SERVING THE SCIENTIFIC AND TECHNOLOGICAL COMMUNITIES

Providing neutron beam methods to the U.S. research community is a central purpose of the NCNR. Intense neutron sources are scarce, as are the advanced instruments needed to fully exploit them. Expert scientists will always recognize opportunities to perform research with the most powerful tools available, so that the existence of the NCNR as the Nation's premier reactor-based neutron facility stimulates considerable demand from the community. However, in order to foster the best possible science, many of our procedures and activities are designed to encourage researchers to learn more about our capabilities, and eventually to obtain instrument time through proposals and collaborations. The first instruments became operational in the NCNR guide hall in 1991, and a formal proposal system was started to accommodate users from universities, industry, and government laboratories. Since then, the quantity and the diversity of research carried out at the NCNR has grown steadily, and the number of research participants (Fig. 1) is now several times larger than it was just a few years ago.

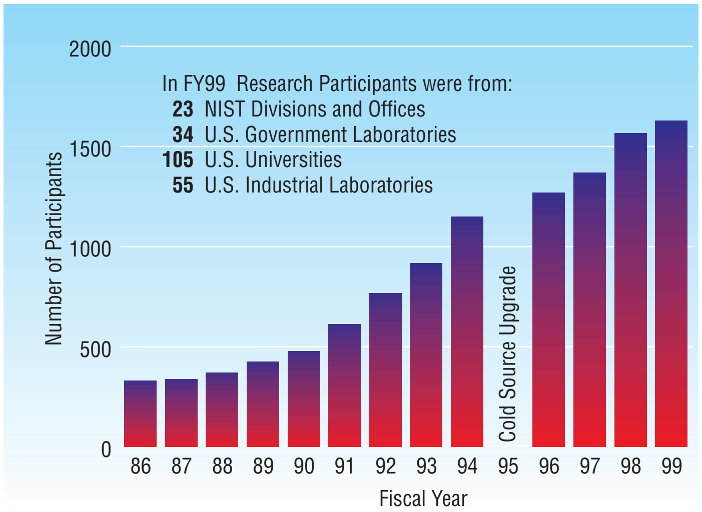

FIGURE 1. Research participants at the NCNR.

THE USER PROGRAM

NIST has always relied on advice from accomplished scientists to assist in formulating policy. The Program Advisory Committee (PAC) is the body primarily responsible for proposal review and recommending user policies for the NCNR, working closely with the Center's Director and staff. Its current membership includes Sanat Kumar (Penn State University, chair), Robert M. Briber (University of Maryland), Michael K. Crawford (DuPont), Dieter K. Schneider (Brookhaven National Laboratory), Thomas P. Russell (University of Massachusetts), Sunil K. Sinha (Argonne National Laboratory), Emile A. Schweikert (Texas A&M University), Laurence Passell (Brookhaven National Laboratory), and Gabrielle G. Long (NIST).

At their meeting in May 1999, the PAC made several recommendations for improving the current system. They felt that program proposals for longer-term projects had not had their intended effect of reducing the burden for external reviewers, and should be discontinued for the time being. Noting a potential for large increases in instrument time for biology-related proposals in the next few years, the addition of another PAC member with expertise in that area was recommended. The PAC discussed the results of a recent independent survey of user satisfaction, coordinated by Anne Mayes of MIT. Ideas for obtaining more feedback from users were also considered. Incidentally, Professor Mayes, the head of the NCNR User's Group, recently won the American Physical Society's Dillon Medal, partly for work carried out using NCNR instruments.

Most of the PAC meeting was devoted to proposal review. With the help of several written reviews for each proposal from selected experts, the PAC considered 151 proposals requesting 1138 instrument-days, and allocated 514 instrument-days to 95 proposals for SANS, reflectometry, SPINS, and time-of-flight instruments. The PAC usually meets twice a year, but because of a planned shutdown for cold source and reactor upgrades, only one meeting was held in 1999.

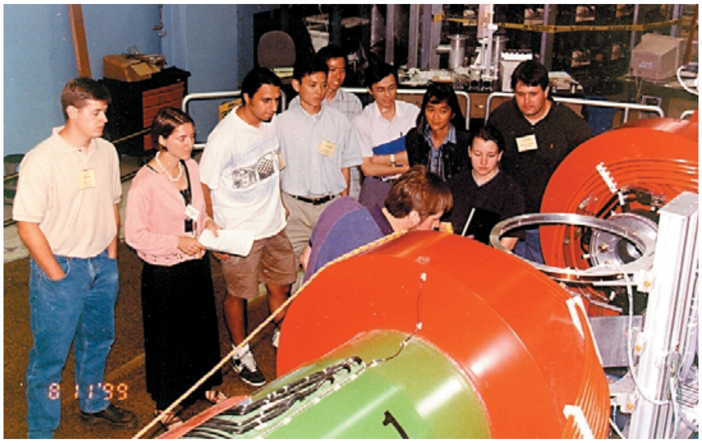

FIGURE 2. Nick Rosov explains the operation of the Neutron Spin Echo Spectrometer to summer school participants.

