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Abstract

In experiments with the CMD-2 detector at the VEPP-2M electron-positron collider at Novosibirsk about 150000 $e^+e^- \to \pi^+\pi^-$ events were recorded in the center-of-mass energy range from 0.61 up to 0.96 GeV. The result of the pion form factor measurement with a 1.4% systematic error is presented. The following values of the ρ-meson and $\rho-\omega$ interference parameters were found: $M_\rho = (775.28 \pm 0.61 \pm 0.20)$ MeV, $\Gamma_\rho = (147.70 \pm 1.29 \pm 0.40)$ MeV, $\Gamma(\rho \to e^+e^-) = (6.93 \pm 0.11 \pm 0.10)$ keV, $Br(\omega \to \pi^+\pi^-) = (1.32 \pm 0.23)\%$.

Contents

1 Introduction

The cross-section of the process $e^+e^- \to \pi^+\pi^-$ is given by

$$\sigma = \frac{\pi\alpha^2}{3s}\beta_\pi^3 \left|F_\pi(s)\right|^2 ,$$

where $F_\pi(s)$ is the pion form factor at the center-of-mass energy squared s and β_π is the pion velocity.

The pion form factor measurement is important for a number of physics problems. Detailed experimental data in the time-like region allows measurement of the parameters of the $\rho(770)$ meson and its radial excitations. Extrapolation of the energy dependence of the pion form factor to the point $s = 0$ gives the value of the pion electromagnetic radius. Exact data on the pion form factor is necessary for precise determination of the ratio

$$R = \sigma(e^+e^- \to hadrons)/\sigma(e^+e^- \to \mu^+\mu^-).$$

Knowledge of R with high accuracy is required to evaluate the hadronic contribution a_μ^{had} to the anomalous magnetic moment of the muon $(g-2)_\mu$ [1]. About 87% of the hadronic contribution in this case comes from $s < 2$ GeV^2/c^2 (VEPP-2M range), and about 72% — from $e^+e^- \to \pi^+\pi^-$ channel with $s < 2$ GeV^2/c^2 [2, 3]. The E821 experiment at BNL [4] has collected its first data in 1997 and will ultimately measure $(g-2)_\mu$ with a 0.35 ppm accuracy. To calculate the hadronic contribution with the desired precision the systematic error in R should be below 0.5%. Therefore a new measurement of the pion form factor with a low systematic error is required.

Experiments at the VEPP-2M collider[5], which started in the early 70s, yielded a number of important results in e^+e^- physics at low center-of-mass energies from 360 to 1400 MeV. The high precision measurement of the pion form factor at VEPP-2M was done in the late 70s – early 80s by OLYA and CMD groups [6]. In the CMD experiment, 24 points from 360 to 820 MeV were studied with a systematic uncertainty of about 2%. In the OLYA experiment, the energy range from 640 to 1400 MeV was scanned with small energy steps and the systematic uncertainty varied from 4% at the ρ-meson peak to 15% at 1400 MeV.

During 1988-92 a new booster was installed to allow higher positron currents and injection of the electron and positron beams directly at the desired energy. During 1991-92 a new detector CMD-2 was installed at VEPP-2M, and in 1992 it started data taking. The pion form factor measurement was one of the major experiments planned at CMD-2. The energy scan of the

ID	Date	$2E$, GeV	Number of energy points	$N_{e^+e^-\to\pi^+\pi^-}$
1	Jan–Feb 1994	0.81–1.02	14	35000
2	Nov–Dec 1994	0.78–0.81	10	66000
3	Mar–Jun 1995	0.61–0.79	20	85000
4	Oct–Nov 1996	0.37–0.52	10	4500
5	Feb–Jun 1997	0.98–1.38	37	75000
6	Mar–Jun 1998	0.36–0.97	37	1900000

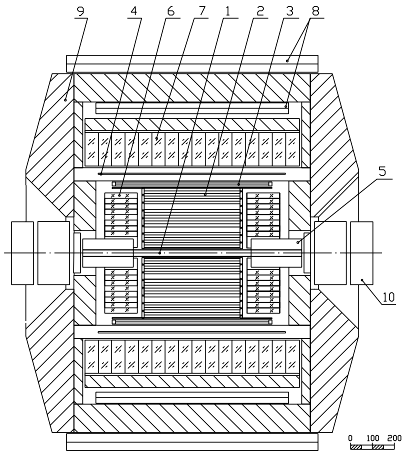
Table 1: CMD-2 runs dedicated to R measurement

whole VEPP-2M 0.36-1.38 GeV energy range was performed in six separate runs listed in Table 1. The energy range below the ϕ meson was scanned twice (in 94-96 and in 98).

In this article we present results of the analysis of the data from runs 1–3. The data were taken at 43 energy points with the center-of-mass energy from 0.61 GeV up to 0.96 GeV with a 0.01 GeV energy step. The small energy step allows calculation of hadronic contributions in model-independent way. In the narrow energy region near the ω-meson the energy steps were $0.002 \div 0.006$ GeV in order to study the ω-meson parameters and the $\rho - \omega$ interference. Since the form factor is changing relatively fast in this energy region, it was important that the beam energy was measured with the help of the resonance depolarization technique at almost all energy points. That allowed a significant decrease of the systematic error coming from the energy uncertainty.

The CMD-2 (Fig. 1) is a general purpose detector consisting of the drift chamber, the proportional Z-chamber, the barrel (CsI) and the endcap (BGO) electromagnetic calorimeters and the muon range system. The drift chamber, Z-chamber and the endcap calorimeters are installed inside a thin superconducting solenoid with a field of 10 kGs. More details on the detector can be found elsewhere [7, 8, 9]. The data described here was taken before the endcap calorimeter was installed.

Two independent triggers were used during data taking. The first one, *charged trigger*, analyses information from the drift chamber and the Z-chamber and triggers the detector if at least one track was found. For 0.81–0.96 GeV energy points there was an additional requirement for the total energy deposition in the calorimeter to be greater than a 20–30 MeV threshold. The second one, *neutral trigger*, triggers the detector according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