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SEARCH FOR A NARROW RESONANCE IN e^+e^- ANNIHILATION AROUND 1.5 GeV

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In the present paper we report the final results on a search for narrow resonances in e^+e^- annihilation around 1.5 GeV, performed at the Adone storage ring ($\gamma\gamma 2$ experiment).

Different theoretical models[1,2] predict the existence of resonances in the energy region 1-2 GeV. In particular the Veneziano mass formula predicts[2] for the radial excitation of the φ meson a family of resonances with equally spaced mass squared $m_n^2 = m_\varphi^2 + n\Delta m^2$ with $\Delta m^2 \simeq 2m_\rho^2$. For n = 1, 2, 3 the expected masses are respectively $m(\varphi') = 1.49$ GeV; $m(\varphi'') = 1.84$ GeV; $m(\varphi''') = 2.14$ GeV.

Experimental evidence has been found[3] for the existence of resonances at 1.82 GeV and 2.1 GeV which can be considered as candidates for φ-like recurrencies. On the other hand preliminary results[4] on multihadron production in e^+e^- annihilation seemed to indicate (Fig. 1) the existence of a narrow resonance (Γ = 2-5 MeV) at an energy W = 1497-1499 MeV. Therefore a systematic search for narrow resonances has been performed at Adone in the energy interval 1.49-1.51 GeV. In these kind of measurements two characteristics of the storage ring are relevant: the total c.m. energy spread and the accuracy in energy setting. For the Adone storage ring, the c.m. energy spread Γ_W(FWHM) depends on the total c.m. energy W according to[5] $\Gamma_W(\mathrm{MeV}) = 0.32\, W^2(\mathrm{GeV}^2)$. Therefore at the considered energy we have $\Gamma_W = 0.72$ MeV. As far as the reproducibility of the beam energy is concerned, a continuous and precise measurement of the magnetic field of the storage ring, and of the RF cavities high voltage, allows to set the beam energy with an accuracy which is estimated to be $\simeq 0.3$ MeV at 1.5 GeV.

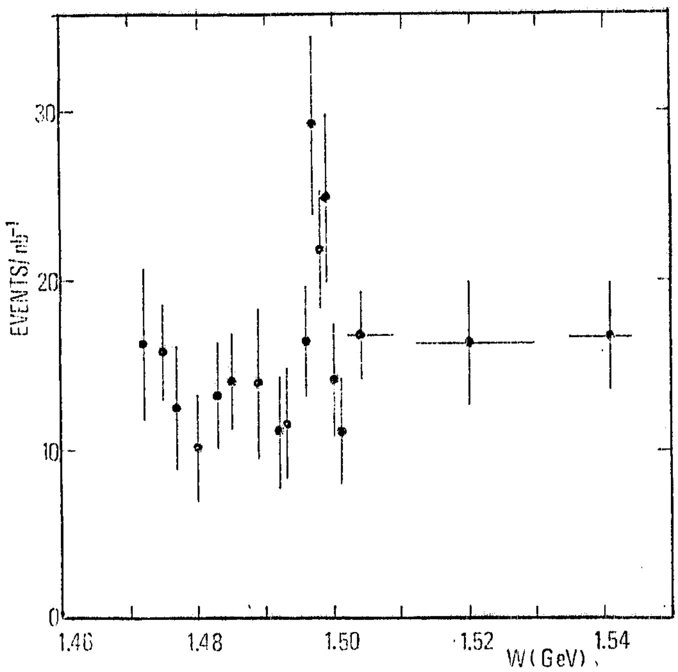

FIG. 1 - Preliminary results on the relative yield of multihadron production obtained before July 1977. Events with at least two observed charged particles have been considered. Data refer to 430 events corresponding to a total integrated luminosity of 28 nb^{-1}.

Taking into account these Adone features the energy interval 1.49-1.51 GeV has been explored in 1 MeV step. Furthermore on both sides of this interval, from 1.42 to 1.6 GeV, data have also been taken and averaged on larger bins in order to have a better statistics. The measured multihadron yield outside the 1.49-1.51 GeV region will determine the shape and amount of a "non-resonant" background in the region of interest.

The data have been collected in two periods. In the first period 1223 events, corresponding to a total integrated luminosity of 106 nb^{-1}, have been collected[(x)] with the standard $\gamma\gamma 2$ set-up[(6, 7)]. In the second period the apparatus has been implemented with a central core of limited streamer tubes[(8, 9)], with bidimensional read out, placed close to the doughnut, around the interaction region. This core allows to reconstruct with a better accuracy the interaction point and to improve the identification of neutral showers, but does not enter in the trigger logic. During this second period, 767 events have been collected, corresponding to a total integrated luminosity of 71 nb^{-1}. The same selection criteria have been applied to the data collected in both periods. Three energy values around 1.5 GeV have been explored with higher statistics. Preliminary results from this second set of data have been already presented[(10)].

In Fig. 2 we report the measured yield vs. total c.m. energy, obtained in both periods of data taking. On the average the two sets of data are in good agreement. Therefore, assuming that the machine energy has the expected reproducibility the two sets of data have been lumped together in each energy interval (Fig. 3). A 1 MeV binning has been kept between 1.49 GeV and 1.51 GeV. From these data the presence of a narrow resonance around 1.5 GeV does not seem to be confirmed. This conclusion is in agreement with that of Ref. (11).

(x) This integrated luminosity includes the 28 nb^{-1} relative to the early data shown in Fig. 1.

