# Aragats Space-Environmental Center (ASEC): Status and SEP Forecasting Possibilities

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The Aragats Solar Environment Center (ASEC) located on Mt. Aragats, in the Republic of Armenia, provides real time monitoring of cosmic particle fluxes. We plan to use this information to establish an early warning system against ***extreme, very large Solar Energetic Particle (SEP) events with hard spectra*** dangerous for the satellite electronics and for the crew of the Space Station. ASEC solar neutron monitors and multidirectional muon monitors operating at altitude 2000 m and 3200 m as well as solar neutron telescopes and electron monitors located at 3200 m are continuously gathering data to detect possible Ground Level Enhancement (GLE) of the secondary particle count rates.
The challenge is to unfold this multidimensional information and forecast spectral characteristics and intensities of the upcoming radiation storms.
The Aragats Space Environmental Center 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 3200 and 2000 m.). At these stations several monitors are continuously measuring intensity of the secondary cosmic ray fluxes and sending data to the Internet each minute (see Table 1).
Two 18NM-64 neutron monitors are in operation at Nor-Amberd and at Aragats research stations. The monitors are equipped with interface cards, providing time integration of counts from 1 sec up to 1 minute. Data from these monitors is available online, real-time at URL http://crdlx5.yerphi.am/neutron/index.html
One of the improvements to the Aragats monitoring facilities includes registration of the variations of the muon flux under different pitch angles. The construction of a multidirectional muon telescope around the Neutron Monitor is already finished. The Nor-Amberd muon multidirectional monitor (NAMMM) consists of two layers of plastic scintillators above and below the NM installation. The lead filter of the NM will absorb electrons and low energy muons. The threshold energy of the detected muons is estimated to be 350 MeV. The readout system of the muon telescope can register all coincidences of detector signals from the up and down layers, thus, allowing us to measure the arrival direction of the muons from 36 directions. NAMMM consists from 6 up and 6 down scintillators, each scintillator having the area of 0.5 $m^2$. Changes in the relative count rates from different directions will point to the approaching magnetized cloud, allowing the forecasting of geomagnetic storms. The changes in count rate pointed on the Sun will prove the solar origin of GLE (neutrons or high energy ions accelerated in the vicinity of Sun).
The Solar Neutron Telescope (SNT-1) at the Aragats station is part of a world-wide network coordinated by the Solar-Terrestrial Laboratory of the Nagoya University. It consists of four 1 $m^2$, 60 cm thick scintillation blocks with anti-coincidence shielding (consisting of the 5 cm. thick 4 $m^2$ palastic scintillators) vetoing only near vertical charged flux. An important advantage of the SNT over the NM is its possibility to estimate the energy of detected neutrons. The amplitude of the SNT output signal is discriminated according to 4 threshold values, corresponding approximately to neutron energies of 50, 100, 150 and 200 MeV. The data from the solar neutron telescope is available online at URL http://crdlx5.yerphi.am/solar.html.
In 2002 an improved installation, SNT-2, will be commissioned with anticoincidence shielding vetoing all charged particles. The proportional counters used for vetoing charged particles will cover the entire detector, thus, providing opportunity to measure neutral and charged + neutral fluxes separately.

At the Aragats high altitude station two surface arrays (MAKET and GAMMA) operate with the main purpose of detecting Extensive Air Showers (EAS) initiated by very high energy primaries $>10^{14}$ eV of galactic origin. The EAS installations are triggered 3-5 times per minute by high energy particles incident on the array area. 1 $m^2$ plastic scintillators overviewed by photomultipliers are used for measuring charged particle densities and arrival times (for the determination of the angles of incidence). The total area of the surface detectors of GAMMA and MAKET installations is about 150 $m^2$. The spacing between detectors varies from several meters to tens of meters.

In the underground hall originally constructed for the once famous but now extinct ANI Cosmic Ray experiment another one hundred fifty of the same type of detectors are located to measure the muon content of the EAS. The absorption in the 6 m thick concrete blocks interspaced by the air gaps of total thickness 4 m and 7 m soil above the 7 m. height underground hall prevents electrons and low energy muons from reaching the scintillation detectors.

The high count rates of the charged component (mostly electrons and muons) at mountain altitudes (~ 500 counts/$m^2$/sec for electrons and ~ 50 counts/$m^2$/sec for 5 GeV muons) and the large area of the electron and muon detectors on Mt. Aragats are very attractive for establishing a monitoring facility for the investigations of the correlations between short term variations of neutron, electron and muon count rates with the enhancing flux of solar ions incident on the earth's atmosphere or/and with approaching shock wave and magnetized cloud of CME.

Muon observations are complementary to neutron registration.

The total count rate due to incident muons from the 90 $m^2$ scintillators of of the Aragats Multidirectional Muon Monitor (AMMM)is approximately ~ 300,000 per minute Thus, the sensitivity of this new installation reaches record value of ~0.2% for one minute count rates, 4 times better comparing with Aragats NM.

Using 27 $m^2$ scintillation detectors located on the top of ANI concrete calorimeter 24 m above the 90 $m^2$ array, we can measure the directions of traversing muons. Detectors on the top are grouped in 3, in the hall in 9 to provide significant amount of coincidences (we expect from 300 to 500 coincidences in 5 minutes). The geometry of the detector arrangement will allow us to detect directions from vertical to 60º declination with accuracy of ~5º. The angular information will allow investigating the precursors of the geomagnetic storms by measuring the anisotropy of the muon arrival. 81 direction of viewing along with huge count rates will provide information for the analysis of the anisotropy pattern, those providing detailed information on the topology of the approaching magnetized cloud.

**Table The parameters of all the detectors at ASEC on Mt. Aragats.**

| Detector | Altitude, *m* | Surface, *m*$^2$ | Threshold(s), *MeV* | In operation since | Count rate, (*min*$^{-1}$) |
|---|---|---|---|---|---|
| Nor-Amberd N M (18NM64) | 2000 | 18 | | 1996 | $2.7 \times 10^4$ |
| Aragats NM (18NM64) | 3200 | 18 | | 2000 | $6.6 \times 10^4$ |
| SNT-1 | 3200 | 4 | 50,100,150,200 | 1998 | $6.7 \times 10^4$ |
| SNT-2* | 3200 | 4 | 50,100,150,200 | | $3.0 \times 10^4$ |
| Nor-Amberd Muon Telescope* | 2000 | 18 | 350 | 2002 | $6.0 \times 10^3$ |
| Aragats Muon Telescope* | 3200 | 90+27 | 5000 | 2002 | $3 \times 10^5$ (only bottom layer) |
| Aragats Electron Monitor* | 3200 | 25 | 10 | 2002 | $10^6$ |

*- Detector under construction