Observation of the decay η → π0γγ — Source link

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Published on: 01 Oct 1982 - Nuovo Cimento Della Societa Italiana Di Fisica A-nuclei Particles and Fields (Società Italiana di Fisica)

Topics: Branching fraction and Hodoscope

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-EP/82-74
June 14th, 1982

OBSERVATION OF THE DECAY $\eta \to \pi^0\gamma\gamma$

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CERN, Geneva, Switzerland

In memory of A.V. Starzev
who passed away unexpectedly on the 14th June 1981

ABSTRACT

The rare radiative decay $\eta \to \pi^0\gamma\gamma$ has been effectively observed and studied at the 70 GeV IHEP accelerator with the hodoscope spectrometer GAMS-2000. The branching ratio for this decay is found to be BR $(\eta \to \pi^0\gamma\gamma) = (9.5 \pm 2.3)\cdot 10^{-4}$.

Submitted to Nuovo Cimento

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OBSERVATION OF THE DECAY $\eta \to \pi^0\gamma\gamma$

1. INTRODUCTION

A previous experiment at IHEP has shown [1] that the branching ratio for the radiative decay of the η meson into π^0 and a photon pair

$$\eta \to \pi^0\gamma\gamma \tag{1}$$

is smaller than 0.3%, bringing an end to a long lasting controversy [2] between current theoretical values lower than 10^{-2} and experimental results of up to 10^{-1} which casted some doubts on schemes like PCAC, current algebra, etc. Apparently experiments in which this process was thought to have been observed have been measuring a contamination mainly due to the intense decay channel

$$\eta \to 3\pi^0 \tag{2}$$

Measurements that have been pursued at the IHEP accelerator have allowed to observe this decay mode for the first time (1). The present work is devoted to these new results.

2. EXPERIMENTAL PROCEDURE

The measurements have been performed with η mesons produced by 30 GeV/c negative pions in the charge-exchange reaction [5]

$$\pi^- p \to \eta\ n. \tag{3}$$

The hodoscope Cerenkov spectrometer GAMS-2000 (for details concerning the set-up see [1,6,7]) has been used to detect the photons emitted by the decaying η's. More details about the spectrometer will be given in a forthcoming paper. Only the modifications which have been brought to the experimental set-up used in the previous work [1] are mentioned here.

The distance L between the liquid-hydrogen target [7] and GAMS has been increased from 9 m to 12 m and the momentum of the π^- beam has been lowered by 30%. The distance between γ-showers impacts on the spectrometer is as a consequence increased by 70%. As a result, spurious processes (like (2)), which could be confused with decay (1) when showers overlap, are better identified. Simultaneously this has brought an improvement of the mass resolution of GAMS for decaying particles ($\sigma_M/M \simeq 1\%$) and easier working conditions for the shower reconstruction programs.

The π^- beam intensity has been increased up to 1.5×10^7 per burst for a proton spill on the internal target of 1.5 s, at the cost of a more intense irradiation of GAMS. In order to avoid a gradual blackening of the lead glass cells which are nearest to the beam, the central radiator cells of GAMS have been replaced by other ones made of a special glass 80 times more radiation resistant [8].

In these conditions the number of events

$$\pi^- p \to M^0 n, \quad M^0 \to m\gamma \qquad (4)$$

detected by the spectrometer, after selection by the trigger system, amounted to ∿ 300 per beam burst. Fast processors have been added to the data acquisition system. They allow to compute the total energy release $\tilde{E} = \Sigma\alpha_j A_j$ and the first radial moment $\tilde{M}_r = \Sigma a_j A_j r_j/L$ of the showers in GAMS, (A_j is the magnitude of the signal in the j-th counter, r_j is its distance to the beam axis and α_j is its normalisation coefficient). The α_j values are determined experimentally during the calibration of GAMS in a 25 GeV/c electron beam [6,7] and are stored in the memory of the processors.

$\tilde{M}_r^2$ is proportional to $(M^2 + p_T^2)$, where M and p_T are the mass and the transverse momentum of the decaying particle, respectively. The selection of events having radial momenta $\tilde{M}_r$ above $\sim$ 350 MeV eliminates most of pion charge exchange processes $\pi^- p \to \pi^0 n$ [9], without affecting the detection efficiency for η mesons. The number of events stored into the computer HP 2100 A is thus brought down to $\sim$ 100 events/pulse only.

During the four days of data taking, 3×10^{11} π^- have reached the liquid-hydrogen target leading to the production of 600,000 η mesons in $\pi^- p \to \eta\, n$ reaction. This number is 30 times larger than the statistics in our previous experiment and in all other works which were devoted to the study of decay (1), altogether. The background due to η decaying into $3\pi^0$ and other processes, which may simulate decay (1), has been lowered at the same time by more than one order of magnitude leading to a level sensitivity $\ll 10^{-3}$ for decay (1).

3. RECONSTRUCTION AND SELECTION OF EVENTS

Data written on magnetic tape (about 2,5 million triggers) have been processed with the help of a set of programs allowing to reconstruct and to make the kinematical analysis of the events [1,7].

