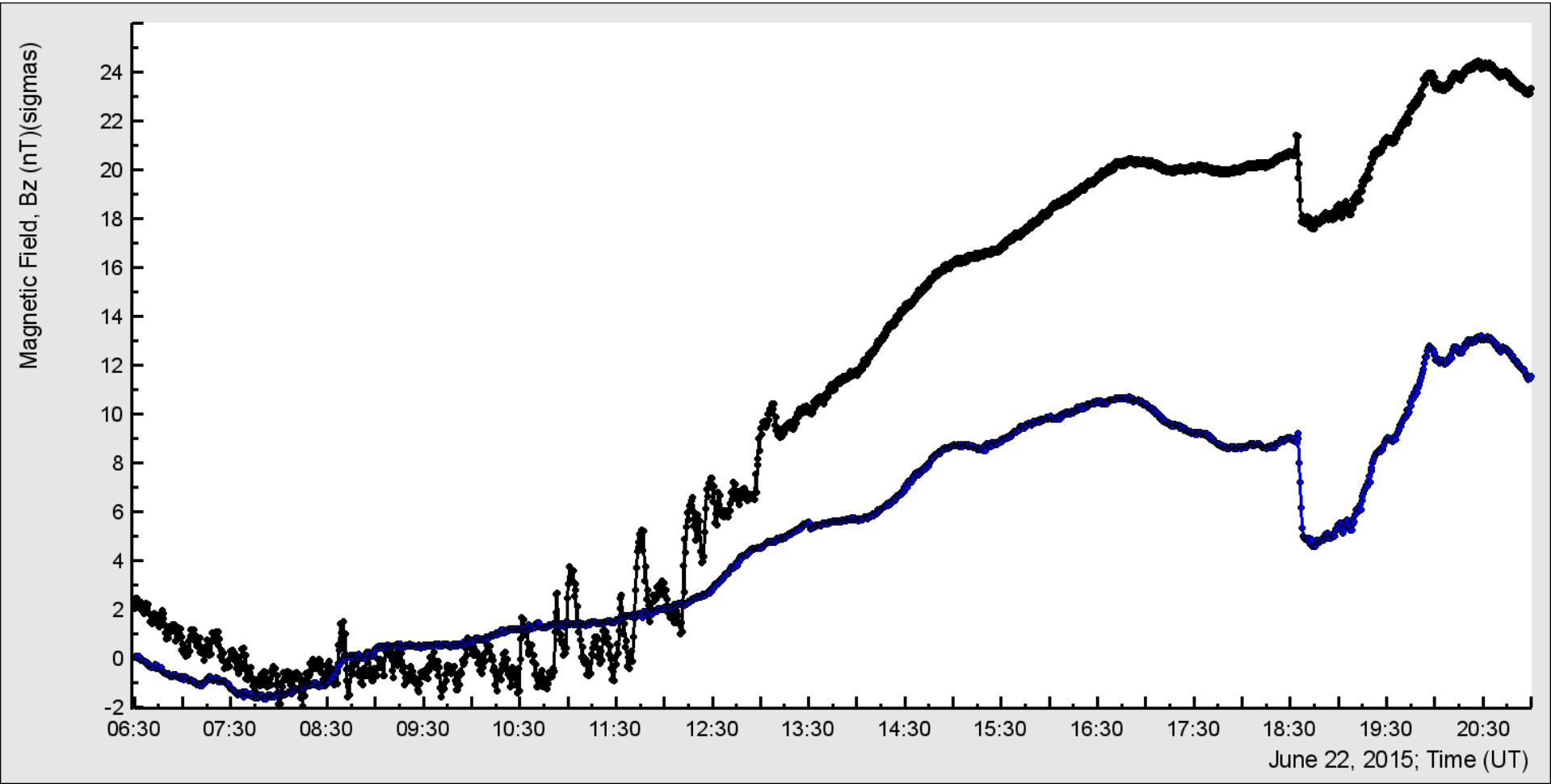
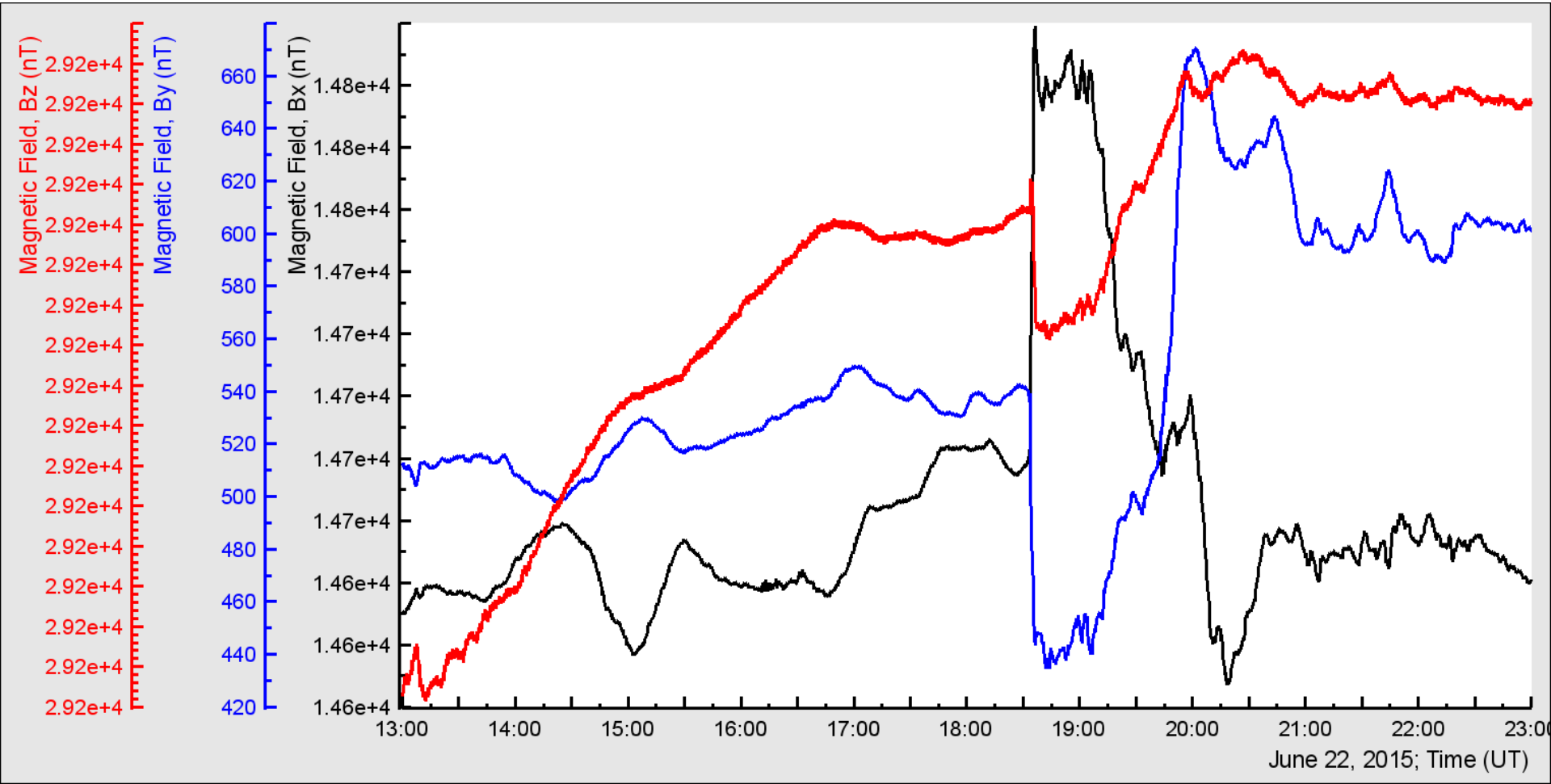
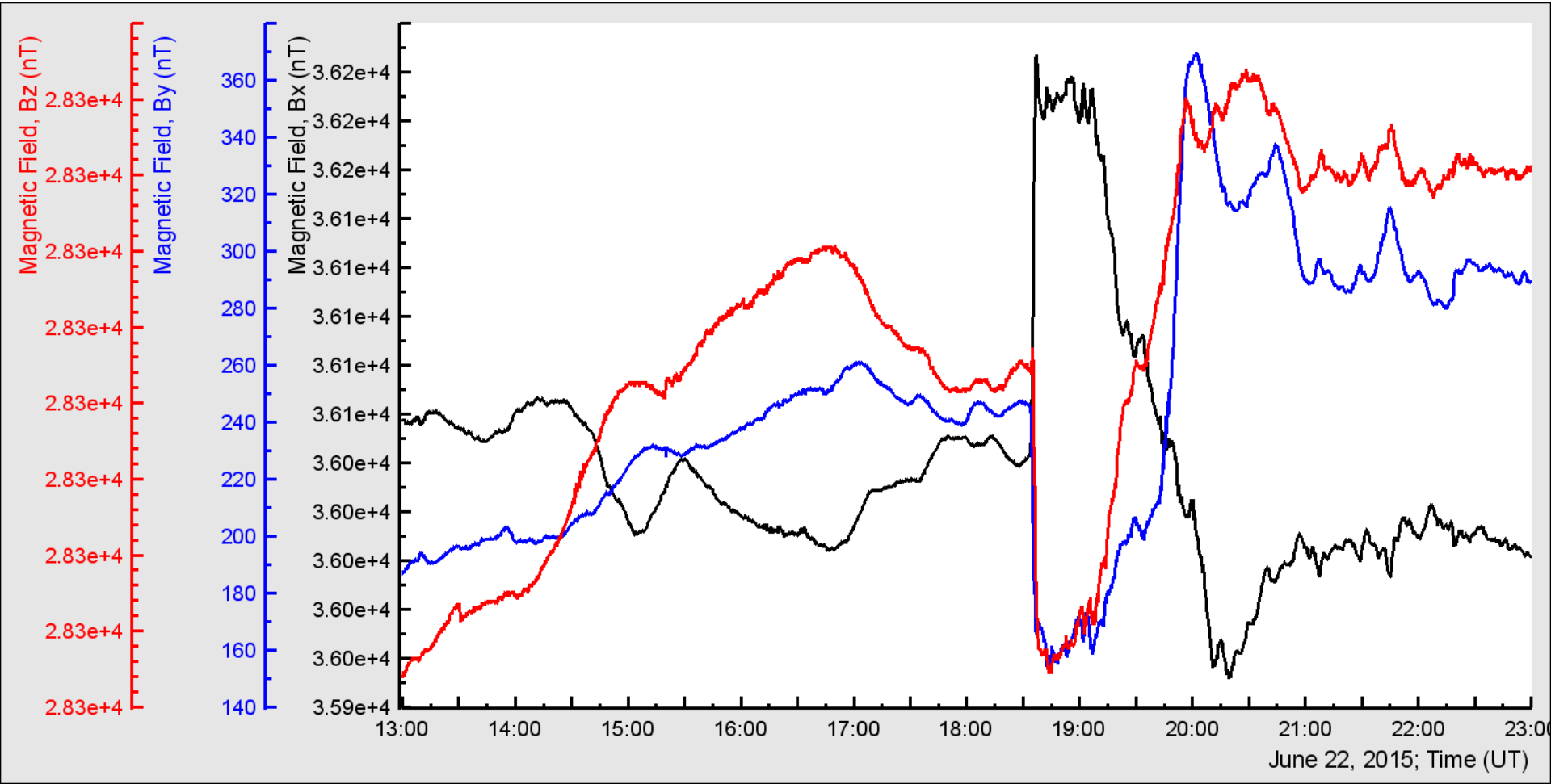
The largest geomagnetic storms of solar cycle 24 so far occurred on 2015, March 17 and June 22 with Dst minima of −223 and −195 nT; The active region produced a CME of about 1000 km s^{-1} associated with an M6.5 flare from N13◦W05◦ peaking at 18:23 UT on June 22.
Bz: Aragats and Nor-Amberd(in number of standard deviations)



3 components of the geomagnetic field measured at Aragats 3200 asl



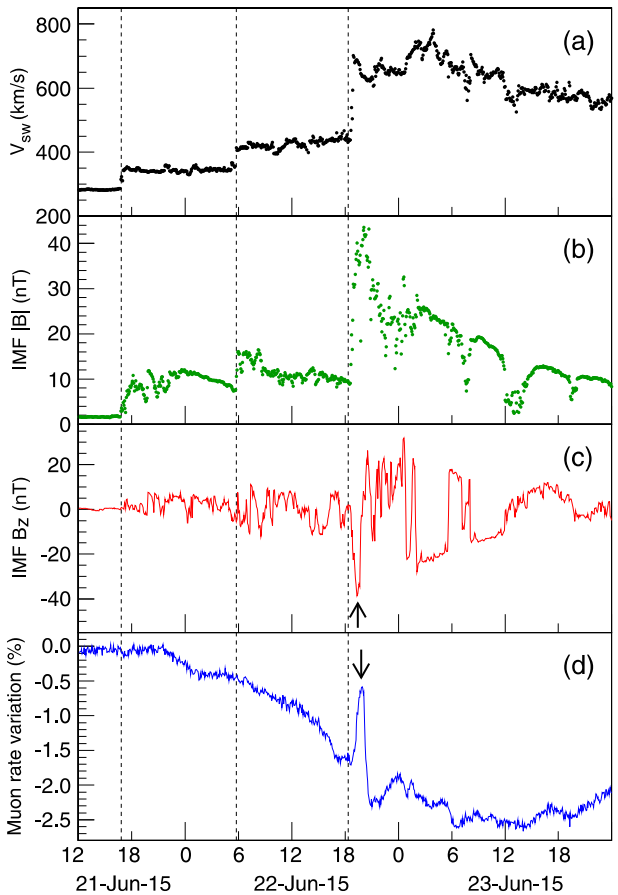
3 components of the geomagnetic field measured at Nor Amberd 2000 asl



The GRAPES-3 tracking muon telescope in Ooty, India (cutoff rigidities 15–24 GV, nine independent directions)

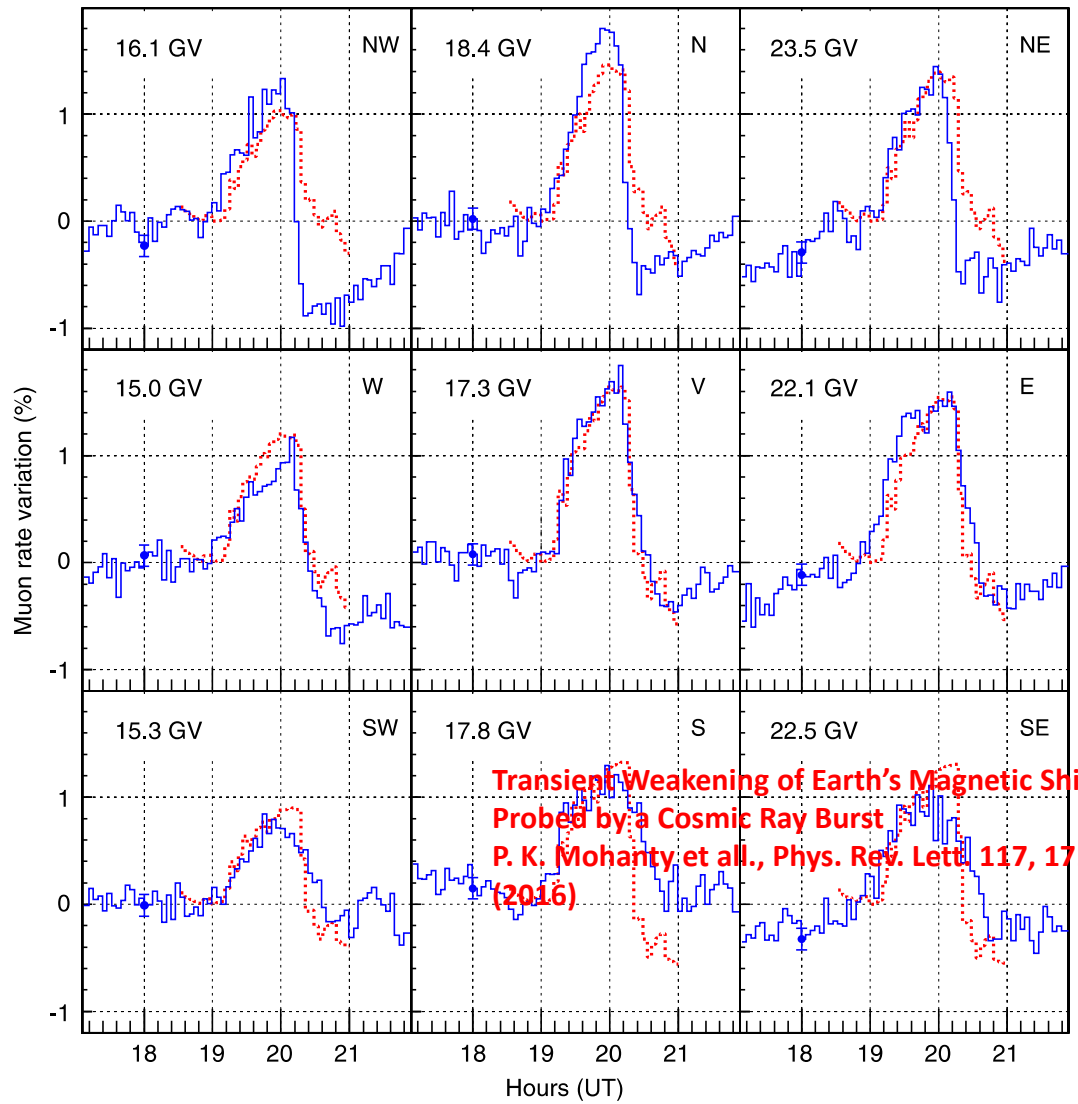
The GRAPES-3 muon telescope in Ooty, India detected a 2 h burst of GCRs starting 22 June 2015 19:00 UT that was strongly correlated with a 40 nT surge in the IMF

(Transient Weakening of Earth's Magnetic Shield Probed by a Cosmic Ray Burst P. K. Mohanty et all., Phys. Rev. Lett. 117, 171101 (2016))



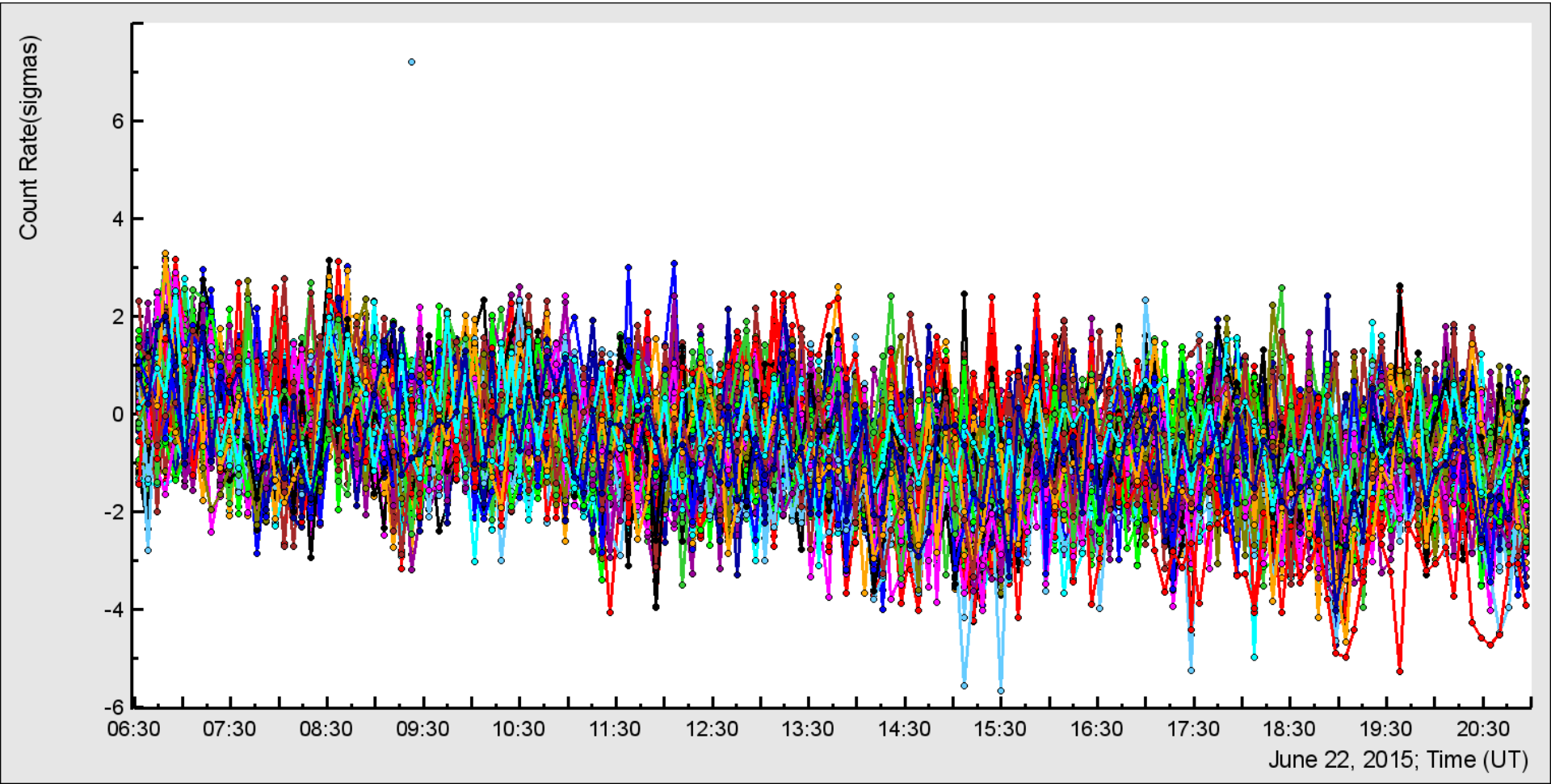
WIND data: (a) V_{SW}, (b) |B|, (c) B_Z,

(d) GRAPES-3 muon-rate. Vertical dashed lines indicate CME arrival times (UT).

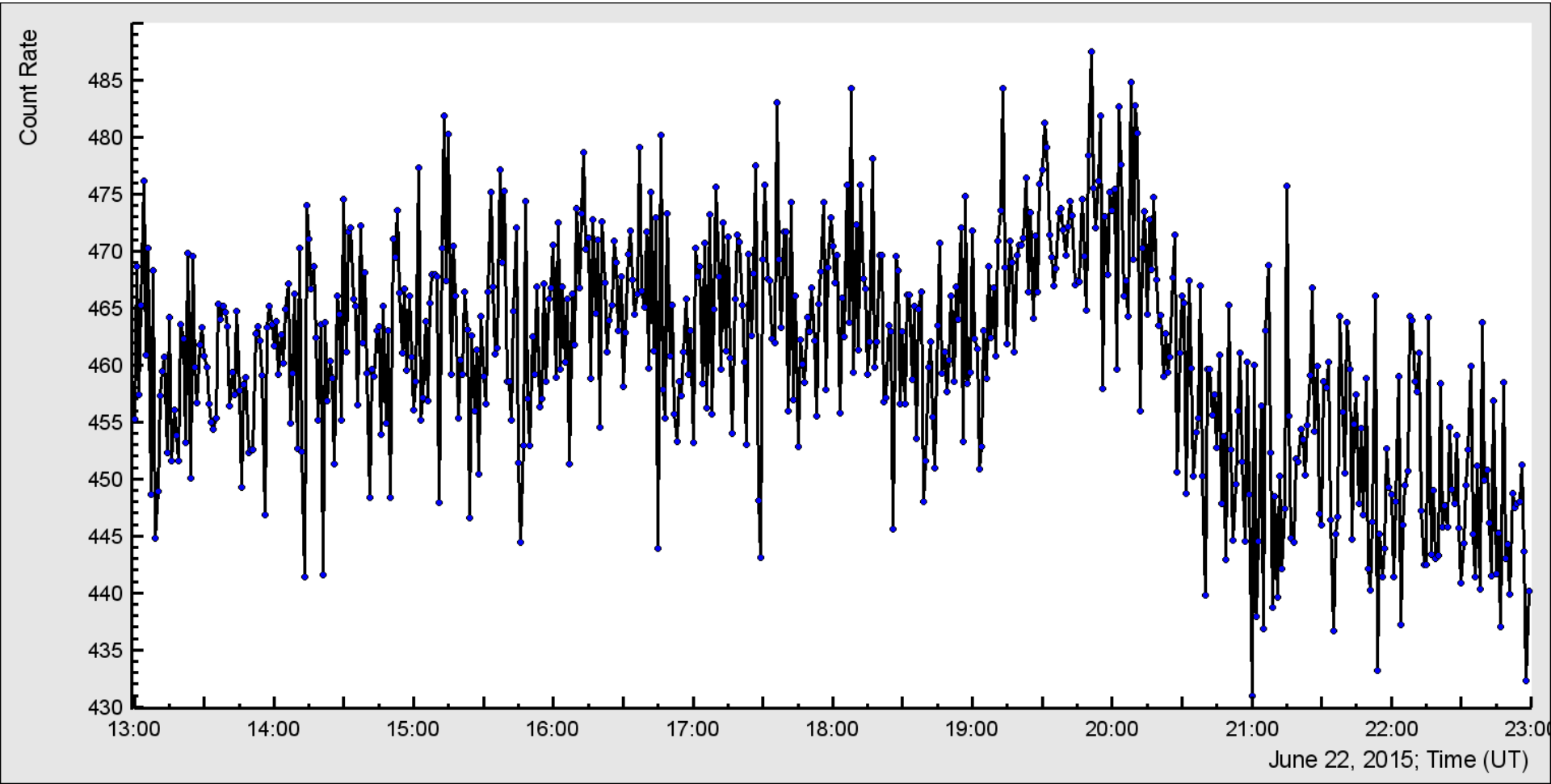


Transient Weakening of Earth's Magnetic Shield Probed by a Cosmic Ray Burst P. K. Mohanty et all., Phys. Rev. Lett. 117, 171101 (2016)

