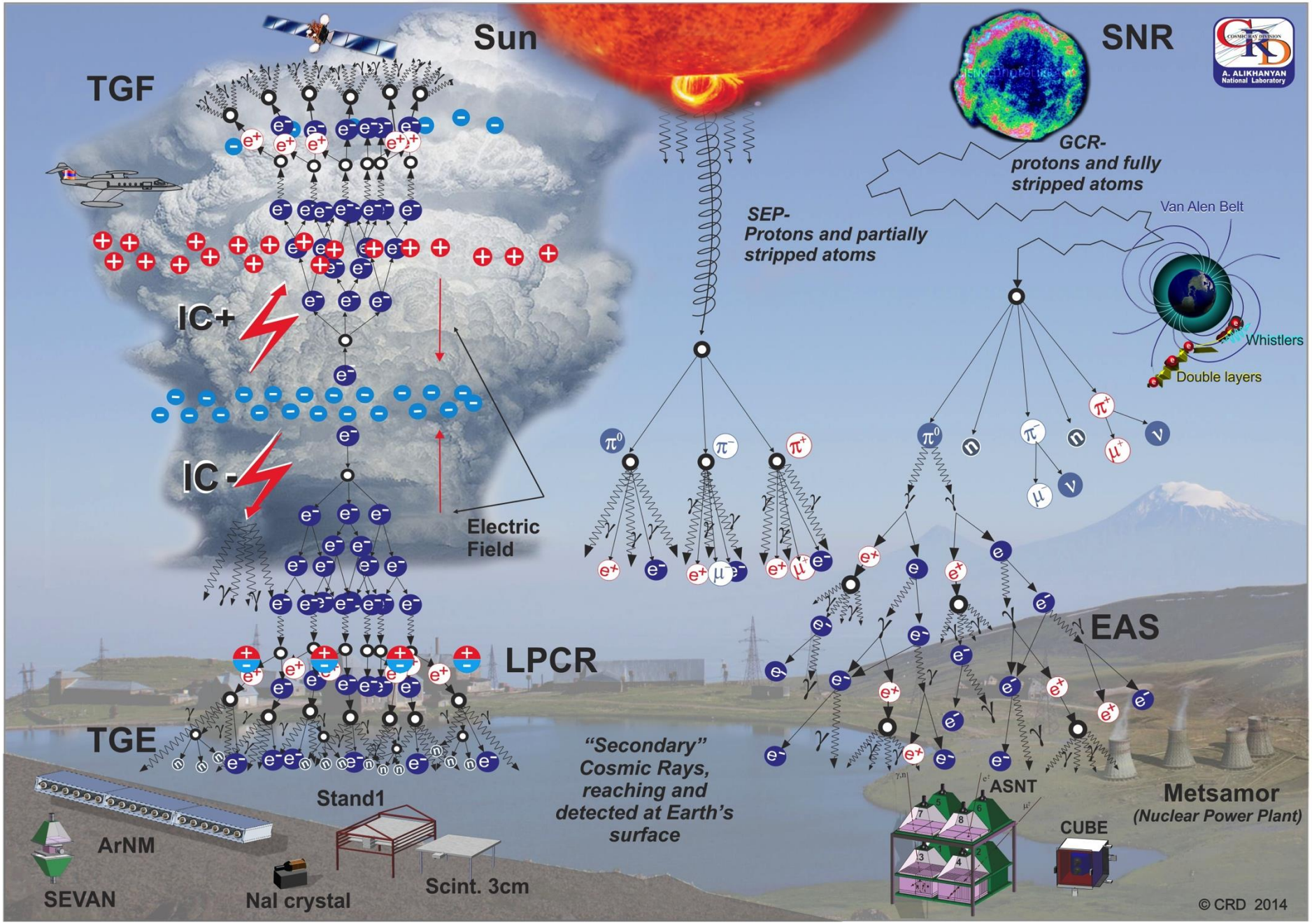
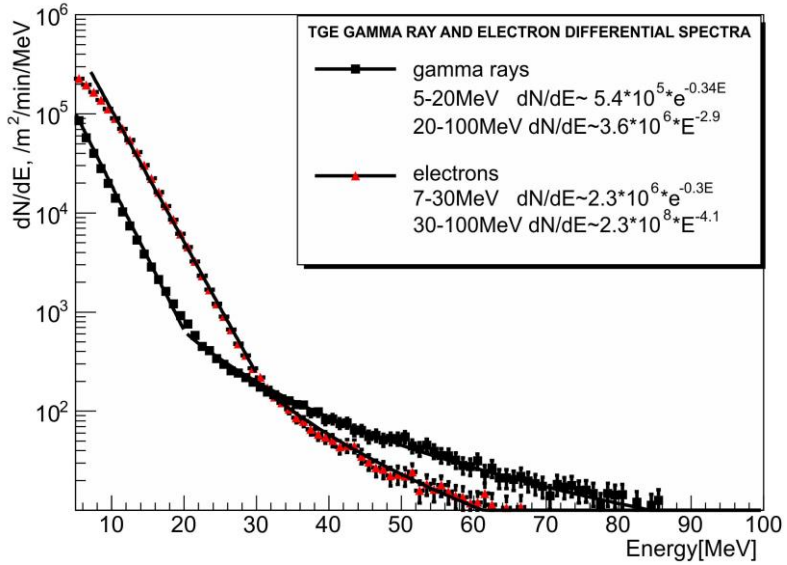
Origin of Secondary Cosmic Rays

