# Fast CCD Detector
# Quick Start Guide

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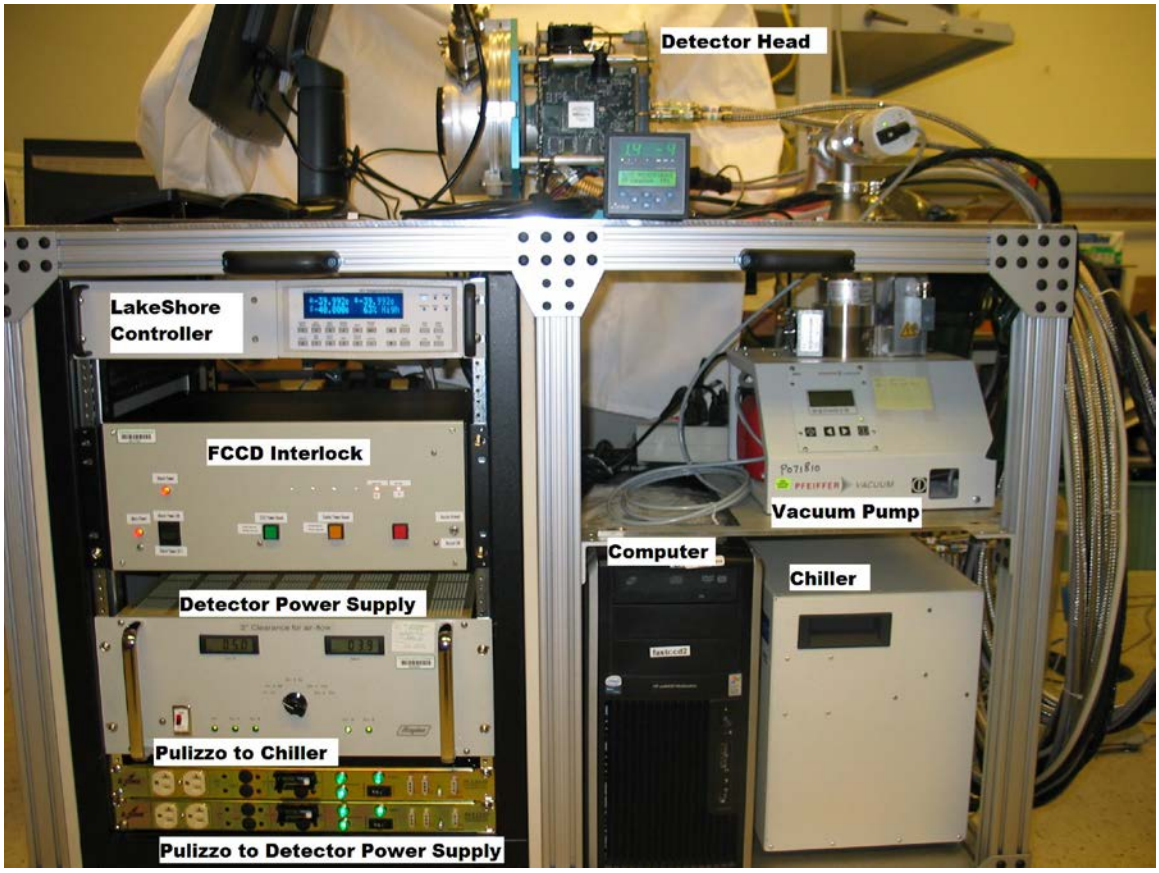
# 1.0 How to set up the detector

The detector resides on a single cart and consists of the following components.

- Detector Head
- Detector Computer
- Chiller
- Vacuum Pump
- Lake Shore Temperature Controller 331
- FCCD Interlock
- Detector Power Supply
- Pulizzo power outlet for Chiller
- Pulizzo power outlet for FCCD Power Supply




It is easiest if the whole cart fits into the hutch. If not you may need to disconnect and reconnect the following:

- Cryo-tiger lines between cryo-head and chiller
- Camera Link cables between the computer and the detector head
- Power supply cable between the power supply and the detector head
- Interlock cable between the interlock and the detector head

Place the detector head where you want it and reconnect.

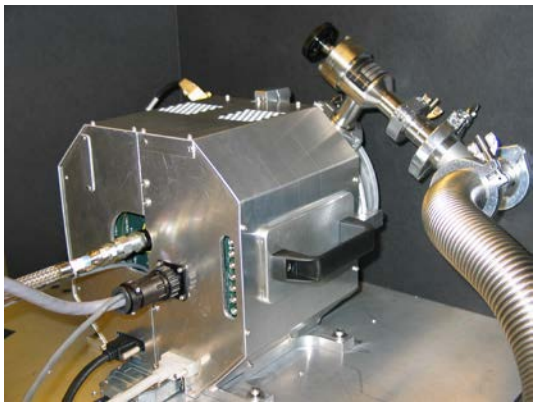
# 2.0 How to turn on and use the detector

Once the detector is properly hooked up, do the following:

1. Plug in the two pulizzis, the power strip, and the vacuum pump. Turn on the power strip. And turn on the vacuum pump.

2. Turn on and log into the detector computer
   a) Username: fastccd
   b) Password: xray2Data

3. **Verify the fans are on** for the back end electronics by holding you hands over the vent holes. If the fans are not on, make sure that the Interlock cable is connected to the back panel of the detector (A black connector with a gray cable) and that the fan power supply is plugged into the isobar power strip.



