OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE U.S. DEPARTMENT OF ENERGY
SNS

The NEUTRON PULSE

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Experimental Facilities Work Going Strong

Excellent progress is being made on the experimental end of the Spallation Neutron Source (SNS) construction site. Work continues aggressively in the target monolith, with recent accomplishments including installation of the proton beam flight tube, the inner target cart liner, more than half of the shutter guides and interstitial blocks, and more. In addition, negotiations are under way to award the contract for follow-on installation work.

In less than a year, the Target Building will be complete. Accordingly, the Operations team has begun to add staff, is drafting procedures and processes, and is focusing on the transition from construction to operations.

Advances in instrumentation are also being made. Designs for all five SNS-funded instruments will be finalized by the end of September. Contracts have been awarded for many long-lead procurements on all of the instruments. The SNS Instruments—Next Generation (SING) project has received U.S. Department of Energy (DOE) approval of the baseline performance, cost, and schedule for the high-resolution chopper spectrometer, high-pressure diffractometer, disordered materials and single-crystal diffractometers, and the hybrid spectrometer.

Instrument Installation Begins

Instrument installation has begun with the March arrival of the evacuated final flight path tank for the backscattering spectrometer. Currently, this instrument has the longest planned flight path and is located ~84 meters from the neutron source to provide the high timing resolution required for its operation. The 14-ft-high, 21-ft-diameter tank had to be transported on three trailers and is now being assembled in the satellite building. The tank is so large that when assembled and evacuated ~350 pounds of air will have been removed.

Other Construction and Installation Progress

In other areas of the project, the Accelerator Systems Division has completed commissioning of the first three tanks of the drift-tube linac (DTL) and expects to complete commissioning of the full DTL, as well as the first section of the coupled-cavity linac, by the end of summer. Also, the ring tunnel is filling out as magnets and associated support equipment are installed.

The Central Lab and Office Building (CLO) will soon be ready for its new residents, and the SNS staff who have been working in the 701 Scarboro Road Building will be moving to the site in June. The structural steel erection on the Center for Nanophase Materials Sciences (CNMS) Building, SNS's first neighbor, is proceeding well also.

In this Issue

Director's Comments

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SNS progress continues, with between 450 to 500 construction workers on site daily. The project is still on schedule and within budget. The president requested $114 million for fiscal year 2005, as anticipated.

In April the project reached 5 million safe working hours—covering both construction and nonconstruction—without a lost day away from work. The construction milestone alone will be 3 million hours. This rate and our recordable injury rate are well below comparable industry averages. It is to the credit of everyone involved in the SNS project, from Knight Jacobs (our construction manager), their contractors and work crews, to everyone else involved in the project, that this level of attention to safety continues to be a daily priority.

Hiring for operations staff and instrument support staff continues. We anticipate the arrival of two additional scientists and a software team leader by early summer.

Collaboration with our international colleagues continues. Two conferences are planned for early June as satellite conferences of the American Conference on Neutron Scattering (ACNS). *Polarized Neutrons in Condensed Matter Investigations 2004* will be held on June 1-4, and a workshop, *Neutrons and Energy for the Future,* is scheduled for June 4-5.

SNS hosted an open house on April 2. Experimental Facilities Director Ian Anderson demonstrates how laser light is diffracted through a sieve, similar to the way neutrons will be scattered at SNS.

SHUG Update

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This is an exciting and important time for current and future users of SNS and the High Flux Isotope Reactor (HFIR). Decisions are being made at the Oak Ridge National Laboratory (ORNL) facilities that will directly affect tomorrow's users. The instruments being developed here are designed to meet the needs of users across a broad range of disciplines, so putting together an active "potential user" group that represents a broad range of disciplines is critical. Current issues being addressed at SNS/HFIR User Group (SHUG) Executive Committee meetings include monitoring and assessing the effectiveness of the newly restarted user program at HFIR, developing a fast access policy, discussing viable methods of attracting new users to the neutron community, providing input to management on lodging, information technology and access issues, and, most certainly, staying abreast of the instrumentation development and time lines for the ORNL neutron facilities. Users are invited to peruse the SHUG web site (www.sns.gov/shug) to read announcements and minutes from Executive Committee meetings and to contact committee members with any questions or concerns.

We look forward to seeing and hearing from many of you at the second ACNS (www.ncnr.nist.gov/acns/) that will be held in College Park, Maryland, June 6–10, 2004. This conference will feature presentations highlighting the capabilities of the instrumentation available for users at the major neutron centers in North America, including the ORNL neutron facilities, and will provide a forum for users to ask questions and raise issues related to these facilities.

