INFLUENCE OF METEOROLOGICAL EFFECTS ON THE INTENSITY OF NEAR-HORIZONTAL COSMIC RAY MUONS

Unique Scientific Facility Experimental Complex NEVOD

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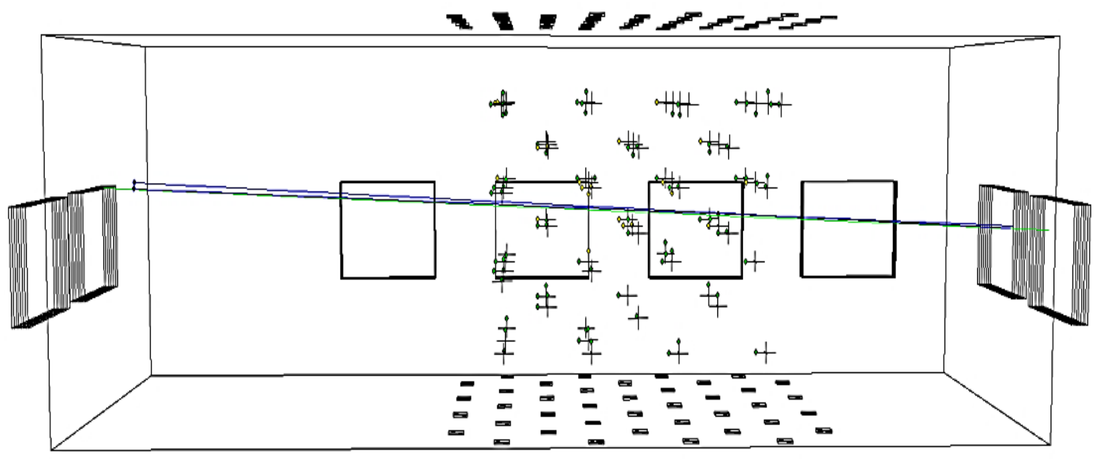
ISCRA 2017

International Symposium on Cosmic Rays and Astrophysics

20 – 22 June 2017, MEPhI, Moscow, Russia

The coordinate-tracking detector DECOR

Experimental data on cosmic ray muons obtained with the coordinate-tracking detector DECOR in 2012 – 2017 are analyzed. DECOR is designed for studying multi-particle events and single muons at large zenith angles. The detector is deployed around the Cherenkov water calorimeter NEVOD. DECOR consists of 8 supermodules (SMs) with total area of ~ 70 m^2. Every SM includes 8 vertical streamer tube chamber planes.



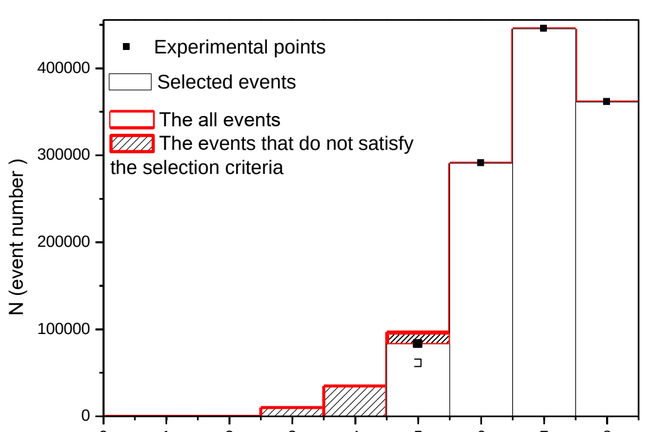
Registered events

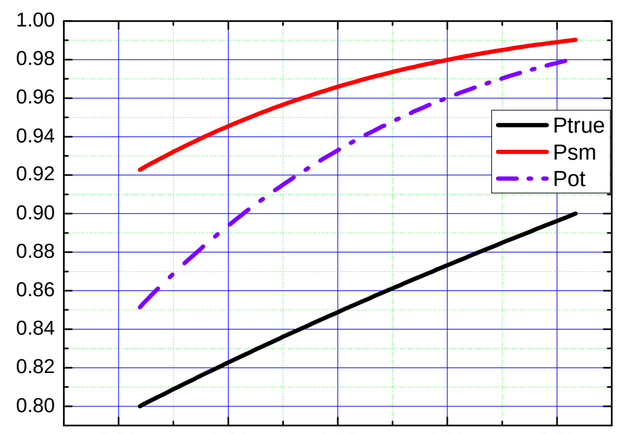
The events reconstructed from the data of SMs located in the opposite short galleries are analyzed. If the track segments registered in two SMs agree within a cone of 5°, it is assumed that both SMs were crossed by the same particle (a muon with energy of at least 7 GeV). Such events correspond to zenith angles from 85° to the horizon. The average zenith angle is 82.5°; the calculated average muon energy is about 100 GeV. Earlier, variations in the intensity of near-horizontal muons were not studied.

