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) has been in operation at Gornergrat since 1998. It represents the European cornerstone of a worldwide network of low- and medium-latitude, high-altitude detectors (as shown in Figure 1) for the identification and the study of high-energy neutrons produced in energetic eruptions at the Sun. Observations of solar neutrons can provide unique information on the acceleration of particles in association with solar flares and coronal mass ejections.

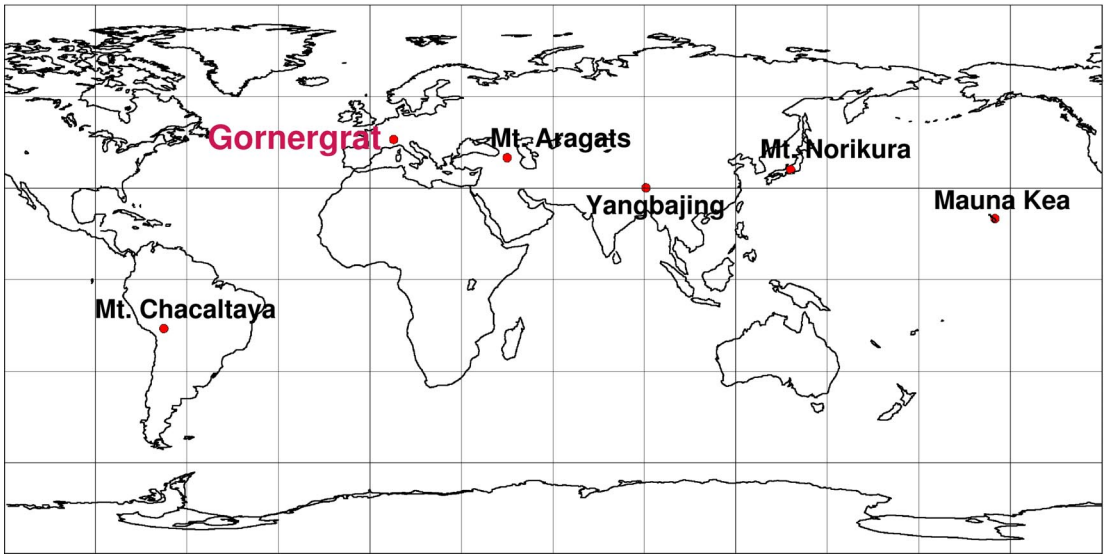


Figure 1: The worldwide network of Solar Neutron Telescopes.

Although SONTEL was in continuous operation during 2002, no solar neutron events were recorded. However, in December 2002, with the Sun showing no evidence for high-energy activity, we again observed a period of increased count rates in association with enhanced environmental radioactivity. This event is similar to the one recorded in April 2001, the cause of which is still unknown.

Several additions were made to the instrumentation. The installation of a new and more powerful uninterruptible power supply (UPS) in March 2002 has clearly

improved the reliability in the operation of the detector. The interesting environmental radioactivity measurements made during a campaign in spring 2001 prompted us to permanently operate a radioactivity monitoring unit in the laboratory container of SONTEL. We installed the same type of environmental radioactivity monitoring unit as used during the 2001 campaign, i.e. a "Gamma Tracer" unit manufactured by Genitron Instruments GmbH, Frankfurt am Main, Germany. For comparison, another "Gamma Tracer" unit was placed in the detector housing of the NM64 neutron monitor at Jungfraujoch. We are convinced that additional measurements will finally help us in identifying the cause of these intensity increases.

For a proper interpretation of the SONTEL recordings, it is essential to know the relationship between the counting rates of the detector and the primary particle flux penetrating the Earth's atmosphere. This relationship can hardly be determined experimentally. Within the scope of his diploma thesis, Michael Moser developed two Monte Carlo applications to determine the detector properties of SONTEL at Gornergrat theoretically. The Monte Carlo codes are based on CERN's GEANT3 libraries, which allow the simulation of the interaction processes of radiation with matter. With an unprecedented degree of particularization, the first application calculates the efficiencies of the various SONTEL channels for neutrons, protons, muons, electrons, and gamma-radiation in the energy range 40 MeV – 20 GeV. The second GEANT3 application determines the secondary particle spectra in the atmosphere above the detector as function of the primary neutron energy. Together, the two programs allow the simulation of the detector response to solar neutrons during solar cosmic ray events. The simulation of a solar neutron event of the same magnitude and type as the one on June 3, 1982, showed that the lowest energy neutron channel of SONTEL can identify solar neutrons above ~ 400 MeV with a significance of up to $\sim 10\sigma$ in the one-minute values. In Figure 2 the simulated relative one-minute counting rates of the SONTEL neutron channels for the June 3, 1982, solar neutron event are compared with the measurements of the 18-IGY neutron monitor at Jungfraujoch. As can be seen, the simulated response of SONTEL is comparable in amplitude with the response of the neutron monitor. In contrast to the neutron monitor recordings, however, the SONTEL data allow for a clear identification of the intensity increase as a solar neutron event via the comparison of the count rates in the SONTEL energy channels with and without anticoincidence of the scintillators and the proportional counters acting as a veto shield. The simulations also revealed certain limitations of SONTEL in its present configuration in providing information on the primary neutron spectrum and the solar neutron arrival direction.

