# High Resolution Camera Software User's Manual

## SOAR Adaptive Module (SAM)

**Revision 3.0, August 2008**

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# Chapter 1:  Getting Things Running

This user manual is intended to describe the use of the High Resolution Camera Software (HRCSOFT) from a user's point of view. It is not a programming manual. For implementations details please read the HRCSOFT Programmer Manual.

## 1.1   Hardware Setup

Before firing up the HRCSOFT, and with the HRC computer turned ON, some hardware has to be powered up:

Power up the Luca Camera. The host computer should be turned ON at this time!

Make sure the filter wheel is powered up and that the RS-232 cable is plugged in.

**IMPORTANT**: The host computer should be turned ON when powering up the Luca CCD. This assures correct detection of the USB device by the host computer.

## 1.2   Starting the HRC Software

### 1.2.1   From favorite terminal window

You can launch the HRCSOFT  program from your favorite terminal. Open a shell window and invoke the HRCSOFT program with the following command:

```
% cd /home/ao/HRCsoft
% ./HRCAPP &
```

Then RUN the VI. Look for the connections in the upper part of the GUI for possible problems. Red color means error.

Press the INIT button to bring the system to operational ready state. After pressing the INIT button the PAN and ICS icons flash to yellow color signaling ACTIVE state while initializing. Wait for them finish. Now the system is ready to take exposures.

### 1.2.2   From Local Desktop

Double click the desktop icon labeled HRCAM. The main Labview VI pops up. Run the VI.

### 1.2.3   From VNC Remote Desktop

Press the button labeled HRCAM  in the application launcher window. The main Labview VI pops up. Run the VI.

## 1.3  Stopping the HRC Software.

To stop the HRC software press first the OFFLINE button to bring the system into OFFLINE state. Then press the SHUTDOWN button to actually quit the application program.

## 1.4  Troubleshooting

Under Linux OS sometimes takes some pain to get the Luca to be recognized by the USB drivers. In that case a small example application produced by the vendor as part of the Linux SDK comes handy to check the link. Follow the steps below to troubleshoot the USB connection:

1. cd to andor/examples/console/image

2. run image command. If the program initializes properly you are done.

3. If the image command returns an error. Try first reinstalling the drivers

   % sudo /sbin/rmmod ehci_hcd

   % sudo /sbin/modprobe ehci_hcd

4. If reinstalling the drivers don't work, try turning the power camera off, reinstalling the drivers and turning the camera power on.

# Chapter 2:  GUI Reference

When the application starts the user is presented with a single window containing the most relevant system status variables. If the boot process ended with no failures then the application is ready to receive commands.
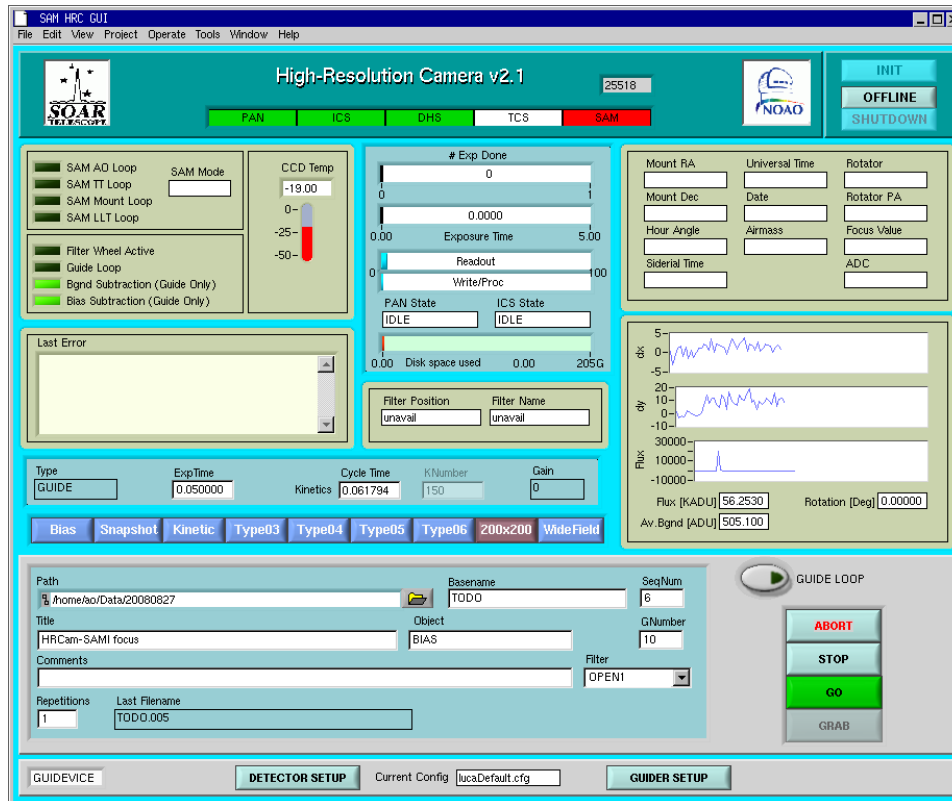


