


CHAPTER 28

Spectrum and net counts rates of ambient low energy (0.2-10.0) MeV gamma rays in São Jose dos Campos in Brazil region

 [doi 10.56238/pacfdnsv1-028](https://doi.org/10.56238/pacfdnsv1-028)

Inacio Malmonge Martin

Physics Department of ITA – Technological Institute of Aeronautics

ABSTRACT

The measurement of the energy spectrum of environmental gamma radiation in the region of São José dos Campos, SP, Brazil, can indicate the radioactive chemical components existing in the land and air of this region. The portion of this radiation produced by primary and secondary cosmic rays are of

lower intensities and vary very little with respect to time on the Earth's surface. Winds and rains also vary the intensity of this gamma radiation near the earth's surface through the exhalation of radon gas. Using a gamma radiation spectrometer calibrated between the lower limit of 180 keV and the upper limit of 10.0 MeV, it was possible to determine these counts as a function of measurement time in this region.

Keywords: environmental gamma radiation, cosmic rays, radon gas.

1 INTRODUCTION

In the ground level of the Earth's surface, ambient ionizing gamma radiation is mainly composed with **ground telluric radiation** and primary and secondary cosmic ray radiation. However, it is difficult to separate over time the intensity of ionizing gamma radiation emanating from each component as the energies overlap. Telluric radiation is given by ^{238}U , ^{235}U , ^{40}K and ^{232}Th that is constant for each region [1]. **Radon gas** coming from the disintegration of ^{238}U on the earth's crust to ^{226}Ra and ^{222}Rn that arrives in the ^{214}Pb , ^{214}Po and ^{214}Bi isotopes, generating alpha and gamma radiation [2]. Primary cosmic radiation consists mainly of galactic and extragalactic protons and those from the Sun, all with high energy that interacts with the Earth's atmosphere producing Extensive Air Showers (EAS) [3]. Another possible source of ionizing radiation in the Earth's lower atmosphere are produced by lightning strikes between earth-clouds and clouds-earth[4]. The lightning cone forms X-rays, gamma rays, neutrons and beta particles [5]. Other sources of ionizing radiation are those produced in medical, dental and hospital clinics, but these are mainly controlled in small areas. Radon (^{222}Rn) are recognized as a major contributor to the dose due to natural radioactivity in the soil, being responsible for approximately half of all human exposure to ionizing radiation, [6]. Radon is a noble gas, emitting alpha particles, produced in the series of natural decay of uranium and thorium, which occur in varying concentrations in diverse geological materials, especially in rocks, soils and waters. Its diffusion and convection in the air occur at low altitudes (approximately <1000 m). Radon migrates from rocks and soils to the atmosphere through cracks, holes and pipes and it enters homes and other buildings. It is evident of oscillations in the emission of radon gas in periods of day and night with moderate doses of gas emission in days of intense rain and dry days with intense sunshine in the region [7]. Another important source of indoor radon gas is the construction materials. The progeny of

radon has received considerable attention in recent decades due to its potential causative effect of lung cancer if deposited in the upper respiratory tract when constantly inhaled, [7].

The rainfall intensity in (mm/min.) was measured with a pluviometer (bascule/bucket) rain gauge and data logger acquisition developed in ITA according to the international recommendations. Very few measures on the presence and variability of gas radon exist in Brazil, which makes it difficult to measure its intensity and factors that interfere with local health.

