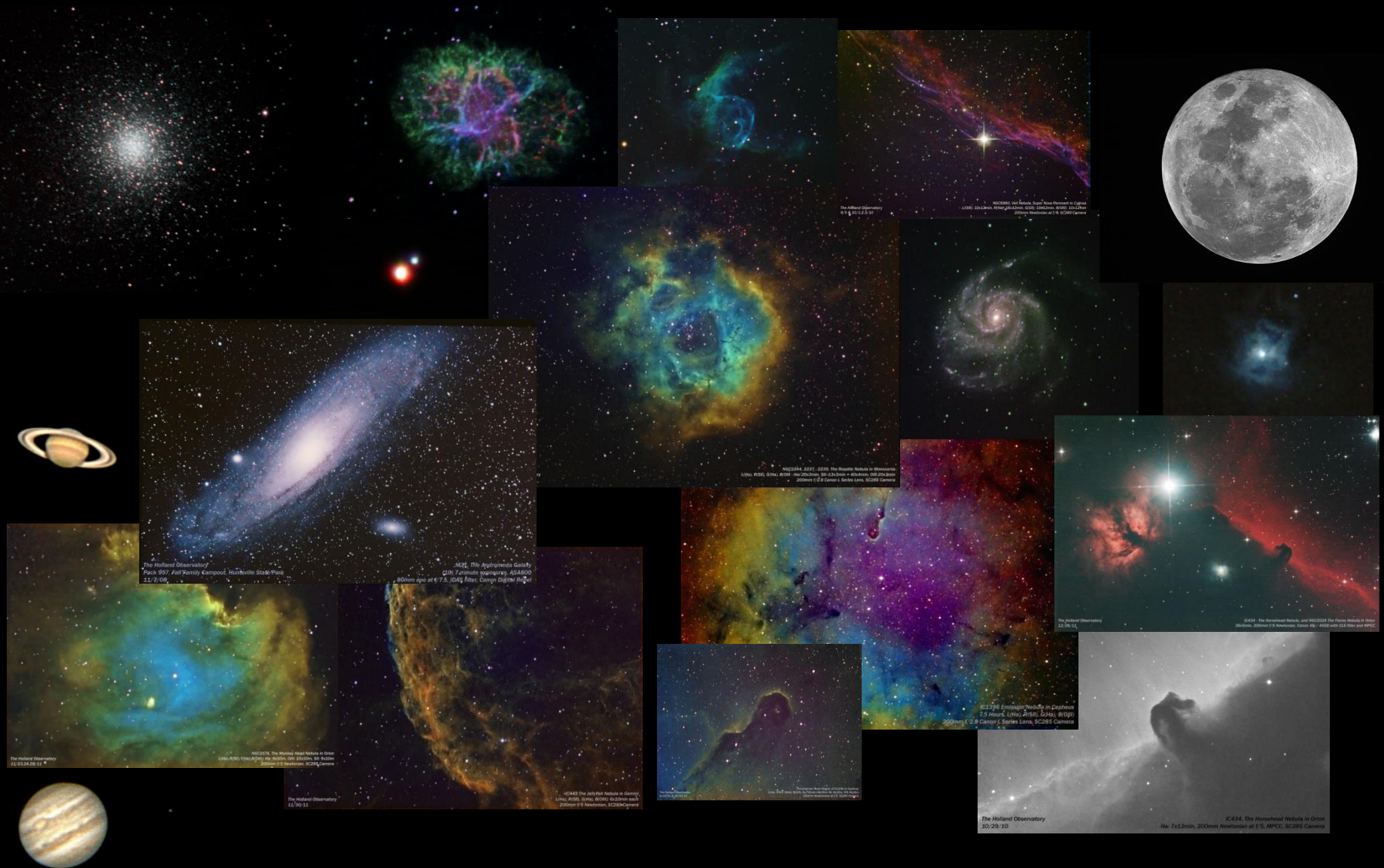


# Astroimaging – Setup and Operation



S. Douglas Holland

# Astroimaging – Setup and Operation

## Outline:

1. Mount
2. Telescope
3. Cameras
4. Balance Mount
5. Acclimation
6. Cabling & Computer
7. Polar Alignment
8. CWD Position
9. 4 Star Align
10. Camera Control Software
11. Focus
12. Install Guide Scope
13. Check / Set Sensor Temp
14. Gather Darks
15. Go To Target
16. Guiding
17. Framing
18. Adjust Guiding
19. Start Image Sequence
20. Flat Lights, Flat Darks, Bias
21. Results



# Astroimaging – Setup and Operation

## Mount



Tripod

Predefined location helps with polar alignment



Marked Location



Polaris – above vent pipe

# Astroimaging – Setup and Operation



Mount – 35 lbs., a little difficult to get in place. Motors seem fragile. Care needed to not damage.

Table – A good table is a big help



# Astroimaging – Setup and Operation



Level –

1. Polar alignment –  
Reproducing position  
aids polar alignment.
2. Mount will work fine if  
not level.

- Add weight.
- Re-check level.



# Astroimaging – Setup and Operation

Polar Scope



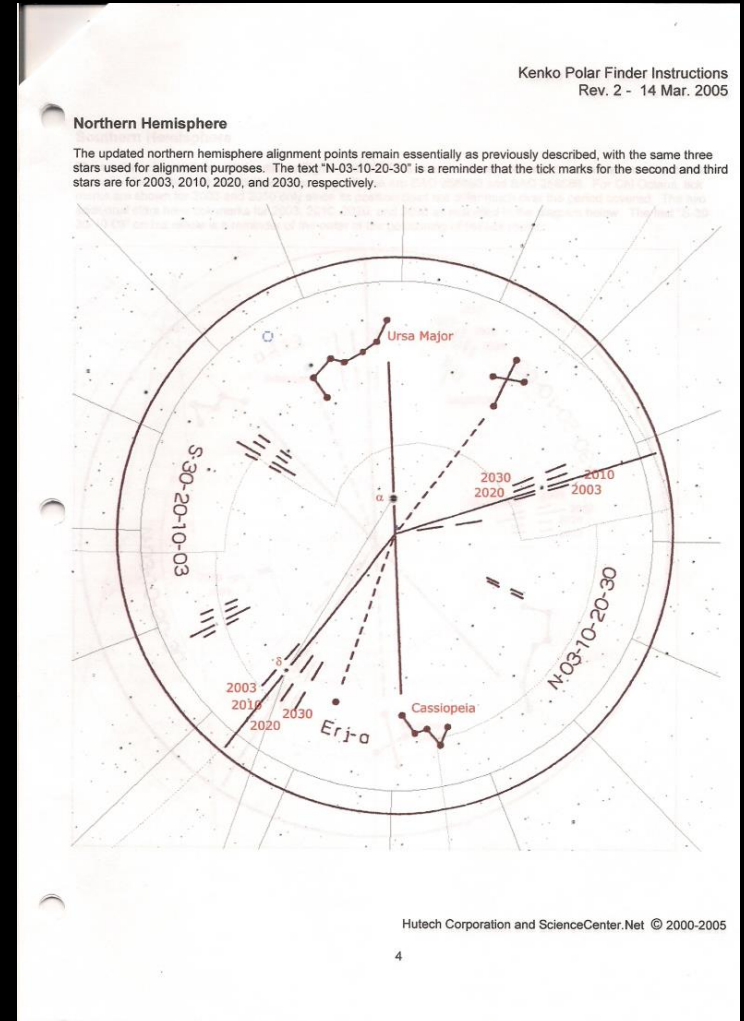
Goes here

# Astroimaging – Setup and Operation

More on polar alignment later –

But:

1. Polar scopes will not work if reticle not aligned.
2. Two polar scopes purchased. Both did not have correctly aligned reticles.
3. Aligned during the day by:
  - a) Pointing center at distant target
  - b) Rotating axis
  - c) Adjusting set screws to get center to stay in center
  - d) Be careful not to break – reticle made of glass



# Astroimaging – Setup and Operation

## Mount Control System



DEC Motor

RA Motor



Velcro



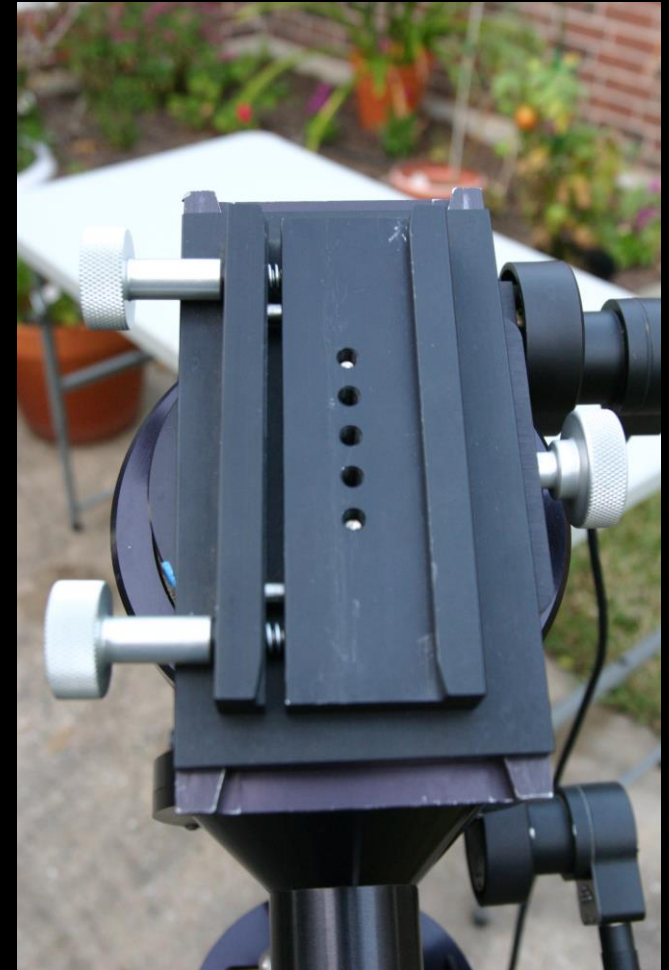


# Astroimaging – Setup and Operation

Saddle – Two common styles:



Losmandy 'D' Style



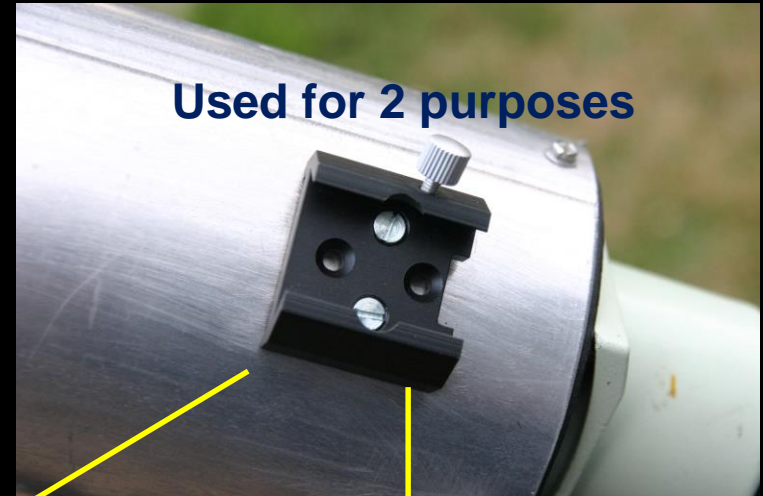
Vixen Style

# Astroimaging – Setup and Operation

## Telescope



Telescope



Used for 2 purposes

Finderscope Dovetail Mount



1x Finder (Red Dot Finder)



Guide Scope & Guide Camera

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# Astroimaging – Setup and Operation

## Options for Guiding



### Guide Scope

Short focal length (132mm)

Low focal ratio (f/3.2)

Pros: Easy to find stars, Super easy to use

Cons: Not on axis with image (flexure), Low focal length limited to short focal length imaging telescope.



