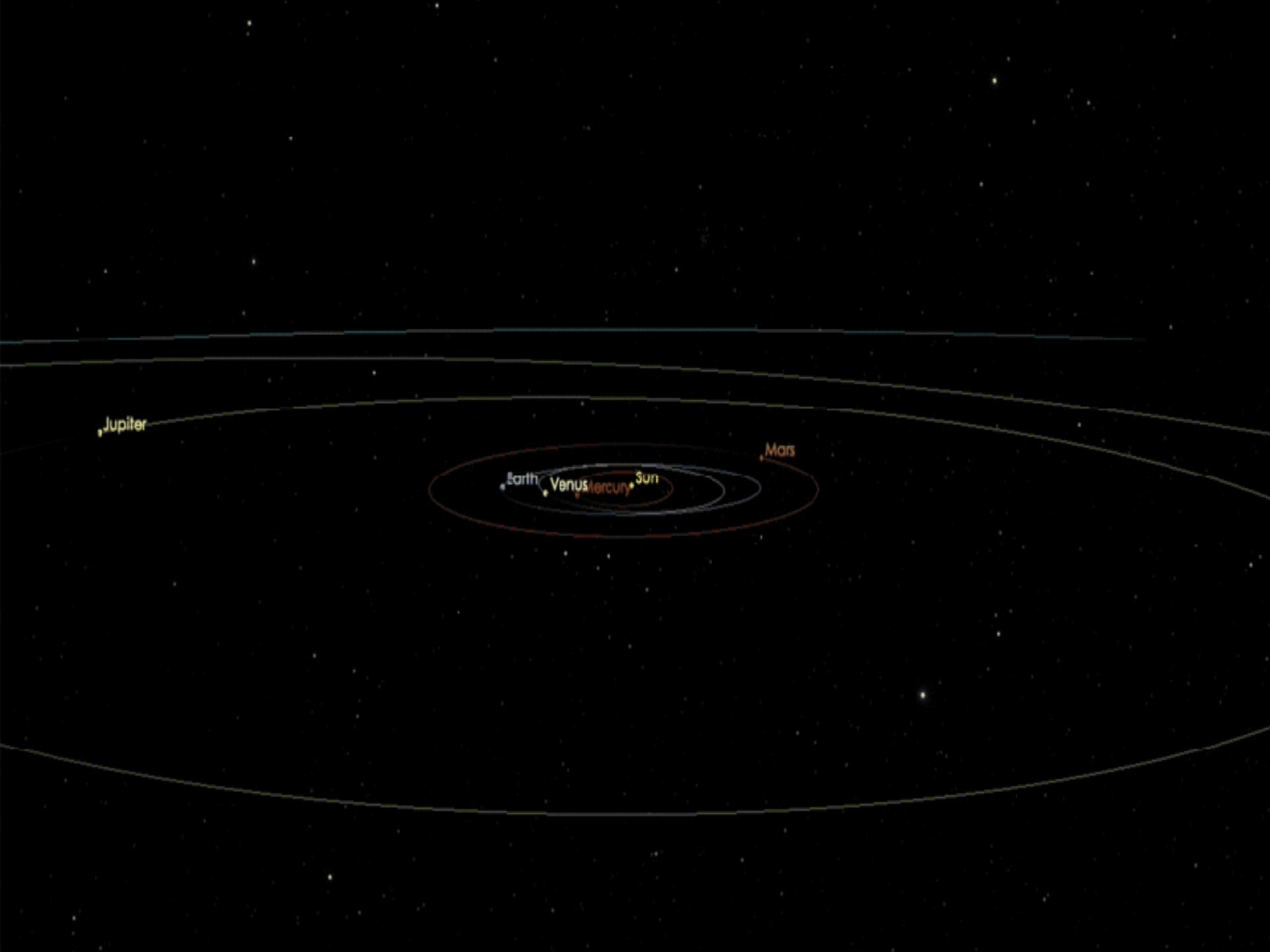
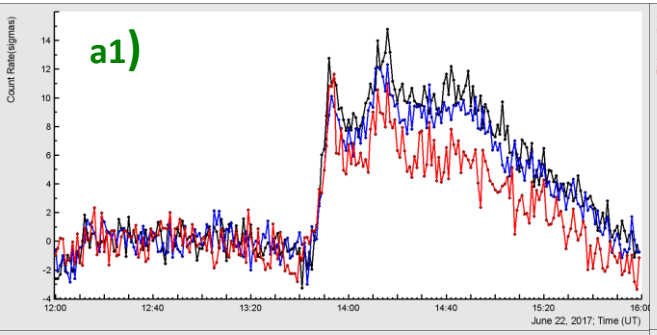
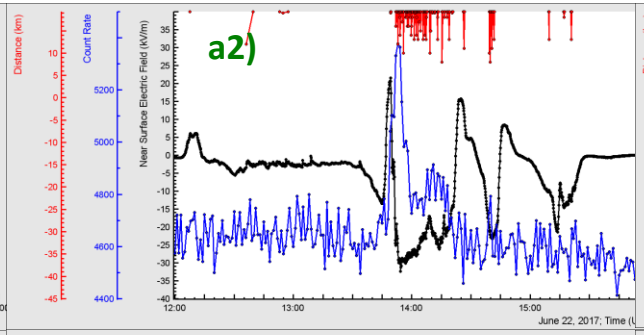

Jupiter
Mars
Earth
Venus
Mercury
Sun

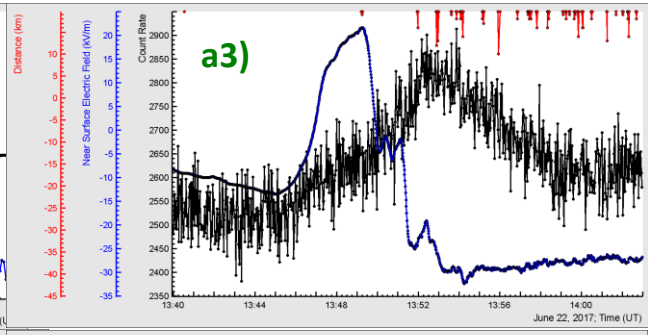
Parameters of 7 Summer- early Autumn TGEs observed on Aragats Mt.

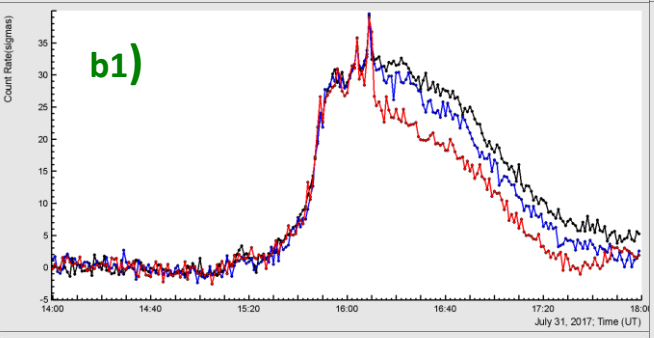
Date	Peak 1	Peak 2	Nσ NaI 1-7	NaI 5	Nσ 100 STAN D1	ΔT >200 KeV min	ΔT >2 MeV min	Dist flash km	Dist. cloud m	-E Kv/m
June 22	13:52	14:14	17	10.2	19.7	135	11	11.5	200	30
July 31	16:04	16:09	40	11	58	240	6	7.6	130	24
Aug.17	18:55	18:57	48	51	33.5	210	4	1.7	200	5.6
Sept.29	21:52	-	16	11	4.7	120	3	11	40	11
Oct. 1	5:58	-	19	9.3	8.4	90	4	16	200	22
Oct.2	8:04	-	8.6	5.7	33	60	3	16	60	21
Oct. 10	14:08	14:10	56	30	32	120	5	1.8	150	22

