



**An Assessment of the National Institute of Standards and Technology Center for Neutron Research: Fiscal Year 2008**  
Panel on Neutron Research, National Research Council

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**AN ASSESSMENT OF THE  
NATIONAL INSTITUTE OF STANDARDS  
AND TECHNOLOGY  
CENTER FOR NEUTRON RESEARCH**

**FISCAL YEAR 2008**

Panel on Neutron Research

Laboratory Assessments Board

Division on Engineering and Physical Sciences

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## Acknowledgment of Reviewers

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

James Jackson, Provo, Utah,  
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Sunil Sinha, University of California, San Diego.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Alton Slay, Warrenton, Virginia. Appointed by the National Research Council, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring panel and the institution.



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## Summary

The National Institute of Standards and Technology [NIST] Center for Neutron Research (NCNR) is a national user facility whose mission is to ensure the availability of neutron measurement capabilities in order to meet the needs of U.S. researchers from industry, academia, and government agencies. This mission is aligned with the mission of NIST, which is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve the quality of life.

As requested by the Director of NIST, the scope of the assessment included the following criteria: (1) the technical merit of the current laboratory programs relative to the current state of the art worldwide; (2) the adequacy of the laboratory facilities, equipment, and human resources, as they affect the quality of the laboratory technical programs; and (3) the degree to which the laboratory programs in measurement science and standards achieve their stated objectives and desired impact. In addition to these three criteria, the panel was asked by the Director of NIST to assess the projects within the laboratory conducted under the America COMPETES Act of 2007, which supports the President's American Competitiveness Initiative (ACI).<sup>1</sup>

The NCNR is an extremely reliable and comprehensive neutron scattering facility. Even as the other neutron source in the nation—the Spallation Neutron Source (SNS)—becomes increasingly operational and the Oak Ridge High Flux Isotope Reactor (HFIR) comes back online, the NCNR will continue to be a vital resource for meeting the broad spectrum of user needs for and scientific objectives related to neutron scattering. The NCNR reliably provides a high flux of neutrons to an evolving suite of high-quality instruments and sample environments. The publication record of the NCNR staff and associated researchers attests to the high quality and quantity of research in diverse areas of fundamental neutron science and condensed-matter physics and engineering.

The ongoing NCNR Expansion Project is critical for maintaining the vitality and capabilities of the facility. The selection and reconfiguration of a new suite of spectrometers are logical and well suited to the present climate for neutron research. The new Configuration Control Program that has been established to coordinate new hardware changes with both the Reactor Operations Engineering Division and the Research Facility Operations Division will be very important in ensuring a smooth transition from the present structure of the facility to the new, expanded configuration to be established over the next few years.

The NCNR is recognized for the exceptionally high quality of technical support provided to users of its facilities. A significant component of this support is the Center for High Resolution Neutron Scattering (CHRNS) Program, which supports users and outreach activities. In order to maintain the present high level of activities, the NCNR

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<sup>1</sup> See Domestic Policy Council, Office of Science and Technology Policy, 2006, *American Competitiveness Initiative*, Washington, D.C. “America COMPETES Act” is the short title for the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act of 2007 (Public Law 110-69).

Expansion Project needs to hire additional instrument scientists and engineers; this objective is being aggressively pursued.

The NCNR has a strong, vibrant user community, including an increasing presence of non-NCNR NIST scientists and engineers. The NCNR User Group (NUG) rates the training facilities and instruments as “good” to “excellent.” NCNR personnel are an essential element of the scientific output, and users evaluated their performance as “excellent.” The NCNR management is responsive to ideas generated by the NUG. For example, in response to concerns regarding sample environment, the NCNR has purchased a new, large-bore magnet and has initiated a Small Grants Program to help users develop and build new sample environment systems.

Developing the next generation of neutron scattering scientists and engineers is a vital part of the NCNR’s program. This work is assisted through the training of postdoctoral scholars working at the NCNR and is strongly advanced through the CHRNS summer schools and graduate student fellowships.

