Estimation of the size of emitting region in the thundercloud

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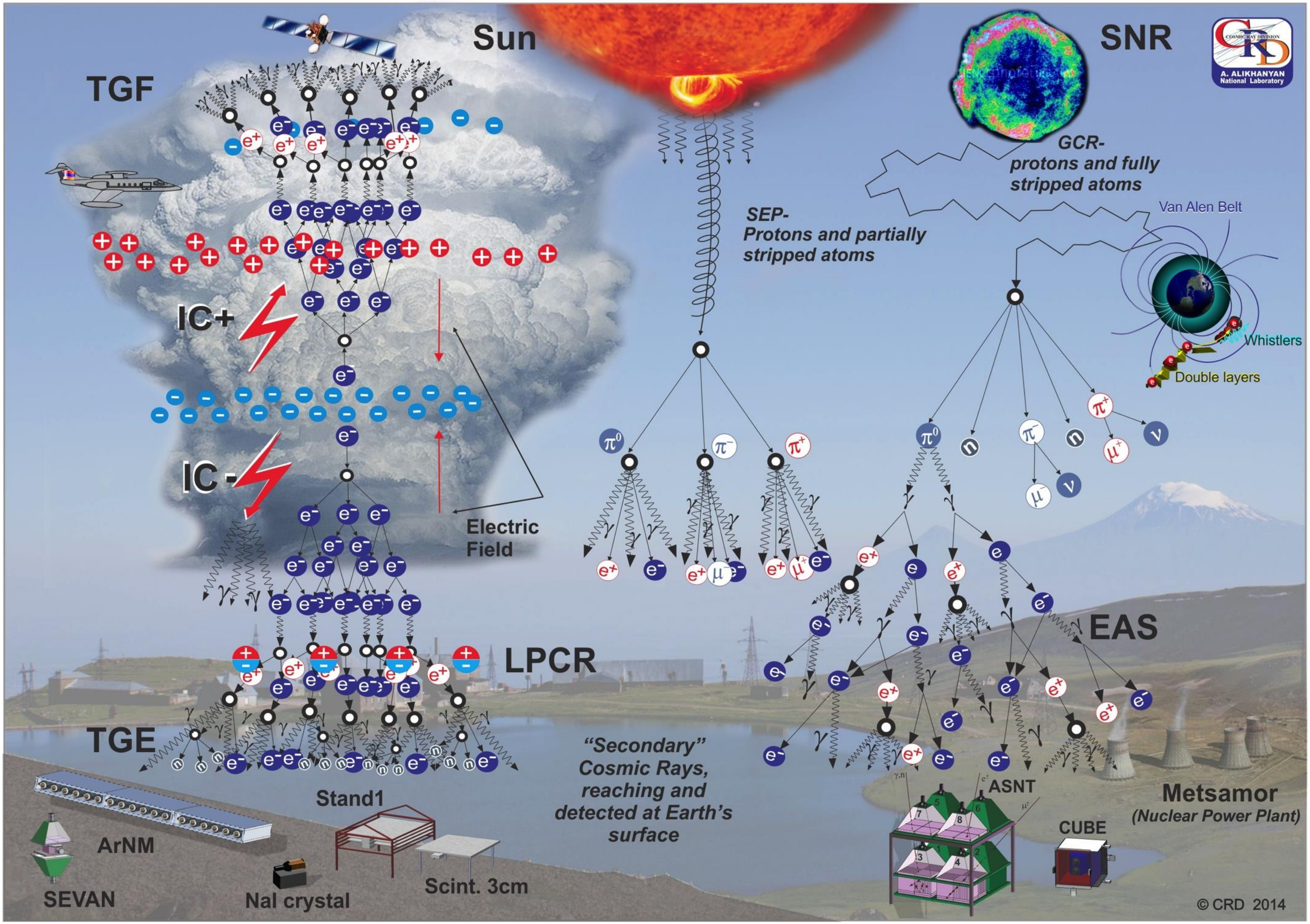
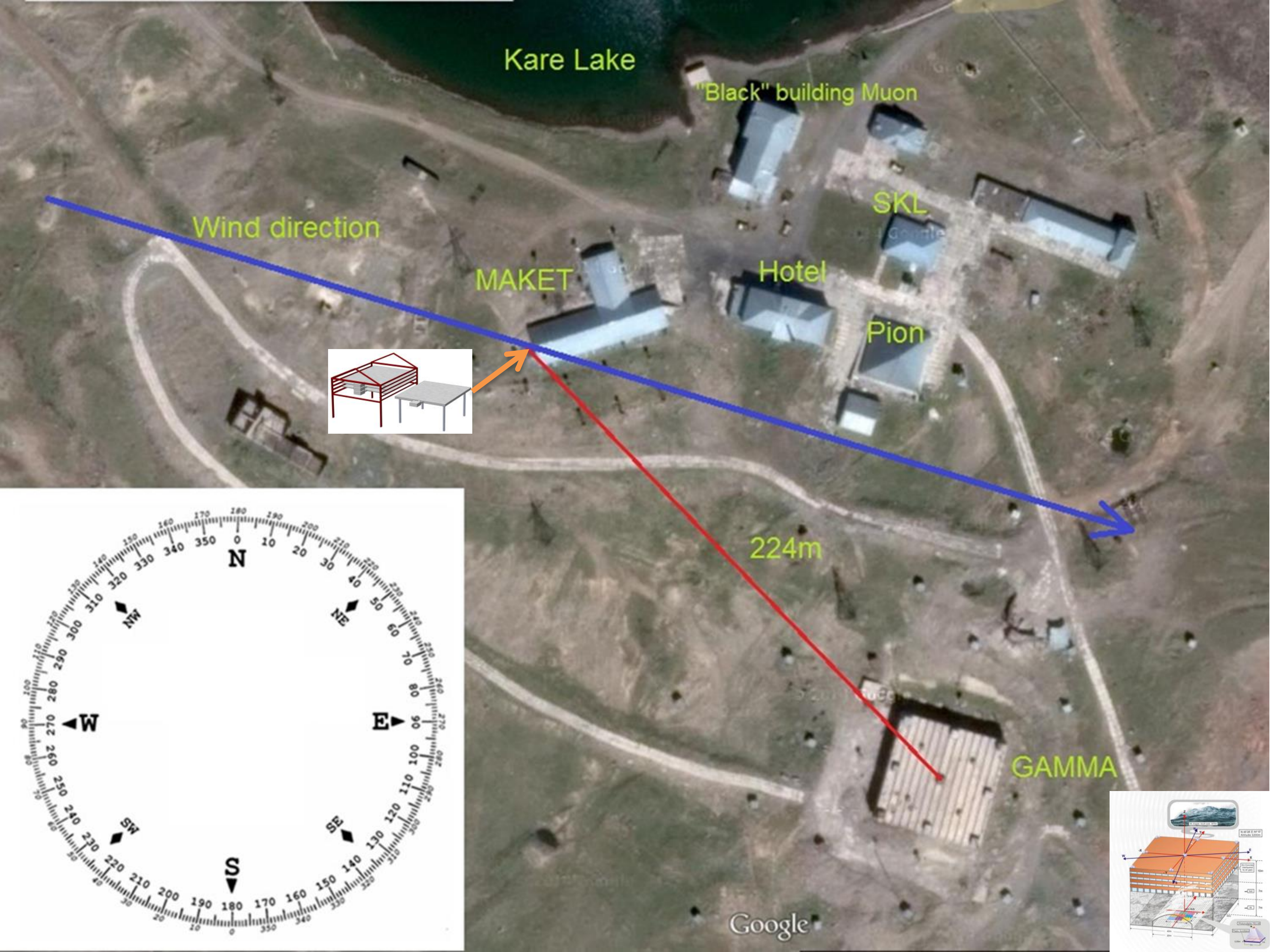
Origin of Secondary Cosmic Rays




