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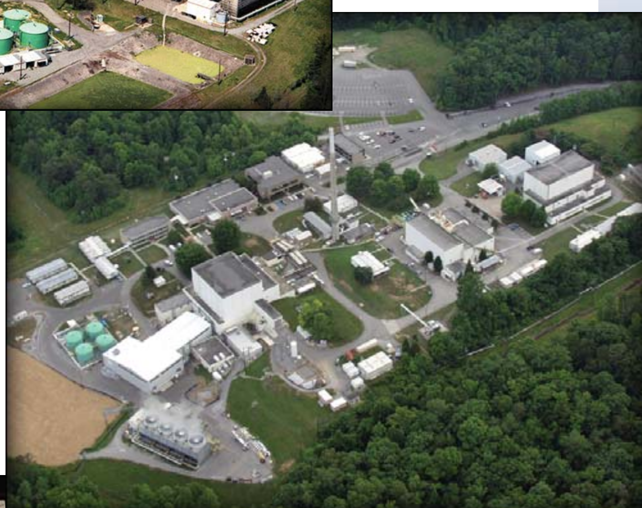
HFIR Restart: A New Era

May 16, 2007, was an exciting day at Oak Ridge National Laboratory (ORNL) as the High Flux Isotope Reactor (HFIR) was restarted, taken to 10% power, and reached its peak power of 85 MW. The restart marks HFIR's 408th run cycle.

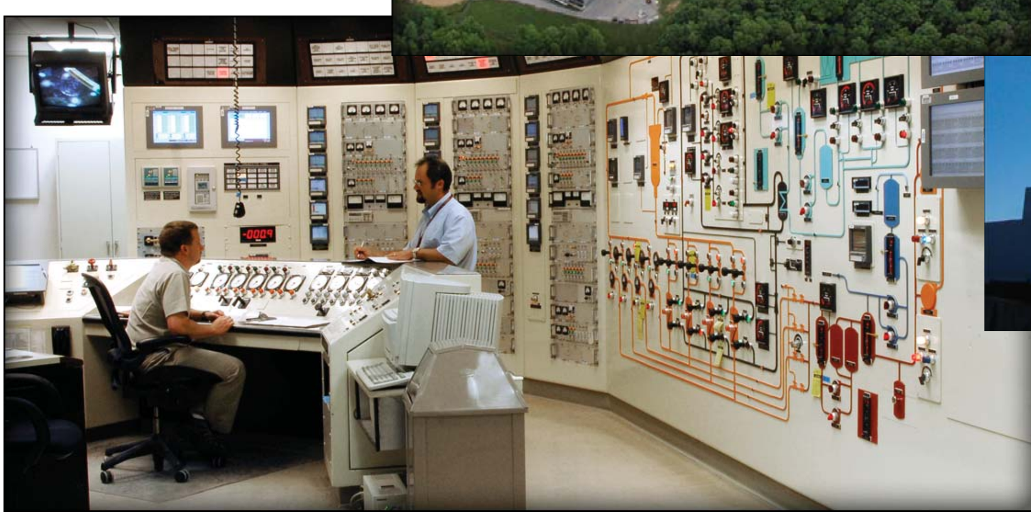
The reactor was shut down for more than a year to install a new cold source. With the successful commissioning of the source and more than $70 million in renovations, HFIR is once again a world-class facility. The cold source has a brightness comparable to the best in the world and is the first forced-circulation super-critical hydrogen cold source placed into a reactor. The source increases the available neutron flux in the 4 to 12 Å range, making HFIR the highest flux reactor-based source of neutrons in the United States. For more details about the cold source, see page 4.

The fully instrumented facility will include 15 state-of-the-art neutron scattering instruments, 7 of which will be designed exclusively for cold neutron experiments. Other additions include new computer control systems and a new guide hall facility. Particularly prominent in the guide hall are the two new small-angle neutron scattering (SANS) instruments, each terminating in a 70-ft-long evacuated cylinder containing a large moveable neutron detector. In addition, laboratories will be equipped for users, and plans are in place to continue improving the overall HFIR facilities.



HFIR in the 1990s (top) and today (right). The rectangular building to the left of the cooling towers houses the new cold source and guide hall for the two small-angle neutron scattering instruments and the cold triple-axis spectrometer. Ample space is available for future development.

After more than a year of being shut down, the plume from the HFIR cooling towers—indicating operation—was a welcome sight.



HFIR control room.

