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24 Gennaio 1975

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 $e^+e^- \rightarrow$ PHOTONS AT THE 3.1 GeV RESONANCE.

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EXPERIMENTAL RESULTS ON THE REACTION $e^+e^- \rightarrow$ PHOTONS
AT THE 3.1 GeV RESONANCE.

In this letter we report some preliminary results of a research
on the channels:

$$(1) \quad e^+e^- \rightarrow \pi^0 \gamma, \eta \gamma (\eta \rightarrow \gamma \gamma)$$

$$(2) \quad e^+e^- \rightarrow \gamma \gamma$$

performed at Adone at energies around the 3.1 GeV resonance. Upper limits
for the cross sections of the channels (1) have been obtained. As far as
reaction (2) is concerned, within the limits of the statistics so far collected,
the results are not inconsistent with the QED predictions.

The experimental set-up has been already described elsewhere⁽¹⁾.
Here we give a more detailed description of the shower detector (SD),
since it is the relevant component of the apparatus as far as the photon

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detection is concerned. The total solid angle of SD for a point-like source is $0.41 \times 4\pi$ sterad for trigger and $0.66 \times 4\pi$ sterad for tracking. The polar angle θ ranges between 30° and 150° . A sketch of the counter and converter arrangement is shown in Fig. 1. In order to detect the reactions (1) and (2) at least two photons are required, one in each of the two

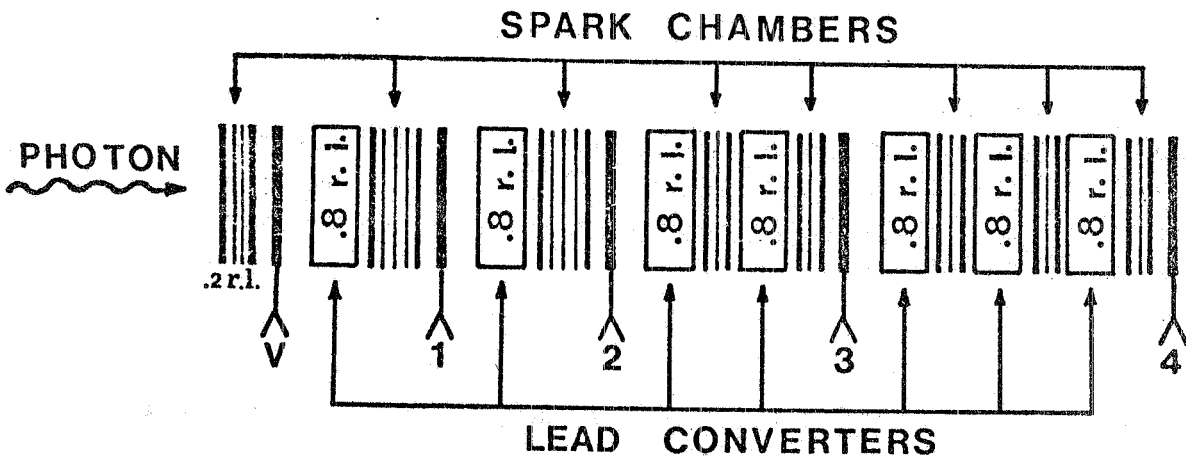


FIG. 1 - A sketch of one of the two main telescopes of the experimental apparatus: scintillation counter, spark chamber and converter arrangement in the shower detector (SD). V, 1, 2, 3 and 4 are scintillation counters.

main telescopes of the set-up. In this case, a photon is defined by the coincidence (see Fig. 1):

$$\bar{V} [(1 \cdot 2 \cdot 3) + (2 \cdot 3 \cdot 4)]$$

A fraction of about 20% of the incident photons converts in the material in front of the veto counter V, thus escaping detection. For the surviving photons the trigger requirement corresponds to a trigger detection efficiency of $\sim 75\%$ for high energy photons⁽²⁾ ($E_\gamma \geq 500$ MeV). Full tracking efficiency is reached in the shower detector for photon energies of about 200 MeV.

EXPERIMENTAL RESULTS. -

This letter refers to a sample of events, in which only photons are detected in the shower detector. In selecting these events, it was required that no charged particle was present either in the main detector (shower detector and side telescopes of ref. 1), or in the forward e^+ tagging system installed inside the Adone bending magnets. The sample of these events was collected in a total integrated luminosity of 19 nb^{-1} at energies ranging from 3090 to 3110 MeV. According to the detected topologies, this sample may be divided into three main classes:

i) two-photon coplanar (within $\pm 5^\circ$) with the beam line: 41 events, whose collinearity distribution is shown in Fig. 2. A collinearity cut of 15° reduces the sample to 39 events.

ii) two-photon non coplanar with the beam line: 10 events.

iii) three-photon configurations: no event at the resonance energy (3098-3104 MeV).

