Measurements of the partonic structure of virtual photons

V.Efremenko, on behalf of the H1 and ZEUS collaborations

Institute for the Theoretical and Experimental Physics, Moscow, Russia
E-mail: valentin.efremenko@itep.ru

Abstract
From the measurements of dijet production, an effective leading order parton density for virtual photons is extracted.

According to modern understanding, real or quasi-real photon can interact with other partons either directly, as a structureless particle (so-called direct process), or through its own parton content (so-called resolved process). In the last case we can study its structure using a probing photon from another electron, as in experiments on e^+e^- colliders, or using the probing parton from proton as in experiments on electron-proton colliders such as HERA.

All this is true for real or quasi-real photons, where the interactions through resolved processes are dominant. However when we move to virtual photons, QCD predicts a drastic decreasing of resolved processes with an increasing of photon virtuality.

A convenient measure of virtuality can be Q^2 - the squared momentum transfer. With increasing Q^2 the distance of the interaction decreases, and the photon does not have time to develop its parton structure. It becomes not resolved and the interaction simplifies to direct process with a pointlike photon.

However, if we can use a tool with better resolution, we still can resolve the photon structure even in the domain of rather high virtuality. The experiments on HERA use as such tool the generation of two jets with high enough transverse energy E_t so that $E_t \gg Q^2$. In this case we can talk about the structure of a virtual photon and investigate it.

H1 analysis is based on data collected at HERA where 820 GeV protons collide with 27 GeV positrons [1] . Only the two highest transverse energy jets were used in the analysis. The Q^2 of these events are very far from the photoproduction region but transverse energies of jets also are high enough.

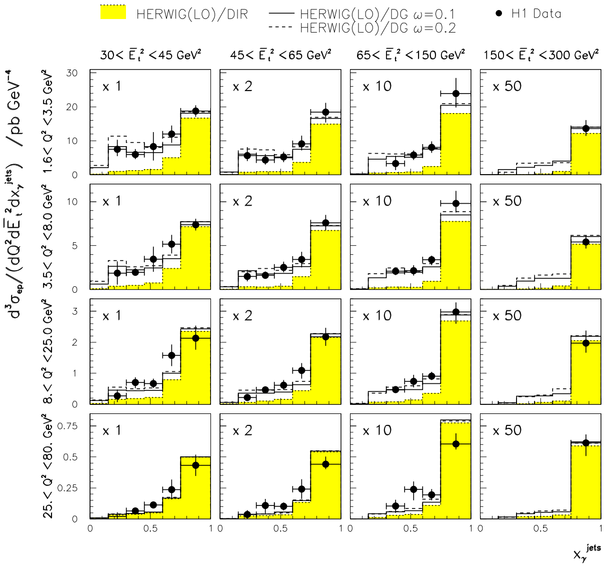

Figure 1. The differential dijet cross section as a function of x_γ^{jets} for different regions of E_t^2 and Q^2. Also shown is the HERWIG(LO)/DG model with two Q^2 suppression factor ω. The direct component of this model is shown as the shaded histogram.

The results of measurements are shown in Fig.1. The triple differential cross sections are plotted versus fractional momentum of parton in photon x_γ^{jets} for different ranges of Q^2 and mean transverse energy $\bar{E}_t$ of jets. The black points here and in the following pictures are data; the histograms are results of the calculation with the HERWIG model. The cross sections decreases strongly with increasing mean transverse energy. It also decreases with increasing Q^2 at fixed energy. The direct component is shown by a shaded histogram. The resolved component is clearly seen in the left part of practically every histogram. However, the resolved part is seen to diminish as Q^2 increases. In $x_\gamma^{jets} = 1$ area there is a peak, which should correspond to the direct process. We see that HERWIG in leading order with Dress-Godbole model [2] and virtuality suppression factor ω gives a reasonable description of data; however, in some areas there are noticeable deviations from the data.

Similar measurements were made by the ZEUS experiment [3]. In Fig.2 the ratio of the resolved component to a direct one as function of Q^2 is shown. A conditional border between two processes is chosen at $x_\gamma = 0.75$. In the ratio, of course, some uncertainties are canceled. The shadow band is the energy scale uncertainty. The solid line is HERWIG calculations with the Schuler-Soestrand [4] virtual parton density model. The dotted and dashed lines are the results of the LEPTO and HERWIG calculations without any Q^2 dependent suppression factor.