4. **Turn on the interlock module**. This requires turning on the switch in the back, then the switch on the front, and then finally pressing a power on button on the front panel. The button is not shown in the image below, but is on the upper left side to the right of the board power LED. After the interlock board is on you need to turn on the power to the computer in the box. This is a small switch in the back of the module.

5. **Verify that the Lake Shore Controller is turned on**, the set point is at -50 degree C and that the heater is in its high range. The interlock box should initialize the Lake Shore controller on power up, but it can be done manually too.
   a) To set the temperature press "set point" +/- 50 enter.
   b) To select the heater range press "Heater Range" until high is on the screen, then press "enter"

6. **Open the Interlock MEDM screen**. This will allow you to monitor two temperatures, a pressure and the power status on the Interlock GUI. **When the detector is on and running** the CCD temperature will be around -50 degree C, the Circuit Boards temperature will be around 35 degree C, the Detector Chamber

pressure will be around .14 mTorr or lower, and the Cooler Power and Board Power should both be on. To Open the MEDM screen:

a) Double click on the "InterlockMedm" Icon in the top middle of the screen

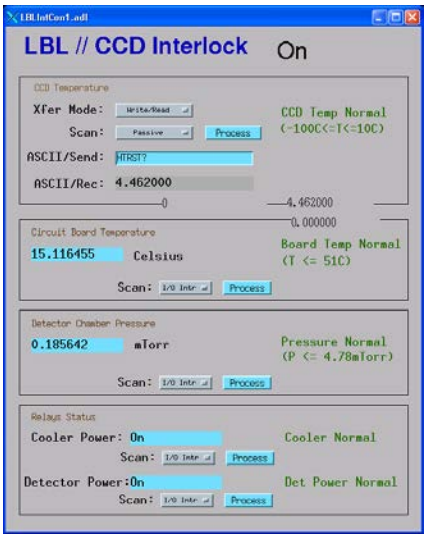



**Figure 1 - Interlock MEDM Screen**

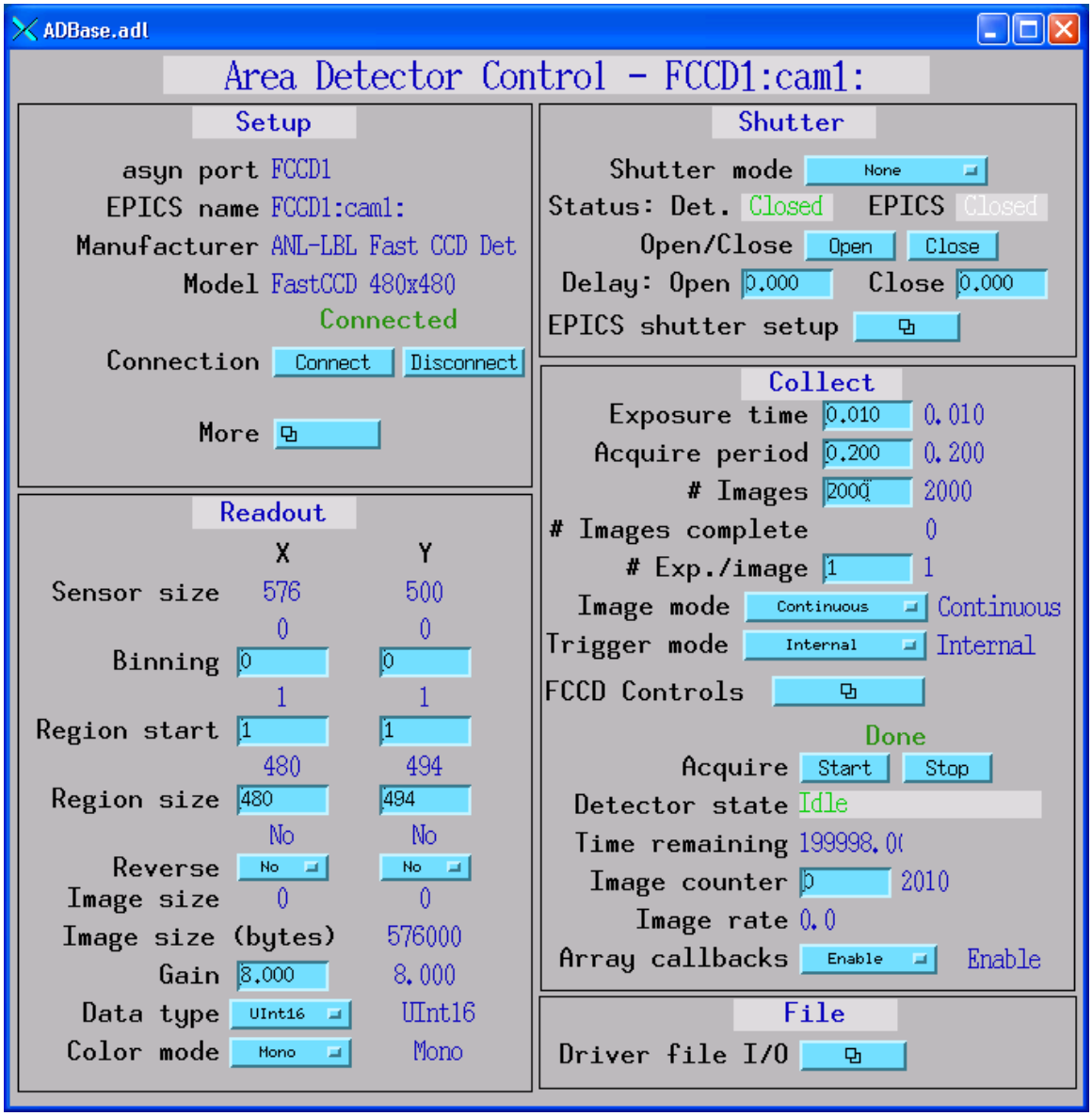
7. **Reset the chiller power** on the interlock box. Do this by pressing the Cooler Power Reset button on the front of the interlock box. Three green lights on the top pulizzi power strip should now be on. If not verify that the top pulizzi is turned on and in the remote mode.