New SHUG members:

David Bowman	Los Alamos National Laboratory
Paul Butler	ORNL/HFIR
Kim Tait	University of Arizona
John Turner	University of Tennessee (UT)
Lynn Walker	Carnegie Mellon University
Angus Wilkinson	Georgia Tech (Vice-Chair 2004)

Returning members:

Takeshi Egami	UT/ORNL (past Chair 2003)
Christina Hoffman	ORNL/SNS (Secretary 2004)
Joanna Krueger	University of North Carolina, Charlotte (Chair 2004)
Nancy Ross	Virginia Tech
Paul Sokol	Penn State (past Vice-Chair 2003)

International Workshop on *Polarized Neutrons in Condensed Matter Investigations* (PNCMI 2004) Washington D.C., June 1–4, 2004

Frank Klose
klosefr@sns.gov

A major international workshop on polarized neutrons will be held on June 1–4, 2004, in Washington, D.C. This workshop will gather scientists working on condensed matter investigations using polarized neutrons and on the development of polarized neutron-scattering techniques. With the help of international experts, PNCMI 2004 will review areas to determine the greatest science opportunities for polarized neutron scattering. PNCMI 2004 will also help develop the roadmap for the technology research and development (R&D) required to facilitate polarized neutron scattering, particularly at *pulsed* neutron sources such as SNS. This workshop should attract U.S. researchers in particular because the American Conference on Neutron Scattering (ACNS 2004) will take place the following week in College Park, Maryland (June 6–10, 2004). In fact, PNCMI 2004 is an official satellite conference of ACNS 2004.

In connection with the PNCMI workshop, a school on polarized neutron scattering is planned for young scientists. The school contains both a tutorial (June 4) and a laboratory course (June 5), with hands-on training using the polarized neutron-scattering instruments at the National Institute of Standards and Technology (NIST) Center for Neutron Research.

For additional information, visit www.sns.gov/pncmi2004/, or contact Frank Klose at klosefr@sns.gov (865-576-5389). The proceedings of the workshop will be published as a special issue of *Physica B: Condensed Matter*. The conference and training session are sponsored by the National Science Foundation (NSF), Division of Materials Research; Oak Ridge Associated Universities; and the DOE Office of Basic Energy Sciences (DOE-BES).

Neutrons and Energy for the Future, Washington, D.C., June 4-5, 2004

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Significant challenges are ahead to identify reliable and economic sources of energy in the United States and throughout the world that can be produced in the needed quantity without increasing pollution. It is expected that basic research will make an important contribution by providing understanding that will both expand the available options in technological approaches and identify new concepts. Neutrons offer unique opportunities to achieve the needed understanding of materials structures and properties. Broadening knowledge among researchers and policy makers of these opportunities is important and needs to be timely. Several recent reports have identified the specific directions for research on “clean energy.” This workshop will use the targeted areas and focus on the particularly high-payoff research opportunities for using neutrons as tools.

This workshop is being organized by the University of Tennessee (UT)/ORNL Joint Institute for Neutron Sciences (JINS) and NMI3, also known as the Neutron Scattering and Muon Spectroscopy Integrated Infrastructure Initiatives. NMI3 is a European Union Framework 6 Program and has absorbed as one of its components the European Union’s Neutron Roundtable. Workshop sponsors include the NSF, Chemistry Division; Oak Ridge Associated Universities; ORNL/SNS; UT; and DOE-BES.

This conference is another satellite event of ACNS 2004. For additional conference information, please visit www.sns.gov/jins/nmi3/, or contact Al Ekkebus at ekkebusae@sns.gov (865-241-5644).

Upcoming Events

PNCMI 2004
Polarized Neutrons in Condensed Matter Investigations
June 1–4, 2004
Washington, D.C.
www.sns.gov/pncmi2004/

Neutrons and Energy for the Future
June 4–5, 2004
Washington, D.C.
www.sns.gov/jins/nmi3/

American Conference on Neutron Scattering
June 6–10, 2004
College Park, Maryland
www.ncnr.nist.gov/acns/

SNS Transition from Construction to High Availability and Reliability in User Operations

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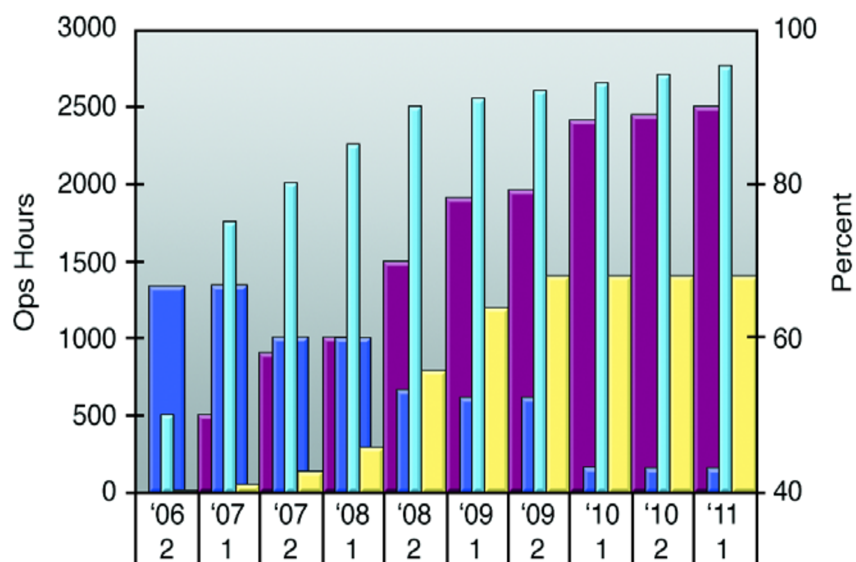
Experience at other major neutron and X-ray user facilities that serve the materials community has shown that high reliability and availability are crucial measures of facility performance in terms of the ability to deliver a robust scientific program. Successful operation of the facility is a big task. The SNS complex includes a front end, 1-GeV H^- linac, compressor ring, and a target station that includes the research instruments. Support facilities will provide cooling water; electrical utilities; 2-K helium; and laboratory, shop, and office space for staff and users. This scientific infrastructure represents an investment of $1.4 billion in support of research into the structure and dynamics of materials. In addition, a nanoscience center and JINS will be located on site, with the potential for other facilities in the future.

