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di Frascati

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THE NOVEMBER J/Ψ REVOLUTION

AFTER 50 YEARS, WITH AN OUTLOOK TO THE FUTURE

18 November 2024 Auditorium Touschek

The INFN Frascati National Laboratory celebrates the fiftieth anniversary of the J/ψ discovery, with its impacts on the Standard Model through insights from key figures and an overview on the future of Particle Physics and Accelerator Technology.

G. Piano Mortemi with the misspelled or forgotten colleagues (Phys. Rev. Lett. 33 (1974), 1408)

R. Balbini Celio, M. Berna-Rodini, G. Caton, L. Jones, G. S., L. Paolufi,
M. Castellano, M. Celveti, S. Patricelli
et al. not misspelled or not forgotten

**PRELIMINARY RESULT OF FRASCATI (ADONE)
ON THE NATURE OF A NEW 3.1-GeV PARTICLE
PRODUCED IN e^+e^- ANNIHILATION.** C. Bacci,
R. Baldini Celio, M. Bernardini, G. Capon,
R. Del Fabbro, M. Grilli, E. Iarocci, L. Jones,
M. Locci, C. Mencuccini, G. P. Murtas, G. Pen-
so, G. Salvini, M. Spano, M. Spinetti, B. Stella,
V. Valente, B. Bartoli, D. Bisello, B. Esposito,
F. Felicetti, P. Monacelli, M. Nigro, L. Paoluzi,
I. Peruzzi, G. Piano Mortari, M. Piccolo, F. Ron-
ga, F. Sebastiani, L. Trasatti, F. Vanoli, G. Bar-
barino, G. Barbiellini, C. Bemporad, R. Biancas-
telli, M. Calveti, M. Castellano, F. Cevenini,
F. Costantini, P. Lariccia, S. Patricelli, P. Par-
ascandolo, E. Sassi, C. Spencer, L. Tortora,
U. Troya, and S. Vitale [Phys. Rev. Lett. 33,
1408 (1974)].

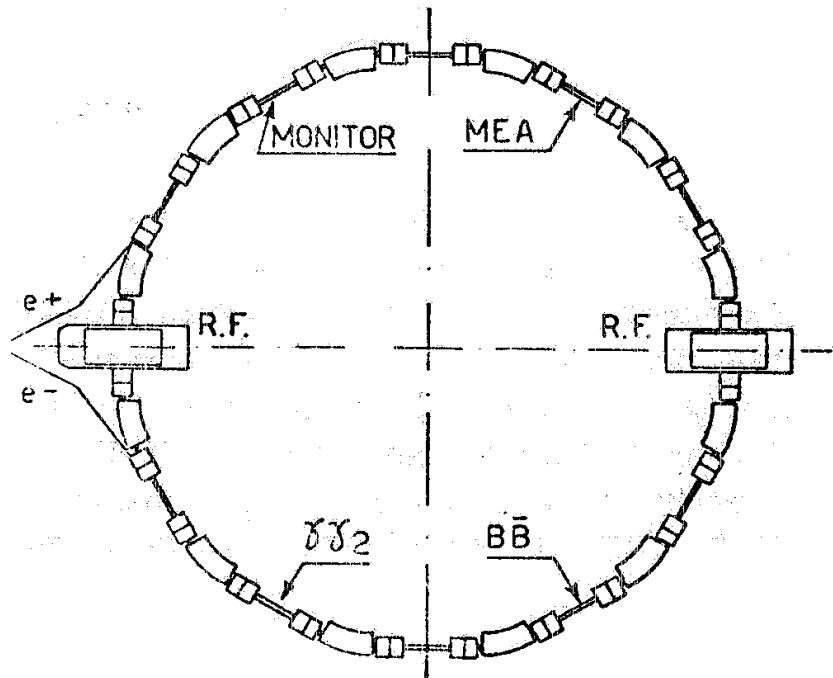
The names of L. Jones and G. Salvini were omitted from the Gamma-Gamma Group, and the names of M. Castellano and S. Patricelli were omitted from the Baryon-Antibaryon Group. Also, the names of R. Baldini Celio, M. Bernardini, G. Capon, L. Paoluzi, G. Piano Mortari, and M. Calveti were misspelled, and M. Spinetti was given two spurious additional initials. The byline addresses were incomplete. The

