“Physics of Auroral Phenomena”, Proc. XXXI Annual Seminar, Apatity, pp. 115- 118, 2008

Polar Geophysical Institute

MODERNIZATION OF THE REGISTRATION OF THE DETAILED INFORMATION IN THE REGULAR BALLOON MONITORING OF COSMIC RAYS IN APATITY AND DOLGOPRUDNY AND THE ABRUPT PERIODICAL DROPS OF THE COUNT RATES

B.B. Gvozdevsky [1], M.B. Krainev [2]

[1]Polar Geophysical Institute, Russian Academy of Sciences, Apatity, Russia
[2]Lebedev Physical Institute, Russian Academy of Sciences, Leninsky Prospect, 53, Moscow, 119991, Russia;
e-mail: krainev@fian.fiandns.mipt.ru

Abstract

We describe the changes in the hard- and software used in recording the detailed information (DI) in the regular balloon monitoring (RBM) of cosmic rays. The results of the DI recording by the programs RBM_DI and COUNTER with the analogue-to-digital converters are compared with the standard information obtained using the analogue selector. Besides, the development of the phenomenon of the abrupt periodical drops in the RBM counting rates in 2007-2008 and some approach to its interpretation are discussed.

1. Introduction

The long-term regular balloon monitoring (RBM) of cosmic rays in the Earth’s atmosphere has been carried out by Lebedev Physical Institute, RAS, since July 1957. For the last 18 years the balloons are launched regularly in three locations: Kola peninsula (Apatity since 2002), Moscow region (Dolgoprudny) and obs. Mirny (Antarctica). The results for more than 50 years allowed to make the important conclusions on the behavior of the galactic and solar cosmic rays. However, the standard method of the RBM data registration (the separation of the pulses coming from the probe only by their length and recording the number of pulses for each minute of the flight) has some disadvantages [1]. To overcome them we started recording simultaneously with the standard data a so called detailed information (DI, the form of each pulse coming from the probe) using the PC and analogue-to-digital converter (ADC). Since 1996 the DI is recorded in Dolgoprudny and since 2005 also in Apatity, now using the program RBM_DI. Besides, since 2003 the RBM data are recorded by the COUNTER program with the sound card, only the length of pulses being analized as before. So now the same data coming from the RBM probe and demodulated by the ground-level receiver are recorded simultaneously by three methods.

In this paper we try to prove the advantages of using the RBM_DI program over the other methods. Besides, the development in 2005-2008 is discussed of the phenomenon of the abrupt periodical drops (APD) in the count rate of the RBM cosmic ray detectors, that was detected using DI and described in detailes earlier [2].

2. The hard- and soft-wares

Until the middle of 2007 the RBM detailed information in both Dolgoprudny and Apatity has been recorded using the program STRAT_L for DOS, working with ADC-board L154 (made by “LCARD” company) for the ESA bus. The time was synchronized with that of the analogue selector using so called “minute” pulses provided by the selector before and after the flight. B 2006-2007 the modern soft- and hard-ware packet RBM_DI has been developed. It works under WINDOWS, with ADC-board LA1.5 (“Rudnev-Shilyaev” company) for the PCI and USB buses, with the time synchronization both to the selector (using the “minute” pulses) and the universal times (using the the tags or pulses-per-second from the GPS Resolution T (“Trimble”). During a few months the DI was recorded by both old and new packets and then the recording proceeded only with RBM_DI (since September, 2007, in Apatity and October, 2007, in Dolgoprudny).

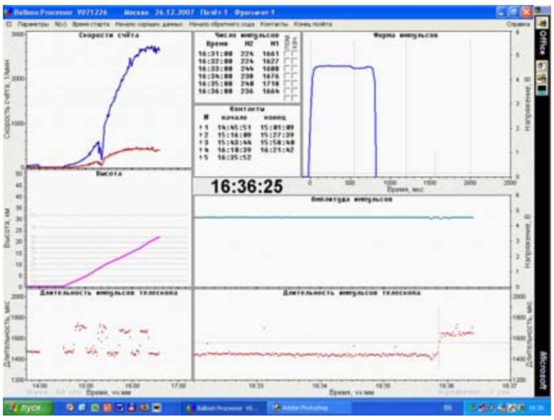

Fig. 1. The main window of the RBM_DI program.

