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METHOD OF DETECTION OF TRANSITION RADIATION BY WIRE CHAMBERS OPERATING IN SELF-QUENCHING STREAMER MODE

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METHOD OF DETECTION OF TRANSITION RADIATION BY WIRE CHAMBERS OPERATING IN SELF-QUENCHING STREAMER MODE

Abstract
Akopdzhanov G.A., Bityukov S.I., Dzhelyadin R.I., Zaitsev A.M., Lapin V.V., Saraikin A.I.
Method of Detection of Transition Radiation by Wire Chambers Operating in Self-Quenching Streamer Mode. Serpukhov, 1984.
p. 11. (IHEP 84-39).
Refs. 4.
A method to detect transition radiation in the presence of fast charged particles background has been proposed. The method exploits specific features in the development of the self-quenching streamer regime. A self-quenching streamer signal in the xenon-isobutane mixture has experimentally been detected. Signals from relativistic particles and X-rays have been separated.

Аннотация
Акопджанов Г.А., Битюков С.И., Джелядин Р.И., Зайцев А.М., Лапин В.В., Сарайкин А.И.
Метод регистрации переходного излучения проволочными камерами с самогасящимся стримерным зарядом. Серпухов, 1984.
11 стр. с рис. (ИФВЭ ОЭФ 84-39).
Библиогр. 4.
Предложен метод выделения рентгеновского переходного излучения на фоне сигнала от релятивистских заряженных частиц,основанный на использовании особенностей развития самогасящегося стримерного разряда. Экспериментально зарегистрирован самогасящийся стримерный разряд в смеси Xe + изобутан.
Получен эффект разделения сигналов от релятивистской частицы и от мягкого рентгена.

One more regime of the wire chambers operation has appeared recently in addition to the well known one, ie, ionization, proportional and Geiger. It is the so-called self-quenching streamer mode (SQS). Some extraordinary properties of this mode make it very promissing for application in a number of experiments. A detailed review of the detectors using the SQS regime is given in paper[1]. In spite of a great amount of experimental results, the model of the SQS regime has not yet been worked out in detail.

We have carried out investigations of the SQS regime on the prototype of the hadron calorimeter detector for DELPHI[2] (fig. 1). Detailed results of these studies will be given elsewhere. The main conclusion important to us in this paper is that SQS pulse occurs in the case, when a sufficiently large number of electrons (cluster) appear near the anode wire. The electron multiplication process creats a narrow column of ions, which leads to a further development of the streamer. Fig. 2 illustrates SQS development. High initial density of ionization (δ-electrons, electrons from photoionization or Compton) or collection of electrons in the vicinity of the anode wire may be the cause of the cluster production. Such a scheme allows us to give a qualitative and, in many cases, quantitative explanation of the basic phenomena which take place in the SQS.Fig.3 presents a pulse-height spectra obtained using ^{55}Fe source (5,9 KeV X-rays) and betas from ^{90}Sr (end-point energy of 2,26 MeV). They were measured at the beginning of the plateau for ^{55}Fe. The difference in the count rates for ^{55}Fe and ^{90}Sr were earlier pointed out in[1,3]. According to the scheme mentioned above the SQS mode is present for ^{55}Fe, and it does not manifest itself in the case with ^{90}Sr because the lack of sufficiently large clusters for the development of the SQS mode at a given high voltage. Pulse height spectra for relativistic particles, obtained at a normal incidence angle to the detector plane and at 10^{o} is given in fig. 4. With the angle increasing up to 10^{o}, the probability for the streamer to appear decreases quite considerably which is due to the fact that incident electrons are distributed along the anode wire.

One may try to use such a selectivity of the SQS regime to a cluster in detecting transition radiation (TR) with the charged particle background (for the review of particle identification methods by TR detectors refer to[4]). Two main questions here are whether the SQS mode is realized in the Xenon mixture with some quenchers and whether the SQS mode in this mixture has the above mentioned selectivity for clusters. To answer these questions we studied the SQS mode in the Xe-isobutane mixture. The SQS mode was observed in a wide range of gas concentrations. As an example we present some spectra obtained with the ^{90}Sr source (fig. 5). Here one can see proportional, streamer and double streamer peaks. With the change of the high voltage their magnitude and probability change as well. To choose an appropriate HV for transition radiation detection and to estimate the selection factor we measured the count rates at different discrimination levels with ^{55}Fe and ^{90}Sr (fig. 6). The ^{55}Fe is used in our case to simulate transition radiation since for the majority of the TR radiators the characteristic energy is ~10 KeV [4]. The difference between count curves is observed in a wide range of discrimination levels from 10 mV up to 65 mV. At U = 4.2 kV the efficiency for ^{55}Fe is 85% and for ^{90}Sr it is 16%. This difference is caused right by the SQS regime selectivity to cluster since in the mixture we used (40% Xe - 60% isobutane) relativistic particle losses are of about 6 keV, that is just the amount ^{55}Fe provides.

