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ADVANCED LIGHT SOURCE

Vol. 6, No. 1

R E P O R T

June 1993

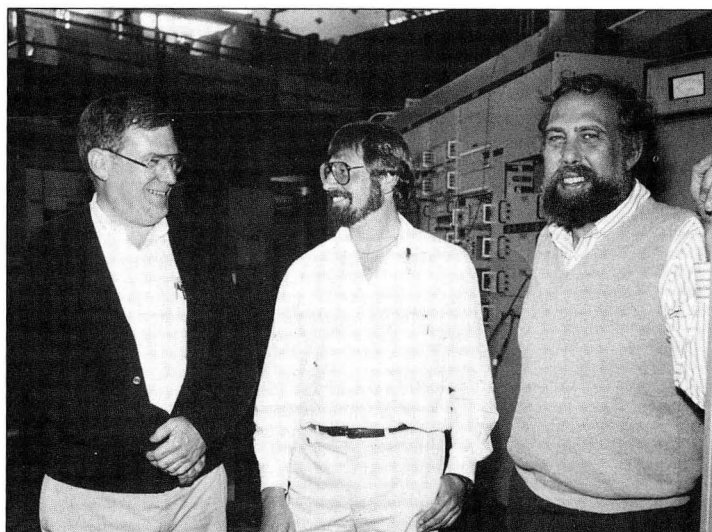
Lawrence Berkeley Laboratory / University of California

ALS Surpasses Performance Goals Achieves 407 mA Current in Storage Ring

On March 24, the ALS achieved 65 mA of electron-beam current in the storage ring, well above the 50-mA project baseline performance requirement. On March 31, the target date for project completion, the beam current surpassed all expectations, reaching 290 mA.

The excitement started on March 16 when the team attempted to store a beam for the first time with the radio frequency (rf) power system connected to the storage-ring accelerating cavities. At approximately 11:00 p.m., after a little fine tuning of the storage-ring magnets, the number of turns on the beam position monitors was observed to increase dramatically from a few hundred to many millions. The beam started to accumulate immediately, and the DC transformer reported a stored current of 6 mA in 4 bunches. On March 19, the current reached 42 mA and fulfilled one of the final commissioning goals by exceeding 7.6 mA in a single bunch.

By April 9, the current exceeded the 400-mA design goal, reaching 407 mA. A week later, the ALS beam attained a lifetime of 68 minutes from 100 mA to 37 mA and a current of 25 mA in a single bunch (three times better than the design goal). The beam lifetime was limited by high pressure caused by photon desorption from photon beam stops; it is expected to increase considerably as the pressure improves. "The success of the project is



Brian M. Kincaid, ALS director; Alan Jackson, leader of the Accelerator Group; and Jay Marx, project director from 1987-92, reveal their delight at the success of the ALS.

due to the solid and active collaboration among workers from all divisions of LBL," said ALS Director Brian M. Kincaid.

Impressive Performance

Progress of the commissioning has been remarkable since electrons were first injected into the storage ring on January 14. After storing the first beam on January 19, the commissioning team quickly reached its short-range goal of 50–200 turns without the rf power system working. By February 10, the team was routinely able to produce more than 250 turns of the electron beam with 1.5 mA of coasting beam in the storage ring. No corrector magnets were used in achieving this result, and the ratio of 0.3 between storage-ring and

booster-synchrotron beam currents indicated quite a high injection efficiency considering the natural dilution ratio of 0.38 between the two rings. Gradual rather than abrupt losses in the coasting beam indicated an acceptable state of machine tuning.

"The speed with which we reached our construction milestone for storage-ring performance sets a new standard in our community and verifies the integrity of our design," explains Alan Jackson, leader of the Accelerator Group. "Commissioning the storage ring was originally scheduled to

take one year, and we did a lot of it in only three months."

As expected, the first results were limited by the buildup of gas pressure in the storage ring. Major causes of

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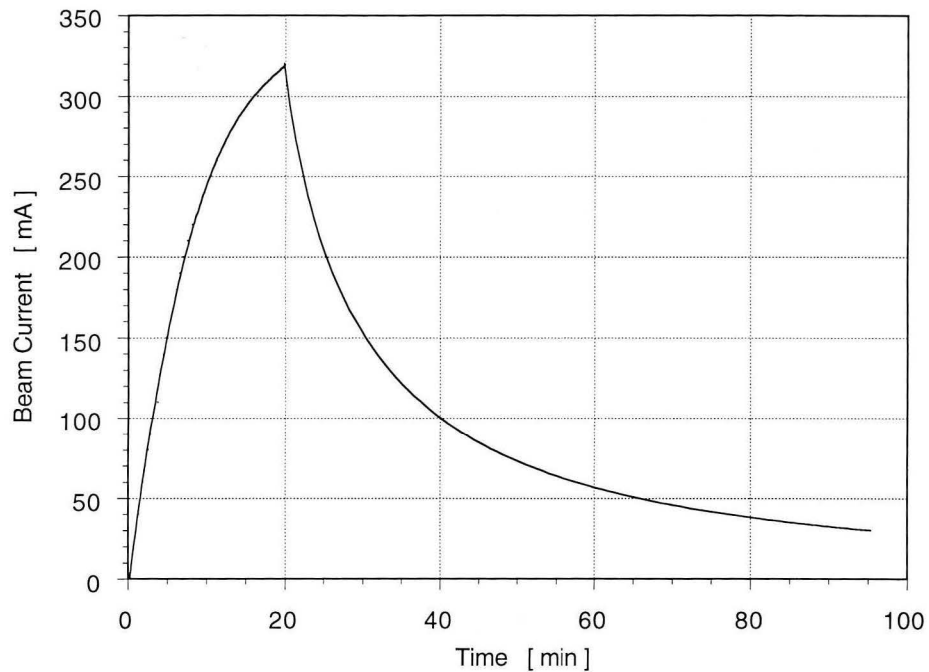
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the buildup were that schedule priorities prohibited bake-out of the storage-ring sector-chambers before electrons were injected into the ring for the first time, and that the titanium sublimation pumps were not used at all during commissioning. The circulating electron beam constantly emits photons that travel through a slot into an antechamber where they are absorbed by photon stops. The impact of a photon on a stop dislodges gas molecules from the surface, causing a rise in pressure. The electrons in the stored beam lose energy when they collide with these gas molecules, thus reducing the amount of time the electron beam lasts in the ring.

As the beam circulates longer and longer, it acts as its own "scrubbing" tool by dislodging the unwanted gas molecules, which are then removed from the ring by vacuum pumps. After just a few weeks of circulating beam in the ring and frequently refilling it to the highest achievable current level, there was a substantial improvement in the vacuum pressure that led to a dramatic rise in stored current and beam lifetime. The plan to bake out a large part of the storage-ring sector-chambers during the summer shutdown will improve vacuum pressure even further before operations resume this fall.

Jay Marx, director of the project from the beginning of construction to October 1992, reflects on the remarkable success of the ALS: "The fast pace



The measured stacking and decay times of stored beam current on April 8, less than one month after storing beam for the first time.

at which the ALS met and exceeded its initial performance goals shows the exceptional quality of the physics design and engineering of the injector and storage ring. The ALS team, the laboratory, and the synchrotron radiation community should feel great pride in this tremendous accomplishment."

Precise Alignment

"One principal factor in the rapid success of storage ring commissioning

was the excellent job done by survey-and-alignment technicians during the past year," says Rod Keller, deputy leader of the Accelerator Group. Until Christmas, the technicians were busy aligning over 200 storage-ring steering and focusing magnets, reducing their remaining local misalignment values to an average of 70 μm , two times better than the original specifications.

Once electron beam was achieved in the storage ring, control-room operators began fine-tuning the magnet fields to keep the beam circulating longer. The computer control system allows operators to assign a given knob to any magnet or magnet family. Adjusting the fields is done by turning knobs to increase or decrease the current values. A graphic representation of the electron beam's position at different locations throughout the accelerator lets the operators instantly see any effects on the beam caused by the changes to the magnetic fields. Fine tuning of the magnets is necessary to constrain the electron beam to an ideal orbit and maintain a small beam size.



Members of the storage-ring commissioning team pose by the ring. Pictured are: Chris Timossi; Rod Keller, deputy leader of the Accelerator Group; Orland Jones, Sue Daly, Hiroshi Nishimura, Jim Julian, Ken Luchini, Marv Nolan, Bob Brokloff, and Jim Hinkson.

Report from the ALS Director

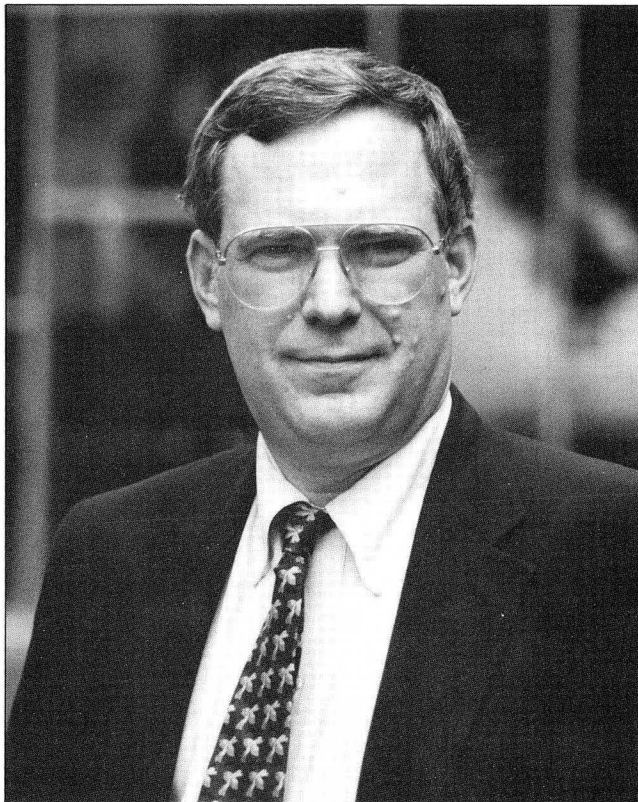
This spring marked a grand finale and a new beginning for the ALS. After six years of planning, designing, building, testing, installing, and aligning components, we completed the ALS construction project—ahead of time and within budget. Yet even while celebrating our success, we began a new mode of operations. The ALS project became the ALS Center—a national user facility—and our current efforts are geared toward preparing the equipment to produce high-quality photon beams so that users can begin to obtain experimental results by fall.

