MAXIMUM STRENGTH OF THE ATMOSPHERIC ELECTRIC FIELD

A. Chilingarian[1], T. Karapetyan[1], M. Zazyan[1], G. Hovsepyan[1], B. Sargsyan[1], N. Nikolova[2], H. Angelov[2], J. Chum[3] and R. Langer[4]

[1]Artem Alikanyan National Lab (Yerevan Physics Institute), Alikhanyan Brothers 2, Yerevan, Armenia
[2]Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences, 15 Noemvri Str., Sofia, Bulgaria
[3]Institute of Atmospheric Physics of the Czech Academy of Sciences, Bocni II 1401, Prague, Czech Republic
[4]Institute of Experimental Physics, Slovak Academy of Sciences, Watsonova 47, Kosice, Slovakia

A. ALIKHANYAN National Laboratory
www.crd.yerphi.am

37 ВСЕРОССИЙСКАЯ КОНФЕРЕНЦИЯ ПО КОСМИЧЕСКИМ ЛУЧАМ

ABSTRACT

Particle detectors of the European Space Environment Viewing and Analysis Network (SEVAN) network located on mountain peaks in Aragats (Armenia), Lomnicky Stit (Slovakia) and Musala (Bulgaria) are well suited for the detection of thunderstorm ground enhancements (TGEs). The modulation of charged particle flux by the electric field of the thundercloud results in a sizable change in the count rate of detectors, which measure fluxes of electrons, gamma rays, and high-energy muons. The relation between electric-field strength and changes of particle-flux count rates is nonlinear and depends on many unknown parameters of the atmospheric electric field and meteorological conditions. Nonetheless, employing tremendous TGEs as a manifestation of the strongest electric field in the thundercloud and by measuring fluxes of three species of secondary cosmic rays (electrons, gamma rays, and muons) by SEVAN detectors located at altitudes of approximately 3 km, we study the extreme strength of the atmospheric electric field. With the simulation of propagation of charged particles in a uniform electric field using the CORSIKA code, we estimate the maximum potential difference in the thunderous atmosphere, which can reach approximately 500 MV.

