Recent results from CMD-2 and SND experiments at VEPP-2M

Simon Eidelman[*][†]

Budker Institute of Nuclear Physics, Russia
E-mail: eidelman@inp.nsk.su

New results on various channels of e^+e^- annihilation into hadrons from CMD-2 and SND experiments at VEPP-2M in Novosibirsk are described. Both detectors collected about 30 pb^{-1} each in the c.m.energy range from 370 MeV to 1380 MeV. The main parameters of the ρ, ω and ϕ mesons were determined with high precision. Rare decay modes of the lightest vector mesons were measured with branching fractions $\sim 10^{-4} - 10^{-5}$. For the first time radiative processes $e^+e^- \to \pi^0\gamma$ and $e^+e^- \to \eta\gamma$ were studied in the whole energy range. Cross sections of e^+e^- annihilation into various hadronic final states were measured.

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[*]Speaker.
[†]For the CMD-2 and SND Collaborations.

Studies of low energy e^+e^- annihilation into hadrons provide important information on the interactions of light quarks and meson spectroscopy. High precision measurements of the exclusive cross sections and R allow an improvement of accuracy in the calculations of hadronic contributions to the muon anomalous magnetic moment a_μ, the value of the fine structure constant $\alpha(M_Z^2)$ and hyperfine splitting in Muonium [1].

Since 1974 the VEPP-2M e^+e^- collider has been successfully running in the Budker Institute of Nuclear Physics in Novosibirsk in the c.m.energy range from the threshold of hadron production to 1400 MeV [2]. Its maximum luminosity reached $\sim 3 \cdot 10^{30}$ cm^{-2}s^{-1} at the ϕ meson energy. In the last series of experiments two detectors, CMD-2 [3] and SND [4], collected about 30 pb^{-1} each from 370 MeV to 1380 MeV.

Both groups measured the cross section of the process $e^+e^- \rightarrow \pi^+\pi^-$ in the energy range of the ρ meson. These results can be used to calculate the leading order hadronic contribution to a_μ shown in Table 1(a) together with that of KLOE [5]. Although the SND result is somewhat higher, they are all compatible within current experimental errors. From a fit of their data shown in Fig. 1(a) the SND group determined the ρ and ω meson parameters compared in Table 1(b) to the world average data.

Group	$a_\mu, 10^{-10}$
CMD-2	378.6 ± 3.6
KLOE	375.6 ± 5.0
SND	385.6 ± 5.2

(a) $a_\mu, 600$ MeV $< \sqrt{s} < 960$ MeV

| Parameter	SND	PDG-2005
M_ρ, MeV	774.9 ± 0.6	775.8 ± 0.5
Γ_ρ, MeV	146.5 ± 1.7	146.4 ± 1.5
$\mathscr{B}(\omega \rightarrow \pi^+\pi^-), \%$	1.75 ± 0.11	1.70 ± 0.27

(b) $\rho - \omega$ Parameters

Table 1: Results in the ρ meson region

SND has completed its analysis of the annihilation into $\pi^0\gamma$ and $\eta\gamma$. Figure 1(b) shows the cross section of the process $e^+e^- \rightarrow \pi^0\gamma$ while in Table 2 their results are compared to the previous world best coming from the CMD-2 detector [6]. SND results are consistent with those from CMD-2 and have higher accuracy.
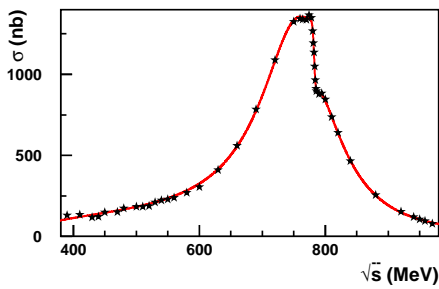
(a) $e^+e^- \rightarrow \pi^+\pi^-$ at SND
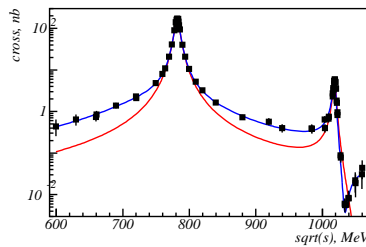
(b) $e^+e^- \rightarrow \pi^0\gamma$ at SND

Figure 1: SND results on $e^+e^- \rightarrow \pi^+\pi^-$ and $e^+e^- \rightarrow \pi^0\gamma$

SND is continuing the analysis of the annihilation into kaon pairs. Results on the charged kaons demonstrated in Fig. 2(a) show that the SND data are above those from OLYA and that there is no evidence for the ϕ'. In contrast to this finding, in the $K_S^0 K_L^0$ mode shown in Fig. 2(b) SND data are consistent with those from CMD-2 and evidence for the ϕ' has been obtained.

