SH.1.3.08

A Program of Solar Neutron Observation with NM-64 Counters at Yangbajing in Tibet

T. Kohno[1], H. Miyasaka[1], M. Matsuoka[1], Y. Yamada[1], S. Shimoda[1], K. Takahashi[1], E. Sakamoto[1], K. Munakata[2], T. Yuda[3], L.K. Ding[4], Y.H. Tan[4], C.S. Zhang[4], Z.Z. Shi[4], H. Wang[4], H.W. Guo[5], X.R. Meng[5], H.Y. Jia[6], J. Mu[7], and N.J. Zhang[8]

[1]*Institute of Physical and Chemical Research(RIKEN), Saitama 351-0198,Japan*
[2]*Department of Physics, Shinshu University, Nagano 390-8621, Japan*
[3]*Institute for Cosmic Ray Research, The University of Tokyo, Tokyo 188-8502, Japan*
[4]*Institute of High Energy Physics, Academia Sinica, Beijing 100039, China*
[5]*Department of Mathematics and Physics, Tibet University, Chengdu 610031, China*
[6]*Department of Physics, South West Jiaotong University, Chengdu 610031, China*
[7]*Department of Physics, Yunnan University, Kunming 650091, China*
[8]*Department of Physics, Shandong University, Jinan 250100, China.*

Abstract

We started the Japan-China international solar neutron observation program at Yangbajing (30.11N 90.53E, 4300m), Tibet. 28 NM-64 counters were installed and the single counts and multiplicities from one to eight for every two adjacent counters are recorded for every second. The mean atmospheric pressure is about 602 hPa and the cosmic ray vertical cut off rigidity is about 14.1 GV. The stable continuous data taking has started on mid October 1998. We got the tentative atmospheric pressure coefficient and obtained counting rate were -0.70 %/hPa and 1.07×10^7 counts/hour. In the current available data of only 5 months' duration, we cannot find apparent 'solar neutron event' yet.

1 Introduction:

After nearly 30 years continuous solar neutron observation at Itabashi (e.g. Takahashi, 1987), Tokyo, totally 28 NM-64 counters were transported to Yangbajing on September 1998. This was held as part of Japan-China international cosmic ray observation program. We have reconstructed this system and tuned up with new electronics. Here we will report about our neutron monitor system and summary of data that we have obtained for 5 months from October 1998 to February 1999.

2 Observation:

The location of the Yangbajing neutron monitor station is at Yangbajing International Cosmic Ray Observatory (30.11°N 90.53°E, 4300m above sea level) which are summarized in Table 1 together with Mt.Norikura and Tokyo station. Table 1 also shows the number of counters, cutoff rigidities and atmospheric pressure (hPa) respectively for each station.

Table 1: Neutron monitor location

	Altitdue (m)	Latitude	Longitude	No. of counters	Cutoff (GV)	Atmospheric pressure (hPa)
Yangbajing	4300	30.11N	90.53E	28	14.1	606*
Mt.Norikura	2700	36.11N	137.55E	12	11.36	730
Tokyo	20	35.75N	139.72E	28	11.61	1034

*From the Tibet air shower group.(e.g. M. Amenomori, 1992)

The observation system consists of 28 NM-64 neutron counters (BP28 produced by Chalk River) and record the single counts and multiplicity 1 to 8 from each two adjacent counters. Figure 1 shows the block diagram of counter system. Each signal from the NM-64 neutron counter, which comes throughout over the discriminator, will be shaped to 500ns-pulse width and input to the each scaler. The gate time for making multiplicity is 1ms. The ’time’ system was all controlled by GPS (Global Positioning System) time standard and the data will store into computer every second. The barometric pressure and room temperature are also measured and included in the data set.

Figure 2 shows the example of the measured intensity (counts/hour) and pressure (hPa) variations at January 1999. The average pressure was 602 hPa for the period of October 1998 to February 1999.

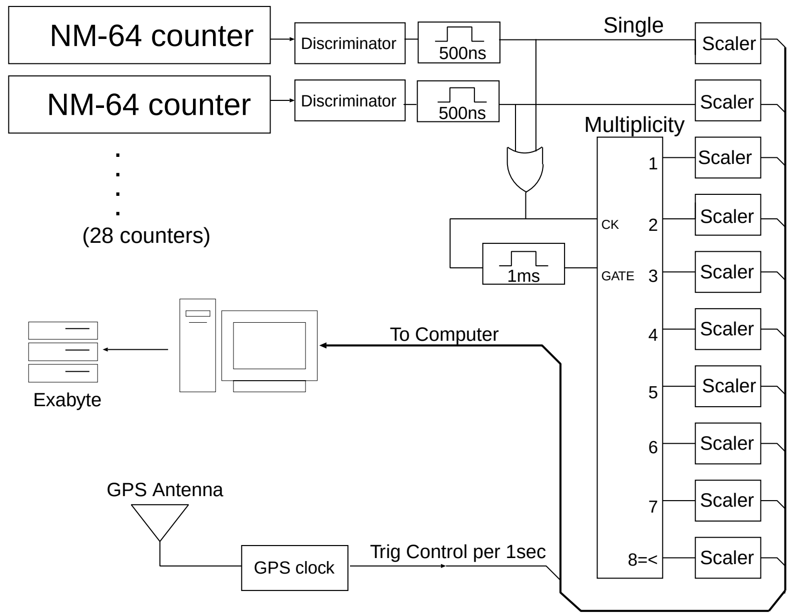

Figure 1: Block diagram of counter system for data acquisition.