*Figure 1: Main GUI. The most relevant indicators and controls are displayed.*

**INIT**. Use this button to initialize the instrument subsystems. During this process the camera cooler will be turned ON, the default parameters of the detector will be loaded, and the filter wheel will be initialized.

**OFFLINE**. Use this button to off-line the instrument subsystems. During this process the camera cooler will be turned OFF, and the last exposure parameters will be saved to the HRCAPP_Default.cfg configuration file (see section 4.1.1 below).

**SHUTDOWN**. Use this button to exit the program. The button is enabled only after the program is in the off-line state.

## 2.1   MAIN > Comm-Links Status Indicator

The comm-link indicator uses a color code to represent the status of the subsystems involved in the HRCSOFT operation: PAN, ICS, DHS, TCS, and SAM. The code is Red = Problems, White = No Connection, Green = Idle, Yellow = Active, and Blue = Off-line.

## 2.2   MAIN > Miscellaneous indicators

**SAM AO Loop**. Status of the SAM deformable mirror control loop.
**SAM TT Loop**. Status of the SAM tip-tilt control loop over SOAR M3 mirror.
**SAM Mount Loop**. Status of the SAM control loop over the SOAR telescope mount.
**SAM LLT Loop**. Status of the SAM control loop over the launch laser telescope.
**SAM Mode**. Name of the currently selected mode for SAM: NGS, LGS, TSNGS.

**Filter Wheel Active**. This indicator is lite when the filter wheel is moving.
**Guide Loop**. Status of the HRCam tip-tilt control loop over SOAR M3 mirror.
**Bgnd Subtraction**. Status of the background subtraction option while guiding.
**Bias Subtraction**. Status of the bias subtraction option while guiding.

**CCD Temperature**. CCD temperature in C degrees.

**Last Error**. Information box showing the last fault registered by the system. Warning and the result of certain operations are also shown here.

## 2.3   MAIN > Exposure Progress Indicators

While taking a exposure, the progress indicator give feedback on the current state of the operation.

**# Exp Done**. This bar presents the number of images acquired during the present sequence. The user can request multiple exposures in the # Exp control.
**Exposure Time**. Shows the elapsed time during the current exposure. Useful during kinematic series of exposures.
**Readout & Write**. The percent of advance in reading images to memory and writing them to disk.
**PAN State**. Camera controller logic device state. The state can be one of IDLE, OFFLINE, ERROR, or ACTIVE.
**ICS State**. Instrument control logic device state. The state can be one of IDLE, OFFLINE, ERROR, or ACTIVE.
**Disk Space Used**. The amount of space left in the volume to which the selected *Path* belongs to. Gets updated after every exposure.

## 2.4  MAIN > Filter Wheel Indicators and Controls

To the right of the main window are the filter wheel indicators and controls.

**Filter Position**. A number from 1 to 10 indicating the current physical wheel position. When moving this indicator shows the word MOVING.
**Filter Name**. A user defined label corresponding to each filter position is shown here. See section 4.1.3 below to learn how to edit the associated configuration file. When moving this indicator shows the word MOVING.