members of the Gamma-Gamma Group are also at Istituto di Fisica dell'Università di Roma, Rome, Italy, and Istituto Nazionale di Fisica Nucleare, Sezione di Roma, Italy. The members of the Magnet Experiment for ADONE Group are also at Istituto di Fisica dell'Università di Napoli, Naples, Italy, and Istituto Nazionale di Fisica Nucleare, Sezione di Napoli, Italy, and Istituto di Fisica dell'Università di Roma, Rome, Italy, and Istituto Nazionale di Fisica Nucleare, Sezione di Roma, Italy. The members of the Baryon-Antibaryon Group are also at Istituto di Fisica dell'Università di Napoli, Naples, Italy, and Istituto Nazionale di Fisica Nucleare, Sezione di Napoli, Italy, and Istituto di Fisica dell'Università di Pisa, Pisa, Italy, and Istituto Nazionale di Fisica Nucleare, Sezione di Pisa, Italy, and Istituto Superiore di Sanità, Rome, Italy, and Istituto Nazionale di Fisica Nucleare, Sezione Sanità, Rome, Italy.

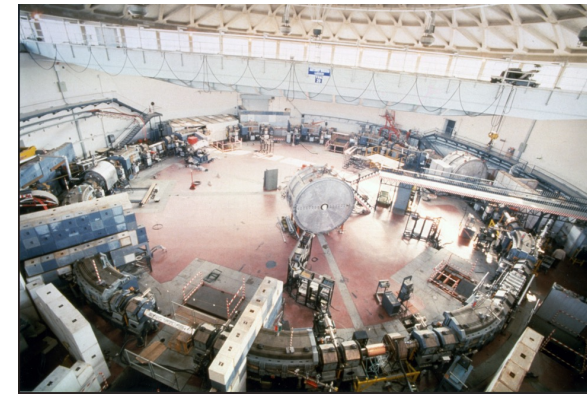
On page 1409, first column, line 5 should read "1.0-MeV steps" instead of "0.5-MeV steps." On page 1409, second column, line 13 should read "120 and 130 MeV" instead of "120 and 180 MeV/c." On page 1410, first column, the equation should be replaced by

$$2\Gamma_{ee^2}/\Gamma_{tot} = 0.8 \pm 0.2 \text{ keV.}$$

Adone parameters (end 1974)

