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ABSTRACT. -

The invariant mass distribution of two-particle neutral systems produced in multihadron e^+e^- annihilation at W = 2.07 - 2.30 GeV, has been studied. Evidence is presented for resonant K^* (892) production at W≃ 2.13 GeV with a total width $\Gamma \gtrsim 30$ MeV.

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Preliminary results on resonant $K^*(892)$ production in e^+e^- annihilation at center of mass energy W = 2.1 GeV has already been presented by the MEA experimental group at Adone[1, 2]. Our attention was first directed to this energy region during a search for J/ψ like resonances in the multihadron cross section. No evidence for such narrow resonances was found in the energy interval explored[3] but some anomalies in the behavior of the yield of detected multihadron events were observed in the interval $2.070 \leq W \leq 2.200$ GeV, called data sample I. Subsequently additional data, data sample II, were collected at W = 2.13, 2.25, and 2.30 GeV to investigate this anomalous behavior.

The experimental apparatus is described in detail elsewhere[4]. The detector consists of wide-gap and narrow-gap spark chambers operated in a magnetic field perpendicular to the e^+e^- beams at Adone. The trigger, which utilizes both scintillation counters and proportional chambers, required at least two charged particles each with a minimum kinetic energy of ~ 130 MeV if a pion or ~ 210 MeV if a kaon, and having an angle between them $\alpha > 90^o$. Photographs of the spark chambers were scanned for candidate multihadron events satisfying one of the following conditions:

a) more than two charged particles detected,
b) two charged particles observed with a non-coplanarity angle relative to the beam of $\Delta\phi \gtrsim 10^o$.

In the selection of e^+e^- multihadron events we have restricted our attention to events with at least three charged particles detected, where background contamination was found to be negligible. The following conditions also were imposed:

a) the detected tracks as recorded by the multiwire proportional chambers were required to converge to within ~ 1 cm. of the interaction point,
b) track pairs which were consistent with the characteristics of gamma-rays converted in the wall of the vacuum chamber were excluded.

A total of 200 such events was observed with a total collected luminosity $L = 138\ nb^{-1}$. Of the detected particles some reached the range chambers located outside the magnet coils thus allowing range measurements. From range-momentum measurements about 25% of measured tracks could be identified as pions. Furthermore for the sample of data collected at fixed energies W = 2.13, 2.25, 2.30 GeV (sample II) the experimental set-up was improved by adding a time-of-flight measurement made over a distance of 1.0 m to a precision of $\sigma_{\Delta t} = \pm 0.8$ ns, and the momentum to a precision of $\Delta p/p = \pm 0.04$ at 500 MeV/c.

From these measurements the probabilities for a particle to be a pion and a kaon were determined.

In order to study possible dynamic correlations between the outgoing particles we have examined the invariant mass distributions of two-particles neutral systems assuming that each particle pair was either $\pi^{\pm}\ \pi^{\mp}$, $K^{\pm}\ \pi^{\mp}$ or $K^{\pm}\ K^{\mp}$, but the mass of each particle was required to be consistent with a particle identification made through the range-momentum measurements. For unidentifiable tracks each was assumed to be in turn a pion and a kaon. Each time a pair of particles contributed to more than one mass combination, an appropriate weight was assigned to each mass combination so that the total contribution of each particle pair to the invariant mass distribution always equaled one. In Fig. 1 the invariant mass distributions for $\pi^{\pm}\ \pi^{\mp}$ and $K^{\pm}\pi^{\mp}$ neutral systems are shown at different overlapping energies intervals for data samples I and II separately. We note that the agreement between sample I and sample II in the overlapping energy region is quite good, thus confirming the initial suggestion of K^{*} production at $W \simeq 2.13$ GeV and allowing the two samples to be added together. In Fig. 2 the $\pi^{\pm}\pi^{\mp}$ and $K^{\pm}\pi^{\mp}$ invariant mass distributions for the combined sample are shown for the data collected at W = 2.12 - 2.14 GeV and outside this energy interval. The $\pi^{\pm}\ \pi^{\mp}$ mass distributions shown an enhancement at the ρ mass both at energies larger and smaller than $W \simeq 2.13$ GeV. This effect although also present at $W \simeq 2.13$ GeV is less evident at this energy because particle pairs which actually originate from K^{*} decay, when they are assumed to be both pions, give invariant masses centered around 600 MeV. Conversely, particle pairs originating from ρ decay give a contribution to the $K^{\pm}\ \pi^{\mp}$ invariant mass distribution around 1050 MeV. The cross hatched area shows respectively the reflection of ρ production $(670 \leq M_{\pi\pi} \leq 870)$ in the $K^{\pm}\pi^{\mp}$ spectrum and of K^{*} production $(840 \leq M_{K\pi} \leq 940)$ in the $\pi^{\pm}\pi^{\mp}$ spectrum. One can see that a K^{*} signal cannot be the result of a reflection. A clear K^{*} signal shows up in the energy interval W = 2.12 - 2.14 GeV, while ρ production is present over all the energy range explored. It is important to note however, that the invariant mass distributions for pairs of tracks having the same charge do not show any anomalous behavior either in the $\pi^{\pm}\ \pi^{\pm}$ or in the $K^{\pm}\ \pi^{\pm}$ system, thus no evidence of experimental bias is present in either sample.

