TEKA Kom. Mot. i Energ. Roln. – OL PAN, 2010, 10A, 339-344

COSMIC RAYS MUON FLUX AT THE SEA LEVEL BY HIGHEST SOLAR ACTIVITY

Vasiliy Kudlenko, Dmitriy Devyatkin, Yuriy Devyatkin

[*] *Volodymyr Dal East-Ukrainian National University, Lugansk, Ukraine*

Summary The results of the analysis of data on registration of vertical cosmic rays muon flux in equatorial part of the Indian ocean are presented. They testify to the presence of precursors of saltatory variations of muon flux and influencing of solar cosmic rays on the value of this flux. Fig.4, Ref. 8.

Key words: cosmic rays**,** muon flux

INTRODUCTION

Some solar flares are accompanied by emission of a significant amount of protons with different energies that influence on cosmic rays (CR) flux in circumterraneous space. Thus intensity of protons flux with high energy can be sufficient to cause the growth of CR flux even on a surface of the Earth. Such events have received the name GLE (from Ground Level Enhancement). They are fixed basically by neutron monitors that allow watching the integrated CR flux. Muons of CR keep the direction of movement of a primary particle and their registration allows to investigate angular variations of a primary CR flux [3].

The analysis of the data on CR muon flux gives the chance to study variations of a primary CR flux, particular of solar origin, with energies inaccessible to neutron monitors.

In this work the data on variations of a vertical muon flux in an equatorial part of Indian ocean during the high solar activity in 1990 are presented. This data has been received during the ninth expedition of SRS "Academician Nikolay Andreev" when it was checking the hypothesis about influence of CR on acoustic noise of ocean at calm [6]. Some of them have been published [5] without detailed analysis as then the basic attention was given to the results concerning to acoustic variant of project DUMAND.

There were two reasons for the repeated analysis of the data on muon flux fixed in the specified area of the World ocean. Firstly, it is a future realization of the idea about possibility of a prediction of strong magnetic storms on precursor of changes of CR flux registered on a surface of the Earth [1]. Secondly, registration of increasing of

muon flux on a surface of the Earth during the event GLE on December 13th 2006 with a help of unique URAGAN hodoscope [8]. This increasing, according to authors, is caused by narrow beam of the fast component of solar protons.

Before it was considered to know when solar CR arrive to Earth during a magnetic storm so then during the main phase of storm and in the beginning of phase of restoration solar CR get in magnetosphere of the Earth enough deep [7], but there were no any convincing data that it significant affects muon flux on a surface of the Earth. This phenomenon, in our opinion, in the presented results is demonstrated.

EXPERIMENT

Experimental data have been received by means of telescopic installation made from two scintillation detectors. Each detector consists of plastic scintillator with the thickness of 2 sm and the area of 600 sm^2 which is watched by ФЭУ-92 photomultiplier tybe . Scintillators are located one over another vertically on distance 70 sm. It corresponds to muons registration in solid angle approximately 0,5 sr in a vertical direction. Such direction, apparently, was important when measuring in an equatorial part of Indian ocean are made. The discrimination threshold was about 0,66 MeV that corresponds to disappearance of sensitivity of detectors to gamma radiation of Cs^{137} isotope . For more reliable allocation of hard component of CR the layer of lead with the thickness 5 sm settled down between scincillators.

EXPERIMENTAL DATA AND DISCUSSION

We expected registration of a stable muon flux with little changes at the expense of atmospheric processes. Sharp spasmodic changes of muon flux during various time of days were absolutely unexpected. The first such spasmodic variation was fixed on October, 30th, 1990 in area with approximate co-ordinates 5^0 $21^{'}$ N and 81^0 $52^{'}$ E. It was noticed that as disrepair of equipment and its further course (Fig. 1) is unknown. On axis of ordinates muon count rate for 15-minutes interval of measurements is shown, on horizontal axis – local time is shown. It is necessary to pay attention to the precursor before beginning of recession .

One of examples of variations of this kind is presented in Fig. 2. These are the data from the November, 6th, 1990, received in area with approximate co-ordinates 4.5^0 S. and 80^0 E. Axes on this picture are as in Fig. 1.

In total from October 30th till November 8th 1990 variations of this kind in six series of measurements (30/X, 1, 3, 5, 6, and 8/XI) were observed. It is noticed that repeatability in duration of jumps and time of their occurrence was not observed.