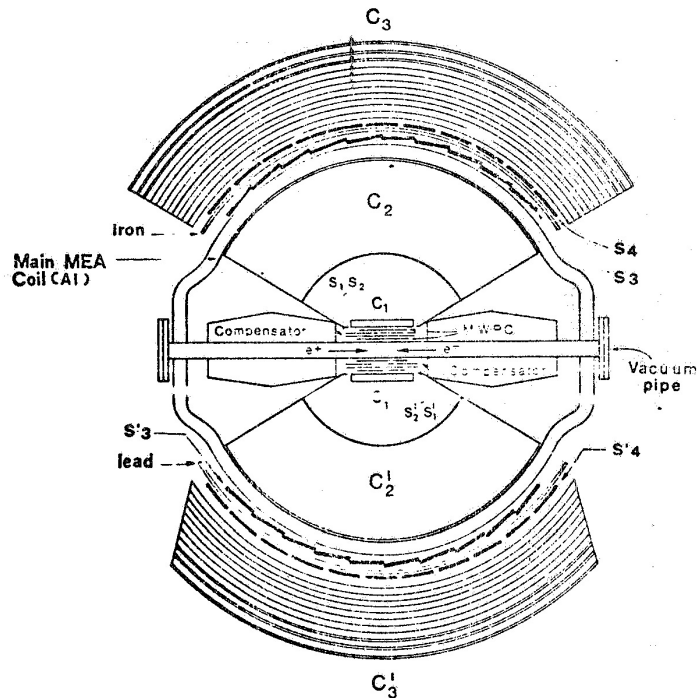


Total length	104. m
Energy (total)	2.2 – 3.1 GeV
Luminosity (@ 3.1 GeV)	$\sim 3 \cdot 10^{29} \text{ cm}^{-2} \text{ sec}^{-1}$
Lum. Region long. (FWHM)	$40 \cdot E^{3/2}_{\text{beam}} \text{ cm}$
Lum. Region (transv.)	$1. \times 0.1 \text{ cm}^2$
Lum. Lifetime	few hours
Injection and ramping times	$\frac{1}{2}$ hour
Energy width (σ)	$0.3 \cdot E^2_{\text{CM}}$ (in GeV) MeV
Energy calibration (abs.)	2 MeV
Energy (re) setting	0.3 MeV
# of bunches/beam	3
Typical integrated luminosity	$1 \text{ nb}^{-1}/\text{day}$

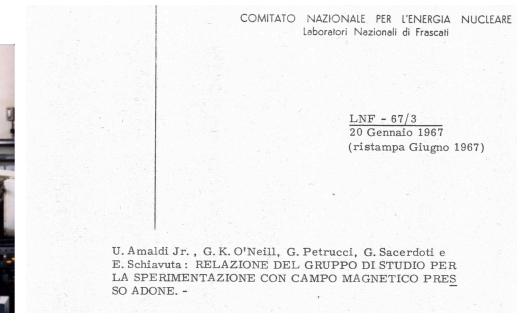
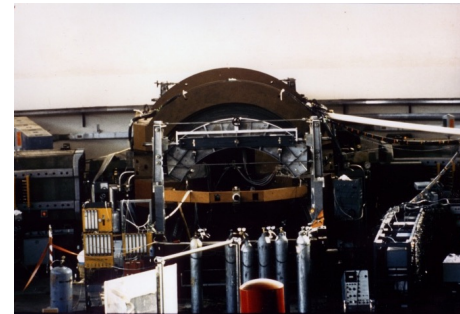


Second generation experiments at ADONE

M.(agnete)E.(sperienze)A.(DONE)



Magnetic apparatus: operational B-field 2.5 KG
 Symmetry axis perpendicular to beam direction. Such choice dictated by the use of optical spark chambers .
 Solid angle coverage (point source) $40\% \cdot 4\pi$.
 (momentum measurement)
 Minimum energy to trigger for a π 130 MeV.
 Beams interaction with detector B-field somehow critical. Compensation needed to few parts 10^{-4} .
 Trigger 2 " π " 130 MeV each.



The news of the “charmed ϕ ”

- On Nov. 11th 1974, in Frascati we were told that a new particle had been found by the S.C.C. Ting group in Brookhaven and by the SLAC-LBL collaboration, Mark I at SPEAR.
- The mass of this new resonance was higher than the nominal max. energy for ADONE (3 GeV), but we set up to look for it pushing the Adone magnet some 100 MeV above the limit.
- It took us three days to find it, as we were having some B-field saturation, but in the night of Nov. 14th we found it.

There it was

- Around 11 P.M. the three experiments were running the n -th energy scan.
- We had a typical trigger counting rate of about 1 every couple of minutes: all of a sudden we had 1 trigger every few tens seconds.
- We were almost on top of the resonance.
- Prof. Giorgio Salvini, running his shift on the gamma gamma2 experiment, had the machine operators open the machine access door (the access door for Adone was few meters above the vacuum pipe) and started looking at the spark chambers of his experiment: they looked like a Christmas tree with a counting rate for multi-particles events never seen before.
- We kept logging events all night and, comes the morning, most of the high energy physicists in the Rome area appeared in the ADONE counting rooms.

The results

- In few days we recorded and analyzed/scanned few hundred events; on Nov. 18th a joint paper from ADONE experiments was published on PRL.

