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V.E.Balakin, G.I.Budker, L.M.Kurdadze, A.P.Onuchin,
S.I.Serednyakov, V.A.Sidorov, A.N.Skrinsky

MEASUREMENT OF $\pi^{\pm}$ AND $K^{\pm}$ PAIR PRODUCTION CROSS-SECTIONS WITH THE COLLIDING BEAMS AT THE ENERGY OF 1180-1340 MeV

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Abstract

Using the electron-positron storage ring VEPP-2 the experiment has been performed to measure the cross-sections of the reactions $e^+e^- \rightarrow \pi^+\pi^-$ and $e^+e^- \rightarrow K^+K^-$ at the region of total energy 1180-1340 MeV. The values of the π -meson and K-meson electromagnetic formfactors obtained are presented.

Investigation of the electromagnetic form-factors of charged π -mesons and K-mesons in the region of timelike momentum transfers in experiments with colliding positron-electron beams started with the works in which vector mesons were studied /1-4/. These experiments were naturally facilitated by the large value of cross-sections in the resonance region.

In this work we present the results of the measurements in the beyond-resonance region of energy accessible for the storage ring VEPP-2. The experiment has been performed in 1970 /5/ at three values of the total energy: 1180, 1260 and 1340 MeV.

The working conditions of the machine during the experiment were characterized by the following parameters: the initial currents were 70 mA and 40 mA for electrons and positrons, respectively, the mean lifetime was about 5 hours, the luminosity averaged over the measurement time was $10^{28} cm^{-2} sec^{-1}$.

The luminosity monitoring has been carried out by detecting the double bremsstrahlung events /6/. The luminosity integral was determined by the process of elastic scattering.

Besides the main measurements - the effect, two kinds of background measurements have been performed: with the beams vertically displaced from each other by a distance of 2 mm and without the beams. In the latter case the system of the synchronization with the r.f.phase was switched off that increased the effective measurement time by a factor of 4.

The detection system used in the experiment (Fig.1) consisted of the optical and wire spark chambers, the scintillation counters and the water Cerenkov counters. The chambers and the counters were rectangular and they covered an angle of $\pm 25^{\circ}$ near the vertical direction. The solid angle of the system was 2x0,8 steradian.

The scintillation counters, the optical "shower" and "range" spark chambers were the same as in the Φ -meson experiment /4/. The total matter thickness of the optical spark chambers was 170 g/cm^2. With their help the range of the particles has been determined as well as the presence of showers in the case of electron detection. The geometrical characteristics of the events have been determined using the wire chambers. From each side of the interaction region three two-coordinate chambers with the ferrite cores were placed /7/. The wire chambers operated on-line with the computer "Minsk-22" /8/, all the information being simultaneously recorded on the magnetic tape. For events selected with the aid of the wire chambers the photo-