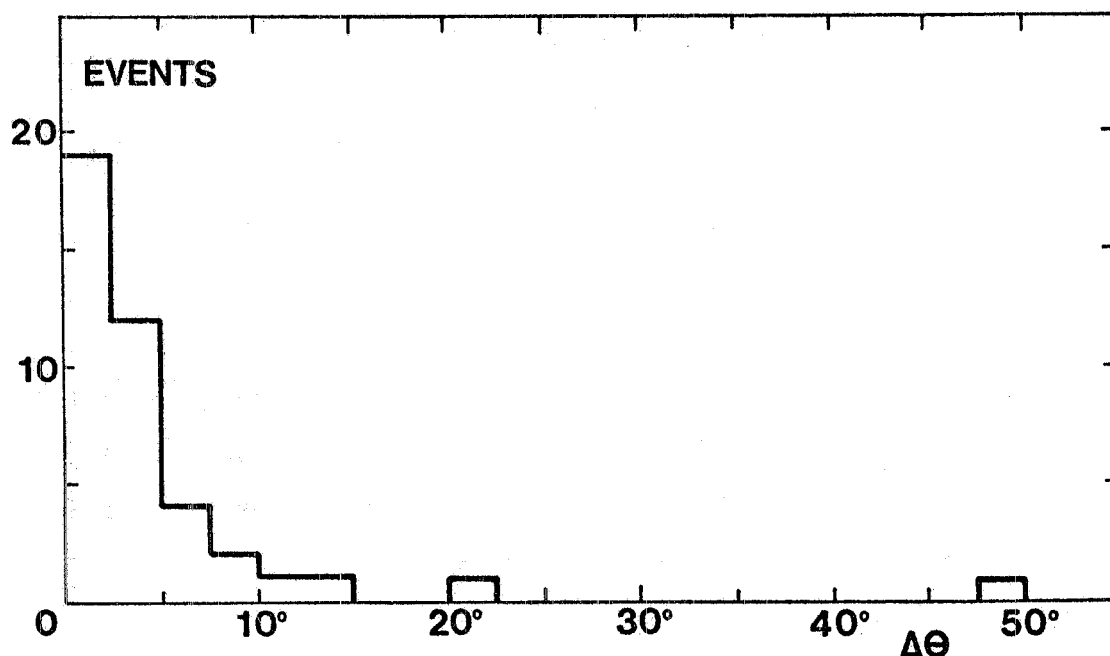


FIG. 2 - Collinearity distribution for two-photon events coplanar with the beam line.

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DATA ANALYSIS.

Reactions(1) have been looked for by considering the configurations with three detected photons in the shower detectors. With the condition that the energy of any photon has to be higher than 200 MeV (full tracking efficiency), our Monte Carlo calculation shows that for reactions (1) the three-photon configuration is favoured by a factor of about 2.5 with respect to the two-photon one.

The absence of three-photon events in the resonance region $[(3101 \pm 3) \text{ MeV}]$ allows us to give the following upper limits for the energy integral of the cross sections at the 3.1 GeV resonance:

$$(3) \quad \int_{3098}^{3104} \sigma_{\pi^0 \gamma}(W) dW < 27 \text{ nb MeV (90\% c.l.)}$$

and

$$(4) \quad \int_{3098}^{3104} \sigma_{\eta \gamma}(W) dW < 89 \text{ nb MeV (90\% c.l.)}$$

In evaluating these upper limits, radiative corrections have not been taken into account. Use was made of the known branching ratio

$$(\eta \rightarrow \gamma \gamma) / (\eta \rightarrow \text{all modes}) = 0.38.$$

By comparing (3) and (4) with the corresponding energy integral of the cross section $\sigma_h(e^+e^- \rightarrow (3.1) \rightarrow \text{many hadrons})$ simultaneously measured by the set-up, the following upper limits for the ratios of the partial decay rates of the 3.1 GeV resonance are found:

$$(5) \quad \frac{\Gamma(\pi^0 \gamma)}{\Gamma_h} < 0.5\% \quad (90\% \text{ c.l.})$$

and

$$(6) \quad \frac{\Gamma(\eta \gamma)}{\Gamma_h} < 1.6\% \quad (90\% \text{ c.l.})$$

With these upper limits, the maximum contamination from the processes (1) to the sample of two-photon collinear events is estimated to be less than 5% (90% c.l.). The excitation curve of the 39 collinear events (class i) is shown in Fig. 3, where the dashed horizontal line, represents the level of the e^+e^- annihilation into two photons reaction, as deduced by averaging the first and the last point. This level turns out to be consistent with the QED predictions as estimated by a Monte Carlo program which takes into account the experimental features of the set-up.

