Introduction to Non-Tracking DSLR Astrophotography

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Introduction

Astrophotography can be rewarding and yet frustrating at times. Purchasing the right equipment for the desired effect may be challenging. Locating clear dark skies can also be a challenge. Equipment may need to be portable enough to be transported to a clear dark sky location. Computer simulations of equipment is a great way to try equipment out before making a purchase. Asking for advice is always a good idea. Canon cameras are generally more friendly towards astrophotography because they began the art. This author used Nikon because that was purchased previously for other uses.

Earth's Rotation

As the earth rotates the stars appear to rotate through the sky above. By aligning the telescope to a fixed point in the sky which isn't moving allows one to track objects using only the Right Ascension (RA) control. The Right Ascension movement compensates for the earths movement and allows the telescope to track an object. The part of the sky that doesn't move is the North Celestial Pole for the Northern hemisphere. In the Northern Hemisphere Polaris is very close to the North Celestial Pole and provides an adequate position for observing. The basic aim of Polar Alignment is to align the telescope mounts Right Ascension (RA) axis to Polaris. The simplest method of polar alignment is simply to aim the RA axis at Polaris. In some cases, star trail photographs are desired. In that case, no tracking should be done.

Tripods, Mounts, and Tracking

The photographic tripod or alt-azimuth mount is the simplest mount. The alt-azimuth mount has two axes of movement: a horizontal axis and a vertical axis. To point the telescope at an object, move it along the horizon (azimuth axis) to the object's horizontal position, and then tilt the telescope, along the altitude axis, to the object's vertical position. It does not align and track stars. This type of mount can be used for binoculars, spotting scopes, cameras, and low power telescopes.

The equatorial mount has two polar aligned axes of rotation: right ascension and declination. However, instead of being oriented up and down, it is tilted at the same angle as the Earth's axis of rotation. This type of mount can track stars manually or automatically when connected to a clock mechanism.

These types of mounts are available in manual or computerized Go-to operation.

Vibration pads can also be used to minimize tripod vibration.

Camera Vibration and Exposure Time

A very important aspect of astrophotography for either camera or telescopes is that the mount MUST be STURDY. Even a micro amount of movement or shake can result in burred photos.

A camera can be mounted on a tracking mount, a non-tracking tripod, or on a telescope, which is mounted to a tracking or non-tracking mount. The earth rotates on its axis at about 1/2-degree per minute. The maximum exposure time will depend upon the focal length of the lens or telescope, the ISO speed of the camera, the pixel size of the sensor, and the declination. Generally, the maximum exposure time is 5 minutes.

A remote shutter release control should always be used to avoid shaking the camera while pressing the shutter release button on the camera. A remote shutter release intervalometer is an inexpensive device that can be set to expose one or multiple exposures over a variable period of time.

DSLRs allow light to enter through the lens. Then, the light is reflected by a mirror to the viewfinder. When, the shutter button is pressed, the mirror flips so that the light will be projected onto a digital sensor or film. When, the mirror moves, the camera will shake, which can result in burred images for long exposure times. Many DSLR cameras have a mirror lockup feature to prevent this. They also have an exposure delay function to prevent camera vibrations during long exposures. The mirror up function stops the mirror from moving when capturing the image to prevent camera vibration. (2 shutter releases for Nikon cameras). The Exposure Delay function waits 1, 2, or 3 seconds after the mirror is raised to capture the image to prevent camera vibration.

ISO, formerly known as ASA, expresses the speed or sensitivity of film or a digital sensor to light. The higher the ISO, the more sensitive the image sensor and therefore the possibility to take pictures in low-light situations. Increasing ISO will decrease exposure time. However, increasing ISO also increases sensor noise or grain in film. For finer detail, use an ISO of 100 or 200. In some cases, this can make the exposure time too long. To accommodate circumstances, increase the ISO. Some digital DSLR cameras today offer ISO speeds as high as 28,000.

Several photos were tested on 5/9/17 at 1/500 second and mirror up made a difference.

Sensor Sizes

There is a great deal of confusion when it comes to comparing crop sensor camera lenses to full frame camera lenses. Often the specification of a crop sensor lens may be stated as 10 mm with a comparable 35 mm focal length of 15 mm. This may give the user the impression that they will have a 15 mm focal length. This is incorrect. The focal length doesn't change. Only the field of view changes. Therefore, it should be stated that the field of view is the same as a 15 mm focal length lens.

A full frame camera projects an image onto a sensor or film that is 36 mm x 24 mm in size. An APS-C camera projects an image that is 23.5 x 15.6 mm in size. An APS-C sensor costs less than a full frame sensor. APS-C lenses are smaller and lighter in weight. Larger sensors are often used for larger size prints.

What is of primary concern is the field of view that is produced by these two sensors. As seen in the diagram below, the field of view that is seen by the full frame sensor is wider than the field of view seen by the APS-C or "crop" sensor. The focal length remains the same, which is often confused. The only aspect that changes is the field of view, not the focal length.

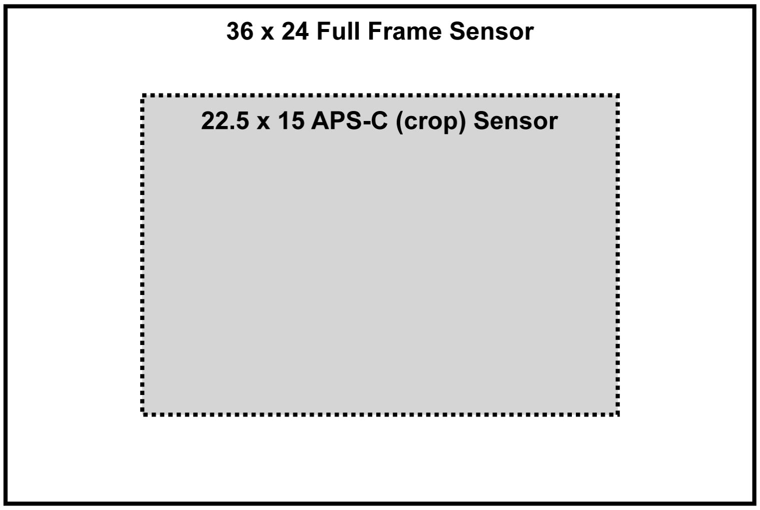
Lens and the images projected onto a sensor are round in shape, whereas the sensors are rectangular in shape. The diameter of the circle needs to be larger than the diagonal of the rectangular sensor. A full frame 35 mm lens must have an image circle larger than 43.27 mm. An APS-C camera lens needs to have an image circle larger than 27.04 mm. If an APS-C lens is used on a full frame camera, the image circle would not be large enough to cover the corners of the sensor. If a full frame camera lens is used on an APS-C camera, it will cover the corners of the APS-C sensor.

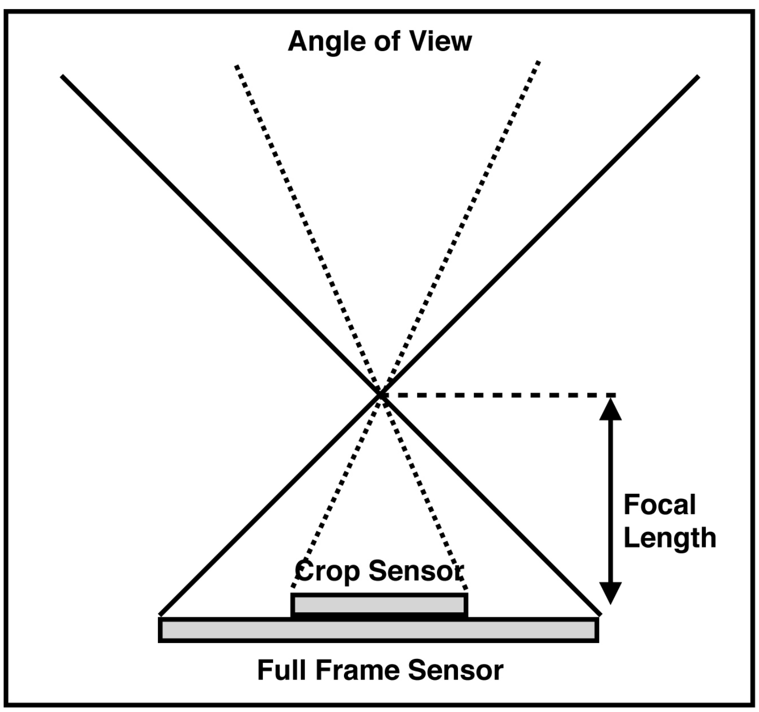
What makes this concept confusing is that when photos are added to a photo software program, they are often enlarged by the software to a specific size. Most people don't pay attention to the enlargement size in the software. Photos are then presented online using the same frame size, which gives the appearance that they are enlarged. But, the photos are not enlarged from the camera, only from the photo software. In this article, the actual photos are presented in actual size format.

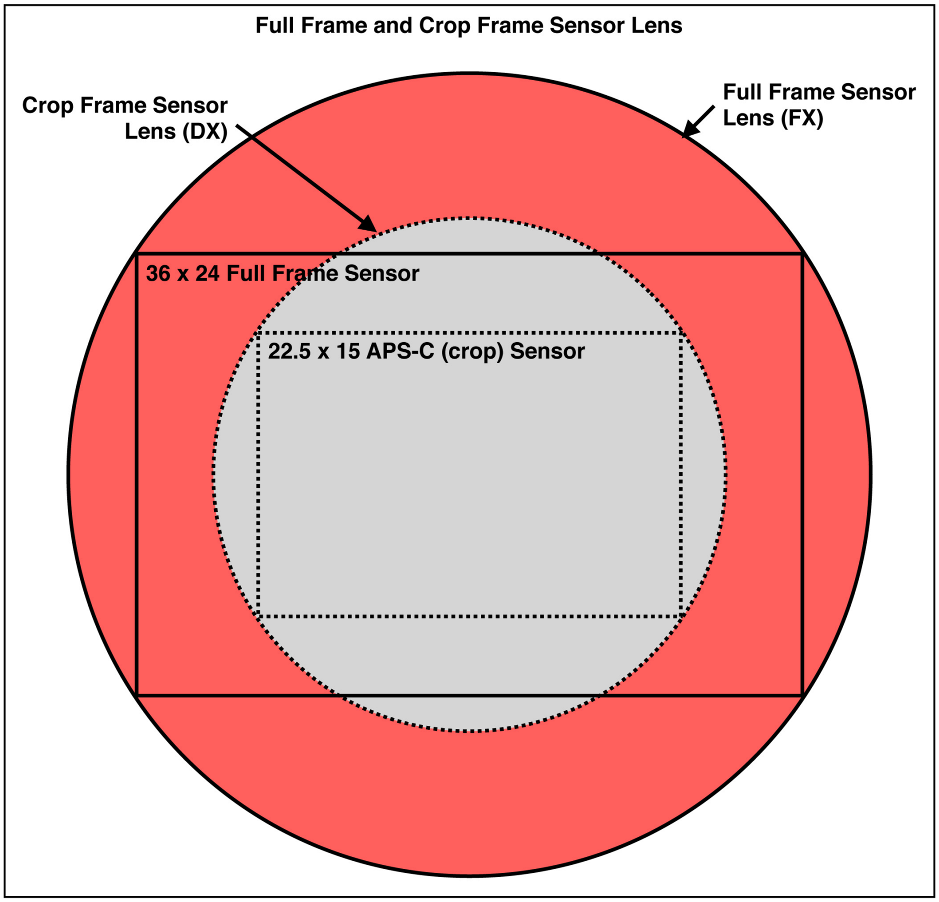
When a DX lens specification says, for example, a 100 mm DX lens is equivalent to a 150 mm FX lens, it is referring to the field of view, not the magnification. It should be stated as the field of view of a 100 mm DX lens is equivalent to the field of view of a 150 mm FX lens.