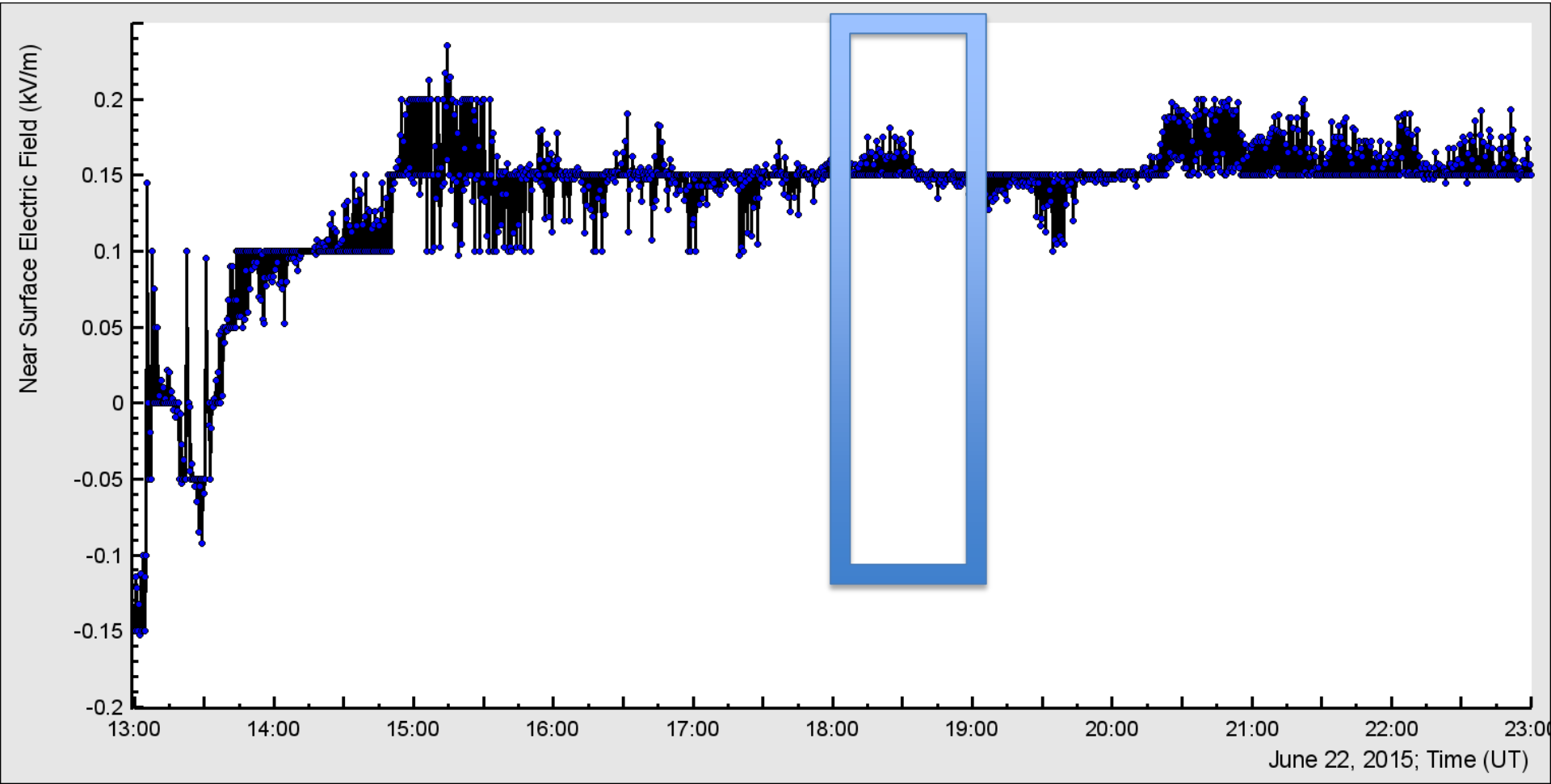
AMMM muon detector evidence



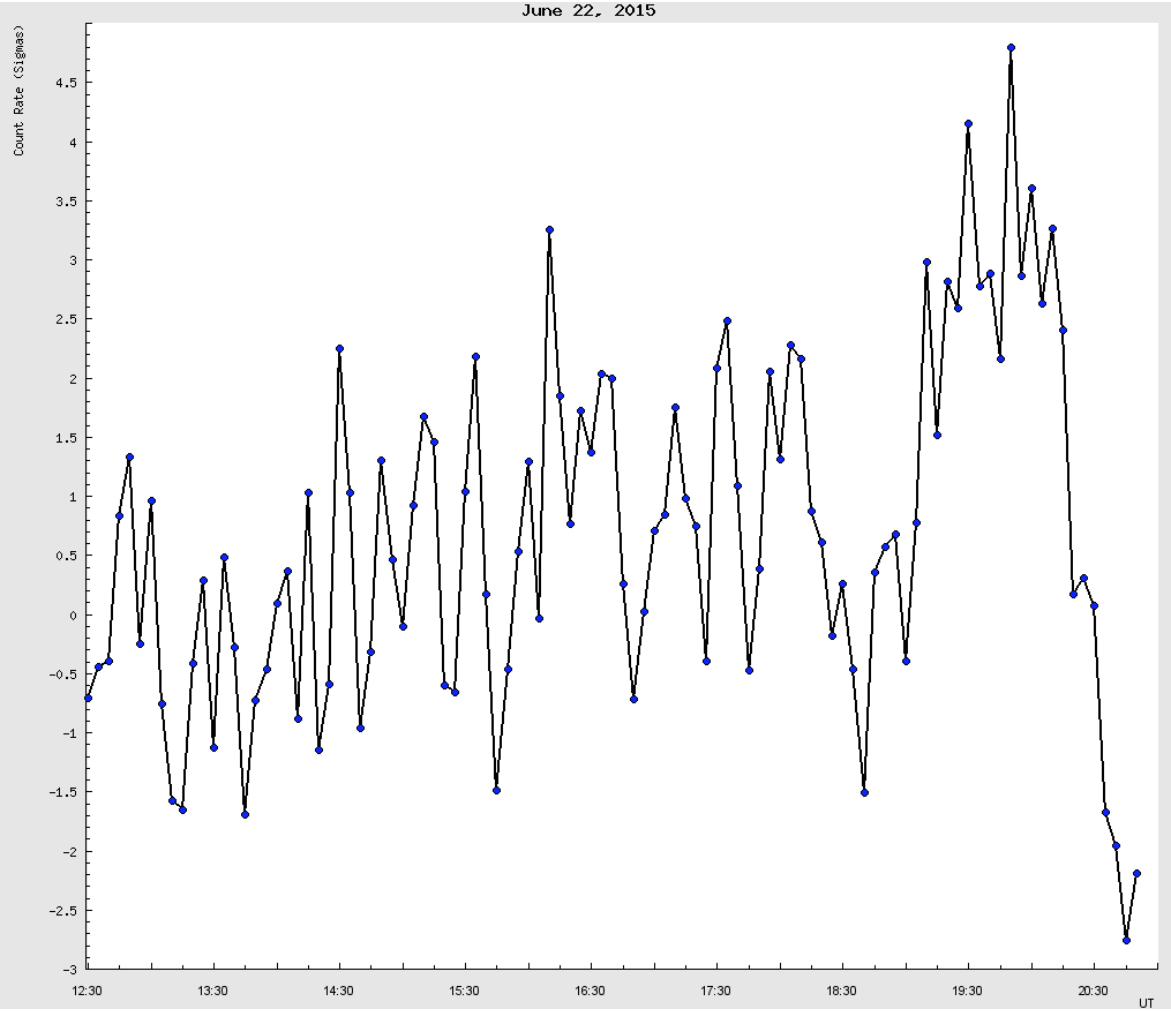
Nor Amberd Neutron monitor: pressure corrected, filtered



MAKET EFM 100 0- nothing special during geomagnetic storm

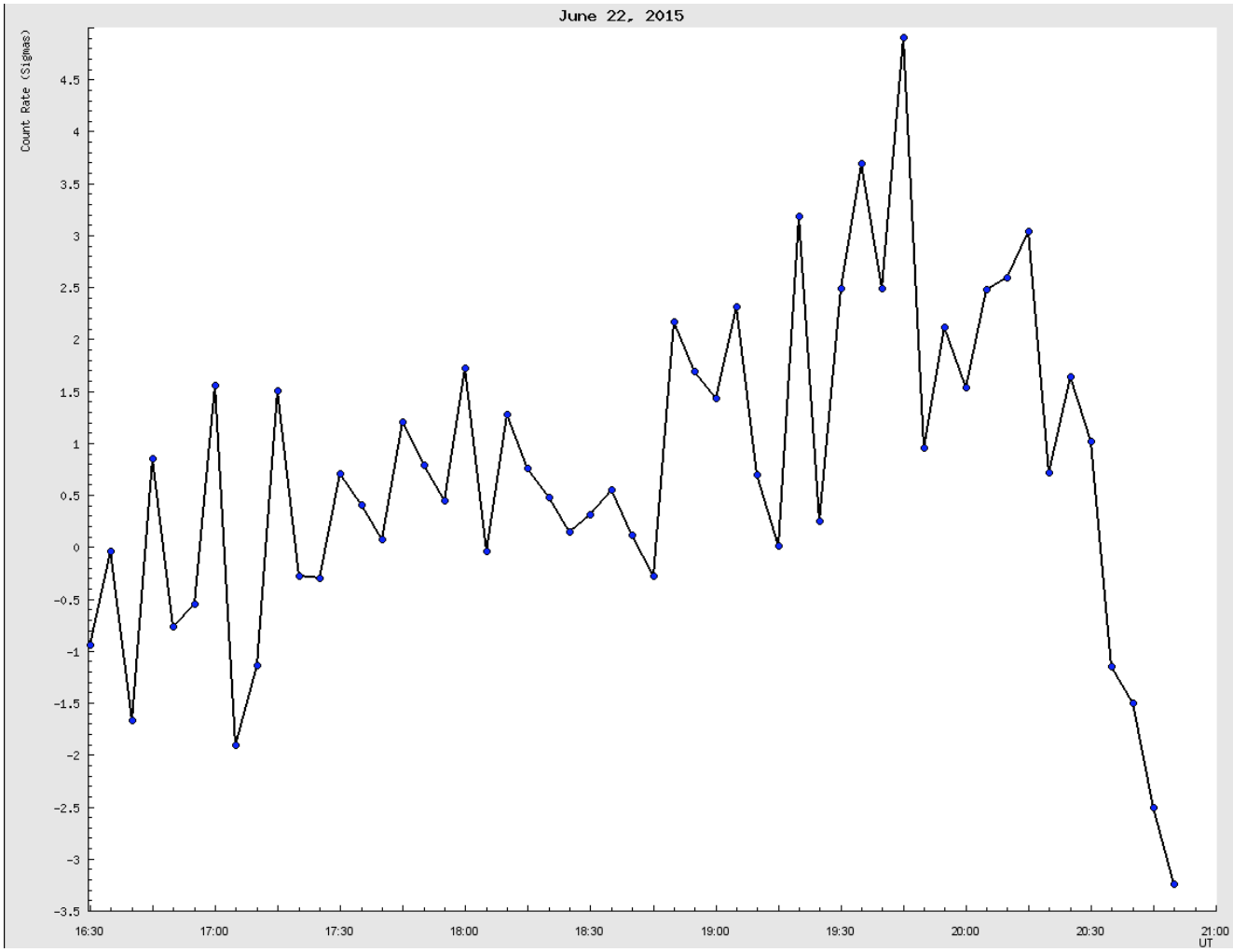


An examination of the worldwide neutron monitor data showed that Almaty, and Nor-Amberd stations located on the night side recorded increased rates coincident with GRAPES-3. However, no significant increase was seen by the instruments on the day side [30-NMDB.EU].

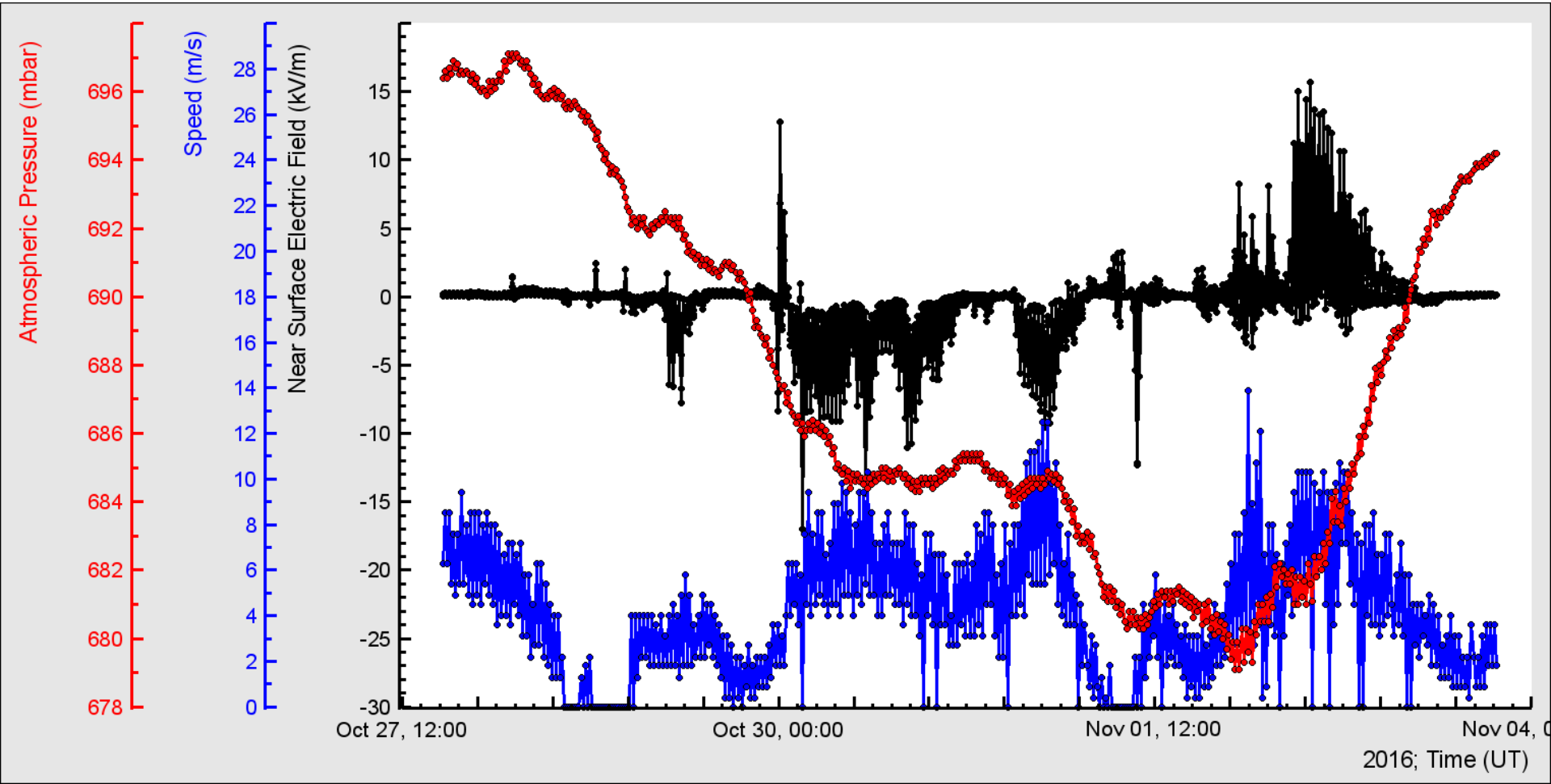


Transient Weakening of Earth's Magnetic Shield Probed by a Cosmic Ray Burst
P. K. Mohanty, K. P. Arunbabu, T. Aziz, S. R. Dugad, S. K. Gupta, B. Hariharan, P. Jagadeesan, A. Jain, S. D. Morris, B. S. Rao, Y. Hayashi, S. Kawakami, A. Oshima, S. Shibata, S. Raha, P. Subramanian, and H. Kojima
Phys. Rev. Lett. 117, 171101 (2016)
Published October 20, 2016

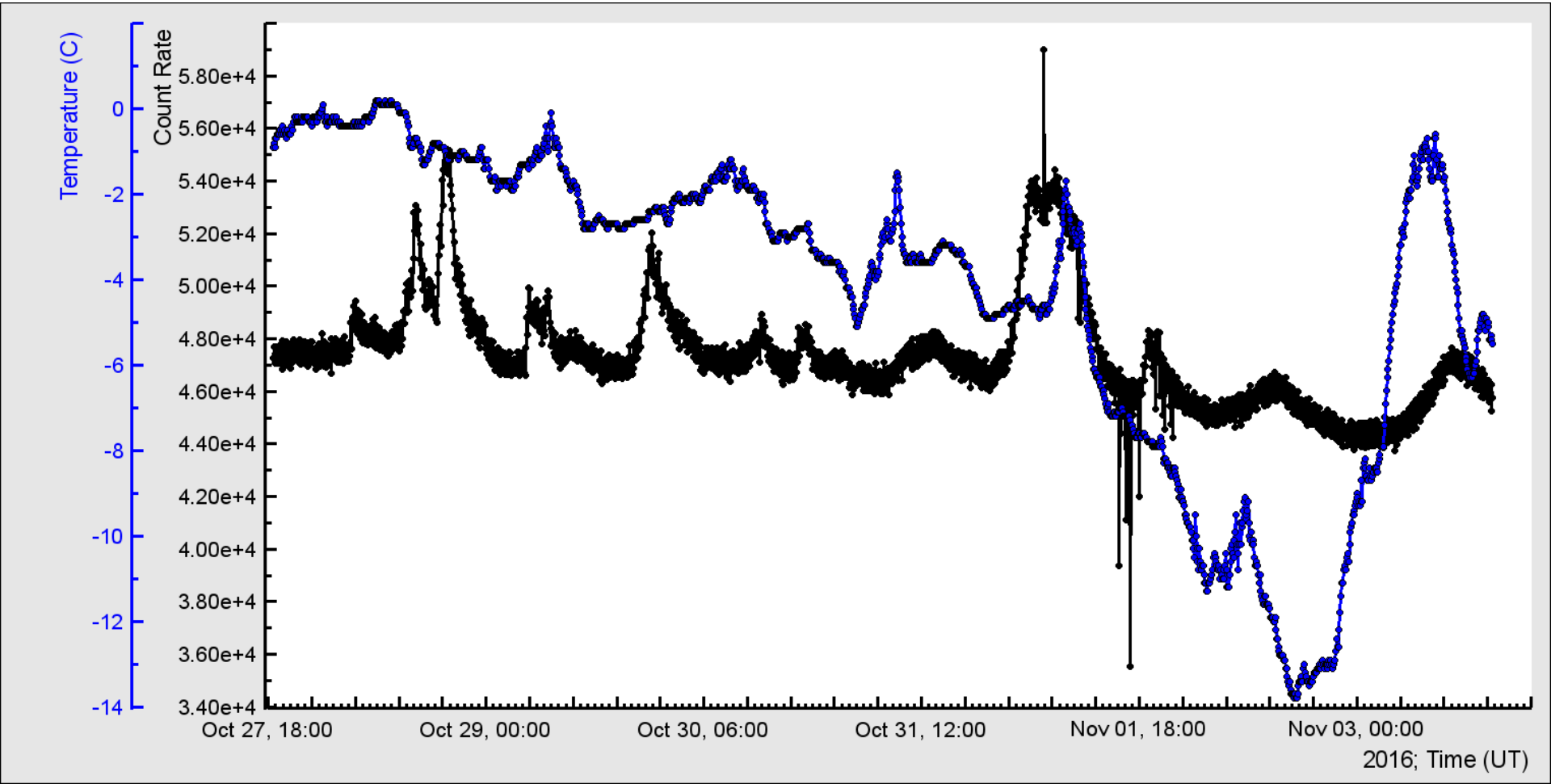
CUBE 8 evidence



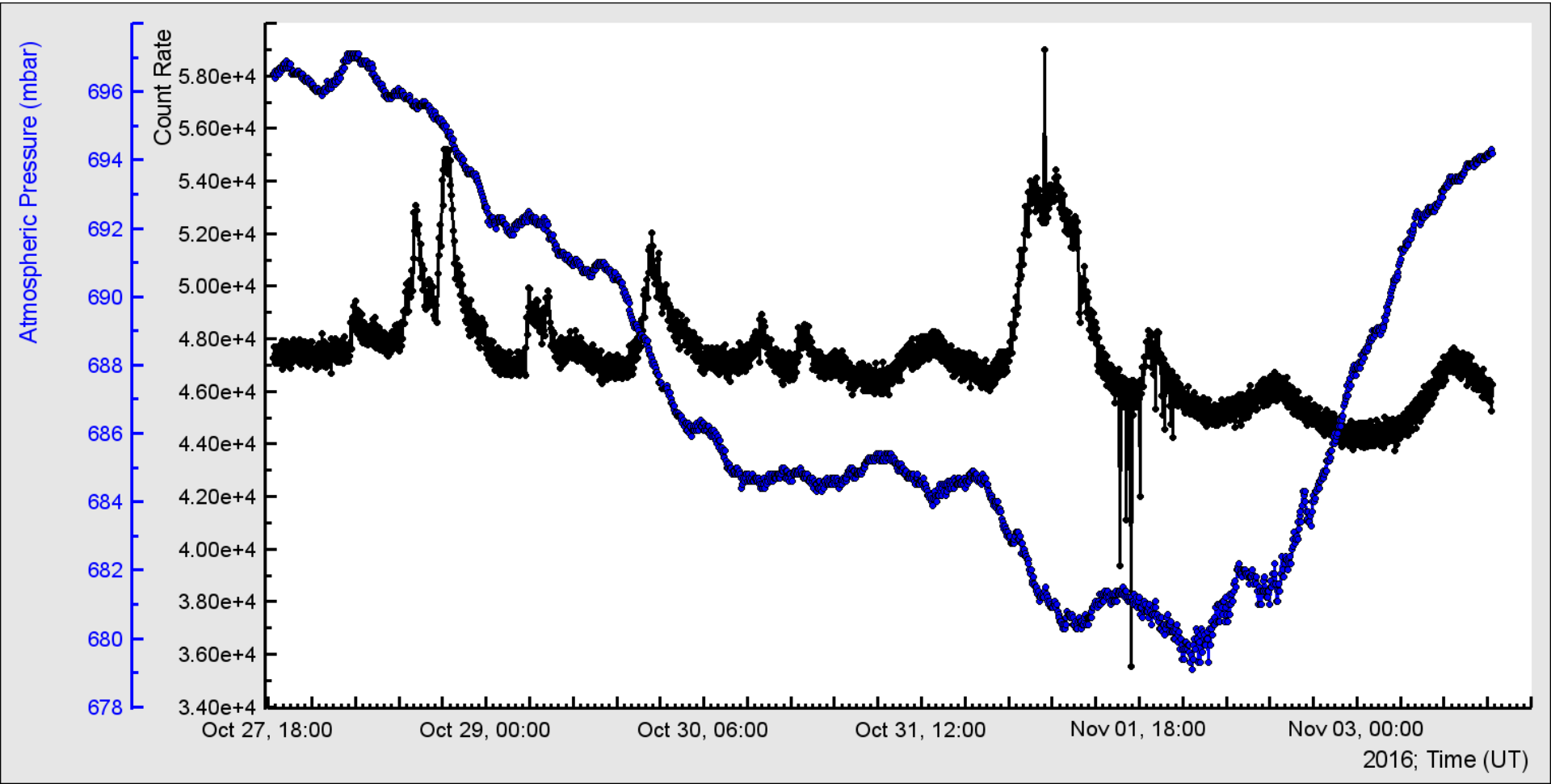
Wind speed is fast both at long negative and positive field, seem atmospheric pressure is not relevant