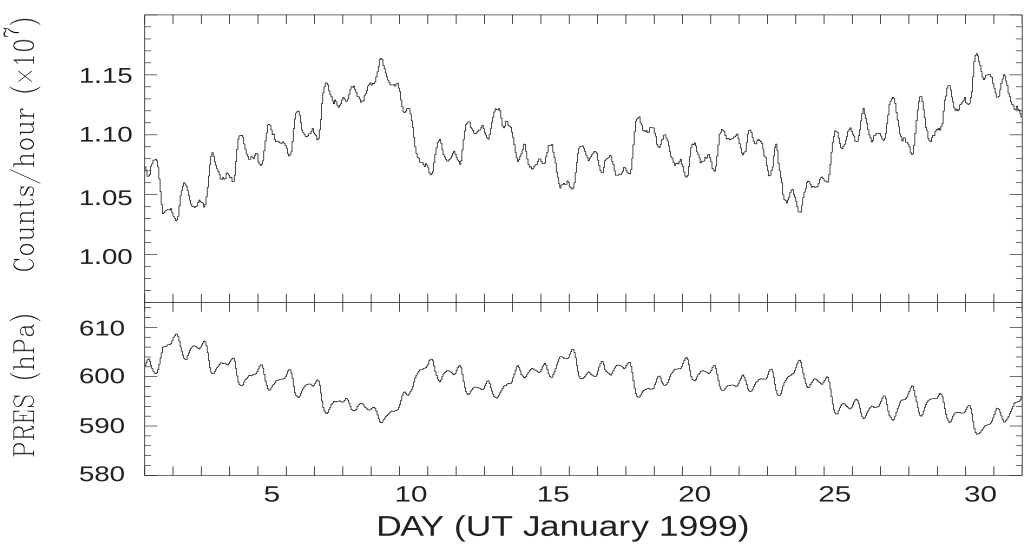

Figure 2: (top) Example of the measured intensity variations (counts/hour) during January 1999. (bottom) The pressure (hPa) variation are also shown.

3 Preliminary analysis:

The continuous observation has started on October 1998. The pressure coefficient (%/hPa) was estimated from the correlation between cosmic ray intensity and barometric pressure. Instead of using whole observation period, we have chosen the data during January 1st 1999 to 11th, which have changed the pressure most largely in short time.

Figure 3 shows the correlation diagram for single counter with hourly counts variation from average intensity (%) vs. pressure variation from average pressure. Average pressure had been used as 606 hPa instead of 602 hPa of our result because of short observation period. The figure also shows the chi-square fit of the correlation. The barometric pressure coefficient was -0.70 $\pm$ 0.01 (%/hPa) with correlation coefficient of -0.99. Table 2 listed 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.

	Barometric Coefficient (%/hPa)
Single	-0.70 $\pm$ 0.01
Multiplicity 1	-0.49 $\pm$ 0.01
Multiplicity 2	-0.74 $\pm$ 0.01
Multiplicity 3	-0.86 $\pm$ 0.01
Multiplicity 4	-0.92 $\pm$ 0.01
Multiplicity 5	-0.94 $\pm$ 0.01
Multiplicity 6	-0.95 $\pm$ 0.01
Multiplicity 7	-0.95 $\pm$ 0.01
Multiplicity 8	-0.97 $\pm$ 0.01

Table 2: Barometric pressure coefficient (%/hPa) for single and multiplicity 1 to 8. The correlation coefficient were -0.99 for all channels.

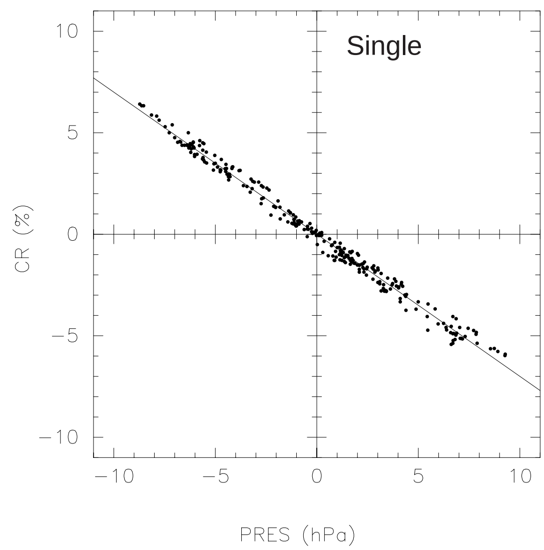

Figure 3: Correlation diagram of hourly intensities vs. barometric pressures. The barometric coefficient was -0.70 $\pm$ 0.01 (%/hPa) and the correlation coefficient was -0.99.