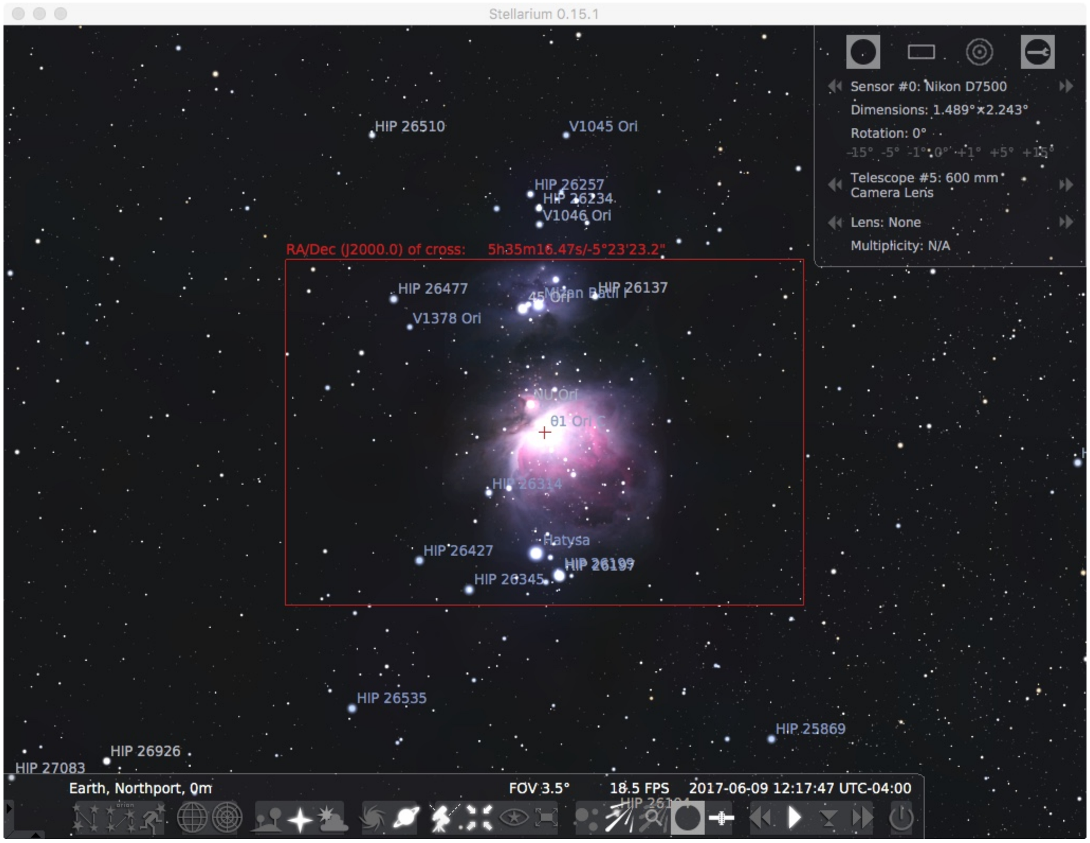
To obtain the field of view obtained with the FX camera using a DX camera, change the lens (or zoom out) from 70 mm to 46.6 mm. In order words, a photo taken with a DX camera and

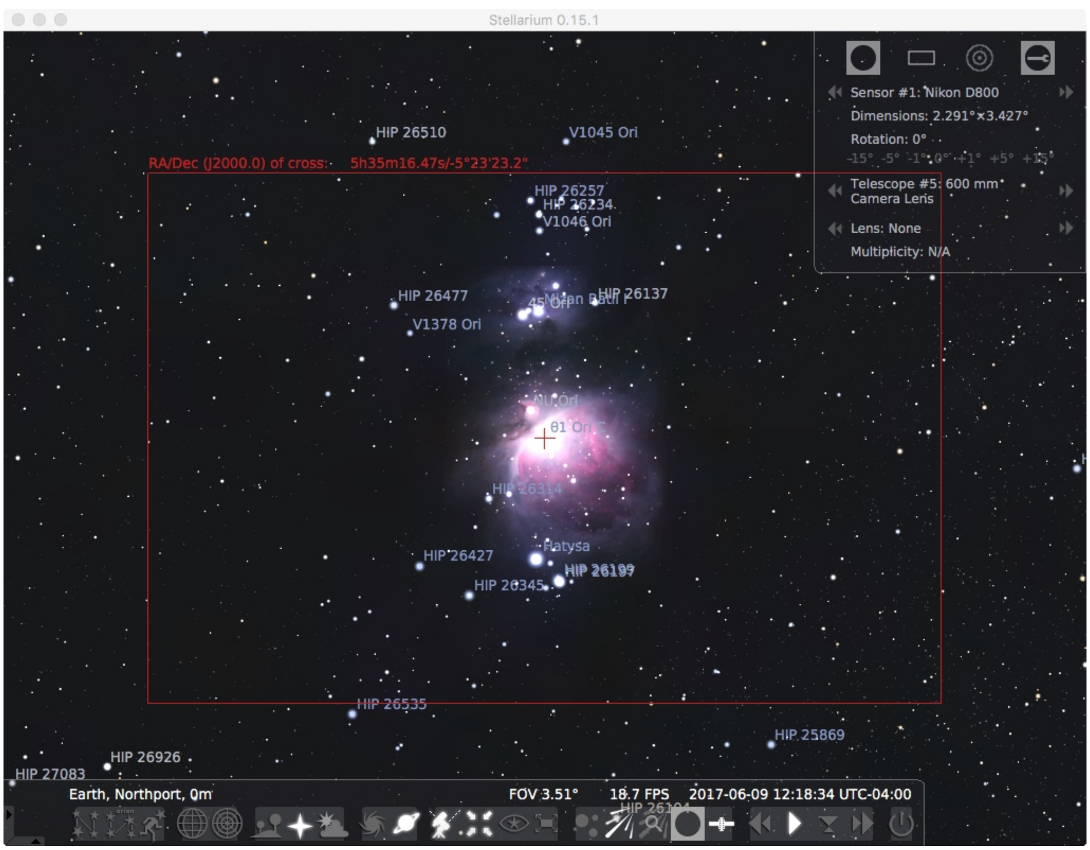
46.6 mm lens would look exactly the same size as the photo taken with an 70 mm FX camera lens. The resolution of an FX camera will be greater than that of a DX camera because the full frame sensor is larger and contains more pixels per size. This is important when printing larger prints. It probably won't make much difference when displaying photos on the web or printing smaller sizes such as 8" x 10".






Full Frame and Crop Frame Sensor Lens
Crop Frame Sensor Lens (DX)
Full Frame Sensor Lens (FX)
36 x 24 Full Frame Sensor
22.5 x 15 APS-C (crop) Sensor





D7500 APS-C Camera vs D800 Full Sensor Camera in Stallarium with 3.5 FOV

D7100 70 mm FX

D800 70 mm FX

D7100 APS-C Camera vs D800 Full Sensor Camera

The same field of view as the D800 camera with 70 mm lens can be obtained using the D7100 with or zoom to 46.6 mm lens.

Correctors and Reducers

Some telescopes have spherical aberrations and some telescopes have chromatic aberrations. Field flatters, reducers, and chromatic corrects can be used to correct these problems.

Generally F6 doesn't require coma corrector while F4 requires a coma corrector

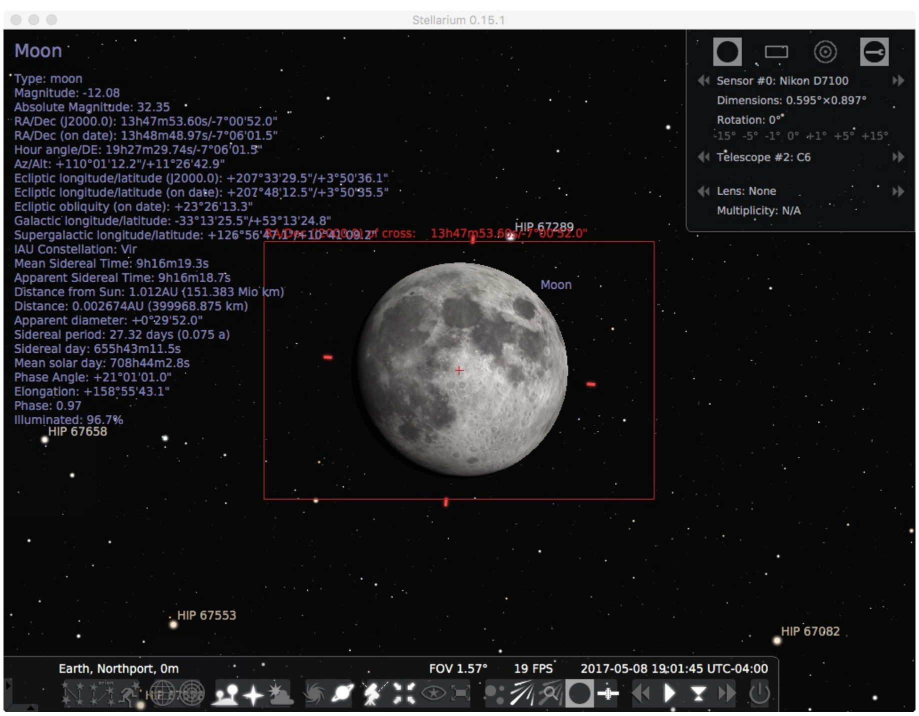
Software Guiding

There are a number of software programs that will time and guide a mount and camera. PHD Guiding is popular and available for mac and pc. Computerized mounts will also guide a camera and telescope.

Planning Equipment with Software

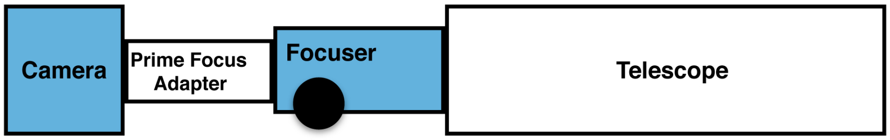
Planning what is going to be photographed and with what equipment can be done easily on a computer using the program "Stallarium." Stallarium can be downloaded for free from http://www.stellarium.org

The Stallarium simulation below represents an ideal photograph of the moon using the Celestron C6 (150 mm x 1500 mm) SCT telescope and the Nikon D7100 camera. The camera frame is represented by the red rectangle surrounding the moon.

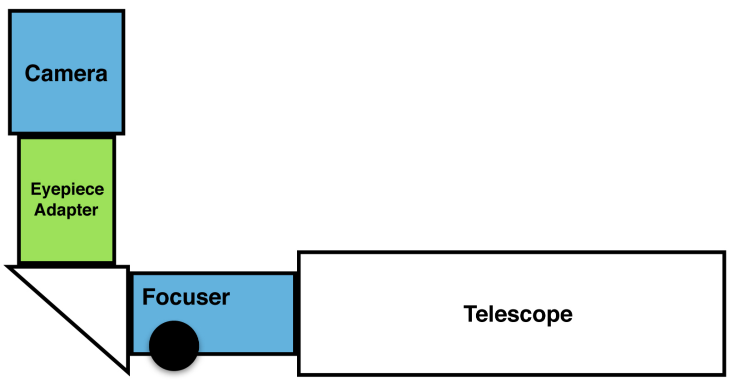


Telescope and Camera Configurations

The diagram below shows a camera connected to the prime focus using a prime focus and T adapter if it is a DSLR. The T adapter is specific for each camera.



The diagram below shows a camera connected to the eyepiece adapter. If the telescope has a 2” focuser, the prime focus connection will create a better image than the 1.25” eyepiece adapter. Although, using an eyepiece adapter may allow for an eyepiece to be inserted to provide additional magnification.



