SEARCH FOR NARROW RESONANCES IN e^+e^- ANNIHILATION INTO HADRONS AT ADONE IN THE MASS REGION 2.5–3.0 GeV/c^2

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The mass region 2.5 to 3.0 GeV/c^2 has been searched for evidence of ψ-like narrow resonances in e^+e^- annihilation into hadrons. No evidence for new narrow resonances has been found with a sensitivity of about the 10% of the integrated cross section of the J/ψ (3100).

A systematic search for narrow resonances in the total hadronic cross section in e^+e^- annihilation over the center-of-mass energy range W = 1.9–3.1 GeV has been performed at Adone, the Frascati 2 × 1.5 GeV storage ring, with the MEA magnetic detector [1]. In this paper we present the results for the energy region W = 2.5–3.0 GeV. Previous data at W = 1.9–2.5 GeV and W = 3.0–3.1 GeV have already been published [2].

A resonance in the reaction:

$$e^+e^- \to X \to \text{hadrons} \qquad (1)$$

is said to be narrow if its total width is negligible with respect to the FWHM machine energy resolution Γ_W At Adone Γ_W is given by the following relation [3]:

$$\Gamma_W\,(\text{MeV}) = 0.32\, W^2\,(\text{GeV}^2), \qquad (2)$$

and consequently we have chosen to explore our energy by 1 MeV steps.

The total collected luminosity was $\mathcal{L} = 86.6\ \text{nb}^{-1}$. No statistically significant evidence for new narrow resonances has been found. The $e^+e^- \to e^+e^-$ Bhabha scattering at small angles (3°–6°) as measured by the Adone machine group in a different interaction region has been used to provide a fast relative luminosity monitor. The $e^+e^- \to e^+e^-$ Bhabha scattering at large angles, as seen by the MEA apparatus, has been used to provide an absolute normalization of the luminosity.

The MEA apparatus is described in some detail in ref. [1] and it consists basically of a set of cylindrical optical spark-chambers inserted into a soleinoidal magnet transverse to the beam orbit, and of a number of hodoscopes of scintillation counters. The trigger of the apparatus requires at least two charged particles, with a minimum kinetic energy of 130 MeV (if pions) in the two opposite halves of the apparatus. We call multihadronic events those events which show the following features:

a) more than two particles are detected;

b) two particles are observed with an acoplanarity angle $\Delta\varphi \geqslant 10°$.

In addition, all events must fulfil the following requirements:

c) correct timing with respect to the bunch-bunch collisions;

d) the charged prongs must converge in the interaction region; an acceptance of ±1 cm in the radial dimensions of the source, as measured by a set of multiwire proportional chambers [1], has been imposed.

Condition b) practically eliminates all contamination from collinear events and cosmic rays, and strongly reduces the contribution from the two photon processes ($e^+e^- \to e^+e^-e^+e^-$ and $e^+e^- \to e^+e^-\mu^+\mu^-$). The background from beam-gas interaction is also strongly reduced by the acoplanarity cut. It should be observed, in addition, that such background is basically energy independent and thus it does not affect the results concerning fine structures in the energy dependence of the cross section. The same argument is valid as far as the detection efficiency of the apparatus for multihadronic events is concerned. Indeed, the detection efficiencies for each final state and the average efficiency are almost independent of energy in the mass range being considered.

