SI Image SGL Software Manual

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Spectral Instruments, Inc.

Tucson, Arizona

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1   SI Image Installation

The SI Image application provides for control of, and image acquisition from, Spectral Instruments cameras through a PCI card 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 2000/XP. Hardware requirements include:

1) A Pentium or equivalent CPU

2) 17 MB free space on the hard drive (5 MB for SI Image and 12 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 96 MB is required for a 1K x 1K device; 1 GB is recommended for a 4K x 4K CCD. If only limited processing is needed, the requirements are lower.

6) One free PCI bus slot

7) A graphics card and display that can support a resolution of at least 1024 x 768 at 64K colors (2 MB graphics memory). 24 or 32 bit color 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 program. If the CDROM does not auto-run, select **Run** from the start button and execute the **Setup.exe** file on the CDROM. The installation program detects 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 2236.cfg file (see Appendix A) contains configuration information for starting the SI Image software. The *.set file (see Appendix B) contains any special parameter settings for the camera.   It also contains the readout and format parameters for your specific

camera. The *.map file (see Appendix C) is a map of the CCD defects which is used to correct the image if desired. The *.str file (see Appendix D) provides a name template for those attributes of the camera that can be set or accessed. The *.set file is camera head specific. The *.bin file is CCD and camera type specific. The CDROM also contains the plug and play drivers (Windows 2000, XP) 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 the drivers on the CDROM and install them. **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 the program 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 necessitates going 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 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. This parameter value is typically 19200 as shipped from the factory. It is selected on the camera controller by a jumper-pin array as discussed in the camera hardware manual. 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.
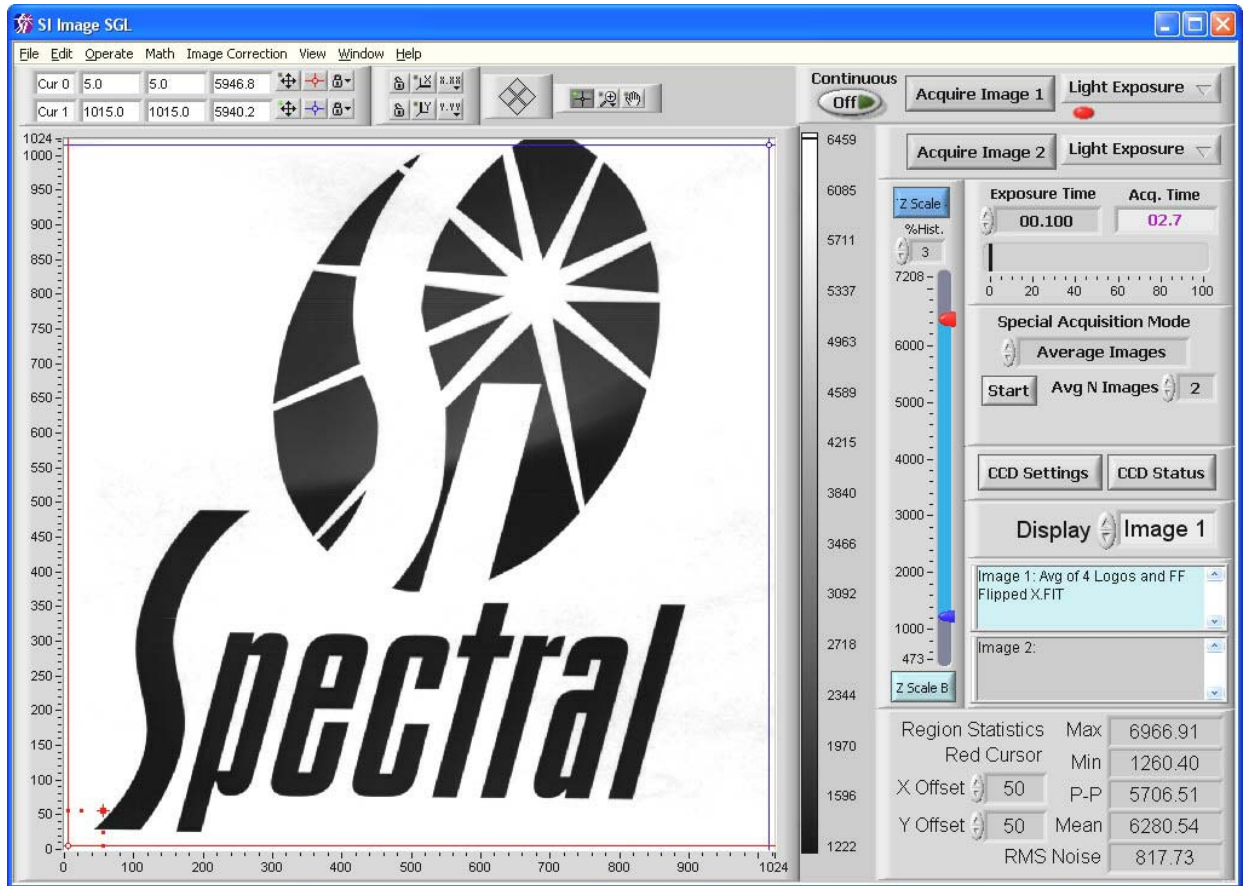
Figure 2.1 SI Image Front Panel

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 configuration file, 2236.cfg, (see Appendix A on page 57) that specifies program specific items. All camera specific information is in the settings file (*.set where * is usually the camera serial number, see Appendix B on page 59). 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 that 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.
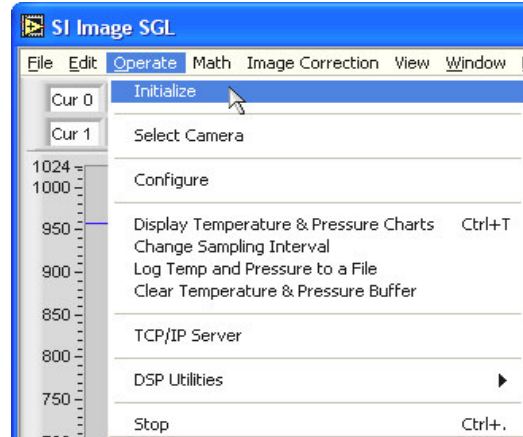
Figure 2.2 Initialize Selection

Selecting the **Initialize** item in the **Operate** menu initializes the camera, which sends the file *.bin to the controller. In 800 Series and higher cameras, the DSP code is stored in an EEPROM 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 condition. With a CryoTiger cooled 600 series camera, if the 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 panel for the **CCD Settings** control is displayed automatically after the camera is initialized. This panel allows setting various **Camera Configuration**
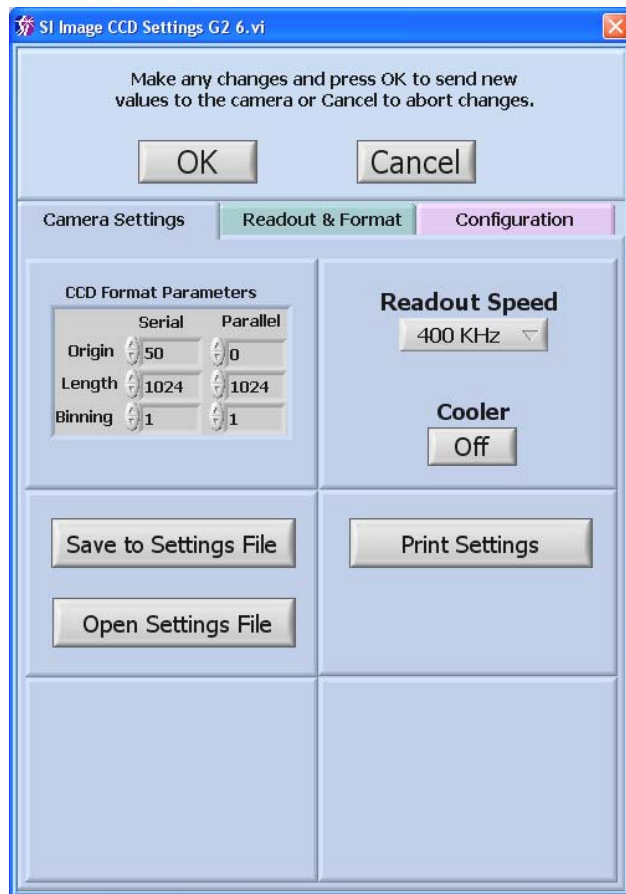
Figure 2.3 CCD Settings Panel

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parameters and **CCD Format Parameters**. The readout format parameters specify the origin, size, and binning of a subarray to be read and are changed frequently for image acquisition. **Readout & Format Parameters** provides access to all of the options available for routine user control of the camera. **Camera Configuration** 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 Setting** are covered later.

Once the **CCD 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. 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 provided tools. The **Display** control, Image 1, 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.

Figure 2.4 Image Type Selector

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** or **F8** short-cut keys resize the visible display to show the entire image. This is set to automatically happen upon the first image acquired following opening the **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. The hot-key **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
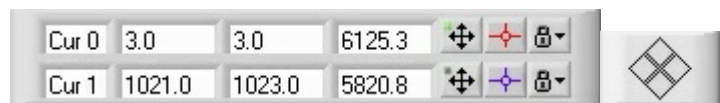
Figure 2.5 Cursor Display

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 (Cur 1) above, X position is 1021, Y position is 1023, and the value of that pixel is 5820.8.   Though this manual is in monochrome, the cursor, Cur 0, is red and the cursor, Cur 1, 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 (in Figure 2.5, Cur 0 is the selected cursor, indicated by the green dot in the button to the right of the pixel value, ⊕) by one pixel in the chosen direction. 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.

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. 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 (Cur 0 or Cur 1) 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

Figure 2.6 Cursor Attributes Control

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 attributes is a control, 🔒▾, that locks the cursor to the lower left corner of the pixel (if 0,0 is the lower left of the image display). 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 cursors can also be moved in the image display, using the mouse, by dragging the selected cursor. 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-

Figure 2.7 Image Display Palette

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 hot-key shortcuts that can be convenient for mode switching. They are: Home - ⬚, Page Up - ⬚, End - ⬚, Page Down - ⬚, F11 - ⬚ and F12 - ⬚.
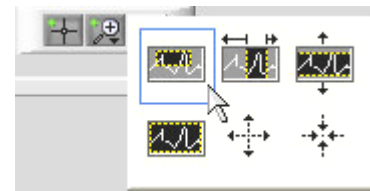
Figure 2.8 Image Zoom Palette

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.

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 hot-key **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 control to the right of the **%Hist** legend.   Five different

selections are available. These are 10%, 5%, 3%, 1% and 0.5% 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.
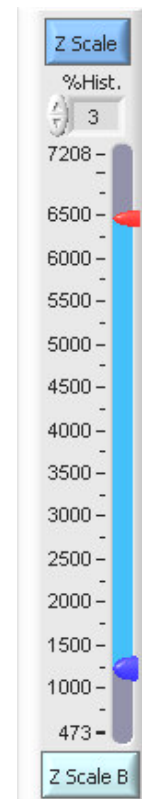
The upper and lower display limits can be edited manually to set the limits of the slider display. Note that this does not change the appearance of the image displayed, it merely changes the slider display and subsequently the slider(s) can be moved into the new range to change the appearance of the image.

The ⟨Z Scale B⟩ 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).

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 2.9 Z Axis Slider Control

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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 shows the View menu with no item highlighted.

2.3.1   Region Of Interest

The first item on the **View** Menu is the **Region of Interest** selector. It opens out to allow selection of the current region of interest (ROI) or reversion to the reference ROI. Figure 2.11 shows the ROI options and the hot-key equivalents.
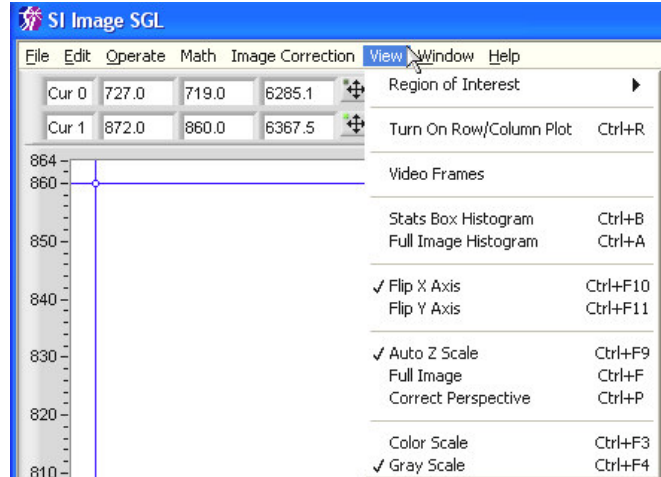
Figure 2.10 View Menu

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, either type **Ctrl+F1** or select the **ROI** slide out and select the **Set ROI** option (Figure 2.11).
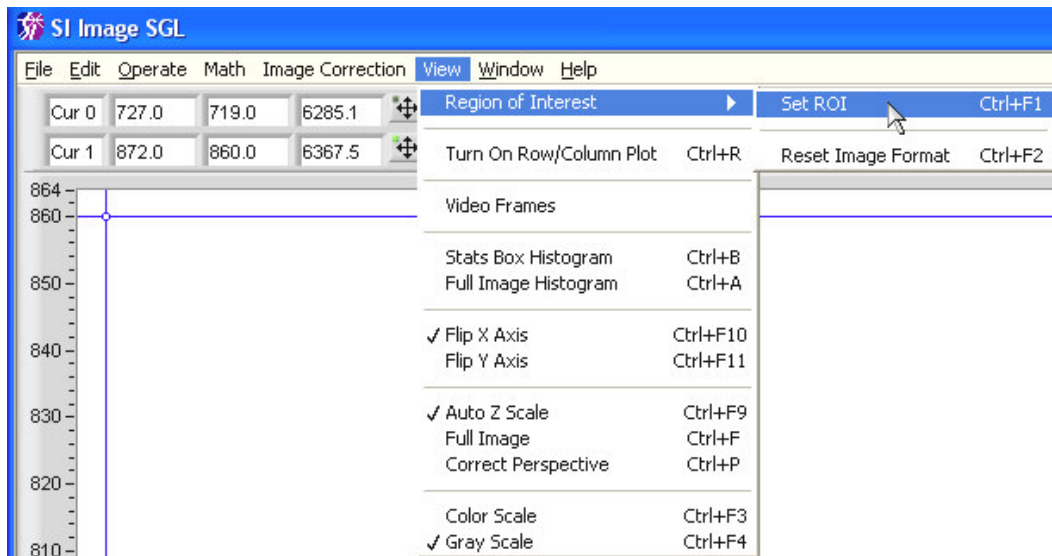
Figure 2.11 ROI Selector

Whenever the OK button is selected in the CCD Settings window, the current displayed readout specification becomes the reference readout selection. After a ROI is selected, the next image acquisition will acquire the ROI. After obtaining an image of

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the ROI, the reference format can be quickly re-established by **Ctrl+F2** or by the **Reset Image Format** option on the ROI slide-out.

