SPALLATION NEUTRON SOURCE
A U.S. Department of Energy Multilaboratory Project
SNS

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Groundbreaking Marks 'Sweet Moment' for SNS

Adapted from the *ORNL Reporter*

The Spallation Neutron Source's construction phase is officially under way. A host of officials and dignitaries, including Vice President Al Gore, Tennessee Gov. Don Sundquist, and Energy Secretary Bill Richardson, along with several hundred invited staff members, trekked to the chilly wooded site on December 15 to break ground for the project.

Vice President Al Gore and a host of dignitaries attended the SNS groundbreaking ceremony. Pictured from left are Rep. Zach Wamp, Rep. Jimmy Duncan, Secretary of Energy Bill Richardson, Tennessee Governor Don Sundquist, Vice President Gore, Sen. Bill Frist, and Rep. Bart Gordon.

The $1.4 billion neutron science facility, "the world's most powerful neutron source," as SNS Executive Director David Moncton described it, is scheduled for completion in 2006. Between now and then the Oak Ridge Reservation tract will be the site of a mammoth construction project, the first U.S. neutron science facility of its scale to be constructed in decades.

A special guest was Clifford Shull, who won the Nobel prize for his pioneering work in neutron scattering with Ernest Wollan. Those initial discoveries at Oak Ridge National Laboratory's (ORNL's) Graphite Reactor paved the way for neutron science's revelations of the secrets of molecular structure. Several of the speakers noted Shull's and Wollan's contribution. The Vice President noted that few knew in those days what neutron science could offer the world, and few will probably be able to forecast what the SNS will make possible in the coming century.

"The true beauty of the SNS is that no one can really know what this tool will be capable of discovering; discoveries nobody can predict," Gore said. He noted that he had come to ORNL previously to announce administration support for the project. Continued on page 8

In This Issue

Director's Comments

David E. Moncton
SNS Executive Director

I began my association with the SNS project in March 1999, and it has been an extraordinary year. I want to share with you my most vivid impressions of this first year. It became clear from the outset that the SNS is top priority at the U.S. Department of Energy (DOE) and within the administration. From the vice president, to the secretary of energy, and down through DOE's Office of Science and the Basic Energy Sciences program there is an unprecedented level of commitment to this project. This commitment also includes the Office of Science and Technology Policy and the Office of Management and Budget. People in all these organizations are working hard on behalf of the future of neutron science.

The challenge to bring a new leadership team quickly to the SNS was the first major item of business. We filled the top few positions within days and all of the top dozen or so positions within weeks with experienced and talented people. The scientific and technical opportunities associated with the SNS are a magnet for top talent. But a great deal of credit is due to the people themselves, many of whom rearranged their professional and personal lives to join this endeavor. When we came to Oak Ridge and began to formally assess the project status, we found a core team of excellent people here and in the partner labs ready to take a "paper" project into construction.

But just as we began, Congress was learning of the problems the project had experienced in its attempt to move from concept to well-defined construction plan. In particular, Congressman Sensenbrenner, chairman of the House Science Committee, visited Oak Ridge and, shortly thereafter, issued a report stating that the project's FY 2000 construction funding should not be approved. At this point, the project faced the dual task of rebuilding both the SNS organization and its reputation in Washington, D.C. And if that weren't enough, the project's technical design needed serious improvement.

I don't have space to discuss how we've met these challenges over the year, but as of March 2000, two accomplishments stand out. First, we now have a design that is more technically robust and scientifically effective. It will be unique in the quality of the facilities for users, from the performance of the instruments to the quality of the labs, offices, and other accommodations. During its lifetime, the facility will support a true renaissance in neutron science. Second, we have made great strides in improving the project's reputation for good management in Washington, D.C. In early March 2000, Chairman Sensenbrenner released a statement of his support of the full FY 2001 budget request of $278.5M. With the continued support of the scientific community, as expressed to members of Congress, the SNS will soon be a reality.

