Title
A GUIDE TO USER FACILITIES AT THE LAWRENCE BERKELEY LABORATORY

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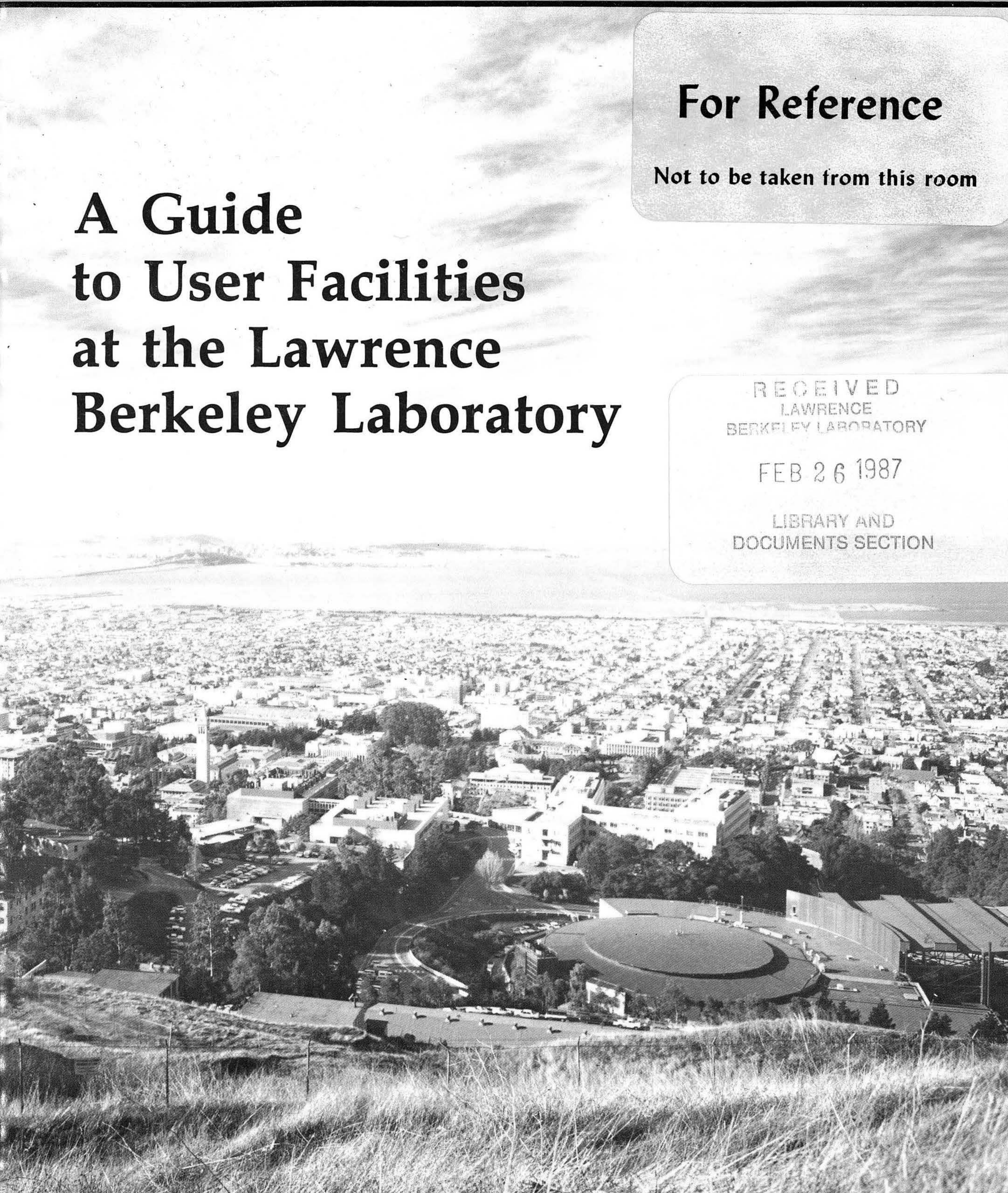
Research Facilities Available to
Researchers, Universities, other Laboratories, and Industry

A Guide to User Facilities at the Lawrence Berkeley Laboratory



Lawrence Berkeley Laboratory University of California Berkeley, CA 94720

A Guide to User Facilities at the Lawrence Berkeley Laboratory

Front cover: View from Lawrence Berkeley Laboratory. In the right foreground is the Bevatron portion of the Bevalac (the circular building) with a partial view of the Experimental Hall. The Campanile tower identifies the Berkeley Campus of the University of California located at the base of the hill. Beyond is the City of Berkeley; across San Francisco Bay is the City of San Francisco, the Golden Gate, and the hills of Marin County.

Back cover: The domed building houses LBL's 184-inch Synchrocyclotron. Beyond is the City of Oakland and the Bay which extends south to near San Jose (out of the picture).

Contents

- **Accelerators**
- **Electron Microscopes**
- **Experimental Treatment**
- **Tritium Labeling**
- **Building Efficiency**

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, conservation and renewable energy resources, materials sciences, instrumentation, and accelerator design.