### Guide Scope

Longer focal length (600mm)

High focal ratio (f/12)

Pros: Easy to find stars, Longer focal length works with longer focal length imaging scope

Cons: Not on axis with image (flexure)

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### Off-Axis Guider



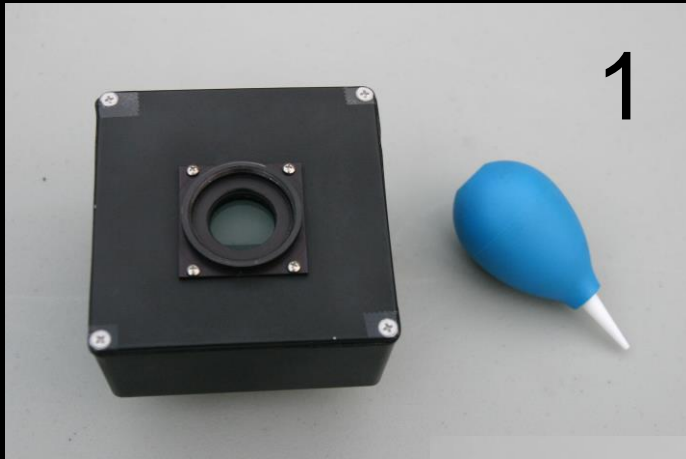
Image scope focal length & focal ratio

Pros: No flexure, Same optics as imaging system

Cons: Can be very difficult to find guide star, drives framing of imaging target, hard to focus guide camera, pick off prism royal pain in the neck for aberrations if not perfectly lined up.

# Astroimaging – Setup and Operation

## Cameras



Focal Reducer  
Produces  $f/6.68$



Hydrogen Alpha (Ha)  
Filter

CCD Camera  
& Bulb Blower



# Astroimaging – Setup and Operation



Focuser before camera



Camera connected to focuser with 48mm extension tubes



Set Guide Camera East & West



Imaging Camera angle due to screw on attachment

# Astroimaging – Setup and Operation



## Set Focus:

1. Keep document of different configuration focus settings
2. Gets close to correct focus

# Astroimaging – Setup and Operation

## Balance Mount



Balance in Declination

Balance in Right Ascension (RA)  
=> Heavy East for imaging



# Astroimaging – Setup and Operation

## Acclimation



Remove dust cap for acclimation





# Astroimaging – Setup and Operation

## Cabling & Computer



Camera Power – Hang on mount



Camera Power



Fabric USB cables – less stiff



Fabric USB cables – no snag

# Astroimaging – Setup and Operation



GPUSB – USB to ST4 Autoguider Port

Two options:

1. Autoguiding Port (ST4 Style)
2. ASCOM (Usually RS232 Port)



# Astroimaging – Setup and Operation



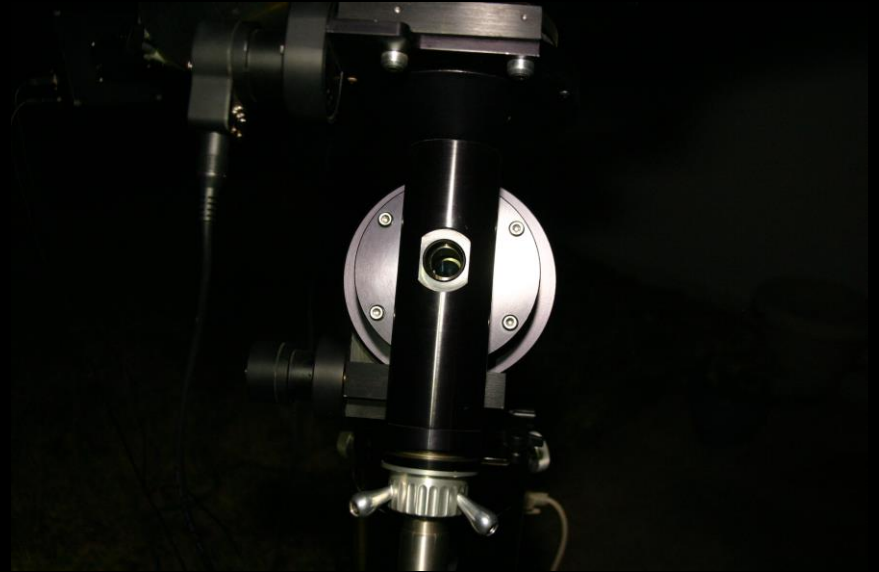
Computer



USB-C to USB 3 adapter – works well

# Astroimaging – Setup and Operation

## Polar Alignment



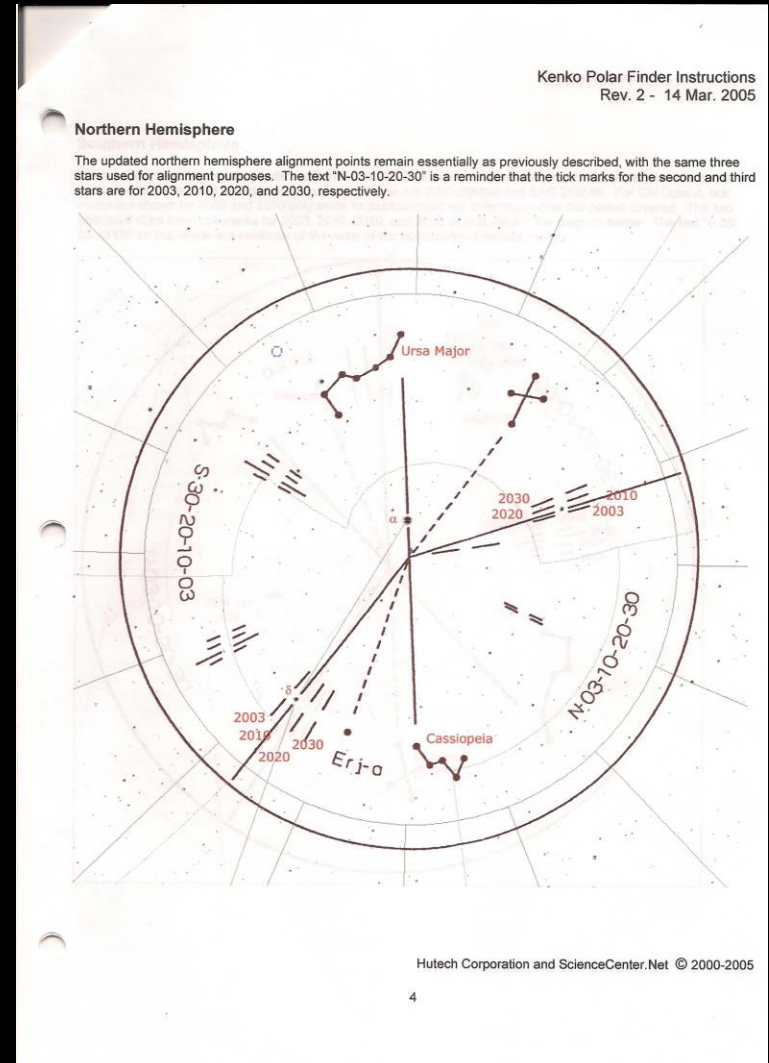
Need to remove covers and rotate in DEC to open up hole for polar alignment scope.

⇒ Met guy at star party that could not figure this out and could not polar align his scope

# Astroimaging – Setup and Operation

## Using Polar Alignment Scope

1. Rotate Polar Scope so that Big Dipper & Cassiopeia are in right place as in sky (on Celestron, rotate entire RA axis)
2. Move Altitude and Azimuth knobs to get Polaris, “Second Star” and “Third Star” in right position
3. Usually able to get within a few arcminutes using this method
4. Illuminator
  - a) Use Illuminator
  - b) Light pollution – not needed
  - c) Shine flashlight in from front of polar scope



# Astroimaging – Setup and Operation

## Counter Weight Down (CWD) Position

Other mounts have “home position” marks.

Also – Utility to return to CWD position when done. Facilitates multiple night setup storing sky modeling data from previous alignment



Right Ascension (RA)



Declination (DEC)

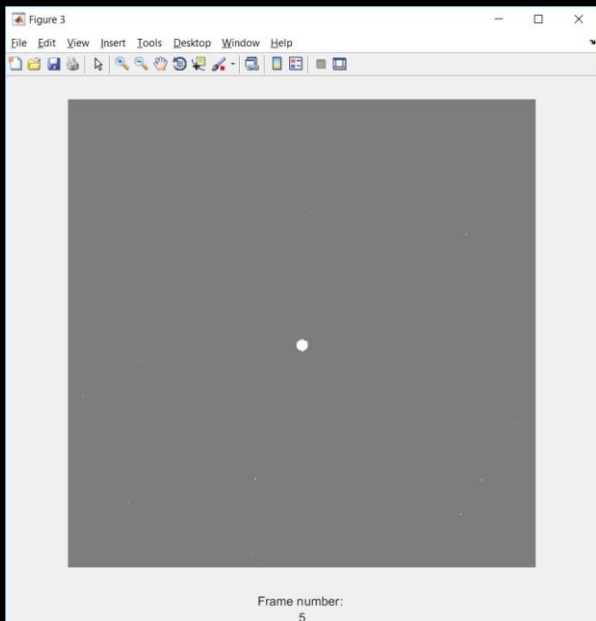
# Astroimaging – Setup and Operation

## 4 Star Alignment

1. Turn scope control system ON
2. Set / check Latitude & Longitude
3. Set / check time & date
4. 4 star align: 2 West, 2 East



Use 1x Finder Scope / Red Dot Finder



- Center star in field of view in imaging camera
- Use Histogram Equalization – Ha filter dims stars
- Re-adjust 1x finder to match imaging camera

# Astroimaging – Setup and Operation

## Camera Control Software

## Backyard EOS for DSLRs

BackyardEOS 3.0.3 - Classic Edition 13:14:35

Camera Information Center

TV BULB ISO 800

Dial M Shutter Release Mirror Off

Quality RAW+L Battery

PHD Daylight Setting

Weather Center

Image Center

Histogram Center

Capture Plan Center

Frame Type Cable support Save To Mirror lock

LIGHTS Camera USB PC 0

Target Name Filter Delay

Exposures	Shutter	Duration	ISO	Pause	
1	1	BULB	1	1600	0
2	0	BULB	1	1600	0
3	0	BULB	1	1600	0
4	0	BULB	1	1600	0
5	0	BULB	1	1600	0

Start Capture Loop Preview Test cable

Log history:  
13:14:17 Canon drivers 'Canon' initialized.  
13:14:19 Shutter counter= 5280  
13:14:20 Canon EOS DIGITAL REBEL XSi CONNECTED!



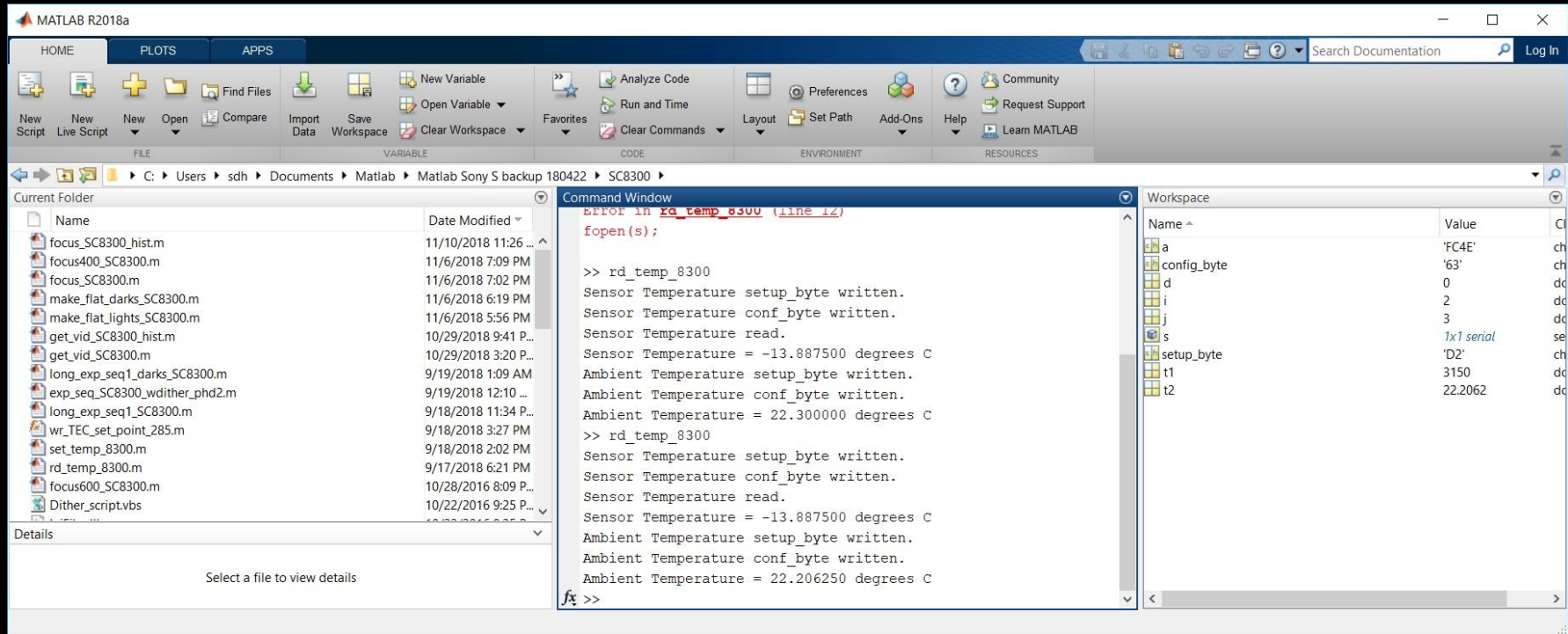
# Astroimaging – Setup and Operation

CCD Cameras -

I use Matlab for imaging camera control – All custom made software.