2.3.2   Turn On Row/Column Plot

The second 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 2.12, containing a graph that shows plots of a single row or column plots, or plots of the average of rows or columns.

Single line plots or averaged plots are selected through the control shown in Figure 2.13.
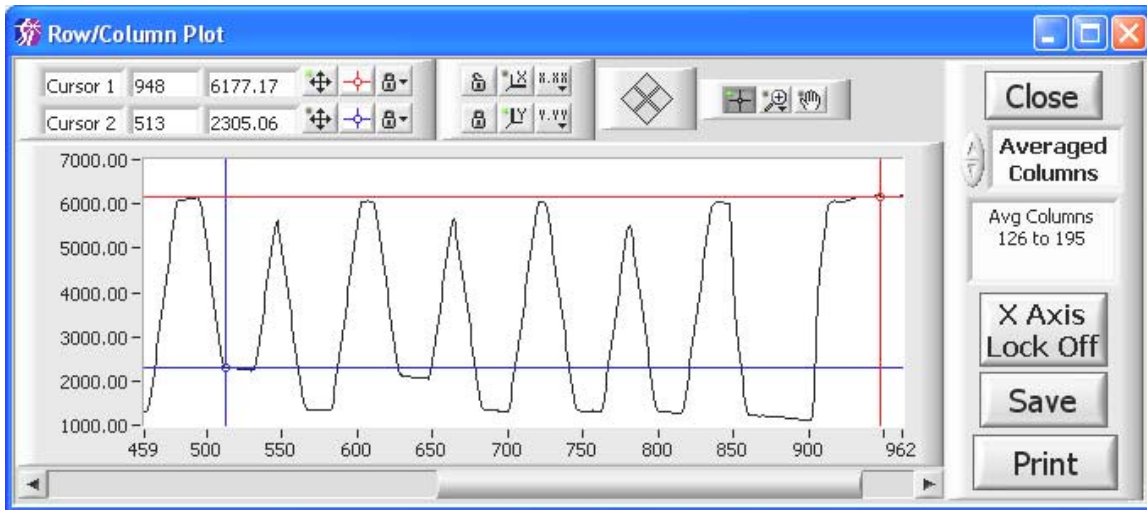
Figure 2.12 Row/Column Plot

Single-row or single-column plots show the pixels located at the position of the red cursor (Cur 0) in the image display. Averaged plots show the average 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 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 region of interest 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 hot-key shortcuts that can be convenient for mode switching. They are: Home - ⊹,

Page Up - 🖑, End - ▨, Page Down - ▨, F11 - ▨ and

Figure 2.13 Plot Type Selector

F12 - ▨. Note that the scale Y-axis is set for autoscale in Figure 2.12.

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The selector, shown as **Averaged Columns** in Figure 2.12, is used to select the row, column, average of rows or average of 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 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 2.12, 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 (coma separated value) text file that is easily read by analysis or spreadsheet programs. The ⎡Close⎤ button closes the Row/Column window.

2.3.3 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 special camera models. Images collected in "video" mode essentially contain multiple frames in single image buffer 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. 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 2.14 Video control window for playback of multi-frame images.

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2.3.4 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 2.15, that has all of the same graphical controls as the plot window. The cursors are usually left in locked mode so that the value of the histogram is
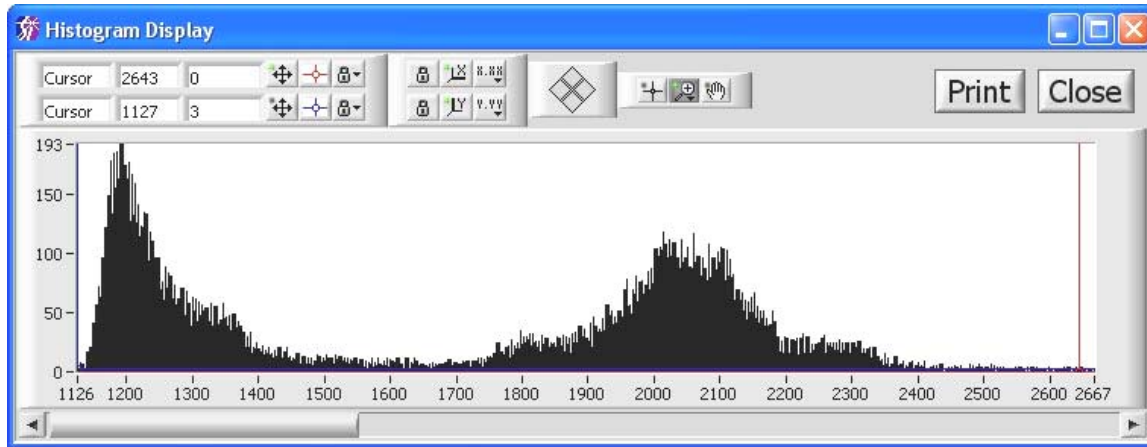
Figure 2.15 Histogram Plot

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. Hot-key **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, either right or left depending on which end is clipped. The scroll bar below the plot can be used to pan the X-axis when the user zooms in on the X-axis.

2.3.5 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.**

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2.3.6 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 **Z Scale** 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 **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.

The next two items, **Color Scale** and **Gray Scale,** select whether the display is shown in gray scale or false color scale. The false color scale allows a greater visual dynamic range, which can be useful in some imaging applications. 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+F3** and for **Gray Scale, Ctrl+F4.**

2.4 File, Edit, Windows and Help Menus

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

2.4.1 File Menu

The **File** menu, (Figure 2.16), 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.
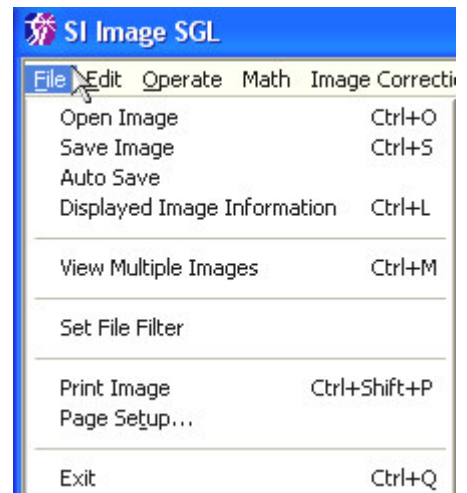
Figure 2.16 File menu
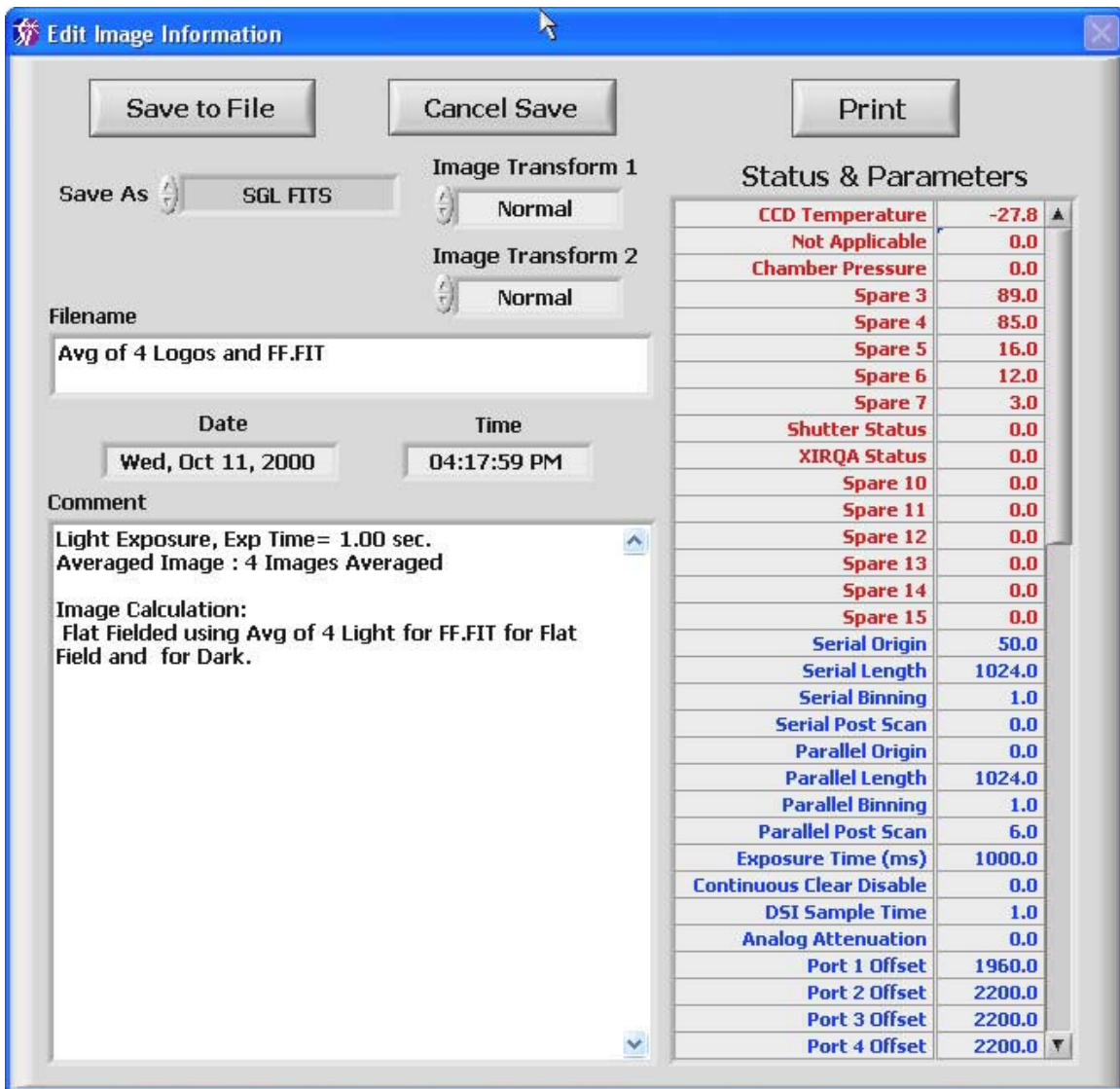
Figure 2.17 Image information window

The **Save Image** function (also accessed by **Ctrl+S** or **F6**) has an additional window (Figure 2.17) so that the file information can be viewed and modified before saving. The 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 2.18) allows selection of the file format in which to save the image. The default format is SGL
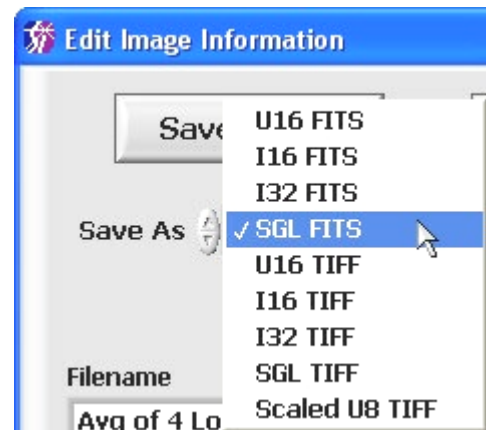
Figure 2.18 Save As control

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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 can be useful when images need to be placed into a document.

The **Image Transform** controls (Figure 2.19) allow the image to be transformed before it is saved. This can be 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.
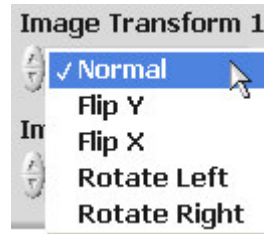
Figure 2.19 Image Transform control

The **Status & Parameters** indicator (Figure 2.17) displays **Camera Status** information in red, **Readout & Format** parameters in blue and **Configuration** parameters in black. The status and parameters are entered automatically when the image was acquired and are not changeable. Note that there are several Spare parameters and this is normal.

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 2.17) 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 2.20) 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 2.20, 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.

Figure 2.20 Auto Save setup window

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 coma separated values (csv) file for easy importing into an Excel spreadsheet. Following the optional log file selection, a window opens, Figure 2.21, where the image files for viewing are selected. The files are selected in the top of the window either by double clicking on them or by
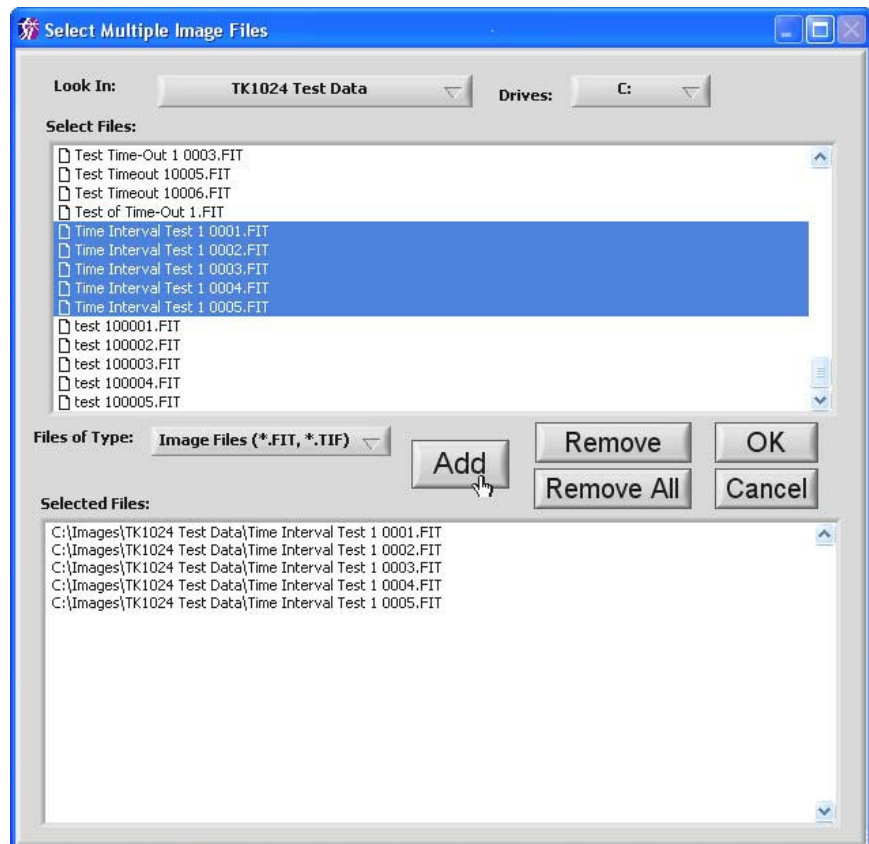
Figure 2.21 Select multiple images for viewing.

selecting and pressing the [Add] button. Multiple files can be selected by holding the Shift key while clicking on the filename, then pressing the [Add] button. Once the files have been selected, press [OK] to begin viewing.

