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Forbush Effects in Total Neutron Monitor Counting Rate and Neutron Multiplicities Recorded by the 6NM-64 of the E. Segre' Observatory at 2025 m and by the Rome 17NM-64

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Abstract

We show some Forbush-decrease events by using 5-minute and 1-hourly data of total neutron monitor counting rate and of detected neutron multiplicities according to observations by the Emilio Segre' Observatory 6NM-64 at the height of 2025 *m* (R_c=10.8 *GV*) and by the Rome 17NM-64 neutron monitor (R_c=6.2 *GV*). By these data it is possible in principle to evaluate approximately the cosmic ray primary variations for each Forbush-decrease (by using the method of coupling functions); also the detected neutron multiplicities can provide additional important information.

1 Introduction:

A short description of foundation of Emilio Segre' Observatory (ESO) in the frame of the Israel-Italy collaboration was given in Dorman et al. (1999a). Continuous measurements of multiplicities 1, 2, 3, 4, 5, 6, 7 and ≥ 8, together with total counting rate, can provide additional information on great cosmic ray events. The ESO data have been corrected for barometric effect by using barometric coefficients determined by Dorman et al. (1999b, c). In this paper we consider some Forbush decrease events. For the evaluation of primary variations in each event, it is possible in a first approximation to use coupling functions for neutron multiplicities obtained by latitude survey (Aleksanyan et al. 1985) and computed by Dorman & Yanke (1981), Dorman et al. (1981). We compare the effects observed by ESO and Rome neutron monitors with some other neutron monitors (Mexico City, Moscow, Apatiti).

2 Coupling Functions for Total Counting Rate and Different Multiplicities:

According to latitude survey data by Aleksanyan et al. (1985), the normalized (at the pole) coupling functions for total counting rate and multiplicities can be approximated by the Dorman (1969) function:

$$W_{om}(R) = a_m k_m R^{-(k_m+1)} \exp\left(-a_m R^{-k_m}\right), \quad (1)$$

where m = tot, 1, 2, 3... The normalized coupling functions at a point with cut-off rigidity R_c will be:

$$W_m(R_c, R) = a_m k_m R^{-(k_m+1)} \exp\left(-a_m R^{-k_m}\right) / \left(1 - \exp\left(-a_m R_c^{-k_m}\right)\right), \text{ for } R \geq R_c, \quad (2)$$

$$W_m(R_c, R) = 0, \text{ for } R < R_c \quad (3)$$

Table 1: a_m and k_m, and R_{max} (position of maximum of normalized coupling function)

Values	Total	m=1	m=2	m=3	m=4	m=5
a_m	8.32	7.16	10.26	13.48	20.30	42.83
k_m	0.87	0.81	0.95	0.98	1.06	1.29
R_{max}, *GV*	4.76	4.21	5.43	6.96	9.15	11.77

Coefficients a_m and k_m, given in Table 1, have been determined by Aleksanyan et al. (1985), in good agreement with theoretical calculations performed by Dorman & Yanke (1981) and Dorman et al. (1981).

3 Expected Amplitudes of Forbush-Decreases:

If the spectrum of primary CR variation can be described by the function

$$\Delta D(R)/D_o(R) = -bR^{-\gamma}, \quad (4)$$

the expected variation in total counting rate or in multiplicity m will be

$$\Delta I_m(R_c)/I_{mo}(R_c) = -bF_m(R_c,\gamma), \quad (5)$$

where $$F_m(R_c,\gamma) = a_m k_m b\left(1-\exp\left(-a_m R_c^{-k_m}\right)\right)^{-1}\int_{R_c}^{\infty} R^{-(k_m+1+\gamma)}\exp\left(-a_m R^{-k_m}\right)dR. \quad (6)$$

By the comparison between the amplitudes of observed Forbush-decreases, as recorded by different multiplicities, with the expected ones according to (5), it is possible to evaluate the parameters b and γ in (4) characterizing the primary CR variation out of the Earth's magnetosphere.

4 July 4, 1998 Event:

This event is characterized by clear pre-increase effect. According to Moscow NM data (R_c=2.46 *GV*, sea level), the decreasing phase started at 17:00 UT of July 4, and the amplitude of decrease was about 3%. The event, as recorded by ESO and Rome NM for total and m=1, 2, 3, is shown in Figures 1a and 1b respectively, and the comparison with Mexico City NM (R_c=9.53 *GV*, altitude 2274 *m*) in Figure 1c. All curves are obtained by 3-hour moving averages.

