Space Environmental Viewing and Analysis Network (SEVAN) – characteristics and first operation results

2013 J. Phys.: Conf. Ser. 409 012222

(http://iopscience.iop.org/1742-6596/409/1/012222)

Journal of Physics: Conference Series **409** (2013) 012222 doi:10.1088/1742-6596/409/1/012222

Space Environmental Viewing and Analysis Network (SEVAN) – characteristics and first operation results

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Abstract. Space Environmental Viewing and Analysis Network is a worldwide network of identical particle detectors located at middle and low latitudes aimed to improve fundamental research of space weather conditions and to provide short- and long-term forecasts of the dangerous consequences of space storms. SEVAN detected changing fluxes of different species of secondary cosmic rays at different altitudes and latitudes, thus turning SEVAN into a powerful integrated device used to explore solar modulation effects. Till to now the SEVAN modules are installed at Aragats Space Environmental Centre in Armenia (3 units at altitudes 800, 2000 and 3200 m a.s.l.), Bulgaria (Moussala), Croatia and India (New-Delhi JNU.) and now under installation in Slovakia, LomnitskySchtit). Recently SEVAN detectors were used for research of new high-energy phenomena originated in terrestrial atmosphere – Thunderstorm Ground Enhancements (TGEs). In 2011 first joint measurements of solar modulation effects were detected by SEVAN network, now under analysis.

1. Introduction

For the basic research of solar physics, solar-terrestrial connections and Space weather, as well as for establishing services of alerting and forecasting of dangerous consequences of space storm the networks of particle detectors located at different geographical coordinates and measuring various species of secondary cosmic rays are of vital importance.A network of particle detectors located at middle to low latitudes known as SEVAN (Space Environment Viewing and Analysis Network, [1.2]) was developed in the framework of the International Heliophysical Year (IHY-2007) and now operates and continue to growth within International Space Weather Initiative (ISWI). SEVAN detectors measure time series of charged and neutral secondary particles born in cascades originating in the atmosphere by nuclear interactions of protons and nuclei accelerated in the Galaxy and nearby the sun. SEVAN modules are operating in Armenia (4 one m^2 standard modules and 2 super modules of 12 identical SEVAN units each arranged above and below 2 standard sections of Nor Amberd neutron monitor 6NM-64; both super modules are capable of muon direction estimation), in Croatia (Zagreb observatory), Bulgaria (Mt. Moussala, India (New-Delhi JNU Univ.) and are under construction in Slovakia (Mt. Lomnicky Stit).The analogical detector is in operation in Tibet [3].
The particle fluxes measured by the new network at medium to low latitudes, combined with information from satellites and particle detector networks at high latitudes, will provide experimental evidence on the most energetic processes in the solar system and will constitute an important element

of the global space weather monitoring and forecasting service. SEVAN network measure charged and neutral fluxes; energy spectra of the solar protons by registering the ground level enhancements (GLEs); distinguish between neutron- and proton-initiated GLEs. SEVAN modules also register Thunderstorm ground enhancements (TGEs), new high-energy phenomena in the atmosphere. SEVAN modules, operated at slopes of Mt. Aragats in Armenia during recent years detect many TGE events in fluxes of gamma rays and high-energy muons, proving existence of the strong electrical fields in the thunderclouds initiating relativistic runaway electron avalanches in the thunderstorm atmospheres [4,-6]. SEVAN detectors was calibrated by the gamma ray flux of the most powerful TGEs and furthermore, the time series of the high energy muons detected by SEVAN open possibility to estimate the electrical structure of the thunderclouds, the key parameter for creating models of both TGE and lightning occurrences.

2. Design of SEVAN Particle Detectors

The basic detecting unit of the SEVAN network (see Figure 1) is assembled from standard slabs of 50 x 50 x 5 cm^3 plastic scintillators. Between two identical assemblies of 100 x 100 x 5 cm^3 scintillators (four standard slabs) are located two 100 x 100 x 5 cm^3 lead absorbers and thick 50 x 50 x 25 cm^3 scintillator assembly (5 standard slabs). A scintillator light capture cone and photo multiplier tube (PMT) are located on the top, bottom and the intermediate layers of detector. The detailed detector charts with all sizes are available from http://aragats.am/SEVAN.

