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The average mass of K^+ and K^- was measured in the reaction $e^+e^-\to\phi\to K^+K^-$ at the VEPP-M storage ring to be 493.670±0.029 MeV. The energy of the colliding beams was determin- by the resonance depolarization method, and the kaon kinetic energy was found from the nge in the nuclear emulsior.

At present there are some measurements of the charged kaon mass /1-6/ and one measur- ent of the charged kaon mass difference /7/. In early papers /1-3/ K^+ and K^- masses re measured with the help of the nuclear emulsion. The following measurements /4-6/ re performed by studying X-ray transitions of kaonic atoms. This method allows to mea- re the negative kaon mass with high accuracy. Using this method the radiative correc- ons must be taken into account. So in the last paper /6/ the authors present the measur- value of the negative kaon mass M_{k^-} = 493.657± 0.020 MeV but they note that the another lculation of the radiative corrections may lead to the different kaon mass value M_{k^-} = 493.696±0.025 MeV. Therefore, it is very desirable to perform measurements of the kaon ss with the same accuracy by using other methods.

In this experiment the average mass of positive and negative charge kaons produced the reaction $e^+e^-\to K^+K^-$ in the ϕ-meson maximum with large cross-section has been asured at the VEPP-2M storage ring. The absolute value of particle energy in the elec- ron-positron storage ring was determined by measuring the average spin precession fre- ency with the help of the resonance beam depolarization by a high-frequency longitudin- magnetic field (LMF). The development of this method /8-10/ made it possible to deter- ne in this experiment the absolute particle energy with the accuracy 10 keV ($\Delta E/E \approx 2 \times 10^{-5}$). The kinetic energies of slow kaons were found from their ranges in nuclear emul- ion.

The geometry of an emulsion chamber placed in one of the straight sections of the torage ring is given in Fig.1.

