

Solar Eclipse Photography

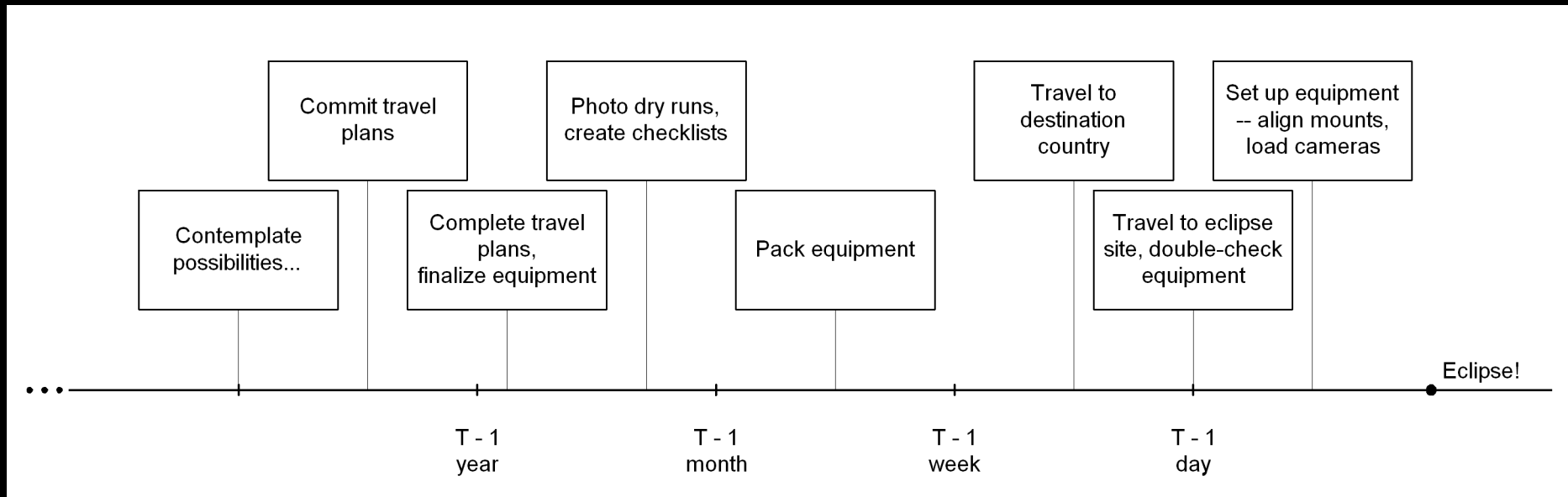
OCA AstroImagers SIG
D. Kodama – 13 June 2017



Why bother with photography?

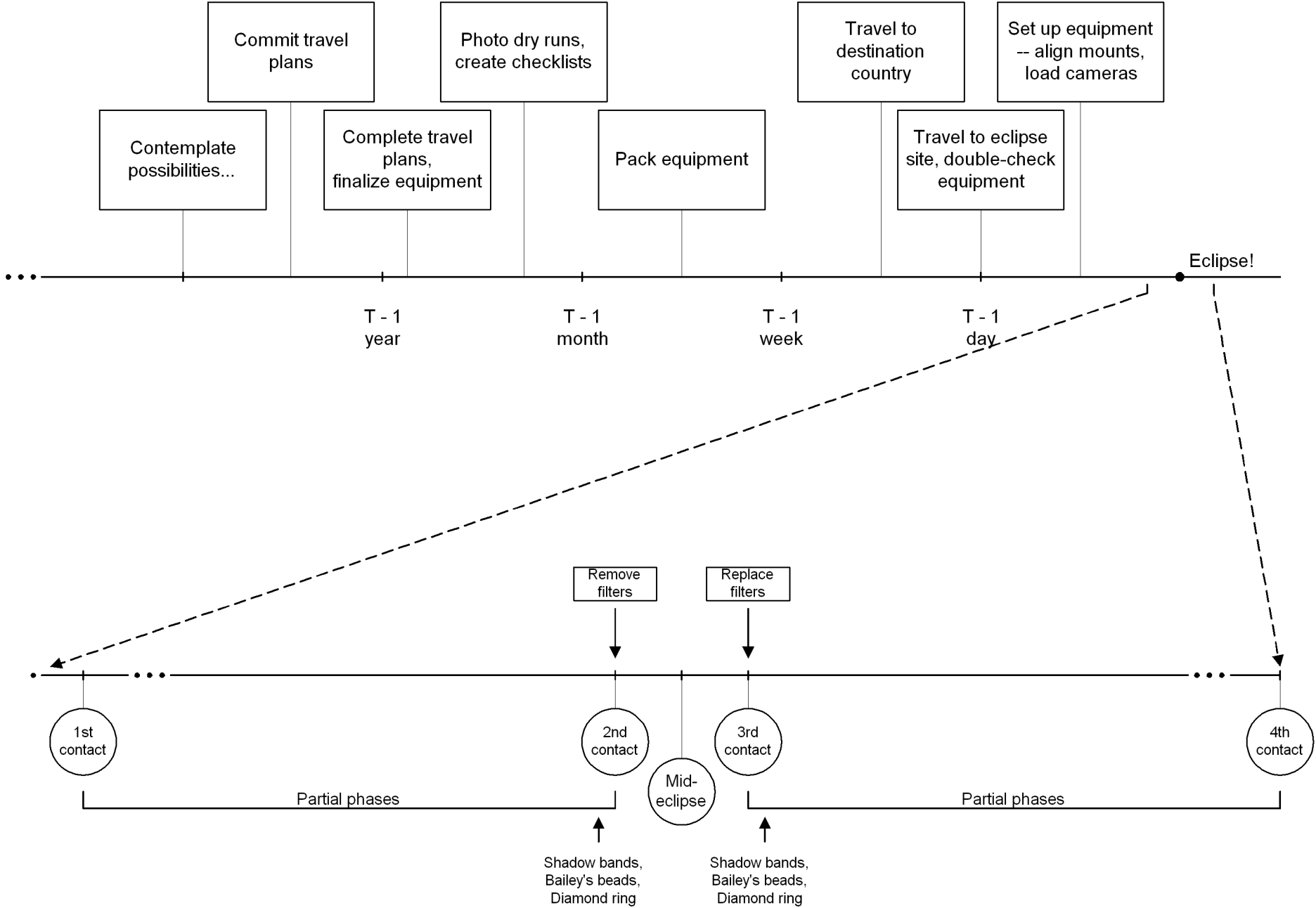
- A permanent record of what **you** experienced! Every photo evokes more memories!
- A sense of accomplishment – capturing a solar eclipse is one of the toughest astrophoto challenges!
- The visual guys keep having to go to eclipses to refresh their memory! (just kidding)

