Title
A Guide to User Facilities at the Lawrence Berkeley Laboratory

Author
Lawrence Berkeley National Laboratory

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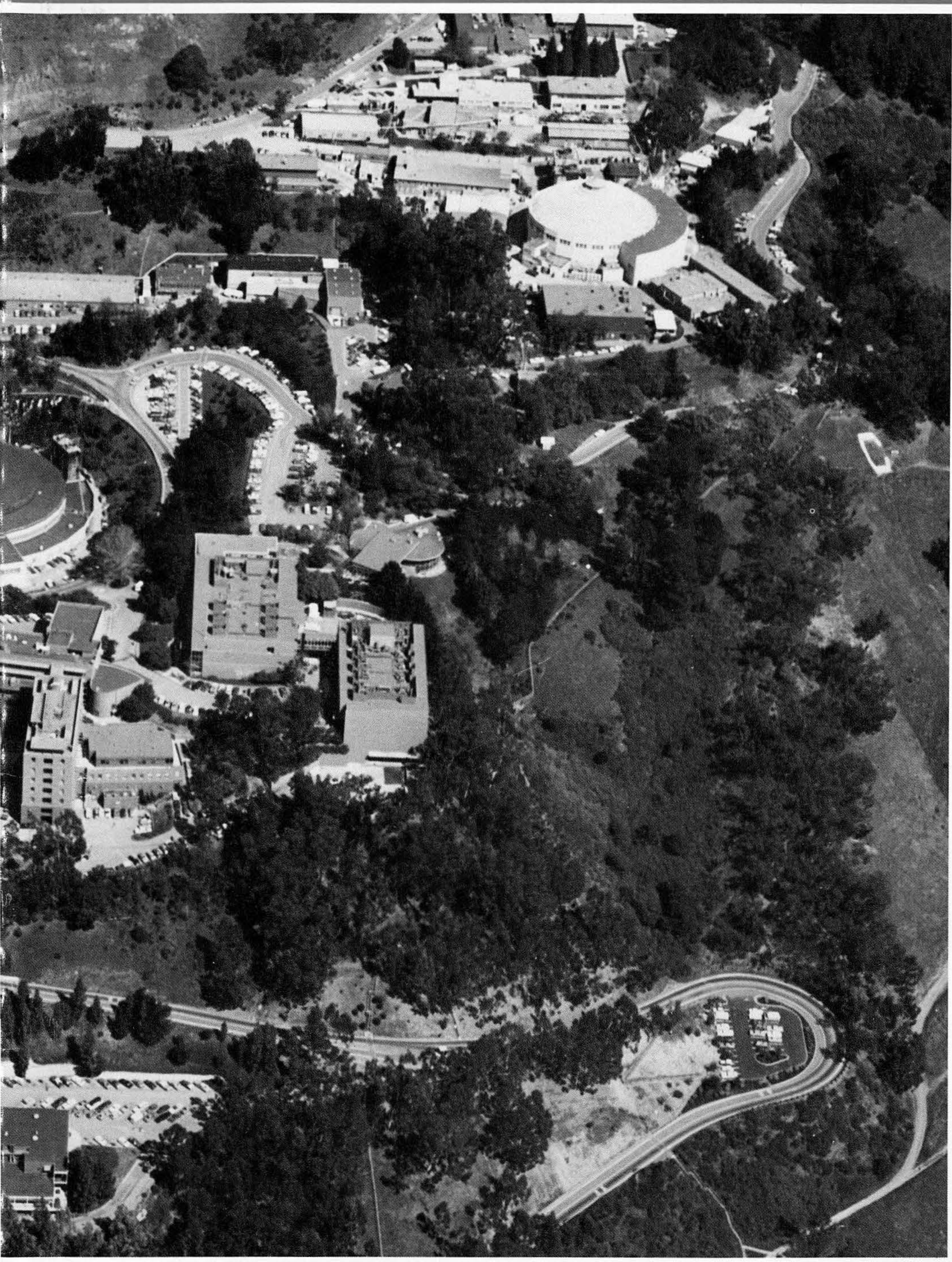
Research Facilities Available to Researchers, Universities, other Laboratories and Industry



A Guide to User Facilities at the Lawrence Berkeley Laboratory

Lawrence Berkeley Laboratory
University of California
Berkeley, Ca 94720

Guide to User Facilities at the Lawrence Berkeley Laboratory

Contents

- Accelerators
- Electron Microscopes
- Experimental Treatment
- Tritium Labeling
- Building Efficiency
- Fusion Energy

Introduction

The Lawrence Berkeley Laboratory (LBL) is a multiprogram national laboratory managed by the University of California for the U.S. Department of Energy (DOE). Located adjacent to the University of California's Berkeley campus, LBL's main purpose is to conduct multidisciplinary research that is appropriate for an energy research laboratory but not suited to the program goals or resources of a university or an industrial laboratory. Such research is conducted in a wide variety of fields including nuclear and high energy physics, basic energy sciences, health and environment, magnetic fusion, conservation and renewable energy resources, and fossil fuels.

Part of LBL's mission includes developing and operating large experimental facilities for the benefit of the scientific community. Several of the major facilities can be utilized for research performed by industries, universities, and other government agencies. In general, the facilities at LBL used by outside researchers are of two types:

1. **National User Facilities**
   These have been formally designated as national user facilities by the Department of Energy, and are available for use by qualified researchers whose proposals are approved by a national review committee.

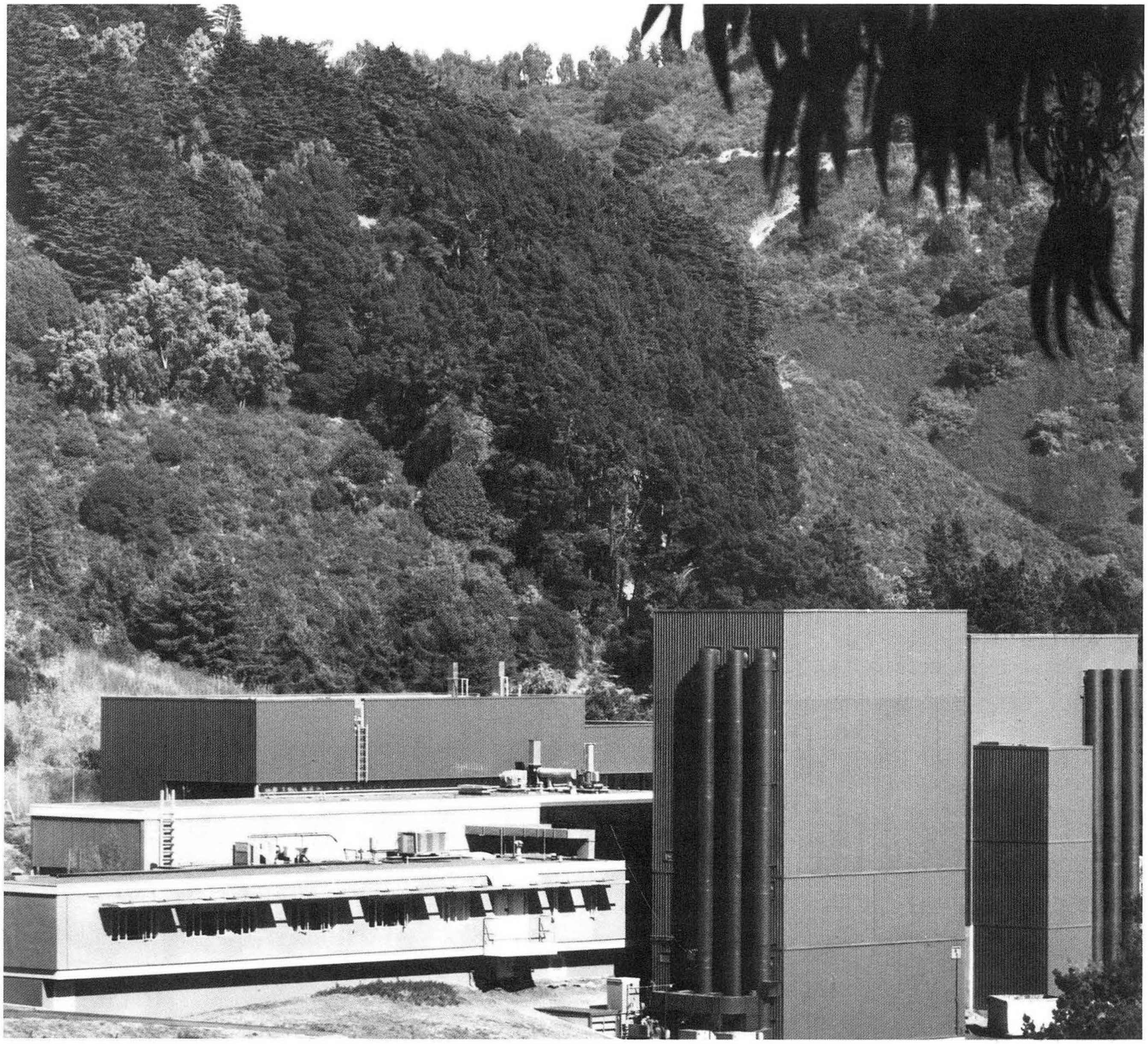
2. **Other LBL User Facilities**
   These facilities lack designation as national user facilities, but are nonetheless available to qualified scientists and engineers.

