Name of research institute or organization:

Physikalisches Institut, Universität Bern

Title of project:

Neutron Monitors - Study of solar and galactic cosmic rays

Project leader and team:

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

Project description:

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 ≥ 3.6 GeV and to solar neutrons with energies as low as ~250 MeV.

In 2005, operation of the two NMs at Jungfraujoch was pursued without major problems. No significant technical modifications were necessary. The recordings 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 daily counting rates of the IGY NM for 2005. The overall count rate of the NMs at Jungfraujoch shows a clear tendency to increase, in anticorrelation with solar activity. Although the sunspot activity cycle 23 is still on its decreasing phase approaching minimum, the Sun again had phases of very high activity e.g. in January and in September 2005. Between January 15 and 20, the solar active region NOAA 10720 produced five powerful solar flares. In association with this major solar activity, several pronounced variations in the ground-level cosmic ray intensity were observed. After a magnetic storm sudden commencement (ssc) on January 17, 2005, at 0748 UT the worldwide network of NMs recorded a significant global decrease in cosmic ray intensity, a so-called Forbush decrease (Fd). The IGY NM at Jungfraujoch observed a maximum decrease in the count rate of about -15 %, as can be seen in Figure 2. Three days later, on January 20, 2005, i.e. still during the Fd, NOAA AR 10720 produced its fifth flare, a X7.1 solar burst with onset time at 0636 UT and peak time at 0952 UT. The flare position on the Sun was at 14°N, 67°W, i.e. near the west limb, and therefore the Earth was well connected to the flare site along the inter-planetary magnetic field lines. Less than 15 minutes after the observation of the flare onset, the first relativistic solar particles arrived near Earth and a solar cosmic ray ground level enhancement (GLE) was observed by the worldwide network of NM stations. This GLE is ranked the second largest in fifty years with gigantic count rate increases at the south polar NM stations McMurdo (almost 3000 %) and South Pole (more than 5000 %). The two NMs at Jungfraujoch observed an increase in the counting rate of about 10 % in the 1-minute values. Both NMs at Jungfraujoch also observed a significant pre-increase in the time interval 0647-0649 UT. Figure 3 shows the relative 1-minute count rates of the IGY NM at Jungfraujoch for January 20, 2005, 0400-1200 UT, and Figure 4 the GLE observed by the NM stations South Pole, Inuvik, Barentsburg, and Jungfraujoch. Figure 4 clearly illustrates the complexity of the event.

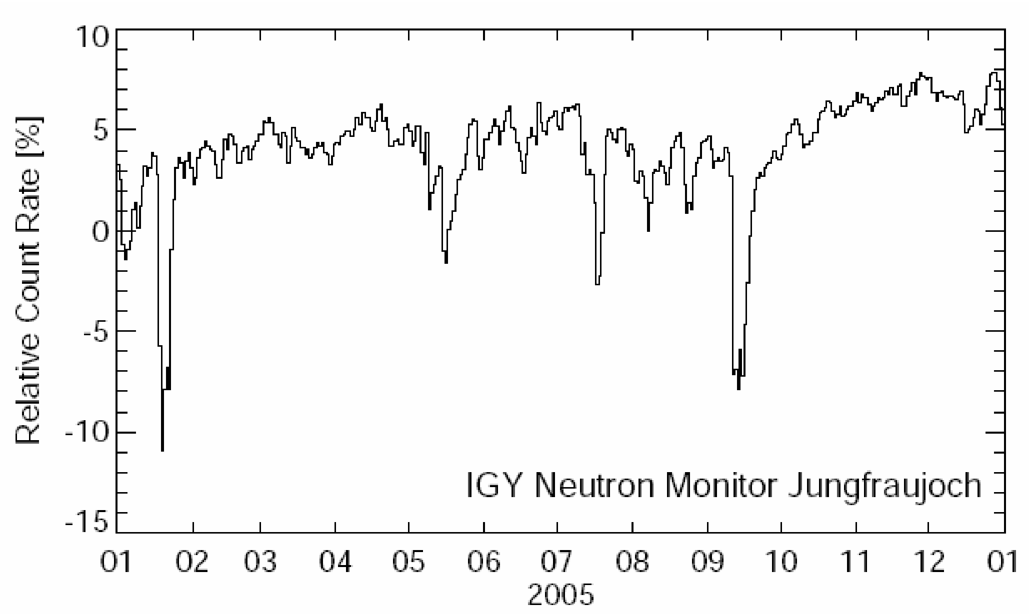

Figure 1: Relative pressure corrected daily counting rates of the IGY NM at Jungfraujoch for 2005.

