MEASUREMENT OF ϕ MESON PARAMETERS WITH CMD-2 DETECTOR AT VEPP-2M COLLIDER

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Abstract

Results of the measurement of the ϕ meson parameters with the general purpose detector CMD-2 at the upgraded e^+e^- collider VEPP-2M at Novosibirsk are presented. This is the first measurement of the four major ϕ decay modes in a single e^+e^- experiment. The results based on about 55,600 identified hadronic events are consistent with previous measurements, and have precision comparable to the current world average.

1 Introduction

Since 1974 the VEPP-2M collider at the Budker Institute of Nuclear Physics in Novosibirsk, Russia, is the only world e^+e^- machine capable of studying e^+e^- annihilation into hadrons at low center of mass energies from the threshold of two pion production up to 1400 MeV [1]. Experiments at VEPP-2M yielded a number of important results in e^+e^- physics, including the most precise pion form factor measurements [2] and studies of the ρ, ω, and ϕ meson decays [3, 4]. During 1988-92 a new booster was installed to allow higher positron currents and injection of the electron and positron beams directly at the beam energy. At the moment VEPP-2M has peak luminosity $L \approx 5 \times 10^{30} cm^{-2}s^{-1}$ at 40 mA per beam at the ϕ center of mass energy.

In this paper we present results on the four major decay modes of the ϕ: $\phi \to K^+K^-$, $\phi \to K_SK_L$, $\phi \to \pi^+\pi^-\pi^0$, and $\phi \to \eta\gamma$ based on about 290 nb^{-1} of the data collected between 497 and 514 MeV per beam during the 1992 runs with the CMD-2 detector [5] shown in Figure 1. The CMD-2 is a general purpose detector consisting of

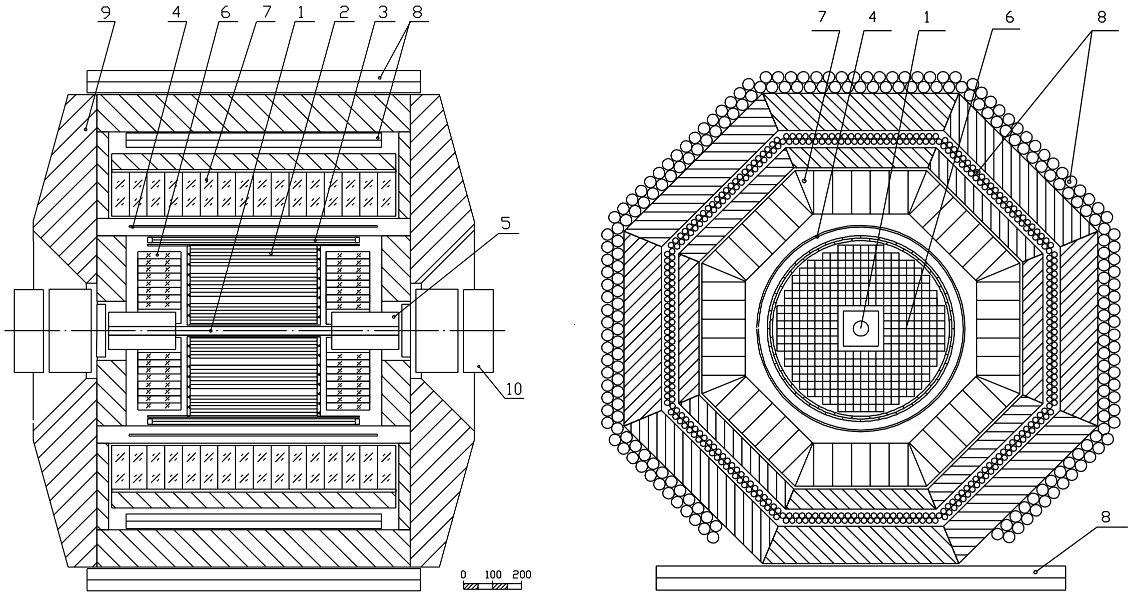

Figure 1: Horizontal and vertical cross sections of the CMD-2 detector. 1 - vacuum chamber; 2 - drift chamber; 3 - Z-chamber; 4 - main solenoid; 5 - compensating solenoid; 6 - storage ring lenses; 7 - calorimeter; 8 - muon range system; 9 - magnet yoke

a drift chamber with about 250 μ resolution transverse to the beam and proportional Z-chamber used for trigger, both inside a thin (0.4 X_0) superconducting solenoid with a field of 1 T. Outside the field, there is a barrel (CsI) calorimeter with 8-10 % energy resolution and a muon range system. A BGO endcap calorimeter has now been added, but was not in place for the data discussed here. More details on the detector can be found elsewhere [6].

