Name of research institute or organization:

Physikalisches Institut, Universität Bern

Title of project:

SONTEL - Solar Neutron Telescope for the identification and the study of high-energy neutrons produced in energetic eruptions at the Sun

Project leader and team

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Project description:

The solar neutron telescope (SONTEL) at Gornergrat, Switzerland, has been in operation since 1998 as the European cornerstone of a worldwide network for the study of high-energy neutrons produced in energetic processes at the Sun. In 2004 SONTEL worked 99.5 % of the time. During this past year no high-energy solar event occurred from which solar neutrons could be expected.

In 2004 we continued the analysis of the cosmic ray measurements of October/November 2003. From a very energetic solar flare (X17.2) on October 28, 2003, a coronal mass ejection was emitted at a high speed directly towards the Earth, leading to a dramatic depression in the cosmic ray flux near Earth at the end of October / beginning of November 2003. The worldwide network of ground-based cosmic ray detectors measured a decrease in the count rates, a so-called Forbush decrease (Fd). In Figure 1 the relative count rates of the IGY neutron monitor at Jungfraujoch and of SONTEL are plotted for the time period 25 October to 8 November 2003. During the main phase of this Fd the data of SONTEL exhibited a special feature as can be seen in Figure 2. In all four energy ranges 40-80, 80-120, 120-160, >160 MeV the ratio of the count rates of the two SONTEL particle channels (*charged+neutral*) and (*neutral*) shows a clear step-like increase of 2-3%, with onset around 10 UT on October 29, 2003, that lasted ~3 days, and then decreased slowly over a period of ~5 days.

This phenomenon has been investigated with Monte Carlo simulations of the cosmic ray cascades in the Earth's atmosphere and of the interactions of the secondary cosmic ray particles within the detector. In order to explain the SONTEL measurements different effects were simulated: modulation of primary cosmic ray spectrum, cutoff variation (minimal energy of a cosmic ray particle to reach the top the Earth atmosphere through the geomagnetic field), and change of the muon component (produced in collisions of cosmic ray particles with nuclei of the Earth’s atmosphere). The results folded with the simulated detector response function do not yet allow to fully explain the observations. To completely understand the role of the different effects in the observed phenomenon further investigations are needed.

