DEVELOPMENT OF A SIMPLIFIED PHOSWICH DETECTOR CONFIGURED WITH PLASTIC SCINTILLATOR BLOCKS COUPLED TO DOUBLE PHOTOMULTIPLIER TUBES

Carlos H. Mesquita, Margarida M. Hamada and Paulo R. Rela
Departamento de Aplicacao na Engenharia e Industria
Instituto de Pesquisas Energeticas e Nucleares-IPEN/CNEN-SP
Cx. Postal 11.049 - Cidade Universitaria- Sao Paulo - BRAZIL

Abstract

The conventional phoswich detectors are configured with two dissimilar response time scintillators and it need a complex electronic system. A new configuration has been made using two similar response time scintillators. The main detector was coupled to one phototube using acrylic light guide. The second detector which was used as Compton-supressor was coupled directly to another phototube. So the signals may be measured easily with more low cost and simplified electronic devices.

INTRODUCTION

Conventional phoswich detectors are assembled by arranging two dissimilar response time scintillators. One of them is composed of a thin piece of scintillating materials that acts as the main detector. It is optically coupled to a larger second scintillating material that has the function of a Compton-suppressor. The double detector is optically coupled to a single photomultiplier and is often called as "phoswich" (or phosphor sandwich)[1,4,9]. It may detect low gamma or X energy radiation and charged particles in high background environment. Previous phoswich designs have typically used inorganic scintillators with long decay times ($t_D \sim 1\ \mu s$) and fast scintillators ($t_D \sim 3ns$)[5,6]. Another pattern uses two plastic scintillators with different decay times ($t_D \sim 3ns$ and $t_D \sim 300ns$)[7,8]. Despite its simplicity it requires a complex electronic device and needs a pulse shape analyzer and a delay time device.

The phoswich adjust is tedious and uneasy. The complexity of the calibration routine and the high cost of the electronic modules have prevented its widespread use. On the other hand, a cheap and simple calibration procedure phoswich could stimulate its use. A prototype has been then developed by following this idea. A new pattern of the phoswich detector was made by using two plastic scintillators of similar response time coupled to a pair of photomultipliers.

Even using a pair of photomultipliers, this device has the advantages of measurement simplicity, not needing the use of a very expensive and complex electronic system. This

0-7803-0513-2/92$03.00 ©IEEE

system allows low energy detection when in presence of a high background environment, using low cost devices and easy calibration procedures.

Both, detector design and construction are shown in this paper and its current experiment performance described.

EXPERIMENTAL SETUP

1. The phoswich detector

Detectors were made using two plastic scintillating material with same diameter and different thickness. The plastic scintillator was fabricated in our laboratory by polymerization of styrene with 0.5% of PPO (1,4-diphenyl-oxazol) and POPOP (1,4-di-2-(5-phenyl-oxazolil))-benzene). Both detectors were made with the same block of plastic scintillator, which has a decay time constant of 2.3 ns[3]. The thin detector was machined with a 50.8 mm diameter. This plastic wheel was semi-immersed at its diameter level in a volume of acrylic resin. The scintillating material was then firmly soldered into an acrylic block once the resin was solidified. These materials were remachined until a 5 mm thickness as shown in fig. 1. Do note that the plastic scintillator wheel maintains its entireness in this block. The portion of acrylic does act as a guide light. To redirect the scintillating light to the photomultiplier tube the guide light was cut in a face of 45° as shown in fig. 1. A light pipe was coupled with silicone grease on the upper side of the 45° cut surface. Then it was coupled to a 25 mm diameter photomultiplier (EMI type 9224A). Later, all surfaces, including the 45° cut surface, were covered with a Teflon tape. This one acts as a good scintillator light reflector.

The Compton-suppressor detector was machined to a 50.8 mm diameter and a 100 mm height. It was directly coupled to a 50 mm diameter photomultiplier (Hamamatsu model R329-02). Similarly, all its lateral surfaces were covered with a Teflon tape. Both detectors were optically detached by a fine aluminum foil placed between their coupled surfaces. Details of the coupling of the entire phoswich detector, including the light guides, photomultipliers and bases are shown in fig. 2.

2- Electronics

The electronics that connect the photomultipliers with the acquisition system are very simple. Signals from each phototube were connected with two distinct preamplifiers and amplifiers. The amplifier signals fed an anticoincidence circuit followed by a time-count system.

The same 1000 volts high-voltage was applied on both photomultipliers. The variable resistor from the voltage divider network of the phototube does work as a gain compensator.

RESULTS AND DISCUSSION

Fig. 3 illustrates ^{241}Am source measurements with and without the aid of the phoswich technique, according to our results. In the same way, fig. 3 shows ^{137}Cs source measurements viewed by means of the herein proposed phoswich. This device was shown to be extremely simple what lead us to think of myriads of different employments. However, being the light collection made at the sides of the detector, it is foreseeable to occur a yield light lost in the photon collection. Accomplished survey results showed a 35% lost, what seems reasonable for not to void the prototype. Other remarkable fact of the detector achieved is that it requires a much less complex electronics than the conventional phoswich detector. Also, the treatments of the signals from both detectors, the thin or main detector and the Compton-supressor, have similar properties. Therefore, due to its electronic treatment, a simpler detector was made.

It is advisable to stress that plastic scintillators may not be the best alternative for phoswich detector project for multiple purposes. Particularly, the plastic scintillator was used once it is currently made out in our laboratory. By employing same detector conception, the use of more efficient scintillators is also advisable. Consequently, better results may be obtained.

