A LOW BACKGROUND DOUBLE FOCUSING NEUTRON MONOCHROMATOR

Work continues on the development of a low background double focusing monochromator which was described in the 1999 NCNR report. The actively controlled double focusing monochromator consists of an array of 315 pyrolytic graphite crystals mounted on 21 thin aluminum blades (see Fig. 1). When buckled, each variable thickness blade conforms in shape to an arc of constant radius providing active vertical focus control. Horizontal focus is accomplished by independently controlling the rotation of each blade.

The design and choice of materials for the system reduces scattering from the supporting structure, a problem common to traditional lead-screw and lever controlled monochromators. Structural material in the beam is limited to the 21 blades and three thin walled aluminum posts. The 315 crystals are accurately suspended with only 630 g of structural material in the beam's direct line of sight.

An engineering mock-up of the focusing system was constructed (see Fig. 2a). This three-blade version of the full-scale 21-blade unit was used to study blade performance, develop control software, quantify horizontal and vertical focus performance, and test mechanical and electrical system components. Figure 2b shows an optical test of vertical focus performance using the mock-up. The three blades are covered with reflective mirrors and illuminated with a white point source. The reflected image is focused onto a screen. Imaging tests such as this, as well as mechanical measurements, have verified that errors in blade shape are negligible compared to contributions due to crystal mosaic over the focal range of interest. Similar optical tests have been used to verify the horizontal focus performance.

The full-scale unit is currently under construction. When completed, the 1300 cm^2 monochromator will be the heart of the new cold neutron spectrometer under development at the NCNR. It is expected to provide an intense monochromatic neutron flux with $0.1 < \Delta E < 0.5$ meV and $\Delta Q \approx 0.1$ Å^{-1} yielding a peak flux of order 1.0×10^8 n/cm^2/s, higher than any currently available worldwide. This new instrument will be ideal for studying materials with excitations having a low characteristic velocity. The enhanced sensitivity will enable inelastic neutron scattering studies of smaller sample size and will provide dynamic information of unprecedented detail when large samples are available.

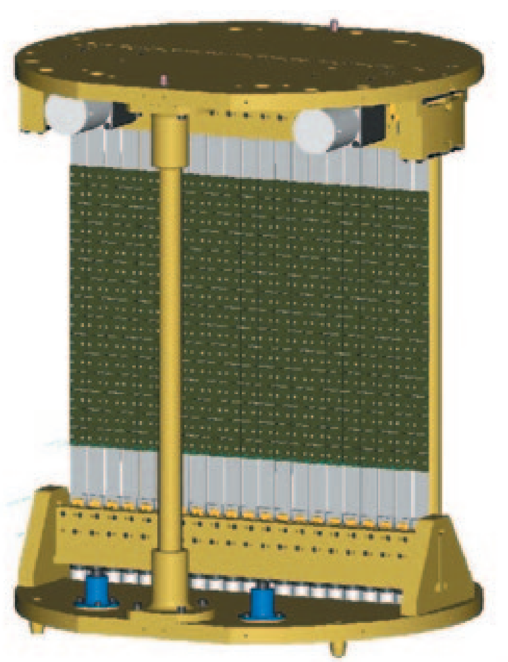

FIGURE 1. Rendered image of the low background doubly focusing monochromator.

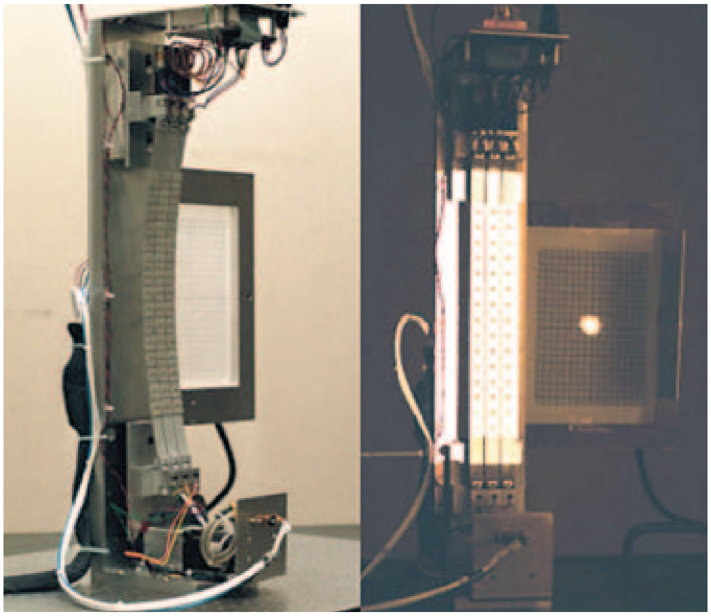

FIGURE 2. Three blade mockup of the double focusing monochromator focusing system. (a) Blades are shown buckled to an arc of a 1 m radius circle. (b) Vertical focusing is optically verified by focusing a white point source onto a screen.

