



Ground Level Events Recorded at Lomnický Stit Neutron Monitor

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Abstract: An updated list of responses to relativistic solar particles and/or to particles accelerated in interplanetary space to high energies for the period 1966 until December 2006 as recorded by a high mountain neutron monitor with nominal vertical cut-off rigidity ~ 4 GV is presented. Data from two recent events are plotted.

Introduction

Continuous measurements of cosmic rays on Lomnický Stit (2634 m, 49.20 N, 20.22 E) in High Tatra mountains started during the IGY in 1958. Neutron monitor placed there was several times reconstructed. Data stored in real time along with the archive of hourly records can be found at <http://neutronmonitor.ta3.sk>. The count rate of ~ 440 s⁻¹ is rather high and the system recorded several GLEs indicating the acceleration at the solar surface or in the interplanetary medium to rigidity at least (~ 4 GV). Since observations of GLEs are important part of space weather effect monitoring, we list here complete table of GLEs observed at that station since 1966 until present. Description of the present system is in [1].

Review of GLEs since 1966

The list of GLEs at Lomnický Stit until 1991 was presented in [2]. From 1968 the IGY monitor was in operation with average count rate of 9.1×10^4 per hour. From January 1972 a 4 tube IQSY monitor with hourly mean of 8.1×10^5 replaced it. Since December 1981 the NM-64 with 8 proportional tubes of type SNM-15 is in operation. Its hourly mean is 1.6×10^6 and 1-minute data are stored. Table 1 in two parts shows the basic informations about GLEs observed until present at Lomnický Stit neutron monitor. Data from events when time resolution was worse than 1 hour are not included.

Table 1. List of GLEs observed at Lomnický Stit (part 1)

GLE No	Date	Flare start	Flare end	Flare max	Position
17	670128	08 E			N22 W150
20	690225	0900	0946	0913	N14 W36
21	690330	0332 E			N19 W103
23	710901	1934 E			S11 W120
25	720807	1449 E	1640	1518	N13 W39
29	770924	0552 E			N10 W120
30	771122	0950 E	1036 D	1005	N23 W41
31	780507	0336 E	0355	0336 U	N23 W68
32	780923	0944	1200	1015	N35 W46
36	811012	0615 E	0830	0620	S22 E35
37	821126	0253 e	0425	0253	S11 W89
38	821207	2336	2447	2354	S14 W81
39	840216	0736	0753	0743	S12 W90
41	890816	0100	0210	0119	S16 W88
42	890929	1047	1435	1133	S26 W90
43	891019	1229	2013D	1255	S27 E10
44	891022	1708	2108	1757	S27 W31
45	891024	1739	2118 D	1813	S30 W55
46	891115	0638	0920	0705	N11 W26
47	900521	2212	2339	2217	N35 W36
48	900524	2046	2145	2049	N33 W78
49	900526	2045	2133	2058	
51	910611	0209 E	0320 D	0229 U	N31 W17
52	910615	0633	1117	0831	N33 W69
53	920625	1947	2229	2011U	N09 W67
54	921102	0310	0427	0314	S23 W90
55	971106	1122 E	1244	1156	S18 W63
57	980506	0714	0905	0804	S11 W65
59	000714	1012 E	1146	1021 U	N22 W07
60	010415	1336	1535	1349	S20 W85
61	010418	0211	0216	0214	S20 W1mb
63	011226	0432	0823	0514	N08 W54
64	020824	0049	0131	0112	S02 W81
65	031028	0951	1124	1110	S16 E08
66	031029	2037	2101	2049	S15 W02
67	031102	1703	1739	1725	S14 W56
68	050117	0659	1007	0952	N15 W25

69	050120	0636	0726	0701	N14 W61
70	061213	0214	0257	0240	S06 W23

Table 1. List of GLEs observed at Lomnicky Stit (part 2)

GLE No	Date	Importance Opt./Xray	GLE onset	GLE max	Incr. %, pm.
17	670128	3B/	0715-0730	1000-1015	5.0 b,c
20	690225	2B/	0900-1000	0900-1000	1.3 d
21	690330	1N/	0600-0700	0700-1400	1.5 b,d,e
23	710901		2100-2200	2300-2400	2.1 b,c,d
25	720807	3B/	1630-1650	1700-1710	1.9
29	770924		0645-0650	0940-0955	3.9 b
30	771122	2B/X1	1015-1025	1035-1040	4.2
31	780507	2N/X2	0335-0340	0340-0345	32.9
32	780923	3B/X1	1000-1100	1100-1200	1.2 d
36	811012	2B	0650-0655	0755-0810	3.6
37	821126	2B/X4	0310-0315	0320-0430	1.5 g
38	821207	0B/X2	2350-2355	0000-0005	9.1
39	840216		0905-0910	0910-0915	3.7
41	890816	2N/X20	0150-0155	0225-0230	2.6 i
42	890929	/X9	1145-1150	1230-1245	178.3
43	891019	4B/X13	1330-1335	1430-1435	9.7
44	891022	2B/X2	1800-1805	1805-1810	1.5 g
45	891024	3B/X5	1825-1830	1915-1920	22.2
46	891115	3B/X3	0700-0705	0700-0705	1.4
47	900521	2B/X5	2235-2240	2300-2315	5.1
48	900524	1B/X9	2100-2105	2115-2120	6.5
49	900526	/X1	2205-2215	2210-2250	1.3 g
51	910611	3B/X12	0230-0245	0440-0455	2.4
52	910615	3B/X12	0845-0855	0925-0935	3.6
53	920625	2B/X3	2010-2015	2010-2015	1.2
54	921102	2B/	0635-0640	0635-0640	1.1
55	971106	2B/X9	1225-1230	1335-1340	3.0
57	980506	1N/X2	0925-0930	0935-0940	1.2
59	000714	3B/X5	1025-1030	1040-1050	2.2
60	010415	2B/X14	1345-1350	1420-1425	12.2

