

3 Observing Cookbook

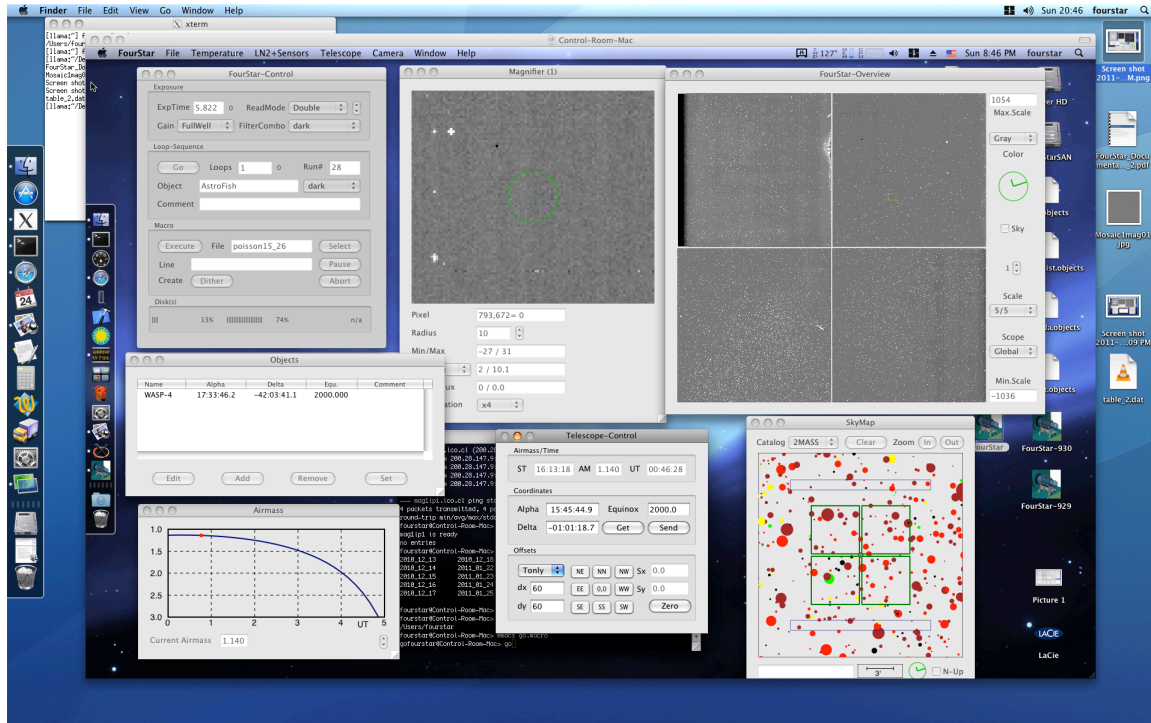
3.1 Quick Tips/Hints

1. An external USB hard drive is the most effective way to transfer data. Depending on the mode of operation a typical observing run can generate 20-100GB and the mountain network is not designed to handle data transfers of this size to home institutions. A DVD/Blu-Ray writer is also available.
2. For point sources, the bright magnitude limits are roughly 11th – 12th magnitude for the J, H and Ks filters.
3. By default, the rotator mode should be “OFFSET”. This means North will be up, East will be left when pointing South of a declination of -29.0. If pointing North of -29.0 the orientation will be: North down, East right. Other rotation angles can be specified in the target list.
4. For targets that pass through/near (3-degrees) the zenith the telescope will need to be moved and the target re-acquired once it has cleared the zenith. This is a good time for a standard star!
5. For point sources that need to be offset from the optical axis, we recommend using chip 2.
6. An exposure time calculator is available at:
<http://obs.carnegiescience.edu/instrumentation/FourStar/calc.html>
7. There is currently no official reduction pipeline for these data, but it is coming!

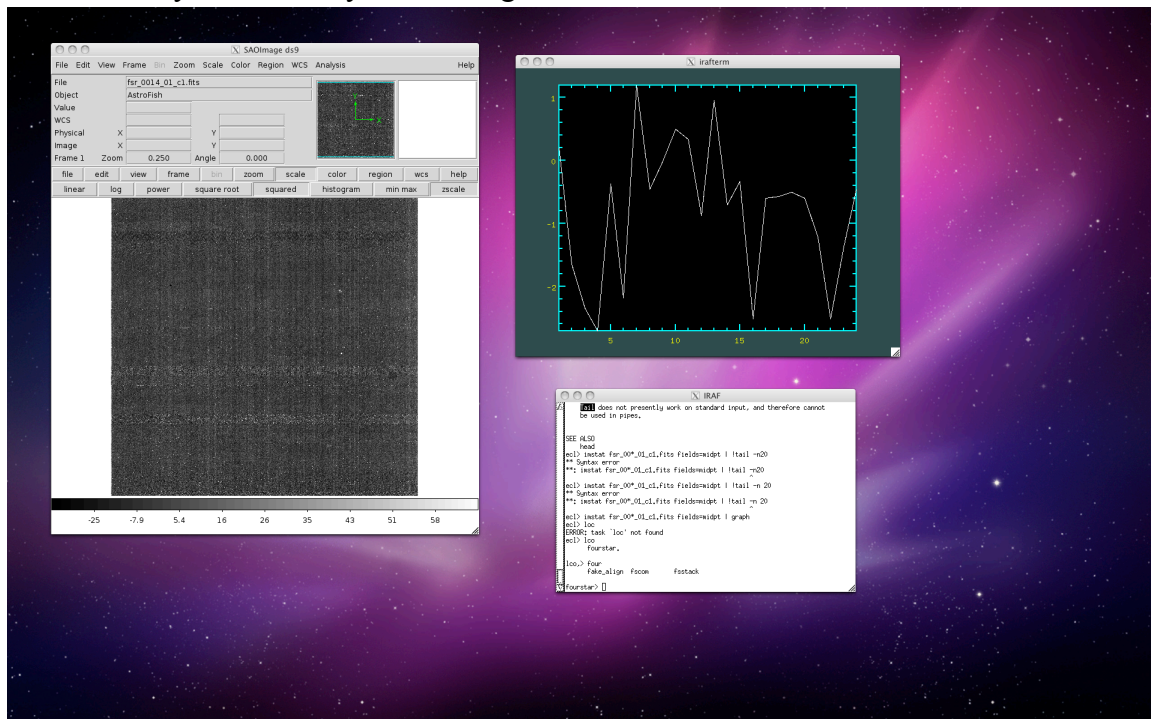
3.2 Control Room Computers

When you arrive in the control room, FourStar should be ready for you to use. Either of the control room computers (Burro or Llama) should be connected to the FourStar Control-Room-Mac.

- The primary monitor should show the screen-sharing window, which should display a number of smaller windows pertinent to FourStar.



- The secondary monitor may be showing an IRAF session.



3.3 Target List

It isn't necessary to load a target list into the FourStar interface, you can simply tell the telescope operator where to go or provide them with a list. But it is useful to have a list loaded in FourStar.

- A target list may be created prior to arriving. All that is needed is a simple text file containing the following columns (separated by a pipe |): Object name, RA, DEC, EQUINOX, POSITION ANGLE, comment (optional). The coordinates can be sexigesimal or decimal and the filename extension should be “.objects”. An example target list with the filename:

strange.objects

```
something | 10:00:00 | -56:00:00 | 2000 | 0 |
```

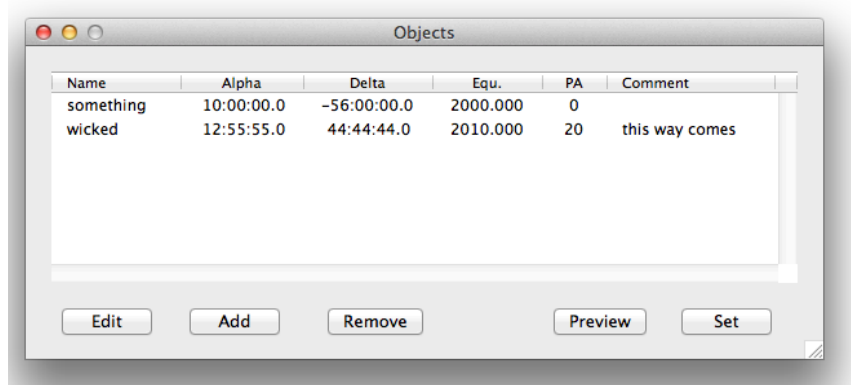
```
wicked | 12:55:55 | 44:44:44 | 2010 | 20 | this way comes
```

To load the file upon arrival, it is best to transfer the file you created to the FourStar Computer one of these recommended ways:

- Place the file on a USB drive and insert the drive into the FourStar USB hub in the Control Room. Copy the file from your USB drive to the FourStar Desktop.
- If you brought a laptop and are connected to the network you can scp the file to the FourStar computer. Note: The control room computers ignore incoming ssh requests thus you may only ssh/scp **from** the FourStar computer. For example:

```
fourstar@Control-Room-Mac> scp user@dl08-49.lco.cl:/path/to/list.objects /Users/fourstar/Desktop
```

With the file now locally available you can select it from the FourStar File menu: Open ObjectList... (or ⌘O). The list can be sorted by RA (Alpha), or any header title by clicking on the header title (Alpha, for example). The order can be reversed by clicking it again.



