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EVIDENCE FOR IOTA PRODUCTION IN HIGH ENERGY e^+e^- – ANNIHILATION

JADE COLLABORATION

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ABSTRACT

The inclusive production of iota mesons in e^+e^- - annihilations at $\sqrt{s} \sim 36.0\ GeV$ is investigated with the JADE detector at PETRA. 13 candidates for the $\iota(1440)$ state are reconstructed through their decay into $K^0_s K^\pm \pi^\mp$. A cross section (times branching ratio) of $\sigma \cdot B = 4.7 \pm 1.3 \pm 1.7\ pb$ is observed. Within the errors the iota yield is independent of the event shape.

Up to now the pseudoscalar state $\iota(1440)$ has been seen only in radiative decays of the J/ψ reported by the experiments MARK II [1], Crystal Ball [2] and MARK III [3] at the SLAC storage ring SPEAR and by the DM2 experiment [4] at the Orsay storage ring DCI.

The $\iota(1440)$ meson is a glueball candidate and therefore, it is interesting to look for this state at higher centre of mass energies where a glueball could be produced in the fragmentation of quarks and gluons.

The data reported here were obtained with the JADE detector at the DESY storage ring PETRA. The data were taken during 1980 - 1984 at centre of mass energies in the range between 29.9 GeV and 46.78 GeV with an average energy of $\sqrt{s} \sim 36.0\ GeV$. The integrated luminosity is $\int Ldt = 92.4\ pb^{-1}$ with 27056 annihilation events into multihadronic final states which were selected by a method described in a previous publication [5].

In this analysis the iota state is identified via the decay

$$\iota \rightarrow \delta^\pm \pi^\mp \rightarrow (K^0_s K^\pm)\, \pi^\mp \qquad (1)$$

where δ denotes the $K\overline{K}$ threshold enhancement. K^0_s-mesons are observed in the decay mode $K^0_s \rightarrow \pi^+\pi^-$. The procedure to select K^0_s has been described in a previous publication [6]. The K^0_s vertex was determined in the $r\phi$ plane (perpendicular to the beam) and the difference of the z coordinates of the pions at the decay vertex was required to be $|z_{\pi^+} - z_{\pi^-}| < 20\ mm$. The K^0_s was defined by the cut $|M(\pi^+\pi^-) - M_{K^0}| < 100\ MeV$. To improve the mass resolution a kinematical 1C - fit was made to the K^0 hypothesis, fixing the K^0 mass.

Charged K's were identified by the energy loss dE/dx measured in the central drift chamber. The resolution of the dE/dx measurement ($\sim$ 8.0%) allows an identification of charged K's only for low momenta. Therefore the cut

$$p(K^{\pm}) < 0.65 \ GeV/c \quad (2)$$

was applied. For each accepted charged track we calculate the probability P_K that it is a kaon. For the reconstruction of ι states this probability was required to exceed 30%. Charged kaons were then combined with K^0_s candidates to form a δ defined by

$$M(K^0_s \, K^{\pm}) < 1.25 \ GeV. \quad (3)$$

Combining the δ with an additional charged track coming from the event vertex assuming the track to be a pion, the mass $M(K^0_s K^{\pm}\pi^{\mp})$ was calculated. The corresponding mass distribution is given in fig. 1 a. A signal can be seen at a mass of $M = 1.49 \pm 0.03 \ GeV$. The signal is insensitive to the particular values of the cuts given above. The signal width of about 100 MeV is consistent with the experimental mass resolution as obtained from Monte Carlo calculations assuming $\Gamma(\iota) = 50 \ MeV$. The observed events in the signal region are interpreted as iota candidates. Confirmation of this assumption would require a spin-parity analysis, which is not possible with the present data sample because of lack of statistics.

To estimate the background, the mass of the combination $(K^0_s K^{\pm}\pi^{\pm})$ with total charge ± 2 was calculated using the same cuts. The $M(K^0_s K^{\pm}\pi^{\pm})$ mass distribution which is given in fig. 1 b does not show a significant structure.

The mass value of the signal in fig. 1 a is somewhat higher than, but compatible within errors with previously measured values using the radiative decay of the J/ψ [1 - 4]. If the 'signal' event sample is defined by

$$1.40 < M(K^0_s K^{\pm}\pi^{\mp}) < 1.55 \ GeV \quad (4)$$

20 entries are obtained (including 6 background entries) coming from 13 events which are candidates for the iota state.

For the determination of the cross section the acceptance was calculated using the Lund-Monte Carlo program [7] including initial state radiation effects. The generated events were processed by routines which determined the trajectory of each particle through the JADE detector and which took into account energy losses and resolution functions. The simulated events were then subjected to the same analysis as the real data so that the acceptance and mass resolution could be determined. The resulting detection efficiency is 3.2 % including all cuts.