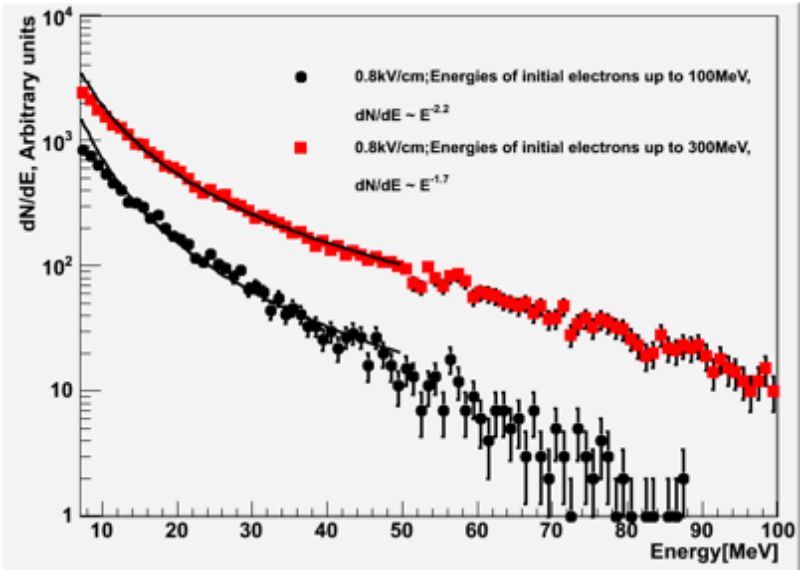


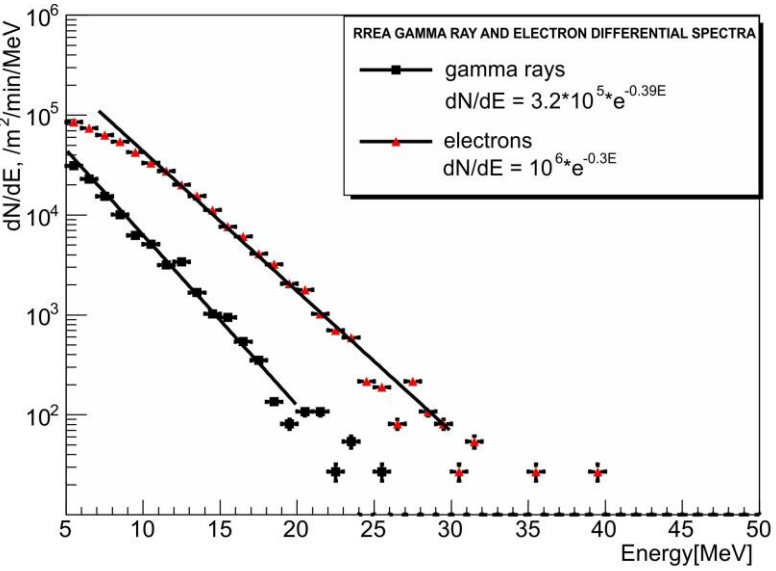
Discussions

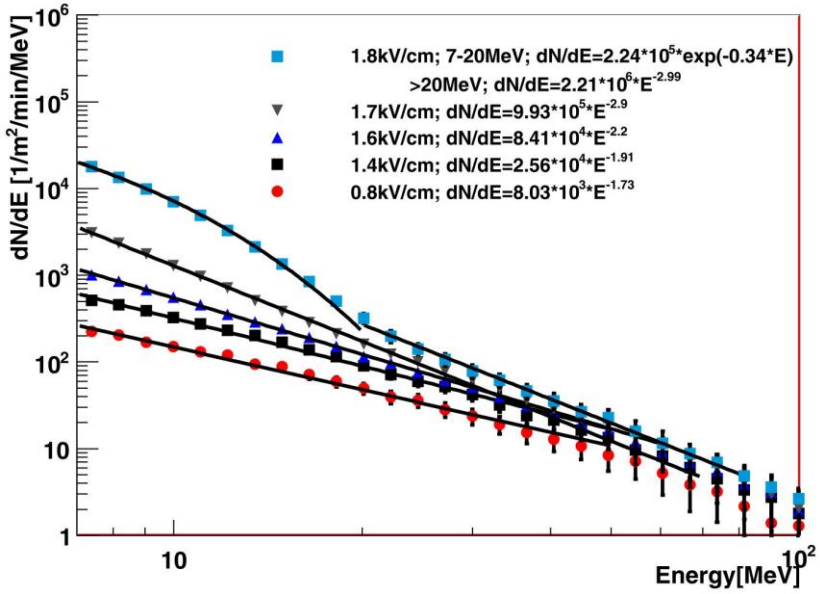
- TGEs and TGFs – symmetric processes?
- Lower dipole – upper dipole (positive – negative electric field); electrons accelerated downwards – upwards; IC- lightnings; IC+ lightnings;
- TGE – need developed LPCR – transient phenomenon; needs high RE, washed down by rain (origin of Long TGE) 0bserved and proved; TGF – dipole always present in thundercloud;
- RREA - observed in TGE, however – very rare process – manifestation – huge enhancements of flux, ECSses, exponential spectra; Don't observed in TGF; don't provide enough seed electrons if not include unproven exotic processes;
- MOS – power law energy spectra – observed in TGE; modest enhancement – most of TGE events; do not considered in TGF;
