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Study of temporal changes of the Forbush decrease amplitude spectrum exponent by means of muon hodoscope URAGAN

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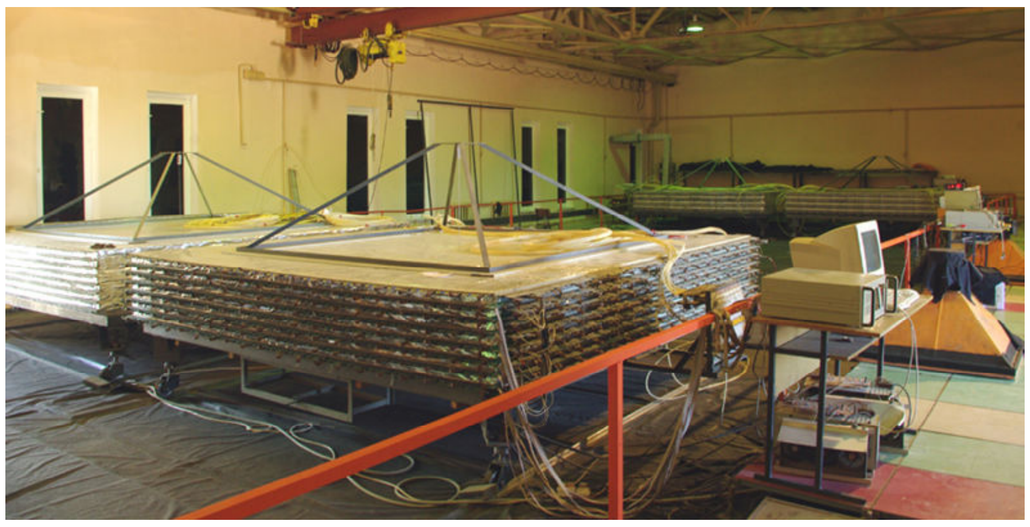
Detector and experimental data

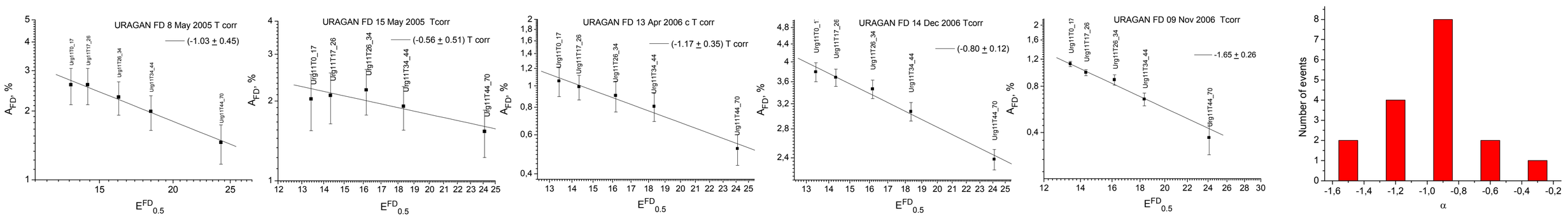


Muon hodoscope URAGAN consists of four supermodules (SM) and provides particle detection in a wide range of zenith angles (from 0^o up to 80^o) with spatial and angular resolution about 1 cm and 0.7^o. For the analysis, both integral counting rate and counting rates from five intervals of zenith angle: 0^o–17^o, 17^o–26^o, 26^o–34^o, 34^o–44^o and > 44^o are considered. Threshold energies of the setup depend on zenith angle and lie within the limits from 200 MeV to 600 MeV.

Analysis of muon flux intensity changes during Forbush effects detected by muon hodoscope URAGAN [1] at a decline stage of the 23rd solar activity cycle is presented. For the analysis, integral muon counting rate (10-minute data) corrected for barometric and temperature effects as well as counting rates in five zenith-angular intervals are used. The amplitudes of the decrease of muon counting rate during FD were obtained using a special unified technique [2]. Most FDs in the analyzed period have small amplitudes, and only 3 events have amplitudes more than 4% according to Moscow Neutron Monitor data (8, 15 May 2005 and 14 Dec 2006). Median energies of primary protons ($E_{0.5}$) which give the contribution to the changes of counting rate of the muon hodoscope for different zenith angle intervals were calculated and lie within the limits from 13 to 24 GeV [2].