We did not attempt to optimize the rejection factor by varying the gas mixture and thickness of the wires, because such details depend on the physical problem studied. Note that the rejection factor observed is at the level of the modern TR-detectors. The rejection factor for charge particles cannot be higher than the one given by the δ-electron spectrum and for our mixture it is $5\cdot 10^{-2}$ at the detection threshold of 5 keV.

Thus a possibility to use the chambers in the SQS mode for transition radiation detection has shown. Here the streamer formation mechanism is widely used. The main positive properties of the chambers in the SQS regime which are a large value of the signal and thick wire (~100 μ) allow to simplify the electronics and the construction of the detectors and to increase their reliability. However the main disadvantage of these chambers, ie worse counting rates as compared with the proportional chambers does not manifest itself in transition radiation detection since the chambers work at lower efficiency of charged particle detection.

In conclusion the authors express their gratitude to DELPHI hadron calorimeter group for the streamer tubes they supplied us with, which were used in the studies. We also thank E.N.Chernov for set-up assembling, N.K.Vishnevsky, V.F.Obraztsov, V.K.Semenov, G.I.Sorokin for helpful discussions.

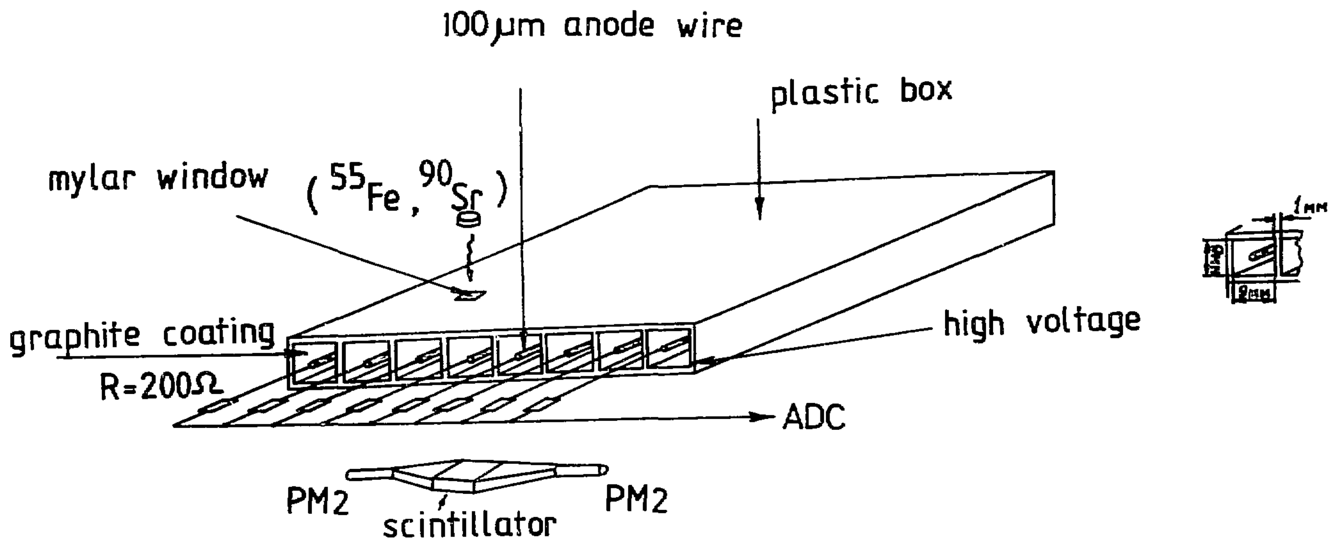

Fig. 1. The setup.