Target System Update

T. Gabriel

The development of the SNS Target System, including preliminary design and research and development (R&D), is progressing as planned. A global overview of the target/instrument hall is shown in Fig. 1. The mercury-based target system, which will receive the short-pulsed, proton beam (2 MW, 1-GeV protons, 60 Hz, <1.0 μs/pulse), will be located in the center of the bulk shielding. As shown in Fig. 1, the shielding is slightly left of center, with the maintenance cells to the

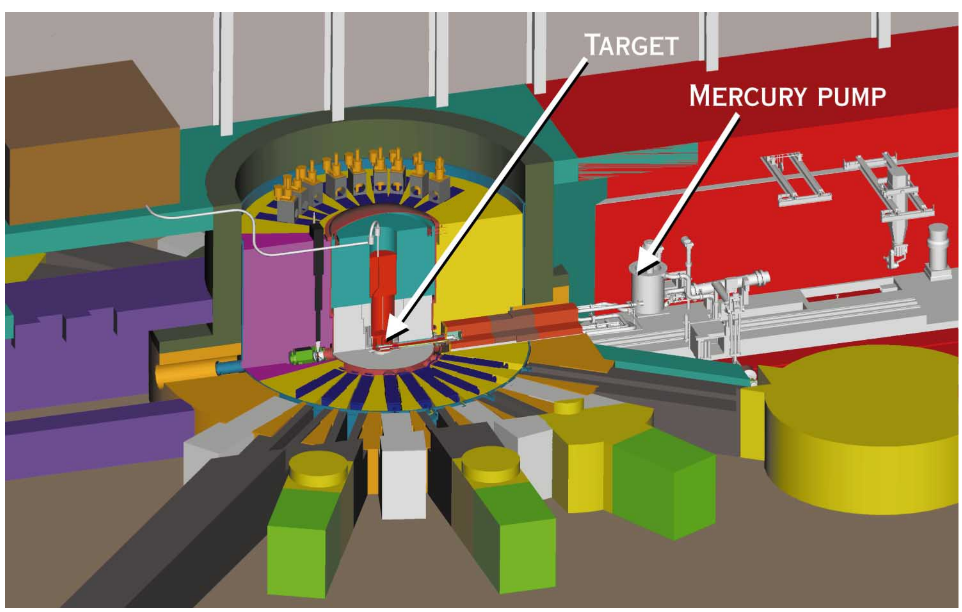

Fig.1. Cross-sectional view of the bulk shielding, shutters, instruments, maintenance cells, and mercury target.