Successful accelerator-based user facilities have been able to deliver reliability with respect to schedule approaching 95% and availability of up to 5000 hours per year. This is true for both synchrotron X-ray facilities and spallation neutron sources such as ISIS and the Intense Pulsed Neutron Source (IPNS). Operating SNS at unprecedented power levels for 5000 hours annually at 95% is a challenging goal that will not be met immediately on the construction completion date of June 2006. Following a two-year period of commissioning and ramping up of power level, we anticipate being able to operate in user mode (defined at >90% availability) in the megawatt-level power range. As experience with operation is gained, we plan to approach the ultimate goal of 5000 full-power hours per year at 95% reliability.

Ultimately, the typical mode of operation for SNS will be similar to synchrotron radiation light sources, where a short break is planned each week for preventive maintenance and setup of accelerator and experimental equipment. SNS will measure reliability with respect to *scheduled user beam operation*; scheduled downtime for maintenance does not impact reliability since it can be planned around. Scheduled downtime does affect overall availability, but in general we believe the user community will prefer planned vs unplanned outages, even if it implies somewhat lower overall availability. Similarly, the user community will be willing to accept reduced hours of operation if it yields improved reliability, even at the expense of overall reduced integrated beam current.

These two factors mean that SNS will optimize user-mode operation to achieve at least 90% reliability with the number of scheduled beam hours and power level chosen, based on operating experience that is anticipated to meet the reliability constraint. In doing so, it is important to understand that the duration of down time events is also important. Generally, very short beam interruptions are not a problem except in specific time-sensitive experiments that are not typical, although they do occur. In fact, some facilities exclude short duration trips from their reliability statistics since they do not adversely impact users. Because typical experiments are several days to a week or two in duration, shut downs of that duration are most important. Instrument reliability is every bit as important as beam reliability, and the same goals apply, which implies instrument reliability of about 98%.

Figure 1 shows a reasonable planning basis for the early years of SNS operation in six-month intervals of calendar years. The gradual increase of the three user parameters (user hours, beam power, and reliability) is based on the currently foreseen program in which the commissioning of the instruments—as well as the



	'06 2	'07 1	'07 2	'08 1	'08 2	'09 1	'09 2	'10 1	'10 2	'11 1
User Ops hours	0	500	900	1000	1500	1900	1950	2400	2450	2500
Accel. Physics	1344	1344	1008	1008	672	624	624	168	168	168
Beam Power/kW	3	50	150	300	800	1200	1400	1400	1400	1400
Reliability (%)	50	75	80	85	90	91	92	93	94	95

Half-Year Period

Fig. 1. Accelerator operation and availability in six-month intervals following project completion.

continuous development, construction, and installation of the instruments—will require significant time, especially during the first two years of operation. At the same time, there is a necessity to approach the beam power design goal carefully, to guarantee both safety and well-controlled operation of the mercury target.

In the initial six-month period following construction completion, the project will focus on regulatory requirements. During these low-power operations, neutron production will be sufficient for beam tests of instruments to verify detector performance and timing, etc., but not adequate for a full suite of experimental availability. There will be minimal need for reliability, although advance notice of beam availability on a weekly scale will assist in good time management.

After regulatory requirements are complete, SNS will be able to initiate higher power operation. The first six months of high-power operation will also be used for test experiments and for debugging instrument control and data analysis software. Beam power should be sufficient to permit testing of the full range of experimental capability (including inelastic scattering), which implies at least 50 kW or so operation at 75% reliability.

This plan foresees that in the second half of 2007 the facility will deliver 900 hours of beam time with a beam power comparable to the best in the world (150 kW). Within these 900 hours, availability of the complex should approach 80% to permit conducting experiments with external scientists in a "user-friendly" mode and to further refine data analysis software. The first half of 2008 should see progress to beam power beyond that available at any other facility (300 kW), with continued progress in reliability. By the second half of 2008, two years after construction completion, the user program will commence with 90% reliability and close to megawatt power levels.

