U.S. Neutron Scientists Settle for Less

Internal squabbling, reduced funding, and a lack of political support are forcing U.S. neutron researchers to play catch-up to Europe and Japan

Selling big U.S. science projects is tough these days. Just ask the small and fractious community of U.S. scientists who examine the structure of materials by bombarding them with neutrons. Just 2 years ago they were pinning their hopes on a $3 billion dollar research reactor. After that project was canceled they staked their future on a $1 billion accelerator, which now looks unattainable as well. So this spring neutron-scattering researchers bit the fiscal bullet, proposing a mere $250 million in upgrades to existing Department of Energy (DOE) facilities.

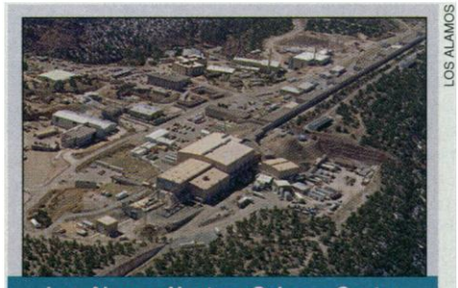
The result? DOE officials have praised the blueprint, but they are quick to add that the department's overall budget is shrinking too fast to accommodate all the projects in the near term. "Whether we can deliver on this plan is a matter of discussion," says Martha Krebs, who directs DOE energy research. Other DOE managers say there is only enough money in the immediate future to upgrade a facility at New Mexico's Los Alamos National Laboratory and that the rest will have to wait their turn. What's more, an aging accelerator at Argonne National Laboratory in Illinois might have to be closed to help pay for the upgrades.

The message is a bitter pill for neutron researchers to swallow, given their history of disappointment and the success of their European and Japanese colleagues (see box on next page). It's another sign, they say, of the lack of respect for a field that makes important contributions to science and to the development of commercially valuable products. "We're the Rodney Dangerfield of scientific facilities," sighs Bill Appleton, associate director at Oak Ridge National Laboratory in Tennessee, which operates one of the government's three neutron-source reactors.

But a lack of support from tight-fisted bureaucrats and politicians isn't the only reason for the field's precarious condition. The DOE labs, which host most of the nation's neutron sources, traditionally wage bitter battles for limited resources. The squabbling, in turn, has made it hard for neutron scientists—many of whom are based at the labs—to speak with one voice. And the price for that lack of unity has been weakened political clout.

An inside look

Even as the field faces hard times, the value of the research is not in question. "The scientific case has been made—this is purely a budget issue," says Appleton. And the stakes are high.

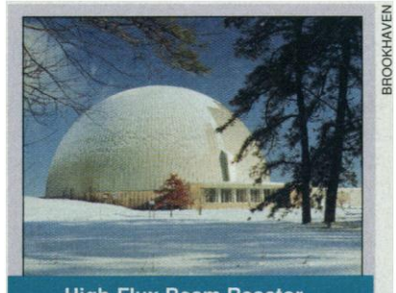


LOS ALAMOS

Los Alamos Neutron Science Center
Los Alamos National Laboratory
Built: 1985
Upgrade Cost: $33 million

"I'm worried it's all going to disappear, that a whole sector of science is not going to be available to U.S. scientists," says Anthony Kossiakoff, director of protein engineering at Genentech, a San Francisco–area biotechnology company that uses neutron-scattering techniques to develop new products.

Neutrons are prized for their ability to penetrate deeply into any material and then scatter, carrying important clues about its makeup. They can easily locate lighter atoms common in liquids, such as oxygen or hydrogen, offering researchers better insight into their structure than more commonly used x-rays. That information helps researchers design new materials, including polymers and superconductors, with tremendous commercial potential. But generating neutrons, unlike x-rays, requires massive machines—nuclear reactors or accelerators that are too expensive for any single university or company.



BROOKHAVEN

High-Flux Beam Reactor
Brookhaven National Laboratory
Built: 1965
Upgrade Cost: $150 million

DOE's Brookhaven National Laboratory in New York and Oak Ridge National Laboratory, as well as the Commerce Department's National Institute of Standards and Technology (NIST), have nuclear reactors that produce steady and reliable streams of neutrons by nuclear fission. Reactors have the advantage of being able to produce both high-energy, or thermal, neutrons and low-energy, or cold neutrons, which increasingly are favored by industrial users as their longer wavelengths provide a better view into the large-scale structures of polymers, crystals, and complex fluids.