## 2.5  MAIN > TCS Status Parameters

**Mount RA**. Right Ascention

**Mount Dec**. Declination

**Hour Angle**.

**UT.** Universal time.

**Date.**

**Airmass**.

**Rotator.** Rotator mechanical angle.

**Rotator PA**. Rotator position angle.

**Focus**.

**ADC**. Atmospheric Dispersion Corrector.

## 2.6  MAIN > Guider Status Charts and Indicators

**DX, DY, and Flux Charts**. These charts get updated every second with samples of the current centroid errors and flux. Units of flux are Kilo ADU's.

**Av.Bgnd**. Average background estimate in the guide box.

**Rotation**. Amount of rotation from mount elevation and Nasmyth rotator to be applied to the centroid errors to transform from X-Y CCD coordinates to M3 coordinates.

## 2.7  MAIN > Exposure Parameters Pane

Use the Labeled buttons in this pane to select among various predefined exposure modes. Each button is configurable through a configuration file. The predefined modes are Snapshot, Kinetic, 200x200 and WideField. See section 4.3 below for directions on how to edit the files.

To the bottom of the main window is the exposure parameters pane. The user will most often interact with this set of controls.

**Type**. Acquisition mode: Single, Kinetic, or Guide. Under kinetic mode a sequence of exposures is taken by the camera at a predefined cycle time, and stored as a FITS data cube in disk. Under Guider mode the camera is set to run in RTA mode and the GRAB button is used to save exposure sequences.

**ExpTime**. Exposure time in seconds. The minimum value accepted by the controller is 0.00001 second.

**Cycle Time**. Time between start of exposures under kinetic mode. The input box is enabled when the kinetic acquisition mode is selected.

**KNumber**. Number of exposures to take under kinetic mode. The input box is enabled when the kinetic acquisition mode is selected.

**Gain**. Current EMCCD gain


**Path**. Directory path in which the images will be stored.

**Basename**. Root name for the exposure. File name will be form by appending the sequence number to this base name.

**SeqNum**. Sequence number. A positive integer that will be appended to the base name to form the actual image file name.

**Title**. User defined title. Associated to the TITLE keyword in the FITS file.

**Object**. Object name. Associated to the OBJECT keyword in the produced FITS file.

**Gnumber**. Number of frames to grab under guider mode.

**Comments**. User defined comments. Associated to keyword COMMENT in the produced FITS file.

**Filter**. Filter for the exposure.

**Repetitions**. Number of exposures to take. Each exposure will be saved to its own FITS file.

**Last Filename**. Name of the last image file written to disk.


**ABORT**. Use this button to abort the current acquisition.

**STOP**. Use this button to stop the current acquisition. This command will wait for the current exposure to finish and then will stop any further activities.

**GO**. Start and exposure sequence. When the GO button is pressed the exposure parameters are passed to the controller and then the acquisition starts.

**GRAB**. Only available while exposing under Guide mode. Command the software to grab and save to disk the number of images set by the exposure parameters.

**Detector Setup**. Press this button to open the detector setup window. See section 2.7.1 below for more details.

**Current Config**. This label presents the current detector configuration file loaded as defined in the HRCAPP_Default configuration file (see section 4.1.4 below).

**Guider Setup**. Press this button to open the guider setup window. See section 4.1.4 below for more details.
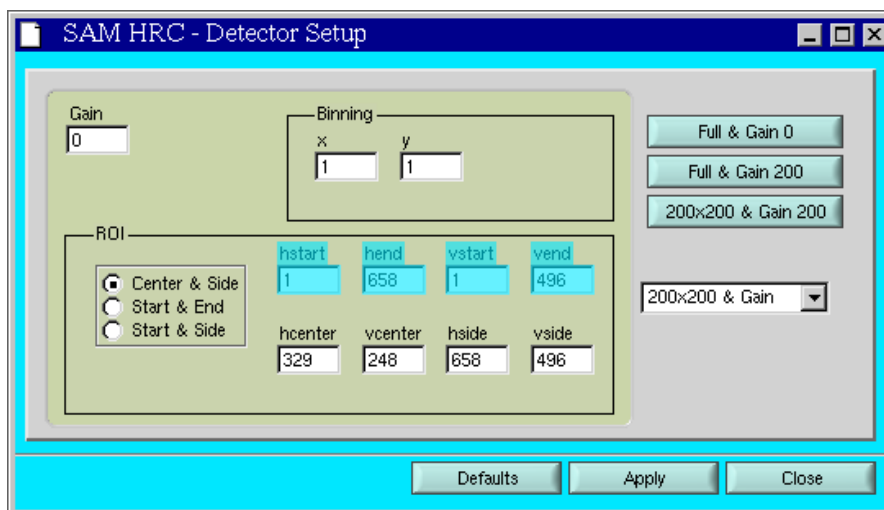