Project Completed, Design Goal Achieved

The final phase of the construction project—commissioning the storage ring—thrilled participants and observers alike. Its most remarkable aspect was the speed with which it progressed. Every few days of the year's first quarter seemed to bring another breakthrough. March 16 was especially significant. It was the day we turned on the rf power system for the first time and immediately stored an electron beam. From then on, the electron-beam current increased almost daily toward the 50-mA goal required for project completion. We surpassed this a week ahead of schedule on March 24, when 65 mA of current were stored in the ring. But the real culmination of commissioning came about two weeks later when the ALS stored 407 mA, exceeding the 400-mA design goal.

ALS Team Shares Credit for Engineering Triumph

The fact that the system worked as soon as it was turned on is a testimony to the knowledge and skill of the project team. We witnessed a true engineering triumph that could not have happened unless all compo-



ALS Director Brian M. Kincaid.

nents were operating to virtual perfection. I want to acknowledge specifically:

- The Mechanical Systems Group for designing, building, installing, and aligning the accelerator-system and storage-ring components, including the vacuum system and the arc sectors with their magnetic lattice.
- The Electronics Systems Group for designing and building the extremely successful rf system, beam position monitoring system, and accelerator control system.
- The Accelerator Systems Group and the Center for Beam Physics, for specifying the requirements to produce and maintain an electron beam smaller in size and divergence than in any other synchrotron light source. This work led to one of the most rapid and efficient commissioning efforts in the history of synchrotron radiation.

In the limited space of this report, I cannot hope to name all the contributions of these groups nor to express the praise each one is due.

Early Advocates Made ALS Possible

I also want to acknowledge those whose early leadership made the ALS possible. In the early 1980s, LBL Director Dave Shirley, himself a synchrotron-radiation user, first conceived of the project as part of a National Center for Advanced Materials (NCAM). Although NCAM appeared in President Reagan's FY83 budget, it was not funded; however, during the period 1983–1986, the idea of the ALS remained alive and continued to receive support. Among its major advocates within LBL were Martha Krebs, associate laboratory director for planning and development, and Herman Grunder, then the director of LBL's Accelerator and Fusion Research Division, both of whom helped gain support for the ALS on Capitol Hill.

David Attwood (then the ALS scientific director and now head of LBL's Center for X-Ray Optics) took on the task of developing support for the project in the scientific community. One of his methods was to organize workshops on the capabilities and applications of the proposed ALS. At a pivotal workshop, held in November 1985, the participants (including potential ALS users) "hammered out" a set of design parameters for the ALS based on their needs. These were incorporated into the ALS conceptual design report (CDR), which was submitted to the DOE in July 1986. This document convinced the DOE of the project's viability, much to the credit of Klaus Berkner, present associate laboratory director for operations, who led the CDR effort. As a result of the contributions of these leaders, the first ALS funding of \$1.5 million for an engineering design was awarded in FY 1987, and the remainder of the \$95 million in construction funds followed the next year.

I especially want to acknowledge the role of Jay Marx. Jay was ALS project director from June 1987 to

October 1992. He organized the project, built the team, and led it to the brink of completion. The major portion of the credit for its success is rightfully his.

Thanks to User Community

Our user community also deserves credit. I want to thank you for your steady support and assure you that, in return, we are striving to provide the best support for your research. We want you to think of the

“The ALS proves we have the knowledge and dedication to build a world-class scientific facility on time and within budget.”

ALS Center as the best place to work, not only because of the characteristics of its light, but also because of the high quality of its user services.

Guarantee High-Quality User Services

To guarantee quality in our operations and therefore the best service for our users, I have appointed Ben Feinberg, former head of the Bevalac Operations Program, to the position of ALS operations head. In this role, he will oversee day-to-day activities, allowing more time for me to concentrate on expanding the ALS user community and developing sources of funding to enhance our facilities.

In closing, I must say that I feel proud and fortunate to be leading the ALS Center as we open our doors to users. At a time when some say U.S. expertise in science and technology is slipping, the ALS proves we have the knowledge, skill, and dedication to build a world-class scientific facility on time, within budget, and to a level of perfection rarely achieved on a comparable scale. ■

Brian M. Kincaid
ALS Director

Ben Feinberg Named Head of Operations

ALS Director Brian M. Kincaid announced that Ben Feinberg will be head of operations, a position created to reflect the new status of the ALS as an operating facility. Working directly under Kincaid, Feinberg will be responsible for all aspects of internal ALS operations. The new Head of Operations position is important to the “future success of the ALS,” explains Kincaid. “It gives me the freedom to direct my efforts outwards instead of overseeing the day-to-day operations. I will have more opportunity to promote the scientific opportunities of the ALS and strengthen our relationship with the Department of Energy.”

Feinberg comes to the ALS from LBL’s Bevalac facility, where he was in charge of program operations. “As head of operations, my role is to take responsibility for what happens in the running of the ALS and to do what is necessary to make it operate smoothly,” says Feinberg. In his recent capacity as leader of an independent LBL group to review the ALS’ readiness for operations, he gained valuable experience in the workings of the facility.

Working alongside Feinberg is ALS Project Manager Ron Yourd. Yourd is coordinating the shutdown activities and installation of experimental equipment for the beamlines (see Scientific Research article on p. 5). In June, he will start a year at DOE headquarters in Washington, D.C., to provide technical assistance to the Construction Management Support Division.

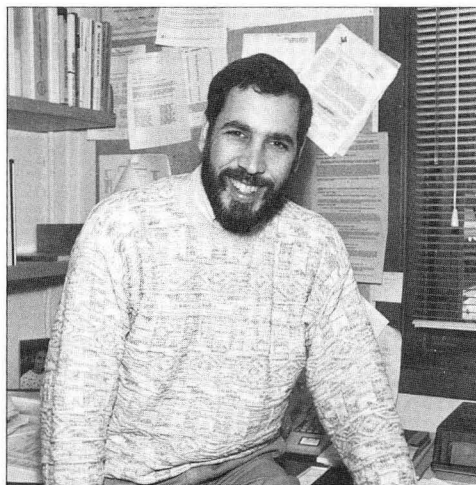
Major Improvements for Users

Feinberg is well qualified to ensure the greatest possible use of the ALS for scientific research. At the Bevalac, his group carried out major improvements to increase beam intensity. Feinberg then originated a project that increased the machine’s duty cycle by taking advantage of the improved intensity. The result was a threefold improvement in productivity for most users. He was also responsible for ensuring that accelerator operations at the Bevalac continued without interruption throughout the DOE Tiger Team visit in 1991.

Feinberg received a B.S. in physics at the University of Rochester in 1969

and a Ph.D. in plasma physics at Columbia in 1974. He joined the Magnetic Fusion Energy Group at LBL in 1976, working on a toroidal magnetic cusp experiment (Tormac), an alternative concept for the magnetic confinement of fusion plasmas. In 1984, Feinberg started working for the Bevalac as a SuperHILAC accelerator physicist. His group made the first accelerator use of laced electromagnetic-permanent magnet quadrupoles conceived by LBL’s Klaus Halbach.

In 1988, Feinberg was promoted to section leader of the Bevalac Planning and Development Group, where he was responsible for accelerator improvements. He became operations program head in 1989. Feinberg has also collaborated with the High-Energy Atomic Physics (HEAP) group for several years on a variety of research projects using relativistic heavy-ion beams. ■



Ben Feinberg joins the ALS as head of operations.

Scientific Research Program to Start in August

Eagerly awaited by researchers in the physical, chemical, materials, and life sciences, the ALS is nearly open for business. The next few months will be spent preparing for beamline operations to begin in August 1993. Essential tasks include installing two undulators and several beamline front ends plus coordinating the arrival and installation of user equipment.

The ALS floor will host two undulators and three bend-magnet beamlines within the first few months of operation, representing four participating research teams (PRTs). The two undulators, called U5 because of their 5.0-cm period, were designed and constructed at the ALS and will be installed in sectors 7 and 8 of the storage ring. The two user bend-magnet beamlines will be in sectors 9 and 10. In addition, the ALS will operate a diagnostic beamline designated 3.1.

Road Map of Operations

Beamline 7.0 will be operated by a PRT primarily interested in materials

science and the physics and chemistry of surfaces and interfaces. With this beamline, experimenters can match the world's record in resolving power over a range of 100–1000 eV and at the same time exceed the photon flux of today's x-ray sources, both in the laboratory and at synchrotron facilities. Refocus optics will take advantage of the excellent emittance of the electron beam to provide a spot 50 μm in diameter at the sample. The PRT spokesperson is Brian Tonner (University of Wisconsin, Milwaukee).

A second U5 beamline designated 8.0 will be used by a PRT led by Joachim Stöhr and Franz Himpsel (both at IBM), and by Thomas Callcott (University of Tennessee), David Ederer (Tulane University), and Rupert Perera (LBL). The initial research program will investigate the electronic and crystallographic structure of surfaces using established techniques such as core-level photoelectron spectroscopy, near-edge x-ray absorption spectroscopy, and photon-in, photon-out spectroscopy.