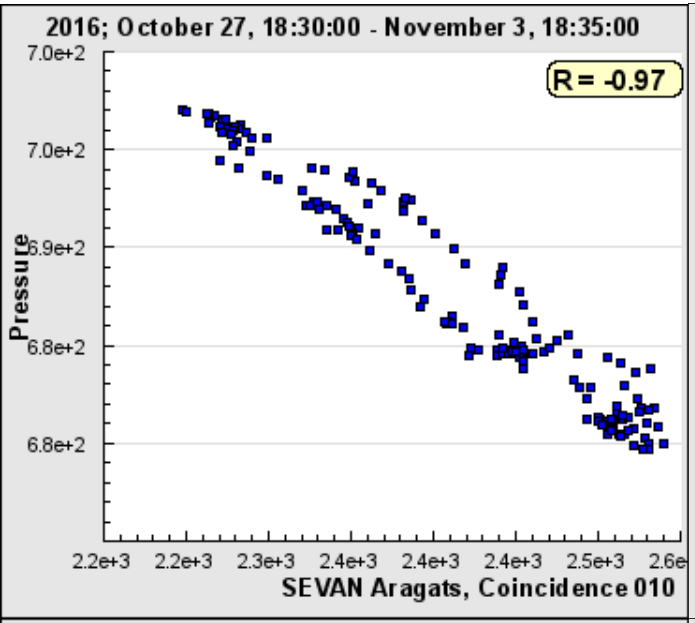
Temperature vs NaI 1

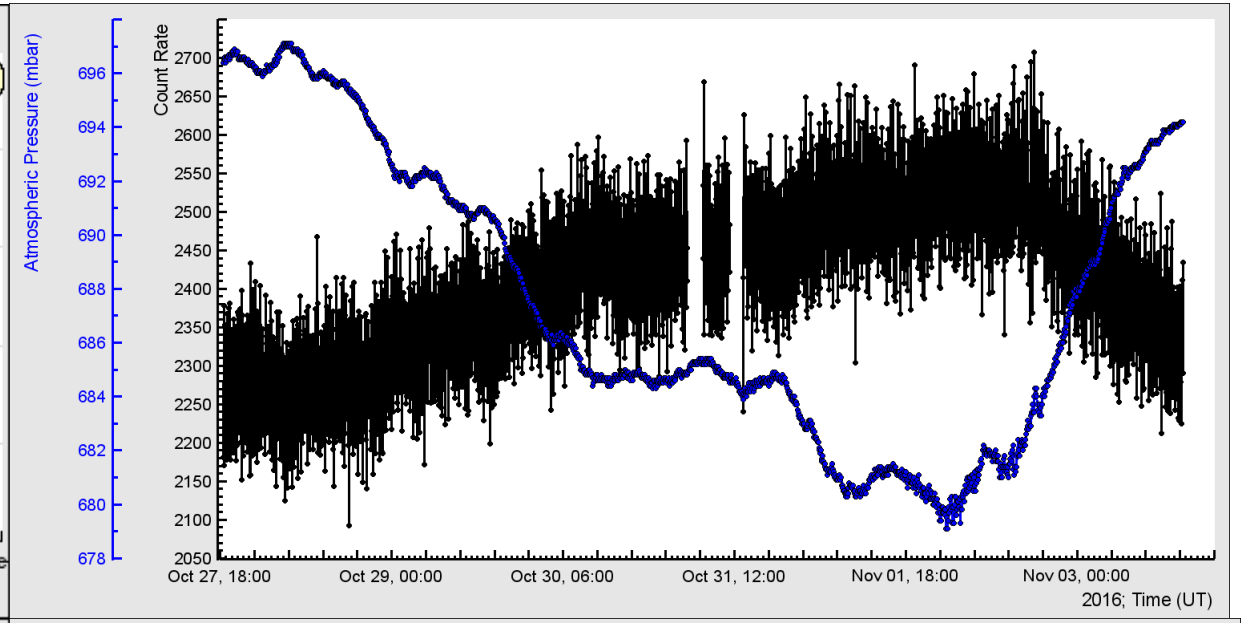


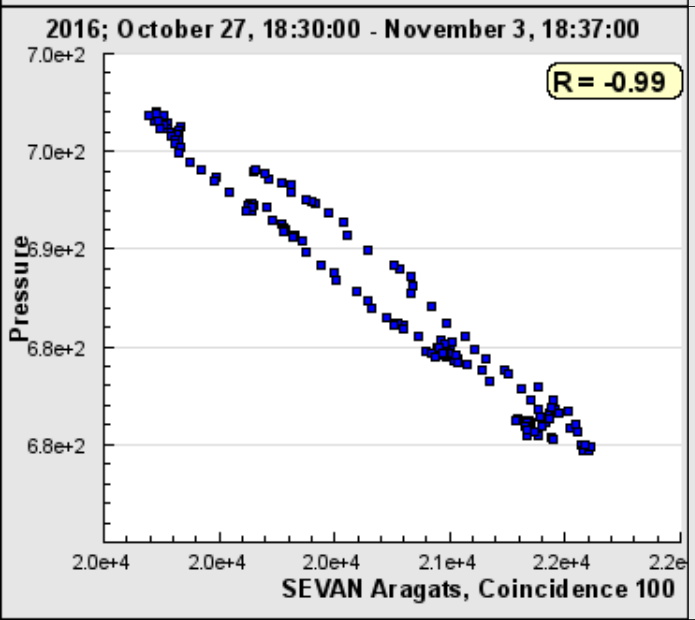
Pressure vs NaI 1

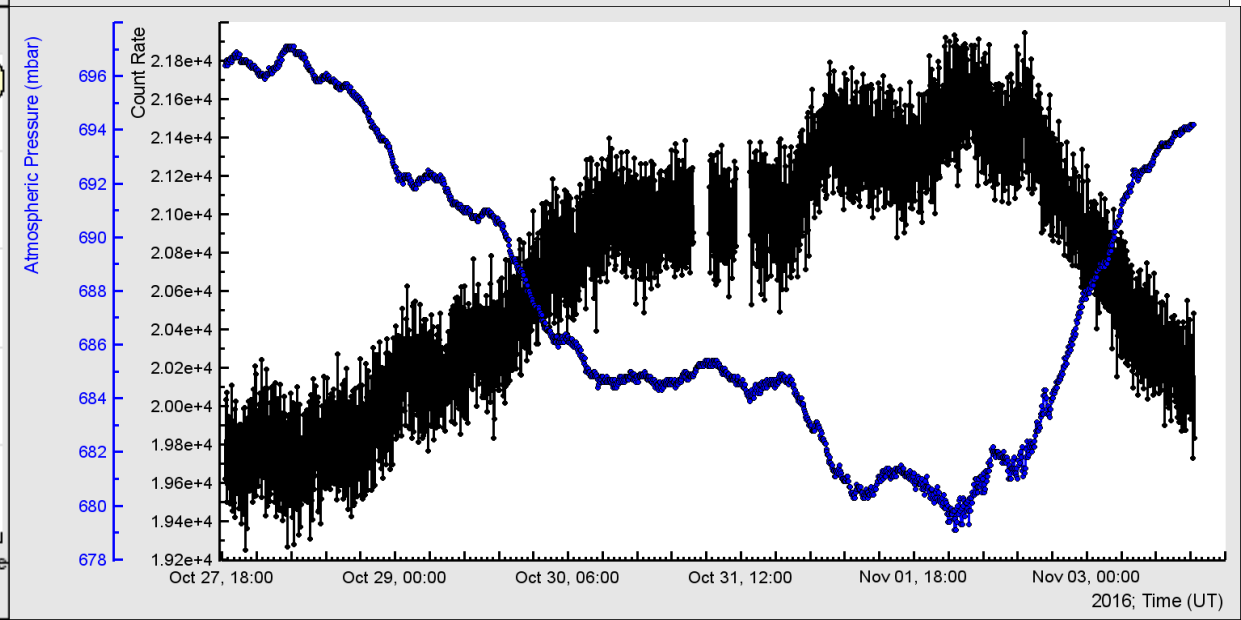


SEVAN combinations: low energy electrons equal sensible to pressure as neutrals

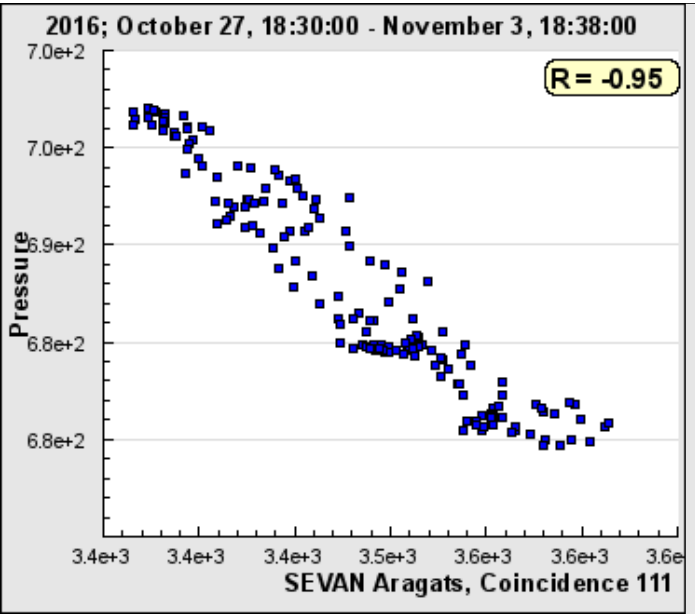


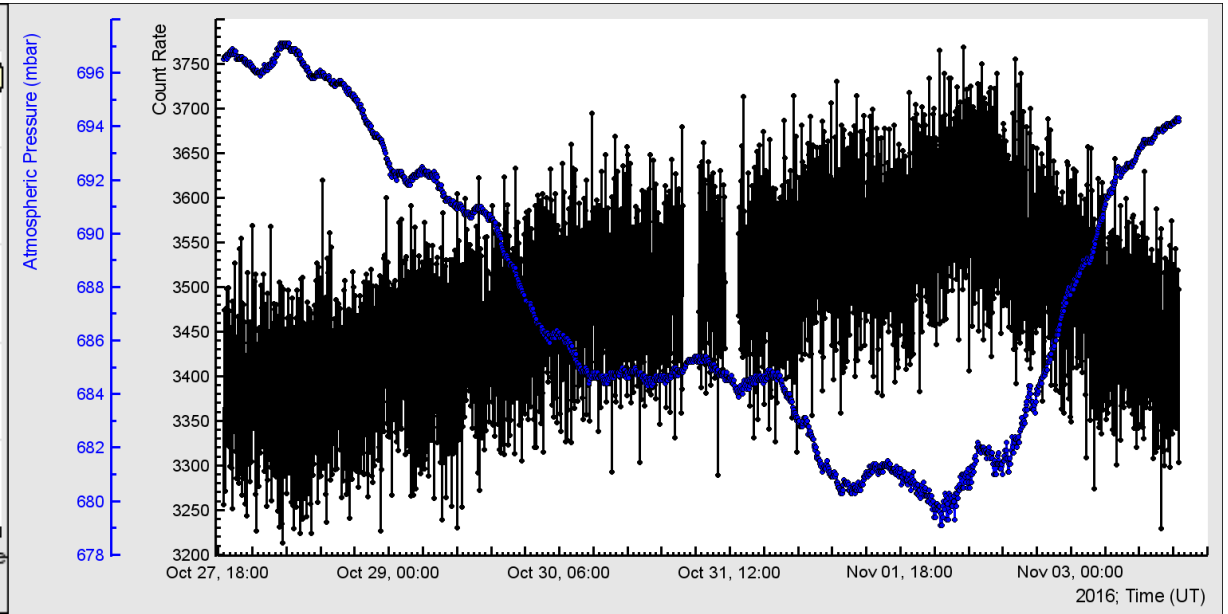




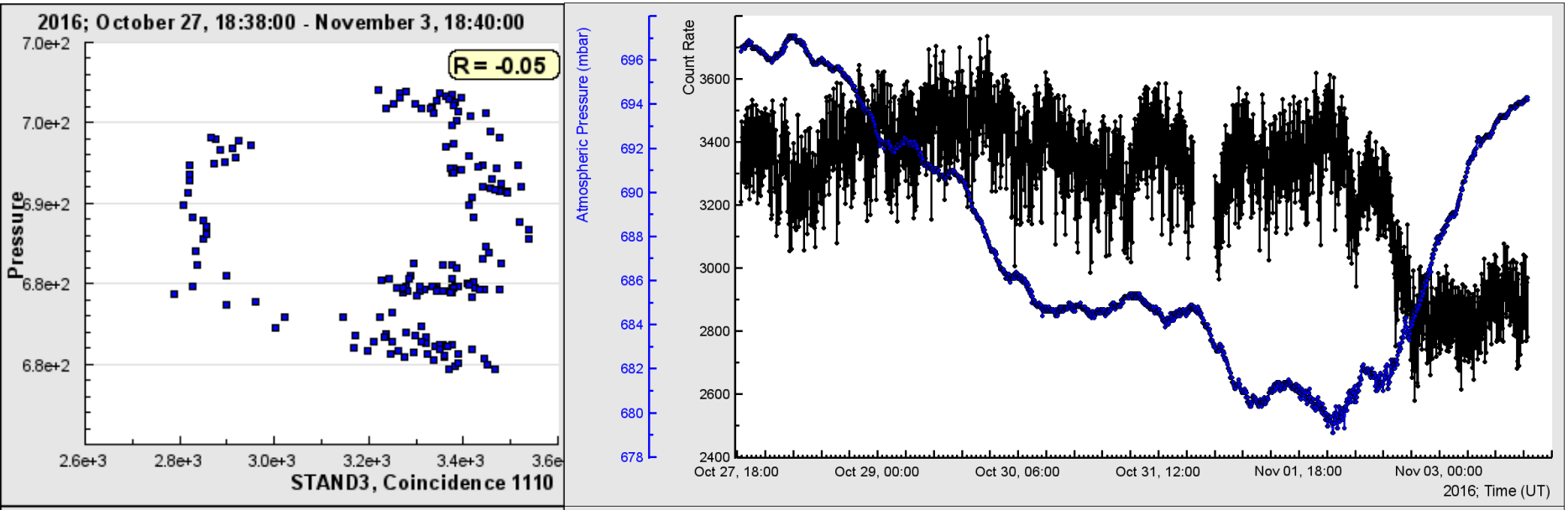


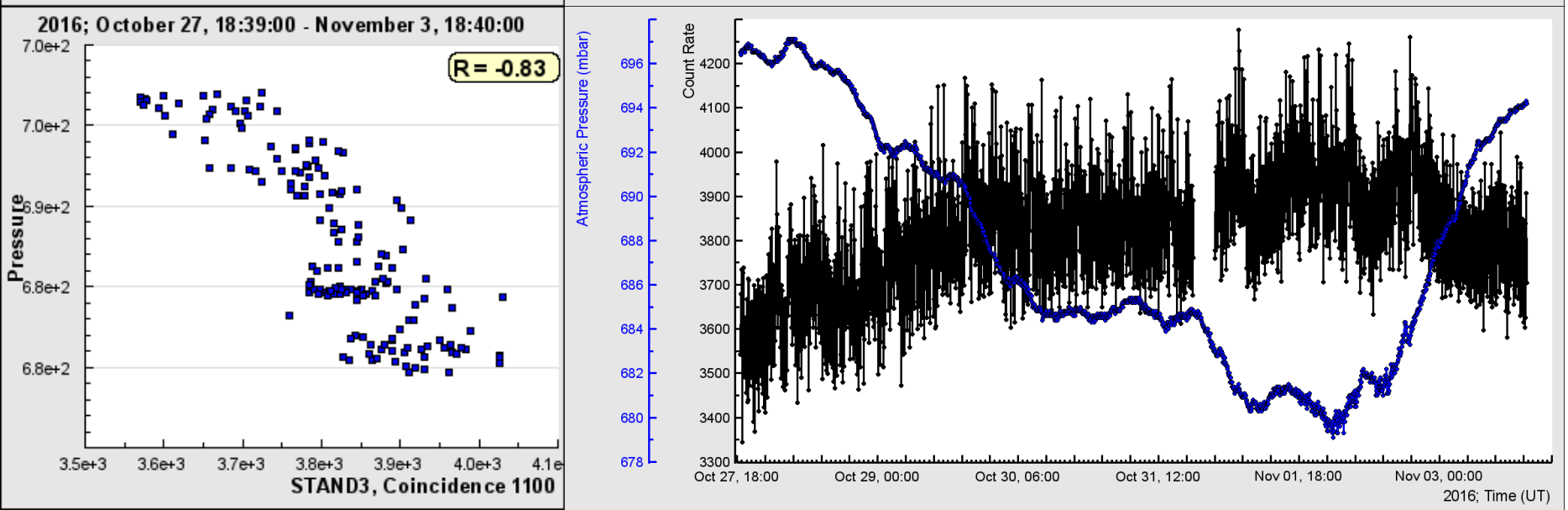
High energy muons as well very sensitive to changes of the atmospheric pressure





Drastic difference between STAND3 1100 and 1110 combinations

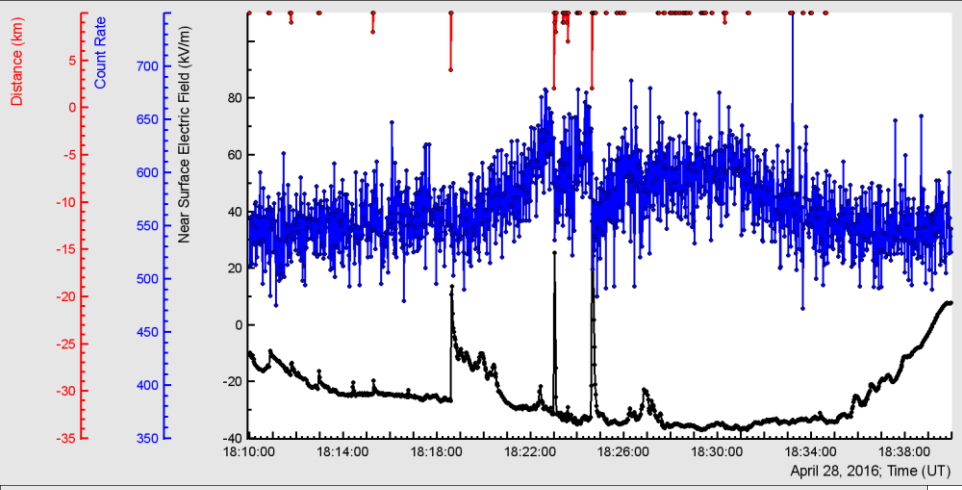


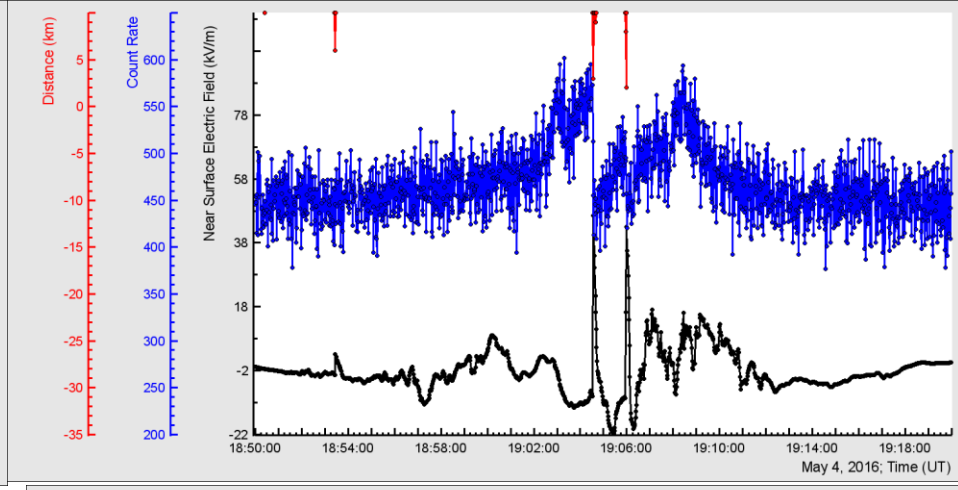


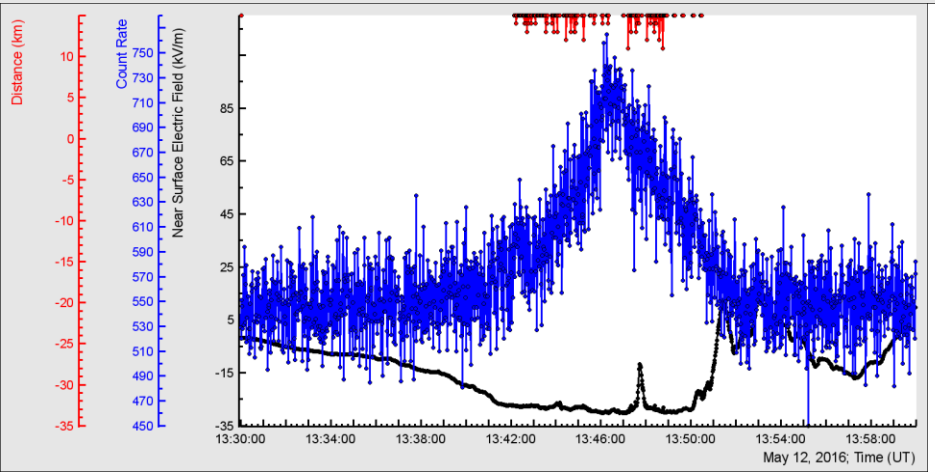
2016 TGE summary

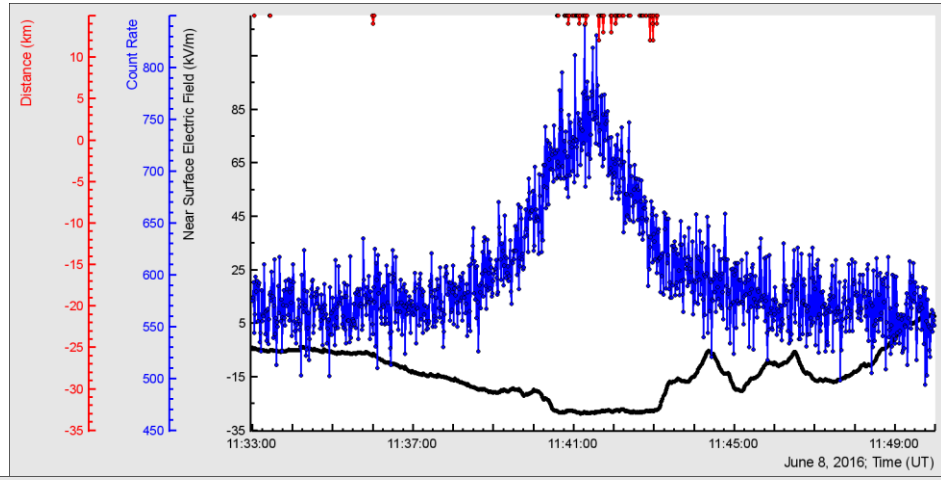
Main parameters of the 2016 TGE events

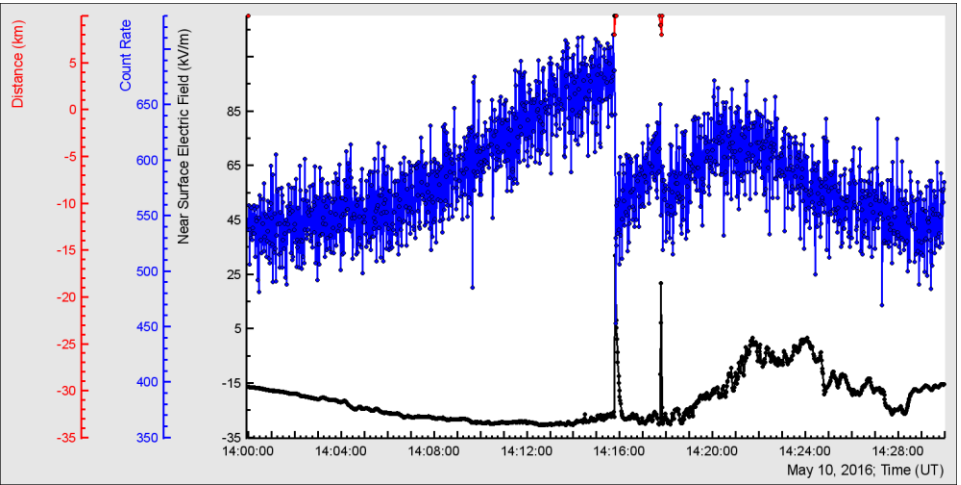
N	Date	Start of TGE (UT) and el. field value kV/m	Time of maximum (UT) and el. field kV/m	TGE significance %/N of sigma STAND1 MAKET100	time (min)	Drop of flux %	Surge of el. field kV/m	EFM Dist. km	*Interrupt by light.*	
1	4/03	19:02/-5.5	19:10/-5.8	12.6/18	8			10		
2	28/04	18.19 -6.3	18:23 -13	20.6/22.6 18.5/20.5	4 5:30	13.2 15	60 71	1.9 1.9	2	
3	4/05	18:57 -2.4	19:04 -12.3	45.7/56	7 8:30	27 14	54.5 52.5	1.9 2.9	2	
4	12/05	13:40/-15	13:47/-29	13/27	7			10.8		
5	15/5	02.21 15	02:27 -27	20.6/17	6 7:20	17.7 16.5	56 57.7	9.7 4	2	
6	4/6	01:17/-3.3	01:25/-21.3	17.9/17.6	8	15.9	43.1	3	1	
7	8/6	11:37/-15	11:42/-26.5	32.1/37	5					
8	11/6	11:38 41	11:48 -27	26.2/36.7	10 15	19.2 9.5	51.6 36.1	1.8 1.9		
9	16/6	1:53 -15	10:02 -26	18/28	9 12	25 11	57 53.3	9.6 5.8	2	
10	28/7	13:50 4	13:55 -16	34/44	5	14.5	38.6	1.8	1	

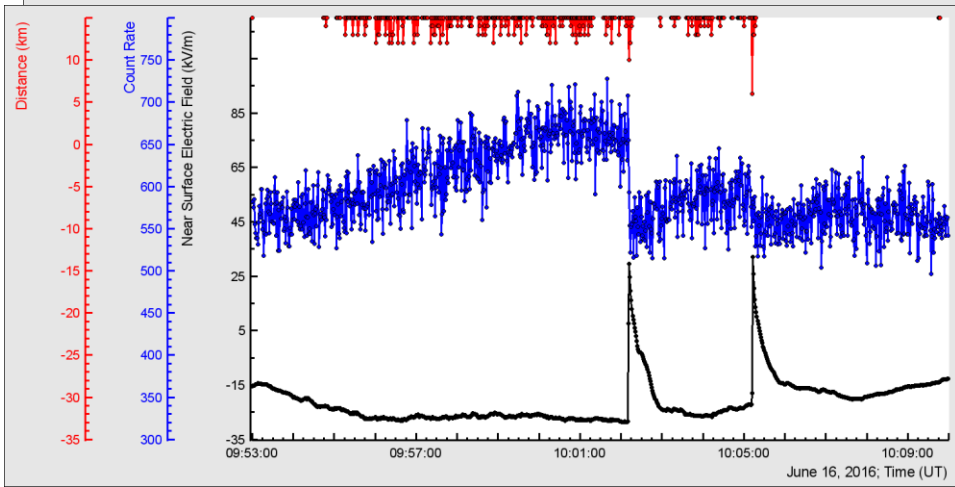

Distance (km)
Count Rate
Near Surface Electric Field (kV/m)
18:10:00
18:14:00
18:18:00
18:22:00
18:26:00
18:30:00
18:34:00
18:38:00
April 28, 2016; Time (UT)

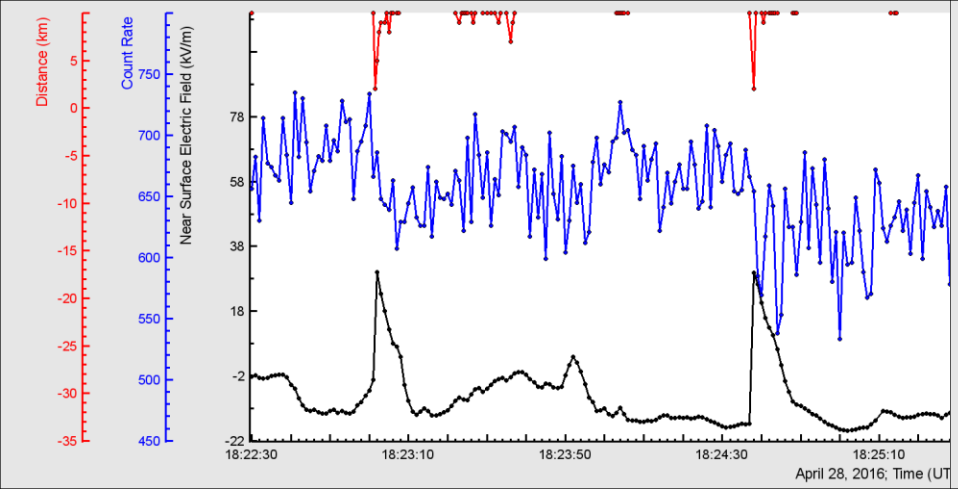

Distance (km)
Count Rate
Near Surface Electric Field (kV/m)
18:50:00
18:54:00
18:58:00
19:02:00
19:06:00
19:10:00
19:14:00
19:18:00
May 4, 2016; Time (UT)

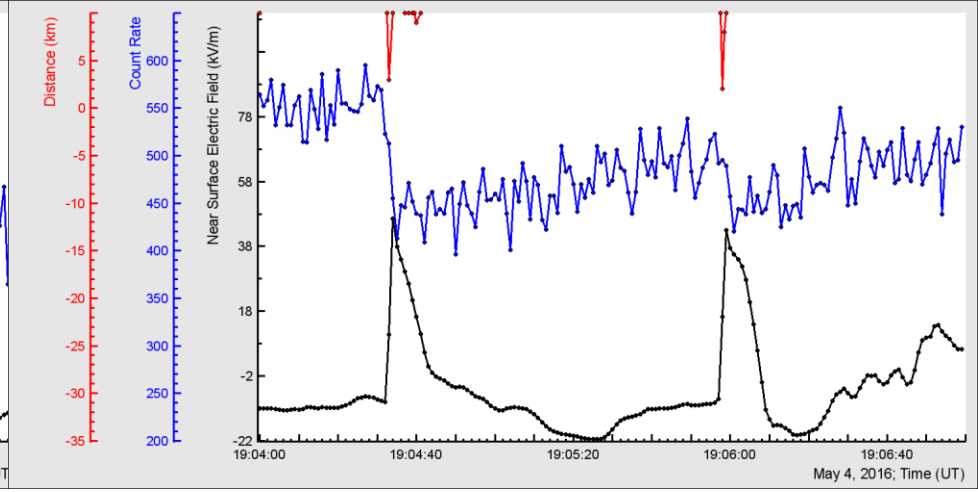

Distance (km)
Count Rate
Near Surface Electric Field (kV/m)
13:30:00
13:34:00
13:38:00
13:42:00
13:46:00
13:50:00
13:54:00
13:58:00
May 12, 2016; Time (UT)