This guide describes LBL's User Facilities. At the end of each description, an LBL contact person is listed. That individual can provide specific information about the technical and procedural aspects for making use of the facility described.

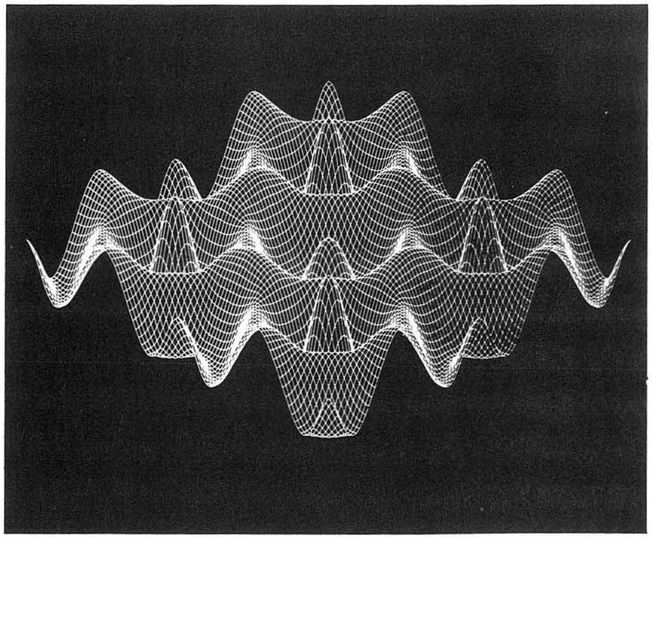
For questions about this guide, contact:

Robert J. Morris
Office of Research and
Technology Applications
B 80C
Lawrence Berkeley Laboratory
Berkeley, CA 94720

(415) 486-6502



▲Using the microscopes at LBL's National Center for Electron Microscopy, materials scientists and biologists can study specimens under the conditions found in real environments, and distinguish individual atoms even in closely-packed structures. The Atomic Resolution Microscope (ARM) is housed in the silo on the right, the 1.5 MeV microscope in the silo on the left.



National
User
Facilities

The National Center for Electron Microscopy

The National Center for Electron Microscopy is a user-oriented facility designed to make available a wide range of microstructural and microchemical characterization techniques for concentrated application to materials problems. The microscopes in the Center enable materials scientists and biologists to study samples under the most realistic conditions possible and to distinguish individual atoms even in closely packed metallic and ceramic structures. Researchers can look at the behavior of materials in the atmospheres encountered during the reduction of ores, in the process of corrosion, and in other conditions that occur in practical situations.

In 1981, the Center's first year of operation, a 1.5 MeV high voltage electron microscope (HVEM) was installed. This is the most powerful and versatile such instrument in the United States. Capable of operation at a beam energy of 1.5 MeV, the HVEM's major advantage is that it can penetrate more deeply into materials than can other electron microscopes, providing images previously thought unattainable. This instrument is also equipped with an environmental stage for *in situ* studies of gas-solid reactions at high temperatures, and will soon be fitted with an electron energy-loss spectrometer for high-energy spectroscopic studies. Seventy research proposals for the use of this microscope have already been approved by the eleven-member HVEM steering committee (four from LBL and seven from other institutions).

The most recent addition is the 400–1000 kV atomic resolution microscope (ARM)—the highest resolution microscope in the world with a demonstrated point resolution of 1.6 Å. Both microscopes are mounted on a 90-metric-ton vibration isolation pad and stand 9 meters tall. The Center was dedicated in September 1983.

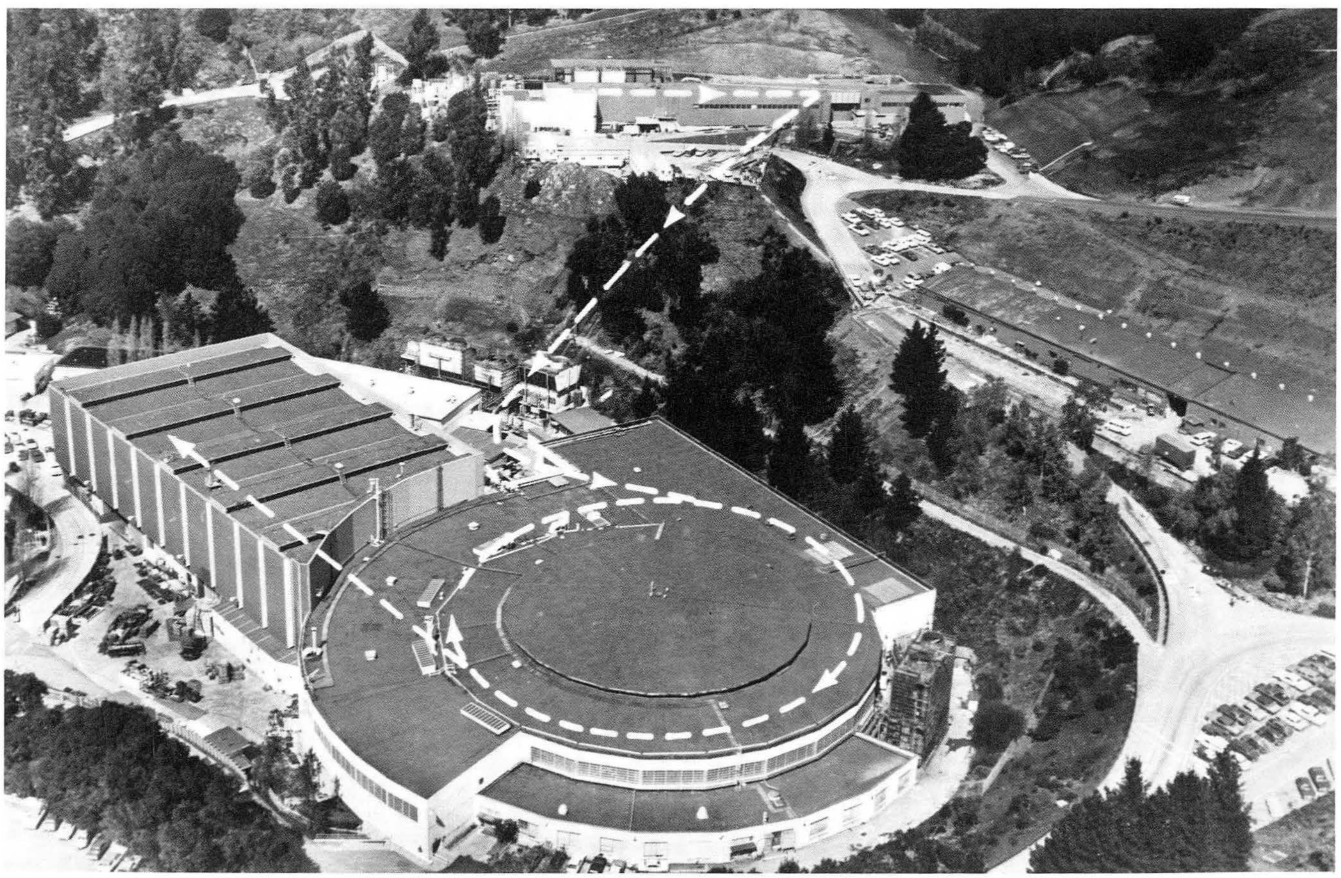
Users of the Center have included many researchers from universities and government laboratories, as well as industrial firms involved in energy development and semiconductor research. Review of research proposals and recommendations to the LBL Director concerning them are the responsibility of the Center's Steering Committee, whose present Chairman is J. Hren of the University of Florida.