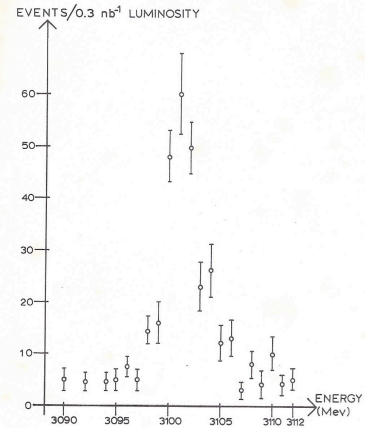


FIG. 1. Result from the Gamma-Gamma Group, total of 446 events. The number of events per 0.3 nb^{-1} luminosity is plotted versus the total c.m. energy of the machine.

TABLE I. Rate of events as a function of the total energy (MEA Group).

Total energy (MeV)	Total No. of events/ 0.6-nb^{-1} luminosity	Hadronic events (noncollinear events)
3090	2 ± 2	0
3092	4 ± 3	2 ± 2
3094.5	4 ± 2	0
3096.5	4 ± 2	3 ± 2
3098.5	4 ± 2	3 ± 2
3100.5	26 ± 5	20 ± 5
3102.5	23 ± 4	15 ± 3
3104.5	10 ± 3	6 ± 2
3106.5	4 ± 2	0
3108.5	5 ± 2	1 ± 1
3110.5	4 ± 2	2 ± 1
3112	4 ± 3	0

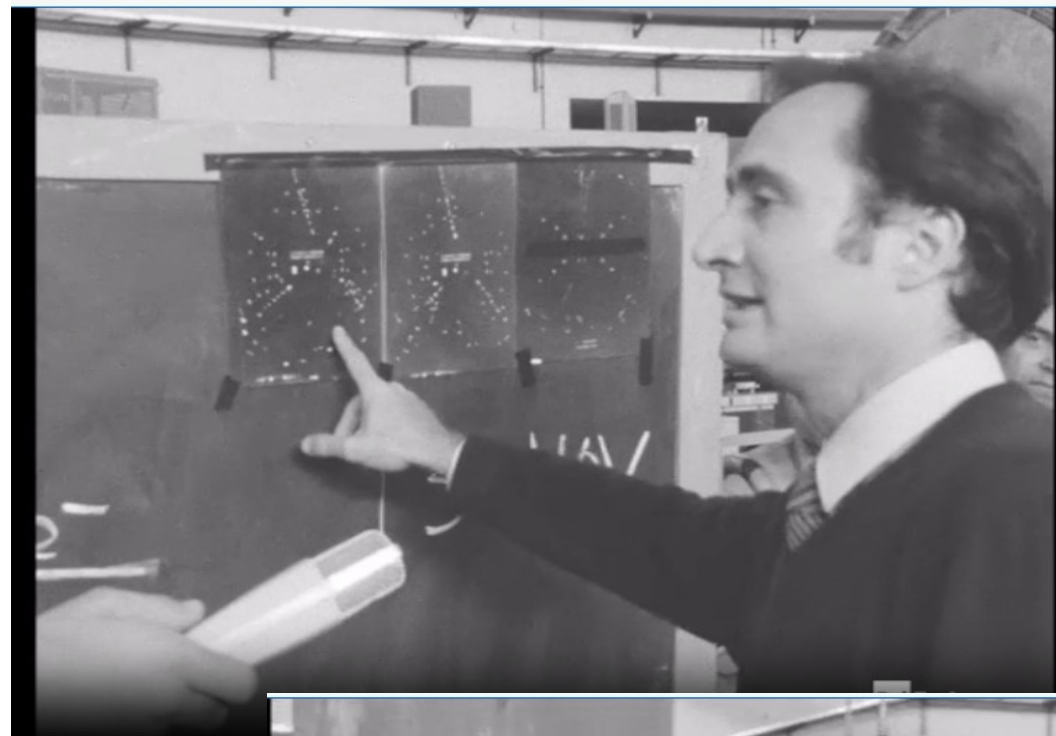
Few odds and ends

- The PRL paper was dictated over the phone by Giorgio Bellettini (then director of the Laboratory).
- It took quite a while, as the words had to be spelled one by one by Giorgio.
- The result was quite a disaster regarding the spelling of the authors' names.....Typical spelling error: usually S as in sierra but Giorgio used S as Salvini.
- The original paper was dated Nov. 18thbut a new version with the right authors' names, institutions' names and few typos was released on Dec. 2nd.