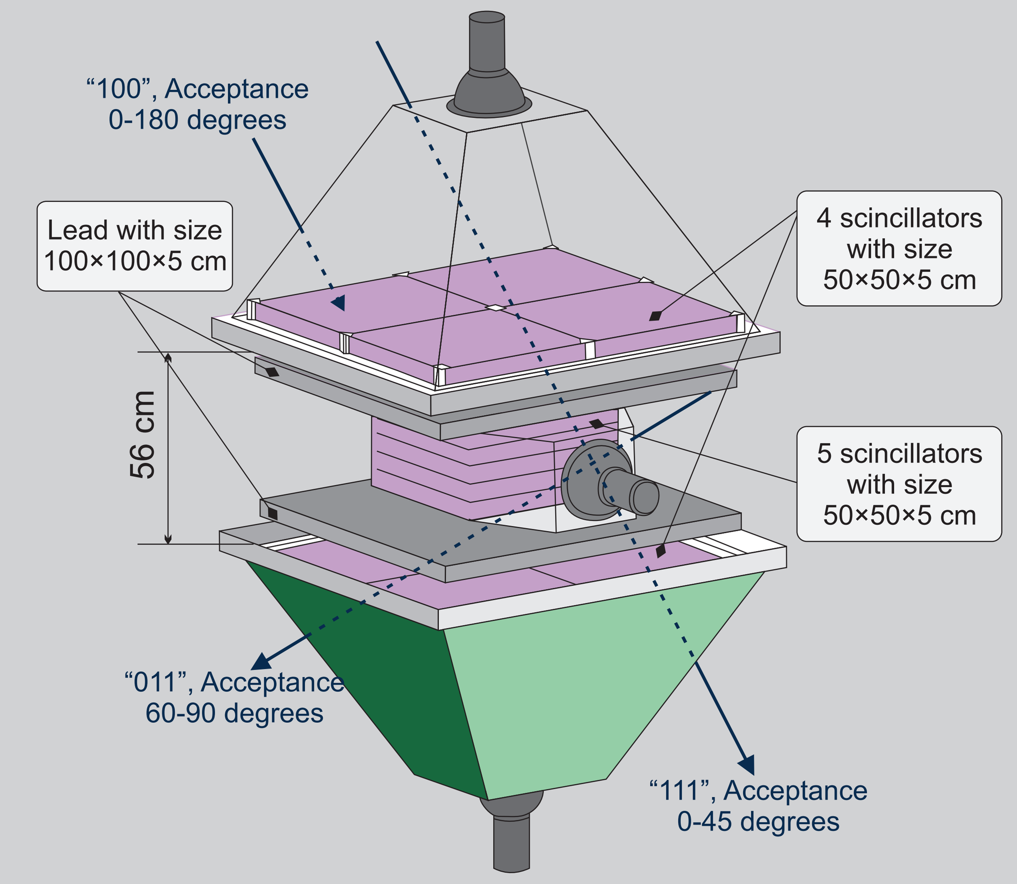

Figure 1. Module of the European "Space Environmental Viewing and Analysis Network" (SEVAN).

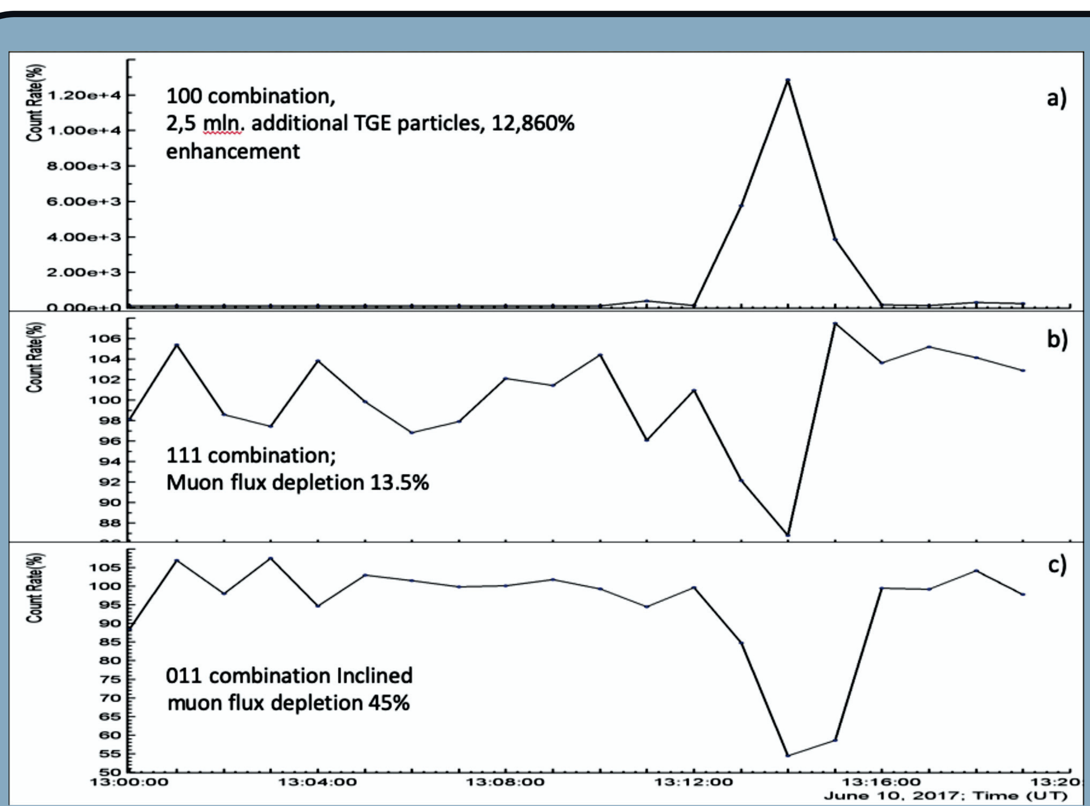

Figure 2. Extreme TGE event detected by the SEVAN detector located on Lomnicky Stit mountain: (a)–TGE particles—electrons and gamma rays; (b) high-energy muons; (c) inclined muons.