◀ **The console of the 1.5 MeV microscope occupies the second story of its three-story silo. An accelerator is on the top level, the 90-metric-ton vibration pad, standing 9 meters high, is located on the ground level.**

◀ **The computer-generated image shows the electron distribution in barium titanium (the electrons are seen as peaks).**

CONTACT: LBL Materials and Molecular Research Division, Bldg. 62-203, Lawrence Berkeley Laboratory, Berkeley, CA 94720.

▲ Part of the recent vacuum system upgrade at the Bevatron/Bevalac includes a liner which was installed in three-meter sections. Accelerator designers have created an ultra-high vacuum environment in which to accelerate intense and energetic particle beams, by freezing extraneous molecules to the super-cooled liner walls.



The Bevalac

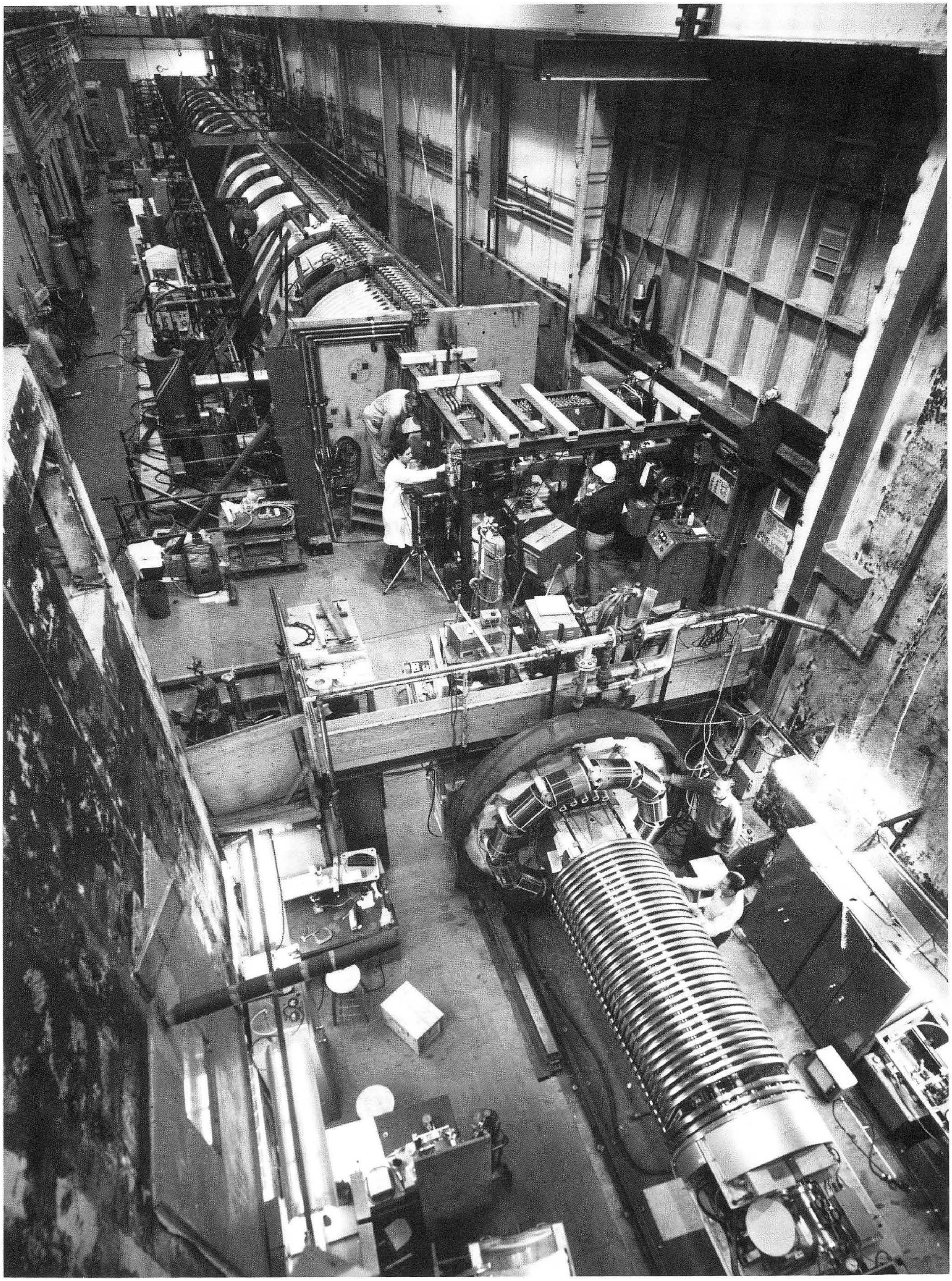
The Bevalac is made up of the combined Bevatron (a synchrotron) and the SuperHILAC (a linear accelerator). The Bevalac can accelerate heavy ions to any energy between 50 MeV/nucleon (where it overlaps with lower-energy machines) and 2100 MeV/nucleon (an energy no other facility in the world can reach with heavy ions). In some modes of operation the Bevatron local injector is used. The Bevalac has several large detector facilities: (a) HISS, a very-large-volume, heavy-ion superconducting spectrometer with large-area detection systems; (b) the Plastic Ball and Wall, a multiplicity detector with over 1000 detector elements, jointly funded by the U.S. and West Germany; (c) TASS, a two-armed magnetic spectrometer system; (d) a pion detector system jointly funded by the U.S. and Japan; (e) LEBL, a low-energy beam line designed to host a variety of experiments at energies from 50 to 250 MeV/nucleon; and (f) a magnetically surrounded streamer chamber.

Among the world's accelerators, the Bevalac is unique in affording an opportunity to study collisions between nuclei at energies sufficient to convert nuclear matter into hadronic matter—a state in which neutrons and protons, their excited states (such as delta resonances), and free pions all coexist. It supports programs in peripheral fragmentation reactions, pion production with heavy ions, central collisions that create nuclear matter complexes under extreme conditions of compression and stress, and reactions in nuclear matter. In addition, one-third of the Bevalac operating time is used in support of biomedical research, including a trial program of heavy-ion cancer therapy (see "Heavy Charged-Particle Treatment Facility").

Groups from all over the world visit LBL to take advantage of these extraordinary scientific opportunities. Bevalac nuclear science and biomedical research programs are reviewed by separate Program Advisory Committees (PACs). Each PAC then recommends to the LBL Director which proposals should be approved and how much beam time should be allotted. At present, the chairman of the nuclear science PAC is B. Vogt of the University of British Columbia, Vancouver, B.C., and the chairman of the biology and medicine PAC is R.J.M. Fry of the Oak Ridge National Laboratory.

◄**The Bevalac — a combination of the Bevatron and SuperHILAC working in tandem — is the only accelerator facility in the world that provides ions as heavy as uranium at velocities close to the speed of light. The arrow shows the path of the heavy ions, which are produced and accelerated at the SuperHILAC (rear), then steered through a transfer line into the Bevatron (the circular building in the foreground) where they are further accelerated and routed to the various research areas.**

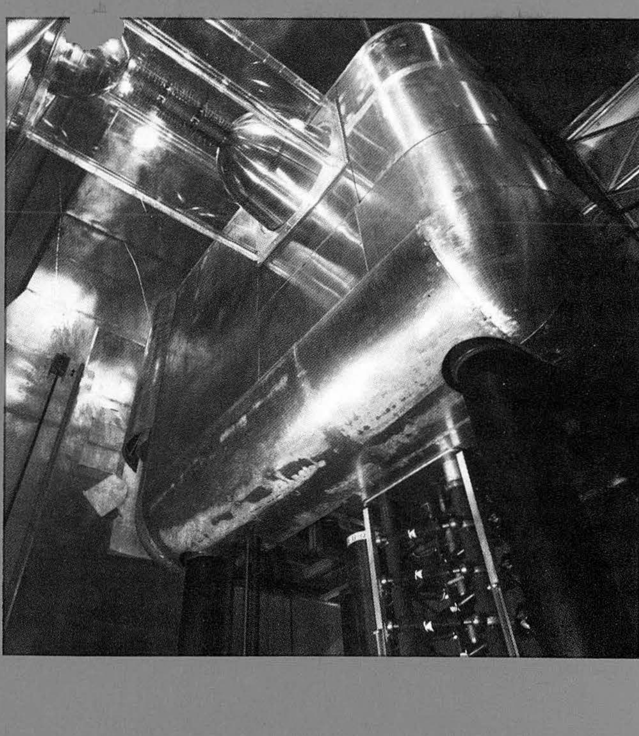
CONTACT: Jose Alonso, Bldg. 51-208, Accelerator and Fusion Research Division, Lawrence Berkeley Laboratory, Berkeley, CA 94720



▲The SuperHILAC, LBL's linear accelerator, is shown during modifications without its normal shielding. More than half the nuclear science research at the SuperHILAC and the Bevalac is conducted by visiting research groups.