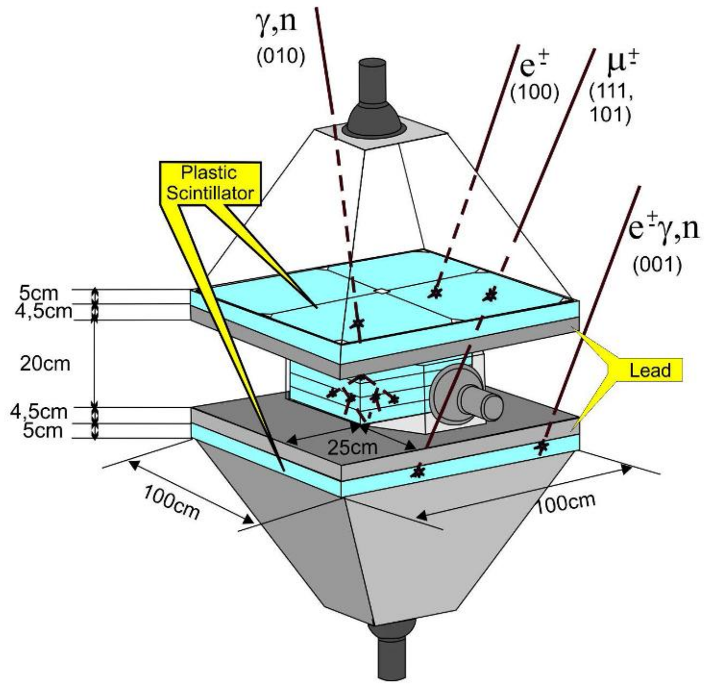

Figure 1.Basic detecting unit of the SEVAN network.

Incoming neutral particles undergo nuclear reactions in the thick 25 cm plastic scintillator and produce protons and other charged particles. In the upper 5 cm thick scintillator charged particles are registered

very effectively; however for the nuclear interactions of neutral particles there is not enough matter. When a neutral particle traverses the top thin (5 cm) scintillator, usually no signal is produced. The absence of the signal in the upper scintillators, coinciding with the signal in the middle scintillator, points to neutral particle detection. The coincidence of signals from the top and bottom scintillators indicates the traversal of high-energy muons. Lead absorbers improve the efficiency of the neutral flux detection and filtered low energy charged particles
If we denote by ‘‘1’’ the signal from a scintillator and by ‘‘0’’ the absence of a signal, then the following combinations of the 3-layered detector output are possible:
111 and 101—traversal of high energy muon; 010—traversal of a neutral particle;100—traversal of a low energy charged particle stopped in the scintillator or in the first lead absorber (energy less than *100 MeV).110—traversal of a higher energy charged particle stopped in the second lead absorber. 001—registration of inclined charged particles

3. Forbush decrease events detected by the SEVAN network in the beginning of the 24-th solar activity cycle

In the middle of February 2011 the active region AR 11158 unleashed 3 solar flares of class M6.6 (13 February, solar coordinates S19, W03), M2.2 (14 February, solar coordinates S20, W14) and strongest X2.2 (15 February, solar coordinates S19, W03S21, W18). All 3 flares were accompanied with CMEs headed to the earth direction. The worldwide network of neutron monitors detects at 18 February sizeable Forbush decrease (FD). The SEVAN network as well detects FD by 3 monitors located in Armenia and by Balkanian monitors located in Zagreb observatory (Croatia) and Mt. Moussala (Bulgaria). The SEVAN module locates in India do not register FD due to large geomagnetic cutoff.

