Photoproduction of jets and prompt photons

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Jet and prompt photon production in the photon-proton collisions has been studied for the center of mass energy interval $120 < W_{\gamma p} < 270$ GeV. The data were collected with the ZEUS detector at HERA. Recent results are presented.

1. INTRODUCTION

Jet and prompt photon production in the photoproduction are interesting processes to study parton densities in the photon and to test QCD. During 1995-97 data taking period the ZEUS experiment collected more than $40\,\mathrm{pb}^{-1}$ of data. The jet and prompt photon cross sections and the mean subjet multiplicity in jets are presented here.

2. INCLUSIVE JET AND HIGH-MASS DIJET CROSS SECTIONS

The jet cross sections were measured using k_T cluster algorithm [1]. The measured kinematic range is restricted to $134 < W_{\gamma p} < 277$ GeV and $Q^2 \leq 4$ GeV^2, where Q^2 is the virtuality of the exchanged photon. Since there is no merging ambiguity in the k_T cluster algorithm, experimental data can be compared with the theory without an add-hoc parameter such as R_{SEP}[2] which is used in the cone algorithm.

The inclusive jet cross section $d\sigma/dE_T^{jet}$ has been measured for jets in the range $17 < E_T^{jet} < 74$ GeV integrated over the $-0.75 < \eta^{jet} < 2.5$. The measured cross section is presented in Fig. 1. The data is compared with NLO QCD calculations [3] based on three different photon parton densities, the GS96, GRV-HO and AFG. All the NLO calculations give a reasonable description of the data up to the highest E_T^{jet} studied, $E_T^{jet} \sim 74$ GeV.

The polar angle distribution of the jets in the dijet center of mass system ($|\cos\theta^*|$) has been measured for events with at least two jets with $E_T^{jet} > 14$ GeV and $-1 < \eta^{jet} < 2.5$. The dijet

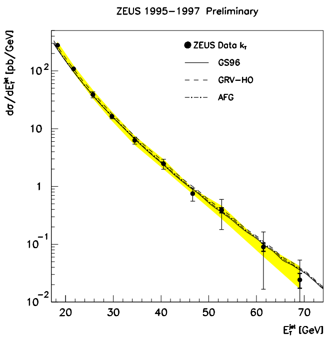

Figure 1. Inclusive jet cross section $d\sigma/dE_T^{jet}$ integrated over $-0.75 < \eta^{jet} < 2.5$. The inner error bars represent the statistical errors and the outer error bars show the quadratic sum of the statistics and systematic errors with the exception of the absolute energy scale. The shaded band displays the energy scale uncertainty.

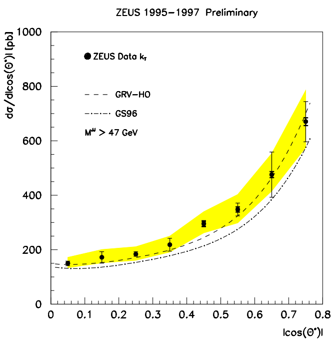

Figure 2. Dijet cross section $d\sigma/d|\cos\theta^*|$ for $M^{JJ} > 47$ GeV. The error bars are as described for Fig. 1.

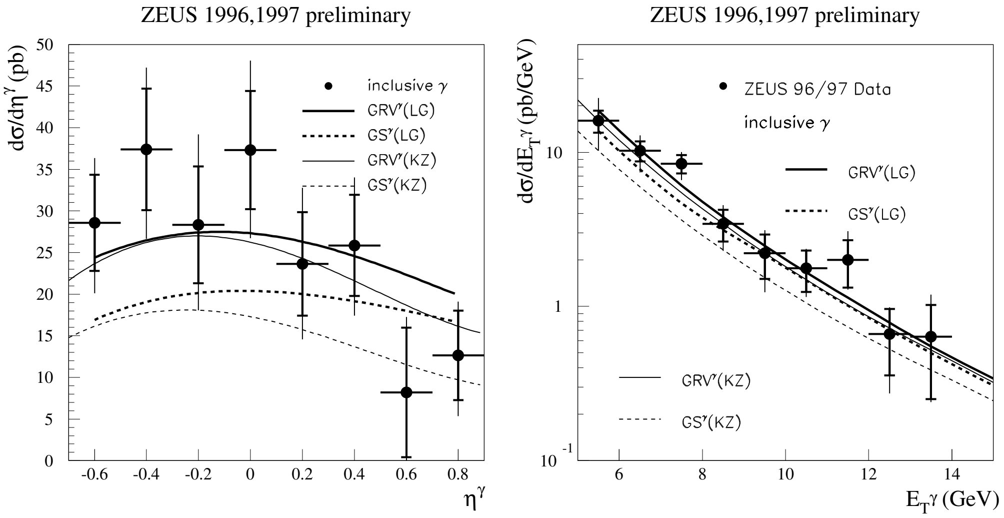

Figure 3. Left: Inclusive prompt photon cross section $d\sigma/d\eta^\gamma$ integrated over $5 < E_T^\gamma < 10$ GeV. Right: Inclusive prompt photon cross section $d\sigma/dE_T^\gamma$ integrated over $-0.7 < \eta^\gamma < 0.9$. The inner error bars represent the statistical errors and the outer error bars show the quadratic sum of the statistical and systematic errors.

mass is required to be greater than 47 GeV. The cross section $d\sigma/d|\cos\theta^*|$ is shown in Fig. 2 and compared with NLO QCD calculations [4] using the GRV-HO and GS96 parametrizations for the photon parton densities. The NLO calculations describe reasonably well the shape of the data. In magnitude the GRV-HO curve lies closer to the data.

