jet transverse energy, $E_{\rm T}^{\rm jet}$, and pseudorapidity, $\eta^{\rm jet}$, for inclusive jet production in photoproduction are presented. The measurements are corrected to the hadron level and compared with next-to-leading order (NLO) calculations including resolved and direct processes and using available NLO photon PDFs. The data were collected with the H1 detector at the HERA collider in 1996 and 1997, in which positrons of energy 27.5 GeV collided with protons of energy 820 GeV. The total data sample corresponds to an integrated luminosity of 24.1 ± 0.4 pb^{-1}.

2. Data selection and analysis method

We measure untagged photoproduction *i.e.* we anti-select for scattered positron in a lead/scintillating-fiber calorimeter (SPACAL) and Liquid Argon (LAr) calorimeter[2]. Both calorimeters have fine-grained electromagnetic and hadronic parts allowing for effective rejection of the neutral current (NC) deep inelastic scattering (DIS). The anti-positron selection limits virtuality of incoming photon to the range $Q^2 < 1$ GeV^2

As we do not see the scattered positron, the inelasticity variable y has to be reconstructed from the energies and longitudinal momenta of all objects in the final state. The event sample is restricted to the kinematic region $0.1 \le y \le 0.9$, corresponding to a photon-proton center-of-mass energy W [3] between 95 and 285 GeV.

The contamination from beam-gas background was reduced to a negligible level by demanding a well-reconstructed vertex in the interaction region. Cosmic shower and halo muon backgrounds were then rejected by using a set of topological muon finders in addition to the requirement that the missing transverse momentum is small compared to the total transverse energy of the events: $\not{P}_{\rm T}/\sqrt{E_{\rm T}} \le (2.5~{\rm GeV})^{1/2}$.

The inclusive jet sample was defined by keeping all events for which at least one jet with a transverse energy greater than 21 GeV in the pseudorapidity region $-1 \le \eta^{\rm jet} \le 2.5$ was reconstructed. The jet search was

[1] Pseudorapidity is defined as $\eta \equiv -\ln(\tan\,\theta/2)$ where θ is the polar angle with respect to the proton direction. H1 uses a coordinate system whose origin is defined by the nominal interaction point. The forward $+z$ direction denotes the direction of the incident proton beam.

[2] A detailed description of the H1 detector can be found elsewhere [1].

[3] $W = \sqrt{ys}$, where s is the squared e^+p center-of-mass energy.

performed in the laboratory frame by applying the inclusive $k_{\rm T}$ cluster algorithm [2] to all "objects" in the final state. Combined objects were defined using calorimeter clusters complemented by tracks measured in the tracking system. At this stage of the selection, the overall non ep background was estimated to correspond to less than 1 % of the data sample. The resulting event sample consists of 17 460 jets reconstructed in 13 389 events.

The HERWIG 5.9 [4] and PYTHIA 5.7 [3] Monte Carlo samples have been used to correct the data for the inefficiencies of the selection criteria and for migrations caused by detector effects. A reasonable description of the data, in particular of the observed energy flow around the jet axis was obtained for both generators. The mean values of the correction factors calculated with PYTHIA and HERWIG were used to correct bin-by-bin the data to the hadron level.

Various sources of systematic errors have been taken into account. The largest is the 4% uncertainty in the absolute hadronic energy scale of the LAr calorimeter, which leads to an uncertainty of 15 to 20 % on the measurements. Other contributions are model dependency of the bin-by-bin correction ($\sim$ 10 %),the trigger efficiency (5 %) and the uncertainty in the luminosity determination for this data sample (1.5 %).

3. Results

In this section, the measured differential cross-sections are presented and compared with NLO QCD calculations [6] based on the subtraction method. The CTEQ5M [7] parameterization of the proton PDF was used for the calculations. GRV-HO [5] was chosen as the standard parameterization of the photon PDF for this analysis. AFG-HO [8] and GSG-HO [9] were also used for comparison. The renormalisation and factorisation scales were set to $\mu_{\rm R} = \mu_{\rm F} = 1/2 \sum E_{\rm T}^{\rm parton}$. These scales were varied by a factor of 2 up and down in order to estimate the uncertainty corresponding to the missing higher-order terms.

Since the NLO QCD calculations refer to jets of partons, the predicted cross-sections have been further corrected to the hadron level, by taking the average of the ratios of cross-sections at the hadron and parton levels as given by PYTHIA and HERWIG.

The measured differential e^+p cross-section $d\sigma/dE_{\rm T}^{\rm jet}$ for inclusive jet production integrated over $-1 \leq \eta^{\rm jet} \leq 2.5$ in the kinematic region defined by $Q^2 \leq 1$ GeV^2 and $95 \leq W \leq 285$ GeV is shown in figure 1.

