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S. Merolli and M. Roccella: REALIZATION AND SETTING UP OF A NEUTRON SPECTROMETER IN THE RANGE FROM 0.2 - 12 MeV.

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S. Merolli and M. Roccella: REALIZATION AND SETTING UP OF A NEUTRON SPECTROMETER IN THE RANGE FROM 0.2÷12 MeV. -

SUMMARY. -

A neutron spectrometer has been realized using γ-n discrimination on the pulse shape in a trans-stilbene crystal.

Discrimination efficiency has proved to be higher than 1‰ up to proton energies of about 150-200 keV. The efficiency of proton detection was proctically equal to 1 for protons of energy $\gtrsim$ 0.6 MeV. In order to extend the energy range of utilization of the spectrometer to lower values, proton detection efficiency has been measured up to 150 keV discriminating γ from neutrons in an Am-Be source by means of time-of-flight. An efficiency of about 30% has been measured at such energies.

The spectrometer has been realized especially in view of its exploitation at γ high dose rate and arrangements have been adopted for this purpose that allow to improve discrimination power of a factor higher than 10.

I - INTRODUCTION. -

The purpose of the present work is the realization of a neutron spectrometer fit for covering an energy range from 200 keV to 10÷15 MeV, to be utilized outside the shieldings of high energy accelerators where a γ-n field is usually present.

We have pointed to an organic scintillator spectrometer considering the good efficiency of such detectors to neutrons as well as the good possibilities of discrimination some of them present.

Anyway, it must be noticed that discrimination based on the shape of the pulse may sometimes prove inadequate around accelerators on account of the low duty-cycle of these machines.

To attenuate this inadequacy arrangements have been introduced that allow, in presence of γ high dose rate, the improvement of discriminating power up to a factor of about 20.

The arrangements lie in the elimination of the events occurring at intervals shorter than the time required for the electronic elaboration of each pulse.

Moreover, it has to be pointed out that it is very interesting to know neutron spectra around accelerators up to energies of the order of 100-200 keV, considering that up to such energies the quality factor of neutrons is considerably high and near its maximum value.

Nuclear emulsions are not fit for the purpose, because they do not allow to go below 0.5 MeV; on the other hand, while He^3 spectrometers can descend down to the energies we are interested in, in the presence of energies > 1 MeV they require complicated mathematical elaborations with results often affected by remarkable errors.

As to spectrometers based on P.S.D., in case a discrimination efficiency equal to a few ‰ over all energies range should be aimed at, the efficiency of detection of recoil protons is seen to differ considerably from 1 at energies below $0.5 \div 0.6$ MeV. Therefore, a measurement of the efficiency as a function of the energy of recoil protons has proved to be necessary. The measurement has been made by selecting neutrons from γ emitted by an Am-Be source with the time-of-flight technique. The efficiency obtained for 30 keV, eq. el. energy, recoil protons is of about 30%, while the discrimation efficiency is lower than 2‰ at all energies.

II - DESCRIPTION OF THE SPECTROMETER. -

The technique used for the γ-n discrimination is based on the zero-crossing pulse shape discrimation system operating on a trans-stilbene crystal with a diameter of 2"x1".

The output of a 56 A.V.P. phototube is directed to a 410 Ortec amplifier where it is shaped with integration and differentiation constants equal to 0.1 and 0.5 μsec. respectively.

The blockscheme of the circuit is shown in Fig. 1.

