Publ. Obs. Astron. Belgrade No. 44 (1993), 99–102

THE MEASUREMENTS OF TIME VARIATIONS OF COSMIC RAYS IN YUGOSLAVIA

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The time variations of cosmic-ray intensities have been systematically studied for at least some 50 years now, the first comprehensive review being by Elliot H. (1952). An enormous amount of data has been collected by a multitude of measuring stations scattered all over the world (Allkofer C.O. et al. 1984) and from that vast material much has been learned about the cosmic rays themselves as well as about the many astrophysical phenomena which influence their intensity. The intensity of primary and secondary cosmic rays vary on different time scales; long term variations have periods of one or more years while the short term ones are of periods from one day to a year. There are also shorter and aperiodic changes of intensity lasting for hours and maybe even less. All those variations are ascribed to terrestrial, solar and galactic causes, ranging from trivial meteorological conditions through solar flares to elusive galactic magnetic fields, and many models have been developed to account for all the effects observed. (Due to the blockade of scientific information we have no knowledge of the recent developments in the field.)

In Yugoslavia, however, the intensity of cosmic rays has never been systematically measured and no local data on variations of this intensity exist. We thus here give a short information about the potentials of our nuclear physics community in this respect which it may propose to the astrophysical community by using modest and mostly already available means.

For the purposes of cosmic-ray intensity monitoring a wide range of specific detectors exists. Main requirements are the discrimination of cosmic-ray events from those induced by other environmental radiations and large active areas in order to have good statistical sensitivity. They may be either telescopes or single detectors of adequate construction. Needless to say that neither of such detectors we possess at the moment.

We have, however, for the very different needs of a thallium solar neutrino experiment (Aničin I. et al. 1988), developed a simple single detector method for cosmic-ray intensity measurements which exploits the common detectors used in standard gamma-ray spectroscopy work (Aničin I. et al . 1991). The method is based on the fact that the cosmic rays, which at the bottom of the atmosphere consist mostly of high-energy secondary muons, passing through the detector medium loose some energy (typically 2 MeV/gcm^{-2}) and produce part of the continuos background spectrum. The low-energy part of this background spectrum below some 3 MeV is intermingled with the part produced by other environmental radiations but the higher-energy part is practically completely due to the cosmic rays. In the usual gamma-ray spectroscopy work those events usually end up as saturated pulses and the counting of those pulses offers the possibility to monitor the cosmic-ray intensity. We have also developed (D. Jovanović of "Digital Design", Belgrade) a low-cost multiscaler card operated by a standard AT computer which is well suited for the job. This is thus the only addition to a standard gamma-ray spectroscopy system needed to measure the variation of the intensity of secondary cosmic rays on Earth with time. An example of such measurement is shown in Fig. 1.

