The Looming Neutron Gap

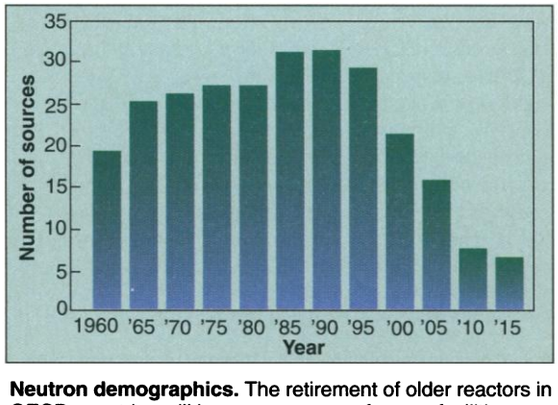
The cancellation of the U.S. Advanced Neutron Source will add to a growing shortage of prime facilities and increase Europe's lead in the field

Last year, neutron scattering researchers finally got the scientific recognition many felt has long been their due when two of the field's founding fathers—Bertram Brockhouse and Clifford Shull—won the Nobel Prize for physics. It was belated tribute for a technique now widely used to probe deep into the heart of materials as diverse as electronic components and biological molecules. Adding to the excitement in the discipline, neutron scattering researchers have been looking forward to a major technological advance: a pair of sources in the planning stage that would dramatically increase the intensity of neutron beams at their disposal. In the United States, the Advanced Neutron Source (ANS), a $2.8 billion purpose-built reactor, would produce 10 times the neutron flux of the world's current best, while the European Spallation Source (ESS), a rival technology based on particle accelerators, would put Europe firmly at the forefront of this newer technique.

Last week, however, that bright future suffered a serious blow when the Clinton Administration struck the ANS out of the 1996 budget request after 10 years of planning costing $100 million. The Administration cited the machine's high cost as well as concerns over its use of weapons-grade uranium as fuel. The loss is a serious blow to the field, which has not had a new top-rank reactor source in more than 20 years. Although the U.S. government has proposed diverting ANS planning funds to design a new American spallation source, going back to the drawing board could lead to delays. Moreover, a tussle over where the new facility would be sited, and confusion over a proposal for the source to do double duty as a producer of tritium for nuclear weapons, could dim funding prospects.

European researchers, who have yet to secure funding for constructing the ESS, are not rejoicing over their colleagues' misfortune. "It has made me extremely unhappy," says Dieter Richter, director of neutron scattering at the KFA nuclear research center in Jülich, Germany. "For 25 years there has been no new top-level source; the next step was expected from the U.S. ... It is a bad blow for the whole field."

It is not just the loss of the ultimate reactor that has upset researchers. "We need more neutrons," says John Finney of University College London (UCL). "The Americans are in a particularly bad state. They need a new source." Of the more than 30 neutron sources currently operating around the world, most are multipurpose research reactors built in the 1950s, '60s, and '70s sporting weak neutron beams that are of limited use. Only about a dozen sources make serious contributions to neutron scattering research; all are oversubscribed, and only a handful will be operating in 10 years' time (see chart). New sources can take a decade or more to design and build, and although several new facilities are in various stages of planning, only one is under construction—the SINQ spallation source in Switzerland.



Neutron demographics. The retirement of older reactors in OECD countries will increase pressure for new facilities.

The neutron demand

Neutrons are in such high demand because they can reveal inner secrets of matter hidden to electron beams or x-rays. Because neutrons are electrically neutral, when they penetrate a material, they ignore the clouds of electrons circling atoms and interact directly with the nucleus via the strong nuclear force. This enables them not only to probe deep into the sample but also to distinguish between atoms that may have similar electron clouds but different nuclei. Neutrons also have magnetic properties that make them an ideal probe of the microscopic magnetism within materials. "At the end of the day, the neutron is a pretty important particle; it feels all the fundamental forces and is an important test bed," says physicist Mike Pendlebury of the Institut Laue-Langevin (ILL) in Grenoble, France.

Neutron scattering has scored some notable successes in recent years, such as unraveling the crystal structures of high-temperature superconductors and fullerenes, and is now exciting a lot of interest among biologists for probing large organic molecules. But the limiting factor for the discipline is the intensity of the neutron beams: Reactors, originally the only sources of neutrons, produce pathetically weak beams compared to, say, a synchrotron's x-ray beam. Experiments that need a lot of neutrons might take weeks at a medium-level source, but only hours at top-rank one. Neutron intensity drives the field forward and allows researchers to carry out experiments that would otherwise be impossible.