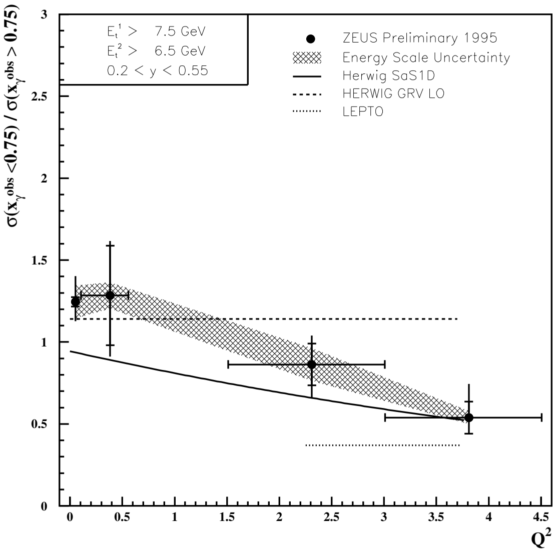

Figure 2. Ratio of the cross sections for events with $x_\gamma > 0.75$ and $x_\gamma < 0.75$.

The unfolding method was applied to the distribution of measured values, and corrected distributions were obtained using the HERWIG model. Using the measured cross section we can extract the so-called effective parton densities for virtual photons based on the developed method of Single Effective Subprocess Approximation [5]. The differential cross section depends on the flux of gammas from a positron, the density of partons in a gamma, the density of partons in a proton and the matrix elements depending on angular distributions. Using the fact that elementary processes have similar angular distribution and differ mainly by colour factor, we can extract the effective parton density of virtual photon $\tilde{f}_\gamma$. The results are shown in Fig.3.

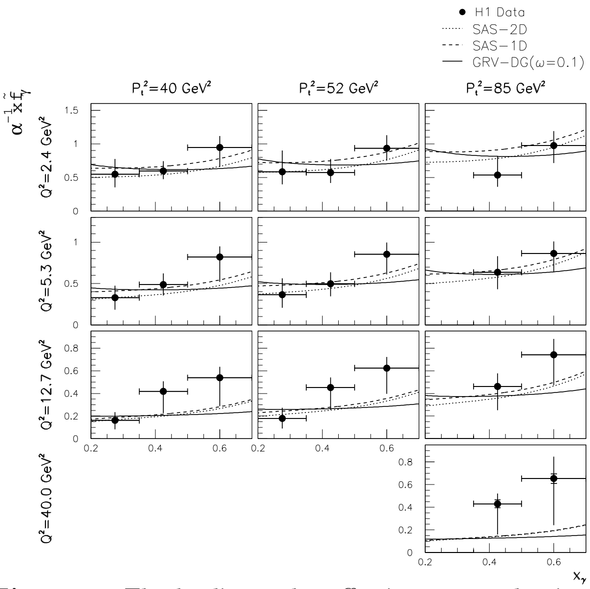

Figure 3. The leading order effective parton density of the photon as a function of x_γ for different values of Q^2 and P_t^2. Also shown are predictions from Schuler-Soestrand and Dress-Godbole models.

The effective parton density tends to rise with x_γ in the region studied. This shape of fractional momentum distribution is characteristic of photon structure. The data are described by the models, where parton density function evolves with Q^2.

Let me finish with the following conclusion. We see clear evidence for virtual photon structure up to $Q^2 = 80\,GeV^2$. Description of deep enelastic scattering needs models where resolved process are included. The measurements are consistent with QCD prediction, that as Q^2 is close to transverse energy square the virtual photon structure reduces to direct process. And the last important message is that effective parton density of virtual photons is measured for the first time in the experiment.

References

[1] H1 Collaboration, Adloff C 1998, DESY-98-205
[2] Dress M and Godbole R 1994 Phys.Rev. **D50** 3124
[3] Kcira D 1999 PHOTON-99 Freiburg
[4] Sjöstrand T and Schuler G 1996 Phys.Lett. **B376** 193
[5] Combridge B and Maxwell C 1984 Nucl.Phys. **B239** 429