Eclipse Photography

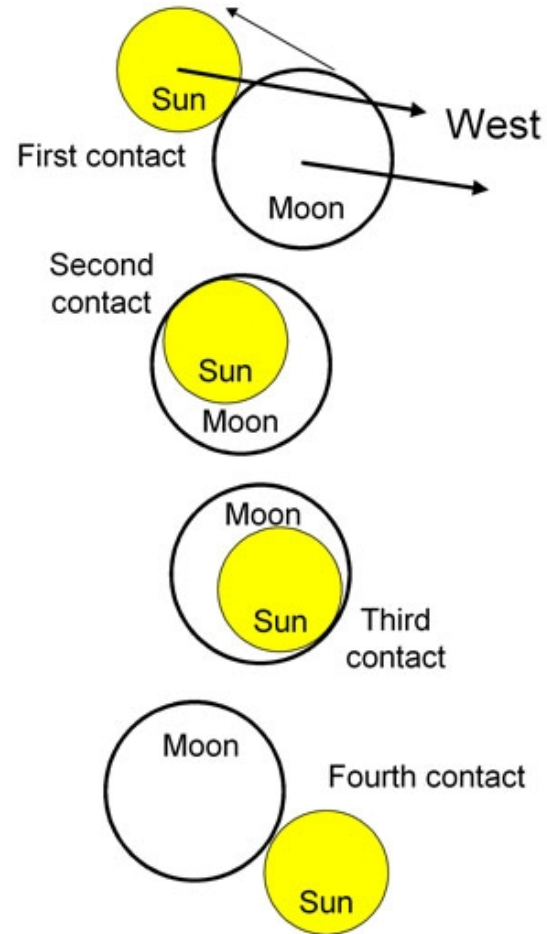


Eclipse planning time line

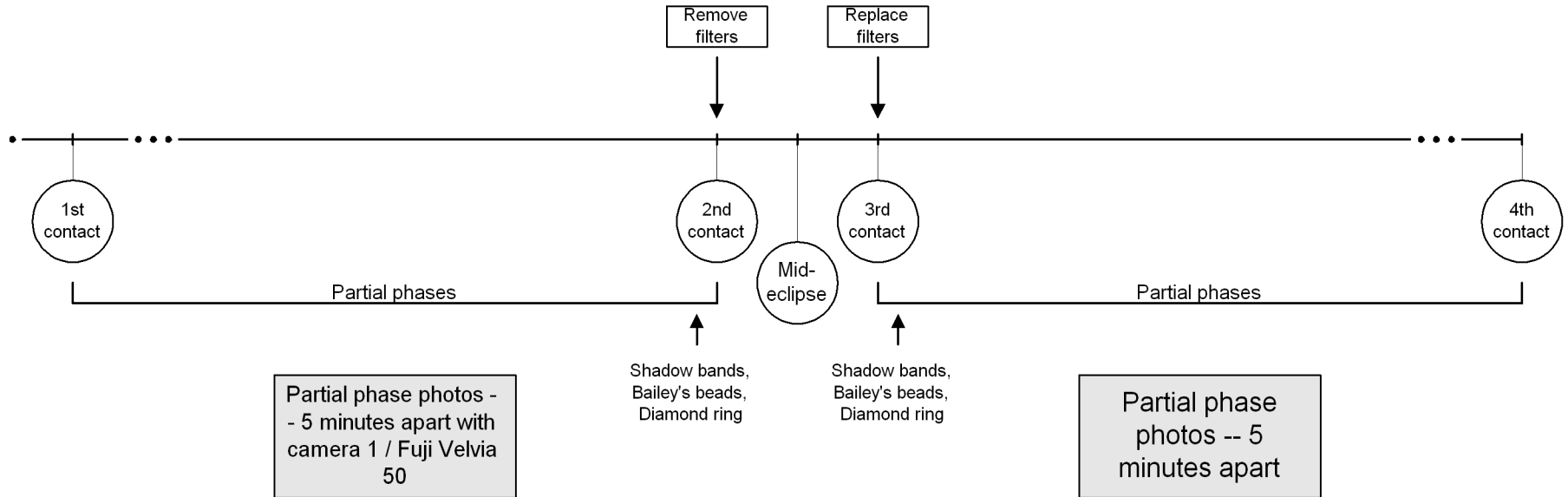
Eclipse Photography



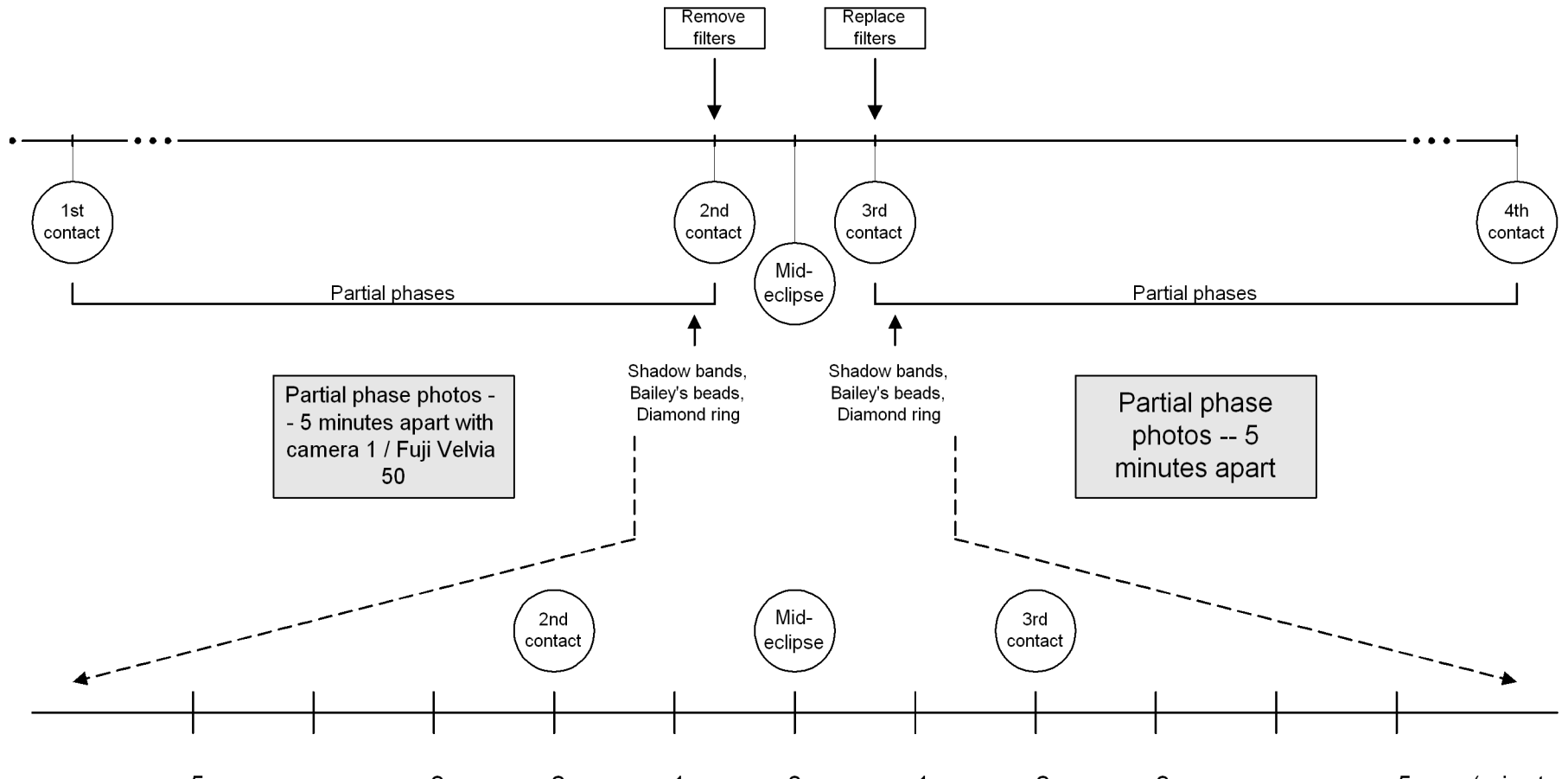
Eclipse Photography



Eclipse Photography



Eclipse Photography





Eclipse Planning Includes Anticipating Problems!

What if the sun isn't visible until just before totality?
Can you align your mount, point at the sun, and focus quickly?

Can you remove your solar filter smoothly?

What if the scope is bumped off the sun just at totality?
Can you reset pointing without panic? Hint: your sun-finder won't work.

What if totality is so dark you can't see your controls?
You may need to have a small red illuminator.

What if your camera automation fails?
You may need to have a Plan B manual mode.



Where and when to go?

- Check the NASA web page:
<http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html>
- Pay attention to the predicted cloud cover, sun angle, and accessibility considerations discussed in the individual eclipse bulletins.
- Go where you can see more than just the eclipse. If the eclipse is clouded out, you want to still have an enjoyable trip!

