

A TRANSISTORIZED GAMMA-GAMMA COINCIDENCE SPECTROMETER

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Abstract. A completely transistorized coincidence spectrometer which could be used to study direct and coincidence gamma-gamma spectra is shown. The constructed electronic circuits, characteristics and performances of such spectrometer are presented. Direct and coincidence spectra for the decay of ^{152}Eu are also presented.

Introduction

Study of decay schemes of radioactive nuclei offers one of the most important methods to study the nuclear structure¹⁾. Direct spectra, coincidence spectra as well as angular correlation measurements supply very important knowledge about the decay scheme of the studied nucleus. A coincidence spectrometer which could be also used for angular correlation experiments is one of the most important equipments for any nuclear physics laboratory. Therefore, we have found it useful to construct a completely transistorized coincidence spectrometer. This spectrometer could be used to study direct gamma spectra, gamma-gamma coincidence spectra and moments of excited levels by angular correlation methods. It is also possible to measure beta-gamma or alpha-gamma coincidence by simply choosing suitable scintillators for beta- or alpha-particles. The spectrometer could be easily modified to study beta-gamma, alpha-gamma or gamma-gamma coincidences using high resolution detectors such as Ge(Li) detectors or surface barrier detectors (under construction) for alpha or beta particles.

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The purpose of this work is therefore to construct such a spectrometer. The spectrometer has been tested using ^{22}Na and ^{60}Co sources. For the completeness of the work ^{152}Eu has been simply investigated²⁾.

General Description

Fig. 1 shows a block diagram of the whole spectrometer. We have constructed two scintillation detectors³⁾ using two 153 AVP photomultipliers (PM) each of which is coupled to a $2'' \times 2''$ NaI(Tl) crystal. Pulses from the anode of each PM are fed to a variable resolving time fast coincidence circuit after suitable amplification and shaping. Part of the spectrum from one of the photomultiplier detectors PM(2) could be selected by a zero crossing single channel analyzer and then fed to one of the inputs of a slow coincidence circuit through a phase inverter and shaper. The other input of the slow coincidence circuit receives pulses from the output of the fast coincidence circuit after passing through a suitable delay circuit. The output pulses from the slow coincidence circuits are used to gate a 512 LABEN multichannel analyzer after being amplified, shaped and delayed by suitable circuits. The multichannel analyzer receives a direct spectrum from PM(1) through a suitable linear amplifier and a delay line.

The two detectors are mounted on an angular correlation table Fig. 2 with a movable source holder in the center of the table. Owing to the finite size of the detectors, the table permits coincidence measurements at angles varying from 60° to 240° .

Electronic Circuits

All the electronic circuits presented in fig. 1 except the linear amplifier and the zero crossing single channel analyzer in channel (2) have been constructed for the present work²⁾, however, only fast circuits will be presented.

(i) Fast Amplifiers:

Two identical fast amplifiers have been constructed. Fig. 3 shows the circuit of one of these amplifiers. It consists of a capacitive differentiator (200 pf) followed by an unsaturated differential amplifier (T_1 and T_2) and a gated ampli

(T₃). T₄ and T₅ act as an amplifying stage followed by an emitter follower. The gain of this amplifier has been found to be in the order of 100. Its band width mounts to about 20 M Hz. The input pulses (from the photomultiplier) have about 25 ns rise-time and 5 μ s duration while the output pulses from the circuit have about 10 ns rise-time and 200 ns duration.

(ii) Fast Shapers:

Fig. 4 shows the circuit of one of the fast shapers used in the present work. It consists simply from a differentiating stage using a 25 pf capacitance followed by two amplifying stages (T₁ and T₂) and then an emitter follower T₃. The output pulses from such circuit are of about 7 volts amplitude and 20 ns duration.

(iii) Variable Resolving Time Fast Coincidences:

Fig. 5 shows the circuit used which consists of a fast coincidence stage, a fast discriminator stage and a fast shaper. The resolving time of the coincidence circuit could be changed by changing the discrimination level of the fast discriminator. The coincidence stage consists of two tunnel diodes whose biases are adjusted so that only negative pulses of amplitudes greater than 6 Volts can produce tunnel effects⁴). The output of the coincidence stage depends on the delay time between the two input pulses. For maximum overlap, the output pulses are of height ≈ 0.5 volts and duration time ≈ 40 ns. These pulses are fed to the discriminator through the emitter follower T₁. The fast discriminator used consists of two tunnel diodes followed by an amplifier T₂. The discriminator lower level and hence the resolution of the coincidence could be varied from 0 to 0.5 volt using two variable resistors 10 K Ω and 820 Ω .