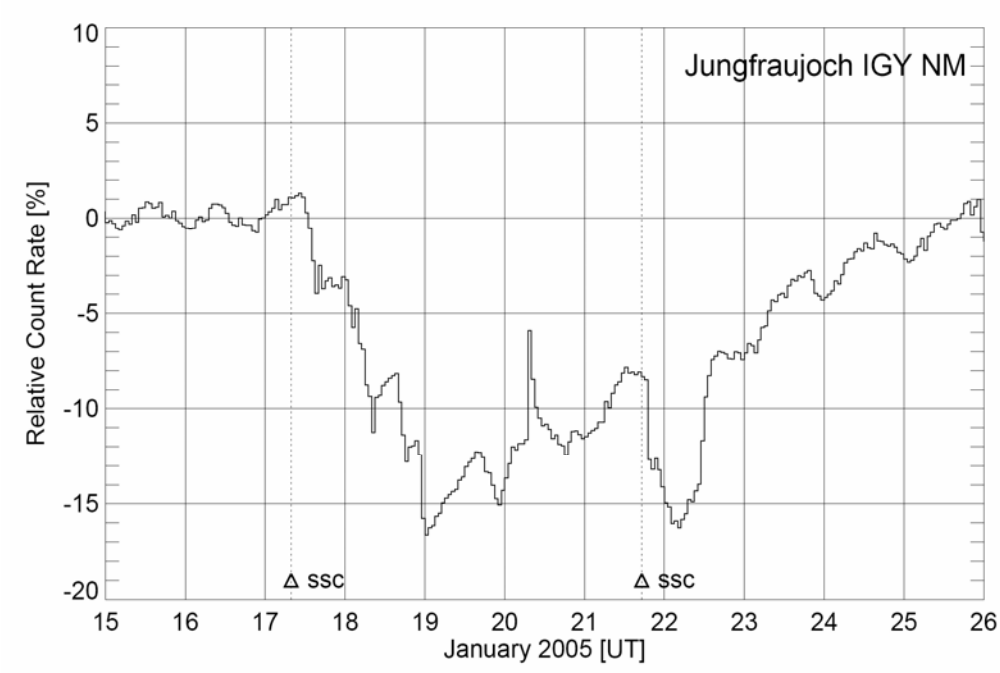

Figure 2: Relative pressure corrected hourly counting rates of the IGY NM at Jungfraujoch for the time interval 15-25 January 2005.

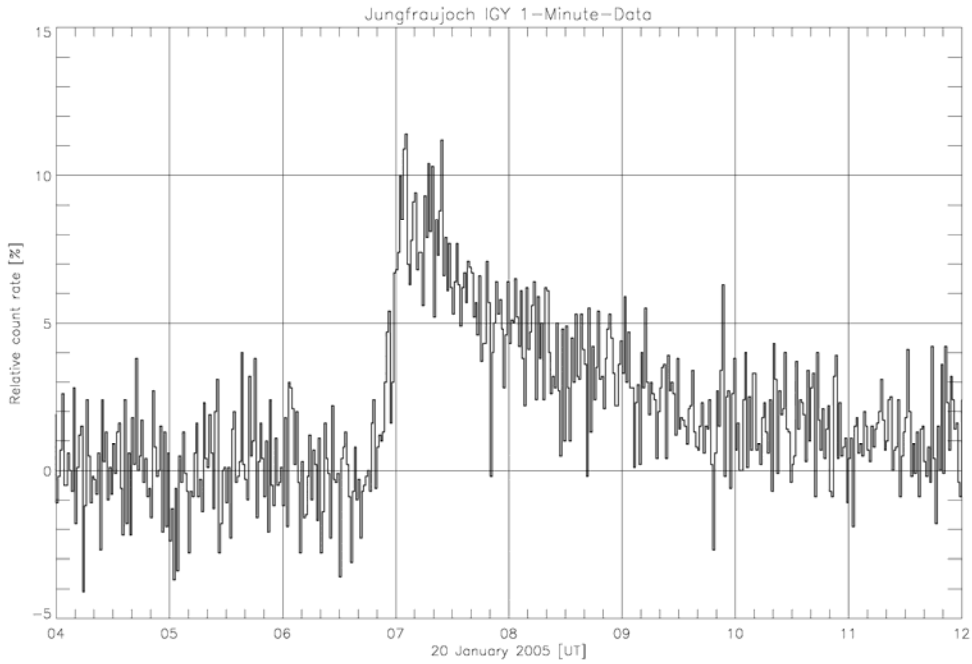

Figure 3: Relative pressure corrected 1-minute counting rates of the IGY NM at Jungfraujoch for January 20, 2005, 0400-1200 UT.