2 Analysis

The luminosity was determined using the observed number N_{coll} of the collinear e^+e^-, $\mu^+\mu^-$, and $\pi^+\pi^-$ events:

$$L = \frac{N_{coll}}{\sigma_{coll}\epsilon_{rec}\epsilon_{trig}},$$

where

$$\sigma_{coll} = \sigma_{ee}(1+\delta_{rad,e}) + \sigma_{\mu\mu}(1+\delta_{rad,\mu}) + \sigma_{\pi\pi}(1+\delta_{rad,\pi})$$

is the sum of the Born cross sections for the collinear events with radiative corrections obtained by Monte Carlo simulation of the detector, ϵ_{rec} is the reconstruction efficiency for collinear events, ϵ_{trig} is the trigger efficiency. The values of σ_{ee} and $\sigma_{\mu\mu}$ are calculated from quantum electrodynamics while that of $\sigma_{\pi\pi}$ is evaluated by using the values of form factor as previously measured [2].

For each channel the number of events N_{hadr} was selected and the following formula was used for the calculation of the cross section at each energy point:

$$\sigma = \frac{N_{hadr}}{L\epsilon_{\mathrm{MC}}\epsilon_{rec}\epsilon_{trig}(1+\delta_{rad})}.$$

The Monte Carlo simulation of the detector is based on GEANT code, and a sufficiently large sample of events for each channel of interest has been generated (from 6k $\eta\gamma$ to 250k K^+K^-). This allows determination of the detector efficiency (ϵ_{MC}) with a 1-4 % statistical uncertainty specified below for each decay mode. Separately described are systematic uncertainties to be added in quadrature.

When the number of hadronic events is normalized to the number of collinear events the systematic uncertainties of the reconstruction efficiency cancel to the level of 2 % included in the systematic uncertainty of each energy point.

Special dedicated runs were used to estimate trigger efficiency for each channel studied. The trigger efficiency uncertainties at the level of 2-4% were included in the overall systematic uncertainty of the peak cross section and branching ratio for each channel.

The high statistical accuracy achieved in this experiment and even higher data samples expected in future runs require knowledge of the radiative corrections with an accuracy better than 0.5%. Radiative corrections for the cross sections of the main channels of e^+e^- annihilation into hadrons and leptons were calculated according to [8, 9, 10]. For leptonic channels ($e^+e^-, \mu^+\mu^-$) the radiation of both initial and final state particles was taken into account. The theoretical uncertainty of the cross sections for $\mu^+\mu^-$ and hadronic channels corrected for radiative effects varied from 0.2% to 0.5% depending on the reaction channel. For Bhabha scattering the results of Ref. [10] were used. The theoretical uncertainty in that work is about 1%, which is more than the required 0.5% stipulated above and can be improved by taking into account the contribution of the next order diagrams. More details can be found elsewhere [11].

The selection criteria for collinear events used for luminosity determination were:

–The average momentum of the two charged tracks is greater than 240 MeV/c, and the transverse momentum of each track is less than 800 MeV/c.

–The azimuthal angle difference ($\Delta\phi$) is less than 0.1 radian.

–The polar angle of the tracks θ is between 1.0 and 2.14 radian.

–The radial distance from the beam axis to the vertex is less than 0.5 cm.

After these cuts σ_{coll} is about 530 nb^{-1}.

Besides the systematic uncertainty in the determination of ϵ_{rec} for individual energy points, the common 3% systematic error in the luminosity measurement comes from the uncertainty in the fiducial solid angle and from the uncertainty in the radiative corrections for Bhabha events.