*Figure 2: Detector setup window. Predefined detector configurations are available from a configuration file.*

### 2.7.1   MAIN > Detector Setup Window

Use this window to configure the detector readout parameters: EMCCD gain, binning factors, and regions of interest. When the window is opened the current parameters are shown. Enter the new parameters and the press the *Apply* button to actually set the new values. Use the *Defaults* button to restore all the parameters to their default value. When ready close the window by pressing the *Close* button.

### 2.7.2   MAIN > Guider Setup Window

The guider can be configured and calibrated by using the Guider Setup Window.

**Transformation Matrix Tab**. To transform from CCD X-Y coordinates to M3 elevation-azimuth coordinates the guider core applies multiplies the x-y error vector by a transformation matrix. The matrix contains a fixed and a variable component. The fixed component is measured once and accounts for a fixed rotation between the X axis and the elevation axis of M3 (Nasmyth rotator and mount elevation at zero), and for the gain between x-y and el-az in ADU/pixel. The variable component accounts for the Nasmyth rotation and mount elevation. To

measure the fixed component the GUIDER SETUP window provides the Transformation Matrix tab.

**Parameters**. Use this tab to modified the size and position  of the guide box. This can be done anytime. Loop gain can also be adjusted from here. The default value for the gain can be changed in the lucaDefault.cfg file.

# Chapter 3: Common Operations

## 3.1 Taking a Single Exposure

Follow the steps below to take a single exposure.

1. Check that the status icons at the top of the main window GUI are all green. That indicates that the program is in the IDLE state and ready to receive commands.

2. Select the **SNAPSHOT** type of exposure using the radio buttons in the exposure controls pane (Figure 3)
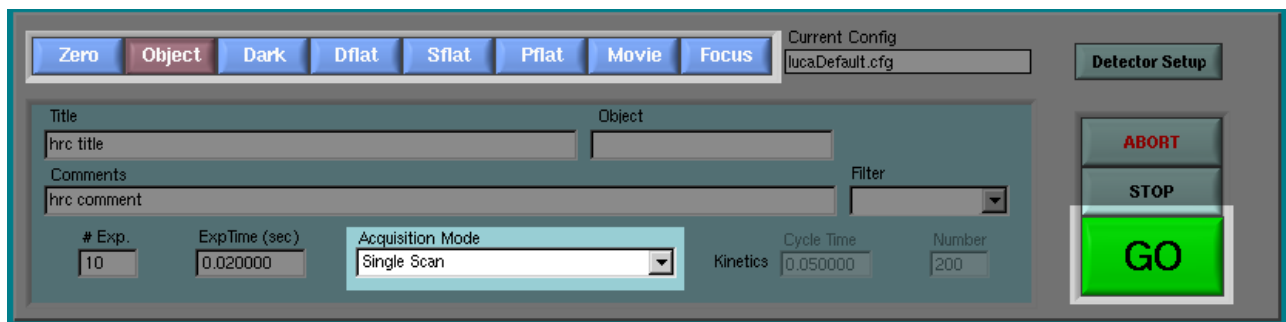


*Figure 3: Use the radio buttons to select the type of exposure. Controls will be enabled/disabled depending on the selected mode.*

3. Optionally enter a title, comments, and object name. These fields will be added as keywords to the produced FITS file.

4. Optionally select from the Filter combo box the filter to use during the exposure.

5. Press GO. The status icons go from green to yellow (ACTIVE state) and back to green to indicate that the frame has been taken. If the real-time display is running (see chapter 4.1.4 below) the frame will be displayed.

## 3.2 Taking a Kinetic Series

1. Check that the status icons at the top of the main window GUI are all green. That indicates that the program is in the IDLE state and ready to receive commands.