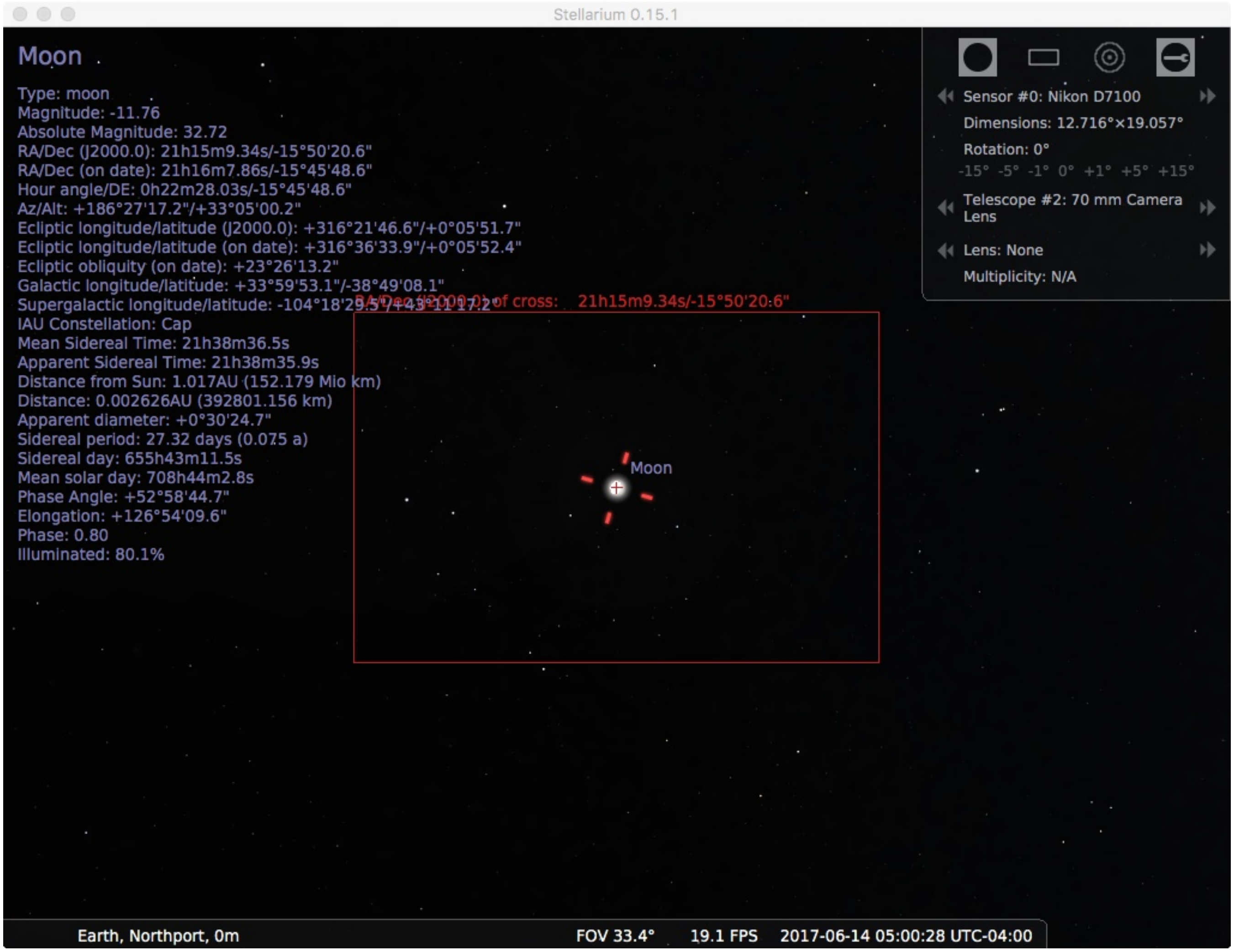
The next problem to solve is what optics to use? There are many different cameras, telescopes, eyepieces, barlow lenses, teleconverters, etc. For wide field astrophotography, many astronomers use only a camera and wide angle lens.

Comparison of Optics for Imaging the Moon

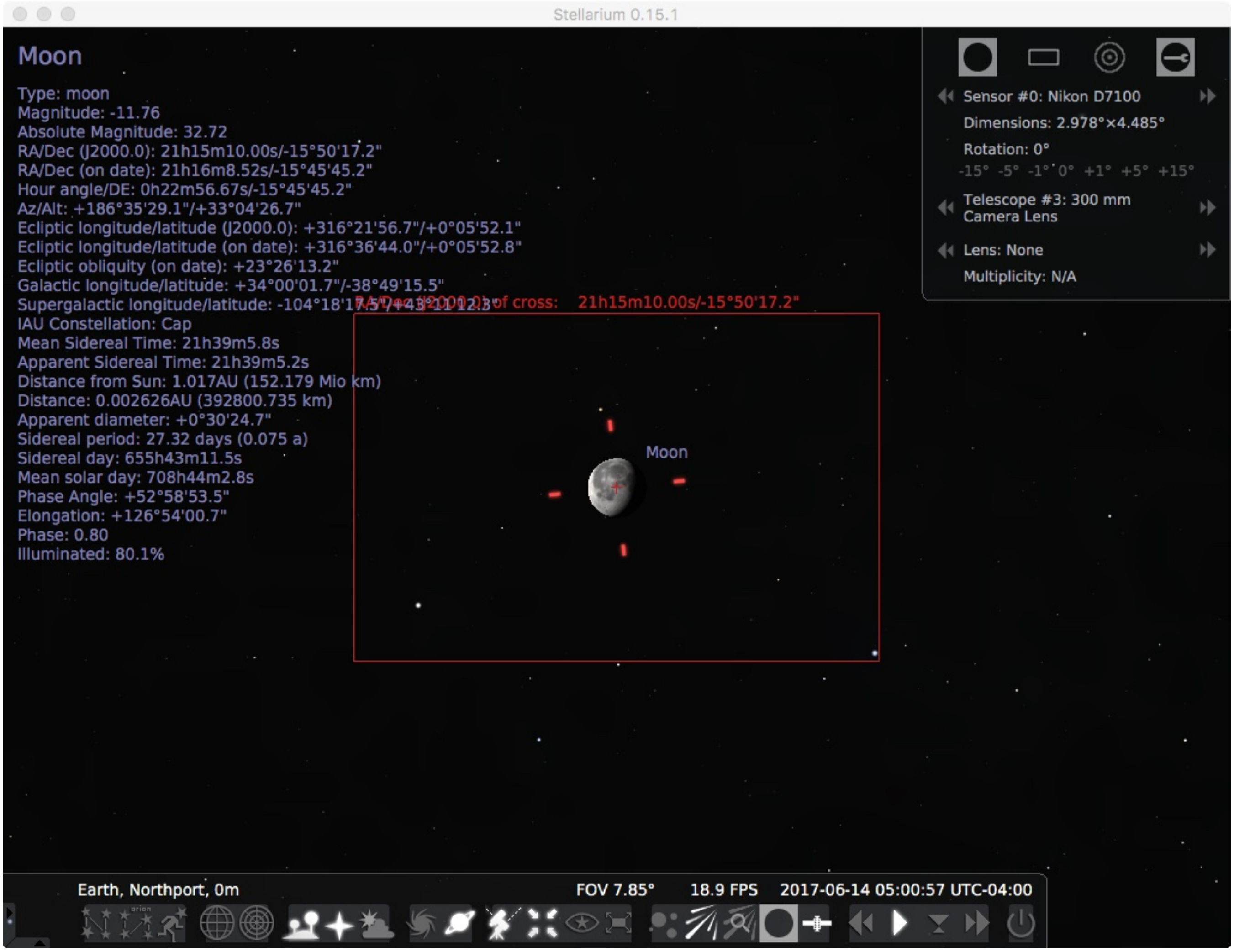
The following photos represent various configurations as produced by the computer program Stallarium. The camera field of view is shown within the red rectangle. We are now in the realm of focal length being of primary concern. Stallarium is available free for mac and pc.