The energy dependence of K^{*} production is presented in Fig. 3. Here the yield of K^{*} mass combinations $(800 \leq M_{K\pi} \leq 1000$ MeV) is plotted as a function of a total c. m. energy. In the calculation of K^{*} the contributions of the particle pairs which, when assumed to be both pions, gave invariant masses in the region $(670\ \text{MeV} \leq M_{\pi\pi} \leq 870\ \text{MeV})$ were subtracted out.

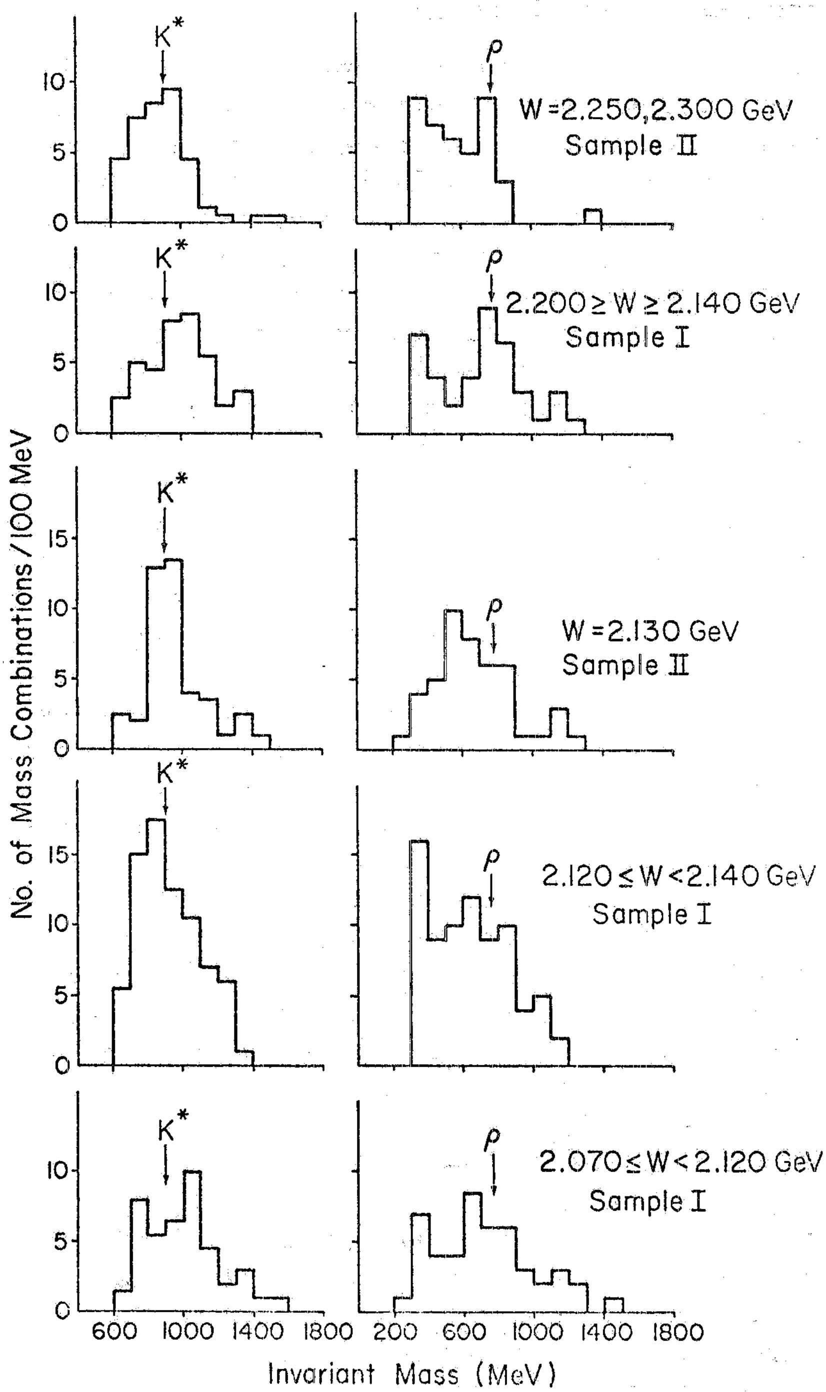

FIG. 1 - Invariant mass distributions for $K^{\pm}\pi^{\mp}$ and $\pi^{\pm}\pi^{\mp}$ two particle neutral system at different total c. m. energies, W.

