The process $e^+e^- \to K_SK_L$ in the energy range 2E from 1.04 to 1.38 GeV

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The preliminary results of the cross section $e^+e^- \to K_SK_L$ measurements in the energy range 2E from 1.04 to 1.38 GeV are presented. It is shown that the cross section agrees with Vector Dominance Model (VDM) if ρ, ω and ϕ mesons are taken into account.

1. Introduction

Presently the cross section of the process $e^+e^- \to K_SK_L$ is measured with a high accuracy only in the vicinity of the ϕ-meson peak. Data at higher energy were obtained by OLYA detector (Novosibirsk) [1] in the energy range $2E_0 = 1060 \div 1400\ MeV$ and DM1 detector (Orsay) in the energy range $2E_0 = 1400 \div 2200\ MeV$ [2]. The K_SK_L production cross section gives contribution into the total cross section $e^+e^- \to$ *hardrons* used in the integrals of QCD sum rules and is important for study of radial excitations of light vector mesons. As the achieved accuracy in previous experiments was not high, the new measurements are desirable. In this work $e^+e^- \to K_SK_L$ cross section has been measured between 1.04 and 1.38 GeV with the SND at VEPP-2M e^+e^- collider.

2. Data analysis and fitting

The SND detector [3],[4] was designed mainly for detailed investigation of e^+e^- annihilation into multi-photon final states in the energy range of VEPP-2M collider $2E_0 = 400 \div 1400\ MeV$.

In 1997 two scans were performed of the energy range $2E_0$ from 960 to 1380 MeV with a step of 10 MeV and total integrated luminosity of 6.3 pb^{-1}.

The process

$$e^+e^- \to K_SK_L, \quad (1)$$

was studied in the decay mode $K_S \to \pi^0\pi^0 \to 4\gamma$. The main background processes are:

$$e^+e^- \to \phi\gamma \to K_SK_L\gamma, \quad (2)$$

$$e^+e^- \to \omega\pi^0 \to \pi^0\pi^0\gamma, \quad (3)$$

where the process (2) is a return to the ϕ-meson resonance with an emission of a radiative photon by initial particles. Cosmic and beam background are also present.

The following primary selection criteria were applied: number of found photons $N_\gamma \geq 4$, number of found charge particles $N_c = 0$. Events with a cosmic track found in the calorimeter were rejected.

For all selected events kinematical fit was done assuming presence of $K_S \to \pi^0\pi^0 \to 4\gamma$ decay. All possible photon quadruplets were tested and one with the smallest χ^2 found ($\chi^2_{K_S\to2\pi^0}$). Following selections were applied to events with $\chi^2_{K_S\to2\pi^0} < 100$:

Sel.1 $E_{tot}/2E_0 < 0.8$, total energy deposition in the calorimeter, normalized by the center of mass energy.

Sel.2 $|P_\parallel/E_{tot}| < 0.25$, absolute value of longitudinal momentum of all detected particles normalized by the total energy deposition, assuming that all particles are photons.

Sel.3 $\zeta_{max} < 0$, photon quality parameter, the likelihood of a hypothesis, that given transverse energy profile of a cluster of hit crystals in the calorimeter can be attributed to a single photon ([5], [6]). This parameter distinguishes events with isolated photon showers, from events, with overlapping showers or clusters of hit crystals from K_L decays or nuclear interactions.

Sel.4 $\theta_{min} > 27°$, minimum angle between photon direction and beam axis.

Sel.5 $350 < M_{rec} < 550$ MeV, recoil mass of the reconstructed K_S-meson.

The Sel.3 and Sel.4 selection criteria were applied only for photons from reconstructed K_S decay.

Total of 1494 events survived the cuts.

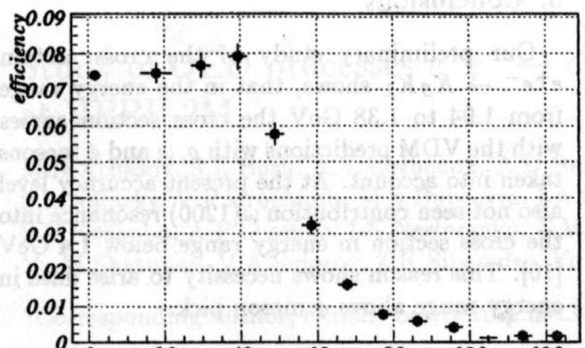

Figure 1. The process (2) detection efficiency dependence on the energy of radiative photon. The point $E_\gamma \sim 0$ corresponds to efficiency of the process (1).

Total of 1494 events survived the cuts.

The detection efficiency for the process under study, was obtained from MC simulation which also took into account emission of a radiative photon by initial particles [7]. Detection efficiency as a function of the radiative photon energy is shown in Fig. 1.

K_S-meson recoil mass distributions in three energy regions (Fig. 2) obtained without Sel.2 and Sel.5 cuts, show good separation of the processes (1) and (2) at energy above $\sqrt{s} \sim 1.10$ GeV. The Sel.2 suppress process (2) which have large values of $|P_{\|}/E_{tot}|$.

Distribution over $\chi^2_{K_S\to 2\pi^0}$ for the selected events shown in Fig. 3 was used for background estimation.

