Estimation of volumetric activity of Radon (^{222}Rn) at Aragats outdoors and indoors (SKL) using the intensity of the Bi214 line (609 keV)

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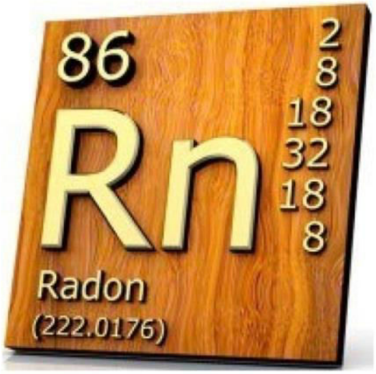
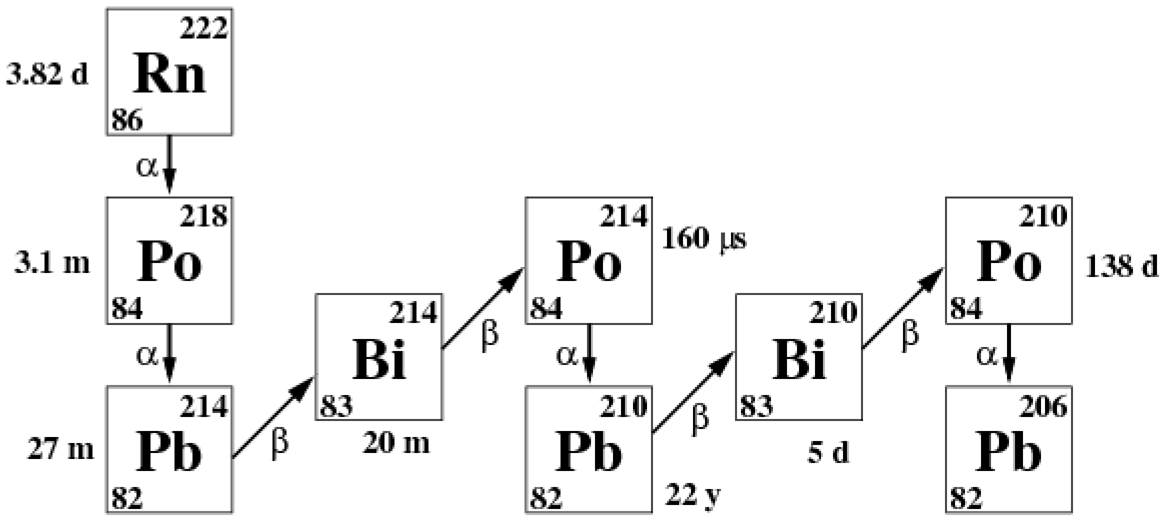
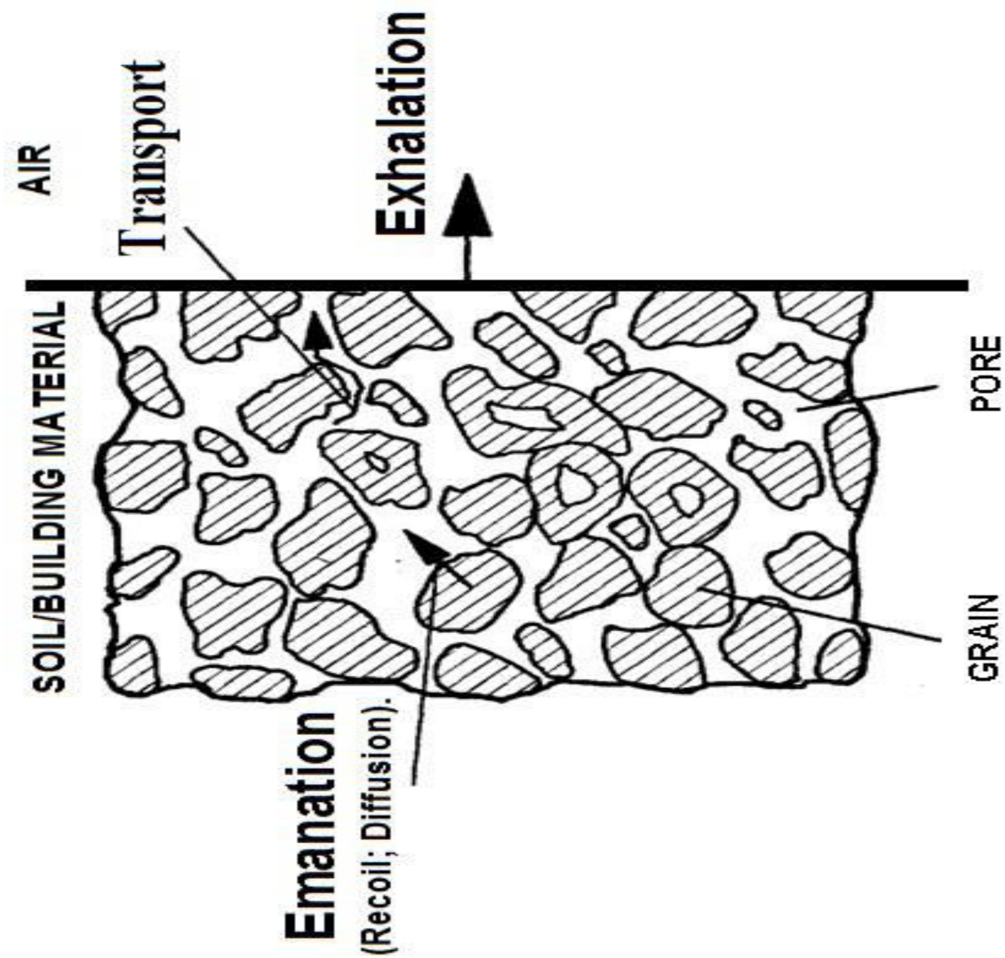
1. All daughter nuclides of radon-222 are either positively charged or neutral and cannot significantly rise into the upper atmosphere under conditions of alternating electric fields.
2. On the other hand, exponential results show that growth of the gamma photons independent of the polarity of the alternating (perturbed) electric field.
3. as shown by mathematical calculations, the transfer of nuclides from the lower layers to the upper layers leads to a decrease in the count of gamma photons.

The excess of gamma photons can apparently be explained by a change in meteorological conditions



222Rn α	→	218Po α	→	214Pb β,γ	→	214Bi β,γ
3,82 d.		3,11 min.		26,8 min.		19,8 min
Neutral		+		+		+


222
Rn
86
3.82 d
α
218
Po
84
3.1 m
α
214
Pb
82
27 m
β
214
Bi
83
20 m
β
214
Po
84
160 μs
α
210
Pb
82
22 y
β
210
Bi
83
5 d
β
210
Po
84
138 d
α
206
Pb
82



Exhalation Rate---[Bq m-2.s-1] ;

Volumetric activity in the Atmosphere--------[Bq m-3].

The average exhalation rate of radon from the ground is 5–50 mBq/m^{2}s, leading to a near ground level radon concentration of 1–10 Bq/m^3, but varies widely with ground conditions

Concentrations of radon in the outdoor environment are affected by exhalation rates from the ground and atmospheric mixing phenomena. In turbulent conditions -turbulent mixing. Stable atmospheric stratification (temperature inversions), such as typically occur in daytime, much more vertical mixing occurs than at night, when inversions can trap radon close to the ground. This means that outdoor radon concentrations can vary diurnally by more than a factor of ten. There are also seasonal variations, related to the effects of precipitation, or to changes in prevailing winds. Typical long-term average outdoor radon concentrations are about 10 Bq/m^3 each for radon-222 and radon-220. However, long-term average concentrations of radon-222 vary from approximately 1 to more than 100 Bq/m^3, with the former typical of isolated small islands and the latter typical of sites with high radon exhalation rates over large areas.

. Moreover, progeny concentrations are affected by the depletion due to fallout, washout, rainout, and other scavenging effects. It is known that the physical processes mentioned above are dependent on certain meteorological parameters specific to the planetary boundary layer: air temperature, soil temperature, atmospheric pressure, wind speed, precipitations and relative humidity.

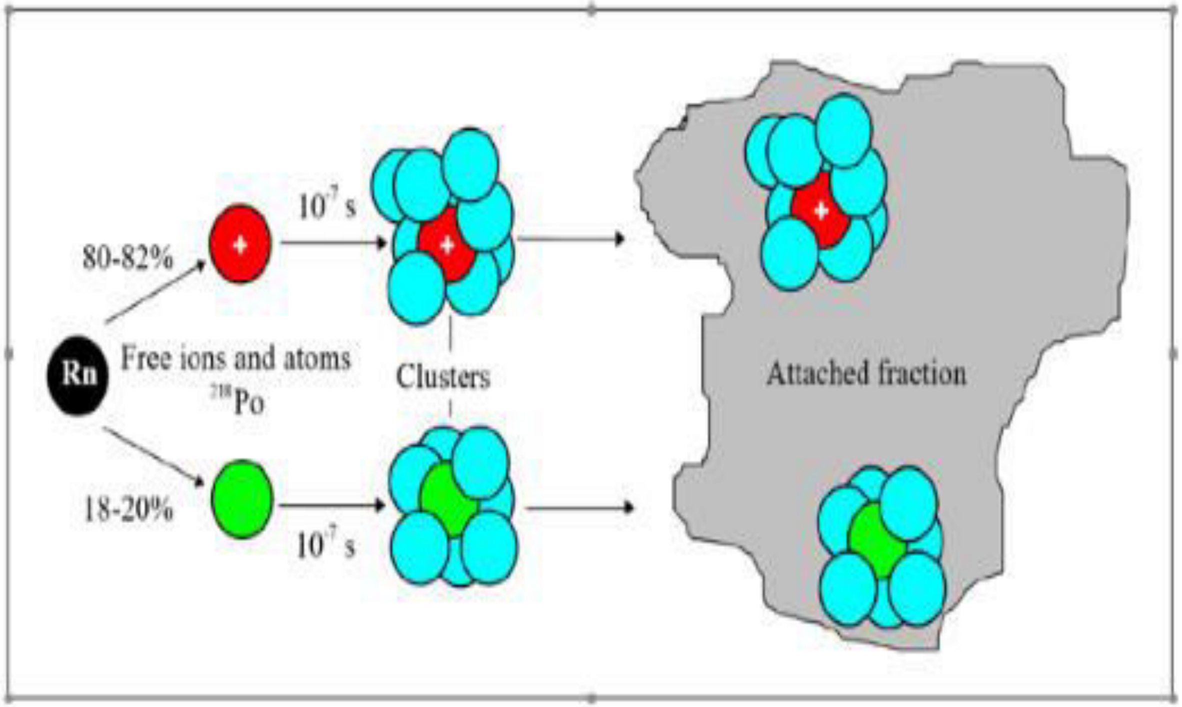


Fig. 1. Basic processes of radon decay product behaviour in air defining the concept of "unattached" and "attached" fractions [1]