HFIR Chronology

1965 Original safety analysis submitted to the U.S. Atomic Energy Commission

1965 Initial criticality

1966 Full-power operation (100 MW)

1975 First permanent reflector replacement outage

1983 Second permanent reflector replacement outage

1986 HFIR shut down for vessel embrittlement and management concerns

1989 Reactor resumes low-power operation

1989 Full-power operation (85 MW)

2001 Third permanent reflector replacement outage

2002 Enlarged beam line HB-2 and shutter installed

2007 Beam line HB-4 cold source installed and commissioned

Upcoming Operations Schedule

Cycle	
410A	Aug 15–Sep 3
410B	Sep 26–Sep 30
411	Nov 14–Dec 7
412	Dec 19–Jan 11

Initial Neutron Scattering Experiments

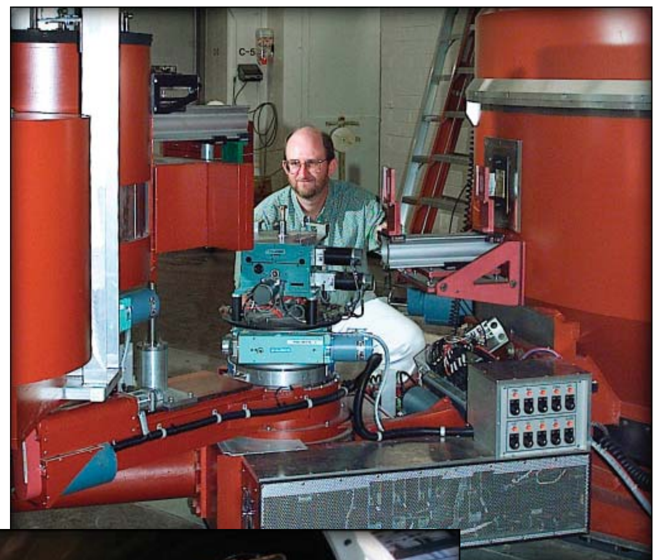
During the recently completed cycle 408, the three thermal Triple-Axis spectrometers and the Residual Stress Diffractometer were operational. Out of more than 40 proposals, 12 experiments were conducted by in-house research staff and 22 external users. Experiments included studies of high-temperature superconductors, manganese and ruthenium oxides, heavy fermions, and low-dimensional materials.

The cold source ran smoothly at 20 K and delivered long-wavelength cold neutrons to the two new SANS instruments, which are still being commissioned. The first data from the Bio-SANS instrument are shown on page 3. Although the instrument is not fully calibrated and optimized, initial results look promising, with diffraction standards within 2% of expected values.

Experiments scheduled during the initial cycles include

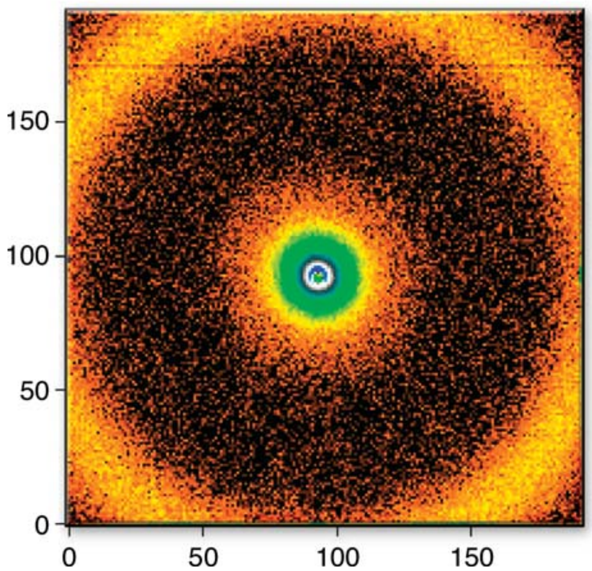
- Experiments to create new materials with beneficial properties, based on polymer nanocomposites, which are "hard" nanoparticles surrounded by a "soft" polymer matrix.
- Studies to make crystals from membrane proteins—which determine interaction and communication between living cells—to better understand the membrane proteins' structure and function.
- Examination of how high-pressure carbon dioxide is absorbed by and migrates through different types of coal to help develop new, more efficient ways to sequester CO_2 in the hope of reducing greenhouse gas emissions.

In response to the recent call for proposals for HFIR cycles 410 through 412, we have received more than 150 proposals requesting almost 800 days of beam time.

