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A B S T R A C T

Using the electron-positron colliding beam machine VEPP-2 the experiment has been performed in which the cross-sections of the reactions $e^+e^- \to \pi^+\pi^-$ and $e^+e^- \to K^+K^-$ were measured in the energy region I,I8-I,34 Gev. The experimental values of the formfactors lie higher than curves extrapolated from the ρ- and ϕ-meson region.

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Investigation of the electromagnetic formfactors 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: 1,18, 1,26 and 1,34 GeV.

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

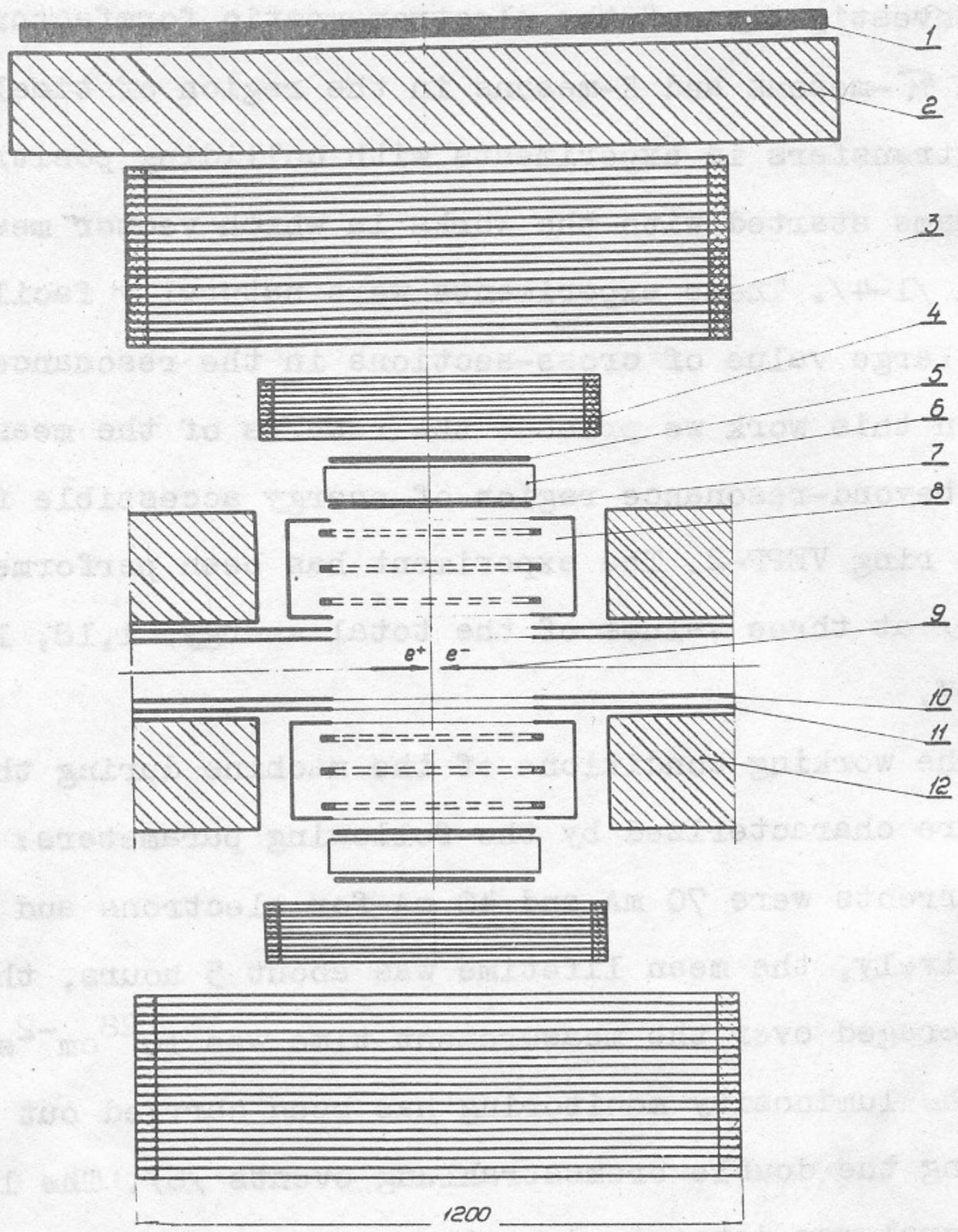

Fig.1. General view of the experimental set-up: 1-anticoincidence scintillation counter; 2-lead; 3-optical "range" spark chamber; 4-optical "shower" spark chamber; 5,7-scintillation counters; 6-water Cerenkov counter; 8-coordinate wire spark chambers; 9-interaction region; 10 and 11-inner and outer vacuum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

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. The wire chambers operated on-line with the computer "Minsk-22", all the information being simultaneously recorded on the magnetic tape. For events selected with the aid of the wire chambers the photographs from the optical spark chambers were scanned.