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
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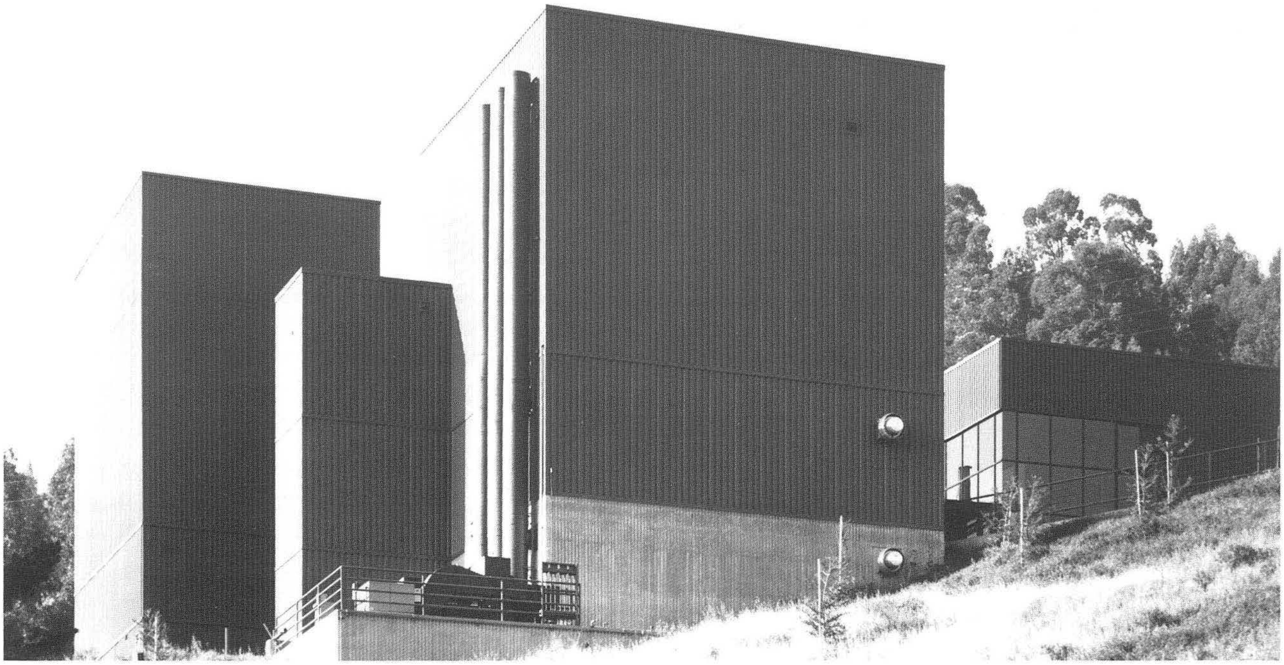
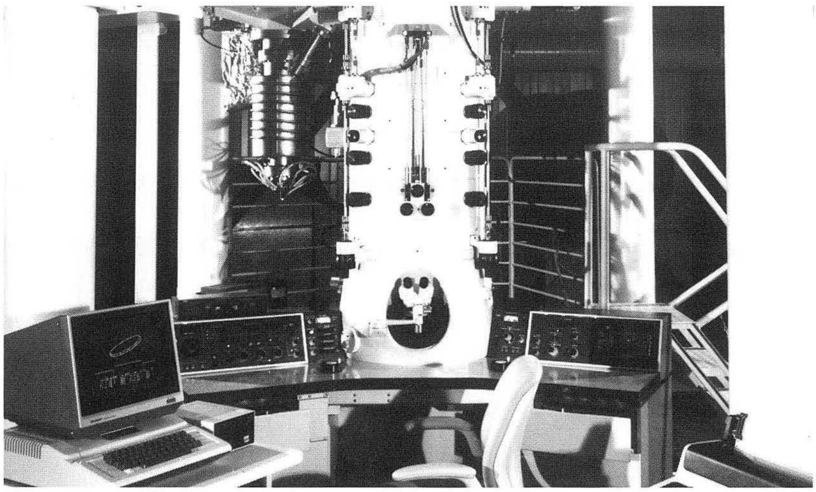
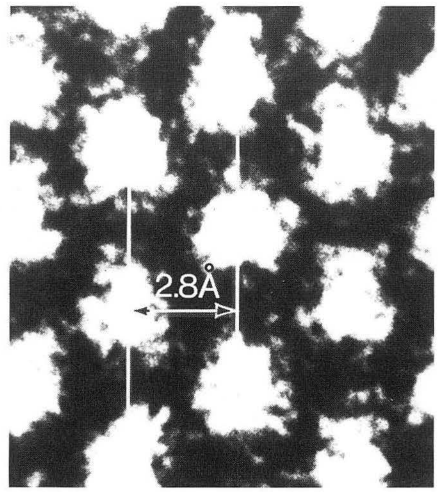


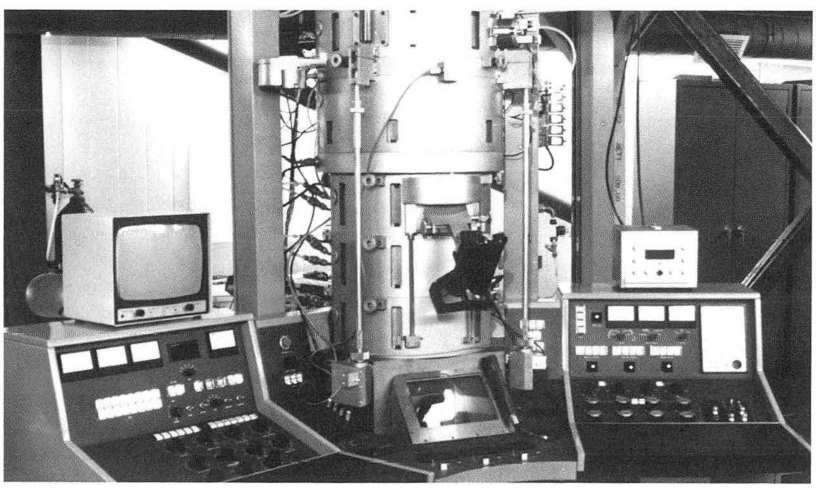
In the National Center for Electron Microscopy, special mounts isolate microscopes from vibrations transmitted through the earth. User support is available through computer facilities, specimen preparation laboratories, optical diffractometers, and darkrooms in the building.

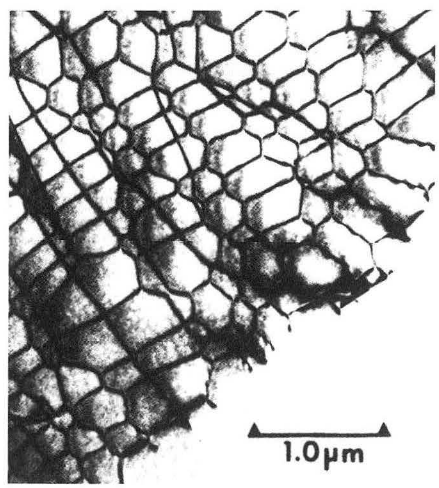


Operator's console at the Atomic Resolution Microscope, which provides the highest resolution of any microscope in the world. Electrons in the central accelerating column are accelerated downwardly through a specimen by a 400,000 to 1 million volt field, producing images with a maximum resolution of 0.15 nanometers.



An atomic resolution image of gallium arsenide in the [011] orientation in which all the atomic species are clearly distinguishable.





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.

Presently available microscopes include a 1 MeV Atomic Resolution Microscope (ARM) for ultra-high resolution imaging (approximately 0.15 nm), a 15 MeV HVEM (0.3 nm) designed for dynamic in-situ studies, a 200 kV analytical electron microscope for energy-dispersive x-ray and electron energy loss spectroscopy, and a 200 kV high-resolution instrument (0.24 nm). A comprehensive computing facility networks the microscopes, allowing on-line image analysis, enhancement and simulation, as well as quantification of microanalytical spectra. Further program support is provided by continuing software and instrument development. Other support facilities include specimen preparation laboratories, optical diffractometers, and photographic darkrooms.