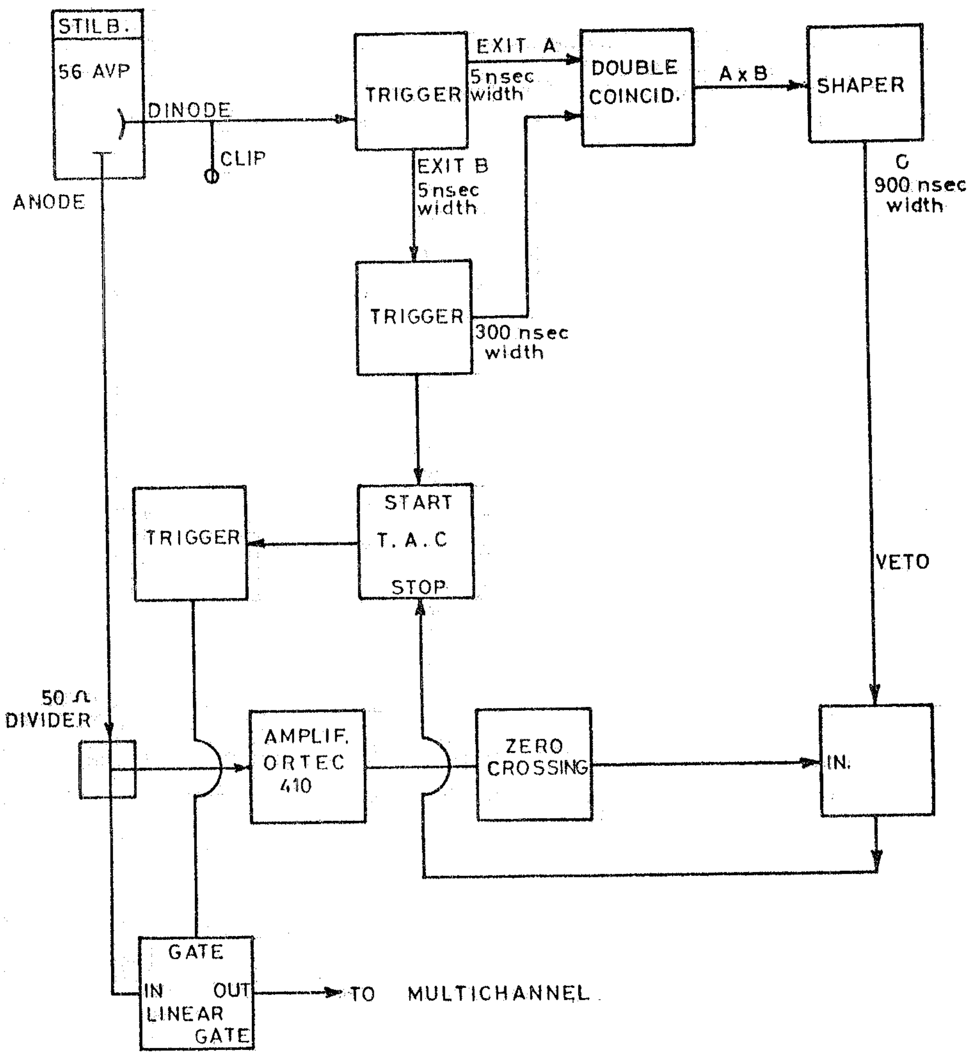

FIG. 1 - Block scheme of pulse shape discriminating circuit.

The fast electronic used was EG. & G. In order to attenuate the effects of pile-up, the output of the anode is shaped and then divided in two channels A and B.

Channel A is directed to a coincidence channel B is retarded for about 10 nsec, shaped for about 300 nsec and then directed to the same coincidence. The output of the coincidence, shaped for 900 nsec, is used as veto in the stop signal that is conveyed to the time-amplitude converter.

It appears clear that by means of these arrangements all events are eliminated that are separated in time more than 10 nsec and less than 300 nsec. Because zero-crossing occurs with a delay from 200 to

300 nsec on the average, zero-crossing shift due to pile-up is mostly avoided, as well as the subsequent deterioration of discriminating power.

Fig. 2 show the percentages of γ above discrimination threshold with and without veto, (the discriminating treshold corrisponds to the efficiency curve of Fig. 5) as a function of the number of γ/sec at zero threshold.

The measurement of the efficiency has been made utilizing an Am-Be source laying inside a Pb container about 0.5 cm in thickness on the purpose of eliminating low energy γ-ray contribution of americium.

The block scheme for the measurement of efficiency is shown in Fig. 3.

The resolution power of coincidence between stilbene and NAI was of about 20 nsec. The delay between γ and neutrons has been fixed at 50 nsec; neutron source has been put at distances of 1,5 m from stilbene and of about 10 cm from NAI. The efficiency of recoil protons has been obtained calculating the ratio between the spectrum of recoil protons with discrimination threshold considered equal to zero and the spectrum of recoil protons with the discrimination threshold fixed previously.