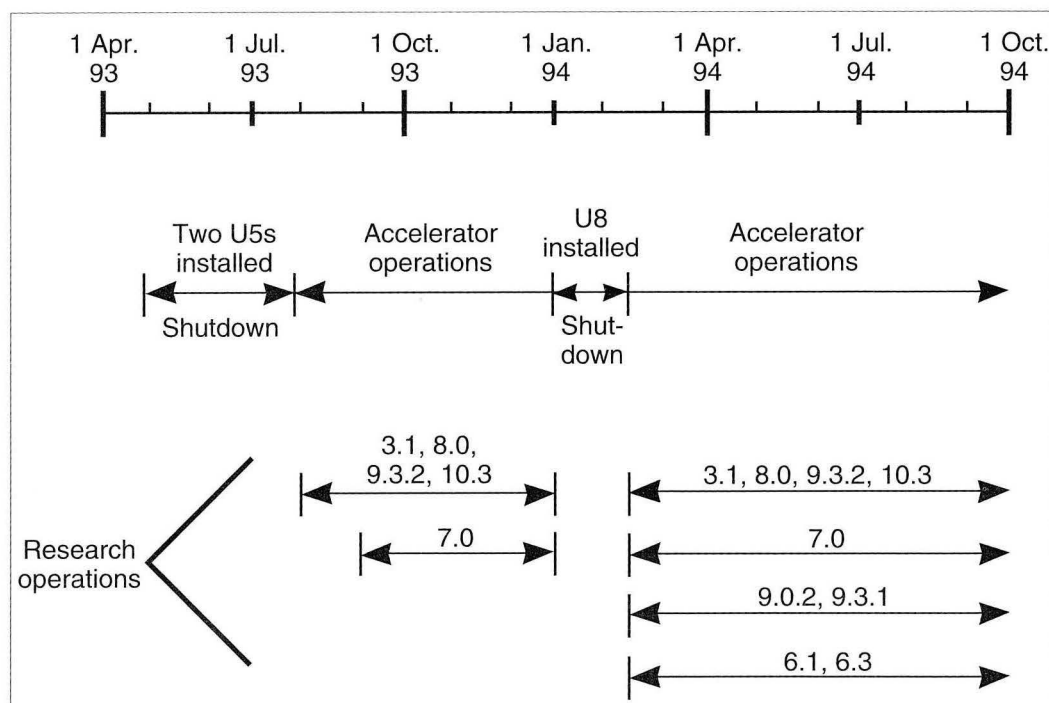
Bend-Magnet Beamlines

Three bend-magnet beamlines are planned for the start of operations: 9.3.2, 10.3, and 3.1. Beamline 9.3.2 was formerly in operation as the vacuum ultraviolet (VUV) beamline 6-1 at the Stanford Synchrotron Radiation Laboratory. Its major components are being moved to the ALS and modified to make the best use of this facility's brighter synchrotron radiation.

The 9.3.2 beamline will be dedicated to the study of problems in materials and chemical sciences using high-resolution electron spectroscopy. Of special interest are the electronic, atomic, and magnetic structures of metal and semiconductor surfaces and interfaces, and microcluster growth on these surfaces. The beamline has a spherical grating monochromator (SGM) with three interchangeable gratings for selecting photon energies from 30 eV to 1.5 keV. Charles Fadley (U.C. Davis and LBL) is spokesperson for the PRT operating the beamline.

The second bend-magnet beamline, 10.3, is being built at LBL by the Center for X-Ray Optics (CXRO). It will have two white-light branches (10.3.1 and 10.3.2). One experimental station will be dedicated to materials science experiments, especially ceramics, and the other to developing advanced microprobe instrumentation. With a 1- μm^2 spot size beam of high-intensity x rays, it will be able to rapidly produce elemental images with femtogram sensitivity and micron spatial resolution. The PRT spokesperson for the beamline is Albert Thompson (CXRO).

Beamline 3.1 is a diagnostic beamline to provide 1:1 images of the electron beam in the storage ring, thereby measuring the emittance of the beam. The beamline was designed by Ed Melczar of the ALS Experimental Systems Group.



The storage-ring schedule for the first year of ALS operations.

Program Development in 1994

Additional beamlines will be available in the spring of 1994, after a brief shutdown period in which the U8 undulator will be installed in sector 9 of the ring. The 8-cm-period undulator, designed and assembled by the ALS Mechanical Engineering Group, will have two beamline branches for experiments. The 9.0.2 beamline is for atomic and molecular photoelectron, photoionization, and fluorescence spectroscopy at photon energies ranging from 20 to 300 eV. It will have a permanent differential-pumping section for gas-phase experiments. The straight-through branch (9.0.1), available in 1995, will be used to study chemical dynamics.

The 9.3.1 bend-magnet beamline will use a double-crystal monochromator for high-resolution gas-phase, solid-state, and biological spectroscopy in the photon-energy range from 700 eV to 6 keV.

Beamline 6.1 will be dedicated to high-resolution zone-plate microscopy. Beamline 6.3 is for highly-accurate metrology of x-ray optical components, particularly those used in soft x-ray projection lithography, and to make measurements on x-ray optical systems such as microscope or telescope optics. The beamline is being funded by the Advanced Research Project Agency (ARPA). ■

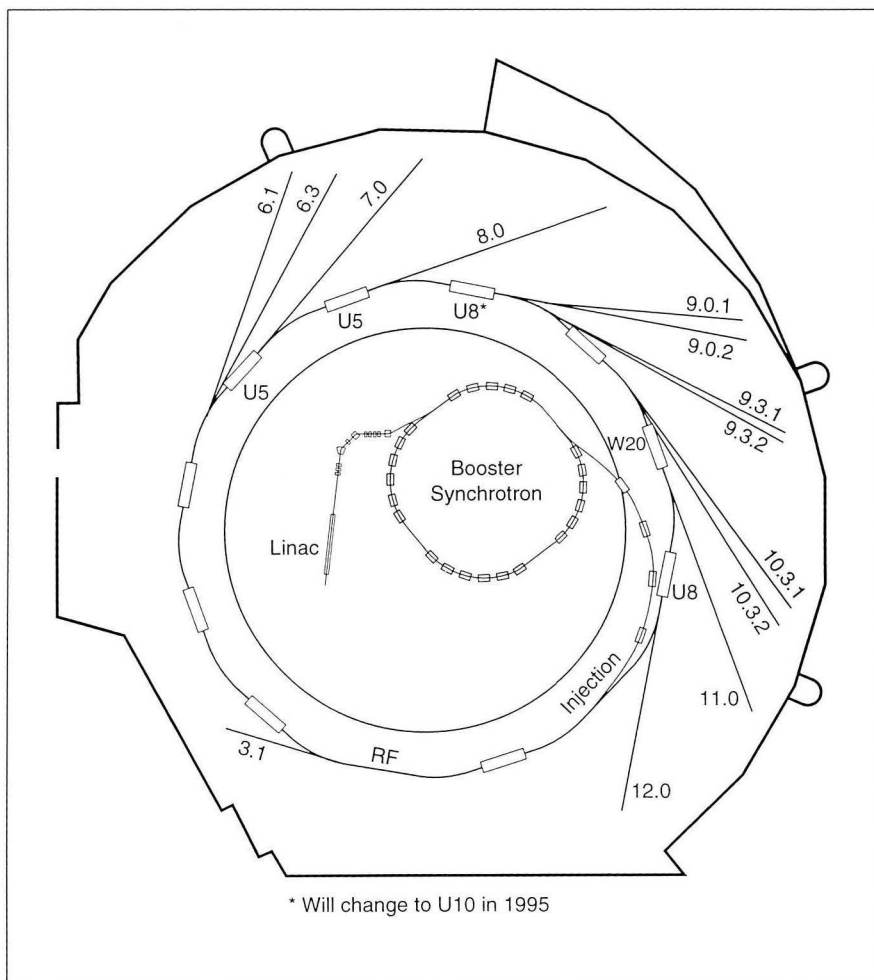


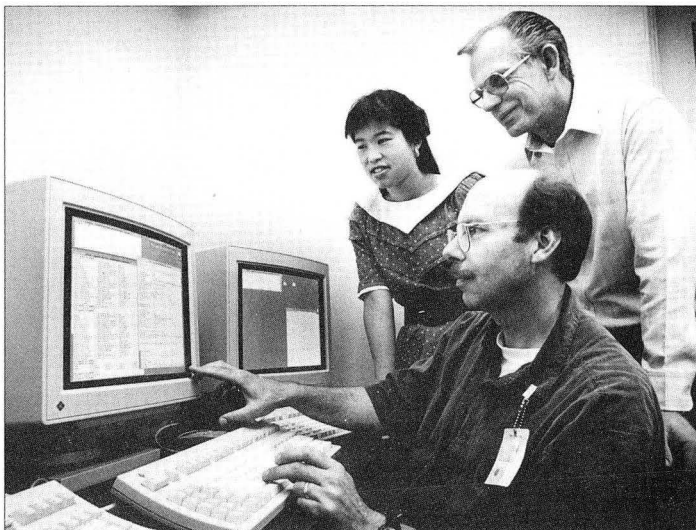
Diagram of the ALS floor showing the beamlines planned for construction through 1995.

Beamline	Source	Research	Energy Range
3.1	Bend magnet	Diagnostic beamline	200 eV
6.1	Bend magnet	High-resolution zone-plate microscopy	250–600 eV
6.3	Bend magnet	Metrology and standards	50–4000 eV
7.0	U5 undulator	Surfaces and materials, spectromicroscopy	70–1200 eV
8.0	U5 undulator	Surfaces and materials	70–1200 eV
9.0.1	U8 undulator	Chemical dynamics	5–30 eV
9.0.2	U8 undulator	Atomic physics and chemistry	20–300 eV
9.3.1	Bend magnet	Atomic and materials science (double crystal)	700 eV–6 keV
9.3.2	Bend magnet	Chemical and materials science	30–1500 eV
10.3	Bend magnet	Materials science and advanced microprobe instrumentation	2–10 keV
11.0	W20 elliptical wiggler	Materials science and biology, magnetism	50 eV–10 keV
12.0	U8 undulator	X-ray projection lithography	60–320 eV

The beamlines and areas of research for 1993–1995 operations.

