Green Light for Long-Awaited Facility

The Spallation Neutron Source will be the largest new science project in the U.S. budget. It will give neutron-scattering scientists a welcome boost after the demise of the Advanced Neutron Source

It's been a tough decade for U.S. researchers who rely on powerful neutron beams for diverse work in physics, chemistry, biology, and materials science. They sat frustrated on the sidelines in the late 1980s, unable to win support for an up-to-date facility. And when they were on the verge of securing approval for the $3 billion Advanced Neutron Source (ANS) in 1995, the Administration withdrew its support for the giant reactor, citing rising costs and nuclear proliferation concerns. Yet another blow came last year, when a tritium leak shuttered—perhaps permanently—an important reactor at Brookhaven National Laboratory. U.S. scientists have been forced to grit their teeth and board planes to work at more modern neutron sources in Europe. "The community is kind of numb," says one leading researcher.

Now those same scientists are feeling a rush of adrenaline. Vice President Al Gore was expected to announce this week that the White House will back plans to build a $1.3 billion Spallation Neutron Source (SNS) at Oak Ridge National Laboratory in his home state of Tennessee. The facility, which would generate neutrons with an accelerator instead of a reactor (see sidebar), will be the biggest new science project in the budget to be submitted to Congress next month. Prospects that construction could start by 2000 appear good, say those familiar with the effort. A bipartisan group of lawmakers supports it, the federal budget crunch is easing, and the diverse neutron community appears solidly behind the new project. And unlike previous DOE facilities, which primarily were the domain of individual labs, this one will be built as an ambitious collaborative effort of five labs. This approach not only makes technical sense but will also create a political juggernaut, its supporters say. Skeptics, however, worry that the management structure—which a few complain smells more of pork than practicality—could prove too cumbersome and expensive. And they caution that federal funding remains tight.

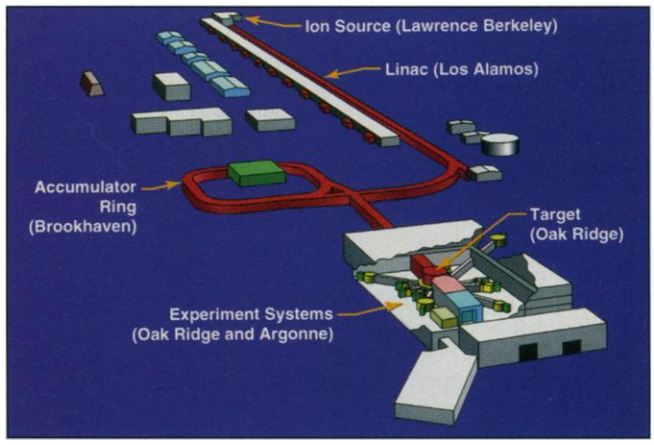
If it is built, the SNS will be the most powerful accelerator-driven neutron source in the world. Its neutron beams will be used to probe the structure of liquids or solids in ways that other particles cannot, and the data it generates will allow materials scientists to design new materials such as superconductors, chemists to develop new polymers, and biologists to trace the flow of proteins in blood. Despite these concrete applications, however, "it's been a long and exhausting task to generate enthusiasm in politicians" for such a facility, says one senior neutron researcher.

Nuclear fizzle

When the ax fell on the ANS in early 1995, it devastated supporters. "I'm still not over it," says Frank Bates, a chemical engineer at the University of Minnesota, Minneapolis, and president of the Neutron Scattering Society of America. "Eight years of work for nothing." Oak Ridge officials, however, quickly shifted gears. Within days of the ANS cancellation, DOE ordered a team of labs led by Oak Ridge to come up with plans for an alternative facility that would cost $1 billion or less. DOE and lab officials knew that a neutron source based on a nuclear reactor, like ANS, would be out of the question, so the new facility would have to be an accelerator source. "I live in the real political world, and nothing we can do will get us a reactor," says Oak Ridge director Al Trivelpiece.

