

PERFORMANCE OF A STATION FOR LONG TERM MONITORING OF THE ATMOSPHERIC GROUND LAYER STATUS IN URBAN SITES

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The performance of a station for long term atmospheric monitoring situated at the Astronomical Observatory of the Sofia University in Sofia is considered. The ability of the station to register the change in the environmental radiation due to changes in the meteorological status of the atmosphere is demonstrated. The long term efficiency and stability of the station are analyzed. Some suggestions aimed at the increasing the stability of the logarithmic gamma-spectrometer are discussed.

Keywords: environmental radiation, long term stability

1. INTRODUCTION

There are a lot of facts that the concentrations of some pollutants of the bottom 10 km layer of the atmosphere have been significantly increased during the last century. An example is the tropospheric ozone which is a key element (together with the NO₂) in the formation of the photochemical smog in the urban sites.

Another integral factor determining the quality of the atmosphere in the large urbanized areas is the environmental radiation. The main sources of the natural radioactivity of the air are the decay products of uranium and thorium, some remaining long living isotopes (⁴⁰K) and the secondary cosmic radiation. A special attention should be given to the radon (²²²Rn) decay products since their exhalation rate out of the soil depends on the atmospheric status and in some cases it can reach considerably high values. As it is well known, the radiation increases the risk of malignant neoplasms and that of mutagenic effects in all living organisms.

It is impossible to study the influence of the atmospheric pollutants on the environmental quality by sporadic measurements. Their concentrations vary sharply with the time. Moreover, their dynamics has both slow (seasonal and longer cycles) and fast components (air transfer, precipitations etc.). So, the long term systematic and continuous observations of those factors and their joint analysis are the basic fundament for the scientific investigations of the climate change.

2. THE STATION BASED AT THE ASTRONOMICAL OBSERVATORY SITE OF THE SOFIA UNIVERSITY

The astronomical observatory of the Sofia University is situated within the Tzar Boris's Garden in the central part of the Sofia city. Data taken from this station are representative for the highly urbanized territories. The site is secured, it has a good

infrastructure and communication facilities, and this is why we have built the first station for long term monitoring of the atmospheric ground layer there.

The system includes an automatic meteorological station ensuring representative meteorological data. The air temperature and humidity are recorded at 0.5m and 4m above the ground; other parameters include the wind speed and direction (10m above the ground), the total solar radiation, soil temperature and the precipitation amount. The ozone concentration in the ground layer is controlled by a TECO49 ozonometer.

The dose rate of the environmental radiation is determined by a logarithmic spectral analyzer [1], situated 1m above the ground level; the latter is covered by grass and is far from massive buildings. The system is sensitive in the energy region 30 keV – 3 MeV. A cylindrical scintillation crystal of NaI(Tl) is used with $\Phi=63$ mm x H=63 mm. Data are recorded each 10min. The spectrometer memory can store up to 240 records; so a 40 hours autonomous work of the system is guaranteed.

The data of the meteorological station and those of the logarithmic spectral analyzer are transferred to a personal computer. The meteorological station is connected with the PC by a galvanic isolated RS232 interface. Environmental radiation data are transferred using a RS485 interface which is connected through a galvanic isolated RS232 adapter to the same PC. All data are sent by Internet to a data server situated at the Department of Physics of the Sofia University.

First data collected with the station are from May 2006. The biennial practical experience with the station has motivated us to present the following analysis of the data quality and the system stability.

3. RESULTS

3.1. Typical observation data

It has been observed that the dose rate as well as the count rate of the registered events are increased at precipitation periods. Fig.1 shows the change of the dose rate on May 31, 2008. A sharp increasing of the dose rate is clearly observed at the beginning of the rain which is attributed to a 'washing down' of the vertically stratified radon by the falling rain drops.

