Users Guide for the GE amorphous Silicon "Angio" Flat Panel Detector

BTS group

Revision 3 (Last update 02/20/2009)

Content:

I) General Description

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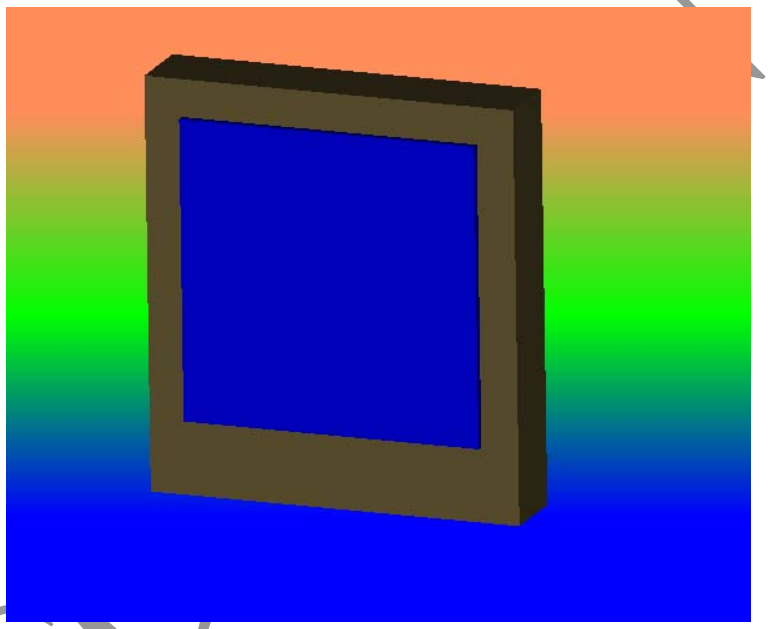
The GE detector, designed for medical X-ray machines, uses a plate of amorphous silicon to detect X-rays of high energy, on the order of 60keV to 80keV. The X-rays are converted to optical photons with a 500um thick CsI phosphor screen. The screen is about 70% efficient for 60keV X-rays. Note that direct conversion of X-rays to electronic charge is not done.

The detector is an array of diodes reversed biased at 9V. The diodes are initially charged to 9V, being used like capacitors. When light hits the diode, the charge drains proportionally to the number of photons. When the diode is recharged, the amount of charge needed to recharge is recorded as the amount of light which hit that pixel. One 80keV X-ray puts about 1400 electrons into a pixel. The read noise of each pixel is about 1400 electrons, making one 80keV X-ray giving an SNR of near 1, which is barely visible.

The detector has 2048*2048 pixels, to make a square 410mm*410mm detector. The pixel size is 200um. A simple drawing of the detector is shown below.



The readout electronics include readout modules with a total of 4096 A/D converters (2048 for each half of the detector). GE has developed ASICS with 32 A/D per chip arranged in 256-channel modules, allowing for the required miniaturization. The detector is read two rows at a time (one row from each half), so that at each conversion cycle 4096 pixels are read simultaneously. The detector electronics dissipate about 90W of heat, so the detector is water cooled to maintain stable Silicon imager temperature..

The images can be read out in 125ms for a 2Kx2K image and 23ms for a 1Kx1K image, binned 2x2 or the center 1Kx1K without binning. The 2K images read at a maximum rate of 8Hz, and

1K at 30Hz. The data are read with 14 bit precision. Gains of the camera range from 275e-/ADU to 8000e-/ADU.

The software runs on a Windows machine and uses a COM interface. The core DLL which runs the camera is called ADEPT. Visual Basic scripts are used to create a GUI, supplied by GE. They supply also a command console package to call the DLL.

II) How to start the software.

