29th International Cosmic Ray Conference Pune (2005) **1**, 205-208

Increase of the Solar Energetic Particle Flux on January 20, 2005

V.E. Timofeev[a], P.A. Krivoshapkin[a], V.G. Grigoryev[a], A.N. Prihodko[a],
V.M. Migunov[a] and A.T. Filippov[b]
(a) Yu.G. Shafer Institute of Cosmophysical Research and Aeronomy, 31 Lenin Ave., 677980, Yakutsk, Russia
(b) Physical-Technical Institute of M.K Ammosov Yakutsk State University,48 Kulakovsky Street,677007 Yakutsk, Russia
Presenter: V. Timofeev (vetimofeev@ikfi.ysn.ru), rus-timofeev-V-abs2-sh15-poster

Peculiarities of the increase of $E > 1$ GeV particle flux with during on the solar flare on January 20, 2005 are studied. The amplitude of increase (~130% by the Yakutsk data) is comparable with the events on May 7, 1978 it constitutes $E > 1$ GeV and on September 29, 1989 but it has the steeper energy spectrum. In this event the extreme anisotropy of particle flow has two peaks in the intensity maximum as in the case May $E > 1$ GeV 7 1978. On the basis of preliminary analysis of data one can explain the observed peculiarity of the event by two ways. Firstly, the anisotropy of particle intensity can be a consequence of collimation of particle flux in IMF magnetic inhomogeneties carried away by the solar wind. Secondly, such a behavior of intensity in maximum is caused by the peculiarity of particle acceleration source in the solar flare itself.

1. Introduction

At the end of October and at the beginning of November, 2003 three powerful chromospheres flares took place near the minimum of their activity on the Sun [1]. Those flares were accompanied by the increase of intensity of energetic particles at the level of the Earth and magnetic storms in 1,5÷2 days after the solar flares. The cosmic ray solar flares with $E > 1$ GeV on October 28, 29 and November 2 were registered by the Tixie and Yakutsk stations. Such solar flares repeated many times with the generation of relativistic particles are observed extremely seldom, there were only few similar events for 50 years of continuous observations by data of cosmic ray stations.

Practically in the minimum of activity on January 20, 2005 on the Sun the powerful flare with a generation of energetic particles has taken place suddenly. In value of the increase of solar cosmic rays it enters into the ten of the largest events of energetic particles of solar origin .

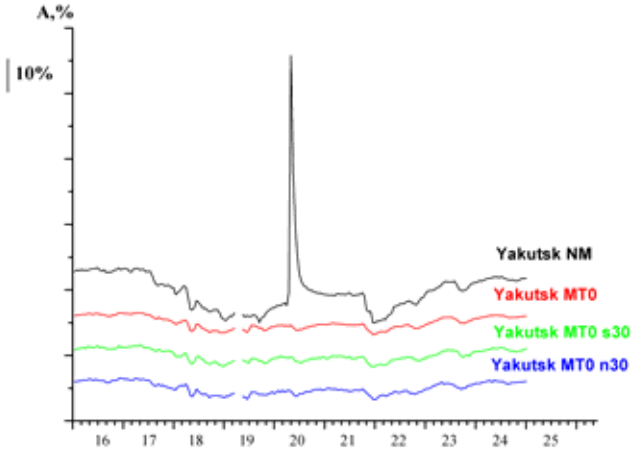

Figure 1. Variations of cosmic ray intensity of January 1, 2005 by data of the Yakutsk array complex.

It is known that solar flares take place on the branches of increase and decrease of the 11-Year solar activity cycle. The events, which have taken place recently, show that this regularity is not always kept.

Below main characteristics of the increase of energetic particles on January 20, 2005 are given briefly by data of neutron monitors of Tixie and Yakutsk enlisting the world network station data, direct measurement of solar flares and interplanetary magnetic field (IMF). An explanation of the observed peculiarities of the present event is given.