Performance

Fig. 6 illustrates the resolving curves of the fast coincidence unit for ²²Na, ⁶⁰Co, and ¹⁵²Eu sources. For ²²Na curve the resolution (2 σ) was of the order of 36 ns while the slope of the curve has a T_{1/2} \approx 10 ns. The ratio of accidental to true coincidences is $\leq 2\%$. The spectrometer has been tested by performing direct and coincidence spectra in ²²Na and ⁶⁰Co sources.

In case of ^{22}Na source fig. 7 it is clear that the 1.275 MeV line is completely absent from the coincidence spectra, while for ^{60}Co curves fig. 8 the ratio between the intensities of the 1.18 and 1.33 MeV lines are greatly affected according to the position of the chosen window.

The spectrometer has been also used to study direct and coincidence spectra in the decay of $^{152}\text{Eu} \rightarrow ^{152}\text{Sm}$ and $^{152}\text{Eu} \rightarrow ^{152}\text{Gd}$. A simplified decay scheme including the investigated transitions is illustrated in fig. 9. The direct spectrum (I) obtained as well as coincidence spectra (II, III, IV) for different chosen windows are shown in fig. 10. When the multichannel analyzer was gated with the 122 KeV line in ^{152}Sm ($2^+ \rightarrow 0^+$ transition), the 0.245, 0.965, 1.09, 1.11 and 1.41 MeV lines are well observed while the 0.344 and 0.779 MeV lines due to ^{152}Gd , ~~are~~ are highly attenuated. When the multichannel analyzer was gated in the 0.344 MeV line in ^{152}Gd ($2^+ \rightarrow 0^+$ transition) the most pronounced line was the 0.779 MeV. When gating the multichannel analyzer by the 0.779 MeV in ^{152}Gd , the most pronounced line was the 0.344 MeV.

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Figure Caption

- Fig. (1) A block diagram of the apparatus.
- Fig. (2) Gamma-gamma angular correlation table.
- Fig. (3) A transistorized fast amplifier circuit.
- Fig. (4) A transistorized fast shaper circuit.
- Fig. (5) A transistorized variable resolving fast coincidence circuit.
- Fig. (6) Resolving time curves of the fast coincidence unit for ^{22}Na , ^{60}Co and ^{152}Eu sources.
- Fig. (7) Gamma-gamma coincidence spectrum using ^{22}Na source.
- Fig. (8) Gamma-gamma coincidence spectra using ^{60}Co source.
- Fig. (9) Simplified decay scheme of the decay of ^{152}Eu . Energies indicated by arrows are those observed by the system.
- Fig. (10) Gamma-gamma coincidence spectra using ^{152}Eu source.

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البحث يتكون من وصف شامل لمطياف جاما - جاما تظايقى يمكن به دراسة الطيف
الجامى المباشر والتظايقى كما يصلح أيضا لدراسة التوزيع الزاوى للأشعة المنبعثة
من النواة . وقد تم بناء جميع دوائر المطياف من الترانزستور وكذلك كاشفين لأشعة
جاما من النوع الوهمضى . كما يمكن استعمال هذا المطياف باستخدام كواشف
نصف موصلة تصلح لجسيمات بيتا وأشعة جاما . وقد ذكر فى البحث
جميع خصائصها واما نيات المطياف وقد تم تجريبه على بعض الأنوية العيارية
مثل الصوديوم ٢٢ والكوبلت ٦٠ . وشمل البحث أيضا عرضا مبسطا
لبعض القياسات التى تمت بواسطة الجهاز لدراسة نواة الأورونيوم ١٥٢