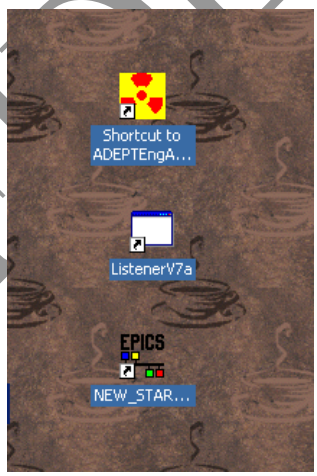
All critical programs have icons on the desktop in the upper right corner. ***Please do not move them.***

User: **ge_admin**
Password: XXXXXX

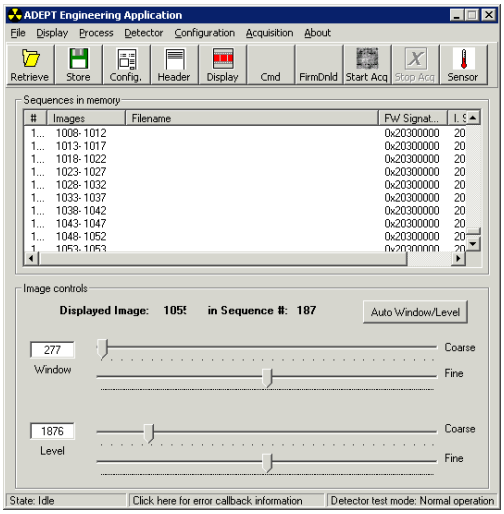
There are currently 3 software packages that need to be started to run the GE a-Si detector. They include:

- AdeptCore Engineering Application ("AEA")
- Listener (currently version = V10)
- EPICS.

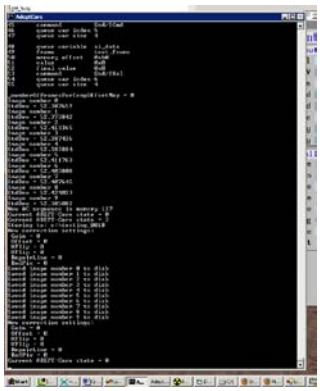
The three icons are shown below.



1) First, start the **AEA**. It will start 2 windows: the AEA and the AdeptCore terminal window.
   – AdeptCore gives low-level information about what is going on. (The only thing you need to check in the AdeptCore terminal is if the "signature" is correct. For Rad mode (2k x 2k), the signature should be 0x02030000. See Appendix A). You normally do not need to use the AEA window, so you can just **minimize** it. (***Don't close it.***)

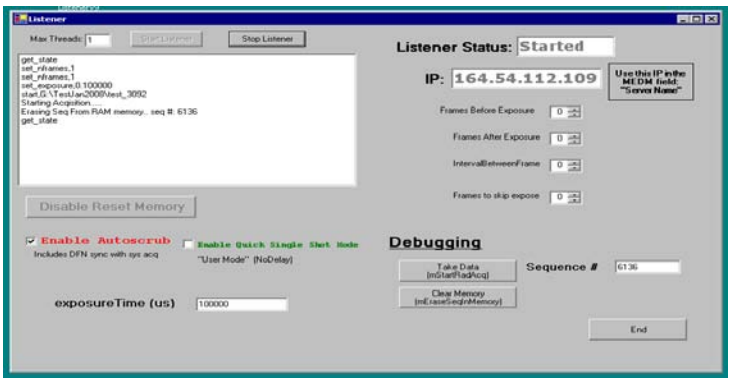


AEA Application (**Minimize!!**)



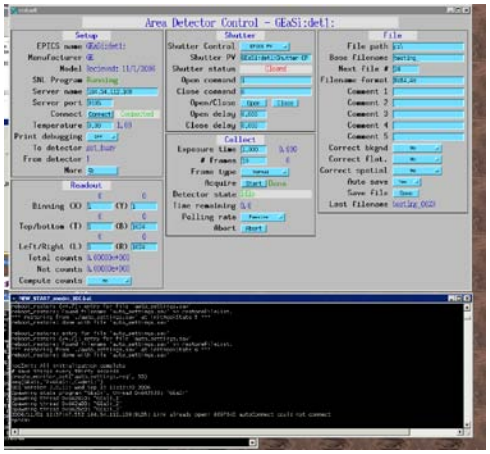
AdeptCore
(Low-level detector Info)

2) Start **Listener**. (May take up to 2 minutes to start. ***Make sure it is started!***)
   - This window allows you to turn on and off the Autoscrub. We recommend that you leave it Enabled.
   - We also recommend that the Reset memory is Enabled. This deletes a sequence of images from RAM memory at the end of the sequence.
   - Under normal operation the "Enable Quick Single Shot Mode" checkbox should be left unchecked. See Appendix E for its usage. Please note that only one single frame per sequence will be taken if this box is checked.
   - The Listener functions as a link between EPICS and AdeptCore. You will see commands that are sent from EPICS to the detector/AdeptCore. (Note: Listener will not start until the "Settling time" is zero. This is at the bottom of the Config Window of the AEA.)
   - The software allows you to change the number of before and after frames, but typically these are set to zero and the "during" or real data frames are set in the MEDM screen below.

