Experimental study of the $e^+ e^- \to K^+ K^-$ process cross section with the SND detector at the VEPP-2000 $e^+ e^-$ collider

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Abstract: In experiments at the VEPP-2000 $e^+ e^-$ collider with the SND detector the $e^+ e^- \to K^+ K^-$ process cross section has been measured in the energy range 1.05～2.0 GeV. Its value was found to be consistent with previous measurements.

Key words: collider; experiment; calorimeter; mesons

VEPP-2000 对撞机上 SND 探测器对于 $e^+ e^- \to K^+ K^-$ 过程的研究

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摘要:在 VEPP-2000 对撞机上的 SND 探测器进行的实验中,测量了质心能量区间为 1.05～2.0 GeV 下的 $e^+ e^- \to K^+ K^-$ 过程的截面. 测得的截面值与之前的测量值相吻合.

关键词:对撞机;实验;量能器;介子

0 Introduction

Experimental study of the $e^+ e^- \to K^+ K^-$ process is of interest because of its considerable contribution to the total $e^+ e^- \to$ hadrons cross section, which is important for $(g-2)_\mu$ factor and α_{em} constant at Z-mass. The isovector part of this cross section is related to the $\tau \to K^+ K^0 \nu_\tau$ decay mass spectrum. In addition, the $e^+ e^- \to K^+ K^-$ cross section can be used to specify the excited vector meson parameters.

This process has been studied in many experiments, the latest are experiments at VEPP-2M[1-2] and BABAR[3].

In this talk the $e^+ e^- \to K^+ K^-$ cross section was measured at VEPP-2000 collider[4] with the

SND detector[5-8]. The important feature of the SND detector is the aerogel Cherenkov detector with $n = 1.13$ index of refraction[9], used in our study to separate pions and kaons.

The data were collected during 2011 and 2012 runs, the integrated luminosity in the energy range $1.05 \sim 2.0$ GeV is about 35 pb^{-1}.

1 Data analysis

In our analysis the events were selected with two collinear tracks coming from the interaction region. Besides the $K^+ K^-$ events, the similar collinear processes $e^+ e^- \to e^+ e^-$, $\mu^+ \mu^-$, $\pi^+ \pi^-$, $p\bar{p}$ and cosmic muon events contribute to this class. To suppress the $\mu^+ \mu^-$ and $\pi^+ \pi^-$ background we require that one of the tracks hit the Cherenkov counter, which produces the veto signal from these events. The $K^+ K^-$ events don't produce the Cherenkov signal in our momentum range. To suppress the background from $p\bar{p}$ events, the dE/dx cut was imposed for one of two tracks: $dE/dx_K < 1.5 \cdot dE/dx_e$, where indices K and e correspond to kaons and electrons. The $e^+ e^- \to e^+ e^-$ background was subtracted using the total energy deposition in calorimeter (shown as a peak 1 in Fig. 1). The background from the multihadron processes like $e^+ e^- \to \pi^+ \pi^- \pi^0$, $\pi^+ \pi^- \pi^0 \pi^0$,
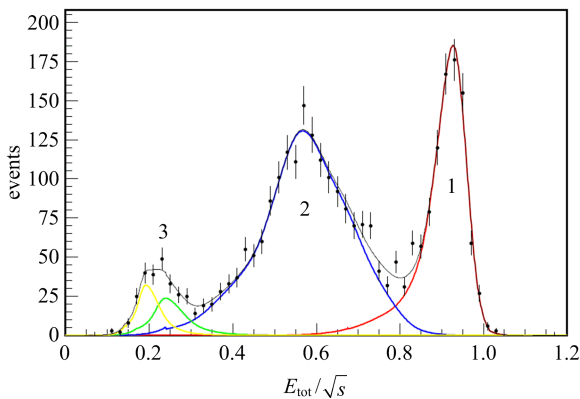
The lines are the approximation curves for the signal and background processes.

Fig. 1 The distribution of the normalized energy deposition in calorimeter at $E = 1.425$ GeV

$K^+ K^- \pi^0$, etc. was subtracted by the sideband method in the $\Delta\phi - \Delta\theta$ plane, where $\Delta\phi$ and $\Delta\theta$ are

noncolinearity angles in ϕ and θ planes for the pair of tracks.