The following recommendations are directed at further enhancing the effectiveness of the NCNR in the pursuit of its goals. The NCNR should carry out the following:

- Enhance the soft-condensed-matter efforts of the facility in the following ways:
  - Continue the development of new technical capabilities that will allow the NCNR to maintain leadership in key research areas that complement those of other facilities such as the SNS and HFIR;
  - Aggressively pursue the ongoing recruitment effort for a scientific leader in experimental soft condensed matter;
  - Continue the development of the soft-matter consortium between the NCNR, the Polymers Division in the NIST Materials Science and Engineering Laboratory, and the University of Delaware;
  - Vigorously search for a biochemist jointly with the NIST Chemical Science and Technology Laboratory (CSTL) to participate in the rejuvenation of biological topics at the NCNR;
  - Increase network building with bioscientists in other institutions; and
  - Broaden the theory effort in the directions of statistical physics and biophysics.
- Sustain NCNR operation and reactor maintenance efforts during the NCNR Expansion Project by carrying out the following:
  - Schedule all of the planned reactor upgrades, including the repair of the thermal heat shield, the upgrade of the reactor control instrumentation, the installation of a spent-fuel pool liner, and the installation of the second cold neutron source;
  - Dialogue with the NUG concerning access to facilities during the construction phase; and
  - Continue actively attending to the matter of maintaining the

- scientific openness of the facility within the constraints of increasing security demands.
- Continue improvements to the user program including the following:
    - Plan for substantially expanded outreach (for example, workshops and extended scientific programs) when the planned new office building becomes available;
    - Maintain the regular rotation schedule of new members onto the Beam Time Allocation Committee; and
    - Increase attention to data access and improved analysis software for users after they leave the NCNR.

## The Charge to the Panel and the Assessment Process

At the request of the National Institute of Standards and Technology, the National Academies, through its National Research Council (NRC), has since 1959 annually assembled panels of experts from academia, industry, medicine, and other scientific and engineering environments to assess the quality and effectiveness of the NIST measurements and standards laboratories, of which there are now nine,<sup>2</sup> as well as the adequacy of the laboratories' resources. In 2008, NIST requested that five of its laboratories be assessed: the Building and Fire Research Laboratory, the Manufacturing Engineering Laboratory, the Materials Science and Engineering Laboratory, the NIST Center for Neutron Research, and the Physics Laboratory. Each of these was assessed by a separate panel of experts; the findings of the respective panels are summarized in separate reports. This report summarizes the findings of the Panel on Neutron Research.

For the fiscal year (FY) 2008 assessment, NIST requested that the panel consider the following criteria as part of its assessment:

1. The technical merit of the current laboratory programs relative to the current state of the art worldwide;
2. The adequacy of the laboratory facilities, equipment, and human resources, as they affect the quality of the laboratory technical programs; and
3. The degree to which the laboratory programs in measurement science and standards achieve their stated objectives and desired impact.

In addition, because NIST has begun to receive increases in funding through the President's ACI and the America COMPETES Act of 2007, the Director of NIST also requested that the assessment panels specifically examine and review the progress of all of the FY 2007-funded initiatives relevant to their respective laboratories and comment on these program growth areas explicitly in their reports.

The context of this technical assessment is the mission of NIST, which is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve the quality of life. The NIST laboratories conduct research to anticipate future metrology and standards needs, to enable new scientific and technological advances, and to improve and refine existing measurement methods and services.

In order to accomplish the assessment, the NRC assembled a panel of 13 volunteers whose expertise matched that of the work performed by the NCNR staff.<sup>3</sup> The panel members visited the NCNR facility at Gaithersburg, Maryland, for a day and a half, during which time they attended presentations, tours, demonstrations, and interactive

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<sup>2</sup> The nine NIST laboratories are the Building and Fire Research Laboratory, the Center for Nanoscale Science and Technology, the Chemical Science and Technology Laboratory, the Electronics and Electrical Engineering Laboratory, the Information Technology Laboratory, the Manufacturing Engineering Laboratory, the Materials Science and Engineering Laboratory, the NIST Center for Neutron Research, and the Physics Laboratory.

<sup>3</sup> See <http://www.ncnr.nist.gov/> for more information on NCNR programs. Accessed August 12, 2008.

sessions with NCNR staff. Subsequently, the panel members assembled for another day during which they conducted interactive sessions with NCNR managers and with leaders of NCNR user groups and met in a closed session to deliberate on the panel's findings and to define the contents of this assessment report.