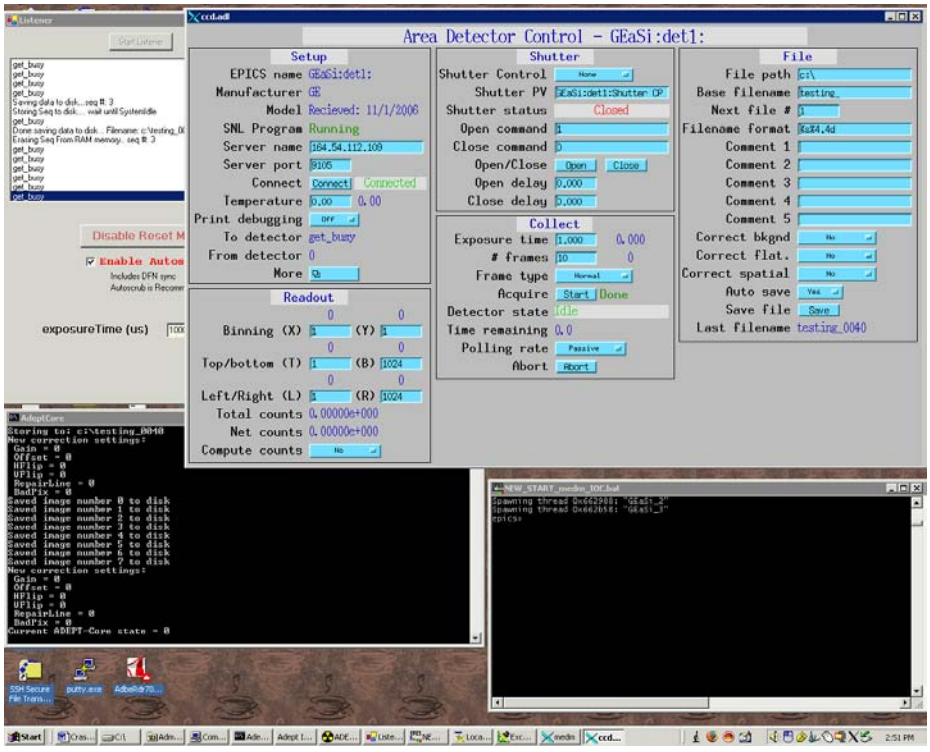


Listener ***(Make sure it is started!)***

3) Start **EPICS**. Make sure the Server Name matches the IP address from the listener. The EPICS shell terminal can be minimized but make sure you do NOT start more than one, e.g. if you have to re-start.