More general eclipse site planning info on my site
<http://astrocamera.net>

Example Location: Jackson, WY

Eclipse Photography

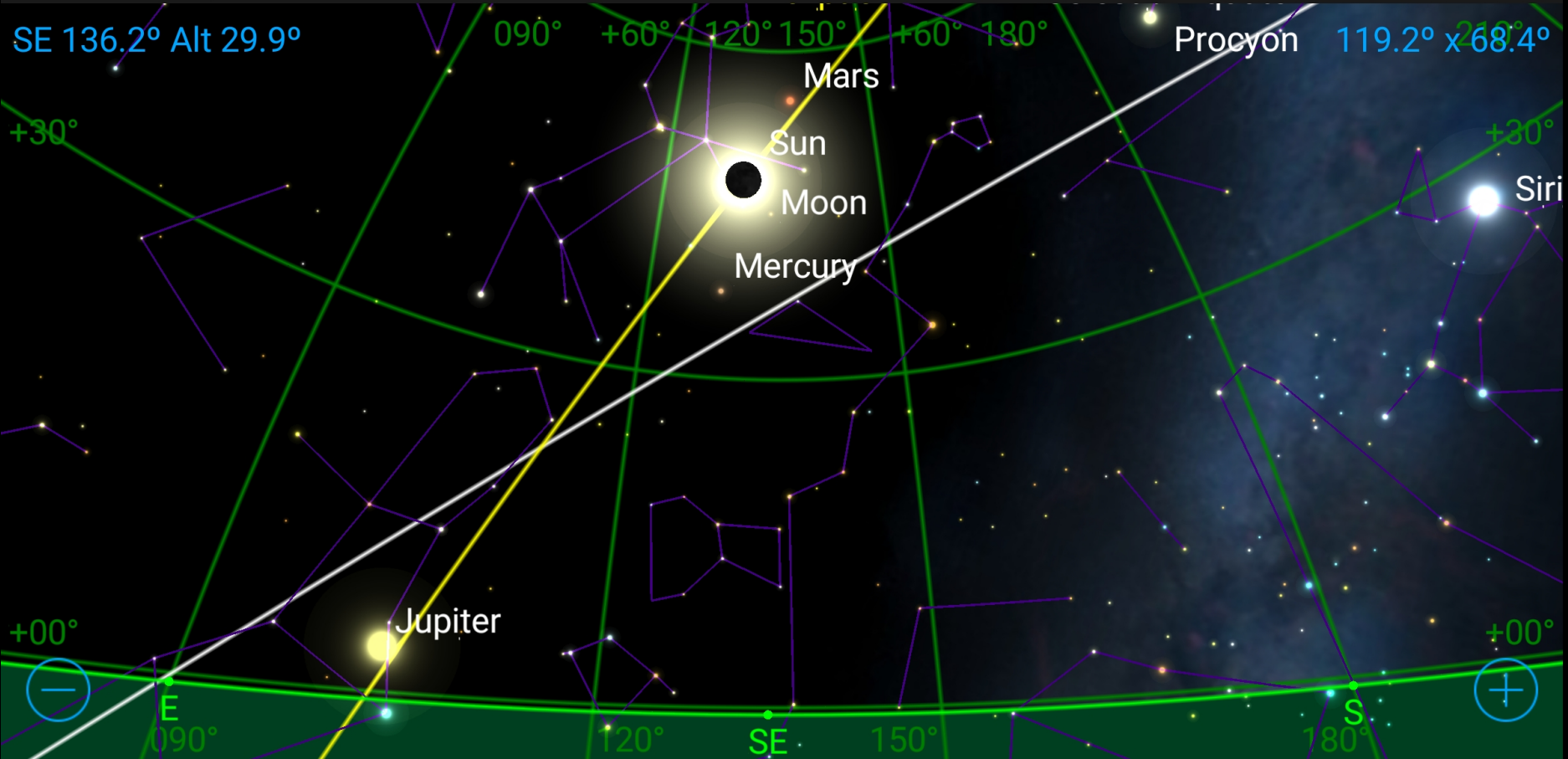


Jackson, Wyoming

Mon Aug 21, 2017 11:23:27 AM

SE 136.2° Alt 29.9°

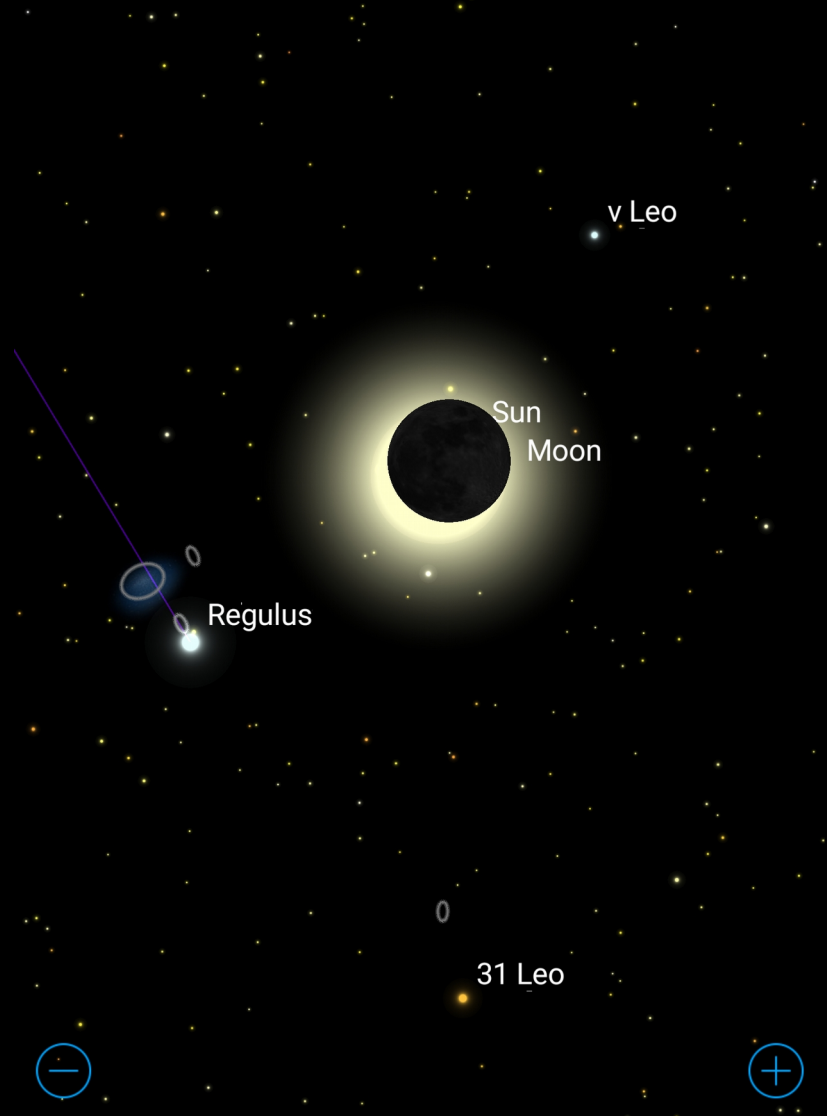
Procyon 119.2° x 268.4°



- Search
- Info
- Center
- Settings
- Time
- Scope
- Orbit
- Compass
- Night
-
- Help

Jackson, Wyoming Mon Aug 21, 2017 11:23:27 AM

SE 130° 35' 03.2" Alt +48° 31' 07.3" 3.6° x 5.2°



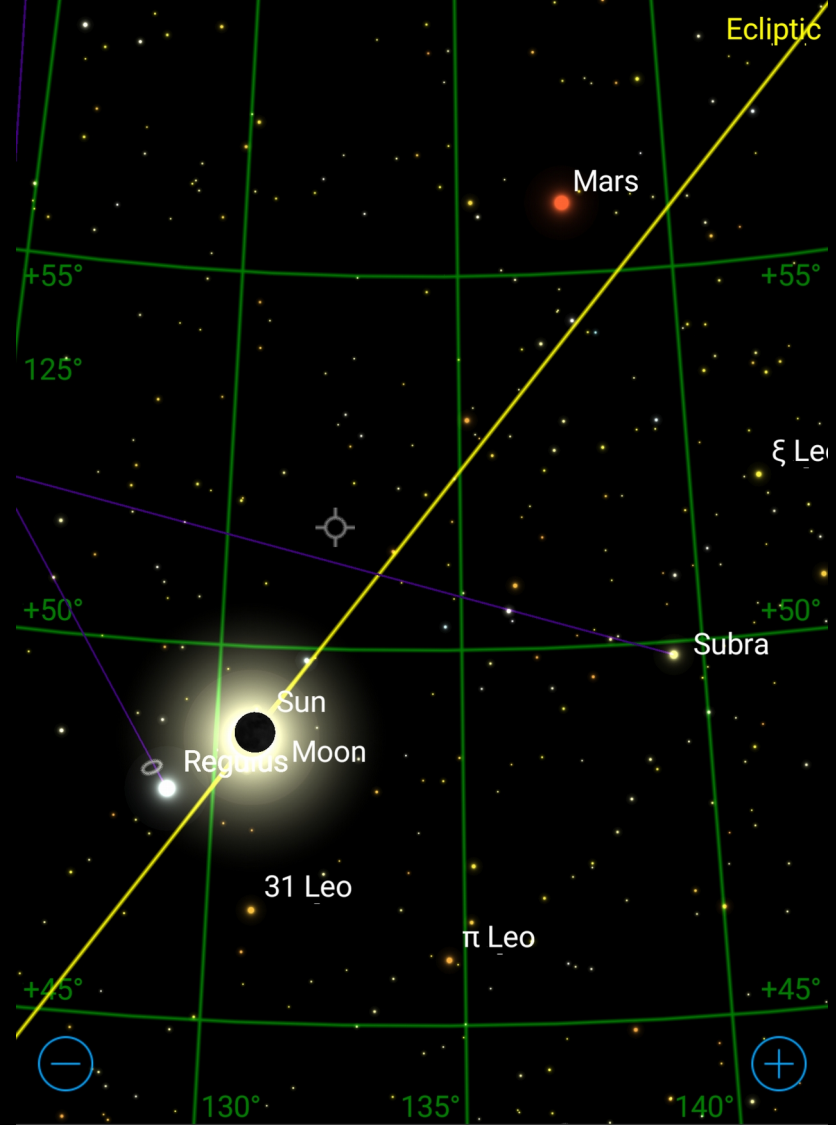
Search Info Center Settings Time Scope Orbit Comp

Eclipse Photography



Jackson, Wyoming Mon Aug 21, 2017 1

SE 134° 10' 21.6" Alt +51° 36' 41.7" 140° 10.8° x 15.8°



Search Info Center Settings Time Scope Orbit Comp



How to Get There?