The SuperHILAC

The SuperHILAC is a heavy-ion linear accelerator that works together with the Bevatron to form the Bevalac facility. The SuperHILAC can operate in a time-shared mode with pulse-to-pulse energy variability (2.4 to 8.5 MeV/nucleon) *and* particle variability for all ions up to ^{238}U. Three injectors, each optimized for a particular mass region, make the SuperHILAC unique in its ability to deliver multiple high-mass ($A \geqslant 100$) and high-intensity ion beams. (Only the UNILAC at GSI, Darmstadt, West Germany, can deliver comparable beams, but it lacks time-sharing capability.) In normal time-shared Bevalac operation, the SuperHILAC sends 2 pulses per second to the Bevatron, 32 pulses per second of another heavy-ion to a different research group, and 2 pulses per second of either beam (at a different energy if desired) for a parasitic experiment at the SuperHILAC. At present, the SuperHILAC serves users in any of 11 experimental areas. Major experimental facilities include an actinide-target bombardment area, a gas-filled magnetic spectrometer, and a new on-line isotope separator with high-mass resolution and overall efficiency as high as 20% for nuclides throughout the periodic table.

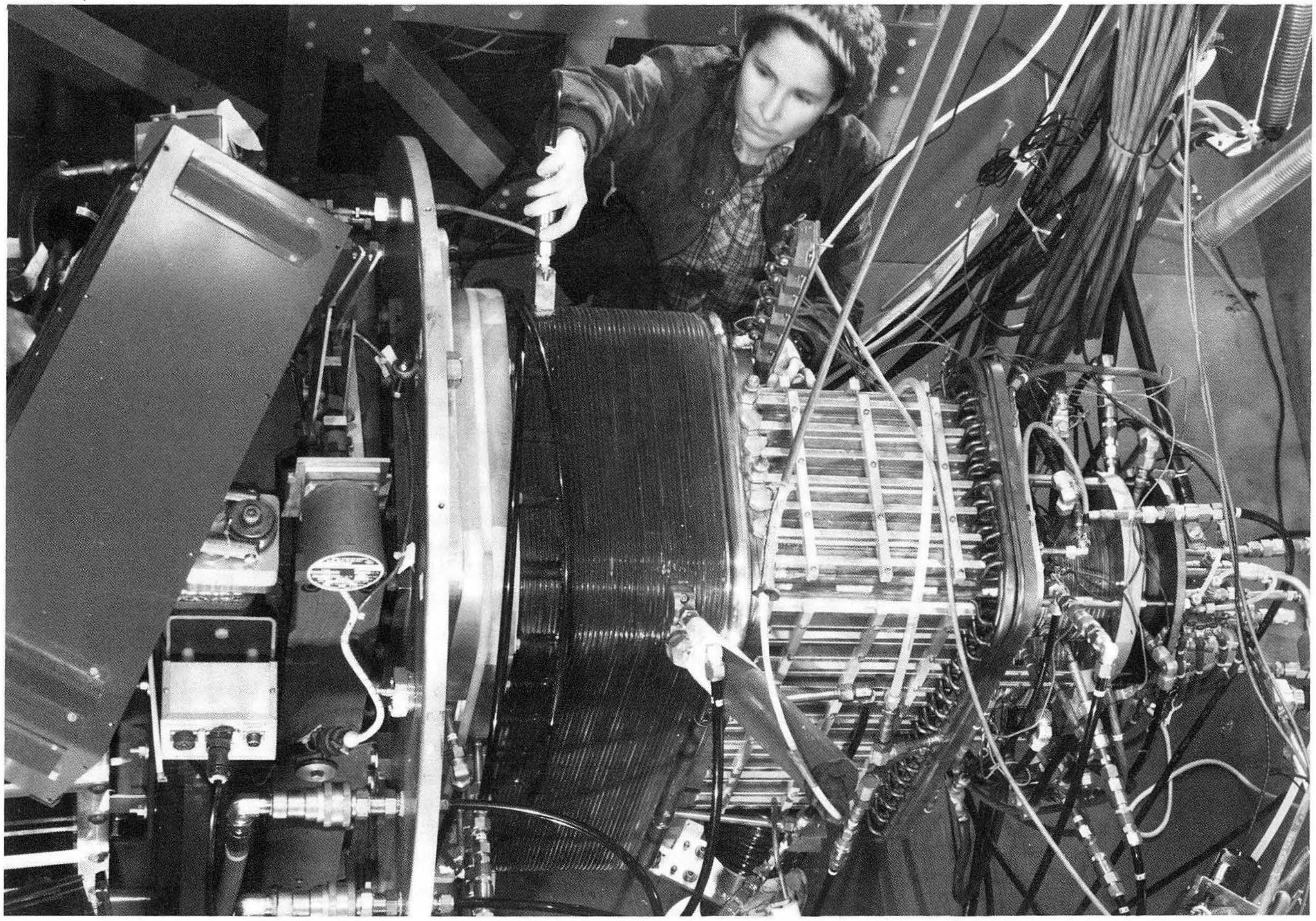


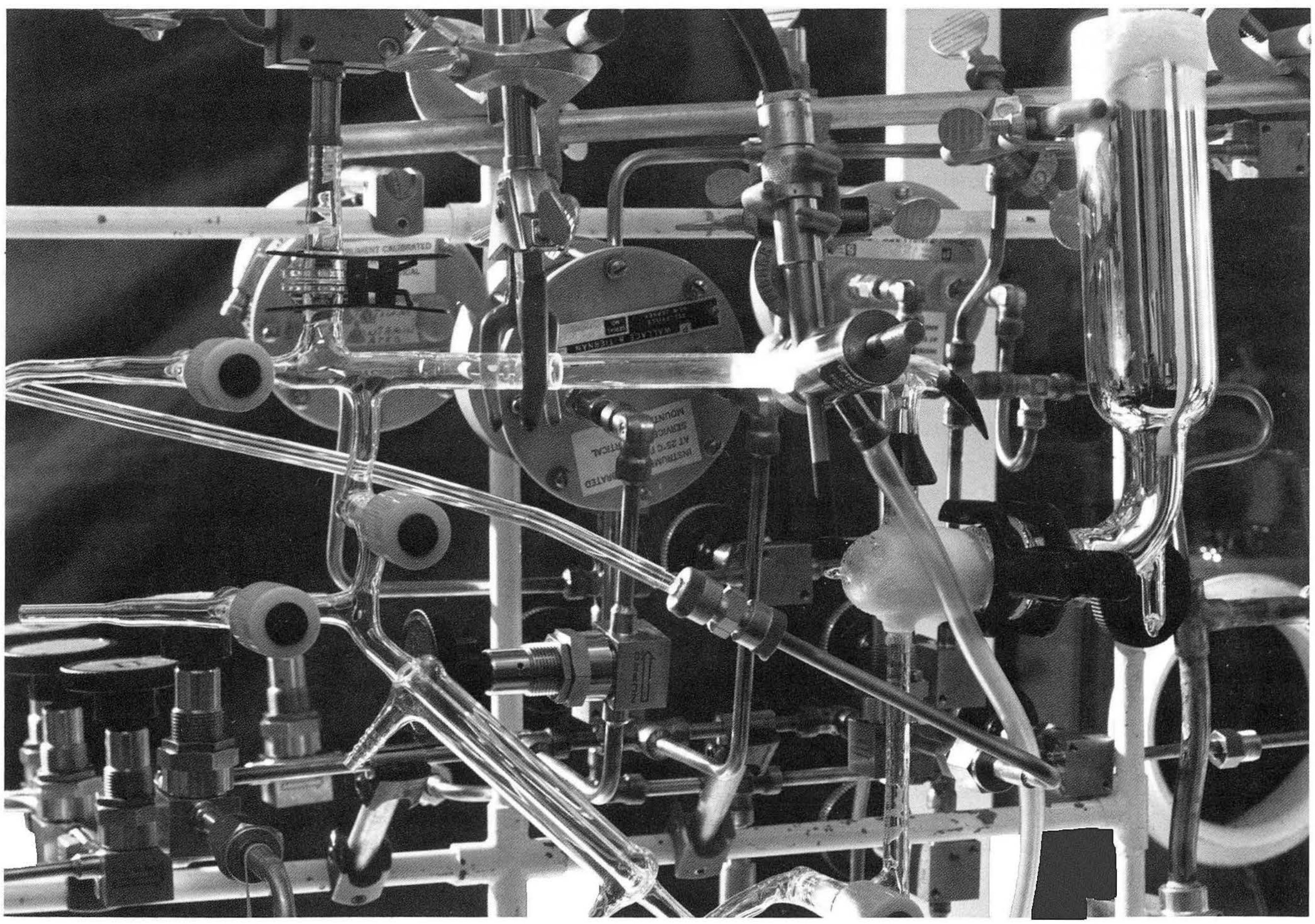
The SuperHILAC has long been in the U.S. vanguard of discovery of new heavy elements such as ^{102}No and ^{103}Lr, in strong competition with a USSR effort at JINR, Dubna, and more recently, a West German effort at the UNILAC. The SuperHILAC plays a preeminent role in elucidating many of the global features of the fusion, deeply inelastic (damped), and fission reactions that epitomize collective nuclear phenomena. Because of its very-high-charge and high-mass beam, the SuperHILAC also plays an essential role in studies of nuclear structure, including such aspects as pairing correlations, nuclear collective structures, and the effects of high nuclear temperature. Physics work at the SuperHILAC concentrates on atomic spectroscopy (especially of ions with very high charges and low recoil velocities) and inner-shell ionization processes during high-Z ion-atom collisions. (Many of these projects are relevant to the study of the interstellar medium, to the design of fusion devices, and to the design of an x-ray laser device.) Finally, work in the area of exotic nuclei involves the study of elements near the limits of particle and fission stability, the synthesis of new elements and isotopes, the study of reaction mechanisms for their production, and the investigation of their radioactive and chemical properties.

