USER FACILITIES
at the
LAWRENCE BERKELEY LABORATORY

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LBL USER FACILITIES

Many of the LBL research facilities as well as much of their associated equipment have long been available to qualified outside users. Of these, the facilities used by outside researchers are of two types: 1) those that have a formal, designated status as a national research facility (the Bevalac, the SuperHILAC, the 88" Cyclotron, and the National Center for Electron Microscopy), and 2) those that lack such formal status and user procedures, but which are used to a significant degree by outside scientists and engineers. The Tritium Labeling Facility is awaiting funding for conversion into a national facility; nearly half of its use is by outside researchers.

NATIONAL RESEARCH FACILITIES

The SuperHILAC

The SuperHILAC is a heavy-ion linear accelerator operating in a timeshared mode with pulse-to-pulse energy variability (2.4 to 8.5 MeV/A) and particle variability for all ions up to ^{238}U. A third injector, just coming on line, makes the SuperHILAC unique in its ability to deliver multiple high mass (A $\geq$100) and high intensity ion beams. (Only the UNILAC at GSI, Darmstadt, West Germany can deliver comparable beams, but without timesharing capability.) Normal timeshared operation of the SuperHILAC involves the use of 32 pulses per second of a heavy ion beam by its principal research group, the sending of 2 pulses per second of a different ion to the Bevatron (this combined operation is called the Bevalac facility), and the use of 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.

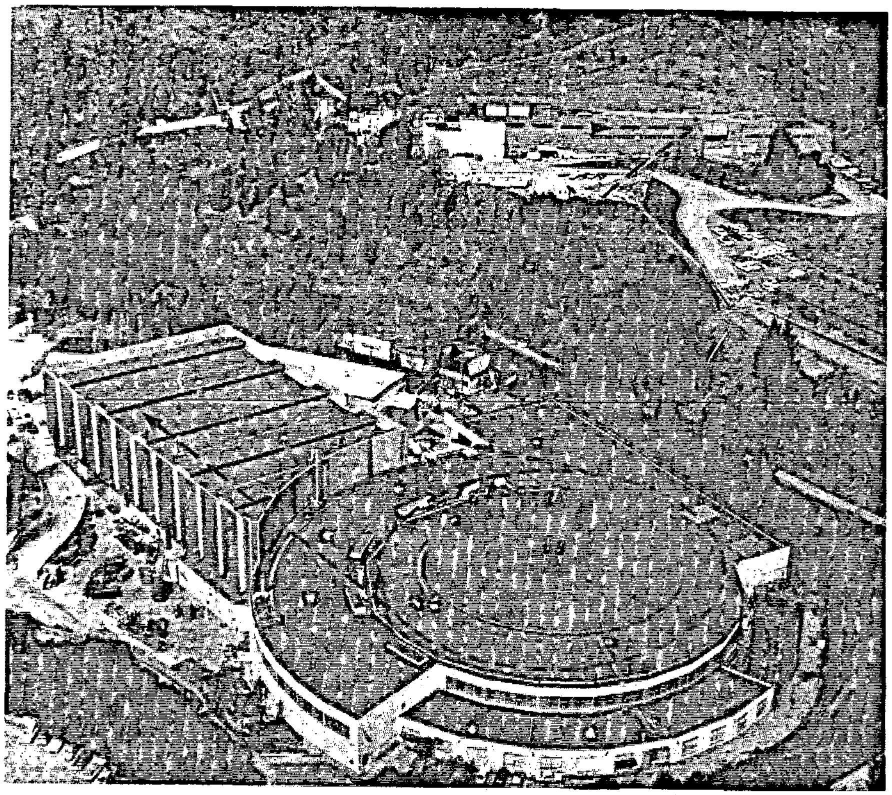
The SuperHILAC has long been the U.S. vanguard of discovery of new heavy elements such as ^{102}No and ^{103}Lr, in strong competition with a USSR effort at JINR, Dubna and, more recently, a West German effort at the UNILAC. The SuperHILAC plays a pre-eminent role in elucidating many of the global features of the fusion, deeply inelastic (damped), and fission reactions that epitomize collective nuclear phenomena. Because of its very high charge and mass beams, 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. Atomic physics work at the SuperHILAC concentrates on atomic spectroscopy (especially of very high charge state, low velocity recoil ions) 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 (PAC), whose present chairman is P. Bond of the Brookhaven National Laboratory.

