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ON THE POSSIBLE IMPROVEMENTS IN THE FREQUENT BALLOON COSMIC RAY MONITORING IN THE EARTH'S ATMOSPHERE

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Abstract. The means of improving the quality of the experiment of frequent balloon cosmic ray monitoring conducted by the Lebedev Physical Institute are discussed.

1. Introduction

The experiment on the frequent balloon cosmic ray monitoring (FBCRM) has been carried out by the Lebedev Physical Institute since 1957. The main sites of the balloon launches are Kola peninsula (Loparskaya, Olenya, Apatity), Moscow region (Dolgoprudny) and Antarctica (obs. Mirny). Although very simple, the experiment has provided the valuable findings on the behavior of the galactic and solar cosmic rays, on some magnetospheric phenomena and processes in the atmosphere (see [1-4]). However, there are a few flaws in the experimental procedure limiting the accuracy of the FBCRM data. In this paper I briefly discuss my private views on these flaws and the means to overcome them.

2. The standard FBCRM experiment.

Fig. 1 schematically depicts the principal features of the experiment: a balloon flying upward and moving with the horizontal winds; a probe suspended to it by a strip and oscillating around the vertical; a ground-based receiver-recorder complex; an extraneous noise source. The probe includes a baro-detector, two Geiger counter telescope aligned along the strip and a radio-transmitter emitting a pulse each time an ionizing particle passes though the above counter (the shorter pulse) or the telescope (the longer pulse). The receiver picks up both the useful pulses, coming from the FBCRM probe with the amplitude depending on the distance to the probe and the orientation of the transmitter's antenna aligned with the strip (the directional diagram of the antenna is shown), and the noise pulses. The recorder separates the received pulses according to their duration into two groups and counts the number of corresponding pulses for each minute of the flight.

Figure 1. The schematic view of the FBCRM experiment and the virtual combined launch of the FBCRM and aerological probes. The FBCRM probe and receiver-recorder complex are designated as CR, while AERO stands for those of the aerological monitoring. The graphic file with the Apatity view from the website of PGI was used.

3. The standard and detailed information about pulses

Although the duration of the flight is approximately 2-3 hours and we are interested mostly in the smooth time profile of the detectors' counting rates, the finite (one minute) interval of data sampling is, to my mind, one of the flaws of the standard information recorded during the FBCRM experiment. It gives no way to rejecting very short but intense bursts of noise pulses, the fast drifts of the frequencies, turbulence etc., forcing one to discard the whole minute of data.

The second, and very important, drawback of standard information recorded during the flight is that the separation of the detected radio pulses into two groups is achieved using only one pulse parameter (its length or duration), neglecting its amplitude and form. It prevents separating the useful pulses (corresponding to the passage of the ionizing particle through the omnidirectional Geiger counter or the telescope) from the pulses of the same length due to the noise.

To overcome these flaws we suggested [5-6] recording a much more comprehensive information coming from the FBCRM probe. We fed the output voltage from the receiver to the analogue-to-digital converter that yielded the value of voltage at regular small intervals (25-50 µs). If this value exceeds some small threshold (160 mV), it is stored into the memory. The continuous set of the stored voltage values is a digital analogue of the pulse. As the length of the useful FBCRM pulses exceeds 500 µs, the form of each pulse detected by the receiver is reproduced rather well. We have registered this digital information for more than 1100 flights in Dolgoprudny for the last nine years.

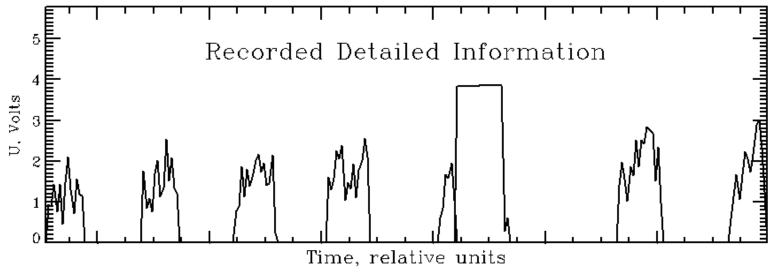

Figure 2. Example of time sequence of the received pulses reconstructed using the recorded RDI.