- A new empty target list may also be created from the File menu.
- Once a file is open, objects can be (Add)ed / or (Edit)ed using the buttons on the bottom of the window.

3.3.1 Permanent Target Lists

There are a few standard target lists that are available in the ~/Desktop/fs_objects folder. These are:

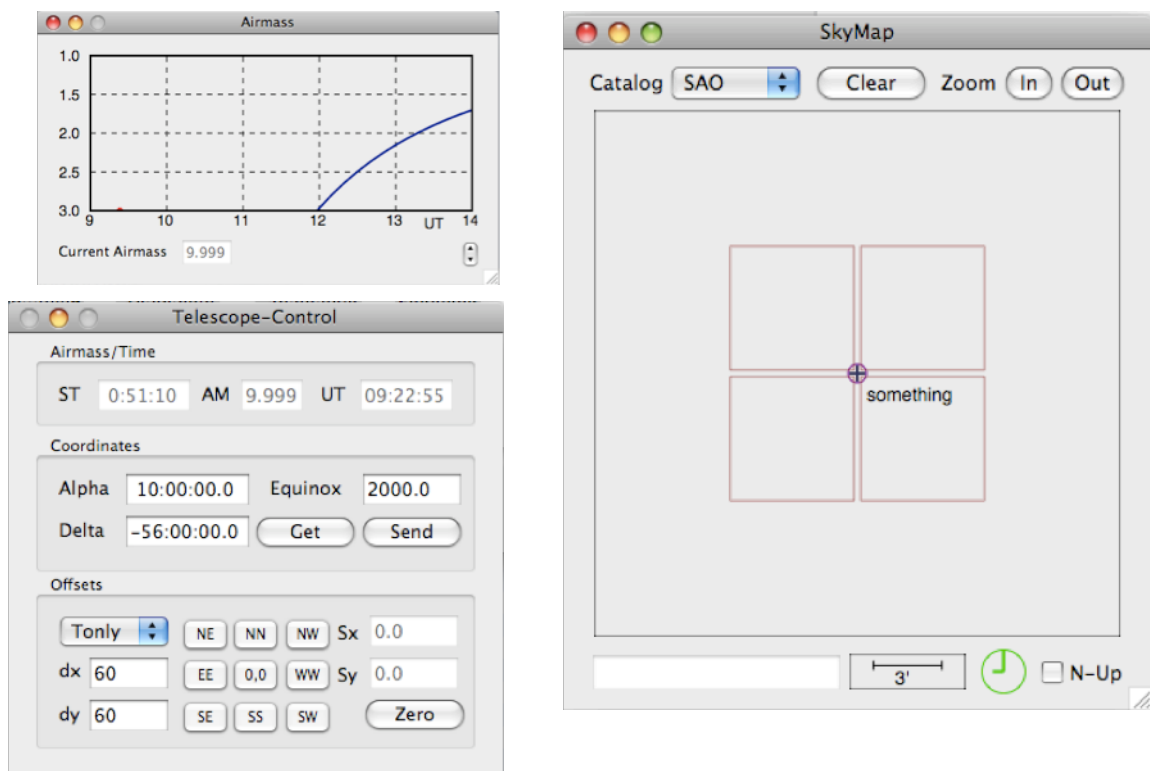
- twiflats.objects: A list of (relatively) sparse fields for flat-fielding in the sky.
- standards.object: A list of HST ([CALSPEC](#)) spectro-photometric standards with magnitudes determined by convolving the observed/model spectrum with the FourStar filters profiles.

3.3.2 Previewing an object in the Target list

Select an entry in the object list and click “Preview”. The Telescope-Control and SkyMap palettes will center on the object's coordinates and the airmass tool will update showing the current airmass and projected airmass for the selected object. The image header information will not be updated in the FourStar-Control window.

3.3.3 Moving to an object in the Target list

1. Select an entry in the object list and click “Set”. The Telescope-Control and SkyMap palettes will center on the object's coordinates and the airmass tool will update showing the current airmass and projected airmass for the selected object. The image header information will also update.



2. If the field / airmass look correct then click the “Send” button in the Telescope-Control window to send the coordinates to the telescope operator and they will slew the telescope.

3.4 Placing the Target in the Right Spot

The telescope coordinates are centered on the gap between all four FourStar detectors. Thus, if your object is a point or otherwise compact source or you will want to offset to one of the other arrays. If you are observing an extended object and plan on dithering to cover the gap then this should not be a problem.

We currently recommend using chip 2 for placing targets that only require one array. Once an object has been acquired by the telescope inform the Telescope operator that you will be applying an offset so they don't start guiding yet. Verify the orientation and position by clicking the “Get” button and viewing the current telescope position/orientation in the SkyMap tool. Set the dx and dy offsets to 170 each and select Tonly. If North is up then you want to click the “NE” button to move the telescope NE and place the object on chip 2.

If the rotation is arbitrary and you don't want do a coordinate rotation transformation in your head, then hold the control-key down and click in the SkyMap window where you want the telescope to be relative to your object. The Sx and Sy boxes should have updated the necessary offsets. Click the “0,0” to move the telescope to the position you selected.

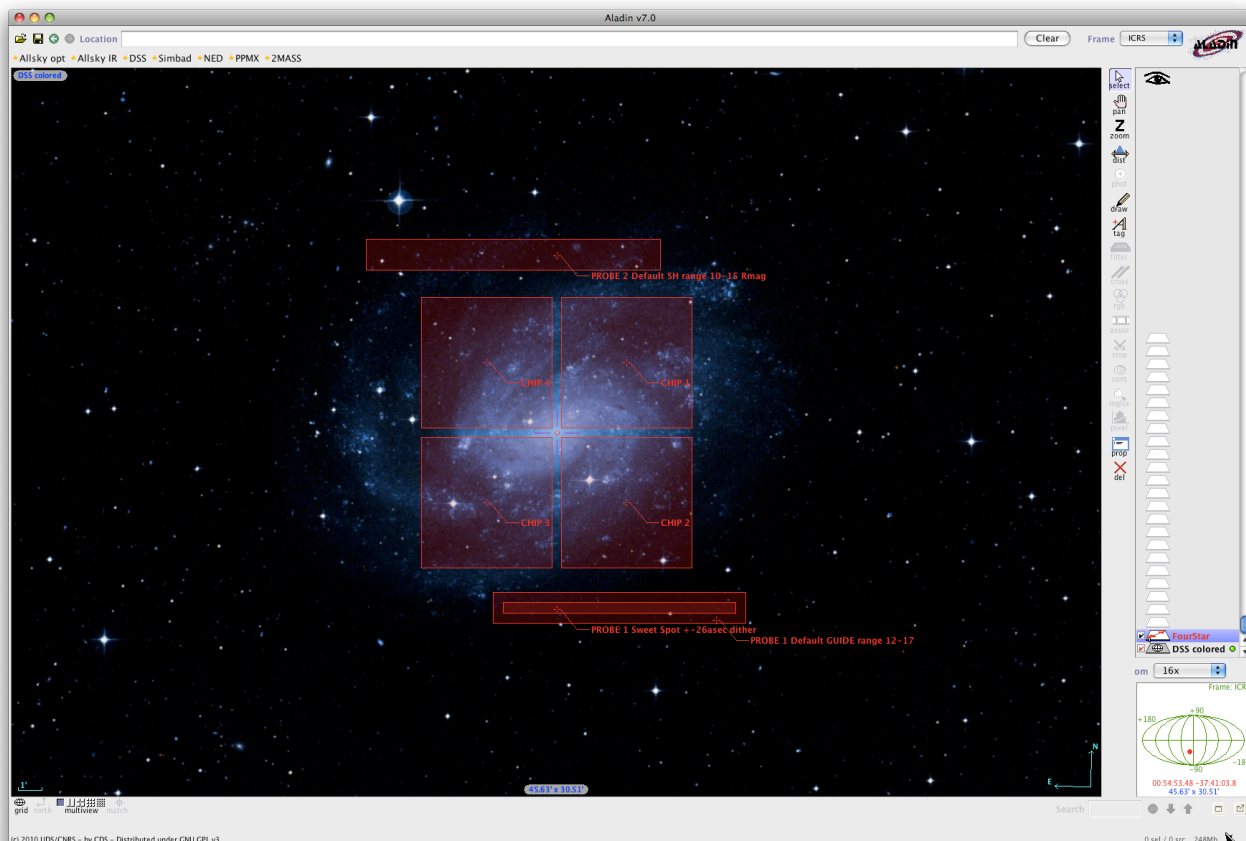
Once you have the object centered where you want you may consider clicking the “Zero” button. This will zero the offsets such that you can return to this location by clicking “0,0” again should a macro get aborted in the middle of a sequence and is left offset from the original position.