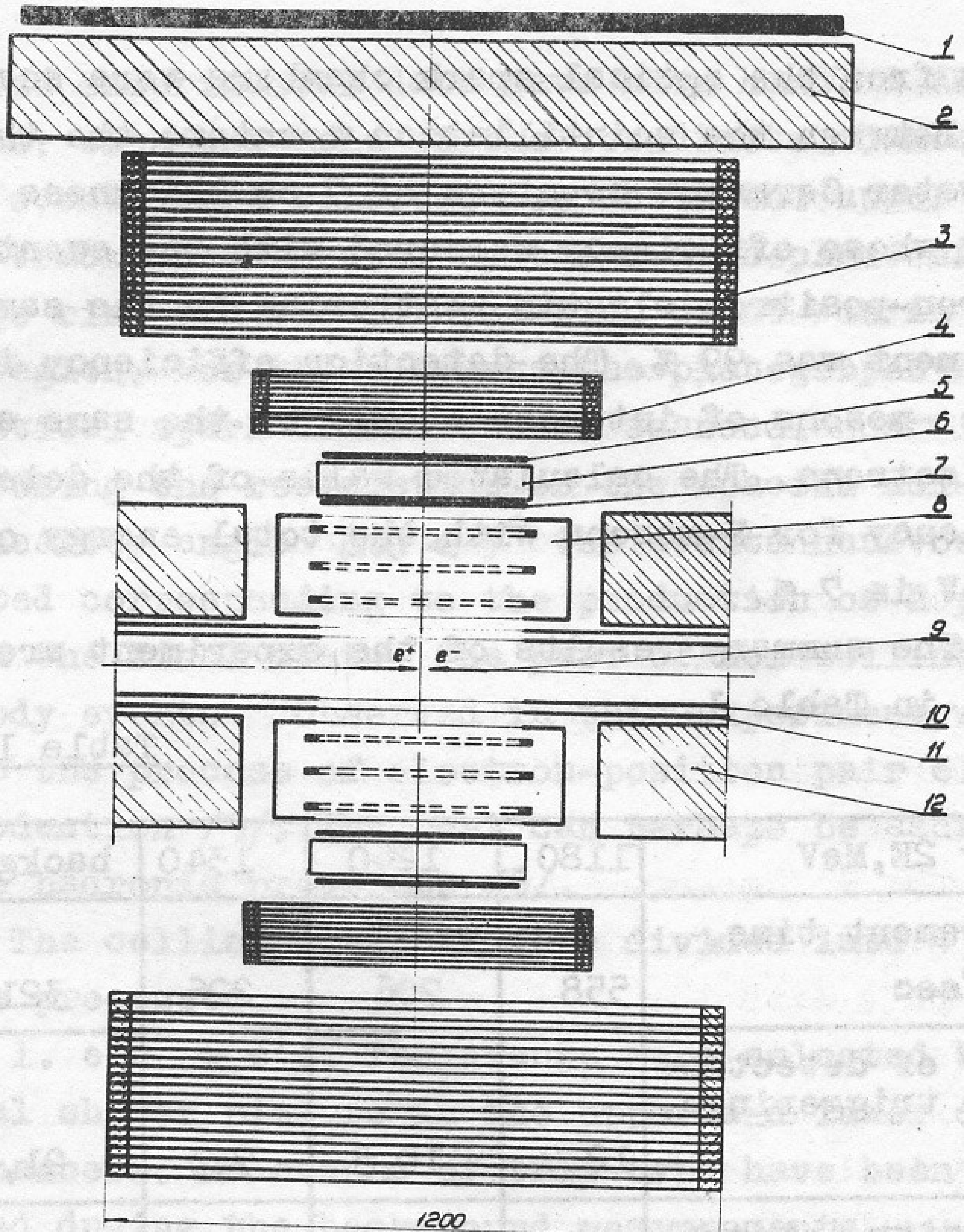

Fig.1. General view of the experimental set-up: 1-anticoincidence scintillation counter; 2-lead; 3-optical "range" spark chamber; 4-optical "shower" spark chamber; 5,7-scintillation counters; 6-water Cerenkov counter; 8-coordinate wire spark chambers; 9-interaction region; 10 and 11-inner and outer vacuum chambers; 12-storage ring magnet.

graphs from the optical spark chambers were scanned.

Between the scintillation counters the threshold water Cerenkov counters of 7 cm thickness were placed whose efficiency measured with the events of electron-positron elastic scattering in the same experiment was 99 %. The detection efficiency for the π -mesons of interest should be the same as for electrons. The calculated value of the detection efficiency for K-mesons with the total energy of 670 MeV is 7 %.

The summary results of the experiment are presented in Table 1.

Table 1

Energy 2E, MeV	1180	1260	1340	background
Measurement time, 10^3 sec	558	706	226	3214
Number of detection system triggerings, 10^3	12,7	10,5	7,3	21,8
Luminosity integral, 10^{33} cm^{-2}	6,0	5,1	2,4	-
Number of events e^+e^- e^+e^-	207	142	55	-

The experimental data have been handled as follows: with the help of the coordinate chambers those events were selected for which the upper and lower tracks intersected in the median plane of the storage ring and the intersection point was in the beam region. For those events the photographs from the optical spark chambers were scanned.

Using the restriction on the spacial non-collinearity angle $\Delta\omega < 5^{\circ}$ the events have been selected corresponding to the production of 2 particles in the final state. The part of non-collinear-manybody events observed in this experiment was due to the process of electron-positron pair electroproduction /9/. The rest can perhaps be ascribed to the hadronic processes /5/.