Think **SMALL**
for the group
size (unless
you like being
herded
around like
cattle).

- On your own – A **lot** of work! Really only feasible if it's in the U.S. or you have foreign contacts. You are competing with agents booking whole hotels and planes!
- Commercial Tour – Not the ideal solution. Problems happen with organizers who don't know what is required for an eclipse.
- Eclipse Tour – Much better! The more eclipse experience, the better, and experience in dealing with foreign travel agencies is a big plus.
- Eclipse Tour with Astrophotographer – Best! An experienced world travel eclipse group, with properly motivated leader is what you want!

Equipment?

Eclipse Photography



- Top 3 considerations: #1 – Weight, #2 – Weight, #3 – Weight! Assume that **you** will have to carry all of your equipment and luggage. Baggage allowances are shrinking and excess luggage charges are climbing!
- Tracking mount – conveniently keeps the sun centered and essential for long exposures of the corona.
- Optics – Small SCT or folded mirror scopes are light and compact for the focal length needed. Good refractors tend to be better for contrast and minimizing stray reflections.
- Cameras – Video is easy-- 2K video should be “standard”, go for 4K when possible. For stills, use DSLR shooting in RAW mode.

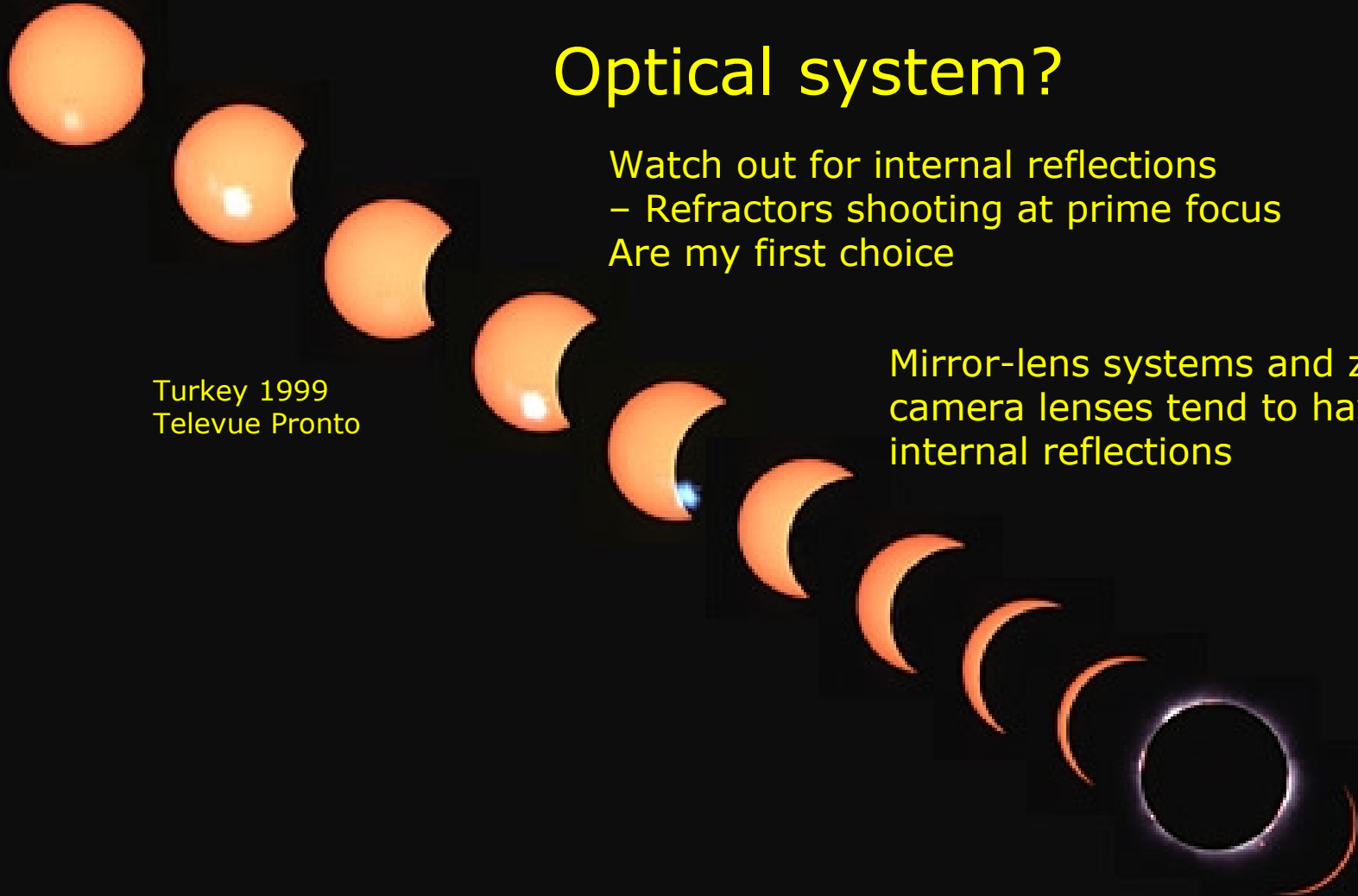


Optical system?

Watch out for internal reflections
- Refractors shooting at prime focus
Are my first choice