- Seeds: TGE – CR electrons – simulated agree with observations; TGF -the thunderstorm must have produced about 10^{17} high-energy electrons (average energy is 7 MeV), in order to account for the fluence of gamma rays recorded at the spacecraft many hundreds of kilometers away,
- Particle fluxes and lightnings – no direct causal relation; occurred after TGE and TGF.
- High energy physics in atmosphere - perspectives for coming years:
- Satellite missions;
- compare observed TGE characteristics with TGFs: will be it possible to recover individual, not cumulative TGF energy spectra? Compare spectral indices? Why TGF spectra are nor exponential if origin is avalanche process?

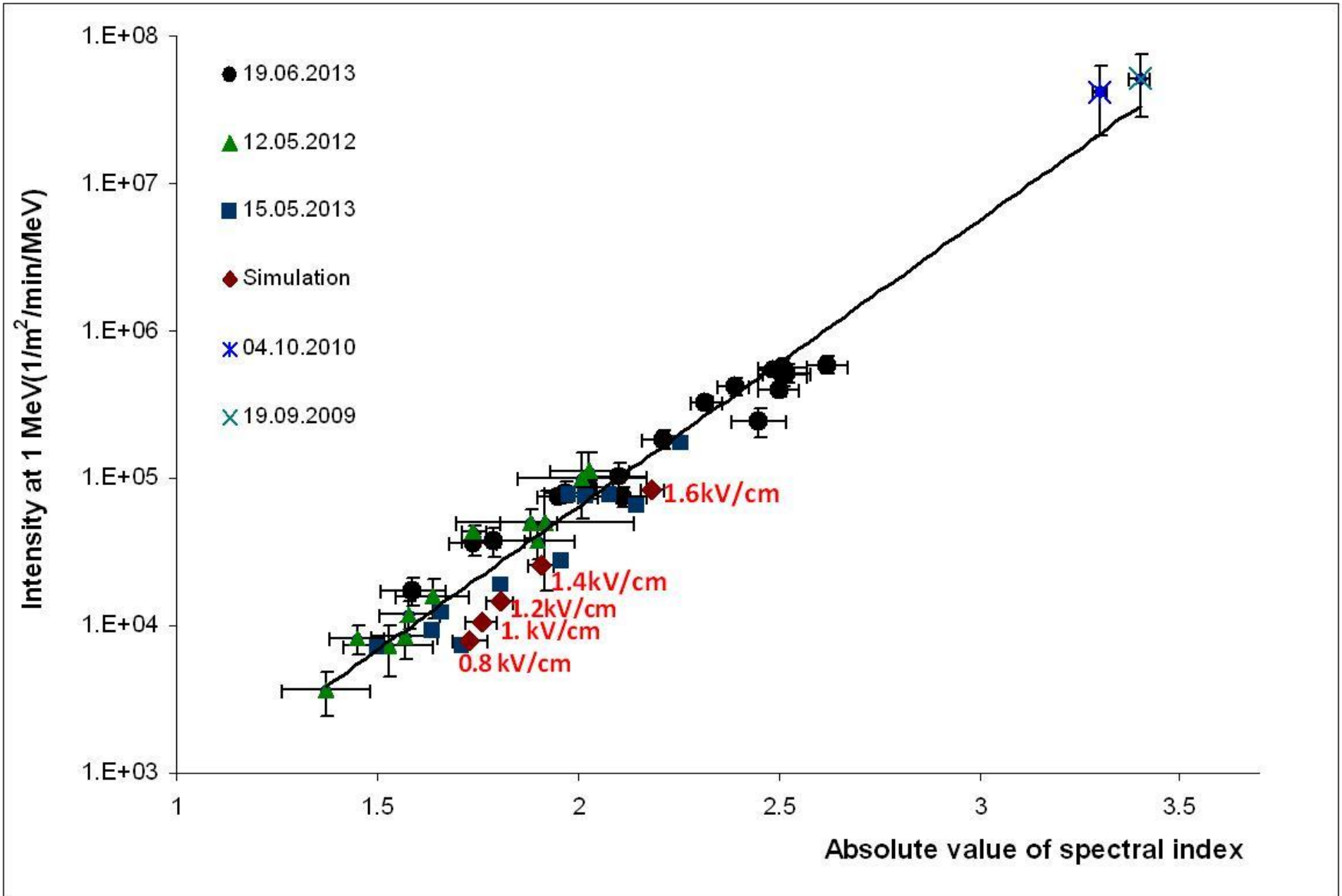
2-component model of TGE: GEANT4 simulation of TGE: Uniform Electrical fields of 0.8 – 1.8 kV/m, started from 5000 m till 3350Observation on 3200. Seeds: CR ambient electrons