The new reconstruction program looks for showers and evaluates the coordinates and energy of each γ making use of the information gathered on shower shape and fluctuations during the calibration of the spectrometer with electrons of 10 GeV and 25 GeV. Events are sorted out according to the multiplicity m of γ's emitted in reaction (4). It has been much improved with regard to the version used in our previous work [1], giving a better separation of near-lying showers. Classification ambiguities are much reduced. Less than a few per cent of events need to be transferred between adjacent classes m and m $\pm$ 1 during the course of analysis. Technical improvements of the spectrometer GAMS have brought the minimum energy threshold for γ-detection down to $E_{\gamma min} = 0.15$ GeV, resulting in better constraints on decay (2) and a large reduction of the main background.

Events classified in class m = 4 have been retained for further kinematical analysis. Those which satisfy the kinematics of reactions

$$\pi^- p \rightarrow \pi^0 \pi^0 n, \qquad (5)$$

$$\pi^- p \rightarrow K^0_S \Lambda, \quad K^0_S \rightarrow 2\pi^0 \qquad (6)$$

or $\pi^- p \rightarrow \eta\pi^0 n$ [10], with $\chi^2 < 12$ (99% confidence level), have been discarded. The compatibility of the remaining events with the hypotheses $M^0 \rightarrow \pi^0\gamma\gamma$ and $M^0 \rightarrow \eta\gamma\gamma$ has been checked. If the value of χ^2 is smallest and not larger than 7 (97% confidence level). When the first hypothesis is retained, events are further considered as possible candidates for reaction

$$\pi^- p \rightarrow \pi^0 \gamma\gamma n. \qquad (7)$$

Then, the region of small M^0 transverse momenta $p_T < 0.3$ GeV/c has been excluded in order to reduce the background,. At the cost of a 20% loss of good events (3)[5], this allowed to suppress the contribution of reactions like (5), which, going through one-pion exchange, are concentrated at small p_T [11], and the contribution of fortuitous coincidences.

Contamination due to reactions like (5) and (6),giving π^0 pairs in the final state, is further suppressed by selecting events where the mass corresponding to the pair of non correlated γ's in (7) is larger than 180 MeV/c^2 only. Of these reactions, the most tricky source of background is certainly (6) (in the case where the K^0_S decays at a few meters from the target). The detection of the decay products of the recoil hyperons by the counters of the guard system, which surrounds the target in the set-up, allowed to reduce the contribution of reaction (6) to the level of a few percents of the main process (3).

The minimum value of energy threshold $E_{\gamma min}$ has only been used in the γ-reconstruction program in order to reduce as much as possible the main background which comes from decay (2), when any two γ's are being missed. One drawback of such a low threshold is that the program sometimes finds spurious low energy γ's generated by the noise of the counters and of the electronics of the spectrometer. At the stage of the kinematical analysis, a quite higher energy threshold for the γ's, E_{th}, has been used. By increasing E_{th}, the above mentionned instrumental background decreases fastly.

4. MASS SPECTRA

The effective mass spectrum of the $\pi^0\gamma\gamma$ system, constructed from the events which have passed through the selection procedure described above, is shown in fig. 2(a). A narrow peak, with a statistical significance exceeding 7 standard deviations, shows up in the region of the η mass.

This peak has been fitted with a Gaussian distribution $F_g(M - \bar{M}, \sigma_M)$, the parameters $\bar{M}$ and σ_M and the normalisation being left free. The background part of the spectrum, which is bell-shaped with a maximum near 500 MeV, has been fitted with a polynomial function $F_b(M)$. This procedure provides a statistically significant description of the measured spectrum as $\chi^2/n_D \lesssim 1$ (e.g.figs. 2(a) and 2(b)).

The evaluated $\bar{M}$ value is found to be independent of the threshold energy E_{th}, value between 0.5 GeV and 3.5 GeV. It is equal to (549 ± 2) MeV/c², a value which agrees within 0.2% with the tabulated η mass.

The region of the mass spectrun around 1 GeV/c² has been studied to check the linearity of the spectrometer and the accuracy of its calibration. Here too a peak appears in the mass spectrum of the $\pi^0\gamma\gamma$ system. It is due to the rare decay $\eta' \to \omega\gamma \to \pi^0\gamma\gamma$ (BR = 2×10^{-3}) [2] of η'(958) mesons produced in reaction (4). The final state topology is the same as that of decay (1). The position of the η' peak agrees to 0.4% with the value given in the tables for the η' mass. The measured value of the K^0_S mass in reaction (6) is also in good agreement (0.3%) with the tables, which demonstrates the accuracy of the mass scale of GAMS.

The width of the η-peak shows also no dependence on the γ energy threshold E_{th}. The value $\sigma_M = (7.2 \pm 1.5)$MeV/c² obtained in the fit, agrees with the intrinsic resolution of the apparatus (8.5 MeV/c²).

5. SIMULATION PROCEDURE

A simulation procedure based on a bank of measured showers has been developed to determine the registration efficiency for decay (1) and the value of $BR(\eta \to \pi^0\gamma\gamma) = \Gamma(\eta \to \pi^0\gamma\gamma)/\Gamma(\eta \to all)$.

