BNL--24182-(Rev.10/92)

DE93 004894

HFBR HANDBOOK 1992

High Flux Beam Reactor

Editors:
J. D. Axe, R. Greenberg
HFBR Scientific Program

Brookhaven National Laboratory
Associated Universities, Inc.
Upton, New York 11973 USA

Under contract No. DE-AC02-76CH00016 with the United States Department of Energy

DISCLAIMER

Inquiries and/or requests for assistance may be directed to:

HFBR User Administration Office
Director's Office/HFBR Scientific Program
Physics Building 510A, Room 1-30
Brookhaven National Laboratory
Upton, New York 11973 USA
Telephone: (516) 282-5564
FAX: (516) 282-5888

Introduction

Welcome to the High Flux Beam Reactor (HFBR), one of the world premier neutron research facilities. This manual is intended primarily to acquaint outside users (and new Brookhaven staff members) with (almost) everything they need to know to work at the HFBR and to help make the stay at Brookhaven pleasant as well as profitable. Safety Training Programs to comply with U.S. Department of Energy (DOE) mandates are in progress at BNL. There are several safety training requirements which must be met before users can obtain unescorted access to the HFBR. The Reactor Division has prepared specific safety training manuals which are to be sent to experimenters well in advance of their expected arrival at BNL to conduct experiments. Please familiarize yourself with this material and carefully pay strict attention to all the safety and security procedures that are in force at the HFBR. Not only your safety, but the continued operation of the facility, depends upon compliance.

This is the third edition of the HFBR Handbook. I believe that each one has become more useful. I particularly thank Rae Greenberg, the HFBR User Coordinator/Administrator for the success of the present edition. If there are questions that are not covered here, I would bet a fair amount that Rae Greenberg, Ext. 5564, can provide the answer.

John D. Axe
HFBR Scientific Program Head

Contents

Appendices

Acknowledgments

Thanks are due to those PRT members who were responsible for updating the instrument information and to the technicians, designers, and engineers who provided the drawings and figures.

Special thanks are extended to BNL Photography and Graphic Arts Division for their valuable assistance and to photographers Peter Horton, Mort Rosen, and Roger Stoutenburgh whose photos appear in this edition.

We are grateful to the editors of the April 1978 Edition of the HFBR Handbook: B.C. Frazer, R.E. Chrien, S. Shapiro, and D.C. Rorer, and the editors of the August 1983 Edition: S. Shapiro, D.C. Rorer, and H. Kuper for their contributions to the previous editions. In some areas what they had written could be updated, but not otherwise improved upon, and therefore was happily borrowed.

Credits:

Design:
Patricia Yalden
Alan Schmidtchen
Photography and Graphic Arts Division

Composition:
Michele Dickerson
Photography and Graphic Arts Division

Reactor Logo:
Walter J. Morrison
Reactor Division

Technical Editing:
Katherine J. Vivirito
Avril D. Woodhead
Technical Information Division

I

The High Flux Beam Research Reactor

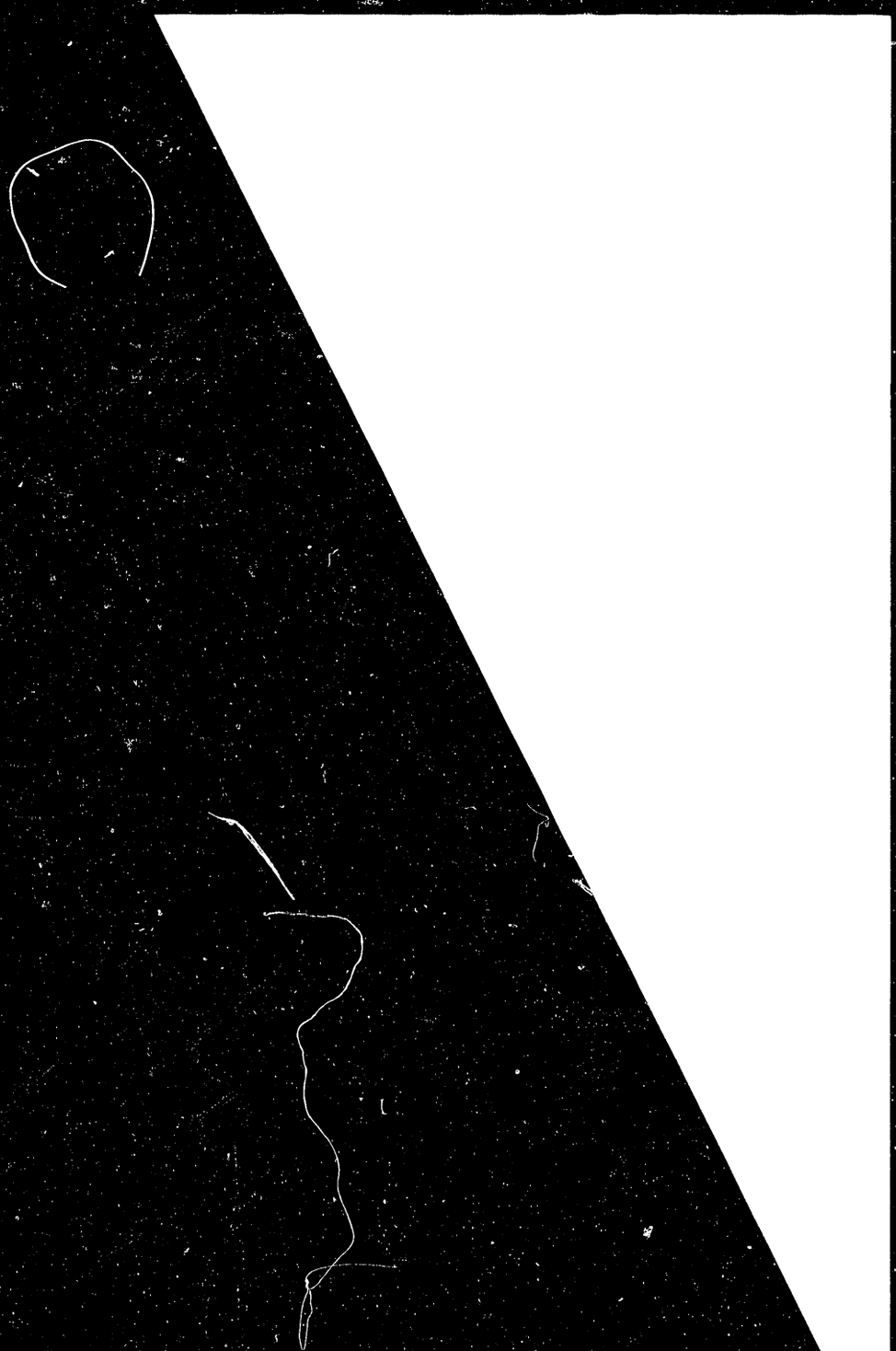


Figure 1. The core of the HEBR viewed from above.

The High Flux Beam Research Reactor

Since their discovery by Sir James Chadwick in 1932, neutrons have been studied not only in themselves, but have provided an extremely powerful tool for studying matter on the nuclear, atomic, and molecular levels. Neutrons have been used as probes by nuclear and solid state physicists, chemists, and most recently, by biologists. As techniques for using neutrons have developed in these various disciplines, there has been an accompanying need for higher levels of neutron flux in order to carry out more complex and sophisticated experiments. The Brookhaven High Flux Beam Reactor (HFBR) was designed to meet this need, providing a peak thermal flux of 1.05×10^{15} neutrons/cm^2-sec at a power of 60 megawatts (Table 1).

The HFBR first achieved criticality on October 31, 1965, approximately four years after construction began, and became available for general experimental use at full power several months later. The initial construction cost of the HFBR was $12.5 million, and its current annual operating cost is approximately $23 million (including associated overhead cost distributions).

GENERAL DESCRIPTION OF THE REACTOR

The HFBR uses highly enriched U-235 fuel and a heavy water moderator to sustain a controlled nuclear reaction. The core (Figure 1) consists of 28 elements, each containing 19 curved fuel plates (of the Materials Testing Reactor Type). In each plate U_3O_8 powder is mixed with aluminum powder to form a cermet core, which is encased in aluminum cladding. The cladding acts as a barrier or containment for the highly radioactive isotopes formed as fission products during the chain reaction.

The fuel elements are placed in a roughly cylindrical arrangement inside a spherical aluminum reactor vessel. The core is approximately 53 cm high and 48 cm in diameter, has an active volume of about 97 liters and contains a maximum of 9.8 kilograms of U-235. The D_2O moderator is pumped downward through the spaces between the fuel element plates at a pressure of 1.4×10^6 pascals, carrying away the 60 megawatts of thermal energy developed in the core during normal reactor operation. The D_2O is circulated through a pair of heat exchangers, where the heat is transferred to an H_2O secondary loop, which dissipates the heat into the air through a set of cooling towers.

Table 1.

HFBR Statistics

Reactor power	60 million watts
Total fast neutron flux, fuel region	2.4×10^{15} n/cm^2-sec
Maximum thermal flux, reflector	1.05×10^{15} n/cm^2-sec
Active core volume	97 liters
Active height of core	52.7 cm
Diameter of core (equivalent cylinder)	47.8 cm
Number of fuel elements in core	28
Dimensions of fuel element	
Cross section (19 fuel plates)	8.113 × 7.163 cm
Length of 2 outer plates	58.4 cm
Length of 17 inner plates	52.7 cm
Total length	154.4 cm
Uranium-235 content of fuel element	351 g
Total uranium-235 loading	9.8 kg
Reactor coolant	heavy water (D_2O)
Total coolant flow rate	1150 liters/sec
Maximum operating coolant pressure	1.72×10^6 pascals
Maximum operating inlet coolant temperature	65° C
Maximum temperature at fuel element surface	≈175°C
Number of control rods	16
Dimensions of control rod cross section (rods are right angles)	7.6 × 7.6 × 1.78 cm
Length of main rods	102.9 cm
Length of auxiliary rods	31.8 cm
Neutron absorber in rods	Dy_2O_3 and Eu_2O_3
Diameter of spherical portion of reactor vessel	208.3 cm
Diameter of neck of reactor	121.9 cm
Thickness of thermal shield (lead and steel)	22.9 cm
Minimum thickness of biological shield (heavy concrete)	243.8 cm

Outside the reactor vessel is a water-cooled thermal shield of steel and lead 23 cm thick (Figure 2). This secondary vessel protects the surrounding outer shield from excessive heating by radiation from the reactor and provides containment to keep the core covered with heavy water in the event of a leak in the reactor vessel. An outer shield, known as the biological shield, protects the reactor operators and experimenters from the radiation produced in the reactor. The biological shield, which has a minimum thickness of 2.4 meters, is a mixture of heavy concrete and steel punchings.

In contrast to most reactors, which are designed to minimize the escape of neutrons from the core, the HFBR has been expressly designed to maximize the number of neutrons available in external beams. This is accomplished through the choice of coolant material and core configuration. Heavy water, rather than light water, was selected as the coolant and moderator in this reactor. The volume of D_2O flowing through the core to cool the fuel elements does not provide sufficient moderation to thermalize all the neutrons within the core. A large number of fast and epithermal neutrons thus escape from the region of the fuel, and subsequently, are moderated in the large volume of D_2O reflector surrounding the core. Some of the resulting thermal neutrons are reflected back into the core where they help to sustain the nuclear chain reaction. This choice of materials and configuration results in a unique neutron distribution in which the useful thermal neutron population peaks in the reflector, where the neutrons are directly accessible to the beam tubes (Figure 3). The numbers of higher energy neutrons, which are normally not desirable in the beams, are highest within the core. Power density peaks at the periphery, rather than at the center of the core as in most other reactors.

Sixteen control rods containing dysprosium and europium oxides act as neutron "poisons" to absorb thermal neutrons and control the rate at which the nuclear reaction takes place (Figure 4). These rods are located just outside the core and are arranged into two groups, a main bank, which can be raised above the core, and an auxiliary bank, which can be lowered below the core. Shutdown of the chain reaction is accomplished by masking the core from the return of thermal neutrons from the reflector by covering the sides of the core with the control rod blades. During normal operation, the neutron flux is maintained constant at the core midplane by withdrawing the control rods approximately symmetrically from the top and bottom of the core as fuel burnup progresses.

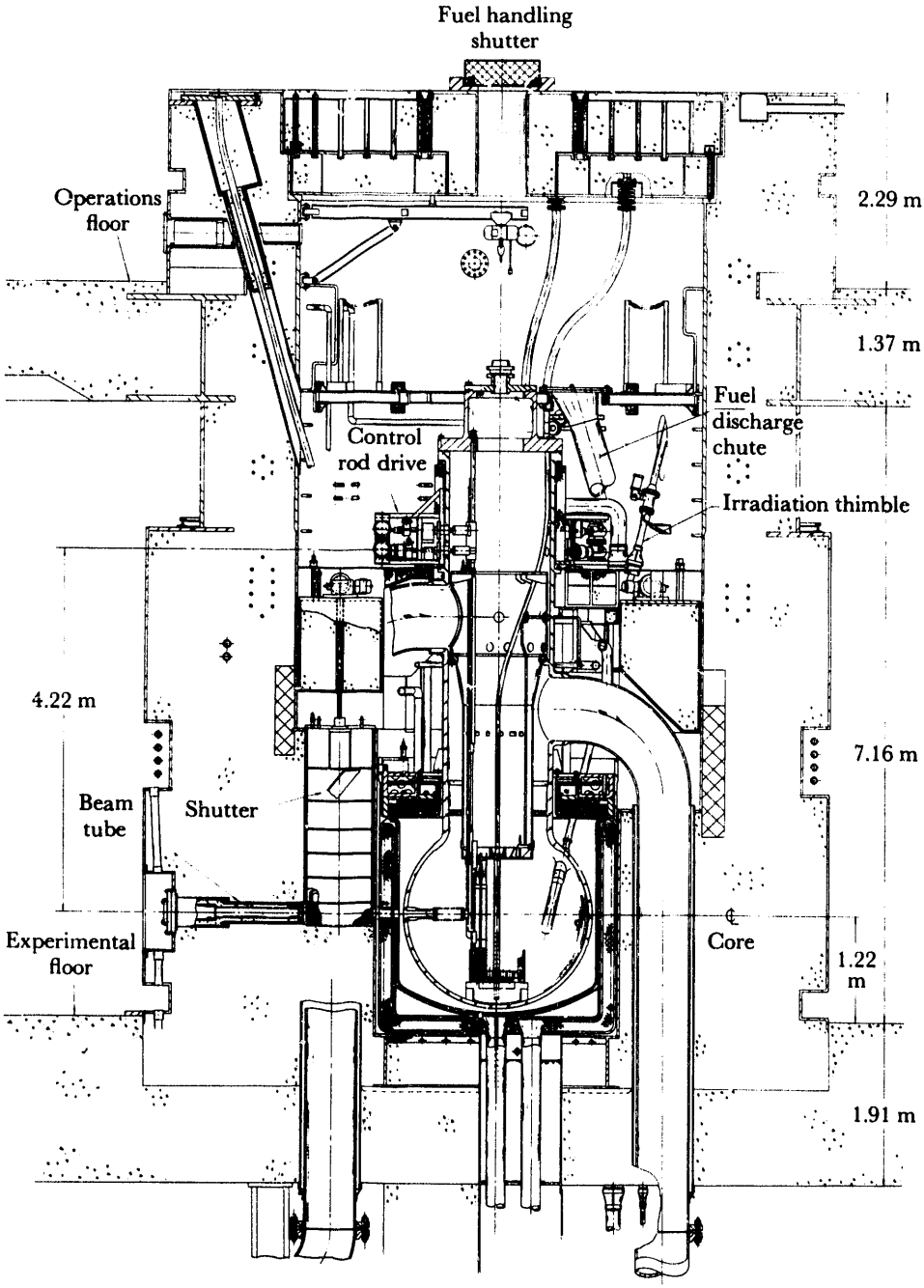


Figure 2. Elevation of the reactor vessel shielding, showing a typical beam tube, shutter, and thimble.

The HFBR is operated 24 hours per day for 24 days. The refueling shutdown normally lasts for 5 to 7 days, depending on the amount of maintenance and surveillance testing.

For safety reasons, all nuclear reactors are designed with a negative temperature coefficient of reactivity, so that any power surges which might occur will be self-limiting due to the automatic decrease in reactivity as the reactor heats up. This safety feature has an important effect on the maximum length of the operating cycle which can be obtained at the HFBR. During the summer, the efficiency of the cooling towers can vary over a wide range in a short time, depending on air temperature and humidity. The corresponding changes in temperature of the reactor coolant produce changes in the reactivity, which become especially significant near the end of the fuel cycle, when there is little excess reactivity to spare. Under such conditions negative reactivity effects can sometimes result in insufficient reactivity to sustain the chain reaction and can cause a premature shutdown, shortening the operating cycle by as much as one

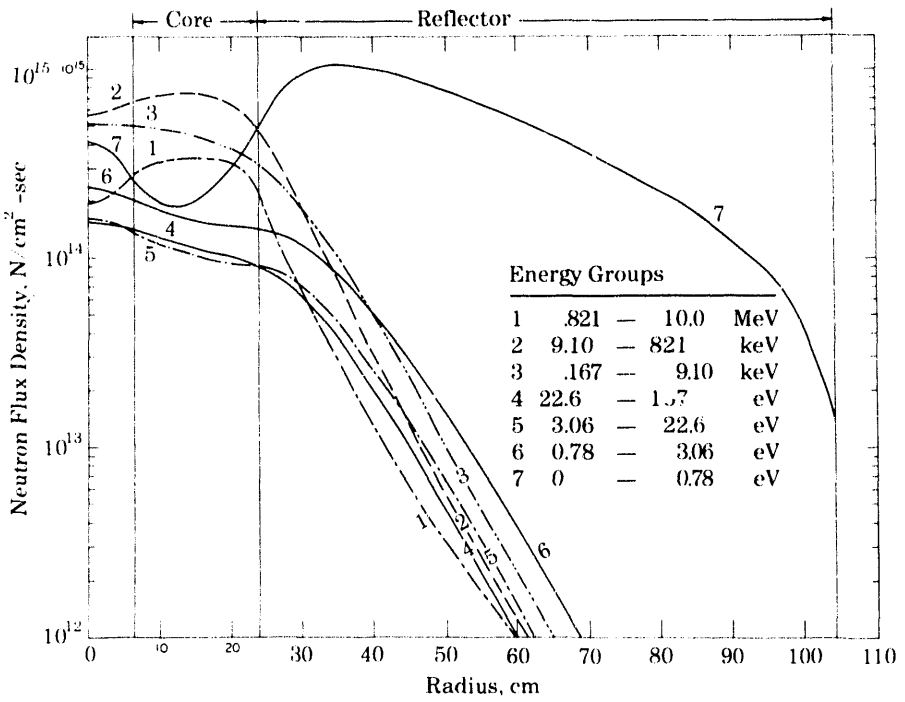


Figure 3. Calculated neutron flux distribution as a function of radial distance from the center of the core.

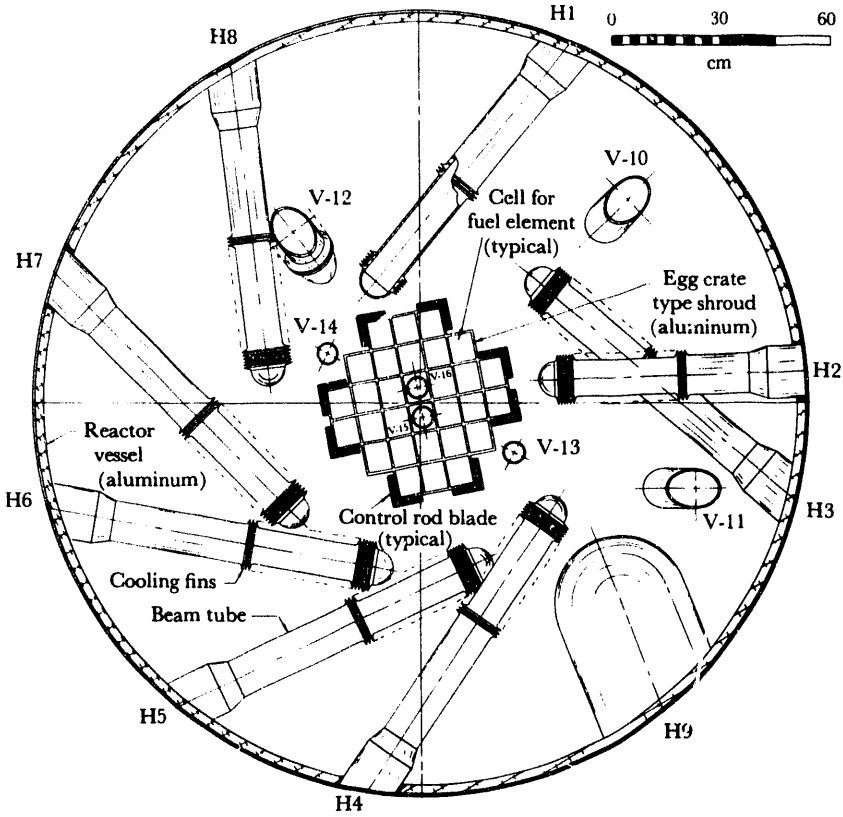


Figure 4. Plan view of the location of the experimental beam tubes and irradiation facilities within the reactor vessel.

day. Conversely, cold winter days coinciding with the end of the fuel cycle can prolong the cycle.

THE CONFINEMENT BUILDING

The reactor, its auxiliary equipment, and its experimental facilities are contained in a welded steel hemisphere 53.6 meters in diameter. While the reactor is in operation, the air pressure inside the building is kept slightly lower than the atmospheric pressure outside to insure that any air leakage is inward rather than outward. Access to the building is provided by a system of air locks. This building provides the final confinement barrier against the escape of radioactive material into the environment. All ventilation air leaving the building is processed through high-efficiency

particulate filters and charcoal absorbers before being discharged from a 100-meter stack.

There are three basic floors in the building. The bottom floor is known as the Equipment Level, whose main features are a shielded cell in the center of the floor, containing the primary coolant system pumps and heat exchangers, and the fuel storage canal. The highly radioactive spent fuel elements are discharged into the canal through a chute passing down from the top of the reactor vessel through the concrete shielding. The canal has storage capacity for as many as 833 elements. The canal is 6 meters deep for most of its length, with a 9-meter deep pit at the end of the fuel discharge chute. The spent fuel elements are stored under the shielding water of the canal until most of the radioactivity has died away and they can be shipped off site to a fuel reprocessing plant to recover the unused uranium-235.

Other auxiliary equipment located on this floor include heat exchangers and pumps for the coolant for the thermal shield and the biological shield, purification systems for the D_2O coolant and canal water, as well as the equipment supplying the building with electrical power, steam, hot water, and compressed air.

The Experimental Area occupies the middle floor. The reactor is located in the center of the floor, with its nine horizontal beam ports surrounded by massive shielding and complex equipment for external beam experiments. Laboratories, computer equipment rooms, and a health physics office are also located on this floor. A radial 18000 kg traveling beam crane serves this area. Access for trucks and fork lifts is provided by two separate air locks. There is a balcony above the main floor for observation which accommodates washrooms, offices, and air conditioning equipment. A machine shop is located adjacent to this level outside the confinement building.

The Operations Area is on the top floor of the building. The shielding structure of the reactor rises 2.3 meters above floor level in the center of this area. The reactor control room, the pumps and heat exchangers for the cooling system for the vertical irradiation tubes, the D_2O storage tank for the primary coolant system, offices, work rooms, and the fuel storage vault are located on this floor. An 18000-kg overhead crane services the top of the reactor and the adjacent area in which replacement of spent fuel elements takes place.

BEAM TUBE DESIGN

Figures 5 to 9 in this Section provide information which may be helpful to users in understanding the capabilities of the various instruments described in Section III, or in planning their experiments if some new type of installation is contemplated. Several types of beam tubes were incorporated into the design of the HFBR. Figure 5 shows H2, the only tube which "looks" directly at the core; it was designed specifically for nuclear studies employing fast neutrons. H3 is typical of the single thermal neutron tubes (Figure 6), used also at H1, H5, H7, and H8. Dual thermal tubes are used at H4 (Figure 7) and H6, facilitating development of two beam lines at each of these ports. Figure 8 shows H9, a special large diameter tube, which was designed to accommodate a cold neutron moderator. Figure 9 shows a more-or-less typical section in elevation of a beam tube penetration through the biological shield into the reactor vessel, along with a typical installation double-axis spectrometer.

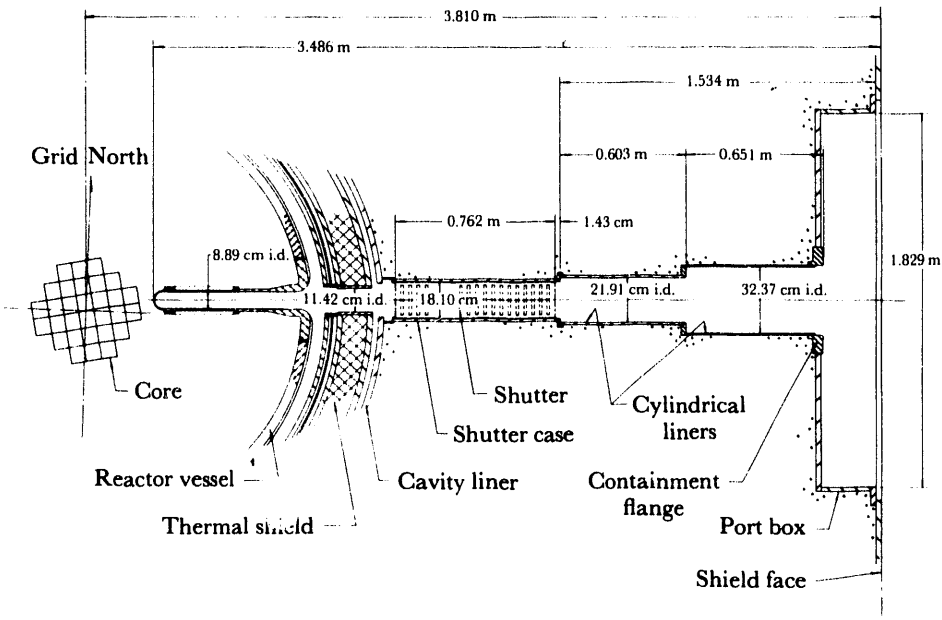


Figure 5. Plan of the beam tube H2 at the HFBR.

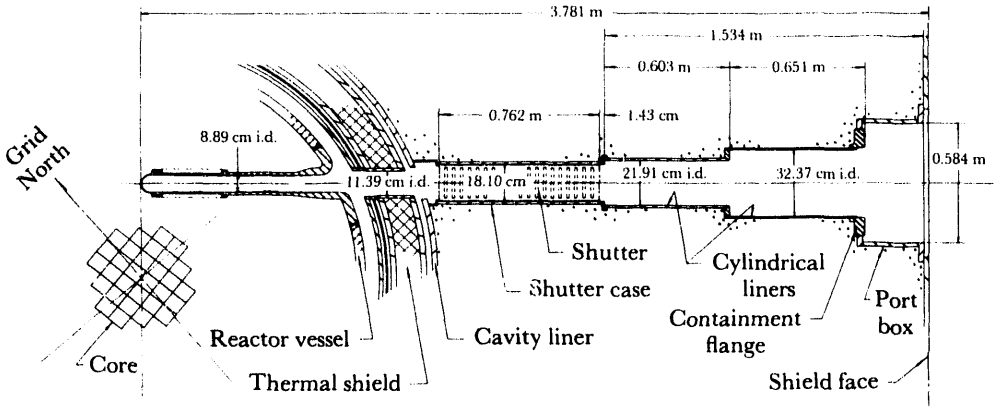


Figure 6. Plan of the beam tube H3 at the HFBR, which is typical of thermal tubes.

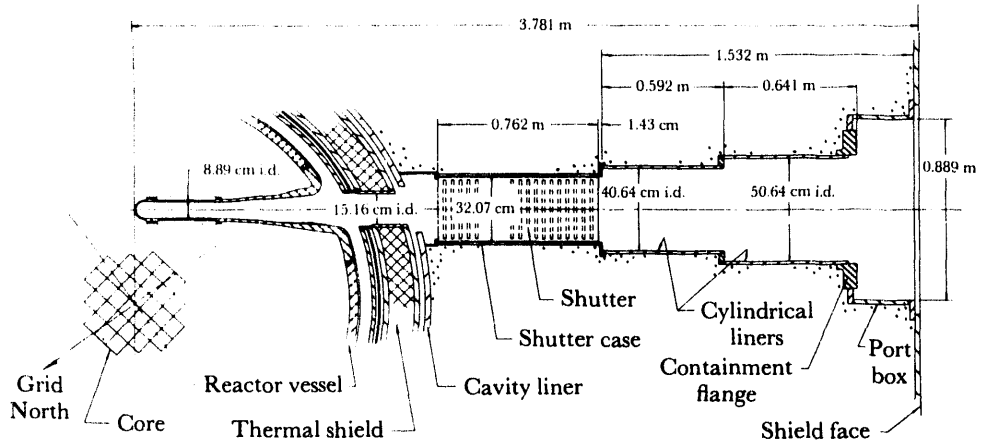


Figure 7. Plan of the beam tube H4, which is typical of dual thermal tubes at the HFBR.

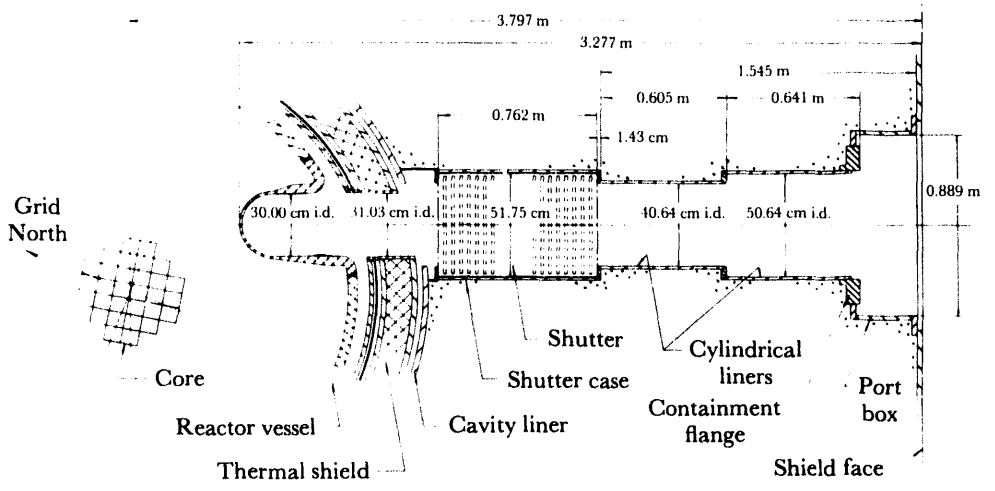


Figure 8. Plan of the beam tube H9 at the HFBR.

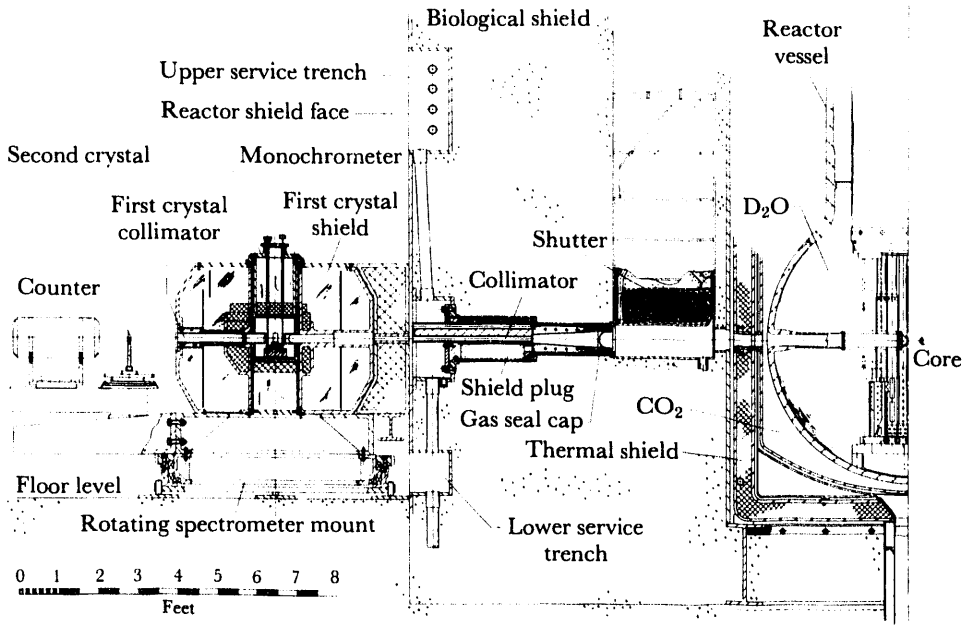


Figure 9. Elevation of the double-axis spectrometer and the beam tube (typical).

COLD NEUTRON MODERATOR

To provide intense beams of very low energy neutrons (≤5 meV), a liquid-hydrogen moderator system has been installed in the beam thimble of H9. The moderator chamber contains 1.4 liters of liquid hydrogen and is located near the inner end of the thimble as shown in Figure 10. Circulating cold helium gas from an external refrigerator maintains the hydrogen at a temperature of 19K. Neutrons from the surrounding heavy water blanket are moderated by scattering processes within the cold hydrogen, thus shifting the spectral distribution of the emerging beam towards lower energies. In operation, the system serves as a cold neutron source for three separate beams, designated as A, B, and C on Figure 10. The experimental stations for these beams are described under Section III., Experimental Beam Facilities.