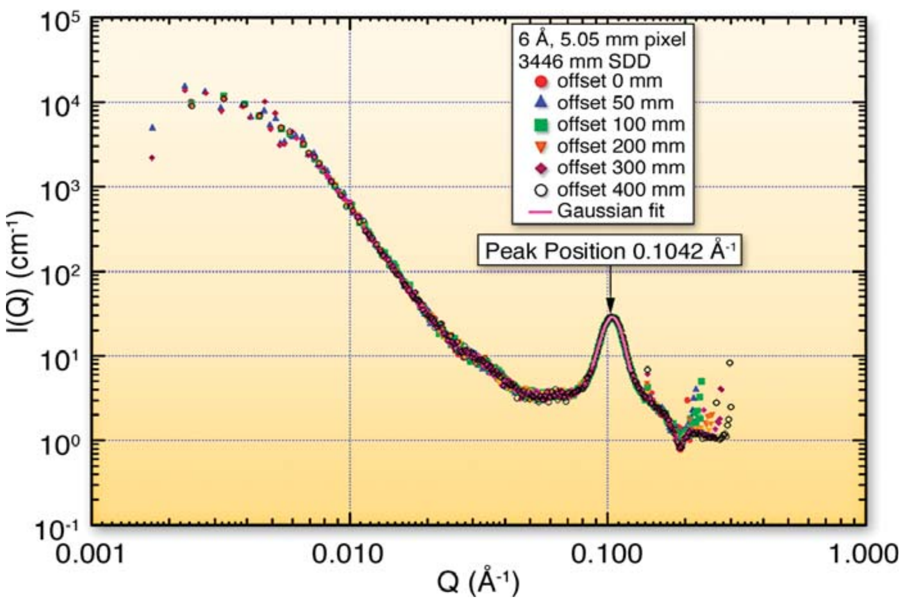


Lee Robertson, leader for the HFIR Instrument Support Group, working on the Triple-Axis Spectrometer on beam line HB-1.

Katherine Atchley (Low Q Instrument Group) and Doug Jones (HFIR Instrument Support Group) working on the SANS detectors.



Left: two-dimensional scattering pattern. Below: reduced scattering curve from a standard calibration sample of a polymer blend with diffraction peaks from the Bio-SANS instrument.



Congratulations from the Scientific Community

The restart of HFIR was the result of the dedicated efforts of many people. Recognition of those efforts came from all over the scientific community. Here are just a few:

"Congratulations. In BES, we recognize the immense role that you have played in turning HFIR around. You have done a great job. We look forward to hearing more about how HFIR is doing over the next few weeks." *Pat Dehmer, Associate Director of Science for the U.S. Department of Energy Office of Basic Energy Sciences*

"Please convey my congratulations to the team. This is a most significant event." *Don McConnell, Chief Operating Officer, Battelle Laboratory Operations*

"I'm . . . enthusiastic and appreciative of the accomplishment . . . . Please add my big thanks to Kelly B., Ron C., and all of the others who worked diligently to achieve this important milestone. Well done!" *Carl Kohrt, President and Chief Executive Officer of Battelle*

User Program Instruments

HFIR has six neutron scattering instruments in the user program and is accepting proposals for each of them.

Beam line	
HB-1	Polarized Triple-Axis Spectrometer
HB-1A	Fixed Incident Energy Triple-Axis Spectrometer
HB-2B	Residual Stress Diffractometer
HB-3	Triple-Axis Spectrometer
CG-2	Small-Angle Neutron Scattering Diffractometer (SANS1)
CG-3	Biological Small-Angle Neutron Scattering Instrument (Bio-SANS)

Other HFIR Instruments

Four more neutron scattering instruments are in the commissioning or construction phase.

In commissioning:

HB-2C	U.S.–Japan WAND
HB-3A	Single-Crystal Four-Circle Diffractometer

To be commissioned in 2008:

HB-2A	Powder Diffractometer
CG-4C	U.S.–Japan Cold Neutron Triple-Axis Spectrometer

Five beam lines are available for future development. For more information about HFIR instruments, see http://neutrons.ornl.gov/hfir_instrument_systems.

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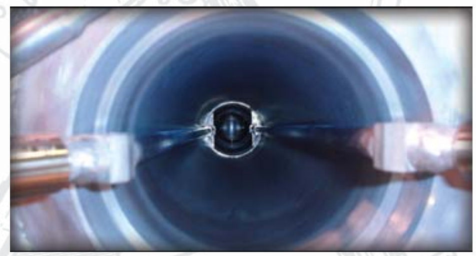
HFIR Cold Source

For neutron scattering experiments, it's ideal to match the wavelength and energy of the neutron to the length and energy scales, respectively, of the materials under investigation. Therefore, for studying large-scale structures (e.g., molecular organization, nanopore-size distributions, and aggregate size and shape) and low-energy excitations (e.g., excitations in frustrated systems and various problems in magnetism, superconductivity, and correlated electron systems), the best neutrons are those with long wavelengths and low energies—cold neutrons.

The thermal neutron spectrum of a reactor produces neutrons with wavelengths on the order of a few tenths of a nanometer, well matched to the study of atomic lengths scales and lattice vibrational energies. By passing the thermal neutrons through a container of low-temperature liquid hydrogen, the neutrons are slowed down by inelastic collisions with the hydrogen. This produces slower, long-wavelength neutrons better suited for studies of soft matter and low-energy excitations.

Among reactor-based neutron sources, the brightness of the HFIR cold source is equaled only by that at the Institut Laue-Langevin in Grenoble, France. In addition to being well matched to the experiments, cold neutrons reflect well from surfaces and thus can be transported over long distances with little loss. The HFIR source illuminates four neutron guides, bringing beams to seven new instrument positions in the new cold guide hall. Two of the guides are instrumented with the now operational SANS instruments.



View of the cold source looking up into the circulation tube during fabrication.

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For the latest user updates, see the users web site at neutrons.ornl.gov/users.