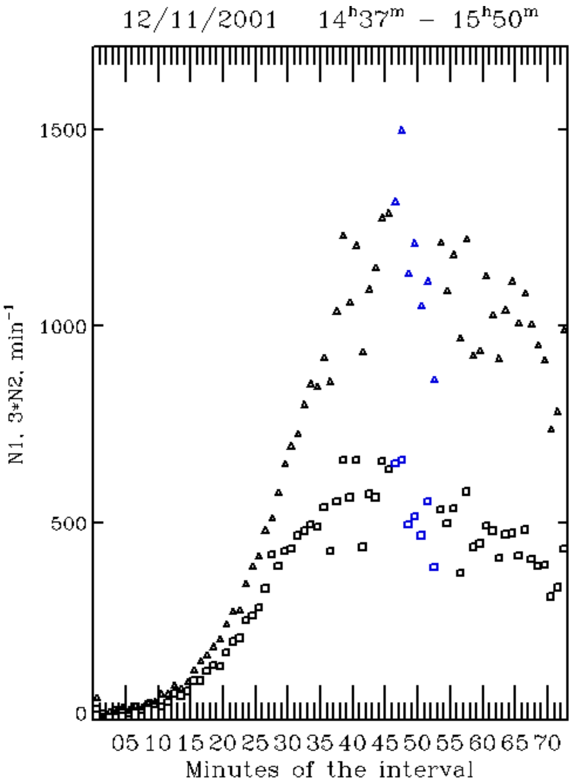

Figure 3. The standard information on N1(t) and N2(t) in the flight indicated above the plot. The data for 7 minutes around the maximum of the count rate time profiles are of different colour.

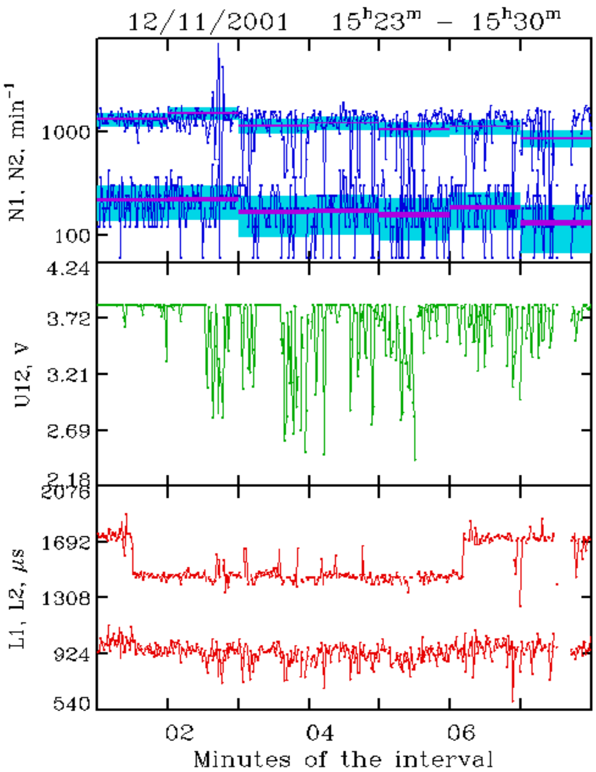

Figure 4. The one-second averages of the count rates (top), amplitude (middle) and the length of the pulses (bottom) for the 7 minutes isolated in Fig. 3, reconstructed using the restricted detailed information.

However up to now we have not added to it the amplification coefficient of the receiver, which would allow us to get the pulses incoming to the input of the receiver. That is why we call the above digital pulses recorded during the flight the FBCRM restricted detailed information (RDI), while by the detailed information (DI) we mean RDI plus the amplification coefficient. In Fig. 2 an example of the time sequence of the received pulses reconstructed using the restricted detailed information is shown (taken from the minute with the highest counting rate *N1* of the omnidirectional counter in the flight which standard information is illustrated in Fig. 3). It is easily seen how the useful pulse (the almost regular rectangle) differs both in its amplitude and form from the noise pulses.