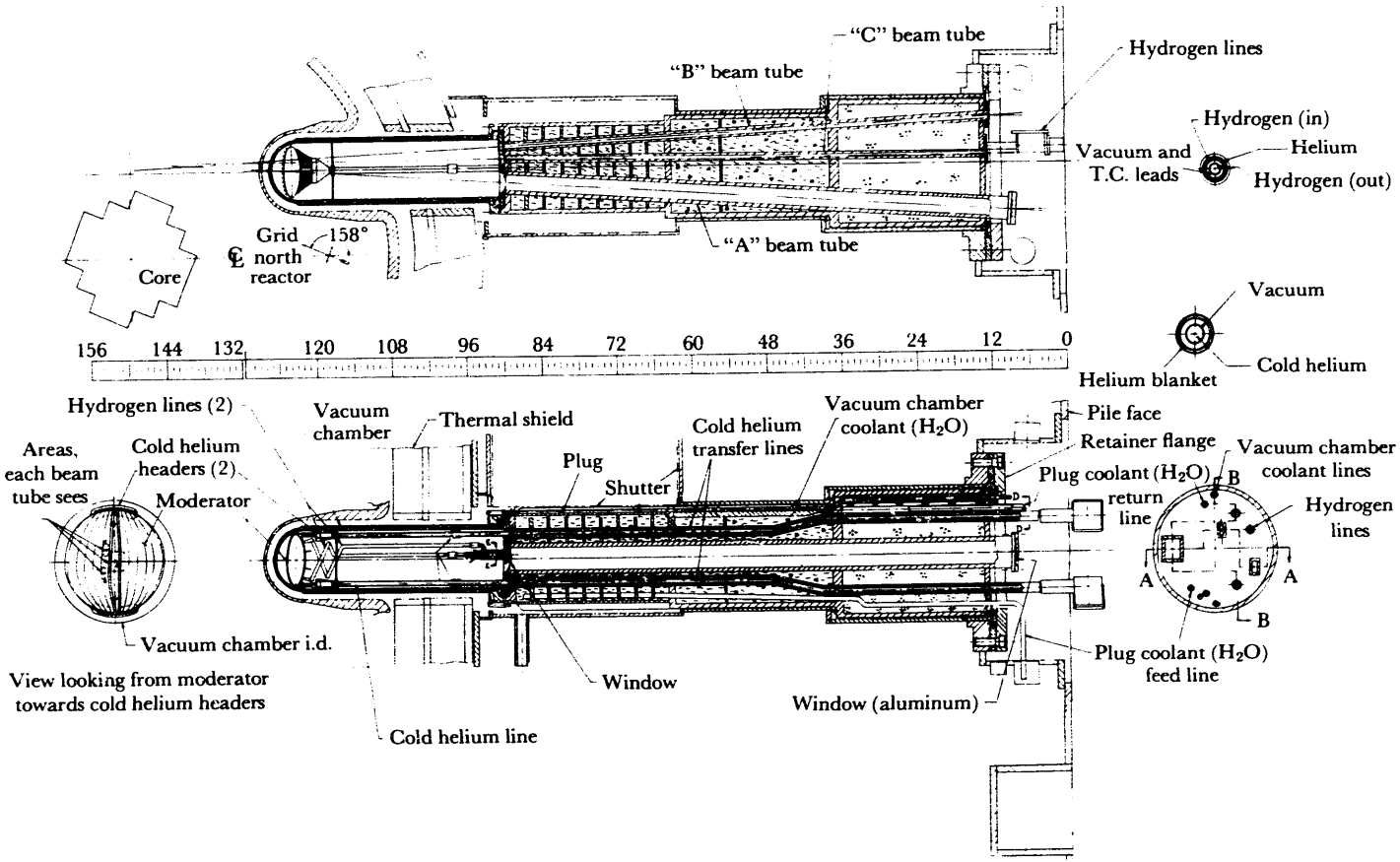
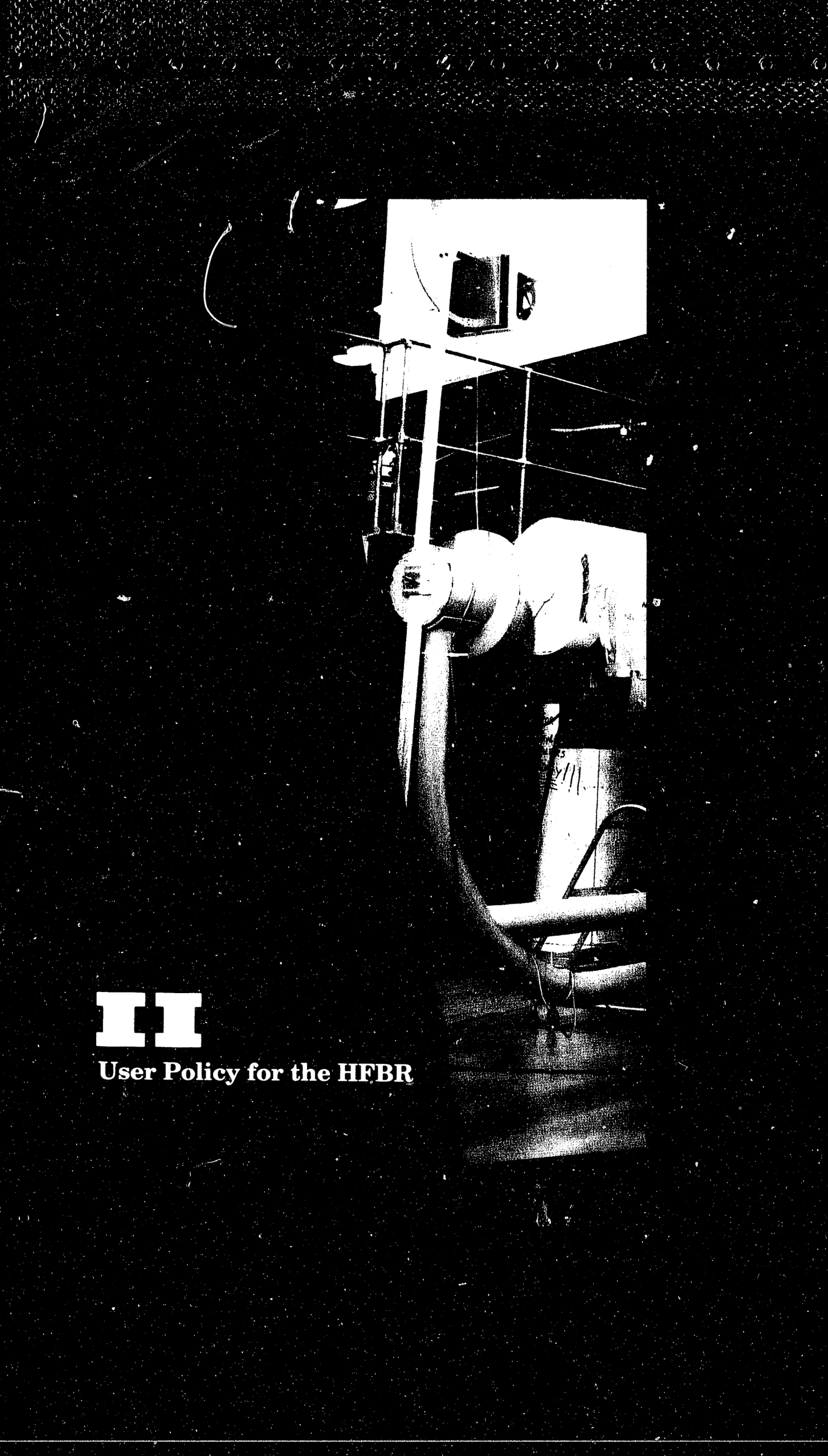


Figure 10. Cold neutron moderator and plug assembly installed in H9.



II

User Policy for the HFBR

2

II User Policy for the HFBR

The facilities described in this handbook are open to the general scientific community. Refer to the Policy Statement for Use of the HFBR in this section.

OVERVIEW OF THE PROCEDURE FOR RESEARCH PROPOSAL SUBMISSION

General users are encouraged to arrange with a BNL staff member to act as a local contact and to discuss the technical feasibility of the experiment before proposal submission. Proposal forms and information may be obtained from the HFBR User Administration Office (516) 282-5564. Research proposals for beam time allocation at the HFBR should be submitted to that office for forwarding to the appropriate HFBR Program Advisory Committee (PAC), Technical Subcommittee for review. Proposals are accepted for consideration throughout the year and the review process is continuous. Each proposal is evaluated for its scientific merit, technical feasibility, and safety criteria by the review committee representing the scientific discipline of the proposed research. Biology, Chemistry, Condensed Matter Physics, Materials Sciences, Nuclear Physics, and Positron Physics each have a technical subcommittee with members making recommendations to the chairman of the subcommittee, a member of the PAC. The result of the committee's review is sent to the spokesperson of the proposed experiment. Notification of approved proposals will include the name and phone number of the BNL Participating Research Team (PRT) member, who should be contacted to schedule the experiment.

There is no charge for beam time at the HFBR under nonproprietary research agreements, and researchers are expected to publish the results of their research in the scientific literature. Experimenters are urged to submit an "Experiment Report Form" (Page 4 of the proposal form) as soon as possible after completing an experiment, and a copy of any material to be published should be sent when it is available. This material will be included in annual reports and various budgetary reports. Proprietary research agreements can also be executed. but at the full-cost recovery rate. Technical questions may be directed to the HFBR Scientific Program Head, John D. Axe, Bldg. 510A, (516) 282-3821.

Submit Research Proposals to:

HFBR Program Advisory Committee; c/o Rae Greenberg, HFBR User Administration Office; Brookhaven National Laboratory; Director's Office/Physics Bldg. 510A; Upton, NY 11973 (Tel. 516-282-5564).

HFBR FACULTY-STUDENT SUPPORT PROGRAM

DOE is the sponsor of a faculty-student support program at the HFBR. Financial support for travel is available to enable faculty and student research teams to come to BNL to conduct research at the HFBR. Nine beam ports deliver intense external beams of thermal and subthermal neutrons to its 15 experimental stations. More information concerning the instruments and experimental programs are available upon request. To fulfill the educational and training goals of the program, it is intended that the research opportunity provided at the HFBR meet criteria of scientific excellence, that the results will be communicated to the scientific community, and that young scientists carry out their work in the field of neutron scattering investigations in solid state or nuclear physics, chemistry, or structural biology.

The guidelines for participating in the HFBR Faculty-Student Support Program are as follows:

Eligibility

U.S. Citizens or Permanent Resident Aliens from U.S. educational institutions.

Requests must be sponsored by a faculty member.

Preference will be given to applicants who do not have alternate sources of travel funds. (Reimbursement of expenses may be made provided that such payment does not represent dual compensation from any other U.S. Government Source.)

Preference will be given to first-time or infrequent users who do not have established funded research programs in neutron scattering.

Reimbursement

Authorized Travel expenses will be reimbursed in accordance with BNL's Domestic Travel Policy (SPI No. 4-01).

Airfare: Coach class at lowest fare.

Private Auto: Mileage at $.25 per mile, but not to exceed the cost of applicable airfare.

BNL Housing: Dormitory (maximum per diem); Guest House/Apartment/Single occupancy (no per diem); double occupancy ($25/day per diem).

Per Diem: Up to a maximum of $34 per day.

Applications for support should be submitted a month in advance of the anticipated visit to BNL.

The appropriate acknowledgment when referencing work sponsored by the HFBR Faculty-Student Research Support Program is: *"[Experimenter's Name(s)] "gratefully acknowledges support from the Department of Energy's Division of University and Industry Programs, Office of Energy Research, as a HFBR Faculty-Student Research Support Program participant."*

Applications and information are available from:

Rae Greenberg, HFBR User Administrator
Brookhaven National Laboratory
Director's Office/Physics Bldg. 510A, Rm. 1-30
Upton, New York 11973
Telephone: (516) 282-5564

POLICY FOR USE OF THE HFBR

Introduction

The policy for using the High Flux Beam Reactor (HFBR) at Brookhaven National Laboratory enables scientists at Brookhaven, at other national laboratories, at universities, and at industrial laboratories to cooperate in the use of existing spectrometers and in the design and fabrication of new facilities. Research should be conducted with a minimum of formal administrative interaction and with maximum room for spontaneous developments. To achieve these objectives, present and future experimental facilities at the HFBR will be divided into two categories — general user facilities and several spectrometers managed, designed, and instrumented by Participating Research Teams (PRTs).

A PRT is a group of qualified scientists with common research interests. It should consist of scientists from national laboratories, whose funds come from the DOE and other government agencies; industrial scientists with funds from their own institutions or from government agencies; university scientists with funds from the National Science Foundation (NSF) or other government agencies; or any combination of these. In return for its management and development of spectrometers, the PRT will be given priority use of these spectrometers for up to three-quarters of the scheduled beam time. The performance of a PRT will be reviewed periodically with respect to its scientific accomplishments and fulfillment of obligations to other HFBR users.

General users or user groups have access to the general user facilities and to the unawarded fraction of time on the spectrometers assigned to the PRTs. In the latter case, members of the PRT will be expected to provide technical assistance and, where mutually desirable, scientific collaboration with the "user" carrying out the experiment. Non-members of the PRTs will not be required to enter into a scientific collaboration as a condition for using a PRT spectrometer. Regular users of the HFBR are encouraged to become members of a PRT, by participating in the maintenance and development of experimental facilities.

Approval for Use of the HFBR

A Program Advisory Committee (PAC), appointed by the Director of Brookhaven National Laboratory, provides advice on the use of the HFBR. The PAC will have a broadly based membership consisting of specialists in the relevant scientific disciplines, from outside the laboratory and within. The PAC will obtain recommendations from technical subcommittees, chaired by a member of the PAC, and representing the different scientific disciplines.

Among the issues upon which the PAC will give advice are:

a. priorities for the use of the experimental facilities.
b. formation of PRTs.
c. approval of experiments for a general user or user group.

Proposals will be solicited for the use of the HFBR facility, including the formation of PRTs. Working through its subcommittees, the PAC will review and rank these proposals, taking into account not only scientific merit, but also resources available to specific proposed PRTs.

Approval for experiments for a general user or user group will be granted by the Laboratory Director, on advice of the PAC. For a PRT spectrometer, this approval will be granted in consultation with the spokesperson of the relevant PRT. Details of scheduling a PRT spectrometer will be left jointly to the user and PRT spokesperson.

Use of the HFBR by Participating Research Teams

Standing of PRT Members

Upon approval to place instruments at the HFBR, PRT members will be considered to be members of the HFBR community and will be expected to cooperate fully in providing services to general users, in improving operating conditions at the HFBR, and sharing designs for general instrumentation. A PRT may make changes in its membership provided they do not constitute a major reorganization. Such changes should be reported to the Program Advisory Committee.

Term of PRT

Each PRT shall submit an annual report of its activities and, every three years, its performance will be reviewed for its scientific accomplishments and the fulfillment of its obligations to other HFBR users. In the case of a PRT based on a new instrument, there will be an annual progress report during the construction period, but the three-year period for review of scientific accomplishments will start on the date that the instrument is commissioned.

PRT Service to Users

Each PRT will allocate a specific portion, not less than 25%, of the total operating time of each of its spectrometers for use by non-PRT members. The PRTs, acting as members of the HFBR community, will provide liaison and support to general users. This support includes keeping a file of appropriate information on spectrometer components, but does not necessarily include the provision of ancillary equipment needed to maintain environments for experimental samples. The PRT is responsible for scheduling time on its spectrometers for its own members and for general users.

Disputes

Any disputes about the use of the HFBR should be considered by the appropriate scientific subcommittee. If the subcommittee can not resolve the dispute, it should be referred to the full Program Advisory Committee.

Beam Charges

In accordance with the DOE policy, there will be no charge for the use of the HFBR provided that the research is of documented programmatic interest to the DOE, and the PRT user agrees to publish the results of the research in the scientific or technical literature. If the HFBR facility is used for proprietary research, a full-cost recovery fee will be charged for the amount of beam time used at a specified rate.

All individuals working at BNL must obtain an appointment with the Laboratory and must execute the appropriate Patent Agreement. [Refer to "Appointments" in Section V, General Information.]

PROPRIETARY RESEARCH

Proprietary research is work conducted under the U.S. Department of Energy (DOE) "Class Waiver of Government Rights in Inventions Arising

from the Use of DOE Facilities and Facility Contractors By or For Third Party Sponsors." Such research may be conducted by private individuals, representatives from educational institutions, nonprofit organizations, or industry. Under the terms of the DOE Class Waiver, the user is obligated to pay the full-cost recovery rate for usage of the HFBR; in return the user has the option to take title to any inventions made during the proprietary research program and to protect all proprietary technical data generated during the proprietary research program. The terms and conditions under which such proprietary research may be conducted at the HFBR are set forth in the *HFBR Proprietary User's Agreement.*

The following steps outline the sequence that a proprietary user goes through to conduct proprietary research at the HFBR, including procedures related to requirements before and after an experimental run is performed at the HFBR under a proprietary user's agreement.

1) A user who wants to conduct proprietary research at the HFBR must first enter into a formal HFBR Proprietary User's Agreement with Associated Universities, Inc., (AUI), operator of Brookhaven National Laboratory. Such an Agreement is between AUI and the legal entity sponsoring the research (i.e., the private individual, university, or corporation). The Agreement is prepared by the BNL Office of Technology Transfer, and any questions pertaining to negotiating such an agreement should be directed to M.C. Bogosian, BNL's Patent Counsel, at (516) 282-7338.

2) Once the HFBR Proprietary User's Agreement is finalized, proprietary users must submit a nonproprietary description of the experimental work to be performed at the HFBR facility by submitting an *HFBR Proprietary Research Proposal Form.* Proposals for proprietary research may be submitted for an experiment or an experimental program. In many cases there are numerous research proposals covered by one proprietary user's agreement. Failure to submit this form in advance of an experimental run violates the User's Agreement and jeopardizes the intellectual property rights of the proprietary user.

3) HFBR Proprietary Research Proposals are to be submitted to the HFBR User Administrator, who will process the proposal to obtain programmatic approval from the HFBR management. At that time a confirmation letter will be sent to the proprietary user along with a proposal number.

4) Proprietary users who have received programmatic approval will be required to set up an account with Brookhaven to suitably cover charges they will incur. This can be done by forwarding a purchase order

to Mr. Bernard J. McAlary, Business Manager. This order should state that it is for proprietary research expenses and should identify who will have signature authorization for charging expenses against this account, state the authorized charge ceiling of the account, and the expiration date of the order. It is requested that individual accounts be established for each Proprietary Research Proposal.

Send the Purchase Order to BNL's Business Manager:

Mr. Bernard J. McAlary
Brookhaven National Laboratory
Director's Office, Building 460
Upton, New York 11973
Telephone: (516) 282-3330

5) At this point the proprietary user has fulfilled all necessary requirements as outlined in the HFBR Proprietary User's Agreement. However, all visitors working at the HFBR must obtain a Guest Appointment with the Laboratory [Refer to Appointment Procedure, Section V, General Information]. This can be arranged with the HFBR User Administrator, located in the Physics Building 510 (Room 1-30), Telephone (516) 282-5564. Researchers should check in at this office as soon as possible after arriving at BNL to obtain an application card for a photo I.D. and to schedule the safety and access orientation training at the HFBR, which is required to obtain an access card and radiation badge.

6) The proprietary user is required to submit an *HFBR Cost Reimbursable Reporting Form* to the HFBR User Administrator at the end of each month in which experiments were performed. Invoices will be sent to the proprietary user based on the information in this form.

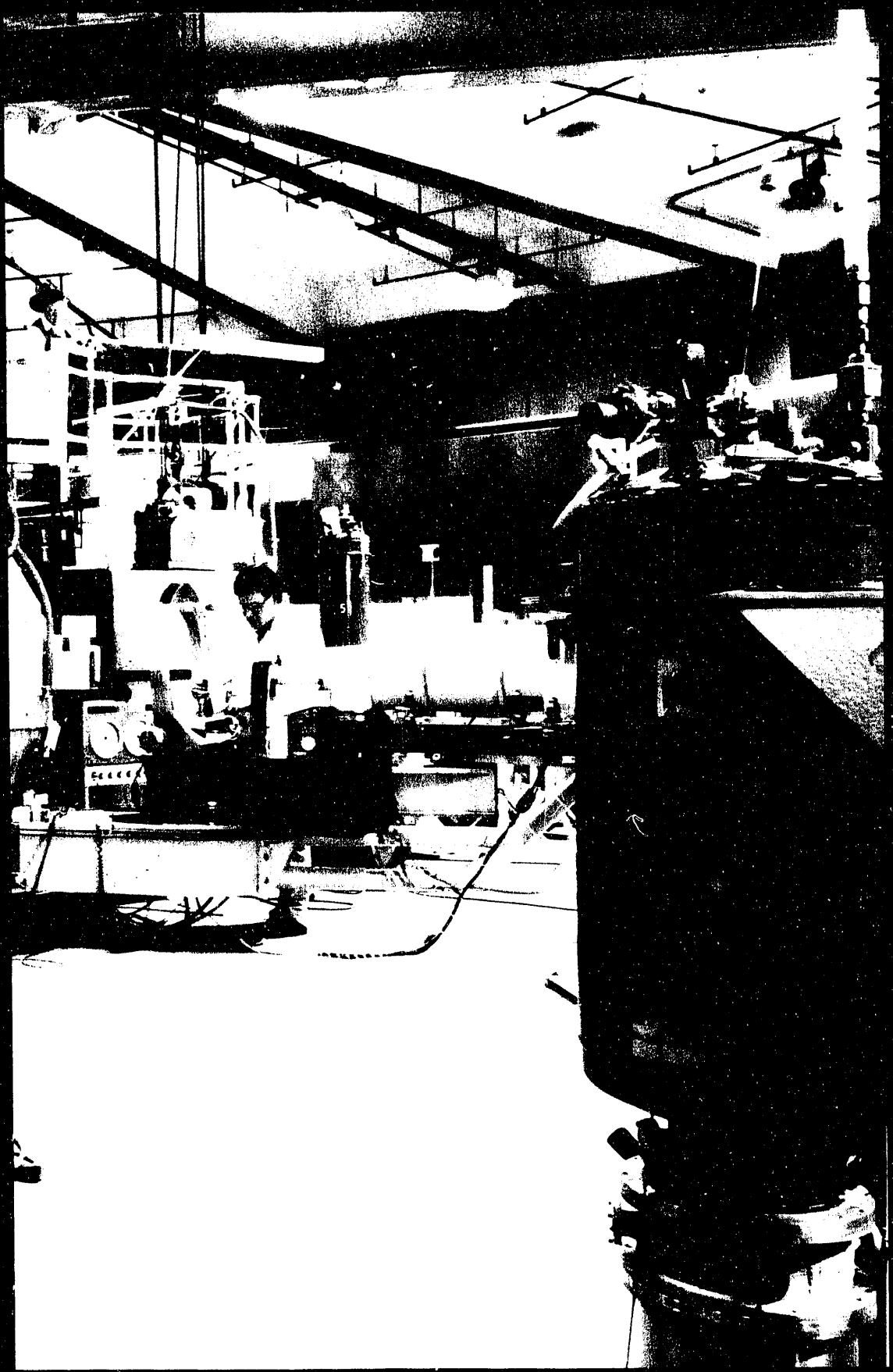
7) In accordance with the HFBR Proprietary User's Agreement, upon completion of the proprietary experiment or experimental program, the proprietary user must submit to the HFBR User Administrator a nonproprietary description of the work performed (Forms available).

Questions pertaining to proprietary research at the HFBR should be directed to:

John D. Axe
HFBR Scientific Program Head
Director's Office, Physics Bldg. 510A
Brookhaven National Laboratory
Upton, New York 11973
Telephone: (516) 282-3821

III

Experimental Beam Facilities



Experimental Beam Facilities

The instruments available at the HFBR have been developed to cover a wide range of scientific studies. Figure 13 shows a schematic floor layout of the various beam ports, H1 through H9, and the basic experimental installations at each port. The latter may be classified according to their main use:

Nuclear Physics

H1-B

H2 (TRISTAN)

Inelastic Scattering

(Cold Neutrons)

[Triple-axis Spectrometers also useful for Diffraction]

H4-M

H5

H9-A

H7

H8

Neutron Diffraction

H1-A Powder Diffraction

H4-S Powder Diffraction*

H6-M Single Crystal Diffraction

H6-S Single Crystal Diffraction

H9-D Reflectometry

*H4-S is also used for single crystal diffraction and inelastic scattering

Biological and Small Angle Scattering Studies

H3-A Protein Crystallography

H3-B Intermediate Resolution

SANS

H9-B High Resolution SANS

Details on these experimental stations are given in the subsections which follow.

HFBR EXPERIMENTAL STATIONS

		Extension
H1-A	Spectrometer (High Resolution Neutron Powder Diffractometer)	3182
H1-B	Spectrometer (Nuclear Physics)	4407
H2	TRISTAN Mass Separator (Nuclear Physics)	4407
H3-A	Spectrometer for Protein Crystallography	4440
H3-B	Spectrometer for Intermediate Resolution SANS Station	4440
H4-M	Spectrometer (Polarized Beam-Inelastic)	4412
H4-S	Spectrometer (Powder Diffraction & Inelastic Scattering)	4167
H5	Spectrometer (Inelastic Scattering)	4438
H6-M	Spectrometer (Diffraction)	3939
H6-S	Spectrometer (Diffraction)	3939
H7	Spectrometer (Inelastic Scattering)	4404
H8	Spectrometer (Polarized Beams, Inelastic Scattering)	4404
H9-A	Spectrometer (Inelastic Scattering Cold Neutrons)	2329
H9-B	Spectrometer for Small Angle Scattering	4440
H9-D	Reflection Spectrometer	2329

ADDITIONAL CONTACTS

Research Coordinator 5204

Reactor Operations 4442

Computer Room 4411

Control Room 4417/4418

Safety & Environmental Protection Group at HFBR 4424
Pager (3456) 0135

Reactor Division Management, Bldg. 120 ..... 4061/4056
FAX No. 2560

HFBR Receptionist 4432/4433

Status of Operations at the HFBR 7575

HFBR, Bldg 750 ..... FAX No. 5218

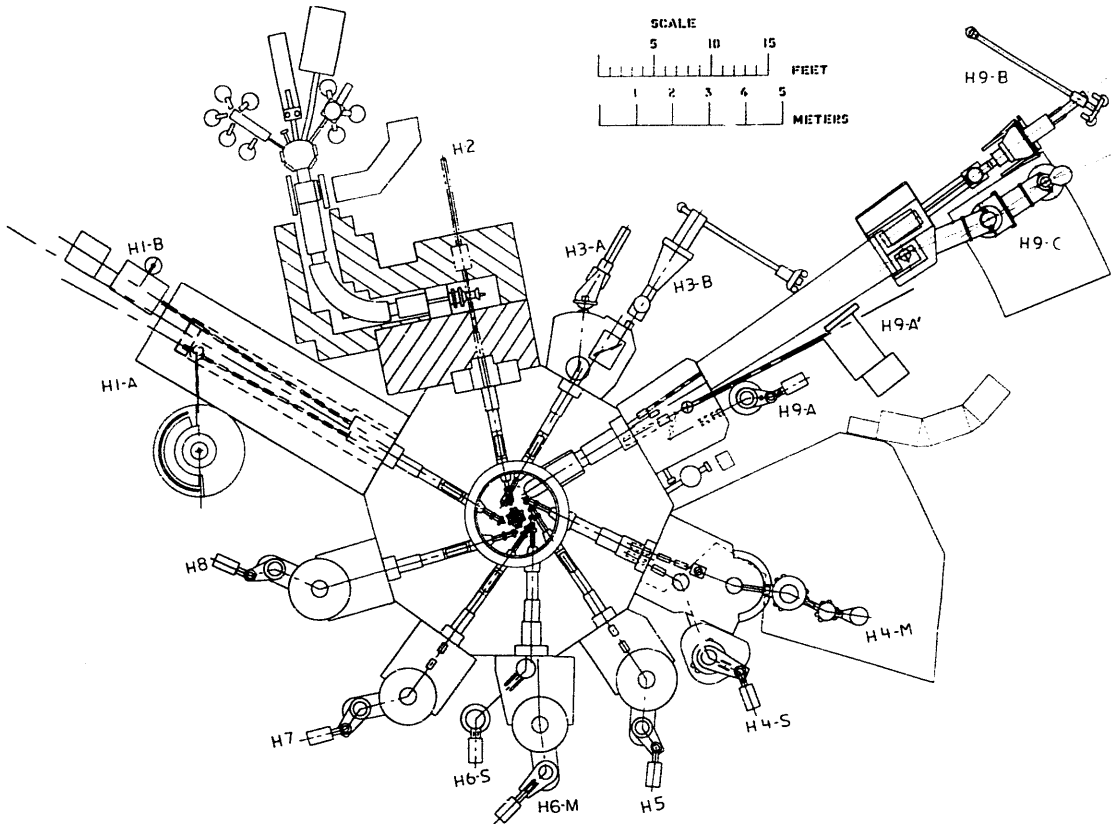


Figure 13. Schematic of the Experimental Floor of the Reactor, beam ports H1-H9.

H1-A SPECTROMETER (HIGH RESOLUTION NEUTRON POWDER DIFFRACTOMETER)

Presently under construction, the High Resolution Neutron Powder Diffractometer will provide an instrument dedicated to structural studies of polycrystalline materials of interest in solid state physics, solid state chemistry, materials science, and mineralogy. It will be capable of higher resolution ($\Delta d/d = 5\times10^{-4}$) than is presently available in the United States. It will make feasible structural determinations on materials with large unit cells, and will extend the possibilities for *ab initio* structure determinations, the study of micro-strain and small crystallite size effects into new areas.

The resolution is tailored to be highest at large scattering angle, where the Bragg peak density is greatest. This is achieved by a careful matching of collimation and large monochromator scattering angle, which is fixed at 120°. A series of focussing (venetian-blind) monochromator crystals will provide a range of wavelengths. The initial monochromator will be (511) Ge, with λ=1.9Å. Figure 14 shows the layout of the spectrometer. The detector assembly consists of 64 film collimators of 5 min resolution, each backed by a Helium-3 detector. The collimators are on 2.5 degree centers, covering a total of 160 degrees. The details of the data acquisition and analysis equipment are not yet finalized.

The High Resolution Neutron Powder Diffractometer will be operated in a Participating Research Team (PRT) mode, the PRT using 50% of the available time and general users the remaining 50%.

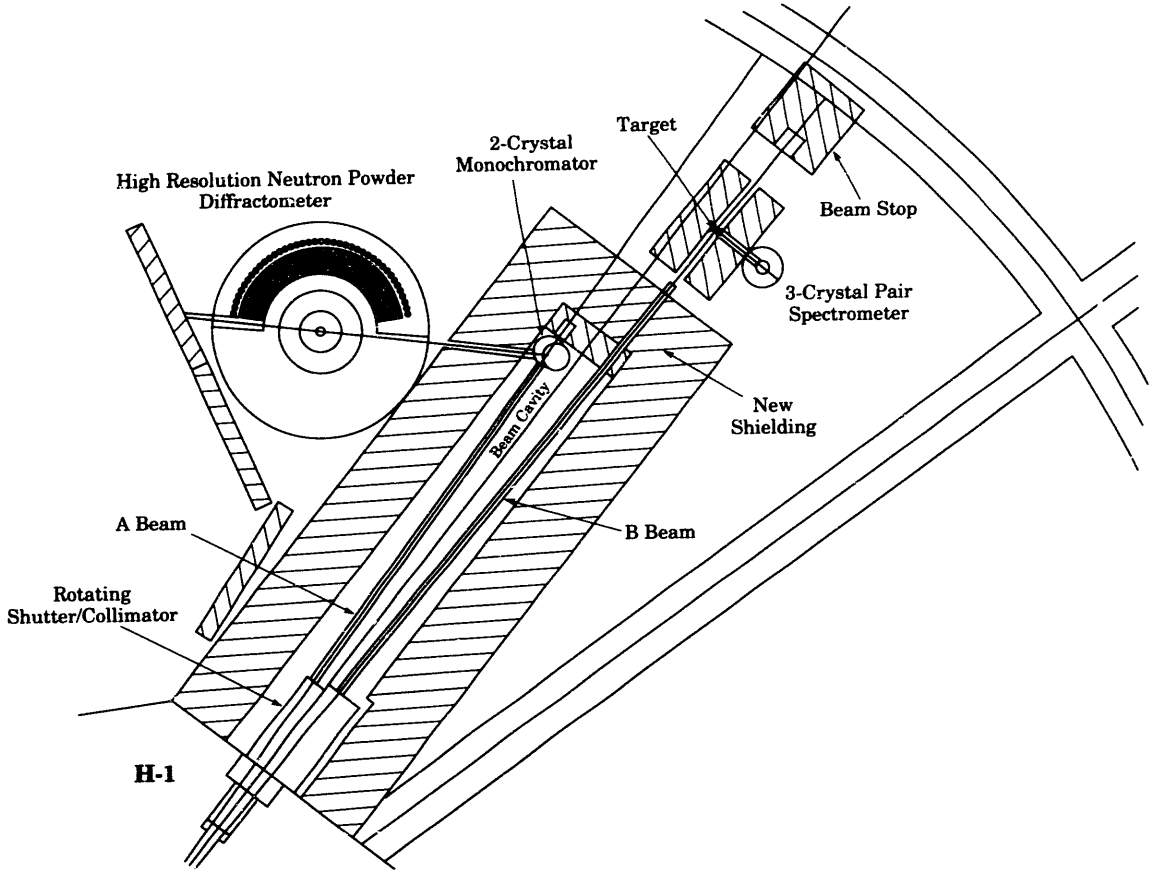


Figure 14. Schematic view of High Resolution Neutron Powder Diffractometer (H1-A) and 3-crystal Pair Spectrometer (H1-B).

H1-B ARC SPECTROMETER (NUCLEAR PHYSICS)

At H1-B, a flexible, external sample facility offers sources for capture studies in the keV range using the Average Resonance Capture (ARC) technique. Filters for tailoring the beam are contained in a 4-position rotary collimator external to the reactor shield. A set of filters can be rapidly interchanged so as to span a broad range of neutron energies in a study of a single nuclide. A 3-crystal pair spectrometer (Figure 14) is used to detect primary γ-rays in (n,γ) experiments using filtered beams at thermal, 2 keV, and 24 keV with an efficiency of about 3% relative to a 7.6×7.6 cm² NaI standard detector. Data are routed into a Micro VAX II computer for analysis.

H1-B Station Parameters

Filter	Beam Energy	Width (FWHM)	Size (cm)	Intensity (n/sec)	Purity (%)
22.86 cm Fe 36.20 cm Al 6.35 cm S	24.3 keV	2.0 keV	7.27×2.8	1.4×10^{7}	98
68.58 cm ^{56}Fe (98.87%)	24.3 keV	1.0 keV	7.27×2.8	1.5×10^{6}	80
30.48 cm ^{56}Fe 17.78 cm Al	24.3 keV	1.7 keV	7.27×2.8	4.20×10^{7}	95
71.1 cm Sc	2.0 keV	0.9 keV	7.27×2.8	7.1×10^{7}	70
Bi single crystal	thermal	Maxwellian	<7.27×2.8 (variable)	~10^{9}	

Detector: 3-crystal pair spectrometer

H2 TRISTAN MASS SEPARATOR (NUCLEAR PHYSICS)

Ion sources of thermal, plasma, and specialized types are used to provide beams ranging in intensity from 10^2-10^7 atoms/sec.