Well separated γ's from the decay $\eta \to 2\gamma$, which are detected in the spectrometer together with those produced in decay (1), have been used as a source of real individual showers. The set of amplitudes A_j in the "fired" cells of showers produced by 150.000 γ's of various energies have been stored in a spectrometer data bank.

In a first stage, events produced in reaction (3) have been generated by the method of Monte-Carlo using the known t-dependence of the differential cross-section [5]. The phase space distribution has been assumed to be uniform. Further, the information stored in the bank of showers has been used for each γ entering GAMS. After, the generated events have been analysed with the help of the very same set of programs which has been used for the analysis of the experimental data. The detection efficiency ε of the spectrometer determined in this way takes naturally into account the acceptance of the set-up, the efficiency of the programs ensuring the reconstruction and the kinematical analysis and the selection criteria for the events.

In order to check the accuracy of this procedure, simulated values of ε have been determined for both decays $\eta \to 2\gamma$ and $\eta \to 3\pi^0$. They have been compared with the number of events detected in the spectrometer.

The efficiency ε decreases quickly as the multiplicity m increases, essentially following the relationship $(1 - mE_{th}/E)^m$. For the considered decays, ε amounts to 0.8 (m = 2) and to 0.23 (m = 6) with E_{th} = 0.5 GeV. Notwithstanding such a large difference, the ratio of decay widths $\Gamma(\eta \to 2\gamma)/\Gamma(\eta \to 3\pi^0)$ obtained from the number of events found experimentally and the calculated efficiencies, agrees within 10% with the value quoted in table [2].

A smaller error is expected for the detection efficiency in case of decay (1), which has a much simpler topology (m = 4) than decay (2).

6. PARTIAL WIDTH OF THE DECAY $\eta \to \pi^0\gamma\gamma$

The number N of decays $\eta \to \pi^0\gamma\gamma$, observed experimentally for several predetermined values of E_{th}, the threshold energy for γ detection in GAMS, is shown on fig. 3. With increasing threshold energy, N decreases rapidly, in qualitative agreement with the factor $(1-E_{th}(\text{GeV})/7.5)$[4] (see above).

The detection efficiency ε for decay (1) is shown on the same figure (full curve). It has been normalized to the number of measured events with E_{th} = 2GeV (at this point ε = 0.13, taking into account all selection criteria). The calculated curve reproduces well the experimentally observed $N(E_{th})$. This confirms the correctness of the method followed to separate events corresponding to decay (1) from the background.

The partial width for the decay $\eta \to \pi^0\gamma\gamma$ has been deduced from the number of events detected with E_{th} = 2 GeV (the error is minimum at this threshold value) normalized to the number of $\eta \to 2\gamma$ decays measured simultaneously. The resulting ratio of decay widths is $\Gamma(\eta \to \pi^0\gamma\gamma)/\Gamma(\eta \to 2\gamma) = (2.5 \pm 0.6)\cdot 10^{-3}$. From this and from the known branching ratio for the decay $\eta \to 2\gamma$ [2]. It follows that

$$BR(\eta \to \pi^0\gamma\gamma) = (9.5 \pm 2.3)\cdot 10^{-4}. \qquad (8)$$

The largest contribution to the error is statistical (19%). The error also includes a systematic contribution (14%) (including the uncertainty linked with the background subtraction procedure).

The measured ratio of decay widths and the previously measured value of $\Gamma(\eta \rightarrow 2\gamma)$ [12], give $\Gamma(\eta \rightarrow \pi^0\gamma\gamma) = (0.81 \pm 0.22)$ eV.

7. BACKGROUND ANALYSIS

The contribution of various processes to the background part of the spectrum (dashed curve on fig. 2) has been evaluated with the same simulation method, based on a bank of real showers. The simulated events have been submitted to the same treatment and selection procedures as those which were used to construct the experimental mass spectra.

The curve "$2\pi^0$" on fig. 4 shows the mass-spectrum of candidate $\pi^0\gamma\gamma n$ events which could have been confused with $\pi^0\pi^0 n$ events. The analogous contribution from $K_S^0\,\Lambda$ is labelled "K^0". These spectra have been normalized to the number of registred events of each type. The normalization is in good agreement with the known cross-sections for these reactions. The contribution of the process $\pi^- p \rightarrow 3\pi^0 n$ has been determined in the same manner. It appears to be one order of magnitude lower than in the case of $\pi^- p \rightarrow \pi^0\pi^0 n$.

The contribution to the background due to the small number of events belonging to the topological class m = 3 which have been "pumped" into class m = 4 in presence of a spurious shower is represented on fig. 4 by the curve "(3γ)". Its evaluation is based on the observation of similar misclassifications of $\eta \rightarrow 2\gamma$ which are wrongly put in class m = 3.

The contributions of all these reactions to the measured background spectrum F_b are not very large. Their sum is practically constant over the considered mass interval and does not exceed 10% of the η-peak.

In order to simulate the background due to η's decaying into $3\pi^0$, two processes have been considered. The first is linked with such events that have been misdirected in class m = 4 by the reconstruction program (overlapping showers in the spectrometer, γ's of energy lower than the threshold value $E_{\gamma min}$, etc...) though all six γ's have reached the spectrometer. This kind of background is represented on fig. 4, by the curve "η_1".