The first file is opened and a control window opens, Figure 2.22, 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 [II] 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 a particular image in the series, a number can be entered 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 in displayed on the **File Name** indicator.
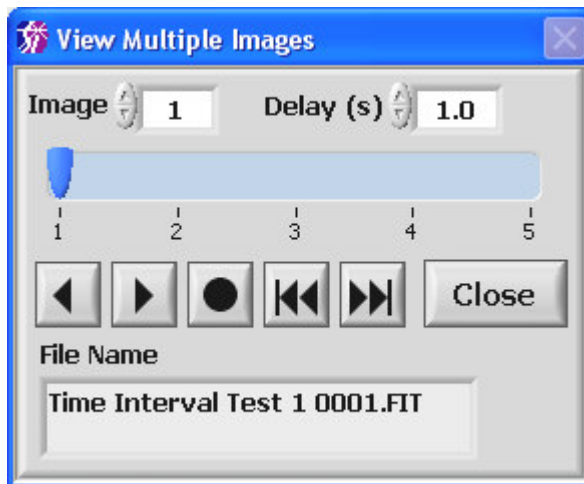
Figure 2.22 View Multiple Images control window

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.

2.4.2   Edit Menu

The **Edit** menu provides the standard Windows edit functions (Figure 2.23). These can be used when editing text or values in controls.
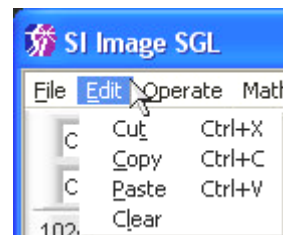
Figure 2.23 Edit Menu

2.4.3   Windows Menu

The **Windows** menu (Figure 2.24) 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.
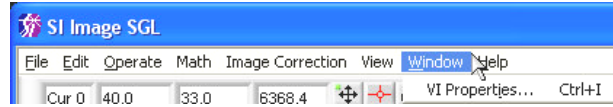
Figure 2.24 Windows Menu

2.4.4   Help Menu

The **Help** menu (Figure 2.25) 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**

Figure 2.25 Help Menu

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 2.26 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.
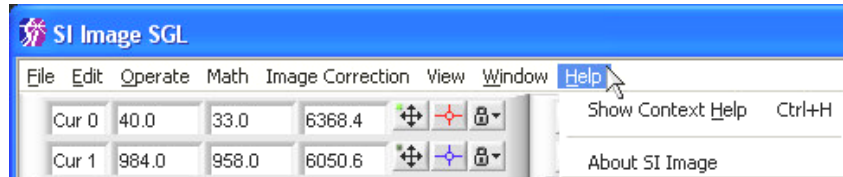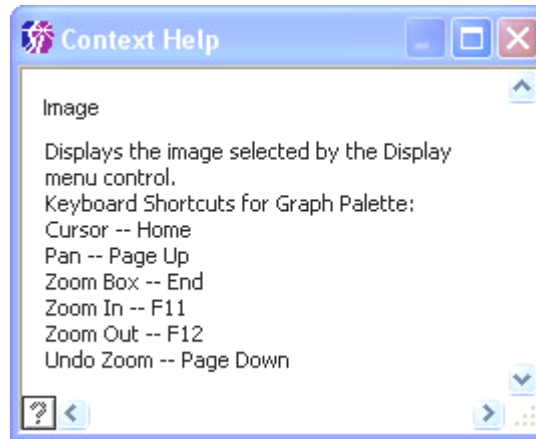
Figure 2.26 Show Help Window

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
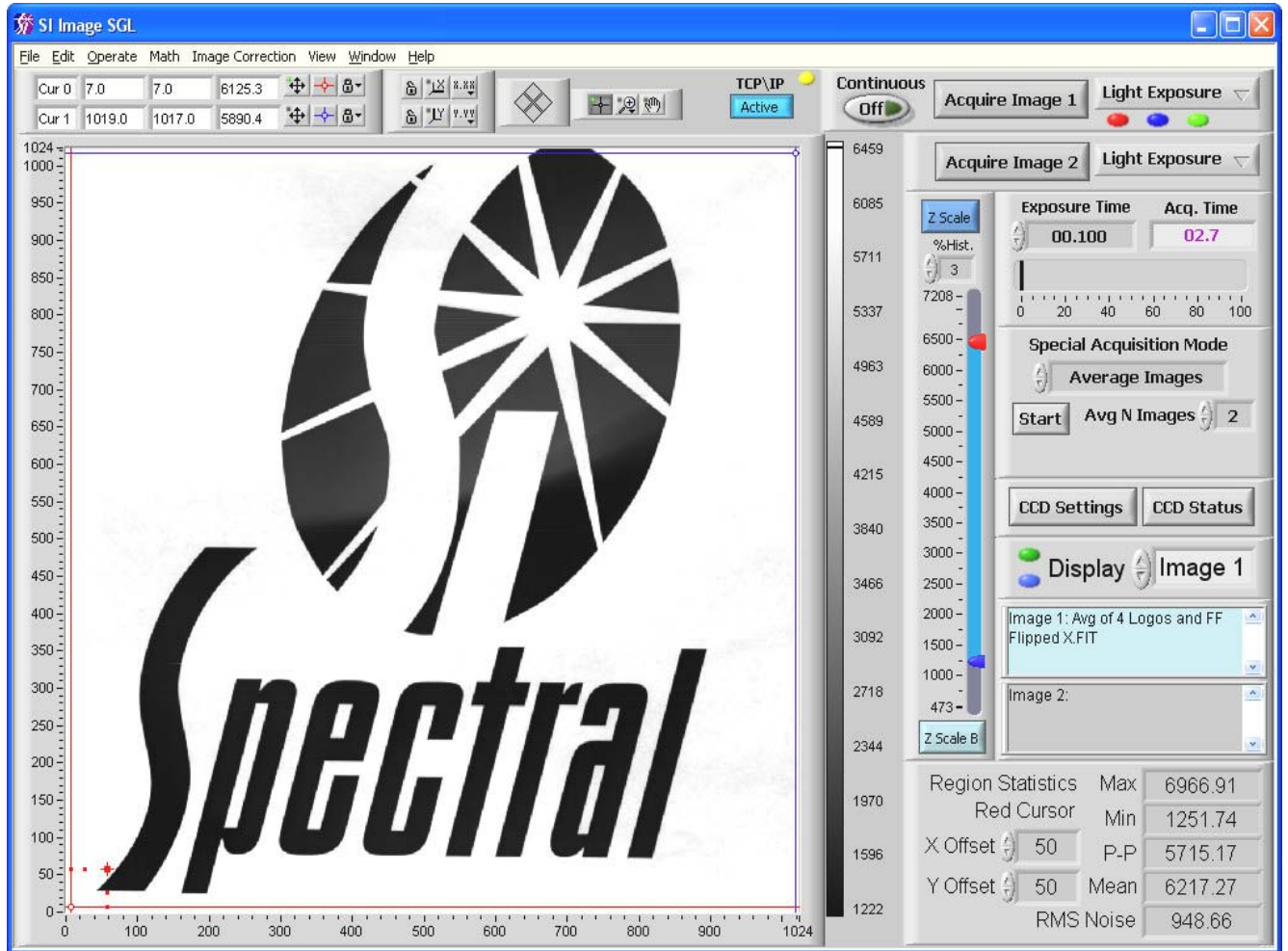
Figure 3.1 SI Image Front Panel

panel shown in Figure 2.1 except 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 if the camera's temperature or pressure is 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 step is to initialize the camera. The 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

Figure 3.2 Operate Menu

once they are powered up. The 500 Series most of the 600 Series cameras need to have the DPS code downloaded to the camera before the camera can start normal communications. The **Initialize** menu item determines if the camera needs to have the DSP code downloaded and does so if necessary. The **CCD Settings** window (discussed in detail in Section 3.2) is automatically opened following initialization.
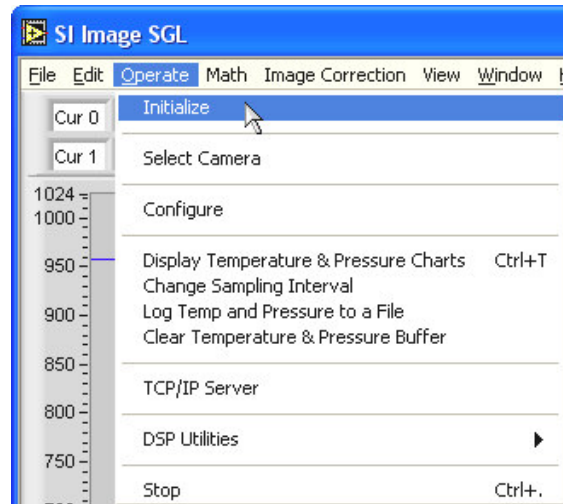
3.1.2 Select Camera

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 600-107.set. The Cancel button closes the window without changing the current settings file. This window is also displayed when the program first starts if there is more than one *.set file in the folder with the main SI Image SGL program.
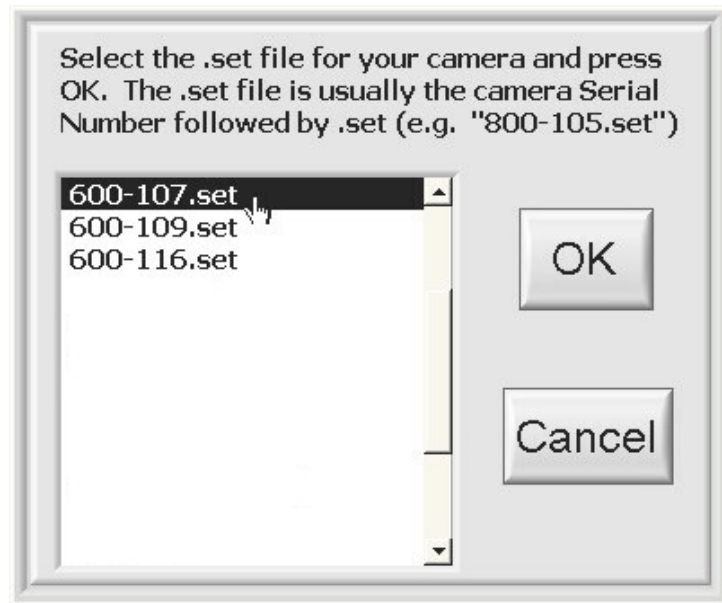
Figure 3.3 Select Camera window

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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 2236.cfg file (program
specific items, see Appendix
A) and settings file (camera
specific items, the filename
is '*serial number*.set', see
Appendix B) that are
installed with the program.
Both of these files are text

Figure 3.4 Software Configuration Window

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.

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
each Camera User Manual for baud rates supported).

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 49.

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
0. 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 2236.cfg 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 [folder icon] button and browsing disk

folders. Browse to the desired folder and press the [Select Cur Dir] 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 [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 for the log file that is automatically named using the date, such as 'Jan 01, 2004.TPL'. In this way, there is one file for each day if the logging is left on for multiple
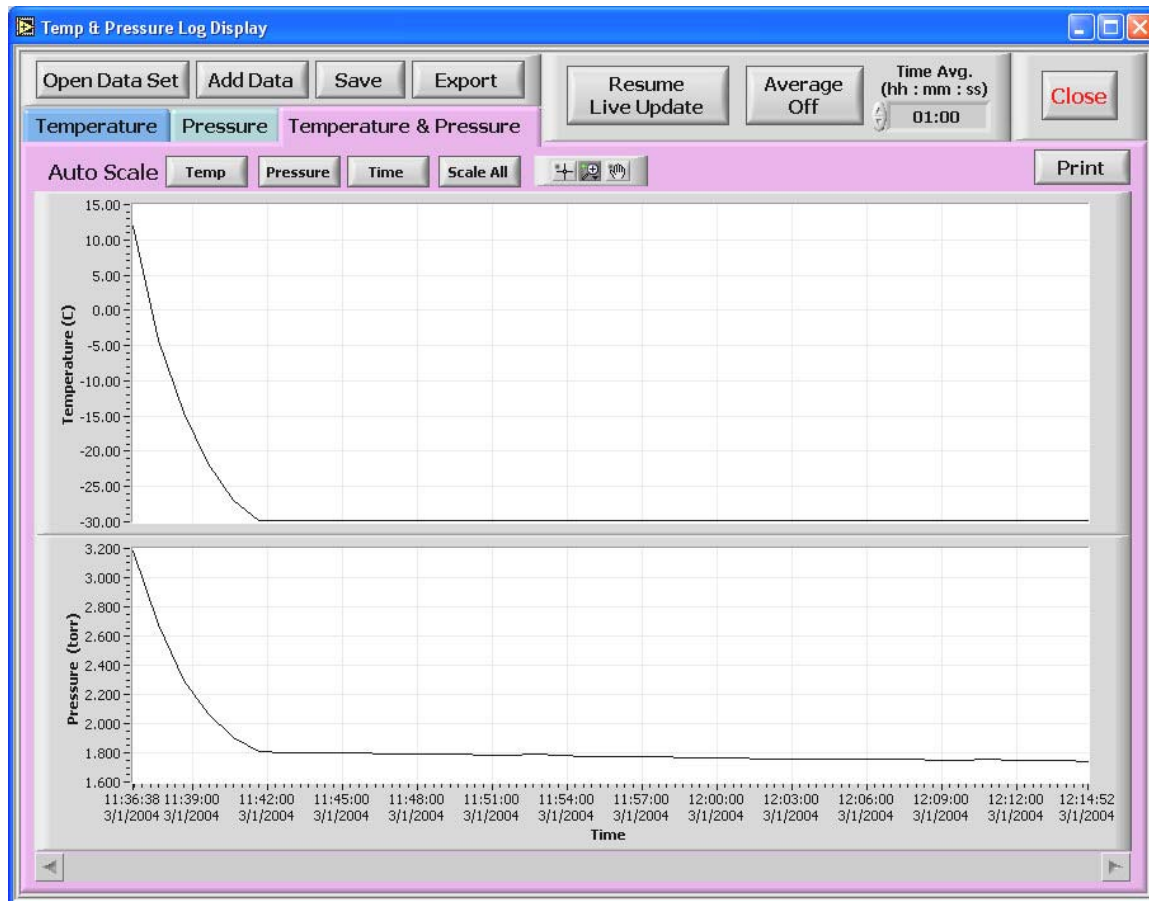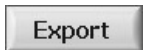
Figure 3.5 Monitor Temperature and Pressure window

days. These files can later be combined in the Temp & Pressure Log Display window. 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 and that is not the case for the log file.

