

An Introduction To Astro- Photography

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Astro-Photographers Do It In The Dark

Types of Astro-Photography

- There are two types of Astro-Photography:-
- Landscape Astro-Photography – Star Trails, Milky Way, Aurora.
- ‘Pure’ Astro-Photography – Moon, Planets, DSOs → Galaxies, Nebula.
- All types of Astro-Photography require planning. 4 W’s:-
 - What to photograph.
 - When to photograph.
 - Where to photograph.
 - Weather to bother!!

What – Planetarium Software

Stellarium

- Free Download from www.stellarium.org.
- Windows, Mac or Linux – Mobile version also available.
- Shows the night sky for any location/date.
- Shows framing of objects by setting your Focal Length and camera sensor size.
- Shows compass settings – note that objects are highest in the sky when due south.



When – Day, Night and Twilight

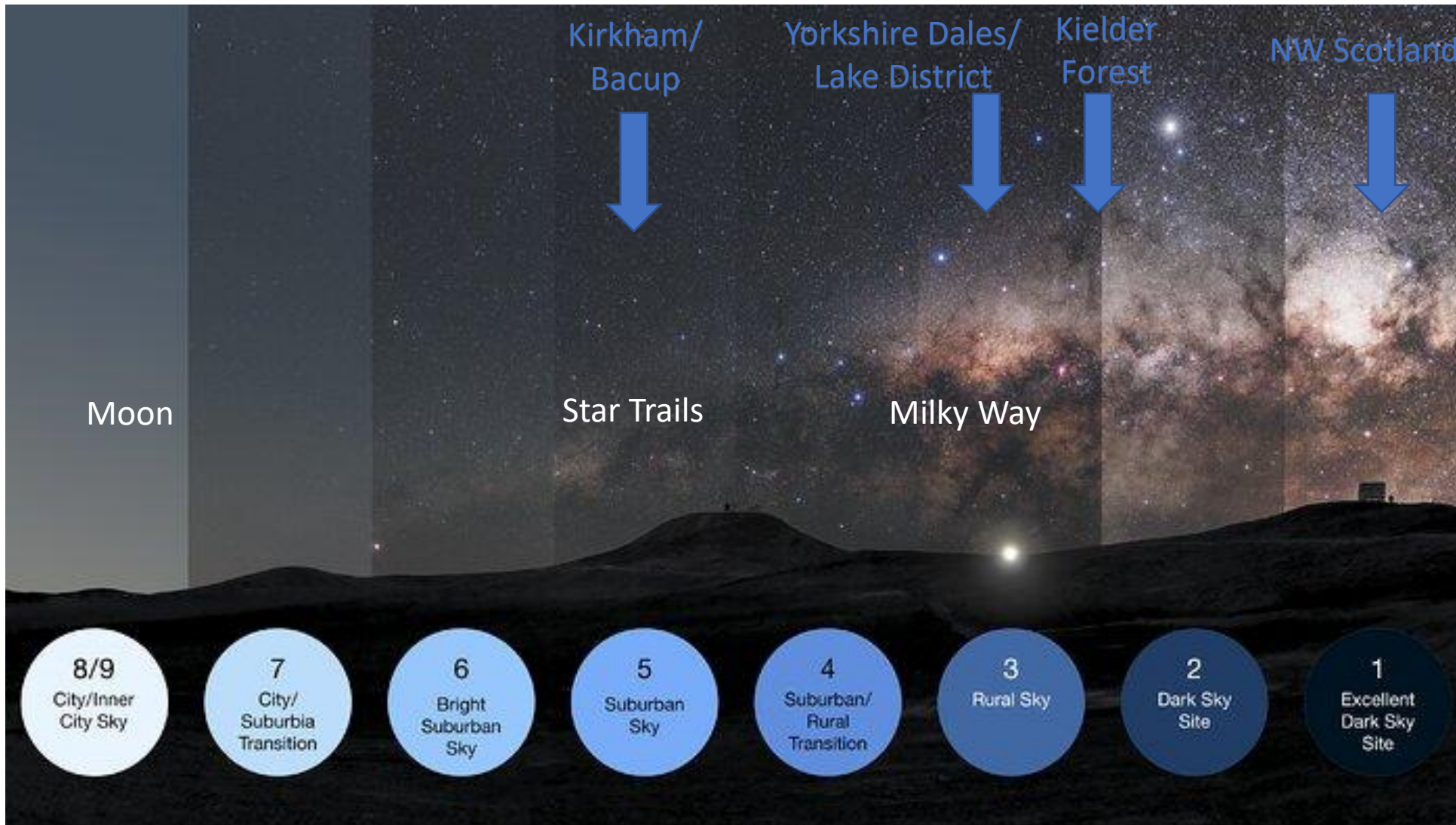


- Google Search for Twilight Times
- www.clearoutside.com
- Mobile app: Golden Hour

• **Note** – in late May, June and July, we never reach true Night in North-West UK.

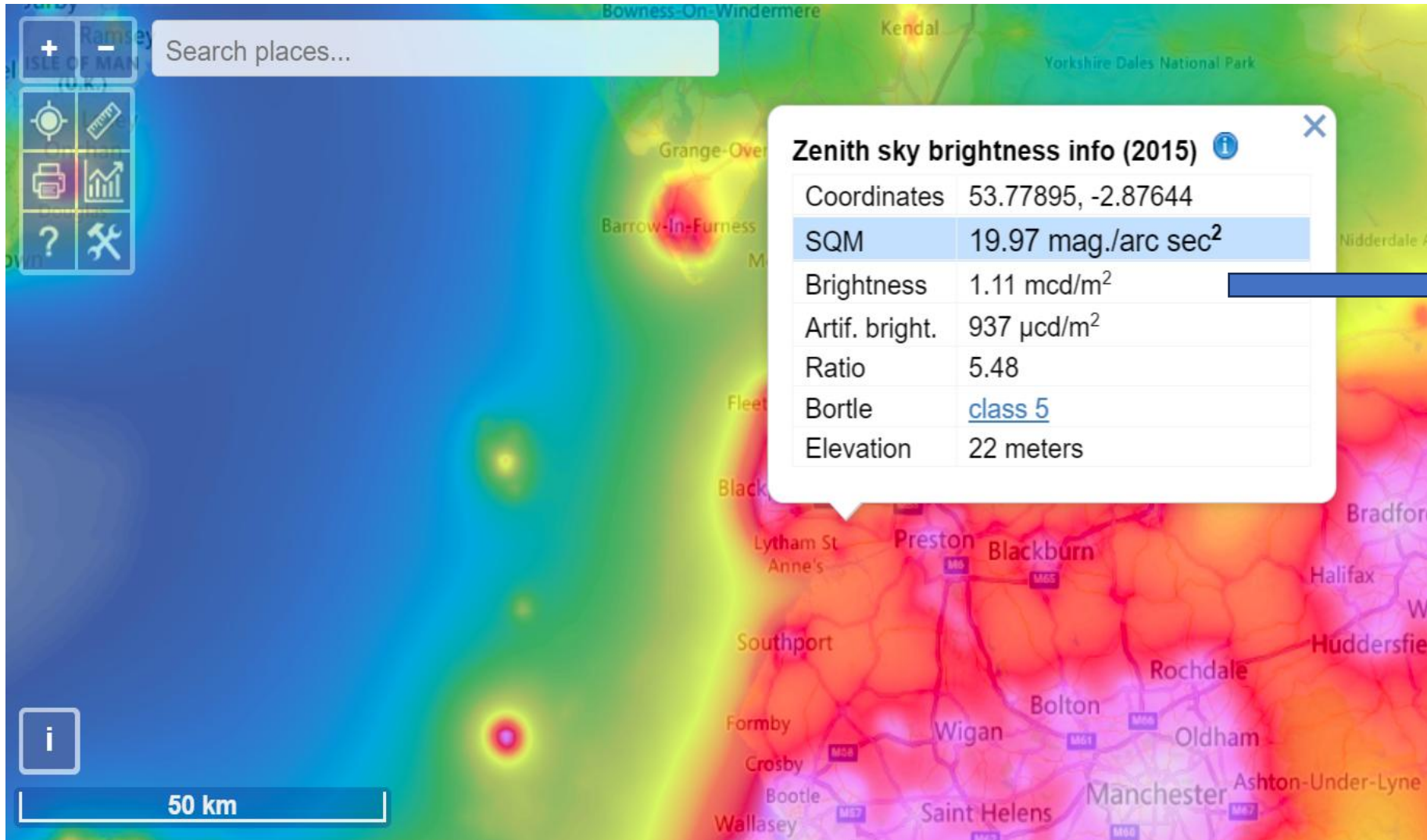
Where - Light Pollution

- Light Pollution is measured on the Bortle Scale, or by sky brightness.