Moon - APS-C, 14 mm FL Lens

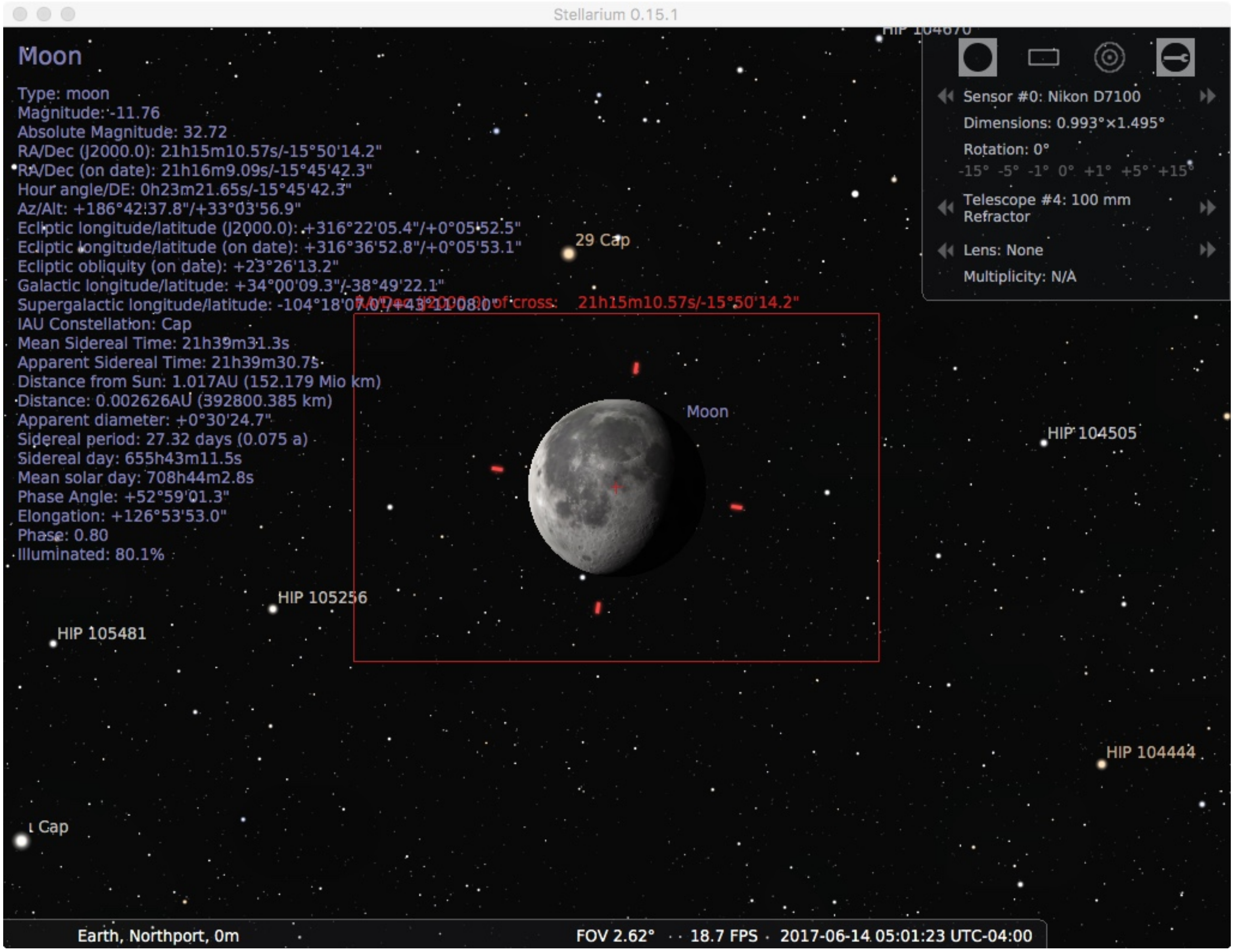
Moon - APS-C, 24 mm FL Lens



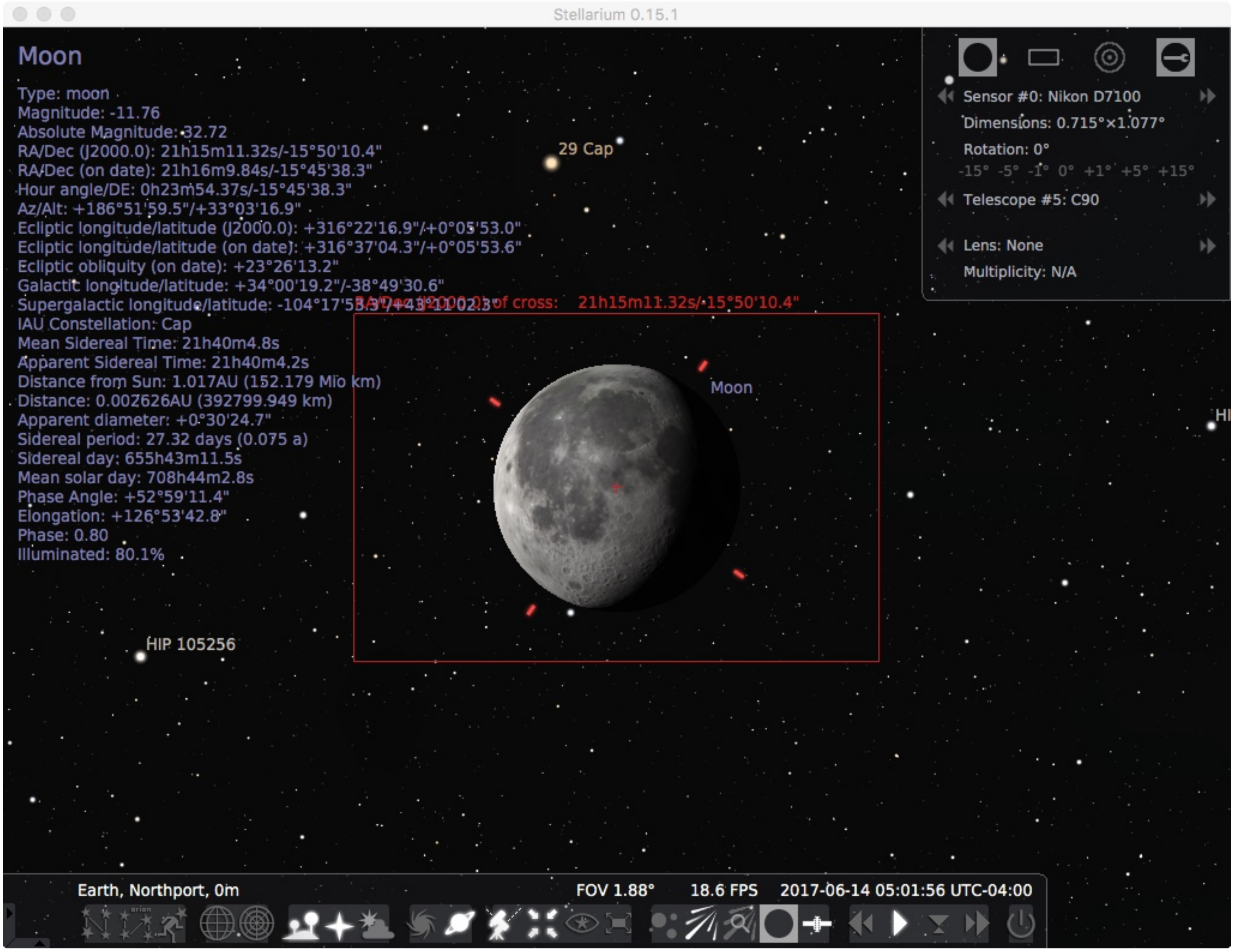
Moon - APS-C, 70 mm FL Lens



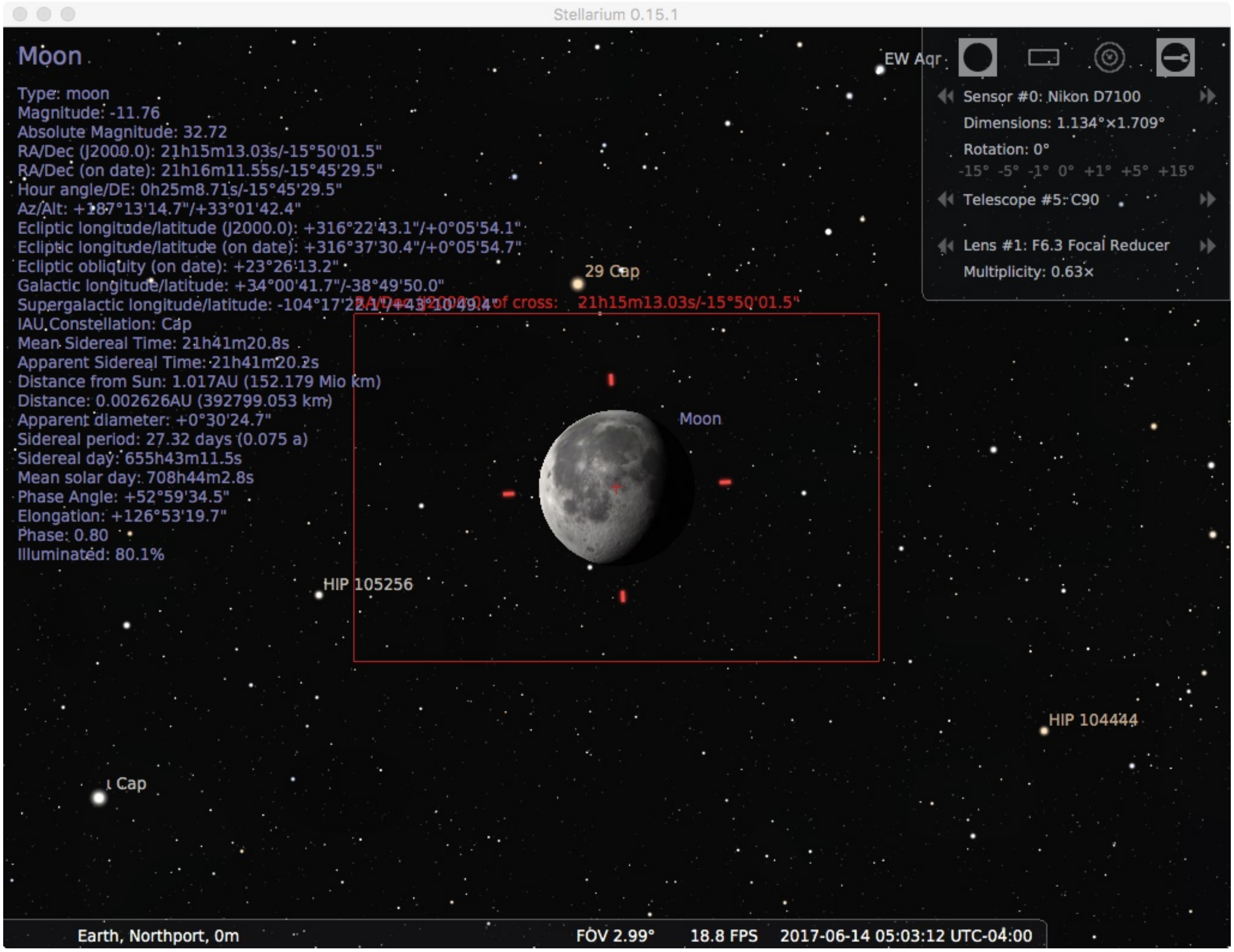
Moon - APS-C, 300 mm FL Lens



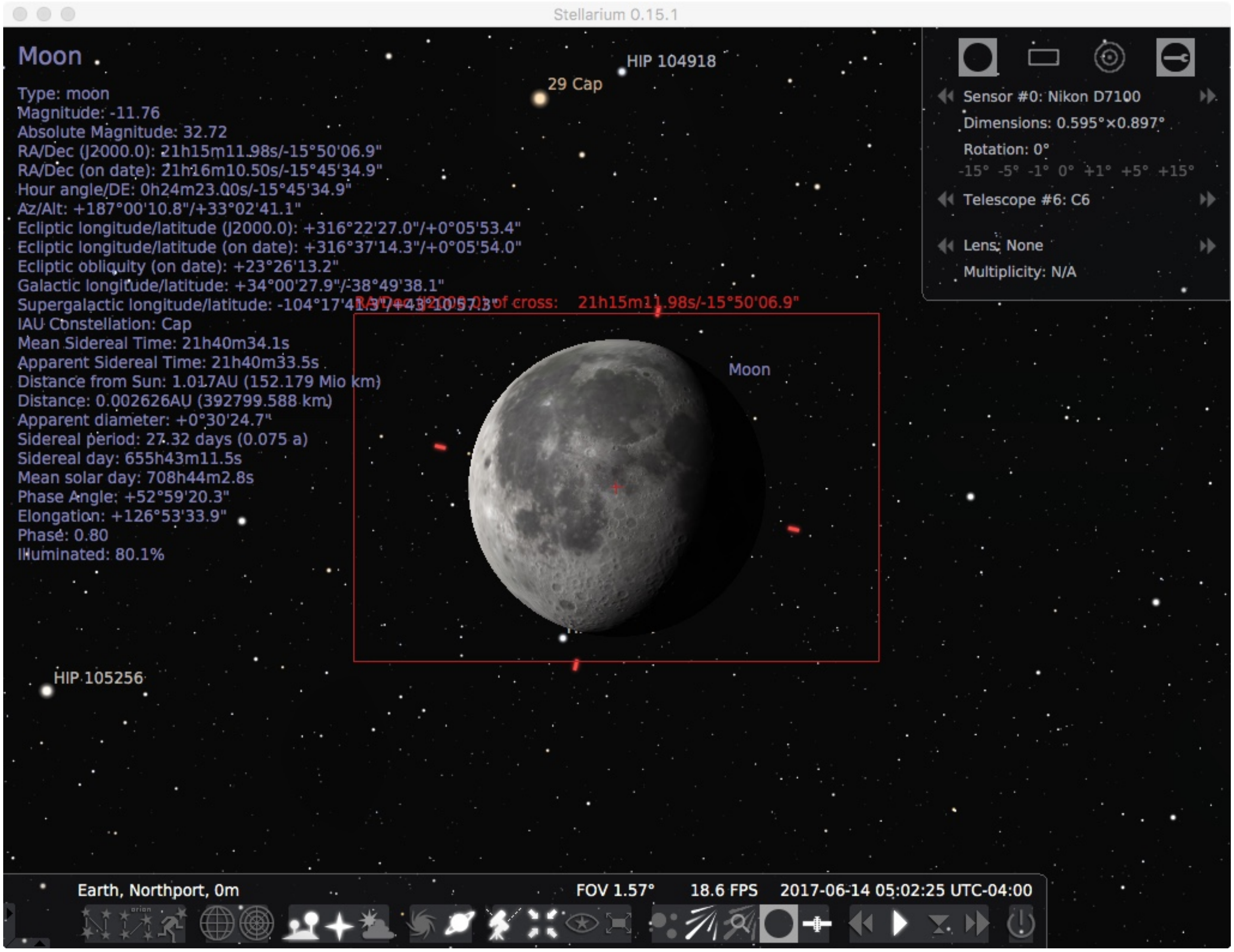
Moon - APS-C, 900 mm FL Telescope



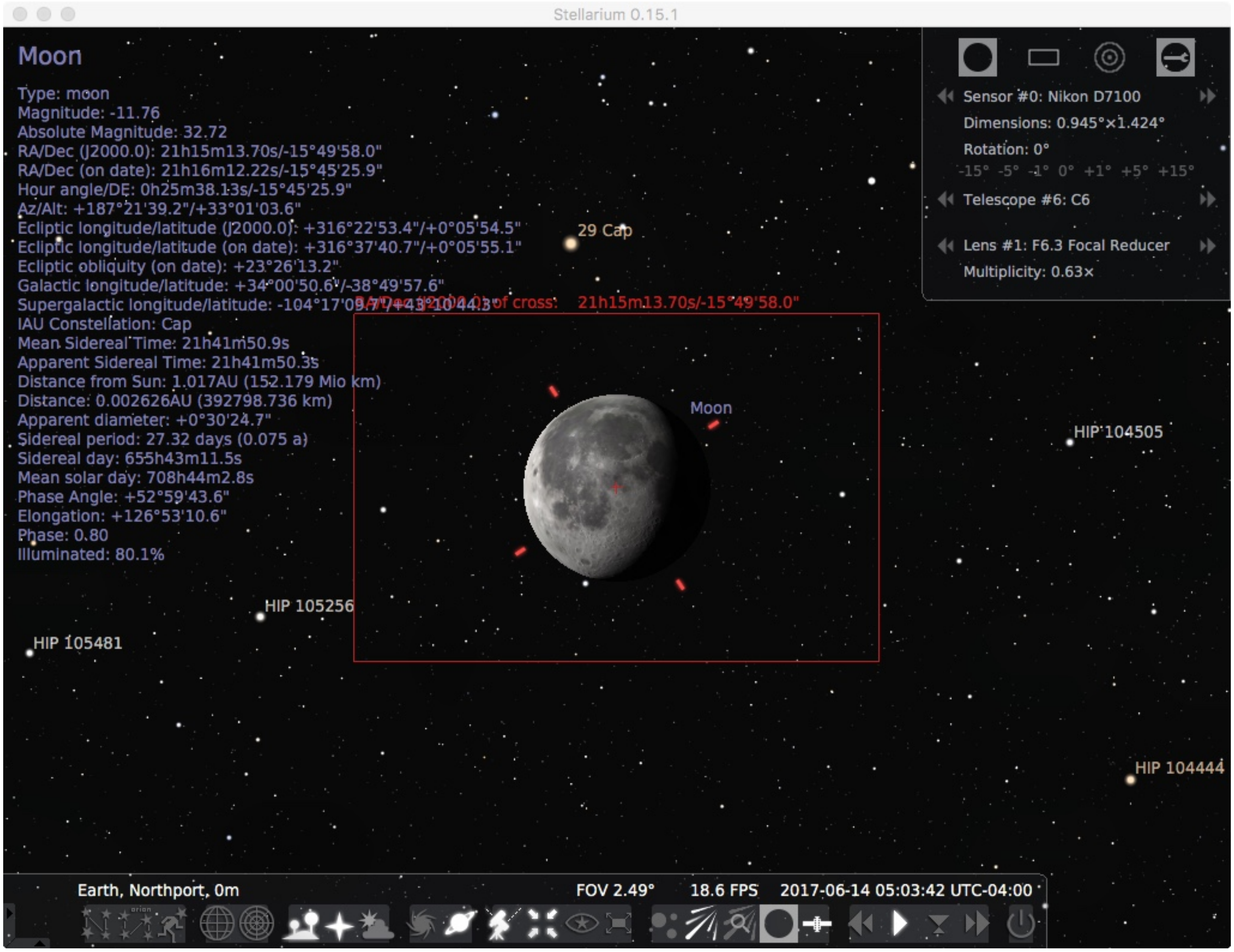
