Seaborg's Plutonium?

A Case Study in Nuclear Forensics

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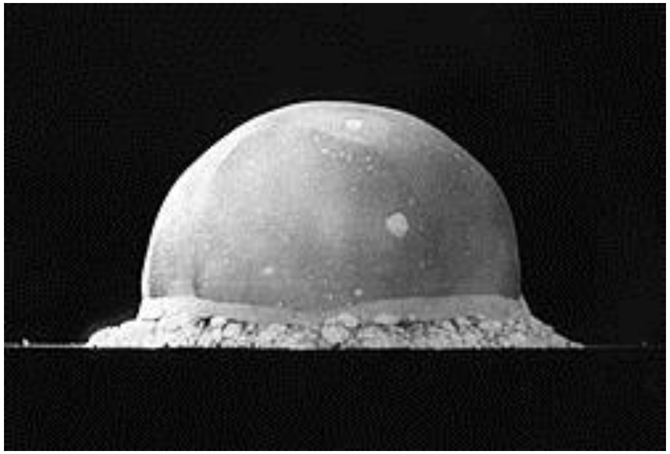
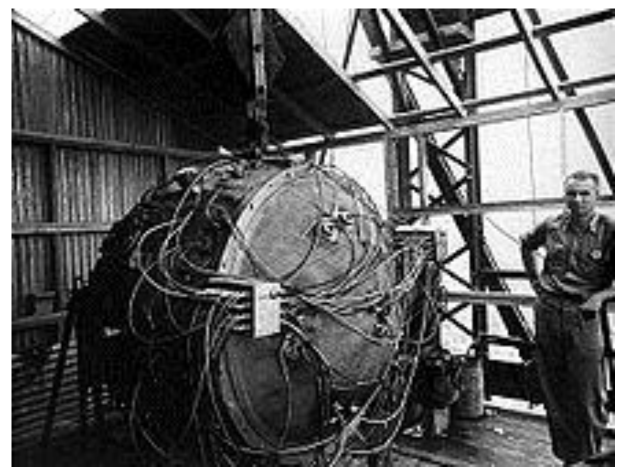
February 24, 2015

Berkeley UNIVERSITY OF CALIFORNIA Nuclear Engineering

What do the objects shown in the next three slides share in common?