DOE officials said in a statement that Oak Ridge was the "preferred site" for the project. It was, as DOE and lab officials frequently say, Oak Ridge's turn to build a major new scientific facility. But the decision rankled some, because Los Alamos National Laboratory in New Mexico, Brookhaven in Upton, New York, and Argonne National Laboratory outside Chicago all have greater experience in accelerators than the reactor-oriented Oak Ridge has. "Oak Ridge was a Johnny-come-lately" to the spallation field, sniffs one lab official. While cooperating with Oak Ridge, those labs quietly worked on their own alternative projects.

The odds of any spallation source being built, however, looked slim 3 years ago, given the push to balance the federal budget and the low priority assigned the project within DOE after the ANS debacle (*Science*, 9 August 1996, p. 728). But Trivelpiece and Bill Appleton, former ANS chief and now SNS associate director at the lab, set out to create a single project that could draw on the expertise and political firepower of five labs. "Our problem was we didn't have the technical know-how, so we went to each lab and asked about their capability," recalls Appleton. "Some labs held out and said they could do it cheaper, but the agreement formed quite naturally." Ultimately, other lab officials acquiesced when it became clear that infighting would kill the project in the cradle. "There was no hard sell—they saw the future as well as we did," says Appleton.



SOURCE: OAK RIDGE NATIONAL LABORATORY

Accelerating science. Neutron source slated for 2005 completion at Oak Ridge will be world's most powerful accelerator-driven source.

The collaboration that emerged is a technical winner, Appleton maintains, because it allows each lab to contribute its expertise. Lawrence Berkeley National Laboratory in Berkeley, California, is responsible for the ion source, while Los Alamos will oversee the linear accelerator. Brookhaven will design the accumulator ring, while Argonne will handle instruments and experimental facilities. Oak Ridge officials will oversee the entire effort and provide the target apparatus.

While Appleton pieced together the design team, Trivelpiece worked on the politics. He set up a meeting between Tennessee Governor Don Sundquist (R), staffers for Gore, and Jack Gibbons, President Bill Clinton's science adviser. Sundquist and Gibbons were old friends, because Gibbons had worked for years at Oak Ridge and Sundquist had served on the board of Gibbons's Office of Technology Assessment during his tenure in Washington as a congressman. To emphasize Tennessee's commitment to the spallation source,

An Accelerator to Boost Neutron Science

Neutrons are packed inside the nucleus of every atom heavier than hydrogen. It's getting the darn things out, so they can be used to probe materials and molecules, that has been the problem for frustrated American neutron scientists. Not that they don't know how, but they have lacked any prospect of a cutting-edge neutron facility since the demise, 3 years ago, of a proposed reactor in which nuclear fission would have provided a copious, steady flood of neutrons. Most of those scientists agree, however, that the intense bursts of neutrons from the accelerator-driven Spallation Neutron Source (SNS), which may be built at Oak Ridge National Laboratory (see main text), would be every bit as good a remedy for their frustration—and, all in all, might be better.

Reactor partisans hold that their technique of choice is still superior for some studies. But "the world is going in the direction of spallation sources," says Frank Fradin of Argonne National Laboratory outside Chicago. Lower cost is one reason, and there's a key technical advantage as well. The energy range of the neutrons scattered from a sample is a crucial clue to its structure. In a reactor, researchers generally must sieve one neutron energy at a time from the mixture that continually streams from the reactor. But in a spallation source, the energies of all the neutrons scattered from a microsecond neutron pulse can be gauged at once, by their different "times of flight" to a detector.

SNS would produce its neutron pulses by first collecting bunches of protons in an "accumulator ring" after they had been accelerated to an energy of a billion electron volts. Sixty times a second, bunches would be extracted to blast flowing, liquid mercury, shattering and boiling its nuclei to release bursts of neutrons. The neutrons would pass through one of several "moderators," depending on the experiment: water to produce hot, or high-energy, neutrons for a wide range of studies in materials science, structural biology, and polymer science, and liquid hydrogen for the cold neutrons used in studying especially large spatial scales or the fine vibrations of molecules.

Thanks to its 1-megawatt accelerator and assorted technical advances, SNS would have a neutron flux at least 10 times larger than that of the best comparable spallation source—ISIS in the United Kingdom. And its data-collection rate should be more than 100 times higher than that of ISIS, which is already ahead of the best reactors, says Gabriel Aeppli of the NEC Research Institute in Princeton, New Jersey. The high data rate would aid studies of small, complex chunks of material, which require long "exposure" times today. Fradin says it would also open the way to mapping out three-dimensional pictures of stresses in large volumes of material—say, in a turbine rotor made of advanced ceramics.

