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

THE NEUTRON PULSE

Volume 2
Number 2
Fall 2001

Construction Update

Moving more than a million cubic yards of earth and drilling target foundation piles were the prelude for pouring concrete for the front-end building on June 13, 2001. A year and a half after the groundbreaking, significant advances are being made in both construction and technology development.

In early July, pouring of the linac tunnel began with use of a movable slip form that is speeding construction. With the completed excavation of the storage ring tunnel, all major site excavations are now complete. Recently, a $9.9M contract was awarded for 30,000 cubic yards of reinforced concrete foundations for the target building. Construction of support facilities, such as the site water tower, power substation, cooling tower, and the central utilities building, began this fall.

Good progress is being made on all technical components of the front end, linac, ring, target, and instruments. On April 20, 2001, Berkeley Lab produced the first radio-frequency (RF) accelerator beam in an RF quadrupole for the front-end system. Linac design and modeling is progressing toward testing and procurement at both Los Alamos and Jefferson laboratories. Procurements for niobium superconducting cavities and the cryomodule prototype program at Thomas Jefferson National Accelerator Facility are on track. Major magnet procurements for the accumulator ring have been made at Brookhaven. At Oak Ridge's Target Test Facility, testing of piping for liquid mercury in the target has successfully resolved flow problems and has led to an improved piping design.

The project has now formally approved and funded five instruments, and university-led consortia have secured funding for an additional two. We are continuing to develop new instrument concepts and to work with the scientific community to achieve viable instrument designs. For more details, see the redesigned instrumentation web site at www.sns.anl.gov and the instrument articles in this issue.

Progress is also being made on the scientific side. In conjunction with the University of Tennessee (UT), we have established the Joint Institute for Neutron Sciences (JINS). In early October, JINS coordinated a successful tutorial and symposium on the applications of neutron scattering to materials science and engineering. These events were sponsored by Oak Ridge Associated Universities, UT, Oak Ridge National Laboratory (ORNL), Georgia Tech, and North Carolina State. More than 150 people attended.

Construction continues to be on schedule and within budget. Daily construction progress can be followed with the SNS web cam at http://it.sns.ornl.gov/webcam/.

Director's Comments

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How Chestnut Ridge has changed! On July 14, the SNS project site was visited by the new Secretary of Energy, Spencer Abraham. This trip compared favorably with the last such visit for the groundbreaking ceremony almost two years ago. Then, a lot of imagination was needed to position the linac in relation to the target on a tree-covered hilltop several miles from ORNL. This issue of *The Pulse* gives some highlights of recent, rapid progress both on and off site, with instruments as the main focus.

During this year's appropriation process, the SNS enjoyed bipartisan support, as both the House and Senate provided full funding of the Department of Energy's (DOE's) request of $291.4M for fiscal year 2002. This request is the largest the project will make, with funding requests decreasing as the project approaches completion. Our Congressional support is the result of the continued success of the entire SNS project team at the six partner laboratories and the support provided by the scientific community.

The first 200 cubic yards of concrete poured at SNS in June 2001 was for the front-end building.

This issue announces the next user meeting, to be held in Knoxville, Tennessee, on June 23–27, 2002. The meeting will be in conjunction with the first American Conference on Neutron Scattering (ACNS). *ACNS I* will showcase recent scientific results of neutron science in a variety of scientific disciplines. It will also provide a venue for giving us your opinion on matters affecting operation of the SNS as a scientific user facility. On the last day of the conference, attendees will have the opportunity to tour the SNS construction site and the experimental facilities at the High Flux Isotope Reactor (HFIR).

The project continues to stay within budget and on schedule. In addition, the project continues to have an excellent safety record thanks to the high regard for safety exhibited by everyone involved in the project at all levels and locations across the country. This year promises to be one of exciting progress as the outline on Chestnut Ridge takes shape.