4 Solar flare event:

After our neutron monitor has started the continuous observation, the solar flares occurred in November 23rd and 28th. These flares were near noon at local Tibet time and good condition for observe of these events. The flare size were X=2.2 and X=3.3 and the acceleration time of ions were assumed to be at $6^h35^m30^s$ and $5^h32^m30^s$ in Universal time (Hoshida et al., 1999) respectively. The top panels of figure 4 shows the time profiles of pressure corrected count for November 23rd at the left side and the same profiles of November 28th at the right side. The figure also shows the statistical significance at the each bottom panels. These are estimated by $\sigma = (N_{obs} - N_{back})/\sqrt{N_{back}}$ where N_{obs} and N_{back} are the total counts in 3 minute and the background counts which are running averaged for $\pm$30 minute. The vertical solid line represents excess counts (Hoshida et al., 1999) of the other solar neutron telescope at same observatory in Tibet (as ICRR - Nagoya univ. solar neutron telescope, Katayose et al. 1999). At this time our neutron monitor shows the excess about 1.9σ and 1.7 σ respectively.

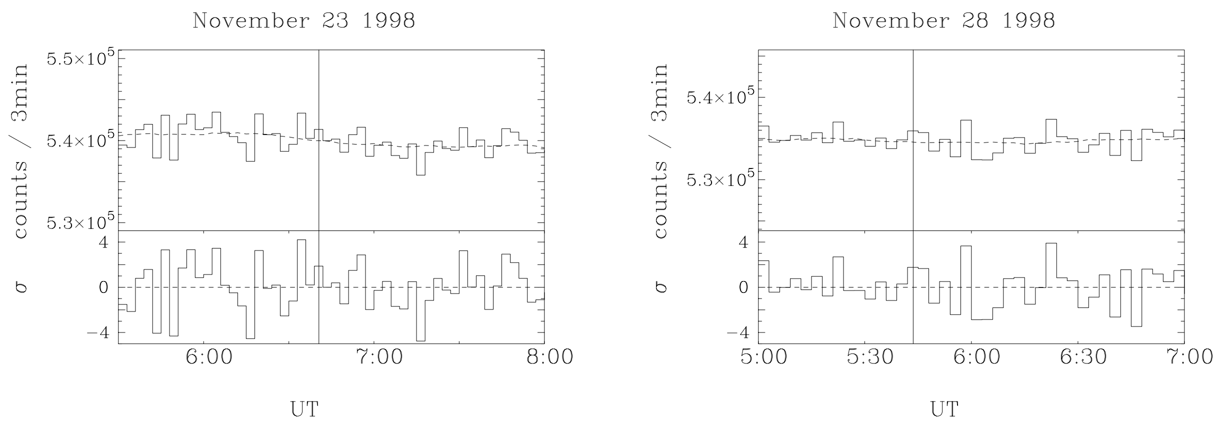

Figure 4: (top)Time profile of count rate for November 23rd (left) and 28th (right). (bottom) Statistical significance for each flares. The vertical solid line shows the excess time of ICRR - Nagoya unvi. solar neutron telescope.

5 Discussion and Summary:

The average hourly counts rate at Tibet station was 1.07×10^7. To estimate the efficiency of solar neutron detection, the ratio of intensity of neutrons originating from a solar flare to cosmic ray background will be as,

$$S/N = \frac{\Delta I_0 exp(-X(\theta)/\lambda_{SN})}{\sqrt{I}} \quad (1)$$

where $X(\theta)$ is atmospheric depth in the sun's zenith direction θ, λ_{SN} is attenuation lengths for neutrons related to a solar flare, ΔI_0 and I represent the solar flare neutrons at the top of the atmosphere and average intensity respectively. For the λ_{SN} we adopt 110 g/cm^2 and for the θ we adopt the summer solstice time sun's direction which are 6.7° (Yangbajing), 12.7° (Mt.Norikura) and 12.4° (Tokyo) respectively. Assuming as the same level of neutron intensity has came at top of the air with θ, we could compare of the efficiency of each station. The Tibet station has 17 times higher than Tokyo station and 3 times higher than Mt.Norikura station.

Even of those high efficiency, we have not find the apparent 'solar neutron event' yet in the current available data (from October 1998 to February 1999).

Acknowledgments

The authors gratefully acknowledge to the Tibet air shower group headed by Professor Yuda for supporting and guiding our all works at Tibet.

References

Amenomori, M., el al. 1992, Phys. Rev. Lett. 69, 2468
Hoshida, T., el al. 1999, Proc. 26th ICRC (Utah), this conference SH.1.3.02
Katayose, Y., el al. 1999, Proc. 26th ICRC (Utah), this conference SH.1.3.07
Takahashi, K., Wada, M., Yoshimori, M., Kusunose, M., & Kondo, I. 1987, Proc. 20th ICRC (Moscow) 3, 82