[1] J.Porstendörfer,Properties and behavior of radon and thoron and their decay products in the air. J. Aerosol Sci. 25(1994)

Secular equillibrium

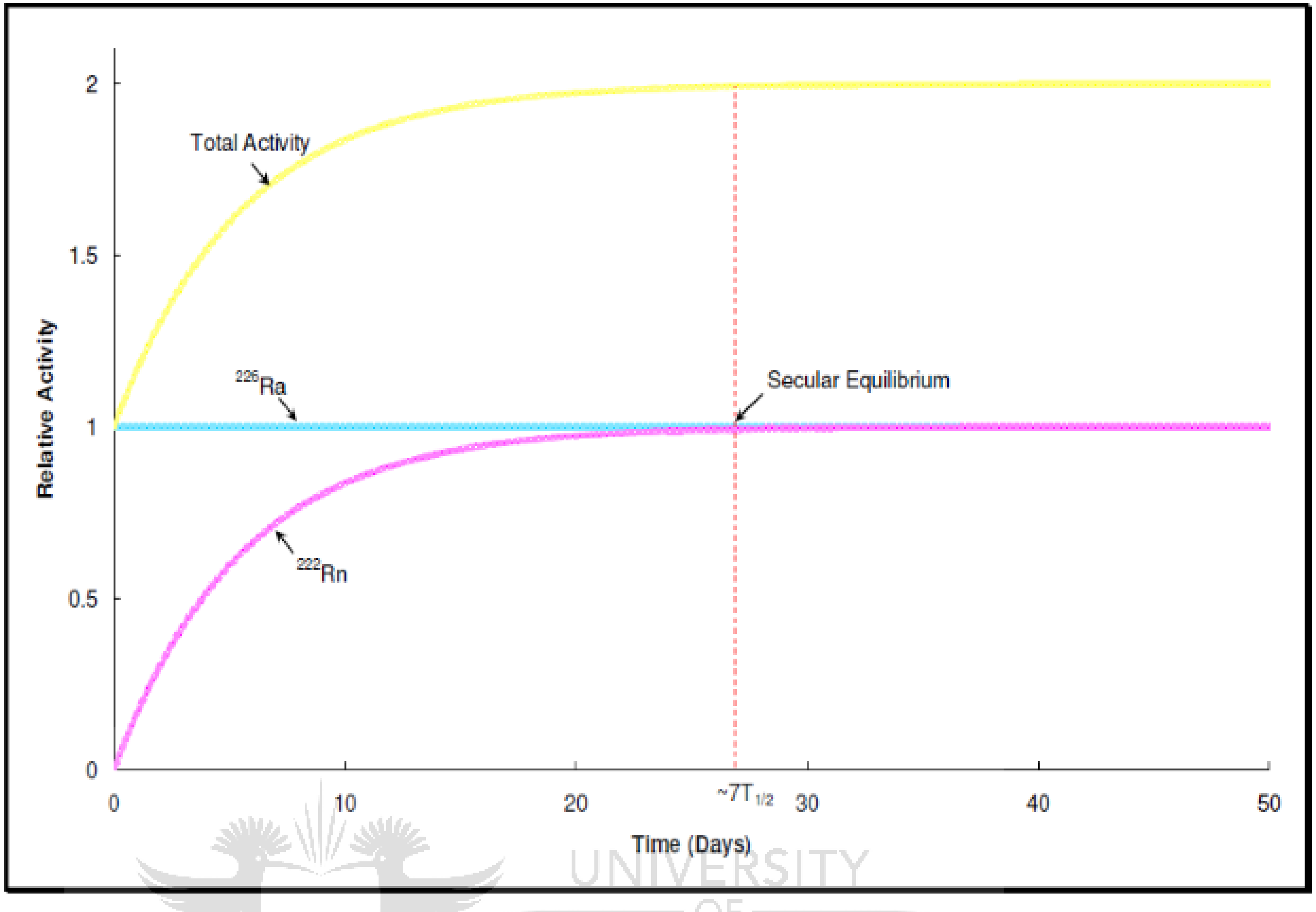


Figure 2.2 Secular equillibrium between 226Ra and its daughter, 222Rn

Transient equilibrium

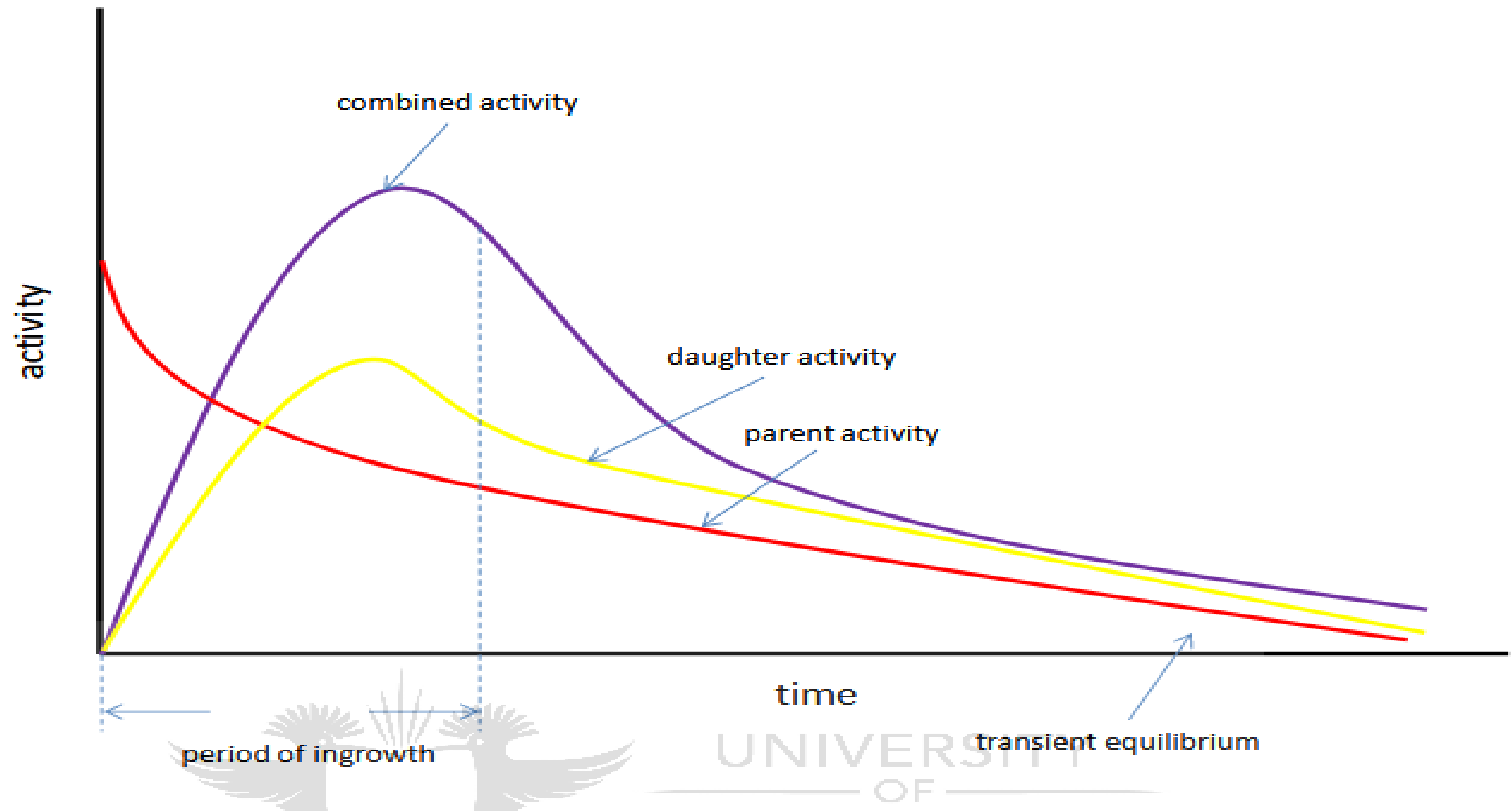


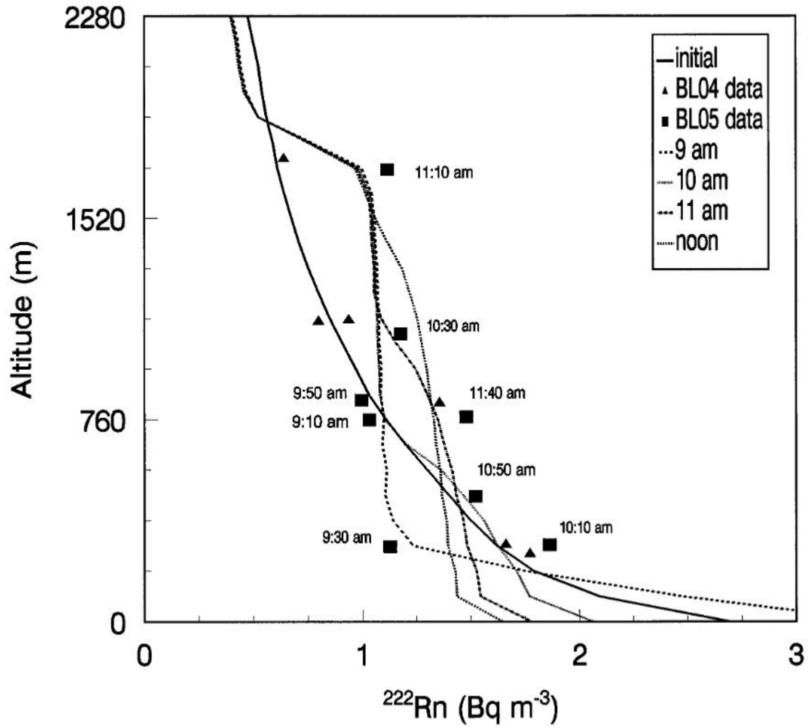
Figure 2.3 An illustration of transient equilibrium.