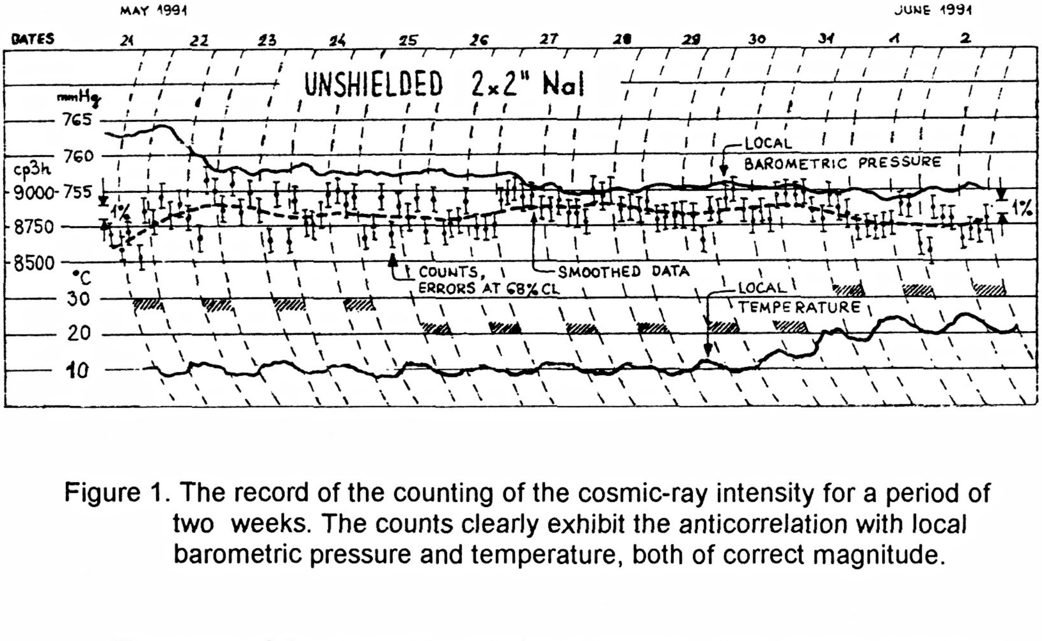

Figure 1. The record of the counting of the cosmic-ray intensity for a period of two weeks. The counts clearly exhibit the anticorrelation with local barometric pressure and temperature, both of correct magnitude.

The extent of the observable variation of intensity of the shortest duration is determined by the counting statistics, i.e. by the detector size. As a rule-of-thumb one may think of the detector with the cross section A (cm^2) of 100 cm^2 to yield about 3 counts per second and we may define a counting constant $k \approx 0.03$ cpspcm^2. The relative counting error of the count c is $r = \Delta c/c = 1/\sqrt{c}$ and if the measurement time is T seconds all the relevant quantities are connected as $T \cong 1/kAr^2$. With a detector of $A = 100$ cm^2 a change in the intensity of 1% (at the level of 10000 counts) may thus be observed in a counting time of 1 hour but a 10% change is observable on the scale of some 30 seconds (all on the 68% CL). Our standard detectors are typically of the cross-sections of about 25 cm^2 and the change of the order of 1% would be observed only if it lasted for at least 3 to 4 hours. If better sensitivity is needed bigger low-cost liquid scintillation detectors could be tailored for the purpose.

If such measurements are continuously performed at a number of more or less distant places, after correcting for local meteorological conditions, cross-correlations between the counts and correlations with geomagnetic data reveal whether the variations are local or occur at a larger scale. This also provides a means to checking the results. Fig. 2 is a map of potential measurement stations where measurements could be organized at low cost and with little additional effort.

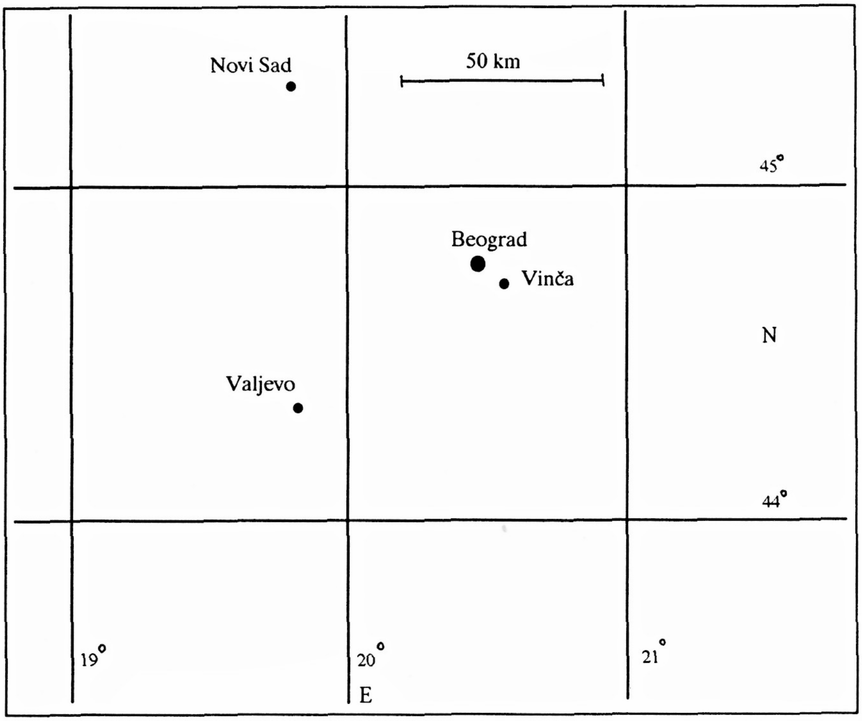

Figure 2. Map of the potential measuring stations at mutual distances ranging from 10 to 100 km

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