=> Custom made CCD cameras.

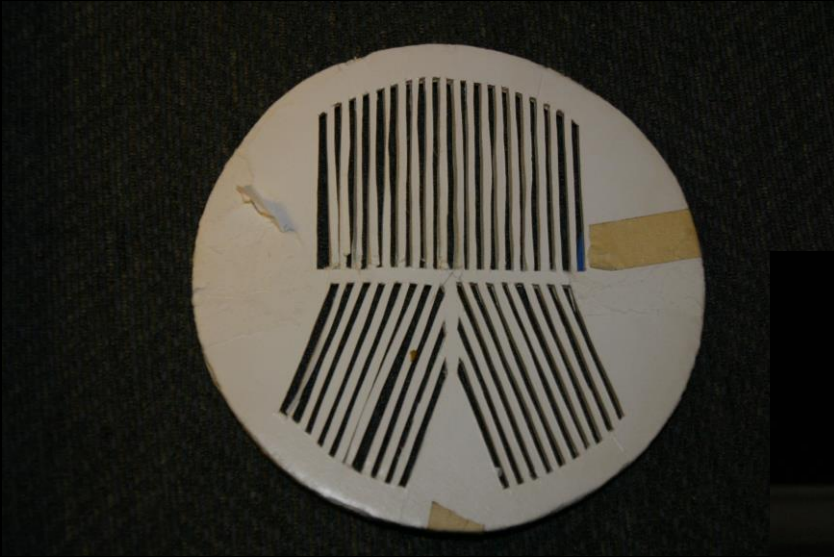
Other commercially available options: MaximDL, Sequence Generator Pro, etc.



# Astroimaging – Setup and Operation

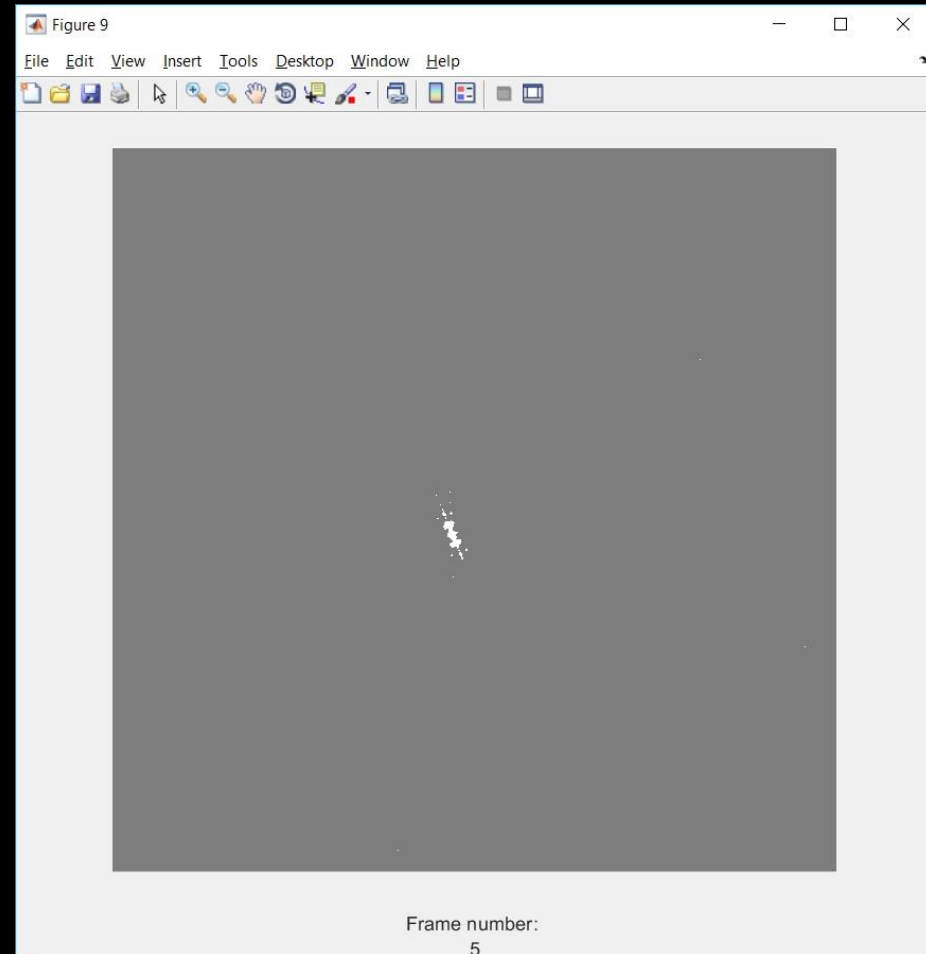
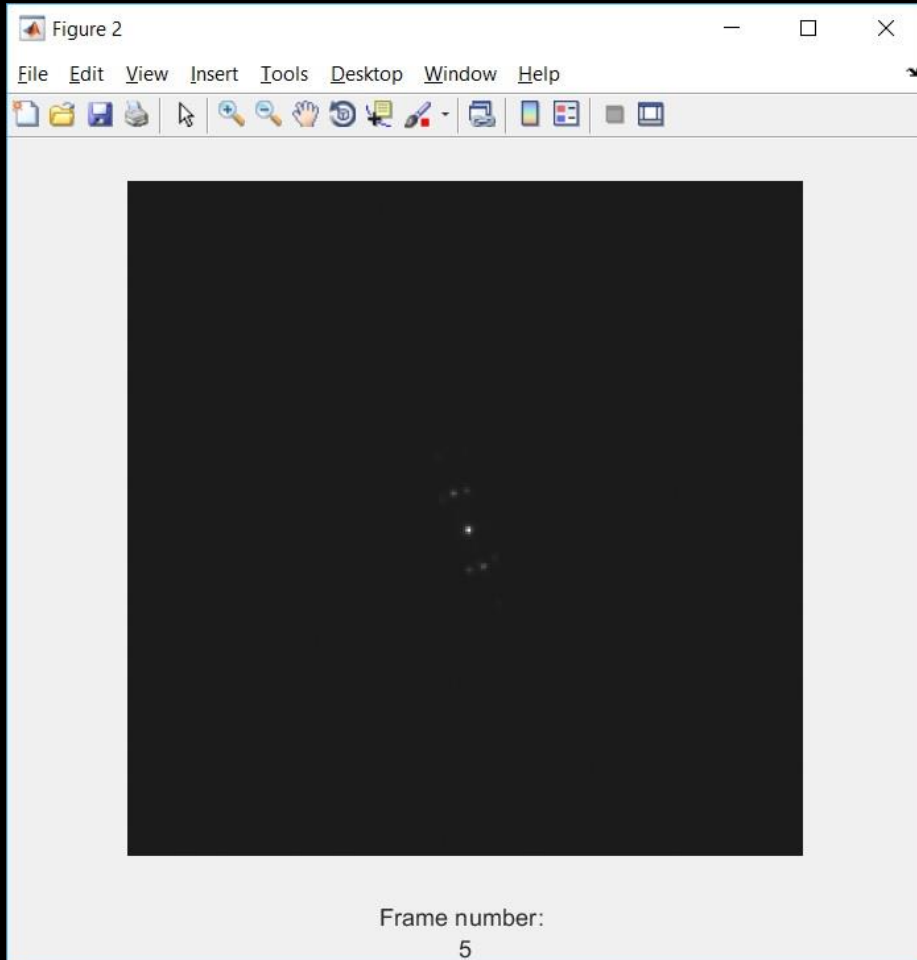
## Focus