Data Storage Workshop

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When SNS becomes operational in 2006, the data from neutron-scattering experiments are expected to be between 1 to 10 terabytes per year and will increase dramatically in the years following. To discuss the various issues associated with the storage and accessibility of this data, a workshop sponsored by the SNS Experimental Facilities Division was held in Oak Ridge on August 2, 2001. Attending the workshop were users, representatives from a number of SNS groups, and members of the ORNL Computational Physics and Computer Science divisions. The one-day meeting provided a forum for discussion of hardware and software needs from both the user standpoint and from those who must design and maintain the infrastructure. In addition to the discussion of storage and access of neutron-scattering data, important questions were raised about how analysis software will be used and maintained. It was concluded that a workshop devoted entirely to the matter of analysis software would be useful. Such a workshop would tentatively take place next year during the users conference in Oak Ridge. Topics of discussion would vary from coding and testing requirements to software package availability and maintenance. This workshop would provide a forum for the user community to contribute to the look and feel of the SNS analysis software at an early stage in the development process. Interested parties should contact Rick Riedel.

JINS

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The Joint Institute for Neutron Sciences (JINS) is up and running. UT and ORNL founded the institute to serve as an intellectual center for the neutron sciences and as the gateway for users of ORNL's neutron beam facilities. The user community has provided input on JINS since 1998, when the concept was introduced at the SNS Instrumentation Workshop held in Knoxville, Tennessee.

JINS will become an intellectual focus for the neutron science community. With the SNS and an upgraded HFIR, the community will have access to both state-of-the-art pulsed and steady-state neutron sources. JINS will enhance and support research using the neutron beams of both facilities. Fellowship and sabbatical programs will draw the best neutron scientists from institutions all over the world for interactions with the resident staff and user communities. Modern computational, communication, and networking services will encourage interactive scientific and video and teleconferencing and will provide data acquisition and analysis capabilities. JINS will also foster joint faculty positions between ORNL and its university partners and will assist multi-institutional research teams in developing new applications involving neutron scattering and other uses of neutron beams. The SNS, HFIR, and JINS will be places for neutron science to flourish and grow.

JINS will be located in a housing and conference facility to be constructed near SNS using $8M in funding from the State of Tennessee. It will serve as a gateway for all outside users of SNS and HFIR and will have a key role in increasing the size, sophistication, and diversity of the user community. As part of its education and outreach mission, JINS will organize workshops and summer schools for researchers, student and faculty programs for researchers in residence, and educational partnerships with schools and colleges. It will partner with area colleges in developing the workforce needed to operate SNS in 2006 and beyond.

Artist's conception of the SNS showing where JINS will be built.

Focused Workshops

JINS has planned two focused workshops in the 2001-02 academic year for prospective and current users of neutron beams. The first was held Oct. 1–3, 2001, in Oak Ridge and was titled "Applications of Neutron Scattering to Materials Science and Engineering." The second, tentatively scheduled for late Spring 2002, will cover neutrons in biology.

Study Groups

JINS welcomes inquiries and proposals for short-term, multidisciplinary study groups that develop new research foci in the neutron sciences. Outcomes may include applications of neutron-scattering techniques to the study of major new categories of materials using existing instruments, formation of instrument teams that implement new instrumentation concepts, and development of single- or multi-institutional research clusters whose members develop into major users of SNS and HFIR beam lines.

Neutron Sciences Fellowship and Research Participation Program

This program will bring together the combined resources of ORNL, JINS, the Oak Ridge Institute for Science and Education, and other DOE facilities with neutron science programs. The program is designed to encourage graduate students and faculty to study and conduct research in neutron science areas that use the capabilities of the SNS, HFIR, and other facilities designated by DOE. The first awards are planned for fall 2002.

