NCAM not peer-reviewed, critics say; review panel named

In response to widespread criticism of the proposed National Center for Advanced Materials at Lawrence Berkeley Laboratory, the Department of Energy has formed an *ad hoc* review panel. Headed by Al Narath of Sandia Laboratories, the panel has been asked to review the technical and programmatic aspects of NCAM.

The FY 1984 DOE budget requested $38 million for an Advanced Materials Research initiative (PHYSICS TODAY, April, page 49). The budget for the National Center for Advanced Materials is $35 million; of this amount $30.2 million is for LBL and the rest is for the Stanford Synchrotron Radiation Laboratory. The remainder of the initiative ($3 million) is for the National Synchrotron Light Source at Brookhaven. NCAM has been characterized by Presidential Science Adviser George Keyworth as "an exciting prospect for a new level of interaction between academic, Federal and industrial scientists." In a talk before the APS meeting in Baltimore in April (see page 45), Keyworth said, "Some people have pointed out that there are other research institutions better known for work in materials science—so why has this center been established there? That's a fair question. The answer is that we have to find ways to better couple the Federal labs to current national needs. And LBL is uniquely suited—a Federal laboratory located on an outstanding university campus, and in a region noted for innovative industry." NCAM would cost a total of $265.0 million over the next six years; of this amount $138.9 million is for construction.

A key feature of NCAM is an Advanced Light Source, a 1.3-GeV electron storage ring optimized for insertion devices (both wigglers and undulators) to enhance photon production. ALS will cover the energy range 0.1–5000 eV—from infrared, through optical to soft x rays. Construction cost for ALS would be $83.8 million; this figure includes the cost of the insertion devices and beam lines.

Other major components of NCAM are: a Surface Science and Catalysis Laboratory, an Advanced Materials Synthesis Laboratory and an Advanced Device Concepts Laboratory.

History. Last June, Lawrence Berkeley Lab, best known for its work in nuclear and particle physics, submitted a preliminary proposal to DOE for NCAM and described it to DOE senior officials during the LBL presentation of its annual institutional plan. During the summer of 1982 a few insiders knew Berkeley was proposing an expensive synchrotron-radiation source but the scheme was not expected to be funded in the near future.

When the subcommittee on synchrotron-radiation facilities of the Solid State Sciences Committee (of the National Academy of Sciences) convened last July, DOE told the subcommittee that, in guiding DOE for the FY 1984 budget process, it need not consider the Berkeley proposal. The final report of the subcommittee (headed by David Lynch of Iowa State) concluded (PHYSICS TODAY, February, page 21) that when all current facilities in the US begin full-time operation for users they will be fully utilized. The report said, "Development of the remaining potential experimental stations at existing facilities will satisfy predicted demand until 1985." The subcommittee did not predict demand beyond the next five years. These new facilities, now coming into operation, are the National Synchrotron Light Source at Brookhaven, which has an 800-MeV ring for uv and soft x rays and a 2.5-GeV ring for x rays, and Aladdin at the University of Wisconsin, a 1-GeV ring for uv and soft x rays. If NCAM is approved by Congress this year, the Advanced Light Source would be operating by the end of 1989.

Although NCAM had not been enthusiastically received by DOE, David Shirley, director of LBL, apparently discussed the NCAM proposal with Science Adviser Keyworth and persuaded him of its importance. Shirley told us that in the light of a two-year-long administration review of multidisciplinary national labs, hearings before Congressional committees, the review of multiprogram labs by the Energy Research Advisory Board, the White House Science Council study of national labs, and the private-sector survey, there is a very strong message: The multiprogram labs must be redirected to address future national needs. The ERAB report "DOE Multiprogram Laboratories" (PHYSICS TODAY, January, page 59), Shirley said, recommends the establishment of a lead mission for each of DOEs major labs. "That led to the genesis of NCAM." Further, he said, "The country is overdue for a next-generation light source."

In late October, at Keyworth's request, a National Academy of Sciences panel headed by Theodore Geballe (Stanford) briefed Keyworth on materials science, identifying those fields likely to return the highest scientific dividends from incremental boosts in the FY 1984 budget. The panel felt that both expensive facilities and less-expensive university research are essential. The greatest need, if further funds become available, is for supplying state-of-the-art instruments (in the $0.5–1 million range) to individual university research groups, the panel told Keyworth.