After all cuts the data sample consists mainly of events of the process (1). A number of events of the process (2) are present. The remaining background events is assumed to have approximately uniform $\chi^2_{K_S\to 2\pi^0}$ distribution. The assumption is based on the study of $\chi^2_{K_S\to 2\pi^0}$ distribution in the regions where background processes dominate. All events were divided into 2 classes:

1. $\chi^2_{K_S\to 2\pi^0} < 25$
2. $25 < \chi^2_{K_S\to 2\pi^0} < 100$

The number of events for each class was fitted according to the following formula:

$$N_i = \sigma_0 \varepsilon_i R L + \sigma_\gamma \varepsilon_{\gamma i} L + \alpha_i N_B,$$

where σ_0 is Born cross section of the process (1), σ_γ – the cross section of the process (2) with the

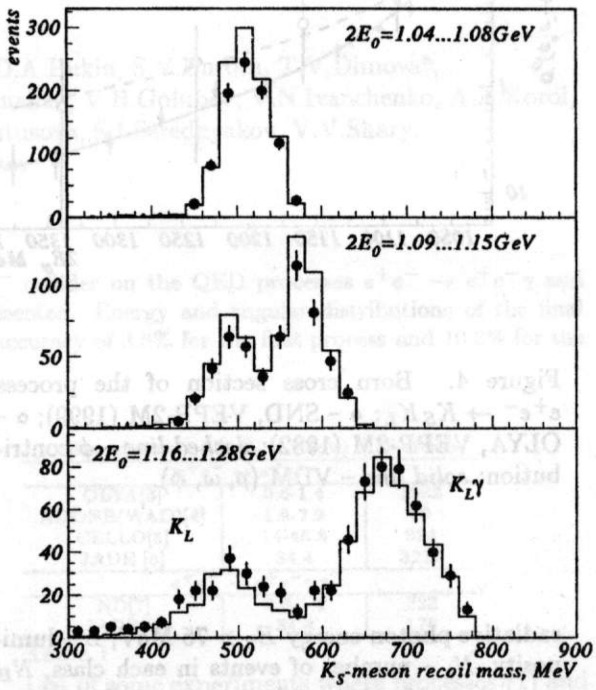

Figure 2. K_S-meson recoil mass in three energy regions. *Points* – SND experiment, *histogram* – MC simulation.

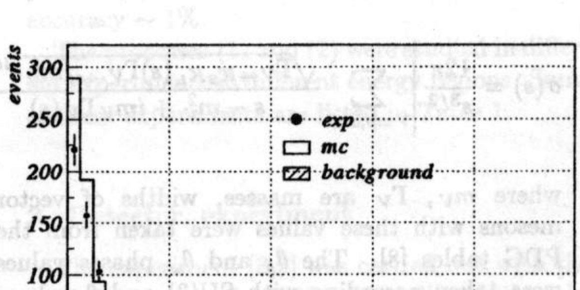

Figure 3. Distribution of χ^2 of hypothesis $K_S \to 2\pi^o \to 4\gamma$

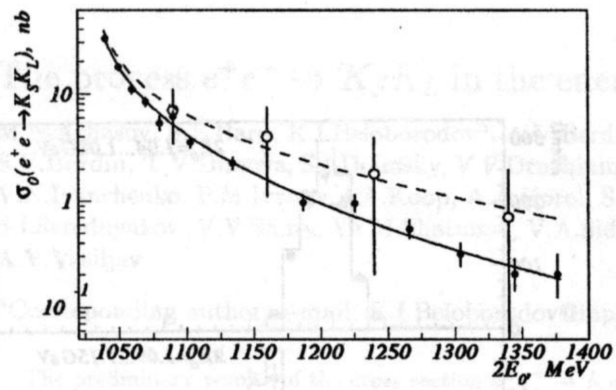

Figure 4. Born cross section of the process $e^+e^- \to K_S K_L$: • – SND, VEPP-2M (1999); ∘ – OLYA, VEPP-2M (1982); *dashed line* – ϕ contribution; *solid line* – VDM (ρ, ω, ϕ).

radiative photon energy $E_\gamma > 75$ MeV, L – luminosity, N_i – number of events in each class, N_B – number of background events, ε_i and $\varepsilon_{\gamma i}$ – detection efficiencies for the processes (1) and (2) respectively, and α_i – background part in each class ($\alpha_1 = 0.25$ and $\alpha_2 = 0.75$)

The fit was performed for both classes simultaneously. The class 1 with a small background was the most important for evaluation of the Born cross section σ_0. The second class was used to determine background contribution.

In VDM the Born cross section (1) can be written as:

$$\sigma(s) = \frac{12\pi}{s^{3/2}} \left| \sum_{V=\rho,\omega,\phi} \frac{\sqrt{\Gamma_{V\to K_S K_L}(s)\Gamma_{V\to ee} m_V^3}\, e^{i\theta_V}}{s - m_V^2 + i m_V \Gamma_V(s)} \right|^2, \quad (4)$$

where m_V, Γ_V are masses, widths of vector mesons with these values were taken from the PDG tables [8]. The θ_ρ and θ_ω phases values were taken according with SU(3) and θ_ϕ phase was taken from [9].

Fit result is shown on the Fig. 4.

The systematic error in cross section is about 10% at energy $2E_0$=1.04 GeV and 15% at $2E_0$=1.38 GeV and consist of systematic errors of the luminosity, background estimation and distributions discrepancies such as $\chi^2_{K_S\to 2\pi^0}$, M_{rec} and others.

One can see VDM gives a good description of reaction (1) cross section in the energy region from 1.04 to 1.38 GeV.

3. Conclusions

Our preliminary study of the cross section $e^+e^- \to K_S K_L$ shows, that in the energy range from 1.04 to 1.38 GeV the cross section agrees with the VDM predictions with ρ, ω and ϕ mesons taken into account. At the present accuracy level also not seen contribution $\omega(1200)$ resonance into the cross section in energy range below 1.4 GeV [10]. This reason shows necessity to arise data in energy range above ϕ meson pick.

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