The detection efficiency of the $e^+ e^- \to K^+ K^-$ process versus beam energy is shown in Fig. 2. The dependence of the detection efficiency on the radiative photon energy in Fig. 3 is taken into account. The correction coefficient from the kinematic cut is estimated to be $c_{\text{kin}} = 1.0076 \pm 0.0022$, the correction from Cherenkov counter is $c_{\text{ch}} = 1.0035 \pm 0.0012$, and the geometry correction is $c_{\text{geom}} = 1.0025 \pm 0.0013$.
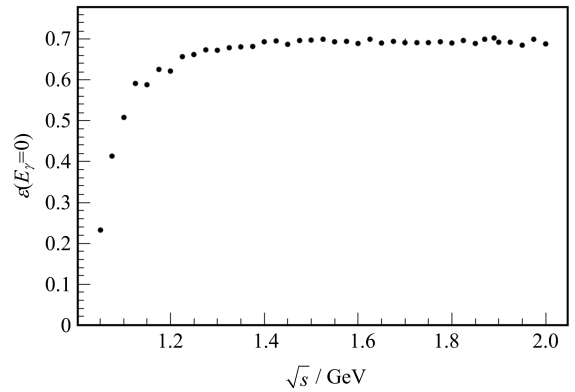

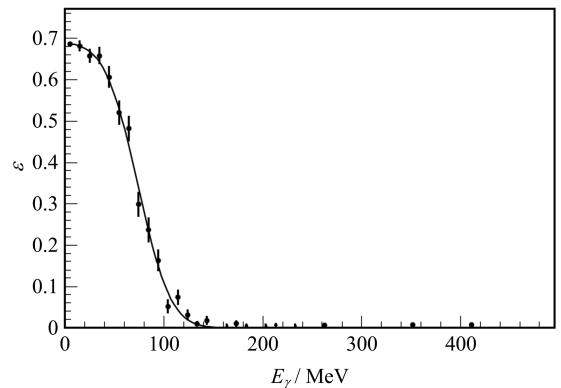**Fig. 2 The detection efficiency of the process $e^+ e^- \to K^+ K^-$ versus energy**

Fig. 3 The detection efficiency of the process $e^+ e^- \to K^+ K^-$ versus radiative photon energy at $E = 1.6$ GeV

2 The total cross section

The visible cross section σ_{vis} of the process under study is related to the total cross section σ_0:

$$\sigma_{\text{vis}}(\sqrt{s}) = \int_0^1 dz \cdot \sigma_0(\sqrt{s(1-z)}) \cdot F(z,s) \cdot \varepsilon(\sqrt{s},z) \tag{1}$$

where $s = E^2$, $F(z,s)$ is the probability for the initial particles to emit the photon carrying the

fraction of energy $\sqrt{s}$, $\varepsilon(\sqrt{s}, z)$ is a detection efficiency as a function of $\sqrt{s}$ and z.

The total cross section σ_0 is determined using the following procedure. The measured visible cross section at each energy point as a function of energy $\sigma_{\text{vis}} = N/IL$ (here N is a number of selected events, IL is an integrated luminosity) is approximated by a function calculated using Eq. (1) with some model for the total cross section. As a result of the approximation the parameters of this model are calculated together with the function $R(s) = \sigma_{\text{vis}}(s)/\sigma_0(s)$. Experimental values for the total cross section are determined, and then according to the following equation:

$$\sigma_0 = \frac{\sigma_{\text{vis}}}{R(s)} \tag{2}$$

Model dependence of the result is estimated by varying the total cross section models.

In Fig. 4 the obtained values of the cross section versus energy are presented together with the previously measured BABAR result. The good agreement between both measurements is seen. The rise of the cross section at ~ 1 GeV is due to the $\phi(1020)$ state, and the structure at ~ 1.7 GeV comes from the contribution of the $\phi(1680)$ resonance.
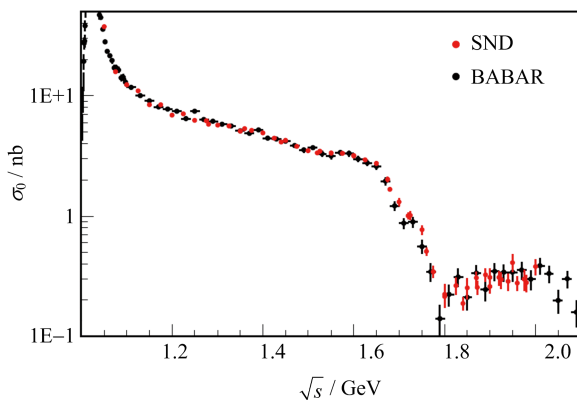

Fig. 4　The total cross section of the $e^+e^- \to K^+K^-$
process from this work and BABAR[3]

The systematic uncertainty in the measured cross section is defined by the luminosity accuracy 1%, the detection efficiency error 1.3%, radiative correction error 0.1%. Total uncertainty is about 1.7%.

3　Conclusion

The cross section of the $e^+e^- \to K^+K^-$ process in the energy range $1.05 \sim 2.0$ GeV was measured at the VEPP-2000 e^+e^- collider with the SND detector. The measured cross section well agrees with existing data.

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