NUCLEAR PROLIFERATION

German Lab Points the Way In Hunt for 'Hot' Plutonium

Lufthansa Flight 3369 from Moscow to Munich typically carries an assortment of German executives, Russian tourists, and diplomats. But on 10 August, the Boeing 737 also bore a more sinister passenger—a lead-lined suitcase holding three-quarters of a pound of plutonium. The arrests of three men—two Spaniards and a Colombian—at Munich International Airport as they claimed the deadly baggage ended a successful sting aimed at disrupting an alleged international smuggling ring. But for scientists, the response by the police was merely the opening page of a technological detective story whose final chapter has yet to be completed. As the accused were led off to jail, scientists were left to puzzle out the exact nature of the nuclear material in the suitcase and, more importantly, where it came from. By applying a battery of tests, they have narrowed the prime suspect sources to a handful of research labs.

Because the Bavarian police department is a bit short of nuclear physicists, it rushed the contraband to a European Union laboratory 150 miles northwest of Munich. The lab, the European Trans-Uranium Institute (ETUI) in Karlsruhe, specializes in tracing the origins of stolen nuclear material. "It's a very businesslike place," says Lawrence Berkeley Laboratory Nobel laureate Glenn Seaborg, who has visited ETUI. Not a place to hang out in the hallways and shoot the breeze, says Seaborg, who co-discovered plutonium 54 years ago. "But they are very competent people," he adds.

The suitcase contained a steel cylinder that held 560 grams of a dark-gray powder. The first order of business was to get a better idea of what was in the container. Radioactivity measurements indicated that the sample was a strong source of gamma rays, suggesting it consisted of a large amount of odd-numbered isotopes of plutonium. (Plutonium exists in five isotopes, 238 to 242.) That discovery was alarming, because the primary ingredient in many nuclear weapons is an odd-numbered plutonium isotope—239.

The next step was to scan the powder for emitted neutrons. Even-numbered isotopes, because they have a higher rate of spontaneous fissions than odd-numbered isotopes, slough off more neutrons. The good news was that the sample emitted lots of neutrons—too many, says ETUI physicist Roland Schenkel, for the plutonium to be "weapons-grade," defined as 93% plutonium 239.

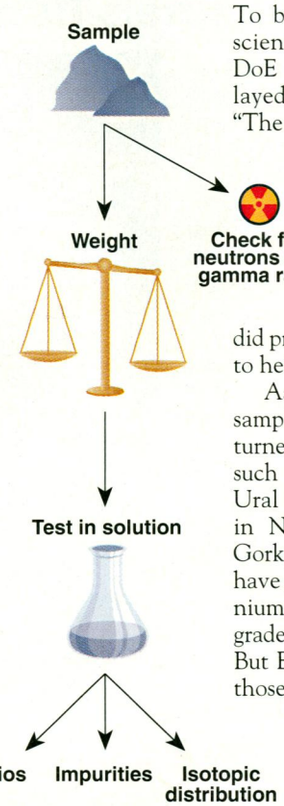
The ETUI sleuths then turned to what Schenkel calls a "high-precision" analysis. The goal was to learn whether the sample came from a military or a civilian source. The first part of that analysis required dissolving part of the sample in nitric acid and analyzing the solution in a K-edge densitometer, which beams x-rays at the solution to determine the densities of dissolved elements. This would reveal the ratio of plutonium to uranium, information that would suggest the kind of reactor the fuel was fabricated for. The ETUI scientists already suspected the powder to be high-reactivity Mox, a mix of plutonium oxide and uranium oxide used as fuel in some reactors. However, they found that the plutonium-uranium ratio of the contraband "was not consistent with the stuff being burned in a Mox fuel operation," says a chemical engineer at Oak Ridge National Laboratory who requested anonymity.

Foiled, the ETUI scientists turned to a new line of investigation: measuring the proportion of the various plutonium isotopes, which varies according to how long plutonium is irradiated in a reactor. "From this data you can postulate what kind of reactor the plutonium came from," says Arne Olson, a nuclear engineer at Argonne (Illinois) National Laboratory. Again, however, the results were inconclusive: The impounded Mox had a "funny" composition, says Seaborg. Of the 350 grams of plutonium in the powder sample, about 87% was plutonium 239. This isotopic purity placed the plutonium in a gray area between what is produced by military and civilian reactors.