2 MATERIAL AND METHODS

The gamma ray detector used here for the 200 keV to 10.0 MeV energy range interval photons consists of a 3 inch high by 3 inch diameter Thallium doped NaI (Tl) scintillation crystal. This crystal directly coupled to a photomultiplier (PM) that records the pulses coming from the amplified scintillator and a digital analog converter with signals recorded by a computer laptop [8]. This experimental setup (Figure 1) is located in the inner room of a tower 25 m high relative to the ground (ACA Tower). The scintillator attached to the photomultiplier is wrapped in a thin layer of aluminum to make it portable. The set (scintillator + associated electronics + data acquisition) relies only on a laptop with a charged battery to measure radiation for up to 10 continuous hours. However, for long measurement series, electricity or photovoltaic power is used. The scintillator and associated electronics were calibrated in energy and intensity counts per minute in the ITA teaching experimental physics laboratory using radioactive sources and a 0.2 to 10.0 MeV spectral analyzer [9]. On the upper ceiling of the room shown at the top of the tower, a scale rain gauge was installed to measure the intensity of rainfall every minute. In that same room with open windows, an ionization chamber (see Figure 3) was installed to measure the intensity of radon gas at every hour[10,11].

Fig. 1: View of gamma scintillator with associated electronics and computer, (author).



Fig. 2 - Aerial and ground view of the tower ACA and his environmental field region in São José dos Campos, SP, Brazil (23° 12'45" S, 45° 52'00" W), (author).



3 RESULTS AND DISCUSSIONS

The spectrum of five measurements at different locations and dates is presented all close to the coordinates of (23° 12'45" S, 45° 52'00" W), sites already worked by man and without debris or rubbish with possible components, chemical or organic.

Figure 3 shows the measurements of the spectrum observed at an altitude of 25 meters and on the ground of the tower compared with the spectrum taken inside a house 1 km away from Earth surface in São José dos Campos.

Fig. 3 – Environmental spectrum measurements at ITA campus in one tower 25 meters high, and one house one kilometer next to the tower (author).