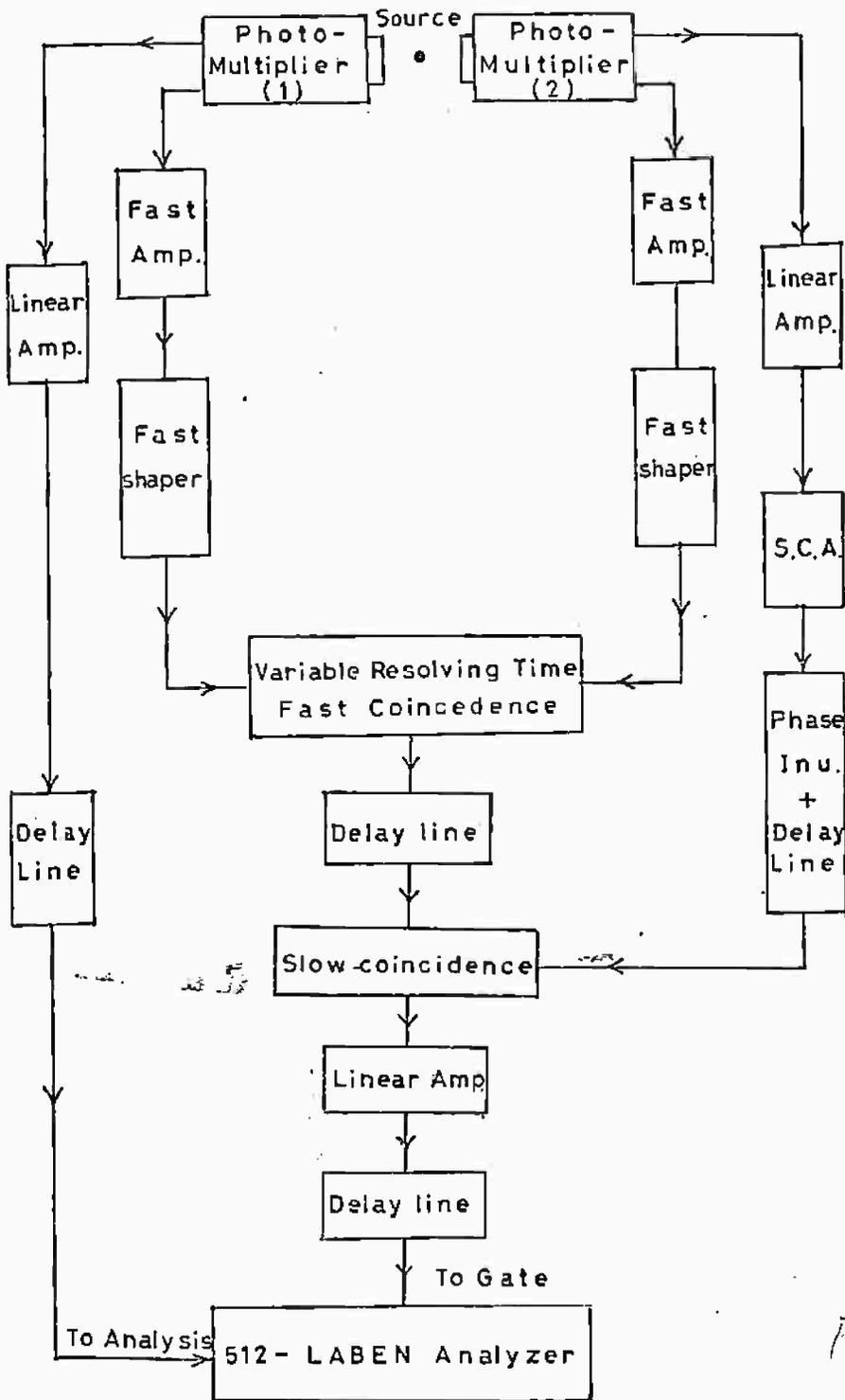


Fig 1