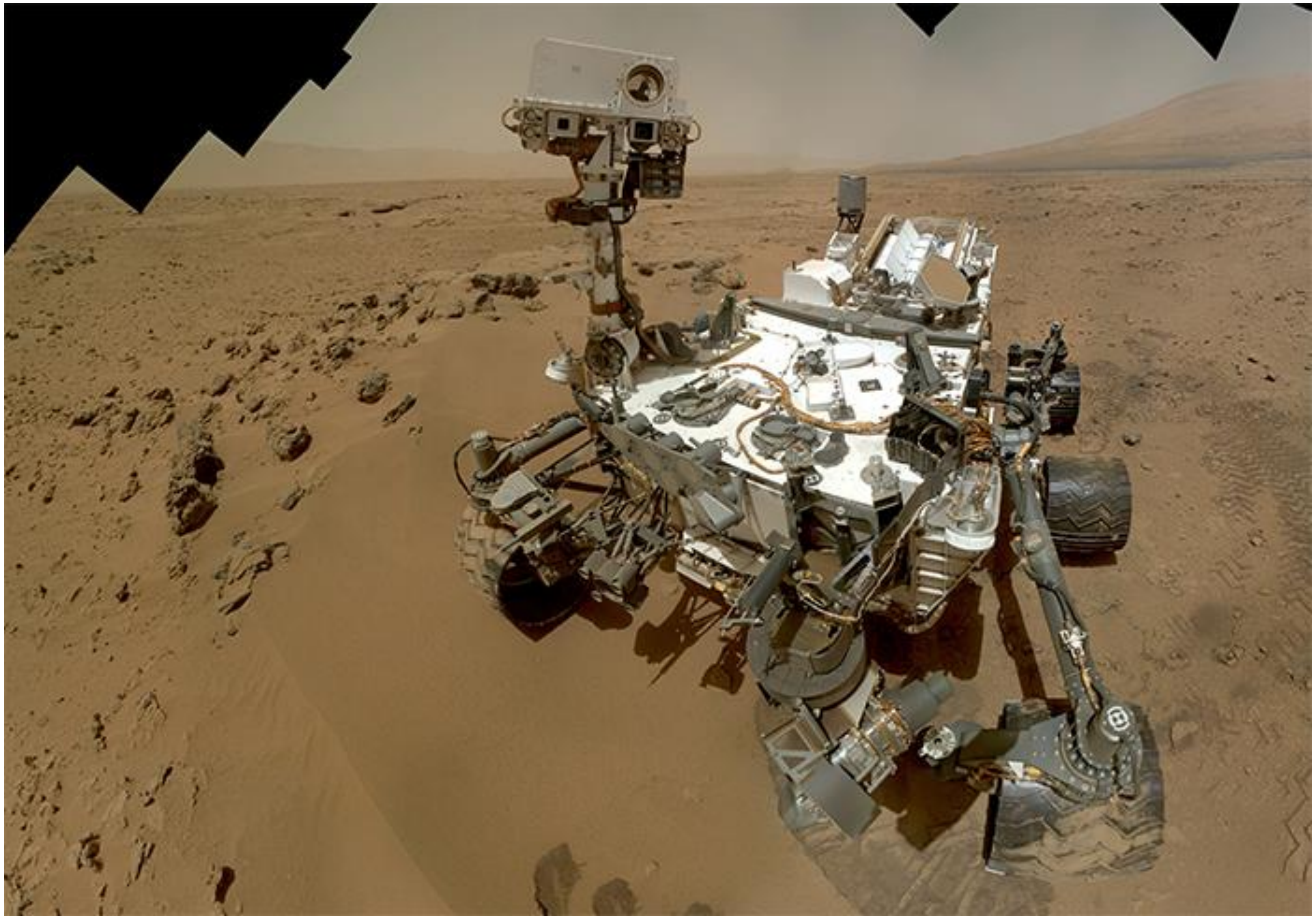
Trinity: First Nuclear Weapon Explosion

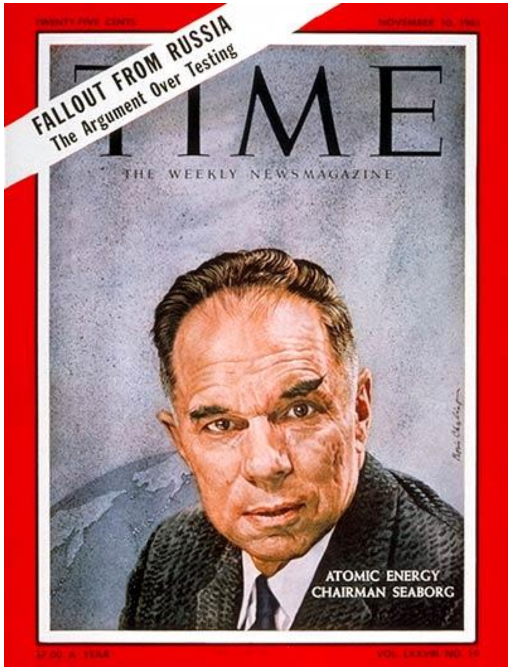


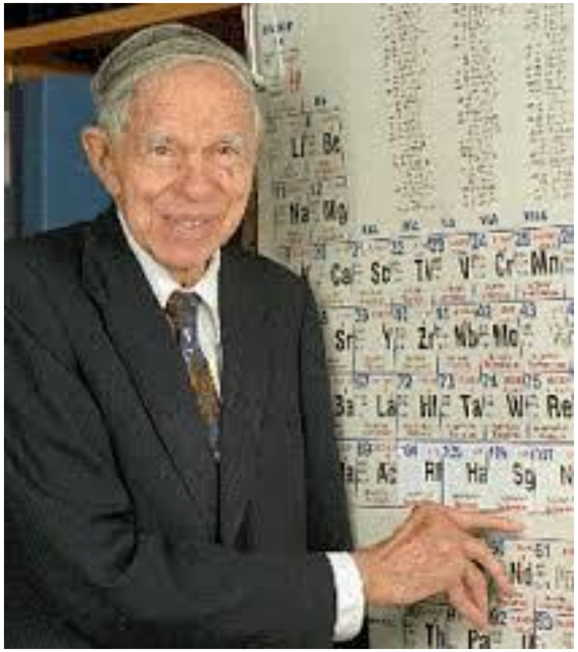


Ionization-Type Smoke Detector

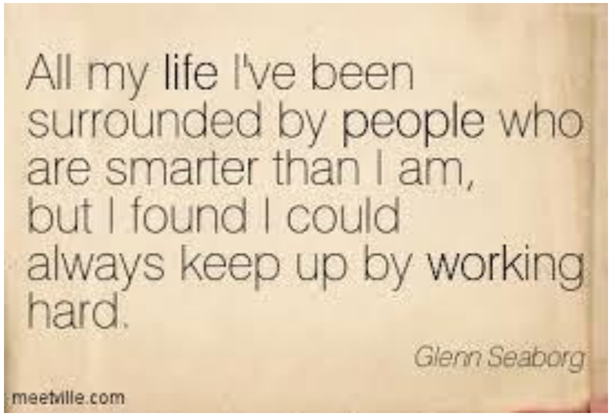
Curiosity Rover on Mars



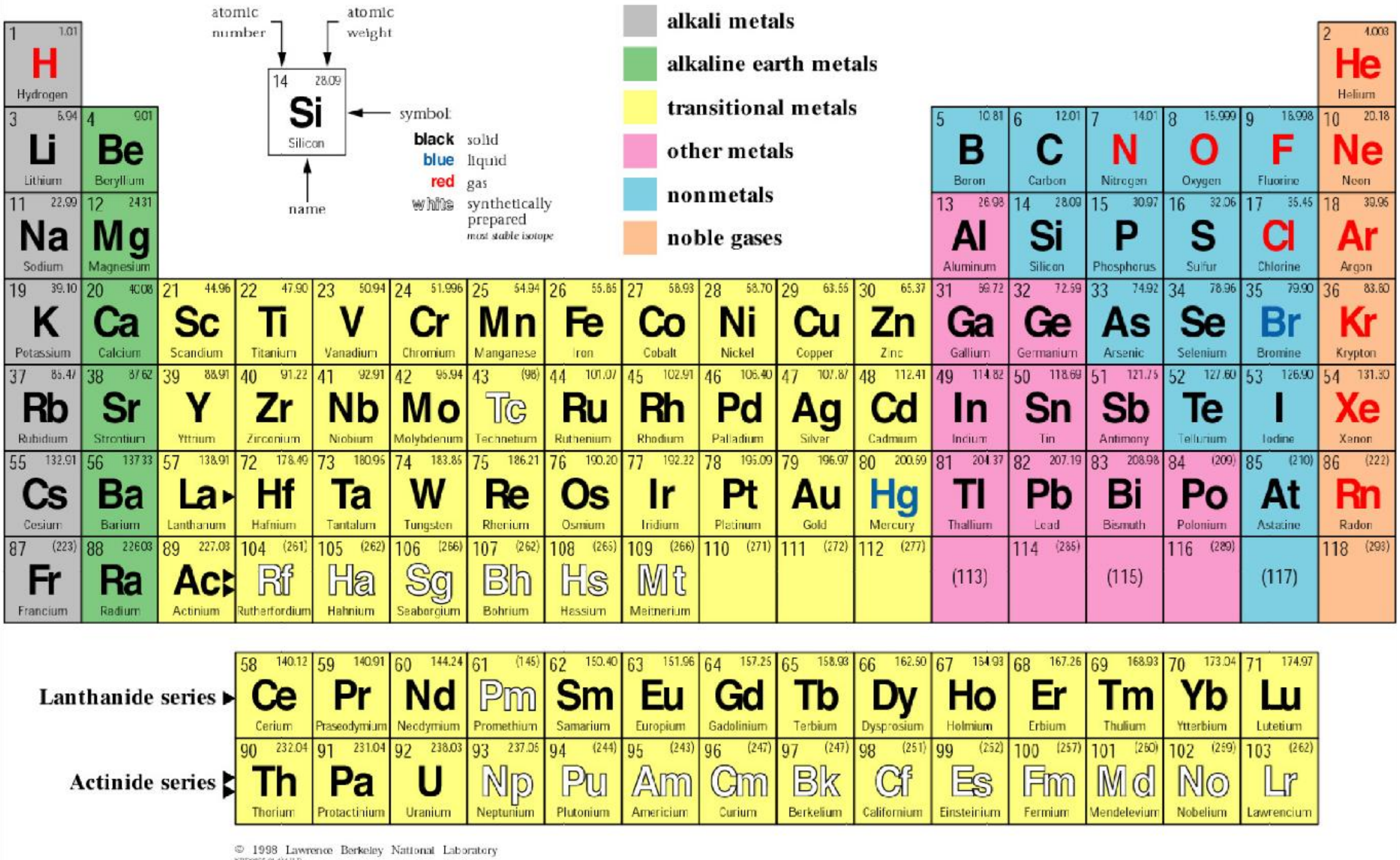




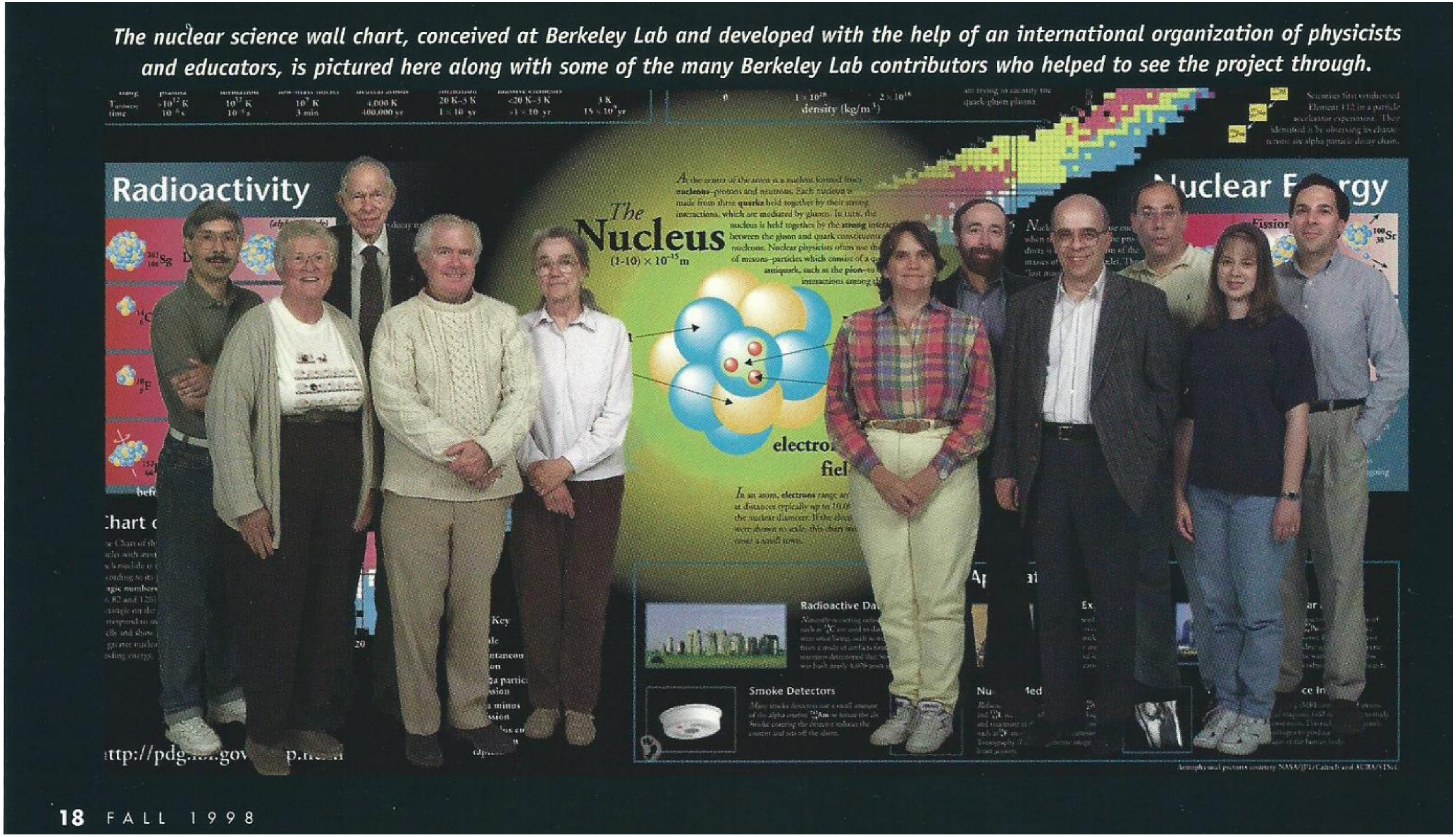
The Nobel Prize in Chemistry 1951 was awarded jointly to Edwin Mattison McMillan and Glenn Theodore Seaborg *"for their discoveries in the chemistry of the transuranium elements"*