The main advantages of the registration and visualization of the data recording using the RBM_DI packet over those when the program COUNTER is used are as follows:

- The main window of the RBM_DI program (Fig. 1) gives the operator all the necessary information (the views of the cosmic ray detector count rates as a function of time or atmospheric depth, the altitude of the probe and the state of the barodetector – with low time resolution for the whole flight; the views of the amplitude of the pulses and the state of the barodetector – with high time resolution for the last 5 minutes of the flight; the tables of the count rates for the last 7 minutes and of the times when the state of the barodetector changed; the digital oscillograph) and the possibilities to make the decisions (to change the time resolutions and some other parameters). The COUNTER program does not provide any oscillograph and gives the operator only the view of the cosmic ray detector count rates as a function of time with the low time resolution for the whole flight and the table of the count rates for the last minutes.
- The RBM_DI automatically finds the moments when the state of the barodetector changed. If necessary the operator can change these decisions. The COUNTER program does not provide any such possibilities.
- The RBM_DI provides the synchronization to the selector or universal times while the COUNTER cuts the time into the minutes using only the time of the PC.
- The RBM_DI records both the detailed and the standard informations (as a standard protocol file used for saving the Selector data and in the COUNTER format).
- The RBM_DI writes and saves the data on the hard disc in real time while the COUNTER writes them in the temporary memory. So in case of some failure the COUNTER data are lost while those recorded by RBM_DI are safe. Besides, the RBM_DI can connect the data of the different fragments of the flight separated by the failure.

3. The count rates of the RBM detectors

For the long-term experiments such as RBM in case the method of, e. g., data registration changes, it is most impotant to save the homogeneity of the data. In our case it means that the cosmic ray count rates for each minute of the flight determined by the RBM_DI or COUNTER should not differ significantly from those determined by the analogue Selector, which made it during the previous years. To check this correspondence we considered the difference $\Delta N = N - N_{SEL}$ (where N is the count rate per minute determined by the RBM_DI or COUNTER, and N_{SEL} statistical uncertainty of N_{SEL}.is that recorded by the Selector) divided by the

In Fig. 2 the distribution over this quantity is shown for all minutes of each flight in Apatity and Dolgoprudny in November 2007 – January 2008 and of a few flights in February 2008. When calculating the average relative difference and its RMS, also shown in Fig.2 for RBM_DI and COUNTER, only the minutes with $\mathrm{abs}(\Delta N/\sigma_{SEL}) < 2$ were considered. Besides, the integral percentage of minutes when $\mathrm{abs}(\Delta N/\sigma_{SEL}) > 2$ is shown.

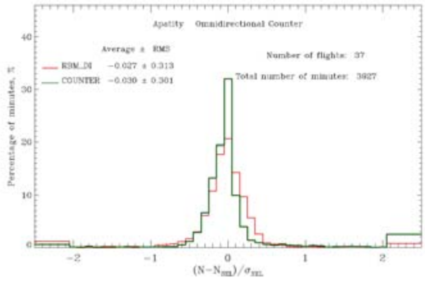

Fig. 2. The relative difference between the RBM cosmic ray detector count rates determined by the analogue and digital methods.

The main fact following from Fig. 2 is the small value of the average and RMS of the relative difference, which means that there is practically no systematic omitions or additional counts in the count rates determined by all three methods when compared with the statistical uncertainty of the data. So if one considers the smallness of the difference between different data compared with their statistical uncertainty as a criterium of closeness of these data, then the standard RBM data determined by the analogue and both of digital methods (using the RBM_DI and COUNTER programs) are close to each other. It means that the change from the classical (analogue) to any of the digital metods does not spoil the homogeneity of the RBM results.