The most probable decay channel of the ϕ is that to two charged kaons. At the energy around the ϕ meson mass produced kaons have too low kinetic energy to penetrate through the material of drift chamber walls, so that the Z-chamber can be fired only by secondary particles from nuclear interactions or decays of stopped kaons. To avoid large systematic uncertainties in the determination of absolute efficiencies caused by the incorrect simulation of nuclear interactions for low energy kaons in the current version of GEANT, we use only K^+K^- events with one kaon decaying in flight within 6 cm radially from the interaction region. Although because of the long decay length of kaons (about 50 cm at these energies) this requirement severely reduces the number of events, it guarantees that at least one particle is energetic enough to produce a trigger. The cuts used in the selection of the event sample were:

–The momentum of the charged decay product in the kaon rest frame is between 110 and 360 MeV/c.

–The opening angle between the decay product and the kaon is between 0.15 and 3.0 radian.

–The angle of the secondary muon or pion as well as the kaon angle with respect to the z-axis is between 1.0 and 2.14 radian to guarantee a hit of the barrel calorimeter and provide a trigger.

–The decay vertex is between 0.5 cm and 6 cm from the center of the detector radially.

The Monte Carlo detection efficiency averaged over the ϕ energy range is (2.03 ± 0.03)% and decreases slightly with energy. The total number of K^+K^- events with one identified decay is 2913.

To measure the branching ratio of the ϕ decay into K_SK_L events with the decay $K_S \to \pi^+\pi^-$ were selected among the events with two charged tracks. It was assumed that charged tracks are pions and the cuts imposed are listed below :

–There are two tracks in the drift chamber making a vertex within 3 cm of the beam radially.

–The average momentum of two charged pions (supposedly coming from the K_S decay) is between 180 and 250 MeV/c.

–M_{inv}, the invariant mass of two charged pions is between 450 and 550 MeV/c^2.

–The corresponding missing momentum is between 60 and 150 MeV/c.

–Each charged pion has a momentum between 140 and 290 MeV/c.

–The polar angle of each pion is between 0.8 and 2.34 radian.

The average Monte Carlo efficiency over the ϕ meson region is (35.9 $\pm$ 0.2)% and decreases with energy. For this channel the total sample of events with a reconstructed K_S is 40,644. About 400 events with both K_S and K_L decays are separately reconstructed.

The three-pion final state was searched for in a sample of events with two charged tracks. The tracks assumed to be pions must satisfy the following requirements:

–The vertex formed by the charged tracks is within 0.5 cm of the beam position radially.

–The momentum of each charged track is less than 500 MeV/c.

–The missing momentum (of the supposed neutral pion) is between 100 and 500 MeV/c.

–The missing mass squared (of the supposed neutral pion) is between –100000 and 120000 MeV^2/c^4.

–The average momentum of the two charged tracks is between 230 and 400 MeV/c.

–The polar angle of each pion is between 0.8 and 2.34 radian.

–The azimuthal angular acollinearity is larger than 0.15 radian, and $\Delta\psi$ (the opening angle between two charged tracks) is less than 2.5 radian to remove $K_S \to \pi^+\pi^-$ background.

The requirement that the neutral pion could be reconstructed from the photon showers in the CsI calorimeter was not applied since: 1) it reduced the number of events by a factor of two because of the solid angle of the CsI calorimeter, and 2) the fraction of the reconstructed π^0 was different for simulated and real events, probably due to the presence of some background clusters in real data. Events with good reconstructed neutral pions were used, however, to estimate nonresonance background coming from four pion production. The corresponding number of background events, normalized to the integrated luminosity, was subtracted from the event number at each energy point.

Simulation of this decay mode shows that in the narrow energy range studied the efficiency is (18.6$\pm$0.2)% independently of the center of mass energy. The total number of reconstructed events was 11,761.

The decay mode of the ϕ to $\eta\gamma$, with a branching ratio of about 1%, is searched for using the three pion decay of the η ($\eta \to \pi^+\pi^-\pi^0$). This mode is selected from a sample of events with two tracks of opposite charge. The selected tracks are assumed to be pions and should satisfy the following requirements:

–The opening angle between two tracks is less than 2.5 radian, in order to remove $K_S K_L$ events and azimuthal angular acollinearity is greater than 0.15 radian to remove K^+K^- events.