THE BT-7 THERMAL TRIPLE AXIS ANALYZER/DETECTOR SYSTEM

As part of the modernization of the thermal neutron spectrometers a new triple-axis instrument is being designed for the BT-7 thermal beam port. For the analyzer portion of this machine several different types of systems have been proposed. One type is a horizontally focused pyrolytic graphite analyzer system shown in Fig. 3. The analyzer crystal system consists of 13 pyrolytic graphite blades, each 2 cm wide and 15 cm high, with either an individual detector for each of the 13 blades, or a position-sensitive detector using all the blades at once.

This is the modern equivalent of our present analyzer systems, and is expected to be the workhorse for the new thermal triple axis instruments. The blades of the analyzer can be freely rotated by 360 degrees and individually positioned, while the entire unit can be rotated as a whole to achieve the desired focusing condition. Each blade can then be matched with a detector that is capable of being positioned individually by a stepper motor on a circular track around the analyzers. A straight-through beam monitor is incorporated into the shielding behind the analyzer crystals to continuously monitor the flux of neutrons entering the analyzer system. A separate diffraction detector is also provided, which can be moved in front of the analyzer if the energy-integrated signal is to be measured.

The general design philosophy is to make the instrument as user friendly as possible while still meeting all the desired operating criteria. These include a built-in magnetic guide field for polarized beam operation; and various beam defining systems such as collimators, beam apertures, spin flippers, and filters. Ease of exchanging beam collimators before and after the analyzer crystals is an important design feature that presents an engineering challenge. Extracting the wiring from all the moving detectors and motors inside the system will also be a technical challenge.

A second type of analyzer system will consist of a series of up to 30 individual and isolated analyzer/detector systems. Other analyzer options, to be developed in the future, include incorporating a velocity selector into the analyzer system, and developing a "conventional" double-focusing analyzer with a single, well-shielded detector.

THERMAL NEUTRON PROMPT GAMMA-RAY ACTIVATION ANALYSIS (PGAA) FACILITY AT VT-5.

The vertical beam tube VT-5 thermal neutron PGAA facility is being upgraded through a collaboration of members of the NCNR, the Nuclear Methods Group, and the U.S. Food and Drug Administration. The current facility consists of an internal neutron-collimating beam tube and shutter assembly, an external beam tube, sample chamber, a beam stop, and a gamma-ray detection system. All components except the internal beam tube and shutter assembly will be replaced and a sapphire filter installed in the shutter assembly. The new components will be designed to reduce background count rates and improve detection limits. The external components will be constructed as a single unit to simplify removal and re-assembly of the instrument to make room for reactor refueling.