The NLO QCD prediction including hadronisation effect is shown in the figure together with its theoretical uncertainty. Higher order correction improves agreement with the data everywhere, but the improvement is sig-

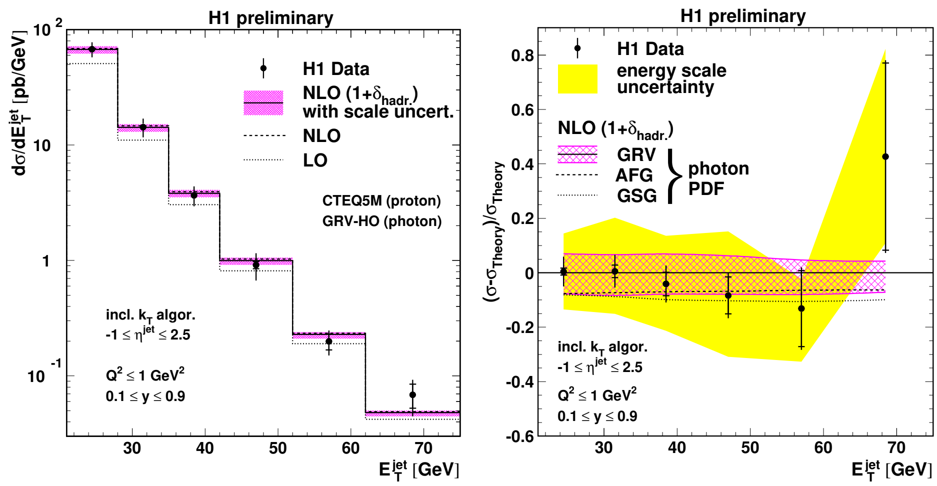

Fig. 1. Left: the measured differential e^+p cross-section $d\sigma/dE_{\rm T}^{\rm jet}$ for inclusive jet production.The inner error bars represent the statistical errors of the data, and the outer show the statistical and systematic uncertainties added in quadrature. The hatched band displays the uncertainty on the NLO QCD calculation. Right: the relative difference between the measured differential cross-section and the NLO calculation based on GRV-HO and CTEQ5M parameterizations of the photon and proton parton densities, including hadronisation corrections. The absolute energy scale uncertainty is shown separately as a shaded band.

nificant only for $E_{\rm T}^{\rm jet} < 30$ GeV. The fractional difference between the data and the QCD prediction is shown in the right part of figure 1.

The differential cross-section $d\sigma/d\eta^{\rm jet}$, shown in figure 2, is most sensitive to the photon PDF. The calculated cross-section using the GRV-HO photon PDF gives a fair description of the data. The calculations using AFG-HO and GSG-HO lie slightly below the data at low $\eta^{\rm jet}$, however theoretical and experimental uncertainties do not allow to discriminate between photon PDF's.

4. Summary

A new measurement of inclusive high $E_{\rm T}$ jet production cross-sections in quasi-real photoproduction ($Q^2 \leq 1$ GeV^2) interactions has been presented. Within the experimental and theoretical uncertainties, the measured distributions are well described by NLO QCD calculations. At present the data precision and theoretical uncertainties (scale dependence) do not allow to discriminate between various photon PDFs.

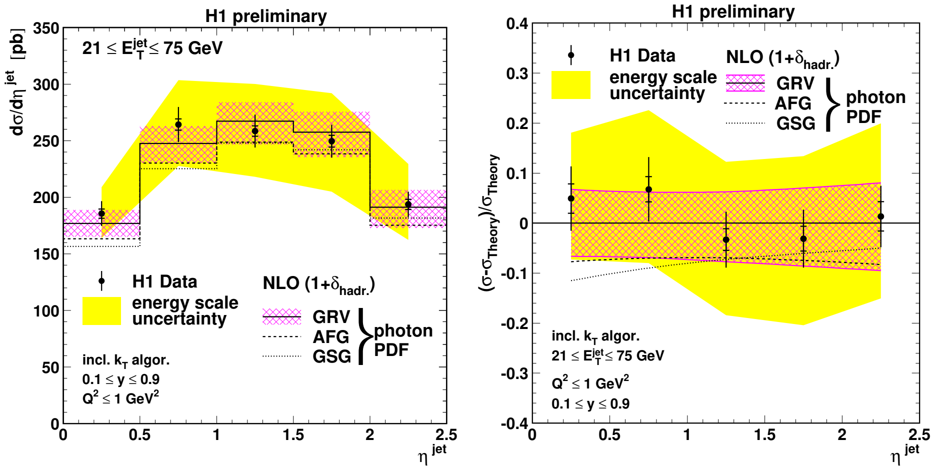

Fig. 2. Left: the measured differential e^+p cross-section $d\sigma/d\eta^{\rm jet}$ for inclusive jet production using the inclusive $k_{\rm T}$ algorithm integrated over $21 \leq E_{\rm T}^{\rm jet} \leq 75$ GeV in the kinematic region defined by $Q^2 \leq 1$ GeV^2 and $0.1 \leq y \leq 0.9$. Data are compared with NLO QCD predictions obtained by using GRV-HO, AFG-HO and GSG-HO photon PDF's and CTEQ5M proton PDF. Right: the relative difference between the measured differential cross section and the NLO calculation.

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