Bahtinov Mask – Make or buy



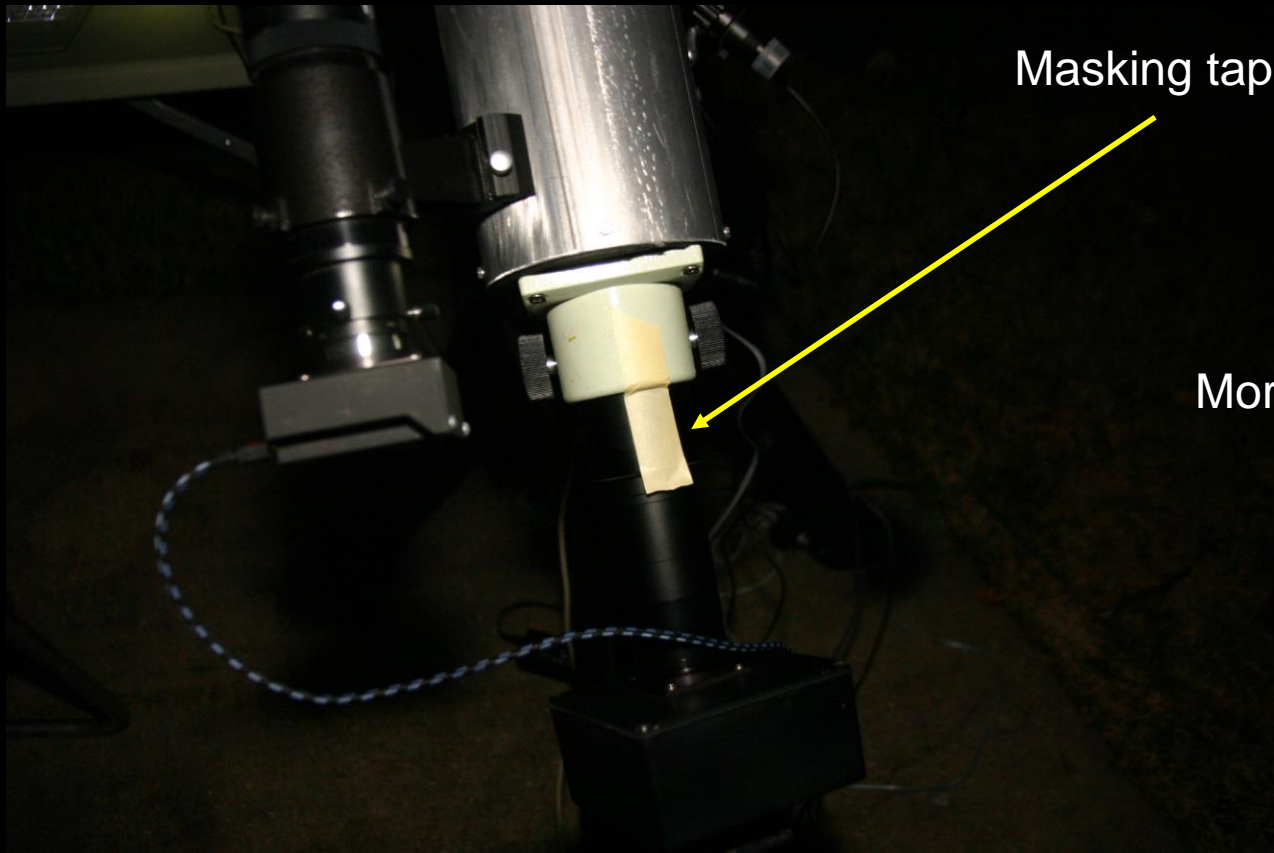
# Astroimaging – Setup and Operation

## 4x – No Histogram Equalization



## 1x – Histogram Equalization

# Astroimaging – Setup and Operation



Masking tape focus lock

More on this later =>

# Astroimaging – Setup and Operation

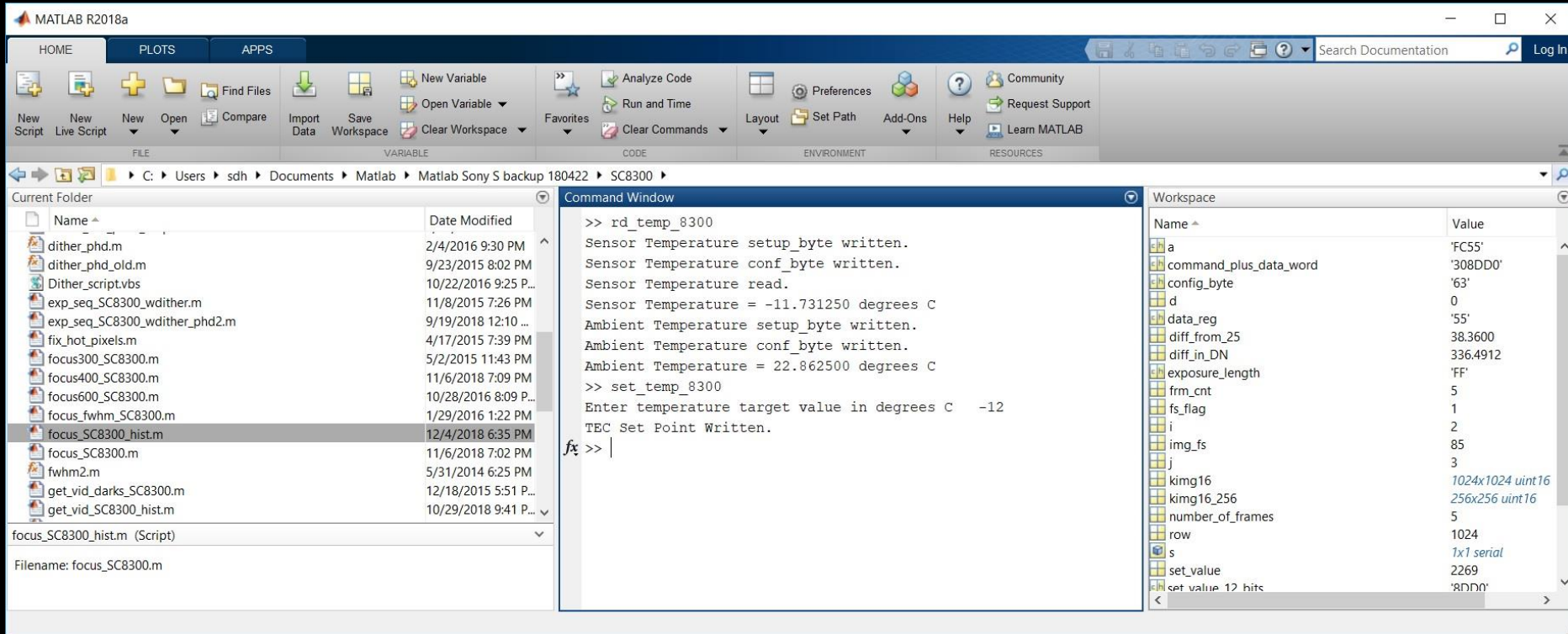
## Install Guide Scope

Remove 1x Finder,  
replace with Guide  
Scope



# Astroimaging – Setup and Operation

## Check / Set Sensor Temperature



The image shows the MATLAB R2018a interface. The Command Window displays the following output from a script:

```
>> rd_temp_8300
Sensor Temperature setup_byte written.
Sensor Temperature conf_byte written.
Sensor Temperature read.
Sensor Temperature = -11.731250 degrees C
Ambient Temperature setup_byte written.
Ambient Temperature conf_byte written.
Ambient Temperature = 22.862500 degrees C
>> set_temp_8300
Enter temperature target value in degrees C -12
TEC Set Point Written.
fx >> |
```

The Workspace window shows the following variables:

Name	Value
a	'FC55'
command_plus_data_word	'308DD0'
config_byte	'63'
d	0
data_reg	'55'
diff_from_25	38.3600
diff_in_DN	336.4912
exposure_length	'FF'
frm_cnt	5
fs_flag	1
i	2
img_fs	85
j	3
king16	1024x1024 uint16
king16_256	256x256 uint16
number_of_frames	5
row	1024
s	1x1 serial
set_value	2269
set_value_12_bits	'8DD0'

=> Need to decide on a constant temperature for imaging

# Astroimaging – Setup and Operation

## Gather Darks

Target not yet in view due to trees. Gather darks while waiting.

Dark calibration frames required to subtract thermal noise from images.

The screenshot displays the Celestron's TheSky software interface. The main window shows a star chart with various celestial objects labeled, including Auriga, California Nebula, Flaming Star, M36, M37, M38, and the Crab Nebula (M1). A red circle highlights the target object, IC 417. An "Object Information" window is open, providing details for IC 417:

Object Information	
Object:	IC 417
Type:	Nebula
Magnitude:	30.00
Right Ascension:	05h 29m 22s
Declination:	+34° 26' 47"
Azimuth:	69° 50' 54"
Altitude:	+47° 02' 21"
IC 417	
Dreyer description: Very large, diffused, 6th magnitude star involve	
RA: 05h 29m 21.9s Dec: +34° 26' 47"	
RA: 05h 28m 06.0s Dec: +34° 26' 00" (Epoch 2000)	
Az: 69° 50' 54" Alt: +47° 02' 21"	
Size: 13.0'	
From Cursor position:	
Angular separation: 17° 14' 14"	

The software interface includes a menu bar (File, Edit, View, Orientation, Data, Tools, Help), a toolbar with various icons, and a status bar at the bottom showing coordinates (RA: 02h 18m 25.2s, Dec: +24° 05' 18"), FOV: 61° 36' 14", and the date/time: 12/11/2018 9:03 PM.


# Astroimaging – Setup and Operation

Gray 1:4 dark\_10min\_m12\_3 | dark\_10min\_m12\_3.tif

dark\_10min\_m12\_3

Cover scope with dust cap  
Use mechanical shutter too

- 9 x 10 min exposures
- 1.5 hours



Gray 8:1 dark\_10min\_m12\_3 | dark\_10min\_m12\_3.tif

dark\_10min\_m12\_3

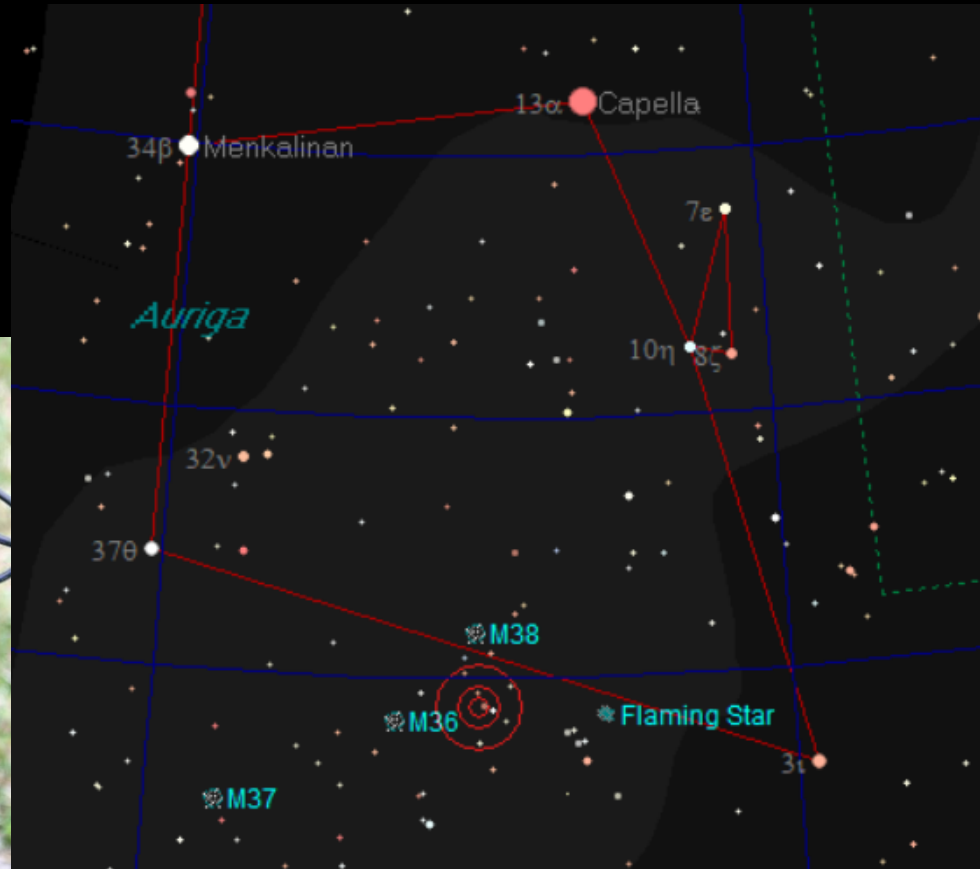




# Astroimaging – Setup and Operation

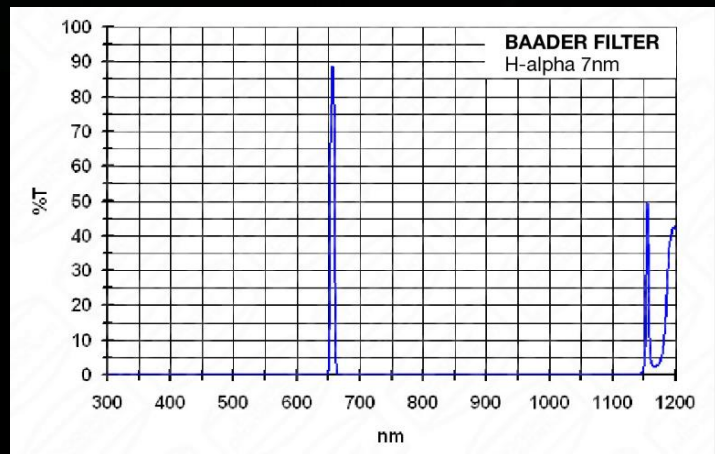
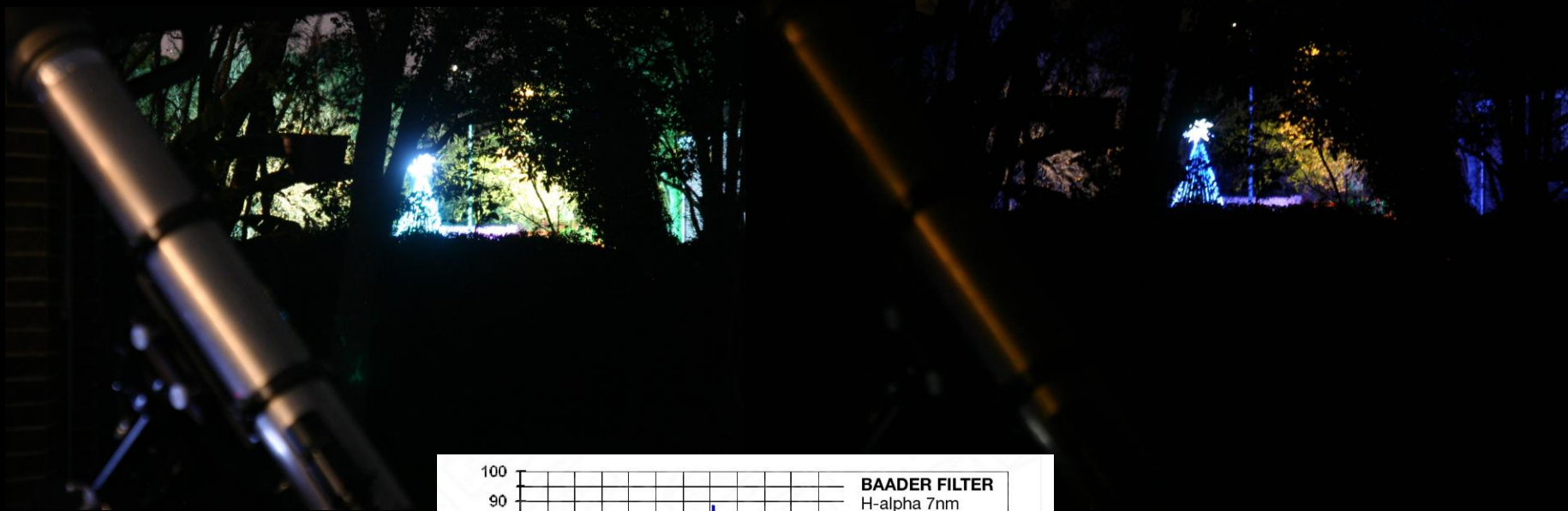
## Go To Target