ETUI researchers then analyzed the sample in a glow discharge mass spectrometer for small amounts of impurities that may provide clues to the origin of the material. Finding an impurity such as the element americium, for instance, a decay product of plutonium 241, would help confirm that the material came from Russian sources. "In the United States, americium has been removed when reprocessing plutonium for warheads, while I understand that in the former Soviet Union americium removal was unnecessary because fresh weapons-grade plutonium was produced in reactors," says Alexander DeVolpi, a physicist at Argonne. The Europeans also remove americium, he says.

Another element that helps flag a sample's origin is gallium, which is often used as a stabilizer. "If you found gallium," DeVolpi says, "it's reasonable to expect it was there for fabricating pits"—the shaped metallic plutonium installed in warheads. Schenkel refused to reveal results of ETUI's analysis of impurities, and sources at the U.S. Department of Energy (DoE) say they had no information as *Science* went to press.

Next, the ETUI scientists wanted to know if the information gleaned from the tests "fits any [facility] we know," says Schenkel. But like trying to catch a thief who's never been fingerprinted, all the analyses may be for naught unless the matching information is already in the ETUI database.



Step by step. Scientists have put the confiscated plutonium through rigorous analysis to track down its source.

To broaden their search, ETUI scientists sent their results to DoE headquarters, which relayed the data to its weapons labs. "The United States might have some information on file to compare their data against computer models we have developed," says DeVolpi. Indeed, a DoE official says the department did provide classified information to help rule out possible sources.

As information about the sample accumulated, suspicions turned to Russia's weapons labs such as Chelyabinsk-70 in the Ural Mountains or Arzamas-16 in Nizhnii Novgorod, formerly Gorky. There, scientists could have produced Mox rich in plutonium 239 by mixing weapons-grade plutonium with uranium. But ETUI and others considered those sites improbable suspects. Both facilities, say DeVolpi and other scientists, are fenced in and impose strict criteria for entering and leaving. Experts also doubt the material came from nuclear fuel processing centers such as Chelyabinsk-65, which, like the nearby weapons labs, are guarded closely. "I don't have any reason to believe that the Russian weapons labs don't have good safeguarding systems set up," says Alan Waltar, manager of the nuclear engineering group at Westinghouse in Hanford, Washington, and president of the American Nuclear Society.

A more likely source, the scientists reasoned, would be a nuclear power plant or

associated fuel-fabrication facility, or a research institute. Fuel-fabrication facilities are likely candidates for a nuclear thief, DeVolpi says. Such facilities, where uranium and plutonium are converted to oxide and stored, include Elektrostal near Moscow, the Chim Concentrate fuel factory in Novosibirsk, Russia, and Ust'-Kamenogorsk in Kazakhstan. However, other experts are banking on scientific institutes. "Because the material out of Munich is high in plutonium, I would suspect a research reactor rather than a power plant," says William Sutcliffe, a physicist at the Center for Security and Technology Studies at Lawrence Livermore National Laboratory.

So that leaves the question: Which research reactor? ETUI investigators considered the Kurchatov Institute, a physics research lab in Moscow. "We happen to know that the [Kurchatov has] an electromagnetic isotope separator" that could be used to increase the composition of plutonium-239, says the Oak Ridge scientist. But the Kurchatov probably is not the culprit in this case—"it wouldn't have enough material," says Vladimir Minkov, an Argonne nuclear engineer and former employee of the Krzhizhanovsky Power Engineering Institute.

Minkov, who has been in close contact in recent weeks with Russian atomic energy officials and other Russian scientists, has his own candidates that best fit the technical profile drawn by ETUI and have less stringent security than the weapons labs. They are the Buchvar Institute of Inorganic Materials in Moscow, the Institute of Physics and Power Engineering in Obninsk outside Moscow, and the Institute of Atomic Reactors in Dimitrovgrad, 500 miles east of Moscow. Several other weapons experts contacted by *Science* concurred with Minkov's list.

