STATISTICAL ANALYSIS OF THUNDERSTORM TRIGGERED ENHANCEMENTS IN COSMIC RAY DATA

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ABSTRACT

Particle detectors of Aragats Space Environmental Center (ASEC) located in Armenia routinely measure changing fluxes of the different species of the secondary cosmic rays. Along with Solar modulation effects (Forbush decreases, Ground level enhancements, Geomagnetic effects) detectors registered several coherent enhancements associated with thunderstorms. 72 significant events detected in 2007-2010, at Solar activity minimum, unambiguously point on Relativistic Runaway Electron Avalanche (RREA) process in thunderstorm atmosphere in presence of strong electrical fields. In present report we perform initial taxonomy of events and investigate distribution of events in different secondary fluxes by duration and magnitude. Also nontrivial correlations between measurements by different particle detector were outlined and discussed.

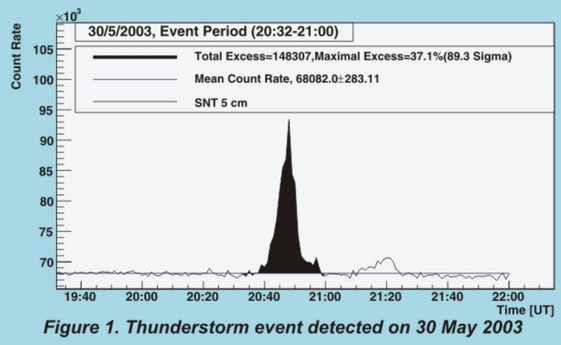

Figure 1. Thunderstorm event detected on 30 May 2003

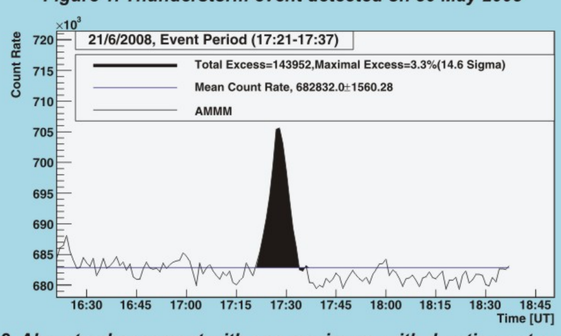

Figure 2. Abrupt enhancement with one maximum, with duration not exceeding 10-15 minutes

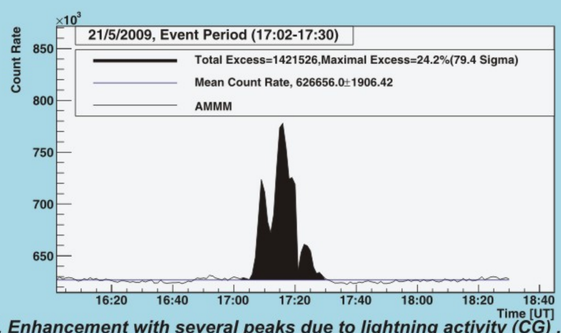

Figure 3. Enhancement with several peaks due to lightning activity (CG) , duration ~30 minutes

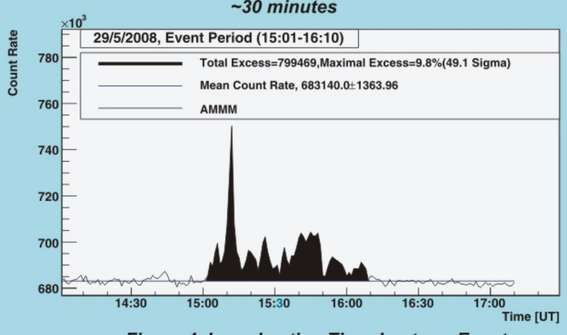

Figure 4. Long Lasting Thunderstorm Event

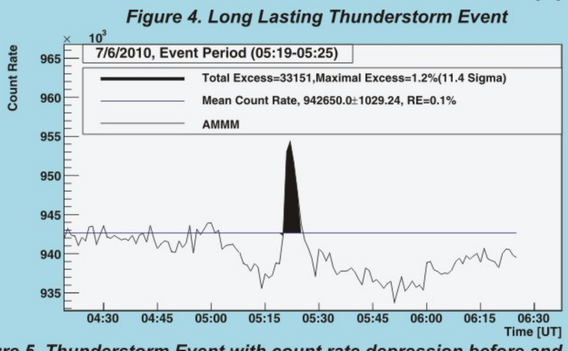

Figure 5. Thunderstorm Event with count rate depression before and after enhancement

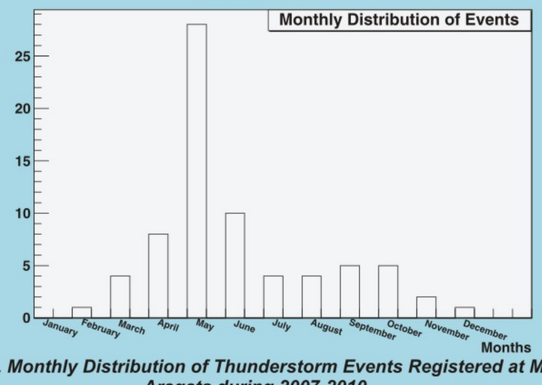

Figure 6. Monthly Distribution of Thunderstorm Events Registered at Mount Aragats during 2007-2010

