

A System for Integrated Collection and Analysis of Crystallographic Diffraction Data

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A set of linked software modules has been installed at the A1 station of CHESS, the Cornell High Energy Synchrotron Source, which, with the underlying hardware, allows crystallographic users of the facility to evaluate crystals, collect diffraction images and process the images rapidly and with assurance of the quality of the resultant data, thereby making most efficient use of their beam time. The system includes a CCD detector and its controlling software, with a graphical user interface, a convenient oscillation camera featuring automated alignment with the X-ray beam, a program for optimizing crystal rotation range, and the *HKL* data-reduction package. Principles embodied in this system are applicable to other facilities where crystallographic data are routinely collected.

Keywords: crystallographic data collection; software packages; strategy; CCD detectors; CHESS; MAD; macromolecular crystallography.

1. Introduction

Crystallographers, particularly macromolecular crystallographers, come to synchrotron sources to collect diffraction data on crystals which are too small, too weakly diffracting or too radiation-sensitive for study with a laboratory X-ray source, or to make use of the tunability of the synchrotron beam to collect multiwavelength data. Data collection is a relatively small part of the structure solution process, shown schematically in Fig. 1, and most crystallographers are not interested in the details of the X-ray source, data-collection method and data-reduction procedure provided that they obtain complete high-quality data in a minimum amount of time. Operators of synchrotron sources have long recognized this fact, and considerable effort has been expended in determining the desirable features of software made available to the users of a crystallography beamline, with special attention being given to the graphical user interface to be used (Sweet, 1995; Wakatsuki, 1996). Our emphasis here is on the entire crystal evaluation/data-collection/data-analysis system, of which the data graphical user interface is only one part.

In optimizing a facility for macromolecular crystallographers, all three steps in the second row of Fig. 1 must be considered. Fig. 2 shows in more detail what is involved in phase 2 of the structure solution, and it is clear that the steps are not sequential but are concurrent interacting processes. Ideally, the typical crystallographic user would like to place a container of crystals into a machine, push a button, and have a set of indexed, scaled, merged structure-factor amplitudes (complete, and of the best possible quality for the crystals) pop out. This is not now, and may never be, feasible, but there is much that

may be done to make the process shown in Fig. 2 as easy, efficient and idiot-proof as possible. One of the goals of MacCHESS (the facility for Macromolecular diffraction at the Cornell High Energy Synchrotron Source) is to do just that, and we report here on the development of a system, installed at the A1 station at CHESS, which approaches this goal. Similar systems of hardware and software have been developed, and are continuing to evolve, at other synchrotron sources, for example the beamline control system at beamline X-12C of the National Synchrotron Light Source (Sweet & Skinner, 1996) and the *PXGEN* system at Daresbury (Kinder, McSweeney & Duke, 1996).

2. Requirements for optimal data collection/analysis

Most crystallographic users collect data by the oscillation method, in which a crystal is exposed to X-rays while being rotated about an axis (the 'spindle') perpendicular to the beam; the rotation may be a single sweep or a back-and-forth oscillation, and typically covers a range of 0.1–5.0°. A data set consists of a series of oscillations covering a total range of ~30–360°, depending on the crystal symmetry and orientation. Diffraction patterns are recorded on a two-dimensional detector. The crystal is mounted on a goniostat which provides the spindle rotation and may include other rotation axes for optimizing crystal orientation. Crystals, particularly of macromolecules, are often flash frozen to ~100 K in order to reduce radiation damage, which limits the useful lifetime of a typical unfrozen protein crystal in the synchrotron beam to a few minutes.

The first step in data collection is to mount a crystal and center it in the X-ray beam. This step is difficult to automate, so current efforts are directed towards making manual crystal manipulations as easy as possible. Access for crystal mounting is provided by having a removable beam stop and easy translation of the detector back out of the way, and space for a microscope is provided on the table holding the experimental setup. A video camera provides a highly magnified view of the crystal; flexible fiber-optic light sources allow illumination of the crystal from any direction and cross-hairs (adjustable, checked before each user begins) show the position of the direct beam on the video display. Manual rotation of the spindle and translation of the crystal along it are easily performed.