Threshold water Cerenkov counters were used to separate π - and K-mesons. Their efficiency measured in the same experiment with the events of electron-positron elastic scattering was 99 %. The detection efficiency for the π -mesons of interest was the same as for electrons. The calculated value of the detection efficiency for K-mesons with a total energy of 670 MeV was 7 %, for 590 and 630 MeV being less than 1 %.

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

Table 1

Energy 2E, GeV	1,18	1,26	1,34	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 $e^+e^- \rightarrow e^+e^-$	239	174	67	-

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 double electron-positron pair electroproduction /7,8/. The rest can perhaps be ascribed to the hadronic processes /5,8/.

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

1. $e^+e^- \to e^+e^-$. 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. $e^+e^- \to \mu^+\mu^-$. 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 /9/.

3. $e^+e^- \to \pi^+\pi^-$. The particles range due to nuclear absorption ends in any place of the optical chamber. The additional requirement for 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.

The main difficulty during the selection of pion pair production events consisted in separation of π -mesons and electrons when the photographs from the optical spark chambers were scanned. The separation requirements were rather high because the number of elastic scattering events was almost two orders greater than that of pion pairs (the separation had been performed by the correlation analysis method described in /1/).

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, GeV	1,18	1,26	1,34
Number of events, $\pi^+\pi^-$	$5,5\ ^{+3,2}_{-2,5}$	$6,1\ ^{+4,0}_{-2,7}$	$1,1\ ^{+3,8}_{-1,0}$
σ_π , $10^{-33}cm^2$	$22\ ^{+13}_{-10}$	$33\ ^{+21}_{-15}$	$12\ ^{+37}_{-11}$
$\lvert F_\pi \rvert^2$	$1,6\ ^{+1,0}_{-0,7}$	$2,8\ ^{+1,9}_{-1,2}$	$1,1\ ^{+3,3}_{-1,0}$

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 /10/.

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 /5,8/ was estimated to be negligible.

Fig.2 gives the experimental values of the formfactor. The curve in the Figure was extrapolated from the Gounaris-Sakurai curve in the ρ -meson region /11/, its parameters being determined by averaging the results of Novosibirsk and new Orsay experiments /12, 13/.

In the Figure all the experimental points lie higher then those of the calculated curve. The probability of statistical consistency of the experimental data with the theoretical curve is 1 %.

4. $e^+e^- \to K^+K^-$. 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 1,18 GeV 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 concerning 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, GeV	1,18	1,26	1,34
Number of events, K^+K^-	1	1	2
$\sigma_K \cdot 10^{-33} cm^2$	$2,9\ ^{+6,6}_{-2,4}$	$3,4\ ^{+7,8}_{-2,9}$	$12\ ^{+16}_{-8}$
$\lvert F_K \rvert^2$	$1,2\ ^{+2,8}_{-1,0}$	$1,1\ ^{+2,5}_{-1,0}$	$3,4\ ^{+4,4}_{-2,2}$