But reactors present political difficulties. Los Alamos National Laboratory and Argonne National Laboratory instead use accelerators to send pulses of high-energy protons into heavy-metal targets. The collisions generate thermal neutrons. In theory, extremely powerful spallation sources also could produce cold neutrons, but the technology to do so lags behind reactors.

U.S. researchers pioneered neutron science in the 1940s, but today all the major U.S. research reactors are more than 25 years old, and the two accelerators date from the early 1980s. As long ago as 1984, a DOE advisory panel recommended major enhancements to existing sources as well as a far more powerful reactor, the Advanced Neutron Source (ANS), to maintain U.S. leadership. But the Advanced Photon Source, an accelerator that uses synchrotron radiation to analyze materials, won top priority. (This spring Argonne officials commissioned their $450 million facility.) "Second place in the late 1980s was not a good place to be" given the emerging fiscal crunch, says Jack Rush, who directs NIST's reactor.

Congress grew reluctant to fund mega-physics facilities—it killed the $11 billion Superconducting Super Collider, an accelerator for particle physics, in 1993. So the ANS quickly ran into trouble once money was needed to go beyond the design stage. It also drew withering criticism from anti-nuclear groups, who argued that it would undermine U.S. attempts to discourage the use of highly enriched fuel in other nations. And fiscal conservatives screamed after ANS's price tag nearly tripled the original cost estimates. In early 1995 the Administration canceled the project, which was planned for Oak Ridge (*Science*, 11 November 1994, p. 963). "It priced itself out of existence," says Thomas Russell, a senior IBM scientist in San Jose, California, and DOE adviser.

Researchers next pinned their hopes on a $1 billion, 1-megawatt spallation source—again, based at Oak Ridge—that could be upgraded into a 5-megawatt facility, similar

Europe and Japan Burst Ahead on Neutron Facilities

While neutron scientists in the United States squabble over a few modest facility upgrades (see main text), their counterparts in Europe last week were celebrating the breaking of ground for a $500 million research reactor outside Munich, Germany. The 20-megawatt reactor project—called FRM-2—is expected to consolidate Europe's position as the leader in the field for at least the next 2 decades.

The project so far has successfully weathered criticism from antinuclear forces, opposition from a U.S. government worried about the nuclear proliferation risk posed by the reactor's enriched uranium fuel, and recent domestic budget cuts (*Science*, 19 July, p. 303). When completed in 2001, FRM-2 will join the Institut Laue-Langevin (ILL) in France, a half-dozen other smaller reactors, and the ISIS spallation source in Britain, which uses an accelerator to produce neutrons. Together these facilities serve 3500 neutron researchers in Europe—more than five times the number of U.S. users. And FRM-2 isn't the end of the road: A 5-megawatt European Spallation Source is now planned to begin operating in 2010.

Why is Europe able to push ahead in a field invented in the United States? "The DOE [Department of Energy] environment is more restrictive," says Reinhard Scherm, director of ILL. The DOE labs, he says, historically have had fewer ties to the broader scientific community than in Europe and thus can marshal less political support for their programs. Another senior European manager is more blunt. Europe does better "because we don't have DOE." Since the early days of neutron research in the United States, he says, "the entire research program has been in the hands of a very few in-house staffers." While that is changing, he says the tradition of insularity has hampered efforts to build a broad and powerful constituency.

Japan is also moving forward aggressively in the field. The JRR-3 reactor underwent a major upgrade that was completed in 1990, and the National Laboratory for High-Energy Physics (KEK) in Tsukuba has a spallation source, the Neutron Scattering Facility, that dates from 1980. Japanese researchers have long wanted a more powerful neutron source—and now they are on the verge of getting their wish, says Hironobu Ikeda, director of KEK's Booster Synchrotron Utilization Facility.

The new spallation source, which would be more powerful than ISIS, would be part of the Japan Hadron Project, a $700 million synchrotron. "We really have to push hard for government approval of a project of this size," says Ikeda, who emphasizes that he is still waiting for the final go-ahead. But preliminary work has been funded, and he hopes that construction will begin in 1998 and take 4 years.

Ironically, U.S. industry may be a major beneficiary of the push to bolster facilities in Europe and Japan, say European and U.S. officials, because of its heavy use of such facilities to design improved materials and other products. National borders apparently don't concern these companies. IBM, Exxon, and AT&T, notes one DOE official with chagrin, are avid users of Britain's ISIS. **–A.L.**

Reporting by Daniel Clery in Cambridge, U.K., and Dennis Normile in Tokyo.

to a planned European accelerator. A five-lab team led by Oak Ridge won $8 million to start work on a design, and a rough outline will be completed this month. The study will continue into 1997.