For more information, see www.sns.gov/jins/initiatives.htm

Neutron-Scattering Instrument Update

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The instrument budget has now stabilized at $62M for five instruments, although it is hoped that project contingency may be available to fund one or more additional instruments at a later date. The five instruments currently being built from project funds are (1) a backscattering spectrometer with 2-μeV resolution (Ken Herwig);* (2) a vertical surface (magnetism) reflectometer (Frank Klose) and (3) a horizontal surface (liquids) reflectometer (John Ankner), both of which are capable of measuring reflectivities down to at least 10^{-9}; (4) a small-angle scattering instrument with Q-range extended to cover 0.001-10 $Å^{-1}$ (Jinkui Zhao); and (5) a third-generation powder diffractometer with wide angular coverage and 1.5×10^{-3} resolution at 90° (Jason Hodges). Instrument development teams (IDTs) have formed and have secured funding from external sources to design and construct two additional instruments: (1) a multichopper spectrometer with 10-100 μeV resolution (Paul Sokol, IDT spokesperson; Garrett Granroth, instrument scientist) and (2) a Fermi-chopper spectrometer with 1% resolution, optimized for low-angle scattering

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Names of instrument scientists are in parentheses.

SHUG Update

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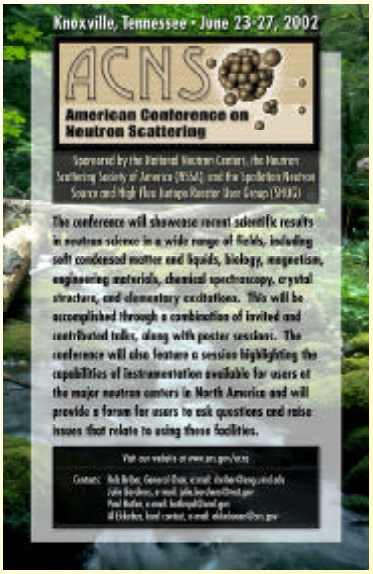
The SNS and HFIR User Group (SHUG) Executive Committee is continuing its work in several areas in anticipation of the upgraded and new facilities for neutron scattering at ORNL.

A primary function of the committee is to advise facility management of the two facilities regarding user policies. Several of the committee's recent activities relate to this function. In April, we met at the SNS site in Oak Ridge to discuss SNS and HFIR issues with SNS Associate Laboratory Director Thom Mason, ORNL Associate Laboratory Director for Physical and Computational Sciences Jim Roberto, ORNL Neutron-Scattering Section Head Herb Mook, and SNS User Program Manager Al Ekkebus. At the end of the meeting, the Executive Committee was given a tour of the SNS construction site, which is quite impressive.



In May, the committee submitted recommendations to SNS concerning discretionary beam time allocations for the Instrument Advisory Team and IDT instruments once the SNS begins operation. These recommendations are being considered by SNS in the final formulation of beam time allocation policies. Finally, Thom Mason and Jim Roberto were guests at our August Executive Committee conference phone call to continue discussions of user issues. We received updates from them on construction and instrumentation projects at the SNS and the HFIR facilities.

Another function of the committee is to give advice to various groups on issues of interest to the neutron-scattering community. Professor Lee Magid, acting JINS director, was our guest for the July phone conference. Lee sought the committee's advice concerning programmatic initiatives for JINS.

In conjunction with the Neutron Scattering Society of America, the Executive Committee is organizing the *ACNS I*, mentioned in the Director's Comments. The conference will be held approximately every other year and will serve as a showcase for scientific developments in the many areas of neutron scattering as well as a national user meeting for the various U.S. neutron-scattering centers. For more information, see the official conference web site, www.sns.gov/acns.

Finally, in accordance with the SHUG bylaws, we are conducting elections for new members this fall.