The approach of the panel to the assessment relied on the experience, technical knowledge, and expertise of its members, whose backgrounds were carefully matched to the technical areas of NCNR activities. The panel reviewed selected examples of the technological research presented by the NCNR; because of time constraints, it was not possible to review the NCNR programs and projects exhaustively. The examples reviewed by the panel were selected by the NCNR. The panel's goal was to identify and report salient examples of accomplishments and opportunities for further improvement with respect to the following: the technical merit of the NCNR work, its perceived relevance to NIST's own definition of its mission in support of national priorities, and specific elements of the NCNR's resource infrastructure that are intended to support the technical work. These highlighted examples are intended collectively to portray an overall impression of the laboratory, while preserving useful suggestions specific to projects and programs that the panel considered to be of special note within the set of those examined. The assessment is currently scheduled to be repeated annually, which will allow, over time, exposure to the broad spectrum of NCNR activity. While the panel applied a largely qualitative rather than a quantitative approach to the assessment, it is possible that future assessments will be informed by further consideration of various analytical methods that can be applied.

The comments in this report are not intended to address each program within the NCNR exhaustively. Instead, this report identifies key issues and focuses on representative programs and projects relevant to those issues. Given the necessarily nonexhaustive nature of the review process, the omission of any particular NCNR program or project should not be interpreted as a negative reflection on the omitted program or project.

The rest of this report is organized in five brief chapters: "General Assessment of the NIST Center for Neutron Research," "Science and Technology at the Center," "Facilities and Human Resources," "The Center as a User Facility," and "Conclusions." The three chapters following the "General Assessment" address the criteria that the NIST Director requested the panel to include in its assessment. The progress of all of the FY 2007-funded initiatives relevant to the ACI and the America COMPETES Act is discussed in a section in the chapter "Facilities and Human Resources." Detailed information on NCNR activities and programs can be found on the NCNR Web site, [www.ncnr.nist.gov](http://www.ncnr.nist.gov), or in published documents. The NCNR's annual report—*NIST Center for Neutron Research: 2007 Accomplishments and Opportunities*—in particular highlights scientific research at the center, lists publications, provides titles of current research projects, and gives information on instrumentation, the planned new guide hall, and other developments.

## **General Assessment of the NIST Center for Neutron Research**

The NIST Center for Neutron Research is a national user facility whose mission is to ensure the availability of neutron measurement capabilities in order to meet the needs of U.S. researchers from industry, academia, and government agencies. The NCNR continues to provide reliably a high flux of neutrons to an evolving suite of high-quality instruments and sample environments. The array of thermal and cold neutron instruments available at the NCNR enables measurements over a wide range of time, energy, and length scales.

These capabilities of the NCNR play a critical role in advancing science and developing new technologies in the United States and enable NIST to fulfill its role of promoting science, standards, technology, and the American Competitiveness Initiative. The new instruments and upgrades associated with the planned facility expansion over the next few years will ensure that the NCNR continues to provide users with access to internationally competitive instruments.

## Science and Technology at the Center

The NIST Center for Neutron Research is involved in a diverse range of scientific topics, and exciting research opportunities abound. The publication record of the NCNR staff and associated researchers attests to the high quality and quantity of work carried out at the center's facilities. During the past year, the period of this assessment, NCNR and associated researchers produced more than 350 publications, 33 of which appeared in noteworthy journals. Several of these publications are outstanding contributions to science. The topics, which attest to the breadth of the work, include fundamental neutron physics and a number of directions in condensed-matter science and engineering, such as correlated electron systems and correlated spin systems, glass physics, hydrogen storage, polymer physics, complex fluids, and rheology. The Center for High Resolution Neutron Scattering, which includes six instruments, has played a significant role in this level of accomplishment. Nearly half of the important publications are associated with the CHRNS Program.