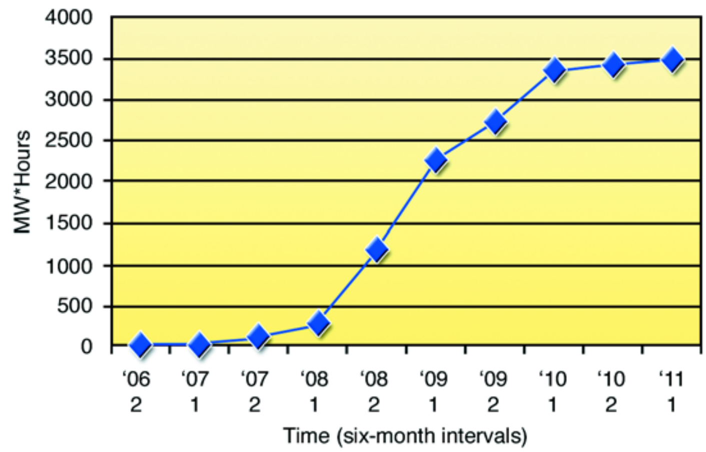


Fig. 2. Integrated beam power following project completion.

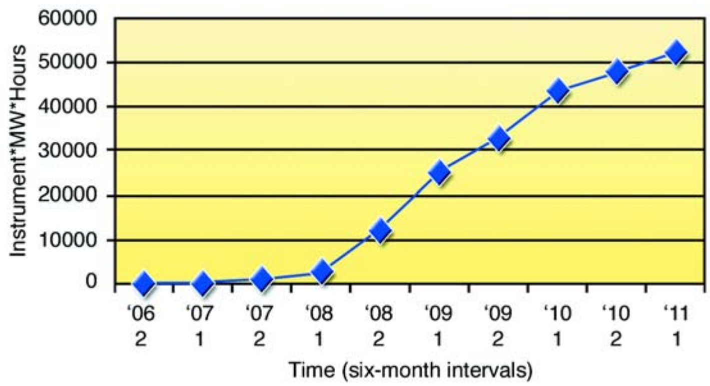


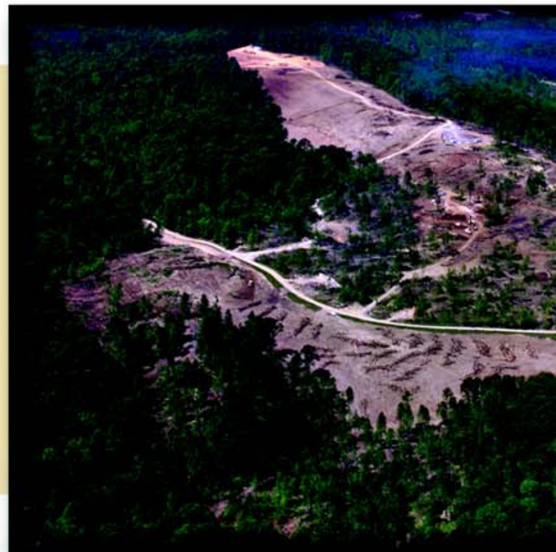
Fig. 3. Instrument-weighted integrated beam power.

The preceding data can be used to project the future integrated beam power delivered in each six-month interval (Fig. 2). For comparison, the corresponding data for ISIS in 2000 is 260 MW hours. By adding in the expected growth of the instrument suite (approximately nine instruments by the start of user operations and two per year after that), the growth of overall scientific capacity can be gauged in Fig. 3 (for ISIS in 2000, this was 4680 instrument megawatt hours). This figure of merit will continue to grow beyond the time frame of the current projection as an additional 15 instruments (for a total of 24) are completed and power is increased as upgrades to the accelerator and target are made over the operating life of the facility.

In addition to reliability issues in design and provision for adequate spares in the construction project, this plan implies robust operational funding during the early years of operation. Also included are typical improvements of the radio-frequency systems, debugging of components, and the anticipated need for equipment replacement. Also paramount are well-trained target and accelerator operations staff, along with instrument scientists and support groups. Together these will provide a successful beginning for research at SNS.

Source: Article condensed from *The Spallation Neutron Source: Operational Aspects and Reliability in the Transition from Reliability to Fully Committed User Operation*, SNS 102000000-TR0004-R00, UT-Battelle, LLC, Oak Ridge Natl. Lab., Feb. 2002.

September 1998



May 2000

October 2002

Transformation of the SNS site. Construction is about 85% complete.

April 2001

May 2003

April 2004

Central Laboratory and Office Building

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The SNS CLO contains 250,000 ft^2 of space for more than 400 staff and users. In addition to office space, the CLO will contain large shop areas, conference and training rooms, a receiving department, the central control room, and large spaces for laboratories—all dedicated to the scientific mission of SNS.

