Speckle Instrument GUI - Linux User Guide

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Table of Contents

1. Introduction

The Speckle Instrument GUI has been developed by The Random Factory (Tucson, AZ) in collaboration with the Speckle Instrument PI (Steve Howell) and collaborators (Nic Scott, and Mark Everett - KPNO).

2. Installation

The GUI and accompanying packages are packaged using the **gzipped tar** archives. To install the package :

cd $HOME
tar xvzf speckle-control-x.y.z.tgz

where x.y.z is the appropriate version number.

This installation will place the files in the directory *$HOME/speckle-control*. Although it is possible to install the software to a different location, this is not recommended as it will be necessary to manually change the location in some of the scripts included with the drivers.

Run the Andor drivers installation script

cd $HOME/speckle-control/andor-driver
sudo ./install_andor

Configure the USB devices for rw access

cd $HOME/speckle-control
./setDevicePermissions

FOR GEMINI :

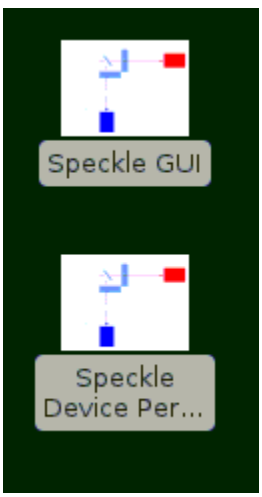
The Gemini computers are running a different version of Linux and need different links in the shared libraries. Unpack the prebuilt shared libraries by doing

cd $HOME/speckle-control
tar xzf untar-this-for-speckle-gemini-libs

Once this setup has been completed, the interface can be started with the command

~/startspeckle2

These USB permissions can also be set using the desktop icon, and the program can also be launched with an icon double-click as well.



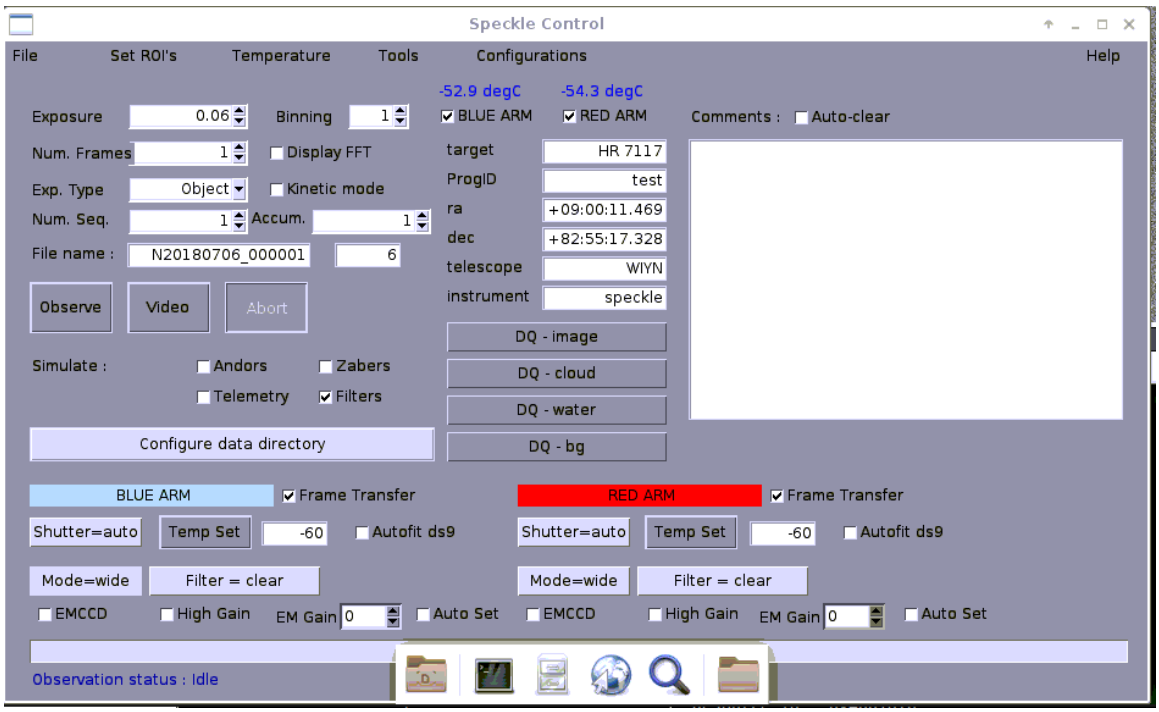
3. Graphical user interface.

The graphical user interface provides easy access to the major functions such as image acquisition, temperature control, and device setup and configuration.

The program will open a small main window, and then create a message window which shows the progress of the system startup operations.

Once the message window closes, the system is ready for use. The cameras are initialized, and temperature control has been switched on.

3.1 The main window



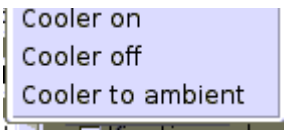
Most of the time the controls in this window will be the focus of observing activities.

The following elements are provided :

3.1.1 Configurations menu

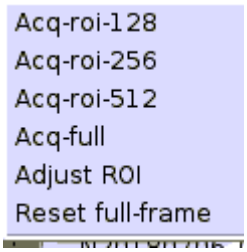
This menu provides quick setup for a range of commonly used observing or setup configurations. Each is a simple script (the sources can be found in $HOME/speckle-control/config-scripts, and any new scripts which are added to this directory will be available as menu options after a GUI restart)

3.1.2 Temperature menu



This menu provides control over the camera cooler usage. Cooling may be switched on or off, and the “ramp to ambient” option may also be selected (this is applied when the camera is shutdown). The actual temperature setpoints are individually controlled using entry boxes in the main window.

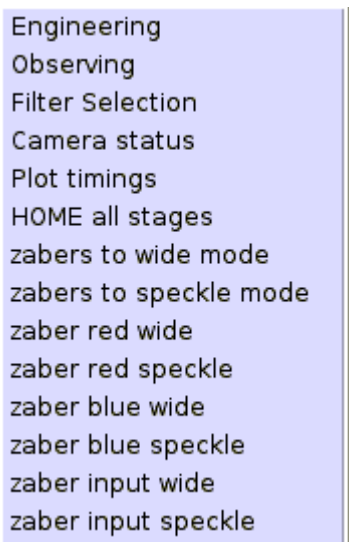
3.1.3 Set ROI's menu



This menu provides control over the data acquisition geometry. A range of "region of interest" sizes can be selected, or the geometry can be reset to include the full frame. If an ROI is chosen, then an image will be taken with each camera , and the best ROI of the requested size will be automatically generated centered on the brightest target in the image(s). If it is necessary to manually adjust the calculated ROI's, then selected that option and then use the ds9 controls to move them, and then click OK on the dialog.