Where – Light Pollution

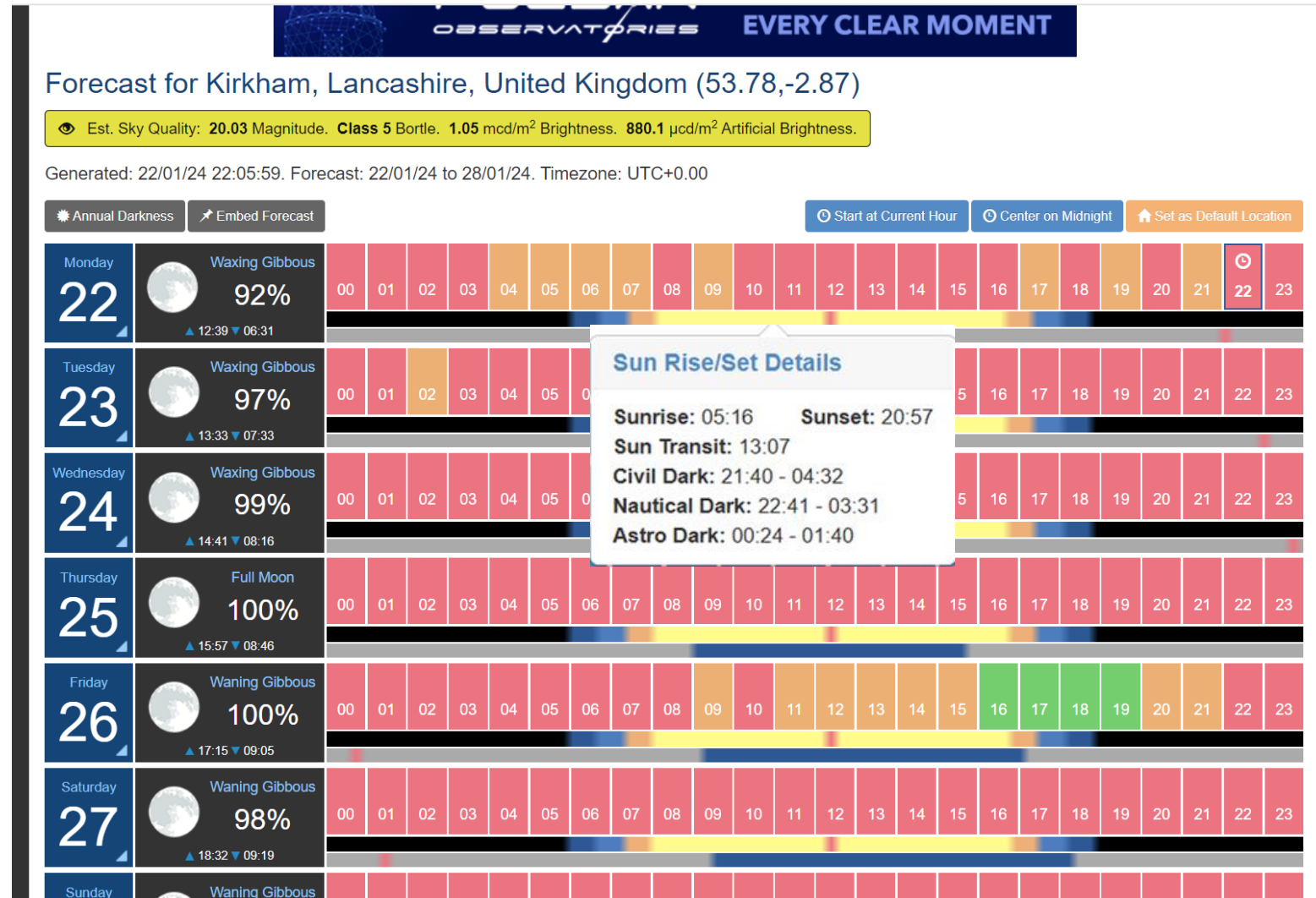
- Light Pollution Map: www.lightpollutionmap.info



- Brightness = 1.11
- Darkest skies have brightness = 0.171, so my sky is ~6 times as bright.
- I have to expose for 6 times as long to gather the same detail as a Dark Sky site.
- Bacup:
 - Brightness 1.03.
 - Factor – 6.0

Weather

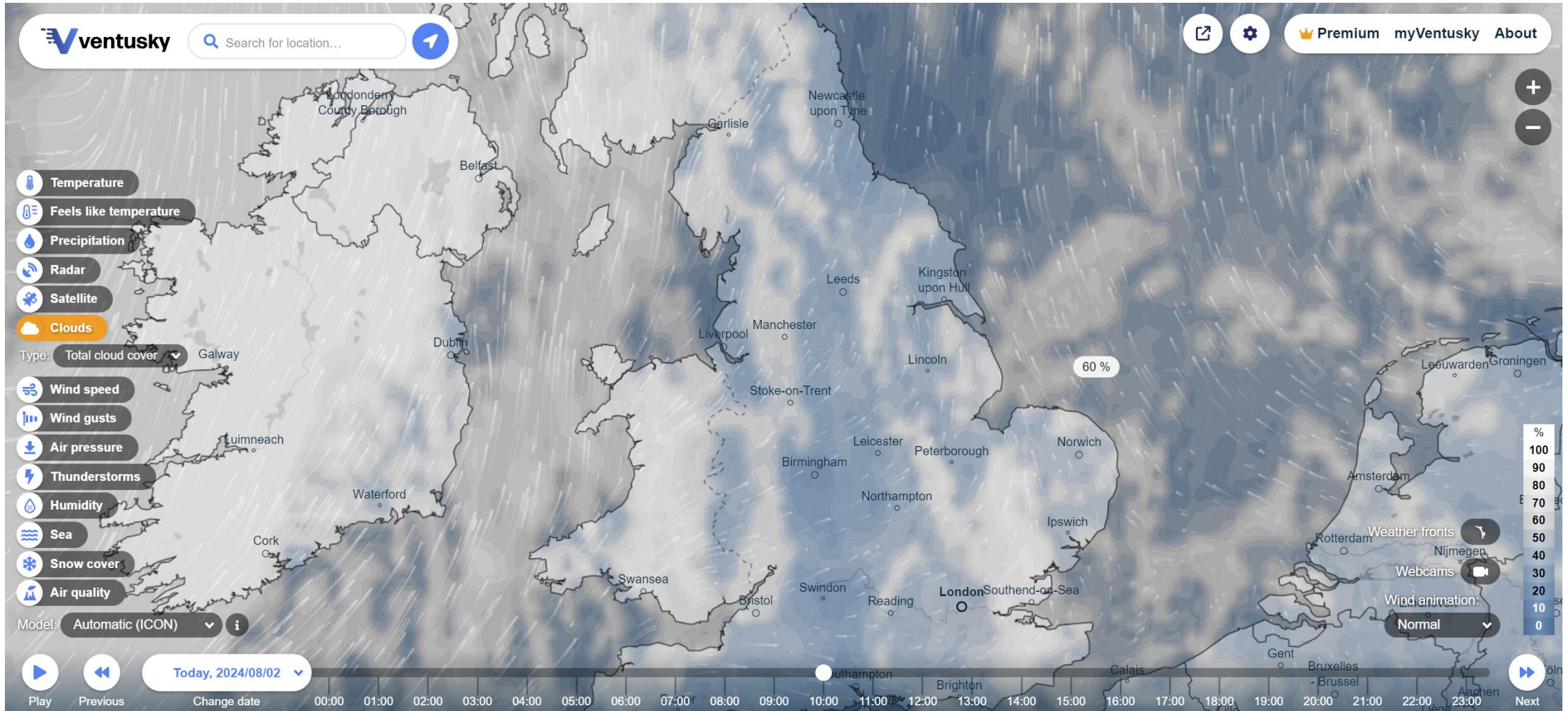
- **Clear Outside** –
 - Astro Weather Forecast
 - On-Line version at www.clearoutside.com. Free phone app also available.
 - Expands for Cloud Cover, Temperature, Rain, Fog, Wind
- 
- Shows sunrise, sunset, moonrise, moonset, moon phase, Twilight times.
 - Also shows Light Pollution levels



Summary colour shows weather to bother – usually **Red** in UK!

Weather

www.ventusky.com – shows predicted cloud cover (also wind, rain, temperature etc).
Mobile App also available.



The Moon

- Not affected by light pollution.
- Required equipment –
Camera, Long Lens, Tripod.

Stellarium View:-
Full Frame Camera @ 600mm



The Moon - Technique

- **Partial Moon** → A Full Moon looks flat and lacking detail.
- **Lens** → Longest Zoom, Mount on Tripod, Image Stabilisation off.
- **Camera Settings** → Similar to terrestrial settings:-
 - Moderate aperture ~ F8-10 → good depth of field.
 - Fairly short exposure times ~1/50s.
 - Low ISO ~ 100 – 200.
- **Manual focus** → Live View, Zoom in on rear screen, focus on 'The Terminator'.
- **Avoid Camera Shake** →
 - Remote shutter release or timer delay (10sec).
 - Lock the mirror up (DSLR)
 - Use electronic shutter if available.
- **Lucky Imaging** → Take several images to increase chance of clear air.

Half Moon



- APS-C Camera.
- 600mm Lens + 1.4 Converter. → 1344mm Effective Focal Length.
- F9, 1/50s, ISO200

Planets are too small without specialist equipment.

