



# **SI Image SGL Software Manual**

**(Software P/N 2479 Rev. E)**

**P/N 2523**

**Manual Rev. D**

©2011

Spectral Instruments, Inc.

Tucson, Arizona

The copyright below pertains to the TIFF library used in the tiff2vi.dll:

Copyright (c) 1992-1997 Sam Leffler

Copyright (c) 1992-1997 Silicon Graphics, Inc.

Permission to use, copy, modify, distribute, and sell this software and its documentation for any purpose is hereby granted without fee, provided that (i) the above copyright notices and this permission notice appear in all copies of the software and related documentation, and (ii) the names of Sam Leffler and Silicon Graphics may not be used in any advertising or publicity relating to the software without the specific, prior written permission of Sam Leffler and Silicon Graphics.

THE SOFTWARE IS PROVIDED "AS-IS" AND WITHOUT WARRANTY OF ANY KIND, EXPRESS, IMPLIED OR OTHERWISE, INCLUDING WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

IN NO EVENT SHALL SAM LEFFLER OR SILICON GRAPHICS BE LIABLE FOR ANY SPECIAL, INCIDENTAL, INDIRECT OR CONSEQUENTIAL DAMAGES OF ANY KIND, OR ANY DAMAGES WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS, WHETHER OR NOT ADVISED OF THE POSSIBILITY OF DAMAGE, AND ON ANY THEORY OF LIABILITY, ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE

## Table of Contents

1	SI Image Installation .....	1
1.1	Computer Hardware Requirements.....	1
1.2	Installing the SI IMAGE Application Software.....	1
1.3	Arithmetic Models .....	2
1.4	Uninstalling SI Image Software.....	2
1.5	Hardware Check.....	2
2	SI Image Virtual Instrument .....	5
2.1	Starting the SI Image Application, Operate Menu.....	5
2.2	Image Display Tools .....	7
2.2.1	Cursor Display .....	8
2.2.2	Image Display Palette .....	9
2.2.3	Z Axis Scaling.....	10
2.3	View Menu.....	11
2.3.1	Region Of Interest.....	11
2.3.2	Zoom Windows.....	12
2.3.3	Turn On Row/Column Plot.....	13
2.3.4	Video Frames .....	14
2.3.5	Show Image Scroll Bar .....	14
2.3.6	Histograms .....	15
2.3.7	Display Axes .....	15
2.3.8	Image Scaling.....	16
2.4	File, Edit, Window and Help Menus .....	17
2.4.1	File Menu .....	17
2.4.2	Edit Menu.....	21

2.4.3	Window Menu .....	21
2.4.4	Help Menu .....	22
3	SI Image - Controlling the Camera.....	23
3.1	Operate Menu.....	24
3.1.1	Initialize .....	24
3.1.2	Select Camera .....	24
3.1.3	Configure .....	25
3.1.4	Monitoring Temperature and Pressure.....	27
3.1.5	TCP/IP Server .....	29
3.1.6	DSP Utilities .....	30
3.1.7	Stop .....	30
3.2	CCD Settings .....	31
3.2.1	Camera Settings .....	31
3.2.2	Readout Modes .....	33
3.2.3	Readout and Format Parameters .....	36
3.2.4	Camera Configuration Parameters .....	39
3.3	CCD Status.....	43
3.4	Acquiring an Image.....	45
3.5	Getting Statistics .....	46
3.6	Special Acquisition Modes .....	47
3.6.1	Average Images Acquisition.....	47
3.6.2	Multiple Image Acquisition .....	48
3.6.3	Multiple Frames Acquisitions.....	50
3.6.4	Focus .....	54
4	Image Math .....	55

4.1	Math Menu.....	55
4.2	Image Corrections Menu.....	56
4.2.1	Flat Fielding .....	56
4.2.2	Defect Correction.....	58
4.2.3	Serial Overscan Bias Correction.....	59
4.2.4	Average Images .....	60
4.2.5	Subtract Background.....	61
4.2.6	Auto Corrections .....	61
5	Special Camera Features.....	63
5.1	Triggered Operation.....	63
5.2	Time Delay Integration (TDI) readout Modes .....	64
6	SI Image SGL TCP/IP Camera Control.....	65
6.1	TCP IP packet definition.....	65
6.1.1	Command packet (10 bytes + parameter structure) .....	65
6.1.2	Acknowledge packet (8 bytes).....	65
6.1.3	Data packet (14 bytes + data structure – see below).....	66
6.1.4	Image packet (30 bytes + Image structure).....	66
6.2	Data Packet Structures .....	66
6.2.1	Status structure 2002 (4*N bytes).....	66
6.2.2	Arbitrary byte array structure 2003 (n bytes) .....	66
6.2.3	Acquisition Status structure 2004 (8 bytes) .....	67
6.2.4	Image Header structure 2006 (variable length) .....	67
6.2.5	Command Done structure 2007 (2 bytes) .....	67
6.2.6	SI Image Settings structure 2008 (42 bytes) .....	67
6.2.7	Camera Parameters structure 2009 (256 bytes) .....	68

6.3	Camera Commands:.....	68
6.3.1	Get Status From Camera.....	68
6.3.2	Set Acquisition Mode .....	68
6.3.3	Set Exposure Time.....	68
6.3.4	Set Acquisition Type.....	69
6.3.5	Acquire.....	69
6.3.6	Mode Parameter Values for Image Acquisition.....	69
6.3.7	Save As Values for Image Acquisition.....	69
6.3.8	Set Number of Averages .....	70
6.3.9	Set Number of Frames .....	70
6.3.10	Set Multiple Frame Buffer Mode.....	70
6.3.11	Get SI Image Settings .....	71
6.3.12	Set Readout Mode.....	71
6.3.13	Set CCD Format Parameters .....	71
6.3.14	Set any Readout & Format Parameter .....	71
6.3.15	Set any Configuration Parameter .....	72
6.3.16	Turn Cooler On/Off .....	72
6.3.17	Set Save to Folder Path .....	72
6.3.18	Inquire Acquisition Status.....	72
6.3.19	Terminate Acquisition .....	73
6.3.20	Retrieve Image .....	73
6.3.21	Get Image Header .....	73
6.3.22	Save Image.....	73
6.3.23	Get Camera Parameters.....	73
6.3.24	Expose and Shift N Lines .....	74

6.3.25	Image Acquisition .....	75
6.3.26	Dark Acquisition .....	75
6.3.27	Test Pattern Acquisition .....	75
6.3.28	Triggered Acquisition .....	76
6.3.29	Averaged Light Images Acquisition .....	76
6.3.30	Averaged Dark Images Acquisition .....	76
6.3.31	Averaged Triggered Images Acquisition .....	77
6.3.32	TDI (Time Delay Integration) Acquisition, Internally paced .....	77
6.3.33	TDI (Time Delay Integration) Acquisition, Externally paced .....	77
6.3.34	Command Summary Table .....	78
7	Appendix A .....	79
8	Appendix B .....	81
9	Appendix C .....	82

## Table of Figures

Figure 2.1 SI Image Front Panel .....	5
Figure 2.2 Initialize Selection .....	6
Figure 2.3 CCD Settings Panel .....	6
Figure 2.4 Image Type Selector .....	7
Figure 2.5 Cursor Display.....	8
Figure 2.6 Cursor Attributes Control .....	8
Figure 2.7 Image Display Palette.....	9
Figure 2.8 Image Zoom Palette.....	9
Figure 2.9 Z Axis Slider Control .....	10
Figure 2.10 View Menu .....	11
Figure 2.11 Zoom Window Control Panel.....	12
Figure 2.12 Zoomed Image Display .....	12
Figure 2.13 Cursor in Image .....	12
Figure 2.14 Row/Column Plot .....	13
Figure 2.15 Plot Type Selector .....	13
Figure 2.16 Video control window for playback of multi-frame images. ....	14
Figure 2.17 Histogram Plot.....	15
Figure 2.18 Non-Linear Gray Scale Window .....	16
Figure 2.19 File menu .....	17
Figure 2.20 Image Information window .....	17
Figure 2.21 Save As control.....	18
Figure 2.22 Image Transform control .....	18
Figure 2.23 Readout & Format parameters tab in Image Information window.....	19
Figure 2.24 Auto Save setup window .....	19

Figure 2.25 Select multiple images for viewing .....	20
Figure 2.26 View Multiple Images control window .....	20
Figure 2.27 Edit Menu .....	21
Figure 2.28 Windows Menu .....	21
Figure 2.29 Help Menu .....	22
Figure 2.30 Show Help Window .....	22
Figure 3.1 SI Image Front Panel .....	23
Figure 3.2 Operate Menu .....	24
Figure 3.3 Select Camera window .....	24
Figure 3.4 Software Configuration Window .....	25
Figure 3.5 Monitor Temperature and Pressure window .....	27
Figure 3.6 Temperature & Pressure Log Display File Menu.....	28
Figure 3.7 Temperature and Pressure Warnings .....	29
Figure 3.8 DSP Utilities .....	30
Figure 3.9 CCD Settings Window .....	31
Figure 3.10 Mode 0 window setting only the readout speed.....	34
Figure 3.11 Save a mode that changes the number of ports. ....	35
Figure 3.12 CCD Format Parameters for 2 Port Readout.....	36
Figure 3.13 Readout and Format Parameters Window .....	37
Figure 3.14 Camera Configuration Window .....	39
Figure 3.16 Flags Tab in the CCD Status Window .....	44
Figure 3.17 Acquire Image Controls .....	45
Figure 3.18 Image Type Menu.....	45
Figure 3.19 Exposure Time Controls and Progress Indicator.....	46
Figure 3.20 Image Statistics Information.....	46

Figure 3.21 Acquisition Mode Menu.....	47
Figure 3.22 Average Images Setup.....	47
Figure 3.23 Average Images Progress .....	47
Figure 3.24 Multiple Acquisition Controls.....	48
Figure 3.25 Multiple Acquisition initial setup window .....	48
Figure 3.26 File Type Selection.....	49
Figure 3.27 File Path Dialog Window .....	50
Figure 3.28 Multiple Frames Mode .....	51
Figure 3.29 Multiple Frame File Setup using Data-Time.....	51
Figure 3.30 Multiple Frame File Setup using Series .....	52
Figure 3.33 View Multiple-Frame Image Control.....	53
Figure 3.34 Focus Window.....	54
Figure 4.1 Math Menu .....	55
Figure 4.2 Add Constant to Image 1 .....	55
Figure 4.3 Post Binning Menu .....	56
Figure 4.4 User Defined Binning.....	56
Figure 4.5 Image Correction menu .....	56
Figure 4.6 Files Set LEDs.....	57
Figure 4.7 Open Defects Correction Map.....	58
Figure 4.8 Set Serial Overscan Bias Region .....	59
Figure 4.9 Select Multiple Files for Averaging .....	60
Figure 4.10 Auto Corrections Menu .....	61
Figure 4.11 Auto Correction LEDs.....	61
Figure 5.1 Triggered Mode .....	63
Figure 5.2 TDI Acquisition Mode .....	64





# **1 SI Image Installation**

The SI Image application provides for control of, and image acquisition from, Spectral Instruments' cameras through a PCI card and ethernet camera interface. Operations provided include the ability to set camera operating parameters and image readout parameters as well as image acquisition, display, calibration and archiving functions.

## **1.1 Computer Hardware Requirements**

The SI Image application runs under Windows 32 Bit 2000/XP/Vista/7 and 64 Bit Vista/7. Hardware requirements include:

- 1) A Pentium or equivalent CPU
- 2) 110 MB free space on the hard drive (10 MB for SI Image and 100 MB for the LabVIEW runtime engine)
- 3) A CDROM drive
- 4) A mouse with at least two buttons
- 5) Adequate memory; memory requirements depend on the size of the CCD. Since image buffers are single precision floating point for more accurate processing, memory requirements are high. A minimum of 512 MB is required for a 1K x 1K device; 2 GB is recommended for a 4K x 4K CCD. Memory requirements are lower if limited image processing is needed.
- 6) One free PCI bus slot
- 7) A graphics card and display that can support a resolution of at least 1024 x 768 at 32 bit color (256 MB graphics memory) is recommended for best image viewing.

## **1.2 Installing the SI IMAGE Application Software**

The SI Image acquisition application is supplied on a CDROM that also contains the installation programs. There are two separate installation folders on the CDROM, one for 32 bit and one for 64 bit operating systems. If the CDROM does not auto-run, select **Run** from the start button and execute the **Setup.bat** file on the CDROM. The installation program identifies the operating system, installs the correct files and makes the appropriate registry entries. There are five files on the CDROM that are specific to your type of camera and the CCD that is installed in it. The xxx.bin file (where xxx is camera system specific) is the DSP code for the camera controller and is specific to the CCD sensor in the camera. The SI Image.ini file (see Appendix A) contains configuration information for starting the SI Image software. The \*.set file is camera head specific containing any special parameter settings for the camera. It also contains

the readout and format parameters for your specific camera. The \*.map file (see Appendix B) is a map of the CCD defects which is used to correct the image if desired. The xxx.cfg file provides name and information for the parameters of the camera that can be set or accessed and is associated with the DSP code (xxx.bin). The xxx.bin file is CCD and camera type specific.

The CDROM also contains the plug and play drivers (Windows 2000, XP, Vista and 7) for the PCI interface card. Following the software installation, leave the CDROM in the drive and turn off the computer. Install the PCI card and restart the computer. The plug and play should find the new card and launch the plug and play wizard. There are two folders on the CD, **Driver\_32bit** and **Driver\_64bit** that contain the installation files for the 32 and 64 bit operating system drivers. Direct the plug and play wizard to the folder that is appropriate for operating system being used. **Note that you must have administrative privileges to install the driver.** The driver is able to support multiple PCI interface cards in the same computer. The software can control one camera per instance of the software. The file **SpecInst.ini** (in the folder with other support files, **C:\Users\Public\Documents\SI Image SGL E** on Windows Vista/7 and in Windows XP, **C:\Documents and Settings\All Users\Documents\SI Image SGL E**) instructs the software which PCI card to use. This is a text-based file and comments within the file describe how to select the active card. The default setting is for a single card.

### 1.3 Arithmetic Models

While an image is acquired as an unsigned 16-bit integer image from camera systems, it is converted to a single precision floating point (SGL) image within the program. This involves converting from 2 bytes per pixel to 4 bytes per pixel, using twice as much memory but allowing much more precision and flexibility for image processing. This is important when doing image subtraction where negative values can result and image averaging and flat-fielding where fractional values can be significant.

It should be noted that 12-bit, 14-bit, and 16 bit CCD cameras physically saturate the analog processing systems at pixel values of 4095, 16383, and 65535 respectively.

### 1.4 Uninstalling SI Image Software

If the SI Image software ever needs to be uninstalled, use the Add/Remove Programs (Windows 2000/XP) or Programs (Windows Vista/7) item in the Windows Control Panel.

### 1.5 Hardware Check

The camera uses a serial communications protocol to communicate between the camera interface, the PCI card, and the camera controller. The driver sets the baud rate for the UART on the PCI card from a parameter supplied by the user in the \*.set file. This parameter value can range from 9600 to 250,000 depending on the camera. See the camera hardware manual for selecting the baud rate when necessary. As long as the default baud rate is used, there is no action to take relative to hardware operation except

to turn on the camera power. If the baud rate is ever changed on the controller, it is necessary that the hardware selection in the controller and the value in the \*.set file agree.



## 2 SI Image Virtual Instrument

The SI Image application uses the *Virtual Instrument* (VI) concept where the various buttons, knobs, dials, displays and controls that you would expect to find on an instrument are replaced by graphical equivalents that appear on the computer screen. The instrument hardware no longer has physical controls. The combination of computer screen, keyboard, and mouse replace their function in ways that can be easily optimized for specific tasks.

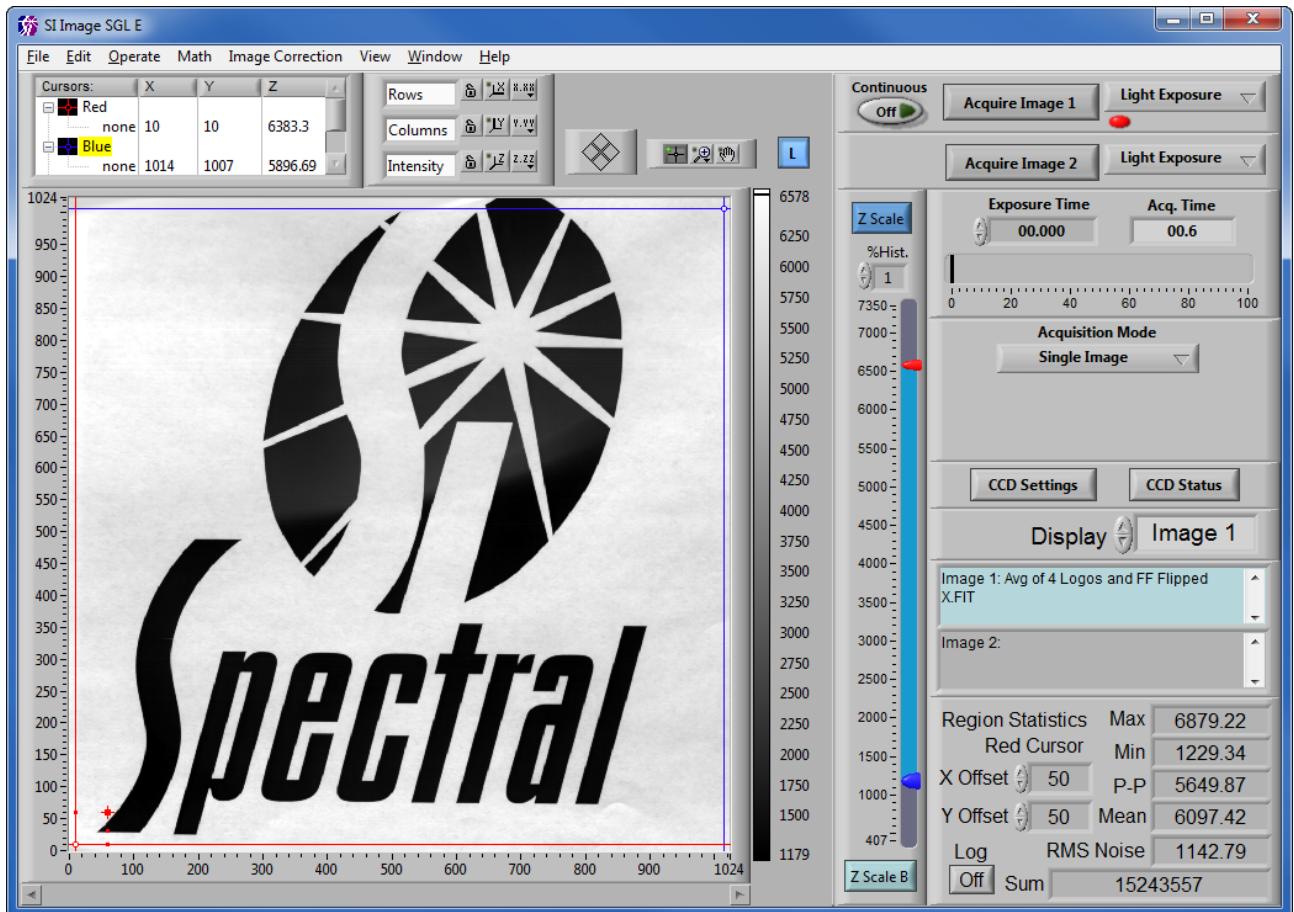


Figure 2.1 SI Image Front Panel

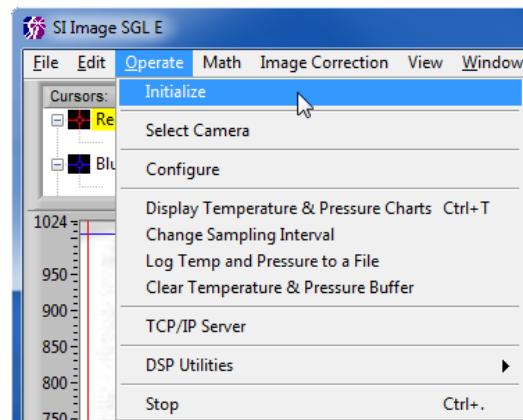
### 2.1 Starting the SI Image Application, Operate Menu

This section gives a brief description of how to operate the camera. More detailed explanations of the operation and functionality of the software are given in Section 3. During installation, a program Group is created. The SI Image application can be started in the normal Windows fashion from the Start menu or from the icon in the program group.

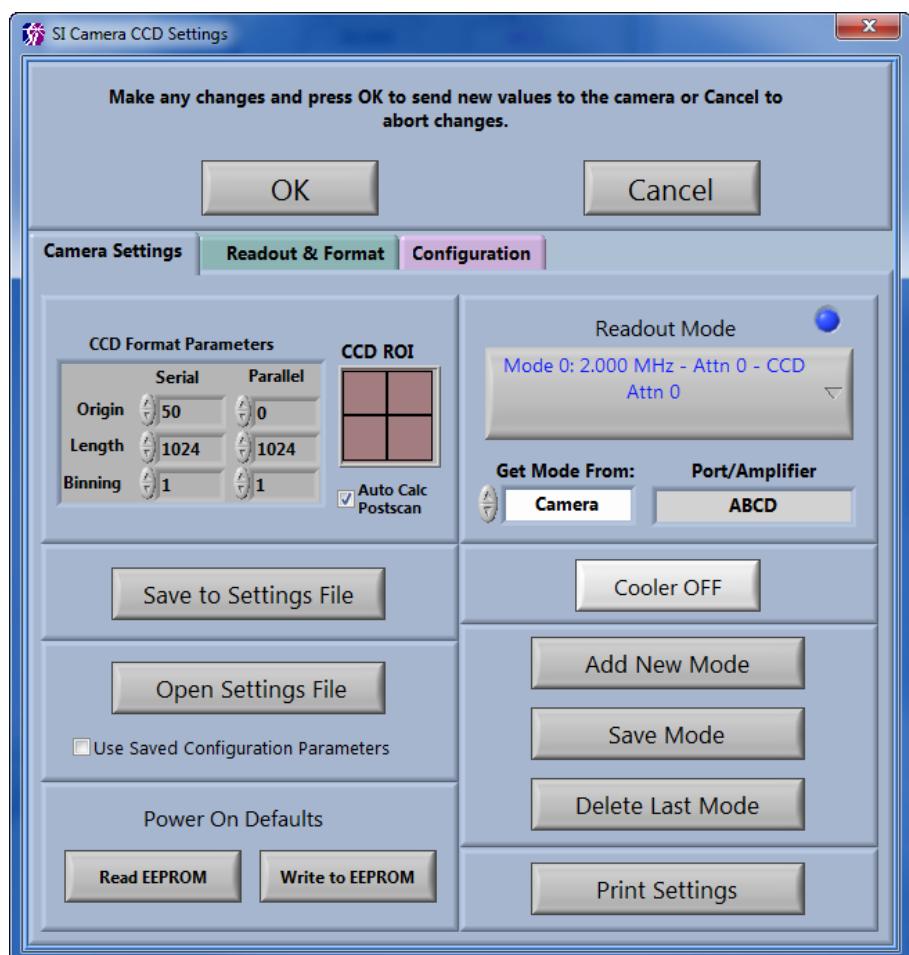
When the application is started, it loads the software configuration file, SI Image.ini, (see Appendix A on page 79) that specifies program specific items. All camera specific information is in the settings file (\*.set where \* is usually the camera serial number). If there is more than one settings file in the folder with the main SI Image program, a dialog box will open to ask the user to select the desired file. This is useful if more than one camera is being used with the same computer or if settings files have been created for specific camera configurations. The default values should be OK to run the camera. Changing these configuration values is discussed in Section 3.

Prior to initialization of the camera, any functions that require communication with the camera are disabled and the associated buttons on the panel are “grayed out”. This allows the application to be run on archived files without a camera attached.

Selecting the **Initialize** item in the **Operate** menu initializes the camera. In some newer 600 Series and 800 Series and higher cameras, the DSP code is stored in an EEPROM in the camera head so it is not necessary to send it to the camera during initialization. After camera initialization, the controller either opens and closes the shutter once (Series 500), briefly sounds the alarm (Series 600), or flashes the power LED three times (Series 800 and higher) to indicate successful initialization. If this does not occur, the camera has not been properly initialized and will not operate. Error messages appear if the camera power is not on, a cable is disconnected, or the wrong baud rate setting was selected. Follow the instructions in the error message to correct the



**Figure 2.2 Initialize Selection**



**Figure 2.3 CCD Settings Panel**

condition. If a CryoTiger cooled 600 or 1100 series camera is re-initialized once the cooling has started, the CryoTiger will be turned off and there will be a short delay before it restarts.

The window for the **SI Camera CCD Settings** is displayed automatically (Figure 2.3) after the camera is initialized. This window allows setting various operational parameters of the camera. **CCD Format Parameters** On the **Camera Settings** tab specify the origin, size, and binning of a sub-array to be read and are changed frequently for image acquisition. The **Readout & Format** tab provides access to all of the options available for routine user control of the camera. The **Configuration** tab parameters specify all of the settings for camera parameters that are established during the fabrication and testing. These are not intended to be changed during normal use but the capability is provided.

To begin with, the default parameters are probably fine and the **OK** button can be pressed so that an image can be acquired. Details of the **CCD Settings** are covered later.

Once the camera settings are established, image acquisition and display may proceed. Two image buffers are allocated in the program, **Image 1** and **Image 2**. Images can be acquired into

either buffer by pressing **Acquire Image 1** or **Acquire Image 2**.

Each button is associated with a “type” selector (see Figure 2.4) located immediately to its right. The selector offers a choice of Light Exposure, Dark Exposure or Test Image (depending on the camera, other options may be available). After setting the desired exposure time, pressing either of the **Acquire** buttons proceeds to operate the camera to obtain an image of the type indicated into the buffer selected. Once an image is in a buffer, the display of that image can be modified using any of the



**Figure 2.4 Image Type Selector**

provided tools. The **Display** control,  , indicates the image buffer being displayed and is also used to select the image buffer to display. When a new image is acquired, the **Display** control is automatically set so that the new image is displayed on the screen.

It is important to note that the new image may not be the same size as the image area shown currently in the visible display. The **Ctrl+F** keyboard shortcut or hotkey resizes the visible display to show the entire image. This is set to automatically happen upon the first image acquired after opening the **SI Camera CCD Settings** window or selecting a region of interest (ROI will be discussed later). Depending upon the user-controlled size of the Front Panel (Figure 2.1), the display may represent square image pixels as rectangles. Pressing **Ctrl+P** redraws the display with proper pixel aspect ratio although this may result in some portion of the display panel being unused and shown in gray.

## 2.2 Image Display Tools

Several tools are provided which affect the image display by changing the gray scale mapping, zooming, panning and contrast. These tools are accessed by on-screen controls

(buttons, sliders and indicators). Other tools in the **View** menu are used for examining the image.

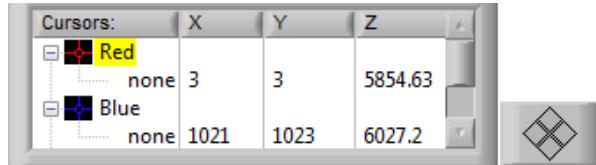
### 2.2.1 Cursor Display

The two cursors in the image display can be used to read pixel values from the image, to control the viewing of a row/column plot and to specify a region of interest. Figure 2.5 shows

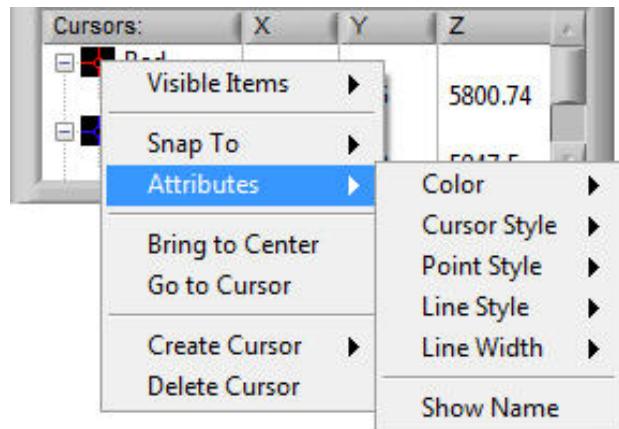
the cursor display on the front panel. Three numeric indicators are associated with each cursor. For the Blue Cursor above, X position is 1021, Y position is 1023, and the value of that pixel is 6027.2. Though the printed version of this manual is in monochrome, the cursor, Red, is red and the cursor, Blue, is blue on the screen. The group of four diamonds, to the right of the cursor display, provides one method of moving the cursors in the image display. The four diamonds are buttons that move the selected cursor by one pixel in the chosen direction (in Figure 2.5, Red is the selected cursor, indicated by the yellow highlight of the cursor name). Both cursors may be selected as being active at once and, if both are active, they are moved together by the arrow buttons. The cursor is selected either by clicking on the cursor in the image display or clicking on the selection button, , for the desired cursor. The cursors can also be moved by directly dragging the cursor in the image display.

