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Cosmic Ray measurements at Lomnický Peak: possibilities of developments in CCS

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Abstract. Basic characteristics of measurements provided by the neutron monitor (NM) at Lomnicky Peak are shortly presented. The aims and expected acquisition of the cosmic ray (CR) measurements in IEP SAS via the support from EU fund in the newly established „Centre of Space Research: Space Weather Influences“ (CCS) are discussed.

Key words: cosmic rays – space weather

1. Introduction

One type of the measurements at Lomnický Peak (LS, altitude 2634 m in the High Tatras, 49.40N, 20.22 E, geomagnetic cut-off ∼4 GV) is a continuous observation of the secondary CR flux by means of NM run by IEP SAS Košice. CR measurements in High Tatra have a rather long tradition. Some information related to the initiation of the CR measurements in our conditions can be found e.g. in papers by Pernegr et al. (1953); Chaloupka and Petržílka (1955); Dubinský et al. (1960); Petržílka (1960). The experience obtained during the IGY has been utilized in the subsequent modernisation of the measurements.

2. Some of the hitherto results

There have been two types of relations between CR and space weather: direct and indirect ones (Kudela et al., 2000; Kudela and Storini, 2002). For both of them the measurements at high mountains is important. Observations of particles accelerated in solar flares and producing a secondary response at the ground (GLE events) belong to the first type. More information about GLEs detected at LS till now and on other results based on LS NM data can be found in (Kudela and Langer, 2009). An important result was the first ground based observation of the solar neutrons during the flare in 1982 (Debrunner et al., 1983; Efimov et al., 1983). During GLEs the radiation dose in airplanes increases (Spurný and Dachev, 2001). Long term measurements by NM at LS helped to describe the variability of CR on various time scales as well as to determine the presence of several quasi-periodic contributions to the CR signal (e.g. Kudela et al., 1991; 2002). The CR temporal variability and/or anisotropy is changing in several cases ahead of geoeffective events related to space weather. An analysis of NM measurements at LS contributed to that aspect too (e.g. Kudela et al., 1995).

3. Current scheme of the measurements and long-lasting outline of CR intensity at LS

Measurements take place via 8 detectors of the type SNM-15 filled by $^{10}BF_3$ utilizing the fact that the cross-section of the reaction $^{10}B(n,\alpha)^{10}Li$ is high and increases with a decrease of the neutron velocity. The concept and design of NM is described e.g. by Simpson (1958). Recording of the CR intensity by NM at LS is done by utilization of two independent systems, namely (i) SMP-01 (count rate of the sums of four pairs of detectors), and (ii) SAPI (count rate of each indvidual detector). The dead time of SMP-01 is 15 $/mju$s. During that time interval the pulses from two detectors are not counted. This is why the count rates of a SAPI system is slightly higher. The average ratio SAPI/SMP-01 is 1.0035. The recording system is schematically seen from Figure 1. There have been from the system S-1 (an ancestor of SMP-01) available hourly data since December 1, 1981 and 5-min resolution data since April 1982 and after it already from SMP-01 data with 1-min resolution since June 27, 1990. SAPI data have been available with 1-min resolution since June 10, 1992. The restoration of older data back to 1970 is possible from paper tapes and from the CAWSES data base. The measurements are accessible in real time at `http://neutronmonitor.ta3.sk`. This site includes also the archive of hourly data and a list of GLEs observed.

Since 2001 the multiplicity measurement of CR in a part of NM has been recorded. Two methods are used, namely (i) the "classical" one with recording of pulses during 1 ms after each initialization pulse, and (ii) measurements of the time difference between two subsequent pulses.

Long term measurements with the device 8-NM-64 are illustrated in Figure 2.