As time progresses, the parent, daughter and (parent + daughter) activities can be characterized by essentially the same decay constant (this is evident from Equation 2.16for $t \rightarrow \infty$), as illustrated inFigure2.3. [The Accurate…]

H, м	^{222}Rn, %	H, м	^{220}Th, %
0,01	100	0	100
1,00	95	5	70
10,0	87	10	50
100	69	25	20
1000	38	50	5

Табл. 6. Изменение концентрации радона и торона с высото

^{222}Rn		^{220}Rn	
Высота, м	Содержание, %	Высота, м	Содержание, %
0,01	100	0	100
1	95	5	70
10	87	10	50
100	69	25	20
1000	38	50	5
[illegible]	7	100	0,5



Based on the above data take approximately

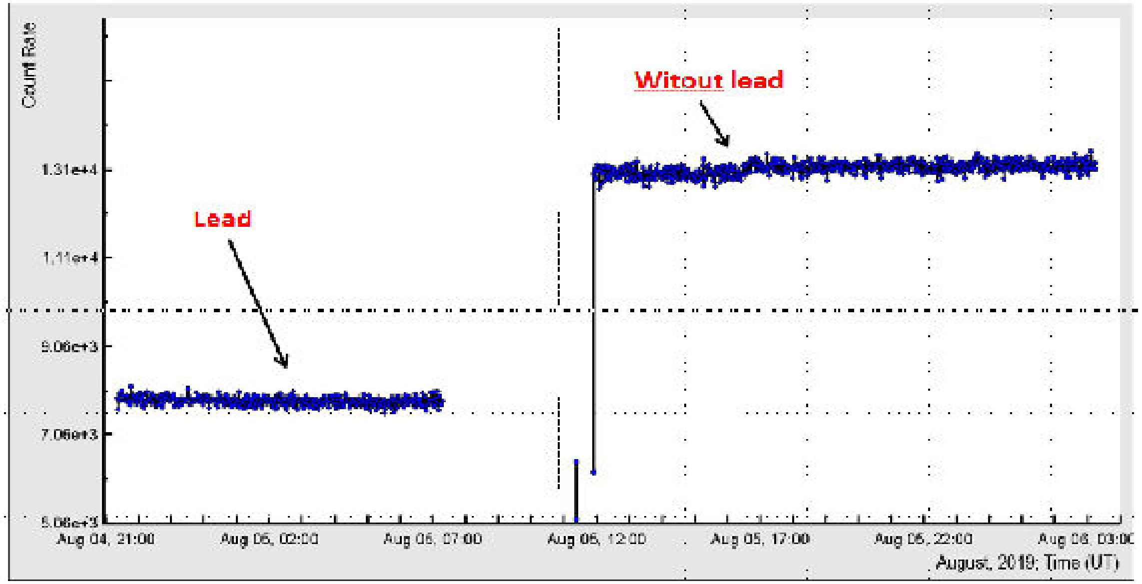
$A(h)=A_0 e^{-\lambda h}$;

wher-A_0-*Volumetric Activity of* ^{222}Rn

at surface layer;

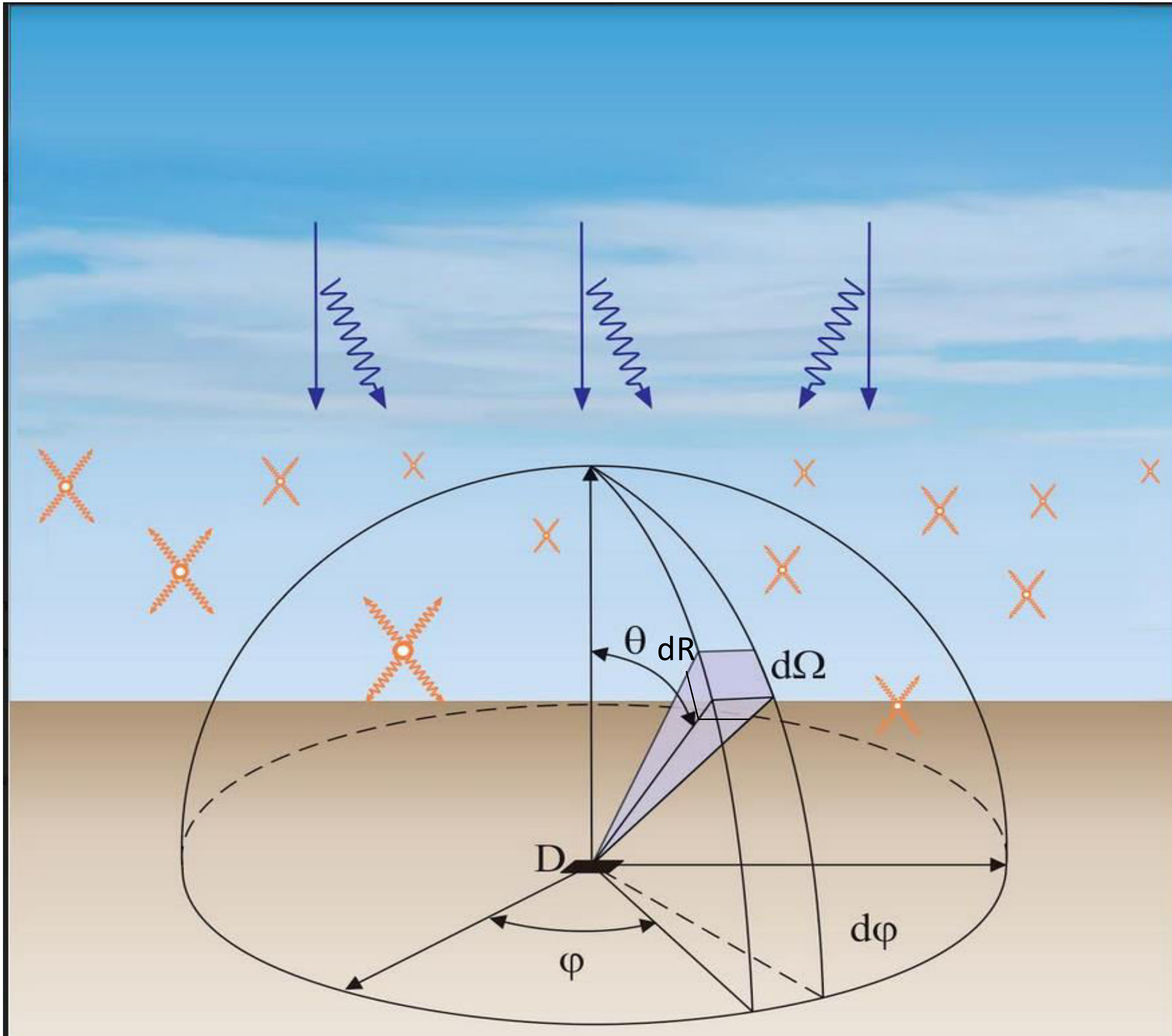
$\lambda = 0.0015\ m^{-1}$;

Det. ORTEC NaI(Tl)



Tab. 05 August 2019 det. ORTEC NaI(Tl) 1h

	Without lead	Lead	Difference	%
0.26 -10 MeV	779110	467282	311828	40
0.33 -0.38 MeV	23613	11898	11715	49,6
0.56 -0.66 MeV	26007	14193	11814	45,4
1 -1.2 MeV	5790	3216	2574	44,5
1.34 - 1.57 MeV	17387	9868	7519	43,2
1.62 - 1.9 MeV	2216	1046	1170	52,8


θ
dR
dΩ
D
φ
dφ

Direct measurement of the concentrations of all short-lived decay products of222Rn and220Rn are difficult and limited. They are estimated from considerations of equilibrium (or disequilibrium) between these nuclides and their respective decay products

By integrating in spherical coordinates and by taking into account the azimuthal symmetry of the model, the Count Rate (I) 609keV photons emitted by atmospheric 214Bi and registered by the NaI(ORTEC) is given by the following equation:

By integrating in spherical coordinates and by taking into account the azimuthal symmetry of the model, the Count Rate (*I*) 609keV photons emitted by atmospheric 214Bi and registered by the NaI(ORTEC) is given by the following equation:

$$I=\frac{1}{4\pi}K\,A_0\,S\int_{\varphi=0}^{2\pi}\int_{\theta=0}^{\pi/2}\int_{R=1}^{Rm}e^{-\lambda R\cos\theta}e^{-\mu R}\sin\theta\,dR\,d\theta\,d\varphi;$$