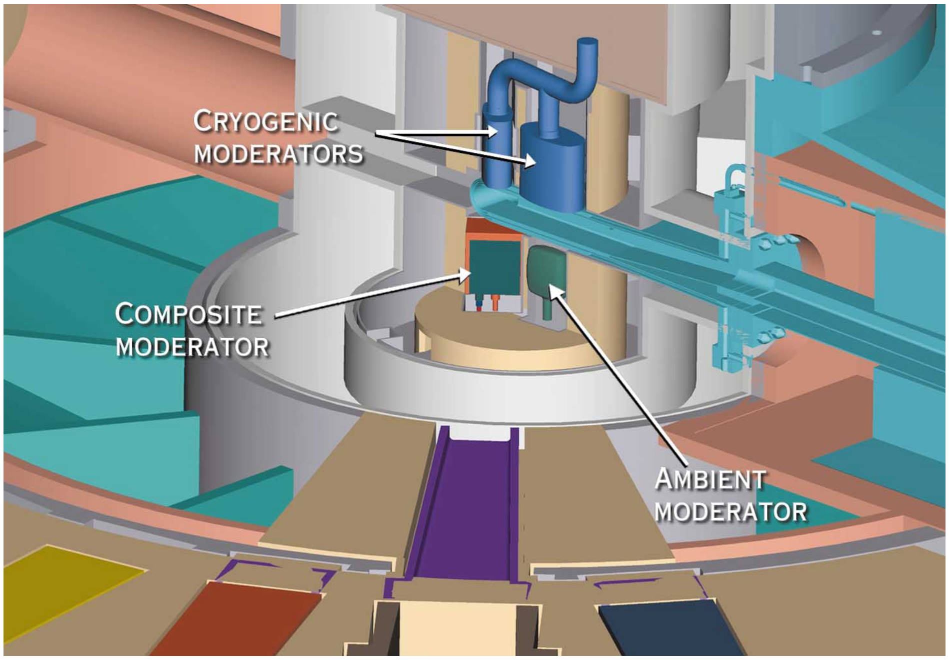

Fig. 2. Cross-sectional view of the cryogenic, composite, and ambient moderators and the mercury target.

right. The first maintenance cell will monitor and maintain the mercury process and pumping system. Additionally, because the system is designed to require only five days for replacement of the stainless steel (SS316L) target container and because the first maintenance cell will allow replacement every six weeks, a good availability of neutrons will be maintained. The remaining cells will be used for storage, maintenance, and shipping of various components such as shutters, the proton beam window, and the inner core plug that holds the moderators.

A sliced section of the target, moderator, and reflector system is shown in Fig. 2. Cryogenic moderators [supercritical light hydrogen (H_2) @ 19 K] are located on the top of the target. The upstream bottom moderator will contain a composite of supercritical light hydrogen and light water. The purpose of this composite is to increase the number of neutrons in the 100 K range. Neutrons in this energy range can be used for a multitude of applications. Preliminary analysis indicates that this increase could approach the neutron yield expected from a liquid methane moderator. The downstream bottom moderator is ambient light water.

In support of the target design, we have focused our R&D program on the development of a mercury target system and have included research in thermal shock, thermal hydraulics, material damage and compatibility, and remote handling. All of our large R&D mercury loops are now operational. The use of these loops will yield valuable information on thermal hydraulics, remote handling, and operator requirements and training. The enclosure structure and part of the mercury loop structure are shown in Fig. 3. This structure is a prototypical mercury loop that will be similar to the one used in the actual SNS facility. The target end is located in the left side of the enclosure. The motor and sump pump can be seen on the right side. The system, which holds about 20 metric tons of mercury, became operational on October 31, 1999, and reached its

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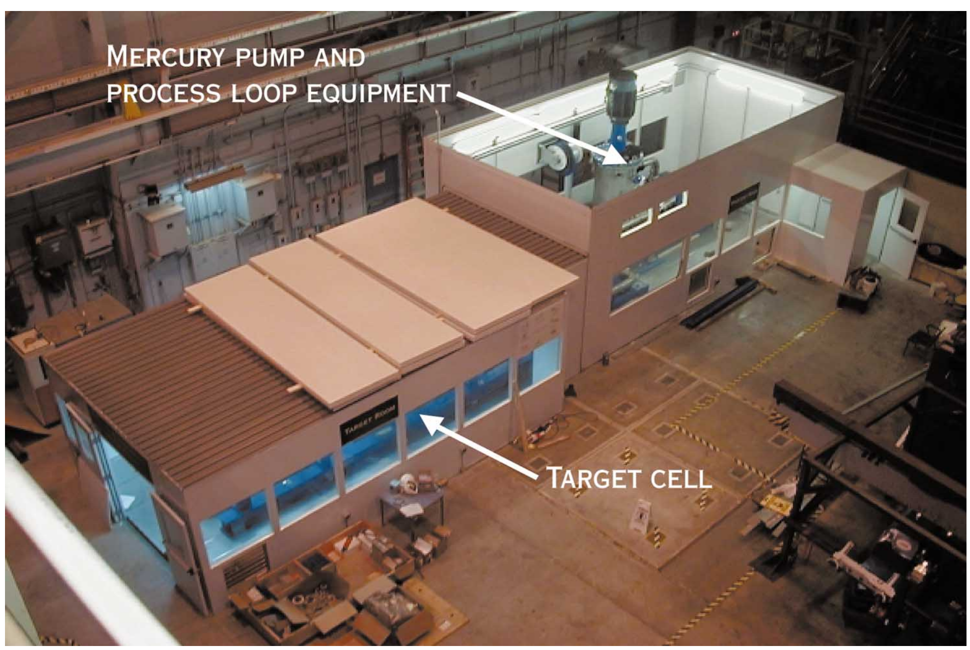