Mirror-lens systems and zoom
camera lenses tend to have
internal reflections

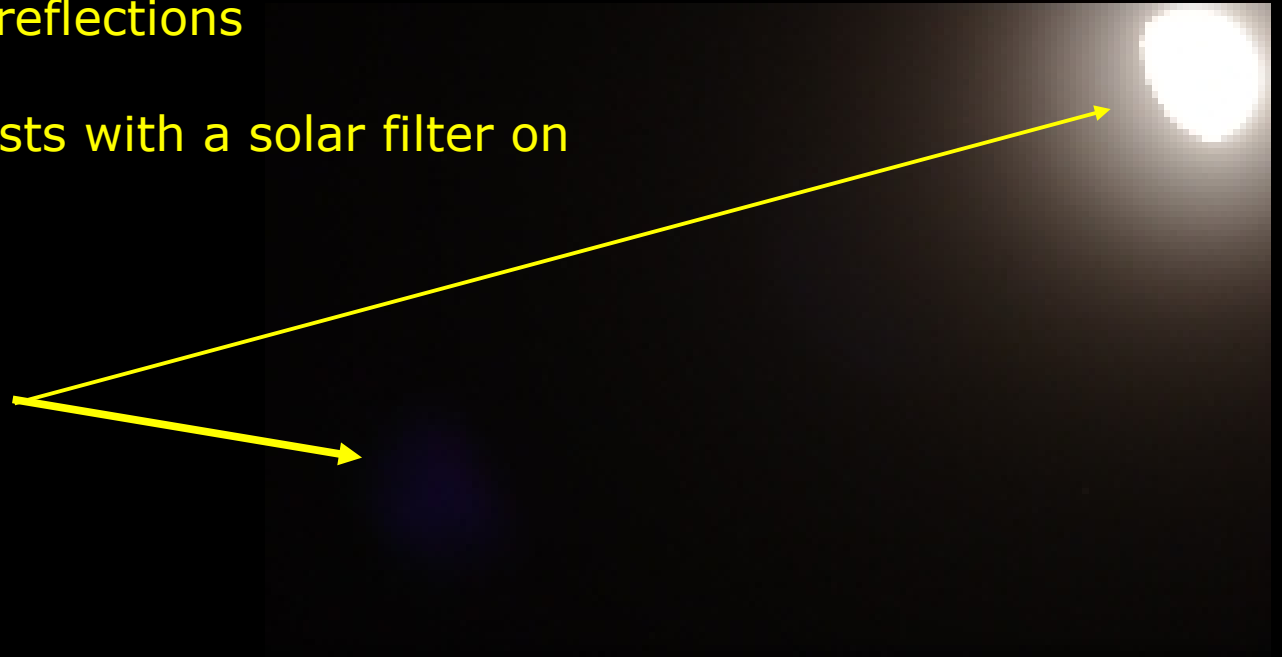
Turkey 1999
Televue Pronto



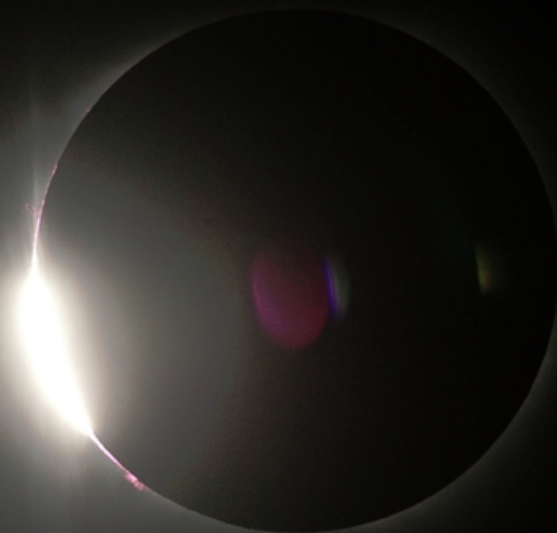


Testing for Internal Reflections

- Shoot the moon at various locations within your frame
- Overexpose shots to reveal potential reflections
- Repeat tests with a solar filter on the sun



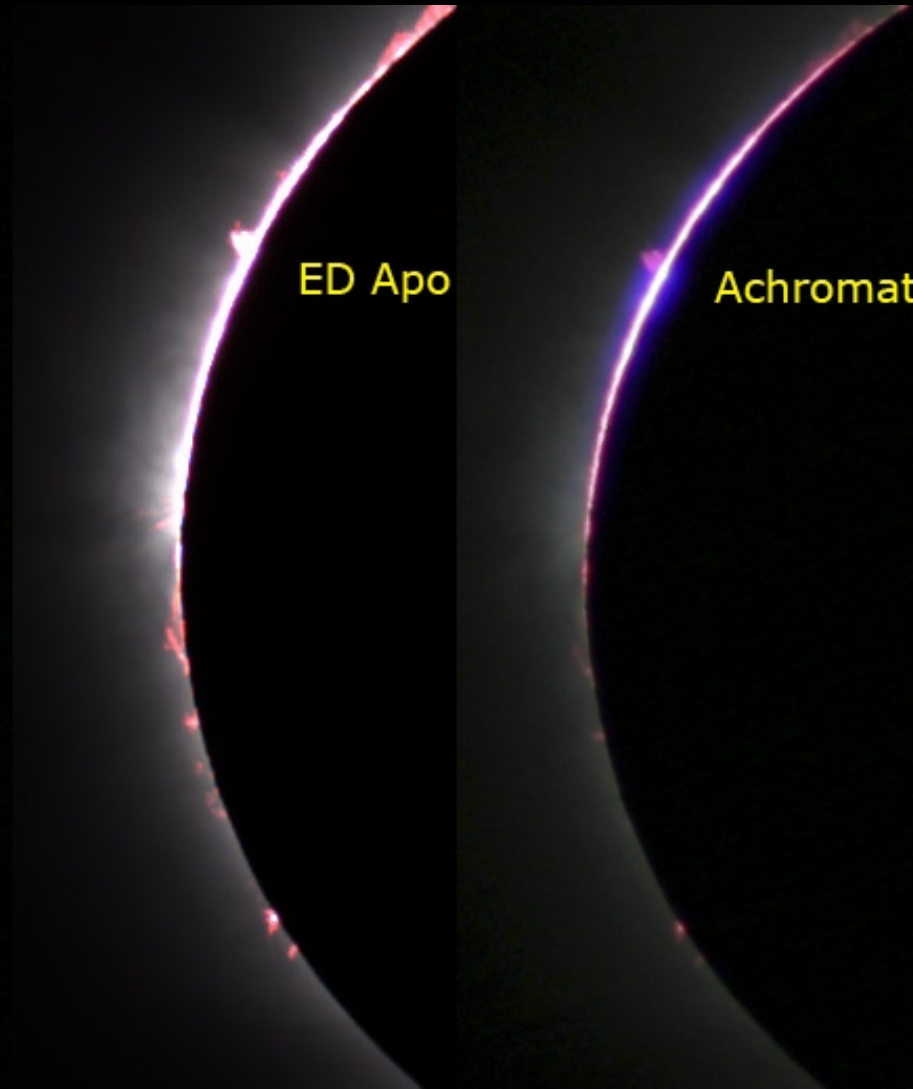
Eclipse Photography





Equipment?

Apo vs. Achro - makes a difference for broadband solar photography





Mounts

- Stationary photo tripod - OK for wide-angle, very inconvenient for medium to long focal length.

If you must use a photo tripod, use a fluid pan-head for video photography, or one with slow motion controls and be sure to have a sun-finder attached.

- Equatorial tracking mount – essential for “serious” photography (long focal length)



Cameras

- DSLR's or "Mirrorless" cameras are preferred for manual mode capabilities – Manual focus, manual exposure, and RAW format option.
- Video is great for capturing the experience, but frames are compressed and lower resolution compared to modern still cameras. As with still cameras, you want to turn off autofocus and auto-exposure.
- Use cell phones, sport cameras, and even dash cams for additional angles, but auto-focus and auto-exposure are big disadvantages.



Exposure and Filters

- The main difficulty in eclipse photography is the range of brightness.
- Partial phases require filtering of optical density $OD=5$. This is a factor of 1:100,000. Standard photographic neutral density (ND) filters aren't adequate.
- Unfiltered total phase has a dynamic range of ~ 12 photographic stops (1:4096) from chromosphere to outer corona.
- **For visual use, do not remove filters until full totality.** Even if you avoid permanent eye damage, looking at the sun for an instant can cause an after-image that will ruin your view of the eclipse!



Exposure and Filters

- For photographic use with small lenses and telescopes, removal of filters ~20 seconds before totality has not caused any sensor problems for me.
- Do not screw filters in. This will make it difficult to remove filters at 2nd contact.
- When removing filters at 2nd contact, put them where you can find them quickly and replace them at 3rd contact.



Exposure

Refer to Espenak's table on the NASA site for exposure guidelines

Specific settings depend on what feature you want to capture, focal ratio of your lens, ISO selection, and exposure length desired.

TABLE 2
SOLAR ECLIPSE EXPOSURE GUIDE

| <i>ISO</i> | <i>f/Number</i> | | | | | | | | | |
|------------|-----------------|-----|-----|-----|-----|----|----|-----|-----|--|
| 25 | 1.4 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 22 | |
| 50 | 2 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 22 | 32 | |
| 100 | 2.8 | 4 | 5.6 | 8 | 11 | 16 | 22 | 32 | 44 | |
| 200 | 4 | 5.6 | 8 | 11 | 16 | 22 | 32 | 44 | 64 | |
| 400 | 5.6 | 8 | 11 | 16 | 22 | 32 | 44 | 64 | 88 | |
| 800 | 8 | 11 | 16 | 22 | 32 | 44 | 64 | 88 | 128 | |
| 1600 | 11 | 16 | 22 | 32 | 44 | 64 | 88 | 128 | 176 | |

