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A possible GLE event in association with solar flare on January 20, 2005

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A GLE event associated with a x7.1/2b solar flare at 06:36UT on January 20, 2005 was detected by solar neutron telescope located in Yangbajing Cosmic Ray Observatory, Tibet (90.53°E, 30.11°N, 4300m a.s.l.). The statistical significance excess of the signal was 6.0σ during 07:00-07:20UT recorded by energy channel ch1 (E>40MeV) of solar neutron telescope, but there was no clear statistical significance excess from energy channel ch2(E> 80MeV), ch3(E> 120MeV) and ch4 (E>160MeV), also no statistical significance excess from solar direction.

1. Introduction

The study of the solar particle acceleration mechanism at high energies is an important subject, but beyond 10GeV, few data exist demonstrating acceleration of protons or ions. Yangbajing internation cosmic ray obsrvationa, Tibet is one of the best stations in the world for observation solar particles. Solar neutron telescope, Tibet can detect not only neutrons in a wide energy, but also high energetic protons due to the high geomagnetic cutoff rigidity at Yangbaing (geomagnetic vertical cutoff rigidity is 14.1GV). Using the IGRF95 model Storini et.al have calculated the geomagnetic cutoff rigidity at Yangbajing with pitch angle, and the energetic particles beyond 20 GeV can arrive at regardless of their pitch angles[1]. Solar neutron telescope installed here consists of 9 m^2 scintillation counters and four arrays of proportional counters which identify the incoming direction of neutrons[2][3][8] , and has been in normal performance since October 1998.

2. Flare of January 20, 2005

On January 20, 2005, a solar X-ray flare (x7.1/2b) at solar active region 10720 was observed by GOES 12(W75) and GOES 10(W135) at 06:36UT, peaked at 07:01UT about 25 minutes since onset time, and ended at 07:26UT. Its optical heliographic coordinates was N12W58. The $>$100MeV protons peaked at 652 pfu at 07:10UT measured by GOES11(W107), which was the highest $>$100MeV proton flux level observed since October 1989, and ended at 18:45UT on January 21. A GLE event was recorded by many neutron monitors. There was a large 8,400 sfu Tenflare, Type II (712 km/s) radio emission at 06:44UT and Type IV radio sweeps at 06:43UT accompanying with this flare. An associated CME was observed off the NW limb. A strong shock was observed at ACE after about 23 hours. Solar wind speed also rose quickly to a maximum of 987 km/s at 19:26UT on January 21, 2005. Total IMF field intensity rapidly increased to 38 nT [4]. During this flare, SOHO also observed that X-ray and proton flux increased rapidly. Integral Satellite was at the nightside, but RHESSI observed that the γ($>$1MeV)ray flux from the sun increased at 06:42UT.

From 06:36UT to 07:26UT, the sun was over Tibet. The altitude of the Yangbajing Cosmic Ray Observatory is 4300m a.s.l., and the vertical air mass is 600g/cm^2 [5]. At that time, the zenith of the sun was $\sim$52°-$\sim$53°, and the air mass for the line of sight to the sun was 997g/cm^2. But for the refraction effect of solar neutron caused by the diffraction process between neutron and nuclei in the air [7], the path length of the neutron from the sun to the earth surface at Yangbajing was about 747g/cm^2, which was shorter than expected[8].

3. Analysis and Discussion

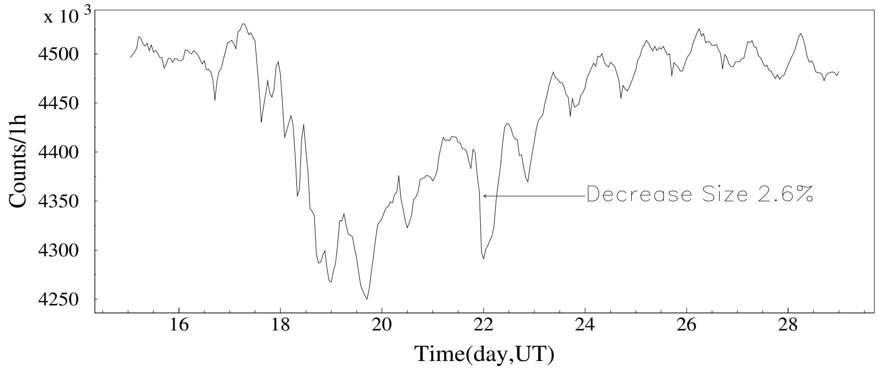

Figure 1.

Solar activity was very intense between January 17, 2005 and January 23, 2005[4], figure 1. presents an overview of cosmic ray intensity recorded by our solar neutron telescope during this period. a weak and sharp peak on January 20 and a Forbush Decrease of $\sim$ 5 hour duration on January 21 were observed, which were associated with the solar flare of Jan. 20 2005 . Figure 2. shows the analysis results on this peak with our solar neutron telescope data.