Forbush decrease amplitude spectrum and its temporal changes

For 17 events, the dependences of FD amplitude on the median energy of primary protons were constructed and approximated by a power-law function E^{α}. Examples of such approximations are plotted below. The distribution of the values of power-law indexes is presented in the right figure. For most of the events, $\alpha \sim -1$.

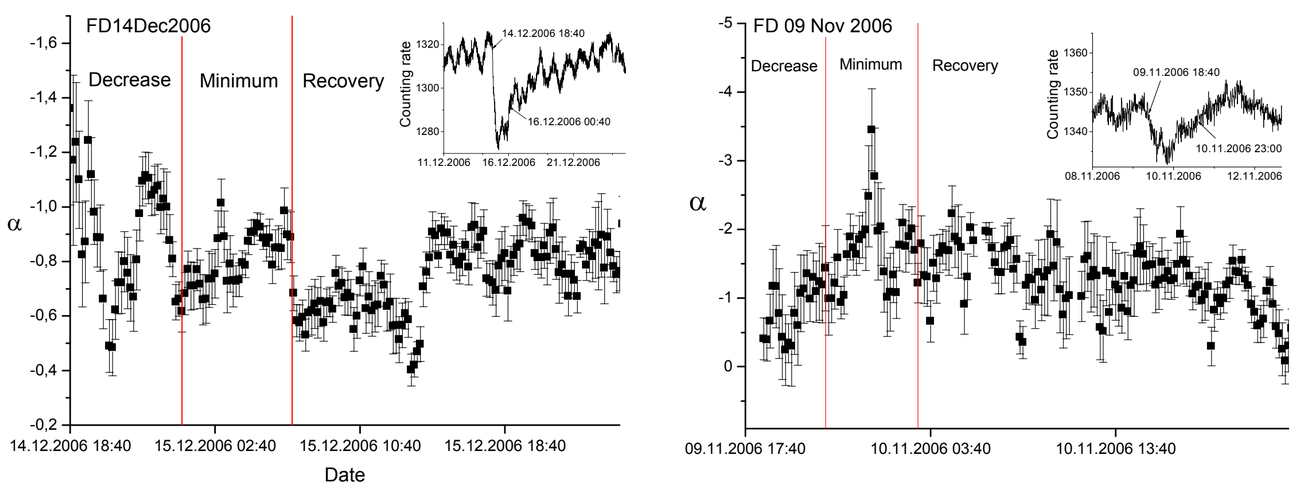


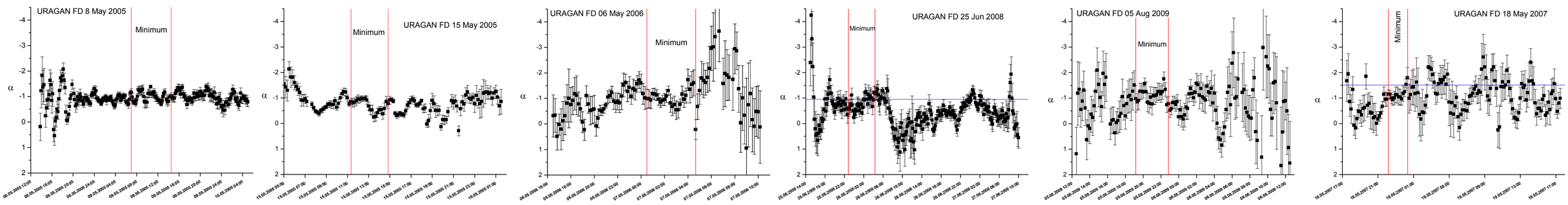
The main attention in this work is pointed to a study of temporal changes of amplitude spectrum exponent during different phases of Forbush effects. A similar research was performed earlier for the Forbush decrease of September 9, 2005 using the data of three neutron monitors and muon telescope at Nagoya [3]. Temporal and angular resolution of the muon hodoscope URAGAN allows to solve this task using a single detector.