The Temp & Pressure Log Display window allows the data to be viewed as temperature only, pressure only or a combination of temperature and pressure as show in Figure 3.5 by selecting the appropriate tab. Each view can also be printed using its associated print button. 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.
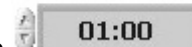
The **Pause Live Update** button allows the live update to be paused while the graph on the screen is being manipulated or examined. If the live update is not paused and the graph is zoomed in on a region, when an update occurs, the graph auto-scales so that new data is in the graph. The live update is automatically paused when a data set is opened or if an additional data set is added to the plot. Pressing **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 graph's data. 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. The **Save** button allows the currently displayed data set to be saved to a file that can later be opened in the Temp & Pressure Log Display window. The **Export** button will export the current data set to a CSV (coma 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 data-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.

The **Average Off** button allows the data in the graph to be averaged over time. It is an On/Off button and the data will be processed using the **Time Avg. (hh : mm : ss) 01:00** control to set the time over which to average the data. A value of **05:00** will average each successive five minutes of data. When averaging is on, it is applied to either the live data or data opened from a file. When the **Time Avg.** value is changed, the original data is processed using the new value and displayed in the graph.
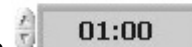
An additional set of indicators at the top of the main window to the left of the **Continuous** button (Figure 3.6), indicate temperature and pressure warnings. These LEDs are visible only when an error condition exists. From the top down:

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
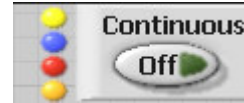
**Figure 3.6
Temperature and
Pressure Warnings**

The limits that trigger these warnings are in the settings file 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 a subset of the SI Image program's functions. This is useful where another program is used for control of a process that needs to initiate an image acquisition in 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 initializes the camera and sets all the camera parameters in the SI Image program. 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 and obtain the image header that contains all the operating parameters of the camera during the last image acquisition. 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 on 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.

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3.1.6　DSP Utilities

The **DSP Utilities**
consist of two items,
Download DSP Code
and **Save DSP Code to
EEPROM.** These will
not be 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.
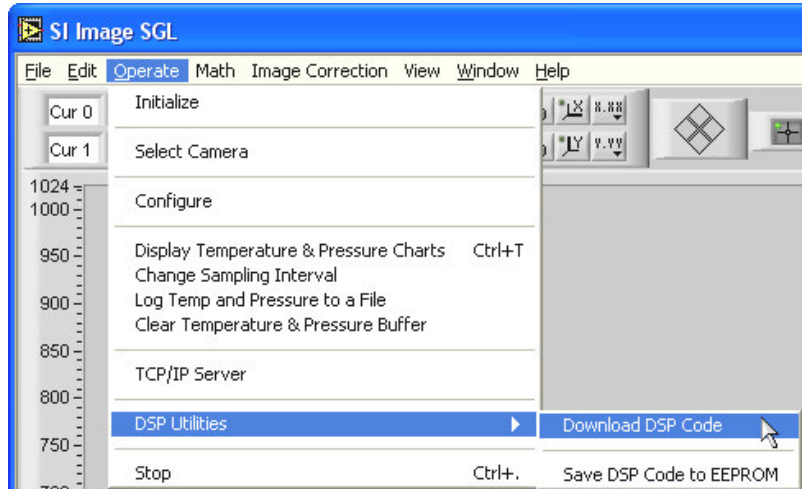
Figure 3.7　DSP Utilities

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.

3.2 CCD Settings

The [CCD Settings] button opens a window (Figure 3.8) where all the operating parameters of the camera can be set. The parameters that are changed in normal operation are accessible in the main **CCD Settings** tab. Two groups of more detailed settings that are not changed as often are accessed by the tabs labeled **Readout & Format** and **Configuration**.

3.2.1 Readout and Format Parameters

The **CCD Format Parameters** control the region of the CCD that is used and the binning. 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 calculated automatically and can be viewed along with the more detailed readout and format parameters by selecting the **Readout & Format** tab.
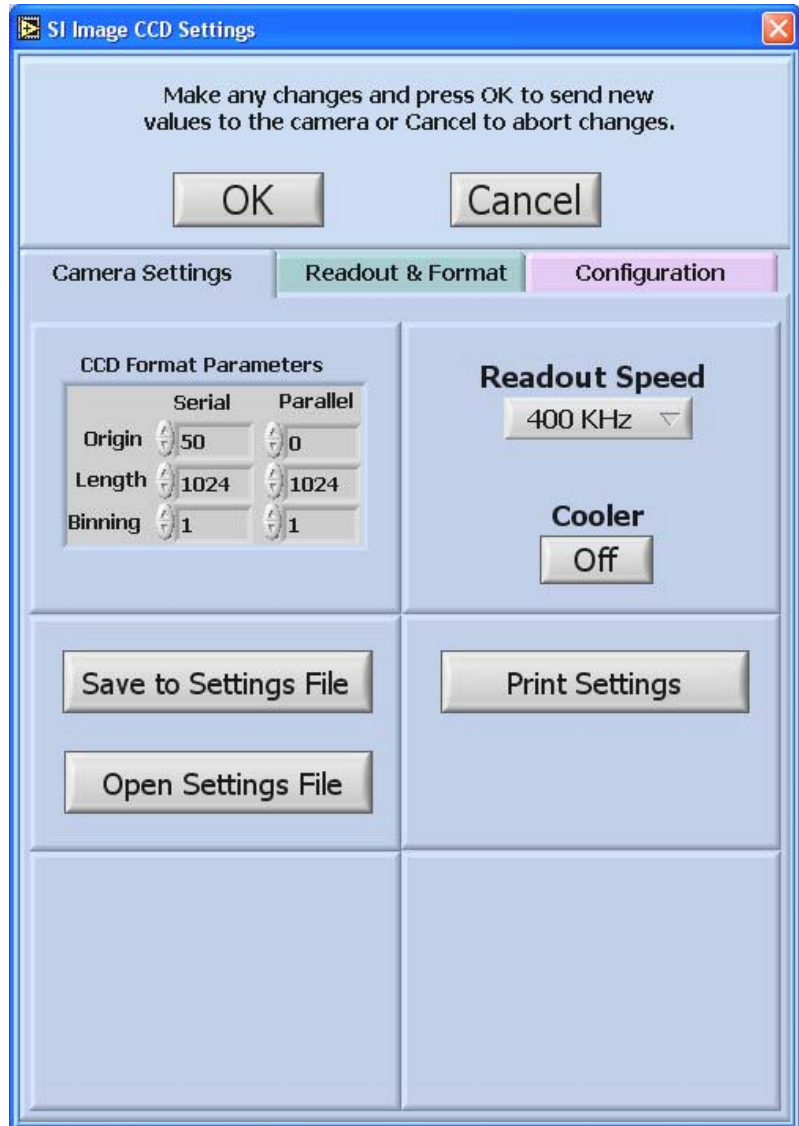
Figure 3.8 CCD Settings Window

This displays the window in Figure 3.9 that shows the detailed readout and format parameters for the camera. These items are not changed in normal operation of the camera but are available to the user for inspection and can be modified for more advanced applications.

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The CCD format parameters are the same as in the main **CCD Settings** window with the addition of the **Post Scan** values. The **Exposure Time (ms)** is the same as setting the exposure time from the main front panel except that here it is in units of ms. The **Continuous Clear Disable** controls whether the CCD is in a continuous clear mode between image acquisitions. The default value is 0 for enabled, while a value of 1 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, value of 2, where the continuous clear is disabled and not re-enabled after an image acquisition. See the camera hardware manual for details.
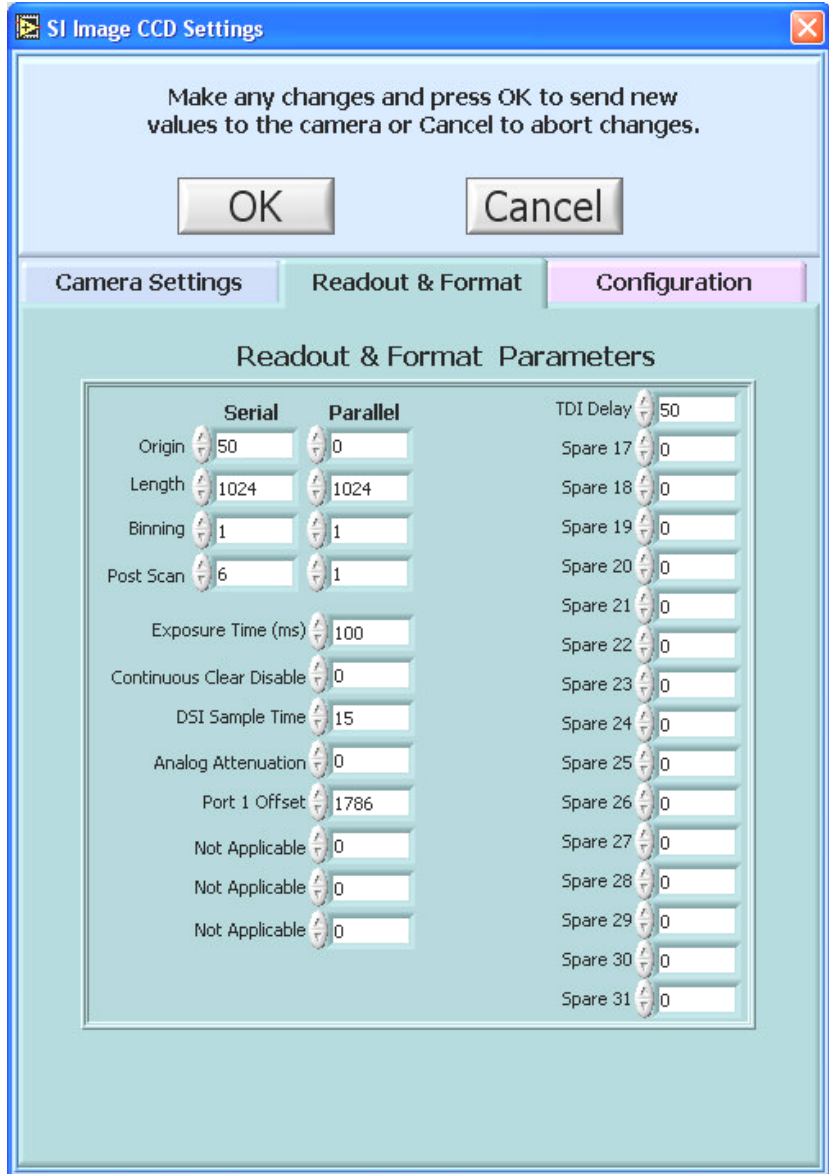
Figure 3.9 Readout and Format Parameters Window

The **DSI Sample Time, Attenuation**, and **Port Offsets** values are set automatically when the **Readout Speed** is selected in the main **CCD Settings** window but can be overridden with this control for advanced applications. In the Figure 3.9, only Port 1 Offset is labeled since a single port camera was being used. If this was for a multiport camera, the 'Not Applicable' labels would be Port (2, 3 or 4) Offset as needed.

The Dual Slope Integrator (DSI) sample time is the parameter that permits the camera readout speed to be changed in order to balance readout noise against readout time. 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 large DSI parameter. 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 **T**ime **D**elay **I**ntegration delay that is used when the camera is run in TDI mode. The delay is in μs and sets the delay between parallel shifts on the CCD.

The rest of the parameters below **TDI Delay** are not present on all cameras or are spare placeholders for future camera functions and have no effect at this time. See Appendix B for a description of these parameters. See each camera hardware manual for applicability.

 The **Readout Speed** control, 400 KHz ▽ , on the **Camera** Settings tab is a pull-down menu that allows selection of the different readout speeds that are permissible for the camera system. As mentioned above, the DSI Sample Time, Attenuation, and the Port Offsets are automatically set depending on the Readout Speed selected from values stored in the Settings (*.set) file.

The Save to Settings File button saves the readout and format parameters and readout speed settings to a *.set file that can later be recalled using the Open Settings File button.

Multiple *.set files are useful for various applications that require different readout formats. The file that is automatically loaded when the camera is initialized is set in the software configuration window accessed by the **Configure** item in the **Operate** menu from the main front panel (see Section 3.1.3).