3.4.1 Using ALADIN

We recommend using the ALADIN sky atlas tool to assist in planning observations. The tool can be accessed via the web or downloaded and used locally; the website is: <http://aladin.u-strasbg.fr/>

In the example below ALADIN has been installed on a local machine. Apparently, running ALADIN locally requires a bit of RAM (~1GB) so the web version may work better if you have less than 1GB of RAM on your computer.

1. In the main ALADIN window, type the coordinates or name of the object you wish to observe.
2. Load the [FourStar.fov](#) file to overlay the FourStar footprint on the sky.
3. Rotate the field of view to the desired position angle.
 - If your target declination is less than -29:02:00 (the observatory's latitude) then the default roll angle will be 0° (North up, East left).
 - If your target declination is greater than -29:02:00 then the default roll angle will be 180° (South up, West left).
4. Adjust the position of the FourStar fov until a suitable guide star is found the “sweet spot” of the guider field and a suitable Shack-Hartmann star is found in the Probe-2 region.
5. Record the position of the FourStar footprint by either reading the cursor value near the center of the fov or by “right-clicking” the fov layer on the right of the screen



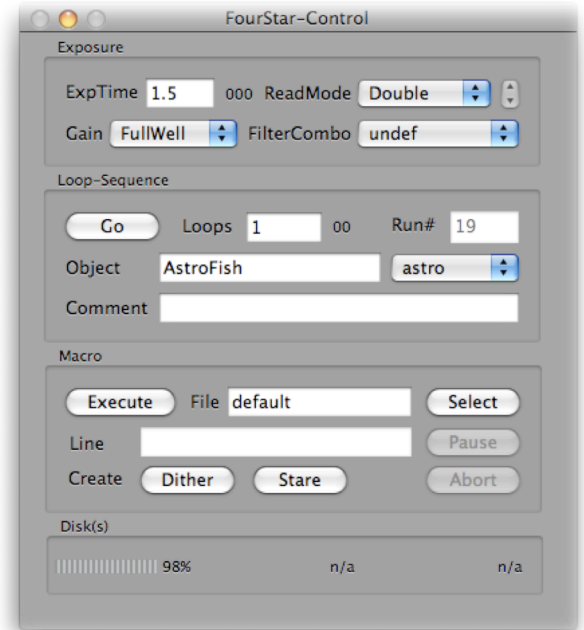
3.4.2 Using DS9

Coming soon!

3.5 Taking an Image

In the FourStar-Control window, set the parameters for the exposure.

1. Gain: For most observations, the default Gain, FullWell, is recommended. Only in cases with faint sources and low background counts will the LoNoise gain be warranted. The LoNoise option provides ~16 electron read noise versus 21 electrons for Fullwell.
2. ReadMode: the default, CDS, is recommended; see 6.14-Read-Out Schemes for details.
3. FilterCombo: select the desired filter.
4. ExpTime: set the exposure time. It will default to the nearest possible exposure time possible. We generally don't recommend taking exposures shorter than 5.8 s if it can be avoided, since the saturation limit goes as: $1/(1+1.456/\text{ExpTime})$. Thus, for a 1.456s exposure the saturation limit is half of nominal well-depth. An exposure time calculator is available at: <http://obs.carnegiescience.edu/instrumentation/FourStar/calc.html>
5. Loops: The number of repeats to take at the current position. If running SH, we recommend this number be $\sim(60\text{s} / \text{ExpTime})$, that is, stay at each dither position at least a minute.
6. Go: Take a series of (Loops)-number of exposure at the current position, no dithering.



3.5.1 Using Dither Macros

To create pre-packaged dither patterns click on the “Dither” button on the FourStar-Control panel. A panel will appear as shown in Figure 3.1.

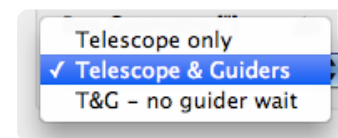
The two boxes within the Create-Macro GUI contain the following:

Dither: Defines the dither step details.

1. Step [”]: The step size in arc-seconds between dithers; the default is 26 and is generally a good size. There is a 19” gap between the arrays so this will create an overlap.
2. Pattern: see Figure 3.2 for example patterns.
 - a. dice5-30: A square-5 pattern rotated by 30 degrees E of N. The 30-degree angle is adjustable.
 - b. square9-30: A square-9 pattern rotated by 30 degrees E of N. The angle is adjustable. The angle allows for better filling of the chip gaps. If you are observing at a position angle of 30-degrees you may want to change this to 0-degrees to achieve the relative dither rotation.
 - c. random-N: A random pattern, starting at the current location and returning to the current location
 - d. poisson-N: A Poisson random, uniformly spaced dither pattern, it does not include the current location, but returns to it when finished.



3. Box Geometry [”]: only applicable with the poisson method. It defines the rectangular box dimensions that the random points should lay within.
dX: box width of random distribution along the E-W direction
dY: box width of random distribution along the N-S direction.
4. Movement options:
 - Telescope only: Only moves the telescope, no guiding, or SH, usually used for sky-flat dither patterns and standard star patterns.
 - Telescope & Guiders: Select this if you want to use coordinated guider moves. This is used when guiding and running SH. There is a ~12s overhead while the guider moves and locks.
 - T&G – no guider wait: **Experimental**, but good results so far. Starts an exposure after the telescope moves, ~2s overhead.
5. Pause After: Pause after a move before starting an exposure. Gives the user a chance to verify that the telescope has re-acquired the guide star and everything is okay.

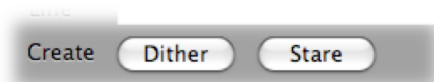


Extended Source: Defines whether to include off-target dithers for background measurements.

1. Checkbox: select if you need to move off source to get background; i.e. extended sources.
2. On Sky Pattern: select a different dither pattern for the sky observations.
3. Sky-Offset [”]: the amount in arc-seconds to move off source E-W | N-S
4. Order: The order to perform the Sky – Object – Sky observations.
5. Cycles: The number of times to repeat the S-O-S cycle.

3.5.2 Using Stare Macros

A stare pattern is where you stare the same place without dithering. Useful for dome flats or times when you want to keep an object at the same place. To create stare patterns click on the “Stare” button on the FourStar-Control panel. A panel will appear as shown in Figure 3.1.



The settings that appear are:

- ExpTime: Set the exposure time of each image in the current configuration, Leave blank to use current exposure time.
- Filter: Either Leave alone or select a new filter.
- Loops: Set the number of loops, currently the maximum is 64.
- Repeats: The number of times to repeat this same combination. Just like hitting “Go” n-times.

The + and – buttons let you add or remove more sequences (up to 10). When you click “Done” the macro will overwrite the “stare.macro” file and load automatically. Click “Execute” to begin.

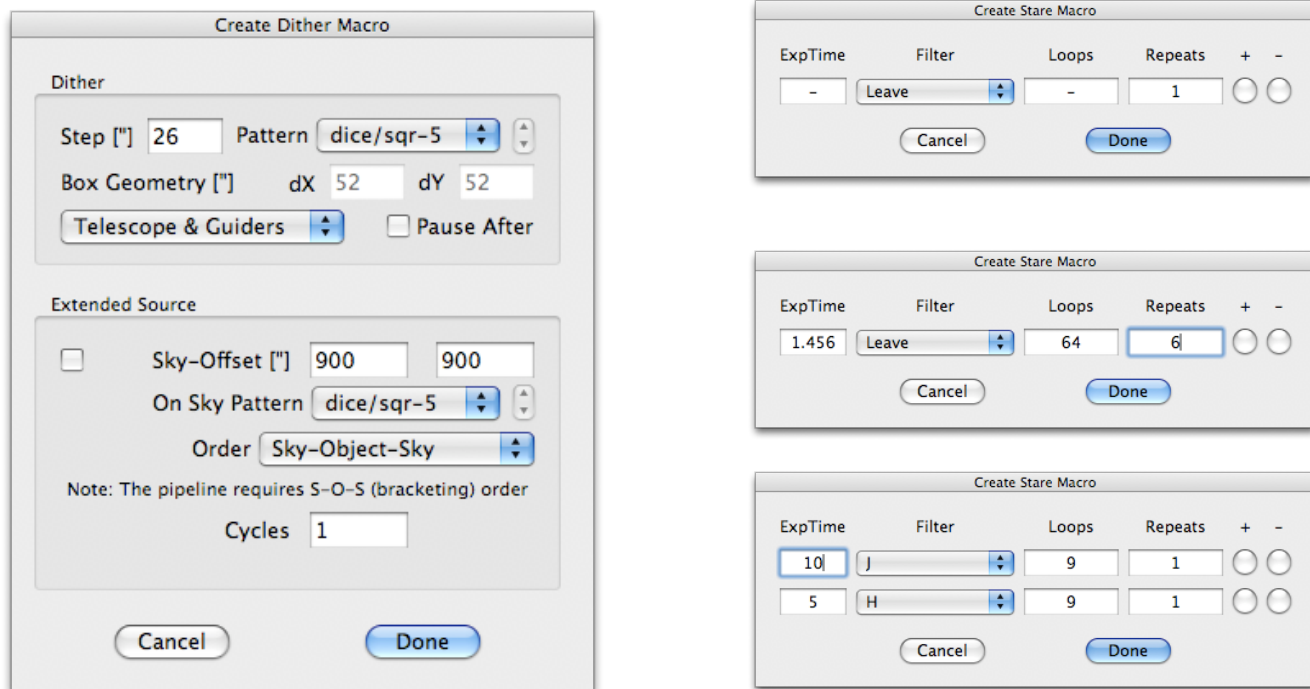


Figure 3.1 Create Macro and Create Stare options box.