Intervals for each phase of the event were divided with increments of 30 - 60 minutes. The amplitudes of the decrease at different time points (τ_i) have been calculated as follows:

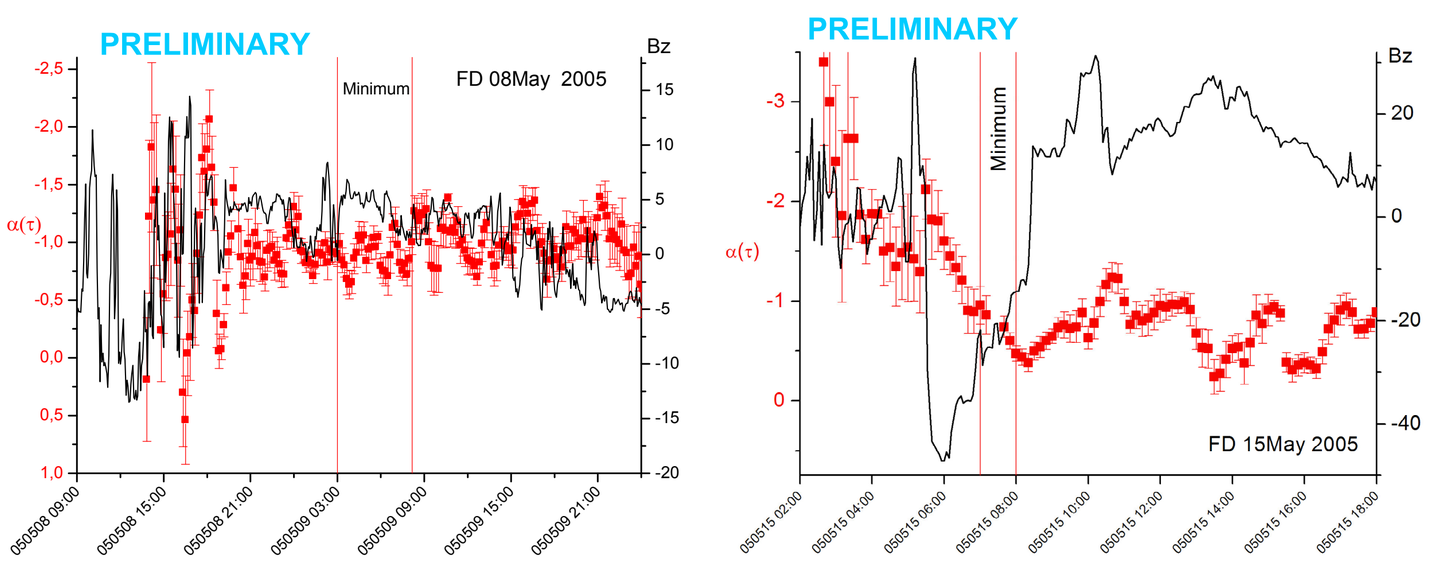
$$A_{FD}(\tau_i) = \frac{I_b - I(\tau_i)}{I_b} \times 100\%$$

where I_b - average counting rate prior to the decrease begin, $I(\tau_i)$ – hour average counting rate at each step. Temporal dependences of the power index α for several Forbush decrease events are presented in the figures.





Temporal behavior of the power-law index of the spectrum of amplitudes in the phase of decrease and phase of recovery heavily vary from event to event, while at a minimum phase the value of index is more stable. In general, it can be concluded that the spectrum index α is different in each event; probably these changes are related to specific heliospheric disturbances in the Earth vicinity. In the figures (see below) changes of α for two different events 8 and 15 May, 2005 are compared with the characteristics of the interplanetary magnetic field (B_z).



Conclusion

Thus, as a result of the analysis of 17 Forbush decreases registered by muon hodoscope URAGAN from 2005 to 2009, for the first time by means of a single detector the temporal changes of power-law indexes of Forbush decrease amplitude spectrum have been investigated.

[1] N.S. Barbashina et al., Instr. and Exp. Tech., 51, No.2, 180, 2008.
[2] N.S. Barbashina et al., Proc. 21st ECRS, Koshice, Slovakia, 335, 2008.
[3] A. Wawrzynczak, M.Alania, Advances in Space Research, 45, 622, 2010.

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