Where: *I-is Count Rate* $[s^{-1}]$;

$K=K_{eff}K_p$;

K_{eff}-- *intr. eff.ORTEC at609keV(*^{214}Bi)

K_p --relative intensity of 609keV;

A_0 – *Volumetric Activity of* ^{222}Rn *[Bq/*m^3*],* at ground level

S- Detector area $[m^2]$;

R- Distance [m];

μ- Attenuation coefficient for dry air $[m^{-1}]$;

λ- Height Attenuation coefficient $[m^{-1}]$;

θ- Zenith Angle; *φ-* Azimuth angle;

For:

$K = K_{eff} K_p = 0.38 x 0.47$;

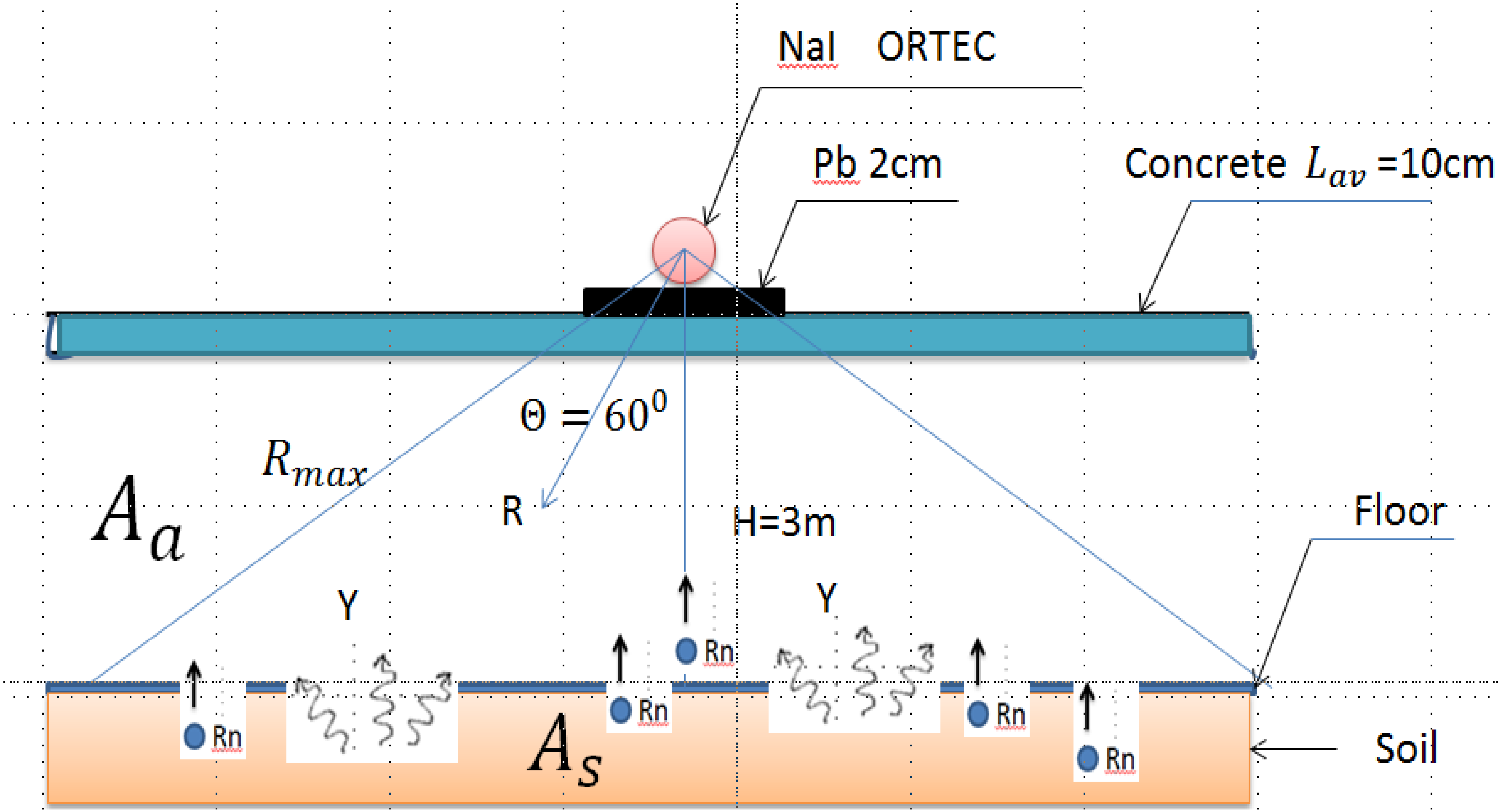
S(ORTEC)= 0.005 m^2;

μ=0.0696 m^{-1};

λ =0.0015 m^{-1};

I= 14193h^{-1}= 3.94c^{-1}. We get:

$$A_0 = 72\ Bq/m^3.$$



NaI ORTEC
Pb 2cm
Concrete L_{av} =10cm
$\Theta = 60^0$
R_{max}
R
H=3m
Floor
A_a
Y
Y
Rn
Rn
Rn
Rn
Rn
A_s
Soil

Typical radon emanation rates from the earth's surface:

-2 * 10-4 Bq / m2s for rocks,
-(8-21) * 10-3 Bq / m2s for mountain soils,
-(4-50) * 10-3 Bq / m2s for ??soils,
-(5-38) * 10-3 Bq / m2s for desert soils (21-53) * 10-3 Bq / -m2s for black soils.
-In areas with anomalous geology and geochemistry of underlying rocks, the rate of radon exhalation reaches 5.25 * 102 Bq / m2s.
Weighted average over the area of the earth exhalation rate of radon 1.6 * 10-2 Bq / m2s

The content of radon in soil air varies from 2.6 * 103 to 4.4 * 104 Bq / m3

The Russia measurements -In general, the values of ^{222}Rn in the surface layer of the atmosphere, over the territory of Russia, vary from 0.5 to 75 Bq / m3

- Rn flux from the soil --- 0.014 to 0.097 Bq / m2s with maximum values in the mountainous regions of the Urals, Southern Siberia and the Far East. average value is 0.040 Bq / m2s .The measurements were taken from a mobile laboratory which was part of a passenger train moving along the Trans-Siberian Railway from Moscow to Vladivostok.

Based on the above data for our calculations, select-A_s= 44 kBq/m2.

For:

$K = K_{eff} K_p = 0.38x0.47$;

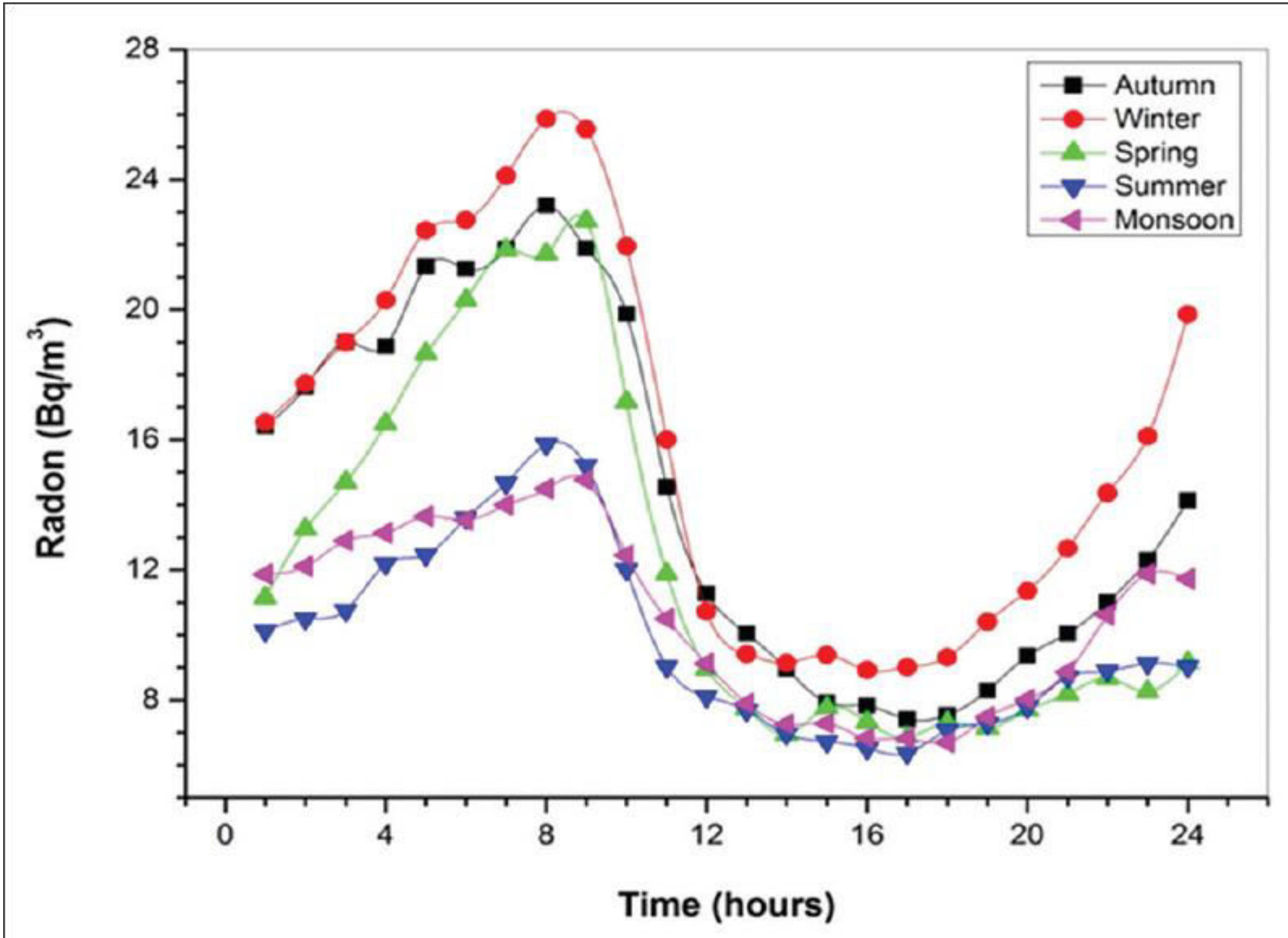
S(ORTEC)= 0.005 m^2;