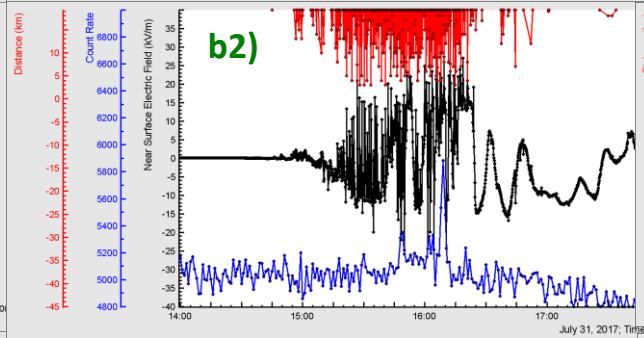
2017 Summer TGEs, Aragats, Armenia

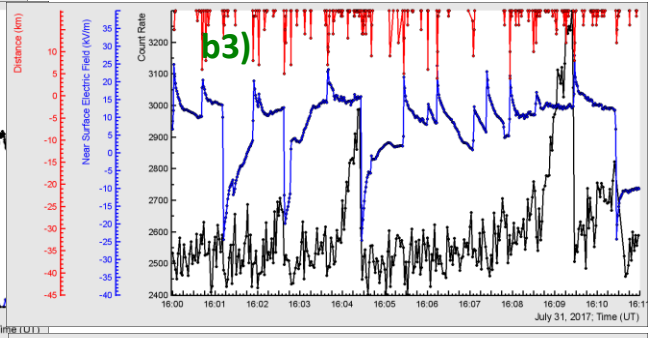


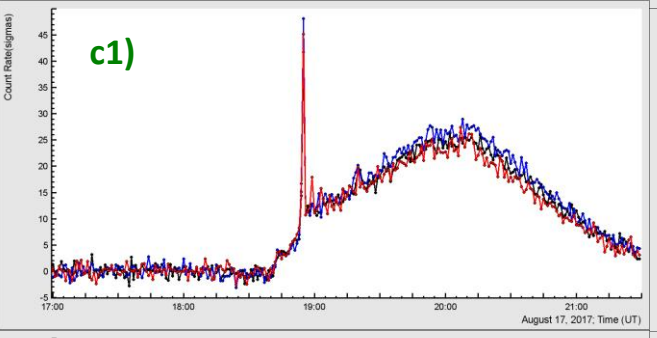


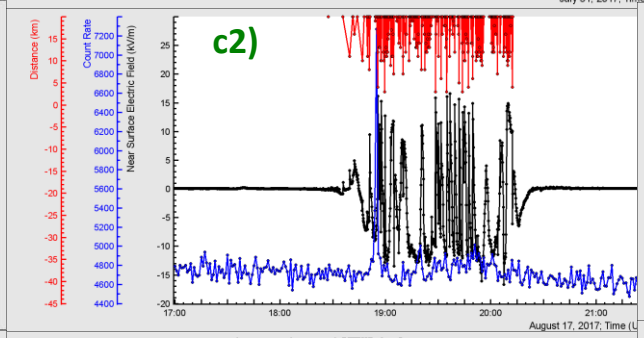


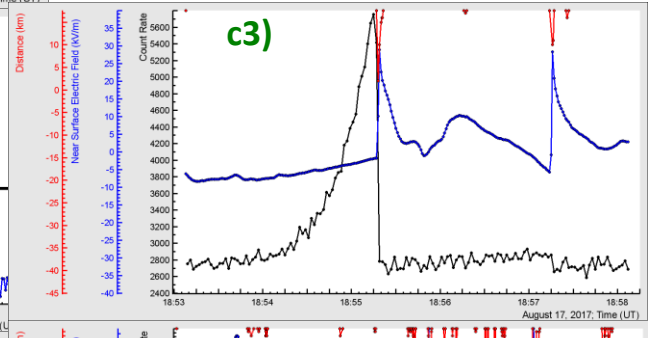


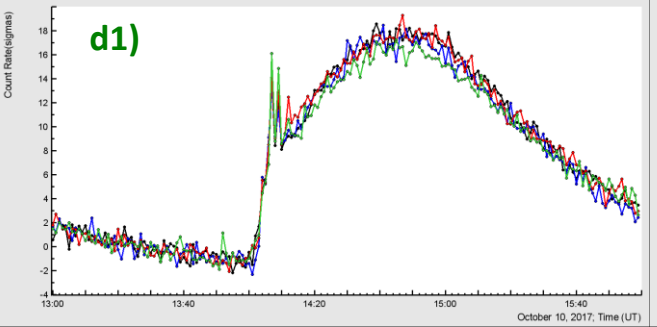


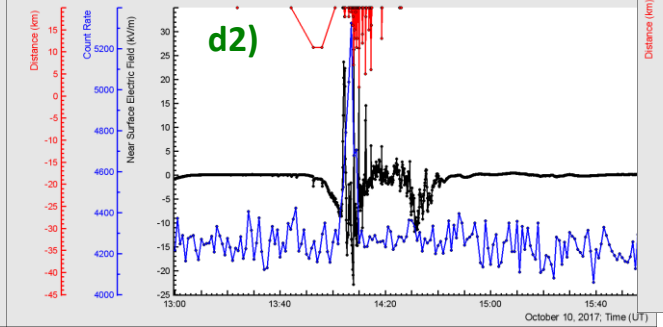