To get good data from small crystals, the X-ray beam should be intense, small and stable. At A1, a 24-pole wiggler source and focusing optics including a bent triangular single-crystal monochromator and a bent mirror satisfy the first two requirements, providing 4.5×10^{11} photons s^{-1} through a 0.3 mm collimator at a beam current of 100 mA (Fontes, 1995). Because CHESS is not a dedicated synchrotron source, beam intensity is not constant over long periods of time. Fills are 60–90 min long and there is typically a 50% decrease in intensity during a fill. This is usually not a major problem, however, as an entire data set can often be collected within one or two fills, and a 50% change in intensity does not cause serious problems for scaling routines. Positional stability of the beam is usually good and any drift is (i) easily detected by continuous monitoring of the beam passing through the collimator, and (ii) readily compensated for by automated realignment of the experimental apparatus, as described below.

The ideal detector for macromolecular crystallography is accurate, sensitive, fast, capable of recording a wide range of intensities and large enough to collect data to the diffraction limit of the crystal. It is essential that the software provided with the detector allow immediate detailed examination of images. The preferred detectors in use today are imaging plates and CCD (charge-coupled device) detectors; CHESS has both. At A1, a CCD from Area Detector Systems Corporation is installed. This device contains 1152×1152 70 μm pixels; it has a readout time

of 9.5 s and a dynamic range of $\sim 5 \times 10^4$. The detector is protected from accidental exposure to the direct beam by a safety shutter equipped with a photocell; the shutter will open only when the beam is coming through the collimator but the signal from the photocell is below a specified limit. The software used to operate the detector constitutes an important part of the A1 data-collection system and is described in some detail in §3.

Station equipment other than X-ray optical elements and detector also needs to be reliable, easy to operate, and appropriate for recording crystallographic diffraction data. Each station at CHESS is equipped with a Hewlett-Packard (H-P) 9000/945i workstation, running UNIX and the VUE window manager, which features multiple 'workspaces' and a handy customizable control panel for system and user functions. Station hardware is operated using a KineticSystems crate or (recently) an Oregon MicroSystems VME crate, which is connected to the computer's SCSI bus. To insure that experiments will not be disrupted by network problems, software necessary for data collection resides on the computers at each station. When more than one computer is needed for data collection, they are connected by a local network which is isolated from the main building network by a bridge.

The flexible well tested program *SPEC* (Certified Scientific Software, Inc.) is used to control motors, shutters, timers and other devices. An extensive set of locally written *SPEC* macros allows users to perform most experiments

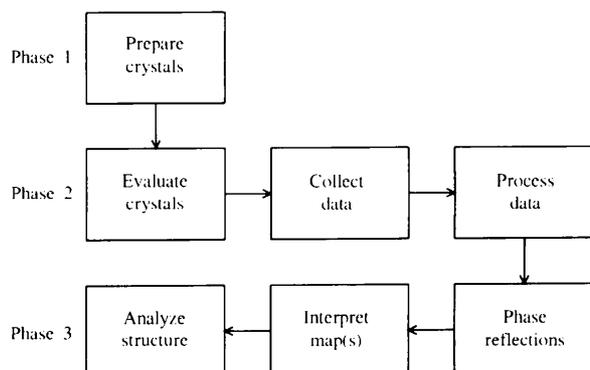


Figure 1
Steps in the determination of a macromolecular crystal structure.

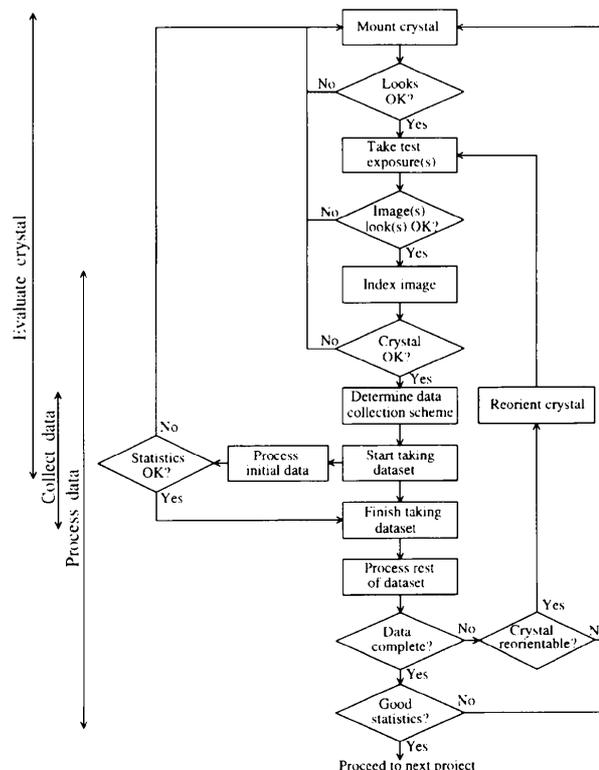


Figure 2
Schematic diagram of the work carried out by a crystallographer collecting data at a synchrotron source.