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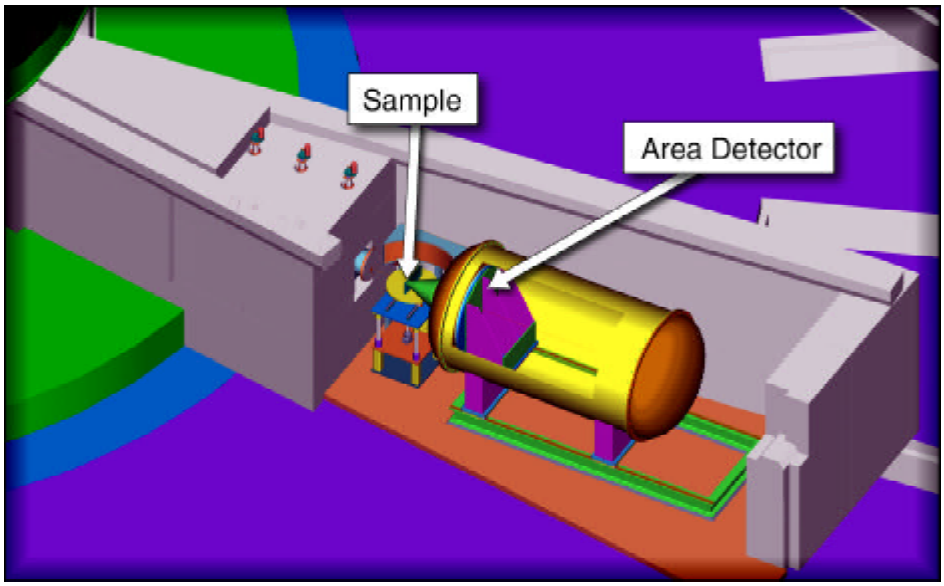
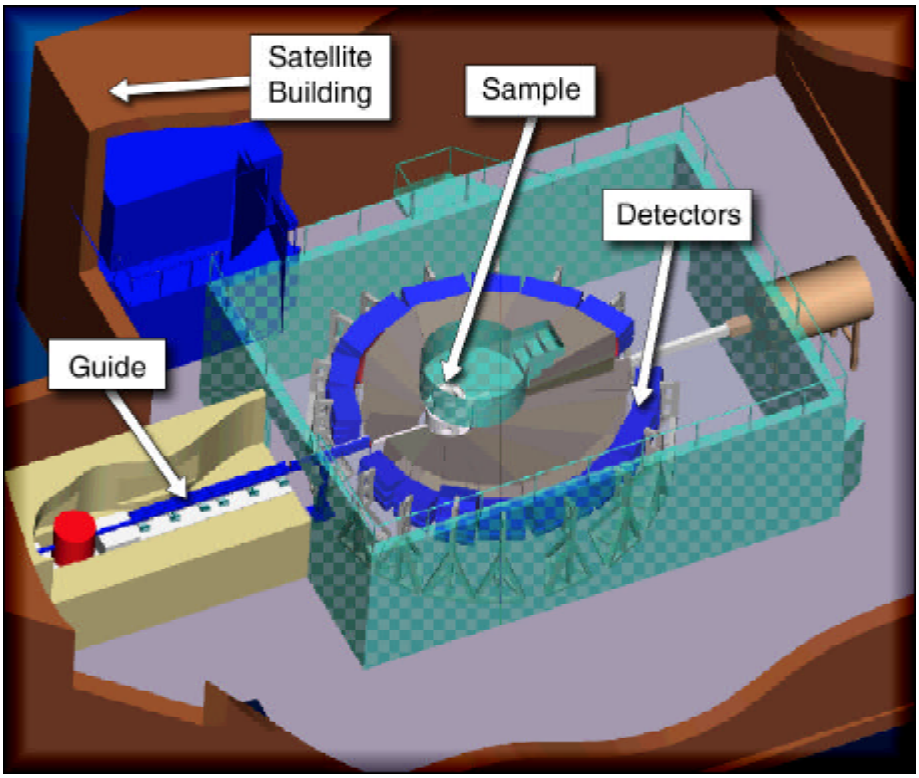
(Brent Fultz, IDT spokesperson; Doug Abernathy, instrument scientist). Designs for the backscattering spectrometer and the two reflectometers are well along (*Neutron Pulse*, Vol. 1, No. 1), and procurements are under way. The conceptual design for the small-angle scattering instrument is also well developed (*Neutron Pulse*, Vol. 1, No. 2). Designs for the powder diffractometer and for the two IDT instruments are proceeding rapidly, and procurements are expected to begin by the end of 2002.