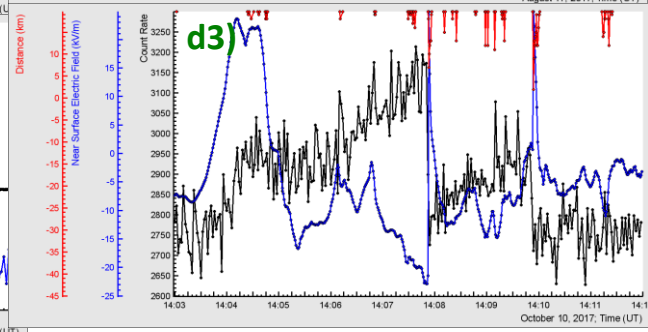




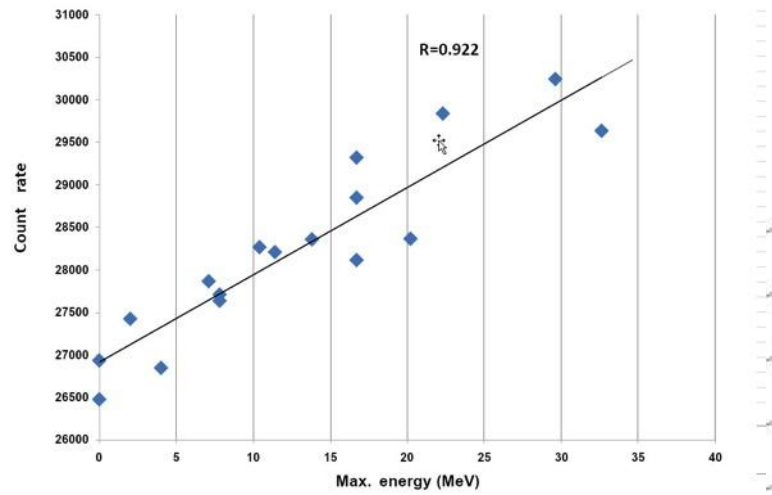


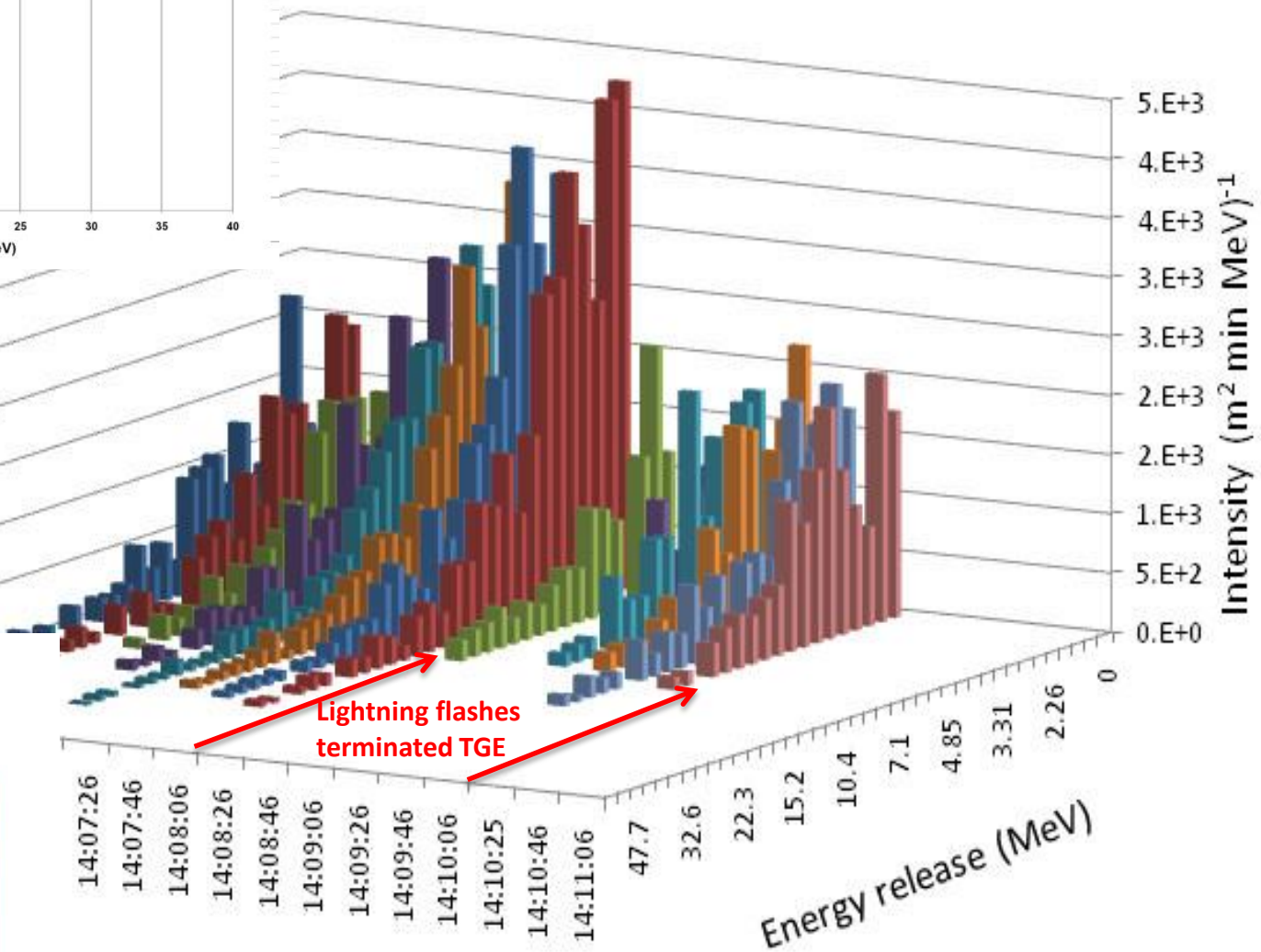


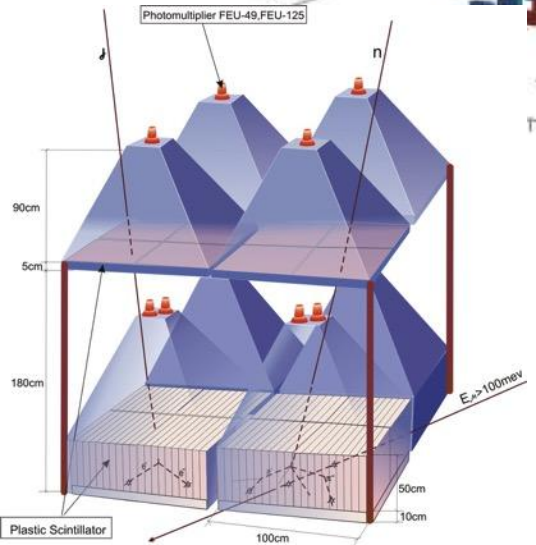




Normal polarity intracloud flashes terminate TGE 2 times

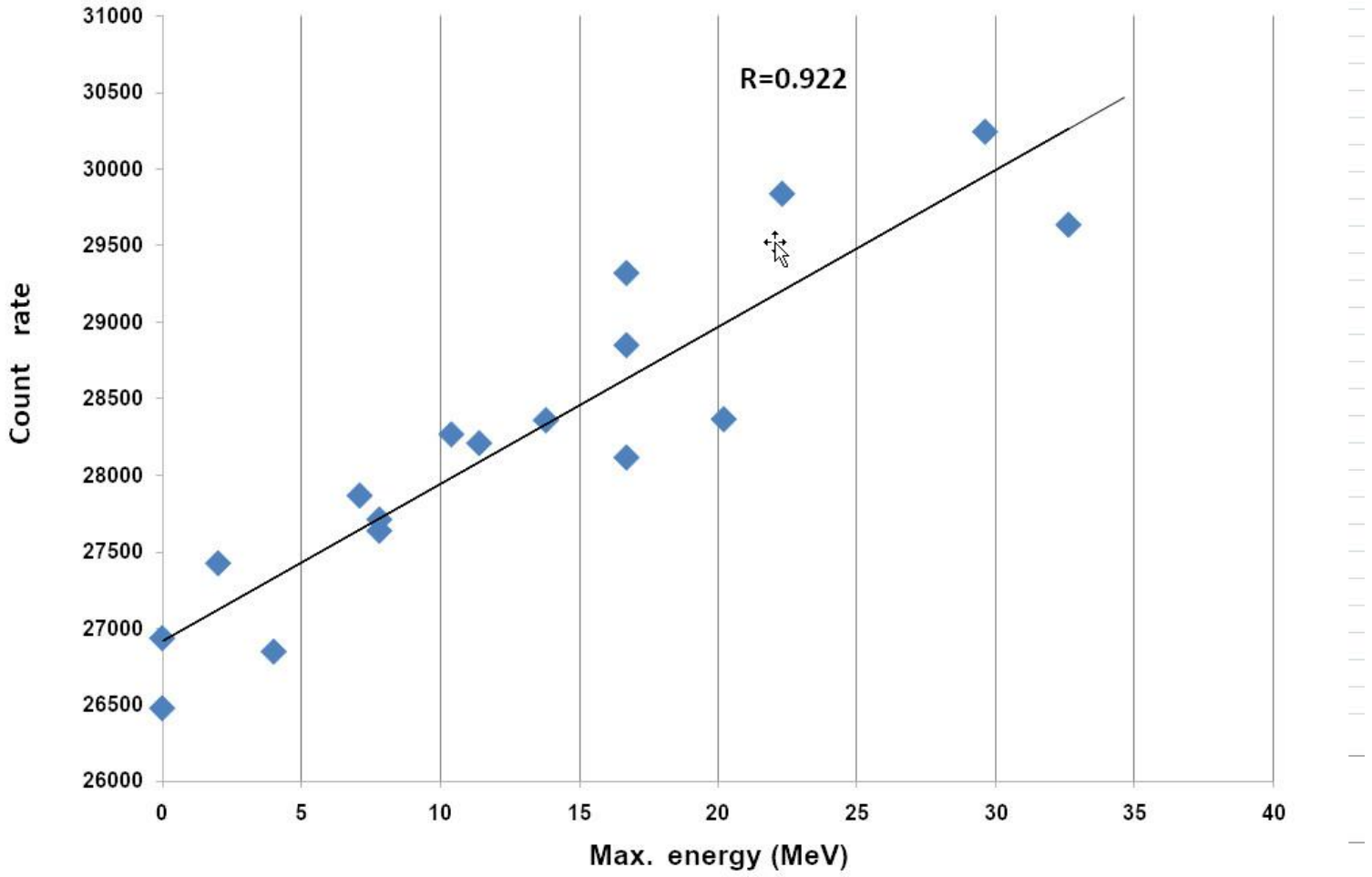


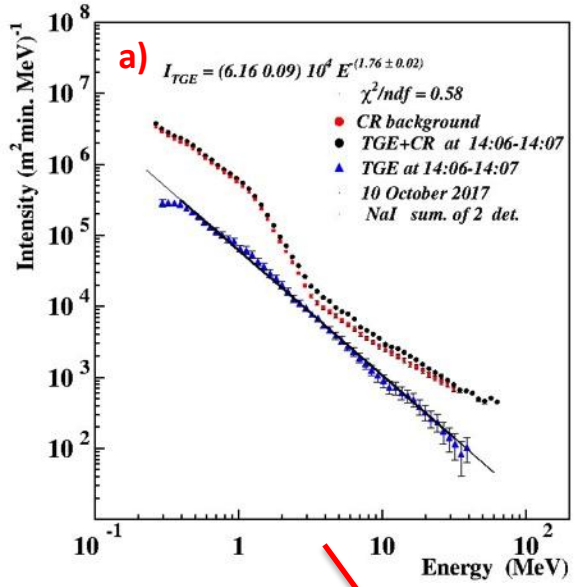