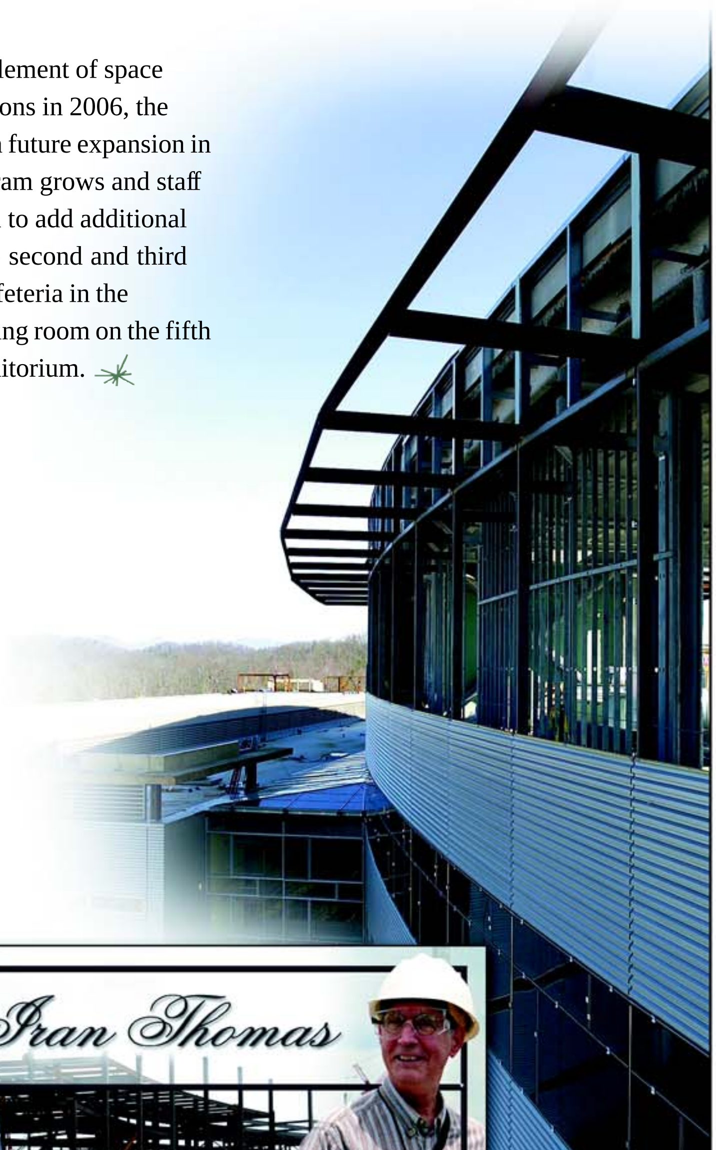
The building is shaped in two curved sections, or arcs, with the four stories of laboratories between them. The south arc, closest to Bethel Valley Road and the Smoky Mountains, contains five floors and a basement, a variety of conference and training rooms, a library, and staff offices.

The north arc, with three stories and a basement, is closest to the Target Building and the Cumberland Mountains. This arc contains the main SNS control room, which will be staffed 24 hours per day by operations personnel. It will also have open office areas and computers for data analysis for the users and will be linked to the Target Building by a walkway.

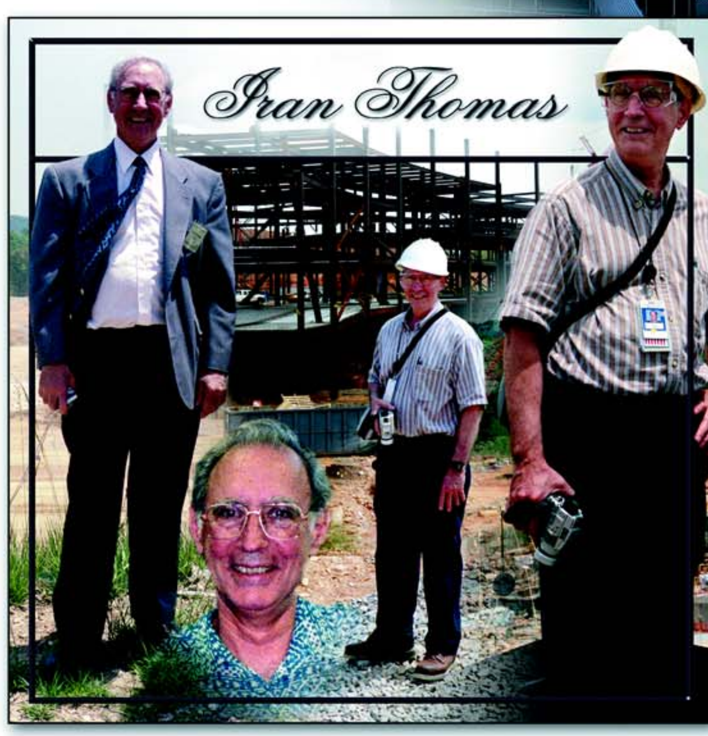
The CLO also connects to the CNMS, which is planned for completion in March 2005. The two facilities complement one another not only in their scientific mission but also in architectural style.

