from A.P.

Alexander Litvinenko

Death by Radiation Poisoning?

Shortly after his death, the UK's Health Protection Agency HPA stated tests had established Litvinenko had significant amounts of the radioactive isotope polonium-210 in his body. This was most likely inhaled or ingested, and traces of it were found at several London locations: in his Muswell Hill home, at a hotel in Grosvenor Square, and at the sushi restaurant where he had met Scaramella on November 1, and where he regularly held meetings, including a October 16 meeting with two Russians. Traces were also found in a former Russian oligarch Boris Berezovsky's offices and his residence in Mayfair.

British and US government sources both said the use of 210Po as a poison has never been documented before, and this was probably the first time a person has been tested for the presence of polonium-210 in his or her body

From Wikopedia

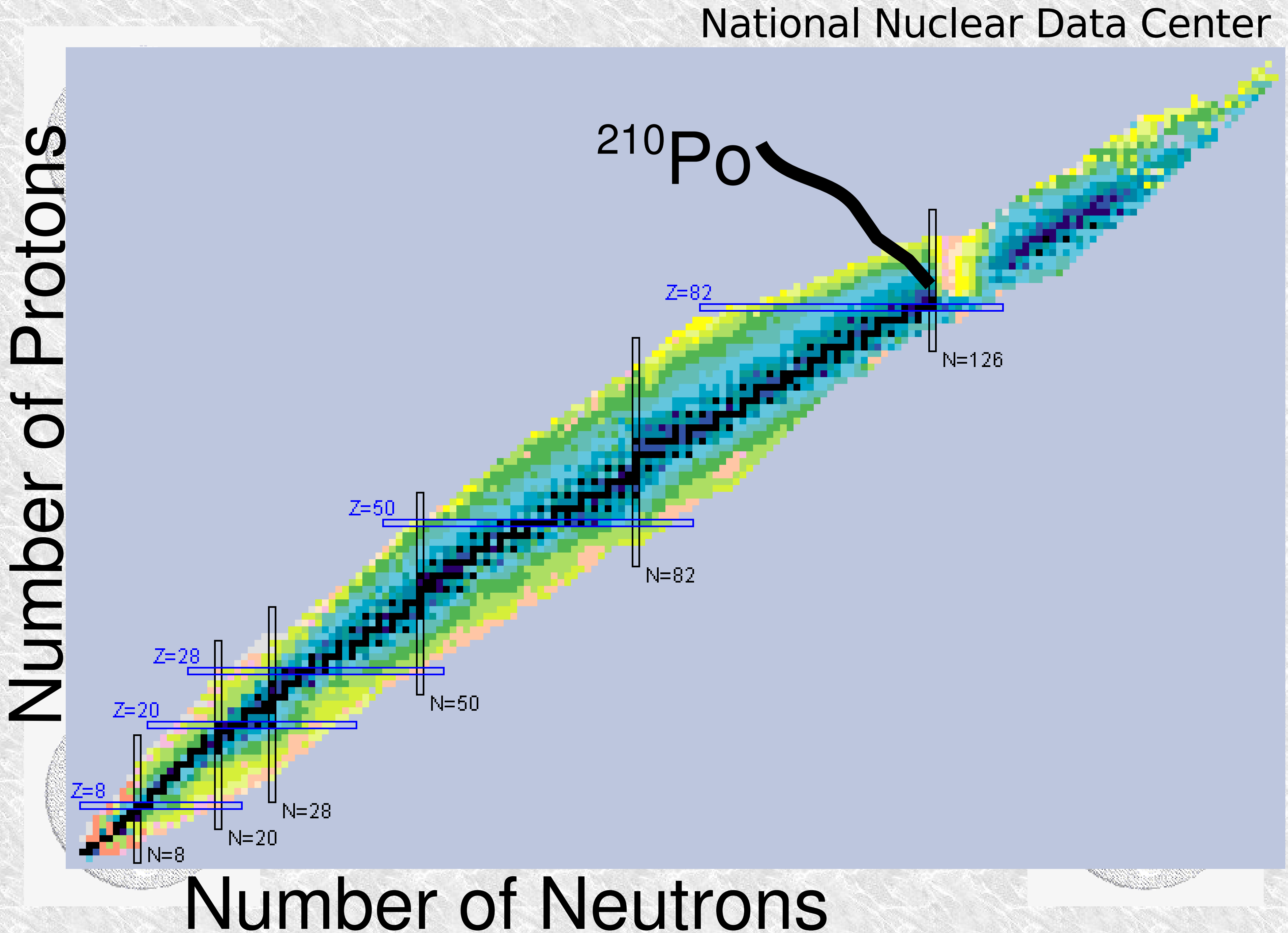
Uses for ^{210}Po

It has been used as a neutron trigger for nuclear weapons.