Beamline Instrument Control

Now that the ALS storage ring is operational, beamline developers have stepped up their efforts to meet installation deadlines. By October 1993, five beamlines are scheduled to be installed and working—two of them designed and built by the ALS staff and a third brought from Stanford Synchrotron Radiation Laboratory and adapted by the ALS staff. A vital part of this effort is the design and implementation of beamline control systems—the task of the ALS Controls Group led by Joyce Young.



Members of the ALS Controls Group confer on an EPICS application for beamline instrument control: Joyce Young and Al Robb (standing), Carl Cork (seated).

Three-Layer Architecture

Controls Group member Carl Cork developed the overall system design, which calls for three subsystems: one for radiation safety, which triggers interlocks to prevent exposure of personnel to radiation; the second for the protection of beamline components from damage caused by vacuum failure or excessive heating; and the third for controlling beamline mirrors, monochromators, and other instruments involved in performing experiments. All beamlines, whether built by the ALS staff or by participating research teams, will incorporate the radiation-safety subsystem design, which was developed in detail by Art Ritchie of the ALS Electrical Group. The beamlines built or adapted by the ALS staff will also incorporate the equipment-protection and instrument-control subsystem designs, although beamline developers from any organization can opt to use these designs for their ALS beamlines.

Each of the subsystems constitutes a layer in the system's three-layer architecture. In this scheme, the radiation-safety system is at the bottom and has the highest functional priority, the equipment-protection system is the middle layer and has second priority, and the instrument-control system is at

the top with the lowest functional priority. Each component in the beamline is directly controlled by only one of these systems. For instance, the personnel safety shutter is directly controlled by the radiation-safety system, the vacuum valves by the equipment-protection system, and motors that move optical components by the instrument-control system. The three subsystems communicate with one another by relaying messages through the layers.

Instrument-Control System Functions

Of the three subsystems, the instrument-control system is the one with which beamline users will interact firsthand. It will enable a user at a workstation to:

- Manipulate or obtain feedback from the beamline components over which the subsystem has direct control.
- Send requests to the other two subsystems. For instance, a user could ask the radiation-safety system to close the personnel safety shutter.
- Obtain status information from the main control system, which runs the ALS accelerator.

Implementation with EPICS

Implementation of the instrument-control system is the task of Al Robb and Bill Brown, both Controls Group members. They are using the Experimental Physics and Industrial Control System (EPICS), a package of software tools that Robb calls "a control system in a box." Initially developed at Los Alamos National Laboratory (LANL) and enhanced at Argonne National Laboratory, EPICS is especially tailored for accelerators and beamlines. Because it was developed with DOE funds,

its source code was made available to LBL without cost.

The EPICS family of users includes several DOE facilities besides the ALS: the Advanced Photon Source (APS) at Argonne National Laboratory, the Superconducting Super Collider (SSC), the Gammasphere at LBL, and the Advanced Free Electron Laser at LANL. Because EPICS users from the national laboratories are all trying to solve similar problems, they have formed a collaboration. Each lab has its own set of tasks to perform and shares the results with its partners in the collaboration. For example, LBL's contribution will be a utility for backup and restoration.

According to Young, "Working with the other laboratories cuts way back on development time. For instance, we plan to use an ion-gauge driver (control program) that was developed at the APS. Because the code is already written and tested, we should be able to get it up and running in a matter of days."

Virtues of EPICS

"The virtues of EPICS," said Cork, "are its open architecture and the fact that it is fully distributed, data-driven, and fast."

The "open architecture" allows the system to employ industry-standard components such as UNIX workstations, Ethernet, and VME controller crates. "Fully distributed" means that any number of workstations and VME crates can be added. Each crate is a local intelligent subsystem that runs the software needed for controlling input/output (I/O) from a given set of beamline instruments and for conditioning the output data to the user's specifications. The set of instruments assigned to a crate and the software that drives them can easily be redistributed if the need arises. Furthermore, because the system is "data-driven," one need only edit a descriptor file to change parameters that control the collection of data from a given beamline instrument. Since rewriting code is not necessary, such changes are quick and easy. As for speed, the system will provide about 2000 screen updates per second on any workstation in the network.

System Hardware

The physical structure of the system is simple. For each beamline, there are four types of hardware

components: (1) user workstation(s), (2) VME crate(s) for controlling beamline instrumentation, (3) a gateway to the ALS accelerator control system, and (4) a local area network (Ethernet) connecting the other components.

The EPICS user interface software

The ALS Controls Group will provide simple graphic interface applications that users with UNIX workstations can tailor to their specific needs or use as is.

runs on UNIX-based workstations. Sun-4 workstations will be used for ALS-built beamlines; however, anticipating user demand, the Controls Group plans to port the

Channel Access software to PC Windows. A PC can then be used in lieu of or in addition to a UNIX workstation.

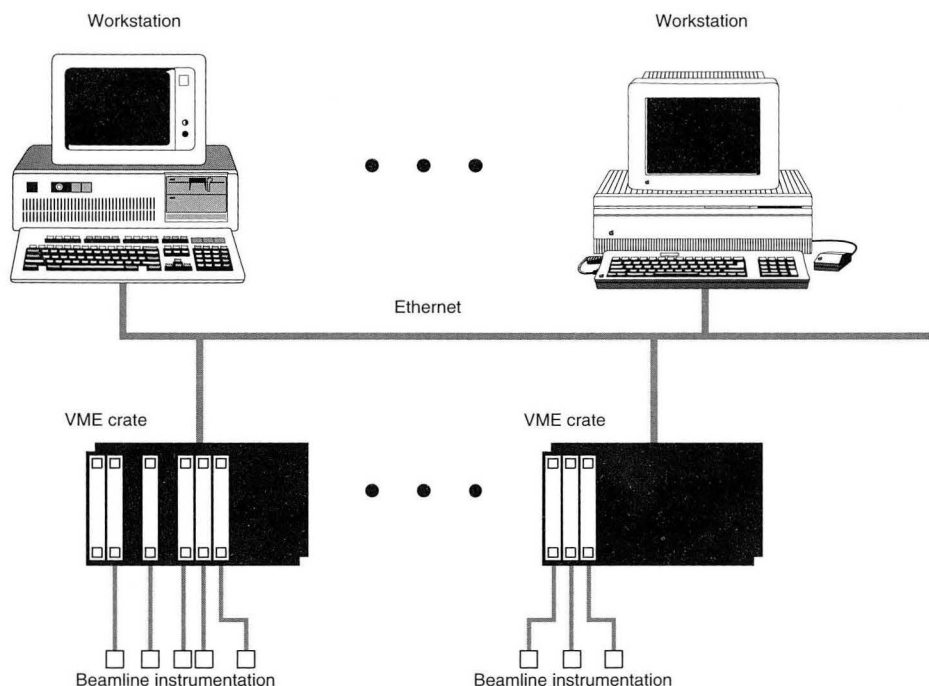
The VME crates contain a Motorola 68030 or 68040 processor running the EPICS server layered on VxWorks, a real-time operating system. Such systems are optimized to respond rapidly to I/O events—the most common transaction in a control system. VxWorks enables the rapid acquisition of data from beamline instruments to the EPICS database, which resides in the processor's memory. The VME crate also contains I/O boards that perform various functions such as motor control, analog-to-digital (A/D) conversion, D/A conversion, digital input and output, and bus connection (for example, IEEE-488 or RS-232). Each beamline instrument is connected to an I/O board. For example, a diagnostic detector with analog signal output would be connected to an A/D board to convert the signal to data that can be read by the processor and plotted at the workstation. Motors that move monochromator gratings or other beamline components would be connected to motor-control boards.

A VME crate also serves as the gateway to the ALS accelerator control system. It will enable beamline users to get information about the status of the accelerator and the electron beam. It will also relay information from the beamline's front end, for example, ion-gauge pressure readings or the status (open or closed) of the personnel safety shutter. Furthermore, on undulator beamlines, this gateway will convey users' instructions to change the undulator's gap. Designed as a filtered communications channel, the gateway screens instructions to prevent inappropriate or unsafe requests from going through.

System Software

EPICS provides the following software:

- A memory-resident database distributed among the VME crates in the system. In the database, developers define the system configuration for each crate and the channel-to-channel interactions.
- Drivers for a wide variety of I/O devices.



In a beamline instrument-control system, workstations communicate via Ethernet with VME crates containing input/output boards. These, in turn, communicate with beamline instrumentation such as diagnostics and motors for moving optics. A system may have any number of workstations and VME crates, and each workstation can communicate with any instrument in the system.

- A protocol called "Channel Access" that provides communications between the user workstations and the various beamline devices via the database.
- Tools for developing a graphic user interface for device control.

Users can take advantage of the interface tools to develop graphic applications that make it convenient to operate their beamlines. For instance, Tony Warwick, leader of ALS Beamline R&D and Operations, plans an interface for Beamline 7.0 that will let users select a wavelength by scanning. In this operation, a monochromator grating will rotate while, at the same time, the exit slit will move to maintain its location at the grating focus. This interface will also let users control motorized apertures and diagnostics in the "white" part of the beam to deter-

mine the beam position and remove excess power before the monochromator. Another feature will allow users to view plots of detector signals produced either through voltage-to-frequency conversion and counting or through analog-to-digital conversion.