–The vertex should be radially within 0.5 cm of the detector center and longitudinally within 10 cm.

–The invariant mass of two pions is less than 520 MeV/c^2.

–The missing mass squared of the two pions is greater than 100000 MeV^2/c^4 (missing mass is greater than 330 MeV/c^2).

The most energetic photon is assumed to be the photon from the primary $\phi \to \eta\gamma$ decay. Taking the η direction to be opposite to the photon candidate and calculating the η energy from the known beam energy under the assumption of the $\phi \to \eta\gamma$ decay, one can calculate the missing mass in the rest system of the η and select the events with a peak at the π^0 mass corresponding to $\eta \to \pi^+\pi^-\pi^0$ decays.

The Monte Carlo efficiency for extracting $\eta\gamma$ events is (5.6±0.2)%. The total number of found events was 279±21.

3 Results and Discussion

The energy of the machine was set roughly by the dipole magnet currents. A precise determination of the beam energy can be made using the measurement of the average momentum of the kaons in the K^+K^- final state at each energy point:

$$E_{beam} = \sqrt{p_K^2 + m_K^2} + \Delta_{dE/dx} + \Delta_{rad},$$

where $\Delta_{dE/dx}$ is the average ionization loss of the charged kaon and Δ_{rad} is the average radiative correction due to the emission of real photons.

The average momentum resolution σ_{p_K} for the kaons with momenta around 110 MeV/c is about 5 MeV/c and determined mostly by the multiple scattering in the drift chamber. The statistical uncertainty in the beam energy is determined as

$$\sigma_{E_{beam}} = \frac{\sigma_{p_K} p_K}{E_{beam}\sqrt{N}},$$

where N is the number of found K^+K^- pairs. These uncertainties are very small and, depending on the number of events at each energy point, are in the range of 0.017 - 0.040 MeV. Temperature variation effects increased the errors to 0.030-0.060 MeV.

The dE/dx correction, together with Δ_{rad}, were obtained as a function of kaon momentum by GEANT simulation of charged kaon events in the detector. The estimated uncertainty of this determination of 0.015 MeV was added quadratically to the statistical errors above.

An independent absolute beam energy measurement by the resonance depolarization method was performed at four energy points and was used to study systematic errors of the described procedure. As a result, the overall systematic error of the single beam energy determination was estimated to be 0.024 MeV or 0.048 MeV in the ϕ meson mass.

The estimated error in the slope of the calibration curve gives not more than 0.010 MeV systematic error in the ϕ meson width.

Table 1 presents energies, integrated luminosities and cross sections for each channel.

The uncertainties of the cross sections include both statistical and systematic errors which were introduced for each point separately. Also included were errors caused by the influence of the uncertainty of energy determination on the radiative corrections and on the cross sections themselves.

The experimental cross sections measured for each decay mode were used to obtain the ϕ meson parameters by fitting experimental points to corresponding resonance curves.

The cross section of the kaon production can be written as:

$$\sigma(s) = \frac{\pi \cdot \alpha^2}{12} \cdot \frac{P_{2K}(s)}{s^{5/2}} \cdot |F_K(s)|^2,$$

where s is the center of mass energy squared, P_{2K}(s) is a phase space for two kaons, and F_K(s) is the kaon formfactor which in the framework of the vector dominance model (VDM) can be written as:

$$F_{K^\pm}(s) = (\frac{g_{\rho\gamma}g_{\rho K\bar{K}}}{\Delta\rho} + \frac{g_{\omega\gamma}g_{\omega K\bar{K}}}{\Delta\omega} + \frac{g_{\phi\gamma}g_{\phi K\bar{K}}}{\Delta\phi}) \cdot \sqrt{C}(s)$$

and

$$F_{K^0}(s) = -\frac{g_{\rho\gamma}g_{\rho K\bar{K}}}{\Delta\rho} + \frac{g_{\omega\gamma}g_{\omega K\bar{K}}}{\Delta\omega} + \frac{g_{\phi\gamma}g_{\phi K\bar{K}}}{\Delta\phi}.$$