It can be used as an atomic heat source to power Radioisotope thermoelectric generators via thermoelectric materials.

Russian secret services allegedly use polonium for smudging currency bills so that they can trace them.

It has been used in a recent high profile nuclear crime.


National Nuclear Data Center
^{210}Po
Z=82
Z=50
Z=28
Z=20
Z=8
N=126
N=82
N=50
N=28
N=20
N=8
Number of Protons
Number of Neutrons

National Nuclear Data Center

85	207At 1.80 H ε	208At 1.63 H ε	209At 5.41 H ε	210At 8.1 H ε	211At 7.214 H ε	212At 0.314 S α	213At 125 NS α	214At 558 NS α	215At 0.10 MS α
	206Po 8.8 D ε	207Po 5.80 H ε	208Po 2.898 Y α	209Po 102 Y α	210Po 138.376 D α	211Po 0.516 S α	212Po 0.299 µS α	213Po 3.65 µS α	214Po 164.3 µS α
83	205Bi 15.31 D ε	206Bi 6.243 D ε	207Bi 32.9 Y ε	208Bi 3.68E+5 Y ε	209Bi STABLE 100%	210Bi 5.012 D β-	211Bi 2.14 M α	212Bi 60.55 M β-	213Bi 45.59 M β-
	204Pb ≥1.4E+17 Y 1.4% α	205Pb 1.73E+7 Y ε	206Pb STABLE 24.1%	207Pb STABLE 22.1%	208Pb STABLE 52.4%	209Pb 3.253 H β-	210Pb 22.20 Y β-	211Pb 36.1 M β-	212Pb 10.64 H β-
81	203Tl STABLE 29.524%	204Tl 3.78 Y β-	205Tl STABLE 70.476%	206Tl 4.200 M β-	207Tl 4.77 M β-	208Tl 3.053 M β-	209Tl 2.161 M β-	210Tl 1.30 M β-	211Tl >300 NS β-
	122		124		126		128		130

^{209}Bi + n --> ^{210}Bi --> ^{210}Po + e- + v

From Wikopedia

Interesting Tibits

Also called tentatively "Radium F", polonium was discovered by Marie Curie and her husband Pierre Curie in 1898 and was later named after Marie's native land of Poland (Latin: Polonia).

A milligram of ^{210}Po emits as many alpha particles as 5 grams of radium. A single gram of ^{210}Po generates 150 watts of power.