2. Select the **KINETIC** type of exposure[1] using the radio buttons in the exposure controls pane (Figure 4)

---

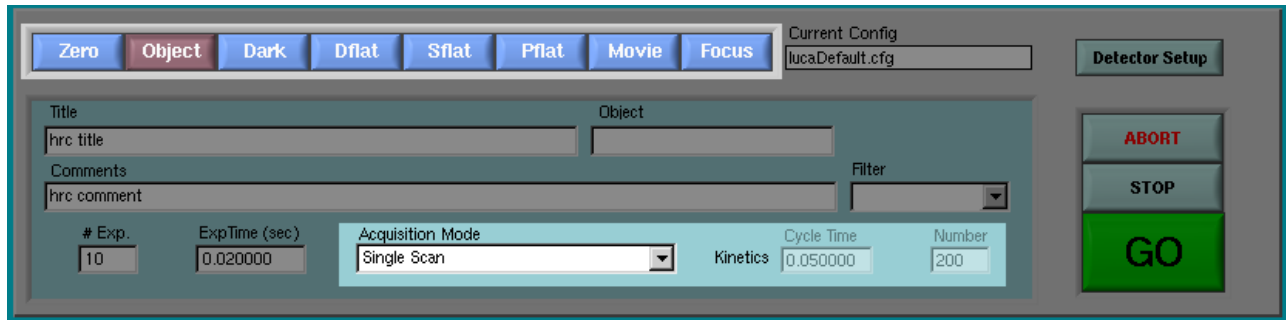1 It is possible to select though the Kinetic mode under all modes but Movie.

*Figure 4: Select OBJECT type and Kinetics mode to take a kinetics series. Use the Cycle Time and Number boxes to set the time between start of exposures and number of frames in the series.*

3. Enter the Kinetic cycle time and the number of kinetic frames to take in the *Cycle Time* and *KNumber* input boxes.

4. Optionally enter a title, comments, and object name. These fields will be added as keywords to the produced FITS file.

5. Optionally select from the Filter combo box the filter to use during the exposure.

6. Press GO. The status icons go from green to yellow (ACTIVE state) and back to green to indicate that the series has ended. If the real-time display is running the data cube will be displayed. This might take a while depending on the number and size of the frames in the data cube.

## 3.3  Auto Guiding

The HRCSOFT can acquire images or sequence of images while guiding on the acquired object. A special type of exposure called GUIDE has been added to the existing HRCam software. When selected, the Luca is put to work under Run Till Abort (RTA) acquisition mode and X-Y centroid error are computed for each frame. The centroid error is then integrated and sent to the SOAR telescope M3 mirror. At any time during this process the user can grab sequences of images and saved them to disk in the usual FITS file format. For example, a typical sequence of actions for taking a guided exposure will be:

1. Select the **200x200** or **WIDEFIELD** type of exposure

2. Enter the exposure parameters (path, base name, sequence number, title, comments, object, filter, time, number)

3. Optionally set detector gain and geometry

4. Press GO to start acquisition

5. Close the guide loop on the observed object

6. Grab a sequence of exposures

7. Open the guide loop

8. Press ABORT to stop acquisition

9. Back to 2 or finish

## 3.4  Changing The Detector Readout Parameters

1. Open the Detector Setup window (section 2.7.1 above)

2. Enter in the input boxes the desired values.

3. Optionally select predefined configurations using the buttons or the combo box to the right of the GUI window. This configuration are stored in the PIPS_Default.cfg configuration file (see section 4.1.7 below).

4. Press the Apply button to set the new parameters. In case of error it is always possible to go back to the default parameters by pressing the Defaults button.

5. Use the Close button or the ESC key to quit the GUI window.

## 3.5  Taking A Bias Calibration For Guided Exposures

1. Select the **BIAS**  type of exposure.

2. Optionally set the detector geometry for the bias.

3. Press GO to take the calibration.

The bias calibration will be stored in memory and disk for the currently selected geometry. The copy in memory will then be available any time the matching geometry is selected or until a new calibration is taken for that geometry. Bias calibration for other geometries will create new copies. The number of frames to average is set in the corresponding configuration file for this mode (see section 4.3 below.)