8. When the pressure is ≤ 8 x $10^{-4}$ mtorr, **turn on the chiller** by flipping the switch on the side of the chiller up. If the vacuum pressure is too high, the interlock should turn off the chiller to prevent frost from building up inside the detector.

9. When the lakeshore shows the temperature of -50 degree C from "control A" temperature, you can **reset the detector power on the interlock box** by pressing the CCD power reset button on the front of the interlock box. The three green lights on the bottom pulizzo should all be on. When this is true, the **detector power supply can be turned on** with the switch in the front of the power supply. If not verify that the bottom pulizzi is turned on and in the remote mode. The interlock system will prevent the detector from being turned on if the system is not under vacuum and not cold enough.

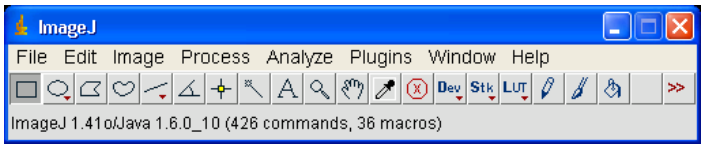
10. On the Computer, open the MEDM GUIs by clicking on the MEDM icon. At first all of the fields will be white, until you start up the ioc program. Once the MEDM screens are open start the ioc by pressing on the IOC icon. Observer the text and make sure it comes up properly. At the end of the boot up you should see the message "FCCDSerial: wait: Sending FCCD Configuration file: FCCD_config_default.txt" which is followed by "FCCDSerial: NIOS reply: InfMod ver 11-21-2008 at 11:15PM" and then FCCDSerial: DONE SENDING FCCD configuration file"

    To have the detector start taking images use the Area Detector Control MEDM screen. As an example you could set the Exposure time to 10 msec, the acquire period to 200 msec, and the Trigger mode to continuous. Then in the Acquire row press "start". You should see the Image counter counting. These images are not saved, but will allow you to look at raw images with Imagej.




NOTE: As shown, FCCD_config_defalt.txt is the default configuration file. It may be switch to "1jtw-2x-clocks-voltages-fcrics-Apr07d.txt" for 2x mode. (lower gain higher dynamic range)

11. To use ImageJ to view raw images:
    a) first start ImageJ by clicking on the ImageJ icon.

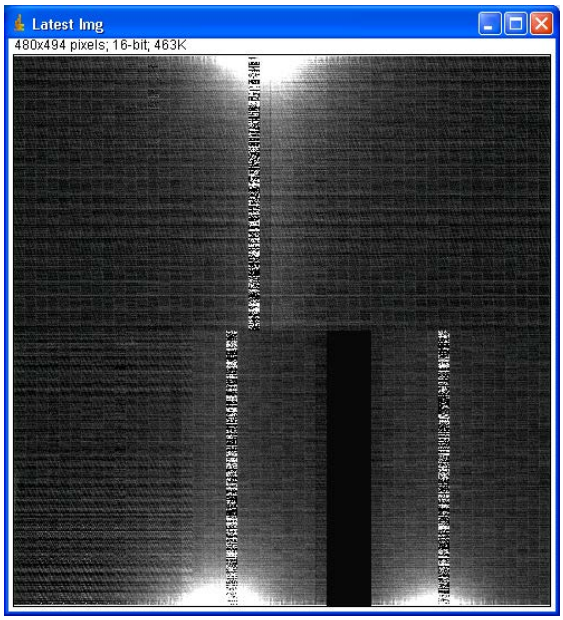


b) From the ImageJ window select Plugins->EpicsCA->epics ca Viewer

c)


d) In the Image J EPICS_AD_Viewer Plugin make sure that the PVPrefex is set to FCCD1:

e) If the detector is collecting images you will be able to press the Start button. This will popup an imagej view with the last image captured. To set the Brightness/Contrast you can either press "Shift-C" or from the ImageJ window select Image->Adjust->Brightness/Contrast. Adjust it so you can see the image as below.




