SH 3.6.43

Emilio Segre′ Observatory and Expected Time-Variations in Neutron Monitor Total and Multiplicities Counting Rates Caused by Cosmic Ray Particle Energy Change in the Periods of Thunderstorms

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Abstract

In the first part of paper we give short description of the Israelo-Italian Emilio Segre′ Observatory (33°18.3′N, 35°47.2′E, 2025 *m* above sea level, R_c=10.8 *GV*), established in June 1998. In the second part, on the basis of theoretical model (Dorman & Dorman 1995, 1999; Dorman et al. 1995) of atmospheric electric field effect in the neutron monitor total counting rate and counting rates of different neutron multiplicities, we calculate the expected cosmic ray time variations in the different channels of 6NM-64 neutron monitor of Emilio Segre′ Observatory in the periods before and during thunderstorms. Our calculations show that one-minute data of 6NM-64 neutron monitor of Emilio Segre′ Observatory and one minute data of EFS-1000 sensor of atmospheric electric field can be used for obtaining important information on atmospheric electric field space-time distribution.

1 Introduction:

The Mobile Cosmic Ray Neutron Monitor (6NM-64) was prepared in Rome in the frame of the Israelo-Italian Collaboration, and transferred to Israel in June 1998. We did measurements of air pressure, total neutron monitor counting rate and intensities of neutron multiplicities ≥1, ≥2, ≥3, ≥4, ≥5, ≥6, ≥7 and ≥8 in Haifa port (sea level), near the lower ski-lift station of Mt. Hermon (1400 *m* a.s.l.), and near the upper ski-lift station of Mt. Hermon (2025 *m*). By these data we determined approximately cosmic ray barometric coefficients for total neutron monitor counting rate, as well as for detected multiplicities 1, 2, 3, 4, 5, 6, 7, and ≥8, by taking into account also information on primary cosmic ray variations on the base of Rome neutron monitor data (Dorman et al. 1999a). From June 1998 the Israelo-Italian Observatory (33°18.3′N, 35°47.2′E, 2025 *m* a.s.l., R_c=10.8 *GV*) is working properly, furnishing computer-based one-minute data of cosmic ray neutron intensity (from two separate 3NM-64 sections) and neutron multiplicities ≥1, ≥2, ≥3, ≥4, ≥5, ≥6, ≥7 and ≥8, as well as data on air pressure, internal temperature and humidity, low voltage supplies for electronics and high voltage supply for neutron counters. We used the obtained data for determining barometric coefficients to be used for proper corrections for barometric effect. By these coefficients we corrected data of total neutron monitor counting rate and intensities of different multiplicities for changes in air pressure (Dorman et al. 1999b). From January 1999 we put in operation the detectors of wind speed (for determining Bernoulli effect on barometric pressure) and of external air temperature (for tentatively correcting the data for temperature effect). From May 1999 a detector of atmospheric electric field EFS 1000 started to operate (to investigate the atmospheric electric field influence on cosmic ray intensity). The Observatory was named in honor of the Italian scientist, winner of Nobel Prize, Emilio Segre' (1905-1989).

2 Israel-Italy Collaboration, Foundation and Operation of the Emilio Segre' Cosmic Ray Observatory:

The Israel-Italy Collaboration in cosmic ray research was established in 1995. In 1997 it was possible to start in Rome the realization of a cosmic ray neutron monitor mobile Observatory to be installed in Israel on Mt. Hermon. At the beginning of June 1998, the mobile Observatory was in operation on Mt. Hermon.

2.1 Block-Scheme of Observatory: In Figure 1 we show a block scheme of the main components of the Emilio Segre' Observatory.