SUMMER SCHOOL ON METHODS AND APPLICATIONS OF NEUTRON SPECTROSCOPY

Each summer for the past five years, the NCNR has held a one-week school to introduce researchers to the methods of neutron scattering. Organized by senior staff members John Copley and Peter Gehring, the 1999 summer school was devoted to spectroscopy with neutrons, with an emphasis on the opportunities afforded by new instruments in the guide hall. Most of the 32 participants, chosen from almost 60 who applied, were graduate students and postdoctoral fellows. The curriculum consisted of lectures by NCNR staff and experts from other institutions, tours of the facility, and four three-hour, hands-on, sessions at instruments in the guide hall. Informal discussions among students and the resident staff were also an important part of the school's activities.

Beginning with lectures on the fundamental concepts of nuclear and magnetic scattering, the agenda turned to talks on applications of neutron spectroscopy to a wide range of research topics. Subsequent presentations covered the reactor and cold source, specific scattering techniques, computer modeling and ab initio calculations, and the operating principles of various spectrometers used in the experimental sessions. In the latter, students and staff used time-of-flight, backscattering, triple-axis, and neutron spin-echo spectrometers to measure, respectively, quasielastic scattering from water, rotational tunneling in solid methyl iodide, magnetic excitations in a geometrically frustrated antiferromagnet, and coherent scattering from the time domain in a system of spherical micelles. (The last example is illustrated in the article on the Neutron Spin Echo Spectrometer.) The lecture materials will be placed on the NCNR website, in order to reach as wide an audience as possible.

THE CENTER FOR HIGH-RESOLUTION NEUTRON SCATTERING (CHRNS)

Supported by the National Science Foundation (NSF), CHRNS is a very important component of the user program. It operates a suite of three instruments, including a 30 m SANS machine, the SPINS triple-axis spectrometer, and a double-crystal, high-resolution SANS. The last of these is under construction. Approximately 40 % of the instrument time allocated by the PAC goes to experiments carried out on CHRNS instruments. The NSF is currently reviewing the CHRNS renewal proposal, which requests support for upgrading existing instruments and including an improved 9 m SANS instrument within CHRNS. Approval would mean an increase of more than 50 % in CHRNS' capacity to serve users.

COLLABORATIONS

Direct collaborations on specific experiments remain a common way for users to pursue their ideas using NCNR facilities, 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 on these and all other NCNR instruments is also devoted to experiments that are collaborations with non-NIST users.

Another mode of access to the NCNR is through Participating Research Teams (PRTs). In this case, groups of researchers from various institutions join forces to build and operate an instrument. Typically, 50 % to 75 % of the time on the instrument is then reserved for the PRT, and the remaining time is allocated to general user proposals. For example, a PRT involving ExxonMobil, the University of Minnesota, Texaco R&D and NIST cooperates on the NG-7 30 m SANS instrument. Similar arrangements involving other PRTs apply to the horizontal-sample reflectometer, the high-resolution powder diffractometer, and the neutron spin-echo spectrometer.

INDEPENDENT PROGRAMS

There are a number of programs of long standing located at the NCNR which involve other parts of NIST, universities, industrial laboratories, or other government agencies.

The **Polymers Division** of the Materials Science and Engineering Laboratory has two major program elements at the NCNR. In the first, the purpose is to help the U.S. microelectronics industry in addressing their most pressing materials measurement and standards issues. In today's ICs and packages, the feature size on a chip is ever shrinking, approaching 250 nm, while the size of a polymer molecule is typically 5 nm to10 nm. As feature size shrinks, the structure and properties of interfaces play an increasingly important role in controlling the properties of the polymer layers used in interconnects and packages. NIST scientists use both neutron reflectivity and other neutron scattering methods to characterize polymer/metal interfaces with regard to local chain mobility, moisture absorption, glass transition temperature, and crystalline structure. In the second program element, the objective is to understand underlying principles of phase behavior and phase separation kinetics of polymer blends, both in the bulk and on surfaces, in order to help control morphology and structure during processing. SANS and reflectivity measurements in equilibrium, in transient conditions, and under external fields 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, and fibers.

The **ExxonMobil Research and Engineering Company** is a member of the Participating Research Team (PRT) that operates, maintains, and conducts research at the NG-7 30 m SANS instrument and the recently commissioned NG-5 Neutron Spin Echo Spectrometer. The mission is to use those instruments, as well as other neutron scattering techniques, in activities that complement research at ExxonMobil's main laboratories as well as at its affiliates' laboratories around the world. The aim of these activities is to deepen understanding of the nature of ExxonMobil's products and processes, so as to improve customer service and to improve the return on shareholders' investment. Accordingly, 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. ExxonMobil regards its participation in the NCNR and collaborations with NIST and other PRT members not only as an excellent investment for the company, but also as 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** of the 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 (RNAA) 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. The 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 participating in the construction of a new filter analyzer neutron spectrometer, along with the **University of California at Santa Barbara**, DuPont, Hughes, and Allied Signal. The **University of Minnesota** participates in two PRTs, the NG-7 30 m SANS and the NG-7 reflectometer. The **University of Massachusetts** also participates in the latter PRT.