with a few simple commands. Of particular interest to crystallographers is the *oscam* set of macros, which includes all the commands needed to collect oscillation data. In *oscam*, great care has been taken (LaIuppa & Irving, 1993) to insure that the oscillation range recorded is precisely the one requested. Checks are performed to verify that the beam is getting through the collimator, the beam stop is in place (for CCD detectors), the exposure time/oscillation range combination is within the capabilities of the spindle motor, and that the oscillation endpoints on successive passes through the range are consistent.

For crystallographic users, the standard equipment in the hutch includes a shutter/collimator assembly, a single-axis goniostat on which the crystal is mounted, a video camera/telescope for centering the crystal, a removable beam stop and a detector (CCD detector or set of imaging plates mounted on a carousel). A crystal cooling system, from Molecular Structure Corporation, provides a flow of cold gas along the spindle axis and is suitable for either freezing in the stream or mounting pre-frozen crystals, as well as for cooling unfrozen crystals. Ion chambers before and after the collimator monitor the beam intensity. The entire experimental setup is mounted on a motorized optical table, which is adjusted to maximize counts through the collimator without disturbing the relationships among collimator, crystal, cooling nozzle and centering telescope. This adjustment is made by a rapid, fully automated sequence of translations and rotations: it incorporates a check for sufficient beam, real-time plots of counts *versus* position for each translation and rotation, and the ability to abort the process at any time and return the table to its initial position.

The idea of having an interface which makes it obvious to the most inexperienced users how to conduct their experiment is appealing but probably not very practical, especially when it comes to dealing with actual crystal handling and with resolving problems. Hence, user training and support are important elements of collecting data efficiently. A MacCHESS operator is assigned to train each incoming group of users. With the facilities now available, this process takes no more than a few hours, even for naive users. The time can be reduced if prospective users have acquainted themselves with the information available on the World Wide Web at <http://www.chess.cornell.edu> before coming to CHESS. Some of the more useful documents on the Web site are: a technical description of the CHESS facility, forms for submitting a proposal to CHESS, suggestions for planning a monochromatic or multiwavelength crystallographic experiment, a guide to operating a station, manuals for the various detectors, references to relevant publications, a staff directory and the current machine status. A selection of this documentation, in hard copy, is kept at each station for ready reference. When troubleshooting is required, the Web site, which includes a search engine, provides comprehensive on-line help (easily accessed using Netscape from any CHESS computer) for both users and CHESS staff. A CHESS operator is always on site to handle

situations where physical help is needed, and a MacCHESS operator is on call in case of difficulties with the specialized crystallographic equipment.

3. Data collection and processing at A1

3.1. ADX and related components

The elements of the data-collection and -analysis system at the A1 station are shown in Fig. 3. The system consists of a number of modules running on three different computers. The modular approach of the system allows for easy modification of the system for different hardware arrangements or for use of different processing software. Communication between modules is primarily by socket connections, but in some cases by pipes or by files written by one program and read by another. Socket connections may be either intra- or intercomputer; those between computers use standard TCP/IP protocols over Ethernet connections. To the user, most of the intermodule communication is transparent. Several of the modules may also be run in stand-alone mode, so that display, data reduction and beamline control functions may be carried out independently of data collection.

The majority of the modules shown are units of the ADX system (Area Detector Systems Corporation). This system was originally written for the MAR scanner system sold by Area Detector Systems Corporation and has been modified for the CCD detector; the version here has been customized to run with CHESS beamline hardware and software. ADX includes a central coordinator *ccd_dc*, a graphical user interface *adx_ccd_control*, a beamline control routine *ccd_bl_al*, a detector control routine *CCDSYS*, a data-file transformation routine *ccd_xform*, an image display routine *adxv* and a routine to display system status

