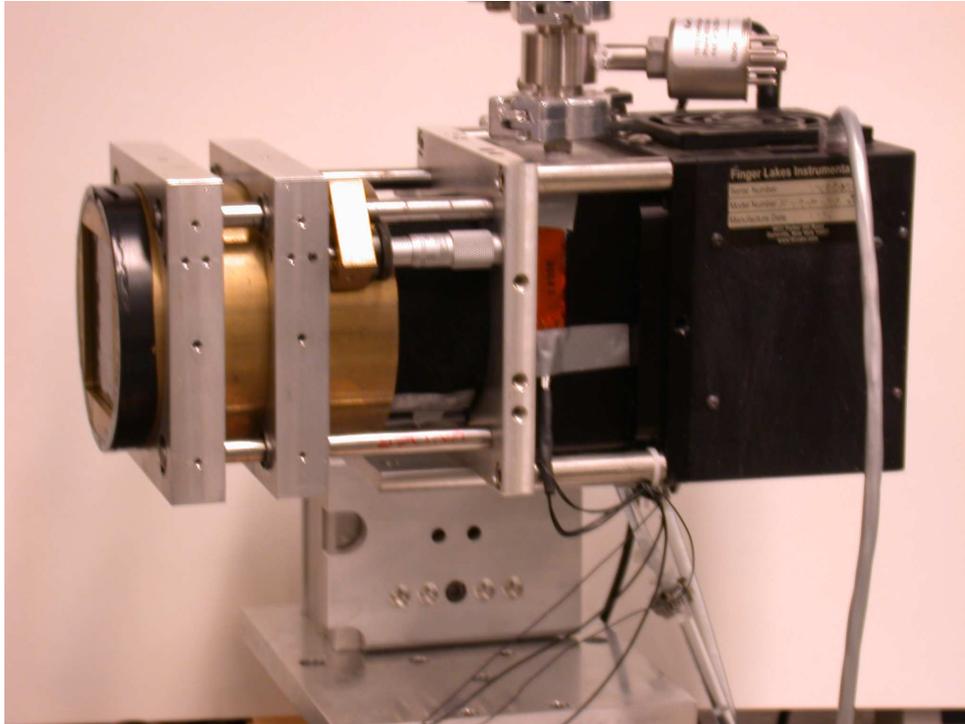


# Operating Instructions for the FLI Lens-Coupled X-ray Detector

Revision C



Written by  
Darol Chamberlain  
607-255-0909

Cornell High Energy Synchrotron Source  
Wilson Laboratory  
Cornell University  
Ithaca, NY 14853  
607-255-7163

## A. Detector Connections Set-up

1. Connect the rear hose fittings on the detector to a NesLab circulating water chiller. Turn the NesLab on and set to 15 °C.
2. Connect the two sets of banana plug connectors coming from heaters attached to the CCD housing to a ~19V power supply (maximum 28V). The heaters prevent condensation from occurring on the camera window.
3. Connect the rear RJ-45 socket on the camera to the FLI parallel port plug-in adapter using the special 10-wire cable provided by FLI (standard Ethernet cable has 8 wires). Plug the adapter into the parallel port of the Linux computer set up to run this detector.



4. Connect the FLI 24V DC power module to the power jack on top of the camera and then plug the module into AC power. **Note:** Never connect the module to the power jack after applying AC power to the module power supply. “Hot Plugging” the camera can blow the thermoelectric cooler fuse.

## B. Software Set-up

1. Log into the Linux computer running the detector as specuser using the usual password.
2. Open a terminal, then enter:  
**cd camserver**  
**./camserver**

The response should indicate that the computer is communicating with the FLI camera. A response that includes the CCD chip model (SI-003A), number of pixels in the array and the detector temperature shows that information has been read from the FLI camera.

3. Open a second terminal, then enter:  
**cd tvx**  
**./tvx.**

4. At the TVX prompt (\*), enter:  
**\*get “/home/specuser/tvx/default.gl”**

This sets the default image and graph directory paths to /home/specuser/images. “Connection has full control of camera” should appear in the camserver window.