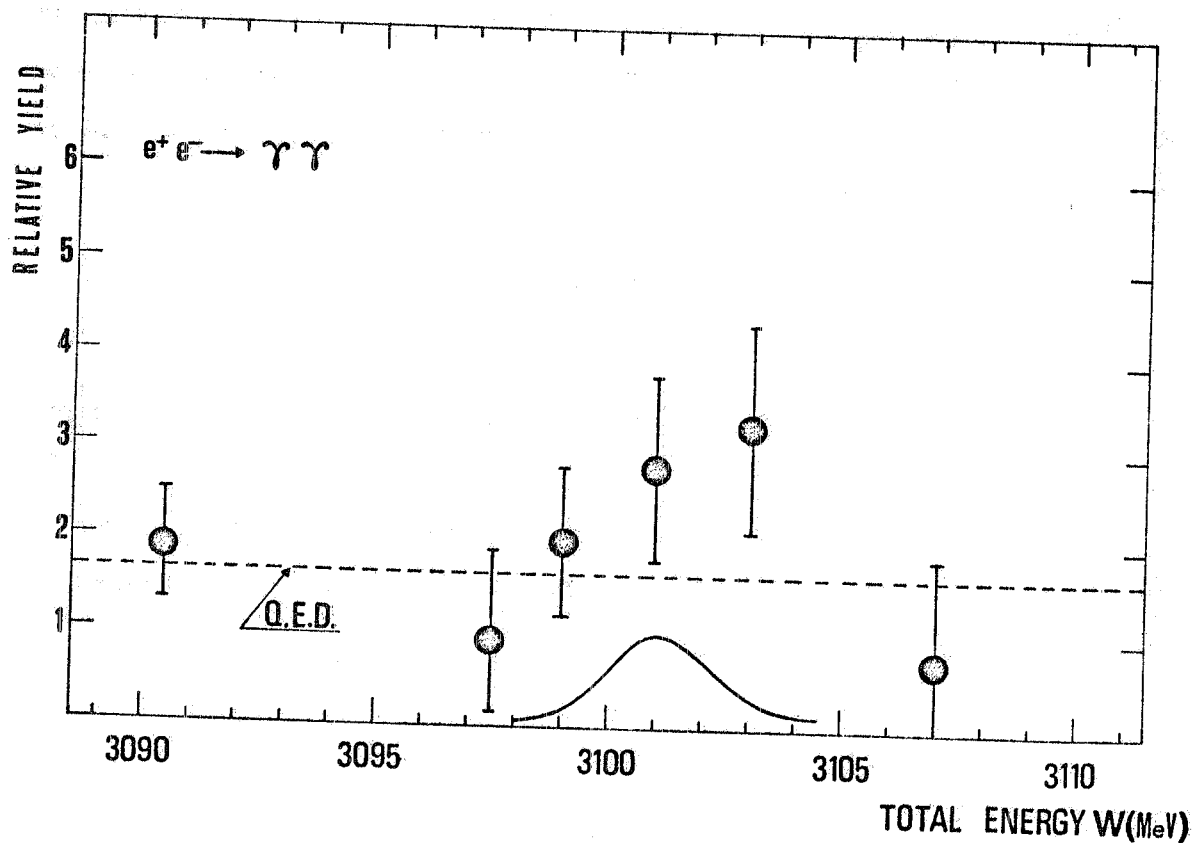


FIG. 3 - Relative yield for the production of collinear photon pairs as a function of the total c.m. energy. The absolute value of this energy at Adone is known to ± 4 MeV. The horizontal dashed line represents the $e^+e^- \rightarrow \gamma\gamma$ level as deduced by averaging the first and the last point. The position and shape of the 3.1 GeV resonance is also shown.

In Fig. 3 the position and shape of the 3.1 GeV resonance is also shown, as deduced from the many hadron excitation curve in the same set-up.

The absolute luminosity was measured by the small angle Bhabha scattering and the double bremsstrahlung as detected by the monitoring system of the machine group. This luminosity measurement is consistent with the wide angle Bhabha scattering detected in our set-up outside the resonance (see ref. 1). Although one may feel that there is an excess of rate in the resonance region, we observe that, within the rather large statistical errors, the data are consistent with the QED expectations. An estimate of the order of magnitude of a possible enhancement of the yield at the resonance is given by the ratio r between the experimental rate in the resonance region and outside it:

$$r = \frac{\gamma\gamma \text{ yield } (3098 \leq W \leq 3104)}{\gamma\gamma \text{ yield } (W < 3098; W > 3104)} = 1.6 \pm 0.6$$

Data collection is in progress in order to reduce the statistical error on this figure.

While sending this paper to the press, we received the first results of a similar research going on at Doris⁽³⁾. These data are consistent with our results.

We warmly thank the machine group for the excellent running of Adone and the continuous support provided to the experiment. A particular thank is due to V. Bidoli for his unvaluable technical assistance during the measurement.

The stimulating discussions with R. Gatto, N. Cabibbo and the Frascati theoretical group are also deeply acknowledged.

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