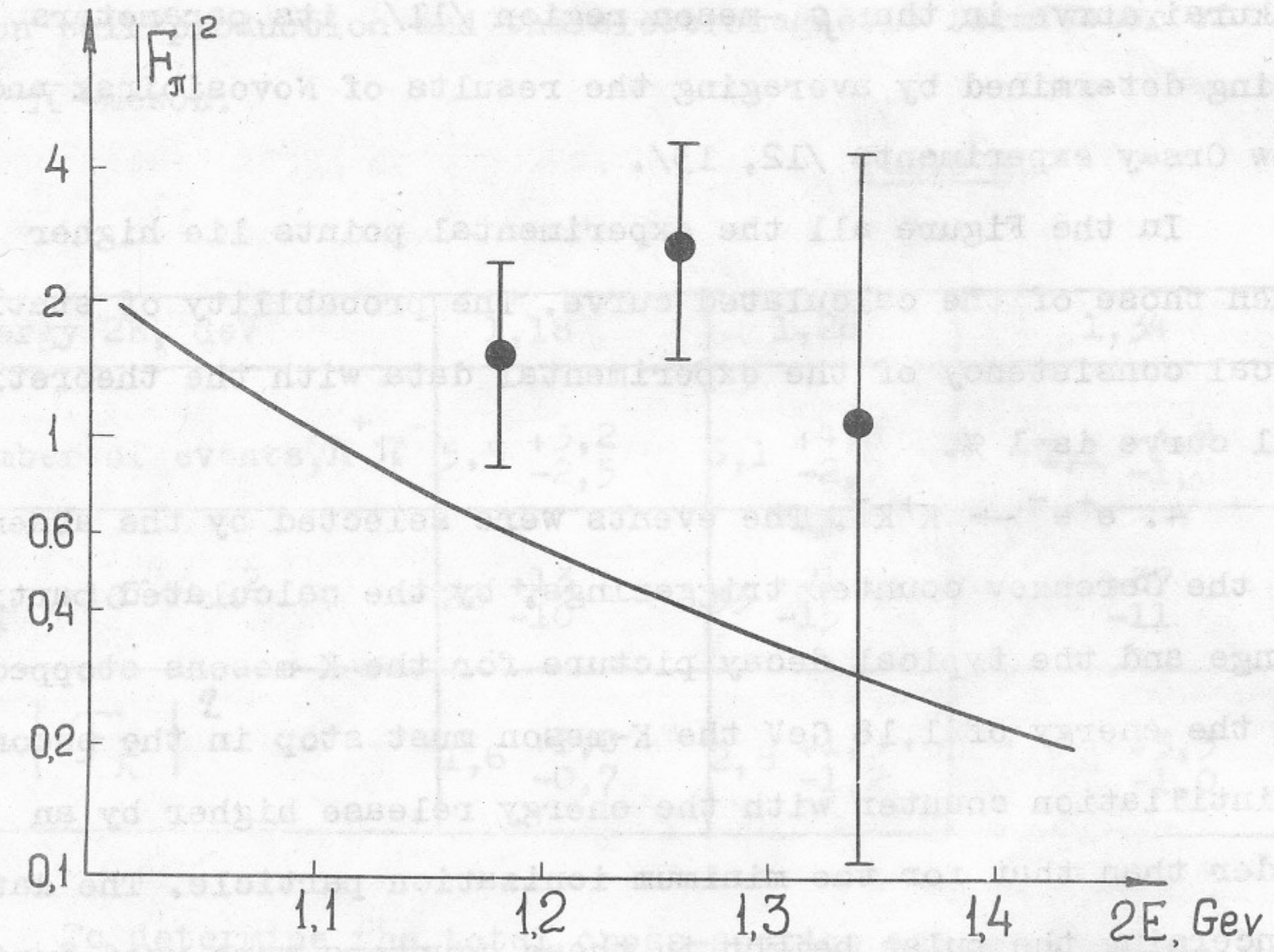

Fig.2. Experimental values of the π-meson formfactor squared. A solid curve corresponds to the Gounaris-Sakurai formula extrapolated from the ρ-meson region /1,14,15/.

For comparison with the experiment the K-meson formfactor was used in the form of the sum of the ρ-, ω- and ϕ-meson contributions. Taking into account $m_\rho \approx m_\omega$ the formfactor can be conveniently written as

$$F_K(s) = \frac{g_{\phi KK}}{g_\phi} \frac{m_\phi^2}{s - m_\phi^2} \pm \left| \frac{g_{\omega KK}}{g_\omega} + \frac{g_{\rho KK}}{g_\rho} \right| \cdot \frac{m_\rho^2}{s - m_\rho^2}$$

Using the normalization condition $F_K(0) = 1$ one can exclude the unknown constants $g_{\omega KK}$ and $g_{\rho KK}$. In Fig.3 there are presented the experimental values of the formfactor squared as well as 3 calculated curves. One of them is the extrapolation of the Breit-Wigner curve from the ϕ-meson region and the other two correspond to the ρ- and ω-contribution with the sign "+" or "-".

To draw the curves we have used the value $g_{\phi KK}/g_\phi$ obtained by averaging the experimental data of Orsay /3/ and Novosibirsk /4/.

The probability of statistical consistency of the experimental data with the Breit-Wigner curve is $P(B.-W.) = 2{,}3\ \%$ and for the curves accounting for ρ- and ω-mesons $P(+) = 9\ \%$ and $P(-) = 0{,}4\ \%$ for the sign "+" and "-", respectively. Thus, the sign "-" is excluded.

It is interesting that the experimental values of the formfactors both for π- and K-mesons lie higher than the corresponding extrapolations from the ρ- and ϕ-regions.

