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Recent status of YBJ neutron monitor observation

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Abstract. The Japan-China international solar neutron observation program at Yangbajing (30.11N 90.53E, 4300m), Tibet has been started in October 1998. 28 NM-64 counters were installed and the single counts and multiplicities from one to eight counts are recorded for every second. Now we have more than 2 and a half-year data for October 1998 to April 2001.Recently we have observed a large Forbush decease related to the solar flare series occurred at April 2001. We also searched for a possible solar neutron signal using our data and the GOSE X-ray data but we could not find any significant signal during this period.

1 Introduction

After nearly 30 years continuous solar neutron observation at Itabashi, Tokyo, totally 28 NM-64 counters were transported to Yangbajing (YBJ) on September 1998 (Kohno, 1999). This was held as part of Japan-China international cosmic ray observation program. The stable continuous data taking has started since October 1998 and working through the solar maximum phase.

The observation of solar neutrons produced by solar flares provides us the information of flare process and the ions acceleration mechanisms. Although to observe solar neutron at the ground base station has a grate difficulty because these event are rare and transient.

Here we will report about the search for the solar neutron events observed at YBJ NM during the period of 1999 to 2001.

2 Observation

The location of the YBJ neutron monitor (NM) station is at Yangbajing International Cosmic Ray Observatory (30.11°N 90.53°E, 4300m above sea level, cutoff rigidity 14.1GV).

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Altitude (m)	4300
Latitude	30.11N
Longitude	90.53E
Number of counters	28
Cutoff regidity (GV)	14.1
Atomospheric pressure (hPa)	606
	Barometric Coefficient (%/hPa)
Single	-0.70 ± 0.01
Multiplicity 1	-0.49 ± 0.01
Multiplicity 2	-0.74 ± 0.01
Multiplicity 3	-0.86 ± 0.01
Multiplicity 4	-0.92 ± 0.01
Multiplicity 5	-0.94 ± 0.01
Multiplicity 6	-0.95 ± 0.01
Multiplicity 7	-0.95 ± 0.01
Multiplicity 8	-0.97 ± 0.01

Table 1. YBJ neutron monitor general features and the barometric pressure coefficient (%/hPa) for single and multiplicity 1 to 8. The correlation coefficient of barometric pressure coefficient were 0.99 for all channels.

The observation system consists of 28 NM-64 neutron counters (BP28 produced by Chalk River) and records the single counts and multiplicity 1 to 8 from each two adjacent counters. These are summarized in Table 1 together with the barometric pressure coefficient for all channels from single to multiplicity 8.

Pressure collection had been done to the raw data by these coefficient and the count rate of the single was 1.07×10^7 counts/hour and the average multiplicity was 1.6.

As YBJ NM station is located at high altitude (4300m) and low the latitude (30°), we can expect a high efficiency to observe a solar neutron. To say efficiency as the ratio of intensity of neutrons originating from a solar flare to cosmic ray background (S/N) will be 17 times higher than Tokyo station and 3 times higher than Mt.Norikura station.