12. To save a series of images to an IMM file the following steps need to be done.
    a) In the Area Detector Control MEDM screen
        I. In the Acquire row press "Stop"
        II. Set you Exposure time
        III. Set you Acquire period
        IV. Set the # Images to the number of images you want to collect
        V. Make the Image mode = multiple
        VI. You may want to clear the Image counter by typing 0 and pressing enter in the Image counter box.
    b) In the FCCD1:IMM MEDM screen
        I. Enter the File path
        II. Enter the File name
        III. You may zero out the Next file by typing 0 and pressing enter in the Next file # box
        IV. Set Auto Increment to yes
        V. Set the Write mode to stream

VI. Set the # Capture to the number of file you want to write to the IMM file. This should match the # Images written in the Area Detector Control MEDM screen
VII. In the Capture row press Start

c) In the Area Detector Control MEDM screen press Acquire Start
d) You should observer the counters in both Medm screens count up until they hit the desired number of images. Then it should stop and the file should be written.
e) To repeat another batch of images one only needs to press Capture Start followed by Acquire Start.

# 3.0 Turning off the system

Do the following steps if the system is being turned off for a couple of days.

1. In the FCCD GUI, put the Exposure Mode in Single mode
2. In the FCCD GUI, turn off the CCD
3. In the FCCD GUI, close the serial port
4. Turn off the CCD Power Supply
5. Turn off the cryo-tiger chiller
6. Turn off the Detector
7. Leave the vacuum pump on

If the system is being turned off for a few hours it is sufficient to just:

1. In the FCCD GUI, put the Exposure Mode in Single mode
2. In the FCCD GUI, turn off the CCD

Turning off the system to move it:

1. In the FCCD GUI, put the Exposure Mode in Single mode
2. In the FCCD GUI, turn off the CCD
3. In the FCCD GUI, close the serial port
4. Turn off the CCD Power Supply
5. Turn off the cryo-tiger chiller
6. Wait for the Detector to warm up to room temperature – 1 to 2 hours!
7. Turn off the vacuum pump AFTER THE DETECTOR IS WARM!
8. Turn off the Computer
9. Turn off the Interlock
10. Unplug all of the power cables
11. Put the Detector Head back on the Cart. This may require removing some cables and hoses.
12. Wind up all hoses and cables so that they are not dragging on the floor.
13. Move detector

# 4.0 Detector Trigger and Shutter Control

The detector can be triggered in a number of different ways.

1. External trigger with a signal going into a lemo connector on the back of the detector.
2. Software controlled trigger with a PC command
3. Fixed number of triggers started by either a single software trigger or an external Trigger. The time between triggers is the same specified for the focus mode.
4. Focus mode which generates a series of triggers with a specified time between triggers.

When a trigger happens, its starts an exposure delay and a shutter delay. Both delays have independent range of 0 to 1048575 usec. At the end of a delay then the exposure time or shutter time start. The exposure and shutter time both have an independent range of 0 to 1048575 msec. It should be noted that if you are using the internal control for the time between triggers that the trigger cycle must meet the two conditions below.

Trigger Cycle >= Exposure Delay + Exposure Time + Readout Time
And
Trigger Cycle >= Shutter Delay + Shutter Time

The FCCD User GUI below shows how the user can modify the Exposure Mode, and set the various parameters.

NEW GUI HERE

A typical way to hook up the detector would be to use an external signal to trigger the detector, and then use the shutter signal from the detector to control the shutter. You can define the “Delay between T->E”, “Exposure Time”, “Delay between T->S” and the “Shutter Time” to control you integration time and to synchronize the detector with external devices.