Go To IC417 in Auriga  
via hand controller



# Astroimaging – Setup and Operation

A word about light pollution



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# Astroimaging – Setup and Operation

## Guiding

The screenshot shows the PHD2 Guiding software interface. The main window title is "PHD2 Guiding 2.6.5 - AT8RC\_SC2M034a\_OAG". The menu bar includes "File", "Tools", "View", "Darks", "Bookmarks", and "Help". The main area is currently blank. A "Connect Equipment" dialog box is open, showing the following configuration:

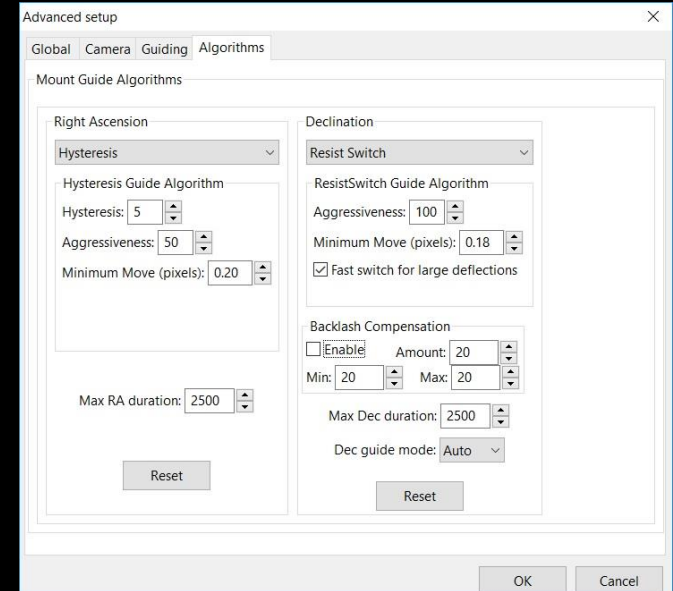
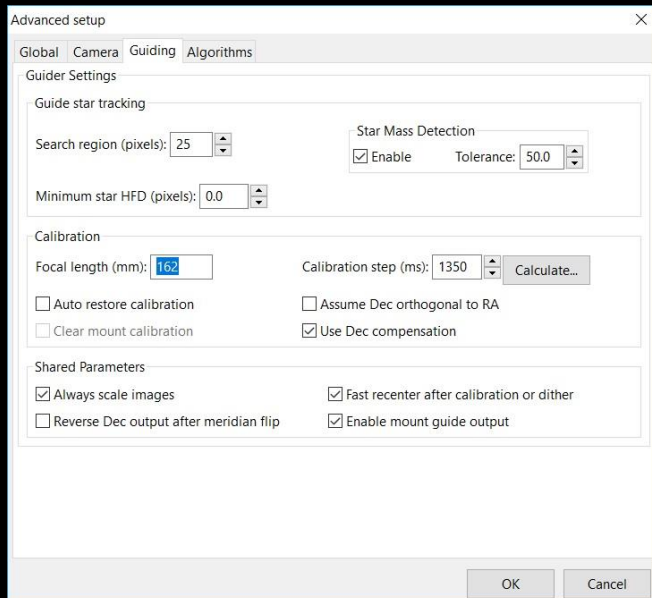
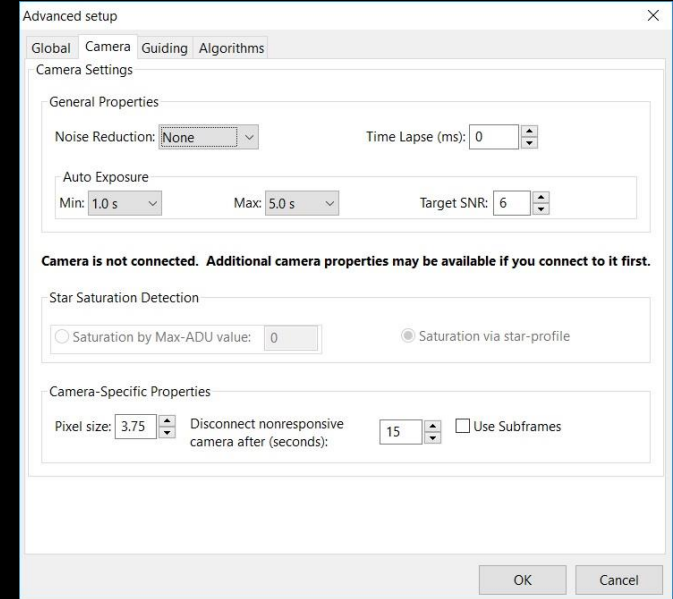
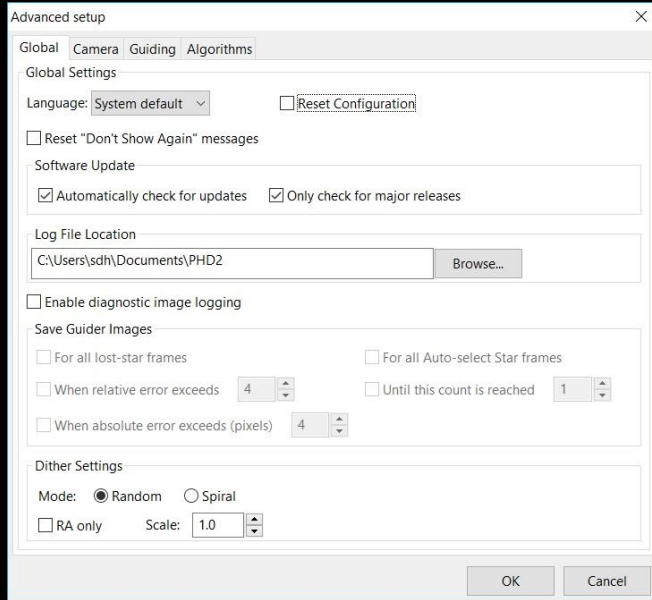
- Equipment profile: 162mm\_Guide\_Scope\_SC2M034a
- Camera: SC2M034a Camera (ASCOM)
- Mount: GPUSB
- Aux Mount: None

Each equipment item has a "Connect" button. The dialog also includes "Connect All", "Disconnect All", and "Close" buttons at the bottom. A "More Equipment ..." button is also present.

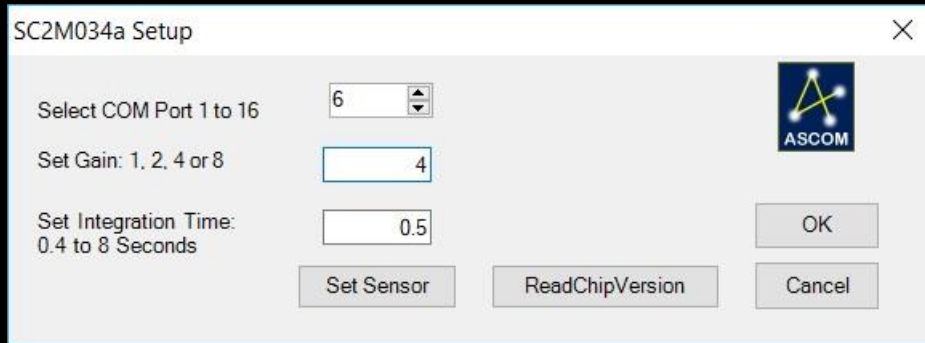
At the bottom of the main window, there is a control bar with icons for a pencil, a refresh symbol, a crosshair, a "STOP" sign, a "1.0 s" dropdown menu, a slider, a brain icon, and a gear icon. Below this bar are three status indicators: "Dark" (red), "Cal" (yellow), and a red dot.

PHD2 Guiding

# Astroimaging – Setup and Operation

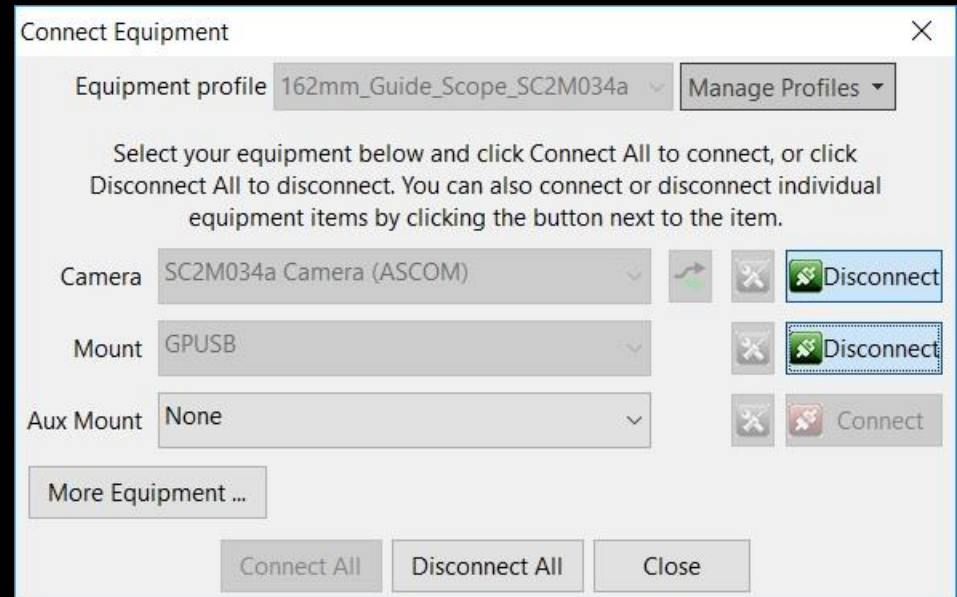


# Astroimaging – Setup and Operation



Camera configuration

Connect camera & mount



# Astroimaging – Setup and Operation

The screenshot displays the PHD2 Guiding software interface. The window title is "PHD2 Guiding 2.6.5 - 162mm\_Guide\_Scope\_SC2M034a". The menu bar includes "File", "Tools", "View", "Darks", "Bookmarks", and "Help". The main view shows a dark field of stars with a green box highlighting a specific star. The control panel at the bottom includes icons for a pencil, a refresh symbol, a green circle with a crosshair, a red "STOP" sign, a dropdown menu set to "1.0 s", a slider, a brain icon, and a gear icon. The status bar at the bottom shows "Looping", "SNR 20.3", "Dark", "Cal", and a green indicator light.

Looping	SNR 20.3	Dark	Cal	●
---------	----------	------	-----	---

# Astroimaging – Setup and Operation

PHD2 Guiding 2.6.5 - 162mm\_Guide\_Scope\_SC2M034a

File Tools View Darks Bookmarks Help

West step 1, dist=0.0 | SNR 20.7 | Dark Cal

Clearing backlash step 3 | SNR 20.5 | Dark Cal

The screenshot shows the PHD2 Guiding software interface. The main window displays a dark field with a green crosshair. The status bar at the bottom indicates the current step and distance. The first step is 'West step 1, dist=0.0' with an SNR of 20.7. The second step is 'Clearing backlash step 3' with an SNR of 20.5. The interface includes a menu bar, a toolbar with icons for various functions, and a control panel with a 'STOP' button and a slider.