After preliminary analysis, 732 data sets (runs) with a duration from 10 to 40 hours of «live time» were selected. The total live time amounted to 23546 hours. About 3% of available data were excluded from consideration because of some fault conditions were disclosed in them or runs were lasting less than 10 hours.

The rate of the events exhibits variations significantly exceeding the statistical errors. It is shown that these variations are related as to changes in the meteorological conditions (atmospheric pressure and air temperature), so to changes of the temperature in the galleries where the detector is located and of the pressure in the streamer tube chambers.

In order to estimate the influence of operation conditions on the efficiency of event reconstruction, the distribution of events in the number of hit planes was analyzed. The figure below shows this distribution for the supermodule SM00 in the 12th series of measurements.





$P^{truncated}$- the estimate of the efficiency of planes of the number of triggered planes in events with near-horizontal muons in the SM for each data set.

P^{true} – the actual average plane efficiency

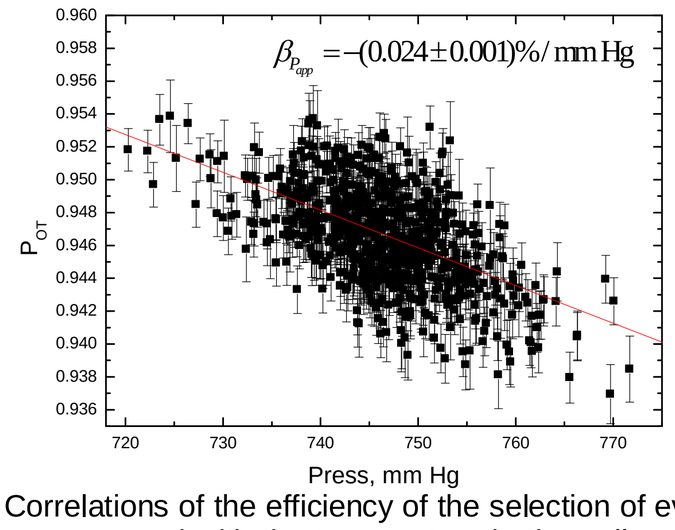
P^{SM} – the efficiency of the supermodule.

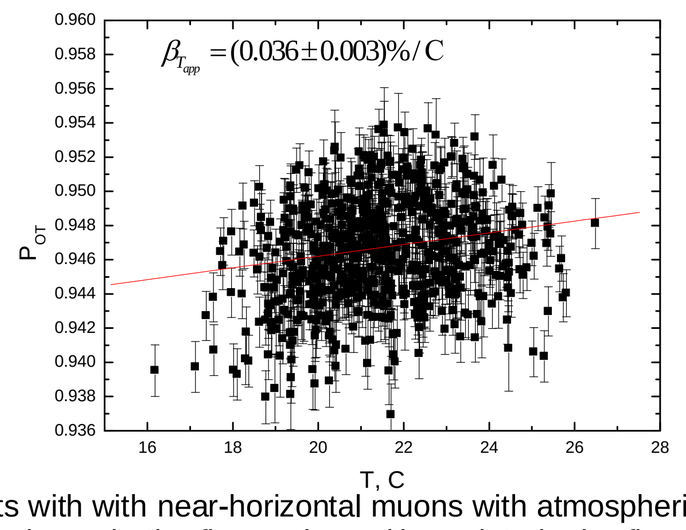
P^{OT}- the efficiency of the selection of events with near-horizontal muons

$$P^{OT} = \left(rP_{00}P_{06} + P_{00}P_{07} + P_{01}P_{06} + rP_{01}P_{07}\right) / \left(2\left(r+1\right)\right)$$

where the cross pairs of supermodules (CM00 and CM06, CM01 and CM07) enter with a weight r = 0.93, which is determined by the geometry of their location.

The influence of the barometric pressure and the temperature in the gallery on the efficiency of event selection



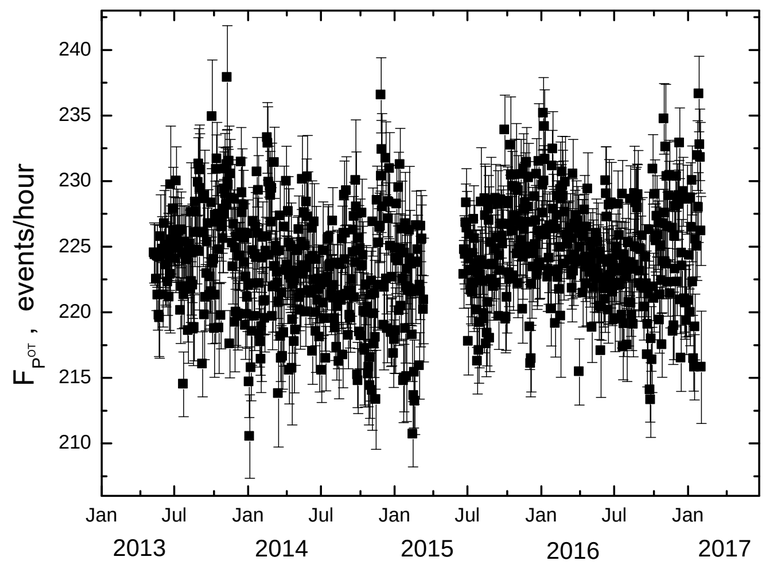


Correlations of the efficiency of the selection of events with with near-horizontal muons with atmospheric pressure and with the temperature in the gallery are shown in the figure above (the points in the figure correspond to the average efficiency of the selection of events with near-horizontal muons obtained for each data set).