Kare Lake
"Black" building Muon
SKL
Wind direction
MAKET
Hotel
Pion
224m
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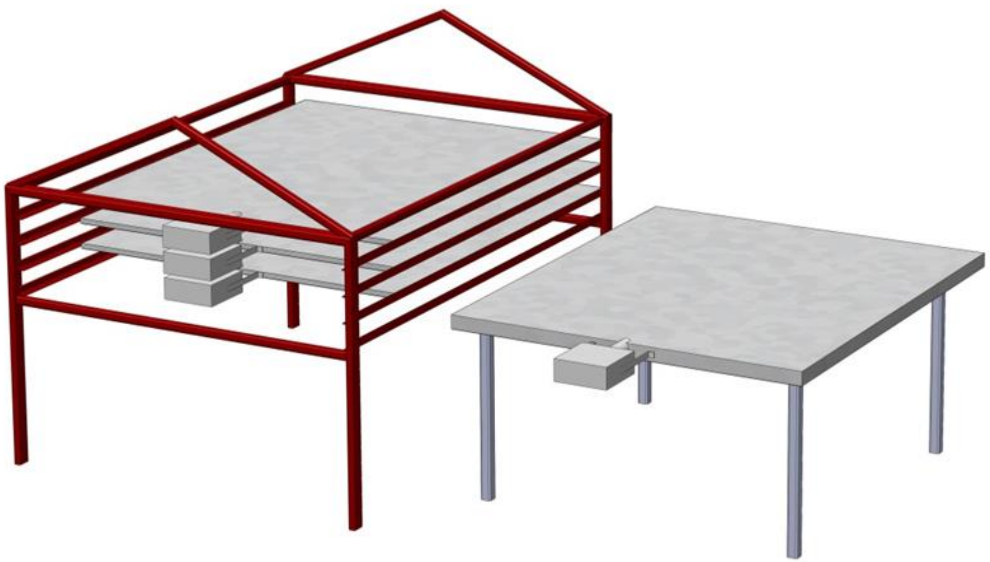
DESCRIPTION OF ARAGATS SPACE ENVIRONMENTAL CENTRE (ASEC) MONITORS