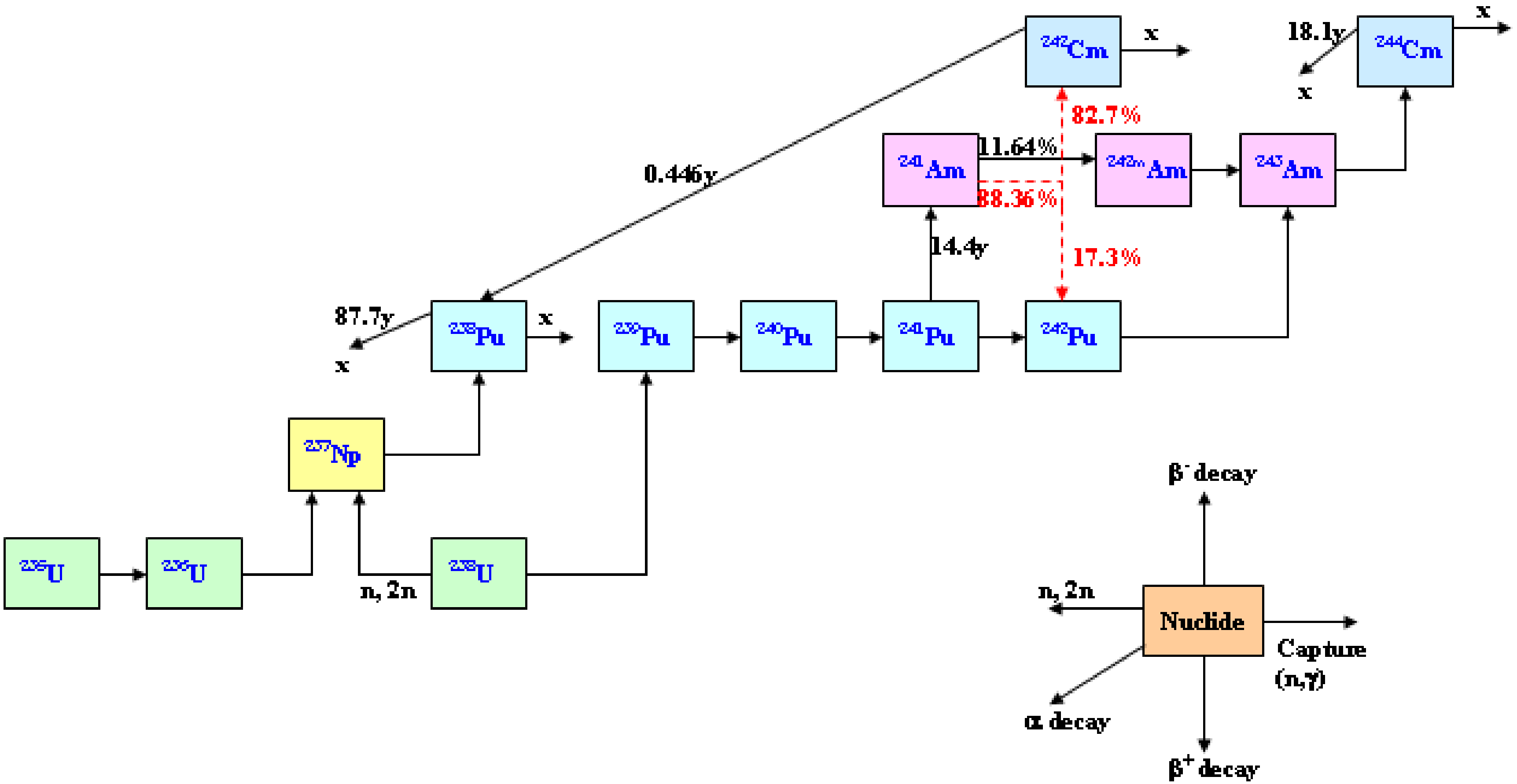
Periodic Table of the Elements



Seaborg participated in the development of the Nuclear Science Wallchart



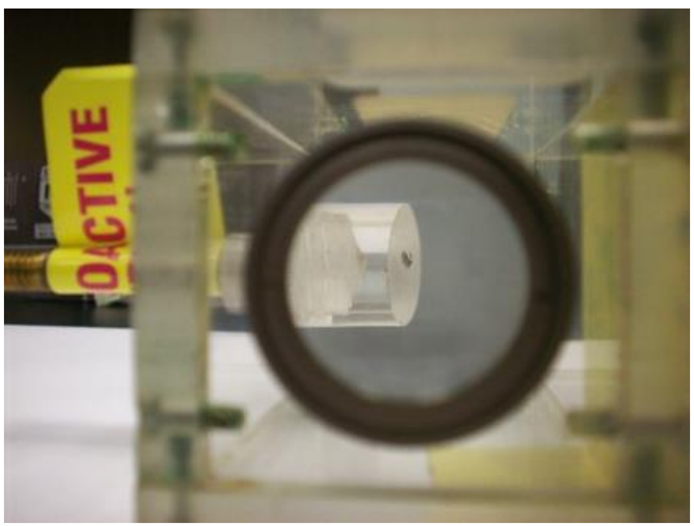
Production of Plutonium Isotopes



(a)

(b)

(c)



(a) outside of sample box with labels

(b) head-on view showing plastic rod with sample attached

(c) side view showing sample attached to plastic rod.