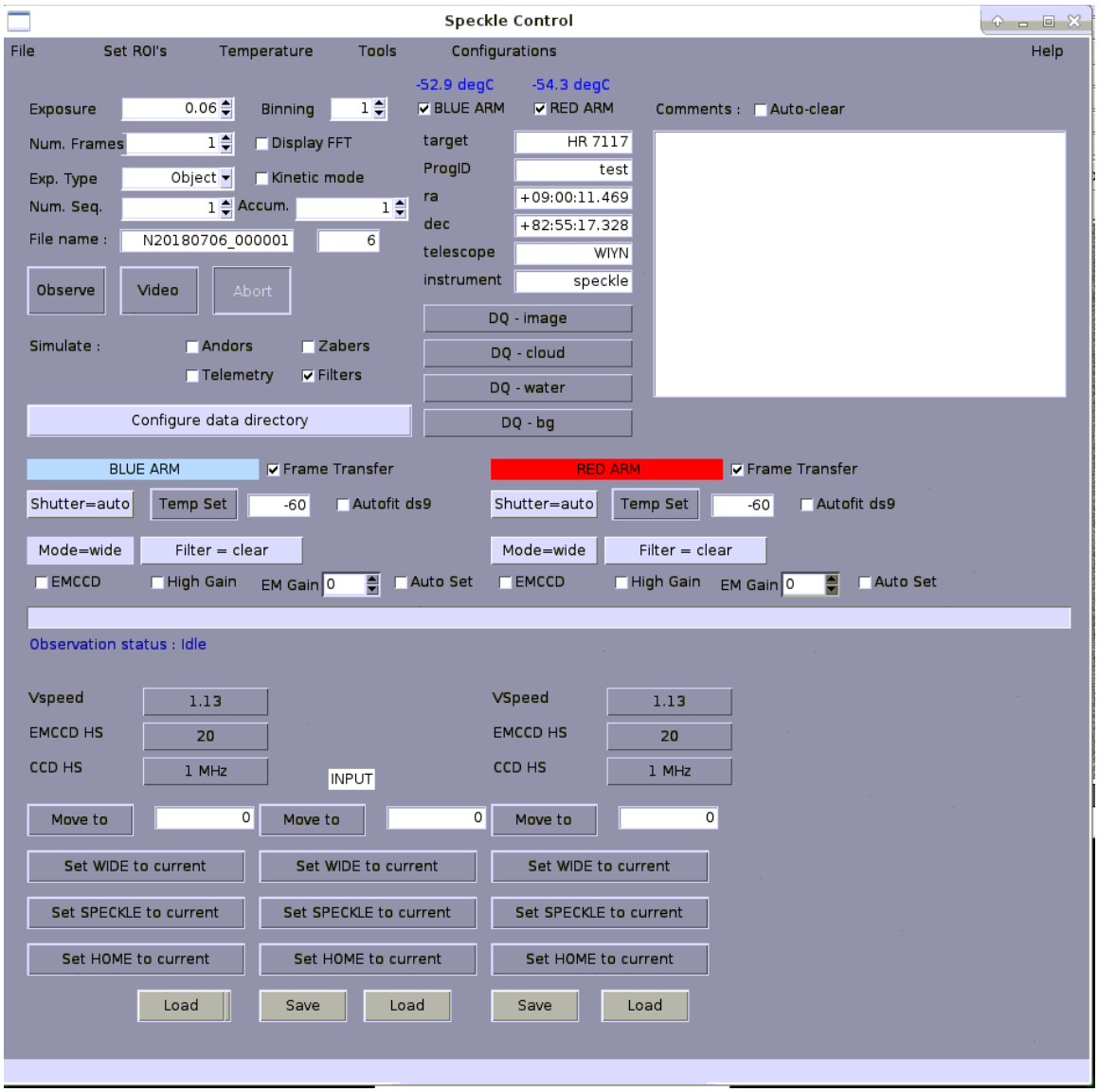
3.1.4 Tools menu

This menu provides access to a set of commonly used option. There are two main types



of item , GUI window visibility/mode, and Zaber stage motions.

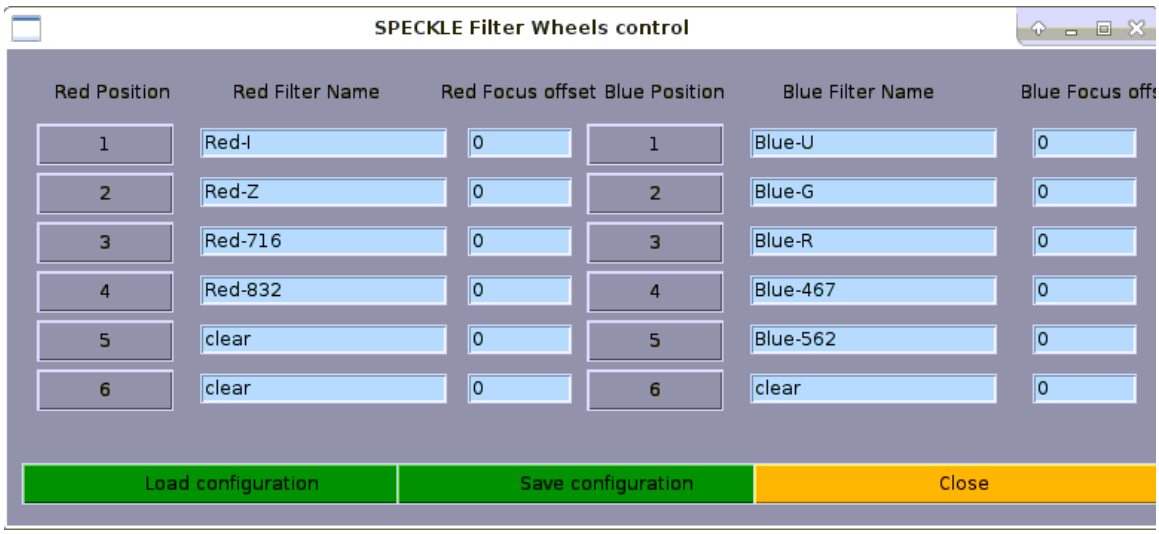
The “Engineering” option resizes the main window to make visible an extra set of controls generally used for equipment characterization and setup.



The detailed readout parameters of each camera can be manipulated, and the zaber station positions edited and loaded/saved. For Gemini, extra controls for the Focus and Pickoff stages, and the pico motors are also included.

The “Observing” option returns the main window geometry to the default , hiding the Engineering controls.

The “Filter Selection” option opens the Filter Wheel control window.

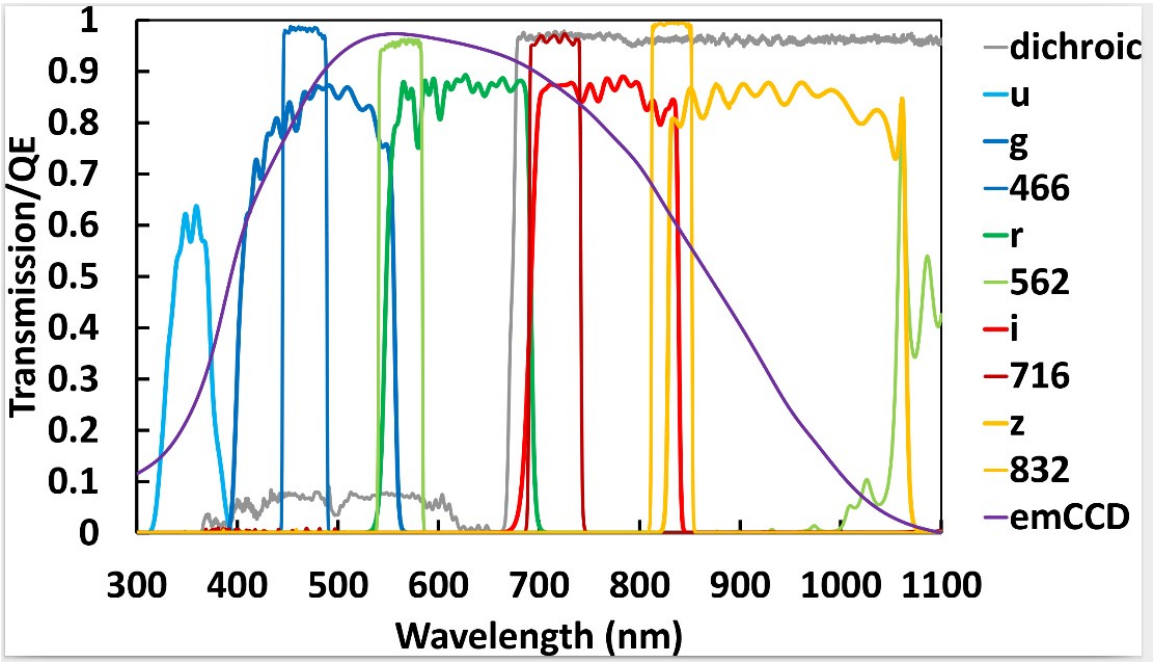


This provides options to rename filters and load/save the configurations. There is a placeholder for providing focus offset but this is not yet implemented.

