Meteorological effects of a single cosmic ray component by the data of Baksan air shower array Andyrchy

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Abstract

Interest enlarges to study of cosmic ray variations with using of single component of the extensive air shower (EAS) arrays. But the data correction on meteorological effects is necessary to be accorded quantitative results in this case. The EAS arrays have high statistical accuracy. Therefore study of meteorological effects of cosmic rays with high accuracy represents independent interest. The barometric factor of regression was obtained directly from experimental data. The Andyrchy data set accumulated during 6 years was analysed. The experimental results satisfactorily are in agreement with the expected theory values.

1. Introduction

Recently interest to studying of cosmic ray variations with use a single component of Extensive Air Shower (EAS) arrays has risen. In particular, on Baksan EAS-arrays Andyrchy and Carpet [1-3], on MILAGRITO [4] and on GRAND [5] the increases of intensity caused by solar cosmic rays are fixed during powerful flashes. For reception of quantitative results is necessary to correct data on meteorological effects. EAS-arrays have high statistical accuracy at registration of single components. Therefore studying of meteorological effects of cosmic rays with such accuracy represents also independent interest. Barometric and temperature factors of regression can be received directly from experimental data, and also can be calculated theoretically [6, 7]. The analysis of data of the Baksan EAS-array Andyrchy is submitted in the work. Researches have been directed on revealing of dependence of counting rate for the single component on pressure and on temperature of air.

2. Description of Detector

The Baksan Neutrino Observatory is located in a point with geographical coordinates 43.28°N and 42.69°E. The rigidity of effective geomagnetic cut-off makes 5.7 GV. The EAS-array Andyrchy [8] consist of 37 detectors made of plastic scintillator with area 1×1 m^2 and with thickness 5 cm. The distance between detectors makes 40 m. The center of the Andyrchy is at height of 2060 m above

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sea level. Total counting rate of the installation makes 11500 s^{-1}. The installation is consist of four parts. Such scheme is used for the control over stability of work. There are the 1-second counting rate of each part and of installations as a whole.

3. Technique

Atmospheric pressure (accuracy 0.1 mb), temperature of air (accuracy 0.1°C) and temperature inside each detector are measured once a 15 minute. Therefore in the analysis the data of average counting rate were used for 15-minute interval. The data of a temperature profile of atmosphere above point of registration on Baksan are absent. Connection of temperatures of various layers of air has statistical, correlating character.

The uniformity of the initial data is important for the study of meteorological variations. Preliminary selection of the information for the subsequent analysis was carried out. At the first stage 15-minute intervals were excluded if the sharp change of counting rate, pressure or temperatures was observed with magnitude more, than 5σ in comparison with the previous interval. The experimental meteorological factors of regress for the single component was received by using both correlation and regression standard analysis. Factors for binary correlation and regress between counting rate N and pressure p, and also between N and temperature t were calculated. Two-factorial regress was calculated also at simultaneous correlation $N(p,t)$. The listed factors were calculated on a data set within each month. It is impossible to take into account correctly temperature effect for muon because there are no data for temperature profile of atmosphere. According to the theory [7] the dependence on interval duration can appear in this case. For check that the analysis has been carried out on 3-day continuous intervals of the data. Last requirement is essential for exception of possible uncontrollable jumps of data. 3-day intervals in 10 times are shorter than month and the requirement of continuity does not result in the big losses of the information. The further selection was carried out on the value of correlation factor.

4. Results

The 6 years (1996-2001) data of Andyrchy has been analysed. The factors for correlation and for regress have been found at definition of dependence of the counting rate from pressure value. The figures resulted below evidently show behavior of regress factor $R(p)$. In figure 1 the monthly and 3-day values of regress factors are shown. It is visible, that for the majority of points close values $R(p)$ are observed. For monthly intervals (the left panel on fig.1) average value makes $R(p) = -0.36 \pm 0.14$ $\%/mb$. For 3-day intervals it is equal -0.37 ± 0.13 $\%/mb$ (the right panel). They practically precisely coincide. However, errors are excessively great. First of all it is connected to several points which deviations