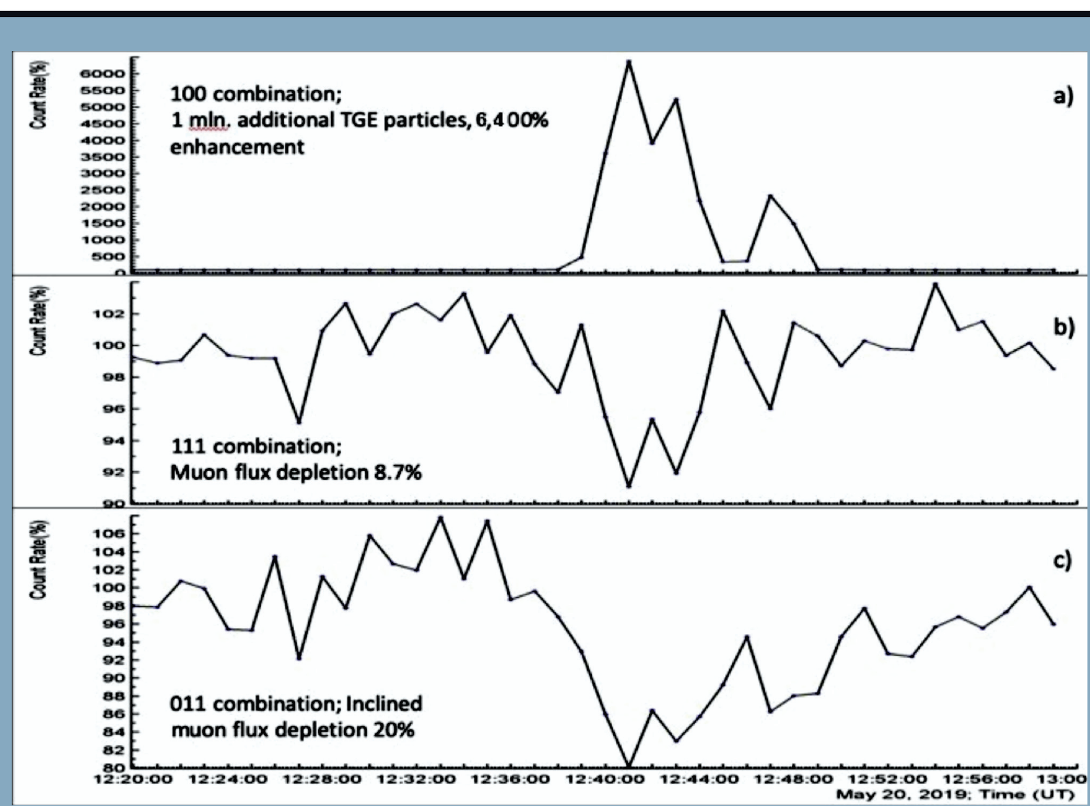

Figure 3. Very large TGE event detected by the SEVAN detector located on Musala mountain: (a) TGE particles—electrons and gamma rays; (b) high-energy muons; (c) inclined muons.

