CIRCULATION OF RADON PROGENY IN THE TERRESTRIAL ATMOSPHERE DURING THUNDERSTORMS

A. Chilingarian, G. Hovsepyan and B. Sargsyan

A. Alikhanyan National Lab (Yerevan Physics Institute), Yerevan, Armenia

www.crd.yerphi.am

37 ВСЕРОССИЙСКАЯ КОНФЕРЕНЦИЯ ПО КОСМИЧЕСКИМ ЛУЧАМ

ABSTRACT

We describe a new phenomenon in atmospheric physics—222Rn progeny circulation during thunderstorms. The enhancement of the natural gamma radiation during thunderstorms was measured with precise gamma ray spectrometers. Results of measurements performed at Aragats mountain in Armenia during summer 2020 demonstrate the Rn progeny lifted to the atmosphere by a near-surface electric field are returned backward to the ground by rain precipitation. Thus, thunderstorms not only return negative charge to the Earth by lightning flashes but also maintain Rn progeny circulation in the atmosphere; it this way, significantly enlarging natural gamma radiation above the Earth surface and Radon concentration in the atmosphere.

Figure 1. ORTEC firm gamma spectrometer (NaI(Tl), FWHM ~7.7% at 0.6 MeV, surrounded by 4-cm thick lead filters.

Table 1
Composition of the Background Gamma Radiation Measured by ORTEC Spectrometer Surrounded From All Sides by the 4-cm Thick Lead Filter

Total intensity 0.3 - 3 MeV	214Pb 354 KeV	Peak 511 KeV	214Bi 609 KeV	214Bi 768 KeV	AC _228 911KeV	214Bi 1.12 MeV	214Bi 1.76 MeV	214Bi 2.2 MeV	K 40 1.46MeV	Tl 208 2.6 MeV	CR + Compton scatter
912	8	31	2	4	4	3	3	3	22	4	828
100%	0,9	3,4	0,2	0,4	0,4	0,3	0,3	0,3	2,4	0,4	90,6

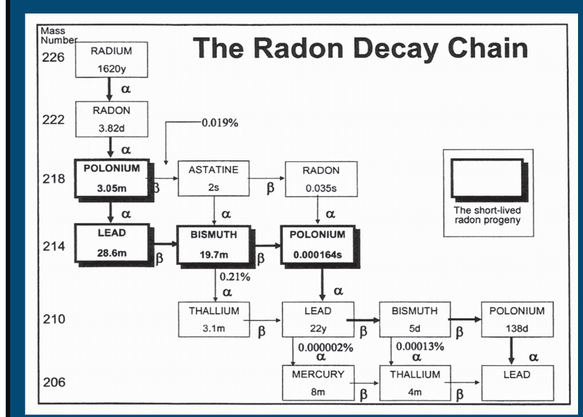
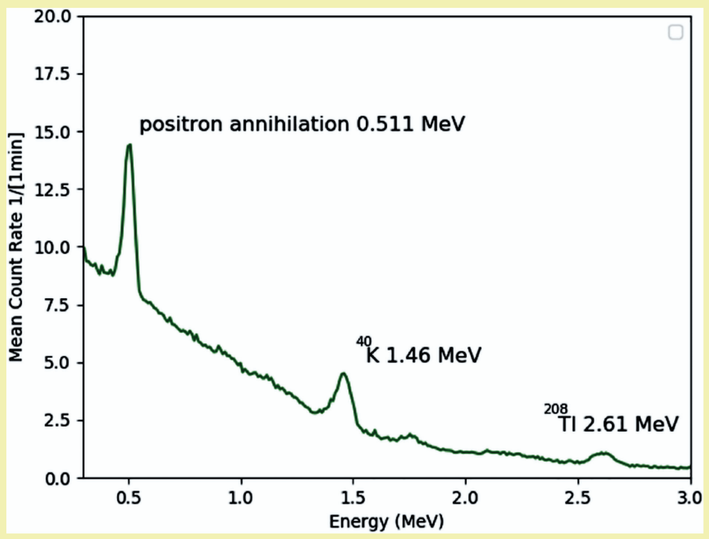


Figure 2. Energy spectra of the background measured by the ORTEC spectrometer surrounded by lead filter.