The small-angle scattering spectrometer, one of the instruments recently selected for construction by the SNS.

The Experimental Facilities Advisory Committee (EFAC) met in March and recommended four more instrument concepts as worthy of construction at the SNS, bringing us to a total of ten instruments that have been so recommended. These are the seven already funded instruments identified previously plus an engineering-materials diffractometer (Xun-Li Wang), an ultrahigh-pressure diffractometer (Chris Tulk), and a disordered-materials diffractometer (Chris Tulk). Data sheets for all ten of the recommended instruments and for other instrument concepts still under study can be found at www.sns.gov/users/instrument_data_sheets.pdf, with additional material at www.sns.gov/users/data_sheet_cover_material.pdf. The EFAC is responsible for recommendations regarding beam line allocation for scattering instruments, and the SNS Advisory Board (SNSAB) has similar responsibilities for recommendations on nonscattering applications. In addition to the ten instruments recommended by the EFAC, the SNSAB has recommended that an SNS beam line be allocated for fundamental physics experiments. The next SNSAB meeting will be in December.



Secondary flight path for the powder diffractometer, one of the instruments recently selected for construction by the SNS. The sample is 60 m from the moderator, necessitating that the secondary flight path be in a satellite building outside the target building.

Further information about SNS instrument systems activities can be found at www.sns.anl.gov.

Cold Neutron Chopper Spectrometer

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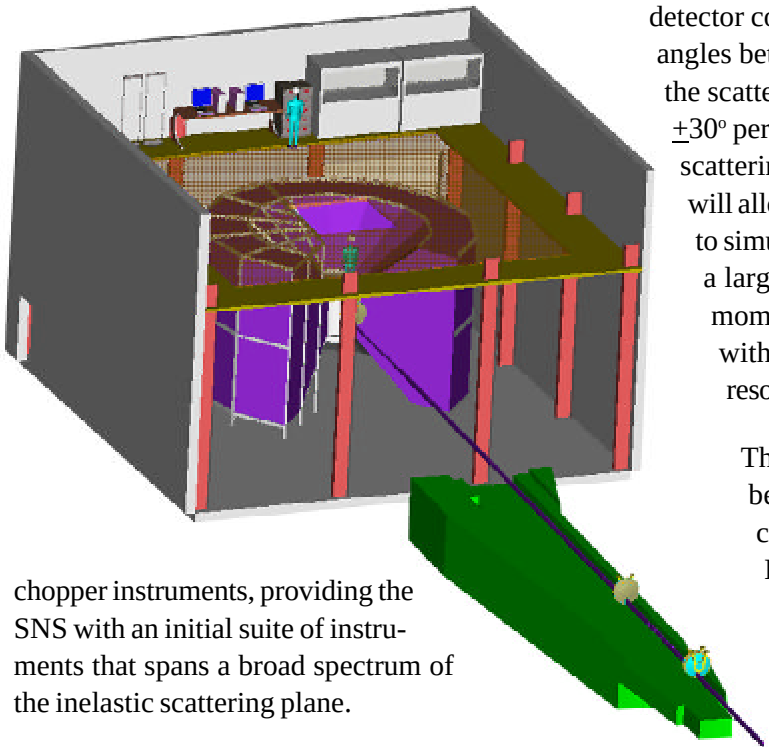
The Cold Neutron Chopper Spectrometer (CNCS) is a multichopper spectrometer designed to provide both high-energy and Q resolution at low incident energies (2-50 meV). These capabilities will allow the instrument to address a variety of scientific problems in areas as diverse as biomaterials, polymers, cements, magnetic systems, geological systems, and quantum liquids. These topics are at the forefront in many different areas, such as condensed matter physics, materials science, chemistry, biology, and environmental science. The flux on CNCS, which is expected to be two orders of magnitude greater than current state-of-the-art instruments, will allow it to address many exciting and technologically relevant problems not possible at present. In addition, the energy resolution and momentum transfers of the CNCS are complementary to the planned backscattering and Fermi chopper instruments, providing the SNS with an initial suite of instruments that spans a broad spectrum of the inelastic scattering plane.