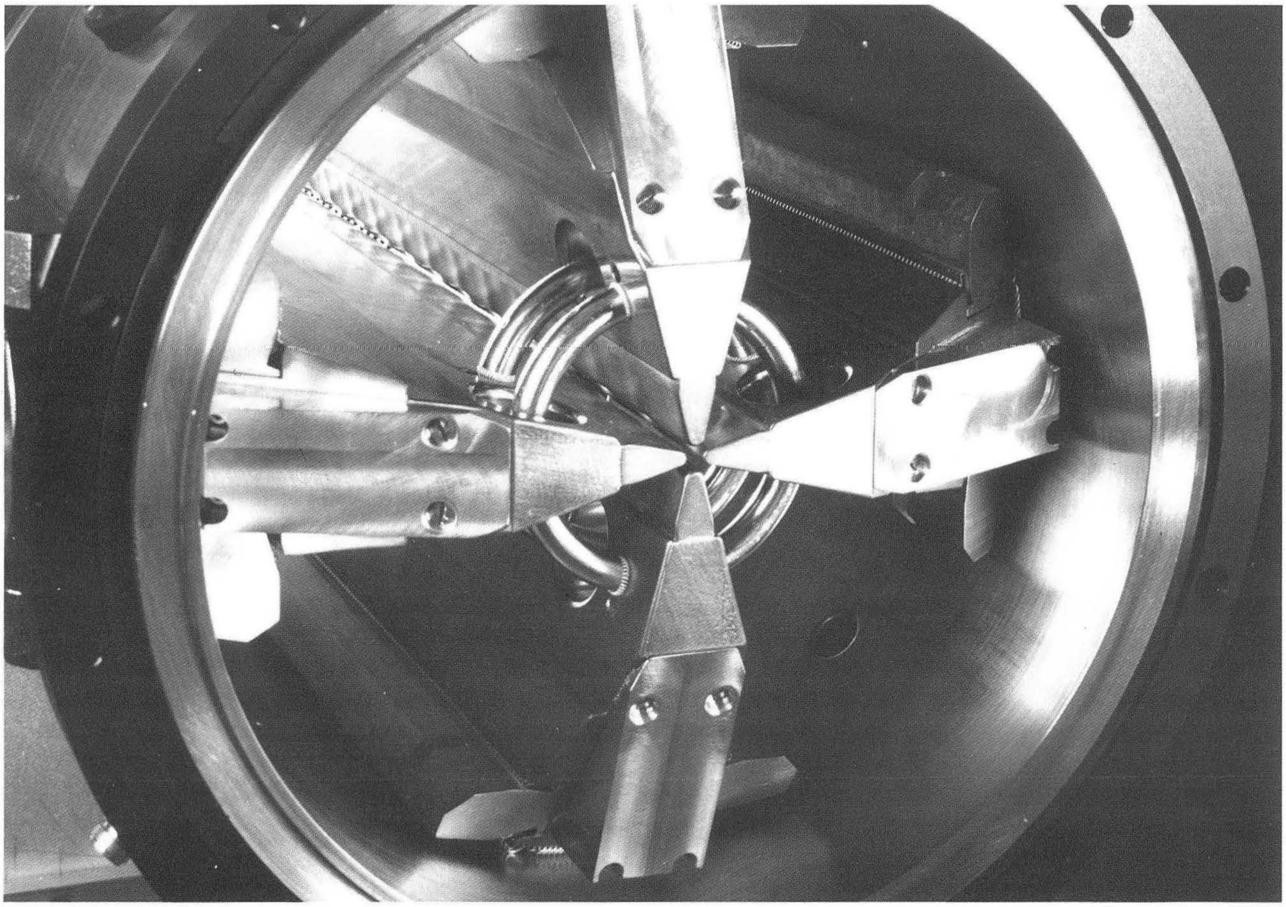
Unique capabilities are provided by the two high-voltage electron microscopes. The 400-1000 kV ARM, the highest resolution microscope in the world, can image at the atomic level the densely-packed structures typical of metals, the ionic species in ceramics, and the interfacial structure controlling semiconductor properties. It also has a high-angle specimen tilting stage that allows these atomic structures to be imaged in different projections. The HVEM is the most powerful and versatile instrument in the United States. Images can be formed with electrons of any energy between 150 and 1500 kV. At 1500 kV the beam can penetrate thicker sections than can other electron microscopes, providing images of internal structures representative of bulk materials. The instrument is also equipped with stages for specimen heating, cooling, and straining experiments and an environmental cell for studying gas-solid reactions at elevated temperatures.

Users of the Center have included many researchers from universities and government laboratories, as well as industries involved in energy development and semiconductor research. Review and approval of research proposals and guidance in the operation of the Center are the responsibility of the Center's eleven-member steering committee, whose present chairman is J. Hren of North Carolina State University.

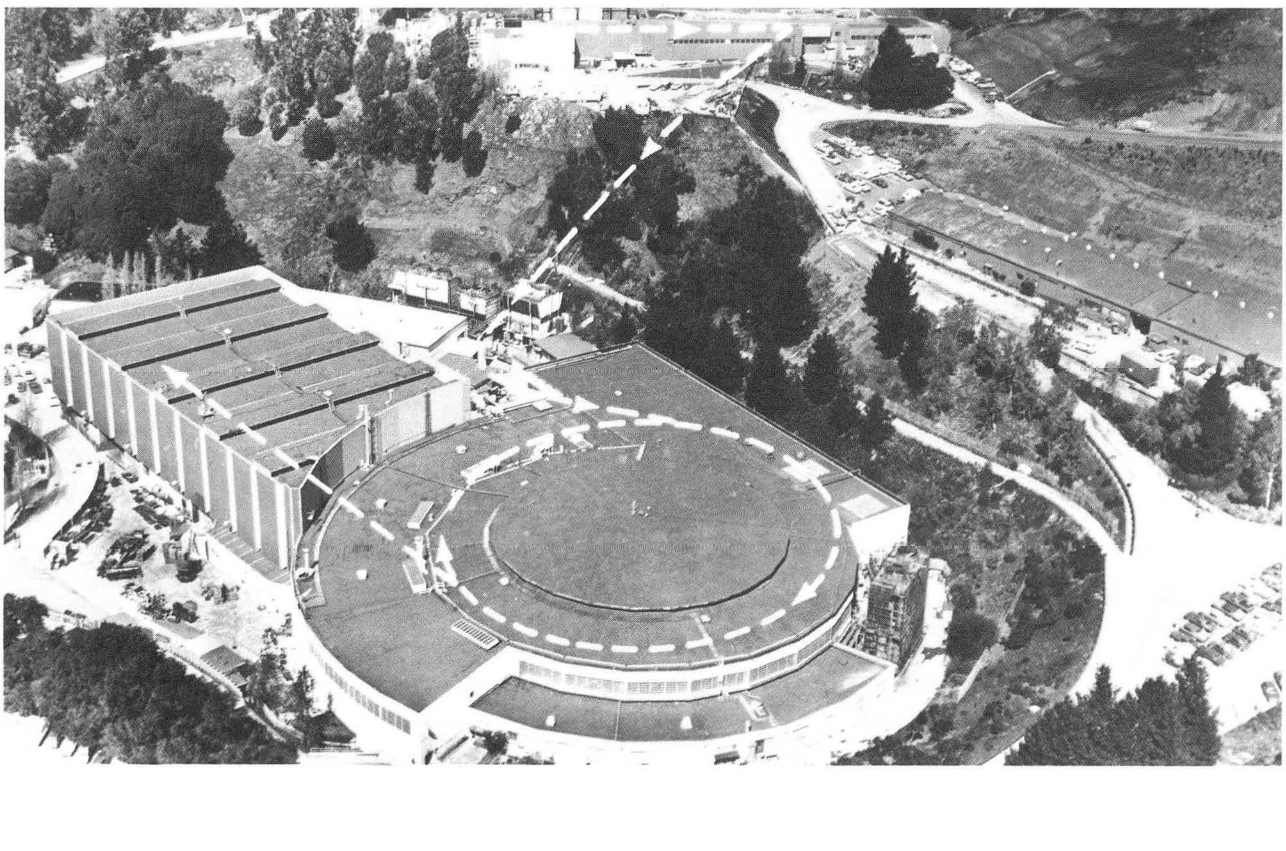
◄ **In the 1.5 million volt HVEM, specimens may be heated, deformed, and cooled in the specimen chamber while a magnified image can be viewed through the window at the base of the column.**

◄ **A single crystal of germanium in the HVEM is shown after deformation at 890°C. A hexagonal network of screw dislocations in the main slip plane was formed while the crystal was compressed along a <123> axis.**

CONTACT: Madeline Moore, NCEM, Bldg. 72, Lawrence Berkeley Laboratory, Berkeley, CA 94720 (415) 486-5006



The Radio-Frequency Quadrupole (RFQ) Accelerator is used in the Bevalac local injector system for accelerating ions up to argon to energies up to 140 kiloelectron volts. Ions are accelerated away from the observer's position along the space between the tips of the four vanes.



