SIMULATIONS OF RELATIVISTIC RUNAWAY ELECTRON AVALANCHE (RREA) PROCESS IN THE THUNDERSTORM ATMOSPHERS

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ABSTRACT

Atmospheric Electric Fields connected with thunderstorm activity cause increases in the count rates of surface particle detectors. In this work we consider behavior of Secondary Cosmic Ray electrons in uniform Electric fields with different strengths by GEANT4 code. The Secondary Cosmic Ray electron spectrum at 3400m altitude was generated in Atmospheric Electric Fields of 100 m length. The electron and gamma (generated by bremsstrahlung) fluxes reached the ground level where Aragats Space Environmental (ASEC) detector is located. Dependences of electron/gamma ratios on free (without electric fields) path in the atmosphere were calculated. Neutron production by photonuclear reaction was also considered.

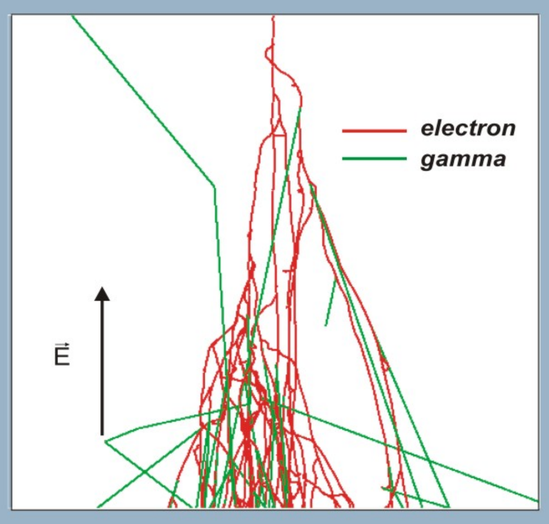

Figure 1. An example of the Relativistic Runaway Electron Avalanche (RREA) process in thunderstorm atmosphere (E = 5kV/cm)

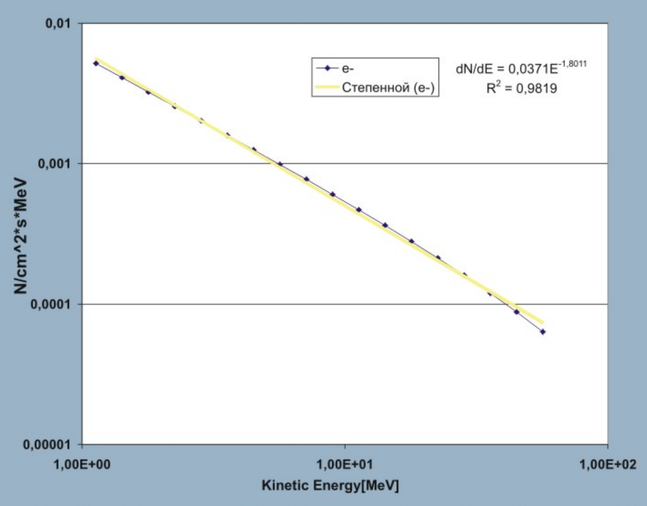

Figure 2. Differential spectra of Secondary Cosmic Ray electrons at 3400m altitudealtitude

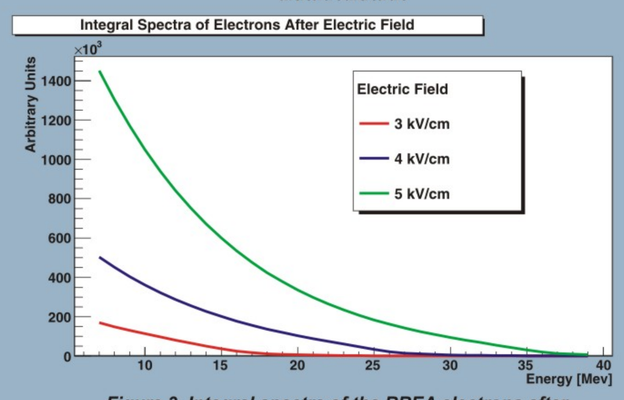

Figure 3. Integral spectra of the RREA electrons after multiplication/acceleration in the Atmospheric Electric fields of different

