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ASSEMBLY OF A LOW-LEVEL BETA RADIATION MEASUREMENT SYSTEM

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ABSTRACT

Beta radiation detection systems are used in different fields, such as: environment, industry, medicine and radiation protection. In this study, a measurement system using a 3mm plastic scintillator was assembled. This detector dimension provides an efficient detection for beta radiation and practically no interference from the laboratory background radiation. A limitation for the environmental measurement application is the high rate of background radiation. With the use of an anti-coincidence system a background of at the most 2 counts per second was obtained.

Key Words: beta, detector, anti-coincidence

RESUMO

Sistemas de detecção de radiação beta são usados em diferentes campos tais como: ambiental, indústria, medicina e proteção radiológica. Neste estudo, um sistema de medida que usa um detector plástico cintilador de 3mm foi montado. Esta dimensão de detector permite uma detecção eficiente da radiação beta e praticamente sem interferência da radiação de fundo do laboratório. Uma limitação para a aplicação em medida ambiental é a taxa de radiação de fundo. Com o uso de um sistema de anti-coincidência foi obtido uma taxa de radiação de fundo de no máximo 2 contagens por segundo.

Descritores: beta, detector, anti-coincidência.

I. INTRODUCTION

In this article the study and the assembly of a measurement system for beta radiation detection is presented. Systems of beta radiation measurements are necessary since several radioactive beta-emitting substances, such as plutonium, cesium, strontium, iodine, and tritium, may impose health risks. These substances are biologically significant. Biological significance is a result of a combination of high decay energy, biogeochemical availability and efficient energy transfer to biological systems [1]. These elements are always produced during nuclear accidents and in industrial processes where nuclear materials are used.

In areas affected by nuclear accidents the level of present radionuclides in the environment is loud, consequently the level of present radiation in victuals of the vegetable and animal origin is loud. The Selentec Environmental Technologies developed a process for remotion of Sr-90 and Cs-137 from milk produced in Ukraine, an area affected by Chernobyl accident [2].

Sr-90 and Cs-137 are very dangerous for health in situations where bioconcentration occurs, for example in cow milk. Sr-90 resembles Calcium, in the way it incorporates in the organism, mainly in bones and teeth. In regions affected by radioactive accidents, it is bioconcentrated in the cows milk and tissues. Cs-137 is chemically similar to potassium and it occurs in high level concentration, but Sr-90 dominates the interest [2]. The detection of these radionuclides is necessary, because their ingestion cause damage to the health.

Beta radiation detection systems used in environmental measurements need to have minimum background counts. The combination of two detectors, a plastic scintillator and a NaI(Tl), is particularly satisfactory for this purpose [3].

II. MATERIALS AND METHODS

The plastic scintillator detector used in this work was produced in the "Centro de Tecnologia das Radiações do IPEN-CNEN/SP" laboratories, as described by Hamada and col. [4]. The dimensions of the scintillator plastic detector used are 50 mm diameter and 3 mm thickness. Figure 1 shows the detector, the photomultiplier and the photomultiplier base.

The plastic scintillator was used as the main detector and a NaI(Tl) detector of 3x3 inches was used as the secondary detector.

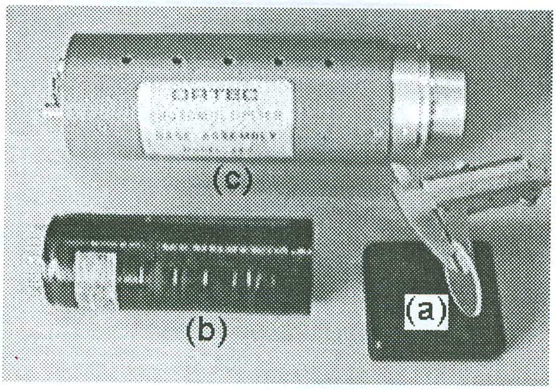

Figure 1 - (a) Scintillator plastic detector, (b) Photomultiplier e (c) Photomultiplier base.