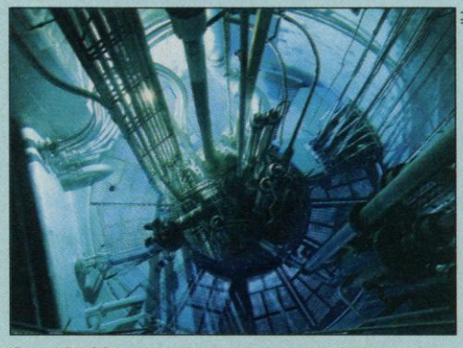
This craving for neutron intensity led to a surge of reactor-building in the 1960s and '70s. Although the foundations of neutron scattering were laid in North America, in recent years Europe has boasted the facility with the highest flux reactor and the best range of instruments: the ILL. First switched on in 1971, ILL ruled for two decades, until it was shut down after the discovery of cracks in the cooling system. It powered up again last month with a new core, resuming its place at the forefront of the field (*Science*, 13 January, p. 167). "For at least a decade, ILL remains the most powerful neutron source in the world. Technically, it could last 25 years more," says Ekkehardt Bauer, chief of ILL's reactor division. ILL is also the world's only international neutron facility, the majority of funds coming from France, Germany, and the United Kingdom, with minor contributions from Austria, Switzerland, and Spain.

In recent years, Europe has also been the leader in an alternative technology for generating neutrons: using an accelerator to smash a beam of protons into a heavy target—preferably made of uranium—knocking out neutrons. Four such spallation sources opened in 1985: two in the United States, one in Europe, and one in Japan. Currently the most powerful source is the U.K.'s ISIS facility at the Rutherford Appleton Laboratory near Oxford. "We've been very fortunate in Europe, better than in the States," says Gavin Williams, head of ISIS's diffraction and muons division. Japan entered the game late, with a relatively weak spallation source and a medium-scale reactor source, opened in 1990.

Funding Pressures Erode Spirit of Open Access

The imbalance between the number and quality of neutron research facilities on either side of the Atlantic (see main story) is likely to send U.S. researchers scrambling for access to European neutrons. But they may have trouble getting a place on a beamline.

Because of a squeeze on its budget in 1991, the Institut Laue-Langevin (ILL), the world's premier facility for neutron scattering research in Grenoble, France, has set up a system under which instrument time is allotted to its funding nations in proportion to their contributions. Experimental teams from other countries are barred access unless they collaborate with a team from a funding nation. "It's very sad, but with the present rules of the game it was inevitable," says physicist John Finney of University College London.



ILL

Core facility. ILL's reactor, newly refurbished.

This restrictive policy was put in place after the United Kingdom, which had been paying a bit less than one third of the cost of running ILL—with equal shares from France and Germany—cut its contribution. France and Germany also reduced their support, but by a lesser amount. As the three countries were no longer making equal contributions, France and Germany insisted on a system of national quotas. The quota system came into effect last fall when ILL reopened after an overhaul. "U.S. researchers will go on working with Europeans. ... There will not be much change for scientists," insists Dieter Richter, director of neutron scattering at the KFA nuclear research center in Jülich, Germany.

Others, however, think it is the beginning of a worrying trend. "[Europe] can no more play the game of openness because it is short of operating money," says Françoise Praderie, coordinator of the Organization for Economic Cooperation and Development's (OECD's) Megascience Forum. "Boards in all facilities are starting to look at quotas," she says. U.S. researchers are particularly worried about this development because neutron scattering is not the only field where Europe now has a lead: Grenoble also hosts the world's top synchrotron radiation source, and CERN in nearby Geneva will soon have the most powerful particle accelerator.

Indeed, for several years, the U.S. Liaison Committee of the International Union of Pure and Applied Physics has been promoting a set of guidelines for large multi-user facilities. They include a statement that "regional or national affiliations of the experimental teams should not influence the selection of an experiment nor the priority accorded to it." U.S. researchers argue that by restricting access, European facilities could destroy the open atmosphere of academic research and the free exchange of information and techniques. "We feel they are cutting off their nose to spite their face," says Dennis McWhan, associate director for basic energy sciences at Brookhaven National Laboratory.

The guidelines were, however, opposed by some European delegates at an OECD meeting on future neutron sources held in Knoxville, Tennessee, last November. "The U.S. wants to establish an open-door policy, but access to U.S. installations is not always so open," says Philippe Leconte, French associate director of ILL. "Reciprocal free access for neutrons is not a good deal for us," adds British Associate Director Alan Leadbetter.

