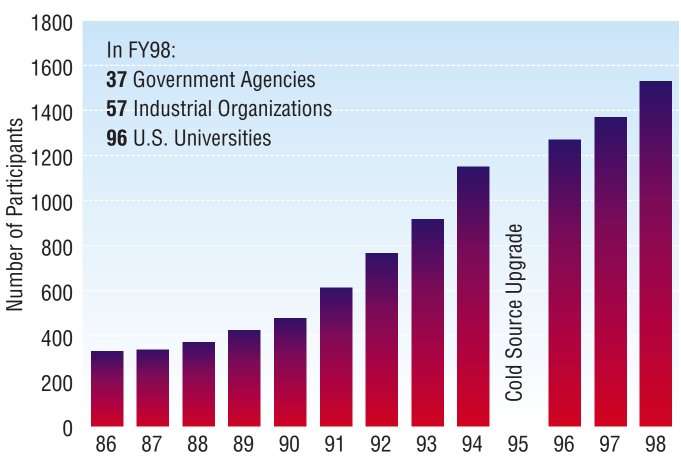
A USER FACILITY: NEUTRONS FOR THE U.S. RESEARCH COMMUNITY

The NCNR is a national resource, providing state-of-the-art neutron beam instrumentation for industry, government, and university research programs. User activity has increased rapidly as the number and capability of the instruments has risen. As shown in Fig.1, user participation has tripled since the start of operations in the NCNR guide hall in 1990.

The bar at far right in Fig. 1 represents participants from 96 universities, 37 government institutions, 57 U.S. industrial laboratories, and many foreign institutions. Participants include those who were at the NCNR at least once for an experiment or collaborated in other ways, such as sample preparation or co-authoring a publication. NIST researchers comprise a small fraction of the total user population, but are naturally a critical factor, often enabling other users to perform the best measurements possible.

The NCNR has always striven to enable researchers to obtain access through procedures that are appropriate for their needs, without excessive delay or bureaucracy. In practice, that has meant allowing several different modes of access through formal proposals, informal collaborations, and Participating Research Teams. In some cases, industrial R&D of a proprietary nature is carried out at the NCNR, provided that appropriate beam-time charges are paid on a full-cost-recovery basis to the U.S. government.



Research at the NCNR

FORMAL USER PROGRAM

The Program Advisory Committee (PAC) is the body primarily responsible for proposal review and user policies. The PAC advises the NCNR Director on these and other aspects of the NCNR operation. Its current (1997-1998) membership includes Jill Trewhella (chair, Los Alamos National Laboratory), William Graessley (Princeton University), Sanat Kumar (Penn State University), Gabrielle Long (NIST), Laurence Passell (Brookhaven National Laboratory), Sunil Sinha (Argonne National Laboratory), Thomas Russell (University of Massachusetts), and Emile Schweikert (Texas A&M University). The PAC membership represents a wide range of expertise in neutron beam research, and advises NIST on many aspects of the research activities and instrumentation at the NCNR, especially those concerning user interaction.

The most direct area of involvement for the PAC lies in the formal research proposal system, which is based on a submission deadline and subsequent review at six- to eight-month intervals. After each deadline, proposals are peer-reviewed by mail or electronic mail by experts in the research area specific to each proposal. The PAC then meets to consider the proposals with their reviews, together with technical and safety reviews provided by NCNR staff, and makes recommendations for approval or rejection and allocation of specific amounts of beam time for each proposal.

The PAC met twice at NIST during FY 1998, first on November 21, 1997, and again on July 13-14, 1998. One-hundred and thirty proposals were reviewed on the first occasion, and 162 proposals requesting 1563 instrument-days on the second. The review was confined to proposals for small-angle neutron scattering (SANS), reflectometry, cold-neutron triple-axis spectrometry, and time-of-flight spectroscopy. Other categories of proposals, such as powder diffractometry and chemical analysis, are reviewed on a continuing basis rather than at the regular PAC meetings. Both the number of proposals and the number of requested instrument-days show a continuing growth. For comparison, the call for proposals in August 1995 stimulated 100 proposals requesting 549 instrument-days.