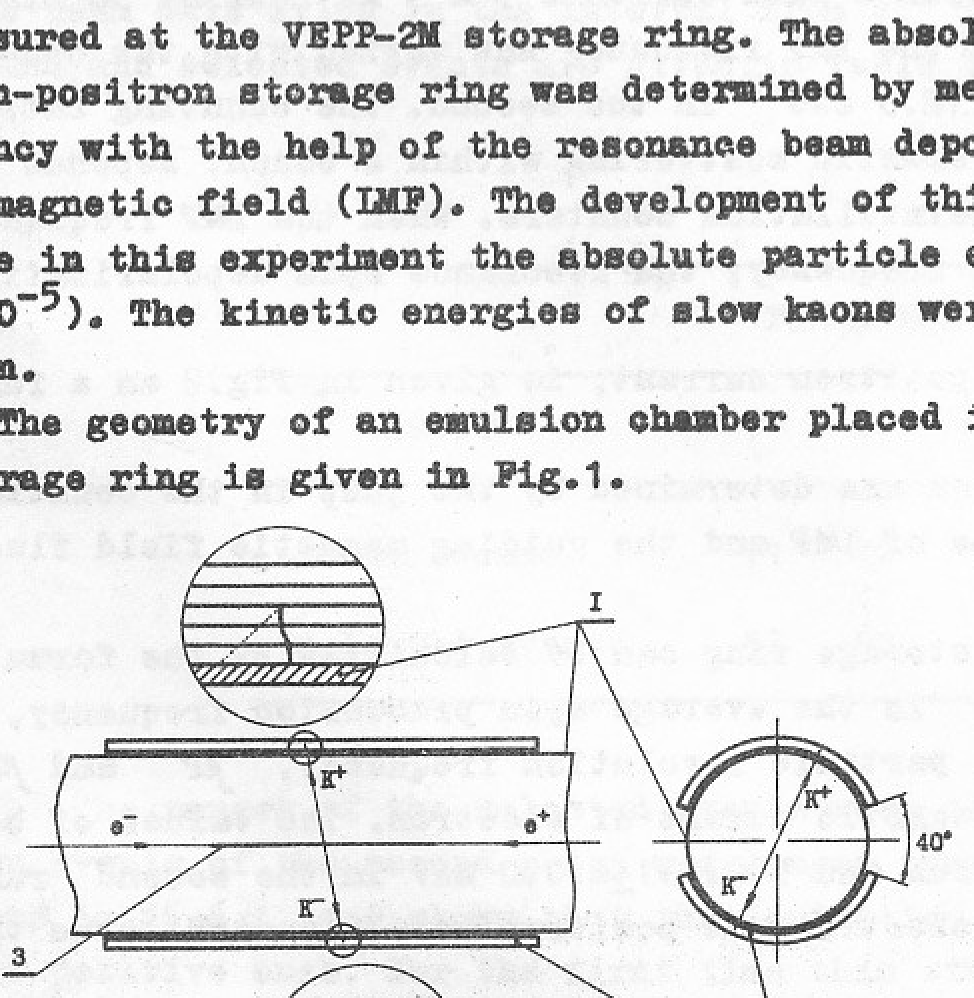

Fig.1 The emulsion chamber scheme:
1 - the storage ring vacuum tube,
2 - the emulsion pellicles,
3 - the interaction region.

Kaons, as a rule, come from the interaction region in the perpendicular direction to beam axis, penetrate through the stainless steel vacuum tube with 36 mm in diameter and stop in the emulsion pellicles. The emulsion chamber consisted of two symmetrically placed stacks of five 400 μ thick emulsion pellicles of BR-2. In such a geometry about 75% of produced kaons stopped in the emulsion stacks. For precise determination of the kaon kinetic energies by their ranges weight, thickness and area of each pellicle were measured. The stacks were placed in the stainless steel hermetic container. The average thicknesses of the vacuum tube and container wall were determined by weighting to be 0.1070 ± 0.0001 g/cm^2 and 0.0718 ± 0.0001 g/cm^2, respectively.

The error in kaon mass determination depends essentially upon the range-energy relation accuracy. To calculate the range-energy relation for BR-2 emulsion the results of experimental calibration /11/ and calculations /12/ for Ilford G-5 emulsion were used with small corrections for different composition structure and water contents. Besides this the range-energy relations for emulsion and stainless steel were calibrated by the monoenergetic protons with the energy 40.01 ± 0.04 MeV from HAP-M storage ring /13/. As a result, the range-energy relation for BR-2 emulsion and stainless steel were obtained and they gave a possibility to measure the kinetic energy of the positive charge kaons in the reaction $e^+e^- \to \phi \to K^+K^-$ with the 0.1% accuracy.

Two runs were made in this experiment. Every run was conducted in the following way. The positron beam with initial curremt about 30 mA was polarized during two hours at the energy 650 MeV which is close to maximum energy of the storage ring. The polarization time of the beam is inversely proportional to the fifth degree of the energy and is equal to about one hour at this energy. Then the energy of polarised beam was decreased to that corresponding to the ϕ-meson maximum. After some time necessary for relaxation of the storage ring systems IMF was switched on and the spin precession frequency of the beam was measured. After that, the electron beam was injected into the storage ring and the emulsion chamber was put on. The guiding magnetic field was kept at the constant value with the accuracy 2×10^{-5}. The first emulsion chamber was exposed with currents 3x3 mA^2 during 50 minutes and the second one was exposed with currents 5 x 5 mA^2 during 30 minutes.

To find the spin precession frequency, the IMF frequency was varied with the constant rate 6.5 sec^{-2} in the first run and 12.5 sec^{-2} in the second. The counting rate of particles, escaped from the beam due to elastic scattering within a bunch, depends on the beam polarization and was measured by scintillation counters. When the IMF frequency is getting divisible by the spin precession frequency, the resonance spin depolarization takes place.

The value of $\dot{N}/I_+^2$, where I_+ is the positron current, is given in Fig.2 as a function of IMF frequency for two runs.

The average frequency of spin precession was determined by the jump in the counting rate. The amplitude, modulation, change rate of IMF and the guiding magnetic field fluctuations were taken into account.

