The great Jefferson Parkway hot sample kerfuffle

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September 5, 2019

The 'hot' Rocky Flats soil sample reported on August 16th in the Denver Post was due to a big (8.8 micron; 1 micron = 10^{-6} m) rare 'hot particle'. A single such hot particle can completely dominate a sample's count rate.

- 'Hot particles' are tiny, very radioactive flecks of insoluble alpha particle emitters (like plutonium dioxide, PuO_2). Health concerns about inhaled plutonium particles stuck in the lung were raised in 1974 and provoked intense research for 3-4 years. By 1978 it was clear (based on animal experiments) that respirable (large) hot particles were not especially toxic since (i) their non-uniform dose is less dangerous than an equivalent dose of radiation *uniformly* (see figure) delivered, and (ii) they produce fewer cancers as well [1, 2].

- It is straightforward to estimate the lifetime cancer risks from inhaling these. PuO_2 is more dense than lead, so it strongly absorbs its own alpha particles when thick enough. You would need to inhale (DOE, details unspecified) 5000 (my independent calculations, 3600) 3 micron diameter hot particles (my estimate: 20 million of the most likely size in Rocky Flats soil) to raise your risk of cancer by 1%. About 400 8.8 micron particles would give the same dose.

- There certainly *are* large hot particles in Rocky Flats soil. NIST soil standards prepared from samples collected in 1978 note that there are about 1.8 particles per 90 grams of dry soil, but did not specify their size or radioactivity. Large hot particles are *not* common in Rocky Flats soil; see the size distribution in the figure. Dr. Michael Ketterer's initial report on soil sampling in early July along the Jefferson Parkway corridor discusses results for six 'composite' samples, drawn from about 150 kg of soil taken to a depth of about 5 cm from 15 m × 15 square areas. Of his 42 distinct (and, at present, 143 Parkway) measurements, no other sample was found to be 'hot'.

- The rarity of large hot particles and the fact that you could inhale thousands of them without appreciable changes in lifetime cancer risk means that they do not represent a health hazard. As NIST's 2007 standard notes, "The SRM is a dried sterilized soil and poses no chemical or biological hazard. However, inhalation or ingestion of the material should be avoided." Inhalation of large hot particles is regarded as very unlikely [4]. RESRAD (the DOE software tool for assessing health risk from residual radionuclide contamination) includes inhalation and ingestion in the estimates that the excess risk of cancer from Rocky Flats is 2×10^{-6} [5].

Respirable particles are those with a diameter (were they spherical) of less than about 4 microns. Since the radiation dose depends on the cube of the particle diameter, a 1 micron particle is only 4% as radioactive as a 3 micron one. Ordinary Rocky Flats particles range up to 0.4 microns or so.

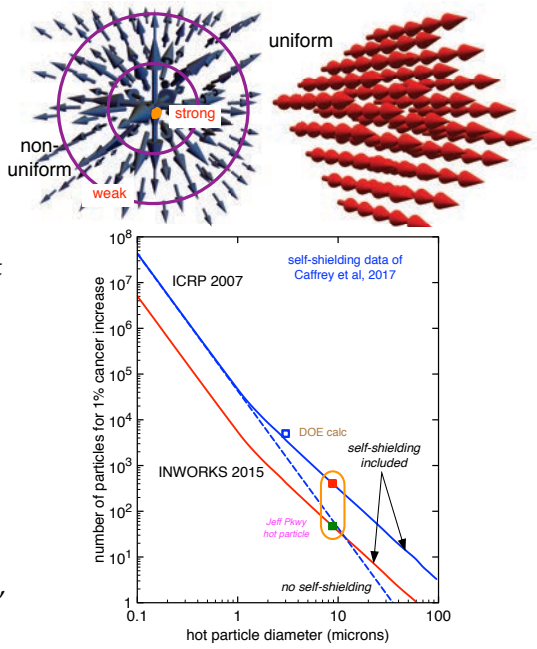

Figure 1: Number of inhaled hot particles needed to raise cancer risk by 1%. DOE figure for 3 micron particle shown as open square. Red and blue lines indicate different sources of risk vs. radiation dose.

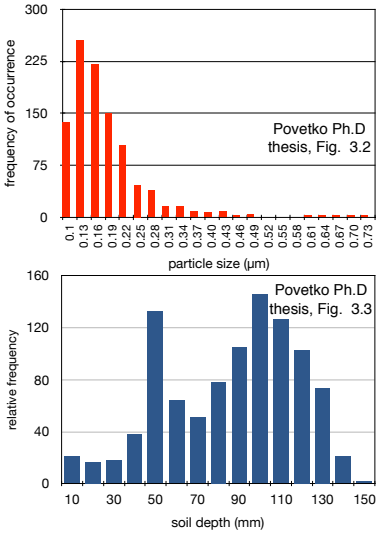

Figure 2: Properties of soil actinide (presumably plutonium) particles in Rocky Flats soil, redrawn from [3].

Background information: (i) Plutonium and americium from the Rocky Flats plant account for less than 3% of total soil radioactivity; the rest is natural. (See the figure.); (ii) Measured ambient radiation levels on trails in the Refuge and even in the DOE-controlled 'central operable unit' are low-nomal Front Range normal background, entirely consistent with the NIST soil results.

Note: Green links and citations in text on previous page are *clickable*, as are the URLs below.

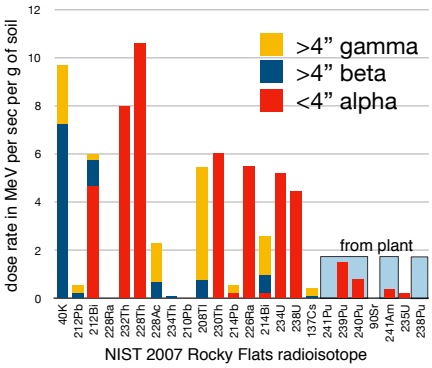

Figure 3: Radiation (not radioactivity) from radioisotopes in Refuge soil resolved into alpha radiation (range less than 4 inches), beta, and gamma. Soil radioactivity of the *fallout* isotope 137Cs is higher than from plutonium!

References

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