

Name of research institute or organization:

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**Physikalisches Institut, Universität Bern**

Title of project:

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Neutron monitors - Study of solar and galactic cosmic rays

Project leader and team:

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Prof. Erwin Flückiger, project leader  
Dr. Rolf Bütikofer, Dr. Michael R. Moser

Project description:

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The Cosmic Ray Group of the Division for Space Research and Planetary Sciences of the Physikalisches Institut at the University of Bern, Switzerland, operates two standardized neutron monitors (NM) at Jungfraujoch: an 18-IGY NM (since 1958) and a 3-NM64 NM (since 1986). NMs provide key information about the interactions of galactic cosmic radiation with the plasma and the magnetic fields in the heliosphere and about the production of energetic cosmic rays at the Sun, as well as about geomagnetic, atmospheric, and environmental effects. They ideally complement space observations. The NMs at Jungfraujoch are part of a worldwide network of standardized cosmic ray detectors. By using the Earth's magnetic field as a giant spectrometer, this network determines the energy dependence of primary cosmic ray intensity variations in the GeV range. Furthermore, the high altitude of Jungfraujoch provides good response to solar protons  $\geq 3.6$  GeV and to solar neutrons with energies as low as  $\sim 250$  MeV. In addition to the NMs, a device to measure environmental radioactivity has been in operation since 2002 in the housing of the NM64 by the Bern Cosmic Ray Group.

In 2006, operation of the two NMs at Jungfraujoch and of the environmental radioactivity measurements was pursued without major problems. No significant technical modifications were necessary. The radioactivity detector had to be sent for repair and exchange of battery to the manufacturer in Germany. The recordings of the NM measurements are published in near-real time on the webpage (<http://cosray.unibe.ch>), and in special reports after processing. In addition, the data are submitted to the World Data Centers in Boulder and Tokyo in electronic form.

Figure 1 shows the daily counting rates of the IGY NM for 2006. Compared to the count rate behavior in 2004 and 2005, the IGY NM had a more stable counting rate in 2006. The counting rate increased about 4% during the first three months in 2006, and seemed to be at a constant level afterwards. However, in December 2006 the Sun had an active intermezzo with several solar bursts. In association with these solar eruptions galactic cosmic rays near Earth were temporarily depressed after the passage of interplanetary magnetic disturbances over the Earth on 7 December and 15 December 2006. On 13 December 2006 the Sun produced a X3.4 class solar burst at  $6^{\circ}\text{S}$ ,  $23^{\circ}\text{W}$  with onset time at 0214 UT and maximum at 0240 UT. The worldwide network of NM stations observed a ground level enhancement (GLE) with onset time  $\sim 0248$  UT. Figure 2 shows the count rates of the IGY and the NM64 NMs at Jungfraujoch during this event in the time interval 0100 UT–0500 UT. Both detectors measured an increase due to solar cosmic rays of almost 10% in the 1-minute data. Although the maximum amplitude of this increase is similar to the one on 20 January

2005, the solar cosmic ray flux during the maximum phase on 13 December 2006 near Earth was smaller by at least two orders of magnitude at the rigidity of  $\sim 1$  GV. In addition, the count rates of the Jungfraujoch NMs reached the pre-event level on 13 December 2006 only about 20 minutes after the event onset, whereas during the GLE on 20 January 2005 the count rate was at an increased level over  $\sim 10$  hours. A hard energy spectrum during the maximum phase of the GLE on 13 December 2006 is the main the reason that the Jungfraujoch NMs observed again an increase of almost 10% in the 1-minute data. The direction of interplanetary magnetic field lines during this event were close to to the nominal direction of the interplanetary magnetic field (IMF). Because solar cosmic rays follow the IMF lines, NMs with line of sight in the direction of the IMF can detect solar cosmic ray particles. During the GLE on 13 December 2006 the location at Jungfraujoch was ideal to detect solar cosmic rays with energies  $\geq 3.5$  GeV. At present a detailed analysis of the NM network measurements during the GLE on 13 December 2006 is in progress.

