BEVALAC USER'S HANDBOOK

DISCLAIMER

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Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

April 1990

Prepared for the U.S. Department of Energy under Contract No. DE-AC03-76SF00098

MASTER

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SECTION I

1. GENERAL INFORMATION

Lawrence Berkeley Laboratory is a national facility operated by the Regents of the University of California under Contract 98 with the Department of Energy. The Bevalac is operated by the Accelerator and Fusion Research Division of the Lawrence Berkeley Laboratory. Research at the Bevalac is conducted by both staff and guest scientists whose research proposals have been approved by the Lawrence Berkeley Laboratory Management, which is advised by an international panel.

A scientific director for the nuclear science program at the accelerator is appointed by the LBL Nuclear Science Division to provide leadership for the research on the floor and to coordinate long-term improvements. Lee Schroeder has held this post at the Bevalac from 1986 to 1989. The Biology and Medicine division appoints a scientific director for the Biomed program at the Bevalac. Tom Budinger presently holds this position. Jose Alonso has been in charge of operations at the Bevalac from 1980 - 1989. Presently, he is taking a two-year leave, and during this period Ben Feinberg is in charge of operations.

1a. ACCELERATOR RESEARCH COORDINATION OFFICE

The Accelerator Research Coordination Office (ARC Office) located in Room 208 at the Bevalac is designed to streamline communications with researchers and to coordinate all services for experimenters at the Bevalac. In addition to this Bevalac Nuclear Science handbook, there is a separate handbook for the biomedical users at the Bevalac. All handbooks are available from the ARC Office.

Research proposals should be submitted to the ARC Office. Questions you may have regarding any phase of your experiment, from conception to execution, may also be directed to this office for a quick response. Office staff will also handle business and administrative details for guest experimenters.

Established near the ARC Office in Room 205 is a reference library of reprints and/or preprints of reports and publications of work done at the Bevalac. Additions to the library are welcome at all times. When sending the publications to the ARC Office, please make reference to the specific experiment number that was assigned to the experiment.

Maps of the Berkeley and LBL areas are included in this section; additional copies are available from the ARC Office.

Before beginning a run, check with the ARC Office regarding the status of the machine and your experiment. Also, let us know to what extent your run was successful and in what ways we could help you conduct your research more effectively.

The ARC Office is located just inside the front door of the Bevalac. The mailing address is:

Accelerator Research Coordination Office
MS 51-208
Lawrence Berkeley Laboratory
1 Cyclotron Road
Berkeley, California 94720
415/486-5185 or FTS 451-5185

Computer address:

BITNET BEVOPS@LBL.GOV
VMSNET CSA::BEVOPS

**Ib. IDENTIFICATION CARDS, PERSONAL DOSIMETERS, PARKING
PASSES, PATENT AGREEMENT**

Each guest experimenter must comply with the requirements of the Department of Energy and complete these forms:

- a) Participating Guest Information
- b) Guest Patent Agreement
- c) Medical Information for Participating Guest

before his/her scheduled experiment is to start. A copy of each form has been included in the following pages. The quickest way to satisfy these requirements is to call or write to the ARC Office as soon as you know the dates that you will be coming for your experiment so that the forms can be mailed to you and completed ahead of your visit to LBL. The forms can then be mailed back

PARTICIPATING GUEST INFORMATION
LAWRENCE BERKELEY LABORATORY, BERKELEY

- ☐ RENEWAL ☐ NEW GUEST ☐ FORMER GUEST ☐ FORMER EMPLOYEE
☐ ON RENEWAL CHECK IF NO CHANGE OR ADDITION IN THE SECTION

GUEST NUMBER

1	NAME (Last)	(First)	(Middle Name or Initial)	TELEPHONE NO IN BAY AREA
ADDRESS IN S F BAY AREA (Number and Street)			(City)	(Zip Code)
PERMANENT ADDRESS (Number and Street)			(City)	(State) (Country or Zip Code)
LABORATORY CONTACT (Name)			(Division/Department)	PAYROLL ACCT NO

2 DESCRIPTION OF ACTIVITY (Reason for visit, facility to be used, nature of experiment)

WILL BE WITH LABORATORY	LAB PHONE	MAIL STOP	BUILDING	ROOM
FROM	TO			

3 IF FILM BADGE IS REQUIRED, PLEASE GIVE BIRTH DATE

SOC SEC NO

4 ☐ U.S. CITIZEN ☐ OTHER IF "OTHER", PLEASE SPECIFY COUNTRY OF CITIZENSHIP

5 JOB CATEGORY STATUS AT LBL - CHECK ONE BOX

- ☐ FACULTY ☐ STAFF SCIENTIST ☐ POST DOC ☐ GSRA ☐ STUDENT ☐ MANAGEMENT ☐ TECHNICAL ☐ ADM/CLERICAL
☐ OTHER (Please Specify) _____

6 FROM: Name of Academic/University/Industry/National Laboratory/Other (e.g. Foundation, U.S. Govt., Medical Hospital, PG&E)	DEPARTMENT
ADDRESS (Number and Street)	(City) (State) (Zip Code) TELEPHONE NO

7 ARE YOU AN EMPLOYEE OF THE ABOVE ORGANIZATION? IF NO, PLEASE INDICATE SOURCE OF FINANCIAL SUPPORT DURING THIS VISIT

☐ YES ☐ NO

IF YOU ARE A GRADUATE STUDENT OR POST DOC, PLEASE INDICATE BASIS OF SUPPORT:

/ UC Berkeley: If not UCR, specify Campus
 / Grant / Fellowship / OTHER (Please Specify) _____

8 THE LAWRENCE BERKELEY LABORATORY IS UNABLE TO PROVIDE WORKER'S COMPENSATION BENEFITS IN THE EVENT OF A WORK-INCURRED INJURY TO A PARTICIPATING GUEST THAT IS ONE WHO IS NOT ON THE PAY ROLL OF THE LABORATORY. Whom should the Laboratory contact to ascertain whether or not you are covered for Worker's Compensation benefits? In the event of an injury while working at the Laboratory this information would be needed. (See Section 10 below for person to notify in case of emergency.)

NAME	TELEPHONE NO
ADDRESS (Number and Street)	(City) (State) (Country or Zip Code)

9 IF COVERED BY A MEDICAL OR HEALTH INSURANCE PLAN, PLEASE GIVE NAME AND CARRIER

10 PERSON TO NOTIFY IN CASE OF EMERGENCY	(Name)	RELATIONSHIP	TELEPHONE
ADDRESS (Number and Street)	(City)	(State)	Country or Zip Code

I hereby agree to abide by all rules and regulations of the Lawrence Berkeley Laboratory and the University of California as set forth in their respectively approved policies and procedures.

11 SIGNATURE OF GUEST

DATE

12 PREPARED BY

APPROVED BY

Division/Department Secretary

Lab. Ext.

Division/Department Head

4/5

DIST/RTN: White - Foreign Visitors/Employee
 Green - Medical Services
 Canary - Telephone Services
 Pink - Protective Services
 Goldenrod - Host Department

**UNIVERSITY OF CALIFORNIA
LAWRENCE BERKELEY LABORATORY
PATENT AGREEMENT**

This agreement is made by me with The Regents of the University of California, a corporation, hereinafter called "University", in part consideration of my employment, and of wages and/or salary to be paid to me during any period of my employment, by University, and/or my utilization of University research facilities.

By execution of this agreement I understand that I am not waiving any rights to a percentage of royalty payments received by University, as set forth in the University Policy Regarding Patents hereinafter called "Policy". I further understand that I may, with the approval of the University, request a waiver determination by the U.S. Government on my identified inventions as set forth in 41 CFR 9-9.109-6, where applicable.

I agree that every possible patentable device, process, plant, or product, hereinafter referred to as "invention", which I conceive, make (first actually reduce to practice), or develop while employed by University, or during the course of my utilization of any University research facilities, shall be examined by University to determine rights and equities in accordance with the Policy, and I shall promptly furnish University with complete information with respect to each.

In the event any such invention shall be deemed by University to be patentable, and University desires, pursuant to determination by University as to its rights and equities therein, to seek patent protection thereon, I shall execute any documents and do all things necessary, at University's expense, to assign to University all rights, title and interest therein and to assist University in securing patent protection thereon. The scope of this provision is limited by California Labor Code section 2870, to which notice is given below, to the extent said Labor Code provision is consistent with federal law. In the event I protest the University's determination regarding any rights or interests in an invention, I agree: (a) to proceed with any University requested assignment or assistance; (b) to give the University notice of that protest no later than the execution date of any of the above-described documents or assignment; and (c) to reimburse the University for all expenses and costs it encounters in its patent application attempts, if any such protest is subsequently sustained or agreed to.

I shall do all things necessary to enable University to perform its obligations to grantors of funds for research or contracting agencies as said obligations have been undertaken by University, including the University's obligations regarding patents and technical and scientific records under Contract No. DE-AC03-76SF00098. (Contract-98) with the U.S. Government. With reference to Contract-98 I agree to abide by and fully perform the terms of Clause 35 of said contract, excerpts of which are set forth on the reverse side of this agreement, as they may be amended from time to time, to the extent applicable to me, and further agree that I will report all such inventions to the Director, Lawrence Berkeley Laboratory (LBL), or his designee. To protect the patent interests of the University and the Government, I agree not to publish any information regarding scientific or technical developments made or conceived in the course of or under Contract-98 without prior approval obtained from the Director, LBL, or his designee for this purpose.

University may relinquish to me all or a part of its right to any such invention, if, in its judgment, the criteria set forth in the Policy have been met.

I agree to be bound hereunder for and during any periods of employment by University or for any period during which I conceive, make (first actually reduce to practice), or develop any invention during the course of my utilization of any University research facilities.

In signing this agreement I understand that the law, of which notification is given below, applies to me, but that I am still required to disclose all my inventions to the University.

NOTICE

This agreement does not apply to an invention which qualifies fully under the provisions of Labor Code section 2870 of the State of California, to the extent said Labor Code provision is consistent with federal law. Said Labor Code provision provides that:

Any provision in an employment agreement which provides that an employee shall assign or offer to assign any of his or her rights in an invention to his or her employer shall not apply to an invention for which no equipment, supplies, facility, or trade secret information of the employer was used and which was developed entirely on the employee's own time, and (a) which does not relate (1) to the business of the employer, or (2) to the employer's actual or demonstrably anticipated research or development, or (b) which does not result from any work performed by the employee for the employer. Any provision which purports to apply to such an invention is to that extent against the public policy of this state and is to that extent void and unenforceable.

In any suit or action arising under this law, the burden of proof shall be on the individual claiming the benefits of its provisions.

Employee/Guest Name: _____
(Please Print)

Employee/Guest Signature: _____ Date: _____

Witness Signature: _____ Date: _____

Excerpts from Clause 35 Contract No. DE-AC03-76SF00098

(b) *Allocation of principal rights.* (1) Assignment to the Government. The University agrees to assign to the Government the entire right, title, and interest throughout the world in and to each Subject Invention, except to the extent that rights are retained by the University under paragraphs (b) (2) and (c) of this clause.

(e) *Invention identification disclosures and reports.* (1) The University shall establish and maintain active and effective procedures to ensure that Subject Inventions are promptly identified and timely disclosed. These procedures shall include the maintenance of laboratory notebooks or equivalent records and any other records that are reasonably necessary to document the conception and/or the first actual reduction to practice of Subject Inventions, and records which show that the procedures for identifying and disclosing the inventions are followed.

(f) *Publications.* It is recognized that during the course of the work under this contract, the University or its employees may from time to time desire to release or publish information regarding scientific or technical developments made or conceived in the course of or under this contract. In order that public disclosure of such information will not adversely affect the patent interests of DOE or the University, patent approval for release or publication shall be secured from Patent Counsel prior to any such release or publication.

NOTE

At LBL, patent related duties and functions have been delegated by the Director to the LBL Patent Department. Employees are therefore requested to contact LBL Patent Department for processing of patent matters. Similarly, any questions relating to the DOE and University regulations and policies relating to patents and inventions should be directed to the Patent Department.

Revised: September 1984

**MEDICAL INFORMATION FOR PARTICIPATING GUESTS
OF THE LAWRENCE BERKELEY LABORATORY
BERKELEY, CALIFORNIA**

DATE _____

Name _____
Last First Initial

From _____
(Name of Institution, Company, etc.)

Will be working at LBL from _____ to _____
Date Date

Date of last Physical Examination: _____

Industrial ☐

Private ☐

Name, Address and Telephone Number of physician who would have medical information in case of emergency.

Please list any health condition (diabetes, heart trouble, etc.) or medication (digitalis, allergy to penicillin, etc.) that would be important to a physician treating you for a sudden illness or injury.

THIS INFORMATION IS NECESSARY IF YOU ARE INJURED OR BECOME ILL WHILE AT THE LAWRENCE BERKELEY LABORATORY. IT WILL BE HELD IN CONFIDENCE BY OUR MEDICAL DEPARTMENT.

(PLEASE FOLD THIS SHEET IN HALF, STAPLE IT AND DROP IT IN LBL MAIL. IT IS PREADDRESSED)

to the ARC Office if there is sufficient time, Faxed (486-5788), or hand carried to the ARC Office upon your arrival. In either case, your first stop at LBL will be the ARC Office to check in. After a brief review of the guest forms and a few instructions, your next stop will be the Pass Office in Building 90 where a picture will be taken and an identification badge will be made for you.

Please have your automobile license number with you if you wish a parking pass to gain entry into LBL with your car for the duration of your stay. However, because it is very difficult to park your car at LBL during the weekday daytime hours due to the limited number of parking spaces available, we recommend that you take the LBL shuttle buses. They operate between the hours of 6:40 a.m. and 6:50 p.m, Mondays through Fridays. The shuttle bus routes and schedules are shown on the following pages .

It is essential that you have an LBL neutron and gamma personal dosimeter during your stay. If you do not have one, you may apply for a temporary dosimeter at the ARC Office. All dosimeters are exchanged monthly. Please drop off your dosimeter at the ARC Office after your run or when leaving LBL. If you plan to return to LBL within the **same month**, please notify the staff in the ARC Office so that the dosimeter can be kept until your return. Before the issuance of the personal dosimeter, you will be required to undergo radiation safety training. (See Section II for more information on radiation safety training.

Ic. FOREIGN VISITORS

If there are any foreign nationals to be included in your visiting group at Berkeley, LBL's Foreign Personnel and Visitor Arrangements Department can provide the necessary visa documentation. However, please allow at least 30 days for this visa process for all foreign nationals, except Soviet Bloc visitors. For Soviet Bloc visitors, allow 3 to 4 months for DOE approval in addition to the visa documentation time.

Foreign Personnel and Visitor Arrangements can provide visitor guides to the Bay Area. Temporary housing can be arranged through the Housing Office on the University of California

DAYTIME
8:40 a.m. to 4:00 p.m.

2 buses provide 10-minute headway

EVENING
4:10 p.m. to 5:50 p.m.

Bus departs every 10 minutes from Bldg. 65 directly down Hearst, Oxford, and Center to Shattuck (Bart Station) and returns by regular daytime route via Milvia and Hearst to Bldg. 65.

5:50 p.m. to 6:50 p.m.

1 bus provides 20-minute headway Last bus leaves Bldg. 65 at 6:50 p.m.

■ DAYTIME Bus Stop
● EVENING Bus Stop

-8-

LBL ON-SITE SHUTTLE BUS ROUTES

June 1989

LBL SHUTTLE BUS SCHEDULE

OFF-SITE SHUTTLE (Red Flag)
 Route: 65 — Cyprien Road — Gayley —
 Hearst — Olden — Center —
 Minna — Hearst — Cyprien Road —
 65 (see this for detail)

BART STATION (Center & Shattuck)	
Stop 45	Stop 62
8:05 a.m.	8:05 a.m.
8:40 a.m.	8:30 a.m.
every 10 min.	every 10 min.
(after 4:00 p.m., no service along Gayley & Shattuck, but via Hearst.)	every 10 min.
3:30 p.m.	8:00 p.m.
3:10 p.m.	8:00 p.m.
3:00 p.m.	1:40 p.m.
2:50 p.m.	1:30 p.m.