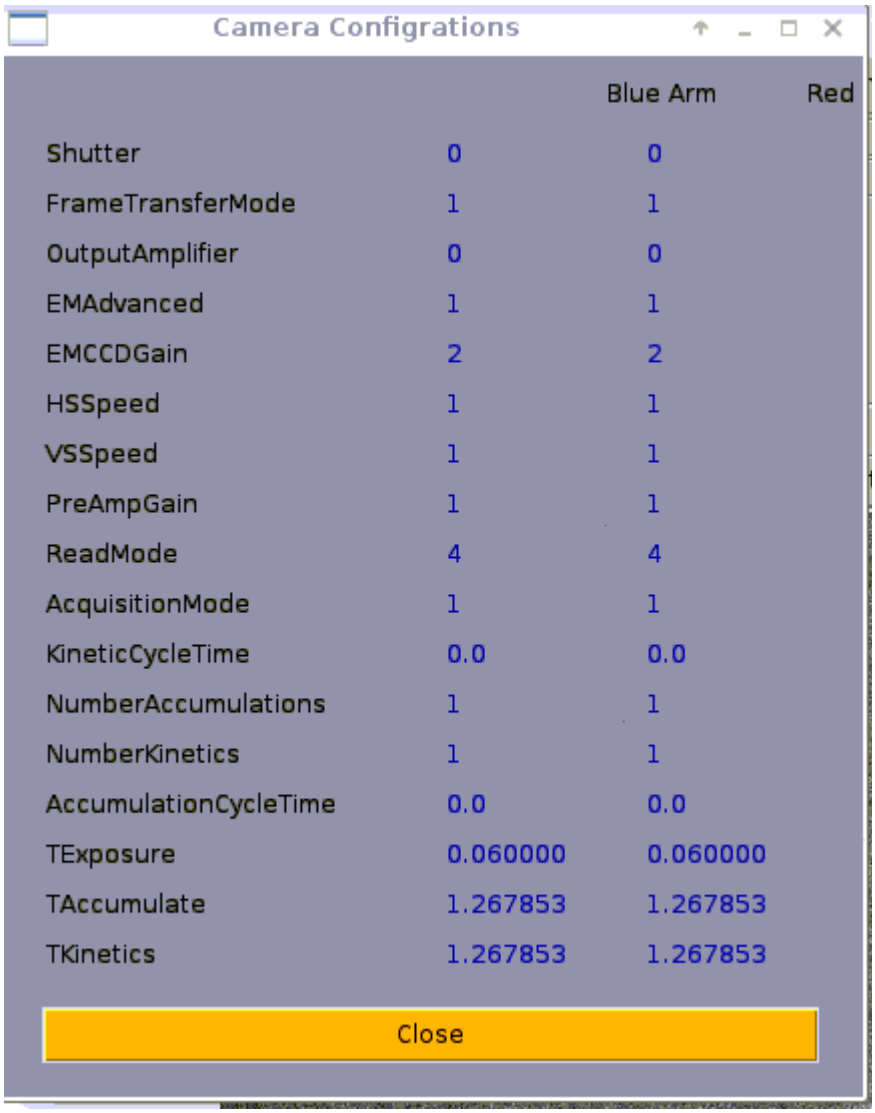
Filter Transmission & Efficiency Curves

NESSI uses a dichroic beamsplitter to separate the incoming light (at 686nm) into blue and red channels before focusing on the two identical cameras, which operate simultaneously. The speckle filter choice will be one of 467nm or 562nm paired with one of 716nm or 832nm. NESSI's SDSS filters are also listed below (although not used for speckle imaging). Data are in nanometers and fractional efficiencies as quoted by the manufacturer.

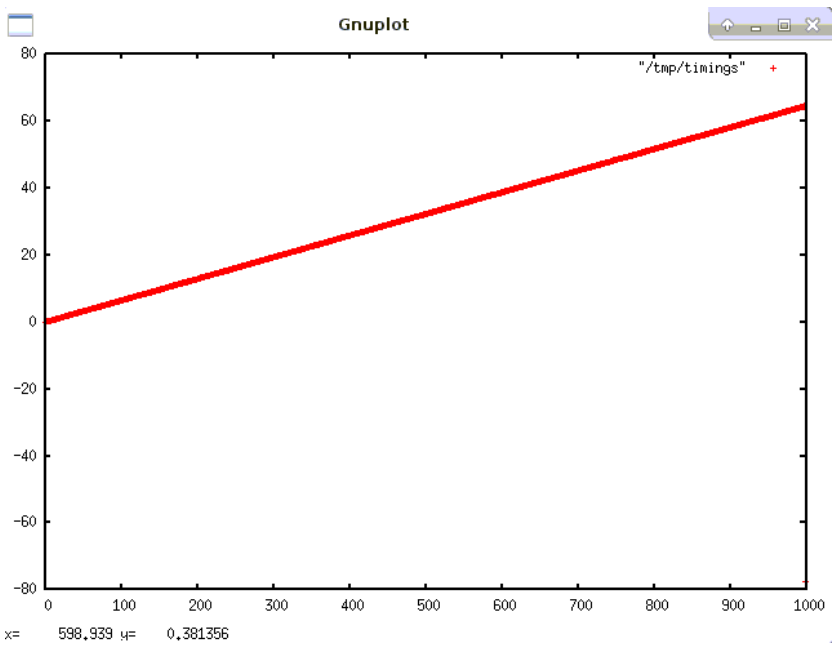
Name	c. wave (nm)	FWHM (nm)	diffraction limit (arcsec FWHM)	data
467	467.1	44.0	0.034	nessi_467.dat
562	562.3	43.6	0.040	nessi_562.dat
716	716.0	51.5	0.051	nessi_716.dat
832	832.0	40.4	0.060	nessi_832.dat
u	354.3	32.7		nessi_u.dat
g	480.0	151.1		nessi_g.dat
r	620.0	143.5		nessi_r.dat
i	765.4	146.4		nessi_i.dat
z	943.3	242.7		nessi_z.dat


Transmission/QE
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
300
400
500
600
700
800
900
1000
1100
Wavelength (nm)
dichroic
u
g
466
r
562
i
716
z
832
emCCD

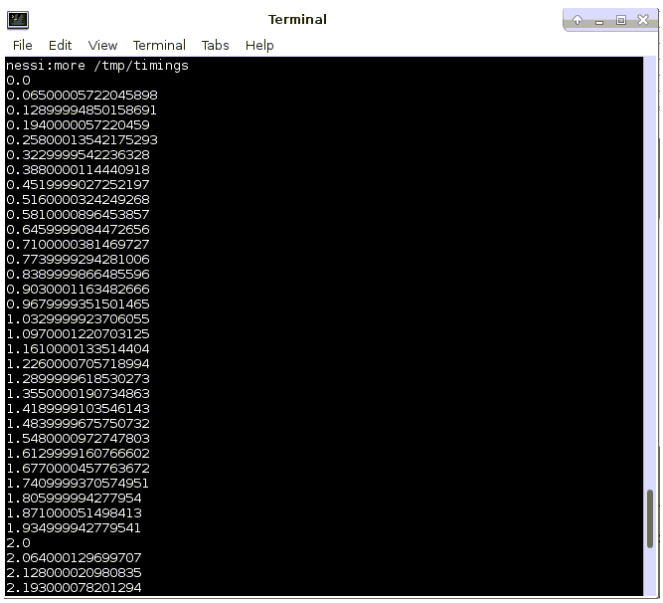
The “Camera Status” option opens a window showing the current settings of the main camera configuration and readout parameters.



The “Plot timings” option opens a file selection dialog. Selecting a data cube image-name will plot the time history of that cube's exposures (delta times with 0 = 1st frame time).