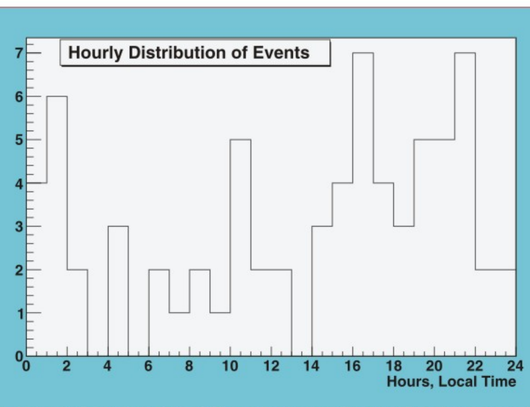

Figure 7. Hourly Distribution of Thunderstorm Events Registered at Mount Aragats during 2007-2010 (in good agreement with hourly distribution of the lightning activity)

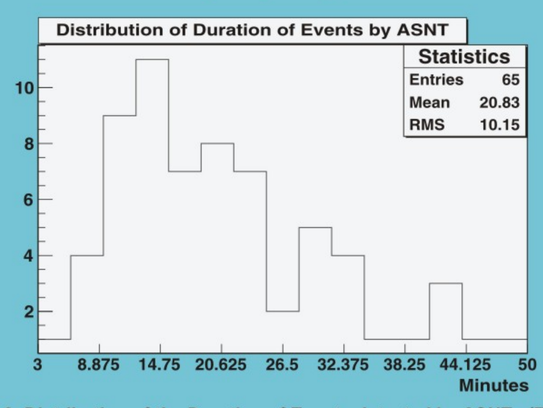

Figure 8. Distribution of the Duration of Events detected by ASNT (First and second types of events only)

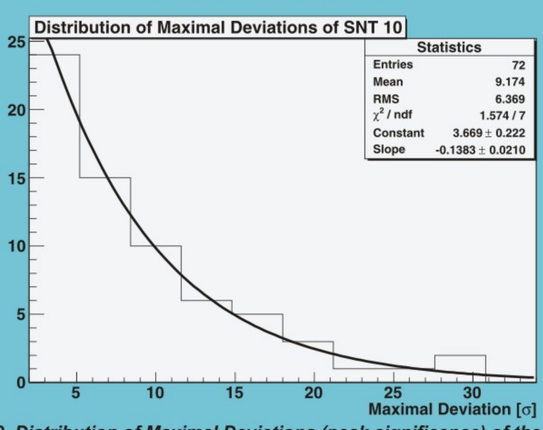

Figure 9. Distribution of Maximal Deviations (peak significance) of the events detected by ASNT 10 coincidence (signal in upper 5 cm thick scintillator and no signal in the bottom 60 cm thick scintillator

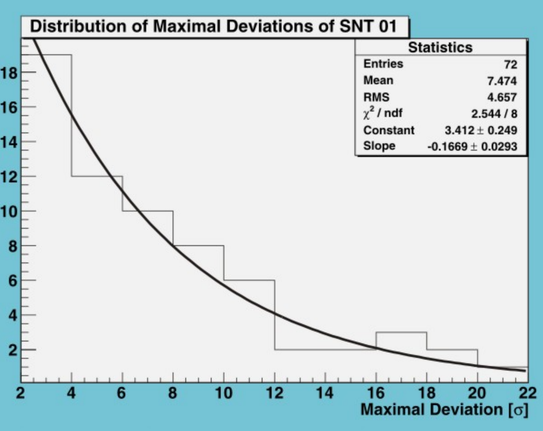

Figure 10. Distribution of Maximal Deviations (peak significance) of the events detected by ASNT 01 Coincidence (no signal in the upper 5 cm thick scintillator and signal in the bottom 60 cm thick scintillator (electron detection is suppressed)

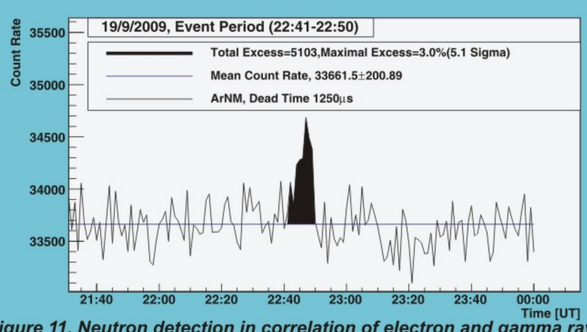

Figure 11. Neutron detection in correlation of electron and gamma ray flux: September 19, 1 minute time series of the Aragats Neutron Monitor