An on-line, isotope separator facility called TRISTAN is installed at the H2 beam line (Figures 15-16). An ion source containing 5g of ^{235}U in a thermal flux of 2.5×10^{10} n/cm^2/sec produces ions of rare short-lived, neutron-rich fission products. The ions are electrostatically extracted, accelerated to 50-60 keV, and separated by a 90° bending magnet. At the focal plane of the magnet the ions of the selected mass pass through a slit and are directed by a switching magnet to one of four experimental instrument stations. Ge, Si, and BaF_2 detectors are used for γ-ray and conversion electron spectroscopy picosecond-range-lifetime measurements (with the FEST technique). A 74 kG magnet is used for perturbed angular correlation studies. Data are recorded and preprocessed by a CAMAC-linked PDP and Micro-VAX II computer system

Figure 15. Experimenters at the TRISTAN mass separator facility located at H2.

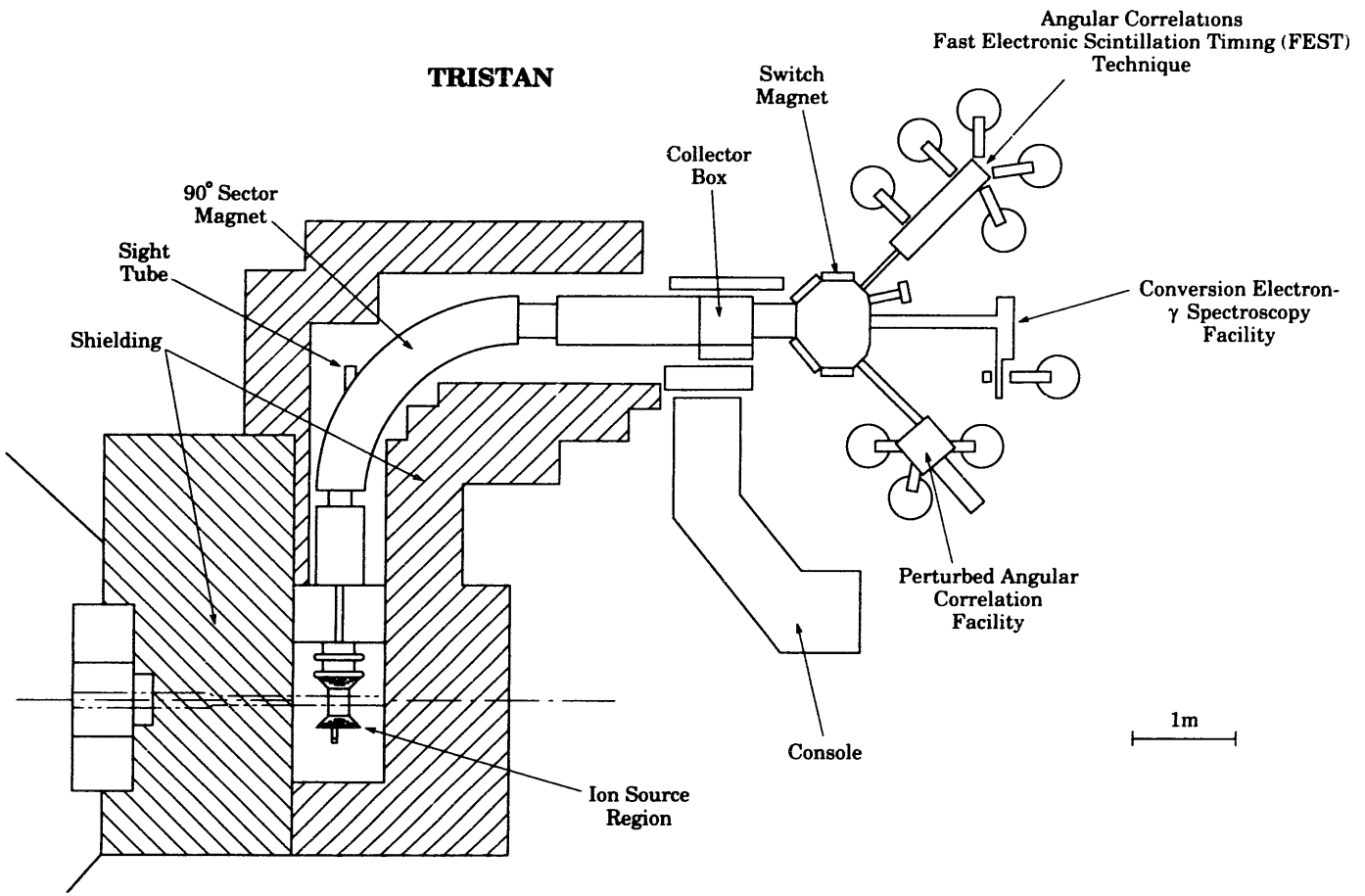


Figure 16. Schematic plan of TRISTAN installed at H2.

H3-A S
FOR PROTEIN CRYSTALLOGRAPHY

This protein crystallographic station features a two-dimensional position-sensitive counter on a four-circle diffractometer. The computer system controls the diffractometer, processes the counter data and permits on-line interactive display. The position-sensitive counter has an efficiency of ~80% with a resolution of 1.5 mm and a counting rate of $\sim 10^5$ c sec; data are directly encoded into an extended memory in a time slicing mode. There is a remote-controlled monochromator (pyrolytic graphite) with variable circular focusing collimation and provisions for filters.

H3-A Station Parameters

Flux at sample	$\sim 2.8 \times 10^7 n/cm^2$-sec
Monochromator	(002) pyrolytic graphite, $2\theta = 27.15°$ (focusing)
Filter	Pyrolytic graphite
Wavelength λ	1.57 Å (33 meV) (variable)
Beam size at sample (FWHM)	6 mm diameter, 20′ divergence (variable)
Sample scattering angles	$-80° < 2\theta < 80°$
Detector	^{3}He filled position-sensitive detector 20×18 cm, 256×128 pixels. Detector to sample distance is 510 - 2000 mm. Counter resolution= 1.5 mm.
Efficiency	~80%

H3-B INTERMEDIATE RESOLUTION SANS STATION

The H3-B spectrometer (Figure 17) is designed for a study of partially ordered systems, such as stacked biological membranes and model membranes. It may also be used for solution scattering studies of small molecules, micelles, and vesicles. The incoming neutron beam is monochromated by reflections from two parallel multilayer monochromators placed inside the shielding blocks (Figure 18). The spectrometer consists of a 20cm×20cm position-sensitive detector, a linear sample changer and an auxiliary cradle, a time-slicing processor with a switching time of a few microseconds, and a computer system for on-line analysis and display of data and results.

H3-B Station Parameters

Wavelength	1.7 - 4.5Å
Wavelength Bandwidth ($\Delta\lambda/\lambda$)	0.03 - 0.15
Maximum beam size at sample	1.0cm (H)×2.0cm (V)
Sample scattering angle (2θ)	-5 to 40°
Sample to detector distance	50 - 250cm
Detector dimensions	20cm×20cm
Detector resolution	1.3mm (H), 2.5mm (V)
Q range	0.01 - 3.0Å^{-1}

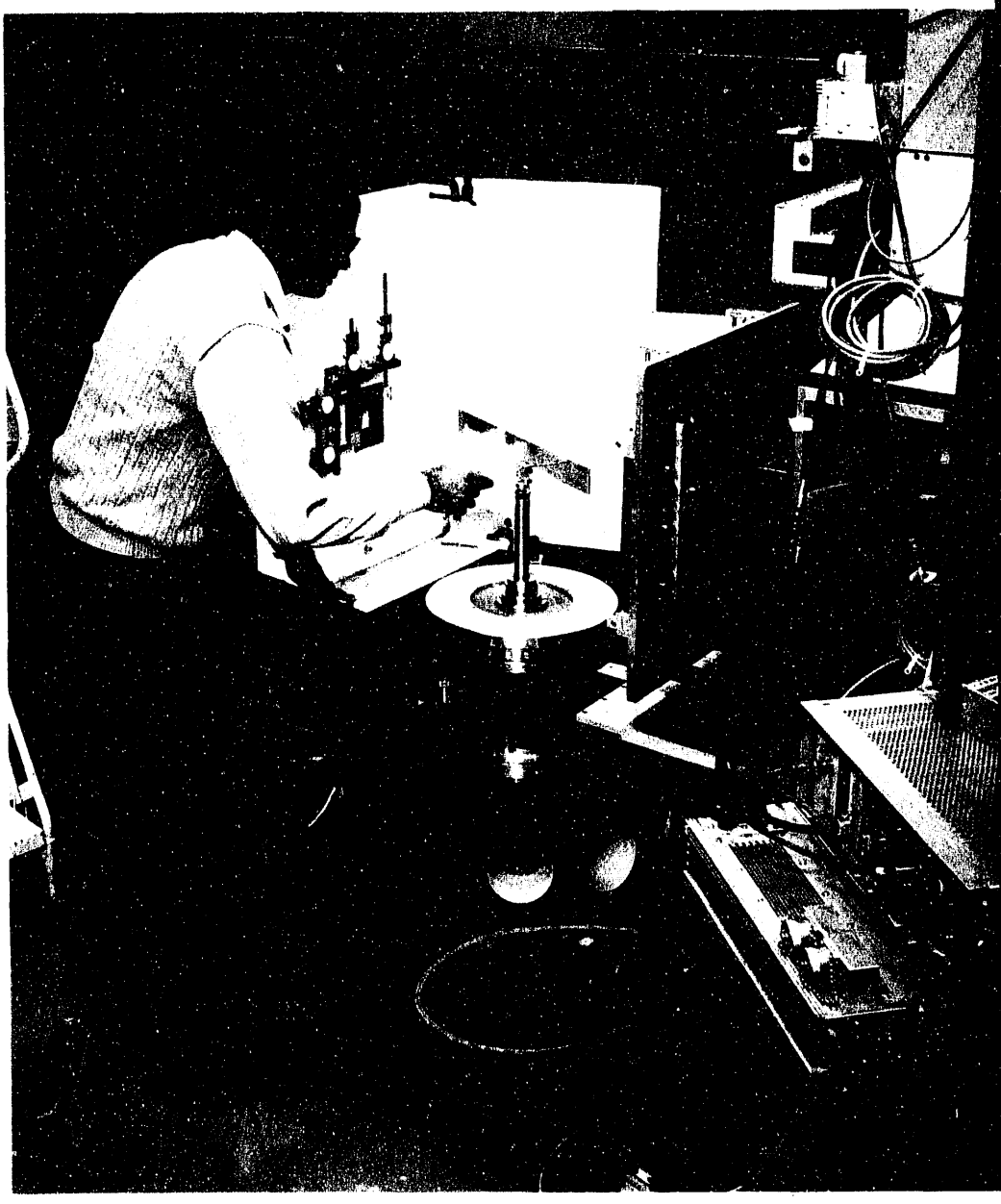


Figure 17. Anand Saxena at the intermediate resolution SANS spectrometer at H3-B.

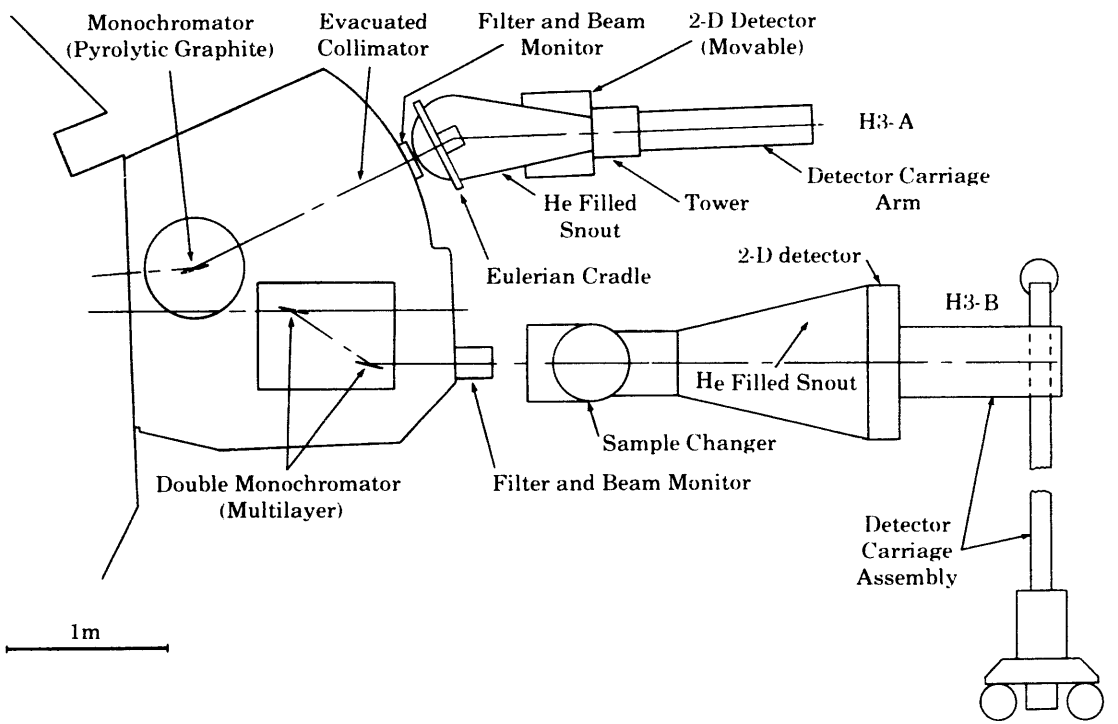


Figure 18. Schematic plan of spectrometers installed at H3.

H4-M SPECTROMETER
(POLARIZED BEAM, INELASTIC SCATTERING)

The H4-M is a triple-axis spectrometer constructed by the U.S.-Japan Cooperative Research Program in Neutron Scattering (Figures 19-20). Both incident and final neutron energies can be scanned in a conventional triple-axis mode of operation by using either focusing pyrolytic graphite (002) or Heusler (111) polarizing monochromators, or analyzers for unpolarized or polarized neutron scattering, respectively. Optional in-pile Pb and Be filters are provided to remove higher order beam contamination. The sample table is equipped with the standard two arm goniometer which is compatible with a variety of cryostats and furnaces. Sample and analyzer tables move on air pads, and the distances between monochromator, sample, and analyzer are adjustable. For polarized beam work, high efficiency flat coil π-flippers and guide fields are available. Time-of-flight capabilities with several detectors are also available. The collimators are the high-efficiency film type.

H4-M Station Parameters

Flux at monochromator position	3.5×10^{9}n/cm^2-sec
Monochromator scattering angle	$10°<2\theta_M<95°$
E_0 or λ_0 (PG 002)	$3.3<E_0<240$ meV $4.95>\lambda_0<0.58$ Å
Beam size	3.8×7.6 cm^2
Sample scattering angle	$-20°<2\theta_S<155°$
Drum to sample axis distance	$0.7<L<3$ m
Detector	^{3}He
In-pile collimation	20′, 40′
External collimation	5′, 10′, 20′, 40′ or 80′

Figure 19. Leonid Rebelsky aligns a cryostat at the H4M 3-axis spectrometer.

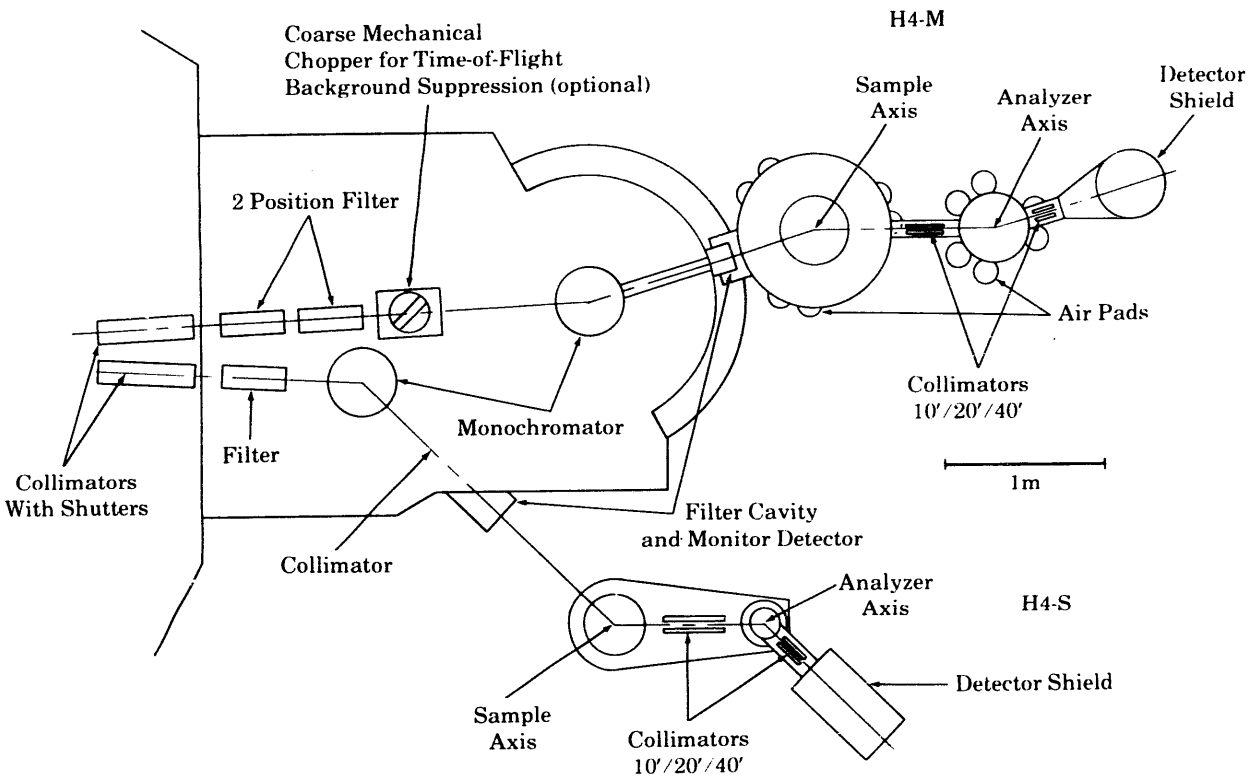


Figure 20. Schematic of neutron spectrometers installed at H4.

H4-S SPECTROMETER
(POWDER DIFFRACTION AND INELASTIC SCATTERING)

The H4-S spectrometer is used for a broad program of materials science research and is operated by a consortium, including the University of Pennsylvania, Exxon, IBM, DuPont, Ohio State University, and Brookhaven (Figure 21). A fixed monochromator take-off angle of 2θ=41.1° gives an incident energy of either 14.7 meV or 44.2 meV by remote selection of pyrolytic graphite (002) or silicon (220) crystals. A quick-change feature allows either triple-axis single-detector or double-axis multi-detector (10 counters) modes of operation. This is a particularly useful combination for a wide range of powder diffraction experiments with a maximum Q of 8Å^{-1} and a minimum $\Delta Q/Q$ of 3×10^{-3}. Samples can be studied over a temperature range 1.2K <T<800K, and a high-pressure cell is available. Technical and scientific support for first-time users is available.

H4-S Station Parameters

Flux at monochromator position	4.0×10^{9} n/cm^2-sec
Monochromator scattering angle	$2\theta_M$=41.4°
E_0 or λ_0 with (PG 002)	14.7 meV (2.34 Å)
E_0 or λ_0 (Si 220)	44.2 meV (1.36 Å)
Beam size at sample	5 (h)×2.5 (w) cm^2
Sample scattering angle	$-30°<2\theta_S<125°$
In-pile collimation	20′, 40′
External collimation	10′, 20′, 40′
Detectors	^{3}He

Figure 21. Scientists from Exxon Corporation and the University of Pennsylvania adjusting a furnace on the H4S spectrometer. Left: David Vaknin (now at Ames Laboratory); Right: D. Scott Coburn (now at BNL).

H5 SPECTROMETER (INELASTIC SCATTERING)

H5 is a triple-axis spectrometer used primarily for single crystal inelastic experiments, although it can often be used effectively for studying polycrystalline and amorphous samples (Figures 22-23). The instrument is fully automated for variable incident neutron energies. It is normally equipped with (002) pyrolytic graphite monochromator and analyzer crystals, but Be, Cu, Zn, and Ge monochromators are also available. Optional in-pile Be and pyrolytic graphite filters are provided for removing higher order contamination. The sample table is equipped with manual two-axis goniometers with ±10° range, and is compatible with a variety of available cryostats and furnaces. External collimation (other than in-pile) is provided by Soller slits with a 5.1×5.1 cm^2 cross section. The beam incident on the sample is monitored by a high transmission, low efficiency uranium foil detector. A 15 element multi-collimator/detector array is also available for powder diffraction studies.

H5 Station Parameters

Flux at monochromator position (20′ in-pile collimation)	4.2×10^9 n/cm^2-sec
Monochromator scattering angle	$10°<2\theta_M<55°$
E_0 or λ_0 (PG 002)	$8.5<E_0<240$ meV $3.09>\lambda_0>0.58$ Å
Beam size	5×3.1 cm^2
Sample scattering angle	$-45°<2\theta_S<125°$
Analyzer scattering angle	$-100°<2\theta_A<100°$
In-pile collimation	10′, 20′, or 40′
External collimation	10′, 20′, or 40′
Detector	BF_3

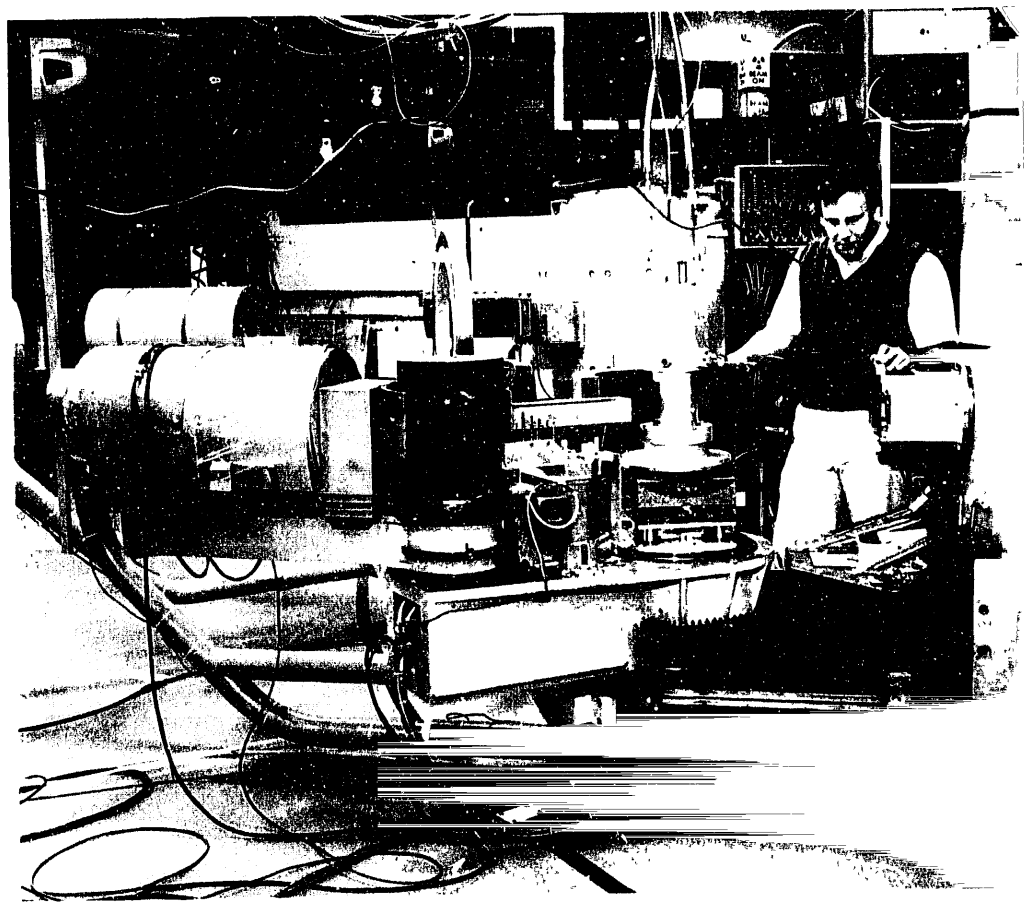


Figure 22. John Larese adjusts the beam at the H5 triple-axis spectrometer.

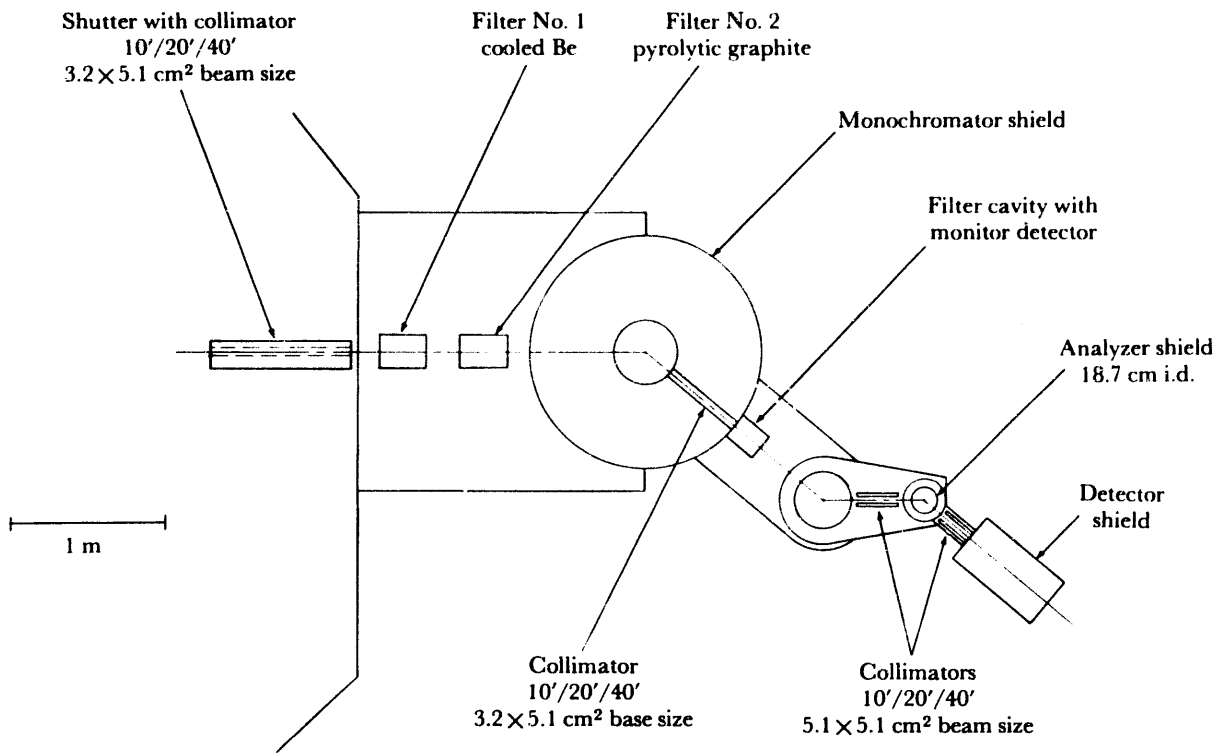


Figure 23. Schematic plan of the triple-axis spectrometer installed at H5.

H6-M SPECTROMETER (DIFFRACTION)

H6-M is a triple-axis spectrometer used primarily for single crystal elastic studies (Figures 24-25). A single crystal monochromator is used with a variable scattering angle allowing for a choice of incident wavelengths. The spectrometer is equipped with a computer-controlled 4-circle goniometer, which allows complete freedom in orienting single crystal samples. A variety of cryostats and furnaces are available for work over a wide temperature range. An extensive library of operating programs provides automatic reflection centering, unit cell and orientation matrix refinement, and collection of diffraction intensities by the step scan method. The spectrometer control computer is connected to the BNL local area network, so that the data are readily accessible for processing, from hosts both on- and off-site.

H6-M Station Parameters

Flux at monochromator (20′ in-pile collimation)	4.1×10^9 n/cm^2-sec
Monochromator scattering angle	$21°<2\theta_M<56°$
λ_0 or E_0 (Be 002)	$1.69>\lambda_0>0.65$ Å $28.5<E_0<192$ meV
Beam size (maximum)	3.2 (h)×4.9 (w) cm^2
Sample scattering angle	$-30°<2\theta_S<113°$
Analyzer scattering angle	$-120°<2\theta_A<120°$
In-pile collimation	1.9 cm diam hole, or 20′
External collimation	10′, 20′, or 40′
Detector	BF_3

H6-S SPECTROMETER (DIFFRACTION)

H6-S is a spectrometer used primarily for single crystal elastic scattering measurements. A single crystal monochromator is used with a fixed scattering angle ($2\theta_M$=34°) corresponding to λ=1.16 Å for the Ge (220) reflection or λ=1.05 Å for Be (002). The spectrometer is equipped with a computer-controlled 4-circle goniometer which allows complete freedom in orienting single crystal samples. A variety of cryostats and furnaces are available for work over a wide temperature range. An extensive library of operating programs is available for automatic reflection centering, unit cell and orientation matrix refinement, and collection of diffraction intensities by the step scan method. The spectrometer control computer is connected to the BNL local area network, so that the data are readily accessible for processing, from hosts both on- and off-site.

H6-S Station Parameters

Flux at monochromator	6.6×10^9 n/cm^2-sec
Monochromator scattering angle	$2\theta_M$=34°
λ, Ge (220) or Be (002)	1.16 Å or 1.05 Å
Beam size	0.6 cm — 2.5 cm (diam)
Sample scattering angle	$-21<2\theta_S<109°$
In-pile collimation	20′, 40′
External collimation	10′, 20′, or 40′
Detector	BF_3

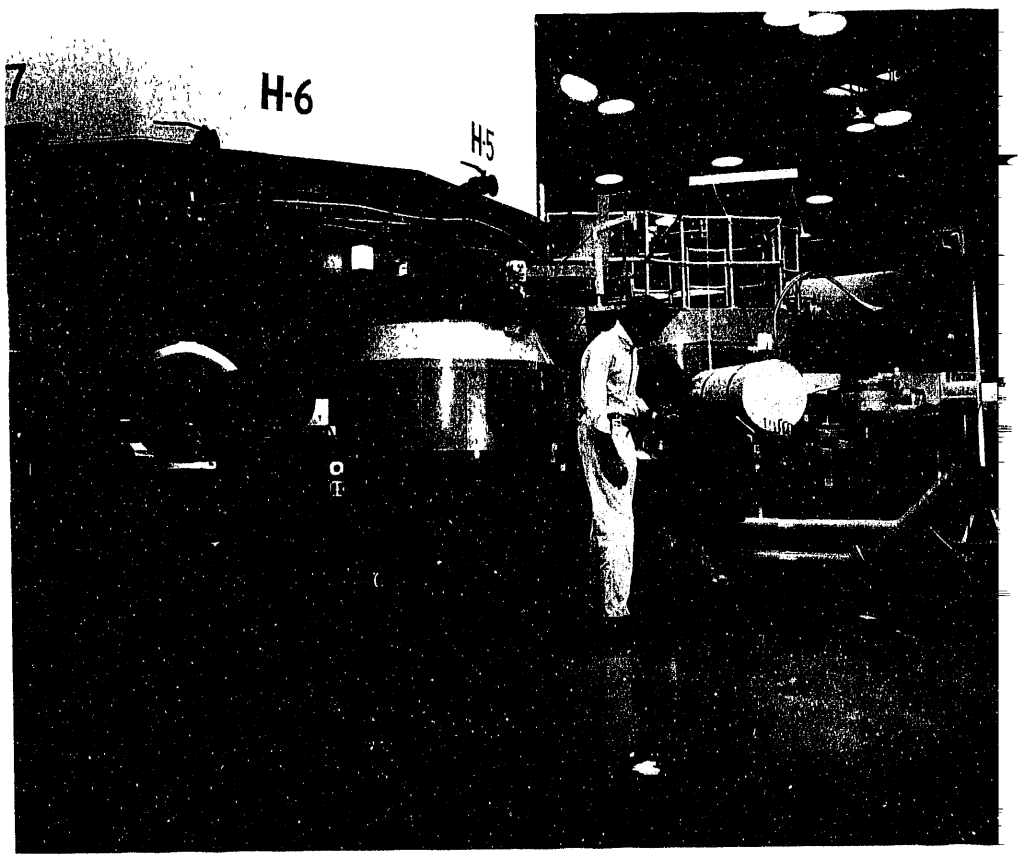
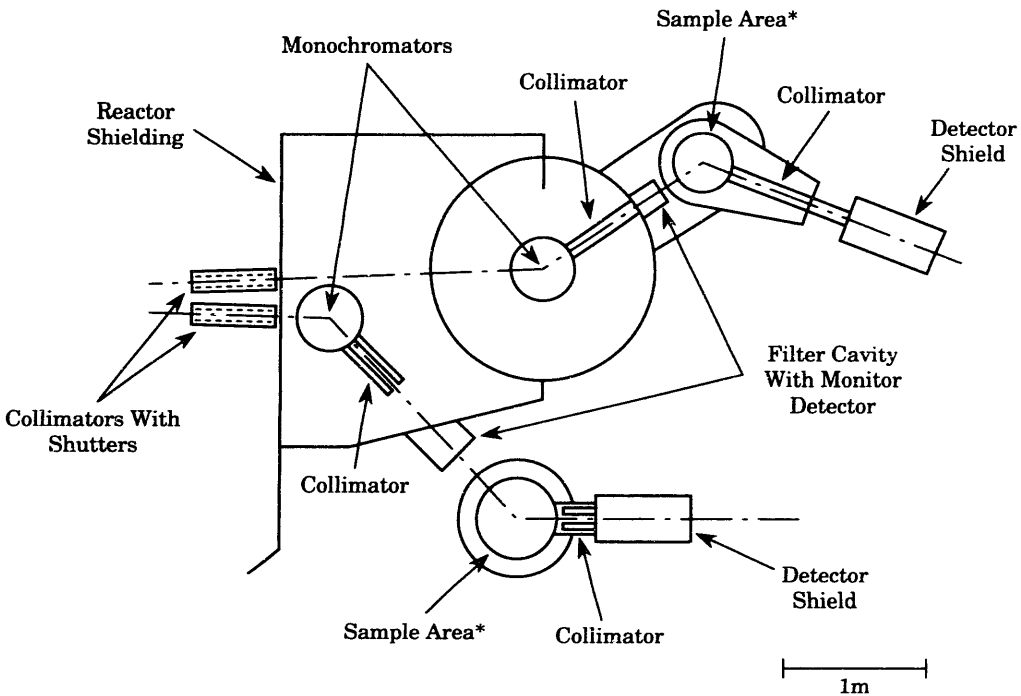


Figure 24. Tom Koetzle prepares an experiment on the H6-M diffractometer. H6-S is to the left.



* Location of a 4-circle diffractometer.

Figure 25. Schematic plan of spectrometers installed at H6-M (top) and H6-S (bottom).