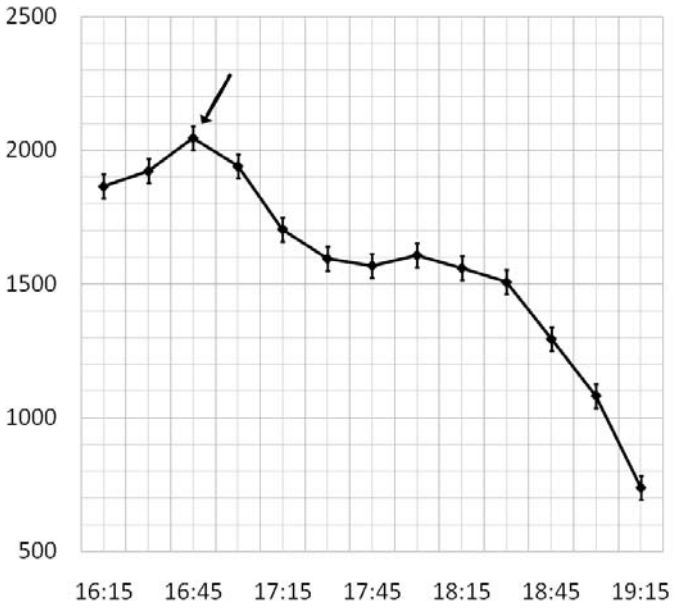

Fig. 1. Count rate of a vertical muon flux on October 30th 1990

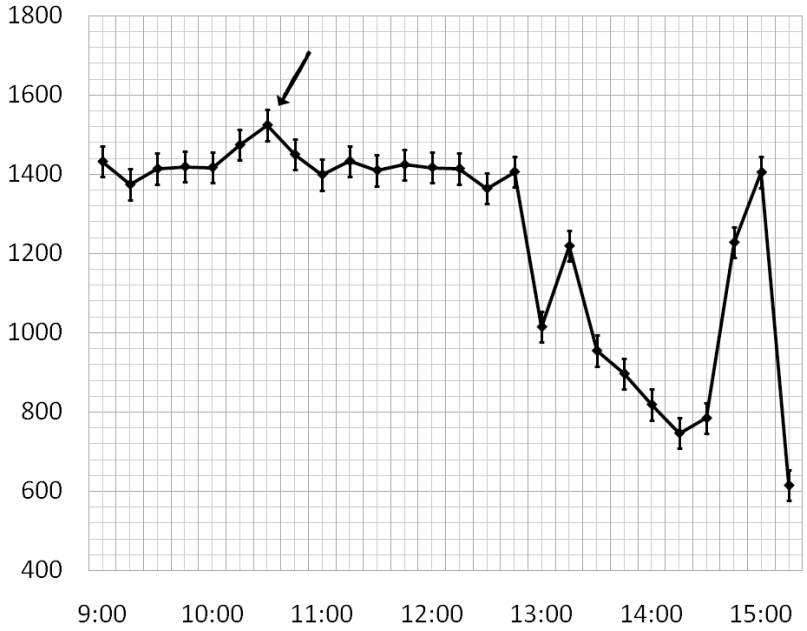

Fig. 2. Count rate of a vertical muon flux on November 6th 1990

If jumps are connected with presence of active areas on the Sun so that, at preservation of these areas, spasmodic variations should be observed again in 27 days. And, really, the following variation of this type was observed on November, 26th in area with approximate co-ordinates 1^0 4' N and 66^0 31' E. In a time course of this variation there was no similarity from a curve from October, 30th. From November, 26th till December, 7th spasmodic variations of muon flux are fixed only in 4 series of measurements. In total during the expidition in Indian ocean in 29 series of measurements since October, 28th till December, 14th, 1990 spasmodic variations of a vertical muon flux are fixed in 10 series. Precursors in the form of small lifting were accurately observed in three series of measurements. They advanced abrupt recession of a vertical muon flux approximately on 2,5 – 3 hours. We expected that through the following 27 days the situation would repeat again, but experimental data testify that further muon flux, fixed by our installation, was constant. This constancy was noted in 33 series of measurements in Red sea, Mediterranean sea and Atlantic ocean.