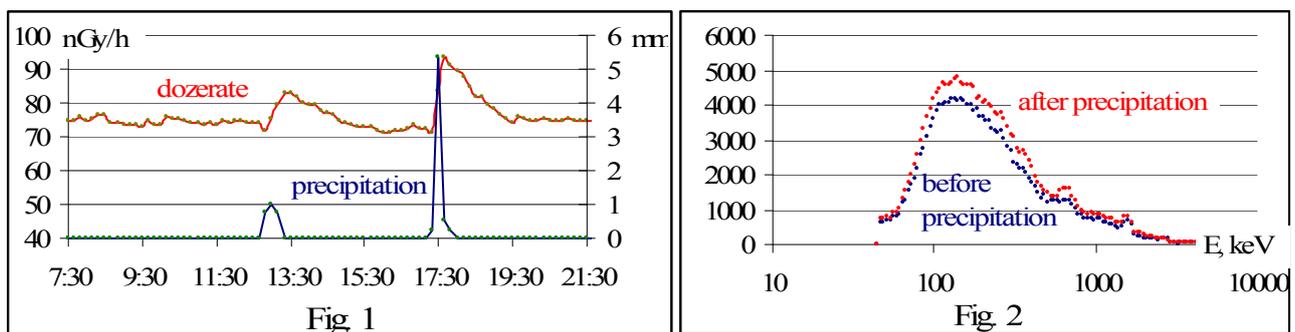


Fig.2 shows the gamma spectrum immediately before the rain and at its beginning. All spectrum channels register increased number of events. Moreover, a clear photopeak at 609keV is observed which is due to ^{208}Tl , a radon decay product.

3.2. Long term stability and reliability

The logarithmic spectrometer has not measured during the whole observation period due to technical and organization reasons (maintenance, long time electric power faults, defects, etc.). The monthly efficiency of the system is presented on Fig.3.

For a full biennial period (September 2006 - August 2008) 98840 spectra have

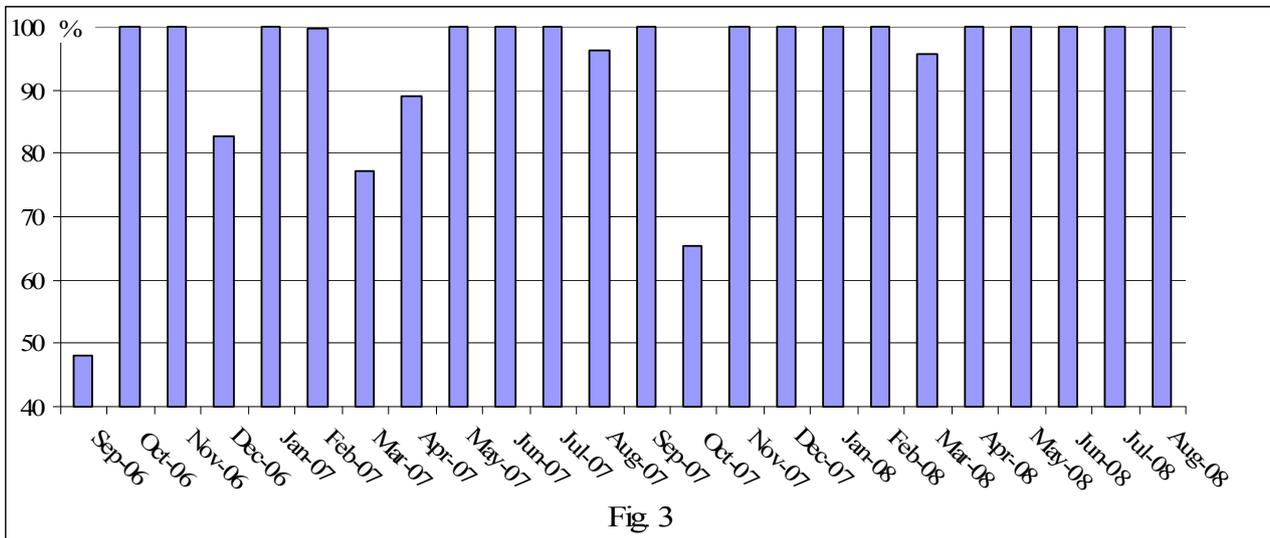


Fig 3

been successfully registered and 6412 are lost, corresponding to 94 per cent efficiency. That result may be considered as good, taking into account that no maintenance personnel for the system is committed. The system stability has been increased during the second year up to 96.7 per cent.