## 3.6  Measuring the Transformation Matrix

1. Open the Guide Setup Window and select the Transformation Matrix tab

2. With a star in the field, press the GET TRANSFORMATION button to measure the matrix and then APPLY TRANSFORMATION to pass the matrix to the guider core.

**IMPORTANT**: the signs for the elevation and rotator angles to use have to determined in advanced. Edit the lucaDefault.cfg file to include the sign values.

## 3.7  Automatic Image Post-Processing

The HRCSOFT is capable of post processing the acquired image or sequence of images by enabling post-processing in the HRCRTD software. The HRCRTD will run a user defined script that will receive as arguments the name of the file and an output directory. The script has to be capable of handling the

--file and --outdir command line parameters.

The name of the script and the output directory can be changed by editing the HRCRTD software configuration file HRCRTD/config/hrcrtd.ini. Look for keywords POSTPROSCRIPT and OUTDIR.

So far a script called speckle.py written in Python is provided for computing the power spectrum of an averaged sequence of exposures stored in a data cube.

To enable/disable post-processing check/uncheck the "Enable Post-Processing" checkbox in the HRCRTD window.

# Chapter 4:  Configuration Files

Configuration files provide a mean to set multiple system parameters to some predefined value. Some of the parameters can be changed by the user during run-time, others will remain fixed and can only be changed by editing the files and restarting the software application. A detailed description of the configuration files and their parameters follows.

## 4.1  Configuration Files

Most configuration files follow a common format. Files are divided in multiple sections, each one beginning with a keyword enclosed in square brackets. Each section lists a parameter name followed by an equal sign and its value. A semicolon marks the beginning of a short parameter description.

```
[Section Keyword]
Parameter = Value        ; this is the parameter description
```

The name and path of these files is fixed and can not be modified since they are hard coded in the software. Some of these files have keywords to point to other configuration files which can have user defined names.

All configuration files are expected to live in the directory */home/ao/HRCSoft/config/HRC*.

### 4.1.1  ENV_Default.cfg

This file defines the behavior of the ENV_MAIN module, the SML task spawner and monitor.

```
[ENVIRONMENT]
MainVisible=                          ; make the module visible or not
[DEVICES]
<YOUR DEVICE NAME>=<ITS PATH> ; List of logic devices to spawn
.
.
[SERVERS]
<MY SERVER NAME>=""           ; List of SCLN servers to spawn
[TRANSLATIONS]                ; Logic device proxys
<DEVICE A>=<DEVICE B> TX <DEVICE A>
```

### 4.1.2  ENVSCLN_Default.cfg

The SML uses the SOAR communication library (SCLN) when communication happens over the net. The SCLN is an implementation of a network communication layer that suites the interoperability requirements of the SOAR telescope environment.

Each section in the configuration file defines a client-server pair with the corresponding listening port.

```
[CommLib]
Version=                 ;Version for which this configuration is usable
```

```
        [MY DEVICE]
        IP_Server=              ;IP address of the server
        IP_Client=              ;IP address of the client
        IP_Port=                ;Remote port number
```

For more information on the SCLN and its protocol read the document "*SOAR Communication Library New*" available at the SAM web site archive.

## 4.1.3  Filters_Default.cfg

The configuration file is FILTER_Default.cfg. It has multiple sections to support more than one filter wheel, in tandem configuration.  The main section is SETUP_FILTER_. Here all the combinations are described in the form of filter combos. The remaining sections are specific to each wheel. When moving filters by name, it is the combo name the one used.

```
        [SETUP_FILTER_W1_]
        SETUP_FILTER_W1_SIZE=10
        SETUP_FILTER_W1_P1_NAME=OPEN
        SETUP_FILTER_W1_P1_FOCOFF=0.000000
        .
        .
        [SETUP_FILTER_]
        SETUP_FILTER_SIZE=10
        SETUP_FILTER_F1_NAME=OPEN1
        SETUP_FILTER_F1_POSW1=1
        SETUP_FILTER_F1_POSW2=1
        SETUP_FILTER_F1_FOCOFF=0.000000
        SETUP_FILTER_F1_COMBO=OPEN+OPEN
        SETUP_FILTER_F1_COLOR=16777215
        .
        .
```