The two spectra were performed for a duration of about 130.000 sec; in both cases accidentals have been subtracted. The number of good events detected in both cases has proved to be of about 10.000 and the ratio between good events and accidental ones has proved to be of about 3.

Shown in Fig. 4 are the spectra of recoil protons obtained for the measurement of efficiency; the curve of the efficiency as a function of the energy of recoil protons is given in Fig. 5.

III - CONCLUSIONS. -

The results obtained show that the spectrometer set up in the present work presents such characteristics it can be used profitably for the spectrometry of neutrons also around high energy accelerator shielding.

Particularly, the remarkable improvement obtained in the γ-n discrimination makes one foresee its possible utilization also in γ-n mixed fields, where γ flux is remarkably higher than neutron flux. Such conditions may easily be present around electron accelerators.

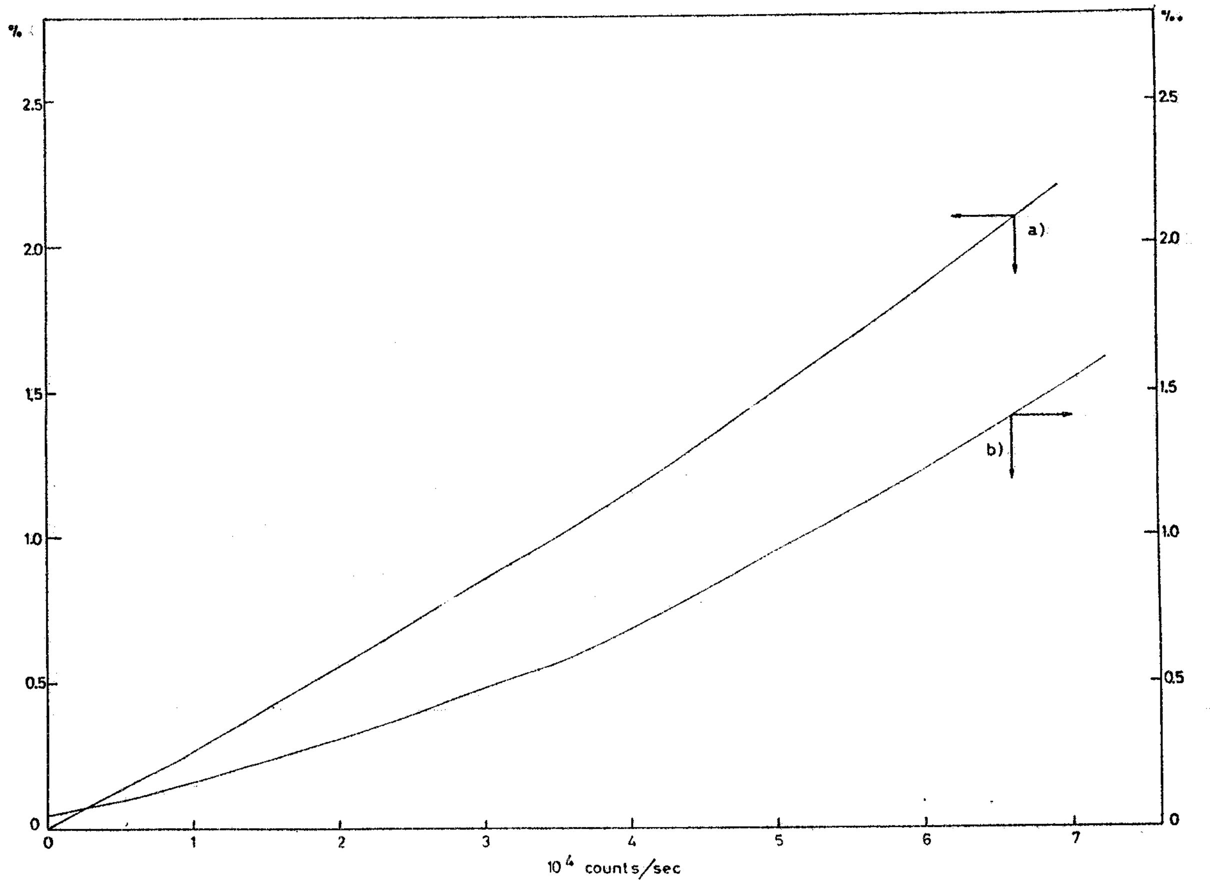

FIG. 2 - Percent of γ above discriminating treshold versus counting rate at zero treshold - Curve a) without veto, curve b) with veto.

