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ENVIRONMENTAL LOW ENERGY NEUTRONS MEASUREMENTS NEAR GROUND LEVEL IN SÃO JOSÉ DOS CAMPOS, SP, BRAZIL

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ABSTRACT

In this study are presented measurements of cosmic ray induced neutrons near ground level in the region of São José dos Campos, SP, Brazil ~ ($22^0$12´S, $45^0$50´W), during 2008 to January 2018. It was used to perform these measurements two tubes of He-3, with250 cm^2ofsensitive area and with ~4atmospheres of internal pressure in each tube. The measurements were performed in one-minute interval and in free environmental situation above earth surface. It was thus given the background in count rate per minute of the region over time, which is a function of dry land, wet land and presence of electrical discharges (lightning)in the area. Taking in account efficiency of 0.60 to measure neutrons pulses in the tube, the sensitive area and energy range of 10 eV to 10.0 MeV. During dry period, the background measured were (1, 1 x 10^{-4} neutrons/cm^2 MeV. s). During wet and rainfall period this background changing mostly due to water density increasing on ground. The lightning presence in that region also induces neutrons in same direction of the ray and with great intensity. In this period of measurements 2008 to 2018 and in that region the environmental neutrons fluxes measured shows increases during strong rainfalls and one day periodicity during dry surface and warms days.

Keywords: *neutrons, lightning, rainfalls*

I. INTRODUCTION

It was assumed initially that the neutron flux observed at the ground level is constituted of the energetic particles coming directly from the overlying air or those backscattered (albedo) from the terrestrial surface. The neutrons of the crust origin were considered priori markedly less than those from the cosmic rays. A discovery of a link between atmospheric radon concentration and seismologic activity [1] increased interest for studies of the crust origin radiation. Subsequent studies of a near-ground neutron flux demonstrate that a flux of the crust neutrons is comparable to or even exceeding that originates from cosmic rays. Observations of the natural neutrons are a promising basis for development of techniques of environmental monitoring including seismology activity [2], hydrology [3] and possibly climate change or space weather. Linked to this is the need for more accurate.

II. METHOD & MATERIAL

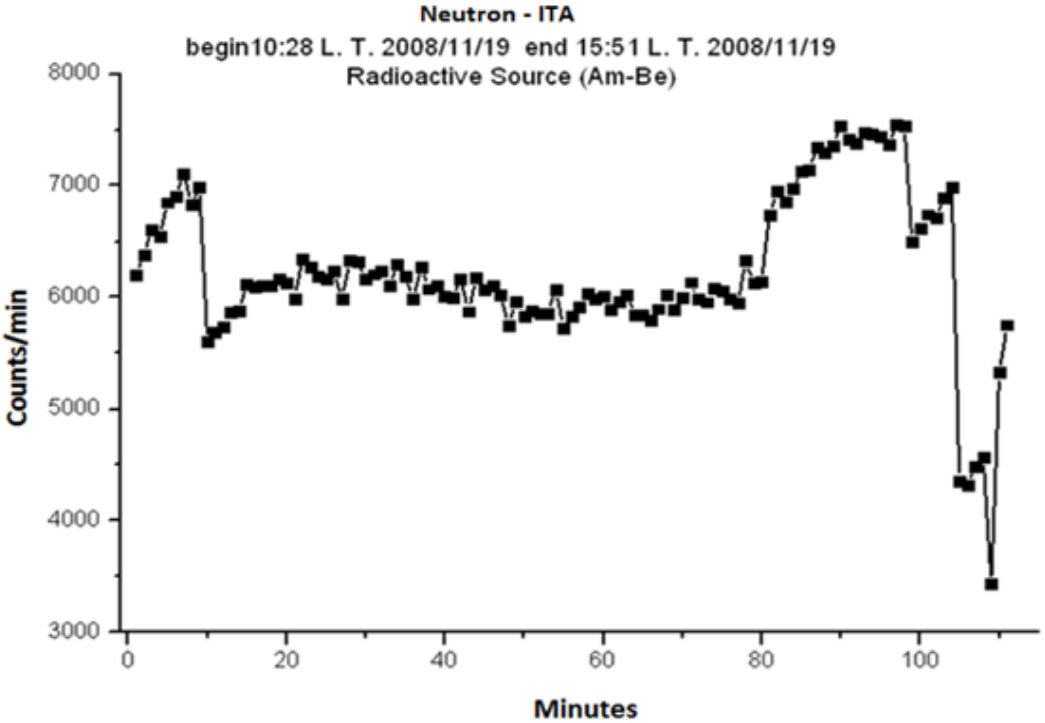
For continuous measures of the intensity of neutrons were used two tubes of gas He-3 filled with 4 atmospheres of internal pressure. A paraffin moderator of 10 cm radius was placed around the tubes in form of sphere to slow down their velocity/energy and increasing the efficiency of detection [4,5]. TheHe-3 tubes were fed with avoltageof1500VDCanddata acquisition was performed by a special electronic set (PMI-30) manufactured by company Aware Electronics Inc., USA. Through an analogue to digital converter (ADC) the signals were amplified and digitized by PMI-30, using software coming from the same company were stored in archives .txt, using aDell630 laptop. To monitor measures a graph was generated on the computer screen in same time every minute. Thus this portable set was calibrated in the range of energy and pulse height signals with neutron radioactivesources^{241} (Am-Be), ^{252}Cfand^{210}Po, at energies below 4.5 MeV (http://www.nist.gov/calibrations/neutron.cfm). The method used to display each record of measurements was taking using intervals of 1minute.Soa file with days or weeks or even months of measures was saved. The year, month, day

