# The unveiled states of americium

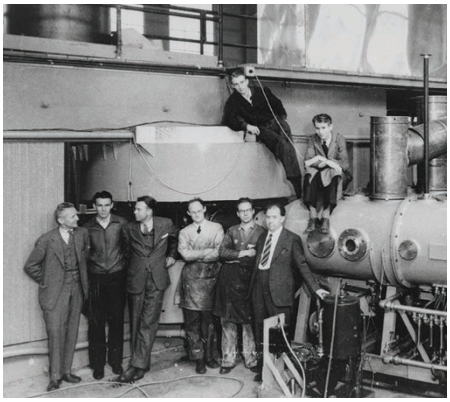
Made under a cloak of wartime secrecy, yet announced in the most public of ways — a radioactive element that governments insist we take into our homes. **Ben Still** explains how element 95 is one of real contradiction.

The Manhattan project gave rise to the world's first atomic bombs, which relied on the chain reaction of two particular fissile isotopes of uranium and plutonium. $^{235}$U, having been enriched from its natural abundancy, was used for the first atomic weapon. Little Boy, as it was codenamed, was dropped on Hiroshima on the 6th of August, 1945. Three days later the second atomic bomb, Fat Man, was detonated over Nagasaki: for this bomb, high densities of neutrons in nuclear 'breeder' reactors transformed abundant $^{238}$U into $^{239}$Pu.

It was realized early in the project that if the $^{239}$Pu in the Fat Man bomb were to be transportable and only reach criticality (the point at which nuclear chain reaction can be self-sustained) when desired, then any and all impurities had to be carefully studied and understood[1]. It was the task of those working in the Metallurgical Laboratory (Met Lab) at the University of Chicago (now the Argonne National Laboratory) to identify and analyse the properties of these new synthetic elements.

Some isotopes were notoriously difficult to extract and so scientists at Berkeley Laboratory used Ernest Lawrence's atom smasher — a 60-inch cyclotron — to create them in a controlled environment. Samples of $^{238}$U and $^{239}$Pu were bombarded with high-energy alpha particles (helium nuclei) to recreate environs present in breeder reactors. With $^{239}$Pu this process resulted in element 96, now named curium, whereas with $^{238}$U it produced element 95. Using this method, the Berkeley scientists were able to obtain a large enough quantity of both new elements to enable the team at the Met Lab to identify their properties.

After irradiating $^{238}$U with $^{4}$He nuclei they discovered a hitherto unseen low-energy emission — the β-decay of $^{241}$Pu. This process, transforming one neutron into a proton, resulted in an element with atomic number 95 and mass number 241. In the autumn of 1944 this observation was the first confirmed sighting of element 95 (ref. 2). Further experiments produced other isotopes, of which the $^{243}$95 isotope was found to be the most stable. The very existence of the element was classified and would remain secret until the war came to a close.



Ernest Lawrence (third from the left) and his team in front of the 60-inch cyclotron that produced the first measureable sample of americium.

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Once the cloak of secrecy was shed in late 1945, the discovery of elements 95 and 96 was announced to the world in an unexpected way. Their unveiling was planned for the American Chemical Society's national meeting, scheduled for the 16th of November. Instead, Glenn T. Seaborg told a national audience live on radio during a show called *Quiz Kids* five days before the conference[3]. He was asked by a child contestant if any other elements, aside from plutonium and neptunium, had been discovered at the Met Lab during the war. Seaborg disclosed the discovery of elements 95 and 96, telling his young audience "now you'll have to tell your teachers to change the 92 elements in your schoolbook to 96 elements".

Element 95 was named americium (Am) by Seaborg and his team[2], giving recognition to the location of its discovery, but also mirroring its lanthanide opposite number: europium. It is the only radioactive element that governments insist we keep in our homes. $AmO_2$ is a key component of smoke detectors: around 0.3 μg of the isotope $^{241}$Am sits inside a sealed metal box at the heart of the device, spitting out alpha radiation. The small electric charge arising from ionization of air by the alpha radiation lets the detector know everything is just fine. However, large smoke particles absorbing the alpha radiation reduce the amount of ionization and thus electric current, which triggers the detector to sound the alarm.

Americium is most commonly trivalent in solution, with tetravalency also frequent in solids such as the oxide mentioned above. However, states +2 to +7 have been reported experimentally, and even Am(VIII) has been suggested as being potentially accessible — albeit somewhat speculatively[4].

Although the radioactivity of plutonium is used to provide thermonuclear energy to deep space exploration satellites, there are ever tighter regulations around its sale and use on account of its fissile nature. Americium on the other hand is non-fissile, which is enticing European space scientists to consider using it as a plutonium alternative for future missions[5].

Ever since its discovery was announced on live radio, element 95 has found its way into our homes, and it could soon be powering our exploration to the furthest reaches of the cosmos. ❐

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