FLAO System operator manual

1. Introduction

1.1. System description

1.1.1. Adaptive Secondary (AdSec)

1.1.2. Wavefront Sensor (WFS)

1.1.3. Realtime loop

2. Software overview

2.1. Control computers

The FLAO software runs on two workstations, called **wfsdx** and **adsecdx**, dedicated respectively to control the WFS and the Adaptive Secondary. These workstations are AO-specific and are not part of the TCS server farm, but are accessible via ssh from any TCS machine or operator/observer workstation. The software runs on these workstations as user **AOeng**.

2.2. Complete start/stop/restart

The FLAO software is not a single program, but a collection of processes dedicated to hardware control, plus several more processes which coordinate their actions to perform most AO operations. All processes are normally always running, but it may happen that the software must be shutdown and/or restarted (for example, in case of computer power failures).
A few commands have been implemented on the two workstations to start and stop the complete list of processes. These are:

- **w_start** (on wfsdx) to start all the wfs-related processes
- **w_stop** (on wfsdx) to stop all the wfs-related processes
- **w_restart** (on wfsdx) to execute a stop followed by a restart
- **w_check** (on wfsdx) to check whether the wfs software is running

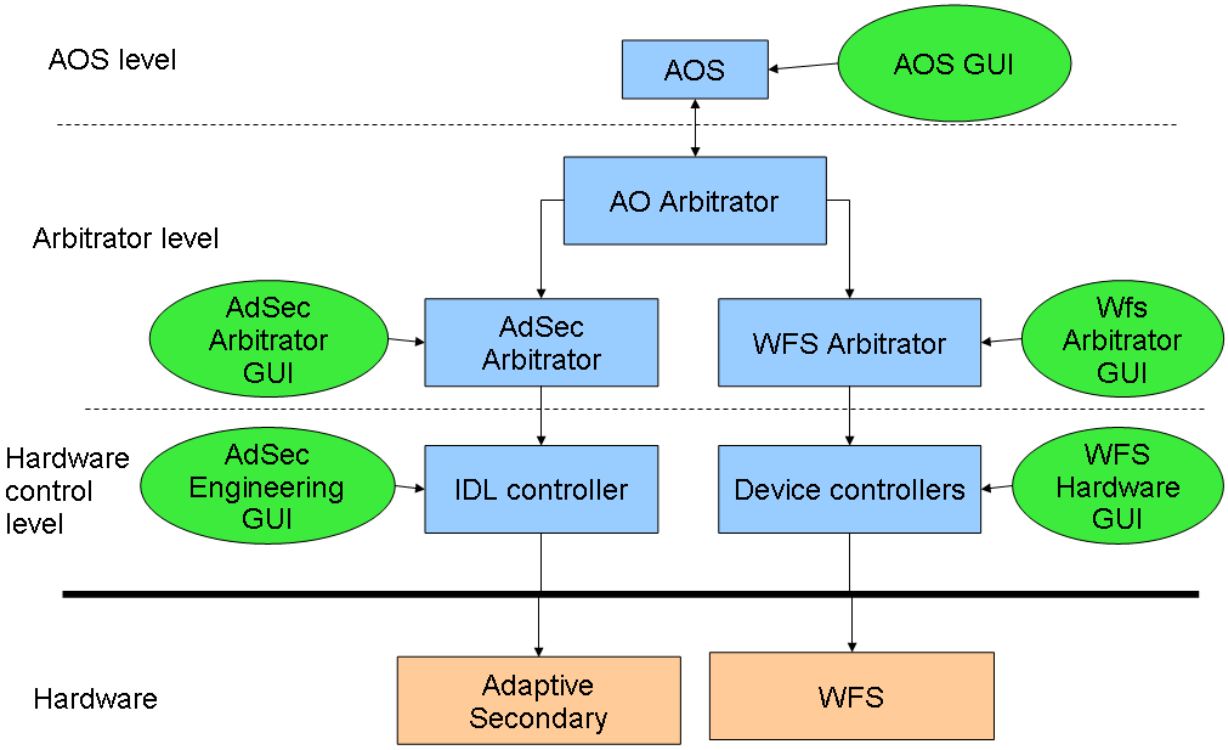
- **adsc_start** (on adsecdx) to start all adsec-related processes
- **adsc_stop** (on adsecdx) to stop all adsec-related processes
- **adsc_restart** (on adsecdx) to execute a stop followed by a restart
- **adsc_check** (on adsecdx) to check whether the adsec software is running

All these commands are text-based and can be issued by any text terminal on the control workstation. They will report the execution status and any errors which may arise. Multiple start commands will cause no harm.

The two software sets (wfs and adsec) are in constant communication but are independent and can be stopped/started separately in any order.

2.3. Overall software scheme

The following diagram gives a general description of how the AO software is structured:



Note the various horizontal levels: AOS, Arbitrator, Hardware control.

The following paragraphs give a short description of the various software components, including the three levels detailed above.

2.3.1. System processes

The lowest (and usually invisible) level is composed by the system processes which perform all housekeeping and message-passing tasks, and which mantain the overall AO status. A detailed knowledge of these processes is not required except for debug purposes, since at this level all operations are automatic.

However a list of the fundamental processes follows:

- MsgD-RTBD (message daemon and real-time database): one copy for each workstation is running. Manages message passing between all the other processes, maintains a central variable repository (similar to the telescope Data Dictionary), and manages shared memory buffer for quick transfer of sizeable volumes of diagnostic data. Any kind of problem with the MsgD is usually fatal to the AO system, requiring a complete restart.
- MirrorController: the name is slightly misleading since this is the main hardware-communicator process also for the WFS. Manages communication with the Microgate BCUs onboard the Secondary Mirror and the WFS.
- MasterDiagnostic: manages the diagnostic data stream coming from the AO hardware
- Pinger: keeps an eye on the AO network and signals if something goes offline.

2.3.2. AdSec control processes

The actual AdSec control program is written the IDL language and is managed by the IdlCtrl process. The IdlCtrl allows command-line like access to the IDL control process for debug purposes, but the usual method of controlling the mirror is to use high-level interfaces like the AdSec Arbitrator (see chapters 2.3.4 and chapter 8). Various other processes handle housekeeping details of the mirror hardware, and perform continuous surveillance of the mirror safety. These safety mechanisms can shut down the mirror at any time, either in seeing limited or AO observations, if they detect some unsafe condition in the mirror shape or forces.

2.3.2.1. IDL issues

The use of IDL code requires an IDL license to be always available. Usually this is implemented with an IDL license server, to which the IDL program connects to verify that license validity. If this license server is not working or otherwise unavailable, the IDL program will not start (or stop in a short time if it was running). Failure of the IDL license server will cause the Adaptive Secondary to shut down for safety, and will cause some malfunctions, but not complete shutdown, on the WFS software.

2.3.3. WFS control processes

The WFS system does not have a single main hardware control process like the AdSec, but is instead distributed into a number of processes, each of which takes care of controlling a single hardware device. The coordination is then done in the Wfs Arbitrator process (see next chapter). IDL is used sparingly, but similar license problems exist as in the AdSec software.

2.3.4. Arbitrators

Coordination at the subsystem level (wfs and adsec) is done by the Arbitrator processes. The Adaptive Secondary has its own Arbitrator, as the WFS has. The Arbitrator hides the actual hardware implementation, and instead makes available a few high-level commands which implement the more common AO operations. The Arbitrator GUIs are the main interface to the AO system during engineering operations.

2.3.5. AOS

The AO system is interfaced to the rest of the telescope through the AOS (AO Subsystem). This is a normal TCS subsystem running on the TCS server farm. The AOS exports the AO commands (a dozen or so) needed to perform seeing-limited and AO observations. The AOS GUI is the main interface to the AO system during normal observation.

2.4. Engineering interface levels

In order to setup, calibrate and debug the system, a number of engineering interfaces are provided. Each interface works at a certain level, and is independent of the others. Thus, they can override each other and care must be taken not to give conflicting commands. These conditions are noted where possible in this manual.

As a general rule, an interface for a high-level process (for example one of the Arbitrators) will override commands given from a lower-level interface (for example, the WFS arbitrator GUI).

It is therefore recommended to work with the highest available level. In addition, experience has shown that the complexity of the system is such that, when using the low-level GUIs, many details can be forgotten or overlooked even by experienced operators. Usage of the high-level interface make things easier, because most things are performed by scripts which will ensure that all details are properly taken into account.

3. AOS GUI

The AOS telescope subsystem makes available to the TCS and IIF all the AO commands needed for observation. These commands are intended to be sent from either the TCS command sequencer or the instrument observing block, but they can also be manually issued from the AOSGUI by the telescope operator if needed.

3.1. Starting the GUI

The AOSGUI can be started from any tcs machine. The syntax is:

```
AOSGUI [side]
```

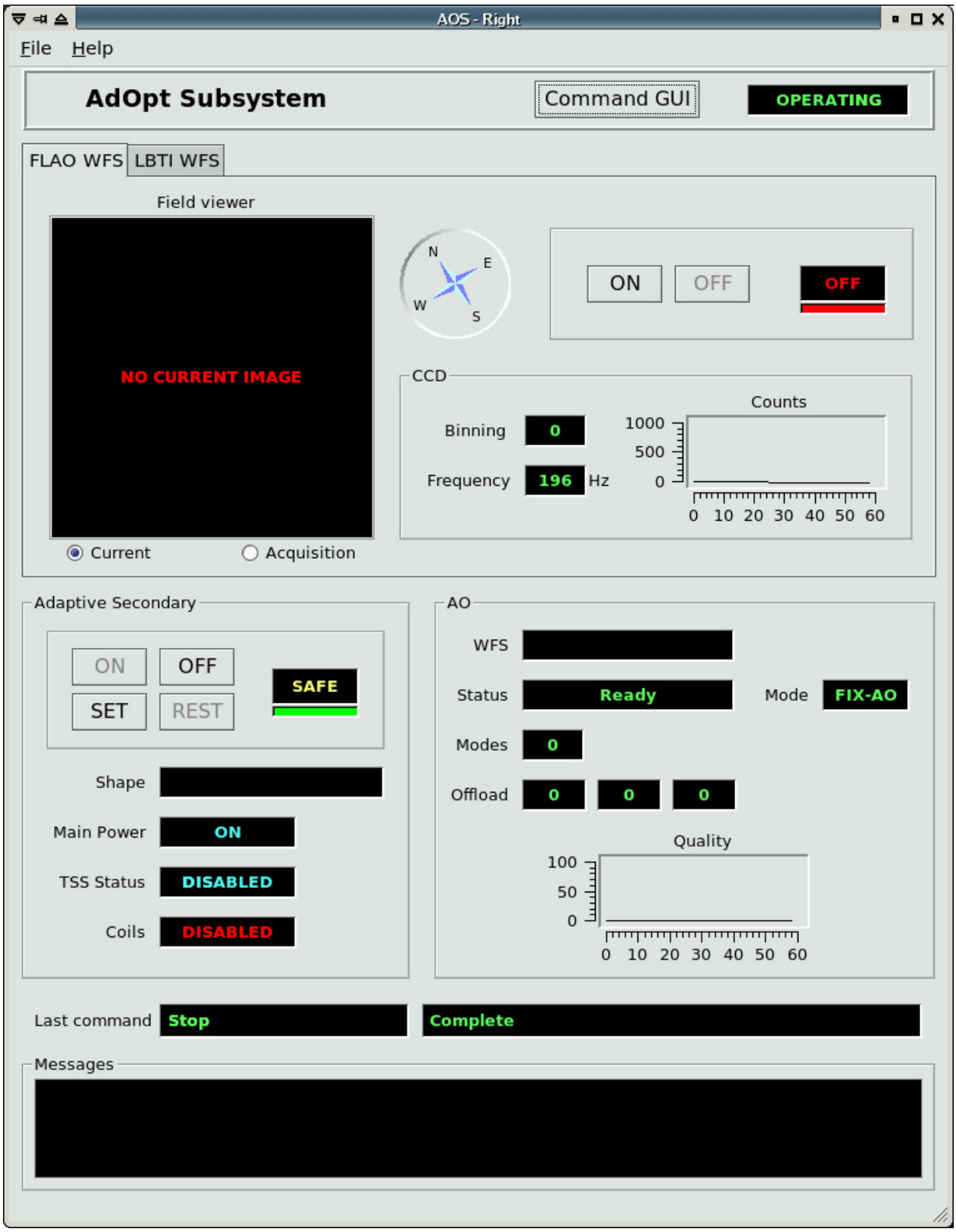
where [side] is either “left” or “right”. In case the side parameter is omitted, the left side is assumed by default.

The two purposes of this GUI are:

- display AO status information
- provide an interface to send commands to the AOS

3.2. Status information display

The main AOS GUI window is a status display with all main AO parameters. The window will become red if the AOS is not running properly.



3.2.1. Connection to the AO system

The connection status can have two values:

- **disconnected**: the AOS is not able to talk with the AO system. This may happen because the Adaptive Secondary software is not running on **adsecdx**;
- **operating**: the AOS is connected to the AO system and can send/receive commands.

3.2.2. Overall AO system status

The AO panel shows high-level parameters about the AO system:

- Mode: can assume several values:
  - FIX-AO: seeing-limited (“fixed”) mode
  - TTM-AO: tip-tilt only correction
  - ACE-AO: full AO correction
- WFS: shows which focal station has been selected
- Status: shows the overall AO state machine status
- Modes: shows how many modes are being corrected
- Offload: shows the magnitude of the current tip, tilt and focus offload
- Quality: …

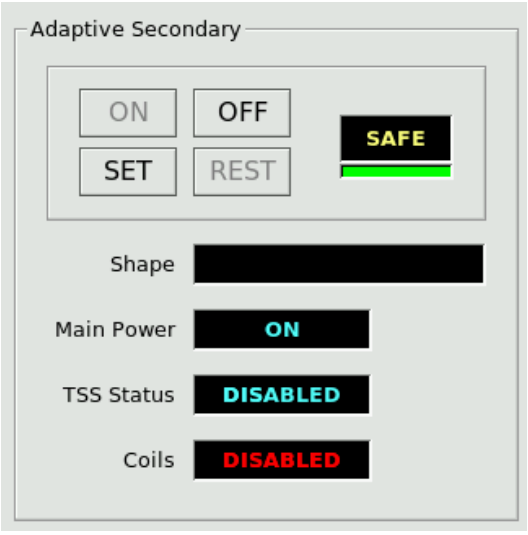
3.2.3. Wfs status and commands

The WFS status window shows the main WFS parameters:

- Field viewer: shows either:
  - The current technical viewer (ccd47) image
  - The technical viewer image used in the last source acquisition

  The compass right to the image shows the direction of the sky North
- CCD: show the current ccd binning, frequency (frame rate) and illumination level in counts in the last 60 seconds. Binning may be zero if the ccd is off.
- On/off: the two buttons ON and OFF control the power to the WFS unit. The ON button, in addition to simply turn on the power, will also perform a setup of the unit, thus taking some minutes to complete.
- Status label: the status label can show either ON or OFF depending on the WFS power status. The colored bar at the bottom represents the software status and will be either green or red, the latter case signaling a problem in the wfs software. There is currently no way of detailing or correcting such a problem from the AOS GUI, and the engineering interface must be used instead (see chapters 2.2 and 10.1 for how to check for software health)

3.2.4. Adaptive Secondary status



The Adaptive Secondary panel shows the following status information:

- Shape: name of the last loaded shape file (usually called a “flat”)
- Main Power: status (ON or OFF) of the three-phase power to the unit. Also controls power to the hexapod
- TSS Status: status of the wind protection system
- Coils: status of the voice coils of the adaptive secondary.

3.2.5. Adaptive Secondary on/off/set/rest

The adaptive secondary status indicator, right of the button group, can have three values:

- OFF: power to the unit is off
- SAFE: unit is powered on and in safe condition (shell rested)
- SET: unit is powered on and shell is set for observation.

Four buttons control the power and shell status of the Adaptive Secondary:

- On: turns on the power to the unit and goes to SAFE status. Takes about a minute to execute
- Set: sets the shell and goes to SET status. Takes about two minutes to execute.
- Rest: rests the shell from the set position and goes back to SAFE status. Takes a few seconds to execute
- Off: turns off the power to the unit and goes to SAFE status. Takes a few seconds to execute.

3.2.5.1. Safety locks

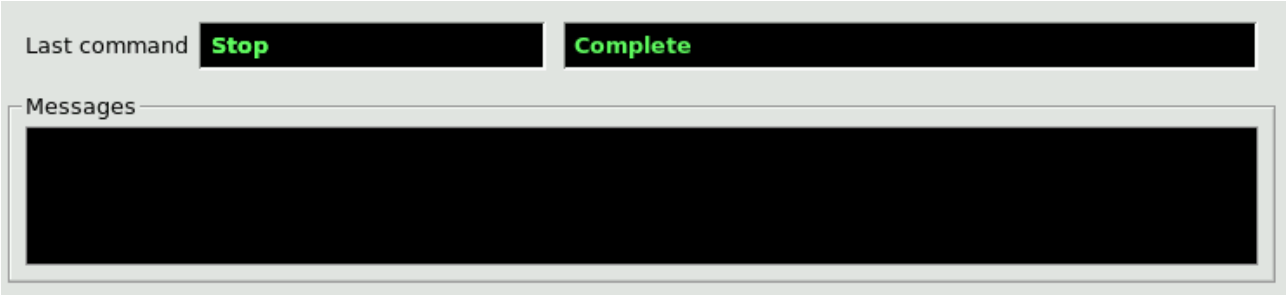
In order to ensure the safety of the Adaptive Secondary, the shell can be set only if the following conditions are met:

- Telescope elevation is 26 degrees or higher
- Swing arm is deployed
- Wind speed is under 8 m/s

If any of these condition is not satisfied, the Set command will be refused. If the shell was already set, it will be rested immediately. The safety feature is fast enough even in the worst case of the telescope slewing down to zero degrees.
If for some reason any of these information do not reach the AO system (for example, the elevation value stops updating), it will be treated as an out-of-range condition and trigger the safety lock.

