Directional Variation of 5 GeV Muon Flux Observed in the Underground Muon Telescope

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Abstract

The small muon telescope is placed in the underground laboratory. The muon energy threshold is about 5 GeV which corresponds to primary CR energies above 15 GeV (maximal contribution at 100 GeV). We have observed a number of Forbush Decrease events which made a 1-2 percent fall in observed counting rate.
The telescope has 2 degrees directional accuracy. This allows to study the directional variation of muon flux at the disturbance time. We present analysis of directional variation in time with respect to neutron monitor Forbush Decrease registration. The model explanation for observed differences between FD events will be presented.
The project of large underground muon detector will be presented.

1. Introduction

We analyse the directional variation of the muon flux in the periods of enhanced solar activity in order to find precursor cosmic ray anisotropies associated with coming geomagnetic disturbances.

The directional telescope for muon registrations is located in the underground laboratory under the 13 m of soil [2]. The telescope is built of 4 layers of Geiger–Müller's tubes. The length of the effective area of the counter is equal to 80–81 cm, the diameter of the counter equals 3.7 cm. Each layer consists of 20 counters, so 80 counters in total. The random noise of individual GM counter is at the level of 25 Hz. The telescope is triggered by 4–fold coincidence such that only one tube from each layer has been hit. 5 GeV muons in most are deflected by not more than 3° from the direction of parent particle, and are scattered by $\sim 2°$ in the ground. The registration accuracy is $\sim 2°$. The pressure correction coefficient equals to -0.000579.
The ground level EAS array scintillation counters are also included in CR varia-

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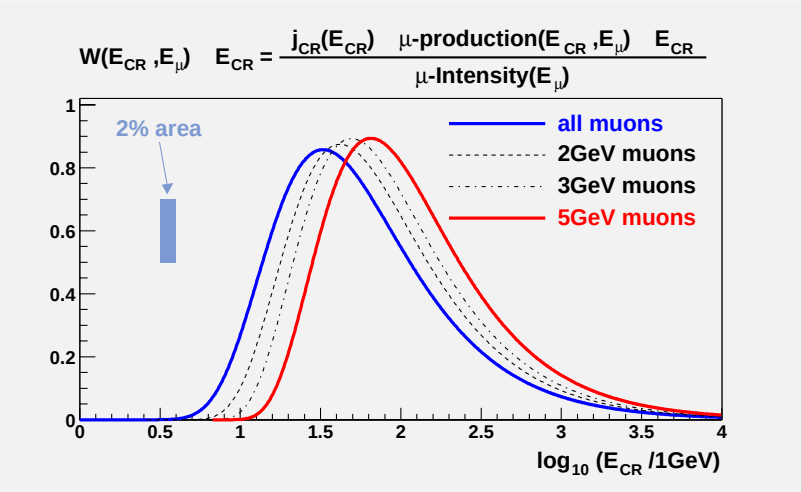

Fig. 1. The relative response of muon flux vs. primary CR energy.

tion analysis: they counting rate is monitored. The pressure correction coefficient for ground level muon observation is equal to -0.00217. Relative (normalized) response dependence on the primary CR energy for surface muons (0.5 GeV) and underground muons (5 GeV) were obtained using CORSIKA simulation code and are presented in the Fig 1.

2. Example of Forbush Decrease registration.

In the Fig 2. an example of muon flux variation during FD is presented. As 5 GeV muons correspond to much higher cosmic ray energies than geomagnetic cut-off, their intensity variation differs significantly from variation observed in neutron monitors.

To perform directional analysis we produce a pattern (table) of counting rates from all possible directions defined as constant difference between the detector X (Y) position in top layer and detector X (Y) position in the bottom layer. It is a table (39 × 39) spanning from -19 to 19 in X and Y. Then we grouped directions into 9 regions. Relative variations in standard sigma units are shown in the Fig 3.

3. Discussion.

We have performed similar analysis to that presented in the Figs 2. and 3. for several FDs. The precursors of geomagnetic storms shown in [4] were not noticed in our data. The main reason is the small detector size (and counting rate).

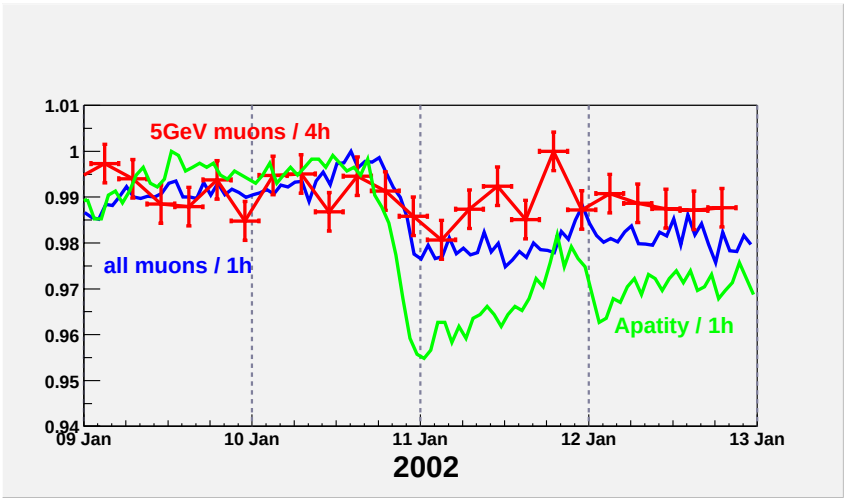

Fig. 2. Muon intensity variation during Forbush Decrease and comparison with Apatity Neutron Monitor data [1].