Meson	SND	CMD-2	Meson	SND	CMD-2
$\rho, 10^{-4}$	5.02 ± 0.73	6.71 ± 1.34	$\rho, 10^{-4}$	2.77 ± 0.31	3.39 ± 0.48
$\omega, 10^{-2}$	8.49 ± 0.26	9.01 ± 0.59	$\omega, 10^{-4}$	4.22 ± 0.50	4.75 ± 0.78
$\phi, 10^{-3}$	1.36 ± 0.10	1.26 ± 0.10	$\phi, 10^{-2}$	1.341 ± 0.052	1.287 ± 0.064

Branching fractions $\mathscr{B}(V \to \pi^0 \gamma)$ Branching fractions $\mathscr{B}(V \to \eta \gamma)$

Table 2: SND and CMD-2 results on $e^+ e^- \to \pi^0 \gamma, \eta \gamma$
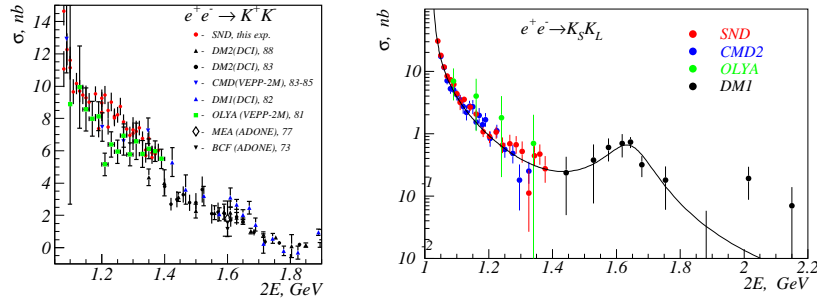
(a) $e^+ e^- \to K^+ K^-$ (b) $e^+ e^- \to K_S^0 K_L^0$

**Figure 2:** SND results on $e^+ e^- \to K^+ K^-, K_S^0 K_L^0$

CMD-2 made a simultaneous analysis of the four main decay modes of the ϕ meson. A combined fit of the data allows to obtain in a single experiment the accuracy of its main parameters close to the world average one [7], see Table 3. They also measured the energy dependence of the ratio of the $K^+ K^-$ and $K_S^0 K_L^0$ yields predicted by Ref. [8].

Quantity	CMD-2	PDG-2005
M_ϕ, MeV	1019.444 ± 0.026	1019.456 ± 0.020
Γ_ϕ, MeV	4.256 ± 0.031	4.26 ± 0.05
$\mathscr{B}(\phi \to e^+ e^-), 10^{-4}$	2.86 ± 0.05	2.98 ± 0.04

Table 3: CMD-2 results on the ϕ meson parameters

Analysis of the process $e^+ e^- \to \pi^+ \pi^- \pi^0 \pi^0$ by CMD-2 (Fig. 3) allowed to conclude that it is dominated by $a_1 \pi$ and $\omega \pi$ and due to their interference $\sigma_{\pi^+ \pi^- 2\pi^0} \neq \sigma_{a_1 \pi} + \sigma_{\omega \pi}$. It is also observed that separation of $a_1 \pi$ and $\omega \pi$ differs in CMD-2 and SND [9].

CMD-2 performed analysis of the reaction $e^+ e^- \to \pi^+ \pi^- \pi^0$ and concluded that $m_{\pi\pi}$ spectra show $\rho \pi$ dominance with an $\omega \pi$ admixture; a combined fit of SND [10], CMD-2 and BaBar [11] data is consistent with two higher ω states [7]; the cross sections obtained by DM2 [12] are signif-
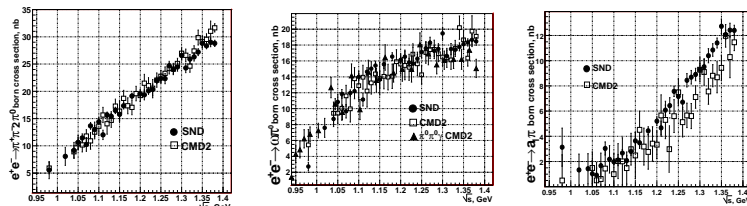
Figure 3: CMD-2 results on $e^+ e^- \to \pi^+ \pi^- \pi^0 \pi^0$

Decay	CMD-2	SND	RPP-2004	Theory
$\omega \to \pi^0 e^+ e^-$	$8.19 \pm 0.71 \pm 0.62$	$8.09 \pm 0.53 \pm 0.79$	5.9 ± 1.9	$7.2 - 8.0$
$\omega \to \eta e^+ e^-$	< 0.11	–	–	$0.020 - 0.048$
$\rho \to \pi^0 e^+ e^-$	< 0.16	–	–	$0.041 - 0.065$
$\rho \to \eta e^+ e^-$	< 0.07	–	–	$0.022 - 0.032$

Table 4: Branching fractions of conversion decays, 10^{-4}

icantly lower than those of BaBar.

Table 4 shows results of a study of conversion decays of the ρ and ω mesons, which provide a further test of the Vector Dominance Model and allow a measurement of transition form factors. In addition, precise knowledge of their branching ratios is necessary to estimate the background in searches for quark-gluon plasma.

In conclusion, we reported a high precision measurement of the main parameters of the ρ, ω, ϕ, which showed validity of the Vector Dominance Model. Various rare decay modes of the light vector mesons were studied with a sensitivity to $\mathscr{B} \sim 10^{-5} - 10^{-6}$. Exclusive hadronic final states were measured with low systematic errors allowing significant improvement in $a_\mu^{\text{had,LO}}$.

Future progress is expected from experiments at the upgraded collider VEPP-2000 [13] with the maximum center-of-mass energy 2 GeV and luminosity 10^{32} cm^{-2}s^{-1}.

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