3. PROMPT PHOTON CROSS SECTION

Measurement of cross sections for prompt photon production have the advantage that the hadronization effect are largely suppressed. The cross sections $d\sigma/d\eta^\gamma$ and $d\sigma/dE_T^\gamma$ have been measured for the photons with $5 < E_T^\gamma < 10$ GeV and $-0.7 < \eta^\gamma < 0.9$ respectively, in the kinematic range $120 < W_{\gamma p} < 270$ GeV and $Q^2 < 1$ GeV^2. In this kenematic range, the prompt photon cross section is mainly sensitive to the quark densities in the photon [5]. The prompt photon signal is statistically separated from background due to π^0 and η mesons by comparing the pattern of the energy deposit in the calorimeter. Fig. 3 shows the measured cross sections. The NLO QCD calculations [6] using the GRV and GS parametrizations for the photon parton densities are shown in the figures. Both the η^γ and E_T^γ distributions are generally described by the NLO QCD calculations. Away from the largest η^γ bins, the prediction with the GRV gives better description of the data.

4. SUBJET MULTIPLICITY

Subjets are jet-like objects within a jet and are expected to reflect the partonic structure inside the jets. The mean subjet multiplicity [7], $\langle n_{subjet}\rangle$, is expected to be larger in the gluon jets than in the quark jets due to the larger color charge of the gluon.

Subjets in a jet are identified in the following way. For a given jet found by the k_T cluster algorithm, the same algorithm is rerun on the particles (or calorimeter cells) assigned to that jet. For every pair (i,j) of particles the quantity

$$d_{ij} = min(E_T^i, E_T^j)^2 \times (\Delta\eta_{ij}^2 + \Delta\phi_{ij}^2)$$

is computed and the clustering is stopped when all d_{ij} are above

$$d_{cut} = y_{cut} \times (E_T^{jet})^2.$$

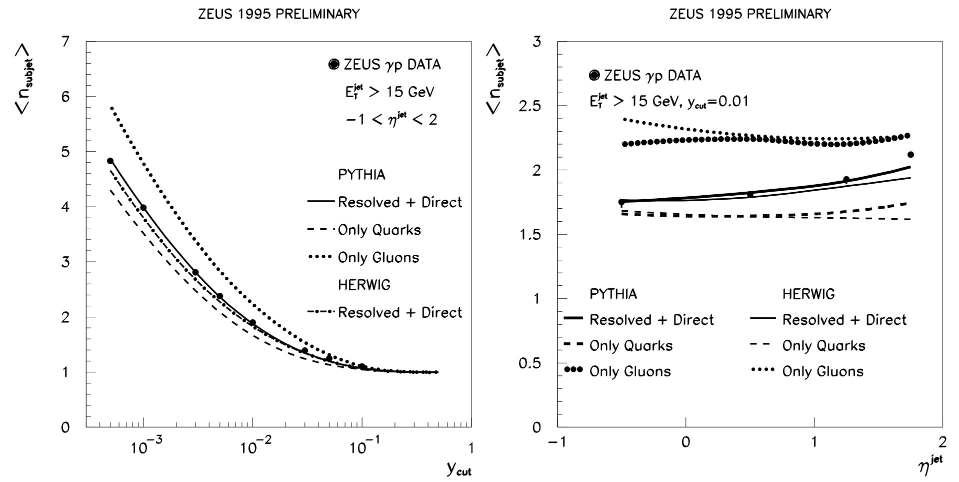

Figure 4. Left: y_{cut} dependence of the mean subjet multiplicity for the jet with $E_T^{jet} > 15$ GeV and $-1 < \eta^{jet} < 2$. Right: η^{jet} dependence of the mean subjet multiplicity at $y_{cut} = 0.01$. The error bars show the quadratic sum of the statistical and systematic errors. Various predictions of PYTHIA and HERWIG are shown: all jets (solid line), quark jets (dashed line) and gluon jets (dotted line).

The remaining objects are called subjets.

The $\langle n_{subjet} \rangle$ have been measured for the jet with $E_T^{jet} > 15$ GeV and $-1 < \eta^{jet} < 2$. The events were selected from the kinematic range $134 < W_{\gamma p} < 277$ GeV and $Q^2 < 1$ GeV^2. The y_{cut} dependence of the $\langle n_{subjet} \rangle$ is shown in Fig. 4 (left). In the figures the predictions from the PYTHIA and HERWIG Monte Carlo are also plotted. As expected, the gluon jets have larger mean subjet multiplicity. The right plot shows the η^{jet} dependence of the $\langle n_{subjet} \rangle$ at $y_{cut} = 10^{-2}$. It is observed that the measured mean subjet multiplicity increases as η^{jet} increases. The trend is well described by PYTHIA and HERWIG and it is consistent with the predicted increase in the fraction of gluon jets as η^{jet} increases.

5. SUMMARY

Inclusive jet, high-mass dijet and prompt photon cross sections have been measured in photoproduction at HERA. The measured cross sections are reasonably well described by the NLO QCD calculations. The calculations based on the GRV photon parton densities give better description of the data than those based on the GS.

The mean subjet multiplicity has been measured by using the k_T cluster algorithm. It is observed that the mean subjet multiplicity becomes larger as η^{jet} increases. This behavior is consistent with an increasing fraction of gluon jets as η^{jet} increases.

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