The background subtraction was performed by fitting the $M(K^0_s K^{\pm}\pi^{\mp})$ spectrum to a gaussian superimposed on a constant background. Since the branching

ratio $B(\iota \to K^0_s K^{\pm}\pi^{\mp})$ is unknown, only the product of cross section times branching ratio can be given:

$$\sigma(e^+e^- \to \iota + X) \cdot B(\iota \to K^0_s K^{\pm}\pi^{\mp}) = 4.7 \pm 1.3 \pm 1.7 \ pb \quad (5)$$

The energy range over which the ι state can be reconstructed is limited due to cut (2) to $x_\iota \leq 0.23$ with $x_\iota = E_\iota / E_{beam}$. The cross section (5) includes an extrapolation to the unobserved region $x \geq 0.23$ assuming the symmetric Lund fragmentation function for the iota state. The cross section in the region assessed by the experiment is $\sigma \cdot B = 1.3 \pm 0.4 \pm 0.4 \ pb$.

If the iota is a glueball state one might speculate that its production is more frequent in events with gluon hard bremsstrahlung (3 jet events). Comparing the ι yield in two- and three-jet events, however, does not show a difference compared to other hadrons like K^0_s.

In summary, first evidence for continuum iota production at centre of mass energies around 36 GeV has been presented. As the iota state is a glueball candidate it would be interesting to study the production characteristics in detail. Such an investigation, however, would require considerably higher statistics.

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FIGURE CAPTIONS

Fig. 1 (a)
Distribution of $M(K_s^0 K^\pm \pi^\mp)$ with the requirement $M(K_s^0\, K^\pm)\ <\ 1.25\ GeV$.

Fig. 1 (b)
Distribution of $M(K_s^0 K^\pm \pi^\pm)$ with the requirement $M(K_s^0\, K^\pm)\ <\ 1.25\ GeV$.

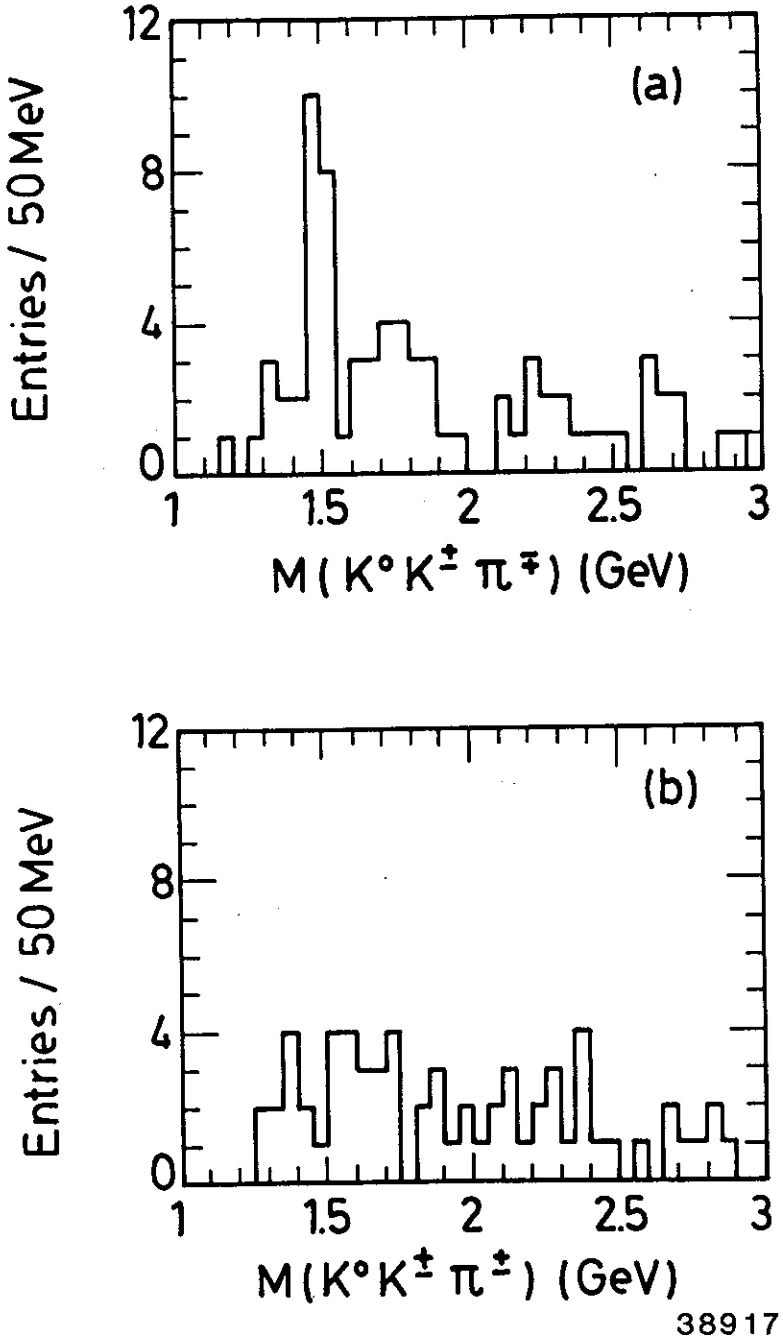

Fig. 1