Neutron Monitor Data for Jungfraujoch and Bern during the Ground-Level Solar Cosmic Ray Event on 13 December 2006

R. Bütikofer and E.O. Flückiger
Physikalisches Institut, Universität Bern
Sidlerstrasse 5, CH-3012 Bern, Switzerland

January 16, 2007

Abstract

This report includes information on the processing and use of the data for the solar cosmic ray ground-level event (GLE) on 13 December 2006 obtained by the IGY and NM64 neutron monitors at Jungfraujoch and the special neutron monitor in Bern, all of which are operated by the Cosmic Ray Group at the University of Bern, Switzerland.

Neutron Monitors

`http://cosray.unibe.ch`

IGY neutron monitor at Jungfraujoch

The standard IGY neutron monitor with 18 BF_3-counters is housed on top of the Sphinx Observatory of the High Altitude Research Station Jungfraujoch.

Geographic latitude:	46.55 N
Geographic longitude:	7.98 E
Effective vertical cutoff rigidity, Epoch 2006.95:	4.5 GV
Altitude	3570 m asl

This detector is an integral part of the worldwide network of neutron monitors, and data of this monitor have been published regularly since 1958 (Debrunner et al., 1987).

IQSY-NM64 neutron monitor at Jungfraujoch

The IQSY-NM64 neutron monitor with 3 counter tubes is housed on the roof of the High Altitude Research Station Jungfraujoch.

Geographic latitude:	46.55 N
Geographic longitude:	7.98 E
Effective vertical cutoff rigidity, Epoch 2006.95:	4.5 GV
Altitude	3475 m asl

This monitor has been in operation since 1986 (Debrunner et al., 1987; Schubnell, 1988).

Special neutron monitor at Bern

The special neutron monitor with 58 IGY-type counter tubes (Bütikofer, 1988) is housed on the roof of the Physikalisches Institut of the University of Bern.

Geographic latitude:	46.95 N
Geographic longitude:	7.456 E
Effective vertical cutoff rigidity, Epoch 2006.95:	4.35 GV
Altitude	570 m asl

This monitor has been in operation since 1977.

Preparation of GLE Data

The last full hour (in UT) before the onset of the particle increase at Earth was used as the baseline time interval, i.e. 13 December 2006, 0100 - 0200 UT.

The data given in the data files for the Jungfraujoch neutron monitors are listed in Table 1. For the Bern neutron monitor, the same data are given with the difference that the small-time data include 5- minute values only. All data are presented in the "Standard Format for Cosmic Ray Ground-Level Event Data" as suggested by Shea et al. (1987), and additions according to the document "STANDARD FORMAT FOR COSMIC RAY GROUND-LEVEL ENHANCEMENT DATA" at the GLE data base. The following names were used to identify the different monitors: JUNGFRAUJ for the 18-IGY and JUNGFRAU2 for the 3-NM64 neutron monitors at Jungfraujoch, BERN for the special neutron monitor in Bern.

Hourly data	12 December 2006	0000 - 2400 UT
1-minute data	13 December 2006	0000 - 0800 UT
Hourly data	13 December 2006	0800 - 2400 UT
	14 December 2006	0000 - 2400 UT

Table 1: Data given in the data files for the Jungfraujoch neutron monitors.

For reasons of consistency all counting rates of the neutron monitors were normalized with the same correction factors as used for the publications on our website `http://cosray.unibe.ch` and for data sent to the world data centers. The factors for the time interval during the event are given in Table 2 for the different sections of the neutron monitors.

neutron monitor	section 1	section 2	section 3
IGY neutron monitor Jungfraujoch	0.885	0.908	0.792
NM64 neutron monitor Jungfraujoch	0.975	1.006	1.010
special neutron monitor Bern	1.067	1.000	1.060 / 1.000

Table 2: Correction factors used to normalize the counting rates of the neutron monitors during the event.

Pressure corrected hourly averages were obtained from pressure corrected 1-minute values. The hourly pressure values were obtained by averaging the 1-minute pressure readings.

Section 3 of the IGY neutron monitor at Jungfraujoch is the central section. Section 1 is west of section 3 (towards the building) and section 2 is east of section 3. In the NM64 neutron monitor Jungfraujoch section 1 is located toward the mountain, section 2 is the central section and section 3 is located toward the glacier. For the special neutron monitor in Bern section 1 is AL+AR+BL+BR and section 2 is CL+CR. In contrast to the data books where the count rates of the sections FL and FR are not taken into account, the data in this report include all sections of the special neutron monitor. Section 3 therefore is DL+DR+EL+ER+FL+FR. The correction factor for (DL+DR+EL+ER) is 1.060, whereas for (FL+FR) it is 1.000. For details see (Bütikofer, 1988).