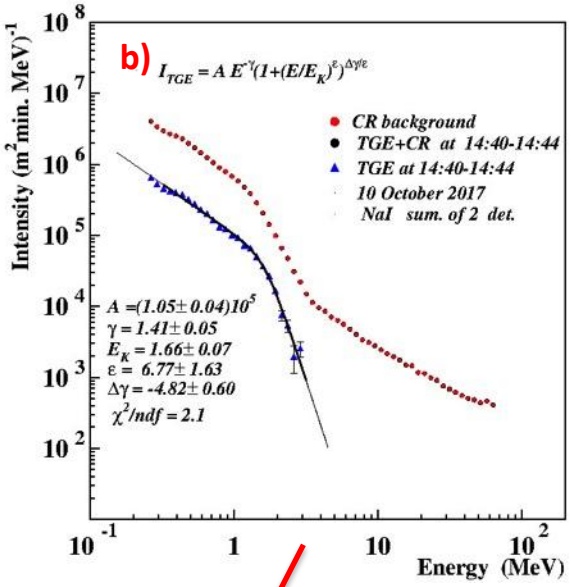


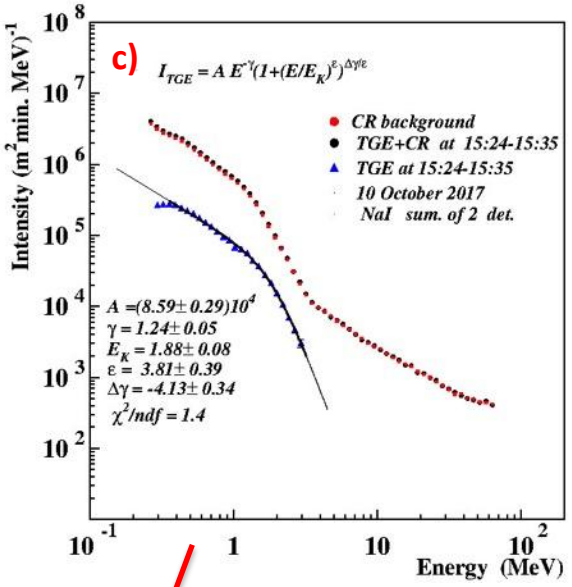
ASNT: 60 cm thick scintillators store energy release histograms each 20 seconds

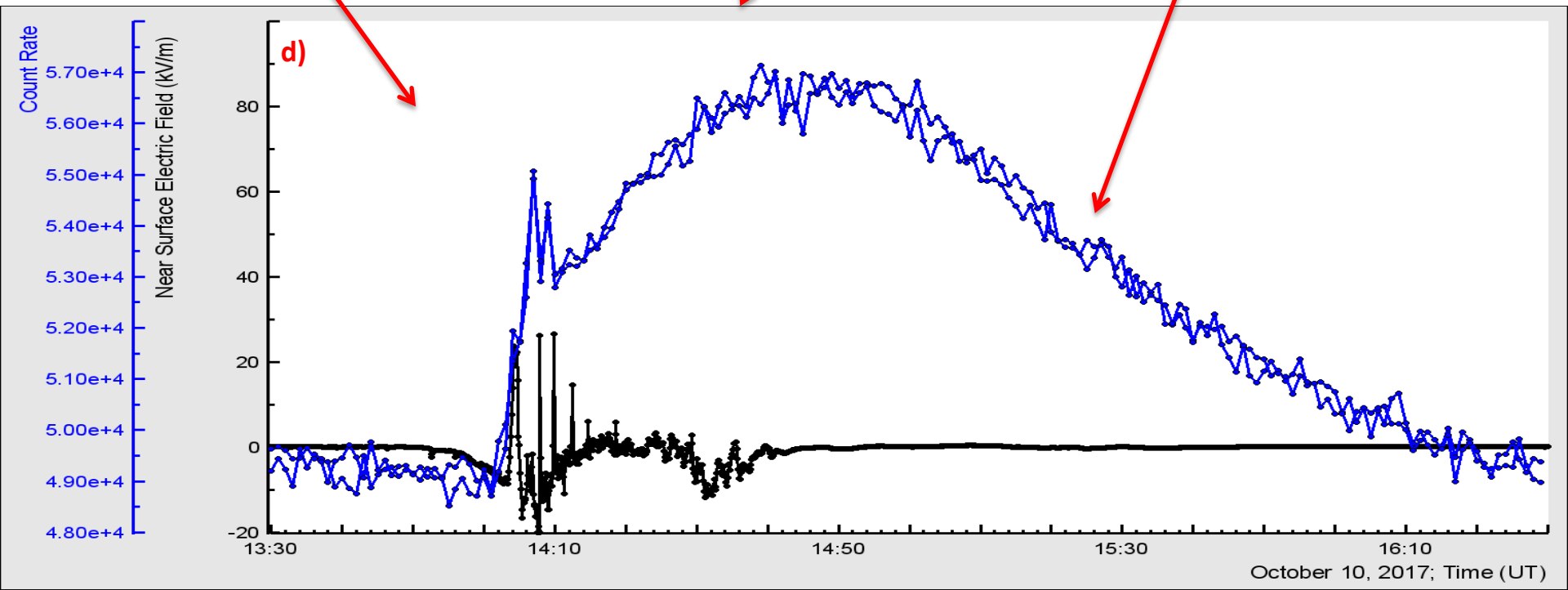
Correlation of gamma ray flux intensity and maximal energy (in strong electric fields avalanches are both intense and energetic).

