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:

Prof. Erwin Flückiger, project leader
Dr. Rolf Bütikofer, Dr. Benoît Pirard

Project description:

The solar neutron telescope (SONTEL) at Gornergrat, Switzerland, has been in continous 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 [Flückiger, E. O., R. Bütikofer, Y. Muraki, Y. Matsubara, T. Koi, H. Tsuchiya, T. Hoshida, T. Sako and T. Sakai, A New Solar Neutron Telescope At Gornergrat, Proc. 16th European Cosmic Ray Symposium, rayos cósmicos 98, 219, Universidad de Alcalá, Spain, 1998]. Since 2002 the environmental radiation at Gornergrat has also been monitored by a conventional GammaTracer unit designed and manufactured by Genitron Instruments GmbH, Frankfurt, Germany.

In 2008 the operation of SONTEL and of the GammaTRACER was continued. The solar acticity during 2008 was very low, and no solar flare candidates were observed that could have emitted a solar neutron flux observable at ground level.

In the absence of new events the research work of the solar neutron community during the report period was characterized by the comprehensive analysis of the solar neutron event on 7 September 2005. This event occurred in association with an X17 flare shortly after 1730 UT. As illustrated in Figure 1 the zenith angle of the Sun at European longitudes at this time of the day was too large for solar neutrons to be observed at Gornergrat. However, the American continent was in an optimal position. The Solar Neutron Telescopes and neutron monitors located at Mount Chacaltaya, Bolivia, and Sierra Negra, Mexico, recorded a clear solar neutron signal with statistical significance of more than 10σ (Figure 2). The increase in the counting rates lasted for more than 20 minutes. This is the first solar neutron event during which Solar Neutron Telescope records provided spectral information by the different energy channels. Beside the solar neutron signal, intense emissions of gamma-rays were also observed on the INTEGRAL (INTErnational Gamma-Ray Astrophysics Laboratory) satellite, and during the decay phase of the event by the gamma ray detectors on the RHESSI (Reuven Ramaty High Energy Solar Spectroscopic Imager) satellite. From their analyis Watanabe et al. [Watanabe, K., S. Krucker, R. Lin, R. Murphy, G. Share, M. Harris, and M. Gros, Physics of ion acceleration in the solar flare on 7 September 2005 determines gamma-ray and neutron production, 37th COSPAR Scientific Assembly, 13-20 July 2008, Montreal, Canada., p.3429] concluded that relativistic solar neutrons were produced at the same time as the gamma-ray line emission and that ions were accelerated continuously at the emission site.