The propagators of the vector mesons are $\Delta v = s - m_v^2 + i\sqrt{s}\Gamma_v(s)$, with the energy dependence of the width as in [12]:

$$\Gamma_\rho(s) = \Gamma_\rho \cdot \frac{m_\rho^2 P_{2\pi}(s)}{sP_{2\pi}(m_\rho^2)},$$

$$\Gamma_\omega(s) = \Gamma_\omega \cdot (B_{3\pi}\frac{s^{3/2}P_{3\pi}(s)}{m_\omega^3 P_{3\pi}(m_\omega^2)} + B_{2\pi}\frac{m_\omega^2 P_{2\pi}(s)}{sP_{2\pi}(m_\omega^2)} + B_{\pi^0\gamma}\frac{m_\omega^2 P_{\pi^0\gamma}(s)}{sP_{\pi^0\gamma}(m_\omega^2)}),$$

$$\Gamma_\phi(s) = \Gamma_\phi \cdot (B_{K^+K^-}\frac{m_\phi^2 P_{2K^\pm}(s)}{sP_{2K^\pm}(m_\phi^2)} + B_{K_SK_L}\frac{m_\phi^2 P_{2K^0}(s)}{sP_{2K^0}(m_\phi^2)} + B_{3\pi}\frac{s^{3/2}P_{3\pi}(s)}{m_\phi^3 P_{3\pi}(m_\phi^2)} + B_{\eta\gamma}\frac{m_\phi^2 P_{\eta\gamma}(s)}{sP_{\eta\gamma}(m_\phi^2)}),$$

where B_f are the branching ratios of the major decay modes of ρ, ω and ϕ and P_f(s) are phase space factors. For two-particle decays the phase space factor is determined by the momentum of final particle as P_f(s)=(s/4-m_f^2)$^{3/2}$, for the radiative decay into $\eta\gamma$ $P_{\eta\gamma}(s) = (\sqrt{s}(1 - m_\eta^2/s)/2)^3$ and for the three pion final state it is a function obtained by numerical calculation assuming the $\phi \to \rho\pi \to 3\pi$ model [12]. C(s) is the factor describing the interaction of the charged kaons in the final state which is absent for the neutral kaon mode.

Using the experimental values of the electronic widths [14] for the coupling constants $g_{v\gamma}$ and assuming SU(3) relations with ideal mixing

$$g_{\rho K\bar{K}} = g_{\omega K\bar{K}} = \frac{1}{\sqrt{2}}g_{\phi K\bar{K}},$$

the kaon formfactors may be expressed like

$$F_{K^\pm}(s) = g_{\phi\gamma}g_{\phi K\bar{K}} \cdot \sqrt{C}(s) \cdot (\Delta\rho^{-1} + \frac{1}{3}\Delta\omega^{-1} + \Delta\phi^{-1}),$$

$$F_{K^0}(s) = g_{\phi\gamma}g_{\phi K\bar{K}} \cdot (-\Delta\rho^{-1} + \frac{1}{3}\Delta\omega^{-1} + \Delta\phi^{-1}).$$

In the approximation of soft photon exchange the factor $C(s)$ may be written as C(s)=Z(1+$Z^2/4\pi^2$)/(1-e^{-Z}), Z=$2\pi m_K/p_K$ [13] and increases the cross section by about 5% (usually referred to as a Coulomb factor). In our kaon momentum range and at the present level of experimental statistics the energy dependence is negligible and the Coulomb factor may be included in the coupling constant for charged kaons, making it different from the one for neutral kaons during the fits. It should be emphasized once again that the particular expression for the Coulomb factor used above is based on the assumption of exchange by soft photons only. A more sophisticated approach could in principle further change the relation between charged and neutral kaon constants.