μ(ordinary concrete) =0.08236cm^2/g;---0.16472cm^{-1};

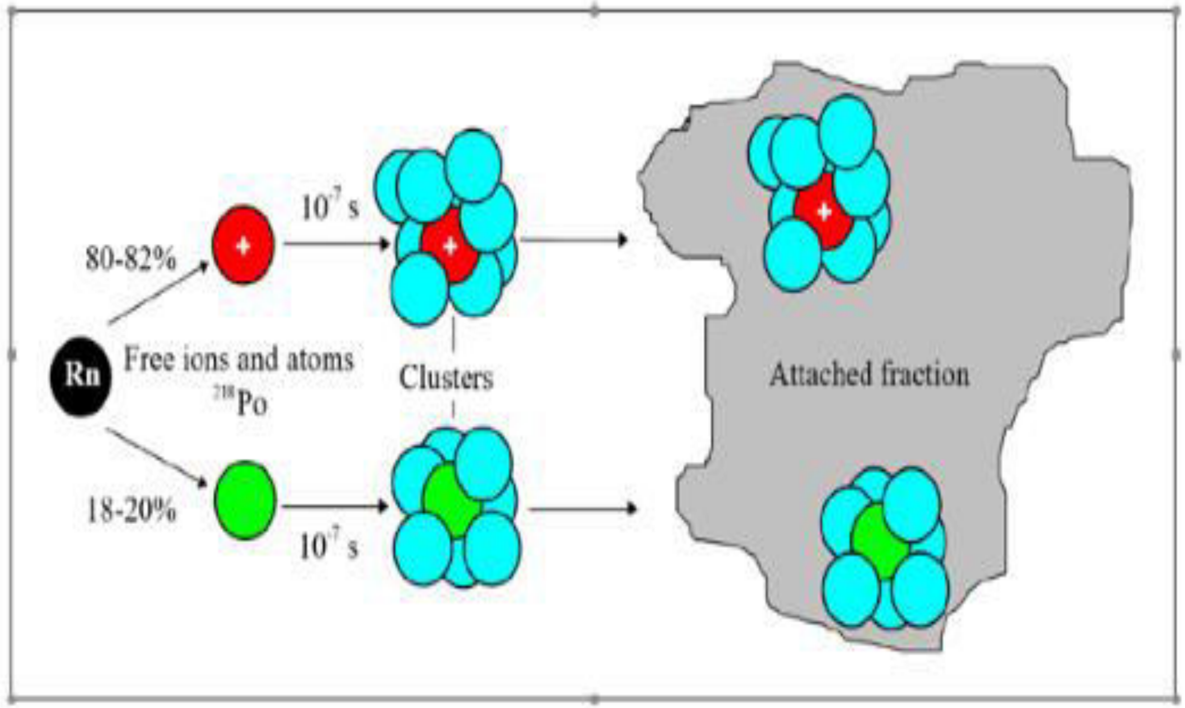
A_a=72Bq/m^3;

A_s=44kBq/m^3. We get:

1)-I=20 h^{-1}; 2)-I=9442 h^{-1} .(By ORTEC=11814 h^{-1}).



Radon (Bq/m^3)
Time (hours)
Autumn
Winter
Spring
Summer
Monsoon
28
24
20
16
12
8
0
4
8
12
16
20
24



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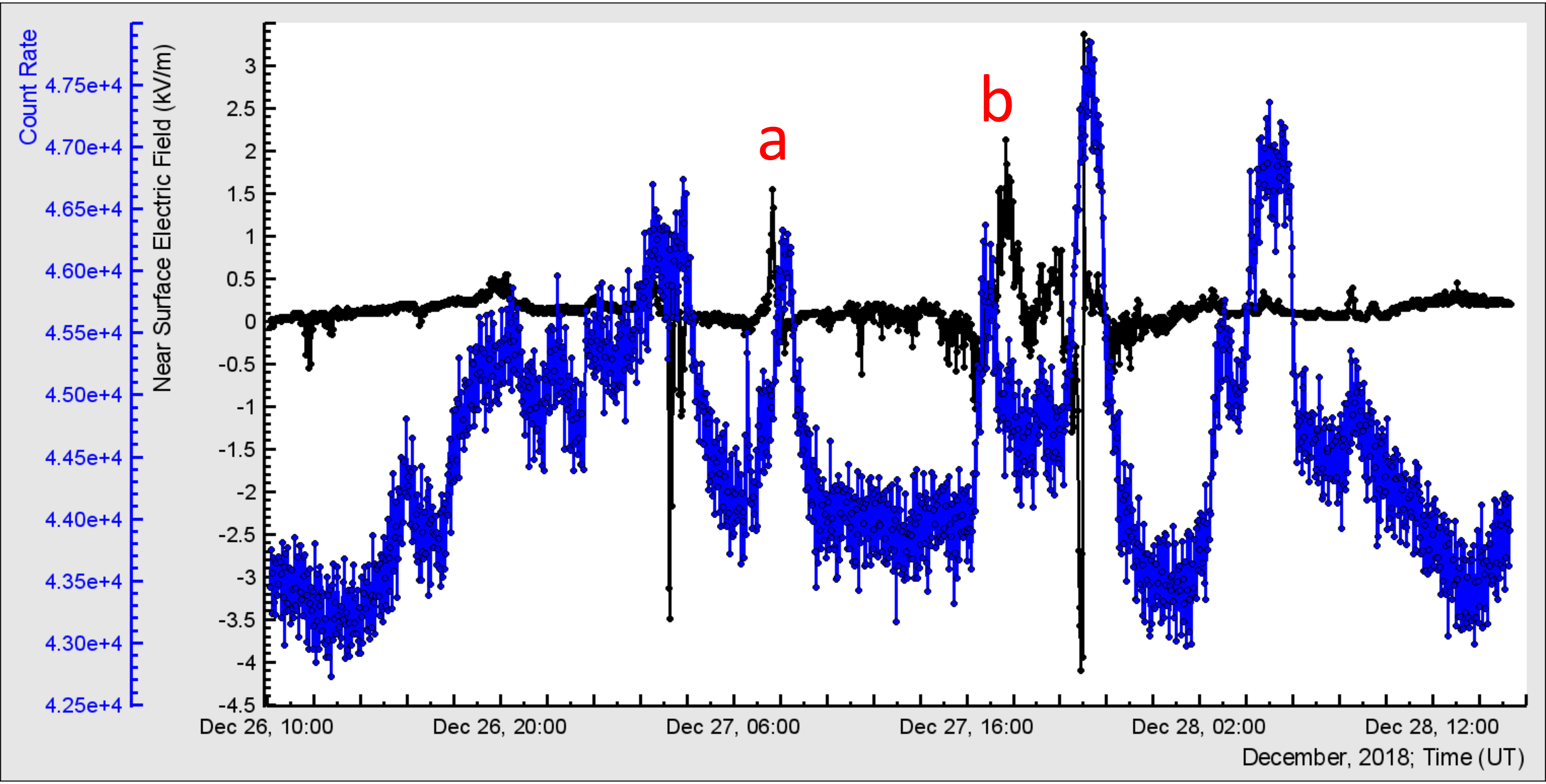
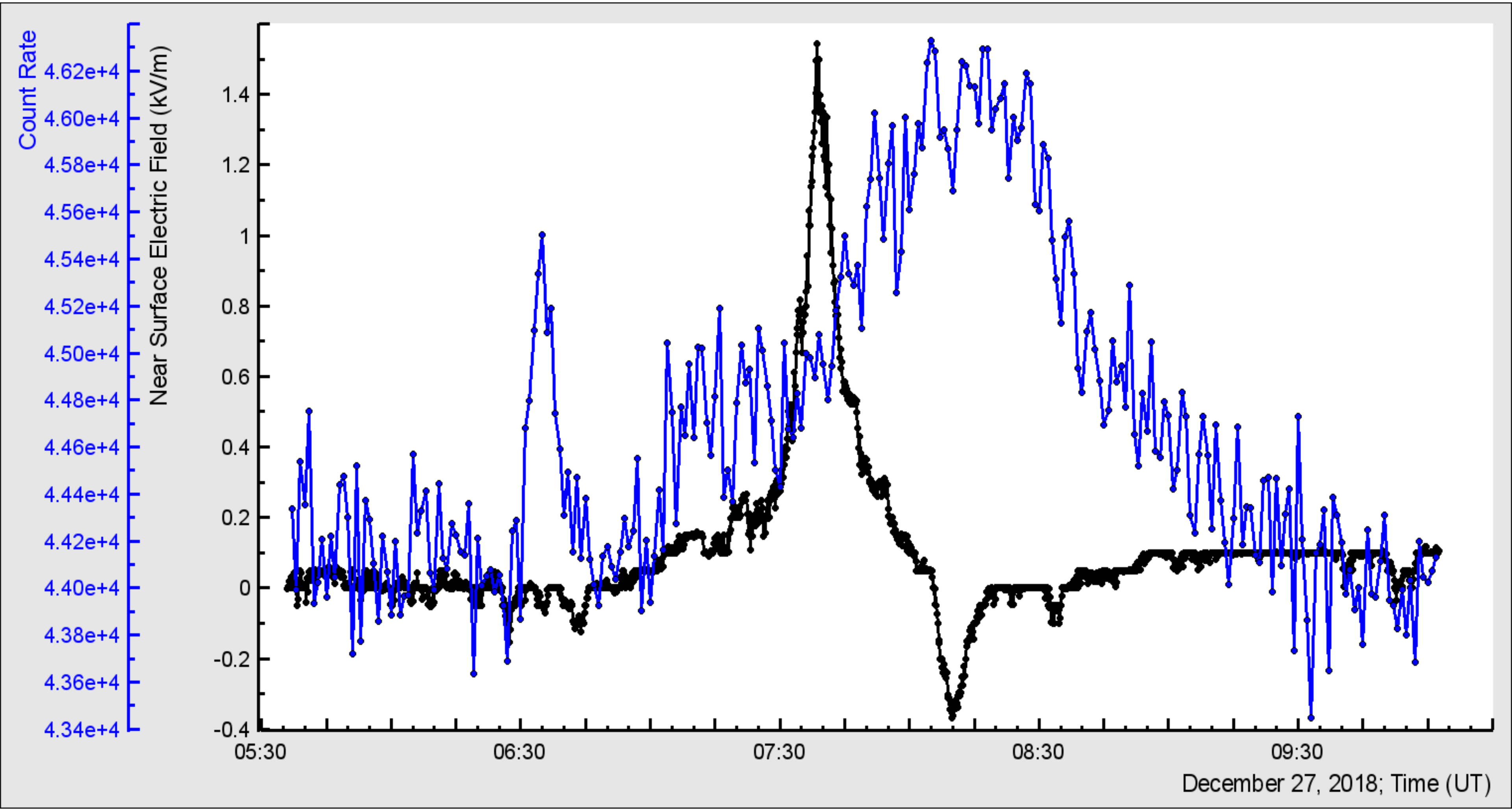
Dec.