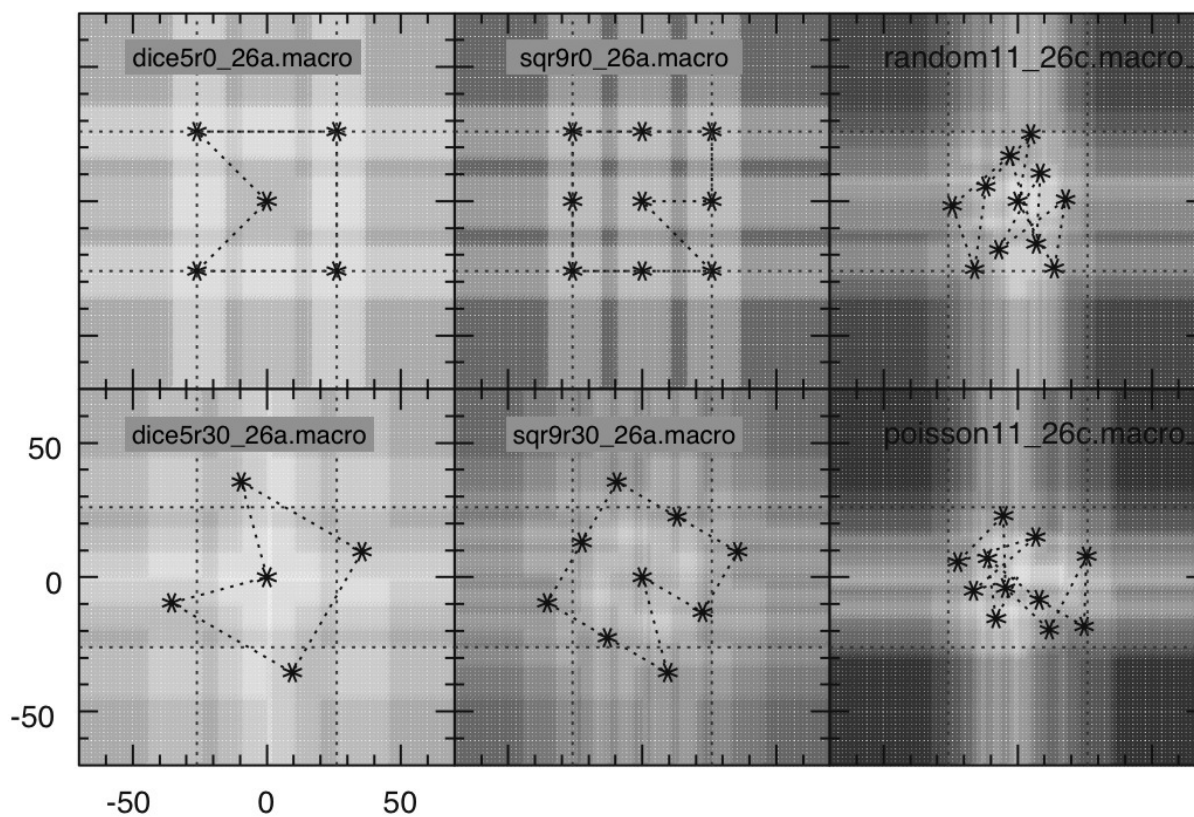


Figure 3.2 Representative dither patterns available.

3.6 Displaying the Image

The FourStar-Overview window automatically displays the most recent image. The Magnifier window allows for quick region of interest statistics, such as average background counts; see 6.1.2.1-Quicklook and Magnifier Display.

3.6.1 Using DS9

Do not try to open the image with DS9 or use IRAF from within the screen-sharing session. The VNC protocols do not play nicely with the X-windows protocols. Instead, using Burro or Llama open a terminal and type the command:

```
[burro:~]obs?% 4star  
fourstar@Control-Room-Mac> goiraf
```

3.6.2 Using IRAF

Some simple quick-look scripts have been created using IRAF. These scripts are intended for quick-look purposes only and should not be used to create data products. Upon starting IRAF the directory will automatically be changed to the most recent date and the relevant packages will be loaded.

3.6.2.1 FSCOM script

This script subtracts (default) one image from another using the imarith function and then (optional) mosaics the 4 images together to create a quick-look image for the field. It also runs SExtractor on the output image and decides if the image is in focus and responds with a corrective action if needed. This is useful for focus or quick image identification.

Examples:

```
cl>fscm 5 4
```

subtract fsr_0004_01_c?.fits from fsr_0005_01_c?.fits, creates a mosaic image called 0005_0004.fits and launches an imexam session for that mosaic image.

```
cl>fscm 0 0
```

subtract “second latest image” from “the latest image”, creates a mosaic and launches an imexam session for that mosaic image.

```
cl>fscm 0 0 c=2
```

subtract “second latest image” from “the latest image”, for chip 2 only and launches an imexam session for that image.

The output message from fscm should state the average fwhm for however many stellar-like sources it found. Also, it should report an average ellipticity and a suggestion about what to do.

Example fscom output: Change the focus.

```
The average fwhm (28 stars) is  3.96 pixels or  0.63 arcseconds
The average ellipticity is    0.12 with an angle of  49.04 degrees.
At a rotation of 180 this corresponds to  49.04 degrees N of E,

Suggest moving focus 0.7 more positive.
```

Example fscom output: Focus is good.

```
The average fwhm (32 stars) is  3.44 pixels or  0.55 arcseconds
The average ellipticity is    0.02 with an angle of  36.11 degrees.
At a rotation of 180 this corresponds to  36.11 degrees N of E,

The average ellipticity looks okay (<0.1), focus is probably good
The image is displayed and imexam is running (hit "q" to exit) The WCS is
loaded and should be accurate to 10"
```

Example fscom output: If the ellipticity is not along the typical astigmatic direction then the focus may be okay, but there are telescope vibrations from wind or guiding errors.

```
The average fwhm (10 stars) is  6.11 pixels or  0.97 arcseconds
The average ellipticity is    0.10 with an angle of  14.31 degrees.
At a rotation of    0 this corresponds to  14.31 degrees N of E,

The ellipticity along this axis may be due to Telescope Shake or Guiding
Errors. If the wind is high try closing some of the louvers, then try again.
```

Of course, just because the output says something, it is still up to the observer to decide if the images are actually okay or not, which is why the image is displayed in imexam by default. The observer should use the “e” and “r” keys over a star to see if the image quality is acceptable.

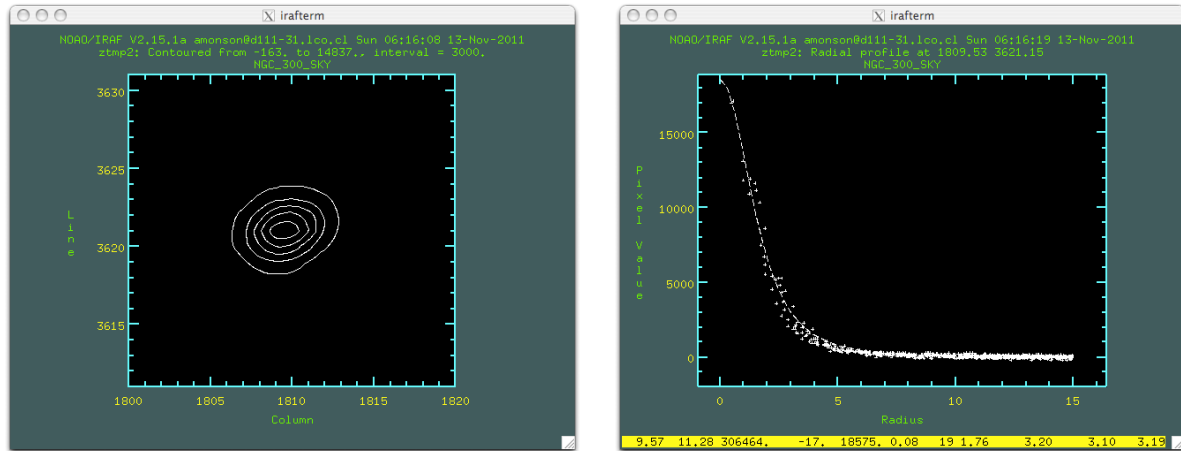
3.6.2.2 Am I in Focus?