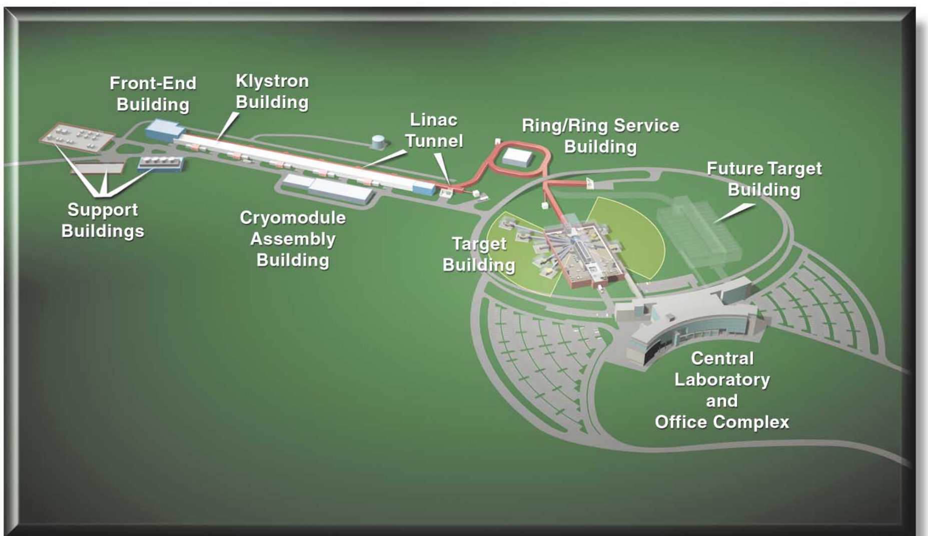
Fig. 3. Target Test Facility showing the location of the target cell, mercury pump, and process loop equipment. In the actual facility, the proton beam would be coming from the left side.

SNS Instrumentation

T. E. Mason and R. K Crawford

When SNS is complete and operating at 2 MW, it will offer unprecedented performance for neutron-scattering research, with more than an order of magnitude higher flux than any existing facility. To realize the potential this offers for research in chemistry, condensed matter physics, materials science and engineering, and biology, a world-class suite of instruments is being developed that makes optimal use of the SNS beams and that is suited to the needs of users across a broad range of disciplines. The mechanisms by which instruments are built and operated will be responsive to varying degrees of experience, from new graduate students and first-time neutron users to experienced users with an interest in instrument design.

As a DOE user facility, the SNS construction budget includes funds for an initial suite of instruments that will be available to users through a peer-reviewed proposal system. These instruments are being selected in consultation with the user community, following advice from our Instrument Oversight Committee (IOC), chaired by Dan Neumann from the National Institute of Standards and Technology, and are being designed in consultation with prospective users through instrument advisory teams (IATs). We expect that 75% of the beam time on this instrument suite will be avail-able through the proposal system, with the remaining 25% for use by in-house scientific staff, for testing and calibration, for feasibility studies by users before submission of proposals, and for rapid response experiments that occur outside the regular proposal schedule.



Spallation Neutron Source site plan.