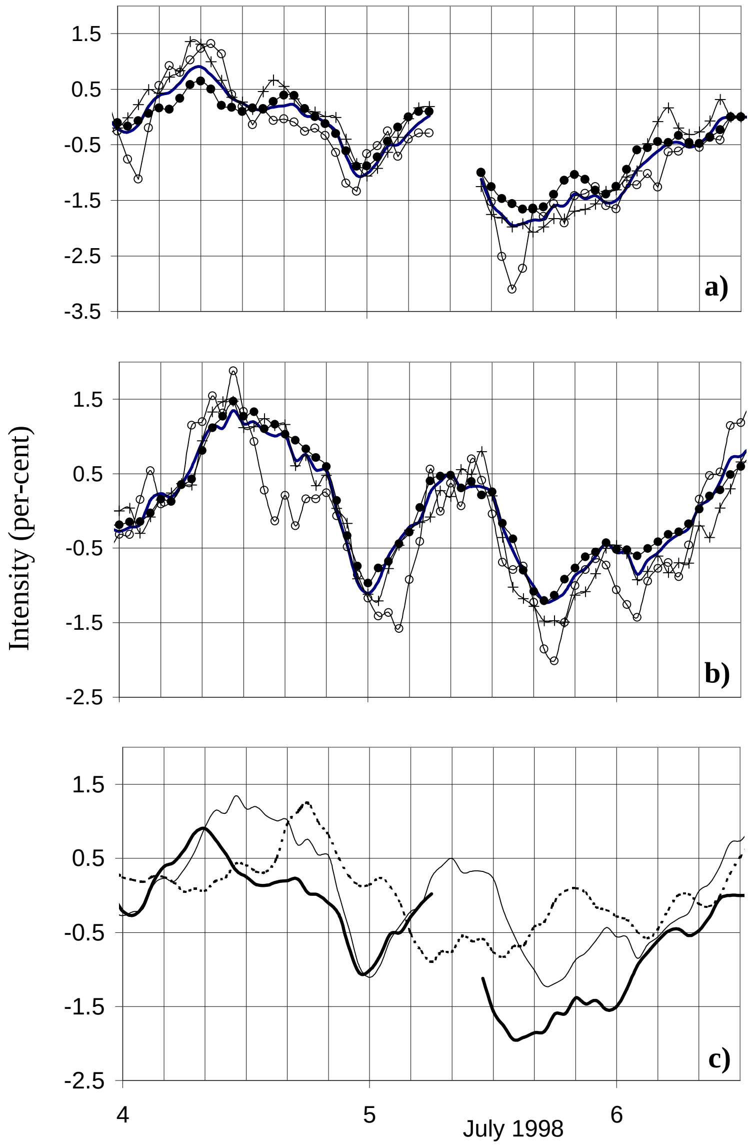

Figure 1: July 4, 1998 event.
ESO (a) and Rome (b) NM-64: total counting rate (thick line), m=1 (●), m=2 (+), m=3 (o).
(c): NM-64 total counting rate, ESO (thick line), Rome (thin line), Mexico City (dashed line).

5 August 26, 1998 Event:

Also this event is characterized by clear pre-increase effect. According to Moscow NM the Forbush-decrease started at 06:00 UT of August 26, the amplitude of decrease was about 6.5%. A long period of recovery phase has been observed. Results of observations by ESO and Rome NM for total and m = 1, 2, 3 are shown in Figures 2a and 2b, and comparison with Mexico City NM (R_c=9.53 *GV*, altitude 2274 *m*) in Figure 2c. All curves are obtained by 3-hour moving averages.