PHD2 Guiding 2.6.5 - 162mm\_Guide\_Scope\_SC2M034a

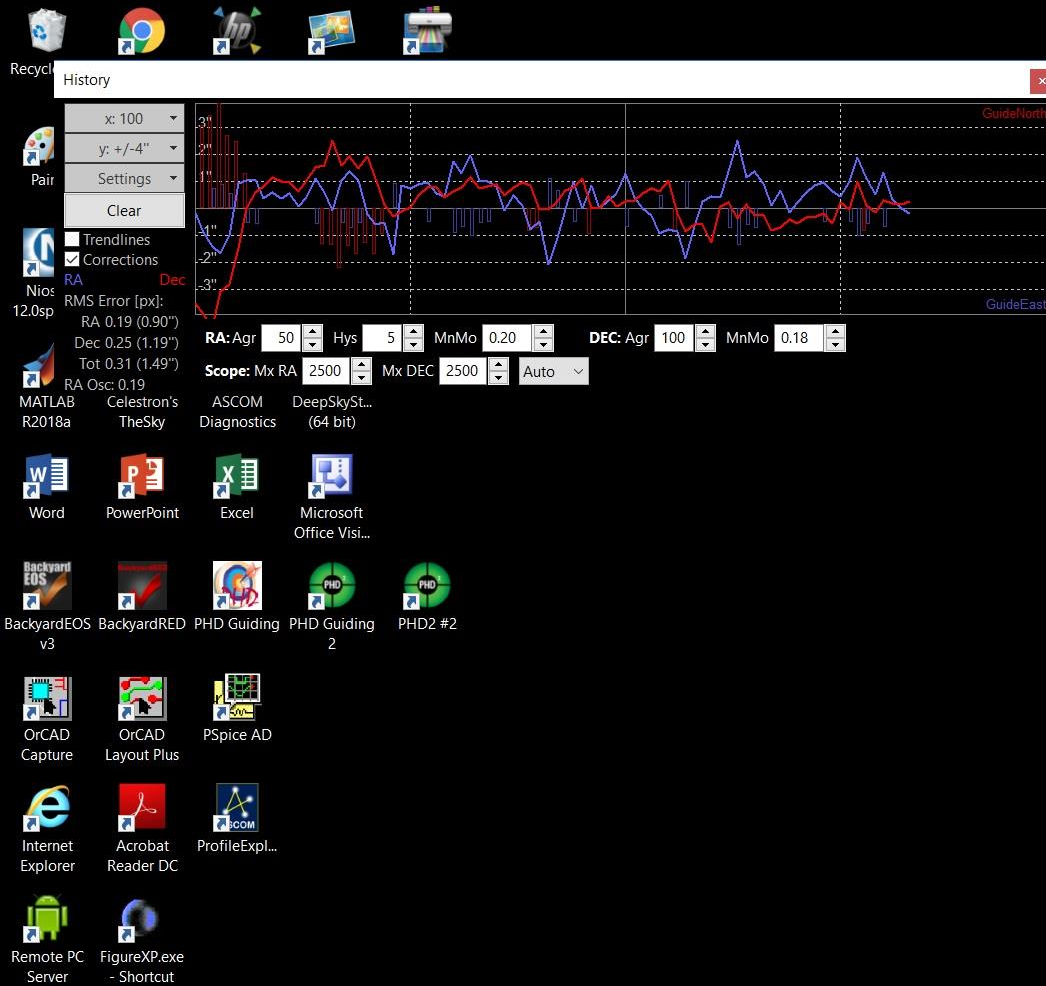
File Tools View Darks Bookmarks Help

West step 11, dist=18.9 | SNR 20.5 | Dark Cal

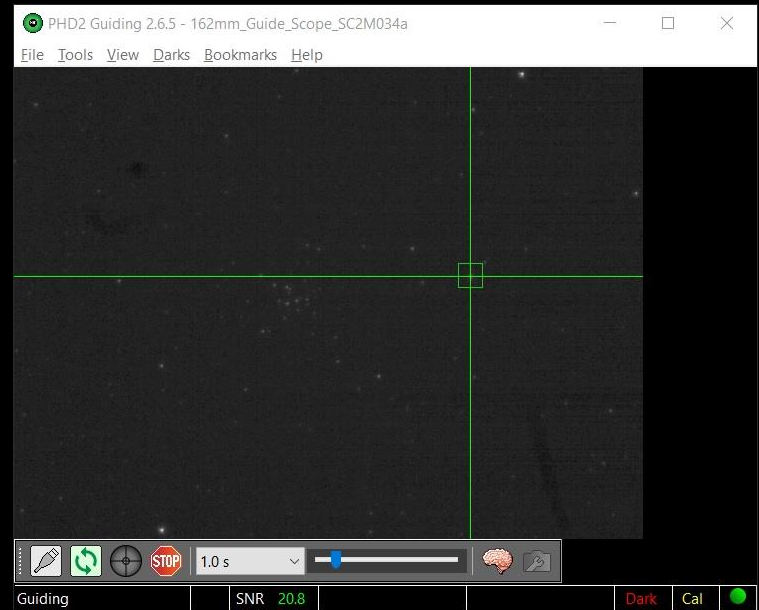
South step 4, dist=23.9 | SNR 20.8 | Dark Cal

The screenshot shows the PHD2 Guiding software interface. The main window displays a dark field with a green crosshair. The status bar at the bottom indicates the current step and distance. The eleventh step is 'West step 11, dist=18.9' with an SNR of 20.5. The fourteenth step is 'South step 4, dist=23.9' with an SNR of 20.8. The interface includes a menu bar, a toolbar with icons for various functions, and a control panel with a 'STOP' button and a slider.

