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EVIDENCE FOR A RESONANT BEHAVIOUR IN e^+e^- ANNIHILATION INTO HADRONS, AROUND 1820 MeV, AT ADONE.

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EVIDENCE FOR A RESONANT BEHAVIOUR IN e^+e^- ANNIHILATION INTO HADRONS, AROUND 1820 MeV, AT ADONE.

ABSTRACT. -

Multihadron production has been measured at the Adone e^+e^- storage ring in the c.m. energy region 1600 ÷ 1900 MeV. A resonant behaviour is observed, centered at 1819 ± 5 (± 2) MeV, with a width of 24 ± 5 (± 4) MeV. This effect is observed only in the events with 3 or 4 charged particles together with photons, but not in those without photons.

The results reported in this letter are part of a systematic study of e^+e^- annihilation into hadrons at c.m. energies 1600 ÷ 1900 MeV being conducted at the Adone storage ring.

The experimental set up has already been used in the investigation of the J/ψ resonance[1], in the search of other J/ψ-like narrow states[2] and in the measurement of the total multihadronic cross section in the energy range 1900 ÷ 3100 MeV[3].

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The apparatus is shown in Fig. 1. It consists of two large semi cylindrical telescopes placed above and below the interaction region, with their axes perpendicular to the e^+e^- beam line. These telescopes consist of a sandwich of scintillation counters, optical spark chambers

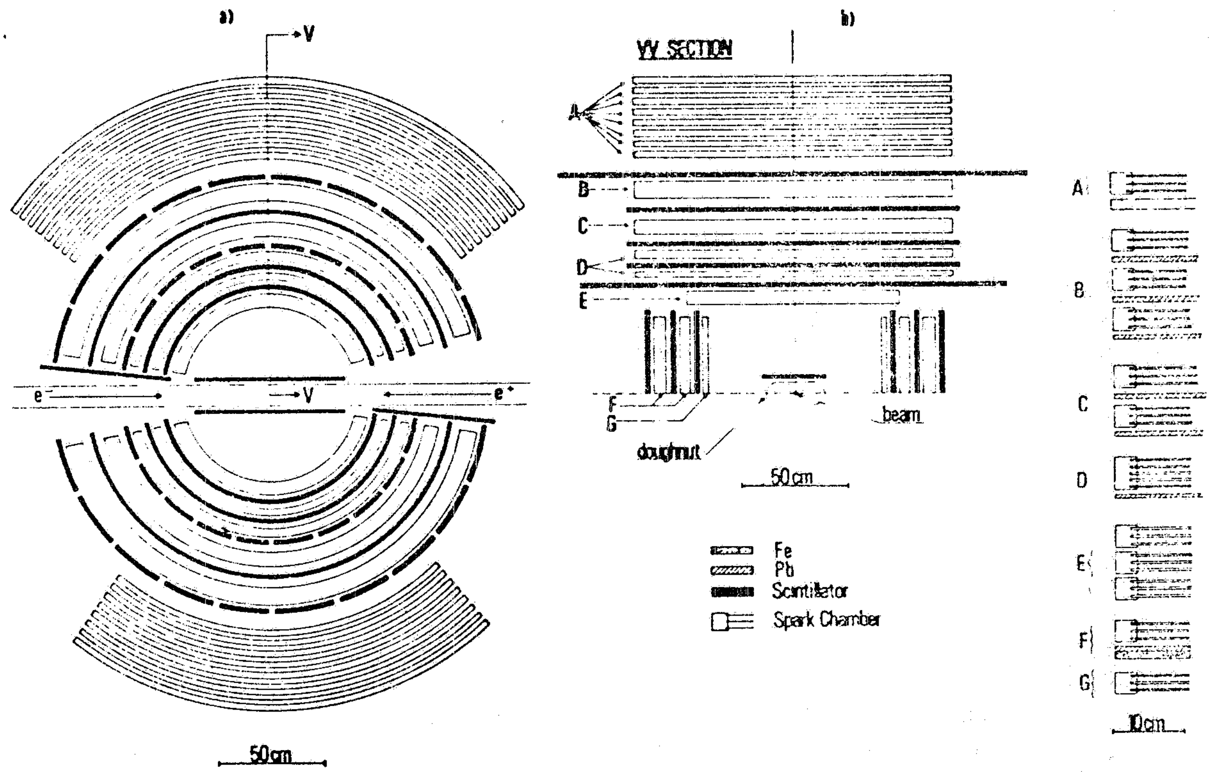

FIG. 1 - Experimental set-up. a) Front view from the center of Adone; b) Cross sectional view in the plane normal to the beams.

and lead converters, arranged in such a way as to optimize electromagnetic showers detection. The total solid angle covered by this part of the set up, assuming a point-like source, is $(0.41 \times 4\pi)$ sr for triggering and $(0.66 \times 4\pi)$ sr. for tracking. The total thickness of the shower detector is 5.5 radiation lengths. The photon detection efficiency is reported in Fig. 2 as a function of photon energy.