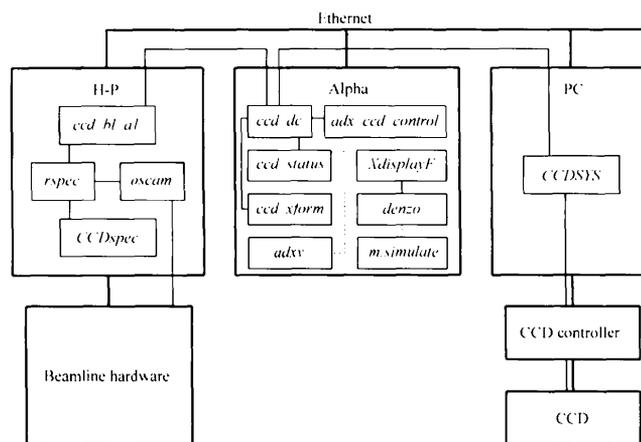


Figure 3 Components of the data-collection and -analysis operation using the Area Detector Systems Corporation CCD detector. Large boxes represent hardware components and thick connecting lines represent physical links between components. Small boxes inside the larger ones designate programs and thin lines represent flow of data and control information. Solid lines are used for socket connections and dotted lines for indirect communication through files.

ccd_status. An additional routine, *optimal_run*, may be used to aid in determining data-collection strategy; at CHESS the independent program *m.simulate* (see below) is usually used instead for this purpose.

On startup, *ccd_dc* establishes socket connections to *adx_ccd_control*, *ccd_status*, *ccd_xform*, *ccd_bl_al* and *CCDSYS*, all of these processes having been initiated with a single command on each of the three computers. *adx* is started and stopped separately as needed. Most user interaction with the system occurs through the graphical user interface, which runs on a DEC Alpha computer. *adx_ccd_control* presents the user with a main control panel including *SETUP*, *DISPLAY*, *PROCESS*, *STOP* and *EXIT* buttons. Each of these (except *EXIT*) brings up a menu when activated; many of the menu items cause control windows to pop up. On-line help is available from the menu bar on each of these windows.

There are several *SETUP* functions, of which the most important are *Manual Control*, *Snapshot* and *Run(s)*. *Manual Control* provides control over the X-ray shutter and oscillation camera. Camera parameters, which may be either adjusted or 'defined' (i.e. the software value is altered without affecting the hardware), include crystal-detector distance and rotation angles (the current A1 camera has only φ , but the program can also handle κ and ω angles). *Snapshot* is used to take a single exposure of a specified time and oscillation range (stills are possible). When the exposure is complete, the raw image is processed by *ccd_xform* and *adx* is started (if not already running) to display the corrected diffraction pattern. Fig. 4 shows the monitor screen of the Alpha after taking a snapshot. One or more such snapshots are used for initial evaluation of crystal quality, to check the position of the direct beam and to determine appropriate experimental parameters. The *Run(s)* window is used to set up and initiate one or more series of exposures, i.e. to start data collection proper.

Crystal quality is evaluated first by visual inspection of the image for evidence of a single crystal (spot positions fit the expected pattern for diffraction from a single lattice) that is undistorted (spots are round or slightly elliptical), of reasonable mosaicity (no more spots than expected for the oscillation range used) and diffracts to an adequate limiting resolution (diffraction pattern extends out to large enough radius). To aid in this evaluation, *adx* provides convenient brightness and contrast controls, zoom and pan capabilities, and a display of resolution as a function of position on the image. More accurate determination of mosaicity and confirmation of the presence of a single crystal can be made using the *HKL* package, as described in §3.3. Experimental parameters to be determined include detector positioning, oscillation range and exposure time. The detector can be translated perpendicular to the X-ray beam as well as along it; an appropriate position is one for which the most closely spaced spots on the image are resolvable (easily checked by zooming in on the spots in question) and as little as possible of the diffraction pattern is lost off the edges of the detector. An appropriate oscillation range is one which produces

as many spots as possible on the image without giving overlapping spots or excessive background. The presence of overlaps can often be determined visually, but should be checked using *m.simulate* or *denzo* (see below), which can also determine whether overlaps will occur when the crystal is rotated to other spindle angles. An appropriate exposure time produces an image with clearly visible weak spots but few 'overloads' (spots containing saturated pixels) in the resolution range of interest. *adx* aids this determination by displaying pixels above some cutoff value (which can be changed) in a distinctive color.

During data collection, *ccd_dc* sends commands at appropriate times to *ccd_bl_al* to take exposures, to *CCDSYS* to read out the detector, and to *ccd_xform* to apply corrections to the image files. CCD problems detected by *CCDSYS* or beamline problems detected by *ccd_bl_al* are reported to *ccd_dc*, which either retries the exposure or puts up a message and waits for user input, depending on the nature of the problem. *ccd_status* maintains a current status window, showing the status of the detector, current image name, spindle angle, remaining disk space etc.