As shown in Figure 2., a clear excess of ch1(E>40MeV) was found between 7:00-07:05UT in 5-minute data, and the corresponding statistical significance excess is 3.7σ, total is 6.0σ in 20 minutes between 07:00-07:20UT. But significance excess of ch2(E >80MeV), ch3(E >120MeV), ch4(E>160MeV) was in the same level with the background during the 07:00 - 07:20UT. Supposing that detected neutrons were from the sun associated to the onset time of this X7.1/2B solar flare, according to the onset time of X-ray flare, γ ray, Type II radio emission and Type IV radio emission, we can assume that the acceleration time of the ion was between 06:28UT and 06:35UT.the neutron was produced through the interaction between proton and neuclei(H,He,C,O,H,He)in solar atmosphere, or thorough the break up of ^{4}He having a binding energy $\sim$28MeV [6]. From ch1, the detected time of the neutrons by solar neutron telescope was between 07:00UT and 07:20UT, the flight time from the sun to the earth was 25 minutes - 52 minutes.the kinetic energy of neutron estimated was about 12 MeV - 57 MeV. Such low-energy neutron would decay in the interplanetary space and be attenuated in the air before arriving at the surface at Yangbajing.the signal of ch1 detected by solar neutron telescope was not from the solar neutrons.

The data of solar neutron telescope are also analyzed according to the incidence direction. Considering the sun's position, the refraction effect with neutron, and decreasing background from galactic cosmic rays, we choose the south 6 directions (corresponding channel: X1Y4,X0Y4,X2Y4,X1Y6,X0Y6,X2Y6)to represent the solar direction, the north 6 directions (corresponding channel: X1Y3,X0Y3,X2Y3,X1Y5,X0Y5,X2Y5) to represent the anti-solar direction. The results are shown in the bottom panel of Figure 2.. 1.1σ excess was observed from the south between 07:05 and 07:10, there was no other clear excess from 07:00 to 07:20UT. And a -0.6σ decrease was seen from the north direction between 07:05 and 07:10UT, but the statistical excess was less at the interval 07:00-07:05UT. there was not clear statistical difference between south and north direction from 07:00 to 07:20UT. solar neutron telescope didn't detect the higher energetic solar neutrons during this solar flare.

4. Conclusion

The solar proton event(E >100MeV) associated with the flare of January 20, 2005 recorded by GOES-11 and SOHO satellite showed most hardest spectrum among their records. Following this many neutron monitors