In mid-November, the DOE Council on Materials Science, headed by David Lazarus (University of Illinois), was briefed for half an hour by Gabor Somorjai of Berkeley about the NCAM proposal. At that time Lazarus thought the proposal was just about to be submitted, not that it was about to be in the DOE FY 1984 budget proposal. The Council was not asked for comment.

In December some members of the Solid State Sciences Committee learned that NCAM was in fact in the DOE FY 1984 budget, and early in January four of them visited LBL to discuss NCAM plans. Also early in January a small group of accelerator experts visited LBL at Shirley's invitation, to do a technical critique of the accelerator design for the Advanced Light Source. In mid-January the new Materials R & D Panel (headed by Robert Pry of Gould Inc) of the Energy Research Advisory Board met for the first time and was briefed on DOE

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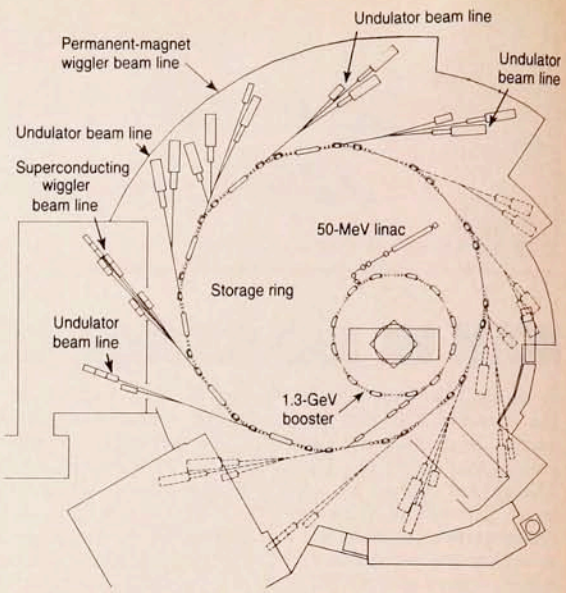
materials-science plans. According to one subcommittee member, even at that late date in the budget process the NCAM plans were not discussed. Two weeks later, the President sent his budget proposal to Congress with NCAM as a new initiative.

Criticisms. On 8–9 February an open forum of the Solid State Sciences Committee was held at the Academy and attended by about 100 persons. Among the speakers were Don Fuqua (D., Fla.), chairman of the House Committee on Science and Technology, Keyworth, James Kane (deputy director of the Office of Energy Research in DOE), and Shirley (who presented Berkeley's plans for NCAM). Many of those attending were openly critical of the NCAM plans. Among the criticisms: lack of traditional peer review; no need for a new synchrotron radiation source at this time; the source should be higher in energy (electron energies of about 6 GeV); NCAM might harm other materials-science research; LBL did not have much history of cooperation with industry, although such cooperation is a major feature of NCAM.

Because the House Science and Technology Committee is responsible for authorizing the DOE R&D budget, many materials scientists wrote to Fuqua; about 75 letters were received, many of them highly critical. At DOE authorization hearings before the Fuqua committee in March, OER director Alvin Trivelpiece said he was establishing an *ad hoc* committee to review the technical and programmatic aspects of NCAM.

In a letter to Narath dated 31 March, defining the committee's role, Trivelpiece explained the multiple motivations for NCAM: (some of these considerations concerning NCAM came from the ERAB Multipurpose Laboratory Review Panel) that DOE should redirect its labs into new and scientifically more productive activities; should use its labs to support higher education; should seek to get them more involved with industry in ways that help improve the US industrial science and technology base; "and finally, that it not regard its laboratories simply as sites at which various unrelated technical projects are performed for the different departmental elements, but rather regard the laboratories, to the extent possible, as institutions and treat them accordingly."

Trivelpiece asked the *ad hoc* committee to conduct a technical review of the various proposed facilities, their cost, and their appropriateness to their proposed purposes. He asked them to review proposed organizational arrangements, the establishment and charters for standing advisory mechanisms, and the plans for involvement with US industry, other national labs and universities.



ALS, the Advanced Light Source to be built at the National Center for Advanced Materials at Lawrence Berkeley Lab. The beam line whose source is a permanent-wiggler magnet would have photons as high as 10 keV in the forward direction. The beam line whose source is a superconducting wiggler would have photons as high as 40 keV in the forward direction.

