Neutron monitors – Study of solar and galactic cosmic rays

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1. Project description

The Physics Institute at the University of Bern, Switzerland, operates two standardized neutron monitors (NMs) 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 (GCR) with the plasma and the magnetic fields in the heliosphere and about the production of energetic CRs at or near the Sun (solar cosmic rays, SCR), as well as about geomagnetic, atmospheric, and environmental effects. The NMs at Jungfraujoch are part of a worldwide network of standardized CR detectors. By using the Earth's magnetic field as a giant spectrometer, this network determines the energy dependence of primary CR intensity variations near Earth in the energy range ~500 MeV to ~20 GeV. Thereby, NMs ideally complement space observations, which mainly cover the energy range below the range of NMs.

Furthermore, the high altitude of Jungfraujoch provides a good response to solar protons ≥3.6 GeV and to solar neutrons with energies as low as ~250 MeV. NMs also play an important role in the space weather domain.

In 2022, operation of the two NMs at Jungfraujoch was pursued without major problems. The recordings of the NM measurements are published in near real-time in the NM database NMDB (http://www.nmdb.eu). Figure 1 shows the relative monthly count rates of the IGY NM at Jungfraujoch (lower panel) since it was put into operation in 1958. The GCR are always present, and their intensity shows an 11-year variation in anti-correlation with the solar activity characterized by the smoothed sunspot number plotted in the upper panel of Figure 1.

Since 08 October 2022 the old data taking system at the IGY NM, which was in operation in parallel to the new Kiel system since October 2020, was stopped.

End of November 2022 Stephan Böttcher and Jonas Zumkeller from the University of Kiel integrated the new data taking system in the NM64 NM and changed the current Kiel system at the IGY NM on the roof of the Sphinx building at Jungfraujoch. With the new data taking system of the IGY NM, it is possible to survey additionally to the count rate also the count rate as function of the trigger level of the counting impulse voltage during ongoing operation of the NM. First investigations have shown that the counting impulse spectrum of one section of counter tubes may not be stable. Further observations are needed.

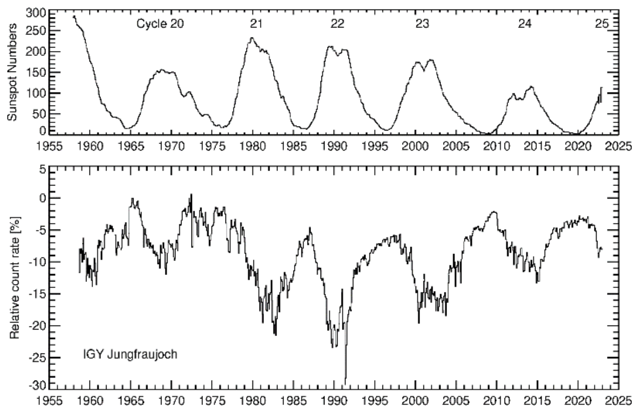

Figure 1. Smoothed monthly total sunspot numbers (Source: WDC-SILSO, Royal Observatory of Belgium, Brussels (www.sidc.be/silso/datafiles), top panel), relative pressure corrected monthly average counting rates of IGY NM at Jungfraujoch (bottom panel) for the years 1958-2022. The NM count rate is expressed in relative units with respect to May 1965.

Since September 2002 a radiation monitoring unit "GammaTracer" is operated in the detector housing of the NM64 NM as was reported in previous activity reports, see e.g. the activity report of 2002 (http://www.hfsjg.ch/reports/2002/pdf/30.pdf). The GammaTracer device is now in operation for more than 20 years, i.e. during a time period over almost two solar cycles. Figure 2 shows the measured monthly mean photon dose rate in [nSv/h] over the whole measuring period. The data gap in 2006 is caused by the exchange of the battery in the GammaTracer device by the manufacturer Genitron Instruments GmbH, Frankfurt, Germany. In 2013 we let rebuild the GammaTracer so that it is supplied via a power supply instead of a battery. This caused a longer measurement interruption.

