Berkeley Advanced Materials Center OK'd

A synchrotron radiation light source is the centerpiece for the National Center for Advanced Materials at the Lawrence Berkeley Laboratory

The National Center for Advanced Materials (NCAM) has in the space of a few months leaped from a proposal from the Lawrence Berkeley Laboratory to a place in President Reagan's fiscal 1984 budget. Presidential Science Advisor George A. Keyworth II told *Science* that NCAM is "the single highest priority project" in the Department of Energy's (DOE's) research plans.

Centered around a new synchrotron radiation facility that will house the brightest vacuum ultraviolet and soft x-ray source ever of this type, NCAM will comprise three laboratories devoted respectively to surface science and catalysis, materials synthesis, and device concepts. The plan is for NCAM to have significant industrial participation in the planning, execution, and funding of the research, a mix that has helped the project in the Reagan Administration.

During the 6 years it will take to complete the synchrotron radiation facility and the three laboratories, DOE expects to spend a total of $263.8 million on NCAM, including $138.9 million for construction costs. The light source will require almost $84 million, and $13.8 million will go to the Stanford Synchrotron Radiation Laboratory to learn how to generate, handle, and use x-ray beams of very high brightness.

The rapid rise of NCAM through the Washington bureaucracy has come without the benefit of a thorough review of the proposal by the materials science and synchrotron radiation communities. "It's unfortunate that there was no input from the science community," was one comment. It is therefore difficult to gauge how widespread the support for NCAM is and to speculate about what influence this may have on the chances for congressional approval.

What will NCAM do and why should it be established in the first place? In an interview, David Shirley, director of the Lawrence Berkeley Laboratory, explained that NCAM will be explicitly directed toward "advanced" materials. Many technologically useful materials have thermodynamically nonequilibrium compositions and structures and are in a sense artificial. Advanced materials are highly artificial in that materials scientists are more and more able to circumvent the limitations of thermodynamics and kinetics. In some cases, control of composition and structure over distances as small as a single atomic spacing has been achieved.

The three laboratories that comprise NCAM and their initial research programs build upon established areas of expertise at Berkeley. At the same time, they focus on areas likely to be important to American industry in the medium and long terms. Shirley says the overall theme of advanced materials responds to a great national need. For example, a 1981 report by DOE's Energy Research Advisory Board gave increased funding for materials research a high priority. Moreover, in other countries, notably Japan, research seems to be focused on specific goals with industrial, university, and government-sponsored laboratories working together. Materials research also provides a major mission for Berkeley, which some observers think has needed redirection.

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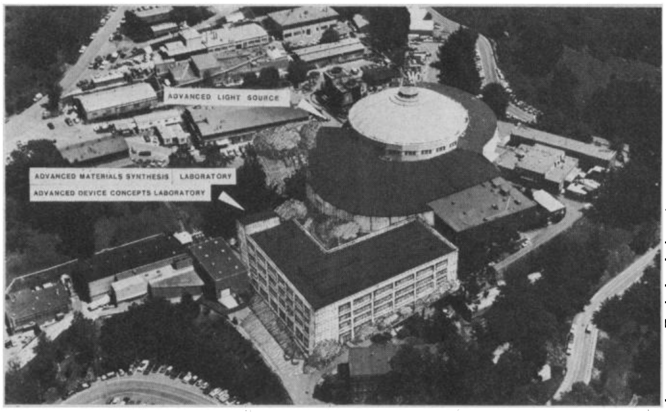
The Berkeley laboratory and the University of California campus are in close physical proximity, and both institutions benefit directly from this. There is a major overlap of personnel, for example, with 600 graduate students working in the laboratory and with 150 campus faculty and staff having joint appointments. Ties with industry, however, are less well developed. Shirley wants "to break new ground in forming collaborative arrangements with U.S. industry."

Among the mechanisms to draw in industrial participation is an advisory board composed of representatives from the federal laboratories, from universities, and from industry. The role of the advisory board is to provide intellectual input—"What are the advanced materials problems that will be important in five to fifteen years?" There will be an NCAM affiliates program, members of which will contribute to the design, construction, and operation of research facilities. Similarly, NCAM will have what has become known as participating research teams or PRT's, which all the synchrotron radiation centers have used to different degrees. In return for guaranteed long-term access to synchrotron radiation, the PRT, which may come from industry, from a university, or both in collaboration, pays for a beam line and an experimental station. Finally, there will be an industrial fellows program. Researchers nominated by their company's management and selected in a competitive process will come to Berkeley to work on specific problems of direct interest to the company.

Eugene Haller, serving as NCAM's scientific program director, summarizes as follows the research programs that he hopes will get under way immediately. He emphasizes that these investigations do not need to wait for the completion of the synchrotron light source but can be run in parallel with its construction.