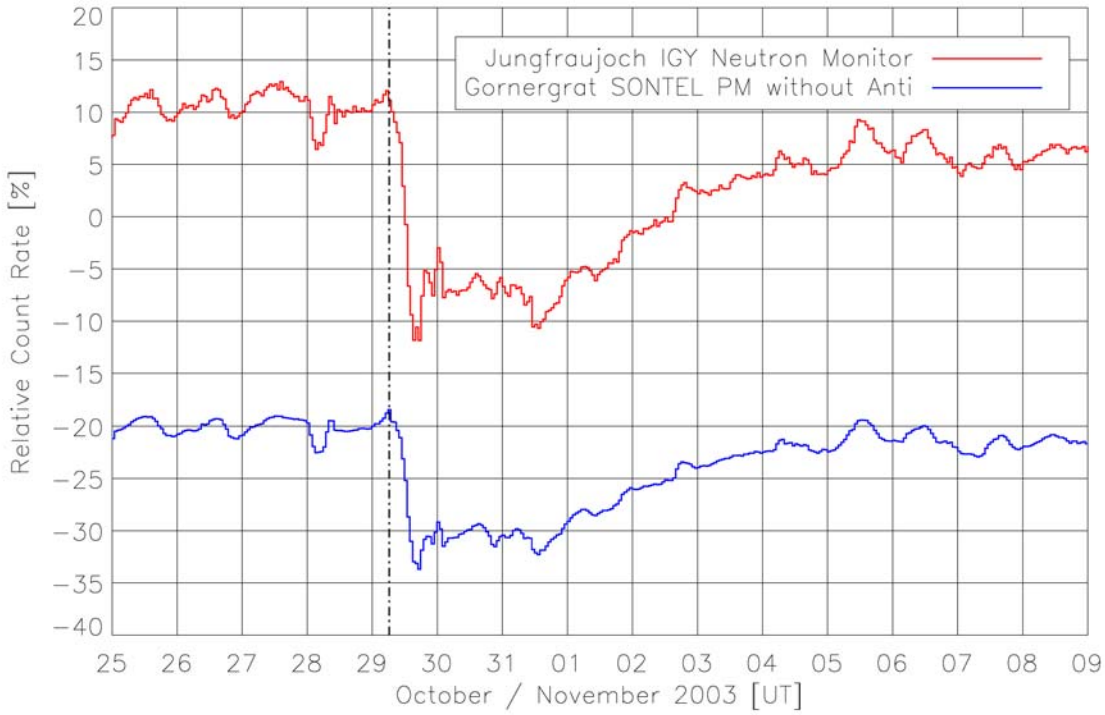

Figure 1: Relative count rates of IGY neutron monitor (red line) and of SONTEL at Gornergrat (blue line).

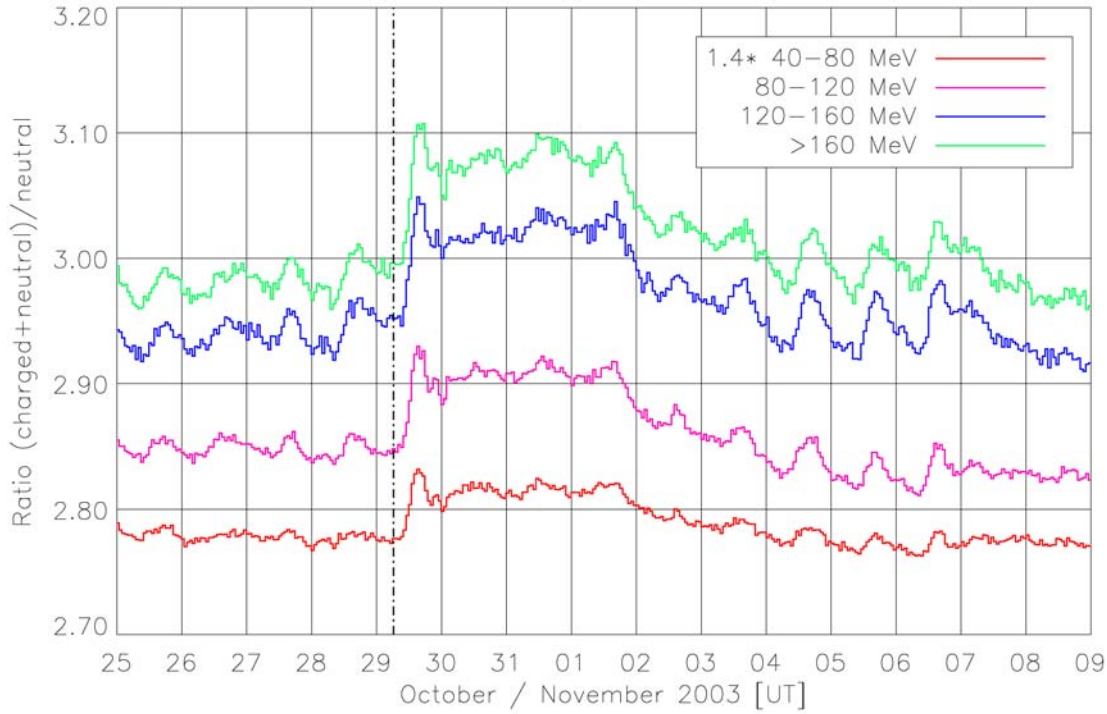

Figure 2: Ratio of the count rates of the two SONTEL particle channels (charged+neutral) and neutral. Time series are shown for the time-interval October 25 to November 8, 2003 (hourly values, pressure corrected data). The vertical dashed-dotted line indicates the passage of the coronal mass ejection over the Earth.

In the period covered by this report a special study was also conducted for a better understanding of the characteristics of the SONTEL detector. In August 2004 the energies of the four discriminator levels were measured by using the muon flux of the secondary cosmic radiation in the Earth's atmosphere. The measurements showed that the different energy channels are somewhat lower than supposed and that the boundaries are not sharp. This can explain the increases in the count rates of the lowest energy channels that coincide with outgassing radon from the ground and with radioactive wash out during precipitations (see our activity report 2003). Figure 3 shows the distribution of the deposited energies in the scintillators of SONTEL that are counted in the energy channel 40-80 MeV.