The SNS move into the CLO will begin in June when the Experimental Facilities Division moves to the 4th floor on the south side of the building. Additional stages of building completion will occur in subsequent months, with the building being completely finished by mid-Autumn 2004. Other project staff will initially move into lab areas in the basement and first floor and into offices on the north side of the building in June.

In addition to the complement of space needed to begin operations in 2006, the CLO was designed with future expansion in mind. As the user program grows and staff increases, there is room to add additional laboratory space on the second and third floors, a kitchen and cafeteria in the basement, a small meeting room on the fifth floor, and a 350-seat auditorium.



When completed, the SNS auditorium will be named after Iran Thomas, late DOE-BES deputy director, who provided the guiding vision behind many of DOE's large user facilities.



What's up at the Center for Nanophase Materials Sciences? Steel . . . and the First Users!

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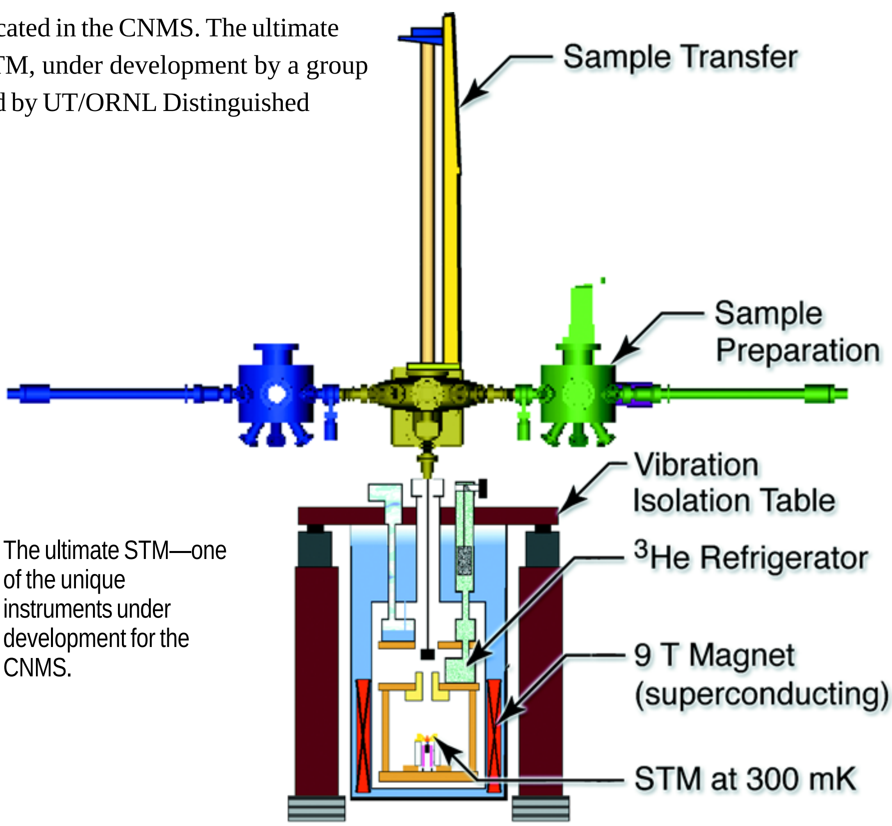
Artist's conception of the CNMS.

April 2004 aerial highlighting construction of the CNMS alongside the SNS CLO.

In December 2003, the first steel went up at the CNMS, SNS's sister facility on the construction site. By March, steel was in place for all four levels, as well as the single-story clean room, and it's now easy to imagine how the final building will look. The steel for the skylight is also going up, and the bridges to the SNS CLO Building, complete with extra width for interaction spaces, are in place.

In addition, the road north of the CNMS is being brought down to its final level—significantly reducing the water runoff into the "pit," the future home of the ultimate scanning tunneling microscope (STM). This instrument will be one of the unique instruments for nanoscience that will be located in the CNMS. The ultimate STM, under development by a group led by UT/ORNL Distinguished Scientist Ward Plummer, will be used to evaluate the quantum response of nano objects with single atom spectroscopy and atomically resolved spectroscopy maps at temperatures from 300 mK to 150 K and at magnetic fields up to 9 tesla. Needless to say, this is an ultrahigh vacuum cryogenic instrument.



The ultimate STM—one of the unique instruments under development for the CNMS.

Last September, CNMS had its first call for user-initiated research proposals. This is a limited program that will use existing ORNL facilities. More than 70 proposals were received from across the United States, Europe, and China. Following peer review, about 40 proposals were selected (list at www.cnms.ornl.gov). The first users have arrived to start experiments involving synthesis and characterization of polymers, carbon nanotubes, and composites. Many of these users are also taking advantage of ORNL facilities that have partnership arrangements with the CNMS, including the new interim clean room and the specialized electron microscopy facilities in the SHaRE and High-Temperature Materials Laboratory user facilities. The first user projects in the CNMS Nanomaterials Theory Institute are also under way.

Finally, in February CNMS had a successful review of the detailed FY 06–08 operations budgets. The coming months will include ordering the balance of the technical equipment for the facility, completion of construction, and more user research. Also coming up in late summer is the second call for proposals. In the next issue of *The Neutron Pulse*: the CNMS Nanofabrication Facility!