5. To change the default image directory path enter:

**\*imagepath /home/specuser/<directory path>**

6. To check the temperature of the CCD, enter in the camserver window:

**\*flicommand getccdtemp**

This should return: **camserver: interface.c [550] CCD temp -34.76** when the CCD is fully cooled.

7. To get a complete list of TVX commands and user variables enter in the TVX terminal window:

**\*menu**

### C. Taking an Image

1. To set the exposure time to 10 seconds, enter in the TVX window:

**\*expt=10**

2. To take an image, enter:

**\*exp im0**

where **im0** is the name of the tif data file. After an initial delay of ~5 seconds, the shutter will open for the set exposure time. After the exposure is completed, 23 seconds are needed to download the image from the camera. The download is complete after receiving the message:

**0\*filling image from: (<image file name and path>)**

3. After taking an data image, take a background image of the same duration by entering:

**\*bkg im1**

where **im1** is the name of the background file. **bkg** takes an image without opening the shutter.

4. To subtract out the pixels hit by stray radiation (i.e. zingers), multiple sets of data and background images must be taken with the same exposure time.

### D. Viewing and Processing Data and Background Files

1. Data and background files are generated with a positive offset of approximately 10400. To view these images, enter:

**\*disp im0 10400 20000 5**

where **im0** is the name of the image file, **10400** is the highest pixel value that is rendered black, and **20000** is the lowest pixel value that is white (best value varies with amount of signal recorded). The final entry (i.e. **5**) is a scale value between 1 and 20 that determines the gray scale rendering of pixels between the black and white limits.

2. Many image manipulations can be performed with the **move** command, such as:

**\*move im2=im1/2** (sets **im2** equal to **im1** divided by 2)

**\*move im3=im1+im2** (sets **im3** equal to the sum of **im1** and **im2**)

**\*move im1=im1-5000** (subtracts 5000 from each pixel of **im1**)

3. There are two TVX instructions for removing zingers from data and background image sets:

**\*dezing im3 im1 im2 <optional additional images>**

where **im3** is the destination file name given to the average of **im1**, **im2** and any additional images after the zingers have been removed.

**\*move im3=im1:im2**

causes the sum of **im1** and **im2** to be stored in **im3** after the zingers have been removed.

4. After combined files without zingers have been made for both the data and background image sets, the two files can be subtracted from each other. The resulting difference file has the desired data with zero offset, lacking only the intensity and distortion corrections.
5. Note: It is possible to take images using the full 65535 ADUs possible with 16 bits per pixel. However most TVX commands see the values as 16-bit 2's compliment numbers so anything over  $2^{15}$  is treated as a negative. If there are pixels with values greater than  $2^{15}$  in an image, the entire image (and its companion background images) can be divided by 2 using either:

**\*move im2=im1/2**                    (**im2** is set to  $\frac{1}{2}$  **im1**)

**\*move im2=im1>>1**                (**im2** is set to **im1** right shifted by one)

This should be done before the addition or subtraction of any images to avoid negative pixel values giving erroneous results.

## **E. Focusing the Detector**

1. Checking the detector focus requires a suitable hole mask and a defuse source of x-rays large enough to cover the active area of the detector. MacCHESS has both a tungsten mask with a 1mm pitch square array of 75 um holes and a TruFocus TCM-5000M powered x-ray generator (see Bill Miller). To use the generator, proper safety precautions must be followed. At CHESS, the generator can only be used inside a hutch with the generator interlocked with the hutch door.
2. Before focusing, check the proper attachment and positioning of the lens system parts with the detector. To do this, the Velcro attached wraparound light shields should be removed. First, make sure the brass lens extension (screwed into the detector) and the Nikon bayonet style lens mount (screwed into the extension) are screwed on as far possible (both are right hand threads). The lens must be securely locked into the mount. Working out from the detector, the first movable ring on the AF Micro-Nikkor 60mm F/2.8D lens controls the F-stop, which should be fully open (turned all the way clockwise when facing the detector). The M (manual) or A (autofocus) switch should be in the M position. The large lens screw focusing ring should be set to the minimum distance (all the way clockwise when facing the detector). Reattach the Velcro attached wraparound light shields.
3. Tape the hole mask to the front of the detector and place the detector about one meter from the TruFocus x-ray source. Adjustments to the focus are made by varying the distance between the lens and the phosphor screen using the micrometer adjustment on the side of the detector. The correct focus is found by comparing images of the hole mask taken at various positions on a trial-and-error basis. Note: The micrometer adjustment is highly susceptible to backlash. Each position should be arrived at while turning the micrometer in the same direction. When the blurriness of the hole images has been eliminated, the detector is focused.