The colored bar at the bottom of the status indicator represents the software status and will be either green or red, the latter case signaling a problem in the AdSec software. There is currently no way of detailing or correcting such a problem from the AOS GUI, and the engineering interface must be used instead (see chapters 2.2 and 10.1 for how to check for software health)

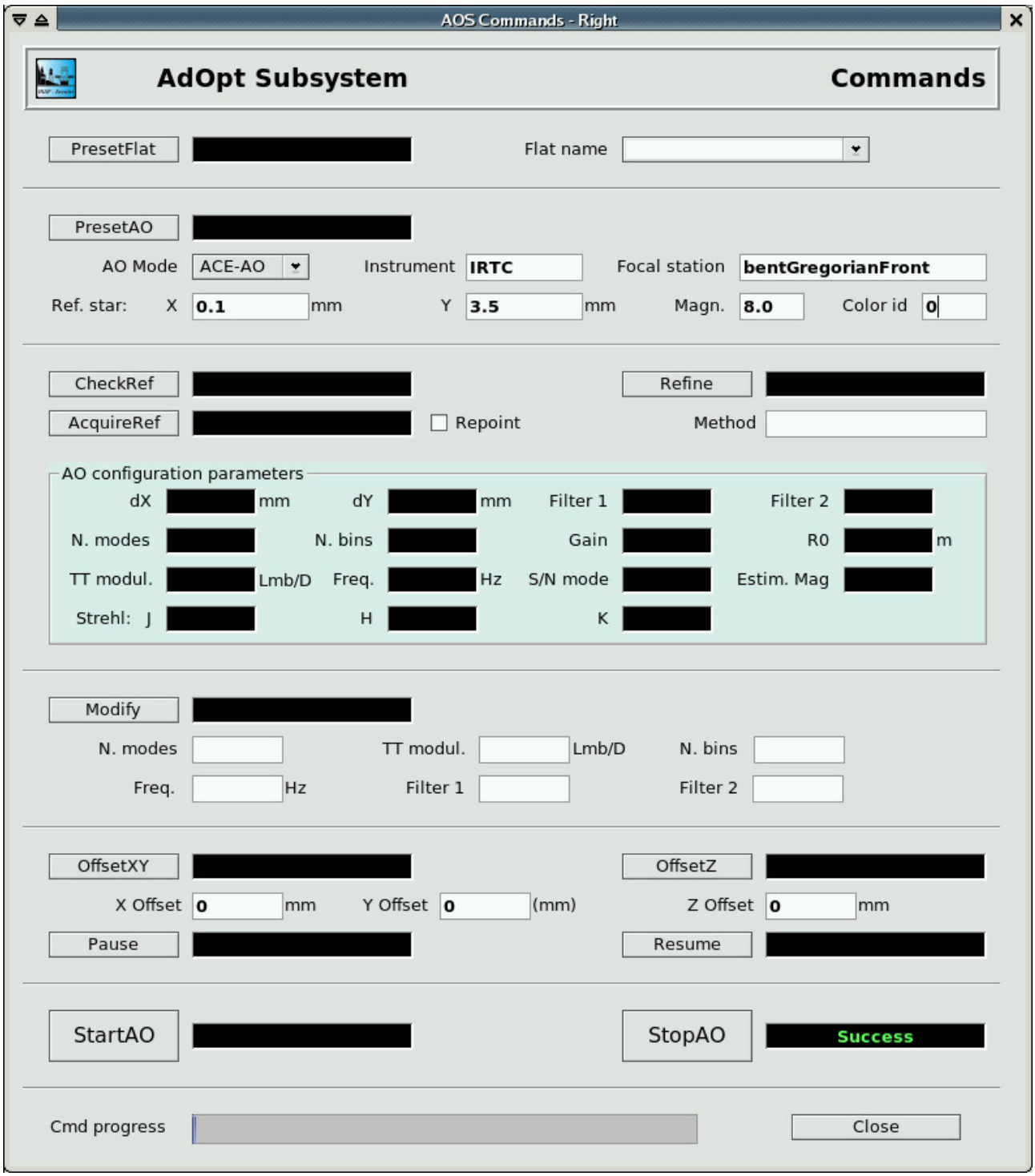
3.2.6. Command execution reporting



When any command is started, the name of the command is reported in the lower part of the GUI, along with the string “Running”. When the command completes correctly, the string “Complete” is reported. If there is any error, the error string is reported instead, and added to the message box below. Additional messages may appear in the message box during command execution, offloads, etc.

3.3. Command GUI

Clicking on the “Command GUI” button at the top of the AOS GUI opens the Command GUI sub-window:



3.3.1. AO commands

Each AO command has its own command button. Many command have parameters which appear next to the corresponding button.
The parameter input boxes serve both as input and as output: when a command is sent by the IIF, the corresponding parameters are written into the input boxes. Alternatively, the operator can input the parameter manually (or modify the ones written before automatically) and send the command manually.
Each command has a status indicator next to it which can have three values:

- Running: the command is currently executed
- Success: the command has completed successfully

- Failure: the command could not complete because of an error. Additional error information is available on the main AOS GUI window.

Error conditions include the refusing of a command because it was not allowed in the current AO status.

The progress bar at the bottom shows the command execution progress with respect to the command timeout. It is not possible at the moment to interrupt a command during execution.

4. Engineering GUIs

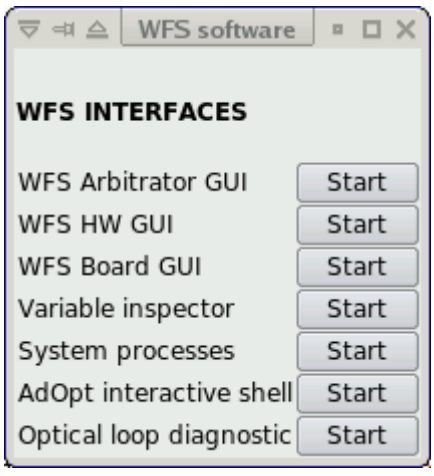
Unlike the AOSGUI, all the AO engineering GUIs must be started from the AO control computers (see chapter 2.1).

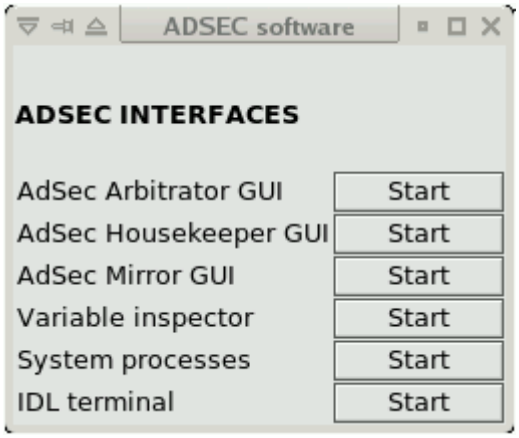
4.1. Starting the Engineering GUIs

A quick-start panel exists on both computers to star the relevant engineering interfaces. This panel is called:

- **wfseng** on wfsdx
- **adsceng** on adseceng

The panels can be started typing their name on any terminal (an X connection must be present). Each panel shows the interfaces available for the system, which can be started clicking the “Start” button next to their name. Unless otherwise noted, multiple copies of the interfaces can be started without limitations.





WFS and Adaptive Secondary quick-start panels.

Alternatively, all interfaces can be started typing their name on a terminal. The correct program name is noted in the description of the interface, and is resumed here:

- WfsControl (on wfsdx) starts the Wfs Arbitrator GUI

- AdSecControl (on adsecdx) starts the AdSec Arbitrator GUI
- AdOptControl (on adsecdx) starts the AO Arbitrator GUI
- wfshw.py (on wfsdx) starts the Wfs Hardware GUI
- BoardGui (on wfsdx) starts the board status display
- AdSecMirGui (on adsecdx) starts the mirror status display
- ccd_viewer.py (on wfsdx) starts the ccd viewer
- vartool_AO.py (on either computer) starts the RTDB interface (viewer/editor)

These GUIs are described in detail in the following chapters.

5. Wfs board status GUI

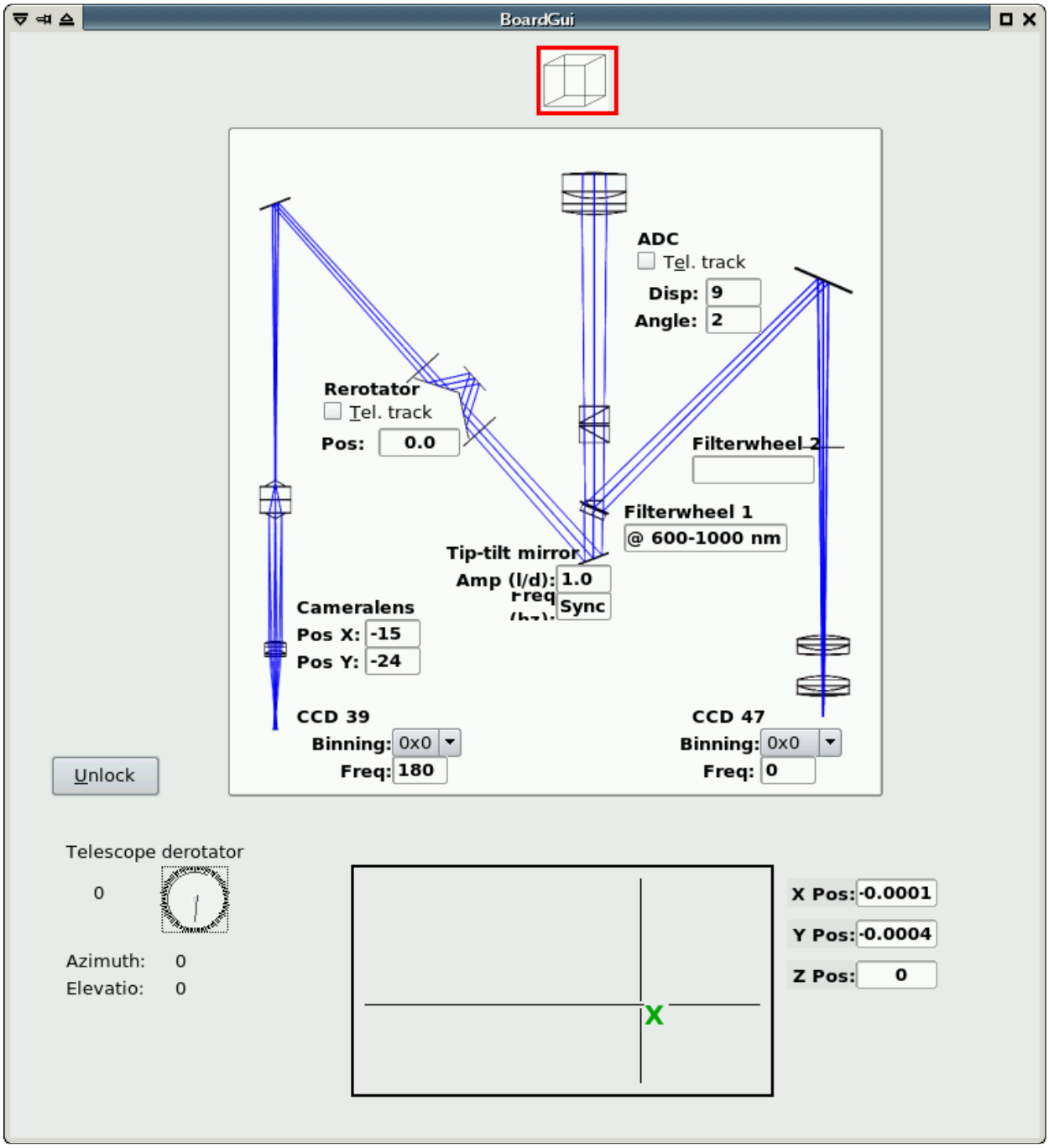
The Wfs board GUI shows the status of the various WFS devices.

5.1. Starting the GUI

The WFS Board Status GUI can be started from the wfseng panel (see []), or from a terminal on wfsdx with the following command:

```
BoardGui
```

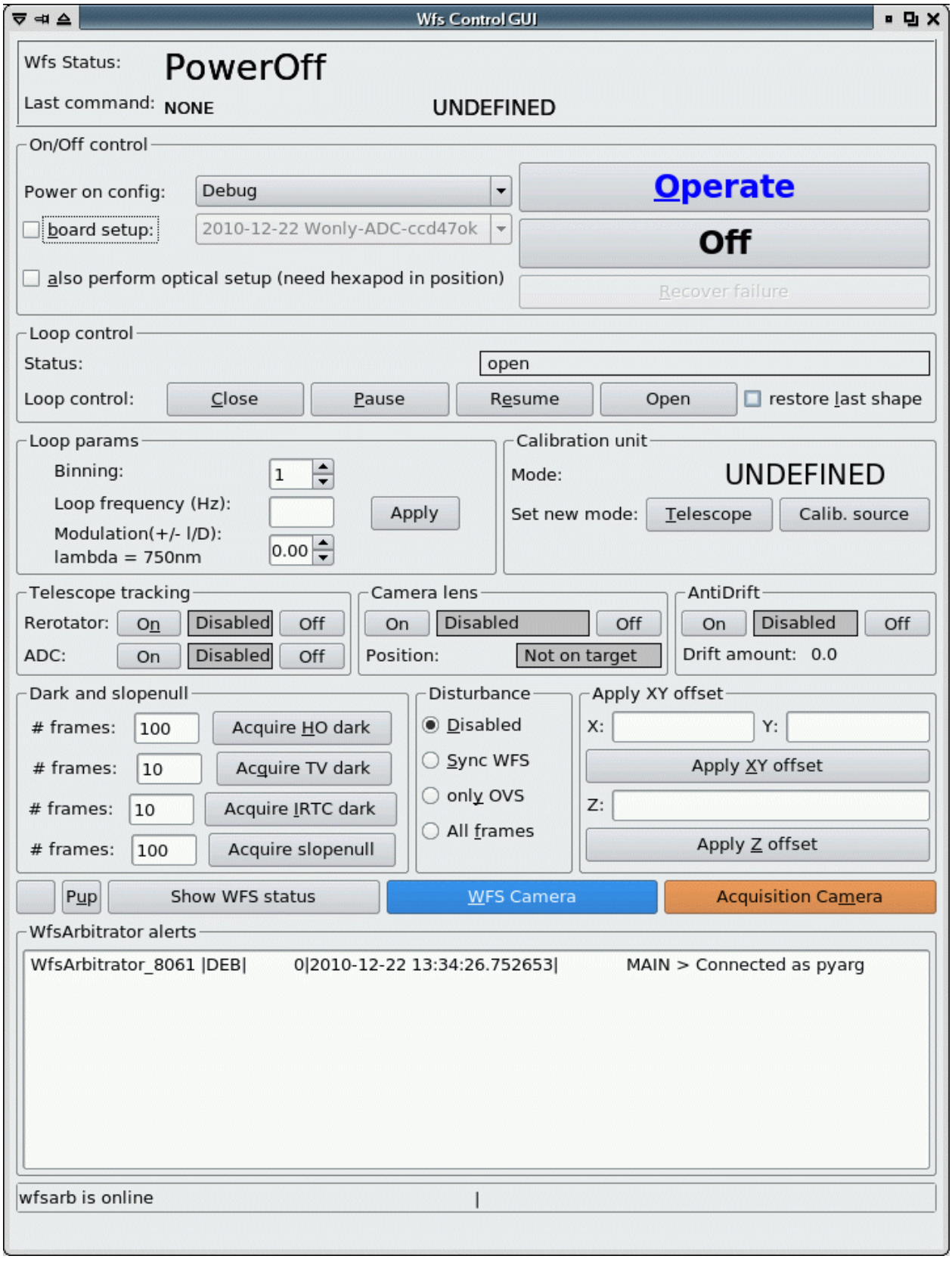
5.2. GUI description



The GUI is a read-only display of the position of the various WFS devices. For each device, only the most relevant information is shown (e.g. filterwheel position, ccd binning and integration frequency, etc). The Cube icon at the top moves to show the actual physical position of the cube beam splitter, and has a red outline when it is in the reference source beam path. The rectangular display at the bottom is a map of the focal plane FoV available to the WFS stages, and the current position is shown with a green ‘X’. When the stages are moving, a red circle is also drawn to indicate the target position. On the lower left, a resume of telescope position and rotation is shown.

6. Wfs Arbitrator GUI

The WFS arbitrator GUI is used to send commands to the WFS Arbitrator, which provides high-level commands to manage the WFS like startup/shutdown procedures, wfs configuration, dark frame acquisition, etc. Commands are implemented in the WFS state machine as described in CAN687f400.



6.1. Starting the GUI

The WFS Arbitrator GUI can be started from the wfseng panel (see []), or from a terminal on wfsdx with the following command:

```
WfsControl
```

6.2. GUI description

All GUI actions are implemented as one of the arbitrator commands described in CAN687f400. This has several consequences:

- only one command can be executed at a time. To send another command, one must wait for the previous command completion. The GUI will prevent the operator from sending multiple commands, graying out all buttons while a command is executing
- Not all commands are available at all times, depending on the state machine status. The GUI will either gray out buttons corresponding to unavailable commands, or display an error box if the command could not be received.
- Commands parameters are validated before execution. If an out-of-range or otherwise invalid parameter is entered, a “Validation failed” error will be displayed.

6.2.1. Status indicators

At the top of the GUI, the following status information is shown:

- Wfs Status: tells the operator in which state the WFS is at the moment, and therefore which commands are available. Also, in the GUI commands which are not available at the moment are grayed out.
  Note: if the Wfs Arbitrator program is not running, or not correctly responding, the Status will be “offline” and no commands will be executed.
- Last executed commands: shows the name of the last command executed by the WFS arbitrator
- Command execution status: shows whether a command is executing at the moment, or the result of the last command as described in []. When a command is executing, all GUI buttons are inactive.

6.2.2. Startup/Shutdown commands

Starting up the WFS requires turning on the various wfs devices in the correct order. This is managed by the WFS arbitrator command "Operate", that takes two arguments: a list of devices to turn on (the "configuration") and optionally a command file to setup each harware device (the "board setup file"). The configuration files are pre-determined by the programmer and are not generally modifiable by the operator, while the setup files can be found in the WFS calibration directory as described in [] and may be modified as needed. For correct operation from the AOS, at least one setup file with the same name as the current istrument (e.g. "IRTC") must be present.

To startup the WFS:

- select the configuration in the drop-down box
- (optionally) select the setup file in the drow-down box, checking the "apply setup" checkbox
- press the "Operate" button.

Execution of the Operate command will often take several minutes.

To turn off the WFS:

- press the "Off" button

Execution of the "Off" commands takes a few seconds.

The startup sequence turns on and prepares for operation all devices in the configuration list. Movements are homed, CCDs are configured to default values, etc.

6.2.3. AO parameters

The "parameters" section is used to configure the main AO-relevant parameters: ccd frame rate, binning and tip-tilt modulation. These parameters are applied together.

