WORLDWIDE NETWORK OF PARTICLE DETECTORS SEVAN: 10 YEARS OF OPERATION

V.Babayan[1], A.Chilingarian[1,2], T.Karapetyan[1], B.Mailyan[3] and M.Zazyan[1]

[1]A. Alikhanyan National Lab (Yerevan Physics Institute), 2 Alikhanyan Brothers, Yerevan 0036, Armenia
[2]National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Moscow 115409, Russian Federation
[3] Geospace Physics Laboratory, Florida Institute of Technology, Fl, USA

ABSTRACT

In 1957, in a display of unprecedented international cooperation, more than 66.000 scientists and engineers from 67 nations participated in the International Geophysical Year (IGY1957). Fifty years on, the International Heliophysical Year (IHY 2007) again drew scientists and engineers from around the globe in a coordinated observation campaign of the heliosphere and its effects on planet Earth. The United Nations Office for Outer Space Affairs, through the United Nations Basic Space Science Initiative (UNBSSI), assists scientists and engineers from all over the world in participating in the International Heliophysical Year (IHY). A most successful IHY 2007 program is to deploy arrays of small, inexpensive instruments around the world to provide global measurements of ionospheric and heliospheric phenomena. The small instrument program is a partnership between instrument providers and instrument hosts in developing countries. The lead scientist provides the instruments and helps to install and run it; the host country place facilities provides manpower for instrument maintenance and operation to obtain data with the instrument. The lead scientists institution developed joint databases, provide tools for user-friendly access to data from the network, assisted in staff training and paper writing to promote space science activities in developing countries.

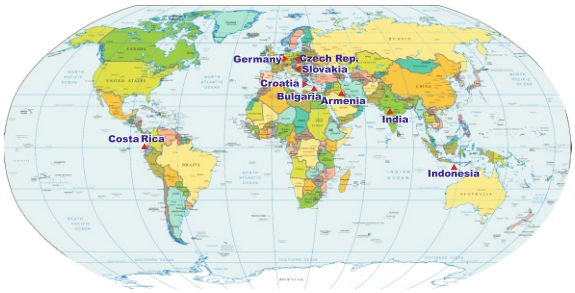
"Space Environment Viewing and Analysis Network" (SEVAN) aim to improve the fundamental research on particle acceleration in the vicinity of sun and - space environment conditions. The new type of particle detectors simultaneously measures changing fluxes of most species of secondary cosmic rays, thus turning into a powerful integrated device for exploration of solar modulation effects. The SEVAN modules are operating at the Aragats Space Environmental Center (ASEC) in Armenia, in Croatia, Bulgaria, Slovakia and India.

The network of hybrid particle detectors, measuring neutral and charged fluxes provide the following advantages over existing detector networks measuring single species of secondary cosmic rays (Neutron Monitors and Muon detectors):

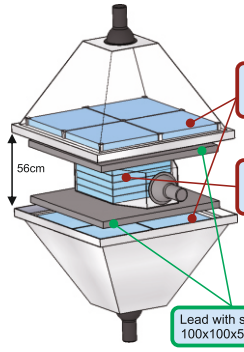
- Measure count rates of the 3 species of the Secondary cosmic rays (SCR): charged particles with energy threshold 7 MeV, neutral particles (gamma rays and neutrons) and high-energy muons (above 250 MeV);
- Probe different populations of primary cosmic rays with rigidities from 7 GV up to 20 GV;
- Classify GLEs in "neutron" or "proton" initiated events;
- Estimate and analyze correlation matrices among different fluxes;
- Enlarge the reliability of Space Weather alerts due to detection of 3 particle fluxes instead of only one in existing neutron monitor and muon telescope worldwide networks;
- Perform research on runaway electron acceleration during thunderstorms; research the enigma of lightning.

In the paper we present the most interesting results of SEVAN network operation last decade devoted to 10-th anniversary of the IHY-2007.

POSSIBLE LOCATIONS OF THE SPACE ENVIRONMENTVIEWING AND ANALYSIS NETWORK



SPACE ENVIRONMENT VIEWING AND ANALYSIS NETWORK" (SEVAN)



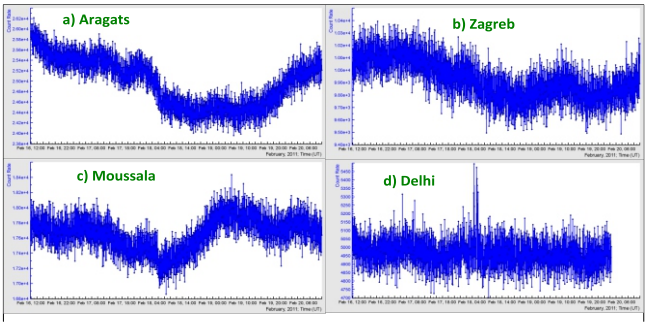
111&101 - traversal of high energy muon;
010 - traversal of the neutral particle;
100 - traversal of low energy charged particle
110 - traversal of higher energy charged particle stopped in the second lead absorber.

GEOPHYSICAL CHARACTERISTICS OF POSSIBLE SEVAN SITES.