The data can also be examined in the file /tmp/timings after a plot.



The rest of the options command the motion of the relevant Zaber stages to the requested position(s). Feedback on the positions can be seen in the Mimic diagram, and in the debug log window.

3.2 Observations

The top left section of the main window contains a group of controls related to the sequencing and initiation of observations.

The exposure time can be specified (in seconds) using the spinbox , or a value can

be typed into the entry box area.

The number of frames to take can be specified using the spinbox, or a value can be typed into the entry box area. For Kinetic series, this specifies the number of exposures in each

datacube. For non-kinetic mode it specifies the number of individual exposures to be taken.

The Exp Type menu can be used to select common exposure types. Dark, Flat, etc.

This has little effect except over the shutter control, but the type is recorded in the image

headers.

The Num Seq spinbox can be used to repeat a set of observations multiple times.

The Accum spinbox can be used to select the number of exposures to be accumulated before each camera readout. The exposures are thereby “co-added” by the camera.

This is normally used in conjunction with Kinetic series operations.

The File name entry box is used to specify the base name for the FITS files. It will be expanded to add Sequence and Frame number where appropriate as the files are stored.

The current frame number is shown to the right , and will auto-increment as data is taken.

The Observe button start a sequence of observations (could be just a singleton).

The Video button starts a display only sequence , it must be canceled using the

Abort button before data acqusition Observations can commence.

The binning spinbox controls the binning factor in both x and y dimensions.

The Display FFT option chooses whether to display the raw image data, or to display an

FFT of the data instead.

The Kinetic mode option selects the Kinetic Series mode where the data is assembled into a data cube where the third dimension is time. In this mode an array of (TAI) timing information about the exposures is also included in the FITS file as a Binary table Extension.

Immediately below the Observing section is a set of options to switch on simulation mode for the various components. This is primarily intended for off-line testing , but could also be useful for operating in a degraded mode (eg. No filter control). Simulation options can also be set before starting the GUI (See the simulationMode file for an example).

The right side of the main window is focused on the meta data which will be included in the FITS headers. Some of this is automatically populated with data from the Telescope telemetry services. There are also menus for selecting a variety of Data Quality specifications, and a comments area (this area may be flagged to auto-clear after each exposure if required).

The current state of each camera (enabled, temperature) is prominently displayed top-center of the main window.

The lower section of the window contains the major camera operating control.

From here, the temperature setpoint, Filter, Shutter state, Frame Transfer mode, EM mode and gain can be changed. There are also options to enable EM gain advisory popups, and to Auto set the gain. Finally the display of the images in ds9 can be set to autofit or not (frame size)

Number of Image Sets to Acquire Per Target

The performance of speckle imaging is quite sensitive to conditions like seeing, so there are no strict rules to follow for determining the ideal number of image sets to acquire on a target of given brightness.

Observers targeting stars fainter than V=13 should plan on acquiring multiple image sets and those observing brighter stars may also benefit from taking multiple sets. This will depend on how they balance better contrast depth/image quality vs. number of targets visited. Multiple image sets per star can also help under less than optimal observing conditions and, given the several minutes needed to set up observing of each new target, many users may want to devote comparable time to exposures.

Each image set requires 1 minute of telescope time. Acquiring a target with a short slew requires 3 minutes and with a long slew, 5 minutes. Since a science target requires a point source observation, additional time is needed for that (about 4 minutes). Refer to the guide on estimating observing time for more information.

Note that we have found the signal-to-noise ratio for detecting secondary sources in speckle images does not grow as rapidly with exposure time as it would in traditional

CCD imaging (ie. with the square root of time). Proposers may not expect to achieve the same contrast limits on faint stars as bright ones (5 magnitudes may be achievable on 12th magnitude stars and 3 magnitudes on 14th magnitude stars.) The table below only suggests numbers of image sets to take for various magnitude stars:

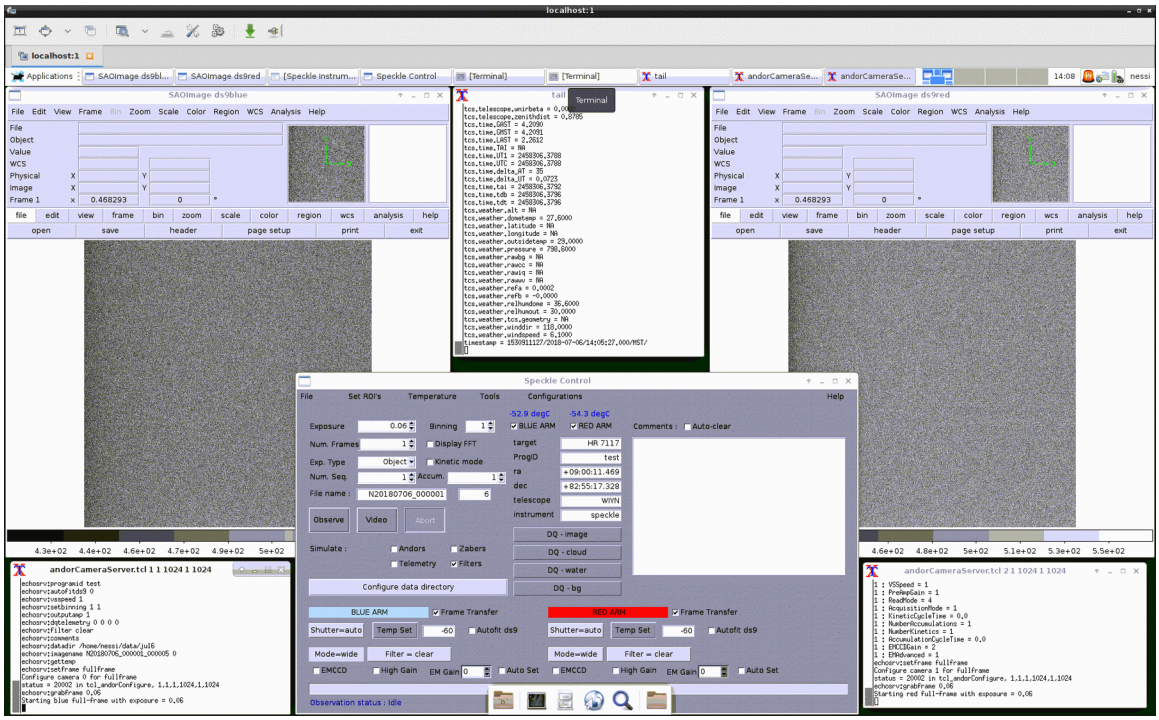
V or R	# image sets
<12	1-3
12-12.5	3
12.5-13	5
13-13.5	7
>13.5	9

(Mark Everett (everett@noao.edu).