In fig. 1 the detected yield versus total energy is

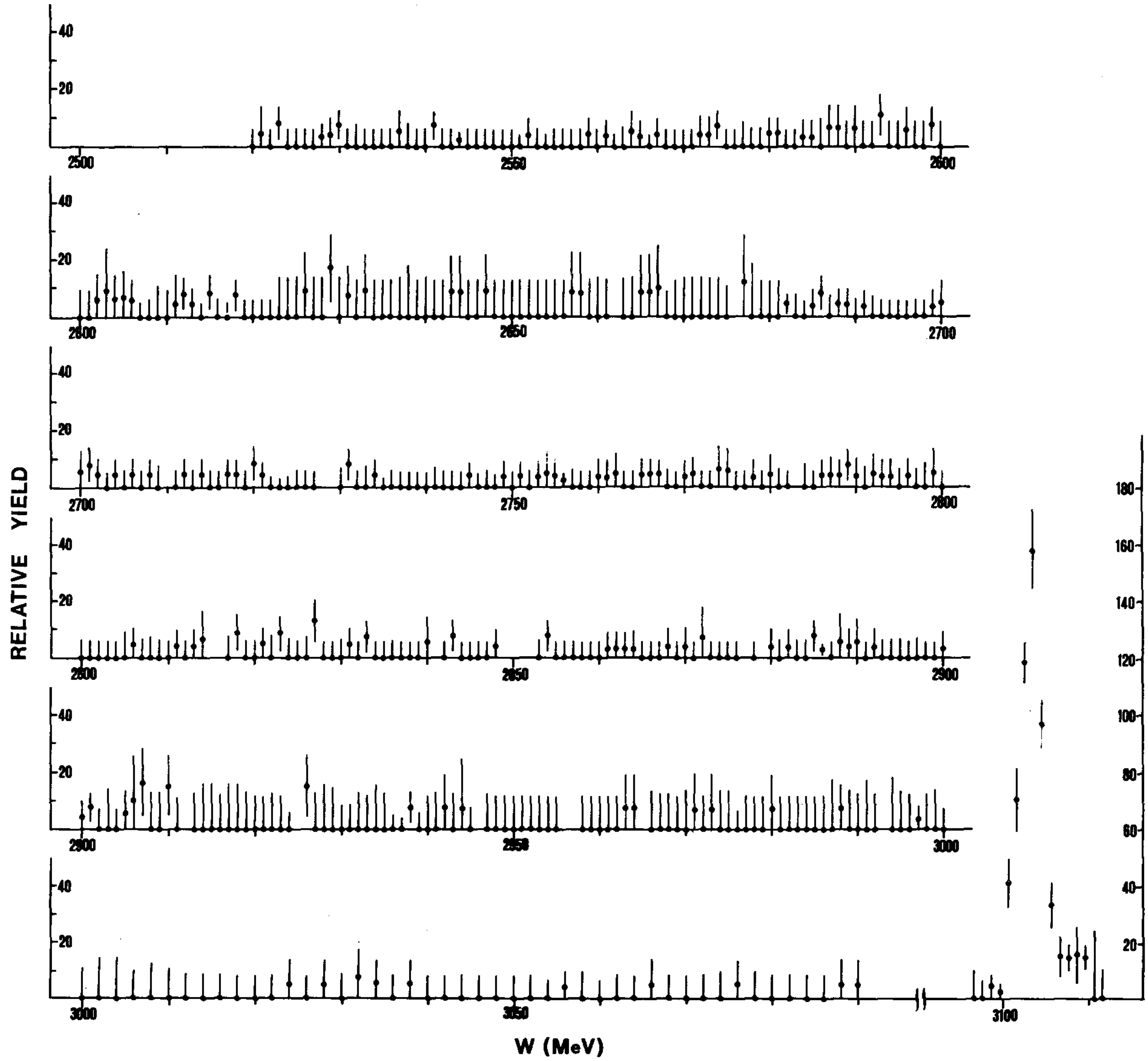

Fig. 1.

shown. The $J/\psi(3100)$ peak as detected by the apparatus is also reported for comparison. Quoted errors are statistical only.

No significant structures can be seen in the total mass range explored. In order to derive an upper limit for the production cross-section of new resonances times their branching ratio into more than two hadrons, we have proceeded as follows.

A narrow resonance would be observed in the excitation curve as a gaussian bump with a width equal to the energy spread of the machine, distorted by radiative effects. Since in the explored energy range (W = 2.5–3.0 GeV) the machine spread Γ_W varies from 2.1 to 2.8 MeV, the evaluation of the upper limit of the integrated yield (Y_R^{Int}) from a narrow resonance at the energy W_0 has been performed based on the number of events contained in all possible three consecutive energy bins, viz. in any 3 MeV wide energy intervals centered at W_0, ($N(W_0)$). Over such energy interval the fractional yield from a narrow resonance gives a contribution which can range from 60% to 74% of the total yield, depending on Γ_W. From the observed rate $N(W_0)$ and using Poisson statistics we have evaluated $N^*(W_0)$, the upper limit (with 90% probability) to the true rate. The maximum integrated yield from a possible narrow resonance Y_R^{Int} is related to $N^*(W_0)$ by the relation:

$$N^*(W_0) = \sum_{i=1}^{3} \left[Y_{NR} + \frac{Y_R^{Int}}{\sqrt{2\pi}\,\sigma_W} \exp\left(- \frac{(W_i - W_0)^2}{2\sigma_W^2} \right) \right] \mathcal{L}_i \tag{3}$$

where $W_1 = W_0 - \Delta W$, $W_2 = W_0$, $W_3 = W_0 + \Delta W$ with ΔW equal to the step of the energy scan (1 MeV); Y_{NR} is the mean value of the observed yield due to non resonant hadronic production and $\mathcal{L}_i$ is the luminosity corresponding to the energy bin involved. From eq. (3) one can derive Y_R^{Int} and work out the ratio $Y_R^{Int}/Y_{J/\psi}^{Int}$ relative to the measured integrated yield of the J/ψ. Assuming the detection efficiency of the apparatus to be equal for the J/ψ and for the hypothetical resonance at W_0, this ratio is equal to the ratio between the integrated cross sections, and it can be used to derive an upper limit for the hadronic cross-section of the new resonance.

Table 1

Energy region (MeV)	$\sigma_R^{Int}/\sigma_{J/\psi}^{Int}$ upper limits (90% c.l.)
2520–2599	0.06
2600–2699	0.12
2700–2799	0.07
2800–2899	0.07
2900–3000	0.14

The results of this procedure are quoted in table 1. The region $2520 \leqslant W \leqslant 3000$ MeV has been split for convenience in five intervals, for which all data have been analysed together to produce single upper limits.

We would like to express our deep gratitude to the Adone Staff Group for the very efficient running of the machine achieved in the delicate conditions required by this experiment.

References

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