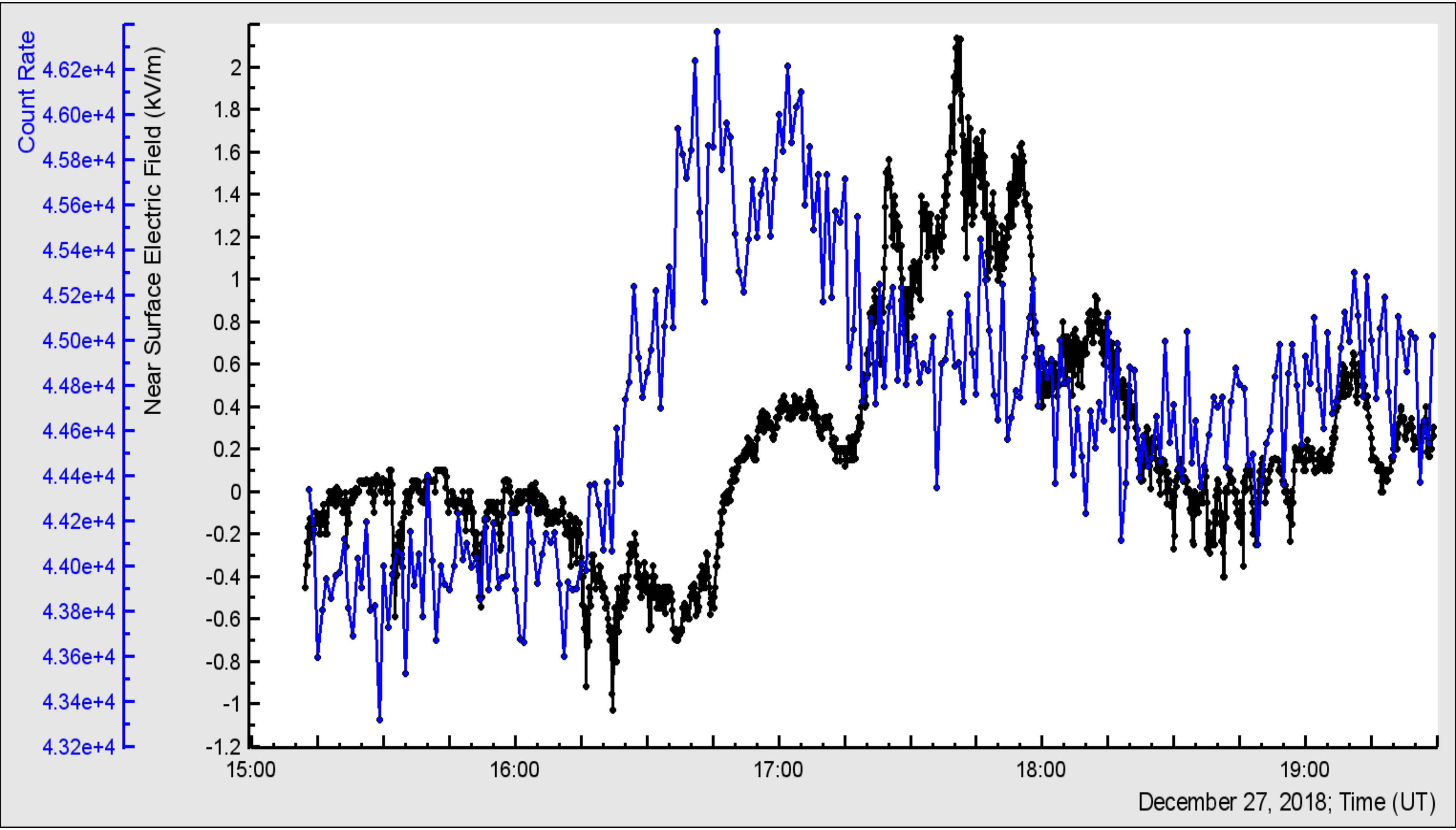


Count Rate
4.75e+4
4.70e+4
4.65e+4
4.60e+4
4.55e+4
4.50e+4
4.45e+4
4.40e+4
4.35e+4
4.30e+4
4.25e+4
Near Surface Electric Field (kV/m)
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
a
b
Dec 26, 10:00
Dec 26, 20:00
Dec 27, 06:00
Dec 27, 16:00
Dec 28, 02:00
Dec 28, 12:00
December, 2018; Time (UT)

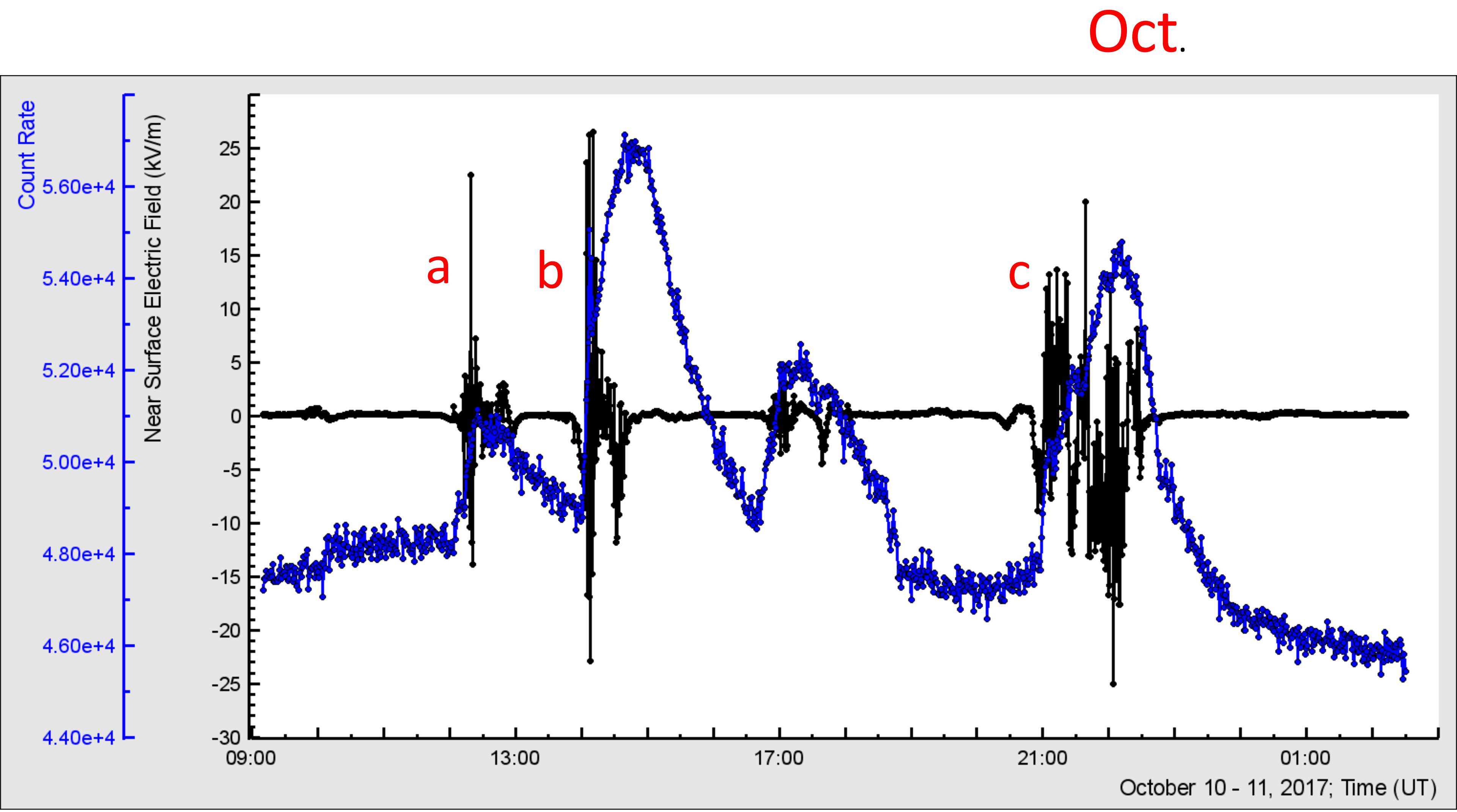
Dec. a


Count Rate
4.62e+4
4.60e+4
4.58e+4
4.56e+4
4.54e+4
4.52e+4
4.50e+4
4.48e+4
4.46e+4
4.44e+4
4.42e+4
4.40e+4
4.38e+4
4.36e+4
4.34e+4
Near Surface Electric Field (kV/m)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
05:30
06:30
07:30
08:30
09:30
December 27, 2018; Time (UT)