hour and minute was also shown in this file. The graphs were made with various types of software facilitating the display of measuresin time and analyses of the physical phenomena involved. To provide measurements of meteorological parameters (pressure, temperature, humidity and rainfall) a specific data logger was installed in same place giving these samples also in same 1-minute interval [6].

III. RESULT & DISCUSSION

Two experimental sets of neutron detector as described above were installed at different places in SãoJosédos Campos, SP. The first measurements were performed for calibration in energy with a neutron source^{241} (Am-Be) as shown in Figure1. No calibration was realized with absolute intensity but only in relative way. The background neutrons measurements in 2008 in ITA is showed in Figure2.In Figure 3 shows the background count rate and increasing due to burst neutrons in the atmosphere surrounded the detector provoked by lightning in the region. More information's related with presence in the region of lightning were reported in [7]. During April 12 and 13, 2009 intense rainfalls have occurred in ITA region and the neutrons flux measured in this period showed clearly augmentation (see Figure 4). These results it was in according with the project Cosmos international [8]. In Figure 5 it is showed the measurements of neutrons during end of 2010 and beginning of 2011 with very normal background of neutrons and without presence in this period of lightning in the region. In Figure 6 it is observed the measurements of neutrons from December 2015, 23 to 28, were several rainfalls have occurred. The growing of neutrons flux in the place it was clearly observed in the period. During the period of February 28 to March 03 of 2016, it is observed good correlation between neutron flux and rainfalls in the region plotted in the Figure 7 (see [8,9]). In the Figure 8 it is plotted the neutrons observations during 2016 in very dryer period warm and without clouds and raindrops. It appears the (day/night) cycles in neutrons flux due to radon gas presence in the region. In 2017 it was plotted in Figure 9 the variation on neutrons flux measurements corresponding dryer, warm and clouds/rains period. End of December of 2017 to January, 17 of 2018 was observed 3 periods of moderate rain and more 3 periods of dryer weather make visible influences in intensity and cycles variations on neutron flux.

Figure 1:



Counts per minute of neutron intensity at 2 meter distance from the source above described