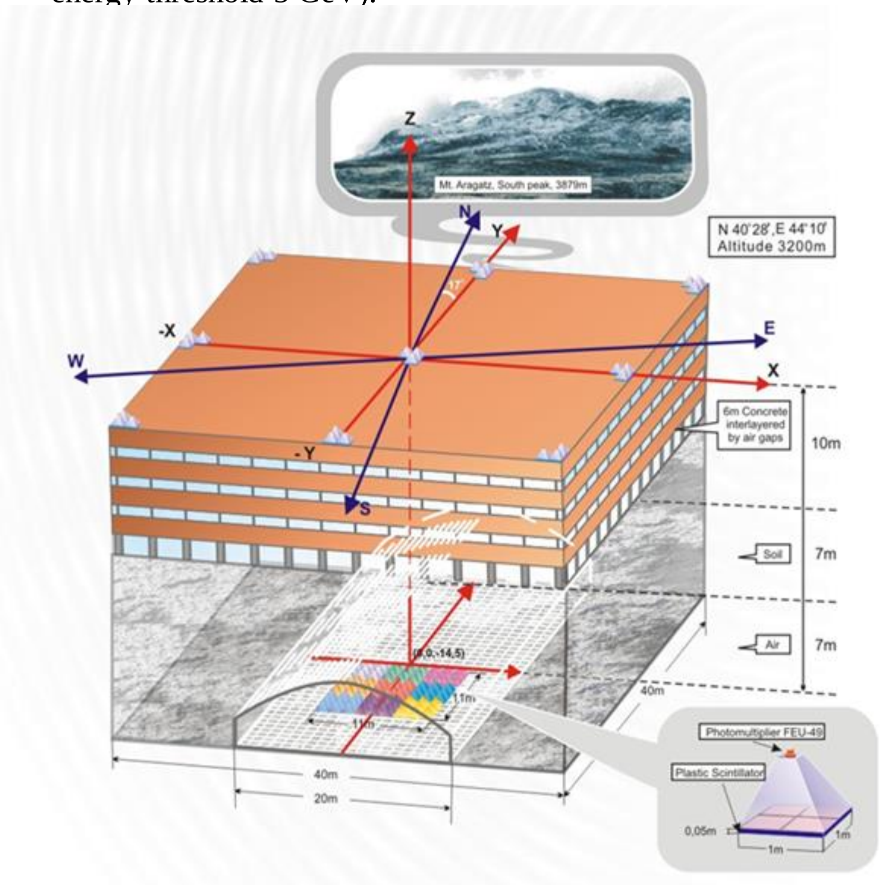
STAND

The **STAND** detector (3200m a.s.l), exclusively designed for the TGE research comprise of three-layers assembly of 1 cm thick and 1m^2 sensitive area molded plastic scintillators one above the other and 3cm thick scintillator located aside. Outdoor location, 1 cm thickness and three-layer design allow to measure flux of TGE electrons with 3 different energy thresholds starting from 1.5 MeV and to recover integral spectrum of TGE electrons. Proper tuning of the detector provides 98-99% signal detection efficiency simultaneously suppressing electronic noise down to 1-2%. The DAQ electronics allows measuring and storing all coincidences of the detector channel operation. For instance, coincidence “111” means that all 3 layers register particle, minimal energy of charged particles giving signal in all 3 layers should be above 10 MeV; coincidence “100” means that only upper detector registers particle – the energy threshold of this coincidence is equal ~1.5 MeV. The energy threshold of 3 cm thick scintillator is about ~5 MeV.



