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Search for Narrow Resonances in e^+e^- Annihilation at Adone in the Mass Region $(1.42 \div 1.92)$ GeV/c^2.

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A systematic search for narrow resonances in the reaction

$$e^+e^- \rightarrow \text{hadrons}\,, \tag{1}$$

over the centre-of-mass energy range $W = (1.4 \div 3.1)$ 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 $W = (1.42 \div 1.92)$ GeV; previous results for the energy region $W = (1.92 \div 3.10)$ GeV have already been published (2,3).

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(1) W. W. Ash, D. C. Cheng, B. Esposito, F. Felicetti, A. Marini, H. Ogren, I. Peruzzi, M. Piccolo, F. Ronga, G. Sacerdoti, L. Trasatti, G. T. Zorn, B. Bartoli, B. Coluzzi, A. Nigro, V. Silvestrini, F. Vanoli, D. Bisello, A. Mulachiè, M. Nigro, L. Pescara, R. Santangelo, E. Schiavuta, D. Scannicchio, P. Monacelli, L. Paoluzi, G. Piano Mortari and F. Sebastiani: *Nucl. Instr. and Meth.*, **148**, 431 (1978).

(2) B. Esposito, F. Felicetti, I. Peruzzi, M. Piccolo, F. Ronga, A. Marini, B. Bartoli, A. Nigro F. Vanoli, D. Bisello, M. Nigro, L. Pescara, P. Monacelli, L. Paoluzi, G. Piano Mortari, R. Santonico and F. Sebastiani: *Phys. Lett.*, **58** B, 478 (1975).

(3) B. Esposito, F. Felicetti, A. Marini, F. Ronga, M. E. Biagini, P. Monacelli, L. Paoluzi, G. Piano Mortari, A. Sciubba, F. Sebastiani, D. Bisello, M. Nigro, L. Pescara, A. Nigro and F. Vanoli: *Phys. Lett.*, **64** B, 362 (1976).