The Bevalac

The Bevatron is a synchrotron that can accelerate heavy ions from either the SuperHILAC (the Bevalac mode) or its local injector to any energy between 50 MeV/A (where it overlaps with lower energy machines) and 2100 MeV/A (where it is the only facility in the world with such high energy heavy ions). It has several large detector facilities recently completed: (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 50-250 MeV/A; and (f) a magnetically surrounded streamer chamber.

The Bevalac has the unique capability worldwide to study collisions between nuclei at energies sufficient to convert nuclear matter into hadronic matter 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 which the nucleonic character of nuclei is isolated from effects of coherent 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. Both Bevalac nuclear science and biomedical research programs are reviewed by (separate) Program Advisory Committees.



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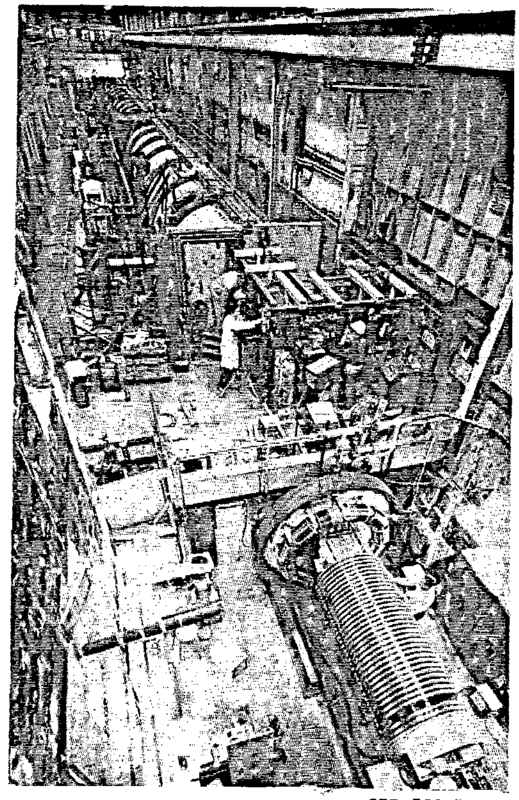

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The Bevalac (left) is the only accelerator facility in the world that provides ions as heavy as uranium at relativistic energies. The arrow shows the path of the heavy ions, which are produced and accelerated at the SuperHILAC (rear) then steered through a transfer line into the Bevatron (the circular building in the foreground) where they are further accelerated and routed to the various research areas. The SuperHILAC (right) is shown here during modifications, without its normal shielding. More than half the nuclear science at these two national research facilities is conducted by visiting research groups.

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 H. Feshbach of the Massachusetts Institute of Technology, and the chairman of the biology and medicine PAC is R. F. Kallman of Stanford University.

The 88-Inch Cyclotron

The LBL 88-Inch Cyclotron, operated by the Nuclear Science Division, is a variable energy isochronous cyclotron with spiral ridge focusing. It provides beams of both light and heavy ions for nuclear, biomedical and applied research. Light ion beams include protons through ^4He at energies up to 60 and 140 MeV, respectively, and polarized protons and deuterons, with energies equal to those of the unpolarized beams. Heavy ions up to A = 40 are available with sufficient energy (160 Q^2/A, where Q is the charge state of the ion) for the study of nuclear reactions and nuclear structure. The 88-Inch Cyclotron serves users in any of eight experimental areas. Major experimental facilities include the High Level Cave designed to safely handle very high beam currents for radioisotope production, a quadrupole-sextupole-dipole (QSD) spectrometer system, a 60 inch scattering chamber, a streamer chamber for scanning events with high multiplicities, the on-line Recoil Atom Mass Analyzer (RAMA), and a time-of-flight spectrometer.