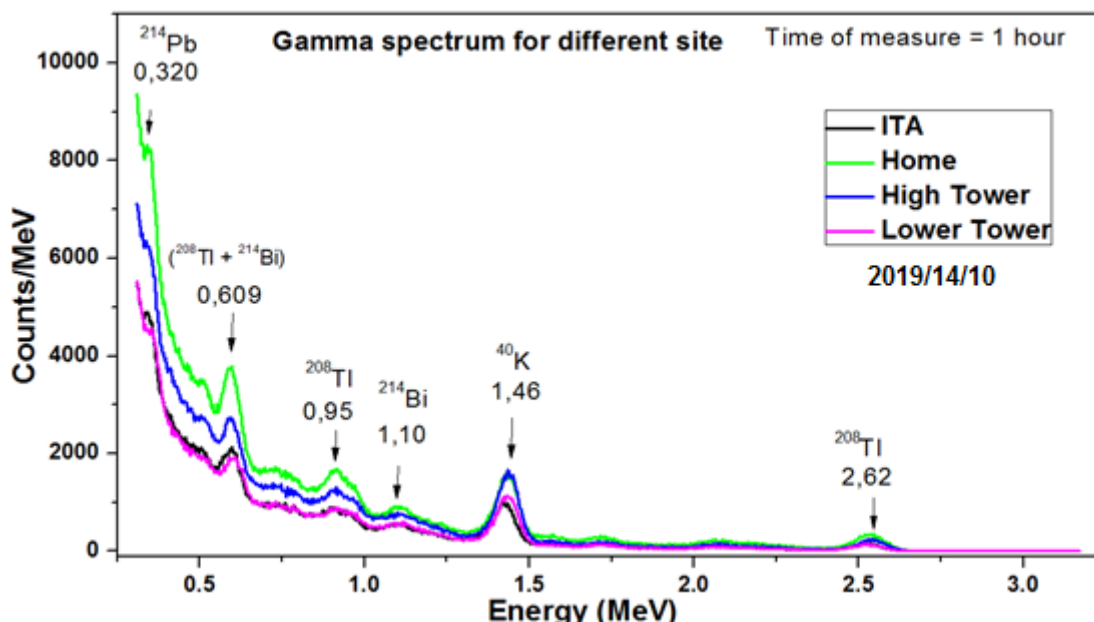


Figure 4 shows measurements of the gamma ray spectrum in April 2020 for 30

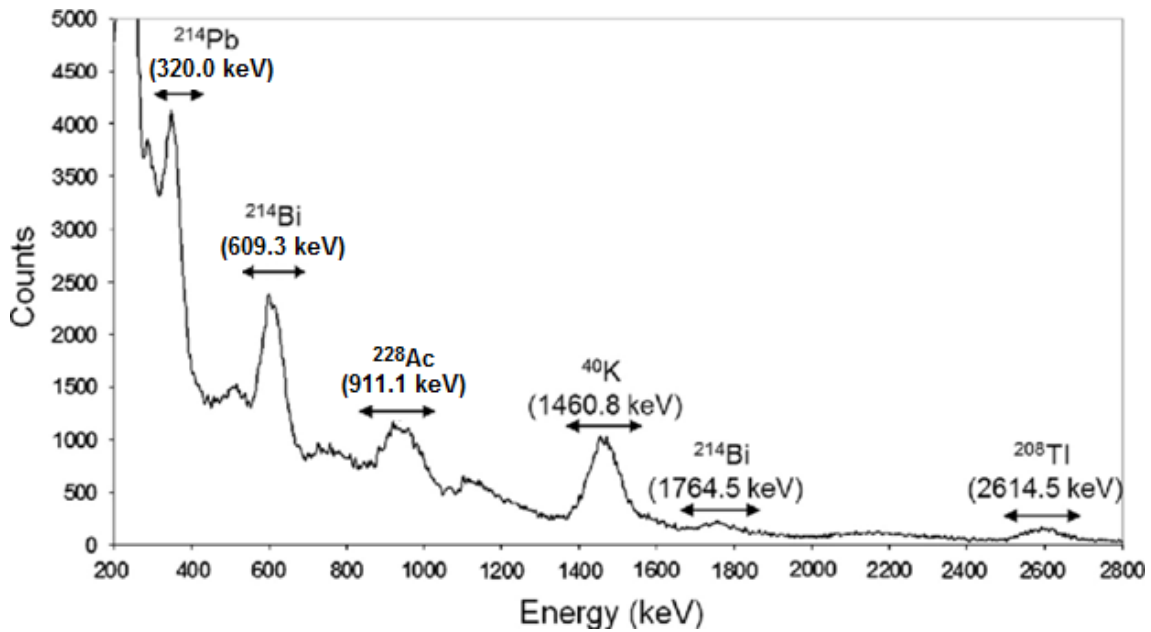
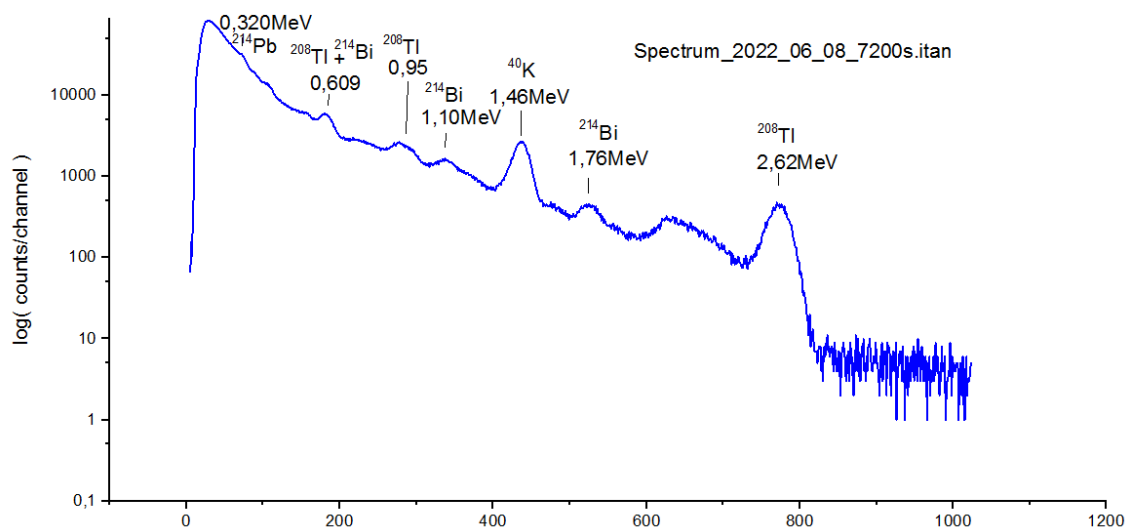


Fig. 4 – Spectrum measured at the ITA campus near the electromagnetism laboratory for experimental classes for second year students of the ITA, F46L course in April 2020 (author).