The two 30-m SANS diffractometers still account for the largest category of proposals (67 during the last proposal round), but proposals for the two reflectometers have risen to a comparable number (58 during the last round). The demand for SANS is now rising relatively slowly, while that for reflectometry still shows strong growth. The oversubscription in number of instrument-days (i.e., days requested divided by days available) was approximately 3 for reflectometry, and approximately 2 for SANS and inelastic scattering. The oversubscription for the reflectometers was high at both PAC meetings in FY 1998, despite the provision of more instrument-days for users at the second meeting. There are plans to construct another reflectometer in the near future to accommodate the increasing demand, especially in the area of biology, where experiments can require large blocks of beam time.

The demand for high-resolution inelastic neutron scattering is also increasing. The number of proposals for the SPINS spectrometer (cold-neutron triple-axis with polarized beam option) was 15 in Nov. 1997, and 24 in July 1998. In the last instance, the oversubscription in instrument-days was 2.9. Requests for the Fermi-chopper time-of-flight spectrometer also showed growth, with 9 proposals in 1996, 13 proposals in Nov. 1997, and 15 proposals in July 1998, with an oversubscription of 1.4 at the last PAC meeting. The three new inelastic scattering instruments about to come into operation will stimulate further demand, so that this proposal category should show a substantial increase in the near future. The next call for proposals will offer the backscattering spectrometer, which is now operational, to users on a limited basis. The disk-chopper time-of-flight spectrometer and the spin-echo spectrometer are nearing completion and will be offered to users in the near future.

In addition, time on the 32-detector powder diffraction instrument at BT-1 is also available for users through proposals. For the present, sufficient time is available for all proposals received, and time is directly scheduled by the NCNR staff when proposals are received. During the past year, approximately 80 proposals were granted time on this instrument, approximately half of which were from outside users.

Some users devote a substantial part of their research effort to neutron scattering measurements at the NCNR. At the most recent PAC meeting, it was felt that these users would make best use of their instrument time if they could be assured of access to beam time distributed over an extended period of about two years. The PAC therefore recommended that a new proposal category be instituted, called program proposals. The latter would be longer and more detailed than a regular proposal, describing a course of measurement rather than a single experiment. NCNR management agreed to implement program proposals on a trial basis.

COLLABORATIONS

Direct collaborations remain a common way to access the instruments at the NCNR, accounting for approximately 60% of the number of instrument-days. The thermal-neutron triple-axis spectrometers are mainly scheduled in this way. Most of the time reserved for NIST researchers on other instruments is also devoted to experiments that are collaborations with non-NIST personnel.

PARTICIPATING RESEARCH TEAMS

Another mode of access to NCNR instrumentation takes place through Participating Research Teams (PRT). In this case, groups of researchers join together to build and operate an instrument, using additional funding derived outside of NIST (although NIST does participate in some PRTs). Three-quarters of the time on such instruments is reserved for the PRT, and the balance is allocated to general user proposals. Several instruments have been developed in this way, and others are under consideration. One particular version of this is the Center for High Resolution Neutron Scattering (CHRNS), which is funded by the National Science Foundation (NSF) and NIST. The instruments include a 30 m SANS machine, a Spin Polarized Inelastic Neutron Spectrometer (SPINS), and a perfect crystal very low angle SANS now under development at BT-5. In CHRNS, all of the NSF time is returned to the general user community for allocation by the PAC. A detailed description of the activities of CHRNS is prepared as an annual report to the NSF, and is available on request.