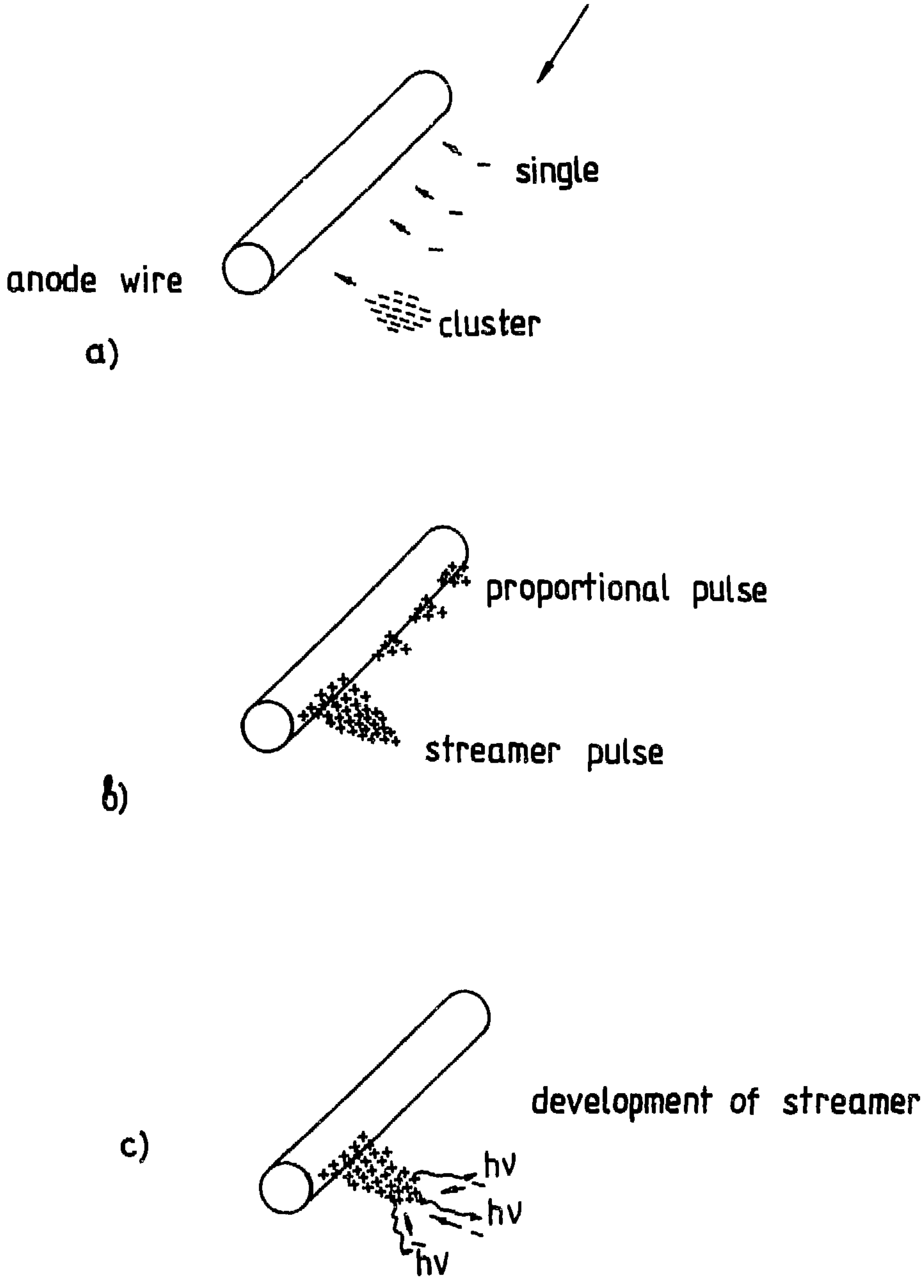

Fig. 2. Streamer production mechanism in the wire chambers a) primary ionization; b) gas amplification in the wire field; c) streamer development.