The Fundamental Neutron Physics Group continues to be productive and innovative. Its scientific goals are well aligned with the national goals for U.S. nuclear physics as articulated in the Nuclear Science Advisory Committee (NSAC) Long Range Plan of 2007.<sup>4</sup> As befits a group at NIST, many of the skills of the group are directed toward measuring quantities to unprecedented precision. The most speculative experiment is the proposal to study the neutron electric dipole moment (EDM) by means of neutron transmission in a silicon single crystal. The systematics of the measurement, which will likely represent a formidable challenge, remain to be identified. Nevertheless, the technique is sufficiently novel that proceeding with a test measurement is encouraged. The Fundamental Neutron Physics Group is carrying out excellent science that should be further developed.

An important effort at the NCNR, begun over 3 years ago, is being directed at the problem of hydrogen storage. The hydrogen storage project is a key element in the development of fuel cell technology that may well play a future central role in clean, fuel-efficient transportation modules. This is an excellent example of the NCNR's interfacing with industrial partners. The work on metal hydrides is particularly impressive. Neutron facilities are well suited for studies like this on hydrogen storage. The work should be continued, with an effort to understand the underlying physics. Strong connections should be built to related research at other national laboratories and at universities.

It is important that the NCNR continue to commit to research on biological materials and on soft condensed matter. This research is becoming increasingly urgent as the contribution of biotechnology to the nation's commerce becomes more substantial. Important potential applications for the use of neutrons in studying biologically pertinent systems include resolving the structure and dynamics of membranes, of proteins in membranes, and of genetic material inside viral capsids. Some work on these topics is underway at the NCNR, but there should be more. For example, the collaborative work between the NCNR and the National Institutes of Health (NIH) on neutron scattering of

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<sup>4</sup> Nuclear Science Advisory Committee, 2007, *The Frontiers of Nuclear Science: A Long Range Plan*, available at <http://www.sc.doe.gov/np/nsac/docs/Nuclear-Science.Low-Res.pdf>. Accessed September 2, 2008.



osmotically stressed biological systems is worthwhile. In the study of protein-associated water, researchers were able to probe the protein-water structure using small-angle neutron scattering (SANS). There was also an NCNR-NIH collaboration on the study of clathrin, a major component in the protein coats of certain post-Golgi and endocytic vesicles. The transformation between “basket” and open forms is visible by dynamic light scattering and SANS, with SANS revealing features not visible by light scattering.

A stumbling block to substantially increased research in these areas is the very modest level of expertise in biology and biophysics at the NCNR or elsewhere at NIST. The NRC’s assessment report for FY 2007 encouraged the NCNR to address this perceived problem by means of direct hires and/or the development of new partnerships.<sup>5</sup> In the soft-matter area, despite good efforts there was no success in attracting a strong scientific leader. The NCNR made two hiring offers last year, but neither candidate accepted a position. To enhance its biological efforts, the NCNR is looking to partner with NIST’s Chemical Science and Technology Laboratory to search for a biochemist, with the expectation that the person’s primary activity would be to use neutron scattering. There is now an effort to hire a person to lead the research in the structure and dynamics of membranes; that individual will be stationed in the CSTL but would have a neutron focus and thereby be in a position to nucleate future collaborative efforts.

Still, there is need at the NCNR for continued network building with scientists in other institutions. The Center for Advanced Research in Biotechnology, involving NIST and the University of Maryland, is a step in the right direction. NIST should continue to undertake such steps. For example, there are continuing possibilities to build connections with NIH, especially if it is possible to support more joint postdoctoral positions. In addition, the NCNR is hoping to develop a consortium with the Polymers Division at NIST’s Materials Science and Engineering Laboratory and the University of Delaware.

There is insufficient theoretical guidance at the NCNR in statistical physics. This is not to deny outstanding work in this area. For example, the studies of oxide pyrochlorites are impressive. These materials exhibit transitions between phases of spin matter that are low-temperature analogues of liquid water and ice. The work illustrates how the capabilities of the NCNR can provide insight into the statistical physics of materials. The way in which NCNR capabilities provided information on the behavior of so-called relaxors is also impressive. However, the absence of a strong enough representation in statistical mechanics by the theorists at the NCNR and NIST impedes possible links to scientists interested in measurements on biophysical systems. It also limits the vision associated with the NCNR research on complex fluids, rheology, and materials. While sophisticated and inventive measurements have been made in each of these areas—for example, on the behavior of structured fluids under shear and on the fracture of solids under strain—applications of statistical physics have the potential to help NCNR scientists and their co-workers gain even further insight from their measurements. For this reason, as has been noted in previous NRC assessment reports, the theory program at the NCNR would substantially benefit by broadening in the directions of statistical physics and biophysics.