–D.C.

Europe: A scattered approach

Despite the number of powerful sources in Europe, European researchers are already facing a neutron gap that is expected to widen in the years ahead. Many instruments at the top facilities receive two or three times more proposals than they can run; two instruments at ISIS are as much as five times oversubscribed. "Every European source is rejecting good science," says UCL's Finney.

Signs of this intensifying demand were picked up by a panel of scientists advising the European Commission in 1990 on large facilities. Its report advised a major initiative to develop a next-generation source for Europe. This led to a series of meetings jointly organized by Rutherford Appleton Laboratory and KFA Jülich, at which experts hammered out basic plans for the ESS, which would be some 30 times more powerful than ISIS. Last year the design team, supported by eight European countries, received a grant from the European Union for detailed planning; when that is finished, they will have to find construction funds.

In spite of this international initiative, most European countries are still going their own way in neutron research, holding onto small national reactors and in two cases even considering new national sources. The Munich Technical University is waiting for the go-ahead on a new reactor that would use weapons-grade uranium as fuel, while Austrian researchers are trying to drum up support in neighboring countries for a new spallation source called Austron.

Many neutron researchers believe sinking money in these new medium-level sources is a distraction from efforts to develop high-quality sources, especially when use of the current top-level facilities—ILL and ISIS—is restricted due to lack of funds. In 1991, ILL's three main funding nations cut its budget 15% because of budget restrictions back home, and the institute was forced to mothball several instruments, limiting itself to 25 when there is room for up to 40. "With a little more money, we can do a lot more at ILL. It is cost effective compared to building a new facility," says Reinhard Scherm, director of ILL. Andrew Taylor, head of the ISIS facility, adds that for a modest $60 million a second target station could be built at ISIS and the proton beam split between the two. "We could double the capacity of ISIS and negate the need for Austron," he says.

This growing competition is exactly the kind of development a panel of senior researchers and policy-makers has been trying to avoid. The Megascience Forum, a unit of the Paris-based Organization for Economic Cooperation and Development, has been trying to encourage international cooperation in the field. At meetings in November 1993 at Risø in Denmark and in Knoxville, Tennessee, last November, the forum said Europe should consider closing many of its national reactor sources to concentrate funds in international facilities. "Our aim was to coordinate, but it did not come about in practice," says astronomer Françoise Praderie, the forum's coordinator.

United States: Back to the drawing board

If European researchers are divided on the best approach to filling the neutron gap, their colleagues across the Atlantic are facing an even bigger debate as they come to grips with the loss of the ANS. The ANS was picked as the top choice 2 years ago by a panel of physicists chaired by Walter Kohn, a University of California physicist. The Kohn panel, commissioned by the Department of

Energy, also recommended building a 1-megawatt spallation source, but it gave ANS the higher priority. DOE, which could only afford one facility, began planning for the ANS and chose Oak Ridge National Laboratory in Tennessee as its home.

Last week, however, the Clinton Administration changed direction and opted for a spallation source. DOE and national lab sources believe the proposed source would have a power of at least 1 megawatt, cost about $1 billion, and could be operating by the planned 2003 completion date of the ANS. But debates about where the machine should be built and whether it should serve as a tritium production facility could get in the way of that ambitious timetable.

The budget document says Oak Ridge is the "preferred site," despite its lack of experience with accelerators. The laboratory has not built any major facility in years, and "it's fair to say it's their turn," a manager at another lab concedes. "They have the strongest program of materials research," adds Jim Decker, deputy chief of DOE's energy research office. Administration officials note that Tennessee is also Vice President Al Gore's home state—and presidential science adviser Jack Gibbons is a former Oak Ridge researcher. But other national labs—Brookhaven, Los Alamos, and Argonne—have their own proposals for spallation sources, and lab officials have been meeting with members of Congress and their staffs in the past 2 weeks to make their cases.

Another difficulty could arise if the Administration insists that the accelerator be used for both civilian research and producing tritium, a vital ingredient of nuclear weapons. The dual uses are tempting to White House officials eager to create a broader political constituency in an era of declining budgets. But Oak Ridge Director Al Trivelpiece rejects this idea as impractical. "These are two separate paths," he says. Decker agrees: "Our experience is that dual-use facilities just don't work. You can't just combine these two facilities and save a lot of money."