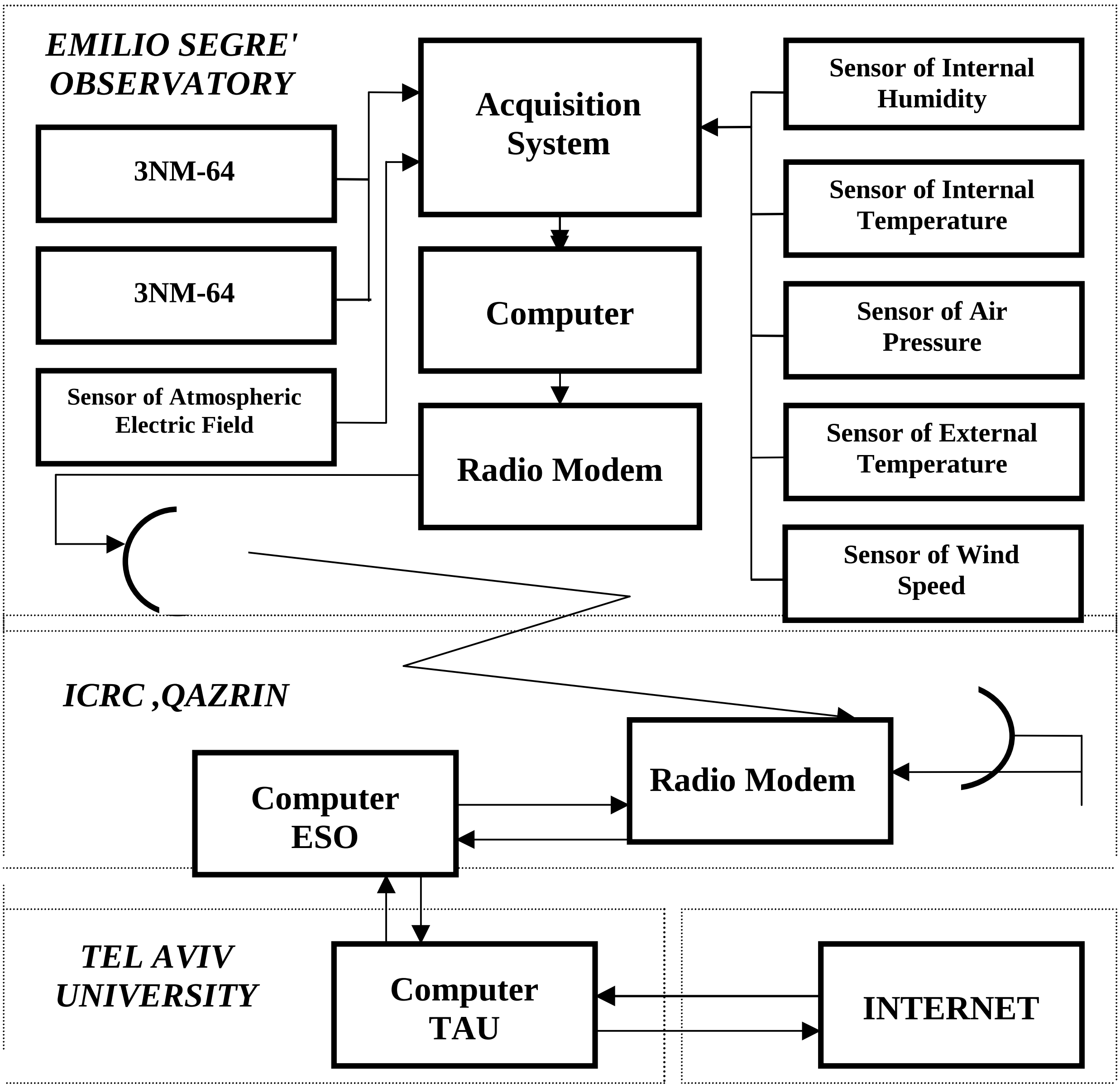

Figure 1: A schematic representation of the Emilio Segre' Observatory main features

2.2 Acquisition System: In Figure 2 we show the control panel of the acquisition system. By easy selection and visualization of the main features of the acquisition system, the operator may easily control the overall functional behavior.

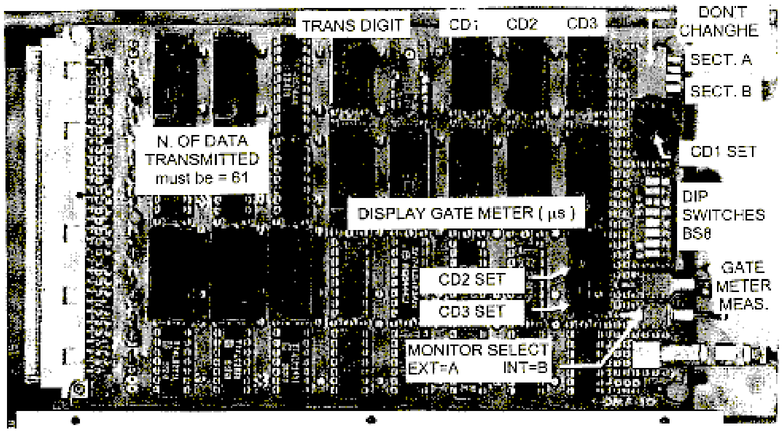

Figure 2: Control panel of the acquisition system

The acquisition program has been developed in HP Instrument Basic Language, including the use of standard IEEE-488 instructions and standard commands for programmable instruments.

2.3 General View of the Experiment: In Figure 3 we show a view of the Emilio Segre' mobile Laboratory during operation on Mt. Hermon.