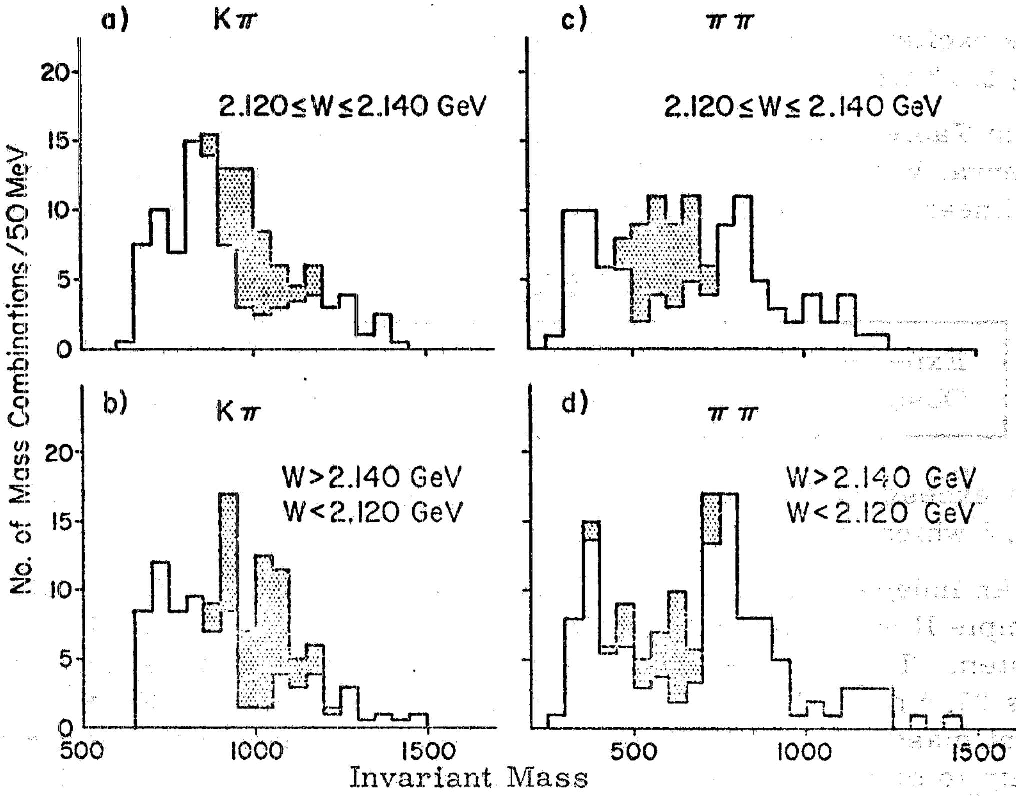

FIG. 2 - Invariant mass distributions for $K^{\pm}\pi^{\mp}$ and $\pi^{\pm}\pi^{\mp}$ two-particle neutral systems, a), c) W=2. 12-2. 14 GeV; b), d) W$\lesssim$ 2. 12 GeV and W $\gtrsim$ 2. 14 GeV. Cross-hatched areas show respectively the reflection of ρ production (670 MeV $\lesssim M_{\pi\pi} \lesssim$ 870 MeV) in the $K^{\pm}\pi^{\mp}$ mass distribution and of K^* production (840 $\lesssim M_{\pi\pi} \lesssim$ 940 MeV) in the $\pi^{\pm}\pi^{\mp}$ mass distribution.