H7 SPECTROMETER (INELASTIC SCATTERING)

H7 is a triple-axis spectrometer used primarily for single crystal inelastic neutron scattering experiments, although it can also be used effectively for studying polycrystalline and amorphous samples (Figures 26-27). H7 is fully automated for variable incident neutron energies, and scans with a fixed final energy can be performed. The spectrometer is normally equipped with pyrolytic graphite (002) monochromator and analyzer crystals, but Be, Cu, Zn, and Ge monochromators are also available. Optional in-pile Be and pyrolytic graphite filters are provided for removing higher order beam contamination. Be and PG filters can also be placed after the sample for the fixed analyzer type of scan. The sample table is equipped with a manual two-axis goniometer with a ±10° range and is compatible with a variety of available cryostats and furnaces. External collimation (other than in-pile) is provided by Soller slits with a 5×5 cm^2 cross section.

H7 Station Parameters

Flux at monochromator position (20′ collimation in-pile)	4.1×10^9 n/cm^2-sec
Monochromator scattering angle	$10°<2\theta_M<75°$
E_0 or λ_0 (PG 002)	$4.9<E_0<240$ meV $4.1>\lambda_0>0.58$ Å
Beam size at sample	5 (h)×3.1 (w) cm^2
Sample scattering angle	$-45°<2\theta_A<128°$
Analyzer scattering angle	$-100°<2\theta_A<100°$
In-pile collimation	10′, 20′, 40′
External collimation	10′, 20′, 40′
Detector	^{3}He

Figure 26. At the H7 Spectrometer (from left) Bernhard Keimer (MIT) and Kazu Yamada (Tohoku University, Japan) are adjusting the spectrometer; Thomas Thurston (BNL) is pulling out a mask that will be used to define the neutron beam; and John Tranquada (sitting) and Gen Shirane (BNL) are checking the sample temperature. These researchers, along with Robert Birgeneau of MIT, are studying high temperature superconductors.

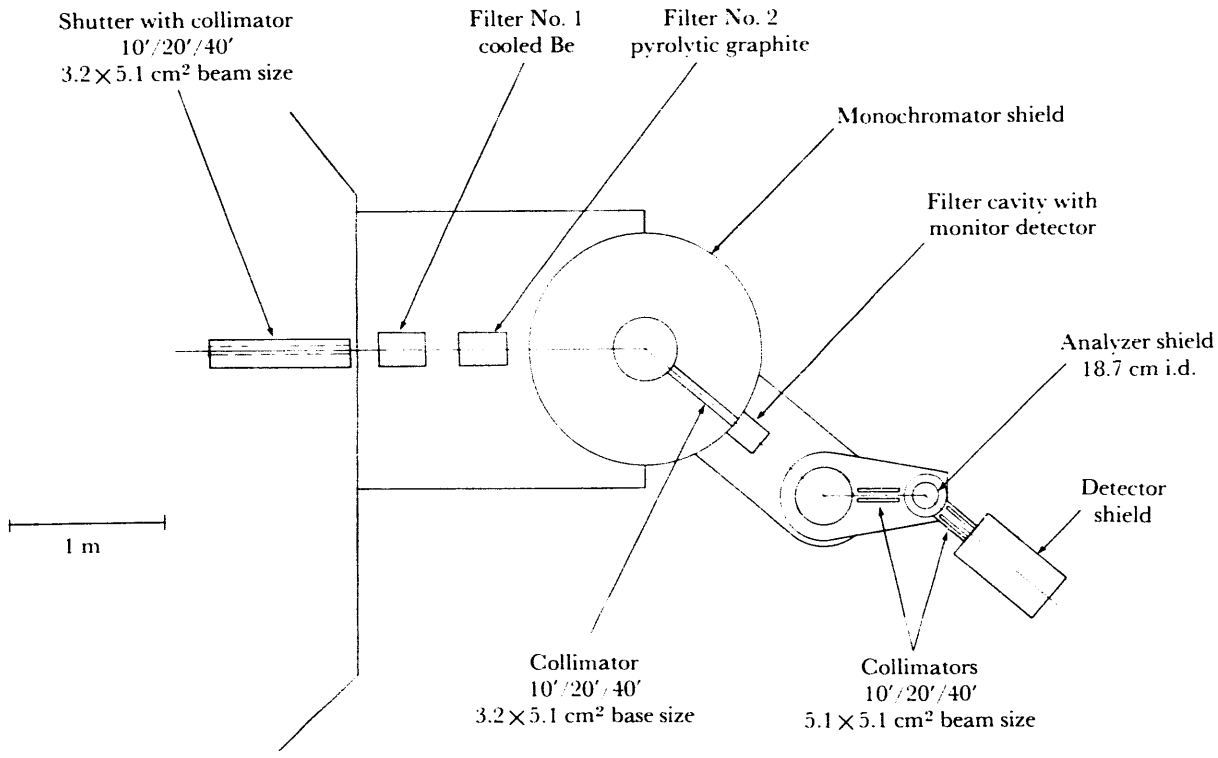


Figure 27. Schematic plan of the triple-axis spectrometer installed at H7.

H8 SPECTROMETER
(POLARIZED BEAM, INELASTIC SCATTERING)

H8 is a triple-axis spectrometer used primarily for single crystal inelastic neutron scattering experiments (Figures 28-29). It is equipped with a monochromator housing that can accommodate a PG (002) crystal or a Heusler (111) crystal, for unpolarized and polarized neutron work, respectively. The incident energy can be varied remotely so scans with a fixed final energy can be performed. A Heusler (111) analyzing crystal, magnetic flippers, and guide fields can easily be positioned to allow for use as a fully polarized beam instrument. Cooled Be and pyrolytic graphite crystals are available for removing higher order beam contamination. The sample table is equipped with a manual two-axis goniometer with a $\pm 10°$ range and is compatible with a variety of available cryostats and furnaces. External collimation is provided by Soller slits with a 5×5 cm^2 cross section.

H8 Station Parameters

Flux at monochromator position (20′ in-pile collimation)	4.2×10^9 n/cm^2-sec
Monochromator scattering angle	$10° < 2\theta_M < 75°$
E_0 or λ_0 (PG 002)	$4.9 < E_0 < 240$ meV $4.1 > \lambda_0 0.58$ Å
Beam size	5 (h)×3.1 (w) cm^2
Sample scattering angle	$-45° < 2\theta_S < 140°$
Analyzer scattering angle	$100° < 2\theta_A < 100°$
In-pile collimation	10′, 20′, 40′
External collimation	10′, 20′, 40′
Detector	BF_3

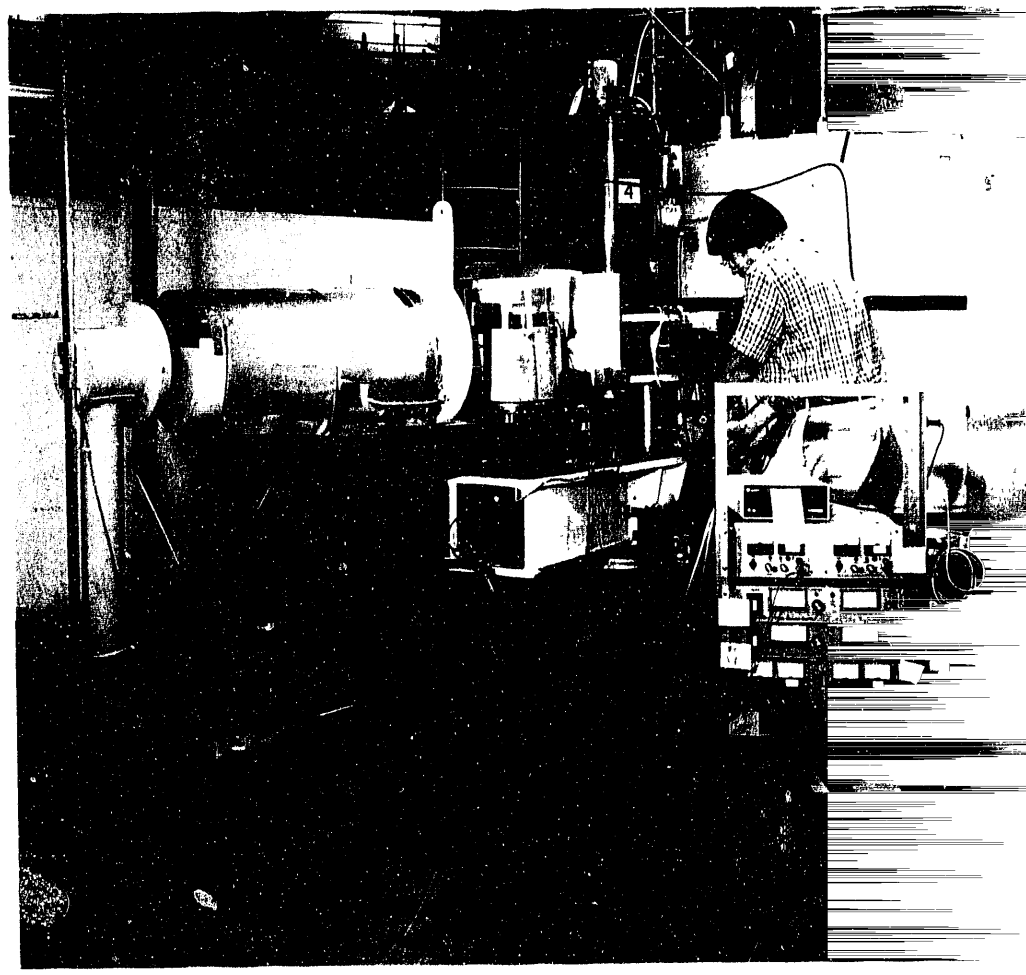


Figure 28. John Tranquada adjusts the polarized beam on the H8 triple-axis spectrometer.

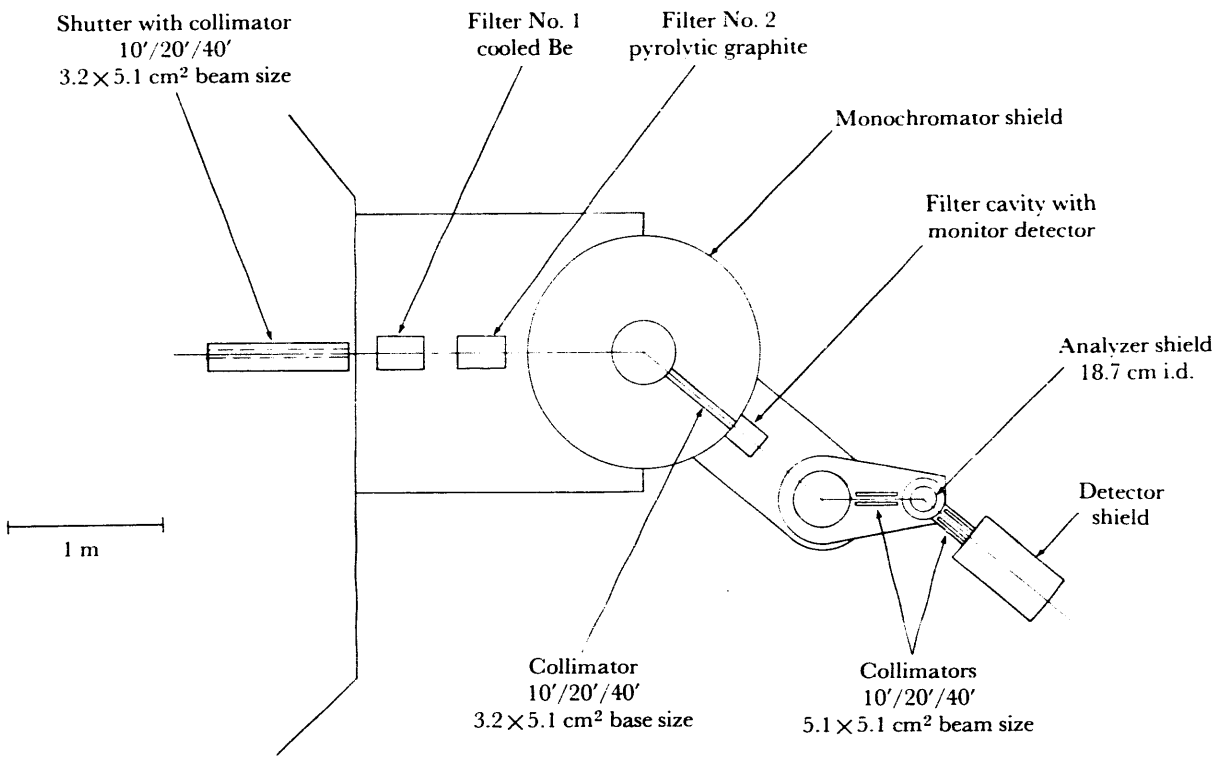


Figure 29. Schematic plan of the triple-axis spectrometer installed at H8.

H9-A SPECTROMETER
(INELASTIC SCATTERING — COLD NEUTRONS)

H9-A is a triple-axis spectrometer situated on the cold neutron facility (Figures 30-31). It is used for high resolution inelastic neutron scattering studies of single crystal, polycrystalline, or amorphous samples. It is equipped with a double monochromator arrangement which allows for large monochromator scattering angles. A Be filter is placed before the monochromator for elimination of higher order beam contamination. The sample table is equipped with a manual two-axis goniometer with a $\pm 10°$ tilt range about two orthogonal horizontal axes, and is compatible with a range of available cryostats and furnaces. External collimation (other than in-pile) is provided by Soller slits with a 5×5 cm^2 cross section.

H9-A Station Parameters

Monochromator scattering angle	$60° < 2\theta_M < 134°$
E_0 or λ_0 (PG 002)	$2.15 < E_0 < 7.3$ meV $6.2 > \lambda_0 > 3.3$ Å
Beam size at sample	7.5 (h)×5 (w) cm^2
Sample scattering angle	$-50° < 2\theta_S < 150°$
Analyzer scattering angle	$-125° < 2\theta_A < 125°$
In-pile collimation	15′, 30′, or 60′
External collimation	15′, 30′, or 60′ before sample 10′, 20′, or 40′ after sample
Detector	BF_3

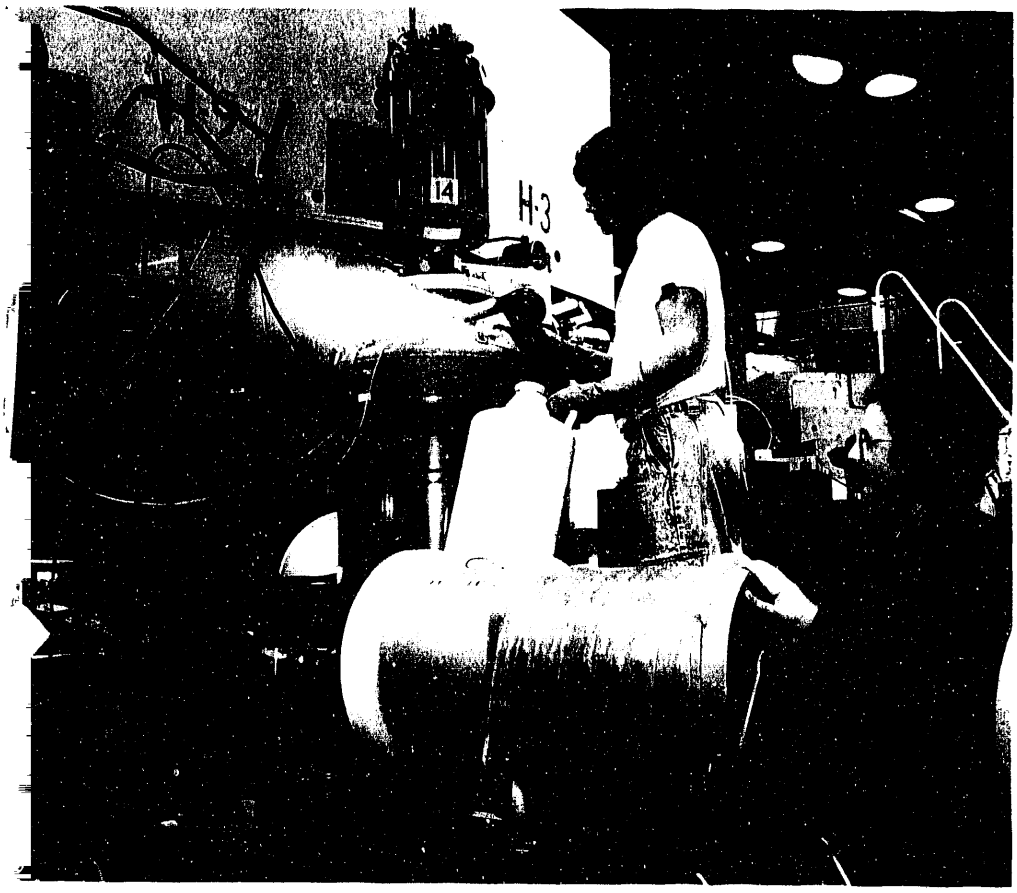


Figure 30. James Biancarosa (top) and Hamid Moudden (lower right) fill the cryostat on the H9A spectrometer.

H9-B SPECTROMETER
(SMALL ANGLE SCATTERING — BIOLOGICAL STRUCTURE)

The H9-B spectrometer is used primarily for small angle scattering studies on macromolecular biological structures. A temperature-controlled sample changer is available for automated measurement of several sample solutions in spectroscopic cells. Alternatively, substrates may be oriented on a vertical sample axis. The sample table is also compatible with HFBR ancilliary equipment, including cryostats, magnets and furnaces. A high-resolution area detector of 50×50 cm^2 is used to record scattering patterns on a 128×128 pixel grid. The sample-to-detector distance is variable between about 50 to 200 cm and the detector can move about the sample axis on a 45° arc (Figure 32)

The spectrometer uses a Be-filtered cold moderator beam emerging from Ni-coated neutron guides (25.4×50.8 mm). Monochromatization is achieved with exchangeable Ni-Ti or Fe-Mn multilayers with bilayer spacings between 50 and 150 Å. The monochromatic beam is collimated over a length of 2 m by a series of apertures of decreasing diameter. Typically, the primary beam has a diameter of 6 mm at the sample. A Micro VAX 3500 computer with a large external time-slicing memory is used for experimental control and data analysis.

H9-B Spectrometer Parameters

Wavelength range	4 — 8 Å
Wavelength spread (FWHM)	6 — 15%
Beam divergence (FWHM, horizontal)	14′
Flux at sample (5 Å, 6 mm beam)	2×10^6 n/cm^2-sec
Detector area	50×50 cm^2
Detector resolution	2.5 mm
Sample-detector distance	50 — 200 cm
Range of scattering angles	0 — 45°
Best spectrometer resolution	1090 Å
Minimum Q (λ=5 Å, 2 m detector distance)	0.002 $Å^{-1}$

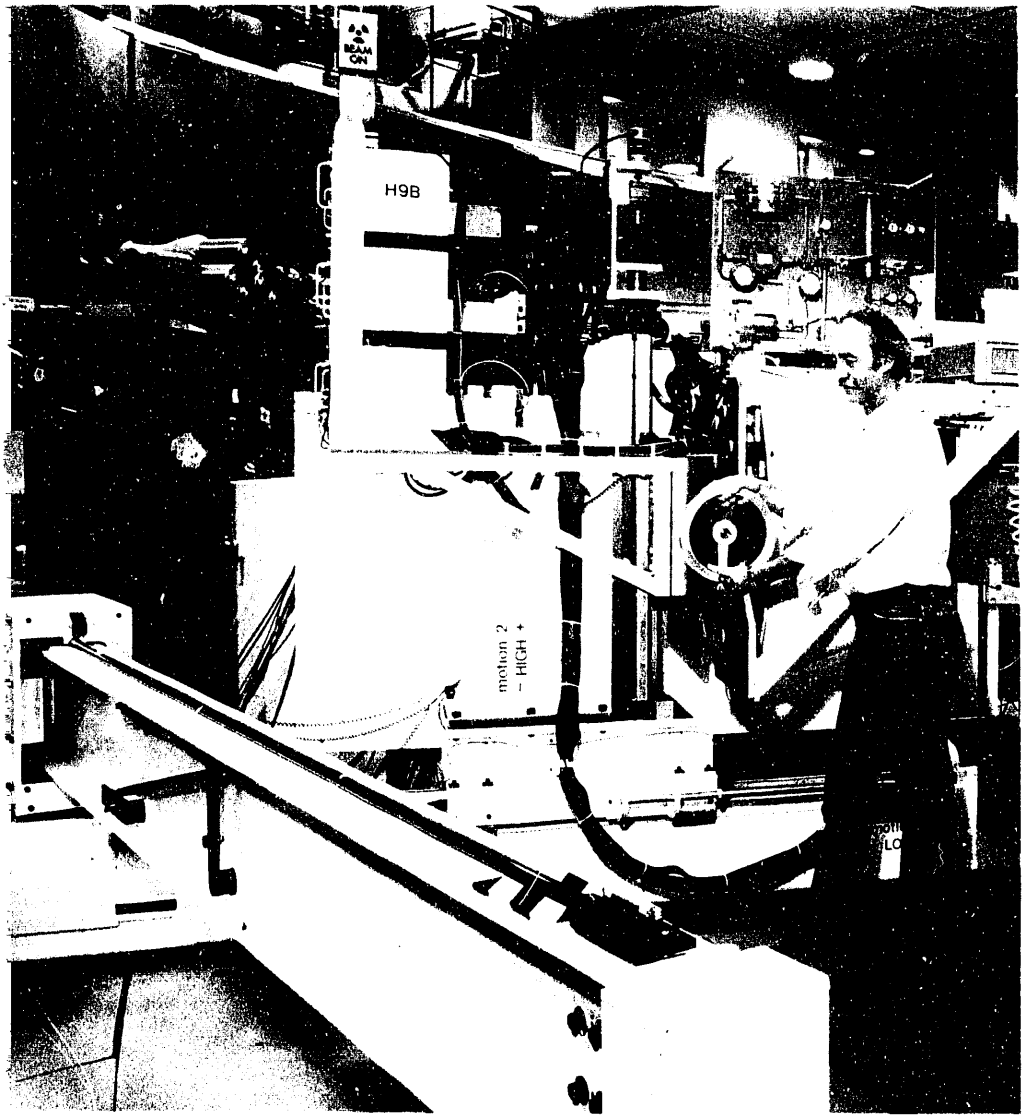


Figure 31. Dieter Schneider adjusting the detector on the H9 SANS spectrometer.

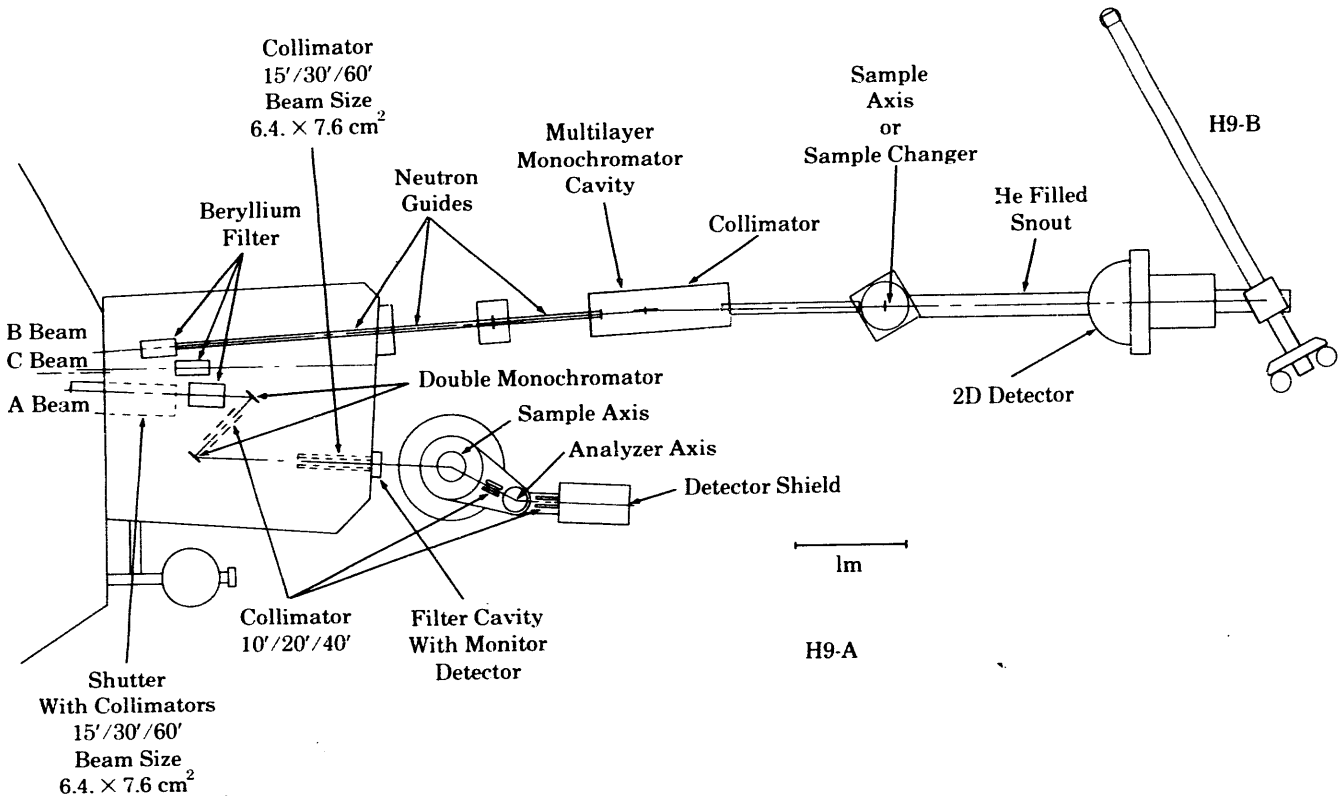


Figure 32. Schematic plan of spectrometers installed at H9.

H9-D NEUTRON REFLECTION SPECTROMETER

The neutron reflection spectrometer probes density distributions normal to liquid-vapor, solid-vapor, and, in certain cases, liquid-solid interfaces (Figure 33 and Figure 33a). Density profiles are deduced from the scattering vector ($\vec{Q}$)-dependence of the reflected intensity. The instrument employs a flat, monochromatic 4.16 Å ribbon beam, which is deflected -- either up or down — onto a horizontal sample surface or interface. A well-shielded ^{3}He detector is used to monitor the reflected intensity. Incident beam height and tilt angle, sample height, exit beam tilt angle and detector height are under computer control. Scans can be made at the users option with $\vec{Q}$ either perpendicular or parallel to the reflecting plane.

H9-D Neutron Reflection Spectrometer Parameters

INSTRUMENT SPECIFICATIONS	
Samples	Accommodates liquid or solid samples up to 40cm long on a dynamic, vibration-isolation platform.
Neutron beam	4.16 Å horizontal ribbon beam 0-5mm high and 5cm wide. Beam tilts ±5 degrees from the horizontal.
Detector	^{3}He
Scattering Vector (Q) range	0.0025 - 0.25Å^{-1}
Q-resolution	± 0.001Å^{-1}
Reflectivity range	1-10^{-6}
COMPUTER-CONTROLLED SCANNING MODES	
Specular scan	Q variable. ΔQ perpendicular to surface.
Off-specular scan	Q fixed. ΔQ parallel to surface.

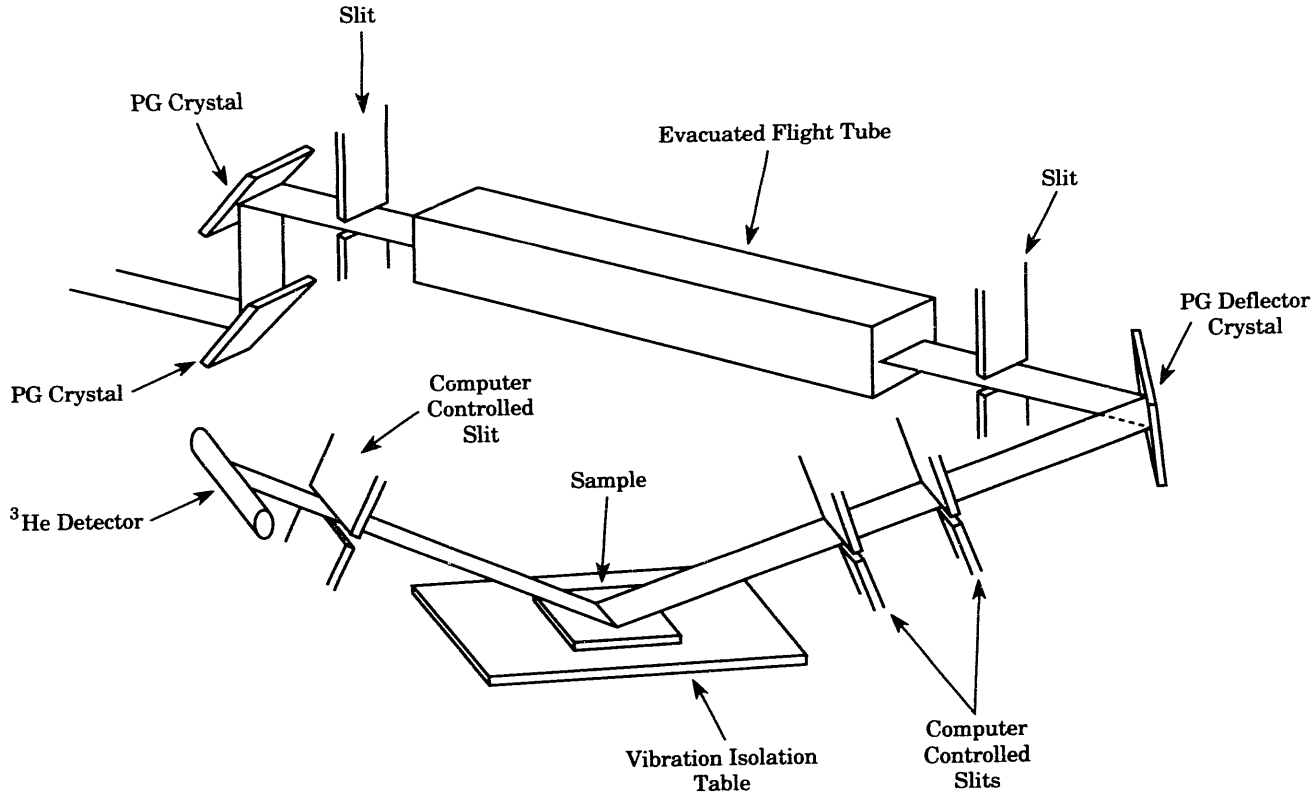


Figure 33. H9-D Neutron Reflection Spectrometer.

Figure 33a. From left, Frank Langdon, Richard Rothe Jr., and Michael Taylor check the instrument parameters of the neutron reflectometer.

ANCILLARY EQUIPMENT

A variety of cryostats, furnaces, and magnets is available to control the sample environment. Most of the instruments have standardized mounts or adaptors so as to permit ready interchangeability at various experimental stations. The ranges covered are given below.

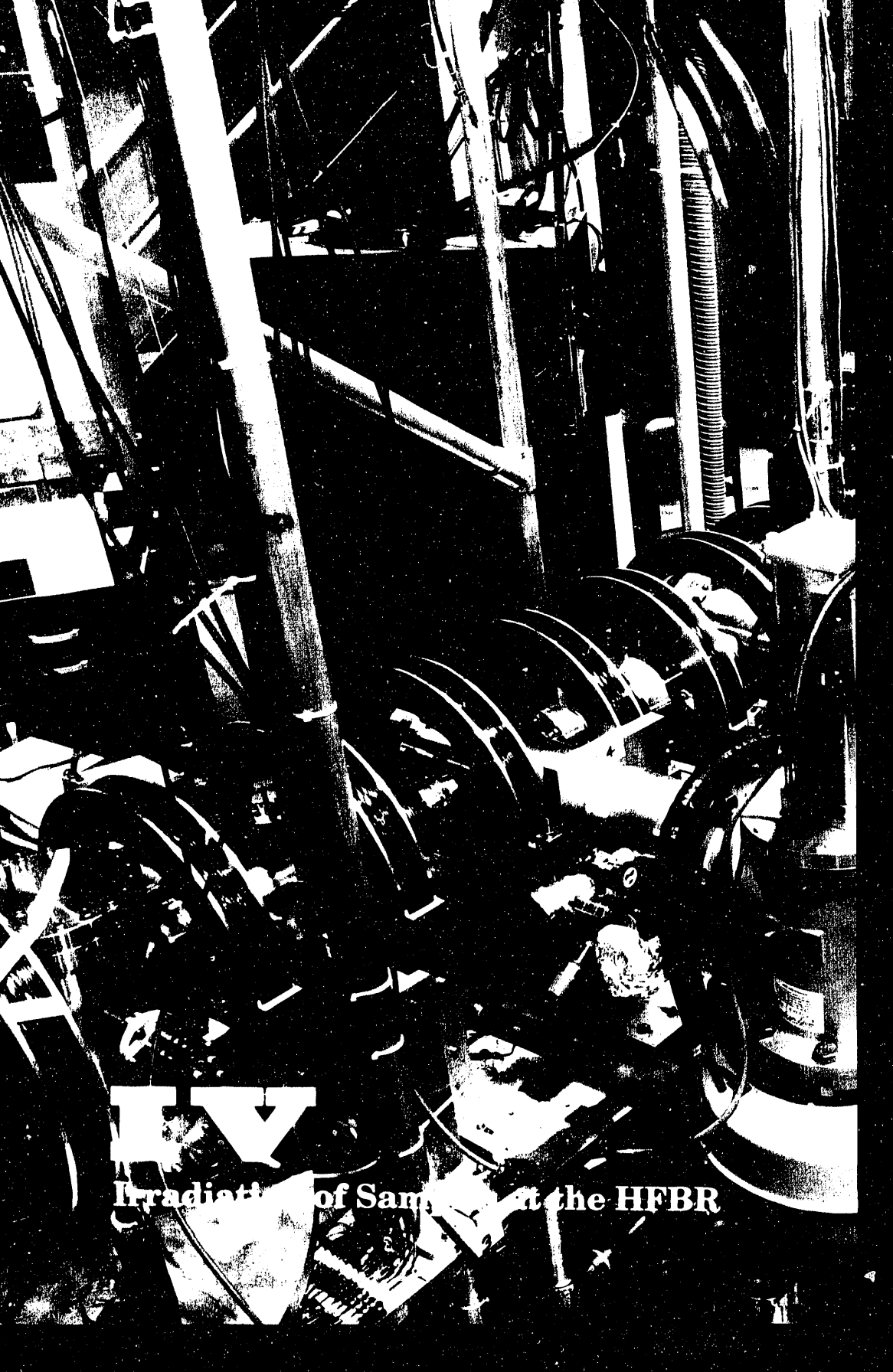
Cryostats and refrigerators	$0.03K<T<325K$
Furnaces and ovens	$300K<T<1700K$
Magnets	0—90 kG vertical 0—24 kG horizontal
Magnet with warm bore for membrane orientation	0—80 kG horizontal
Pressure	0 to 30 k bar

COMPUTER CONTROL SYSTEM

The various scientific disciplines using the reactor have different needs for control and data acquisition. Each instrument is controlled by computer and data are collected and stored either on magnetic tape or on disc. Some preliminary on-line data analysis is performed at the HFBR but many of the data are transferred to a larger computer at the user's laboratory, where the final data analyses are performed.

