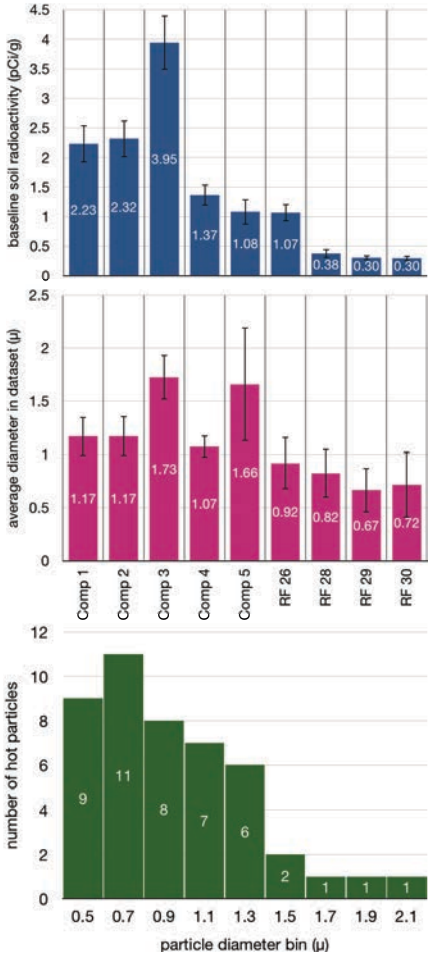
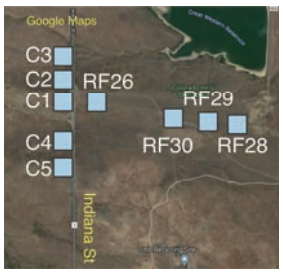
NEGLIGIBLE HEALTH RISKS FROM HOT PARTICLES DETECTED IN ROCKY FLATS SOIL





data & refs

- CDPHE approach (June 2020): even if all soil were contaminated at same level as single 2019 "hot sample", DOE radiation modeling software RESRAD predicts very small risk
- Here: **direct** application of international standard route to cancer risk of inhaled PuO_2 hot particles stuck in lung

A brief history of Rocky Flats hot particles measurements

- Hot particles are the *most common* way for nuclear plant workers to be exposed and are common in soil around many former plants.
- The health impact was intensely studied in the early to mid 1970s; the situation was clear by about 1978 (animal data, experience of plant workers, including Rocky Flats): less dangerous than an equivalent uniform dose.
- Hot particles in Rocky Flats soil have been measured in several waves: McDowell and Whicker of CSU (1978) sized 1700 particle; NIST soil standards (1981, 2007) based on soil collected in the 1970s noted their presence, and 2000 Povetko Ph.D thesis, with samples drawn from the area 200 m easy of the '903 pad', characterized 989 hot particles.
- The most thorough recent measurement of 'large' hot particles on the eastern Rocky Flats boundary now becomes the unpublished data from 2019 measurements of Ketterer&Szechenyi.

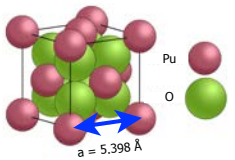
Read the document about hot particles for details on the history and dosimetry.

Contribution of RF plant workers

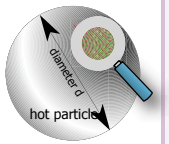
Rocky Flats plant workers contributed a great deal from the 1970s through the present to U.S. and ICRP standards for plutonium hot particle inhalation. From 1978: "*Rocky Flats Group.* This group also consists of 25 persons, who have inhaled $^{239}PuO_2$ aerosols as a result of a fire in a ^{239}Pu manufacturing plant in Rocky Flats on October 15, 1965; a mass related average of the aerodynamic particle diameter was 0.3μm. In all of these persons the ^{239}Pu activity in the lung was in excess of the permissible limit; it corresponded on the average to 10^4-10^5 hot particles with an activity of more than 0.07 pCi per particle" [diameter $\gtrsim$ 0.6μ]. No excess cancers found. See references for a survey of NIOSH studies of RF workers through 2005. As noted in the August 2019 article, *USTUR Special Session Roundtable—-US Transuranium and Uranium Registries (USTUR): A Five-decade Follow-up of Plutonium and Uranium Workers* "At Rocky Flats, a bioassay program was established to follow workers after they terminated employment. The resulting data continue to help researchers to improve the biokinetic models that are used to estimate intakes and radiation doses…"

Methodology

- *Physics:* Compute number of decays per second from $^{239}PuO_2$ hot particle of specified diameter.
- *Biology:* Use International Commission on Radiological Protection (ICRP) or DOE/EPA/U.S. risk or dose coefficients to relate activity to dose. ICRP dose coefficient size indicates biological effectiveness in causing cancer risk, time-dependence includes Pu excretion over time.
- Only dose route is inhalation: use EPA data on average and maximum inhaled dust per day for scenarios. [Swallowed: almost all excreted.]
- Use K&S data (average size of hot particles, numbers per kg of soil) to determine how many particles and how much dirt must be inhaled for outcomes.
- Make conservative estimates.