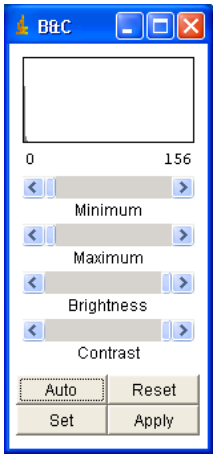
| LEMO | Function |
|---|---|
| J10 | Trigger Input |
| J12 | Input – Not Used |
| J13 | Input – Not Used |
| J8 | Exposure Output |
| J9 | Shutter Output |
| J11 | Shutter Output |

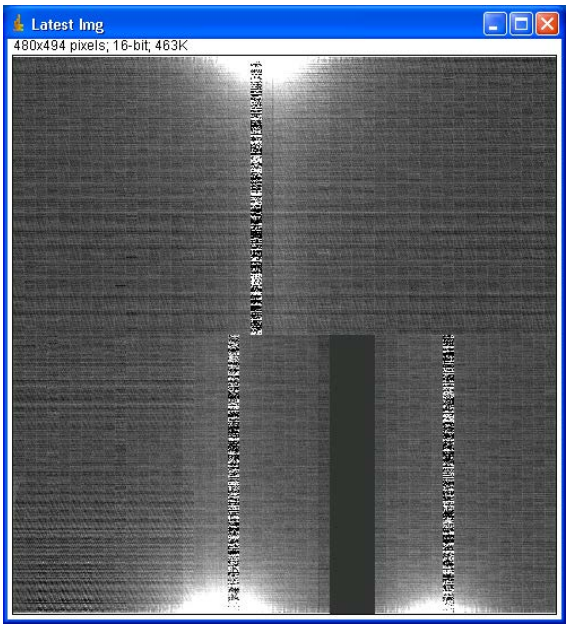
# 5.0 Using Anaconda board with onboard FPGA to subtract dark image and perform data compression

Below are the steps to perform dark image subtraction with the Coreco anaconda frame grabber board:

1. Start imageJ and run Plugins->EpicsCA->epics ca decomp
   The following window should appear. Make sure all of the PVs are filled in correctly. This version of the displayer will automatically switch between raw images and compressed images.

2. In the Image J Epics CA Plugin press Start. When there are images being captured they will appear in a display. You can set the background and contrast by pressing "Shift & C". To start images perform steps 3->6 and press Acquire Start.




3. In ADBase.adl - Set Exposure time (.010)
4. In ADBase.adl - Set Acquire period (.020)
5. In ADBase.adl - Set Image mode = Continuous

6. In ADBase.adl – press Acquire Start to take some images and view them in imageJ. Then stop the images by pressing Acquire Stop.
7. In FPGASEC8.adl put into SumMeanImg. For some reason SumStdImg mode did not work last time I tried it.
    a. When you switch to this mode the Detector state in ADBase will briefly change to Waiting. Wait for the Detector state to go back to Idle before continuing.
8. Set Num Images to Average to 64 or some $2^n$ value. 16 is the minimum number.
9. In ADBase.adl set the Image counter to 0 by entering 0 and pressing enter. This is just so you can easily see the number of images collected, and is not really nessisary.
10. In ADBase.adl press Image mode = Continuous and Acquire Start
    a. The image counter will count to the number of images you set to average and then stop itself.
    b. An image will be saved in the D:\cal directory, and will have a name MeanCal_date_time.tif
11. In FPGASEC8.adl press the Load Image. It should grab the last image saved to the D:\cal director. You should see Coreco message screen cycles through the following states and others I couldn't read.
    a. Coreco Armed and Ready
    b. FPGA IDLE
    c. Load CCF File
    d. Store Image file
    e. FPGA Store Dark
    f. FPGA PASS
    g. Load CCF file
    h. Coreco Armed and Ready
12. In FPGASEC8.adl put into DarkSub mode
13. In ADBase.adl press Acquire Start and observe the dark subtracted images in imageJ

To perform real time data compression one needs to perform the steps to capture an average dark image (outlined above) and then perform the steps below.
:
:

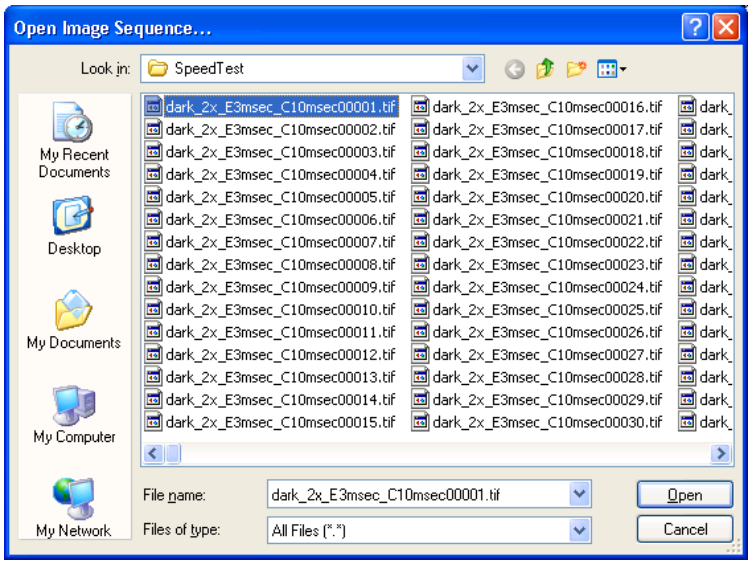
# 6.0 ImageJ Plug-ins

I have implemented a number of plug-ins in ImageJ for manipulate a stack of images. Below I have outlined how to use these plug-ins.

