Description of Beamline 10.3.2

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I. What it's for

This beamline is designed for X-ray microprobe with white or monochromatic light with a spot size of 3-10μm. This spot size was deemed to be small enough for many technical and environmental applications while being big enough to allow a larger flux on the sample than, say, 7.3.3. The beamline is designed around one particular type of experiment which has two steps: first, do fluorescence mapping to see the distributions of several elements in a sample, then do XAS on one or more specific spots which were identified by the mapping.

The beamline is therefore designed to allow fluorescence mapping using an XY stage and either white or monochromatic excitation. Any areas which fluorescence mapping identified as interesting can be investigated more closely with XAS. In addition, a CCD has been ordered which will allow powder diffraction for species identification. This beamline will not have the special mechanics used on 7.3.3 to allow accurate micro-mapping of strain in single crystals.

The energy range is from 2.7keV (sulfur K-edge) to about 17keV. The range is limited on the low end by absorption in Be windows and the few inches of air the incident and fluorescent X-rays must go through. On the high end, the limits are due to the cutoff of the mirrors and the falloff of the source intensity. Since this is a bending-magnet line, the spectrum is a bit softer than one might want for hard X-ray work.

II. How it does it

Figure 1 shows a diagram of the optics, taken from the document in which the present upgrade was proposed. There is a 1:1 focusing mirror ("M1") which transfers an image of the source onto a set of roller slits. These slits define a new, virtual source which is then demagnified by the rest of the optics. The next optical element after the roller slits is a vertically-deflecting plane-parabola mirror ("M2") which collimates the beam in the vertical direction. A set of slits just upstream of this mirror allows one to illuminate only a chosen part of M2 for better beam quality.

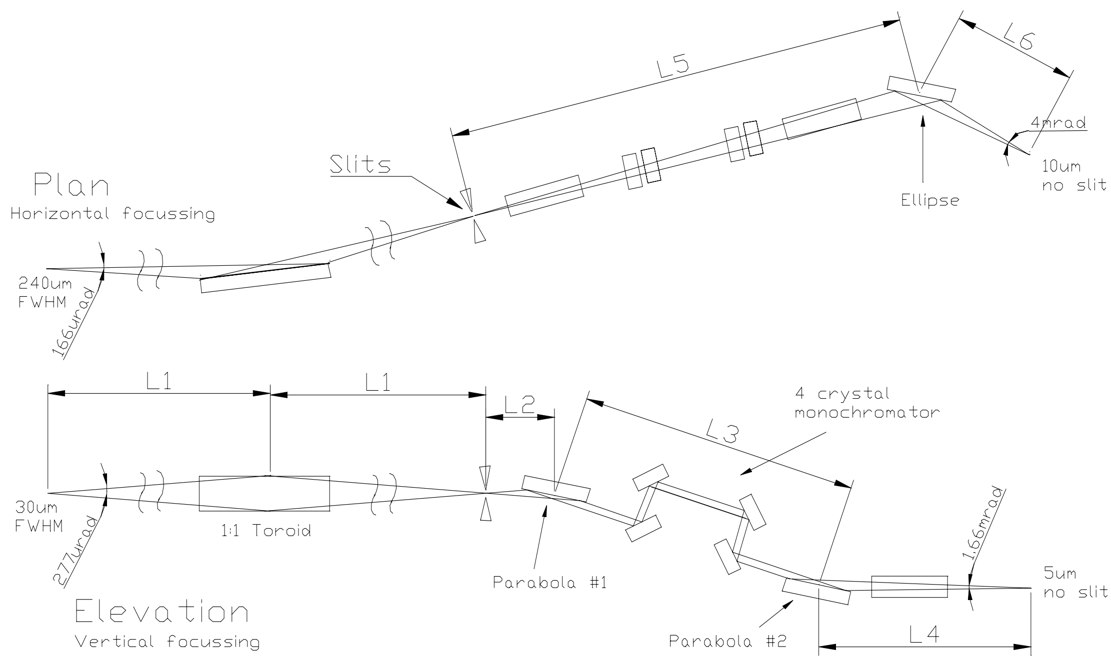

Figure 1. Optical layout. The dimensions L1..L6 and mirror types are as follows:

	Mirror	Type	Active area
L1 = 14.75m			
L2 = 1.44m	*M1*	*1:1 toroid*	*612 x 4.63mm*
L3 = 0.820m	*M2*	*V parabola*	*100 x 0.23mm*
L4 = 0.26m	*M3*	*V parabola*	*100 x 0.37mm*
L5 = 2.4m	*M4*	*H ellipse*	*100 x 0.66 mm*
L6 = 0.12m			

Mirror grazing angles = 4 mrads (coating = 8nm Rh on 20nm Pt on 5nm Cr)

The M2 mirror prepares the beam for the four-crystal monochromator. This device is a tape-drive design like the one on 7.3.3 but with ferrofluid seals which allow it to run in vacuum, and it uses Si111 channel-cut crystals. M3 then focuses in the vertical. The demagnification in this direction is the ratio of the focal lengths of M2 and M3, which is the ratio of L2 to L4, so is 5.54:1. The horizontal focusing is done by the single mirror M4, whose demagnification is L5/L6=20:1. Since the source is about 260x44μm^2 (Figure 1 has old values which are not correct), the image at full flux is thus 13x8 μm^2. Smaller spots can be obtained by slitting down on the roller slits, with loss of flux.

The mirrors are coated with Rh on Pt, which gives the wide energy range of Pt while suppressing the L-edge structure Pt alone would impose on the reflectivity curve. The Cr is a glue layer.

The sample sits in a holder which rides on an XY stage placed at 45^o to the beam. This stage is computer-controlled and has the ability to send out pulses at regular intervals as it moves. These pulses can be used to control counting hardware so that spectra can be obtained on the fly as the stage moves.

The main detector is a 7-element Ge detector. Instead of a bank of MCAs, we have a device called a DXP ("Digital X-ray Processor – the vendor's name). This device takes the output from the preamps and performs MCA-like functions, but completely digitally, and under computer control. It can operate in two modes – MCA, in which it bins the incoming counts into 1024 channels for each detector, and SCA, in which it stores up to 16 region-of-interest (ROI) sums. In the latter mode, it can store a set of these sums for each detector at each point in a scan line of the stage. Thus, one can do SCA mapping very efficiently with no overhead time for starting and stopping the stage.

In addition to the Ge detector, we have two ion chambers and a monitor for the incident beam. This monitor is either a channeltron which looks at the photoelectrons coming off the vacuum side of the exit window of the optics chamber, or a photodiode which looks at the scattered light from that window. The latter has the advantage that it doesn't need good vacuum. All of these devices are analog current sources. We have two Kiethley current amplifiers whose gains can be programmed via GPIB bus. The analog signals from these amplifiers then go into either an A/D or a V/F followed by a counter. We therefore have the flexibility to take almost any kind of signal a user might want to record.

The stage isn't the only thing which generates counting gate pulses. In order to assure that the various counters and the Ge detector all count at exactly the same times during EXAFS scanning, we have a software-controlled pulse generator which enables all the counters and the detector. The counters and the pulse generator are all channels of a National Instruments (NI) 6602 board.

Figure 2 shows a schematic of the electronics and dataflow. There are three computers, called Endstation, PXI and Analysis. The Endstation machine is the one the user interacts with during data-taking. It controls the stage and the detector (through the DXP). The PXI machine, named for its bus type, controls the monochromator, slits, first mirror (the others are fixed) and A/D converters. Server programs run on this machine which let the Endstation computer control all these functions. Thus, when the EXAFS program needs to tell the monochromator to go to the next energy, it issues a call to a server over TCP/IP. This call is picked up by a program running on the PXI machine, which also reports back the state of the monochromator. This architecture allows many different programs to access common functions without having to redo all the code. The PXI machine's server is part of a user-interface program which can be used to move motors, slits and the monochromator without having to run the EXAFS or XY-mapping program. Since it does take time to talk over a server, the Endstation machine is directly connected to the DXP, stage and counters.