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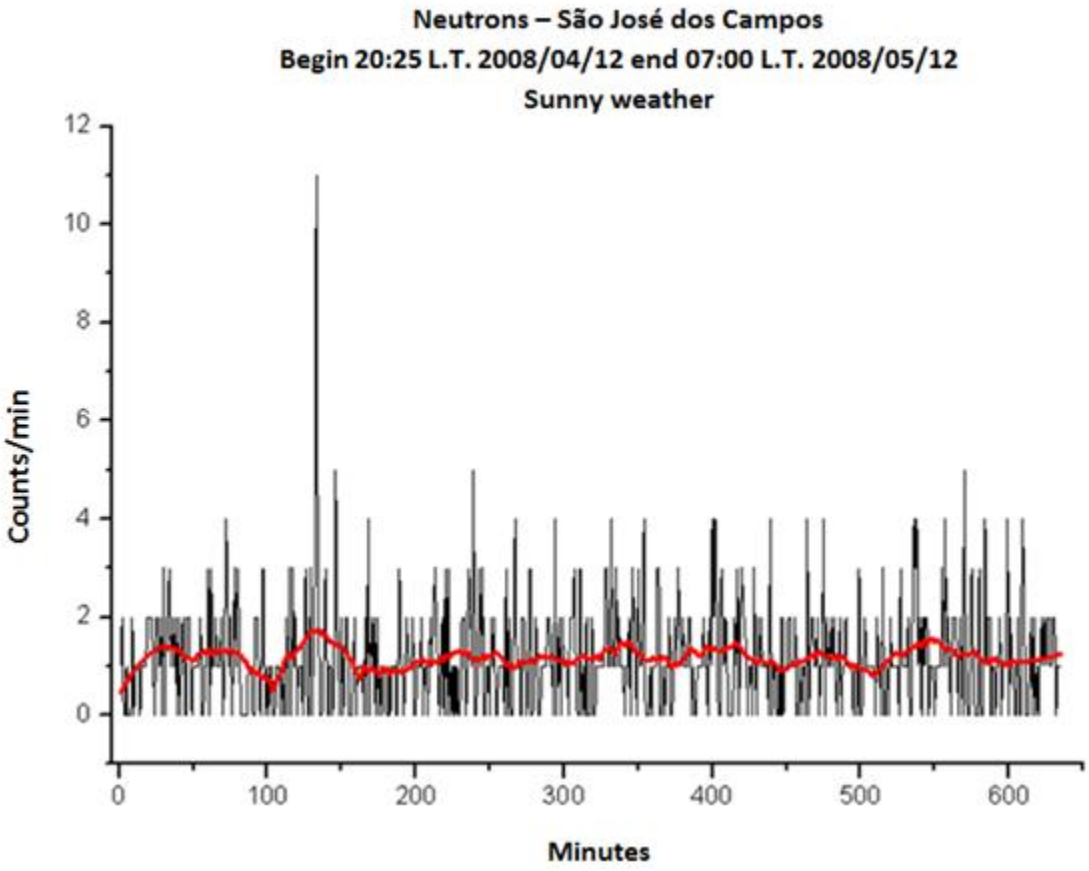
Figure 2:



Measurements of neutrons in ITA during clear day and dry weather on 04/12/2008.Red line is smoothed in 1 hour

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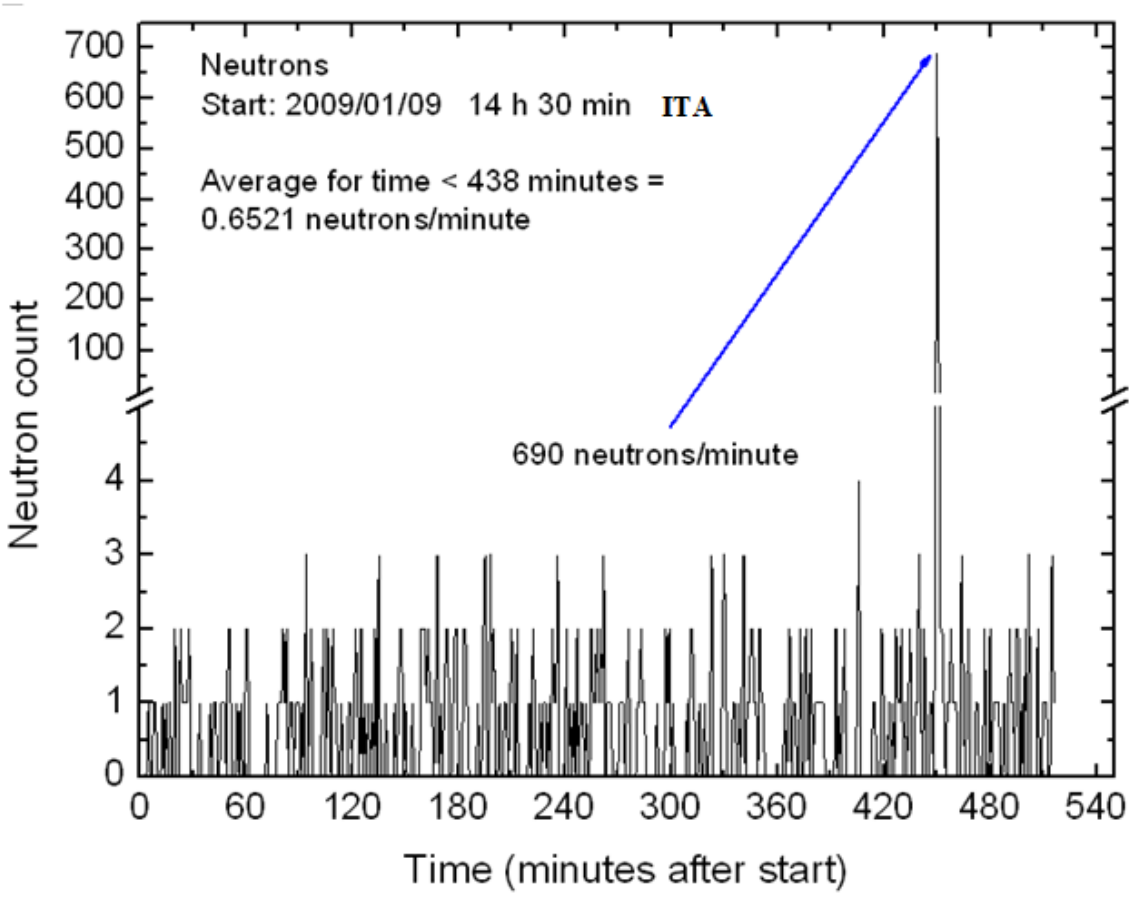
Figure 3:



Atmospheric neutrons produced and observed in ITA during lightning's in region [7].

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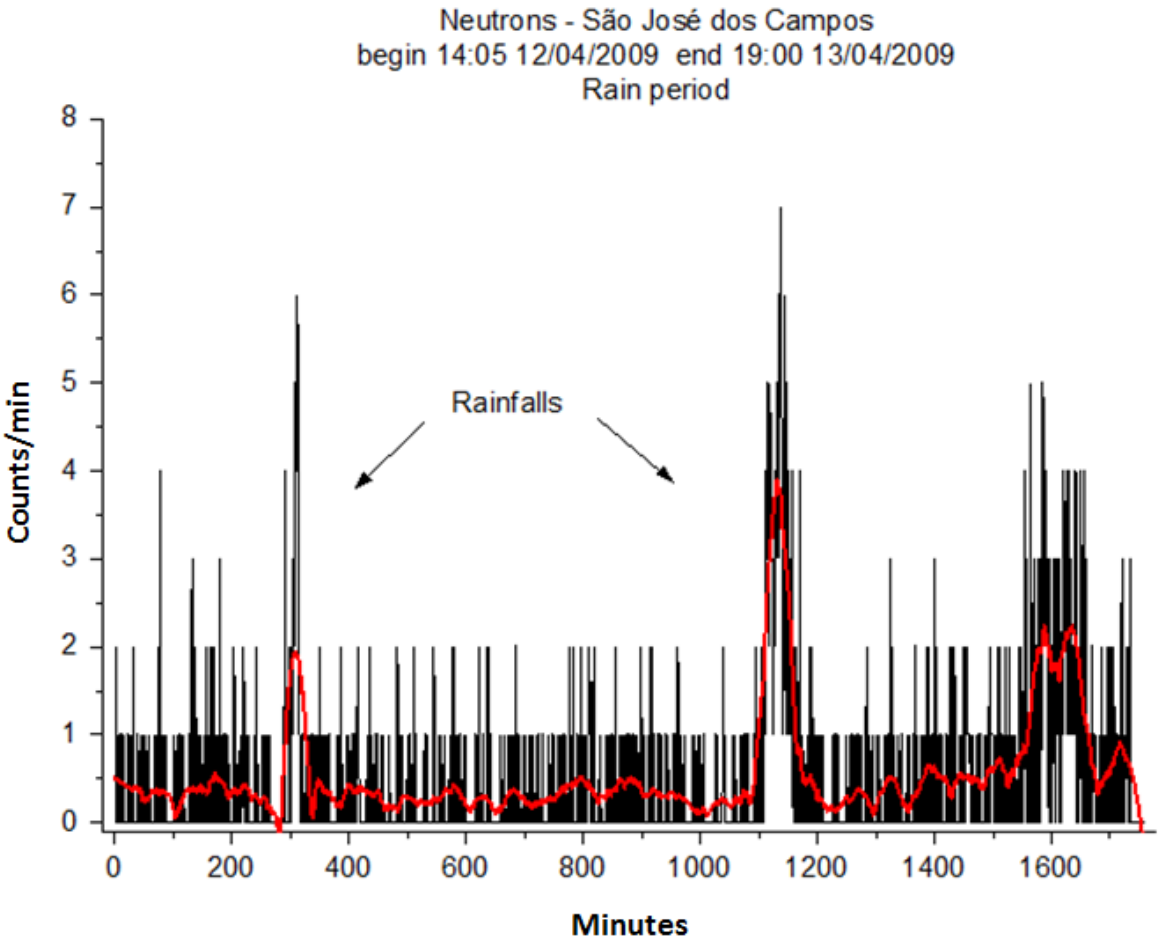
Figure 4:



Measurements of neutrons in rain period in April of 2009 in ITA

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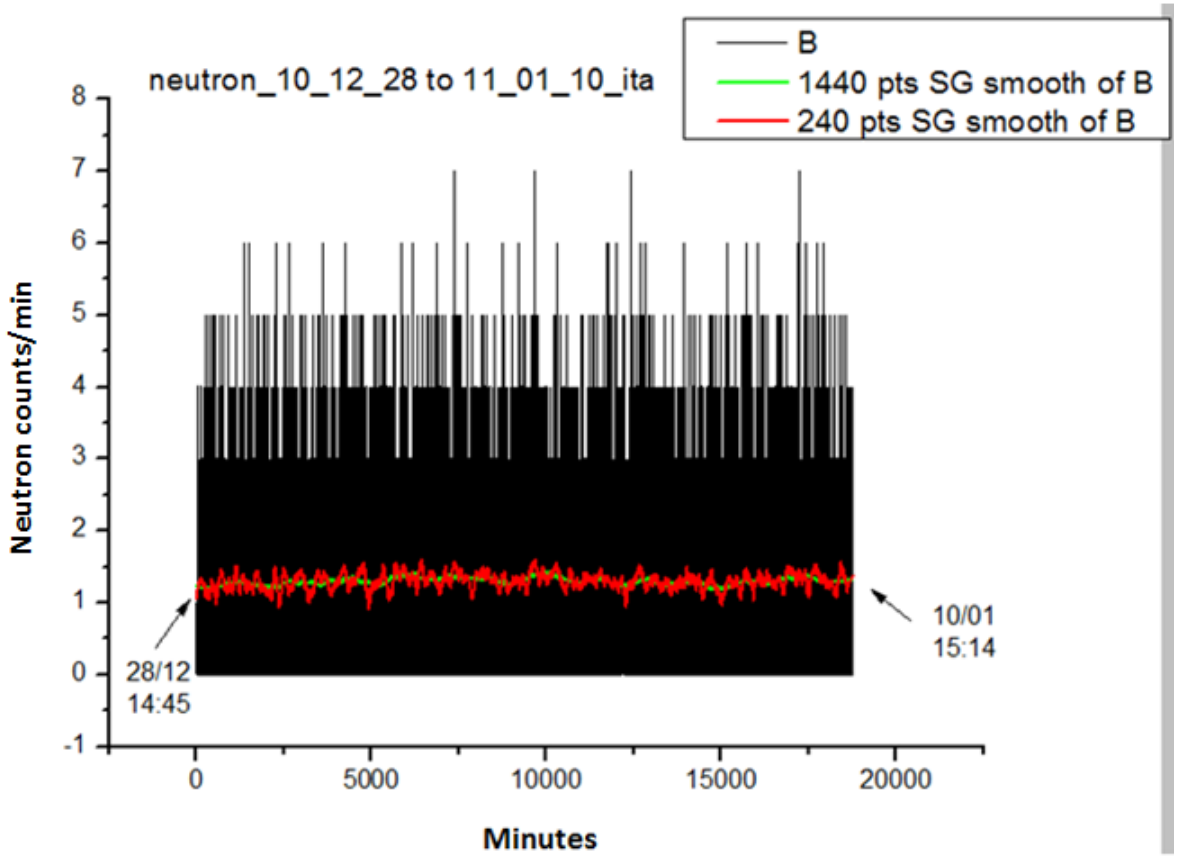
Figure 5:



Monitoring of neutrons counts rate in ITA during 28 December 2010 to 10 January 2011. Green line is smoothed value in one day and red line in 240 minutes