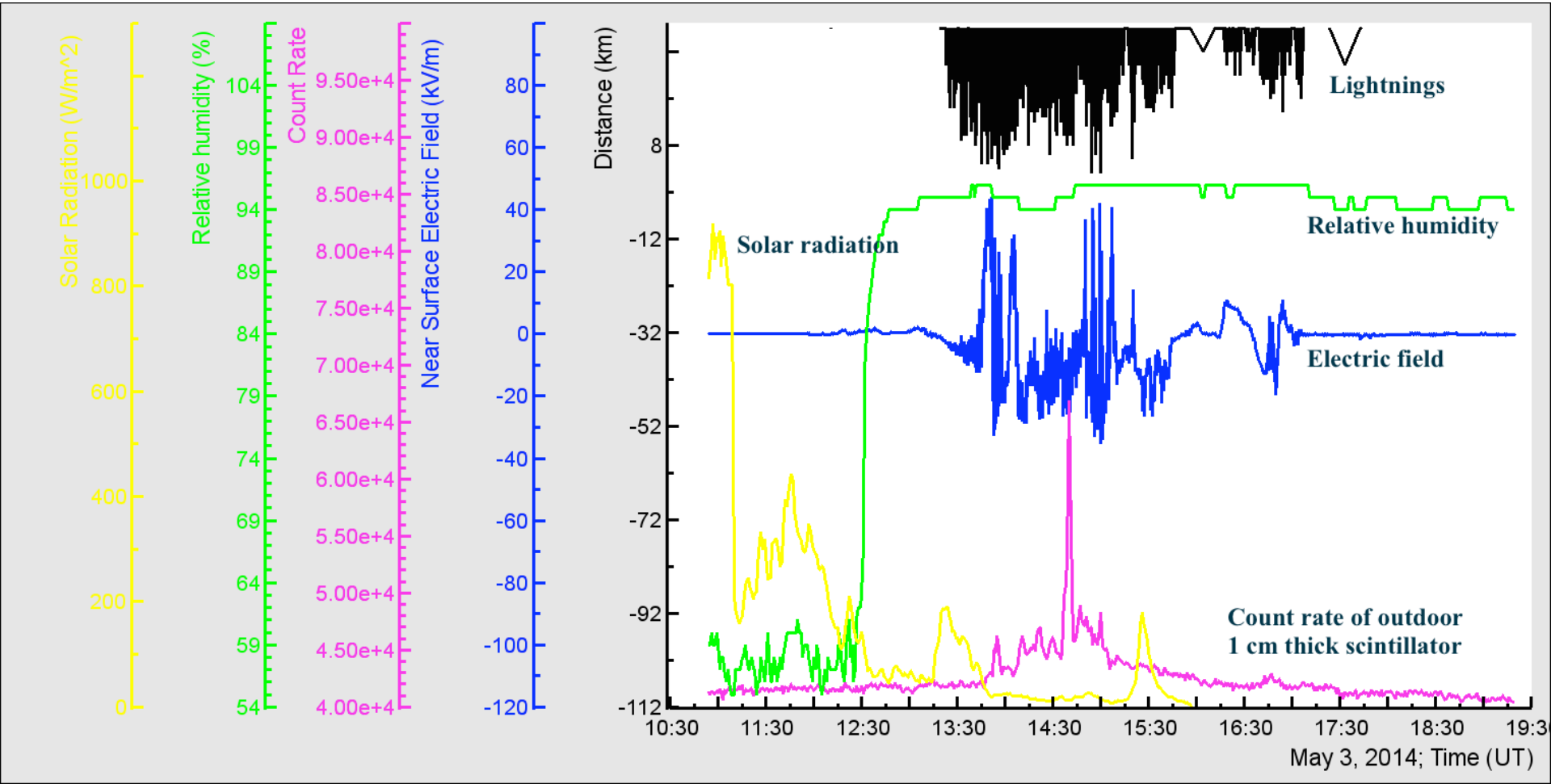




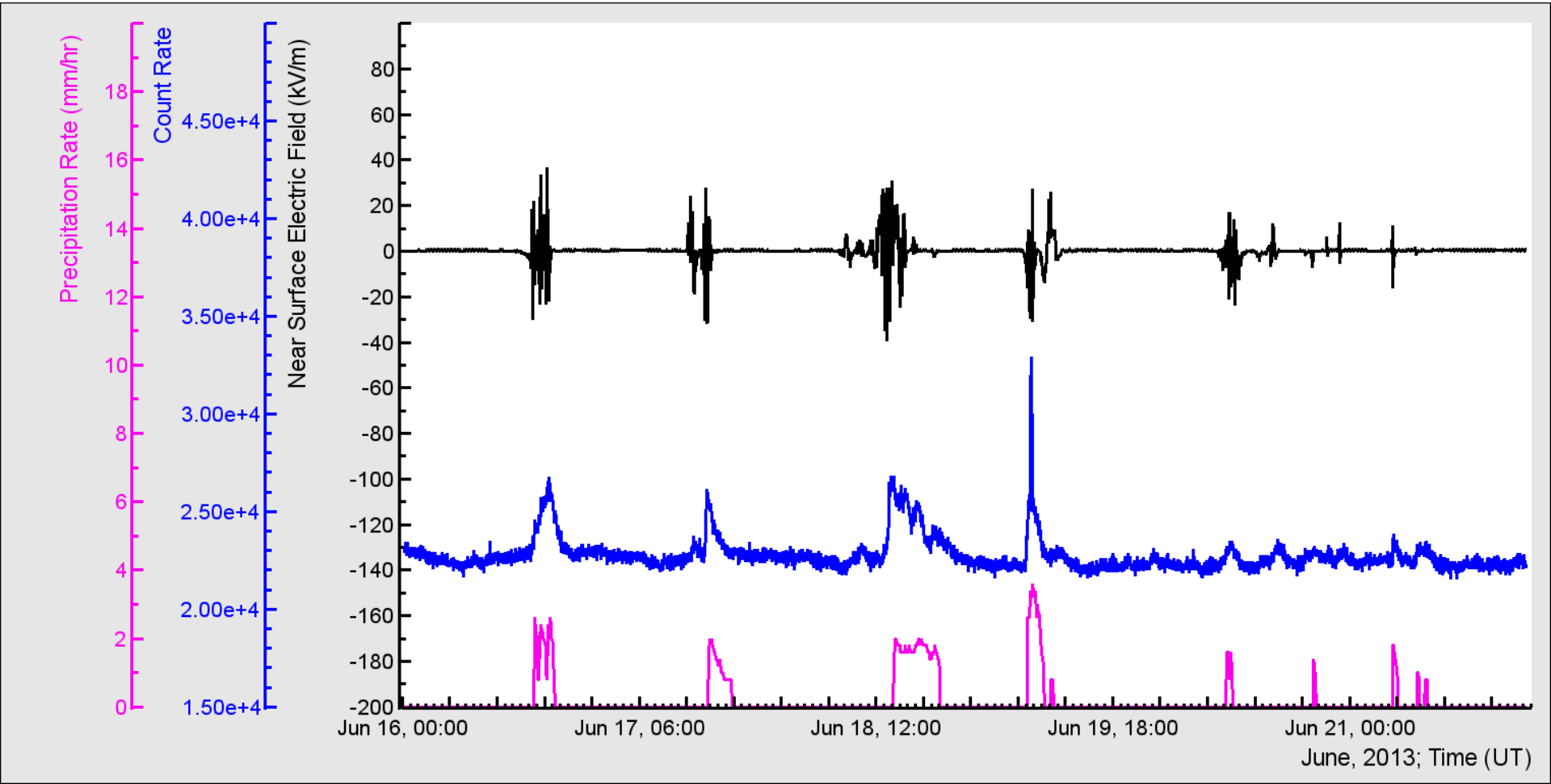



1.E+08
1.E+07
1.E+06
1.E+05
1.E+04
1.E+03
Intensity at 1 MeV(1/m²/min/MeV)
19.06.2013
12.05.2012
15.05.2013
Simulation
04.10.2010
19.09.2009
1.6kV/cm
1.4kV/cm
1.2kV/cm
1. kV/cm
0.8 kV/cm
1
1.5
2
2.5
3
3.5
Absolute value of spectral index