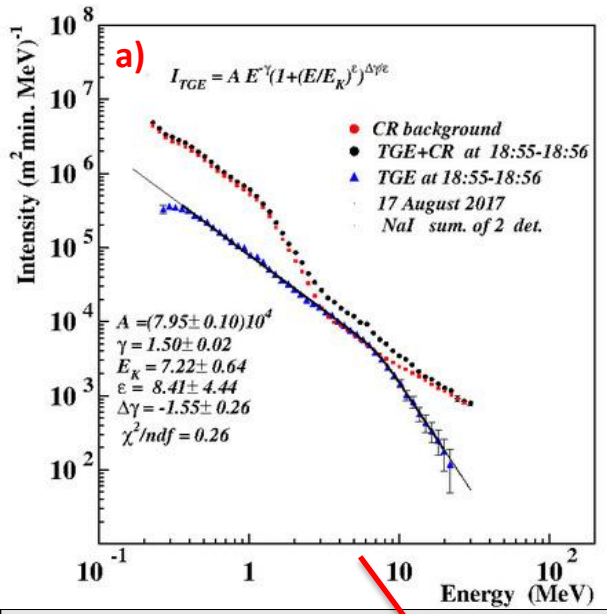


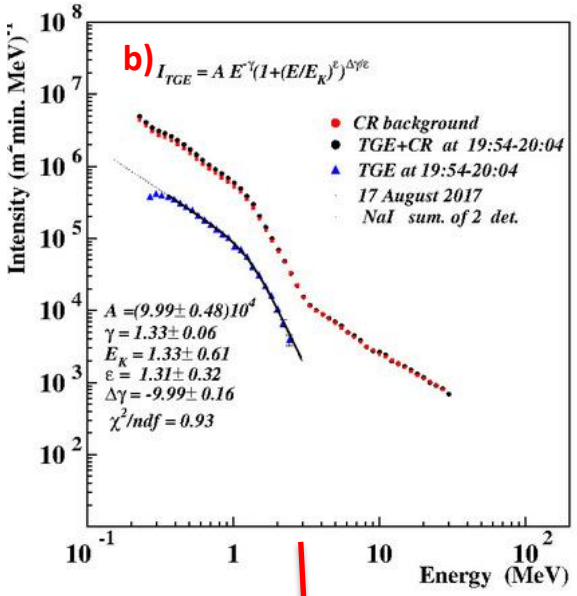

a)
$I_{TGE} = (6.16\ 0.09)\ 10^4\ E^{-(1.76 \pm 0.02)}$
$\chi^2/ndf = 0.58$
CR background
TGE+CR at 14:06-14:07
TGE at 14:06-14:07
10 October 2017
NaI sum. of 2 det.
Intensity (m^{2}min. MeV)$^{-1}$
Energy (MeV)

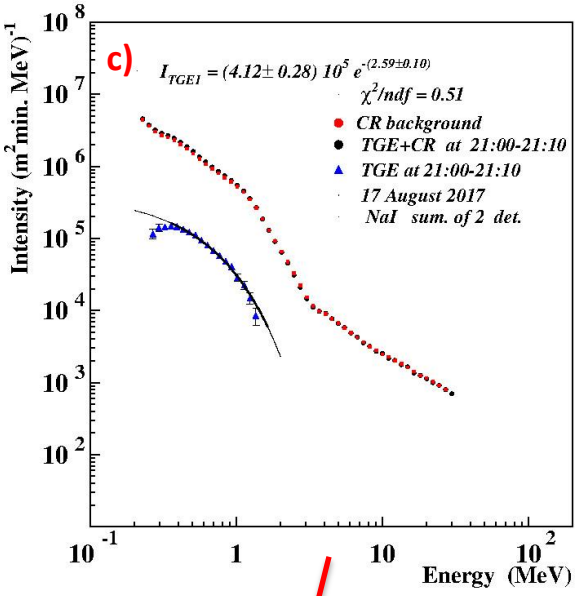

b)
$I_{TGE} = A\ E^{-\gamma}(1+(E/E_K)^{\varepsilon})^{\Delta\gamma/\varepsilon}$
CR background
TGE+CR at 14:40-14:44
TGE at 14:40-14:44
10 October 2017
NaI sum. of 2 det.
$A = (1.05 \pm 0.04)10^5$
$\gamma = 1.41 \pm 0.05$
$E_K = 1.66 \pm 0.07$
$\varepsilon = 6.77 \pm 1.63$
$\Delta\gamma = -4.82 \pm 0.60$
$\chi^2/ndf = 2.1$
Intensity (m^{2}min. MeV)$^{-1}$
Energy (MeV)

