RHCPP 99-016

2 August, 1999

The hadronic structure function F_2^γ for quasi-real photons

G D Cowan

Physics Dept., Royal Holloway, University of London, Egham, Surrey, TW20 0EX, UK

E-mail: g.cowan@rhbnc.ac.uk

Abstract

Results on the hadronic structure of the photon are presented, including recent measurements of F_2^γ from the ALEPH, L3 and OPAL experiments.†

1. Introduction

Electron-positron colliders provide the opportunity to investigate the hadronic structure of the photon through the two-photon reaction $e^+e^- \to e^+e^- +$ hadrons. Single-tag events, where one electron remains in the beam pipe and the other is measured with an angle $\theta_{\rm tag}$ and energy $E_{\rm tag}$, can be viewed as the deep inelastic scattering of an electron and an (almost) real photon. The differential cross section of $Q^2 = 2E_{\rm tag}E_{\rm beam}(1 - \cos\theta_{\rm tag})$ and $x = Q^2/(Q^2 + W^2)$, where W is the invariant mass of the hadrons, can be directly related to the photon structure function $F_2^\gamma(x, Q^2)$. The formalism of single-tag $\gamma\gamma$ collisions is described in e.g. [1].

Here recent measurements of F_2^γ based on data from the ALEPH [2], L3 [3,4] and OPAL [5] experiments at the LEP e^+e^- collider are presented.

2. Unfolding F_2^γ

An important source of uncertainty in measurements of the x distribution are the corrections that must be introduced to account for detector acceptance and resolution (unfolding). These corrections require a response matrix, obtained by means of a Monte Carlo model where events are generated and the detector response simulated.

Scatter plots from Monte Carlo studies by ALEPH of measured vs. true values of x are shown in Fig. 1. The four plots are for events with different values of the variable E_{17}, defined as the total energy of the particles within 17° of the beam line. One can see that events with low E_{17} have much better x resolution. The response matrix for x obtained from a Monte Carlo model corresponds to the average x resolution resulting from the model's E_{17} distribution. The uncertainty in the unfolded x

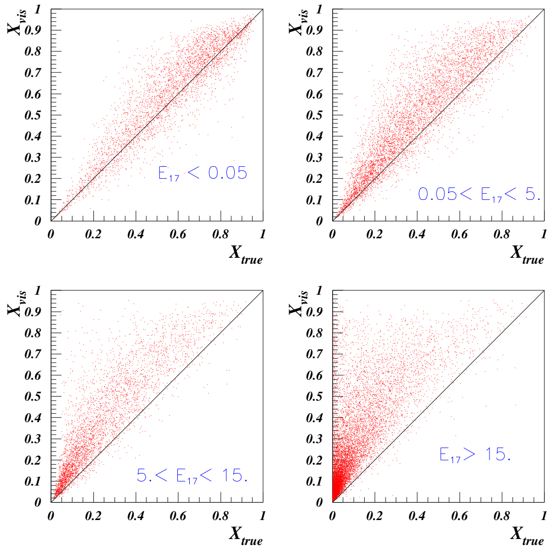

Figure 1. Plots of the measured vs. true values of x for events with different values (in GeV) of E_{17} (see text).

distribution due to this model dependence has been an important source of systematic error in previous measurements. If, however, E_{17} is measured from the data, then this uncertainty is avoided. In addition, one obtains smaller statistical errors, since those events for which x is well measured (low E_{17}) are given a higher weight and their information is not diluted by events with poor x resolution.

The results presented here by the ALEPH and OPAL experiments are based on two-dimensional unfolding methods using both x and an additional variable such as E_{17}. More information on unfolding can be found in [6, 7]. Further improvements have been obtained by OPAL and L3 by including kinematic information from the tagged electron in order to estimate the hadronic mass W.

† Presented at the EPS HEP'99 Conference, Tampere, Finland, 15–21 July, 1999.

3. Results and conclusions

Figures 2–4 show the photon structure function in several Q^2 ranges measured using data from LEP2 by the ALEPH, L3 and OPAL experiments. Also shown on the plots are predicted parametrisations of F_2^γ from several groups identified by the initials of the authors; the references can be found in [2, 3, 4, 5]. The measurements from ALEPH and OPAL show good agreement with the prediction of GRV [8], while the L3 measurement is somewhat higher, especially at low x. Improved measurements are to be expected in the future as more of the LEP2 data are analysed.