3.3. Atmospheric influence on the system

The NaI(Tl) scintillation detectors have a strong temperature drift which yields a deterioration of the energy calibration of the system and, as a consequence, a significant error in the dose rate evaluation. So, some special procedures ([2], [3]) are

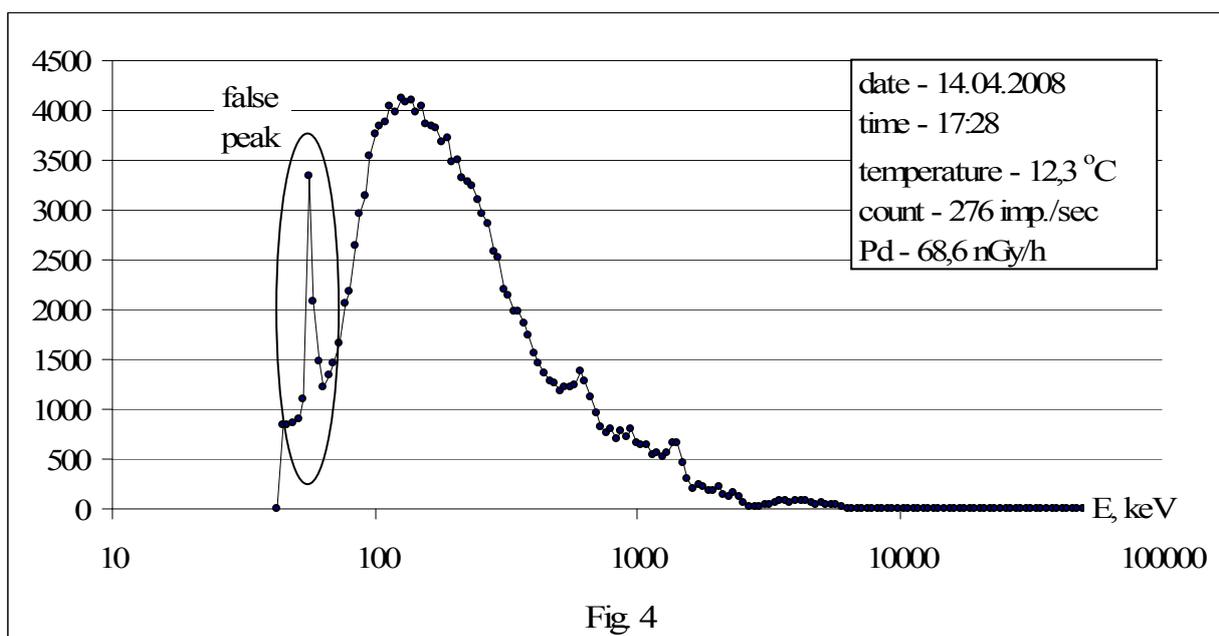


Fig 4

needed for a calculation of the energy calibration for each registered spectrum.

A serious problem arises from the temperature change of the scintillation decay time [4]. Since we use a dynamical method for fetching and shaping the detector signal (by a RLC circuit), this change yields a non-linearity in the transfer function in certain temperature interval. The latter is manifested by a false peak in the spectrum which is not due to registered gamma rays at the corresponding energy (Fig.4). In the example shown on Fig.4 the dose rate error arising from the false peak is -8.7 per cent and it is due to the fact that some events caused by higher energy gamma rays are registered in the lower spectrometer channels.

The distortion of the spectral shape can extent to such a degree that the spectrum cannot be further processed. That lowers the useful system efficiency by limiting the number of the analyzable spectra. A plot of the system efficiency and that of the 'good' spectra is shown on Fig.5. It is seen that the most problems take place in the spring and the autumn periods when the temperature variations are the largest.