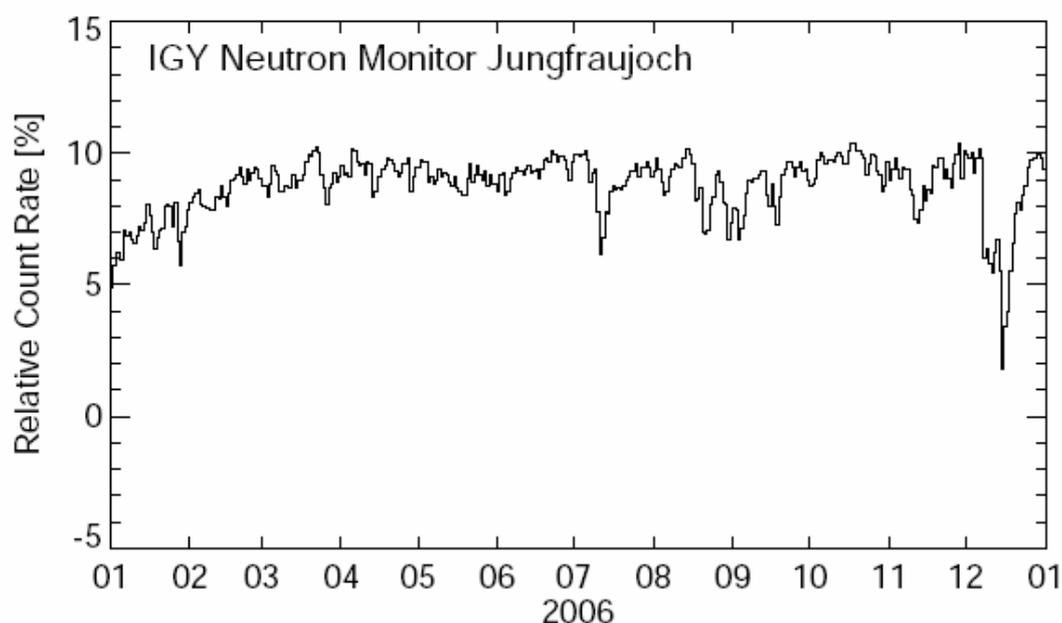


Figure 1: Relative pressure corrected daily counting rates of the IGY neutron monitor at Jungfraujoch for 2006.

