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Observation of Forbush decrease by the narrow angle muon telescope at Mt. Norikura

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Abstract. The narrow angle muon telescope at Mt. Norikura has been operated since May 1998. The telescope covers 50 degrees of the sky with angular resolution of about 7 degrees. Forbush decrease larger than about 4 percent were observed of five events. The differences of the counting rate from a level before Forbush decrease are plotted in the two-dimentional map of 21 times 21 bin. The time sequence of the plot indicates that the decrement of viewing directions of the telescopes are not uniform and the decrement start from a directional side in sharp decreasing phase of all events. This may due to the geometrical relation with the viewing directions of the telescopes to the front of the cloud , when the magnetic cloud that go to the direction decided by the position of the solar flare arrive at the Earth

1 Forbush decrease

We observed Forbush decrease of cosmic rays larger than about 4 percent of five events. as shown in Figure 1.

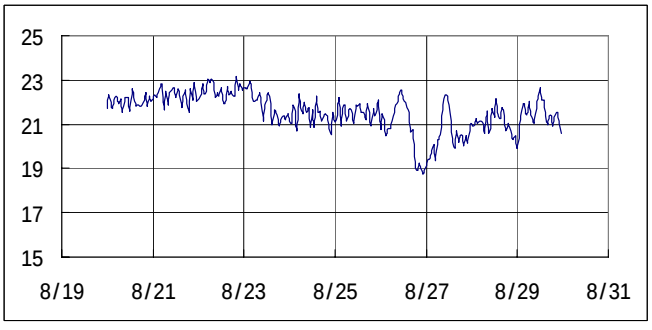

Figure 1a 1998 August event The variation of the vertical telescope is shown in unit of percent. The time is local time in Japan.

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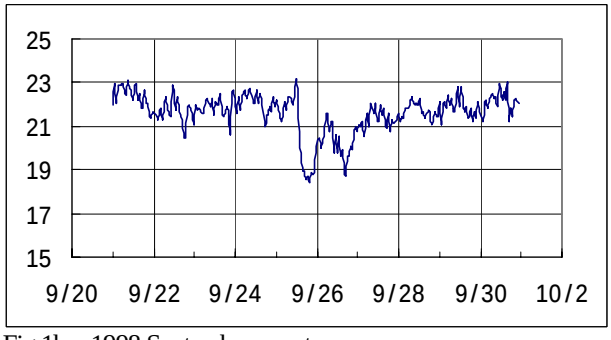


Fig 1b 1998 September event

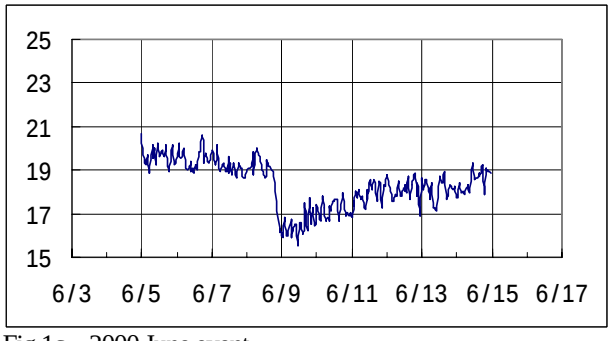


Fig 1c 2000 June event

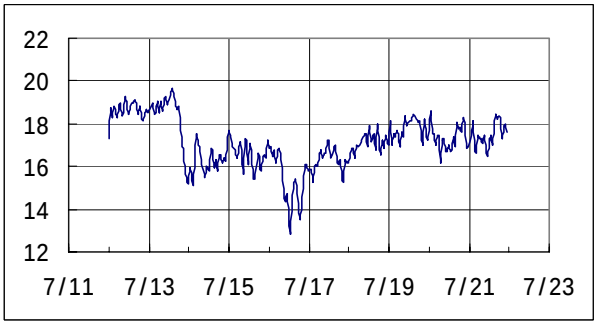


Fig1d 2000 July event

It's date and the posision of the corresponding solar flare shown in Table 1.

Date of Forbush decrease				Importance	Position
1	1998	August	26	3B	N35E09
2	1998	September	25	3B	N18E09
3	2000	June	8	3B	N20E18
4	2000	July	13	2B	N17E27
5	2000	July	16	3B	?