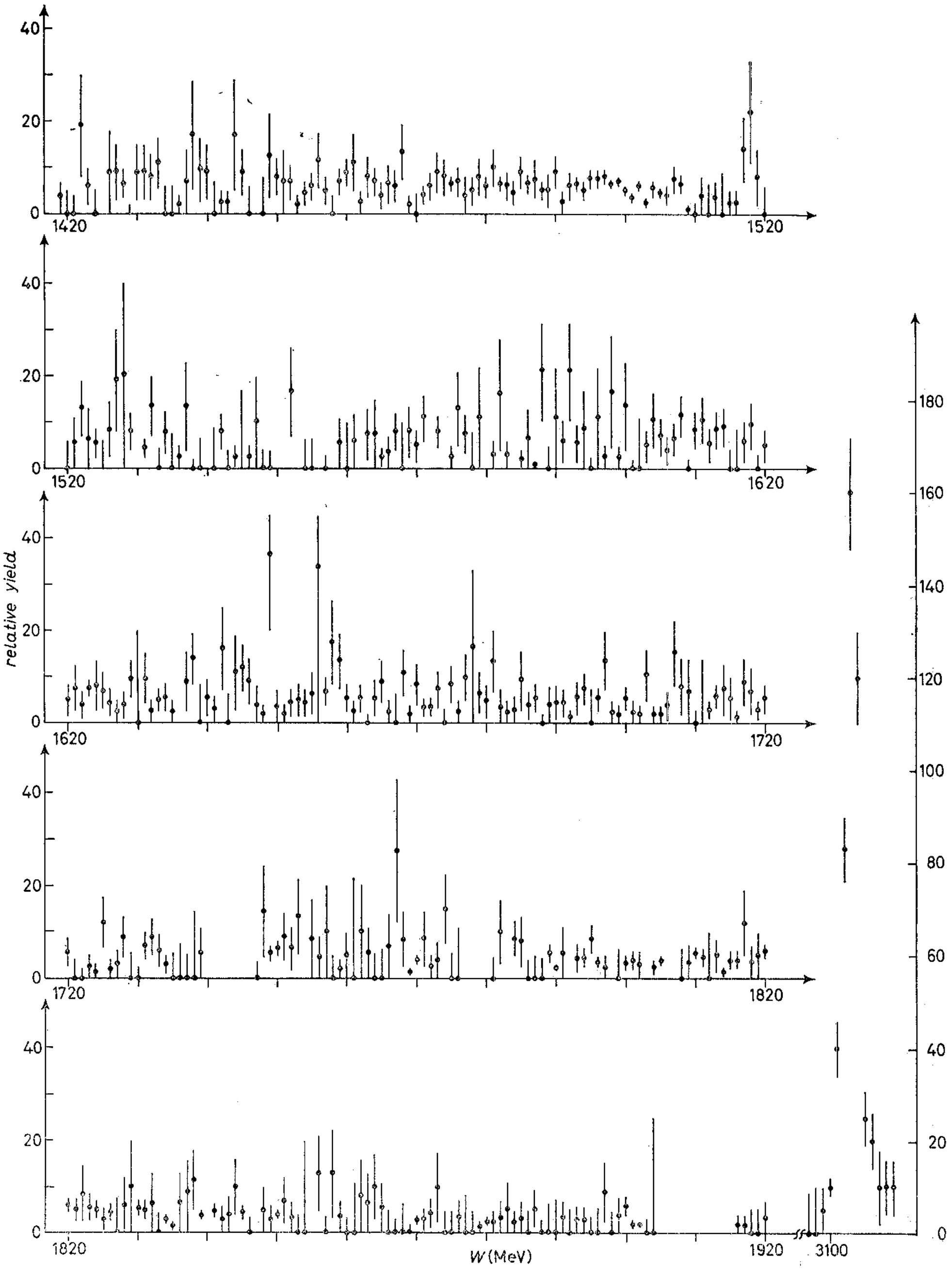

Fig. 1. – Detected yield of reaction $e^+e^- \to$ hadrons *vs.* total energy.

A resonance in the reaction (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 (MeV) $= 0.32 W^2$ (GeV^2), therefore we have chosen to explore our energy interval with 1 MeV steps.

The MEA apparatus, described in ref. (^{1}), consists of a solenoidal magnet transverse to the e^+e^- intersection region and of a set of optical spark chambers, multiwire proportional chambers and scintillation counters. The trigger requires at least two charged particles, with a minimum kinetic energy of 130 MeV (if pions), in the two opposite halves of the apparatus. Events from reaction (1) are required to present: *a*) two charged particles observed with an acoplanarity angle $\Delta\varphi \geqslant 10°$ or more than two charged particles detected; *b*) correct timing with respect to the bunch-bunch collisions; *c*) proper position of the source point as measured by the multiwire proportional chambers.

The detection efficiency of the apparatus for hadronic events has a smooth energy dependence and thus it does not affect the results concerning fine structures of the cross-section.

The same argument is valid for the background from beam-gas interactions, strongly reduced by the acoplanarity cut, which is basically energy independent.

The total collected luminosity was $\mathscr{L} = 279\,\text{nb}^{-1}$. The $e^+e^- \to e^+e^-$ Bhabha scattering rate at small angles ($3° \div 5°$) 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 rate at large angles ($|\cos\theta| \leqslant 0.7$), as measured by the MEA apparatus, has been used to provide an absolute-luminosity monitor.

In fig. 1 the detected yield of reaction (1) *vs.* total energy is shown; the J/ψ(3100) peak, as detected by our apparatus, is reported for comparison. The quoted errors are statistical only.

No significant structure can be seen in the explored energy range. In order to set upper limits for narrow resonances, we have proceeded as previously (^{2,3}). Since in the energy region $W = (1.42 \div 1.92)$ GeV the machine spread varies from 0.7 to 1.2 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 obtained from the number of events, $N(W_0)$, contained in all possible two consecutive energy bins. Over such energy intervals the minimum contributions (see fig. 2) of a narrow resonance to the observed yield can range from 27% to 49% of its total integrated 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

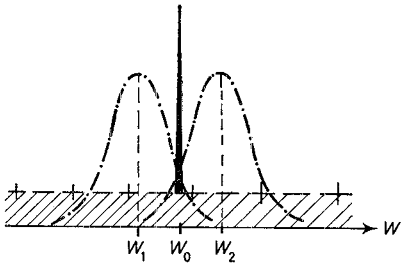

Fig. 2. – A narrow resonance at the energy W_0 provides the minimum contribution to the number of events measured in two consecutive energy bins (W_1, W_2) when $W_0 = W_1 + (W_2 - W_1)/2$: ——— narrow resonance; – – – – – nonresonant hadronic production; —·—·— machine energy resolution.