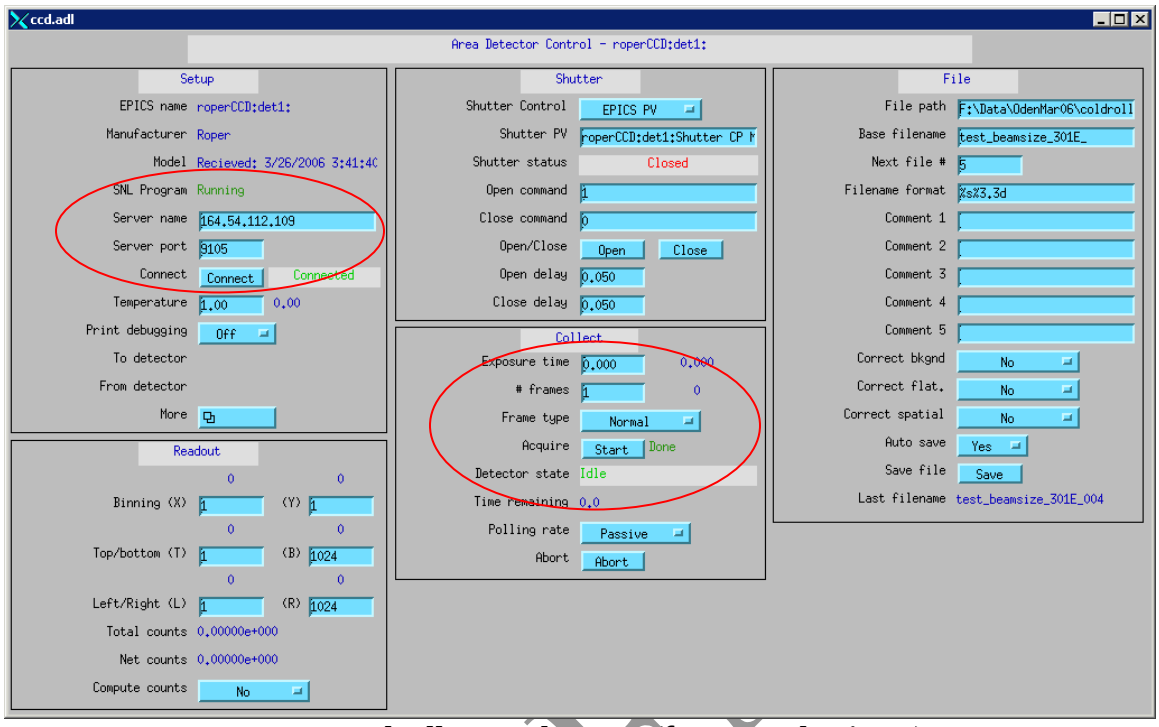


MEDM control window & epics terminal
You can minimize the epics terminal.
Be careful to have only one instance of EPICS



Recommended Desktop Layout

III) Control PVs.



MEDM ccd.adl control screen (from Mark Rivers)

- Most commands are not implemented for GE detector (yet). Ones that work are circled.
- The "Connect" button is used to reconnect if the Listener or Adept program crashes.
- The first time that the Detector moves to the new subnet (i.e., a new sector), you need to change the Server name to match the IP address of the computer. The Listener will display this. You need to enter this IP address into the MEDM screen and click on the "Connect" button. The EPICS autosave application will save this value from here after.

1) **Exposure Time**: This is for each frame/image and is in units of SECONDS, here. [In GE's language, it's the "time between frames (TBF)".]

2) **# Frames**: The number of images you want in your sequence. ***Must be less than 260 or the system will crash!***

3) **File Path**: ***Make sure that this path actually exists!*** It is recommended to keep the file path fixed during the run and only change the filename. Also, include a \ at the end of the path (e.g., **C:\Data**)

4) **AcquirePOLL** – If you are using spec, please trigger image acquisitions with the AcquirePOLL PV. There is also an AcquireCLBK, but is only useful when using EPICS sscan record.

5) **DetectorState:**

"Idle" (0)
"Acquire" (1)
"Error" (7) (e.g., disk full)

- **NOTE**: If you do a pv_get of DetectorState, you will get a string back (i.e., Idle or Acquire). I think there is a way to get an integer, but I don't know, yet.
- **NOTE**: In "Rad" mode, detector is 2k x 2k (no binning) with a 125 ms readout (8 fps). This speed is for no acquisition time, so real usage can only be slower. "The Angio" is 1k x 1k (2 x 2 binned) 0.033 ms readout (30 fps), and a 1k x 1k image is also possible in a ROI mode. The instructions below are for "Rad" mode.

6) **Gain Settings:**
   - ***For RAD firmware, use Timing Mode = 0 and Ramp = 3***
   - ***See Detector_Settings_Angio.xls file for complete discussion on gain settings and voltages.***