The FourStar system has some astigmatism, so there is noticeable ellipticity to point sources when they are on one side of focus or the other; see Figure 3.3. The nominal focus values are provided in Table 3-1 and should be very close to correct. Corrections from these values are usually less than 2.0 (the units are in mm) and typically increments of 0.5 are good enough.

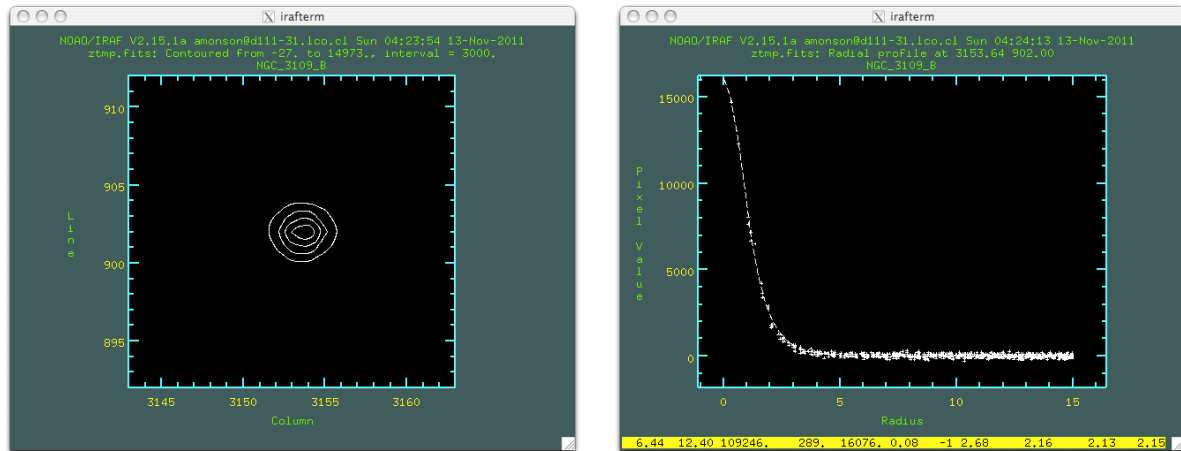
When moving to a new filter, let the telescope operator know which filter so they can move to the correct focus position. If a new focus is desired, ask the telescope operator to change to the new focus value. If, for example, the focus is currently -18.5 and fscom suggests moving 0.7 more positive then ask the operator to change to a focus of -17.8.

Figure 3.3 Focus Examples for the default rotation angle (0 or 180).

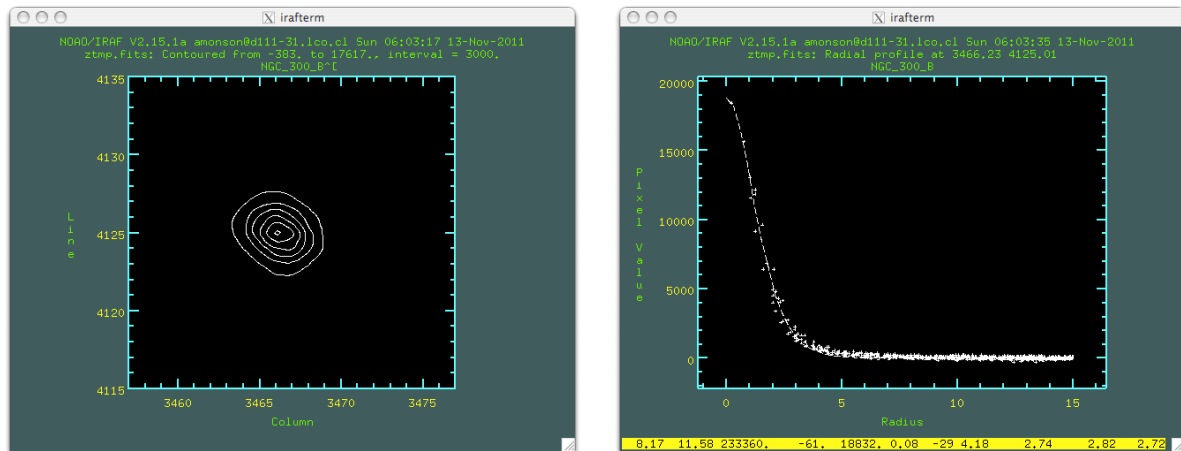
Out of Focus. The stellar contours are elongated lower-left to upper-right and the radial profile has some scatter. Focus should be moved positive by 0.5 units.



Good Focus. The stellar contours are circular and the radial profile is sharp and clean.



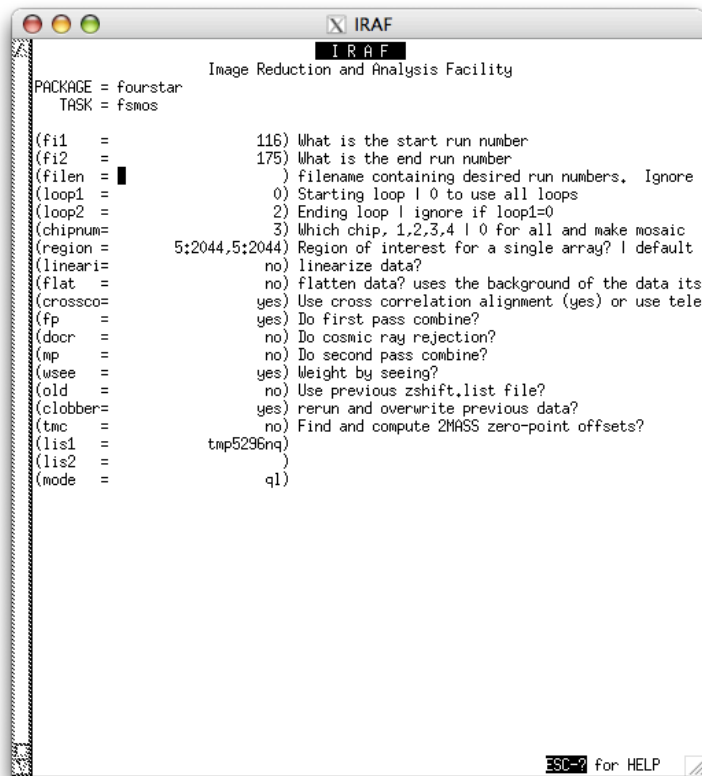
Out of Focus. The stellar contours are elongated upper-left to lower-right and the radial profile has some scatter. Focus should be moved more negative by 0.5 units.



3.6.2.3 FSMOS script

This script uses the IRAF task `xdimsum` to co-add multiple (dithered) images together to create a background-subtracted image for one of the arrays (multiple arrays not implemented yet). The background is subtracted from each image and then those images are combined together using telescope offsets found in the header or, optionally using cross-correlation (takes longer). This is useful for creating deeper quick-look images. Currently all parameters must be set editing the `fsmos` parameter file using: `epar fsmos`

Example:



Combine the runs 116 through 175 for chip 3. Co-add all the loops within each run first. Use the entire active imaging area. To save time don't linearize, flatten, cosmic ray reject or do a second pass. Weight the images by their average fwhm for the final combine step.

The `tmc` option will find the 2MASS stars in the field and bring up an interactive display to find the photometric zero-point of the image.

3.7 Official Reduction Pipeline

FourStar REDuction (FSRED) is available on the mountain and available for download from the FourStar website (<http://instrumentation.obs.carnegiescience.edu/FourStar/SOFTWARE/reduction.html>) for use at home institutions. The pipeline is primarily a set of c-shell (.csh) scripts which call IRAF tasks such as `imcombine` and a few other custom C executables. It also makes use of SExtractor, SCAMP and SWARP for resampling and alignment. All necessary executables are bundled in the FSRED package, one simply needs to execute the install script to install all needed software on their computer, if it does not already exist.

3.7.1 Running FSRED at LCO, accessing Data-Red-3

If you are observing at LCO and want to run the FSRED pipeline it is necessary to screen-share to Nasmyth-Mac; a FourStar computer. From either the Mac Mini's from the "obs" account. Do the following:

- On the mac mini from the Finder application under the Go menu, click Connect to Server (or ⌘K). Enter or select the Server Address: **vnc://observer@fourstarfw:60002** and click Connect. Enter the password "@bserver" in the pop-up dialog box.
- From a Terminal "cd" to the ~/Data directory and make a new directory for the data, preferably with the same date format as the raw data:
-

3.8 Data Transfer

We recommend plugging an external USB drive to the FourStar USB hub in the Control Room. The disk should appear on the Desktop of the Control-Room-Mac screen-sharing window. The recommended procedure is to rsync the data periodically throughout the night from a terminal on the Control-Room-Mac.