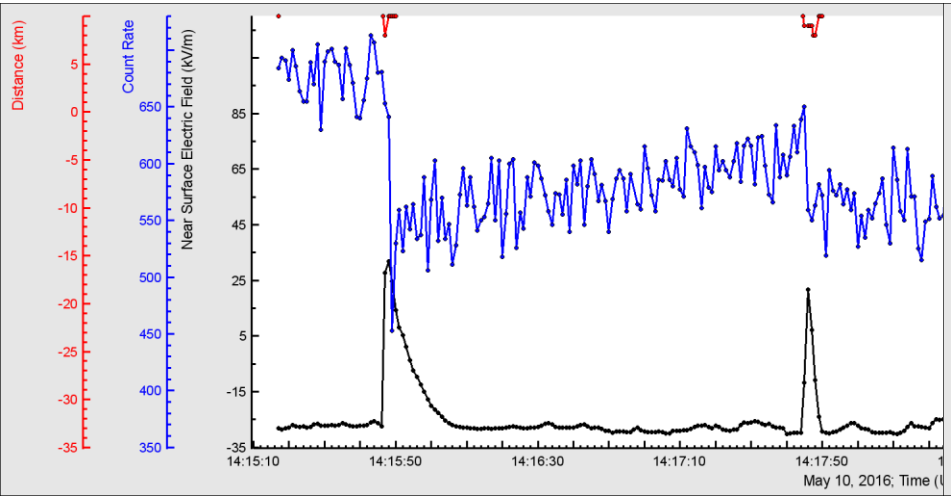

Distance (km)
Count Rate
Near Surface Electric Field (kV/m)
11:33:00
11:37:00
11:41:00
11:45:00
11:49:00
June 8, 2016; Time (UT)

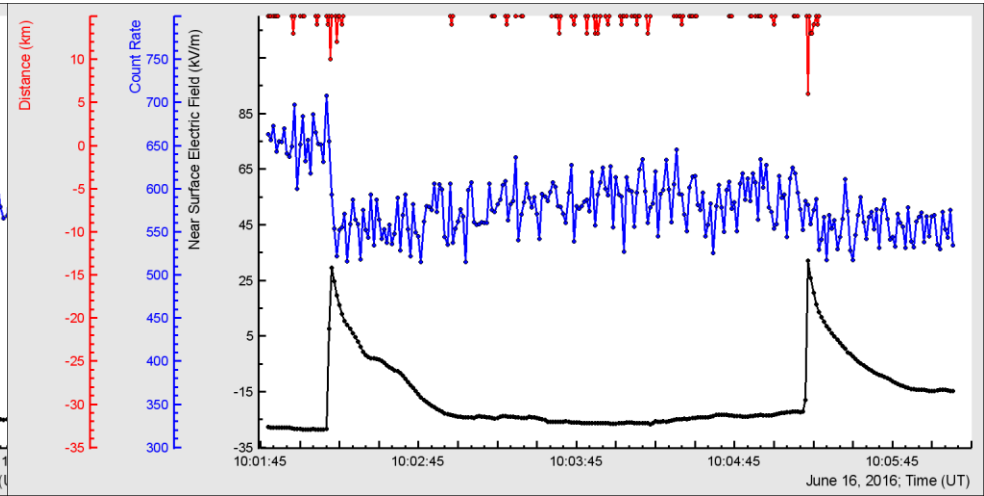

Distance (km)
Count Rate
Near Surface Electric Field (kV/m)
14:00:00
14:04:00
14:08:00
14:12:00
14:16:00
14:20:00
14:24:00
14:28:00
May 10, 2016; Time (UT)


Distance (km)
Count Rate
Near Surface Electric Field (kV/m)
09:53:00
09:57:00
10:01:00
10:05:00
10:09:00
June 16, 2016; Time (UT)


Distance (km)
Count Rate
Near Surface Electric Field (kV/m)
18:22:30
18:23:10
18:23:50
18:24:30
18:25:10
April 28, 2016; Time (UT


Distance (km)
Count Rate
Near Surface Electric Field (kV/m)
19:04:00
19:04:40
19:05:20
19:06:00
19:06:40
May 4, 2016; Time (UT)


Distance (km)
Count Rate
Near Surface Electric Field (kV/m)
14:15:10
14:15:50
14:16:30
14:17:10
14:17:50
May 10, 2016; Time (


Distance (km)
Count Rate
Near Surface Electric Field (kV/m)
10:01:45
10:02:45
10:03:45
10:04:45
10:05:45
June 16, 2016; Time (UT)

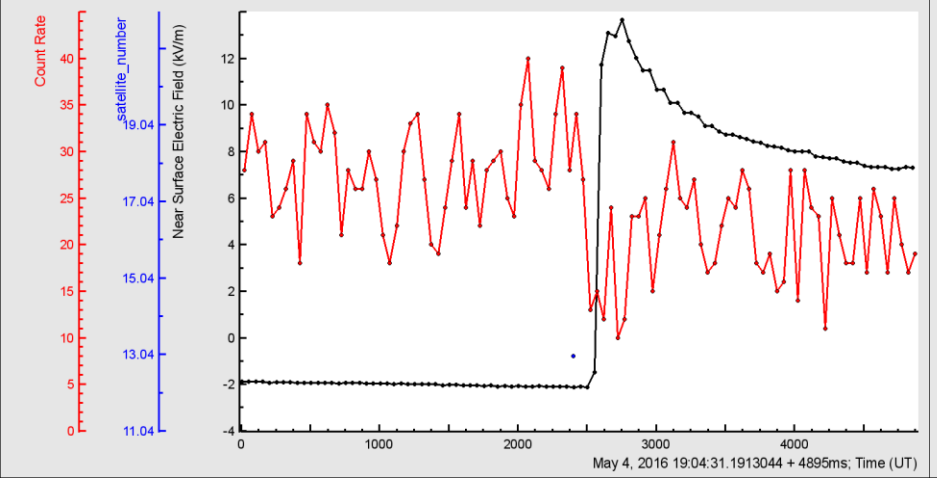
Main parameters of the 2016 TGE large TGE events

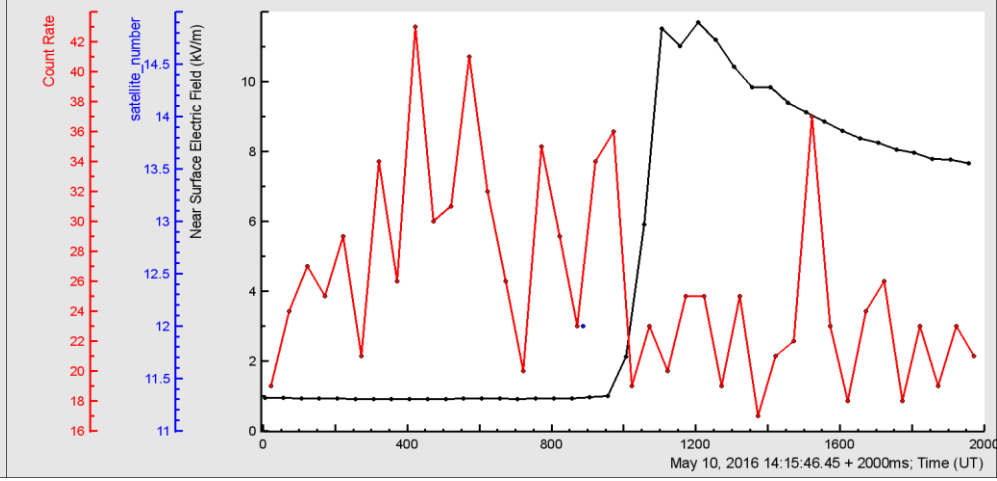
N	Date	Start of TGE (UT) and el. field value kV/m	Time of maximum (UT) and el. field kV/m	TGE significance %/N of sigma STAND1 MAKET100	time (min)	Drop of flux %	Surge of el. field kV/m	EFM Dist. km	*Interrupt by light.*	
1	4/03	19:02/-5.5	19:10/-5.8	12.6/18	8			10		
2	28/04	18.19 -6.3	18:23 -13	20.6/22.6 18.5/20.5	4 5:30	13.2 15	60 71	1.9 1.9	2	
3	4/05	18:57 -2.4	19:04 -12.3	45.7/56	7 8:30	27 14	54.5 52.5	1.9 2.9	2	
4	12/05	13:40/-15	13:47/-29	13/27	7			10.8		
5	15/5	02.21 15	02:27 -27	20.6/17	6 7:20	17.7 16.5	56 57.7	9.7 4	2	
6	4/6	01:17/-3.3	01:25/-21.3	17.9/17.6	8	15.9	43.1	3	1	
7	8/6	11:37/-15	11:42/-26.5	32.1/37	5					
8	11/6	11:38 41	11:48 -27	26.2/36.7	10 15	19.2 9.5	51.6 36.1	1.8 1.9	2	
9	16/6	1:53 -15	10:02 -26	18/28	9 12	25 11	57 53.3	9.6 5.8	2	
10	28/7	13:50 4	13:55 -16	34/44	5	14.5	38.6	1.8	1	

28 July 2016 13:54 TGE abruptly terminated by lightning

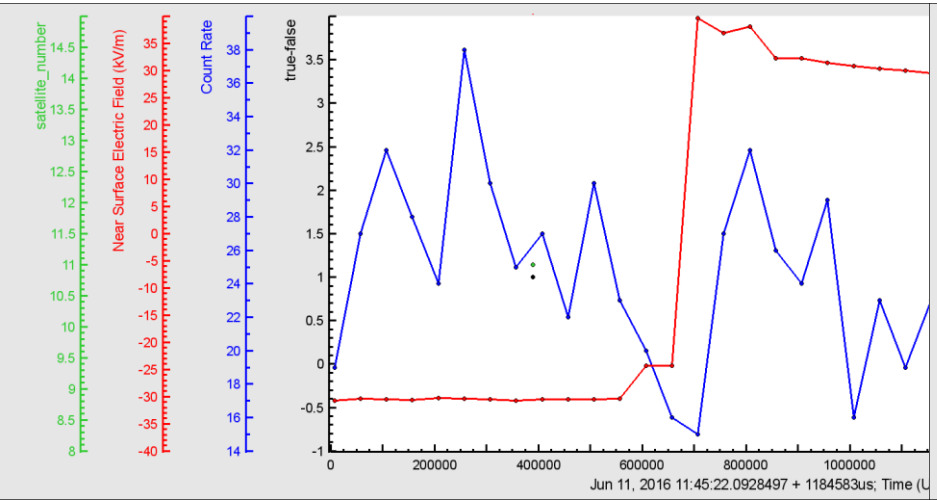
Date 28 July 2016	e intensity ($1/m^2min$) scint. N 7	γ intensity (1/ scint. N 7m^2min)	e/ γ (%)	e intensity ($1/m^2min$) scint. N 8	γ intensity ($1/m^2min$) scint. N 8	e/ γ (%)
13:52-13:53	276	2492	11	216	2100	10
13:53-13:54	404	18180	2.2	0	10860	-
13:54-13:55	628	30656	2.0	40	17616	0.2
13:55-13:56	975	21120	4.6	344	10564	3.3
13:56-13:57	88	11552	0.8	140	6728	2
13:57-13:58	28	3856	0.7	0	2240	-

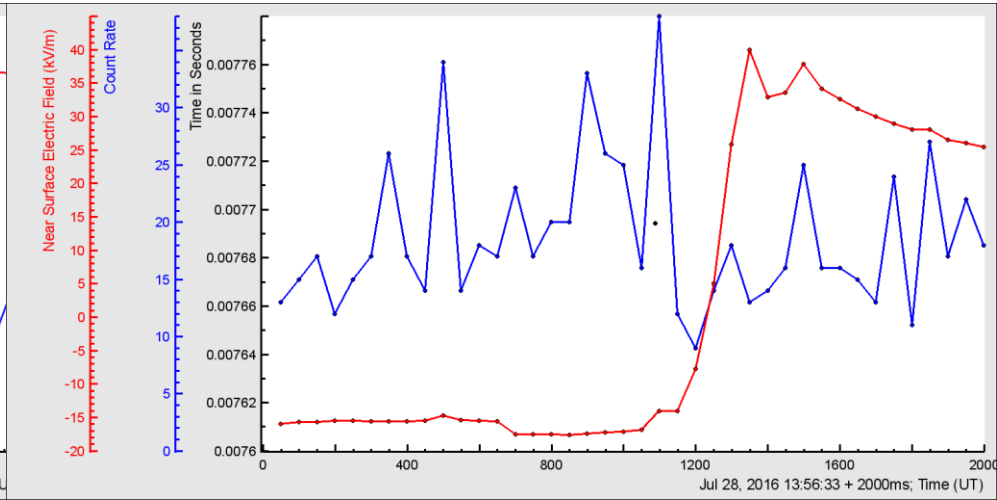
?

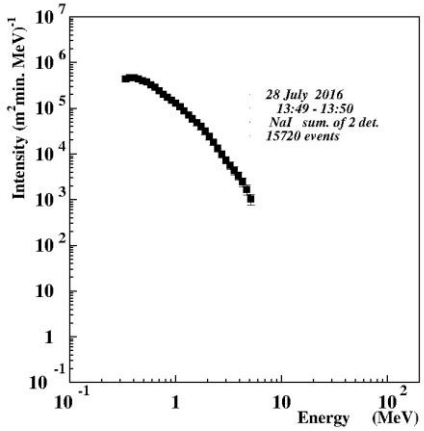

Count Rate
satellite_number
Near Surface Electric Field (kV/m)
May 4, 2016 19:04:31.1913044 + 4895ms; Time (UT)

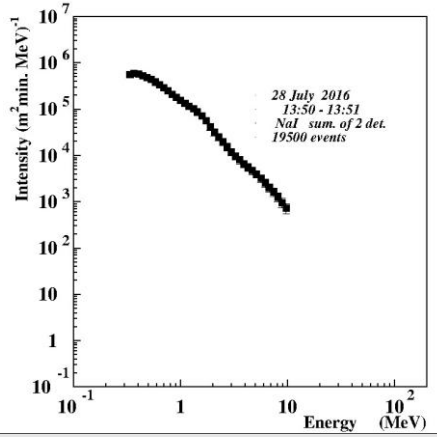

Count Rate
satellite_number
Near Surface Electric Field (kV/m)
May 10, 2016 14:15:46.45 + 2000ms; Time (UT)

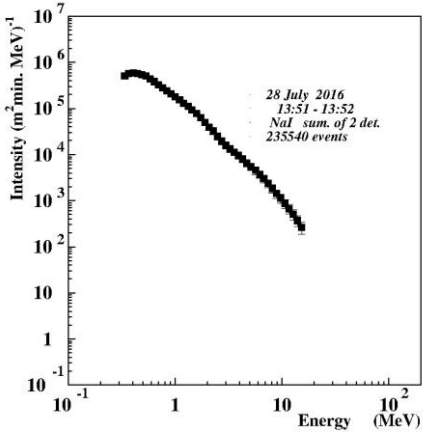

2016-07-28
13:56:34-03

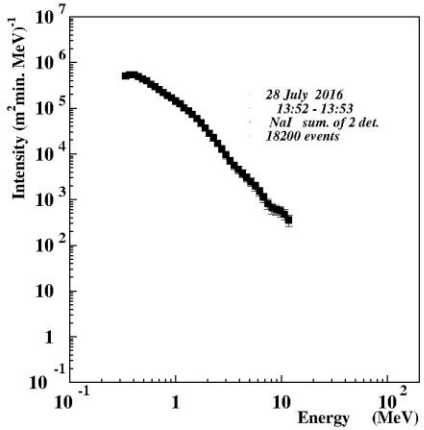

satellite_number
Near Surface Electric Field (kV/m)
Count Rate
true-false
Jun 11, 2016 11:45:22.0928497 + 1184583us; Time (U

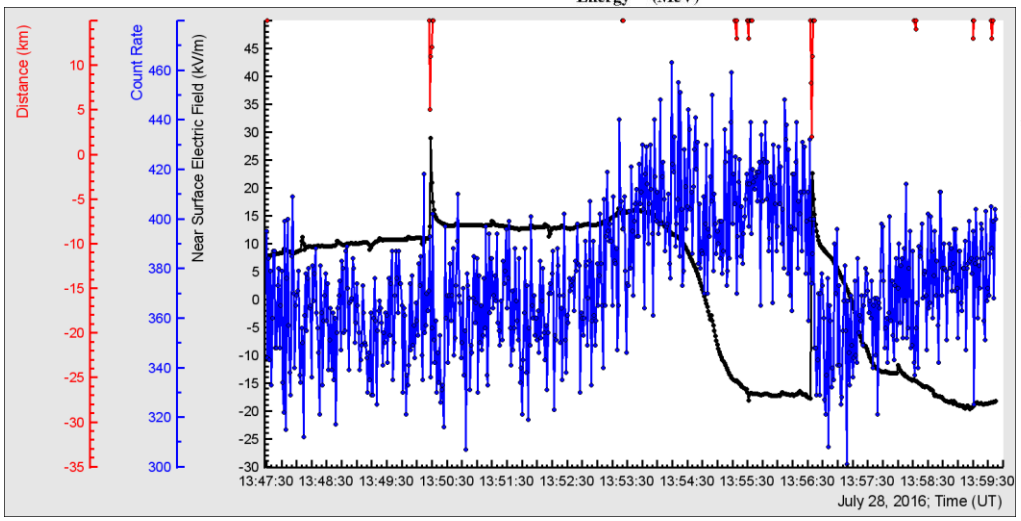

Near Surface Electric Field (kV/m)
Count Rate
Time in Seconds
Jul 28, 2016 13:56:33 + 2000ms; Time (UT)

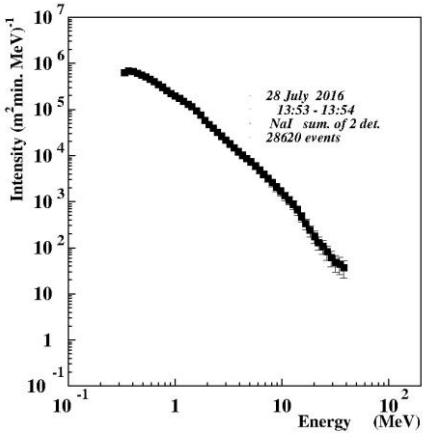

28 July 2016
13:49 - 13:50
NaI sum. of 2 det.
15720 events
Intensity (m²min. MeV)⁻¹
Energy (MeV)

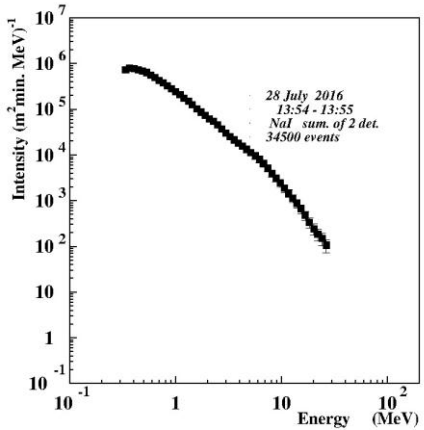

28 July 2016
13:50 - 13:51
NaI sum. of 2 det.
19500 events
Intensity (m²min. MeV)⁻¹
Energy (MeV)

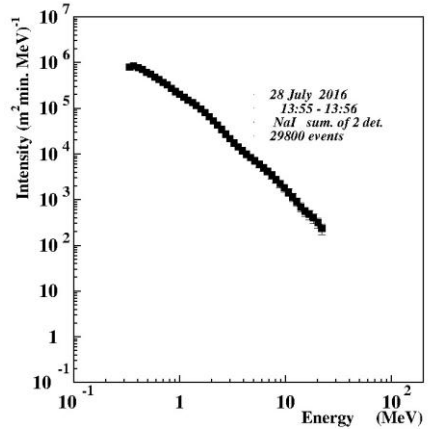

28 July 2016
13:51 - 13:52
NaI sum. of 2 det.
235540 events
Intensity (m²min. MeV)⁻¹
Energy (MeV)

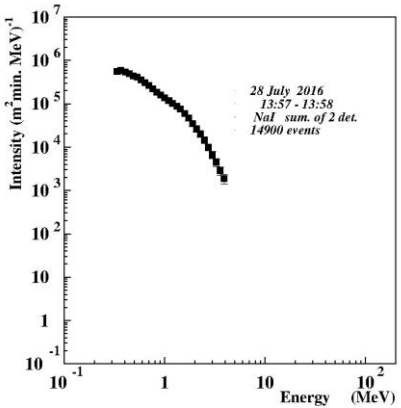

28 July 2016
13:52 - 13:53
NaI sum. of 2 det.
18200 events
Intensity (m²min. MeV)⁻¹
Energy (MeV)


Distance (km)
Count Rate
Near Surface Electric Field (kV/m)
13:47:30 13:48:30 13:49:30 13:50:30 13:51:30 13:52:30 13:53:30 13:54:30 13:55:30 13:56:30 13:57:30 13:58:30 13:59:30
July 28, 2016; Time (UT)


28 July 2016
13:53 - 13:54
NaI sum. of 2 det.
28620 events
Intensity (m²min. MeV)⁻¹
Energy (MeV)


28 July 2016
13:54 - 13:55
NaI sum. of 2 det.
34500 events
Intensity (m²min. MeV)⁻¹
Energy (MeV)

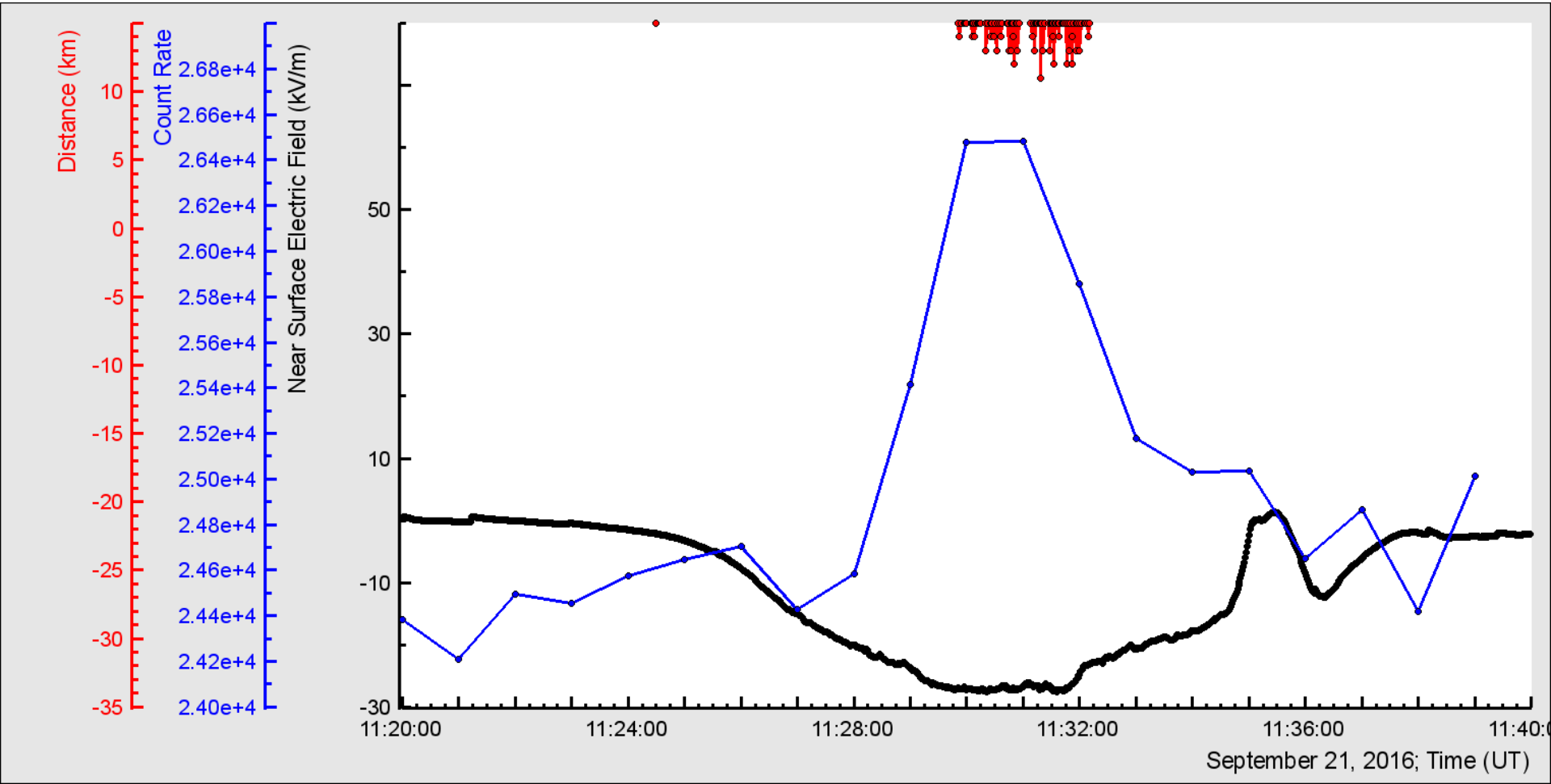

28 July 2016
13:55 - 13:56
NaI sum. of 2 det.
29800 events
Intensity (m²min. MeV)⁻¹
Energy (MeV)


28 July 2016
13:57 - 13:58
NaI sum. of 2 det.
14900 events
Intensity (m²min. MeV)⁻¹
Energy (MeV)

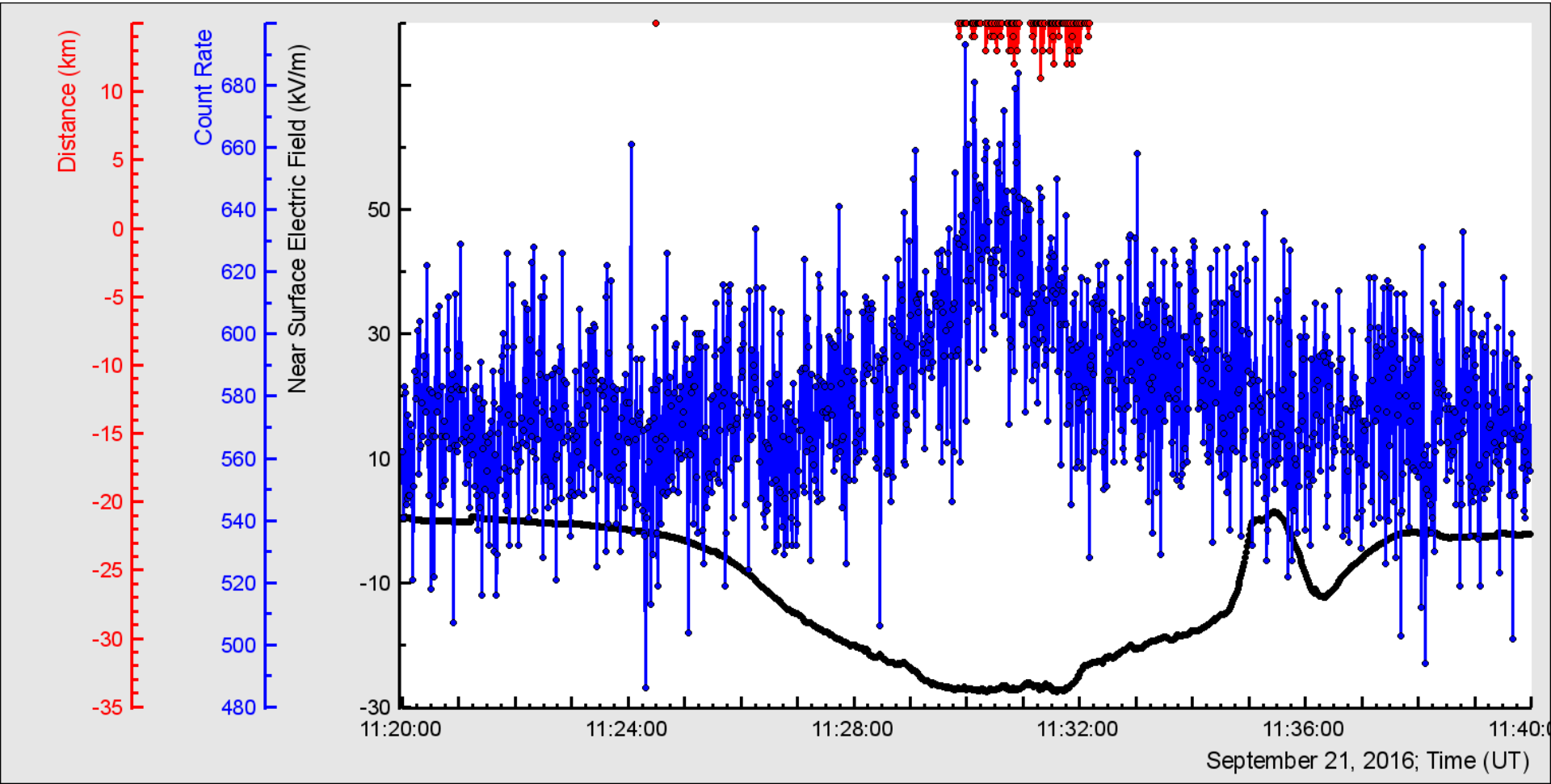
Cosmic Ray background and its MSE along with recovered TGE flux by 20 sec energy releases in the first 60-cm thick scintillator of ASNT detector (only first 11 codes 1.6 – 4.2 MeV are shown)