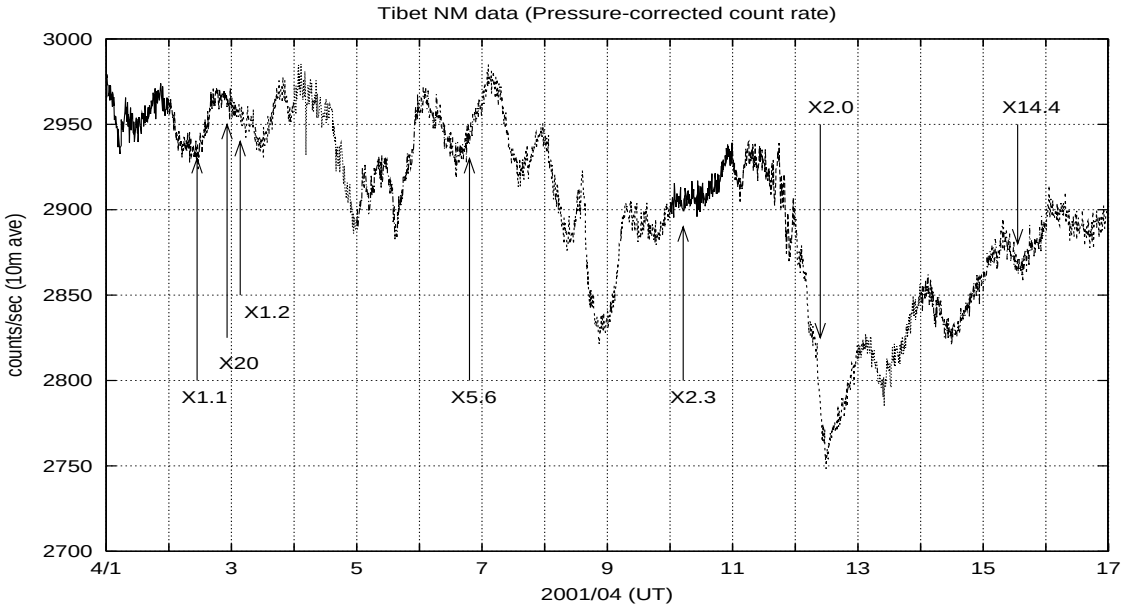

Fig. 1. YBJ NM count rate variation in April 2001. Pressure corrected 10 minute averaged count rate are shown. The figure also shows the onset of X-ray event correspond to the GOSE data.

3 Solar flare

During our observation, X- and M- class solar flare has occurred several times. If the YBJ NM is in the right position toward the sun and the solar neutron has enough high intensity, some excess may observe from the NM.

Recently sun has produced the large flare (X- and M- class) series in April 2001. Figure 1 shows the counts rate (counts per seconds ; 10 minute average) of the YBJ NM. The figure also shows the onset of X-ray event correspond to the GOSE data. As figure shows, we have observed large Forbush decease (about 4 %) related to this solar flare series.

We do not find any significant GLEs in this period where some other high latitude NM station has observed at April 15th.

3.1 Two X-class flares

Since 1999, two X-class flares have occurred when the YBJ NM station was noon. One of this event occurred during a large flare series at April 2001 as describe above. The time and the size of flare were November 24th 2000 04:55 UT with X2.0 and April 10th 2001 05:06 UT with X2.3 respectively.

Figure 2 shows the time variation of YBJ NM 3-minute counts rate during those solar flares. Variations are obtained by 1 hour ($\pm$ 30 minute) moving averages. The vertical solid line shown in the figure is onset of X-ray events.

As figure shows we do not find any significant signal from those data.

3.2 Search for solar neutrons

For the next step, we choose the flares grater than M3, which occurred during 4:00 (UT) to 8:00 (UT). This time correspond to $\pm$ 2 hour around noon at geographical local time in Tibet. In this case we have 10 events during our observation period (January 1999 - April 2001). These events are summarized in Table 2.

	Flare onset	Size and importance
1	4 Jun 1999 06:52	M3.9/2B
2	2 Jun 2000 06:52	M4.1/1N
3	9 Jul 2000 07:15	M5.7/1N
4	19 Jul 2000 06:45	M6.4/3N
5	25 Jul 2000 04:40	M3.7/2N
6	16 Sep 2000 04:06	M5.9/2B
7	1 Oct 2000 06:23	M5.0/–
8	24 Nov 2000 04:55	X2.0/3B
9	10 Mar 2001 04:00	M6.7/1B
10	10 Apr 2001 05:06	X2.3/3B

Table 2. Solar flare events occurred at the noon of YBJ NM station during 1999 - 2001. This table shows the onset time of X-ray flare, size and importance.

For all of these flares, we calculated the time variation of the 3-minute counts rate obtained by 1-hour ($\pm$ 30 minute)