3.2.2 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 by changing the parameters and pressing the OK button. In this case, the parameters are sent to RAM in the
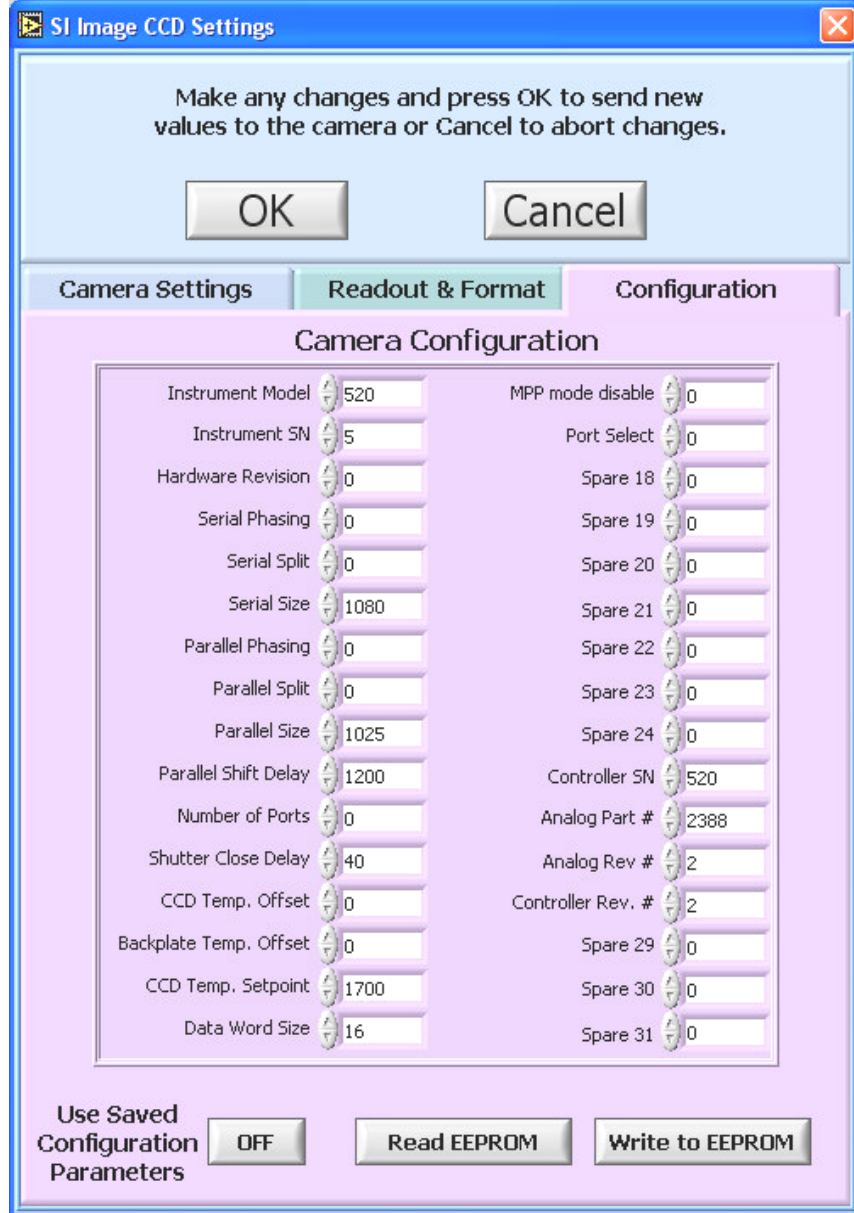
Figure 3.10 Camera Configuration Window

controller and not written to the EEPROM. They will stay in effect only until the camera is initialized again. If the Write to EEPROM button 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, because these settings are normally determined for each camera for optimum performance. If the Cancel button is pressed, any changes made are canceled. The Read EEPROM button reads the configuration parameters from the

EEPROM and displays them in the **Camera Configuration** table. This can be useful for diagnostic purposes or for making an archive of the factory settings.

The first three parameters are self-explanatory. The **Phasing**, **Split** and **Number of Ports** parameters are interrelated.   **Serial** and **Parallel Phasing** control the direction of the shift in the serial and parallel registers. Information about the direction is contained in the test report for each camera. **Serial** and **Parallel Split** defines whether the respective register is split such that it is read out to multiple ports. A value of 0 is for no split, 1 is for split. The split is only used in multiple port cameras. Split=1 and phasing=0 is the normal setting for four-port readout. Note that for single port readout the number of ports must be set to 0 and on a 600 Series camera, the analog cable from the selected port must be connected to Channel A at the controller. Phasing and split are then used to select the port from which a CCD is read out as a single port imager from a multi-port sensor. Currently the software supports one, two and four port readout CCDs. The **Number of Ports** parameter is set to 0 for one port, 1 for two port and 3 for four port cameras. When multiple ports are used, the **Serial** and **Parallel Size** parameters correspond to the actual 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 readouts at 1 x 1 binning.

Parallel Shift Delay is the delay between the timing states when doing a parallel shift. This parameter is in increments of 100 ns.

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.

All temperature parameters are in Kelvin and in 0.1° increments.

CCD Temp Offset is a single point correction for the temperature calibration.

Backplate Temp Offset is a single point correction for the temperature calibration for the backplate of thermoelectrically cooled cameras.

CCD Temp Setpoint is the temperature to which the camera cools. A value of 1730 corresponds to 173°K or –100 °C.

Data Word Size is the number of bits that the A/D converter uses. All data is read from the camera as unsigned 16 bit integers.

MPP Mode controls whether the CCD is in MPP mode, value of 0, or non-MPP mode, value of 1. MPP stands for **M**ulti-**P**inned **P**hased 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.

Port Select controls which port is read out on devices that have multiple readout ports. This is currently used only on 800 and higher Series cameras.

Below Port Select, the rest of the configuration parameters are camera dependent or spare placeholders for future options.

3.2.3 Printing Settings

All the camera settings can be printed out using the [Print Settings] 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 with different configurations.

3.3 CCD Status

The [CCD Status] button opens a floating window (Figure 3.11) displaying the status of the CCD including the CCD temperature, the backplate temperature for thermoelectrically cooled cameras, and the vacuum pressure in the camera head. While the status window is open, it continues to update the status information except when image acquisition is taking place, at which time a message is displayed indicating status checking is temporarily halted. The status window is always on top of the main front panel and is moved by dragging the window by the title bar.

Pressing the [Close] button stops status checking and closes the window.
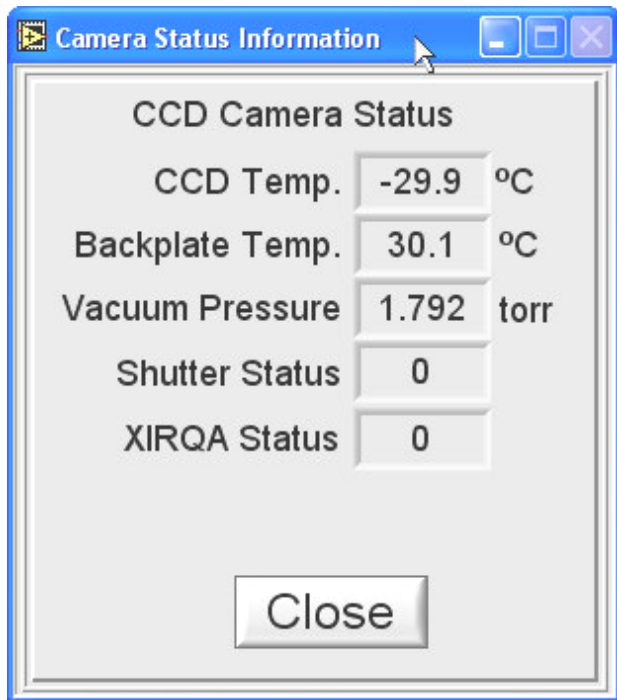
Figure 3.11 CCD Status Window

3.4 Acquiring an Image

Image acquisition is initiated by the controls in the upper right of the front panel (see Figure 3.12). There are two image buffers, Image 1 and Image 2, for acquiring images. The pull-down menu next to

Figure 3.12 Acquire Image Controls

each acquire button selects the type of image to acquire.

The selections are shown in Figure 3.13. **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

Figure 3.13 Image Type Menu

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

Below the image acquisition controls on the front panel are controls for setting the exposure time and a progress indicator (Figure 3.14).   The **Exposure Time** is changed by directly editing the value in the control, 05.000 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 indicating the %
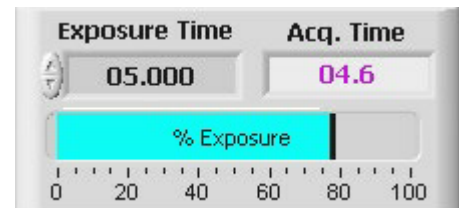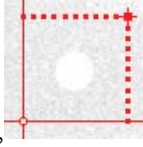
Figure 3.14 Exposure Time Controls and Progress Indicator

Readout complete. The 03.8 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.
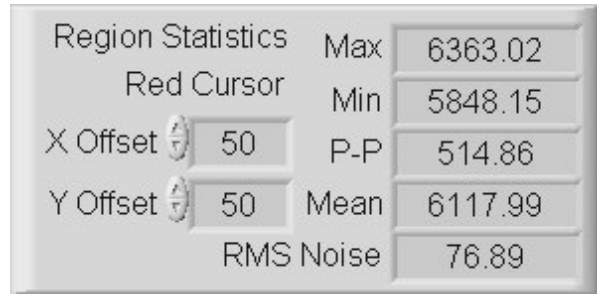
3.5　Getting Statistics

The statistics section of the front panel is shown in Figure 3.15. 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 (Cur 0) and the smaller red 'offset' cursor,
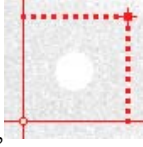
Figure 3.15 Image Statistics Information

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 (Cur 0) 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.

3.6　Special Acquisition Mode

Located in the **Special Acquisition Mode** region of the front panel is a control that allows for selection of averaging multiple images and acquiring multiple images and saving them to the disk.

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 4.2.6 **- Auto Corrections**. When **Average Images** is selected as in Figure 3.16, the user selects the number of images to be averaged using
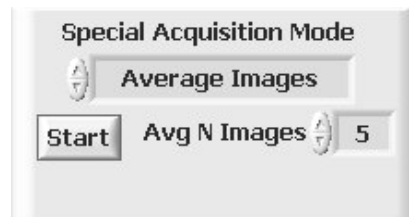
Figure 3.16 Average Images Setup

the **Avg N Images [10]** control. The images are acquired into Image 1 using the exposure time currently set and image type set for Image 1. Once these have been set, the acquisition is initiated by pressing the **Start** button.

New indicators appear to show the progress of the averaging, Figure 3.17. 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** 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.
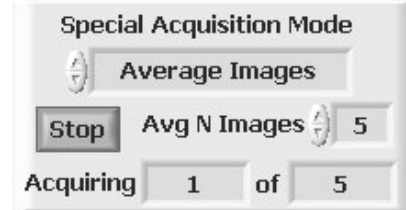
Figure 3.17 Average Images Progress

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 Acquisition mode, the images are saved to the disk automatically. Initially the **Start** button is "grayed out" and not functional until an acquisition has been **Setup**.
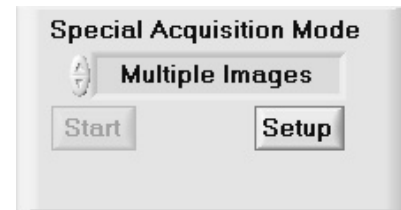
Figure 3.18 Multiple Acquisition Controls

Pressing the **Setup** button brings up a window (Figure 3.19) 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, the mode of acquisition 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 to 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
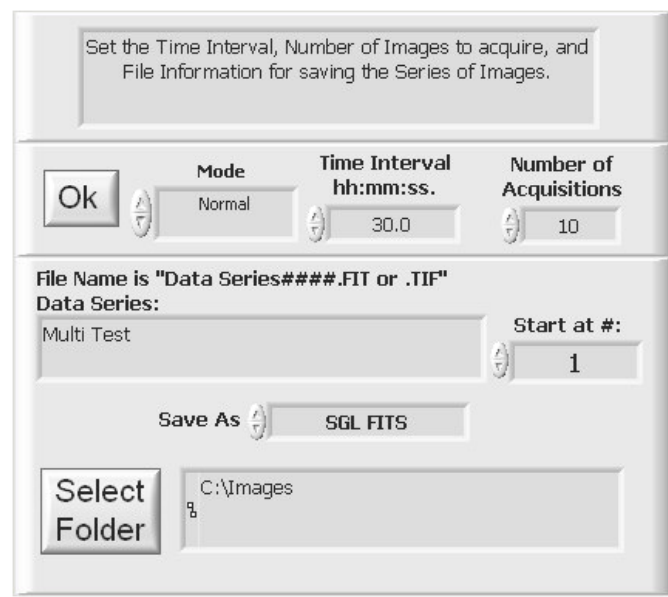
Figure 3.19 Multiple Acquisition initial setup window

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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". The user enters a name and a four-digit count is appended to the name by the program to distinguish each image in a sequence.

Multiple Image Acquisition is provided in two modes. The Normal mode is to obtain, save to disk and display each image waiting for the elapsed

Figure 3.20 Multi Acquisition Mode

time between acquisitions to expire before the next image is acquired. The mode selector shows the two modes that are available, (Figure 3.20**). Fast Save w/o de-interlace** is used to obtain a sequence of images wherein the disk write is overlapped in time with the readout. The 'w/o de-interlace' pertains only to multi-port readouts.

As with regular file saving, seven file types are available as shown in Figure 3.21. 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.
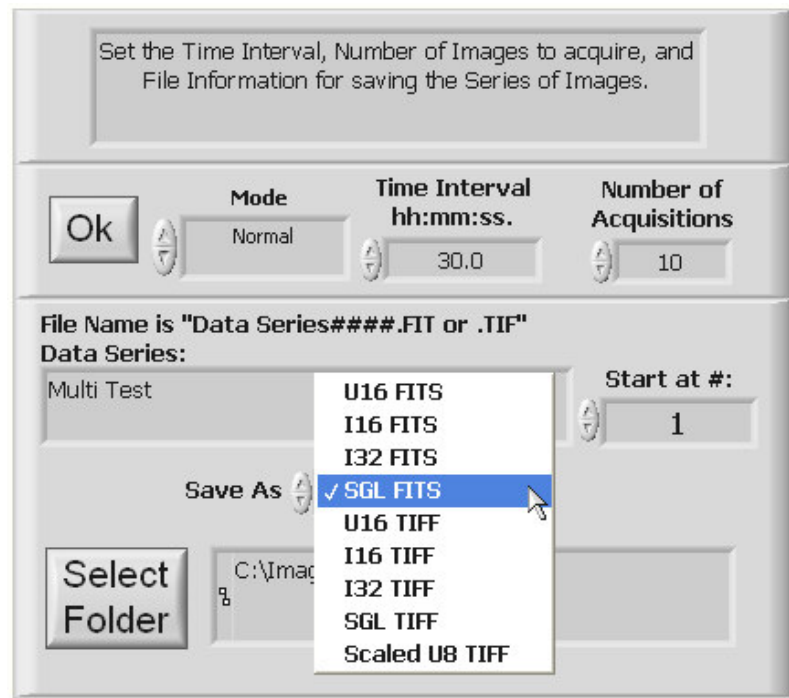
Figure 3.21 File Type Selection

When **Fast Save w/o de-interlace** mode is selected, the file type is restricted to U16 FITS and the **Save As** control takes on a different appearance shown in Figure 3.22.