PuO_2: fluorite structure



$$A = \frac{4\pi}{3}\frac{1}{2}(d/a)^3 \times \frac{\ln 2}{t_{\frac{1}{2}}}$$

activity (decays/sec)

The 1% scenario

Changes in lifestyle (smoking, diet, *etc.*) can change your lifetime cancer risk by 10-20%. A 1% excess lifetime risk of cancer from inhalation of hot particles from Rocky Flats soil is in principle measureable.

1. *Needed dose for 1% excess risk:* Use the ICRP value 0.055 excess risk per Sv of dose: 0.1818 Sv needed. The ICRP 50-year (epidemiological lifetime) 'dose coefficient' relates dose to total *activity* A (decays/sec) which must be inhaled: $A = 1.136 \times 10^4$ Bq.
2. How many hot particles would need to be inhaled? If we pick $d_\mu = 3$ (3 microns, larger than any measured by K&S), 34,700.
3. How much dirt would be needed? With 1200 hot particles per kg of dirt (more than any measured by K&S), 28.9 kg.
4. How long to inhale this much? EPA: 50 mg/day for the top 5% of heavy breathers. It would take 1580 years (24/7 breathing dust) for the 1% excess risk. In 50 years the risk would be 3% as large.

set	part #	kg	years
C1	580,000	930	260,000
C2	580,000	1,100	310,000
C3	180,000	780	210,000
C4	750,000	2,600	700,000
C5	200,000	800	220,000
RF-26	1,200,000	1,700	470,000
RF-28	1,700,000	2,700	730,000
RF-29	3,200,000	3,000	830,000
RF-30	2,600,000	4,500	1,200,000

For 1% excess lifetime risk of cancer, number of particles and mass of RF dirt required, and years of 24/7 inhalation needed

set	HP	samps	pCi/g	$\bar{d}$( )	HP/kg
C1	4	32	2.23	1.2	625
C2	4	39	2.32	1.2	510
C3	2	43	3.95	1.7	230
C4†	2	34	1.37	1.1	300
C5†	2	39	1.08	1.7	260
RF-26†	6	43	1.07	0.92	700
RF-28*	5	40	0.38	0.82	625
RF-29†	9	43	0.30	0.67	1000
RF-30†	4	35	0.30	0.72	570

"Decades of USDOE and CDPHE studies to date have failed to recognize and characterize Rocky Flats originating PuO_2 particles and have not assessed their risks to human health."--Ketterer&Szechenyi ***Claim II***

Complete BS. DOE sponsored many of the studies above over the last 50 years.

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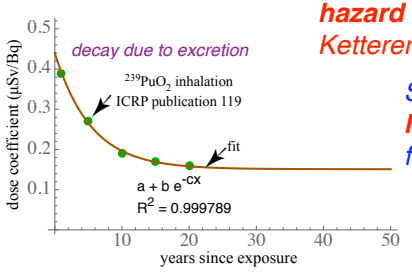
$$\underset{\text{physics}}{A_{\text{'activity'}}} = \frac{4\pi}{3}\frac{1}{2}(d/a)^3 \times \frac{\ln 2}{t_{\frac{1}{2}}} \quad \text{(half-life of radioisotope)}$$

$$= .01214\, d_{\mu}^{3}\ \text{Bq (decays/sec)} \quad \text{(particle diameter in microns)}$$

$$\underset{\text{biology}}{D_{50}[\text{Sv}]_{\text{'dose'}}} = c_{50}A[\text{Bq}] \quad \text{('dose coefficient')}$$

authority	dose coeff	risk/Sv	risk coeff
DOE/EPA	-	-	8.96×10^{-7}
ICRP	1.6×10^{-5}	.055	(8.80×10^{-7})



*"Particles of these dimensions are amenable to transport under strong wind conditions, and represent a **grave hazard** for human inhalation and pulmonary retention."* *Ketterer&Szechenyi **Claim I***

*Same true of any particles of this size. **Grave hazard** meant to provoke hot particle radiation fear in absence of any evidence.*