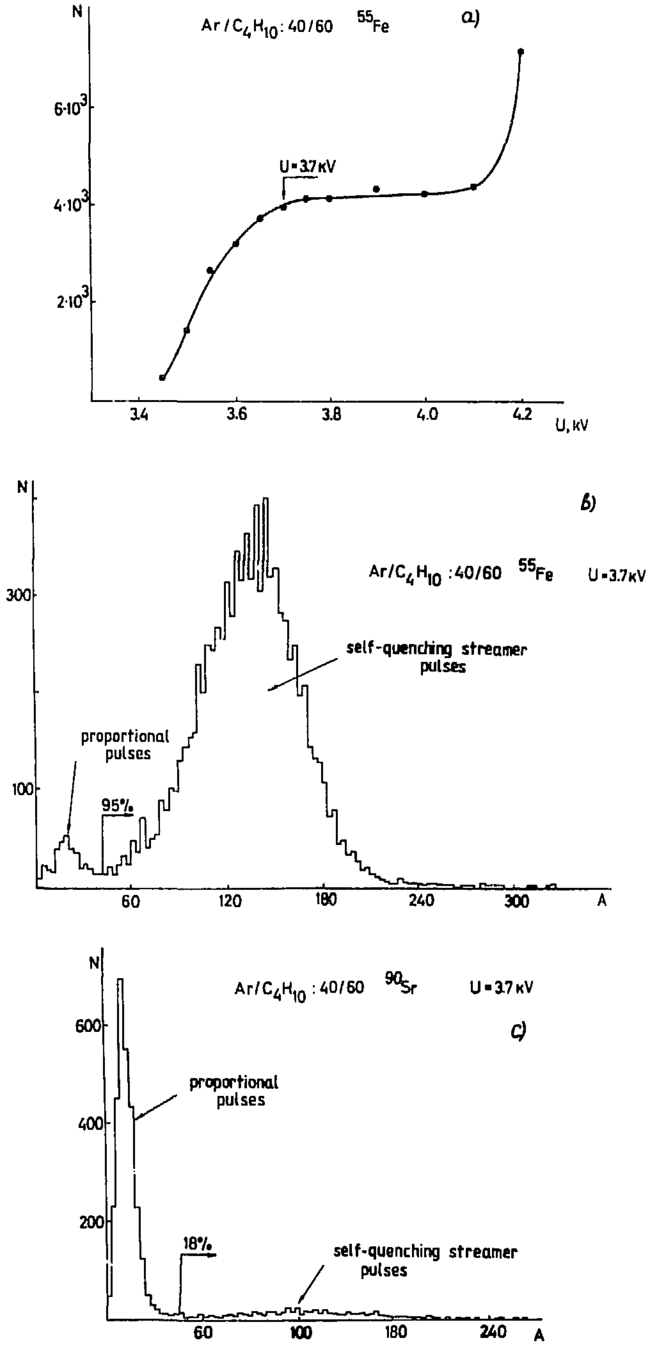

Fig. 3. a) Count rate for ^{55}Fe, Ar/C_4H_{10}: 40/60, discrimination threshold 10 mV, R=50 Ω; b) and c) pulse-height spectra for ^{55}Fe, ^{90}Sr at U = 3,7 kV.

