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Title
The 88* Cyclotron at LBL

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The 88-Inch Cyclotron offers several beamlines on which users can set up test chambers. A joint project involving Aerospace Corporation and LBL is now installing a large vacuum chamber, which will be available to other industrial users.

During FY 93, the cyclotron ran for 4360 hours. Of these, 670 hours or 15% of the time was dedicated to space applications. Forty-four scientists from nine companies took part in the applied studies.

Beam time for industrial users is provided on a cost-recovery basis. FY 94 rates are $616 per hour for users working on federal contracts and $743 per hour for other users. Tune-up time is charged at the same rates as beam time. For a standard cocktail run, tune-up typically takes 2-4 hours.

The 88-Inch Cyclotron runs seven days a week year-round except during three-week maintenance periods in summer and winter. Scheduling is set three times a year in conjunction with the nuclear science scheduling period.

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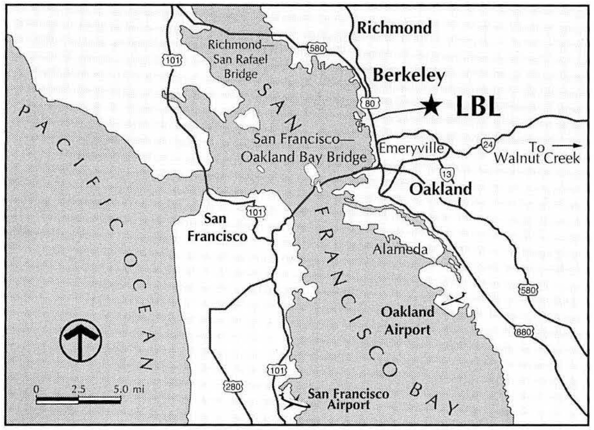
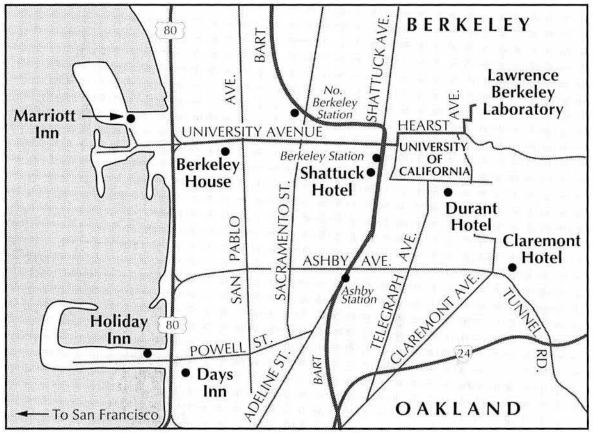


LBL to San Francisco airport: 25 miles
Driving time: 45-60 minutes

LBL to Oakland airport: 16.5 miles
Driving time: 35 minutes



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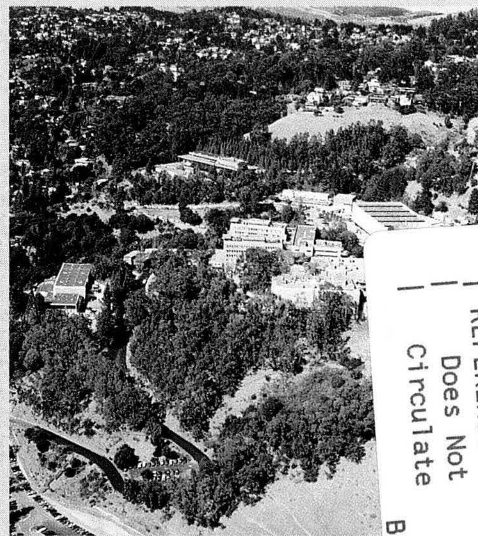
Lawrence Berkeley Laboratory

