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GAMMA RAY DETECTOR CALIBRATION TO MEASURE LOCAL ENVIRONMENT RADIATION

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ABSTRACT

In a recent article the authors describe the origin of gamma radiation or low energy gamma rays up to 10 MeV (Millions of electron Volt). A type of high frequency electromagnetic radiation usually produced by radioactive elements and electrical discharges present in the environment where we live. The intensity of this radiation may vary with each location on the planet. Measurements of gamma radiation from 200 keV to 10.0 MeV were taken at the campus of the Technological Institute of Aeronautics - ITA - in São José dos Campos, SP, Brazil. The detector set plus the associated electronics was previously calibrated in the laboratory using the radioactive sources of Cesium - (Cs-137), Polonium- (Po-210) and Strontium- (Sr-90). These sources provide gamma ray energies at (0.662 keV, 1.17 MeV), alpha particles at 5.4 MeV and electrons at 0.90 keV, respectively. The detector consists of a height-by-diameter (3x 3) inches, Thallium Activated Sodium Iodide [NaI (Tl)] scintillator, associated with a photomultiplier (PM) and associated electronics and data acquisition. Measurements were taken within 10 minutes, in the environment, with each radioactive source and with all radioactive sources placed on the scintillator. The generation of the spectra as a function of energy is always studied at the same time interval. It was thus possible to determine for this location the presence of natural gamma radiation present at the ground-air interface for this energy range using a minimum measurement time interval of 10 minutes.

Keywords: *Ionizing radiation, Gamma rays, Gamma radiation detector*.

I. INTRODUCTION

The spectrum of gamma radiation is usually produced by radioactive chemical elements such as Uranium (238U, 235U), Thorium (232Th) and Potassium (40K) in which they have relatively low wavelengths (λ) in the order of picometers that increases its penetration power in the environment[1]. Due to its high energy rate, it has an ionizing effect and can cause irreparable damage to the cell nucleus of living things. Its production is always associated with alpha or beta radiation. It happens that after the emission of this type of radiation, the atomic nucleus often undergoes a reorganization process that is, passing from an excited state to a lower energy one, giving rise to electromagnetic emissions. Thus, it is common to have an alpha emission followed by a gamma, or a beta emission followed by a gamma [2]. Gamma radiation of different intensities can be measured according to the region in which the equipment is located. The amount of radioactive elements present in the soil varies with each region of planet Earth. Different techniques are already in place to measure this radiation in this energy range both in soil and in air or water [3].

II. METHOD & MATERIAL

The calibrated equipment is a portable system consisting of a crystal (3x3) inches in diameter and thickness. Always protected by a thin, cylindrical aluminum layer, along with a photomultiplier (PM) with a 1500 VDC power supply circuit and data acquisition system provided by the company (Aware Electronics-Inc., USA) [4], always monitored by a PC. The first step of this work was to measure the ambient radiation present at the ITA (Aeronautical Technological Institute) campus in São José dos Campos - SP, Brazil, identifying the intensity of radioactive elements such as Bismuth (214Bi), Potassium (40K) and Thallium (208Tl.) [5]. The acquisition system and the data obtained allow the construction of graphs of radiation intensity versus channel, with a wide sampling of up to 1024 channels [6]. Then using the radioactive sources Cs-137, Po-210 and Sr-90 in the ITA graduate school laboratory, the energy channel transformation was performed. Therefore all graphs presented in this work were reported in

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radiation intensity versus incident radiation energy. This transformation was performed using features from Excel and Origin 2015 software's [7].The gamma-ray monitoring system calibrated in energy range up to 10 MeV work very well to environmental radiation measurements.

III. RESULT & DISCUSSION

The graph in Figure 1 shows for a measure of ITA campus ambient radiation over 10 minutes of sampling the intensity in channel counts versus channel number provided by the Ludlum detector [8].