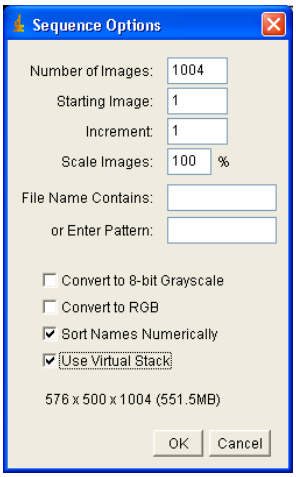
## *6.1 How to subtract a dark image from a stack of images*

1. Start ImageJ

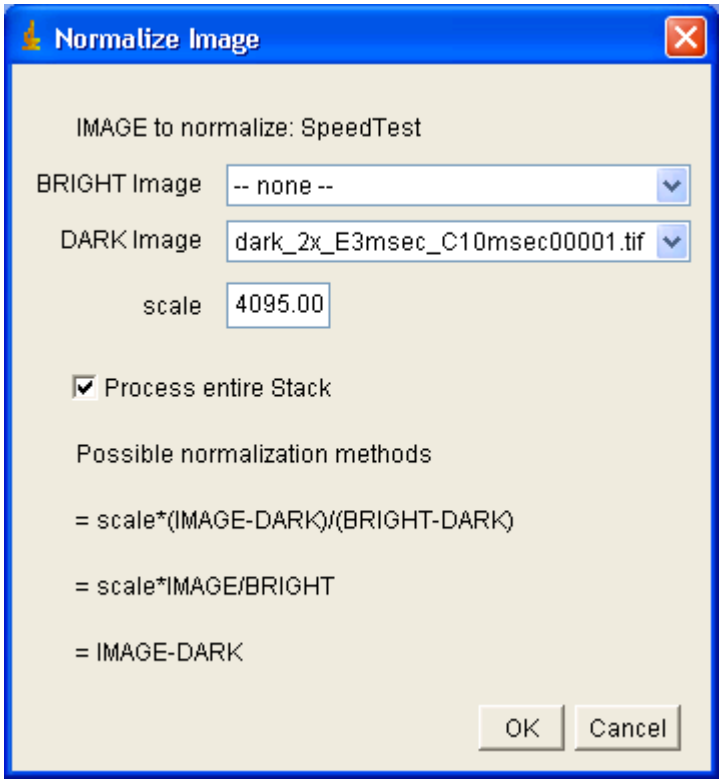
2. File -> Import -> Image Sequence
   a. Use the file browser to select a file in a directory



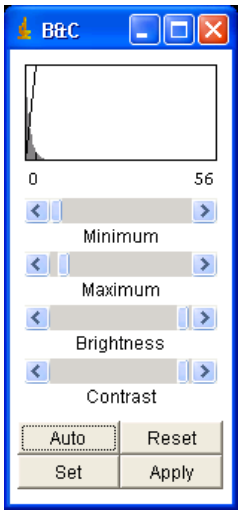

   b. If more than 1000 files are to be opened, click “Use Virtual Stack” in the Sequence Option window.




   c. Open the file to be used as the dark image by clicking File->Open and selecting the file in the file browser and pressing “Open”.
   d. Run the Normalize Plug-in by first selecting the stack of images, then run Plugins->Normalize. This will open the window below. Select the DARK Image to subtract, leave the BRIGHT Image Blank, Select “Process entire Stack” and then click OK. This will normalize all of the images in the stack.




e. To view the images properly you will need to set the brightness and contrast. Image->Adjust->Brightness/Contrast(Ctrl+Shift+C). This will open the window below:




f. Click Set and set the minimum display value to 0 and the maximum display value to 100. Alternatively, use the slides.

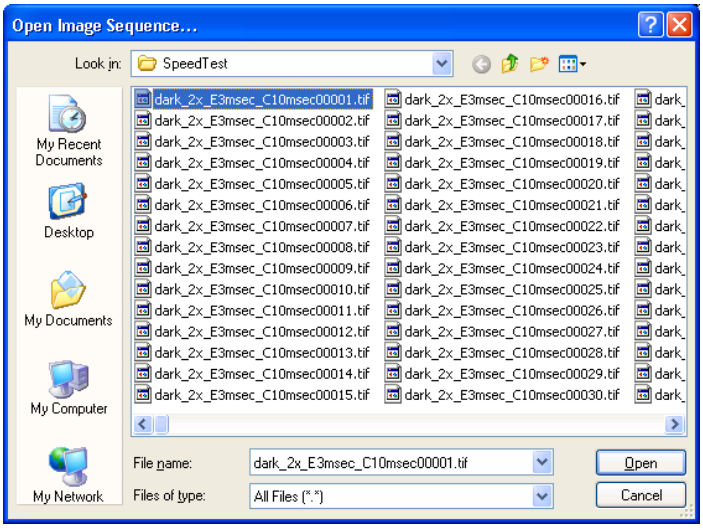
g. Note: The slide on the bottom of the image will move you quickly through the stack.