# Astroimaging – Setup and Operation



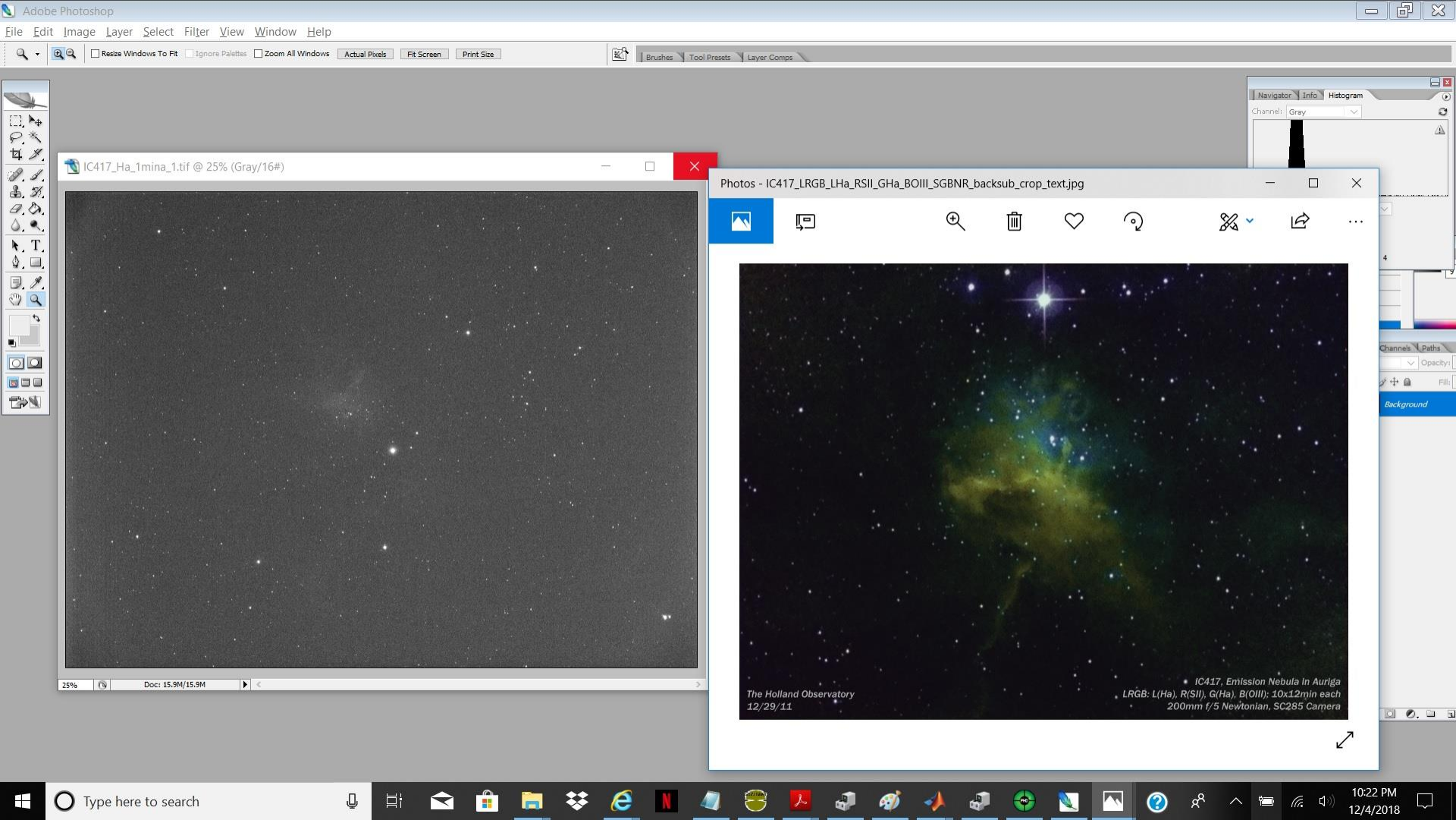
## Graph / History





# Astroimaging – Setup and Operation

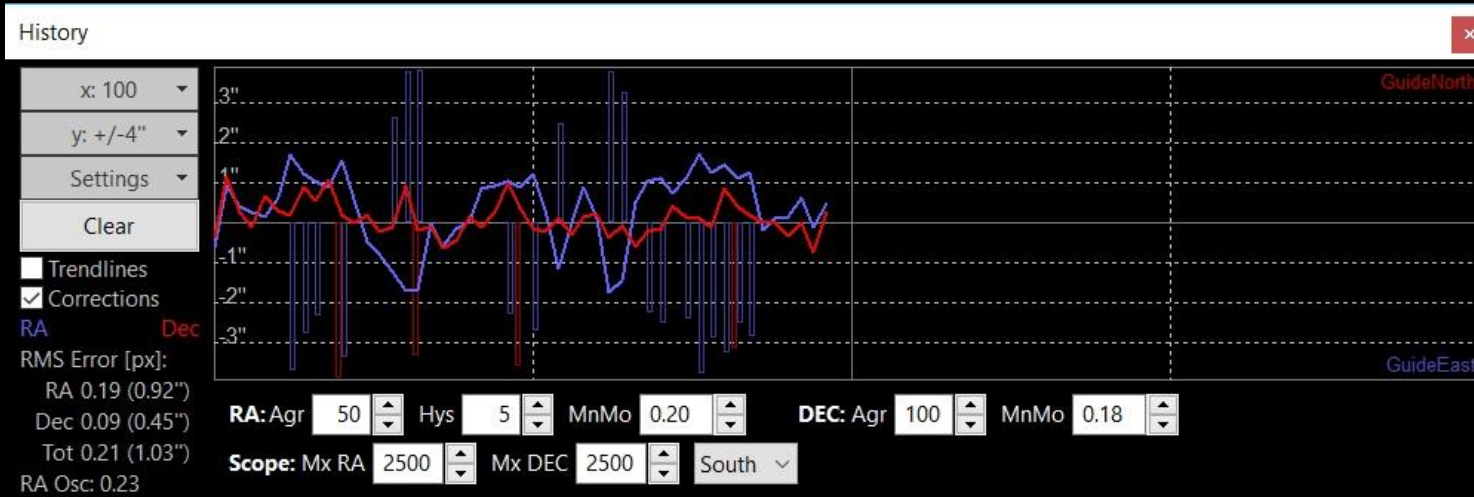
## Framing



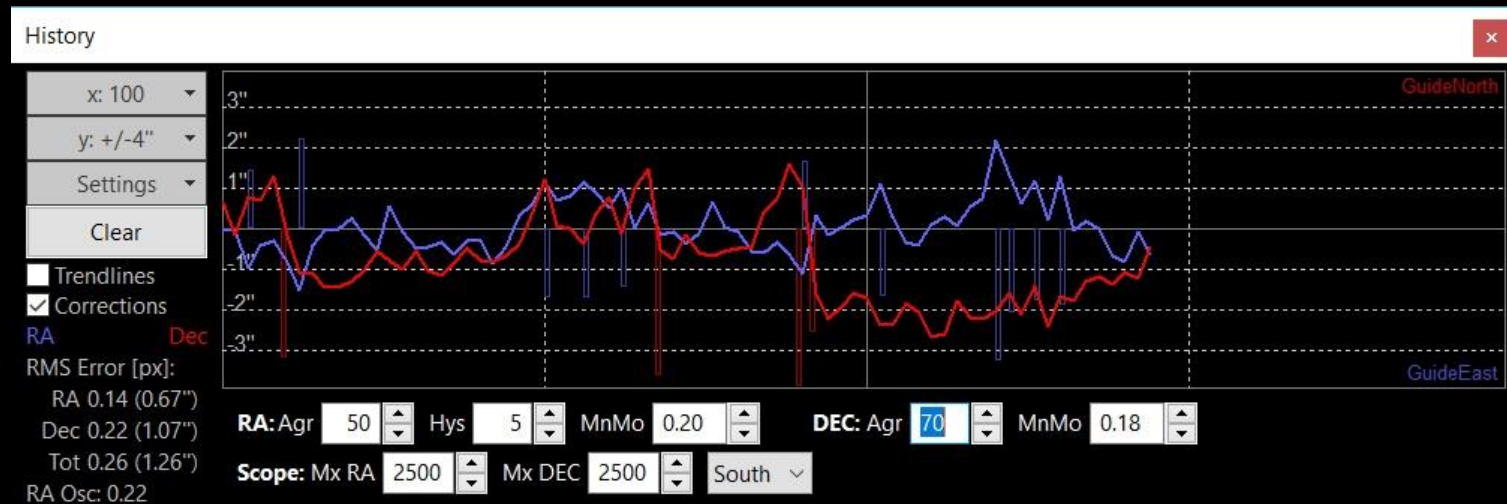
# Astroimaging – Setup and Operation

## Adjust Guiding

## Guide South



Decrease Dec  
Aggressiveness



# Astroimaging – Setup and Operation

## Start Image Sequence

## Imaging with Dithering

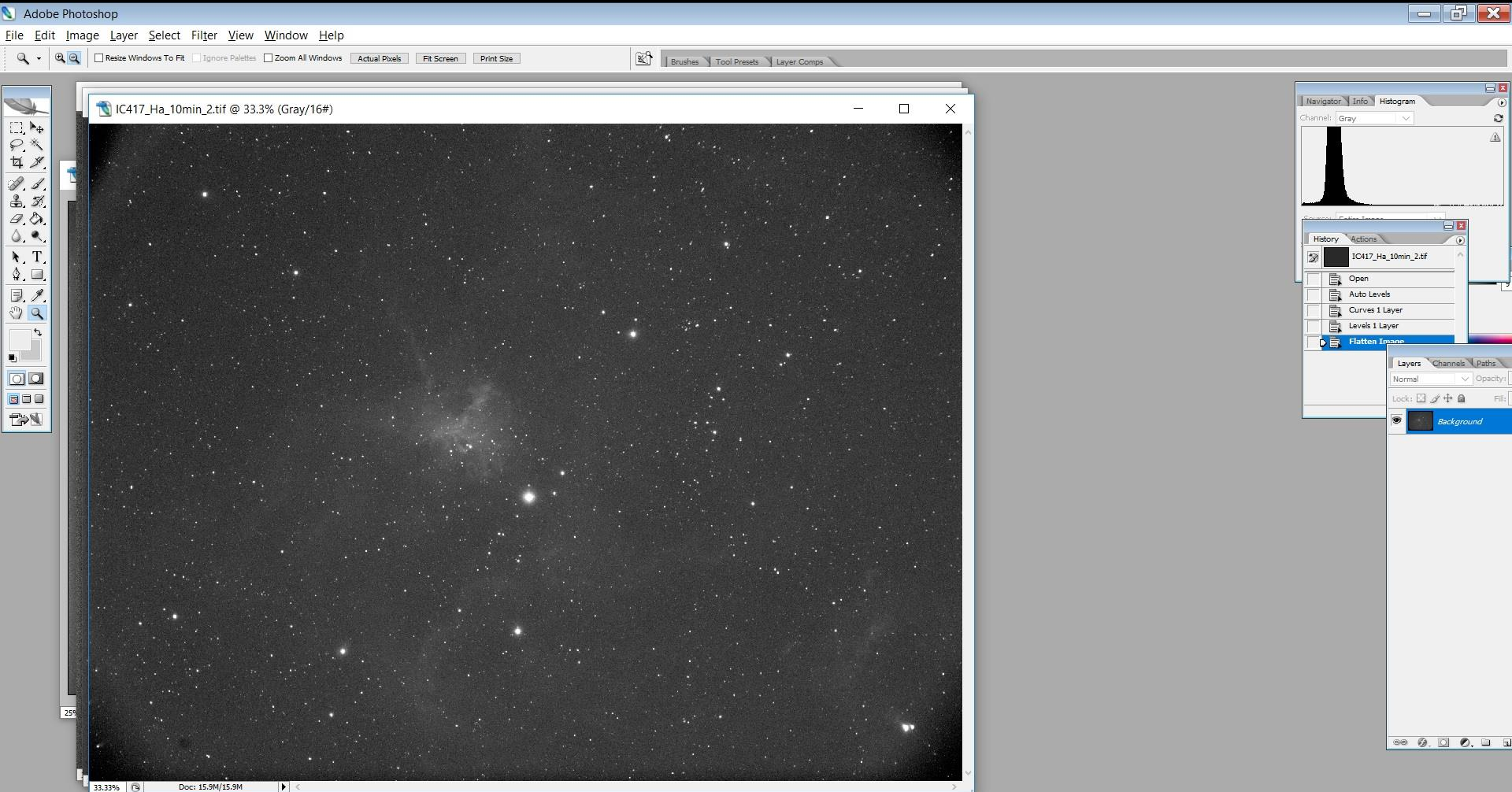
The screenshot displays a Windows desktop environment with several applications open. At the top left, a 'History' window shows a graph of guiding error over time, with axes labeled 'GuideNorth' and 'GuideEast'. Below the graph are controls for 'x: 100', 'y: +/-4"', 'Settings', and 'Clear'. A 'Nios 12.0sp' window shows RMS Error [px]: RA 0.15 (0.72"), Dec 0.16 (0.75"), Tot 0.22 (1.04"), and RA Osc: 0.22. Below this are sliders for RA and DEC settings: RA: Agr 45, Hys 5, MnMo 0.20; DEC: Agr 70, MnMo 0.18. A 'Scope' section shows Mx RA 2500, Mx DEC 2500, and South. To the right, the 'PHD2 Guiding 2.6.5 - 162mm\_Guide\_Scope\_SC2M034a' window shows a dark field of view with a green crosshair and a small white box at the center. Below these, the 'MATLAB R2018a' window is open, showing the Command Window with the following text: 

```
Sensor Temperature conf_byte written.
Sensor Temperature read.
Sensor Temperature = -12.668750 degrees C
Ambient Temperature setup_byte written.
Ambient Temperature conf_byte written.
Ambient Temperature = 20.050000 degrees C
>> set_temp 8300
Enter temperature target value in degrees C -14
TEC Set Point Written.
>> exp_seq_SC8300_wdither_phd2
Enter number of frames 12
Enter exposure time for each frame in minutes 10
Enter file name sequence prefix IC417_Ha_10min_
Image 1 being exposed
```

The Workspace window shows variables: a ('FC37'), command\_plus\_data\_word ('308CB0'), config\_byte ('63'), current\_file\_name ('IC417\_Ha\_1minc...'), d (0), data\_reg ('55'), diff\_from\_25 (40.3600), diff\_in\_DN (354.0351), Exposure\_Length ('FF'), exposure\_time (1), file\_name\_prefix ('IC417\_Ha\_1minc\_'), frm\_cnt (1), fs\_flag (1), i (2). The Windows taskbar at the bottom shows the Start button, search bar, and various application icons. The system tray on the right shows the date and time: 10:56 PM 12/4/2018.

# Astroimaging – Setup and Operation

## Single 10 minute exposure



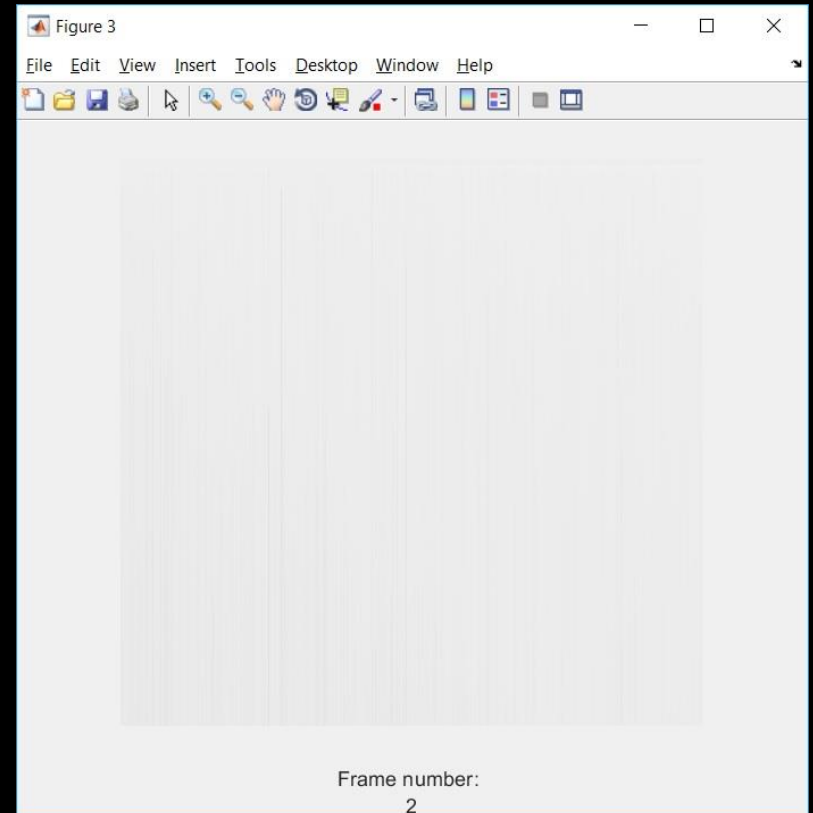
# Astroimaging – Setup and Operation

## Flat Lights, Flat Darks, Bias



Want mid-level grey:  
16 bit images 0 to 65,535  
Want flat light around 32,000

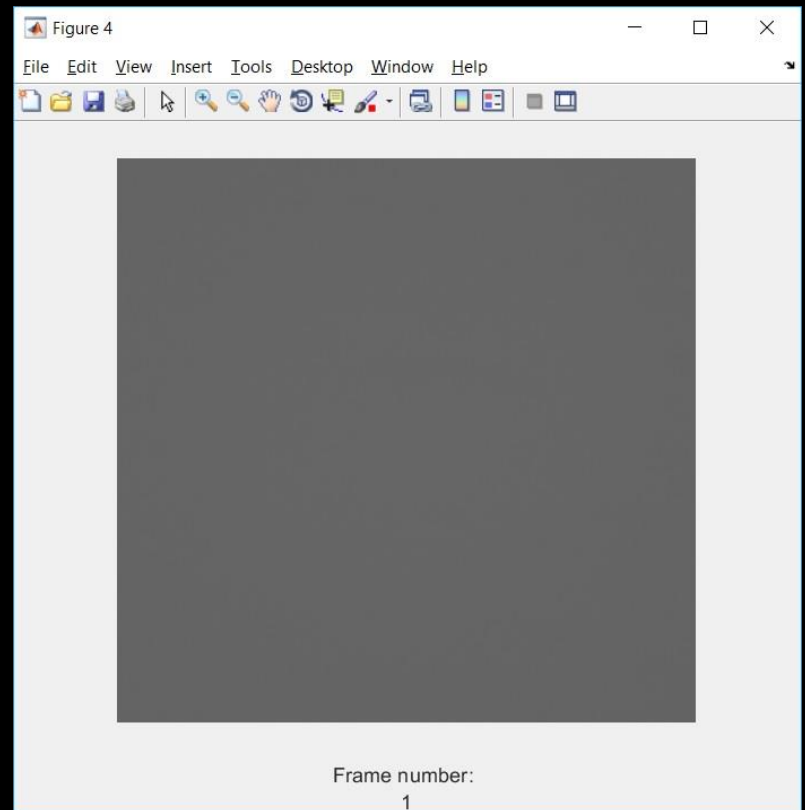
Too bright



# Astroimaging – Setup and Operation



Too dark



# Astroimaging – Setup and Operation



About right

Figure 2

File Edit View Insert Tools Desktop Window Help

```
Image 1 read into array.  
Received first image frame sync byte: 55  
Received second image frame sync byte: 55  
Received third image frame sync byte: 55  
Image frame sync obtained.  
Image 2 read into array.  
  
End of images  
>> mean(mean(kimg16))  
  
ans =  
  
3.2970e+04  
fx >>
```