Such operations will be carried out by selecting options on a computer graphics display. With a mouse, a user can drag a slider to increase or decrease a value, click a button to turn a device on or off, or choose parameters from a menu. Users will also be able to view data from beamline instrumentation in various graphic formats, such as a reading on a dial or a plot that resembles a strip chart.

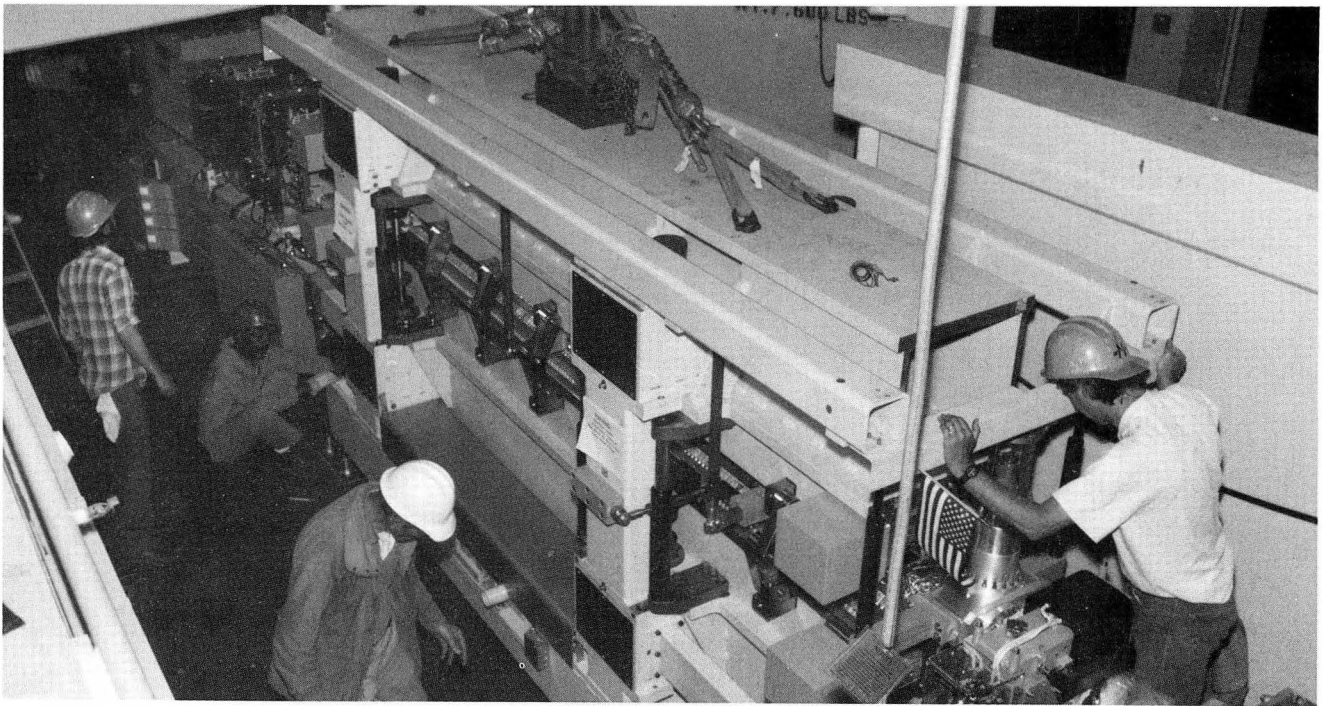
The ALS Controls Group will provide simple graphic interface applications that users with UNIX workstations can tailor to their specific

needs or use as is. For beamline developers who choose PCs instead, the group will provide a library of remote procedure calls that can be used to access the database in the VME crates. By employing these calls, developers can write programs that perform the same types of operations as the graphic interface applications developed through EPICS.

"If enough users ask," said Young, "we will also consider creating interfaces for Macintoshes and other types of computers."

Beamline developers are welcome to consult the Controls Group for more information on instrument control. Contact Joyce Young, MS 10-110, Lawrence Berkeley Laboratory, Berkeley, CA 94720; Phone: (510) 486-6724; Fax: (510) 486-4960; E-mail: jayoung@lbl.gov. ■

First ALS Undulator Installed in Storage Ring



With a few inches to spare, the first of two ALS U5 undulators, designated IDA, was installed in the storage ring on May 7. The 4.55-meter magnetic structure along with its support structure, a combined weight of nearly 25 tons, was lowered into straight-section 8 of the ring after parts of the concrete shielding were removed. In June, the second undulator (IDB) will be installed in section 7.

The two undulators, called U5 because of their 5.0-cm periods, will generate light in the photon-energy range of

about 60 to 1500 eV with the fundamental and the third and fifth harmonics. The calculated fifth harmonic based upon measured fields at the minimum gap of 14 mm is 75% and 73% of the ideal for IDA and IDB respectively, surpassing the design goal of 70%.

The ALS has completed the construction of a third U8 undulator with installation planned during a brief shutdown period in early 1994. It will be located in section 9 of the storage ring.

Vision to Reality

Many Milestones Mark ALS' Road to Success

Start Here



December 1986
ALS Project begins.

December 1987
Congress approves \$18 million for ALS.

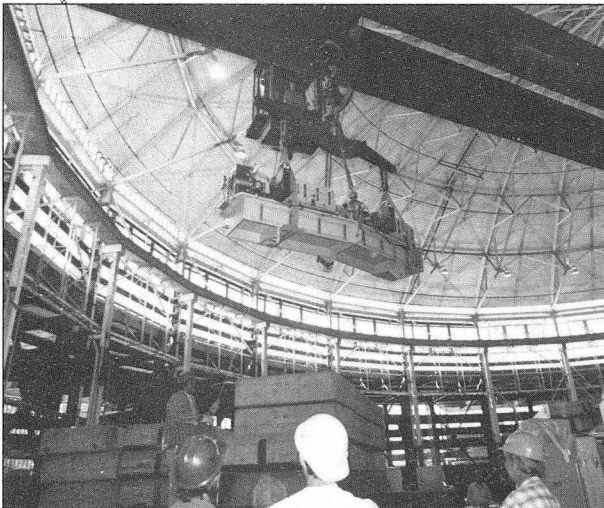
August 1988
Ground-breaking ceremony
launches construction.



April 1989 Project leaders keep close eye on progress.

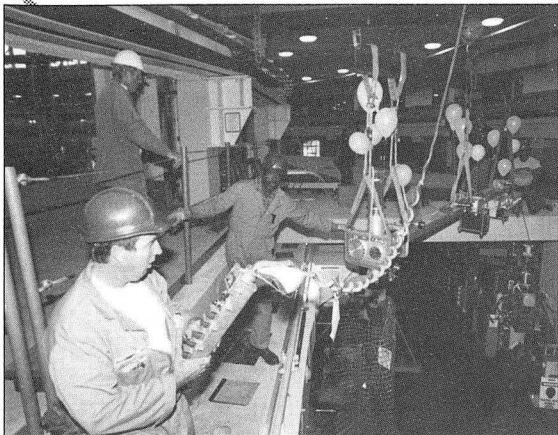
October 1989 Last major
concrete pour for floor and foundation.

March 1990 1st section of the booster
lowered into the shielding enclosure.

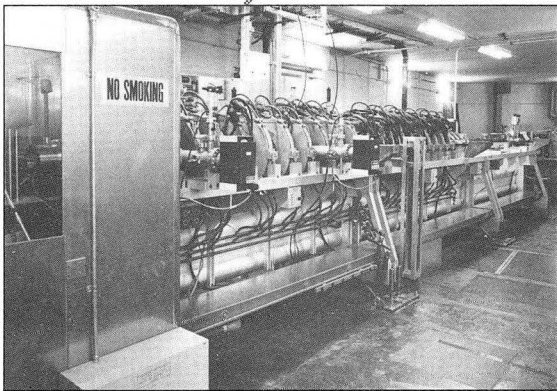


May 1990 Technicians tackle the complex
task of assembling the myriad of magnets
used in the storage ring.

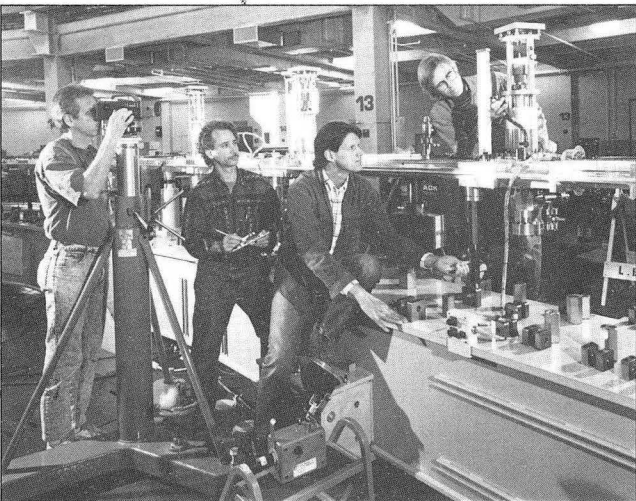
January 1992 Last straight section for storage ring arrives with fanfare.



November 1991 Final storage-ring magnet assembly completed.

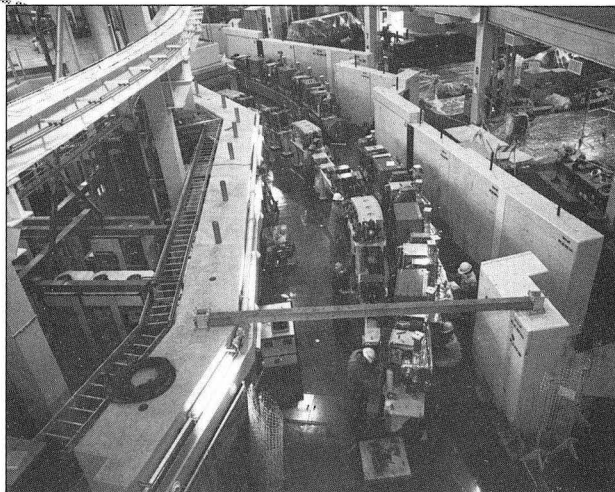


March 1991 Linear accelerator produces first beam on first try.