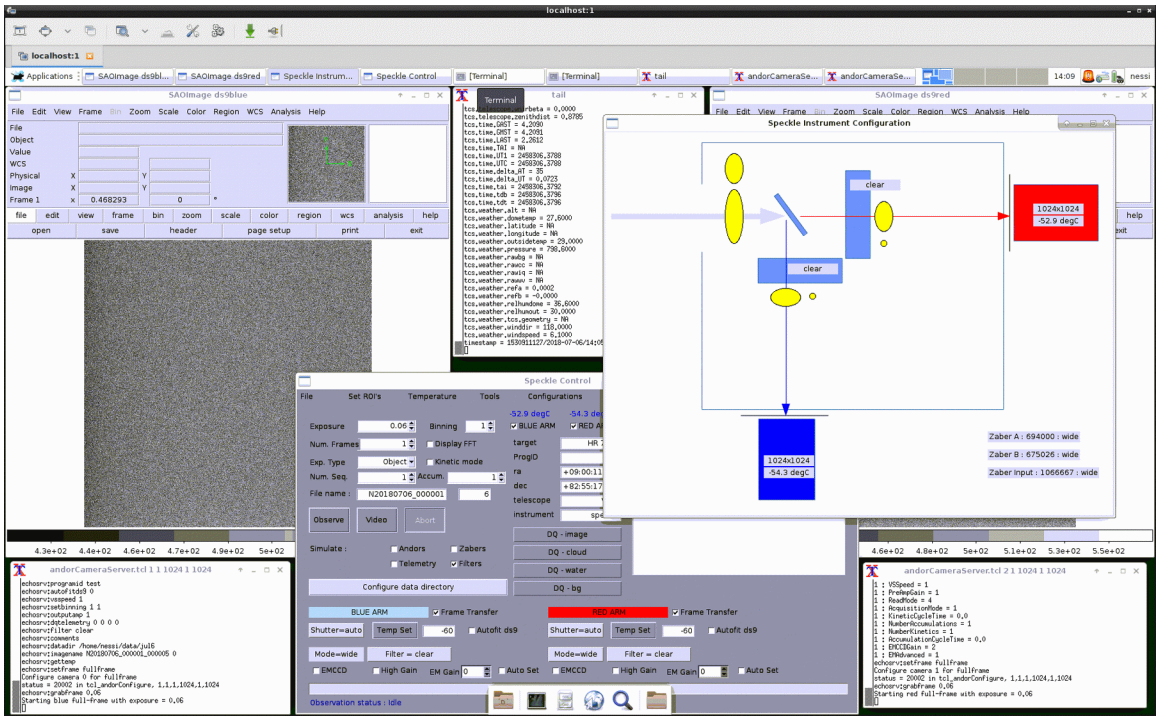
4. Desktop layout

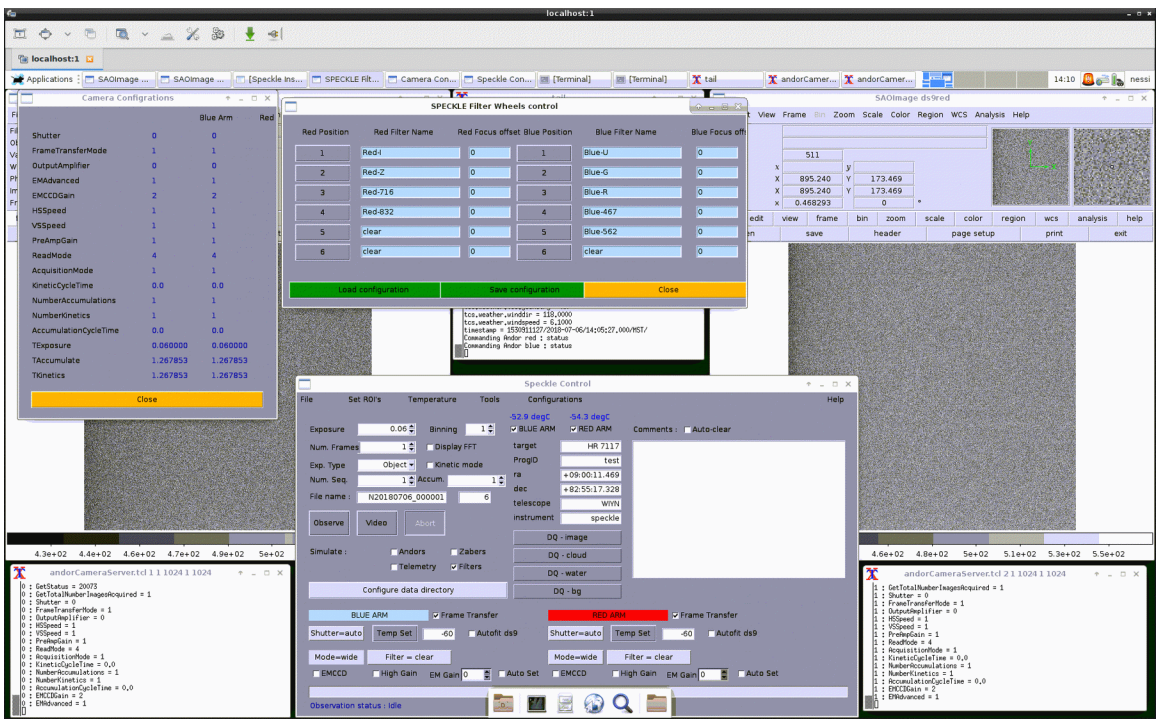
A recommend desktop layout is illustrated below. The main visible components are

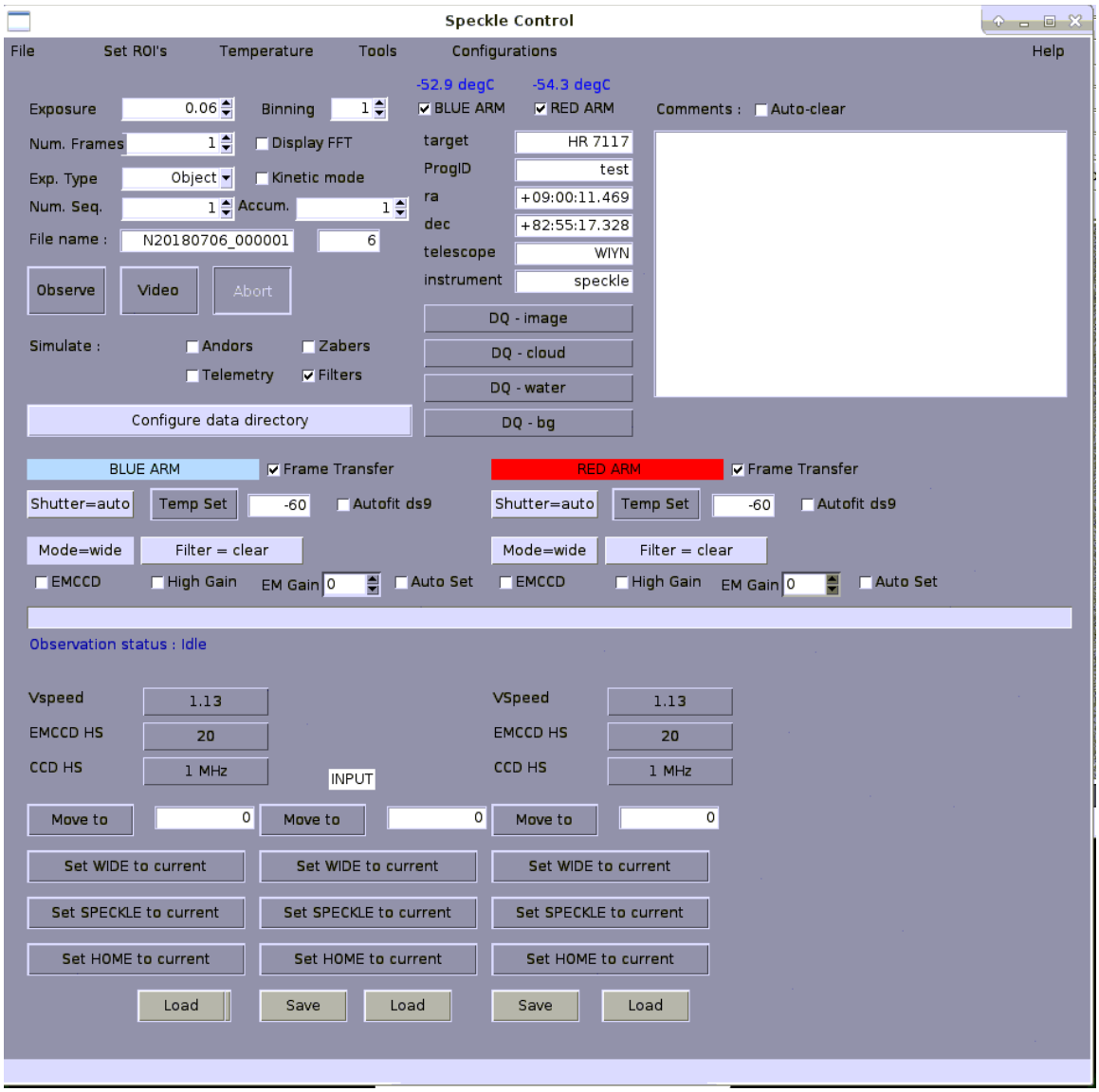
ds9red image viewer for the Red arm camera images.
ds9blue image viewer for the Blue arm camera images.
Top-center xterm showing the debug log.
Lower left xterm showing the Red camera server operations
Lower right xterm showing the Blue camera server operations.
Mid-screen main GUI window.