- enter the desired ccd frame rate in the "frame rate" input box. Frame rate is in Hz and can range from 100 to 1000.
- enter the desired binning in the "binning" input box. Available binnings are 1,2,3 and 4.
- enter the desired tip-tilt modulation in the "modulation" input box. This value will be the modulation radius in lambda/D. Modulation radius can range from 0 to 6 lambda/D.
- Press the "Apply" button.

The WfsArbitrator will apply the new parameters and, if the ccd configuration is changed, take a new dark frame using the filter wheel #1 as described in the later chapter []. Execution of the command will be either very short (less than 1 second, if the ccd parameters are unchanged), or will take 20-30 seconds.

If the ccd or tip-tilt configuration is changed using the lower-level hardware GUI, the Wfs Arbitrator may not realize this. To avoid problems, after using the hardware GUI, always reapply a different value from the last command, to force the Wfs Arbitrator to reconfigure.

Note about the modulation: the modulation parameter is converted to tip-tilt voltage commands using a lookup-table, found in [], based on the ccd frame rate. Not all modulation values are available at all ccd frame rates, for example at a frame rate of 1000 hz the maximum modulation radius is 3 lambda/D. In general, higher frame rates will prevent to use the bigger modulation settings, but a precise specification cannot be given since it depends on the details of the lookup table. The GUI will give an error to the user when an incorrect modulation is entered.

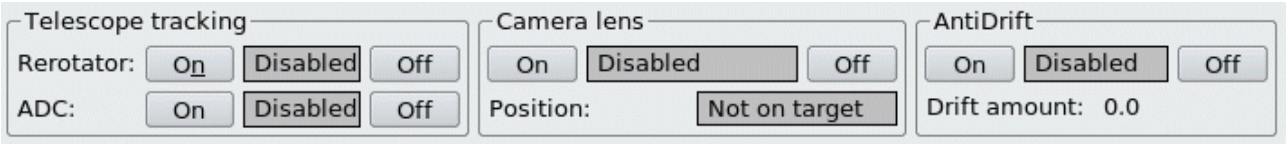
During the setup, the ccd display may fluctuate wildly while the background is taken, and even stop for a minute or so if the ccd binning is changed. This is normal and the display is not to be considered valid until the command has completed.

6.2.4. AO loop open/close/pause

Four buttons manage the AO loop status. Because of the need of coordination between the two systems, the Close and Open buttons will send commands to both the WFS and Adaptive Secondary.

- Close: start sending slopes to the Adaptive Secondary. The secondary must have been previously configured with the correct input port, reconstruction matrix, etc. The button first sends a command to the Adaptive Secondary to configure it with the expected frame rate, and then closes the loop on the WFS.
  This button will also configure the Adaptive Secondary with the disturbance setting, as described later in []
- Pause: suspends the loop stopping the slopes. The secondary mirror remains freezed in shape it had during the last loop iteration. A paused loop can be either resumed or stopped.
- Resume: resumes a previously paused loop. Before resuming, the illumination level on the ccd39 is checked to verify that it similar to the one present when the loop is paused, and the resume command may be refused if the illumination level is too low.
- Open: opens the loop stopping the flow of slopes to the Adaptive Secondary. After that, sends a command to the Adaptive Secondary to inform it that no more slopes are expected. If the “restore last shape” box is checked, the secondary mirror will re-apply the last shape it loaded before closing the loop. Otherwise, the mirror will remain in the position it had during the last loop iteration.

6.2.5. Rotator tracking



When enabled, the Wfs arbitrator will move the pupil rerotator to follow the telescope derotator and keep stable the pupil image on the ccd39. The tracking is applied once per second and has a total delay of 1-2 seconds, which gives an error <0.1 degrees in all observing conditions up to 87° degrees of elevation. When first activated, or when the telescope is slewing, the tracking may take some time to reach the correct position.

The pupil rerotator position is computed with the following formula:

rerotPos = derotPos/2.0 * rerotSign + rerotOffset + trackingOffset

The <derotPos> values comes from the AOS and is the DD derotator position. The <rerotSign> and <rerotOffset> values are read from the Wfs Arbitrator configuration file, using the keywords "RotatorSignBin1", "RotatorOffsetBin1" and similar for the other binnings. If the Sign keyword is missing, a sign of -1 is assumed.
The <trackingOffset> parameter is read each time from the RTDB (see []) and is intended to allow small corrections by the operator.

This tracking is always activated by the AOS when starting an observation.

6.2.6. Camera lens tracking

When enabled, the Wfs arbitrator will measure the current pupil position using feedback from the "pupilcheck" process, and move the camera lens to keep the pupil centers in a predefined position. The status indicator has three values:

- disabled: tracking loop is off and camera lens is not moving
- enabled (not on target): tracking loop is on, but the pupils are off the predefined position, and the camera lens will be moved to recenter them;
- enabled (on traget): tracking loop is on and the pupils are on the predefined position within 0.1 pixels; the camera lens will be left where it is.

Regardless of the "enabled" status, camera lens corrections are only applied during closed loop. This happens because, in open loop, the pupils are too aberrated to have an accurate measure of their position. A consequence of this is that, when the loop is closed, the indicator will temporarily go to "not on target", because the pupil position is only computed every four seconds, and it will take one or two iterations before the actual pupil position is reflected in the target indicator. For this reason, the first camera lens loop iteration is skipped by the WfsArbitrator after closing the loop.

This tracking is always activated by the AOS when closing a loop.

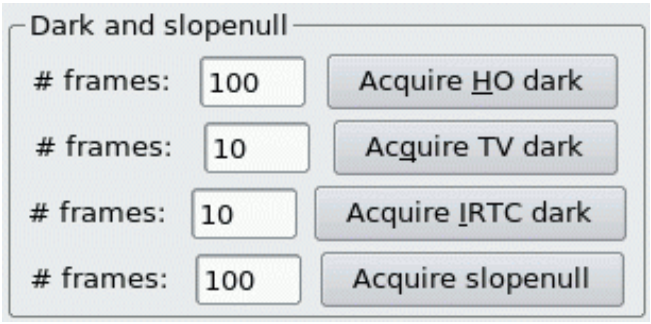
6.2.7. ADC tracking

The ADC tracking will follow the telescope elevation and field orientation moving the ADC wheels to have the correct atmospheric dispersion correction. Operation is similar to the Rotator tracking, except that instead of using a formula, the ADC position is computed using a lookup table found in [] based on the telescope elevation.

6.2.8. Anti drift

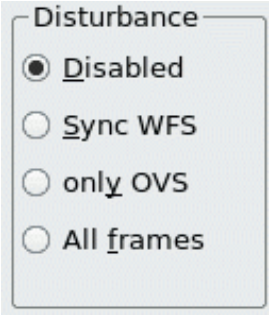
The antidrift loop tries to correct for temperature-depenent drifts of the ccd39 background levels. It will do so cheking the current background level outside the pupils (in the ccd corners), and adjusting the current background frame so that the background-substracted levels are zero. This is done independently on the four ccd quadrants.
Since the BCU can lockup if the background frame is overwritten while the loop is closed, an antidrift correction will temporarily stop the ccd integration, overwrite the background frame, and restart the ccd integration. Because of the slow serial connection to the ccd, this will result in pause of about 0.1 seconds. The antidrift correction will be applied at a maximum rate of 1 Hz, and will slow down as the ccd temperature stabilizes.

6.2.9. Dark frame and slopenull acquisition



These buttons allow the operator to take a dark frame for either ccd, or a slope null frame. To take a dark frame, enter the number of frames to average in the input box next to the button.
When the button is pressed, the filter wheel #1 is rotated to the “silver mirror” position (for the ccd39 background), or to the “empty” position (for the ccd47 background). For the other two buttons, no rotation occurs. After that, the ccd bias levels are equalized (see hardware GUI []) the specified number of frames are integrated, averaged, saved on disk with a tracking number, and sent to the correct BCU as the new background. The ccd display may fluctuate wildly during integration. The ccd39 background acquisition is a sub-procedure of the AO paramter apply command (see []).

6.2.10. Disturbance



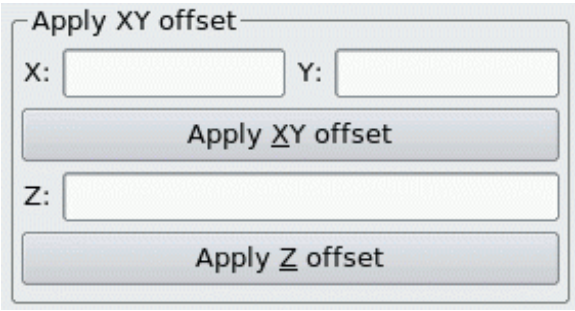
Disturbance application is used to manage the digital disturbance feature of the adaptive secondary. The disturbance commands are loaded on the secondary BCUs, but their application is commanded by the WFS with a bitmask sent together with the slopes. Therefore, to change the disturbance setting, the system must be in closed loop. There are four possible settings:

- Disabled: no disturbance is applied
- Sync WFS: one disturbance frame is applied at each optical loop iterations
- Only OVS: disturbance frames are only applied on oversampled frames (see [])
- All frames: disturbance frames are applied on both optical loop and oversampled frames.

The last setting allows the operator to have a disturbance “running” at a multiple of the optical loop speed, for example the optical loop can be at 200 Hz while the disturbance is applied at 800 Hz. Since oversampled frames are applied at a maximum rate of 890 Hz, this feature is only useful for an optical loop speed up to 445 Hz. Over this speed, the disturbance can only be synchronous with the AO loop.

The disturbance setting can be changed at any time, but will only be applied when in closed loop. If changed in open loop, it will applied at the first loop iteration.

6.2.11. Offsets



The WFS Arbitrator can execute XY and Z offsets moving the stages which support the optical board. All offsets are specified in millimeters on the focal plane (for the XY offset) or along the optical axis (Z). Offsets commands are relative to the current position.

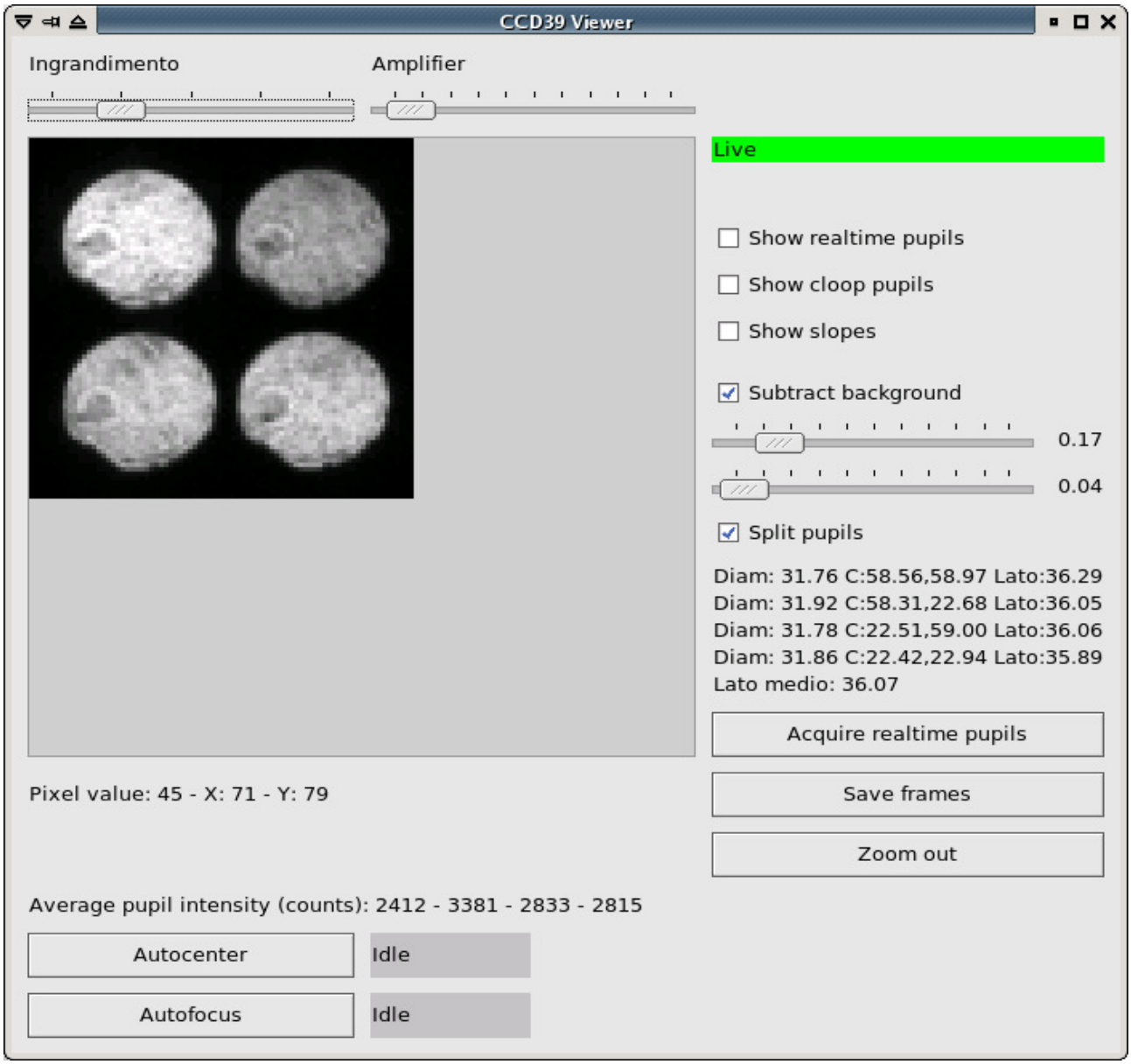
Offsets can be executed regardless of the loop status, but care must taken not to exceed the adaptive secondary tilt or focus range if the loop is closed. By rule of thumb this means about 0.5 millimeters in either X or Y, and 5 millimeters in Z. If the low-order offload is active, the adaptive secondary will offload these tilts to the hexapod in a few seconds, and the offset can be repeated (this coordination is done automatically by the AOArbitrator when long closed loop offsets are requested by the AOS).

XYZ stages are normally braked. The brake is opened when an offset is requested, and closed again when it is completed. This can cause very small jitters (in the order or microns) in the actual stage position. Multiple offests command are applied using the target position, and not the actual stage position, so that these errors are not accumulated.

6.2.12. WFS displays

From the WFS Arbitrator GUI, the two ccd viewers can be started pressing the “WFS Camera” and “Acquisition camera” buttons (for ccd39 and ccd47 respectively). The display program is the same for all ccds, with a few additional features for the ccd39

6.2.13. CCD display



- live indicator: the indicator can be either “Live” (green) or “Not live” (red). “Not live” only means that the display is not receiving frames, and may result from a variety of causes. For example, a “live off” display is normal while the ccd is changing binning.
- image: the image is always shown at a rate of 20 Hz (or slower if the ccd is going slower), to avoid using excessive amount of CPU. This means that, at high AO loop frame rates, the image is heavily decimated. Saturated pixels are shown in red, to avoid confusion with pixels which are white due to lookup table effects.
  The ccd39 image is rotated 90° from the raw one to correct for ccd orientation.
- Pupil positions (ccd39 only): radius, center X and Y position, and interpupil distance are shown for each pupil. This information is refreshed every few seconds.
- Pixel value and position: when moving the mouse over the image, the pixel value of the pixel under the mouse, and its X and Y positions, are shown. The zero position is in the upper-left corner.
- Intensity value (ccd39 only): shows the total intensity value, averaged over the four pupils, and rescaled to be in photons/subaperture/frame. This value is a running mean over the last 100 displayed frames (5 seconds), so can be incorrect in case of rapid fluctuations or while the background frame is being acquired. This value is also incorrect the background frame is missing or outdated.
- Slope rms plot: the plot is continously updated wi the current slope rms and shows the last 20-30 seconds of data.
- Stages on/off: this is a simple indicator to remind the operator that the stage motors are enabled, and may compromise the loop injecting electrical noise. This can be an issue when using the hardware GUI, but is automatically managed when using the AOS or Wfs arbitrator GUI.

6.2.13.1. Controls

- magnification slider: changes the ccd display magnification
- amplifier slider: changes the display lookup table. Higher (towards the right) slider settings cause the lookup table to shift towards low value pixels, while higher value pixels are saturated to white.
- “show realtime pupils” checkbox: when checked, four red circles are drawn on the image to show the current pupil position and diameter as calculated by the “pupilcheck” process.
- “show cloop pupils” checkbox: when checked, four red areas on the ccd are highlighted in red to show the pixels selected for the AO closed loop. The illuminated pupils must coincide with these areas
- “show slopes” checkbox: when checked, the ccd image is replaced with a slope map which show the current slopes as calculated by the BCU. Two maps, for X and Y slopes, are shown. The pixel value indicator shows the value of the slopes under the mouse cursor position.
- “Save frames” button: opens an interface to save frames from the ccd, described in [].
- “Autocenter”/”Autofocus” buttons: start the automatic autocenter/focus scripts. These scripts use the current ccd image as feedback and move the XY or Z stage to center the light on the four pupils, or bring them into focus. Green arrows are drawn over the ccd image to show the stage movement. The scripts will exit when a correct position is reached, signaled by a small green circle display on the ccd image. The “Stop autocenter/focus” button can be used to stop the scripts manually.