The second source of $\eta \to 3\pi^0$ background is due to events, where one or two γ's have fallen outside the limits of GAMS and have not been registered by the guard-system counters [7] due to some inefficiency of these for low energy γ's. This background is represented on fig. 4 by the curve "η_2". Its normalization depends on the number $\eta \to 3\pi^0$ decays and also on the efficiency of the aperture defining counters. It has been determined by comparing measured and simulated 5-γ spectra in the neighbourhood of the η mass.

The spectrum obtained after summation of all contributions to the background, is represented on fig. 4, by the curve "Σ". The main source of background observed in the mass spectrum of the $\pi^0\gamma\gamma$ events (fig. 2) is clearly the decay $\eta \to 3\pi^0$. Though only 0.5% of these decays after selection are responsible for the main part of the background, it is fairly accurately described (compare curves F_b and Σ on fig. 4) by the simulation procedure.

8 DISCUSSION

Starting with the paper of Okubo and Sakita [13] a series of works in which various theoretical models have been applied [3,4,14-20] have been devoted to the calculation of decay (1) $\eta \to \pi^0\gamma\gamma$, The width of this decay (1) has been found to be very sensitive on the choice of the model. Values of BR ($\eta \to \pi^0\gamma\gamma$) vary by five orders of magnitude, from $6 \cdot 10^{-7}$ up to $6 \cdot 10^{-2}$.

The experimental value (8) considerably reduces the variety of theoretical models which might claim to describe the radiative meson decays.

The nearest theoretical estimates (BR $\sim 10^{-3}$) have been obtained with models considering process (1) as mediated by the exchange of vector mesons (vector meson dominance model and similar models).

We would like to thank A.T. Filippov, S.S. Gerstein, and L.D. Soloviev for enlightning discussions concerning the results. We thank the Directorates of CERN and IHEP for their support to this experiment.

REFERENCES

[1] F. Binon, C. Bricman, V.A. Davydov, S.V. Donskov, J. Dufournaud, P. Duteil, M. Gouanère, A.V. Inyakin, V.A. Kachanov, D.B. Kakauridze, G.V. Khaustov, A.V. Kulik, J.P. Lagnaux, A.A. Lednev, Yu.V. Mikhailov, J.P. Peigneux, Yu.D. Prokoshkin, Yu.V. Rodnov, S.A. Sadovsky, A.V. Singovsky, A.V. Starzev, J.P. Stroot, and V.P. Sugonyaev;
Yad. Fiz. 33 (1981) 1534;
Nuovo Cimento Lett. 32 (1981) 45;
See also the Literature quoted there.

[2] Particle Data Group, Rev. Mod. Phys. 52 (1980) 70.

[3] G. Oppo and S. Oneda; Phys. Rev. 160 (1967) 1397.

[4] T.P. Cheng; Phys. Rev. 162 (1967) 1734.

[5] W.D. Apel, K.H. Augenstein, E. Bertolucci, Yu.B. Bushnin, S.V. Donskov, R. Franceschini, M. Givoletti, M.I. Grachev, A.V. Inyakin, R. Johnson, V.A. Kachanov, W. Kittenberger, R.N. Krasnokutsky, M. Krüger, G. Leder, A.A. Lednev, I. Mannelli, Yu.V. Mikhailov, H. Müller, R. Oberparleiter, M. Pernicka, G.M. Pierazzini, Yu.D. Prokoshkin, M. Quaglia, D. Schinzel, H. Schneider, A. Scribano, F. Sergampietri, R.S. Shuvalov, G. Sigurdsson, H.M. Staudenmaier, M. Steuer, A. Thys, A.N. Toropin and M.L. Vincelli;
Yad. Fiz. 29 (1979) 1519;
Nucl. Phys. B152 (1979) 1.

[6] F. Binon C. Bricman, V.A. Davydov, S.V. Donskov, J. Dufournaud, P. Duteil, M. Gouanère, A.V. Inyakin, V.A. Kachanov, D.B. Kakauridze, G.V. Khaustov, A.V. Kulik, J.P. Lagnaux, A.A. Lednev, Yu.V. Mikhailov, J.P. Peigneux, Yu.D. Prokhoshkin, Yu.V. Rodnov, R. Roosen, S.A. Sadovsky, D. Sillou, A.V. Starzev, J.P. Stroot, and V.P. Sugonyaev;
Nucl. Instr. Meth. 188 (1981) 507.

[7] F. Binon, V.A. Davydov, S.V. Donskov, J. Dufournaud, P. Duteil, M. Gouanère, A.V. Inyakin, V.A. Kachanov, D.B. Kakauridze, G.V. Khaustov, Yu. S. Khodirev, A.V. Kulik, J.P. Lagnaux, A.A. Lednev, Yu. V. Mikhailov, J.P. Peigneux, Yu.D. Prokoshkin, Yu.D. Rodnov, R. Roosen, S.A. Sadovsky, A.V. Starzev, J.P. Stroot, V.P. Sugonyaev and A.E. Yakutin;
Yad. Fiz. 33 (1981) 1244;
Zeit. Phys. C. 9 (1981) 109.