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<sup>5</sup> National Research Council, 2007, *An Assessment of the National Institute of Standards and Technology Center for Neutron Research: Fiscal Year 2007*, Washington, D.C.: The National Academies Press.

## **Facilities and Human Resources**

### **REACTOR OPERATIONS AND RESOURCE NEEDS OF THE EXPANDING FACILITY**

In recent years, the NCNR has been an extremely reliable and comprehensive neutron scattering facility and will continue to be a vital resource for meeting the broad spectrum of user needs for and scientific objectives related to neutron scattering in the future. Because the panel does not have quantitative data from the other neutron scattering centers, both national and international, it cannot provide a detailed comparative analysis of parameters such as beam delivery, user statistics, the number and quality of the experiments, publication statistics, and so on. Such a study is planned for the 2009 panel. The NCNR's reactor has continued to perform very reliably, with 256 days of availability out of a possible 258 in the past year.

The management of reactor operations, maintenance, and equipment updating is being carried out with careful attention in order to ensure a high level of availability of the facility to users. The two NCNR operational groups, the Research Facility Operations Division and the Reactor Operations Engineering Division, meet prior to each shutdown to discuss the coordination required for maintenance activities. In addition, another group has been meeting to plan the activities that will take place before, during, and after the long shutdown required for the NCNR expansion. Furthermore, a relatively new Configuration Control Program has been established to coordinate all new hardware changes with both the Reactor Operations Engineering Division and the Research Facility Operations Division. This program will be very important for ensuring a smooth transition from the present structure of the facility to the new, expanded configuration to be established over the next few years.

Reactor operations is one of the major activities that have been identified and under study at the NCNR for some time. These activities include upgrading the reactor control room console, installing a new liner for the spent-fuel pool, repairing the secondary piping systems, and installing a new cold source in the reactor enclosure.

The lean and economical management style of the NCNR Reactor Operations Engineering Division has served the facility and the users well over the years. The safety record over the years has been excellent, and this aspect is a major component of the certification review that is nearing completion. However, there are now new challenges that, to be met successfully, will require additional human and financial resources. For the most part, major NCNR budget increases have been directed toward user support and instrumentation. While operations have been adequately supported, the new needs for additional engineering staff and funds for the repair of the reactor's thermal heat shield will bring additional costs. In order to ensure excellent performance of the neutron source into the future with the expanded guide hall and instrumentation, it is important that the increased needs for expanded operations support not be forgotten.

## THE NCNR EXPANSION PROJECT FUNDED UNDER THE AMERICA COMPETES ACT

The NCNR Expansion Project, funded under the America COMPETES Act of 2007 in support of the ACI, is critical for maintaining the vitality and capability of the facility. The selection of a new suite of spectrometers and the reconfiguration, in order to maximize productivity, of the existing state-of-the-art instruments are coherent and well thought out. Specifically, the small-angle scattering instruments support a vibrant program and an operation that is among the world's best. The addition of very small angle neutron scattering provides a vital link between the current 30 meter SANS and ultra small-angle neutron scattering instruments. The innovative design will enable good resolution without a loss of flux. The addition of a dedicated-phase imaging facility, driven by applications such as fuel cell design but also applicable to a wide range of other problems, will further develop this unique program and leadership in the field at the NCNR. Likewise, the reflectometers—Chromatic Analysis Neutron Diffractometer or Reflectometer (CANDOR) and Multiple Angle Grazing Incidence K [vector] (MAGIK)—are innovative, demonstrating the creativity and expertise of the staff. The potential of these instruments is high and may dramatically impact the science capabilities of reactor sources in the context of the SNS. The reconfiguration and isolation of magnetically sensitive instruments will enable further gains in the optimization of the facility. The BT-7 thermal triple-axis detector, essentially a new instrument, has been created to respond to perceived user need. The selection of new instruments and ancillary equipment has been and continues to be carried out in the context of the SNS pulsed source's becoming increasingly operational.