Lunar Eclipse

Total Eclipse ~ Every 2.5 Years → Next one in UK 20th Dec 2029



2:15AM
F5, ISO100, 1/400s

3:30AM
F5, ISO400, 13s

Factor of 20,000 in brightness

Star Trails

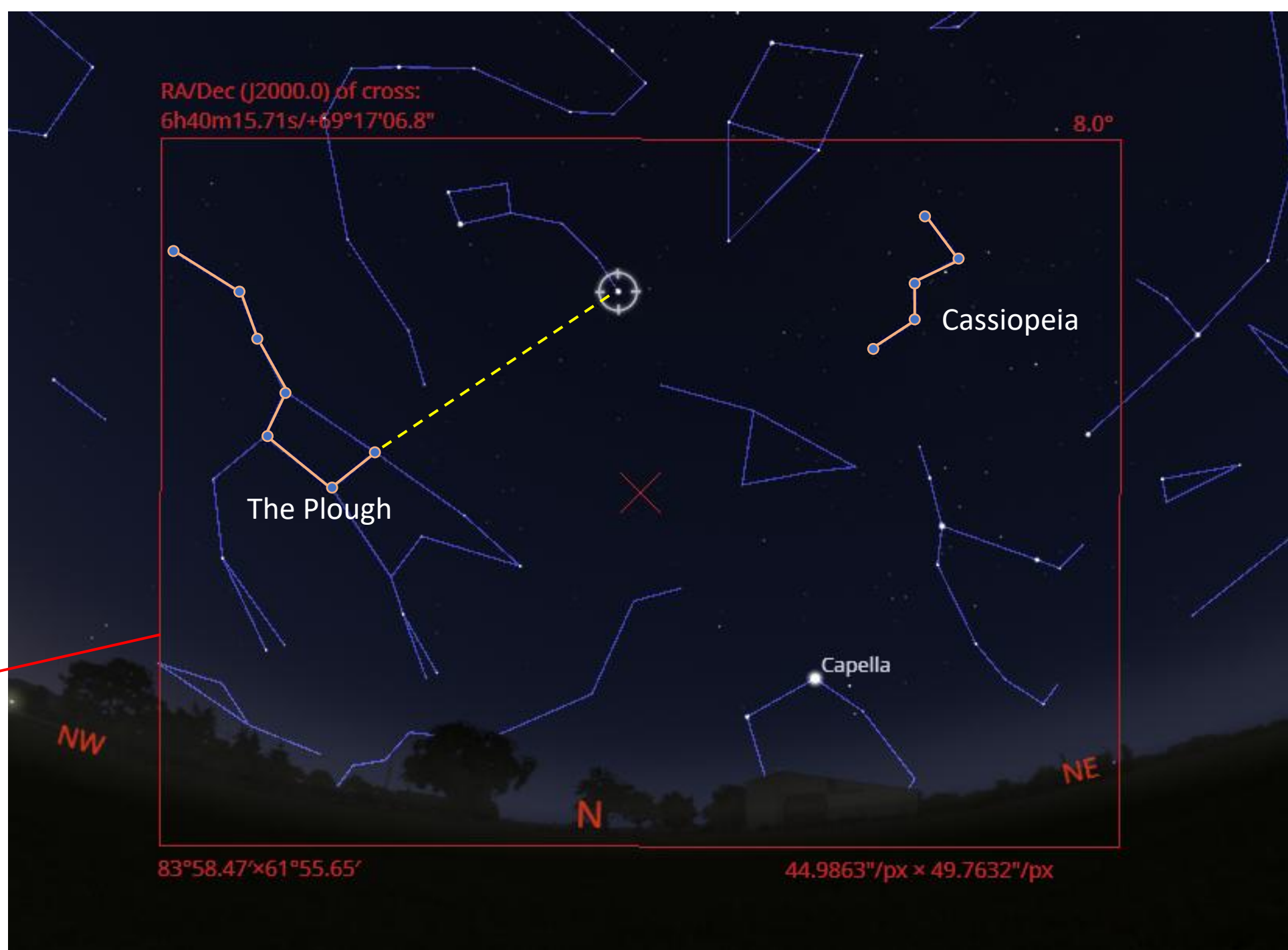
- Very dark skies not essential - Bortle 5 or better.
- Required Equipment – Camera, Wide Angle Lens, Tripod.
- Intervalometer (optional) and Spare Batteries(useful).

- Look north and include the Pole Star for circular star trails.
- Include some foreground interest pointing into the sky – lone tree, isolated building.

Finding Polaris

Find the Plough, then follow a line from the pointer stars.

20mm Lens on Full Frame Camera.



Star Trails Technique

- **Multiple 'shorter' exposures** → Very long exposures will over-expose.
- **Shutter Speed:** ~30s.
- **Aperture:** Widest possible → Gathers more light.
- **ISO:** moderate (800–1600) → Preserves star colour.
- **Long Exposure NR:** Turn Off.
- **Manual Focus (Live View):**
 - High ISO, point at bright star.
 - Magnify on rear screen, adjust focus until star is smallest.
 - Reset ISO, frame shot.
- **Image Type:** Shoot in RAW.
- **Test Shot** → Check focus & framing.
- **Shooting:** Use **intervalometer** (~1s gap) or keep pressing shutter (no timer delay).
- **Duration:** Capture continuously for ~1 hour.

Star Trails Example

Bortle 3/4 Boundary –
Single Unprocessed
Exposure

14mm Focal Length.
30sec, F4, ISO1600.

1 of 110 images taken
over 55 minutes).



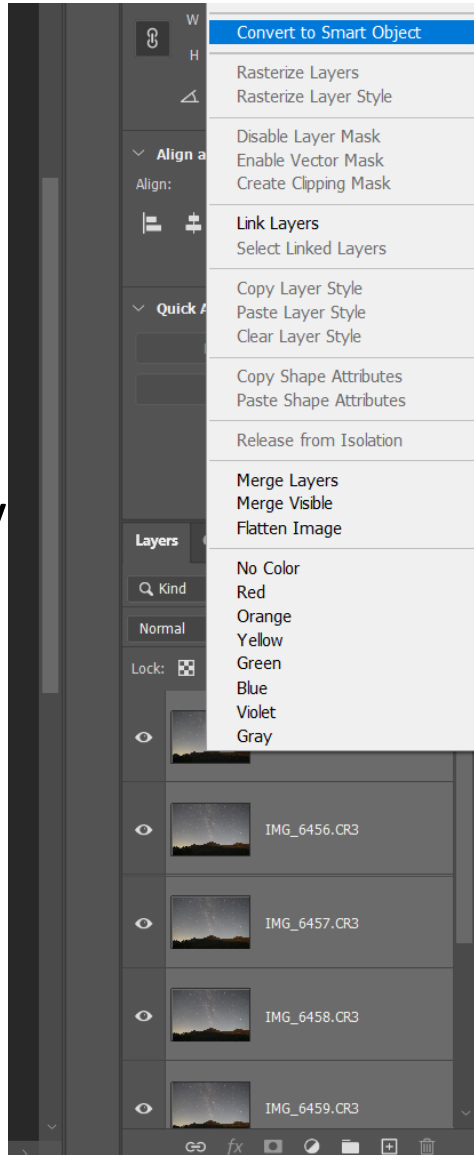
Star Trails Processing

- **Option 1** - StarStaX – Free Download (Not Tested)
 - <https://markus-enzweiler.de/software/starstax/#download>
- **Option 2** – Lightroom/Photoshop
- Open images in Lightroom and apply lens profile (corrects aberrations).
- **1) Foreground Image** - Open images into Photoshop as layers. Select all layers, convert to Smart Object and change the Stack Mode to Mean or Median → Reduces noise.
- **2) Star Trails Image** - Open images again in Photoshop, keep bottom layer blend mode as Normal and set all other layers to Lighten blend mode → Accumulates the star trails.
- **3) Combine Images** - Flatten Star Trails layers and copy onto the Foreground image using a Lighten blend mode.

Star Trails Processing – Smart Object Blend

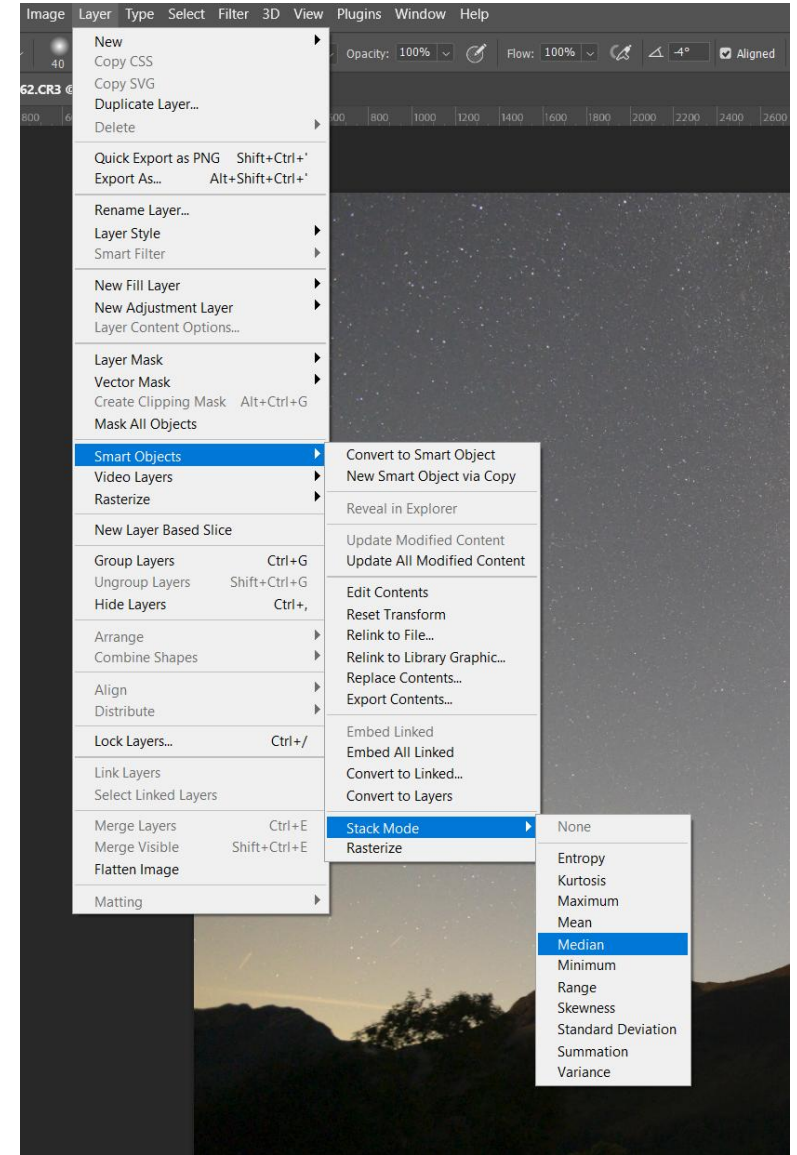
Select All Layers, Right click and select Convert To Smart Object.