[8] A.V. Inyakin, D.B. Kakauridze, A.A. Lednev, Yu.D. Prokoshkin, and A.V. Singovsky;
Preprint IHEP 82-6, Serpukhov;

[9] W.D. Apel, K.H. Augenstein, E. Bertolucci, S.V. Donskov, A.V. Inyakin, R. Johnson, V.A. Kachanov, R.N. Krasnokutsky, M. Krüger, G. Leder, A.A. Lednev, I. Mannelli, Yu.V. Mikhailov, H. Müller, G.M. Pierazzini, Yu.D. Prokoshkin, M. Quaglia, D. Schinzel, H. Schneider, A. Scribano, F. Sergampietri, R.S. Shuvalov, G. Sigurdsson, M. Steuer, A.N. Toropin and M.L. Vincelli;
Yad. Fiz. 30 (1979) 373;
Nucl. Phys. B154 (1979) 189.

[10] W.D. Apel, K.H. Augenstein, E. Bertolucci, S.V. Donskov, A.V. Inyakin, V.A. Kachanov, R. Abdel Khalek, R.N. Krasnokutsky, M. Krüger, G. Leder, A.A. Lednev, I. Mannelli, Yu.V. Mikhailov, H. Müller, G.M. Pierazzini, Yu.D. Prokoshkin, M. Quaglia, H. Schneider, A. Scribano, F. Sergiampietri, R.S. Shuvalov, G. Sigurdsson and M.L. Vincelli;
Nucl. Phys. B193 (1981) 269.

[11] V.N. Bolotov, V.V. Isakov, D.B. Kakauridze, Yu.D. Prokoshkin, S.A. Sadovski and G.V. Khaustov;
Yad. Fiz. 24 (1976) 106.

[12] A. Browman, J. DeWire, B. Gittelman, K.M. Hanson, R. Lewis and E. Loh;
Phys. Rev. Lett., 32 (1974) 1067.

[13] S. Okubo and B. Sakita; Phys. Rev. Lett. 11 (1963) 50.

[14] W. Alles, A. Baracca and A. Tiemblo Ramos;
Nuovo Cimento., 45A (1966) 272.

[15] G.J. Gounaris; Phys. Rev. D2 (1970) 2734.

[16] N.D.H. Dass; Phys. Rev. D7 (1973) 1458.

[17] M.P. Gokhale, S.H. Patil and S.D. Rindani;
Phys. Rev. D14 (1976) 2250.

[18] M.K. Volkov, D. Ebert; Yad. Fiz. 30 (1979) 1420.

[19] S. Chakrabarty, A.N. Mitra and I. Santhanam;
Phys. Lett. 84B (1979) 119.

[20] G.V. Efimov, M.A. Ivanov and E.A. Nogovitsyn;
Yad. Fiz. 34 (1981) 264.

FIGURE CAPTIONS

Fig. 1 Mass resolution of the spectrometer GAMS-2000 for M^0 particles produced in reaction (4) decaying into $3\pi^0$. The peak corresponds to $\eta \to 3\pi^0$. The arrow points to the value of the η mass given in the tables. The mass resolution of GAMS is characterized by $\sigma_M = 5.1$ MeV/c², $\sigma_M/M = 0.9\%$. The curve is a Gaussian distribution. It practically coincides with the distribution of events simulated with real showers (see below).

Fig. 2(a) Mass spectrum of the $\pi^0\gamma\gamma$ system measured in reaction (7). The arrow points to the η mass. The dashed curve is a polynonial function F_b which describes the background part of the spectrum.

(b) Mass spectrum in the region of the η-meson obtained from fig. 2(a) after subtraction of the background distribution F_b (dashed curve). The dotted curve is the Gaussian distribution $F_g(M-\bar{M},\sigma_M)$ obtained with the best estimates of the parameters, after fitting: $\bar{M} = 549$ MeV/c², $\sigma_M = 7.2$ MeV/c². The measured spectrum has been fitted by a superposition of F_g and F_b with a $\chi^2/n_D = 0.7$.

Fig. 3 Number of events observed for the decay $\eta \to \pi^0\gamma\gamma$ for various values of the threshold energy E_{th}. The curve is the detection efficiency for this decay mode normalized to the point E_{th} = 2 GeV.

Fig. 4 Simulated background using a bank of real showers. N is the number of events candidate for reaction $\pi^- p \to \pi^0 \gamma\gamma n$ per $\Delta M = 5$ MeV/c^2 mass interval of the $\pi^0\gamma\gamma$ system. "$2\pi^0$" and "K^0" are the contributions of processes (5) and (6), respectively. "(3γ)" is the background linked to events "pumped" from class m = 3 in to class m = 4. "η_1" and "η_2" are the contributions to the background of decay $\eta \to 3\ \pi^0$ (see text). "Σ" is the sum of the above mentionned contributions. F_b is a polynomial function which describes the background part of the spectrum on fig. 2. This spectrum corresponds to $E_{th} = 2$ GeV. An analogous agreement between Σ and F_b is obtained for other threshold values E_{th}, ranging from 0.5 to 3.5 GeV also.