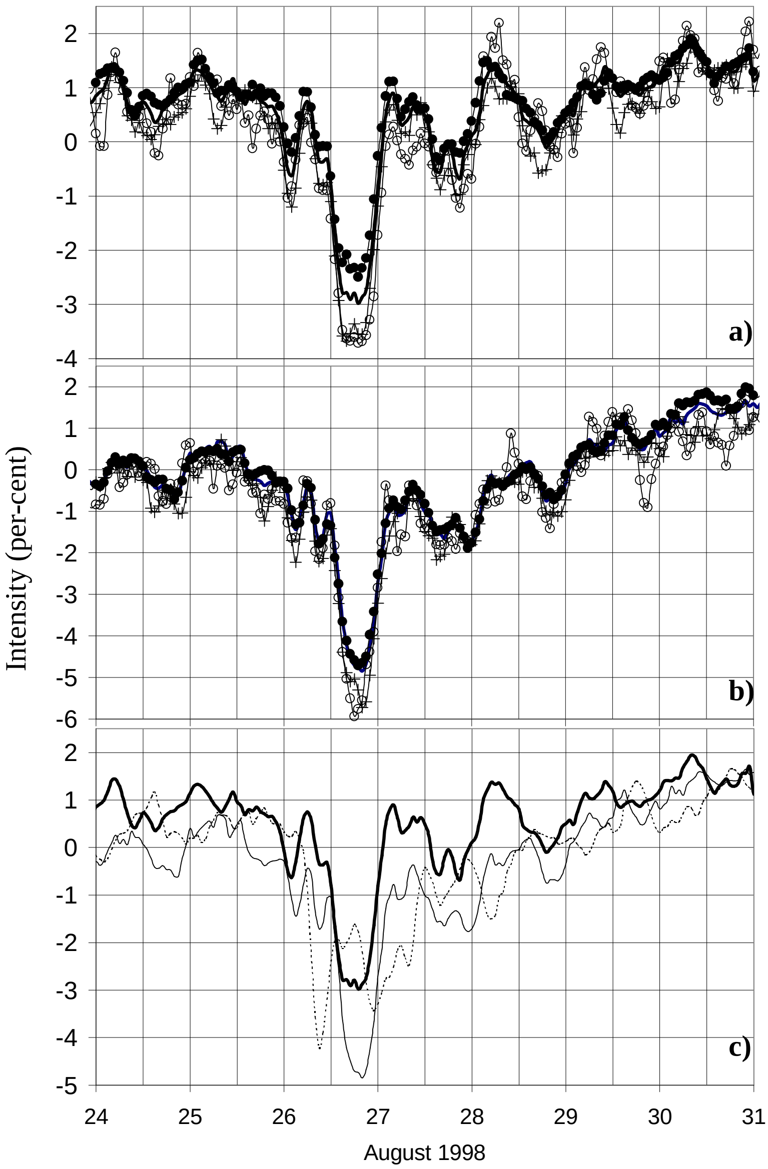

Figure 2: August 26, 1998 event.
ESO (a) and Rome (b) NM-64: total counting rate (thick line), m=1 (●), m=2 (+), m=3 (o).
(c): NM-64 total counting rate, ESO (thick line), Rome (thin line), Mexico City (dashed line).

6 September 24, 1998 Event:

Also this Forbush decrease has a clear pre-increase effect. The beginning of the event at Moscow NM is at 23.45 UT, with amplitude 9%; in Apatiti the amplitude is about 9.5%. Results of observations by ESO and Rome NM for total and m = 1, 2, 3, 4 are shown in Figures 3a and 3b, and the comparison with Mexico City NM (R_c=9.53 *GV*, altitude 2274 *m*) in Figure 3c. All curves are obtained by 3-hour moving averages.

7 November 8, 1998 Event:

This event is particularly interesting for the great pre-increase and pre-decrease before Forbush-decrease. According to Moscow NM the event started at 4.15 UT of November 8, with maximum amplitude ~7%. About the same amplitude was observed by Apatiti NM and Goose Bay NM (R_c=0.6 *GV*). Muon telescope at Hobart (R_c=2.5 *GV*) shows a clear pre-decrease effect and Forbush-decrease with amplitude ~4%. Muon telescope at Mt. Norikura (R_c=11.5 *GV*) shows a clear pre-increase and pre-decrease effects and amplitude of Forbush-decrease ~4% (Watanabe, 1999). Results of observations by ESO and Rome NM for total and m = 1, 2, 3 4, 5 are shown in Figures 4a and 4b, and the comparison with Mexico City NM in Figure 4c.