The Analysis machine is for off-line processing of data. It takes the data from the Endstation machine via the standard Map Network Drive mechanism. By having the user work on a copy of the data, we assure that the original will not be accidentally corrupted. This separation of data-taking and analysis also allows one to do intensive analysis of one set of data while another is being taken.

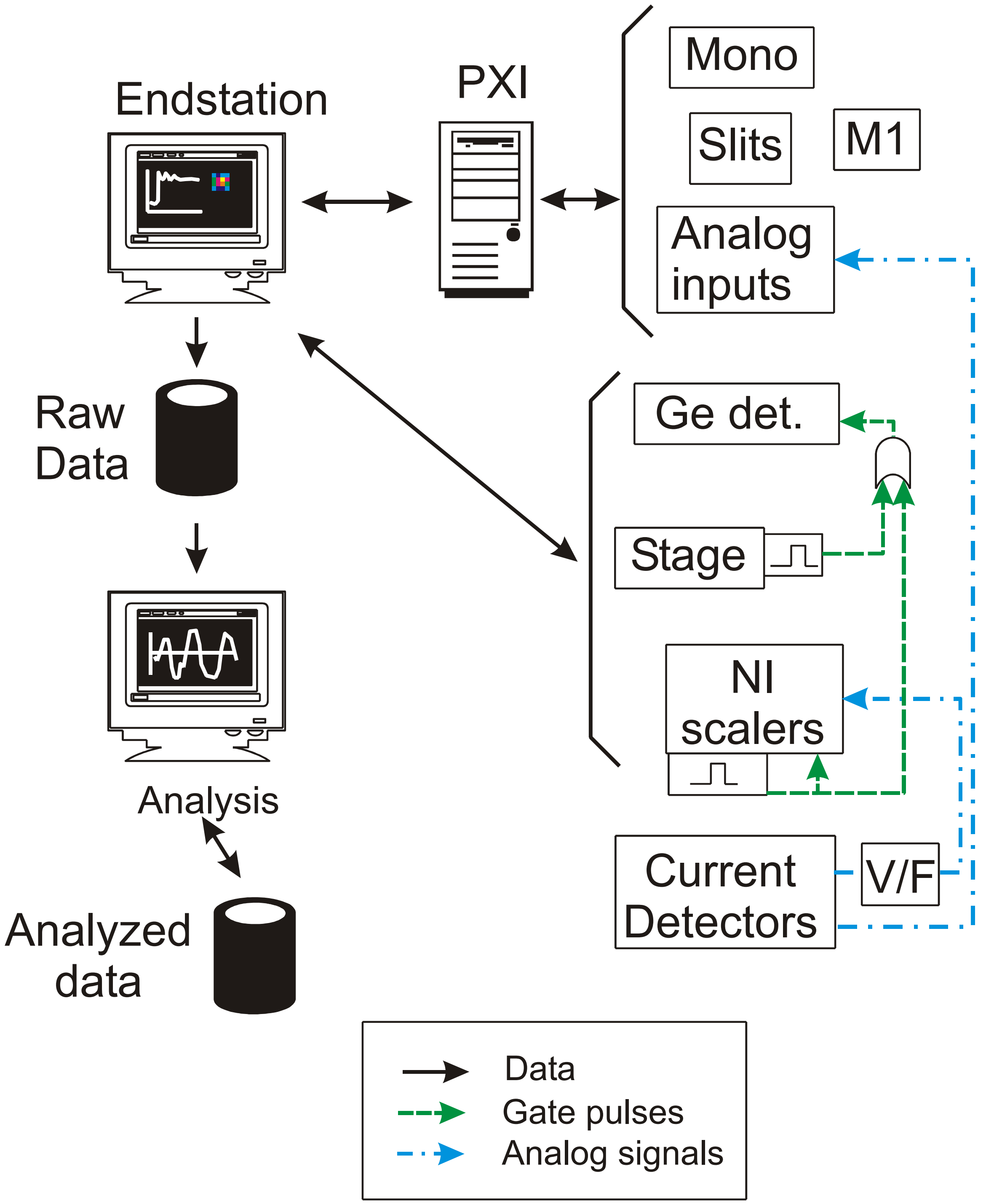

Figure 2. Schematic of the electronics and computer setup showing the three computers, called here Endstation, PXI and Analysis. "Current Detectors" refers to ion chambers, channeltrons or the like.

III. Physical description

The M1 mirror is close to the wall and has no adjustments which aren't controlled from the PXI computer. After that is a long beampipe, followed by the roller slits near the hutch. These are inside a 6" cross with gears and motors visible, all inside a Plexiglas box. A viewport on the upstream side allows one to see whether there's beam coming in. The next component is a 2-3/4" cross containing a photodiode on a manual vertical translator. There is an in-line Be window between the roller slits and the photodiode cross. The photodiode is used for tuning M1 so that it sends the beam through the roller slits. After that comes the hutch. Inside the hutch, a short bellows connects the beampipe to the optics chamber, which is kept under vacuum or He. This chamber contains the mirrors other than M1, the monochromator, and the I0 monitor. Just downstream of the chamber is the sample holder., mounted on a plate connected to the XY stage. The detector looks at the sample from an inch or two away.

Figure 3 shows the layout of the hutch and its contents. To give an idea of scale, the hutch interior is about 2.65x2.85m^2. The hutch is a side-station so there's another beampipe coming through it. There is a small area of about half a meter squared on the optical table behind the stage, and another 60cm between the end of the optical table and the back wall of the hutch. Several cables drape over the table to the equipment rack behind the 10.3.1 beampipe. There is a patch panel near that rack which connects to one at the console. The optical table has a standard pattern of ¼-20 sealed-bottom holes drilled into it. A reasonable supply of dogs, clamps and other optical hardware is available.

There is an LN2 transfer line and an auto-fill system for the 7-element detector. If we use another detector, it has to be filled manually. There is also a gas manifold for ion-chamber gases. Since this manifold is shared with 10.3.1, cylinder changes should be coordinated with the people on that line.