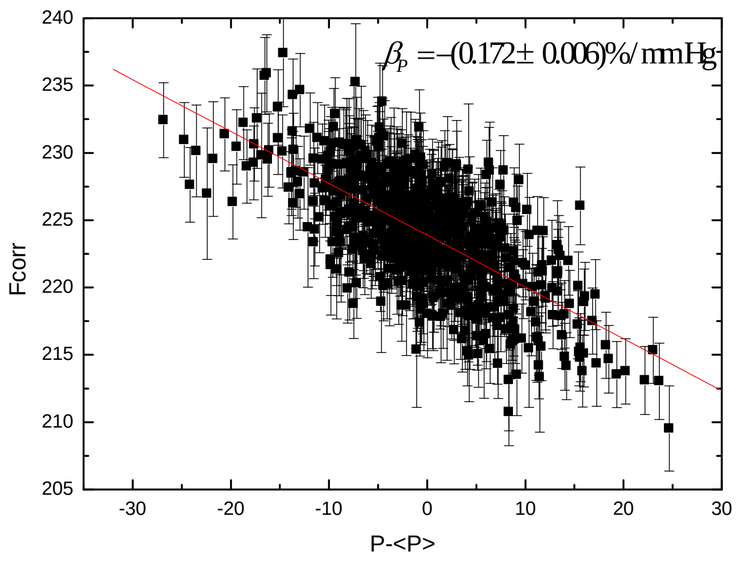
The correction for the hardware effect in the frequency of selected events with near-horizontal muons

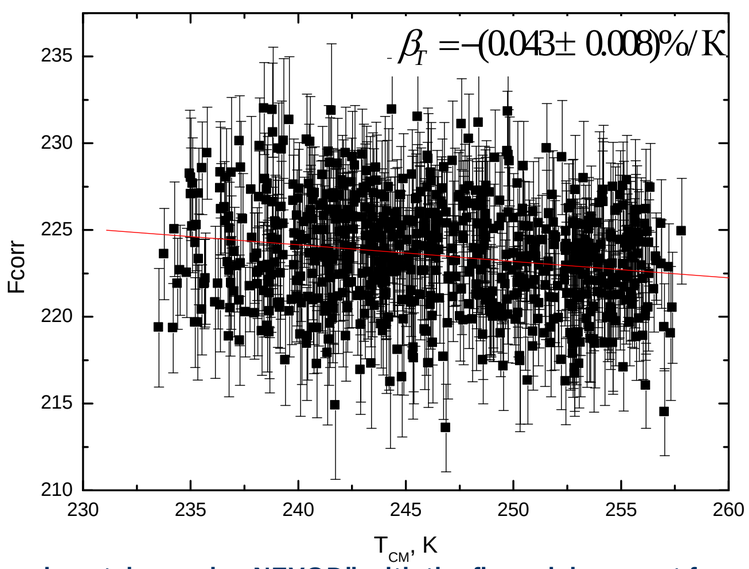
To introduce corrections for changes in the efficiency of the selection of events related to hardware factors, the efficiency of selecting events with near-horizontal events was calculated, and a correction was introduced for the hardware effect to the frequency of the selected events with the near-horizontal muons.

$$F_{P^{OT}} = \left(F \pm \sigma_F\right) / \left(P^{OT} \pm \sigma_{P^{OT}}\right) \qquad \sigma_{F_{P^{OT}}} = F_{P^{OT}} \sqrt{\left(\sigma_F / F\right)^2 + \left(\sigma_{P^{OT}} / P^{OT}\right)^2}$$



Barometric and temperature coefficients





To find the corrected values of the barometric and temperature coefficients, the frequency of events, corrected for the hardware effects, is approximated by a function of the following form:

$$F = F_{POT}(1+\beta_P \Delta P)(1+\beta_T \Delta T)$$

The atmospheric pressure and the temperature can correlate, therefore it was necessary to evaluate barometric and temperature coefficients simultaneously.

The values of meteorological coefficients obtained after introducing correction for the hardware effects are shown in the figures.

The work was performed at the Unique Scientific Facility "Experimental complex NEVOD" with the financial support from the State provided by the Russian Ministry of Education and Science (project No RFMEFI59114X0002 and MEPhI Academic Excellence Project No 02.a03.21.0005)