However there is a difference even small as it is between the minute count rates determined by the three methods and we do not quite understand its source. First, we attributed it to the difference in the times used in different methods. However, it occurred that it is not the case, as the relative difference between the the results of the Selector and RBM_DI changed little after the times used in these methods were synchronized. Probably, it can be explained by the thresholds for the amplitude and length of the pulses used for the separation of the useful pulses (those from the probe) from the noise pulses in different methods.

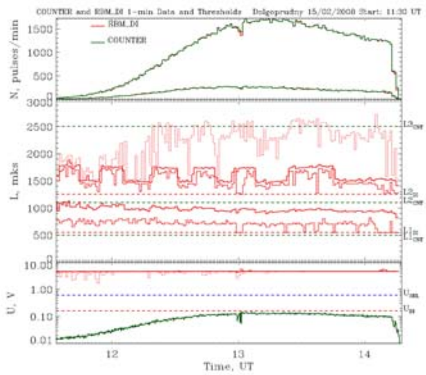

Fig. 3. The time profiles of the omnidirectional counter and telescope count rates (the upper panel); The minimal (the dark dots), average (the solid curve) and maximal (the lighter dots) values of the pulse length (the middle panel) and of the pulse amplitude (lower

panel) with respect to the thresholds (horizontal dashed lines) used by different methods.

It can be seen from the lower panel of Fig. 3, that the amplitude threshold are not important as the thresholds for all three methods all the time are much lower than the minimal values of the amplitude. On the contrary, as it follows from the middle panel, the minimal values of the length both of the "omnidirectional" and "telescope" pulses often are equal to the theresholds. It means that during such minutes most probably there are some useful pulses with the length lower than the thresholds. So such pulses will be considered as noise pulses and not counted, their number being different for different methods.

3. On the abrupt periodical drops in the RBM cosmic ray count rate

By the abrupt periodical drops in the RBM cosmic ray count rate we mean a wellknown to all members of the RBM team strong decrease in the count rate of the RBM cosmic ray detectors for a period of 5-20 minutes often accompanied by the pronounced oscillation of the amplitude of pulses received. It is implied that it is due to free oscillation of the probe around the vertical. However only analysis of the detailed information allowed to formulate the important characteristic features of this phenomenon:

- Its periodical nature (the count rates decrease practically to zero for 1 second after each 5-8 seconds of good data, especially in Apatity);
- Much more pronounced effects in Apatity than in Dolgoprudny;
- A significant increase in the number of pulses with the length lower the threshold accompanying the decrease in the number of useful pulses;
- The dependence of the effect on some conditions of the experiment (the velocity of the rise of the balloon; possibly, the phase of the solar cycle).

The APD phenomenon (as it looked in the middle of 2007) is described in detailes in [2]. Here we shall only check if anything changed in its periodicity (Fig. 4) and time behavior (Fig. 5, 6) after one more year and, possibly, change in the hardware (the ADC-board). Besides, we shall discuss one of the possible interpretations of the phenomenon (Fig. 7).

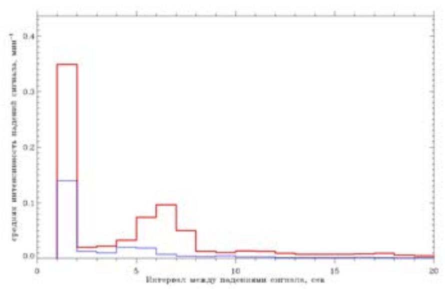

Fig. 4. The hystograms of the rate of drops summed over all flights as functions of intervals between the seconds for which the data dropped for Apatity (the red solid line) and Dolgoprudny (the blue dotted line).