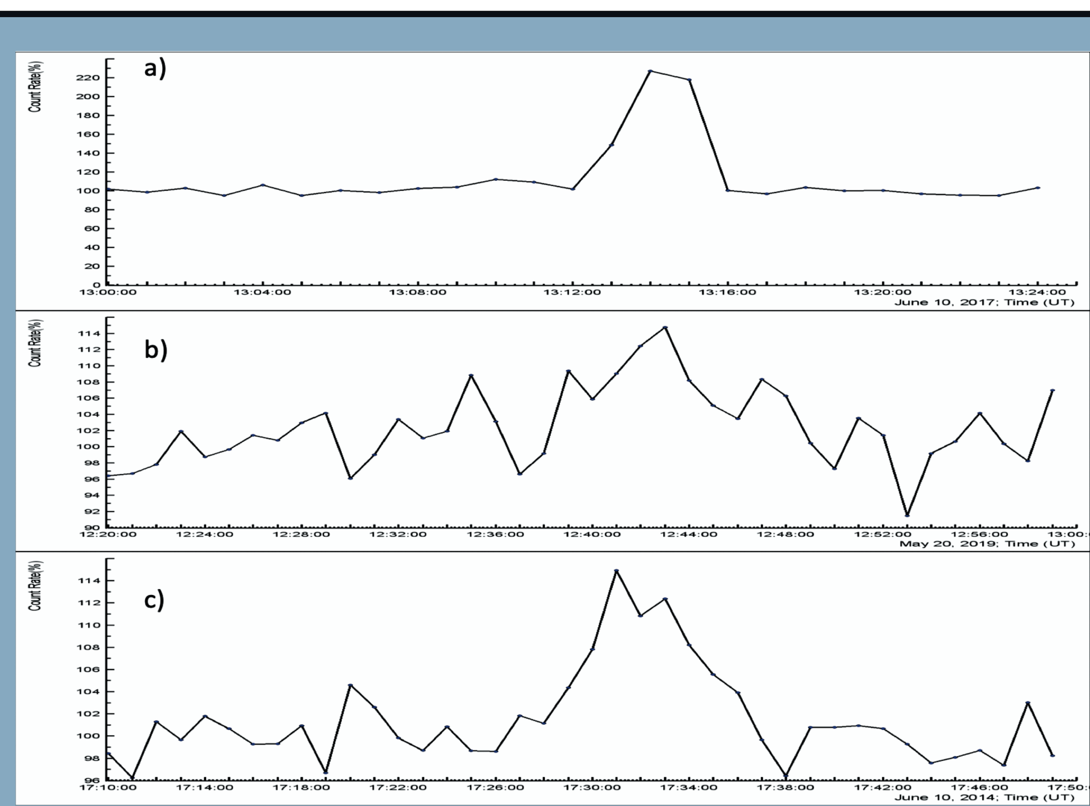

Figure 4. Extreme TGE events detected by the SEVAN 010 combination detector located on Lomnicky Stit (a), Musala (b), and Aragats (c)

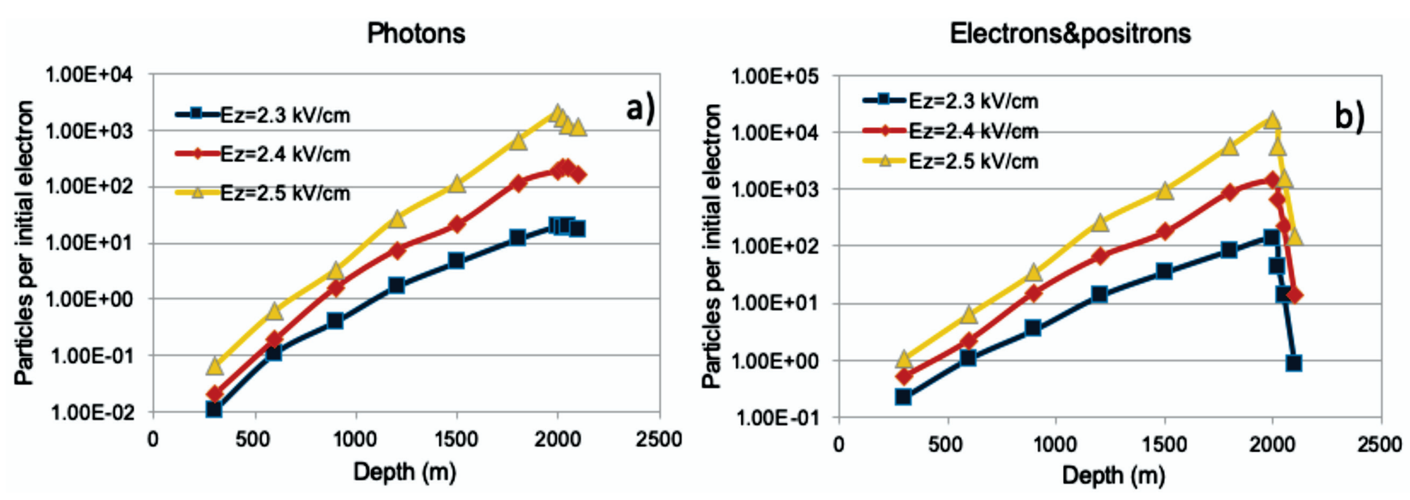

Figure 5. Development of the electromagnetic avalanche in the atmosphere. The avalanche started at 4600 m, 2 km above the SEVAN detector. The number of avalanche particles is calculated each 300 m. After exiting from the electric field, the avalanche is followed an additional 100 m.