All data:

```
fourstar@Control-Room-Mac> rsync -av --modify-window=2 ~/Data/2011_09_07 /Volumes/USER_DRIVE
```

The raw data:

```
fourstar@Control-Room-Mac> rsync -av --modify-window=2 ~/Data/2011_09_07/fsr*  
/Volumes/USER_DRIVE/2011_09_07
```

If you have a laptop on the network and want to copy data directly to your laptop, determine your laptops address:

All data:

```
fourstar@Control-Room-Mac> rsync -av --modify-window=2 ~/Data/2011_09_07 user@d108-  
49.lco.cl:/Volumes/USER_DRIVE
```

The raw data:

```
fourstar@Control-Room-Mac> rsync -av --modify-window=2 ~/Data/2011_09_07/fsr* user@d108-  
49.lco.cl:/Volumes/USER_DRIVE
```

- The `-a` option (archive) is necessary to prevent overwriting the data on subsequent repeats of the command, `-t` would also work, but `-a` preserves all file links if they exist.
- The `-v` option simply sets the verbosity and allows the user to view the files being copied.
- The `--modify-window=2` option only replaces files if the local copy is more that 2 seconds newer than the remote copy. The default setting is zero and re-writes the data if the remote disk is FAT32 since the time stamp on FAT32 is only accurate to ± 1 s.

3.9 Recommended Strategies and Procedures

We recommend using Gain=**FullWell** and ReadMode=**Double** for most observations. Only for the NB1.18 or the NB 2.09 filters should other modes be considered.

We recommend a minimum Fourstar exposure time of 5.822s, even for FLATS. This allows for a larger dynamic range.

An exposure time calculator is available:

<http://obs.carnegiescience.edu/instrumentation/FourStar/calc.html>

The basic imaging characteristics are presented in Table 3-1, which provides some typical values for exposure information.

Table 3-1 Suggested parameter values for FourStar.

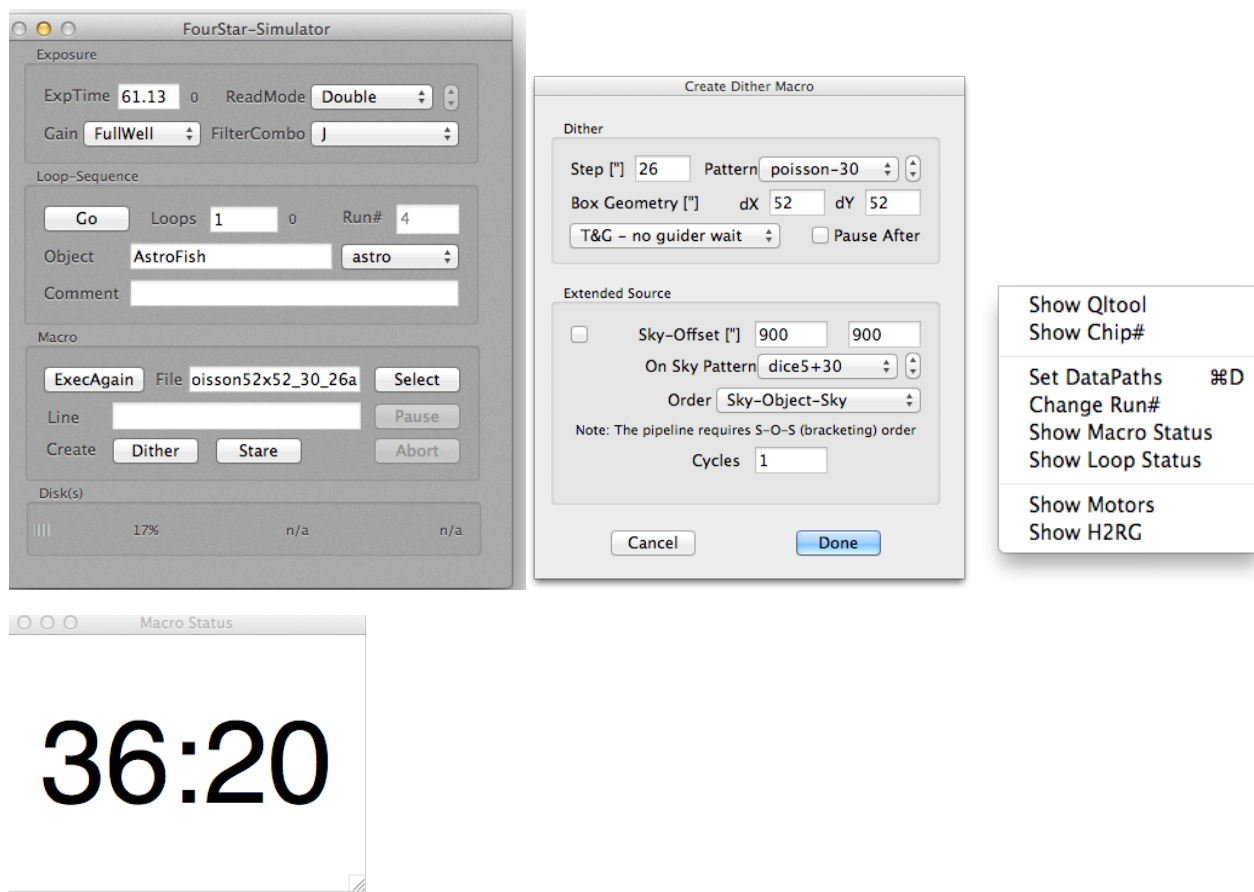
Filter	Focus offset P2 default	Focus offset P1	Gain	Mode	Sky Lo DN/s	Sky Ave DN/s	Sky Hi DN/s	ZP Vegamag DN/s	k'	Bright Limit (vegamag)
J	-18.5	-16.0	FullWell	CDS	100	125	150	26.15	0.10	11.0
H	-18.5	-16.0	FullWell	CDS	150	200	250	25.84	0.05	11.3
Ks	-21.0	-18.5	FullWell	CDS	300	450	600	25.02	0.05	11.5
H1	-19.1	-16.6	FullWell	CDS	70	95	120	25.16	0.05	11.5
Hs	-18.7	-16.2	FullWell	CDS	70	95	120	25.30	0.05	11.3
J1	-19.5	-17.0	FullWell	CDS	30	40	50	25.66	0.10	11
J2	-19.5	-17.0	FullWell	CDS	30	40	50	25.64	0.10	11
J3	-19.5	-17.0	FullWell	CDS	60	80	100	25.56	0.10	11

Decide if you need the Shack-Hartmann sensor running continuously or not, here is a guide:

If using the Shack-Hartmann (SH) sensor allow at least one minute at each location for the system to complete a SH cycle. For standard stars this is not necessary. SH can be done on either probe 1 or probe 2 (default). There is a 2.5mm focus offset between these two probes so switch between then will cost ~2 minutes. Also, there is some overhead for each new field because it takes time for the probes to move to the selected guide/SH stars.

3.9.1 Deep Fields: no crowding and no large extended features.

In these cases the background sky will be taken from the data itself and there is no need to take additional sky frames. Slew to the target field and make sure the object is in the correct location; offset to chip 2 if required. Ask the telescope operator to start guiding and start the shack-hartmann (if the exposures are long enough to warrant using them). While the operator is selecting appropriate guide stars, use this time to select a dither macro by clicking the “Dither” button. In many cases 30-minutes or more will be spent on an object in a single filter so choose something like: “poisson-30” and “T&G – no guider wait.” Click “Done” and the “File” text box should now read poisson52x52_30_26a. Set the exposure time to something that will not saturate the background. Also if you would like to use 2MASS field stars as calibrators don’t pick too high an exposure time or they will all saturate. Set the number of loops to something that will yield 1-2 minutes (Loops x ExpTime) per dither pointing to allow for shack-hartmann to run. Click Execute to start the macro.