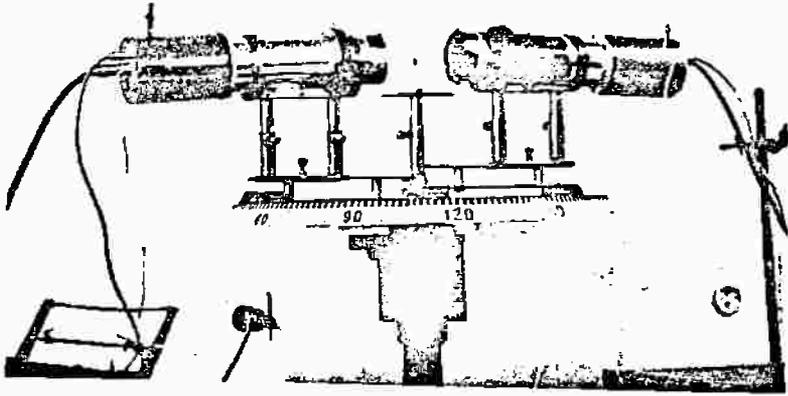
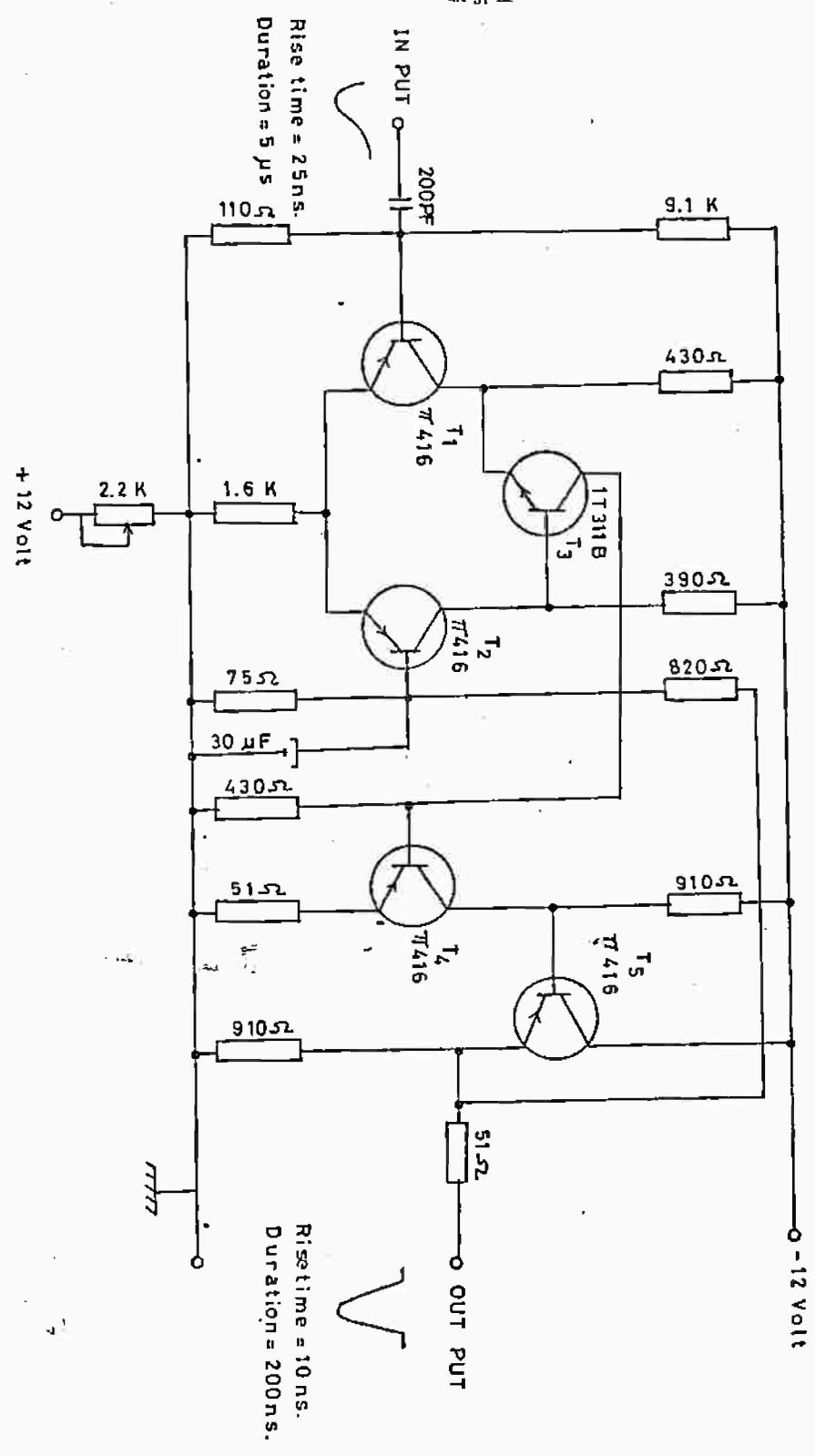