Dec. b

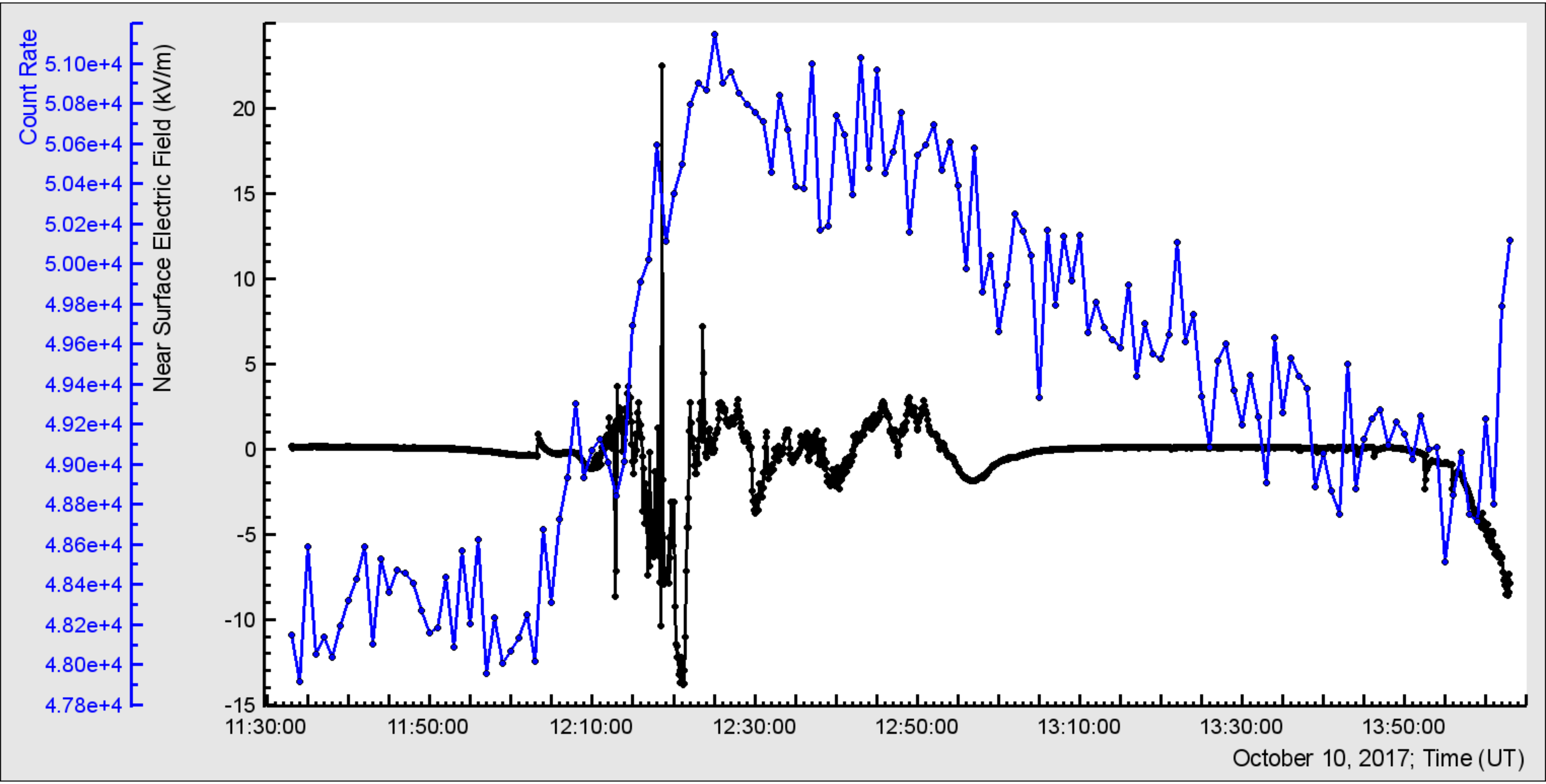


Count Rate
4.62e+4
4.60e+4
4.58e+4
4.56e+4
4.54e+4
4.52e+4
4.50e+4
4.48e+4
4.46e+4
4.44e+4
4.42e+4
4.40e+4
4.38e+4
4.36e+4
4.34e+4
4.32e+4
Near Surface Electric Field (kV/m)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
15:00
16:00
17:00
18:00
19:00
December 27, 2018; Time (UT)



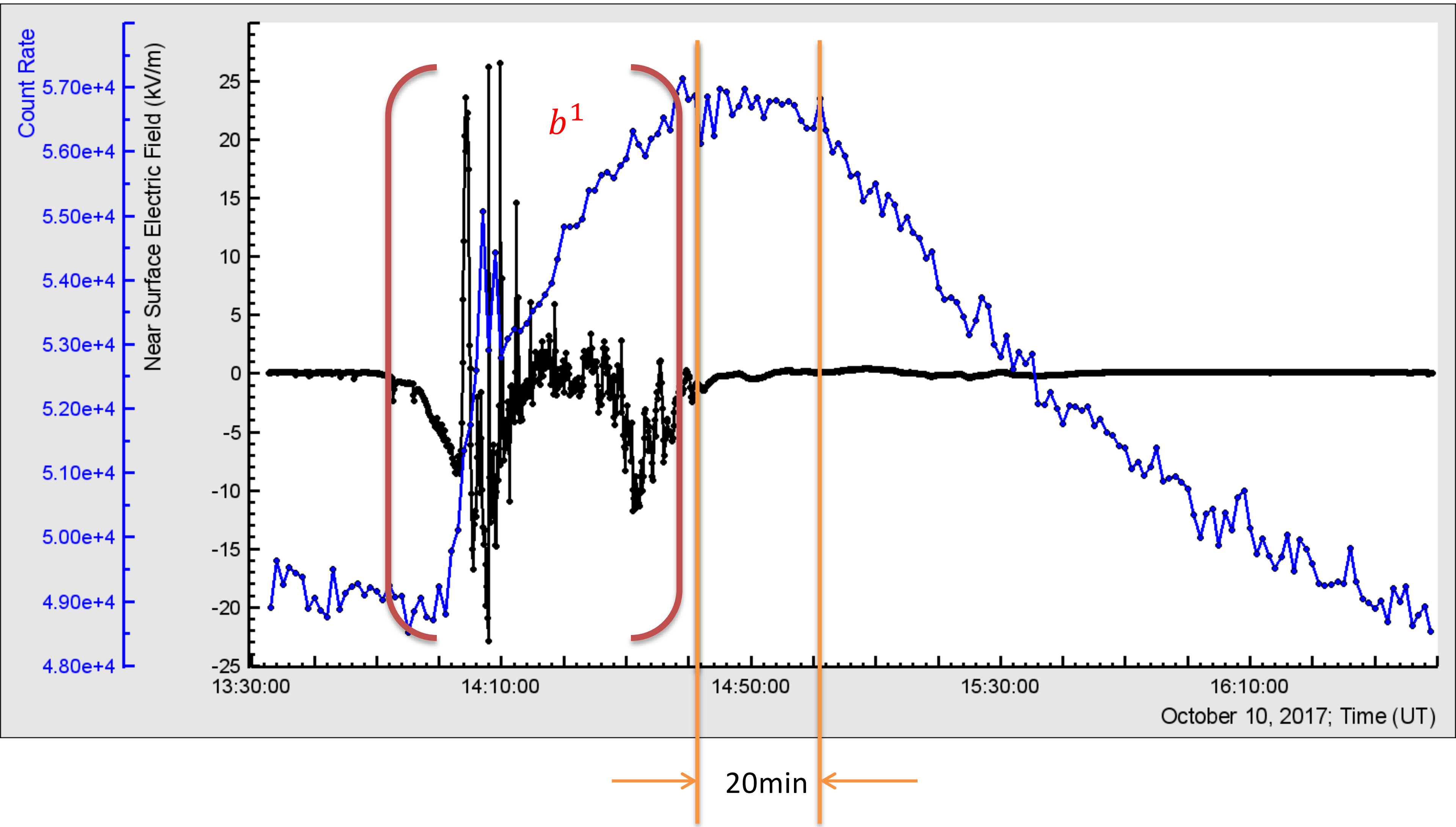
Oct.
a
b
c
Count Rate
5.60e+4
5.40e+4
5.20e+4
5.00e+4
4.80e+4
4.60e+4
4.40e+4
Near Surface Electric Field (kV/m)
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
09:00
13:00
17:00
21:00
01:00
October 10 - 11, 2017; Time (UT)