January 1991 Accurate surveying ensures precise alignment of equipment.

May 1992 Efforts focus on installation of storage-ring components.

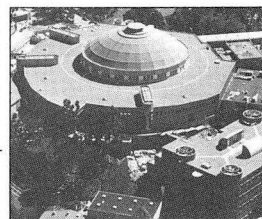


December 1992 Storage ring is completed.



March 16, 1993 ALS achieves 6 mA of beam current.

March 31, 1993
Beam current reaches 290 mA—exceeding project baseline requirements.



THE SECRETARY OF ENERGY
WASHINGTON, D.C.
March 30, 1993

Dr. Charles Shank
Director
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

Dear Dr. Shank:

Congratulations on the successful completion of the new Advanced Light Source. Please convey my appreciation to the Lawrence Berkeley Laboratory staff members who contributed to this effort, especially Drs. Brian Kincaid and Jay Marx who guided the project. Achieving the first stored beam in the storage ring with all systems operating was a crucial milestone.

We are proud that this project will soon contribute to the Nation's technology base.

Sincerely,

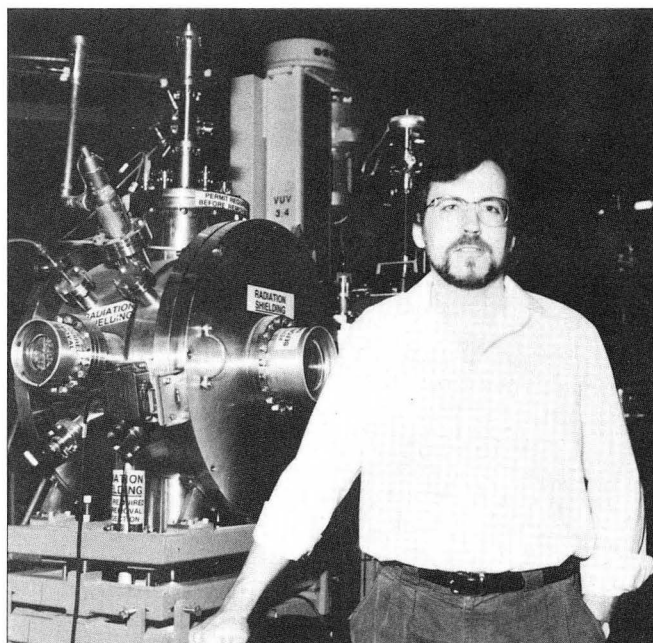
Hazel R. O'Leary

New Group Leaders Appointed

Experimental Systems

Howard Padmore joined the ALS staff as leader of the Experimental Systems Group on April 19, replacing Phil Heimann, who has been acting group leader since October 1992. The Experimental Systems Group designs insertion devices, beamlines, and advanced x-ray optics. Padmore is internationally recognized for his work with synchrotron-radiation optical systems. He comes to LBL from the Synchrotron Radiation Source (SRS) at Daresbury (UK), where he was head of the Soft X-Ray Group.

Padmore earned a B.Sc. in 1977 and a Ph.D. in 1983 at Leicester University—both in physics. The subject of the doctoral thesis is, "Soft X-Ray Emission Spectroscopy of the Heavy Rare Earths." In 1982, he joined the Surface Science Group at Daresbury where he conducted some of the first experiments using photoemission spectroscopy at the



ALS Experimental Systems Group Leader Howard Padmore stands with a beamline experimental station at the SRS.

SRS. The limitations of the early measurements led him to concentrate

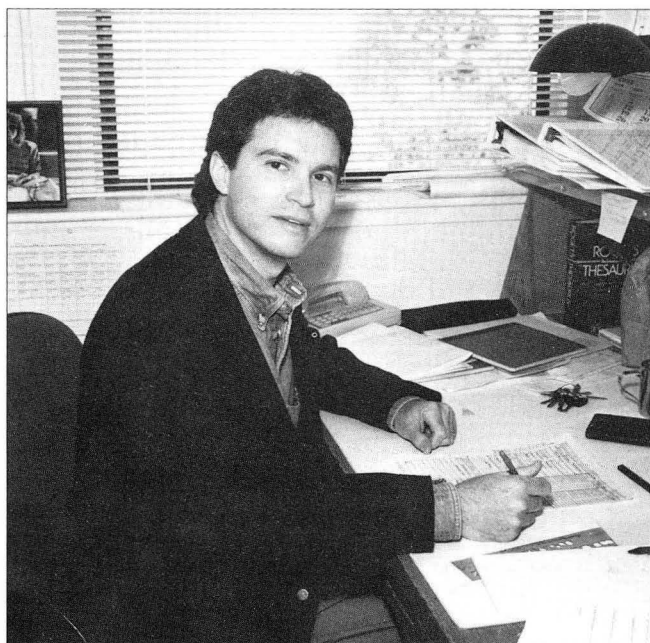
on the design and implementation of a new generation of instrumentation.

Over the past two years, Padmore has been involved with formulating plans for an advanced vacuum ultraviolet (VUV) storage ring at Daresbury and for a high-energy machine to replace the existing SRS. His current research interests include theoretical and experimental work on multi-layer diffraction gratings and their use in emission spectroscopy, development of techniques in grazing incidence, soft x-ray

absorption spectroscopy, and photoelectron microscopy.

Planning and Development

On March 12, ALS Director Brian M. Kincaid appointed Jim Krupnick as leader of a new Planning and Develop-



Jim Krupnick is the leader of new Planning and Development Group.

ment Group. The group's addition to the organizational structure reflects the ALS' recent change from a construction project to an operating facility. The primary responsibilities of the group include management of special projects and planning and management of ALS budgets. Krupnick has been involved with the ALS for over six years as the assistant project manager. He has extensive experience with managing costs, schedules, and technical progress—key tasks of the new group.

Planning and Development will assist engineering and research teams with formulating proposals, schedules, and budgets for new and existing projects. The group will then be responsible for following the projects through to completion. Currently, the group is overseeing two design and construction projects financed by DOE Accelerator and Reactor Improvements and Modifications (ARIM) funds: a transverse damping system for the storage ring and an elliptical wiggler insertion device. The damping system uses extremely fast electrostatic kickers to reduce transverse oscillations in the stored electron beam. Its completion is targeted for late fall. The elliptical wiggler will produce elliptically polarized synchrotron radiation that is useful for many types of research, such as the investigation of magnetic materials. Design of the device is under way with construction to be finished by the end of 1995. ■

From the Chairperson, Users' Executive Committee

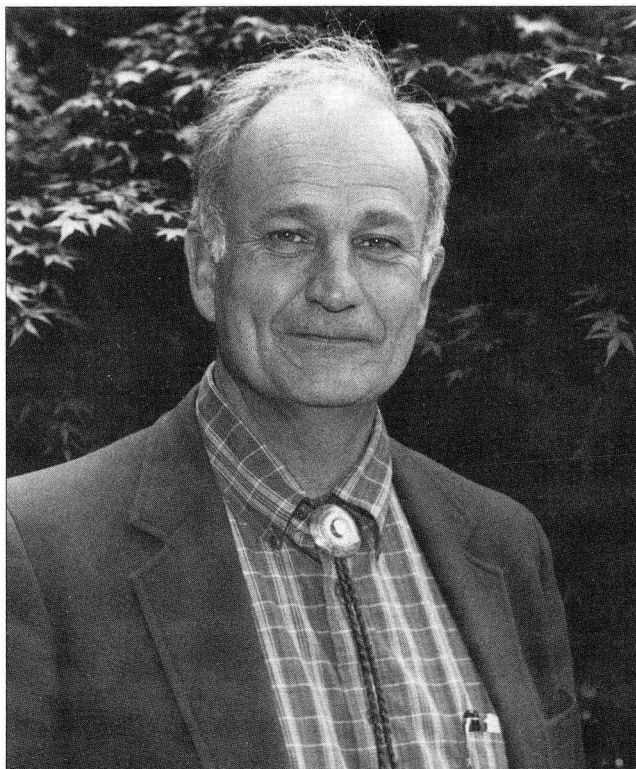
Praise for ALS on Project Completion

During late March and early April, faxes appeared in my mailbox every few days announcing one tremendous achievement after another at the ALS. An electron beam was stored and accelerated for the first time on March 16, reaching a current of 6 mA. This was the first day on which the commissioning team used the rf system, which for all its complexity, worked as soon as it was turned on. Each fax brought news of higher current, easily surpassing the 50-mA requirement for project completion. On March 31, the date on which the construction project officially ended, the current reached almost 300 mA, and only a few days later, passed the 400-mA design goal, reaching 407 mA. The ALS had far exceeded expectations so soon after the storage ring was completed!

Every day marks outstanding progress at the facility. These historic events are just a culmination of the years of patient, dedicated, and careful work that has been done by the staff and management of the ALS. When the first electron beam coasted in the booster ring, Alan Jackson glowed with pride as he showed the Users' Executive Committee (UEC) the oscilloscope trace of the beam. Now the intense electron beam circling the storage ring at virtually the speed of light will soon be providing x rays for scientific research.

Technology, Teamwork, and Skill

In December 1992, during our last UEC meeting, the committee toured the ALS. As I chatted with one of the engineers, I reflected on the enormity of this undertaking. The engineer remarked nonchalantly that it was all in a day's work. I asked myself how many miles of wire are required for control and sensing? How many different technologies are united? How many different skills are harmo-



David Ederer of Tulane University is chairperson of the Users' Executive Committee for 1993.

niously blended? How many different people must work as a team to make this happen? I thought of the artistically graceful machined pieces of aluminum that make up the vacuum chamber, the care and professional touch that was used in constructing the magnets, and the unusual engineering skills that are required for earthquake protection. I marvel at how this incredible effort had to be sustained by the team for years.