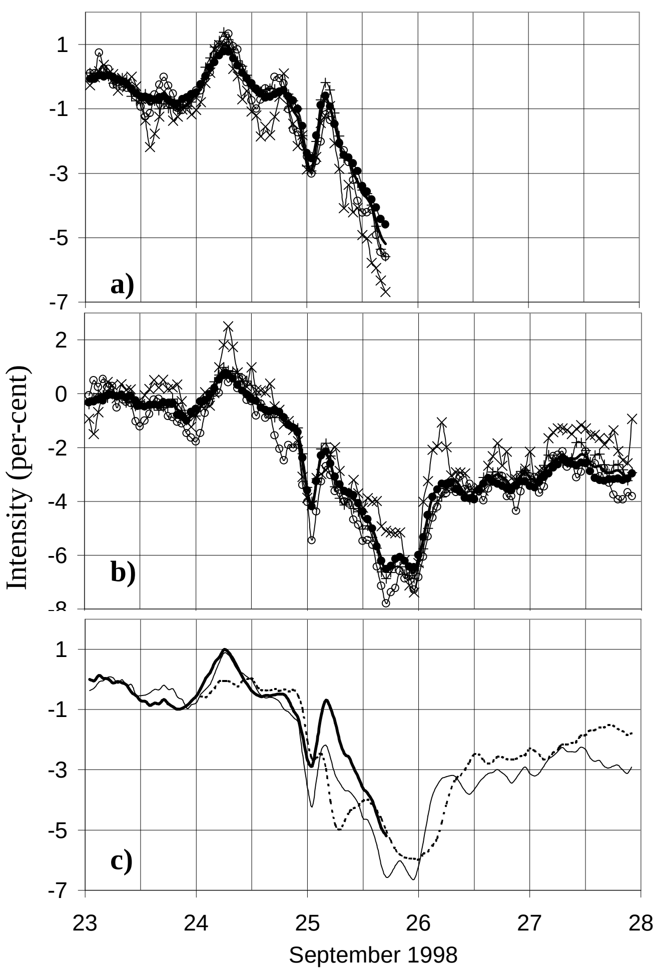

Figure 3: September 24, 1998 event. For symbols see Figure 2; m=4 (x).

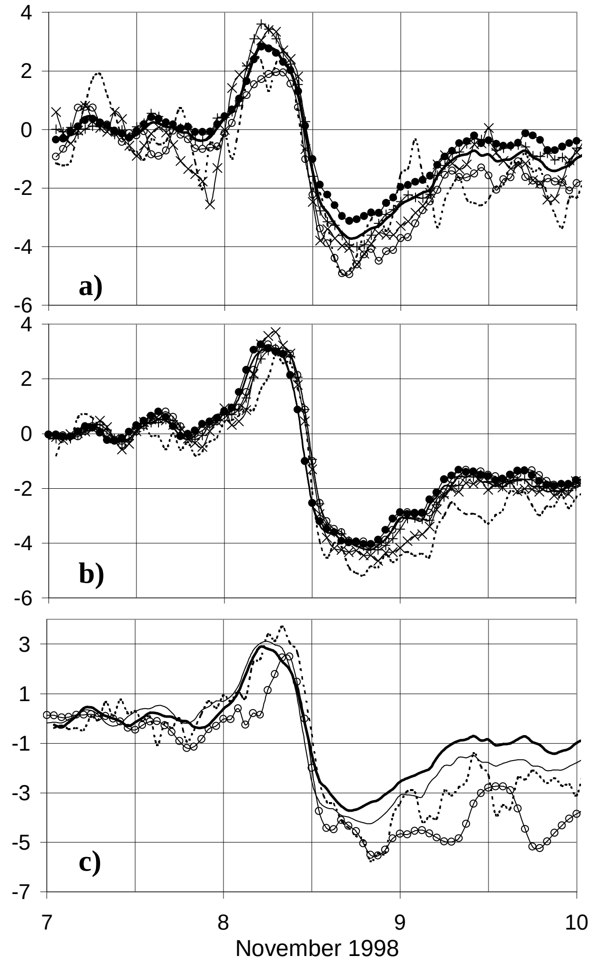

Figure 4: November 8, 1998 event. For symbols see Fig.2 & 3; m=5 (dashed); in c) Apatiti NM (o)

8 Conclusions

- For small events (as July 4 and August 26, 1998) it is possible to use multiplicities m=1, 2, and 3. Higher multiplicities (up to m=4 and 5) can be used for great events (as September 24 and November 8, 1998).
- In all events there are precursory effects which can be used for forecasting Forbush-decreases connected with great geomagnetic storms.
- For great events it is possible to use multiplicity data to obtain additional information on primary spectrum of CR variations out of the Earth's magnetosphere, according to Sections 2 and 3.

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