Moon - APS-C, 1250 mm FL Telescope



Moon - APS-C, 1250 mm FL FR.63 Telescope

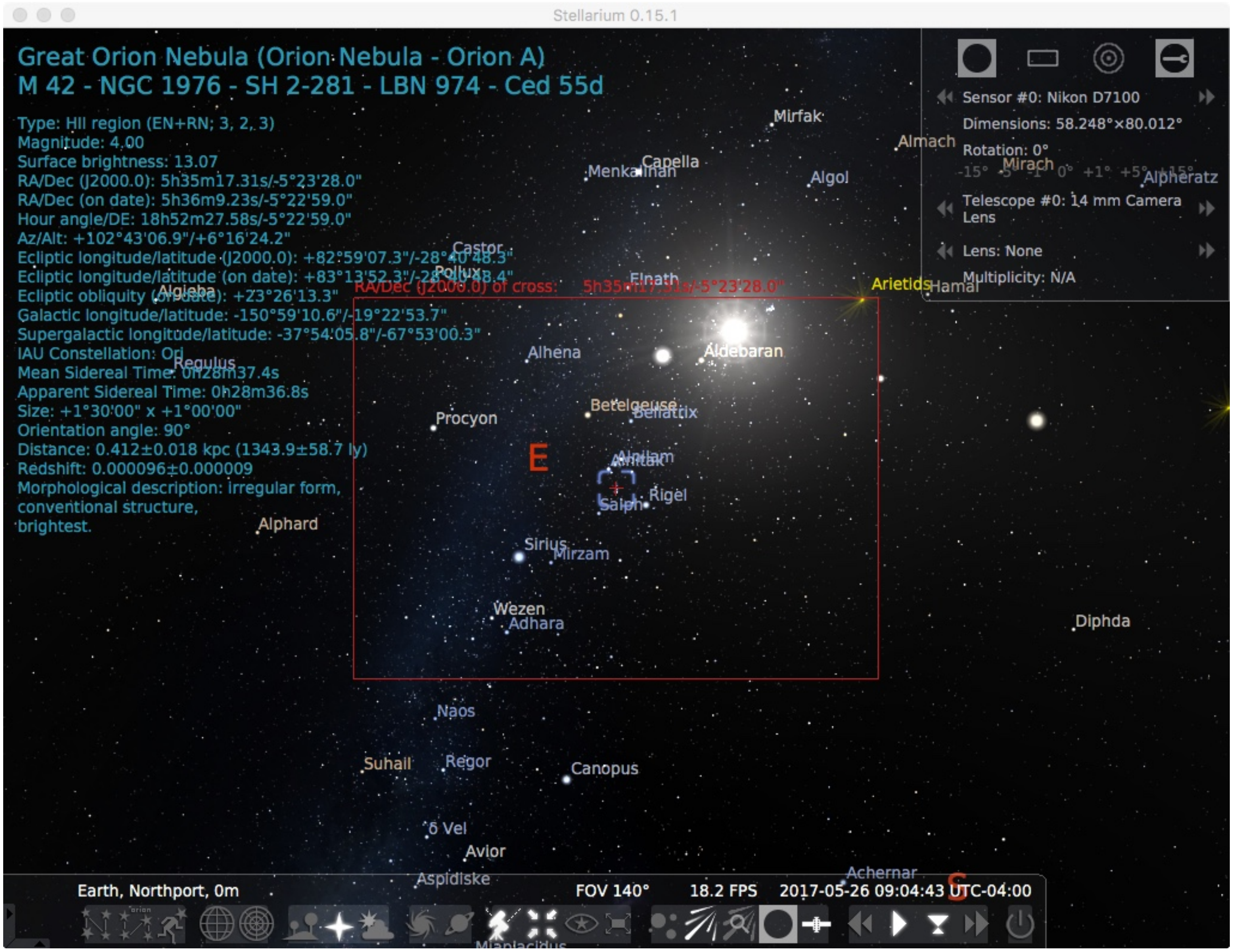


Moon - APS-C, 1500 mm FL Telescope

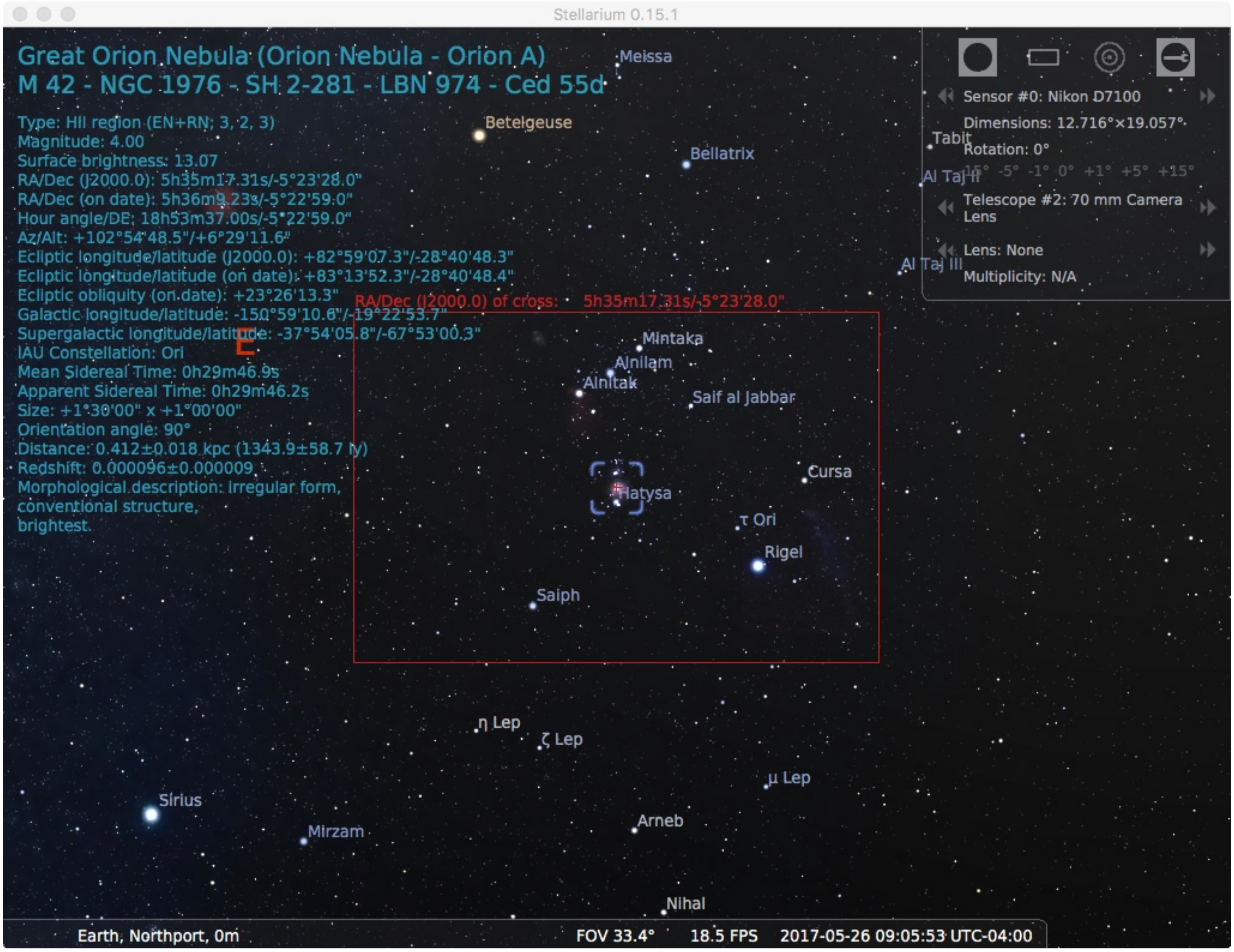


Moon - APS-C, 1500 mm FL FR.63 Telescope

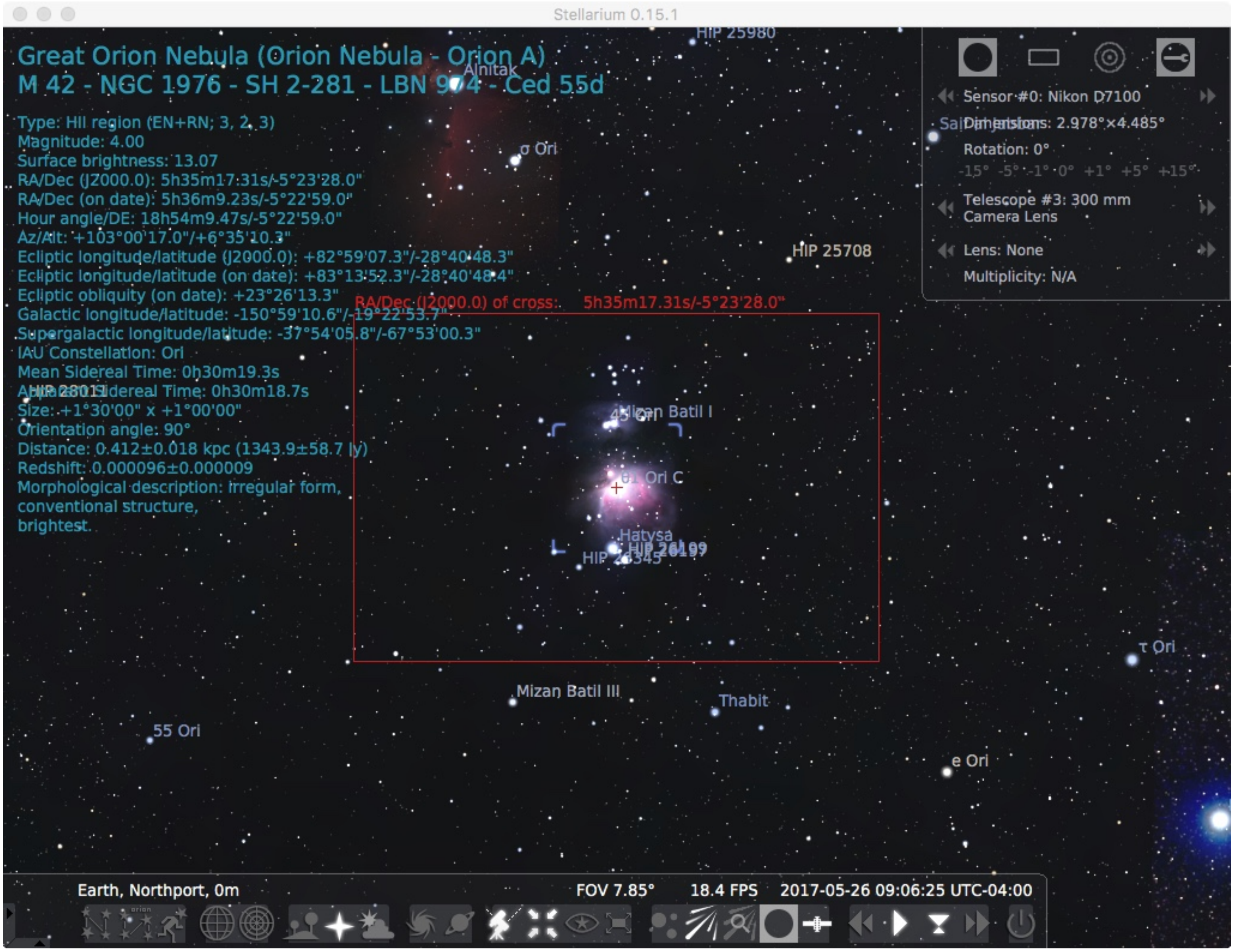
Comparison of Optics for Imaging the Orion Nebula