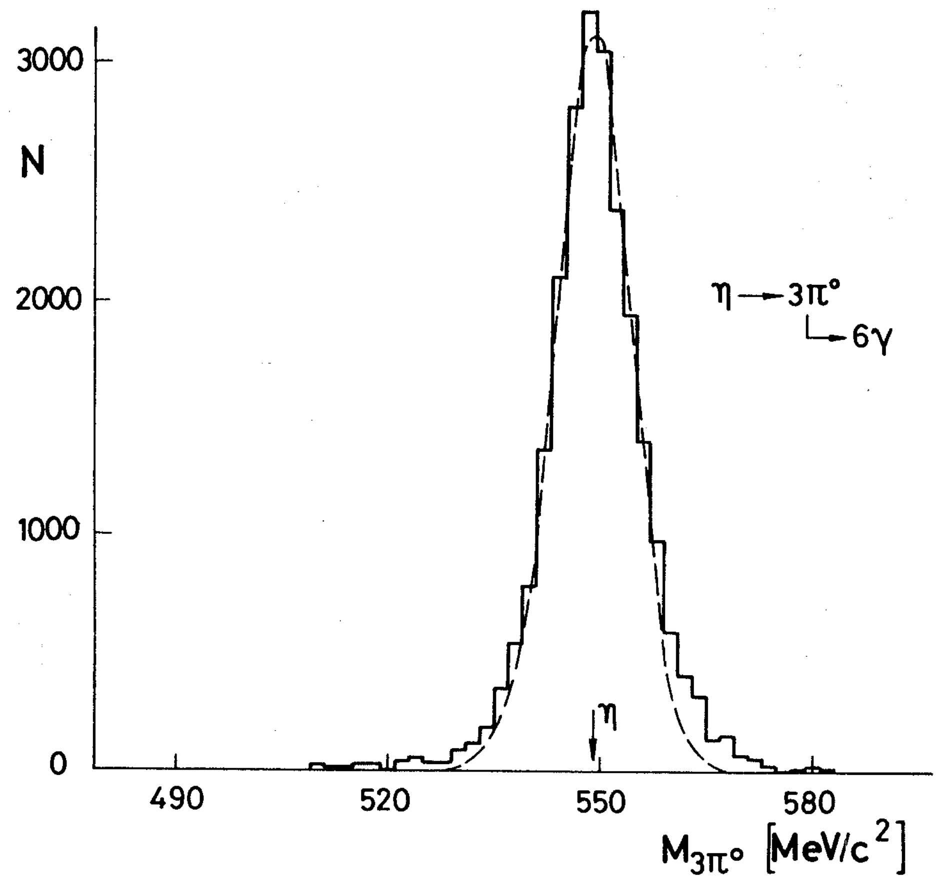
3000
N
2000
1000
0
490
520
550
580
$M_{3\pi^0}$ [MeV/c^2]
$\eta \rightarrow 3\pi^0$
$\rightarrow 6\gamma$
η