To the right of the cursor selection button is a control, , that allows setting the cursor attributes including the color and style of the cursor using a right click pull-down menu. The cursor attributes can be modified as shown in Figure 2.6. With this control, the **Color**, **Cursor Style**, **Point Style**, **Line Style**, and **Line Width** can be changed. The **Show Name** option displays the cursor name (Red or Blue) next to the cursor in the image display. Any settings modified here continue until the program is restarted at which time the attributes revert to the initial defaults. **Bring to Center** positions the selected cursor in the center of the display. This is not used often since the cursor positions are monitored such that they are always in the viewed area

even after zooming. To the right of the cursor display is a button, , that locks the cursor to the lower left corner of the pixel (if 0,0 is the lower left of the image display).



**Figure 2.5 Cursor Display**



**Figure 2.6 Cursor Attributes Control**

When the control is clicked, the cursor is unlocked, , and the cursor is able to move within a pixel and the X-Y readouts display fractional values. The indicators in the cursor display are automatically updated as either cursor is moved. Since the mouse is also used for zooming in the display, the cursor mode, , must be selected in the image display palette, discussed in the next section.

### 2.2.2 Image Display Palette

On either side of the cursor movement diamond are the image display palette components shown in Figure 2.7, the scale palette (left) and the graph palette (right). On the scale palette are axis scale lock buttons, , that, when clicked-on, lock the autoscale on for the X or Y-axis of the display. In this mode, , when a new image is displayed, the selected axis will auto scale. When unlocked, , the axis will not autoscale when the image display is updated. The  and  buttons are autoscale buttons for each axis. These can be used to autoscale a single time to restore the full image on the selected axis after a zoom has been performed. The next set of buttons to the right,  and , allow the format and precision of the axis labels to be modified. The graph palette controls how the mouse interacts with the image display. When a graph palette button is selected, its color darkens and a green LED is illuminated in the upper left corner of the button. The  button on the left of the palette is the cursor select button that puts the image pointer in cursor mode when it is in the image display. This mode allows the user to move the image cursors by dragging them around the image display. The other two modes of the image pointer are zoom and pan. The zoom tool, , is shown expanded in Figure 2.8. The tools include a zoom box , X-axis zoom , Y-axis zoom , undo zoom , zoom in , and zoom out .

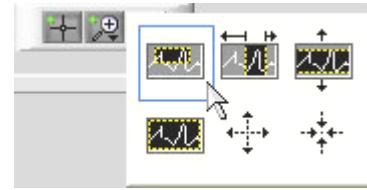
The appearance of the image pointer in the image display area changes depending on which zoom tool is selected. Some of these buttons also have hotkey shortcuts that can be convenient for mode switching.

They are: Home - , Page Up - , End - , Page Down - , F11 -  and F12 - .

Zooming can also be performed by directly editing the minimum and maximum values of the X and Y-axes on the image display. In addition, typing the minimum value into the maximum on an axis reverses that axis. For instance, if the X-axis is 0-1024 and you directly edit the maximum value of 1024 and make it 0, the axis flips and makes 1024 be on the left and 0 on the right. This can be useful to make an image direct reading, to display text properly for instance. A selection is also provided on the View menu to allow the X- and Y-axes to be reversed.



**Figure 2.7 Image Display Palette**



**Figure 2.8 Image Zoom Palette**

The final button in the palette is the pan button , which allows the displayed area to be moved about by pressing and dragging the mouse in the display area. Note that the appearance of the image pointer in the image display changes to look like the selection button depending on the mode chosen.

### 2.2.3 Z Axis Scaling

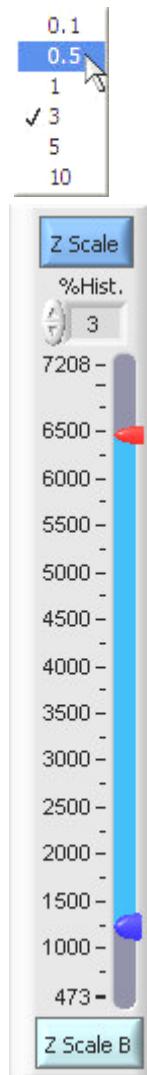
The  button scales the Z-axis gray scale or color scale of the image. The hotkey **F9** also performs this function. When the button is blue, it has been set to autoscale mode where the Z-axis is automatically scaled whenever a new image is displayed. When autoscale is off, the button is gray. This is controlled in the **View** menu discussed in the next section. The range of the scale is determined from a histogram of all of the pixels in the image currently displayed. The histogram is clipped from the ends by the

amount selected using the **%Hist** control just below the  button. Five different selections are available. These are 10%, 5%, 3%, 1%, 0.5% and 0.1% of the pixels. Selection is made by clicking the up or down arrows or by clicking in the numeric display window, which provides access to the range of options available. As shown, the current selection is checked indicating 3% but the new selection will be 0.5% as indicated by the highlight. Pixels are discarded equally from each end of the histogram until the percentage selected has been eliminated. This allows a selectable percentage of the pixels to be ignored in computing the minimum and maximum for the image display avoiding dark and bright artifacts affecting the scaling. The slider is then formatted to indicate the range of pixels to be used in displaying the image.

The Z-axis scaling can also be modified using the slider controls. In addition, when this is performed, the Z-axis slider, Figure 2.9, is scaled with a range slightly larger than the specified limits. The two-slider controls can be used to change the minimum and maximum of the image display using the mouse, thereby changing the contrast of the display. When one of the sliders hits its limit, the limit is automatically changed to enable further scaling in that direction. The selected slider, the bottom slider in Figure 2.9, is the last one that the mouse clicked on. The selected slider is slightly enlarged.

The upper and lower display limits can be edited manually by clicking on the number to be edited to set the limits of the slider display. Note that this does not change the appearance of the image displayed, it merely changes the slider display and subsequently the slider(s) can be moved into the new range to change the appearance of the image.

The  button scales the image using the pixels within the box formed by the Red cursor and the red offset cursor that define the statistics region (see section 3.5).



**Figure 2.9 Z Axis Slider Control**

## 2.3 View Menu

Two sets of terminology are used in this manual when attributes of the image display are discussed. The display utilizes a standard graphics Cartesian coordinate system and some items are specified by X- and Y- values. The image is composed of rows (displayed vertically) and columns (displayed horizontally). The image is read out from the sensor one row at a time. The first row is located at X-coordinate 0. The first pixel of the each row is located at Y-coordinate 0. The length of a row is the serial dimension as set in the CCD Settings. The length of a column is the parallel dimension as set in the CCD Settings. The last pixel in each row is displayed at the maximum Y, and the last pixel in each column is displayed at the maximum X coordinate of the image display palette. X and Y coordinates on the image display can be reversed, by selections discussed later, so there is no intrinsic left or bottom associations between image display and coordinate value 0.

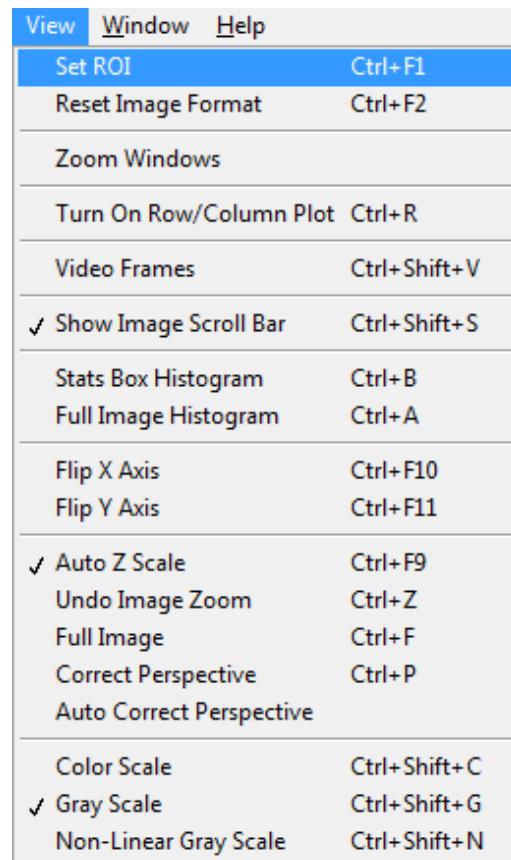


Figure 2.10 View Menu

Additional image display tools are provided in the **View** pull-down menu at the top of the front panel window. This menu operates like a standard Windows menu (Figure 2.10).

### 2.3.1 Region Of Interest

The first item on the **View** Menu is the **Set ROI** which allows selection of the current region of interest (ROI). A ROI is defined as the area within the two image cursors. The Red and Blue cursors, positioned arbitrarily within the image, delineate an area to readout from the camera when a new ROI is selected. To select a ROI at the current cursor position, type **Ctrl+F1** or select the **Set ROI** menu option. When a ROI is selected the first time (you can also select a new ROI when viewing a previously selected ROI), the current displayed readout format becomes the reference readout format. After a ROI is selected, the next image acquisition will acquire the ROI. After obtaining an image of the ROI, the reference format can be quickly re-established by **Ctrl+F2** or by the **Reset Image Format** menu option.

### 2.3.2 Zoom Windows

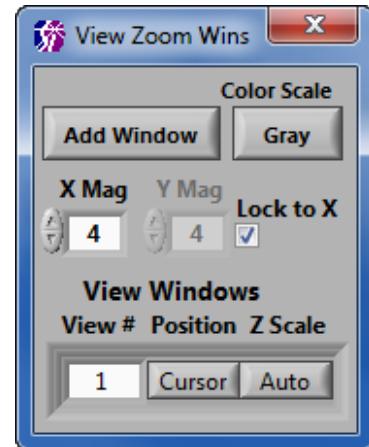
The next item on the menu is **Zoom Windows** which provides floating windows that display a magnified view of the image. When this item is selected, two new windows pop up. One is the **View Zoom Wins** control panel, Figure 2.11, and the other is the zoomed image display, Figure 2.12. The zoomed image display has the View # and the cursor coordinates in the title bar. The view is tied to the **Blue Cursor** in the image display and is centered on the cursor, Figure 2.13.

The zoomed image window is resizable and floating so that it can be moved so as not to obstruct the main image.

When the zoomed window is made larger, the magnification remains the same and it shows more of the image. The **View Zoom Wins** window is also moveable

and expandable using the **Add Window** button. Before adding a second zoom window, normally the previous window will be locked to the current cursor position by pressing the **Cursor** button associated with the window View # 1. The button will change to **Locked** indicating that it will no longer follow the cursor but stay at the current image coordinates.

When a zoom view is added, the **View Zoom Wins** window expands to show View # 2 with its associated buttons. The Z Scale buttons can be **Auto** or **Locked**. In auto-scale mode, the zoomed window will scale to the minimum and maximum pixel values automatically as the cursor is moved or the image is changed. The **Color Scale** button allows the image to be changed from gray scale to a false color scale that provides a larger visual dynamic range. Initially the magnification in the Y (vertical) direction is locked to the magnification in the X (horizontal) direction and the **Y Mag** control is disabled. When the **X Mag** is changed the **Y Mag** changes as well to maintain the correct perspective. By un-checking the **Lock to X** control, the magnifications can be varied separately. Multiple locked zoom windows can be useful for focusing where several places in an image need to be monitored in detail.



**Figure 2.11** Zoom Window Control Panel



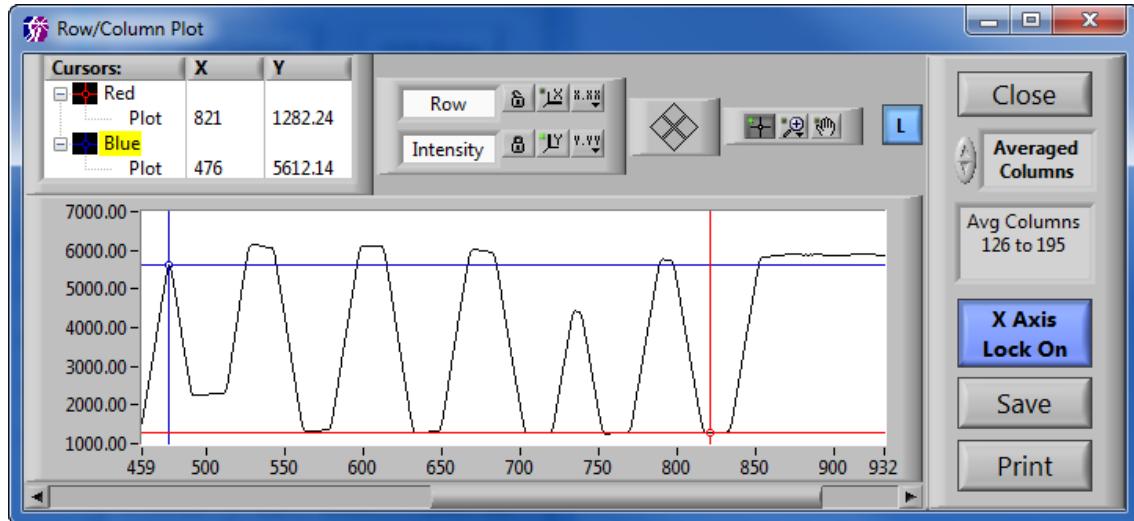
**Figure 2.12** Zoomed Image Display



**Figure 2.13** Cursor in Image

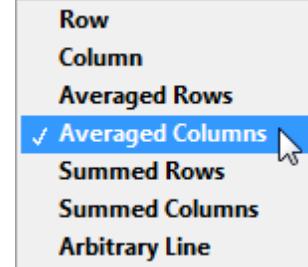
### 2.3.3 Turn On Row/Column Plot

The next item on the menu is **Turn On Row/Column Plot** and is accessed by the hot key **Ctrl+R**. This function opens a floating window (Figure 2.14) containing a graph that shows plots of a single row or column, the average of rows or columns, summed rows or columns, or an arbitrary line in the image between the two cursors.



**Figure 2.14 Row/Column Plot**

Plots types are selected through the control shown in Figure 2.15. Single-row or single-column plots show the pixels located at the position of the Red cursor in the image display. Averaged or summed plots show the average or sum of the pixels between the Red and Blue cursors. The arbitrary line plot shows the intensity data along an arbitrary line between the two cursor in the image. As a cursor is moved in the image display, the line data shown in the Row/Column Plot window is updated automatically. The plot window floats and is always on top of the Front Panel so that it can be moved allowing simultaneous viewing of the plot region in the image. The plot window has cursor controls, indicators, and zoom controls similar to those provided with the image cursors as discussed above. Some of these palette buttons also have hotkey shortcuts that can be convenient for mode switching. They are: Home - , Page Up - , End - , Page Down - , F11 - , and F12 - . Note that the scale Y-axis is set for autoscale in Figure 2.14.



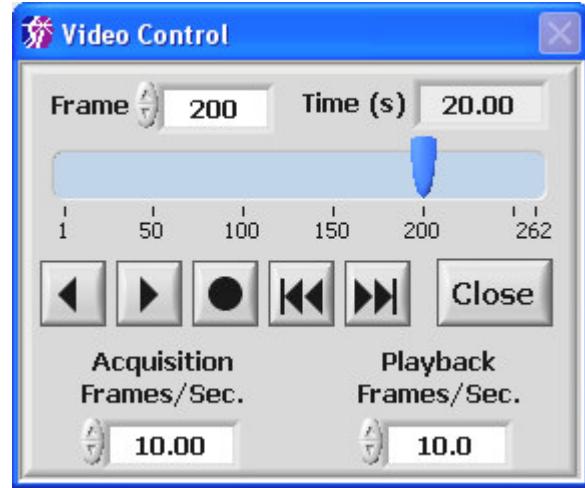
**Figure 2.15 Plot Type Selector**

The selector, shown as **Averaged Columns** in Figure 2.14, is used to select the row, column, average of rows, average of columns, summed rows, summed columns or an arbitrary line from the image display. The indicator below the plot type selector shows

the number (or the range) of the row(s) or column(s) being displayed. The **X Axis Lock On** button locks the X-axis of the graph display to the length of the selected row or column from the image display. When the X-axis lock is off and the X-axis is zoomed in on as in Figure 2.14, the scroll bar beneath the plot will pan the plot along the X-axis. Pressing the **Print** button prints the selected plot to the Windows printer. The **Save** button allows the line plot to be saved to a CSV (comma separated value) text file that is easily read by analysis or spreadsheet programs. The **Close** button closes the Row/Column window.

### 2.3.4 Video Frames

The **Video Frames** item on the menu provides for playback of high-speed acquisitions where multiple frames are contained in a single image file. This type of acquisition is available only on certain camera models. Images collected in “video” mode essentially contain multiple frames in a single image file and each frame is viewed by changing the X axis scale range since the frames are side-by side along the X axis of the image display. The **Frame** control displays which frame is being viewed and can be used to jump to a particular frame in the sequence. The bar scale also indicates the frame being viewed and can be utilized to jump to a particular frame using the mouse to move its position indicator. The **Time (s)** indicator (the (s) indicates seconds) displays the actual time in the sequence and is dependent on the value of the **Acquisition Frames/Sec** control that is set by the user. The **Playback Frames/Sec** control allows the speed of the playback to be changed. To initiate playback, press the **▶** button and the playback starts in the forward direction. The button will change to **⏸** during playback indicating that pressing it will pause the playback. The **◀** button plays in reverse. The middle button, **●**, selects single or continuous play. The default is single where the play will stop at the last frame. When in continuous mode, **●**, after the last frame, the sequence will start again at the beginning when viewing in the forward direction. The other two buttons, **◀◀** and **▶▶**, cause a single frame step in the indicated direction.



**Figure 2.16** Video control window for playback of multi-frame images.

### 2.3.5 Show Image Scroll Bar

This option turns on/off a horizontal scroll bar at the bottom of the image display that allows a zoomed in image to be scrolled in the horizontal direction. The default is off.

### 2.3.6 Histograms

**Stats Box Histogram** and **Full Image Histogram** provide two options for generating a histogram of image pixel data. Either the region that defines the stats box or the entire image is used depending upon the selection made (see section 3.5 for a description of the "stats box"). Selecting either option brings up a second floating window, shown in Figure 2.17, that has all of the same graphical controls as the plot

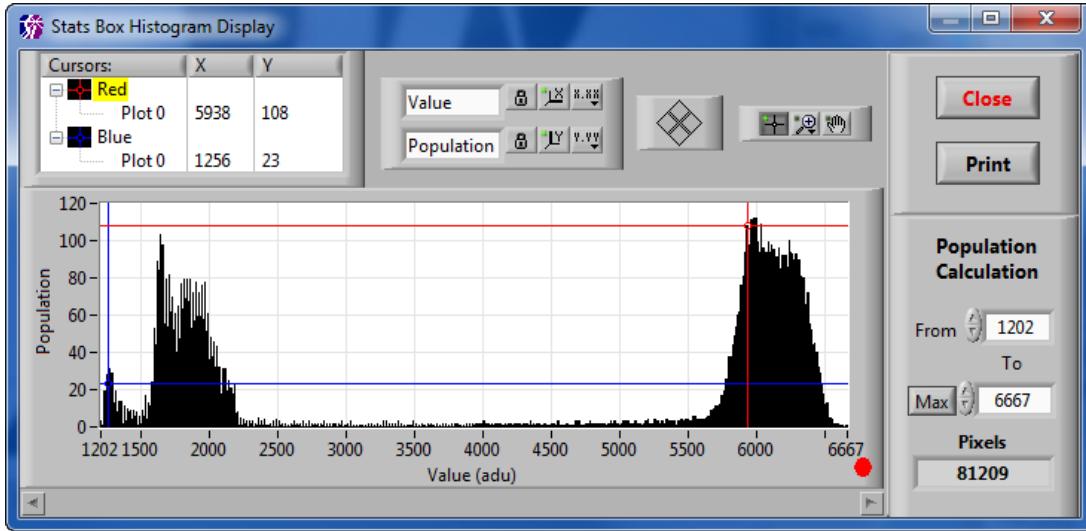


Figure 2.17 Histogram Plot

window. The cursors are usually left in locked mode so that the value of the histogram is updated in the cursor display as the cursor is moved. The shortcut keys for the cursor palette functions are the same as in the Row/Column Plot window. Hotkey **Ctrl+B** activates the stats box histogram while **Ctrl+A** brings up the full image histogram. Since the image is in floating point representation (SGL), the range of values could be very large for a histogram especially after an image divide. To prevent the size of the histogram from being exceedingly large, the histogram is clipped to its significant portion when the difference between the maximum and minimum far exceeds 2,000,000. If the histogram has been clipped, a red LED is displayed in the lower corner of the plot, either right or left depending on which end is clipped (see in the lower right in Figure 2.17 Histogram Plot). The scroll bar below the plot can be used to pan the X-axis when the user zooms in on the X-axis. There is also a tool for calculating the population or number of pixels in the histogram between two values.

### 2.3.7 Display Axes

**Flip X Axis** and **Flip Y Axis** are mode selectors, which upon selection, show a  to indicate the status and also perform the image reversal on the displayed image. Only the display is reversed. The image data is not held in reversed format and all math and file manipulation activities will operate on the original format image. Subsequent images are displayed in the selected mode. The hotkey for toggling **Flip X Axis** is **Ctrl+F10** and for **Flip Y Axis**, **Ctrl+F11**.

### 2.3.8 Image Scaling

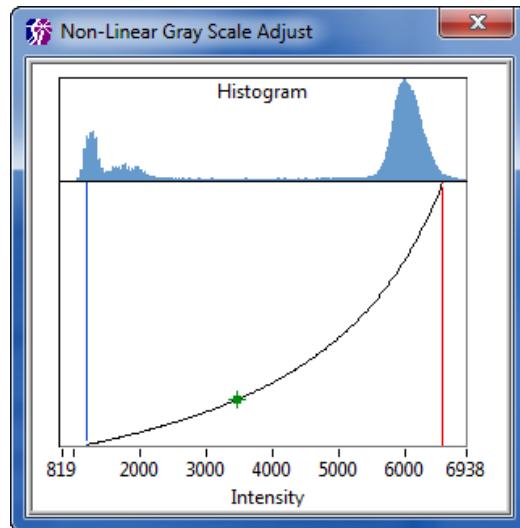
The **Auto Z Scale** menu item turns on or off the auto Z scale function. When activated, there is a  next to the menu item and every time a new image is displayed the  button, discussed above, is automatically pressed. The color of the button is blue when in auto mode and gray when in manual mode. The default and most common mode of operation for the SI Image acquisition program is autoscale. The hotkey for toggling **Auto Z Scale** is **Ctrl+F9**.

The **Undo Image Zoom** menu item will reverse up to 9 previous image zooms. The associated hotkey is **Ctrl+Z**.

The **Full Image** menu item is useful to return the image display to the full image after zooming in to a region. It can be activated in the menu or by hotkeys of **Ctrl+F** or **F8**.

The **Correct Perspective** menu item scales the X and Y-axis so that the pixels in the display are square. This is useful when using the zoom tools where it is easy to distort the display perspective. This function is activated in the menu or by the **Ctrl+P** hotkey. There is also a **Auto Correct Perspective** menu item that will perform a correct perspective when **Full Image** is selected and whenever the ROI or acquisition mode is changed.

The next three items, **Color Scale**, **Gray Scale**, and **Non-Linear Gray Scale**, select whether the display is shown in false color scale, gray scale or a non-linear gray scale. The false color scale allows a greater visual dynamic range, which can be useful in some imaging applications. The non-linear gray scale also is useful for images with large dynamic ranges to visualize lighter or darker areas of the image. When **Non-Linear Gray Scale** is selected, a window pops up (Figure 2.18) to enable adjusting of the non-linear scaling. The window shows the histogram of the image at the top and has three controls that can be used to adjust the image scaling. The blue line on the left and the red line on the right can be moved with the mouse to set the minimum and maximum for the image Z scale. The green cursor, , allows the curvature of the non-linear scaling to be adjusted.



**Figure 2.18 Non-Linear Gray Scale Window**

Selecting one of the options automatically de-selects the other. The current mode selected is indicated by a check. The hotkey for toggling **Color Scale** is **Ctrl+Shift+C**. for **Gray Scale**, **Ctrl+Shift+G** and for **Non-Linear Grayscale**, **Ctrl+Shift+N**.

## 2.4 File, Edit, Window and Help Menus

The **File**, **Edit**, **Window** and **Help** menus contain items similar to a normal Windows program with a few differences.

### 2.4.1 File Menu

The **File** menu, (Figure 2.19), as in most Windows programs, allows the user to open and save files, perform page setup and printing, and exit the program. The open and save functions operate on the image buffer that is being displayed. The normal Windows dialogs are used for file selection in the **Open Image** (also accessed by **Ctrl+O** or **F5**) and **Page Setup** functions. The **Open Image** function automatically determines the file type, FITS or TIFF, and opens the file.

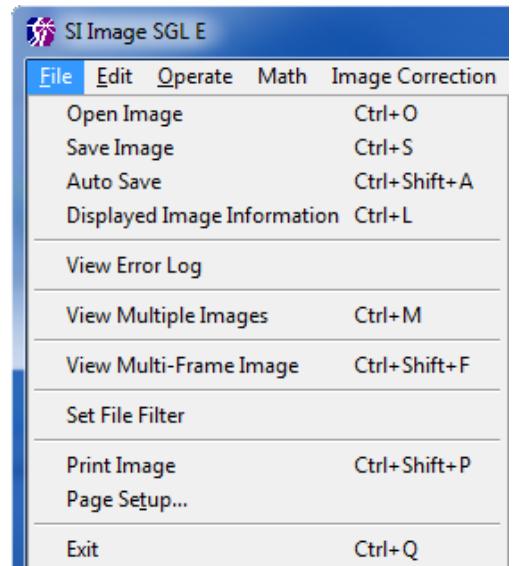


Figure 2.19 File menu

The **Save Image** function (also accessed by **Ctrl+S** or **F6**) has an additional window (Figure 2.20) so that the file information can be viewed and modified before saving. The

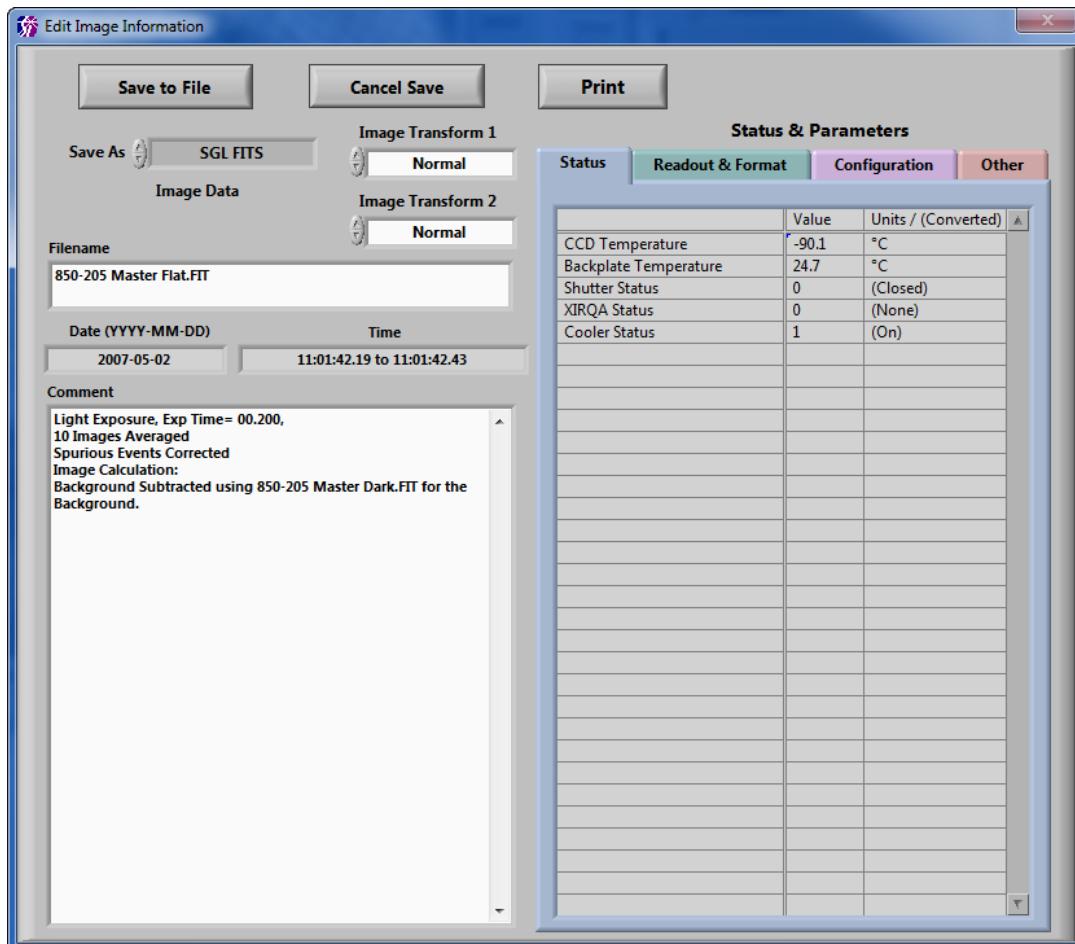


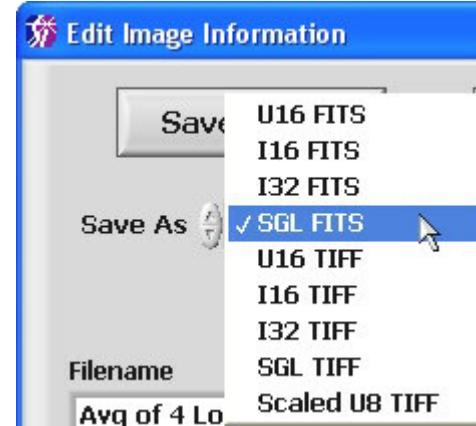
Figure 2.20 Image Information window

file name can be entered at this time, or when the path is selected in the Windows dialog that is opened when the information window is closed. The time and date stamps are automatically entered when the image is acquired and are not changeable. The comment field allows a variable length comment to be saved with the image file.