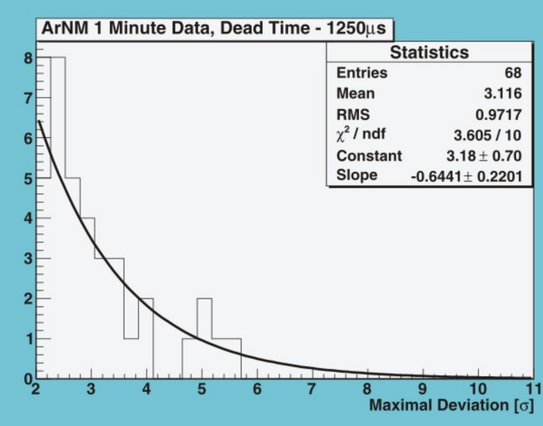

Figure 12. Neutron Detection: Distribution of Maximal Deviations (peak significance) of the events detected by the Aragats Neutron Monitor

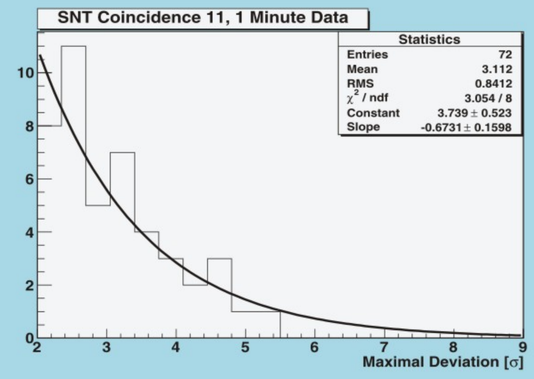

Figure 13. Distribution of Maximal Deviations (peak significance) of the events detected by ASNT 11 Coincidence (signal in the upper 5 cm thick scintillator and signal in the bottom 60 cm thick scintillator (mostly electrons, or gamma rays with energy greater than 25-30 MeV)

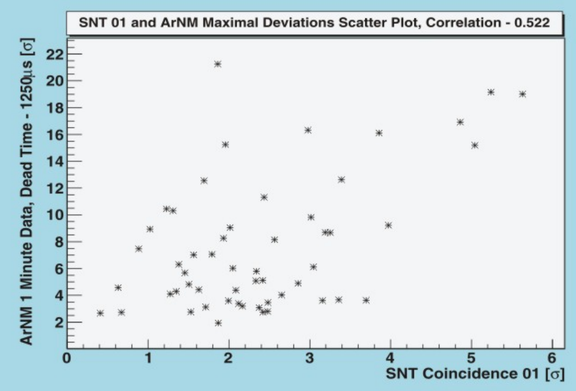

Figure 14. Scatter Plot of Maximal Deviations of ArNM and SNT 01(Gamma-rays)

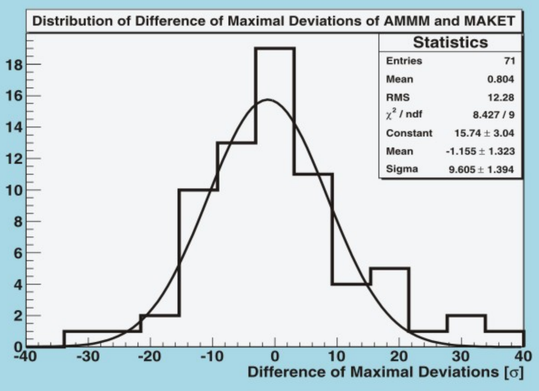

Figure 15. Distribution of the differences between maximal signal detected by AMMM and Outdoor MAKET plastic scintillators with thickness 5 cm and area of 1 m²

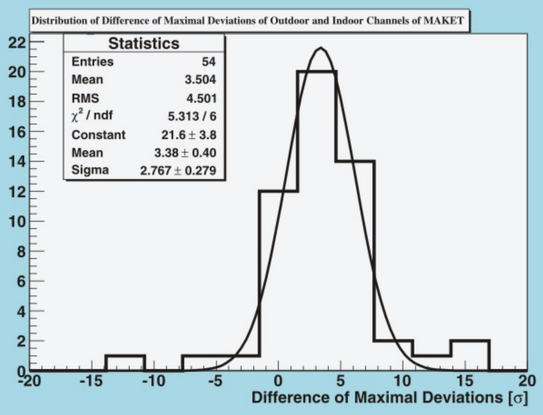

Figure 16. Distribution of the differences between maximal signal detected by the outdoor and indoor MAKET plastic scintillators with thickness 5 cm

CONCLUSION

Statistical analysis of the RREA events prove the correlation of the detected enhancements with Thunderstorm activity at Aragats both with month (yearly) and hour (daily) distributions. Four types of events were outlined and described: having one peak, several peaks, extremely long duration and accompanied with mean count rate depression before and/or peak.

Distributions of duration and maximums of events registered by ASEC detectors help to understand the interconnections between electron and gamma ray components of the RREA, as well as to see connections between gamma and neutron production.

Histograms of the difference of outdoor detectors located at maximal distance of 400 m and demonstrated similar enhancements prove the rather large size of the RREA process. Obtained difference of the indoor and outdoor detectors helps to obtain the energy spectra of the RREA electrons presented in another poster.

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