Newspapers and Television at Adone







Interpretation(s)

- The end of 1974 was a hectic period for the theoreticians, who were trying to assess the nature of “3.1” particle.
 - A colored state
 - A new quantum number ground state
 - A vector boson (.... careful not the Z_0)
- We tested the last hypothesis looking at the charge asymmetry in the $\mu^+\mu^-$ channel.
- I remember Franco Felicetti, Francesco Ronga and Carlo Bernardini talking about the paper by Altarelli et al.

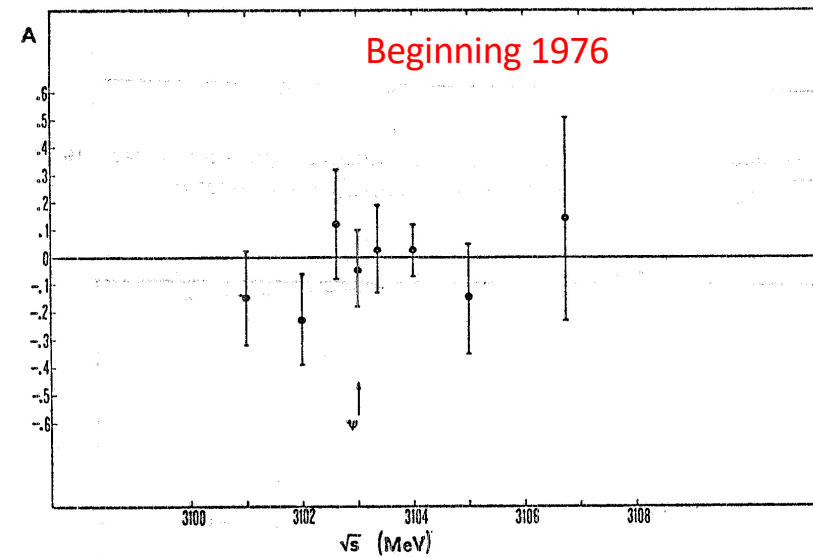
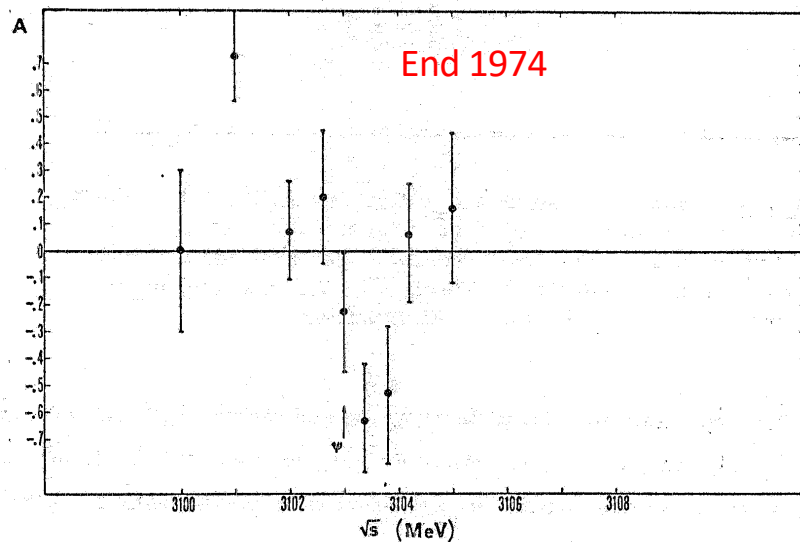
Is the 3104-MeV Vector Meson the ϕ_c or the W_0 ?
G. Altarelli, N. Cabibbo R. Petronzio (Rome Un.), L. Maiani (ISS), G. Parisi (LNF)
Lett. Nuovo Cim. 11 (1974) 14, 609-612

At the end of the year.....