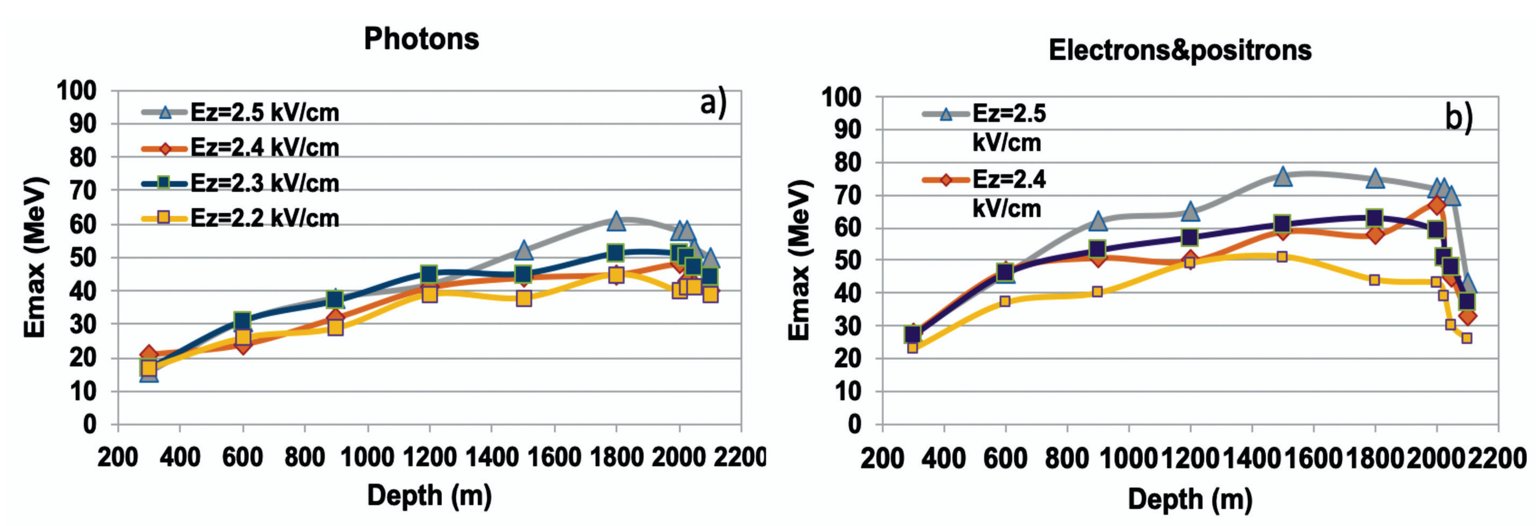

Figure 6. Maximum energies of RREA electrons and gamma rays. The avalanche started at 4600 m, 2 km above the SEVAN detector. The maximum energies of the avalanche particles are calculated each 300 m. After exiting from the electric field, the avalanche is followed an additional 400 m. Simulations were performed with a fixed energy of seed particles (1 MeV) to avoid large gamma-ray energies due to MOS and not the RREA process.

Name	Mean 1/min	σ	Mean 1/sec	13:14 1/sec	13:14 1/min	%	N
Upper	25 047	171	417	42 233	2 534 000	10 013	101
Coincidence 111 muons	1929	48	32.2	27.8	1666	87	
Coincidence 100	19 550	142	326	42 100	2 526 000	12 890	130
Coincidence 010	1468	39	24.5	55.5	3326	25	2.7
Neutron monitor	29 640	265	494	1187	71 220	140	20

TABLE I. Mean values of the count rates of particle detectors located at Lomnicky Stit and extreme values at the maximum flux minute registered on 10 June 2017.

	Electron Counts /m2 sec	Gamma – ray Counts /m2 sec	Sum el. + gamma /m2 sec	Total expected counts (x 455)
2.4 kV/cm 50m	175	13	188	85,540
2.4 kV/cm 100m	11	10	21	9555
2.5 kV/cm 50m	1268	76	1344	611,520
2.5 kV/cm 100m	119	68	187	85,085
SEVAN L.S. 10.6.2017 upper				42,223

TABLE II. Simulated count rates in the upper scintillator of the SEVAN detector for different configurations of the atmospheric electric field.

CONCLUSIONS

We confirm that TGE observations are frequent and routine not only on Aragats (where approximately 95% of the published TGE world collection is observed) but also on other mountaintops where thunderclouds are near to the Earth's surface. The characteristics of measured particle fluxes, electric fields and lightning occurrences confirm the physical effects connected with TGE origination. At a sharp mountaintop at Lomnicky Stit, the electric field reaches larger strengths and enhancements of count rates are much bigger. The muon stopping effect [10], first observed by the particle detectors at Aragats, was also detected at Lomnicky Stit with a much "deeper" decline of the count rate of high-energy muons. Both the muon depletion measured at Lomnicky Stit and a much larger enhancement of the low-energy electron and gamma-ray flux than on Aragats led to a larger potential difference (voltage) during extreme TGEs, derived from the comparison with simulation trials. The observed enhancements of gamma-ray and electron fluxes measured by the upper scintillator of SEVAN as compared with CORSIKA simulations of the RREA imply the maximum ≈500 MV potential difference present in the atmosphere during the minute of the highest flux (and consequently, highest strength of the electric field) measured by the SEVAN detector at Lomnicky Stit on 10 June 2017.