After the time interval, mode and number of acquisitions have been specified, press the Select Folder button to open a file dialog window (Figure 3.23) 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. For example, as shown in Figure 3.22, 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.
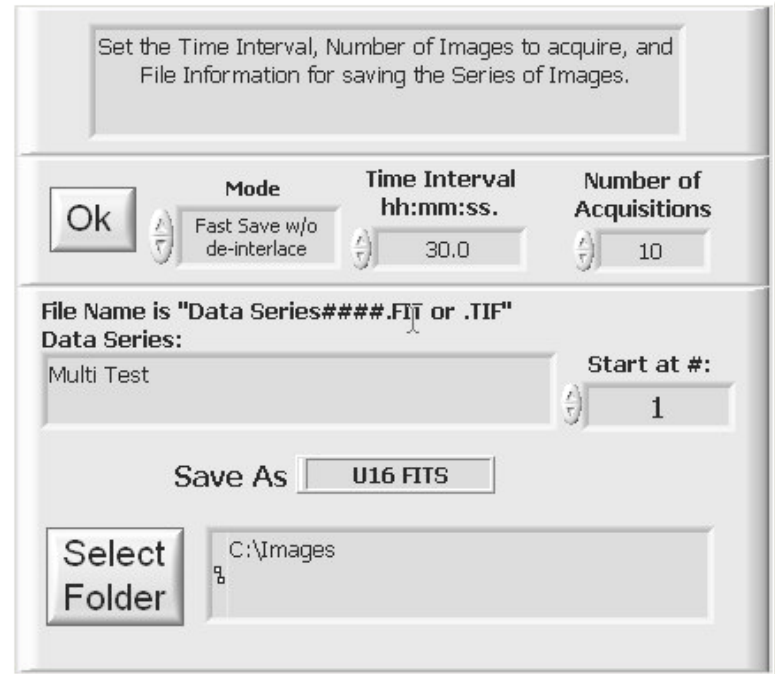
Figure 3.22 Multiple Acquisition Setup in Fast Save mode
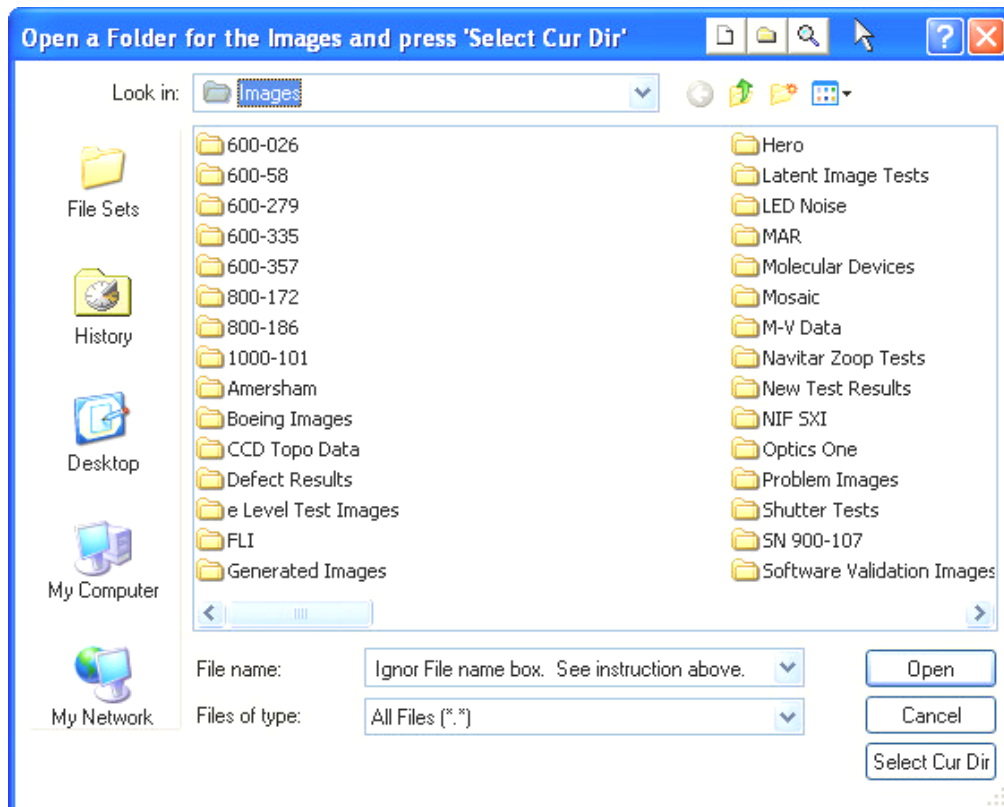
Figure 3.23 Set Path File Dialog Window

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 acquisition is initiated by pressing the, now active, Start button shown in Figure 3.24. The **Progress** indicator (Figure 3.14) shows the progress of each image acquisition and the Acquiring 0 of 10 indicators display the progress in the sequence of images.

Fast Save w/o de-interlace only writes .FIT files because this file type permits the image to be written "on-the-fly" whereas the .TIF format requires access to the entire data set so the tags can be properly created before the file is written.

Figure 3.24 Multiple Acquisition Progress Indicator

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.
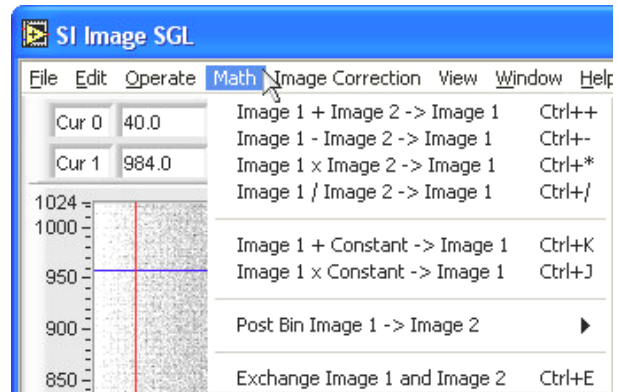
Figure 4.1 Math Menu

Functions are provided to add a constant to Image 1 and to multiply Image 1 by a constant. Selecting **Image 1 + Constant → Image 1** function brings up the dialog box shown in Figure 4.3. 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 **Image 1 x Constant → Image 1**, shown in Figure 4.2.

Figure 4.3 Add Constant to an Image

Figure 4.2 Multiple Image by a Constant
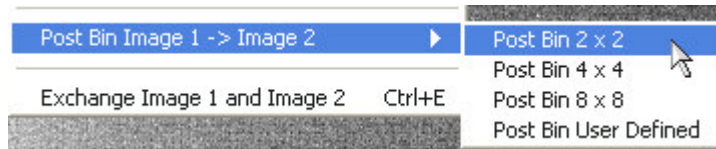
Figure 4.4 Post Binning Menu

The post binning function (Figure 4.4) 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 4.5) allows the user to set arbitrary binning factors.

The function, **Exchange Image 1 and Image 2**, allows the interchange of the contents of Image 1 and Image 2 for selecting which image is operated on.

Figure 4.5 User Definned Binning

4.2 Image Corrections Menu

The **Image Correction** menu, Figure 4.6, 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 4.6. 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.
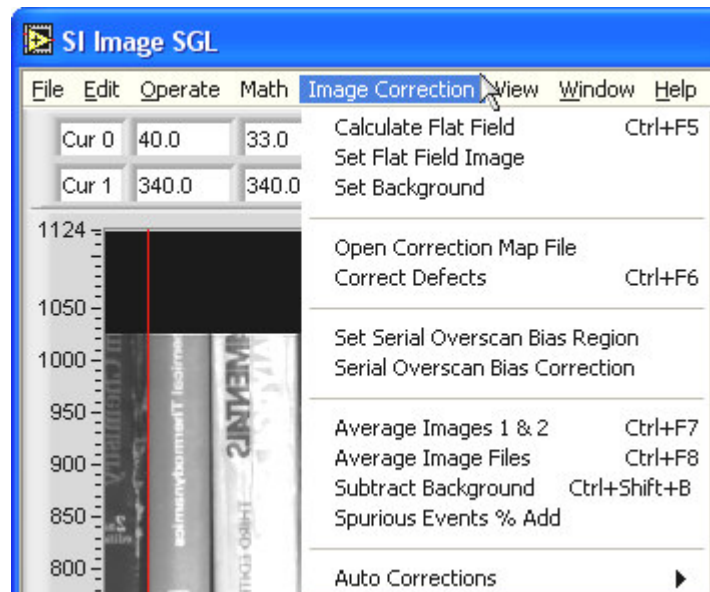
4.2.1 Flat Fielding

Figure 4.6 Image Correction menu

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 set. A 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 dark image to a file.

Next, the flat field image must be collected. To flat field an image it is necessary first to obtain a flat image that has an average pixel value well above the dark signal level. Generally, a flat field mean level above ¼ saturation is preferred to preserve significance in the result. The image should be flat! This is not easy to achieve in most circumstances but 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 place 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 that these images have been set. Figure 4.7 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 4.7 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 have been opened. Select the **Open Correction Map File** from the **Image Correction** menu and select the correction map file as shown below in Figure 4.8. 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 C on page 63.
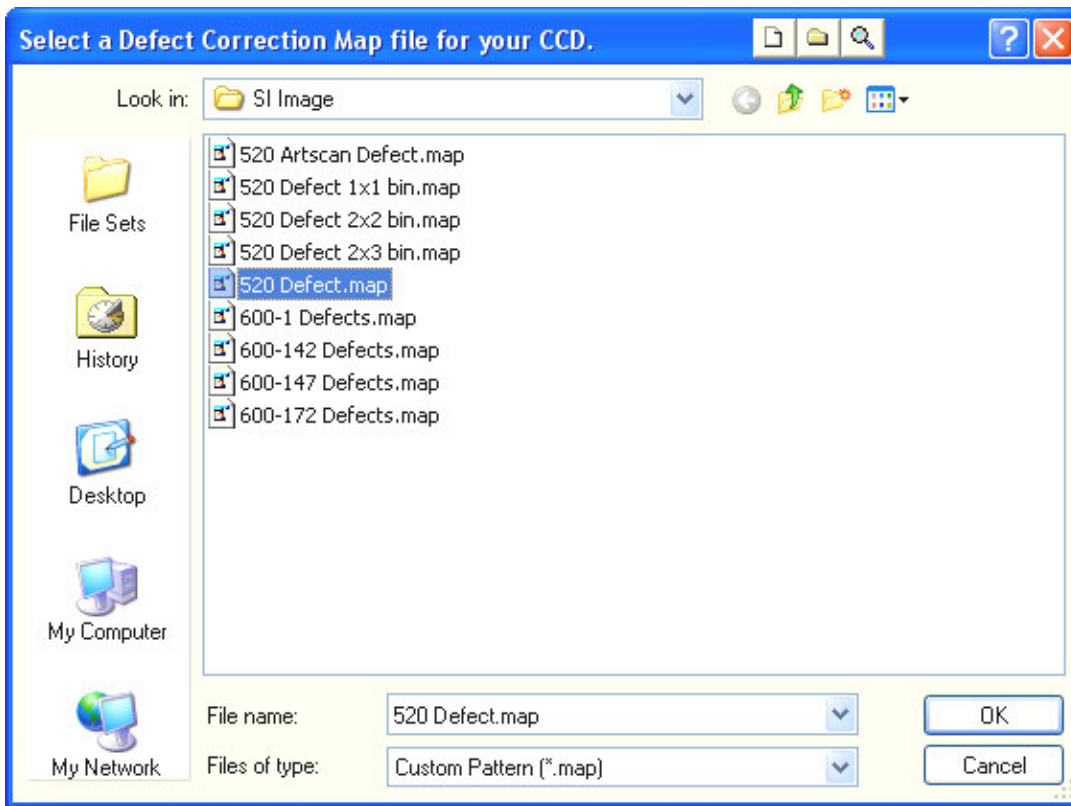
Figure 4.8 Open Defects Correction Map

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 that 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 4.9) that sets the overscan region to be used for the correction. In Figure 4.9, this would be for a 1024 x 1024 CD where the serial length was set to >1100. As images are viewed in the program with 0,0 being in the lower left for the image display, CCD rows are vertical and the serial overscan is 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. Following the processing of all the row, the average of all the overscan row values is added to the entire image to bring the level back to its approximate initial value.
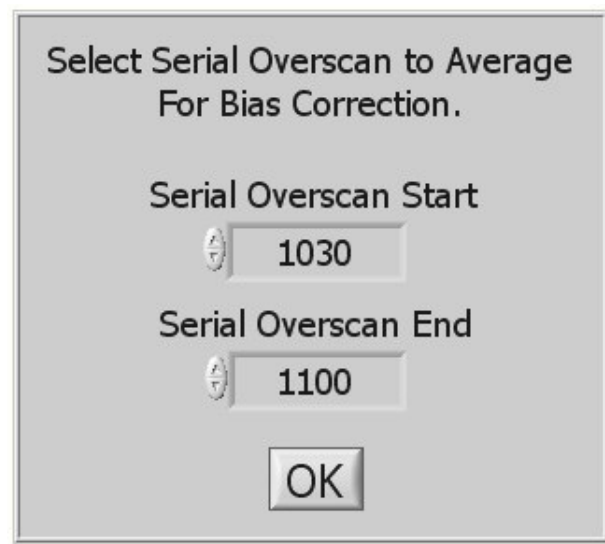
Figure 4.9 Set Serial Overscan Bias Region