Schematic of the cold neutron chopper spectrometer.



The CNCS will be located 35 m from the source on a cold-neutron guide at beam line 5. Two high-resolution choppers, one to shape the neutron pulse from the moderator and a second to provide final energy selection, will provide adjustable energy resolutions between 10 and 100 *m*eV. The final flight path, with a length of 3-4 m, will have a highly pixilated detector covering scattering angles between $\pm 140^{o}$ in the scattering plane and $\pm 30^{o}$ perpendicular to the scattering plane. This will allow the instrument to simultaneously cover a large range of momentum transfer with excellent Q resolution.

The instrument will be designed and constructed by an IDT, one of the first for an SNS instrument. The IDT is led by Paul Sokol (Pennsylvania State University) and has more than 30 members from universities and national laboratories. An executive committee has been formed consisting of Sokol (chair), Meigan Aronson (University of Michigan), Sow-Hsin Chen (Massachusetts Institute of Technology),

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ARCS: A High-Resolution Direct-Geometry Chopper Spectrometer at the SNS

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DOE has funded construction of a high-resolution, direct-geometry, time-of-flight chopper spectrometer (ARCS) for the SNS. ARCS will be optimized to provide a high neutron flux at the sample and a large solid angle of detector coverage. ARCS will advance the understanding of dynamic processes in materials. The instrument is designed to measure excitations in materials and condensed matter having energies from a few thousandths to about 1 electron volt, with an efficiency better than any existing high-energy chopper spectrometer. Typical research topics involving ARCS include (1) studies of vibrational excitations and their relationship to phase diagrams and equations of state of materials, including materials with correlated electrons, and (2) studies of spin correlations in magnets, superconductors, and materials close to metal-insulator transitions.

To date, inelastic neutron-scattering experiments have been constrained by low neutron flux, forcing experimental compromises in energy resolution, momentum resolution, and in the number of spectra that can be measured. With its high detection efficiency and its location at the SNS high-power target station, ARCS will free experimenters from many restrictions caused by low flux. The uncompromising

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Sample Environments for the SNS

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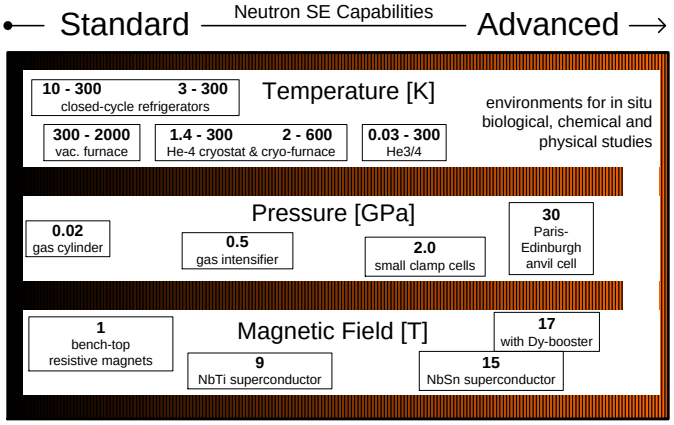
Researchers will need advanced sample environment (SE) support to reap the full benefits of the SNS. Capabilities such as rapid sample changing, rapid temperature stabilization, safe and reliable generation of extreme pressure and magnetic fields, and provisions for a wide range of in situ studies will open up tremendous opportunities. Although there is no guarantee that all of these capabilities will be on hand when we open our doors at the SNS, a number of internal and external efforts are moving us in the right direction.