Code of ADC	1	2	3	4	5	6	7	8	9	10	11
Energy(MeV)	1.6	1.8	2.0	2.2	2.4	2.6	2.9	3.2	3.5	3.8	4.2
CR background	756.5	923.0	623.9	804.1	941.6	897.3	839.2	781.6	727.2	678.1	630.3
CR variance	27.5	30.4	25.0	28.4	30.7	30.0	29.0	28.0	27.0	26.0	25.1
13:56:22 –13:56:41	291.5	296.0	223.1	285.9	380.4	313.7	246.8	207.4	222.8	213.9	195.7
13:56:42 -13:57:01	135.5	225.0	140.1	164.9	223.4	97.7	107.8	48.4	139.8	115.9	86.7
13:57:02 -13:57:21	-26.5	14.0	29.1	49.9	26.4	41.7	0.8	47.4	-10.2	88.9	39.7
Code of ADC	15	16	17	18	19	20	21	22	23	24	25
Energy(MeV)	6.2	6.8	7.4	8.2	0.9	10.0	10.9	12.0	13.2	14.5	15.9
CR background	510.5	499.2	485.4	477.5	469.0	462.7	454.7	446.9	439.3	435.5	430.7
CR variance	22.6	22.3	22.0	21.9	21.7	21.5	21.3	21.1	21.0	20.9	20.8
13:56:22 –13:56:41	105.5	102.8	43.6	31.5	36.0	11.3	-3.7	24.1	11.7	-3.5	37.3
13:56:42 -13:57:01	114.5	93.8	52.6	28.5	71.0	47.3	11.3	23.1	30.7	22.5	22.3
13:57:02 -13:57:21	23.5	28.8	29.6	-27.5	7.0	0.3	-20.7	-0.9	-6.3	6.5	32.3

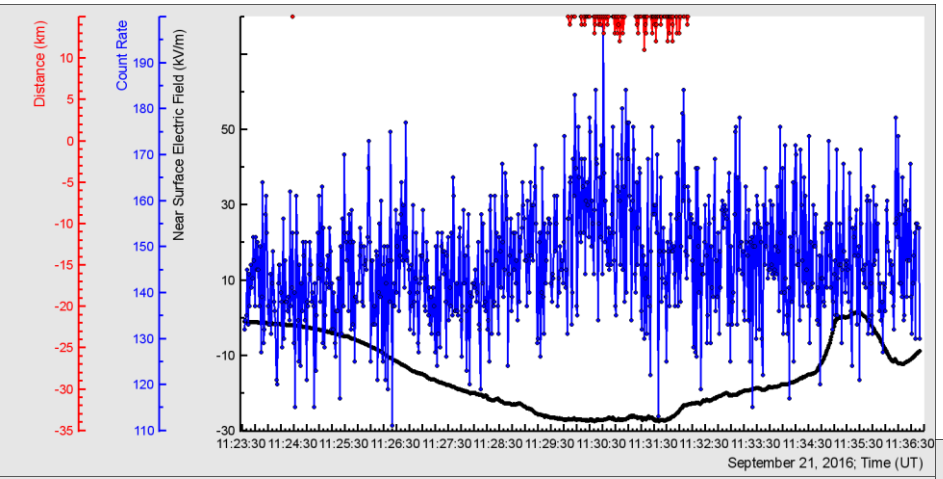
September 21: One-minute time-series of STAND1 100 combination; flux enhancement 10% (14.4σ); lightning distance 10.8

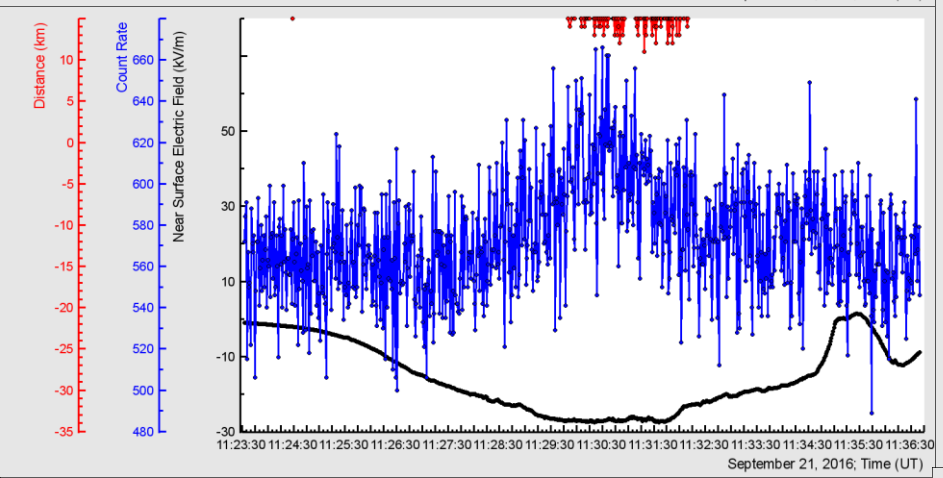


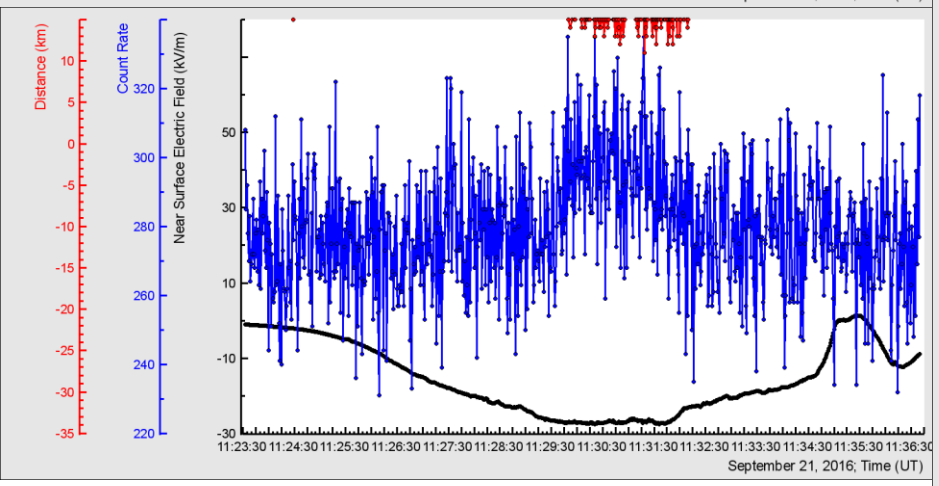
GAMMA EFM and MAKET STAND1 3 cm thick

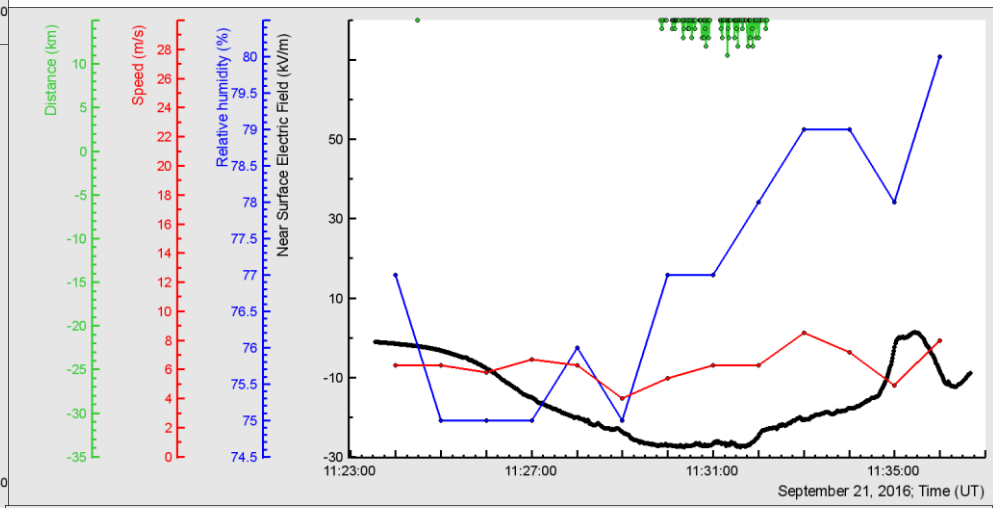


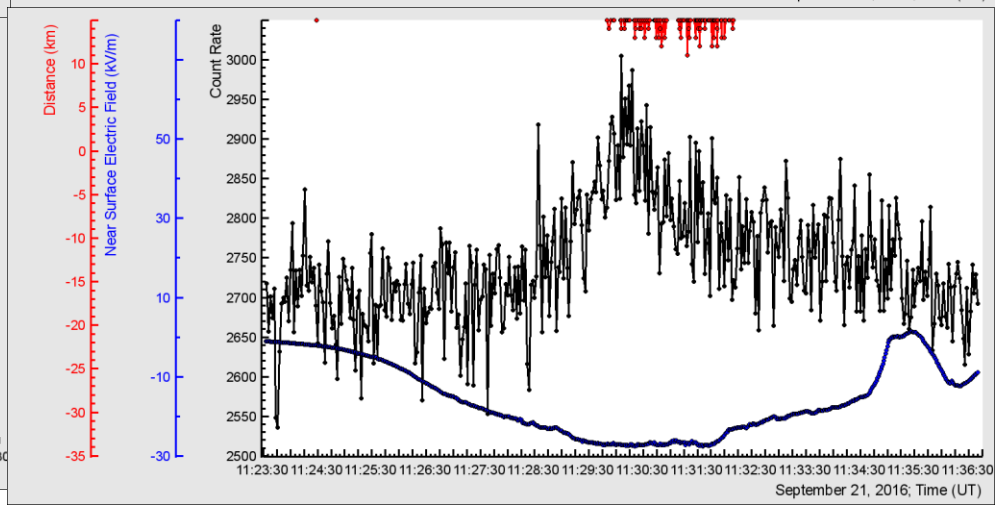
Gamma upper, MAKET upper and SKL upper 60 cm thick: “Razladka”











Main parameters of the 2016 TGE large TGE events

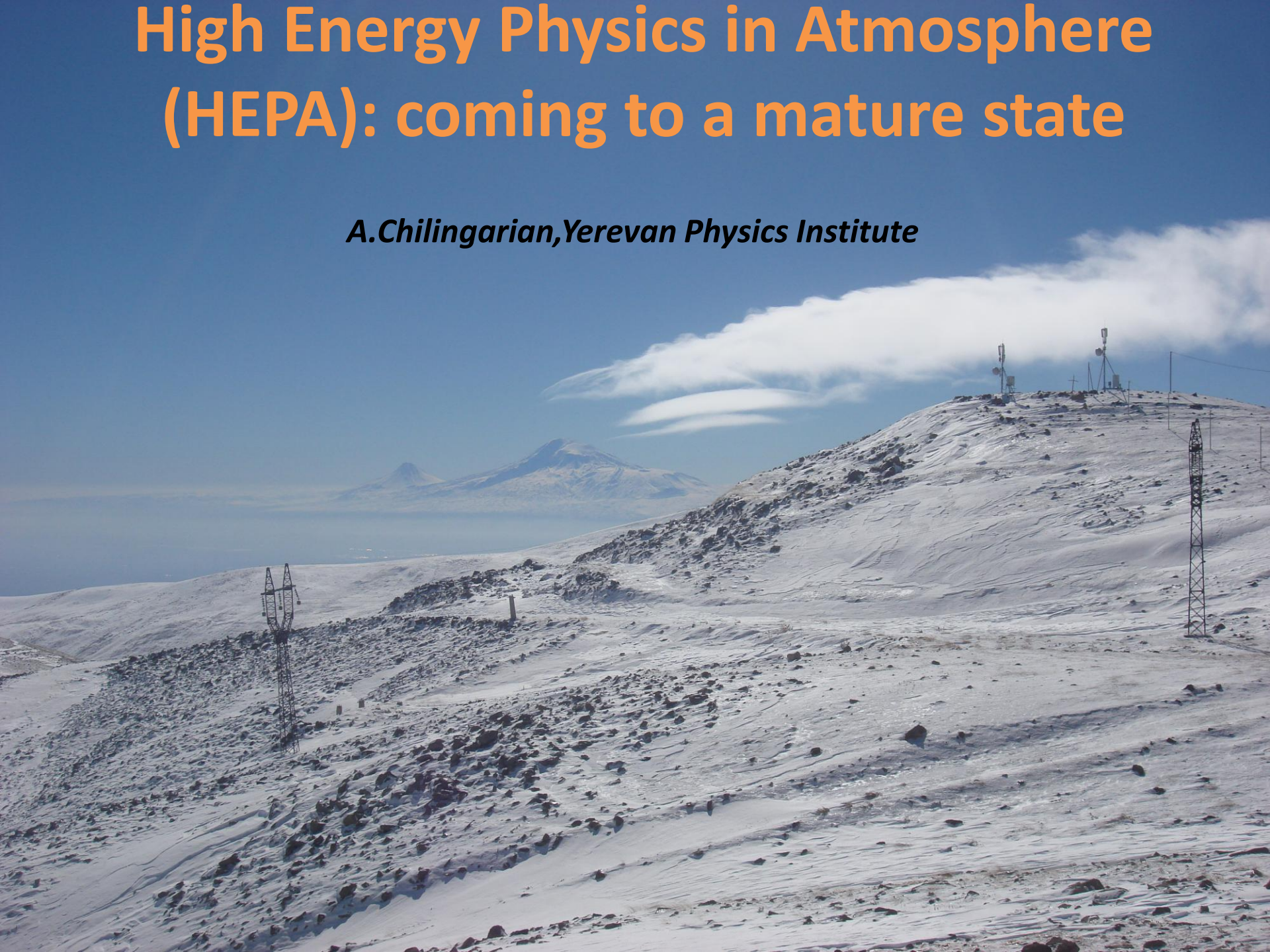
N	Date	Start of TGE (UT) and el. field value kV/m	Time of maximum (UT) and el. field kV/m	TGE significance %/N of sigma STAND1 MAKET100	time (min)	Drop of flux %	Surge of el. field kV/m	EFM Dist. km	*Interrupt by light.*	
1	4/03	19:02/-5.5	19:10/-5.8	12.6/18	8			10		
2	28/04	18.19 -6.3	18:23 -13	20.6/22.6 18.5/20.5	4 5:30	13.2 15	60 71	1.9 1.9	2	
3	4/05	18:57 -2.4	19:04 -12.3	45.7/56	7 8:30	27 14	54.5 52.5	1.9 2.9	2	
4	12/05	13:40/-15	13:47/-29	13/27	7			10.8		
5	15/5	02.21 15	02:27 -27	20.6/17	6 7:20	17.7 16.5	56 57.7	9.7 4	2	
6	4/6	01:17/-3.3	01:25/-21.3	17.9/17.6	8	15.9	43.1	3	1	
7	8/6	11:37/-15	11:42/-26.5	32.1/37	5					
8	11/6	11:38 41	11:48 -27	26.2/36.7	10 15	19.2 9.5	51.6 36.1	1.8 1.9	2	
9	16/6	1:53 -15	10:02 -26	18/28	9 12	25 11	57 53.3	9.6 5.8	2	
10	28/7	13:50 4	13:55 -16	34/44	5	14.5	38.6	1.8	1	

60% of lightning hit the same place nearby Aragats station: a lot of iron there?

Aragats camera1 13:56:34.100

High Energy Physics in Atmosphere (HEPA): coming to a mature state

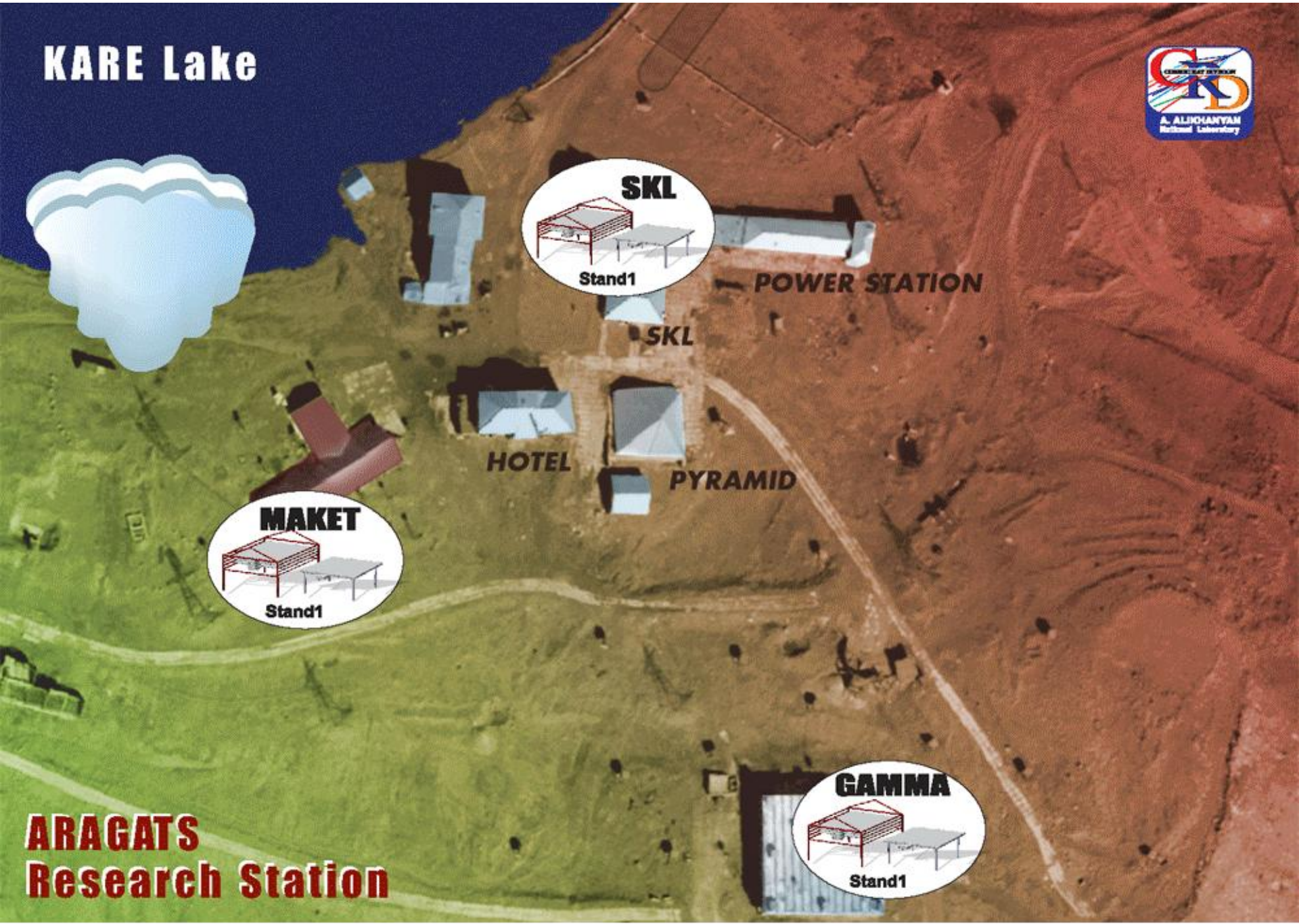
A.Chilingarian,Yerevan Physics Institute



Research of Thunderstorm Ground enhancements (TGE)

- **Helps to establish new Model of Lightning initiation;**
- **Reject hypothesis of the high-energy particle (neutrons and gamma photons) origination in the lightning bolt.**


Aragats 2015/06/03 15:17:18
Aragats CAMERA 1
2015-06-03
15:17:19-27


KARE Lake
SKL
Stand1
POWER STATION
SKL
HOTEL
PYRAMID
MAKET
Stand1
GAMMA
Stand1
ARAGATS
Research Station

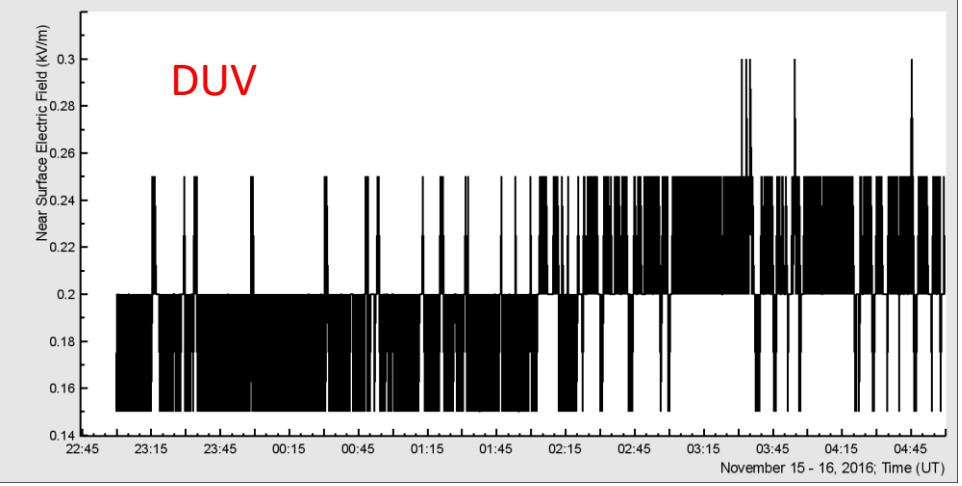

Aragats 2015/06/03 15:30:53
Aragats CAMERA 1
2015-06-03
15:30:55-04
Aragats 2015/06/03 15:33:54
Aragats CAMERA 1
2015-06-03
15:33:56-21
Aragats 2015/06/03 15:35:05
Aragats CAMERA 1
2015-06-03
15:35:07-03
Aragats 2015/06/03 15:35:05
Aragats CAMERA 1
2015-06-03
15:35:07-12

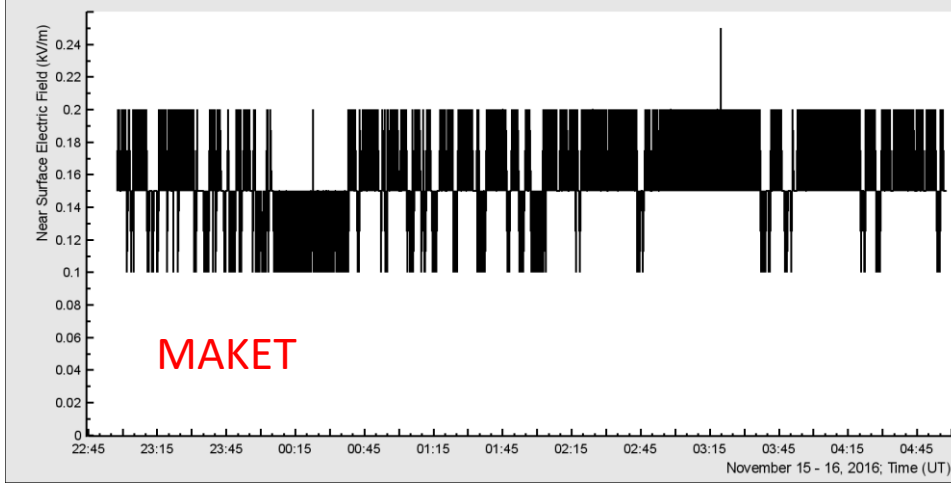
16 June, 20-second energy release spectra in 60 cm thick plastic scintillator before the lightning occurred at 10:02:11; the enhancement of count rate in the 22 ADC channels (1.62- 15.9 MeV) to be compared with CR MSE (red); lightning at 10:02:11

Code of ADC	1	2	3	4	5	6	7	8	9	10	11
Energy(MeV)	1.6	1.8	2.0	2.2	2.4	2.6	2.9	3.2	3.5	3.8	4.2
CR background	952.0	1112.0	735.0	892.0	1013.0	941.0	867.0	808.0	754.0	708.0	664.0
CR variance	30.9	33.3	27.1	29.9	31.8	30.7	29.4	28.4	27.5	26.6	25.8
10:02:04 -10:02:23	161.2	175.0	85.4	196.3	227.6	239.0	212.7	122.0	144.4	161.6	152.8
10:02:24 -10:02:43	**90.2**	**14.0**	**121.4**	**47.3**	**18.6**	**50.0**	**75.7**	**99.0**	**15.4**	**19.6**	**38.8**
10:02:44 -10:03:03	**-5.8**	**81.0**	**43.4**	**45.3**	**-50.4**	**5.0**	**-1.3**	**20.0**	**-20.6**	**-0.4**	**14.8**
Code of ADC	15	16	17	18	19	20	21	22	23	24	25
Energy(MeV)	6.2	6.8	7.4	8.2	0.9	10.0	10.9	12.0	13.2	14.5	15.9
CR background	526.6	510.9	492.3	479.7	474.1	462.1	455.0	449.3	446.2	435.7	429.9
CR variance	22.9	22.6	22.2	21.9	21.8	21.5	21.3	21.2	21.1	20.9	20.7
10:02:04 -10:02:23	80.4	114.1	83.7	36.3	29.9	35.9	33.0	57.7	27.8	18.3	39.1
10:02:24 -10:02:43	**12.4**	**-6.9**	**52.7**	**3.3**	**-1.1**	**38.9**	**0.0**	**1.7**	**23.8**	**31.3**	**26.1**
10:02:44 -10:03:03	**-9.6**	**3.1**	**12.7**	**-16.7**	**19.9**	**-1.1**	**7.0**	**-0.3**	**15.8**	**33.3**	**6.1**

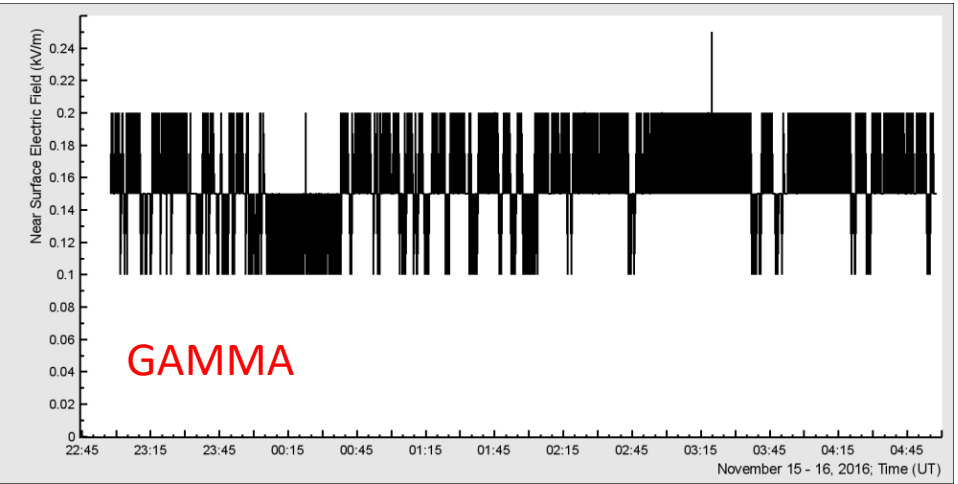
Lightning initiation- TGE is necessary'!