In addition to providing a fast start on instruments for SNS users, the initial instrument suite will allow the development of core technologies such as choppers, data acquisition systems, and control software that will form the basis for similar systems in other instruments. These systems will be standardized where appropriate to simplify use and maintenance and to reduce costs. Full "target-to-detector" computer simulation is being developed to optimize and integrate target and instrument design. In many cases, the SNS will require instrument technologies beyond the current state of the art. Consequently, our construction budget for instruments is supplemented by a significant R&D program, which will allow development of new technologies that will form the basis for the initial instrument suite and provide room for growth.

Although the current instrumentation budget allows for 10 or 11 best-in-class neutron-scattering instruments, a total of 24 can be accommodated on the high-power target station. Over time, new instruments will be built for the additional beam lines as part of the normal operating life of the SNS. However, to achieve full utilization of SNS, with the possibility of serving the focused research needs of groups willing to commit to building and operating neutron instruments, it is desirable to provide for instrumentation built by instrument development teams (IDTs) that may or may not include SNS as a member. IDTs would provide at least partial funding for an instrument and would receive dedicated beam time in return for their financial commitment. For an instrument fully funded (including operation) by the IDT, up to 75% of beam time could be reserved for the IDT, with the remainder open to general users.

The basic principles by which instruments are approved for SNS are the same, whichever mode of access is involved. The main criteria for instrument selection are the scientific program and the need for the unique capabilities of the SNS. The SNS is committed to seamless user access and instrument optimization across the facility. Instruments should be built on the beam line that best suits their requirements, and access for users should be uniform across the facility, independent of the funding source for the instrument. Guidelines for instrument proposals that will facilitate fair and systematic evaluation are being developed in consultation with our advisory committees as well as the broader user community. A proposal to develop a conceptual design for the second long wavelength target station has been submitted to the National Science Foundation. Plans are in place to obtain input at the upcoming Users Meeting and Instrumentation Workshop to be held May 22-24 in Washington, D.C. Additional information about the conference or comments and suggestions regarding the instrument suite may be directed to the SNS Experimental Facilities Division Director, Dr. Thom Mason (masont@sns.gov), or the SNS Instrument Systems Team Leader, Dr. Kent Crawford (rkcrawford@anl.gov).

Call for Instrument Teams

Interested in forming or joining an instrument team?

In consultation with our advisory committees and the broader user community, we will be developing and finalizing guidelines for instrument proposals during late spring and early summer this year.

You should begin thinking now about your future research program at the SNS and begin forming groups to build innovative neutron-scattering instruments to deliver maximum benefit from the SNS performance characteristics. Some instrument advisory teams have already been formed. To join an existing team or start a new one related to neutron-scattering applications not yet covered, please contact the Instrument Systems Group at Argonne: **www.sns.anl.gov.**

The proposal process will begin with a letter of intent, broadly outlining the proposal with sufficient detail to allow us to evaluate scientific potential and funding mechanism(s). This applies to SNS project-funded instruments (with an instrument advisory team) and totally externally funded instruments (with an instrument development team).

For information, please contact Joyce Shepherd, SNS User Facility Administrator, 865-241-5644, e-mail: shepherdjw@sns.gov.

The instrument proposal process will be performed in two phases: an initial letter of intent followed by a detailed proposal. The letter of intent will broadly outline the proposal with sufficient detail for evaluating the scientific potential, funding mechanism(s), and management plan. An approved letter of intent would be followed by a more