The Bevalac

The Bevalac is made up of the Bevatron (a synchrotron) working together with a linear accelerator ion source: either the SuperHILAC or the newly upgraded local Bevatron injector, which can provide the lighter ions. 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).

The Bevalac has several large detector and beam line facilities:

(a) HISS, a very-large-volume, heavy-ion superconducting spectrometer with large-area detection systems;
(b) newly developed capabilities for separating fragmentation products, which allow delivery of beams of short-lived radioactive nuclei, vastly expanding the inventory of available ions;
(c) a pion detector system jointly funded by the U.S. and Japan;
(d) a dilepton spectrometer for detection of energetic lepton pairs;
(e) LEBL, a low-energy beam line designed to host a variety of experiments at energies from 50 to 250 MeV/nucleon;
(f) a magnetically surrounded streamer chamber;
(g) a new multi-use low-energy line, serving as a kaon spectrometer and a second low-energy experimental area.

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. Research interests pursued at the Bevalac include:

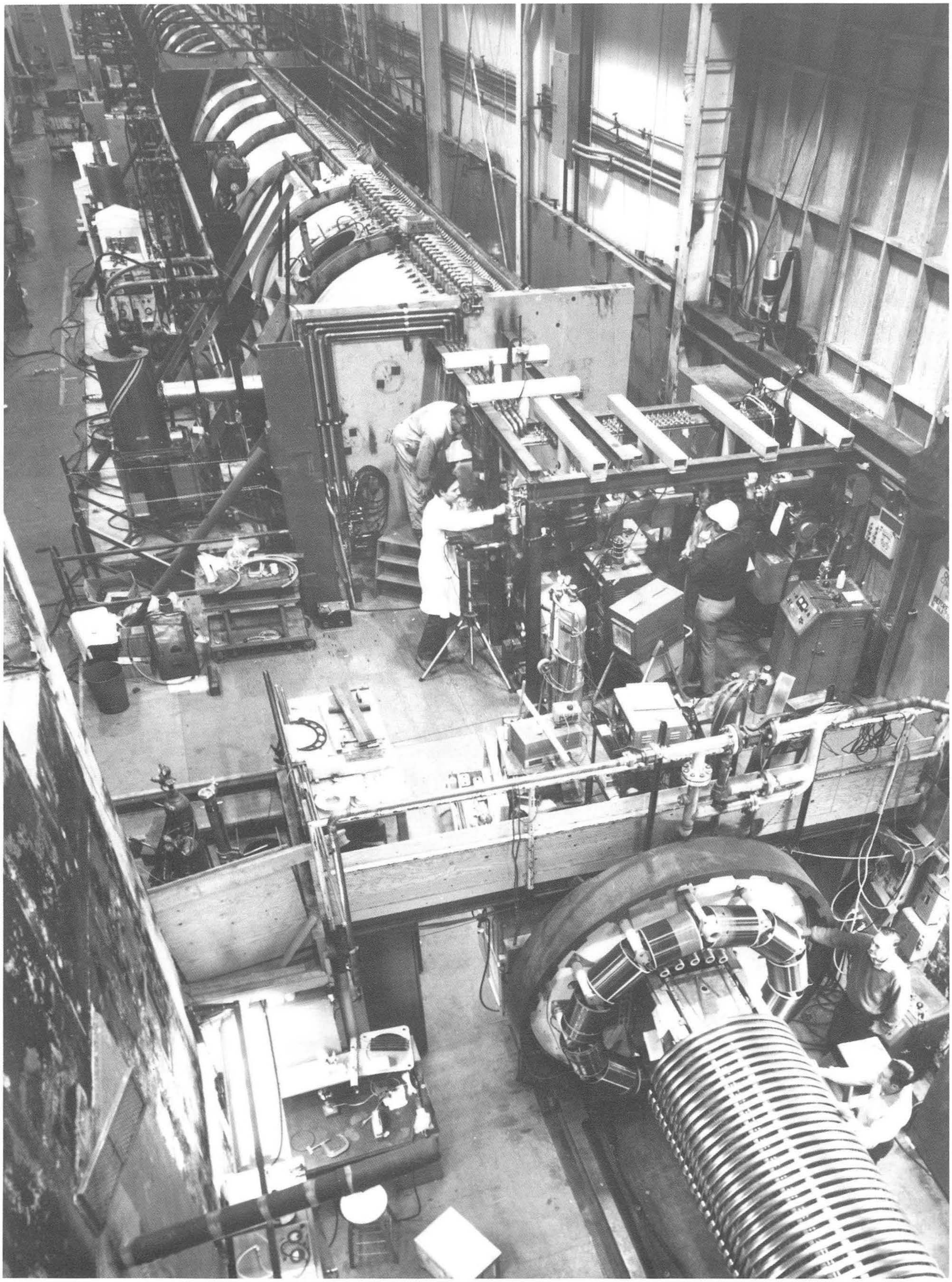
(a) studies of nuclei far from stability, using radioactive beams;
(b) searches for new isotopes among the products of nuclear projectile fragmentation;
(c) production mechanisms of pions, kaons, hyperons, and antiparticles in nuclear matter;
(d) studies of the atomic physics of highly ionized, very heavy atoms, such as U^{91+};
(e) studies of the equation of state of nuclear matter at high densities and temperatures;
(f) searches for new forms of matter, such as pion condensates, density isomers, and the quark-gluon plasma;
(g) searches for free quarks.

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 sciences 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 P. Siemens of Texas A & M University, and the chairman of the biology and medicine PAC is M.A. Bagshaw of the Stanford University Medical Center.

◄ **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.**

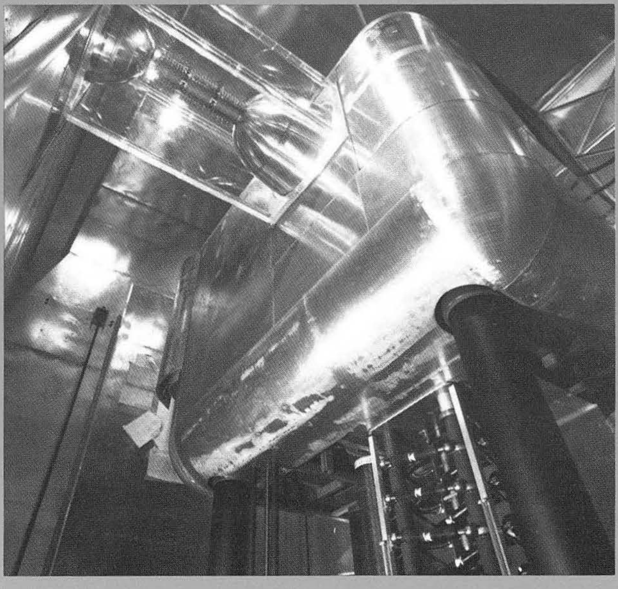
CONTACT: Jose Alonso, Accelerator and Fusion Research Division, Bldg. 51-208, Lawrence Berkeley Laboratory, Berkeley, CA 94720 (415) 486-5575



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 (<1.2 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 possibly yet another ion at a different energy for a parasitic experiment at the SuperHILAC. At present, the SuperHILAC serves users in any of 11 experimental areas. Major experimental facilities include a 60-inch general-purpose scattering chamber, an actinide-target bombardment area, a gas-filled magnetic spectrometer, and an on-line isotope separator with high mass resolution and overall efficiency as high as 20% for nuclides throughout the periodic table.