DOE also must decide whether a 1-megawatt accelerator will be powerful enough to keep U.S. scientists on the cutting edge of neutron-scattering research. There is considerable support for going straight for a 5-megawatt source, but it is not yet proven that such a powerful source is technically possible, and developing the technology could lead to even longer delays. The key problem is cooling the target. Taylor says that ISIS's target—which he describes as "the most irradiated piece of metal on earth"—can only dissipate 350 kilowatts of heat.

DOE is also toying with the idea of upgrading one of its reactors to keep scientists busy. "A complementary facility would be very good, but it is a question of whether we can afford it," says Decker. Dennis McWhan, chief of basic energy sciences at Brookhaven, says upgrading Brookhaven's existing reactor could be done for about $200 million.

Decker says he expects to have a revised plan for neutron-scattering research ready within a year. But until the next century, U.S. researchers will have to traipse across the Atlantic to conduct their experiments at the world's cutting-edge neutron-scattering facilities. And that will not be a happy solution. "Airplane tickets don't work," says Trivelpiece. "You need a center of gravity in this country." KFA's Richter agrees and says that researchers on both sides of the Atlantic should learn from the ANS' lesson. "We must do whatever is necessary to get a new source. But we must not go after something that again may fail."

–Daniel Clery and Andrew Lawler

Additional reporting by Alexander Hellemans.

CLINICAL TRIALS

Fisher Clashes With NCI—Again

Bernard Fisher, the University of Pittsburgh physician whose management of a major breast cancer study was investigated by Congress last year, is in another legal joust with the federal government.

Last March, Fisher and a research collaboration he then chaired—the National Surgical Adjuvant Breast and Bowel Project (NSABP)—got into trouble with their sponsor, the National Cancer Institute (NCI), over the handling of fraudulent data from an NSABP clinic in Montreal. Fisher had reported the fraud, but his refusal to impose new auditing rules and cooperate with NCI on a reanalysis of the data led to his removal as NSABP's chair (*Science*, 25 March 1994, p. 1679, and 10 June 1994, p. 1537). Now Fisher is refusing to buckle to an ultimatum that he publish the reanalyzed data, saying the job of incorporating data from a complete audit of the program last year cannot be hurried. This time he's invoking the Constitution in his defense.

In a series of scathing letters over the past 4 weeks, Fisher's attorney, Robert Charrow of Crowell & Moring in Washington, D.C., has charged that NCI is threatening to deprive Fisher of his First Amendment rights. Specifically, Charrow claims that NCI is trying to exercise "prior restraint" by dictating when and where Fisher must submit his revised analysis for publication. NCI had demanded that Fisher and his NSABP colleagues send a corrected analysis of their cancer data to the NCI and to the *New England Journal of Medicine* no later than 10 February.

NCI official Richard Ungerleider says the agency set this deadline because all the information for a reanalysis had been collected by the end of 1994, and "we feel that it's time that the data be made available to the public." The deadline was issued in a 12 January letter to NSABP's current chief, Ronald Herberman. Although Fisher was dismissed from NSABP, Herberman regards him as lead author on the key study, a comparison of "lumpectomy" versus mastectomy in stopping breast cancer.

"People seem to think this [reanalysis] can be done in an evening—but it can't."

—Bernard Fisher

Previous analyses have shown lumpectomy to be just as reliable as complete mastectomy, and Fisher says the new analysis supports that conclusion. But he refuses to jump at NCI's command. "People seem to think this [reanalysis] is the kind of thing that can be done in an evening—but it can't," grumbles Fisher, who is still writing up the text.

Fisher and Charrow are disputing NCI's right to force the pace. Charrow says that in 1991, federal courts ruled definitively (in *Board of Trustees of Leland Stanford University v. Sullivan*) that the Constitution protects a faculty member's right to publish as he or she pleases. And in a letter to the National Institutes of Health (NIH) on 23 January, Charrow warned that officials who violate "a well articulated Constitutional norm ... can and will be held personally liable for any damages resulting therefrom."

Ungerleider seems shaken by Fisher's tactics, noting, "He's threatening me and the NCI." Ungerleider and other NCI officials remain eager to publish the data and close this chapter in NCI's history. As *Science* went to press, however, NCI announced that it was inclined to let the deadline slip 2 weeks.

While Fisher and NIH are at legal swords' points, others seem eager to back away from controversy. NSABP's Herberman, for example, says, "We're optimistic that it all can get done pretty soon." Jerome Kassirer, editor of the *New England Journal of Medicine*, says NSABP has told him he will be receiving the article "by the end of February." But Fisher only says: "We are planning to get this completed just as fast as we can."

–Eliot Marshall