Oct. a



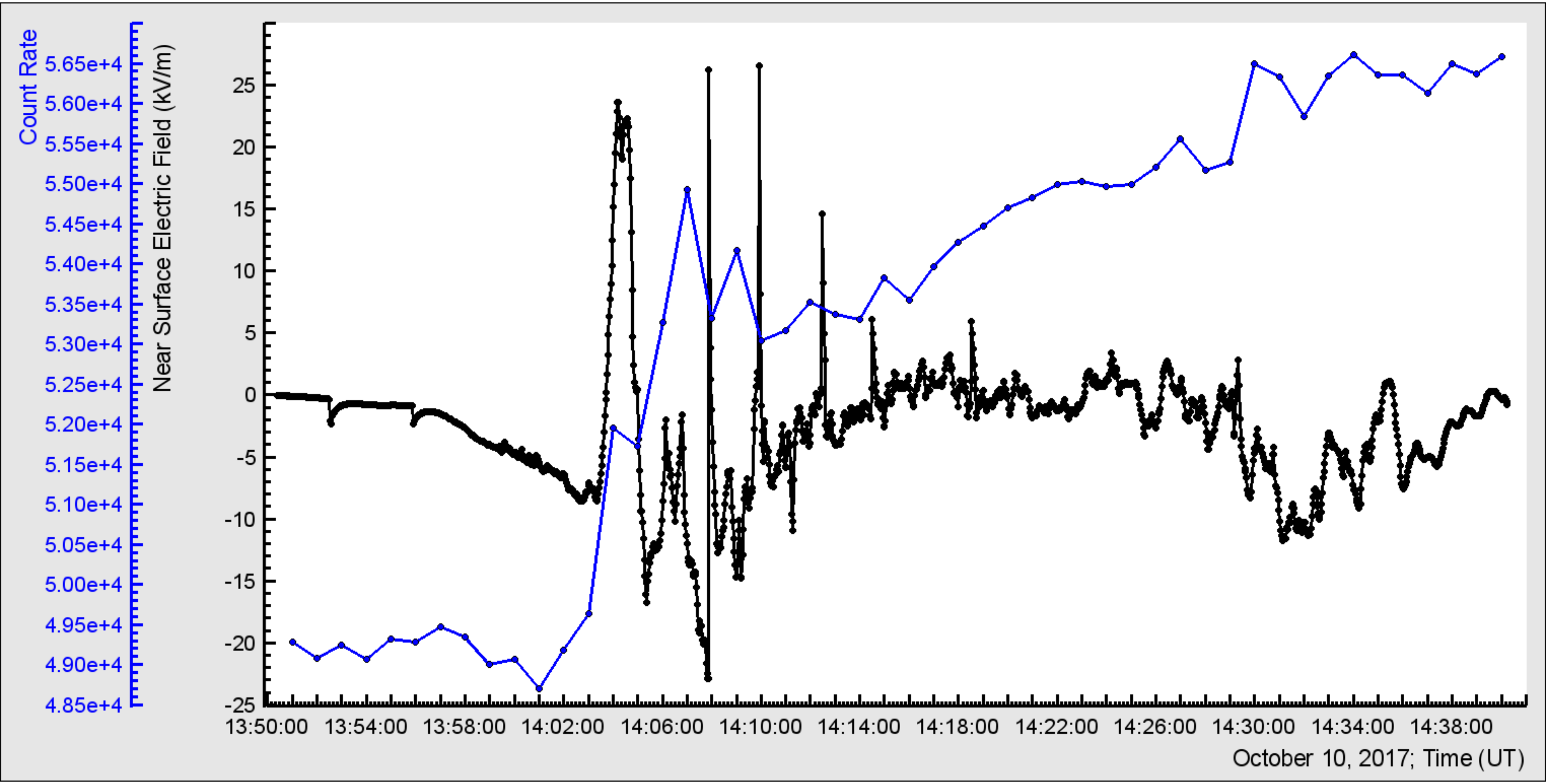
Count Rate
5.10e+4
5.08e+4
5.06e+4
5.04e+4
5.02e+4
5.00e+4
4.98e+4
4.96e+4
4.94e+4
4.92e+4
4.90e+4
4.88e+4
4.86e+4
4.84e+4
4.82e+4
4.80e+4
4.78e+4
Near Surface Electric Field (kV/m)
20
15
10
5
0
-5
-10
-15
11:30:00
11:50:00
12:10:00
12:30:00
12:50:00
13:10:00
13:30:00
13:50:00
October 10, 2017; Time (UT)

Oct. b



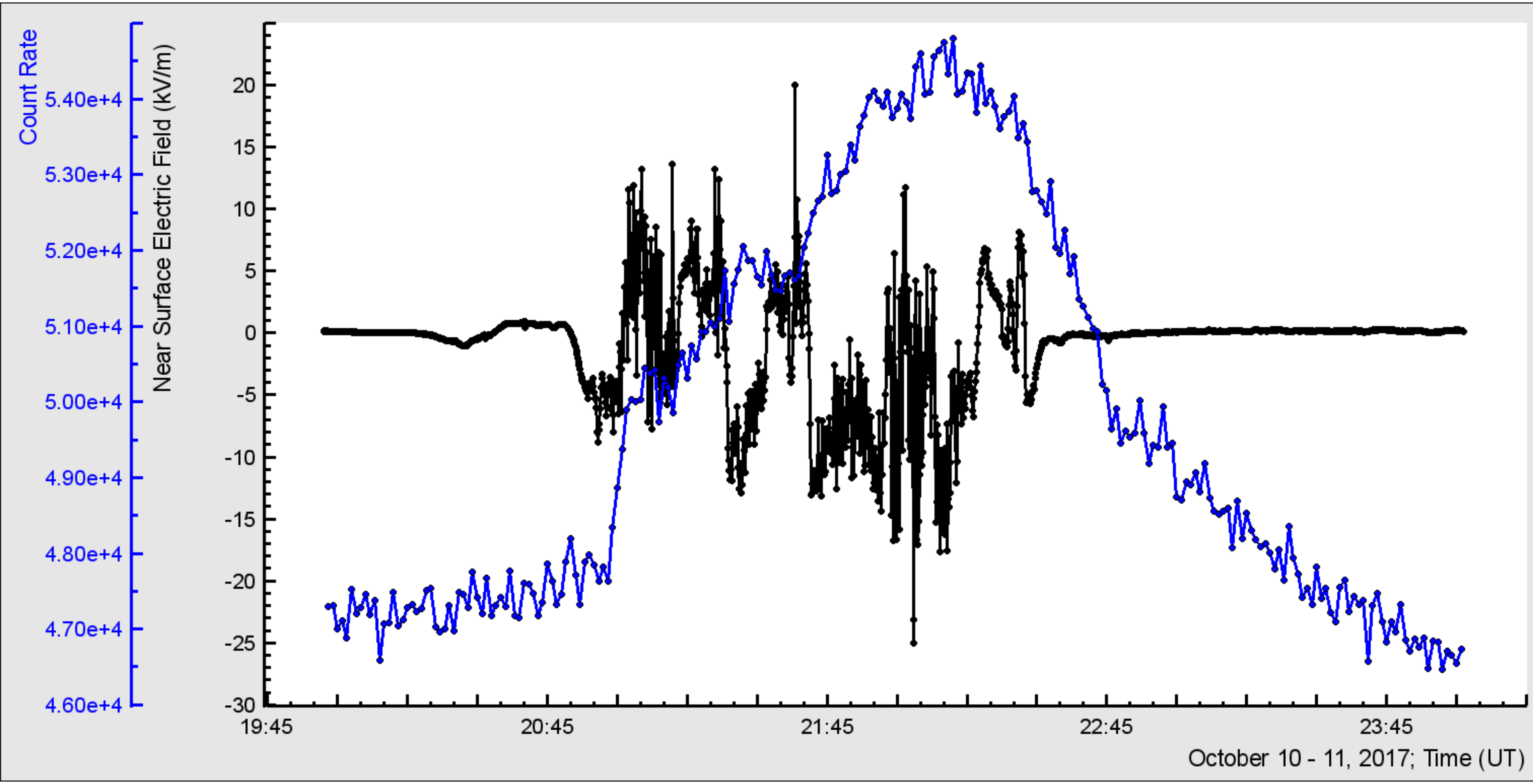
Count Rate
5.70e+4
5.60e+4
5.50e+4
5.40e+4
5.30e+4
5.20e+4
5.10e+4
5.00e+4
4.90e+4
4.80e+4
Near Surface Electric Field (kV/m)
25
20
15
10
5
0
-5
-10
-15
-20
-25
b^1
13:30:00
14:10:00
14:50:00
15:30:00
16:10:00
October 10, 2017; Time (UT)
20min

b^1



Count Rate
5.65e+4
5.60e+4
5.55e+4
5.50e+4
5.45e+4
5.40e+4
5.35e+4
5.30e+4
5.25e+4
5.20e+4
5.15e+4
5.10e+4
5.05e+4
5.00e+4
4.95e+4
4.90e+4
4.85e+4
Near Surface Electric Field (kV/m)
25
20
15
10
5
0
-5
-10
-15
-20
-25
13:50:00
13:54:00
13:58:00
14:02:00
14:06:00
14:10:00
14:14:00
14:18:00
14:22:00
14:26:00
14:30:00
14:34:00
14:38:00
October 10, 2017; Time (UT)

Oct. c



Count Rate
5.40e+4
5.30e+4
5.20e+4
5.10e+4
5.00e+4
4.90e+4
4.80e+4
4.70e+4
4.60e+4
Near Surface Electric Field (kV/m)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
19:45
20:45
21:45
22:45
23:45
October 10 - 11, 2017; Time (UT)

Conclusion

1.Most of the gamma coming from closer horizontal directions.!
2. A significant part (40%) of the gamma falling on the detectors (under the roof SKL) comes directly from the underlying soil.
3. Any changes gamma photon flux (if A_{ex} is constant) possible with vertical "compression" of the Radon and its daughter nuclides vertical distribution
4. Or A_{ex} changing bay weather conditions.

1. All daughter nuclides of radon-222 are either positively charged or neutral and cannot significantly rise into the upper atmosphere under conditions of alternating electric fields.
2. On the other hand, exponential results show that growth of the gamma photons independent of the polarity of the alternating (perturbed) electric field.
3. as shown by mathematical calculations, the transfer of nuclides from the lower layers to the upper layers leads to a decrease in the count of gamma photons.

The excess of gamma photons can apparently be explained by a change in meteorological conditions

Thank you for attention