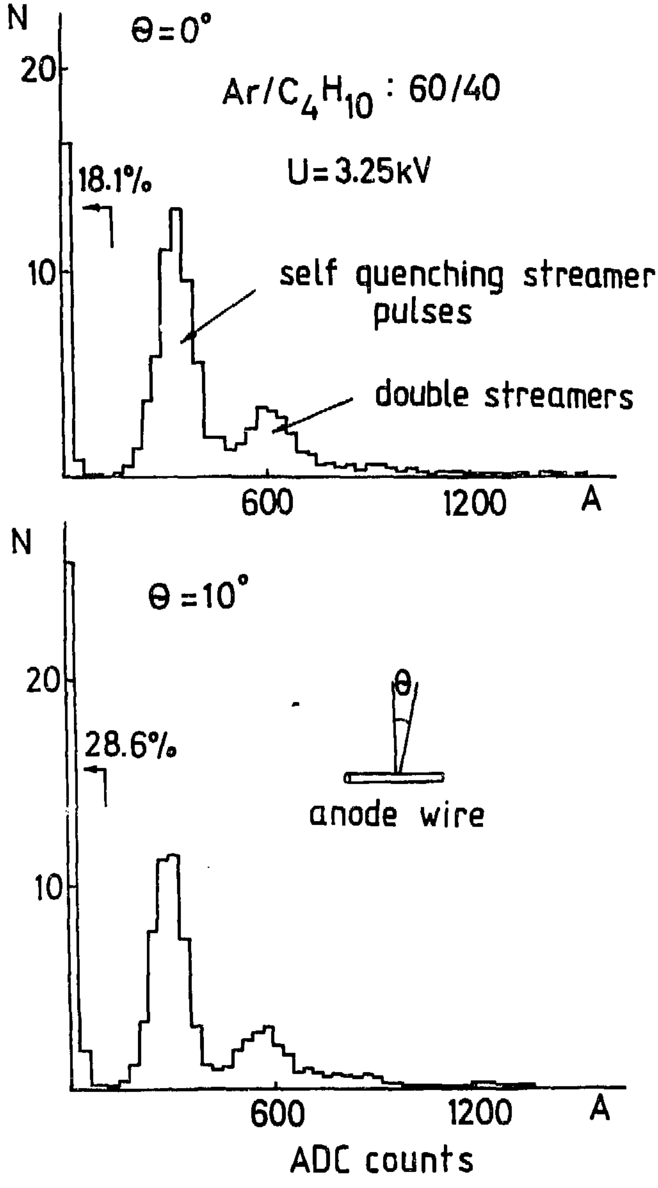

Fig. 4. Pulse-height spectra for relativistic particles at incidence angle to the wire 0° and 10°. Mixture Ar/C_4H_{10}:60/40, U = 3,25 kV.

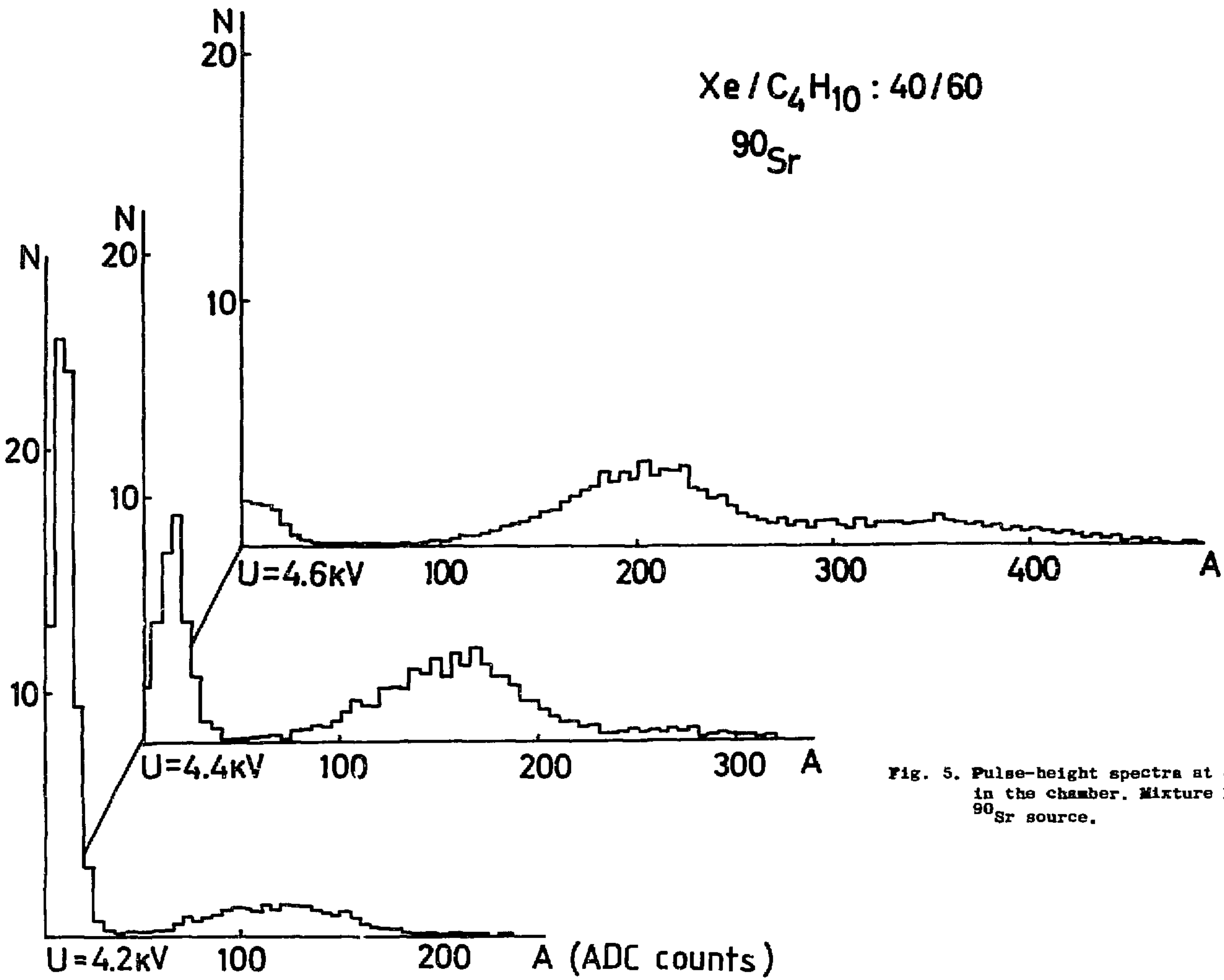

Fig. 5. Pulse-height spectra at different HV in the chamber. Mixture Xe/C_4H_{10}: 40/60. ^{90}Sr source.