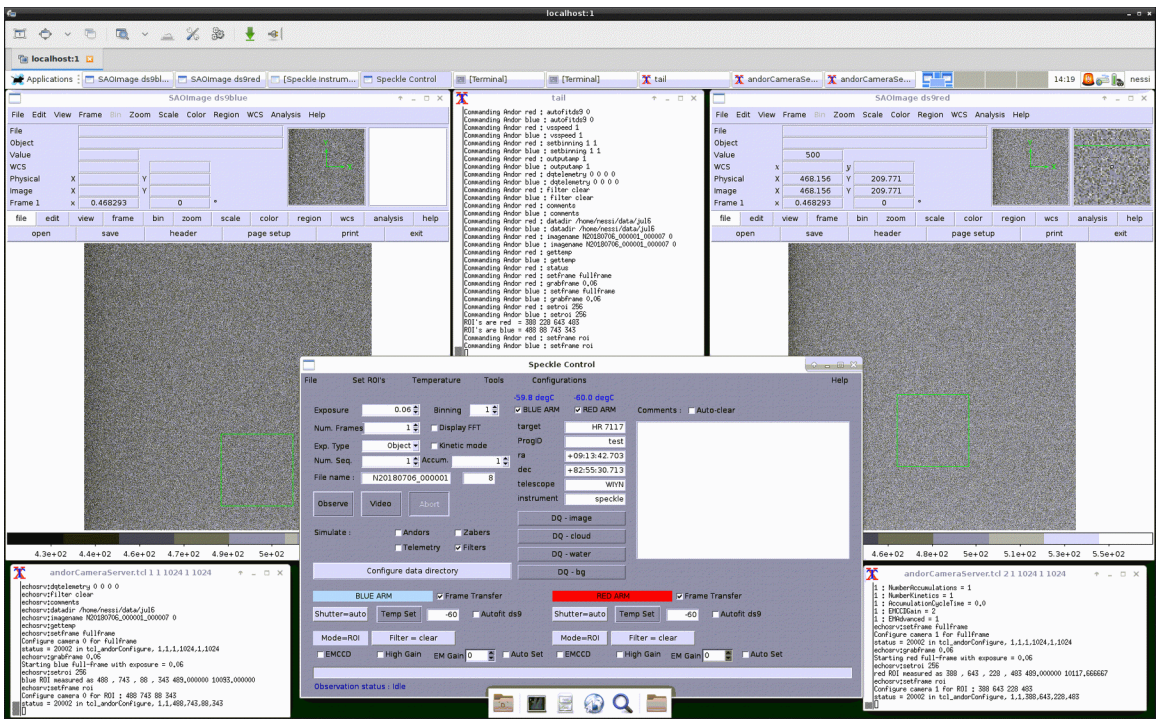
The following example also show typical popup windows for the Mimic diagram and Filter Wheels and Camera status windows.


localhost:1
SAOImage ds9blue
SAOImage ds9red
Speckle Instrument Configuration
clear
clear
1024x1024
-52.9 degC
1024x1024
-54.3 degC
Zaber A : 694000 : wide
Zaber B : 675026 : wide
Zaber Input : 1066667 : wide
Speckle Control
Observe
Video
Abort
Configure data directory
BLUE ARM
RED ARM
Frame Transfer
Observation status : Idle
andorCameraServer.tcl 1 1 1024 1 1024
andorCameraServer.tcl 2 1 1024 1 1024

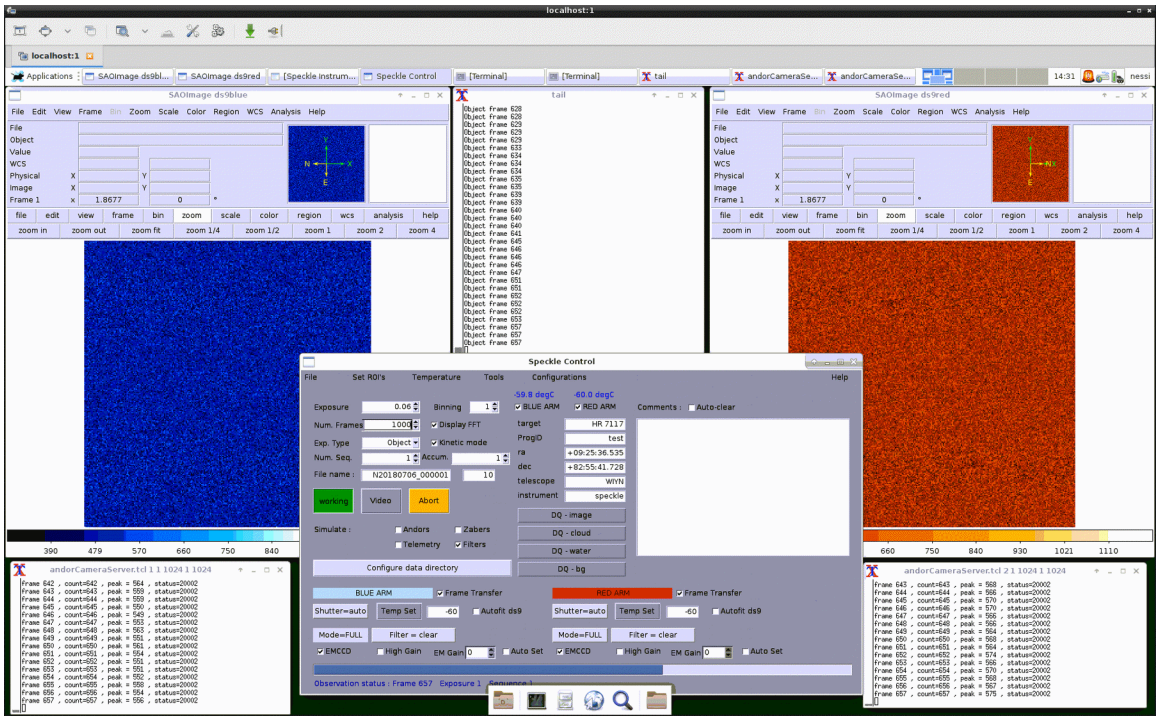

localhost:1
Camera Configurations
SPECKLE Filter Wheels control
Red Position
Red Filter Name
Red Focus offset
Blue Position
Blue Filter Name
Blue Focus offset
Lead configuration
Save configuration
Close
SAOImage ds9red
Speckle Control
Observe
Video
Abort
Configure data directory
BLUE ARM
RED ARM
Frame Transfer
Observation status : Idle
andorCameraServer.tcl 1 1 1024 1 1024
andorCameraServer.tcl 2 1 1024 1 1024


Speckle Control
File
Set ROI's
Temperature
Tools
Configurations
Help
-52.9 degC
-54.3 degC
Exposure
0.06
Binning
1
BLUE ARM
RED ARM
Comments :
Auto-clear
Num. Frames
1
Display FFT
target
HR 7117
Exp. Type
Object
Kinetic mode
ProgID
test
Num. Seq.
1
Accum.
1
ra
+09:00:11.469
File name :
N20180706_000001
6
dec
+82:55:17.328
telescope
WIYN
instrument
speckle
Observe
Video
Abort
DQ - image
Simulate :
Andors
Zabers
DQ - cloud
Telemetry
Filters
DQ - water
Configure data directory
DQ - bg
BLUE ARM
Frame Transfer
RED ARM
Frame Transfer
Shutter=auto
Temp Set
-60
Autofit ds9
Shutter=auto
Temp Set
-60
Autofit ds9
Mode=wide
Filter = clear
Mode=wide
Filter = clear
EMCCD
High Gain
EM Gain
0
Auto Set
EMCCD
High Gain
EM Gain
0
Auto Set
Observation status : Idle
Vspeed
1.13
VSpeed
1.13
EMCCD HS
20
EMCCD HS
20
CCD HS
1 MHz
INPUT
CCD HS
1 MHz
Move to
0
Move to
0
Move to
0
Set WIDE to current
Set WIDE to current
Set WIDE to current
Set SPECKLE to current
Set SPECKLE to current
Set SPECKLE to current
Set HOME to current
Set HOME to current
Set HOME to current
Load
Save
Load
Save
Load

This desktop shows an example of the appearance after an ROI selection , each ds9 window shows the chosen region, and the numeric parameters can be seen in the camera server log windows.