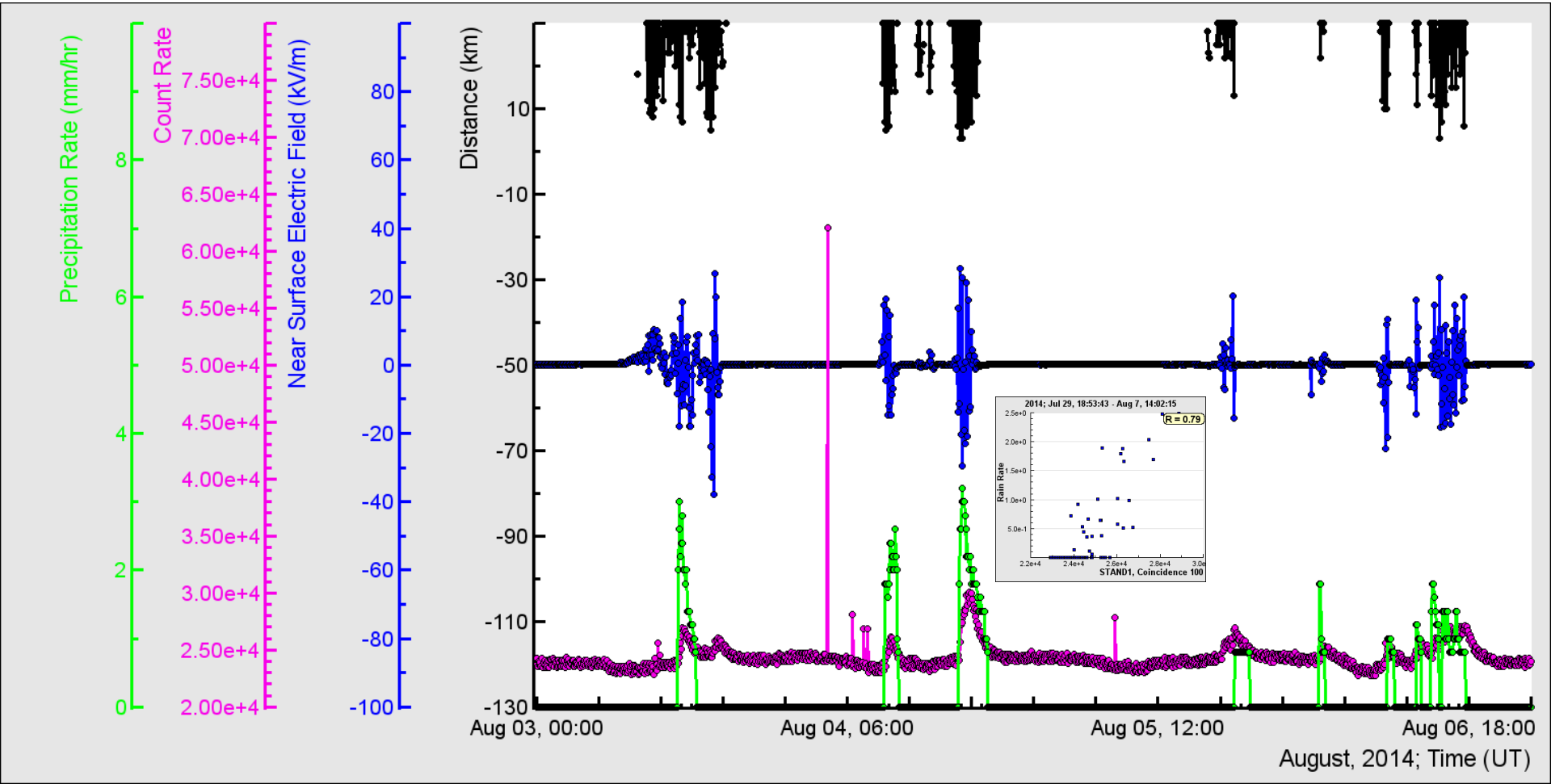
TGE is coincided with rise of Humidity – LPCR development