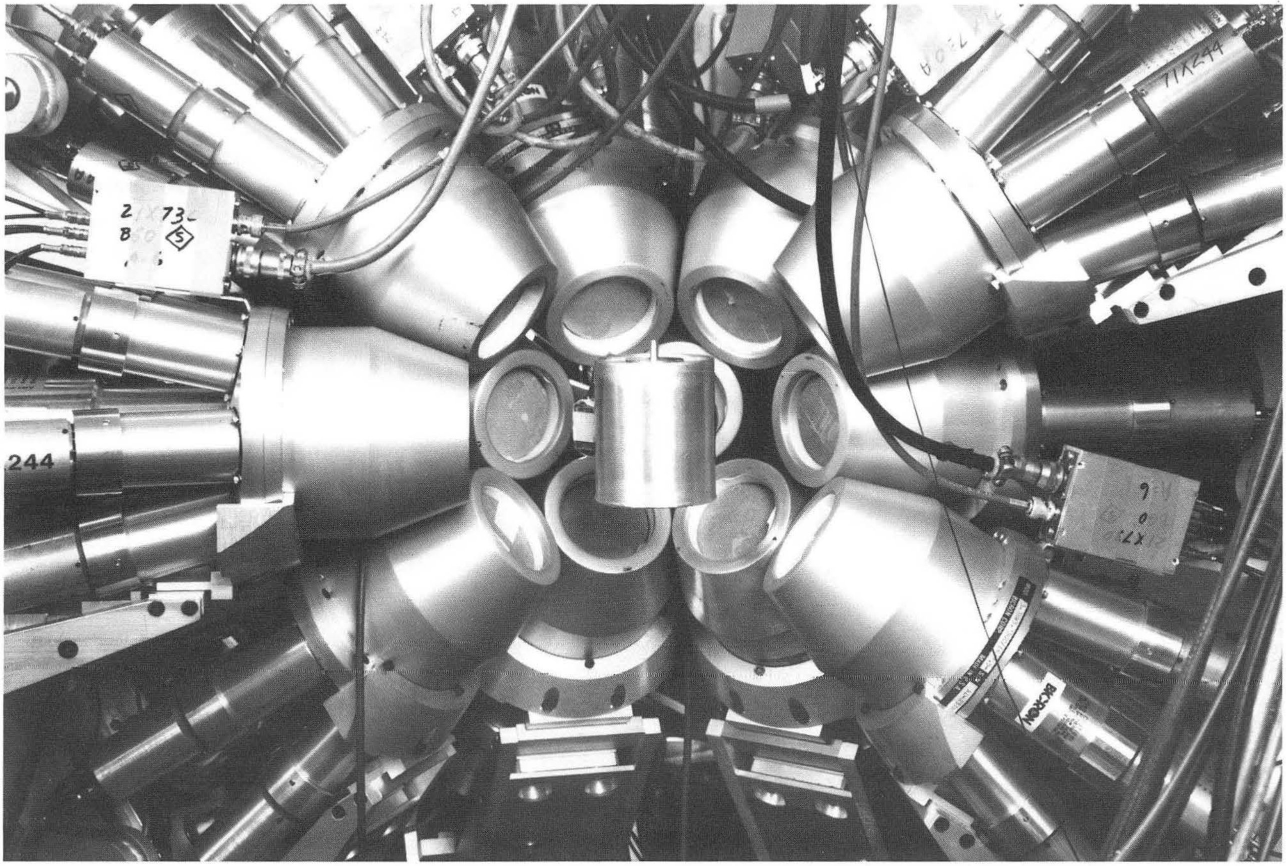


The SuperHILAC has long been in the U.S. vanguard of discovery of new heavy elements from nobelium (102) to 106 (as yet unnamed), in strong competition with a USSR effort at JINR, Dubna, and more recently, a West German effort at the UNILAC. The SuperHILAC plays a pre-eminent role in elucidating many 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 structures, including such aspects as pairing correlations, nuclear collective structures, electromagnetic moments of high-spin states, and the effects of high nuclear temperature. Atomic 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, 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.

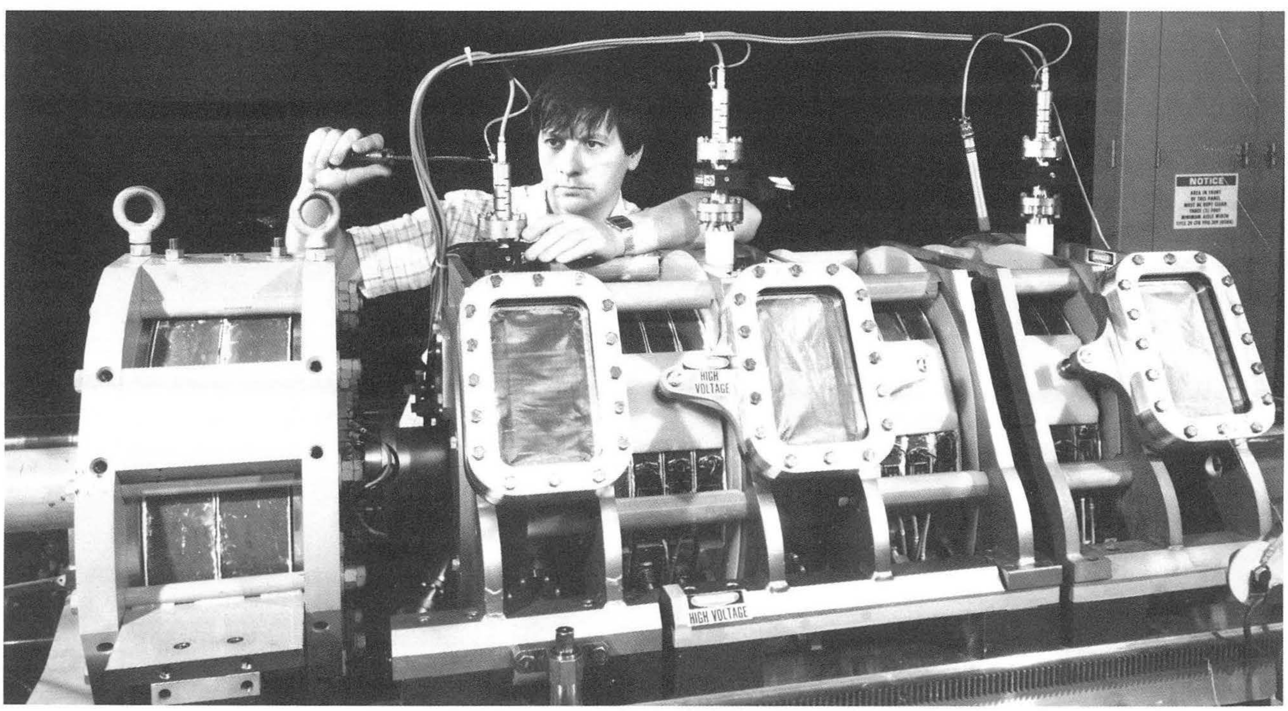
More than half of these studies are conducted by researchers from other laboratories and universities. Research proposals are reviewed periodically by a Program Advisory Committee, whose present chairman is J. Hardy of Canada's Chalk River National Laboratory.