In the special neutron monitor in Bern the counter tubes are placed at different positions relative to the absorbers. Therefore different barometric pressure coefficients were used for the pressure correction of the count rates of the different sections. The barometric pressure coefficients according to Bütikofer (1988) were used, see Table 3.

section	barometric coefficient in % / mmHg
AL, AR	-0.975
BL, BR	-0.961
CL, CR	-0.962
DL, DR	-0.920
EL, ER	-0.948
FL, FR	-0.928

Table 3: Barometric pressure coefficients for the special neutron monitor in Bern according to Bütikofer (1988)

The barometric pressure coefficient of -0.9557 % / mmHg given in line 3 of the header of the standard GLE format for the special neutron monitor in Bern corresponds to an average barometric pressure coefficient for the total count rate.

During several time intervals on 13 and 14 December 2006 either one or all three sections of the NM64 detector showed erroneus count rates or the entire monitor was not working. In Table 4 the time intervals are listed when the precision of the data is reduced or the neutron monitor was not operating.

Time interval [UT]	Comments
13.12.2006 1200–1300	Section 2 erroneous (1246–1248 UT)
14.12.2006 0800–1100	Neutron monitor not working (0825–1044 UT)
14.12.2006 1100–1200	Section 2 erroneous (1044–1200 UT)
14.12.2006 1200–1300	Section 2 erroneous (1200–1225), all sections erroneous (1227–1228 UT)
14.12.2006 1400–1500	All sections erroneous (1410–1411 UT)
14.12.2006 1700–1800	Section 2 erroneous (1716–1740 UT)

Table 4: Time intervals during which specific problems have occured at the NM64 neutron monitor at Jungfraujoch.

Measurements of Swiss neutron monitors

In the Figures 1-3 the relative pressure corrected counting rates of the Swiss neutron monitors are plotted for 13 December 2006, 0100-0500 UT.

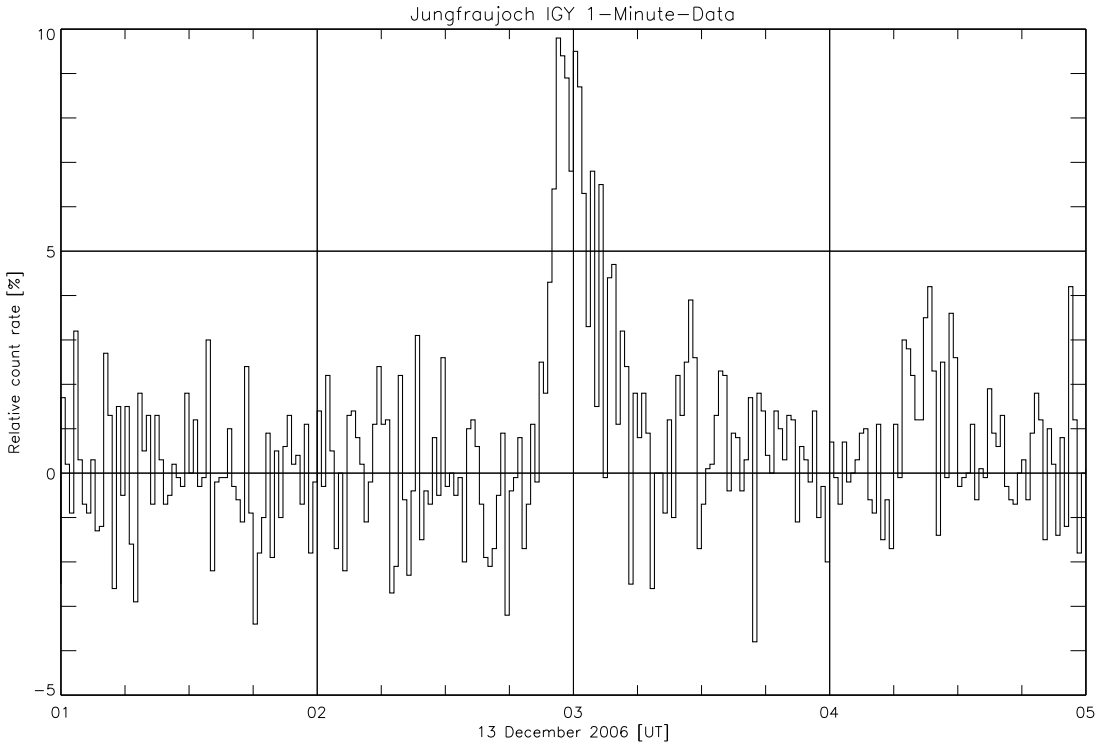

Figure 1: Relative pressure corrected 1-minute data of the IGY neutron monitor at Jungfraujoch on 13 December 2006, 0100-0500 UT.