| <i>Subject</i> | <i>Q</i> | <i>Shutter Speed</i> | | | | | | | | | |
|--|----------|----------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <i>Solar Eclipse</i> | | | | | | | | | | | |
| Partial ¹ - 4.0 ND | 11 | — | — | — | 1/4000 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1/125 | 1/125 |
| Partial ¹ - 5.0 ND | 8 | 1/4000 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1/125 | 1/60 | 1/30 | 1/15 | 1/15 |
| Baily's Beads ² | 11 | — | — | — | 1/4000 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1/125 | 1/125 |
| Chromosphere | 10 | — | — | 1/4000 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1/125 | 1/60 | 1/60 |
| Prominences | 9 | — | 1/4000 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1/125 | 1/60 | 1/30 | 1/30 |
| Corona - 0.1 R _s | 7 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1/125 | 1/60 | 1/30 | 1/15 | 1/8 | 1/8 |
| Corona - 0.2 R _s ³ | 5 | 1/500 | 1/250 | 1/125 | 1/60 | 1/30 | 1/15 | 1/8 | 1/4 | 1/2 | 1/2 |
| Corona - 0.5 R _s | 3 | 1/125 | 1/60 | 1/30 | 1/15 | 1/8 | 1/4 | 1/2 | 1 sec | 2 sec | 2 sec |
| Corona - 1.0 R _s | 1 | 1/30 | 1/15 | 1/8 | 1/4 | 1/2 | 1 sec | 2 sec | 4 sec | 8 sec | 8 sec |
| Corona - 2.0 R _s | 0 | 1/15 | 1/8 | 1/4 | 1/2 | 1 sec | 2 sec | 4 sec | 8 sec | 15 sec | 15 sec |
| Corona - 4.0 R _s | -1 | 1/8 | 1/4 | 1/2 | 1 sec | 2 sec | 4 sec | 8 sec | 15 sec | 30 sec | 30 sec |
| Corona - 8.0 R _s | -3 | 1/2 | 1 sec | 2 sec | 4 sec | 8 sec | 15 sec | 30 sec | 1 min | 2 min | 2 min |

Exposure Formula: $t = f^2 / (I \times 2^Q)$ where: t = exposure time (sec)
 f = f/number or focal ratio
 I = ISO film speed
 Q = brightness exponent

Abbreviations: ND = Neutral Density Filter.
 R_s = Solar Radii.

Notes: ¹ Exposures for partial phases are also good for annular eclipses.
² Baily's Beads are extremely bright and change rapidly.
³ This exposure also recommended for the 'Diamond Ring' effect.

I. Espenak - 1996 March

<https://eclipse.gsfc.nasa.gov/image/SEexpo.gif>

Exposure Example

Eclipse Photography



TABLE 2
SOLAR ECLIPSE EXPOSURE GUIDE

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| 400 | 5.6 | 8 | 11 | 16 | 22 | 32 | 44 | 64 | 88 | 128 |
| 800 | 8 | 11 | 16 | 22 | 32 | 44 | 64 | 88 | 128 | 176 |
| 1600 | 11 | 16 | 22 | 32 | 44 | 64 | 88 | 128 | 176 | |

| <i>Subject</i> | <i>φ</i> | <i>Shutter Speed</i> | | | | | | | | | |
|--|----------|----------------------|--------|--------|--------|--------|--------|--------|--------|--------|--|
| <i>Solar Eclipse</i> | | | | | | | | | | | |
| Partial ¹ - 4.0 ND | 11 | — | — | — | 1/4000 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1/125 | |
| Partial ¹ - 5.0 ND | 8 | 1/4000 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1/125 | 1/60 | 1/30 | 1/15 | |
| Baily's Beads ² | 11 | — | — | — | 1/4000 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1/125 | |
| Chromosphere | 10 | — | — | 1/4000 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1/125 | 1/60 | |
| Prominences | 9 | — | 1/4000 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1/125 | 1/60 | 1/30 | |
| Corona - 0.1 R _s | 7 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1/125 | 1/60 | 1/30 | 1/15 | 1/8 | |
| Corona - 0.2 R _s ³ | 5 | 1/500 | 1/250 | 1/125 | 1/60 | 1/30 | 1/15 | 1/8 | 1/4 | 1/2 | |
| Corona - 0.5 R _s | 3 | 1/125 | 1/60 | 1/30 | 1/15 | 1/8 | 1/4 | 1/2 | 1 sec | 2 sec | |
| Corona - 1.0 R _s | 1 | 1/30 | 1/15 | 1/8 | 1/4 | 1/2 | 1 sec | 2 sec | 4 sec | 8 sec | |
| Corona - 2.0 R _s | 0 | 1/15 | 1/8 | 1/4 | 1/2 | 1 sec | 2 sec | 4 sec | 8 sec | 15 sec | |
| Corona - 4.0 R _s | -1 | 1/8 | 1/4 | 1/2 | 1 sec | 2 sec | 4 sec | 8 sec | 15 sec | 30 sec | |
| Corona - 8.0 R _s | -3 | 1/2 | 1 sec | 2 sec | 4 sec | 8 sec | 15 sec | 30 sec | 1 min | 2 min | |



Bracketing for HDR Composites

- Capturing the full dynamic range of the corona requires exposure bracketing.
- Virtually all cameras will require external control to do the full range bracket.
- Excellent sky transparency required.



Bracketing for HDR Composites

D. Kodama • 29 March 2006 • Jalu, Libya



Inner corona at mid-totality - Fuji Velvia (ISO 50) 1/2 sec.

Eclipse Photography



D. Kodama
Jalu, Libya
29 March 2006

Composited (HDR) corona - 1/1000 - 1 sec.



Bracketing for HDR Composites



D. Kodama
Jalu, Libya
29 March 2006

Composited (HDR) corona - 1/1000 - 2 sec.



Eclipse Photography



My Basic Setup

- German Equatorial Mount – a medium-weight (non-go-to) mount Losmandy GM8 or Vixen GP with “disposable tripod”
- Borg 100ED, 640mm FL
- Nikon D600 full-frame DSLR
- Hinode solar guider
- Video camcorder (not shown)
- 12VDC 18Ah battery



Eclipse Photography



“Disposable” tripod is made from a 2-by-4 and some plywood.

Short tripod sections fit in a medium suitcase.

Cheap enough tripod legs to throw away after eclipses requiring airplane flights.

Stable enough to withstand moderate wind for short exposures required for eclipses.

On some trips, the counterweight and battery were replaced by D-cells (given away after eclipse)