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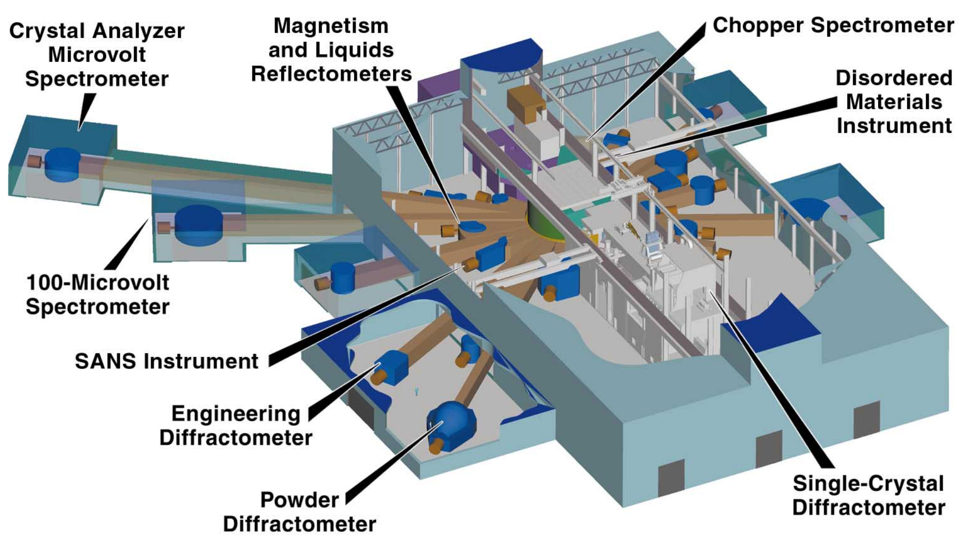


Schematic instrument suite for the SNS. The final instrumentation will be determined by the user community through the Instrument Oversight Committee.

SNS INSTRUMENTATION (CONTINUED FROM PAGE 5)

detailed proposal. The IOC, as well as expert review, will be involved at the appropriate stage. Similar guidelines would be followed for other (nonscattering) uses of the SNS facilities, with the modification that review would be by the Scientific Advisory Committee, supplemented by subject matter experts (because the IOC is a neutron-scattering expert panel). Such potential uses of the SNS would also be subject to the condition that they not compromise the neutron-scattering mission of the SNS and that the funding must be incremental to the project and cover all incurred costs. In addition to project-funded instruments (with an IAT) and totally externally funded instruments (with an IDT), there is a possibility for hybrid arrangements that would be negotiated on a case-by-case basis with the understanding that funding level and dedicated beam time are commensurate.

The instrument development effort for the initial suite of SNS instruments is primarily based at Argonne National Laboratory. The instrument selection process has begun, and the instrument R&D program is well under way. FY 1999 was a year of great activity and significant change for the Instrument Systems Group. The following are some of the significant accomplishments:

- Our staff increased from 6 to 22 full-time equivalents. New staff members include a mix of scientists, electrical and mechanical engineers, mechanical designers and technicians, and administrative personnel.
- Our budget doubled to permit the construction of ten best-in-class instruments.
- Preliminary conceptual designs were prepared for a micro-electron volt backscattering spectrometer, a chopper spectrometer, a third-generation powder diffractometer, a single-crystal diffractometer, and two reflectometers. These choices were based on the recommendations of the IOC.
- The IOC decided that the concepts for the backscattering spectrometer and two reflectometers were ready for further development. These designs are highlighted in the next two articles.
- External proposals for detector R&D were solicited. Four such proposals were accepted and funded.
- A prototype neutron chopper was designed and fabricated, and a prototype high-speed Fermi chopper was designed and ordered.
- The Instrument Systems Group worked closely with the Target Systems Group to develop design modifications that significantly enhance the optimization of the combined target station and instruments.