The correction process performed by *ccd_xform* follows that developed by the Gruner group for their CCD detector (Tate *et al.*, 1995). Corrections include: (i) subtraction of a 'dark-current' image, obtained from a pair of images taken with the shutter closed, (ii) correction for geometric distortion introduced by the fiber-optic taper which couples the phosphor surface at the front of the detector with the actual CCD chip and (iii) correction for intensity errors due to nonuniform response of the detector; all operations are performed on a pixel-by-pixel basis. For snapshots, a standard 10 s dark-current image is normally used, although a new one may be produced if desired, e.g. for an unusually long or short exposure. For a data-collection run, an appropriate dark-current image is determined before any data images are taken. Corrections (ii) and (iii) use standard calibration files which only need to be redetermined once or twice a year.

The *DISPLAY* button starts up *adx*, which has its own set of windows, including a control panel and the image display window. In *Follow Images* mode, *adx* displays each corrected image file as soon as it is created by *ccd_xform*. In normal mode, a *Load* control window is used to select the file to be displayed. The *PROCESS* menu is used to start up data processing software, described in more detail below. The *STOP* button causes data collection to pause, without halting the processes. A *Restart* button in the *Run(s)* window allows collection to resume at the point where it stopped, or a new run may be initiated. The restart feature is particularly useful at CHESS, where fills are short and a frozen crystal can last for many hours.

On the H-P computer, *ccd_bl_al* receives commands over its socket connection with *ccd_dc*, reformats them, and passes them on to *rspec* via another socket. *rspec* is a recently developed program which acts as a communications hub between *SPEC*, other programs and the user. It supports communication via sockets, remote procedure

calls, a serial port and pseudoterminals. Links to several different programs, which need not all be running on the same computer, may be open simultaneously. Customization is provided by means of an initialization file, which specifies which programs are to start up and what options are in effect. Commands received by *rspec* from *ccd_bl_al* are passed on to *SPEC* (with *oscam* macros in effect) to operate the experimental hardware. Each exposure is performed using a single macro, *do_osc*, which uses a hardware timing generator to insure accurate sequencing of spindle rotations and shutter operations. Synchronization of CCD operation with the exposure, which is less critical, is provided by *ccd_dc*, which initializes the detector before commanding *rspec* to start the exposure and starts detector readout when *rspec* returns an exposure-complete signal.

rspec also mediates between *SPEC* and *CCDspec*. The latter program is a small graphical user interface which has buttons for several useful *SPEC* functions. Most commonly, it is used to initiate the automated table alignment procedure, but it can also be employed to redefine table parameters, check and reconfigure motors, and interrupt and

restart *SPEC*. These functions allow the user, or in some cases the *CHES*S operator, to recover from most station problems. In case of unusual difficulties, an *rspec OpsTerm* window is available for entry of direct *SPEC* commands; it is seldom necessary to terminate the data-collection processes in order to resolve problems. Extensive help on *SPEC* is included in the *CHES*S Web site. Also found on the H-P is a control panel, constructed using functions of the VUE window manager, for starting processes on the H-P with a single mouse click; the panel also includes buttons for stopping processes on both the H-P and the Alpha. Fig. 5 shows the monitor screen of the H-P during data collection.

A Pentium PC, running Windows, controls the CCD detector, a function for which it is better suited than a UNIX workstation because of the need to be fully dedicated to detector readout when it is occurring. The *CCDSYS* program receives commands over a socket connection from *ccd_dc* and transmits them to the CCD controller. When an image is requested, it reads out the CCD and transmits the data, over another socket connection, to *ccd_xform*; *ccd_xform* then writes the raw image to disk and also