The shower detector is completed by the addition of a set of 8 bigap spark chambers sandwiched between 9 iron layers 1.5 cm thick, covering a solid angle of $(0.27 \times 4\pi)$ sr. The total thickness of the apparatus corresponds to the range of a 300 MeV pion.

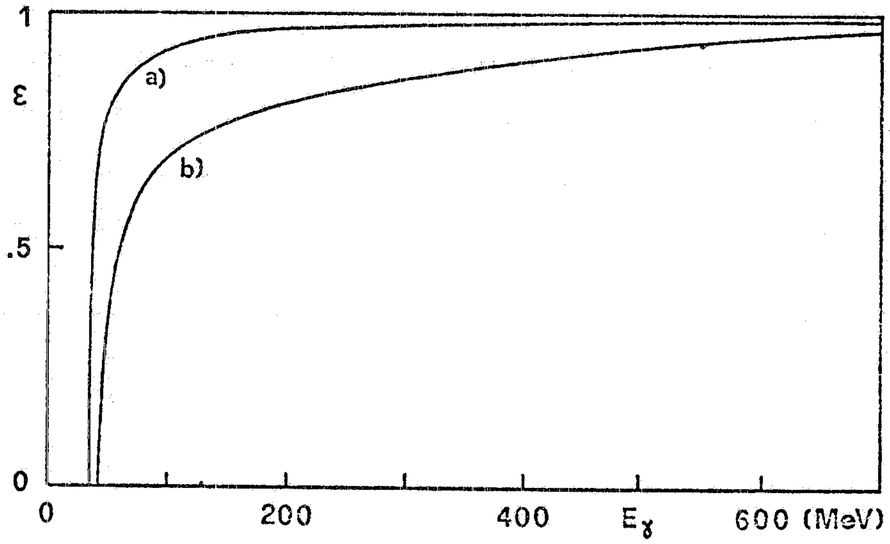

FIG. 2 - Photon detection efficiency, vs. photon energy, according to a Monte Carlo calculation, if the photon is required to fire at least one layer (curve a) or two layers (curve b) of scintillation counters.

A pair of circular side telescopes (spark chambers with magnetostrictive read-out, lead absorbers and scintillation counters) complete the detection system covering a solid angle of $(0.15 \times 4\pi)$ sr for point-like source.

The total c.m. energy spread (FWHM) of the machine is about 1 MeV at the present energies.

The machine luminosity was measured by using large angle Bhabha scattering detected in our apparatus.

The trigger logic requires a coincidence between the upper and the lower telescopes. For each telescope a 6-fold coincidence between all scintillation layers is required. This would correspond to at least one penetrating charged particle ($T_\pi \gtrsim 120$ MeV) or to a low energy charged particle ($T_\pi \gtrsim 35$ MeV) together with one or more converted photons.

We have collected 894 multihadronic events for a total integrated luminosity of 93 nb^{-1}. In the following we will restrict our analysis to 473 multihadronic events with at least 3 charged particles ($\gtrsim$3C events). The machine and cosmic ray backgrounds in this sample were found to be negligible. The relative yield (number of events/integrated luminosity) for these events, versus the total c.m. energy W, is shown in Fig. 3. The cross sections for the production of ($\geq 4\pi^{\pm} + n\pi^{0}$; $n \geq 0$), estimated from these data, are in good agree-