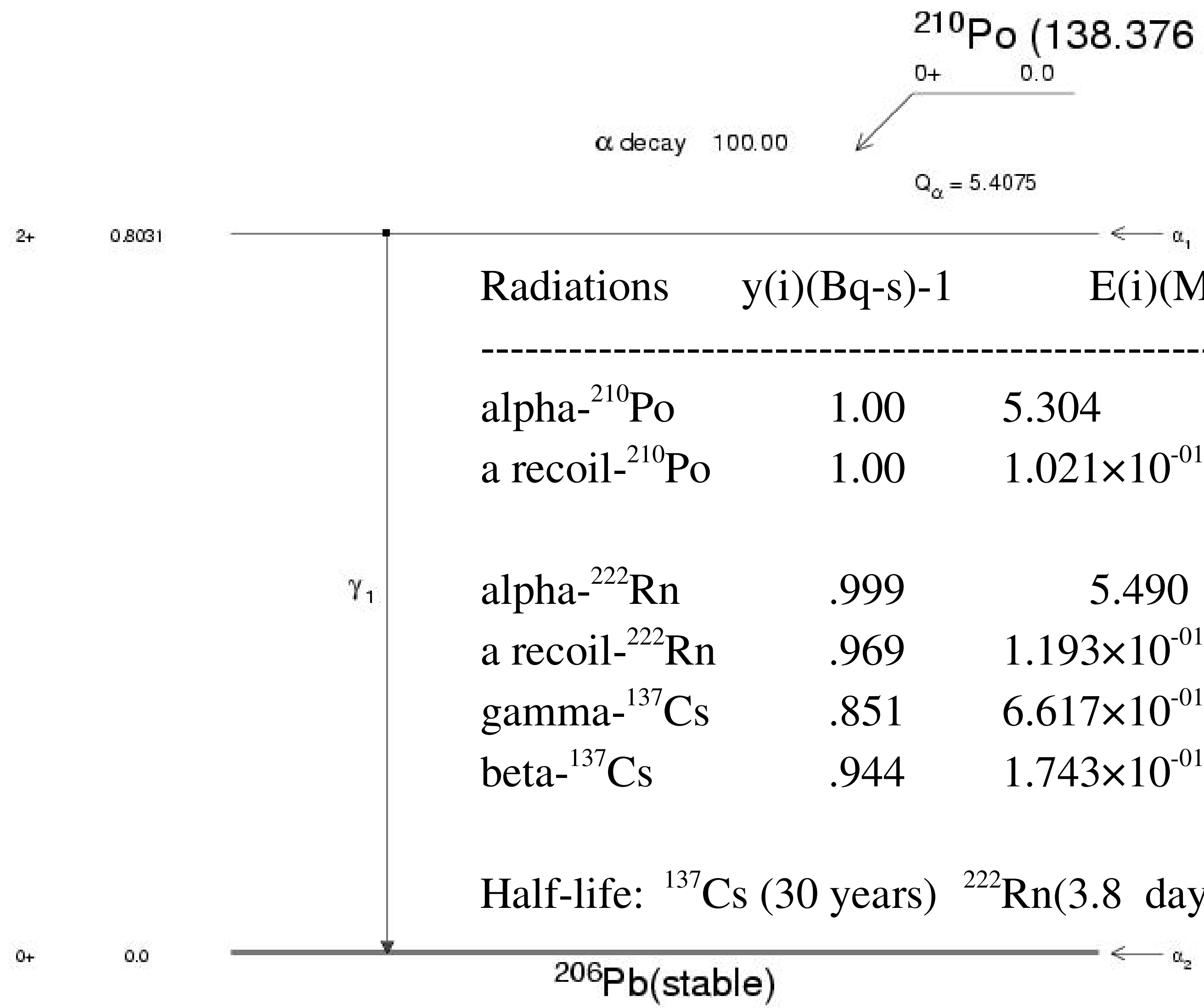
Only about 100 grams is produced each year,

^{210}Po (in common with ^{238}Pu) has the ability to become airborne with ease: if a sample is heated in air to 328 K (55°C, 131°F), 50% of it is vaporized in 45 hours

Polonium is an extremely toxic element: weight-for-weight, its toxicity is around 109 times greater than hydrogen cyanide.

The maximum allowable body burden for ingested polonium is a particle weighing only 6.8 picograms.

Litvinenko was probably the first person ever to die of the acute α-radiation effects of Polonium, although Irene Joliot-Curie was actually the first person ever to die from the radiation effects of Polonium (due to a single intake) in the late 1950's.



Radiations	y(i)(Bq-s)-1	E(i)(MeV)	y(i)×E(i)
alpha-^{210}Po	1.00	5.304	5.30
a recoil-^{210}Po	1.00	1.021×10^{-01}	1.02×10^{-01}
alpha-^{222}Rn	.999	5.490	5.490
a recoil-^{222}Rn	.969	1.193×10^{-01}	1.16×10^{-01}
gamma-^{137}Cs	.851	6.617×10^{-01}	5.63×10^{-01}
beta-^{137}Cs	.944	1.743×10^{-01}	1.65×10^{-01}

Half-life: ^{137}Cs (30 years) ^{222}Rn(3.8 days)

biological damage = y*E*activity*Quality Factor

Some Calculations....

activity*y(i)*E(i) = 9.2×10^{20} eV/(g s)=1.5×10^{2}W/g

=1.5×10^{5} Grays/s (1 Gray = 1 Joule/Kg)

1 Sievert = 1 Gray x QF (Quality Factor) – biological damage

QF:(~1 for gamma, beta, ~5 for neutrons, ~10 for proton, ~20 for alpha)

If inhaled QF is multiplied by 5!

So 1 gram of ^{210}Po has 1.5×10^{4}Sv/s!

