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Space Weather Observatory at Aragats mountain in Armenia

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The Aragats Space-Environmental Center (ASEC) provides monitoring of different species of secondary cosmic rays and consists of two high altitude research stations on Mt. Aragats in Armenia. Geographic coordinates: 40°30'N, 44°10'E, cutoff rigidity: ~7.6 GV. The two 18NM-64 neutron monitors, are operated at Nor-Amberd (2000m elevation), and at Aragats, (3200m elevation) research stations; the monitors are equipped with interface cards, providing time integration of counts from 1 sec up to 1 minute. The Solar Neutron Telescope (SNT), is in operation at the Aragats research station. The main detecting volume consists of four 1 m2 surface, 60 cm thick scintillation blocks overviewed by photomultipliers. The Nor-Amberd Muon Multidirectional Monitor (NAMMM)consists of two layers of plastic scintillators above and below two of the three sections of the Nor Amberd NM. The lead (Pb) filter of the NM absorbs electrons and low energy muons. The NAMMM consists of 6 up and 6 down scintillators, each having the area of 0.81 m^2. The distance between layers is ~ 1 m. The data acquisition system of the NAMMM can register all coincidences of detector signals from the upper and lower layers, thus enabling monitoring of the directional information.

1. Introduction

Radiation and Geomagnetic storms, which are elements of Space Weather, are part of the major obstacles for Space Operations. Reliable forecasting of the arrival of these dangerous elements is of vital importance for orbiting flights and some surface industries. In addition to the fleet of space-born instruments, worldwide networks of particle detectors spread along different latitudes and longitudes, provide valuable information on the intensity and anisotropy of the variable cosmic ray fluxes.

Starting from 1996 we are developing various detectors to measure fluxes of different components of secondary cosmic rays at the Aragats research stations of the Alikhanian Physics Institute in Armenia. In 1996 we restarted our first detector - the Nor Amberd Neutron Monitor 18NM64 (2000m above sea level). A similar detector was commissioned and started to take data at the Aragats research station (3200m above sea level) in 2000. A Solar Neutron Telescope (SNT) is in operation at the Aragats station since 1997, as part of the worldwide network coordinated by the Solar-Terrestrial laboratory of the Nagoya University [1]. In addition to the primary goal of detecting the direct neutron flux from the Sun, the SNT also has the possibility to detect muon fluxes and roughly measure the direction of the incident muons. Another monitoring system is based on the scintillation detectors of the Extensive Air Shower (EAS) surface arrays, MAKET-ANI and GAMMA, located on Mt. Aragats at 3200 m above sea level. The muon scintillation multidirectional monitor system started operation at the Nor Amberd research station in 2002. Data Acquisition (DAQ) system was modernized in 2005.

Flexible 32-bit microcontroller based electronics is designed to support the combined neutron-muon detector system and utilize the correlated information from cosmic ray secondary fluxes, including environmental parameters (temperature, pressure, magnetic field). Microcontroller based DAQ systems and high precision time synchronization of the remote installations via Global Positioning System (GPS) receivers are crucial ingredients of the new facilities on Mt. Aragats.

2. The Aragats Space Environment Center (ASEC)

The ASEC, [2,3] consists of two high altitude stations on Mt. Aragats in Armenia. Geographic coordinates: 40°30'N, 44°10'E. Cutoff rigidity: ~7.6 GV, altitude 3200m and 2000m. At these stations several monitors continuously measure the intensity of the secondary cosmic ray fluxes and send data to the Internet in real time. The specifications of the ASEC monitors are shown in Table 1.. The two 18NM-64 neutron monitors (Moraal et al., 2000), in operation at Nor-Amberd (2000m elevation), and at Aragats, (3200m elevation) research stations are called the Nor Amberd Neutron Monitor (NANM), and the Aragats Neutron Monitor (ArNM), respectively. The monitors are equipped with interface cards, providing time integration of counts from 1 sec up to 1 minute.

The main detecting volume Solar of Neutron Telescope (SNT) consists of four 1 m^2 surface, 60 cm thick scintillation blocks overviewed by photomultipliers type FEU-49 with 12 cm large photocathode. The detecting volume is formed from standard 50 x 50 x 5cm slabs, stacked vertically on the horizontal slab of 100 x 100 x 5 cm (total 164 slabs). Four, same-type scintillator slabs of 5 cm thick and 1 m^2 surface are located 1 m above the detecting volume (Figure 1), with the goal to veto the near vertical charged flux. Total count rate of the veto detectors is also registered and reflects variations in the low energy charged component. Incoming neutrons in nuclear reactions produce protons inside the thick scintillator target.