CONTACT: Jose Alonso, Accelerator and Fusion Research Division, Bldg. 51-208, Lawrence Berkeley Laboratory, Berkeley, CA 94720 (415) 486-5575

◄ Abel, one of three injectors 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.



A 21-element array of Compton-suppressed high-resolution germanium gamma-ray detectors for studies of nuclei at high spin. (In this view, only twelve detectors can be seen.) A charged particle beam from the Cyclotron bombards the target at the center of the array, producing the gamma rays to be studied.



An Electron Cyclotron Resonance (ECR) ion source provides a variety of high charge state particles which are then further accelerated in the 88-Inch Cyclotron. Ions are guided out of the source to the 88-Inch Cyclotron through the beam pipe at left.

The 88-Inch Cyclotron

The 88-Inch Cyclotron is operated as a national facility for experimental research mainly in nuclear science but also in other areas such as biomedicine, atomic physics, surface physics, and radiation damage in semiconductors. The cyclotron can accelerate all ions from hydrogen through krypton to energies above the Coulomb barrier (~5 MeV/nucleon) for targets as heavy as uranium. The maximum energy for heavy ions is 140 MeV q^2/A, where q and A are the charge and mass of the accelerated ion, respectively. This corresponds to energies of 35–20 MeV/nucleon for ions with mass A=4–40. Polarized ions (protons and deuterons) are produced by a high-current atomic beam polarized ion source and are then accelerated to energies as high as 55 MeV.

The recent completion of a high-charge-state Electron Cyclotron Resonance (ECR) ion source has greatly extended the available range of ions and energies. For example, the maximum energy for a neon beam has doubled and, for an argon beam, has increased by a factor of five. Recently, a beam of ^{36}Ar ions was accelerated to an energy of 1 GeV. The acceleration of metallic ions, which is made practical by the ECR source, has greatly increased the possible species of beams. Magnesium and calcium beams are now used regularly in experiments. This ion source is the first of its type to operate in the United States and presently offers high-charge-state ions at intensities comparable to or exceeding the performance of other ECR sources throughout the world.

Research programs at the cyclotron comprise a broad and diversified enterprise that reflects the versatility of the accelerator. The basic research program is focused in four major areas: (1) investigation of heavy-ion reaction mechanisms over a wide range of energies; (2) production and study of exotic nuclei far from stability; (3) structure of nuclei at high angular momentum; and (4) a new program in nuclear astrophysics. In addition, the cyclotron provides beams for the application of nuclear techniques to other areas of research, including biology and medicine, radioisotope production, and the study of cosmic-ray damage to satellite electronic components.

An extensive complement of experimental equipment is located in the experimental areas adjacent to the cyclotron. In particular, a new 21-element array of Compton-suppressed high-resolution germanium detectors has just come into use for studies of nuclei at high spin. A large NaI gamma-ray spectrometer has been acquired and is being installed for research using polarized beams and heavy ions. There is also a large-diameter scattering chamber, a high-resolution magnetic spectrometer, a time-of-flight spectrometer, and an on-line isotope separator for the study of exotic nuclei.

Beam time is allocated on the basis of written proposals that are evaluated by a Program Advisory Committee composed of scientists from outside institutions and from LBL. Scheduling of experiments is done on a weekly basis. Outside users who must make travel arrangements are accommodated with advance scheduling. A users' organization, also composed of scientists from LBL and from other laboratories and universities nationwide, gives advice on user policy.

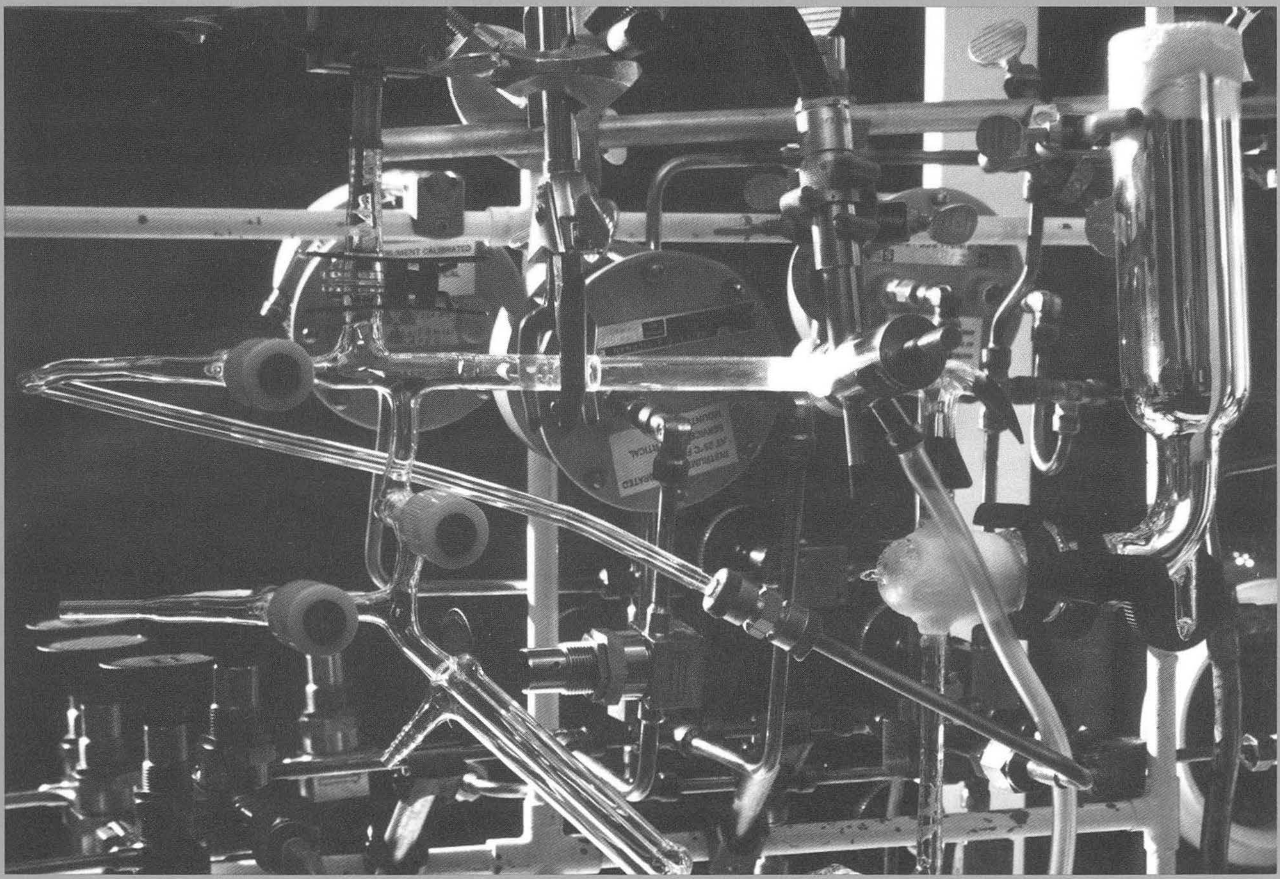
CONTACT: R.G. Stokstad, Bldg. 88, Lawrence Berkeley Laboratory, Berkeley, CA 94720 (415) 486-5088

