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NEW DATA ON $e^+e^- \to \pi^+\pi^-$ CROSS SECTION WITH CMD-2 IN ENERGY RANGE $\sqrt{s}$=0.37 - 1.38 GeV

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1 Introduction

The measurement of the $e^+e^- \to \pi^+\pi^-$ cross section is important for a number of physical problems. Along with the most straightforward usage for determination of the parameters of the $\rho(770)$ meson and its radial excitations, this process gives the dominant contribution to the hadronic part of the muon anomalous magnetic moment (a_μ). In our previous papers [1, 2] we reported results of the determination of the $e^+e^- \to \pi^+\pi^-$ cross section in the energy region $\sqrt{s} = 0.6 \div 0.96$ GeV. In this publication we present preliminary results based on integrated luminosity of 30 pb^{-1} collected in the whole energy range covered by VEPP-2M.

The $\pi^+\pi^-$ cross section was studied at the VEPP-2M [3] electron-positron

* On behalf of the CMD-2 Collaboration

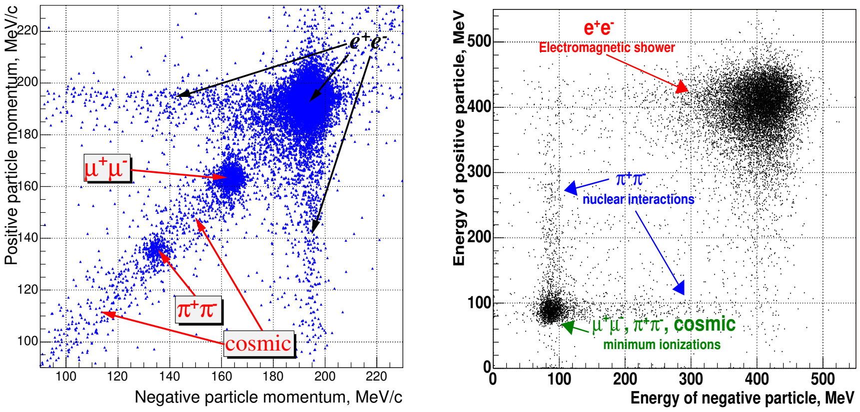

Figure 1: *Left: Particle momenta distribution at* $\sqrt{s} = 0.39$ *GeV. Right: Energy deposition distribution at* $\sqrt{s} = 0.98$ *GeV.*

collider with the beam energy from 180 to 700 MeV and maximum luminosity $3 \cdot 10^{30}\mathrm{cm}^{-2}\mathrm{sec}^{-1}$. The pion form factor measurement was one of the major goals of the CMD-2 experiment which is described in some detail in works [4, 5]. 670 thousands $\pi^+\pi^-$ events were detected in 118 energy points.

2 Selection

The main selection criteria are based on particle parameters measured in the drift chamber allowing efficient rejection of non-collinear events. For particle separation either energy deposition in the calorimeter (at c.m. energies above 0.6 GeV) or particle momenta measured in the drift chamber (at c.m. energies below 0.6 GeV) were used (Fig.1). Above 0.6 GeV the number of cosmic events was determined from the spatial distribution of vertex, while the number of muon events was fixed relative to the number of e^+e^- events according to QED. In both energy ranges the separation was based on the minimization of unbinned likelihood function. The number of selected events is shown in Table 1. The pion form factor is presented in Fig.2. The fit was performed according to the Gounaris-Sakurai parametrization with the $\rho(770)$, ω, $\phi(1020)$, $\rho(1450)$ and $\rho(1700)$ mesons included.

Table 1: *Number of events*

e^+e^-	$\mu^+\mu^-$	$\pi^+\pi^-$	cosmic	number of points	energy range, $\sqrt{s}$	
number of events, 10^3						
164	16	114	17	43	$610 \div 960$ MeV	94-95 scan [1)]
96	9	4	5	10	$370 \div 520$ MeV	96 scan
710	65	520	19	29	$600 \div 960$ MeV	98 scan
840	81	33	14	36	$980 \div 1380$ MeV	97 scan

