# BETA DOSIMETRY WITH SURFACE BARRIER DETECTORS*

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## INTRODUCTION

In the vicinity of small, unshielded radioactive substances, the dose rate due to beta radiation may be substantially higher than the dose rate produced by gamma radiation. However, for radiation protection monitoring, a small dosimeter for β-radiation is still needed, by means of which it will be possible to determine the dose rate on the surface of radioactive substances in an energy-independent manner.

A very small dose rate meter for β-radiation has been proposed by G. Nentwig (1) (2). He uses scintillators of 10 - 25 mg/cm² thickness and counts the pulses exceeding a suitable discriminator threshold. A low-energy beta particle, passing through the scintillator in the same way as a β-particle of high energy while giving off only part of its energy, generates a larger pulse, since the linear stopping power dE/dx increases with dropping β-energy. In connection with a suitable discriminator threshold, a pulse generated by such a particle has a higher probability of surpassing the threshold than a pulse produced by a β-particle of higher energy. By variation of the scintillator thickness and discriminator threshold, Nentwig obtains a small β-dosimeter featuring an energy-independent indication. To our knowledge, this interesting proposal made by Nentwig has not been further pursued.

Nentwig's idea has been transferred by us from scintillators to semiconductor detectors (3). In the case of surface barrier detectors, the thickness of the sensitive layer is changed with the aid of the detector voltage. At low voltages, very small detector thicknesses can be obtained.

## EXPERIMENTAL DESCRIPTION

By means of a surface barrier detector, the count rate was determined for various detector voltages and discriminator thresholds. As described by Nentwig (1) (2), the pulse rate surpassing a set discriminator threshold was determined integrally. In addition, a single-channel analyzer was used, and the channel width was adjusted optimally as a further parameter.

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Measurements were conducted using a ND-7-S[1] detector with an active surface of 7 mm². The detector was covered additionally with a light-tight plastic foil of 1 mg/cm². Measurements were taken at several distances from different ß-emitters. For the individual measuring points, the dose rate had been determined by means of an extrapolation chamber featuring a front electrode thickness of 7 mg/cm².

The ß-emitters used were one nuclide of low peak energy (Pm-147), one of medium peak energy (Tl-204), and one of high peak energy (Sr-90/Y-90). In the case of Sr-90/Y-90, the Sr-90 radiation could be absorbed by plexiglass. Additional measurements were carried out on the secondary normal for ß-radiation developed by PTB (Physikalisch Technische Bundesanatalt, Braunschweig) (4).

## EXPERIMENTAL RESULTS

The sensitivity[2] was determined for various detector voltages, discriminator thresholds and for 2 time constants of the amplifier (0.25 µs and 0.5 µs). In connection with measurements using the single-channel analyzer, the channel width is varied additionally.

When using the discriminator, counting all of the pulses which surpass a set threshold as was done by Nentwig (1) (2), an energy-independent determination of the ß-dose rate was only possible with the time constant of 0.25 µs (Fig. 1). For further measurements, the discriminator threshold of 200 mV was generally selected. The sensitivity to ß-radiation is then equal to 6.7 cpm/mrad/h within ± 20 %. In the course of earlier investigations (3), we had not succeeded in determining the ß-dose rate in an energy-independent manner without the single-channel analyzer.

The use of a single-channel analyzer permits an energy-independent determination of the ß-dose rate with both time constants.

Fig. 2 shows the energy dependence of the sensitivity to $\gamma$-radiation. For Cs-137-$\gamma$-radiation, the sensitivity is equal to that for ß-radiation.

The sensitivity as a function of the dose rate is shown in Fig. 3. With Sr-90-ß-radiation it was only possible to measure up to 600 rad/h. When measuring with the time constant of 0.25 µs, the sensitivity to $\gamma$-radiation only decreased by 20 % at 1400 rad/h as

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[1] Canberra Elektronik GmbH

[2] Sensitivity denotes the ratio of count rate : dose rate below 7 mg/cm² for measurements using the discriminator, and the ratio of count rate in the channel : dose rate below 7 mg/cm² for measurements using the single-channel analyzer.

compared to values at low dose rates. A corresponding decrease in sensitivity already occurs at 300 rad/h in connection with measurements with 0.5 µs and the single-channel analyzer.