Neutron Facility Managers Meet at Argonne

The neutron facility managers met at the Argonne National Laboratory IPNS on January 14, 2004. All major North American neutron-scattering facilities were represented.

Facility updates: Chalk River noted its support by industry, the intent to extend the operating license, and instrument upgrades. HFIR provided details of instrument upgrades and of the increase in use by the academic community. IPNS described instrument upgrades and user education efforts with an expected increase in users. NIST mentioned, in part, license renewal submission, the upcoming ACNS 2004 and NIST/NSF summer school, and its scheduled facility maintenance later in 2004. The Los Alamos Neutron Science Center highlighted the new beam line for isotope production that is sponsored by the DOE Office of Nuclear Energy, their education efforts, and facility upgrades later this year. SNS summarized its on-schedule and on-budget status and the project's excellent environment, safety, and health record.

Fast access: Fast access typically involves a quick turnaround between proposal submission and a limited amount of facility beam time; it is used for scientifically compelling research in a rapidly evolving field. Some facilities do not have a portion of independent investigator user time devoted strictly to fast access. Some managers believe this need is most effectively met when the user is in direct contact with the instrument scientist.

Proposal forms: Managers indicated that the design and content of proposal forms were heavily influenced by their advisory committees. Much of the information appeared to be similar and allowed easy conversion from the format of one facility to the format for another facility; however, managers concurred that a common proposal format was a good goal, with appropriate local options.

Experimental report: Each facility has specific roles for the experimental report, such as a report to facility managers on strengths or weaknesses in facility operations or to note progress on a research program proposal. Because some facilities do not request or require a report, while others publish them annually, the content will vary by facility.

User groups: Activities of facility user groups were discussed, and managers suggested that leaders of user groups might value joint discussions. The Neutron Scattering Society of America will be asked about its interest in hosting a council of the chairs of facility neutron user groups.

Performance measures: While discussing performance measures, managers mentioned several measures involving staff, the number of instruments, and users. John Root (National Research Council of Canada, Chalk River) volunteered to survey neutron facility heads for productivity maxims.

R&D updates: The Novel Instruments Concepts Team was proposed as providing an environment to stimulate the process of developing instrumentation and training new instrumentalists. At an SNS October 2003 workshop, SNS data archiving, visualization, and analysis efforts were identified with an integrated environment where tools and capabilities can be brought together to solve users' visualization and analysis problems. European and U.S. research efforts were identified and discussed in areas such as detectors, polarized neutrons, and ^{3}He spin filters.

Training: The potential for common radiological training at neutron-scattering facilities was explored. All facilities have site-specific components that are not transferable. DOE facilities require radiation worker training and practice and are willing to recognize this training from other DOE sites; DOE cross-certification appears to be the only opportunity to work together on this issue.

Collaborations: There is a reciprocal agreement among the light sources to accept General Employee Radiation Training; additional training is needed for site-specific and beam-line-specific issues. Synchrotron directors met in October 2002 and are several iterations into a draft access policy. Extensive coordination is ongoing between the Advanced Light Source and the Stanford Synchrotron Radiation Laboratory. Preliminary meetings have been held about the creation of a common web site that would help promote light source activities. A joint user access policy will be drafted for consideration by neutron facility managers at next year's meeting.

Access requirements: Neutron user facilities have institutional and governmental limits placed on them concerning the on-site presence of users. Site access is typically based on appropriate identification and perhaps a criminal records check and some general training. Unescorted access to experimental facilities requires radiological and site-specific training and perhaps more detailed background investigations. Changes regarding visas and biometric indicators have occurred in access requirements for foreign nationals coming into the United States, particularly for visitors from sensitive countries.

Next meeting: Some light sources and other neutron facilities have expressed interest in participating in future meetings.