The cross section may be rewritten in terms of σ^0 - the cross section in the peak of the resonance for the selected channel:

$$\sigma_K(s) = \sigma_K^0 \cdot \frac{P_{2K}(s)}{P_{2K}(m_\phi^2)} \cdot \frac{m_\phi^7 \Gamma_\phi^2}{s^{5/2}} \cdot | \pm \Delta\rho^{-1} + \frac{1}{3}\Delta\omega^{-1} + \Delta\phi^{-1}|^2.$$

For the decays into $\pi^+\pi^-\pi^0$ and $\eta\gamma$ in the frame of the VDM the cross section may be written in the same way as:

$$\sigma_{3\pi,\eta\gamma}(s) = \frac{P_{3\pi,\eta\gamma}(s)}{s^{3/2}} \cdot |A_\omega + A_\phi e^{i\delta_\phi} + A_{bkg}|^2,$$

$$A_v = \frac{m_v^{5/2}\Gamma_v^0\sqrt{\sigma^0/P(m_v^2)}}{\Delta v},$$

$$A_{bkg} = m_\phi^{3/2}\sqrt{\sigma_{bkg}/P(m_\phi^2)},$$

where σ_{bkg} and δ_ϕ are the nonresonant background cross section and a relative phase of ϕ-ω mixing respectively. Only the dominant interference with ω is included. The peak cross sections for ω were calculated from the Particle Data Group (PDG) values of the width and branching ratios [14]. The nonresonant background cross section σ_{bkg} was determined only for the three pion channel.

All four processes were fitted together. The peak cross sections σ^0 for each mode, mass and width of ϕ and nonresonant background were parameters in the fit. The relative phase δ_ϕ for the three pion decay mode was fixed because the narrow energy range studied does not permit to evaluate its value with good accuracy. The value δ_ϕ = $(155 \pm 15)^o$ was taken from the most precise measurement presented in [4]. The following results were obtained:

m_ϕ = 1019.420 $\pm$ 0.036 $\pm$ 0.048 MeV ,
Γ_ϕ = 4.443 $\pm$ 0.084 $\pm$ 0.020 MeV,
$\sigma(\phi \to K^+K^-)$ = 2001 $\pm$ 65 $\pm$ 82 nb,
$\sigma(\phi \to K_S K_L)$ = 1361 $\pm$ 25 $\pm$ 49 nb,
$\sigma(\phi \to 3\pi)$ = 654 $\pm$ 26 $\pm$ 30 nb ,
$\sigma(\phi \to \eta\gamma)$ = 48.2 $\pm$ 3.6 $\pm$ 3.2 nb,
σ_{bkg}=0.61$\pm$0.37 nb .

The first error represents the statistical uncertainty which includes all systematic uncertainties for each individual energy point and, for the three pion decay mode, the uncertainty in the relative phase and background subtraction. The second one is the overall systematic uncertainty, which, for the cross sections, comes from the uncertainties in the trigger efficiencies (2-4% depending on the channel), simulated efficiencies (about 1-4%) and from the uncertainty in the luminosity measurement (3%). The systematic errors in the mass and width come from the systematic uncertainty in the energy determination from the average charged kaon momentum.

Note that the obtained value of the nonresonant background may be due to the influence of the higher resonances. For example, $\omega(1400)$ with the parameters from [14] and a relative phase equal to zero will result in the same value of σ_{bkg}. Another possibility is that there exists some additional non-resonant coupling due to box anomalies [15].

The excitation curves of the ϕ in different modes, together with the experimental points, are shown in Figure 2.