7. WFS Hardware GUI

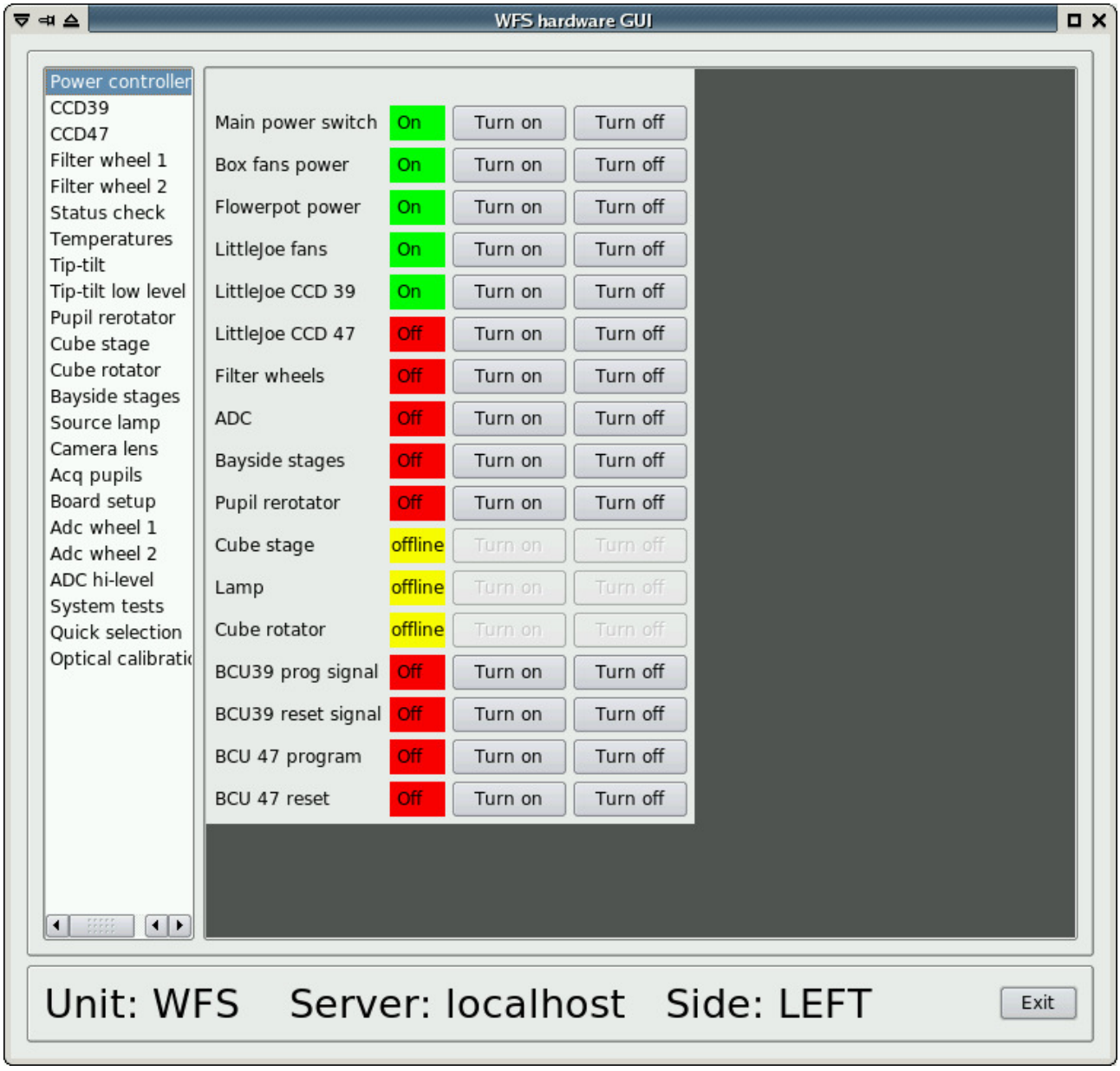
The WFS hardware GUI allows low-level control of the wfs devices.
Warning: if the higher-level Arbitrators and AOS software are running, their command can conflict with those sent by the operator. Always use the higher possible GUI level, unless a specific reason exists.

7.1. Starting the GUI

The WFS Hardware GUI can be started from the wfseng interface or started from a terminal on wfsdx with the following command:

```
wfshw.py
```

7.2. GUI description



The Hardware GUI has a list of devices on the left side. Clicking on a device name will display the corresponding window on the right side. At the bottom, three displays help identify which WFS is being operated on:

- Unit: identifies the WFS by name (may be W1, W2, etc.)
- Server: identifies the computer operating the WFS. Generally "localhost", meaning that it is the same computer where the GUI is running, but can be different as the GUI can run somewhere else if properly configured.
- Side: shows the telescope side (either "RIGHT" or "LEFT").

7.2.1. Power controller

(pictured above)
This panel shows all the on/off switches in the wfs system. The switches can be controlled by different hardware devices, and so some or all of them may be unreachable if the controlling device is powered off. The GUI shows this condition graying out the on/off buttons, and marking "offline" their status.
A mimimum set of devices is kept always on, as long as the input 110VAC line is active. These are:

- the MiniMC fiber/copper Ethernet converter
- the internal 5-port Ethernet switch
- the left-box TS8 Ethernet/serial converte
- the PIC-based power board

Correspondingly, a few (on W#1) or most (on W#2) power switches are always available because they are located on the PIC-based power board.

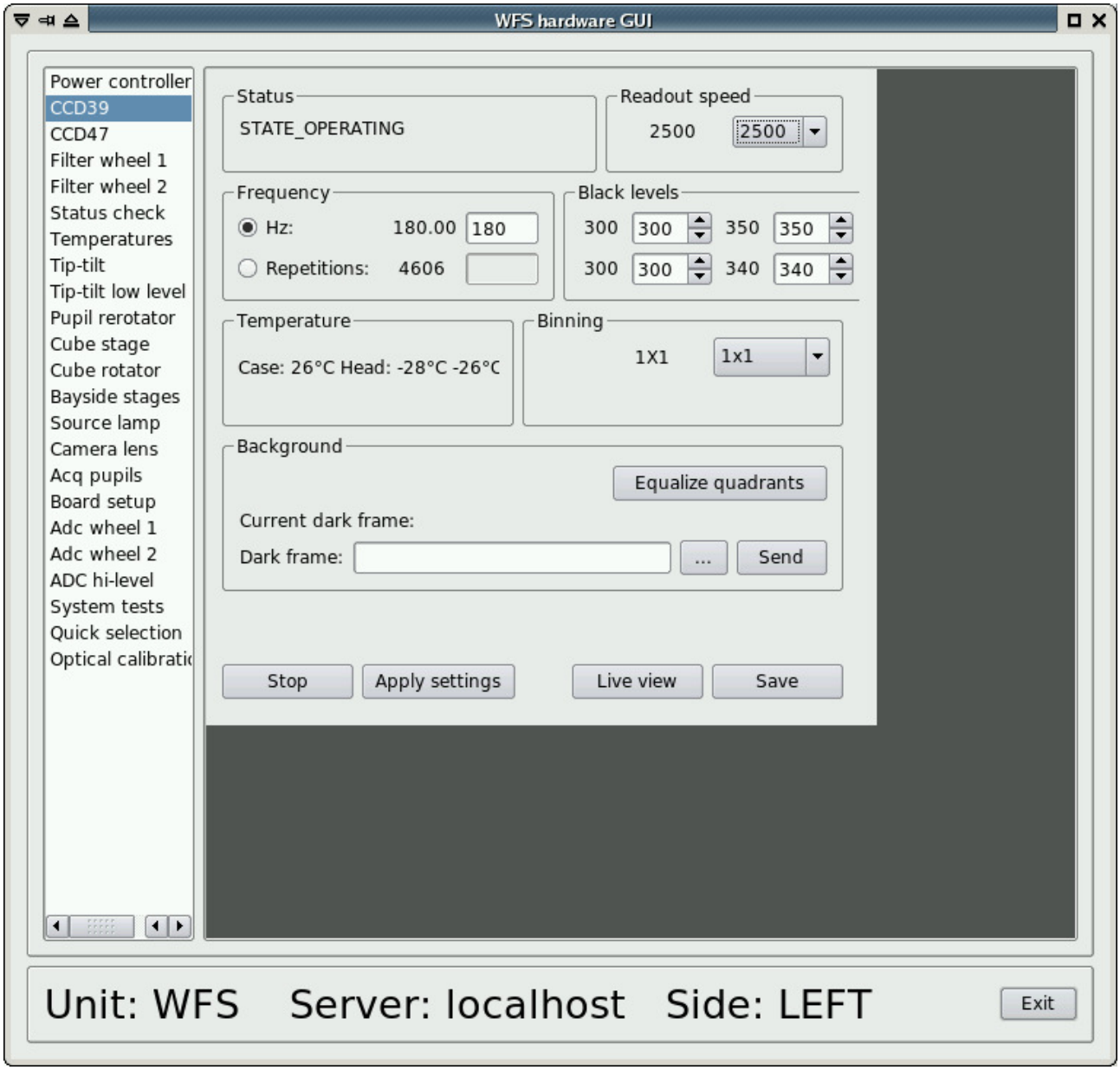
A list of the switches and what they do follows:

- Main power switch: controls the internal power supply for CCDs and BCUs.
- Box fans: controls the fans on the electronics boxes covers.
- Flowerpot: controls the flowerpot board, which in turn will allow control of the cube and reference lamp.
- Little joe fans: controls the fans on the little joe ccd controllers.
- Ccd39 and 47: controls the two little joe controllers.
- Filter wheels: controls the two filterwheels. The wheels will move to the home position upon starting.
- ADC: controls the two adc wheel motors. The wheels will move to the home position upon starting.
- Bayside stages: on W#1, controls the 110 V power supply for the stages motor. The stages will not move and will need to be homed manually from their panel (see [])
- Pupil rerotator: controls the pupil rerotator. The movement will move to the home position upon starting.
- Cube stage and rotator: controls the two motor controlling the cube position and rotation. Both movements will move to the home position when starting.
- Lamp: controls the reference lamp on (an additional intensity control is available separately)

Four more switches control the "reset" and "program" lines of the two BCUs. The "reset" lines will hold the BCU in reset status for as long as they are on. The "program" lines are sampled by the BCU when starting (or when the "reset" line is turned down) to select one of two internal memory

banks from which to load their program. These four switches are not normally needed for operation, unless a hardware problem on the BCU arises.

7.2.2. CCD39



The ccd39 panel shows the current ccd39 status and parameters, and allows the operator to change those parameters.

7.2.2.1. Status

Can have the following values:

- NOCONNECTION: ccd controller is either turned off or not reacheable over the network
- CONFIGURING: configuration parameters are being loaded through the serial line
- READY: ccd controller is ready, but not integrating frames.

- OPERATING: ccd is integrating frames

7.2.2.2. Controls

When first starting, only the binning drop-down box is available, because the ccd must be configured with one of the available binning. Selecting a binning from the drop-down box causes a configuration program to start, running in a separate xterm to display debug information. While this xterm is open, the hardware GUI is freezed. Binning configuration takes about 30 seconds.
Once a binning is configured, the other parameters are set to some default value and can be adjusted by the operator.

Parameters are set from the panel input boxes and then applied together when the "apply settings" button is pressed.

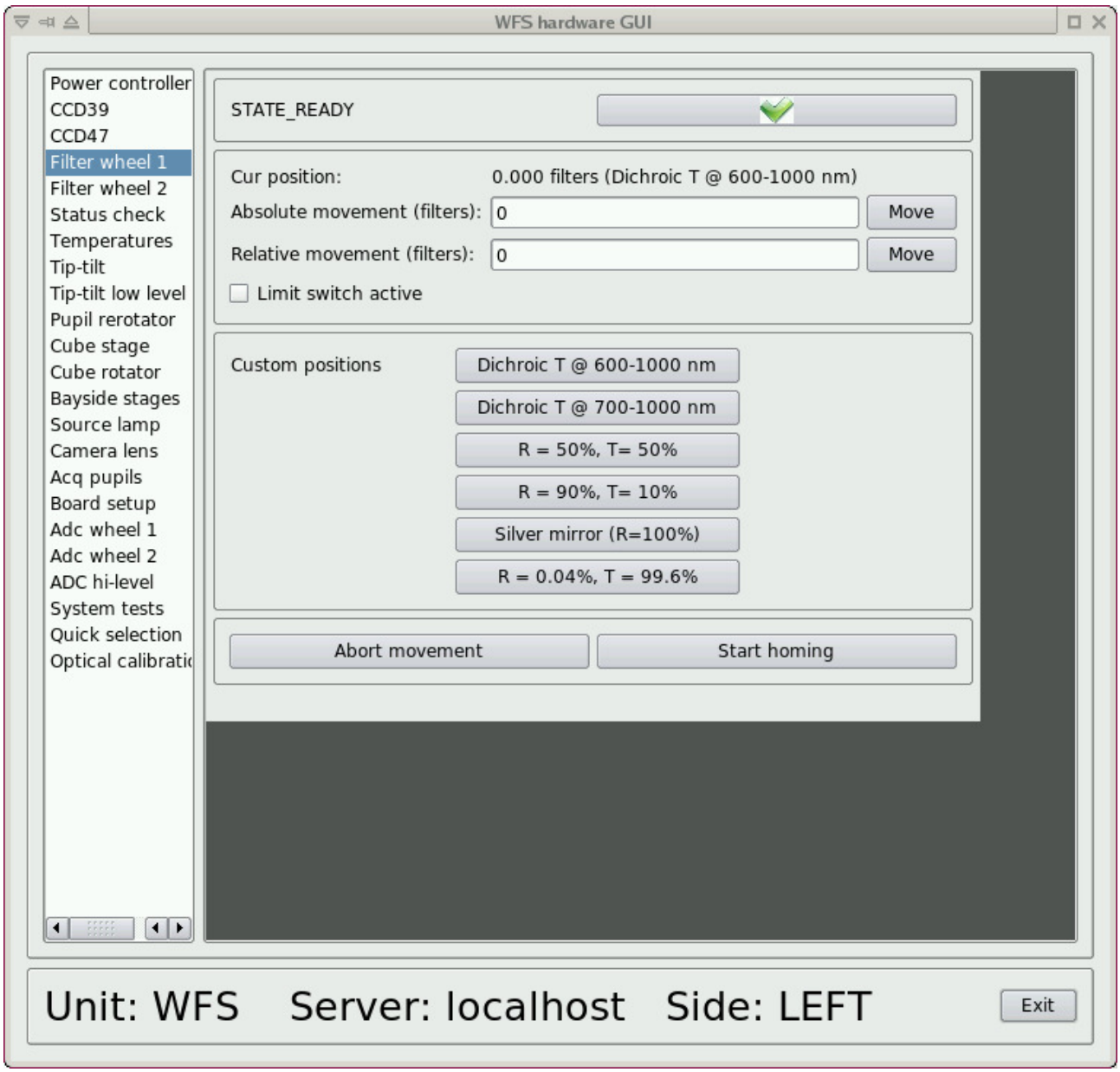
- **Frequency/repetitions**: either a frequency (frame rate) or "repetitions" number can be entered. The little joe controller cannot integrate a specified frame rate, but has instead a delay for integration with a minimum time defined by the frame readout time, plus a delay computed as the number of "repetitions" multiplied by a base delay interval (variable for each readout speed). When a frequency value is entered, the control program will approximate it with the closes possible value as allowed by the current delay interval. Typical errors range from a fraction of Hz at low speeds up to 1 or 2 Hz at high speeds (1000 hz or more). The maximum possible repetition number is 65535.
  SAFETY WARNING: the tip-tilt mirror is often hardware-locked to the ccd frame rate (see tip-tilt section). The ccd39 has the capability of going much faster than 1 Khz, thereby entering the tip-tilt resonating frequency range and possibly breaking it. For this reason, the GUI will refuse frequency settings over 600 Hz, and the Wfs Arbitrator GUI must be used (the Wfs Arbitrator will perform the necessary safety checks and refuse unsafe settings). However, the repetition value has no similar checks and using it, especially at binnings from 2 up, is dangerous as it can result in frequencies of 3Khz or more. Always use the frequency setting and not the repetitions settings, unless you know what you are doing.
- **Black levels:** the four (ccd39) or two (ccd47) quadrants each have their independent bias level, called "black level". A higher black level corresponds to a lower pixel value for the same illumination level. A black level "unit" corresponds to 20 counts, or about 10 photons.
- **"Equalize quadrants" button**: starts an automatic procedure to adjust the black levels so that every ccd quadrant has an average level of 200 counts (prior to background subtraction). The procedure takes a few seconds to converge. This button should be used when ambient light, articificial illumination and internal wfs lamp are off, otherwise an incorrect level will be reached. In addition, if the artificial illumination is flickering at 120 Hz, the procedure will not converge since the ccd is seeing a variable amount of light, and it will giveup after a while.
- **Temperature display**: three temperatures are given: "case" is a sensor inside the electronics case of the little joe controller. "Head" are two sensors on the ccd chip itself. The first sensor has a lower limit of 19°C, the other two of -40 °C. Hence, during winter observation they are often pegged to the lower limit.
- **Background:** shows the current dark frame loaded on the BCU, and allows the operator to select another file and send it to the BCU.
- **"Start"/"Stop" button**: stars and stops ccd integration. Integration is started by default after a binning is applied.
- **"Live view" button**: starts the ccd viewer described in []
- **"Save" button:** starts an interface to save frames from the ccd, described in [].

7.2.3. CCD47

This window is identical to the one for the ccd39, except for a few differences:

- the ccd47 has only 2 quadrants, so only 2 black levels are available
- available binings are 1,2,4 and 16.
- frame rates are much lower and the repetition setting changes little. Frame rate is essentially fixed by the chosen binning.

7.2.4. Filter wheel #1



The filterwheel panel shows the current filter wheel status and position. The position is not valid until the motor has been turned on and homed, and the GUI shows this graying out the position display.

The movement is in “filters” unit (1.0 correspond to the angle between two filters) and can be either absolute or relative:

- absolute movement is an offset from the home position.
- Relative movement is an offset from the current position

Position can be decimal, for example a movement to 0.5 will position the wheel halfway between two filters.