High Rate SANS Detector R&D

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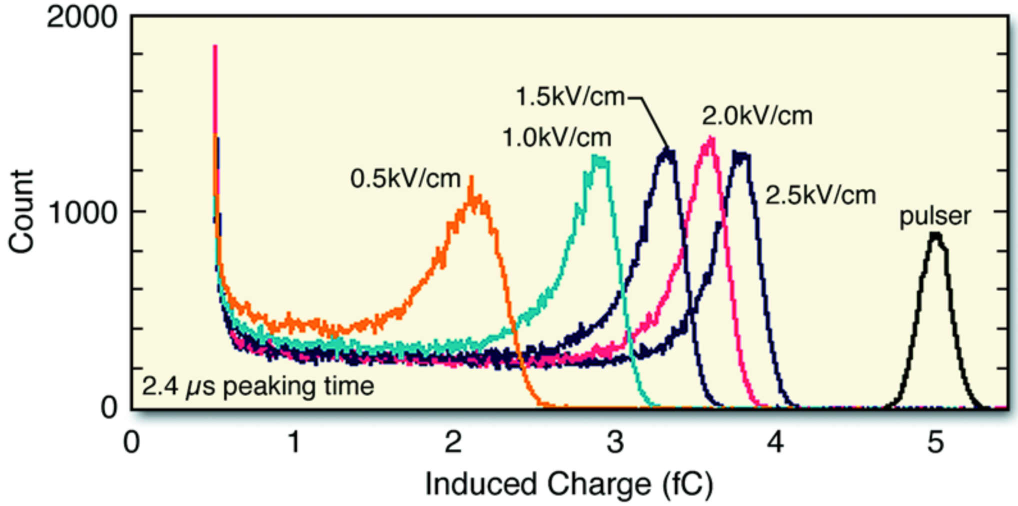
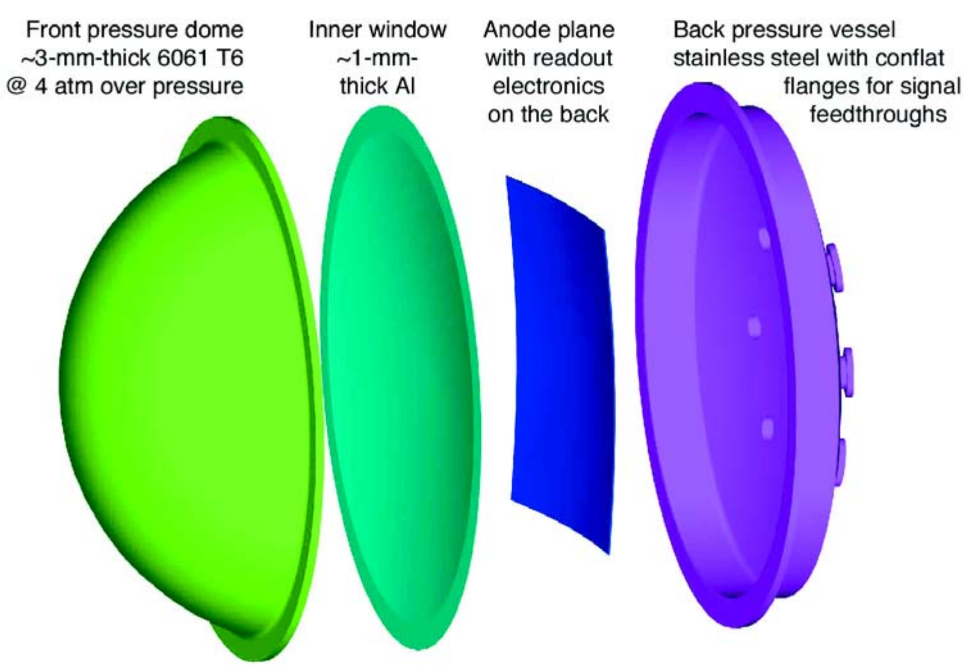


Collected charge from neutrons in the prototype as a function of shaping time.

The neutron flux at SNS will exceed the rate capabilities of currently available detector systems. In fact, for the small-angle neutron scattering (SANS) and reflectometer instruments, the detectors will saturate with only 1% of the available neutron flux. To remedy this situation, the Division of Scientific User Facilities of the DOE-BES has agreed to fund a proposal to develop a high-rate SANS detector that operates in ionization mode.

Typical SANS detectors are multiwire proportional chambers filled with helium and operating with gas gain. These detectors saturate at a low rate and possess an upper count rate limit because space charge builds up in the gas. To overcome this limitation, scientists from the Instrumentation Division at Brookhaven National Laboratory (BNL), the Engineering Sciences and Technology Division at ORNL, and the Experimental Facilities Division at SNS will fabricate a detector that operates in ionization mode or with unity gain.



Design of a large-area, position-sensitive ionization chamber—detector construction.

This detector will have a 400-cm^2 active area that is read out with a 32 × 32 array of discrete anode pixels. In addition to being the first large-area neutron detector operating in ionization mode, it will also be the first to have a discrete anode array read in parallel and the first to have the front-end electronics located within the chamber volume. All of these advances are possible because of recent developments in electronics technology.

Before this proposal, Dr. Bo Yu at BNL completed a proof-of-principle experiment with a small prototype. The figure above shows the charge collected from neutrons in the prototype as a function of shaping time. The neutron peak is well separated from the background, and a high degree of noise discrimination is possible.

When completed in 2007, this new detector will be able to detect and process 20 million neutrons per second. Detectors with this capability will not only improve the quality of existing research at spallation sources but will also open up areas of research in materials science that were not previously possible at neutron-scattering facilities.

SNS is funded by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences

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www.sns.gov

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Eastward view of the SNS site, April 7, 2004. The Klystron Building is prominent in the center, running the length of the underground linear accelerator tunnel. For more SNS photos, see the SNS Photo Gallery at web.ornl.gov/sci/iris/search_sns.shtml.

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User Administration Office
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SNS 110040400-NL0006-R00

For the latest user updates, see the SNS users web site at www.sns.gov/users/users.htm.