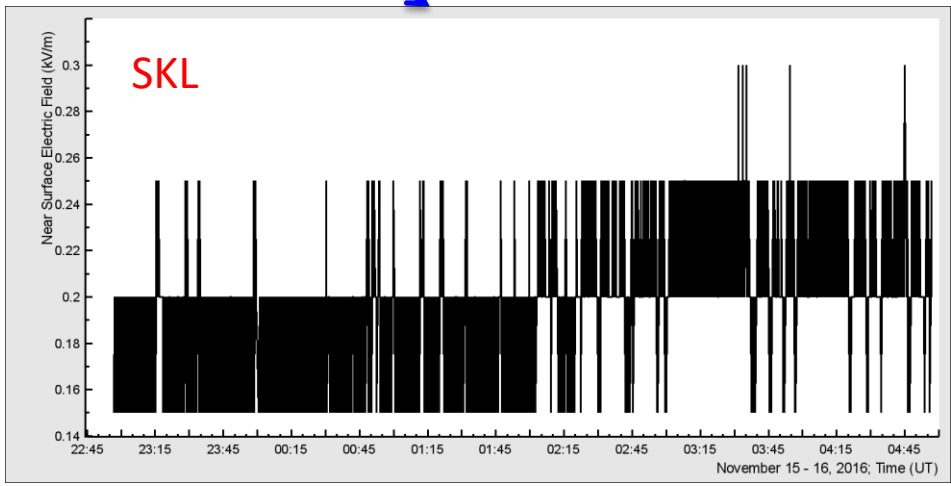
1. Locally in the cloud electric field exceed the threshold of unleashing RREA without any relation to lightning;
2. TGE started reach maximum in several minutes and make enough ionization to open conductive channel for the lightning leader;
3. When leader reach earth's surface lightning strike and abruptly terminate the particle flux;
4. "The charging engine" recovers the electric field in the same or another local place in the thundercloud;
5. If storm continues Go To to 1; Else If thunderstorm calms Stop!

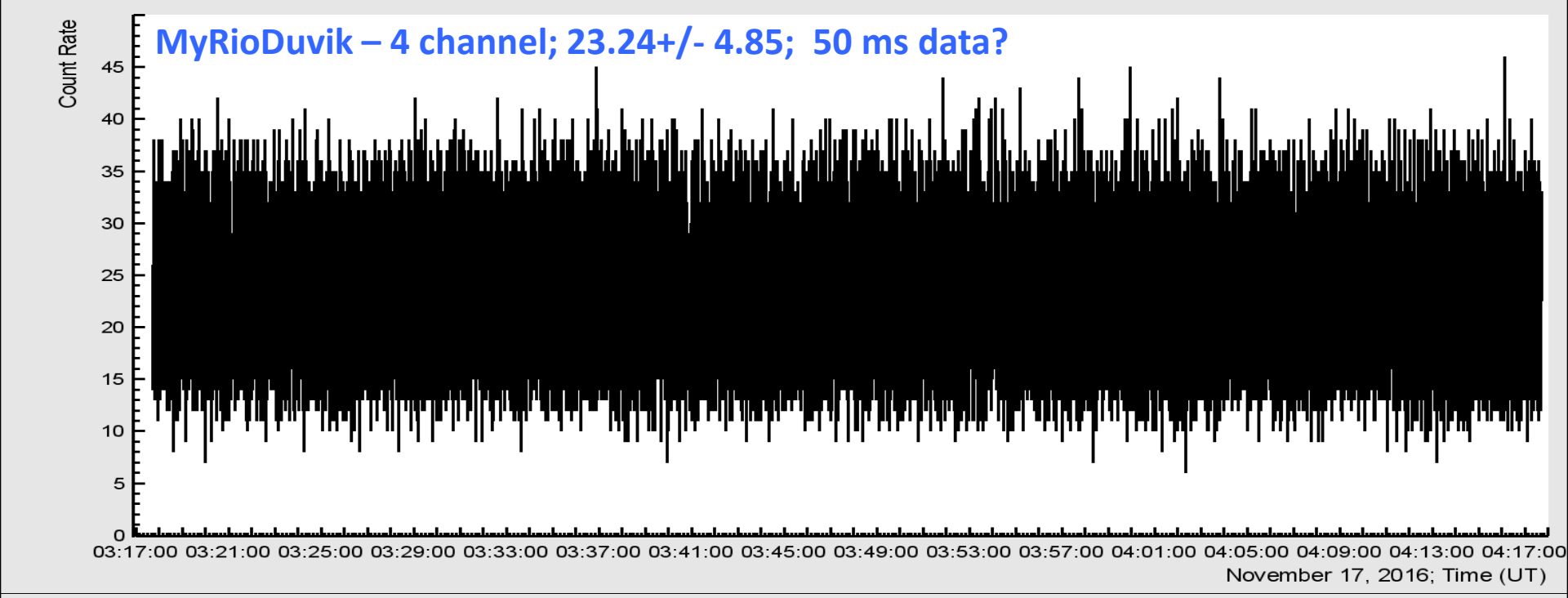


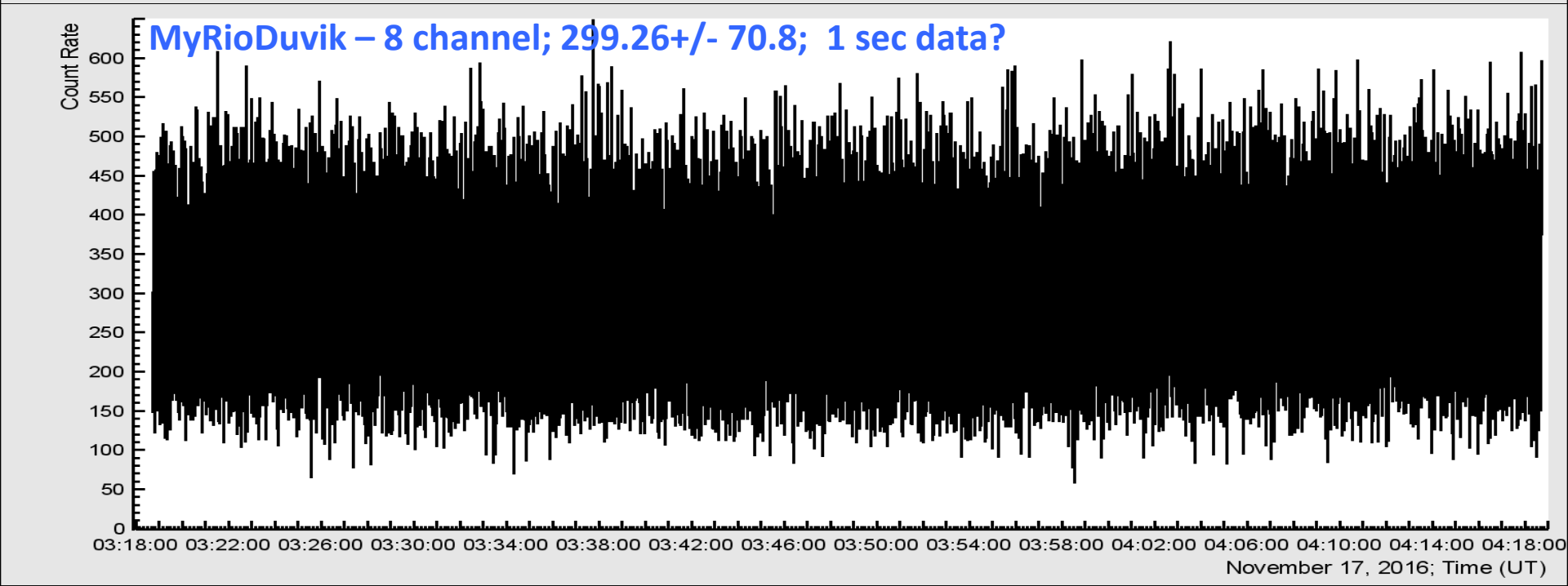


DUV take field from SKL EFM, why not from MAKET?
MAST EFM data is missing!?
MAST distance to lightning is not listed in ADEI.
“Neutron” detector data (DUV) is missing!
We have to attach 5cm thick scintillator instead of “Bogomolov” to pico trigger!

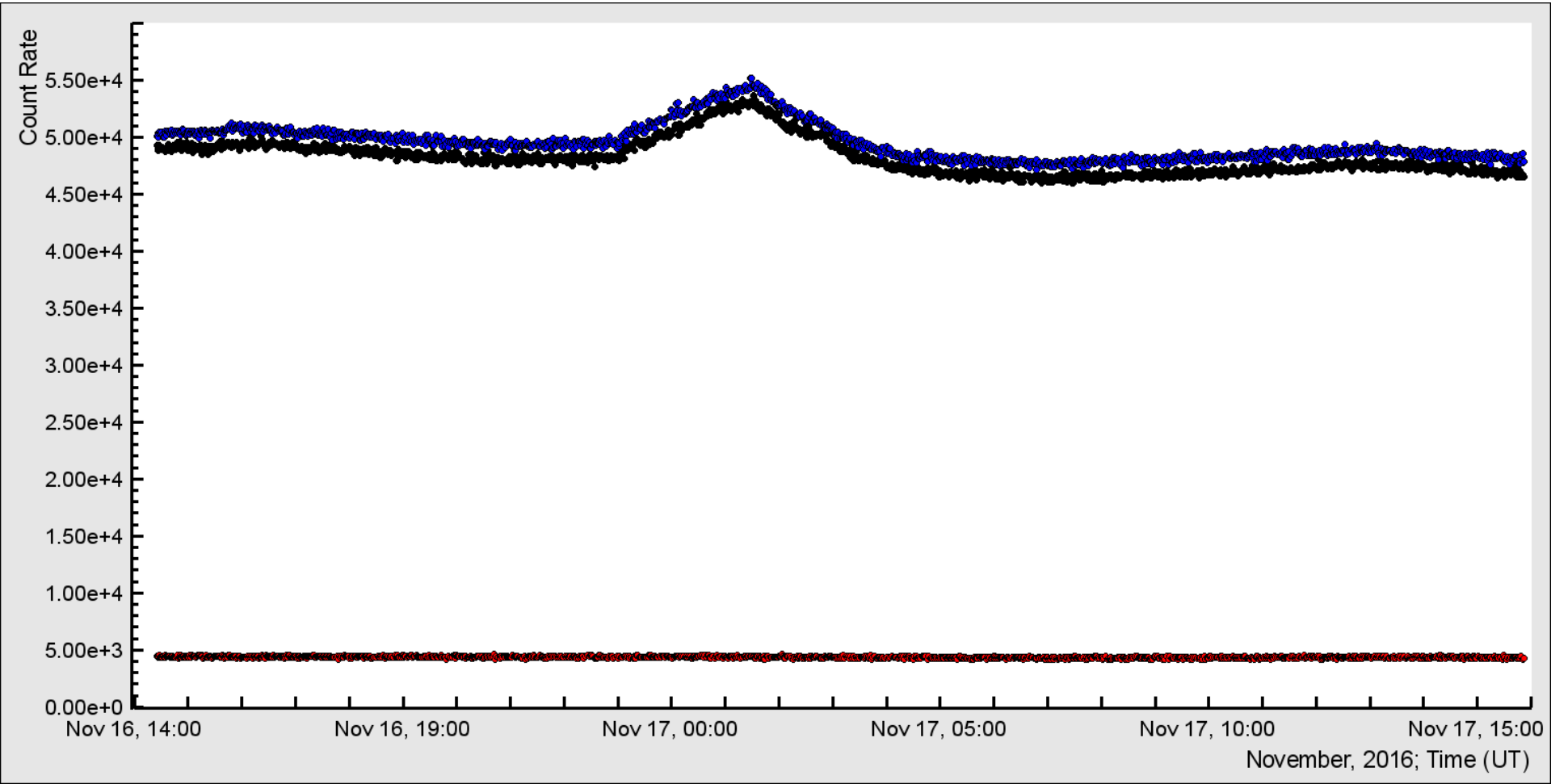




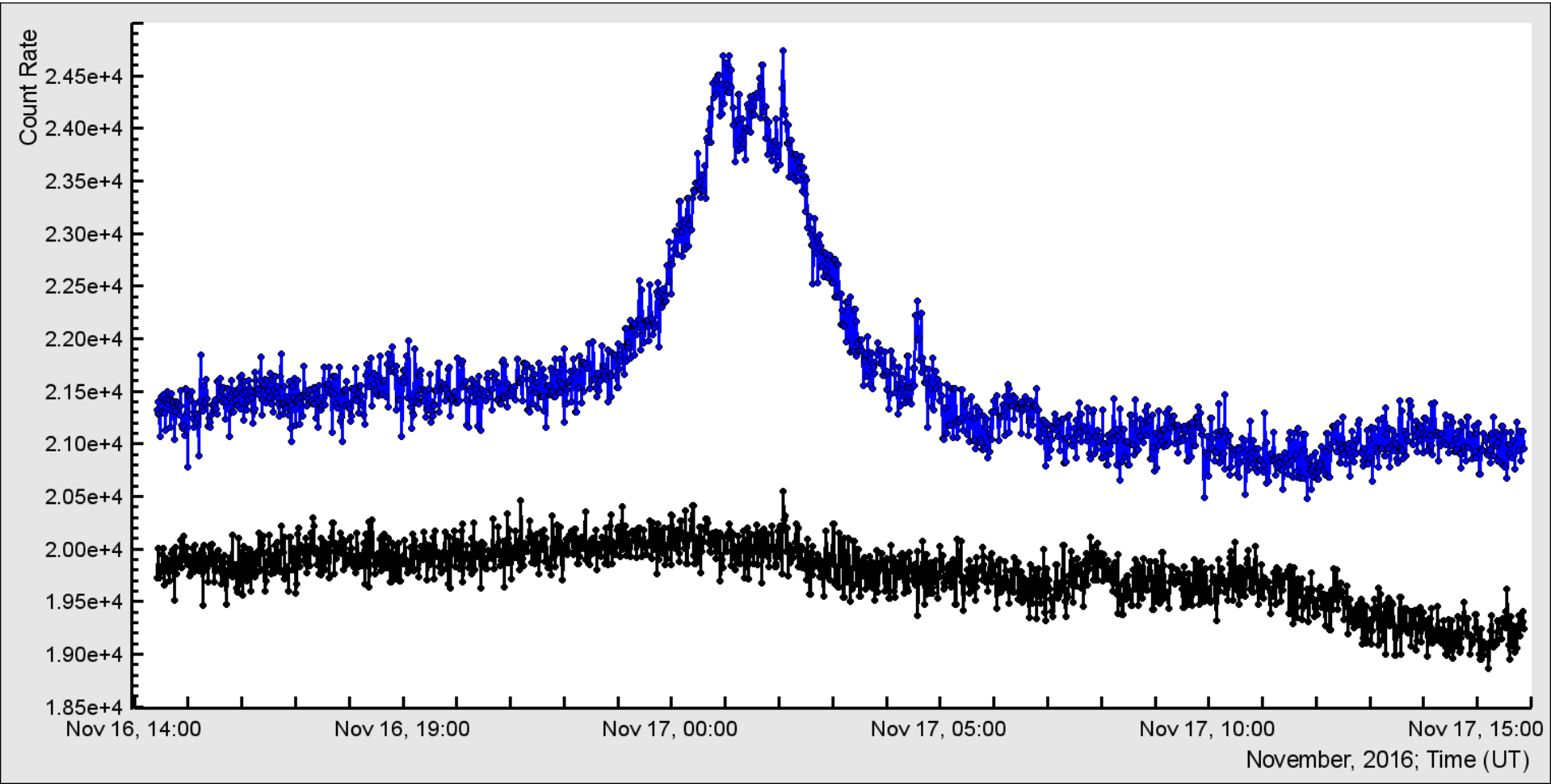

MyRioDuvik – 4 channel; 23.24+/- 4.85; 50 ms data?
Count Rate
0
5
10
15
20
25
30
35
40
45
03:17:00 03:21:00 03:25:00 03:29:00 03:33:00 03:37:00 03:41:00 03:45:00 03:49:00 03:53:00 03:57:00 04:01:00 04:05:00 04:09:00 04:13:00 04:17:00
November 17, 2016; Time (UT)


MyRioDuvik – 8 channel; 299.26+/- 70.8; 1 sec data?
Count Rate
0
50
100
150
200
250
300
350
400
450
500
550
600
03:18:00 03:22:00 03:26:00 03:30:00 03:34:00 03:38:00 03:42:00 03:46:00 03:50:00 03:54:00 03:58:00 04:02:00 04:06:00 04:10:00 04:14:00 04:18:00
November 17, 2016; Time (UT)

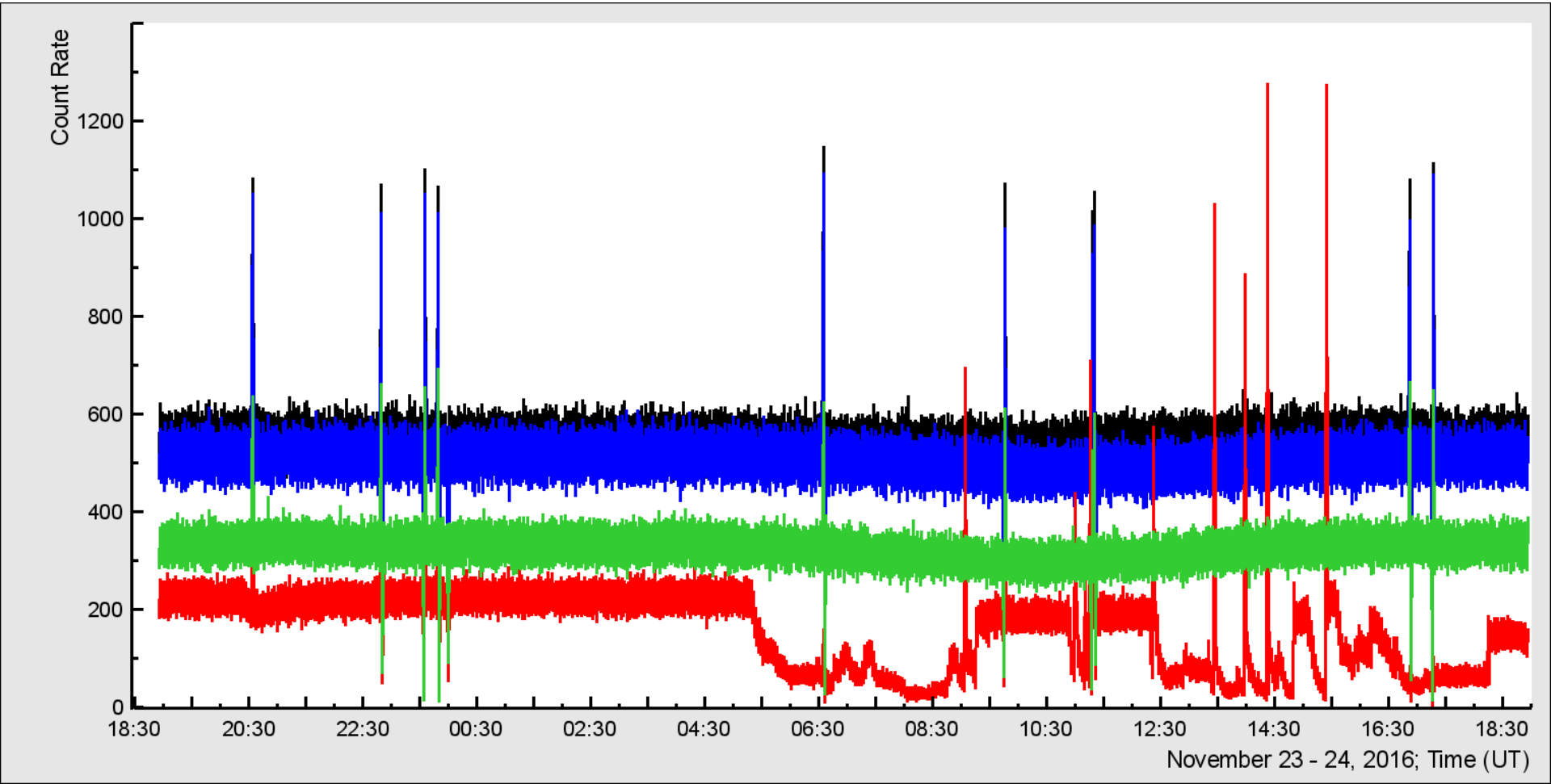
Long lasting TGE; NaI spectrometers N 1 and 2 (energy threshold 0.4 MeV) and 5 (energy threshold 4 MEV)



Long lasting TGE; STAND1 detector signal only in upper scintillator(energy threshold 0.8 MeV) and in 2 upper scintillators (energy threshold 4 MEV)



What happens with STAND1 MAKET?