AMMM

Aragats Multidirectional Muon Monitor (3200m a.s.l) **(AMMM)** consists of 5 cm thick 1 m2 plastic scintillators located outdoors and in underground hall beneath 14 m of concrete and soil. Upper layer is composed of 29 scintillators; underground detector consists of 90 scintillators of the same type. (for registering high energy muons with energy threshold 5 GeV).



Wireless Vantage Pro2™ Plus

Weather Station **Wireless Vantage Pro2™ Plus** located in Aragats (3200m) and Nor-Amberd (2000m) stations register the following meteorological parameters.

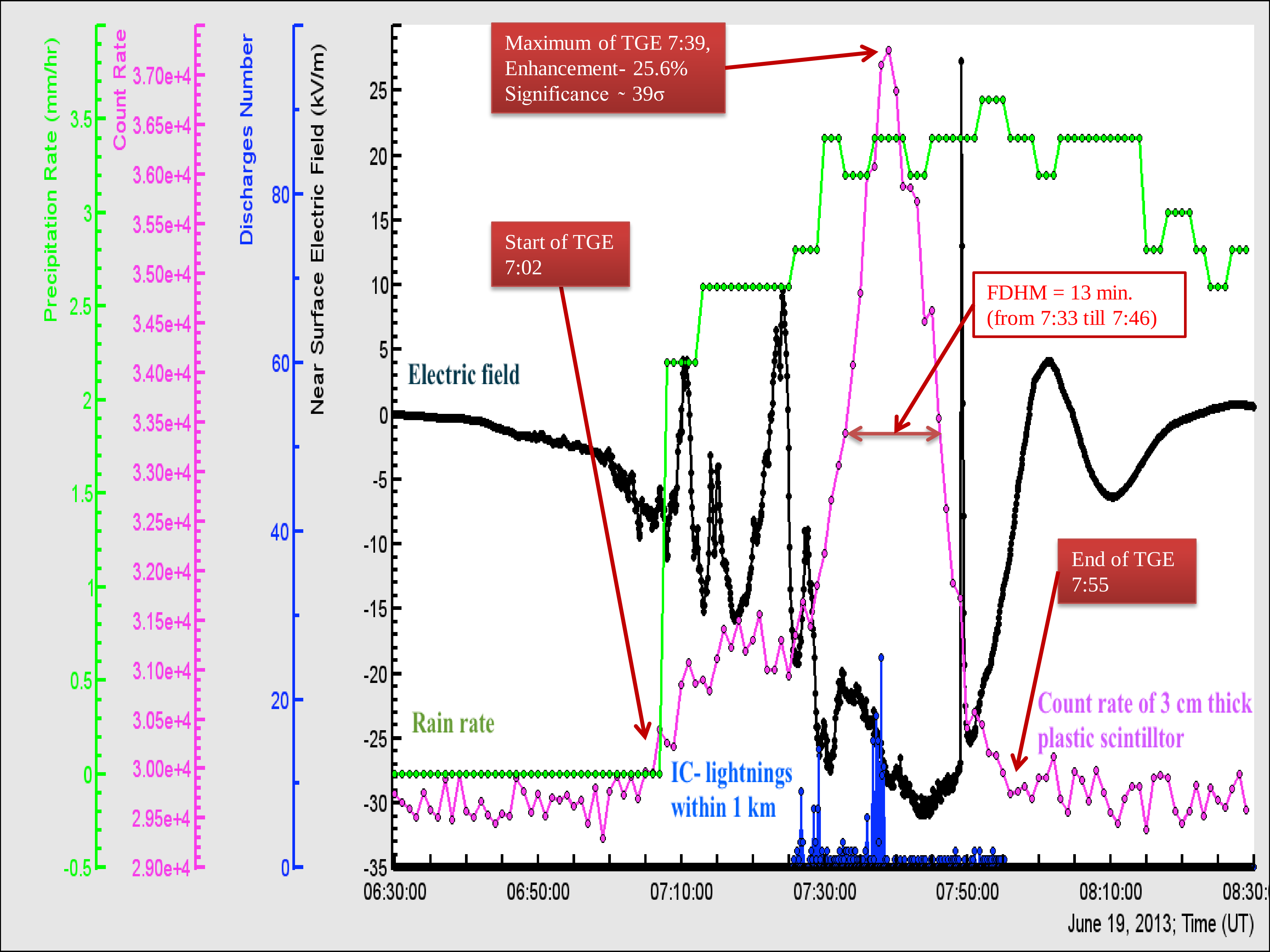
- **Outside Temperature in Celsius**
- **Inside Temperature in Celsius**
- **Outside Humidity in percent**
- **Inside Humidity in percent**
- **Wind Speed in m/s**
- **Wind Direction**
- **Solar radiation in Watts per square meter**
- **UV Index**
- **UV dose in MEDs**
- **Rain in mm**
- **Rain Rate in mm/hr**
- **Atmospheric air pressure in mbar.**

And many other parameters which are calculated from mentioned measured variables.