HILL SHUTTLE (Blue Flag)
 Route: 63 — 16 — 15 — 1070 — 354 — 46A
 27:52 25:25 — 16 — 15 — 12
 62:05 72 — 16 — 15 — 254
 80

8:30 a.m. — 7:20 a.m. Direct Service from Stop 55	
Stop 63	Stop 27
7:30 a.m.	7:25 a.m.
7:40 a.m.	7:35 a.m.
7:50 a.m.	7:45 a.m.
every 10 min.	every 10 min.
4:40 p.m.	4:45 p.m.
4:50 p.m.	4:55 p.m.
5:00 p.m.	5:05 p.m.
5:10 p.m.	5:15 p.m.
5:20 p.m.	5:25 p.m.
5:30 p.m.	5:35 p.m.
5:40 p.m.	5:45 p.m.

STRAWBERRY SHUTTLE (Yellow Flag)
 Route: 62 — Strawberry Canyon —
 Hearst Mining Circle (Carnegie) —
 Strawberry Canyon — 62

Moving Circle	
Stop 62	Stop 62
8:10 a.m.	8:15 a.m.
8:25 a.m.	8:30 a.m.
8:40 a.m.	8:45 a.m.
8:55 a.m.	9:00 a.m.
9:10 a.m.	9:15 a.m.
9:25 a.m.	9:30 a.m.
9:40 a.m.	9:45 a.m.
9:55 a.m.	10:00 a.m.
10:10 a.m.	10:15 a.m.
every 10 min.	every 10 min.
3:40 p.m.	3:45 p.m.
3:55 p.m.	4:00 p.m.
4:10 p.m.	4:15 p.m.
4:25 p.m.	4:30 p.m.
4:40 p.m.	4:45 p.m.
4:55 p.m.	5:00 p.m.

LABORATORY GATE INFORMATION (Monday—Friday, excluding holidays)

GATE	OPEN	CLOSE
Blackberry Canyon	Open at all times	
Grizzly Peak	6:30 a.m.	9:00 a.m.
	4:00 a.m.	6:30 p.m.
Strawberry Canyon	8:30 a.m.	6:30 p.m.

--- BLUE FLAG ROUTE

..... YELLOW FLAG ROUTE

☆ BUS STOP

○ SIGNAL FOR PICK-UP

campus. There is a \$45.00 fee for 2 months access vacancy listing for this service. You may avail yourself of their services by contacting them directly. The address and telephone number is as follows:

Faculty/Staff Housing Coordinator
University of California
2401 Bowditch Street
Berkeley, California 94720
415-642-0667

Id. FINANCIAL ARRANGEMENTS FOR LBL SERVICES

Once a proposal has been accepted, the guest user should arrange for his home institution to establish an expense account with the Laboratory. This account can be used to cover such services as the following:

- a. miscellaneous LBL storeroom materials and supplies,
- b. purchase of materials,
- c. design and fabrication of specialized equipment by the LBL shops,
- d. graphic arts and copying services,
- e. special telephone service, and
- f. data reduction and computer use at the LBL computer center.

Guest users generally are charged at the same rates for these services as are LBL users. The rates include Laboratory overhead costs. Total charges for specific services may depend in part upon the degree of collaboration with LBL research groups. Estimates of the services desired, including a reasonable allowance for contingency, should be made in order to prepare a purchase order, which should contain the following information:

- a. Description of services, such as general supplies and services required from LBL in support of Experiment #____
- b. Term of the order consistent with expectations of stay at the Laboratory.

- c. Approximate dollar amount. Not-to-exceed amounts are not acceptable. Estimated amounts can easily be augmented.
- d. Names of participating personnel who may incur and approve costs against the account. A principal investigator should be identified as being responsible to see that the dollar amount and time limit of the order are not exceeded.
- e. Acknowledgment, such as the following, to satisfy the Laboratory's contractual obligation: "It is understood that all work hereunder is to be performed in accordance with the terms and conditions of Contract DE-AC03-76SF00098 between DOE and the Regents of the University of California. No other terms or conditions shall apply unless specifically agreed upon in writing by the University."

Purchase orders and any questions regarding them should be addressed to:

Lawrence Berkeley Laboratory
Office of Sponsored Research
MS 936A
Lawrence Berkeley Laboratory
1 Cyclotron Road
Berkeley, CA 94720

Telephone inquiries can be made to 415-486-4126.

Ie. BEVALAC PHYSICAL SCIENCES USER'S ASSOCIATION

The Bevalac Physical Sciences User's Association is an organization of active scientists and engineers with a special interest in the Bevalac and its research program. The purpose of this Association is to provide a formal channel for the exchange of information among scientists interested in the Bevalac and between these scientists and the Bevalac Program Advisory Committees. The Association also provides a means for offering advice and counsel to the Bevalac management on operating policy and facilities through its Technical Advisory Committee. Presently, Peggy McMahan acts as the contact person for their activities. The membership is open to practicing scientists and engineers who will be added to the roster upon receipt of a written request, or upon submission of an experiment proposal to the ARC Office. The Association

Charter and other information may be obtained from Lee S. Schroeder, Lawrence Berkeley Laboratory, Building 70A, Room 3307, 1 Cyclotron Road, Berkeley, CA 94720.

If. **MAKING A BEVALAC PROPOSAL**

Proposals for Bevalac experiments are reviewed by one of two Program Advisory Committees (PAC). Each committee, one for nuclear science and one for biology and medicine, recommends to the LBL Director which of the proposals should be approved and for how many hours of beam time.

**BEVALAC PROGRAM ADVISORY COMMITTEE
NUCLEAR SCIENCE PANEL (1990)**

Dr. Sheldon Datz
Oak Ridge National Laboratory
Physics Department
Mail Stop 6377
Oak Ridge, TN 37830

Dr. Victor Viola
Department of Chemistry
University of Indiana
Bloomington, IN 47405

Dr. Konrad Gelbke
Michigan State University
Cyclotron Laboratory
East Lansing, MI 48824

Dr. Peggy McMahan (Ex-Officio-Member)
Lawrence Berkeley Laboratory
Mail Stop 71-259
Berkeley, CA 94720

Dr. Alfred Goldhaber
State University of New York (SUNY)
Physics Department
Stony Brook, NY 11794-3800

Dr. Franz Plasil
Oak Ridge National Laboratory
Physics Department
Oak Ridge, TN 37830

Dr. Miklos Gyulassy
Lawrence Berkeley Laboratory
Mail Stop 70A-3307
Berkeley, CA 94720

Dr. Lee S. Schroeder (Ex-Officio Member)
Lawrence Berkeley Laboratory
Building 70A - Room 3307
Berkeley, CA 94720

Dr. Walter F. Henning
GSI - Darmstadt
Postfach 110541
6100 Darmstadt 11, West Germany

Dr. Richard Madey
Kent State University
Smith Laboratory of Physics
Kent, OH 44242

Dr. Gary Krebs (Ex-Officio Member)
Lawrence Berkeley Laboratory
MS 51-208, #1 Cyclotron Road
Berkeley, CA 94720

The Committee considers proposals at formal meetings which are presently held twice a year.

An announcement is sent to all interested experimenters approximately 2 months prior to each formal meeting of the PAC. The deadline for submission of a proposal for consideration at an upcoming Bevalac Nuclear Science meeting is six weeks prior to that meeting. However, proposals may be submitted at any time for the subsequent meeting.

The proposals should have the form and content shown on the following page (NOTE: Running and tune-up time requests on all Bevalac proposals should be **hours** rather than shifts.) Proposals should be sent to the Accelerator Research Coordination Office, Building 51, Room 208.

A summary of past Bevalac proposals together with a current schedule of accepted proposals can be obtained from the ARC Office.

Some research time at the Bevalac is scheduled for parasitic operation. The general definition of a parasitic experiment is one that requires a negligible amount of beam, equipment and manpower. In addition, it must not interfere with the primary operations schedule. It is difficult to mount a full-fledged experiment parasitically, but it is possible for a scheduled primary experiment to obtain beam in a parasitic mode for tuning or calibration purposes. Such parasitic beam may well be very different in ion, energy, and intensity from that desired in the main experiment, but will be very useful to the investigator(s) just prior to the start of a scheduled run.

Requests for parasitic beam time, which fit the requirements cited above, should be submitted to the ARC office.

LBL management has made a decision to allocate a small percentage of nuclear science beam time to measurements involving the calibration of equipment and detectors. Proposals for the use of this time may be sent to the ARC Office at any time. Scheduling will be arranged by Fred Lothrop (x-7726) of the ARC Office. It is possible that a few additional calibration measurements can be made on a parasitic basis. Proposals for scientific experiments in cosmic ray science or

Lawrence Berkeley Laboratory

Proposal for Bevalac Nuclear Science Experiment

ARC Office
Use Only

Twenty (20) copies required - a separate set for each experiment, sent to the Accelerator Research Coordination Office, Building 51, Room 208, Lawrence Berkeley Laboratory, Berkeley, CA 94720

(ARC Office Use Only) (Date Received)	Date:	Experimenters - complete list (name, institution, title or position, address, and telephone number):	
	Group:		
	Institution:		
	Spokesperson (name, institution, address, telephone number):		
(ARC Office Use Only) (Disposition)	TIME REQUEST SUMMARY		
	Particle	Energy	Beam Line: Hours requested (Data-taking & tuncup)
Title of Experiment (60 characters or fewer):			
Summary of Experiment (for circulation; do not exceed space provided):			

1. **Research goals of the Experiment.** Describe the experiment to be performed, giving details of:
 - (a) measurements to be made
 - (b) method of making the measurements
 - (c) extraction of quantities of physical interest
 - (d) resolution in energy, momentum, angle, etc.
 - (e) statistical accuracy
 - (f) elimination of background
 - (g) beam time requested
 - (h) method of reducing the data to a form suitable for comparison to experiment and theory
 - (i) potential physical knowledge to be gained in relationship to other experiments and to theory.
2. **Beam Parameters.** State the beam particle(s) to be used, the Bevatron beam line (if it exists) and the physical location of the target area. State any special requirements for external beam foci. Give desired beam intensity, energy and pulse characteristics.
3. **Beam Location.** If a new beam line is required, describe fully in terms of physical location and any desired special requirements or constraints. A diagram should be included. All transport equipment should be listed together with the power or current requirements (see Experimenter's Handbook for magnet and separate characteristics) for each element. Beam diagnostic and monitoring requirements should be stated.
4. **Target.** Describe target material, size, location, and any special requirements.
5. **Detection Equipment.** List equipment used, e.g., streamer chamber or spark chambers, hydrogen target, gas Cerenkov counters, scintillation counters, etc. Please include a complete list of the electronics that you expect to get from the electronic equipment pool.
6. **Safety** - The design, operating procedures and operating mode of all hazardous equipment (equipment using flammable gases, toxic substances, pressure devices, etc.) must be approved by the LBL Safety Committee. Accompanying each PAC letter, which allocates beam time for accepted experiments, will be a Safety Check Sheet. This check sheet, a copy of which is shown in Section 1k of the User's Handbook (1990) must be filled-out and on file at the ARC office before your experiment is scheduled.
7. **Readiness.** At what date will your complete apparatus be ready for installation?
8. **Run Conditions.** State length of run required in terms of tune-up time and data-taking time in hours. Is data-taking time continuous or broken?
9. **Other Commitments.** List commitments of the group or individual in the group to other experiments. Include information regarding status of the other experiment(s), e.g., whether it is proposed, accepted, scheduled, or operational. Include dates and state which accelerator is used in other experiments.
10. **Other Information.** List any other details that will be important to scheduling, set-up, or operation of the experiment including resources needed from the Bevatron Staff which have not been mentioned in the preceding sections.

astrophysics are welcomed as freely competitive with other nuclear science proposals for beam time at the Bevalac and will be considered on their merits by the PAC.

Ig. SCHEDULE

After an experiment is approved by the LBL Director, it is integrated into the Bevalac research schedule at the earliest practical date. Precise scheduling of shifts is accomplished through communications between the experimenter and Fred Lothrop of the ARC Office. However, beam will not be delivered to an experimental area until a safety review of the experiment is carried out. Section Ik. describes the procedures for carrying out this review.

Standard operation for the Bevalac is composed of six to eight months of around-the-clock operation per year within a nine month calendar period. This schedule is subject to change.

During the running periods, short shutdowns are scheduled every week for routine accelerator maintenance. In addition, longer shutdowns are scheduled around holidays for maintenance, equipment installation, and budgetary considerations.

Specific operating programs for the Bevalac are developed during weekly meetings of the Accelerator Staff Scheduling Committee, and are generated at least two months in advance of the actual running period. Experimenters may usually expect to have at least two months' notice of their running date on the accelerator.

The regular accelerator schedule has the following general structure (see example -next page):

<u>Monday:</u>	Maintenance and studies
<u>Tuesday through Friday, day shift:</u>	Radiotherapy.
<u>Nights and weekends:</u>	Nuclear Science.
<u>Solid weeks of running:</u>	If deemed desirable, experiments may be scheduled for continuous block running over a period of a week or more.

These are the normal operating conditions. The routine is sometimes changed for special runs, such as experiments with new beams, as the need arises.

Budget related shutdowns of the experimental program are scheduled during the year as required. During these periods, machine development (on a limited basis) and maintenance programs are carried out.

1h. PLANNING A SCHEDULED EXPERIMENT

Once your proposal has been accepted, the Accelerator Research Coordinator, Gary Krebs (x-7727), can help coordinate the planning of your experiment. A beam line coordinator will have been assigned to you by laboratory management to assist you in interfacing your experimental setup with the Bevalac and to address safety issues. **But before your experiment can be scheduled**, the following information must be forwarded to the Accelerator Research Coordinator:

1. Names and phone numbers of those who will be participating in the experiment, and, if they are guests, the dates of their arrivals. **All guests must complete guest forms before working at LBL.**
2. Drawings of the planned experimental setup. These should include elements of the beam transport system and placement of targets, counters, shielding, and required housings or enclosures.
3. An "Initial Safety Check Sheet for Bevalac/SuperHILAC Users" form, shown in Section 1k.
4. Any unusually large requirements for utilities (A.C. power, cooling water, compressed air, etc.).
5. Beam characteristics such as particle, energy, charge state, intensity, spill length, beam structure (instantaneous rate) and flattop requirements. Momentum and flux of ions which are expected to be present at any position along the experimenter's beam line where personnel can be exposed.
6. Any special requirements such as vacuum coupling to the Bevalac, special targetry, pulse tailoring or instrument gas requirements.

7. Any special beam collimation devices.
8. Data acquisition requirements.

II. FACILITIES AND SERVICES AVAILABLE TO EXPERIMENTERS

A number of facilities and services are provided at the Bevalac to aid experimenters in the design, construction, setup and operation of their experiments. The ARC office staff will put the experimenter in contact with the Bevalac Operations and Engineering groups, to assist in the design and layout of experiments. This may include providing layout drawings and the surveying and alignment of experimental equipment during the installation of the experiment. The Engineering and Coordination groups also help the experimenters in the design and installation of their equipment and advise with regard to safety requirements. Setup and removal of the experiment is performed by the Bevalac staff in conjunction with the engineers and experimenters. In addition, the Bevalac Operations and Laboratory support groups also provide the following services and support items on a basis consistent with available Laboratory facilities and effort:

1. Maintenance and operation of the beam transport system to the experimental area, including vacuum pipes, standard mass slits, standard separators, beam diagnostics, etc.
2. Scientific, engineering and other support assistance required for layout arrangement, placement and connection of Laboratory-supplied standard experimental equipment. This includes the use of any of the existing available auxiliary equipment such as beam transport magnets, power supplies, spectrometers, quadrupoles and separators.
3. Work and office space, as it is available.
4. Equipment handling services, e.g. cranes, forklifts, etc. (to be operated only by designated personnel).
5. A.C. and D.C. power.
6. Deionized water and compressed air. Instrument quality air may be provided, if necessary.

7. Housing in the experimental area for monitoring and control equipment, as well as local communications systems.
8. Reasonable quantities of liquid nitrogen and inexpensive bottled gases.
9. Assistance in repair and maintenance of electronics, as available.
10. Assistance in unloading of trucks or vans and temporary storage of equipment.
11. Bevalac shop facilities for small construction jobs and emergency repair work.
12. Assistance in the design and installation of radiation shielding for both personnel and equipment.
13. Electronics equipment pool including power supplies, NIM and CAMAC modules, cables, etc. [Contact Mel Flores (x-5575 or x-5831) if you would like to know what items are available from this pool and the procedure for signing them out and returning them.]