FEEDBACK FROM USERS

Users are encouraged to offer their comments concerning the instrumentation, operations, and policies at the NCNR. Their input is being obtained in several ways. First, the NCNR local contact personnel interact directly with each research group using the facility. This informal method typically identifies concerns about a specific instrument. Responsibility for action then resides with the cognizant NCNR instrument scientist. Users may also offer comments on a form provided on the facility Web pages. The NCNR Researcher's Group, an independent body currently chaired by Professor Anne Mayes of MIT, is in the process of obtaining further information through a survey of its membership.

OTHER COMMUNICATION WITH USERS

For the past several years, the primary means of communication with the NCNR user community has been through electronic mail and the facility Web pages at http://rrdjazz.nist.gov. For almost all the major neutron scattering instruments, beam time requests that are not formal proposals must be submitted through a Web page form. Most formal proposals for beam time are submitted using the same form, accounting for approximately 80% of proposals received in response to the last call. The current hit rate for the NCNR web page is 1 M/year. Electronic submission has many advantages, facilitating the compilation of a comprehensive database on investigators, proposals, referees, and experiments. This is extremely useful in the increasingly complicated task of assigning and scheduling beam time and equipment, and in making administrative decisions concerning NCNR operations.

INDEPENDENT PROGRAMS

The **Polymers Division** of the Materials Science and Engineering Laboratory has two major program elements at the NCNR. For the first, the objectives are to help the U.S. microelectronics and supporting infrastructure industries by addressing their most pressing materials measurement and standards issues. In today's ICs and packages the feature size is ever shrinking, e.g., on the chip level the feature size is approaching 250 nm while the size of a polymer molecule is typically 5-10 nm. As feature size shrinks the structure and properties of interfaces play an increasingly important role controlling the properties of the polymer layers used in interconnects and packages. In this program both neutron reflectivity and neutron scattering have played an essential role for characterizing polymer/metal interfaces including local chain mobility, moisture absorption, glass transition temperature and crystalline structure. For the second, the objective is to understand the underlying principles of phase behavior and phase separation kinetics in the bulk and on surfaces of polymer blends in order to facilitate morphology/structure control during processing. SANS and reflectivity measurements in equilibrium, in transient, and under external field provide essential information for general understanding as well as for specific application of polymer blend/alloy systems. Customers include material producers and users, ranging from chemical, rubber, tire, and automotive companies, to small molding and compounding companies. The focus of research on polymeric materials includes commodity, engineering and specialty plastic resins, elastomers, coatings, adhesives, films, foams, fibers, and non-woven's.

The **Exxon Research and Engineering Company** is a member of the Participating Research Team (PRT) that operates, maintains, and conducts neutron-related research activities at the NCNR's NG7-30M SANS and NG5-Neutron Spin Echo Spectrometer (to be dedicated soon) instruments. The mission is to use those instruments, as well as other neutron scattering techniques, to conduct scientific research that complements the research activities at Exxon's main laboratories as well as at its affiliates' laboratories throughout the world. The aim of these research activities is to deepen knowledge of the nature of the products and processes of the business so as to better serve customers and to improve the return on shareholders' investment. In line with that, and taking full advantage of the unique properties of neutrons, most of the experiments use SANS or other neutron techniques to study the structure and dynamics of hydrocarbon materials, especially in the fields of polymers, complex fluids, and petroleum mixtures. Exxon views its participation in the NCNR and collaborations with NIST and other PRT members as an excellent investment for the company and a good way to contribute to the scientific health of the nation.

