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E.O.Agasian, A.S.Alexanian, T.L.Asatiani,
A.O.Gasparian, V.A.Ivanov, G.K.Megrabian,
G.G.Mkrtchian, R.N.Pikhtelev

SEPARATION OF ELECTRON-PHOTON SHOWERS BY MEANS OF SCINTILLATION COUNTERS *)

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E.O.AGASIAN, A.S.ALEXANIAN, T.L.ASATIANI, A.O.GASPARIAN,

V.A.IVANOV, G.K.MEGRABIAN, G.G.MKRTCHIAN, R.N.PIKHTELEV

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I. INTRODUCTION

Studying the photoproduction of neutral mesons (π^0, η^0, χ^0, etc.) by means of decay γ-quanta one meets a problem connected with their effective and reliable detection in the background of intense flux of single charged particles.

A system consisting of scintillation counters allows to solve this problem even with not so high amplitute resolution of separate counters. The amplitute resolution of all the system determined by the ionization loss fluctuations may be improved using a pulse height discrimination for separate scintillation counters.

In this work it is given the results of the study of a large scintillation counter system carried out with electron and photon beams of Yerevan Electron Synchrotron.

The system consists of six 55x55x2 cm^3 plastic scintillation counters. Two FEU-30 type photomultipliers collect the light from two sides of each counter through 40 cm long plexiglass light pipes. The light pipes and scintillator are glued together with epoxy pitch ED-5 while the optical contact between the multipliers and light pipes is provided by KV-3 type vaseline with a refraction index n=1.42. White paper is used as reflective layer.

For the especially selected photomultipliers with about similar characteristics we selected dividers according to their amplitude maxima which, as it is well known, provides the best time and amplitude resolution.

2. DESCRIPTION OF THE SYSTEM

The study of the characteristics of the scintillation counters has been carried out with a 2 GeV electron beam. The scheme of the arrangement is given in Fig.1. Two 10x5x2 mm^3 scintillation counters C_1 and C_2 separate electron beam with energy resolution $\Delta E/E \sim 2\%$ which then passes through the system of large scintillation counters. The pulses from two photomultipliers of each large scintillation counter are summed by the linear summators "Σ". For an effective summation of two short pulses there are cable forming lines at the entrances of all the linear summators. The pulse delay time on the forming cable is chosen equal to the pulse front length. As a result pulses with a top plato length $\sim$ (5-6)nsec are formed. In these conditions the summary pulse amplitude does not depend on the particle passage place due to the delay conditioned by the passage of light in the large scintillators. In the case of this method it is required the coincidence of the pulses at the entrances of the summators whithin the length of their fronts.

Whith the help of dividers at the entrances of the summators the pulse amplitudes from both photomultipliers of each scintillation counter are made equal each to other when the electrons pass through the geometric center of the given scintillator. Then the amplitudes of the pulses coming to the discriminators "D" are equalized (with an accuracy ±5%) by means of the amplifiers "Y". The discrimination level of "D" is established by a calibrated pulse generator. The coincidence pulse opens the linear gate from which the pulses go to a pulse height analyzer

AI-128 from one of six counters (S_{1-6}). Thus, one makes pulse height analisis for each counter provided a simultaneous amplitude discrimination of all the remained counters.

3. RESULTS

Using the above described system it has been studied the dependence of the pulse amplitudes and amplitude resolution of the scintillation counters on the particle passage place in the counters (see Fig.1) when;

1. The pulses from one of two photomultipliers of the counter are given to the summator;
2. The pulses from both photomultipliers are summed.

The mean values of the amplitudes are given in Table I.

TABLE I

The place of electron passage through the counter (see Fig.1)	0	1	2	3	4	5	6	7
The amplitude from single photomultiplier (relative units)	0	8	7.5	10	6.5	6	5	6
The amplitude of the sum from both multipliers (relative units)	0	16.5	13.5	17	12.5	16	13	15

For one of the photomultipliers the relative inhomogeneity ΔA is equal to ±33% while in the case of summing the pulses of both photomultipliers $\Delta A=\pm 15\%$. For some counters the inhomogeneity is $\sim \pm 6\%$. Such a difference is explained mainly by the epoxy layer transparency inhomogeneity in various places of the glue between the light pipes and scintillators.

