DELPHI Collaboration

DELPHI 2001-133 CONF 544
29 October 2001

Total Cross-section Measurements in $\gamma\gamma$collisions at very low Q^2 at LEP2

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Abstract

The multihadron production in the reaction $e^+e^- \rightarrow e^+e^- + hadrons$ has been studied for the first time at LEP2 energies with both scattered e^+ and e^- detected at very low Q^2, measured by the DELPHI VSAT. A reasonable agreement between data and full simulation is demonstrated and the total $\gamma\gamma$ hadronic cross-section is estimated for the $\gamma\gamma$ center of mass energy up to 100 GeV.

Proceedings from talk presented at the PHOTON 2001 conference.
Ascona - Switzerland, September 2-7, 2001.

1 The VSAT Detector and Background Processes

The Very Small Angle Tagger (VSAT) detector covers an azimuthal angle between 3 and 10 mrad, resulting in a Q^2 region from 0.02 to 0.8 GeV at LEP II energies. This is an attractive region for $\gamma\gamma$-studies as the error of interpolating the total cross-section to zero Q^2 is small and at the same time the cross-section is large enough to detect both outgoing leptons from with reasonable statistics. The VSAT detector [1], [2] consists of four modules placed on each side of the beam-pipe ±7.7 meters from the interaction point.

The energy resolution of the VSAT detector is about 4.5% at 100 GeV, resulting in a precise measurement of the invariant mass of the $\gamma\gamma$-system in double tag $\gamma\gamma$-events. About 510 pb^{-1} of data collected from 1998, 1999 and 2000 were used in this study, with about 320 expected double tag $\gamma\gamma$-events after cuts on the hadronic system ($W > 3\ GeV$ and at least 3 charged tracks). Unfortunately, there are two huge background processes that disturb the data collected. The VSAT detector has however also a very precise measurement of the position of the incoming particles in x and y (about 200 μm), which allows for signal and background separation.

One obvious background is a bhabha event in coincidence with a no-tag $\gamma\gamma$-event. These events are however very symmetric and can be totally rejected without any significant loss of the $\gamma\gamma$-signal (less than 1.5%). More troublesome is the off-energy background electrons, which can either be in coincidence with a single tag or a no-tag $\gamma\gamma$-event. To get reasonable purity in the final data heavy cuts are imposed in the y-energy phase space (Fig. 1) of the VSAT detector. A purity above 75% in the resulting double tag sample could then be obtained with less than 40% of signal loss (Fig. 2).

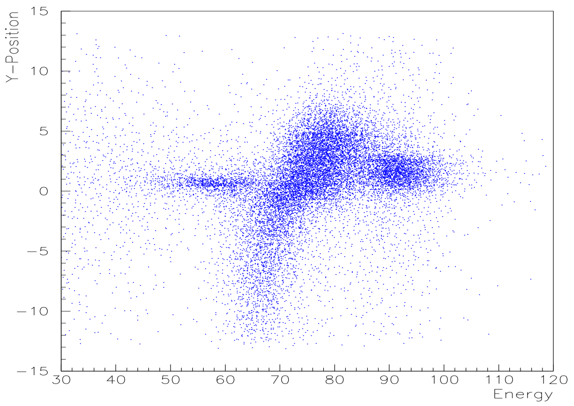

Figure 1: The off-energy background come from two different locations, which result in a complicated structure in the VSAT y-position and energy phase space.

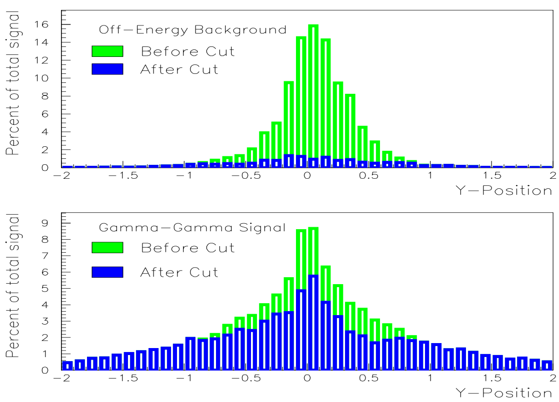

Figure 2: The impact of the off-energy background cuts on the off-energy background and the $\gamma\gamma$-Monte Carlo sample (single tag).