Light-ion nuclear research at the 88-Inch Cyclotron includes studies of light and exotic nuclei far from stability and the investigation of reaction mechanisms, such as the advent of fission-like phenomena in deeply inelastic collisions. Spin-polarization phenomena and fundamental nuclear symmetries are studied with the excellent polarized proton and deuteron beams.

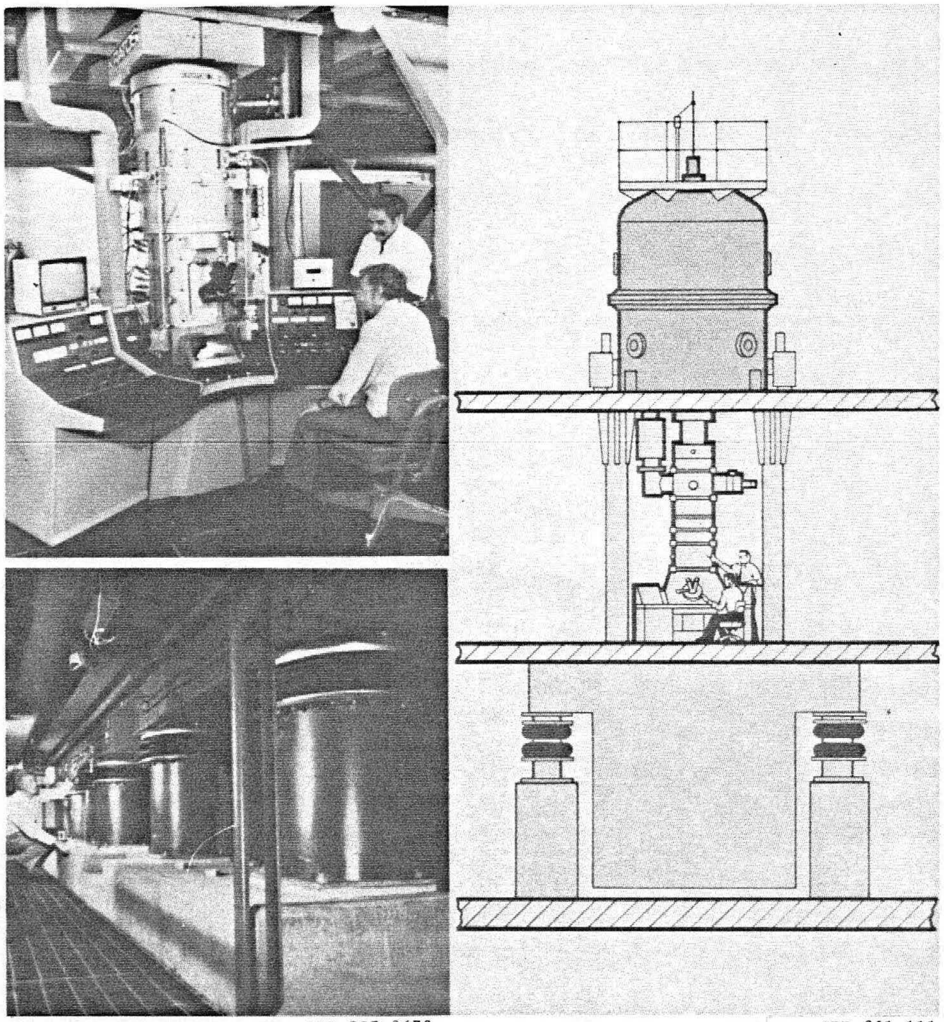
Experimental heavy ion nuclear research focuses primarily on investigations of heavy ion reaction mechanisms, the study of exotic nuclei far from the valley of stability, the spectroscopy of high spin states of nuclei, studies of collective motion in heavy-ion induced reactions and searches for and studies of unusual transuranium isotopes and elements.