## 4.1.4  HRCAPP_Default.cfg

Use this configuration file to keep the default values for the HRC software daemon.

```
        [SETUP_EXPPARAMS_]
        REPEATS=            ; number of exposures in a sequence
        TIME=               ; exposure time
        ACQMODE=            ; 1 = single scan mode, 4 = kinetics mode
        KINETICS=           ; number of frames in a kinetics series
        KINETICSCYCLE=      ; time between start of exposure in kinetic series
        SEQNUM=             ; sequence number to build file name
        PATHBASE=           ; default directory path to store images
        TITLE=                  ; default title
        COMMENT=            ; default comments
        OBSERVER=           ; default observer

        [SETUP_DHE_]
        CONFIGNORMAL=       ; default detector configuration

        [SETUP_DHS_]
        <KEYWORD>=<TOPIC>_      ; LUT between KEYWORD name and database
```

The SETUP_DHS_ section stores a lookup table between FITS keywords and database topics. Keyword values are stored in the database under topics. To program uses <TOPIC_> and <KEYWORD> to build the database variable and obtain the keyword value.

### 4.1.5  INSDEVICE_Default.cfg

This is the configuration file for the filter wheel. Right now has a single key that identifies the serial port to which the filter wheel is connected.

```
[GENERAL]
COM=2
```

### 4.1.6  lucaDefault.cfg

This is the default camera controller configuration. Although this configuration file has been named lucaDefault.cfg here, its name can be anything. The keyword CONFIGNORMAL in HRCAPP_Default.cfg points the right name.

```
[GENERAL]
TEMPERATURE=-20          ; temperature set-point in C degrees
DETSIZEX=658               ; detector size in x
DETSIZEY=496               ; detector size in y

[ARRAY VOLTAGES]
EMGAIN=0                 ; EMCCD gain [0-255]

[READOUTPARAMS]
READMODE=4               ; read mode, 4 = image
ACQMODE=1               ; acquisition mode, 1=single, 3=kinetics

[EXPOSUREPARAMS]
EXPOSURETIME=0.10       ; exposure time in seconds
IMAGE="1 1 1 658 1 496" ; binning and region of interest
KINETICS=1              ; number of kinetic frames
KINETICSCYCLE=0.2       ; time between kinetics frames
ACCUMULATIONS=1         ; number of frames to accumulate
ACCUMULATIONSCYCLE=0.2  ; time between accumulations
TRIGGERMODE=0           ; 0=software
```

### 4.1.7  PIPS_Default.cfg

This is the configuration file for the Detector Setup Plugin. Each section correspond to a detector setup that defines the ROI and the EMCDD gain to use. When the window is open the section contents are loaded. The first three sections of the file are assigned to the three quick setup buttons available and the boolean text for each button is updated to show the section name it corresponds to.

All sections including the ones assigned to the quick setup buttons are listed in the setup combo box. The configuration file sections include five keywords

```
[Section Name]
GAIN=       ; EMCCD gain to use
HCENTER=    ; ROI center in x
VCENTER=    ; ROI center in y
```

```
    HSIDE=               ; ROI side in x
    VSIDE=               ; ROI side in y
```

## 4.2  Header Templates – HRC.HDR

The header template is used by the program to generate FITS file headers. Each line of the line correspond to a keyword. If the word database is included then the value to fill in is extracted from the program database. Otherwise the value in the template file is used. A brief example follows

```
    FILENAME='database          ' /Original host filename
    TITLE  ='database           ' /Observation title
    OBJECT ='database           ' /Observation object
    OBSTYPE ='database          ' /Observation type
```

Each keyword in the example above will get its value from the program database.

## 4.3  Exposure Modes

The HRCSOFT supports various predefined exposure modes via configuration files. These predefined modes are then accessible from the main GUI through the radio buttons in the exposure parameters pain.

The files are plain text files named *TypeXX-ObSession.txt*, where *XX* is a correlative number matching a radio button. The file contains fields separated by semicolons.