Doses

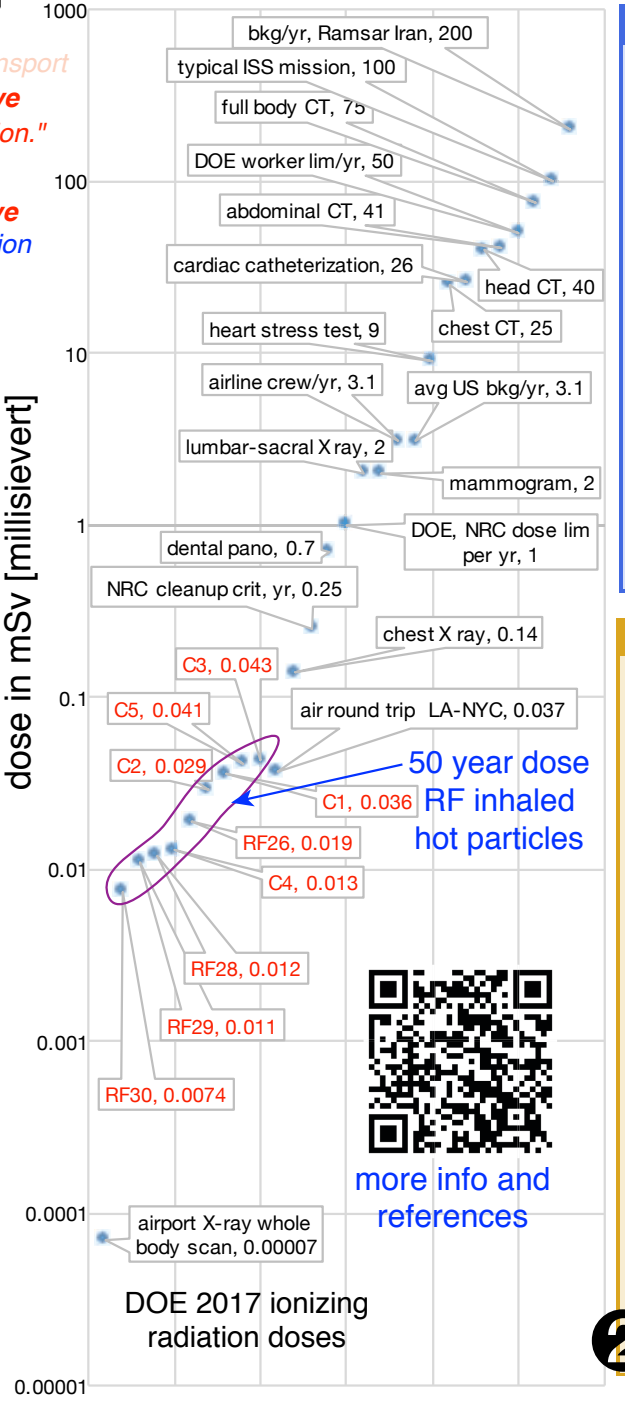
What is radiation dose from inhaling Rocky Flats hot particles for 50 years? For 5 years (as in Jefferson Parkway project)?
Ingredients: K&S hot particle data [average diameters, number per kg of soil] + EPA data on dust inhalation rates + international or U.S. dose or risk coefficients.

- From average diameter compute average 'activity' [decays/sec] of 1 inhaled hot particle.
- Assume K&S data holds for surface dirt inhaled as dust. Use EPA value 10 mg/day inhaled/ingested dust. This plus measured data yields number of hot particles inhaled during dose period.
- Use ICRP 'dose coefficient' (includes biological elimination of ^{239}Pu over time) to relate absorbed *activity* (decays per second) to 50-year radiation *dose* (in millisievert, mSv). *These are based partly on experience of Rocky Flats plant workers*, are revised using follow-up data on nuclear plant workers, USTUR program, **contradicting K&S Claim II**.

Significance

- Methodology would be recognized, accepted by international or U.S. agencies.
- Doses near or somewhat below 100 mSv have only rarely been shown to have any measureable health effects. The 50-year dose is 2,300 times smaller; 5 year dose is 23,000 smaller.
- 50 year dose comparable to or less than for a New York to Los Angeles round trip flight.
- Number of hot particles which must be inhaled for even in principle detectable 1% excess cancer risk ranges from 200,000 up to 3,000,000 depending on particle size and location. This would take hundeds of thousands to millions of years (far beyond even the half-life of ^{239}Pu) to inhale. [See main reference document.]

Risks from now-common medical procedures (e.g., abdominal CT scan) are generally neglected even though they are 1000 times larger than those from the 50-year doses. Health risks from any plausible scenario for Rocky Flats hot particle inhalation are *negligible*, **contradicting K&S Claim I.**



Takeaway messages

- Rocky Flats hot particles noted, characterized since the 1970s
- International, U.S. cancer risk values for inhaled $^{239}PuO_2$ in fact are partly based on the experiences of Rocky Flats plant workers
- 50-year risks from inhaling hot particles from RF soil are comparable to those for a round trip transcontinental plane flight
- Physically impossible for public or worker to inhale enough hot particles in dust to increase lifetime risk by detectable amount

Good to know

- Use of the 'linear no-threshold' description for how cancer risk depends on radiation dose considerably overestimates risk in low-dose case (below about 100 mSv) case.
- About 97% of total Rocky Flats soil radioactivity (95% of alpha radiation) comes from natural radioisotopes.
- Ketterer failed to read health physics or radiation regulation literature. Claims highlighted above *would not survive peer review* in reputable journal.
- Rocky Mountain Peace& Justice Center has been a reliable source of misinformation and evidence-free fearmongering for >15 years.
- Opponents of Refuge use are non-physical scientists unable to make quantitative estimates of radiation risk, dose.