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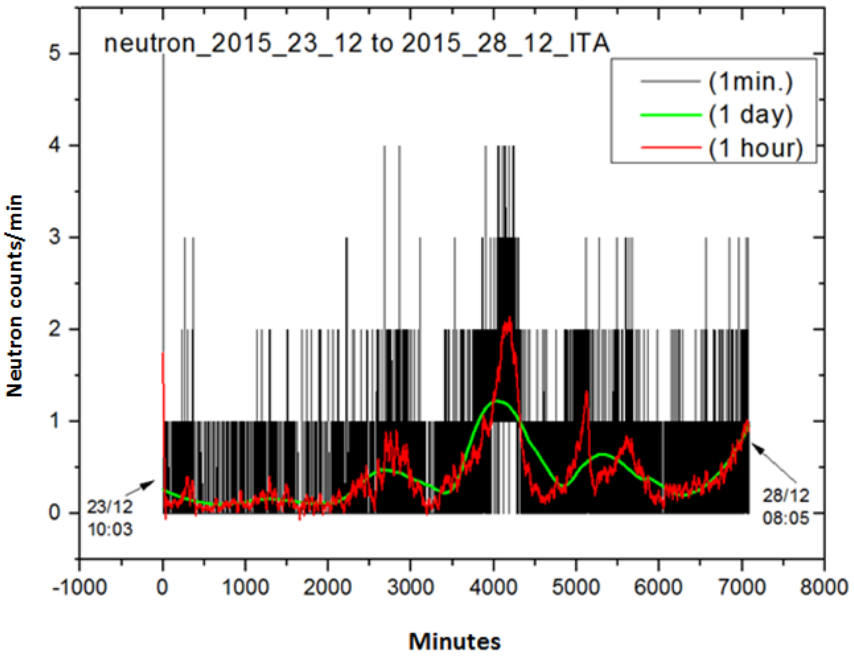
Figure 6:



Neutrons measurements from 23 to 28 of December, 2015

Figure 7:

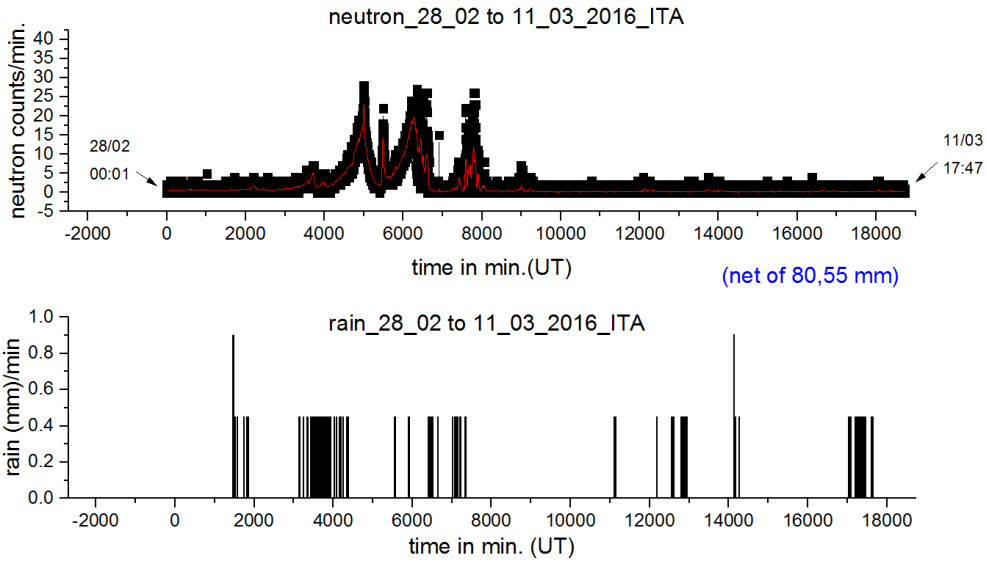


Fig. 7 - Measurements of neutron flux and intensity of rainfall each minute from February 28 to March 03, 2016