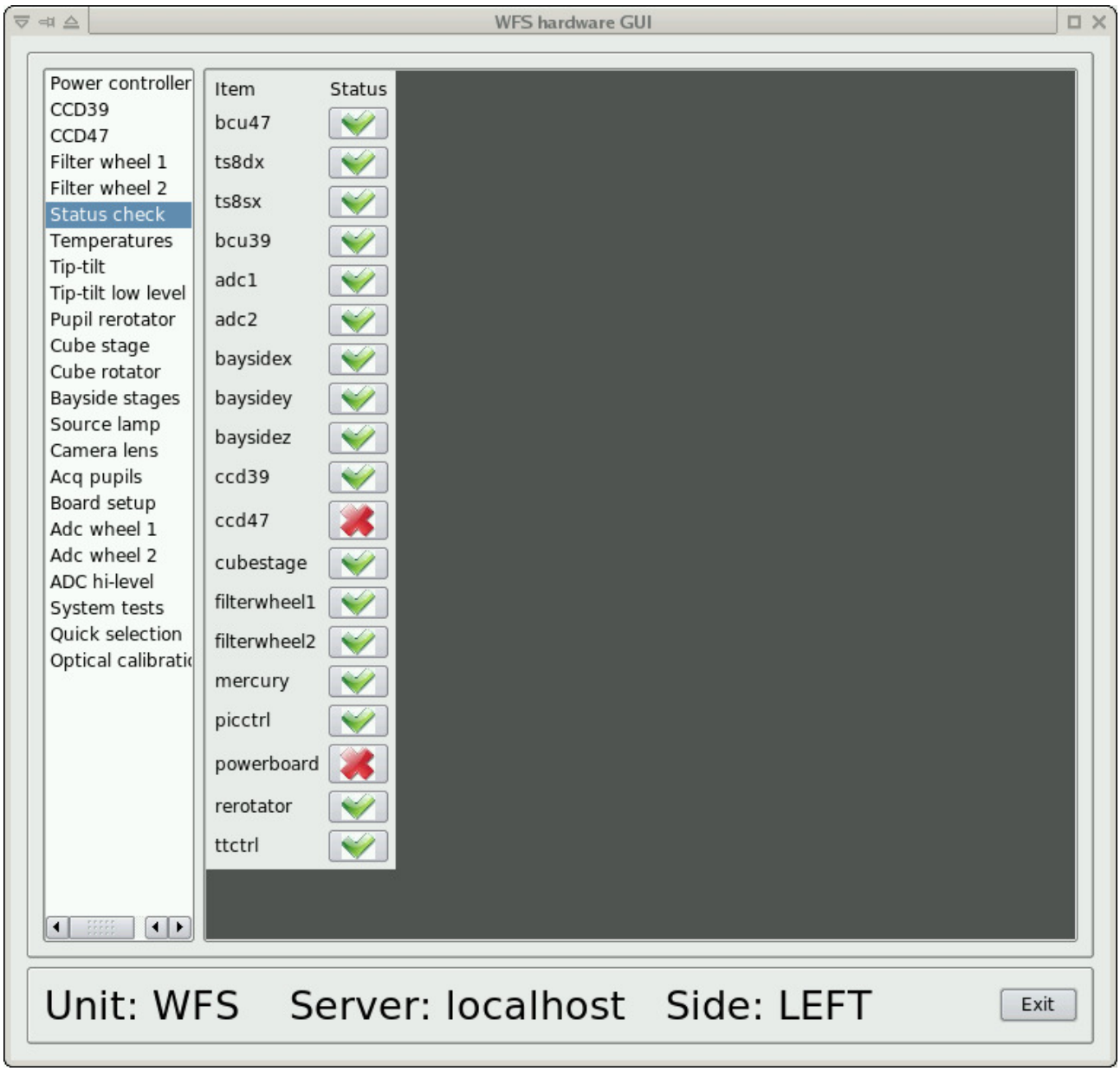
The custom position buttons are dynamic and are built from the custom positions defined in the filter wheel's configuration file. Clicking on those buttons will immediately move the filter wheel to the custom position. When the filterwheel is on a position defined as custom position, the name will be displayed along the numeric position (as in the screenshot above).

- “Abort movement” will stop any current movement of the filterwheel
- “Start homing” will start the home position search procedure. This is automatically triggered when the filterwheel is powered up.

7.2.5. Filter wheel #2

This panel is functionally identical to the Filter wheel #1 panel.

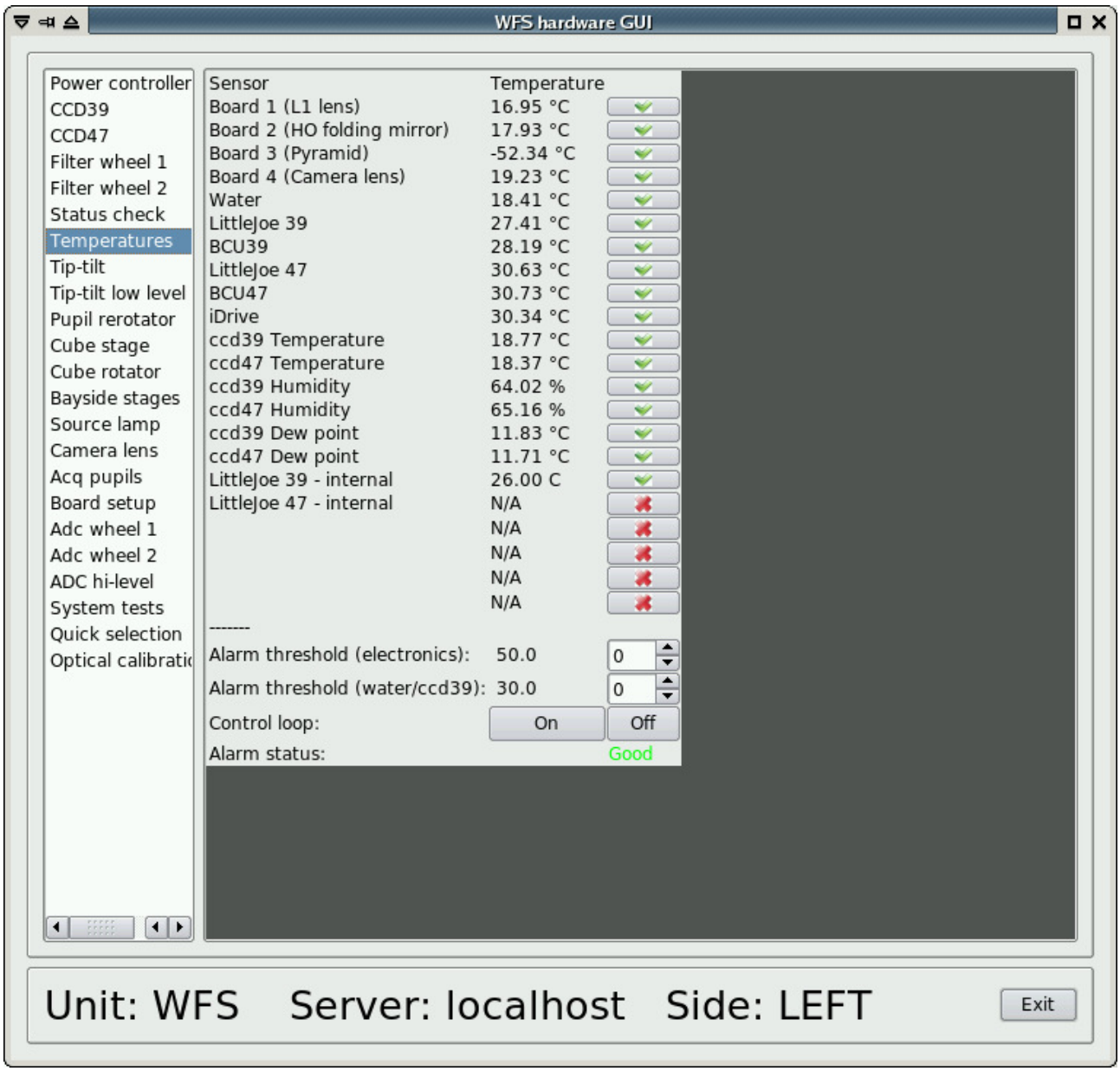
7.2.6. Status check



This panel shows the status of all wfs devices. Status are either red or green. A green status means that both the software and the hardware for the specified devices is ready. In normal wfs operation, everything is green

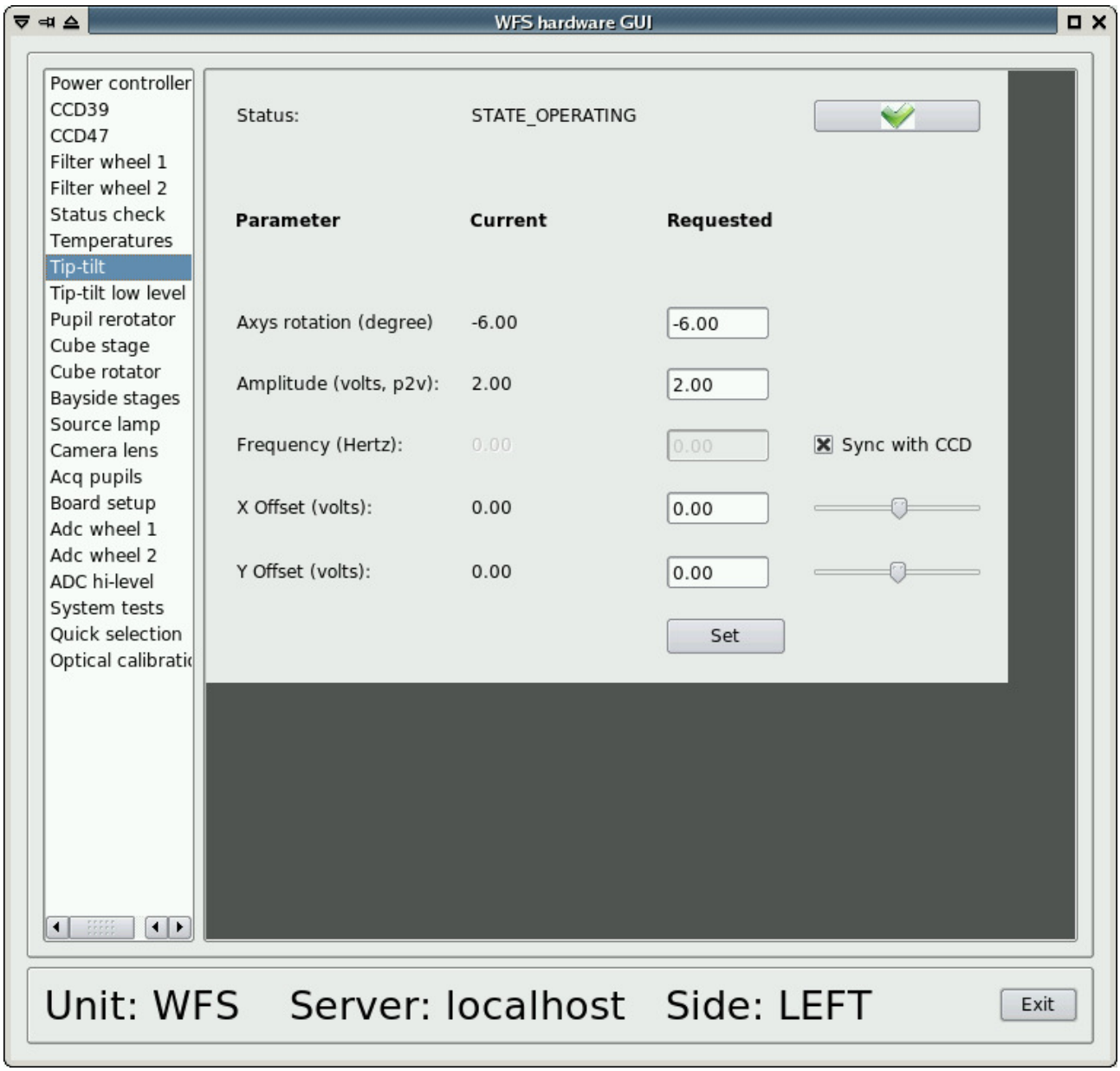
If the power on configuration was incomplete (as in this example, where the configuration was excluding the ccd47), it is normal that the excluded devices appear in red.

7.2.7. Temperatures



Shows all the temperature readings collected from various parts of the wfs. Update rates varies from once every few seconds to once every 30 seconds depending on the sensor. If a sensor does not answer for more than a minute, “N/A” (not available) is shown. Sensors can also be not available if the corresponding devices are off or otherwise unreachable.
The lower section controls the over temperature protection system: the PIC-based control board will automatically shut the WFS off if any of the sensors goes over the specified thresholds. Two different thresholds are available: one for the sensors on the electronics, and one for the water intake and CCD temperature.

7.2.8. Tip-tilt

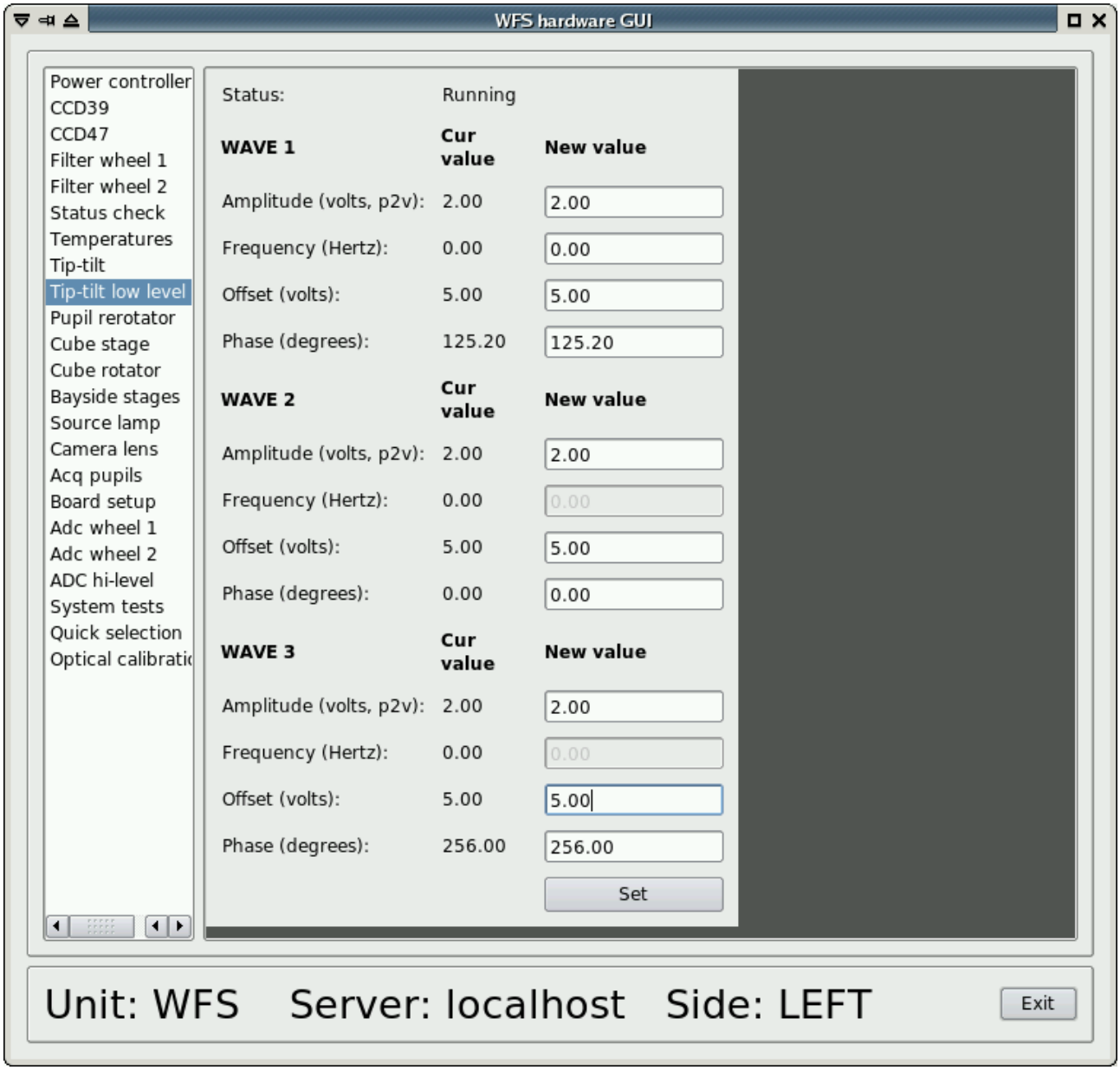


The tip-tilt panel shows both the current values and the input boxes for the requested values. All requested values are applied when the “Set” button is pressed (empty values default to zero). The tip-tilt is a three-axis device, but the control is done over two virtual axes that are remapped on the three real axis.

- axis rotation: controls the orientation of the XY reference system
- amplitude: controls the overall modulation amplitude, specified in volts (0-10V)
- Frequency: controls the modulation frequency. If the “Sync with ccd” checkbox is set, this value will be ignored (a zero is sent to the BCU), and the frequency will be synced to ccd frame rate using the tip-tilt fiber.
  Note: it is not possible to sync with the ccd frame rate when the ccd is turned off or otherwise unavailable. This condition is detected and the checkbox will be unavailable in this case.
- X and Y offsets: change the modulation center, from -5 to +5V, with zero being the nominal range center. Either the input boxes or the sliders can be used. Slider changes are applied immediately without pressing the “Set” button.
  Note: When applying X and Y offsets, the tip-tilt controller may reduce the modulation amplitude so that the maximum voltage applied does not exceed 10 V, as sum of offset plus

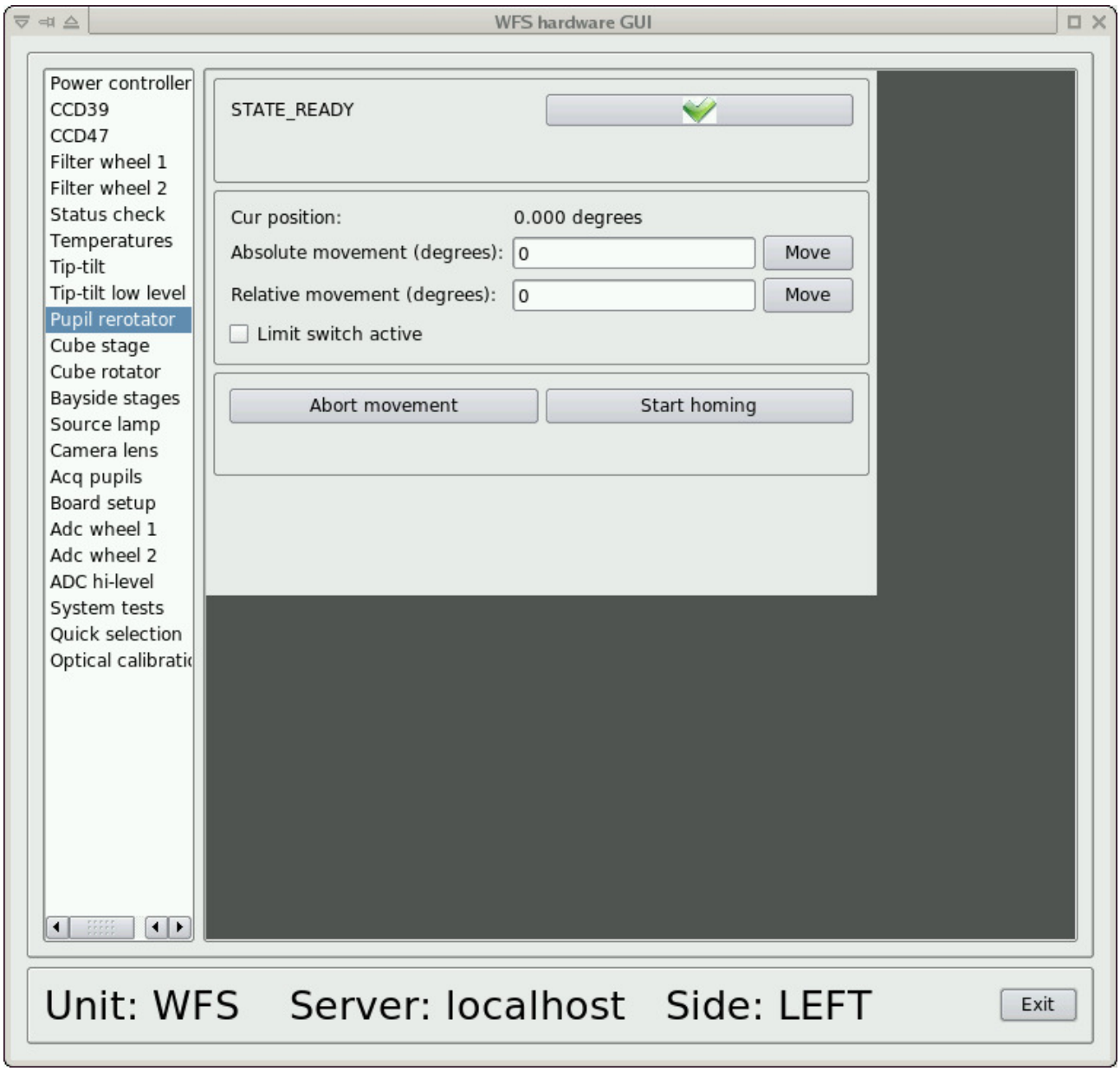
semi-amplitude. This is shown in the GUI as a reduction of the current amplitude with respect to the requested value.