4. Neutron monitor at Lomnický Peak in the international network of cosmic ray stations

Within the frame of the 7th Framework Program of the European Union with the acronyme NMDB (Neutron Monitor Data Base), the measurement of NM at LS was connected into the network of European and other NMs. Information about the project and access to the data base is at `http://www.nmdb.eu`. The project leads to (i) the design of the unified structure of data base for each NM of the network; (ii) construction of the data base added by archival data and updated continuously with the real time records and 1-min resolution; (iii) construction of the interface for read-out and corrections; and (iv) development of the application and service software for automatical producing of alerts important for space weather effects in real time.

5. Possibilities for CR measurements supported by structural funds of EU

One of the tasks which can be solved with the support of the project is the renovation of detectors in the present NM at LS (replacing the old tubes SNM-15 by the new ones). After the beginning of the project (CCS) the price of tubes filled by ^{3}He (the reaction ^{3}He(n, p)^{3}H is used for producing neutrons inside the monitor) intended to replace the old tubes, unexpectedly and strongly increased. Thus a new solution was searched for. Another laboratories in Europe intending to build new NMs met with the same problem (e.g. Universidad de Alcala, Spain, private communication). To utilize efficiently the allocated support we solved the problem similarly as our colleagues in Spain, namely we ordered detectors filled with $^{10}BF_3$. These tubes with comparable characteristics to ^{3}He, are substantially cheaper than the originally planned ^{3}He detectors. To assure the stability of long term measurements checked by ratios of count rates of the pairs of tubes and/or of the individual detectors, we suppose to replace three of the current detectors SNM-15 by three $^{10}BF_3$ tubes during 2011. Another triad of detectors will be placed according to possibilities at LS without lead. So the element of the CR spectrometer will be achieved at LS. After at least one year checking of the count rate ratios of the ^{3}He tube (now inserted into a Pb ring), four SNM-15 tubes and the newly inserted three $^{10}BF_3$ detectors into the existing construction of NM (with Pb), there will be in 2013 adopted a conclusion about replacement of all SNM-15 tubes by the new detectors filled with $^{10}BF_3$. Until then the two pairs of the purchased $^{10}BF_3$ will be put into operation as monitors without lead in Stará Lesná and Košice. Such arrangement allows to provide the spectrometry of another type, based on a comparison of the count rate at LS and at a lower altitude, at the site with the identical cut-off rigidity. The local production of thermal neutrons will be estimated by the comparison of the lead-free monitors in Stará Lesná and Košice. Three point measurements of thermal neutrons will be possible in addition to NM at a high altitude.

The support from the structural funds of EU offers an opportunity to enlarge the energy interval of neutrons measured (not only those produced by CR) and to disseminate the knowledge about primary CR at the unique position of LS. NM without lead is mainly sensitive to secondary neutrons with energy of a few MeV. A system of simultaneous measurements by a lead-free monitor and NM (estimate of spectra of primary CR) is successfully exploited at sites with low cut-off rigidities (e.g. Su Yeon Oh et al., 2009). At LS (middle latitudes) it will be possible to utilize such system as an additional element for providing the alert described e.g. in Mavromichalaki et al. (2010).

An important point of the new detection system is identification of the time of each impulse. So e.g. „bursts“ of neutrons corresponding to the specific interactions of CR in the atmosphere, or related to the atmospheric and processes on the ground, will be possible to study. Recently e.g. a lead-free monitor utilizing $^{10}BF_3$ detectors at a high altitude and high cut-off rigidity (Gulmarg, India, cut-off rigidity 11.4 GV) described in (Shah et al., 2010) observed bursts of neutrons within an interval of 50 ms. The occurrence of the bursts was changing during the solar flares. The calibration method described in the cited paper can be used for LS measurements.

A lead-free NM can be utilized additionally in at least two types of studies related to environmental research. Recently, Martin and Alves (2010) reportedan abrupt sharp increase of the count rate of thermal neutrons corresponding to the strong lightning activity. Earlier published papers described so-called the TGF effects (terrestrial gamma ray flashes) with energy above 10 MeV related to lightning activity. Such photons are observed not only on the ground but also on low altitude satellites. Carlson et al. (2010) stress that these effects can produce also neutrons. Another possible type of studies with upgraded neutron measurements within the project is conjunction of thermal neutron increases with seismic events reported e.g. by Antonova et al. (2009) and Alexeenko et al. (2009).