At this point it might be good to remove the over scan areas. Do this by following the procedure in the next section.

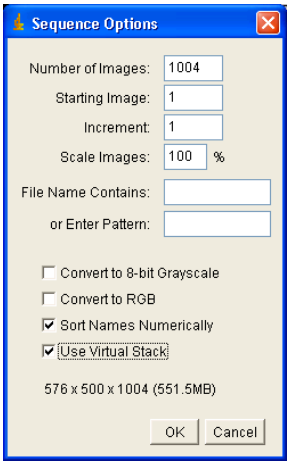
## 5.2 How to removing over scan from a stack of images

1. Start ImageJ
2. File -> Import -> Image Sequence

   h. Use the file browser to select a file in a directory




   i. If more than 1000 files are to be opened, click “Use Virtual Stack” in the Sequence Option window.



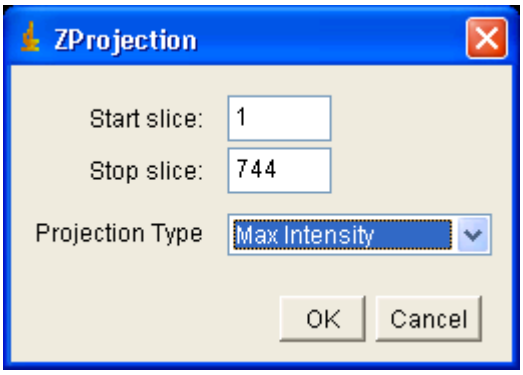

   j. In ImageJ select Plugins->FCCD RemoveOverScan
   k. This will create a new stack of images with the over scan removed. The new images will all start with FCCDClean.... This process needs to be made faster!
   l. To make the image look proper the offset and contrast may need to be adjusted. This can be done by selecting Image->Adjust-

>Brightness/Contrast (Ctrl+Shift+C). Use the sliders in the window to adjust the image pallet.

One could also remove the three noisy ADCs by selecting the plugin “FCCD RemoveNoiseAndOS”.

## 5.2 How to do ImageJ z-projections

Another useful feature of image J is to look at a pixel-by-pixel projection of a stack with the maximum, minimum, or the average values of the pixels for the entire stack. This can be done by selecting: Image->Stacks->Z Project..

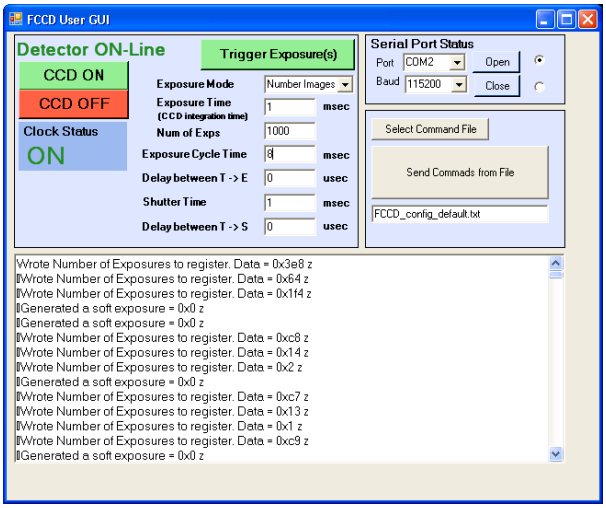



Click OK.
This will open up the projection in a new window.
If you look at the maximum values, it is easy to see zingers that were captured in the stack of images.

# 6.0 Storing images at full speed

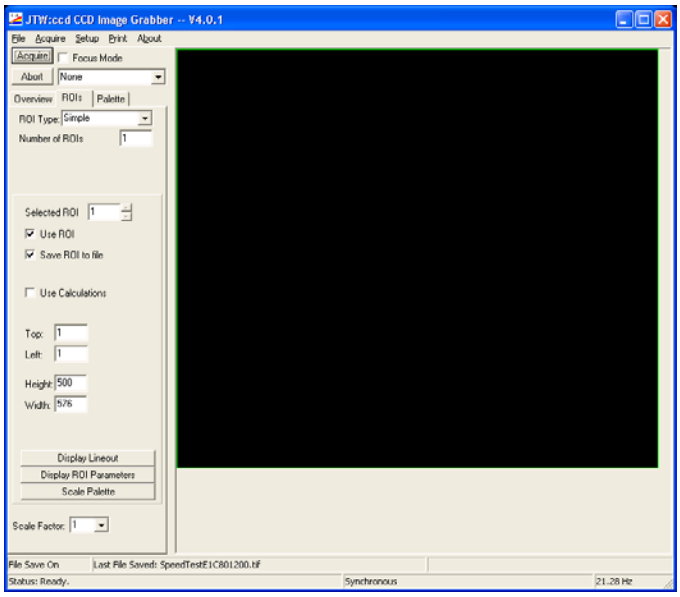
For now, you can only go at full speed for a fixed number of images equal to the size of the storage buffer in the frame grabber. This is around 1000 images.