So, spasmodic variations of a vertical muon flux are fixed only in at equatorial part of Indian ocean. 27 – days interval between the beginning of occurrence of such variations specifies in their connection with active areas on the Sun. It is possible to explain the received results, having assumed that the directed fluxs of solar protons, despite a high geomagnetic threshold at equator, get deeply into atmosphere of the Earth. Variations of this flux lead to variations of a vertical muon flux. As acknowledgement of this there is the data received in area with approximate co-ordinates 6^0 N and 76^0 E. (Fig. 3).

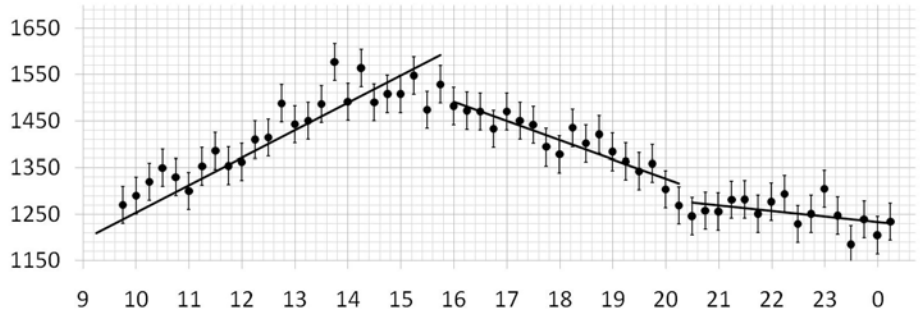

Fig. 3. Count rate of a vertical muon flux in area with co-ordinates 6^0 N and 76^0 E

The growth of vertical muon flux in the first half of a day and recession in the second is noted on it. Such dependences are fixed at clear calm weather. They cannot be explained by air heating as the temperature coefficient, as well as the barometric coefficient, for muon flux is negative. The conclusion that here connection of a vertical muon flux and Sun heights over horizon is demonstrated, looks strange enough. It is possible to explain the obtained data if to assume the presence of anomalies in magnetosphere of the Earth over some areas of Indian ocean.

Since 2000 similar researches were intermittently spent in Lugansk city (48, 6^0 N, 39, 3^0 E). They have been connected with performance of degree works by students

and spent both on telescopic installation and on the detector with scintillator with the thickness of 10 sm [4]. Known connections of cosmic rays muon flux with atmospheric pressure and temperature were observed, also daily and 27 – days variations, but variations with «equatorial» scope have not been fixed.

If talk about muons from high energy SCR, registration of a vertical flux in an equatorial zone when the sun's in zenith, makes sense. If muon flux on a surface of the Earth at high latitudes is connected with solar activity it should change during a solar eclipse. Our data on count rate of a vertical muon flux in solid angle 0,5 sr during such event on March, 29th, 2006 in fig. 4 is presented. The count are recorded every 5 minutes. It is possible to speak about some fall of this flux during the eclipse, despite muon telescope was not direct to the Sun.