After the cuts 263 double tag events were seen with an expected background of 66 events. This is presented in Table 1 along with the expected purities for each year, the same numbers are also shown for the single tag sample. In total about 200 double tag and 26000 single tag $\gamma\gamma$-events are thus expected after the cuts.

Year	Lum.(pb^{-1})	D-tag	$\gamma\gamma$	Purity	$\gamma\gamma$-loss	Single Tag	Purity
1998	138	78	56	0.72	0.43	8650	0.84
1999	220	111	83	0.75	0.32	13273	0.86
2000	152	74	58	0.79	0.37	8487	0.88
Tot	510	263	197	0.75	0.36	30410	0.86

Table 1: The luminosity, number of double and single tag events in VSAT after cuts.

2 The TWOGAM Monte Carlo

In this analysis the TWOGAM [3] generator was used, which implements three different models: a soft interaction term described by the generalized Vector meson Dominance Model (VDM), a perturbative term described by the Quark Parton Model (QPM) with direct quark exchange, and a term for the hard scattering of the partonic constituents of the photon, the so-called Resolved Photon Contribution (QCD-RPC). The Gordon-Storrow parameterization with a $p_t^{min} = 2.05 \pm 0.020\ GeV/c$ cut-off value was used to separate the RPC from the non-perturbative contribution.

This parameter was adjusted by comparing MC and data for different distributions. The invariant mass of the hadronic system is shown for both the different MC-components and the data in Fig. 3. The p_t^{min} was adjusted by taking the ratio between data and MC, and the value that produced the most flat distribution were taken. From Fig. 4 it is clear that the value of about 2.05 for p_t^{min} is to prefer, rather than the value of 1.88 previously used [4].

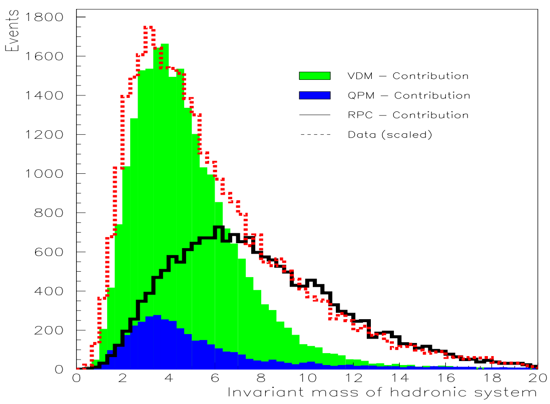

Figure 3: The invariant mass of the different model contributions and data.

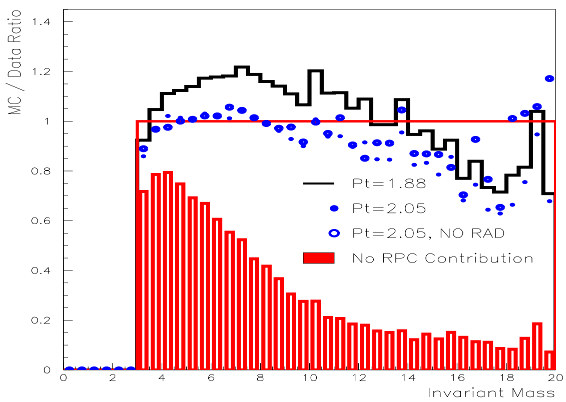

Figure 4: The ratio between data and and MC for different values of p_t^{min}.

The TWOGAM MC was generated both with and without radiative corrections, with no major difference in Fig. 4. The double tag data do however show better agreement between data and MC with radiative correction than without and was therefore used in this analysis. Agreement within errors between data and MC was found, both in the VSAT double and single tag sample. The TWOGAM generator could therefore be used to extrapolated VSAT data to the total cross-section. The relative contributions of the different components as a function of Q^2 and W can be seen in Fig. 5 and Fig. 6.