This creates a single layer – only the top layer is visible, but data from underlying layers is still present.



From Top Menu, Select Layer → Smart Objects → Stack Mode → Median or Mean

This produces an image that is the average of all layers.



Noise Reduction By Stacking

- All images contain noise. When we brighten a dark image (high ISO or post processing), we amplify the noise, making it visible.
- To reduce noise we need to expose for longer:-

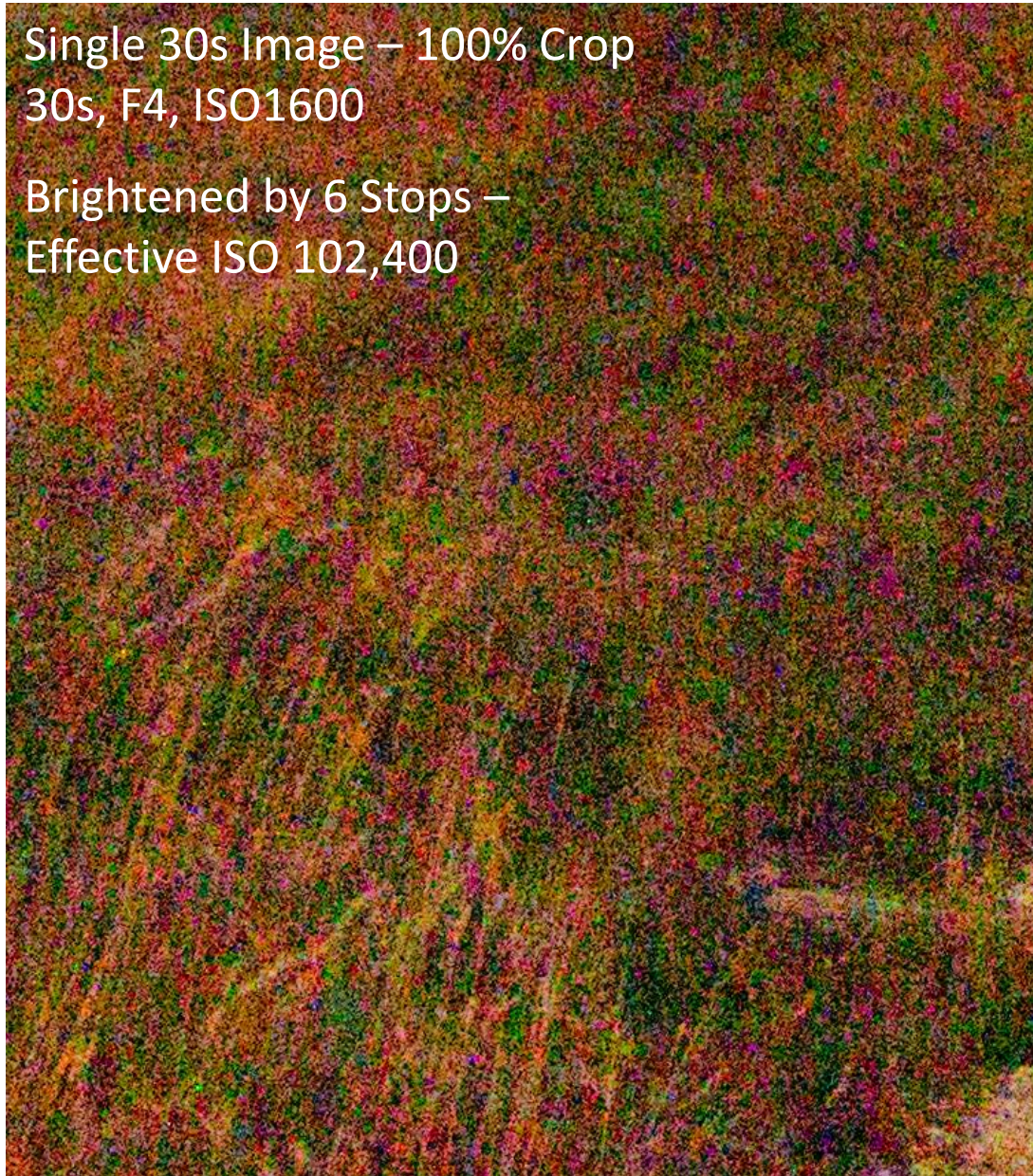
• Signal/Noise Ratio improves in proportion to $\sqrt{\text{Exposure time}}$.

- Several stacked frames gives the same benefit as a single long exposure → it is the TOTAL integration time that matters.
 - Stack 4 Images → Signal/Noise improves by a factor of 2.
 - Stack 16 Images → Signal/Noise ratio improves by a factor of 4.

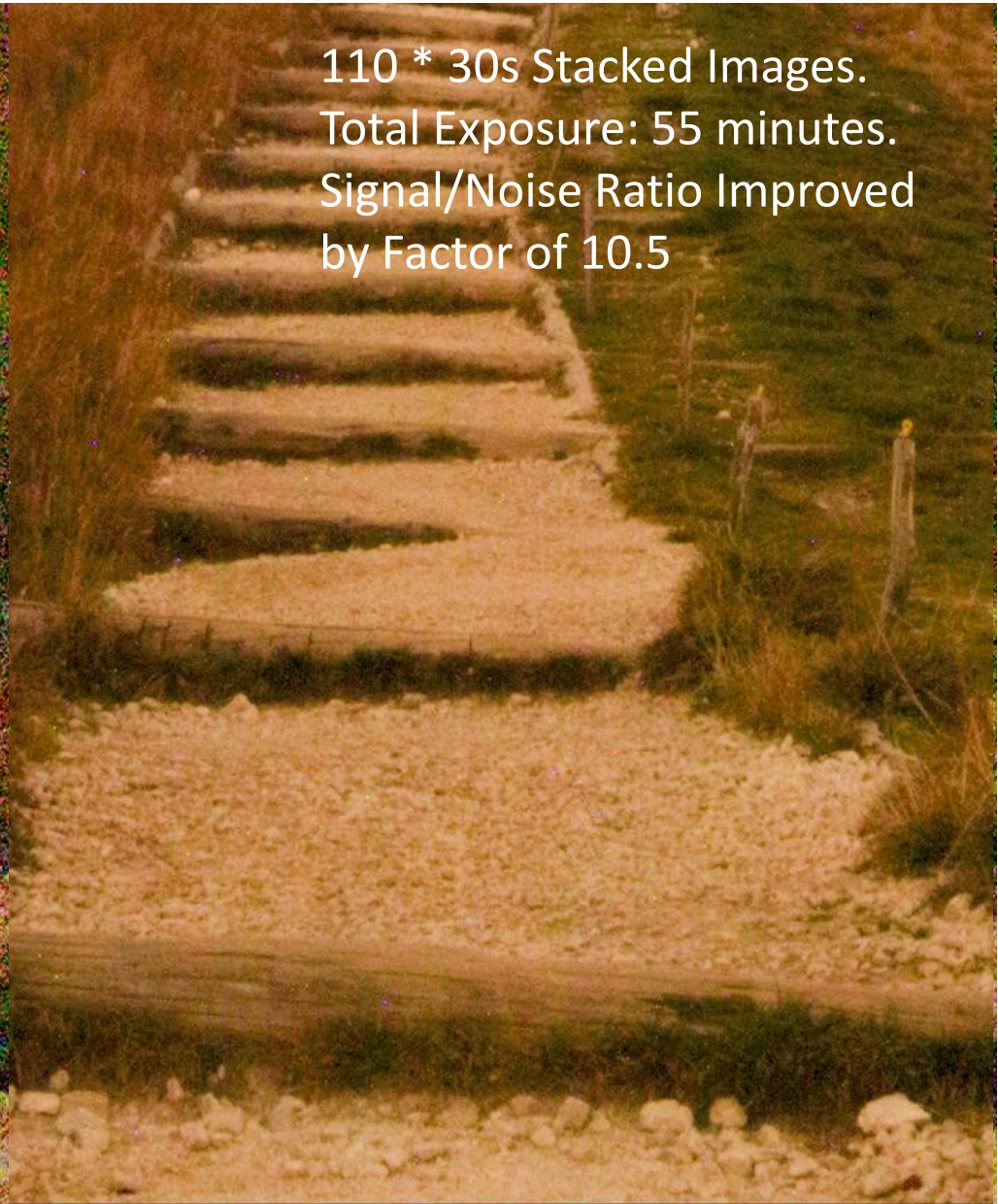
Benefit Of Stacking

Single 30s Image – 100% Crop
30s, F4, ISO1600

Brightened by 6 Stops –
Effective ISO 102,400



110 * 30s Stacked Images.
Total Exposure: 55 minutes.
Signal/Noise Ratio Improved
by Factor of 10.5



Star Trails Processing

- 1) Stacked and averaged Foreground Image.



