ISTITUTO NAZIONALE DI FISICA NUCLEARE
Laboratori Nazionali di Frascati

INFN-LNF-78/41(R)
5 Ottobre 1978

M. Ambrosio, C. Bemporad, R. Biancastelli, G. Brosco, M. Calvetti, L. Cerrito, F. Costantini, G. R. Giannini, P. Lariccia, G. Paternoster, L. Tortora and U. Troya: A SEARCH FOR NARROW RESONANCES PRODUCED BY e^+e^- ANNIHILATION IN THE MASS REGION FROM 1.4 TO 1.75 GeV/c^2.

Servizio Documentazione
dei Laboratori Nazionali di Frascati
Cas. Postale 13 - Frascati (Roma)

INFN - Laboratori Nazionali di Frascati
Servizio Documentazione

LNF-78/41(R)
5 Ottobre 1978

A SEARCH FOR NARROW RESONANCES PRODUCED BY e^+e^- ANNIHILATION IN THE MASS REGION FROM 1.4 TO 1.75 GeV/c^2.

M. Ambrosio, L. Cerrito, G. Paternoster, L. Tortora (x), U. Troya
Istituto di Fisica dell'Università di Napoli and INFN, Sezione di Napoli.

C. Bemporad (o), G. Brosco, M. Calvetti, F. Costantini, G. R. Giannini and P. Lariccia
Istituto di Fisica dell'Università di Pisa and INFN, Sezione di Pisa.

R. Biancastelli
Istituto Superiore di Sanità, Roma and INFN, Sezione Sanità.

Abstract.

~~We searched for~~ New narrow resonances are searched in the mass region from 1.42 to 1.75 GeV/c^2 at ADONE.
No evidence was found for states having an integrated hadronic cross section larger than 8% of the J/ψ (3100) one (at 90% C. L.).

(x) Permanent address: Istituto Superiore di Sanità, Roma.
(o) Now at Istituto di Fisica dell'Università di Lecce.

A systematic search for narrow resonances in the total cross section for $e^+ e^-$ annihilation into hadrons was initiated at ADONE since the 1974 J/ψ discovery.
Results obtained in the CM energy region from 2.5 to 3.1 GeV have already been published (1).

We present here the results of the search in the CM energy region from 1.4 to 1.75 GeV, which was carried out during 1977 and 1978 by our group; the total collected luminosity was $L = 138.3\ nb^{-1}$.

By narrow resonance we mean a bump in the total hadronic cross section whose experimental width is much smaller than the machine CM energy resolution Γ_W.
At ADONE, Γ_W is given by the relation (2)

$$\Gamma_W (\mathrm{MeV}) = 0.32\ W^2\ (\mathrm{GeV}^2)\ \text{(full width half maximum)}. \qquad (1)$$

(i. e. Γ_W varies between 0.65 and 1.0 MeV in the $1.4 < W < 1.75$ GeV energy interval).

The search for narrow resonances at ADONE is carried out by changing the energy of the colliding beams in steps ΔW comparable with Γ_W.
The CM energy W is mainly determined by the operating magnetic field of the machine. However, variations of the frequency of the accelerating RF, which is tuned from time to time for optimum machine performace, cause small deviations (typically fractions of 1 MeV) of W with respect to the value determined from magnetic field measurements (3).
In the present exploration the machine magnetic field was changed in steps corresponding to a nominal ΔW of 1 MeV; the RF correction, later applied, made the real ΔW step slightly variable in size.
Most of the energy region we studied was covered in more than one successive passage; nevertheless a few apparatus breakdowns or a few very large RF shifts left small gaps in the energy scan (4).
The experimental points in the scan correspond to a typical luminosity of 200 μb^{-1}, they have a variable spacing of about 1 MeV on the average and are taken at a rate of 5 to 10 points/day (5).

The experimental apparatus was described in some detail in ref. (6).
It is composed of four hodoscopes (from the interaction region outward: HOD 1, 2, 3, 4) each made up of sixteen scintillation counter elements (HOD 1, 2, 4 plastic; HOD 3 liquid scintillator $35 g/cm^2$ thick).
The system has a cylindrical symmetry around the interaction region of the $e^+ e^-$ beams and it covers a total solid angle for point like source of about $0.70 \times 4\pi$.

Twelve of the 16 HOD 4 elements are separated from HOD 3 by 2. 5 RL of iron-lead radiator.
All counters respond linearly to the energy loss of the detected particles.
Four cylindrical magnetostrictive wire chambers (4 gaps) track charged particles between HOD 1 and HOD 2.
The pattern of the fired counters, their pulse height and time information, the information from the spark chambers, were all recorded on magnetic tape for each event.
The apparatus was already used in a similar search for narrow states(1).
The absolute luminosity of the machine was obtained by the small angle Bhabha scattering, measured in one of the ADONE straight sections.