Note that the first few columns off the active portion of the image should be avoided, as are the 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 4.10) where the image files to be averaged are selected. The files are selected in the top of the window either by double clicking on them or by selecting and pressing the [Add] button. Multiple files can be selected by holding the Shift key for continuous selection or the Ctrl key for non-continuous selection, while clicking on the filename, then pressing the [Add] button. Once the files have been selected, press [OK] to begin averaging. The final averaged image is in Image 1.
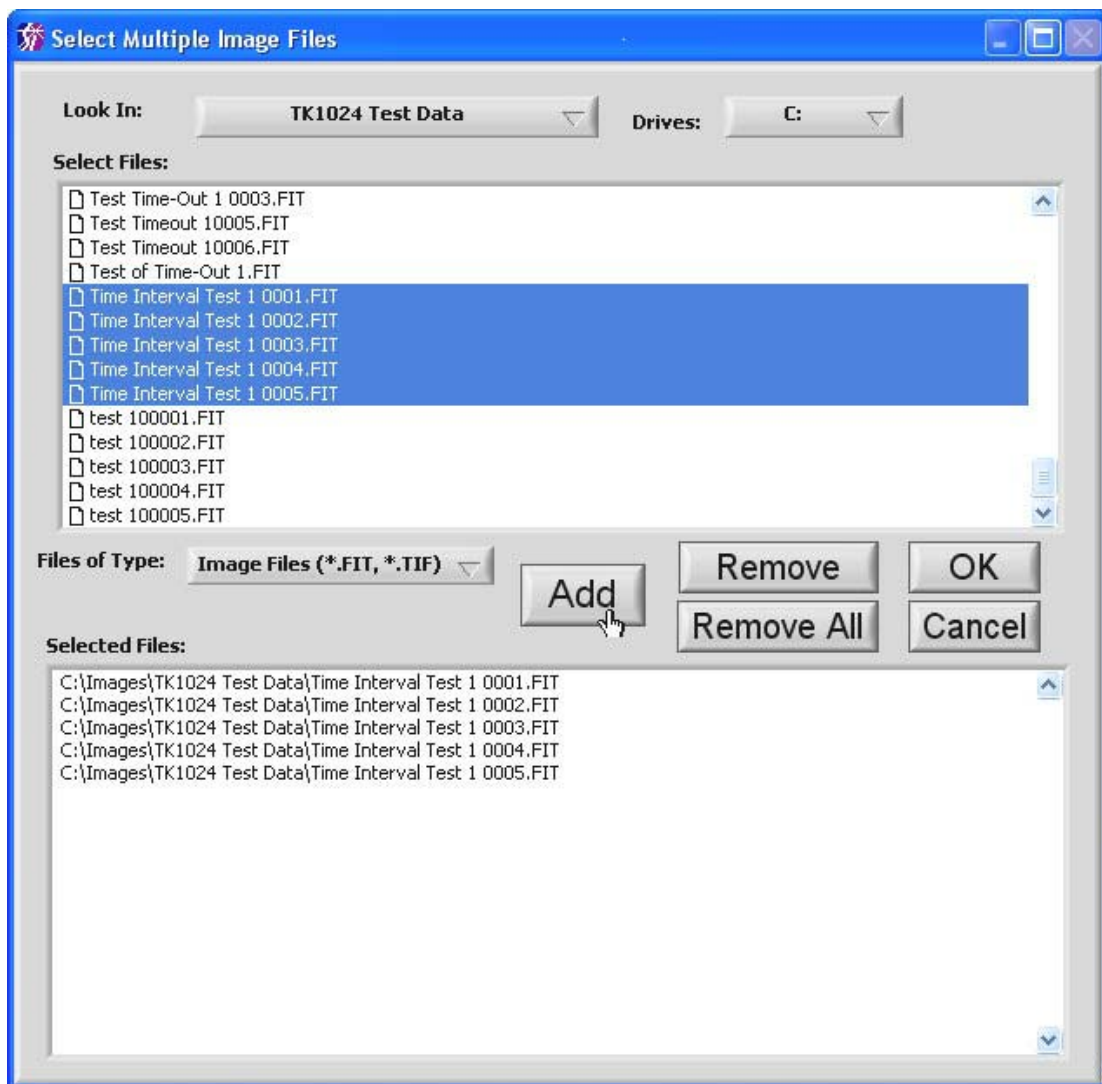
Figure 4.10 Select Multiple Files for Averaging

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 for this function to be enabled.

4.2.6 Auto Corrections

The **Auto Corrections** menu item (Figure 4.11) 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 set are applied before the image is saved. When doing averaged images acquisition, the corrections are applied to the final averaged image.
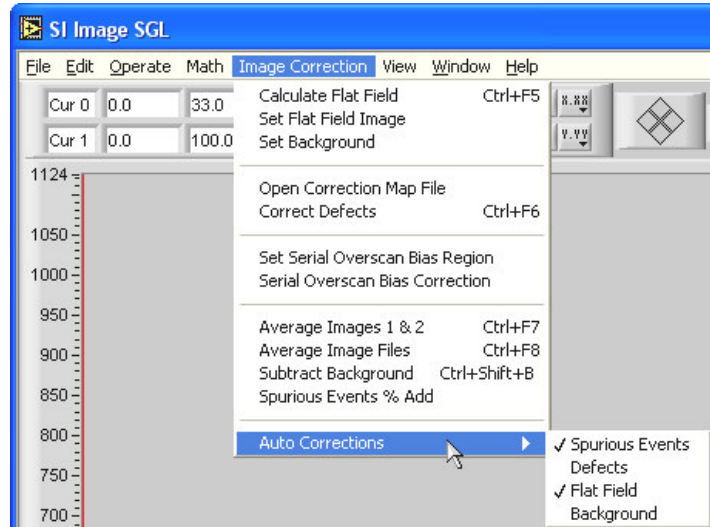
Figure 4.11 Auto Corrections Menu

The S**purious Events** correction corrects for any random occurring hot 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. The **Spurious Events % Add** menu item controls how
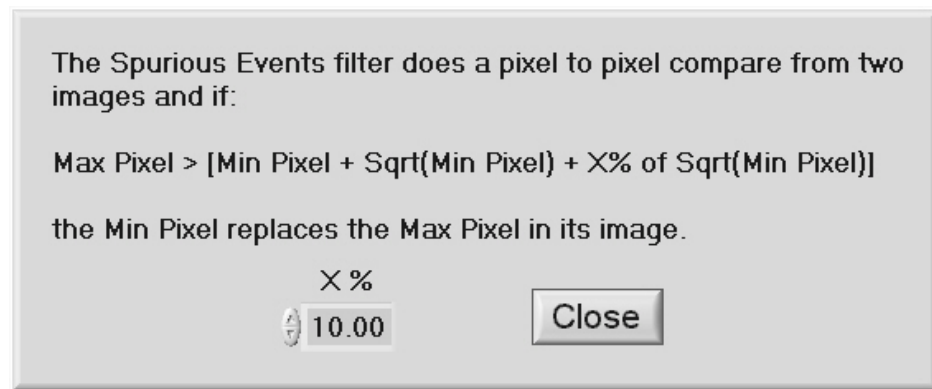
Figure 4.12 Spurious Events % Add Window

spurious events are detected as shown in Figure 4.12.

To enable spurious events correction during image averaging, select the **Spurious Events** menu item shown in Figure 4.11. When it is selected, a ✓ appears next to the

menu item and a red LED appears below the acquisition type control shown in Figure 4.13. This is enabled by default when the program starts.

The LEDs shown in Figure 4.13 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.

Figure 4.13 Auto Correction LEDs

Figure 4.13 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 applied after image acquisition. The LED on the right is purple and indicates that an automatic background subtract correction will be applied after image acquisition. 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 only used 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 where 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:

<p align="center">Triggered Acquisition=TRUE</p>

is read from the *.set settings file. When this software switch setting is encountered at startup, the program presents an additional exposure mode as 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

Figure 5.1 Triggered Mode

depending on the CCD) and the camera integrates signal for a time period that is 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.

On some cameras there is also a Readout & Format parameter **Command on Trigger.** This parameter allows the user to select optional commands to be performed on trigger.

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 **T**ime **D**elay **I**ntegration (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 TDI image is of fixed length and the size of the 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 settings file, see Appendix B on page 59. Not all cameras are capable of externally paced TDI acquisition.

Figure 5.2 TDI Acquisition Mode

5.3   MultiPort Readout

Cameras with more than one readout port produce a data stream to the computer that presents the incoming pixels in an interleaved, or round robin, order. To generate a "proper" image, the pixel stream must be de-interleaved before it is displayed. This occurs routinely within the SI Image program when the CCD number of ports is more than 0. Within the Multiple Acquisition option, the program provides a mode where saving the image to a disk file is overlapped with image readout. This permits maximum frame rates to be achieved. The image display is updated as a foreground task. This means that not every image that is acquired is displayed during the sequence acquisition. Only saving to disk can be overlapped with the readout. Interleaved images read from disk are de-interleaved before they are displayed so they can then be saved again to disk as normal image files.

Files that are saved directly to disk overlapped with the image readout are of type FITS only. This is because TIFF is a blocked structure and the entire image is required to develop the block structure.

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 **InquireAcquisitionStatus** and **TerminateAcquisition** are special cases in that they do NOT return an **Acknowledge** packet, only a data packet.
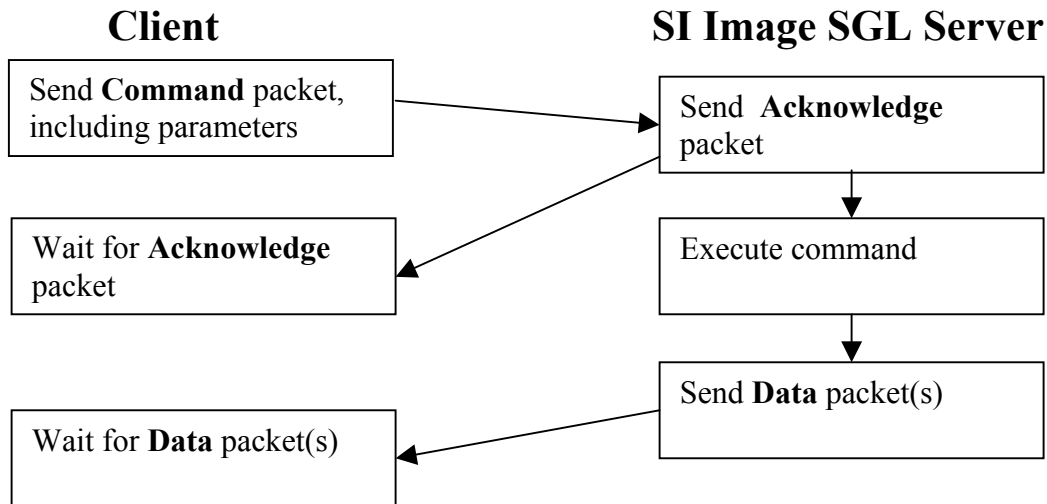
6.1 TCP IP packet definition

All transfer is binary. Data are sent in big endian format. The optimal packet size for image packets is ~5KB.

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	arbitrary format	

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

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 Image type data – big endian

6.2 Data Packet Structures:

6.2.1 Status structure 2002 (60 bytes)

Name	Type	Description
CCDTemperature	U32	CCD Temperature
BackplateTemperature	U32	* Back plate temperature
CCDChamberPressure	U32	* CCD Chamber Pressure
Spare3	U32	spare
Spare4	U32	spare
Spare5	U32	spare
Spare6	U32	spare
Spare7	U32	spare
ShutterStatus	U32	0 = closed and 1 = open
XIRQStatus	U32	0 = no external IRQ and 1 = external IRQ occurred
Spare10	U32	spare
Spare11	U32	spare
Spare12	U32	spare
Spare13	U32	spare
Spare14	U32	spare
Spare15	U32	spare

*Not active on all cameras

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 (see Appendix B) for the image.

6.2.5 Command Done structure 2007 (2 bytes)

Name	Type	Description
Function Number	U16	function that was executed

6.3   Camera Commands:

6.3.1   GetStatus FromCamera

- Camera Command
- Receives the camera status

Function number: 1011
Parameters: none
Returns: Data packet 2002 (Status structure)

6.3.2   Image Acquisition

- Camera Command
- Starts an image acquisition

Function number: 1012
Parameters: U32: Exposure time
                               U16: Mode (see 6.3.3 below)
                               U16: Buffer Number (1 or 2)
                               U16: Save As (see 6.3.4 below)
                               File Name String (null terminated)
Returns: Command Done Data packet or Image packets depending on the Mode

6.3.3   Mode Parameter values:

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

6.3.4   Save As:

0 – U16 FITS
1 – I16 FITS
2 – I32 FITS
3 – SGL FITS
4 – U16 TIFF
5 – I16 TIFF
6 – I32 TIFF
7 – SGL TIFF

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6.3.5   Dark Acquisition

- Camera Command
- Starts an acquisition without opening the shutter

Function number: 1013
Parameters: U32: Exposure time
                     U16: Mode (see 6.3.3 above)
                     U16: Buffer Number (1 or 2)
                     U16: Save As (see 6.3.4 above)
                     File Name String (null terminated)
Returns: Command Done Data packet or Image packets depending on the Mode

6.3.6   Test Pattern Acquisition

- Camera Command
- Starts an acquisition of a test pattern

Function number: 1014
Parameters: U32: Exposure time
                     U16: Mode (see 6.3.3 above)
                     U16: Buffer Number (1 or 2)
                     U16: Save As (see 6.3.4 above)
                     File Name String (null terminated)
Returns: Command Done Data packet or Image packets depending on the Mode

6.3.7   Triggered Acquisition

- Camera Command
- Starts an image acquisition with trigger

Function number: 1016
Parameters: U32: Exposure time
                     U16: Mode (see 6.3.3 above)
                     U16: Buffer Number (1 or 2)
                     U16: Save As (see 6.3.4 above)
                     File Name String (null terminated)
Returns: Command Done Data packet or Image packets depending on the Mode

6.3.8   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

6.3.9   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.

6.3.10 Retrieve Image

- Server Command
- Retrieves the current image

Function number: 1019
Parameters: U16: Buffer Number (1 or 2)
   Returns: Multiple Image packets

6.3.11 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

6.3.12   Averaged Light Images Acquisition

- Camera Command
- Starts an Average Images acquisition

Function Number: 1028
Parameters: U32: Exposure time
                              U16: Mode (see 6.3.3 above)
                              U16: Number of images to average (1 or 2)
                              U16: Save As (see 6.3.4 above)
                              File Name String (null terminated)
Returns: Command Done Data packet or Image packets depending on the Mode

6.3.13   Averaged Dark Images Acquisition

- Camera Command
- Starts an Average Images acquisition

Function Number: 1029
Parameters: U32: Exposure time
                              U16: Mode (see 6.3.3 above)
                              U16: Number of images to average (1 or 2)
                              U16: Save As (see 6.3.4 above)
                              File Name String (null terminated)
Returns: Command Done Data packet or Image packets depending on the Mode

6.3.14 Averaged Triggered Images Acquisition

- Camera Command
- Starts an Average Images acquisition

Function Number: 1030
Parameters: U32: Exposure time
                              U16: Mode (see 6.3.3 above)
                              U16: Number of images to average (1 or 2)
                              U16: Save As (see 6.3.4 above)
                              File Name String (null terminated)
Returns: Command Done Data packet or Image packets depending on the Mode

6.3.15 Save Image

- Server Command
- Saves Image on the server

Function Number: 1031
Parameters: U16: Buffer Number (1 or 2)
                              U16: Save As (see 6.3.4 above)
                              File Name String (null terminated)
Returns: Data Packet 2007 (Command Done structure)

6.3.16 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 6.3.3 above)
    U16: Buffer Number (1 or 2)
    U16: Save As (see 6.3.4 above)
    File Name String (null terminated)

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

6.3.17 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 6.3.3 above)
    U16: Buffer Number (1 or 2)
    U16: Save As (see 6.3.4 above)
    File Name String (null terminated)

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

7   Appendix A

A file, 2236.cfg, is opened automatically by the SI Image program. For this reason, a file named 2236.cfg 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 2236.cfg file is installed along with the software. 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=8	Screen location for the left-hand edge of the program window.
Window Top=46	Screen location for the top edge of the program window.
Window Right=1017	Screen location for the right-hand edge of program window.
Window Bottom=721	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

The structure and entries within this file are universal across all of the cameras offered by Spectral Instruments. The 2236.cfg 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 a 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, ***.set**, contains all the camera specific information and is opened by the SI Image program. The file must exist in the directory with the SI Image software. When the SI Image software is installed from the CDROM, a custom version of the *.set file specific to a camera is included.   The name of the set file is "(Serial Number).set" (e.g. 800-115.set). If only one ***.set** file is in the folder with the program, it is opened when the program starts. If more than one is present, the user will be prompted to select the correct one from a list that matches the camera being used.

