Montserrat Natural World Cluster – November 13, 2017
Technical FAQ for the film "Containment"

(a) *What is a half-life?* Radioactive materials, such as the isotope *Plutonium-239* used in nuclear weapons and mentioned prominently in "Containment," decay over time. This process takes place at a *characteristic rate*, usually described by giving what is known as the *half-life*. The half-life is, by definition,

the time necessary for a sample of a given mass originally to decay to one-half of its original mass.

As a formula, if Q_0 is the amount originally present, and the half life is $T_{1/2}$ then the amount present at time t is given by:

$$Q(t) = Q_0 \cdot \left(\frac{1}{2}\right)^{t/T_{1/2}}.$$

Many of you have probably done problems in precalculus or calculus classes based on this sort of formula. But what does this *really mean* in more intuitive terms? The half-life of Plutonium-239 is approxmimately

$$24,100 \text{ years.}$$

The graph on the back of this sheet shows how a 100 kg sample of Plutonium-239 (this would be enough to create about 5 nuclear bombs) decays over time.

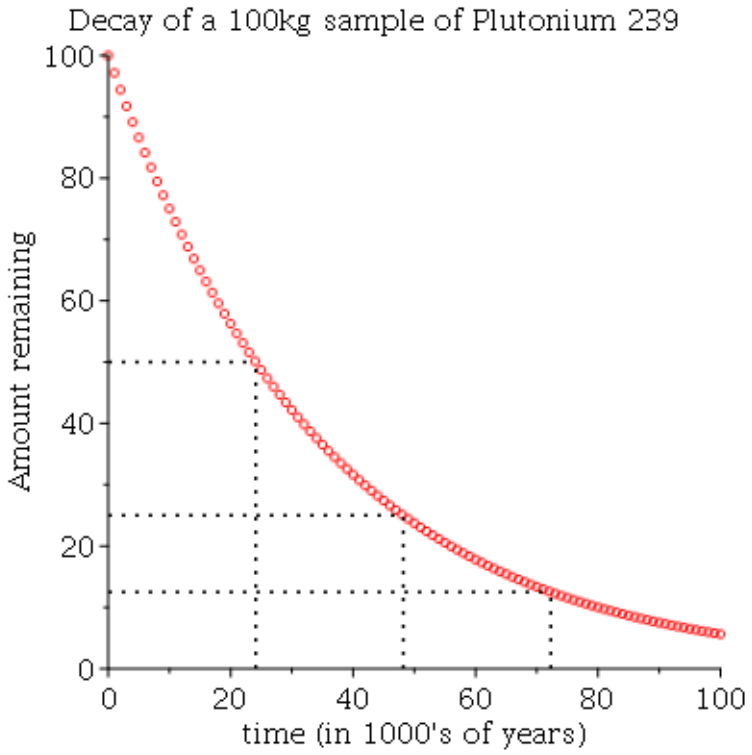
- At $t = 24,100$ years (1 half-life), one half of the original, or 50 kg are left
- At $t = 48,200$ years (2 half-lives), one half of the 50 kg, or 25 kg are left
- At $t = 72,300$ years (3 half-lives), one half of the 25 kg, or 12.5 kg are left
- and so on ...

(b) *Why is this of concern?* It has been estimated that a pound (454 grams) of Plutonium inhaled as Plutonium Oxide dust could give cancer to two million people.[1]

(c) *Why can't we just launch all this waste into space and let it fall into the sun?* Well, the main reason is that there is *so much of it, now.* As of 2010, the WIPP facility highlighted in "Containment" had already accepted about 7.2×10^4 cubic meters of waste and stored it. With current rocket technology, we would need thousands of rockets to launch what was already stored. If each launch has a probability of success of .999 and we launch a thousand times, the probability that there is *at least one launch accident* would be $1-(.999)^{1000} = .6323$, or about 62%. Even one launch accident could have catastrophic results (see (b) above).

(d) *Isn't this just an engineering problem?* In a sense, maybe. But the time scales involved and the difficulty of even thinking about communicating with people thousands of years in the future (if there are any of us left) is what "Containment" is about.

[1] Bernard L. Cohen. The Nuclear Energy Option. Plenum Press, 1990.


Decay of a 100kg sample of Plutonium 239
Amount remaining
time (in 1000's of years)
0
20
40
60
80
100