The data were analysed to obtain an experimental yield for events with three or more charged particles detected in the apparatus (≥ 3 C) events).
Cosmic ray and machine background were measured to be always smaller than 15% in this event category.
The selection criteria were based on the event topology and on the energy loss (7) registered by the hodoscopes.
Time of flight, between elements of HOD 1 and HOD 4 or between HOD 1 and the machine "beam crossing" signal, was used to reject cosmic ray and machine generated background.

The results of the scan are presented in Fig. 1.
No significant narrow structure can be seen in the explored CM energy region.
A narrow resonance would appear as a gaussian bump with a width equal to the energy spread of the machine, distorted by radiative corrections and superimposed to the local hadronic production level.
Since the scan was performed and repeated with somewhat variable steps, we used the following expression (8) to derive a 90% CL upper limit for the integrated resonant yield Y_R^{Int}:

$$N(W_0) = \int_{\Delta W} N(W, W_0)\, dW = \int_{\Delta W} \left[Y_{NR}(W_0) + \frac{Y_R^{Int}(W_0)}{\sqrt{2\pi}\, \sigma_W} \cdot e^{-\frac{(W-W_0)^2}{2\sigma_W^2}} f(W, W_0) \right] L(W)\, dW\,, \qquad (2)$$

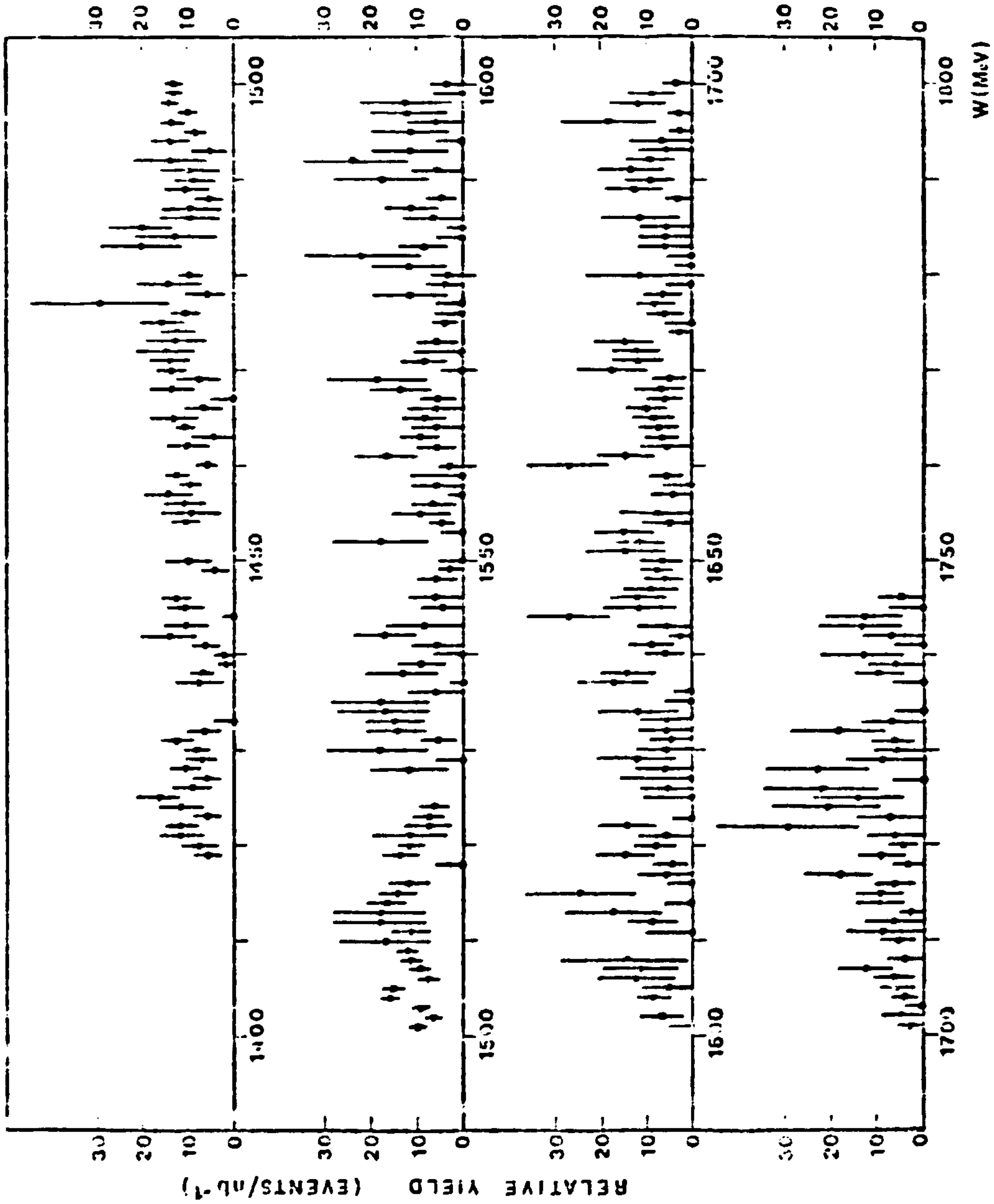


FIG. 1 - Relative yield for the reaction $e^+ e^- \to$ hadrons ($\geq$ 3C events; see text) as a function of the total CM energy W.