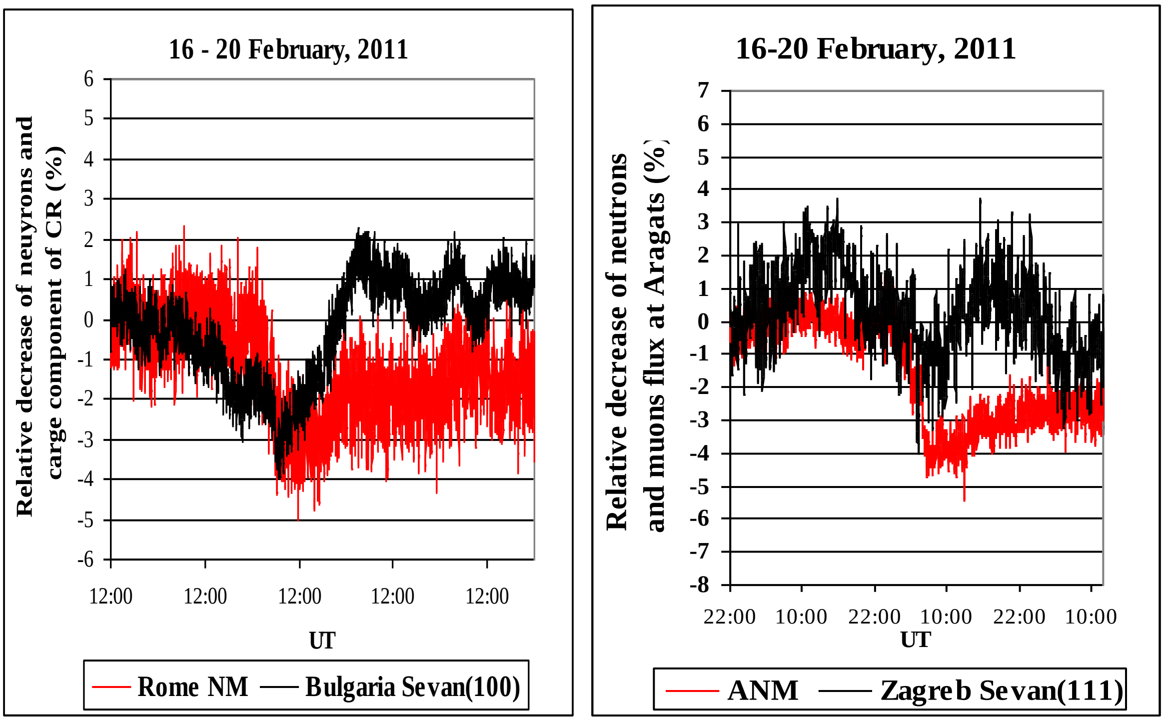

Figure 2. The time profiles of the FD on 18 February, 2011 measured by Zagreb and Moussala SEVAN monitors in comparison with Rome Neutron monitor and Aragats Neutron monitor. The low energy charged particles (combination 100) and high-energy muons (combination 111) are recovering much faster comparing with neutrons measured by Rome and Aragats Neutron monitors.

As we can see in Figure 2 the overall patterns of FD detected in charged particle fluxes are very similar to the ones measured by neutron monitors. However, there are several differences due to location of detectors at different latitudes, longitudes and altitudes. The FD phenomena is global phenomena influenced all globe (may be not the equatorial regions only where the cutoff rigidity is very large); nevertheless the detection of the local differences in time profiles of FD produced by primary particles of different energies is very important and allows to recover the event anisotropy and sometimes also the shape of the ICME. The SEVAN network located on different longitudes (from Zagreb to Delhi) gives possibility to explore FD's shape and the magnitude longitudinal dependence and character of the disturbance and its source. The amplitude of FD is dependent on the speed, size, and value of magnetic field of ICMEs [7]. In this respect registration of FD also in low and high energy charged particle fluxes can bring additional information for the developing of the model of ICME – magnetosphere interactions.

Conclusion

Networks of particle detectors on Earth's surface provide timely information and constitute an important element of planetary Space Weather warning services. The big advantage of ground based particle detectors is their consistency, 24 h coverage, and multi- year operation. In contrast the planned life of the satellites and spacecraft is only a few years, they are affected by the same solar blast that they should alert, and space-born facilities instead of sending warnings are usually set in the stand-by mode. The multi-particle detectors probe different populations of primary cosmic rays. The basic detector of the SEVAN network is designed to measure fluxes of neutrons and gamma rays, of low energy charged particles and high-energy muons. The rich information obtained from the SEVAN network allows estimation of the energy spectra of the highest energy Solar CR (SCR). The SEVAN network is sensitive to very weak fluxes of SCR above 10 GeV, a very poorly explored region of the highest energy. Summarizing, the hybrid particle detectors, measuring neutral and charged fluxes provide the following advantages over existing detector networks measuring single species of secondary cosmic rays:

- Enlarged statistical accuracy of measurements;
- Probe different populations of primary cosmic rays with rigidities from 3 GV up to 20– 30 GV;
- Reconstruct SCR spectra and determine position of the spectral ''knees'';
- Classify GLEs in ''neutron'' or ''proton'' initiated events;
- Gives possibilities to investigate energy dependences of the barometric coefficients and diurnal wave;
- Estimate and analyze correlation matrices among different fluxes;
- Significantly enlarge the reliability of Space Weather alerts due to detection of three particle fluxes instead of only one in existing neutron monitor and muon telescope world-wide networks.

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