



## Detection of runaway electrons – a journey 100 years long

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In the beginning of last century C.T.R. Wilson proposes that strong electrical field of the thunderclouds might accelerate electrons to very high energies. However, this and many other electromagnetic processes in our atmosphere are poorly understood till now; the key questions about the thundercloud electrification and lightning initiation remain unanswered. During recent decades several observations of gamma ray, electron and neutron fluxes correlated with thunderstorms were reported. Nonetheless, the origin of these fluxes is under debate till now. The direct registration of the particle showers initiated by the runaway electrons (the most popular theory) was missing. We present the experimental evidence of the microsecond duration electron bursts originated from runaway electrons accelerated in thunderclouds. The first direct experimental observation of the RREA process was made at Aragats in 2009 with a network of 16 plastic scintillators distributing on the area of  $\sim 1000$  m<sup>2</sup> registering 8-fold enhancement of particle showers during maximal flux of TGE. The statistical analysis of  $\sim 200$  detected particle showers reveals their systematic difference from the Extensive Air Shower (EAS) events: the density was much lower and spatial spread of the electrons was much more uniform (particle distribution in EAS has characteristic bell-like form). The particle showers from the thunderclouds were named – Cloud extensive showers (CESs). A SEC phenomenon is very rare: only 3 largest TGEs from 300 were accompanied by SEC observation. CESs originated from individual runaway electrons accelerated in the cloud just above the detector. RREA (CES) phenomenon is very local and depends on the height of cloud above detector and on the strength of electric field in it. Both parameters are fast changing and only during several minutes cascades from runaway electrons can be developed enough to cover several thousand square meters of surface. Only very suitable location and large sizes of the scintillators allow detect CES on Aragats and for the first time prove existence of RREA phenomena.