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LNF-78/56(P)
29 Novembre 1978

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TOTAL HADRONIC CROSS SECTION FROM e^+e^- ANNIHILATION IN THE TOTAL C. M. ENERGY RANGE 1920-3090 MeV.

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C. Bacci[(x)], R. Baldini-Celio, G. Capon, R. Del Fabbro, G. De Zorzi[(x)], M. Grilli[(o)], E. Iarocci, G. La Rosa, C. Mencuccini[(+)], G. P. Murtas, G. Penso[(x)], M. Spinetti, B. Stella[(x)] and V. Valente :

TOTAL HADRONIC CROSS SECTION FROM e^+e^- ANNIHILATION IN THE TOTAL C. M. ENERGY RANGE 1920-3090 MeV.

The total cross section for the reaction

$$e^+ e^- \longrightarrow \text{hadrons} \qquad (1)$$

has been measured at Adone storage ring, in the total c. m. energy range 1920 - 3090 MeV.

The experimental apparatus (Fig. 1), already described in detail[(1, 2)], consists mainly of two large semicylindrical telescopes (plastic scintillators, lead converters and optical spark chambers) located above and below the interaction region with their axes perpendicu-

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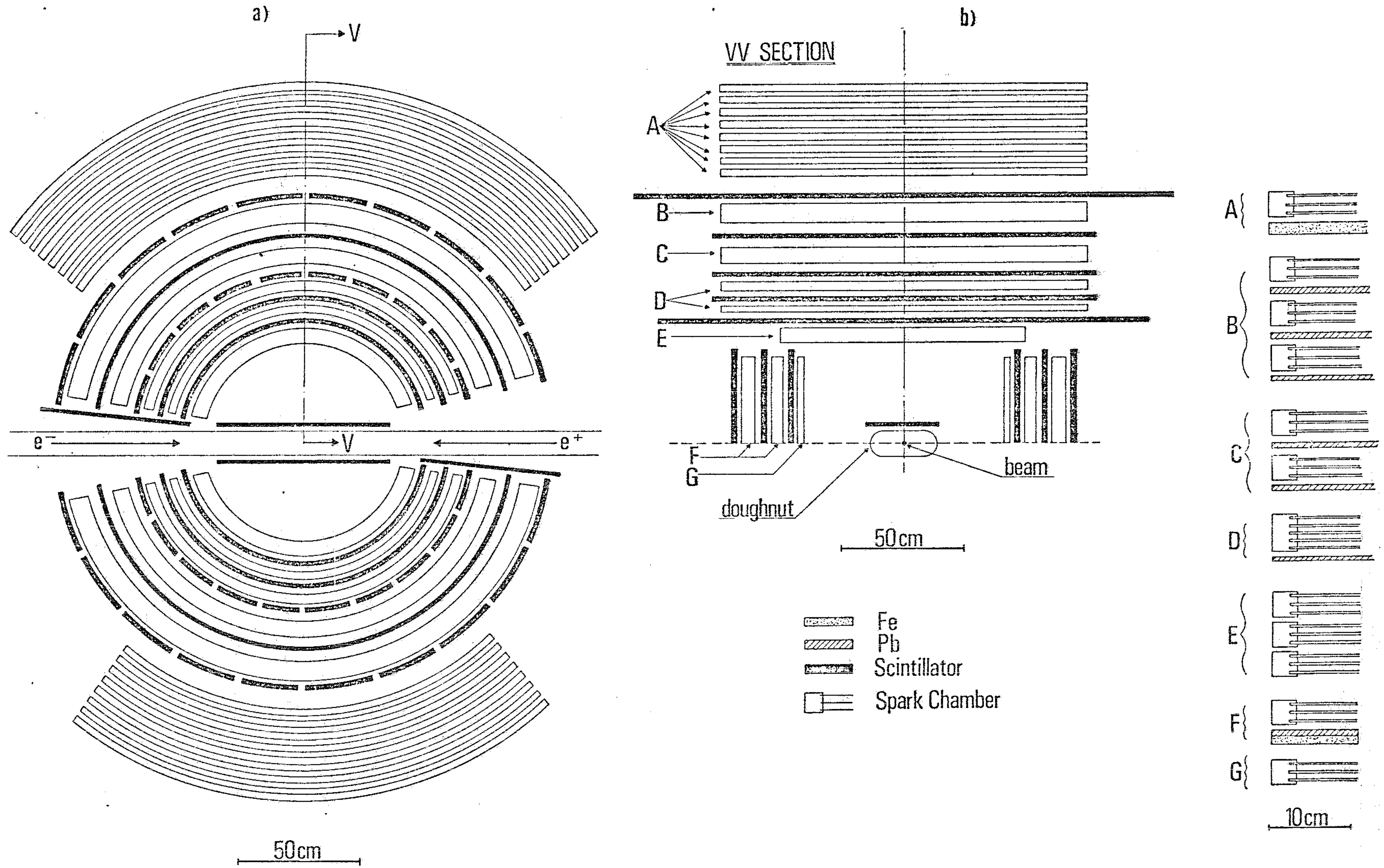

FIG. 1 - Experimental set-up.

lar to the beam line. The solid angle covered by the set up is $0.41 \times 4\pi$ sr for the triggering counters and $0.66 \times 4\pi$ sr for the optical spark chambers. The total thickness of 5.5 radiation length allows us to detect photons with a good efficiency.