7.2.9. Tip-tilt low level



This panel allows individual control of the three tip-tilt axes. For each axis, amplitude, offset and phase can be set independently, while the frequency is locked to be the same. The nominal offset center here is 5 volts, and ranges from 0 to 10V.

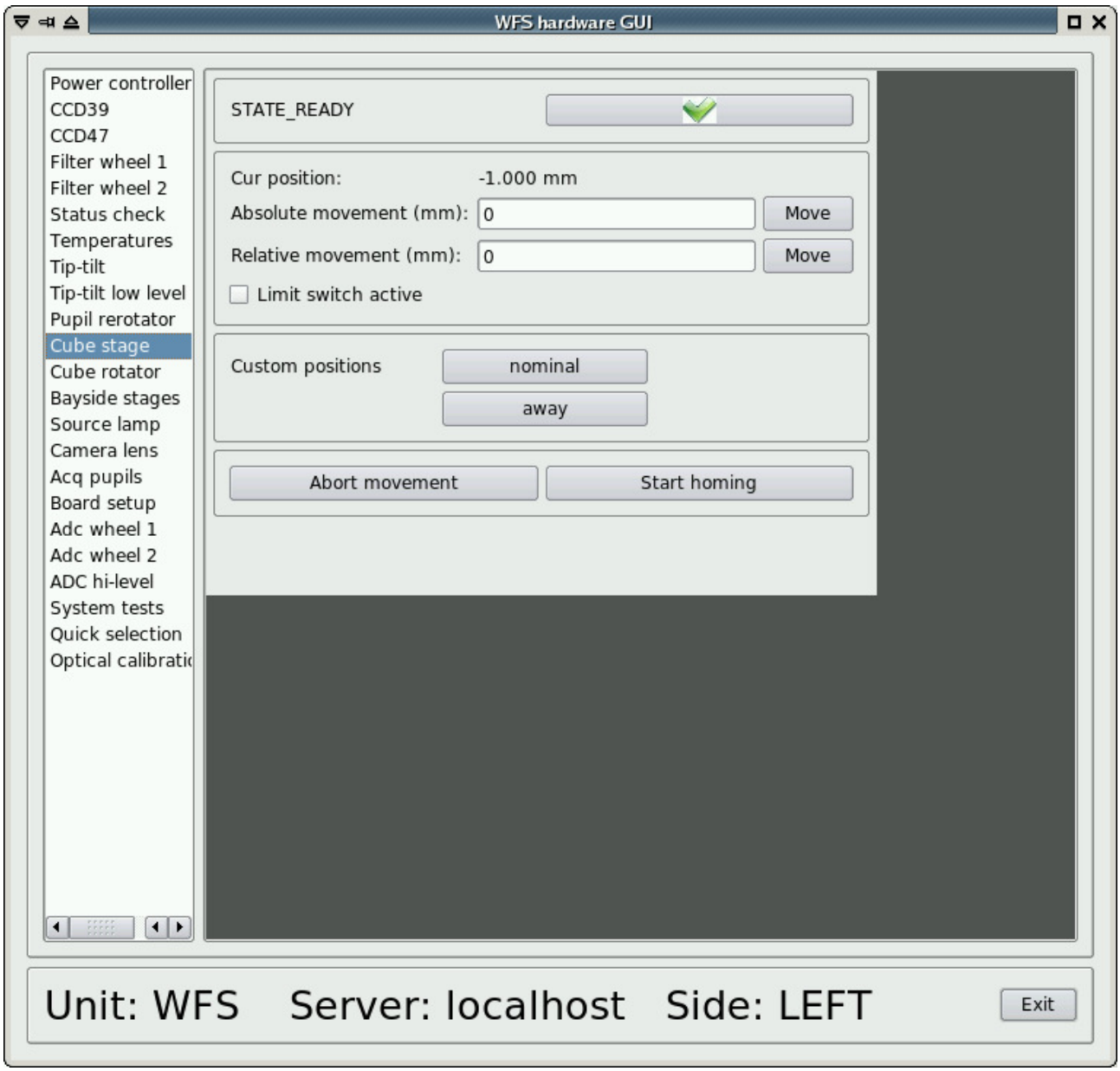
7.2.10. Pupil rerotator



This panel commands the pupil rerotator and is functionally similar to the one of the filter wheel #1, except that the movement unit is in degrees. Also, the pupil rerotator has a limit switch that will prevent movement lower than zero degrees, or any other backward movement crossing a 360° threshold. So, once the position has advanced over 360°, it will not go lower than that until the movement is power cycled.

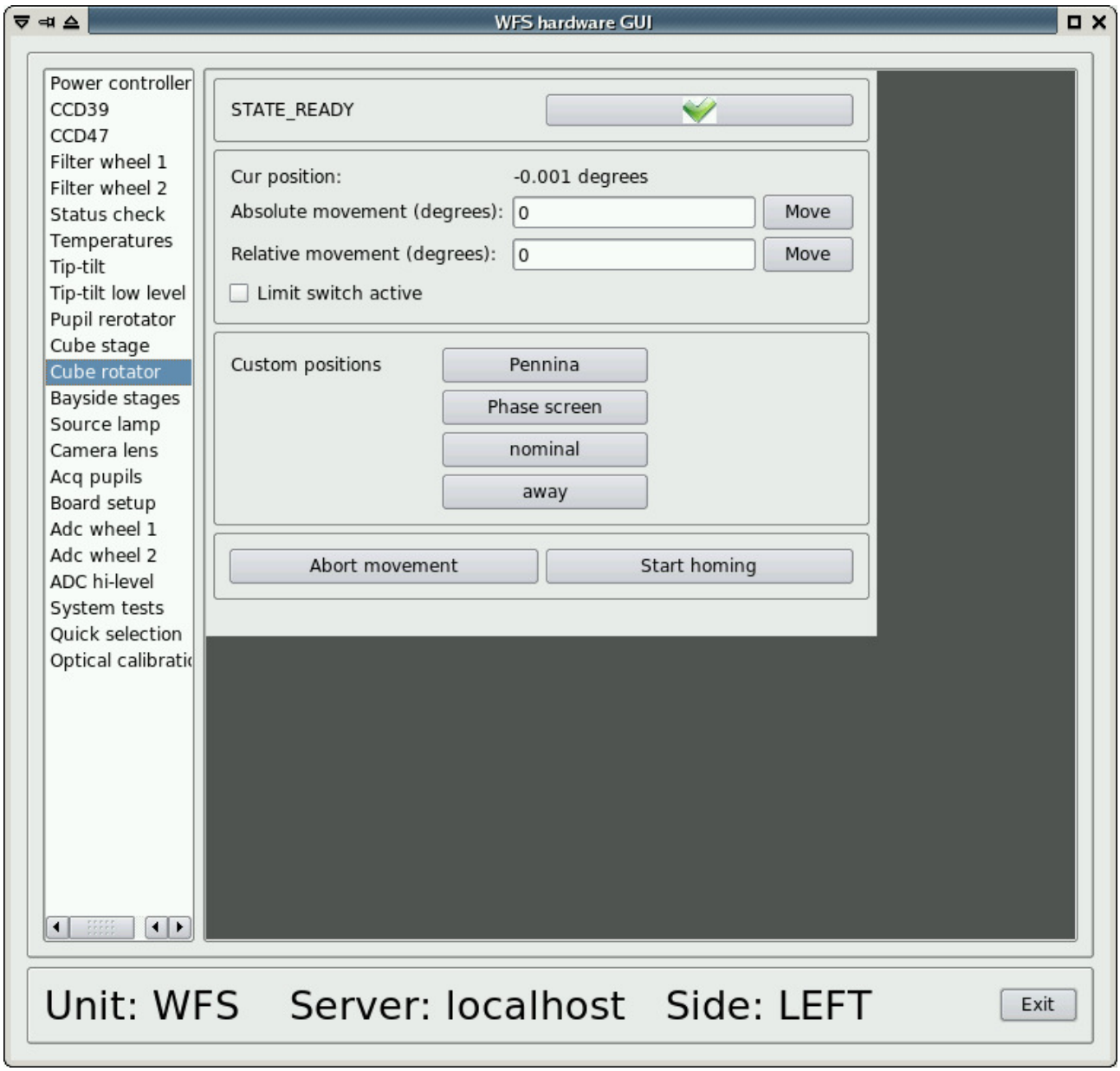
When using the AOS or WfsArbitrator, this condition is automatically avoided. Furthermore, the rotator tracking is on at virtually all times, and it will continuously send commands, rendering this panel basically useless until the tracking is stopped.

7.2.11. Cube stage



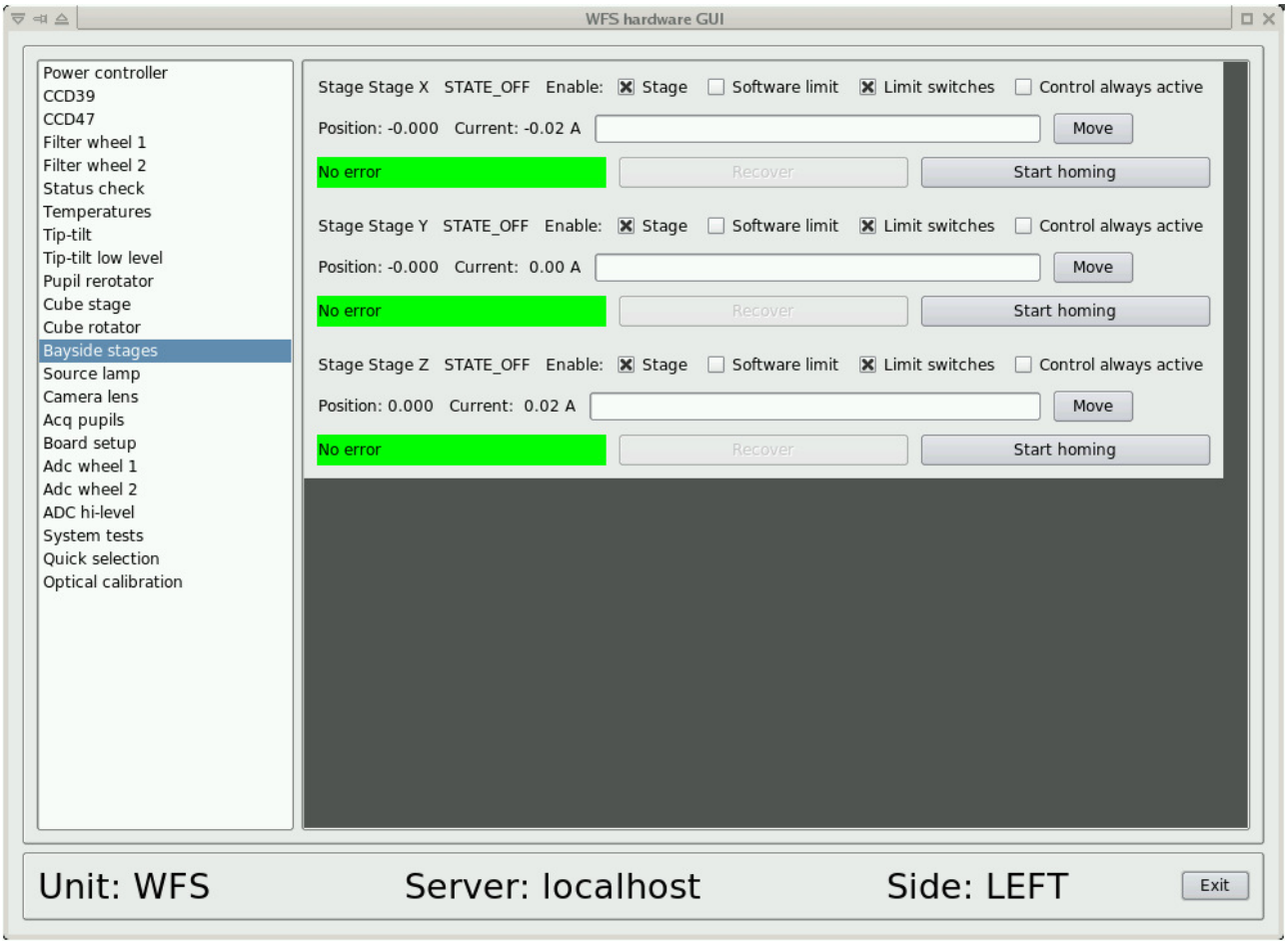
This panel commands the cube stage, which is a linear movement with two limit switches. Units is in millimeters. Apart from this, it is functionally identical to the filter wheel #1 panel.

7.2.12. Cube rotator



This panel commands the cube rotator, which is a rotary movement without limitations on movement. Unit is in degrees and precision of movement is on the order of 0.01 degrees. The panel is functionally identical to the filter wheel #1 panel.

7.2.13. Bayside stages



7.2.13.1. Displays

The bayside stage panel shows the status of each of the three XYZ stages. For each stage a status is reported:

- NOCONNECTION: stage is off or otherwise unreachable
- CONNECTED: stage is reachable, connection in progress
- OFF: stage is ready, motor disabled, brake set
- OPERATING: stage is moving and/or actively mantaining a position

Position display: the current position is shown, as an offset from the homing position. If the homing procedure has not been performed, the position where the stage was when it was turned on is assumed as zero. The stage positions use the following reference system:

[diagram]

Note that the X stage has a home position towards the left movement limit, and thus valid positions range from 0 down to -120 mm. Y and Z stages instead move from the home position up to about +88 and +70 mm respectively.

Current display: the current adsorbed by the motor is shown in Ampere. An adsorption of 1 or 2 amperes is normal. If the display is stuck at 4 amperes, it means that some mechanical obstruction is present and the current limiter is in action.

7.2.13.2. Controls

For each stage, the following checkboxes are available:

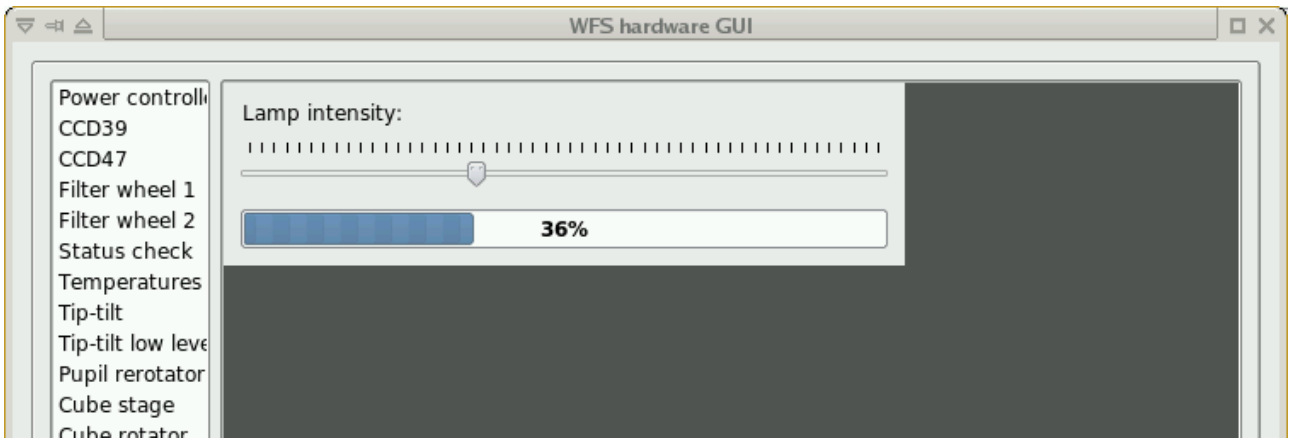
- **“enable stage”** this must be checked to allow the stage to move. Unchecking this checkbox will cause the stage to stop immediately and brake in the current position
- **“software limit”** enforces the sofware movement limits, defined in the stage configuration files.
- **“limit switches”** enables the electrical limit switches that prevent the stages from reaching the mechanical movement limits. This is usually always enabled.
- **“control always active”** avoids braking the stage once a movement is done, allowing the motor to actively keep the position. If the checkbox is activated before a movement, the setting will be applied on the next movement. If unchecked while the motor is maintaining a position, it will cause the stage to set the brake and stop there.

Other controls:

“Move” button: the move button will move the stage to the position specified in the main inputbox. Only absolute positioning (offset from the home position) is available.