Researchers hope to bring the high neutron flux and the time-of-flight technique to bear on what Aeppli calls "the single most exciting problem of condensed-matter physics": how electrons pair to produce superconductivity at relatively high temperatures in some materials. Researchers at existing neutron facilities are struggling to knock the electrons apart and chart their binding energies, but "we need a bigger hammer in order to succeed," says Aeppli. For him and many other researchers, that hammer is the SNS. **–James Glanz**

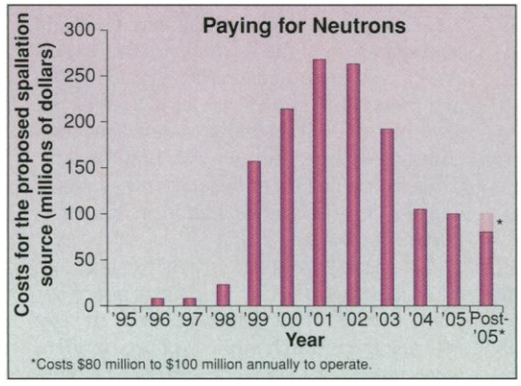
Sundquist pledged $8 million in state funds for a Joint Institute for Neutron Sciences at Oak Ridge. Meanwhile, both Tennessee senators, along with Representative Zach Wamp (R–TN), who represents the Oak Ridge district, agreed to back the effort.

While Trivelpiece emphasizes that the five-lab SNS collaboration is the best way to develop the technology, he also allows that "it's a great way to deal with the politics." Los Alamos's involvement, for example, has won over Senator Pete Domenici (R–NM)—who chairs the DOE funding panel—to the project. "Senator Domenici has to be a key player," says Appleton. "The fact that Los Alamos is on the critical path certainly helps."

Crossed fingers

The SNS's management structure worries some, however. "There are a lot of positive aspects to it—such as the politics—but there are complexities, too. You have to rely on five labs to get it built," says Jack Rush, who manages the materials science and engineering lab at the National Institute of Standards and Technology in Gaithersburg, Maryland. "We're all keeping our fingers crossed."

Jim Decker, DOE deputy energy research director, admits that at first he was skeptical of the multilab structure because "this is more difficult to manage" than a typical one-lab program. But he's convinced that the new approach—allowing designers to work largely at their home labs—makes more fiscal sense than moving accelerator experts from other labs to Oak Ridge. "That's very expensive," he says. New communication technology will allow widely separated team members to share design drawings and teleconference in ways impossible just a decade ago, he notes. The key to success, he adds, will be to ensure that Oak Ridge maintains full responsibility for the overall effort.



SOURCE: OAK RIDGE NATIONAL LABORATORY

In putting together the project, says Decker, the lab is doing "a terrific job." He cites two independent SNS cost reviews that came in with numbers nearly matching those of Oak Ridge. The lab estimated that the facility would cost $1.26 billion over 6 years; both cost reviews suggested adding at least a year to construction, and one recommended adding some instrumentation as well, bringing the total to $1.33 billion. The original $1 billion DOE figure, say Oak Ridge officials, did not take into account the added year, additional instruments, design changes that will allow the facility to be upgraded cheaply, and inflation.

Supporters say the cost—far less than that of the ANS—should make it more palatable to members of Congress. But one congressional aide warns that "any big new project is in question," despite talk of a rosier budget picture. "DOE energy programs like this are pretty low on the food chain" of appropriations, the staffer adds. In addition, the House Science Committee was rankled last year when DOE officials refused to consider possibly cheaper alternatives to the Oak Ridge site. DOE managers explained privately that any attempt to yank the SNS out of Tennessee would anger the White House and state delegation, jeopardizing the project.

In the meantime, neutron-scattering researchers are cautiously optimistic that the promise of an SNS will assuage the pain of the past few years. "There are still a lot of feelings of depression and anxiety, but things have brightened a bit," says Rush. Adds James Jorgenson, who heads Argonne's neutron-scattering team: "We're still alive—and that's really fantastic." **–Andrew Lawler**