IDENTIFICATION OF EQUIPMENT BY NON-BNL RESEARCH STAFF

HFBR users from outside institutions are required to clearly identify the ownership of their equipment so that it can be easily distinguished from property of the U.S. Government. A permanent identification tag (property of and the name of the institution) on the equipment will eliminate confusion and satisfy the identification requirements that BNL, as a contractor for the U.S. Department of Energy, must meet. These requirements are contained in the Federal Property Management Regulations and the DOE Property Management Regulations. If further information is required, contact B.J. McAlary at Ext. 3330.



IV

Irradiation of Samples at the HFBR

Irradiation of Samples at the HFBR

Irradiation experiments at the HFBR play an important role in the overall research program (Figure 34). Seven vertical thimbles provide a variety of neutron energy spectra for sample irradiations. Thermal or slow neutrons are used primarily for neutron activation analysis ("finger-printing" unknown substances by artificially induced radioactivity) and for producing special purpose radioisotopes. Due to the high neutron flux available, it is possible to produce highly radioactive samples from small quantities of material (high specific activity), and to produce certain isotopes in quantities unattainable by any other practical means. Fast neutron irradiations are an important tool for the study of radiation damage in materials.

Three of the irradiation thimbles (V10, V11, and V12) are located in the reflector portion of the reactor, while the others are positioned at the core edge (V13 and V14) and at the core center (V15 and V16) (Figure 35). The thimbles are fitted with a set of reentrant tubes connected to a separate D_2O cooling system, which circulates a flow of 45 liter/min downward through the center and upward through the outer annular region of each tube. Samples are placed in aluminum capsules which are immersed in the D_2O for cooling. Each capsule is attached to the end of a 10 meter length of 6 mm diameter aluminum tubing, which is used to lower the sample capsule into the reactor and to withdraw it after the irradiation. In addition, this tubing can be used to vent the capsule, to fill it with gas for heat transfer, and to bring out a pair of thermocouple leads, if desired. A hydraulic "rabbit" is also available at Facility V11, which permits rapid insertion and retrieval of samples for precisely-timed irradiations of short duration.

An example of a use of Facility V14 is the production of a positron beam. A copper sphere of 0.15 inches in diameter is inserted into Facility V14 and upon two days of irradiation a positron emitting source (^{64}Cu), which has a half-life of 12.8 hours and an activity of 20 curies of positrons, is produced by the reaction $^{63}Cu+n \rightarrow {}^{64}Cu+\gamma$ ($\sigma = 4$ barns). Presently, a consortium of physicists from BNL, universities, and industry is using this facility to produce an intense ($10^8 s^{-1}$), low energy (0-15/keV), monoenergetic ($\Delta E = \pm 2$ eV at 150 eV) beam of positrons to study surfaces of solids. The intense positron beam is also used to produce a neutral beam of positronium atoms. Other uses of the high flux neutron facility include the production of radioisotopes for various medical purposes.

Irradiations can be scheduled by contacting the Reactor Research Coordination at extension 5204. All proposed irradiations are reviewed by the Research Coordinator for their potential impact on reactor safety. Proposed irradiations of samples, which might cause large reactivity changes or present unusual hazards, such as those involving fissionable materials, or materials which can decompose and react with vessel components or reactor coolant, must be reviewed and approved by the Reactor Safety Committee before they can be placed in the reactor.

HFBR Irradiation Facilities

Flux, n/cm ^{2}sec				Useable Dimensions	
Facility	Thermal	Fast (>1 MeV)	Heating Rate, W/g (in aluminum)	Diam (cm)	Length (cm)
V10	2.7×10^{14}	7.5×10^{11}	0.38	2.4	7.6
V11	1.5×10^{14}	9.0×10^{10}	0.23	2.0	7.6
V12	3.8×10^{14}	8.3×10^{11}	1.20	2.4	7.6
V14	8.3×10^{14}	9.0×10^{13}	6.0	1.9	7.6
V15	2.0×10^{14}	3.0×10^{14}	12.0	1.9	7.6
V16	2.0×10^{14}	3.0×10^{14}	12.0	1.9	7.6

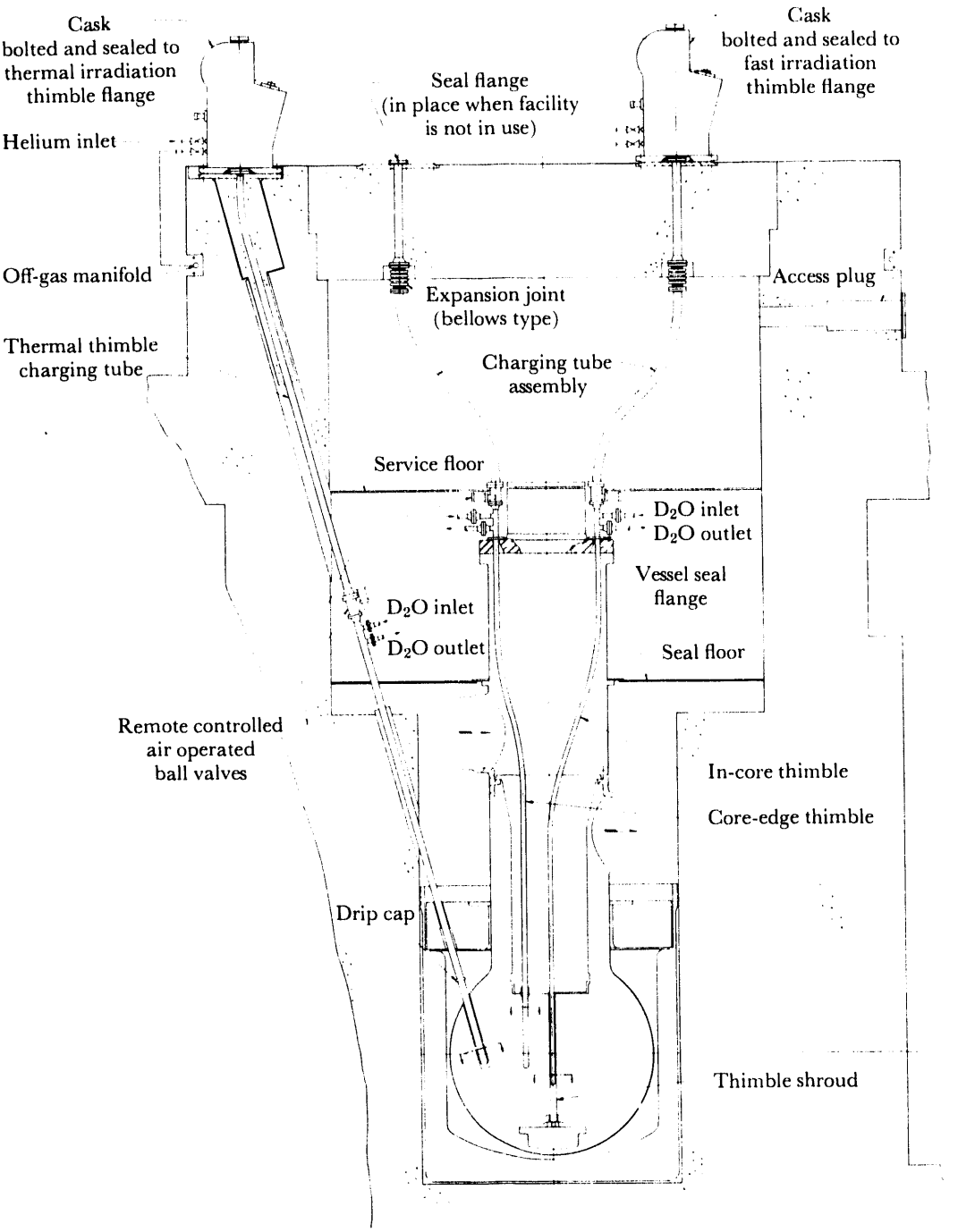
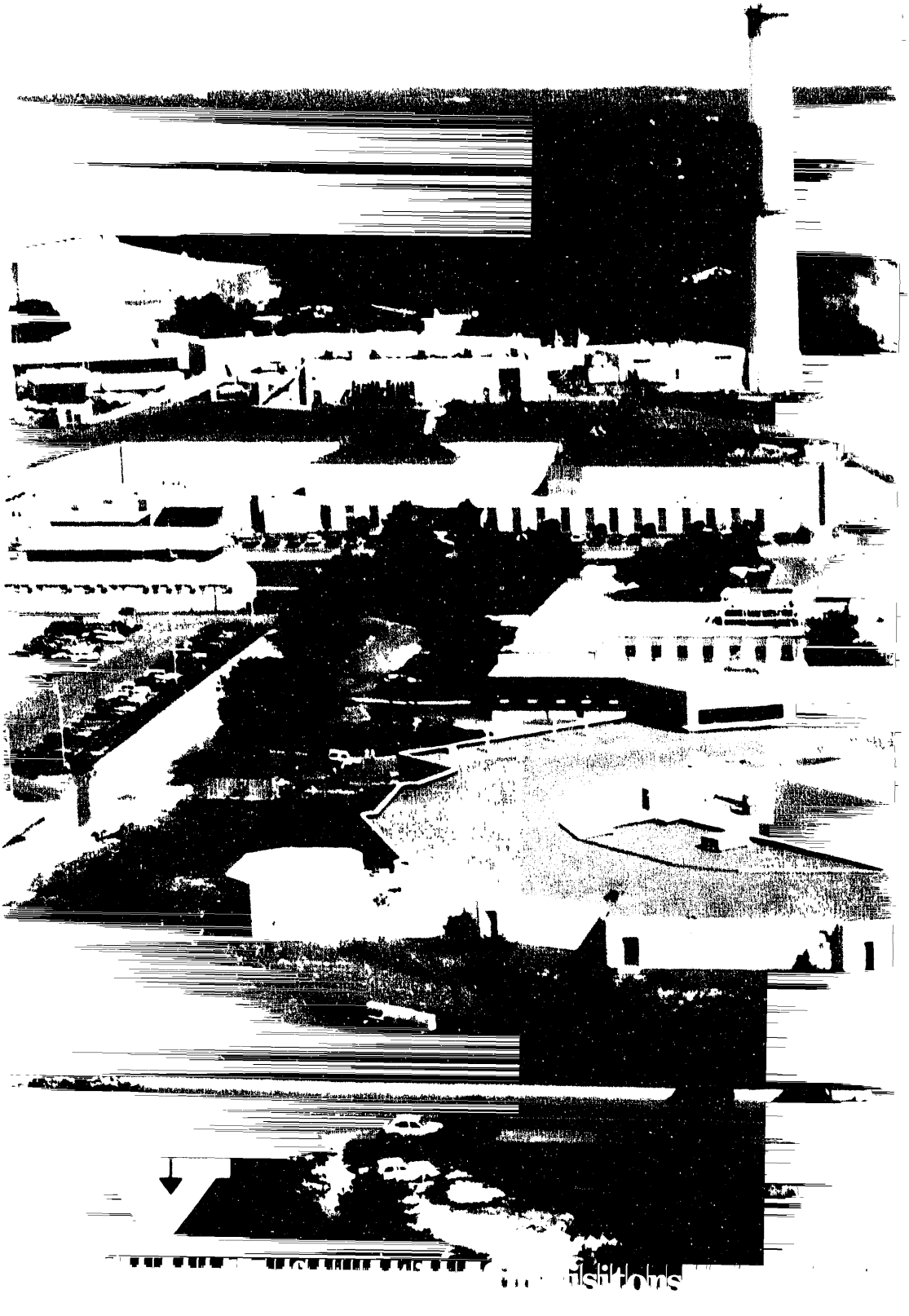


Figure 35. Elevation showing the location of several irradiation thimbles within the reactor.



General Information for Visitors

THE LABORATORY AND ITS ORGANIZATION

The Brookhaven National Laboratory is operated by Associated Universities, Inc. (AUI) under a prime contract with the Department of Energy (DOE). Nine northeastern universities sponsor AUI. The Board of Trustees consists of two representatives from each university (one a principal administrative or corporate officer, and the other a scientist) and not more than six Trustees-at-Large. Visiting Committees, appointed by AUI, provide a continuing independent evaluation of the research programs carried out by the various Scientific Departments. Figures 37 and 38 show the internal organizational structure of the Laboratory. A site map is shown in Section VI.

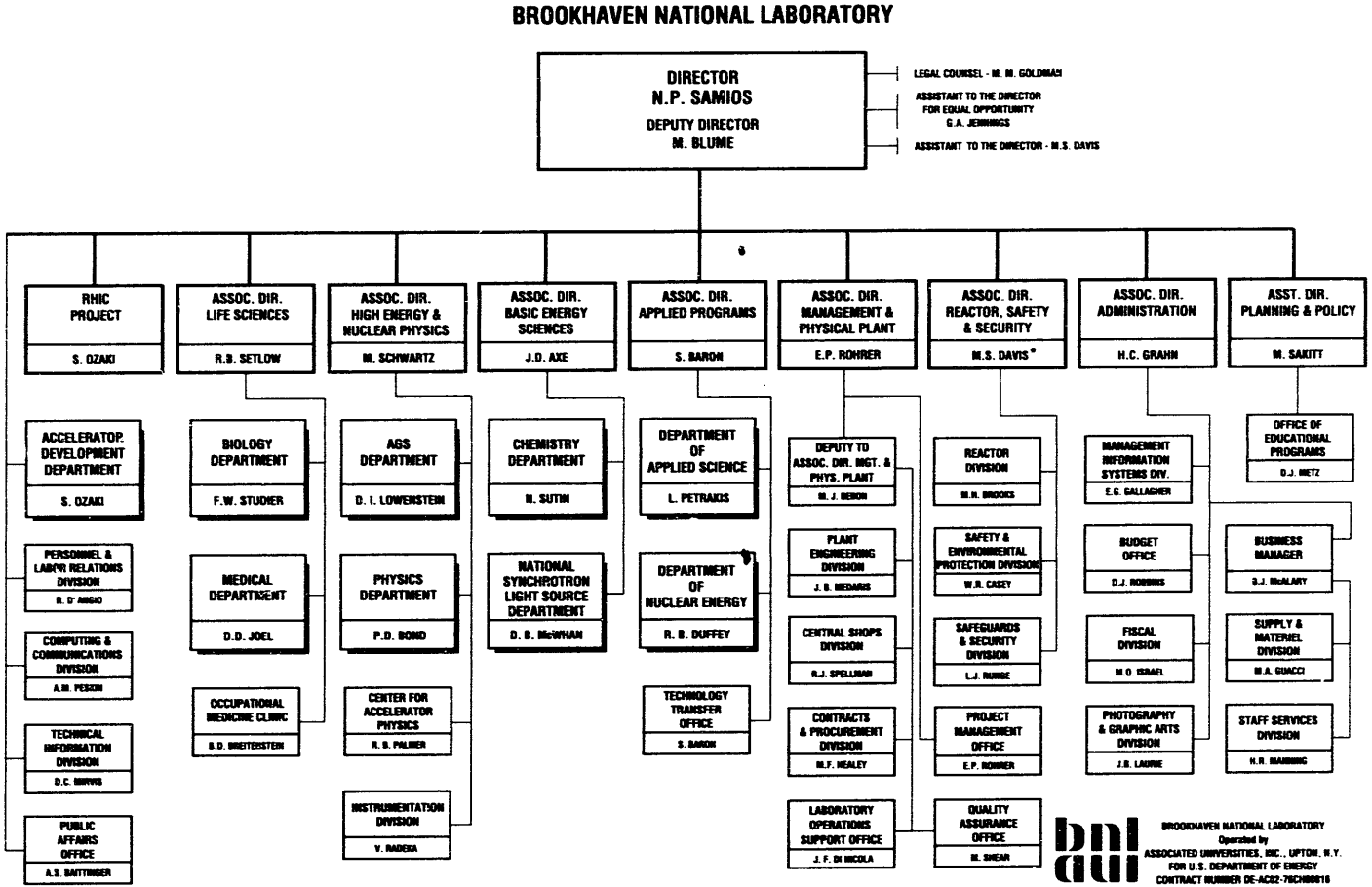
The formation of AUI in 1946 and the subsequent establishment of Brookhaven provided a new approach to the support of research by the Federal government, especially with regard to the development and use of large scale research tools and other specialized equipment inappropriate for construction and operation by an individual university. These facilities are used by Brookhaven staff members in research and development work in national programs under DOE direction. From its inception as a National Laboratory, however, Brookhaven has promoted the use of its special facilities by qualified visiting scientists without regard to their institutional affiliations.

APPOINTMENTS

All individuals associated with BNL (employees, guests/research collaborators, visiting scientists, facility users) are required to have an active appointment with the Laboratory and a valid identification card. HFBR Users can arrange for a Guest Appointment and obtain Identification Card/Security Badge Applications via the HFBR User Administrator's Office, located in the Physics Building 510A, Room 1-30 [Telephone: 516-282-5564] or through the Scientific Department sponsoring their assignment. U.S. citizens may activate a Guest Appointment at the time of the initial visit and signing in at BNL.

Foreign Nationals

Assignments of foreign nationals and visits of sensitive country nationals require U.S. Department of Energy approval. Depending upon citizenship and category of assignment, this approval may require up to three (3) months for processing.* To assure compliance with current



*ACTING

Figure 37. BNL Organizational Chart.

SCIENTIFIC

CODE	DEPARTMENT/DIVISION	BLDG	HEAD	EXT.	OFFICE CONTACT	EXT.	OTHERS
DD	ACCELERATOR DEVELOPMENT	1005S	Satoshi Ozaki	5590	*Anne Flood* Ginny Waterman	4779 5663	E Willen, 7118, A Ruggiero, 4997 Also see RHIC
AD	AGS	911B	Derek I Lowenstein	4611	*Paula Hughes*	4619	J Becker, 3960, W Weng, 2135, P Pile, 4643, K Prelec, 4777
EE	APPLIED SCIENCE	179A	Leon Petrakis	3037	*Pat Taylor*	2452	R Melucci, 2911
BO	BIOLOGY	463	F William Studier	3416	Kathy Folkers	3415	I Rosati, 3366, B McGahern, 3392
CO	CHEMISTRY	555	Norman Sutin	4301	Bonnie Hulse	4301	F Terrano, 4302
AO	*COMPUTING & COMMUNICATIONS*	515	Arnold Peskin	4161	Muriel Kolomick	4109	G Campbell, 4168, S Rideout, 4108
IO	INSTRUMENTATION	535B	Veljko Radeka	4266	Barbara Gaer	4231	C Williams, 5061
MO	MEDICAL	490	*Darrel D Joel*	3568	Marie Susa	3673	D Maresca, 3564
LS	NATIONAL SYNCHROTRON LIGHT SOURCE	725B	Denis McWhan	4966	Lynn McBrien	2297	S Krinsky, 4740, W Thomlinson, 3937, W J Foyt, 4752
NE	NUCLEAR ENERGY	197C	Romney Duffey	2454	Carmen Falkenbach	2663	R Bari, 2629, B Penn, 7213
OM	OCCUPATIONAL MEDICINE CLINIC	490	Bryce Breitenstein	3668	*M Jeanne Matkovich*	3671	*Alternate Phys*., 3669, Admin., 3564, Clinic, 3670, EAP, 4567, Health Promotions, 5923
PO	PHYSICS	510	Peter D Bond	4063	Pat Valli	3717	M Murtagh, 3874, M Strongin, 3763, P Sikivie, 3860
RO	REACTOR	120	Michael Brooks	4061	Pam Yeary	4070	S Golden, 4400, D Rorer, 4056, L Junker, 4416
HP	SAFETY & ENVIRONMENTAL PROTECTION	535A	W Robert Casey	4654	Louisa Morrison	4207	L Kalbach, 2780

PROJECTS

RC	RHIC	1005S	Satoshi Ozaki	5590	Ginny Waterman	5663	M Harrison, 7173, T Ludlam, 7968, J Hauser, 3307, H Foelsche, 2219, J Sondericker, 4737
	SXLS	725	Richard Heese	4902	Judy Thompson	2145	R Lake, 2579, W J Foyt, 4752

ADMINISTRATIVE

SC	CENTRAL SHOPS	*462U*	*Richard Spellman*	3351	Rosemary Taylor	3356	E Harmer, 3352
PR	CONTRACTS & PROCUREMENT	355	Mary-Faith Healey	3179	Barbara Simpson	7643	A J Salvo, 3194, F J Altrui, 3155
DO	DIRECTOR'S OFFICE	460	Nicholas P Samios	2772	*Lillian Kouchinsky*	2772	
		460	Herbert L Kinney	7989			
	Deputy Director	460	Martin Blume	3735	Jane Schwaner	3834	
	Public Affairs Office	134	Anne S Baittinger	5055	Janet Silas	2345	A Cohen, 5054; M Rowe, 5056 J Tempel, 4049
	Office of Equal Opportunity	185A	*Glenn Jennings*	3318		2821	J Taylor, 2703, F Ligon, 3709
	Applied Programs	460	Seymour Baron	3339	Eleanor Hughes	3339	
	Office of Technology Transfer	460	Seymour Baron	3339	Eleanor Hughes	3339	
		902C	Margaret Bogosian	7338	*Arlene Wolochuk*	3341	V P Myles, 3312, M Yanez, 3341
	Administration	460	Henry C Grahn	3317	Beth Blevins	5630	G Ogeka 3439, A Romano, 4024, R Busch, 3555
	Budget Officer	460	Donald Robbins	3313	Jane Bennett	5406	E Byrne, 5674
	Foreign Travel	460	Jane Bennett	5406	Elena Sasso	3319	
	Business Manager	460	Bernard J McAlary	3330	*Carole Kerr*	7100	G Irving, 7957, R Kito, 3320
	Reactor, Safety & Security	460	M Sue Davis*	3711	Janice Lamb	3711	J Dolan, 3711
	Office of Environmental Restoration	51M	Alan Raphael	5854	Regina Dorr	2818	
	Management & Physical Plant	460	E Parke Rohrer	7818	Ruth Ann Lutz	7774	M *Bebon*, 3434
	Quality Assurance	902B	Marvin Shear	7155	Patricia Gassaway	3689	V Gutierrez, 2395, I Brown, 2827
	H E & Nuclear Physics	510F	*Melvin Schwartz*	7711	Laura Zaharatos	3830	P Yamin, 4949, E Zukowski, 3866
	Life Sciences	463	Richard Setlow	3391	Kathy Folkers	3415	
	Basic Energy Sciences	510A	John Axe	3821	Rae Groenberg	5564	
	Planning & Policy		Mark Sakitt	3812	*Carol Joyce*	3325	
	Office of Educational Programs	438	Donald J Metz	3054	Dawn Mosoff	4503	
	Legal Counsel	460	Michael Goldman	3324	Carol Joyce	3325	
FO	FISCAL	134A	Mark Israel	2494	April Donegain	2459	V Bilms, 2483, M DuBois, 2487, F Hohmann, 3259
MS	MANAGEMENT INFO SYSTEMS	459	Edward Gallagher	7786	Joan Barrow	3290	G Malcolm, 7654; R Jansson, 3306, G Paul, 7427, J Lemmon, 3882, C Pohlig, 3301
	Administrative Systems	459					
PE	PERSONNEL	185	Robert D'Angio	2113	Dot Marelli	2885	R Schonberg, 2881
	Compensation & Projects	185	Virginia Brown	2874	Pat Gorden	2880	
	Employee Relations	185	Susan Foster	2888	Karen Adelwerth	4262	
	Employment	185	Marsha Kipperman	2871	Rosa Palmore	2882	N Sobrito, 7996
	Insurance	185	Richard Schonberg	2881	Joyce Wund	7516	*Personnel Services*, 2877
	Labor Relations	185	William Hempfling	2878	Karen Adelwerth	4262	S Foster, 2888
	Office Scientific Personnel	185A	*E Gail Williams*	3338	Edy Thornhill	7813	L Barry, 7814, P Manzella, 3336
	Records	185	Bonnie Miller	2875	Darlene Peragine	2876	L Barone, 2876
	Recreation	185	M Kay Dellimore	2873			
	Salary Administration	185	Robert G Kelly	3782	*Barbara Schmidt*	2886	P Gorden, 2880, P Esposito, 2879
	Suggestion Program	185	Susan Foster	2888	Karen Adelwerth	4262	
	Training Office & Supv Development	185	Mary White	7994	Debbie Maceluch	5126	M Pandorf, 5256, Tuition, 7631
PG	PHOTOGRAPHY & GRAPHIC ARTS	197B	John Laurie	7640	Phyllis Domenech	2907	W Bottinger, 2955,
	Graphic Arts	197B	Kenneth Boehm	2935	Dolores Janes	2907	Copy Service, 2950,
	Photography	118	Morton Rosen	2388	Helga Pirozzi	2381	
	Video	493	Doug Humphrey	3680			
EP	PLANT ENGINEERING	134C	Bruce Medaris	7676	*Linda Masem*	2478	Div Off., 2500; Maint Svc., 2468
			Edward Murphy	3466			A Warren, 2015, G Kaczmarczyk, 4532, S Perino, 2477, M Schaeffer, 7941, T Timko, 7805
SE	SAFEGUARDS & SECURITY	050	Larry Runge	7759	Nancy Griffin	4177	R Giesler, 7799, Police Duty Capt., 2231, R *Reaver*, 2355, K Dahms, 4051
SS	STAFF SERVICES	179B	H Ronald Manning	2525	*Joan Perullo*	2549	E *Skrezec*, 2526, Housing, 2541, Special Prog Svcs, 2553, Trvl, 2531, Auto Shop, 3260, Mail, 2534, Transp., 2535, Records Hldg., 2340
			Dennis Joyce	4218			
SM	SUPPLY & MATERIEL	211	Michael Guacci	2976	Carole McNulty	2977	R Hannel, 2309, J Scharpeger, 2974, M Bennett, 2441, R DiLello, 7238, D Cunningham, 4599, G Dioguardo, 2597
ID	TECHNICAL INFORMATION	477	Diane Mirvis	3489	Arline Willsey	3490	M Harned, 7832
AUI	ASSOCIATED UNIVERSITIES INC						
	Internal Audit	134A	Frank Federmann	2482	Elinor Adams	5221	Deborah Johnson, 5176
	Vice President	460	Daniel J Swanson	3328			
	Washington Office		Robert Hughes, President		Nora Steenson		*Virginia Grudichak*
	Tel No (202) 462-1676		Thomas Davin, VP, Counsel				
	1400 16th Street, N.W.		*Jerome Hudis*, VP, Cont., Sec'y				
	Washington, D.C. 20036		Carol Whitley, Asst Sec'y				
DOE	*DEPARTMENT OF ENERGY*	464	Carson Nealy	3424	Doris Porter	3427	F Crescenzo, 3433, J Shands, 3435, R Gordon, 3346, M Buller, 3430, M Holland, 3552, J Yeck, 2393

*ACTING

7/92

Figure 38. BNL Department/Division Contacts.

DOE regulations, it is essential that prospective HFBR Users, who are foreign nationals, apply for Guest Appointments well in advance of the startup date of an experiment or the effective date of an assignment at BNL. For example, DOE Order 1240.2A* requires that an indices check ("a procedure whereby a request is made to appropriate U.S. Government agencies to determine if information exists on a particular foreign national") be satisfactorily completed prior to the assignment of a foreign national, when the assignment involves any of the following categories: (1) Sensitive Country National; (2) Stateless Person; (3) Access to a Security Facility; (4) Sensitive Subject Category. An approved indices check is required before an appointment, an I.D. Badge, and HFBR Access can be obtained.

To initiate the approval process, all foreign nationals are requested to provide the following information, for themselves and accompanying family members, at least 3 months prior to the proposed assignment at BNL: (1) First, Middle, and Last Name, (2) Sex, (3) Country of Citizenship, (4) Date of Birth, (5) City and Country of Birth, (6) Name and Address of Place of Work, (7) Passport Number and Expiration Date, (8) Type of Visa and Expiration Date. [Send to HFBR User Administrator, FAX (516) 282-5888.]

This information is required for completion of DOE Form IA-473 (*Request for Foreign National Unclassified Visit or Assignment)* by the HFBR User Administrator's office or appropriate scientific departmental office to seek the approval of DOE that is required to appoint aliens.

Guest appointments are usually valid for 1 or 2 years and are renewable; it is important that users keep their appointments active. Temporary I.D. cards for family members may be obtained at the Personnel Division (Bldg. 185). Guests must make their own provisions for medical insurance, since no coverage is provided under a Guest Appointment. An exception is made for foreign visitors, who may participate in the Brookhaven insurance plan at their own expense. [*Additional information is available at Personnel: 516-282-2877.]*

*** BNL has applied for a full exclusion from the provisions of DOE Order 1240.2A. If this exclusion is approved by DOE, sensitive-country nationals who require access to the Experimental Level of the HFBR will no longer require Indices Checks or IA-473s [unless a sensitive subject is involved]. Form IA-473 will no longer be required for the visit or assignment of foreign national HFBR users unless DOE funds are used to reimburse reverse foreign travel costs. Form IA-473 will continue to be required for high level and protocol visits by foreign nationals.**

ACCESS TO THE HFBR

Requests for an Access Card and placement of a user's name on the HFBR Access List must be recommended by the BNL Department to which the user is assigned. The "Access Card Request Form" requires the signature of the appropriate Chairperson, Division Head, or designated agent authorized to approve these requests. [The HFBR Scientific Program Head and the HFBR User Administrator (located in the Physics Bldg. 510, Rm. 1-31 and 1-30) are among the designated agents for HFBR Users.] All applications must also be approved by the Reactor Division, certifying that the user has successfully completed the HFBR Safety Training and Access Orientation Program. Identification cards can then be encoded by the Security and Safeguards Division (SSD) to provide access to the experimental level. A "Q" or "L" Security Clearance is required for access to other areas of the HFBR. The SSD Information Security Office is located in the lobby of the Brookhaven Center, Bldg. 30 (Ext. 2493) and is open from 8:30 a.m. to 5:00 p.m., Monday — Friday.

Unescorted Access. To gain unescorted access to the experimental floor and balcony area of the HFBR, guest experimenters must successfully complete a number of safety training and indoctrination requirements which include (but are not limited to) the following:

Access training

- Radiation Worker and Radioactive Materials Control Training (to obtain a film badge); challenge exam option if less than a 2-week stay. Retraining is required every two years.

- Reactor Division General Employee Training (GET)
  - GET Level Ia. Short-Term Visiting Scientific Personnel; (less than a 2-week stay); Challenge Exam option
  - GET Level IV (more than a 2-week stay, or a frequent facility user); Challenge Exam option

- HFBR Access Indoctrination
  (Available from the HFBR receptionist)

Beam line training

- Posting and Self-monitoring Training
  (Available from HFBR S&EP Representative)

- Beam Line Safety Manual Training
  (Available from Beam Line Safety Coordinator)

These requirements are Department of Energy (DOE) mandated to assure the safe operation of the facility.

In place of formal classroom training, short-term guest experimenters have the option of receiving the training manuals in advance in order to be prepared to pass challenge exams on arrival at BNL. To allow sufficient time for this material to be sent to users for their review, and to facilitate administrative and safety training requirements on arrival at BNL, the following procedures have been developed:

Procedures for Guest Users to Obtain Unescorted Access to the HFBR

1. The cognizant BNL contact person should arrange to have a completed *Information Needed for HFBR Entry Form* forwarded to the HFBR Receptionist in Bldg. 750 well in advance of the proposed arrival date of an experimenter. Note that a BNL Guest Number or Life Number and term of appointment must be specified on this form. [Guest Appointments are arranged through the HFBR User Administrator's Office, Physics Bldg. 510A, Ext. 5564, or through the Scientific Department sponsoring the assignment.]

2. The HFBR Receptionist enters the information provided on the form into the security computer access control system and sends an information packet to the guest. The packet will contain study materials for General Employee Training and Radiation Safety.

3. Upon arrival at BNL, the guest checks in at the HFBR User's Office or at the department of assignment. [Salaried or Research Collaborator appointees are to check in at Personnel, Bldg. 185.] The guest signs the appropriate forms to validate the appointment and obtains a completed and signed *Identification Card/Security Badge Application* and *Access Card Request Form*, for access to the Experimental Level of the HFBR.

4. Challenge exams are scheduled via the HFBR Receptionist (Bldg. 750, Ext. 4432). Whenever possible, challenge exams/training should be scheduled in advance, so that experimenters may take the exams and receive training on the day of check-in at BNL.

5. The guest reports to the HFBR (or other designated location) with the access request form, to take the challenge exams. If unsuccessful

in passing the challenge exams, the guest must arrange to attend a class for General Employee and/or Radiation Worker Training.

6. Upon successful completion of the challenge exams or General Employee and Radiation Worker Training, the guest is issued a blue card by the trainer, and the HFBR receptionist arranges with Health Physics for a temporary film badge to be issued to the guest.

7. The guest receives access training from the HFBR receptionist.

8. Upon completion of access training, the Reactor Division ES&H Coordinator or HFBR Plant Manager approves the access request form, and the HFBR receptionist takes the I.D. photograph of the guest.

9. The HFBR receptionist collects the approved access request form, the I.D. photo, and completed Security Badge Application form for all incoming HFBR guests. Once each day, the receptionist delivers these items to the Safeguards and Security Division (SSD), where the information on each guest is entered into the security computer access control system and the magnetically encoded security I.D. badges are prepared for each guest. Time Zone 1 Access permits Monday through Sunday, any hour access.

10. The SSD will deliver the encoded badges to the HFBR receptionist by the end of the day.

11. After obtaining the encoded photo I.D. badge at the HFBR, the guest should verify that the badge functions correctly to unlock the door at the HFBR access portal.

12. **NOTE:** At the reactor, I.D. and film badges are required to be worn at all times. If a person forgets his/her badge, a blank encoded visitor's badge may be obtained from the HFBR receptionist. Lost badges must be reported immediately to Security Headquarters.

Procedures for Guests to Obtain Escorted Access to the HFBR

1. Information for individual visitors must be given to the HFBR Receptionist (Ext. 4432) at least two hours in advance of the visit.