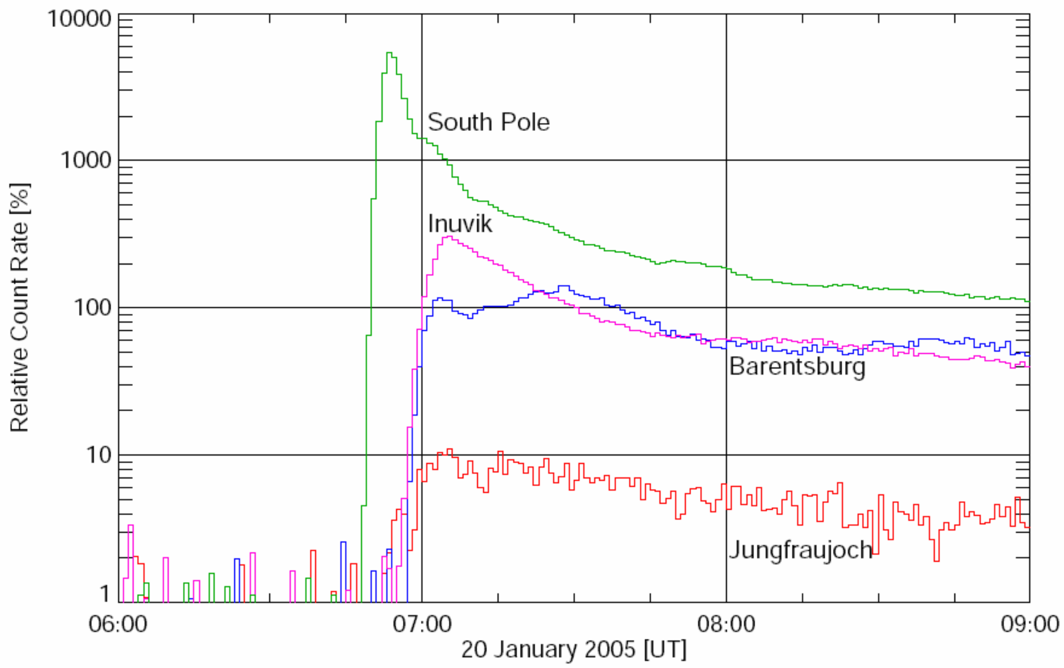

Figure 4: Relative pressure corrected 1-minute counting rates of the NM stations South Pole, Inuvik, Barentsburg and Jungfraujoch (IGY and NM64 combined) for January 20, 2005, 0400-1200 UT.

From the recordings of the Swiss cosmic ray detectors and of the worldwide network of NMs, we determined the characteristics of the solar particle flux near Earth (spectral form, amplitude, pitch angle distribution). Due to the fact that the groundbased cosmic ray detectors around the world measured significantly different and complex intensity-time profiles, the determination of the GLE parameters has proved rather difficult. This GLE was characterized by a very narrow beam of solar cosmic ray particles (protons) during the first minutes of the event, but already some minutes after the event onset the particle flux was clearly less anisotropic. The energy spectrum changed from very hard at the beginning of the GLE to a very soft spectrum within ~10 minutes. However, it seems that the spectrum became again somewhat harder later in the event. This may be an indication for a second population of solar cosmic rays that was accelerated during a second phase of the event. In Figure 5 the directional solar proton flux, $J_{\parallel}$, in the presumed source direction, is plotted for the initial, the main, and the decay phase as recorded by the south polar stations. For comparison the galactic cosmic ray spectrum as of January 2005 is also shown. The detailed analysis of this unique event is still in progress. First findings have been reported at three international conferences.