The plastic scintillator was coupled to a RCA photomultiplier unit model 8575 with silicon grease of 1McStokes, in agreement with the analysis done by Hamada and col. [5].

In order to obtain a minimum background, an anti-coincidence unit was used. For the anti-coincidence measurements the plastic scintillator as main detector and the NaI(Tl) as secondary detector were used. The measurements system is presented in the Figure 2.

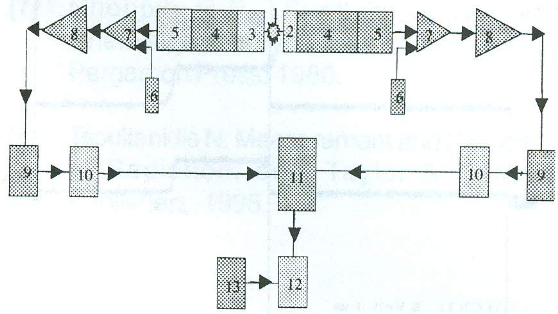

Figure 2 – Scheme of the assembling detectors and associated electronics - (1) Beta source, (2) Plastic scintillator, (3) NaI(Tl), (4) Photomultiplier (5) Photomultiplier base, (6) High voltage power supply, (7) Preamplifier, (8) Amplifier, (9) Single channel analyzer, (9), (10) Gate & delay generator, (11) Fast coincidence unit, (12) Counter, (13) Timer.

__Anti-Coincidence.__ For the anti-coincidence measurements, the main detector output signal (plastic scintillator) enters the coincidence connector and the output signal of the secondary detector [NaI(Tl)] enters the anti-coincidence connector, in the fast coincidence unit. When there is coincidence of the signals the anti-coincidence inhibits the output signal. When there is not coincidence of the signs, the output of the main detector is measured.

The resolving time of the anti-coincidence was adjusted to 2.0 ms. When the secondary detector pulse arises before the main detector pulse in the 0.0s – 2.0ms range, there is not output signal. The Figure 3 shows the output signals of the plastic scintillator and NaI(Tl) detectors after passing to the electronics system; the difference between the signals rise is 2.0ms. The range of the anti-coincidence is exhibited in figures 3 and 4. Figure 5 shows one situation where anti-coincidence does not occur, so there is output signal.

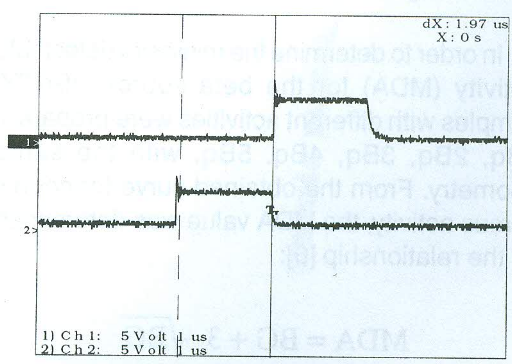

Figure 3 – Input signals in anti-coincidence unit. (1) Plastic scintillator, (2) NaI(Tl). No output signal.

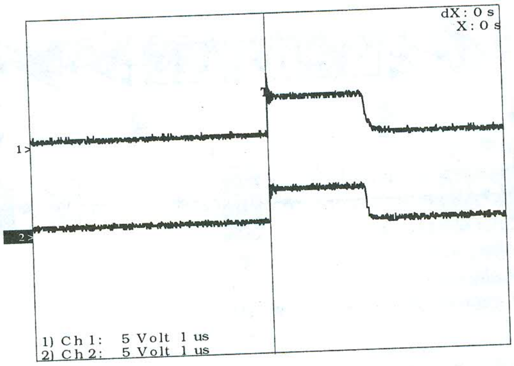

Figure 4 – Input signals in anti-coincidence unit. (1) Plastic scintillator, (2) NaI(Tl). No output signal