2. Information for group tours of the Experimental Level must be submitted to the HFBR Receptionist 24 hours in advance.

3. Include the following information on each visitor:
   A. Full name (accurate spelling)
   B. Affiliation
   C. Citizenship (Date of birth, city and country of birth information is required for sensitive country nationals.)
   D. BNL Life Number or Guest Number if applicable.
   E. Date/Time of Visit
   F. Name, Life Number, affiliation of authorized escort

4. **NOTE:** One person from the authorized access list may escort up to ten visitors on the Experimental Level. The group must be kept together. Authorized persons from the **secure area** access list may escort up to four visitors on the Operations Level or Equipment Level (U.S. Citizenship and 24 hour notice is required.)

5. Visitors are not permitted access outside of normal working hours unless prior approval is obtained from the Reactor Division Management.

PATENT AGREEMENTS

Patent Agreements must be executed by all individuals who will work at BNL. Members of the regular BNL staff and salaried visitors execute an Employee Patent Agreement; facility guest users sign an Agreement For Use of a DOE Designated User Facility (DUFA); and scientific guests/research collaborators not working at one of BNL's user facilities execute a Guest Patent Agreement, prior to or at the time of activation of appointment.

BNL is also authorized to enter into Cooperative Research and Development Agreements (CRADAs) with industrial and/or university partners. CRADAs are appropriate where there is the possibility that a joint effort by the Laboratory and its partners will result in a commercial product or process based upon a Laboratory technology, capability or facility.

Details regarding HFBR Proprietary Research Agreements are outlined in Section II of this Handbook, User Policy for the HFBR. Questions pertaining to patent and licensing provisions of the DOE/AUI Prime Contract may be directed to Margaret C. Bogosian, Deputy Manager, Office of Technology Transfer, Ext. 7338.

AGREEMENT FOR THE USE OF THE HIGH FLUX BEAM REACTOR (HFBR) — A DOE DESIGNATED USER FACILITY (DUFA AGREEMENTS)

A pre-condition to access the HFBR to conduct non-proprietary research is the execution of the "Agreement for the Use of the HFBR — A DOE Designated User Facility." This can be done either before or at the time of activation of appointment. This agreement is entered into by the institution with which the guest scientist is affiliated and the Associated Universities, Inc. (AUI), which operates BNL, under contract with the United States Government as represented by the U.S. Department of Energy (DOE). In implementing the DOE User Facility Class Waiver, the first representative from an institution to perform research at the HFBR is requested to sign the agreement. This agreement is forwarded to BNL's Patent Counsel and a formal contract is entered into between AUI, Inc./BNL and the guest scientist's institution. All future guest scientists from that institution are asked to sign a form, which is a "Supplement to the Agreement for the Use of a DOE Designated User Facility," and the execution date of the original agreement is referenced. There is no charge for beam time at the HFBR under the non-proprietary agreement. The intellectual property provisions of the agreement provide the user institution with the option to take title to any patents made during research at the HFBR, but give DOE title to all data generated at the facility. Guest Scientists are expected to publish the results of their research in the scientific literature, when such results are appropriate for publication.

Publications

HFBR Users are requested to forward a copy of any publication(s) resulting from their work at the HFBR [preprint/reprint — identified by HFBR Proposal No.] to the HFBR User Administration Office. The appropriate acknowledgment when referencing work done at the HFBR is:

> "This research was conducted at the High Flux Beam Reactor, Brookhaven National Laboratory, and supported by the Division of Materials Sciences, U.S. Department of Energy, under Contract No. DE-AC02-76CH00016."

Guest Patent Agreement

Scientific Guests whose primary purpose in coming to BNL is not to conduct research at a user facility, but who may need access as an incidental rather than substantive part of the research program,

must sign the Guest Patent Agreement before or at the time of activation of their appointment.

Employees of DOE or other DOE Contractors are not required to execute a BNL Patent Agreement.

Visitors who come to BNL to observe the facilities, arrange for future experimental work, employment, or other scientific cooperation, will not be required to execute a Patent Agreement, or an Agreement for Use of the HFBR — A DOE Designated User Facility.

LABORATORY HOUSING
Housing Office (Ext. 2541, Bldg. 179B, 2 Center St.)

BNL has on-site housing units, which include the Guest House, dormitory residences, and furnished apartments. Detached units — mobile homes and cottages — are available during the summer months, June through mid September. A map of the Apartment Area is shown in Figure 39.

Rooms at the Guest House consist of two single beds, a private bathroom, TV, and air conditioning. Single or double occupancy and daily and weekly rates are available.

The dormitory residences contain single rooms with shared bathroom and kitchen facilities. The men's dorms are Cavendish, Compton, and Fleming Houses. Curie House is a residence for women. Rooms are available at daily, weekly, and monthly rates.

Apartments (1-4 Bedroom) and Efficiency Units (1-2 rooms and 1-room connecting type) are supplied with furniture, towels and bed linen, kitchen facilities and utensils, as well as irons, toasters, electric brooms and fans. There are TV antenna connections in the apartments and efficiencies, but not in the detached or mobile units. The electricity available is 120 volt AC, 60 Hz. Coin-operated laundry facilities (washers and dryers) are located in the apartment area.

BNL housing is for the temporary accommodation of individuals appointed to participate in research programs at the Lab. Thus, with the exception of visitor-status individuals, a valid appointment with the Laboratory is required for on-site lodging. Researchers with accompanying family members are given priority for accommodations

in the apartments. Depending upon availability, Facility User Teams, which include senior staff, students and technicians, may be assigned family-type accommodations for periods of 1 to 12 months in accordance with the BNL regulations for On-Site Team Housing-Designated User Facilities. Department approval is required in advance.

New appointees and visitors to the Lab request on-site housing via the department or division that is sponsoring the assignment or visit. Researchers who have an appointment with the Lab may make dorm room reservations for intermittent stays directly with the Housing Office, except when summer housing is involved. The summer program is in effect from June to mid September, and each scientific department is allocated a certain number of housing units for visitors. Usually summer housing requirements must be determined by April, therefore it is essential that arrangements be made in advance. Housing Agreements must be executed before occupancy for all accommodations when tenancy is for thirty days or longer. The Staff Services Division at BNL is responsible for the management and administration of Housing and the assignment of housing units in accordance with the policy outlined in SPI No. 5-08.

The Housing Office (located in Bldg. 179B, Telephone 516-282-2541) is staffed during working hours at the Lab from 8:30 a.m. to 5:00 p.m, Monday through Friday, except holidays. A night clerk is on duty in the Housing Office, Monday through Friday, except holidays from 5:00 p.m. to midnight; Sunday — 4:00 p.m. to midnight. During these hours, lodging keys can be picked up, rent paid for less than thirty days occupancy, and checkout can be accomplished. For rentals over thirty days, prompt payment of rents and telephone bills are to paid to the BNL Cashier (Bldg. 134J) upon receipt of monthly statements. Checks should be made payable to Brookhaven National Laboratory and must be drawn against a U.S. bank.

For those individuals arriving at BNL when the Housing Office is closed (holidays, Saturdays, Sunday before 4:00 p.m., or after midnight) lodging keys for reserved lodging are held at the Laboratory Police Headquarters (Safeguards & Security Division) Bldg. 50, 2 Upton Road, Ext. 2238.

Reservations are guaranteed and to avoid "no-show" billing, reservations must be cancelled by 1:00 p.m. on scheduled day of arrival by calling the Housing Office (Ext. 2541), or the Lab Police (Ext. 2238), accordingly.

Colonial Taxi will meet the flights arriving at L.I. MacArthur. For reservations: (516) 589-7878 or (516) 588-7878; Toll Free 800-832-7878 (within NY State); 800-645-7878 (outside NY State).

Rail Service, The Long Island Rail Road (LIRR)

The LIRR offers rail service between New York City (Pennsylvania Station) and Long Island. The railroad station most convenient in terms of schedules for visitors bound for BNL is the station at Patchogue, NY. Monday through Friday (except holidays), a BNL Lab driver meets the 8:26 a.m. train from Penn Station on its arrival at 9:57 a.m. in Patchogue. Passengers are then driven to their destinations at the BNL site. At other times Taxi service is usually available.

Visitors bound for New York City can make arrangements to be driven to the Ronkonkoma railroad station (Monday through Friday (except holidays), to board the 4:46 p.m. train, which arrives at Pennsylvania Station at 6:08 p.m. For reservations for Transportation's shuttle service, call Ext. 2535. Travelers must be at the Transportation Office, Staff Services, Bldg. 179B, by 4:00 p.m. For current information regarding these schedules, contact BNL's Transportation Office (2535).

Many trains, including the two mentioned above, make a scheduled stop at the Jamaica railroad station, which is the nearest connection to LaGuardia and JFK airports. Rail schedules change somewhat each season, so it is recommended that schedules be verified.

24 Hour - Travel Information Numbers for LIRR
New York City.....(718) 454-5477
Eastern Suffolk County.....(516) 758-5477

Auto/Ferry Service

Cross Sound Ferry provides year-round ferry service for automobiles and passengers traveling between New London, Connecticut, and Orient Point, L.I., New York. For schedules, reservations, and rates, call (516) 323-2525 or (516) 323-2743 in NY, and (203) 443-5281 in CT.

Bridgeport & Port Jefferson Steamboat Company provides year-round ferry service between Bridgeport, Connecticut, and Port Jefferson, L.I., NY. For schedules, reservations, and rates, call (516) 473-0286 in NY, and (203) 367-3043 or (203) 367-8571 in CT.

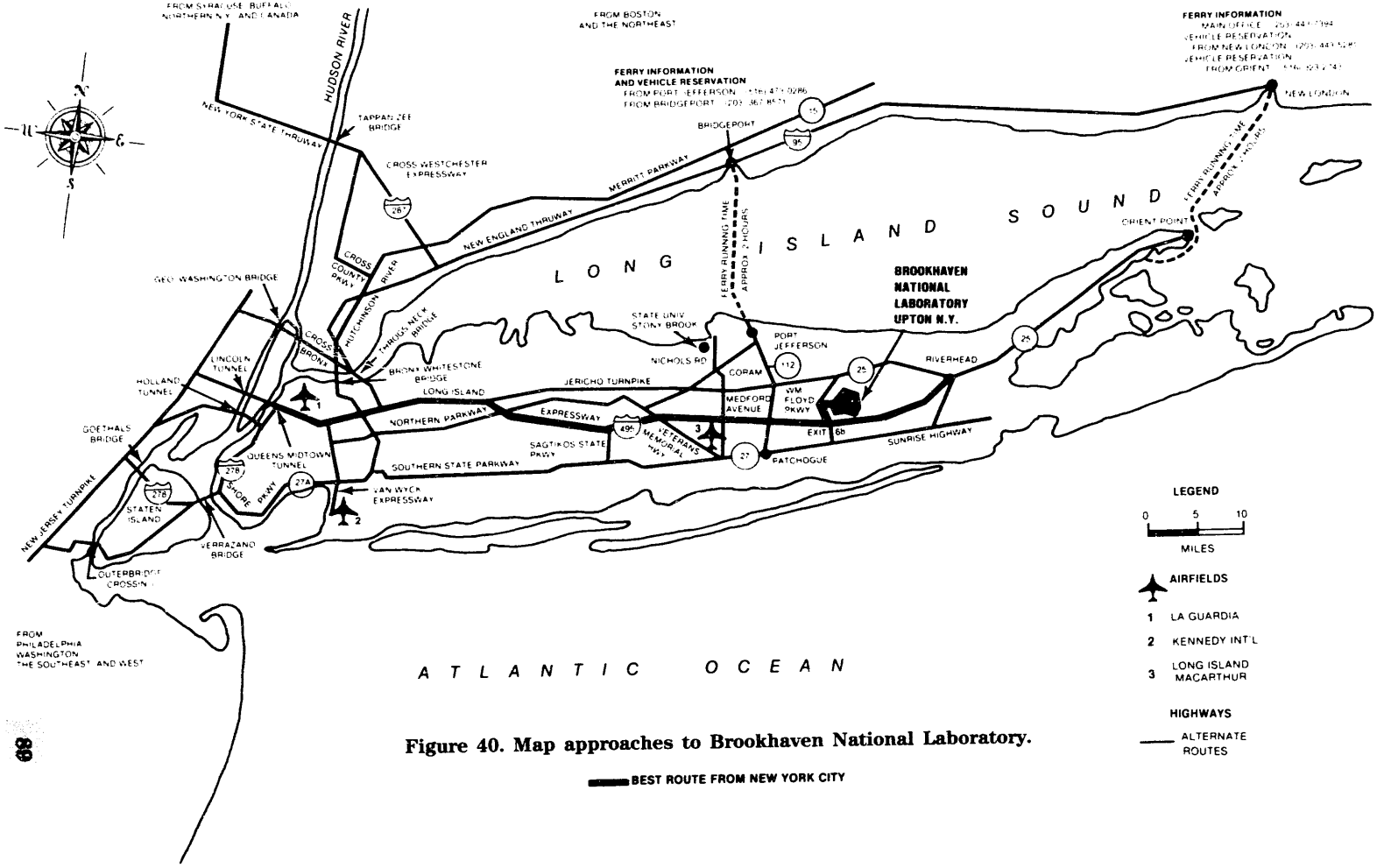


Figure 40. Map approaches to Brookhaven National Laboratory.

VI

Ancillary On-Site Services

MAP LEGEND

The right hand numbers on the table below correspond to those in circles on the map and are arranged in ascending order from left to right.

BUILDING NAME	Bldg. No.	Map No.
Accelerator Development Department	902	16
Administrative Data Processing	459	22
Administration	460	27
Alternating Gradient Synchrotron (AGS) Department	911	32
Alternating Gradient Synchrotron (AGS) Ring	913	24
Applied Science	179	26
Atmospheric Chemistry Laboratory (DAS)	426	41
Atmospheric Sciences (DAS)	51	1
Bank	193	52
Berkner Hall	488	9
Biology	463	30
Booster (AGS)	942	14
Brookhaven Center	30	7
Brookhaven Linac Isotope Producer (BLIP)	931B	14
Cafeteria	488	9
Calibration	348	2
Cavendish House (Men's Residence)	153	12
Central Shops	462	29
Chemistry	555	19
Chemistry Linac Irradiation Facility (CLIF)	931A	14
Child Development Center (See Apartment Area Map)	373	61
Clinic	490	23
Collider Center	1005S	60
Compton House (Men's Residence)	170	3
Computing and Communications	515	44
Contracts and Procurement	355	37
Curie House (Women's Residence)	258	5
Cyclotron	901	43
Data Processing	459	22
DOE-BHO	464	40
Energy Process Technology Division (DAS)	526	59
Energy Sciences and Technology (DAS)	815	47
Energy Storage and Conversion and CPMG (DAS)	120	56
Environmental Protection Division (SEP)	535	50
Environmental Research Center (DAS)	318	45
Exhibition Center	701	33
Fire Department	599	4
Fiscal	134	25
Fleming House (Men's Residence)	180	10
Gas Reactor Research (DNE)	703	33
Graphic Arts	197	17
Guest House	257	6
High Flux Beam Reactor (HFBR)	750	48
Hospital	490	23
Hot Laboratory (Medical)	801	42
Housing Office	179	26
Instrumentation	535	50
Linear Accelerator - 200 MEV	930	8
Management and Information System	459	22
Medical Research Center	490	23
Metallurgy (DAS)	480	49
National Center for Analysis of Energy Systems (DAS)	475	11
National Nuclear Data Center (DNE)	197	18
National Synchrotron Light Source	725	51
Nuclear Energy, Department of	197	18
Nuclear Waste Management (DNE)	830	54
Oceanography (DAS)	194	39
Personnel	185	38
PETT VI	906	34
Photography	118	36
Physics	510	35
Plant Engineering	134	25
Police Headquarters	50	13
Pool-Gymnasium	478	28
Post Office	179	26
Power Transmission Research Facility	933	53
Public Affairs	134	25
Radiation Effects Facility	938, 939	15
Reactor Analysis DIV-DNE	475B	11
Reactor Division	703	33
Reactor Safety (DNE)	130, 820	21, 55
Research Library	477	20
Residences, Men's	153, 170, 180	12, 3, 10
Residences, Women's	258	5
Safeguards and Security Division	50	13
Safety Division	129, 535	50
Science Education Center	438	62
Service Station	630	46
Shipping and Receiving	89	58
Supply and Materiel	211	57
Tandem Van de Graaff	901	43
Technical Support Organization (DNE)	197	18
Telephone Switch Room	449	63
Thermal and Fast Reactor Safety	130	21
Transportation and Travel Office	179	26
BNL Video	493	31
Visitor's Exhibit Center	701	33

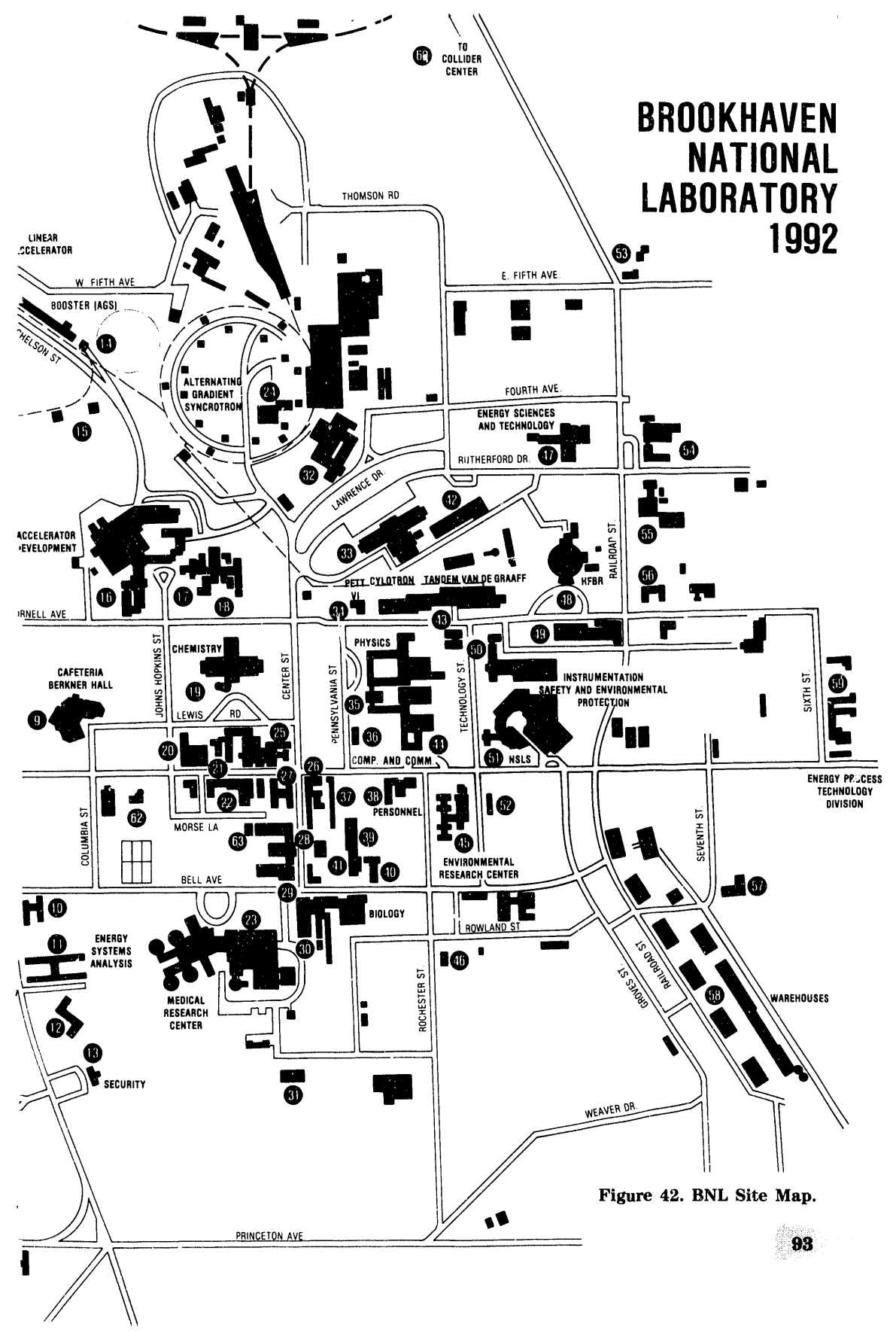


Figure 42. BNL Site Map.

Ancillary On-site Services

(Refer to BNL Site Map, Figure 42.)

AUTOMOBILE SERVICE STATION. (Location: Bldg. 630, 14 Rochester Street, Ext. 4034)

A full-service Gulf gas station is located on site and is open from 8:00 AM to 6:00 PM, Monday-Friday (except Lab. holidays). Mechanics are on duty to provide towing, auto repair, and inspections. "Friendly's" is an official State of New York Inspection Station. Gulf, MasterCard, Discover, and Visa credit cards are accepted.

BANKING SERVICES. (Location: Bldg. 193, 2 South Technology Street, Ext. 2790)

Teachers Federal Credit Union (TFCU) is a full-service financial institution. Anyone holding a valid BNL identification card is eligible to join the credit union and take full advantage of its services. The hours at the BNL branch of TFCU are as follows:

Mon. - Wed.	9:00 a.m. to 4:30 p.m.
Thursday	9:00 a.m. to 5:00 p.m.
Friday	8:30 a.m. to 4:30 p.m.

An Automatic Teller Machine (ATM) is located in the front lobby entrance to Berkner Hall, Bldg. 488, and is accessible 24 hours a day. TFCU is part of the NYCE, Instabank, SAM, and CIRRUS ATM Networks.

BERKNER HALL. (Bldg. 488, 11 Brookhaven Ave., Conferences, Ext. 3547)

The Cafeteria is located at Berkner Hall; see the **Cafeteria Schedule.**

Berkner Hall serves as a conference and meeting center at BNL. In addition, many concerts, art exhibits, and theatre productions are held at Berkner throughout the year. Facilities include Meeting Rooms A, B, C, and D, the Auditorium, Lobby, and Dining Area. Jane Guido, Staff Services Division, Ext. 2553, can be contacted to reserve meeting space at Berkner.

BERA (Brookhaven Employees' Recreation Association) Sales Office. (Ext. 3347)

BERA, open 9:00 a.m. to 1:30 p.m., Monday-Friday, is located at Berkner Hall. Film and film processing, greeting cards, postcards, T-shirts, sweatshirts, as well as tickets for special sport and cultural events are among the services available.

BROOKHAVEN BULLETIN. (Bldg. 134, 35 Brookhaven Ave., Ext. 2345)

The *Brookhaven Bulletin* is a weekly BNL newspaper published by the Public Affairs Office. It is distributed to all departments and divisions each Friday and contains articles on forthcoming events, special reports on research highlights, and schedules of various activities, which include cultural, social, and sporting events. The classified ad section is very useful for buying or selling a wide range of items and as a source of listings of off-site real estate. The deadline for submitting a classified ad is 4:30 p.m. Friday for inclusion in the following Friday's edition. Classified Ad forms are available at Public Affairs and from the HFBR User Administration Office.

BROOKHAVEN CENTER (CENTER CLUB). (Bldg. 30, 23 S. Upton Rd., Kitchen, Ext. 2204, Conferences, Ext. 2202/2203)

Schedule:

Monday-Friday	
5:00 p.m. to 11:00 p.m.	Bar Service, Dinner, and Snacks
Sunday	
5:00 p.m. to 9:00 p.m.	Bar Service, Dinner, and Snacks
Saturday	Closed

The Brookhaven Center serves as a conference center at BNL as well as a social meeting place on-site. Amenities include a TV Lounge, Tap Room, Dining Area, Patio, and other facilities. The Center Club is open evenings — Monday through Friday — from 5:00 p.m. to 11:30 p.m. Snacks and bar service is available until 11:00 p.m; table service and an expanded menu featuring appetizers, omlettes, grilled sandwiches, burgers, and a variety of side dishes and soups, is available until 10:00 p.m. Dinner specials are featured Sunday through Friday, from 5:00 p.m. to approximately 7:00 p.m. [Holiday closings are announced in the Brookhaven Bulletin.]

To reserve or obtain information on the availability and capacity of the facilities at the Brookhaven Center, contact Jane Guido, Staff Services Division, Ext. 2553, in the early planning stages of a conference or special event.

CAFETERIA. (Location: Berkner Hall, Bldg. 488, 11 Brookhaven Ave., Ext. 3541)

Schedule: Monday - Friday

7:30 a.m. - 10:30 a.m.	**Breakfast**
10:30 a.m. - 11:15 a.m.	Coffee, Snack Bar
11:15 a.m. - 1:30 p.m.	**Luncheon**
1:30 p.m. - 3:45 p.m.	Coffee, Snack Bar
4:00 p.m.	**Cafeteria Closes**

Dinner - See Brookhaven Center

Schedule: Saturday, Sunday, & Holidays

9:00 a.m. - 2:00 p.m.	Snack Bar Service

CASHIER SERVICES. (Location: Bldg. 134J, 37 Brookhaven Avenue, Ext. 2474)

The BNL Cashier is authorized to cash personal and institutional checks (which are payable to the bearer) up to $200; petty cash vouchers (original receipts required) up to $100; and Travel Cash Advances (if accompanied by an approved Standard Travel Authorization or travel voucher). Petty cash vouchers exceeding $100 require additional approval before they can be cashed, and the Fiscal Officer, located in the same building, has authorization to approve such vouchers. Cashier services are available to BNL employees as well as to individuals who have an appointment with the Laboratory. Presentation of a valid BNL I.D. card is required. Third-party checks, IRS, and payroll checks cannot be cashed by the Cashier.

CASHIER'S HOURS:

Monday - Thursday:	8:45 a.m. to 4:45 p.m.
Friday:	7:45 a.m. to 4:45 p.m.
(Hrs. Closed)	9:15 a.m. to 10:00 a.m.
	1:00 p.m. to 2:00 p.m.
	3:00 p.m. to 3:15 p.m.

The Cashier's Office is the place to pay monthly on-site housing and telephone bills; make checks payable to Brookhaven National Laboratory.

COMPUTERS AND SOFTWARE. (Computing and Communications Division (CCD), Bldg. 515, 61 Brookhaven Ave.)

Requests for information concerning computer services can be directed to the appropriate contacts at the Computing and Communications Division, some of which include:

Central Scientific Computing Services - L. Lawrence, Ext. 4107
PC Software Sales - D. McCambridge, Ext. 4127
Workstations & CADCAM - T. Daniels, Ext. 5555
Networking - D. Stampf, Ext. 4148
PCs - D. Litcher, Ext. 7587; E. Taylor, Ext. 7589
Macintosh Center - M. Borowski, Ext. 3895
Computer Information (Help Desk) - Ext. 4159

All orders for computers, software, and services must be submitted via an ILR (Intra-Laboratory Requisition) approving the expense and indicating the account to be charged.

CONFERENCE AND MEETING ROOMS ON SITE. Refer to the Yellow Pages of the BNL Telephone Directory for the list of conference rooms on-site, their capacity, and the name and extension of the person to call for reservations. Robin Scarola (Ext. 3872, Rm. 1-45) is the Physics Department's contact person to reserve conference rooms in Physics, Building 510.

EDITORIAL SERVICE. (Technical Information Division (TID), Bldg. 477B, 22 Lewis Rd.)

The Editorial Service provides a range of services from editing of journal articles, conference papers, technical and scientific informal and formal reports, symposia proceedings, and proposals to technical and administrative manuals. All services are free; call Ext. 3482 or 3486.

FOOD SERVICES. (See Brookhaven Center and Cafeteria, Berkner Hall).

Food service is available on-site at the Cafeteria and at the Brookhaven Center during the hours specified above. A Breakfast Truck, located in the parking lot across from Berkner, offers coffee, rolls, pastries, newspapers, for sale, 7:00 a.m. to 8:15 a.m., Monday to Friday. Also, during Lab hours, a Lunch Truck with sandwiches, snacks, and beverages for sale makes scheduled stops at many buildings on-site. Vended Food Service is available at all times at Bldg. 912, 35 Lawrence.

Service America Corporation (SAC), the food services contractor on-site, has expanded and innovative services in progress. SAC is equipped to cater full course dinners for hundreds of people, to small luncheon meetings, cocktail parties, and coffee breaks. Information on procedures, setting up an account, menus and cost guidelines for planning meetings, conferences and special events can be found in the "Conference Coordinator's Guide Book," by the Staff Services Division, Ext. 2553. Requests for coffee break items, alcoholic beverages, and soft drinks are arranged with Patrick Glynn, Special Services Supervisor for BNL (Ext. 2553 or Pager 3456-0117). Chris Fautas, Food Service Director of SAC is available at the Cafeteria, Ext. 3541, to assist with arranging dinner and cocktail parties, buffets, luncheons, and special-event food services.

The Restaurant Guide published by BNL's Public Affairs Office lists Fast Food and Take-Out restaurants nearest the Lab as well the name, location, telephone number, hours, and menu price range of general dining restaurants in the area and beyond. Copies of this useful guide are available at the Public Affairs Office, Bldg. 134, Ext. 2345 and from the HFBR User Administration Office, Ext. 5564.

Stores/Shopping Trips. Although there are no stores on-site, grocery stores and pharmacies are located within five miles of BNL; and Patchogue, a large village, is 15 miles away. BNL's Transportation Office organizes shopping trips for the convenience of persons living on-site without the use of private autos. By appointment only, Tuesday and Friday mornings at 9:45 a.m., a bus will leave from the Children's Bus Shelter in the apartment area to transport individuals to the Four Corners in Patchogue or to the Pathmark Shopping Center located in Shirley. At noon, travelers are met and transported back to the Lab. Saturday mornings, shuttle bus service is available to the Shirley Pathmark shopping center from Fleming House parking lot beginning at 8:30 a.m., with the last bus returning from Shirley at noon. *Call Transportation, Ext. 2535, one day in advance for reservations and to confirm schedules.*

Farmers' Market. Locally grown fresh fruits, vegetables, flowers, homemade pies, and breads are for sale on-site by a group of Long Island farmers, each Wednesday, from approximately May 31 until just before Thanksgiving. The Farmers' Market is held from 11:30 a.m. to 1:30 p.m. (Wednesdays) in the parking lot north of the tennis courts along Brookhaven Avenue.

LAUNDRY FACILITIES. (Apartment Area, Bldg. 363, Ext. 3196)

A Laundry with coined-operated washers and dryers is located in the apartment area and is open 7 days a week, 24 hours a day. Any problems which arise should be reported to the Housing Office (Ext. 2541).

LIBRARIES.

BNL Research Library (Bldg. 477A, Circulation Desk, Ext. 3483, Library Research Service, Ext. 3487) is open and staffed during the following hours:

Schedule:	**Monday-Friday**	8:30 a.m. to 9:00 p.m.
	Saturday-Sunday	10:00 a.m. to 6:00 p.m.

The Electronic Reference Service is available from Monday to Thursday, from 8:30 a.m. to 7:00 p.m.

Most departments on-site maintain small reference libraries, and information regarding their use can be obtained by calling the department's administration office.

Longwood Public Library (Middle Country Road, Middle Island, NY, (516) 924-6400) may be used by on-site residents. Application forms for joining the library are available at the BNL Research Library.

State University of New York at Stony Brook Library (Telephone: (516) 632-7160 re hours; 632-7110, reference) may be used by BNL staff. Apply at the library's Circulation Desk (third floor) on campus.

LOST AND FOUND. (Recreation Office, Personnel, Bldg. 185)

Call Ext. 2873 for items lost or found on-site. In addition, arrange to have a notice included in the Brookhaven Bulletin.

MEDICAL CLINIC. (Bldg. 490, 30 Bell Avenue, Ext. 3670)

Routine employee health services are available from the Occupational Medicine Clinic (OMC) during regular working hours, Monday through Friday (except holidays) from 8:30 a.m. to 5:00 p.m. Clinic physicians are on duty and will evaluate and may treat persons who come to the Clinic for medical assistance. Referral or transport to an emergency room at a local hospital may be required at the discretion of the Clinic physician.

The BNL Police Group, Ext. 2238, can always be reached for information regarding situations which may require their attention.

For non-emergency personal and family medical care, users are expected to see private physicians and to use facilities off-site. Physicians at the clinic may be consulted for information on physicians practicing in the area.

MEDICAL EMERGENCIES. (Ext. 2222)

Emergency medical assistance from the Fire/Rescue Emergency Medical Technicians, located at BNL's Firehouse, can be obtained at any time by calling the Laboratory's emergency extension **2222.**

For off-site emergencies, Call 911.

NEWSPAPERS. (Cafeteria, Bldg. 488)

The New York Times, *The Wall Street Journal*, *The Daily News*, *Newsday*, and some local newspapers are on sale, Monday-Friday, at the Cafeteria, Berkner Hall, and from the Breakfast Truck, 7:00 a.m. to 8:15 a.m.

NOTARIES PUBLIC. There are about 30 notaries on site in the various departments. The following represents only a few who happen to be located near the HFBR:

Director's Office, Bldg. 460	
Carol Joyce	Ext. 3325
Personnel Division, Bldg. 185	
Donna Dowling	Ext. 2754
M. Kay Dellimore	Ext. 2873
Physics Department, Bldg. 510	
Sandra Sanchez	Ext. 3793
Robin Scarola	Ext. 3872

PHOTOGRAPHY AND GRAPHIC ARTS. (Bldg. 197B, Cornell Avenue, Ext. 2955)

The Photography and Graphic Arts Division provides a complete range of photography and graphic art services both at its on-site facilities and through full service contractors. Most services are charged at an hourly rate against the requestor's account via an open or yearly Intra-Laboratory Requisition.

Composition, Printing, Quick Copy, and Technical Publishing (word processing) services may or may not incur charges, depending upon the size of the job. A description of the services available include:

Composition (Bldg. 197, Ext. 2952). Typesetting and floppy disk data conversion are available. To minimize mistakes and costly delays, it is recommended that material for typesetting be first reviewed by the Technical Information Division's editorial staff and the Graphic Arts' design staff.

Copy Service Center - "Quick Copy." (Bldg. 197, Ext. 2900; Redball Pick up, Ext. 2950). "Quick Copy" is equipped to handle large and small copying needs at BNL and makes every effort to meet delivery requirements. The copy service supervisor should be consulted in connection with special requests or emergency deadlines. Quick Copy provides routine pick up and delivery service to and from central points within most buildings on-site, and will make special trips when "Redball" Service is required. "Over the counter" service needs can usually be met as well. A completed BNL F 2222B order form should accompany each request for copy service.

Copy Machines -- Self-Service. There are copy machines in most buildings on-site which may be used for short runs of official documents. In the Physics Department, Bldg. 510, a copy machine is adjacent to the mail room on the first floor, and one is in the Physics Library on the second floor. Thermal copier machines for making transparencies are also available at these locations in Physics.