The collinear events were divided into 4 types of the processes.

1. $e^+e^- \rightarrow e^+e^-$. The events were selected by the typical shower picture in the upper and lower optical chambers. No events of this type have been discovered during the background measurements.

2. $e^+e^- \rightarrow \mu^+\mu^-$. The range for both particles exceeds the thickness of the optical chambers. The analysis of the process of the μ-meson pair production is given in the separate work /10/.

3. $e^+e^- \rightarrow \pi^+\pi^-$. The particles range ends in any place of the optical chamber. The additional

requirement to the selection of these events was the triggering of both Cerenkov counters.

The background measurements showed that the main background to this process was due to the cosmic particles. Therefore, the background was normalized by the ratio of the measurement time spent on the effect and on the background. To reduce the background of the cosmic particles those events were excluded for which the track in the upper chambers continued up to the end of the range chamber. Besides that the solid angle was reduced by 10 %. Under these conditions 5 background events remained.

In Table 2 the number of events detected is given as well as the values of the total cross-section of the π -meson pair production and the electromagnetic formfactor of the π -meson.

Table 2

Energy 2E, MeV	1180	1260	1340
$\pi^+\pi^-$ .Effect	6	6	2
Background normalized	0,9	1,1	0,4
σ_π, $10^{-33}cm^2$	21^{+11}_{-9}	28^{+17}_{-23}	19^{+16}_{-15}
$\vert F_\pi \vert^2$	$1,5^{+0,8}_{-0,7}$	$2,2^{+1,3}_{-1,0}$	$1,7^{+1,4}_{-1,3}$

To determine the total cross-section the monitoring process of electron-positron elastic scattering was used the events of it being selected by the same geometrical criteria as those of the π-meson pairs. In this case the problems of determination of the π-meson events selection efficiency should not be considered and the radiative corrections are highly compensated /11/.

The error in the value of σ_{π} includes besides the statistical errors the possible errors connected with the mixing of the events of elastic scattering and those of the π-meson pair production as well as the erroneous determination of the probability of the π-meson nuclear absorption in the chambers. The contribution of the manybody events /5/ was estimated to be negligible.

The ratio of the measured cross-section of the π-meson pair production to that of pointlike π-mesons gives the value of the formfactor squared. In Fig.2 the experimental values of the formfactor are shown together with the Breit-Wigner curve extrapolated from the region of the ρ-meson resonance /1,2/. The experimental point at the energy of 1020 MeV has been taken from the work /4/.

In the figure all the experimental points lie higher than those of the Breit-Wigner curve. The question whether this exceeding is the consequence