More than half of these studies are conducted by researchers from other laboratories and universities. Research proposals are reviewed periodically by a Program Advisory Committee, whose present chairman is D. Fossan of the State University of New York at Stony Brook.

CONTACT: Jose Alonso, Bldg. 51-208, Accelerator and Fusion Research Division, Lawrence Berkeley Laboratory, Berkeley, CA 94720

◀ **Abel, the newest injector at the SuperHILAC, extends the accelerator's capabilities to include high-intensity beams of ions as heavy as uranium. To the left of the terminal house are accelerating columns which give the ions their first boost; beneath are the high-voltage rectifier decks.**





Neutral Beam Engineering Test Facility (NBETF)

This large installation is operated to test deuterium neutral-beam injector systems for the U. S. Magnetic Fusion Energy Program. The high-voltage system provides 120 kV and 50 A for 30-sec pulses at a 10% repetition rate; fast switching is provided to remove the power from the source in a few microseconds. An actively cooled, adjustable beam dump has the capacity to dissipate 6 MW of beam power with a maximum power of 2 kW/cm^2. The facility is in a shielded vault for neutron protection during deuterium operation.

A scheduling committee composed of representatives of Lawrence Berkeley Laboratory, Oak Ridge National Laboratory, Lawrence Livermore National Laboratory, and the U.S. Department of Energy provides oversight and advice on the use of the NBETF.

CONTACT: Philip A. Pincosy, Bldg. 4-230, Accelerator and Fusion Research Division, Lawrence Berkeley Laboratory, Berkeley, CA 94720.

▲**The experimental neutral beam injector is used by researchers working with large-scale magnetic confinement systems for fusion energy development. Viewed from above, the injector includes (from right to left) an ion source that produces positive ions, an accelerator, and the chamber where the ions are neutralized so they can cross the magnetic fields that confine the superheated gas which fuels the fusion energy process.**

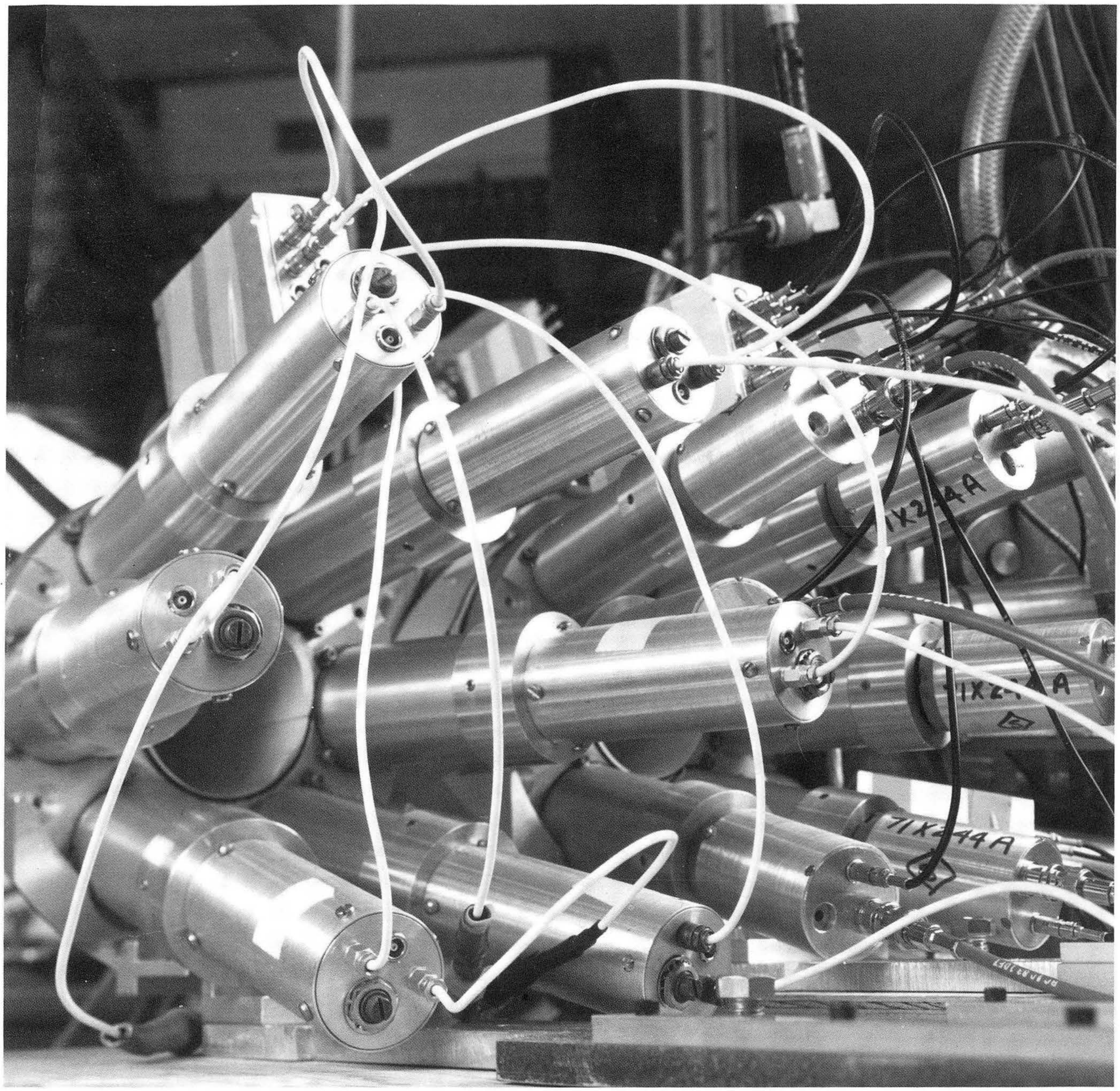
National Labeling Tritium Facility

LBL operates a tritium labeling facility that is used by both LBL personnel and outside researchers to attain high specific activities of tritium in compounds that will subsequently serve as tracers in chemical and biomedical research. The facility is equipped to handle kilocurie amounts of T_2 and curie amounts of T_2O. Labeling is done by a variety of techniques, including microwave discharges, catalytic tritio-hydrogenation, iodo displacements, and catalytic exchanges.