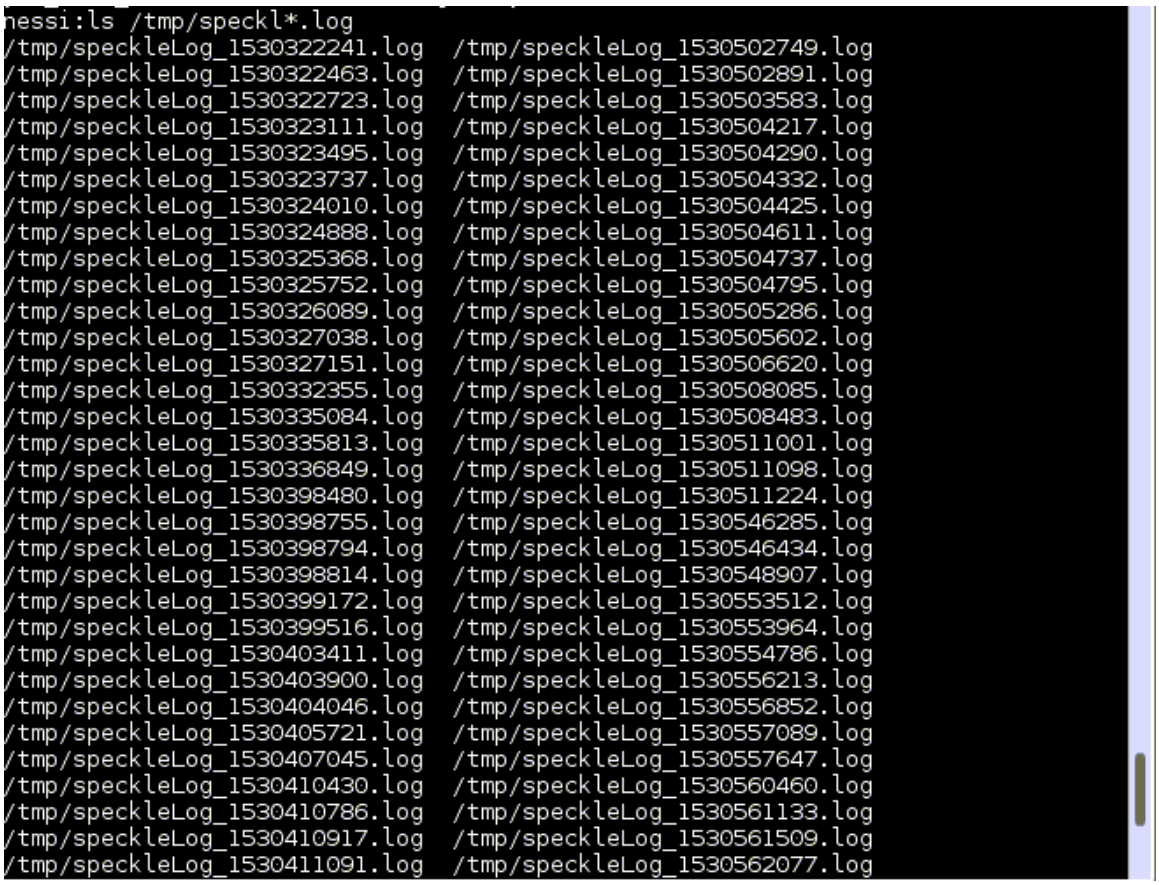


This desktop shows a typical observing sequence in progress, the progress bar and associated status update as the series progresses. Note that in this instance we are displaying the FFT instead of the raw image data.


localhost:1
SAOImage ds9blue
tail
SAOImage ds9red
Speckle Control
File
Set ROI's
Temperature
Tools
Configurations
Help
Exposure
Binning
Num. Frames
Exp. Type
Num. Seq.
File name :
working
Video
Abort
Simulate :
Andors
Zabers
Telemetry
Filters
Configure data directory
BLUE ARM
RED ARM
Frame Transfer
Shutter=auto
Temp Set
Autofit ds9
Mode=FULL
Filter = clear
EMCCD
High Gain
EM Gain
Auto Set
target
ProgID
ra
dec
telescope
instrument
DQ - image
DQ - cloud
DQ - water
DQ - bg
Comments :
Auto-clear
Observation status : Frame 657 Exposure 1 Sequence 1
andorCameraServer.tcl 1 1 1024 1 1024
andorCameraServer.tcl 2 1 1024 1 1024

5 Log files

All GUI controlled operations are logged to disk. The files are named according to the cpu clock at the startup and stored in the /tmp directory.



6. Command Line usage

There is a rich set of commands to allow interactive and scripted usage.
To access the command line it is necessary to source the *startspeckle-cmds* script from the speckle-control directory and then type

source gui-scripts/gui2.tcl

The following commands are available

Filter Wheel :

loadFiltersConfig [filename]
saveFiltersConfig [filename]
echoFiltersConfig
selectfilter arm filter-number
findWheels
resetFilterWheel arm

Zaber stages :

loadZaberConfig [filename]
saveZaberConfig [filename]
echoZaberConfig
zaberPrintProperties
zaberConnect
zaberDisconnect
homeZabers
zaberCheck
zaberSetPos name position
zabersStopAll
zaberGoto name station

Pico Stages : **Gemini only**

loadPicosConfig [filename]

savePicosConfig [filename]

echoPicosConfig

picosConnect

picoCommand axis cmd

picoSet axis parameter value

Andor Cameras :

Command may be issued from the GUI command line, scripted , or optionally by telnet to ports 2001, 2002. When using the command line the syntax is

commandAndor arm "command and parameters"

or *commandAndors "command and parameters"*

accumulationcycletime seconds

acquisition index

autofitds9 0/1

baseclamp 0/1

comments comment1|comment2|....

configure hbin vbin vstart vend hstart hend preamp vsspeed ccdhss emccdhss

datadir data-directory

dqtelemetry rawiq rawcc raqwv rawbg

emadvanced index

emccdgain 0/1

fastVideo exposure xs ys dim

fitsbits data-format

forceroi xs xe ys ye

frametransfer index

gettemp

grabcube exposure xs ys dim

grabframe exposure

grabroi exposure xs ys dim

hsspeed amp index

imagename image-name

kineticcycletime seconds

locatestar smooth dim

numberaccumulations count

numberkinetics count

outputamp index

positiontelem input-zaber field-zaber filter

preampgain index

programid program-id

readmode index

reset mode

setexposure seconds

setframe mode

setroi mode

settemperature degrees

shutdown

shutter index

status

version

vsamplitude index

vsspeed index

whicharm

7. Recompiling the shared libraries

Low level functionality is provided in C/C++ for speed , and this code is wrapped using tcl and loaded into the interpreter at runtime.
To move the code to a different version of Linux it may be necessary to recompile the libraries in the following directories. Each has either a Makefile or a set of build steps (e.g. andor/buildAndorWrap).