Measurements of the dose dependence are shown in Fig. 4 on a second detector. The sensitivity to radiation from 2 nuclides for 2 settings of the electronic system was determined in each case after irradiation with a predefined dose. Up to doses of 50 000 rad, no sensitivity change could be observed.

One disadvantage of the detectors lies in the fact that they become easily defective. For this reason, further measurements are planned using ion-implanted silicon detectors.

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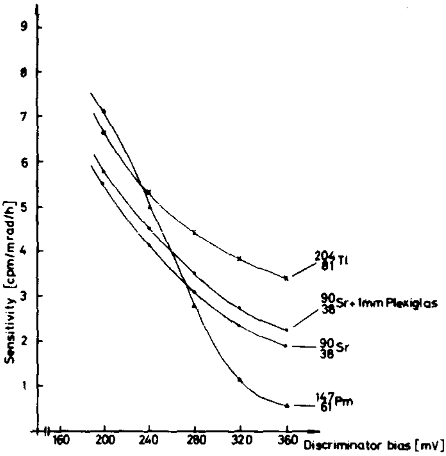


Fig.1: Sensitivity as a function of the discriminator bias for ß-radiation of different nuclides

Detector: ND-7-S; number 1998
Detector voltage: -20 V
Gain: 100 x
Shaping time constant: 0,25 µs

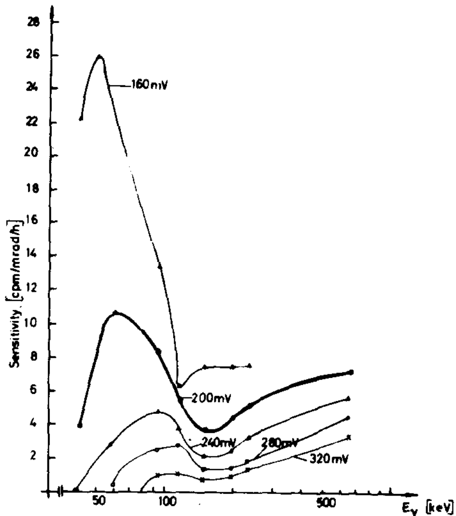


Fig.2: Sensitivity as a function of the γ-energie Parameters are the discriminator bias

Detector voltage: -20 V
Shaping time constant: 0,25µs

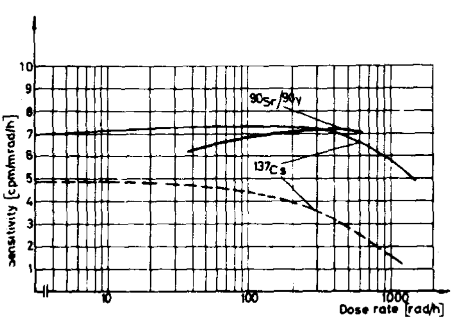


Fig.3: Sensitivity as a function of the dose rate for $^{90}$Sr/$^{90}$Y ß-rays and $^{137}$Cs γ-rays

Detector: ND-7-S
Detector voltage: -20V

—— Discriminator, bias 200 mV, shaping time constant 0,25 µs

- - Single channel analyser; bias 240mV; channel width 130 mV Shaping time constant 0,5 µs

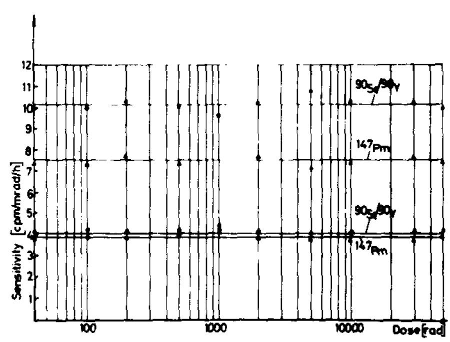


Fig.4: Sensitivity as a function of the dose for $^{90}$Sr/$^{90}$Y - and $^{147}$Pm-ß-radiation

Detector: ND-7-S, number 1999
Shaping time constant 0,25µs
• Discriminator, bias 200 mV
• Single channel analyser; bias 230 mV, channel width 100 mV