2. Results

As the direct measurements show a series of large chromospheric flares on the Sun with coordinates 65° - 67° W [2] was observed between 0600 and 0700 UT on January 20, 2005. At 0636 UT the Earth-orbital satellites have registered the bursts in X-ray radiation, then the arrival of in the energy range of $10 \leq E \leq 400$ MeV has been observed almost immediately. The index of energetic spectrum has been very rigid with the index 2,15÷2,18. As opposed to low energies, the increase of energetic particles with $E > 1$ GeV has a soft spectrum. As seen from Fig. 1, this event is not practically observed at sea level by data of muon telescopes at the Yakutsk station. The Fig. 2 presents the 5-min data of neutron supermonitors of Tixie and Yakutsk stations. As seen from the Figure the increase has begun at the Tixie station at 0655 UT, at the Yakutsk station at 0650 UT with the value of increase of energetic particles 85% and 63%, respectively. By one-minute registration data of the Apatity station the increase of energetic has the value of 200%.

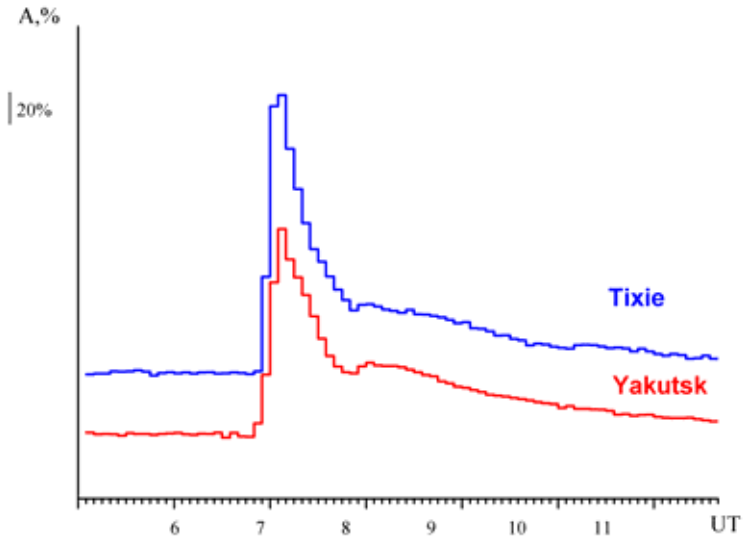

Figure 2. Temporal change of solar cosmic rays by 5-min data of cosmic ray stations of Tixie and Yakutsk.

It should be noted that the energetic particle flux has reached its maximum during 10 min that it is extremely seldom for such events. If we analyze the one-minute data of the South Pole station. Mc Murdo station and the Newark station, the increase up to the maximum has lasted only 5-6 minutes. Moreover, by data of some stations (see Fig. 3 the increase peak has a thin structure with two maxim between 0650 and 0710 UT. The

first maximum is greater in amplitude, than the second one by data of some stations and, vice versa, by data of other stations. Thus, the solar cosmic ray flare by data of the ground stations has, besides a great amplitude, other two peculiarities: firstly, it is the extremely fast increase up to the intensity maximum and the decrease after the first maximum and, secondly, the double maximum of this increase of energetic particles. These two peculiarities of the given event don't allow to describe it by the model of anisotropy diffusion [3, 4] as a indivisible event. Such an extremely anisotropic flux of relativistic particles from the solar bursts for the whole observation period has been registered only during the events on November 18, 1960, May 3, 1978 and September 29, 1989.

3. Discussion of results

Thus, this raises the question of explanation of such unusual behavior of the flux of the observed particles from the solar burst of January 20, 2005. The application of anisotropic diffusion model [4] to the first maximum by data of the Mc Murdo station for determination of particle injection time on the Sun gives the meaning t = 0636 UT. In this case the time of particle propagation from the source up to the Earth is 12÷16 minutes that is fully acceptable for the relativistic particles from the source with the west longitudinal coordinates. The time of injection for the second increase by data of the Newark and New week gives the meaning t = 0643 UT. This, as we consider, demonstrates either the repeated particle acceleration or to the second source of energetic particles. It counts in favour of this version that the decrease of intensity also takes place by two power laws (see Fig. 3). Thus, one can explain two maxima of the particle flux by the