Moreover, the plastic detector is an inexpensive device and has fast scintillating properties. Therefore, it may be then employed in dynamic studies in which speed is required. Another advantage this developed phoswich presents, is the possibility of permitting the easy changing of the scintillation plate to improve the detection of different kinds of radioactive sources. Compton-suppressor photomultiplier could be replaced by new photodiodes(2) being so the size of the device reduced. Like any other phoswich detector this prototype is also foreseen for larger sensitive areas.

This research was supported by the CNPq

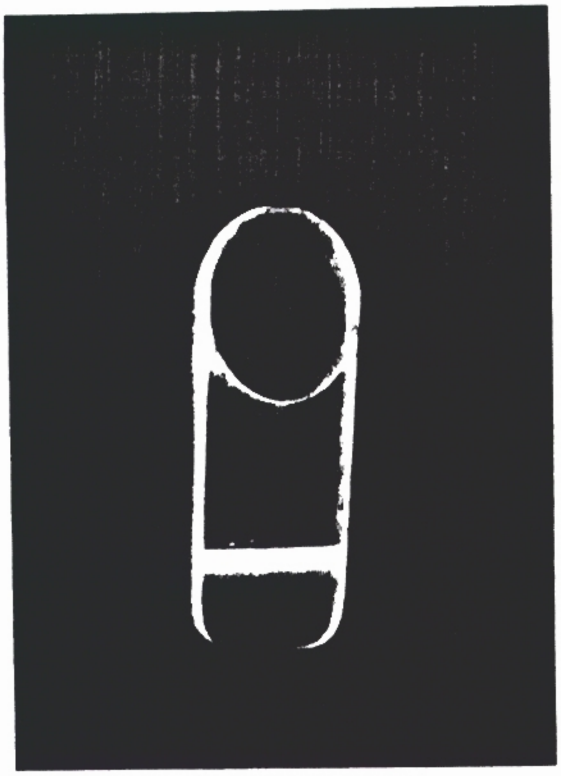

Figure 1. Scintillation plate

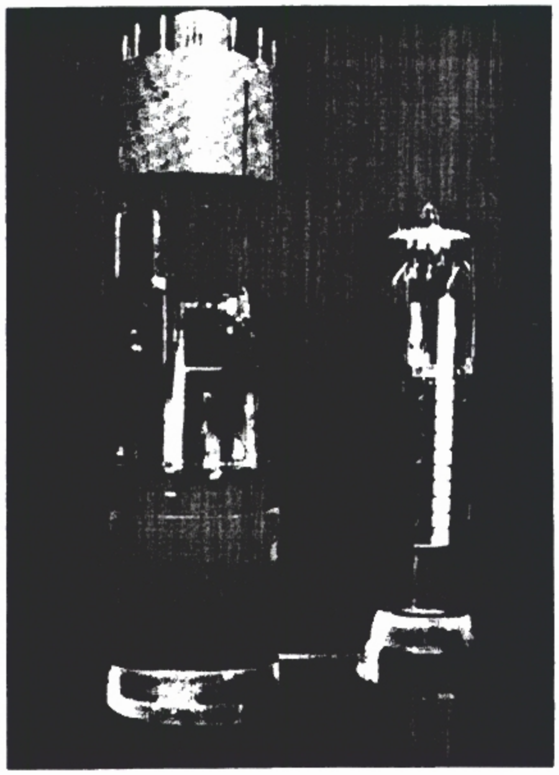

Figure 2. Details of the coupling of the entire phoswich detector

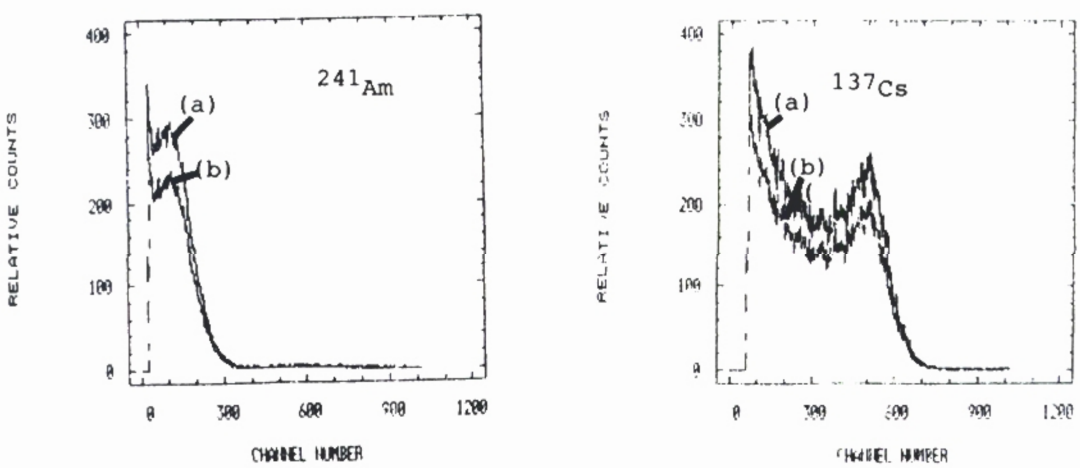

Figure 3. Spectra of ^{241}Am and ^{137}Cs with (**b**) and without (**a**) Compton Supressor

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