Schenkel has declined to say whether ETUI has found a match for the confiscated plutonium. And Russian officials have denied that there is any plutonium missing from their military bases or scientific institutions, a claim that physicist Wolfgang Panofsky, chair of a National Academy of Sciences panel that produced a recent report on plutonium management, says is "not credible." Even so, ETUI scientists and German police hope to collaborate with Russian officials to determine the exact source of the plutonium that flew into Munich 3 weeks ago—and to prevent a repetition.

–Richard Stone

ASTRONOMY

Scopes and Squirrels Return to Court

Once again, Arizona astronomers hoping to peer deep into space with a new telescope are seeing nothing but squirrels and lawyers. In a decade-long turf war over the summit of Arizona's Mount Graham, the astronomical community has frequently sparred with environmentalists bent on keeping telescopes off the mountaintop, largely because it's the only home for the endangered Mount Graham red squirrel. Until this summer, astronomers have won all their legal battles. But last week, a U.S. appeals court handed down a ruling that will—for the time being—keep them from preparing a site for one of the world's most powerful optical telescopes.

BOB MILES/ARIZONA GAME AND FISH COMMISSION

Seeing red. Environmentalists seeking to protect the endangered Mount Graham red squirrel have blocked new telescope construction on the mountain.

This latest court decision denied the University of Arizona's emergency request to lift an injunction against further work on the summit. That injunction had been granted by a lower court judge in late July when he ruled that new environmental and biological impact reviews were needed because astronomers had changed the planned location of the telescope. In an ironic twist, researchers argue that they had made the site change to minimize harm to wildlife. "I thought these people were on the side of the squirrels. In my view, this is pure obstructionism," says Arizona astronomer Roger Angel. Robert Smith of the Sierra Club doesn't disagree: "We simply don't want them to build telescopes."

For more than a decade, the University of Arizona has spearheaded the push to build a world-class observatory on the summit of Mount Graham. Despite opposition from the Mount Graham Coalition, which includes groups like the Sierra Club, the National Audubon Society, and the National Wildlife Federation, astronomers have so far managed to erect two telescopes. And last December, after getting permission from the U.S. Forest Service and the Fish and Wildlife Service, the university began cutting down trees as site preparation for a third instrument: the Large Binocular Telescope (LBT), a $60-million facility that would combine the light-gathering powers of two 8-meter mirrors. Although the red squirrel furor has scared away a number of LBT backers, two partners, the Research Corporation of Tucson and an Italian consortium, have remained on board.

As soon as those trees fell, however, a new round of controversy erupted. Astronomers had gotten federal approval to shift the telescope's site to another peak on the mountaintop, about 1000 feet from the original site. Similar site changes had been made for other structures on the mountain, says Angel, and university and U.S. Forest Service biologists monitoring the squirrel population had concluded that the new site would have less effect on the squirrels. Not everyone shares that view. "The jury is still out on whether it's better or worse," says Roger Featherstone of the coalition.

The site change did, however, provide observatory opponents like Featherstone with an opening to stall the project. In 1988, in a move that infuriated environmentalists, the Arizona astronomers successfully lobbied Congress for a law that exempted the observatory from the Endangered Species Act and the National Environmental Policy Act, both of which would have required federal reviews of biological and environmental impact of any development on the mountain. Those exemptions, however, were limited in the law to the first three planned telescope sites, says Kimberly Walley, a lawyer who represents the coalition.

So when Arizona began work on the new LBT site, environmentalists filed suit against the U.S. Forest Service and the Fish and Wildlife Service, claiming that they were bound to conduct extensive reviews of the new site before construction could move forward. On 28 July, Tucson district court judge Alfredo Marquez agreed and ordered a halt to work on the LBT site.

The appeals court last week declined to lift the injunction, but quickly scheduled a full hearing on the issue for November. The court also ruled that the university could petition the lower court to continue with work that would do no irreparable harm to the summit. Though they've lost this first fight, university astronomers are optimistic that the LBT will still end up as a neighbor to the red squirrel, noting that the same appeals court has ruled in their favor five previous times. "I'm confident we'll do a third telescope" on Mount Graham, says Peter Strittmatter, director of Arizona's Steward Observatory.

–John Travis