Star Trails Processing

- 1) Stacked and averaged Foreground Image.
- 2) Adjust Colour temperature/brightness in Camera Raw.
- 3) Lighten Sky/Foreground selectively using masks.



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- 4) Introduce Stacked Star Layer.



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- 5) Change Blend Mode to Lighten.



Star Trails Processing

- 1) Stacked and averaged Foreground Image.
- 2) Adjust Colour temperature/brightness in Camera Raw.
- 3) Lighten Sky/Foreground selectively using masks.
- 4) Introduce Stacked Star Layer.
- 5) Change Blend Mode to Lighten.
- 6) Clone out plane trails and some final adjustments.



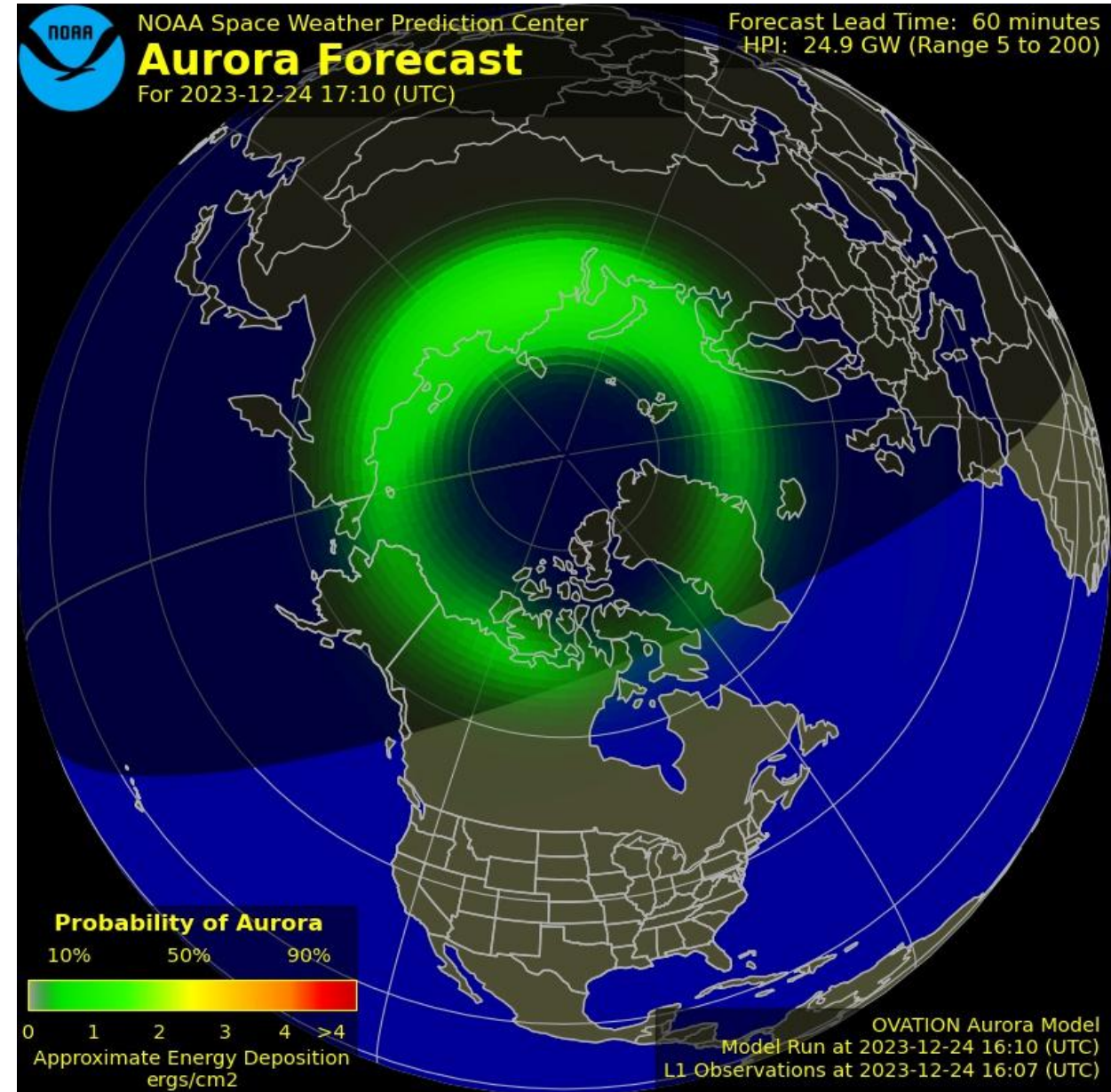
Stairway To Heaven!

The Aurora Borealis

- Aurora - created by high energy charged particles from the sun entering Earth's Atmosphere.
- The particles are guided by Earth's magnetic field and enter the atmosphere close to the poles ~ 60-75deg latitude.
- They interact with the atmosphere at different altitudes producing different colours:-
 - Green → Oxygen at 60 to 90 miles height
 - Red → Oxygen at 180-250 miles height
 - Blue/Purple → Nitrogen at 60 miles height
- In UK, we often only see red because it is at the highest altitude.
- The sun's activity varies on an 11 year cycle. The Solar Maximum is occurring 2024/25.

Aurora Forecasts

- Many websites offer Aurora Forecasts or text alerts. Eg For UK:-
 - <https://aurorawatch.lancs.ac.uk/alerts/>
- **Mobile App: Aurora Alert**
- The Space Weather Prediction Center gives a very accurate 30-90 Minute Forecast, based on a satellite 1.5 million km closer to the sun:-
 - <https://www.swpc.noaa.gov/products/aurora-30-minute-forecast>



Aurora Technique

- **Clear View North** → UK Aurora likely on the Northern Horizon, low light pollution will help.
- **Photograph over water** → for ‘twice the value!’
- **Remove Filters** → Aurora light creates interference rings between filter and lens.
- **Camera/Lens** → Camera on Tripod, Wide Angle lens, Manual exposure, Wide Aperture.
- **Exposure times** → ~5sec to show aurora shapes. Longer exposures will blur the movement.
- **ISO** → Depends on aurora strength, adjust for best exposure.
- **Manual Focus** → Use Live View on a bright star.
- **Timer** → 2 sec timer to avoid camera shake (optional).
- **Foreground** → It at very dark site. Take extra longer exposures for foreground stacking.

The Milky Way

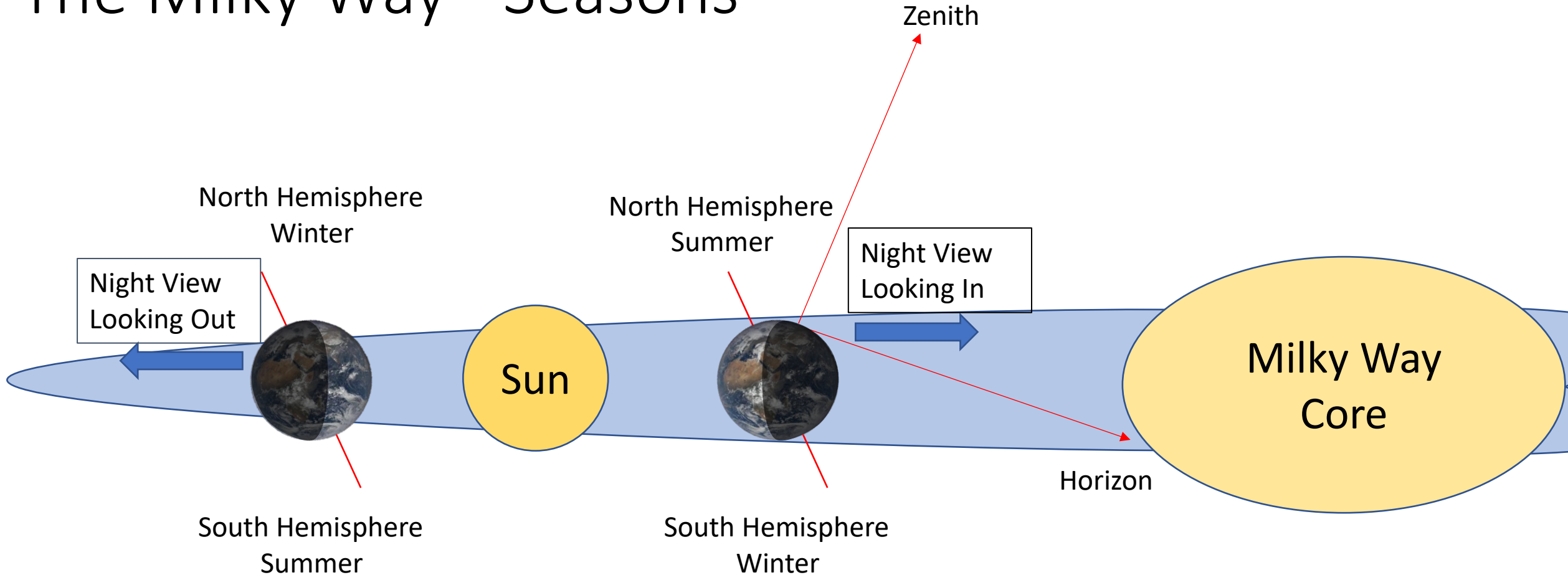
- The Milky Way is our local spiral galaxy.
- It contains ~ 250,000,000,000 stars and is 100,000 Light Years in diameter.

- **Context: Voyager 1 Spacecraft.**
 - Would orbit Earth in ~ 40 minutes.
 - Travels ~ 1 Million miles a day.
 - Would take 1.8 Billion Years to cross Milky Way.