SHOP FACILITIES

In addition to the services listed above, Laboratory mechanical and electrical shop facilities are available to visiting investigators for the design, fabrication, repair and rebuilding of experimental apparatus. However, visiting groups normally are encouraged to use shop facilities at their own institutions because the time required there may be substantially shorter than at LBL, where shops typically are committed heavily to LBL work requests. For apparatus which needs repair or remodeling during the time an experiment is running, every effort will be made to expedite the work, consistent with the shop load and experimental priorities. The ARC Office staff can determine the availability of shop and engineering services and initiate contacts for work to be done. Charges for engineering and shop services will be billed at prevailing LBL rates to the user's established account.

Ij. BEVALAC PERSONNEL ASSIGNMENTS

Many of the people named below and on the following page will be involved in your experiment planning and operation, and can be contacted for assistance. General questions, however, should be referred to the ARC Office.

AFRD Unit	Contact Persons	Extension Nos.
Accelerator Operations	B. Feinberg	-7725 or -5185 (preferably)
	R. M. Miller	-5578
Research Coordination	G. F. Krebs	-7727 or -5185
	F. H. G. Lothrop	-7726 or -5185
	M. A. McMahan	-7783
Bevalac Development	B. Feinberg	-7788 or -5185
	R. M. Richter	-7722 or -5575
	J. W. Staples	-7732 or -5831
	M. M. Tekawa	-5575
	E. Zajec	-7721 or -5578
Radiation Safety	P. R. LaPlant	-5831 or -5251
Safety	R. R. Stevenson	-5251
	K. R. Biscay	7606
	E. Zajec	-7721 or -5575
Accelerator Computer Systems	S. A. Lewis	-7702 or -5831
	J. R. Guggemos	-7734 or -5831
	L. L. Shalz	-7729 or -5575
	R. D. Dwinell	-7701 or -5831
Electrical Engineering	L. A. Brusse	-7703 or -5831
	J. G. Henderson	-7701 or -5831
	H. J. Oakley	-5576
	R. Stradiner	-5831
	K. D. Woolfe	-7739 or -5831
	H. J. Oakley	-5576
Electrical Maintenance	D. B. Hunt	-5834
Mechanical Engineering	R. M. Reimers	-5832
	S. R. Abbott	-7738
	J. M. Haughian	-6162
	R. V. Aita	-7715 or -5575
Mechanical Coordination	J. P. Brannigan	-31338 or -5575
	H. M. Ellison	-7716 or -5575
	P. M. Howell	-31200 or -5575
	B. S. Kude	-5575
	R. Frias	-5575
Motor Generators	W. D. Faust	-5575

EXPERIMENTAL SUPPORT

Experimental Support	Contact Person	Extension No.
General Research Coordination	G. F. Krebs	-7727 or -5185
Scheduling	F. H. G. Lothrop	-7726 or -5575
Physicist in charge of Beamline Coordination		
Beams 26, 30, 44	G. F. Krebs	-7727 or -5185
Beams 39, 44	M.A. McMahan	7783
Beam 42	H. J. Crawford	-6962
Beam 40	H. J. Crawford	-6962
Beamline Electronic Engineer	I. M. Flores	-5831
Mechanical Engineering	D. B. Hunt	-5834
Electrical Coordination	J. G. Henderson	-4801
TPC/Streamer Chamber	J. P. Brannigan	-31338
Plant Facilities(water, air systems, etc.)	R. A. Berninzoni	-5387
Electronics Counting Equipment Maintenance	L. R. Lawler	-6234
Set up of Experiments	J. P. Brannigan	-5414 or -5575
	R. S. Everett	-7719
Electronics Pool	I. M. Flores	-5831
	J. P. Brannigan	-5414 or -5575
Magnetic Measurements	D. H. Nelson	-5378
Computer Facilities	C. P. McParland	-6956 or -5575
	M. A. McMahan	-7783
Computer Repairs (Real Time System Group)	T. Viola	-7553
	O. W. Jones	-7545
ARC Office	K. E. Williams	-5185
	C. F. Gardner	-5187
Safety:		
Radiation/Shielding	P. R. LaPlant	-7626 or -7729
Gases	D. B. Hunt	-5834
General	R. R. Stevenson	-7724
Chairman, Bevalac Safety Comm.	E. Zajec	-7721

Ik. GENERAL SAFETY

Each experimental installation at the Bevalac is reviewed for compliance with safety standards from both radiation and occupational hazard aspects. Prior to scheduling your experiment, an "Initial Safety Check for Bevalac/SuperHILAC Users" form, shown on the following page, must be filled out by the principal investigator. The principal investigator must appoint a Group Safety Coordinator who will work with the Bevalac's beam line coordinator to ensure that compliance with LBL safety regulations has been met. (A beam line coordinator is assigned to each experiment by laboratory management.) The general Bevalac safety committee, chaired by Emery Zajec, has subgroups which review radiation safety and gas safety. Safety procedures and policies for the Bevalac area are contained in **PUB-3000, Health and Safety Manual**. These policies and procedures apply to anyone doing work in the area, including user groups, and it is expected that they will be familiar to all. Copies of the safety manual are available from the main control room, the ARC office, and in each experimental data collection area. The documents deal primarily with radiation hazards and installation procedures and requirements for hazardous materials and research equipment likely to be used at LBL. High pressure Cerenkov counters, and high voltages on spark chambers must be designed and installed properly. Policies and procedures for the use of nonradioactive hazardous materials (flammable fluids, toxic substances, gases, etc.) as well as electrical safety, are detailed in the manuals. Experimental setups *must* be designed and built to conform to these LBL standards. Guidelines from OSHA are followed as closely as possible.

The experimental areas, or caves, at the Bevalac are secured by an elaborate safety chain involving keyed doors and video surveillance. When entering a locked and secured cave, the MCR must be notified and each individual must take a separate key. The procedures that must be followed are posted on the experimenters' shack doors and are called "Search and Secure Procedures".

Potential radiation hazards at the Bevalac are dealt with by Health Physicist Pierre LaPlant (x-7626 or -7737) who operates within DOE regulations and uses the appropriate guidelines set

INITIAL SAFETY CHECK FOR BEVALAC/SUPERHILAC USERS

Before your experiment can be scheduled, you must fill out and return to the Bevalac Accelerator Research Coordination Office the following preliminary safety check list. The Principal Investigator of your group must designate a Group Safety Coordinator. The Bevalac Beam Line Coordinator, as designated in the PAC approval letter, will work with your Group Safety Coordinator and develop a plan for the safe conduct of the experiment. The Bevalac Safety Committee will review the plans and participate in a final review of the setup prior to run-time.

Date:		Experiment No.	
Principal Investigator:			
Group Safety Coordinator:			
Beamline Coordinator:			
QUESTIONS		ANSWERS	
1) What gases do you intend to use in your detectors?	<div style="border-bottom: 1px solid black; height: 15px; margin-bottom: 5px;"></div> <div style="border-bottom: 1px solid black; height: 15px; margin-bottom: 5px;"></div> <div style="border-bottom: 1px solid black; height: 15px;"></div>		
2) Will your apparatus utilize: 2.a high pressure or vacuum vessels? 2.b cryogenic systems?	<div style="border-bottom: 1px solid black; height: 15px; margin-bottom: 5px;"></div> <div style="border-bottom: 1px solid black; height: 15px;"></div>		
3) If you intend to use a radioactive source during the course of your experiment, complete the following:	Isotope: _____ Radiation emitted: _____ Activity: _____ Ownership: _____		
4) Will you require high voltage to operate your experimental apparatus? Voltage levels used:	<div style="border-bottom: 1px solid black; height: 15px; margin-bottom: 5px;"></div> <div style="border-bottom: 1px solid black; height: 15px;"></div>		
5) Do you anticipate using any toxic substances in your experimental set-up?	<div style="border-bottom: 1px solid black; height: 15px; margin-bottom: 5px;"></div> <div style="border-bottom: 1px solid black; height: 15px;"></div>		
6) Do you anticipate requiring special mechanical or rigging support for your apparatus?	<div style="border-bottom: 1px solid black; height: 15px; margin-bottom: 5px;"></div> <div style="border-bottom: 1px solid black; height: 15px;"></div>		
7) Do you expect any part of your apparatus to become radioactive during the course of your experiment?	<div style="border-bottom: 1px solid black; height: 15px; margin-bottom: 5px;"></div> <div style="border-bottom: 1px solid black; height: 15px;"></div>		

forth in 1978 by Subcommittee N43-4 of the American National Standards Institute and published in NBS Handbook 107, June 1978.

II. SAFETY TRAINING

All experimenters working within the Bevalac complex must have in their possession at all times a personal radiation dosimeter. These are issued in the ARC office on arrival at LBL and must be exchanged monthly. Upon departure, the dosimeter must be turned into the ARC office; (on weekends at the MCR).

However, before a dosimeter can be issued, the Department of Energy stipulates that you and all members of your group meet their radiation safety training requirements. Experimenter safety training is provided in the form of video presentations addressing radiation safety, personal dosimeter usage and Bevalac experimenter safety orientation. A brief written exam is also required and will be administered directly after the training. You should allow about one-and-a-half hours to fulfill these safety requirements. For individuals who have been trained at some other DOE Lab, the DOE regulations stipulate that "Generic training (not specific to a facility) may be waived provided: this training has been received at another DOE facility; there is provision of proof-of-training in the form of certification document containing individual's name, date of training and specific topics covered; and an appropriate official has certified the training of the individual...." (DOE document, DOE 5480.11 [1988]). Annual staff training sessions are scheduled for First Aid, CPR and other accelerator specific topics. Experimenters on extended visits are encouraged to attend these classes when possible.

Im. RADIOACTIVE SOURCES

All LBL radioactive source users, including guests, are responsible for the safe use, location and condition of the source at all times. Each source user is still responsible if he lends his source to someone else. All users of radioactive sources must notify the EH&S source office by letter of

his/her use of a source. This letter should include information on the names of sources, work location, time span for usage and names of individuals using the sources. All users will be given information upon arrival on LBL procedures concerning the use of radioactive sources.

Environmental Health and Safety has a variety of sources available for counter calibrations, simulations, etc. These sources will be lent only to principal investigators or LBL senior staff scientists, so if you have need of a source please ask your LBL contact or collaborator to obtain one. The source office of Environmental Health and Safety, will assist in locating the source appropriate to your needs. The source office is located at B75B at x-7605.

Environmental Health and Safety Operations has the authority to enforce the following sealed radioactive source control regulations:

1. A lockable cabinet, but preferably a fire safe, bearing the sign "Caution Radioactive Materials", shall be provided for all sources not in use. Research equipment that must contain sources shall have a radiation sign with the source identification affixed to it; it should be made secure as possible, e.g. a locked area is preferred.
2. When a source is no longer needed, the user may return the source or have the source temporarily stored by contacting the EH&S Department, x-5251.
3. Radioactive sources shall not be removed from LBL without written authorization from the Property Management Department. Make applications for authorization through the EH&S Operations Group, x-5251.
4. The user of an EH&S source (typically having Serial Number HC_____) shall not tamper with, transfer, nor destroy the source without approval of the EH&S Operations Group.
5. Sources left unattended in unauthorized areas shall be confiscated and stored by the EH&S Department. A confiscated source shall not be released to its former user without authorization from the Director's Office.

6. The user of a HC numbered source shall produce the source for an annual inspection when requested by the EH&S Source Controller.

<u>Class</u>	<u>Definition</u>	<u>Lost, Reported to:</u>
A	- up to 10 body burdens	LBL Administration
B	- 11 body burdens or over	DOE/SAN Administration

7. Notify the EH&S Department immediately if any source cannot be located. If after a reasonable search it cannot be found, a memo to Jim Haley in EH&S Department is required. It must state when and where the source was last used and its possible disposition.
8. The user of an HC numbered source shall return the source to the EH&S Operations Group upon termination. Termination processing should not be completed until all sources are returned.

TRANSPORTATION OF RADIOACTIVE MATERIALS **SHIPMENT OF RADIOISOTOPES FROM LBL**

Removal of radioactive materials from the Laboratory will not be permitted unless written authorization is obtained from the Director's Office. Radioactive materials include **anything** that emits measurable radiation of alphas, betas, or gammas, whether that material was originally intended as a source, a target, or neither.

Application for authorization will be made by the EH&S group after it receives your HAZARDOUS MATERIAL REQUEST FOR SHIPMENT form (RL-3634) which you must fill out if you intend to have radioactive material moved from the Laboratory. See Section 21, page 27 - 28 of the LBL publication **Health and Safety Manual** LBL-3000 (July 1986) for additional information on shipping radioactive materials.. At the proper time, after authorization is obtained, EH & S will pick up your material, pack it, and send it to the destination you have specified.

SHIPMENT OF SOURCES TO LBL

If you intend to ship a radioactive source from your home institution to LBL you must contact the health and safety group at your institution and ask them to make arrangements with EH&S at LBL for the proper transportation of your material. All incoming shipments are to be routed through EH&S. They will inspect the package for proper shipping requirements and possible damage, and then deliver it to the area you have specified. Shipment here includes any method of bringing the material into the laboratory. Packages are to be addressed as follows, or taken to EH&S Transportation immediately upon arrival:

University of California
Lawrence Berkeley Laboratory, Bevalac Experiment #____
Attn: J. T. Haley
Bldg. 75, Rm. 113
Berkeley, CA 94720

SHIPMENT OF SOURCES WITHIN LBL

Inter-building transferral of radioactive material or equipment must be done by the Environmental Health and Safety Transportation Group.

STORAGE OF SOURCES AT LBL

Environmental Health and Safety is responsible for proper storage of any radioactive source. Sources not in use must be stored in a locked container or storage area approved by EH&S for that type of source. Each container and storage area must be marked with the sign:

"CAUTION--RADIOACTIVE MATERIAL"

PURCHASE OF SOURCES

Sources may be purchased by experimenters through the EH&S office , x-7605. The buyer need not be an LBL employee, but must show need for a source. "Used" sources are available from LBL stock, and new sources will be bought from outside vendors if that is your need.

ACTIVATED MATERIAL

Material in or near a beam line may be activated during an experiment. Before any material is removed from the Bevalac it must be checked for radioactivity. If the material shows no activity a 'No Activity' tag will be attached. For outside users at the Bevalac this procedure is especially important. No material will be allowed out of the Bevalac without the 'No Activity' label or suitable shipping document required for active materials. Contact the office of Environmental Health and Safety (x-5251) for assistance.

If you need assistance other than between 8:00 AM - 4:00 PM, Monday thru Friday, you will need to make special provisions in advance. Ask your beam line coordinator for assistance.

SECTION II

II. THE BEVALAC AND ITS OPERATION

IIa. HISTORY OF THE BEVALAC

The history of accelerated heavy ion beams goes back to the very beginning of cyclotron development with E. O. Lawrence. As early as 1940 C^{+6} was accelerated to a total energy of 50 MeV in the 37-inch cyclotron. The first heavy ion induced nuclear reactions were produced in 1950, again with C^{+6} , at 120 MeV in the 60-inch cyclotron.

Several research groups at LBL had been interested in a high energy accelerator of medium heavy ions throughout the 1960's. However, scarce funding prevented the realization of this heavy ion capability until the 1970's. In 1971 a novel means of obtaining heavy ion beams in the billion electron volt range was suggested by Al Ghiorso, et al. The idea simply was to combine the new injector capability of the SuperHILAC with the high energy capability of the Bevatron. In August of that same year acceleration and extraction of nitrogen ions from the Bevatron's injector was successful. Other light ions were also made available to the nuclear science and biomedical communities. The facility with which the Bevatron was adapted to heavy ion operation pointed the way to modifications of the SuperHILAC for delivery of heavy (up to uranium) beams to the Bevatron. The Atomic Energy Commission funded this Bevalac (Bevatron-SuperHILAC) project in 1972, and in August, 1974, just three years after the initial feasibility tests, the Bevalac was operational with intense beams of light to medium mass ions (carbon to iron) at energies to 2 GeV/amu. Regular operation of the Bevalac began almost immediately for Biomedical research and then nuclear science, as the physicists restructured their research programs to delve into multi-nucleon interaction studies.