## F. Intensity and Distortion Correcting the Images

1. The files needed for intensity and distortion corrections have been placed in the directory: **/home/specuser/tvx/corfiles**. The current (10/05) files are:

**FLI12kvIcor1.tif** Intensity correction file with x-ray generator set to 12 kV. This is the default intensity correction file and is optimum for ~8 keV x-rays.

**FLI18kvIcor1.tif** Intensity correction file with x-ray generator set to 18 kV. This file can be used for x-ray energies greater than 12 keV. Due to the high quality and uniformity of the phosphor layer, the difference between corrections done with these two files will be less than one percent.

**FLIXcor1.tif FLIYcor1.tif** X and Y spatial distortion correction files good for no binning. No correction files are currently available for binning greater than one. Note: All four correction files are good only with the detector in its current configuration (active area = 59x59 mm). Any adjustment to the lens system would require a new set of correction files.

2. First, set the files used for intensity and distortion corrections using the commands:

```
*setint /home/specuser/tvx/corfiles/FLI1XkvIcor1
```

```
*setdist /home/.../corfiles/FLIXcor1 /home/.../corfiles/FLIYcor1
```

3. Intensity and distortion corrections can then be performed by:

```
*move im2=im1!imc      (im2 set to intensity and distortion corrected im1)
```

4. The user now has the final image file in tif format with no offset, and it has been intensity and distortion corrected.

## G. Final Instructions

In case of software difficulties that don't respond to the usual rebootings, the computer parallel port may need to be reset. This can be done in a Linux terminal window by a "superuser" with:

```
su      (request to be a superuser needs the root password, see Phil S.)
cd /proc/fli/fliport_0
echo "1">reset
```

From this directory the cat instruction can be used to generate useful information for debugging.

## H. Interfacing with SPEC, Checking the Necessary Macros (at start of run)

1. The following procedures are designed to work at C-Line. Similar steps could be made to work at other stations using their own versions of the necessary macros. On the station computer in a Linux window type:

```
cd /home/specuser/Macros
```

```
ls
```

The resulting macro list must include **fli\_ccd\_mode.mac** and **userlist.mac**, as well as a directory **FL\_c1** (or **FL\_XX**, with **XX** = appropriate station name).

After typing:

```
cd FL_c1
```

**ls**

The file **fliccd\_for\_c1.mac** should be in this directory.

2. The listing of user macros, **userlist.mac**, needs to reference **fli\_ccd\_mode.mac**. In a SPEC window on the station computer, open an editor by entering:

**umedit userlist.mac**

The macro should contain the line:

**udo fli\_ccd\_mode.mac**

3. The macro **fli\_ccd\_mode.mac** needs the correct IP address for the detector computer. To determine this address, open a Linux terminal on the detector computer and type:

**/sbin/ifconfig**

Look for: **inet addr: 128.84...** where the **128.84...** number is the IP address.

4. Check that the macros on the station computer use the correct IP address for the detector computer by typing:

**umedit FL\_c1/fliccd\_for\_c1.mac**

Look for the line:

**HOSTIP\_HOSTPORT = "128.84..."** with the correct IP address in it. If

the address is incorrect, use the editor to correct it. Save the corrected file and exit the editor.

## **I. Interfacing with SPEC, Starting Conditions**

In most all cases, Chess users want to take images on the FLI detector under SPEC control. In that case the images should be taken using just CAMSERVER and SPEC without TVX, which can interfere with SPEC's connection to CAMSERVER. This can be done using the following procedures:

1. Start CAMSERVER on the detector computer (see Section B.2). In a Linux window enter:

**cd camserver**

**./camserver**

2. To start SPEC on the station computer, open a Linux window and navigate to the folder in which data will be stored for the current CHESS experiment:

**cd /home/specuser/<experiment/group folder name>**

Opening SPEC from that location sets the default location of all SPEC data files.