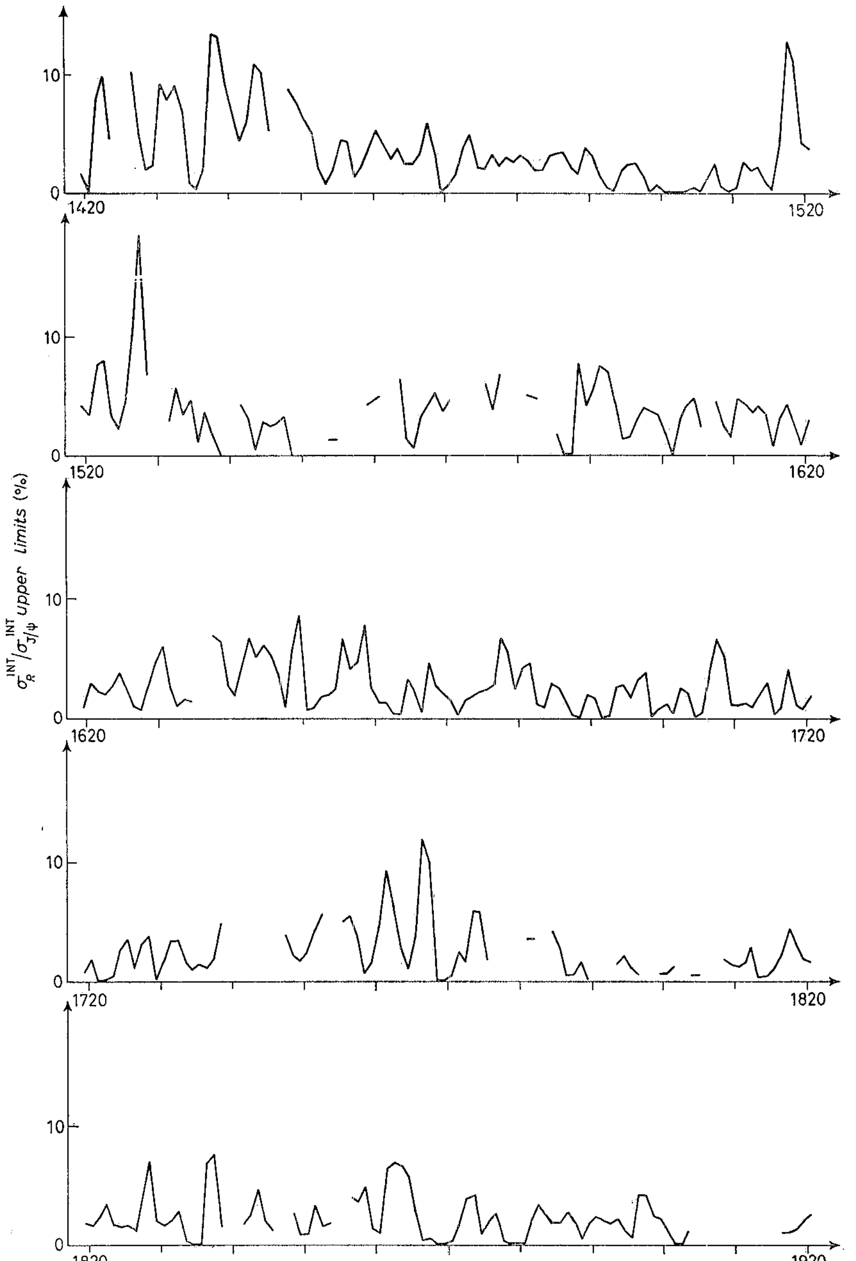

Fig. 3. – Upper limit (90% confidence level) of the ratio $\sigma_R^{\text{int}}/\sigma_{J/\varphi}^{\text{int}}$ *vs.* total energy.

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

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

where $W_1=W_0-\Delta W/2$, $W_2=W_0+\Delta W/2$ with ΔW equal to the step of the energy scan (1 MeV); Y_{NR} is the mean value of the observed yield due to nonresonant hadronic production and $\mathscr{L}_i$ the luminosity corresponding to the energy bin involved.

From eq. (2) we have derived Y_R^{int} and worked out the ratio $Y_R^{\text{int}}/Y_{J/\psi}^{\text{int}}$ 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 hypothetical narrow resonance at W_0, this ratio is equal to the ratio $\sigma_R^{\text{int}}/\sigma_{J/\psi}^{\text{int}}$ between the integrated cross-sections, and provides the upper limit for the hadronic cross-section of the possible narrow resonance. In fig. 3 the upper limit (90% confidence level) of the ratio $\sigma_R^{\text{int}}/\sigma_{J/\psi}^{\text{int}}$ *vs.* total energy is shown. There is no evidence for new narrow resonances, with a sensitivity of about the 15% of the integrated cross-section of the J/ψ(3100).

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