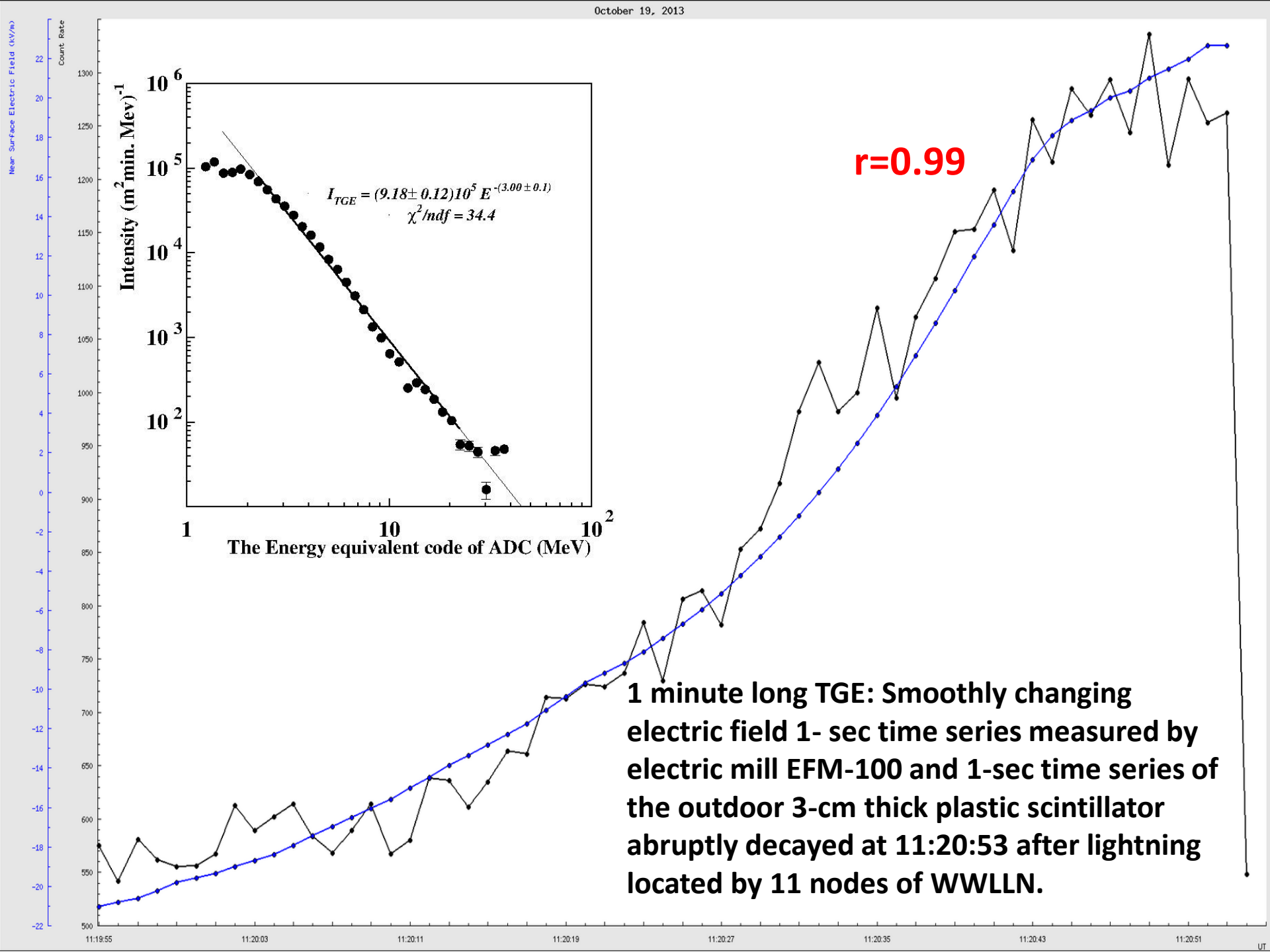


Charge reside on rain droplets making LPCR and- lower dipole accelerated electrons downward



After finishing of rain TGE fast decays – rain wash down LPCR and lower dipole decays as well