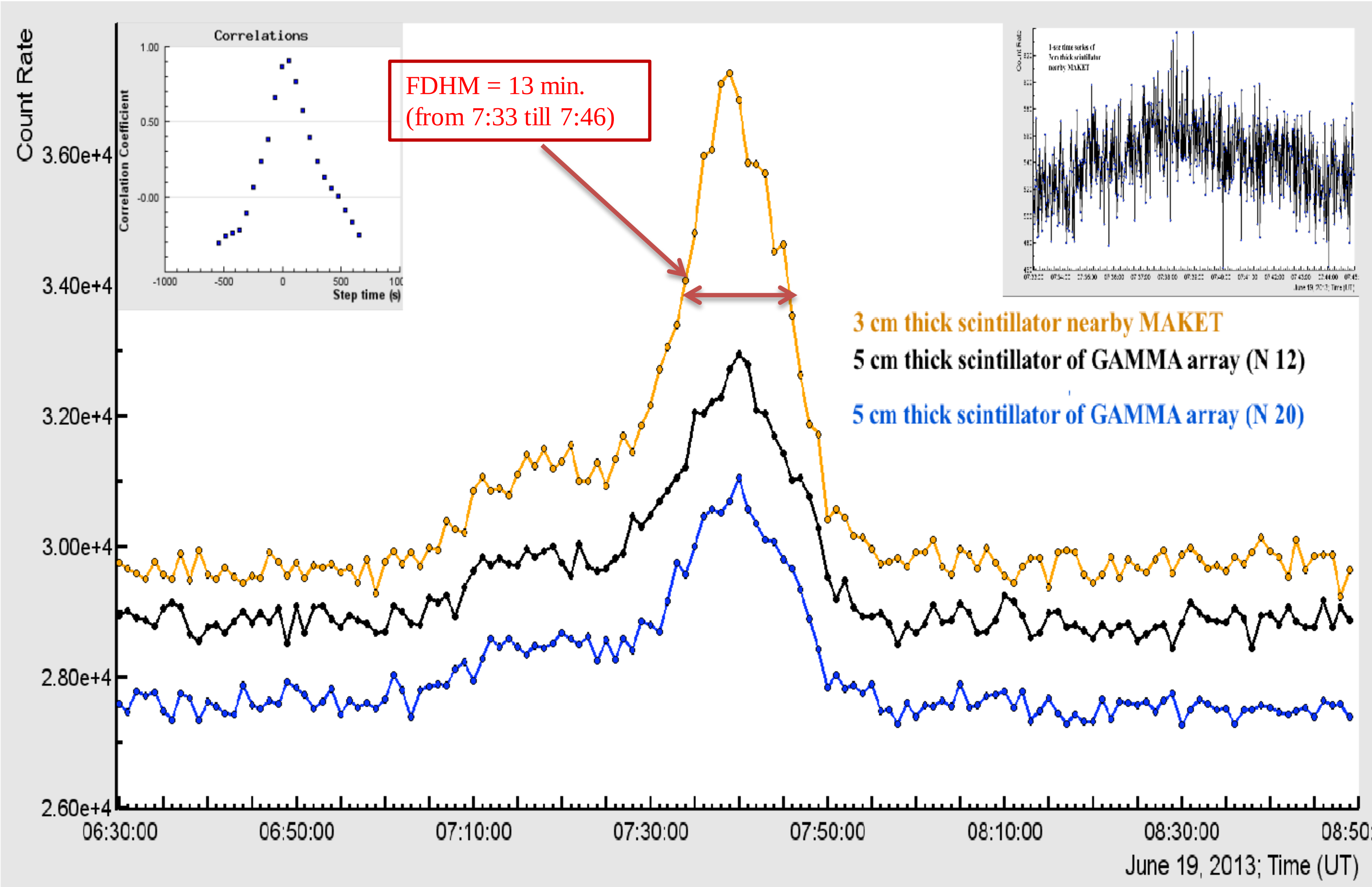
Electric Field Monitor Boltek EFM-100

Boltek EFM-100 detects not only nearby lightning but also the atmospheric conditions which precede lightning. Boltek EFM-100 Electric Field Monitor also measures the static electric field generated by thunderclouds electric field in Volts per meter (measurement accuracy 5%.). Lightning is detected as a sudden change in the static electric field. The electric charge contained in a thundercloud also generates an electric field. This field can be measured on the ground. EFM-100 can