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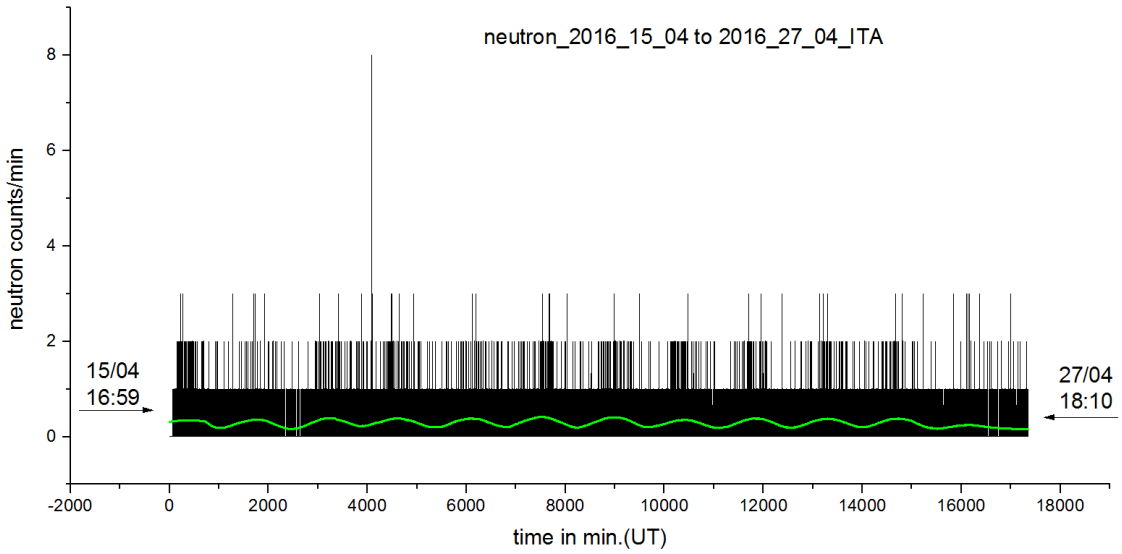
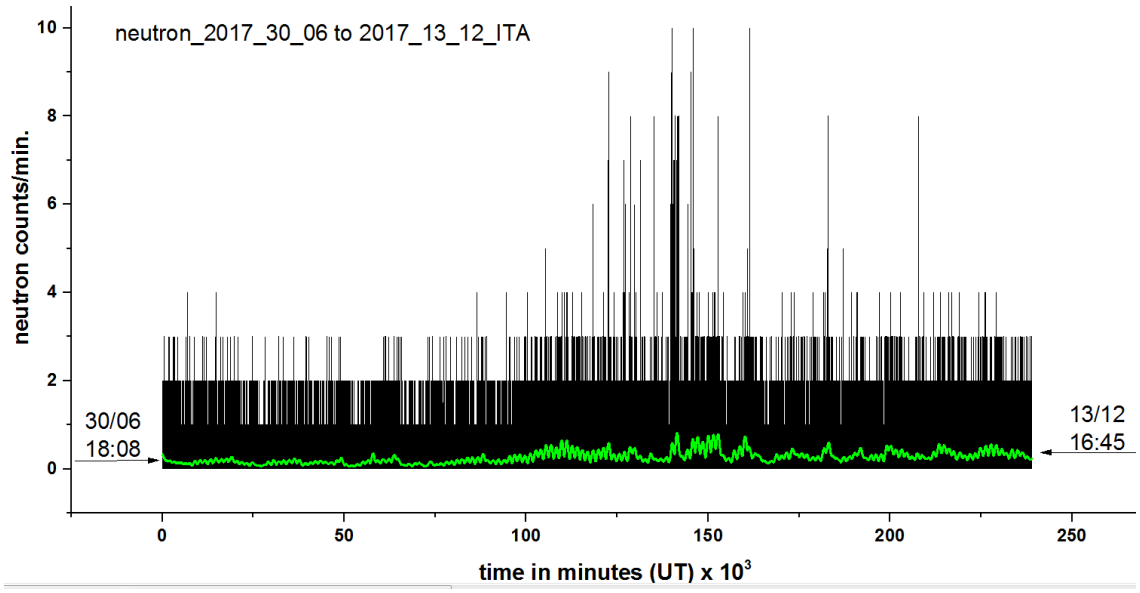
Figure 8:



Neutrons flux measurements during 2016 dryer period in the region

Figure 9:



Neutrons measurements in function of dryer and clouds/rains period in 2017

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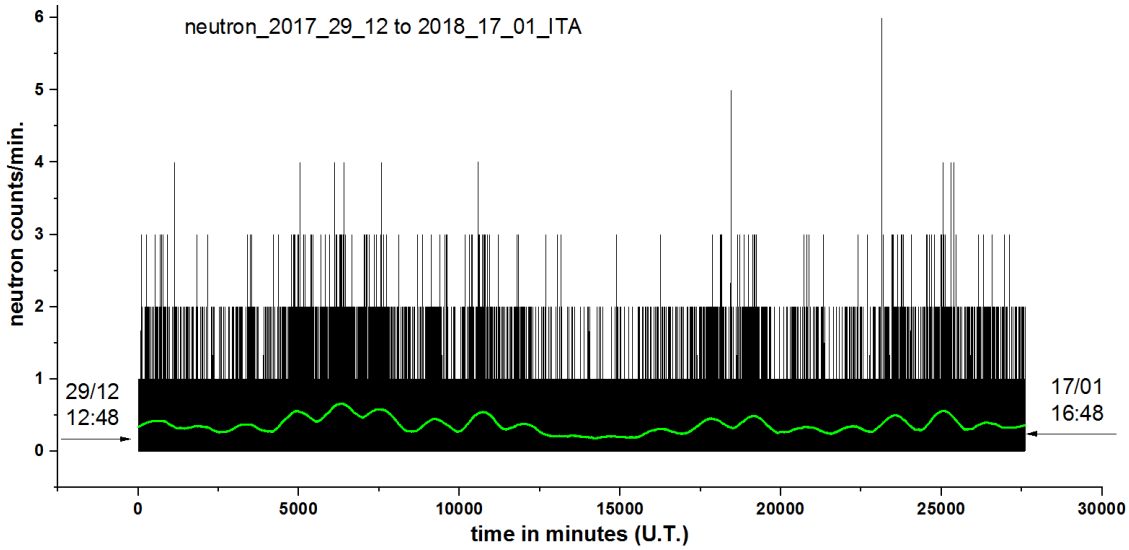
Figure 10:



Observed neutron flux during end of 2017 and begin of 2018

IV. CONCLUSION

From 2008 to 2018 years the environmental neutron flux were monitored in the region of São José dos Campos, SP, Brazil. The background flux without rain and lightning stay in 0 to 1 counts per minute giving a mean value of (1, 1 x 10-4 neutrons/cm^2. MeV. s). After strong rain always appeared un increasing of neutrons produced on ground with (α, H) reactions. During dryer weather the periodicity and intensity of neutrons was function of temperature and the (day/night) variations due to (α, n) reactions from radon gas presence.

V. ACKNOWLEDGEMENTS

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REFERENCES

1. *Ulomov, V. I., and Mavashev, B. Z. 1967. "O predvesnike sil'nogo tecktonicheskog zemietryarsenia (A precursor of a strong tectonic earthquake)." Doklady Earth Sciences Sections 176: 9-11.*
2. *Gregorič, A., Vaupotič, J., and Gabrovseǩ, F. 2013. "Reasons for Large Fluctuation of Radon and CO2 Levels in a Dead-end Passage of a Karst Cave (Postojna Cave, Slovenia)." Natural Hazards and Earth System Sciences 13: 287–297.*
3. *Desilets, D., Zreda, M., and Prabu, T. 2006. "Extended scaling factors for in situ cosmogenic nuclides: New measurements at low latitude." Earth and Planetary Science Letters 246 (3–4): 265–276.*
4. *Nakamura, T. 2014. 2014. "Cosmic-Ray Neutrons Spectrometry and Dosimetry." Journal of Nuclear Science and Technology 45 (5): 1-7.*
5. *Yajima, K., Yasuda, H., Takada, M., Sato, T., Goka, T., Matsumoto, H., Nakamura, T. 2010. "Measurements of Cosmic-Ray Neutron Energy Spectra from Thermal to 15 MeV with Bonner Ball Neutron Detector in Aircraft." Journal of Nuclear Science and Technology 47 (1): 31–39.*
6. *Martin, I. M., Germano, J. S. E., and Takaki, T. M. 2013. "ITA-DATALOGGER: Continuous Monitoring of Pressure, Relative Humidity, Temperature, Rainfall Intensity and Dose of Ionizing Radiation near the*

Surface of the Earth in São José dos Campos, SP, Brazil." Presented at 65th Annual Meeting of Brazilian Science for Progress Society (SBPC), Recife, Brazil.

7. *Martin, I. M., Alves, M. A. 2010. "Observations of a Possible Neutron Burst Associate with a Lightning Discharge in Brazil." Journal Geophysical Research 115 (A00E11): 1-4.*
8. *Zreda, M., Desilets, D., Ferré, T. P. A., Scott, R. L. 2008. "Measuring Soil Moisture Content Non-Invasively At Intermediate Spatial Scale Using Cosmic-ray Neutrons." Geophysics ResearchLetters 35 (L21402): 1-5.*
9. *Martin, I. M., Gomes, M. P., Ferro, M. A. S., Pinto, M. L. A., Antônio, F. C. 2013. "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 3 (4): 138-141.*