The 88-Inch Cyclotron



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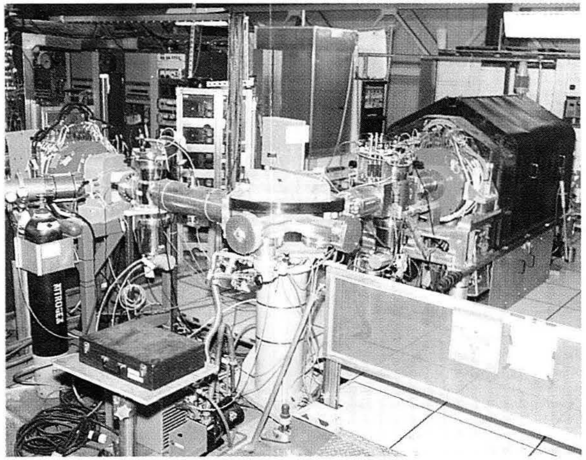
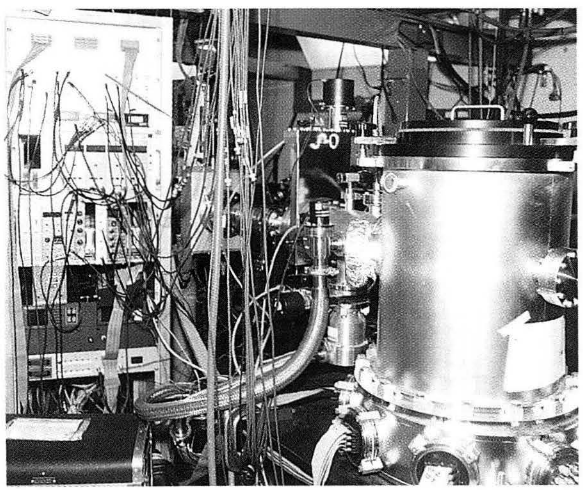


The 88-Inch Cyclotron is a versatile, reliable accelerator of ion beams as light as hydrogen and as heavy as uranium. Located at Lawrence Berkeley Laboratory (LBL) in the hills above the University of California, the facility has been serving researchers from LBL, other national laboratories, universities, and foreign institutions since 1962. Although its primary mission is to support basic research in nuclear physics and nuclear chemistry, its beams are used by the U.S. aerospace industry for testing computer chips, calibrating instruments for satellites, and testing charge-coupled devices.

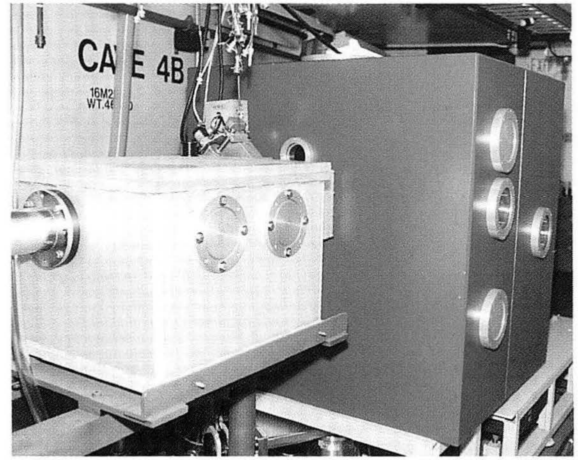
The central component of the facility is a sector-focused, variable-energy cyclotron fed by two electron cyclotron resonance (ECR) high-charge-state ion sources—the LBL ECR and the Advanced ECR. This combination produces heavy-ion beams from helium to neon with energies up to 32 MeV/nucleon. For heavier ions, the maximum energy per nucleon decreases with increasing mass. Typical examples are:



Ion	Maximum Energy (MeV/nucleon)
Argon	23
Krypton	14
Xenon	8
Bismuth	5

Most metallic ions and all gaseous ions between these examples have been accelerated. The few ions that have not been accelerated can be developed as needed. The facility produces beams of light ions—p, d, ^{3}He, and ^{4}He—with total energies of up to 55, 65, 135, and 130 MeV, respectively. Polarized beams at intensities of up to 0.5 microampere are also available.

Combined with either ECR source, the 88-Inch Cyclotron can run ion "cocktails"—mixtures of ions with near-identical charge-to-mass ratios. This capability is especially useful for radiation-effects testing. Because the cyclotron itself acts as a mass analyzer to separate the ions, operators can switch from one ion to another simply by turning a dial. As a result, changing the ionization delivered to a component under test is easily done in a matter of minutes, thereby increasing efficiency and saving money for the user.



The following tables list the components of two typical cocktails in common use for radiation-effects testing, with the corresponding linear energy transfer (LET) values and ranges in silicon.

Low-Energy Cocktail

Ion	Energy (MeV)	LET (MeV/mg/cm^2)	Range (µ)
$^{15}N^{+3}$	67	3.0	68
$^{20}Ne^{+4}$	90	5.6	53
$^{40}Ar^{+8}$	180	15.0	48
$^{59}Co^{+12}$	266	27.4	45
$^{65}Cu^{+13}$	293	30.3	45
$^{86}Kr^{+17}$	378	40.9	47
$^{136}Xe^{+27}$	603	68.9	50

High-Energy Cocktail

Ion	Energy (MeV)	LET (MeV/mg/cm^2)	Range (µ)
$^{4}He^{+2}$	130	0.055	5.66
$^{14}N^{+7}$	455	0.682	1.63
$^{20}Ne^{+10}$	650	1.403	1.15
$^{36}Ar^{+18}$	1170	4.586	0.67