- Here is what we found :
- Aver. asymmetry = $(49-53)/(49+53) = -.04 \pm .1$
- We decide to split the measurement vs. energy and we ended up with an unexplainable result. Statistics had the last word:
- In the 2 MeV region below the peak we found:
 - Asymmetry = $(32-16)/(32+16) = .33 \pm .14$
- In the 2 MeV region above the peak we found:
 - Asymmetry = $(12-28)/(12+28) = -.40 \pm .14$

Sometimes statistics hit you hard

- And this was the case :
- It took one year of data taking to smooth out the fluctuation...



**Experimental Study of the New 3.1 GeV Particle
by e^+e^- Collision at ADONE.**

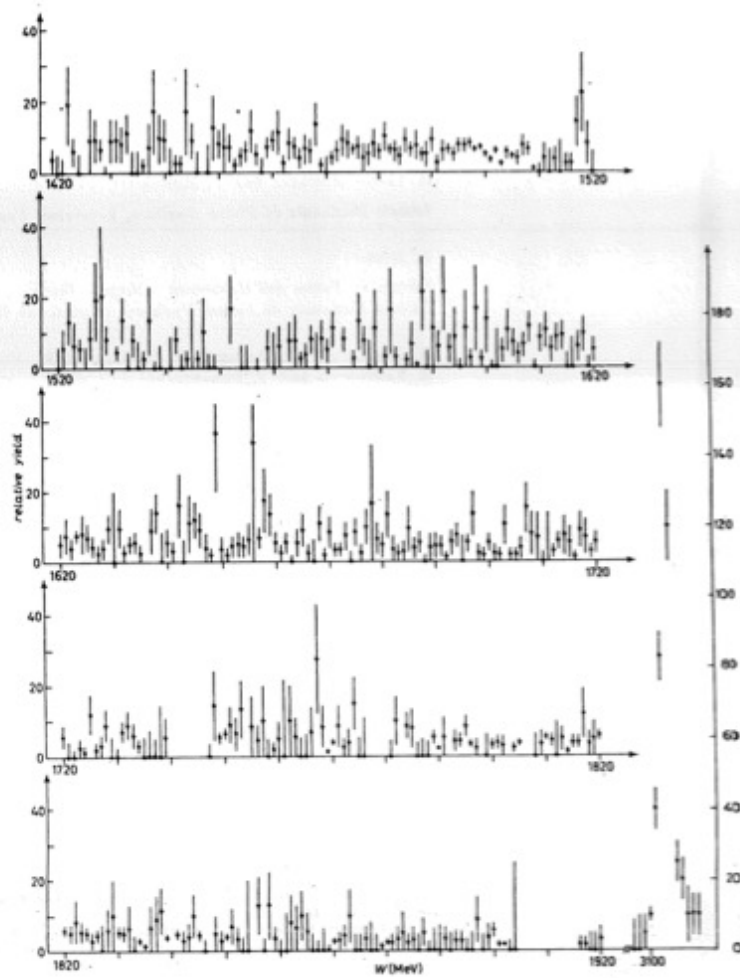
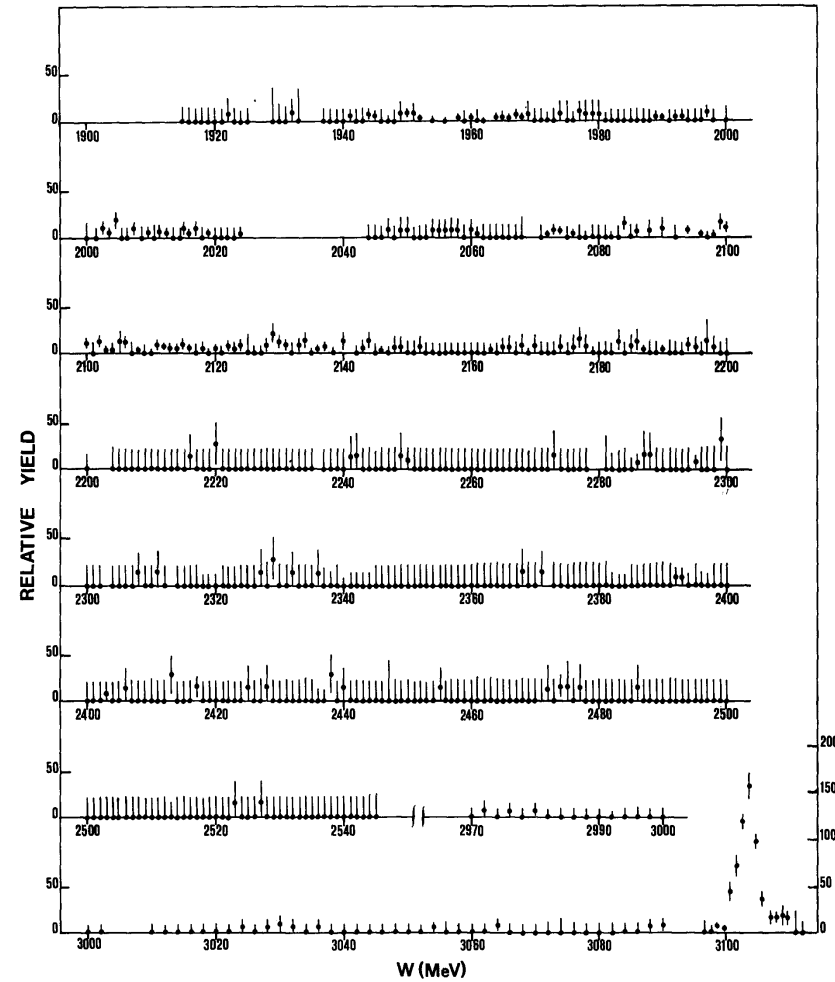
**SEARCH FOR NARROW RESONANCES IN e^+e^- ANNIHILATION
INTO HADRONS AT ADONE**