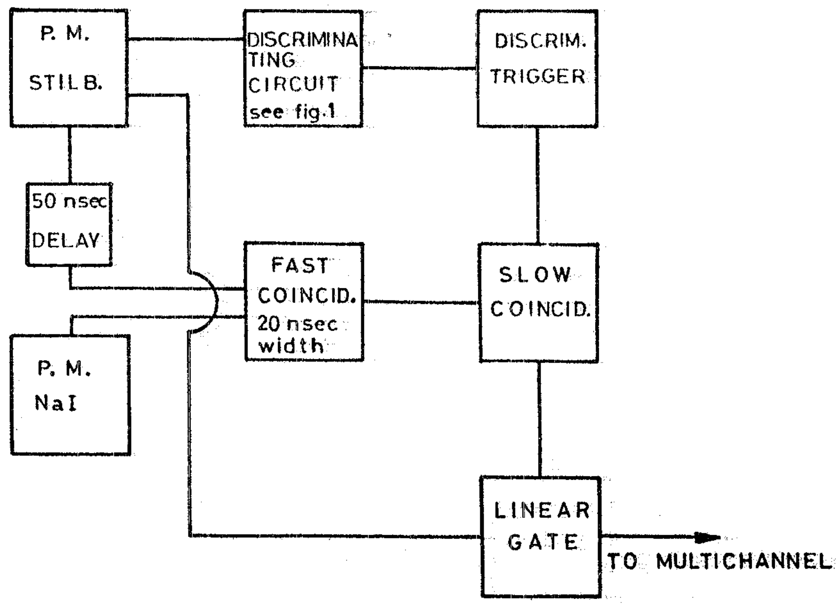

FIG. 3 - Block scheme for the measurement of efficiency to protons at low energy.

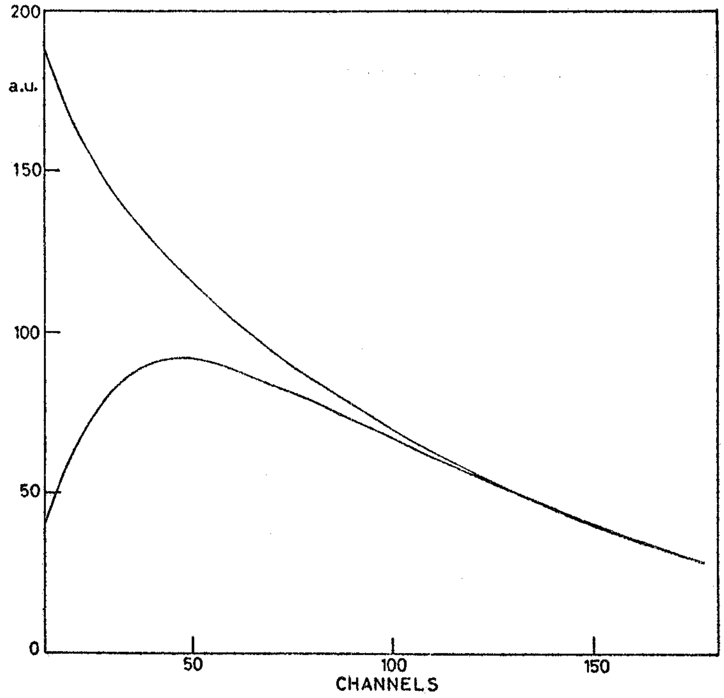

FIG. 4 - Recoil protons spectra for the efficiency, versus light. Upper curve with discriminating treshold equal to zero, lower curve with previously fixed discriminating treshold.