The amplitude inhomogeneity factor ΔA corresponding to the maximum of the amplitude spectrum is defined in the following way:

$$A=\pm\frac{A_{max}-A_{min}}{A_{max}+A_{min}}$$

where A_{max} and A_{min} are the largest and least values of the amplitude A.

In the case of summing of the pulses from both photomultipliers the amplitude resolution (FWHM) of a counter is $\sim 42\%$ for particles with minimal ionization.

The amplitude spectra obtained for a scintillation counter in the case of summing of the pulses from both photomultipliers are shown in Fig.2. The curve "1" is obtained when a single particle passes perpendicularly through the scintillator. From figure it is seen that the distribution has an asymmetric shape which is conditioned by the fluctuations of ionization losses. The curve "2" is obtained in a geometry when the angle between the beam and scintillator axes is 30°. In this case the particle path in the scintillator is twice greater than in normal case; the amount of light produced in the scintillator is equivalent to that of two relativistic particles with normal incident. As one could expect the amplitude corresponding to the maximum of the distribution "2" is twice larger than that of distribution "1" while the amplitude resolution (FWHM) is ~ 37%.

Similar study of a system of 17 scintillation counters with 100 cm length has been carried out in the work [1].

The obtained results allow to estimate quantitively the possibility of pulse height resolution in the case when one, two and more particles pass through a system of six scintillation counters. The results of such an analisis are presented in Fig.3. The curves a) and b) in Fig.3 show that when one suppresses the detection effectiveness for single particles down to a level ~ 1% the system maintains the detection effectiveness for two particles at ~ 100%.

In order to study the frequency (loading) characteristics the scintillation counters have been placed near the photon beam with an intensivity ~ $5\cdot10^{8}$eq. γ- quantasec^{-1} passing perpendicularly to the counters plane at a distance ~ 2 cm from the counters edge. The light diodes installed on the counters allowed to determine the change of the amplitude spectrum from the light diodes at the moments of the accelerator pulses.

The maxima of the amplitude distributions from the light diodes do not change their position at the moments of beam ejection up to instantaneous loading of each counter ~ 10MHz.

For the above mentioned conditions a system of six counters provides the effective registration of events correlated in time (the time resolution is ~ 20 nsec); the level of the accidental coincidences is less than 5%, i.e., the triggering of the registrating apparature near the beam is mainly called by shower type events.

It is necessary to note that when it is not required a 100% γ-quanta registration effectiveness and there is a need of high level discrimination against the single particle background the placing of a thin convertor (~ 1 radiation length) before the counters allows to obtain a sufficiently high rejection factor (curve c) in Fig. 3). The rejection factor K is defined as the ratio of registration effectiveness of two particles to that of single ones (the same when the convertor is placed).

The results of this work show that a system of scintillation counters allows to separate with sufficient effectiveness the electron-photon showers in a intense background of single particles. It posses good frequency (high loading) characteristics and may find wide application in the study of electromagnetic processes.

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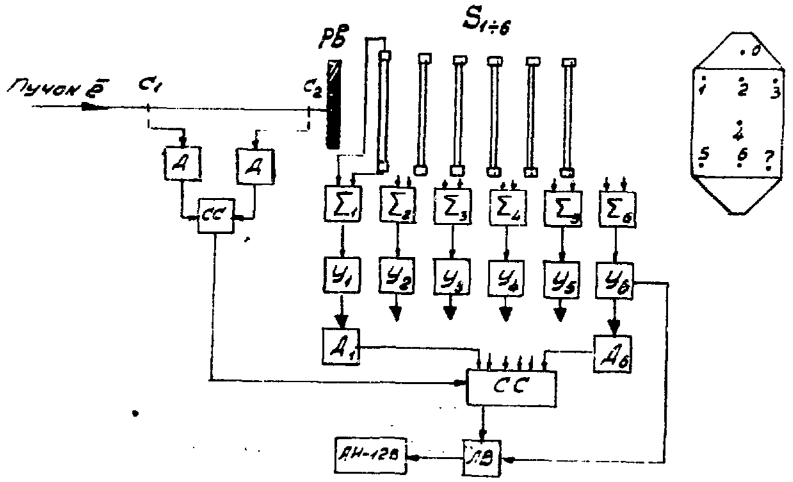