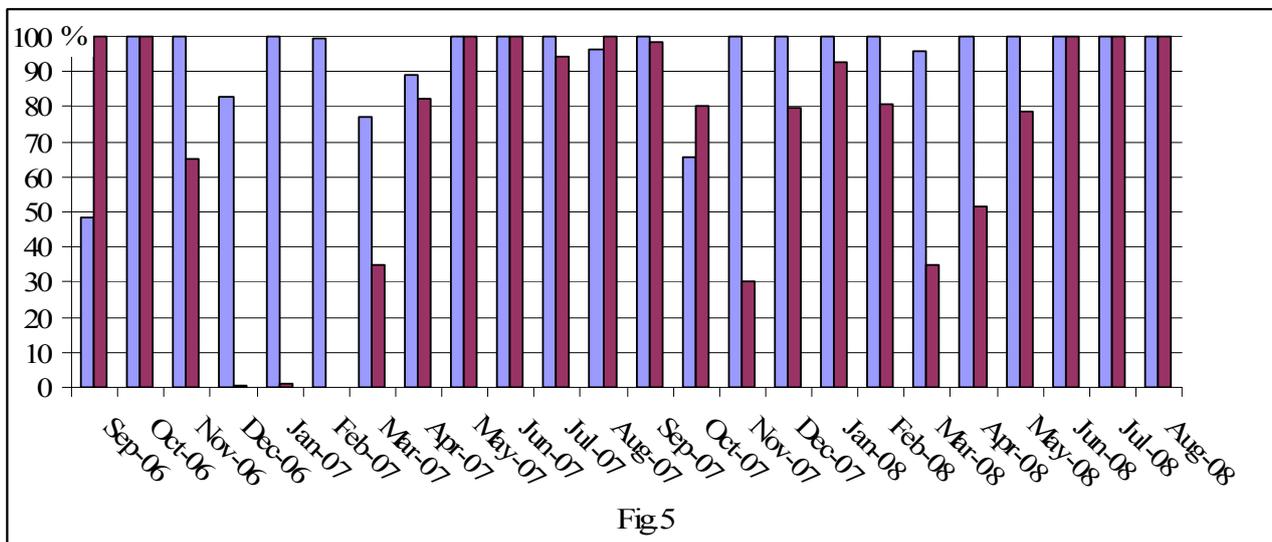


Fig5

3.4. Measures for improvement of the temperature dependence

The logarithmic multichannel analyzer operates in the framework of a stationary system which is powered mostly by mains. In this case, it is a good idea to put the scintillation crystal into a temperature stabilized environment since it is the main source of the above mentioned temperature drift.

A basic requirement to the thermostat is to ensure minimal shielding of the low energy gamma rays. We have used a copper meander with 19 μm depth and 250 μm width produced by etching a 400 μm wide glass fiber plastic. The total impedance of that copper resistor is 18 Ω .

A principal scheme of the electronic regulator is shown on Fig.6. Using the component values shown on the figure, the temperature at the scintillator is stabilized at 27 $^{\circ}\text{C}$. The components are mounted on the same circuit board where the heating element is printed out. Due to its small thickness it is flexible enough to be wrapped around the crystal. The temperature sensor LM335 is in a close contact with the

crystal. A signal $U(T)$ is taken out of the temperature sensor, so that the registering system controls closely the scintillator's temperature.

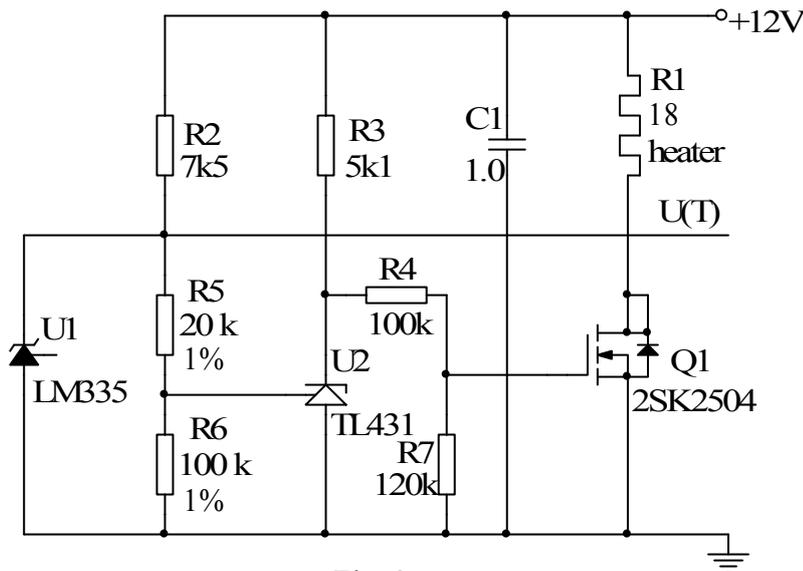


Fig. 6

The laboratory tests of the thermostat demonstrated very good stability - the temperature at the scintillator has been stabilized within 1°C (for the temperatures below the nominal value). An investigation of the system's behavior during the coming autumn is impending.

4. ACKNOWLEDGEMENTS

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