A lethal dose of radiation ~ 5 Sv, occupational limit is ~5×10^{-2}Sv/yr

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^{222}Rn --> ^{218}Po --> ^{214}Pb--> ^{214}Bi -->^{210}Po-->^{210}Pb-->^{210}Bi-->^{210}Po

(23 years and 4 beta and 3 alpha decays later we get to ^{210}Po)

Also often inhaled....

The Scary Kinematics

Alpha:

- $\frac{1}{2} m v^2 = 5$ MeV where $m = 4000$ MeV/c^2 so $v = 1.5\times10^7$ m/s
- It will travel < 1 mm in the body indirectly producing 10-100 X-Rays, ionized electrons, charged particles and the occasional neutron.
- Most X-Rays will travel relatively unimpeded through chest cavity doing further damage (Compton and photoelectric effects) until they hit bone.

Recoiling ionized ^{206}Pb:

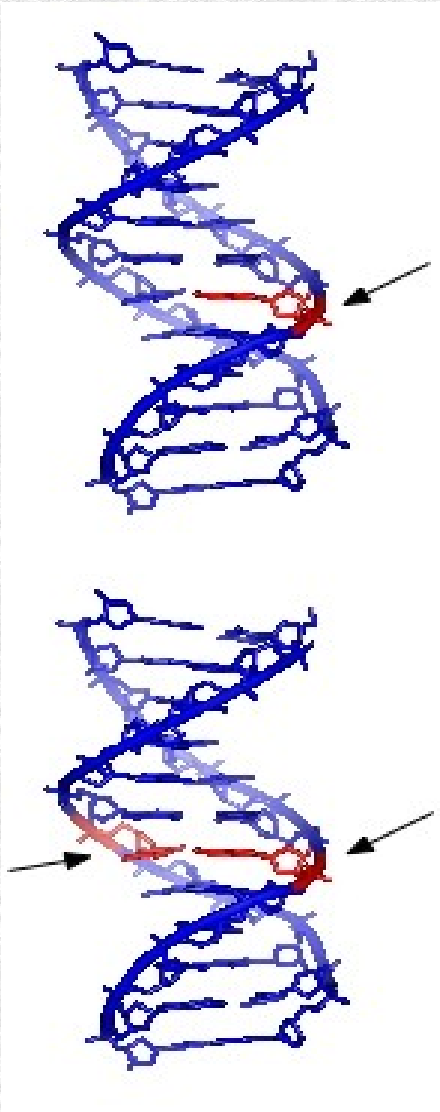
- $MV=mv$ $V=(m/M)v$ $V=3\times10^5$ m/s
- It will travel ~1 um in the body tearing molecules from their bonds
- It will then stay in the body as a heavy metal affecting biological functioning.

From notes by R. Piccard (physics) of Ohio State
http://oak.cats.ohiou.edu/~piccard/radnotes/dose.html

The biologically and medically significant effects of radiation can be divided according to the classes of structures ultimately affected: membranes; proteins, both structural and enzymatic; the various RNA's; and the genetic DNA. Membrane and protein damage may kill promptly, while DNA damage may cause problems in cell replication (hair follicles for example), offspring, or may cause cancer after many years.

When a beam of X-rays strikes, for example, a protein crystal, the energy that is delivered to the crystal or its surroundings may directly break intra-molecular bonds and it may also create chemically active fragments ("free radicals") which can in turn attack the molecules of the crystal. Some of the energy may be expected to break the inter-molecular bonds, disordering the crystal without destroying molecules. Other energy will go into vibrations and other excitations, dissipating throughout the crystal without breaking bonds. It is unlikely, because of the wide range in the strengths of the intra-molecular bonds (from less than 0.1 eV to more than 4 eV), that all of the bonds in a crystal will be equally susceptible to radiation damage.

Experimental evidence in mammalian cells for increased severity of clustered DNA damage with increasing radiation quality, as predicted by biophysical modeling. This has implications for the unique types of clustered damage induced by alpha particles and underpins the relevance of their biological severity.



from Wikipedia

from:

Yokoya, A., Cunniffe, S.M.T., Stevens, D.L and O'Neill, P. Effects of Hydration of the Induced on Strand Breaks, Base Lesions and Clustered Damage in DNA Films by alpha-radiation. J. Phys. Chem B, 107, 832-837 (2003)

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