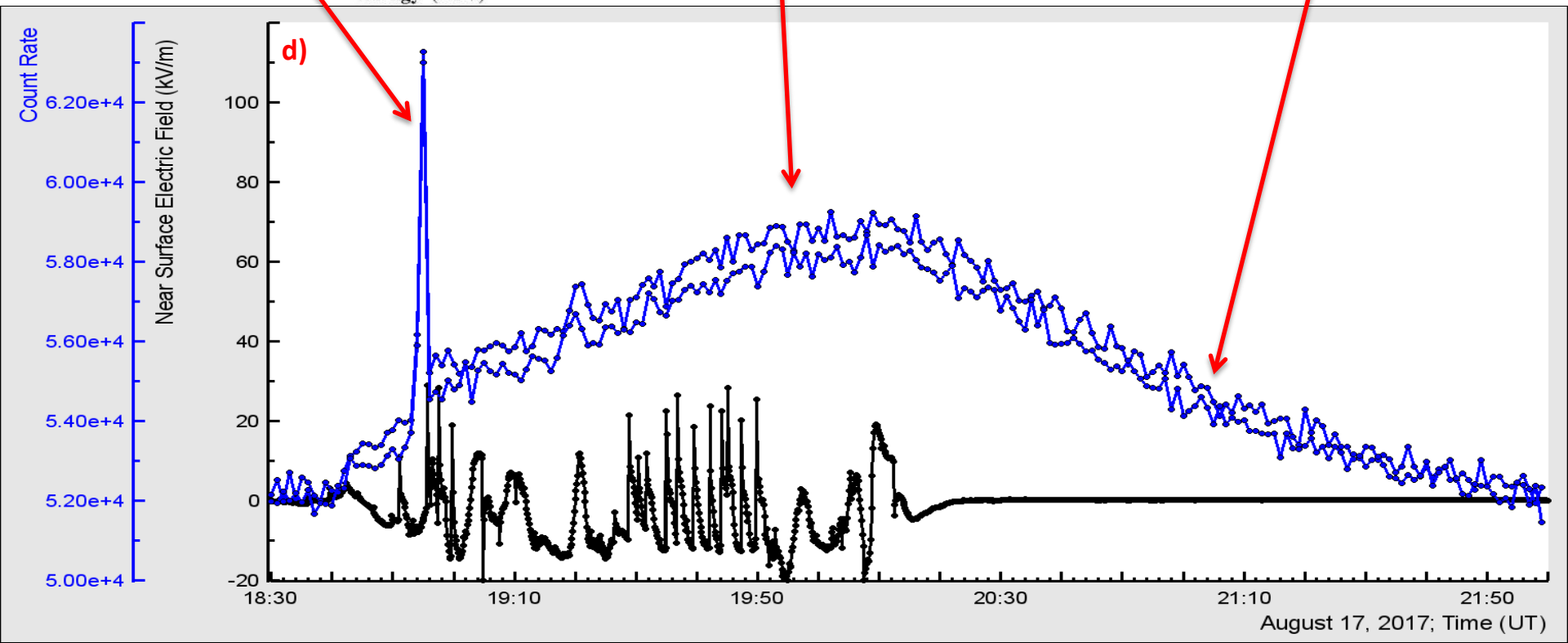

c)
$I_{TGE} = A\ E^{-\gamma}(1+(E/E_K)^{\varepsilon})^{\Delta\gamma/\varepsilon}$
CR background
TGE+CR at 15:24-15:35
TGE at 15:24-15:35
10 October 2017
NaI sum. of 2 det.
$A = (8.59 \pm 0.29)10^4$
$\gamma = 1.24 \pm 0.05$
$E_K = 1.88 \pm 0.08$
$\varepsilon = 3.81 \pm 0.39$
$\Delta\gamma = -4.13 \pm 0.34$
$\chi^2/ndf = 1.4$
Intensity (m^{2}min. MeV)$^{-1}$
Energy (MeV)

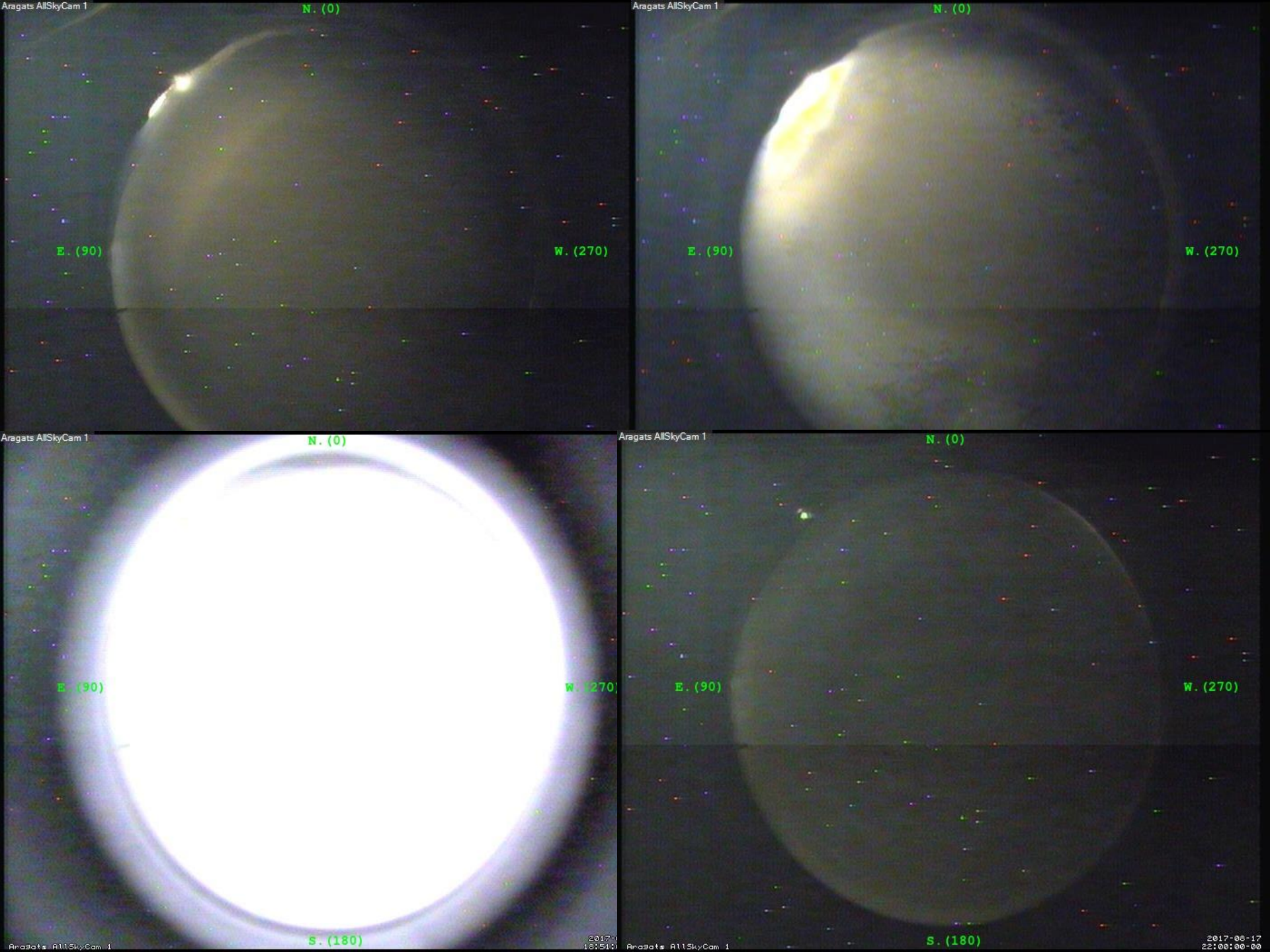

d)
Count Rate
Near Surface Electric Field (kV/m)
13:30
14:10
14:50
15:30
16:10
October 10, 2017; Time (UT)


a)
$I_{TGE} = A\,E^{-\gamma}(1+(E/E_K)^{\varepsilon})^{\Delta\gamma/\varepsilon}$
CR background
TGE+CR at 18:55-18:56
TGE at 18:55-18:56
17 August 2017
NaI sum. of 2 det.
$A = (7.95\pm0.10)10^4$
$\gamma = 1.50\pm0.02$
$E_K = 7.22\pm0.64$
$\varepsilon = 8.41\pm4.44$
$\Delta\gamma = -1.55\pm0.26$
$\chi^2/ndf = 0.26$
Intensity (m^2min. MeV)$^{-1}$
Energy (MeV)