The developed Monte Carlo applications are a convenient tool to simulate possible improvements of the SONTEL detector such as the optimal choice of the discriminator levels or the installation of additional absorbers for an enhanced directional resolution.

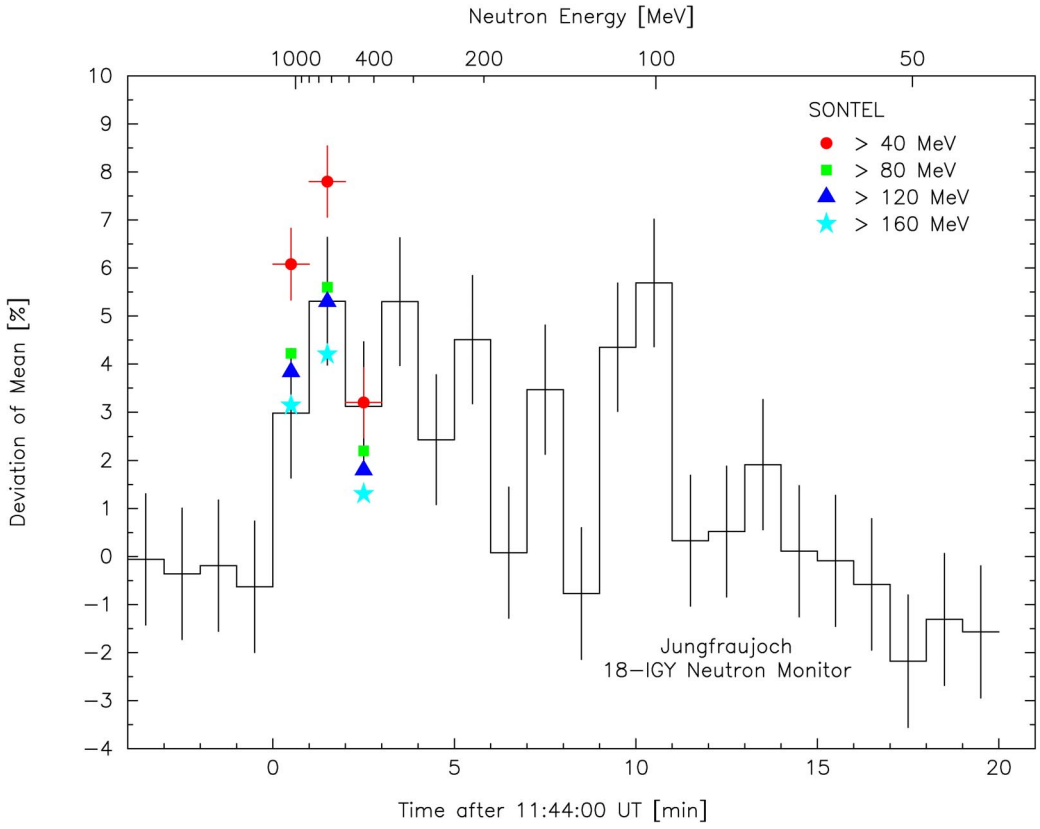


Figure 2: Increase in the 18-IGY neutron monitor counting rate at Jungfraujoch recorded during the solar neutron event on June 3, 1982. The simulated relative increases in the SONTEL neutron channels > 40, > 80, > 120, and > 160 MeV are indicated for three one-minute intervals during the maximum of the solar neutron event.

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Key words:

Astrophysics, cosmic rays, solar neutrons

Internet data bases:

http://kspc4.unibe.ch/sontel.html
http://stelab.nagoya-u.ac.jp/ste-www1/div3/CR/ Neutron/index.html

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Scientific publications and public outreach 2002:

**Conference papers**

Flückiger, E.O., R. Bütikofer, and M.R. Moser, Cosmic Ray Measurements at Jungfraujoch and Gornergrat, Proc. Workshop on 'Atmospheric Research at the Jungfraujoch and in the Alps', Davos, Switzerland, 20 September 2002, Swiss Academy of Sciences SAS, 54-55, 2002.

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**Thesis**

Moser, M.R., Solar Neutron Telescope Gornergrat - Monte Carlo Simulation of Detector Properties, Diploma Thesis, Universität Bern, 2002. Available at http://kspc4.unibe.ch/sontel.html

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