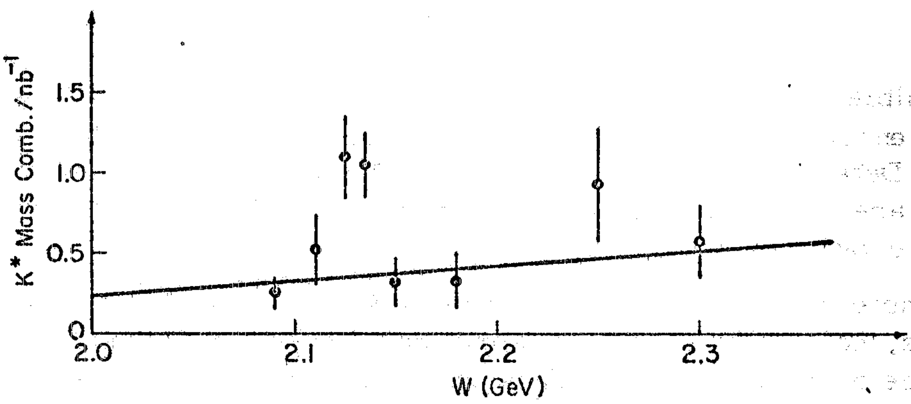

FIG. 3 - Yield of K^* mass combinations (800 $\lesssim M_{\pi\pi} \lesssim$ 1000 MeV) vs. total c. m. energy, W. Shown is a straight-line fit excluding data between 2. 12-2. 14 GeV.

The excitation curve in Fig. 3 shows a resonant behavior centered at $W \simeq 2.13$ GeV with a width $\Gamma \sim 30$ MeV.

In Table I the observed number of K^* combinations in the energy interval W = 2.12 - 2.14 GeV and the expected number as evaluated by linear fit to the data outside this energy interval are given.

TABLE I

Expected K^* mass combinations	13.1 ± 2.5
Observed K^* mass combinations	40.5 ± 5.8

The excess of K^* mass distributions above the background is 27.4 $\pm$ 6.3 which is an enhancement of over four standard deviations.

An independent check of K^* production was obtained from data sample II where K identification was possible by the time-of-flight system. The collected luminosity available for TOF measurements was 37.5 nb^{-1}. With these rather limited statistics the $K^{\pm} \pi^{\mp}$ invariant mass spectra obtained by weighting each track with the probability to be a K or a π, also shows a clear K^* signal at W = 2.13 GeV[2].

To summarize, evidence has been presented for resonant K^* production in multihadron events in the energy interval W = 2.12 - 2.14 GeV. Our data do not allow us to definitely determine the actual final state produced. However, strangeness conservation and detected multiplicity (events with more than four charged prongs have been observed) channels such as

$$e^+e^- \longrightarrow K^* K\pi \qquad (1)$$

$$e^+e^- \longrightarrow K^* K\pi\pi \qquad (2)$$

as possible candidates to explain the data. Actually several events have been found which fulfill the kinematical constraints of the final state $K^* K\pi$. Detection efficiencies of the MEA apparatus for reaction (1) and (2) are, however, very small and no reliable value can be given for the cross section.

We note that the mass region where the observed K^* production appears, coincides with that theoretically expected for the third recurrence of the ϕ meson[5]. Also the total width $\Gamma \sim 30$ MeV would favour the interpretation of this new resonance as a member of the ϕ family. Moreover, recent results at Adone[6] and DCI[7] provided evidence for the existence of new vector mesons in the mass region

$1.4 \div 1.9$ GeV which also fits well into the picture of recurrences of the known vector mesons ρ, ω, and ϕ.

We would like to express our appreciation to the staff of Adone for their efficient collaboration and to the scanning staff of the Laboratori Nazionali di Frascati and of the Universities of Napoli and Padova for their careful work. Our special thanks are also due Dr. V. Valente and Prof. M. Greco for many helpful and stimulating discussions regarding the analysis of the data.

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