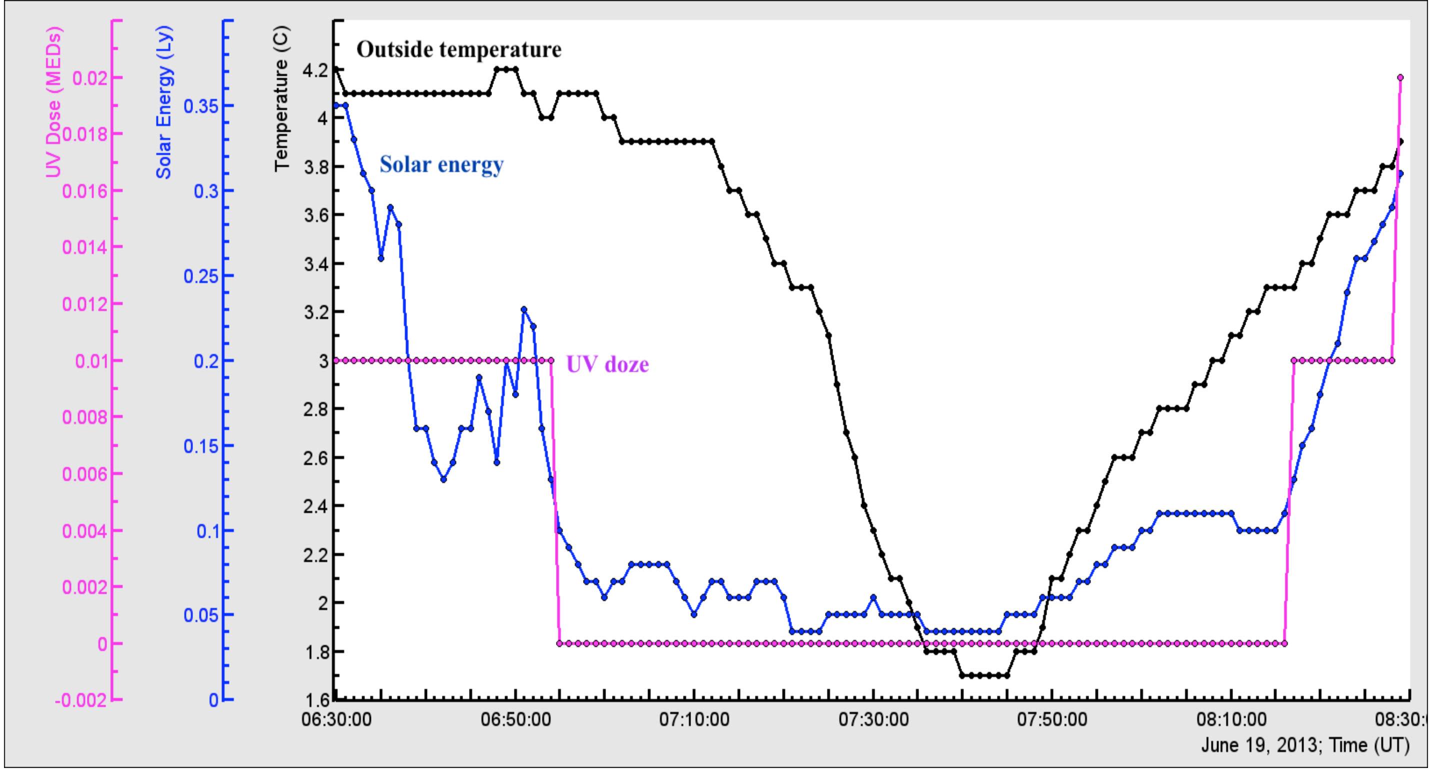
- **Log date, time and distance of nearby lightning.**
- **Monitor lightning up to 38 km away.**
- **Detect the high electric field conditions which precede lightning.**
- **Short-range detector is optimized for close lightning to provide the best distance accuracy while ignoring far away lightning.**
- **Monitor up to four separate locations per PC.**
- **Watch trends develop.**
- **Attention getting alarms.**
- **Review archived data from previous storms.**
- **Stay current with free software updates from the Boltek website.**