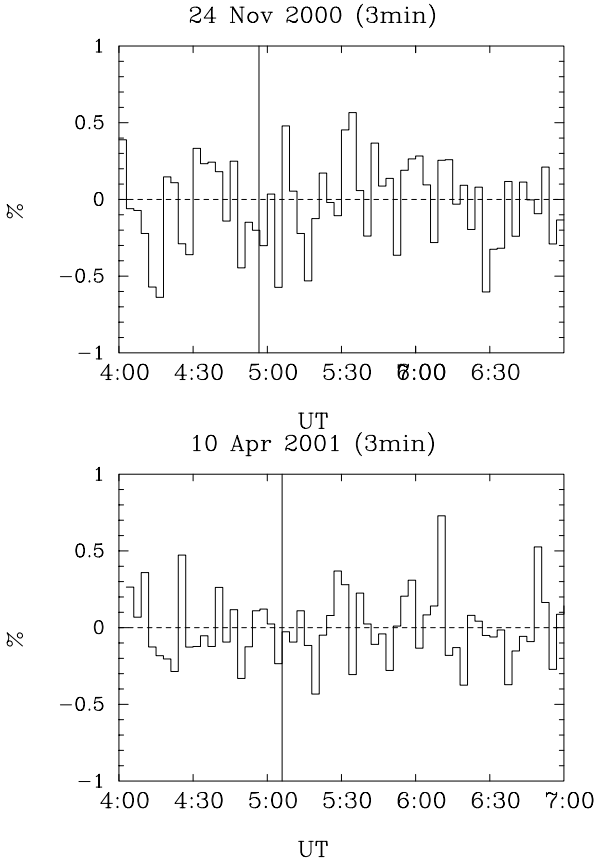

Fig. 2. Solar flare event occurred at 24 Nov 2000 04:55 UT with X2.0 (Top panel) and 10 Apr 2001 05:06 UT with X2.3 (Bottom panel). NM variation shows the 3-mimute counts rate obtained by 1-hour moving average. The vertical solid represent the onset of X-ray event.

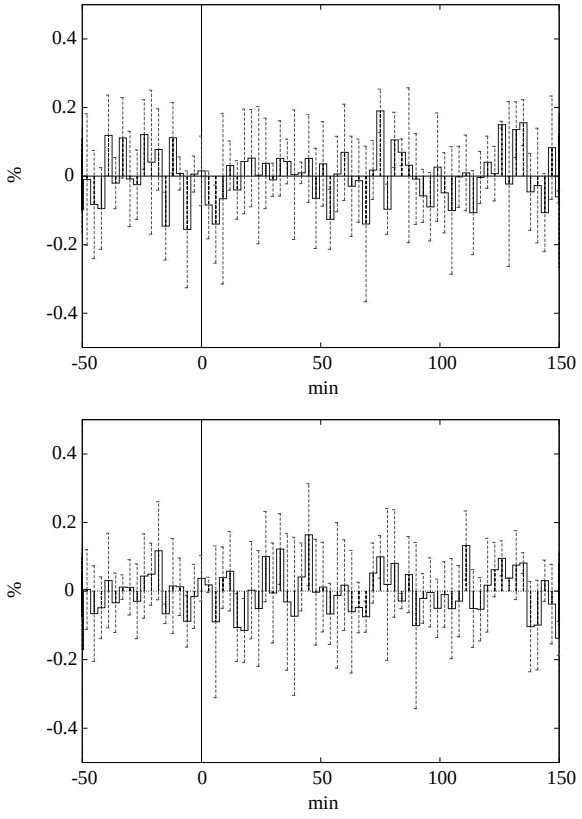

Fig. 3. Mean variation of YBJ NM corresponds to the possible solar neutron event. (Top panel) Single counters count rate and (Bottom panel) the Multiplicity 1 count rate are shown. Variations are shown in minute which the zero represent the onset of X-ray event.

moving average around the flare onset time.

The time stamp of all these data are replaced it based on the onset time of X-ray event and average over all these data set. (e.g. Takahashi et al. 1987, Aushev et al. 1999)

At the top of figure 3 shows the result of mean variation of single counters corresponds to the possible solar neutron event. The errors are the standard deviation. A same procedure has carry out to the Multiplicity data. At the bottom of the figure 3 shows the mean variation of Multiplicity 1.

Even by this method, we could not find any significant signal from our NM. Note that all data are pressure corrected but we have not remove the effect of the GLEs and Forbush decreases.

4 Summary

We have searched a solar neutron signal from YBJ NM but unfortunately we could not find any significant signal. Since this analysis, we did not remove the effect of GLEs and Forbush decreases as described above, we also did not consider for the gamma-ray fluxes and flare region at the sun. To give more precise result we may have to take it account of these effects.

For the summary, YBJ NM station has working for more than 2 and a half-year. During this period we have not observed the significant solar neutron event but related to the solar flares, we have observed four large Forbush decrease event which were grater than 4 %.

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