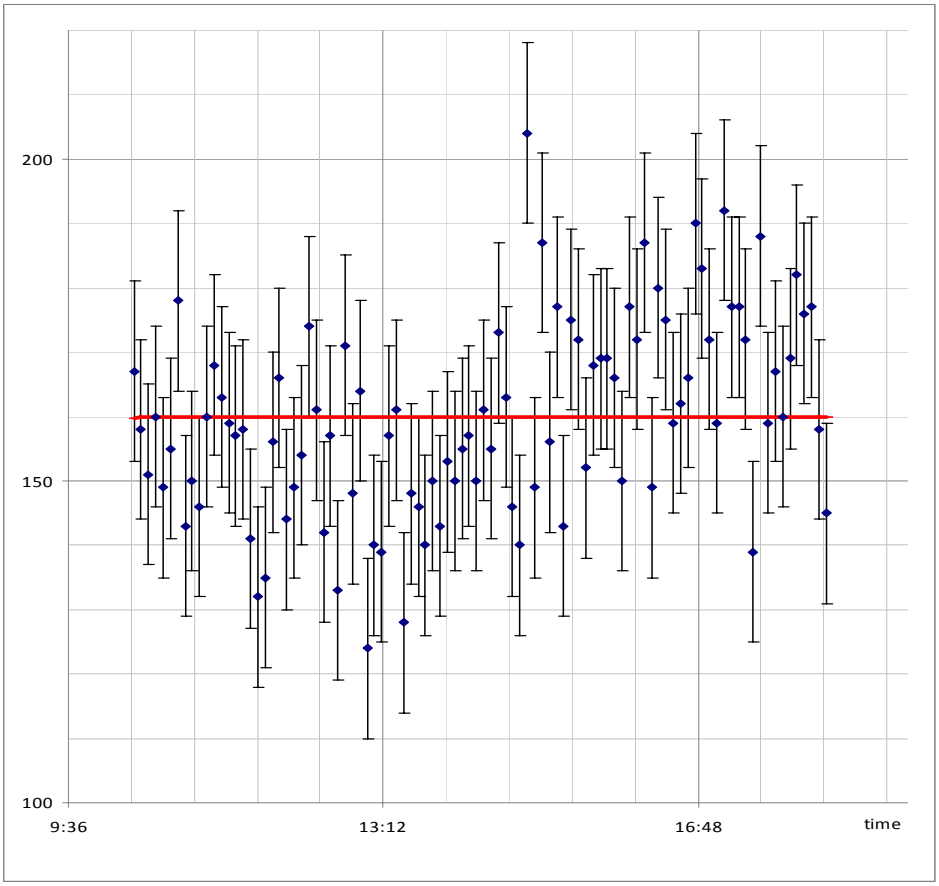

Fig. 4. Count rate of a vertical muon flux March 29th 2006

CONCLUSION

In conclusion we wish to notice that a number of projects of type Ronald Maze [2] for simple muon detectors in network of various educational institutions can play an interesting role in science and education.

REFERENCES

1. Dorman L I. Space weather and dangerous phenomena on the Earth: principles jf great geomagnetic storms forecasting by online cosmic ray date – Annales Geophysicae, 2005, V.23, 2297 – 3002.
2. J. Feder et al. The Roland Maze Project – school-based extensive air shower network – Nucl Phys B – Proc. Suppl., 2006, V151, No1, 430-433.
3. Navia C.E. et al. Is there an enhancement of muons at sea levels from transient events - The Astronomical Journal, 2005, V.621, No2, 1137-1145.
4. Voytenko V.A., Kudlenko V.G., Matsevich S.V. Detector muonov dlya monitoringa atmosfernih processov. – Visnik Shidnoukarainskogo Universitety im. V.Dalya, 2008 №1(59),ч.2, с.191-196.
5. Kudlenko V.G. O kratkovremennih variatsiyah potoka kosmicheskih luchey na yrovne moray. Visnik Shidnoukarainskogo Derzhavnogo Universitety im. V.Dalya, 1998 №3(13), с. 92 – 95.
6. Lyamshev L.M., Furduev A.V., Chelnokov B.I., Yakovlev V.I. Ob odnom mehanizme generatsii podvodnih akusticheskih shumov pri shtile. // Radiatsionnaya akustika. – M.: Nauka, 1987.
7. Myagkova I.N., Bogomolov A.V., Yushkov B.Y., Kudela K. Issledovanie ekstremalnih znacheniy polozheniya granitsi proniknoveniya protonov SKL v magnitosfery Zemli vo vremya magnitnih bur' 2001 – 2005 gg. -30-ya VKKL, Sankt-Peterburg, 2008, sektsiya SKL.
8. Timashkov D.A. i dr. Registratsiya sobitiya GLE 13 decabrya 2006 goda s pomosh'yu muonnogo godoskopa Uragan. – 30-ya VKKL, Sankt-Peterburg, 2008, sektsiya SKL.

ПОТОК МЮОНОВ КОСМИЧЕСКИХ ЛУЧЕЙ НА УРОВНЕ МОРЯ ПРИ ПОВЫШЕННОЙ СОЛНЕЧНОЙ АКТИВНОСТИ

Кудленко В.Г., Девяткин Д.С., Девяткин Ю.С.

Аннотация. Приведены результаты анализа данных по регистрации вертикального потока мюонов космического излучения в экваториальной части Индийского океана. Они свидетельствуют о наличии предвестников скачкообразных вариаций потока мюонов и влиянии СКЛ на величину этого потока.

Ключевые слова: поток мюонов, космические лучи, вариации, измерение.