National Tritium Labeling 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 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: Prof. Henry Rapoport, Dept. of Chemistry (Chemical Biodynamics Division), University of California, Berkeley, CA 94720 (415) 642-2578 or Hiromi Morimoto, Bldg. 75, Chemical Biodynamics Division, Lawrence Berkeley Laboratory, Berkeley, CA 94720 (415) 486-4373



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.

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 and patients with arteriovenous malformations (AVM) 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 January 1986 was 1096, including low-LET-photon control patients and patients not accepted for particle radiation therapy. Cooperative clinical trials for cancer patients are coordinated with the Northern California Oncology Group, the national Therapy Oncology Group, and the Surgical Oncology Group of the Veterans Administration hospitals.

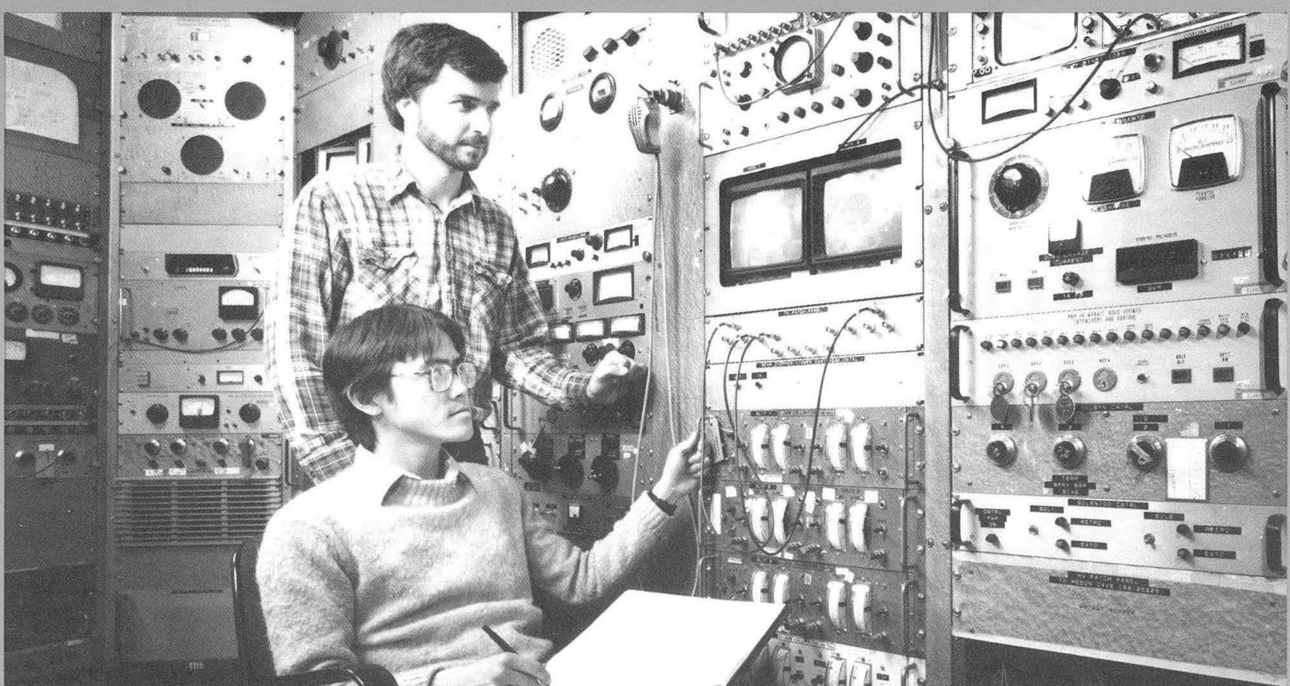
CONTACT: Biology and Medicine Division, Bldg. 1, Lawrence Berkeley Laboratory, Berkeley, CA 94720 (415) 486-5206

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.

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 ^{3}He 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.



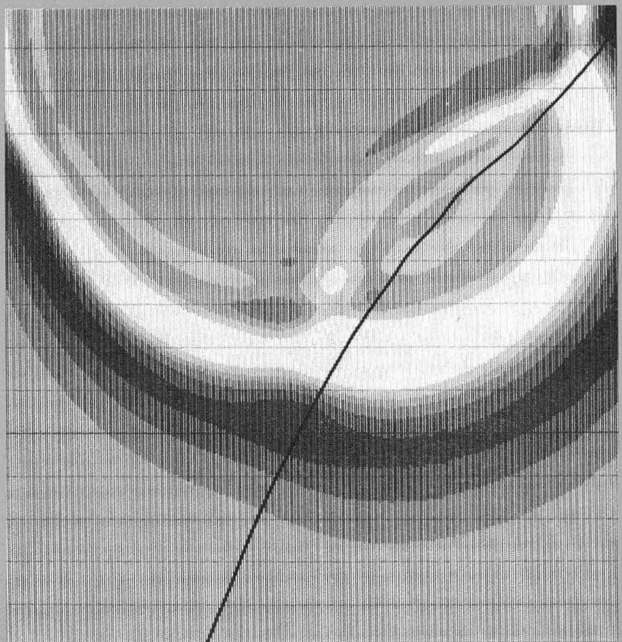
In the Van de Graaff accelerator control room, two graduate students tune the proton beam for their scattering experiment, viewing the beam at various locations down the line on the TV monitors. Experiments include using the ion beam to analyze electronic materials and ongoing studies of radiation damage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

CONTACT: Joseph Jaklevic, Bldg. 70A-3307, Lawrence Berkeley Laboratory, Berkeley, CA 94720 (415) 486-5647

Center for Computational Seismology (CCS)

Seismology is traditionally a data-intensive, multidisciplinary science. Problems in the reduction and analysis of large volumes of data are linked to the need for effective handling, analysis, and graphical presentation of results. 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 Center for Computational Seismology (CCS) combines expertise in computer science, hardware development, data file management and manipulation, numerical analysis, and computer graphics, to produce a powerful capability in seismology at LBL and the University of California, Berkeley. CCS exists within the larger LBL computational complex. CCS is equipped and staffed to support the wide-ranging program of seismological research.