About half the facility's use is by outside researchers, of which about three-quarters are academic and one-quarter industrial. The tritium-labeled compounds, created under close supervision at the facility, are used by researchers in their home laboratories.

CONTACT: Dr. Richard M. Lemmon, Bldg. 3, Lawrence Berkeley Laboratory, Berkeley, CA 94720

◀**Tritium, shown glowing in the center of the photo in the excited state, is used to label compounds which are widely used as radioisotope tracers in the study of biological processes. Many of these radioactive biomolecules are available only from LBL's Tritium Labeling Facility.**



▲Components for the detectors in the new High Resolution Ball are being arranged in three concentric circles around a target. The twenty one germanium detectors measure the energy of gamma rays emitted in beam experiments at the 88-inch cyclotron, providing information about the form and structure of atomic nuclei.

The 88-Inch Cyclotron

The 88-Inch Cyclotron, operated by the Nuclear Science Division, provides variable energy high resolution beams from hydrogen through argon, which are used for studies of nuclear structure and nuclear reaction mechanisms. The cyclotron is also the Laboratory's major source of medical isotopes and its only source of polarized proton and deuteron beams. Ions as heavy as ^{40}Ar can be accelerated to the Coulomb barrier of 5 MeV/nucleon, while lighter heavy ions can reach 20–30 MeV/nucleon. The cyclotron thus operates in the important transition region between low and high energies: 10–30 MeV/nucleon.

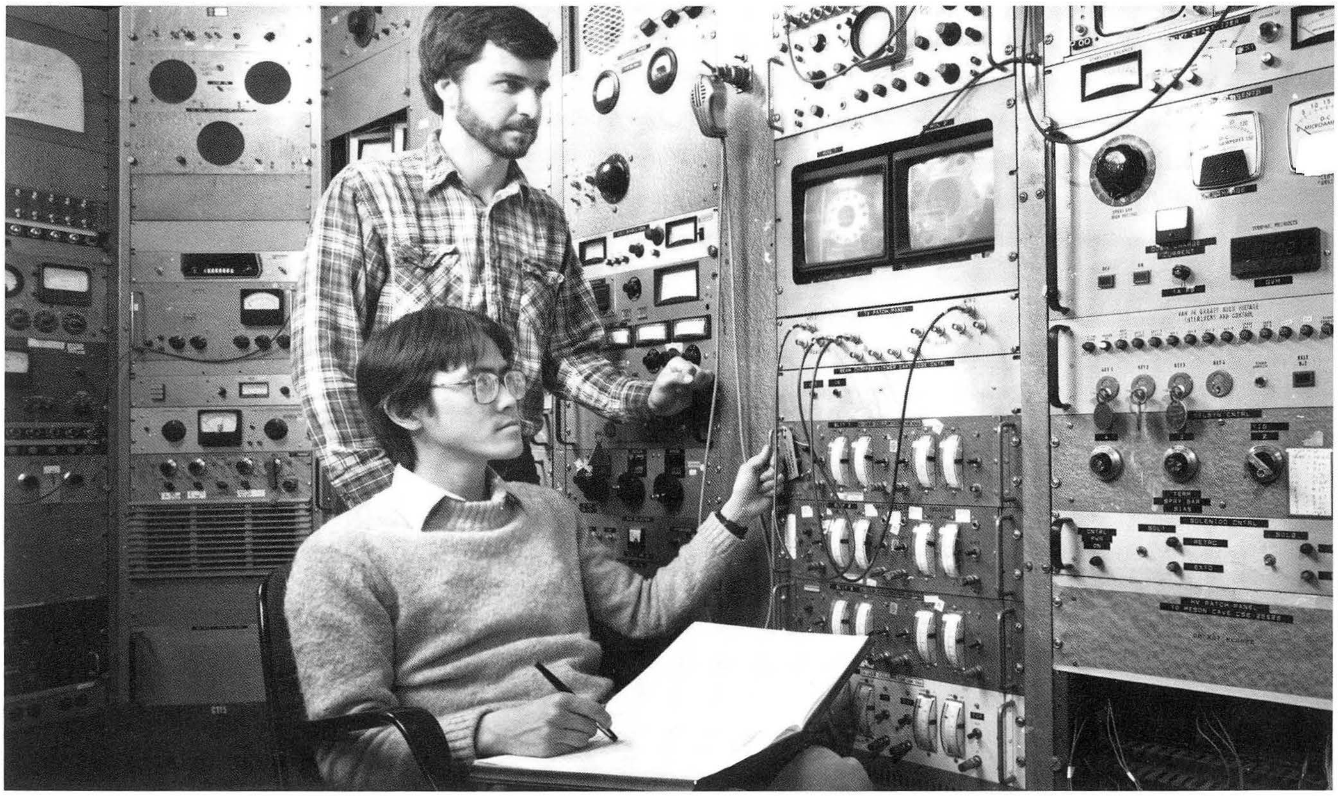
Research programs at the cyclotron comprise a broad and diversified enterprise that reflects the versatility of the accelerator. Basic research in nuclear physics is done with heavy ion and light ion beams, which are used to study nuclear structure and nuclear reaction mechanisms. There is also research in the area of exotic nuclei, heavy element studies and light ion research.

Applied research includes radioisotope production and cellular studies of radiobiological effects with low energy heavy ions; the investigation of cosmic-ray induced errors in digital semiconductor devices; and a study of the enhanced adhesion of thin films through heavy-ion bombardment.

General purpose equipment includes a high resolution magnetic analysis system; a magnetic spectrometer; a time-of-flight system; scattering chambers, and computers. Special purpose equipment, much of it unique to the facility, includes a recoil atom mass analyzer; polarized ion source; sum crystal spectrometer and multiplicity filter for gamma rays; a multi-detector array of BGO-shielded Ge detectors to observe high-spin discrete transitions; a 4 pi "plastic box" detector for charged particles; a spinning wheel analyzer for millisecond isotopes; a high-pressure hydrogen target for (p,p) scattering; and a high level cave.

Scheduling of experiments is done in an open meeting on a weekly basis with a lead time of eight days. Outside users who must make travel arrangements in advance are accommodated with advance scheduling. A users' organization and a Program Advisory Committee, both composed of scientists from LBL and from other laboratories and universities nationwide, determine user policy and guide the scheduling.

CONTACT: R. G. Stokstad; Bldg. 88, Lawrence Berkeley Laboratory, Berkeley, CA 94720.



▲ A radiotherapy technician adjusts a device called a three-dimensional beam compensator, designed to protect certain facial structures during treatment. Posing as a patient is the medical technician who made the plastic head positioner which, with the lasers, is used to precisely position the patient in front of the beam.

▼ In the Van de Graaff accelerator control room, two graduate students tune the proton beam for their scattering experiment, viewing the beam at various locations down the line on the TV monitors. Experiments include using the ion beam to analyze electronic materials and ongoing studies of radiation damage in biological systems.

Other LBL User Facilities

Heavy Charged-Particle Treatment Facility

The Heavy Charged-Particle Treatment Facility is used to conduct LBL's radiotherapy research program, which may benefit certain cancer patients who have been referred to LBL by individual physicians and groups of physicians. The medical staff at LBL reviews, with the patient's physician, each case to determine whether or not this type of radiotherapy is consonant with LBL research aims and could be of help to the patient. If the treatment seems to be appropriate, the therapy is planned and carried out by specialized LBL medical staff. Both the 184-Inch Cyclotron and the Bevalac are used in these treatments.

