CONFERENCE REPORT

Thunderstorms and Elementary Particle Acceleration (TEPA-2016)
Nor Amberd, Armenia, 3–7 October 2016

The problem of the thundercloud electrification and how particle fluxes and lightning are initiated inside thunderclouds are among the biggest unsolved problems in atmospheric sciences. The relationship between thundercloud electrification, lightning initiation, and particle fluxes from the clouds has not been yet unambiguously established. *Cosmic Ray Division of Yerevan Physics Institute (YerPhI), Armenia and Skobeltsyn Institute of Nuclear Physics of Moscow State University (SINP), Russia* already 6th year are organizing Thunderstorms and Elementary Particle Acceleration (TEPA) annual meeting, creating environment for leading scientists and students to meet each other and discuss last discoveries in these fields (see reports of previous TEPA symposia in Fishman and Chilingarian, 2010, Chilingarian, 2013, 2014, 2016).

The CRD have an impressing profile of the investigations in the new emerging field of high-energy physics in the atmosphere. New designed particle detector networks and unique geographical location of Aragats station allows to observe in last 7 years near 500 intensive particle fluxes from the thunderclouds, which were called TGEs – Thunderstorm ground enhancements. Aragats physicists enlarge the TGE research by coherent detection of the electrical and geomagnetic fields, temperature, relative humidity and other meteorological parameters, as well as by detection of the lightning. Adopted multivariate approach allows relate different fluxes, fields and lightning occurrences and finally come to a theory of the TGE. One of most intriguing opportunities opening by observation of the high-energy processes in the atmosphere is their relation to lightning initiation. C.T.R. Wilson postulated acceleration of electrons in the strong electric fields inside thunderclouds in 1924. In 1992 Gurevich et al. developed the theory of the runaway breakdown (RB), now mostly referred to as relativistic runaway electron avalanches - RREA. The separation of positive and negative charges in thundercloud and existence of a stable ambient population of the cosmic ray MeV electrons enables acceleration of the electrons in direction of the Earth's surface and to open space (Terrestrial gamma flashes, TGFs). Thus both TGEs and TGFs precede the lightning activity and can be used for the research of poorly understood lightning initiation processes providing key research instrument – fluxes of electrons, neutrons and gamma rays originated in the thunderclouds. Information acquired from the time series of TGEs and TGFs along with widely used information on the temporal patterns of the radio waveforms will help to develop both reliable model of lightning initiation and detailed mechanism of electron acceleration in thunderclouds.

TOPICS OF THE SYMPOSIUM:

30 participants from Russia, USA, Germany, Israel and Armenia present 20 plenary talks and 10 posters in 5 sessions:

- Research of the Thunderstorm ground enhancements (TGEs) observed by particle detectors located on earth's surface;

- Research of the Terrestrial gamma-ray flashes (TGFs) observed by the orbiting gamma-ray observatories;
- Relation of Lightning to the TGE and TGF;
- Monitoring of TLEs and thunderstorms from the orbit;
- Cloud electrification and atmospheric discharges: measurements and applications.

Two discussions were hold:

- Data bases in high-energy atmospheric physics description and way ways to establish cooperation;
- Do lightning discharges produce relativistic particles?

Visit to Aragats research station 18 km from Nor Amberd conference center near south summit of Aragats Mountain coincide with installation of new detectors measuring UV and IR radiation from lightning bolt (collaboration YerPhI- SINP).

Among the most important results reported and discussed at symposia was the relation of TGEs to lightning.

- During numerous thunderstorms on Aragats there were no particles fluxes registered simultaneously with lightning;
- In 2015-2016 23 events were detected when lightning abruptly terminates particle flux from clouds;
- Investigations of pulses shape from particle detectors and atmospheric discharges prove that all pulses from detectors are electromagnetic interferences (EMI) because:
    - ♦ only some of particle detectors show pulses, for instanced in stacked detectors upper scintillators don't count any peaks and the third bottom detector demonstrate huge peak;
    - ♦ all peaks consist from bipolar pulses, pulses from genuine particles have unipolar shape;
    - ♦ large EASs hitting neutron monitor generate genuine multiple peaks without any relation to lightning.

Observed on Aragats fluxes of electrons, gamma rays and neutrons can be explained with standard RREA + MOS theory with CR electron seeds (Chilingarian, Mailyan and Vanyan, 2012, Chilingarian 2014). Lightning does not generate high-energy particles!

Large TGEs open conductive channel for lightning and usually lightning occurred at LARGE TGEs and stop them! TGE is essential for the lightning initiation!

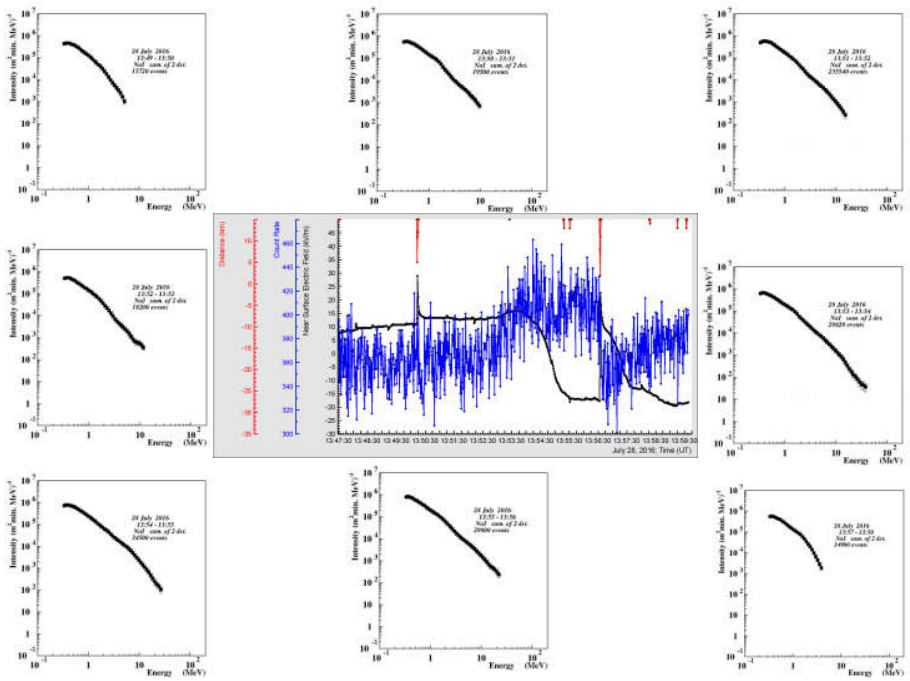

Figure 1 TGE observed on July 28 2016 with lightnings 2 time terminated particle flux. At biginning of TGE (13:49) the energy spectra prolonged up to 10 MeV, reaching 40 MeV at maximal perticle flux at 11:53.

Symposia participants agree that the topic of High-Energy Physics in Atmosphere (HEPA) is well progressing:

- There is big activity in several countries to establish surface particle detectors for research in TGE physics;
- RB/RREA model with CR seeds well explain TGE measurements worldwide;
- Planned research of TLE and TGF from orbit can be coupled with surface measurements;
- The established links with meteorology, atmospheric electricity, Atmospheric Cherenkov Telescopes (ACT) experiments, are very promising;
- Lightning mapping arrays will be very important addition to Aragats facilities;
- New fast electronics will reveal origin of TGEs and TGE-lightning relations;
- Broad collaboration with Space and Lightning physics experiments will significantly improve research and understanding in the new emerging HEPA field.