Similar experiments are being performed in Frascati in the energy range 1,5 - 2,4 GeV. Unfortunately, their detection system doesn't separate π- and K-mesons, thus, they measure in the experiment the sum of the π- and K-formfactors

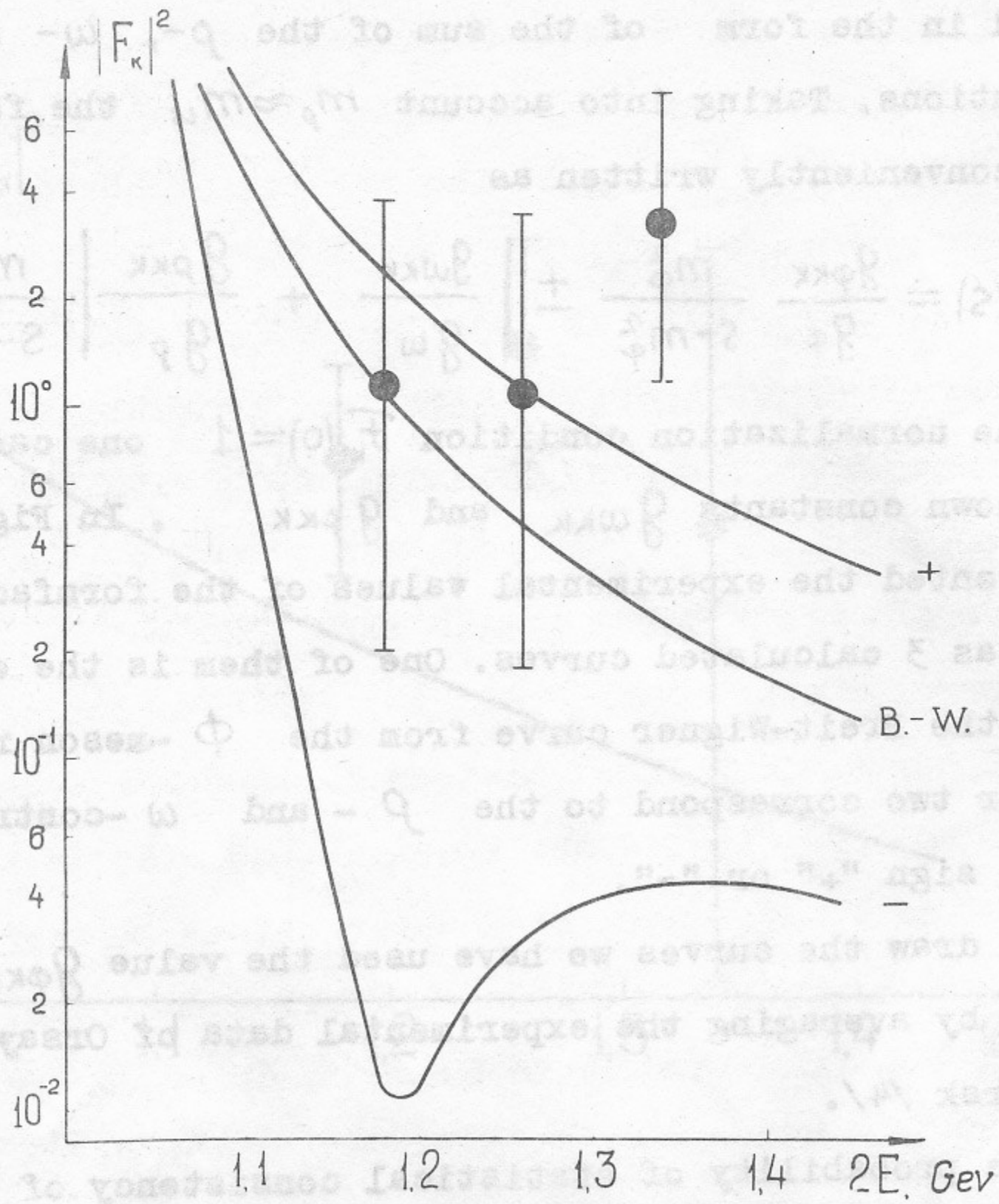

Fig.3. Experimental values of the K-meson formfactor squared. The curve B.W. corresponds to the Breit-Wigner formula extrapolated from the ϕ -meson region. In curves "+" and "-" the contribution of the ρ - and ω -mesons is taken into account with the sign "+" or "-" , respectively.

squared. The preliminary results of these experiments /14/ also indicate that the experimental values lie higher than the Breit-Wigner curve. The reasons for this exceeding are yet not clear. This effect can be probably due to the existence of the ρ' -meson. Another explanation is provided by the contribution of the intermediate multihadronic states suggested by Baier and Fadin /15/.

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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