He went on, "I wish to make clear at the outset that a revisitation of the Department's basic decision to establish this Center, with its associated facilities, is not being requested. That decision was made on the basis of broad institutional concerns in the context of a widely accepted need for enhanced national effort in this area of science." Instead the Narath panel is asked to critique and improve the initial LBL planning so that the best possible features can be included while the project is still in an early phase. The mandate of the Narath committee presumably allows it to ask: Is this light source the wrong machine at the wrong time? But the Narath panel has basically been told it should not question the decision to redirect LBLs effort into a concentration on materials science.

The Narath committee has already met at LBL 22, 23 April and was to meet in Washington 6, 7 June. At that time a representative selection of materials scientists is to be invited to express their views. At least two more meetings will be held before the committee reports back to Trivelpiece by the end of August.

The membership of the *ad hoc* committee is: Narath, David Pistenma (National Cancer Institute), David Davies (National Institutes of Health), Phillip Seiden (IBM Research Center), William Nix (Stanford), Harry Paxton (US Steel), Fred R. Gamble Jr (Exxon Research), John Deutch (MIT), James Krumhansl (Cornell), Kenneth Kliewer (Argonne), David Lynch (Ames Laboratory, Iowa State), Guyford Stever (Universities Research Association) and John Doyle (Hewlett Packard). Donald Stevens of DOE is executive secretary.

Among the letters sent to the Fuqua committee was one by Mildred Dresselhaus, director of the NSF Materials Research Lab at MIT, and president-elect of APS. She said that because of budgetary constraints, "it is unlikely that there will be funds for more than one 'next generation facility' in the next few years . . . [this synchrotron-radiation facility] will have to be optimized to the needs of the research community with regard to energy range and photon flux, subject to the constraints of available technology, funding and identification of the most important research opportunities. It is my impression that workers in the field have not had sufficient opportunity to provide input on these critical issues and that the proposed ALS facility may not be optimized within this framework."

The priorities of all three initiatives, Dresselhaus said, need to be more broadly assessed relative to each other and to the other needs of the materials research community in fields outside synchrotron-radiation research. [Meanwhile SSRL has begun development of a proposal for a pair of storage rings using wigglers and undulators—a low-energy ring (1–2 GeV) and a high-energy ring (5–6 GeV). See the article on page 48 of this issue.]

The DOE Basic Energy Sciences budget for FY 1984, excluding the National Materials Research initiative, increases only 10.4%. This is to be compared with an increase of 23% in the NSF Division of Materials Research budget and to 39% in the DOE materials-science budget including the National Materials Research initiative. Dresselhaus worries that the remainder of the DOE Basic Energy Sciences

budget will be under increased pressure. For the next five years NCAM would be likely to constrain funding of other new facilities for materials research, such as neutron scattering and submicrometer technology. She asked, if more money goes for synchrotron-radiation facilities construction, will there be enough money for research at the present facilities and for instrumenting additional ports at existing facilities and for operating existing facilities in other fields of materials research?

In testimony before the Fuqua committee in March, William Brinkman (Bell Labs), the chairman-elect of the Solid State Sciences Committee, said that to ensure programs involving small amounts of money "from the national point of view are initiated, it is essential that the climate in Washington should not be one where the only new initiatives that can be supported are those which cost hundreds of millions of dollars. One sometimes finds that it is easier to fund a large program, often with the simplest of goals, than to sell the continuous flexible funding of science where priority setting can be made at a level at which knowledgeable decisions are possible."

Lazarus told us, "Materials science fluorishes with diverse input, not with centralized funding and facilities. The Soviets already have the latter model—they have put much more money into materials science than the US has, but only through very concentrated, central laboratories that have produced almost no original research."

When the Fuqua committee ordered the authorization bill to the House at the end of April, its report contained a number of remarks concerning NCAM. Among them: "In its eagerness to move ahead aggressively with the Advanced Materials Research initiative, the Administration apparently has bypassed the preferred review process, which typically involved representatives of the research community."

"Given the possibility of revisions in the NCAM construction plan [as a result of the Narath panel's study], the Committee believes that it is prudent to slow the project during the first year. Consequently the Committee recommends a reduction of $5 million (approximately 20%) in FY 1984 construction funding.... No funds should be obligated for NCAM construction until the *ad hoc* committee has reported to DOE."

