short-term R&D projects. "As NRC's capacity to maintain projects and facilities at the leading edge diminishes, key staff and top scientists may be lost," officials write in the report, dated 31 August.

To recoup its losses, the NRC is asking for annual increases of $16 million in federal funds in each of the next three fiscal years, beginning on 1 April 1999. It is also requesting $165 million for new "strategic initiatives" in five areas: aerospace, genomics, optoelectronics, fuel cells, and information networking. "NRC has been successful in the past because it has been willing to invest for the long term," says president Arthur Carty. "Our strength is medium- to long-term R&D in strategic areas that are absolutely crucial to Canada." Government officials declined to comment on the details of the plan.

The fate of the initiatives, say observers, depends on the NRC's ability to make them stand out in a crowd. The proposal to build an optoelectronics prototyping foundry for small- and medium-sized businesses within the information and telecommunications sectors, for example, is being touted as "unique in the world." But the plan to develop a national genomics program conflicts with a similar initiative from the Medical Research Council (MRC) that has been slow to get off the mark (*Science*, 3 July, p. 20), and with a separate proposal from the Canadian Institutes of Health Research (*Science*, 8 May, p. 821) for a network of centers that could include work in genomics. In fact, the MRC and NRC recently struck a preliminary agreement to develop a joint genomics initiative that would stand a better chance of winning support.

One point in the NRC's favor is the promise of matching funding from industrial and university partners for each of the five proposed initiatives. That commitment is particularly strong for the aerospace proposal, which includes building a center for more energy-efficient generation of gas turbines in Ottawa and an advanced aerospace manufacturing technology facility in Montreal. Some industrial partners have long been urging the government to do more. Last month, in announcing a planned 25% cut over the next 18 months in its R&D workforce, Pratt & Whitney Canada said the government's "commitment to support future R&D is insufficient to allow us to stay fully competitive in the global aerospace market." **–WAYNE KONDRO**

Wayne Kondro writes from Ottawa.

HEAVY ELEMENTS

# Fast Chemistry Snares Stray Plutonium Isotope

Since it was first used to produce nuclear weapons in 1945, plutonium has inspired its share of fear. But the element has inspired mysteries as well, notably the case of its missing isotope. Over the past 50 years, researchers have isolated a total of 17 plutonium isotopes, all with different numbers of neutrons in their nuclei. But one predicted isotope—plutonium-231—remained at large. Now at last the search for plutonium-231 is over. At the American Chemical Society meeting in Boston late last month, a team from the University of California, Berkeley, and the Lawrence Berkeley National Lab (LBNL) reported using some fleet-footed chemistry to pin it down.

"People have been saying all along that it should be there. But it wasn't easy to find," says Alice Mignerey, a nuclear chemist at the University of Maryland, College Park. The challenge came in spotting plutonium-231's characteristic pattern of radioactive decay amid those of other nuclides. "It's really quite a coup these days to measure anything new," says Mignerey. The new isotope isn't likely to find much practical use: It has a half-life of just 8.5 minutes. Still, other nuclear chemists are hailing the discovery for filling in a long-sought piece of the nuclide table and confirming models of nuclide stability.

> "It's really quite a coup these days to measure anything new."
> —Alice Mignerey

Making the isotope was the easy part for the Berkeley team, led by postdoc Carola Laue and chemistry professor Darleane Hoffman. The group used LBNL's cyclotron to bombard a stack of uranium targets with helium-3 ions. As the helium ions—each containing two protons and a neutron—collide with the targets, some or all of their protons and neutrons fuse with the uranium nuclei to produce new nuclides, in this case plutonium, neptunium, uranium, and thorium.

Isotope hunters track their targets by looking for the characteristic chain of decays as an unstable nucleus splits apart or spits out various particles, yielding daughter nuclides that decay further until they reach a stable nuclide. Plutonium-231 is hard to identify, however, because its decay chain includes uranium and neptunium isotopes that can be produced in the same cyclotron reaction, mimicking the plutonium-231 signal. Hence the researchers had to do some rapid chemistry to sift the plutonium isotopes from the other elements in time to watch for the plutonium-231's signature decay chain.

To do so, the researchers gathered the nuclides blasted out of the target into a gas stream flowing into a thin capillary tube. They had spiked the gas with ultrafine potassium chloride particles that bound to the radioactive elements. At the end of the capillary tube the particles, now laced with nuclides, were deposited on a collection plate. To extract the plutonium isotopes, Laue dissolved the potassium chloride in nitric acid, which then passed through a tiny separation column. The column contained an ammonium-based resin, which binds to heavy elements with four positive charges, snagging the plutonium and thorium isotopes. After washing everything else out of the column, Laue flushed out the thorium with hydrochloric acid, then added hydrogen iodide to free the plutonium so it too could be washed out. A quick dry-out left a residue of pure plutonium.

The final challenge came in picking out plutonium-231's decay signal. Calculations suggested that plutonium-231 would either emit an alpha particle to create uranium-227 or snag an electron, converting a proton to a neutron and creating neptunium-231. Plutonium-232, which the cyclotron reaction also produced, emits an alpha to create uranium-228. The decay chains of all three of these daughter nuclides are well known. And because the researchers had previously removed any uranium or neptunium, they could now be sure that if their sensitive detector registered uranium-227 or neptunium-231, these chains originated from plutonium-231. Once they had placed their pure plutonium sample in the detector, "we just watched the [uranium-227 and neptunium-231] signatures grow back in," says Hoffman, confirming the presence of plutonium-231.

Laue and Hoffman note that several other isotopes, such as americium-231, remain to be found. Flushed with solving one mystery, the Berkeley detectives are now off to tackle another. **–ROBERT F. SERVICE**

BROOKHAVEN NATIONAL LAB

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plutonium | Pu228 | Pu229 | Pu230 | Pu231 | Pu232 | Pu233 | Pu234 | Pu235 | Pu236 | Pu237 | Pu238 | Pu239 | Pu240 | Pu241 | Pu242 | Pu243 | Pu244 | Pu245 | Pu246 |
| Neptunium | | Np228 | Np229 | Np230 | Np231 | Np232 | Np233 | Np234 | Np235 | Np236 | Np237 | Np238 | Np239 | Np240 | Np241 | | | | |
| Uranium | U226 | U227 | U228 | U229 | U230 | U231 | U232 | U233 | U234 | U235 | U236 | U237 | U238 | U239 | U240 | | | | |

**Isotope unmasked.** Nuclide table showing the possible decay routes of "missing" isotope plutonium-231.