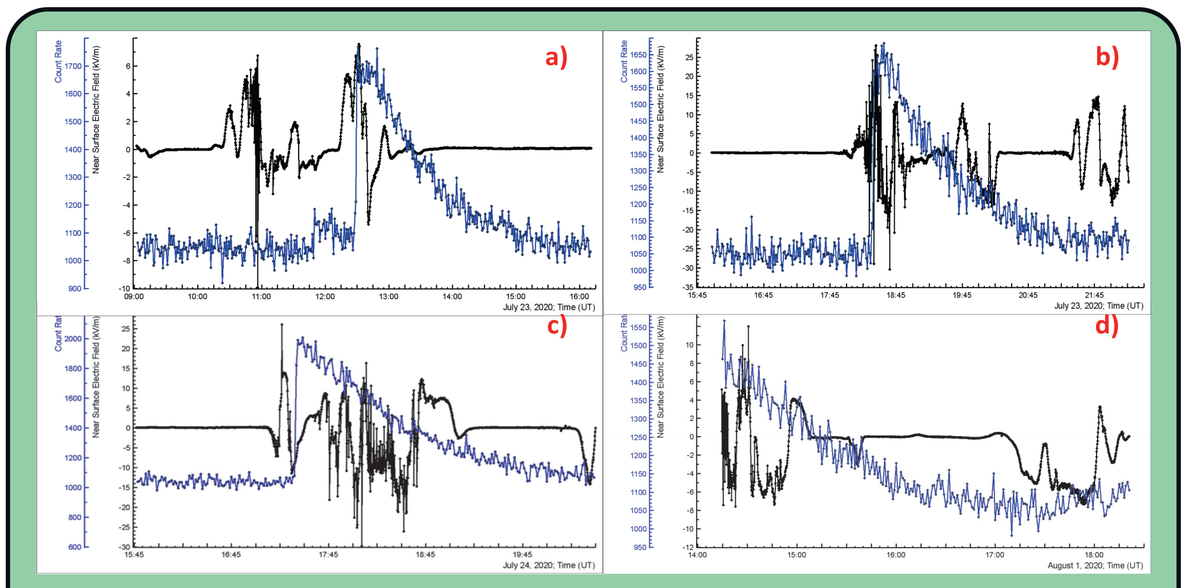


Figure 3. Increase in particle fluxes during the rain of 2020 at the Aragats scientific station, black Surface electric field (KV/m), blue Counter speed (1/min, det. ORTEC), a) and b) 23 July, c) 24 July, d) 01 August

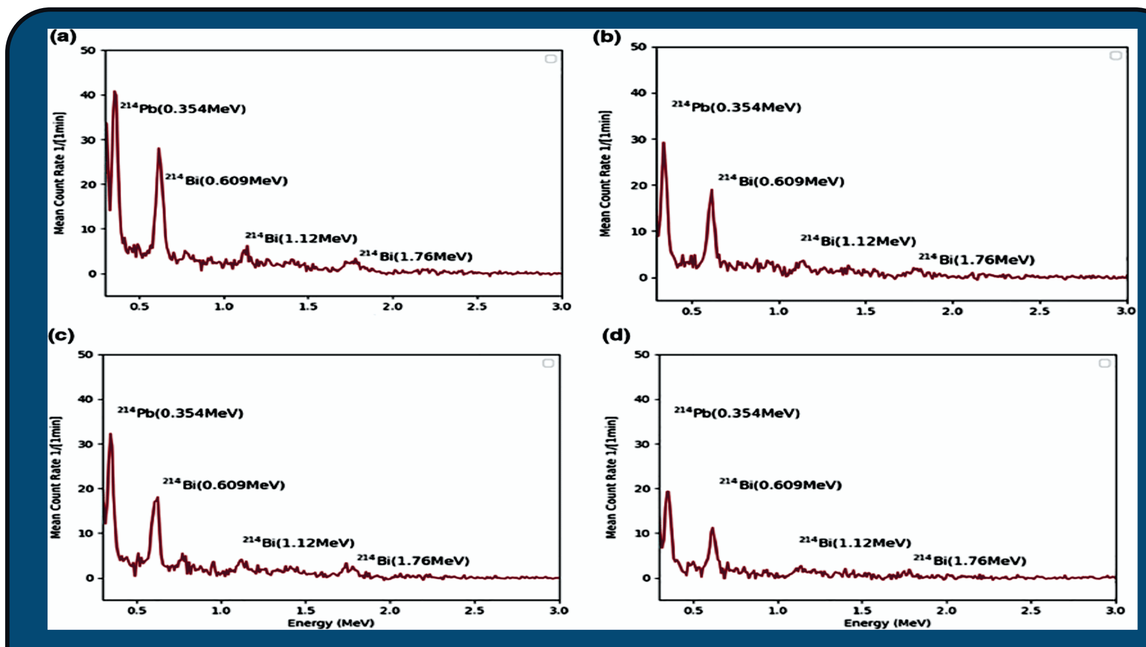


Figure 4. The energy spectra of the rainwater measured by the ORTEC spectrometer covered by 4-cm thick lead filter from all sides: (a) at 12:32 on 23 July; (b) at 18:27 on 23 July; (c) at 17:26 on 24 July; and (d) at 14:16 on 1 August.