The Bevalac was designated as a national heavy ion facility in 1975, and since that time the nuclear science and biomedical research programs have been guided by program advisory committees composed of eminent specialists from around the world.

Interest in heavy ion physics for projectiles beyond argon in the periodic chart, and two fundamental limitations at the Bevalac preventing the delivery of such ions were responsible for the

conception and execution of the Uranium Beams Capability project, started in 1976 and successfully completed at the end of 1981. In earlier operations with heavy ion beams it was clear that the vacuum in the Bevalac was too poor to permit acceleration of ions heavier than iron, and even iron intensities were too low for most nuclear science projects. Suitable intensities of the heavier particles would come about if the Bevalac pressure could be reduced from about 1×10^{-6} to about 1×10^{-10} Torr. This first limitation was overcome by sliding a cryopump vacuum liner inside the beam tube and completely redesigning all the internal equipment to function at temperatures ranging from liquid nitrogen to about 12 degrees Kelvin. The second limitation, very low intensities of very heavy ions from the Adam injector at the SuperHILAC, led to the construction of the third injector, which is a Cockcroft-Walton pre-injector delivering ions to a Wideröe linac which, in turn, feeds them to the SuperHILAC. This third injector, called Abel was added in 1981. At the exit of the SuperHILAC the ions traverse the transferline through an improved vacuum. Improvements to the Bevalac system continue to increase its operational efficiency. The range of ion energies and intensities produced here are presently unavailable at any other accelerator complex in the world.

IIb. DESCRIPTION OF THE BEVALAC

An overall view of the Bevalac is shown in Fig. II-1. Beam formation begins in one of four injectors, three at the SuperHILAC (ADAM, ABEL, and EVE) and a local injector.

SUPERHILAC INJECTORS:

Eve is an air-insulated 850 kV Cockcroft-Walton injector designed to produce beams of ions up to mass 40 (argon). This injector accelerates only gaseous elements or compounds.

Adam is a pressurized 2.5 MV modified Cockcroft-Walton injector used to produce ions of elements from argon up to lanthanum.

Figure 11-1

BEVALAC

OCTOBER 1989

ALAC OVERALL PLAN

18H9544

XBL 8912-4477

Abel is a compound injector comprised of a 750-kV Cockcroft-Walton ion source pre-injector and a Wideröe linear accelerator. Its ion capability ranges from argon through uranium. This injector is especially useful for the production and acceleration of heavy metallic ions.

Adam, Abel, and Eve operate with Penning Ion Gauge (PIG) sources. A metal vapor vacuum Arc (MEVVA) source is presently being installed in Abel, and will provide about five-times more beam for the heaviest elements.

The SuperHILAC accelerates beam in two distinct stages by means of two Alvarez-type linac sections. These are separated by a stripper foil to deliver higher charge-to-mass state ions into the second section. The fully or partially stripped ion beam leaves the SuperHILAC at a maximum energy of 8.5 MeV/amu, and is transported 500 feet, through an elevation drop of 148 feet, to the Bevalac injector line. Beam steering and focusing is achieved with conventional dipole and quadrupole magnets, with segmented Faraday cups and multi-wire grids as beam current and beam position monitors.

The Bevalac has accelerated beams of uranium, for example, at intensities $> 10^7$ per pulse.

LOCAL INJECTOR

Initial operation of the upgraded local injector began in 1985 with the acceleration of silicon ions to 5 MeV/amu. Extensive modification of the 20 MeV proton linac resulted in a series of three linacs optimized for the ion range from helium to argon. The components of the local injector include a PIG ion source, a low energy transport line, an RFQ (Radio Frequency Quadrupole) linac, a new Alvarez prestripper linac, and the modified Alvarez poststripper linac.

Ions of q/A greater than 0.14 are produced in the PIG ion source and are accelerated to 8.4 keV/amu and transported in the low energy beam line through a series of 2 quadrupole doublets, a 70 degrees analysis magnet, and a quadrupole quadruplet to the RFQ. A neon $3+$ beam of 400 particle μA with a normalized emittance of 0.07π cm-mrad has been achieved.

The RFQ accelerates the 8.4 keV/amu beam to 200 keV/amu where it is injected directly into the Alvarez prestripper linac and further accelerated to 800 keV/amu. The beam is then stripped with a carbon foil which raises the q/A to at least 0.32 and is then accelerated to 5 MeV/amu in the second Alvarez tank. A final stripper is used to further raise the q/A if necessary.

The Bevalac has accelerated beams of neon, oxygen, carbon and helium, for example, at intensities of $>10^{10}$ particles/pulse. Silicon and argon beams of high intensities have also been delivered.

SYNCHROTRON

The Bevalac is a weak focusing synchrotron composed of four quadrant magnets of 15.4 meter radius, separated by 6 meter long straight sections. Injection occurs in the East straight section, the accelerator electrode is in the North, and the extraction channel starts with magnets in the East and South. The extracted beam leaves the ring through the West straight section. Injection takes place over many turns within a 500 μ s interval, filling the vacuum ring completely.

Toward the end of the injection pulse, the rf accelerating voltage is turned on. Not quite half of the injected beam is captured in a phase stable region. The frequency of the rf. is programmed to maintain an essentially constant radius in the rising magnetic guide field as the ions gain energy. The magnetic guide field is flat-topped at a pre-determined value to give the desired ion energy.

The radial and vertical dimensions of the beam are determined by the dimensions of the racetrack and the amplitudes of the betatron oscillations. At injection the physical limits permit a beam height of about 15 cm. and a width of about 100 cm. At 12 kG guide field strength the beam has shrunk to about 3 cm. by 18 cm. At an intermediate 4 kG field, the beam dimensions are about 5 cm. by 35 cm. The efficiency of extraction is determined in some measure by the compactness of the beam and thus can be somewhat higher at higher field strengths.

Beam exits the Bevalac by resonant extraction. Horizontal betatron oscillations are driven to perturb the beam orbit until the ion path crosses two septum bending magnets, first in the East and then the South straight sections. The second magnet's field deflects the beam so that it leaves the Bevalac ring in the vicinity of the West straight section, and enters into an ion-optical transport system which directs the beam to any of several destinations.

The pulse rate varies from 10 per minute to 15 per minute; the faster rate is for lower final beam energies. More information is given on the Bevalac pulsing capabilities in section IIc.

COMPUTER CONTROL

A major aspect of Bevalac versatility is the ability to shift rapidly from one operating mode to another, both at the SuperHILAC and the Bevalac. This has been accomplished through the installation of virtually identical data-processing and control systems at the two accelerators. For each system the architecture is that of a central processor (ModComp IV) communicating with several peripheral processors (ModComp II's) which perform the actual machine control tasks. The central units supply stored information to the peripheral ones as needed, and also serve as the point of operator access to the system. In addition, the central processors are being linked with other computer facilities in the accelerator complex. A major upgrade to a single fully distributed control system is underway.

IIc. BEVALAC POWER SUPPLY PULSING CAPABILITIES

The Bevalac power supply has the capability of providing a variety of field strength and flattop lengths to suit specific experimental requirements. The "Full Field Profile" is a Bevalac pulse to a field of 12,575 gauss with a 1.5 second flattop. The repetition rate of this pulse is 10 pulses per minute.

Virtually a continuous selection of field values is available from about 1950 gauss up to the 12,575 gauss level. Repetition rate values from 6 to 15 pulses per minute are allowed as long as

the average power loss in the system does not exceed 5.5 megawatts for two Motor Generator (MG) set operation. One MG set operation is available for field levels up to 7650 gauss and less than 2.75 megawatts loss.

Table IIc, on the following page, shows typical flattop lengths that are available for various fields and repetition rates. Although flattop lengths can be varied between 0.5 seconds and 2.0 seconds, the length of the flattop is commonly 1.5 seconds. The table is a brief index of typical operating pulse profiles. Requested field and flattop length parameters will be used as input data for the computer program that controls the power supply. The "Pulse Profile" that comes the closest to matching the request will be used. Examples of a more complete analysis of two "Bevalac Pulse Profiles" are also included in this chapter. Information on other operational profiles may be obtained from Robert Frias (x-5831).

PARTICLE INDEX OF BEVALAC PULSE PROFILE

Profile Name	Flattop Field (gauss)	Flattop Length (milliseconds)	Repetition Rate (pulses per minute)
12575	12,575	1500	10
12000	12,000	1500	10
11842	11,842	1500	10
11000	11,000	1500	10
10700	10,700	1500	12
10000	10,000	1500	12
9000	9,000	1500	12
8000	8,000	1500	12
Note-7650 Gauss fields and below are usually operated with 1 MG set			
7650	7,650	1500	12
7000	7,000	1500	12
6500	6,500	1200	15
6000	6,000	1500	12
5666	5,666	1500	15
5234	5,234	1500	15
4000	4,000	1500	15
3180	3,180	1500	15
2550	2,550	1500	15

PULSE ANALYSIS - Fields at 12,575 and 7650 Gauss

Analysis of profile 12575 Gauss			
Time to Field		Time at Field	Magnet Current
(msec.)	(gauss)	(msec.)	(amperes)
1624	12575	1500	5152

Pulse length = 4990 millisecond

Two MG Set Operation	
6.0 PPM	3.783 MW
8.5 PPM	4.717 MW
10.0 PPM	5.224 MW

Analysis of profile 7650 Gauss			
Time to Field		Time at Field	Magnet Current
(msec.)	(gauss)	(msec.)	(amperes)
1250	7650	1500	2514

Pulse Length = 3892 milliseconds

Rep Rate	Power Loss	
	One MG	2 MG's
6.0 PPM	1.281 MW	1.831 MW
8.5 PPM	1.501 MW	2.051 MW
10.0 PPM	1.618 MW	2.168 MW
12.0 PPM	1.777 MW	2.327 MW

IId. BEAM SPILL METHODS

All experiments are now done in external beam channels, and the spill methods used are those which excite particle oscillations required for the resonant extraction system. Two spill methods are available; a 'long spill' with the spiller magnet on and a "tailwag" spill with the spiller magnet off. When the long spill method is used, the S1 magnet is turned on and controls the rate at which beam is delivered from circulation to the external beam channel. The current in S1 is comprised of two components, a ramp signal that establishes an approximate rate of spill, and a feedback signal that maintains the spill at the desired rate. The feedback is derived from a thin scintillator-photomultiplier in the external beam channel, or from a detector provided by the user. This spill method is useful with the RF voltage either on or off. Normally the RF is off and fine structure of the beam (40-ns bunches at 400-650 ns period) is eliminated. Beam spills generally will have low frequency modulation induced by ripple in power supply components. Dominant frequencies are approximately 60, 180, 360, 720, and 1440 Hz. The low frequency amplitudes will be small due to the spill circuit feedback action, but the higher frequency structure, resulting in part from long (1-2 ms) excitation times of some particles in the resonant process may be troublesome.

The "tailwag" spill occurs when the spiller magnet is off. A "tailwag" or slope of a few gauss is added to the flattop field, sufficient to move the beam into the unstable area of the aperture. There is little control over spill uniformity in this technique, however extraction efficiency tends to be somewhat higher. Overall, extraction efficiency may range from 15% to 50%.

IIe. BASIC CONSTANTS

The following constants associated with mass and energy were used in calculating the particle mass values given in the Mass Table shown on the following page; "m" is the mass in MeV; "M" is the ratio of the mass of the atom or ion to one twelfth the mass of the Carbon 12 atom; "a" is a subscript to indicate the quantity per atomic mass unit (amu).

Proton:	m_p	=	938.2796 MeV
amu:	m_a	=	931.5016 MeV

The above values are from LBL Particle Properties, 1984 edition.

The ratios of masses (M) for various isotopes were taken from the Chart of Nuclides, Knolls Atomic Power Laboratory, 13th edition, Revised to July 1983.

From the above sources, we have the following basic constants:

Proton:	m_p	=	938.2796 MeV
	M_p	=	1.007276
amu:	m_a	=	931.5016 MeV
	M_a	=	1.00000
Electron:	m_e	=	0.511 MeV
	M_e	=	549×10^{-6}

The values for Bevalac kinetic energy, rigidity and radiofrequency as a function of magnetic field markers are given in the table Bevalac Reference Markers for protons and carbon ions. The values used in calculating this table are the atomic mass of 1/12 the carbon atom (931.5016 MeV) and the Z/M ratio for the various ions. The values tabulated under amu were calculated for carbon 12 and in general apply to all ions where the Z/M ratio is approximately 1/2.

Nominal values for these parameters are available in the main control room (MCR) from a computer routine PAM. Values corrected for magnetic field errors can be secured by contacting operations staff. Energy is given in MeV/amu including proton energy. Proton energy per amu is about 3/4% lower than proton energy. Note the tabulation is per amu, not per nucleon.

The table below gives the extracted beam intensities for representative Bevalac ions. Included are the energy at extraction at top Bevalac field and the charge state during acceleration for the highest intensity beam.

Extracted Beam Intensities Bevalac Particle Inventory					
Ion	Atomic Weight A	Atomic Number Z	Accelerator Charge	Max. Energy MeV/amu	Intensity, Particles/Pulse, @F1
Hydrogen	1	1	1	4900	1.6×10^{10}
	2	1	1	2100	1×10^{10}
Deuterium	2	1	1	2100	2×10^9 *
Helium	3	2	2	3010	3×10^8
	4	2	2	2100	2×10^{10}
Boron	11	5	5	1840	1×10^9
Carbon	12	6	6	2100	1×10^{10}
Nitrogen	14	7	7	2100	1×10^5 *
Oxygen	16	8	8	2100	6×10^9
	18	8	8	1790	3×10^9
Fluorine	19	9	9	1950	1×10^8
Neon	20	12	10	2100	1×10^{10}
	22	10	10	1840	1×10^9
Magnesium	24	12	12	2100	1×10^7
Aluminum	27	13	13	2000	5×10^8
Silicon	28	14	14	2000	1.5×10^9
Sulphur	32	16	16	2100	1×10^6 *
Argon	40	18	18	1815	1×10^9
Calcium	40	20	20	2100	3×10^9
	48	20	20	1640	1×10^7
Titanium	46	22	14	1050	1×10^8
Manganese	55	25	25	1840	1×10^6 *
Iron	56	26	24	1700	2×10^8
			16	1050	5×10^7 *
Nickel	58	28	26	1810	1×10^6
Krypton	84	36	33	1510	1×10^7 *
Niobium	93	41	35	1420	1.5×10^8
			23	770	8×10^7
Xenon	129	54	45	1280	5×10^5
	132	54	45	1240	1×10^5
	136	54	45	1180	3×10^6
	136	54	35	817	3×10^7
Lanthanum	139	57	52	1410	1×10^5
			48	1260	4×10^7
			32	690	8×10^7
			30	587	1×10^8
Holmium	165	67	54	1170	2×10^5
Gold	197	79	61	1080	5×10^5
			37	490	1×10^7
			35	450	5×10^6
			11	50	1×10^5
Uranium	238	92	68	960	1×10^7
			40	410	1×10^7

*Low intensities are at experimenter's request; no maximization has been done.

