The Cross Section for Hadron Production in $\gamma\gamma$ collisions at LEP

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The cross section $\sigma(\gamma\gamma \longrightarrow hadrons)$ is measured at LEP by the L3 and OPAL collaborations in the range 5 GeV $< W_{\gamma\gamma} <$ 145 GeV. The analysis which is model dependant, is performed using the PHOJET and PYTHIA Monte Carlo generators. The L3 and OPAL results are compatible. The observed increase of the cross section with $W_{\gamma\gamma}$ is discussed.

1 Introduction

At LEP2 hadron production in $\gamma\gamma$ collisions dominates all other sources by several orders of magnitude. This reaction must be carefully understood in order to confirm any positive signal concerning new physics. On the other hand, LEP2 offers a good opportunity to probe the photon structure. The photon may interact in a point-like manner. Often a quantum fluctuation transforms the photon into a vector meson $\rho, \omega, \phi, ...$, opening up all the possibilities of hadronic interactions (Regge poles, Pomeron exchange, etc.). In hard scattering the structure of the photon can be resolved into quarks and gluons. The relative amounts of these components and their respective properties are not yet fully understood. There has been an effort by G.A. Schuler and T. Sjöstrand [1] and by R. Engel and J. Ranft [2] (Dual Parton Model) to construct a model consistent with the knowledge accumulated from γp, ep and pp scattering data. Both groups have provided a Monte Carlo generator which can be compared with the data. In PYTHIA [3] where both incoming photons are assumed to be on the mass shell, we have complemented the code by generating the photon flux in the Equivalent Photon Approximation [4] with a cutoff $Q^2 \leq m_\rho^2$. The model is then valid only for events with $Q^2 \simeq 0$. The Monte Carlo generator PHOJET [2] uses the $\gamma\gamma$ luminosity function, $\mathcal{L}_{\gamma\gamma}$, for transverse photons, taking into account the hadronic couplings of the photon by using a generalised vector dominance model. The data analysed here concern only untagged events i.e. the incoming electron and positron escape the detector in the beam pipe, so that $Q^2 \simeq 0$. We present the data collected at $\sqrt{s} = 130$, 136, 161 and 183 GeV from L3 [5] and $\sqrt{s} = 161$ and 172 GeV from OPAL [6].

2 Analysis and results

For the new L3 analysis at $\sqrt{s} = 183$ GeV the selection requires more than 6 particles (pions or photons) and less than 50 GeV energy deposited in the calorimeters. To insure the low Q^2 condition the energy deposited in the lumi monitor ($33 < \theta < 64$ mrad) must be smaller than 50 GeV and the visible mass of the $\gamma\gamma$ system $W_{vis} > 5$ GeV. The comparison between data and monte carlo shows a better agreement between data and PHOJET than PYTHIA. The background contamination, estimated using PYTHIA (for $e^+e^- \longrightarrow hadrons(\gamma), ZZ(\gamma), Zee(\gamma), We\nu(\gamma)$); KORALW ($e^+e^- \longrightarrow W^+W^-$); KORALZ ($e^+e^- \longrightarrow (\gamma/Z^o)^* \longrightarrow \tau^+\tau^-(\gamma); e^+e^- \longrightarrow (\gamma/Z^o)^* \longrightarrow \mu^+\mu^-(\gamma)$) and DIAG36 ($e^+e^- \longrightarrow e^+e^-\tau^+\tau^-$), is smaller than 5 %.

The L3 results are unfolded with both programs (figure 1 a and b), the results are presented as unfolded with the PHOJET while the PYTHIA results are used to estimate the systematic errors. OPAL data are given as an average between PYTHIA and PHOJET results (figure 1-c). In (figure 1-d) the OPAL and L3 data are fitted to the universal total cross section formula : $\sigma_{\gamma\gamma} = As^{\epsilon} + Bs^{\eta}$ (see ref. [7]) where $s = W^2_{\gamma\gamma}$ and ϵ and η are extracted from all total cross section measurements[8]. A difference between OPAL and L3 is found only in the overall scale. The OPAL data are well fitted with the parameters extracted from L3 with a scale factor of 1.24 $\pm$ 0.06. From (figure 1-d) it is clear that the universal fit fails to describe the data at high $W_{\gamma\gamma}$. The data are not sensitive to the η parameter which describe the rapidly falling Regge exchange, but they can determine the parameter ϵ, which characterises the Pomeron exchange. A fit of the separate samples, with only η fixed to -0.47 (ref[8]) gives the values reported in table 1. A value of ϵ about two times higher than in the universal formula[7] is found, which may indicate additional QCD contribution at high values of $W_{\gamma\gamma}$.

Table 1: A, B and ϵ parameters extracted from OPAL and L3 data fits.

	A	B	ϵ
L3 PHOJET	$98. \pm 25.$	$1409. \pm 241.$	0.16 ± 0.03
L3 PYTHIA	$140. \pm 28.$	$859. \pm 247.$	0.14 ± 0.02
OPAL	$90. \pm 70$	$1679. \pm 1156$	0.19 ± 0.09

References

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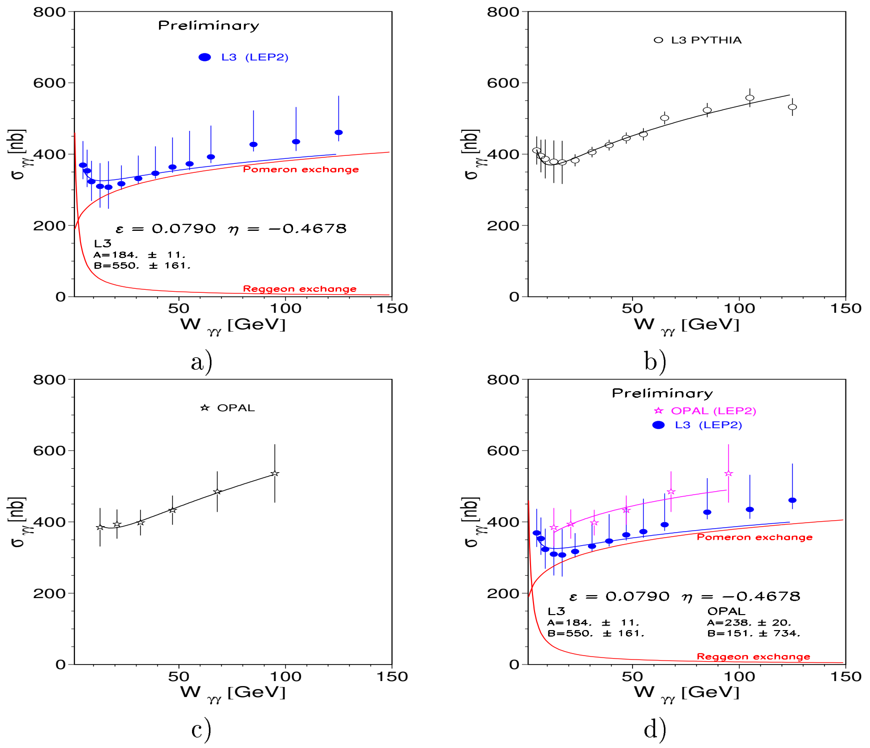

Figure 1: a) L3 data at $130 < \sqrt{s} < 183$ GeV unfolded with PHOJET, b) unfolded with PYTHIA c) OPAL data at $\sqrt{s} = 161$ and 172 GeV, average of the values unfolded with PYTHIA and PHOJET. d) L3 and OPAL data fitted to the universal parametrisation ref[7].