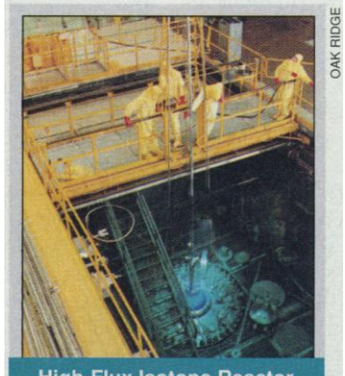
But the entire exercise may be doomed. Last month the Senate nearly cut off funding for the study, citing the lack of money for a $1 billion facility. Since then it has acquiesced to the House's preference for another $8 million to continue the work, but DOE's Krebs does not mince words about the near-term prospects for the spallation source. "A 1-megawatt facility is not part of the plan," she says.

Winners and losers

With the ANS dead and the new spallation source on hold, the neutron community sees an upgrade of existing DOE facilities as a stopgap measure. At Krebs's request, a DOE advisory panel in March issued a plan for about $250 million in upgrades to three facilities, based on cost estimates and timetables worked up by lab managers. The surprise winner is Los Alamos, which in June came up with a late entry to the competition—a relatively inexpensive modification to the Los Alamos Neutron Science Center (LANSCE).

LANSCE directors say the center has been promised $16 million from DOE's defense programs for an upgrade that would increase its intensity to the level of Britain's ISIS, a premier spallation source. LANSCE would still fall short of the British facility in instrumentation, but Krebs's civilian research office would kick in another $17 million to narrow the gap. It's a 5-year project, says Roger Pynn, LANSCE's deputy program director, although a doubled beam current would be available within 3 years.

Los Alamos "has not had a good reputation when it comes to operating reliably," says Russell, who examined the proposal at DOE's request. But despite such reservations, he says the project is doable, while the promise of defense funds proved too tempting an offer for Krebs's cash-strapped office to reject. Pynn says that LANSCE's reliability improved markedly in 1995, matching that of ISIS. "Regardless of proposed [DOE] cuts, we are going forward with the LANSCE upgrade," says Pat Dehmer, director of DOE's Office of Basic Energy Sciences.



OAK RIDGE

High-Flux Isotope Reactor
Oak Ridge National Laboratory

Built: 1966
Upgrade Cost: $70 million

While the LANSCE upgrade is the most secure of the projects recommended by the advisory panel, the panel also urged upgrades to the High-Flux Isotope Reactor at Oak Ridge and the High-Flux Beam Reactor at Brookhaven. The $70 million Oak Ridge modernization would require a 6-month shutdown and take 5 years, says Appleton. The upgrade would give Oak Ridge users a cold neutron source equivalent or better in intensity than the Institut Laue-Langevin in France, although with fewer beam lines and instruments. It also would provide better thermal neutron capabilities and improve isotope production. Dehmer says DOE backs the $10 million cold neutron scattering facility for the reactor but plans to wait before committing to a full upgrade.

The changes to the Brookhaven reactor would cost about $150 million and take it off line between 2002 and 2004, says John Axe, who runs the facility. The upgrade would quadruple its capabilities with only a 25% increase in operating costs, and vastly improve both thermal and cold neutron production. DOE's advisory panel questioned the cost estimate because of uncertainty over the extent of needed repairs to the reactor. Axe says that new data show the facility is in good condition. Nevertheless, Dehmer and Iran Thomas, her deputy, say the upgrade will have to wait until additional money is freed up.

For Argonne, the news is much worse. The lab proposed boosting the power of its aging

ARGONNE

Intense Pulsed Neutron Source
Argonne National Laboratory

Built: 1981
Upgrade Cost: $450 million

Intense Pulsed Neutron Source (IPNS) to almost half a megawatt—but at a cost of $450 million. The advisory panel charged by Krebs with examining the upgrade options rejected the high price tag, and Krebs concurred. "We feel we're being left out," says Bruce Brown, IPNS director, adding that the lab's proposal is the least expensive upgrade that is worth the money. While other lab researchers give IPNS officials high marks for squeezing a lot of science in recent years from a relatively weak source, they say Argonne's proposal ignored fiscal realities.

In the wake of Argonne's aborted proposal, DOE officials are said to be considering closing IPNS to help cover the costs of upgrades at other labs. "It certainly is a target," says Steve Shapiro, a Brookhaven physicist and treasurer of the Neutron Scattering Society (NSS). Dehmer and Thomas decline to discuss IPNS's future, but one lab official predicts the facility will be closed by 2000, as LANSCE comes on line.