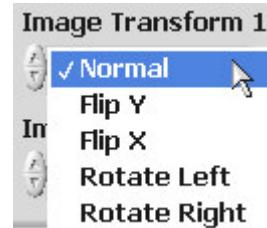
The **Save As** control (Figure 2.21) allows selection of the file format in which to save the image. The default format is SGL FITS. Other formats, either FITS or TIFF, are provided for compatibility with other programs. The 16 bit formats (U16 – unsigned 16 bit integer, I16 – signed 16 bit integer) will of course be half the size of the 32 bit formats (SGL – floating point single precision, I32 – signed 32 bit integer). SGL format is recommended so that no information is lost due to clipping or rounding required when using integer formats. The Scaled U8 TIFF format is a special case where an 8-bit TIFF image is saved scaled as viewed in the image display. This is useful when images need to be placed into a document.

The **Image Transform** controls (Figure 2.22) allow the image to be transformed before it is saved. This is useful when the image will be read by another program that is expecting the orientation of the image to be different than the default orientation. Up to two transformations can be applied to the saved image. The rotations are 90° to the left or right.

The **Status & Parameters** indicator (Figure 2.20) displays tabs for the **Camera Status, Readout & Format** parameters and **Configuration** parameters. There may also be a tab for **Other** parameters if the user takes advantage of this feature (see Appendix C). The status and parameters are entered automatically when the image is acquired and are not editable. The tables have three columns, Name, Value, and Units / (Converted). The value will always be numeric and the Units / (Converted) column will show the Units if they apply or a text of what that value means in parentheses. In Figure 2.20, Cooler Status has a value of 1 which is “converted” to (On). In the case of the Readout & Format parameter DSI Sample Time, a value of 20 could correspond to (800 KHz) readout speed (see Figure 2.23). If **Other** parameters are used from the text file described in Appendix C, the third column becomes Comment.



**Figure 2.21 Save As control**



**Figure 2.22 Image Transform control**

The **Save to File** button saves the changes and closes the window. When saving an image, a Windows dialog opens for selecting a path and optionally changing the file name. The

**Cancel Save** button cancels any changes made to the information and closes the window. When saving an image, this action aborts the saving to disk. The **Print** button provides a printout of the image information on the selected printer.

### The Display Image

**Information** menu item opens the same window used for **Save Image** (Figure 2.20) without the **Save As** and **Image Transform** controls. This can be used to view the image information and edit the file name and the comment.

The **Auto Save** item turns on/off the auto save feature where images are automatically saved after they are acquired. When the item is initially selected, a window is opened (Figure 2.24) where the file name, folder and number in the series to start with are selected. When a new image is acquired, the file is saved and the counter in the file name is incremented. In the example in Figure 2.24, the first image would be “Test Images\_0001.fit” and next would be “Test Images\_0002.fit” etc.

Any automatic corrections selected (see Section 4.2) will be applied before the image file is saved. When **Auto Save** is selected, a  appears next to the menu item in the **File** menu and the **Acquire Image** buttons change from gray to blue.

	Status	Readout & Format	Configuration	Other
Serial Origin	50	Pixels		
Serial Length	2048	Binned Pixels		
Serial Binning	1	Pixels		
Serial Post Scan	0	Pixels		
Parallel Origin	0	Pixels		
Parallel Length	2048	Binned Pixels		
Parallel Binning	1	Pixels		
Parallel Post Scan	0	Pixels		
Exposure Time	1200	ms		
Continuous Clear	0	(Enabled)		
DSI Sample Time	20	(800 KHz)		
Analog Attenuation	0	(Low)		
Port 1 Offset	510			
Port 2 Offset	512			
TDI Delay	1800	us		
Command on Trigger	1	(Open Shutter)		
Port 1 ADC Offset	33501			
Port 2 ADC Offset	32995			

Figure 2.23 Readout & Format parameters tab in Image Information window.

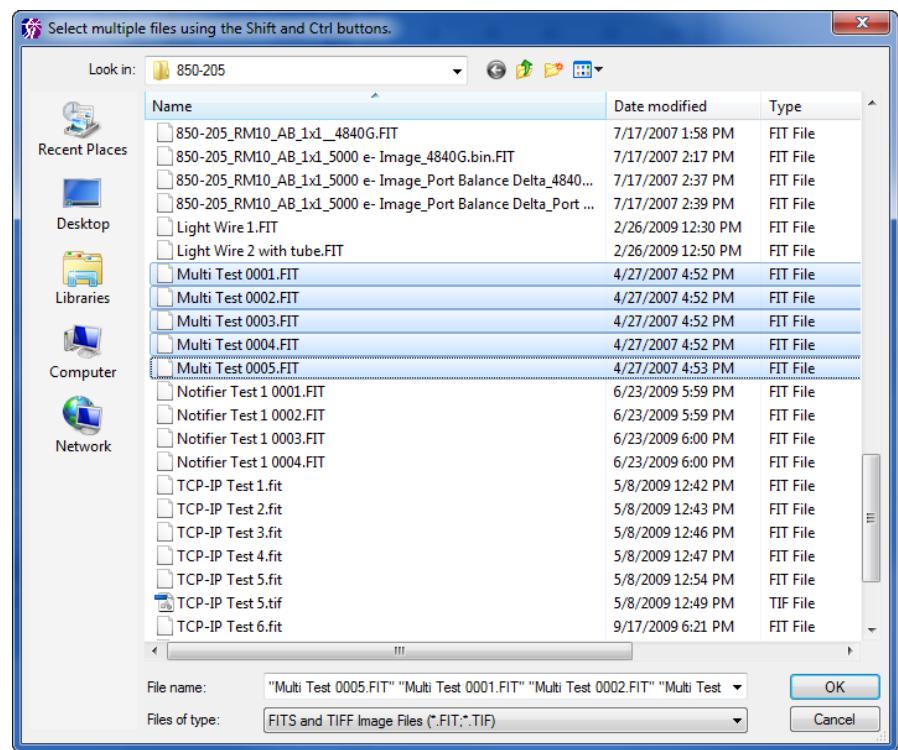


Figure 2.24 Auto Save setup window

The **View Error Log** item opens a window with a log of any errors that have occurred since the program started. There are options to Print, Save to a file and Clear the log.

### The View Multiple Images

menu item allows viewing multiple image files with a set time delay between successive images. Optionally, the region statistics that are displayed in the lower right corner of the main window can be logged to a disk in a comma-separated values (CSV) file for importing into an Excel spreadsheet. Following the optional log file selection, a standard, resizable Windows file selection window opens (Figure 2.25) where the image files for viewing are selected. The files are selected using the normal Windows methods of using the Shift and Ctrl keys and the mouse. Once the files have been selected, press **OK** to begin viewing.

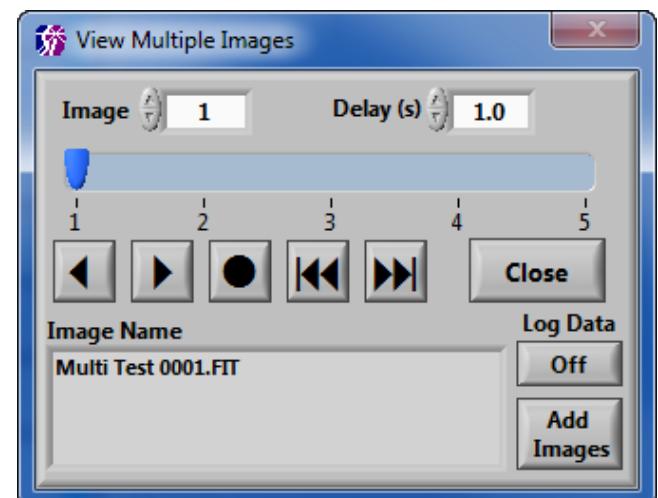


**Figure 2.25 Select multiple images for viewing.**

The first file is opened and a control window opens, Figure 2.26, to control the playback of the image files. To initiate

playback, press the button and the playback starts in the forward direction. The button will change to during playback indicating that pressing it will pause the playback. The button plays in reverse. The middle button, , selects single or continuous play, . The default is single where the play will stop at the last frame. When in continuous mode, after the last frame, the sequence starts again at the beginning when viewing in the forward direction. The other two buttons, and , cause a single image step in the indicated direction.

The **Delay (s)** control ((s) is seconds) sets the time to delay before opening the next image. To jump to



**Figure 2.26 View Multiple Images control window**

a particular image in the series, enter a number into the **Image** control or the mouse can be used to move the indicator on the bar scale. The file name of the image being opened/viewed is displayed on the **Image Name** indicator.

The **View Multi-Frame Images** menu item is used to view multi-frame images that some cameras are capable of taking. A multi-frame image is a special type of image acquisition where the camera acquires several images or frames with a single command and saves them to a multi-frame image file (see Section 3.6.3 for a full description). The full multi-frame image is often too large to load into memory as a single image. This function allows the image to be loaded one frame at a time and displays a control window similar to the View Multiple Images control in Figure 2.26 for flexible viewing of the image frames. If the entire multi-frame image is of a size such that it can be loaded into memory at once, the **Video Frames** item in the **View** menu (see Section 2.3.4) can be used.

The **Set File Filter** menu item allows a filter to be applied to the file names that are displayed when opening an image. For example, a filter of “Test Series 1\*.fit” will only show image files that are FITS files and their names begin with “Test Series 1”. The “?” character can also be used as a single ‘wildcard’ character.

**Print Image** will print the image along with the filename, comment, date, and time of the acquisition and the region statistics for the current cursor setting.

#### 2.4.2 Edit Menu

The **Edit** menu provides the standard Windows edit functions (Figure 2.27). These can be used when editing text or values in controls.

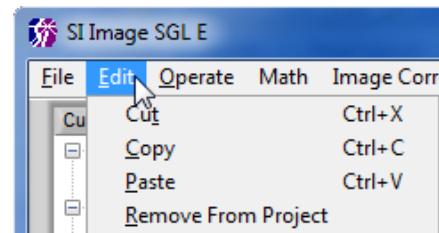


Figure 2.27 Edit Menu

#### 2.4.3 Window Menu

The **Window** menu (Figure 2.28) allows the user to view information about the program. Items of interest in the Info window are the program file path and the memory usage of the program.

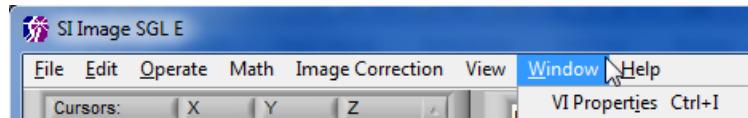


Figure 2.28 Windows Menu

#### 2.4.4 Help Menu

The **Help** menu (Figure 2.29) contains two items. The **About** item, as in most Windows programs, displays information about the program. This includes the revision information for the program, the DSP code, the DLL and driver for the PCI interface card, and the version of Windows that the program is installed for. The **Show Context Help** (also accessed by **Ctrl+H**) opens a floating window that provides information about the item on the front panel of the program that the mouse is over. Figure 2.30 shows the help window when the mouse is over the image display on the front panel. This Help Tool is useful for determining the function of indicators or buttons on the front panel. If a button can be operated with a function key, such as **F1** for the

**Acquire Image 1** button, it is indicated in the **Help** window.

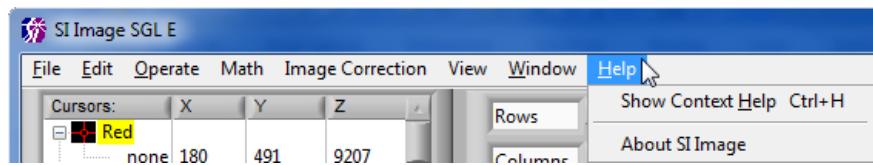


Figure 2.29 Help Menu

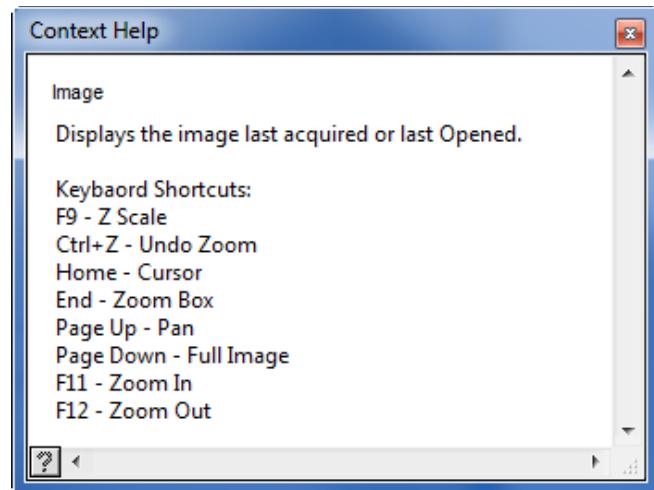


Figure 2.30 Show Help Window

### 3 SI Image - Controlling the Camera

While the last sections covered initial startup and acquiring an image along with general operation of the *Virtual Instrument*, this section covers the camera control functions and image acquisition features of the software in more detail. Figure 3.1 is the same front

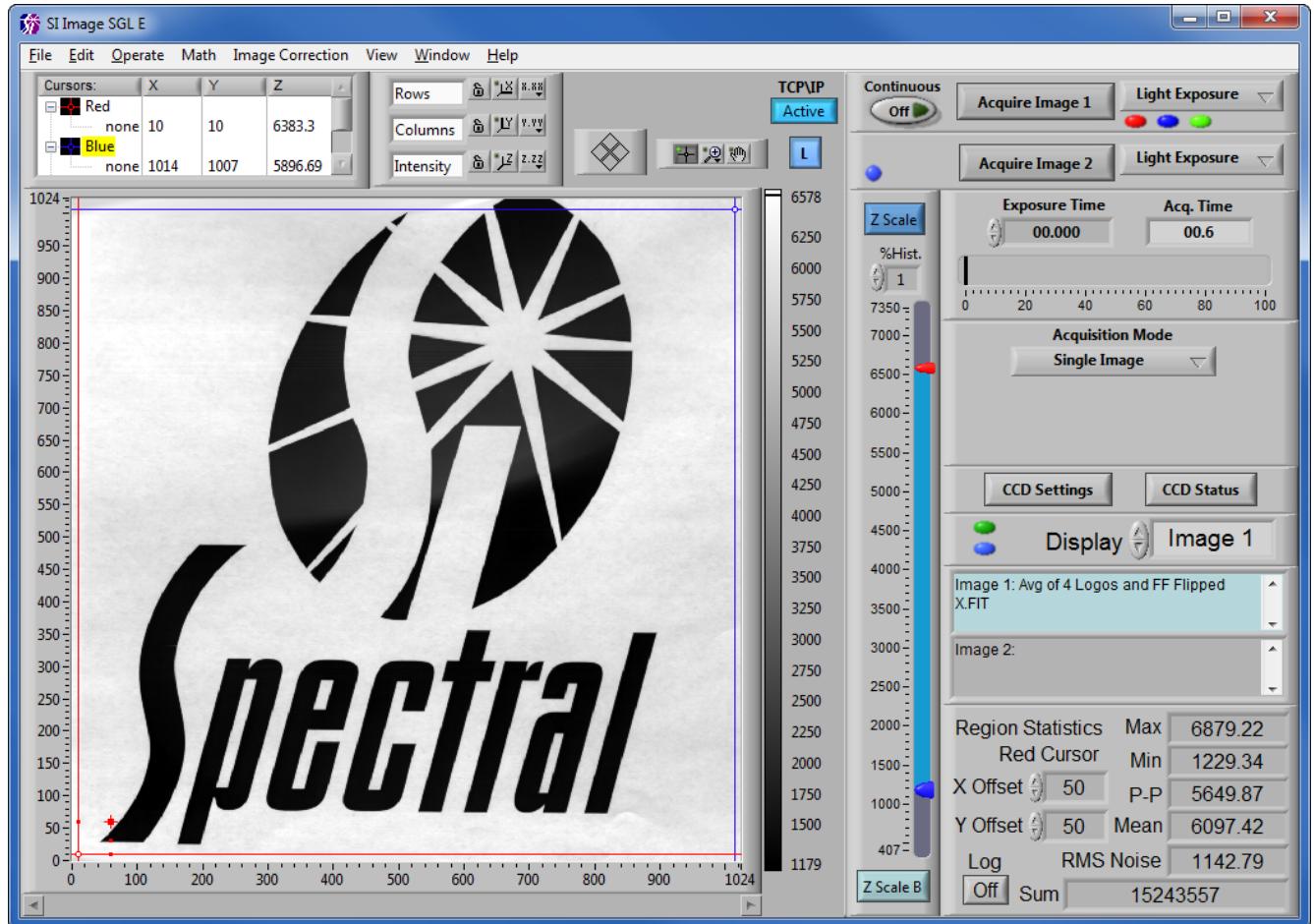


Figure 3.1 SI Image Front Panel

panel shown in Figure 2.1 except that a few additional “LED” indicators, and a TCP/IP button are shown. These LEDs, described in detail later in this section, indicate automatic corrections to be performed, whether files for corrections have been set, and whether the camera’s temperature or pressure are out of a normal range.

## 3.1 Operate Menu

The **Operate** menu, Figure 3.2, contains items concerning the operation of the software and the camera.

### 3.1.1 Initialize

When the program is started and the camera is powered up, the first operation is to initialize the camera. Initialization is different depending on the camera. All 800 Series and above and some newer 600 Series with a fiber-optic interface, have the DSP code stored in an EEPROM in the camera head. These cameras are ready to

communicate as soon as they are powered up. 500 Series and most 600 Series cameras need to have the DSP code downloaded to the camera before the camera can start normal communications. The initialization process determines if the camera needs to have the DSP code downloaded and does so if necessary. The **SI Camera CCD Settings** window (discussed in detail in Section 3.2) is automatically opened following initialization.

### 3.1.2 Select Camera

The **Select Camera** item opens a window (see Figure 3.3) allowing a settings file to be selected that contains the camera-specific information for the camera being used. This allows different cameras to be operated on the same computer in a convenient way. The settings filename is usually the serial number of the camera followed by '.set', such as 800-213.set. The **Cancel** button closes the window without changing the current settings file. This window is displayed when the program first starts if there is more than one \*.set file in the support files folder (C:\Users\Public\Documents\SI Image SGL E on Windows Vista/7 and in Windows XP, C:\Documents and Settings\All Users\Documents\SI Image SGL E).

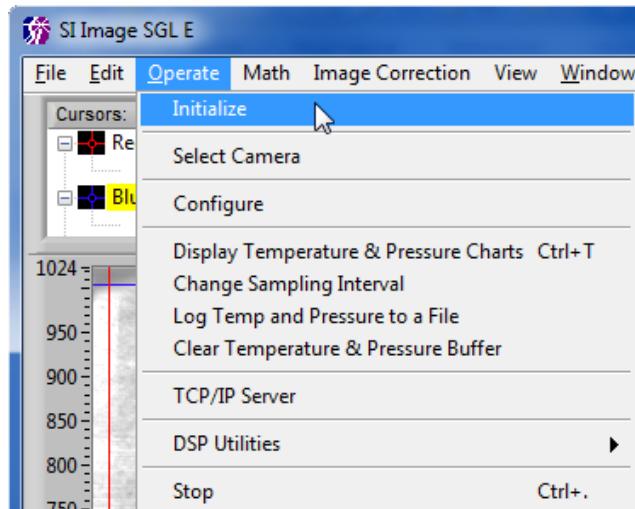


Figure 3.2 Operate Menu

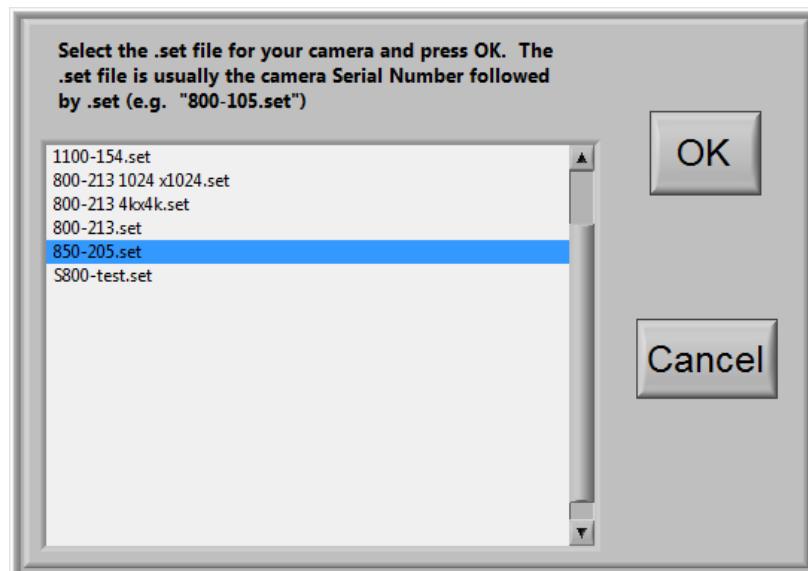
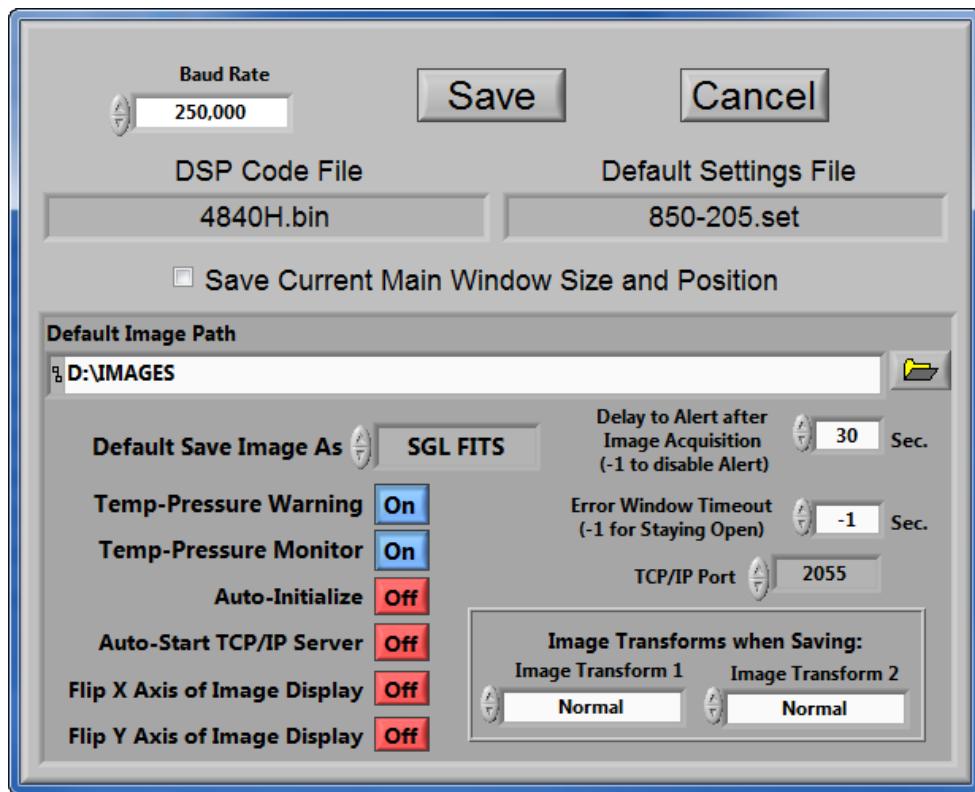


Figure 3.3 Select Camera window

### 3.1.3 Configure

The controls in the **Configure** window are used to set the software and camera configuration parameters that are saved in the SI Image.ini file (program specific items, see Appendix A) and settings file (camera specific items, the filename is ‘*serial number.set*’ or ‘\*.set’) that are installed with the program. Both of these files are text based and can be edited with a text editor. The configuration window is provided to conveniently edit the more common items the user may need to change.



**Figure 3.4 Software Configuration Window**

The default baud rate is fine for most all camera systems. If a different baud rate is set in the camera controller, the value in the software configuration must be changed. The **Baud Rate** control is a pull down selector that allows only the certain baud rates (see the Camera User Manual for baud rates supported).

The **DSP Code File** specifies the filename of the DSP code. This is not normally changed but is useful if custom DSP code is used to implement special camera functions. If new DSP code needs to be downloaded to the camera, refer to **DSP Utilities** in Section 3.1.6.

The **Default Settings File** selects the \*.set filename that is initially read when the camera is initialized and contains the readout and format parameters discussed below in Section 3.2. This is also the file where the DSP code filename and the baud rate are saved since they are camera specific.

When the **Save Current Main Window Size and Position** check box is checked, that information will be saved in the SI Image.ini file so that the main program window will resume the current window size and position the next time the program is started.

The **Default Image Path** sets the starting path for opening and saving image files. The path can be entered directly or selected by pressing the  button and browsing disk folders. Browse to the desired folder and press the  button in the browse window.

The **Default Save Image As** control selects the default image type appearing in the **Save As** control when saving an image. Image types are FITS or TIFF in unsigned 16 bit (U16), signed 16 bit (I16), signed 32 bit (I32), single precision floating point (SGL) and scaled unsigned 8 bit TIFF (Scaled U8 TIFF).

The On/Off buttons allow the user to set the operational program defaults. The SI Image SGL program is set to automatically poll the camera for its temperature and pressure at a set time interval (see Section 3.1.4). If the temperature or pressure is outside limits for that camera, a warning window will alert the user. The **Temp-Pressure Warning** button allows the user to prevent the window from popping up but still monitor the temperature and pressure so that the user can review it. The **Temp-Pressure Monitor** button can be used to turn off the temperature and pressure monitoring. **Auto-Initialize** and **Auto-Start TCP/IP Server** allow the program to automatically initialize the camera and to start the TCP/IP server without user input. This is most useful if there is only one .set file in the folder with the program so that the .set file is automatically selected. In this case, one can start the program and not require user interaction when using the TCP/IP server to operate the camera remotely. The **Flip X & Y** buttons set the image display orientation of the X and Y axis. The default, both buttons off, is to have the lower left corner be 0,0.

The **Delay to Alert after Image Acquisition** sets a time delay after an image is acquired before an acquisition complete alert is displayed. The alert will only appear if there has been no user interaction with the program during the delay time. If the delay time is set to -1, the alert window will be disabled.