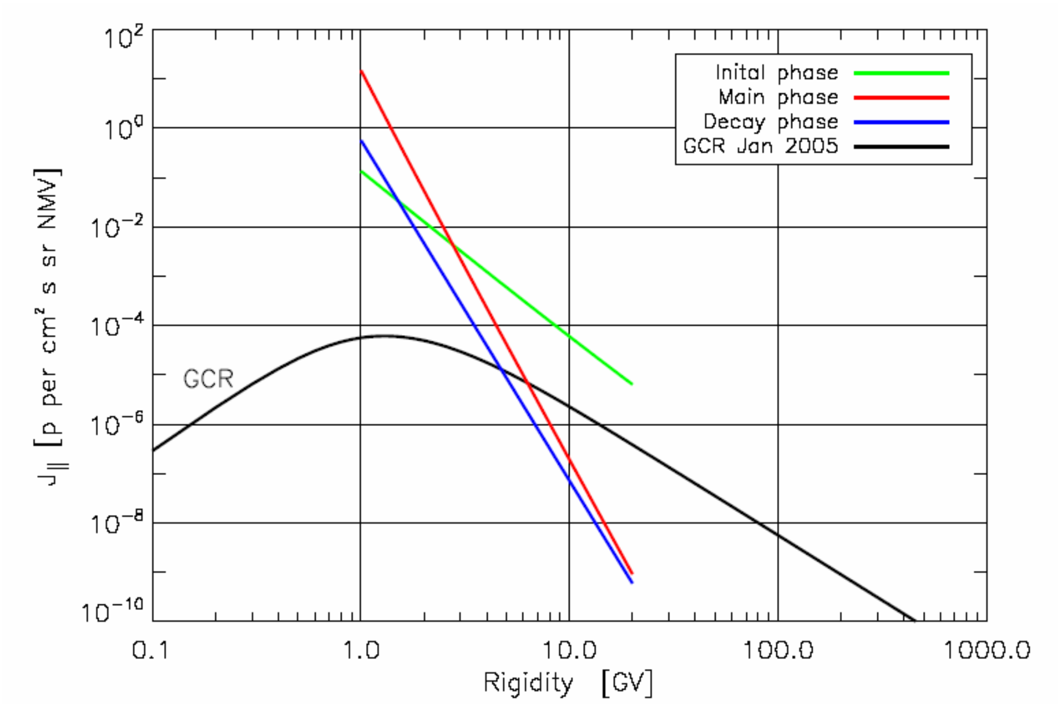

Figure 5: Solar cosmic ray ($J_{\parallel}$) and galactic cosmic ray (GCR) spectra near Earth during the giant solar particle event on January 20, 2005.

Key words:

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

Internet data bases:

http://cosray.unibe.ch

Collaborating partners/networks:

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 2005:

Conference papers

Flückiger, E.O., R. Bütikofer, M.R. Moser, and L. Desorgher, The Cosmic Ray Ground Level Enhancement and the Forbush Decrease in January 2005 - Analysis of the Swiss Cosmic Ray Observations, contributed paper 58-ST-A1500, 2nd Annual Meeting of the Asia Oceania Geosciences Society (AOGS), Singapore, 2005.

Flückiger, E.O., R. Bütikofer, M.R. Moser, and L. Desorgher, The Cosmic Ray Ground Level Enhancement during the Forbush Decrease in January 2005, 29th International Cosmic Ray Conference, Pune, India, August to be published in the conference proceedings, 2005.

Belov, A. V., L. Baisultanova, R. Bütikofer, E. Eroshenko, E. O. Flückiger, G. Mariatos, H. Mavromichalaki, V. Pchelkin and V. G. Yanke, Geomagnetic effects on cosmic rays during the very strong magnetic storms in November 2003 and November 2004, 29th International Cosmic Ray Conference, to be published in the conference proceedings, 2005.

Yanke, V. G., L. Baisultanova, A. V. Belov, R. Bütikofer, E. Eroshenko, E. O. Flückiger, G. Mariatos and H. Mavromichalaki, Variations of geomagnetic cutoff rigidities during the series of geomagnetic storms in January 2005: observations and modeling, 29th International Cosmic Ray Conference, to be published in the conference proceedings, 2005.

Bütikofer, R., E.O. Flückiger, M.R. Moser, and L. Desorgher, The Extreme Cosmic Ray Ground Level Enhancement on January 20, 2005, Solar Extreme Events 2005 (SEE-2005), International Symposium at Nor Amberd, Armenia, to be published in scientific journal Sun and Geosphere, 2005.

Flückiger, E. O., Extreme events and super storms, Invited Talk, Solar Extreme Events 2005 (SEE-2005): Fundamental Science and Applied Aspects, International Symposium at Nor Amberd, Armenia, 2005.

Data books and reports

Bütikofer, R., and E.O. Flückiger, Neutron Monitor Data for Jungfraujoch and Bern during the Ground-Level Solar Cosmic Ray Event on 20 January 2005, internal report, Space Research and Planetary Sciences, Physikalisches Institut, University of Bern, 2005.

Address:

Physikalisches Institut
Universität Bern
Sidlerstrasse 5
CH-3012 Bern

Contacts:

Rolf Bütikofer
Tel.: +41 31 631 4058
Fax: +41 31 631 4405
e-mail: rolf.buetikofer@phim.unibe.ch
URL: http://cosray.unibe.ch