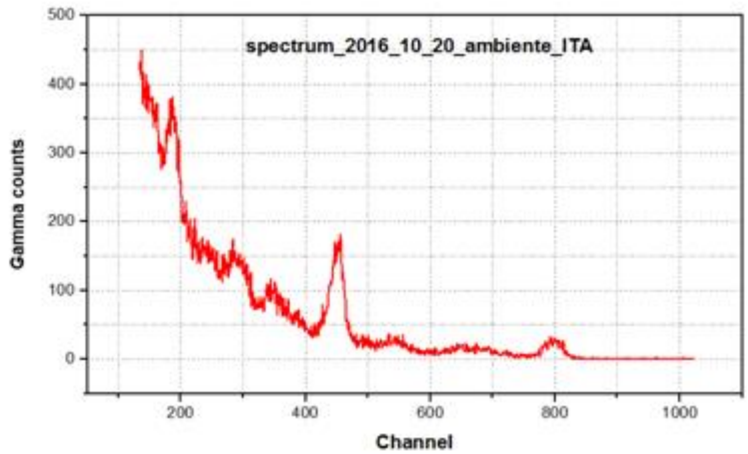

Figure 1: Graph of gamma ray measurement present in the environment (ITA), Intensity X Channel

For the best analysis of the acquired data, the intensity versus channel graph was transformed to intensity versus energy. Made with the help of radioactive sources and Excel and Origin 2015 software. This chart can be seen in Figure 2 below where the channel axis becomes energy equivalent to that channel.

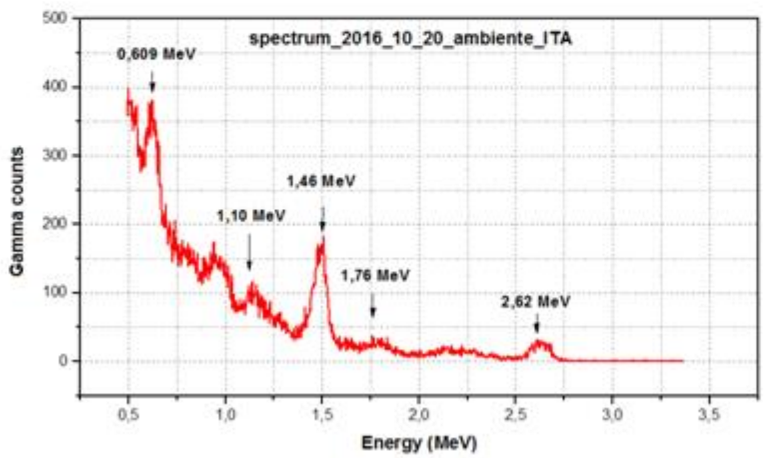

Figure 2: Graph of gamma ray measurement present in the environment, Intensity X Energy.

Then a new measurement was made and the graph plotted, using the radioactive sources Cs-137 (emitting gamma rays), Sr-90 (emitting beta particles) and Po-210 (emitting alpha particles) positioned in direct contact with the equipment. as shown in Figure 3 below. These sources provide gamma ray energies at 0.662 keV and 1.17 MeV, alpha particles at 5.4 MeV and electrons at 0.90 MeV, respectively.

Figure 03: Photo of Gamma ray spectrometer in contact with radioactive sources Cs-137, Sr-90 and Po-210.

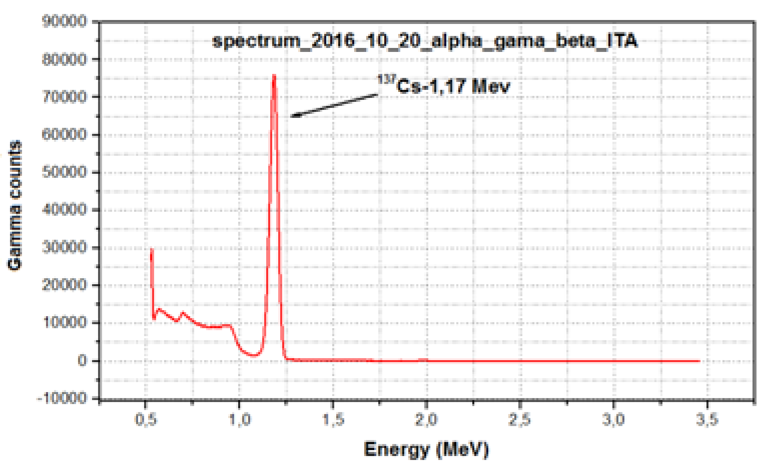

Figure 4: Graph of radiation measurement emitted by radioactive sources: Cs-137, Sr-90 and Po-210.