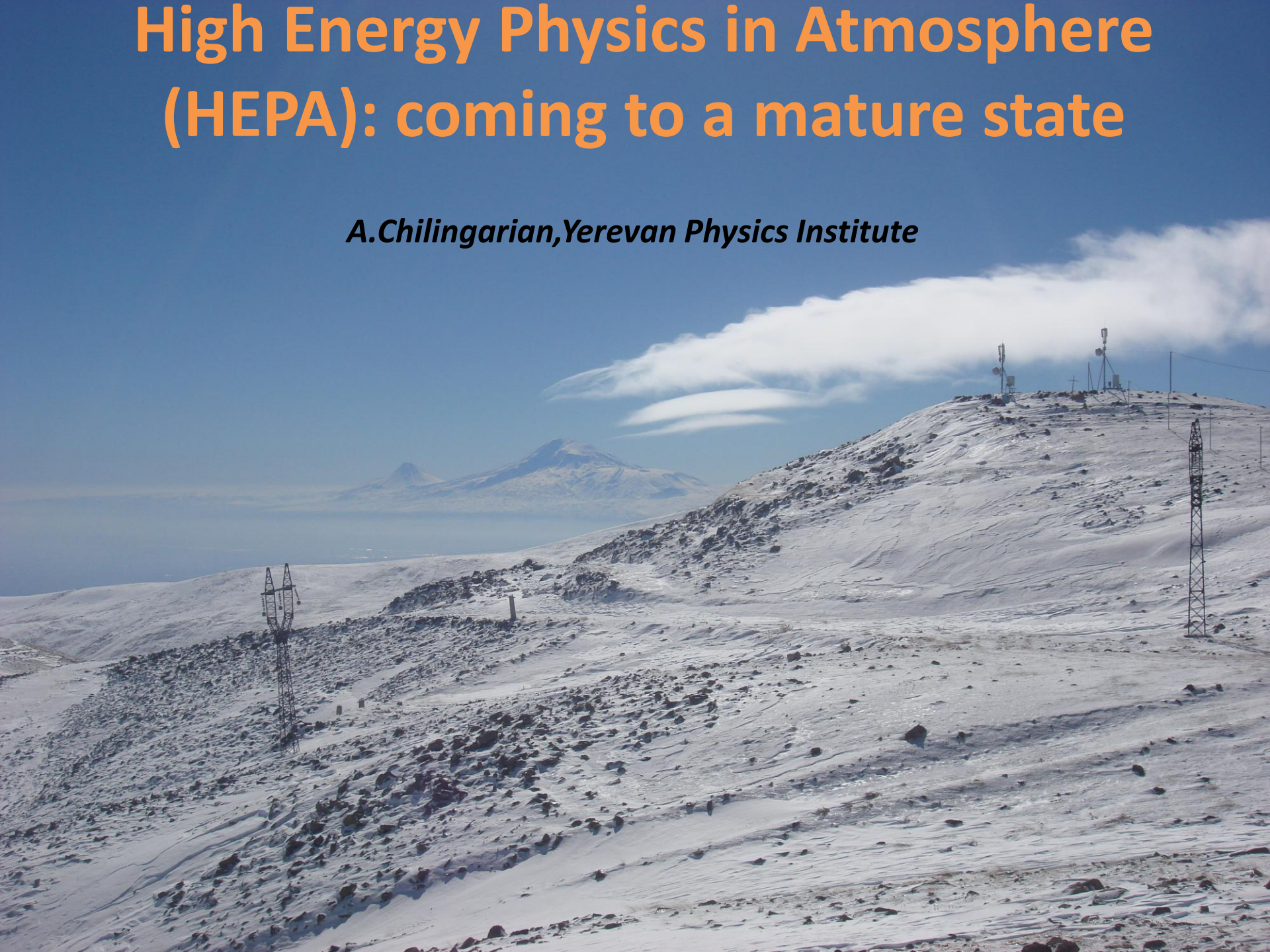


Visit to IKI RAS

- **J.-L. Pinçon** "TARANIS: Mission status and data mission center”
- **A.Chilingarian High Energy Physics in Atmosphere (HEPA): coming to a mature state**
- RNF project: Комплексное исследование механизмов формирования атмосферных источников энергичных частиц и мощного высокочастотного излучения;
- Настоящий проект объединит усилия трёх научных коллективов из России и Армении (ИПФ РАН, ИКИ РАН и ЕрФИ), имеющих большой опыт и возможности для решения сложных задач физики высоких энергий и атмосферного газового разряда;

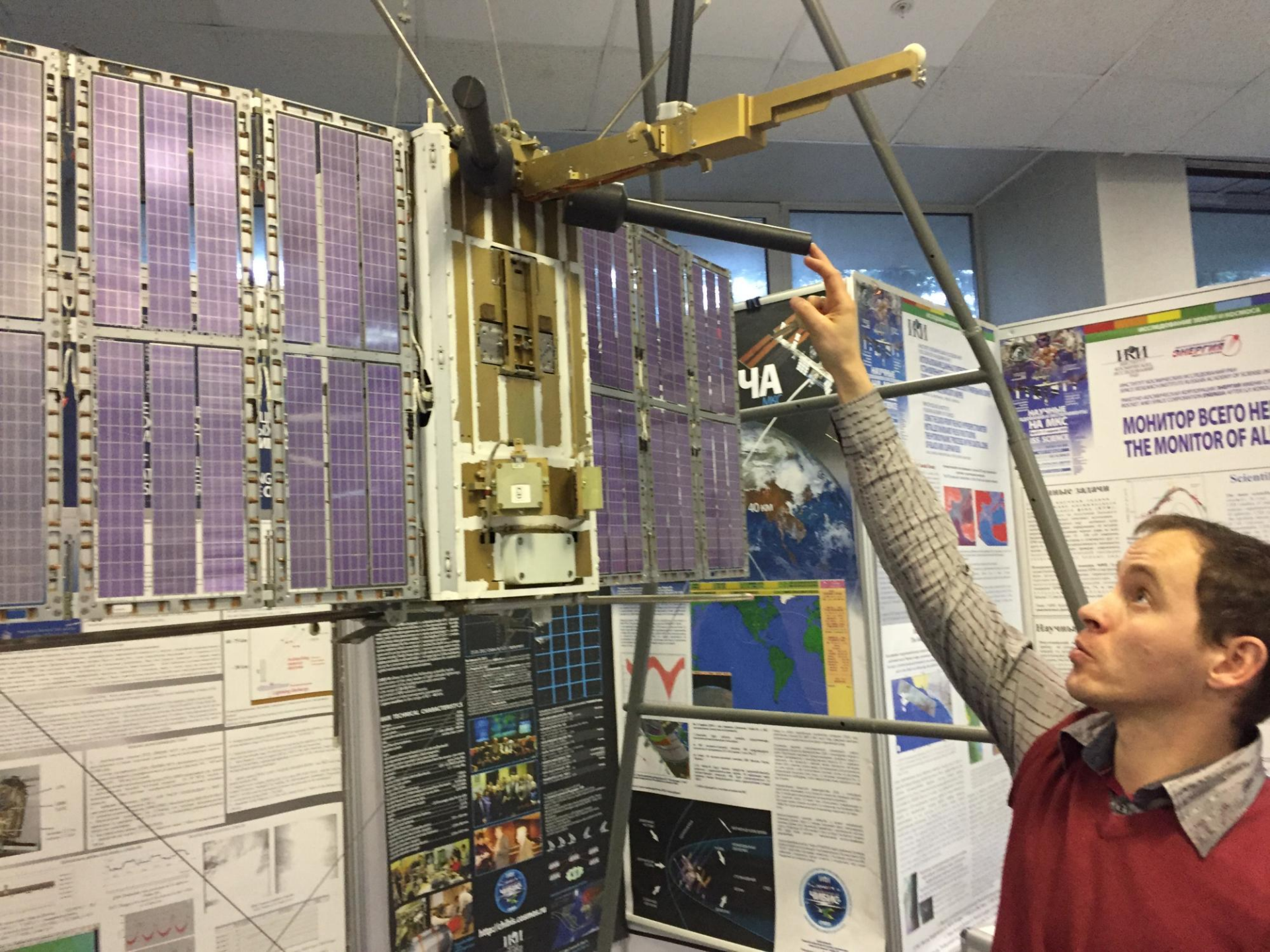
High Energy Physics in Atmosphere (HEPA): coming to a mature state

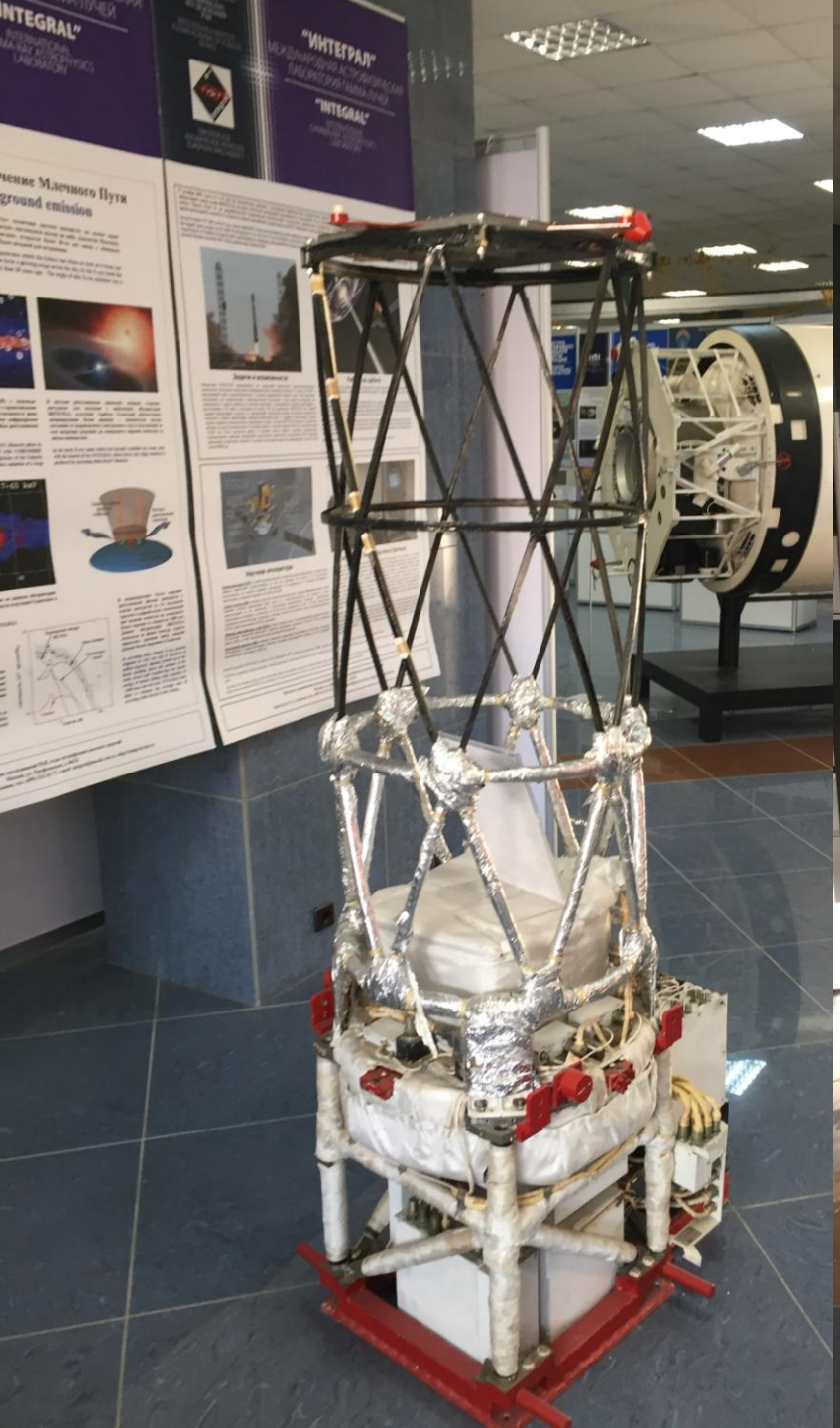
A.Chilingarian,Yerevan Physics Institute



Research of Thunderstorm Ground Enhancements (TGEs)

- **Observations during 2009-2016 of the TGEs and their energy spectra on Aragats as well as detection on the millisecond time scales particle fluxes, lightnings and disturbances of the electrostatic field allows:**
- **To prove the RB Model of Lightning initiation;**
- **Reject hypothesis of the high-energy particle (neutrons and gamma photons) origination in the lightning bolt.**


МОНИТОР ВСЕГО НЕ
THE MONITOR OF AL


"ИНТЕГРАЛ"
"INTEGRAL"


СССР СССР СССР
ИССЛЕДОВАНИЯ ВЕНЕРЫ В ИКИ
INVESTIGATION OF VENUS IN IKI

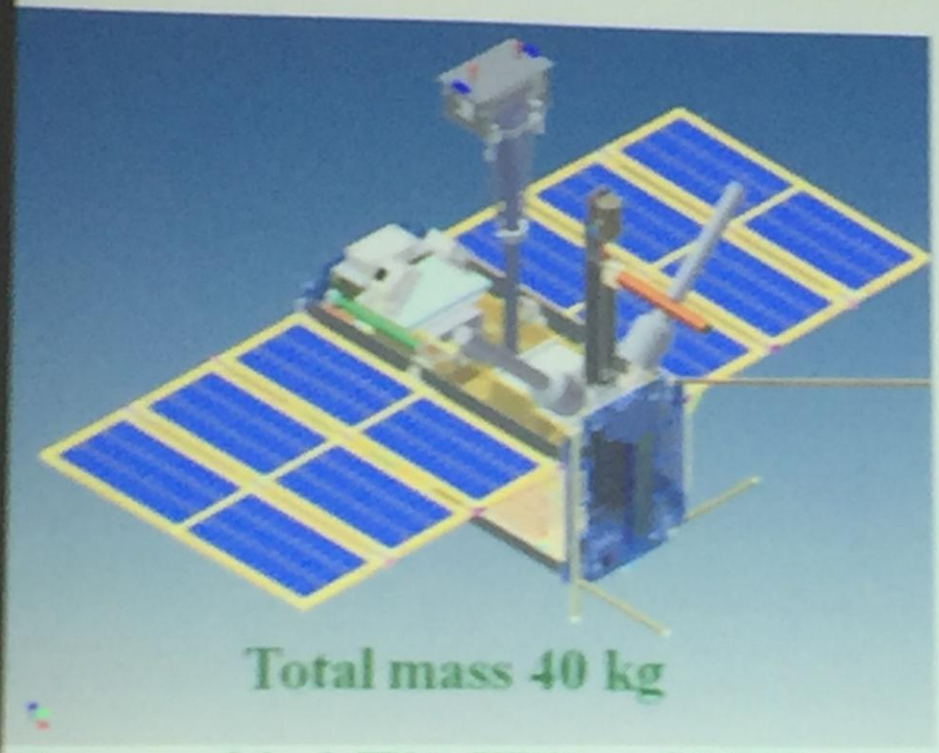

MILESTONES OF THE RUSSIAN
SPACE SCIENCE PROGRAM
FOR THE COMING DECADE
Lev Zelenyi
IKI

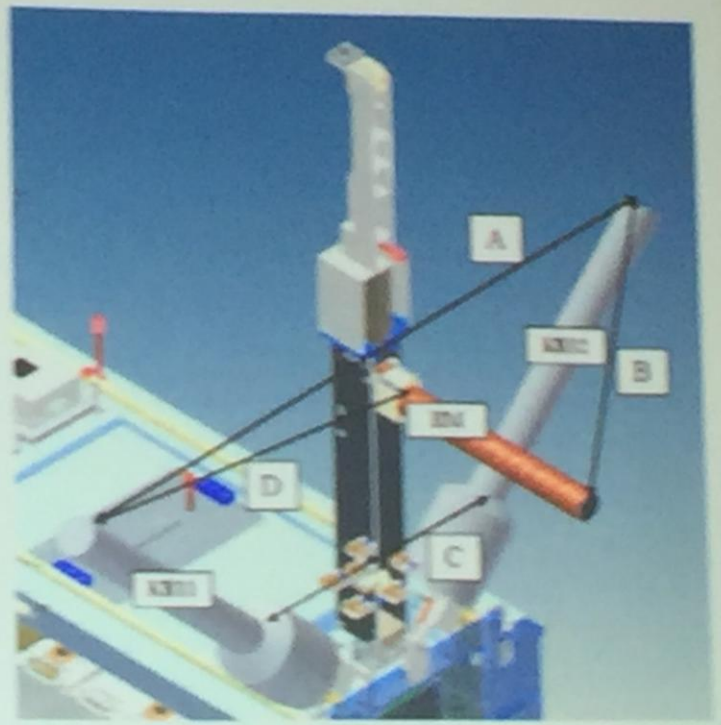
The main results of the VLF/ELF research on micro-satellite "Chibis-M" and parallel experiments.

Micro-satellite "Chibis-M". 2012-2014.

http://chibis.cosmos.ru

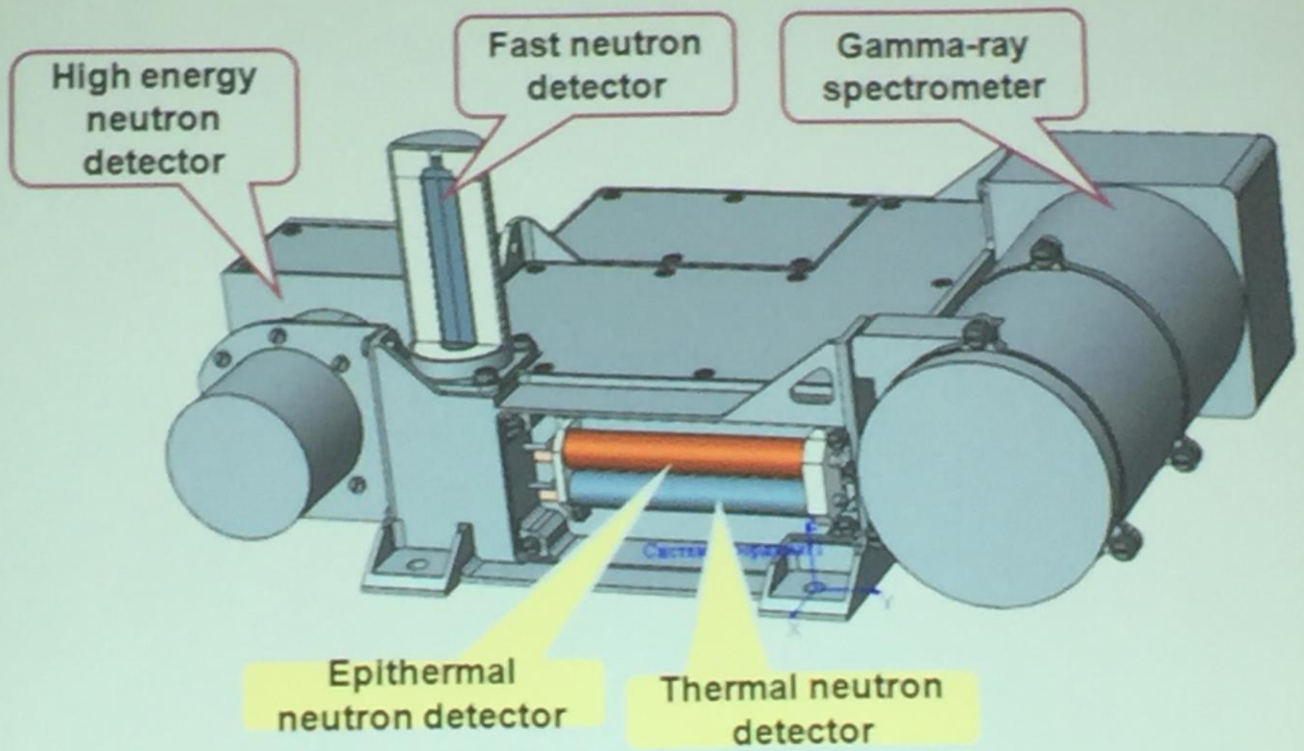
Separation from the Progress raised its orbit altitude and the "Chibis-M" was separated from it and was delivered at the circular orbit 513 km height and 52 deg. inclination.





Sensors of the MWC: KB31 and KB32 – combined wave probes WP (sensor length 245 mm). BM – the induction magnetometer (sensor length 205 mm). Configuration: A = 597 mm; B = 376 mm, C = 250 mm, D = 299 mm

NGS - new gamma-detector

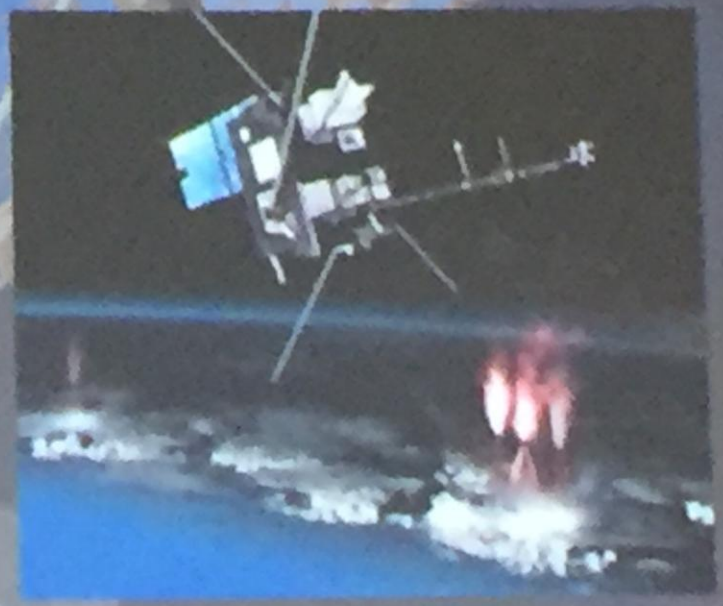


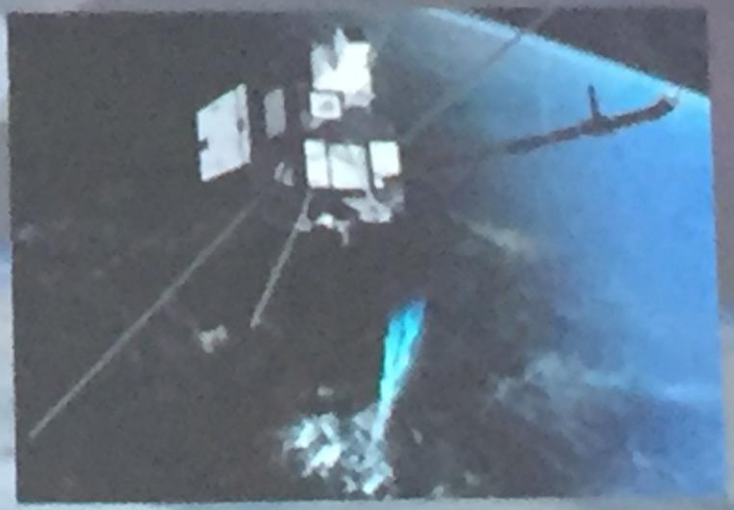
Scientific objectives of TARANIS

- **To advance the physical understanding of the links between TLEs, TGFs and environmental conditions** *(lightning activity, geomagnetic activity, atmosphere/ionosphere coupling, occurrence of Extensive Atmospheric Showers, etc).*

- **To identify all possible signatures associated with these phenomena** *(optical emissions, gamma-rays, electron beams, electromagnetic fields)* **and to provide inputs to test generation mechanisms.**

- **To provide inputs for modeling effects of TLEs, TGFs on the Earth's atmosphere.**





Gamma spectrometer — NGS

Total weight of the science ~ 12 kg

+

Radio frequency analyzer — RFA

+

Comp

=

Science onboard

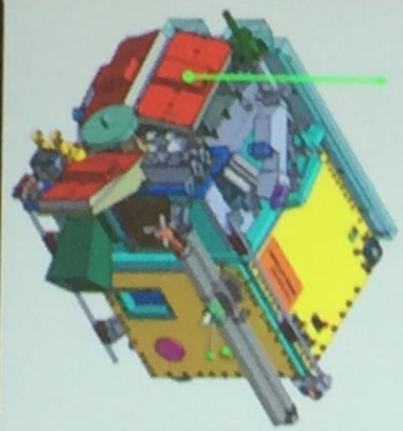
Plasma spectrum analyzer — PSA

+

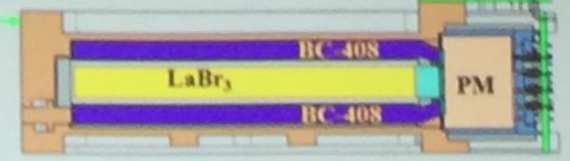
Transmitter — TRANSM

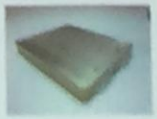
XGRE (PIs : P-L Blelly (IRAP) et F. Lebrun (APC))

Three sensors facing the Earth placed on TARANIS spacecraft with different orientations and one analyzer.



Sandwich : 2 BC-408 + 1 $LaBr_3$





XGRE experiment
- 3 sensors
- Total detection area ~ 850 cm^2

XGRE Sensor
- 4 Detection Units
- ADC converters
  12 bits (LaBr3)
  10 bits (BC408)
- Fast electronics
  dead time = 350 ns

$LaBr_3$ (photons)
- Fast (pulse pile up < 150 ns)
- Good linearity
- Good spectral resolution

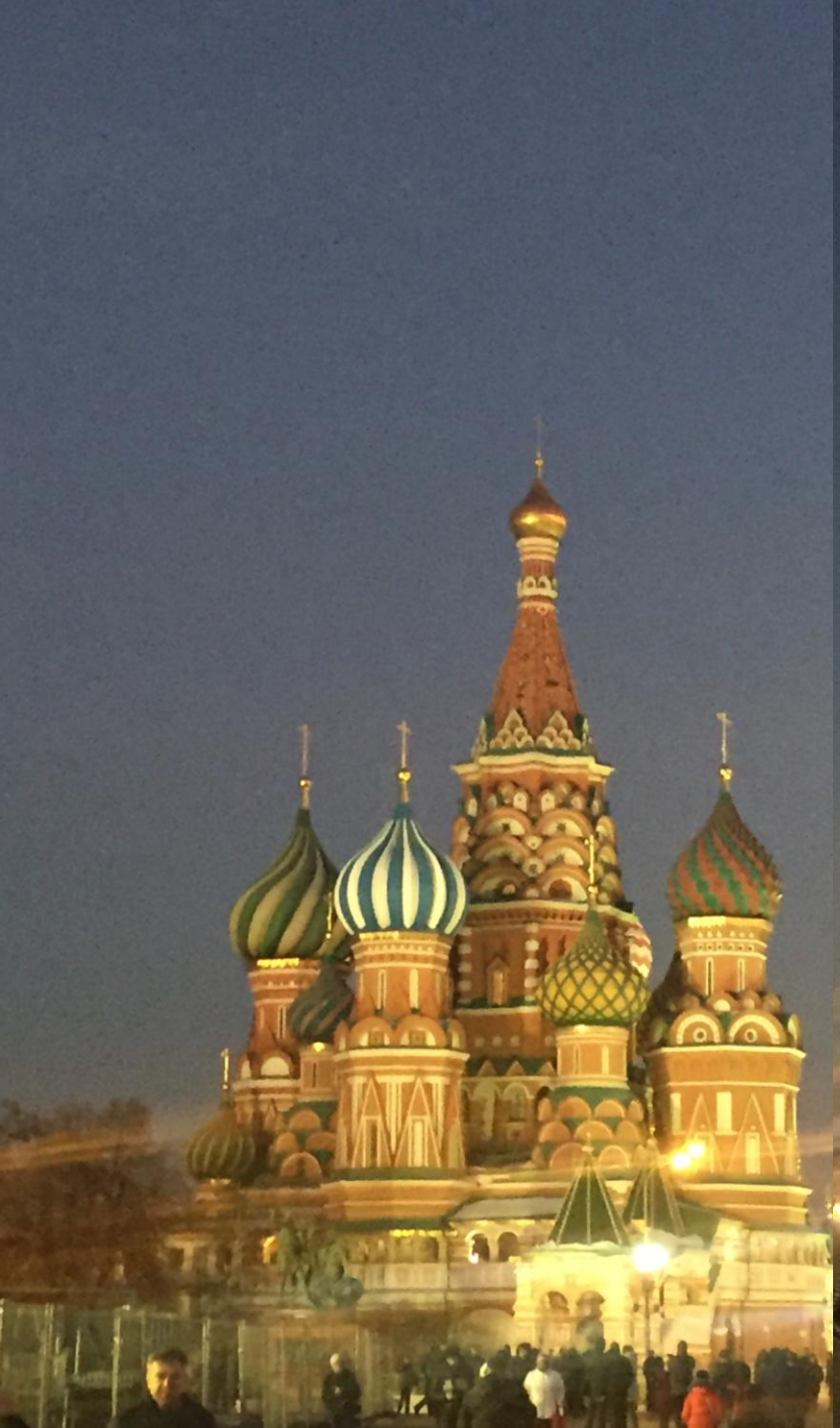
BC-408 (electrons)

Gamma-Rays: energy range [~20 keV – 10 MeV]
(accuracy: 30% at 20 keV ; 10% at 511 keV).