Poor politicking

The need to make such hard choices grates on some neutron researchers. In March Sam Werner, a University of Missouri, Columbia, physicist and then-president of the 700-member NSS, wrote lawmakers about his "deep concern and frustration with DOE's stewardship of facilities for neutron research in the United States." Despite a quarter century of pleas by the labs, Werner complained, there has been "no real support from the DOE" to build new facilities.

The letter outraged members of the NSS's executive committee, who did not approve it before it was sent and feared it would damage the already strained relations between DOE and neutron scientists. Under pressure from the committee, Werner assured Krebs a month later that he wants a "constructive partnership with DOE." NSS members say a senior Argonne official angered by the rejection of the IPNS upgrade drafted Werner's first letter, which they characterized as a case of sour grapes. Neither Werner nor the Argonne official could be reached for comment.

Although the blowup has subsided, the incident underscores the continuing bitterness and angst within the community. "Things are spiraling down, and DOE has to show some leadership," says NIST's Rush. "They have dropped the ball." Dehmer, however, says the anger directed at DOE really stems from the community's unhappiness over the ANS termination. But she detects a change in the past few months. "I have the sense the community is willing to come together to do what's best, although it may not be what they hoped for," she says.

Others say it is too soon to predict an end to the rivalries. But Dehmer says the penalty for disunity will be stiff. "If they don't speak in the same voice and make realistic plans, neutron science won't go anywhere," she says. In other words, when it comes to showing respect, the U.S. neutron community may need to teach by example.

–Andrew Lawler

SPACE STATION

Construction Costs May Bite Into Science

NASA space station officials are planning to divert money set aside for scientific facilities aboard the orbiting laboratory to pay for engineering problems that have surfaced in its construction. The move would likely delay research planned for the station, which will be launched in pieces starting in November 1997. It also worries researchers already concerned about the agency's commitment to science aboard the station.

"Obviously this is of great concern, and it shows a sad state of affairs," says Claude Canizares, the Massachusetts Institute of Technology astrophysicist who chairs the National Research Council's Space Studies Board. NASA officials insist that they will try to limit the proposed funding shift to protect science, and add that the transfer won't affect the station's eventual scientific payoff.

The problem for agency managers is an inflexible $2.1 billion cap on annual spending and a tight assembly schedule. But expensive changes to the first of two nodes, or small modules, are forcing managers to cast a hungry eye on the $280 million a year allocated to design and build seven major science facilities, including a centrifuge, a furnace, and a biological research center. The first node is slated for a December 1997 launch, but testing has raised questions about its structural integrity. To strengthen it, engineers are adding braces at either end. That change and other smaller problems have added to the station's cost.

"They have a cash-flow problem because of the node overruns," says one congressional staffer. "Either they slip the schedule or move the money." How much would be transferred is not yet decided, NASA sources say.

The effort to dip into the science money comes as no surprise to Canizares. "Our cynicism is well-honed," he says. Canizares and other agency advisers complained this spring when NASA headquarters ceded control of the space station budget to Johnson Space Center in Houston (*Science*, 26 April, p. 478). They feared Johnson's focus on engineering would endanger the science money. Canizares says he is nevertheless distressed by NASA's most recent move, as NASA Administrator Daniel Goldin assured him this spring the science budget would be protected. A NASA official said other savings may be found in Johnson's budget or from contractors.

BOEING

Costly connection. NASA may tap science to meet higher costs of building one of the station's connecting nodes.

NASA is moving swiftly to win congressional support. The first step is winning Senate approval in September. The final amount will be worked out later when the House and Senate hammer out a conference agreement on the agency's 1997 spending plan.

The funding transfer could force NASA to postpone shuttle flights dedicated to shipping scientific equipment and experiments to the station, because the payloads may not be ready in time. One agency manager says the agency is exploring ways to provide researchers with additional flights on the shuttle, the Russian Mir station, and on free-flying satellites to make up for the delay. But it is unclear where funding for these flights would come from.

Arnauld Nicogossian, acting chief of NASA's life and microgravity research and applications office, insists that the transfer is not a done deal. "No one is taking any money at this point," he says. "We're working the budget with the space-flight office." And he says his office this year intends to expand to 680 the pool of researchers who conduct space experiments—and who are funded from another account. But those assurances may not be enough to calm skittish researchers.

–Andrew Lawler