Marker pulses are distributed throughout the experimental area and have the definitions listed in the table

Bevalac Reference Markers

Marker Number	Nominal ³ Flux Density Gauss	Momentum ⁴ Per Charge GeV/cq	Rigidity ⁴ Tesla Meters	Kinetic Energy ⁴ GeV/AMU $\pm 0.3\%$		Frequency at Field Marker ⁴ MHz	
				Proton	C ¹² (+6)	Proton	C ¹² (+6)
B 1	1000	0.4572	1.525	0.1047	0.02764	1.0900	0.5932
B 2	2000	0.91441	3.050	0.3691	0.1061	1.7368	1.0966
B 3	3000	1.371	4.574	0.7181	0.2252	2.0540	1.4755
B 4	4000	1.828	6.099	1.109	0.3738	2.2142	1.7434
B 5	5000	2.286	7.624	1.521	0.5430	2.3023	1.9292
B 6	6000	2.743	9.149	1.946	0.7265	2.3548	2.0588
B 7	7000	3.200	10.673	2.379	0.9201	2.3882	2.1509
B 8	8000	3.657	12.198	2.817	1.121		
B 9	9000	4.114	13.723	3.258	1.327	2.4264	2.2672
B10	10000	4.571	15.248	3.701	1.537	2.4379	2.3047
B11	11000	5.028	16.772	4.147	1.750	2.4465	2.3338
B12	12000	5.485	18.297	4.5593	1.965	2.4531	2.3566

- Notes:
1. Additional marker pulses on distribution panels are:
 - a. -40 (40 ms before magnet turn on); Mag ON (magnet turn on); Inj ON(1S, injector turn on trigger); RF ON (2S, RF turn on trigger).
 - b. FT ON (flattop on), FT OFF

These markers indicate the beginning and the ending of the period of constant Bevalac magnetic field.
 2. B marker pips available on request for special requirements to ± 1 gauss, within limits as per Note 3.
 3. The B markers are derived from integrating "B" from a coil covering (radially) the center 2 feet of the aperture of the Bevalac. This field value is corrected for remnant field, about 38 gauss. The system is calibrated against the old I pip system to give the correct field reading at I-27 (magnet current = 5000A; $B = 12,425$ gauss). The field value is for a radius of $599 \frac{3}{8}$ ".
 4. The RF frequency, kinetic energy, momentum, and rigidity are values calculated for the tabulated field values and a closed orbit radius of 602 inches.
 5. Requirements other than nominal on proton energy level or week to week stability should be noted in your experimental proposal and brought to the attention of operations personnel at the start of an experiment.
 6. Time between B marker pips is approximately 121 ms/kG for standard operation.

SECTION III

III. MAJOR FACILITIES AND EXPERIMENTAL AREAS

IIIa. EXTERNAL PARTICLE BEAM AREA

The external particle beam (EPB) area at the Bevalac, introduced in 1963 for proton beams, has evolved into an extremely versatile, flexible facility for heavy ions. In 1985 a dipole triplet (XM4A, B, C) which was used for beam splitting was removed. In its place two new dipoles and a quadrupole doublet were installed. In 1988, the two dipoles were replaced by a single 22" x 100" H magnet. The larger vertical aperture of the new magnets produce less beam contamination and halo, while the new quadrupole doublet is useful for the transporting of radioactive beams. The EPB layout is shown in Fig. III-1. The horizontal dispersion at the second external focal point of the Bevalac is 21mm for 1% rigidity change in the beam ions.

The present external beam facilities include two primary branches (EPB I and EPB II) which have a common vertex at F1. Radiating from the EPB I channel are six beam lines, designated as Beam 39 ("low energy beam line"); Beam 30 and Beam 44 ("septum channel"); and Beam 26, ("streamer chamber"), Beam 40 ("zero-degree spectrometer"), and the Irradiation Station. Radiating from the EPB II channel are two biomedical beam lines B1 and B2 and Beam 42 ("HISS").

Vernier steering magnets provide for the final beam positioning at the foci; some of these magnets rotate about the beam axis such that the beam may be deflected in any direction transverse to the beam axis. Beam positioning and focusing are monitored by wire chambers which can be remotely inserted at the various foci. These 32 wire x 32 wire chambers are monitored in the main control room, but access to the display output is available upon request in any experimental control station. In addition, the portability of the chambers allows for relocation or insertion of special chambers to suit individual experimenter needs for beam monitoring. Beam intensity is provided by secondary emission monitors (SEM) in the EPB channels. More information on the wire chambers and SEM is given in Section IVf of this Users Manual.

Figure III-1

IIIb. MAJOR FACILITIES

Some of the specialized experimental facilities at the Bevalac are summarized below. Information concerning the individual beam line characteristics appears in Section IIId.

In addition to the facilities described below, the Bevalac has a modest resting area located near the experimental areas. Inquire at the Accelerator Research Coordination office for information concerning usage.

THE HEAVY-ION SPECTROMETER SYSTEM (HISS)

The HISS system, located in beamline 42, consists of a 2m diameter, 1m gap superconducting dipole with magnetic fields up to 3.0T. Associated with this large dipole are: a large area scintillator hodoscope, large area drift chambers (2m x 1.5m), a 110 element multiplicity array, the Multiple-Sampling Ionization Chamber (MUSIC) and a Cerenkov detector array. The Cerenkov array was recently used for the study of the fragmentation of a 1.6 GeV/amu ^{40}Ar beam. A resolution of 1 amu for Ar isotopes was achieved using the Cerenkov array in conjunction with the magnetic spectrometer having a 0.5% rigidity acceptance.

HISS can be used for studies of its own or can be integrated into other hybrid systems. A project is now underway to construct a Time-Projection-Chamber (TPC) for studying central nucleus-nucleus collisions. The TPC is scheduled for commissioning in 1991.

TIME PROJECTION CHAMBER

A TPC detector for use inside the HISS dipole will be commissioned in July, 1991. This detector will be able to identify and measure most of the 200 or so mid-rapidity charged particles (p, d, t, ^3He , ^4He , Li, Be, B, C, N and O) produced in each central nucleus-nucleus collision ($^{197}\text{Au} + ^{197}\text{Au}$). It will also have the capability of detecting pions and decayed lambdas with some limitations on either solid angle or event multiplicity.

Two new features have been introduced in the design to permit measurement of high multiplicity events. One feature is the use of full pad coverage of the active volume to perform both dE/dx measurements and tracking (previous designs have relied on the wire signals for the dE/dx measurement). The second feature is placement of the entire electronics on the detector, a new concept, that will find many applications in future big detectors. The mechanical design of the detector calls for the pad plane and electronics to be located directly below the drift volume. The pad plane is a single panel with an array of 8 mm wide by 12 mm long pads covering a 96 cm by 160 cm rectangle (15,360 pads total). The useable vertical drift distance is about 80 cm. The electronics for the pads will be highly multiplexed thus greatly reducing the cabling requirements (128 optical fibers for data transmission). The expected event rate limit for the electronics will vary from 10 to 100 events per one second beam spill, depending on particle multiplicity of the event. A summary of the TPC specifications are listed in the following table.

HISS TPC Characteristics	
Pad Plane Area:	1.5 m x 1.0 m
Number of Pads:	15360 (full coverage)
Pad Size:	12 mm x 8 mm
Drift Distance:	75 cm
Time Sampling Frequency:	10 MHz
Pad Amplifier Shaping Time:	250 ns
Electronics Noise:	700 e rms
Gas Gain:	3000
Gas:	90% Ar + 10% CH ₄
Gas Pressure:	1 atmosphere
B field:	13 KG
Event Rate:	10-80 events/ 1 sec spill
dE/dx (particle range):	$Z=1-8$
	$O, \pi^{\pm}, p, d, t, {}^3He, {}^4He, Li-O$
Two Track Resolution:	2.5 cm
Solid Angle Coverage:	2π Lab.
Multiplicity Capability	200

THE DILEPTON SPECTROMETER (DLS)

The dilepton spectrometer system (DLS), located in beamline 30, was designed to measure the mass spectrum for $e^+ e^-$ pairs up to $M_{e^+ e^-} = 1000$ MeV. The DLS consists of two identical arms consisting of a large aperture dipole magnet ($\Delta\Omega = 170$ msr), scintillator hodoscopes, multi-segmented Cerenkov detectors, and drift chambers. In addition, the DLS system has a multiplicity array for tagging central collisions. The present device is designed to handle beams with $A < 56$. The device was recently upgraded with additional drift chambers in order to handle heavier beams. This large acceptance magnetic spectrometer can also be used to study a broad range of hadronic correlations.

ZERO-DEGREE SPECTROMETER

The Beam 40 zero-degree spectrometer, which is employed to measure projectile fragmentation cross sections, also doubles as a calibration facility. As well, this facility is heavily used for atomic physics experiments analyzing charge state distributions. The spectrometer system can provide variable energy secondary beams of any isotope lighter than the primary beam particle. An average of 15 small experiments such as satellite calibrations and emulsion exposures are performed with this spectrometer every year. Details on the use of this facility are described in "A Facility for Calibration and Short Experiments with Heavy Ions at the Bevalac" (Nuclear Instruments and Methods, 116 21, 1974).

JANUS SPECTROMETER

Located downstream of the DLS in beam 30 is the Janus Spectrometer. This system, consisting of the Janus dipole, hodoscopes and drift chambers is used for pion correlation experiments and searches for exotic nuclei.

KAON SPECTROMETER

At the vertex of beam 30 and beam 44, kaons, pions, etc. may be produced by a secondary production target. The desired particles can then be transported into beam 44 for analysis. Beamline 44 is also used for a low energy beam line and for the purification and transporting of exotic radioactive beams (See Section IIId.).

THE LOW ENERGY BEAM LINE - 39

The Low Energy Beam Line (LEBL) has been established as a Bevalac facility with emphasis on ease of use for outside researchers. The LEBL provides beams with energies from 20 to 200 MeV/nucleon in either a high or low energy-resolution mode. Beams with energies below 30 MeV/nucleon are obtained by degrading the beam after it is extracted from the Bevalac and before it reaches the LEBL.

STREAMER CHAMBER

The Streamer Chamber at beamline 26 offers nearly a 4π solid angle detection system, and can be electronically set to trigger on selected events of interest. The chamber consists of a sensitive volume of $125 \times 57 \times 38 \text{ cm}^3$ mounted inside a picture frame magnet. The magnet has a field capability of 1.32 T for momentum measurement. Each event fulfilling predetermined criteria can be recorded on film to be analyzed later. The Streamer Chamber has recently been improved with the addition of a 384 element scintillator hodoscope which will provide dE/dx and time of flight information for better particle identification. A recent development at the Streamer Chamber is the use of charge coupled device (CCD) cameras. The digitized information from these cameras produce a higher quality image as well as speeding up data analysis. The streamer chamber is scheduled to be decommissioned in the summer of 1990.

BIOMEDICAL FACILITY *

The Bevalac Biomedical Facility is an area specially designated for tumor, tissue, cellular, molecular, neuro, developmental and space radiobiology, radiography, and radiological physics. The Biomedical Facility has its own control room, three irradiation caves, and two preparation rooms. Although reserved for PAC-approved biomedical studies, the area can accommodate simple emulsion exposures and equipment calibrations, as they can be fit into the operating schedule. The maximum beam energy which can be transported into the biomedical area is 1 GeV per nucleon (with $q/m = 0.5$).

Cave I, about 22 x 24 feet and primarily used for radiotherapy, contains a movable alignment bench with the primary shielding, dosimetry, range modulation, and beam field-shaping equipment. A magnet system has been installed that is used instead of the previous lead scattering system to enlarge the beam field.

Cave II is about 20 x 30 feet and has, at present, two major instrumented beam lines. The primary line, used for all of the biological experiments, contains two alignment benches, each about 10 feet long and separated by about 1 meter. The other beam line contains one bench and is primarily used for physics experiments that relate to the radiobiological research.

Cave III is used for radiography, radioactive beam studies, and radiotherapy. The beam line for Cave III runs through Cave II.

The beam can be shared on an alternating basis between Cave I and Cave II and between Cave I and Cave III, but it is not possible to alternate between Cave II and Cave III.

IIIc. DATA ACQUISITION AND ANALYSIS FACILITIES

During the period 1987-1989 the data acquisition facilities at the Bevalac have been extensively modernized. The front end of the new system is a VME crate containing a CPU, memory, ethernet interface, buffering hardware, and some number of VME/CAMAC interface

* A separate handbook exists for this facility.

modules. The data is read from CAMAC by the VME crate and shipped via a local area Ethernet to the Bevax cluster, where it is dumped into memory of one of the two Bevax machines, and written to tape. This data can be accessed for monitoring and display from either of the Bevax computers or from any other computer or workstation on either the local Ethernet or the lab-wide Ethernet. As part of the upgraded facilities, a VAX 3500 fileserver has been acquired which serves up to 20 VAX workstations located in Bldgs. 51, 50, 70, and 71. Much of the present hardware is modular and can be moved between beamlines as needed.

This machine is also available for some amount of off-line data analysis. During the peak Bevalac running periods, resources (typically disk space) do not allow extensive data analysis following an experiment. However, between experimental runs and during off-peak periods, time and disk space are allocated to Bevalac experimenters. The BEVAX facility has several terminals, a local line printer, and a current set of VAX/VMS manuals. It is a suitable area for mounting data tapes, making listings, and running short programs. Unfortunately, as this area is shared by many users, it is not a suitable area for long term program development and debugging.

In addition, the needs of the atomic physics community and other small parameter, high rate experiments is often met by bringing in a MicroVAX 2 workstation with a Starburst PDP-11 based front end CAMAC processor. This system was developed to meet the needs of low energy users at the SuperHILAC and 88" Cyclotron, but has often been used at B40. The monitoring software is the same as used at the SuperHILAC. The HEAP (High Energy Atomic Physics) group uses a PDP 11/70 system for runs in B40.

Hardware:

The BEVAX Cluster

- 2 VAX 11/780 processors
- 1 HSC50 Cluster Disk Controller
- 1 RA60 200MByte disk for system use
- 2 RA81 450MByte disks for experimenters use

- 4 RA82 650MByte disks for experimenters use
- 3 800/1600/6250 BPI Tape Drives
- 1 8 mm tape drive

The BEVLAC Cluster

- 1 VAX 3500 Processor
- 4 550MByte Disks
- 1 800/1600/6250 BPI Tape Drive
- 20 VAXStation 2000 Workstations (located in 51, 50, and 70)

VME Acquisition Systems

- 1 B44/B39
- 1 B40
- 1 HISS
- 1 TPC
- 1 Development

Dedicated Workstations (VS 2000)

- 1 HISS
- 1 TPC
- 1 B44/B39
- 1 Floater
- 1 B26

Beam 44 (INS System)

- 1 PDP11/44 Computer with 256KBytes memory
- 2 800/1600 BPI Tape Drives
- 1 80MByte Disk Drive
- 1 MBD CAMAC Branch Driver

DLS

- 1 VAX 11/750 Computer
- 3 300MByte Disk Drives
- 2 1600/6250 BPI Tape Drives
- 1 MBD CAMAC Driver
- 1 Decnet/Ethernet Interface

Beam 30-2

- 1 VAX 11/750 Computer
- 2 300MByte Disk Drives
- 2 1600/6250 BPI Tape Drives
- 1 1600 BPI Tape Drives
- 1 MBD CAMAC Branch Driver
- 1 Decnet/Ethernet Interface

HEAP:

- 1 PDP 11/70
- 2 80 MByte Disk Drives
- 1 1600 BPI Tape Drive

Software:

The Bevac cluster, BEVLAC Cluster, and all workstations are configured identically using the DEC DFS utility. They have the current VMS operating system (5.1), Decnet, Fortran, C, Pascal. Some online monitoring and analysis programs are supported.

Persons in Charge:**Bevalac Software Group:**

Chuck McParland, Eugene Yee (system manager for both clusters and workstations),

Tom Viola (RTSS, hardware problems)

Beamlines

Chuck McParland, in addition:

B39: Peggy McMahan

B44/LEBL/subthreshold Peggy McMahan

B44/INS: Ken Matsuta

B40: Jack Engelage, Hank Crawford, Leo Greiner

TPC: Howard Matis

DLS: Howard Matis

B30-2: Jim Bisterlich

HEAP: Rich Leres, Harvey Gould

HISS: Chuck McParland

IIIId. RADIOACTIVE BEAMS

Relativistic heavy ion beams have been produced at the Bevalac opening up new avenues for the study of exotic nuclei. The availability of these exotic heavy ion beams makes the Bevalac unique in the world as an experimental facility. Early experiments showed that a few nucleons could be removed from a heavy ion projectile by the process of fragmentation⁽¹⁻³⁾. The newly formed radioactive nuclei then proceed forward with essentially the same velocity as the incident projectiles. Radioactive beams as intense as 10^8 ions/pulse have been produced. Production cross sections are typically 10-40 mb with momentum transfers approximately 100 MeV/c. Shown in Fig. III-2 are the cross sections (1) for isotopes produced in the fragmentation of ^{48}Ca . Typically, beryllium is used as the radioactive beam production target. Low Z materials produce, from multiple scattering and dE/dx effects, the least broadening of the radioactive beam.

Figure III-3 shows the calculated yield of ^{11}C from ^{12}C as a function of the beryllium target thickness along with the incident projectile energy loss and multiple scattering growth. The production of ^{11}C peaks at 1.8% for a 15 g/cm^2 target and drops off as the secondary ion undergoes further reactions and the primary beam attenuates and no longer feeds the ^{11}C production channel as strongly.