- *Surface Science and Catalysis Laboratory*. The building to house this laboratory will be the first one completed. There will be research on zeolite characterization (Heinz Heinemann), theoretical and experimental studies of the arrangements of atoms on atomic surfaces (Marvin Cohen), and investigations of the behavior of surfaces under intense particle and photon bombardment (Gabor Somorjai).
- *Advanced Materials Synthesis Laboratory*. There will be efforts to design and process steel alloys (J. William Morris, Jr.), to grow semiconductor single crystals of ultrahigh purity (Haller), to make theoretical and experimental investigations of phase transitions at high pressure (Leo Falicov), and to synthesize zeolite catalysts for the surface science laboratory.
- *Advanced Device Concepts Laboratory*. There will be attempts to make superconducting devices (SQUID's) for the measurement of minute magnetic fields that operate at temperatures above that of liquid helium (John Clarke), to



Lawrence Berkeley Laboratory

NCAM site

The ALS and the NCAM laboratories will occupy the domed home of Lawrence Berkeley Laboratory's famous 184-inch cyclotron and two new buildings nearby.

develop high-speed infrared detectors (Paul Richards), to use x-rays for the generation of the miniaturized patterns in microcircuits or for imaging biological structures (Thomas Hayes), and to learn how to design structures that are exposed to very high temperatures and thus require the use of brittle ceramics (Anthony Evans and Iain Finnie).

These three laboratories and their research programs will rely heavily on the new synchrotron radiation facility, the Advanced Light Source (ALS). Synchrotron radiation sources are evolving third generation of sources in which most, if not all, the synchrotron radiation comes from special magnets with the generic name "insertion devices," rather than from the dipole bending magnets that keep the electron beam in its approximately circular orbit.

The ALS will be in the form of a 12-sided polygon 170 meters in circumference with rounded corners. One insertion device can fit in each of the straight sections, although the plan is to equip only six of the straight sections initially. In their simplest form, insertion devices consist of alternating arrays of dipole magnets that bend the electrons through a sine wave–shaped trajectory.

One form of the device, the wiggler, tends to have a small number of dipoles but these have high-magnetic fields, whereas the second form, the undulator, has a large number of dipoles but weak fields. Wigglers produce a broad spectrum of radiation having a higher intensity and extending to shorter wavelengths than the light from a dipole bending magnet. Undulators generate even more intense radiation over a rather narrow band whose wavelengths can be controlled by adjusting the strength of the magnetic field and by other means. Berkeley researchers are scheduling an initial complement of two wigglers and four undulators. Light from one insertion device can service more than one experiment, so the plan is to build 14 beam lines with associated optics to guide the light to the experimental stations, as well as to focus it and to select the desired wavelengths.

Tom Elioff, who is directing NCAM's construction, emphasized that the brightness of the synchrotron radiation from the ALS will not be entirely due to the use of insertion devices. Another important feature is the storing of a circulating electron beam (1.3 billion electron volts energy) with a very small emittance. A small emittance means that the electrons can be focused into a beam with a small cross section and that they stay focused because they do not jump about within the beam. This feature in turn means that the synchrotron light comes from an almost pointlike source and hence is very bright. Although there is a certain amount of "specsmanship" involved, Berkeley advertises the ALS as being 10,000 times brighter than existing synchrotron radiation sources.

A high brightness is very important to researchers. Arthur Bienenstock, who is director of the Stanford facility, argues that each increase of a factor of 10 in brightness in the decade of operation there has permitted qualitatively new experiments of increased sensitivity and spectral resolution. The negative side of high brightness is that the optics in beam lines have to withstand very high heat loads from the intense radiation. Stanford's share of the NCAM budget will go partially to dealing with this problem.

In Washington, the reaction to the NCAM proposal has been little short of miraculous. A DOE official noted that the proposal was received only last spring and that "Without the assistance of a lot of people, it wouldn't have come along so quickly." Remarked another observer, "It has moved at the speed of light."

James Kane, deputy director of energy research at DOE, ascribes NCAM's warm reception to the combination of several circumstances, but a principal one was the opportunity to focus research at the national laboratories in a direction beneficial to American industry. Recent reports, one by the Energy Research Advisory Board and one still in progress by the Office of Science and Technology Policy, have called attention to the proper role of the national laboratories, especially in relation to the universities and to industry. The ALS fits neatly into the NCAM package because industrial researchers are getting to be enthusiastic users of the existing synchrotron radiation centers. In fact, industrial PRT's have contributed several million dollars toward beam lines and instrumentation at Brookhaven.

Nonetheless, NCAM has received almost no exposure to the materials science and synchrotron radiation research communities, a cause for concern to some who would prefer a more orderly development of research and facility priorities in these fields. Keyworth, for example, has repeatedly emphasized the need for scientists to sort out their own priorities in a budgetary climate where hard choices have to be made.

The first public discussion of NCAM came last summer when Shirley submitted his concept to a panel established by the National Academy of Sciences to study synchrotron radiation research and the adequacy of existing facilities. The panel was not charged to make recommendations concerning future synchrotron radiation sources, but several panel members have said privately that the feeling was that it was premature to plan a new facility now.

Moreover, the ALS might not be the source that would be recommended by a future panel charged with this responsibility. The ALS is a generator of vacuum ultraviolet and soft x-ray radiation. Some researchers prefer that the next big synchrotron radiation facility be a source of shorter wavelength, hard x-rays, and some are afraid that the expensive ALS may preclude their getting their preferred, even more expensive (over $100 million), machine in the not too distant future.

Shirley emphasizes the National in NCAM. But university-based researchers may look past this and see only a tremendous concentration of resources to the benefit primarily of one campus of the University of California. There is clearly a need for building research community support for NCAM. This process is now under way. Representatives of the academy's Solid State Sciences Committee and of the Council for Chemical Research were briefed at Berkeley in mid-January. And NCAM was formally unveiled on 8 February at a forum held at the academy.—**Arthur L. Robinson**