Keenan Thomas

Low background counting research specialist

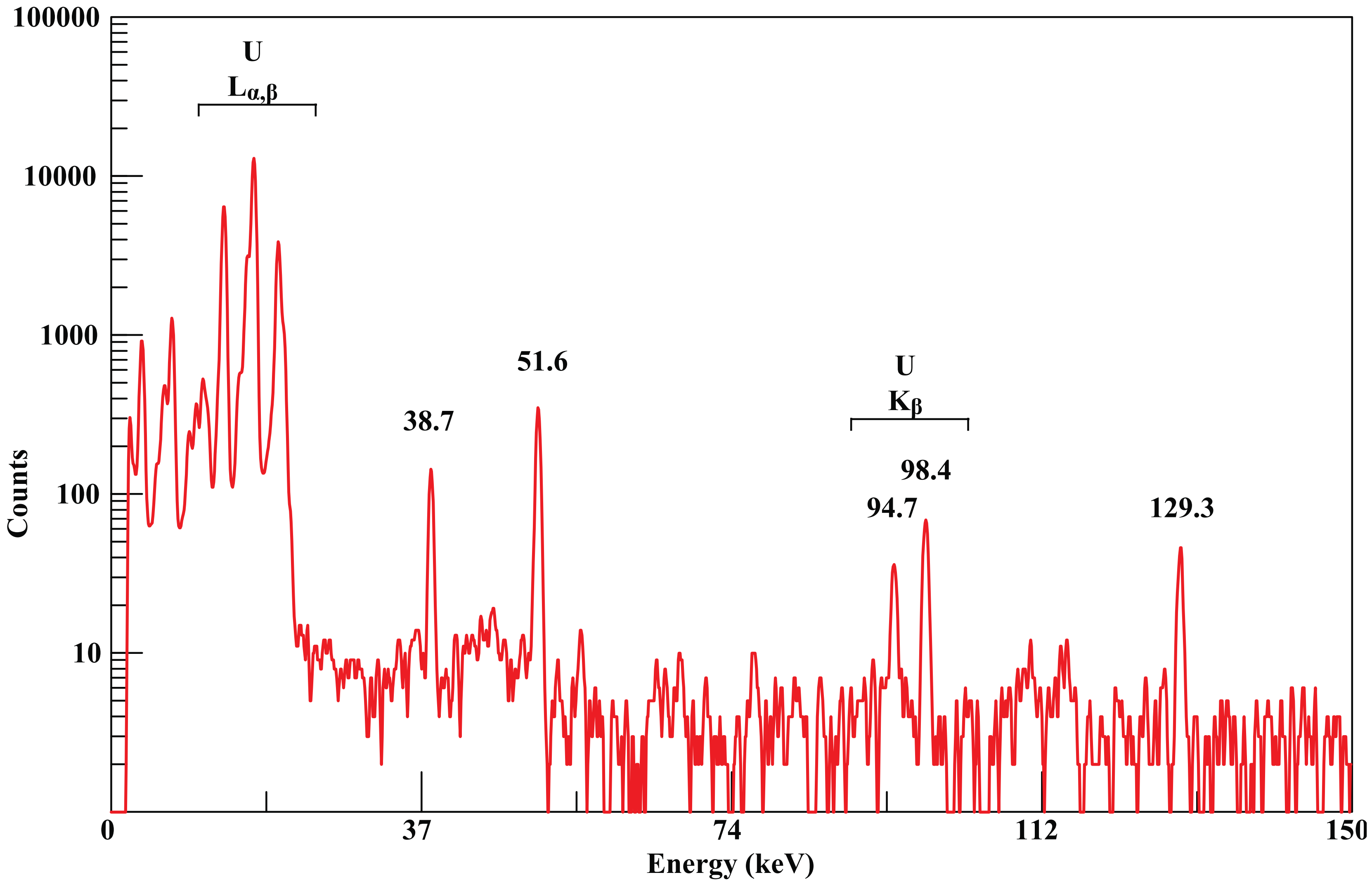
Kristina Telhami

Undergraduate student from San Diego State University

Funded by Nuclear Science and Security Consortium

Planar Ge detector used for measurements of sample S338

36-mm diameter by 13-mm thick planar germanium detector equipped with a thin Be window allowing detection of low-energy gamma rays and x rays. Shielded with 1.27 cm of copper and 5 to 10 cm of lead.