The average energy of the beam in the storage ring can be calculated by the formula /8/ $E = mc^2 (2 - f_s/f_0)\mu_0/\mu'$, where f_s is the average spin precession frequency, $f_0 = (16.76664 \pm 0.00001) \times 10^6$ sec^{-1} is the particle revolution frequency, μ' and μ_0 are the anomalous and normal parts of the magnetic moment of electron. The values of beam energy were 509.345 ± 0.010 MeV in the first run and 509.331 ± 0.010 MeV in the second run. In this experiment the magnetic moments of electron and positron were supposed to be the same.

In both stacks the first pellicle after vacuum tube was seen through and the tracks with high grain density which stopped in the middle of the stack, were selected. For these tracks coordinates and take-in angles were measured. The charge sign identification were carried out by studying interactions and decays of the particles at the end of the range. All the registred events were divided into three groups.

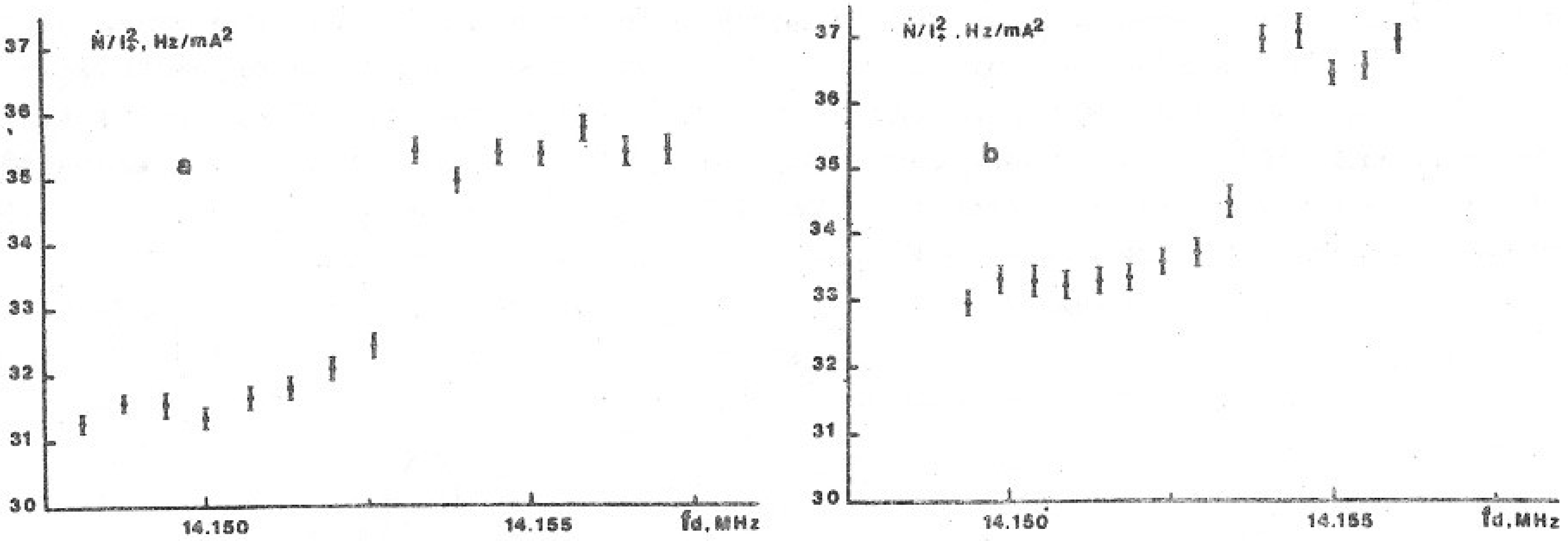

Fig.2. The counting rate divided by the positron current squared as a function of IMF frequency; a - for the first run and b - for the second run.