3.9.2 Deep Fields: crowding and/or large extended features.

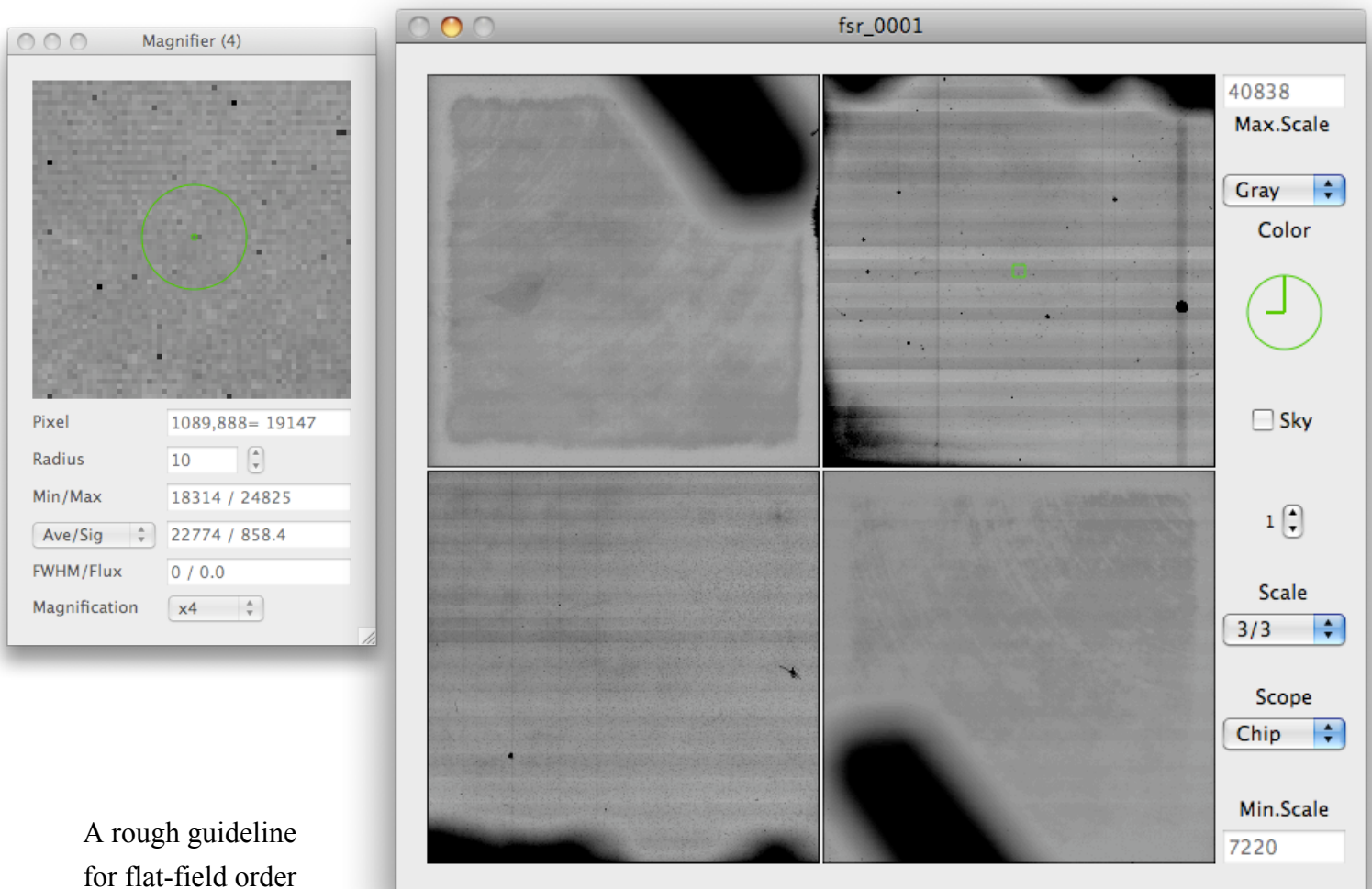
Coming soon...

3.9.3 Flat Fields

Twilight flats are recommended to correct pixel-to-pixel variations in sensitivity. Generally one should start evening Twilight flats at the reddest wavelength and progress blue-ward and in the morning start at the blue and work toward the red. A `twiflat.objects` list can be opened from `~/Desktop/fs_object_lists` which contains regions of (relatively) low stellar density. We recommend a `dice_5` or `square_9` dither pattern.

In the evening, just before sunset, the telescope operator should have the dome and louvers open (the louvers are the vents on the side of the dome). It is always a good idea to confirm that the mirror covers are open, the flat field screen is removed and all lamps/lights are off. The observer can “Send” the twiflat coordinates to the telescope operator and just after the sun sets one can start testing the sky in the Ks filter with 1.456s exposure times. We recommend using at least 5.8s when taking any data on sky to mitigate well depth and non-linearity effects; see 6.14-Read-Out Schemes and Overheads.

An example of a bad flat field: A 1.456s Ks image taken at twilight. Note that the guide probes are visible at the top and bottom of the image. If you see these, ask the telescope operator to remove the guide probes. Also, note the pattern on the arrays. This pattern is indicative of saturation. Also note that the “Ave” box in the Magnifier window quotes 22774 counts. Remember, for short exposure the well depth goes like $1/(1+1.456/\text{Exptime})$. So for $\text{ExpTime}=1.456$ s the well depth is $\frac{1}{2}$ of nominal, or about 25,000 counts.



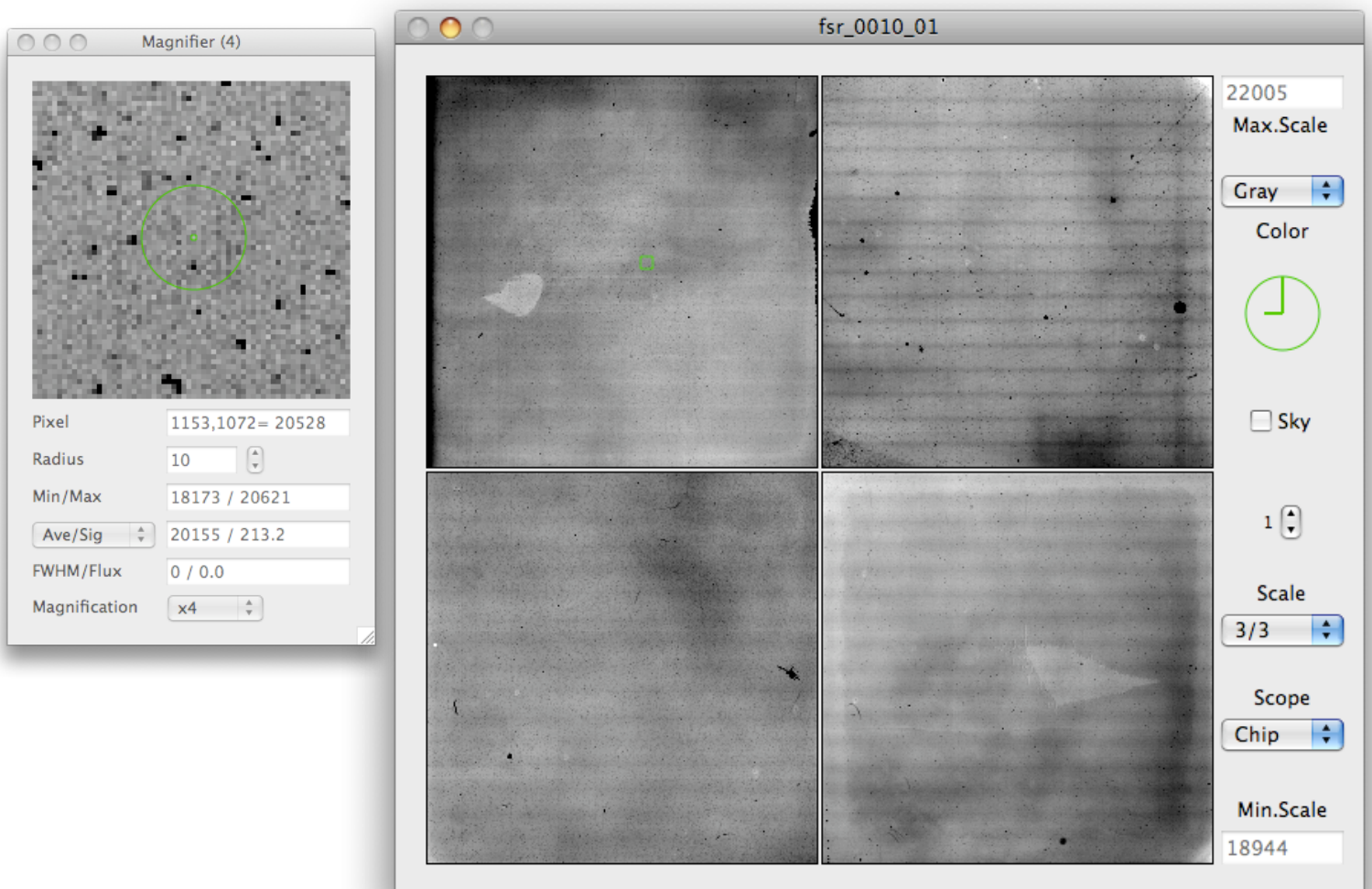
A rough guideline for flat-field order and exposure times is below. Of

course, in reality it is not likely possible to get all these filters in one twilight session. Rather, an

observer should create flats from filters they plan on using that night and scale these times/dither sizes to reach the desired count level; we suggest 10,000 to 25,000 counts with exposure time greater than or equal to 5.8s. For Dawn flat, reverse the order, start at J and work towards Ks.