4. Project of Large Muon Detector.

We are going to use the underground laboratory (17 m × 5.20 m and height of 2.20 m) to construct Large Muon Telescope (total area of 36 m^2). The device would have 4 towers, and each tower would have 3 layers of X,Y plastic scintillator strips 3 m long, 4 cm × 1 cm cross section . The MINOS like [3] strips would be used, were the scintillation light from plastic is transmitted in 1 mm diameter fibre to the multianode phototubes.
The expected counting rate will be about 360 Hz.

5. References

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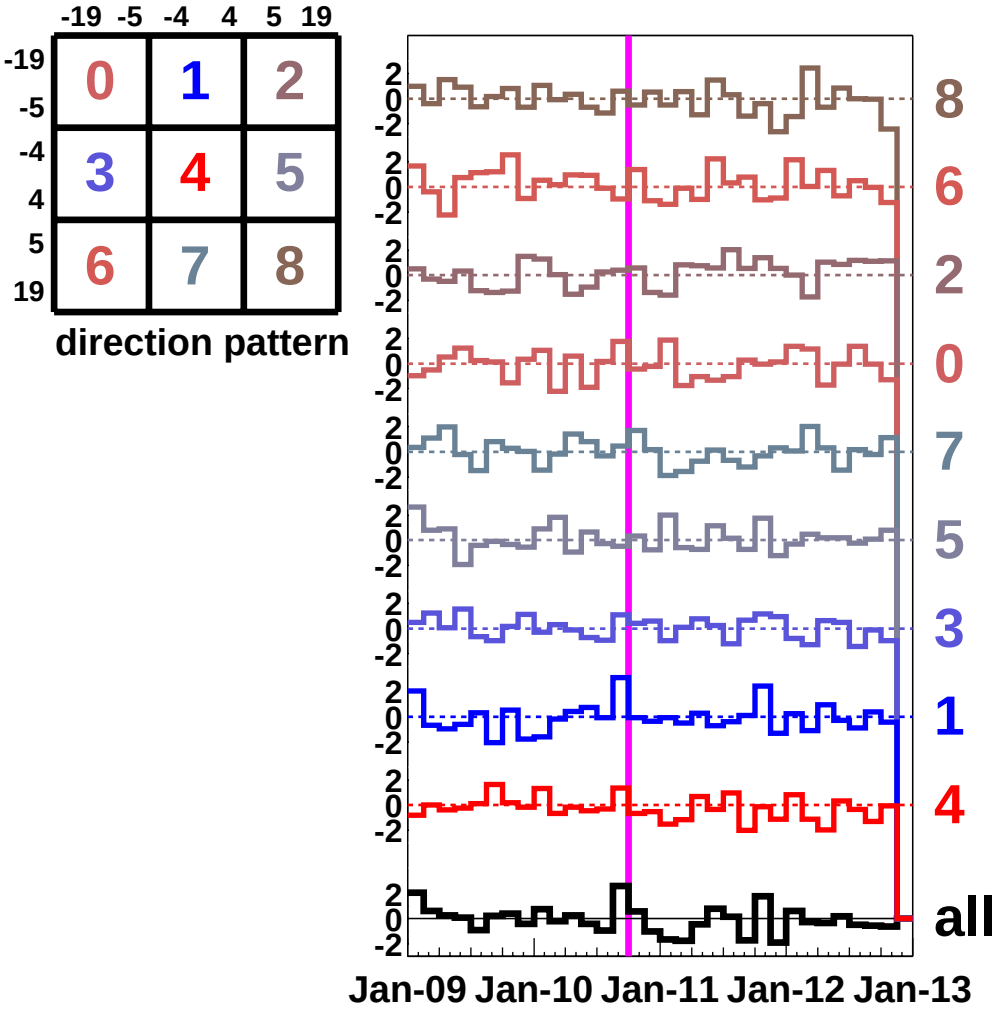

Fig. 3. Relative fluctuation of muon telescope counting rates for different directions. The Figure relates to Forbush Decrease presented in the Fig 2.. The direction pattern is presented on the left diagram. The region numbers correspond to different histograms in the right Figure as indicated on the right side. The histograms represent variation around the average on large time scale in the standard deviation units.The binning is 3 hours. The beginnig of the Forbush Decrease is indicated by vertical line.