Eclipse Photography

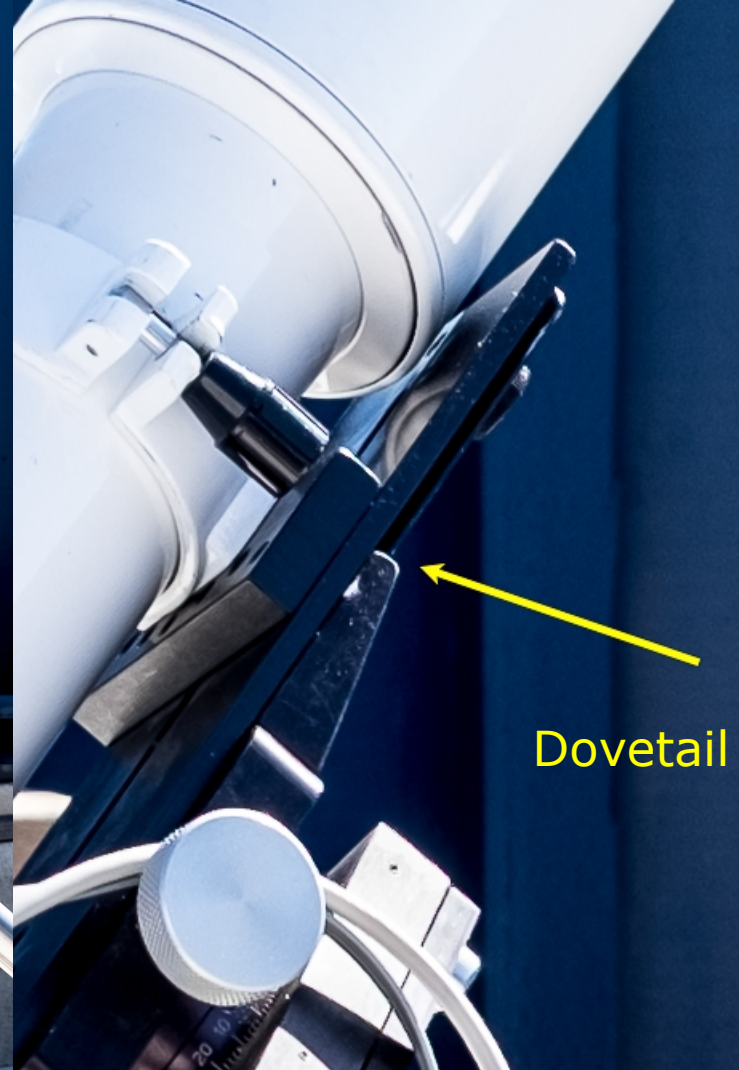
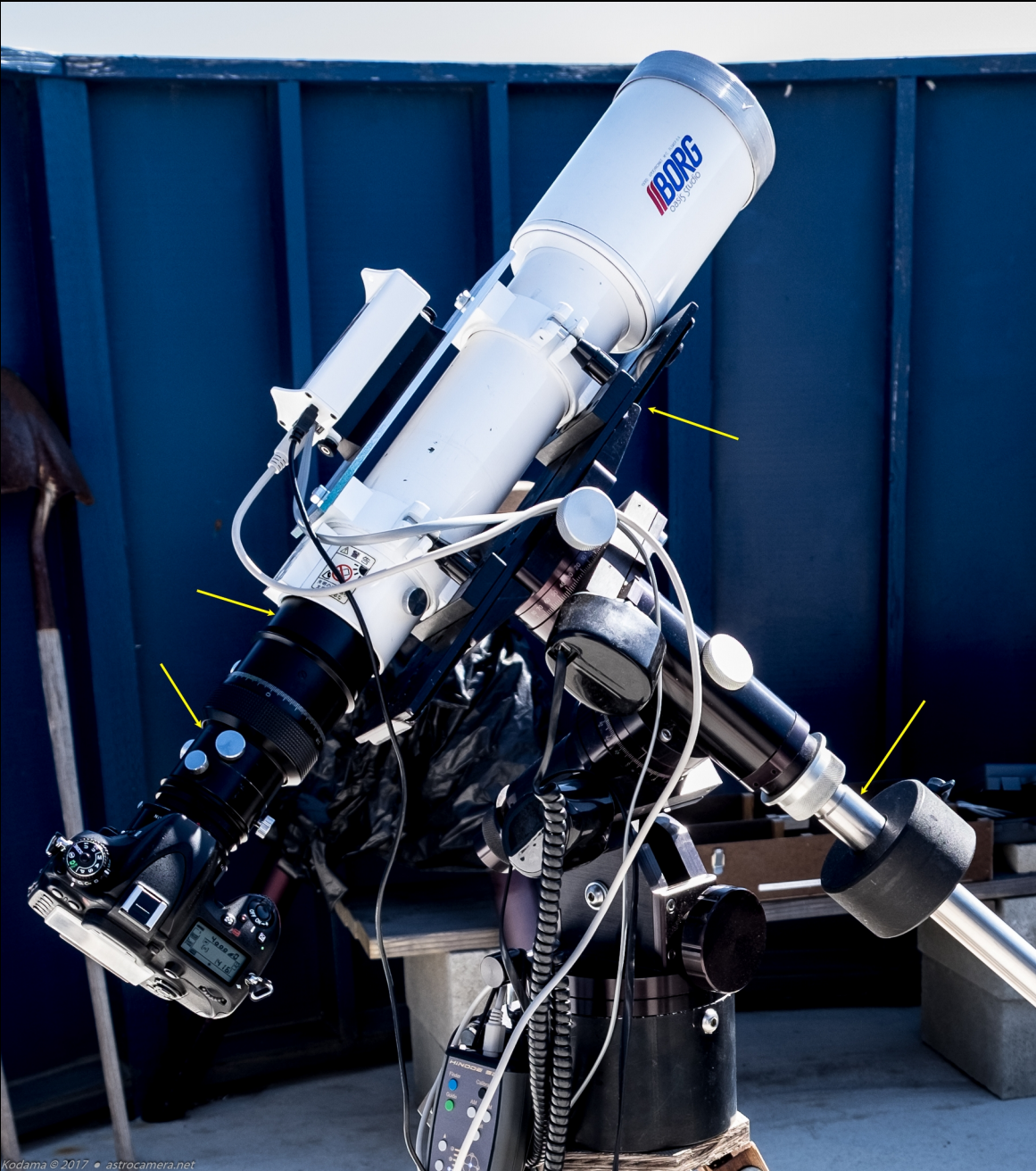


Counterweight set point.



Recommendation:
Document your setup
With photos.

Eclipse Photography



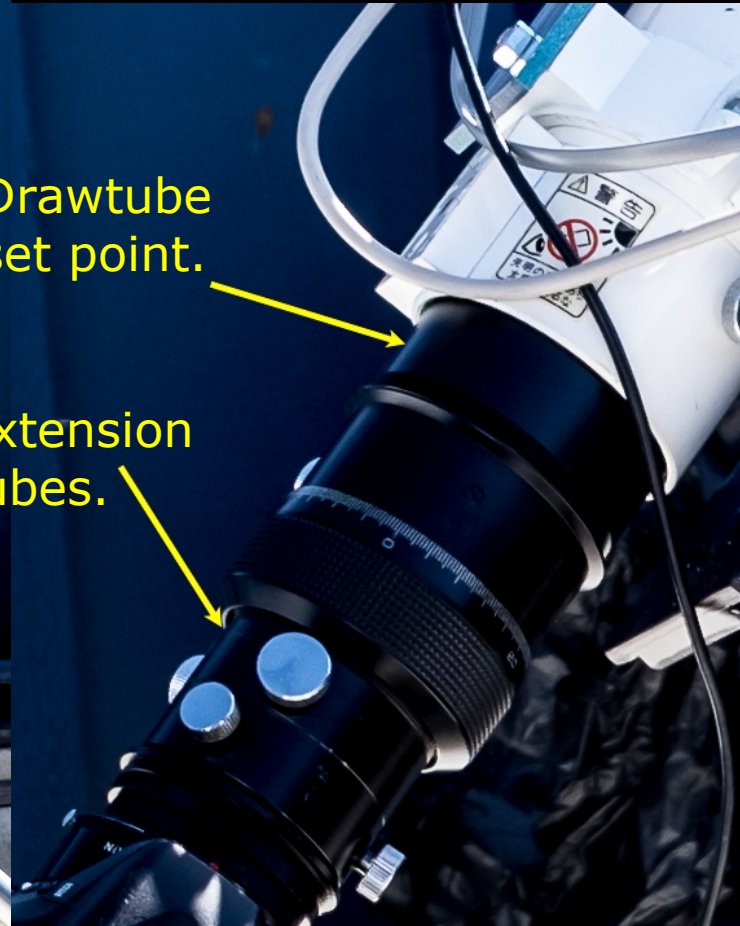
Dovetail

Eclipse Photography



Drawtube
set point.

Extension
tubes.



Eclipse Photography



Hinode solar guider

DC 12V power for mount
with USB 5V power for
Hinode guider.



Equatorial Mount Alignment

- Does NOT require critical polar alignment!
 - it only needs to be good enough to keep the sun decently centered during totality.
- Practice getting aligned in the daytime
 - you may not be at the eclipse site the night before, or it may be cloudy overnight.
- For daytime alignment
 - Level your mount
 - Set your altitude to match your latitude
 - Use a compass or phone app to set azimuth

Compass



N 32°22'22" W 112°2'22"

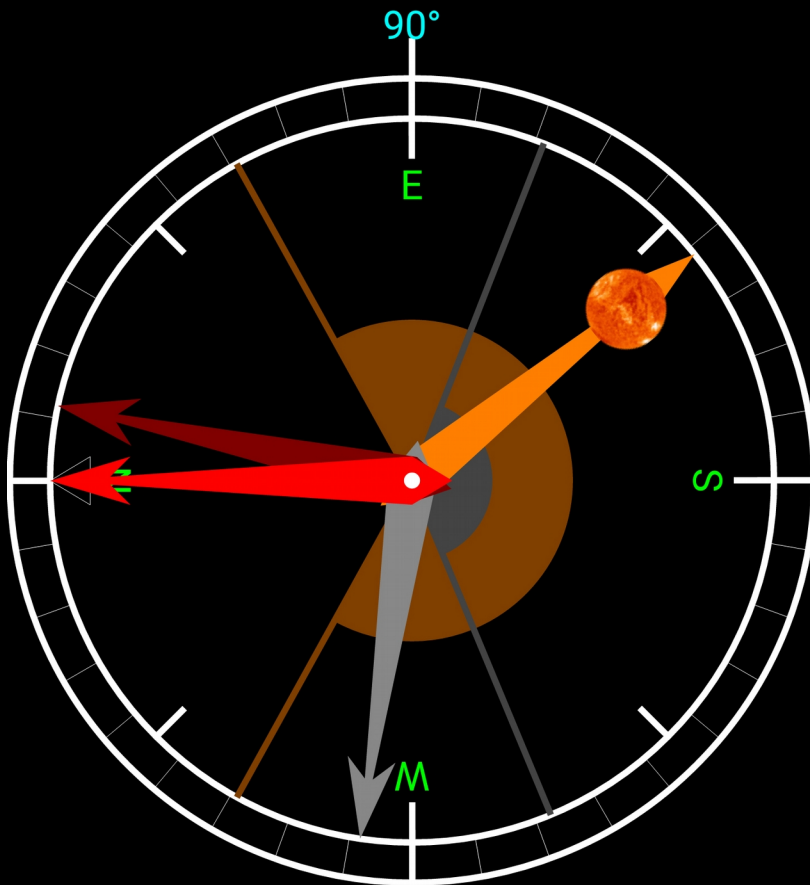
Mag. 48/46 μ T

Eclipse
Photography



Equatorial Mount Alignment

“Living in the Sun” app (Android) allows you to determine north using the current direction of the sun.