It is observed in Figure 4 that gamma radiation 1.17 and 0.662 MeV from the Cs-137 source saturates the other peaks. Then, the radioactive element Cs-137 was removed and a new measurement was performed only with the elements emitting alpha and beta particles shown in Figure 5.

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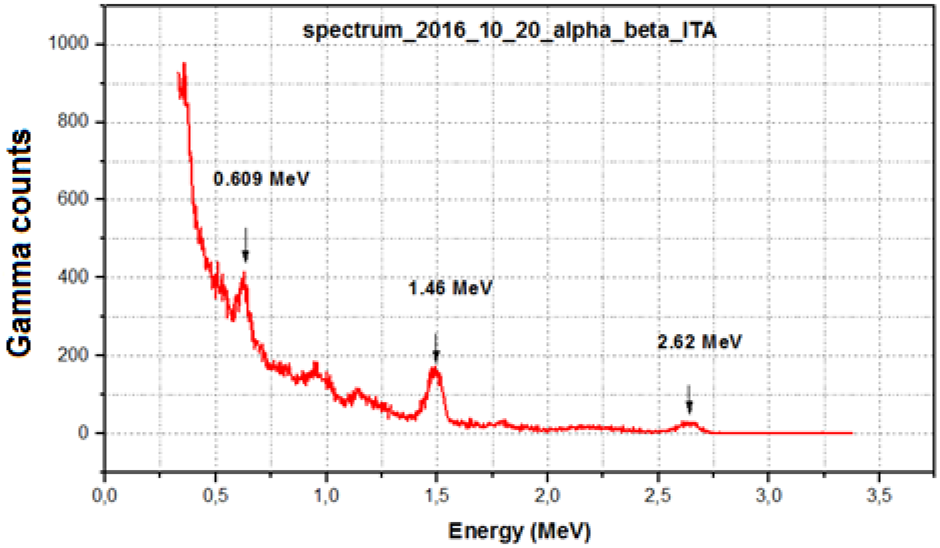

Figure 5: Graph of radiation measurement emitted by Sr-90 and Po-210

In this case the observed measurement is practically the same as the environmental one. The last measurement with the equipment was made using panned uranium stones in the region of the city of Poços de Caldas - MG, Brazil, abundant mine of uranium in this region. Putting them in touch directly with the equipment as well as the previous elements, the gamma radiation spectrum is verified as a function of the energy seen in Figure 6.Several peaks appear between 0.5 to 1.0 MeV corresponding to radioactive elements of the region uranium (Uranite).