Frame number:  
2

# Astroimaging – Setup and Operation

Make flat lights

MATLAB R2018a interface showing the execution of the 'make\_flat\_lights\_SC8300.m' script. The Command Window displays the following output:

```
ans =  
3.2970e+04  
  
>> close all;  
>> make_flat_lights_SC8300  
Enter number of frames 15  
Enter file name sequence prefix flat_light_SC8300_127mm_Refract  
Received first image frame sync byte: 55  
Received second image frame sync byte: 55  
Received third image frame sync byte: 55  
Image frame sync obtained.
```

The Workspace window shows variables:

Name	Value
a	1000x1024 uint16
ans	3.2970e+04
d	0
data_reg	'55'
exposure_length	'FF'
frm_cnt	2
fs_flag	1
i	2
img_fs	85
j	3
king16	1024x1024 uint16
number_of_frames	2
row	1024
s	1x1 serial

MATLAB R2018a interface showing the execution of the 'long\_exp\_seq1\_darks\_SC8300.m' script. The Command Window displays the following output:

```
>> make_flat_darks_SC8300  
Enter number of frames 15  
Enter file name sequence prefix flat_dark_SC8300_127mm_Refractor  
Received first image frame sync byte: 55  
Received second image frame sync byte: 55  
Received third image frame sync byte: 55  
Image frame sync obtained.
```

The Workspace window shows variables:

Name	Value
current_file_name	'flat_light_SC8300...'
d	0
data_reg	'55'
exposure_length	'FF'
file_name_prefix	'flat_light_SC8300...'
frm_cnt	15
fs_flag	1
i	2
img_fs	85
j	3
king16	2504x3326 uint16
number_of_frames	15
row	2504
s	1x1 serial

Make flat  
darks

Make bias

MATLAB R2018a interface showing the execution of the 'long\_exp\_seq1\_darks\_SC8300.m' script. The Command Window displays the following output:

```
End of images  
>> make_flat_darks_SC8300  
Enter number of frames 15  
Enter file name sequence prefix bias_  
Received first image frame sync byte: 55  
Received second image frame sync byte: 55  
Received third image frame sync byte: 55  
Image frame sync obtained.
```

The Workspace window shows variables:

Name	Value
exposure_length	'55'
file_name_prefix	'flat_dark_SC8300...'
frm_cnt	15
fs_flag	1
i	2
img_fs	85
j	3
king16	2504x3326 uint16
number_of_frames	15
row	2504
s	1x1 serial

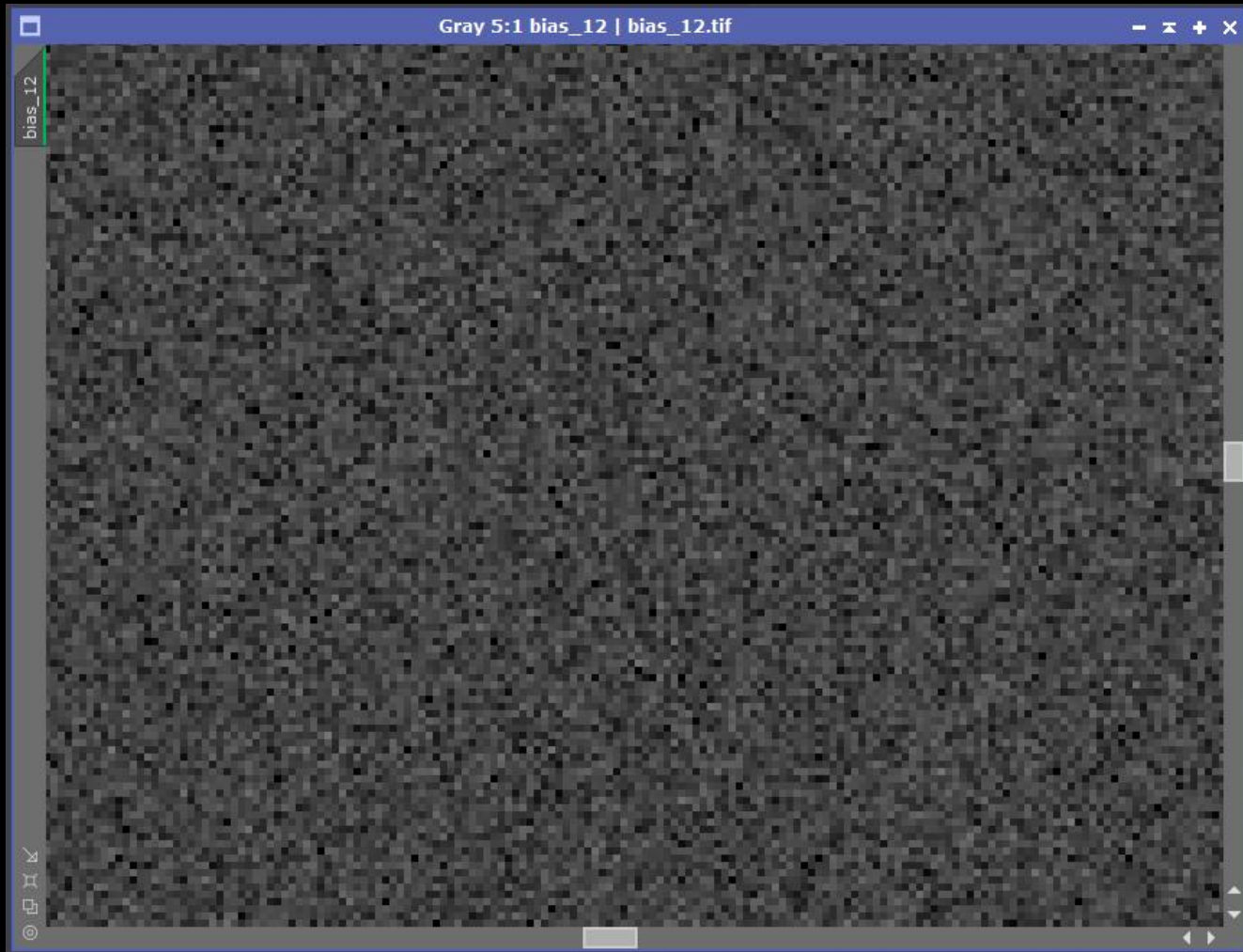


# Astroimaging – Setup and Operation



Flat Light:  
Histogram  
Equalized

# Astroimaging – Setup and Operation



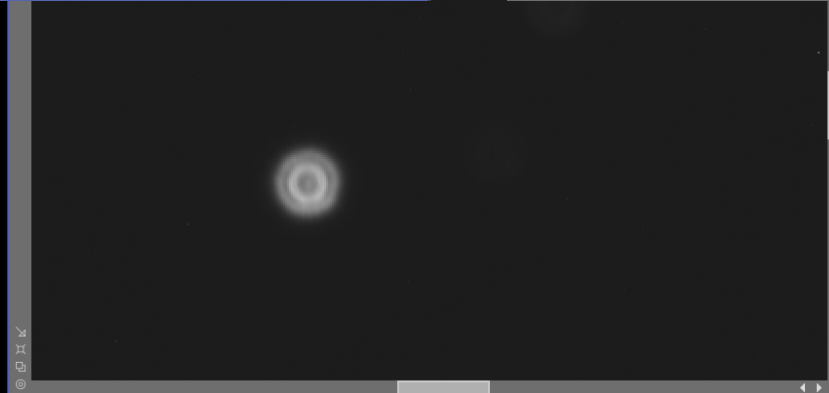
Bias:  
Zoomed In  
Histogram Equalized

# Astroimaging – Setup and Operation

## Results



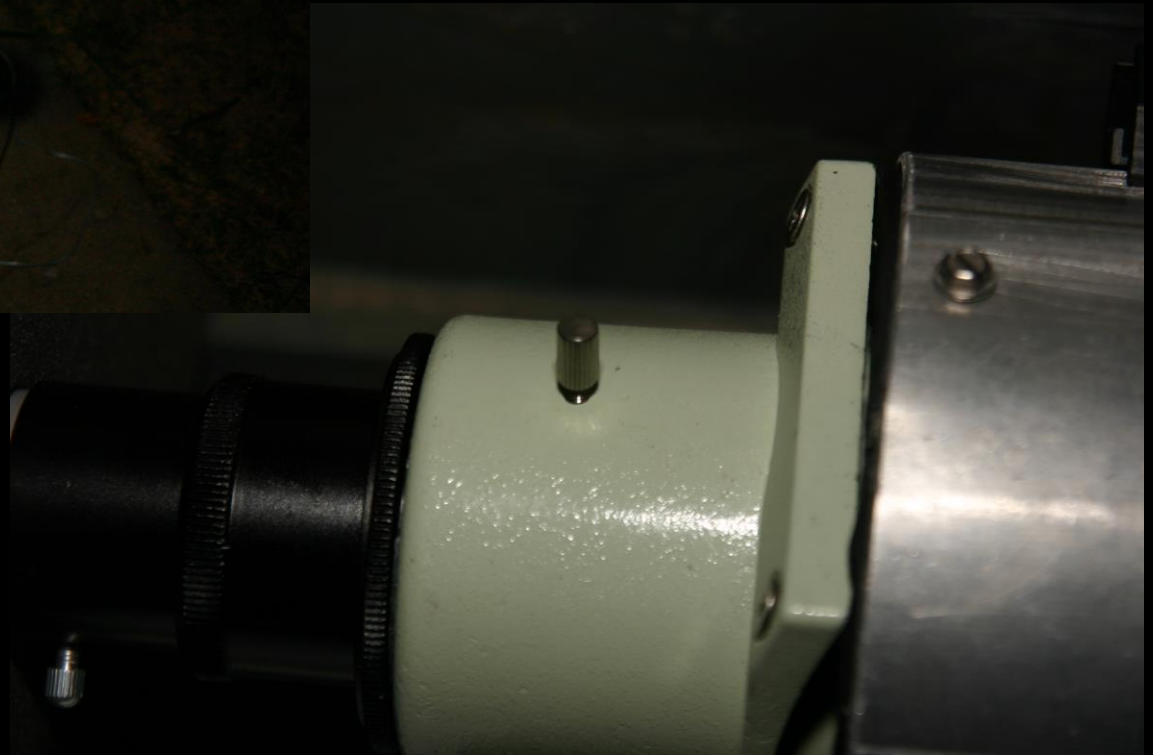
Took 14 x 10  
minute exposures:  
1 to 4: good  
5,6,7: bad tracking  
8 to 14: lost focus



# Astroimaging – Setup and Operation



Focus slip issue:  
Drilled and tapped focus set screw



# Astroimaging – Setup and Operation



- 4 x 10 minutes
- Only 40 minutes
- Vignetting
- Indicates potential for future image

# Astroimaging – Setup and Operation

- Other image taken with same configuration
- 36 x 10 minutes
- 6 hours total



The Holland Observatory  
10/28, 29/18

NGC7000 - North America Nebula in Cygnus  
26 x 10 minute exposures, Hydrogen Alpha (Ha)  
127mm Refractor at f/6.68, SC8300 Camera

# Astroimaging – Setup and Operation

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The End