Table 1 The date of Forbush decrease and the position of the corresponding solar flare

After pressure correction, the differences for ij-th telescope of the counting rate from a level before Forbush decrease are plotted in the two-dimensional map of 21*21 bin of the telescope during Forbush decrease (Y.Ohashi 1997, K.Fujimoto1999).
We estimate the response of the telescope to Forbush decrease. Decrement of the cosmic ray intensity (D_{ij}) for ij-th telescopes are expected, assuming the power exponent --1 of the rigity spectrum of Forbush decrease. We calculate D_{ij} taking into acount the influence of cosmic ray's geomagnetic deflection and nuclear interaction with the terrestrial material (K.Murakami et al. 1979) and also the geometrical configuration of the muon telescope.
Figure 2 shows the 3-D picture of the decrement of the respective telescope for Forbush decrease.

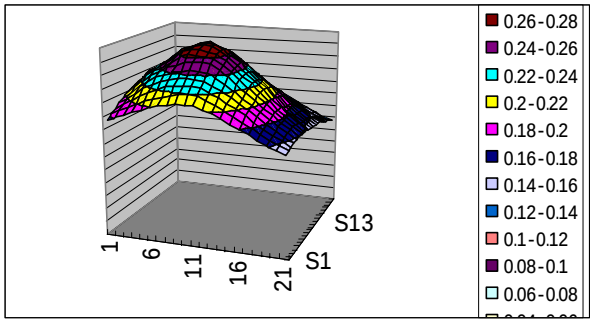
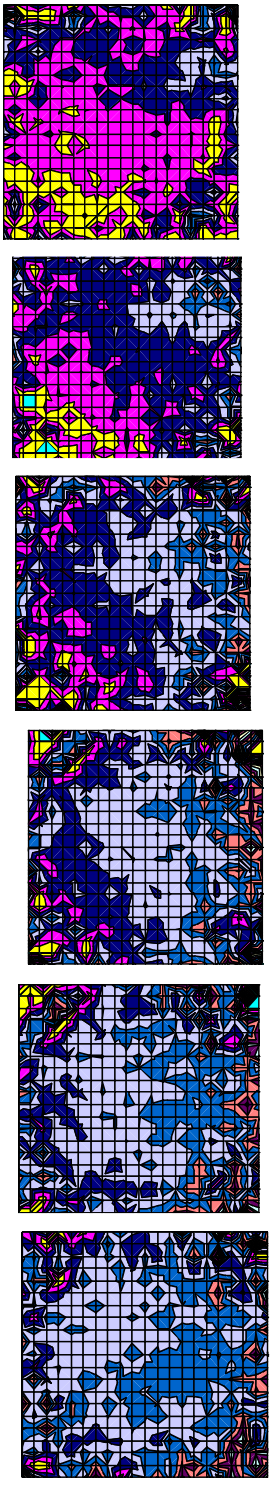


Figure 2 The estimated decrement of the ij-th telescopes due to the Forbush decrease of which the exponent of the rigidity spectrum were assumed with -1. Maximum decrement is a little west side of the vertical .

2 Two-dimensional map during Forbush decrease

To observe justly the sheltering effect for cosmic rays of the wall (disturbance region) of the magnetic cloud, we normalized the observed data of the ij-th telescope to the data of the vertical telescope using the estimated decrement of Forbush decrease (Fujimoto et al. 1999). After above correction, the observed data are plotted in the two-dimensional map of 21*21 bin. In figure 3a-3d are shown 3-D plot at sharp decreasing phase of FD event.