Magnetic analysis systems are used for separating the produced isotopes. Beam purity depends on the transverse emittance of the beam and energy spread. Isotopes with a similar charge-to-mass ratio are accepted by the beam transport system. Utilizing dE/dx the members of this family of isotopes are then separated with a degrader and with further collimation a beam of a single isotope is obtained.

Some references for the production of radioactive beams at the Bevalac are:

- (1) Production of Neutron-Rich Nuclides by Fragmentation of 212 MeV/amu ^{48}Ca .
Westfall, et. al. Phys. Rev. Lett. 43(1979) 1859.
- (2) High Purity Radioactive Heavy Ion Beams at the Bevalac. J. R. Alonso, et al.
IEEE NS-26 (1979) 3003.
- (3) Relativistic Radioactive Heavy Ion Beams at the Bevalac. J. R. Alonso, et.al.
LBL-17829 (1984) 153.
- (4) Measurements of Interaction Cross Sections and Radii of P-shell Nuclei.
I. Tanihata, et al. Phys. Rev. Lett. 55 (1985) 2676
- (5) On the Possible Use of Secondary Radioactive Beams. I. Tanihata.
Vol. 8, Treatise on Heavy Ion Science, D. A. Bromley ed. (1989)

NEUTRON BEAM FROM DEUTERON STRIPPING

Monochromatic neutron beams of up to 3 GeV/c have been obtained from the Bevalac in the past, and the necessary beam line could be set up again if requested. A deuteron beam of twice the

Figure III-2

XBL 799-2810

Isotope cross sections produced
from the fragmentation of ^{48}Ca

Figure III-3

XBL 793-750

Production efficiency and
multiple scattering

momentum is dissociated in a target. The differential cross section and the momentum-spread of the neutron beam has been measured under the following experimental conditions:

(A) Untagged Beam

deuteron momentum	$p(d) = 5.8 \text{ GeV}/c$
production angle	$\theta = 0^\circ$
solid angle n-detector	$\Delta\Omega = 3 \cdot 10^6 \text{ sterad}$
n-counter efficiency	$\epsilon \approx 30\%$ (estimated)
target materials	Be, C, Al, Cu, Pb, U
target length	$\approx 40\%$ of collision length
momentum measurement	by time of flight

Results:

Approximately gaussian momentum distribution

$$p(n,P) \approx 2.9 \text{ GeV}/c$$

$$\frac{\Delta p(n) \text{ (FWHM)}}{p(n)} \quad 3.0\% \text{ (U) to } 3.5\% \text{ (Be)}$$

$$\frac{ds}{\Omega} \text{ (}^\circ\text{)} \quad 60 \text{ barn/sterad (Be) to } 240 \text{ barn/sterad (U) includes correction for counter efficiency (30\%) and finite target thickness) raw yield for } 3 \text{ cm U in a solid angle of } 3 \times 10^{-6} \text{ sterad} \approx 24 \text{ neutrons}/10^6 \text{ deuterons}$$

Note: Low and high-energy tails $p(n)$ outside $p(n,0^\circ)$ (1 ± 0.12) have not been investigated, and their possible contribution is excluded from cross-section values quoted.

(B) Tagged beam

An attempt has been made to measure the momentum distribution of neutrons in coincidence with the protons whose momentum was analyzed in a simple magnetic spectrometer (Resolution $\pm 0.7\%$).

Results:

for uranium a $\Delta p/p(n) \approx 0.7\%$ was obtained (FWHM).
relative tagging fraction varies $\sim$ as $A^{1.2}$.

IIIe. EXPERIMENTAL BEAM LINES

The Bevalac experimental area contains 9 beam lines: one specifically designed for nuclear fragmentation studies (Beam 40), a general purpose, high momentum beam line suitable for high intensity experiments, (Beam 30), a low energy beam line (Beam 39, less than 200 MeV/amu), the Streamer Chamber (Beam 26), the heavy-ion - spectrometer (HISS) beam line(Beam 42), and second low energy beam line which also serves as a high acceptance kaon spectrometer and a secondary particle beam line (Beam 44), an irradiation station for the irradiation of targets, and two Biomedical lines (B1 and B2).

Following in this section are diagrams and characteristics of the Bevalac external particle beamlines.

The standard optics for a given beam line are described in OPTICS HANDBOOK FOR THE BEVALAC (G. Kalnins, G. F. Krebs, M. Tekawa, T. Byrne and J. Alonso LBL-28661). The handbook describes the beam envelopes for each beam line and lists all the parameters used to produce the beam envelopes.

BEAM NO. 26 D

General Description	- Beam line to the streamer chamber
Rigidity limit	- 192 kG-m

SCALE 0 5 10 15 20 25 FEET

OCTOBER 1986

BEVALAC BEAM NO. 26

19F4775

XBL 7910-12428A

Energy range	-	60 to 2100 MeV/nucleon for $e/m = 1/2$
Angular acceptance	-	Horizontal $x' = \pm 7.5$ mr
	-	Vertical $y' = \pm 4.2$ mr
Momentum acceptance	-	$\Delta p/p = \pm 0.85\%$
Emittance	-	5-20 π mm-mr (for energy from 2100 to 60 MeV/nucleon, respectively)
Physicist responsible	-	Gary Krebs
Technician	-	Jim Brannigan

BEAM NO. 30

General Description	-	Beam line to the Dilepton , Janus and pion spectrometers
Rigidity limit	-	192 kG-m
Energy range	-	60 to 2100 MeV/nucleon for $e/m = 1/2$
Angular acceptance	-	Horizontal $x' = \pm 7.5$ mr
	-	Vertical $y' = \pm 5.0$ mr
Momentum acceptance	-	$\Delta p/p = \pm 0.73\%$
Emittance	-	5-20 π mm-mr (for energy from 2100 to 60 MeV/nucleon, respectively)
Physicist responsible	-	Gary Krebs

BEAM NO. 39

General Description	-	Low energy beam line
Rigidity limit	-	42 kG-m
Energy range	-	60 to 190 MeV/nucleon for $e/m = 1/2$
Angular acceptance	-	Horizontal $x' = \pm 6.1$ mr

OCTOBER 1986

BEVALAC BEAM NO. 30

19F4786

XBL 7910-12429

		Vertical $y' = \pm 7.5$ mr
Momentum acceptance	-	$\Delta p/p = \pm 0.60\%$
Emitance	-	10-30 π mm-mr (for energy from 190 to 60 MeV/nucleon, respectively)
Physicists responsible	-	Peggy McMahan

BEAM NO. 40

The Beam 40 zero-degree spectrometer is used to measure projectile fragmentation cross sections. It also doubles as a calibration facility, and emulsion exposure facility. Atomic physics experiments are also carried out at this facility. The spectrometer system can provide variable energy beams and secondary beams of any isotope lighter than the primary beam particle. The details on use of this system are explained in "A Facility for Calibration and Short Experiments with Heavy Ions at the Bevalac" (Nuclear Instruments and Methods, 116 21, 1974).

Rigidity limit	-	192 kG-m
Energy range	-	60 to 2100 MeV/nucleon for $e/m = 1/2$
Angular acceptance	-	Horizontal $x' = \pm 7.5$ mr Vertical $y' = \pm 4.7$ mr
Momentum acceptance	-	$\Delta p/p = \pm 1.5\%$
Emitance	-	5-20 π mm-mr (for energy from 2100 to 60 MeV/nucleon, respectively)
Physicist responsible	-	Hank Crawford

BEAM NO. 42 - Heavy Ion Spectrometer System (HISS)

The Heavy-Ion Spectrometer System (HISS) consists of a 2 m diameter, 1 m gap superconducting dipole. The maximum field of the dipole is 35 kG. Other detectors associated with the HISS facility are: large area time-of-flight hodoscopes, large area drift chambers (2m x 1.5m), a

OCTOBER 1969

BEVALAC BEAM NO. 40

19F4805

XBL 7910-12425A

110 element multiplicity array, the Multiple-Sampling Ionization Chamber (MUSIC) and velocity Cerenkov detectors.

Rigidity limit	-	192 kG-m
Energy range	-	60 to 2100 MeV/nucleon for $e/m=1/2$
Angular acceptance	-	Horizontal $x' = \pm 3.7$ mr Vertical $y' = \pm 6.4$ mr
Momentum acceptance	-	$\Delta p/p = \pm 6.2\%$
Emittance	-	5-20 π mm-mr (for energy from 2100 to 60 MeV/nucleon, respectively)
Physicist responsible	-	Hank Crawford

BEAM NO. 44

Beam 44 was designed to operate both as a second low energy beam line and as a kaon (or pion) spectrometer. Since its completion in the spring of 1985 it has also been used as a delivery system for radioactive beams. The beam line can operate with or without an intermediate focus (F4) inside the experimental cave.

Rigidity limit	-	80 kG-m without F4 focus 65 kG-m with F4 focus
Energy range	-	600 MeV/nucleon without F4 focus for $e/m=1/2$ 400 MeV/nucleon with F4 for $e/m = 1/2$
Angular acceptance	-	Horizontal $x' = \pm 7.5$ mr Vertical $y' = \pm 5.0$ mr
Momentum acceptance	-	$\Delta p/p = \pm 0.73\%$
Emittance	-	10-30 π mm-mr (for energy from 600 to 60 MeV/nucleon, respectively)

SCALE 0 5 10 15 20 25 FEET

OCTOBER 1988

BEVALAC BEAM NO. 42
12H7405

XBL 8912-4383

Physicists responsible	-	Peggy McMahan
(low energy experiments)
	-	Gary Krebs
(Radioactive beams, secondary beams)

BIOMEDICAL BEAMS B1, B2 AND B3

These lines provide transport of heavy ion beams to Areas I and II in the Biomedical area. Area I is used for human patient therapy and radiography. Area II is used for radiobiology experiments and some radiography.

Rigidity limit	-	120 kG-m
Energy limit	-	1100 MeV/nucleon for $e/m = 1/2$
Angular acceptance	-	Horizontal $x' = \pm 3.7$ mr
Vertical $y' = \pm 6.4$ mr
Momentum acceptance	-	$\Delta p/p = \pm 4.2\%$ (B1), $\pm 0.85\%$ (B2)
Emitance	-	10-50 π mm-mr (for energy from
2100 to 40 MeV/nucleon, respectively)
Physicists responsible	-	W. Chu, B. Ludewigt, and T. Renner

BEVALAC BEAM NO. 44

2252696

XBL 8511-4737

XBL 8511-4738

SECTION IV

IV. EXPERIMENTAL EQUIPMENT

IVa. DIPOLE MAGNET SUMMARIES, DIAGRAMS AND LOCATIONS

This section includes tables accompanied by diagrams of pertinent dimensions summarizing the specifications of most Bevalac dipole magnets. Separate tables list the location and availability of the magnets and particle separators.

Following this summary are graphs of magnetization curves of the dipole magnets listed (except where noted); indexes are provided.

BEVALAC EX

Dipole Magnet	No. of Turns	Gap (In)	Approx Magnet Res (OHMS)	Approx Magnet Induct. (Henry)	Practical M	
					Current (Amps)	Volt (Volts)
9 x 12C	680	4.0	0.585		200	117
12 x 36C	64	4.43	0.0433	0.019	2570	110
13 x 24C	240	6.0	0.182		1100	200
13 x 36C	96	8.62	0.0282		2500	71
16 x 36C	180	8.0	0.0815		2000	163
16 x 36C	180	6.0				
8 x 30 H VST	88	9.25	0.083		800	66
12 x 12 H	552	12.5	1.702	0.518	10.5	18
12 x 60 H	128	4.15	0.112		2000	224
12 x 60 H		7.13				
15 x 84 H	126	4.38	0.146	0.244	1580	238
16 x 72 H	96	5.4	0.051	0.0663	2200	112
18 x 36 H PH	192	8.0	0.081		2200	176
18 x 36 H (PPA)	184	6.0	0.088		1160	102
18 x 36 LPH	368	8.0	0.178		1500	276
18 x 38 H S	144	8.38	0.069	0.054	3000	200
18 x 60 H	180	8.0	0.0854		2000	170
18 x 60 H		6.0				
18 x 60 H		4.0				
19 x 84 H	96	4.38	0.120	0.218	1500	180
22 x 66 H	300	17.73	0.207		1900	393
22 x 66 H	300	7.9				
27 x 54 QCH	160	5.40	0.124	0.268	1515	189
29 x 36 H	336	8.19	0.298		1200	350
37 DIA. H	770	23.0	0.318		1200	382
38 x 18 H (PF)	368	26.1	0.170	0.218	1500	276
40 x 36 H	180	8.12	0.094		2600	244
40 x 36 H		18.0				
60 DIA. H	640	12.0	0.241	1.96	1500	361
60 DIA. H	640	22.0				
60 DIA. H	288	5.6	0.0584	0.986	1091	127
72 x 184 (PPA)	288	18.0	0.214		1000	214

AC EXPERIMENTAL MAGNETS - SUMMARY

Practical Maximums			Measured Magnetic Quantities			Engineering Design Notes	Magnetic Measurements	
Volt (Volts)	Power (KW)	Approx Field (KG)	Current (Amps)	Field (KG)	Length (In)		Engineering Notes	Data Books
117	23	12.5	200	12.5	15.2		MT-71,166	294,356
110	286	18	2000	14.2	40.5	M3176	MT-201	471
200	220	18	1000	17.5	30.0	M307-01M12	MT-93,97,152,170	292,442
71	177	12.4	2400	12.0	41.7	M4072	MT-216	523
163	326	19.7	2000	19.7	40.8	7307-05M3	MT-127,193,226	348,430,441
								441
66	53	3.8	800	3.8	37.4	M3490	MT-71,166	522
18	0.19	0.215	10.5	0.215	21.2	M 4666A		557
224	448	23.0	1600	19.4	65.7		MT-46,57,150,160	185,463
			1600	13.1	69.9			
238	376	20.0	1000	14.0	88.6	7308-04 M5	MT-195	438
112	247	17.3	2100	17.0	74.7	M4619		543
176	388	21.5	2200	21.1	42.5	7307-01 M13	MT-68,77,184	293,427,439
102	118	17.0	1160	17.0	42.7	M4471	MT-227	520
276	400	24.4	1500	24.4	42.7	7307-01M33	MT-96,100,110,142,194	317,428,440
200	600	21.4	3000	21.4	43.7	M4304		510
170	340	20.8	2000	20.8	60.7	M3275	MT-181	451,474
								474
			1600	2.43	59.3			
180	270	15.6	800	8.5	89.8		MT-223	438
393	7747	18.0	1600	10.3		M4580		585
							MT-267	585
189	286	20.1	1515	20.1		M4605		540
350	420	19.5	1200	19.5	42.5	4902-02M15	MT-104,106,177,188,189,199	329,454,461
382	460	9.9	1200	9.9	52.4			466
276	400		1360	8.3	34.0	BEV 984	BEV 2002	501
244	635	21.4	2500	21.3	41.6	M4476		514
			2500	12.5	48.3			
361	540	21.9	1000	19.7	71.7		MT 196	462
			1500	17.1	77.9			485
127	139	19.1	1091	19.1	63.9			548
214	214	7.5	1000	7.5	27.2		MT-229	515

BEVALAC EXPERIMENTAL MAGNETS- VARIATIONS IN 60" DIA. H MAGNETS

*This sketch shows the main points of difference.
All coils and yokes are interchangeable.*

**MK I Yoke (Solid)
MK I Coils (bifilar) N = 640**

M5 #1
 Fab. 1964
 Pole tip dia. 60"
 Design gap 10 1/4"
 Assembly - 13Q6825
 Design current 1065 amps
 Max. current I = 1500 amps

**MK II Yoke (Plug)
MK I Coils (bifilar) N = 640**

M5 #2
 Fab. 1966
 Pole tip dia. 63"
 Design gap 16 1/8"
 Assembly - 14P9225
 Design current 1065 amps
 Max. current I = 1500 amps

**MK II Yoke (Plug)
MK II Coils (quadrifilar) N = 320**

M5 #2
 Fab. 1968
 Pole tip dia. 63"
 Design gap 16 1/8"
 Assembly - 16A9185
 Design current 4260 amps.