The Fundamental Neutron Physics Group has assembled cutting-edge beam-line capabilities on cold neutron lines 6 and 7 and has developed technologies that have been adopted at the other leading neutron science laboratories. For example, a potassium intercalated graphite monochromator was developed to scatter 8.9 angstrom neutrons into the ultracold neutron (UCN) beam line on NG6 as part of the neutron lifetime experiment. The technology for building monochromators has now been adopted at the Institut Laue-Langevin (ILL) in Grenoble, France, and it will also be used on the UCN beam line that feeds the neutron EDM target station at the SNS. The neutron interferometer and optics facility on line 7 is unique in the United States and has enabled the most precise measurements of neutron- few body scattering lengths and a new measurement of the neutron charge radius.

Through improved guide performance and source upgrade, the NCNR Expansion Project promises a factor-of-six more neutrons on some beam lines. This is a very significant advance, bringing intensities close to what is achieved at ILL—the leader until now in fundamental neutron physics. It is conceivable that experiments now planned for the SNS could in the future move to the NCNR to take advantage of this intense flux, particularly for situations in which the characteristics of a pulsed beam are not essential. Additional opportunities may exist from recent developments in neutron microfocusing optics—for example, Kirkpatrick-Baez mirrors. These optics can now produce <100 micron beams and increase flux on samples by more than four orders of magnitude. These advances will open up new diffraction and spectroscopy experiments on small

single crystals, heterogeneous materials, and samples in extreme environments. In general, neutron optics techniques, which continue to improve, could be adapted for a number of instruments, for example, the multi-axis crystal spectrometer.

The NCNR also has the opportunity to establish important niche areas. For example, building on its strengths in sample environments by continuing to improve the instrumentation for variable temperature (both high temperature and cryogenic), high pressure (gas apparatus and anvil), and magnetic and electric fields is an opportunity for neutron scattering measurements on materials under multiple extreme environments that either are not possible or are limited at the SNS. In this context, the NCNR has purchased a new, large-bore magnet and has initiated a Small Grants Program to develop and build sample environments. This novel approach, implemented by the facility management, is to provide a funding opportunity call through the Grants.gov Web site to leverage the robust user community to develop new sample environments and capabilities. The panel recognizes the importance of facilities for a broad range of sample environments and views this as an area in which the NCNR should maintain an aggressive program for development.

The Expansion Project poses significant challenges for continuing a vibrant user program in the presence of construction activities. The NCNR is well recognized for the exceptionally high quality of technical support provided to users of its facilities. The hiring of additional personnel is being aggressively pursued, and resources appear to be sufficient to navigate this process effectively. Significant progress has been made with the hiring of three new instrument scientists; recruitment for one more is proceeding. In addition, some progress has been made in the hiring of engineers needed for the new project workload. The completion of the Expansion Project and the hiring and development of the requisite scientific and technical support staff are critical components for the long-term health of the facility. In this area, the panel firmly endorses the overall NCNR staffing strategy and in addition recommends expanding its population of postdoctoral researchers. The availability of increased office space, which is part of the Expansion Project, should also allow for an expansion of the NCNR program for postdoctoral scholars. These talented individuals form the foundation for the next generation of neutron scientists and engineers, and their support and scientific nurturing should continue to be one of the NCNR's highest priorities.

As discussed earlier, synergistic collaborations within the NIST complex are currently being pursued, and joint hiring with other laboratories will help expand the scientific programs of both the NCNR and the other laboratory groups. These arrangements have high potential to further increase the vitality of the NCNR and NIST, more generally. Furthermore, the NCNR Expansion Project offers the possibility of further developing human resources external to the NIST complex through visiting sabbatical or joint positions. With the increased office and laboratory space, the opportunity to accommodate visitors from academia, industry, and other national laboratories will be enhanced. The infrastructure required to hold focused workshops and to facilitate extended stays of months to a year for researchers could provide a mechanism for developing new areas of scientific enterprise and assisting the training of the next generation of scientists with expertise in neutron scattering. Likewise, vigorous and continued efforts to leverage the local scientific community—for example, the

Howard Hughes Medical Institute, NIH, and universities—should be aggressively pursued.