First of all, the SNS Sample Environment Team is introducing design standards to cover basic needs such as defining the interface geometry between our SE devices and neutron instruments. We are also developing specifications for many shared accessories (cables, fittings, carts, etc.) that can have a huge impact on reliability. Reinventing the wheel is not on our agenda, so we are examining existing SE technology at laboratories worldwide and are surveying the commercial market. This allows us to better assess our options and make wise research and development (R&D) decisions.

The SNS will likely pursue one or two internally driven R&D efforts to provide widely needed capabilities such as automated sample changing in cryogenic and extreme environments. These internal efforts will hardly cover all of our needs, but fortunately some external teams are launching R&D initiatives in anticipation of SNS startup. Efforts are under way in areas including "large" volume anvil presses (>1 mm^3 at 100 GPa), gas pressure cells (3 GPa), reactive atmosphere furnaces, and in situ environments allowing studies of biological materials.

The way things are taking shape, it looks like the SNS may enjoy the best of both worlds: the organization and standardization associated with a centralized SE team and the flow of fresh ideas coming from all corners of the community. We urge all interested parties to dive into the mix and help unleash the full potential of the SNS.



Neutron-scattering SE technology at a glance. Various types of devices are listed within the small rectangles and are positioned on the chart according to their function and capability. Note that on the right-hand side of the chart the three parametric categories merge, emphasizing that "advanced" devices are often multifunctional. The SNS will pursue many capabilities on this end of the chart.

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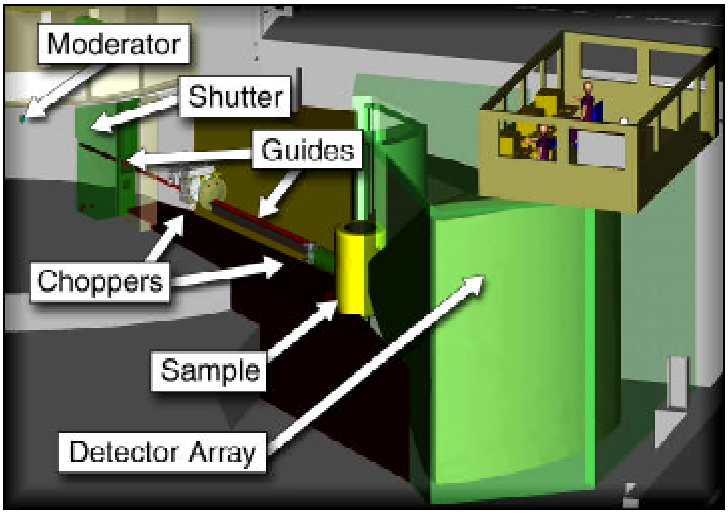
hardware and advanced software of ARCS will enable new experiments with a sophistication not yet achieved with chopper spectrometers.

The principal investigator for the ARCS project is Brent Fultz of the California Institute of Technology, and the chief scientist is Doug Abernathy of ORNL. More about ARCS is available at www.caltech.edu/~matsci/btf/ARCS.html.



Schematic of the high-resolution, direct-geometry chopper spectrometer.

The Spallation Neutron Source
is funded by the
U.S. Department of Energy,
Office of Science,
Office of Basic Energy Sciences

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Robert Dimeo (National Institute of Standards and Technology), Garrett Granroth (SNS), Herbert Strauss (Lawrence Berkeley National Laboratory), and Haskell Taub (University of Missouri). The IDT has received funding from DOE to pursue construction of the CNCS. Additional information is available at the IDT web site (sokol.phys.psu.edu/CNCS), from Paul Sokol, and from the instrument scientist, Garrett Granroth (ggranroth@anl.gov).

Construction at the target building foundation.

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2001-02755A SNS 110040400-NL0002-R00

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

SNS is managed by UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. Department of Energy.