**Label**. Single word to be used as button label.

**Type**. Valid types are SINGLE, KINETIC, GUIDE and BIAS.

**Exposure** Time. Value in seconds.

**Knumber**. Number of kinetics in a KINETIC type of exposure.

**Kcycle**. Time between kinetic exposures in seconds.

**Geometry**. Six numbers representing x binning, y binning, x start, x end, y start and y end.

**Gain**. EMCCD gain from 0 to 255.

# Chapter 5: Trouble-Shooting

## 5.1 The ENV_MAIN Monitor

The HRC software has been written using SML (SOAR message library). SML applications use the ENV_MAIN module to spawn an monitor the activity of the software modules that built an SML application. If ENV_MAIN module is visible or not depends on the configuration file ENV_Default.cfg.

The HRC software has the ENV_MAIN module visible for trouble-shooting purposes. The module usually lives minimized in the task bar, and the user can open it at any time to check in detail the status of the logic devices. By using the SHOW buttons array the user can choose to open a device, check status, etc.

## 5.2 The PAN indicator Is In Red after Startup/Initialization

Check that the camera power is on, then that the USB cable is pluged in. Always turn the PC on first and only when the booting has finished turn the camera on. Use the ENV_MAIN module and look for the PAN_DEVICE for further information.

## 5.3 The Initialization times out and the Filters show "no response"

Check that the filter wheel is powered on and that the serial cable is connected to the right port (see section 4.1.5 above for details on the configuration file). Use the ENV_MAIN module and look for the INS_DEVICE for further information.

## 5.4 The GUI indicators Went Bananas!

Restart the application. This symptom might indicate an out of sync problem between logic devices in their message queues. It is known that Labview runs its networking implementation in the user interface thread. Things like blocking the execution of the thread (intense use of user interface resources) can cause a drop in communications, and this in turn can cause races conditions that right now the message library can neither prevent nor detect. A future implementation of SML might deal with this problem.

# Chapter 6:  Real Time Display

An application was written specially to suit the need of real time display capabilities when using the High-resolution camera. The HRCRTD software is a stand alone piece of software that continuously monitor the selected directory for new images and display them using ds9 as its display server.
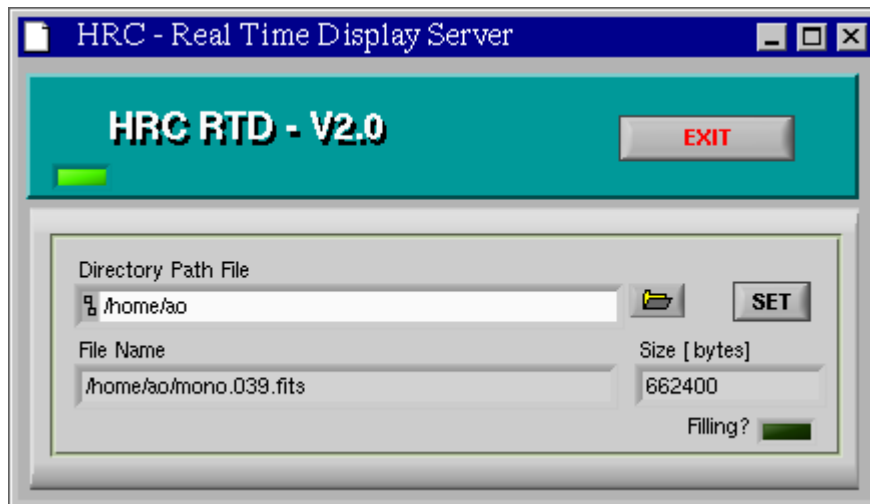


*Figure 5: The HRCam real time display continuously monitors a directory for new images and display them using ds9.*

When a new FITS file is written to the specified directory, the HRCRTD program waits until the file is closed before asking ds9 to display it. The communication between the HRCRTD program and ds9 is done using the XPA utilities. Ds9 and the XPA utilities plus documentation are available at http://hea-www.harvard.edu/RD/ds9.

# Chapter 7: Glossary

DHE                             Detector head electronics

ICDevice                        Stands for Instrument Control Device. Is one of the logic devices
                                that built the HRCAPP daemon.

ICS                             Instrument Control System

PAN                             Pixel Acquisition Node. Logix unit representing the DHE plus
                                interfaces.