Fig. 1

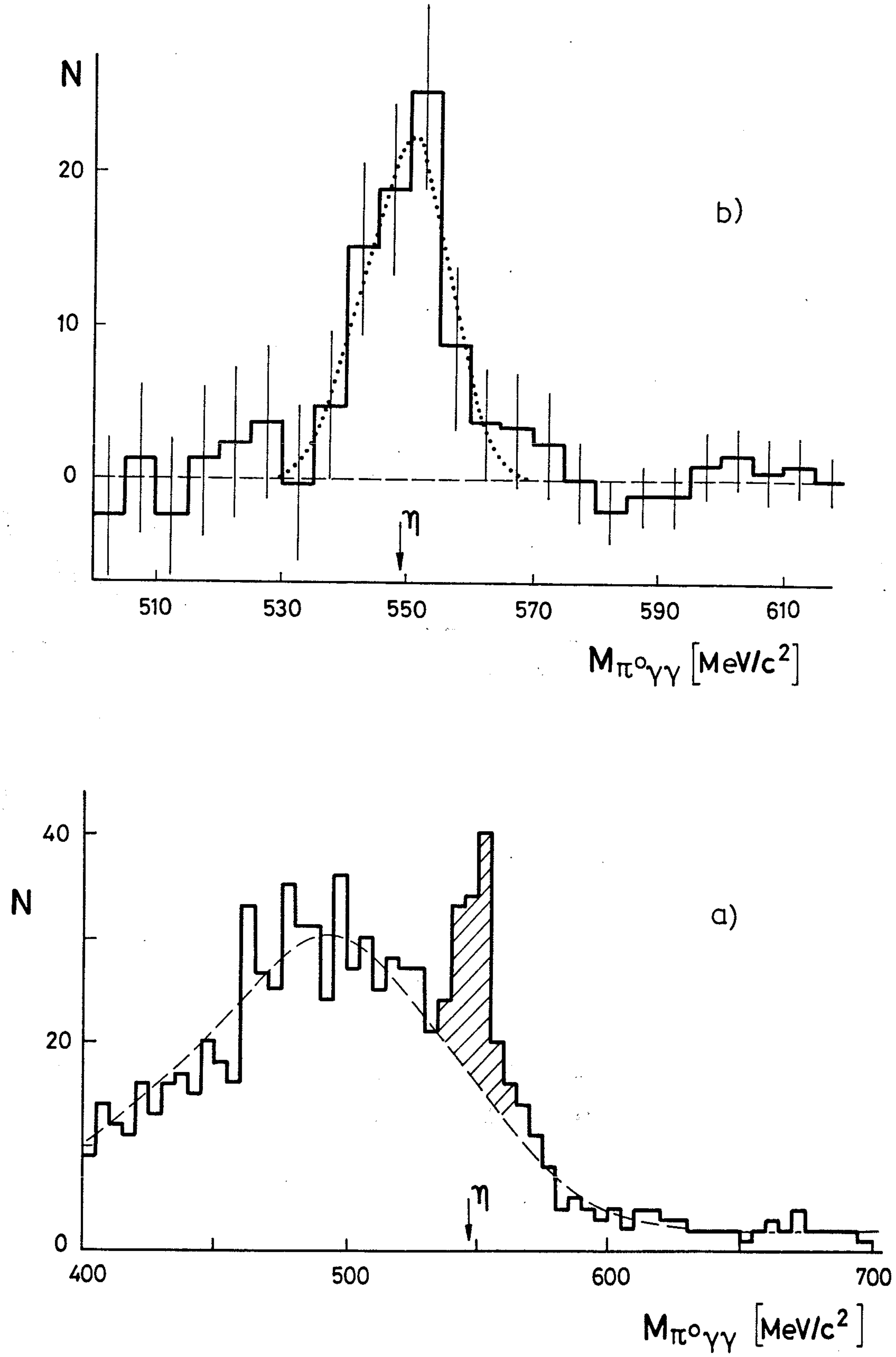
N
20
10
0
b)
η
510
530
550
570
590
610
$M_{\pi^o\gamma\gamma}$ [MeV/c^2]
40
N
20
0
a)
η
400
500
600
700
$M_{\pi^o\gamma\gamma}$ [MeV/c^2]