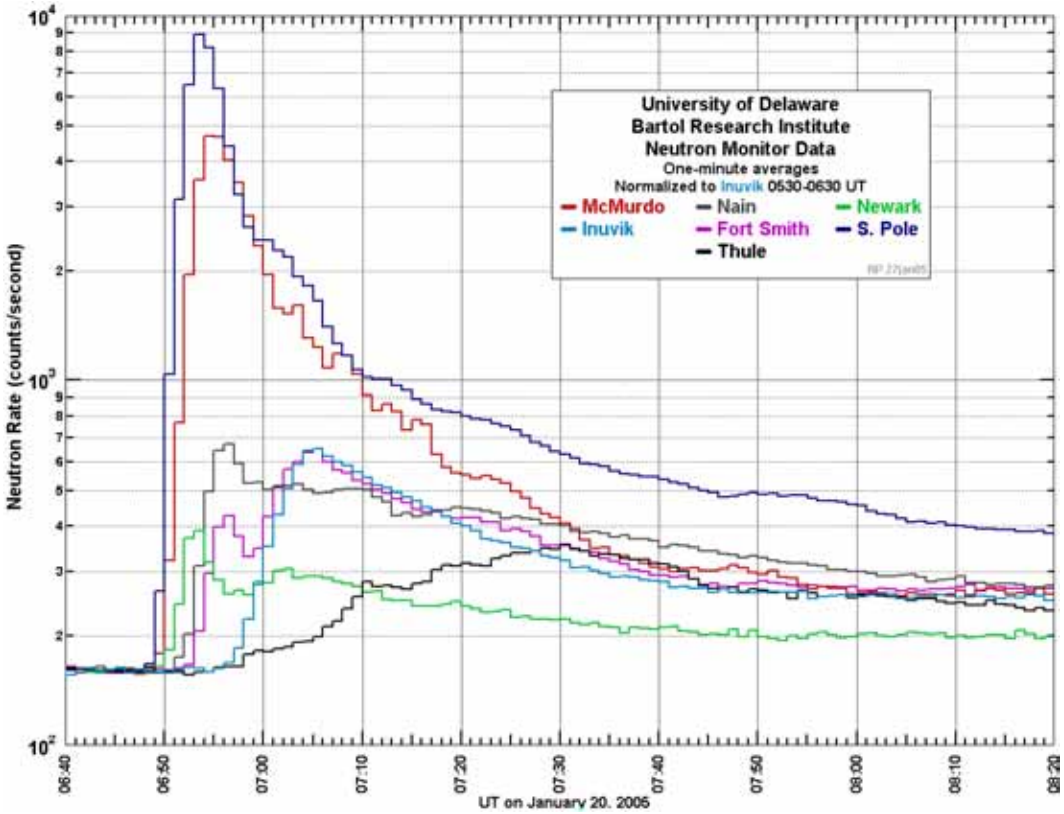

Figure 3. Temporal change of solar cosmic rays by 1-min data from the world network stations of Mc Murdo, Fort Smith, Newark.

superposition of temporal intensity profiles from two sources or the solar flarehas generated energetic particles twice. The observations on the Sun show that at that time the significant chromospheric bursts in H_α and soft X-ray in the region of N 4270 with coordinates (N 12°, W 58°) with the onset at 0635, 0639 and 0641 UT.

One of the alternative explanation of unusual anisotropy of the energetic particle flux is the fact that cosmic ray stations on the Earth observe the collimated particle beam in IMF which, in turn, oscillate with a definite frequency. But the absence of complete data of IMF does not allow to assert unambiguously in favour of such an explanation.

4. Conclusions

On the basis of preliminary analysis of peculiarities the of energetic particle flare of January 20, 2005 one can conclude the following:

1. The source of energetic particles is a solar flare with western longitudinal coordinates.
2. The increase of particles in maximum has two pronounced peaks of the intensity.
3. The observed event can be explained either as a superposition of two sources of generation of fast particles or by a double generation of energetic particles in one active region.

5. Acknowledgements

The work was partly supported by RFBR (grants 03-02-96026 and 05-02-16954) and by the support programmer of leading scientific schools of RF (grants 422.2003.2).

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