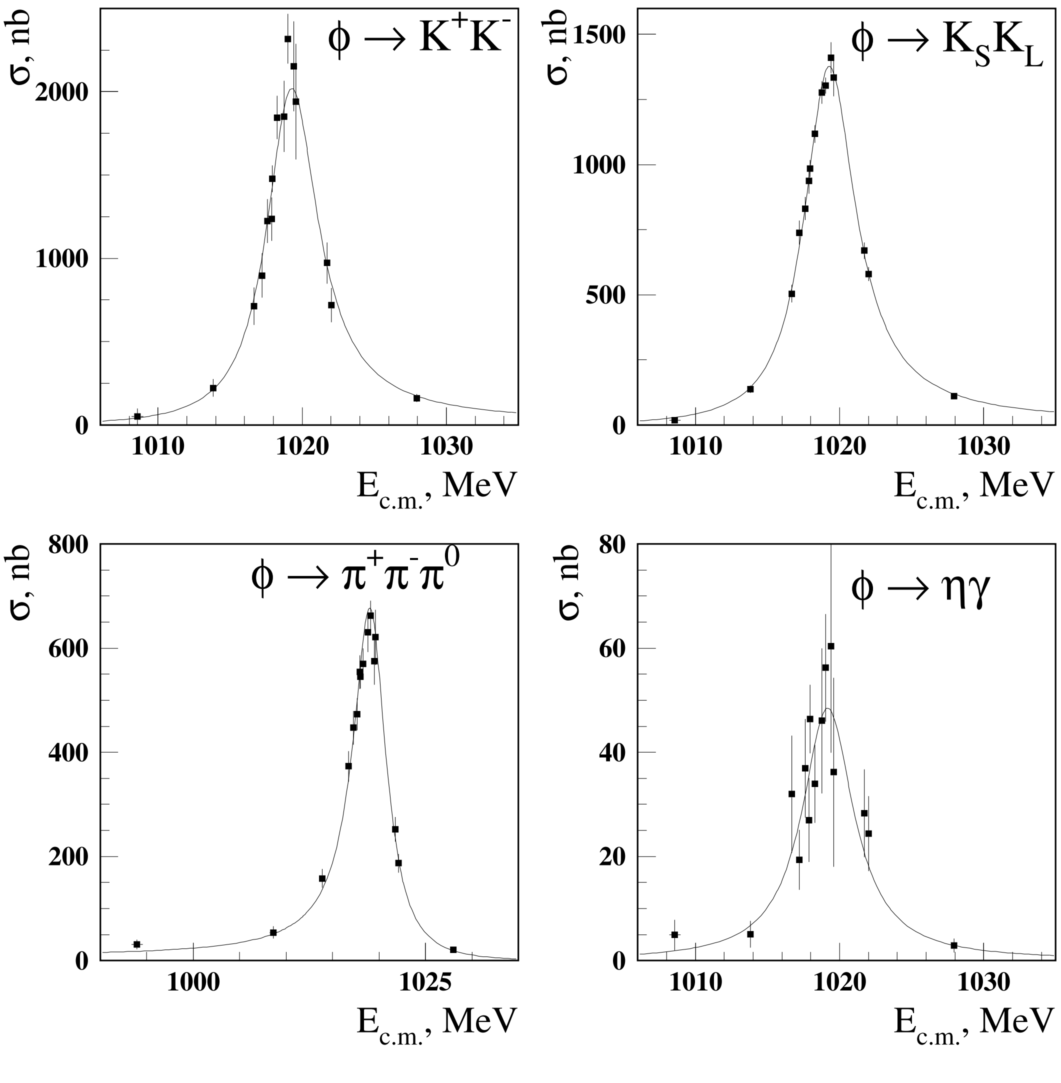

Figure 2: The excitation curves for ϕ-meson in different channels.

In this experiment all four major decay modes were simultaneously measured in one detector and therefore the branching ratios can be obtained as ratios of integrals over excitation curves independently of the width of the ϕ and the normalization uncertainties related to the luminosity measurements. In this case instead of using σ^0_{peak} for each mode $\sigma^0_{peak} \cdot \Gamma_\phi$ was a free fit parameter allowing to remove correlations in the errors. The following results were obtained:

$$\begin{aligned}
&\mathrm{B}(\phi \to K^+K^-) = 49.2 \pm 1.2\ \%\ ,\\
&\mathrm{B}(\phi \to K_S K_L) = 33.5 \pm 1.0\ \%\ ,\\
&\mathrm{B}(\phi \to 3\pi) = 16.1 \pm 0.8\ \%\ ,\\
&\mathrm{B}(\phi \to \eta\gamma) = 1.18 \pm 0.11\ \%\ .
\end{aligned}$$

The errors given here correspond to the statistical and systematic uncertainties added in quadrature. The branching ratios have not been corrected for the known 0.2% of decays to other modes, since this correction is much less than our errors. The electron width and branching ratio to e^+e^- of the ϕ can also be calculated independently as $\Gamma_{ee} = m^2_\phi/12\pi \cdot \sum \sigma^0_i \Gamma_\phi$, assuming $\sum B_i = 1$ and are found to be

$$\begin{aligned}
&\Gamma_{ee} = 1.28 \pm 0.05\ \mathrm{keV},\\
&\mathrm{B}(\phi \to \mathrm{ee}) = (2.88 \pm 0.09)\times 10^{-4}.
\end{aligned}$$

All results of the measurements are consistent with the PDG values [14]. There is a small (approximately 2 σ) difference in the Γ_{ee} and B($\phi \to$ee) - the PDG gives 1.37±0.05 keV and $(3.09\pm0.07)\times10^{-4}$ respectively. All the previous experiments which determined B($\phi \to$ee) measured only some of the ϕ-meson decays and had to rely on additional assumptions about the branching ratios of unobserved modes. It was the mode $\phi \to K^+K^-$ which was frequently missing and use of its branching ratio from other sources could result in additional systematic errors.