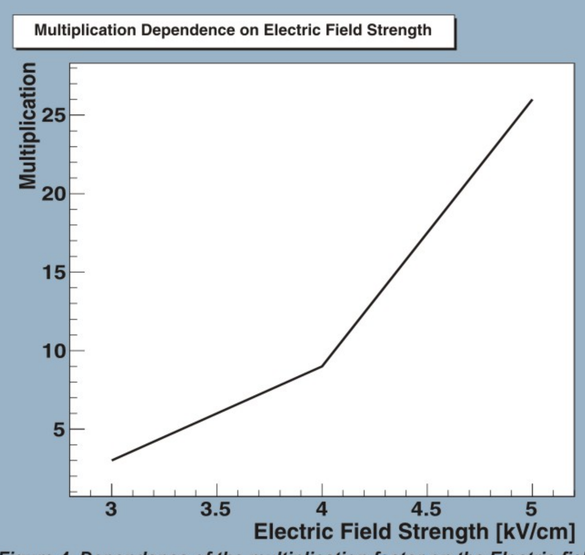

Figure 4. Dependence of the multiplication factor on the Electric field

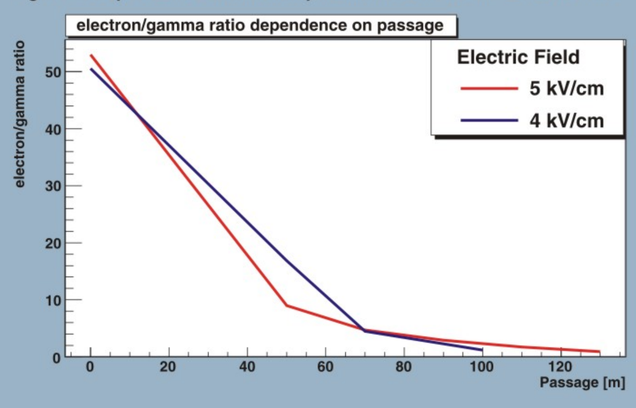

Figure 5. Dependence of the electron/gamma ratio on free (without

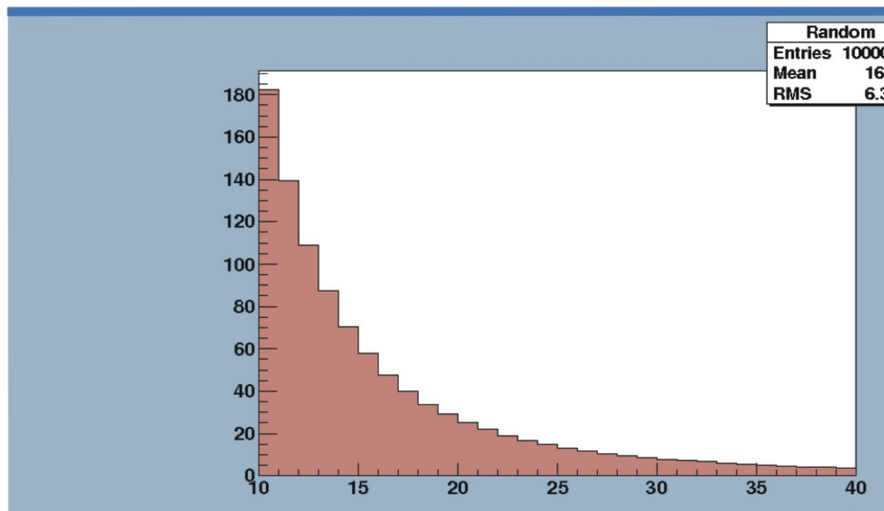

Figure 6. Differential spectra of the incident gamma-ray flux (power law E^(-2.96)) used for the Investigations of the neutron production. neutrons atmosphere