Graphic Design. (Bldg. 197, Ext. 7288 or 2935) The Graphic Design staff should be consulted for specialized art service needs. They are available to offer artistic and production recommendations, coordinate the technical aspects of a publication, brochure, or other type of job, work out a production schedule and help prevent costly mistakes and delays.

Illustration. (Bldg. 197, Ext. 2913) The Illustration Section's staff, using traditional methods as well as images generated on a Macintosh computer, can provide all types of drawings for publications or presentations. Illustrations are converted to glossy prints by the Photography Section, so sufficient lead time is required.

Micrographics. (Bldg. 197, Ext. 2973) Microfilm output (fiche, 35mm, 16mm) of computer-generated material is available through the Micrographics Group at no charge to the user. Further graphics

information is available through the Computing and Communication Division (Ext. 3216).

Photography. (Bldg. 118, Photographic Orders Ext. 2381, Photographers, Ext. 2382, Video, Exts. 3680, 2382) Photography provides complete photographic services for documenting of equipment or experiments, photomicrography, visual displays, passport photos, slides, overhead transparencies, color and black and white prints. Normal completion time is approximately one week, but in an emergency, every effort is made to meet a deadline. Negatives are kept on file for reordering purposes.

Printing Services. (Bldg. 197, Ext. 2953 or 2935) Services are available for the printing of both technical and nontechnical publications, i.e., reports, brochures, research proposals, conference proceedings, newsletters, and forms. Continuous forms and carbon type forms are procured by Graphic Arts through the U.S. Government Printing Office.

Word Processing Services. (Bldg. 197, Ext. 2926) Word processing services are available at the Technical Publishing Center for the preparation of scientific, technical, and administrative documents from handwritten manuscripts, computer disks, telecommunications, and other methods. The Technical Publishing Center's supervisor should be contacted to discuss the particulars of a job and delivery requirements.

POST OFFICE — U.S. MAIL - UPTON, NY. (Bldg. 179 (Staff Services Bldg.) 2 Center Street, Ext. 2539)

Window Service:	8:30 a.m.-4:45 p.m.	Monday-Friday
U.S. Mail Dispatched:	11:25 a.m. and 4:35 p.m.	Monday-Friday
	7:00 a.m.	Saturday

Express Mail: 11:30 a.m. and 4:15 p.m. Monday-Friday
(Hand carry to post office, allow sufficient time for handling before dispatch.)

Since there is no mail delivery to the on-site housing units, guest researchers may have personal and official mail sent to the mailstop of their department of assignment. If this is inconvenient for family members living on-site, an option is to rent a post office box at the Upton Post Office.

Mail is picked up and delivered to all departments or divisions on-site twice a day - mornings and afternoons - by the **BNL Mail Room (Ext. 2534 , also located in the Staff Services, Bldg. 179).** (Schedules vary for each department — mail is delivered and picked up at the Physics Department Mail Room, located near the front lobby in Bldg. 510, at ~ 9:30 a.m. and ~ 2:30 p.m.) Personal mail must have the proper postage affixed; official mail can be deposited without postage, and requires a return address and sender's name. Official mailings which require postage of $15.00 or more for a single piece, or $50.00 for volume mailing of multiple pieces and all Express Mail, require an Intra-Laboratory Requisition (ILR) approving the expense and indicating the account to be charged.

For convenience, there is a U.S. Mailbox in the parking lot across from Berkner Hall. Mail deposited there will be picked up and brought to the Upton Post Office every weekday at 10:30 a.m. and 4:00 p.m.

PRIVATE VEHICLES — ACCESS TO BNL SITE.

Laboratory employees and guest researchers who regularly drive privately-owned vehicles on-site are required to register them. A BNL vehicle registration sticker must be displayed on the vehicle. The Safeguards and Security Division (SSD) is authorized to issue and renew these stickers. Application cards are available at SSD — Information Security Office, located in the lobby of the Brookhaven Center, Bldg. 30, (Ext. 2493). Hours are 8:30 a.m. to 5:00 p.m., Monday-Friday, and proof of ownership or vehicle registration is required.

Caution: The speed limit (30 miles per hour in most areas), traffic and parking regulations are strictly enforced on-site. SSD is equipped with radar and is authorized to issue speeding and parking citations. Fifty dollar fines can be imposed and charged to department or user accounts.

PURCHASING — Off-Site Vendors. (Division of Contracts & Procurement, Bldg. 355, Ext. 3159)

When material is required from an off-site vendor, the requisitioner prepares a *Purchasing Request - Work Copy Form* (BNL F 2420 B), obtains the required account approval, and submits the request to their department business office for transmission to the Division of Contracts & Procurement (DCP). (Sole Source Justification (Form 2270) must accompany Work Copy Forms for purchases over $1000, otherwise the order will go out for competitive bid.) In the Physics

Department, purchasing requests are handled by Sherrie Reeve's Office (*Room 1-52, Ext. 2414*), where the necessary department approvals are obtained, and the request is entered into the IPAP (Integrated Inventory, Purchasing and Accounts Payable) system. At DCP, a Buyer/Contracts Specialist is assigned to take action to process the purchase order, making certain delivery and other requirements can be met. Copies of the request in its various stages, work copy to purchase order, are sent to the requisitioner for information.

RECREATION — ON-SITE. (The Brookhaven Employees' Association (BERA), Recreation Office, Personnel, Bldg. 185, Ext. 2873)

BNL's location on 5,265 acres of wooded and open land in the center of Long Island is conducive to a broad range of recreational activities. Running, bicycling, swimming, handball, softball, tennis, birdwatching, and picnicking are some popular lunchtime activities. After hours, there is a selection of more than forty organized sports and cultural groups to join. The Aerobic Dance Club, Astronomical Society, Badminton Club, Basketball League, Camera Club, Chess Club, Concert Committee, Cooking Exchange, Golf League, Mountain & Canoe Club, Quilting Club, Racquetball Club, Soccer League, Theater Group are among the activities available. *For a brochure and/or further information, call M. Kay Dellimore at Ext. 2873.*

BNL Recreational Facilities.

Brookhaven Employees Recreation Park features athletic fields (softball, football, soccer, and cricket pitch), an archery range, volleyball courts, and picnic area. Group party reservations may be made at the Recreation Office.

The Gymnasium (Bldg. 461, 3 Center Street) is open weekdays from 11:00 a.m. to 2:00 p.m., and 5:00 p.m. to 9:00 p.m. for employees' general activities — weight and exercise rooms, basketball/indoor tennis court, and women's locker room. The gym is also opened, 9:00 a.m. to 6:00 p.m., Saturdays (except summer months).

The Parcourse Fitness Circuit is located north of West Fourth Avenue. The Parcourse is spread throughout a setting of pine woods and consists of a series of 18 exercise stations set up in a serpentine trail of 1.57 miles.

The Recreation Building (Bldg. 317, York Lane, Ext. 3033) is located in the apartment area. It is open Tuesday, Wednesday, and

Thursday evenings throughout the year and is available as a lounge or meeting place. Employee group party reservations may be made at the Recreation Office.

The Swimming Pool (Bldg. 478, 5 Center Street, Ext. 3496, next to the Gymnasium) is a 100-ft. indoor swimming pool, with locker rooms, hot showers, and lifeguard(s) in attendance at all times. Season Tickets for four months (individual and family membership) as well as daily admission rates for employee or family member* or guest** are available at the pool.

Pool hours may vary slightly each season (September-December; January-April; May-August) and the new season's schedule will appear in the Brookhaven Bulletin. Information is also available by contacting the Recreation Office, Ext. 2873. Usually the pool is open **Monday - Friday:** 11:00 a.m. to 1:30 p.m. employees (appointees) only; 1:30 to 2:00 p.m. reserved for speed swimming and training; (Summer months: 2:00 p.m. to 3:30 p.m. children's lessons, 3:45 p.m. to 9:00 p.m.); and 5:00 p.m. to 9:00 p.m. employees, families, and guests; **Saturday and Sunday:** 1:00 p.m. to 5:00 p.m. employees, families and guests.

*(*Family member - must live in the employee's household; **Guest ruling - One guest per employee is permitted. Advance arrangements for more guests, up to a maximum of five at any one time, must be made at the Recreation Office, Personnel, Ext. 2873).*

Tennis Courts. Six outdoor courts located on Bell Avenue are available year-round and are operated on a signup basis during peak hours of the summer tennis season. Tournaments are held during the summer months.

SHIPPING/RECEIVING.

Outbound Shipments. The Shipping Section of the Supply & Materiel Division (Location: Bldg. T-89, 16 S. Railroad Avenue, Ext. 2311) is responsible for all shipping activities of the Laboratory. Substantial discount programs with carriers in all modes of transportation have been established. There is a daily scheduled pickup at Shipping for outbound shipments, Monday through Friday, that is available to all Laboratory users. Outbound packages, accompanied by an IPAP generated shipping memo (with an account to be charged, justification for premium transportation, Bar Code numbers indicated for Capital or Sensitive Equipment, Purchase Order referenced and Contracts & Procurement approved when appropriate) should be

brought to the Shipping Section, Bldg. T-89, by 2:00 p.m. of the day shipment is required. Premium transportation includes: Air transport; Courier Service (e.g., Federal Express and all forms of overnight delivery); Van Lines; and Exclusive Use Carriers.

Shipment of equipment to foreign countries may require an Export License issued by the Department of Commerce. Licensing approvals generally require six to eight weeks after submission of required information. The Traffic Office (Ext. 2309, 2325) should be contacted for information and assistance.

Inbound Shipments. All incoming materials, supplies, or equipment purchased for the Laboratory should be delivered to Central Receiving (Location: Bldg. T-89, 16 S. Railroad Avenue, Ext. 2310). This will ensure savings in transportation as well as facilitating the updating of the Integrated Inventory, Purchasing, and Accounts Payable System (IPAP).

For non-purchase order shipments, e.g., documents and blueprints, delivery can be made directly by the carrier to the addressee providing the address is corectly shown on the package:

Requestor's Name
Building Number, Room Number, Extension No.
c/o Brookhaven National Laboratory
Upton, New York 11973.

It is important that departments and divisions notify the Traffic Office (Ext. 2309, 2325) of any shipments being made to BNL from foreign countries, including the shipment of personal goods for visiting scientists and new employees when the Laboratory is the cosignee. All inbound shipments from foreign countries must be cleared through U.S. Customs. Lack of proper identification and information can result in long delays for clearance and/or imposition of import duties by U.S. Customs.

The Traffic Office is also responsible for coordinating the household moves of new employees within the United States that have been approved by the Personnel Division or the Office of Scientific Personnel.

SUPPLIES/STOCKROOMS.

The Supply & Material (S&M) Division, in addition to their main warehouses located on South Railroad Avenue, maintains small

stockrooms in most departments and divisions on-site. The Physics Stockroom in Bldg. 510 stocks stationery items, data disks, some electronics, tubing, hoses and miscellaneous items, where employees and users can withdraw items from the shelves, charging replacement inventory items to their account and I.D. numbers. A complete set of updated stock catalogs are available in the Physics Stockroom for ordering stock issue on form BNL F 1134A (Inventory Stock Requisition). Delivery of the requested items is usually made to the Physics Stockroom within 24 hours once an order has been entered into the IPAP system. The stock catalogs are divided into the following categories which contain a full description of each item, standard packaging information, unit of issue, and the BNL Stock Number: Chemicals, Electrical, Electronics, Fastners, General, Glassware, Lab Supplies, Maintenance, Metals, Plastics, Plumbing, Heating & Refrigeration, Safety Equipment, Semiconductors, Stationery, and Tools. In addition to the above descriptive catalogs, a Master Index Catalog is available to identify the proper stocking location.

Emergency Withdrawals. Requisitioners may phone in emergency requests to the S&M data entry center (Ext. 2970) for immediate pickup at the stocking location. These requests should be held to an absolute minimum, and the requisitioner should have all the information available when calling in an emergency order (Catalog stock numbers, account number, name, and life or guest number of a person with signature authority for that account). A pickup number (Pick Ticket) will be assigned for reference when picking up the item at the appropriate warehouse.

TELECOMMUNICATIONS.

The Staff Services Division (BNL Mail Room, Bldg. 179, Exts. 2534/2547) is responsible for Telegraph, TWX, TELEX, and facsimile services and for operating the Laboratory Mail Services. The Computing and Communications Division's Networking, Engineering and Telecommunications group (CCD/NET) is responsible for telephone [Ext. 2000] and data communications services [Ext. 4199].

Facsimile Service. During working hours, BNL Mail Room personnel provide services for facsimile transmission of official material. This FAX machine is operational for unattended reception at all times, 24 hours a day. If one receives a message at this central number, he/she will receive a phone call from the Mail Room, and has the option of picking up the FAX or having it delivered by intralab mail.

GENERAL FAX No. at BNL:
Commercial (516) 282-3000

Many departments and divisions and groups on-site have FAX machines, and permission can be obtained from a particular group to send or receive messages at one of these more convenient locations.

Telegrams. Official and personal telegrams can be sent during working hours (8:30 a.m. to 5:00 p.m.) with the assistance of BNL Mail Room staff. Messages should be typed or clearly written on a BNL Telegram Request Form. Lab telephone operators will assist in sending telegrams at other times (8 a.m. or after Lab hours (5:00 p.m. - 6:30 p.m.). For receiving messages, the service numbers are:

Cable Address ..... **BROOKLAB UPTONNY**
TWX **510-228-1291**
TELEX ..... **6852516 BNL DOE**

Teletype. Commercial teletype facilities are available during working hours at the BNL Mail Room for official business only.

Telephone Service. The Laboratory telephone system is available to employees and guest researchers for placing official work-related calls. Each phone extension must have an account designated for charges. The GTE system that is installed on-site provides many features to save time and promote efficiency. These include providing each station with its own seven digit number and Treatment (level of access and restriction), the capability of transferring calls within the site, conference calls, station camp-on with call-back, call forwarding, etc. Descriptions and instructions for using these features are described in detail in the BNL Telephone Directory. The directory, published annually, contains employees' telephone extensions and mail drops, department contacts, and other telephone information organized in useful ways. Laboratory telephone operators (Dial "0") have the most updated extension listings and can provide assistance when necessary. Operators are on duty during regular workdays between 8:00 a.m. and 6:30 p.m.; at other times, BNL's General number (2123) is answered by a recorded message. Thus, it is important that individuals provide contacts with their telephone extension number so that they can be reached directly: (516) 282 +4 digit extension number.

282-INFO. Recorded message for Lab closings or delayed openings.

On-Site Calls. Laboratory extensions are reached by dialing the 4 digit extension number.

Off-Site Calls. Require access codes:

9 followed by 7 digits for calls to area code 516.
9 followed by 10 digits for calls to area codes other than 516.
9 followed by 800 number
8 Followed by a 10 digit commercial number (for FTS calls).

(Refer to Treatment explanations in BNL Telephone Directory regarding access areas.)

International Calls. International direct dialing is available on FAX Machines, Treatments 1, 8, 9 phones, plus residential housing units — Apartments, houses, mobiles, and efficiency units. Others must dial the Lab operator for assistance.

9-011, followed by country code, city code, local number

Long Distance Information. Long Distance information may be dialed directly for any area code to which one has access; 9+, area code, 555-1212. For area code 516 information, the area code is not dialed. Other Long Distance and FTS Information can be obtained via the BNL Telephone Operator.

Equipment Trouble. All telephone equipment problems should be reported immediately to Ext. 4031.

New Installations, Changes and Disconnects must be requested by submitting an IntraLab Requisition (ILR) to the Computing and Communications Division/NET Section, which will issue all orders to the Telephone Company.

Paging. To call a person who has a pocket pager, dial 3456, obtain a short burst of dial tone, dial the 4 digit pager number, and when beeping stops, identify yourself (name and extension) and deliver a brief message.

Personal Calls. Employees are urged to limit personal calls and are encouraged to use one of the 30 pay phones on site. Personal calls involving charges may be placed through the BNL operator in one of the following ways: (1) Collect; (2) Third-party charge to caller's

own private telephone; and (3) Telephone Calling Card. Service charges are involved for these services.

Accepting incoming official collect calls is permitted.

TRAVEL OFFICE. (Staff Services Division, Bldg. 179B, Center Street, Ext. 2531)

All travel reservations for official Laboratory business must be made by BNL's Travel Office. Flight, hotel, car rental, and other travel information is available by calling or visiting the Travel Office on-site. Reservations are booked and confirmation promptly given to the traveler. A printout of the itinerary will be included with the airline tickets, and confirmation numbers and rates for hotels and car rentals will be indicated. BNL has car rental agreements with Budget, National, and Avis; Lab travelers can obtain identification cards from the Travel Office. Airline tickets for official travel are delivered to each department on site. [The BNL Travel Office is not authorized to arrange strictly personal travel.] Travelers are expected to be familar with travel policy rules as outlined in the Standard Practice Instructions (SPI) 4-01 for domestic travel and SPI 4-02 for foreign travel.

VISA INFORMATION — (Office of Scientific Personnel (OSP), Bldg. 185A, 58 Brookhaven Ave., Ext. 3338/3336).

The Office of Scientific Personnel (OSP) has on staff a Foreign Scientist Advisor who can be consulted about visas when appointments are being considered for foreign nationals. Foreign nationals coming to BNL from abroad should contact a U.S. Embassy or Consulate to obtain information regarding visas. Extensions of visas for staff or guests already holding appointments at BNL are handled by OSP.

WEEKLY CALENDAR.

The *Weekly Calendar*, published by the Public Affairs Office, includes a listing of colloquia, lectures, symposia, seminars, workshops and conferences to be held on-site. It is distributed to all departments and divisions either Friday afternoon or Monday morning. Notices to be included in the Weekly Calendar must be received by the Public Affairs Office by noon on Tuesday. Submissions must be typed and follow exactly the format used in the Weekly Calendar. Physics Department personnel should submit Weekly Calendar announcements to Robin Scarola before 5:00 p.m. on Mondays so that she can coordinate the department's list.

WEATHER FORECAST

Call Meteorology, Ext. 2263, for a recorded message on weather conditions on Long Island, which is updated mornings and afternoons. In the event of severe storms (snow, hurricanes, etc.) call 282-INFO or listen to local radio stations for information on Lab closings or delayed openings.

Additional Information of Interest to Family Members

Family members of appointees to BNL may obtain temporary I.D. cards from the Personnel Division, Bldg. 185A, for access to recreational and other facilities and activities at BNL.

Hospitality Committee. The spouses of Lab appointees are assis' in getting acquainted with the area and other families living on-site by the Hospitality Committee. The members of the committee, who are the spouses of BNL staff, sponsor morning get-togethers on-site, with babysitting provided, arrange museum tours, invite guest speakers, and hold other special events, all of which are advertised in the Brookhaven Bulletin and open to all. A hospitality folder, distributed to all the apartments can be obtained from the Housing Office (Ext. 2541). It contains a brochure of the activities of the Brookhaven Employees' Recreation Association (BERA), as well as sketch maps showing local shopping facilities, ferry schedules, a Long Island Railroad timetable, and other materials which are useful to newcomers to the Lab. *Dorothy Marelli (Ext. 4262) in the Personnel Office, acts as a liaison agent, and can provide further information.*

Child Care — The BNL Child Development Center (CDC). CDC is an on-site child care center for the children of Lab employees, offering complete child care 5 days a week from 8:30 a.m. to 5:00 p.m., for children ages 8 weeks to five years. CDC is located in the apartment area on Yale Road, Bldg. 373. Registration information is available from CDC Director Deborah O'Neil, Ext. 7426.

Nursery School — on-site. The Upton Nursery School, organized by a group of Lab parents in 1965, is a cooperative, nonprofit nursery school for three and four year old children of Lab employees or appointees. Certified teachers conduct small classes for these different age groups, and activities include art and nature projects, individual and group play, singing, cooking, and activities which develop language skills, dexterity and awareness. The school year begins in September and ends in June. Classes meet three times a week — Monday, Tuesday,

and Thursday — from 8:30 a.m. to 11:30 a.m — in the Recreation Building located in the apartment area on site. The continued success of the Upton Nursery School depends on the participation of parents during the school year. Parents help as teachers' assistants on a revolving basis and manage the school's business by serving as officers on the general board which administers the school. Since enrollment is limited, inquiries for registration should be made early (before anticipated arrival at BNL) by contacting Elaine Gerhardstein-Wong, Enrollment Chairperson, at (516) 475-4525 or by writing to the Upton Nursery School, P.O. Box 324, Upton, New York, 11973.

Schools. Brookhaven National Lab is located in the Longwood Central School District, and the children of BNL employees or appointees who are living on-site are eligible to attend public schools (Grades Kindergarten through high school, Grade 12) as residents of the district, at no cost for education or bus transportation to and from school. The school term begins a day or two after Labor Day (first Monday in September) and ends late June. Registration takes place at the Longwood Central School District, Middle Island-Yaphank Road, Middle Island, New York 11953. A copy of a BNL housing agreement or lease will serve as the required proof of residency. For further information regarding registration, immunizations, health exam, and other requirements, telephone (516) 345-2162.

For the college bound, families living on-site may qualify for New York State residency tuition. Local colleges include Suffolk County Community College, Selden, NY, St. Joseph's College, Patchogue, NY, and the State University of New York at Stony Brook, NY.

Laboratory Summer Program for Children. Annually, BERA sponsors a summer recreation program for children featuring American Red Cross swimming classes at the pool and a tennis program. This program is open to children of all Laboratory employees and to the children of researchers living on-site. For safety purposes, children participating in the swimming program must meet the minimum height requirement of 42 inches. Further information regarding applications, registration fees, and dates is available by contacting the Recreation Office in Personnel (Ext. 2873).

Recreation Off-Site. Brookhaven National Laboratory is located in Brookhaven Town, the largest of Suffolk County's ten townships, on Long Island. The area — a total of 253 square miles — is surrounded by bodies of water. The Great South Bay and the Atlantic Ocean on the South Shore, the Long Island Sound and Peconic Bay on the North

Shore, as well as the many inland lakes and rivers foster a summer resort atmosphere with a myriad of activities to delight all ages. Below is a sampling of what the area has to offer.

(The following is reprinted from the NSLS Experimenter's Handbook and the Brookhaven Town Brochure, "This Summer in Brookhaven ")

a. ***Special Events.*** Most towns and villages on Long Island sponsor summer festivals and arts and crafts shows. These events are listed in the *Newsday*, Weekend Section on Fridays. Brookhaven Lab's Tour Guide Office offer tours of BNL during the summer months. Further information can be obtained by calling Ext. 4049.

b. ***One-Day Escapes.*** The Bridgeport and Port Jefferson Steamboat Company [(516) 473-0286], conducts one-day tours to numerous locations in New England. Reservations must be made 72 hours in advance. The tours include round trip ferry and bus transportation, admission fees, tour guide, and some dinners. The tour prices range from $35 to $50. The tours offered include:

Mystic Seaport (Connecticut): 17-acre museum dedicated to New England's rich maritime history.

Mystic Marinelife Aquarium (Connecticut): 6,000 living specimens of undersea life, grouped in 34 major displays.

Old Sturbridge Village (Massachusetts): outdoor museum of living history presents the story of life in rural New England between the years 1790 when the nation was new and 1840 when traditional ways of life began to change.

Boston (Massachusetts): The excursion gives you the freedom to tour Boston on your own.

Newport (Rhode Island): Newport features a mansion tour and time for shopping at Newport's famed Brick Market Place.

Other day trips:

Hyde Park (New York): Visit Franklin D. Roosevelt's birthplace and residence.

Oyster Bay (New York): Visit Sagamore Hill, home of Theodore Roosevelt (922-4447).

Other Getaways include Ivy League Football games at the Yale Bowl, The Big E (New England's end-of-summer festival), jai alai games in Connecticut, and Brotherhood wineries. During the summer months the Port Jefferson Ferry offers moonlight dance parties and cruises to nowhere.

c. ***New York City.*** New York is world renowned for its historic, cultural, and recreational sites. Places to visit include: Empire State Building, Statue of Liberty, Circle Line Cruise of Manhattan, Lincoln Center, Rockefeller Center, Radio City Music Hall, Broadway Theatres, World Trade Center, New York Stock Exchange, and numerous Museums (Museum of Natural History, Metropolitan Museum of Art, Museum of Modern Art, Intrepid Air and Space Museum). World renowned musicians can be heard almost any night of the week in New York's many nightclubs and concert halls.

d. ***Beaches and Parks in Suffolk County.*** Some of the world's finest beaches are located on Long Island with ideal summer conditions for water recreation.

Fire Island National Seashore: 289-4810.
Heckscher State Park (East Islip): 581-2100.
Hither Hills State Park (Montauk): 668-2461
Jones Beach State Park (Wantagh): 785-1600.
Orient Beach State Park (Orient): 323-2440.
Robert Moses State Park (Babylon): 669-0449.
Sunken Meadow State Park (Kings Park) 269-4333.
Wildwood State Park (Wading River): 929-4314.

e. ***Amusement Parks.***

Adventureland (East Farmingdale): 694-6868.
Adventureland at Splish Splash (Calverton) 727-3600.
Arcadia Amusements (Bayville): 587-8426.
Kiddie Park (Garden City Park): 746-7551.
Nunley's Carousel (Baldwin): 223-4742.

f. ***Sporting Events.***

Professional Sports: Baseball - The Mets at Shea Stadium (718) 507-8499; or the Yankees at Yankee Stadium (212) 293-6000. Ice hockey - The Islanders at Nassau Coliseum or the Rangers at Madison Square Garden. Basketball - New York Knicks at Madison Square Garden (212) 947-5850.

Polo (Bethpage State Park): events every Saturday and Sunday during the summer, call 249-0701.

Golf: contact the BERA Golf League, Ext. 2873.

Horse Races (Belmont Race Track): (718) 641-4700.

Other Events include horseback riding, deep sea fishing, automobile racing, ice skating, biking, sailing, canoeing, etc.

g. ***Long Island Museums and Quiet Places*** (see Suffolk County Yellow Pages for further listings).

Museums: Carriage House 751-0066 (Stony Brook), Vanderbilt Museum (262-7800) and Planetarium (757-STAR) (Centerport), Montauk Point Lighthouse Museum 668-2544, Museum of Long Island Natural Science 632-8230 (Stony Brook), Old Bethpage Village Restoration 420-5280, Whaling Museum 725-0770 (Sag Harbor).

Quiet Places: Bayard Cutting Arboretum (Oakdale): 581-1002; Clark Garden of the Brooklyn Botanical Garden: 621-7568; Old Westbury Gardens (Westbury): 333-0048; the Planting Fields Arboretum (Brookville): 922-9200 and the Sunken Forest (ferry from Sayville): 589-8980.

h. ***Towns of Interest.*** Long Island has many historic and quaint villages and towns. For an afternoon of relaxation and fun visit Port Jefferson, "The Hamptons," East Hampton, Westhampton Beach, Southampton, Greenport, Montauk, or Amagansett.

i. ***For the Children.***

The Animal Farm (Manorville): 878-1785.
The Bronx Zoo (Bronx): (212) 367-1010.
Long Island Game Farm (Manorville): 878-6644.

j. ***Music and Theater on Long Island.*** The Westbury Music Fair offers musical fare year round. Concerts are given at the outdoor theater at Jones Beach (221-1000). Many town and villages also offer concerts during the summer months.

Long Island offers good theatrical productions:

Arena Players (Farmingdale): 293-0674.
Broadhollow Theater (Farmingdale): 752-1400.

The Gateway Playhouse (Bellport): 286-1133.
Theater Three (Port Jefferson): 928-9100.
State University at Stony Brook
Fine Arts Center (Stony Brook): 689-6000.
John Drew Theater (East Hampton): 324-4051.

k. ***Wineries.*** For further information call the Long Island Grape Growers Association at 727-7850.

Bridgehampton Winery (Bridgehampton): 537-3155.
Hargrave Vineyard (Cutchogue): 734-5111.
Lenz Vineyard (Peconic): 734-6010.
Palmer Vineyards (Aquebogue): 722-4080
Pindar (Peconic): 734-6200.

Further information and maps can be obtained by contacting the Long Island Tourist and Convention Commission at (516) 234-4959. The Community Pages in the Suffolk County Telephone book also offer information on points of interest. Please note that Parking Permits are required at Brookhaven Town Beaches. Permanent residents of Brookhaven Town can obtain free parking stickers at all beaches, upon presenting their resident vehicle registration, plus driver's license, tax bill, or voter registration. Temporary residents living on-site can obtain a free parking permit card. A copy of your automobile registration, even if the vehicle is registered out-of-state, and a statement of BNL employment written on BNL letterhead, should be mailed to: Box A, Town of Brookhaven, Parks & Recreation Office, Coram, NY 11727, or visit the office at 1130 Old Town Road, Coram, Monday-Friday, 9:00 a.m. to 4:00 p.m.

Appendices

Appendices

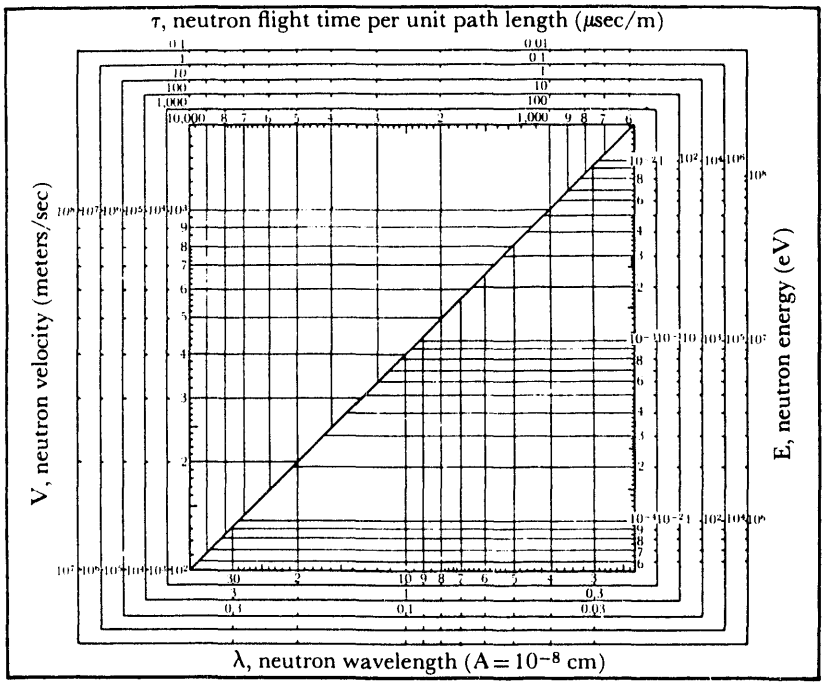
A. PHYSICAL CONSTANTS AND CONVERSION FACTORS

Avogadro's number	$N_A=6.02204\times10^{23}$ molecules/mol
Boltzmann's constant	$k_B=1.38066\times10^{-16}$ erg/K
Planck's constant	$h=6.6262\times10^{-27}$ erg sec $\hbar=1.0546\times10^{-27}$ erg sec
Bohr magneton	$\mu_B=9.2741\times10^{-21}$ erg/gauss
Nuclear magneton	$\mu_N=5.0508\times10^{-24}$ erg/gauss
Neutron magnetic moment	$\mu_n=1.913$ nuclear magnetons
Neutron rest mass	$m_n=1.0086650$ (atomic mass units) $m_n=1.67495\times10^{-24}$ g
Proton rest mass	$m_p=1.0072765$ (atomic mass units) $m_p=1.67265\times10^{-24}$ g
Electron rest mass	$m_e=5.48580\times10^{-4}$ (atomic mass units) $m_e=0.51100$ MeV
Speed of light (vac)	$c=2.997925\times10^{10}$ cm/sec

Multiply	by	to get
Atomic mass units	1.6606×10^{-24}	grams
	9.3150×10^{8}	electron volts
Barns	1×10^{-24}	square cm
Electron volts	1.60219×10^{-12}	ergs
Curies	3.70×10^{10}	disintegrations/sec
Half-life	1.443	meanlife = (decay constant)$^{-1}$
Roentgens	1	esu of ions/cm^3, standard air
	5.24×10^{7}	MeV absorbed/g air

B. WAVELENGTH, FREQUENCY, ENERGY RELATIONSHIPS

		Value at 1 eV
Neutron wavelength:	$\lambda(\text{Å}) = \dfrac{0.286}{\sqrt{E(eV)}}$	0.286 Å
Time-of-flight:	$t(\mu\text{sec/m}) = 253\lambda(\text{Å}) = 72.4\ E(eV)$	72.4 μsec/m
Frequency:	$\nu(\text{Hz}) = \dfrac{E(eV)}{h}$	2.4180×10^{14} Hz = 241.80 THz
	$\omega(\text{sec}^{-1}) = 2\pi\nu$	151.93×10^{13} sec^{-1}
Neutron wave number:	$\kappa(\text{Å}^{-1}) = \dfrac{2\pi}{\lambda(\text{Å})}$	21.95 Å^{-1}
Optical wave number:	$\dfrac{\nu(\text{sec}^{-1})}{c(\text{cm sec}^{-1})}$	8.0655×10^{3} cm^{-1}
Temperature:	$K = \dfrac{h\nu(eV)}{k_B(\text{erg K}^{-1})}$	1.1605×10^{4}K



Definitions of symbols: $\lambda(A) = 0.286/\sqrt{E(eV)}$; $V(m/sec) = 1.383\times10^{4}\sqrt{E(eV)}$; $\tau(\mu sec/m) = 72.2/\sqrt{E(eV)}$

Above 10 MeV: $E = 52.2680\left(\frac{10}{\tau}\right)^{2} + 4.3617\left(\frac{10}{\tau}\right)^{4} + 0.4044\left(\frac{10}{\tau}\right)^{6} + 0.0394\left(\frac{10}{\tau}\right)^{8} + 0.0039\left(\frac{10}{\tau}\right)^{10}$

Graph relating neutron energy, wavelength, velocity, and time-of-flight. Courtesy McGraw-Hill.

C. RADIATION UNITS

Unit of absorbed dose = rad = 100 ergs absorbed energy per gram of material.

Unit of dose equivalent = rem = (absorbed dose) × (quality factor)

Type of Radiation	Quality Factor
Beta and Gamma Rays	1
Neutrons (0-1 keV)	2
Neutrons (1 MeV)	11

Exposure to a thermal neutron flux of 680 neutrons/cm^2-sec will result in a dose equivalent rate of 2.5 mrem/hour, or 100 mrem per 40-hour week.

See the BNL Safety Manual for further information and for radiation exposure guidelines.