The Committee urged that "support for NCAM should not come at the expense of other worthy advanced materials research initiatives." But the Committee "believes that the Administration's LBL/NCAM proposal must be regarded also as an institution-building measure and not only as an enhancement for an important research field." Finally the Committee urged improved long-range planning and priority setting for the Basic Energy Sciences program including a clear delineation of the respective DOE and NSF responsibilities.

LBL director Shirley, replying to some of the criticisms of NCAM, told us, "We're seeking and receiving community input." Since January, he said, more than 60 letters firmly supporting NCAM and welcoming possible collaboration have been received from major universities and from industry. More than 175 scientists from 20 universities, seven national labs and a dozen industrial labs attended an ALS workshop 9–11 May to plan the insertion devices and beam-line designs. On 23 May scientists from Varian, Bell Labs, IBM Watson Research Center, Atlantic Richfield, Catalytica, Hewlett-Packard, Rockwell, Dow Chemical, Exxon, Union Carbide, Ford, Boeing, Chevron, Westinghouse and Xerox were to attend a workshop on industrial participation. During the summer LBL will begin seeking a director for NCAM with the hope of having the director begin work in the Fall. Also during the Fall workshops on each of the other parts of NCAM are to be held: the Surface Science and Catalysis Laboratory, the Advanced Materials Synthesis Laboratory, and the Advanced Device Concepts Laboratory. Shirley said that LBL has not yet developed a complete description of the NCAM scientific programs. "Our proposals are still tentative."

The Advanced Light Source, Shirley said, is optimized for high brightness in the vacuum uv and soft x-ray part of the spectrum. It is the first storage ring optimized for insertion devices. Instead of extracting radiation from the bending magnets, the radiation is generated in special magnetic devices located in the straight sections. Synchrotron radiation produced by these insertion devices can be significantly more brilliant than that produced by the bending magnets of the ring. From an accelerator-design point of view, Shirley said, "We know how to do that for this low energy range." But he said that the heat load from wigglers is a significant problem for higher-energy machines.

ALS has a circumference of 182 meters (about the same circumference as the NSLS 2.5-GeV ring), has been designed with low emittance, and will have 12 straight sections. These 12 straight sections can accommodate either wiggler or undulator insertions that can produce either very high intensity or very high brightness. (See the article on page 48 of this issue.) ALS is designed to provide pulses as short as tens of picoseconds.

Although ALS has been optimized for 1.3-GeV electrons, it can also operate at electron energies up to 1.9 GeV. By using undulators ALS can then produce 10-keV photons and by use of a superconducting wiggler, 40-keV photons. But at these higher energies, the emittance will be higher, spectral brilliance will be reduced and electron bunch lengths will increase.

Some critics had noted that the relatively low-energy ALS would be ideal for the research interests of David Shirley and not so well suited to most materials scientists. Others had noted that the LBL site could not accommodate a larger (and thereby higher-energy) storage ring. Shirley told us, "Of the thirty storage rings in the world, a sizable fraction are low-energy rings." These include Aladdin, the NBS source (280 MeV), the vacuum uv ring at NSLS and (the 800-MeV) BESSY in Berlin. Shirley believes Berkeley can do more science with a low-energy ring—covering four decades of the electromagnetic spectrum—from 0.1 to 5000 eV—across the K edge of most of the light elements, such as carbon, oxygen, nitrogen, sulfur and silicon. "The only way you can get to the edges you need is with low-energy, soft x rays."

As examples of ALS science, he cited EXAFS (not Shirley's speciality), all of photochemistry with optical and uv radiation, studies of transient phenomena taking advantage of the ALS picosecond pulses, and studies with a very bright infrared source (equivalent to 3×10^5 K).

Concerning the size limitations of the LBL site, Shirley said LBL had considered building a larger electron storage ring and had felt it could find a site for such larger ring in Berkeley. But it opted for the 1.3-GeV ring in the NCAM proposal. —GBL

Superlattices from mismatched materials

Leo Esaki and Raphael Tsu at IBM pointed out in 1970 that imposing an artificial periodicity one or two orders of magnitude larger than the natural lattice spacing on a semiconductor crystal ought to yield novel and potentially useful electrical and optical effects. Since then, considerable work has been done on fabricating and investigating the properties of superlattices—epitaxially grown stacks of alternating thin layers (on the order of a hundred angstroms) of two different semiconductor materials. But until