Fig.1. The scheme of the experiment; C_1, C_2: 10x5x2 mm^3 scintillation counters; S_{1-6}: 550x550x20 mm^3 scintillation counters; Y. amplifiers; D. discriminators; CC. coincidence circuits; LB. linear gates; AU-128. pulse height analyzer.

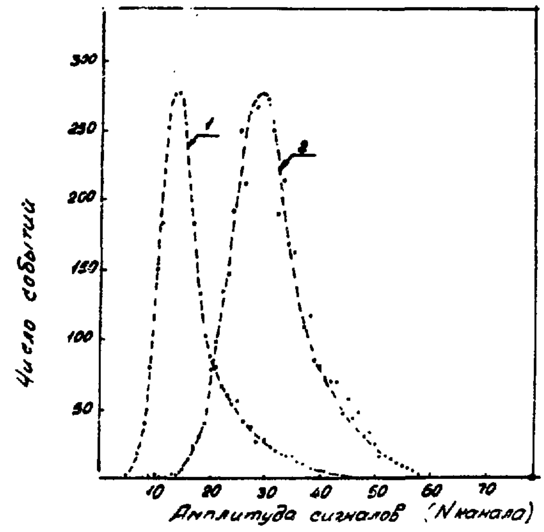

Fig. 2. The scintillation counter amplitude spectrum for single (curve "1") and two (curve "2") particles with minimal ionization.

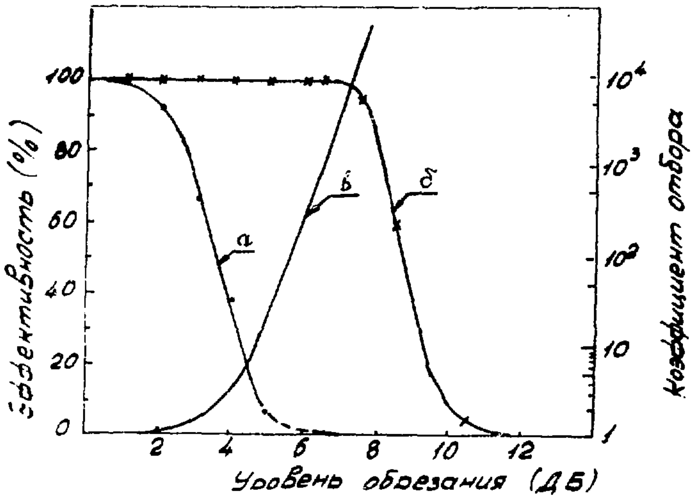

Fig.3. The dependence of the registration effectiveness for single (a), two (b) particles and rejection factor of separating two and single particles (c) on the amplitude discrimination level for a system of six scintillation counters.

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Э.О.АГАСЯН,А.С.АЛЕКСАНЯН,Т.Л.АСАТИАНИ,
А.О.ГАСПАРЯН,В.А.ИВАНОВ,Г.К. МЕГРАБЯН,
Г.Г.МКРТЧЯН,Р.Н.ПИХТЕЛЕВ

ВЫДЕЛЕНИЕ ЭЛЕКТРОННО-ФОТОННЫХ ЛИВНЕЙ
С ПОМОЩЬЮ СИСТЕМЫ СЦИНТИЛЛЯЦИОННЫХ СЧЕТЧИКОВ
(на английском языке)

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