To keep current on these and other Instrument Systems activities, please see *www.sns.anl.gov.*

2-μeV Backscattering Spectrometer

K. W. Herwig

This instrument is a near-backscattering, crystal-analyzer spectrometer designed to provide extremely high-energy resolution ($\delta\omega = 2.2\ \mu$eV FWHM, elastic). The design requires a long initial guide section of 84 m from moderator to sample to achieve the timing resolution necessary to achieve the desired $\delta\omega$. The scattering chamber design is illustrated in Fig. 1. Neutrons focused onto the sample by the supermirror funnel scatter towards the analyzer crystals. The strained, perfect silicon (111) crystals reflect neutrons

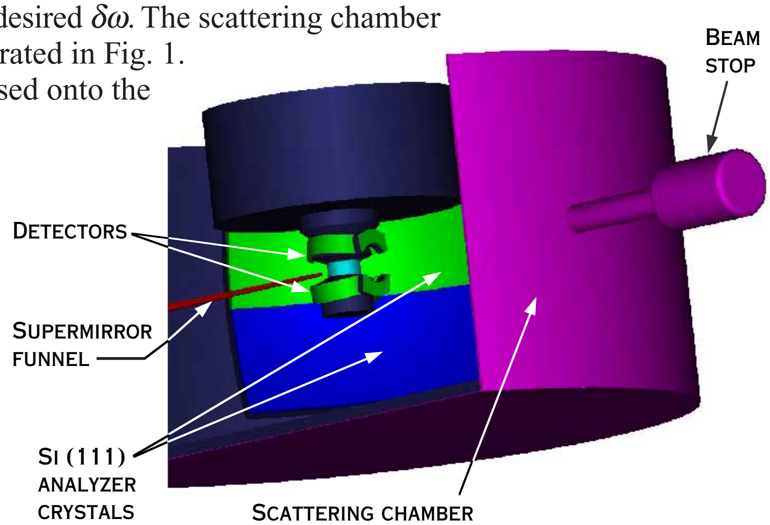
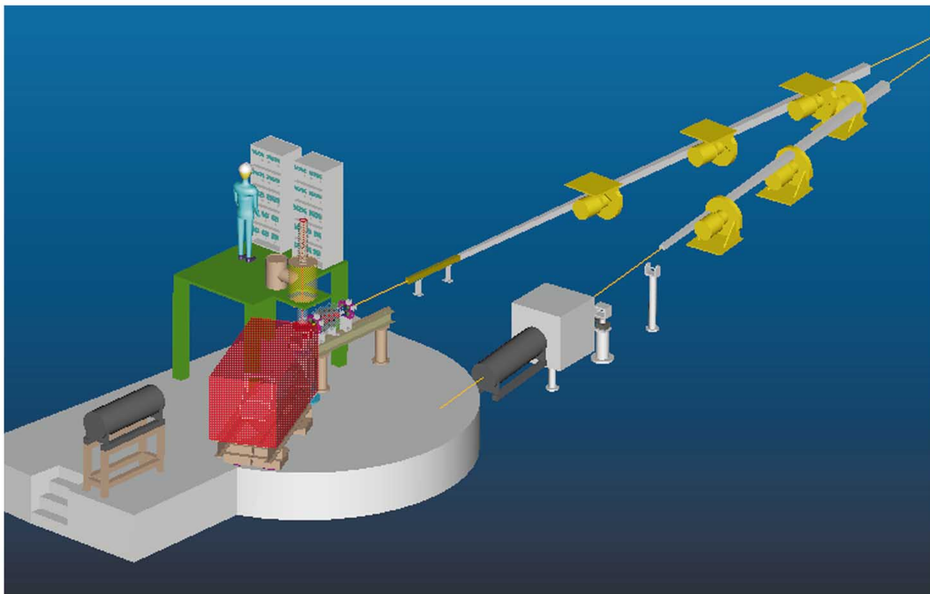


FIG. 1. VIEW OF THE SCATTERING CHAMBER OF THE BACKSCATTERING SPECTROMETER. WITH THE ANALYZER CRYSTALS LOCATED 2.5 M FROM THE SAMPLE, THE CHAMBER WILL HAVE A DIAMETER OF APPROXIMATELY 6 M.

with a narrow distribution of energies centered at 2.082 meV onto the detectors. The design is optimized for quasi-elastic scattering but will provide 0.1% resolution in energy transfer ω, up to $\omega = 18$ meV. This spectrometer will provide an unprecedented dynamic range near the elastic peak of $-258\ \mu eV < \omega < 258\ \mu eV$, about seven times that of comparable reactor-based instruments. For experiments that require the full dynamic range available at reactor-based instruments (or greater), we expect this spectrometer to have an effective count rate of ~100 times that of the current best spectrometers.