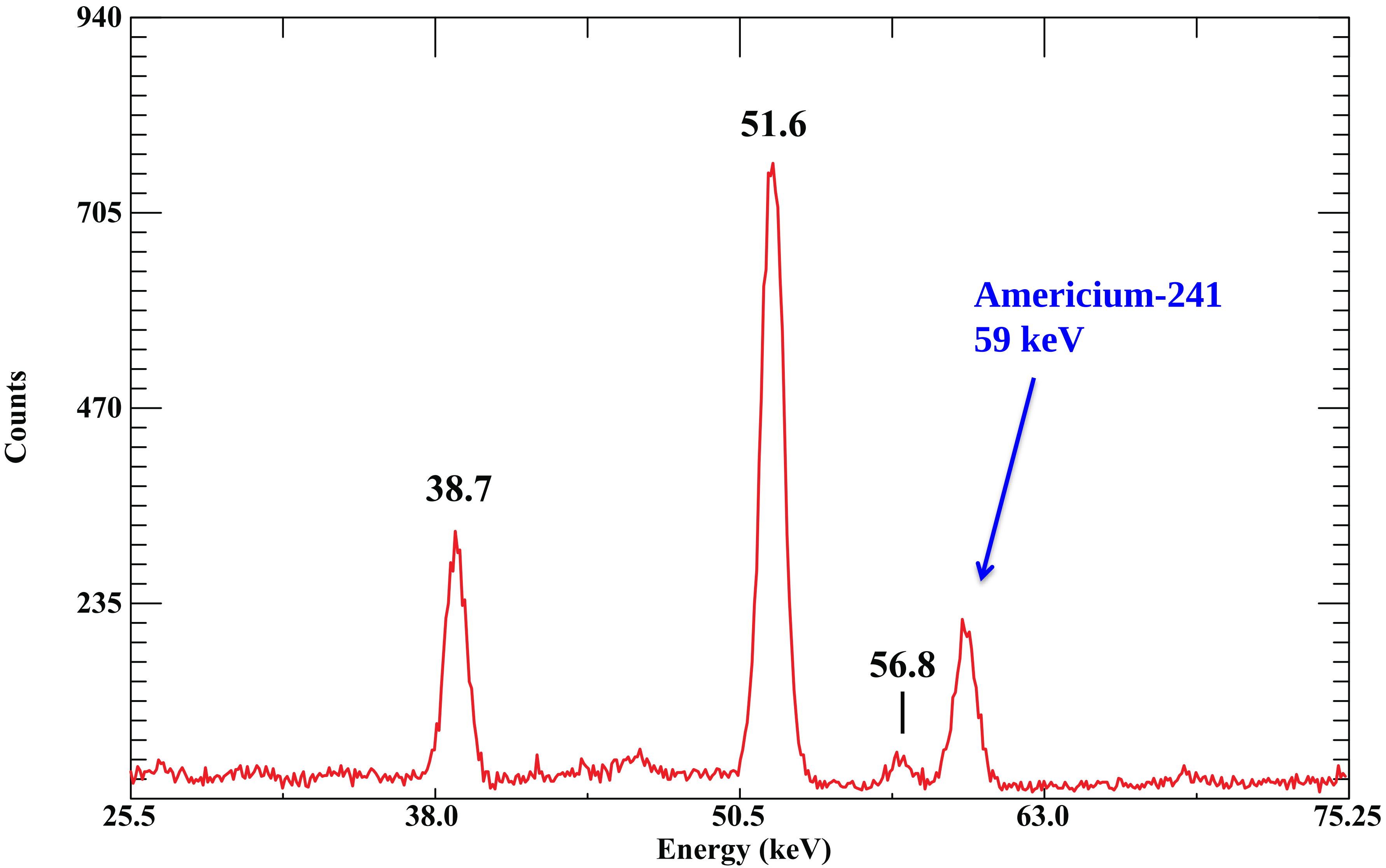


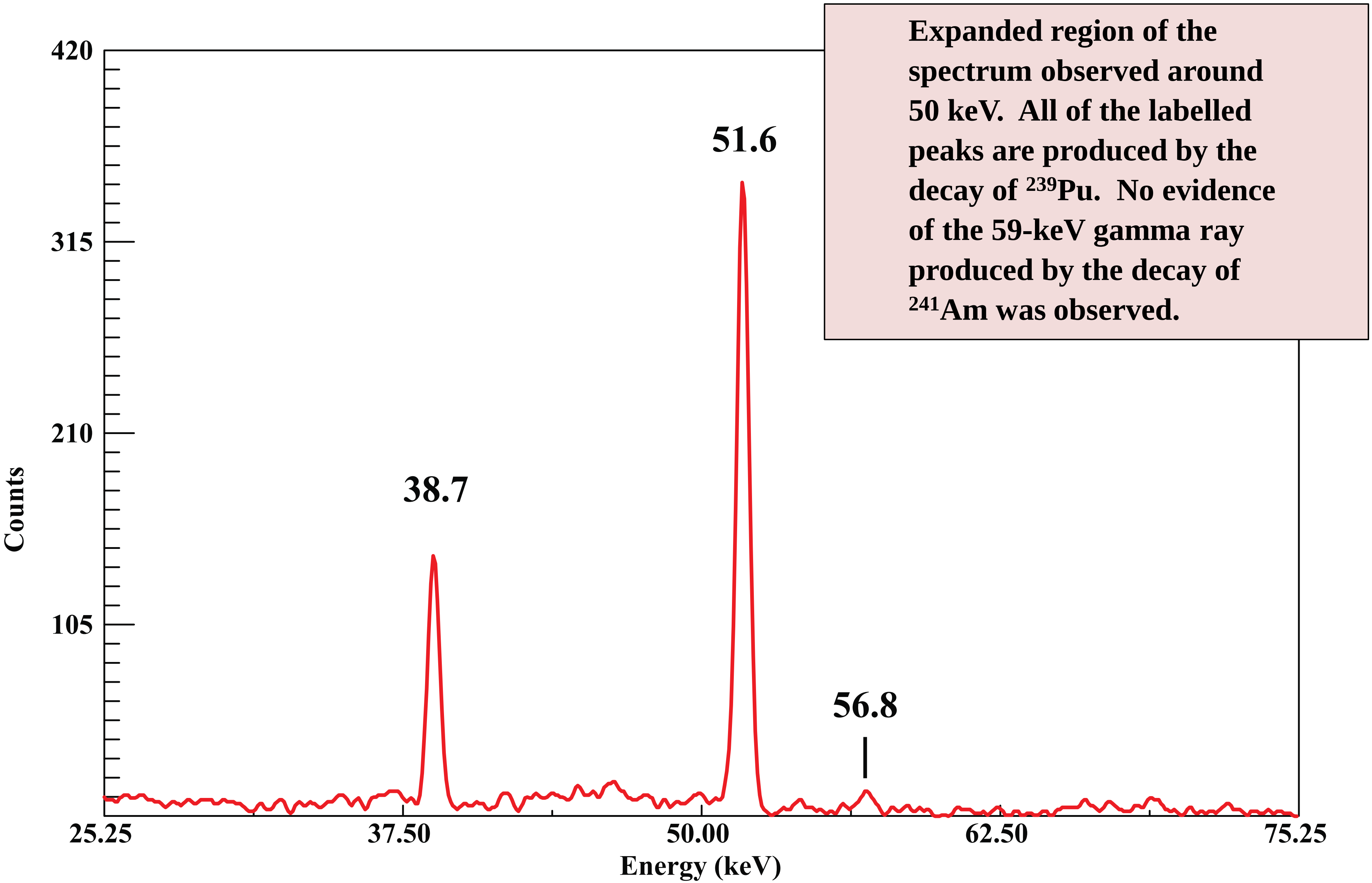
Background subtracted spectrum observed from Sample S338. All of the labelled peaks are x-rays and gamma rays produced by the decay of ^{239}Pu.

To determine the mass of ^{239}Pu contained in S338, we:

1. **Measured the efficiency of our detector using calibrated sources of ^{57}Co, ^{137}Cs, and ^{241}Am. These sources provide x-ray and gamma-ray lines at 26, 32, 36, 59, 122, and 136 keV.**
2. **Gamma-rays emitted from the S338 sample had to pass through the 0.63-cm thick wall of the plastic box in which it is contained. In order to account for the attenuation this produced, we placed a 0.63-cm thick block of polyethylene between our sources and the detector.**
3. **We extracted the peak areas of the 38.7, 51.6, and 129.3-keV lines from the spectrum obtained from S338 and then determined the sample mass from each line. Results were averaged to establish the mass of ^{239}Pu contained in sample S338 to be 2.0 $\pm$ 0.3 μg.**
4. **Seaborg stated that the first weighed sample contained 2.77 μg of PuO_2 with no uncertainty given. This would imply a ^{239}Pu mass of 2.44 μg.**
5. **Thus, the mass we determined is in reasonably good agreement with what Seaborg stated.**

Gamma Spectrum from the same detector of "modern" Pu.




420
315
210
105
Counts
38.7
51.6
56.8
25.25
37.50
50.00
62.50
75.25
Energy (keV)
Expanded region of the spectrum observed around 50 keV. All of the labelled peaks are produced by the decay of ^{239}Pu. No evidence of the 59-keV gamma ray produced by the decay of ^{241}Am was observed.

In his reports, Seaborg states that 45 kg of uranium irradiated for 2 months with neutrons (produced by deuteron breakup) produced 200 μg of Pu.

From this one can infer a total neutron fluence

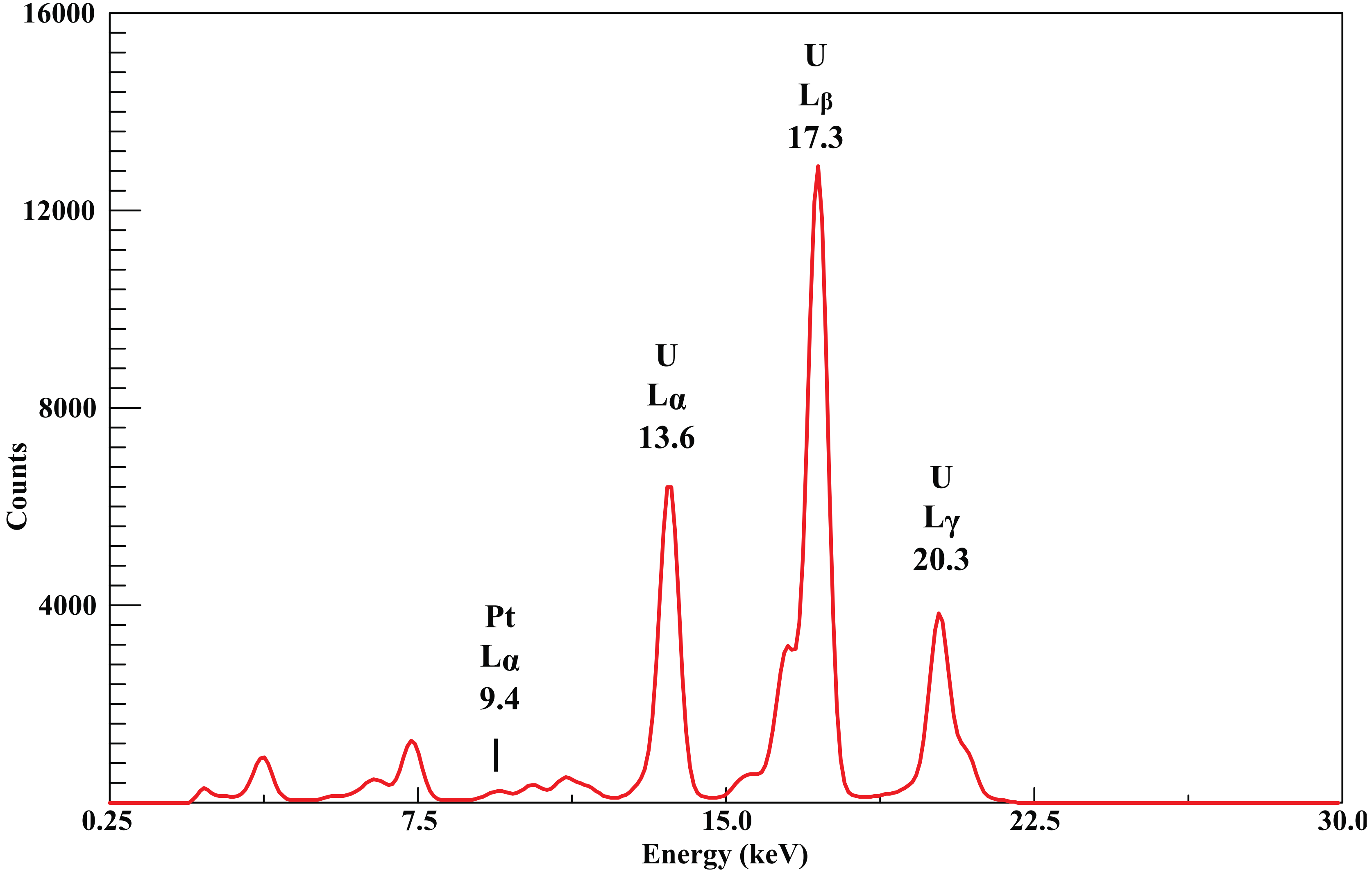
$$\Phi_n = 2\text{x}10^{15} \text{ neutrons/cm}^2$$