The total number of patients referred to LBL in the period July 1975 to March 1984 was 680, including low-LET-photon control patients and patients not accepted for particle radiation therapy. Cooperative clinical trials are coordinated with the Northern California Oncology Group, the national Therapy Oncology Group, and the Surgical Oncology group of the Veterans Administration hospitals.

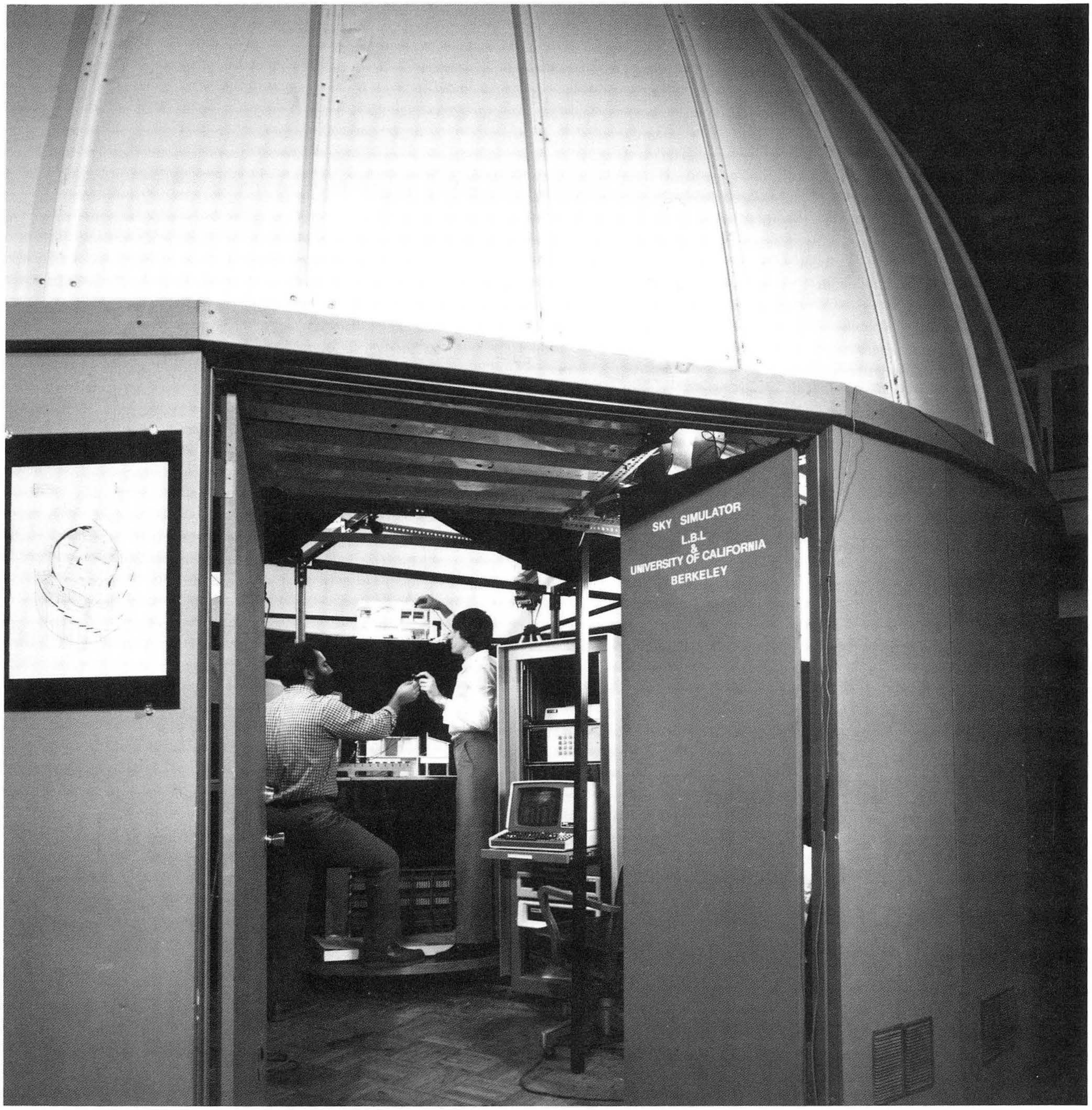
CONTACT: Division of Biology and Medicine, Bldg. 1, Lawrence Berkeley Laboratory, Berkeley, CA 94720.

2.5 MeV Van de Graaff Facility

This facility is available to outside users for applications that involve the need for a variety of positive ions at accelerated energies from 300 keV to 2.5 MeV. The machine is currently configured for acceleration of protons, alphas, and ^3He ions, although other heavier gaseous sources can be accommodated for specific projects. A complete facility for Rutherford backscattering spectroscopy (RBS) is available for surface analysis and channeling studies. This system includes two semiconductor detector spectrometers and an externally adjustable goniometer for both reflection and transmission measurements. The system can be modified to perform proton-induced x-ray fluorescence analysis (PIXIE), if necessary.

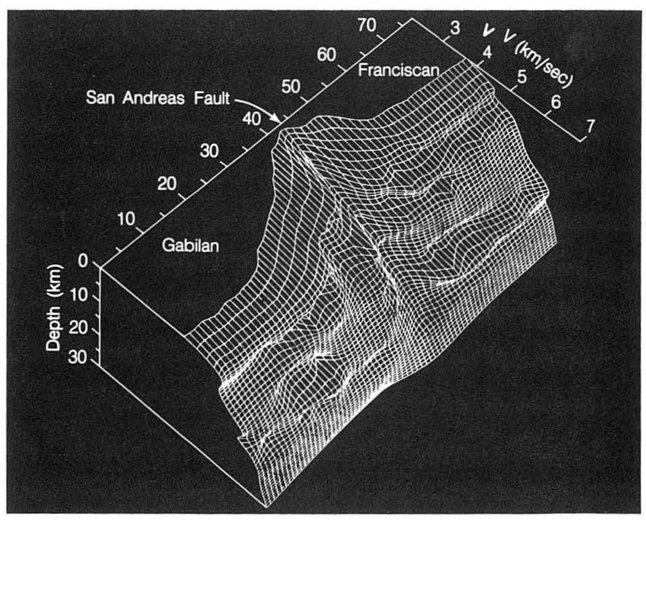
Users include University of California faculty members and a number of groups representing semiconductor companies in the area. Activities include the study of ion-implanted layers in semiconductor materials and the characterization of semiconductor surfaces under various fabrication processes.

CONTACT: Joseph Jaklevic, Bldg. 70A-3307, Lawrence Berkeley Laboratory, Berkeley, CA 94720



▲The 24-foot daylight simulator was designed and built on the University of California Berkeley campus to simulate a wide range of overcast and clear sky conditions. Light levels are measured in scale models of buildings placed under the artificial sky.

▶The computer graphic is derived from seismic signals which were recorded by the Automated Seismic Processor (ASP), a portable processor used in the field for precisely picturing seismic events — both natural and man-made. Data from ASP is an example of the vast quantity of regional and worldwide data that is interpreted at the Center for Computational Seismology (CCS), a facility developed by earth scientists at LBL's Computer Center.



Sky Simulator

The Windows and Daylighting Group (part of the Applied Science Division) operates a 24-foot-diameter hemispherical artificial sky designed to assist with studies of daylight illuminance. Electronic control of light sources within the hemisphere can recreate luminous distributions typical of clear, uniform, or overcast skies representative of any desired location, orientation, climate, and season. The hemisphere can accommodate scale models of buildings up to four feet square. Light levels within the models are measured by 60 photosensors and the measurements used to predict daylight illuminance conditions within full-sized buildings.

The simulator, located in Wurster Hall on the University of California's Berkeley campus, can also simulate the effects of direct sun and ground-reflected light. The electronically controlled light sources, the array of 60 photosensors, and a new data acquisition system combine to provide exact, reproducible information rapidly.

Studies in this facility examine the potential performance of designs intended to maximize the benefits of daylight utilization while minimizing glare and unwanted solar heat gain. Studies are also being performed to validate various computer models for predicting interior daylight illuminance. The facility is used in collaboration with researchers from many countries and has been made available to design firms wishing to evaluate projects that incorporate daylighting strategies.