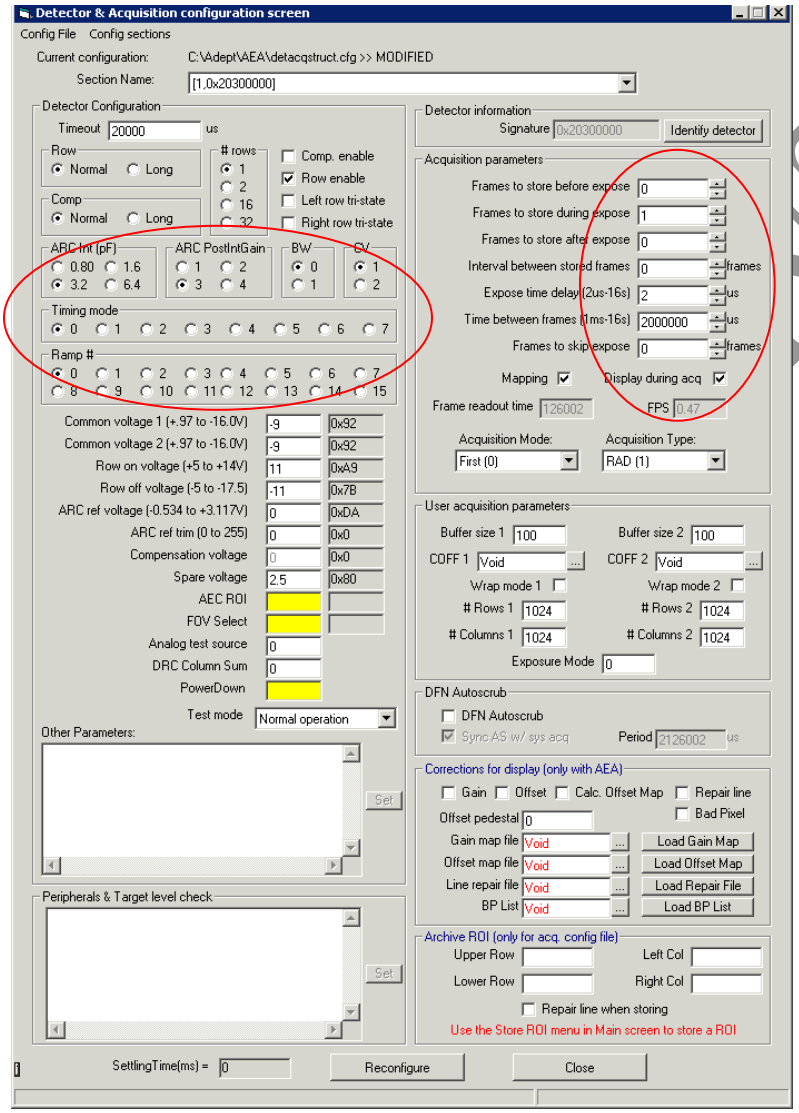
IV) Known Problems:

1) Occasionally the real-time image display on the second monitor will disappear. You will see errors after each image/frame is read into the RAM memory buffer (e.g., "**_processthread1**"). The data are still valid. To fix this, you need to restart AdeptCore, and thus EPICS and the Listener. We have reported this problem to GE, but they are unsure of the cause.

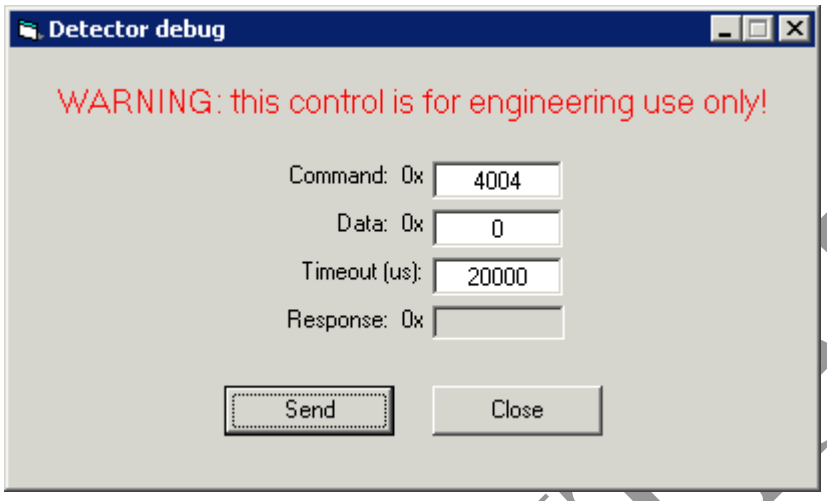
2) From the EPICS interface…. the ***very first time*** that you try to acquire a sequence of images, the exposure time and number of images are NOT those which are specified in the EPICS screen. Rather, the EPICS screen uses the parameters last in the Adept AEA Config window. But all other acqusisitons from EPICS seem to work and you can change the exposure time and number of images without a problem.

V) Expert AdeptEngApp Config Window (do not use unless you fully understand the consequences.)

- Most fields should not be changed. Fields to modify:
  - Time between frames
  - Gain (see gain table) – See Detector_Settings_Angio.xls file
  - For RAD firmware, use ***Timing Mode = 0 and Ramp = 3***
  - Check if Signature is correct. If not, see Appendix A
- Normally, leave "Frames to store before exposure" and "Frames to store after exposure" to be 0.
- Time between frames is your exposure time.