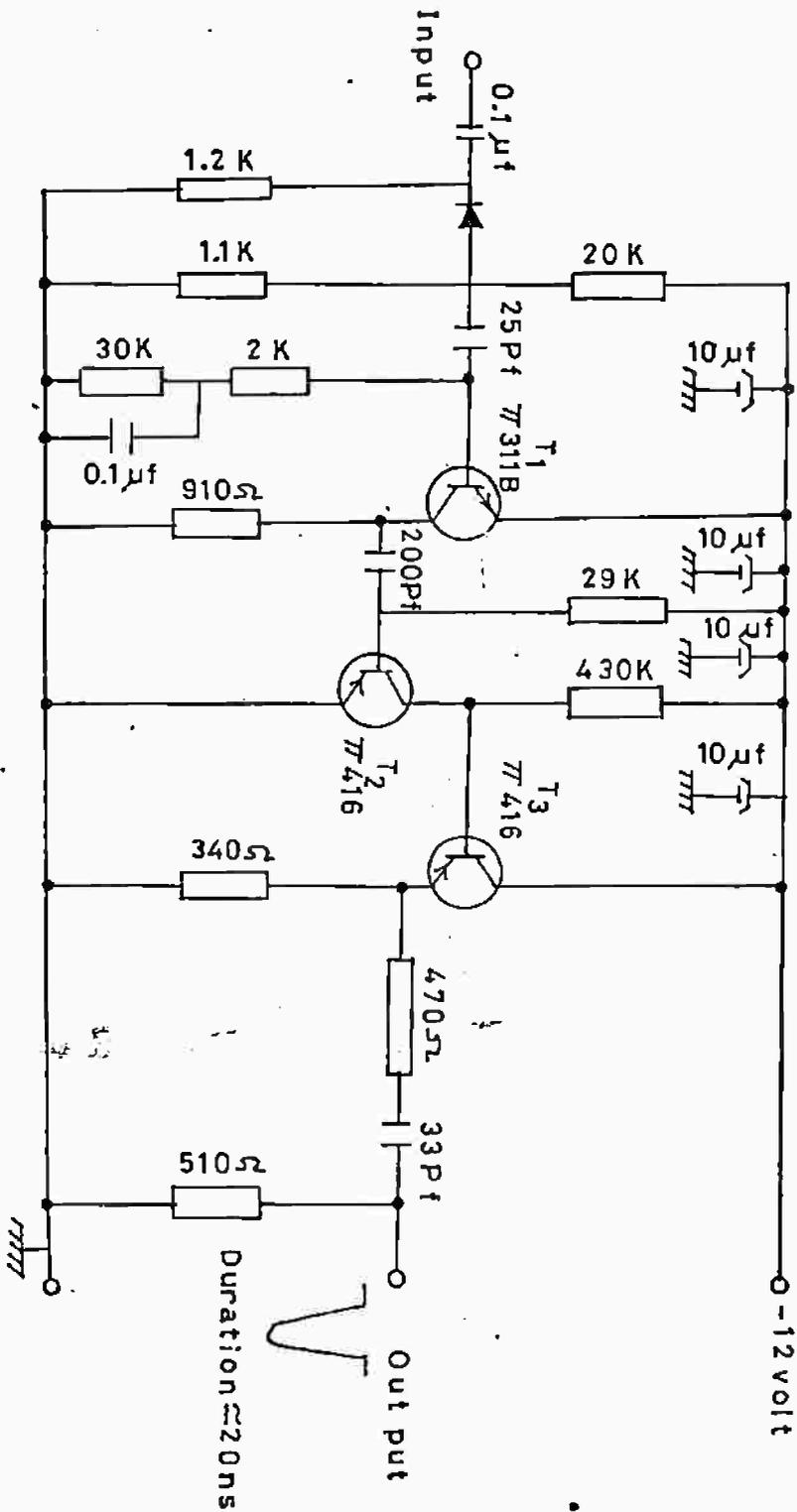