Sun 141°19' 76°44'
Moon 278°16' -45°25'



Equatorial Mount Alignment



Tracking comparison (sidereal mount rate used)



Equatorial Mount Alignment

Youtube link to tracking comparison (previous slide):
<https://youtu.be/hewf1pcK0iE>

See Hinode guiding through a partial solar eclipse:
<https://www.youtube.com/watch?v=fWuyUM68sDY>



Focusing

- Best to use sunspots as focusing targets
- Follow the sun several days ahead to know where the spots are located. Ref:
<https://sohowww.nascom.nasa.gov/data/realtime-images.html>
- Use the smallest spots to find the focus point.
- Use camera's live view with maximum magnification.
- Be aware that you may have difficulty seeing your camera's LCD screen in sunlight.



Automation

- Automating partial phase shots is relatively easy – use in-camera intervalometer if available or external intervalometer if not.
- Use in-camera bracketing sequence or external smart controller (e.g. *Promote* controller)
- PC or Mac control options are also available – Great if they work for you. I opt to avoid the additional complexity, weight, and power required.

--- *In all cases practice, practice, practice!* ---



Automation

Promote® Control

Advanced DSLR Remote Control



“Promote” – An advanced intervalometer capable of running an HDR bracketing sequence.

... just got one. Trying this out on the 2017 eclipse...

Shooting the Wide Shot

Eclipse Photography



- A wide-angle shot can be a good complement to your telescopic shots and not hard to get.
- No tracking mount is required.
- You may be able to capture the brighter planets if the sky is transparent.
- Wide-angle shots are also good for capturing the “atmosphere” of the event (i.e. crowd shots).





The Wide View

Venus

Mercury



China (2008) - 35mm lens on
35mm film (manual exposure)



The Wide View



Easter Island (2010) - 15mm fisheye lens
on 35mm film (manual exposure)



Cell Phone Experiments



No Filter



Lens fully filtered
- overexposed, bloomed



Filtered exposure OK
but image is tiny.



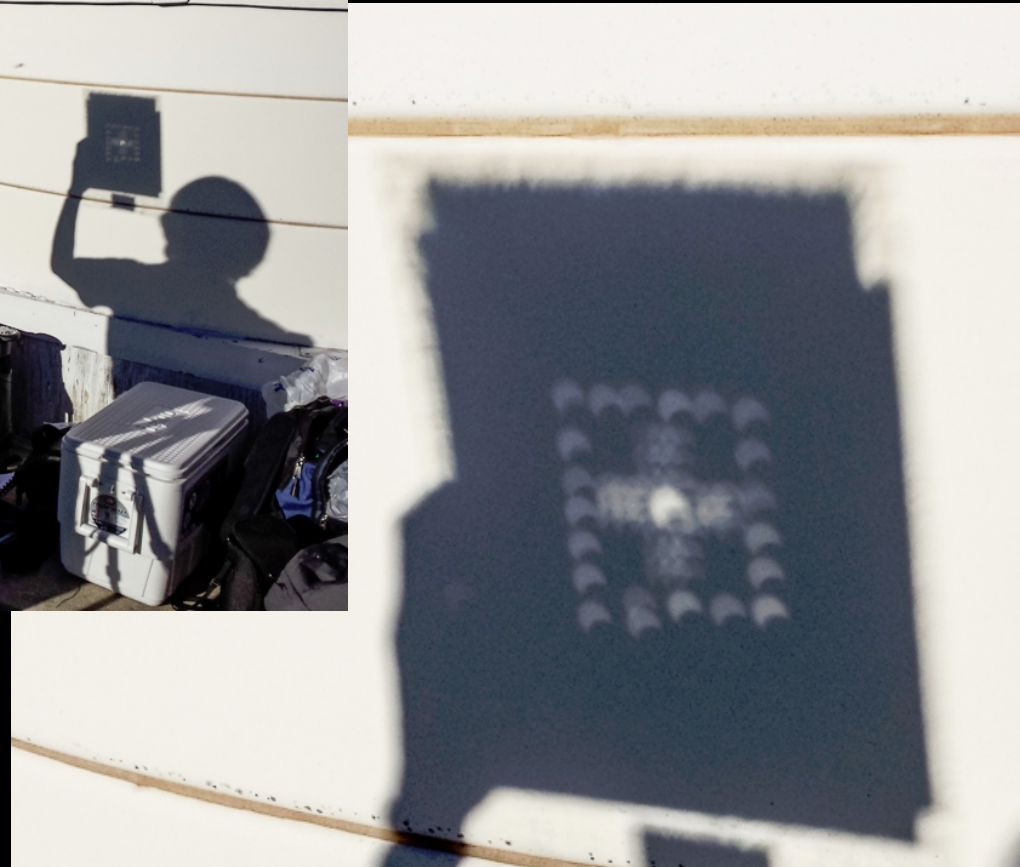
To get a proper exposure the
filter must leak some light
from the side.



Shooting Pinhole Images



2014 – New Mexico state
shape and state flag design
as pinhole pattern.





Things that aren't obvious...

(Until you blow it)

- Filters for partial phases must be loose enough to come off and go back on easily!
- It can get dark during totality and you have no time to dark adapt! Be familiar with your equipment and have a small flashlight ready to go.
- Keep calm. All the visual guys around you may be going nuts, but you're there for some serious photography. Keep visual observers well away from your setup!



Things that aren't obvious...

(Until you blow it)

- Be deliberate in your movements around the equipment, especially during totality. If you lose the sun, you have almost no chance to recover!
- Filters must come off **before** 2nd contact if you want to photograph the Diamond Ring and Bailey's beads. I consider within 30 seconds of contact OK, but you must come to your own decision based on your equipment.
- Check ahead to insure that your cameras and scopes will clear your tripod legs as it tracks the sun.



Things that aren't obvious...

(Until you blow it)

- Use a cable release or wireless remote-controlled camera to minimize vibration, especially if you are recording video on the same mount.
- Remember that the moon is moving during the eclipse. This is important to remember for composite shots of the corona. Also, prominences and other features will disappear from the 2nd contact point and new ones will appear at the 3rd contact point.



Things that aren't obvious

(Until you blow it)

- Plan for contingencies – what's your backup plan if your main camera fails? What will you do if your mount falls over? The worst case scenario ought to be for you to sit back and visually enjoy the eclipse. There's lots of time for expressions of aggravation after totality!
- If you plan to photograph until 4th contact, be sure your other group members are aware that you're still busy until the eclipse is really over. Visual observers think the whole show is over right after 3rd contact!



Additional Recommendations for Photographers

- Delineate your equipment "keep out" area with "caution" tape.
- If you are near other people, someone will inevitably want to look through your telescope. Set up a visual observing scope or binoculars on a tripod to keep curious visitors occupied and away from your photo setup.





Practice! Practice! Practice!

- Pack your equipment, then unpack it and set it up.
- Practice mount alignment.
- Run through your imaging sequence in real time.

If you need an eclipse simulation, try using the uncut version of my 2010 Easter Island Eclipse. On a desktop PC, run the Youtube video at 2x speed.

<https://www.youtube.com/watch?v=jLCEPbxVxds>



Reminders for 2017

- Anticipate traffic gridlock! Get to your site early.
- Be careful not to park your hot car on dry grass.
- Plan your bathroom break appropriately.
- Plan for shortages of food, water, and gas.