The **Nuclear Methods Group** (Analytical Chemistry Division, Chemical Science and Technology Laboratory) has as its principal goals the development and application of nuclear analytical techniques for the determination of elemental compositions with greater accuracy, higher sensitivity and better selectivity. A high level of competence has been developed in both instrumental and radiochemical neutron activation analysis (INAA and RNAA). In addition, the group has pioneered the use of cold neutron beams as analytical probes with both prompt gamma activation analysis (PGAA) and neutron depth profiling (NDP). PGAA measures the total amount of a particular analyte present throughout a sample by the analysis of the prompt gamma-rays emitted during neutron capture. NDP, on the other hand, determines concentrations of several important elements (isotopes) as a function of depth within the first few micrometers of a surface by energy analysis of the prompt charged-particles emitted during neutron bombardment. These techniques (INAA, RNAA, PGAA, and NDP) provide a powerful combination of complementary tools to address a wide variety of analytical problems of great importance in science and technology, and are used to help certify a large number of NIST Standard Reference Materials. During the past several years, a large part of the Group's efforts has been directed towards the exploitation of the analytical applications of the guided cold-neutron beams available at the NIST Center for Neutron Research. The Group's involvement has been to design and construct state-of-the-art cold neutron instruments for both PGAA and NDP and provide facilities and measurements for outside users, while retaining and utilizing our existing expertise in INAA and RNAA.

The **Center for Food Safety and Applied Nutrition**, U. S. Food and Drug Administration (FDA), directs and maintains a neutron activation analysis (NAA) facility at the NCNR. This facility provides agency-wide analytical support for special investigations and applications research, complementing other analytical techniques used at FDA with instrumental (INAA), neutron-capture prompt-gamma (PGAA), and radiochemical Neutron Activation Analysis (NAA) procedures, radioisotope X-ray fluorescence spectrometry (RXRFS), and low-level gamma-ray detection. This combination of analytical techniques enables diverse multi-element and radiological information to be obtained for foods and related materials. The NAA facility supports agency quality assurance programs by developing in-house reference materials, by characterizing food-related reference materials with NIST and other agencies, and by verifying analyses for FDA's Total Diet Study Program annually. Other studies include the development of RXRFS methods for screening foodware for the presence of Pb, Cd and other potentially toxic elements, use of INAA to investigate bromate residues in bread products, and use of PGAA to investigate boron nutrition and its relation to bone strength. FDA's NAA laboratory personnel frequently provide intra-agency technical assistance, the most recent example being participation in the production of the document "Accidental Radioactive Contamination of Human Food and Animal Feeds: Recommendations for State and Local Agencies" by the Center for Devices and Radiological Health.

The Neutron Interactions and Dosimetry Group (Physics Laboratory) provides measurement services, standards, and fundamental research in support of NIST's mission as it relates to neutron technology and neutron physics. The national and industrial interests served include scientific instrument calibration, electric power production, radiation protection, defense nuclear energy systems, radiation therapy, neutron radiography, and magnetic resonance imaging. The Group's activities may be represented as three major activities. The first is Fundamental Neutron Physics - including operation of a neutron interferometry and optics facility, development of neutron spin filters based on laser polarization of ^{3}He, measurement of the beta decay lifetime of the neutron, and investigations of other coupling constants and symmetries of the weak interaction. This project involves a large number of collaborators from universities and national laboratories. The second is Standard Neutron Fields and Applications - utilizing both thermal and fast neutron fields for materials dosimetry in nuclear reactor applications and for personnel dosimetry in radiation protection. These neutron fields include thermal neutron beams, "white" and monochromatic cold neutron beams, a thermal-neutron-induced ^{235}U fission neutron field, and ^{252}Cf fission neutron fields, both moderated and unmoderated. The third is Neutron Cross Section Standards - including experimental advancement of the accuracy of neutron cross section standards, as well as evaluation, compilation and dissemination of these standards.

Several universities have also established long term programs at the NCNR. The **University of Maryland** is heavily involved in the use of the NCNR, and maintains several researchers at the facility. **Johns Hopkins University** participates in research programs in solid state physics and in instrument development at the NCNR. The **University of Pennsylvania** is working to help develop biological applications of neutron scattering. It is also, along with the **University of California**, **Santa Barbara**, **DuPont**, **Hughes**, and **Allied Signal** participating in development of a new filter analyzer neutron spectrometer. **The University of Minnesota** participates in two PRTs; the **University of Massachusetts** participates in one.