Fig. 2

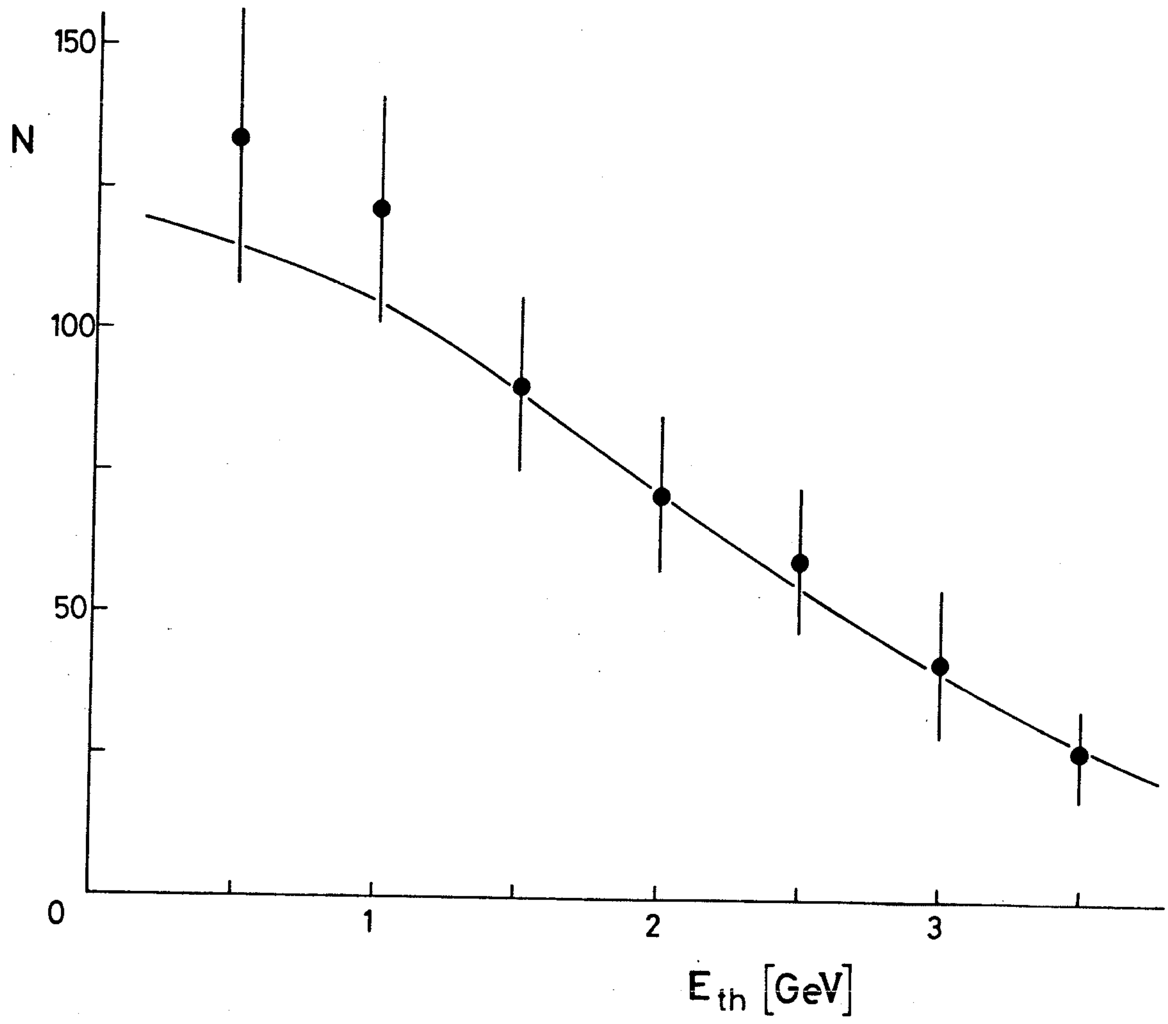

Fig. 3

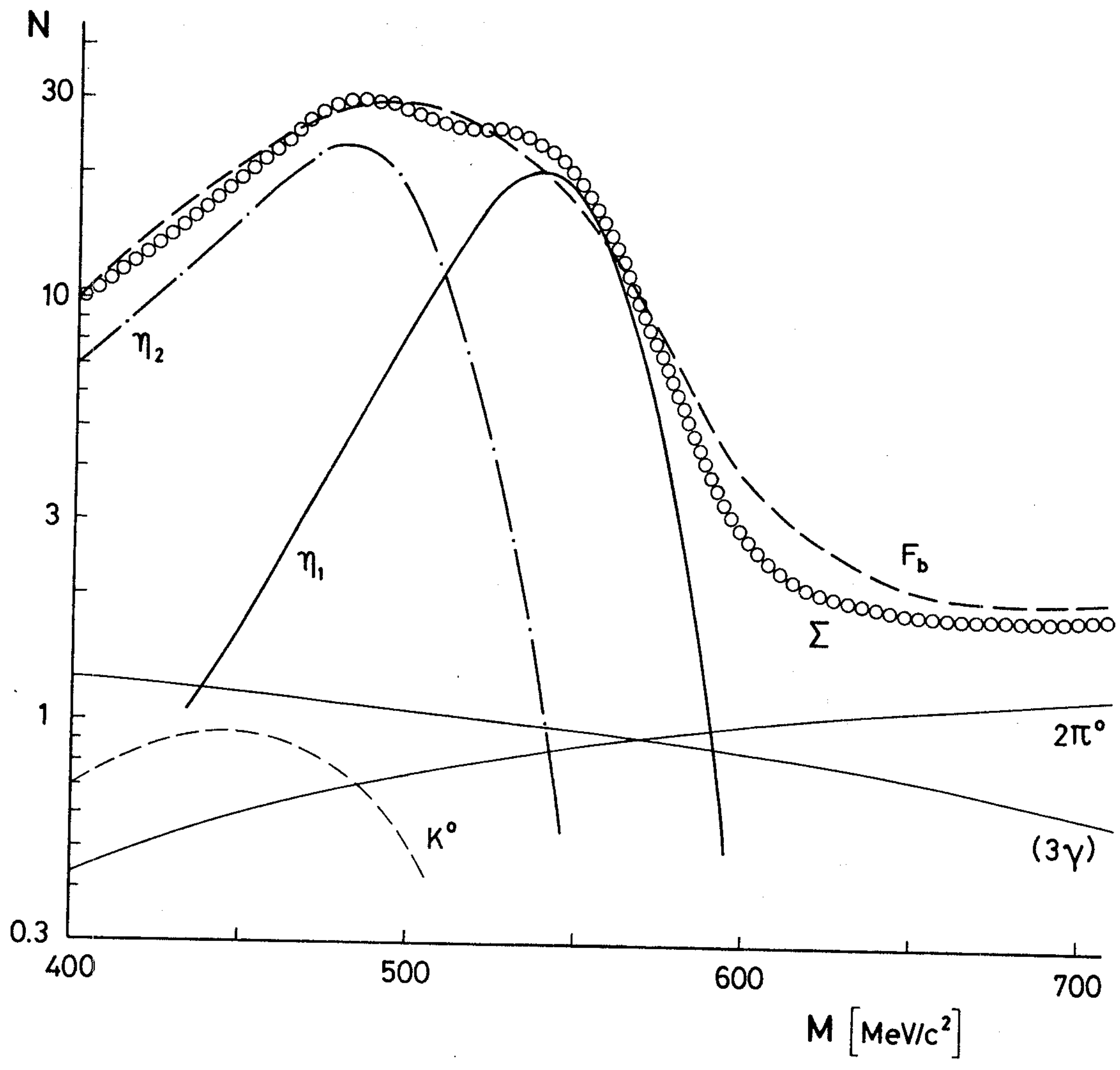
N
30
10
3
1
0.3
400
500
600
700
M [MeV/c²]
η_2
η_1
F_b
Σ
$2\pi^o$
K^o
(3γ)

Fig. 4