The second task of the upgrade of CR measurement at LS is supposed commissioning of the device SEVAN (Chilingarian et al., 2009) which affords information about a different part of the primary CR spectra than NM. SEVAN (Space Enviromental Viewing and Analysis Network) aims to improve basic research of the particle acceleration near the Sun and in interplanetary medium. This new type of a particle detector is promising to accord a new insight into primary CR flux dynamics. Simultaneously SEVAN measures variations of different types of secondary CR particles. Thus it is going to be a hybride device useful for the research of solar modulation effects. SEVAN modules are in a testing operational mode in the space center Aragats in Armenia. The devices are stepwise installed in other countries. Its installation in Slovakia will help in involvement of our measurements additionally into another network of CR world-wide observations. Measurement by SEVAN at LS is important for the network itself too, since this will be one of few places with high statistical accuracy (using high altitude).

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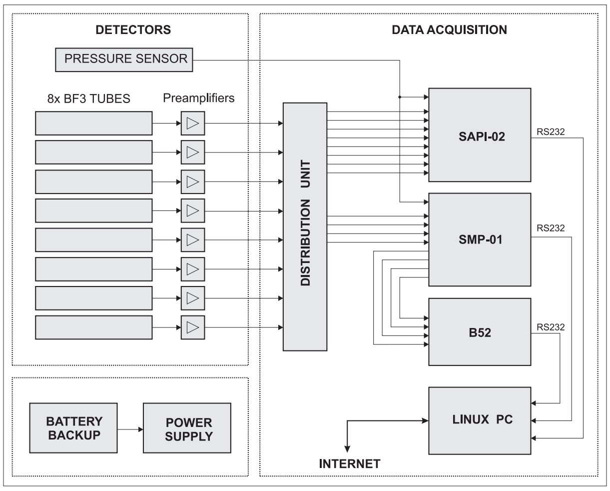

Figure 1. Scheme of the recording system of cosmic ray measurements by the neutron monitor at Lomnický štít.

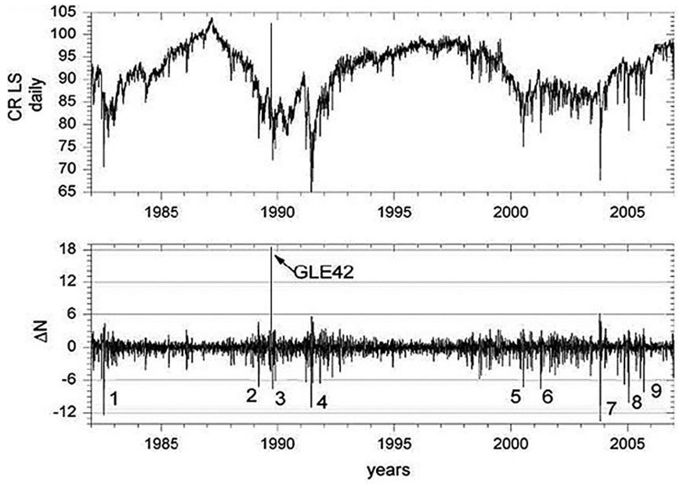

Figure 2. The lower panel displays the difference of the daily average and the smoothed 27-day value. The isolated Forbushdecreases with amplitude >6% are seen: (1) July 14–15, 1982; (2) March 14, 1989; (3) October 29, 1989; (4) June 13, 1991; (5) July 16, 2000; (6) April 12, 2001; (7) October 29–30, 2003; (8) January 19, 2005; (9) July 17–18, 2005. The strongest GLE on September 29, 1989 increased the daily average significantly. 100% corresponds to average in September 1986 (1,745.200 counts per hour).