where:

$N(W_0)$ is the number of ($\geq 3C$) events in an energy interval $\Delta W = 1.5$ MeV centered at W_0;

$Y_{NR}(W_0)$ is the non resonant hadronic yield obtained by averaging the experimental yield $Y(W)$ over an energy interval 20 MeV wide and centered at W_0 (the small ΔW region was excluded from the average);

$L(W)$ is the luminosity collected at an energy W.

The energy spread of the machine is taken into account by the appropriated gaussian; radiative corrections are taken into account by the function $f(W, W_0)$ (9).

The 90% CL upper limit $\tilde{Y}_R^{Int}(W_0)$ to be determined is by definition the maximum value of $Y_R^{Int}(W_0)$, i. e. the hadronic integrated resonant yield, which, when inserted in expression (2), would generate the observed number of events $N(W_0)$ with probability less than 10%, according to Poisson statistics.

An upper limit on $\sigma_R^{Int}(W_0)B$, the integrated cross section multiplied by the branching ratio to topological channels with four or more charged particles, can be deduced from $\tilde{Y}_R^{Int}(W_0)$ by the use of the apparatus detection efficiency for those decay channels (10).
The result is

$$\sigma_R^{Int}(W_0)B < 530 \text{ nb MeV} \quad (\text{at } 90\% \text{ CL})$$

$$1420 < W_0 < 1750 \text{ MeV} . \tag{3}$$

It is customary to compare the limit obtained in narrow resonance searches to the total cross section for J/ψ production; the known topological and total cross sections for J/ψ production (11) can be used to express our result in a different form, namely:

we exclude the existence of any narrow state in the energy region $1.4 < W_0 < 1.75$ GeV having an integrated cross section σ_x^{Int} such that

$$\sigma_x^{Int} > 0.08 \ \sigma_{J/\psi}^{Int} \quad (\text{at } 90\% \text{ CL}). \tag{4}$$

A similar determination of upper limits was also made, under the hypothesis of finite width resonance production. The result is

$$\Gamma = 2.5 \text{ MeV} \qquad \sigma_R^{Int}(W_o)\, B < 845 \text{ nb MeV (at 90\% CL)},$$

$$\Gamma = 5 \text{ MeV} \qquad \sigma_R^{Int}(W_o)\, B < 980 \text{ nb MeV (at 90\% CL)} \tag{5}$$

$$1420 < W_o < 1750 \text{ MeV}.$$

Contributions by G. Barbarino, G. Barbiellini, M. Castellano, S. Patricelli, E. Sassi, S. Vitale, in the early stage of the experiment are gratefully aknowledged.

We warmly thank the members of the ADONE group for the satisfactory machine operation.

Mr. A. Dante gave us a generous technical support.

REFERENCES AND NOTES.

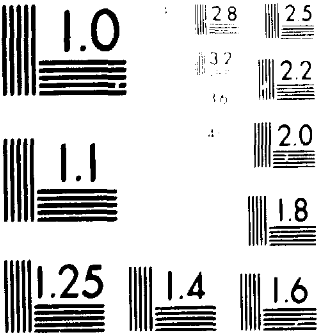
1) C. Bacci et al., Phys. Letters 64B 356 (1976); M. Ambrosio et al., Phys. Letters 64B 359 (1976); M. E. Biagini et al., Phys. Letters 64B 362 (1976).
2) M. Bassetti, ADONE Internal Report E-15 (1974).
3) M. Bassetti, Private Comunication, $\Delta W/W$ - - 16 $(\Delta \nu/\nu_R)$; $\nu_R = 8.5685$ MHz.
4) The $\gamma\gamma 2$ and MEA exps. made a similar narrow resonance search at ADONE (presented at the Tokyo Conference 1978). The three ADONE exps. together ($B\bar{B}$, $\gamma\gamma 2$, MEA) guarantee a more regular energy scan.
5) The energy region around 1500 MeV was explored with higher luminosity. The results will be published separetely.
Preliminary data were presented at the Hamburg Conference 1977.
6) M. Ambrosio et al., Phys. Letters 68B 397 (1977).
7) ($\geqslant$ 3C) events are required to have at least two particles with energy (if pions) larger than 70 MeV and all other particles with energy (if pions) larger than 40 MeV.
8) It is worth noting that upper limits are often quoted which were obtained by different (and more "optimistic") methods. As an example (and always referring to expression (2)) $\widetilde{Y}_R^{Int}$ has been defined as the yield corresponding to a Poisson fluctuation with probability smaller than 10% in respect of the observed number of events N (W_0). In the present search this less correct method would give an upper limit which is better than the one we quote by about a factor 1.5.
9) J. D. Jackson, Nuclear Instr. and Meth. 128 1315 (1976); M. Greco, Nuclear Phys. 63B 398 (1973).
10) The detection efficiency was calculated by the Montecarlo method. Events were generated according to an invariant phase space.
11) C. Bacci et al., Phys. Letters 58B 471 (1975).