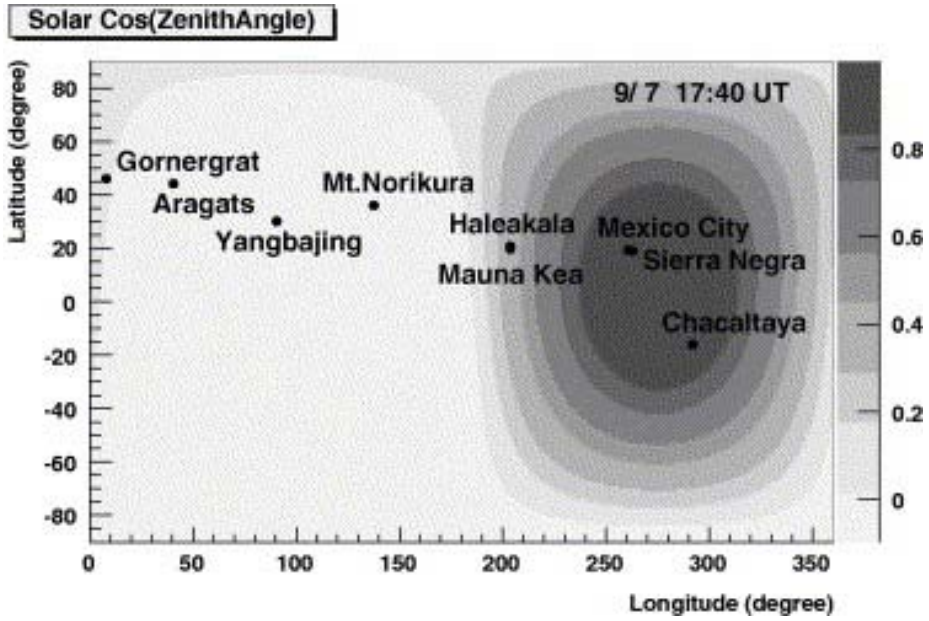

Figure 1: The cosine of the zenith angle of the Sun at 17:40 UT on 7 September 2005 as a function of geographic longitude and latitude. Points represent locations of the neutron detectors [from Watanabe, K., et al., Advances in Space Research, **39**(9), 1462-1466, 2007, doi:10.1016/j.asr.2006.10.021].

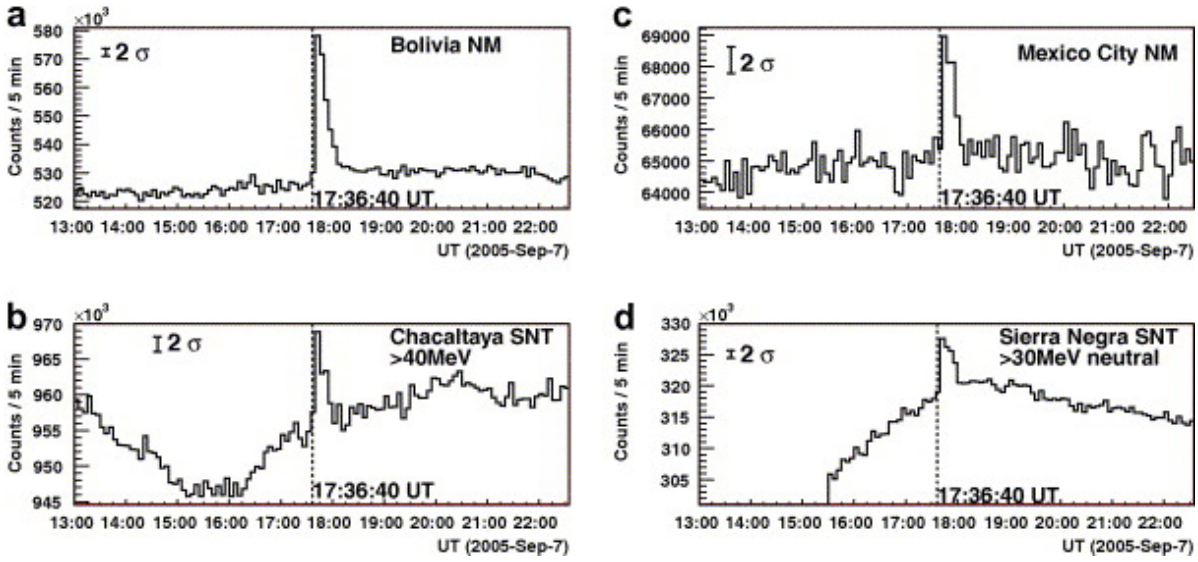

Figure 2: The solar neutron event on 7 September 2005. The plot shows the 5 min counting rate observed by the Bolivia neutron monitor (a), Bolivia solar neutron telescope (>40 MeV channel) (b), Mexico City neutron monitor in Mexico (c), and Sierra Negra solar neutron telescope in Mexico (>30 MeV neutral channel) (d). For the (d), no data were recorded before 15:30 UT due to a blackout [from Watanabe, K., et al., Advances in Space Research, **39**(9), 1462-1466, 2007, doi:10.1016/j.asr.2006.10.021].

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

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Scientific publications and public outreach 2008:

Refereed journal articles

Muraki, Y., Y. Matsubara, S. Masuda, S. Sakakibara, T. Sako, K. Watanabe, R. Bütikofer, E.O. Flückiger, A. Chilingarian, G. Hovsepyan, F. Kakimoto, T. Terasawa, Y. Tsunesada, A. Velarde, P. Evenson, J. Poirier, T. Sakai, Detection of High-Energy Solar Neutrons and Protons by Ground Level Detectors, accepted for publication in Astroparticle Physics, Astroparticle Physics, 29, 229-242, doi:10.1016/j.astropartphys.2007.12.007, 2008.
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