Appendix A – Manual reload of active detector firmware.



- If the signature is not correct: from the AdeptEngApp, press the "Cmd" button. Put "4004" in Command and "0" in Data to force the system to reload the firmware.

- For Rad: From the Config. Button, select the [0x20300000] section from the pull down menu. The other signature are for Angio (Binning, 1k x 1k, 400 micron pixels), and Rad ROI (central portion, 1k x 1k @ pixel = 200 microns).

Appendix B – How to correct frames (i.e., dark , BPM, gain/flatfield correction)?

Ask your Beamline Scientist for the latest incarnation of this processing. These are typically located in: C:\Adept\Tools\Argonne\

Jscript (Microsoft) Correction:
Format: javascript.js imageframe darkframe #imageframes #darkframes

Scripts for PDF (from Karena Chapman/Peter Chupas/Peter Lee)
Typically, you create a MS-DOS batch file in the same directory as your images (e.g., process.bat), which contains commands like those below (assuming 2k x 2k mode!):

```
C:\Adept\Tools\Argonne\correctPDF_KWC.js Ge_A4_0009 dark_16s_50f 50 50
C:\Adept\Tools\Argonne\correctPDF_KWC.js Ge_A5_0010 dark_16s_50f 50 50
C:\Adept\Tools\Argonne\correctPDF_KWC.js Ge_B1_0011 dark_16s_50f 50 50
C:\Adept\Tools\Argonne\correctPDF_KWC.js Ge_B2_0012 dark_16s_50f 50 50
C:\Adept\Tools\Argonne\correctPDF_KWC.js Ge_B3_0013 dark_16s_50f 50 50
C:\Adept\Tools\Argonne\correctPDF_KWC.js Ge_B4_0014 dark_16s_50f 50 50
C:\Adept\Tools\Argonne\correctPDF_KWC.js Ge_B5_0015 dark_16s_50f 50 50
```

This will do a background subtraction, badpixel map, and gain-map/flatfield correction. (Note: the gain map used is from an x-ray tube and contains the spatial structure from the tube, i.e. falling off at the edges, thus is not really a flat-field.)

File Formats:
The corrected frames are stored in a file ending in **".cor",** except that the *8192 byte header is removed*, but the data format is the same as the raw data (2K x 2K, 16-bit unsigned integers). This script also creates an average **(.avg)** and a **.sum** file. The original 8192 byte header is also removed. The data format of the avg files are the same as the raw data (i.e., 2K x 2K, 16-bit unsigned integers (sizeof(unsigned short)). However, the sum files are 32-bit floats/real ((sizeof(float))).

Appendix C – How to use ImageJ

To read in raw GE files:

File → Import → Raw

Settings: 2048 x 2048
16-bit unsigned int
8192 offset (for GE header)
little-endian byte-order
# of Images (depends on how many in your sequence.)
Gap Between images = 0

Appendix D – Autoscrub Info (from German Vera @ GE)