Research supported in the CCS facility includes the processing of seismic reflection profiling data for earth structure, using the commercially available software package DISCO, in a variety of applications. In one mode, CCS serves as the primary processing and archiving center for the CALCRUST consortium of universities studying complex crustal structures in California. CCS also serves as a repository for the U.S. Geological Survey data from the global digital seismographic network, which are used extensively in studies of Earth's deep interior. Using surface-borehole and borehole-borehole data, methods of acoustic tomography are being developed for application to a range of geotechnical problems in geothermal reservoir analysis, nuclear waste repository characterization, in-situ stress measurement, and fracture distribution.

CONTACT: Ernest Majer, Bldg. 50A-1140, Lawrence Berkeley Laboratory, Berkeley, CA 94720 (415) 486-6709

◄ **A time lapse 'shot' of a wavefield propagating in an inhomogeneous velocity structure. The source is at the top center of the picture. This model is a cross section of a tuff-filled caldera. The dark line is the caldera boundary.**

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.

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 accurate and 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 (415) 486-5064

◄ The Mobile Window Thermal Test Facility is taken to different sites to test the energy characteristics of windows under various weather conditions. The window and frame unit in the picture is shown after it has been removed from the test position in the side of the facility.

Mobile Window Thermal Test (MoWiTT) Facility

The Windows and Daylighting Group (part of the Applied Science Division) operates a calorimetric facility for measuring the performance of vertical or horizontal fenestration systems under actual weather conditions with a realistic (room-like) environment. The MoWiTT consists of a pair of room-sized, guarded calorimeters mounted side by side in a mobile structure Each calorimeter may accept a vertical system up to 2.3 m square or a horizontal system up to 1.2 m square for study. The calorimeter rooms measure 2.4 m high × 2.4 m wide × 3.0 m long. The principal feature of the facility is its capability of measuring the net heat flow through each test system with good accuracy and time resolution throughout the diurnal cycle. In addition, simultaneous measurements of weather and solar conditions are made, and up to 200 temperatures or other relevant variables per calorimeter may be collected by the sophisticated data acquisition and control system.

Based at LBL, the MoWiTT normally makes winter measurements in Reno, Nevada and summer measurements in Livermore, California; other locations are also possible. Measurements may be monitored by telephone from LBL, allowing minimal traveling to the field location during data collection.

Studies in the facility examine the comparative performance of different fenestration systems under realistic interior and exterior conditions, the dependence of performance on these conditions, and the interaction between fenestration system and building characteristics. The calorimeters may be used to simulate building interiors with differing thermal mass, air leakage, or HVAC systems. The facility is designed to be capable of studying advanced fenestration systems, i.e., with high R-value and/or time-varying properties.

CONTACT: Joseph Klems, Windows and Daylighting Group, Bldg. 90-3111, Lawrence Berkeley Laboratory, Berkeley, CA 94720 (415) 486-5564

Low Background Counting Facility

The LBL Low Background Counting Facility consists of a heavily shielded vault that 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.

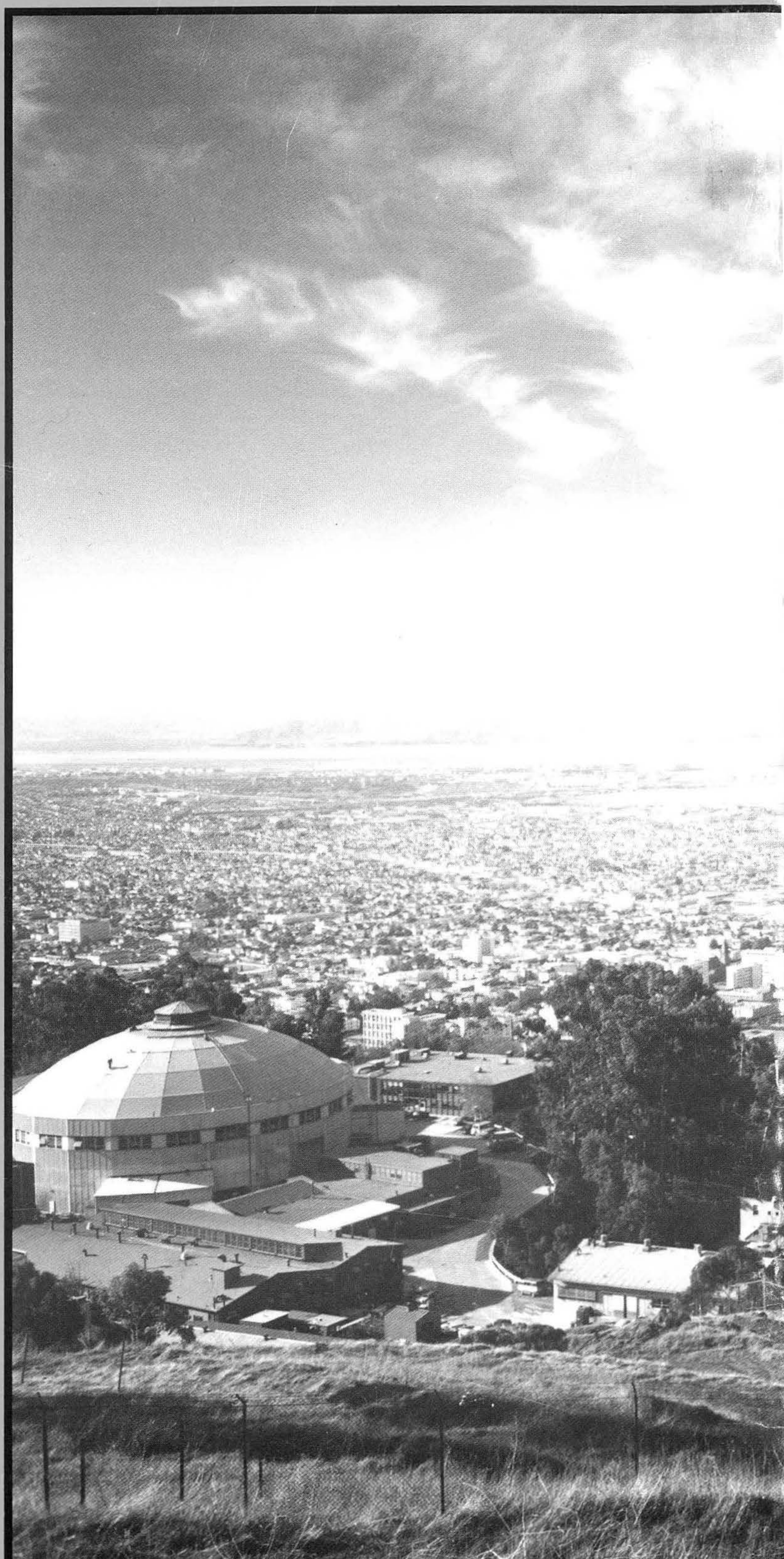
The primary available detectors include a large NaI(TI) scintillation crystal, a large coaxial intrinsic Ge semiconductor detector, and several planar intrinsic Ge semiconductor detectors. Established procedures are in common use for measurement of picocurie amounts of gamma emitters in kilogram quantities 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 installations of additional gamma detectors and data acquisition/analysis equipment.

CONTACT: Alan R. Smith, Bldg. 72-131, Lawrence Berkeley Laboratory, Berkeley, CA 94720 (415) 486-5679 or 5115

◀ **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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