The first group contained τ -decay events and events having only one track at the end of the range with the grain density $g<1.5g_o$, where g_o was the grain density of a relativistic particle. This group contained K^+ and about 10% of K^-. The events with several tracks at the end of the range or with one track having $g>1.5g_o$ was included into the second group. This group contained K^- and about 3% of K^+.

The events with no tracks at the end of the range were included into the third group. This group contained negative kaons, which had no tracks in the interaction point, positive kaons, whose relativistic track had not been found, and protons produced in the vacuum tube of the storage ring.

To reduce the number of background events in each group the particles coming only from the interaction region of the beams and with angles between their trajectories and the beam axis lying in the interval from 45° to 135° were selected. The numbers of the found and selected events are given in Table 1.

Table 1.

	FIRST RUN			SECOND RUN		
GROUP	1	2	3	1	2	3
found events	71	82	102	88	112	130
selected events	53	63	36	68	89	44

The ranges of the selected events were thoroughly measured. The average range for the events of the second group was longer than that of the first group. The range difference is $16\pm6\mu$ and shows that the ionization losses for negative kaons are lower than for positive ones. For the first time this effect was described in /2/ and studied in detail in /14/.

As the calibration of the range-energy relation was made only by positively charged particles, only the events of the first group were used for determination of kaon kinetic energy with a correction for the 10% admixture of K^- in this group. The energy spread of particles in the storage ring, the radiative effects and the fluctuation of kaonic energy losses were taken into account to calculate the kaonic energy spectrum. The energy spread of particles in the storage ring due to quntum fluctuations of synchrotron radiation was calculated to be 0.181±0.002 MeV. The radiation effects were calculated according to /15/ with the mass and width of Φ -meson equal to 1019.7±0.3 MeV and 4.1±0.2 MeV, respectively. The energy distributions of kaons from the first group for two runs, fitted curves and levels of background are given in Fig.3.

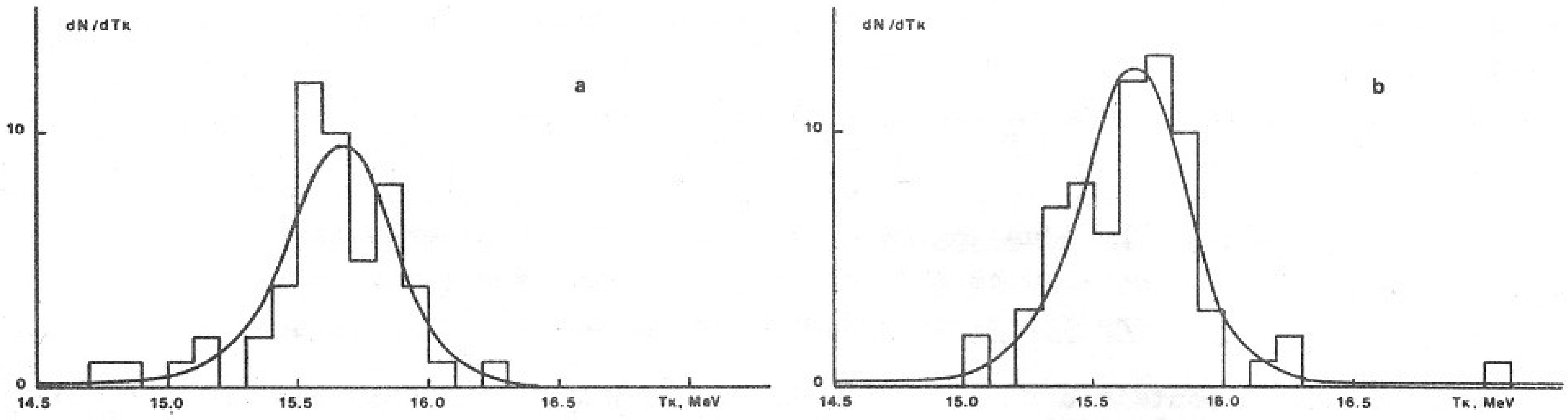

Fig.3. The energy distributions of kaons from the first group:
a - for the first run, b - for the second run.