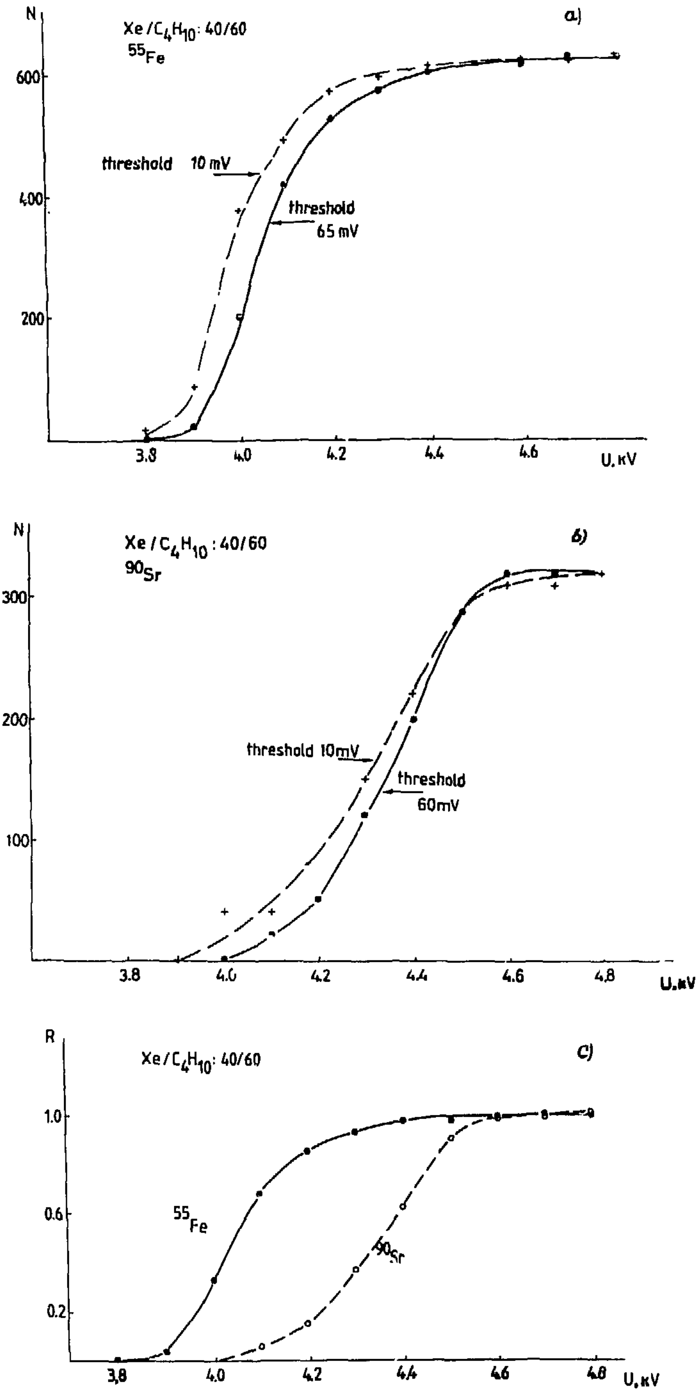

Fig. 6. Count rates Xe/C_4H_{10}:40/60. a) ^{55}Fe, b) ^{90}Sr, c) ^{55}Fe and ^{90}Sr at discrimination level 65 mV, R = 50 Ω

REFERENCES

1. Алексеев Г.Д., Круглов В.В., Хазинс Д.М. - ЭЧАЯ, 1982, 13, с. 703.
2. DELPHI Technical proposal. - CERN/LEPC 83-3, 1983.
3. Atac M., Tollestrup A.V., Potter D. - Preprint Fermilab FN-339, 1981.
4. Долгошеин Б.А. Идентификация частиц высоких энергий с помощью переходного излучения. Тексты лекций. - Москва, изд. МИФИ, 1981.

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