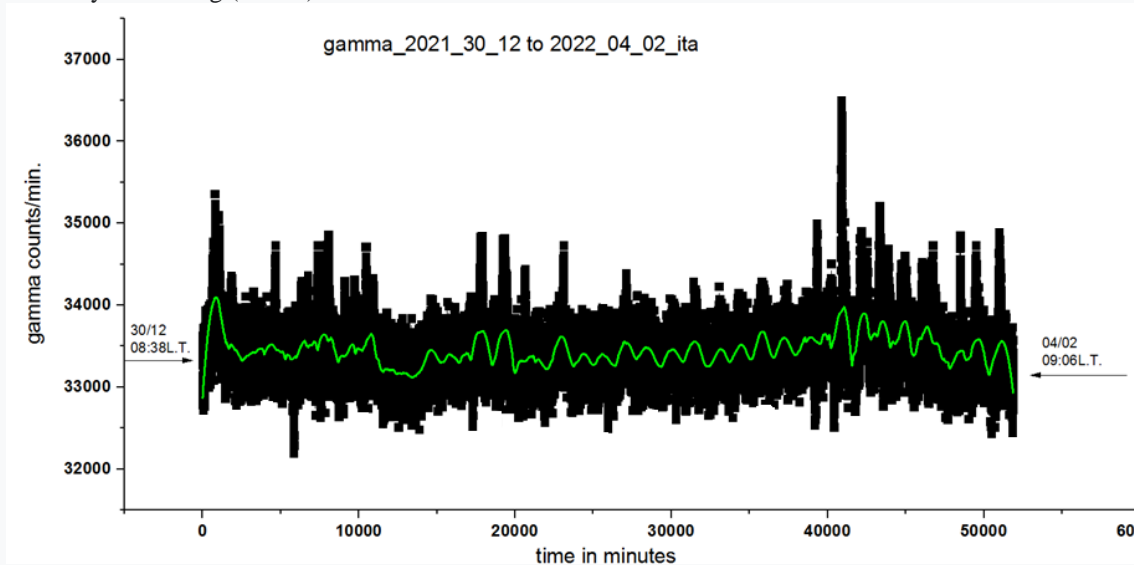
minutes in the electromagnetism laboratory in the old building of the Physics Department at ITA. In figure 5 the same spectrum is shown now with 2 hours of integrated time and in the

Fig. 5 – Measurement of the gamma ray spectrum performed in the new ITA building in the Physics Department, author's room on a logarithmic scale for 2 hours (author).



in the electromagnetism laboratory of the new building of the Physics Department at ITA. Figure 6 plots the measurements of the integral flux of 0.2-10 MeV every minute during December 30, 2021 to February 4, 2022.

Fig. 6 - Count of gamma radiation integrated every minute on the ITA campus from 12/30/2021 to 02/04/2022. The green line correspond one-day smoothing (author).



During the period from January 2014 to July 2022, around 50 spectra were performed in this energy range and in several locations on the ITA campus.

4 CONCLUSION

With this spectrometer with a supply of 600VDC from the NaI(Tl) scintillator and with a minimum of 10 minutes of measurements, it was possible to clearly observe the emission lines of the local surface: ^{208}Tl (2.62MeV), ^{214}Bi (1.76 MeV) , ^{40}K (1.46 MeV),

^{214}Bi (1,10MeV), ^{208}Tl (0.95MeV), [^{208}Tl + ^{214}Bi](0,609MeV) and ^{214}Pb (0,320 MeV). The resolution of these peaks improves as a function of longer measurement times.

