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**

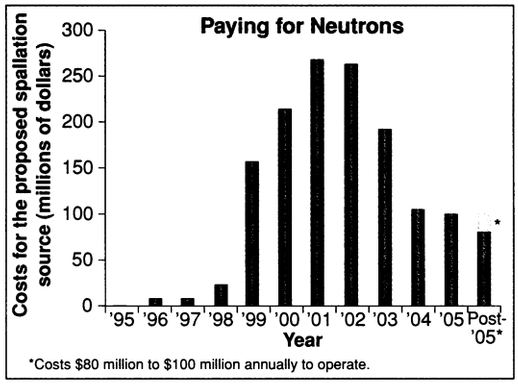
Sundquist pledged $8 million in state funds for a Joint Institute for Neutron Sciences at Oak Ridge. Meanwhile, both Tennessee senators, along with Representative Zach Wamp (R–TN), who represents the Oak Ridge district, agreed to back the effort.

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**