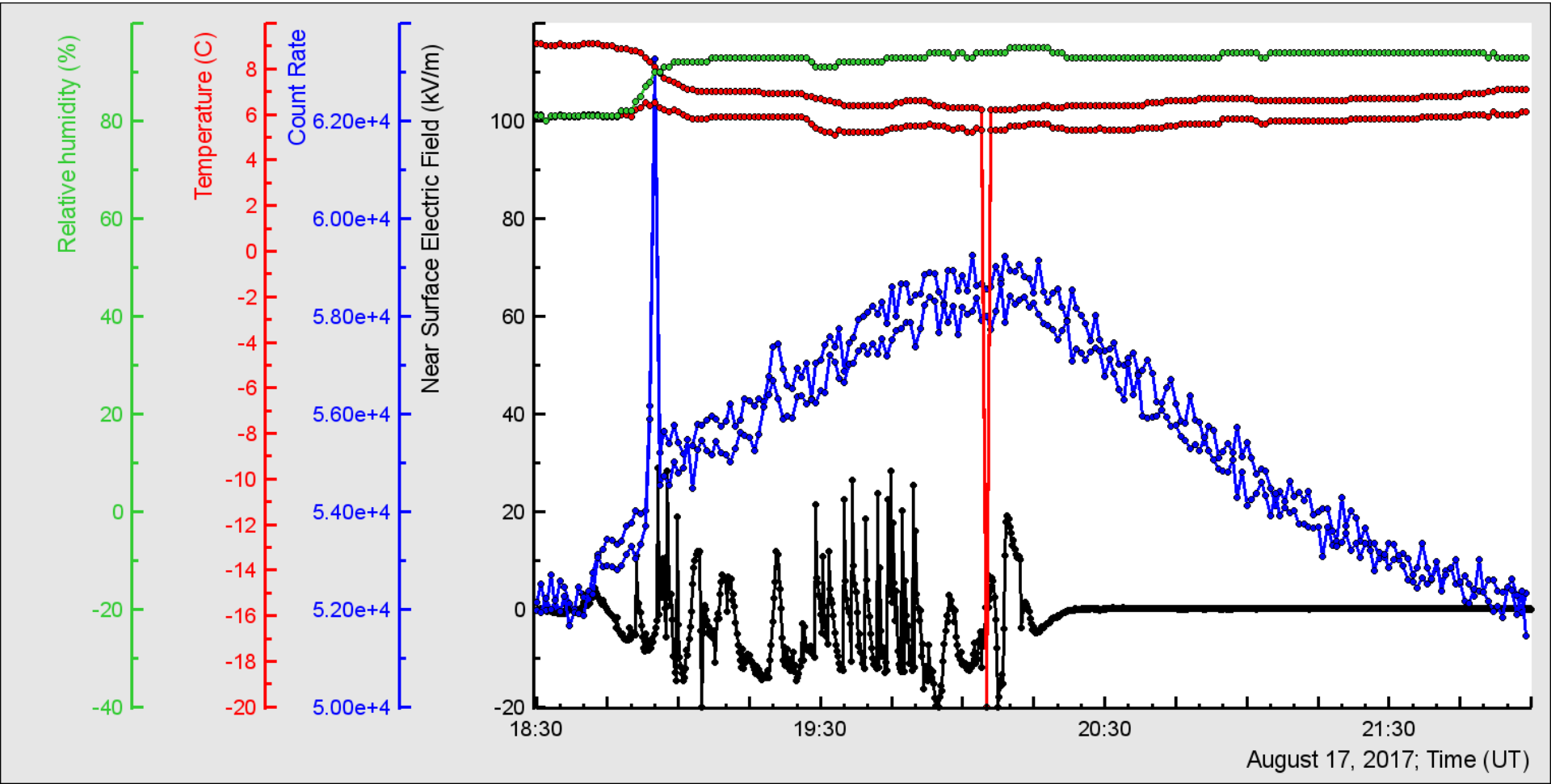

b)
$I_{TGE} = A\,E^{-\gamma}(1+(E/E_K)^{\varepsilon})^{\Delta\gamma/\varepsilon}$
CR background
TGE+CR at 19:54-20:04
TGE at 19:54-20:04
17 August 2017
NaI sum. of 2 det.
$A = (9.99\pm0.48)10^4$
$\gamma = 1.33\pm0.06$
$E_K = 1.33\pm0.61$
$\varepsilon = 1.31\pm0.32$
$\Delta\gamma = -9.99\pm0.16$
$\chi^2/ndf = 0.93$
Intensity (m^2min. MeV)$^{-1}$
Energy (MeV)


c)
$I_{TGE1} = (4.12\pm0.28)\,10^5\,e^{-(2.59\pm0.10)}$
$\chi^2/ndf = 0.51$
CR background
TGE+CR at 21:00-21:10
TGE at 21:00-21:10
17 August 2017
NaI sum. of 2 det.
Intensity (m^2min. MeV)$^{-1}$
Energy (MeV)

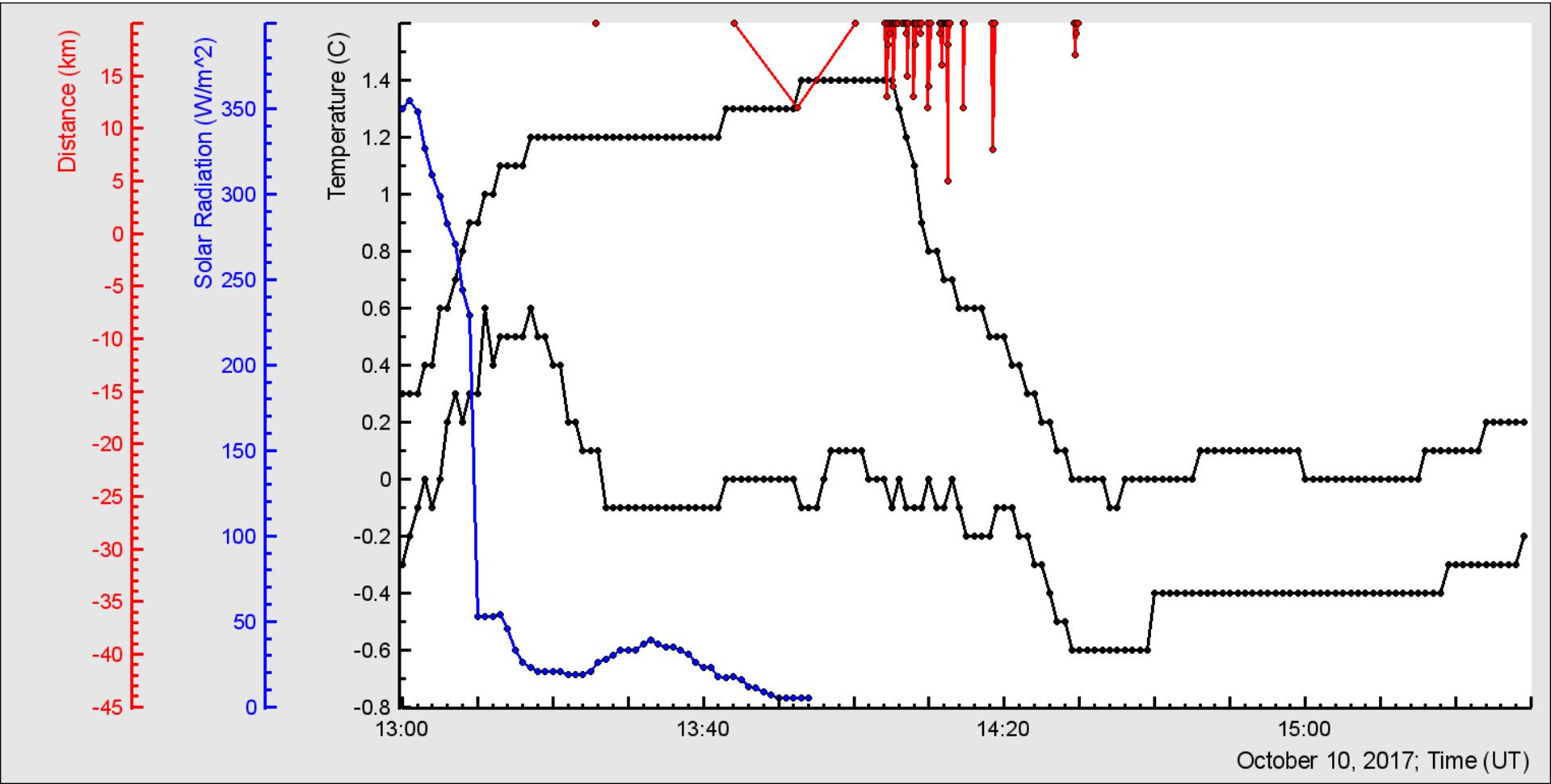

d)
Count Rate
Near Surface Electric Field (kV/m)
6.20e+4
6.00e+4
5.80e+4
5.60e+4
5.40e+4
5.20e+4
5.00e+4
100
80
60
40
20
0
-20
18:30
19:10
19:50
20:30
21:10
21:50
August 17, 2017; Time (UT)