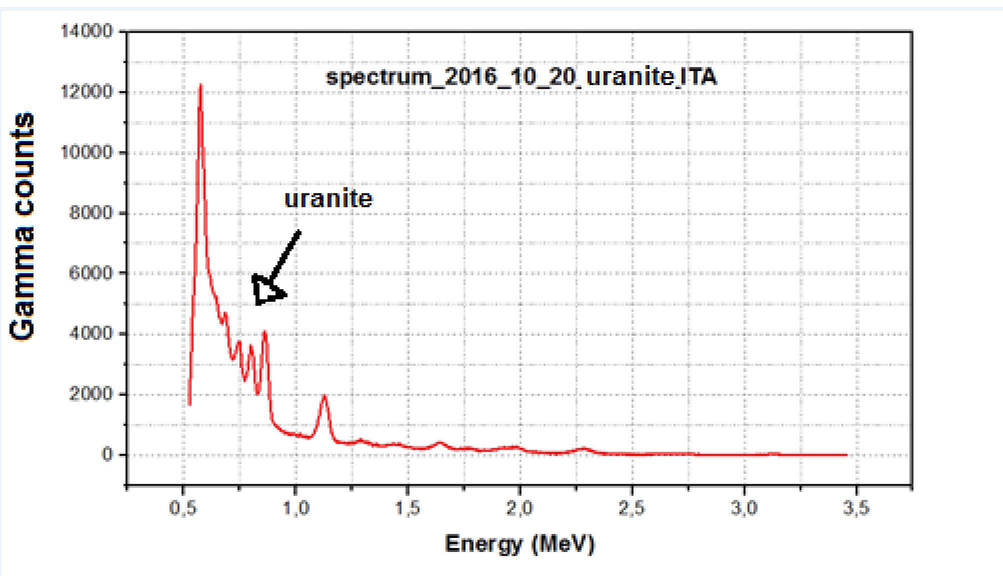

Figure 6 - Spectrum of Uranite samples from Poços de Caldas region, MG, Brazil

The analysis of graphs 1 and 2 clearly showed the environmental radiation present in the ITA campus region, highlighting the peaks of 0.609 MeV (214Bi), 1.10 MeV (214Bi), 1.46 MeV (40K), 1.76 MeV (214Bi) and 2.62 MeV (232Th). Already in the third graph, the radioactive element 137Cs in contact with the detector, emits a high intensity of gamma rays at 1.17 MeV, obfuscates the environmental radiation present at the site. In the fourth graph, there is no change caused by the radioactive elements Sr-90 and Po-210, in which they emit alpha and beta particles. Alpha radiation is easily barred by a sheet of paper, beta by an aluminum plate and gamma by a thick lead plate as shown in Figure 7. Since the detector is protected by a thin layer of aluminum, it is not possible measure alpha and beta radiation with the Gamma ray spectrometer employed in this work. In this case, Geiger Muller with open window is used to be sensitive to these radiations. However with this type of detector (Geiger Muller) it is not possible to make spectra but to measure integrated energy ranges as described by the team's work (reference 1).

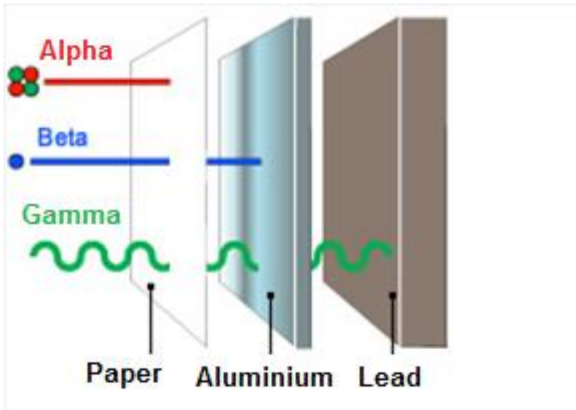

Figure 7 - Demonstration scheme on radiation transmission and absorption employed in this work [9, 10]

Lead is widely used to attenuate gamma radiation in the energy range of this work.

IV. CONCLUSION

For the correct calibration of the gamma radiation detector, five measurements were made. The first of these was the ambient radiation spectrum obtained by human intervention, then alpha (Po-210) radioactive sources at 5.4 MeV, gamma (Cs-137 in which provides gamma rays at 0.662 keV and 1.17MeV). and beta (Sr-90) at 0.90 MeV. In the third measurement, Cs-137 was removed and only the ambient radiation spectrum was obtained, as alpha and beta particles do not penetrate the aluminum layer present in the detector. Finally the radiation emitted by the uranium stones (Uranite) from the region of Poços de Caldas, MG, Brazil. Analyzing the perfect operation of the equipment, highlighting the main peaks in each measure. It is noteworthy that the equipment used is fully portable allowing the analysis of gamma radiation spectra in situ and in numerous regions with relatively good spectral resolution and operate facilities.

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