- The sun is about mid way out from the centre.
- We only see ~4000 bright stars in our local area. Beyond this, the stars merge into the Milky Way.



The Milky Way - Seasons

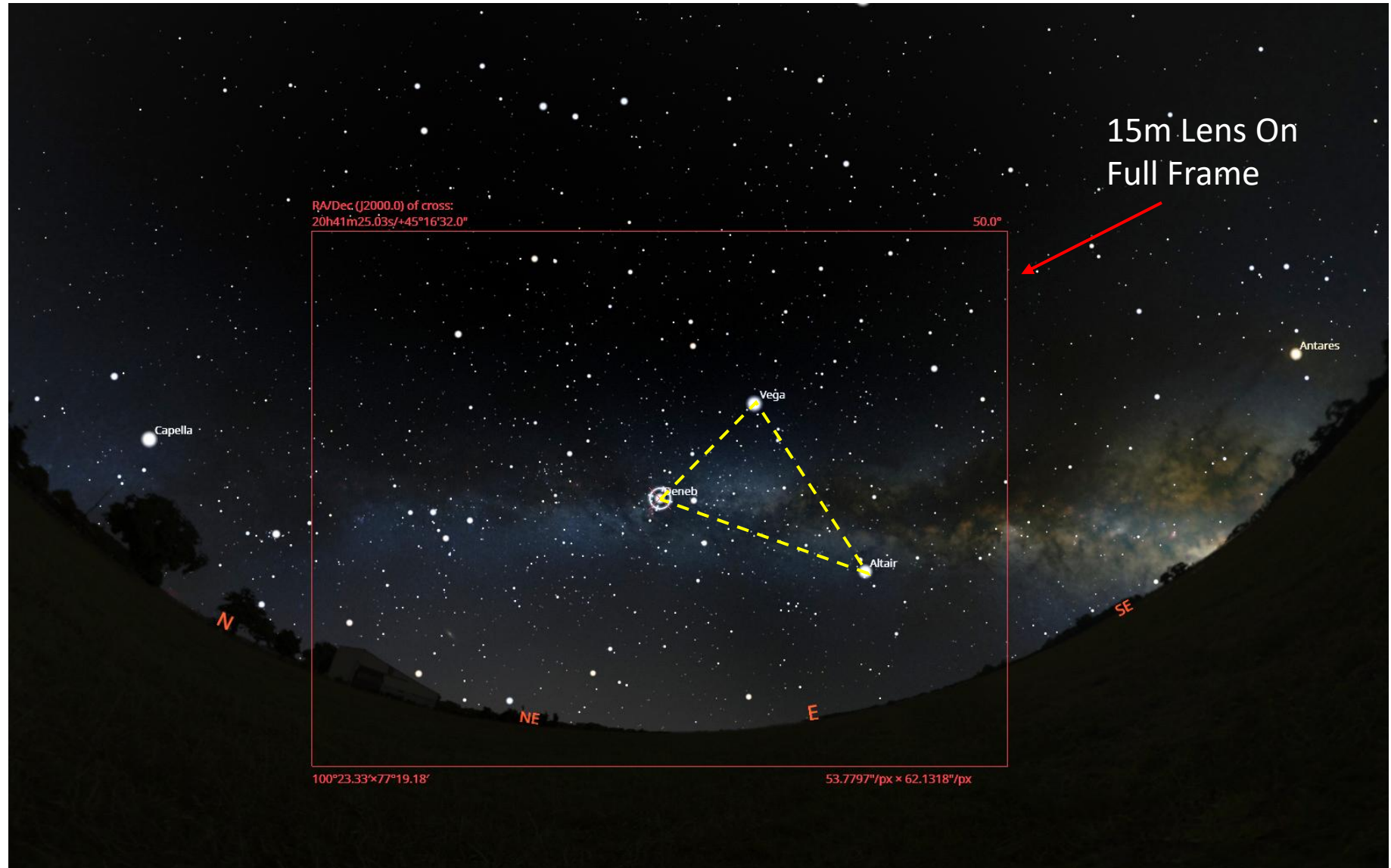


- In Northern Hemisphere, we look into the Milky Way core in Summer, out of the Milky Way in Winter.
- In the UK the Core is always low on the horizon – travel south for a better view.
- The Southern Hemisphere gets best view – the core is high in the sky during the dark winter nights.
- Earth's rotation is also inclined into the plane of the diagram, so the angle of the Milky Way disc varies as Earth rotates.

Milky Way – Spring

1st April – 4AM

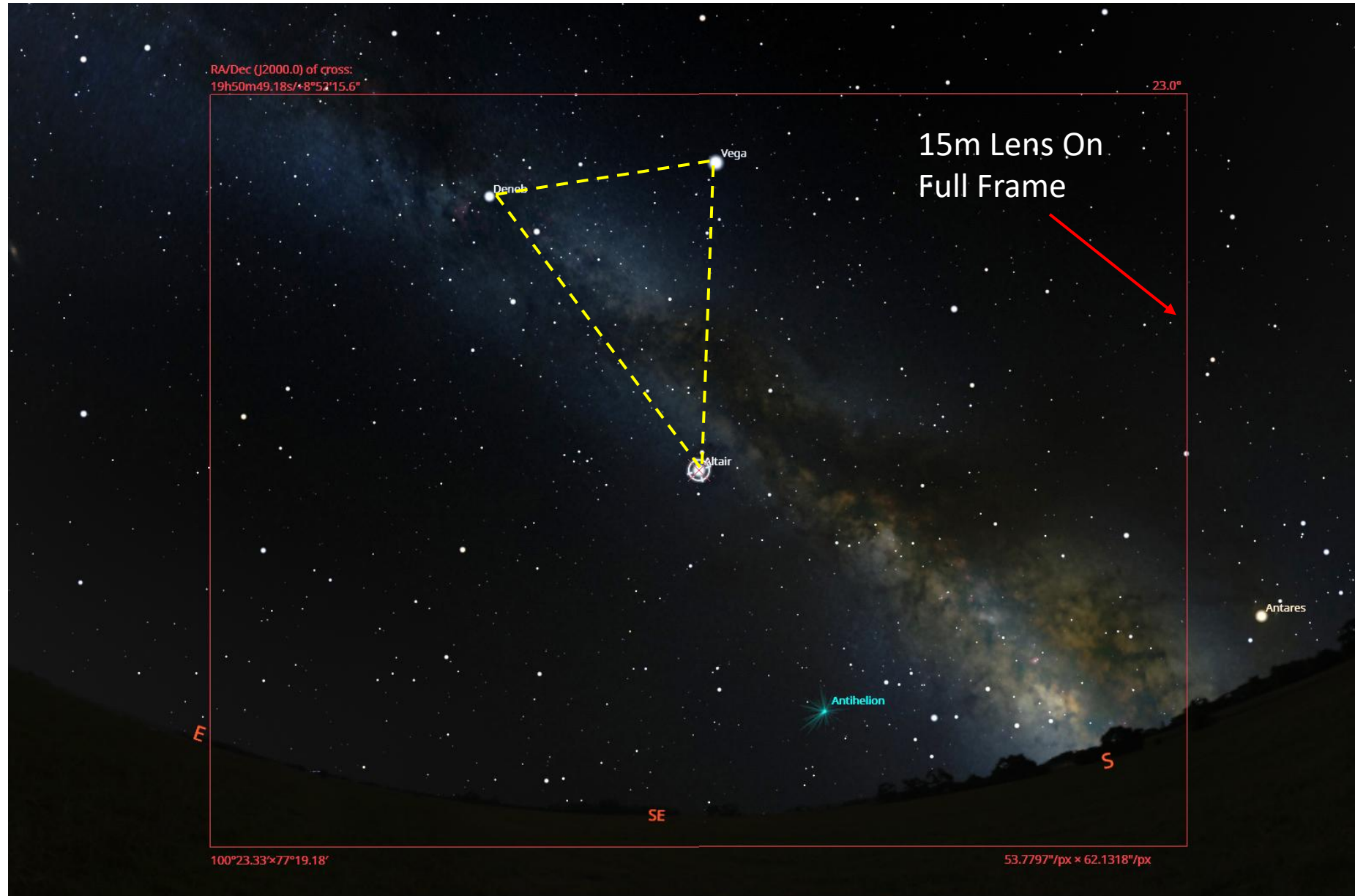
- Milky Way forms an arc in the East.
- The core is below the horizon towards the SE.
- Look for the ‘Summer Triangle’ stars
 - Vega, Deneb, Altair
- Astronomical Night ends at 4:40am.
- To photograph the full arc requires a stitched panorama.