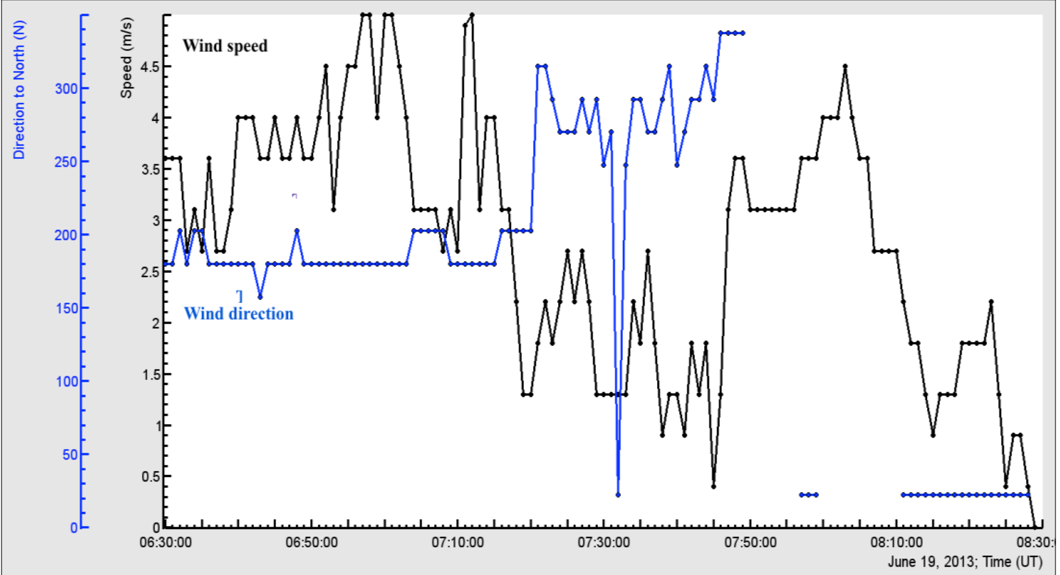
Precipitation Rate (mm/hr)
Count Rate
Discharges Number
Near Surface Electric Field (kV/m)
Maximum of TGE 7:39,
Enhancement- 25.6%
Significance ~ 39σ
Start of TGE
7:02
FDHM = 13 min.
(from 7:33 till 7:46)
Electric field
End of TGE
7:55
Rain rate
IC- lightnings
within 1 km
Count rate of 3 cm thick
plastic scintilltor
06:30:00
06:50:00
07:10:00
07:30:00
07:50:00
08:10:00
08:30:00
June 19, 2013; Time (UT)