The **Error Window Timeout** allows the user to set a timeout on pop up error windows if desired. A value of -1 will cause the error window to stay open until the user closes it. If the timeout is set to automatically close the error window, the errors can be viewed using the **View Error Log** item in the File menu.

The **TCP/IP Port** control allows the port number for the TCP/IP server to be set. The default of 2055 is not used by any common computer functions. For more information about the TCP/IP server functions of this program, see Section 6 on page 65.

The **Image Transforms when Saving** controls allow the setting of the default transforms to be applied to an image before it is saved to a disk file.

**Save** The **Save** button saves the information and closes the window. The **Cancel** button cancels any changes made and closes the window.

### 3.1.4 Monitoring Temperature and Pressure

The temperature and pressure of the camera are automatically logged to an internal buffer on a one-minute interval. The buffer can hold 4,500 readings providing for more than three days of data at the default interval. Once the buffer is full, the oldest data is discarded as new data is entered. The **Monitor Temperature and Pressure** menu item opens a window (Figure 3.5) that displays the temperature and the pressure of the camera in real-time. Each data point has a date-time stamp and the graph is updated as new data is acquired. The **Change Sampling Interval** menu item allows setting a sampling interval down to a minimum of 10 seconds. To have the data logged to a disk file, select the **Log Temp and Pressure to a File** menu item. The user is prompted to select a folder and file name for the log file with the extension TPL. It should be noted that the log file is independent from the internal buffer in that older data is lost from the internal buffer when its fixed size is exceeded which is not the case for the log file.

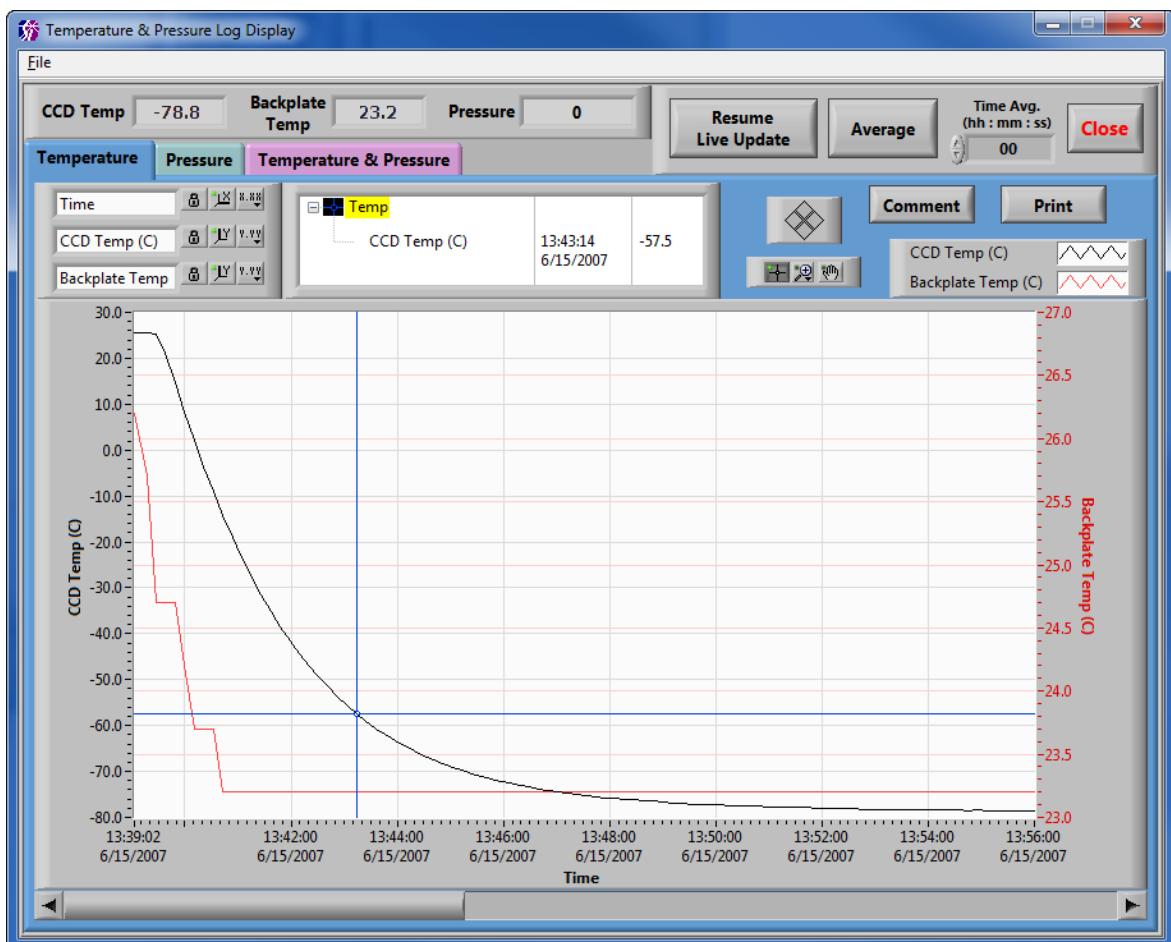


Figure 3.5 Monitor Temperature and Pressure window

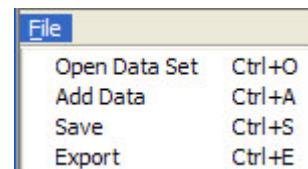
The Temp & Pressure Log Display window allows the data to be viewed as temperature only, pressure only or a combination of temperature and pressure by selecting the appropriate tab. For cameras that have a backplate temperature sensor, which usually applies to thermoelectrically cooled cameras, the temperature plot will show both the CCD Temperature and the Backplate Temperature as shown in Figure 3.5. The Backplate Temperature plot will be red and its values correspond to the Y-axis labels on the right side of the plot. Each view can also be printed using its associated



button with the ability to add a comment to the printout with the **Comment** button prior to printing. The individual **Temperature** and **Pressure** views allow a more detailed analysis of the data with a movable cursor in an expanded display with plot scaling and zooming similar to other graphs in this program. The **Temperature & Pressure** tab provides more of an overview with the standard zoom and pan controls and separate buttons for auto-scaling the individual plot axes and a scale-all-axes button. The single time axis labels at the bottom of the pressure plot apply to both plots. The temperature and pressure indicators at the top of the window display the latest measurements taken.

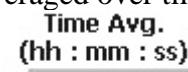
The **Pause Live Update** button allows the live update to be paused while the graph on the screen is being manipulated or examined. If the live update is not paused while the graph is zoomed in on a region, the graph will auto-scale when an update occurs to display newest data point. The live update is automatically paused when a data set is opened or if an additional data set is added to the plot.

The File menu, Figure 3.6, allows the user to open and save the logged data. **Open Data Set** opens a previously saved data set and **Add Data** allows a data set saved to a file to be added to the current data set displayed. Since the data is saved with a real-time stamp for each data sample, the Time axis will display real time for the composite data set. **Save** allows the currently displayed data set to be saved to a file that can later be opened in the Temperature & Pressure Log Display window. **Export** will export the current data set to a CSV (comma separated value) file that can easily be read by other programs such as Excel. Excel will automatically open a CSV file and the first column will be in Excel's default date-time number (days since January 1, 1900). If the format of the first column is set to a custom format of "mm/dd/yyyy h:mm:ss", it is a readable date-time stamp.



**Figure 3.6**  
**Temperature &**  
**Pressure Log Display**  
**File Menu**

The **Average** button allows the data in the graph to be averaged over time. When



pressed, the data in all the plots will be processed using the control to set the time over which to average the data. A value of **05:00** will average each successive five minutes of data. If the live update is on, when new data is obtained, the new data will not be averaged unless the button is pressed again.

An additional set of indicators at the top of the main SI Image window below the **Continuous** button (Figure 3.7), indicate temperature and pressure warnings. These LEDs are visible only when an error condition exists. From the top down:

1. Yellow – CCD temperature is too high
2. Blue – CCD temperature is too low
3. Red – Camera pressure is too high
4. Orange – Camera pressure is too high for the current temperature



**Figure 3.7**  
**Temperature and**  
**Pressure Warnings**

The limits that trigger these warnings are in the **Configuration** parameters table and are entered when the camera is built and configured. If the mouse dwells on one of these LEDs, a tip strip will appear describing its function.

### 3.1.5 TCP/IP Server

The TCP/IP server allows remote control of most of the SI Image program's functions. This is useful where another program is used for control of a process that needs to control camera through the SI Image program. These two programs can run on the same computer or on different computers that are connected over a network. The camera is physically attached to the computer running the SI Image server where the user can initializes the camera and sets all the camera parameters in the SI Image program, or this can be all done remotely using the auto-initialize and auto-start TCP/IP options. A remote client can then initiate an image or averaged image acquisition of a specified exposure time to a specified buffer (Image 1 or Image 2). Modes can be selected where the image is saved on the local computer that is controlling the camera and/or transmitted to the client. The client can also inquire the camera status, camera parameters can be read and set, and the image header that contains all the operating parameters of the camera during the last image acquisition can be obtained. A full description of the server protocol is described in Section 6. The SI Image program is still fully functional while the TCP/IP server is enabled.

The **TCP/IP Server** menu item enables the TCP/IP server in the SI Image program.



Once enabled, a new button, **Waiting**, appears at the top of the SI Image window and the server waits for a client to make a connection on the TCP/IP port that is set in the



**Configure** window. When a client makes a connection, the button changes to **Active** indicating a connection has been made. At this point, the program can be used normally



and also receive commands via TCP/IP. To disable the TCP/IP server, press the **Active** button and it will switch to the Off position and disappear from the window and the server is no longer active.

### 3.1.6 DSP Utilities

The **DSP Utilities** consist of three items, **Download DSP Code**, **Reload DSP Code From EEPROM** and **Save DSP Code to EEPROM**. These are not used in normal operation of the camera since **Initialize** will automatically download the DSP code, specified in the settings file described later, if necessary. **Download DSP Code** is used when the DPS code in the camera needs to be replaced with a newer version. If this is the case, the new DSP

code needs to be placed in the folder with the program and the new DSP code file name needs to be entered into the control in the camera configuration described above in Section 3.1.3. Once new DSP code has been downloaded, the **Save DSP Code to EEPROM** menu item saves the current DSP code into the EEPROM in the camera as the default DSP code. In 500 Series and most 600 Series cameras that do not store the DSP code in the camera, the user will see an error message since the command could not be executed. The **Download DSP Code** may be necessary to reset the camera if a communications error occurs and **Initialize** does not restore proper operation of the camera. An alternative to downloading the DSP code in this situation is to select the **Reload DSP Code From EEPROM** operation that is available on camera models 850 and higher. This operation performs a “warm boot” of the camera without requiring the camera power to be cycled.

**NOTE:** Series 1200 and newer cameras operate differently and require a separate utility to update the firmware in the camera.

### 3.1.7 Stop

The **Stop** menu item halts the program but does not exit as is done by the **Exit** item on the file menu. In this case, the program can be restarted by pressing the  button that appears on the left side of the toolbar near the top of the window when the program is stopped. When the program is restarted, all image buffers are cleared so any images that were not saved are lost.

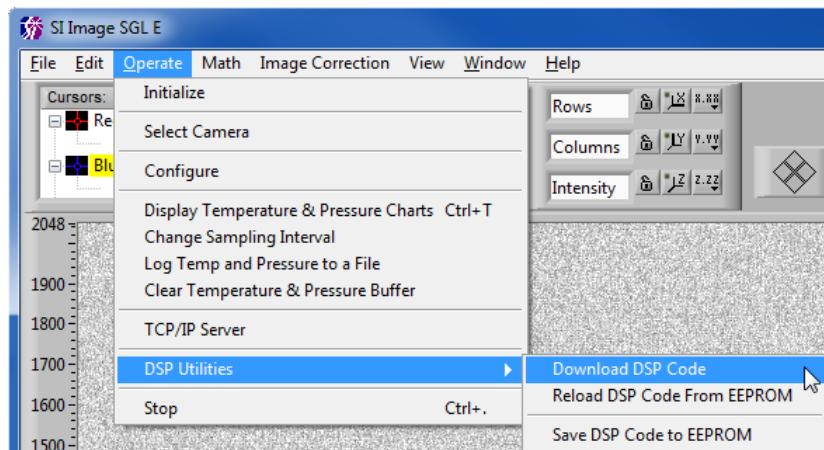


Figure 3.8 DSP Utilities

## 3.2 CCD Settings

The **CCD Settings** button opens a window (Figure 3.9) where all the operating parameters of the camera can be set. The parameters that are changed in normal operation are accessible in the main **Camera Settings** tab. Two groups of more detailed settings that are not changed as often are accessed by the tabs labeled **Readout & Format** and **Configuration**.

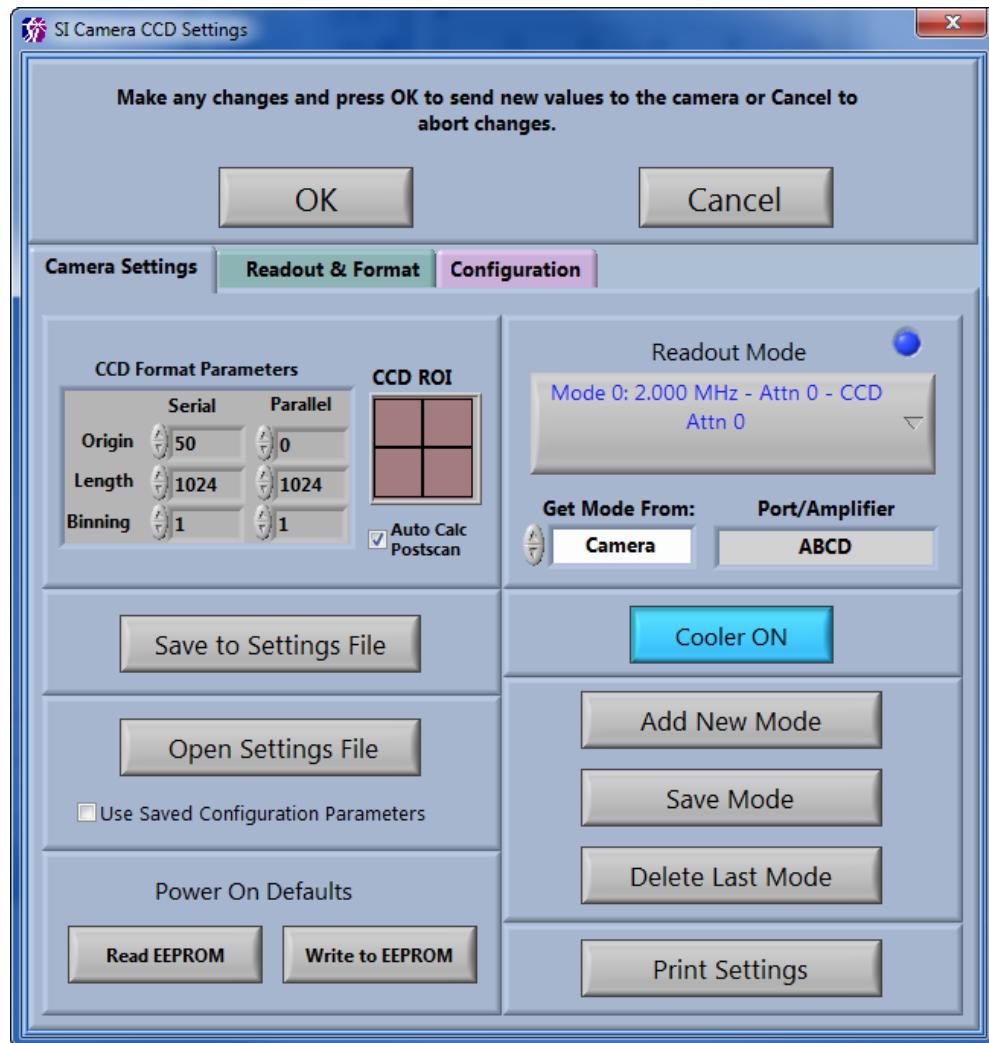


Figure 3.9 CCD Settings Window

### 3.2.1 Camera Settings

The **CCD Format Parameters** control the region of the CCD that is used and the binning. The **Origin** values are in unbinned pixels. The serial origin is often non-zero since there are usually “prescan” pixels at the beginning of the serial register that are not light sensitive. The **Origin** can be set so these pixels are not included in the image. If

binning is being used, the **Length** specified is for binned pixels. For example, if the CCD has 1024 pixels in the serial direction, the origin is set to 0 and binning to 2, the length should be 512 to cover the full length of the CCD. The postscan values are

**Auto Calc**

calculated automatically when the  **Postscan** option is checked and can be viewed along with the more detailed readout and format parameters by selecting the **Readout & Format** tab. This automatic calculation can be turned off when advanced, non-standard readout methods are required. The **Length** is also specified per port which is important when using multiple port CCDs. The **CCD ROI** indicator shows the region of the CCD that is defined by the **CCD Format Parameters**. The CCD sensor area is indicated by the reddish-brown colored filled rectangle while the black rectangle shows the area to be readout. Figure 3.9 shows an example of a 4 port CCD being read out of all 4 ports, (A,B,C and D), and the readout length in each port is 1024 pixels after a prescan on 50 pixels on the serial register. The resulting image will be 2048 by 2048 pixels and the **CCD ROI** indicator shows the 4 quadrants that are being readout.

The **Readout Mode** control selects the readout mode to be used (up to 16 modes can be defined, 0-15). Usually the readout mode sets the readout speed which includes setting the DSI Sample Time, Attenuations and Port Offsets that are applicable for the specific camera. A short summary of the mode is given on the pull-down menu control. The blue LED indicator above the right corner of the **Readout Mode** control is illuminated when the camera has the ability to store readout modes in the camera's EEPROM. In this case, the **Get Mode From:** control is also present and allows the user to select whether to get the mode information from the camera or from a \*.set file. The readout mode can be used to set any of the Readout & Format or Configuration parameters allowing for quick and flexible changing of the camera operation. Following a discussion of the Readout & Format and the Configuration parameters, the use of Readout Modes and \*.set files are covered (Section 1.1).

The  button turns the CCD cooling On/Off. The text in the button indicates the current state of the cooler and the button is also blue when the cooler is on. On some older 600 series cameras that do not have an external relay box, this button is not operational. For cameras that use thermoelectric cooling, it is important to have the cooling water flowing or the fan operating for air cooled cameras before turning the CCD cooling on. CryoTiger cooled cameras with a relay box, have a short delay of ~45 seconds before the CryoTiger turns on.

All the camera settings can be printed out using the  button in the lower right of the **CCD Settings** window. This prints all the Readout & Format and Camera Configuration parameters on a single page. This printout is part of the camera documentation and test results that are supplied with the camera. It provides a good backup of the camera settings in case of a computer malfunction or when the camera is routinely used in different configurations.

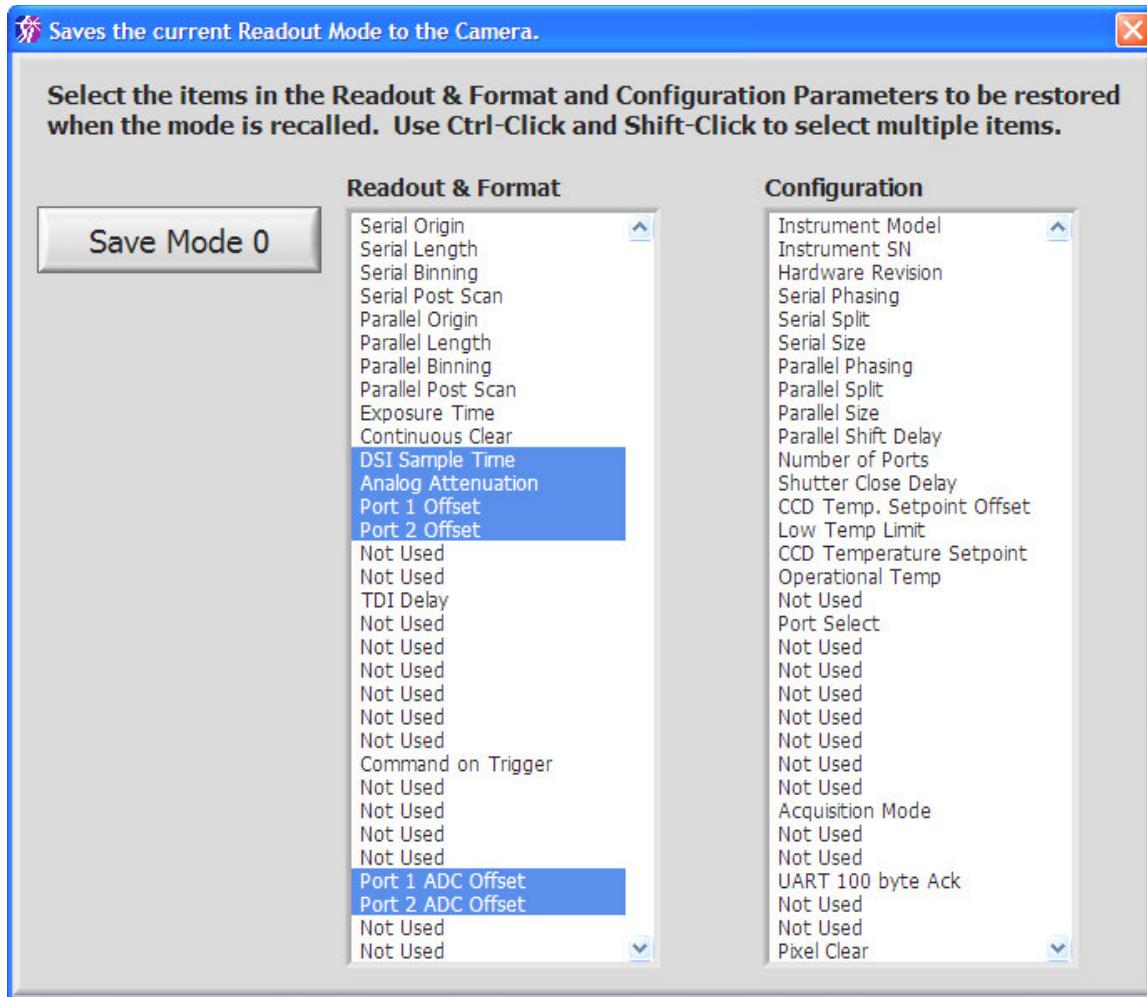
### 3.2.2 Readout Modes

Mode 0: 800 KHz - Attn 0

The **Readout Mode** control, , on the **Camera Settings** tab is a pull-down menu that allows selection of the different readout modes that are configured for the camera system. The standard modes set up at the factory are normally the different readout speeds at which the camera is configured and tested. In cameras that have the ability to save this mode information in the camera, all mode information is read from the camera when it is initialized. When the CCD Settings window opens the first time, an indicator displays that mode information is being read from the camera. Other indicators that the camera is capable of storing modes are: the blue LED above the **Readout Mode** control, the text in the **Readout Mode** control is blue and the **Get Mode From:** control is present. The **Get Mode From:** control has two options, Camera or \*.set file. For cameras that do not have the ability to store mode information in the camera, it is always taken from the \*.set file. Cameras that are mode-capable are shipped with a \*.set file which can serve as a backup of the information in the camera. The \*.set file is a text based file with sections and items within each section. Section names are enclosed in square brackets and include: [Camera Operations], [Readout & Format], [Readout Mode N] where N can be 0 to 15, and [Configuration]. Within each section are the parameter names and assigned values, e.g. Analog Attenuation=0. As mentioned above, the preset modes for a camera are normally the different readout speeds at which the camera has been configured and tested. The readout speed requires that the DSI Sample Time, Analog Attenuation, and the Port Offsets be set as these values are different for different readout speeds. When a Readout Mode is saved, a window pops up to let the user select what parameters are changed when that mode is selected. Figure 3.10 shows this window, selecting the parameters to set the readout speed on a camera that has a CCD with two ports (as seen by the two Port Offsets and two Port ADC Offsets.) Parameters that have been previously selected as part of the readout mode will already be selected (highlighted). Parameters can be selected using the mouse by a Ctrl-Click to select or deselect individual items. A click followed by a Shift-Click will select the multiple parameters between the two selected parameters while deselecting any others in standard Windows behavior. Once the parameters are selected, pressing the

 Save Mode

button will save the mode information to the camera for mode capable camera and to an internal data structure that is used to save it to a settings (\*.set) file.



**Figure 3.10** Mode 0 window setting only the readout speed.

The **Save to Settings File** button saves the current readout and format parameters and all the readout mode settings to a \*.set file that can later be recalled using the **Open Settings File** button. There is an option check-box when opening a \*.set file to use its Configuration parameters. The default is to only use the **Readout & Format** parameters. Cameras that do not have the capability to store readout modes in the camera, use the \*.set file to get the readout mode information. It also serves as a backup of what is in the camera. When a \*.set file is opened, the mode information is read from the \*.set file into the programs internal date structure. If the **Get Mode From:** control is set to “\*.set File”, when the **Readout Mode** is changed, the information will not be recalled from the camera but from the data structure in the program. In this way, readout modes can be read in from a \*.set file and stored into the camera on mode capable cameras.

The **Add New Mode** button takes the information of the current mode and uses it as base for a new readout mode that uses the next available mode number and sets the **Readout Mode** control to the new mode. From here the parameters can be modified and a new mode saved. Note that the text on the **Readout Mode** control will not change until

the mode is saved. The **Delete Last Mode** button will delete the highest number mode (last mode on the pull-down menu).

Readout modes can also be used to set any combination of parameters. One example would be to change from a single port readout to a two port readout. In that case the **Readout Mode** control text will contain more information since more parameters are

being changed, . The **Save Mode** window for this “Mode 10” is shown in Figure 3.11. This example is for a two port CCD that has a readout port on each end of the serial register, an e2v 42-20 CCD. The configuration parameters for the serial register must be set along with **Number of Ports** and **Port Select** parameters.

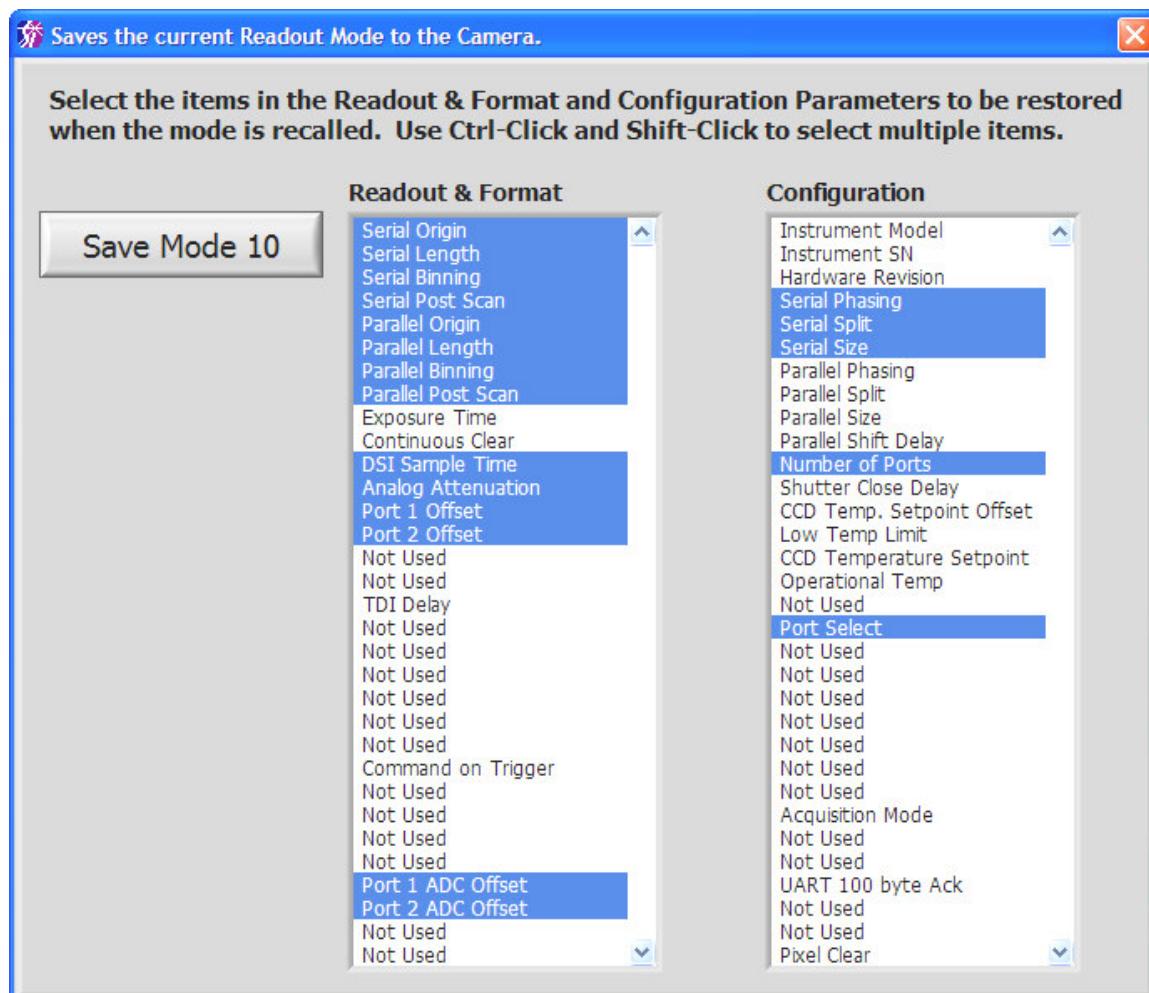


Figure 3.11 Save a mode that changes the number of ports.