D. Coherent Neutron Scattering Amplitudes in Units of 10^{-12} cm
prepared by V.F. Sears (1992)

Element	Isotope	b	Element	Isotope	b	Element	Isotope	b	Element	Isotope	b	Element	Isotope	b	Element	Isotope	b
H		-0.37406	K		0.367	Se		0.797	Cs		0.542	W		0.486		^{182}W	0.697
	^{2}H	0.6671		^{39}K	0.374		^{76}Se	1.22								^{183}W	0.653
	^{3}H	0.4792		^{41}K	0.269		^{78}Se	0.824	Ba		0.507					^{184}W	0.748
							^{80}Se	0.748								^{186}W	-0.072
He	^{4}H	0.326	Ca		0.47				La		0.824						
	^{3}He	0.574-0.148i		^{40}Ca	0.48	Br		0.6795				Re		0.92			
				^{44}Ca	0.142				Ce		0.484						
Li		-0.190				Kr		0.781		^{140}Ce	0.484	Os		1.07			
	^{6}Li	0.200-0.0261i	Sc		1.229					^{142}Ce	0.475		^{188}Os	0.76			
						Rb		0.709					^{190}Os	1.10			
	^{7}Li	-0.222	Ti		-0.3438				Pr		0.458		^{192}Os	1.15			
				^{46}Ti	0.493	Sr		0.702									
Be	^{9}Be	0.779		^{47}Ti	0.363		^{86}Sr	0.567	Nd		0.769						
				^{48}Ti	-0.608		^{88}Sr	0.715		^{142}Nd	0.77	Ir		1.06			
B		0.530-0.213i		^{49}Ti	0.104					^{144}Nd	0.28						
	^{10}B	0.01															
		-0.1066i		^{50}Ti	0.618	Y		0.775		^{146}Nd	0.82	Pt		0.96			
	^{11}B	0.665	V		-0.03824	Zr		0.716	Pm	^{147}Pm	1.26	Au		0.763			
C		0.6646															
	^{12}C	0.6651	Cr		0.3635	Nb		0.7054	Sm	^{149}Sm	-1.92-1.17i	Hg		1.2692			
	^{13}C	0.6119		^{50}Cr	-0.450					^{152}Sm	-0.50						
				^{52}Cr	0.492	Mo		0.6715		^{154}Sm	0.93	Tl		0.8776			
N	^{14}N	0.937															
	^{15}N	0.644	Mn		-0.373	Tc		0.68	Eu		0.722	Pb		0.9405			
										^{153}Eu	0.822						
O	^{16}O	0.5803	Fe		0.945	Ru		0.703	Gd			Bi		0.853			
	^{17}O	0.578		^{54}Fe	0.42						0.65-1.382i						
	^{18}O	0.584		^{56}Fe	0.994	Rh		0.588		^{160}Gd	0.915	Po					
				^{57}Fe	0.23												
F	^{19}F	0.5654				Pd		0.591	Tb		0.738	Rn					
			Co		0.249												
Ne	^{20}Ne	0.4631				Ag		0.5922	Dy		1.69-0.0267i	Ra		1.0			
			Ni		1.03		^{107}Ag	0.7555		^{160}Dy	0.67						
Na	^{23}Na	0.363		^{58}Ni	1.44		^{109}Ag	0.4165		^{161}Dy	1.03	Ac					
				^{60}Ni	0.28					^{162}Dy	-0.14						
Mg		0.5375		^{61}Ni	0.76	Cd		0.487-0.07i		^{163}Dy	0.50	Th		1.031			
	^{24}Mg	0.566		^{62}Ni	-0.87		^{113}Cd	-0.8-.573i		^{164}Dy	4.94						
	^{25}Mg	0.362		^{64}Ni	-0.37		^{114}Cd	0.75				Pa		0.91			
	^{26}Mg	0.489							Ho		0.801						
			Cu		0.7718	In		0.4065-0.00539i				U		0.8417			
Al		0.3449		^{63}Cu	0.643		^{113}In	0.539	Er		0.779		^{235}U	1.047			
				^{65}Cu	1.061					^{166}Er	1.06		^{238}U	0.8402			
Si		0.4149				Sn		0.6225									
			Zn		0.568		^{116}Sn	0.593	Tm		0.707	Np		1.055			
P		0.513		^{64}Zn	0.522		^{118}Sn	0.607									
				^{66}Zn	0.597		^{120}Sn	0.649	Yb		1.243	Pu	^{239}Pu	0.77			
S		0.2847		^{68}Zn	0.603								^{240}Pu	0.35			
						Sb		0.557	Lu		0.721		^{242}Pu	0.81			
Cl		0.9577	Ga		0.7288												
	^{35}Cl	1.165				Te		0.58	Hf		0.777	Am		0.83			
	^{37}Cl	0.308	Ge		0.8185												
						I		0.528	Ta		0.691	Cm		0.95			
Ar		0.1909	As		0.658												
	^{36}Ar	2.49				Xe		0.492									
	^{40}Ar	0.183															

Coherent scattering length for bound atoms. Complex values correspond to neutron wavelength of 1Å. For references and complete data see: "Neutron Scattering Lengths and Cross Sections," V.F. Sears, *Neutron News*, Vol. 3, No. 3, p. 26, 1992

E. Bragg Angles ($2\theta_M$) for Commonly-Used Monochromators

			Germanium				Graphite		Beryllium		Zinc	Magnetite
		d-Spacing (Å)	3.26627	2.00018	1.70576	1.29789	3.35416	1.67708	1.79160	1.14280	2.46755	4.8470
		τ (Å^{-1})	1.92366	3.14131	3.68351	4.84107	1.87325	3.74650	3.50702	5.49806	2.54632	1.2963
E (meV)	k(Å^{-1})	λ (Å)	(111)	(220)	(311)	(331)	(002)	(004)	(002)	(110)	(002)	(111)
0.5	0.4912	12.7908	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.0	0.6947	9.0444	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	137.81
1.5	0.8508	7.3848	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.24
2.0	0.9825	6.3954	156.48	0.00	0.00	0.00	144.86	0.00	0.00	0.00	0.00	82.56
2.5	1.0984	5.7202	122.24	0.00	0.00	0.00	117.01	0.00	0.00	0.00	0.00	72.32
3.0	1.2033	5.2218	106.14	0.00	0.00	0.00	102.23	0.00	0.00	0.00	0.00	65.19
3.5	1.2997	4.8345	95.47	0.00	0.00	0.00	92.22	0.00	0.00	0.00	156.82	59.83
4.0	1.3894	4.5222	87.62	0.00	0.00	0.00	84.77	0.00	0.00	0.00	132.79	55.61
4.5	1.4737	4.2636	81.49	0.00	0.00	0.00	78.92	0.00	0.00	0.00	119.52	52.18
5.0	1.5534	4.0448	76.51	0.00	0.00	0.00	74.16	0.00	0.00	0.00	110.09	49.32
5.5	1.6292	3.8566	72.37	149.18	0.00	0.00	70.18	0.00	0.00	0.00	102.79	46.89
6.0	1.7017	3.6924	68.84	134.74	0.00	0.00	66.79	0.00	0.00	0.00	96.87	44.78
6.5	1.7711	3.5475	65.78	124.95	0.00	0.00	63.85	0.00	163.82	0.00	91.92	42.93
7.0	1.8380	3.4185	63.11	117.42	0.00	0.00	61.27	0.00	145.12	0.00	87.69	41.30
7.5	1.9025	3.3026	60.74	111.29	150.96	0.00	58.98	159.87	134.35	0.00	84.01	39.84
8.0	1.9649	3.1977	58.62	106.14	139.21	0.00	56.94	144.86	126.36	0.00	80.77	38.52
8.5	2.0254	3.1022	56.70	101.70	130.83	0.00	55.09	135.30	119.94	0.00	77.89	37.33
9.0	2.0841	3.0148	54.97	97.81	124.19	0.00	53.41	128.01	114.57	0.00	75.31	36.24
9.5	2.1412	2.9344	53.38	94.37	118.67	0.00	51.88	122.06	109.96	0.00	72.97	35.24
10.0	2.1968	2.8601	51.93	91.28	113.94	0.00	50.47	117.01	105.92	0.00	70.84	34.32
10.5	2.2511	2.7912	50.59	88.49	109.80	0.00	49.17	112.64	102.33	0.00	68.88	33.47
11.0	2.3041	2.7270	49.35	85.95	106.14	0.00	47.97	108.78	99.11	0.00	67.09	32.68
11.5	2.3558	2.6671	48.19	83.63	102.85	0.00	46.85	105.34	96.20	0.00	65.43	31.94
12.0	2.4065	2.6109	47.12	81.49	99.87	0.00	45.81	102.23	93.55	0.00	63.88	31.25
12.5	2.4561	2.5582	46.11	79.51	97.16	160.47	44.83	99.40	91.11	0.00	62.44	30.60
13.0	2.5048	2.5085	45.16	77.67	94.66	150.20	43.92	96.81	88.86	0.00	61.10	29.99
13.5	2.5525	2.4616	44.27	75.95	92.37	142.99	43.05	94.43	86.78	0.00	59.84	29.42
14.0	2.5993	2.4172	43.43	74.35	90.23	137.25	42.24	92.22	84.85	0.00	58.66	28.88
14.5	2.6453	2.3752	42.64	72.85	88.25	132.42	41.47	90.17	83.04	0.00	57.54	28.37
15.0	2.6906	2.3353	41.89	71.43	86.40	128.22	40.74	88.25	81.34	0.00	56.48	27.88
15.5	2.7350	2.2973	41.18	70.10	84.66	124.51	40.05	86.46	79.75	0.00	55.49	27.42
16.0	2.7788	2.2611	40.50	68.84	83.03	121.17	39.40	84.77	78.25	163.21	54.54	26.98
16.5	2.8219	2.2266	39.86	67.64	81.49	118.13	38.77	83.19	76.84	153.90	53.64	26.56
17.0	2.8643	2.1936	39.24	66.51	80.03	115.36	38.17	81.69	75.50	147.38	52.78	26.16
17.5	2.9061	2.1620	38.65	65.43	78.65	112.80	37.60	80.27	74.22	142.15	51.96	25.77
18.0	2.9474	2.1318	38.09	64.40	77.35	110.42	37.06	78.92	73.02	137.72	51.18	25.41
18.5	2.9880	2.1028	37.56	63.42	76.10	108.21	36.54	77.65	71.87	133.86	50.44	25.06
19.0	3.0281	2.0749	37.04	62.49	74.92	106.14	36.04	76.43	70.77	130.41	49.73	24.72
19.5	3.0677	2.0482	36.54	61.59	73.79	104.19	35.55	75.27	69.72	127.30	49.04	24.39
20.0	3.1068	2.0224	36.07	60.74	72.71	102.36	35.09	74.16	68.72	124.46	48.38	24.08
20.5	3.1454	1.9976	35.61	59.91	71.68	100.63	34.65	73.10	67.76	121.85	47.75	23.78
21.0	3.1835	1.9737	35.17	59.12	70.69	98.99	34.22	72.09	66.85	119.43	47.15	23.49
21.5	3.2212	1.9506	34.75	58.37	68.75	97.43	33.81	72.12	65.96	117.17	46.56	23.22
22.0	3.2584	1.9283	34.34	57.64	68.84	95.95	33.41	70.18	65.11	115.06	46.00	22.95
22.5	3.2953	1.9067	33.94	56.93	67.96	94.54	33.03	69.29	64.30	113.07	45.46	22.69
23.0	3.3317	1.8859	33.56	56.25	67.12	93.19	32.66	68.42	63.51	111.20	44.93	22.44
23.5	3.3677	1.8657	33.19	55.60	66.31	91.90	32.30	67.59	62.76	109.43	44.43	22.19
24.0	3.4033	1.8462	32.83	54.97	65.53	90.67	31.95	66.79	62.03	107.75	43.94	21.96
24.5	3.4386	1.8273	32.49	54.36	64.77	89.49	31.61	66.02	61.32	106.16	43.46	21.73

E. Bragg Angles ($2\theta_M$) for Commonly-Used Monochromators (continued)

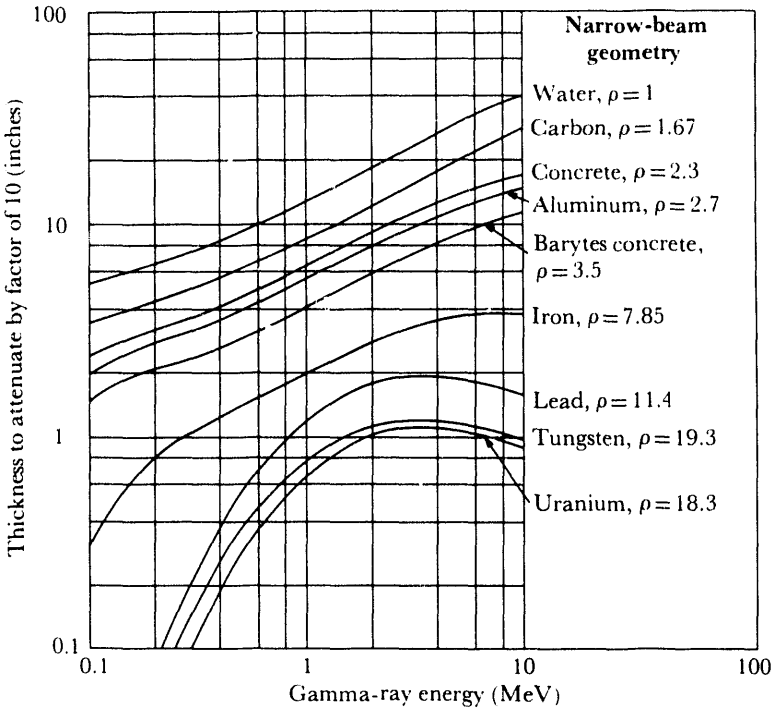
			Germanium				Graphite		Beryllium		Zinc	Magnetite
		d-Spacing (Å)	3.26627	2.00018	1.70576	1.29789	3.35416	1.67708	1.79160	1.14280	2.46755	4.8470
		τ (Å^{-1})	1.92366	3.14131	3.68351	4.84107	1.87325	3.74650	3.50702	5.49806	2.54632	1.2963
E (meV)	k(Å^{-1})	λ (Å)	(111)	(220)	(311)	(331)	(002)	(004)	(002)	(110)	(002)	(111)
25.0	3.4735	1.8089	32.15	53.77	64.04	88.45	31.29	65.27	60.64	104.64	43.00	21.51
25.5	3.5081	1.7911	31.83	53.20	63.34	87.26	30.97	64.55	59.98	103.19	42.56	21.29
26.0	3.5423	1.7738	31.51	52.64	62.66	86.21	30.66	63.85	59.34	101.80	42.13	21.09
26.5	3.5762	1.7569	31.20	52.11	62.00	85.20	30.37	62.18	58.72	100.48	41.71	20.88
27.0	3.6098	1.7406	30.91	51.58	61.36	84.22	30.08	62.52	58.13	99.20	41.30	20.69
27.5	3.6430	1.7247	30.62	51.08	60.74	83.28	29.80	61.89	57.54	97.98	40.91	20.50
28.0	3.6760	1.7092	30.34	50.59	60.13	82.47	29.52	61.27	56.98	96.81	40.53	20.31
28.5	3.7087	1.6942	30.06	50.11	59.55	81.49	29.26	60.68	56.43	95.67	40.16	20.13
29.0	3.7411	1.6795	29.80	49.65	58.98	80.63	29.00	60.10	55.90	94.58	39.79	19.95
29.5	3.7732	1.6652	29.54	49.20	58.43	79.81	28.75	59.53	55.39	93.53	39.44	19.78
30.0	3.8050	1.6513	29.28	48.76	57.90	79.01	28.50	58.98	54.88	92.52	39.10	19.62
30.5	3.8366	1.6377	29.04	48.33	57.38	78.23	28.26	58.45	54.39	91.54	38.76	19.45
31.0	3.8679	1.6244	28.80	47.92	56.87	77.48	28.03	57.93	53.92	90.59	38.44	19.29
31.5	3.8990	1.6115	28.56	47.51	56.38	76.75	27.80	57.43	53.45	89.67	38.12	19.11
32.0	3.9298	1.5988	28.33	47.12	55.89	76.04	27.58	56.94	53.00	88.78	37.81	18.99
32.5	3.9604	1.5865	28.11	46.73	55.43	75.35	27.36	56.46	52.56	87.92	37.50	18.84
33.0	3.9908	1.5744	27.89	46.35	54.97	74.68	27.15	55.99	52.13	87.08	37.21	18.69
33.5	4.0209	1.5626	27.68	45.99	54.52	74.03	26.94	55.53	51.71	86.27	36.92	18.55
34.0	4.0508	1.5511	27.47	45.63	54.09	73.39	26.74	55.09	51.30	85.48	36.64	18.41
34.5	4.0804	1.5398	27.27	45.28	53.66	72.77	26.54	54.66	50.90	84.71	36.36	18.28
35.0	4.1099	1.5288	27.07	44.94	53.25	72.17	26.35	54.23	50.51	83.96	36.09	18.15
35.5	4.1392	1.5180	26.87	44.60	52.84	71.58	26.16	53.82	50.13	83.23	35.83	18.02
36.0	4.1682	1.5074	26.68	44.27	52.44	71.00	25.97	53.41	49.76	82.53	35.57	17.89
36.5	4.1971	1.4970	26.50	43.95	52.06	70.44	25.79	53.02	49.39	81.84	35.32	17.77
37.0	4.2257	1.4869	26.31	43.64	51.68	69.89	25.61	52.63	49.03	81.17	35.07	17.65
37.5	4.2542	1.4770	26.13	43.33	51.31	69.36	25.44	52.25	48.68	80.51	34.83	17.53
38.0	4.2824	1.4672	25.96	43.03	50.94	68.84	25.27	51.88	48.34	79.87	34.59	17.41
38.5	4.3105	1.4576	25.79	42.74	50.59	68.33	25.10	51.52	48.01	79.25	34.36	17.30
39.0	4.3384	1.4483	25.62	42.45	50.24	67.83	24.94	51.16	47.68	78.64	34.13	17.18
39.5	4.3661	1.4391	25.45	42.17	49.90	67.34	24.77	50.81	47.36	78.05	33.91	17.07
40.0	4.3937	1.4301	25.29	41.89	49.57	66.86	26.62	50.47	47.04	77.46	33.69	16.97
40.5	4.4211	1.4212	25.13	41.62	49.24	66.39	24.46	50.14	46.74	76.90	33.47	16.86
41.0	4.4483	1.4125	24.97	41.35	48.92	65.93	24.31	49.81	46.43	76.34	33.26	16.76
41.5	4.4753	1.4040	24.82	41.09	48.60	65.49	24.16	49.49	46.14	75.80	33.06	16.65
42.0	4.5022	1.3956	24.67	40.84	48.29	65.05	24.01	49.17	45.84	75.27	32.85	16.55
42.5	4.5289	1.3874	24.52	40.58	47.99	64.62	23.87	48.87	45.56	74.75	32.65	16.46
43.0	4.5555	1.3793	24.38	40.34	47.69	64.19	23.73	48.56	45.28	74.24	32.46	16.36
43.5	4.5819	1.3713	24.24	40.09	47.40	63.78	23.59	48.26	45.00	73.74	32.27	16.26
44.0	4.6081	1.3635	24.10	39.86	47.12	63.37	23.45	47.97	44.73	73.25	32.08	16.17
44.5	4.6342	1.3558	23.96	39.62	46.83	62.98	23.32	47.68	44.47	72.77	31.89	16.08
45.0	4.6602	1.3483	23.82	39.39	46.56	62.58	23.19	47.40	44.21	72.30	31.71	15.99
45.5	4.6860	1.3408	23.69	39.17	46.29	62.20	23.06	47.13	43.95	71.84	31.53	15.90
46.0	4.7117	1.3335	23.56	38.94	46.02	61.83	22.93	46.85	43.70	71.39	31.35	15.81
46.5	4.7372	1.3263	23.43	38.73	45.76	61.46	22.81	46.59	43.45	70.94	31.18	15.73
47.0	4.7626	1.3193	23.30	38.51	45.50	61.09	22.68	46.32	43.21	70.51	31.01	16.64
47.5	4.7879	1.3123	23.18	38.30	45.25	60.74	22.56	46.06	42.97	70.08	30.84	15.56
48.0	4.8130	1.3055	23.06	38.09	45.00	60.39	22.44	45.81	42.73	69.66	30.68	15.48
48.5	4.8380	1.2987	22.93	37.89	44.75	60.04	22.33	45.56	42.50	69.25	30.51	15.40
49.0	4.8629	1.2921	22.82	37.69	44.51	59.70	22.21	45.31	42.27	68.85	30.36	15.32

E. Bragg Angles ($2\theta_M$) for Commonly-Used Monochromators (continued)

			Germanium				Graphite		Beryllium		Zinc	Magnetite
		d-Spacing (Å)	3.26627	2.00018	1.70576	1.29789	3.35416	1.67708	1.79160	1.14280	2.46755	4.8470
		τ (Å^{-1})	1.92366	3.14131	3.68351	4.84107	1.87325	3.74650	3.50702	5.49806	2.54632	1.2963
E (meV)	k(Å^{-1})	λ (Å)	(111)	(220)	(311)	(331)	(002)	(004)	(002)	(110)	(002)	(111)
50.0	4.9123	1.2791	22.58	37.29	44.04	59.04	21.98	44.33	41.83	68.06	30.04	15.16
51.0	4.9612	1.2665	22.36	36.91	43.58	58.40	21.76	44.37	41.40	67.30	29.74	15.01
52.0	5.0096	1.2542	22.14	36.54	43.14	57.79	21.55	43.92	40.98	66.56	29.45	14.87
53.0	5.0575	1.2423	21.93	36.19	42.71	57.19	21.35	43.48	40.57	65.85	29.16	14.73
54.0	5.1050	1.2308	21.72	35.84	42.30	56.61	21.14	43.05	40.18	65.16	28.88	14.59
55.0	5.1520	1.2196	21.52	35.50	41.89	56.05	20.95	42.64	39.80	64.50	28.61	14.45
56.0	5.1987	1.2086	21.32	35.17	41.50	55.50	20.76	42.24	39.42	63.85	28.35	14.32
57.0	5.2449	1.1980	21.13	34.85	41.12	54.97	20.57	41.85	39.06	63.22	28.10	14.20
58.0	5.2907	1.1876	20.95	34.54	40.74	54.45	20.39	41.47	38.71	62.61	27.85	14.07
59.0	5.3361	1.1775	20.77	34.24	40.38	53.95	20.22	41.10	38.37	62.02	27.61	13.95
60.0	5.3811	1.1676	20.59	33.94	40.03	53.46	20.05	40.74	38.04	61.44	27.37	13.84
61.0	5.4258	1.1580	20.42	33.65	39.69	52.99	19.88	40.39	37.71	60.88	27.14	13.72
62.0	5.4701	1.1486	20.25	33.37	39.35	52.53	19.72	40.05	37.39	60.34	26.92	13.61
63.0	5.5140	1.1395	20.09	33.10	39.03	52.08	19.56	39.72	37.09	59.81	26.70	13.50
64.0	5.5576	1.1306	19.93	32.83	38.71	51.64	19.40	39.40	36.78	59.29	26.49	13.39
65.0	5.6009	1.1218	19.78	32.57	38.40	51.21	19.25	39.08	36.49	58.79	26.28	13.29
66.0	5.6438	1.1133	19.62	32.32	38.09	50.79	19.11	38.77	36.20	58.30	26.07	13.19
67.0	5.6864	1.1050	19.48	32.07	37.80	50.39	18.96	38.47	35.92	57.82	25.88	13.09
68.0	5.7287	1.0968	19.33	31.83	37.51	49.99	18.82	38.17	35.65	57.35	25.68	12.99
69.0	5.7706	1.0888	19.19	31.59	37.22	49.60	18.68	37.88	35.38	56.90	25.49	12.90
70.0	5.8123	1.0810	19.05	31.36	36.95	49.22	18.55	37.60	35.12	56.45	25.31	12.81
71.0	5.8537	1.0734	18.91	31.13	36.68	48.85	18.41	37.33	34.86	56.02	25.12	12.71
72.0	5.8947	1.0659	18.78	30.91	36.41	48.49	18.29	37.06	34.61	55.60	24.95	12.64
73.0	5.9355	1.0586	18.65	30.69	36.15	48.13	18.16	36.79	34.37	55.18	24.77	12.54
74.0	5.9760	1.0514	18.52	30.48	35.90	47.79	18.03	36.54	34.13	54.78	24.60	12.45
75.0	6.0163	1.0444	18.40	30.27	35.65	47.45	17.91	36.28	33.89	54.38	24.43	12.37
76.0	6.0563	1.0375	18.28	30.06	35.41	47.12	17.79	36.04	33.66	53.99	24.27	12.29
77.0	6.0960	1.0307	18.16	29.86	35.17	46.79	17.68	35.79	33.43	53.61	24.11	12.21
78.0	6.1354	1.0241	18.04	29.67	34.94	46.47	17.56	35.55	33.21	53.24	23.95	12.13
79.0	6.1746	1.0176	17.92	29.47	34.71	46.16	17.45	35.32	33.00	52.87	23.80	12.05
80.0	6.2136	1.0112	17.81	29.28	34.48	45.85	17.34	35.09	32.78	52.52	23.65	11.98
81.0	6.2523	1.0049	17.70	29.10	34.26	45.55	17.23	34.87	32.58	52.17	23.50	11.90
82.0	6.2908	.9988	17.59	28.92	34.05	45.26	17.13	34.65	32.37	51.82	23.35	11.83
83.0	6.3290	.9928	17.48	28.74	33.84	44.97	17.02	34.43	32.17	51.49	23.21	11.76
84.0	6.3670	.9868	17.38	28.56	33.63	44.69	16.92	34.22	31.97	51.16	23.07	11.69
85.0	6.4048	.9810	17.27	28.39	33.42	44.41	16.82	34.01	31.78	50.84	22.93	11.62
86.0	6.4424	.9753	17.17	28.22	33.22	44.14	16.72	33.81	31.59	50.52	22.80	11.55
87.0	6.4797	.9697	17.07	28.06	33.03	43.87	16.62	33.61	31.40	50.21	22.66	11.48
88.0	6.5169	.9641	16.97	27.89	32.83	43.61	16.53	33.41	31.22	49.90	22.53	11.42
89.0	6.5538	.9587	16.88	27.73	32.64	43.35	16.43	33.22	31.04	49.60	22.40	11.35
90.0	6.5905	.9534	16.78	27.57	32.46	43.10	16.34	33.03	30.86	49.31	22.28	11.29
91.0	6.6270	.9481	16.69	27.42	32.27	42.85	16.25	32.84	30.69	49.02	22.15	11.23
92.0	6.6633	.9429	16.60	27.27	32.09	42.60	16.16	32.66	30.52	48.73	22.03	11.16
93.0	6.6995	.9379	16.51	27.12	31.91	42.36	16.07	32.47	30.35	48.45	21.91	11.10
94.0	6.7354	.9329	16.42	26.97	31.74	42.12	15.99	32.30	30.18	48.18	21.79	11.04
95.0	6.7711	.9279	16.33	26.83	31.57	41.89	15.90	32.12	30.02	47.91	21.68	10.99
96.0	6.8067	.9231	16.25	26.68	31.40	41.66	15.82	31.95	29.86	47.64	21.56	10.93
97.0	6.8420	.9183	16.16	26.54	31.23	41.44	15.74	31.78	29.70	47.38	21.45	10.87
98.0	6.8772	.9136	16.08	26.40	31.07	41.22	15.66	31.61	29.54	47.12	21.34	10.82

E. Bragg Angles ($2\theta_M$) for Commonly-Used Monochromators (continued)

			Germanium				Graphite		Beryllium		Zinc	Magnetite
		d-Spacing (Å)	3.26627	2.00018	1.70576	1.29789	3.35416	1.67708	1.79160	1.14280	2.46755	4.8470
		τ (Å^{-1})	1.92366	3.14131	3.68351	4.84107	1.87325	3.74650	3.50702	5.49806	2.54632	1.2963
E (meV)	k(Å^{-1})	λ (Å)	(111)	(220)	(311)	(331)	(002)	(004)	(002)	(110)	(002)	(111)
100.0	6.9470	0.9044	15.92	26.13	30.75	40.78	15.50	31.29	29.24	46.62	21.12	10.71
102.0	7.0161	0.8955	15.76	25.87	30.44	40.36	15.34	30.97	28.95	46.14	20.91	10.60
104.0	7.0846	0.8869	15.61	25.62	30.14	39.96	15.19	30.66	28.66	45.66	20.71	10.50
106.0	7.1524	0.8785	15.46	25.37	29.84	39.56	15.05	30.37	28.38	45.21	20.51	10.40
108.0	7.2195	0.8703	15.31	25.13	29.56	39.18	14.91	30.08	28.11	44.76	20.31	10.30
110.0	7.2861	0.8624	15.17	24.90	29.28	38.81	14.77	29.80	27.85	44.33	20.13	10.21
112.0	7.3520	0.8546	15.03	24.67	29.02	38.44	14.64	29.52	27.60	43.91	19.94	10.12
114.0	7.4174	0.8471	14.90	24.45	28.75	38.09	14.51	29.26	27.35	43.51	19.77	10.03
116.0	7.4822	0.8398	14.77	24.24	28.50	37.75	14.38	29.00	27.11	43.11	19.59	9.94
118.0	7.5464	0.8326	14.65	24.03	28.25	37.42	14.26	28.75	26.87	42.73	19.43	9.85
120.0	7.6101	0.8256	14.52	23.82	28.01	37.09	14.14	28.50	26.64	42.35	19.26	9.77
122.0	7.6732	0.8188	14.40	23.62	27.78	36.78	14.02	28.26	26.42	41.99	19.10	9.69
124.0	7.7359	0.8122	14.28	23.43	27.55	36.47	13.91	28.03	26.20	41.63	18.95	9.61
126.0	7.7980	0.8057	14.17	23.24	27.32	36.17	13.80	27.80	25.99	41.28	18.79	9.54
128.0	7.8596	0.7994	14.06	23.05	27.10	35.87	13.69	27.58	25.78	40.95	18.64	9.46
130.0	7.9208	0.7932	13.95	22.87	26.89	35.59	13.58	27.36	25.58	40.62	18.50	9.39
132.0	7.9815	0.7872	13.84	22.70	26.68	35.31	13.48	27.15	25.38	40.29	18.36	9.32
134.0	8.0417	0.7813	13.74	22.53	26.48	35.03	13.38	26.94	25.19	39.98	18.22	9.25
136.0	8.1015	0.7756	13.64	22.36	26.28	34.77	13.28	26.74	25.00	39.67	18.08	9.18
138.0	8.1609	0.7699	13.54	22.19	26.09	34.51	13.18	26.54	24.82	39.37	17.95	9.11
140.0	8.2198	0.7644	13.44	22.03	25.90	34.25	13.09	26.35	24.63	39.08	17.82	9.05
142.0	8.2783	0.7590	13.34	21.87	25.71	34.00	12.99	26.16	24.46	38.79	17.69	8.98
144.0	8.3364	0.7537	13.25	21.72	25.53	33.76	12.90	25.97	24.28	38.51	17.57	8.92
146.0	8.3941	0.7485	13.16	21.57	25.35	33.52	12.81	25.79	24.12	38.23	17.45	8.86
148.0	8.4514	0.7434	13.07	21.42	25.17	33.29	12.73	25.61	23.95	37.96	17.33	8.80
150.0	8.5083	0.7385	12.98	21.28	25.00	33.06	12.64	25.44	23.79	37.70	17.21	8.74
152.0	8.5649	0.7336	12.90	21.13	24.84	32.83	12.56	25.27	23.63	37.44	17.10	8.68
154.0	8.6210	0.7288	12.81	20.99	24.67	32.61	12.47	25.10	23.47	37.19	16.99	8.62
156.0	8.6768	0.7241	12.73	20.86	24.51	32.40	12.39	24.94	23.32	36.94	16.88	8.57
158.0	8.7323	0.7195	12.65	20.72	24.35	32.19	12.31	24.77	23.17	36.70	16.77	8.51
160.0	7.7874	0.7150	12.57	20.59	24.20	31.98	12.24	24.62	23.02	36.46	16.66	8.46
162.0	8.8421	0.7106	12.49	20.46	24.04	31.78	12.16	24.46	22.88	36.23	16.56	8.41
164.0	8.8965	0.7063	12.41	20.34	23.90	31.58	12.09	24.31	22.73	36.00	16.46	8.36
166.0	8.9506	0.7020	12.34	20.21	23.75	31.38	12.01	24.16	22.60	35.77	16.36	8.31
168.0	9.0044	0.6978	12.26	20.09	23.61	31.19	11.94	24.01	22.46	35.55	16.26	8.26
170.0	9.0578	0.6937	12.19	19.97	23.46	31.00	11.87	23.87	22.32	35.34	16.16	8.21
172.0	9.1109	0.6896	12.12	19.85	23.33	30.81	11.80	23.73	22.19	35.12	16.07	8.16
174.0	9.1637	0.6857	12.05	19.74	23.19	30.63	11.73	23.59	22.06	34.91	15.97	8.11
176.0	9.2163	0.6818	11.98	19.62	23.05	30.45	11.67	23.45	21.94	34.71	15.88	8.07
178.0	9.2685	0.6779	11.91	19.51	22.92	30.28	11.60	23.32	21.81	34.51	15.79	8.02
180.0	9.3204	0.6741	11.85	19.40	22.79	30.10	11.54	23.19	21.69	34.31	15.70	7.98
182.0	9.3720	0.6704	11.78	19.30	22.67	29.94	11.47	23.06	21.57	34.11	15.62	7.93
184.0	9.4234	0.6668	11.72	19.19	22.54	29.77	11.41	22.93	21.45	33.92	15.53	7.89
186.0	9.4745	0.6632	11.65	19.08	22.42	29.60	11.35	22.81	21.33	33.73	15.45	7.85
188.0	9.5253	0.6596	11.59	18.98	22.30	29.44	11.29	22.68	21.22	33.55	15.36	7.80
190.0	9.5758	0.6562	11.53	18.88	22.18	29.28	11.23	22.56	21.10	33.37	15.28	7.76
192.0	9.6261	0.6527	11.47	18.78	22.06	20.13	11.17	22.44	20.99	33.19	15.20	7.72
194.0	9.6761	0.6494	11.41	18.68	21.95	28.97	11.11	22.33	20.88	33.01	15.12	7.68
196.0	9.7258	0.6460	11.35	18.59	21.83	28.82	11.05	22.21	20.77	32.84	15.04	7.64
198.0	9.7753	0.6428	11.29	18.49	21.72	28.67	11.00	22.10	20.67	32.67	14.97	7.60
200.0	9.8246	0.6395	11.24	18.40	21.61	28.53	10.94	21.98	20.56	32.50	14.89	7.57



Thickness of $\frac{1}{10}$ value layer for various gamma-ray shielding materials. Courtesy McGraw-Hill.

END

DATE FILMED

3 / 17 / 93