One can see from Fig. 4, first, much more pronounced effect in Apatity than in Dolgoprudny. Second, it is clear that beside the 1 second period common for both locations there is a pronounced effect in the range 5-8 sec in Apatity and a smaller one in approximately the same range (or, rather, 4-7 sec) in Dolgoprudny. If we compare Fig. 5 in [2] with Fig. 4 in this paper it is clear that there are some changes: (1) the first peak (in 1-1 range) became stronger (in Apatity it grew from 0.3 min^{-1} in 2007 to 0.35 min^{-1} in 2008 and in Dolgoprudny from 0.06 min^{-1} in 2007 to 0.14 min^{-1} in 2008); (2) the second peak (in 5-8 or 4-7 ranges) became weaker in Apatity (it decreased from 0.11 min^{-1} in 2007 to 0.09 min^{-1} in 2008) but stronger in Dolgoprudny (it changed from 0.06 min^{-1} in 2007 to 0.14 min^{-1} in 2008). These trends can be seen in Figs. 5, 6, where the time behavior of the rates of APD in these two ranges is shown by the vertical bars with different symbols at the top (the red triangles for Apatity and blue squares for Dolgoprudny). To understand these trends we should process the data in some other way to reveal the meaning of the APD in [1-1]-range.

Just as in [2] the shaded bands in Figs. 5, 6 show the periods when the RBM probes were prepared and launched in Apatity by the Operator-2, different from one that usually attends the experiment (Operator-1). As shown in [2], the velocity of the balloon's rise is higher when the Operator-1 attends the RBM experiment. Besides, the periods when the RBM detailed information was recorded using the new program and ADC-board are shown by the green tilted line shading (of different tilt for Apatity and Dolgoprudny), while the periods when the old program and ADC-board were used are not shaded.

As in 2005-2007, the periods when there were practically no flights with the pronounced APD practically coincide with the periods of smaller velocity of the balloon's rise. One can also notice some weakening of the rate of APD in the range [5-8]-seconds since the middle of 2007, which can be attributed to change of hardware used. However it is not true for [1-1]-range. Besides, the weakening of the APD rate can be manifestation of the gradual decrease in the level of solar activity.

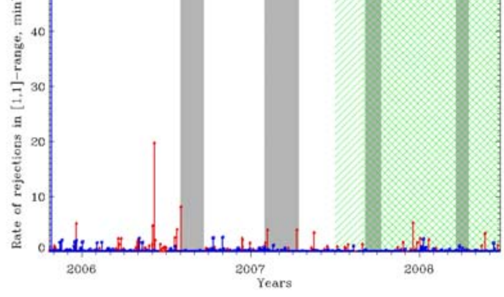

Fig. 5. The time behavior of the rate of APD [1-1]-seconds range.

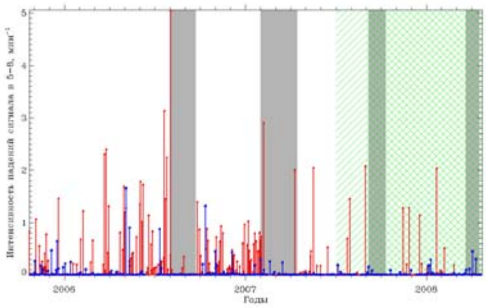

Fig. 6. The same as in Fig. 5 but for [5-8]-range.

The close coincidence of the main APD period (6-7 sec) with the period of the free oscillation of the probe forced us in [2] to consider as the main hypothesis on the nature of APD these oscillations, namely, that the drop of the RBM count rate occurs each second when the axis of the transmitter's antenna points to the ground-based receiver. Earlier it was suggested (N.S. Svirzhevsky), that the presence of the abrupt peaks in the number of the noise pulses coinciding with the drops of the useful ones means that, when the amplitude of the RBM pulse with length $L > L_{01}$ becomes low (only slightly above the threshold of the DI recording, U_{th} = 160 mV), this pulse is splitted into a group of a few (k) shorter pulses with $L_i < L_{01}$, $i = 1,\dots,k$. with the total length of the group L_{gr} the same as the length of the initial useful pulse, $L_{gr}=L$. Having the detailed information we can check this hypothesis.