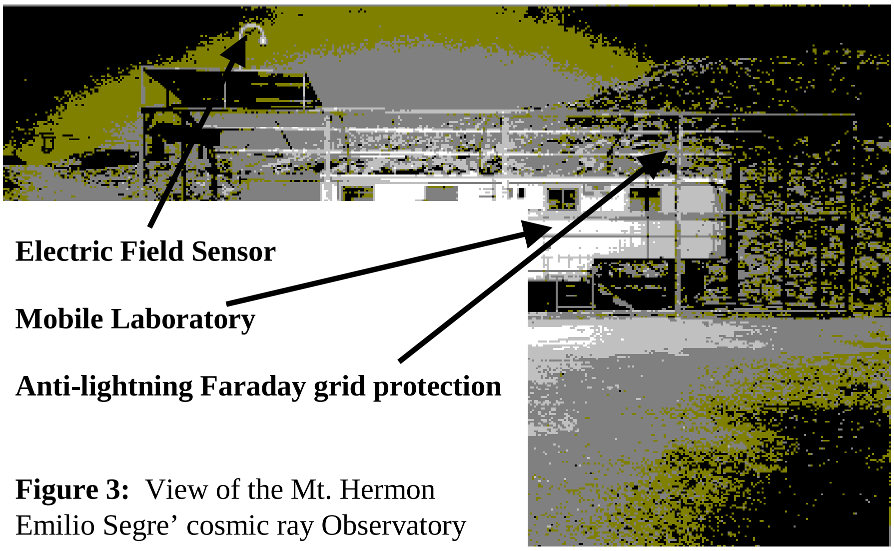

Figure 3: View of the Mt. Hermon Emilio Segre' cosmic ray Observatory

3 Expected Time-Variations in Total and Multiplicities Counting Rates Caused by Cosmic Ray Particle Energy Change in Periods of Thunderstorms near Emilio Segre' Observatory

In periods of thunderstorms the atmospheric electric field can increase up to $\approx 20\,kV/m$ in the layer 3-5 *km*. Such electric field can increase or decrease the energy of single-charged particles by about $20\,MeV/km \approx 0.2\,MeV/\left(g/cm^2\right)$ and produce a total energy change up to 0.1 *GeV*. In quiet periods the energy loss of relativistic muons for air ionization process can be about $a \approx 2\,MeV/\left(g/cm^2\right)$. Therefore, we expect that in periods of thunderstorms with atmospheric electric field $\approx 20\,kV/m$ the parameter a in low atmosphere will increase (if the energy of muons decreases) or decrease (if the energy of muons increases) by about 10%. The increase of parameter *a* leads to decrease muon intensity. It is important that the energy changes of positive and negative muons due to the influence of atmospheric electric field are opposite; in this way the most part of atmospheric electric field effect in cosmic ray muon component or electron-photon component will be compensated. Only due to a small positive excess in secondary cosmic ray particles, it could be possible to observe this effect (Alexeenko et al. 1985, 1987). The formation of lead mesoatoms by soft negative muons, with following escaping of neutrons, leads to the important property of neutron monitor to be sensitive to atmospheric electric field. In Dorman & Dorman (1995), Dorman et al. (1995) it was shown that when atmospheric electric field increases up to $\approx 20\,kV/m$ in the layer about 3 *km*, the total neutron monitor counting rate at sea level is expected to change by about 0.54 %. In Dorman & Dorman (1999) the total atmospheric electric field coefficients for different multiplicities in dependence of altitude, cut-off rigidity and level of solar activity have been estimated. By using these results and by taking into account that the relative part of neutron monitor counting rate caused by formation of lead mesoatoms is proportional to muon component intensity and inverse proportional to nucleonic component intensity, we can estimate that for our neutron monitor (2025 *m* a.s.l., R_c=10.8 GV) the total atmospheric electric field coefficients will be, for the multiplicities 1, 2 and 3,

$$\alpha_E^{1,2,3}(h) \approx (4.6;\ 3.5;\ 1.4)\times 10^{-5}(kV/m)^{-1}\left(g/cm^2\right)^{-1}\% \quad (1)$$

in the period of low solar activity, and

$$\alpha_E^{1,2,3}(h) \approx (5.2;\ 4.0;\ 1.6)\times 10^{-5}(kV/m)^{-1}\left(g/cm^2\right)^{-1}\% \quad (2)$$

in the period of high solar activity. The expected atmospheric electric field effect for different multiplicities *m* in the neutron monitor of Emilio Segre' Observatory will be

$$\left(\frac{\Delta I_k^m}{I_{ko}^i}\right)_E = \int_{h_1}^{h_o} E(h)\alpha_E^m(h)dh, \quad (3)$$

where $E(h)$ is the vertical component of atmospheric electric field from the level h_1 of clouds (of about 3-5 *km*) to the level of observation h_o. Before and during thunderstorms, when the atmospheric electric field can increase up to $\approx 20\,kV/m$ in the layer 3-5 *km* (about 300 g/cm^2), the expected effect in the total counting rate is 0.22 % and in multiplicities 1, 2 and 3 are 0.28, 0.20 and 0.08 % near the minimum of solar activity. Near the maximum of solar activity the atmospheric electric field effect will be a little bigger: in the total counting rate 0.25 % and in multiplicities 1, 2 and 3 it expected 0.31, 0.23 and 0.10 %.

Acknowledgements:

This research for LID and IGZ was supported by Israel Cosmic Ray Center affiliated to Tel Aviv University. Dr. N.L. Zangrilli, Mr. F. Signoretti and Mr. F. Re (IFSI-CNR) are acknowledged for the contribution in realization of acquisition system and software of ESO.

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