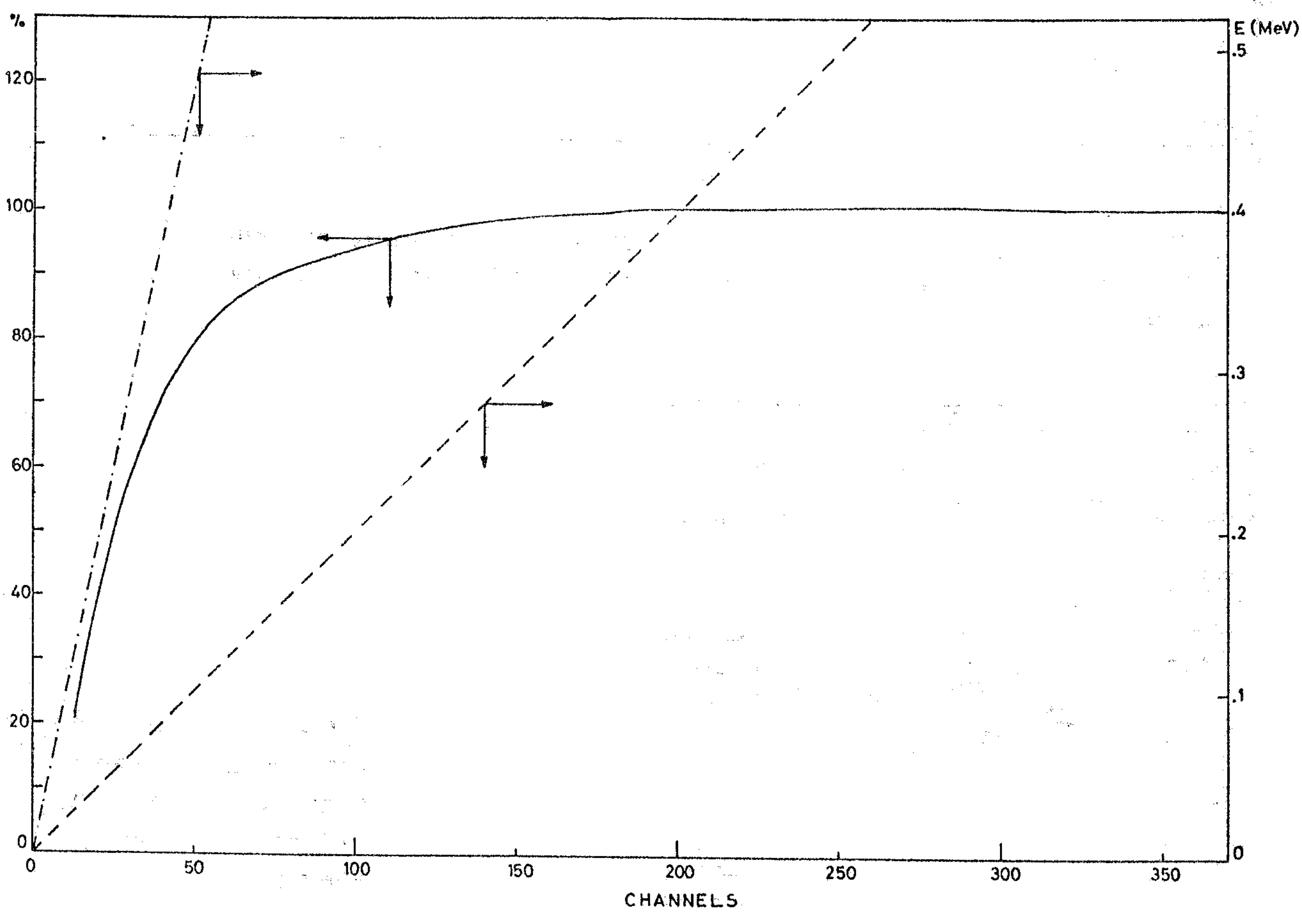

FIG. 5 - Solid curve: efficiency recoil protons versus light. Dashed curve: stilbene response to electrons. Dashed-dotted curve stilbene response to protons[6].

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