Note that our value of the electron width is between the current values of the muon and electron widths quoted by the PDG [14] $\mathrm{B}(\phi \to \mu\mu) = (2.48\pm0.34)\times10^{-4}$.

The final values for the mass and width from all the channels are:

$$\begin{aligned}
&m_\phi = 1019.42 \pm 0.06\ \mathrm{MeV}\ ,\\
&\Gamma_\phi = 4.44 \pm 0.09\ \mathrm{MeV},
\end{aligned}$$

to be compared with the best ones from previous e^+e^- collider experiments: m_ϕ = 1019.54 ± 0.12 MeV, Γ_ϕ=4.36±0.29 MeV [3] and to the PDG average of m_ϕ = 1019.411 ± 0.008 MeV, Γ_ϕ = 4.43 ± 0.06 MeV.

4 Conclusions

The measurement of the parameters of the ϕ and its four major decay modes demonstrates the potential of the CMD2 detector for precise measurements. For the first time the major parameters of the ϕ have been measured in one experiment. The data sample on which the results are based is the largest among e^+e^- experiments and contains about 55,600 identified hadronic events. Analysis of an event sample 5 times the data presented here is in progress and will allow new results on rare decay modes of the ϕ, including channels of interest for the design of ϕ factory detectors as well as more complete studies of systematic uncertainties[7].

The authors are grateful to N.N.Achasov, V.S.Fadin, V.N.Ivanchenko, E.A.Kuraev, and G.N.Shestakov for useful discussions.

We would like to thank J.H.Herald, M.B.James, R.R.Rose, and U.Y. Washington for help with the production of simulated data and the technical personnel of VEPP-2M for the machine and detector support during experimental runs.

The present work was supported in part by grants from the Russian government, and from the government of the United States through grants from the Department of Energy and the National Science Foundation and also from the grant RPT000 of the International Science Foundation.

Table 1: Energy, Integrated luminosity and Experimental Cross Sections for Different Channels.

$E_{c.m.}$, MeV	L, nb^{-1}	$\sigma_{K^+K^-}$, nb	$\sigma_{K_SK_L}$, nb	$\sigma_{\pi^+\pi^-\pi^0}$, nb	$\sigma_{\eta\gamma}$, nb
993.956±0.600	15.4±0.2	-	-	31± 7	-
1008.624±0.402	16.0±0.2	50± 50	18± 5	54± 9	5± 3
1013.882±0.182	12.9±0.2	222± 54	138±14	158±16	5± 3
1016.726±0.090	10.1±0.2	713±114	504±36	373±27	32±11
1017.264±0.096	11.9±0.2	897±134	739±49	447±31	19± 6
1017.654±0.082	15.0±0.2	1224±135	831±47	473±29	37± 9
1017.934±0.082	15.5±0.2	1236±134	937±53	555±30	27± 8
1017.992±0.066	43.1±0.3	1477± 86	985±40	545±20	46± 7
1018.322±0.066	33.5±0.4	1844±143	1118±46	570±28	34± 8
1018.806±0.074	12.4±0.2	1852±219	1277±52	631±37	46±14
1019.070±0.070	25.3±0.3	2317±166	1303±46	662±32	56±10
1019.468±0.104	4.9±0.1	2152±272	1411±62	575±44	60±20
1019.636±0.094	4.1±0.1	1939±347	1334±68	621±51	36±18
1021.762±0.084	14.5±0.3	973±126	669±36	252±22	28± 8
1022.072±0.096	17.1±0.2	719±104	579±30	187±16	24± 7
1027.996±0.124	39.2±0.4	161± 25	110± 6	21± 3	3± 1

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