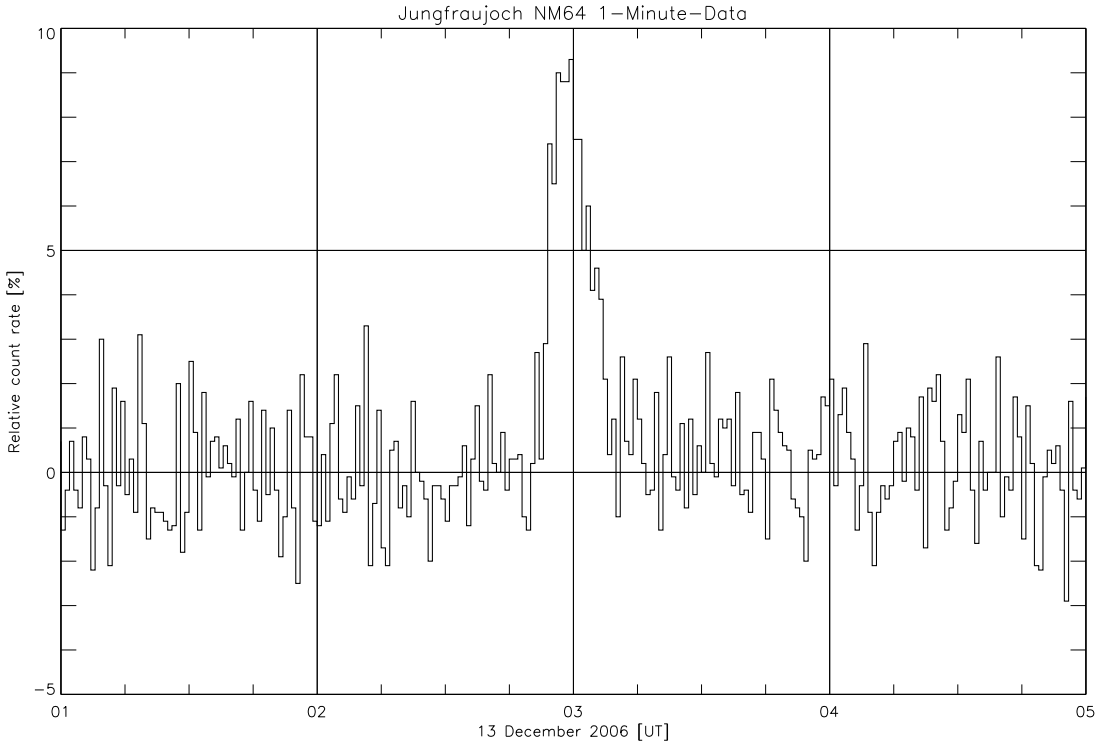

Figure 2: Relative pressure corrected 1-minute data of NM64 neutron monitor at Jungfraujoch on 13 December 2006, 0100-0500 UT.