Type:

**spec** (or **fourc**, etc.)

3. At this point TVX can be started (see Section B.3) so long as no connection is made between TVX and CAMSERVER. Do NOT try to take images with TVX (i.e. do NOT use **\*exp** or **\*bkg**) and do NOT run the **default.gl** file. TVX can be used to view images, do background subtractions and perform intensity and/or distortion corrections of images, none of which involve CAMSERVER.
4. In order to take dark images for background subtraction, the control of the separate in-hutch beam shutter (usually placed in front of the sample) needs to be independent of the SPEC count commands (**ct**, **dscan**, **ascan**, etc). To do this at C-Line, connect the shutter to the 0<sup>th</sup> channel of the VME Digital I/O

board. Once this connection is made, the SPEC commands **opens** and **closes** result in TTL high (open) and low (closed) signals controlling the in-hutch shutter independently from the count commands. NOTE: If SPEC ever returns an error message indicating it can't initiate a count because the shutter is open, typing "**closes**" should solve this problem.

## J. Interfacing with SPEC, Mounting Station Hard Drive on Detector Computer

1. To store images on the station hard drive, the drive needs to be mounted on the detector computer. To check if the drive is mounted, open a Linux terminal on the detector computer and enter:

```
cd /misc
```

```
ls c1
```

If this comes back blank, the station hard drive is NOT mounted on the detector computer.

2. To mount the drive, type in the same Linux window:

```
sudo ./connectc1 and use the standard specuser password.
```

Now any files written to **/misc/c1** from the detector computer will be stored on the station hard drive. If TVX is being used to view or process the images, in the TVX window on the detector computer change the default image directory path (see Section B.5) by typing:

```
*imagepath /misc/c1/<experiment/group folder name>
```

## K. Controlling the FLI detector from SPEC

1. At this point the SPEC computer is ready to take images with the FLI detector. Images will be stored in the same base directory as the other data files. Images files will be assigned the name:

```
<newfile name> _XXX_YYY.tif
```

where <newfile name> is the current file name set with the SPEC **newfile** command, **XXX** is the 3-digit scan number and **YYY** is the 3-digit point number within that scan.

2. To take an image every time SPEC does a count, in the SPEC window type:

```
ccd_on
```

This works with all SPEC commands that initiate single or multiple counts, including **ct**, **dscan**, **ascan**, etc. A 10-point scan will take 10 images. To take a count without taking an image, type:

```
ccd_off
```

3. To take a 10 second dark image for background subtraction, at the SPEC prompt, enter:

```
dark 10
```

SPEC will then take two dark images, dezingers them, and store the resulting average in the file **dark10.tif** in the default data folder.

4. For single images, SPEC can do an automatic dezingering, background subtraction and intensity/distortion corrections when taking the image. For example, after typing:

```
corr 2 10
```

SPEC takes two 10-second images, dezingers them, then subtracts the dark10.tif file from the combined result before performing intensity and distortion corrections. If the spec filename is "jones1", then the raw ccd images will have names like "jones1\_002\_000.tif" (where "2" corresponds to the SPEC scan number), while the corrected image will be "jones1\_002\_cz.tif" (where cz indicated corrected and dezingered).

5. For multiple scanned images, no automatic correction command is available to take images at this time. SPEC commands do however exist to speed this process. For instance, suppose that a scan has been taken using the command:

**dscan th -.1 .1 20 1**

which would take 21 images. If the above scan was scan 9, then the SPEC correction command would look like:

**flcorrect id -s jones1\_009\_0[0-9][0-9].tif -b dark1.tif**

NOTE the use of "-s" rather than "-sz" indicates that the images should NOT be averaged together and dezingered. The output should have names like "jones1\_009\_019\_c.tif". The above should be tested to verify that it is working as intended before critical data is taken.

6. To facilitate the viewing of images, there are normally two adxv processes running, one to look at arbitrary images and one to auto load the current image. To invoke these routines, at the Linux prompt type:

**adxv -autoload &**

which starts the autoloading version while entering:

**adxv &**

loads the non-autoloading versions. TVX commands can also be used to view the images from the detector computer (see Section D).