The Vips library may present more difficulty due to it's many dependencies.
The package can be recompiled using the GNU standard incantations

./configure --prefix=some-installation-directory --without-python
make install

If the configure step does not work , try

sudo apt install automake autogen m4
libtoolize
aclocal
automake --add-missing
autoconf

then try the ./configure step again.

8. Changing hardware components

If it becomes necessary to change out either Filter Wheel or Camera components, the appropriate configuration files will be adjustment. The configuration files are in the

$HOME/speckle-control directory

andorsConfiguration.[telescope]

filtersConfiguration.[telescope]

In each case the serial number information will need to be updated.

The Filter Wheel serial numbers can be found using the lsusb command

```
nessi:lsusb
Bus 001 Device 002: ID 8087:8001 Intel Corp.
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 003 Device 016: ID 05e3:0612 Genesys Logic, Inc. Hub
Bus 003 Device 017: ID 136e:0012 Andor Technology Ltd.
Bus 003 Device 018: ID 136e:0012 Andor Technology Ltd.
Bus 003 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 002 Device 003: ID 8087:0a2a Intel Corp.
Bus 002 Device 044: ID 104d:1011 Newport Corporation
Bus 002 Device 043: ID 104d:1011 Newport Corporation
Bus 002 Device 042: ID 0403:6001 Future Technology Devices International, Ltd FT
232 Serial (UART) IC
Bus 002 Device 041: ID 05e3:0610 Genesys Logic, Inc. 4-port hub
Bus 002 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
nessi:
nessi:
nessi:lsusb -v -s 002:043 | grep iSerial
  iSerial                 128 061D088E010F5400
nessi:lsusb -v -s 002:044 | grep iSerial
  iSerial                 128 1B18177A01135400
nessi:
```

The Andor Serial numbers can be found by examining the “dmesg” log at system boot time.

9.Database

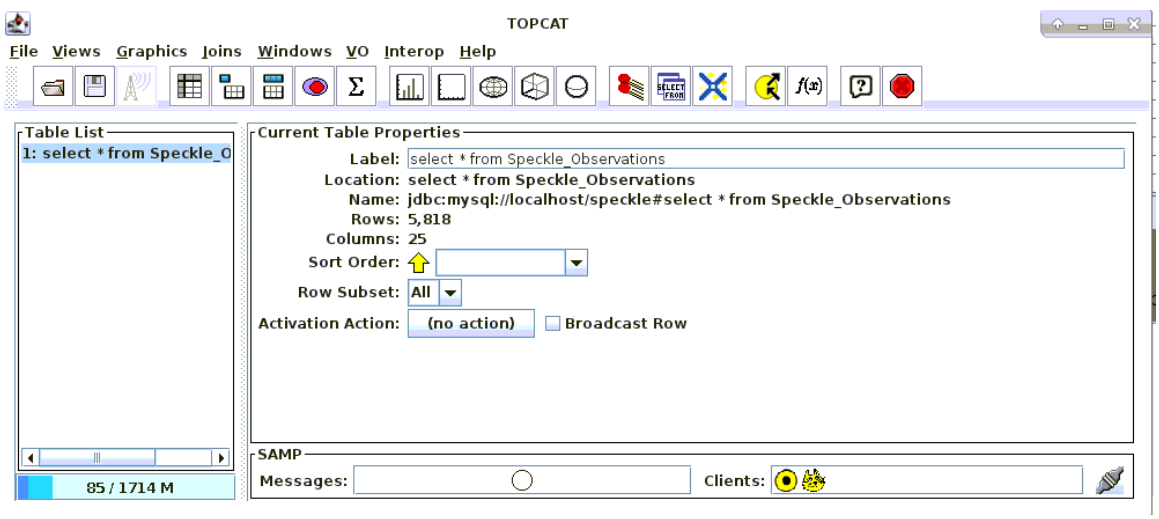
The camera servers automatically log information about each image to the on-board database (Mysql). The database is named “speckle” and the table name is “Speckle_Observations”. It can be viewed using the mysql command line program, or using the TOPCAT GUI.

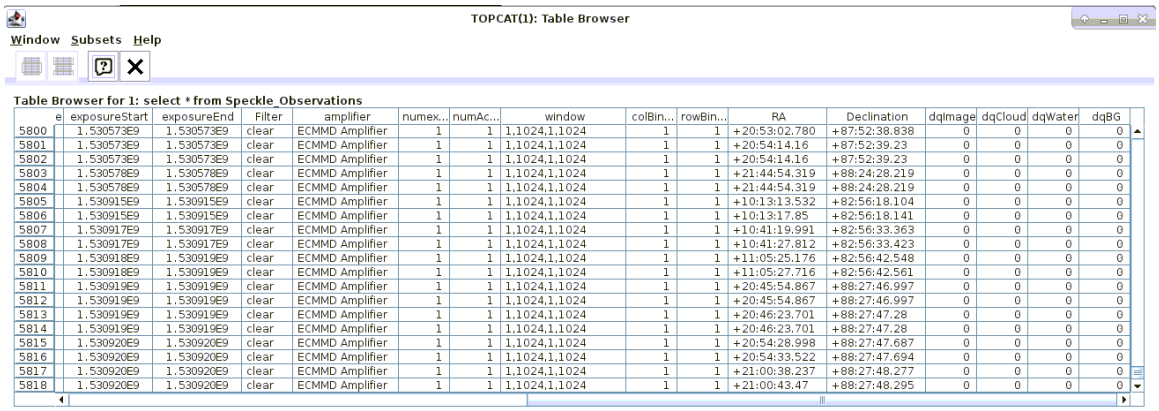
e.g.

mysql –user=root speckle

*select * from Speckle_Observations LIMIT 10;*

Or using the TOPCAT gui





e	exposureStart	exposureEnd	Filter	amplifier	numex...	numAc...	window	colBin...	rowBin...	RA	Declination	dqImage	dqCloud	dqWater	dqBG
5800	1.530573E9	1.530573E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+20:53:02.780	+87:52:38.838	0	0	0	0
5801	1.530573E9	1.530573E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+20:54:14.16	+87:52:39.23	0	0	0	0
5802	1.530573E9	1.530573E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+20:54:14.16	+87:52:39.23	0	0	0	0
5803	1.530578E9	1.530578E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+21:44:54.319	+88:24:28.219	0	0	0	0
5804	1.530578E9	1.530578E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+21:44:54.319	+88:24:28.219	0	0	0	0
5805	1.530915E9	1.530915E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+10:13:13.532	+82:56:18.104	0	0	0	0
5806	1.530915E9	1.530915E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+10:13:17.85	+82:56:18.141	0	0	0	0
5807	1.530917E9	1.530917E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+10:41:19.991	+82:56:33.363	0	0	0	0
5808	1.530917E9	1.530917E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+10:41:27.812	+82:56:33.423	0	0	0	0
5809	1.530918E9	1.530919E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+11:05:25.176	+82:56:42.548	0	0	0	0
5810	1.530918E9	1.530919E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+11:05:27.716	+82:56:42.561	0	0	0	0
5811	1.530919E9	1.530919E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+20:45:54.867	+88:27:46.997	0	0	0	0
5812	1.530919E9	1.530919E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+20:45:54.867	+88:27:46.997	0	0	0	0
5813	1.530919E9	1.530919E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+20:46:23.701	+88:27:47.28	0	0	0	0
5814	1.530919E9	1.530919E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+20:46:23.701	+88:27:47.28	0	0	0	0
5815	1.530920E9	1.530920E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+20:54:28.998	+88:27:47.687	0	0	0	0
5816	1.530920E9	1.530920E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+20:54:33.522	+88:27:47.694	0	0	0	0
5817	1.530920E9	1.530920E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+21:00:38.237	+88:27:48.277	0	0	0	0
5818	1.530920E9	1.530920E9	clear	ECMMD Amplifier	1	1	1,1024,1,1024	1	1	+21:00:43.47	+88:27:48.295	0	0	0	0