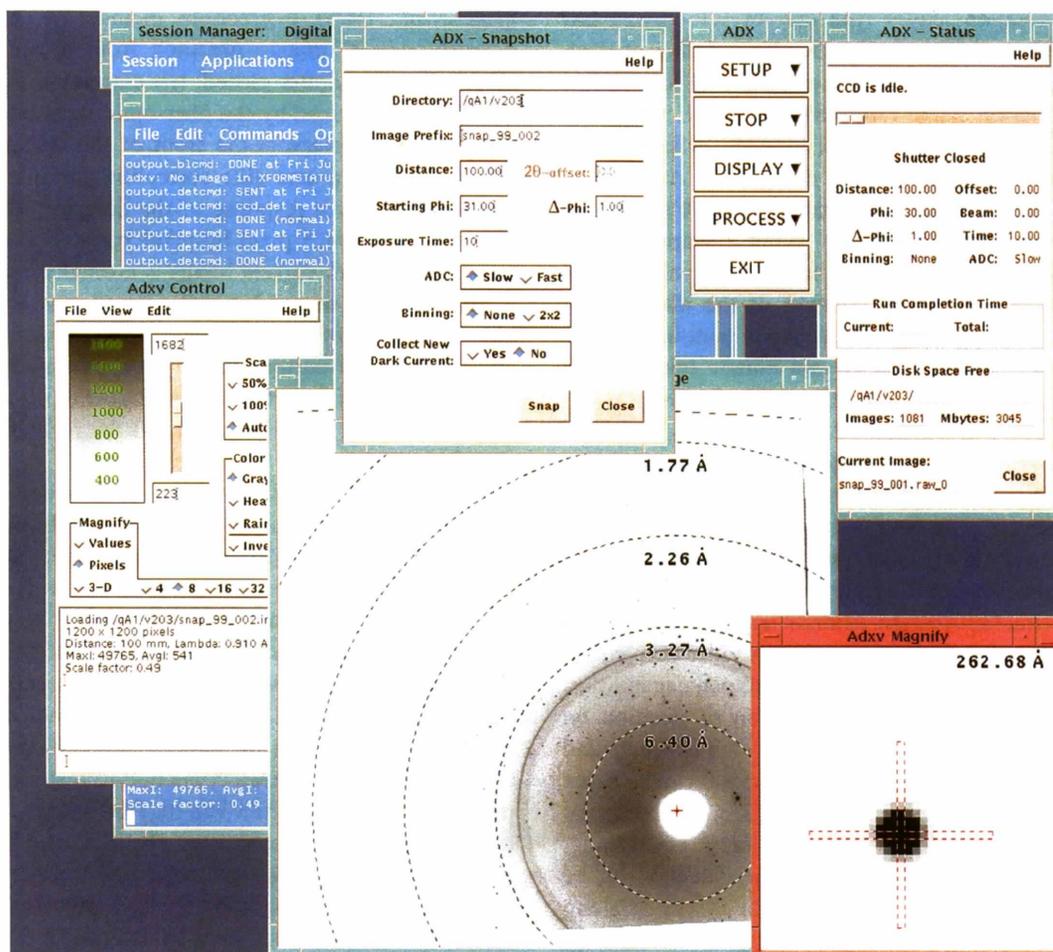


Figure 4

Appearance of the monitor screen of the A1 Alpha computer immediately after taking a snapshot. The ADX snapshot control, main control and status windows appear across the top, and the *adxv* control, display and zoom windows are in the lower half of the screen. The terminal window, mostly hidden by other windows, monitors some of the commands sent between ADX programs.

produces a corrected image. During data transmission and subsequent processing by *ccd_xform*, the next exposure may be running. For short exposures, the time for a complete cycle of initialization, exposure and readout is ~ 20 s; this increases as the exposure time goes above 10 s. Using the ADX system, a typical data acquisition rate is 150 images h^{-1} .

3.2. *m.simulate*

With a frozen crystal, an oscillation frame width (range per exposure) of $\sim 1^\circ$, and a typical exposure time of 20 s, a simple approach to data collection is feasible: collect 180° (if the beam is centered on the detector) or 360° (if the beam position is in the corner) of data; one is guaranteed to get as complete a dataset as possible in an hour or two. However, some crystals require longer exposure times, or can only be used for a limited number of exposures due to radiation damage. For multiwavelength data collection, the number of exposures is multiplied by three or four. In such cases, the increased efficiency provided by collecting only the degrees of rotation required for completeness becomes very worthwhile. The program *m.simulate* provides a means

of determining the appropriate rotation range as well as other experimental parameters.

This program is basically a simulator of diffraction patterns. For any oscillation range it calculates the reflections which will be recorded for given crystal and detector parameters; from these it determines the corresponding fraction of the total unique data (ignoring any anomalous signal) and of unique Bijvoet pairs obtained, and the redundancy of the measurements. For a narrow oscillation range, *i.e.* a single frame, it also determines the number of overlapping spots and can display a simulated image from the selected detector. *m.simulate* has one main window, including an image display area, a status line and a number of control buttons. These buttons are used to bring up subwindows for entry of crystal and experimental parameters, for displaying statistics or for performing special functions. A *Help* button provides assistance in running the program.