The **Serial Phasing** is set to Normal, the **Serial Split** is set to Split and the **Serial Size** is set to one half the full serial register since it is split. In this case that is 1074 since there are 50 prescan pixels and 1024 active pixels on each half of the serial register. The **CCD Format Parameters** must also be set to reflect the parameters for each port. Figure 3.12 shows the format parameters for this readout. The **Serial Origin** has been set to 50 so that the 50 prescan pixels are discarded and the **Serial Length** has been set to 1024 which is half the active pixels in the serial direction. The parallel format parameters are set for the full active area in the parallel direction. This provides for a two port readout of the entire active area of the CCD. The readout speed parameters mentioned above are also included in the mode. This use of modes allows for fast and convenient changing of the number of ports to be used.

	Serial	Parallel
<b>Origin</b>	50	0
<b>Length</b>	1024	2048
<b>Binning</b>	1	1

**Figure 3.12 CCD Format Parameters for 2 Port Readout.**

Another situation where it is desirable to change more than just the readout speed with a mode is when focusing the camera. When focusing, usually the fastest readout speed is wanted and a ROI is set to enable faster image update. A mode could be used here to set the speed and a particular ROI useful for focusing. Modes can also be used to quickly change the binning of the readout at set readout speeds. In this case, only **Readout & Format** parameters for readout speed and format would be selected.

The default readout mode that is loaded when the camera is turned on is Mode 0. The **Read EEPROM** button reads the power on default parameters from the EEPROM.

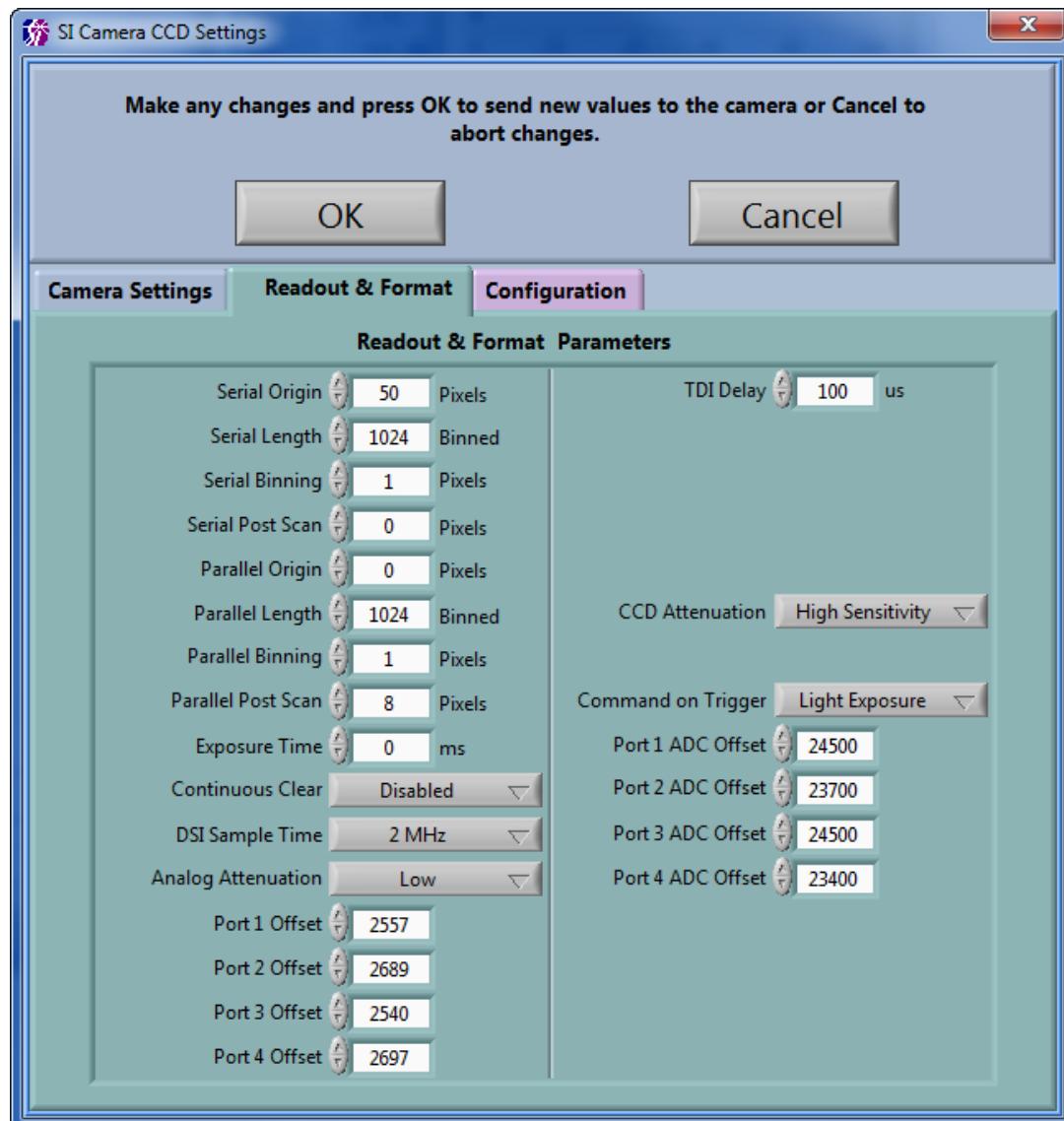
Since Mode 0 is the default mode, the **Write to EEPROM** button is only shown when in Mode 0. When it is pressed, a warning screen pops up to warn the user that the values in the EEPROM will be overwritten. Care should be taken here, especially with the **Configuration** parameters, because these settings are normally determined for each camera for optimum performance.

### 3.2.3 Readout and Format Parameters

The **Readout & Format** tab (Figure 3.13) shows the detailed readout and format parameters for the camera. These items are automatically changed as part of the readout mode in normal operation of the camera but are available to the user for inspection and can be modified for more advanced applications. Some of the controls are numeric input and some are pull-down menus. The pull-down menus are used for items that have only pre-defined values that are associated with the text on the menu. Those values are defined in the configuration file for the camera's DSP code. If the camera uses the DSP code 4840H.bin, the configuration file would be 4840H.cfg. Both the .bin and .cfg files are installed in the folder "C:\Users\Public\Documents\SI Image SGL E" on Windows Vista/7 and in Windows XP, "C:\Documents and Settings\All Users\Documents\SI Image SGL E".

The CCD format parameters are the same as in the main **Camera Settings** tab with the addition of the **Post Scan** values. The **Exposure Time** is the same as setting the exposure time from the main front panel except that here it is in units of ms. **Continuous Clear** controls whether the CCD is in a continuous clear mode between image acquisitions. The default value is **Enabled**. **Disable for One Cycle** disables the continuous clearing until the next image is acquired, at which time continuous clearing is automatically re-enabled. Some cameras also have an additional mode, **Disable**, where the continuous clear is disabled and not re-enabled after an image acquisition. See the camera hardware manual for details.

The **DSI Sample Time**, **Attenuation**, **Port Offsets** and **Port ADC Offsets** values are set automatically when the **Readout Mode** is selected in the main **Camera Settings** tab but



**Figure 3.13 Readout and Format Parameters Window**

can be overridden with these controls for advanced applications. In Figure 3.13, offsets are shown for Port 1 and Port 2 since a two port camera was being used. Other cameras may have single port or four port readout capability and therefore display a different number of port offset controls. Also, not all cameras use a Port ADC Offset, so those controls may not be present.

The **DSI Sample Time** (**Dual Slope Integrator**) is the parameter that permits the camera readout speed to be changed in order to balance readout noise against readout time. There are pre-defined values that correspond to the readout speeds in the menu control for which the camera has been optimized and tested. This parameter is functional only for cameras that use a dual-slope integrator as the analog processor for correlated double sampling. For a discussion of correlated double sampling and the dual-slope integrator, see “Electronic and Computer-Aided Astronomy”, Ian S. Mclean, Ellis Horwok publisher, (1989). Dual-slope integrator analog processors are generally used in Spectral Instruments cameras that have maximum readout speeds of 1 MHz or less.

Increasing the DSI parameter slows the readout speed by 100 ns per increment, resulting in higher sensitivity (lower electrons/ADU) and better signal to noise ratio. The sensitivity scales linearly with the sampling time, and the signal-to-noise improves approximately with the square root of the sampling time. The particular CCD type and the analog processor used in the camera establish the minimum and maximum practical sampling times. The test data shipped with the camera includes results of performance at both typical minimum and absolute maximum DSI sample times.

The analog attenuation parameter is used to **reduce** the sensitivity of the analog processor; increasing the number of electrons/ADU. This is useful in situations where the CCD is being operated near full charge capacity in binned mode, or to offset the **increased** sensitivity of a camera that is being operated with a slow readout speed. The magnitude of attenuation and the number of attenuation settings depend upon the camera configuration. These data are provided in the camera test data document shipped with each camera system.

The **TDI Delay** is the **Time Delay Integration** delay that is used when the camera is run in TDI mode. The delay is in  $\mu\text{s}$  and sets the delay between parallel shifts on the CCD.

Depending on a camera’s abilities, there may be more or less parameters in the **Readout & Format** tab. The parameters discussed above are common to most cameras (with the exception of Port ADC Offsets). Below are parameters that are used by some newer cameras. Future cameras may include parameters that are not covered here.

**Abort Mode:** Selects whether to perform a readout of the CCD or not when an acquisition is aborted during the exposure time. This allows preserving any image information acquired prior to the abort.

**Command on Trigger:** Selects what camera operation to perform when an external trigger is received. Cameras that do not support this parameter, perform a Light Exposure by default.

**CCD Attenuation:** Used on some CCDs to select for either high sensitivity or high dynamic range operation.

**# of Frames:** Some cameras have the ability to acquire multiple frames with a single acquire command. This parameter sets the number of frames to acquire and is discussed in more detail later.

### 3.2.4 Camera Configuration Parameters

The **Configuration** tab allows the user to view and change camera configuration parameters. These parameters are stored in nonvolatile memory (EEPROM) in the camera controller. When the camera is initialized, the parameters are read back from the camera. These parameters are not usually changed except during initial camera setup and testing at Spectral Instruments. Changes can be made without writing to the EEPROM

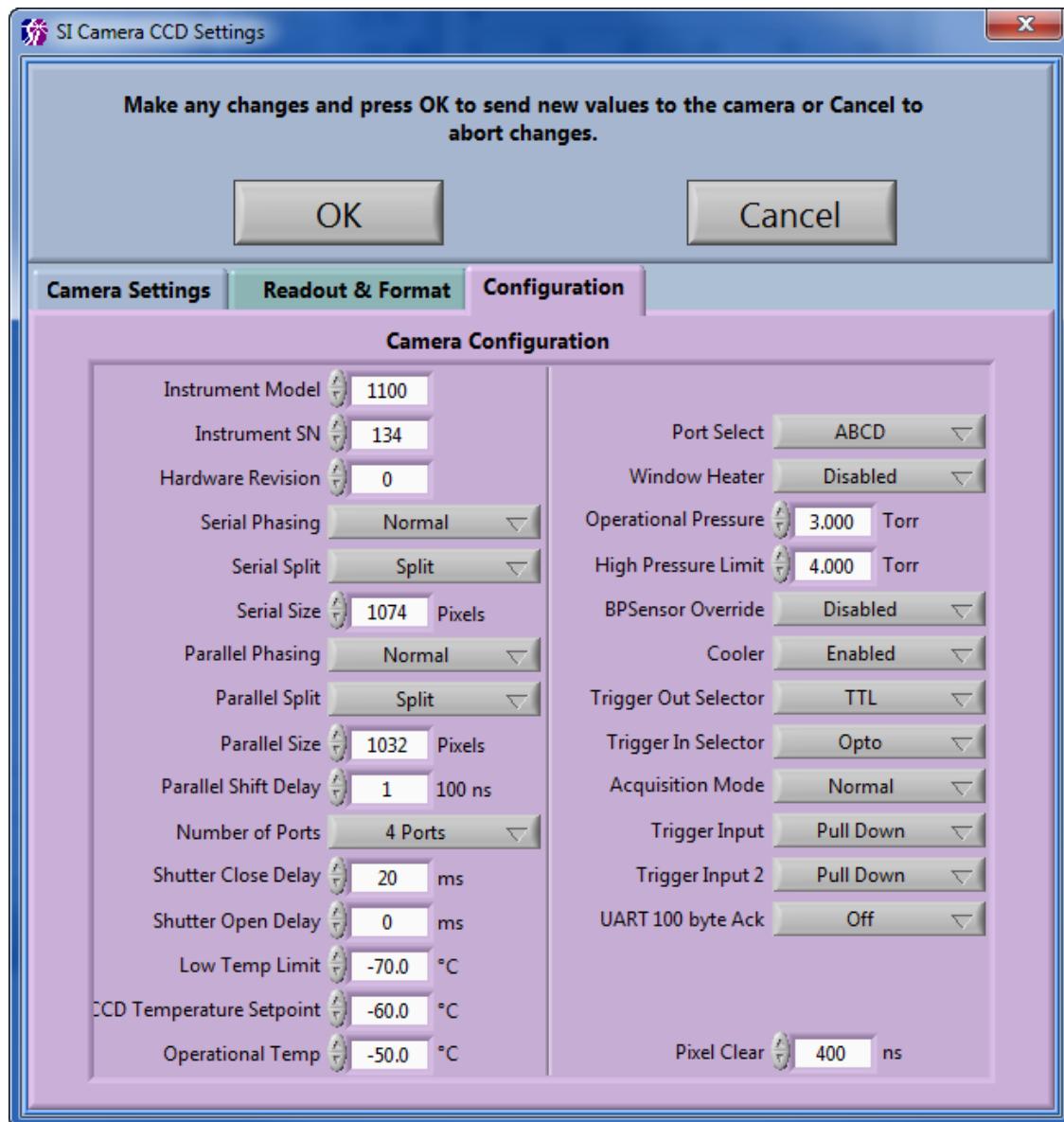


Figure 3.14 Camera Configuration Window

by changing the parameters and pressing the **OK** button. In this case, the parameters are sent to RAM in the controller and not written to the EEPROM. They remain in effect

only until the camera is initialized again. If the **Cancel** button is pressed, any changes made are canceled.

The first three parameters are self-explanatory. The **Phasing**, **Split**, **Number of Ports** and **Port Select** parameters are interrelated and used to select the port/ports from which a CCD is read out. Currently the software supports 1, 2, 4 and 8 port readout CCDs.

**Serial** and **Parallel Phasing** control the direction of the shift in the serial and parallel registers. This is used when selecting ports of a multiport CCD to be used for readout. The phasing is controlled by a pull down menu and can be **Normal** or **Reversed**. Some CCDs do not allow the phasing to be reversed and in that case there will only be **Normal** as an option on the control.

**Serial Split** and **Parallel Split** define whether the respective register is split such that image data is read out to multiple ports. The **Split** controls select either **Normal** or **Split**. The split is only used in multiple port cameras. The normal setting for four-port readout is to have serial and parallel set to **Split** and phasings set to **Normal**. When both the registers are split, the phasing is overridden since the charge is being shifted in opposite directions in the two halves. In the case of a 2 port CCD that has port A on one end of the serial register and port B on the other end with **Serial Split** set to **Normal** (one port readout), **Normal** phasing would direct the readout to port A and **Reversed** to port B.

When doing a multiport readout, the **Number of Ports** and **Port Select** also need to be set properly. In the case of a four port CCD, **Number of Ports** would be set to **4 Ports** and **Port Select** would be set to **ABCD**. When multiple ports are used, the **Serial** and **Parallel Size** parameters correspond to the actual physical size of each section of the CCD. For a 4K x 4K CCD with four ports, the size parameters would be 2K each for serial and parallel when in 4 port readout mode. Depending on the particular CCD and the electronics, there may be some restrictions on how it can be read out.

**Parallel Shift Delay** is the delay between the timing states when doing a parallel shift. This parameter is in increments of 100 ns. This parameter should normally be left at the factory set value.

**Shutter Close Delay** is the delay after the shutter is closed before the CCD readout begins. This delay is in 1 ms increments and must be >0.

**Shutter Open Delay** is the delay following the shutter open signal before the exposure timer is started.

All temperature parameters are entered in the units indicated on the control.

**CCD Temp. Setpoint Offset** is a single point correction for the temperature calibration (not used in all cameras).

**CCD Temperature Setpoint** is the temperature to which the camera cools.

**Low Temp Limit** is the lowest temperature that the camera should be operated at. This is important in cameras that have a fiber optic bonded to the CCD so as not to damage the bond. Also, when a CCD gets too cold, the charge transfer efficiency (CTE) degrades. This usually happens somewhere between -105 and -120 °C. If the CCD temperature goes below the set limit, a warning window is displayed.

**Operational Temp** is the temperature above which a warning window will be displayed to alert the user that the camera is warming up. The warning window will not be displayed until the camera has been cooled below the **Operational Temp** first.

As with **Readout & Format** parameters, depending on a camera's abilities, there may be other parameters in the **Configuration** tab. The parameters discussed above are common to most cameras. Below are parameters that are available in some newer cameras.

**Cold End Temp Setpoint** is the setpoint temperature for the cold end of the CryoTiger cooler on the 1100 series cameras.

**Backplate Temp Offset** is a single point correction for the temperature calibration for the backplate of thermoelectrically cooled cameras (not used in all cameras).

**MPP Mode** controls whether the CCD is in MPP mode, value of 0, or non-MPP mode, value of 1. MPP stands for Multi-Pinned Phased and is also referred to as inverted mode. For a discussion of MPP mode operation of a CCD, see “Electronic and Computer-Aided Astronomy”, Ian S. Mclean, Ellis Horwok publisher, (1989). Not all CCD sensors can be switched between MPP and Non-MPP mode.

**Frame Transfer** allows the switch between normal and frame transfer readout on CCDs that have frame transfer ability.

**Window Heater** turns the window heater On/Off.

**Operational Pressure** sets the maximum pressure that is allowed at or below the operational temperature before a warning window is displayed.

**High Pressure Limit** is the maximum pressure allowed at any temperature before a warning window is displayed.

**BP Sensor Override** is used during the camera manufacturing and should not be needed by the end user. It allows the camera to be operated before the backplate temperature sensor is installed.

**Cooler** is an On/Off parameter the controls the camera cooler. On cameras that have this parameter, it is automatically set by the **Cooler** button on the Camera Settings tab.

**Trigger Out Selector** and **Trigger In Selector** control whether the triggers are opto-isolated or TTL.

**Trigger Input** controls whether the trigger input is set to pull-up or pull-down.

**Acquisition Mode** will usually be set to Normal in regular use. Other settings allow various test patterns for camera diagnostics.

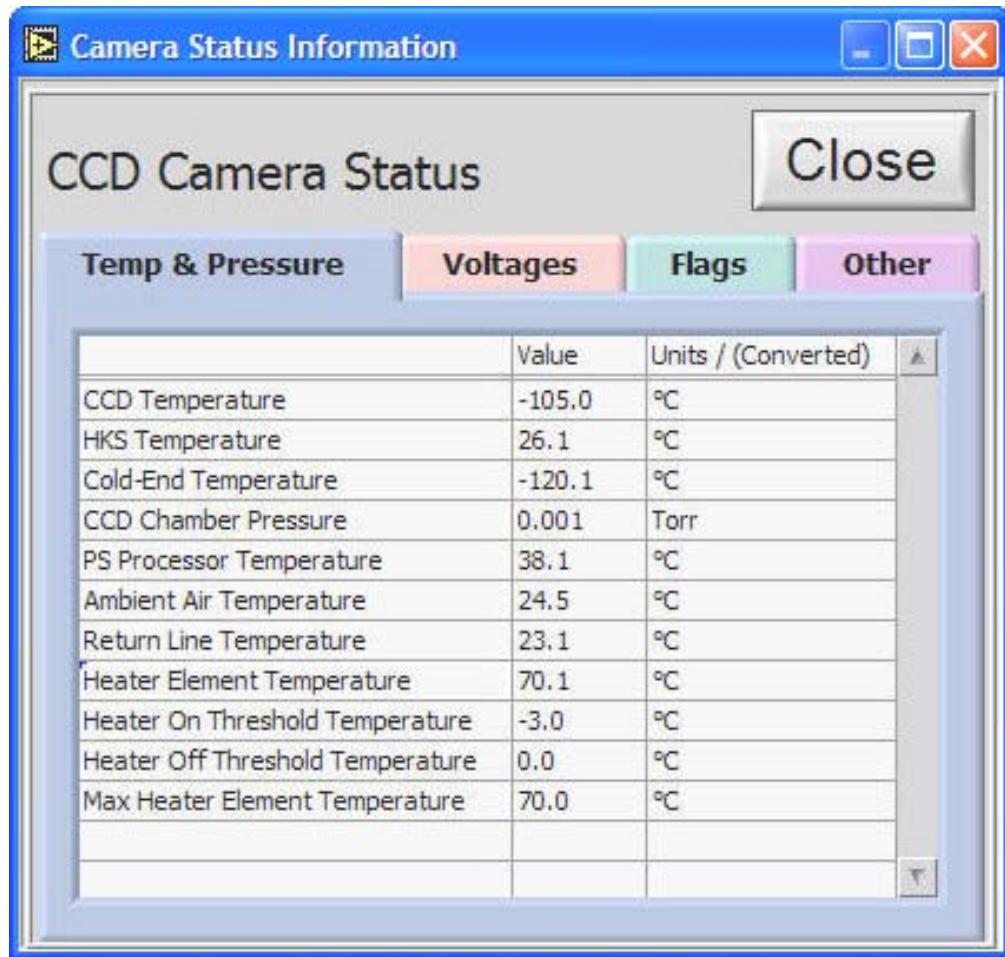
**UART 100 byte Ack** is used to turn On/Off the camera waiting for an acknowledge byte after every 100 bytes sent on the serial communications line. This was added for the Linux operating system where data can be lost if the interrupt is not serviced before the UART FIFO buffer is full.

**CryoTiger Low-Flow Begin** and **CryoTiger Low-Flow End** are on some 1100 series cameras to reduce the CryoTiger gas flow once the camera is at a low temperature. This reduces the need for heating the CryoTiger gas lines.

**Pixel Clear** is the time in ns to clear a single pixel on the CCD. This can be used to calculate the time required to clear the CCD when the CCD is in continuous clear mode (normal mode of operation).

### 3.3 CCD Status

The **CCD Status** button opens a floating window (Figure 3.15) displaying the status of the camera. The status item most often monitored is the CCD Temperature since low noise operation is so dependant on the temperature. Most other status items help in determining if the camera is configured and operating optimally. The status is displayed

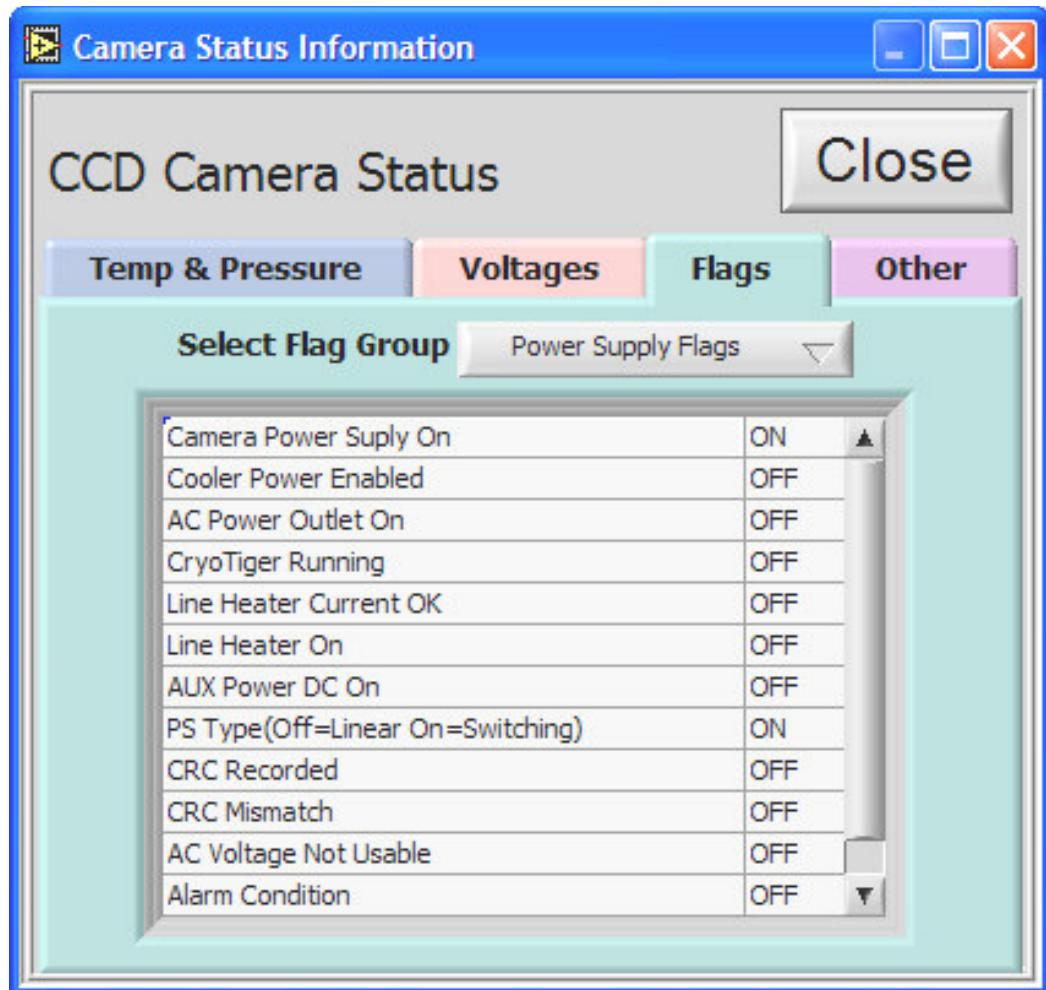


**Figure 3.15 CCD Status Window**

on up to four tabs in the window, **Temp & Pressure**, **Voltages**, **Flags** and **Other**. The **Temp & Pressure** and **Other** tabs are present for all cameras. The **Voltages** and **Flags** tabs are used by 1000, 1100 and 1200 Series cameras but not by the 500, 600 and 800 Series cameras. The example shown here is for a 1100 Series camera. While the status window is open, it continues to update the status information (a green LED blinks in the upper left corner of the window when updating) except when image readout is taking place, at which time a message is displayed indicating status checking is temporarily halted.

The **Voltages** and **Other** tabs display similar lists of status items as seen above. The **Flags** tab, Figure 3.16, displays status items representing their On/Off condition. There is a pull-down menu to select the group to be viewed.

The status window is always on top of the main front panel and is moved by dragging the



**Figure 3.16 Flags Tab in the CCD Status Window**

window by the title bar. The status display table can be extended by using the mouse to pull the bottom of the window down. Pressing the **Close** button stops status checking and closes the window. It is not recommended to leave the status window open while taking important images since the continuous clearing of the CCD is interrupted to service the status request. The status is automatically taken following each image acquisition and placed into the image header that is saved with the image.

### 3.4 Acquiring an Image

Image acquisition is initiated by the controls in the upper right of the front panel (see Figure 3.17). There are two image buffers, Image 1 and Image 2, for acquiring images. The pull-down menu next to each acquire button selects the type of image to acquire.