Orion Nebula - APS-C, 14 mm FL Lens



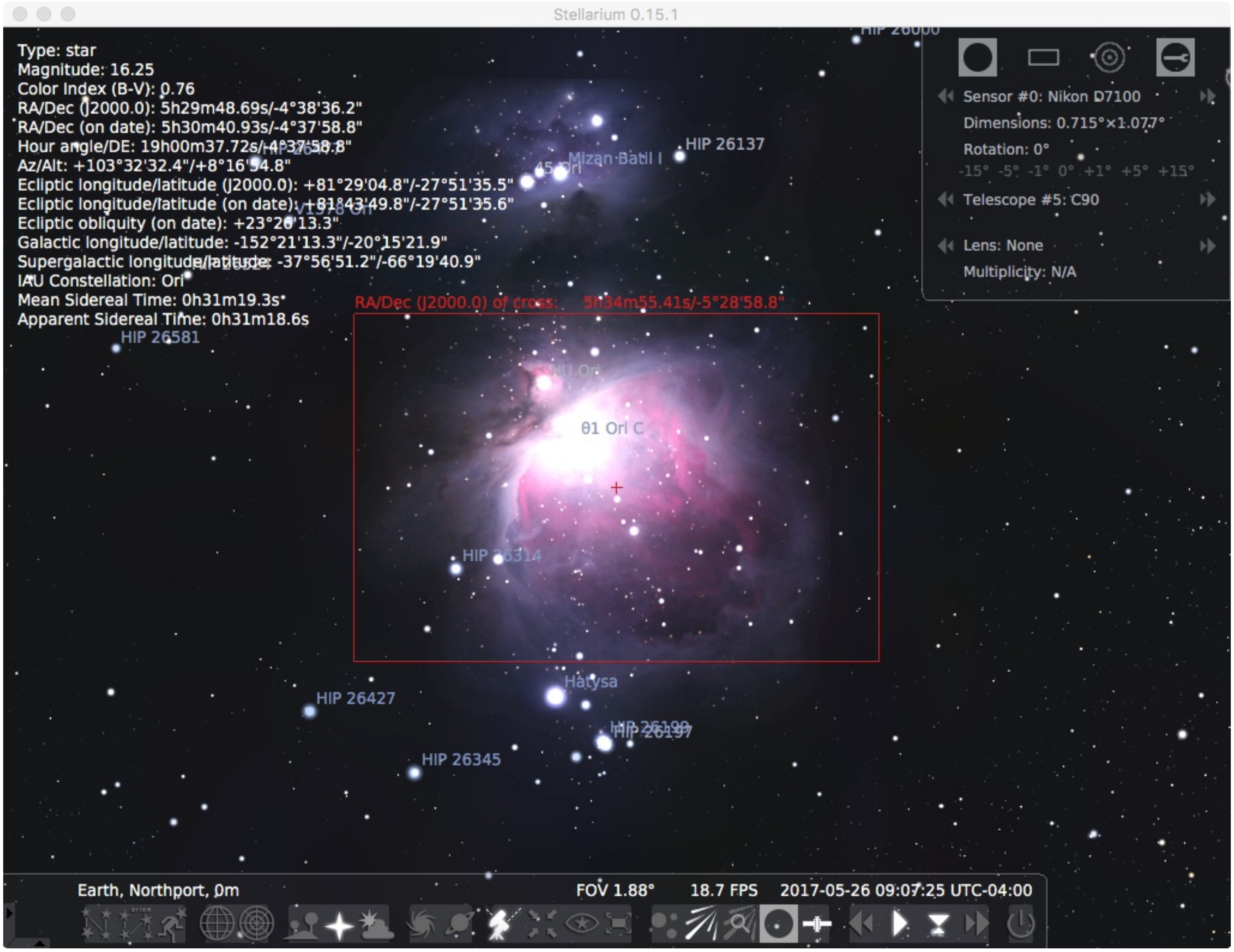
Orion Nebula - APS-C, 70 mm FL Lens



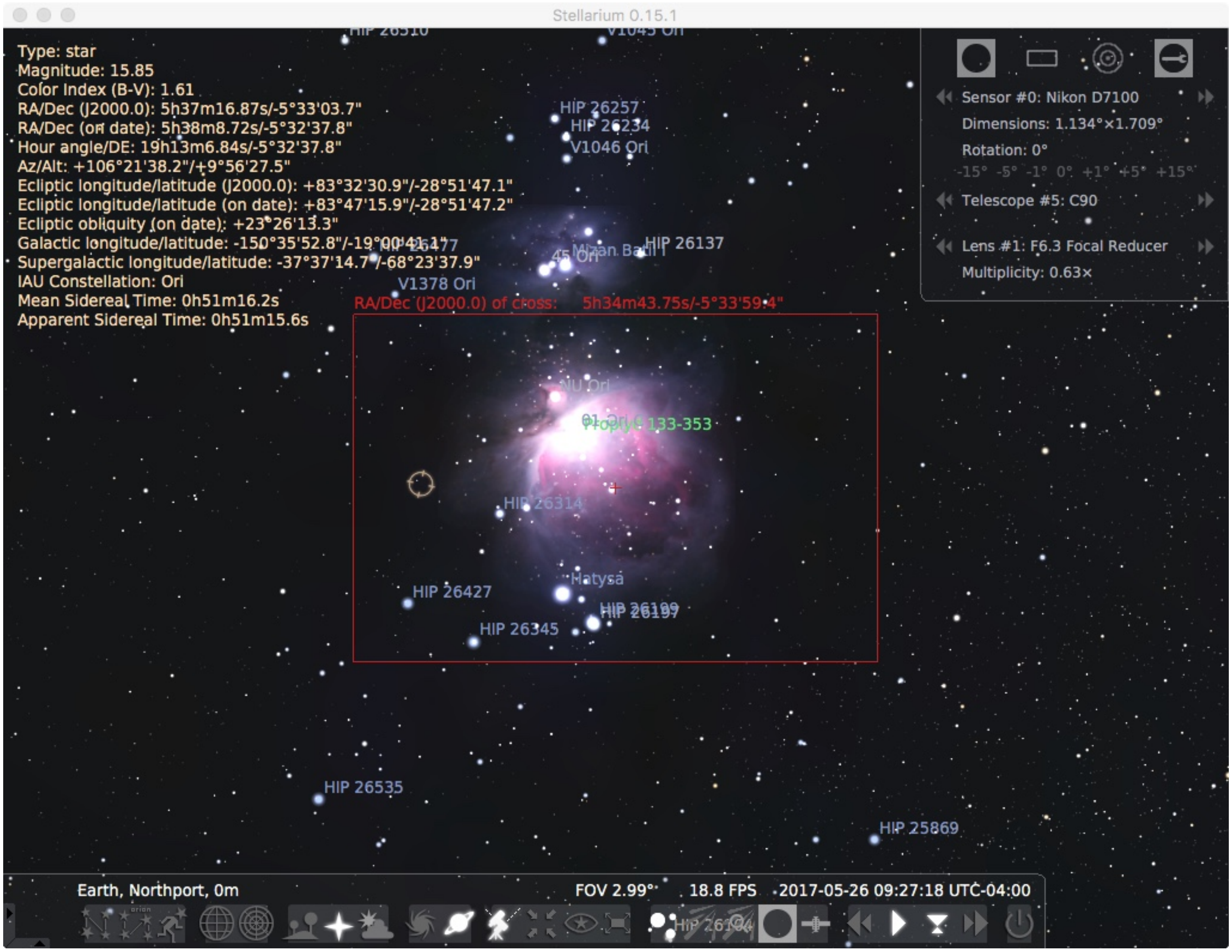
Orion Nebula - APS-C, 300 mm FL Lens

Orion Nebula - APS-C, 900 mm FL Telescope

Orion Nebula - APS-C, 900 mm FL FR.85 Telescope

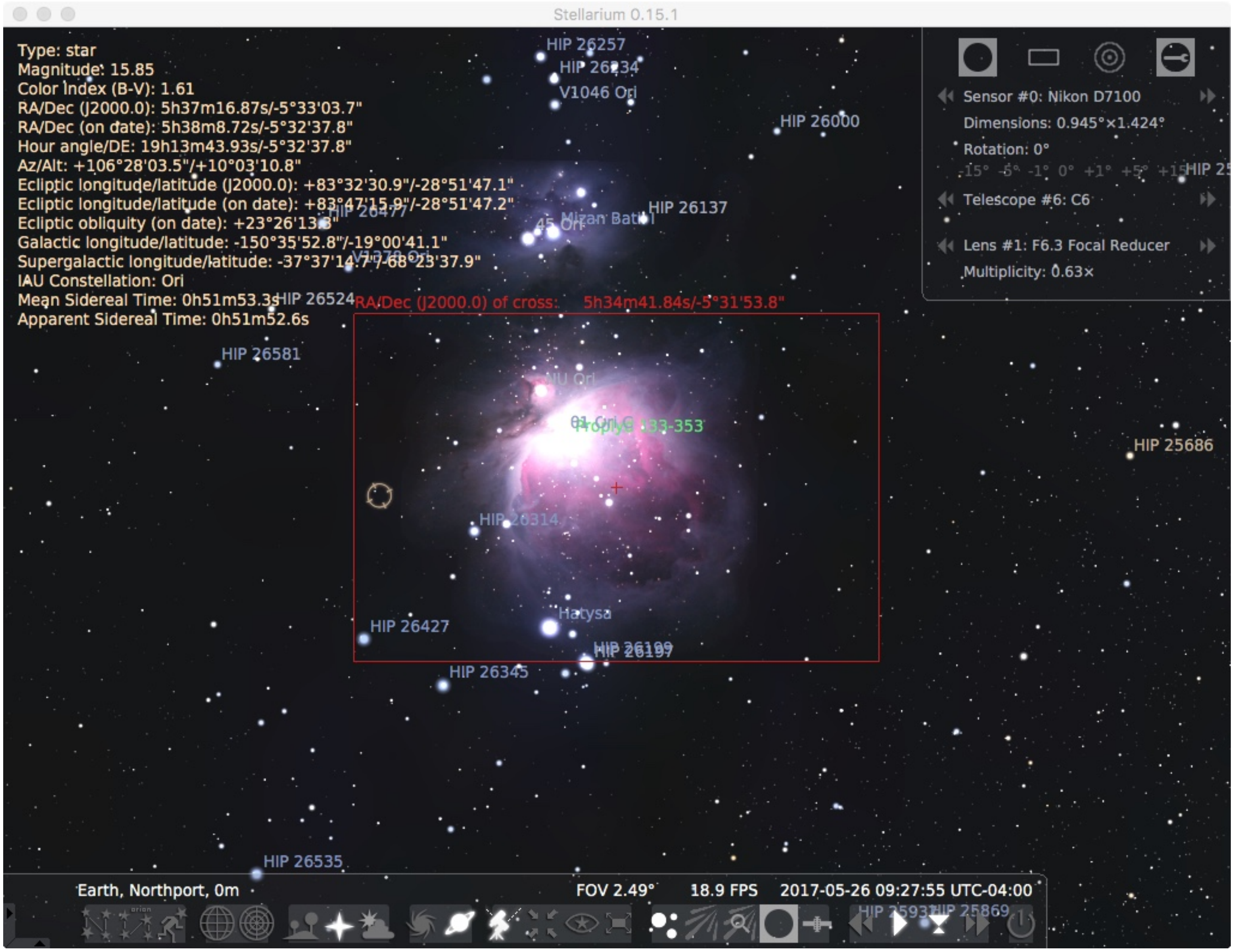


Orion Nebula - APS-C, 1250 mm FL Telescope



Orion Nebula - APS-C, 1250 mm FL FR.85 Telescope

Orion Nebula - APS-C, 1500 mm FL Telescope



Orion Nebula - APS-C, 1500 mm FL FR.85 Telescope

Nikon Mirror Up Mode

1. Select mirror up mode on the mode dial.

2. Frame the picture, focus, then press the shutter release button all the way down to raise the mirror.

3. Press the shutter release button all the way a second time to take the picture. Use the remote shutter release to prevent camera shake.