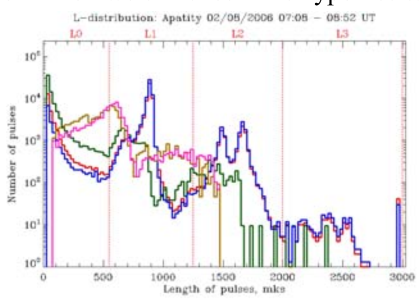

Fig. 7. The length distribution of the pulses for different periods of time in RBM flight in Apatity in 02/08/2006.

In Fig. 7 the length distribution of some groups of pulses for the RBM flight in Apatity is shown as a hystogram. As in [2], the length ranges L0-L3 are shown by the dashed vertical boundaries (those separating L0, L1 and L2 ranges are the standard thresholds for the pulses belonging to the count rates of the omnidiractional counter (L_{01}) and telescope (L_{12}), respectively).The thinnest (red) solid line is for all pulses of the flight, while the thicker (blue) one is for the seconds without drops and the thickest (green) for the seconds with the APD drops. It can be seen that L-distribution for the periods without APD ("Without drops" population) is the same as for all pulses while that for the period with APD ("With drops" population) is quite different, namely, it demonsrates the mentioned lack of useful pulses ($L > L_{01}$) and an excess of the noise pulses ($L < L_{01}$). However if we construct from these two populations ("With drops" and "Without drops") the groups discussed above and compare their L_{gr}-distributions (shown by thinner (magenta) and thicker (brown) dotted histograms for the "With drops" and "Without drops" distributions, respectively), they look almost identical. So what occurred in the seconds with the drops of the RBM cosmic ray detector count rate is not simply the decay of the useful pulses into the groups of the "quasinoise" ones. We need other ideas about the cause of this phenomenon.

4. Conclusions

1. The registration and visualization of the data recording in the RBM experiment using the developed program RBM_DI with the ADC- and GPS-boards has the decisive advantages over those using either analogue selector and oscillator or the simple program COUNTER with the sound card.
2. There is a small difference (much smaller than the statistical uncertaincy) between the average count rates of the RBM cosmic ray detectors determined by different analogue and digital methods. The most probable cause of this difference is the different thresholds for the length of pulses, used in these methods.
3. The effect of the abrupt periodical drops on the count rates of the RBM cosmic ray detectors clearly exists for the 2.5-year period in 2005-2008, although there are some changes when compared with the 1.5-year period in 2005-2007. To make the features of the effect more clear it is necessary to go on with the registration of the RBM detailed information.
4. As to the cause of the APD effect, it is not simply the decay of the useful pulses into the groups of the "quasinoise" ones due to the oscillation of the probe around the vertical. We need other ideas about the cause of this phenomenon.

Acknowledgements. We are greatful to all operators and engineers of the RBM experiments and also to first constructors of the soft- and hardware who made its previous versions: Korolkov D.N. and Kibardin V.M. The registration of the detailed information in Apatity in Dolgoprudny and modernization of the soft-and hardware in 2005-2008 became possible only due to the RFFI grants (05-02-17346 and 08-02-00418).

References

[1] Krainev M.B., On the possible improvement in the frequent balloon cosmic ray monitoring in the Earth's atmosphere, Physics of Auroral Phenomena, Proc. XXVIII Annual Seminar, PGI, Apatity, Russia, 231-234, 2005

[2] Krainev M.B., Some new results from the detailed information in the regular balloon monitoring of cosmic rays in Apatity and Dolgoprudny, Physics of Auroral Phenomena, Proc. XXX Annual Seminar, Apatity, PGI, 2007, pp. 129 - 132