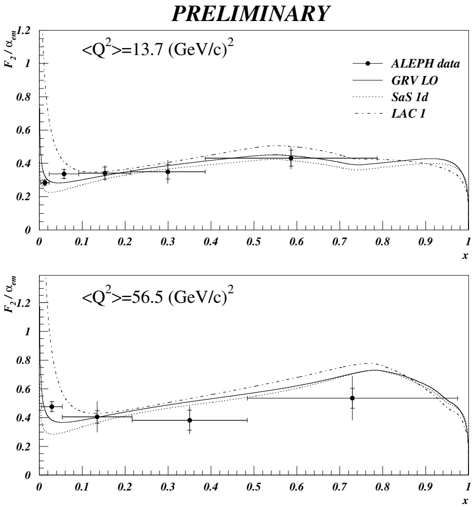

Figure 2. F_2^γ measured by ALEPH [2].

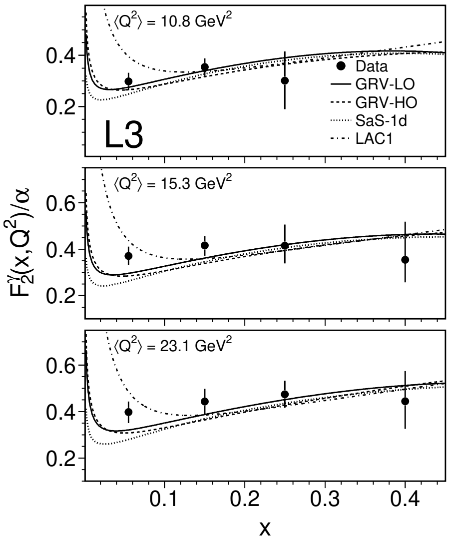

Figure 3. F_2^γ measured by L3 [4].

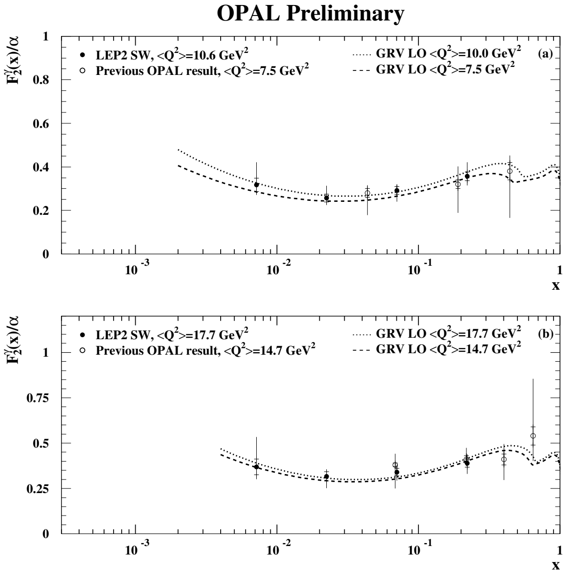

Figure 4. F_2^γ measured by OPAL [5].

4. Acknowledgements

It is a pleasure to thank our parallel session convener, Richard Nisius, as well as my ALEPH colleagues – in particular Klaus Affholderbach and Alex Finch – for their help in preparing this talk. I also thank the organisers of HEP'99 for an enjoyable and interesting conference.

References

[1] P. Aurenche and G.A. Schuler (conveners), $\gamma\gamma$ *Physics* in G. Altarelli, T. Sjöstrand and F. Zwirner (eds.), *Physics at LEP2*, CERN 96-01, vol. 1 (1996) 291.
[2] The ALEPH Collaboration, EPS-HEP99 2-617, *A study of the photon structure function $F_2^\gamma(x, Q^2)$ using two-dimensional unfolding*
[3] The L3 Collaboration, Phys. Lett. B436 (1998) 403; EPS-HEP99 2-271
[4] The L3 Collaboration, Phys. Lett. B447 (1999) 147; EPS-HEP99 2-272
[5] The OPAL Collaboration, EPS-HEP99 2-17, *Measurement of the low-x behaviour of the photon structure function F_2^γ*
[6] S. Cartwright et al., J. Phys. G24 (1998) 457
[7] G. Cowan, *Statistical Data Analysis*, Clarendon Press, Oxford, 1998
[8] M. Glück, E. Reya and A. Vogt, Phys. Rev. D45 (1992) 3986; D46 (1992) 1974