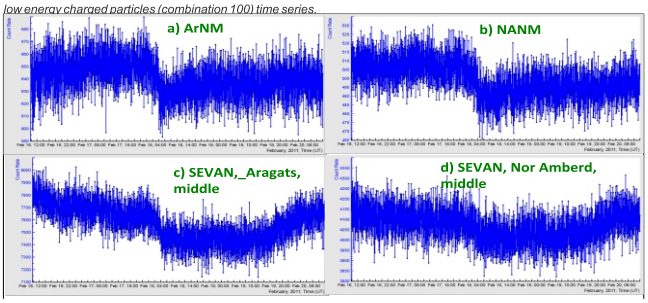
Station	Latitude	Longitude	Altitude (m)	Rc (GV)
Germany(Greifswald)	54.5N	13.23E	6	2.34
Slovakia(Lomnicky Stit)	49.2N	20.22E	2634	3.88
Croatia(Zagreb)	45.82N	15.97E	120	4.89
Bulgaria(Musala)	42.1N	23.35E	2430	6.19
Armenia(Aragats1)	40.25N	44.15E	3200	7.1
Armenia(Aragats2)	40.25N	44.15E	2000	7.1
Israel(Hermon)	33.18N	35.47E	2025	10.39
Costa Rica(San Jose)	10.0N	84.0W	1.2	10.99
China(Tibet)	30.11N	90.53E	4300	13.86
India(Delhi)	28.61N	77.23E	239	6.9
Indonesia(Jakarta)	6.11S	106.45E	8	16.03

FORBUSH DECREASE EVENTS DETECTED BY THE SEVAN NETWORK IN 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. 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. There is good coherence of FD detection by different type detectors.

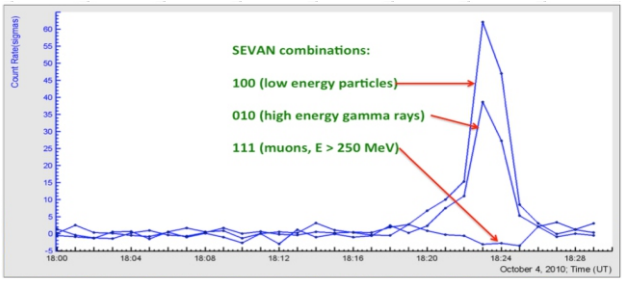


The time profiles of the FD on 18 February, 2011 measured by Aragats, Dehli, Zagreb and Moussala SEVAN monitors The low energy charged particles (combination 100) time series.



THUNDERSTORM GROUND ENHANCEMENTS (TGE) DETECTED BY SEVAN AND MUON DEFICIT

Facilities of the Aragats Space Environment Center (ASEC) (Chilingarian et al, 2003, 2005) observe charged and neutral fluxes of secondary cosmic rays by the variety of particle detectors located in Yerevan and on slopes of Mt. Aragats at altitudes 800, 2000 and 3200 m. Detection of abrupt enhancements of the particle detector count rates correlated with thunderstorm activity, so called Thunderstorm Ground Enhancements (TGEs, Chilingarian et al., 2010, 2011) detected during 2008-2016 years brings >500 events allowing the detailed analyses and taxonomy of new high-energy phenomena in atmosphere. Small TGEs can be explained by the modification of the energy spectra of charged particles in the electrical field of thunderclouds. These effects have been theoretically analyzed in (Dorman and Dorman, 2005). Large enhancements are explained by the Relativistic runaway electron avalanches unleashed in the thundercloud if strength of electric field enhanced the threshold value. Measurements at ASEC and simulation with GEANT4 package confirm additional flux of gamma rays up to 1000% in the energy range 1-10 MeV and up to 5% in the energy range up to 100 MeV . Simultaneously decline in the muon flux at energies above 200 MeV was obtained by simulations and detected by SEVAN detectors. Due to abundance of positive muons over negative (1.3 -1.4 times at 100-500 MeV energies) the decelerating of positive muons in the positive electrical field cannot be compensated by the acceleration of the negative muons in the same field. The consequences of this asymmetry you can see in the Fig. 11: on October 4, 2010 we detected ~6% deficit in the flux muons with energies greater than ~250 MeV, simultaneously detecting huge excess of low energy gamma rays and electrons. In Figure one can see the count rates of the SEVAN detector on 4 October 2010. The threshold of the upper detector due the matter of the roof above is ~ 10MeV.



The count rates of SEVAN 100, 010, and 111 combinations in number of standard deviations.

The positive field in the thundercloud (electrons are accelerated downwards) is stopping positive muons; charge ratio of positive-to-negative muons is (~1.3), therefore we detect ~6% deficit of the muon flux; simultaneously huge TGE is detected in high energy gamma ray flux (010) and low energy particle flux (100).

Both increase of the electron and gamma ray fluxes occur during negative near-ground electrical field. According to our model, TGE event started with formation in the bottom of the cloud of the lower positive charged region (LCPR). LCPR with main middle negative charged layer compose the lower dipole accelerated electrons downward. The SEVAN module gives us possibility to estimate this field at least roughly. Observed deficit ~6% is caused mostly by the positive muons, which spectrum is affected significantly by the positive potential of the thundercloud.