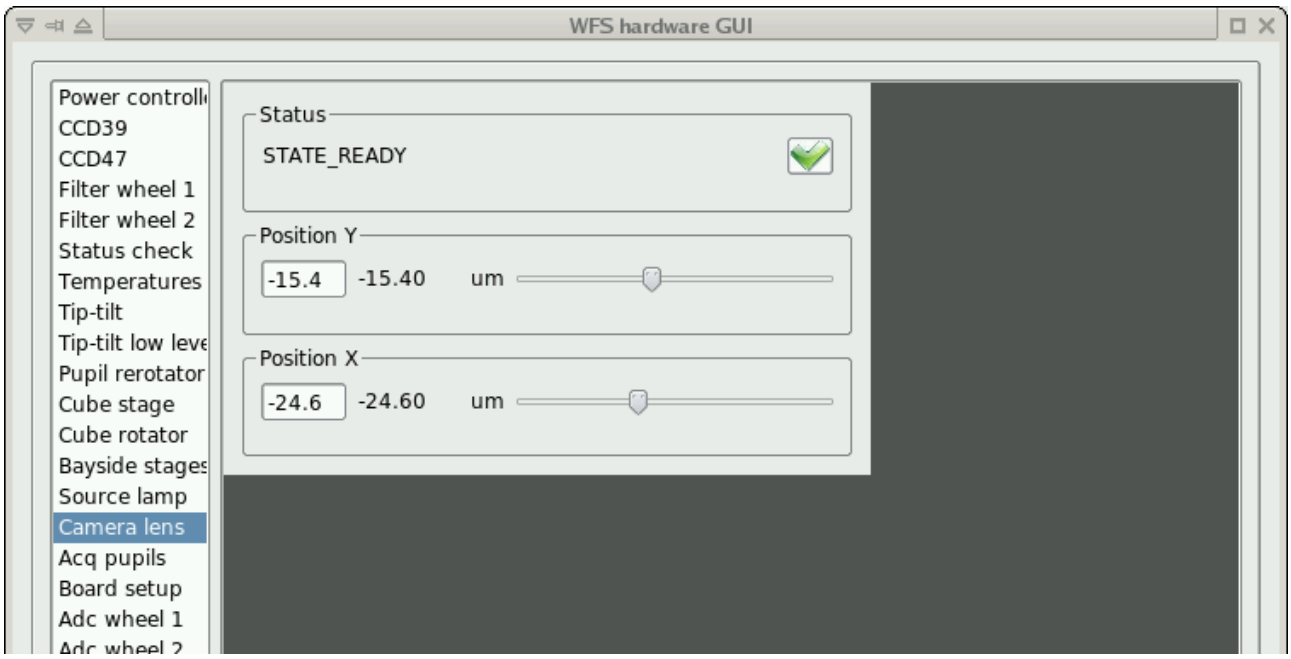
“Start homing”: starts the homing procedure. X stage homes towards the left limit (positive coordinates), while Y and Z stages home toward the lower and backward limit (negative coordinates).

7.2.14. Source lamp



This panel allows the operator to change the reference lamp intensity moving the slider. This is in addition to the lamp on/off control described in []. The actual lamp intensity is displayed as a percentage and will take a few seconds to follow the slider due to delays in the PIC-based flowerpot controller.
Note: the lamp behavior is highly non-linear. At the lowest settings, the lamp is virtually off, then ramps up quickly. Over 50% or so the lamp increases luminosity only marginally.

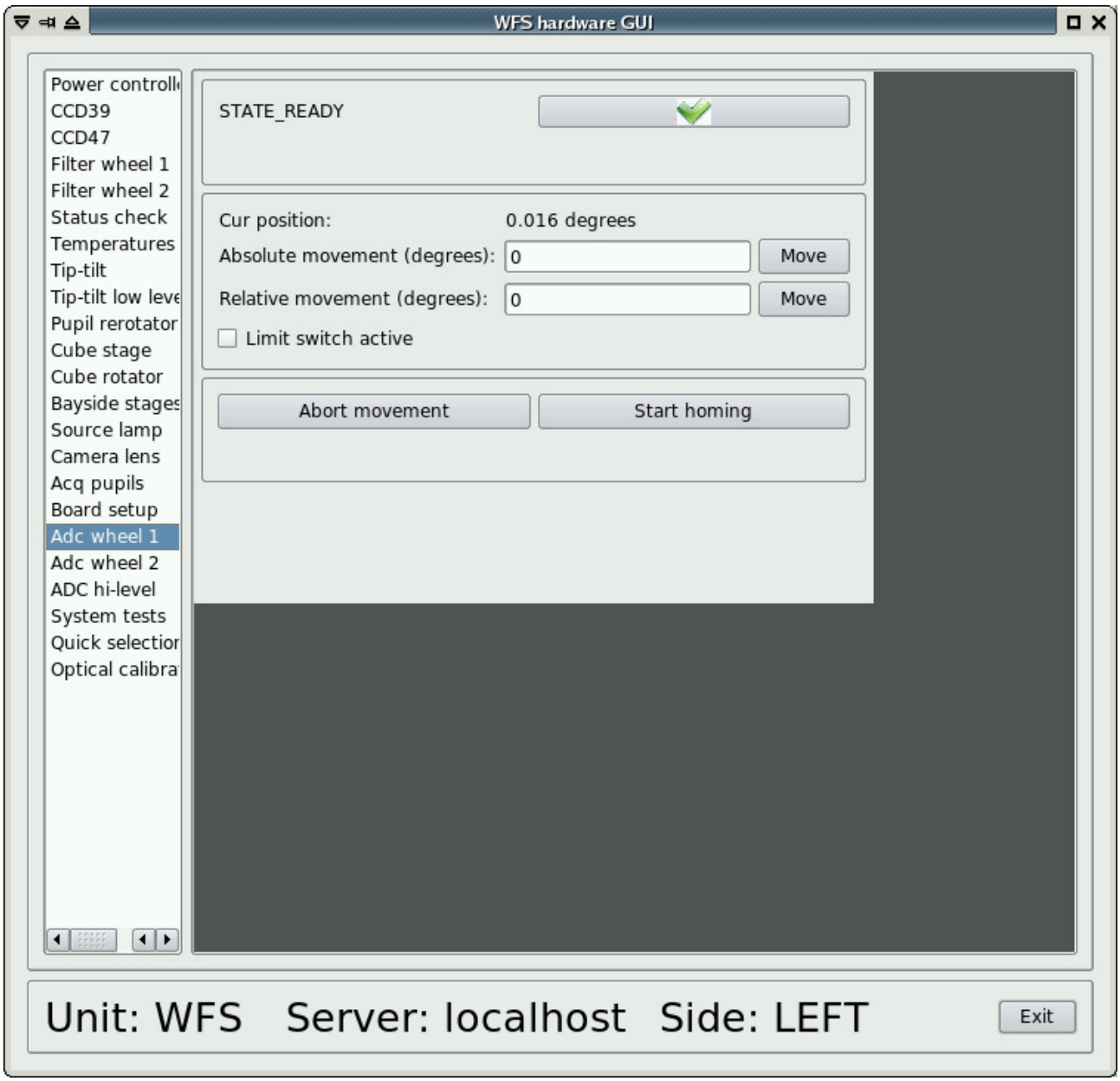
7.2.15. Camera lens



This panel controls the two axis of the cameralens. The cameralens outputs of the BCU are slaved to the ones for the tip-tilt: if the tip-tilt has not been configured, the outputs are not enabled and the cameralens is in the default rest position. Before using the cameralens, the operator must first set the tip-tilt, even giving zero as amplitude and offset.

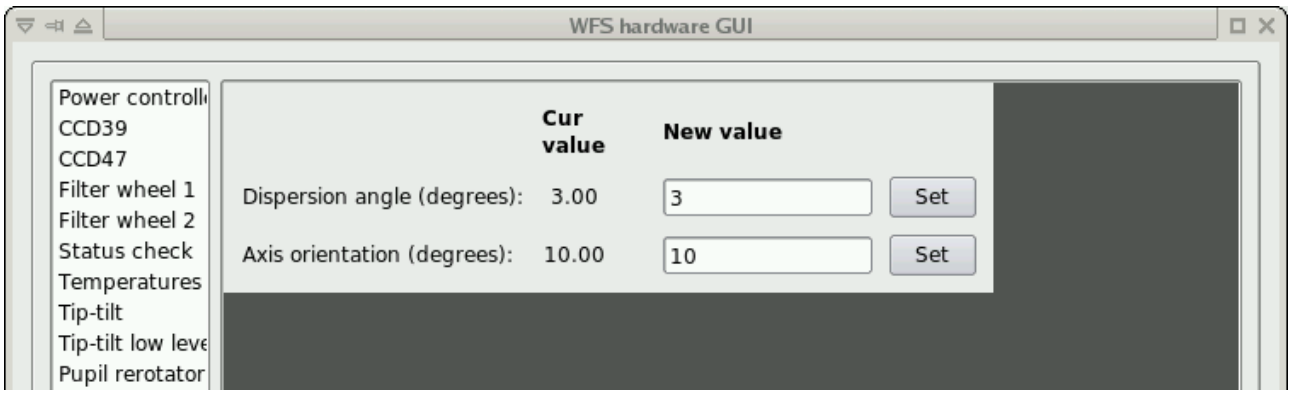
Once the outputs are active, the two sliders control the X and Y camera lens position. The current position is shown, and the position can also be changed writing the new values in the two input boxes and pressing Enter. This action will set both axes at the same time.

7.2.16. ADC wheels #1 and #2



These two panels control the two ADC prism wheels. The unit of movement is in degrees. Apart from this, they are functionally identical to the filter wheel #1 panel.
When using the Wfs Arbitrator ADC tracking, the ADC position is continuously updated and this panel cannot be used.

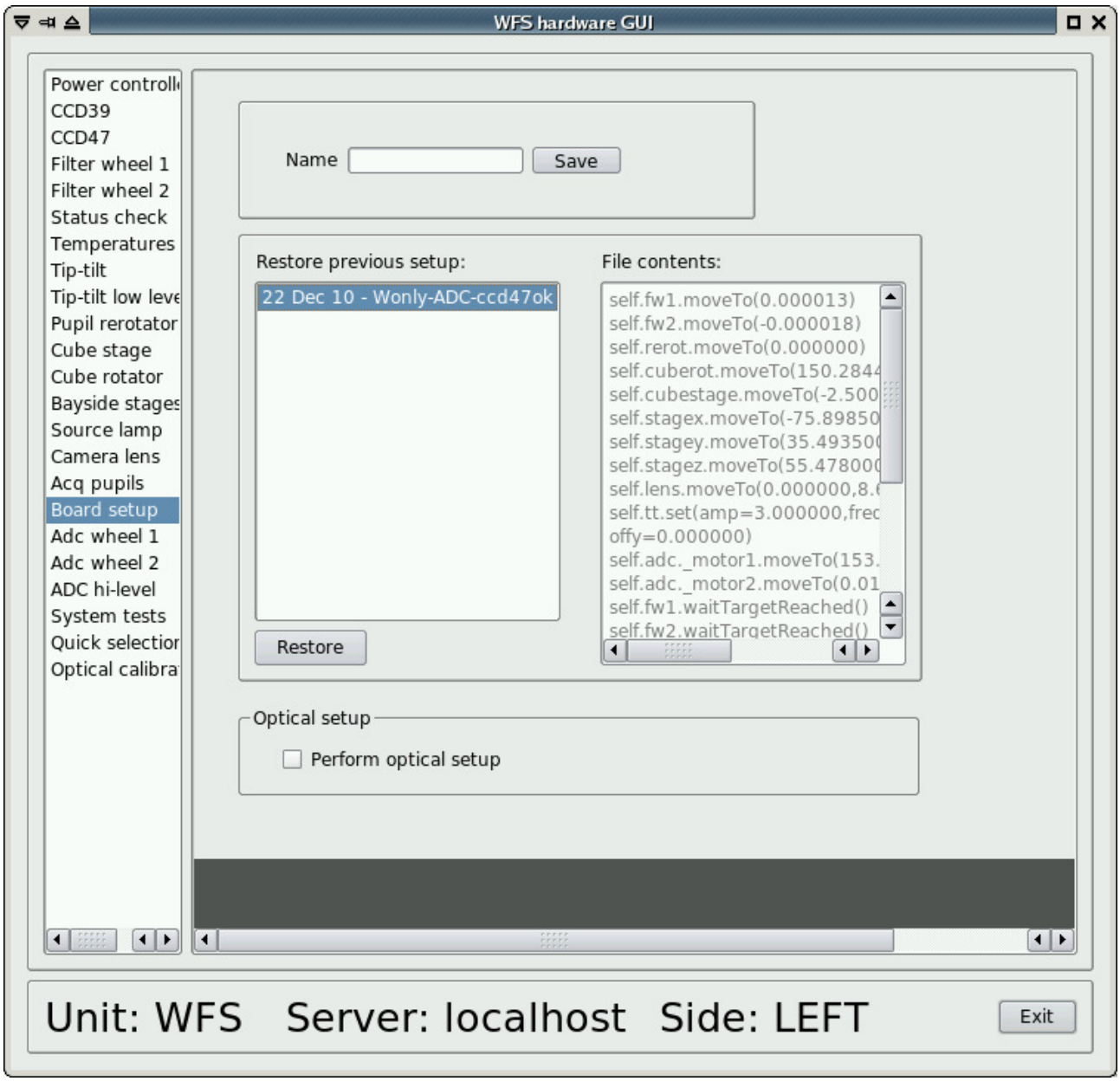
7.2.17. ADC high-level



This panel allows the control of the ADC as a function of two high-level parameters: dispersion angle and axis orientation. There is a direct mapping of these two parameters to the ADC wheels position.

When either of the Set buttons is pressed, both values are sent to the ADC controllers.
When using the Wfs Arbitrator ADC tracking, the ADC position is continously updated and this panel cannot be used.

7.2.18. Board setup



The operator can save the current board configuration using this panel to save a “board setup” file. A board setup is a text file containing commands to set the wfs movements positions. To save the current configuration, enter a descriptive name in the top input box and press “save”. A text file will be generated and saved in a predefined directory (see []), and shown in the list with the date on which it was saved.
Clicking on a filename on the list will display its contents in the right box for inspection. To load a board setup file, select it on the list and press the “Restore” button. An xterm will appear where the script will execute.
Warning: if some devices are off, they will not respond to commands, and the xterm will wait for their response with a timeout which may be quite long. It is safe to simply close the xterm, because all commands are sent in less than one second, and the rest is only waiting for the devices to report their status.

The following parameters are saved/restored:

- filter wheels #1 and #2 positions
- cube stage and rotator positions

- X, Y and Z stages positions
- Camera lens X and Y positions
- Tip tilt modulation amplitude, frequency and offsets
- ADC wheels #1 and #2 positions

7.2.19. System tests

[screenshot]

This panel contains shortcut buttons to start various system tests scripts. Their output, when available, is shown in the box below the buttons. The output text can be copied and pasted. The available scripts are:

- ccd39 RON test: starts the ccd39 RON (ReadOut Noise) test. It will cycle the ccd between the four available readout speeds, and report the results in the box below.

7.2.20. Quick selection

[screenshot]

This panel contains a list of the available calibration files for the BCU (background frames and slopenull frames), displays the currently selected file and allows the operator to select a different file and send it to the BCU. Loading the file is immediate whether in open or closed loop. While operational, use of the WfsArbitrator GUI for the background is recommended.

8. AdSec Arbitrator GUI

The AdSec arbitrator GUI is used to send commands to the AdSec Arbitrator, which provides high-level commands to manage the AdSec like startup/shutdown procedures, shape loading, reconstructor configuration, etc. Commands are implemented in the AdSec state machine as described in [..].

8.1. Starting the GUI

The AdSec Arbitrator GUI can be started from the adsceng panel (see []), or from a terminal on adsecdx with the following command:

```
AdSecControl
```

8.2. GUI description

All GUI actions are implemented as arbitrator commands. The same considerations listed in chapter 6.2 apply.

8.2.1. Status indicators

[screenshot]

At the top of the GUI, the following status information is shown:

- AdSec Arbitrator Status: tells the operator in which state the AdSec is at the moment, and therefore which commands are available. Also, in the GUI commands which are not available at the moment are grayed out.
  Note: if the Wfs Arbitrator program is not running, or not correctly responding, the Status will be "offline" and no commands will be executed.
- Last executed commands: shows the name of the last command executed by the AdSec Arbitrator
- Command execution status: shows whether a command is executing at the moment, or the result of the last command as described in []. When a command is executing, all GUI buttons are inactive.
- Focal station: shows the currently selected focal station (which may be "None" if no focal stations have been selected since the last adsec startup). The selected focal station is the only one allowed to send slopes to the secondary mirror.
- Lab mode: the red label "lab mode enabled" is shown when the arbitrator is in the so-called "lab mode". In this mode, some safety features are disabled. Intentionally, it is not possible to enable the lab mode using the GUI.
- Telescope data (wind, elevation, swing arm status): ….
- Safe skip indicator: ….
- …

8.2.2. Startup/Shutdown command

8.2.2.1. Safety locks

8.2.3. Shape control

8.2.4. Shape offloads

8.2.5. Zernike application

8.2.6. Reconstructor control and gain

8.2.7. Disturbance control

8.2.8. Focal station selection

9. AdSec Arbitrator engineering displays

9.1. AdSec display (AdSec Mir GUI)

The AdSec display shows the current Adaptive Secondary using graphical displays of commands, positions and actuator current (proportional to force). It is a purely read-only GUI.

9.1.1. Starting the GUI

The AdSec Mir GUI can be started from the adsceng panel (see []), or from a terminal on adsecdx with the following command:

```
AdSecMir_GUI
```

9.1.2. GUI description

9.2. AdSec housekeeper GUI

The AdSec housekeeper GUI shows the information collected by the AdSec Housekeeper.

9.2.1. Starting the GUI

The AdSec Housekeeper GUI can be started from the adsceng panel (see []), or from a terminal on adsecdx with the following command:

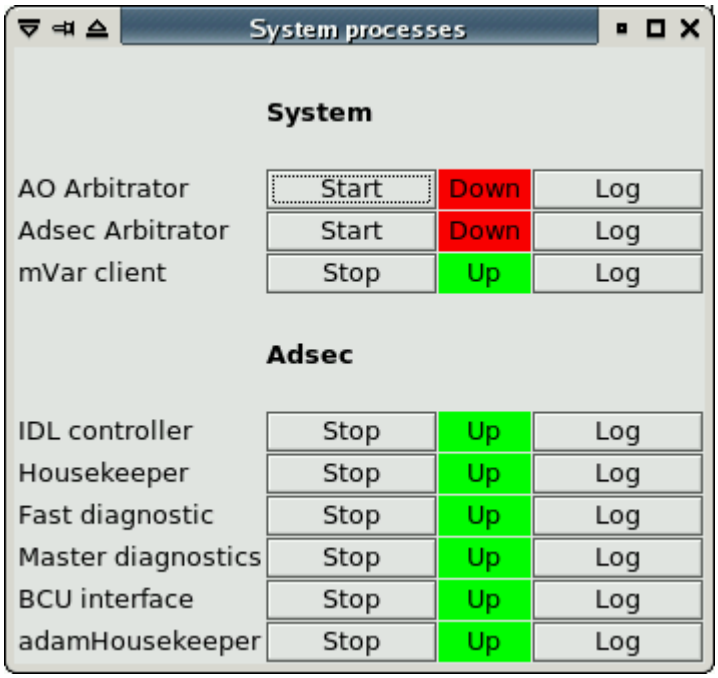
```
Housekeeper_gui
```

9.2.2. GUI description

10. Low-level GUIs

10.1. System processes GUI

The System processes GUI lists all the necessary processes for the subsystem currently configured (either the Adaptive Secondary or the WFS), and shows whether each process is running or not, or if it is being initialized. It also provides buttons to start and stop each process, and to visualize their log file.