Table 1 Characteristics of the ASEC monitors

Detector	Altitude *m*	Surface m^2	Threshold(s) *MeV*	Operation	Count rate (min^{-1})
NANM (18NM64)	2000	18		1996	2.5×10^4
ANM (18NM64)	3200	18		2000	6.2×10^4
SNT-4thresholds + veto	3200	4-60cm thick 4- 5cm thick	130,240,420,700 10	1998	$4.2\times 10^{4*}$ 1.2×10^5
NAMMM	2000	5 + 5	$10 + 350^{***}$	2002	$2.5 \times 10^{4**}$
AMMM	3200	48	5000	2002	$1.2 \times 10^{5**}$
MAKET-ANI	3200	6 x 16 groups	10	1996	1.5×10^5
*Count rate for the first threshold; near vertical charged particles are excluded					
**Total count rate of 48 muon detectors from 100					
*** First number – energy threshold for the upper detector, second number - bottom detector.					

The probability to produce neutrons in 5 cm of scintillator is vanishingly small. The energy deposited due to ionization by protons is measured by photomultipliers over the scintillators. The signal amplitude of the photomultiplier output signals is discriminated according to 4 threshold values of 40, 80, 120 and 160 mV, corresponding to the threshold energies of 130,240,420,700 MeV respectively. An independent registration channel (so called, 0-threshold channel) over views the same scintillator slab and registers the charged and neutral components of secondary cosmic rays without veto and threshold options. One of the advantages of the Aragats monitoring facilities includes registration of the muon flux under different angles of incidence. Simple coincidences techniques allow us to measure fluxes in 16 different combinations of triggered scintillation slabs, as it can be seen in Figure 1. Four of these directions are vertical and also there are pairs of same angular acceptance. Therefore, nine independent directions of incidence can be outlined and used for the anisotropy measurements. Another advantage of the SNT is its connection to the MAKET-ANI surface detectors [4,5]. As one can see in Figure 1, all four 60 cm thick scincillators are overviewed with two photomultipliers. One group of detecting channels feed scalers via 4 discriminators; another group is equipped by logarithmic ADC and is triggered by the primary particles with energy greater than $5 \cdot 10^{14}$ eV.