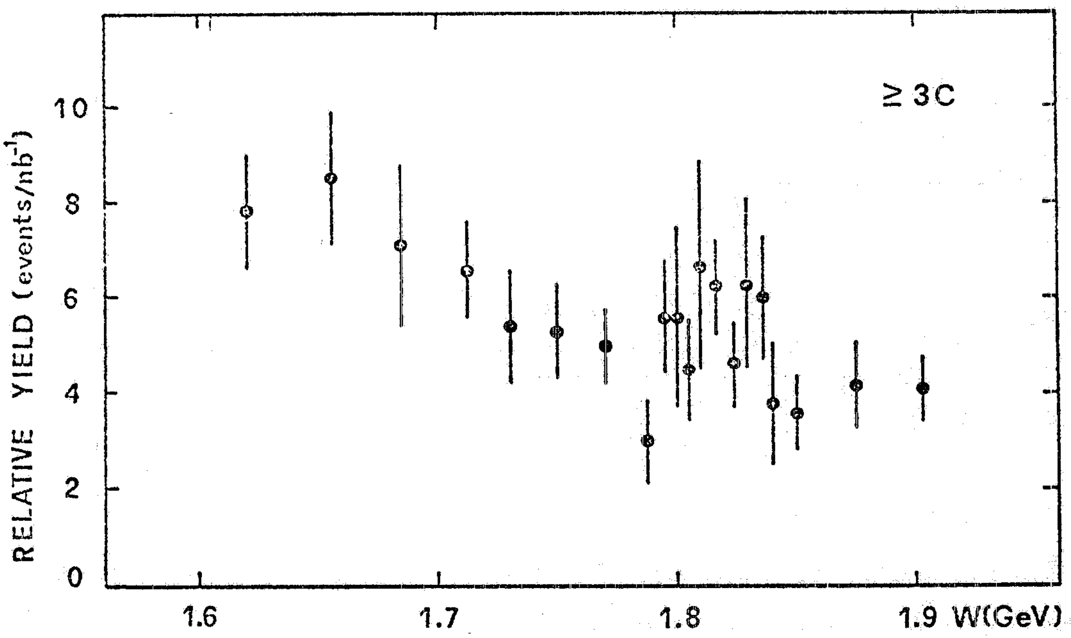

FIG. 3 - Relative yield vs. total c.m. energy for events with at least 3 charged particles, with or without photons.

ment with those previously measured[4, 5] at Adone at 1600, 1770 and 1900 MeV. An enhancement of the relative yield for this class of events is seen in the energy region 1800 ÷ 1840 MeV.

In order to investigate this effect, we have divided our events in the energy region 1750 ÷ 1900 MeV, into two categories: 119 events with 3 or 4 charged particles and one or more detected photons (see Table I); 186 events with 3 or 4 charged particles and no detected photons. The relative yields for these two types of events are shown in Figs. 4a and 4b respectively. A clear resonant behaviour is present around 1820 MeV for the events of the first category but not for the events of the second. The errors quoted in the figures are statistical only. At the present stage of the analysis the resonant channels have not been isolated.

TABLE I

Integrated luminosity ($\mathscr{L}$), number of events (3,4 c + + $\geq 1\gamma$) and relative yield vs. total c. m. energy W.

W (MeV)	$\mathscr{L}$ (nb^{-1})	N 3,4c + $\geq 1\gamma$	N/$\mathscr{L}$ (ev/nb^{-1})
1750	5.19	8	1.5 ± 0.5
1770	8.52	14	1.6 ± 0.5
1788	3.35	3	0.9 ± 0.5
1795	4.21	4	1.0 ± 0.5
1800	1.83	3	1.6 ± 1.0
1805	3.44	7	2.0 ± 0.8
1810	1.42	4	2.8 ± 1.4
1818	6.71	21	3.1 ± 0.7
1824	5.15	12	2.3 ± 0.7
1830	1.97	6	3.0 ± 1.3
1835	3.21	8	2.5 ± 0.9
1840	2.22	3	1.4 ± 0.8
1850	5.08	5	1.0 ± 0.4
1875	5.07	8	1.6 ± 0.6
1902	7.68	13	1.7 ± 0.5