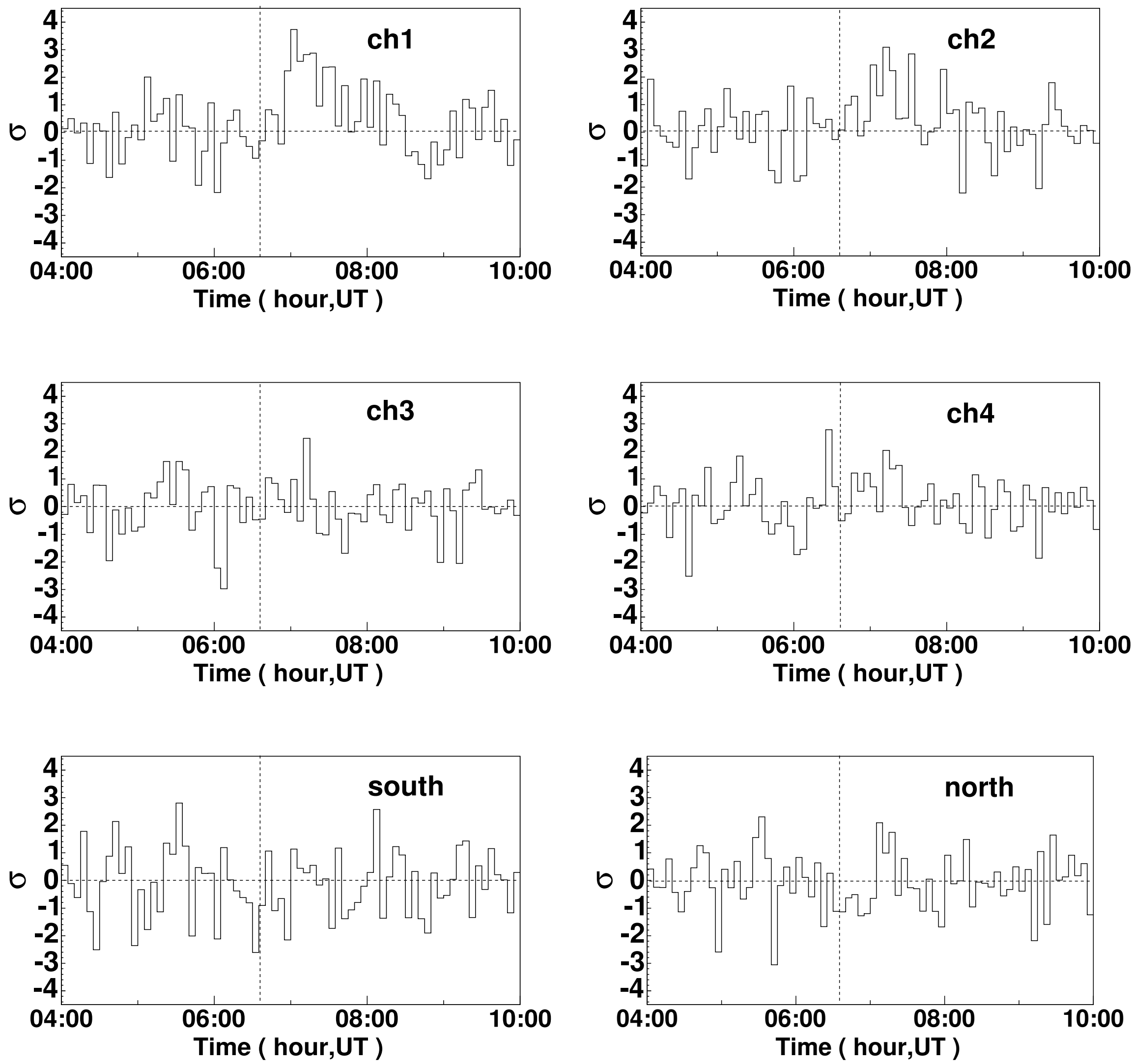

Figure 2. The results of 4 channels and 2 directions are shown. Data are corrected by pressure and temperature. The backgrounds are fitted with data in 04:00 - 06:30UT and 08:30 - 10:00UT. The vertical axes represent the statistical significance excess $\sigma \equiv (C - B)/\sqrt{B}$ and horizontal scales are divided every 5 minutes per step, C presents the counts in 5 minutes and B is corresponding background fitted. The dashed line shows the onset time of this x-ray solar flare.

in the world had an intense increase of counting rate above the background . One of them is Inuvik neutron monitor(68.4°N, 133.7°W), and the peak time recorded 07:04-07:05UT on January 20, 2005 was at night of Inuvik local time. Fort Smith neutron monitor(60.02°N, 111.93°W) also detected this at its night of local time[9]. charged particles can be altered their directions by interplanetary field(IMF)and geomagnetic field, and have probability to get the earth at night of the local time. so this solar proton event is a ground level events(GLE)[10], signal detected at 07:00 UT -07:20UT by our solar neutron telescope was probably caused by solar energetic protons associated with this GLE event.

Yangbajing, Tibet neutron monitor is one of the stations of the worldwide neutron monitor network. It also detected this GLE event[11]. The analysis result was shown in Fig.3. The signal has the same peak time interval in 07:00-07:05UT, and also has a longer duration. This also confirms the solar neutron telescope, Tibet detected this GLE event.

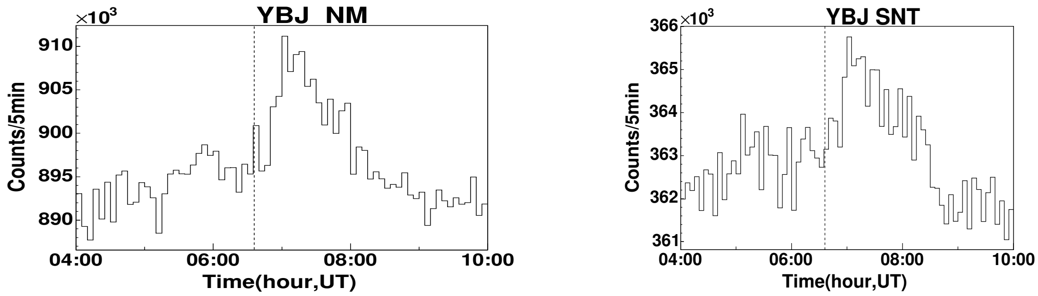

Figure 3. left panel:counting rates of neutron monitor.right panel:counting rates of ch1(E>40MeV) of neutron telescope.vertical dashed line shows the onset time observed of this solar flare

The geomagnetic vertical cutoff rigidity at Yangbajing,Tibet is 14.1GV. To detect by our neutron detectors (including neutron monitor and neutron telescope), energy of primary protons has to be higher than this . This is very important to study the solar ion acceleration mechanism, and also important to study the solar energy up limit.further study will be done on this GLE using solar neutron telescope.

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