Thanks to Team and Leaders

Now at last, we all can celebrate the successful operation of this latest expression of man's art, because the ALS is truly a piece of art—a harmonious blending of so many skills and creative talents. I take this opportunity to express the thanks of all the ALS users to the team members for their dedication and untiring efforts to build this machine and bring it to successful operation. The user com-

munity is especially grateful to Jay Marx for his leadership from the start of the ALS project through most of its duration and to Brian Kincaid for assuming leadership during an especially delicate time and guiding the project to this moment of triumph. Congratulations Jay and Brian!

Undulators Installed Next

Well, the job is not done, but the preview has been so overwhelmingly exciting that the next task, no less difficult, will seem like child's play! Now two of the undulators, which are the heart of the ALS, are being installed. They give the ALS its unique characteristic—high-brightness x-ray beams. The undulators have been as beautifully crafted as the rest of the machine. Brian Kincaid has devoted countless hours overseeing the construction of these magnetic structures to exacting specifications. The 2200

permanent-magnet blocks in each undulator have been individually characterized to meet specifications. On our last tour, the UEC saw how the survey machine, mounted on a completed magnetic structure, glides up and back on its air-bearing ways, recording the magnetic field data crucial for the performance of the undulator. These devices will soon be delivering several hundred watts of highly collimated x rays from an almost point-like source.

Teams Building Beamlines

While the machine is undergoing its commissioning and acceptance tests, members of the user community and the ALS staff are working to build and install the beamlines and instrumentation that will bring to fruition eight years of work to develop the world's brightest x-ray source. The initial scientific program, commencing during the summer, will

focus on the two 5-cm-period undulators. On one, a team from IBM, the University of Tennessee, the National Institute of Standards and Technology, and Tulane University will install instrumentation to study the electronic and surface properties of solids, including semiconductors and magnetic materials. The other undulator beamline will be devoted to a participating research team (PRT), led by Brian Tonner of the University of Wisconsin, that will use the high-brightness beam for microscopy and materials studies.

Several bend-magnet beamlines are also scheduled for completion during this first phase of user operation. One soft x-ray line will be devoted to photoelectron spectroscopy and diffraction, with Chuck Fadley and Zahid Hussain leading the effort. Another bend-magnet line, under the guidance of Al Thompson, will be used for microprobe spectroscopy. Dennis Lindle and Rupert Perera are leading the development of

a bend-magnet beamline for x-ray spectroscopy that will operate in the multi-keV photon-energy range. The first results will be available in time for the ALS users' meeting to be held this year on October 21-22.

"Let the Work Continue"

The next phase of installation will produce a flurry of activity from the atomic and molecular physics PRT, the chemistry PRT, and the team from LBL's Center for X-Ray Optics that will construct beamlines devoted to x-ray

lithography and the development of unique optical devices for the soft x-ray spectral range.

With cutting-edge science and technology development near at hand, the entire user community is ready, willing, and able to make use of the opportunities and challenges that the ALS presents. Congratulations to the ALS staff once again, and let the work continue. ■

**David L. Ederer, Chairperson
ALS Users' Executive Committee**

Mark Your Calendar!

Sixth annual meeting of the
Advanced Light Source Users' Association

**Thursday and Friday,
October 21-22, 1993**

Lawrence Berkeley Laboratory

Letters of Interest

The ALS is now soliciting letters of interest from scientists who wish to conduct research at the facility as independent investigators during the 1993-1994 period. This solicitation will be followed by a request for proposals in the coming year.

Working as an independent investigator is one of two modes of research at the ALS. The other is to work as a member of a participating research team (PRT). PRTs typically build insertion devices and beamlines, as well as experimental stations. Consequently, members will have guaranteed access to their PRT's beamline for a certain fraction of the running time. Independent investigators will also have access to the beamlines, but through a proposal process. Although largely free from the responsibility of furnishing

experimental facilities, independent investigators may wish to furnish their own experimental chambers, depending on their experimental program and the beamline they request.

Initially, three beamlines, each equipped with a spherical-grating monochromator, are expected to be available to independent investigators.

Beamline	Source
7.0	5-cm-period undulator
9.0	8-cm-period undulator
9.3.2	Bend magnet

Information about these beamlines and the first-phase scientific program can be found in PUB-3104, "ALS Beamlines for Independent Investigators," and PUB-706, "First-Phase Scientific Program 1993/1994," which are available from the ALS office. A

fourth beamline (9.3.1), with a bend-magnet source and a double-crystal monochromator, will be available for experiments in 1994.

Because the ALS is funded as a national user facility by the Department of Energy (DOE), Office of Basic Energy Science, there will be no charge for non-proprietary experiments. DOE cost-recovery rules will apply for experiments not intended for the open literature.

To receive instructions for submitting a letter of interest, please contact the ALS administrative staff:

ALS Administration
Letter of Interest
MS 2-400
Lawrence Berkeley Laboratory
Berkeley, CA 94720
Telephone: (510) 486-4067
Fax: (510) 486-7696

Please copy this card for your colleagues

ADVANCED LIGHT SOURCE INFORMATION

To receive information about the ALS, complete this form, clip, fold, and mail (postage-paid).

- ☐ I did not receive a copy of the *Advanced Light Source Report* addressed to me; please add my name to the ALS mailing list.
- ☐ Please send me LBL PUB-703, "Advanced Light Source: Ultraviolet and Soft X-Ray Beams for Research."
- ☐ Please send me LBL PUB-680, "Putting Synchrotron Radiation to Work: New Opportunities for Industrial R&D."
- ☐ Please send me the report of the workshop "Synchrotron Radiation in Transactinium Research."
- ☐ Please send me the report of the workshop "Working Group on Elliptical Wiggler."
- ☐ Please send me the report of the Fifth Annual Meeting of the ALS Users' Association that was held on August 27-28, 1992 at LBL.

NAME _____

INSTITUTION _____

MAILING ADDRESS _____

TELEPHONE _____ FAX _____

COMPUTER-MAIL ADDRESS _____

My major scientific interests are in the fields of

- ☐ Materials Science
- ☐ Chemical Science
- ☐ Life Science
- ☐ Surface Science
- ☐ Atomic and Molecular Science
- ☐ Geosciences
- ☐ Accelerator Science
- ☐ Other _____



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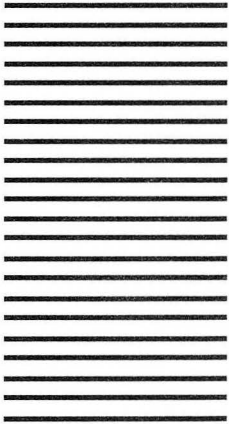
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Berkeley, CA 94720

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Advanced Light Source
MS 2-400



Storage Ring Completion Ends Successful 1992

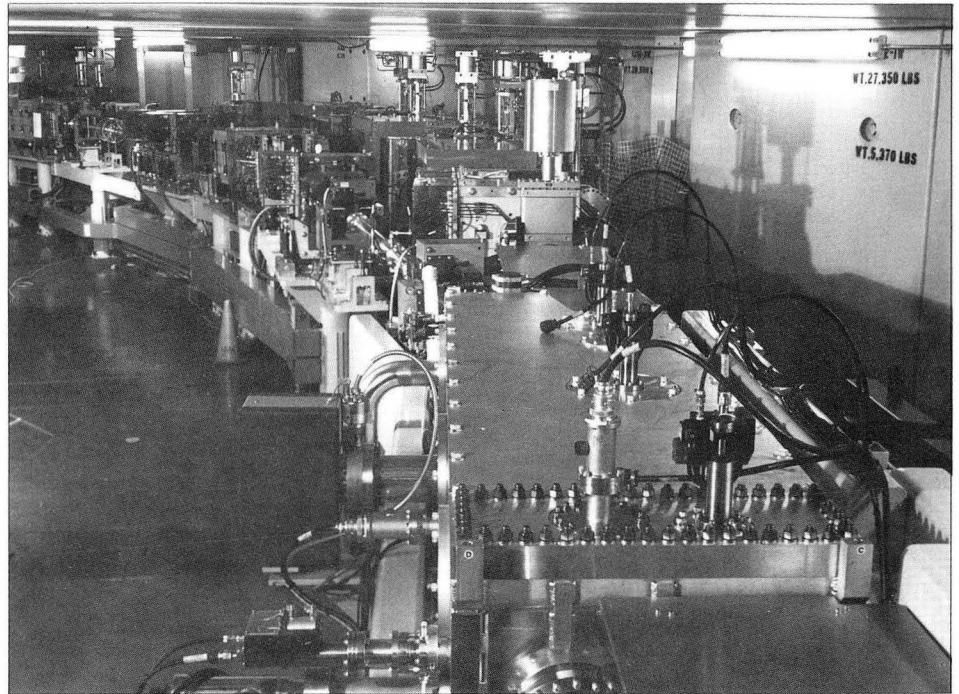
On December 14, the ALS celebrated the mechanical completion of the storage ring—the last major project milestone before injection of electrons into the ring. Successful operation of the ALS barely one month after the ring's completion was a clear demonstration of the excellent work performed by the engineers, physicists, and technicians responsible for storage-ring construction.

Completion of the storage ring was no small task. The storage ring is 197 meters (646 feet) in circumference and consists of 12 arc-sector chambers alternating with 12 straight sections. Each section contains over 100 metal ultra-high vacuum (UHV) seals; 17 bending, focusing and steering magnets; 8 beam-position monitors; and 8 titanium sublimation pumps, all of which require precise assembly, installation, and alignment.