As a result of likelihood function calculation the average values of kaon mass in two runs have been obtained. They differ by 0.010 MeV. The average value for two runs is $M_{k^{+-}}$ = 4 570±0.029 MeV.

The error in the value of charged kaon mass consists of the statistic error 0.021 MeV, the range-energy relation error 0.016 MeV, the electron-positron beam energy error 0.010 MeV and the errors of Φ -meson mass and width 0.004 MeV each one.

It should be emphasized once more that just the average value of K^+ and K^- masses has been measured in this experiment. The comparison of this result with the masses of negative and positive kaons and with the charged kaon mass difference is given in Fig.4.

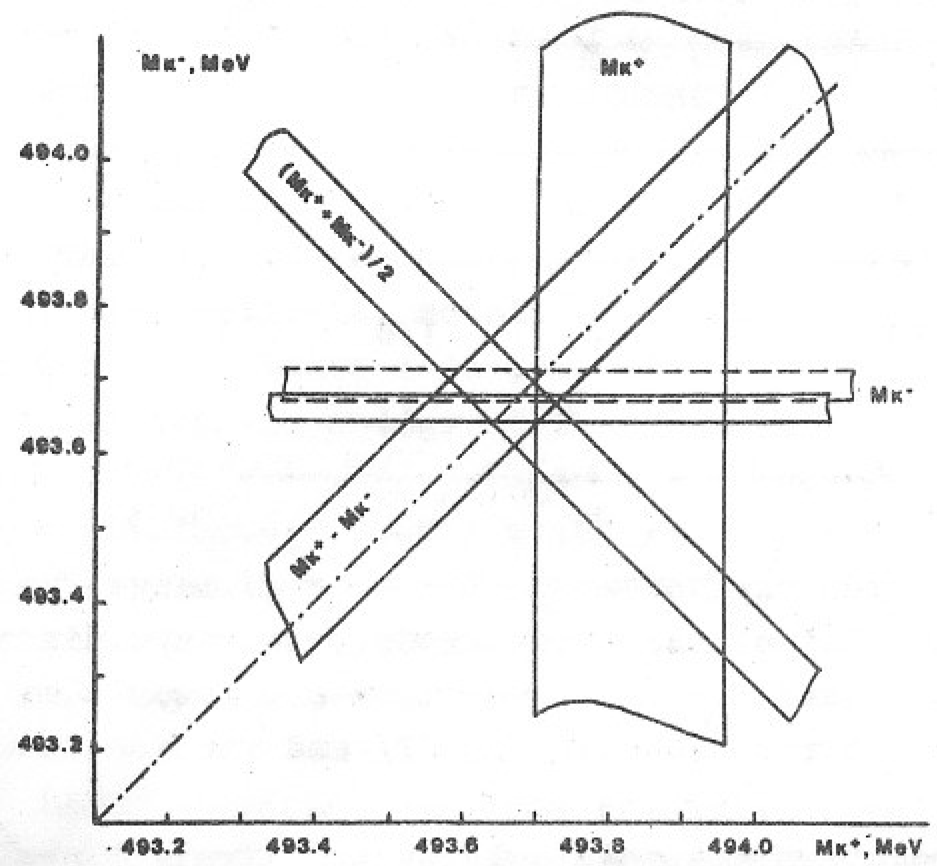

Fig.4. Comparison of the result of this experiment with the masses of negative and positive kaons and with the charge kaon mass difference.

Two values of the negative kaon mass correspond to two possible calculations of the radiative corrections /6/. The dashed-point line shows the CPT prediction.

From the results of experiments /1-7/ and this one illustrated in Fig.4 one can draw conclusion that K^+ and K^- masses are equal with the accuracy $\sim 10^{-4}$. It is consistent with CPT-theorem prediction.

On the other hand, the absence of the discrepancy between kaon masses can be interpreted as a proof of validity of energy calculation formulae for particles in the storage ring and consequently of the relativity theory with the accuracy 10^{-4} at $E/mc^2 = 10^3$ for particles in the noninertial system of reference.

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