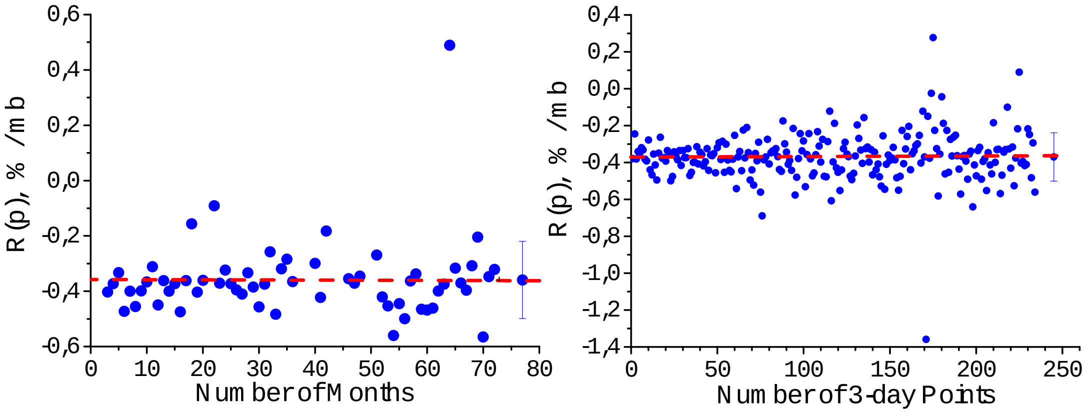

Fig. 1. The factors of regression $R(p)$ for singe component of Andyrcy during 1996 – 2001. Left panel: monthly points. Right panel: 3-day points.

do not explained by statistical uncertainty. The points with factor of correlation >0.8 (by absolute value) have been excluded for reduction of errors and for more exact definition of $R(p)$. It was made also for points with deviation from average more than 2σ. These points usually are poorly statistically provided, or distortion of $R(p)$ is caused by powerful variations not connected with meteorological effects. The result of such selection is submitted on fig.2. Factors of regress are equal in this case -0.382 ± 0.053 $\%/mb$ for monthly intervals and -0.376 ± 0.059 $\%/mb$ for 3-day one. One can see that mean values of $R(p)$ for both monthly and 3-day points is practically equal to each other. It specifies absence of dependence on length of an interval. The factors also are well correspond to theoretically expected values [6, 7].

Search for a correlation of counting rate and temperature has not given result. The corresponding factor of regress within the limits of mistakes is equal to zero. Factors of two-factorial regress $N(p,t)$ have the same values, as well as simple binary correlation. It testifies that at use of 3-day and monthly intervals, the influence of temperature on counting rate is averaged. Nevertheless the temperature effect increases deviation of points concerning average which does not speak statistics.

5. Conclusions

The dependence of the single component intensity of cosmic rays on both pressure and temperature of air is investigated. Value of barometric factors of regress for both monthly and 3-day points is received. The seasonal or long-term changes of barometric factor were not observed for the Andyrchy data. The

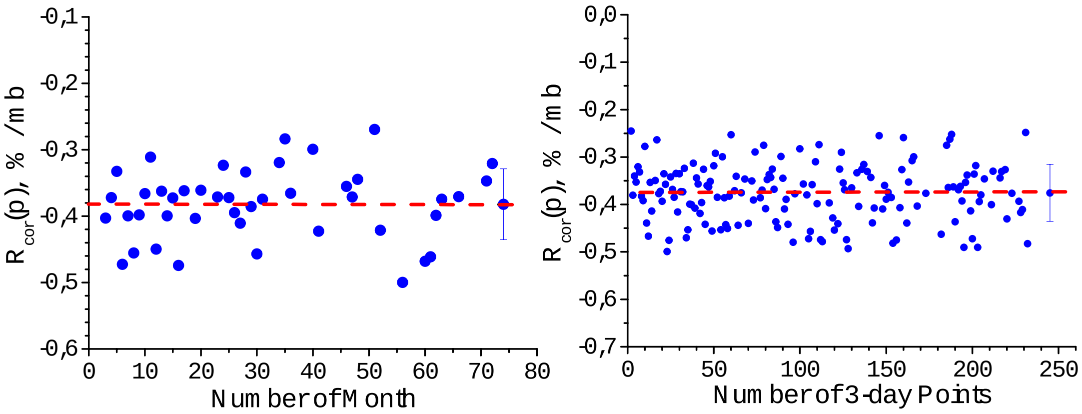

Fig. 2. The corrected factors of regression $R(p)$ for singe component of Andyrcy during 1996 - 2001. Left panel: monthly points. Right panel: 3-day points.

wide scatter of the values can not be explained by statistics, but that is connected with influence of atmospheric factors and extra-atmospheric origin, which was not taken into account. Nevertheless, the average values for all period of observation are well concordant among themselves. Search for correlation dependence between counting rate of the single component of cosmic rays and temperature has not given satisfactory result. It confirms the thesis about necessity of the taking into account of whole temperature profile of atmosphere, but not just a ground layer. The results submitted in work, as a whole are in the good agreement with the standard theory of meteorological effects [6, 7].

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6. References

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