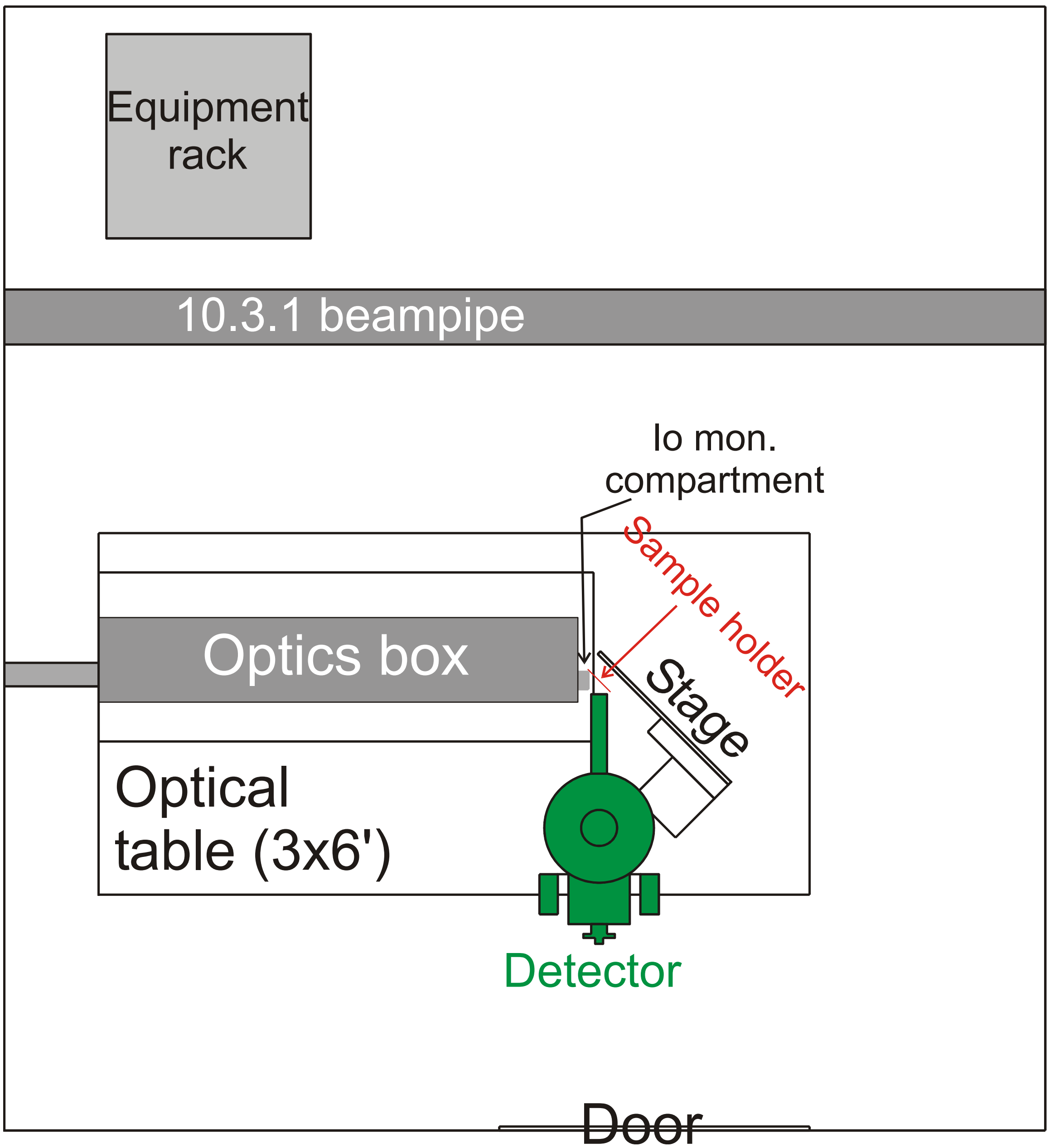

Figure 3. Layout of the hutch.

IV. Software

The software is all homegrown, so using it will require some learning. It's all in LabVIEW, a language in which programs have graphic user interfaces which look and feel rather different from those found in the usual Windows programs. There is another document, "Common LabVIEW Conventions", which users unfamiliar with this language should read.

The EXAFS analysis suite presently consists of WinXAS and a homebrew program for reading the files from the beamline and doing preliminary data editing and averaging. This program can produce 2-column ASCII files which can be put into any EXAFS analysis program. The files from the beamline are ASCII with a simple header so it is easy to convert them to any desired format. There is a manual for the data editor and one is being written for the data-taker (as of mid-September,2001).

The software consists of programs for beamline motor motion, fluorescence mapping, EXAFS scanning, EXAFS analysis and detector management. These will all have their own manuals. A typical sequence of operations might be something like this:

1. Use the motor program to tune M1 so as to bring the beam into the roller slits, thus compensating for motions in the beam. Use this program to set the size of the roller slits and optionally the Huber slits in front of M2, thus trading off beam size against flux.

2. Use the EXAFS scan program to calibrate the monochromator on an edge.

3. Use the XY map program to move the sample to somewhere where the elements of interest may be found. Use either the map or detector management programs to select ROIs for mapping and EXAFS. The ROIs for these two modes might be different.