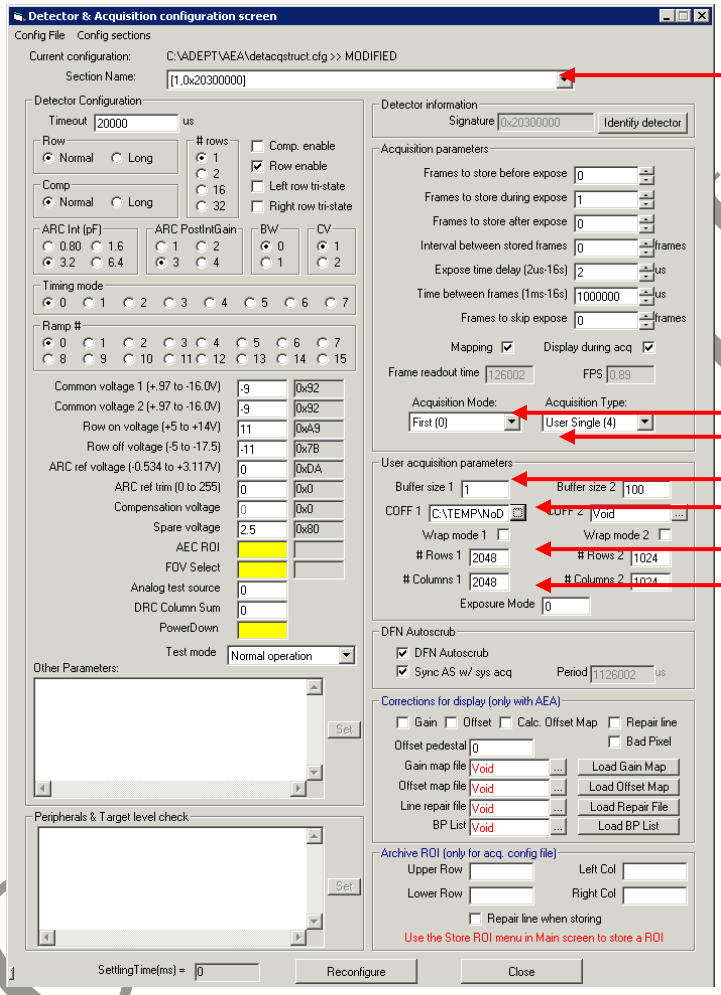
When DFN autoscrub is off, the DFN does not send scrub commands to the detector periodically. If the detector does not receive any scrub or image readout commands from the host for ~15 seconds, it will start autoscrubbing with a short time between scrubs (~5ms). When an acquisition is started, the detector may be running its internal autoscrub or may be just idle, so the time since the last scrub will be variable and will affect the dark frame portion of the images that are acquired. This means that offset subtraction using a previously acquired dark frame will not be complete, i.e. there will be some dark signal left. The amount of dark signal left can potentially change from acquisition to acquisition.

If you want to start an acquisition very quickly, a better solution would be to enable DFN autoscrub, but disable 'Sync A/S w/ sys acq'. In this case, you can specify the autoscrub period, as follows: Scrub Period = Timeout + Autoscrub Delay (labeled Delay in the DFN autoscrub section of the config screen). So, if you are running Rad mode (126ms readout time) and your timeout is 20ms, you could set the Autoscrub Delay to be 116ms, so you have 10ms between scrubs. Then, any acquisition will take from 0 to 136ms to start, plus one extra 126ms frame time. The benefit of doing this is that now your acquisition is repeatable because you are going from scrubbing with a period of 136ms to image acquisition always, and you can acquire a dark image in the same way, so that your offset correction actually gets rid of all the dark portion of the image.

Appendix E – Single shot mode

Single Shot mode allows for one image to taken with very little over head. ***BEWARE: In this mode only ONE image is taken at a time!***

In the Detector & Acquisition configuration screen some parameters must be checked and changed. (Leave both windows open, but minimize)



1,0x2030000

Ac.mode: First (0)

Ac.type: UserSingle(4)

BufferSize: 1

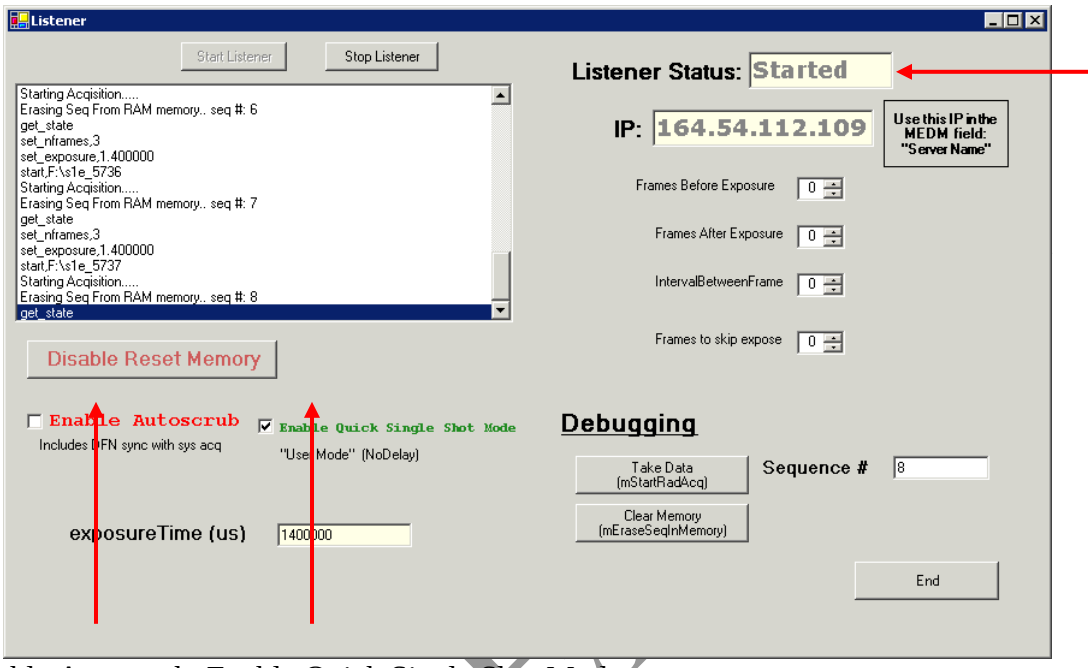
COFF 1: * (see below)