Note: This is about the same as fluence a uranium nucleus in a modern commercial power plant sees in a few seconds !

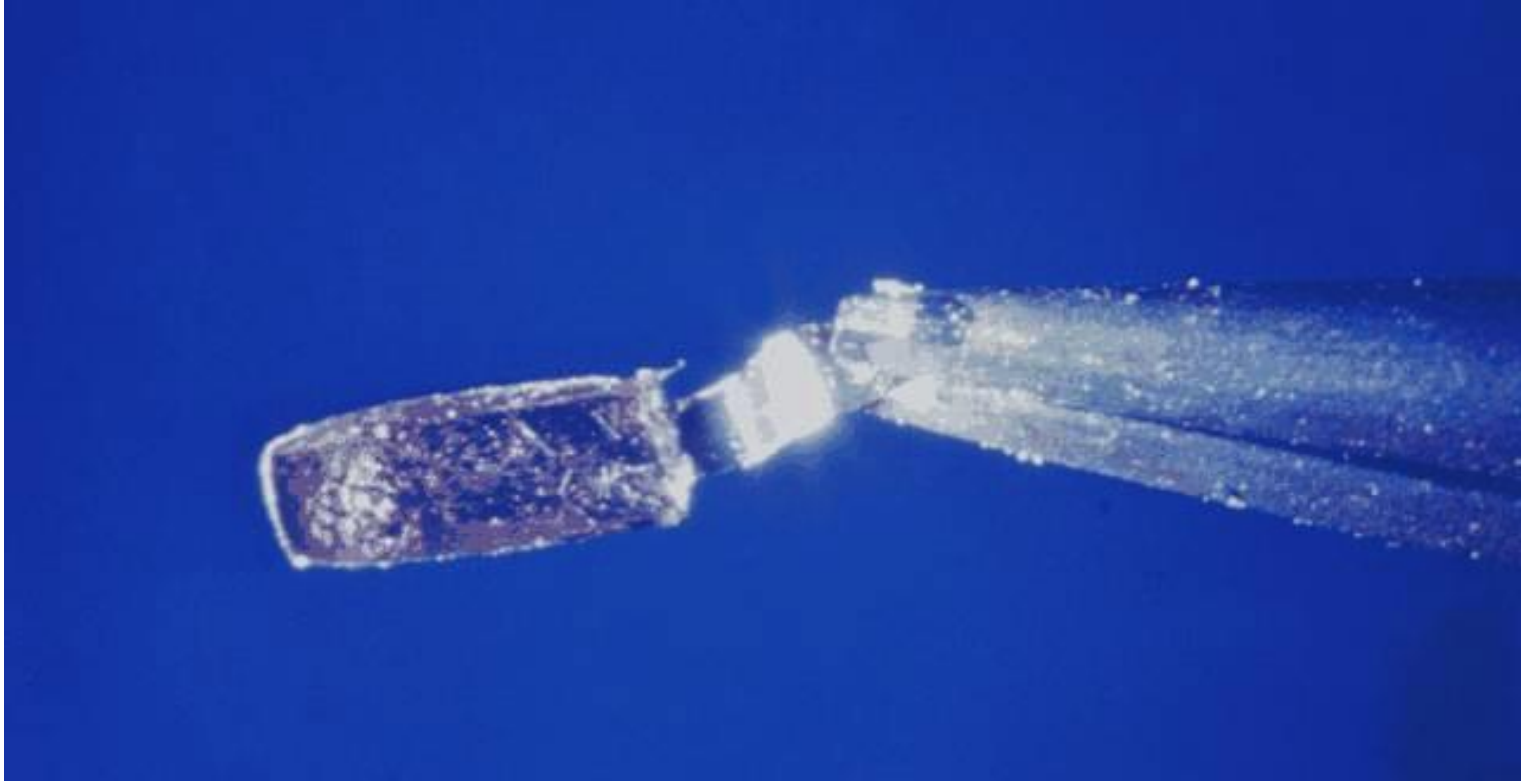
→ expect N(^{239}Pu) : N(^{240}Pu) : N(^{241}Pu) = 1.00: 3x10^{-7} : 6x10^{-14}

After 72 years, almost all of the ^{241}Pu would have decayed to ^{241}Am, producing less than 2μBq of activity(far too small for us to see)

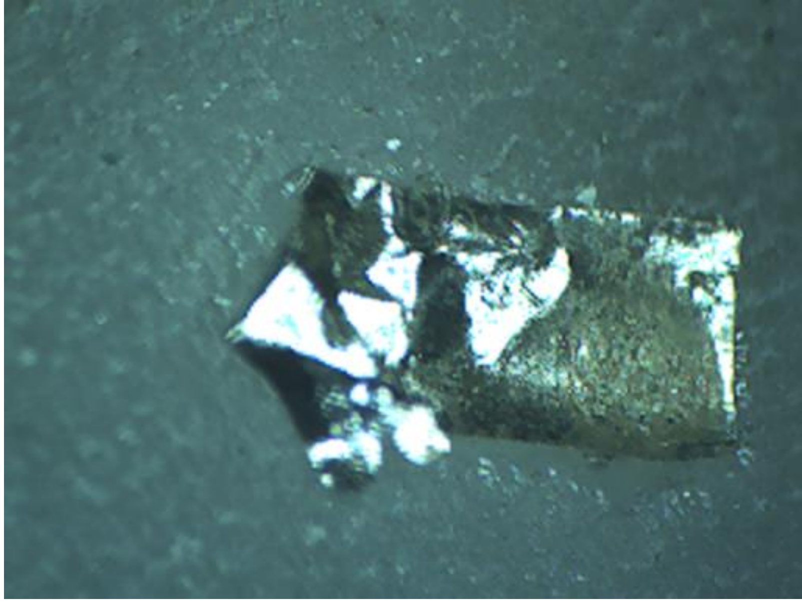
Thus, our failure to observed ^{241}Am is consistent with S338 being Seaborg's plutonium.