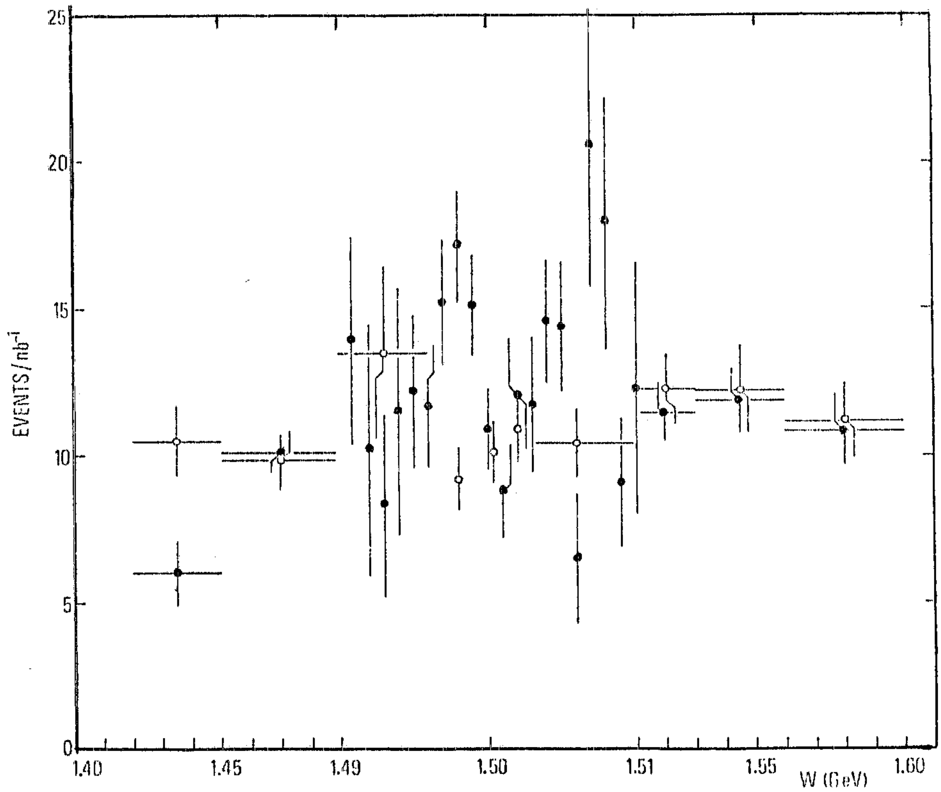

FIG. 2 - Final data on the relative yield of multihadron production. Events with two observed charged prongs plus at least another particle (track or photon) are considered. Full (open) points are obtained without (with) the central core in the set up and refer to 1223 (767) events corresponding to a total integrated luminosity of 106 (71) nb^{-1}.

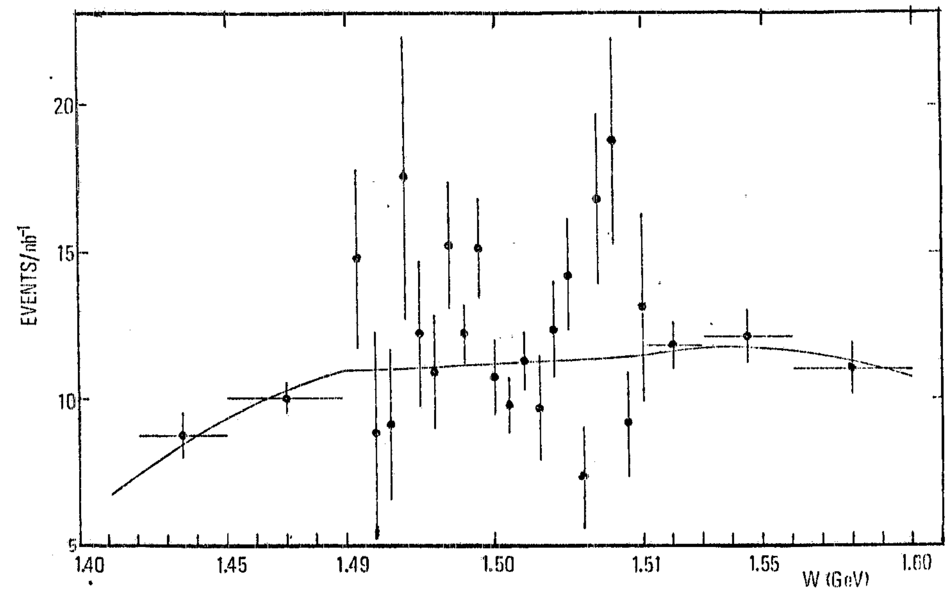

FIG. 3 - Final results on the relative yield of multihadron production. Data collected with the standard and the modified set up has been lumped in 1 MeV bin between 1.49 and 1.51 GeV (scale expanded by a factor ten). The best fit to the data outside the 1.49-1.51 GeV region is shown (see text).

In order to give a quantitative significance to our results, we follow a standard method already used in narrow resonance hunting[7]. The data outside the interval of interest 1.49 - - 1.51 GeV are best fitted (solid line of Fig. 3) using a parabolic formula for the energy behaviour of the total multihadron cross section[9].

This curve is considered as a "non-resonant" background in the interval 1.49 - 1.51 GeV. Taking into account an average detection efficiency[9] $\bar{\varepsilon} = 13\%$ around 1.5 GeV, we deduce in this interval an upper limit (90% confidence level) for the energy integrated resonant cross section Σ.

In Table I we report this upper limit for different widths Γ(FWHM) of an eventual resonance.

TABLE I

Upper limit (90% c.l.) on the energy integrated cross section Σ of a narrow resonance with a mass in the interval 1.49 - 1.51 GeV, for three values of its total width Γ(FWHM).

Γ(MeV)	1	5	10
Σ(nb·GeV)	0.24	0.30	0.41

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