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MEASUREMENT OF TERRESTRIAL NEUTRONS UP TO 10.0 MEV IN SÃO JOSÉ DOS CAMPOS, SP, BRAZIL DURING THE PERIOD OF JANUARY 2015 TO MARCH OF 2015

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ABSTRACT

A portable and compact system based on a He-3 gás tube (LND, USA; model 25311) with an sensitive area of approximately 250 cm² and covered with paraffin (9 cm) was used to detect and monitoring neutrons at ground level in the energy range up to 10.0 MeV, during January 2015 to march of 2015 in São José dos Campos, SP, Brazil (23° 12' S, 45° 52' W). The detector and other hardware instruments are housed in an air-conditioned room placed near ground level. Neutron counts were accumulated at 1-minute intervals continuously. The months of January/March 2015 were normal with respect to rainfall, being with driest and wet altering days in the region. Rainfall and cloud coverage were also normal and temperature reached record levels (30° C). Coincidentally, the average neutron counts for driest days (0.2 neutrons/minute) were also low compared with other rainy days showing the presence of induced cosmic ray neutrons up to 10,0 MeV energy. The measurements and FFT analysis of the data in this three months also show that neutron counts present a daily periodicity and that the peak occurs approximately when the sun is at its highest elevation (zenith) in the sky. This indicates that the neutrons are produced by cosmic rays and that they are not related to the presence of clouds or lighting discharges. Previous studies carried out by our research group in 2010-2014, in the same months, have observed that cloud coverage modulates neutron counts at this location in tropics.

KEYWORDS: Nêutrons, Cosmic Radiation, Monitoring

INTRODUCTION

Neutrons near the Earth's surface in the energy range described above are produced by primary and secondary cosmic radiation and electrical discharges (Babich and Bodikov2013). Neutrons from cosmic radiation are dependent on the altitude on the atmosphere and also latitude, according to measurements taken at the surface and aboard stratospheric balloons at altitudes up to 40 km in Brazil in France and Russia (Martin, IM, 1971). In the soil-air interface, the intensity of neutrons with energy up to 10 MeV depends on the location, on the height above the soil on which the detector is placed. At equal heights neutron counts are maximum at the poles and minimum near the geomagnetic equator. This variation of the intensity of neutrons even close to Earth's surface is due to magnetic cut-off rigidity of the primary cosmic radiation. In the poles it is about 0.1 GV while at the equator it is about 17 GV, and in Sao Jose dos Campos it is in the order of 10 GV. This happens because at the poles all charged particles can reach near the surface, while at the equator only those with energies higher than 17 GV.

RESULTS AND DISCUSSIONS

For the neutron measurements in the energy range up to 10 MeV reported in this work we used a neutron detector (He-3 tube , LND, USA; model 25311) with an area of approximately 250 cm ² and covered with paraffin (9 cm all side). Measurements were carried out from January of 2015 to March of 2015 in São José dos Campos, SP, Brazil. Thermalized neutrons pass through the tube and cause the reaction described below, releasing an energy Q= 764 keV.

$n + {}^{3}He = {}^{1}H + {}^{3}H + Q$

The neutron detector and associated electronics are inside an air conditioned room in the tower (Figure 1).

Figure 1: Detector is Located Inside the Room of Tower

During December 22, 2014 to March 23, 2015 time series of neutron counts were collected. Examples are show in Figures 1 and neutrons were collected for more than 100000 minutes and 28800 minutes (~ 70 days and 20 days, respectively) at one-minute time intervals. The data shows a daily periodicity as well as other spikes in the counts. Some of these spikes might be caused by great amount of rain in the region end of February and all March 2015. Radon gas produce gamma rays near surface that provoke neutron in photon-nuclear interactions (Figs 2, 3 and 4).

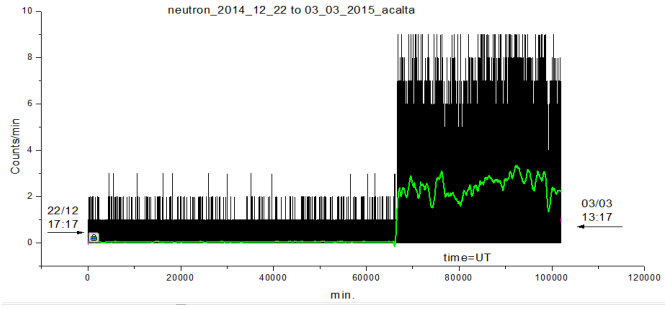

Figure 2: Neutron Counts Collected Over a Period from December 22, 2014 to MARCH 03, 2015 Showing Oscillations and Peaks

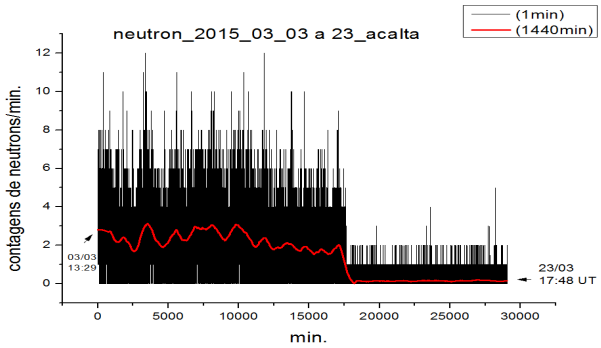

Figure 3: Neutron Counts Collected Over a Period of 2015 from March 3 to March 23. Note the Presence of Daily Oscillations

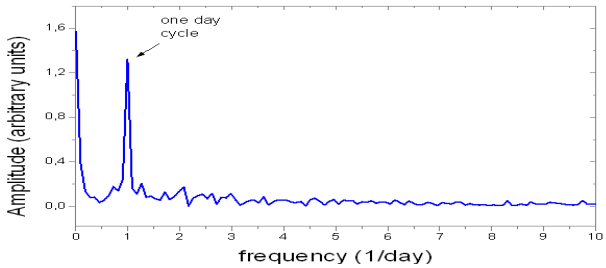

Figure 4: FFT of the Neutron Count Showing the Period of the Main Oscillation in the Counts (Period = 24 h) during all Period of Analysis

CONCLUSIONS

A portable system for measuring environmental neutrons in the energy range of up to 10 MeV near ground has been used continuously was prepared. The system proved its efficiency showing the daily cycle in neutron count rate in a dry and wet climate. Even with a very small sensitive area (~ 250 cm2) the tube and the associated electronics described in this work, recorded neutron count rate oscillation and peaks coming from big amount of water due to rain period. Further work is still needed to determine with better statistics the source of oscillation and the peaks.

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