BEVALAC DIPOLE MAGNETS: LIST OF LOCATIONS

Dipole Magnet	External Particle Extraction Area	Channel I							Channel II					On Loan	Bev Total
		Channel	Septum	Beams					Channel	Beams					
				26	30	39	40	44		42	43	B1	B2		
9 x 12C														SLAC 1	2
12 x 36C															1
13 x 24C														LASAL 3/BNL 1	8
13 x 36CS														HILAC 1	2
16 x 36C				1		2	2	1		1				LASAL 2	12
7-1/2 x 52H			1												1
8 x 30H VST															6
12 x 12H															2
12 x 60H														SLAC 2	2
15 x 84H		1	2												3
16 x 72H												2			2
18 x 36HPH	1					1								BLDG 10 1	6
18 x 36H (PPA)															2
18 x 36LPH													1		5
18 x 38HS														184" 1	1
18 x 60H				1						1	1				6
19 x 84H															1
22 x 66H															1
27 x 54QCH															1
29-1/2 x 32H														TRIUMF 1 /BLDG. 10 1	2
29 x 36H	1													TRIUMF 1	6
33 x 36															1
37 Diam H															1
38 x 18H															2
40 x 36H							1							BLDG. 53 1	2
60 Diam H			1			1									3
72 x 18H (PPA)														NAL 1	1

IVb. DIPOLE MAGNETIZATION DATA

The following graphs present a broad sampling of magnetization data for the Bevalac dipole magnets included in the table, "Bevalac Experimental Magnets - Summary, Dipole Magnets", located on the following page.

The rectangular coordinate system used for describing these data has its origin at the geometric center of the working volume of each magnet. The Z-axis is parallel to the normal beam direction. Except as noted on the graphs, all single-point magnetization measurements were made at the origin and all integral magnetization measurements were made on the y-axis, i.e., $x = 0$, $z \approx 0$.

The graphs included in this section are representative of the more standard geometries of the magnets. LBL Magnetics Measurements Engineering has additional data for special geometries and detailed induction-uniformity data on many magnets. Some of these additional data are referenced in the last columns on the following page.

In experiments where the accuracy of the magnitude of the magnetic induction or of the induction integral is crucial, one should be satisfied that the geometry of the magnet to be used is identical to the geometry of the magnet represented by the data.

A wide range of magnetic measurement instrumentation is available from Magnetic Measurements Engineering located in Building 7, Room 210B, x-5378. The Bevalac has three magnets identified as M5. The M5 (#1) version has 60" diameter pole tips with a 60" diameter removable plug. The coils are flush with the pole tips in the #2 and #3 assemblies while the pole tips are 2" beyond the coils in #1.

DIPOLE MAGNETIZATION DATA

Dipole Magnet	No. of Turns	Gap (In)	B_z vs. 1	$B_z dY$ vs. 1	Index to Figures		$B_z dY/1$ vs 1	$B_z/1$ vs 1
					$B_z dY/1$ vs 1	$B_z dY$		
9 x 12 C	680	4.0	1a	2b	11		12	
9 x 12 C		6.0	1a					
12 x 36 C	64	4.43	1b	2b	17b		17a	
13 x 24 C	240	6.0	1b	2b				
13 x 36 CS	96	8.62	1a	2a				
16 x 36 C	180	8.0	1a	2b	9		10	
16 x 36 C	180	6.0		2b				
8 x 30 H VST	88	9.25	1c	2f				
12 x 12 H	552	12.5	See Summary					
12 x 60 H	128	4.15	1b	2a	3		4	
12 x 60 H	128	7.13	1b	2a				
15 x 84 H	126	4.38	1c	2f	18b		18a	
16 x 72 H	96	5.4	1a	2c				
18 x 36 HPH	192	8.0	1c	2a	7		8	
18 x 36 H(PPA)	184	6.0	1a	2f				
18 x 36 LPH	368	8.0	1b	2b	5		6	
18 x 38 H S	144	8.38	1c	2a				
18 x 60 H	180	8.0	1b	2a	15		16	
18 x 60 H	180	6.0		2a				
18 x 60 H		4.0	1b	2a	13		14	
19 x 84 H	96	4.38	1c	2f				
22 x 66 H	300	17.33						
22 x 66 H	300	7.9						
27 x 54 QCH	160	5.40	1c	?				
29 x 36 H	336	8.19	1a	2f	19		20	
29 x 36 H	336	7.6	1a					
29 x 36 H	336	6.6	1a					
37 DIA. H	770	23.0	See Summary					
38 x 18 H (PF)	368	26.1	1a	2b				
40 x 36 H	180	8.12	1c	2a				
40 x 36 H	180	18.0	1c	2a				
60 DIA H	640	12.0	1d	2c				
60 DIA H	640	22.0	1d	2c	21		22	23
60 DIA H	640	47.0	1d					
60 DIA H	640	52.0	1d					
60 DIA H	288	5.6	1c	2c				
72 x 18 (PPA)	288	18.0	1c	2c

Figure IV-1

Revised: May 1976

XBL 7111-6333

DIPOLE MAGNETS, MAGNETIZATION CURVES

Revised: May 1976

Figure IV-2

XBL 7112-2445

DIPOLE MAGNETS, MAGNETIZATION CURVES

Revised: May 1976

Figure IV-3

XBL 7112-2446

60" DIAMETER "H" MAGNET, MAGNETIZATION CURVES

Figure IV-4

Revised: May 1976

XBL 711 6201

60" DIAMETER "H" MAGNET, MAGNETIZATION CURVES

Figure IV-5

Revised: May 1976

XBL 711 6201

EPB MAGNETS, MAGNETIZATION DATA

Figure IV-6

Revised: May 1976

XBL 7112-2447

Dipole magnets, magnetization curves

Revised February 1979

Figure IV-7

XBL 798-10973

Dipole magnet, integral magnetization data

Revised December 1978

Figure IV-8

XBL 7112-244C

Dipole magnet, integral magnetization data

Figure IV-9

Revised December 1978

XBL 7112-2449

60" DIAMETER H MAGNET, INTEGRAL MAGNETIZATION DATA

Figure IV-10

Revised: May 1976

XBL 711-6292

DIPOLE MAGNET, FIELD INTEGRAL MAGNETIZATION DATA

Revised: May 1976

Figure IV-11

XBL 7112-2450

BENDING MAGNET FIELD INTEGRAL MAGNETIZATION

Figure IV-12

NBL 764-1577

Drawn: May 1976

Figure IV-13

Revised December 1978

XBL 798-10972

DIPOLE MAGNETS, NORMALIZED INTEGRAL DATA

Figure IV-14

Revised: May 1976

XBL 7111 6396

DIPOLE MAGNETS, NORMALIZED INTEGRAL DATA

Revised: May 1976

Figure IV-15

XBL 7111 6397

Revised: May 1976

Figure IV-16

XBL 7111 6398

DIPOLE MAGNETS, NORMALIZED INTEGRAL DATA

Figure IV-17

Revised: May 1976

XBL 711 6399

Revised: May 1976

Figure IV-18

XBL 7111 2400

Figure IV-19

REVISED: May 1976

Figure IV-19

XBL 7111 2401

Figure IV-20

Normalized induction integral, $\int B_z dy$ (kG-in./Ampere)

DIPOLE MAGNETS, NORMALIZED INTEGRAL DATA

Figure IV-21

REVISED: May, 1976

XBL 7111 2403

DIPOLE MAGNETS, NORMALIZED INTEGRAL DATA

Figure IV-22

XBL 71112406

Revised: May 1976

DIPOLE MAGNETS, NORMALIZED INTEGRAL DATA

Figure IV-23

Revised: May 1976

XBL 7112-2466

DIPOLE MAGNETS, NORMALIZED INTEGRAL DATA

Revised: May 1976

XBL 7111 2407

Figure IV-24

Revised: May 1976

Figure IV-25

XBL 7111 2408

Figure IV-26

Figure IV-26

DIPOLE MAGNETS, NORMALIZED INTEGRAL DATA

Figure IV-28

XBL 7111 2412

Revised May 1976

DIPOLE MAGNETS, NORMALIZED INTEGRAL DATA

DIPOLE MAGNETS, NORMALIZED INTEGRAL DATA

Figure IV-29

Revised: May 1976

XBL 764-1570

DIPOLE MAGNETS, NORMALIZED INTEGRAL DATA

Revised: May 1976

XBL 7111 2415

Figure IV-30

Normalized induction integral, $\int B_Z dy / I$ (kG-in./Ampere)

DIPOLE MAGNETS, NORMALIZED INTEGRAL DATA

Revised: May 1976

XBL 7111 2416

Figure IV-31

Figure IV-32

DIPOLE MAGNETS, NORMALIZED INTEGRAL DATA

Redrawn: January 29, 1972

XBL 7116214

Figure IV-33

Revised: May 1976

XBL 7111 2417

Figure IV-34

IVc. FOCUSING MAGNET SUMMARIES, DIAGRAMS AND LOCATIONS

This section includes tables summarizing the specifications of most Bevalac quadrupole and sextupole magnets, accompanied by diagrams of pertinent dimensions. Separate tables list the location and availability of the focusing magnets.

Following this summary are graphs of magnetization curves.

BEVALAC EXP

Focusing Magnet	Turns Per Pole	Bore Dia. (In.)	Approx Magnet Res. (Ohms)	Approx Magnet Induct (M-Henry)	Practical	
					Current (Amps)	Voltage (Volts)
8 Q 9	32	7.80	0.048		560	27.0
LP 8 QUAD 16	39	8.0	0.0292	6.648	1500	36.5
LP 8 QUAD 32	39	8.0	0.0419	10.88	1500	63
HP 8 QUAD 16	38	8.0	0.0674		1200	80
HP 8 QUAD 32	38	8.0	0.1081		1200	128
8 QB 16	24	8.24	0.0191		2750	53
8 QB 32	24	8.24	0.0336	8.0	2750	93
8 QB 48	22	8.24	0.0364	13.47	2360	86
8 QN 16	24	8.24	0.0191	4.56	2750	53
8 QN 32	24	8.24	0.0336		2750	93
8 QS 24	9	8.24	0.0136	0.413	6500	88.7
10 Q 16	33	10.0	0.0604		720	43
12 QUAD 16	84	12.10	0.1799		845	152
12 Q B 24	36	12.37	0.0264		2750	73
12 QB 48	36	12.37	0.0458	21.76	2750	126
12 QN 24	36	12.37	0.0264		2750	73
12 QN 48	36	12.37	0.0458		2750	126
8 x 24 SEXT.	18	8.25	0.0815		600	48.9
8 x 32 SEXT.	17	8.25	0.0420		1400	58.8
12 x 24 SEXT.	8	12.37	0.0612	.082	1100	67.2

EXP AC EXPERIMENTAL MAGNETS - SUMMARY

Voltage (Volts)	Practical Maximums			Measured Magnetic Quantities				Engineering Design Notes	Magnetic Measurements	
	Voltage (Volts)	Power (KW)	Approx Grad. (KG/In)	Current (Amps)	Grad (KG/In)	Grad Integral (KG)	Length (In)		Engineering Notes	Data Book
27.0	27.0	15.2	1.02	560	1.02	11.0	10.8	M4575		537 A
36.5	36.5	55	2.73	1500	2.73			7307-01M43	MT128	323
63	63	94	2.97	1500	2.97			7307-01M39	MT128,MT109	323
80	80	96	2.52	650	1.52			7900-64M1	MT128,58,119	265,300,343
128	128	154	2.52	650	1.52			7900-64M1	MT128,58,119	265,300
53	53	144	3.6	2400	3.23	62.3	19.3	7307-05M6		449
93	93	245	3.6	2600	3.52	122.6	34.8	7307-05M6	MT250	449
86	86	203	3.0	2360		154.6		7308-04M4	MT250	
53	53	144	3.6	2750	3.53	68.5	19.4	7307-05M6		503
93	93	245	3.6	2750	3.65	126.9	34.8	7307-05M6	MT250	503
88.7	88.7	576	3.3	6500	3.31	91.4	27.6	M4154,4155	MT248,MT356	511
43	43	31.1	0.23	720	0.837	15.0	17.9	M4575		537B
52	152	128	1.7	800	1.62				MT146,MT155	343
73	73	200	2.4	2400	2.15	62.3	28.9	7307-05M6	MT245,MT202	452
26	126	346	2.4	2750	2.48	127.5	51.4	7307-05M6	MT250,MT246	492
73	73	200	2.4	2500	2.20	62.9	28.4	7307-05M6		503
26	126	346	2.4	2750	2.44	128.7	52.8	7307-05M6	MT247	503
48.9	48.9	29.3	460G/IN2					M3957		488
58.9	58.9	82.3	940G/IN2	1500		3.48KG/IN		M3921A		488
67.2	67.2	75.6	120G/IN2	700	71G/IN2			M3667B		488

<p>132-32</p> <p>132-32 Plain 27,400[°] * 132-32 Shielded 31,600[°] * 13P784</p>	<p>12 Quad 16-16</p> <p>13L1725 10,000[°]</p>	<p>12 OB 48-48</p> <p>13Q2296-1 Shielded 97,400[°] * 13Q2296-2 Plain 79,600[°] * Cradle Included 13P3824-1</p>
<p>38 48</p> <p>5585 12,380[°]</p>	<p>12 OB 24</p> <p>Adjusting Unit Included 13P9694 Plain 16,590[°] * 13P7794 Shielded 22,635[°] *</p>	<p>12 GN 24 or 48</p> <p>16C1786-1 (24) 13,350[°] * 16C1786-2 (48) 27,500[°] *</p>
<p>16 or 32</p> <p>376-1 (16) 4,300[°] * 376-2 (32) 8,150[°] *</p>	<p>12 OB 24-24</p> <p>13Q2306-1 Shielded 55,100[°] * 13Q2306-2 Plain 42,600[°] * Cradle 13P3734-1</p>	<p>8x24 Sextupole</p> <p>15L4535 3,500[°]</p>
<p>24</p> <p>106 1700[°]</p>	<p>12 OB 24-48-24</p> <p>13Q2286-1 Shielded 102,275[°] * 13Q2286-2 Plain 80,880[°] * Cradle Included 13P3824</p>	<p>8x32 Sextupole</p> <p>15N4005 8000[°]</p>
<p>5</p> <p>76 3400[°]</p>	<p>12 OB 48</p> <p>13Q2316-2 Plain 31,900[°] * 13Q2316-1 Shielded 40,805[°] * 13P3734-2 Cradle 13P7804 Shielded NoCradle</p>	<p>12 x 24 Sextupole</p> <p>14P4055 1000[°]</p>

BEVALAC EXPERIMENTAL MAGNET LISTING

Focusing Magnet	External Beam Channel II				External Beam Channel I								Bevalac Transfer	On Loan	Total In Use	Avail For Use	Bev Total
Beam No.	Chan	B1	B2	Chan					Septum Channel								
8 Q 9														TRIUMF 2	0	1	1
8 QUAD 8														Cornell 2	2	0	2
LP 8 QUAD 16													2	SLAC 6	4	20	24
LP 8 QUAD 32		2	4	2			2			1	2			TRIUMF 2	7	1	18
HP 8 QUAD 16													2		8	6	14
HP QUAD 32							2							HILAC	6	5	11
8 QB 16										4	2				8	3	11
8 QB 32					2	2		2			1				7	1	8
8 QB 48	2								2		4				6	2	8
8 QN 16															0	4	4
8 QN 32					2			2		5					5	0	5
8 QS 24															1	5	6
10 Q 16																2	2
12 QUAD 12			1											TRIUMF 2	2	0	2
12 QUAD 16														LASAL 4	4	4	8
12 QUAD 32															0	1	1
12 QB 24														ARGON 2	4	8	12
12 QB 48															2	6	8
12 QN 24												4			0	4	4
12 QN 48															2	0	2
8 x 24 SEXT.															1	0	1
8 x 32 SEXT.															1	2	2
12 x 24 SEXT.															0	1	1

IVd. FOCUSING MAGNET MAGNETIZATION DATA

The following graphs present a broad sampling of magnetization data for the Bevalac quadrupole magnets listed in the table, "Bevalac Experimental Magnets - Summary, see following page.