Creating A Smooth Path

One of the last storage-ring components to be assembled and installed was the injection straight. Inside this section, the electron beam from the linear-accelerator and booster-synchrotron complex (the injection system) enters the storage ring and adds to the beam of electrons circulating inside the ring.

Raising the current in the ring to the desired value by electron injection typically takes several minutes. Every second, the booster synchrotron adds a new train of electron bunches equaling about 1 mA of current to the circulating beam. Four bump magnets and two septum magnets in the injection straight direct the new electron train



A view of the injection-straight sector of the storage ring. The large center section contains the two septum magnets. Entering from the left is the booster-to-storage-ring transport line carrying the electron beam from the accelerator system.

and the storage-ring electron beam to close, parallel trajectories so they can combine smoothly.

The first two bump magnets bend the circulating electron beam to a path parallel to its original orbit, closer to the inner wall of the vacuum chamber. The electron beam coming from the injection system is guided by the thick and thin septum magnets to an angle parallel to the "bumped" beam. The last two bump magnets redirect both beams to the center of the storage-ring vacuum chamber. The newly injected beam bounces around the stored one for about 20 ms, becoming completely

merged with the stored beam well before the next electron train is injected.

The design of the injection straight calls for the entire section to be able to be moved transversely by ± 1 cm to find the best position for the septum magnets during the injection process. In addition, it allows the magnets to be shifted away from the stored beam after electron injection is complete to prevent possible interference with the beam. Since any offset or discontinuity in the ring's conducting walls will distort internal radio-frequency (rf) fields and disturb the stored beam, the ALS design includes a special array of

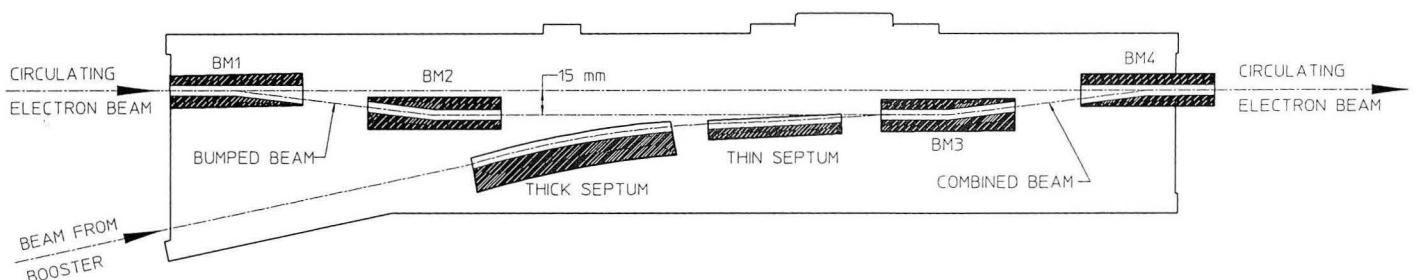


Diagram of the injection straight illustrating how it directs the paths of the electrons from the injection system and the storage ring to combine smoothly.

wires called a “birdcage” to provide a smooth path for the rf fields from the injection straight to the surrounding sections, while allowing for the transverse movement of the injection section.

Verifying the Design

After the storage ring was completed in December, the next step was testing the integrity of its design. The ALS injected electrons into the ring for the first time on January 15, and stored the first beam just four days later. The number of turns of the electron beam continued to improve throughout February and March. On March 16, the first day the radio-frequency power system was operational, the ALS achieved an electron beam with a stored current of 6 mA. By mid-April, the current had exceeded the 400-mA design goal and the electron beam had attained a lifetime of over an hour. The remarkable speed at which the ALS progressed from completing the storage ring to exceeding the project’s ultimate performance target was testimony to the exceptional quality of the storage ring’s design and construction.

Performing Shutdown Tasks

The May to July shutdown period promises to be a busy time for the storage-ring engineers and technicians as well. They will bake out most of the

storage ring sectors to improve vacuum pressure when operations resume. Bake-out is a process by which the UHV components are heated to 120° C while under vacuum to drive off contaminants. To prepare for user experiments, technicians will remove the straight sections of ultra-high-vacuum chamber in sectors 7 and 8 of the ring, which are occupying the space reserved for insertion devices, and replace them with the



The “birdcage” provides a smooth path for rf fields from the injection straight. The wires are beryllium-copper and 0.46 mm (0.018 in) in diameter.

two U5.0 undulators and their special vacuum chambers.

Another task during shutdown will be the realignment of a portion of the storage ring. During storage-ring installation, the concrete shielding was set in place concurrently with the storage ring girders. Data from the latest survey shows that some of the girders have moved by as much as 900 μm since they were originally aligned. A unique design developed at the ALS makes realignment of the girders, along with the magnets and vacuum chambers mounted on them, a straightforward task. Each storage-ring girder is supported on an innovative six-strut kinematic support system. Turning the shaft of a jack screw at each of the six struts adjusts the length of the strut, and allows the 30-ton girder assembly to be easily moved in increments as small as 25 μm . ■



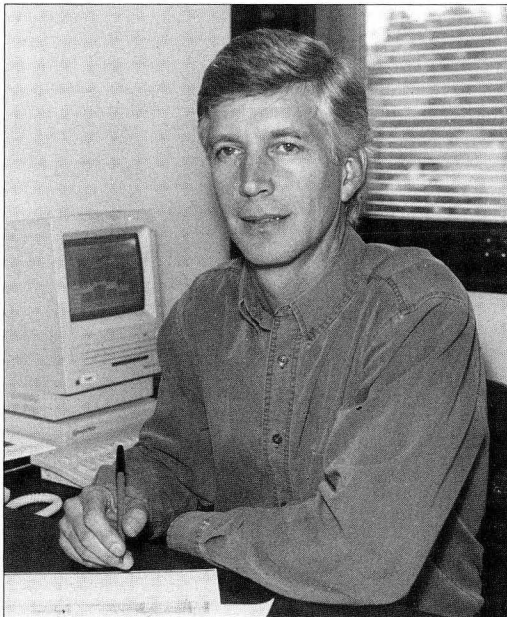
LBL Director Charles V. Shank poses with part of the storage-ring commissioning team. Pictured are (left to right): ALS engineer Tom Henderson, LBL Director Charles V. Shank, installation team representatives Greg Stover, Bill Gath, Michael Decool, Terence Akins, and Greg Morrison; ALS Project Manager Ron Yourd; ALS Director Brian M. Kincaid; and team member Dennis Gibson.

Ray Thatcher is User Support Leader

A top priority of the ALS is to make sure users find a safe and efficient working environment when they arrive. To assist in this effort, Ray Thatcher joined the ALS in January as user support leader. He and his staff of operations coordinators will oversee the activities on the experimental floor to provide assistance to users and ensure compliance with safety regulations. Thatcher will report to the ALS user support head, Fred Schlachter.

The user support leader acts as the technical liaison between users and the ALS infrastructure. Thatcher and the operations coordinators will be the users' first contact for questions or problems concerning safety issues such as interlocks and shielding, and support services including floor-space allocation, housekeeping, and shipping and receiving. They will inspect and enable beamlines, check that users have the appropriate training for the beamline and experimental equipment, and

make sure hazardous materials are handled properly. In addition, the coordinators will help users gain access to LBL and ALS crafts and trades such as survey and alignment crews, crane operators, and electronic and mechanical technicians. During operations, at least one operations



Ray Thatcher is the new user support leader.

coordinator will always be available on the experimental floor.

Thatcher's role is a unique one in that it requires a detailed knowledge of several disciplines and a working knowledge of many others. He must be able to handle anything that comes up on the experimental floor that involves safety and the working environment. Thatcher has more than 14 years experience as an accelerator operator at LBL's HILAC and Bevatron facilities. As an operator, he learned how to deal with the requests of experimental users and provide for their needs.

Since joining the ALS, Thatcher has been coordinating the efforts of the different groups involved in completing facilities that users will need to prepare for and conduct experiments. He organized the completion of the clean-assembly laboratory designed for the assembly of beamline components, end stations, and monochromators. ALS user facilities will ultimately include laboratories, equipment assembly areas, storage areas, a machine shop, and other user space. ■

Elliptical Wiggler Workshop

The ALS held an informal workshop on April 19 to discuss the production and use of elliptically polarized radiation at our facility. The ALS is designing and building a 20-cm-period elliptical wiggler with completion of construction targeted for 1995. More than 40 scientists and engineers participated in the workshop.

Elliptically polarized vacuum-ultraviolet and x-ray radiation is of considerable interest as a tool for the probing of matter. It is ideal for investigating materials exhibiting dichroism—the property of absorbing different amounts of circularly polarized light, depending on whether the polarization is right- or

left-handed. Elliptically polarized light is useful in many areas of research such as materials science, surface science, atomic and molecular physics, chemistry, and biological science. Industrial applications might include a better understanding of the magnetic characteristics of materials and the development of new materials that could be used to produce recording media with greatly increased storage capacities.

Several workshop participants gave brief scientific presentations describing experiments that would take advantage of circularly polarized light produced by an elliptical wiggler. The research proposals

covered a variety of scientific disciplines and demonstrated a high level of interest in elliptically polarized photons over a broad energy range. Some of the topics discussed were atomic physics, magnetic materials, superconductors, and multilayer optics to generate and analyze polarization states.

Presentations by ALS staff members included an overview of insertion devices for elliptical polarization, the performance of an elliptical wiggler and crossed undulator, the hybrid-electromagnet elliptical wiggler design at the ALS, and possible beamline designs. A report of the workshop is available from the ALS upon request. ■

The *Advanced Light Source Report* is published periodically at Lawrence Berkeley Laboratory for members of the Advanced Light Source Users' Association and other interested persons.

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Gloria Lawler

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