Milky Way – Summer

30th June – 0:30AM

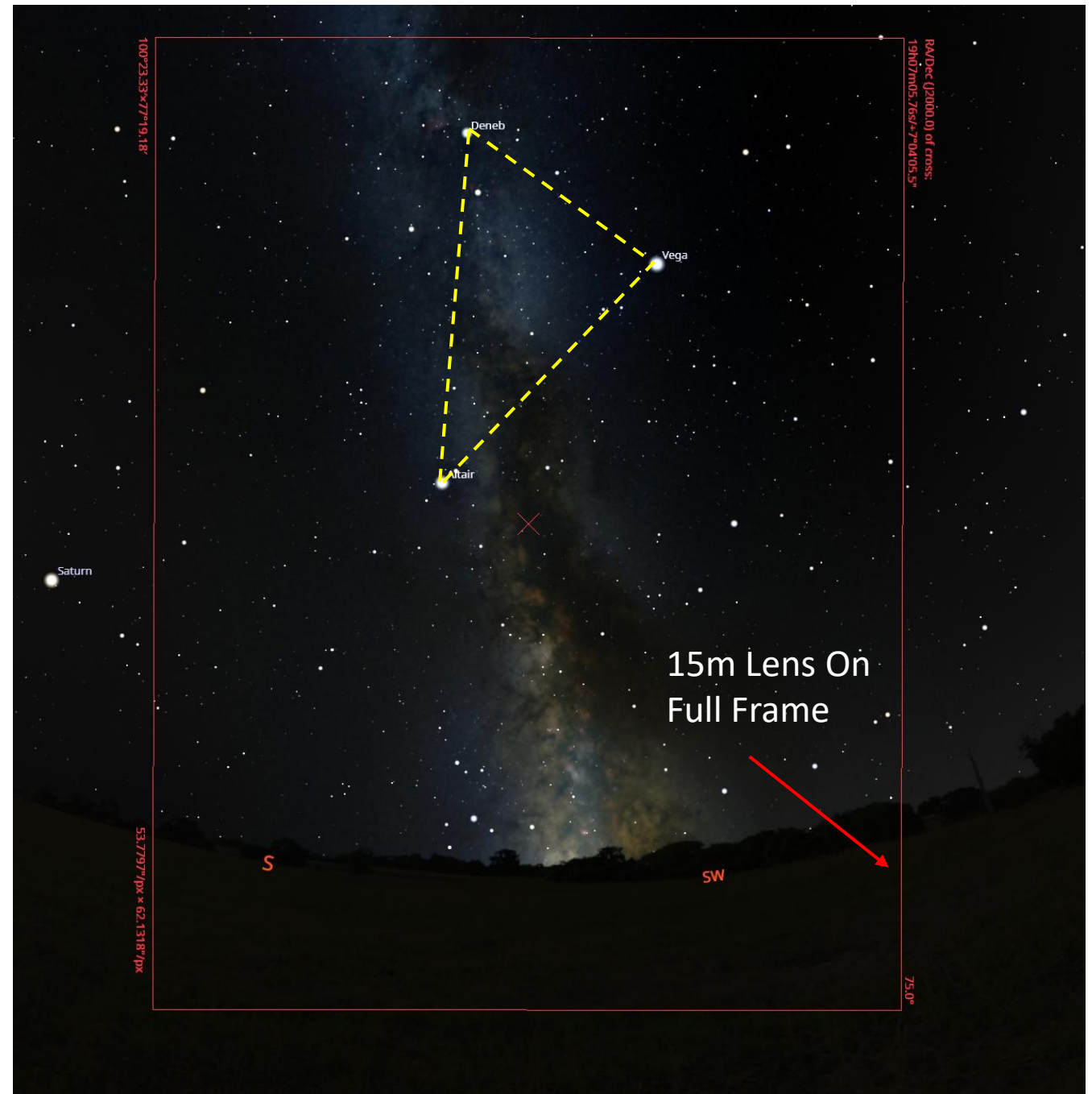
- Milky Way rises from South at ~45deg.
- Best time of year for view of Core from UK - due South, so at its highest.
- Look for the 'Summer Triangle' stars
 - Vega, Deneb, Altair
- No astronomical night in UK, but it is darkest at 1am.



Milky Way - Autumn

15th Sep – 10pm

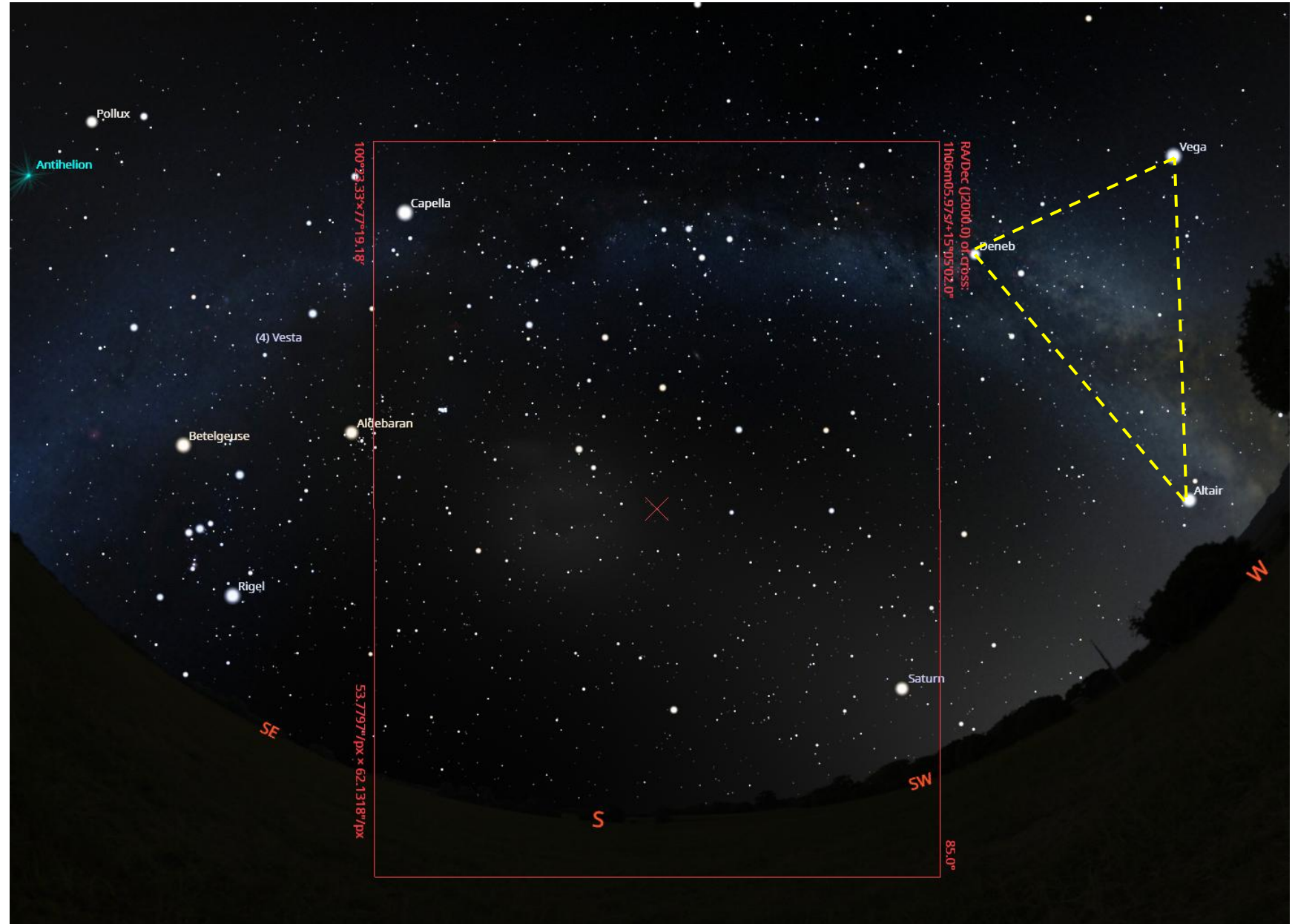
- Milky Way rises vertically in SW.
- Core is below horizon, but the view remains good.
- Look for the 'Summer Triangle' stars – Vega, Deneb, Altair
- Astronomical night starts at 9:30pm.



Milky Way - Winter

31st Dec – 7pm

- Due south, we are looking out of the Milky Way, so arc is quite dim.
- Milky Way core to the west – below the horizon.
- Not the best time for Milky Way photography!



Settings - Shutter Speed

- For sharp stars use a “300 rule” to set Shutter Speed:-

$$\blacktriangleright \text{Shutter Speed} = 300 / (\text{Focal Length} \times \text{Crop Factor})$$

- (NB – A Google search may give a “500” rule → slightly too long).
- **Single Exposure** – Simple, but high noise due to short exposure times.
- **Multiple Stacked Exposures** – Reduces noise, but more complicated as stars must be aligned.
- **Star Tracker** - star trackers follow the stars, allowing longer exposures. See later in the presentation.

Settings – Aperture/ISO

- Use a 'fast' lens and start with maximum aperture – F2.8 is ideal.
- Stars can become deformed in the corners → stopping down may improve star shapes, but reduces light gathering.
- Take a test shot - check star shapes and stop down if necessary.

- ISO is not critical – image will be brightened in post processing.
- Choose an ISO so that you can see the image on the camera screen.
- → ISO 1600-3200. Avoid very high ISO → reduces dynamic range.

Technique – Single Frame (Summer/Autumn)

- Choose a moonless night.
- Camera on tripod, manual focus, image stabilisation off, Long Exposure Noise Reduction off.
- Set maximum aperture, high ISO (~3200). Manually focus on a bright star using Live View.
- Re-frame image. Set shutter speed/ISO/Aperture based on previous slides.
- Use an intervalometer, or 2sec timer to avoid camera shake.
- Take a test shot → Check centre stars for trailing, corner stars for distortion.
 - Adjust Shutter speed or Aperture if necessary.
- Take several images for stacking (~ 3-5 minutes if possible).

Milky Way Technique

Buttermere – Bortle 3

Untracked Image.

F2.8, 30s, ISO 3200

16mm Lens on Full Frame Camera

Focal Length * Exposure = 480



Milky Way Technique

Buttermere – Bortle 3

Untracked Image.