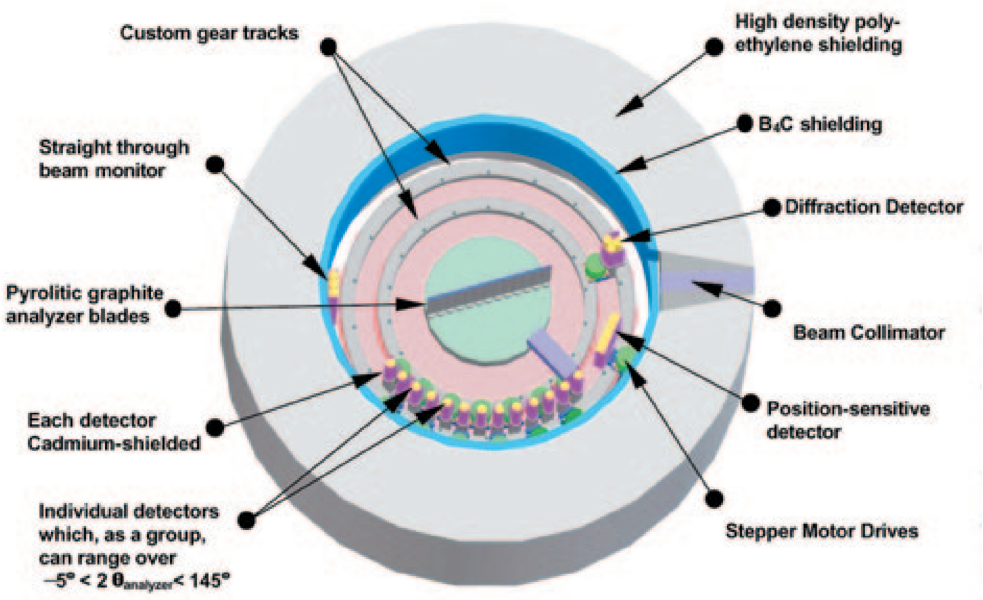

FIGURE 3. Horizontally focused pyrolytic graphite analyzer system for the BT-7 thermal triple-axis spectrometer.

FIGURE 4. Andrzej Rajca (left, University of Nebraska) and NCNR's Sung-Min Choi load a sample under special conditions. For this SANS experiment, the sample had to be kept below 170 K from storage in liquid nitrogen to top-loading into the pre-cooled cryostat. The transfer was performed in a helium atmosphere using a glove bag in order to prevent water condensation on the sample cell surface.

A cylindrical sapphire filter 5.3 cm long (4.3 cm diameter) was added to the shutter. This modification reduced the number of fast neutrons by a factor of five and greatly reduced the low-energy gamma-ray background. The gamma-ray background measured at the perimeter of the apparatus has decreased by a factor of two and the peak-to-background ratios for gamma-ray energies below 500 keV increased by a factor of two to three.

The design of the new system is complete. The steel component of the old beam stop will be replaced by aluminum to eliminate iron capture gamma-ray background. The external beam tube will be evacuated to minimize neutron scattering and capture in air and will be constructed from aluminum tubing lined internally with lithoflex to eliminate the background for boron determinations. The detection system will consist of a 40 % (relative efficiency) germanium detector with a bismuth germanate Compton suppression system. The new system will decrease analysis times and improve detection for most elements determined.

SAMPLE ENVIRONMENT TEAM

Fiscal year 2000 marked the creation of a new Sample Environment Team, dedicated to providing a central resource for the sample environment needs of neutron researchers. This team provides a single contact point to resolve any issue related to the sample conditions during an experiment, such as temperature, pressure, magnetic field, electric field, or *in situ* measurements. The scope of this team includes sample preparation and mounting, equipment scheduling, special equipment configurations, operational procedures, provision of necessary resources, sample storage, and equipment repair. Figure 4 shows researchers loading a sample. In this case a difficult SANS experiment was made possible by the team working with the researchers to choose the appropriate sample environment equipment and operating procedures.

The most visible change during FY2000 is in the high-bay sample preparation area at the NCNR. This area was extensively remodeled to provide more workspace, greater ease of use, more convenient preparation of cryogenic equipment, and better access to sample storage. Additionally, extensive documentation is now available for the most widely used sample environment equipment, the closed-cycle helium refrigerators. This documentation details individually-measured operating characteristics, sample mounting information, temperature sensor data, and operating guidelines. Significant new equipment acquired for the user community in FY2000 is listed in Table 1.

TABLE 1. Significant sample environment purchases during FY2000.

100 mm access top-loading helium cryostat	1.5 K to 300 K, dedicated to time-of-flight spectrometer
70 mm access top-loading helium cryostat	1.5 K to 300 K, general use
Seven additional sample probes for 50 nm, 70 nm, and 100 mm access top-loading helium cryostats	Provide for faster sample changes and specialized needs such as gas handling
Closed-cycle helium refrigerator	10 K to 350 K, dedicated to backscattering spectrometer
Closed-cycle helium refrigerator	10 K to 350 K, general use
Electromagnet	0-0.7 Tesla, dedicated to vertical reflectometer
Thirty indium-sealing sample cans	Mounting of powder samples and single crystal samples
Six temperature controllers	Multiple sensor capability, PID control
Nine turbopumps	10^{-7} mbar base pressure
Two large rotary vane pumps	10^{-4} mbar base pressure