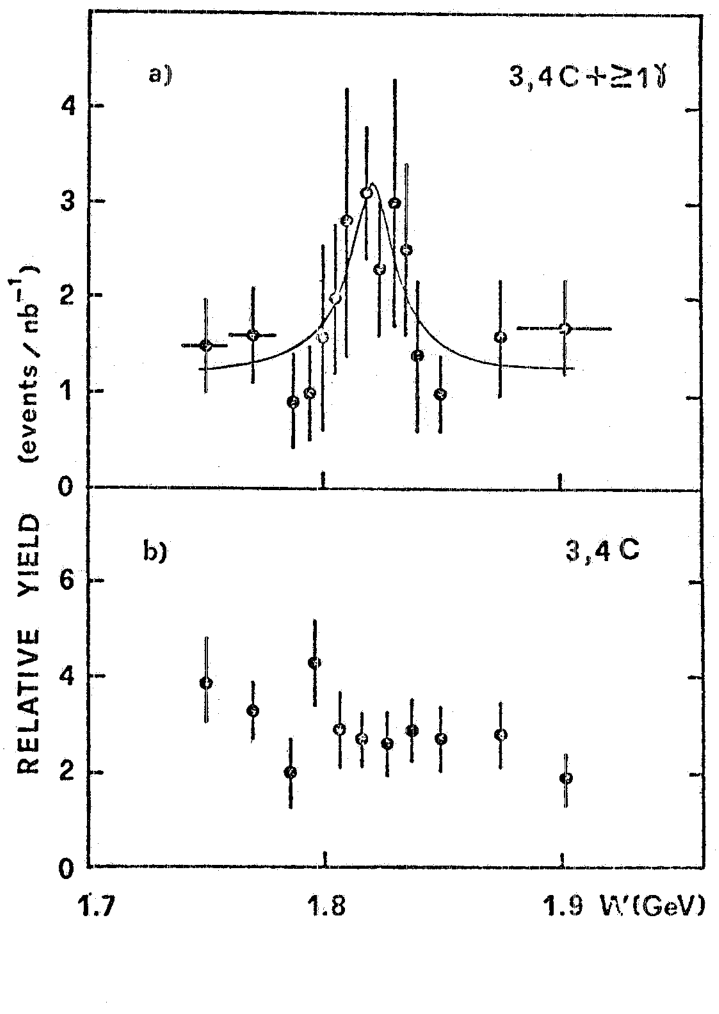

FIG. 4 - Relative yield vs. total c. m. energy for the events with: a) 3 or 4 charged particles plus at least one photon; b) 3 or 4 charged particles without photons. The line represent the best fit of the data with a Breit-Wigner superimposed to a smooth background.

By fitting the data of Fig. 4a with a simple Breit-Wigner superimposed on a smooth background, we obtain (with χ^2/degrees of freedom = 0.6) the following values :

$$M = 1819 \pm 5 \ (\pm 2) \ \text{MeV} ,$$

$$\Gamma = 24 \pm 5 \ (\pm 4) \ \text{MeV} .$$

Given in parenthesis are the estimated systematic errors which, for the mass value, comes from the machine energy calibration and for the width, from uncertainties in the background determination. In the peak region (1805 ÷ 1835) MeV we find 58 events compared with 29 $\pm$ 4 events expected from background interpolation .

The different value of the mass and the much smaller width observed here do not allow us to identify this structure with the recently discovered resonance[6] at W = 1778 MeV in the channel $4\pi^{\pm} + \pi^{0}$. Analysis is in progress to investigate the latter resonance with the full sample of data collected between 1.6 and 1.9 GeV.

Theoretical models of φ recurrences[7] are compatible with the mass and width of the resonant structure we observe.

We would like to thank the machine staff for the efficient operation of Adone. Particular thanks are due to M.A. Melorio for her invaluable collaboration, and to M. Grilli, V. Valente and P. De Santis for their participation in the initial stage of this experiment. Finally, a special thank is due to C. Mencuccini for his substantial support to this experiment.

REFERENCES. -

(1) - R. Baldini-Celio et al., Lett. Nuovo Cimento 11, 711 (1974); C. Bacci et al., Lett. Nuovo Cimento 12, 269 (1975) ; R. Baldini-Celio et al., Phys. Letters 58B, 471 (1975) ; R. Baldini-Celio et al., Phys. Letters 58B, 475 (1975) ; R. Baldini-Celio et al., Lett. Nuovo Cimento 18, 447 (1977).

(2) - R. Baldini-Celio et al., Phys. Letters 58B, 481 (1975) ; C. Bacci et al., Phys. Letters 64B, 356 (1976).

(3) - E. Iarocci, Topical Meeting on Leptons Interaction and New Particles, Trieste (1976) ; G. P. Murtas, XVIII Intern. Conf. on High Energy Physics, Tbilisi (1977).

(4) - F. Ceradini et al., Phys. Letters 42B, 501 (1972).

(5) - B. Esposito et al., Lett. Nuovo Cimento, to be published.

(6) - G. Cosme et al., Phys. Letters 67B, 231 (1977).

(7) - M. Greco, Nuclear Phys. 63B, 398 (1973) ; Frascati report LNF-76/55 (1976).