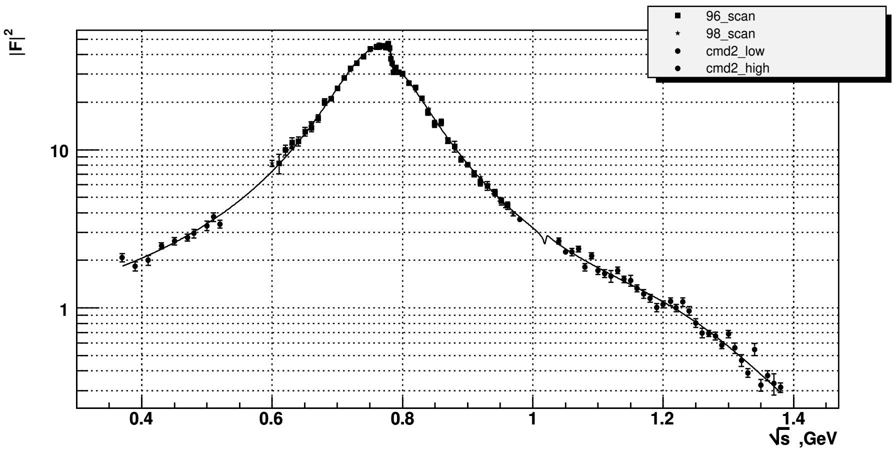

Figure 2: *Pion Form Factor.*

3 Systematic

The overall systematic error is estimated to be 0.6% for ρ-meson region in 96'scan and 1.1% in 98'scan, 1.2% at energies below 0.6 GeV due to a more complicated separation procedure, and 1.3÷5.0% for energies above 1 GeV because the uncertainty in the number of muon events gives a direct contribution to a systematic error of the pion form factor (N_μ/N_π ratio changed from 1 to 7 at $\sqrt{s} = 1 \div 1.4$ GeV). The contributions to systematic error are shown in Table 2.

The fiducial volume is determined by a measurement of polar angle Θ in the drift chamber. Calibration of the drift chamber along the beam axis is based on the Z-chamber which has a systematic error of z-coordinate measurement about 0.1 mm, that corresponds to a systematic error in the form factor near ρ-meson about 0.2%.

The reconstruction efficiency was measured using the experimental data themselves. It was found to be within the 98-100% range at all energies and, within the statistical accuracy, is the same for all types of collinear events. Therefore, it cancels in the form factor calculation. The systematic error of the cancellation for different type of particles was estimated to be better than 0.2%. In 98'scan the degradation of the drift chamber was observed and preliminary conservative estimation of the systematic error is about 0.9%.

Pions could be lost by decays in flight and by nuclear interactions with the detector material. The correction for pion losses was calculated by full detector simulation using FLUKA [6] package for simulation of nuclear interaction. The value of nuclear interaction correction varies from 1.7% to 0.6%. The systematic error of the correction was estimated from uncertainty of experimental data on nuclear cross-sections used in FLUKA.

Radiative corrections were calculated according to Ref. [7] with a declared accuracy of 0.2%.

The increase of systematic error due to background events above the ϕ-meson is related to a decrease of the $N_{\pi\pi}/N_{cosmic}$ ratio.

The absolute beam energy in the ρ-scan in 96'scan was measured with the help of the resonance depolarization method, providing the accuracy better than $\delta E/E \ll 10^{-4}$. It gives a systematic error due to the beam energy measurement of 0.1% near the ρ-meson. In other experemental scans, the collider energy was set by dipole magnets with accuracy $\delta E/E < 10^{-3}$.

4 Conclusion

The preliminary results of the pion form factor measurement in the energy range $\sqrt{s}$=0.37 - 1.38 GeV are presented. They are based on a full experimental data set collected in the CMD-2 experiment. New data in the ρ-meson region have 2 times better statistical precision, and are in a good agreement with our previously published result.

Table 2: *Systematic error.*

Source		Value		
$\sqrt{s} =$	0.37÷0.52	0.6÷0.96		1.04÷1.38 GeV
		95scan	98scan	
Fiducial volume	0.2%	0.2%		0.2÷0.5%
Detection efficiency	0.3%	0.2%	0.9%	0.5÷2.0%
Correction for pion loses	0.2%	0.2%		0.2%
Radiative corrections	0.3%	0.4%		0.5÷2.0%
Background events	$< 0.1\%$	$< 0.1\%$		0.6÷1.6%
Energy calibration of collider	0.3%	0.1%	0.3%	0.7÷1.1%
Full event separation	1.0%	0.2%		0.5÷3.5%
	1.2%	0.6%	1.1%	1.3÷5.0%
statistic error in point	6%	4%	1.5%	5÷13%

5 Acknowledgments

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