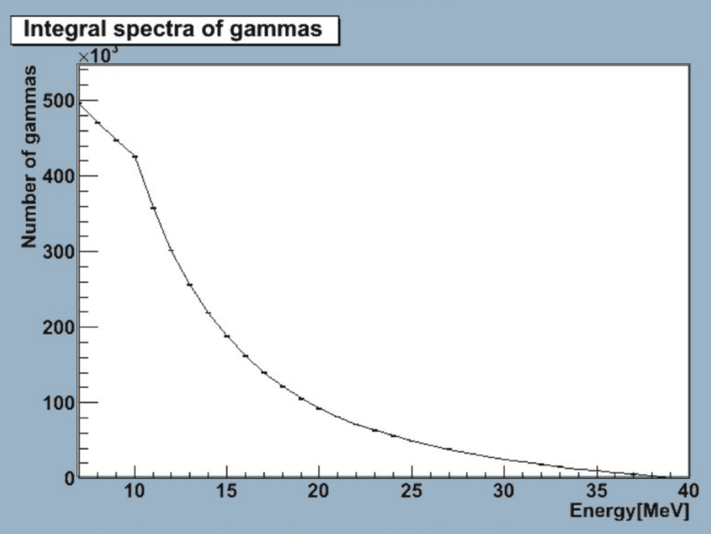

Figure 7. Integral spectra of gammas reached to the ground surface of the volume

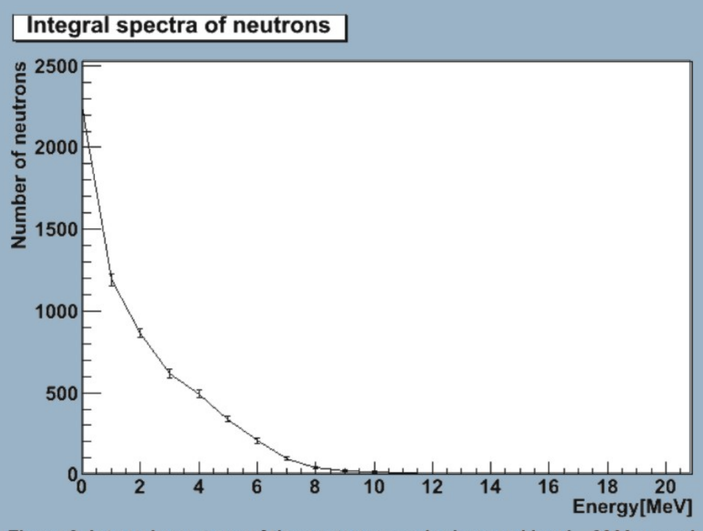

Figure 8. Integral spectrum of the neutrons reached ground level – 3200 m a.s.l.

CONCLUSION

Simulations of the development of electron-photo avalanche in thunderstorm atmospheres in presence of electrical fields larger that the critical one can help to explain the electron, gamma-ray and neutron fluxes detected by the surface particle detectors and develop the physical model of the particle multiplication/acceleration.

However, both structure and value of the electrical fields in the thunderstorm clouds is very poorly investigated and there are no simultaneous measurements of the particle fluxes and corresponding electrical field structures.

Our simulations are the first attempt to get at least very rough estimate the height of the thunderstorm cloud above detector, the elongation of electrical field based on the particle fluxes detected by the Aragats Space Environmental Center detectors.

We test some parameters from simulation, like electron/gamma-ray ratio; number of neutrons at detection level for estimating the structure of the electrical fields. First results point on correlation of the these simulation parameters with investigated entities; however additional simulations and physical models are needed for the reasonable estimates.

REFERENCES

Geant4 User's Guide for Application Developers; Version: geant4.9.2 , CERN, 2009.