VECTOR MESON PRODUCTION IN $\gamma\gamma$ INTERACTIONS AT LEP WITH THE L3 DETECTOR

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Vector Meson Production in untagged $\gamma\gamma$ collisions has been studied with the L3 detector at the LEP e^+e^- collider. Exclusive $\rho - \rho$ production was studied in $\pi^+\pi^-\pi^+\pi^-$ events for $0.5 < W < 8$ GeV. Exclusive $\rho - \omega$ and inclusive ρ and ω production was also observed. The $K_s^0 K^\pm \pi^\mp$ final state with $K_s^0 \to \pi^+\pi^-$ was examined in the resonance region.

1 Introduction

In this work we present the summary of two different analyses currently in progress using data collected by the L3 Experiment [1] at the LEP collider.

An important component of the total hadronic two photon cross-section comes from the interaction of Vector Mesons produced as a quantum fluctuation of the incoming photons. This can be tested directly by the observation of the exclusive production of two Vector Mesons: $e^+e^- \to e^+e^-\rho^0\rho^0$ or $\rho^0\omega^0$.

The second measurement, $e^+e^- \to e^+e^- K_s^0 K^\pm \pi^\mp$, is intended to help in the better interpretation of some specific resonances. One example is the $\eta(1440)$, which is copiously produced in the J/Ψ radiative decays, but no signal was found in two-photon processes, indicating a small two-photon width that favours a glueball interpretation.

All the results included in this work are preliminary, as this write-up represents a snapshot of the work going on in these two specific directions and not the results of a finished study.

2 Vector Meson Production at high W

The interaction of two quasi-real photons at low energies can be described by the Vector Meson Dominance Model (VDM), while at higher energies by perturbative QCD (PQCD). These two regimes were combined into a single model by G. Schuler and T. Sjöstrand. [2] The predictions of this model are included in the Pythia Monte-Carlo program, [3] used throughout this analysis.

Table 1: Comparison of experiments studying the $\gamma\gamma \to \rho^0\rho^0$ process. Shown are the number of 4-track $\gamma\gamma$ events observed, the number of exclusive 4π events and selected $\rho^0\rho^0$ events, together with the e^+e^- luminosity and the centre-of-mass energy.

	4 tracks	$4\ \pi$	$\rho^0\rho^0$	L_{ee} (pb^{-1})	$\sqrt{s}$ (GeV)
L3 (1994)	20771	2754	1940	49.7	91
L3 (1996a)	4485	1354	944	10.9	161
L3 (1996b)	4690	1453	1012	10.3	172
L3 Total	29946	5561	3896	70.9	91 – 172
ARGUS [4]		5701		242	10.2
CELLO [5]			910	11.2	34
PLUTO [6]		2272		28.7	34.7
TASSO [7]		1722		40.9	14 – 36.6
TPC/2γ [8]		4814		73	29

2.1 Event Selection

We studied 4-track events, where all tracks satisfied some quality criteria ($p_t >$ 100 MeV, DCA $\leq$ 10 mm, $N_{hits} \geq 12$). The untagged exclusive $\pi^+\pi^-\pi^+\pi^-$ final state was identified by an antitag condition ($E_{LUMI} <$ 30 GeV) and a cut on the transverse momentum balance ($\Sigma\vec{p}_t(\pi_i) < 0.05$ GeV$^2/c^2$, $i = 1, 4$). By fitting a linear function to this distribution we estimated the non-exclusive background coming from events with undetected particles to be around 25%. $\rho^0\rho^0$ events were separated from the non-resonant background by the requirement $M(\rho^0_{1,2}) < 1.1$ GeV.

The number of events selected at three values of beam energy are shown in table 1 together with data obtained by other experiments that have studied the same final state. Note that earlier experiments concentrated their study on the threshold region, dominated by a controversial resonance, while our analysis is intended to study the high mass region. This is possible due to the large energy and luminosity of LEP.

2.2 Results

Figure 1 shows the invariant mass (W) distribution of the exclusive 4-track events together with the same distribution for the $\rho^0\rho^0$ events at $\sqrt{s} = 91$ GeV, the value of the Z peak and for high energy data at $\sqrt{s} = 161$ and 172 GeV. At low W the phase-space forces all events to be identified as $\rho^0\rho^0$, while as we go to higher W regions the non-resonant 4π channel becomes dominant.

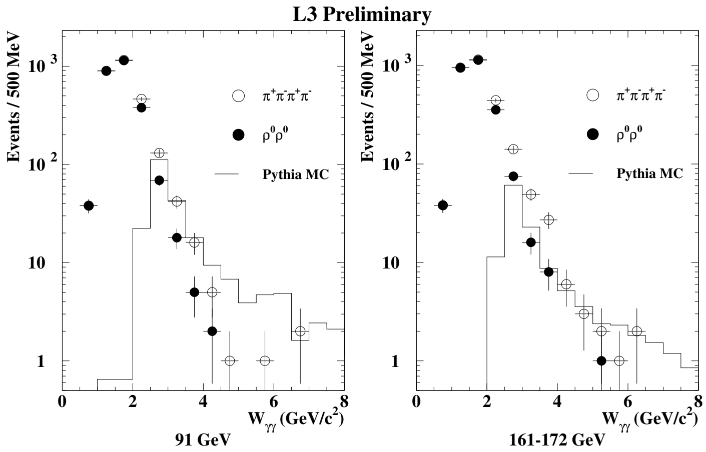

Figure 1: Mass distribution of 4π and $\rho^0\rho^0$ events compared with the PYTHIA prediction.