The trigger logic requires a coincidence between the upper and the lower telescopes. Each telescope can be triggered by only one charged particle with a kinetic energy $T_\pi \geq 120$ MeV ($T_k \geq 190$ MeV). If photons enter one telescope firing the trigger counters, this limit becomes $T_\pi \geq 35$ MeV ($T_k \geq 60$ MeV).

The present results are relative to 1302 events already analyzed[2, 3] in order to search for narrow resonances. They correspond to a total integrated luminosity of 247 nb^{-1} measured by detecting wide angle Bhabha scattering in the apparatus.

The selection criteria require a charged prong in each telescope plus at least another particle (track or photon) in the apparatus. The events coming from $\gamma\gamma$ interactions are identified by means of two tagging counters[4] placed in the Adone bending magnets immediately upstream and downstream with respect to the apparatus. These events are a small fraction of the total number of events, and have not been taken into account in our analysis. Background coming from beam-gas interactions has been estimated by running the machine with a single beam. Practically all these events give only two tracks in the apparatus and therefore are not accepted by our selection criteria.

The selected events are classified into different categories according to the number of observed tracks and photons. The number n_k of events collected in the k-th category is given by:

$$n_k = L \sum_i \varepsilon_{ki} \sigma_i \tag{2}$$

where: L is the integrated luminosity; ε_{ki} is the efficiency for detecting the i-th reaction in the k-th category; σ_i is the corresponding cross section. In evaluating ε_{ki} by Monte-Carlo method, we have assumed that only pions are produced, with a total multiplicity ≤ 8 and with an invariant phase space distribution.

From the linear system (2) the cross section $\sigma_i(W)$ are extracted by a standard maximum likelihood method.

The results, reported in table I are given in terms of R defined by $R = \sum_i \sigma_i / \sigma_{\mu\mu}$. Radiative corrections have not been applied. The quoted errors are statistical only. Systematic energy independent errors are estimated to be $\sim 10\%$ on monitoring and $\sim 15\%$ on efficiency calculations. Furthermore, if the hypothesis that only pions are produced is not correct, an extra energy dependent systematic error is present: in particular if two charged kaons replace two charged pions in all the final states, the detection efficiencies would be practically the same at W = 3 GeV, but would be lowered by a factor ≈ 2 at W = 2 GeV. Of course this effect must be weighted by the fraction of kaons present at the different energies, which is not measured by our experiment.

The improved quality of the present results compared to those obtained by the first generation experiments[(5)] at Adone comes essentially from the larger energy and angular acceptance of the apparatus: this implies less of a dependence of the efficiency on the multiplicities.

In fig. 2 the present results are reported together with other values measured in this energy region; the agreement is satisfactory. Between ~ 1.9 and ~ 2.5 GeV, the data show a possible rise of about half unit of R; this can by interpreted[(6)] as the full opening of the strange degree of freedom.

The average charged $\langle n_c \rangle$ and neutral $\langle n_o \rangle$ multiplicities have been estimated as a function of W. The results are presented in

Table I and fig. 3 together with the data from SLAC-LBL collaboration[7]. The agreement is quite good.

TABLE I

W (MeV)	R	$\langle n_c \rangle$	$\langle n_o \rangle$
1920 - 2000	1.74 ± .17	3.20 ± .11	1.75 ± .15
2000 - 2100	1.86 ± .19	3.35 ± .11	1.85 ± .15
2100 - 2200	2.09 ± .13	3.53 ± .07	1.90 ± .10
2200 - 2540	2.69 ± .27	3.38 ± .11	1.90 ± .15
2540 - 2640	2.89 ± .29	3.40 ± .12	2.35 ± .16
2640 - 2760	2.99 ± .30	3.63 ± .12	2.40 ± .16
2760 - 2980	2.38 ± .19	3.60 ± .11	2.25 ± .15
2980 - 3090	2.46 ± .27		

The solid line (a) of fig. 3 is an overall fit [8] to the SLAC-LBL data[7], given by $\langle n_c \rangle = 2.1 + 1.4 \ln W$. Using this formula together with a linear fit to the charged energy fraction $\langle E_c/W \rangle$ measured by that experiment[7], and assuming that charged and neutral pions have the same momentum distribution, we have deduced the solid line b) of fig. 3. Above 2.5 GeV our charged and neutral multiplicities are compatible with these high energy fits, while at lower energy $\langle n_c \rangle$ ($\langle n_o \rangle$) seems to be higher (lower) with respect to the fit. This effect seems to be confirmed by a preliminary analysis of lower energy data.