The selections are shown in Figure 3.18. **Light Exposure** opens the shutter for the amount of time set in the **Exposure Time** control. **Dark Exposure** integrates for the set exposure time with the shutter closed. **Test Image** (not functional on 500 series cameras) instructs the controller to generate a test pattern and transmit it to the computer. This is useful for testing communications with the camera controller. Some cameras have additional special acquisition modes that are described in Section 5 - Special Camera Features. The default Acquisition Mode is **Single Image**. To acquire an image, press either the **Acquire Image 1** or the **Acquire Image 2** button. The new image appears in the display panel and the

**Display** control,  **Image 1**, indicates which image buffer is displayed. The **Display** control also can be used to select whether

Image 1 or Image 2 is being displayed. The  button, when pressed, initiates continuous acquisition into Image 1. That is, the **Acquire Image 1** button is repeatedly pressed automatically until the  button is pressed again to halt continuous mode. Continuous mode is useful for alignment and focusing the camera.

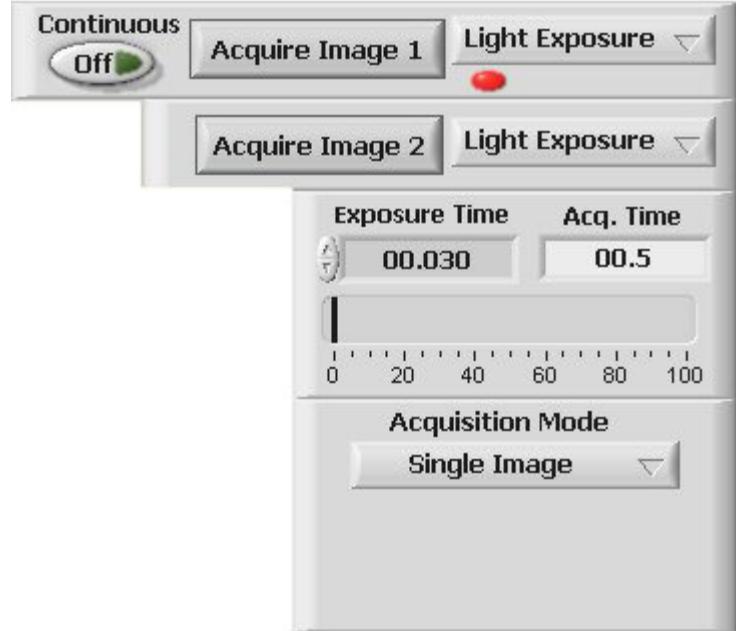


Figure 3.17 Acquire Image Controls



Figure 3.18 Image Type Menu

Below the image acquisition controls on the front panel are controls for setting the exposure time and a progress indicator (Figure 3.19). The **Exposure Time** is changed by directly

**Exposure Time**

 **05.000**

editing the value in the control, or by "nudging" the displayed value by unit increments of 1 second. The units of exposure time are hh:mm:ss.sss. If an exposure is typed in as 60, it will be reformatted to 1:00.000 or one minute. The same could be entered as 1:00. To enter a 100 ms exposure, enter .1. The **Progress** indicator uses a sliding bar to indicate the progress of an image acquisition. The bar starts out blue in color and indicates the % Exposure complete. The progress bar changes to green during the readout phase

**Acq. Time**

 **03.8**

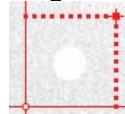
indicating the % Readout complete. The  indicator shows the time left to complete the exposure and readout of the CCD. The time scale is in hh:mm:ss.s with hours and minutes being displayed only if the exposure is long enough to require it. This indicator sometimes goes negative if the initial estimated acquisition time is too short. Following the first acquisition, the actual time measured is used to start the countdown. If the indicator goes negative by more than 10 seconds, it is most likely that an error has occurred and an error dialog will follow.



**Figure 3.19 Exposure Time Controls and Progress Indicator**

### 3.5 Getting Statistics

The statistics section of the front panel is shown in Figure 3.20. The statistics information displayed is for a region of the image that is defined by a resizable



box, the diagonal corners of which are the position of the Red cursor and the smaller red 'offset' cursor, . The position of this offset cursor can be changed by dragging it or by using the X and Y Offset controls on the front panel. When the offset cursor is moved by dragging it with the mouse, the change is reflected in the X and Y Offset controls. When an image is acquired or modified, the statistics are updated for the selected area. To display the statistics for various regions of the image, drag the Red cursor to the desired region (the offset cursor will track along). The offset cursor defaults to always being offset to higher pixel coordinates except when this puts the region outside the image. In this case, the offset cursor is forced to be within the image by reflecting its position about the Red cursor in either axis, while keeping the same

offset value. If a small LED, , appears below the Y Offset label, it is an indication that an error has occurred in the statistics calculation. Clicking on the LED will open a dialog window describing the error. The **Log** button allows the region statistics data to

Region Statistics	Max	103.00
Red Cursor	Min	97.00
X Offset 	P-P	6.00
Y Offset 	Mean	100.00
Log 	RMS Noise	1.23
On	Sum	249992

**Figure 3.20 Image Statistics Information**

be saved in a log file. This can be useful when taking multiple images to automatically save the region statistics.

### 3.6 Special Acquisition Modes

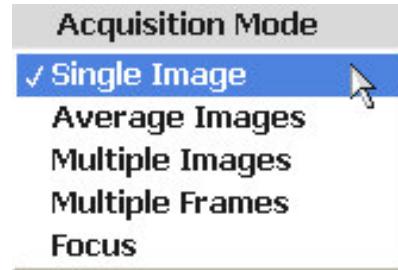
Other acquisition modes depend on the camera capabilities and are selected on the **Acquisition Mode** pull-down menu, Figure 3.21. The first three items are available for all cameras while the last two, **Multiple Frames** and **Focus**, are available and will appear on the menu for cameras that have the ability to do frames acquisition built into the DSP code for those cameras.

#### 3.6.1 Average Images Acquisition

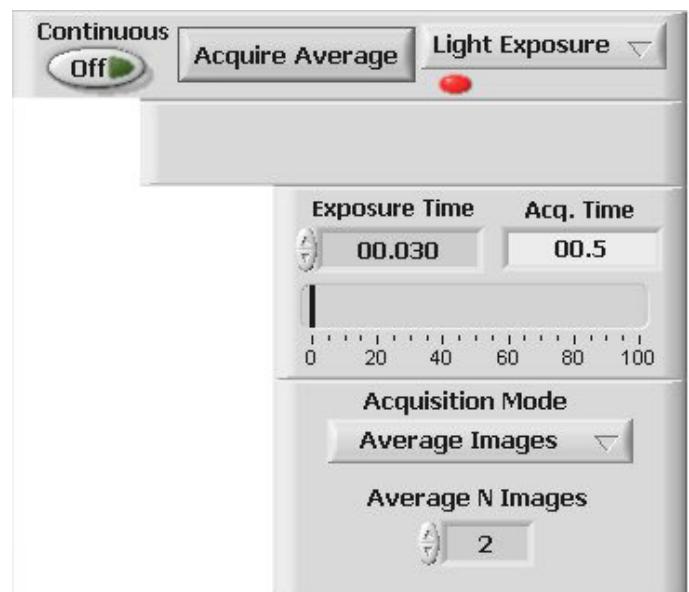
The **Average Images** acquisition is not only used to achieve better signal to noise ratio in acquired images, but an additional option allows the user to turn on a coincidence filter to remove spurious events from the images while doing the averaging. The spurious events filtering is discussed in Section 0 - **Auto Corrections**. When the **Average Images** mode is selected, the front panel changes to reflect the options for this mode (see Figure 3.22). The **Acquire Image 2** controls go away and the **Acquire Image 1** changes to **Acquire Average**. The **Average N Images** control is used to set the number of images to be averaged. When the average images acquisition is started, a progress indicator appears below the **Acquire Average** button (see Figure 3.23). The images are acquired into Image 1 using the current exposure time and the image type set for Image 1.

When the first image is acquired, there is an exchange of Image 1 and Image 2 so that the averaging can take place in the Image 2 buffer. It should be noted that if there are images in either image buffer, they will be

overwritten when the Average Images is started. The **Stop Acquisition** button allows the average images process to be stopped when the current image acquisition is complete. When the selected number of images has been acquired, the final averaged image is moved into Image 1 and displayed. Comments are automatically generated and entered



**Figure 3.21** Acquisition Mode Menu



**Figure 3.22** Average Images Setup



**Figure 3.23** Average Images Progress

**Stop Acquisition** button allows the average images process to be stopped when the current image acquisition is complete. When the selected number of images has been acquired, the final averaged image is moved into Image 1 and displayed. Comments are automatically generated and entered

into the comment section of the image information indicating how many images were averaged.

### 3.6.2 Multiple Image Acquisition

**Multiple Image** acquisition is used to take a sequence of images at a set time interval. It is also used to acquire a sequence of images using the external trigger option, which is discussed further in Section 5.1. In **Multiple Image** acquisition mode, each image is saved to the disk automatically as a separate file. The **Setup** button is initially red and the **Acquire Multiple** button is disabled, indicating that the setup needs to be done before the acquisition can be started.

Pressing the **Setup** button brings up a window (Figure 3.25) that allows setting all the controls necessary to obtain a sequence of images and save them to disk. It is in this window that the time interval, number of acquisitions and the path where files are saved are specified. Care must be taken when setting the time interval so it is longer than the total acquisition time. If the interval set is too short, an error message is displayed and the interval is set to a minimum value. The time interval is set in hh:mm:ss.s, a format like the exposure time control.

The number of acquisitions is either entered into the dialog box or modified by “nudging” the displayed value using the arrows. The acquisitions are saved as files on disk with each image having a unique “name”. This file name is composed of the name entered in the

**Data Series:** control and a four-digit count that is appended to the name by the program to distinguish each image in a sequence. The **Start At #:** control allows the user to specify what that four-digit counter should start at for the multiple image series.

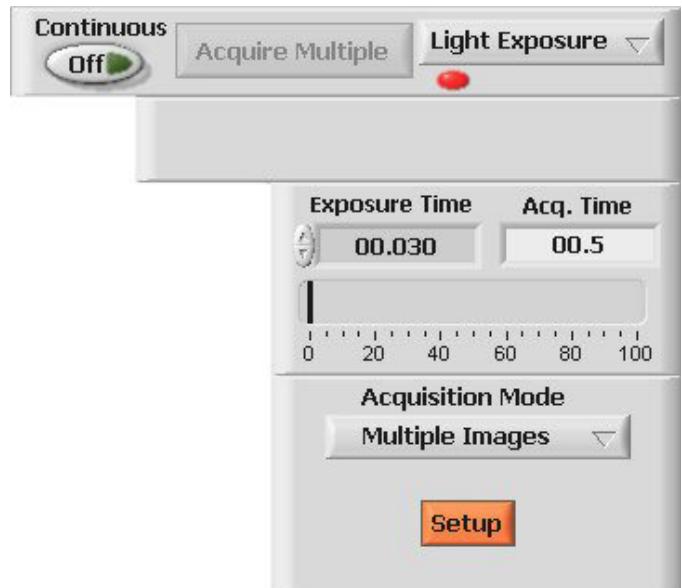


Figure 3.24 Multiple Acquisition Controls

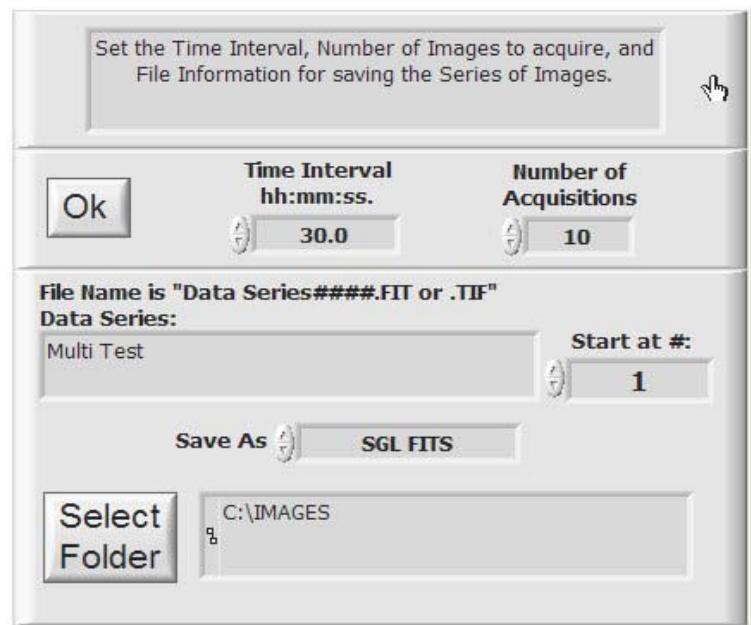
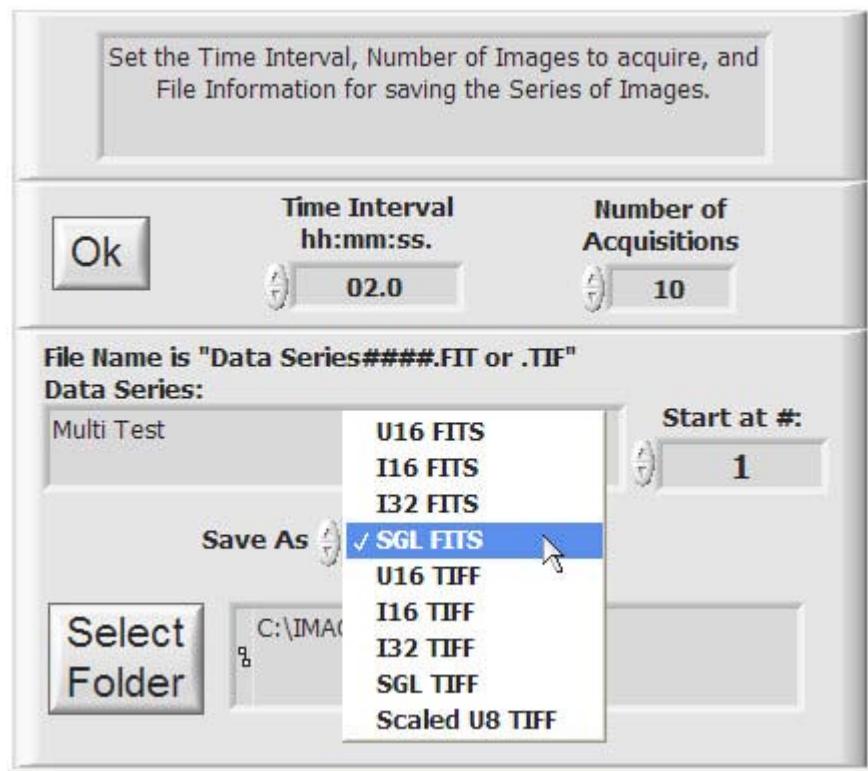


Figure 3.25 Multiple Acquisition initial setup window

As with regular file saving, seven file types are available as shown in Figure 3.26. The file type options are standard in the SI Image environment and the TIFF files can be read into any other program that supports the full range of TIFF file types. The files are saved with a time-of-acquisition that is obtained from the system clock when each acquisition is started.

To select where the images will be saved, press the **Select Folder** button to open a file dialog window (Figure 3.27) and select the folder where the images will be saved. The subsequent files in the multiple acquisition are named by incrementing the file name counter. In the example here, the file name of the first image is "Multi Test\_0001.FIT". The second image acquired would be automatically "Multi Test\_0002.FIT" and so on. Once the file folder is selected, press the **Select Cur Dir** button to close the file dialog window. When all settings are correct, press the **OK** button to close the setup window and return to the main front panel. With the setup complete, multiple image



**Figure 3.26 File Type Selection**

acquisition is initiated by pressing the, now enabled, **Acquire Multiple** button shown in. The **Progress** indicator (Figure 3.19) shows the progress of each image acquisition and the **Acquiring 0 of 10** indicators display the progress in the sequence of images the same as when averaging images.

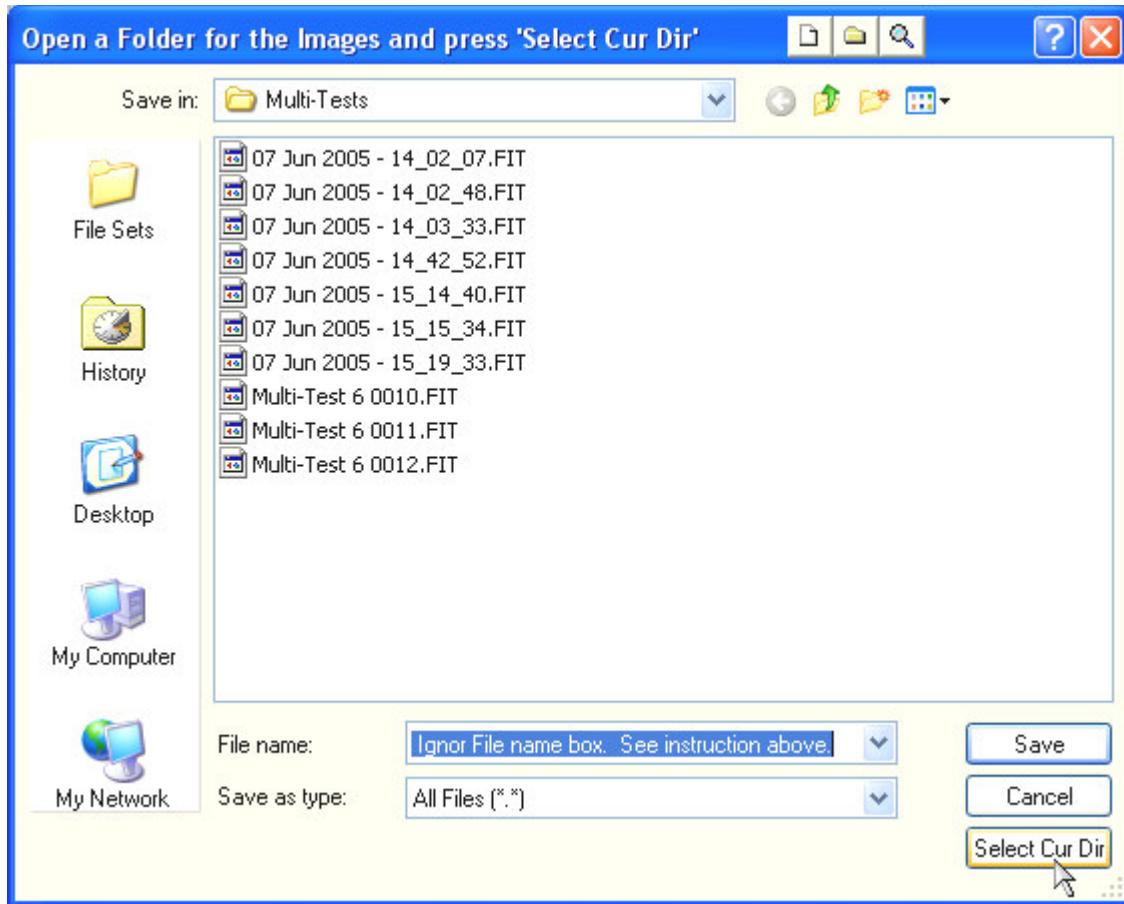


Figure 3.27 File Path Dialog Window

### 3.6.3 Multiple Frames Acquisitions

If a camera is capable of multiple frames acquisition, that option will appear on the **Acquisition Mode** control. **Multiple Frames** mode is an acquisition mode that is optimized for maximum frame rate by having a **Readout & Format** parameter for “# of Frames” and the camera will acquire that number of image frames following a single acquisition command. This mode requires special data handling and flexible saving of the multi-frame images. There are two types of multiple frames acquisition, **Single Frame Buffer** and **Multiple Frame Buffer**. In both types, each frame from the camera is captured in the computer into a single frame DMA (Direct Memory Access) buffer.

In the **Single Frame Buffer** type, the image is copied and de-interlaced if necessary (multi-port readout requires de-interlacing) into a second single-frame buffer and simultaneously written to a multi-framed unsigned 16 bit integer (U16) FITS file on the hard drive. In this way, the memory requirement is minimized since single frame buffers are used and the number of frames is limited by the maximum disk file size of the operating system. The limitation is the speed that the frames can be written to the hard drive.

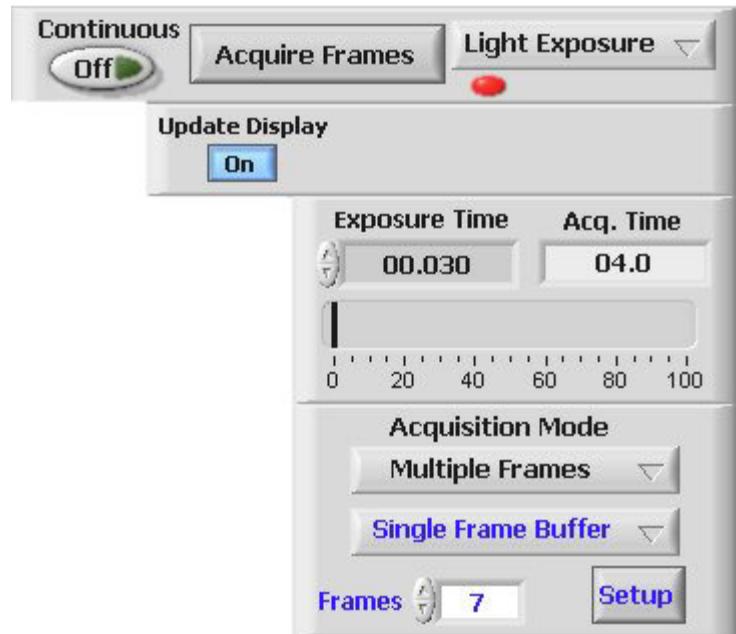
The camera will send the frames as they are acquired and the computer must de-interlace the image and write it to the hard drive fast enough so there is no overlap of frames in the DMA buffer. The de-interlacing of a subsequent frame is held off until the previously de-interlaced buffer is written to the hard drive. In tests on a 2.8 GHz Pentium IV computer, 2106 x 2092 pixel frames were successfully acquired at about 2 frames/sec. while writing to the hard drive. This required a throughput from the camera to the hard drive of 16.8 MB/sec. If there is an overlap of frames, an error dialog will inform the user at the end of the acquisition sequence.

When **Multiple Frames** is selected, the front panel changes as shown in Figure 3.28. The **Setup** button is red at first indicating that the file where the multi-frame image will be written needs to be set. In the setup window, the file naming and the path are entered. There are two naming convention options shown in Figure 3.29 and Figure 3.30. The date and time can be used as the file name or a series name can be entered and a counter in the file name will be incremented. In this way, the setup need only be done once and each subsequent multi-frame image is given a unique file name automatically. The path is selected by pressing the **Select Folder** button and navigating to the desired folder in the file dialog window and pressing the **Select Cur Dir** as discussed above for **Multiple Image Acquisition** mode.

In the **Multiple Frames** mode there is an additional control,

#### **Update Display**

**On**, that enables the display updates to be turned off during the multiple frame acquisitions. Depending on the speed of the computer and its graphics system, turning the update off can allow the computer to keep up with the incoming image data. The update is **On** by default. At the end of the acquisition sequence, only the last frame is displayed.



**Figure 3.28 Multiple Frames Mode**

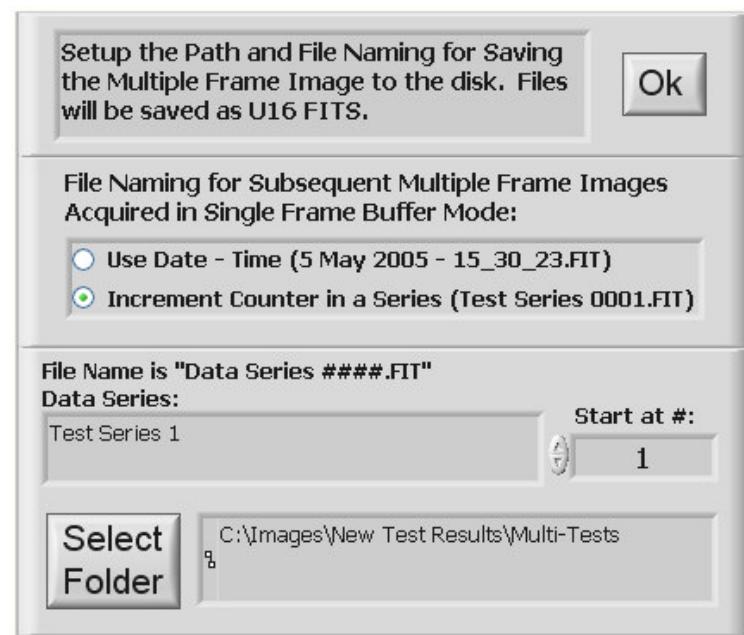


**Figure 3.29 Multiple Frame File Setup using Data51 Time**

A function to look at the frames from a multiple frame image file is discussed later.

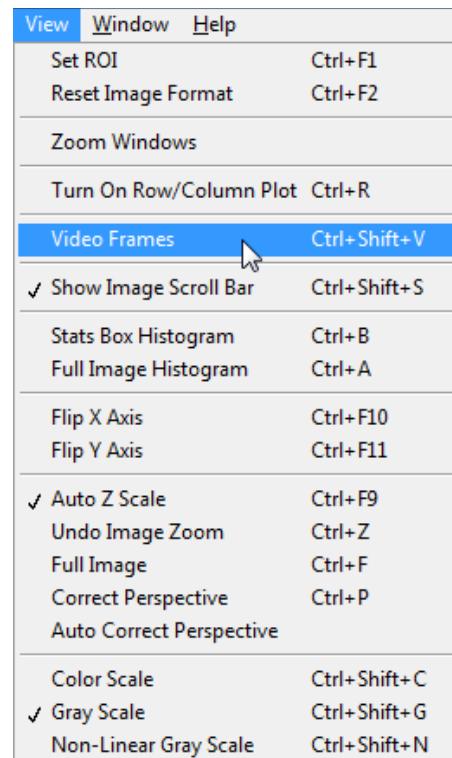
In the **Multiple Frame Buffer** type of acquisition, the DMA buffer is de-interlaced into a multiple frame buffer and not saved to the hard drive. Once the frame sequence is finished, the entire multiple frame image is in the program and can be saved as a normal image, but it is a multiple frame image. No Setup is needed since the file is saved with the usual file functions. The advantage of this type of acquisition is there is no limitation imposed by having to save the frames to the hard drive as they are acquired and the entire image is available in the program at the end of the sequence. The disadvantage is that there has to be enough memory in the computer to hold the, possibly very large, image. Keep in mind that several buffers may be created by the program as different image manipulations are performed. Once the physical memory available in the computer is filled, the operating system will start swapping RAM memory to the hard drive and the speed of the computer will slow greatly and may cause problems with the image acquisition. So, while **Multiple Frame Buffer** allows the maximum acquisition speed, the number of frames will be limited by the memory in the computer.

Viewing the frames of a multiple frame image can be done a few different ways. If the image is acquired using the **Multiple Frame Buffer** type or a multiple frame file is opened using the **Open Image** item on the file menu, all the frames are in the image display buffer. The image as viewed in the image display of the program has the multiple frames along the X axis of the image display. The **Video Frames** item on the **View** menu, Figure 3.31, opens a floating window (see Figure 2.16) to control the X axis of the image display for viewing individual frames of a multiple frame image. This is discussed in section 2.3.4. Alternatively, the **Show Image Scroll Bar** item on the **View** menu can be selected and a scroll bar appears below the image display that can be used to scroll the image display along the X axis. Using either these methods requires that enough computer memory is available since the entire multiple frame image is resident in the memory.