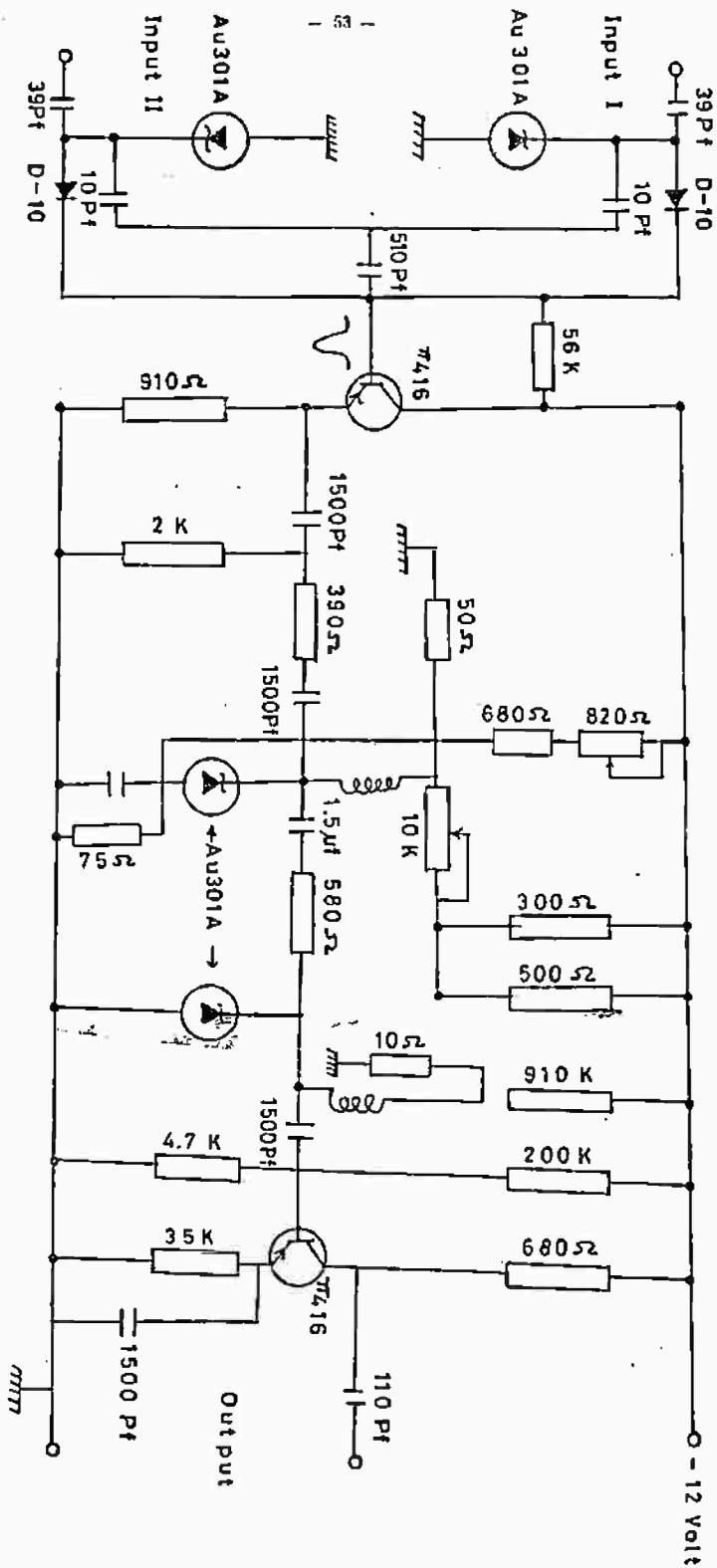
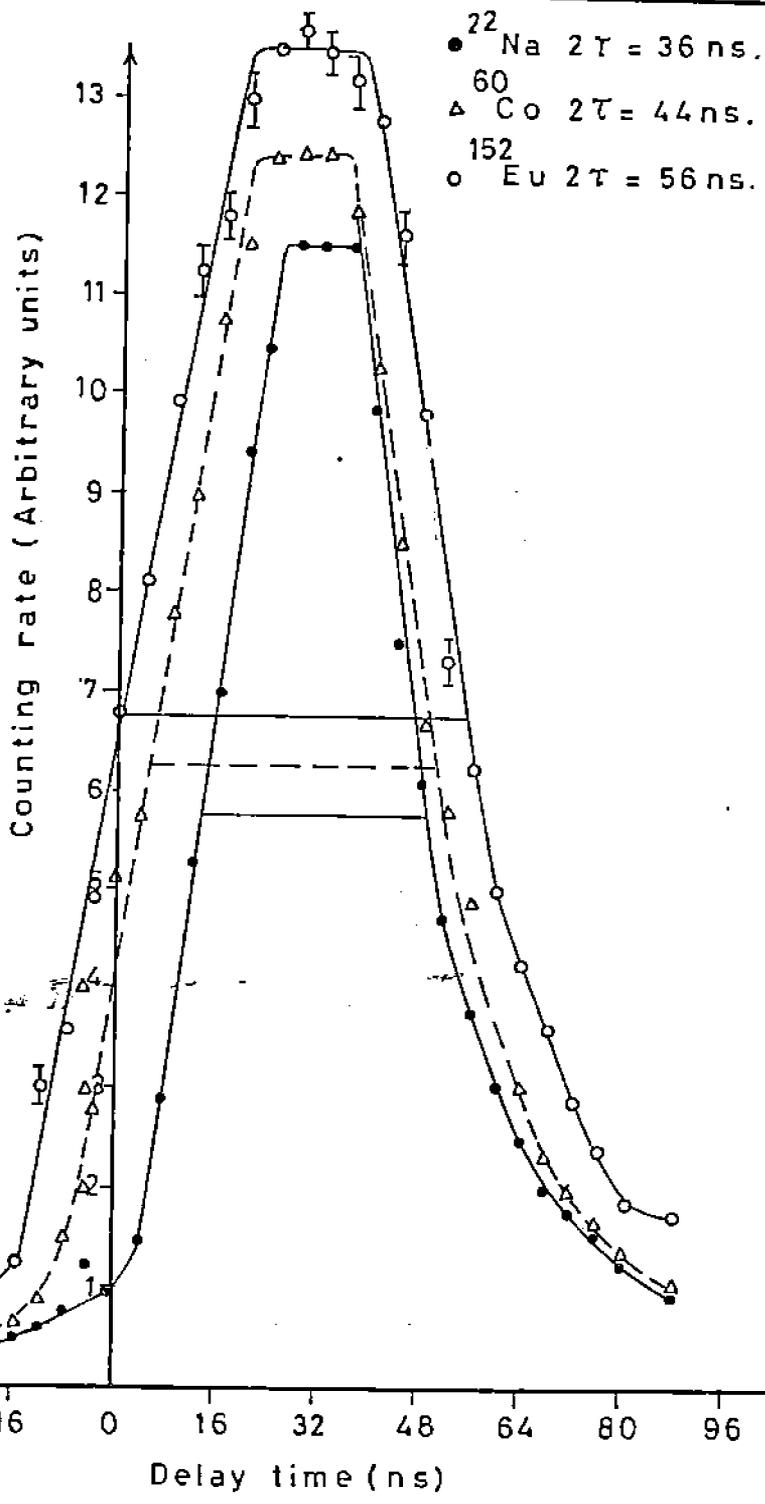