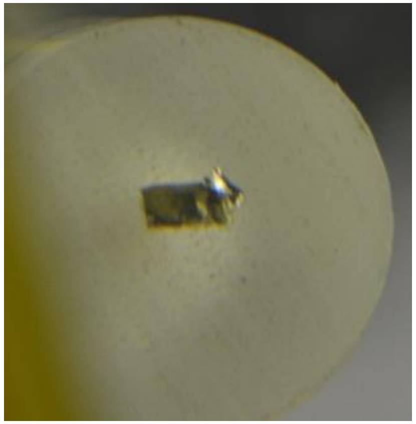


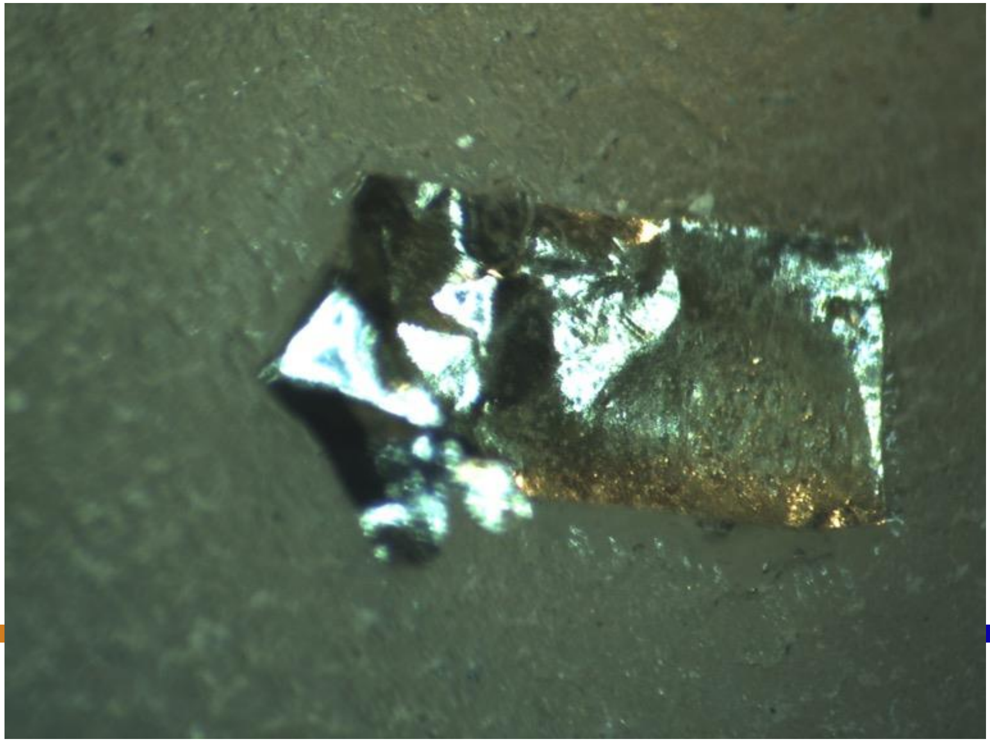
Low-energy portion of the spectrum showing uranium L x-rays produced by the decay of ^{239}Pu. The small peak at 9.4 keV is consistent with being an L_α x-ray of platinum. The peaks at lower energies are likely to be Ge escape peaks produced by the higher energy x-rays



The first sample of ^{239}Pu containing 2.7-micrograms of oxide was weighed on September 10, 1942, at the University of Chicago's Metallurgical Laboratory. It is shown here as a deposit on a platinum foil held by forceps.







If it looks like a duck, swims like a duck, and quacks like a duck, then it probably is a duck.

A **mallard** correctly identified as a duck using the duck test

Reference:

History of MET Lab Section C-I, April 1942 to April 1943, Glenn T. Seaborg (1977), p. 228-235.

NUCLEAR SCIENCE and SECURITY CONSORTIUM

http://arxiv.org/abs/1412.7590

Seaborg's Plutonium ?

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Abstract

Passive x-ray and gamma–ray analysis was performed on UC Berkeley's EH&S Sample S338. The object was found to contain ^{239}Pu. No other radioactive isotopes were observed. The mass of ^{239}Pu contained in this object was determined to be 2.0 ± 0.3 µg. These observations are consistent with the identification of this object being the 2.77-µg PuO_2 sample described by Glenn Seaborg and his collaborators as the first sample of ^{239}Pu that was large enough to be weighed.

Submitted to the American Journal of Physics

http://www.scientificamerican.com/article/manhattan-project-plutonium-lost-to-obscurity-recovered-by-scientists1/

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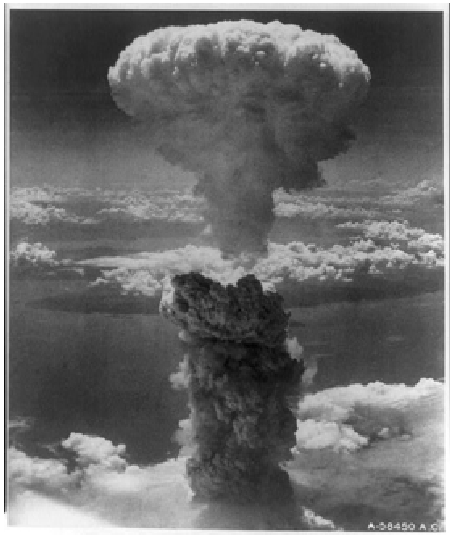
Manhattan Project Plutonium, Lost to Obscurity, Recovered by Scientists

Radioactive signatures identify one of the first pieces of plutonium seen by human eyes

January 15, 2015 | By Andy Extance |



"Fat Man," the atomic bomb dropped by the U.S. on Nagasaki, Japan, in 1945, carried about 6.2 kilograms of enriched plutonium, roughly the size of a softball. The origin of that deadly hunk of metal can be traced back via a tiny sliver weighing less than three millionths of a gram, created in the labs of Manhattan Project researchers. It is a historic fragment, embodying both stunning scientific achievement and deep tragedy—that one bomb killed and wounded at least 64,000 people (estimates vary) as well as hastened Japan's surrender. And in 2007 this historic sample, the first plutonium ever seen by researchers, vanished from the public eye.

Now it has resurfaced in a plastic box in a windowless, secure six-foot by six-foot room in the University of California, Berkeley's Hazardous Material Facility. The tiny lump, derived from Nobel Prize–winning chemist Glenn Seaborg's original discovery of the element, was accompanied by only limited documentation about its origins. But a Berkeley team has found radioactive fingerprints indicating the sliver indeed http://newscenter.berkeley.edu/2015/01/15/seaborg-plutonium/

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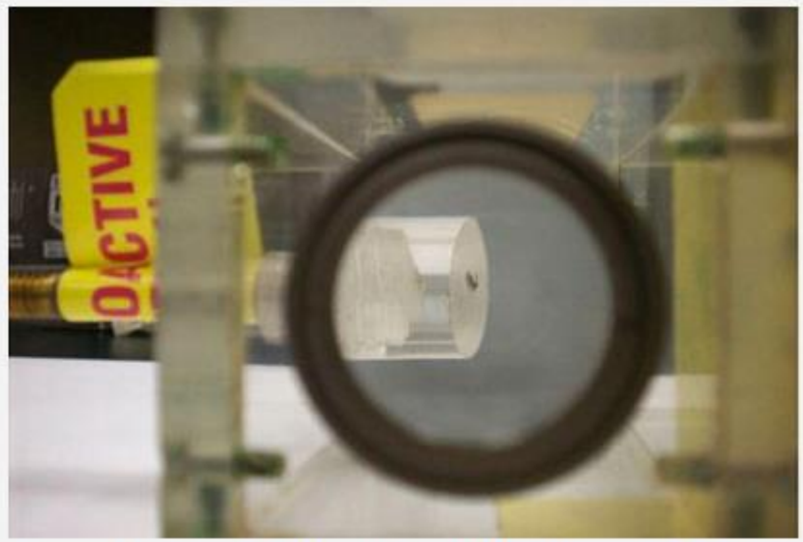
Historic plutonium sample traced to Seaborg, Manhattan Project

By Sarah Yang, Media Relations | January 15, 2015

BERKELEY — A tiny speck of plutonium on the UC Berkeley campus is making news for its connection to a momentous point in history.