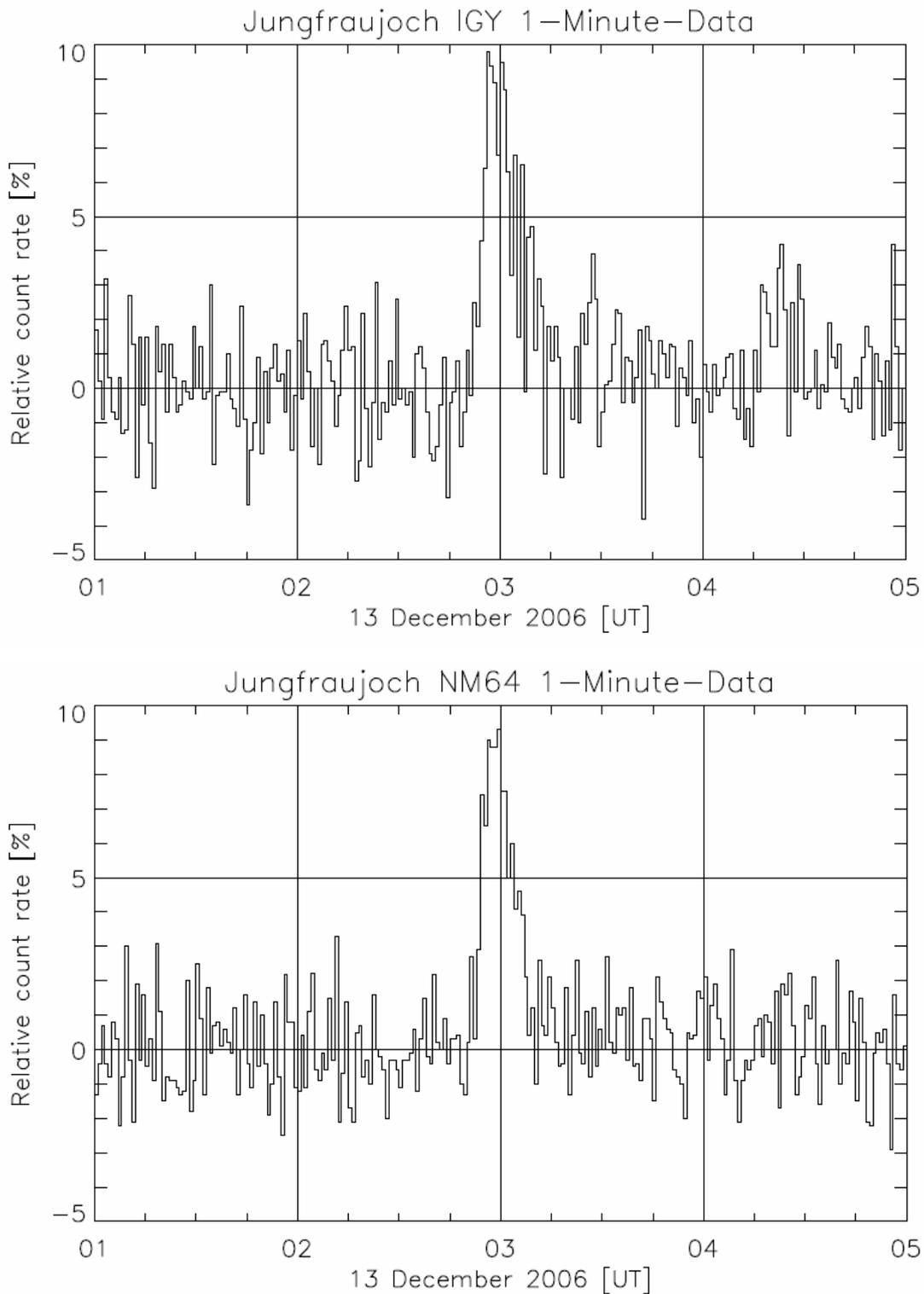


Figure 2: Relative pressure corrected 1-minute counting rates of the IGY (top) and the NM64 (bottom) neutron monitor at Jungfrauoch for 13 December 2006, 0100-0500 UT.

Key words:

Astrophysics, cosmic rays, neutron monitors; solar, heliospheric and magnetospheric phenomena

Internet data bases:

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<http://cosray.unibe.ch>

Collaborating partners/networks:

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International Council of the Scientific Union's (ICSU) Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)

World Data Centers A (Boulder), B (Moscow), C (Japan), International GLE database

Scientific publications and public outreach 2006:

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**Conference papers**

Flückiger, E.O., R. Bütikofer, M.R. Moser, and L. Desorgher, The Extreme Solar Cosmic Ray Particle Event on January 20, 2005, Annual Meeting of the Swiss Physical Society, 2006 in Lausanne, poster presentation.

Flückiger, E.O., R. Bütikofer, M.R. Moser, and L. Desorgher, The Ground Level Enhancement on January 20, 2005, in the Context of Extreme Solar Cosmic Ray Particle Events and Geomagnetic Super Storms, Asia Oceania Geosciences Society 3rd Annual Meeting, 10 - 14 July 2006 in Singapore.

Bütikofer, R., E.O. Flückiger, L. Desorgher, and M.R. Moser, Analysis of the GLE on January 20, 2005: an Update, 20<sup>th</sup> European Cosmic Ray Symposium, Lisbon, Portugal, to be published in the conference proceedings, 2006.

**Data books and reports**

Bütikofer, R., and E.O. Flückiger, Neutron Monitor Data for Jungfrauoch and Bern during the Ground-Level Solar Cosmic Ray Event on 13 December 2006, internal report, Space Research and Planetary Sciences, Physikalisches Institut, University of Bern, 2006.

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