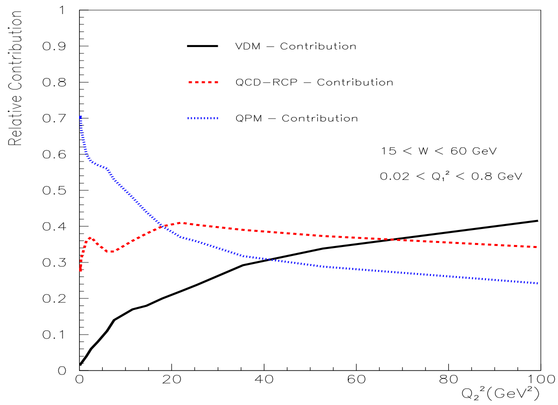

Figure 5: The relative contributions of the different components in TWOGAM as a function of Q^2.

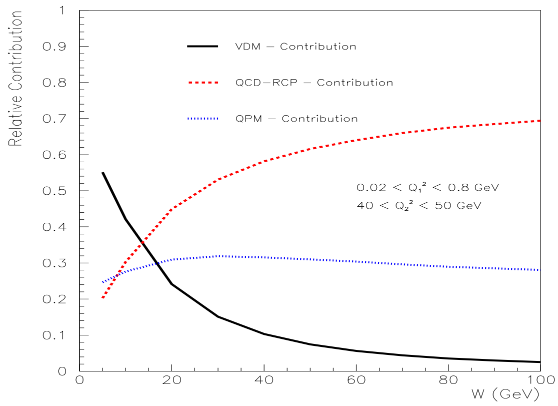

Figure 6: The relative contributions of the different components in TWOGAM generator as a function of W.

The VSAT+STIC (The STIC detector has θ-coverage between 2-10 degrees, with a Q^2 mainly between 10 and 120 GeV^2) double tag data was also probed for the first time. About 220 events were found after cuts on the VSAT data, with an expected background of about 20 events. Reasonable agreement with TWOGAM MC were also found for this data sample.

3 Results

The VSAT data were divided in bins with equal statistics to calculate the total cross-section with the TWOGAM generator with similar errors. The luminosity function was calculated and the data was extrapolated to $Q^2 = 0$ with the GVDM model. The total cross-section as a function of Q^2 and W can be found in Fig. 7 and Fig. 8. From Fig. 8 it is clear that the VSAT double tag data extrapolated with TWOGAM show better agreement with L3 and OPAL data unfolded with PYTHIA than with PHOJET.

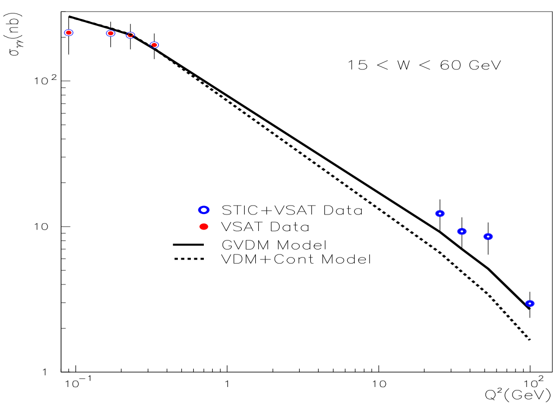

Figure 7: The total cross-section of VSAT (at low Q^2) and VSAT+STIC double tag data as a function of Q^2.

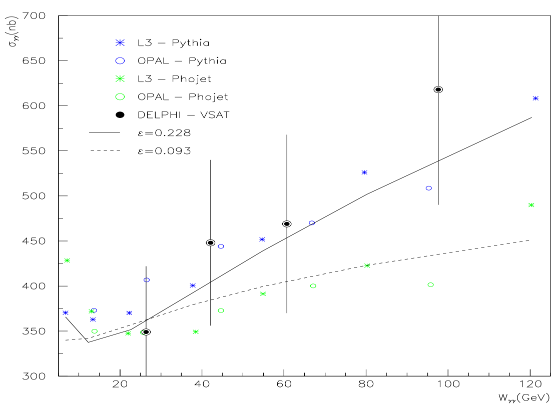

Figure 8: The total cross-section of VSAT double tag data as a function of W ($Q^2 \rightarrow 0$ $from$ $0.02 < Q^2 < 0.8$ GeV^2).

References

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