Note: if a camera doesn't have a mirror up mode, the "Exposure Delay Mode" is an alternative.

Post-processing in Photoshop

Photoshop can be a very useful tool is adjusting brightness, contrast, and sharpness of a photograph. It can also be used to stack multiple photographs together.

Photographing the Moon

Moon photography is often a recommended place to start because it is "easy." Well, it may not be all that easy. It could be a matter of trial and error. By comparison to deep space objects, the moon gives off a lot of light. Therefore, tracking is not required. This makes it easier than DSO photography. Tracking adds a great deal of difficulty to the equation.

The moon moves 1/2 degree, in about 2 minutes. As a general rule, the moon can be photographed for about 2 seconds before the moon's movement becomes a problem. A camera and telephoto lens may be the best equipment to start with. Later, a telescope can be used with adapters, etc.

Teleconverters are often incompatible with certain lenses and cameras. Check the manufacturer's compatibility list before purchasing.

The rule of thumb for a tripod / mount is that it should have a payload capacity of twice the weight of the payload (telescope). Equatorial go-to tracking mounts for telescopes that weigh 10 pounds can weigh in excess of 50 pounds. Camera go-to tracking mounts weigh far less.

The formula for determining the size of the lunar images on a sensor is found by dividing the focal length (in millimeters) by 109 to arrive at the lunar diameter (in millimeters) on the sensor.

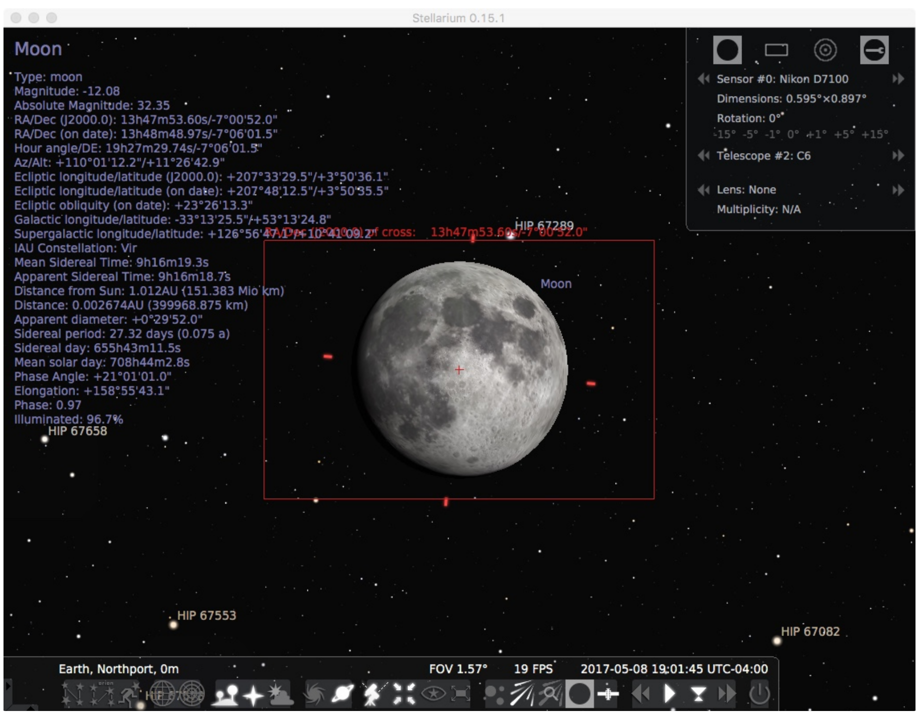
For a DX Format, 23.5 mm x 15.6 mm, 1700 mm = full frame height

For a DX Format, 23.5 mm x 15.6 mm, 850 mm = half frame height

For an FX Format, 35.9 mm x 24 mm, 2616 mm = full frame height

For an FX Format, 35.9 mm x 24 mm, 1308 mm = half frame height

The Stallarium simulation below represents an ideal photograph of the moon using the Celestron C6 (150 mm x 1500 mm) SCT telescope and the Nikon D7100 camera. The camera frame is represented by the red rectangle surrounding the moon. The magnification appears to be ideal.



The moon can even be photographed on a cloudy night with an iPhone. The image below was taken with an iPhone 7 on a cloudy night and processed in Photoshop to increase brightness, contrast, and sharpness. The unsharp filter mask was used and set at 150% (Filter > Sharpen > Unsharp Mask > Amount = 150%).The fence, lower portion of the house, garage, and shed were cropped from the bottom of the photograph. Metadata = f/1.8, 1/15, ISO 800, 3024 x 4032.

Cameras, Telescopes, and Lens

For astrophotography, generally, a lens of 8-24 mm focal length with f/2.8 aperture or greater for wide field photographs is recommended.

For planets, the moon, and deep sky objects, a telescope with a focal length of at least 600 mm is recommended.

For wide field images, a full frame sensor camera is recommended.

Configuration 1 - DSLR with Telephoto Lens

The configuration below is only one of the many different configurations that are possible. Choose what you want to configure and how much you want to spend. There are an almost infinite number of options available. The resource section adds more possibilities. A teleconverter would not be compatible with the 300 mm lens.

Nikon D7100 DSLR Camera (Crop Sensor DSLR Camera)
24.1 MP DX-Format CMOS Sensor, $700

Nikon AF-S VR Zoom-Nikkor 70-300 mm f/4.5-5.6G IF-ED Camera Lens, $500 (or Non ED lens for $200

Olivon TR197-16 Tripod with Head (Tall Tripod) Total Weight is 15 pounds, $250

Celestron Vibration Suppression Pads, ITEM # 93503, $50

Vello ShutterBoss II Timer Remote Switch for Nikon with DC2 Connection, $50

Total $1,550 ($1,250 with non ED Lens)

Configuration 2 - 6 inch Telescope and DSLR

The configuration below is only one of the many different configurations that are possible. Choose what you want to configure and how much you want to spend. There are an almost infinite number of options available. The resource section adds more possibilities.

Celestron C6-A-XLT CG-5 6" f/10 Schmidt-Cassegrain Telescope (OTA), $600
or substitute the C90 MCT Spotting Scope for $200

Celestron 94009 Lens Shade for C6 and C8 Tubes (Black), Item 94009, $25 (not for C90)

Celestron T-Adapter for Schmidt Cassegrain Telescopes (for C6 SCT), ITEM # 93633-A, $25 (not required for C90)

Vello Lens Mount Adapter - T Mount Lens to Nikon F Mount Camera, LANFT, $14

Vixen Porta II Mount Tall, Total Weight is 13.9 pounds, $400

Celestron Vibration Suppression Pads, ITEM # 93503, $50

Nikon D7100 DSLR Camera (Crop Sensor DSLR Camera), $700

Vello ShutterBoss II Timer Remote Switch for Nikon with DC2 Connection, $50

Total $1,864

Photographing the Moon with Configuration 1 - DSLR with Telephoto Lens

1. Attach the telephoto lens to the camera body.

2. Extend the tripod legs, insert the vibration pads under, and attach the camera.

3. Insert the Vello remote switch into the camera.

4. Set the camera to mirror lockup and live view with magnification.
   a. Select mirror up mode on the mode dial.
   b. Frame the picture, focus, then press the shutter release button all the way down to raise the mirror.
   c. Press the shutter release button all the way a second time to take the picture. Use remote shutter release to prevent camera shake.

5. Set the camera to manual and the camera lens to manual focus.

6. Set the ISO to 200.

7. Set the shutter speed to 1/125 seconds. This may need to be adjusted faster or slower.

8. Set the telephoto lens to maximum focal length (300 mm or 600 mm)

9. Aim the camera at the moon.

10. Focus the camera using Live View with magnification.

11. Press the Vello remote switch button and take several photographs, maybe 20 photographs.

12. View the photographs taken. Adjust ISO and shutter speeds if necessary and repeat.

Photographing the Moon with Configuration 2 - Telescope and DSLR

1. If the diagonal is attached to the telescope, remove it.

2. Attach the Vello Lens Mount Adapter to the Celestron T-Adapter

3. Attach one end of the T-Adapter to the camera.

4. Screw the other end of the T-Adapter into the telescope.

5. Extend the legs of the tripod, attach the mount to the tripod, and insert the vibration pads under.

6. Attach the telescope to the mount.

7. Insert the Vello remote switch into the camera.

8. Set the camera to mirror lockup and live view with magnification.
    a. Select mirror up mode on the mode dial.
    b. Frame the picture, focus, then press the shutter release button all the way down to raise the mirror.
    c. Press the shutter release button all the way a second time to take the picture. Use remote shutter release to prevent camera shake.

9. Set the camera to manual and the camera lens to manual focus.

10. Set the ISO to 200.

11. Set the shutter speed to 1/125 seconds. This may need to be adjusted faster or slower.

12. Aim the telescope at the moon.

13. Focus the telescope using Live View on the camera.

14. Press the Vello remote switch button and take several photographs, maybe 20 photographs.

15. If a digital DSLR is used, view the photographs taken. Adjust ISO and shutter speeds if necessary and repeat.

Astrophotography Without Tracking

Is a camera an accessory for a telescope or is a telescope a telephoto lens for a camera? For the following discussion, let the telescope be a telephoto lens for a camera and in this case, a DSLR camera.

Tracking is delicate, tricky, and sometimes a disaster. Imagine the accuracy that is required when photographing over a period of hours. This discussion avoids the use of tracking for most amateur astrophotography. There are many astro-photographs posted on the internet showing excellent astrophotography, including deep space objects (DSO), without tracking.

The light coming from the moon is bright and often requires only a 1/125 second exposure at ISO 200. The light coming from stars in the night sky is very dim and used to require extremely long exposure times, often hours long. However, todays cameras have digital sensors that are far more sensitive than film. Kodachrome had ISO speed from 25 to 200 in the 1970s. The Nikon D7100 digital camera, has ISO speeds up to 25,600. Higher ISO speeds mean shorter exposures. Higher ISO speeds also mean higher sensor noise. Many astrophotographers get excellent results using an ISO speed of 6,400.

Taking multiple short exposure images and stacking them together using a software program will produce an excellent photograph. There are many software programs available for mac and pc. Stacking increases the signal-to-noise ratio and increases the dynamic range. There are a number of theories as to why this happens. Whatever the reason, stacking produces better photographs. How many images to stack? Twenty to one hundred photographs seems like a good number. Each photograph should have adequate exposure to stand on its own. Experiment on your own and see what you come up with.

According to Erwin Matys, Karoline Mrazek (project nightflight), the formula to calculate the MAXIMUM exposure time is: $t = (27000 \times \Delta) / (f \times \cos \delta)$ in the article: "DSLR Astrophotography Untracked," copyright 2015, which can be found at https://www.cloudynights.com/articles/cat/articles/dslr-astrophotography-untracked-r3002

Where:

t = maximum exposure time in [seconds]

δ = object declination (degrees)

Δ = pixel size of DSLR chip in [mm]

f = focal length of lens in [mm]

"We used a 50 mm lens @f/2.8 and a 135 mm lens @f/4 with 3 and 1 second exposures, respectively. Except that our Canon 1100D is modified for optimum H-alpha sensitivity, it is an ordinary, off-the-shelf APS-C sized camera body. Although an unmodified DSLR will record

less red nebulosity it will still work very well for the method described." Erwin Matys, Karoline Mrazek.

The formula calculates the maximum exposure time without producing star trails. Shorter exposure times can be used. A telescope, depending upon size, may gather more light than a camera telephoto lens. Have fun and experiment with exposure times for both. The exposure limit is somewhere around 5 minutes before star trails begin to appear.

As stated in previous chapters, a sturdy tripod/mount and remote shutter release is required. A programmable intervalometer remote shutter release, like the Vello ShutterBoss II Timer Remote Switch, will automatically take multiple exposures at defined shutter speeds. A camera mirror up function will be of great help in reducing camera shake.