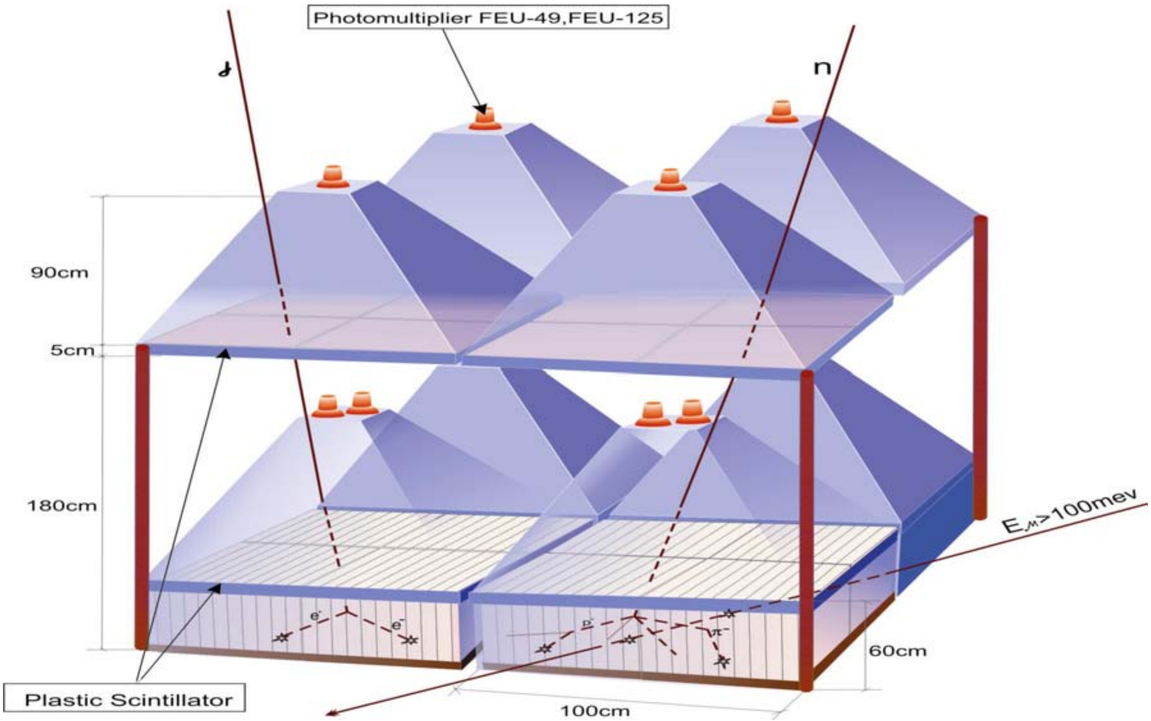

Figure 1. Aragats Solar Neutron Telescope

The Nor-Amberd Muon Multidirectional Monitor NAMMM is described in accompanied paper [6]. Simultaneous detection of variations in low energy charged particles, neutron, and high energy muon fluxes by the ASEC monitors will provide new possibilities for investigating the transient solar events and will allow us to classify Geoeffective events according to their physical nature and magnitude.

3. October-November 2003 (Halloween) Events

As an example of ASEC operation we present the Summary table of the very famous event from the end of October-November 2003. The event is under intensive analysis by several groups, investigating very unusual GLE 65, occurred at 28 October, huge Forbush decrease at October 29-30, and other exciting phenomena. The summary of ASEC detection of Halloween events is depicted in the Figure 2. The observed deficit of neutron flux on both altitudes of 2000 and 3200 m. is ~20%, the low energy muon & electron flux is decreased by 14-15% and high energy muon flux ~6%. All these values are record values measured at Aragats station. GLE also was detected by the ASEC particle detectors, and is still under analysis now.

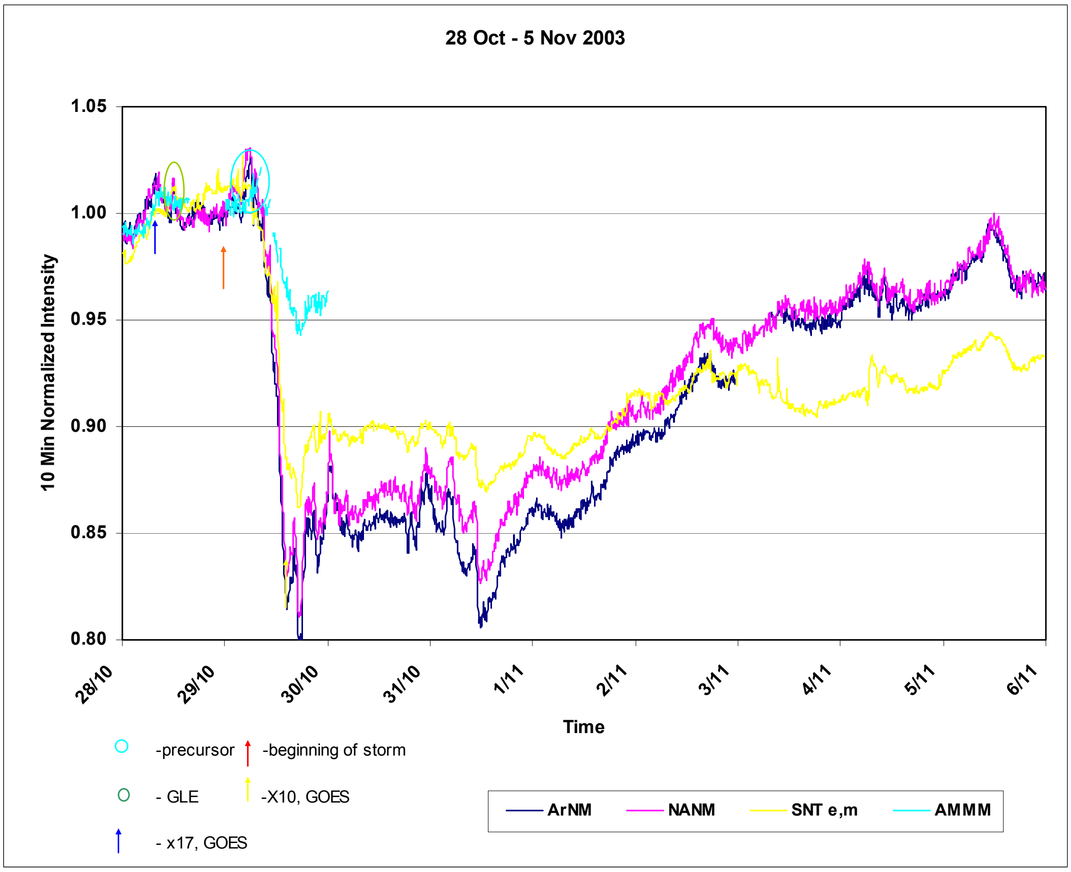

Figure 2. Summary of detection of the 2003 Halloween events

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