61	010418	2B/C2	0235-0240	0315-0320	2.6
63	011226	1B/M7	0540-0550	0550-0555	1.1
64	020824	1F/X3	0150-0155	0205-0210	1.3
65	031028	4B/X17	1113-1114	1118-1119	9.2
66	031029	2B/X10	2137-2138	2142-2143	3.1
67	031102	2B/X8	1720-1725	1740-1745	3.6
68	050117	/X3	1030-1035	1050-1055	1.7
69	050120	/X7	0650-0655	0705-0710	20.6
70	061213	4B/X3	0250-0251	0300-0301	12.2

Comments:

Part 1: D=after,E=before,U=uncertain

Part 2:

b Flare behind the west limb of sun. Position estimated from location of assumed associated active region

c 10 or 15 min. values

d Only hourly data available

e Only 4 hours present in the 7 hour period

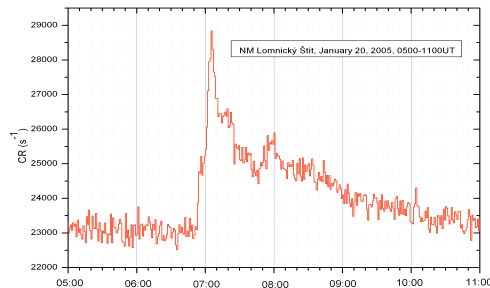
g Broad maximum; data averaged over the time period

i Slight enhancement

Data on solar flares are adopted from [3, 4].

Event on January 20, 2005

One of the largest GLEs described e.g. in papers [5-12] indicated the presence of relativistic ions at Earth orbit. The event was anisotropic one.



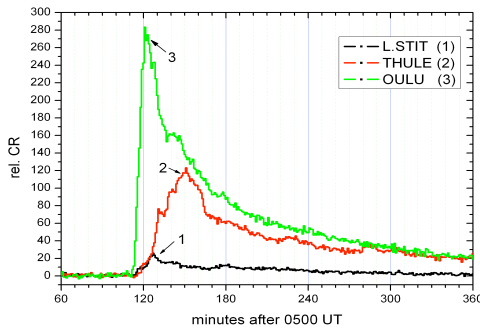


Figure 1: The neutron monitor increases during the event on 20 January 2005. The actual count rate of 1min records at Lomnický Stit and comparison of 5 min data with Oulu and Thule (nominal vertical cutoffs 0.8 GV and ~ 0 GV).

Event on December 13, 2006

For this GLE observed during the solar activity phase with low sunspot numbers the acceleration of ions to rigidity at least ~ 4 GV was inferred.

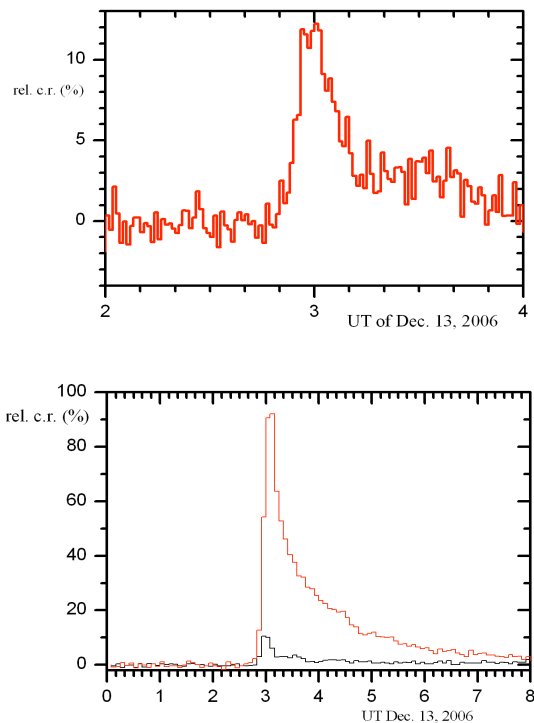


Figure 2: Lomnický Stit neutron monitor record on December 13, 2006: 1 min pressure corrected counting rate (upper) and comparison with strong

increase observed at Oulu neutron monitor (5 min data, lower panel).

Summary

High mountain neutron monitor at Lomnický Stit with relatively high statistical accuracy observed during the period 1966 – 2006 at least 25 GLEs (increase $> 2\%$) indicating effects of acceleration of ions to rigidity > 4 GV on solar surface or in interplanetary space. Also the first ground response from solar neutrons from the flare on June 3, 1982 [13] was observed by that device simultaneously [14].

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