Detector for high-energy solar neutrons at Gornergrat

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Introduction

Since 1998 the solar neutron detector at Gornergrat has been in operation as the European cornerstone of a worldwide network for the study of high energy neutrons produced during energetic processes 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. The first identification of a solar neutron event by ground-based detectors on 3 June, 1982, [1,2] initiated extensive theoretical and experimental work on the production of solar neutrons in high-energy processes at the Sun, their propagation to ~1 AU, and their detection near and at the Earth. One part of the activities was setting up standardized neutron monitors at favourable observational locations, such as Haleakala, Hawaii. Another part was the development of new ground-based detectors with enhanced sensitivity for solar neutrons, [e.g. 3,4]. The "World Neutron Network", initiated by the Solar-Terrestrial Environment Laboratory of the Nagoya University, includes the following stations besides Gornergrat: Mt. Norikura, Japan (138°E, 36°N, 2770m asl), Mt. Chacaltaya, Bolivia (68°W, 16°S, 5250m asl), Mauna Kea, Hawaii (155°W, 20°N, 4200m asl), and Mt.Aragats (45°E, 40°N, 3500m asl).

The detector consists of a horizontal matrix of plastic scintillators. In its initial configuration the scintillators were surrounded at the top and at two sides by proportional counters which veto charged particles [5]. Neutrons are identified by the scintillators in anticoincidence with the veto counters. The detector is capable of determining the energy of incoming neutrons by measuring the energy deposition along the total track length of protons produced inside plastic scintillators by n-p reactions. Scintillation flashes in each scintillator are collected by a photomultiplier. The pulse height obtained by each photomultiplier is discriminated at four levels, which correspond to an energy of a recoil proton of 40 MeV, 80 MeV, 160 MeV, and 240 MeV.

Upgrading of the detector

In autumn 1999 additional proportional counters were added. Four counter units with a total of 32 counter tubes were added on the two open sides of the detector (south and north) to complete the veto system. For the determination of the direction of incoming neutrons, two layers of 20 proportional counters each were added at the bottom under

the plastic scintillators. The counters are aligned in the east-west direction. The final configuration of the whole detector is illustrated in Figure 1.

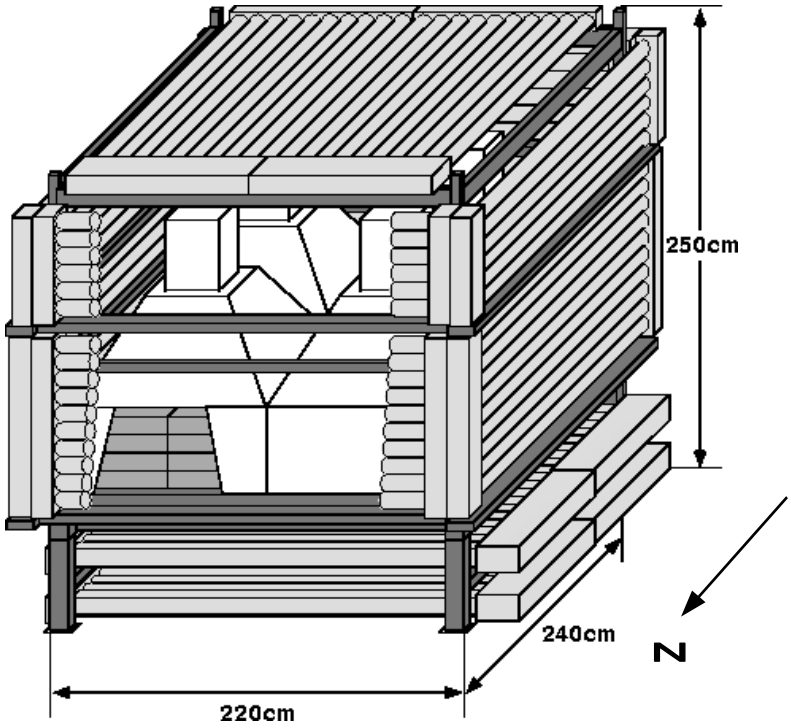

Figure 1: Configuration of the Gornergrat solar neutron detector.

The direction of recoil protons is determined by measuring coincidences between the two bottom layers of proportional counters, as illustrated schematically in Figure 2. Coincidences between two counter tubes in the upper and lower layer with 0, ±1, ±2 horizontal counter tube displacements are measured. Thus we can roughly distinguish among the following zenith angles: 45°N, 30°N, 0°, 30°S and 45°S. By using the directional information it can be ensured that a measured increase in the count rate of the scintillators in anticoincidence with the veto counters during a solar event is due to neutrons coming from the Sun's direction, i.e. solar neutrons.

During the period covered by this report a computer program was developed which automatically transfers the data twice per day via internet from Gornergrat to a server at the University Bern, and generates a webpage of the measurements in near real-time (kspc4.unibe.ch/sontel.html). It is expected that the detector will play an essential role in the study of solar neutron events during the phase of declining activity of solar cycle 23.

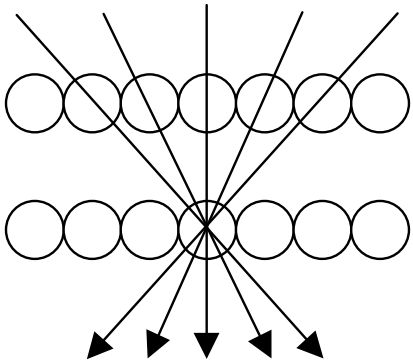

Figure 2: Cross-section in the north-south direction of the bottom proportional counters illustrating the principle for determing directional information. For details see the text.

References:

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