To illustrate how even the restricted detailed information can be used to improve the quality of the FBCRM experiment, the time history of one-second averages of the count rates, amplitude and length of pulses are shown in Fig. 4 for the same 7 minutes as isolated in Fig. 3. One can easily discard the very short interval of the highest count rate in the second minute. The intervals of the count rate and amplitude oscillating (with the period ≈ 6 s) between the normal and rather low values during minutes 2-7 are indicative of the oscillation of the probe around the vertical; studying this process, too low count rate can be accounted for. The sharp change in the length *L2* of the pulses connected with the passes of particles through the telescope enables the precise determination of the moments when the pressure reaches its predetermined values (the moments are coded by the extension and shortening of L2).

Still, the study of the number of pulses and their characteristics averaged over an arbitrarily small time interval, even if useful, is not the best way of using FBCRM detailed information. The method adequate to DI should consist of two stages. The first task is to discard all noise pulses, taking into account the main fact that the characteristics of the useful pulses change regularly from one pulse to another (according to the mean position of the probe with respect to the ground-based complex, its oscillation around the vertical, and the radiation field in the atmosphere), while the characteristics of the noise pulses do not obey this regularity. The second stage should use the unique knowledge of the characteristics of each useful pulse (the time of its occurrence, its amplitude and length) to achieve the most probable parameters of both the probe's trajectory and the radiation field in the atmosphere (see [6]).

4. The horizontal position of the probe and pressure information

The position of the device in the horizontal plane during the flight, quite unknown now, would be of use for the above task of estimating the most probable parameters of the probe trajectory and the radiation field in the atmosphere. Besides, the knowledge of the probe geomagnetic coordinates is important in studying such localized phenomena as electron precipitation from the radiation belts into the atmosphere. Fig. 5 illustrates some sample trajectories of the balloons launched in Apatity. Although the dominant winds are in the East or West directions, it is easily seen that sometimes the balloons are transferred by a few degrees to the North or South (both geographic and geomagnetic), which is rather important for interpretation of the precipitation data, especially for the night launches.

The last but not the least drawback of the FBMCR experiment is rather moderate quality of pressure determination during the flight. We shall not dwell on it; suffice it to say that the atmospheric depth or pressure, along with the cosmic ray intensity outside the magnetosphere, and the geomagnetic field, are the main parameters governing the radiation field in the atmosphere.

Figure 5. The map of the Kola peninsula with the sample trajectories of the balloon launched at Apatity (in fact, the trajectories of the SPARMA balloons launched at Kiruna [7] were used to construct the figure). The dots along the trajectories mark the hour intervals. The geomagnetic latitude thin isolines are also shown.

As a way to overcome the above flaws of the FBCRM experiment, I consider the combined launches of the FBCRM and aerological probes, using the nearest meteorological station carrying out the aerological monitoring (shown schematically in Fig. 1). It provides with good time resolution both the position of the aerological probe (and with it that of the FBCRM probe) and the pressure (calculated by the barometric formula using the results on the position, temperature, and humidity). In principle, these combined launches are possible (both technically and economically) for all main sites of the FBCRM experiment: in Mirny (Antarctica) the launches of the aerological and FBCRM probes are carried out in the same place; in Dolgoprudny the distance between these launch sites is about one kilometer; on Kola peninsula this distance is about forty kilometers. It is significant that the ionizing cosmic ray intensity in the atmosphere is now considered an important meteorological and aerological factor, so the combined launches or the launches of the combined aerological-FBCRM probe (to be developed) are mutually useful.

5. Conclusions

1) Although for nearly 50 years the experiment of the frequent balloon cosmic ray monitoring has provided the valuable findings on the cosmic ray, magnetospheric, and atmospheric phenomena, there are a few flaws in the experimental procedure, limiting the accuracy of the data.

2) The first group of the drawbacks is due to registering only small part of the information incoming from the probe. The present day technique enables relatively simple and inexpensive tackling of this problem by the registration of much more incoming information. For the last nine years we have registered the most part of it (the so called restricted detailed information) for more than 1100 flights in Dolgoprudny. In the nearest future we are going to add to it the amplification coefficient of the receiver, extend the detailed information recording over other sites of the experiment, and to develop the effective methods of its processing.

3) Another group of the drawbacks is due to the moderate quality (or absence) of the information on the characteristics important for the interpretation of the experimental results (first of all, the pressure and the probe position during the flight). To tackle this problem much more efforts (administrative first of all) are needed. However we believe that the combined launches of our and aerological probes, using the nearest meteorological station carrying out the aerological monitoring (and, in the future, the development of the combined probe) could solve this problem.

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