DUSK	Ks	Hl	Hs	H	J3	J2	J1	J
Gain	FullWell	FullWell	FullWell	FullWell	FullWell	FullWell	FullWell	FullWell
Mode	CDS	CDS	CDS	CDS	CDS	CDS	CDS	CDS
Exptime (s)	5.8	5.8	8.7	8.7	11.64	14.56	20.38	20.38
Loop/Dither	1/5	1/5	1/5	1/5	1/5	1/5	1/5	1/5
Flux (cnt/s)	25,000	22,000	20,000	22,000	22,000	15,000	15,000	15,000

An example of a good flat-field frame. A 5.824s, Ks exposure. There are no guide probes vignetting the field. The Average counts are 20,155 DN (for a 5.644s exposure the well is ~40,000). Note how the pattern has changed from the saturated example above.

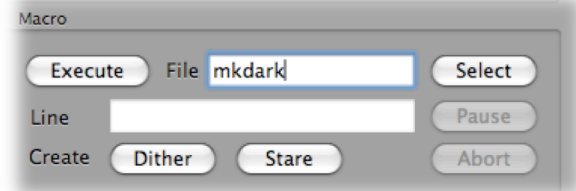


3.9.4 Dark Frames

Dark Frames can be taken by selecting “Dark” from the FilterCombo menu. This crosses two filters that mutually block each other. If no darks are taken then the pipeline will use the most recent dark frames stored in library. It is possible to take a series of Darks during the day of science observations. If exposure times are not known beforehand then darks can be taken at the end of a run. In this case, a python program mkdark.py exists that will create a macro called mkdark based on the exposure information that exists within a certain raw data directory. To run the program, open a terminal on the Control-Room-Mac and change directories to the Raw Data path:

```
[fourstar@Control-Room-Mac]# cd ~/Data  
[fourstar@Control-Room-Mac]# mkdark.py 2011_09_30 9  
This script will take approximately 112.0 min to run.
```

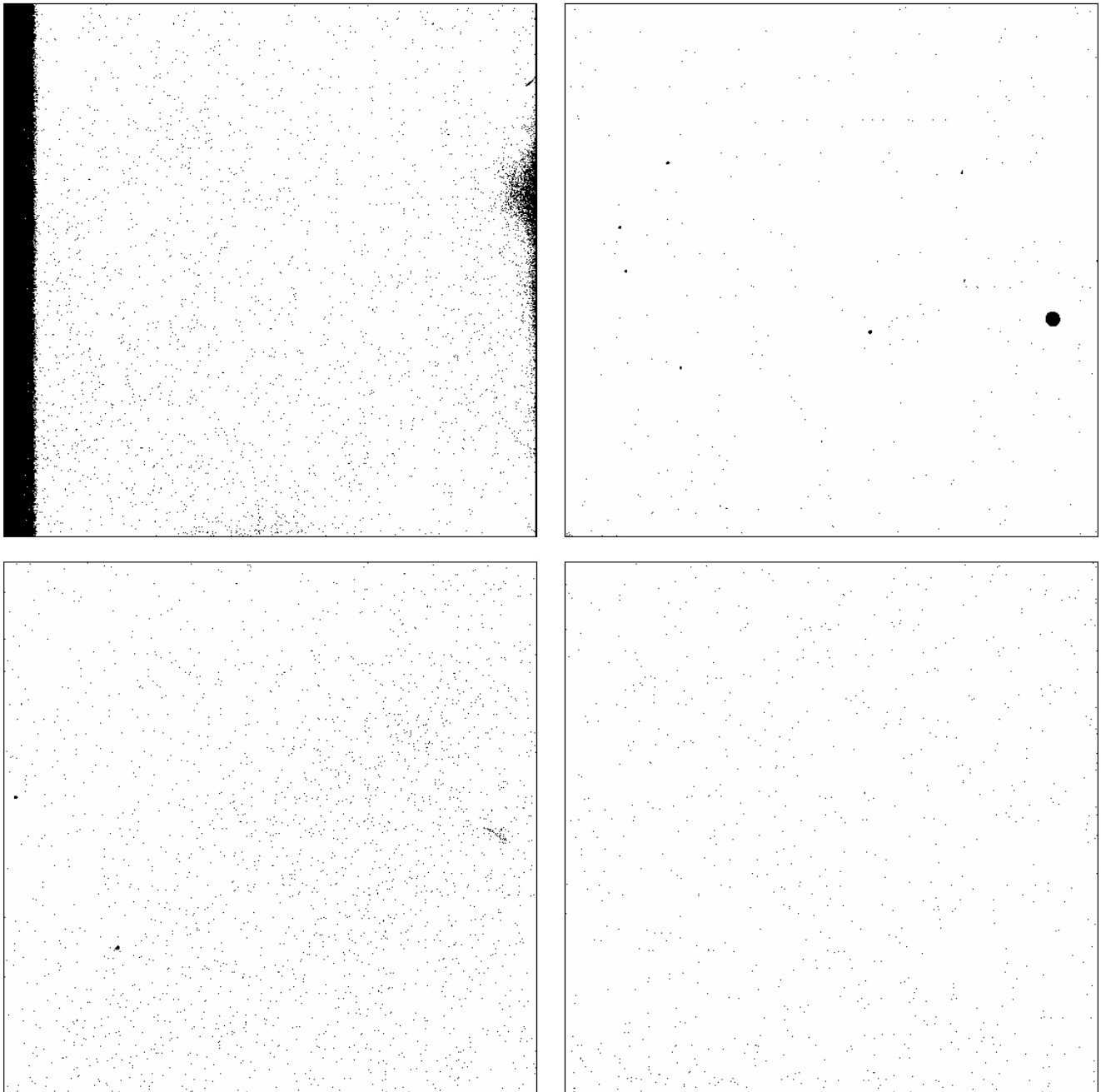
Now in the FourStar-Control window select “Dark” from the FilterCombo list and type mkdark in the macro “File” box and click execute. The script will automatically set the obstype to dark and vary the relevant exposure times, loop numbers, gains, and modes based on the sequences of exposures found in the 2011_09_30 data path. The number of darks to take is set by the trailing 9 in this case.



3.9.5 Bad Pixel Masks

Badpixel / hotpixel frames can be constructed using the ratio flat fields at different exposure times. If no badpixel masks are created the pipeline will use the most recent masks stored in the library. The linearity maps can also be used to classify bad pixels by sigma clipping spurious values, these are online at: <http://obs.carnegiescience.edu/instrumentation/FourStar/calibration.html>

Here is an example showing the distribution of identified bad pixels. The dark edge along chip 4 is due to the particular way the array is reset (line-by-line instead of pixel-by-pixel). This reset mode mitigates first frame effects we have seen in the lab where the first frame in a loop sequence differs from the remaining frames. Unfortunately chip 4 suffers a roll-off effect whereas the other arrays do not.



3.9.6 Dome Flats

Dome Flat Fields are not generally recommended although they can be taken to construct bad pixel masks and used for flat fielding if twilight flats are not available.

From a terminal on Burro or Llama type the command `ffs` to open the dome screen GUI. Click on the screen in button to move the screen over the secondary mirror. The lamps on the secondary are too bright to use with FourStar so the auxiliary lamp located in the dome must be used. The power supply is accessible in the dome; ask the telescope operator for assistance locating it. The lamp is not very stable and some structure can actually be seen in the HI filter from the lamp diffuser. Some exposure time and lamp settings are shown in Table 3-2. **When you are finished make sure to remove the dome flat screen** by clicking the screen out button.

Filter	Gain	Mode	Lamp (V)	Extime (s)	~Flux (DN)
J	FullWell	CDS	1.25	11.644	18,000
J	FullWell	CDS	1.50	2.911	20,000
H	FullWell	CDS	1.25	2.911	17,000
H	FullWell	CDS	1.50	1.456	SAT
Ks	FullWell	CDS	1.25	2.911	25,000
Hs	FullWell	CDS	1.25	8.733	27,000
Hs	FullWell	CDS	1.50	2.911	27,000
HI	FullWell	CDS	1.25	8.733	31,000
HI	FullWell	CDS	1.50	2.911	30,000
J1	FullWell	CDS	1.25	90.24	18,000
J1	FullWell	CDS	1.50	5.824	7,500
J1	FullWell	CDS	1.50	14.56	16,000
J1	FullWell	CDS	1.80	5.824	24,000
J1	FullWell	CDS	2.00	5.824	40,000
J2	FullWell	CDS	1.25	32.02	17,000
J2	FullWell	CDS	1.50	5.824	16,000
J3	FullWell	CDS	1.25	20.38	23,000
J3	FullWell	CDS	1.50	5.824	26,000

Table 3-2 Lamp settings and exposure times for Dome Flats.