The solid line shows the prediction of PYTHIA generated in the region above $W = 2.5$ GeV. A discrepancy between the Monte-Carlo and data at 91 GeV can be observed, while the agreement is better at higher energies. A possible explanation for this difference is a change of the trigger efficiency, which was not taken into account.

2.3 Outlook

With the increase of LEP energy and luminosity enough statistics will be collected in the high mass region to allow the study of the ρ^0 momentum transfer and angular distribution in bins of W, where a change of behaviour is expected. In order to compare directly with QCD model predictions the differential $\gamma\gamma \to \rho^0\rho^0$ cross-section has to be extracted. The study of charged ρ meson production could also provide useful information.

We have observed the process $\gamma\gamma \to \rho^0\omega^0$ followed by $\rho^0 \to \pi^+\pi^-$ and $\omega^0 \to \pi^+\pi^-\pi^0$, with $\pi^0 \to \gamma\gamma$. The number of events observed is smaller and also dominated by low masses.

The study of inclusive ρ^0 and ω^0 production promises very high statistics, but the presence of a large background requires further studies for an efficient background rejection.

3 $K_s^0 K^\pm \pi^\mp$ Final State

In the $\gamma\gamma \rightarrow R \rightarrow K_s^0 K^\pm \pi^\mp$ channel, followed by $K_s^0 \rightarrow \pi^+\pi^-$, various resonances can be studied. The $\eta(1440)$ is copiously produced in the J/Ψ radiative decays, but not in two-photon processes. This small two-photon coupling suggests that it can be a glueball candidate. The $\Gamma_{\gamma\gamma}^{\eta_c}$ radiative width of the η_c charmonium state can also be measured in this process.

3.1 Event Selection

The data sample collected over the years 1991-95 by the L3 detector at 91 GeV centre-of-mass energies of LEP corresponds to an integrated luminosity of 114.35 pb^{-1}. Selected events contain exactly 4 tracks (with $p_t > 100$ MeV and $N_{hits} \geq 12$) and at least one secondary vertex separated by more than 3 mm from the primary vertex. To select exclusive events the antitag condition ($E_{LUMI} < 35$ GeV) and the transverse momentum balance ($\Sigma \vec{p}_t(\pi_i) < 0.04$ GeV$^2/c^2$, $i = 1, 4$) were required. Non-exclusive background was estimated by fitting a linear function to this last distribution. The angle α between the flight path and momentum direction of the K_s^0 candidate defined in the transverse plane had to be less than 75 mrad, and its invariant mass was required to lie between 460 and 530 MeV. Background was estimated from the sidebands of this mass distribution.

3.2 Results

The Dalitz-plot of the $K\pi$ and $K_s^0\pi$ invariant masses together with the two projections is shown in figure 2*(left)*, for the 469 events selected without $K-\pi$ identification, with two entries per event. Both invariant mass distributions are dominated by the $K^*(892)$, but in case of the $K_s^0 - \pi$ distribution a second enhancement in the region of the $K_2^*(1430)$ is also visible.

Figure 2*(right)* shows the $K_s^0 K^\pm \pi^\mp$ invariant mass distribution of the 214 events remaining after $K^\pm - \pi^\mp$ identification based on dE/dx. The dashed line indicates the background calculated from the K_s^0 sidebands and the solid line includes also background from non-exclusive processes with undetected particles, estimated from the distribution of the total momentum balance in the transverse plane.

The absence of a resonance-like structure in the region of the $\eta(1440)$ supports its glueball interpretation. The slight enhancement around 3 GeV can be interpreted as the signal from the charmonium state η_c.

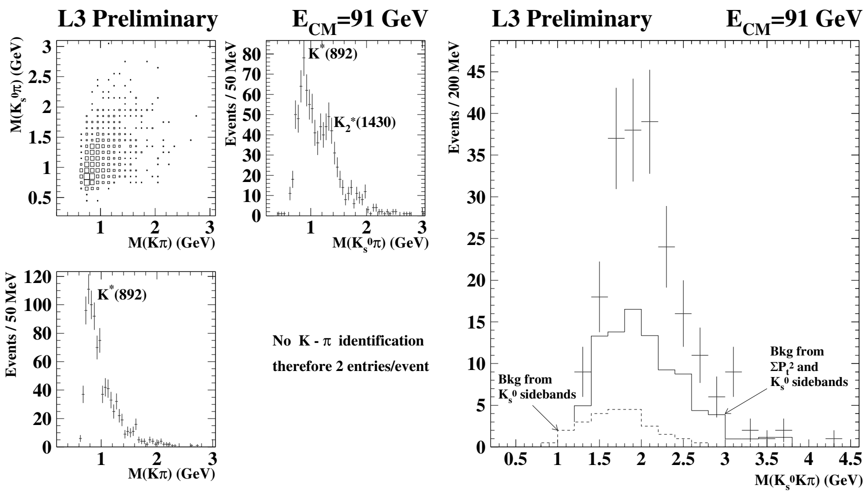

Figure 2: *(Left)* Dalitz-plot of the $K\pi$ and $K_s^0\pi$ invariant masses together with the two projections, with two entries per event. *(Right)* $K_s^0 K^{\pm}\pi^{\mp}$ invariant mass, where the dashed line indicates background calculated from the K_s^0 sidebands and the solid line includes also background from non-exclusive processes with undetected particles.

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