Table 2
Summary of the Gamma Radiation Measurements From the Rainwater by the ORTEC Spectrometer Covered by the 4-cm Thick Lead Filter From All Sides

	Total intensity 0.3-3 MeV	214Pb_354 KeV	Peak _511 KeV	214Bi_609 KeV	214Bi _768 KeV	AC_228 _911KeV	214Bi_1.12 MeV	214Bi_1.76 MeV	214Bi_2.2 MeV	Compton scatter
23 July Mean Count rate 1/min [12:32-12:48]	585	147	5	109	45	26	40	32	7	174
%		25.1	0.9	18.6	7.7	4.4	6.8	5.5	1.2	29.7
23 July Mean Count rate 1/min [18:27 - 18:42]	531	123	6	102	32	43	38	23	8	156
%		23.2	1.1	19.2	6.0	8.1	7.2	4.3	1.5	29.4
24 July Mean Count rate 1/min [17:26 - 17:41]	814	191	8	161	46	41	60	42	12	253
%		23.5	1.0	19.8	5.7	5.0	7.4	5.2	1.5	31.1
01 August Mean Count rate 1/min [14:16 - 14:31]	343	91	9	63	19	13	28	13	8	99
%		26.5	2.6	18.4	5.5	3.8	8.2	3.8	2.3	28.9
Mean %		24.6 ± 1.5	1.4 ± 0.8	19 ± 0.6	6.2 ± 1	5.3 ± 1.9	7.4 ± 0.6	4.7 ± 0.8	1.6 ± 0.5	29.8 ± 0.9

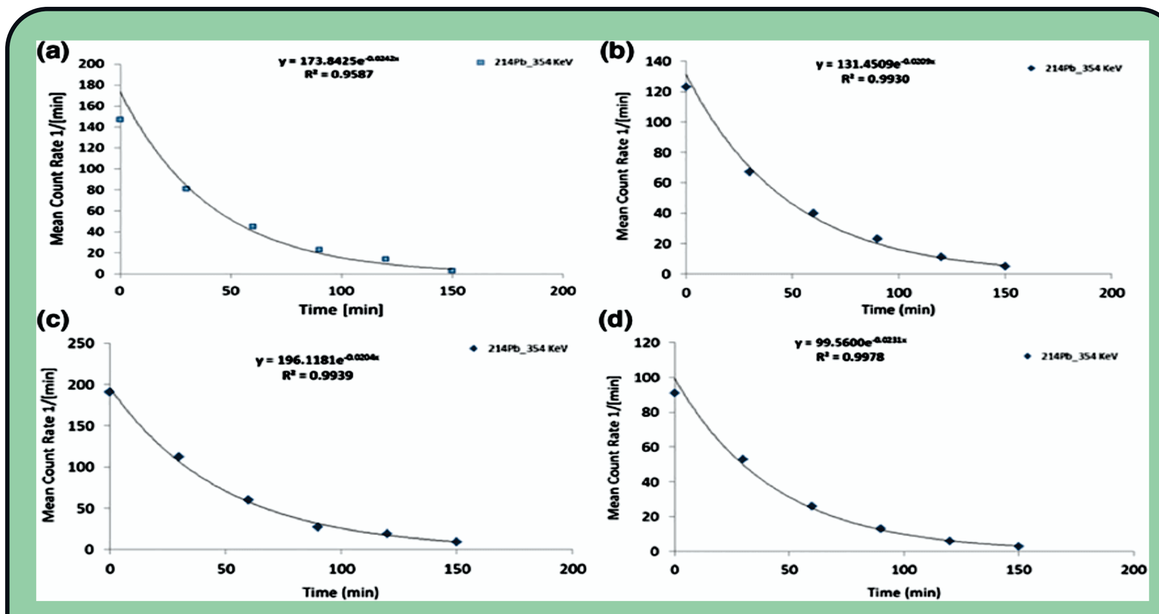


Figure 5. The exponential fit of the decay of the 214Pb isotope. The intensity of the 354 keV line was measured each half-of-hour during 150 min of measurements. Solid line—the exponential fit.

CONCLUSIONS

• We measured the gamma radiation of 222Rn progeny during thunderstorms by precise gamma spectrometers located within the lead filter. The gamma radiation was measured from the rainwater collected during four summer storms on Aragats. The concentration the most abundant gamma emitters in the rainwater 214Pb, 214Bi (609 keV), and 214Bi (1.12 MeV) was 25.3 ± 0.8%, 19.5 ± 1%, and 7.5 ± 0.2% in the first minute of the exposing of the rainwater to the ORTEC spectrometer. In the last, 150th minute of exposition, the concentration of these isotopes changed to 13.5 ± 0.7%, 25.6 ± 1.8%, and 17.1 ± 2.8% accordingly. The overall composition of the 222Rn progeny in rainwater coincides well with one recovered from the registered gamma radiation of the atmospheric origin. Thus, near-surface electric field lifts the 222Rn and its progeny up in the atmosphere and the rain return it backward in this way providing the circulation of the radioactive isotopes and enlarging surface radioactivity during thunderstorms.

• In Figure 4, we show four episodes of the radiation measurements (after subtracting the background). In Table 2, we show the count rates of gamma emitters including radioactive isotopes, positron annihilation, and continuous spectrum of secondary cosmic rays (mostly muons) and gamma rays scattered in the body of the NaI crystal (continuum to the right of each spectral line).

• In Figure 5, we present the decay curve of the most abundant 214Pb isotope. The intensity was measured every 30 min for a period of 15 min and then normalized to the 1-min count rate. Then the measured values were fitted with the exponential function and the half-life time calculated.