Row 1: 2048

Column 1: 2048

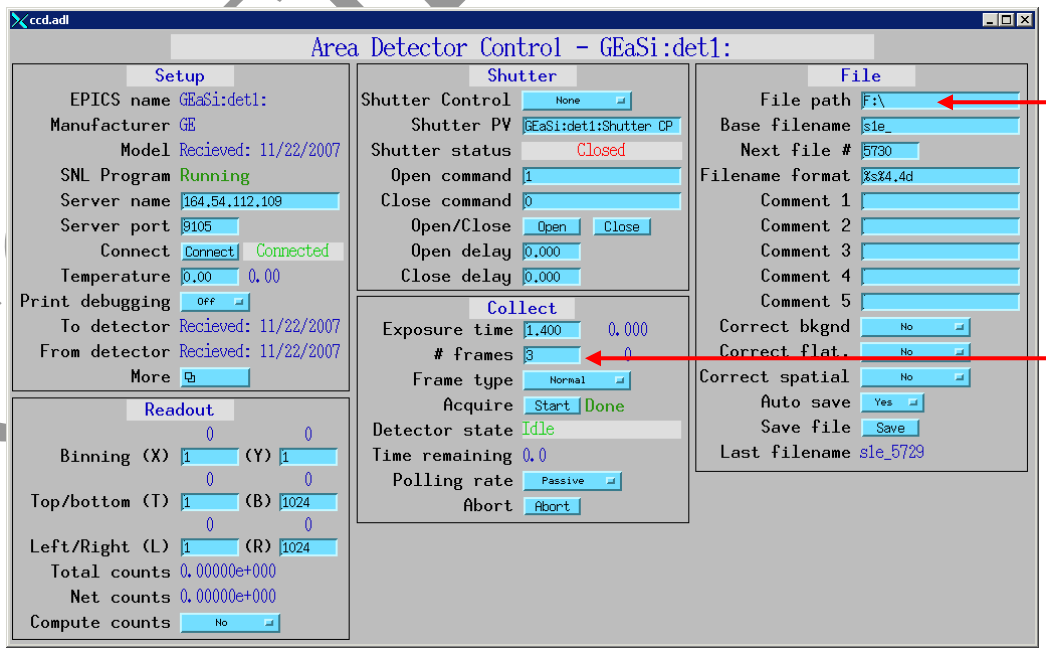
* C:\TEMP\ NoDelayDFNScript.bin

Start up Listener (This may take some time, as the AEA needs some settling time and counts down.) Be patient and make sure Listener has started.



Disable Autoscrub, Enable Quick Single Shot Mode

Finally, start EPICS (start_medm_IOC)



File path: F:\
The line [# frames: 3] is correct, but single frames are collected anyway.

Appendix F – Revision History

Sofware revision history:

Date	name	rev num	remark
1/21/2008	JL	10	Sponge only 2 threads in the Timer1 interrupt routine. One thread take care of the data taking request, which is a long blocking call, and the other one take care of the polling of the detector when the other thread is blocked.
11/6/2009	AM	12d	Changed to AcquirePOLL. EPICS SNL no longer polls to get_state. Instead the Listener sends caputs to DetectorState, AcquriePOLL and AcquireCLBK when done. Also added more error handing to catch things like disk being full, etc.

User guide revision history:

Date	name	rev num	remark
6/27/2007	AM	1	Orginial Version
1/21/2008	JL	2	Order the topic into its present format. Added the single shot mode description.
11/6/2009	AM	2	Change some things about using AcquirePOLL, etc.