The plutonium, safely secured in the campus Hazardous Material Facility, has been identified with near certainty by nuclear scientists as a sample created through the Manhattan Project, led by the late Berkeley physics professor J. Robert Oppenheimer.



Side view of a speck of plutonium created by the Manhattan Project. Created by a team led by Nobel-winning chemist Glenn Seaborg, it was the first sample big enough to be measured and weighed. (Photo courtesy of Eric Norman)

The plutonium sample was created by a team of scientists led by the late Berkeley chemist Glenn Seaborg. The synthesis of plutonium helped Seaborg earn a Nobel Prize in Chemistry in 1951. As part of the Manhattan Project, it was also an achievement that helped give birth to the atomic bomb used in World War II.

"This is the first sample of plutonium that was large enough to be weighed and its mass determined," said Eric Norman, the Berkeley professor of http://physicsbuzz.physicscentral.com/2015/01/identifying-seaborgs-lost-plutonium.html

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Thursday, January 08, 2015

Identifying Seaborg's Lost Plutonium

This is the first sample of plutonium big enough to be seen by the naked eye. Probably. There's a sticker on the side that claiming it's the first plutonium sample large enough to be weighed, but the papers documenting the origins of this atomic artifact have long since disappeared. Scientists at Berkeley have had to rely on nuclear forensics to substantiate whether this radioactive fleck was really produced in 1942 by the physicist who first discovered the element, Glenn Seaborg.

"I am 99 percent sure that's what this is," said Eric Norman, a nuclear engineering professor at the University of California, Berkeley. "[But] we can't prove it unless you find Seaborg's DNA or his fingerprints on it."

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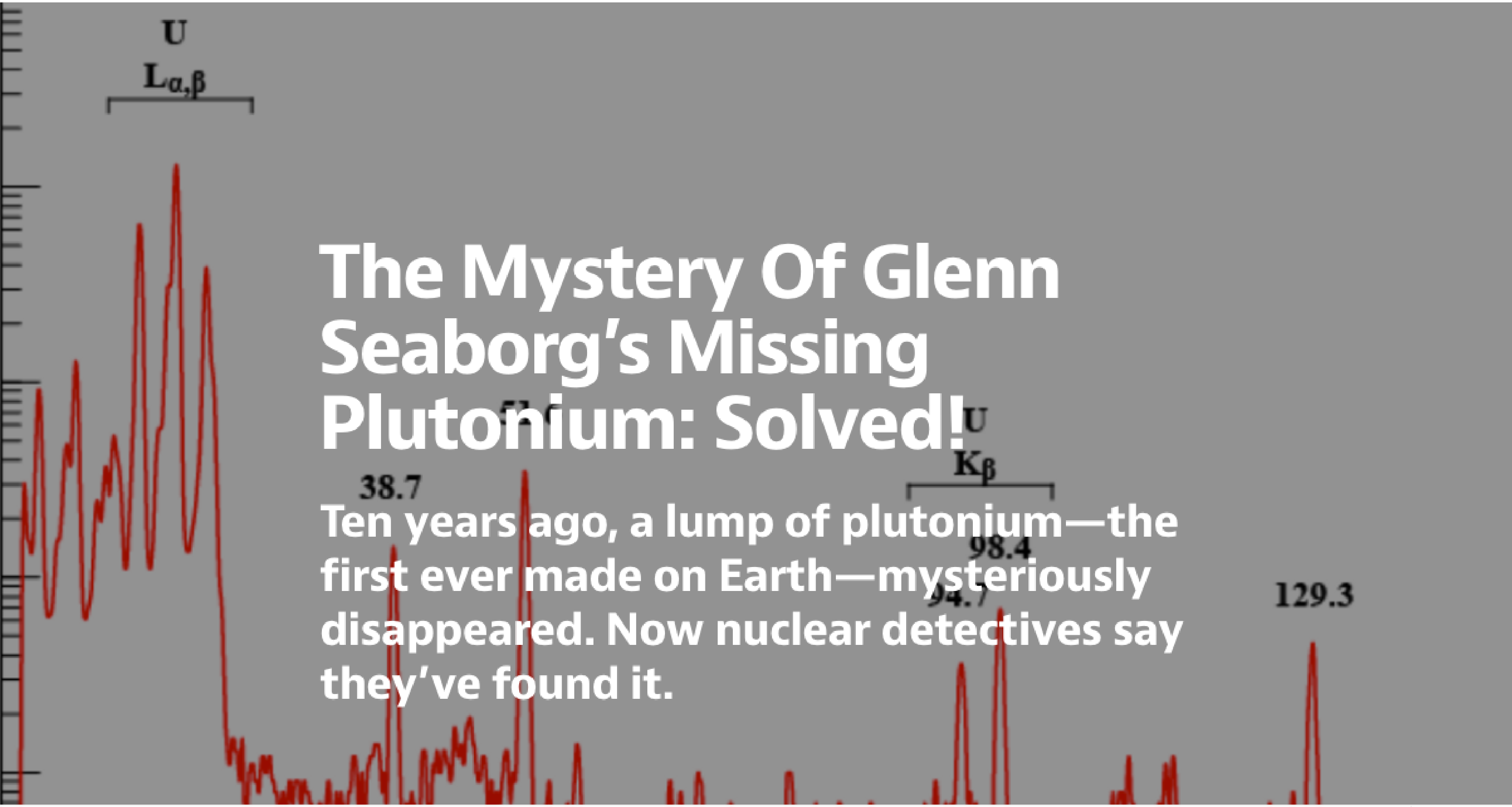

The Mystery Of Glenn Seaborg's Missing Plutonium: Solved!

Ten years ago, a lump of plutonium—the first ever made on Earth—mysteriously disappeared. Now nuclear detectives say they've found it.

The Physics arXiv Blog on Jan 7 · 4 min

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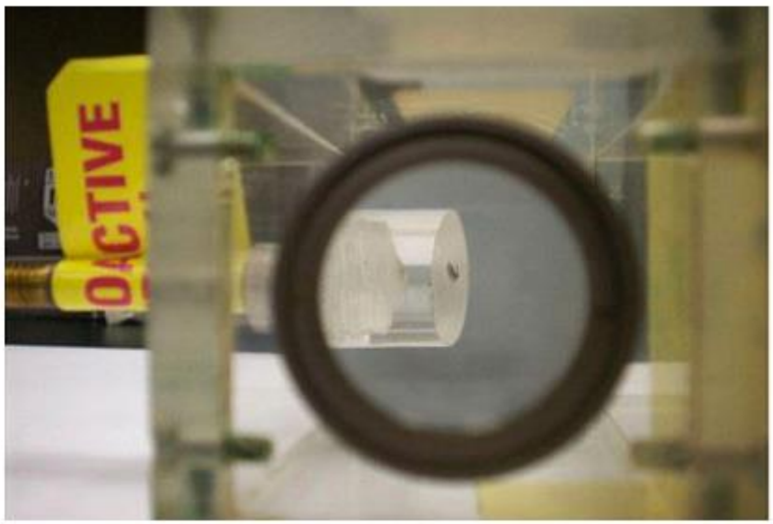

Side view of a speck of plutonium created by the Manhattan Project. Created by a team led by Nobel-winning chemist Glenn Seaborg, it was the first sample big enough to be measured and weighed. Credit: Eric Norman