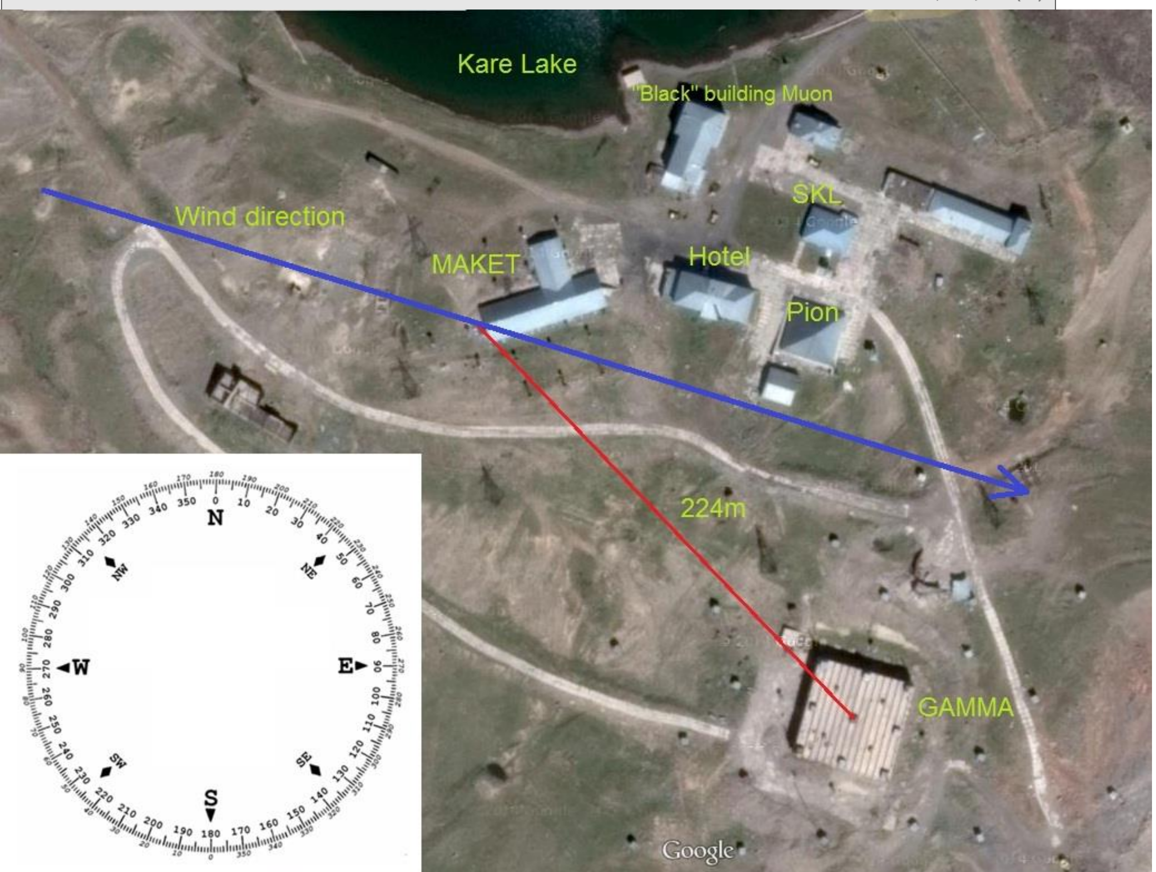


The "standardized" duration of TGE is measured by calculating of the full duration of the TGE main peak on the half-maximum (FDHM). FDHM of the main peak of 19 June TGE equals 13 minutes (from 7:33 till 7:46 and is approximately symmetric relative to a maximum of 7:39).



TGE occurs at suddenly changed meteorological conditions at observation site. At 6:52 solar radiation abruptly decreased as well as the outside temperature. We relate it to cloud appearance and shadowing of the sun. During the whole TGE duration (7:03 - 7:55) mean solar energy reaching the earth's surface was ~39 ± 9 W/m^2; mean temperature ~ 2.7 ± 0.7 C°. During FDHM (7:33 - 7:46) mean solar energy reaching the earth's surface was even less ~30 ± 1.5 W/m^2; mean temperature ~ 1.8 ± 0.1 C°. Both values of averaged radiation and temperature (and especially FDHM averaged) are significantly lower compared with pre-TGE values. Mean value of UV doze declines to zero value approximately in the whole TGE period. Therefore, we conclude that during FDHM thundercloud was directly above particle detectors. Thundercloud contains rain droplets on which Lower Positive Charge Region (LPCR) was sited and electric field was lowered during FDHM with a mean value of ~ -27 ± 3 KV/m. Electrons were accelerated in the cloud just above particle detectors. We suppose that changing particle flux is connected with moving of the thundercloud above the detector. The detector was exposed to radiation emitting "window" in a thundercloud during passing of it above detectors.





During FDHM (7:33 - 7:46) mean wind speed was ~0.74 ± 0.44 m/sec; the mean wind direction was to North ~ 288 ± 24N; it abruptly changes to 28N after TGE attenuation. We can make a rough estimate of cloud size based on wind speed and time of illumination. We assume that only during FDHM the “core” of electrified cloud was above detector (the lower values of flux can be explained by scattered gamma rays). Direction of wind was approximately constant and we can estimate the distance that cloud crosses during 13 minutes of FDHM to be ~ 600 m. Well coinciding with our previous estimates and Japanese groups estimates.

Conclusions

The model of TGE initiation (Chilingarian, 2014) anticipates the development of the lower positive charge region (LPCR) as a necessary condition of electron acceleration in thunderclouds. LPCR is localized to a fairly small volume. Holden et al., 1980 mention that the effect of the field attributable to LPCR development is usually only observable at distances less than 1 km. Therefore, it should alter only locally the electrical field configuration in the thundercloud and the size of the lower dipole formed by LPCR and main negative charged layer in the middle of thundercloud also should be local.

Our estimate of the radiation emitting region in the thundercloud which illuminates earth's surface just below thundercloud well coincide with estimates from other experiments performed at sea level and mountain altitudes and with Holden's et al., estimate. Therefore, we conclude that usually radiation emitting region in the thundercloud is of 0.5 - 1.5 km size and for the TGE registered at 19 June 2013 by Aragats research station facilities at altitude 3200 m it was ~ 600 m.

Thank you for attention