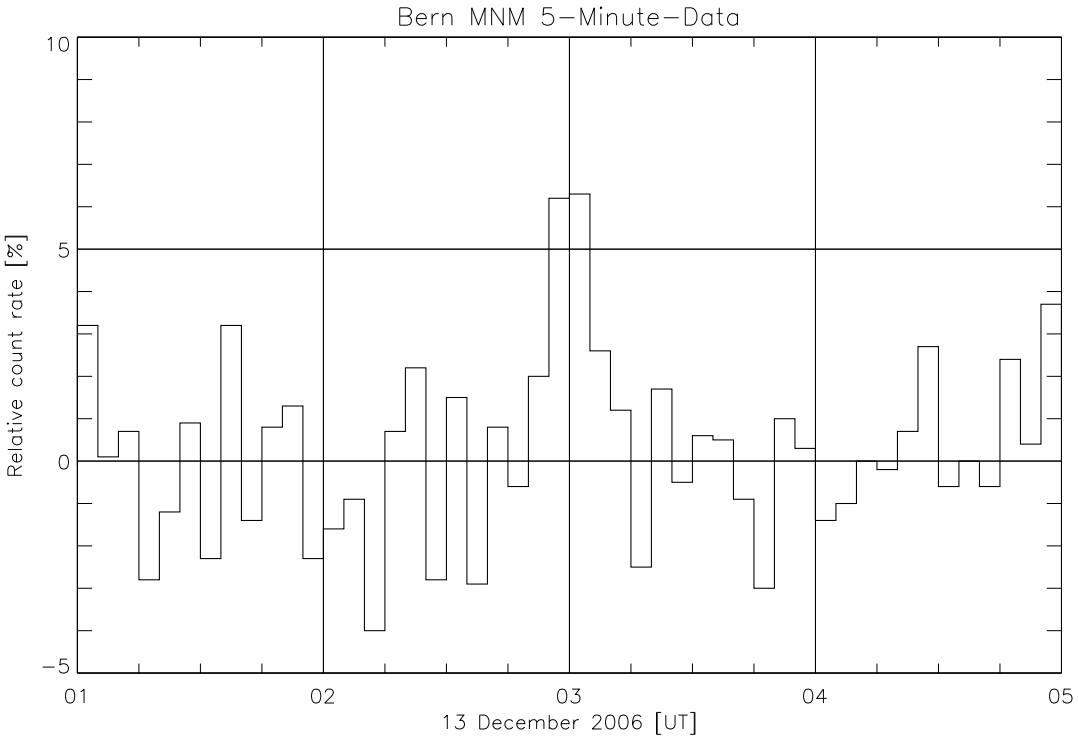

Figure 3: Relative pressure corrected 5-minute data of special neutron monitor at Bern on 13 December 2006, 0100-0500 UT.

In the following tables the characteristics (onset time, maximum) of the GLE data of the Swiss neutron monitors are listed.

IGY Jungfraujoch

1-minute values		
Onset	0252–0253 UT	
Max	0256–0257 UT	9.8%

5-minute values		
Onset	0250–0255 UT	
Max	0255–0300 UT	8.3%

NM64 Jungfraujoch

1-minute values		
Onset	0253–0254 UT	
Max	0259–0300 UT	9.3%

5-minute values		
Onset	0250–0255 UT	
Max	0255–0300 UT	8.5%

Special neutron monitor Bern

5-minute values

Onset	0250–0255 UT	
Max	0300–0305 UT	6.3%

Conditions for Use of Data

The Swiss neutron monitor data may be used under the following conditions:

1. You agree to acknowledge the source of the data in any published use. Example: "Jungfraujoch neutron monitor data were kindly provided by the Cosmic Ray Group, Physikalisches Institut, University of Bern, University of Bern, Switzerland"

2. You agree to send a copy of any paper using these data to:
   Erwin Flückiger
   Physikalisches Institut
   University of Bern
   Sidlerstrasse 5
   CH-3012 Bern / Switzerland

3. You may share these data with colleagues, provided you inform them of these conditions.

While the published data are accurate to the best of our knowledge, we reserve the right to correct errors without notifying users.

Acknowledgments: The operation of the neutron monitor is supported by the Swiss National Science Foundation, grant 200020-113704/1 and by the International Foundation High Altitude Research Stations Jungfraujoch and Gornergrat (HFSJG), CH-3012 Bern, Switzerland.

References

Bütikofer, R. (1988). *Zum Wiederaufbau des Multiplizitätsneutronenmonitors in Bern*. Master thesis, Physikalisches Institut, Universität Bern, Switzerland.

Debrunner, H., E. Flückiger, and M. Schubnell (1987). Present and Future Activities of the Bern Cosmic Ray Group in the Field of Solar Neutrons. In *Workshop on Solar Neutrons; 20th International Cosmic Ray Conference*, Volume 9 of *Special Report of the A.F. Ioffe Physico-Technical Institute of the Academy of Sciences of the USSR*, Moscow.

Schubnell, M. (1988). *Zum Nachweis solarer Neutronen auf Jungfraujoch*. Ph. D. thesis, Universität Bern, Switzerland.

Shea, M., D. Smart, J. Humble, E. Flückiger, L. Gentile, and M. Nichol (1987). A revised standard format for cosmic ray ground-level event data. *20th ICRC, Moscow, Conference Papers 3*, 171.