The 88-Inch Cyclotron is a major source of short-lived radioisotopes for medical research. It is also used for ^{14}C dating and for a variety of applied research projects, including recently, for example, the investigation of radiation damage to satellite electronic components.

The 88-Inch Cyclotron supports a large group of outside users, approximately 25% of the available beam time going to researchers from other laboratories and universities. Informal research proposals are submitted in writing to the Cyclotron Director, R. Stokstad, who reviews each proposal with the advice of two consultants, presently J. G. Cramer (University of Washington) and C. K. Gelbke (Michigan State University). A users' association is in the process of being formed.

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. Its first year of operation, 1981, has seen the installation of the High-Voltage Electron Microscope (HVEM), 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.



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Views of the National Center for Electron Microscopy major instruments. Top left: The microscope and control console of the 1.5-MeV High Voltage Electron Microscope (not shown is the nine-stage Cockcroft-Walton accelerator on the floor above). Bottom left: The highly sensitive system of air springs on which the instrument rests. Right: The Atomic Resolution Microscope presently under development.

The HVEM is mounted on a 90-metric-ton vibration-isolation pad and stands 9 meters tall. It is 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. Several dozen research proposals for the use of this microscope have already been approved by the nine-member HVEM steering committee (four from LBL and five from other institutions).

Proposals to use the facilities of the Center are submitted to the LBL Materials and Molecular Research Division. 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 M. Simnad of the General Atomic Company, San Diego.

OTHER LBL USER FACILITIES

The Laboratory has a number of other research facilities that, although lacking formal "user facility" designations, are heavily used by outside research people. Requests to use these facilities are made to the principal LBL people responsible for the equipment or facility. They make the decisions regarding the use of these facilities based on the principal considerations of suitability of the research, qualifications of the researchers, and the available time. Examples of such facilities at LBL are the Neutral Beam System Test Facility, the Heavy-Ion Treatment Facility, the 2.5-MeV Van de Graaff Accelerator, and the Tritium-Labeling Laboratory.

Neutral Beam System Test Facility (NBSTF)

This large installation is operated to test the injector systems that LBL has developed for Princeton's Tokamak Fusion Test Reactor. It is already operated under contractual arrangements with Princeton, General Atomic

Corporation, and the Lawrence Livermore National Laboratory (LLNL). During the next two years it will be substantially improved so that a variety of injectors can be tested under more severe operating conditions. A new Neutral Beam Engineering Test Facility (NBETF) will result, to be operated as a national user facility in 1983.

Requests to use the NBSTF are directed to Klaus Berkner of the LBL Accelerator and Fusion Division. A steering committee composed of representatives of LBL, Princeton, General Atomics, and LLNL provides oversight and advice on the use of the NBSTF.

Heavy Charged-Particle Treatment Facility

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

Proposals to use the Facility are submitted to the LBL Division of Biology and Medicine. Cooperative clinical trials are coordinated with the Northern California Oncology Group, the national Therapy Oncology Group, and the Surgical Oncology Group of the Veteran's Administration hospitals. The total number of patients referred in the period July 1975 to July 1980 was 313, including low-LET-photon control patients and patients not accepted for particle radiation therapy.

2.5 MeV Van de Graaff Facility

This facility is available to outside users for applications that involve 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. The system can be modified to perform proton-induced x-ray fluorescence analysis (PIXE), if necessary. Current outside 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.

Information regarding the Facility, and procedures for its use, is available from Dr. Joseph Jaklevic, Building 70A, LBL.

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 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.

Requests to use the facility are directed to R. Lemmon of the LBL Chemical Biodynamics Division. The National Institutes of Health has approved funding to convert the facility into a national user facility.