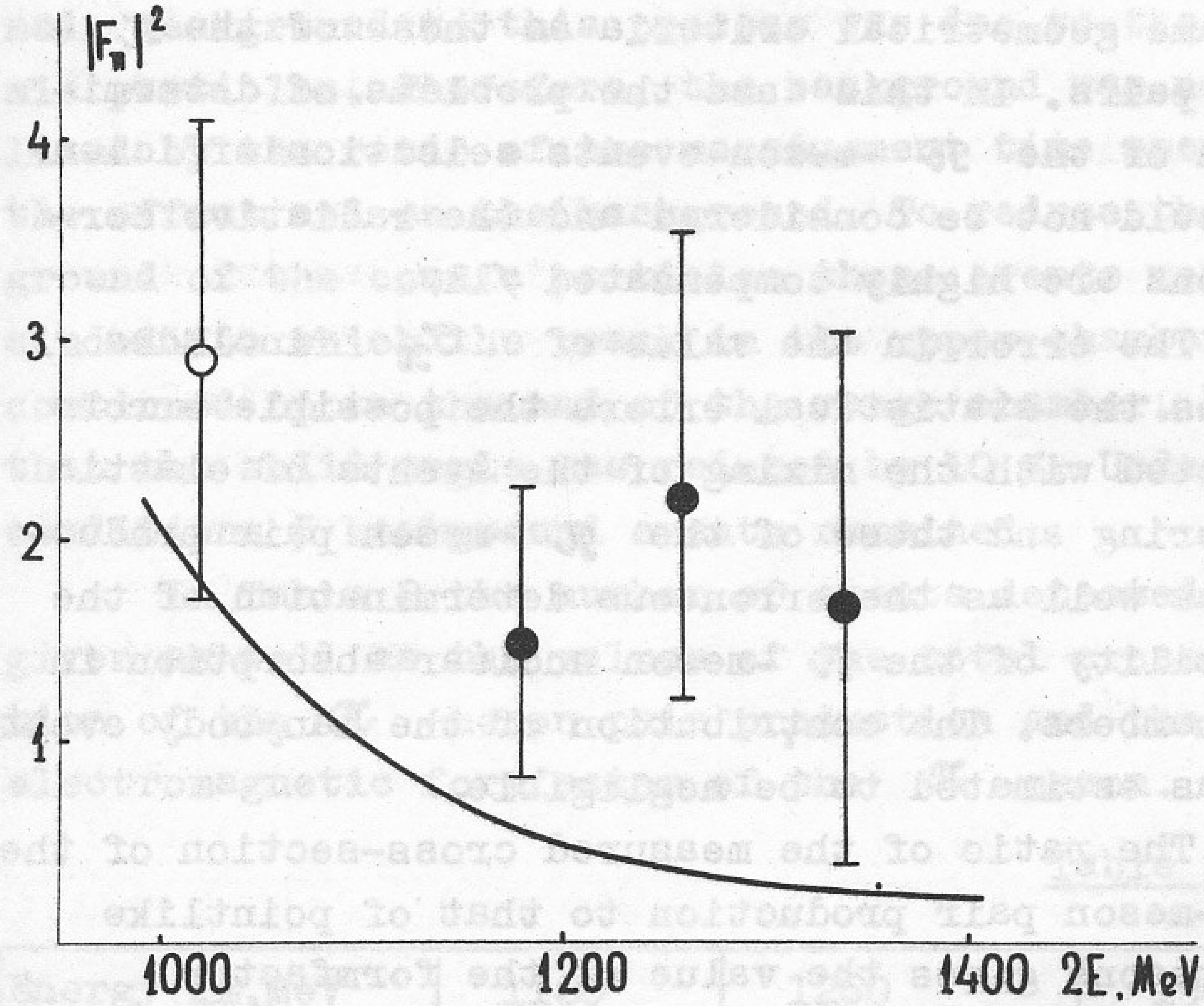

Fig.2. Experimental values of the π -meson form-factor squared. The point at the energy of 1020 MeV is taken from /4/. A solid curve corresponds to the Breit-Wigner formula extrapolated from the ρ -meson region /1,2/.

of the existence of the ρ'-meson with a small coupling constant remains open because of the large statistical errors.

4. $e^+e^- \rightarrow K^+K^-$. The events were selected by the absence of the Cerenkov counter triggerings, by the calculated particle range and the typical decay picture for the K-mesons stopped. At the energy of 1180 MeV the K-meson must stop in the second scintillation counter with the energy release higher by an order than that for the minimum ionization particle. The data about the pulse height in these counters were used during the analysis of the events.

In Table 3 the number of detected events is presented. No events of such a type were discovered in the background.

Table 3

Energy 2E, MeV	1180	1260	1340
$\lvert F_K \rvert^2$ calculation	2,3	1,1	0,7
K^+K^-, calculation	2,0±0,3	1,0±0,2	0,4±0,1
K^+K^-, experimental	1	1	2

To calculate the expected number of events the K-meson formfactor was used in the form

$$\mathcal{F}_K(s) = \frac{g_{\rho KK}}{g_\rho}\frac{m_\rho^2}{m_\rho^2 - s} + \frac{g_{\omega KK}}{g_\omega}\frac{m_\omega^2}{m_\omega^2 - s} + \frac{g_{\varphi KK}}{g_\varphi}\frac{m_\varphi^2}{m_\varphi^2 - s}$$

Using $m_\rho \approx m_\omega$ and the normalization condition $\mathcal{F}_K(0) = 1$ one can exclude the unknowm constants $g_{\rho KK}$ and $g_{\omega KK}$.

In conclusion the authors are grateful to the large group of co-workers who participated in the preparing of the apparatus, data recording and data handling and to A.I.Vainshtein and I.B.Khriplovich for discussions.

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