The results on multiplicity previously obtained at Adone[5] are in agreement with the present value. Work is in progress to extend present results to lower energies.

We would to thank Mrs. M. A. Melorio and Mr. V. Bidoli for their very efficient collaboration.

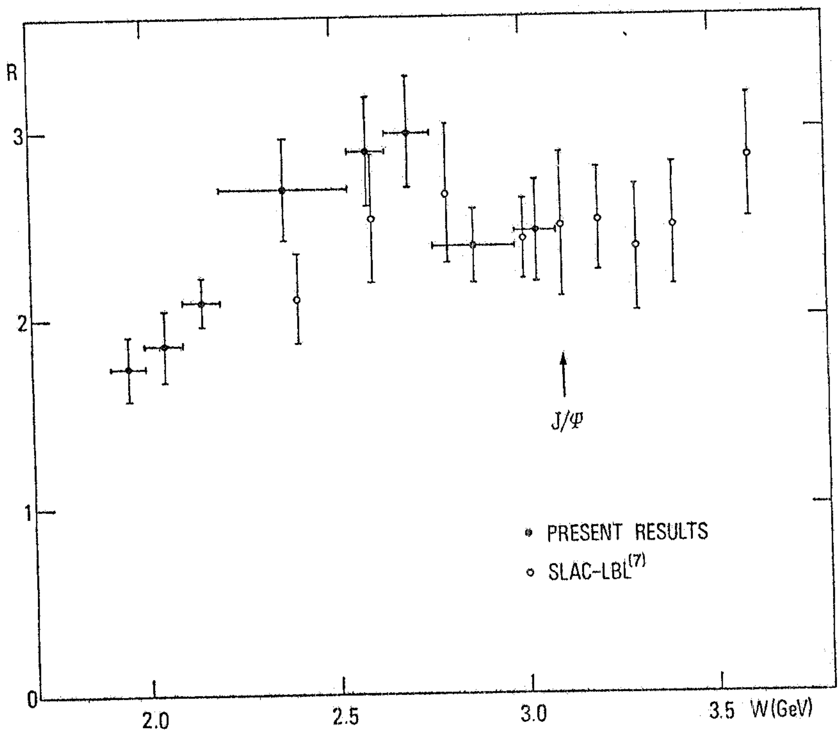

FIG. 2 - $R = \sigma(e^+e^- \rightarrow \text{hadrons})/\sigma(e^+e^- \rightarrow \mu^+\mu^-)$ vs. total c. m. energy W.

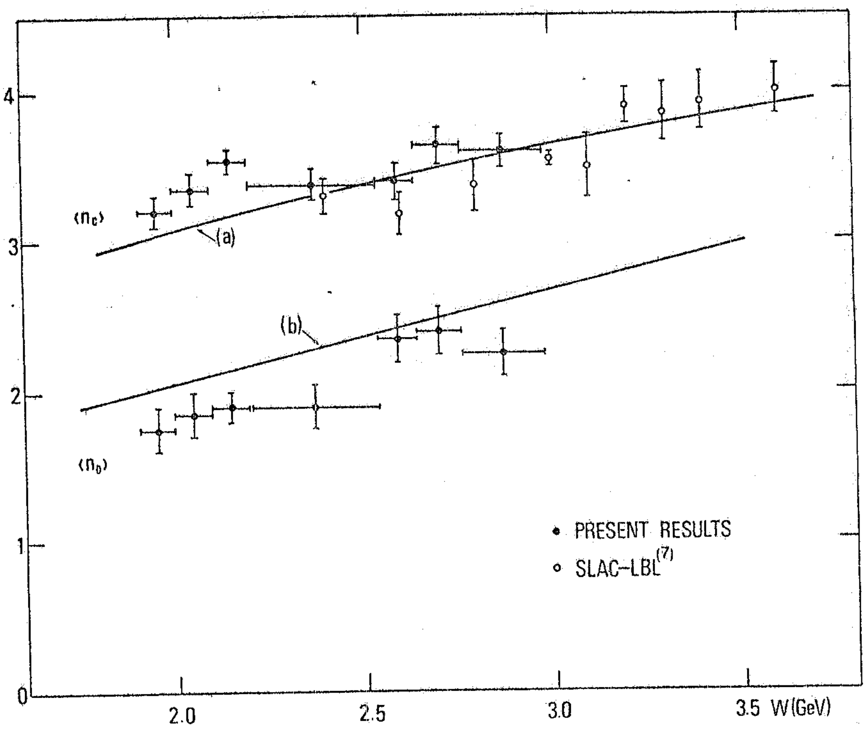

FIG. 3 - Average charged $\langle n_c \rangle$ and neutral $\langle n_0 \rangle$ hadrons multiplicity vs. total c. m. energy W. Solid line (a) is a fit to higher energy data[7]. Solid line (b) is deduced as explai ned in text.

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