**Measurement of the $J/\psi(3100)$ Decay Widths
into e^+e^- and $\mu^+\mu^-$ at Adone.**

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

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

**Angular Distribution of $\mu^+\mu^-$ Pairs in the Reaction $e^+e^- \rightarrow \mu^+\mu^-$ at the
 J/ψ Energy.**

Fig. 1. - Detected yield of reaction $e^+e^- \rightarrow$ hadrons vs. total energy.Fig. 1. Relative yields for the reaction $e^+e^- \rightarrow$ hadrons versus the total c.m. energy W .

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 ($e^+e^- \rightarrow e^+e^-e^+e^-$ and $e^+e^- \rightarrow e^+e^- \mu^+ \mu^-$). 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

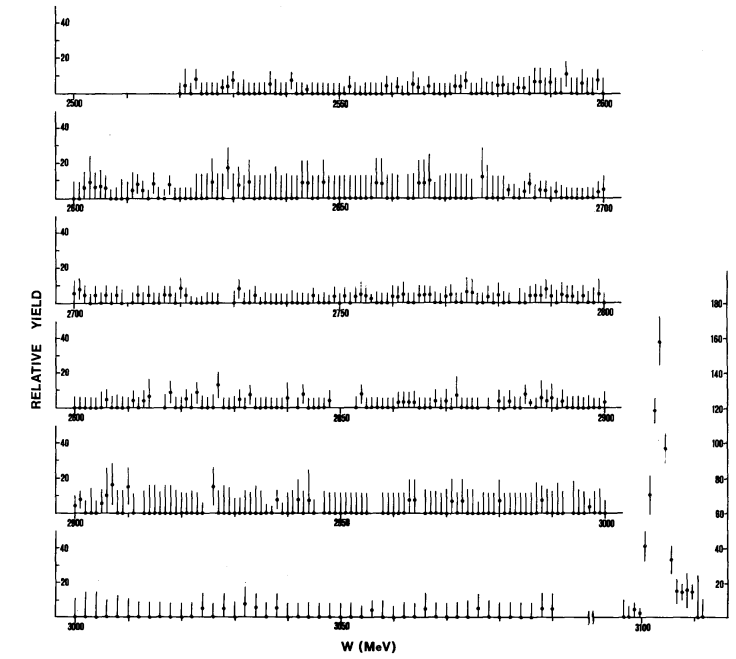


Fig. 1.