THREE-DIMENSIONAL REPRESENTATION OF THE REFLECTOMETRY BEAM LINE, VIEW FROM THE DETECTORS TOWARD DIRECTION OF THE MODERATOR. ON THE LEFT, MAGNETISM INSTRUMENT WITH HORIZONTAL SCATTERING PLANE. ON THE RIGHT, LIQUIDS INSTRUMENT WITH VERTICAL SCATTERING PLANE.

Polarized-Beam and Liquids Reflectometers

F. Klose and J. F. Ankner

Two reflectometers are being considered for installation on a single beam line at SNS, one featuring an incident polarized beam for the study of magnetic materials and one with a horizontal sample surface to facilitate the study of liquids. Both instruments will use advanced neutron optics. Supermirror-coated microguide beam benders eliminate fast-neutron and gamma backgrounds. Tapered supermirror guides transport high flux to the sample position. The incident optics and bandwidth chopper system deliver $\lambda > 2.5$ Å neutrons to the sample at repetition rates of 60, 30, or 20 Hz. Running at 60 Hz, the instruments will be capable of measuring reflectivities of $R < 10^{-9}$, an order-of-magnitude improvement over the best existing instruments. Similar or greater improvements in data-collection rates have exciting implications for kinetic studies.

The polarized-beam reflectometer employs a vertical sample geometry to accommodate large superconducting magnets and other ancillary equipment. In addition to collecting data in reflection geometry, the instrument will have a detector bank at high angles for diffraction studies. Use of a Drabkin-flipper-type beam conditioning device and different polarizer, analyzer, and spin-flipper options are the objects of a vigorous R&D effort.

The liquids instrument features a novel design that uses the broad angular dispersion produced by the tapered guide. By sampling different incident angles (5-15) with beam-defining slits and using the relatively narrow wavelength bandwidth available at 60 Hz, we can efficiently cover a large range of momentum (hQ) transfer. Operation in this mode uses all of the source flux and combines the counting efficiency of a fixed-wavelength reflectometer with the wide Q coverage of a broadband instrument.

TARGET SYSTEM UPDATE (CONTINUED FROM PAGE 3)

design requirements shortly after startup. At the maximum pump speed of 600 rpm, the mercury flows at a rate of ~30 L/s.

Target Systems personnel anticipate completing preliminary design in March 2000 and progressing to detailed design, which will lead to creation of drawings for the manufacture of parts needed to build the Target Systems. Target Systems personnel look forward to a challenging and productive year.

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SNS User Administration Office
701 Scarboro Road
Oak Ridge, TN 37830

E-mail: shepherdjw@sns.gov
Phone: 865-241-5644
Fax: 865-241-5177

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GROUNDBREAKING (CONTINUED FROM PAGE 1)

"Nearly two years ago I was proud to stand here and announce a proposal for a first-year payment to build the most advanced spallation neutron source in the world; to open the floodgates of brand new research and innovation. Today we're breaking ground on that pledge. We're putting America on the path of reclaiming our leadership in the neutron scattering technology that we invented here in the United States of America."

Several of the speakers noted that neutron science, in which the United States has lost its lead because of the lack of facilities, often leads to new products that mean jobs and economic wealth. And Moncton noted that it has been at least 30 years since the United States has built a neutron facility of this scope, "a desperately long time" in terms of scientific endeavor.

"Today's groundbreaking for the Spallation Neutron Source marks the end of this difficult era and the beginning of a renaissance in neutron science," Moncton said. "It's a very sweet moment for all the SNS project staff here and for the collaborating laboratories."

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