CURRENT LNF PREPRINTS AND REPORTS

LNF-78/26(P)	E. Etim and C. Basili: ON THE CONTACT TRANSFORMATIONS OF NON-EQUILIBRIUM THERMODYNAMIC HAMILTONIAN - Submitted to Phys. Letters A.
LNF-78/27(P)	E. Etim and C. Basili: ON THE STOCHASTIC PROPERTIES OF THE THERMODYNAMIC HAMILTONIAN - Submitted to Phys. Letters A.
LNF-78/28(P)	F. Balestra, M. P. Bussa, L. Busso, I. V. Falomkin, R. Garfagnini, C. Guaraldo, A. Maggiora, G. Piragino, G. B. Pontecorvo, Yu. A. Shcherbakov, R. Scrimaglio and A. Zanini: CLUSTERING EFFECTS IN THE PHOTODISINTEGRATION OF ^{4}He AND IN THE (π^+, ^{4}He) ABSORPTION REACTIONS - Presented at the "3rd Intern. Conf. on Clustering Aspects of Nuclear Structure and Nuclear Reactions, Winnipeg, June 1978".
LNF-78/29(P)	C. Bacci, R. Baldini-Celio, G. Battistoni, G. Capon, R. Del Fabbro, G. De Zorzi, E. Iarocci, C. Mencuccini, S. Moriggi, G. P. Murtas, G. Penso, M. Spinetti, B. Stella and L. Trasatti: SEARCH FOR NARROW RESONANCES IN THE MASS REGION 1.45-1.92 GeV IN e^+e^- ANNIHILATION INTO HADRONS - Submitted to Phys. Letters.
LNF-78/30(P)	A. Turrin: JUMPING AN INTRINSIC DEPOLARIZATION RESONANCE IN CYCLIC ACCELERATORS - To be presented at the "III Intern. Symposium on High Energy Physics with Polarized Beams and Polarized Targets, Argonne, October 1978".
LNF-78/31(R)	E. De Sanctis, P. Di Giacomo e V. Lucherini: CALCOLO DELLE CARATTERISTICHE DEL FASCIO DI FOTONI DEL LEALE.
LNF-78/32(P)	N. Lo Iudice and F. Palumbo: POSITIVE PARITY ISOVECTOR COLLECTIVE STATES IN DEFORMED NUCLEI - Submitted to Nuclear Physics.
LNF-78/33(P)	M. Greco, G. Pancheri-Srivastava and Y. Srivastava: WEAK AND RADIATIVE ASYMMETRIES - Submitted to Phys. Letters A.
LNF-78/34(R)	R. Caloi, L. Casano, L. Federici, S. Frullani, G. Giordano, G. Matone, M. Mattioli, G. Pasquariello, P. Picozza, D. Prosperi, P. Pelfer and C. Schaerf: RESONANT NUCLEAR SCATTERING OF γ-RAYS AT A TOOL TO INVESTIGATE THE LADON BEAM CHARACTERISTICS.
LNF-78/36(P)	F. Balestra, M. P. Bussa, L. Busso, I. V. Falomkin, R. Garfagnini, C. Guaraldo, V. I. Lyashenko, A. Maggiora, F. Nichitiu, G. Piragino, G. B. Pontecorvo, R. Scrimaglio and Yu. A. Shcherbakov: ON THE COLLECTIVE ISOBARIC RESONANCE IN PION-NUCLEUS SCATTERING AT INTERMEDIATE ENERGIES - Submitted to Nuclear Physics.
LNF-78/39(R)	A. Esposito, M. Pelliccioni and A. Rindi: RADIATION DOSES AT AN ELECTRON AND POSITRON LINAC AND STORAGE RING.
LNF-78/40(P)	G. P. Murtas: MULTIHADRON PRODUTION IN e^+e^- INTERACTIONS AT ADONE Presented at the "XIX Intern. Conf. on High Energy Physics, Tokyo, Aug. 1978).

AVAILABLE FROM (It is not necessary to write to the authors):

Servizio Documentazione
INFN - Laboratori Nazionali
Casella Postale 13
00044 FRASCATI (Italy).



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A