The cylindrical coordinate system used for describing these data has its origin at the geometric center of the working volume of each magnet. The z -axis, the axis of symmetry, is parallel to the nominal beam direction, and r is directed radially outward from the z -axis. Except as noted on the graphs, all gradient magnetization measurements were made at $z = 0$ and at $r \approx D/4$ where D is the bore diameter. Similarly, all gradient integral measurements were made at $r \approx D/4$.

Figures 41 through 45 display bands of data that reflect variations in individual magnets and accuracy of measurements.

The harmonic content of the 8 QN and 12 QN Quadrupoles is tabulated in the table, "Harmonic Content of Quadrupole Magnets, 8 QB and 12 QB".

QUADRUPOLE MAGNETIZATION DATA

Focusing Magnet	Turns Per Pole	Bore Diameter (Inches)	Former Designation	B/RI vs. I	Index to Figures		
					B/R vs. I	/Bd1/RI	∫Bd1/R
8 Q 9	32	7.80		17	17	16	16
LP 8 QUAD 16	39	8.00	8" x 16" LP	7	6		
LP 8 QUAD 32	39	8.00	8" x 32" LP	7	6		
HP 8 QUAD 16	38	8.00	8" x 16" HP	7	5		
HP 8 QUAD 32	38	8.00	8" x 32" HP	7	5		
8 QB 16	24	8.24	8" x 16" BNL	2	2	3	3
8 QB 32	24	8.24	8" x 32" BNL	2	2	4	4
8 QB 48	22	8.24	8" x 48" BNL		No Curve B/RI $\approx$ 1.264 (Gauss/ in / A)		
8 QN 16	24	8.24	8QN16	10	10	9	9
8 QN 32	24	8.24	8QN32	10	10	8	8
8 QS 24	9	8.24	8QS24	12	13	12	13
10 Q 16	33	10.0		15	15	14	14
12 QUAD 16	84	12.10			No Data		
12 QB 24	36	12.37	12" x 24" BNL	1	1	3	3
12 QB 48	36	12.37	12" x 48" BNL	1	1	44	4
12 QN 24	36	12.37	12QN24	11	11	9	9
11 QN 48	36	12.37	12QN48	11	11	8	8
8 x 24 SEXT.	18	8.25	Sextuple Magnets (No Figures)				
8 x 32 SEXT.	17	8.25					
12 x 24 SEXT.	8	12.37					

HARMONIC CONTENT OF QUADRUPOLE MAGNETS, 8 QB & 12 QB

Values of 6th, 10th, 14th, harmonics in percent of second harmonic, at radius of measurement of 3.668" for 8" bore and 5.668" for 12" bore.

Magnet Current	Central Field			Line Integral			Map No.	Magnet Type
	6	10	14	6	10	14		
600	.014	.069	.048	.710	.037	.058	159	8 QB 16
1800	.030	.042	.037	.709	.011	.048	160	
2200	.044	.057	.058	.676	.025	.056	161	
600	.033	.062	.045	.359	.051	.055	156	8 QB 32
1800	.045	.066	.037	.353	.053	.051	157	
2200	.046	.073	.048	.358	.042	.050	158	
1000	.075	.051	.091	.667	.006	.101	173	12 QB 24
2000	.057	.053	.089	.654	.023	.101	172	
2400	.032	.050	.086	.595	.027	.098	171	
1000	.043	.068	.089	.380	.032	.098	369	12 QB 48
1500	.062	.056	.083	.368	.022	.092	365	
2000	.032	.064	.082	.368	.020	.092	366+370	
2500	.011	.059	.072	.333	.014	.083	362

12 QB QUADRUPOLE MAGNETS, GRADIENT MAGNETIZATION DATA

Figure IV-35

Revised: May 1976

XBL 7112 2418

8 QB QUADRUPOLE MAGNETS, GRADIENT MAGNETIZATION DATA

Figure IV-36

Revised: May 1976

XBL 7112 2419

12 QB 24 & 8 QF 16 QUADRUPOLE MAGNETS,
GRADIENT INTEGRAL MAGNETIZATION DATA

Figure IV-37

Revised: May 1976

XBL 7112 2420

12 QB 48 & 8 QB 32 QUADRUPOLE MAGNETS,
GRADIENT INTEGRAL MAGNETIZATION DATA

Figure IV-38

Revised: May 1976

XBL 7112 2421

HP 8 QUADRUPOLE MAGNETS, GRADIENT MAGNETIZATION DATA

Figure IV-39

NBL 764-157

Drawn: May 1976

LP 8 QUADRUPOLE MAGNETS, GRADIENT MAGNETIZATION DATA

Figure IV-40

NBL 76+1574

Drawn: May 1976

Summary of calibration data on 8" bore quadrupole magnets

Figure IV-41

Revised: May 1976

XBL 7111 2424

12 QN 48 & 8 QN 32 QUADRUPOLE MAGNETS,
GRADIENT INTEGRAL MAGNETIZATION DATA

Revised: May 1976

Figure IV-42

XBL 711 6210

12 QN 24 & 8 QN 16 QUADRUPOLE MAGNETS,
GRADIENT INTEGRAL MAGNETIZATION DATA

Figure IV-43

REVISED May 1976

XBL 711 6211

8 QN QUADRUPOLE MAGNETS, GRADIENT MAGNETIZATION DATA

Figure IV-44

Revised: May 1976

XBL 711-6212

12 ON QUADRUPOLE MAGNETS, GRADIENT MAGNETIZATION DATA
 Figure IV-45

Revised: May 1976

KB5 711-5517

8 QS 24 QUADRUPOLE MAGNET,
 GRADIENT MAGNETIZATION DATA

fig.12a

GRADIENT INTEGRAL MAGNETIZATION

Revised: May 1976

XBL 711 6204

Figure IV-46

8 QS 24 QUADRUPOLE MAGNET,
GRADIENT INTEGRAL MAGNETIZATION

Revised: May 1976

XBL 711 6203

Figure IV-47

10 Q 16 QUADRUPOLE MAGNET,
GRADIENT LINE INTEGRAL MAGNETIZATION AEC NO. 141145

Drawn: May 1976

XBL 764-1575

Figure IV-48

10 Q 16 QUADRUPOLE MAGNET, GRADIENT
MAGNETIZATION AT MAGNET CENTER AEC NO. 141145

Figure IV-49

XBL 764-1573

Drawn: May 1976

8 Q 9 QUADRUPOLE MAGNET AEC NO. 14144
 GRADIENT INTEGRAL MAGNETIZATION DATA

Figure IV-50

Drawn: May 1976

XBL 764-1572

8 Q 9 QUADRUPOLE MAGNET AEC NO. 14144
GRADIENT MAGNETIZATION DATA

Figure IV-51

Drawn: May 1976

XBL 764-1571

IVe. BEVALAC AUXILIARY MAGNET POWER SUPPLIES

Motor Generator Sets	V	I	P(Kw)	Remarks
MG 3	180	2,000	360	Due to preventive maintenance, MG sets are not normally available for use on a "shut down day" without prior arrangement.
MG 4	180	2,000	360	
MG 5	180	2,000	360	
MG 6	405	2,705	1,096	
MG 7A	194	1,225	230	MG's 8 & 9 deliver 5,000 @ 600V (3,000 Kw) when used in series
MG 7B	150	1,600	240	
MG 8	300	2,500	750	
MG 9	300	2,500	750	
MG 11A	250	1,000	250	Note: MG sets are not to be operated below 10% of rated current.
MG 12A	250	1,000	250	
MG 12B	250	1,000	250	
Quantity Rectifiers	V	I	P(Kw)	Remarks
5 28 Kw Perkins	70	400	28	Air Cooled Regulated
7 196 Kw Sel Rex	140	1,400	196	SCR Regulated
12 105 Kw Temescal	75	1,400	105	SCR Regulated
52 112 Kw Regulated	75	1,500	112	SCR Regulated
1 240 Kw Mod. Sel Rex	120	2,000	240	SCR Regulated
2 150 Kw Sel Rex	100	1,500	150	Diode Mag. Amp. Reg.
6 49 Kw Dual Sprague	70/70	700/700	49/49	Diode Mag. Amp. Reg.
7 90 Kw Dual Sel Rex	90/90	1000/1000	90/90	Diode Mag. Amp. Reg.
53 150 Kw Unregulated	50 or 100	1,500	150	Diode Unregulated

IVf. WIRE CHAMBERS AND SECONDARY EMISSION MONITORS

1. Wire Chambers

Located within the external particle beam transport lines is a system of 64 multi-wire chambers. The chambers provide beam position monitoring and aid the main control operators in tuning the transport lines. The chambers are constructed with two orthogonal signal wire grids (32 wires/plane) which produce horizontal and vertical beam profiles. Most chambers have wire spacings of either 2mm or 6mm so that their respective active areas have diameters of 64mm and 192mm. The smaller diameter allows for the accurate monitoring of beam wastes while the larger chamber are typically used near focusing magnets. The wires are made of 0.051mm Be-Cu and wound with 80gm tension. Wire chambers located in air gaps in the beam lines have 0.13mm Kapton windows. The vacuum wire chambers have 0.25mm aluminum windows. In either case the chamber material is about 150 mg/cm². Shown on the following pages is a list of chamber locations, wire spacings and LBL drawing numbers. Ionization produced in the Ar-CO₂ (80% - 20%) chamber gas by the beam ions is collected on each wire and stored on individual capacitors. The analog signal from each wire is multiplexed, amplified and transmitted to a central analog-to-digital converter. The digital signal is transmitted to the main control room where it is stored until called up for display. The chambers have a wide dynamic range of about 10⁴ to 10¹² particles/cm²-sec. The sensitivity of the 6mm chambers to beam particles is about 100 times greater than that of the 2mm chambers.

Table IV-1 - WIRE CHAMBER INDEX

Name	Wire Spacing	Type	Location
XM1	3 mm 11 V x 30 H	Permanent Gas	Ent. XM1
XM2	3 mm 21 V x 15 H	Permanent Gas	Ent. XM2
XM3	3 mm 48 V x 16 H	Permanent Gas	Ent. XM3
XF1	2 mm	Special	Ent. XM4
XQ4	6 mm	Permanent Gas	Ent. XQ4
XM4	6 mm	Permanent Gas	Ent. XM4
X1Q4	6mm	Permanent Gas	Ent. X1Q4 A&B
S1M3	6mm	Permanent Gas	Ent. S1M3
X1/S1F2	3 mm 48 V x 16 H	Permanent Gas	Dnstr. S1M3
X1Q5	6mm	Permanent Gas	Upstr. X1Q5
X2Q4	6mm	Crawford	Ent. X2Q4 A&B
X2F2	2mm	Crawford	Upstr. B3Q1
X2F2A	2mm	Crawford	Upstr. XF2 Coll.
X2Q5	6mm	Permanent Gas	Btwn. XQ5 A&B
BOWC1	6mm	Crawford	Dnstr. B0Q1
B1WC1	6mm	Portable	Dnstr. B1Q1
B1WC2	No chamber at present time		
B2WC1	6mm	Crawford	Dnstr. B2Q1 A & B
B2WC2	6mm	Portable	Bio. Bench
B2WC3	6mm	Portable	Physics Bench
B39WC1	6mm	Permanent Gas	Upstr. B39M2
B39WC2	6mm	Permanent Gas	Upstr. B39M3
B39WC3	6mm	Permanent Gas	Upstr. B39Q1A
B39WC4	6mm	Permanent Gas	Upstr. B39M4
B39WC5	6mm	Permanent Gas	Dnstr. B39SX1
B39WC6	6mm	Permanent Gas	Dnstr. B39M6V
*B39WC7	6mm	Crawford	Dnstr. B39Q2B
B39WC8	6mm (not in use)	Portable	Dnstr. scatter. chamber
B30WC1	6 mm	Cantilever	Upstr. B30M1S
B30WC2	2 mm	Crawford	Dnstr. B30M1S
B30WC3	6 mm	Permanent Gas	Upstr. B30Q5 A&B
B30WC4)	{ Chamber size & location changes with experiment		
B30WC5)			
B30WC6)			
B40WC1	2 mm	Cantilever	Upstr. B40B01
B40WC2	2 mm	Crawford	Dnstr. Prep. Box
B40WC3)	{ Chamber size changes with experiment		
*B40WC4)- H.V. & SIG from B26 W.O. 2	{ Location - Dnstr. "Y" tank (all port. chambers)		
B26WC1	2 mm	Crawford	Upstr. B26M1
B26WC2	6mm	Crawford	Dnstr. B26Q1 A&B
B26WC3	2mm	Crawford	Upstr. B26Q2 A&B
B26WC4)	{ Chamber size changes with experiment		
*B26WC5)	{ Location - streamer chamber house (all port. chambers)		
*B26WC6)			
SIM6	6 mm	Cantilever	Upstr. SIM6
SIQ7	6 mm	Permanent Gas	Upstr. SIQ7A
SIM6S	6 mm	Crawford	Dnstr. SIM6S
SIF3	2 mm	Permanent Gas	Upstr. SIM7

*Chamber channel not in continuous use. Channel may be used for other wire chamber.

Table IV-1 - WIRE CHAMBER INDEX

Name	Wire Spacing	Type	Location
B42WC1	2 mm	Crawford	Dnstr. X2M7
B42WC2	6 mm	Crawford	Btwn. B42Q1 A&B
B42WC3	2 mm	Crawford	B42 F4
B42WC4	6 mm	Crawford	Btwn. B42Q2 A&B
B42WC5	2 mm	Crawford	Upstr. B42 M3
B42WC6	6 mm	Portable	Dnstr. B42Q3C1
B42WC7	6 mm	Portable	Location Varies
B42WC8	6 mm	Portable	Dnstr. HISS Mag.
*B42WC9	No chamber at present time		
B44WC1	2 mm	Crawford	Upstr. B44 Slits
B44WC2	6 mm	Crawford	Upstr. B44 Q2B
B44WC3	6 mm	Portable	Dnstr. B44 MI
B44WC4	No Chamber at present time		
Irrad. Station WC1	6 mm H.O. & SIG from B40WC1	Portable	Btwn. B26 & B40
Irrad. Station WC2	2 mm H.O. & SIG from B26WC1	Portable	Dnstr. X1M6

*Chamber channel not in continuous use. Channel may be used for other wire chamber.

Chamber Type	Wire Spacing	Print No.
7.5" Portable	6 mm (32V/32H)	17K0326
2.5" Portable	2 mm (32V/32H)	17G01696
7.5" Cantilever	6 mm (32V/32H)	17G1926
2.5" Cantilever	2 mm (32V/32H)	17G1696
Cantilever General Assembly		17P0556
Chamber & Feedthru Assembly		17P2266
7.5" Permanent Gas	6 mm (32V/32H)	18H3376
Crawford Type	6 mm & 2 mm (32V/32H)	20E4124
Drive & Box	-----	20E5874
M-1 Plunging Permanent Gas	3 mm (11V/30H)	20P0014
Drive Mechanical	-----	20B3745
M-2 Plunging Permanent Gas	3 mm (22V/15H)	20P0024
Drive Mechanical	-----	20B3755
M-3 Plunging Permanent Gas	3 mm (48V/16H)	17P7266
F-1 Plunging Permanent Gas (Change to Circulating Gas)	2 mm (32V/32H)	18H3216
XM4 Plunging Permanent Gas	3 mm (48V/16H)	17P7266
X1, S1, F2 Plunging Permanent Gas	3 mm (48V/16H)	18H4106
S1, F3 Plunging	2 mm (32V/32H)	17P3646

General Information

- 1) Signal plane wire size .002 beryllium copper, gold plated
- 2) Gas-Argon 80% CO₂ 20%
- 3) Gas-Sharpack formula (magic gas) Methynal 4%, Isobutane 23.52%, Freon 13B1 48%, Balance-Argon

2. Secondary Emission Monitors (SEM)/Ion Chambers

The SEM or ion-chamber is used at the Bevalac for the monitoring of beam intensity. As the ion beam transverses the SEM charge is built up on 11 aluminum sheets (0.00025 in. thick). The signal is then typically fed to a current integrator from which it can then be read out or displayed. The entrance and exit windows of the SEM are made of 0.001 in. aluminum. The SEM is usually calibrated with a scintillator-phototube when cross section information is required for a particular experiment. A number of Secondary Emission Monitors exist for experimenters' use. For counting lower beam intensities, the SEM can be run in the ion-chamber mode. In this mode the monitor is run with Ar-CO₂ gas inside.