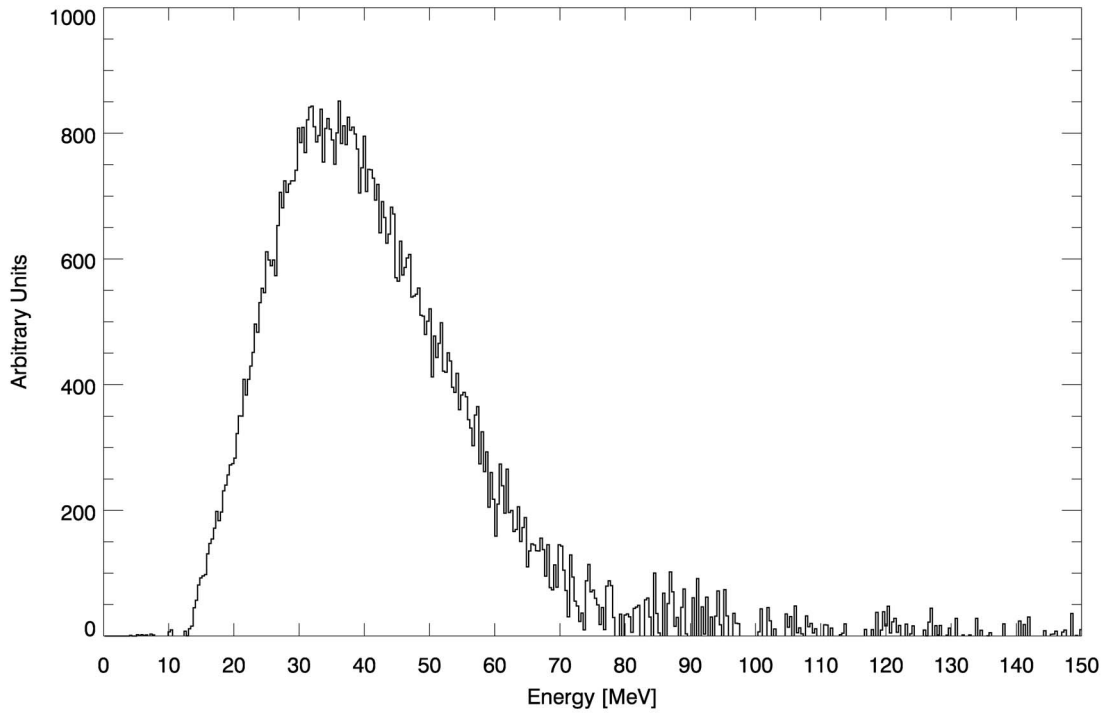

Figure 3: Distribution of the deposited energies in the scintillators of SONTEL that are counted in the energy channel 40-80 MeV.

Key words:

Astrophysics, cosmic rays, solar neutrons

Internet data bases:

http://cosray.unibe.ch
http://stelab.nagoya-u.ac.jp/ste-www1/div3/CR/ Neutron/index.html

Collaborating partners/networks:

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Scientific publications and public outreach 2004:

Conference papers

Flückiger, E.O., R. Bütikofer, L. Desorgher, M.R. Moser, Y. Muraki, Y. Matsubara, T. Sako, H. Tsuchiya, and T. Sakai, The giant Forbush decrease in October/November 2003: Data analysis for the solar neutron detector at Gornergrat, 19th European Cosmic Ray Symposium, Proceedings, Florence, Italy, 2004, to be published in the International Journal of Modern Physics A.

Moser, M.R., E.O. Flückiger, R. Bütikofer, L. Desorgher, Y. Muraki, Y. Matsubara, T. Sako, H. Tsuchiya, and T. Sakai, The extreme solar events and the giant Forbush decrease in October/November 2003: analysis of ground-based cosmic ray data (abstract), COSPAR 2004, Paris, 2004.

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