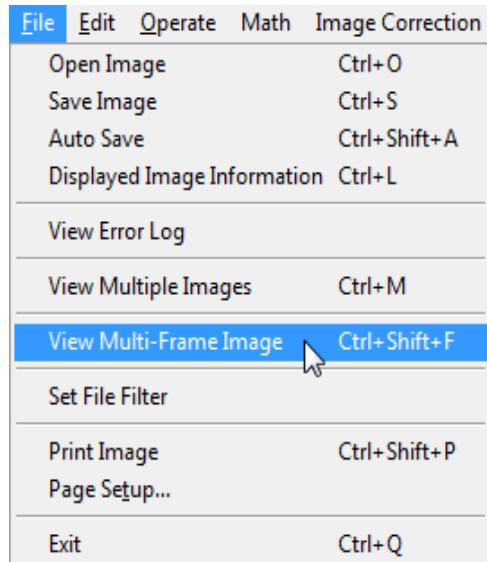
**Figure 3.30** Multiple Frame File Setup using Series

no limitation imposed by having to save the frames to the hard drive as they are acquired and the entire image is available in the program at the end of the sequence. The disadvantage is that there has to be enough memory in the computer to hold the, possibly very large, image. Keep in mind that several buffers may be created by the program as different image manipulations are performed. Once the physical memory available in the computer is filled, the operating system will start swapping RAM memory to the hard drive and the speed of the computer will slow greatly and may cause problems with the image acquisition. So, while **Multiple Frame Buffer**

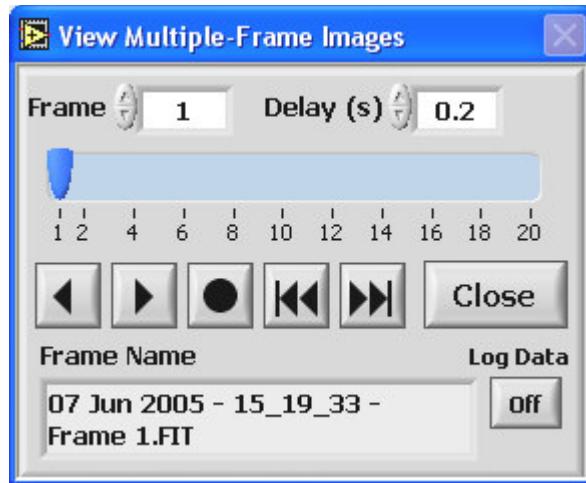


**Figure 3.31** View Video Frames from Multiple Frame Image

The third way to view individual frames of a multiple frame image file is to use the **View Multi-Frame Image** item on the **File** menu (Figure 3.32). This method loads one frame at a time into the computer memory and into the image display. This way a very large multiple frame image can be viewed. When this is selected, a file dialog window allows the multiple frame image file to be selected. Next the **View Multiple-Frame Image** control pops up (Figure 3.33) in a floating window and the first frame is read and displayed in the image display. The controls are the same as used in the **Video Frames Control** window. One additional item is the **Log Data** button that enables the region statistics data from the image frame to be logged to a file as the frames are played back. The **Delay (s)** control sets the dwell time in seconds for each frame during playback. Any individual frame can be saved to a new single frame file by stopping the viewing and doing a normal **Save Image** from the **File** menu.

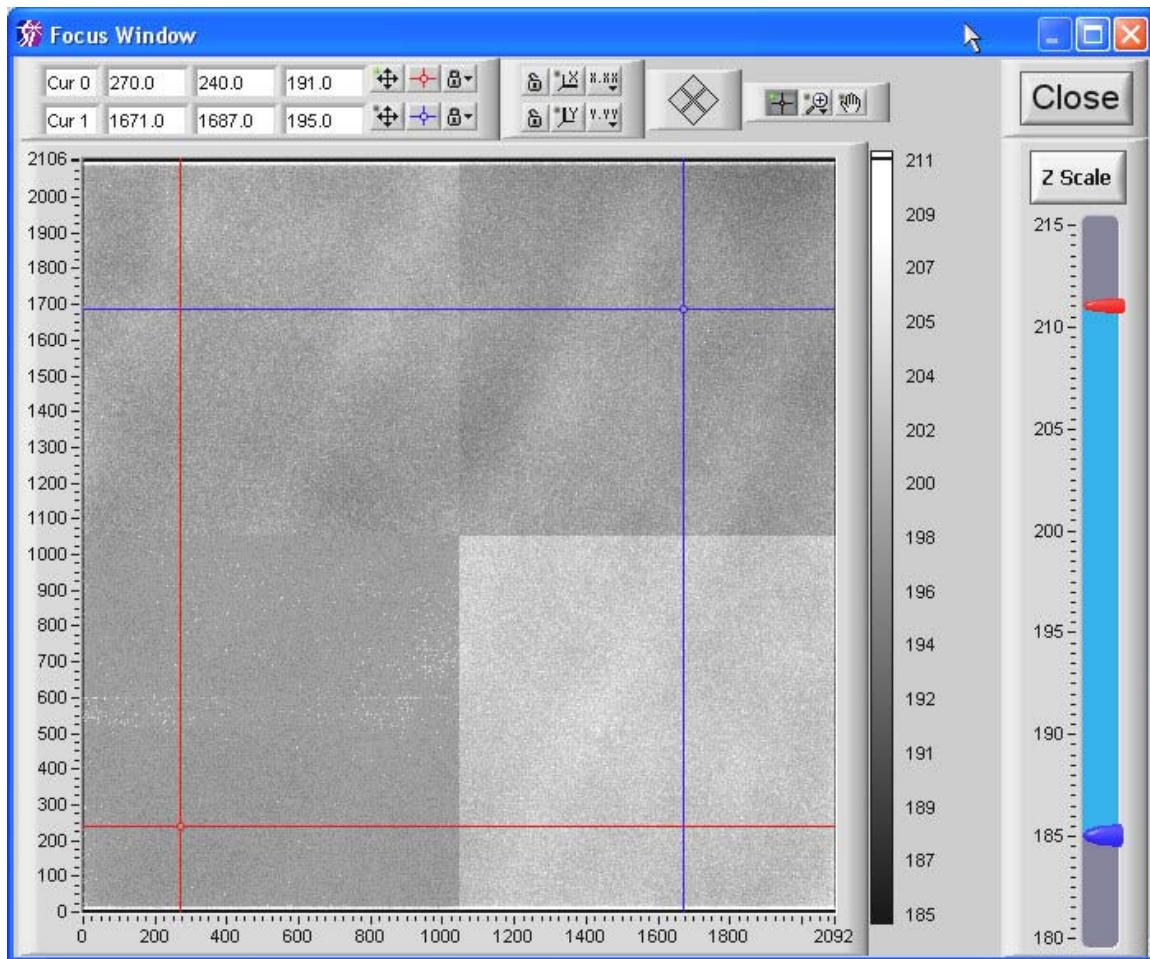


**Figure 3.32 View Multi-Frame Image**



**Figure 3.33 View Multiple-Frame Image Control**

### 3.6.4 Focus



**Figure 3.34 Focus Window**

The last acquisition mode is **Focus**. This mode is only available on cameras that have multiple frames ability. In this mode, the main image acquisition button becomes

**Focus**

and will open a window, Figure 3.34, that is a floating window and its display is optimized for speed. The camera is put in a continuous acquisition mode using the exposure time and readout speed set in the main program window. Images cannot be saved from this window as it is meant only for viewing during instrument adjustment. When the first frame is acquired, the image display scales the Z or intensity axis automatically once. After this, display can be scaled by pressing the **Z Scale** button or by using the Z Scale slider controls to the right of the image display.

## 4 Image Math

### 4.1 Math Menu

Image arithmetic operations and image exchange are included under the **Math** menu shown in Figure 4.1. All image math functions are performed in the default SI Image SGL single precision floating point arithmetic model.

Four image arithmetic functions are provided to combine Image 1 with Image 2, the results replacing the prior contents of Image 1. The images must be the same size to perform image arithmetic. Simple image addition, subtraction, multiplication, and division are obtained by these functions. The result, which is entered into Image 1, is displayed and any plot or histogram currently selected is updated along with the new display. The "stats box" is also updated after every arithmetic operation.

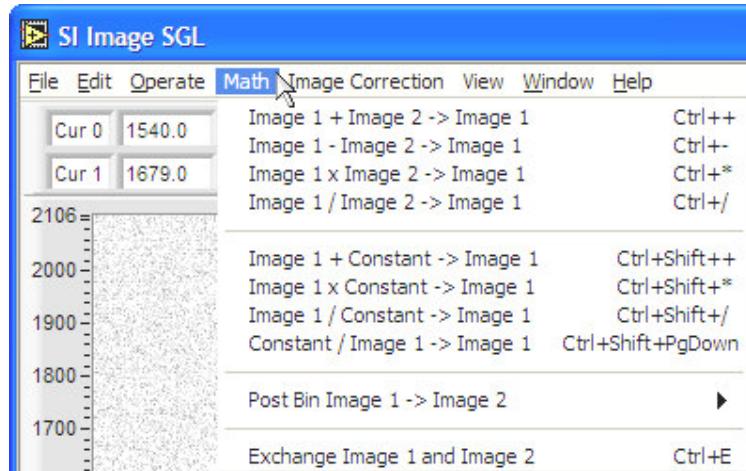


Figure 4.1 Math Menu

Functions are provided to add a constant to Image 1, multiply Image 1 by a constant, divide Image 1 by a constant and divide a constant by Image 1. Selecting **Image 1 + Constant → Image 1** function brings up the dialog box shown in Figure 4.2. The value of the constant used previously is displayed and may be accepted by clicking the OK button or modified either by selecting the displayed number and entering a new value or by "nudging" the displayed value by the arrows. A similar window is used to enter the constant for the other constant operations.

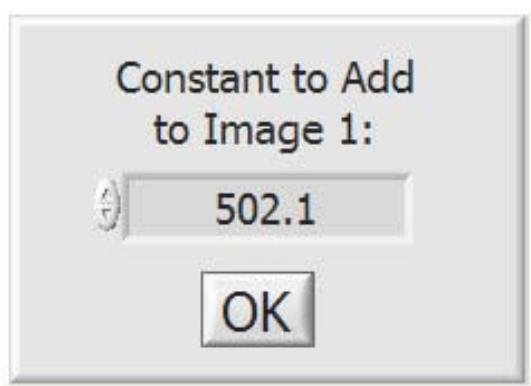
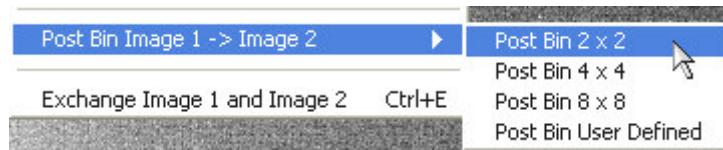


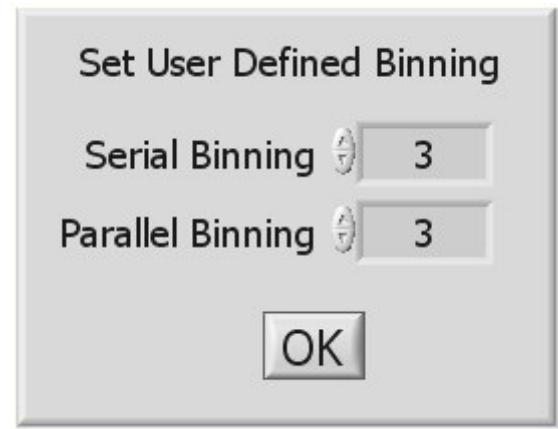
Figure 4.2 Add Constant to Image 1



**Figure 4.3 Post Binning Menu**

The post binning function (Figure 4.3) allows the image to be arithmetically binned after an acquisition has taken place as opposed to normal binning that takes place on the CCD. There are three preset binning options and a user defined option. When the user defined option is selected, a widow (Figure 4.4) allows the user to set arbitrary binning factors.

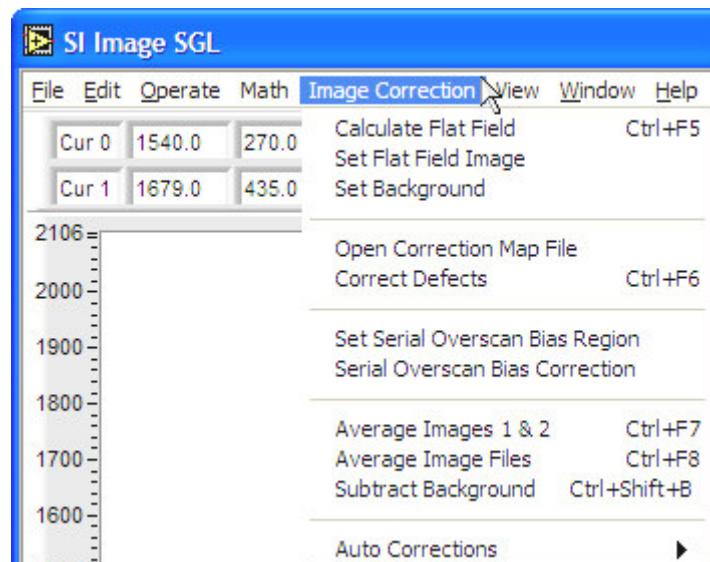
Since most image functions involve Image 1, **Exchange Image 1 and Image 2**, allows the interchange of the contents of Image 1 and Image 2.



**Figure 4.4 User Defined Binning**

## 4.2 Image Corrections Menu

The **Image Correction** menu, Figure 4.5, allows different image corrections and correction options to be implemented. When the program is first started, some of the menu items are disabled, such as the **Correct Defects** menu item in Figure 4.5. The items become enabled when the correction map file is opened in the correct defects case, the images are set for flat field calculations or background subtraction or when the serial overscan bias region is set.



**Figure 4.5 Image Correction menu**

### 4.2.1 Flat Fielding

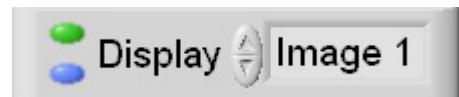
Flat fielding corrects for non-uniformity in the optics and pixel-to-pixel variations in sensitivity of the CCD. Initially, the **Calculate Flat Field** menu item is disabled until the flat field image is established. The recommended procedure is to first collect a dark image for the same exposure time to be used for the flat field image. For best signal

to noise, the dark image should be the average of several acquisitions, with spurious events correction and defects correction set, creating a “master dark image”. Save this master dark image to a file.

Next, the flat field image must be collected. To flat field an image it is necessary to obtain a flat image that has an average pixel value well above the dark signal level. Generally, a flat field mean level above  $\frac{1}{4}$  saturation is preferred to preserve significance in the result. The image should be flat! This is not easy to achieve in most circumstances because it means that the field being viewed must be imaged without a target. The flat field image should also be acquired using the **Average Images** acquisition mode, with spurious events and defects correction set, to improve signal to noise. When the flat field image has been acquired in Image 1, open the “master dark” image into Image 2 and perform a subtraction of the dark image from the flat field. It is recommended to save this “master flat field” image to a file so that it can also be used later. After saving the image to a file, select the **Set Flat Field Image** menu item to enter the image into the flat field calculation buffer.

If the images that are to be flat fielded have the same exposure time as the previously acquired dark, that dark can be used as is in the flat field calculation. Otherwise, a new dark must be acquired using the correct exposure time (**Average Images** acquisition is recommended). Once the dark is acquired, there are two options for how the dark will be used in the flat field calculation. If the computer is short of memory for the size of the CCD being used, the dark image can be placed in Image 2 and the flat field calculation will use it from there. If memory is not a problem, select the **Set Background** item from the menu to place this dark into special buffer for flat field calculation. The advantage of this option is that the Image 2 buffer is free to be used for **Average Images** acquisition on the final image.

It is important to note that both **Set Flat Field Image** and **Set Background** operate on the image that is in the image display. LEDs on the front panel indicate when these images have been set. Figure 4.6 shows these LEDs to the left of the **Display** control. The top LED is green and indicates that the flat field image has been set. The bottom LED is blue and indicates that the background image has been set.



**Figure 4.6 Files Set LEDs**

Now that the appropriate images are in place, an image can be acquired and the **Calculate Flat Field** menu item can be selected to flat field the new image. The acquired image is first corrected for offset by subtracting the dark image. The image is then multiplied by the mean value of the flat field correction image and divided, pixel-by-pixel, by the flat field correction image. Note that absolute pixel values are lost by the flat fielding process. Separate application-specific calibration is required to preserve the numerical integrity of images that are flat fielded. There is a more in depth discussion of this in the camera system user manual.

#### 4.2.2 Defect Correction

To perform defect correction on an image, a correction map file must be open. Select the **Open Correction Map File** from the **Image Correction** menu and select the correction map file as shown below in Figure 4.7. This file is installed when the software is installed and is in the same folder as the program. The file is text based allowing additional entries by the user if necessary. The format is “Column,Start,Length” followed by a carriage return. Once the file has been opened, the **Correct Defects** menu item is enabled and can be selected to correct image defects. For details about the correction map file, see Appendix B on page 81.

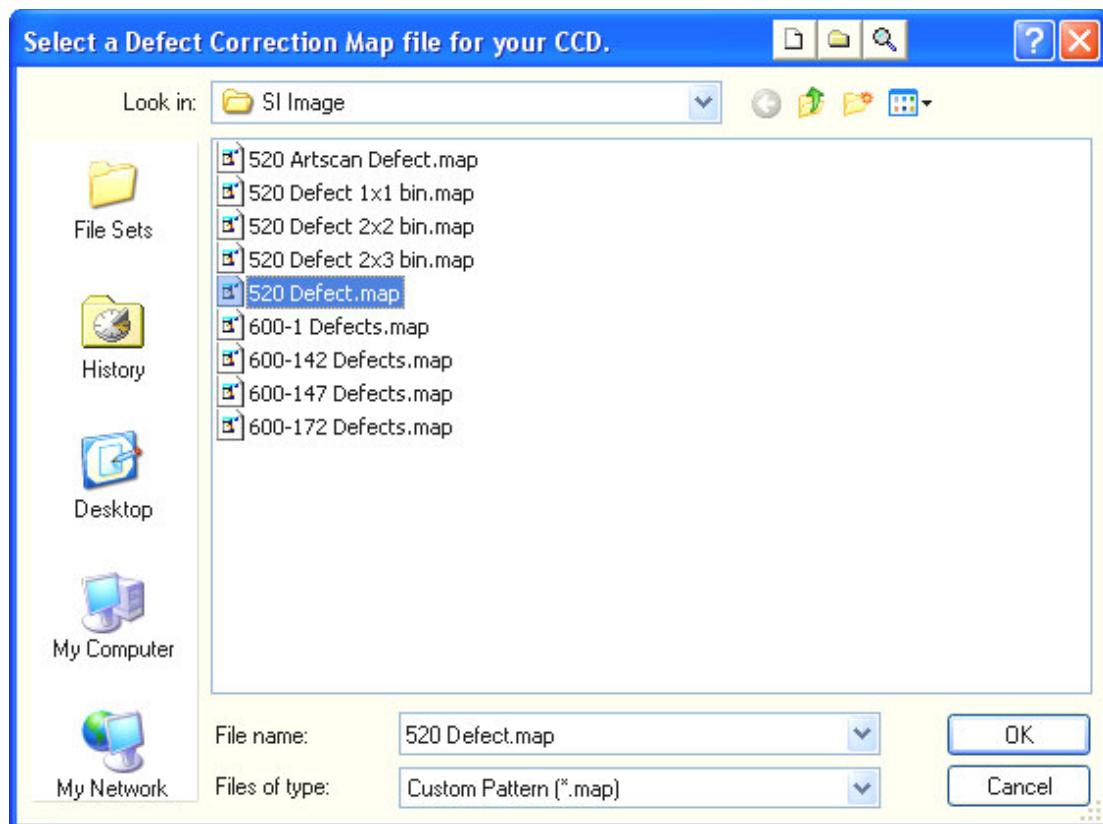
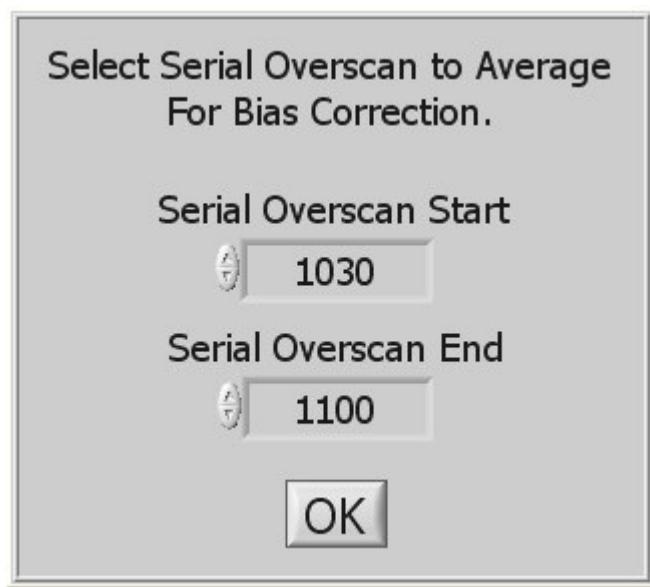


Figure 4.7 Open Defects Correction Map

#### 4.2.3 Serial Overscan Bias Correction

Serial overscan bias correction can be useful when looking at a low light level image that is taken with a slow readout speed. During the readout, the bias level can change a slight amount that is noticeable in a low light image. This correction requires that the image be taken with a serial overscan meaning that the serial length has to be longer than the CCD's serial length so that the overscan can be used to determine the bias and apply the correction. The **Set Serial Overscan Bias Region** menu item opens a window (Figure 4.8) that sets the overscan region to be used for the correction. The values shown in Figure 4.8 would be for a 1024 x 1024 CCD where the serial length was set to at least 1100. As images are viewed in the program with 0,0 being in the lower left of the image display, CCD rows are vertical and the serial overscan appears at the top of the screen. The correction is applied on a row-by-row basis where the average value of the row in the serial overscan region selected is subtracted from the entire row.



**Figure 4.8 Set Serial Overscan Bias Region**

Note that the first few columns off the active portion of the image should be avoided, as well as columns near the end of the image. The former are avoided to skip over CCD edge mask irregularities and the latter because all readout start and stop columns are subject to transient effects.

#### 4.2.4 Average Images

In addition to averaging images as they are acquired, previously acquired images loaded into Images 1 & 2 can be averaged as can image files from a disk. The **Average Images 1 & 2** menu item will do just that and put the averaged image in Image 1. The **Average Image Files** menu item opens a window (Figure 4.9) where the image files to be averaged are selected. The files are selected using the normal Windows methods of using the Shift and Ctrl keys and the mouse. Once the files have been selected, press **OK** to begin averaging. The final averaged image is in Image 1.

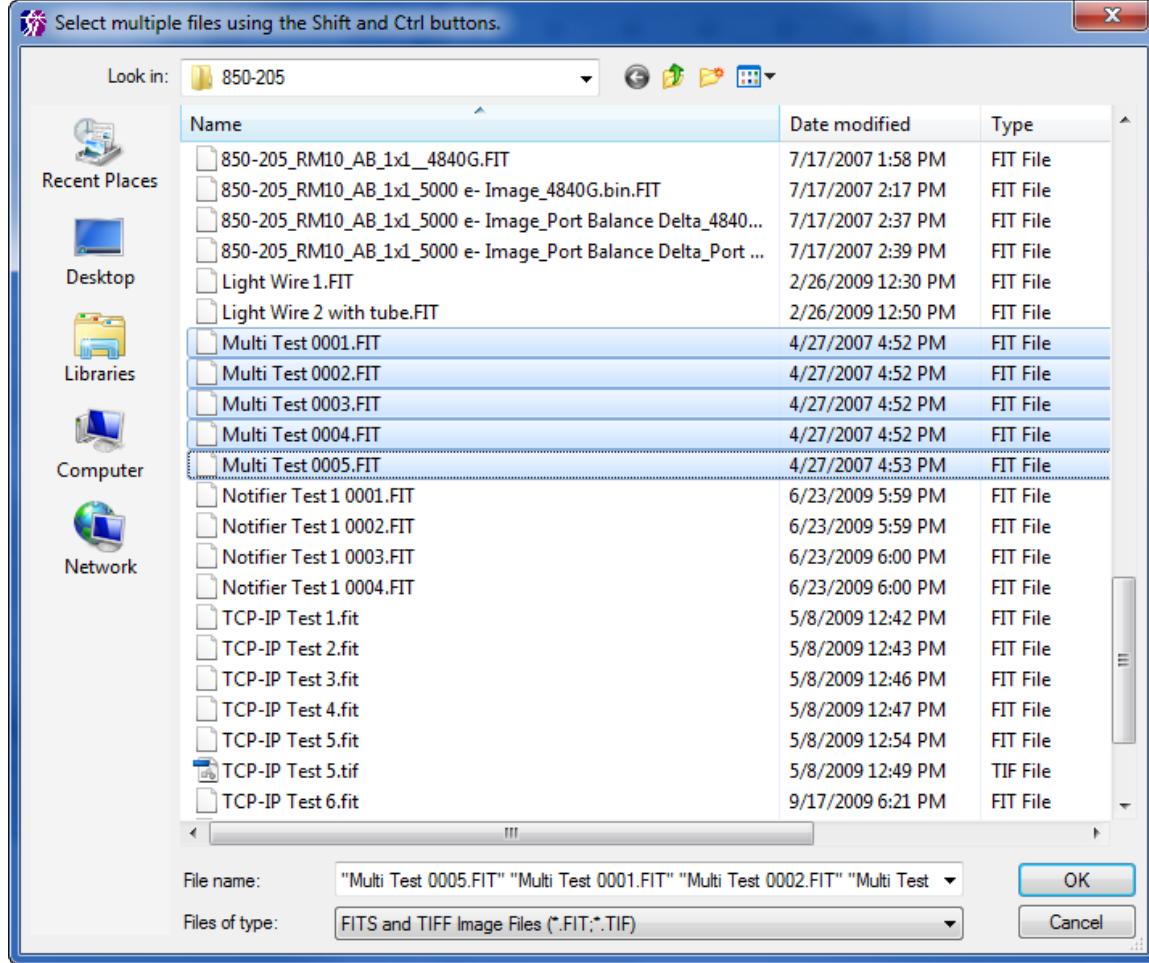


Figure 4.9 Select Multiple Files for Averaging

#### 4.2.5 Subtract Background

The **Subtract Background** menu item subtracts the selected background image from the image in the currently displayed buffer. The background image must be set as described above (in Section 4.2.1 Flat Fielding) for this function to be enabled.

#### 4.2.6 Auto Corrections

The **Auto Corrections** menu item (Figure 4.10) allows image corrections to be applied automatically following image acquisition. When performing a “Multiple Images” acquisition or when the auto-save feature is turned on, any auto corrections selected are applied before the image is saved. When acquiring averaged images, the corrections are applied to the final averaged image.

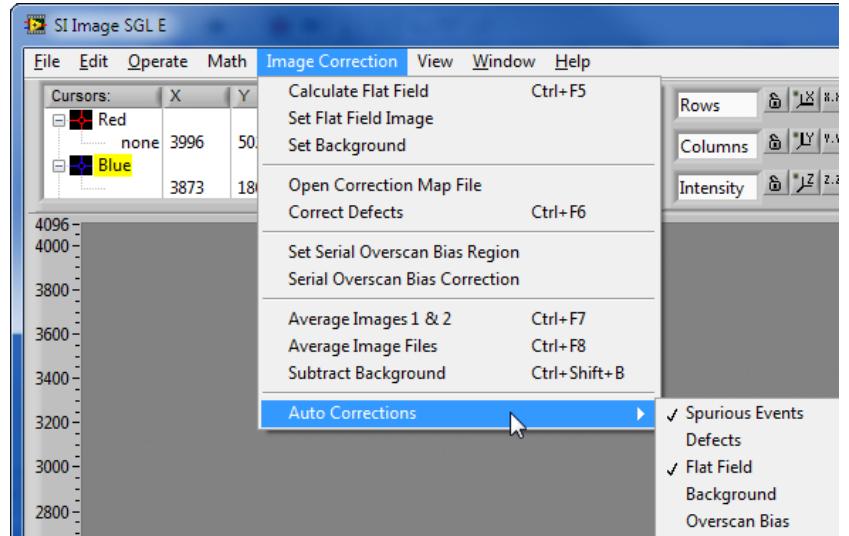


Figure 4.10 Auto Corrections Menu

The **Spurious Events** correction corrects for any random occurring bright pixels that can be caused by high-energy events such as cosmic rays. The filter works, when averaging two images or during averaged image acquisition, by looking for non-coincidental hot pixels. To enable spurious events correction during image averaging, select the **Spurious Events** menu item shown in Figure 4.10. When it is selected, a  appears next to the menu item and a red LED appears below the acquisition type control shown in Figure 4.11. This is enabled by default when the program starts.

The LEDs shown in Figure 4.11 are indicators of the various auto corrections set from the **Auto Corrections** menu.