As input, *m.simulate* requires information about station, detector and crystal parameters, including the crystal orientation. Basic data about all the detectors used at CHESS are known to the program. Other data are supplied by the user or, more conveniently, can be read from the output of auto-indexing on a snapshot. To determine an appropriate total

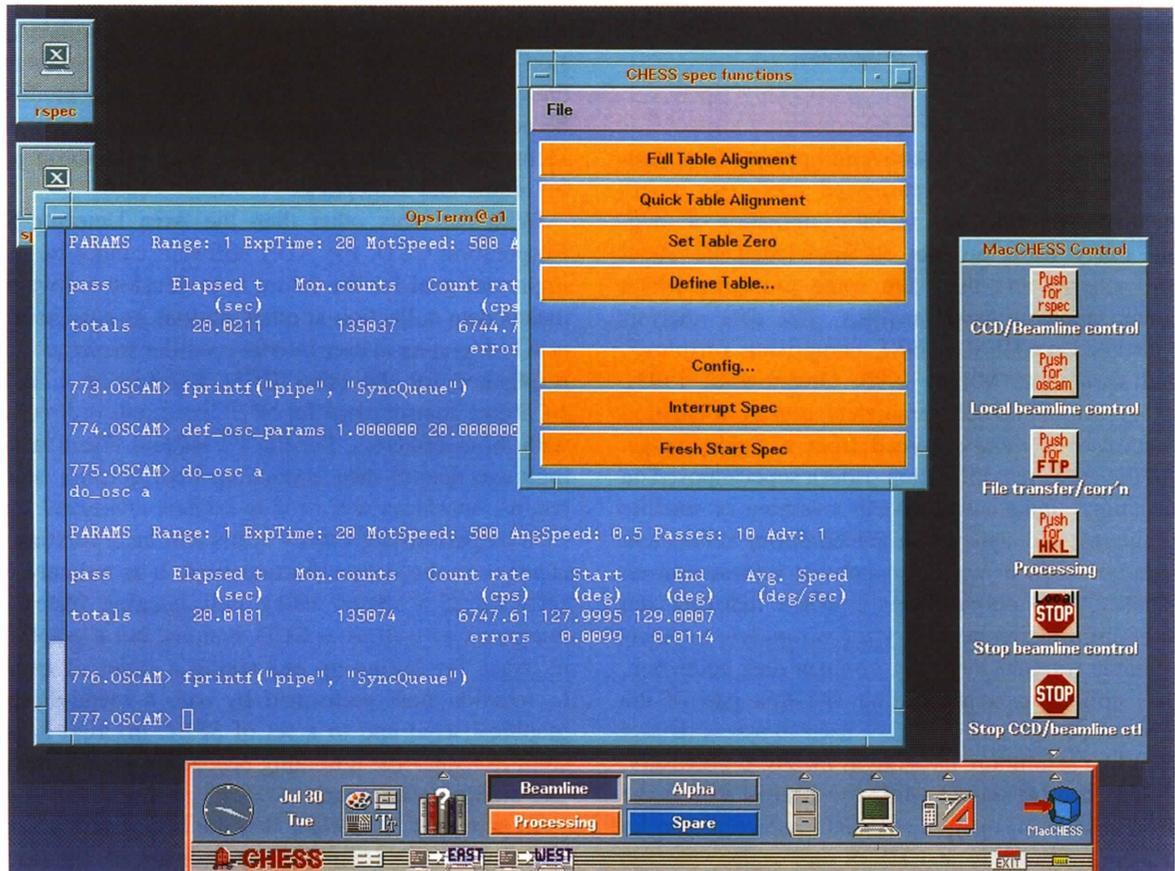


Figure 5

Appearance of the monitor screen of the A1 H-P computer during data collection. The VUE window manager's control panel is at the bottom, the MacCHESS control panel at the right and the *CCDSpec* control window at the top center. The *rspec OpsTerm* window, partially hidden behind the *CCDSpec* window, shows the statistics produced for each exposure.

rotation range, it is only necessary to read such indexing output (using the *Read log file* button) and activate *Optimize spindle range*. The optimization is performed as follows.