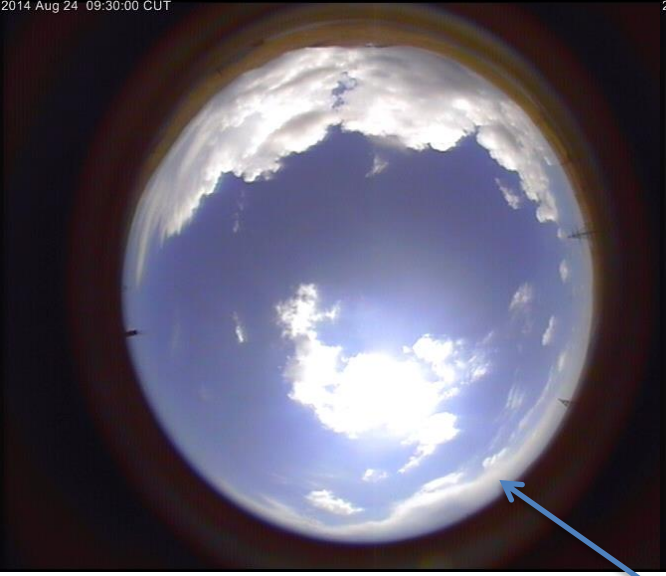



October 19, 2013
Near Surface Electric Field (kV/m)
Count Rate
Intensity (m^{2}min. Mev)$^{-1}$
10^6
10^5
10^4
10^3
10^2
$I_{TGE} = (9.18 \pm 0.12)10^5 E^{-(3.00 \pm 0.1)}$
$\chi^2/ndf = 34.4$
1
10
10^2
The Energy equivalent code of ADC (MeV)
r=0.99
1 minute long TGE: Smoothly changing electric field 1- sec time series measured by electric mill EFM-100 and 1-sec time series of the outdoor 3-cm thick plastic scintillator abruptly decayed at 11:20:53 after lightning located by 11 nodes of WWLLN.
11:19:55
11:20:03
11:20:11
11:20:19
11:20:27
11:20:35
11:20:43
11:20:51
UT

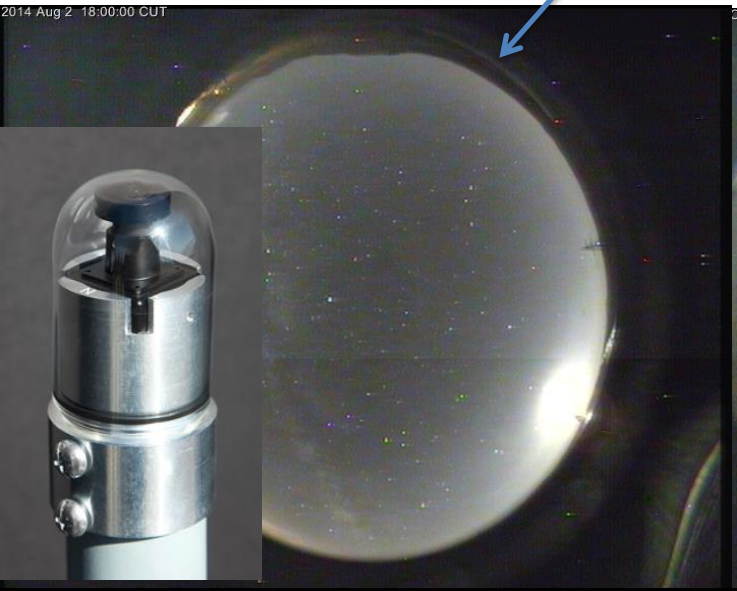
19 October 2013 TGE, 1-sec fluxes at 11:20:49 – 11:20:53 – compared with commulative flux AGILE TGFs

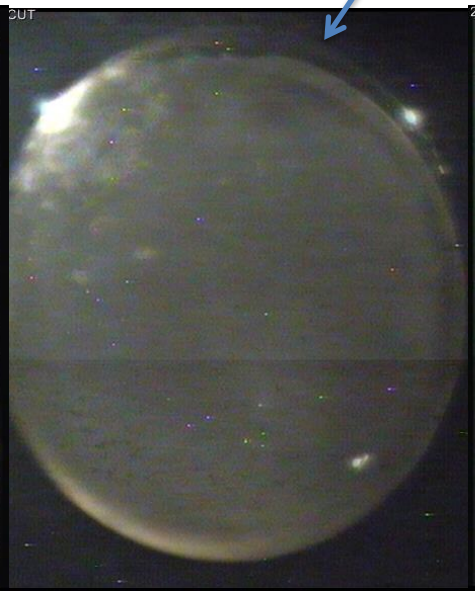
	Mean (CR) count rate 1/sec	TGE peak	TGE flux = PEAK-CR	Detector area (m^2)	Det. eff.	TGE Flux** ($1/cm^2 sec$)
ScI	689+/- 25	1450	50,000	0.0135	0.8	7
3cm thick sc.	532+/- 23	1320	532	1	0.02	4
60 cm thick sc.***	3080+/- 55	10054	3080	1	0.20	1.7
NaI	75+/- 10	345	2340	0.032	0.8	1.2
AGILE 308 TGFs						17

Marisaldi, M., et al. (2014), Properties of terrestrial gamma ray flashes detected by AGILE MCAL below 30 MeV *J. Geophys. Res. Space Physics*, *119*, 1337–1355



Nearby CG; EFM ~0.1-0.2 EFM < +/- 10 kV/m EFM > 20 kV/m





TEPA-2015?

- Comments on TEPA-2014;
- Students support;
- Proceedings? End of 2014.

- TEPA-2015:
- Nor – Amberd? Moscow?
- Dates? August?