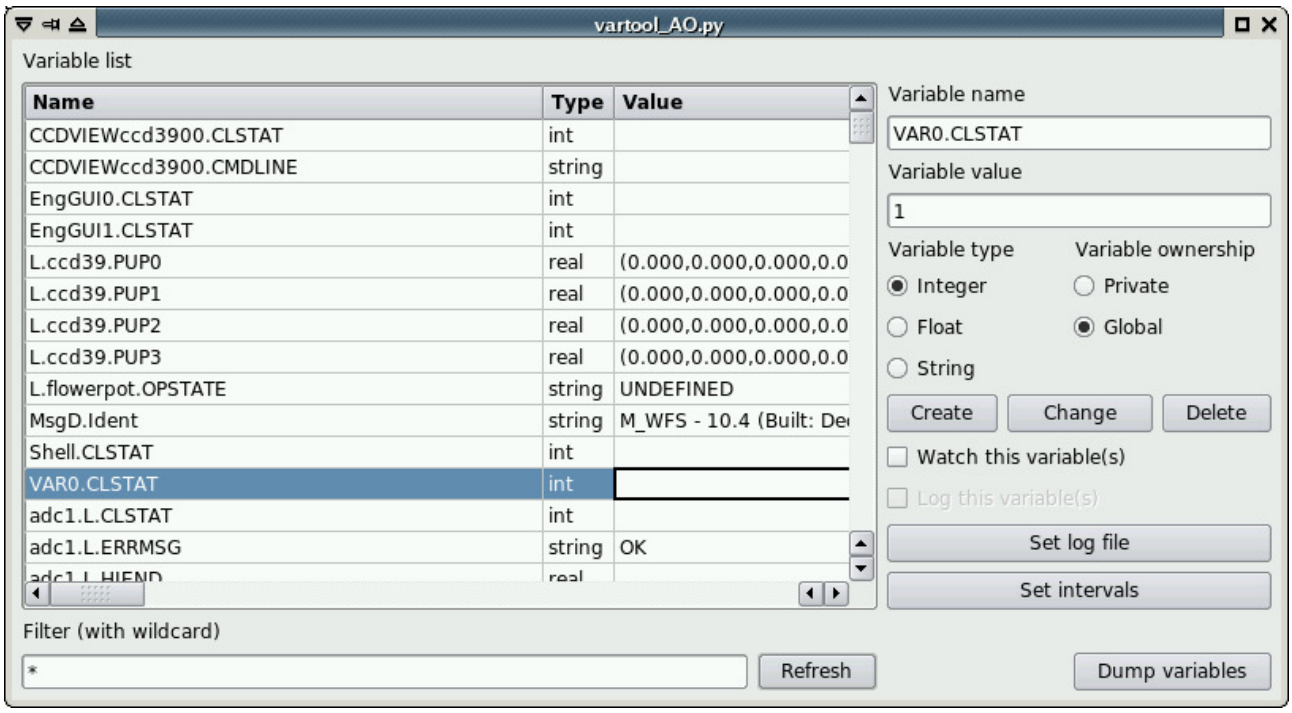
The status indicator of each process can have three values:

- Down (red): the process is not running or not connected to the MsgD
- Init (yellow): the process is running, but not yet correctly initialized
- Up (green): the process is running correctly

The initialization fase is generally very short, except for processes which must wait for some particular condition (for example, the adamHousekeeper will remain in “init” state until the secondary mirror unit is powered on). In normal operating conditions, all lights should be green.

The “log” button will open a window where the log file of the specified process is shown, with color-coded lines for normal logs, error logs, etc. The window does not show the entire log file, but only shows the last part, and follows the changes as they are written. If the process is restarted, the log will continue in the same window. The log window is only a viewer and can be closed at any time with no harm.

10.2. Variable inspector tool



The variable inspector tool is a viewer/editor of the central variable repository maintained by the RTDB. A different variable repository is maintained on each AO computer, even if some information of common interest is replicated.

10.3. Text-based tools

10.3.1. IDL terminal

10.3.2. Python shell

10.3.3. Thrdtest

10.3.4. Consumer

10.3.5. BCUread

10.3.6. Log files

All AO processes, except for graphical interfaces, write information on what they are doing in a log file. Log files are ASCII text and can be opened with any text viewer (see also the logviewer tool, chapter 10.3.8). Care must be taken not to modify the log file if they are opened with an editor such as Emacs or Vi.

The log file has a standardized path and filename:

$ADOPT_LOG/<processname>.<side>.log

Where <processname> is the name of the process, and <side> is the telescope side is it running on. The MsgD has a special name:

$ADOPT_LOG/M_<msgd name>.log

10.3.6.1. Log file archiving

When a process exits, its log file is "archived", that is, is renamed to make room for the new log file which will be created when the process will restart. The archived filename has the format: $ADOPT_LOG/<processname>.<side>.<timestamp>.log

Where <timestamp> is a timestamp in Unix format, recording the time when the file was archived. Log files are automatically archived and re-openened when they reach a predefined length (around 200MB). Log files are also archived when a process, upon starting, finds out that the log file of the previous instance was not correctly archived. The process will then archive the old log file before opening a new one.

Graphical and text interfaces, which can run in multiple copies at the same time, do not write a log file.

10.3.7. Telemetry files

In addition to log files, a few processes also write telemetry files, which are a special case of log files containing mostly numerical data. They are still in ASCII format and have the following naming scheme:

$ADOPT_LOG/<processname>.<side>_TELEMETRY.tel

Telemetry files are archived in a similar manner as the log files.

10.3.8. Log viewer

11. Common tasks

11.1. System preparation

11.1.1. Using the AOSGUI

- Check on the AOSGUI that the software status is OK (AOS connected, and green light on the AdSec and Wfs software status). See chapter 3.2.1.
- Check if the hardware subsystems (again either the AdSec or both the AdSec and the WFS) are turned on. They will be off if the software was just started. Turn on the needed subsystems. See chapters 3.2.3, 3.2.3 and 3.3.1.
- Set the Adaptive Secondary shell (see chapter 3.3.1).
  Note: telescope conditions (like elevation < 25 degrees) may prevent the shell from setting up, or will cause it to rest it afterwards (see chapter 8.2.2.1). The shell will need to be set again after these conditions are resolved.

11.1.2. Using the Arbitrator GUIs

In case the AOS GUI is not available, or the AOS is not working properly, it is still possible to setup the system from the Arbitrator GUIs.

- Check that the software on adsecdx is up and running properly (see chapter 2.2)
- Bring up the **adsceng** panel on the adsecdx computer
- Start the AdSec Arbitrator GUI
- Setup the adaptive secondary using the command buttons in the left column. The complete sequence is:
    - "On" (goes to status Operating)
    - "LoadProgram" (goes to status Ready, corresponding to the SAFE label on the AOS)
    - "SetFlatAo" (goes to status AOSet, corresponding to the SET label on the AOS).

If the adaptive secondary is already halfway through this sequence, only the remaining steps need to be performed. Most of the time, the secondary should be in Ready state (SAFE label on the AOS).

To setup the WFS:

- Check that the software on wfsdx is up and running properly (see chapter 2.2).
- Bring up the **wfseng** panel on the wfsdx computer
- Start the WFS Arbitrator GUI
- Select the configuration "complete with ccd 47" and press the Operate button. The setup operation will take a few minutes to complete.

When the WFS Arbitrator GUI reports that the WFS is in state "Operating", the setup is done and observation can proceed.

11.2. System shutdown after observation

11.2.1. Using the AOSGUI

- Rest the Adaptive Secondary mirror shell (see chapter 3.3.1). Do not turn off the secondary mirror, leave it in the status marked SAFE on the AOS GUI.
- Turn off the WFS (if it was turned on initially)

11.2.2. Using the Arbitrator GUIs

- From the AdSec Arbitrator GUI on adsecdx, press the "Rest" button and verify that it goes to "Ready" state.
- From the WFS Arbitrator GUI on wfsdx, press the "Off" button and verify that it goes to "Off" state.

11.3. Seeing limited observation

11.4. AO observation sequence

AO observations are intended to be performed automatically by the instrument through the IIF. It is possible for the AO operator to intervene to repeat or modify a command using the AOS Command

GUI, where the original command parameters are displayed. In case of a command failure, or if a command must be repeated, the operator can modify the parameters on the AOS Command GUI and repeat the command.

This chapter gives a resume of the typical AO sequence, an overview of what happens during each command, and what is possible for the operator do to in each case.

11.4.1. PresetAO

An AO observation starts with a PresetAO command, which tells the AO system the main parameters of the following observation: which instrument and focal station will be used, and the reference star magnitude and position. The command is received by the AOS and forwarded to the lower-level arbitrators, where the following parameter checks are done:

By the AdSec Arbitrator:

- focal station name is among the ones defined for the Switch BCU input ports

By the Wfs Arbitrator:

- Star magnitude is within the limits of the AO parameters table
- Star position is within the AO field-of-view of the wfs stages
- A board setup file with the same name of the instrument is present

The AO parameters table and AO field-of-view are defined in two different WFS calibration files (see []). The board setup file will be searched in the board setup directory (see []).

If any of the checks fails, the command will report a “Validation failed” or “Retry” error. In this case, the command must be repeated with valid parameters before AO observations can go ahead.

When the parameters are successfully validated, the AdSec and WFS are configured, ccd darks are taken and the board setup file is applied. Tracking loops (rerotator, adc) are turned on. If the WFS CCD displays are active, they may stop for a while during the CCD reconfiguration.

A PresetAO command can be repeated any number of times without harm. Since it may take a certain amount of time (up to a couple of minutes if everything must be reconfigured), the PresetAO can be sent while the telescope is slewing to speed up AO operations.

11.4.1.1. Error conditions and recovery

- Focal station name is not recognized. *Solution*: repeat the command with a recognized focal station name
- Instrument name is not recognized. *Solution*: repeat the command with a recognized instrument name
- Star magnitude is too faint or too bright: *Solution*: repeat the command with a star magnitude within accepted bounds
- Star position outside FoV. *Solution*: repeat the command with a star position inside the accepted FoV
- Any other problem is a symptom of hardware failure. See chapter [].

11.4.2. AcquireRefAO

The AcquireRefAO tells the AO system to acquire the reference star and configure the system for close loop operations. It has no parameters since everything was specified by the previous PresetAO command. When the AcquireRefAO command is received by the AOS, the following sequence happens:

- A sky image is taken wih the ccd47 and the position of the reference star is measured
- WFS stages are moved to bring the reference star on the target position
- The magnitude of the star is measured on the ccd39 and compared with the one given by the system during the PresetAO. If there is a difference, the system is reconfigured (basically repeating a PresetAO command) for the new magnitude.
- The AO loop is temporarily closed with a special set of parameters to center the camera lens.
- Once the camera lens is centered, the temporary AO loop is opened and the system is configured with the final parameters.

A number of things may prevent the command from completing successfully. The following section details the most common problems encountered.

Note: the fact that a temporary AO loop is closed during this command means that telescope guiding and active optics must be stopped during command execution. This is done automatically by the telescope when in ADAPTIVE mode, but must be done manually if the telescope was preset in ACTIVE mode.

11.4.2.1. Error conditions and recovery

- Star not found on ccd47. It may happen that the telescope pointing was not accurate enough (the ccd47 field has a diameter of about 15 arcseconds), or that the star position given the previous PresetAO command was incorrect.
- Star found, but of very different magnitude. In this case the system will assume that the wrong star was found, and will stop.
- Camera lens position not reached: if the seeing is very bad, it may prevent a good measurement of the pupil position on ccd39, causing the camera lens centering to fail.
- AdSec safety failure during the temporary closed loop: see chapter [] regarding this condition.

In case of any error, since there are no parameters for the command, the only option for the operator is to solve the external problem and try again. If any of the parameters sent with the PresetAO command need to change (for example, the star position or magnitude needs to be changed), the operator must first send another PresetAO command and then repeat the AcquireRefAO.

An AcquireRefAO can be repeated any number of times.

11.4.3. StartAO

Once the AcquireRefAO has completed, the loop can be closed immediately with the StartAO command. This command has no parameters and no failure modes (apart from hardware failures), since it just enabled the “fastlink” fiber over which the slopes are transmitted.

Once the system is in closed loop, the realtime part will go on indefinitely until another command is sent, or until a safety failure occurs.

11.4.3.1. Error conditions and recovery

No errors are expected during the command. After that, the system is in closed loop and an AdSec safety failure can occur. See chapter [].

11.4.4. PauseAO/ResumeAO

The PauseAO command suspends the AO loop, while the ResumeAO command resumes a previously paused loop. Their operation include a check on the incoming light on ccd39 before resuming the loop:

PauseAO:

- Records illumination level on ccd39
- Disables the “fastlink” fiber and stops the flow of slopes to the adaptive secondary

ResumeAO:

- Checks that the illumination level is the same as recorded during the ccd39
- Enables the “fastlink” fiber and resumes the flow of slopes to the adaptive secondary

The check on the illumination level prevents resuming the loop if, during the pause, the reference star is not in the WFS field of view anymore. This may happen in case of tracking drifts, or if some incorrect offsets were executed during the pause.

11.4.4.1. Error conditions and recovery

- Illumination level check fails on ccd39 during resume. Solution: if the reference star position is known, fix the WFS position using an OffsetAO command and try again. Otherwise, the loop must be opened with a StopAO command and the AO sequence started again from the PresetAO.

11.4.5. OffsetAO

The OffsetAO can be executed in any condition (loop open, closed, or paused).

If the loop is open or paused, it will be executed simply moving the WFS stages by the specified amount. The reference star will be then lost, unless the same offset is executed by the telescope mount.

If the loop is closed, the WFS stages will be moved in small steps of 0.3 mm, waiting at each step for the tip-tilt offloading to recover the movement. The execution time for the offset is correspondingly greater.

11.4.6. Other failure modes

11.4.6.1. AdSec safety fault

When the loop is closed, the AdSec mirror shape and forces are under continous safety check by the FastDiagnostic process. If an out-of-range condition is detected, the power to the mirror actuators will be turned off, terminating immediately the AO loop and causing the shell to go back to rest position.
In this event, the AdSec mirror will execute its own “RecoverFailure” routine, which brings it back to the Operating state where it is ready to be set again. In the meantime, any AO operation in progress will have been cancelled, and the WFS has been notified of the event and stopped as well in order to stop the flow of slopes to the secondary mirror.

The operator must set the shell again (see chapter 11.1.1) and restart the AO observation from the PresetAO command.

11.4.6.2. Hardware failure

If a hardware failure happens, it will be generally impossible to continue the AO observation. It is not feasible to list all possible hardware failures. What will happen is that commands will start to fail randomly with specific error messages about the faulted hardware component. It will be necessary to look at the Arbitrator GUIs and log files to properly diagnose and fix the problem.

12. Calibration procedures

12.1. Pupil calibration

12.1.1. Pupil acquisition

12.1.2. Pupil optimization

12.2. Interaction matrix calibration

12.2.1. Disturbance generation

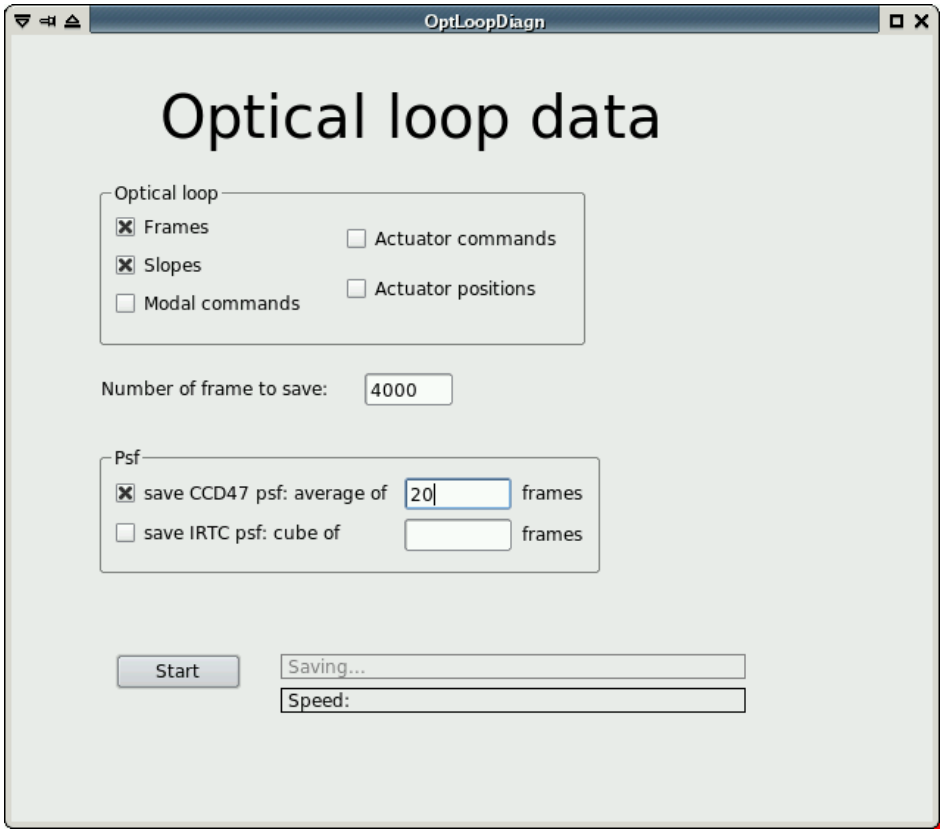
12.2.2. IM acquisition

12.2.3. IM analysing and REC generation

13. Saving diagnostic data

13.1. Data format description

13.2. Optical Loop Diagnostic GUI



14. **Elaboration library (elab_lib)**

15. **AdSec configuration and calibration files**

16. **WFS configuration and calibration files**

17. **Table of wfs, adsec and AO status values and commands accepted**

18. **Diagnostic data formats**

19. **Computer configuration**

20. **Software installation**