Aragats AllSkyCam 1
N. (0)
E. (90)
W. (270)
Aragats AllSkyCam 1
N. (0)
E. (90)
W. (270)
Aragats AllSkyCam 1
N. (0)
E. (90)
W. (270)
S. (180)
Aragats AllSkyCam 1
Aragats AllSkyCam 1
N. (0)
E. (90)
W. (270)
S. (180)
Aragats AllSkyCam 1
2017-08-17
22:00:00-00

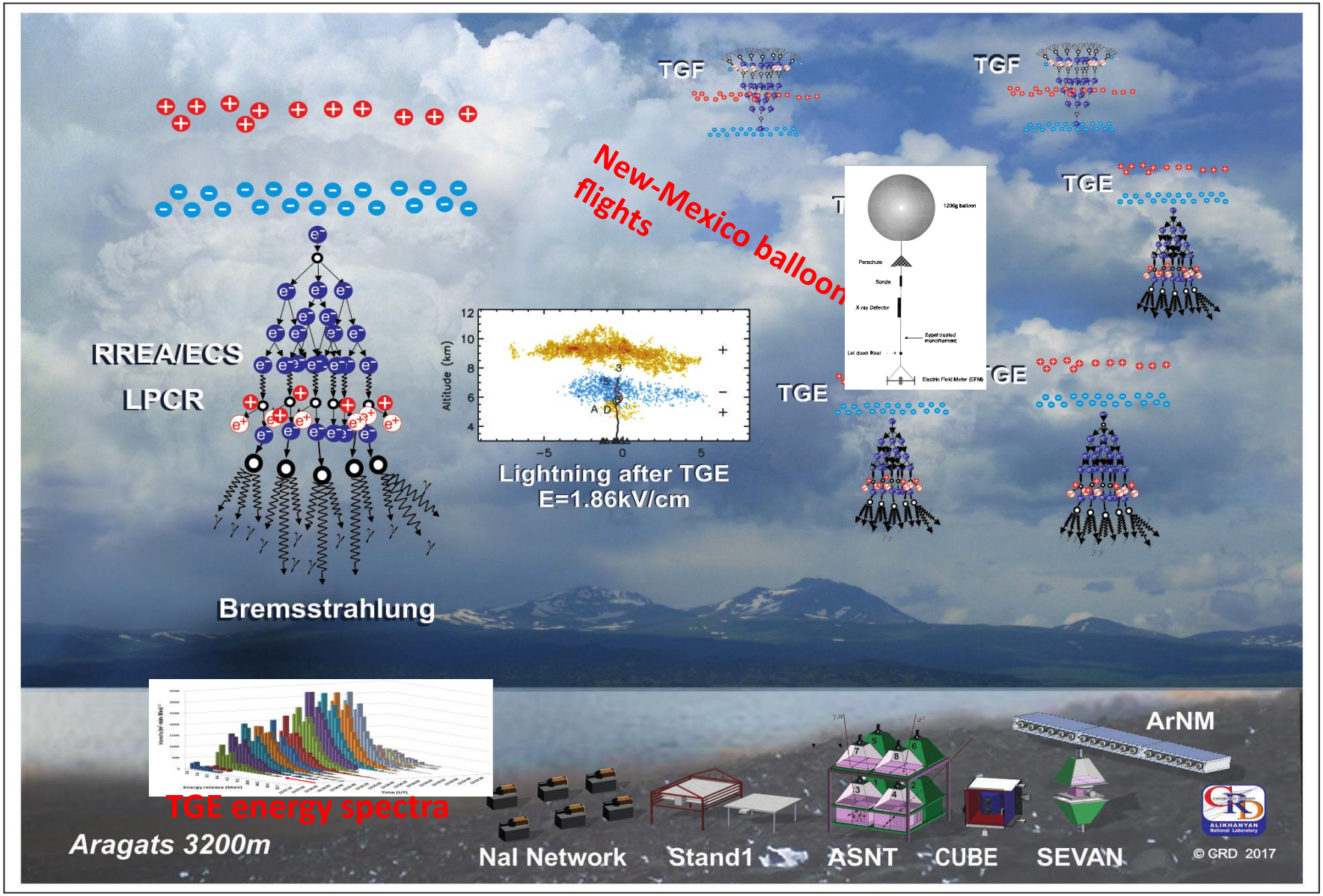
Meteo conditions do not changed after storm and electric field still exist above the detectors, in spite electric mill do not measure any significant disturbances!



Distance to lightning 4.7 km, distance to cloud base at 14:07 – 12.2 -0,1 *122 ~ 130m



Clouds are full of radiation even after storm! One from numerous randomly emerging TGEs in the thundercloud open path to the lightning leader!



2017 Summer-Autumn TGEs at Aragats: continuous radiation from clouds!

- Lowering the energy threshold of Aragats particle detectors dramatically change our understanding of radiation activity in the thunderclouds. Instead of expected short periods of particle bursts connected with approaching cloud with very intense electric field inside, we measure a intense burst of high-energy gamma rays followed by continuous radiation prolonged several hours even after cease of the storm:
- TGEs started abruptly with intense high-energy peak lasting few minutes. After termination of high-energy flux (usually by the negative lightning flux, low-energy flux reaches maximum in many tens minutes followed by prolonged decay lasting a hour and more.
- TGEs occurred during strong storm accompanied by negative (mostly) and positive lightning flashes. However, during growing phase of TGE few lightning flashes occur.
- Negative electric field supports prolonged particle flux; The 11 minute long TGE on 22 June occurred when near surface electric field dips down to -30 kB/m.

- Thus we have several types of TGE gamma ray energy spectra:

- Power law spectra extended up to 40-50 MeV. Duration of TGE comprises 1-10 minutes, usually accompanied with strong negative near-surface electric field. TGE terminated by a negative lightning flash (-CG or normal IC). If lightning activity is outside the storm cell above detector site (>10 km distance) the TGE can prolong up to 10 minutes;
- Low energy (up to ~ 3MeV) gamma ray flux well described by a broken power low with hard spectrum before 1.5-1.8 MeV and fast declining spectrum after a sharp “knee” occurred near 2 MeV. Can be explained by a mixture of MOS process and bremstrahlung gamma rays arriving to detectors under large zenith angles from distant RB/RREA avalanches;
- Low energy gamma ray spectrum prolonged up to 1-1.5 MeV well described by exponential dependences with index 1.5-1.9; maybe pure MOS process.