The LED on the left is

red and signifies that spurious events will be corrected during image averaging. If a pixel is determined to be a spurious event, it is not used for the averaging and the pixel value from the other image is used in the averaged image. Figure 4.11 also shows the *tip-strip* that is displayed when the mouse is held over the LED for a short time. Each LED has an associated tip strip that can be viewed this way. The second LED from the left is blue and indicates that automatic defect correction is enabled. After an image is acquired, if this is enabled, the defect correction will be automatically applied to the image. The third LED from the left is green and indicates that automatic flat field correction will be

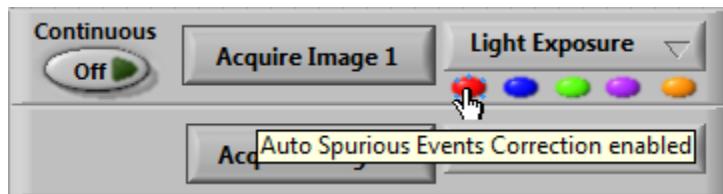


Figure 4.11 Auto Correction LEDs

applied after image acquisition. The fourth LED from the left is purple and indicates that an automatic background subtract correction will be applied after image acquisition. The LED on the right is orange and indicated that the automatic serial overscan bias correct is turned on. Note that the since a background subtraction is part of the flat field correction, either the flat field or background subtract correction can be selected, not both. If both automatic defects and flat field (or background subtract) are set, the defects are corrected before the flat field (or background subtract) is applied. If three corrections are set during Average Images acquisition, the spurious events are corrected during the averaging and the defects correction and flat field or background subtract are applied to the final averaged image.

## 5 Special Camera Features

Several operational modes of a Spectral Instruments CCD camera are used only under special circumstances. These modes become available, on menus described previously, by entries in the file \*.set. These settings are all FALSE unless explicitly entered as being TRUE. Each setting is detailed in sections below.

### 5.1 Triggered Operation

A camera can be set up to acquire an image upon receipt of an external signal. This is accomplished through a contact closure or other TTL signal between two pins at a connector on the camera. See the hardware manual pertaining to your camera for the connector location and pin specification.

An idle camera is maintained in a state such that it is swept clear of charge continuously while not exposing. This keeps the camera instantly ready to expose, which is merely cessation of clearing for the desired exposure time followed by reading the image after the exposure time has elapsed. This instant ready condition is not of special importance in cameras where a mechanical shutter must open and close. There are applications where the light is turned on and off externally and it is possible, through the trigger input, to synchronize the integration activity of the camera to the external light source.

The SI Image program enables a triggered input exposure mode when the entry: **Triggered Acquisition=TRUE** is read from the \*.set settings file. When this software switch setting is encountered at startup, the program presents the additional exposure mode shown in Figure 5.1. When **Triggered Acq.** is selected, a triggered exposure commences at the next trigger after an **Acquire Image 1**, (or **Acquire Image 2**) button is pressed. When the trigger signal is detected, continuous clearing of the camera is terminated (this may take up to a few milliseconds depending on the CCD) and the CCD then integrates signal for a time period determined by the exposure time setting plus the shutter close delay time. The shutter close delay is required to allow the preamplifier to turn on even though no shutter may be installed. Through SI Image, the minimum integration time is one millisecond. Following the integration, the image is readout from the camera and displayed normally and the camera is ready for the next acquisition.

Some cameras also provide a Readout & Format parameter **Command on Trigger**. This parameter allows the user to select optional commands to be performed on trigger.

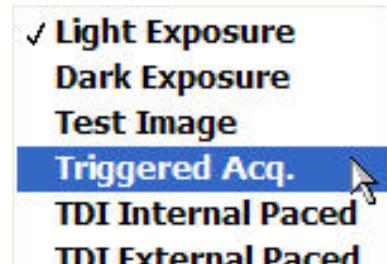


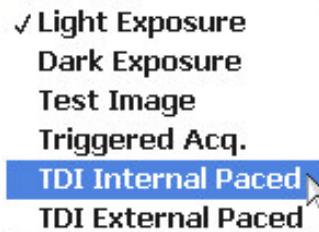
Figure 5.1 Triggered Mode

The following table shows the current list of possible commands associated with the parameter value for cameras with this functionality.

Parameter Value	Command on Trigger
0	Default – Expose and Read CCD
1	Open Shutter
2	Close Shutter
3	Generate Test Image
4	Expose and Read CCD
5	Read CCD Without Exposing
26	Fixed Length, internally paced, TDI Mode Readout

## 5.2 Time Delay Integration (TDI) readout Modes

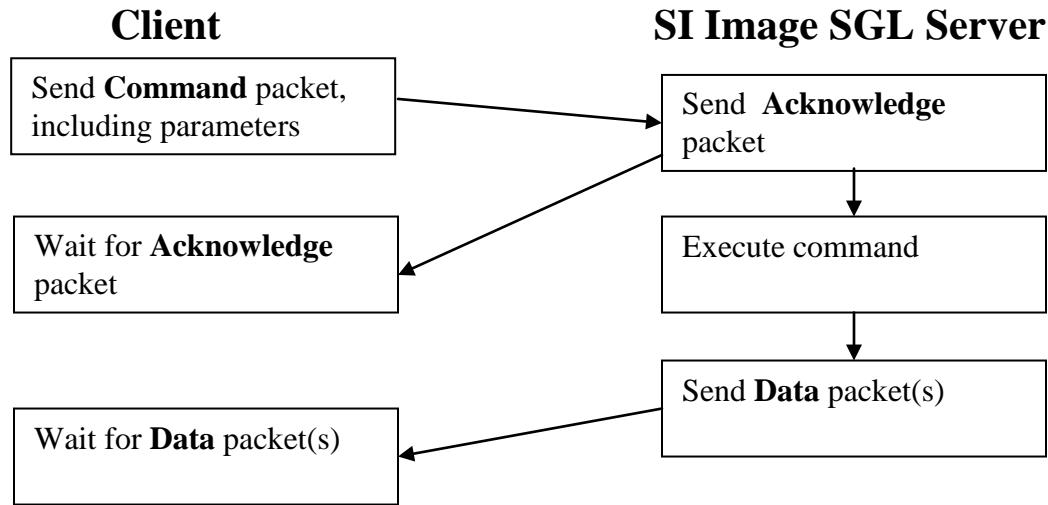
For Time Delay Integration (TDI) readout the shutter remains open while the camera is being readout. This is typically used to allow a longer integration of objects that are moving. In this case, the parallel shift on the CCD is synchronized with the image of the object passing across the CCD device. This synchronization can be accomplished with internal timing using the Readout & Format parameter TDI Delay or external timing using the trigger input to activate a parallel shift. In both cases the final TDI image is of fixed length and the size of this image is limited by the memory available in the computer. The TDI modes are added to the acquisition mode selector (Figure 5.2) by the **TDI Int.=TRUE** and **TDI Ext.=TRUE** items in the [Camera Operation] section of the \*.set file. Not all cameras are capable of externally paced TDI acquisition.



**Figure 5.2 TDI Acquisition Mode**

## 6 SI Image SGL TCP/IP Camera Control

All commands are sent as command packets. Parameters to the server are included in the **Command** packet as specified. The server acknowledges the command immediately with an **Acknowledge** packet. Following this, the server sends the requested **Data** packet(s). **(NOTE:** The commands **Inquire Acquisition Status** and **Terminate Acquisition** are special cases in that they do NOT return an **Acknowledge** packet, only a data packet.



### 6.1 TCP IP packet definition

All transfer is binary. Data are sent in big endian format (most significant byte first).

#### 6.1.1 Command packet (10 bytes + parameter structure)

Packet length	U32	- total number of bytes in packet
Packet identifier	U8	- 128
Camera identifier	U8	- 0 for server commands, Camera number (1..max) otherwise
Function number	U16	- function to be executed (1000 .. 1999)
Parameter structure length	U16	- length of parameter block following (0, if none)
Parameter structure		Dependant on command

#### 6.1.2 Acknowledge packet (8 bytes)

Packet length	U32	- total number of bytes in packet
Packet identifier	U8	- 129
Camera identifier	U8	- Camera ID (1..max)
Accepted flag	U16	- true ( $\neq 0$ ) or false (0)

### 6.1.3 Data packet (14 bytes + data structure – see below)

Packet length	U32	- total number of bytes in packet
Packet identifier	U8	- 131
Camera identifier	U8	- Camera ID (1..max)
Error Code	I32	- 0 = no error
Data type	U16	- 2000 .. 2999
Bytes in Data Structure	U16	- length of data structure that is following
Data structure		arbitrary format (see 6.2 Data Packet Structures)

### 6.1.4 Image packet (30 bytes + Image structure)

Packet length	U32	- total number of bytes in packet
Packet identifier	U8	- 132
Camera identifier	U8	- Camera ID (1..max)
Error Code	I32	- 0 = no error
Image identifier	U16	- a number unique to this image
Image type	U16	- 0=U16, 1=I16, 2=U32, 3=I32, 4=SGL, 5=DBL
Serial Length	U16	- number of columns in the image
Parallel Length	U16	- number of rows in the image
Total number of packets	U16	- total number of packets in this image
Current packet number	U16	- number (0..N) of currently transmitted package
Offset	U32	- packet's offset into the linear image array
Bytes in Image structure	U32	- length of Image structure that is following in bytes
Image structure		n bytes of Image type data – big endian

## 6.2 Data Packet Structures

### 6.2.1 Status structure 2002 (4\*N bytes)

Name	Type	Description
Status Parameter 0	SGL	Camera Dependant – see .cfg file
Status Parameter 1	SGL	
Status Parameter 2	SGL	
.....	SGL	.....
Status Parameter N	SGL	Last Status Parameter

SGL is Single Precision Floating Point number (4 bytes)

The status parameters are defined in the .cfg file that came with the camera. The file is linked to the DSP code, XXXXX.bin DSP code uses XXXXX.cfg. A camera can have a [Status] section and an [Extended Status] section in the .cfg file. If an [Extended Status] section is present, the SI Image Server used the Extended Status to build the Status structure.

### 6.2.2 Arbitrary byte array structure 2003 (n bytes)

Array of n bytes      n x U8

### 6.2.3 Acquisition Status structure 2004 (8 bytes)

Name	Type	Description
% exposure done	U16	% of the exposure time that has elapsed
% readout done	U16	% of the readout that is complete
Relative position of readout	U32	Relative position of readout pointer

### 6.2.4 Image Header structure 2006 (variable length)

Name	Type	Description
Image header	String	Null (0) terminated FITS file header string that contains the required FITS entries, time, date and all the status, readout & format and configuration parameters for the image.

### 6.2.5 Command Done structure 2007 (2 bytes)

Name	Type	Description
Function Number	U16	function that was executed

### 6.2.6 SI Image Settings structure 2008 (42 bytes)

Name	Type	Description
Exposure Time	U32	Exposure time in ms
Number of Readout Modes	U8	Number of Readout Modes defined for the camera
Readout Mode Number	U8	Current Readout Mode
Average N Images	U32	Number of Images to Acquire and Average
Frames	U32	Number of Frames to Acquire
Acquisition Mode	U16	SI Image Acquisition Mode (see 6.3.2)
Acquisition Type	U16	SI Image Acquisition Type (see 6.3.4)
Serial Origin	I32	CCD Format Serial Origin
Serial Length	I32	CCD Format Serial Length
Serial Binning	I32	CCD Format Serial Binning
Parallel Origin	I32	CCD Format Parallel Origin
Parallel Length	I32	CCD Format Parallel Length
Parallel Binning	I32	CCD Format Parallel Binning

### **6.2.7 Camera Parameters structure 2009 (256 bytes)**

Name	Type	Description
Readout & Format Parameter 0	I32	Camera Dependant – see .cfg file
.....	I32	
Readout & Format Parameter 31	I32	Last Readout & Format Parameter
Configuration Parameter 0	I32	Camera Dependant – see .cfg file
.....	I32	.....
Configuration Parameter 31	I32	Last Configuration Parameter

I32 is a signed 32 bit integer. The first 128 bytes contain the Readout & Format Parameters and the second 128 bytes contain the Configuration Parameters.

## **6.3 Camera Commands:**

### **6.3.1 Get Status From Camera**

- Camera Command
- Receives the camera status

Function number: **1011**

Parameters: none

Returns: Data packet 2002 (Status structure)

### **6.3.2 Set Acquisition Mode**

- Camera Command
- Sets the Acquisition Mode

Function number: **1034**

Parameters: U8: Acquisition Mode (0=Single Image, 1=Average, 2=Multiple Images, 3=Multiple Frames, 4=Focus)

Returns: Command Done Data packet

### **6.3.3 Set Exposure Time**

- Camera Command
- Sets the exposure time for subsequent acquisitions

Function number: **1035**

Parameters: U32: Exposure time (in ms)

Returns: Command Done Data packet

### 6.3.4 Set Acquisition Type

- Camera Command
- Sets the Acquisition Type

Function number: **1036**

Parameters: U16: Buffer Number (1 or 2)

U8: Acquisition Type

Returns: Command Done Data packet

#### Acquisition Types:

- |                               |
|-------------------------------|
| 0=Light Exposure              |
| 1=Dark Exposure               |
| 2=Test Exposure               |
| 3=Triggered Exposure          |
| 4=TDI Internal Paced Exposure |
| 5=TDI External Paced Exposure |

### 6.3.5 Acquire

- Camera Command
- Starts an acquisition that has been setup previously

Function number: **1037**

Parameters: U16: Mode (see 6.3.6 below)

U16: Buffer Number (1 or 2)

U16: Save As (see 6.3.7 below)

File Name String (null terminated)

Returns: Command Done Data packet or Image packets depending on the Mode

### 6.3.6 Mode Parameter Values for Image Acquisition

The image is always held in the selected Server Image Buffer after an image is acquired. Depending on the acquisition **Mode**, the image is transmitted to the client and/or saved to the Server's disk.

- 1 Acquire Image and transmit to client when Image data are available
- 2 Acquire Image and hold in Server Image Buffer
- 3 Acquire Image, transmit to client and save to Server's disk when Image data are available
- 4 Acquire Image, save to Server's disk when Image data are available and hold in Server Image Buffer

### 6.3.7 Save As Values for Image Acquisition

- |                     |
|---------------------|
| <b>0</b> – U16 FITS |
| <b>1</b> – I16 FITS |
| <b>2</b> – I32 FITS |
| <b>3</b> – SGL FITS |
| <b>4</b> – U16 TIFF |
| <b>5</b> – I16 TIFF |
| <b>6</b> – I32 TIFF |
| <b>7</b> – SGL TIFF |

### **6.3.8 Set Number of Averages**

- Camera Command
- Sets the Number of Averages in a Average Images Acquisition

Function number: **1038**

Parameters: U16: Number of Averages

Returns: Command Done Data packet

### **6.3.9 Set Number of Frames**

- Camera Command
- Sets the Number of Frames in a Multiple Frame Acquisition

Function number: **1039**

Parameters: U16: Number of Frames

Returns: Command Done Data packet

### **6.3.10 Set Multiple Frame Buffer Mode**

- Camera Command
- Sets Multiple Frame Acquisition Buffer Mode

Function number: **1040**

Parameters: U8: Buffer Mode (0=Single Frame Buffer, 1=Multiple Frame Buffer)

Returns: Command Done Data packet

Notes: In Single Buffer mode, the frames are saved to a multiple frame U16 FITS file and the file name is set to Date-Time mode. In Multiple Frame Buffer mode, if a Save to Server's Disk mode is selected, it is recommended to select FITS format so that the files can be dealt with on a Frame basis.

### **6.3.11 Get SI Image Settings**

- Server Command
- Gets the SI Image program settings (see below)

Function number: **1041**

Parameters: none

Returns: Data packet 2008 (SI Image Settings structure)

### **6.3.12 Set Readout Mode**

- Camera Command
- Sets the Readout Mode Number

Function number: **1042**

Parameters: U8: Readout Mode Number

Returns: Command Done Data packet

### **6.3.13 Set CCD Format Parameters**

- Camera Command
- Sets the CCD Format Parameters

Function number: **1043**

Parameters: I32: Serial Origin

I32: Serial Length

I32: Serial Binning

I32: Parallel Origin

I32: Parallel Length

I32: Parallel Binning

Returns: Command Done Data packet

### **6.3.14 Set any Readout & Format Parameter**

- Camera Command
- Sets any single Readout & Format Parameter

Function number: 1044

Parameters: I32: Parameter Value

Parameter Name String (null terminated)

Returns: Command Done Data Packet

### **6.3.15 Set any Configuration Parameter**

- Camera Command
- Sets any single Configuration Parameter

Function number: 1045

Parameters: I32: Parameter Value

Parameter Name String (null terminated)

Returns: Command Done Data Packet

### **6.3.16 Turn Cooler On/Off**

- Camera Command
- Turns the CCD cooling On/Off

Function number: 1046

Parameters: U8: 0=Off, 1=On

Returns: Command Done Data Packet

### **6.3.17 Set Save to Folder Path**

- Camera Command
- Sets the Folder where subsequent Images will be saved.

Function number: 1047

Parameters: Folder Path String (null terminated)

Returns: Command Done Data Packet

### **6.3.18 Inquire Acquisition Status**

- Camera Command
- Receive status of current acquisition
- **Special case command** where no **Acknowledge** packet is returned. Only a **Data** packet is returned.

Function number: 1017

Parameters: none

Returns: Data Packet 2004 (Acquisition Status structure)

U16: % exposure done

U16: % readout done

U32: Relative position of readout

Notes: No **Acknowledge** packet is returned

### **6.3.19 Terminate Acquisition**

- Camera Command
- Terminates an acquisition in progress
- **Special case command** where no **Acknowledge** packet is returned

Function number: **1018**

Parameters: none

Returns: Data Packet 2007 (Command Done structure)

Notes: If internal buffer was created, it will be destroyed, no **Acknowledge** packet is returned.

### **6.3.20 Retrieve Image**

- Server Command
- Retrieves the current image

Function number: **1019**

Parameters: U16: Buffer Number (1 or 2)

Returns: Multiple Image packets

### **6.3.21 Get Image Header**

- Server Command
- Retrieves complete image header information

Function number: **1024**

Parameters: U16: Buffer Number (1 or 2)

Returns: Data packet 2006 (Image Header structure)

Null (0) terminated FITS file header string that contains the required FITS entries, time, date and all the status, readout & format and configuration parameters for the image.

Notes: sends data packet with all image header information

### **6.3.22 Save Image**

- Server Command
- Saves Image on the server

Function Number: **1031**

Parameters: U16: Buffer Number (1 or 2)

U16: Save As (see 6.3.7 above)

File Name String (null terminated)

Returns: Data Packet 2007 (Command Done structure)

### **6.3.23 Get Camera Parameters**

- Server Command
- Retrieves Parameter Tables from the camera

Function number: **1048**

Parameters: none

Returns: Data packet 2009 (Camera Parameters structure)

### **6.3.24 Expose and Shift N Lines**

- Server Command
- Performs special exposure and is camera specific.

Function number: **1049**

Parameters: none

Returns: Data Packet 2007 (Command Done structure)

This exposure mode is camera specific and performs the following operation:

1. open the shutter
2. wait the shutter delay time
3. expose for the length of time specified by the exposure time parameter
4. close the shutter
5. wait the shutter close delay time
6. shift the number of lines specified by the Number of Lines to Shift parameter (with no TDI delay) and in the direction specified by the Shift Direction parameter.

**NOTE:** The functions in sections 6.3.25 through 6.3.33 are redundant functions that were used in the Rev. C of the SI Image software. They will still function in Rev. E but they do not allow for control of new features that were added in Rev. E.

### 6.3.25 Image Acquisition

- Camera Command
- Starts an image acquisition

Function number: **1012**

Parameters: U32: Exposure time

U16: Mode (see 6.3.6 above)

U16: Buffer Number (1 or 2)

U16: Save As (see 6.3.7 above)

File Name String (null terminated)

Returns: Command Done Data packet or Image packets depending on the Mode

### 6.3.26 Dark Acquisition

- Camera Command
- Starts an acquisition without opening the shutter

Function number: **1013**

Parameters: U32: Exposure time

U16: Mode (see 6.3.6 above)

U16: Buffer Number (1 or 2)

U16: Save As (see 6.3.7 above)

File Name String (null terminated)

Returns: Command Done Data packet or Image packets depending on the Mode

### 6.3.27 Test Pattern Acquisition

- Camera Command
- Starts an acquisition of a test pattern

Function number: **1014**

Parameters: U32: Exposure time

U16: Mode (see 6.3.6 above)

U16: Buffer Number (1 or 2)

U16: Save As (see 6.3.7 above)

File Name String (null terminated)

Returns: Command Done Data packet or Image packets depending on the Mode

### **6.3.28 Triggered Acquisition**

- Camera Command
- Starts an image acquisition with trigger

Function number: **1016**

Parameters: U32: Exposure time

U16: Mode (see 6.3.6 above)

U16: Buffer Number (1 or 2)

U16: Save As (see 6.3.7 above)

File Name String (null terminated)

Returns: Command Done Data packet or Image packets depending on the Mode

### **6.3.29 Averaged Light Images Acquisition**

- Camera Command
- Starts an Average Images acquisition

Function Number: **1028**

Parameters: U32: Exposure time

U16: Mode (see 6.3.6 above)

U16: Number of images to average (1 or 2)

U16: Save As (see 6.3.7 above)

File Name String (null terminated)

Returns: Command Done Data packet or Image packets depending on the Mode

### **6.3.30 Averaged Dark Images Acquisition**

- Camera Command
- Starts an Average Images acquisition

Function Number: **1029**

Parameters: U32: Exposure time

U16: Mode (see 6.3.6 above)

U16: Number of images to average (1 or 2)

U16: Save As (see 6.3.7 above)

File Name String (null terminated)

Returns: Command Done Data packet or Image packets depending on the Mode

### **6.3.31 Averaged Triggered Images Acquisition**

- Camera Command
- Starts an Average Images acquisition

Function Number: **1030**

Parameters: U32: Exposure time  
U16: Mode (see 6.3.6 above)  
U16: Number of images to average (1 or 2)  
U16: Save As (see 6.3.7 above)  
File Name String (null terminated)

Returns: Command Done Data packet or Image packets depending on the Mode

### **6.3.32 TDI (Time Delay Integration) Acquisition, Internally paced**

- Camera Command
- Starts an acquisition without opening the shutter

Function number: **1032**

Parameters: U32: Exposure time  
U16: Mode (see 6.3.6 above)  
U16: Buffer Number (1 or 2)  
U16: Save As (see 6.3.7 above)  
File Name String (null terminated)

Returns: Command Done Data packet or Image packets depending on the Mode

### **6.3.33 TDI (Time Delay Integration) Acquisition, Externally paced**

- Camera Command
- Starts an acquisition without opening the shutter

Function number: **1033**

Parameters: U32: Exposure time  
U16: Mode (see 6.3.6 above)  
U16: Buffer Number (1 or 2)  
U16: Save As (see 6.3.7 above)  
File Name String (null terminated)

Returns: Command Done Data packet or Image packets depending on the Mode

### 6.3.34 Command Summary Table

FUNCTION #	OPERATION
1011	Get Camera Status
1012	Image Acquisition
1013	Dark Acquisition
1014	Test Pattern Acquisition
1016	Triggered Acquisition
1017	Inquire Acquisition Status
1018	Terminate Acquisition
1019	Retrieve Image
1024	Get Image Header
1028	Average Light Images Acquisition
1029	Average Dark Images Acquisition
1030	Average Triggered Images Acquisition
1031	Save Image
1032	TDI (Time Delay Integration) Acquisition, Internally Paced
1033	TDI (Time Delay Integration) Acquisition, Externally Paced
1034	Set Acquisition Mode
1035	Set Exposure Time
1036	Set Acquisition Type
1037	Acquire
1038	Set Number of Averages
1039	Set Number of Frames
1040	Set Multiple Frame Buffer Mode
1041	Get SI Image Settings
1042	Set Readout Mode
1043	Set CCD Format Parameters
1044	Set Single Readout & Format Parameter
1045	Set Single Configuration Parameter
1046	Cooler On/Off
1047	Set Save to Folder Path
1048	Get Camera Parameters
1049	Expose & Shift N Lines

## 7 Appendix A

A file, SI Image.ini, is opened automatically by the SI Image program. For this reason, a file named SI Image.ini must exist in the directory with the SI Image software. When the SI Image software is installed from the CD-ROM, the default version of the SI Image.ini file is installed along with the software. Default item definitions are shown below in **Table A**. The left hand column is the file; the right hand column is annotation.

**Table A**

[Program Configurations]	Section Name
Window Left=7	Screen location for the left-hand edge of the program window.
Window Top=52	Screen location for the top edge of the program window.
Window Right=1016	Screen location for the right-hand edge of program window.
Window Bottom=727	Screen location for the bottom edge of the program window.
TCP/IP Port=2055	TCP/IP server port number
Default Image Path=/C/Images	Default path where images are saved
Save As="SGL FITS"	Default image file type – must be in quotes since there is a space in the string
Acq Alert Delay=30.0	Delay is seconds before an alert window will appear after an image acquisition is complete if there has been no user interaction with the program.
Auto Correct Perspective=FALSE	When TRUE, the X and Y scale of the image display are adjusted to ensure that the geometric perspective is correct.
Error Window Timeout=-1	When set to -1, an error window will remain open until the user interacts with it. Otherwise this set the time in seconds until an error window will automatically close.
Temp-Pressure Warning=TRUE	Enable or disable the temperature/pressure warnings
Temp-Pressure Monitor=TRUE	Enable or disable the background monitoring of the temperature and pressure of the camera.
Auto-TCP/IP = FALSE	Enable or disable auto-start of the TCP/IP server.
Auto-Init = FALSE	Enable or disable auto-initialization of camera.
Flip X = FALSE	If True, image display X axis is flipped, 0 on the right.
Flip Y = FALSE	If True, image display Y axis is flipped, 0 at the top.
Transform 1 = 0	Sets a transform to be performed on the image before saving.
Transform 2 = 0	Sets a transform to be performed on the image before saving.

The structure and entries within this file are universal across all of the cameras offered by Spectral Instruments. The SI Image.ini file contains only program specific information. All camera specific information is contained in the \*.set file described in the next section. The file itself is an editable text file and can be changed using a text editor. It can also be conveniently changed using the **Configure** menu item in the **Operate** menu of the SI Image SGL program.

## 8 Appendix B

A file, \*.map, contains the defect correction information for the associated camera. The name of the \*.map file is normally the camera serial number followed by “Defects.map” (e.g. 600-169 Defects.map).

The content of the file is a comma-delimited table consisting of the column number, the location within the column and the number of contiguous pixels in that defect within that column. The table is generated from images taken with the serial and parallel origins both 0. Corrections from the table are mapped to the target image with the readout and format parameters taken into consideration.

This file can be edited using a text editor to add a defect to the map. The first line of the file specifies the binning (1,1,Binning) that was used to determine the column, start and length values in the file. If this line is not present, 1 x 1 binning is assumed. The second line (Column,Start,Length) is required.

**Table C**, below, illustrates a typical configuration for the \*.map file. The left hand column is the contents of a example file, the right hand column is annotation.

**Table C**

1,1,Binning	Specifies that the values are for 1 x 1 binning
Column,Start,Length	A comment
347,2869,1	A single pixel event
1959,2805,5	A short cluster along one column
2552,0,4096	A full column defect
3894,566,4	A short cluster along one column
3895,568,2	An extension of the above cluster to a second column
3896,569,1	A single pixel extension of the above cluster to a third column.

## 9 Appendix C

User defined parameters can be added to the image file by using a text based file called “**Other Parameters.txt**” (see example box below). This file can be created using a text editor or programmatically from a user program. After an image is acquired, SI Image looks for the above file and adds any items found to the header of the image file. The file is formatted like an “ini” type file with section names in square brackets. Each section is an [Entry #] and each entry contains a **Type**, **Keyword**, **Value**, and **Comment**. The **Type** can be String, Boolean or Numeric. The **Keyword** follows the rules for a FITS file and can be up to 8 characters consisting of the numbers 0-9 and upper case letters A-Z. The **Value** will correspond to the **Type**. The **Value** field can consist of up to 20 characters and the **Comment** field can be up to 46 bytes. For a String, the text should be enclosed in quotes. A Boolean can be T or F. A numeric will be read as a floating point. The **Comment** should also be enclosed in quotes.

```
[Entry 1]
Type=String
Keyword=LOCATE
Value="Tucson, Arizona"
Comment="Observation Location"
[Entry 2]
Type=Boolean
Keyword=BLOCKED
Value=T
Comment="May be blocked"
[Entry 3]
Type=Numeric
Keyword=POSITION
Value=1234.5
Comment="Camera Position"
[Entry 4]
Type=Numeric
Keyword=TEMP
Value=26.4
Comment="Outside temperature"
```