CONTACT: Stephen Selkowitz, Windows and Daylighting Group, Bldg. 90-3111, Lawrence Berkeley Laboratory, Berkeley, CA 94720

Center for Computational Seismology (CCS)

Seismology has traditionally been a data-intensive, multidisciplinary science with consequent problems in the reduction and analysis of large volumes of data on the one hand and in the effective handling, analysis, and presentation of results on the other. To be fully effective in seismology, investigators require data manipulation and storage capabilities beyond those of most computational facilities, along with a sophisticated flexibility in graphics and interactive operations.

The CCS combines expertise in computer science, hardware development, data file management and manipulation, numerical analysis, computer graphics, and seismology at LBL and the University of California, Berkeley to obtain a powerful capability. The CCS exists within a larger computational complex equipped and staffed to support and advance the wide-ranging program of seismological research.

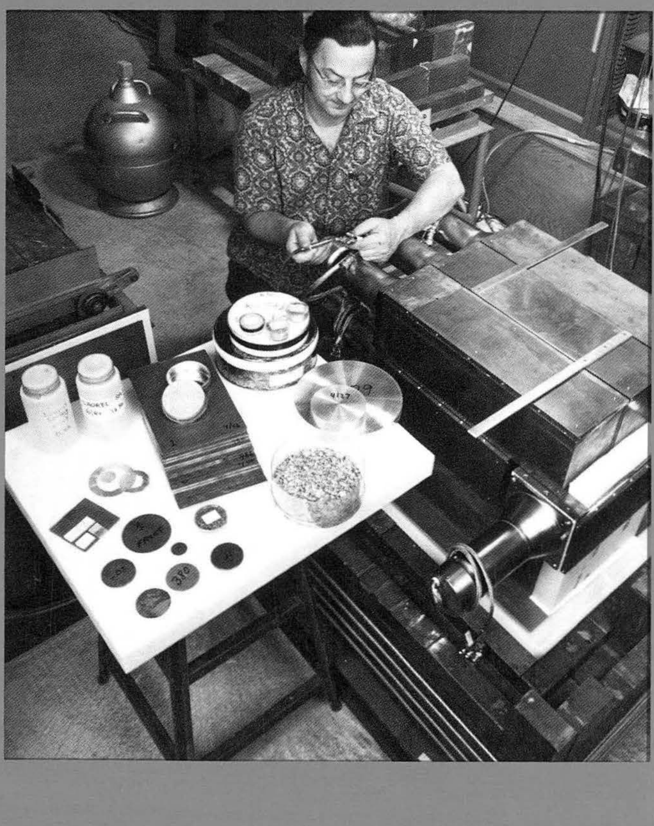
Research includes deep reflection profiling techniques, reflection profiling in thermal regions, source mechanism studies, and wave propagation.

CONTACT: Ernest Majer, Bldg. 50A-1140, Lawrence Berkeley Laboratory, Berkeley, CA 94720

Low Background Counting Facility

The LBL Low Background Counting Facility consists of a heavily shielded vault which provides a very low-background environment for both high-sensitivity and high-resolution gamma-ray detectors, plus an adjacent counting laboratory that houses the associated gamma-spectrometric data acquisition equipment.

The primary available detectors include a large NaI(TI) scintillation crystal, a large coaxial intrinsic Ge semiconductor detector, and several planar intrinsic Ge semiconductor detectors. Established procedures are in common use for measurement of: picocurie amounts of gamma-emitters in kilogram quantities of test materials; the natural radionuclide content of rocks, soils and processed waste; radionuclide contamination in natural and processed materials; disequilibrium conditions in the U-series and Th-series; radon content of and radon emanation from natural and processed materials; and high-accuracy determination of accelerator-produced radionuclides.

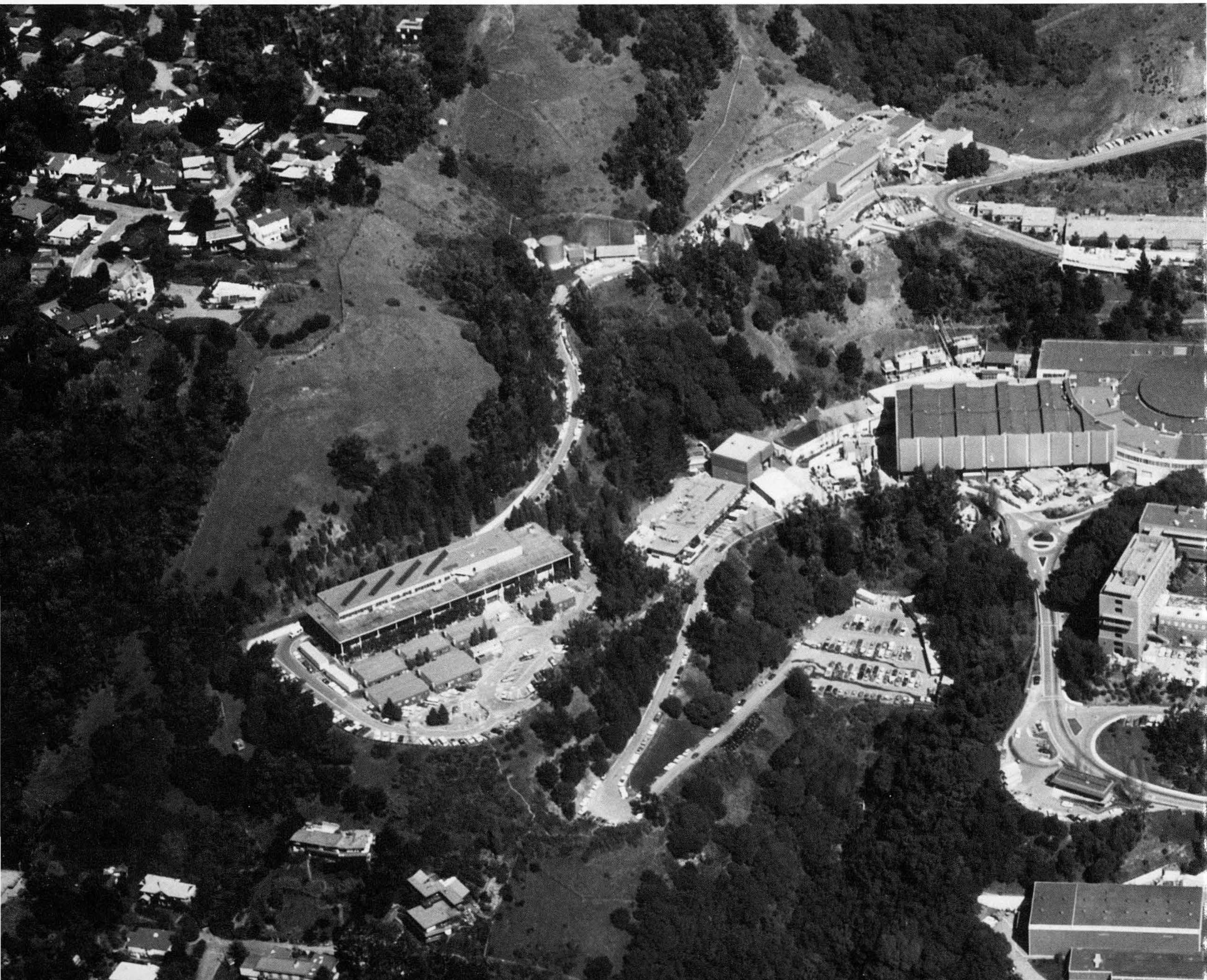


These gamma-detection systems are characterized by carefully determined background response, emphasis on reproducibility and accuracy in results, and frequent checking of performance through use of reference sources and/or materials that are traceable to radionuclide standards certified by the U.S. National Bureau of Standards, the International Atomic Energy Agency, or the New Brunswick Laboratory of the U.S. Department of Energy.

Limited space is available for temporary installation of additional gamma-detectors and data acquisition/analysis equipment.

CONTACT: Alan R. Smith, Bldg. 72-131, Lawrence Berkeley Laboratory, Berkeley, CA 94720

◀ A physicist tests a special array of highly sensitive sodium iodide gamma detectors for a double beta-decay experiment. The detector is one of several detectors in the heavily-shielded vault which provides a low-background environment for detecting extremely low levels of radioactivity in a variety of materials.



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