Below are some screen shots of the Maximum Exposure Calculator at www.allocca.com

Allocca Biotechnology, LLC
202 East Main Street, Suite 102, Huntington, NY 11743
www.allocca.com

Star Trail Exposure Calculator (Maximum Exposure Time Before Star Trails Without Tracking)

This calulator is based on the work of Erwin Matys and Karoline Mrazek of Project Nightflight.
http://project-nightflight.net/DSLR_astrophotography_untracked.pdf

Lens Focal Length: 50 mm

Object Declination: 60 degrees

Pixel Size: 3.90 microns

Maximum DSLR Exposure Time Before Star Trails Without Tracking:

Assuming an ISO of 6,400 or greater:

Each photo exposure = 4.21 seconds (0.07 minutes)
10 photos will take 42.1 seconds (0.7 minutes) in total
20 photos will take 84.2 seconds (1.4 minutes) in total
30 photos will take 126.3 seconds (2.11 minutes) in total
40 photos will take 168.4 seconds (2.81 minutes) in total
50 photos will take 210.5 seconds (3.51 minutes) in total
60 photos will take 252.6 seconds (4.21 minutes) in total
70 photos will take 294.7 seconds (4.91 minutes) in total
80 photos will take 336.8 seconds (5.61 minutes) in total (Over the 5 Minute Limit)
90 photos will take 378.9 seconds (6.32 minutes) in total (Over the 5 Minute Limit)
100 photos will take 421 seconds (7.02 minutes) in total (Over the 5 Minute Limit)
200 photos will take 842 seconds (14.03 minutes) in total (Over the 5 Minute Limit)

The above times do not indicate the exact exposure time -
Only the Maximum exposure time before star trails appear without tracking.

The resulting star trails will have a length of 2 pixels on the image
2 pixels should not be noticeable, expecially on 4,000 pixel images.

Generally, a maximum exposure is approximately 3-5 minutes. The 500 rule states 500/focal length without taking info consideration pixel size or object declination.

Use an intervalometer shutter release and a sturdy tripod.

50 mm FL

Allocca Biotechnology, LLC
202 East Main Street, Suite 102, Huntington, NY 11743
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Star Trail Exposure Calculator (Maximum Exposure Time Before Star Trails Without Tracking)

This calulator is based on the work of Erwin Matys and Karoline Mrazek of Project Nightflight.
http://project-nightflight.net/DSLR_astrophotography_untracked.pdf

Lens Focal Length: 135 mm

Object Declination: 60 degrees

Pixel Size: 3.90 microns

Maximum DSLR Exposure Time Before Star Trails Without Tracking:

Assuming an ISO of 6,400 or greater:

Each photo exposure = 1.56 seconds (0.03 minutes)
10 photos will take 15.6 seconds (0.26 minutes) in total
20 photos will take 31.2 seconds (0.52 minutes) in total
30 photos will take 46.8 seconds (0.78 minutes) in total
40 photos will take 62.4 seconds (1.04 minutes) in total
50 photos will take 78 seconds (1.3 minutes) in total
60 photos will take 93.6 seconds (1.56 minutes) in total
70 photos will take 109.2 seconds (1.82 minutes) in total
80 photos will take 124.8 seconds (2.08 minutes) in total
90 photos will take 140.4 seconds (2.34 minutes) in total
100 photos will take 156 seconds (2.6 minutes) in total
200 photos will take 312 seconds (5.2 minutes) in total (Over the 5 Minute Limit)

The above times do not indicate the exact exposure time -
Only the Maximum exposure time before star trails appear without tracking.

The resulting star trails will have a length of 2 pixels on the image
2 pixels should not be noticeable, expecially on 4,000 pixel images.

Generally, a maximum exposure is approximately 3-5 minutes. The 500 rule states 500/focal length without taking info consideration pixel size or object declination.

Use an intervalometer shutter release and a sturdy tripod.

135 mm FL

Step by Step Instructions to Record the Photograph

1. Setup camera on tripod, mount, and/or telescope.

2. Set up the camera.

3. Aim the camera / telescope.

4. Remove the lens cap and focus the lens.

5. Click on the ShutterBoss start button.

6. Images should automatically be saved to an SD card.

Note: the mirror function on the Nikon camera works by setting the mirror up on the first press of the shutter release button. The photograph is recorded on the second press of the shutter release button. Therefore, to record 20 images using the ShutterBoss, set the ShutterBoss to release the shutter 40 times.

Step by Step Instructions to Process the Images in Photoshop

Method 1

1. File, Scripts, Load files into a stack

2. Select all layers

3. Edit, Auto Align Layers

4. Edit, Auto Blend Layers

5. Save.

6. Process the image by adjusting brightness, contrast, color saturation, etc.

7. Save.

The above method sometimes mis-aligns the photos.

Method 2

1. File, Scripts, Load files into a stack

2. Select all layers

3. Layers, Merge Layers.

4. Save.

5. Process the image by adjusting brightness, contrast, color saturation, etc.

6. Save.

Example 1 - Jupiter and Stars With 70 mm Lens

Data

Sunset: 8:06 pm

Time of Recording: 903 pm to 9:08 pm

Sky Conditions: Significant amount of light pollution. Only Jupiter and a few stars were visible with the naked eye.

Camera: Nikon D7100 DSLR Camera

- Mirror up function set (MUP)
- Manual Exposure
- Bulb
- Lens Aperture set to 5.0
- ISO 6400

Lens: Nikon AF-S VR Zoom-Nikkor 70-300 mm f/4.5-5.6G IF-ED

70 mm

Manual Focus

Vello ShutterBoss II Timer Remote Switch for Nikon with DC2 Connection

3 second time

1 second interval

100 shutter releases (for 50 photos)

Example 2 - Jupiter and Stars With 300 mm Lens

Jupiter, 5-16-17, Nikon D7100, 300mm, 20 x 1 sec, ISO 6400, Photoshop Processed

Data

Sunset: 8:07 pm

Time of Recording: 9:01 pm to 9:03 pm

Sky Conditions: Significant amount of light pollution. Only Jupiter and a few stars were visible with the naked eye.

Camera: Nikon D7100 DSLR Camera
- Mirror up function set (MUP)
- Manual Exposure
- Bulb
- Lens Aperture set to 5.0
- ISO 6400

Lens: Nikon AF-S VR Zoom-Nikkor 70-300 mm f/4.5-5.6G IF-ED
- 300 mm
- Manual Focus

Vello ShutterBoss II Timer Remote Switch for Nikon with DC2 Connection

1 second time
1 second interval
40 shutter releases (for 20 photos)

Example 3 - Moon With C90 Telescope

Data

Time of Recording: 6/3/17 - 9:20 pm

Sky Conditions: Significant amount of light pollution. Only Jupiter and a few stars were visible with the naked eye.

Camera: Nikon D7100 DSLR Camera
  Mirror up function set (MUP)
  Manual Exposure
  1/125
  ISO 200

Telescope: Celestron C90 (90 mm x 1,250 mm)

Vello ShutterBoss II Timer Remote Switch for Nikon with DC2 Connection
  Manual (single photo)

Resources

5/8/17

Nikon Cameras

Nikon D3300 DSLR Camera with 18-55mm Lens
24.2MP DX-Format CMOS (crop size) Sensor
15.17 oz (0.95 pounds) body only
6.88 oz lens
No mirror up function
$450

Nikon D7100 DSLR Camera (Body Only)
24.1 MP DX-Format CMOS (crop size) Sensor
23.8 oz. (1.49 pounds) body only
Mirror up function
$700

Nikon D7500 DSLR Camera (Body Only)
20.9MP DX-Format CMOS (crop size) Sensor
Tilting LCD Monitor
22.6 oz. (1.41 pounds) body only
Mirror up function
$1,250

Nikon D750 DSLR Camera (Body Only)
24.3MP FX-Format CMOS (full size) Sensor
Tilting LCD Monitor
26.4 oz. (1.65 pounds) body only
$1,800

DX (crop size) Lenses

Nikon AF-S DX NIKKOR 55-200mm f/4-5.6G ED VR II Lens, 11 oz., $150

Nikon AF-P DX NIKKOR 18-55mm f/3.5-5.6G VR Lens, 6.9 oz., $250

Nikon AF-S DX NIKKOR 55-300mm f/4.5-5.6G ED VR Lens, 18.7 oz., $400

Nikon AF-S DX NIKKOR 18-300mm f/3.5-6.3G ED VR Lens, 19.4 oz., $700

FX (full size) Lenses

Nikon AF-S NIKKOR 24-85mm f/3.5-4.5G ED VR Lens, 16.3 oz., $500

Nikon AF-S NIKKOR 28-300mm f/3.5-5.6G ED VR Lens, 28.2 oz., $950

Nikon AF-S NIKKOR 24-120mm f/4G ED VR Lens, 25 oz., $1100

Nikon Micro-NIKKOR 105mm f/2.8 Lens, 18.1 oz. $730

Sigma 150-600 mm f/5-6.3 DG OS HSM Contemporary Lens for Nikon F (Camera Lens) $1,000

MCT / SCT Telescopes

Celestron C6-A-XLT CG-5 6" f/10 Schmidt-Cassegrain Telescope (OTA)
6" (150 mm) Schmidt-Cassegrain OTA, 8 pounds
1500 mm Focal Length, f/10 Focal Ratio, $600

C90 Maksutov Spotting Scope (OTA)
3.5” (90 mm) Maksutov-Cassegrain OTA, 5 pounds
1250 mm Focal Length, f/13.8 Focal Ratio, $200

Refractor Telescopes

Sky-Watcher ProED 100 mm Doublet APO Refractor (OTA)
100 mm apochromatic Refractor with ED Schott BK-7 and FPL-53 ED glass
900 mm focal length, f/9, 11 pounds, $750

Astro-Tech AT72ED 72 mm f/6 (72 x 432 mm) ED doublet refractor, 5 pounds, $400

Stellarvue SV80 Access - 80 mm Super ED Refractor f/7 (80 x 560 mm) with 2.5" SV Focuser - SV080-ACCESS, 5.5 pounds, $700

Stellarvue SV80 Access - 80 mm Super ED Refractor f/7 (80 x 560 mm) with 2.5" SV Focuser & 2" Diagonal - SV080-ACCESS-DU, 6.4 pounds, $840

Goto Telescopes

Meade ETX90 Observer f/13.8 (Go to) (90 x 1,250 mm) MCT Telescope, 13.3 pounds total, $500

Celestron 6" NexStar Evolution Computerized Telescope - 12090, 35.4 pounds, $1,300

Tripods / Mounts

Davis & Sanford Magnum P343 Aluminum Tripod with Ball Head, 6 pounds, $130

Olivon TR197-16 Tripod with Head (Tall Tripod), 15 pounds, $250

Vixen Porta II Mount Tall, Product Code: 5863TALL, 15 pounds, $400

Manfrotto MT055XPRO3 Aluminum Tripod, 5.5 pounds, $265

Manfrotto 410 Junior Geared Head with 410PL Quick Release Plate, 2.7 pounds, $275

Miscellaneous

Celestron 94009 Lens Shade for C6 and C8 Tubes (Black), Item 94009, $25 (not for C90)

Celestron T-Adapter for Schmidt Cassegrain Telescopes (for C6 SCT), ITEM # 93633-A, $25 (not required for C90)

Tele Vue SLR Prime Focus Camera Adapter for 2" Focusers, ACM-2000, $60

Vello Lens Mount Adapter - T Mount Lens to Nikon F Mount Camera, LANFT, $14

Celestron Vibration Suppression Pads, ITEM # 93503, $50

Vello ShutterBoss II Timer Remote Switch for Nikon with DC2 Connection, $50

Celestron f/6.3 Reducer Corrector for C Series Telescopes, ITEM # 94175, $150

Celestron RACI Illuminated Right Angle Finderscope, ITEM # 93781, $100

Celestron 8-24 mm 1.25" Zoom Eyepiece, Model Number 93230, $80

Lowepro Photo Classic Series BP 300 AW Backpack, $120

Lowepro ProTactic SH 200 AW Camera Shoulder Bag, $130

Mac Sports Collapsible Folding Outdoor Utility Wagon, Blue, $60

Nalgene HDPE Wide Mouth Round Container, 8 oz., 16 oz., $5