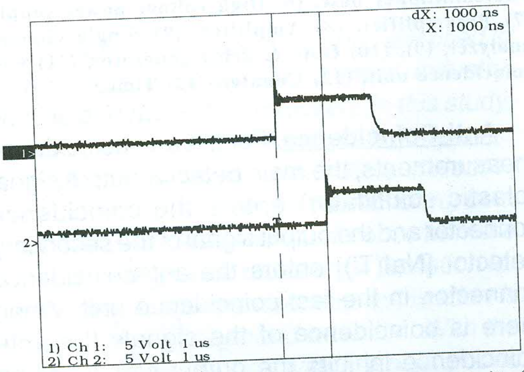

Figure 5 – Input signals in anti-coincidence unit. (1) Plastic scintillator, (2) NaI(Tl). There is output signal.

Measurements. The operation condition and the performance of the gauge system were verified obtaining the beta spectrum of the used radioactive sources, and using the c^2 test and the Gauss curve (68%) [3]. In order to obtain a minimum background value for the beta measurements, anti-coincidence between the plastic scintillator detector and the NaI(Tl) detector signals was carried out.

In order to determine the minimum detectable activity (MDA) for the beta source $^{90}Sr/^{90}Y$, samples with different activities were prepared: 1Bq, 2Bq, 3Bq, 4Bq, 5Bq, with the same geometry. From the obtained curve for counts versus activity, the MDA value was determined by the relationship [6]:

$$MDA = BG + 3 \cdot \sqrt{BG}$$

III. RESULTS

Results. Beta spectra of the sources $^{90}Sr/^{90}Y$ and ^{204}Tl are presented in figures 6 and 7. It was observed that the spectra are continuous in energy as beta spectra described in the literature [3, 7, 8].

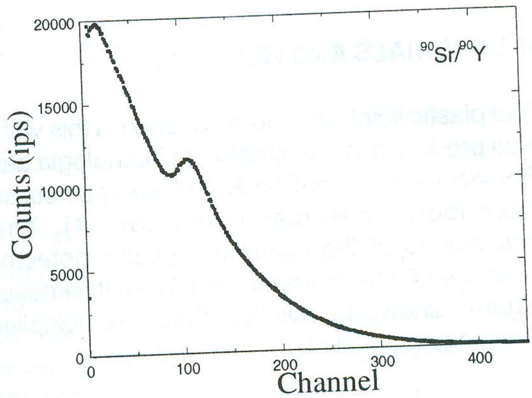

Figure 6 – Beta spectrum $^{90}Sr/^{90}Y$ source

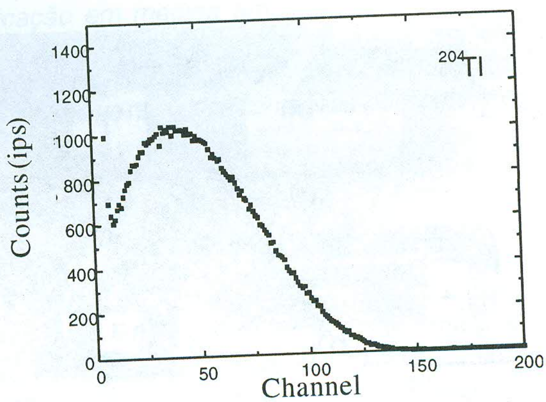

Figure 7 – Beta spectrum ^{204}Tl source

The value of the minimum detectable activity found for our system was of 1,3Bq

The background measurement reached maximum 2.0 counts per second.

With the anti-coincidence unit, the efficiency obtained for the gauge system using a $^{90}Sr/^{90}Y$ source was of 34.6% for geometry 2p.

IV. CONCLUSION

From the beta sources spectra, efficiency of measurement for the small activity of a $^{90}Sr/^{90}Y$ source and data for background obtained, this system proved to be running accordingly and these data are in agreement with the literature.

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