Table B, below, illustrates a typical configuration for the ***.set** file. The left hand column is the file, the right hand column is annotation.

The values in the [Configuration] section are over-written by what is read from the camera head if the camera head has an EEPROM (600 Series and above). The values in the [Readout & Format] section are those settings selected when the parameters were last saved.

Changing the configuration parameters is OK as long as the values in the camera head are not changed. If camera head EEPROM values are changed, the original values should be saved as a hard copy for reference if something does not work afterward.

Table B

[Camera Operation]	Section Name
CCD Type=LM485	Type of CCD used in the camera
DSP Code File Name=2350C.bin	The name of the *.bin file to use with this camera. For 800 Series cameras, this is normally left blank since the DSP code is stored in the camera head.
Baud Rate=19200	The communications speed to use with the camera. This must agree with the baud rate setting on the camera controller. Default is 19200.
Low Temp Limit=-105	The lowest temperature permitted with the camera to be run. (^{o}C)
High Temp Limit=-75	He highest temperature for normal camera operation
High Pressure Limit=5	The pressure reading at which the camera must be pumped to avoid internal condensation.
Pressure@Temp Temperature=-80	The upper limit temperature for checking the cold-camera pressure.
Pressure@Temperature Pressure=0.1	The maximum pressure reading in Torr for safely operating a cold camera head. If the pressure rises above this value at the Pressure@Temp Temperature or lower temperatures, the camera must be pumped.
Triggered Acquisition=TRUE	If True, the software enables externally triggered acquisition as an imaging mode.
TDI Int.=TRUE	If True, the software enables internally paced **T**ime **D**elay **I**ntegration (TDI) as an imaging mode.

TDI Ext.=FALSE	If True, the software enables externally paced **T**ime **D**elay **I**ntegration (TDI) as an imaging mode (not available on all camera models.
TimeOut=2	Sets the timeout in seconds for the software to abort an image acquisition due to a pause in data arriving at the computer once the exposure time has elapsed.
[Additional Parameters]	Section Name
Cooler?=TRUE	TRUE means that a relay switch is provided to allow turning on and off the cooling.
Readout Speed=3	The last saved readout speed to start up next.
[Readout & Format]	Section Name
Serial Origin=0	The default first serial pixel location to start readout.
Serial Length=2200	The default number of serial pixels to readout.
Serial Binning=1	The default serial binning to use.
Serial Post Scan=0	The default number of serial pixels to discard after read.
Parallel Origin=0	The default first parallel pixel location to start readout.
Parallel Length=2200	The default number of parallel pixels to readout.
Parallel Binning=1	The default parallel binning to use.
Parallel Post Scan=0	The default number of parallel pixels to discard after read.
Exposure Time (ms)=60000	The default exposure time in milliseconds.
Continuous Clear Disable=0	0 - continuously clear the sensor when idle 1 - disable continuous clearing and resume after next readout 2 - disable continuous clearing
DSI Sample Time=1	The counter that sets the dual slope integrator readout speed.
Analog Attenuation=0	The default attenuation (like gain) to use.
Port 1 Offset=3174	The digital value to use for setting the offset for port 1.
Port 2 Offset=3174	The digital value to use for setting the offset for port 2.
Port 3 Offset=3174	The digital value to use for setting the offset for port 3.
Port 4 Offset=3174	The digital value to use for setting the offset for port 4.
TDI Delay=100	The number of microseconds to wait between TDI readout rows.
# Lines to Skip=0	Number of lines to skip after reading a subarray – NOT used on all cameras
# of Blank Lines=0	Number of blank lines to read before a parallel shift – NOT used on all cameras
Shift # Lines on Trig=0	Shift the CCD # lines when a trigger is received – NOT used on all cameras
# Samples/Pixel=0	Sample each pixel # times – NOT used on all cameras
CCD Attenuation=0	Sets the CCD amplifier attenuation, 0 is high sensitivity and 1 is high dynamic range – NOT used on all cameras
# of Frames=1	Number of frames in a multi-frame readout – NOT used on all cameras
Command on Trigger	Specifies a command to perform on trigger – see Section 5.1
Spare xx=0	(xx is ~17–31)
Port 1 ADC offset=0	Analog to digital converter offset for port 1
Port 2 ADC offset=0	Analog to digital converter offset for port 2
Port 3 ADC offset=0	Analog to digital converter offset for port 3

Port 4 ADC offset=0	Analog to digital converter offset for port 4
[Readout Speed Info]	Section Name
Readout Speeds Available=4	The number of tested readout speeds.
Readout Speed 0=50000	The number of samples per second for this speed.
DSI Sample Time 0=176	The DSI count value for the first readout speed.
Attenuation 0=0	The default attenuation for readout speed 0.
Port 1 Offset 0=3174	The digital value to use for setting the offset for port 1.
Port 2 Offset 0=3168	The digital value to use for setting the offset for port 2.
Port 3 Offset 0=3162	The digital value to use for setting the offset for port 3.
Port 4 Offset 0=3155	The digital value to use for setting the offset for port 4.
# Samples/Pixel 0=0	Sample each pixel # times – NOT used on all cameras
Readout Speed 1=100000	The number of samples per second for this speed.
DSI Sample Time 1=76	The DSI count value for the second readout speed.
Attenuation 1=0	The default attenuation for readout speed 1.
Port 1 Offset 1=3171	The digital value to use for setting the offset for port 1.
Port 2 Offset 1=3168	The digital value to use for setting the offset for port 2.
Port 3 Offset 1=3158	The digital value to use for setting the offset for port 3.
Port 4 Offset 1=3164	The digital value to use for setting the offset for port 4.
# Samples/Pixel 1=0	Sample each pixel # times – NOT used on all cameras
Readout Speed 2=200000	The number of samples per second for this speed.
DSI Sample Time 2=26	The DSI count value for the third readout speed.
Attenuation 2=0	The default attenuation for readout speed 2.
Port 1 Offset 2=3179	The digital value to use for setting the offset for port 1.
Port 2 Offset 2=3166	The digital value to use for setting the offset for port 2.
Port 3 Offset 2=3156	The digital value to use for setting the offset for port 3.
Port 4 Offset 2=3169	The digital value to use for setting the offset for port 4.
# Samples/Pixel 2=0	Sample each pixel # times – NOT used on all cameras
Readout Speed 3=400000	The number of samples per second for this speed.
DSI Sample Time 3=1	The DSI count value for the third readout speed.
Attenuation 3=2	The default attenuation for readout speed 3.
Port 1 Offset 3=3170	The digital value to use for setting the offset for port 1.
Port 2 Offset 3=3155	The digital value to use for setting the offset for port 2.
Port 3 Offset 3=3148	The digital value to use for setting the offset for port 3.
Port 4 Offset 3=3157	The digital value to use for setting the offset for port 4.
# Samples/Pixel 3=0	Sample each pixel # times – NOT used on all cameras
[Configuration]	Section Name
Instrument Model=620	This is the model number of the camera.
Instrument SN=169	The camera head serial number, generally is also in the name of the *.set file.
Hardware Revision=0	The major revision of the camera head.
Serial Phasing=0	The direction in which the serial register shifts (do not change without knowing what you are doing).
Serial Split=1	=1 if two halves on the serial register are used for multi-port readout.
Serial Size=2048	The length of (each half if split) the serial register to read.

Parallel Phasing=0	The direction in which the parallel register shifts (do not change without knowing what you are doing).
Parallel Split=1	=1 if two halves on the parallel register are used for multi-port readout.
Parallel Size=2048	The length of (each half is split) the parallel register to read.
Parallel Shift Delay=250	The DSP units to delay between parallel clock phases (do not change without knowing what you are doing). This parameter must be > 0!
Number of Ports=3	0-based count of the number of readout ports. This parameter must agree with the serial and parallel split parameters in order to work right.
Shutter Close Delay=200	The milliseconds to delay after the shutter-close command is issued. This must not be 0 and is used to allow time for the preamplifier to turn on before readout.
Not Applicable=0	Parameter normally in this place is not use on the specific camera
CCD Temp. Offset=0	A fudge factor to get the room-temperature reading from the camera head to agree with room temperature (if required).
Backplate Temp. Offset=0	A fudge factor to get the room-temperature reading from the camera back plate to agree with room temperature (if required). Only for TE cooled cameras.
CCD Temp. Setpoint=2043	The temperature in 0.1 Kelvin units to at which to operate the camera. (2043 == -68.7 $^{\circ}$C).
Data Word Size=16	The number of bits per pixel read out.
MPP mode disable=0	0 means operate in MPP mode, 1 says not MPP mode.
Port Select=0	Selects which port is read in multi-port cameras (800 Series cameras only)
Spare xx=0	(xx is 18-24)
Controller SN=5074	The serial number of the controller for the camera.
Analog Part #=1547	The part number of the analog card.
Analog Rev. #=8	The revision level of the analog card.
Controller Rev. #=0	The revision level of the controller.
Spare xx=0	(xx is 29-31)

9   Appendix C

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.

10 Appendix D

A file, *.str contains the names of the parameters used for the camera status parameters, readout and format parameters and configuration parameters. Status Parameters 1 and 2 are used by the program to modify if certain information is displayed. In the **Status** section of the example file shown below, Status Parameter 1 is set to "Not Applicable" which signifies a cryogenically cooled camera. If this was for a TE cooled camera, it would read Status Parameter 1="Backplate Temperature" and that extra parameter will be included when the camera status is displayed for the Backplate Temperature. There is no Backplate Temperature for cryogenically cooled cameras.

[Status]
Status Parameter 0="CCD Temperature"
Status Parameter 1="Not Applicable"
Status Parameter 2="Chamber Pressure"
Status Parameter 3="Spare 3"
Status Parameter 4="Spare 4"
Status Parameter 5="Spare 5"
Status Parameter 6="Spare 6"
Status Parameter 7="Spare 7"
Status Parameter 8="Shutter Status"
Status Parameter 9="XIRQA Status"
Status Parameter 10="Cooler Status"
Status Parameter 11="Spare 11"
Status Parameter 12="Spare 12"
Status Parameter 13="Spare 13"
Status Parameter 14="Spare 14"
Status Parameter 15="Spare 15"

[Readout & Format]
Readout & Format Parameter 0="Serial Origin"
Readout & Format Parameter 1="Serial Length"
Readout & Format Parameter 2="Serial Binning"
Readout & Format Parameter 3="Serial Post Scan"
Readout & Format Parameter 4="Parallel Origin"
Readout & Format Parameter 5="Parallel Length"
Readout & Format Parameter 6="Parallel Binning"
Readout & Format Parameter 7="Parallel Post Scan"
Readout & Format Parameter 8="Exposure Time (ms)"
Readout & Format Parameter 9="Continuous Clear Disable"
Readout & Format Parameter 10="DSI Sample Time"
Readout & Format Parameter 11="Analog Attenuation"
Readout & Format Parameter 12="Port 1 Offset"
Readout & Format Parameter 13="Port 2 Offset"
Readout & Format Parameter 14="Port 3 Offset"
Readout & Format Parameter 15="Port 4 Offset"
Readout & Format Parameter 16="TDI Delay"

Readout & Format Parameter 17="# Lines to Skip "
Readout & Format Parameter 18="# of Blank Lines "
Readout & Format Parameter 19=" Shift # Lines on Trig "
Readout & Format Parameter 20="# Samples/Pixel "
Readout & Format Parameter 21=" CCD Attenuation "
Readout & Format Parameter 22="# of Frames "
Readout & Format Parameter 23="Command on Trigger"
Readout & Format Parameter 24="Spare 24"
Readout & Format Parameter 25="Spare 25"
Readout & Format Parameter 26="Spare 26"
Readout & Format Parameter 27="Spare 27"
Readout & Format Parameter 28=" Port 1 ADC offset"
Readout & Format Parameter 29=" Port 2 ADC offset"
Readout & Format Parameter 30=" Port 3 ADC offset"
Readout & Format Parameter 31=" Port 4 ADC offset"

> **Note: Parameters (17-31) are not used in all cameras**

[Configuration]
Configuration Parameter 0="Instrument Model"
Configuration Parameter 1="Instrument SN"
Configuration Parameter 2="Hardware Revision"
Configuration Parameter 3="Serial Phasing"
Configuration Parameter 4="Serial Split"
Configuration Parameter 5="Serial Size"
Configuration Parameter 6="Parallel Phasing"
Configuration Parameter 7="Parallel Split"
Configuration Parameter 8="Parallel Size"
Configuration Parameter 9="Parallel Shift Delay"
Configuration Parameter 10="Number of Ports"
Configuration Parameter 11="Shutter Close Delay"
Configuration Parameter 12="Not Applicable"
Configuration Parameter 13="Not Applicable"
Configuration Parameter 14="CCD Temp. Setpoint"
Configuration Parameter 15="Data Word Size"
Configuration Parameter 16="MPP mode disable"
Configuration Parameter 17="Port Select"
Configuration Parameter 18="Spare 18"
Configuration Parameter 19="Spare 19"
Configuration Parameter 20="Spare 20"
Configuration Parameter 21="Spare 21"
Configuration Parameter 22="Spare 22"
Configuration Parameter 23="Spare 23"
Configuration Parameter 24="Spare 24"
Configuration Parameter 25="Controller SN"
Configuration Parameter 26="Analog Part #"
Configuration Parameter 27="Analog Rev. #"
Configuration Parameter 28="Controller Rev. #"

Configuration Parameter 29="Spare 29"
Configuration Parameter 30="Spare 30"
Configuration Parameter 31="Spare 31"