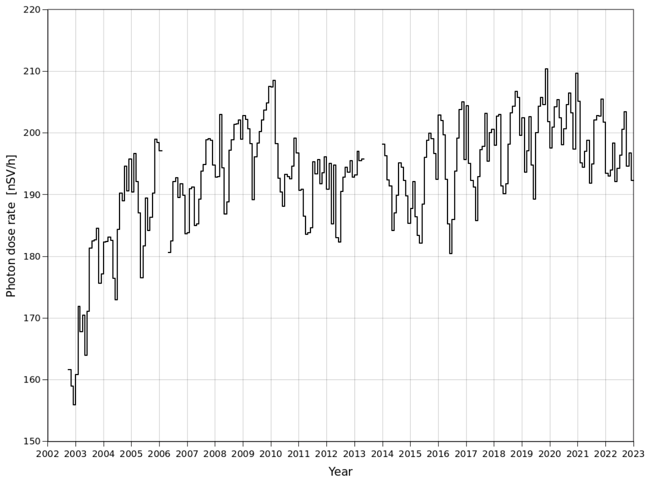

Figure 2. Monthly mean photon dose rates as measured by the GammaTracer within the detector housing of the NM64 NM on the roof of the research station Jungfraujoch, for details see the text.

After 2002 the solar activity showed a clear decrease (see Figure 1, top panel) and as a consequence an increase in the intensity of GCR in the heliosphere is expected. Indeed, the measurements of the GammaTracer showed a pronounced increase during the years 2003/2004 (see Figure 2) which was also observed by the NMs at Jungfraujoch (see Figure 1, bottom panel) as well as by the worldwide network of NMs. The maximum in the data of the GammaTracer was reached at end of 2009 / beginning of 2010. The NM data of the worldwide network showed a broader time range with maximum count rate as can be seen for the IGY NM Jungfraujoch in Figure 1 (bottom panel). From 2011 until about 2014 the GammaTracer seems to observe about constant gamma radiation dose rate at a somewhat decreased level. After 2015 it seems that the GammaTracer shows again a small increase in the photon dose rate. However, this increase is much less pronounced in comparison to the epoch of 2003/2004. During the whole considered time period, the data shows almost during every year a local minimum during spring time which is caused by the snow accumulation behind and on the roof of the detector housing. To eliminate the seasonal variations, Figure 3 shows the relative mean yearly photon rates of the GammaTracer at Jungfraujoch and the relative yearly mean relative count rates of the NM64 NM. The maximum GCR intensity near Earth during solar cycle 24 as measured by the worldwide network of NMs including the two NMs at Jungfraujoch was observed during the year 2009. Also the yearly mean values of the GammaTracer showed a maximum during 2009. The decrease in the count rate of the NM64 NM Jungfraujoch to the minimum in 2014 was about 12% whereas the decrease in the photon rate of the GammaTracer at Jungfraujoch showed a less pronounced decrease of about 5%. The maximum GCR intensity near Earth during solar cycle 25 seems to be in the data of the GammaTracer as well as in the Jungfraujoch NMs during the year 2020. Afterwards with increasing solar activity, the NM64 NM showed a distinct decrease in the counting rate (Figure 1, bottom panel). This decrease of the GCR was seen in the data by the GammaTracer only faintly. A possible cause of this behaviour may be the less distinct variations in the current solar activity cycles (Figure 1, top panel). The continuation of the measurements with the NMs and the GammaTracer at Jungfraujoch may give information to understand the different behaviour of the measurements.

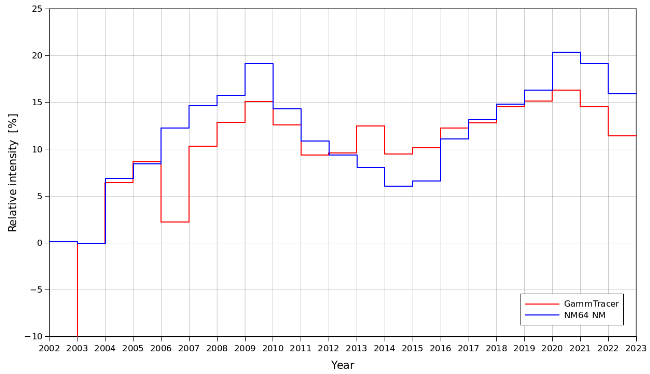

Figure 3. Mean yearly relative photon rate of the GammaTracer at Jungfraujoch (red line) and mean yearly count rate of the NM64 NM Jungfraujoch (blue line). The GammaTracer radiation measurements and the NM count rate are expressed in relative units with respect to the year 2003.

Internet data bases

http://cosray.unibe.ch
http://www.nmdb.eu

Collaborating partners / networks

European FP7 Project Real-Time Database for High Resolution Neutron Monitor Measurements (NMDB): http://www.nmdb.eu
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