## The Center as a User Facility

The NIST Center for Neutron Research is a national user facility whose mission is to ensure the availability of neutron measurement capabilities in order to meet the needs of U.S. researchers from industry, academia, and government agencies. The NCNR user community is robust and eager to obtain access to the NCNR facilities, routinely submitting more than 300 proposals per year. In a recent call for proposals, more than 1,900 days of beam time were requested, corresponding to an average instrument oversubscription of 2.1. The new option to mail in samples for the powder diffractometer is being exercised, providing a good alternative to costly travel and difficult scheduling issues. In 2007, more than 850 users came to the NCNR, and the productivity of the instruments was estimated to be between 50 and 60 users per instrument, a figure on par with European sources. Approximately 10 percent of the participants are NIST personnel from outside the NCNR. The advent of the expanded and upgraded instrument suite is eagerly anticipated by the user community, although some concerns were expressed over intermediate-term access during the expansion.

The NCNR User Group surveys users every 3 years. The most recent survey, conducted in 2007, included responses from students and postdoctoral researchers, staff members, and external principal investigators. Discussion by the panel with the head of the NUG confirmed that users rate the training facilities and instruments as “good” to “excellent.” NCNR personnel are an essential part of the equation, and users evaluated their performance as “excellent.”

The concerns of users were primarily associated with the availability of specialized sample environments, easy access to their data after leaving the facility (via the World Wide Web, for example), and the availability of software and associated tutorials for data analysis. Another important concern was the compatibility of data formats among different facilities, since users would like to be able to easily merge measurements made at the NCNR with those made elsewhere. Finally, office space in the current NCNR building is extremely tight for visiting scientists. This last problem will probably be alleviated by the addition of the new office building as part of the facility expansion.

Management is seen as responsive to ideas generated by the NUG. For example, the NCNR has purchased a new, large-bore magnet and has initiated a Small Grants Program to develop and build sample environments. This innovative approach is an excellent way to take advantage of the capabilities of the user community and should yield some creative results. The Small Grants Program received only one application in 2007, which was unfunded. In 2008, a more aggressive solicitation yielded five or six inquiries that were expected to turn into formal applications. Specialized sample environments may help distinguish and strengthen NCNR capabilities as other U.S. neutron sources come online.

The beam-time allocation process at the NCNR is well run. All proposals are reviewed by three to five external reviewers as well as by members of the Beam Time Allocation Committee. Members of the committee are all external to the NCNR and are appointed by the NCNR in consultation with the National Science Foundation (NSF) for

nominal terms of 3 years. Regular rotation of new members onto the committee is encouraged to maintain fresh perspectives.

The NSF-supported Center for High Resolution Neutron Scattering Program is an important facet of the NCNR and an outstanding example of collaborative activity between government agencies. In addition to providing direct support for a subset of neutron scattering instruments, CHRNS supports key educational and outreach activities. These include summer schools on neutron scattering techniques and Summer Undergraduate Research Fellowships. The NCNR also provides support for graduate students to work with NCNR scientists. These activities are indispensable for developing the next generation of scientists and engineers conversant with neutron scattering.

Security is a continuing issue. To its credit, in contrast to some government installations whose security apparatus impedes contact with the outside, the NCNR is trying to maintain a rational security program in order to allow efficient use of the facility. Two people are employed to facilitate user access. Foreign visitors are required to apply for permission 35 days before arriving at the NCNR, on a par with or shorter than the lead time required at other national facilities. The present system seems to meet all security requirements while keeping the spirit needed in a center of learning. However, this area requires ongoing attention.

## Conclusions

The NIST Center for Neutron Research is a national user facility whose mission is to ensure the availability of neutron measurement capabilities to meet the needs of U.S. researchers from industry, academia, and government agencies. Developing the next generation of neutron scattering scientists and engineers is also a vital part of the NCNR's program.

The NCNR continues to provide reliably a high flux of neutrons to an evolving suite of high-quality instruments and sample environments. The array of thermal and cold neutron instruments available at the NCNR enables measurements over a wide range of time, energy, and length scales.

These capabilities of the NCNR play a critical role in advancing science and developing new technologies in the United States and enable NIST to fulfill its role of promoting science, standards, technology, and the American Competitiveness Initiative. The new instruments and upgrades associated with the planned facility expansion will ensure that the NCNR continues to provide users with access to internationally competitive instruments.