1. Set the FCCD User GUI as below:




2. Set the Image Server Up

   a. Setup-Acquisition – Synchronous, Exosures = 1000, Physical Memory Buffer set to 800000 (1422 buffers Allocated)
   b. Setup-Background = None
   c. Setup-File System – TIFF, File Index 1, Desired Directory, SpeedTestE1C8$#.tif or some other file name
   d. Next to the Abort button, select “None” from the select menu. This will prevent images from being displayed on the screen.
   e. In the ROIs tab check “Use ROI” and check “Save ROI to file”
   f. Finally press “Acquire” in the Image Server. The image server will then be waiting for 1000 images from the detector. If you go to the Overview tab in the Image Server you can see the number of exposures being counted down and what was the last file written.

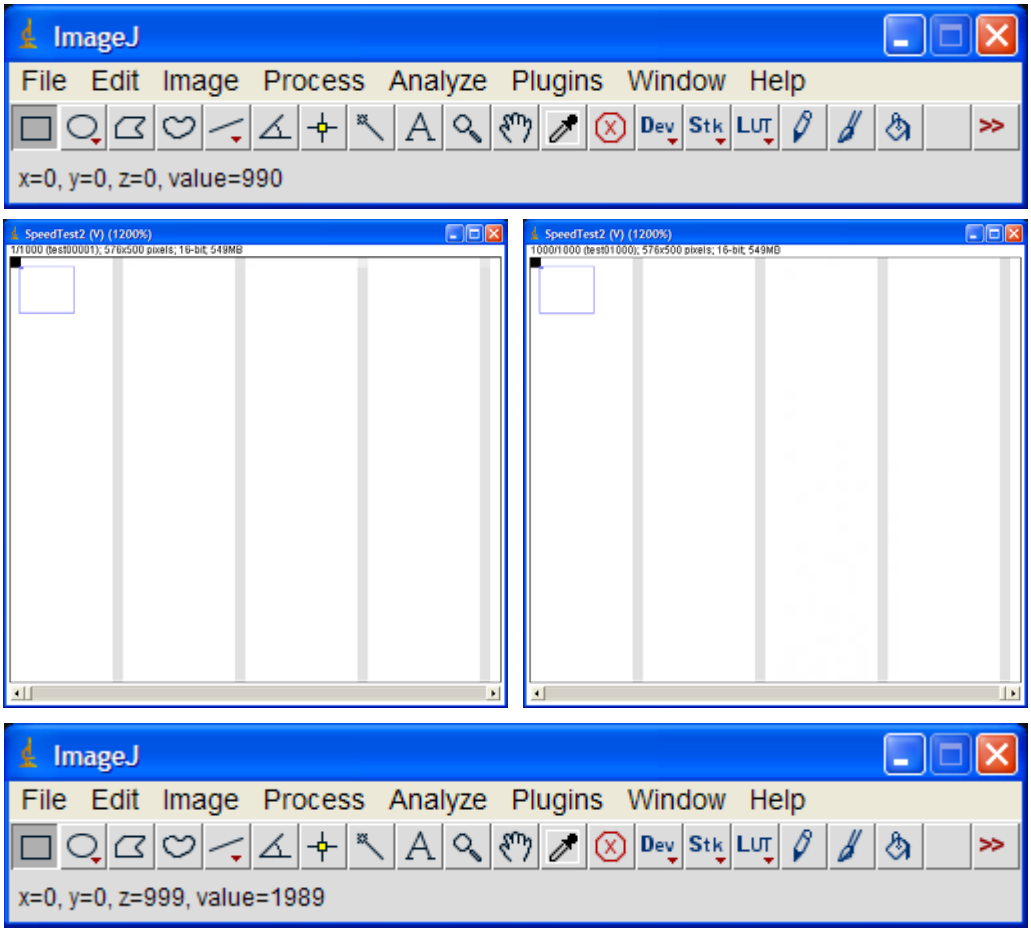



3. Press “Trigger Exposures” in the FCCD GUI.

You should see files being saved in the Image Server. After 1000 images have been saved, the Acquire button in the image server will be come dark again. This indicats that the acquisition is done.

To verify the images were saved without any missing images you can open them up with ImageJ. You may have to select “Use Virtual Stack” if you cannot fit all of the images into memory. The pixel in the upper left corner and lower right hand corner contains an image counter from the FCCD detector. To verify that no images have been dropped verify that this counter has been incremented by a 1000. In image J, zoom into the upper left hand corner of the 1$^{st}$ image and move the cursor over the pixel. Look at the main ImageJ window for the value of that pixel. Then repeat this for the last image. When you subtract the two values, it should be 999.

An example of the screens generated in this process is shown below.




Note: 1989 – 990 = 999