Electrons: energy range [1 MeV – 10 MeV]


10


СЕРГЕЙ
ИВАНОВИЧ
ВАВИЛОВ

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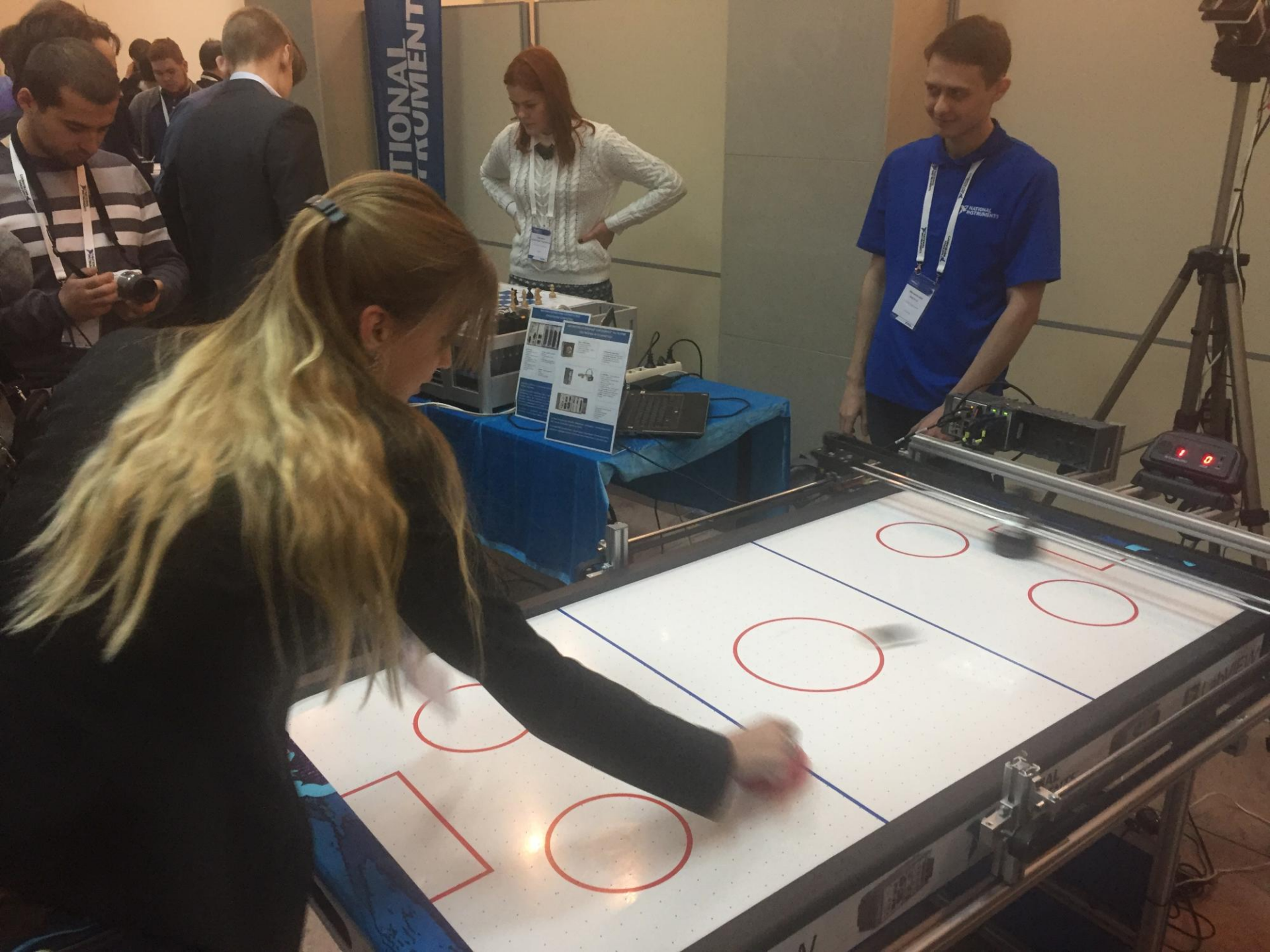
СВЯЩЕННОМУЧЕНИК
ЕРМОГЕН
ПАТРИАРХ
МОСКОВСКИЙ
И
ВСЕЯ РУСИ

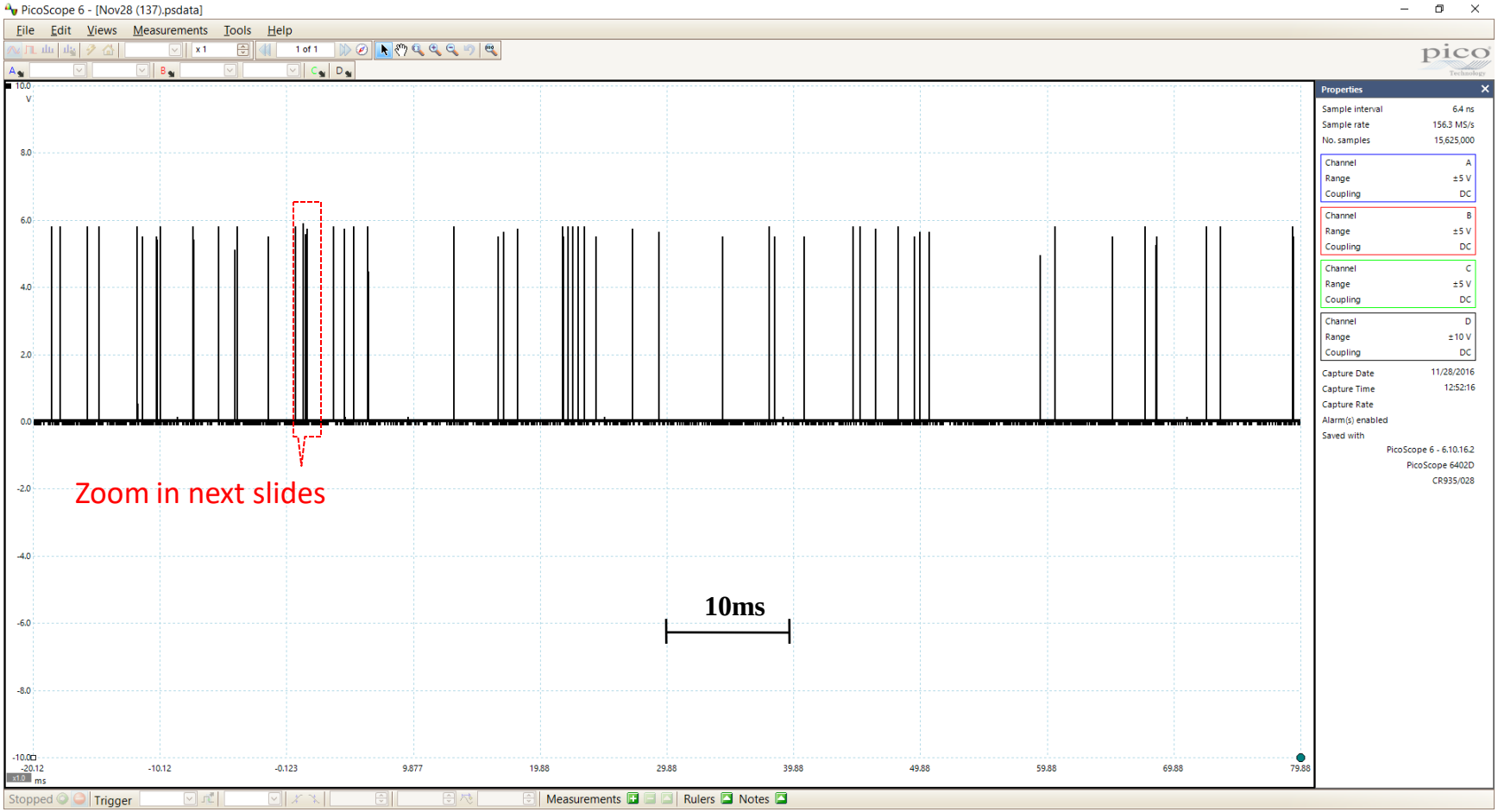

МОСКОВСКИЙ ТЕХНИЧЕСКИЙ УНИВЕРСИ
NATIONAL INSTRUMENTS
LabVIEW
NATIONAL INSTRUMENTS
NIDays - XV ежегодная конференция компании National Instruments
NIDays



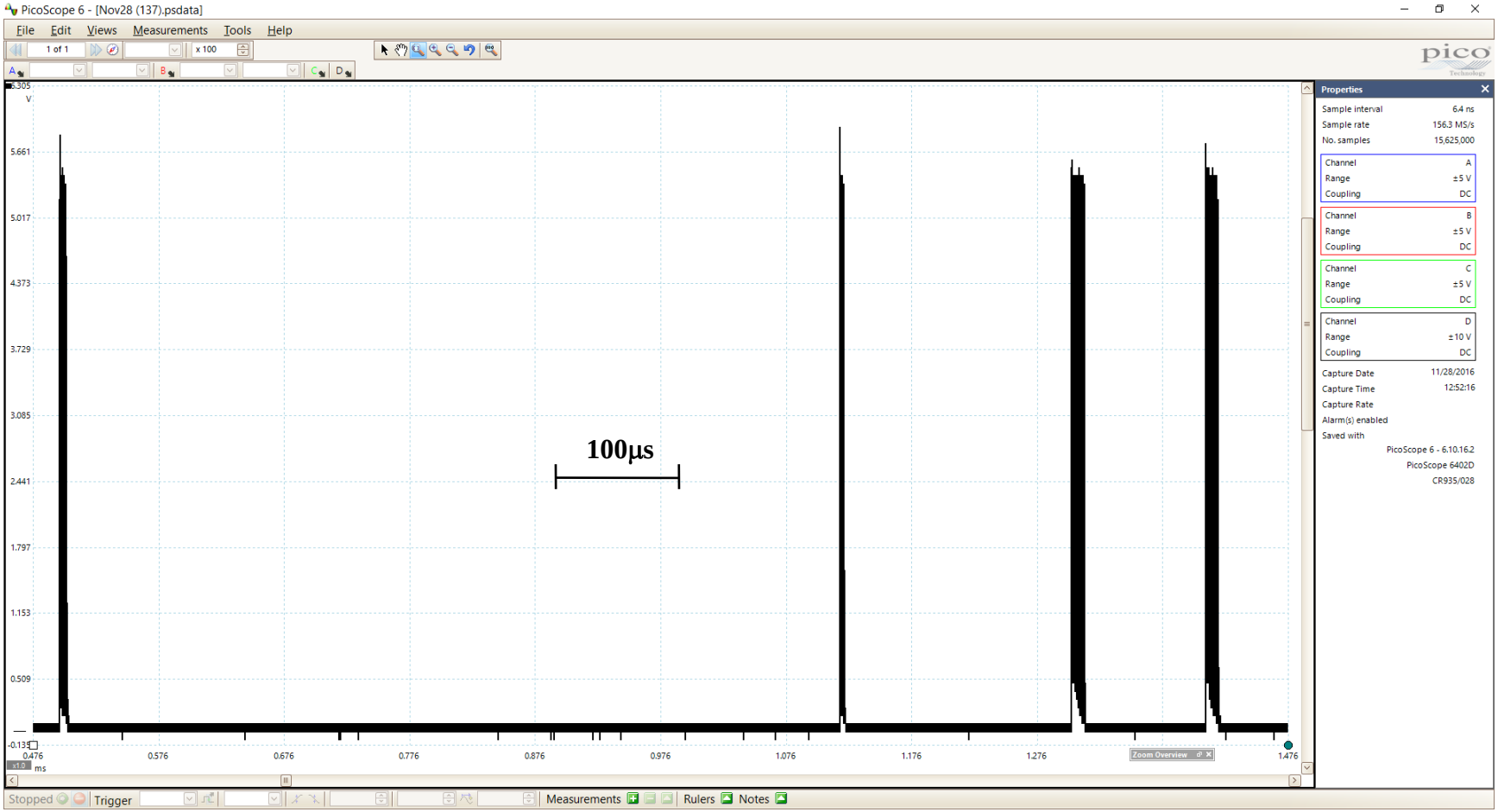
Kolomenskoe; MIFI

Picoscope N4 (HOTEL)
Change of voltage scale in Ch D from 5 to 10V

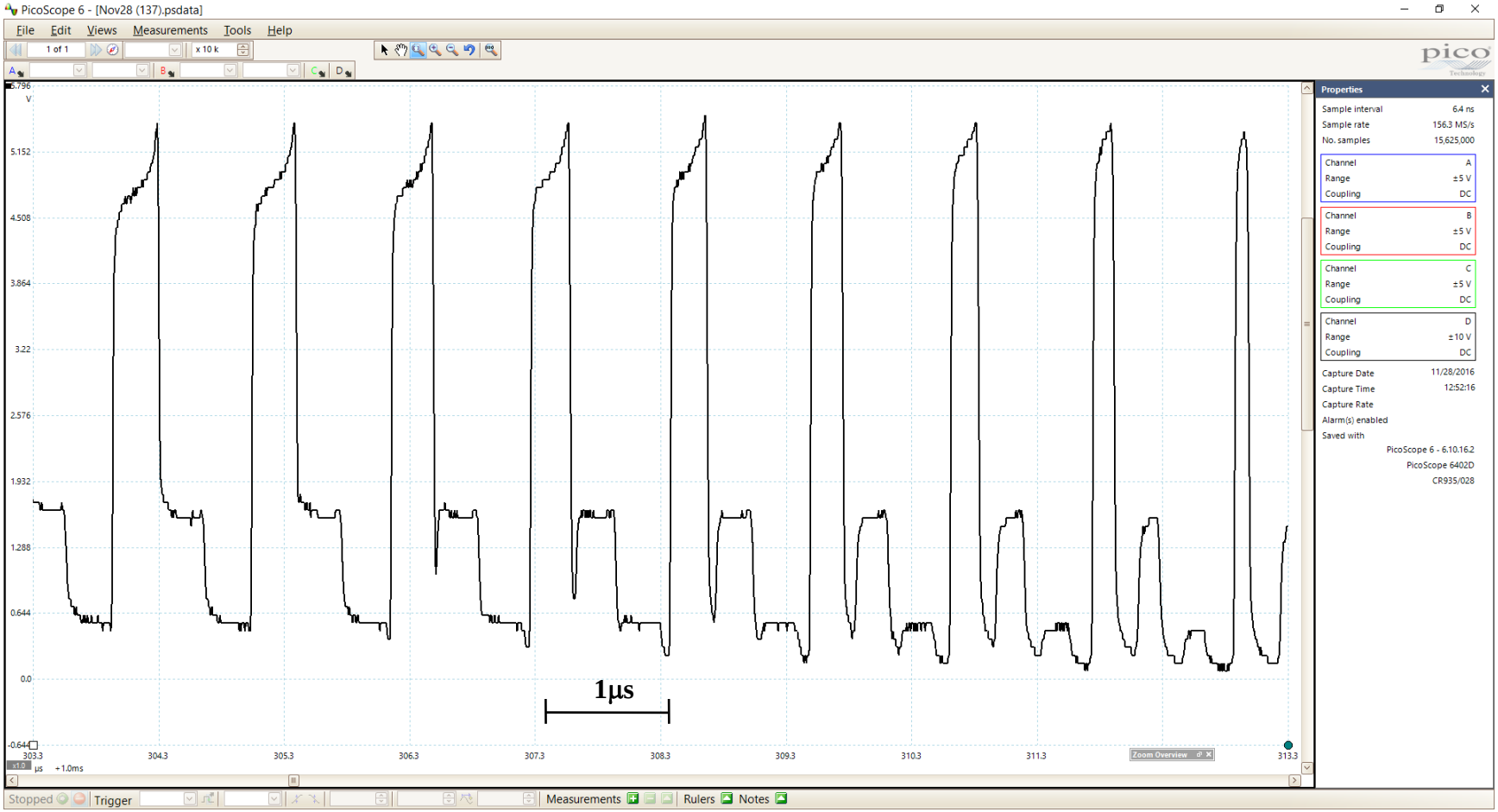
November 28, 2016 Picoscope N4 (HOTEL)
Voltage scale 10V for Ch D



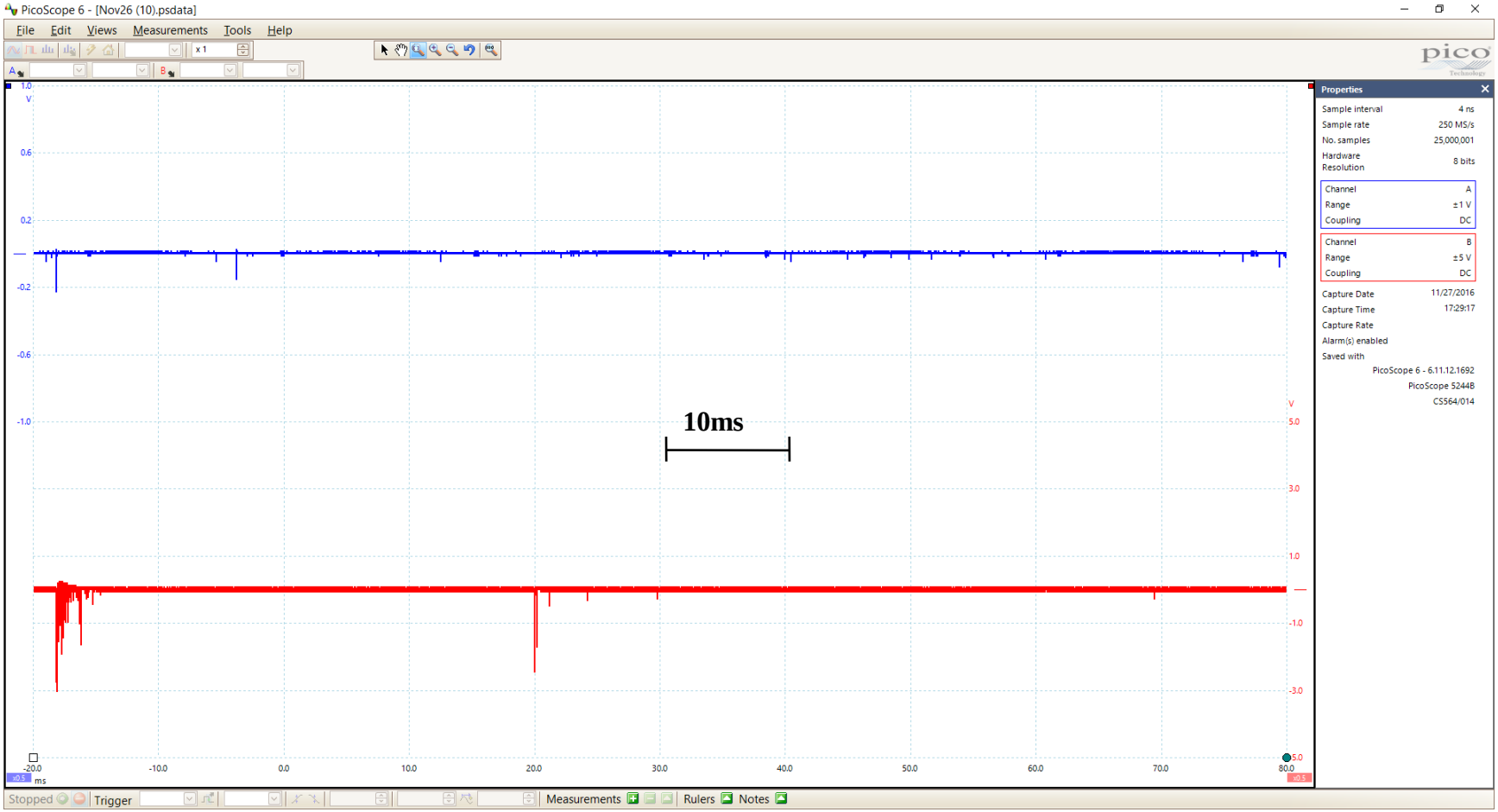
November 28, 2016 Picoscope N4 (HOTEL)
Voltage scale 10V for Ch D



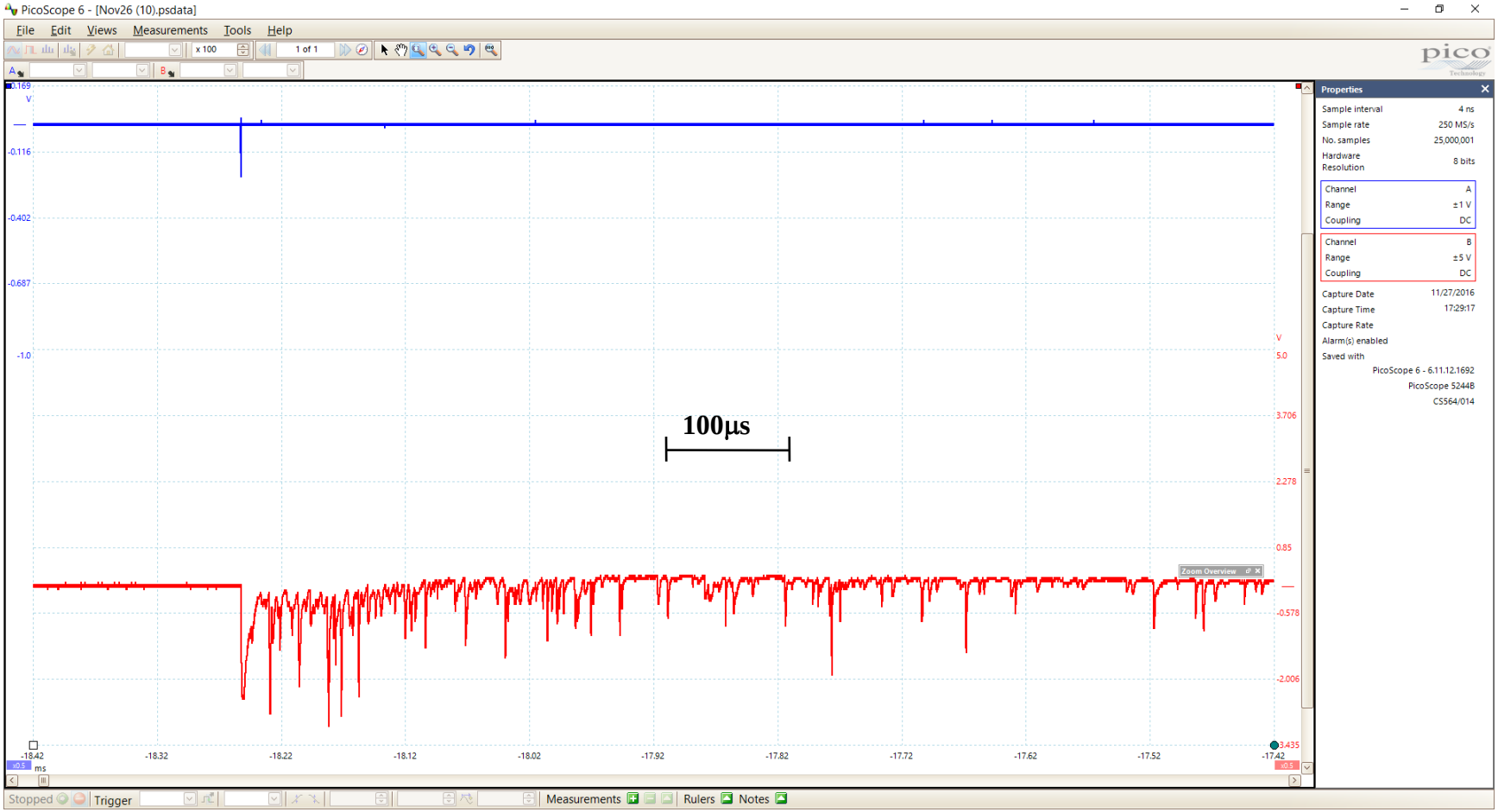
November 28, 2016 Picoscope N4 (HOTEL)
Voltage scale 10V for Ch D



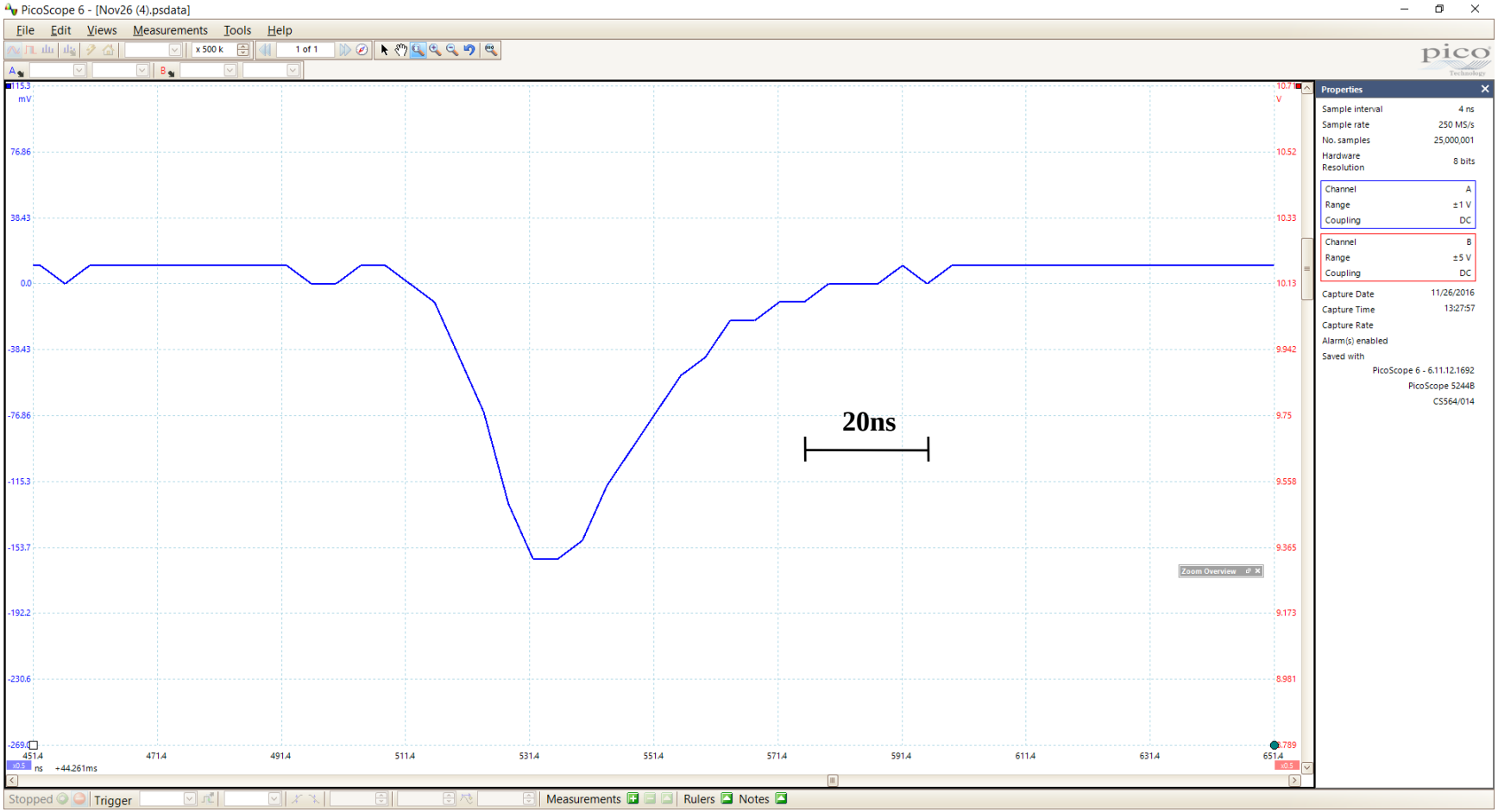
November 27,2016
Picoscope N3 (MAKET)



November 27,2016
Picoscope N3 (MAKET)



November 26,2016
Picoscope N3 (MAKET)
Ch A



November 27,2016
Picoscope N3 (MAKET)
Ch A