For speed, the unit cell is first shrunk by dividing all cell edges by an integer chosen to give a relatively small total number of reflections to the desired resolution. The number of unique reflections for a full 360° rotation, using the shrunken cell, is calculated. Starting from a 0–90° range, the endpoint is raised or lowered until ~90% of the unique reflections for a full rotation are being recorded. Keeping the total range the same, the starting point is stepped from 0 to 350° in 10° increments to find the start and end that give the maximum number of reflections. Then, the start point is raised and the end point is lowered as much as possible without reducing the completeness. The start and end points for recording 100% of the full-rotation unique reflections are found by expanding the 90% range by as little as possible. Returning to the true unit cell, completeness and redundancy statistics are calculated for the recommended (90%) range. Finally, at three points within the recommended range, a check is made of the maximum frame width which will not cause serious overlapping of spots. If desired, the suggested endpoints, and crystal and detector parameters, may be modified and statistics recalculated. The final parameters are then used to set up data-collection runs (at present the user must transfer the information manually, but as only a few numbers are involved this presents no great difficulty).

3.3. Data analysis

An integral part of the data-collection process is at least preliminary data analysis. Experienced users can assess crystal quality quite well from visual examination of snapshots, but many users are not so knowledgeable about oscillation patterns and there are some problems which only become apparent upon analysis. The data analysis package installed at CHESS is *HKL*, comprising *XdisplayF*, *denzo* and *scalepack* (Minor, 1993; Otwinowski, 1993). This package can obtain cell parameters, crystal orientation and an estimate of mosaic spread from a single image. Display of the predicted diffraction pattern superimposed on the actual image immediately reveals twinning or satellite crystal problems, and statistics produced during refinement and integration steps using *denzo* provide information on crystal quality. The output from a *denzo* indexing run contains the information necessary for *m.simulate* to determine a suitable rotation range for efficient data collection. While data collection is proceeding, the first part of the data can be processed and *scalepack* used to assess dataset quality [limiting resolution, merging R , $I/\sigma(I)$]. If necessary, better crystals can be sought while the user is still at the synchrotron source. In many cases, data reduction can be completed during the stay at CHESS and scaled, merged structure-factor amplitudes may be taken home rather than (or in addition to) raw images.

HKL is used for all detectors at CHESS, and most users employ the *mccview* graphical interface to select the

detector type and start up *XdisplayF*, *denzo* and *m.simulate* (if needed). Input to *denzo* is from a terminal window and from user-edited command files for the appropriate detector. *mccview* also directs output from the *denzo* window to a file for input to *m.simulate* and/or archiving. When using the Area Detector Systems Corporation detector, an alternative to *mccview* is available in the form of a graphical interface to *HKL* included in the ADX system. This graphical user interface allows easy entry of *denzo* parameters and eliminates the need to edit command files, but does not currently produce output in a form readable by *m.simulate*.

4. Conclusions

The system installed at the CHESS A1 station goes far towards optimizing the data-collection and -analysis process for macromolecular (and some small-molecule) crystallography. In the seven months that the basic system has been installed, users have collected copious amounts of good data using it, although not all have made full use of the capabilities for integrated crystal evaluation, data collection and data analysis. Several upgrades to the system have enhanced its reliability and ease of use, and recent users have expressed great satisfaction with it.

Enhancements not yet implemented include better communication between *m.simulate* and other modules, expansion of the capabilities of *mccview*, and some refinements to the *HKL* interface of ADX. In addition, new modules may be added to give users more data-processing options or to incorporate tests of data quality other than those provided by *denzo* and *scalepack*.

With detectors other than the Area Detector Systems Corporation CCD, the ADX software cannot be used. An important goal for the future is to develop software which makes data collection at other stations as easy as it is now at A1. A graphical user interface similar to *adx_ccd_control* is planned for the other CCD detectors at CHESS; the *CCDspec* control panel for *SPEC* functions is already in use with these detectors. For the F2 station, which is used for multiwavelength data collection, both detector and *SPEC* control interfaces will need to include additional functions such as performing energy scans and incorporating energy changes in the data-collection runs. It is unlikely that the software at a station using Fuji imaging plates can be integrated as well as at CCD stations, but a graphical user interface for setting up and taking a series of oscillations (a function now performed by *osc*, a menu-driven non-graphical front end to a set of *SPEC* macros) is planned, so as to reduce the retraining needed by users moving from one station to another.

In summary, it is clear that the A1 system works well, although there is room for improvement. A notable feature of the software is that it consists of several separate components rather than being a monolithic system. This feature makes it possible to incorporate existing programs with minimal modification, and eases adaptation of the system to

differing hardware and experimental needs. Implementation of this type of system at other synchrotron sources is entirely possible, and the authors of this paper will be glad to assist anyone wishing to do so.

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