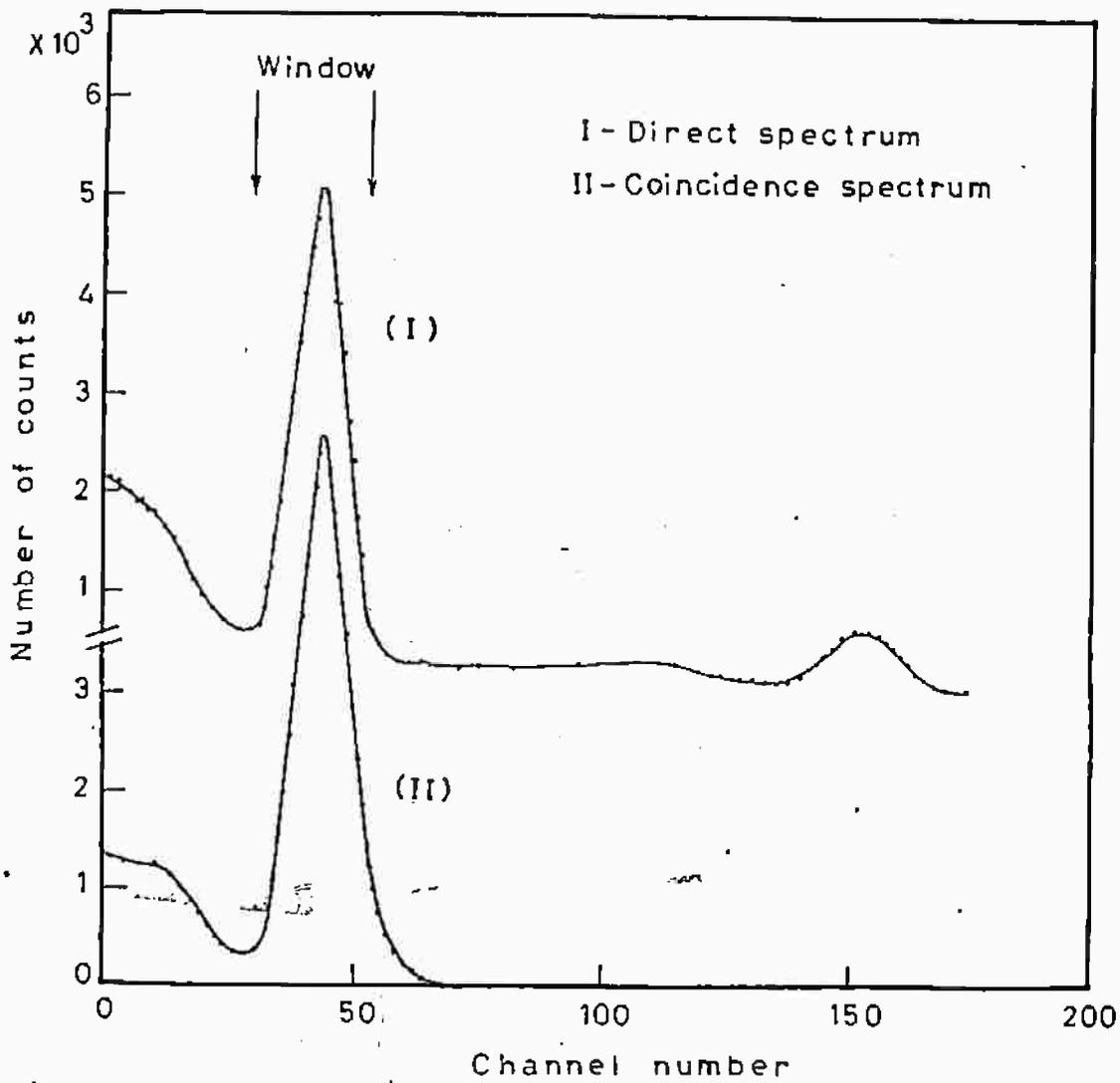
Fig. 2

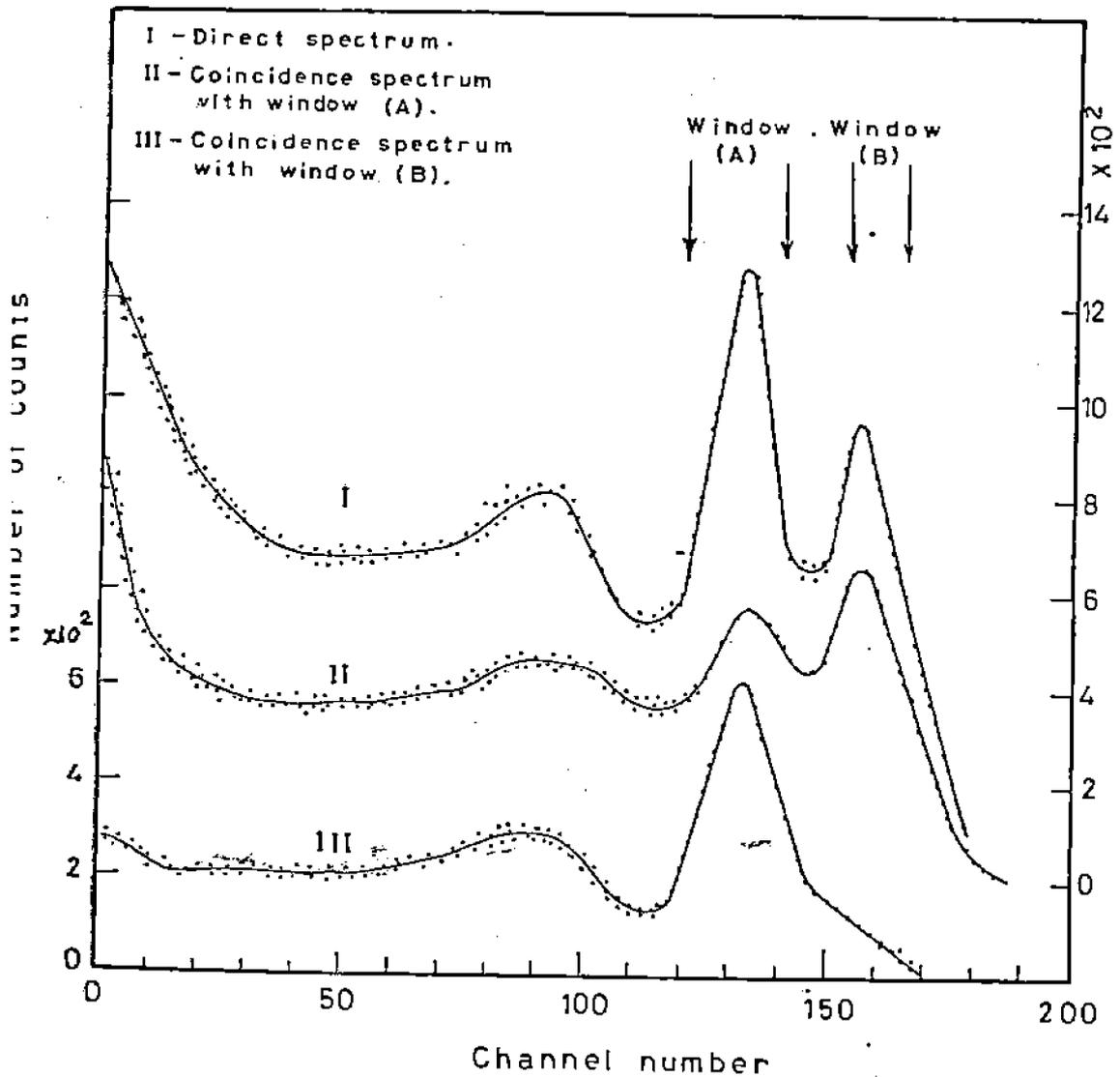












Vertical scale on the left represents spectrum III
Vertical scale on the right represents spectra II & I

Fig 8