In the case of counting per minute, variation in day/night gamma radiation, variation with the presence of rain and relative humidity can be seen. The presence of this local gamma radiation is sensitive to the emission of radon gas at the location and also due to the washing of this gas suspended in the lower cloud layers during heavy rains. These lines observed in the region are part of the decay of the nuclear series of the

^{232}Th , ^{40}K e ^{238}U from earth surface.

ACKNOWLEDGMENT

Thanks to CNPq (National Counsel of Technological and Scientific Development) and CAPES (Coordination for the Improvement of Higher Education Personnel) by the Fellowship Grant Support to the group's researchers and the ITA Division of Fundamental Sciences for supporting this research. Thanks also to INCT-FNA-ITA for supporting this research at ITA.

REFERENCES

[1] Bui-van, N. A.; Martin, I. M.; Turtelli, Jr. A. **Measurements of natural radioactivity from natural, industrial and atmospheric depths.**- *Ciência e Cultura*. Suplemento. 1998, 40(7),407.

[2] Fujinami, N. **Study of radon progeny distribution and radiation dose rate in the atmosphere.** *Japanese J Health Phys*. 2009,44(1), 89-94.

Accessed in:<https://doi.org/10.5453/jhps.44.89>

[3] Grieder, P. K. F. **Extensive air showers: high energy phenomena and astrophysical aspects**, Springer: Verlag Berlin Heidelberg; 2010.[4] [4] [4]

[4] Malyshevsky, V.S. and Fomin, G.V. **Electromagnetic radiation in the atmosphere generated by excess negative charge in a nuclear electromagnetic cascade.** *Russ Phys J*. 2017;59(9):1367-1372.

Accessed in:<https://doi.org/10.1007/s11182-017-0918-9>

[5] JAYANTHI, U. B., Inacio M. Martin et al. **Ground gamma radiation associated with light and rain precipitation.** In: Acharya S, Gupta S, Jagadeesan P, Jain A, Karthikeyan S, Morris S, et al. editors. *Proceedings of the 29th International Cosmic Ray Conference; 2005 Aug 3-10, Pune (India)*. 2005, (1), 177-180.

[6] Martin IM, Gomes MP, Ferro MAS, Pinto MLA, Antônio FC. Measurements of X and gamma radiation at ground level and their correlation with atmospheric electric discharges and rainfall in São José dos Campos, SP, Brazil. *World Environment*. 2013;3(4):138-141. USA

DOI: 10.5923/j.env.20130304.03

[7] SILVA, M. C. et. al., **Ionizing Radiation Measurements using low cost Instruments for teaching in college or high school in Brazil.** *Phys Educ*. 2017, 52(6), 064004.

Accessed in:<https://doi.org/10.1088/1361-6552/aa8420>

Ravisankar, R. et al. **Measurement of natural radioactivity in building materials of Namakkal, Tamilnadu, India using gamma-ray spectrometry.** *Applied Radiation and Isotopes*. 2012, 70(4), 699-704. Accessed in:<https://doi.org/10.1016/j.apradiso.2011.12.001>

[8] Boardman, B. J. **Wilmington:** Aware Electronic Corp. [Accessed in 2017 Jul. 3]. Accessed in: www.aw-el.com

[9] Valdir Guimarães – Radiação – Detectores – Geiger – NaI – Fontes, USP FNC 377 – Classroom Notes - https://www.researchgate.net/profile/Valdir_Guimaraes2 accessed in January 2020.

[10] Gamma rays detectors from AMPTEK – www.amptek.com accessed in January 2020.

[11] Martin IM, Gomes MP, Ferro MAS, Pinto MLA, Antônio FC. Measurements of X and gamma radiation at ground level and their correlation with atmospheric electric discharges and rainfall in São José dos Campos, SP, Brazil. *World Environment*. 2013;3(4):138-141. USA

DOI: 10.5923/j.env.20130304.03