4. Map with the XY map program. If necessary, use this program to do knife-edge scans to verify the spot size.

5. Do EXAFS scans with the EXAFS program.

6. Analyze EXAFS data on the analysis computer.

The program for moving motors is called "BL 10.3.2 Main VI". There is a shortcut to it on the PXI machine's desktop. When activated, it spawns a sub-program called "Single Motor Monitor". Use this to move motors. The list of motors include real motors like Monochromator and 'pseudo'-motors like Mono eV. Pseudomotors function like real ones, except that there is a conversion between their 'positions' and the positions of the real motors from which they're derived. Thus, the Mono eV pseudomotor actually runs the Monochromator motor, but reports its position in eV instead of angle. Each motor, real or pseudo-, can be moved to a position or reset so it thinks it's at a new position. The only motors the user should deal with are:

M1 Roll	This moves the beam vertically on the roller slits.
M1 Tilt	Moves the beam horizontally on the roller slits.
Vertical Slit Size	Rotates the roller slits to adjust their vertical opening.
Horizontal Slit Size	Rotates the roller slits to adjust their horizontal opening.
Monochromator	Moves to a given Bragg angle. Go to 0^{o} for white beam.
Mono eV	Moves to a given energy in eV.

Touching any other motors may produce undesirable consequences.

V. Procedural details

Hutch access is as in any other beamline with a hutch. The search button is on the upstream wall. When closing the hutch door, it's a good idea to hold it closed while removing the key because it tends to "bounce" a little.

The two Keithley current amps are in the equipment rack in the hutch. The outputs of these go to the patch panel. Outside the hutch, these signals go to a pair of V/F converters. The outputs of these V/F's are presently converted to TTL by means of SCAs. The outputs of these go to ratemeters and to a breakout panel for the 6602 scalers. Channels 1,3 and 5 of these scalers are available. Channel 0 is used for gate-pulse generation, and channels 2 and 4 don't seem to work. Alternatively, one can use the DACs, whose inputs are located in a patch panel near the motor controllers (big black rackmount boxes). The Keithleys are programmable using a program on the PXI machine. There's a shortcut to that program on the PXI desktop.

The data-taking software requires some configuration files to tell it what counters and detectors are present and how to use them. Some of the work of editing the EXAFS configurations can be done through the MCA utility. However, it may still be necessary to edit them by hand. The format of these files is explained in the manuals for the programs.

It is likely that the M1 mirror will need adjusting before and during the run. The procedure for doing this is as follows:

1. Lower the white-beam monitor photodiode into the beam. A mark on the linear feedthrough shows where to put it.

2. Open the slits wide using the "Single Motor Monitor" program on the PXI computer. This program should already be running. There is a control which lets you select the motor you want to manipulate. Choose "Vertical Slit Size". Type "100" into the box labeled "goal" and hit the Move button. If the size goes down to negative values, hit Stop and then hit Move again. Do the same with the Horizontal Slit Size, only make the value 400.

3. There is a current amplifier atop the box which encloses the slit assembly. Make sure its output is connected to one of the DVM displays. Adjust the gain until there's a reading. If you can't get a reading, make sure the shutter is open, and if that doesn't work, try power-cycling the current amp.

4. Using Single Motor Monitor, reduce the slit size to 50(H)x10(V). Increase the gain on the current amp until you get a signal.

5. Using the Jog controls on Single Motor Monitor, maximize the signal by tweaking the M1Roll and Tilt. The steps should be 0.02 for the Roll and 0.002 for the Tilt. Note that the Roll motor is sometimes slow, so wait for the Move Complete light to come on before doing another jog.

6. Now reset the slits to whatever size you want. Since the slit size indication is a little unreliable at small sizes, use the fraction of beam that gets through as a measure of size.

7. Don't forget to raise the photodiode before trying to use the beam.

This manual is being written during the commissioning of the beamline. It is therefore not possible to describe a robust set of "how-to" instructions. This will come later. I wanted to get this manual out in its present form so that users will have some information to work with.