A new C-line station and its scientific capabilities

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The old C line stations, C1 and C2, have a long and successful history as the primary EXAFS hutches for CHESS. In particular, the C2 "workhorse" monochromator has been optimized for energy step scanning in ranges between 6 and 35 keV. We are currently in the process of completely rebuilding the C line, creating a single large station with many new capabilities. The C2 monochromator will be relocated to B2 (a space slightly larger then C2) where it will continue to provide x-rays for EXAFS and near-edge spectroscopies. Both the B2 and C hutches will have improved gas handling and toxic venting.

The scientific capabilities of C line will shift and beams for a much broader range of experiments will become available. The new C line hutch will be a spacious facility with a mission that includes both monochromatic high-resolution 4-circle diffraction and continuous energy range, focused beam data collection using the latest methods in diffraction and absorption spectroscopy. The x-ray optics, which are housed in a new vacuum coffin, will include both a highly flexible double bounce monochromator with sagittal focusing and a large side diffraction focusing monochromator (see photo below). Either system can be used with a mirror for vertical focusing and/or harmonic rejection. The station is white-beam capable, equipped with both a large 4-circle diffractometer, and a "floatable" precision optical table used for mounting experiments that intercept the side bounce focused beam.

Experiments in small angle scattering, topography, energy-dispersive diffraction and absorption, multi-wavelength and monochromatic crystallography, angle-dispersive high-pressure diffraction, and methods of anomalous scattering powder diffraction can be accommodated. Up to 6 milliradians of bend magnetic radiation, with a 10.5keV critical energy, can be intercepted and focused by these monochromators. By coupling this large angular acceptance with the small size of the C line source and the modest heat loads offered by the bend magnet, we anticipate the focused beam intensity to approach half that available at the CHESS wiggler stations.

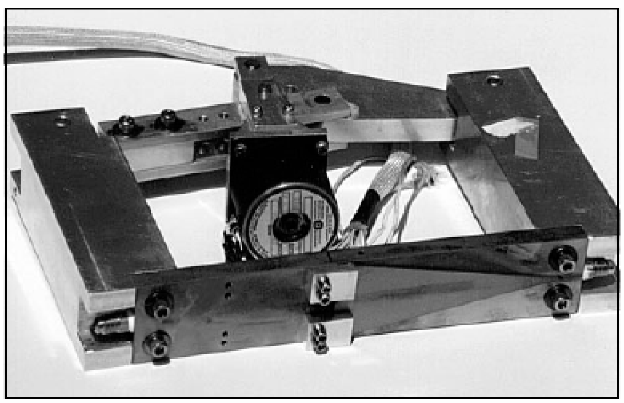
Examples of the scientific work that could be done at the new C station. The stations' white beam, mirror reflected white beam, or wide-band pass multilayer diffracted x-rays can be used for Laue diffraction [1], high energy fluorescence [2], and microbeam work with tapered capillary optics (as articles on pages 37 and 41).

The 4-circle diffractometer will be positioned to use focused double-bounce monochromatic beam for high resolution studies of electronic and/or magnetic properties of ordered bulk or surface structures. With our start-up optics, the focused beam energy should range up to 20keV, with useful flux (unfocused) up to 35keV. The monochromator will have a water-cooled first crystal and is designed to permit the use of multi-layers and asymmetrically cut crystals.

The newest and perhaps most exciting experiments will use a continuously bent, horizontal focusing side-bounce monochromator positioned downstream of the double-bounce system. Generally the station is setup to use one monochromator at a time by translating the other out of position in the coffin. Each mono has an associated set of shutters that permits white beam to remain on the crystal. The shutter is controlled by the user and opened to bring beam into the station.

The side-bounce monochromator is generally operated in one of two arrangements: monochromatic (or Rowland circle) focusing mode where the energy width is minimized, and energy dispersive (or over focused) mode for which the beam spot at the sample is usually under 1mm in horizontal size, but the energy width is as large as 1 keV. The energy range for the side-bounce beam depends on the crystal chosen and the focusing geometry, but overall it will match that of the double-bounce monochromator. For side-bounce work, the hutch has been designed to permit a focal ratio of distances (source-to-mono/mono-to-focus) up to 12:1 (see layout on opposite page). Harmonic rejection is controlled by a mirror placed between the monochromator and sample.