F igure 3a from 16h L.T. to 21h L.T. of 1998 Aug. 26

Figure 3b Event 2 from 13h L.T. to 18h L.T. at 1998 9/25

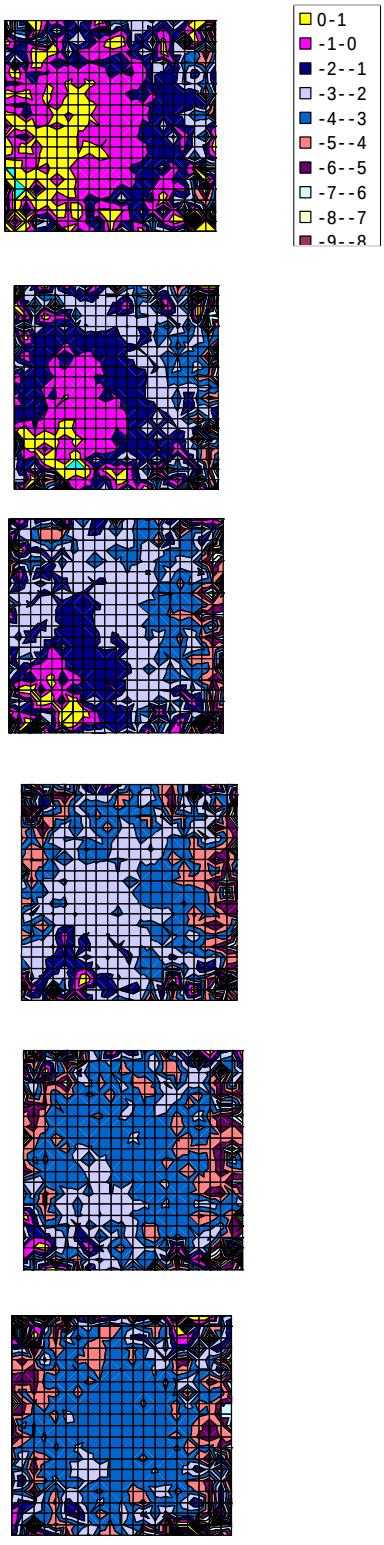
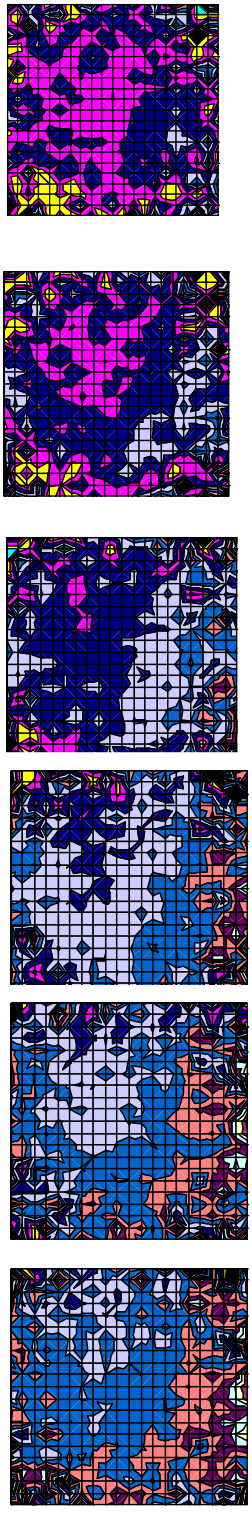


Figure 3 c Event3 from 18h to 23h 2000 6/8



In the figure , it is seen that the decrement start from NE-telescope in event 1, NE in event 2, E in event 3 and SE in event 4, respectively. The front of magnetic cloud (ejecta) arrived at 16h L.T. in event 1, 13h in event 2, 18h in event 3 and 19h in event 4 as seen in figure 1. At the time, the telescopes at Mt. Norikura sweep early the front of the ejecta at NE-side telescope in event 1, NE-side telescope in event 2, E-side telescope in event 3 and SE-side telescope in event 4, respectively. After the front passed the Earth, the decrement of all telescope become almost uniform. The tendency starting from a viewing direction of the telescope due to the geometrical relation with the viewing direction of the telescope to the front of the ejecta. Now, we observe only the event that the posision of the solar flare are east side. If we observe the event at the various posision of the solar flare, we dynamically can draw the picture that the ejecta pass the Earth

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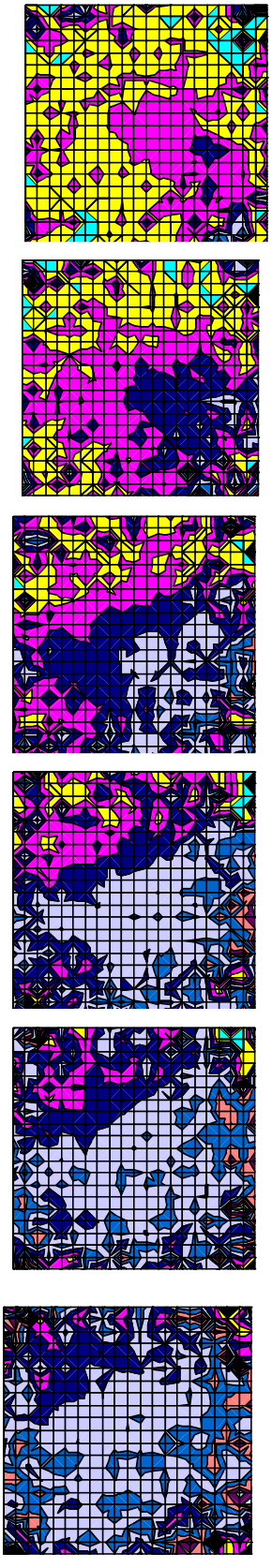

Figure 3d From 19 L.T. at 2000 7/16 to 0h at 7/17