The Rowland circle mode is best suited for experiments in small angle scattering, monochromatic-oscillation crystallography, scattering from liquid surfaces, and angle-dispersive high-pressure diffraction. On the other hand, the energy dispersive arrangement produces a beam with well defined (angular) dispersion over a continuous energy range. In this mode the experimenter can take advantage of linear (or area) detectors to collect data simultaneously over a range in angle and/or energy. For the side diffracted beam, the location of the focus (and therefore the users experiment) is a function of energy and focal ratio. We



The horizontal crystal bender. The triangular crystal is supported by a water-cooled copper block.

will therefore provide an optical table that can be moved (or floated) on air-bearings into a precise position and orientation.

Users at CHESS have access to several area detectors as well as a linear photodiode array (or PDA) system with a user-friendly data collection interface [3,4] (developed at CHESS and running under SPEC) specifically designed for parallel data collection. In addition, CHESS has helped pioneer the development of so-called energy dispersive optical (EDO) methods, particularly in diffraction [5].

Examples of the scientific applications of EDO include: x-ray absorption spectroscopy [6] (in transmission), continuous energy diffraction spectroscopes such as DAFS [7] (diffraction anomalous fine-structure) and CEDS [8] (continuous energy diffraction spectroscopy), time resolved spectroscopies [9], limited energy range Laue diffraction [10], specialized oscillation photography, anomalous scattering in powder diffraction [11], and continuous high resolution longitudinal diffraction measurements on single crystals [12].

Planned station start-up. The new beamline will be commissioned during the start of CHESS running in October 1995. Both monochromators are being modified for water-cooling, and vacuum-compatibility. The vacuum coffin should be fabricated by the end of June, and internal components assembled by the end of summer. Silicon (111) and (220) crystal sets are being cut for the double bounce mono, and new and longer triangle shaped crystals will be added to an existing set for the side-bounce bender. The first experiments by outside users should be underway within 1-2 months of machine start-up. We encourage CHESS users to contact and discuss possible experiments for C line with Ken Finkelstein or any other CHESS staff scientist.

1. J. Hajdu and L.N. Johnson, *Biochemistry* **29**, 1669 (1990).
2. Baryshev, Kulpanov and Shrinsky in "Handbook of Synchrotron Radiation" vol. 3, p. 639, ed. Brown and Moncton, (Elsevier 1991).
3. The CHESS PDA software system (including a user manual available through CHESS administration) was developed as part of an engineering co-op project by Matt Borthwick, a Cornell undergraduate.
4. Some properties of energy dispersive optics and of the PDA detector were discussed in the Spring 1994 CHESS newsletter on pp. 28-29.
5. K.D. Finkelstein and Mark Sutton, *Nuc. Inst. and Meth.* **A347**, 495 (1994).
6. R.P. Phizackerley *et.al., J. Appl.Cryst.* **16**, 220 (1983).
7. H.Stragier et.al., *Phys. Rev. Lett.* **69**, 3064 (1992).
8. P.L. Lee et.al., Rev. Sci. Instrum. **65**, 2206 (1994).
9. A Fontaine *et.al., Topics in Current Chemistry* **151**, (Springer, Berlin, 1989).
10. P. Lee *et.al, Rev. Sci. Instrum.* **66**, 1425 (1995).
11. M.A. Beno *et.al, Rev. Sci. Instrum.* **66**, 1308 (1995).
12. M. Sutton et. al., *Nuc. Inst. and Meth.* **A355**, 654 (1995).

(below) Plan view of the new C line cave and hutch. The tunnel wall and CESR dipole magnets are visible at top. The C line white beam enters the figure from the left. Up to 6 milliradians can be intercepted by either of two monochromators: a double bounce mono (the position of the second, sagittal crystal is indicated) and located in the same coffin, a focusing side-diffraction mono. Typical locations for the stations 2 optical tables are shown. One table supports a large 4-circle vertical diffractometer, the second table can float on air pads and be positioned in the side-reflected beam. Rays representing the extrema in energy from silicon(111) are indicated for this monochromator. Vertical focusing mirrors can be placed in the coffin (downstream of the first mono) or in the hutch (for the side-bounce beam).