F2.8, 30s, ISO 3200

16mm Lens on Full Frame Camera

Focal Length * Exposure = 480

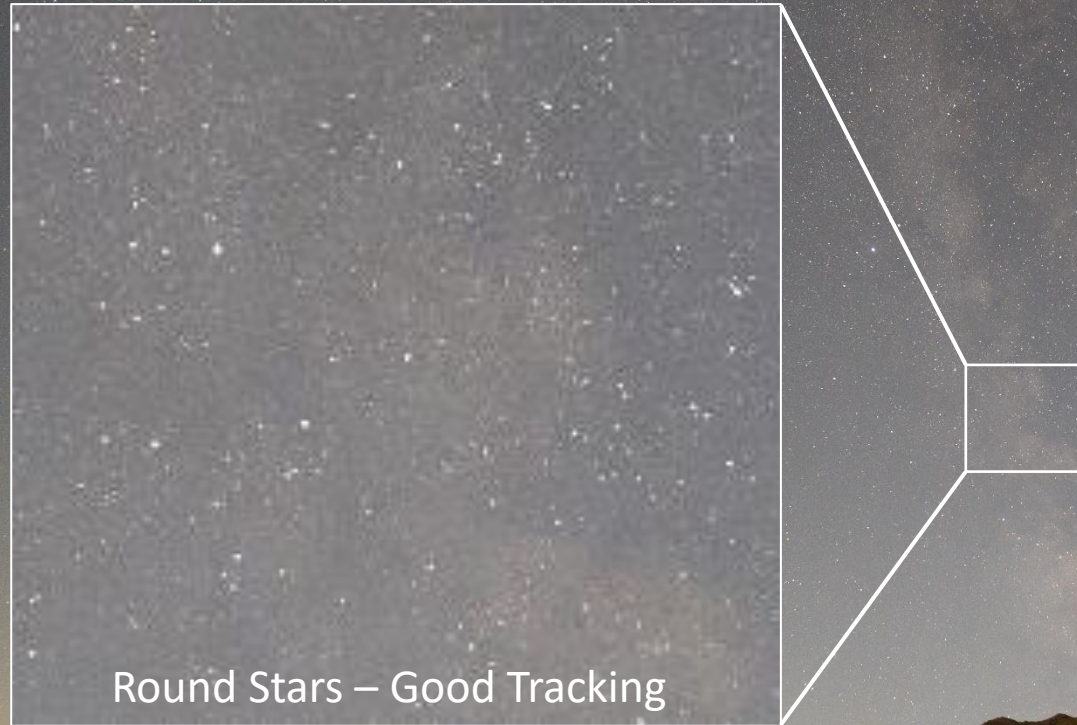


200% Crop – Some star trailing using 500 Rule

Milky Way Technique

Buttermere – Bortle 3

Tracked Image



Milky Way Stacking Technique

If stacking multiple exposures:-

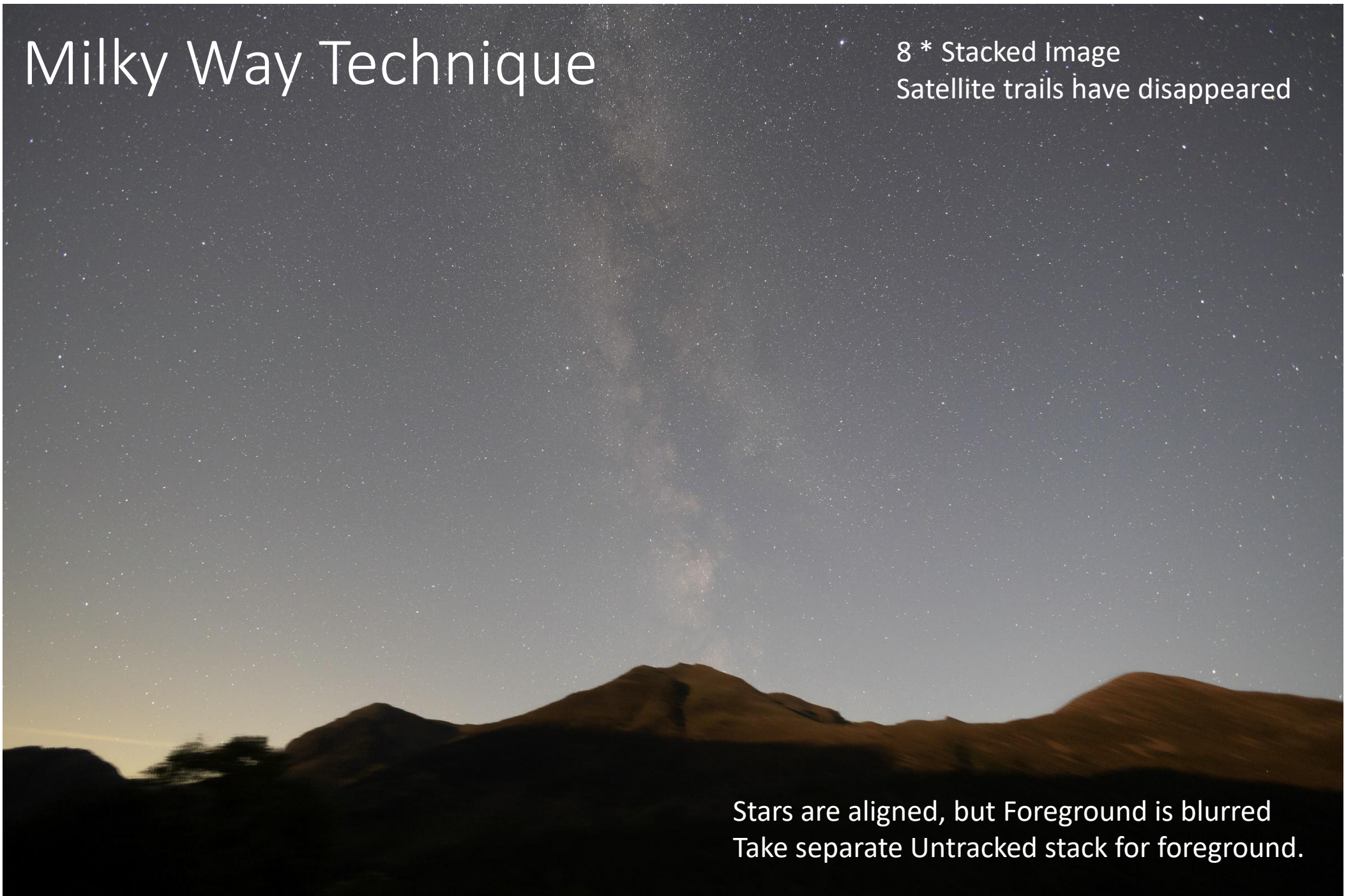
Two stacks will be required – one with stars aligned, the other with foreground aligned.

- **Initial Corrections** → Apply Lens corrections in Lightroom, then export as TIFF images for stacking.
- **Foreground Images** → Should align automatically in Photoshop → Same approach as Star Trails Foreground (Smart Object → Mean Blend).
- **Tracked Sky Images** → Should align automatically.
- **Untracked Sky Images** → Difficult to align → use specialist stacking software:-
 - **Sequator** - <https://sites.google.com/view/sequator/download>
 - **Starry Landscape Stacker** (Mac - \$40) - <https://apps.apple.com/us/app/starry-landscape-stacker/id550326617?mt=12>

Milky Way Technique

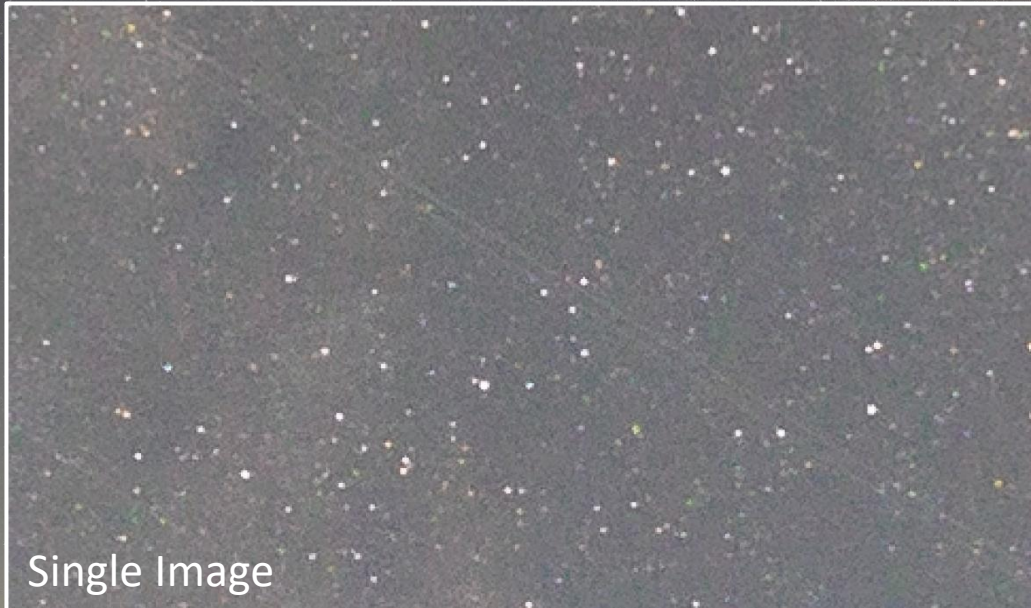
8 * Stacked Image
Satellite trails have disappeared

Stars are aligned, but Foreground is blurred
Take separate Untracked stack for foreground.

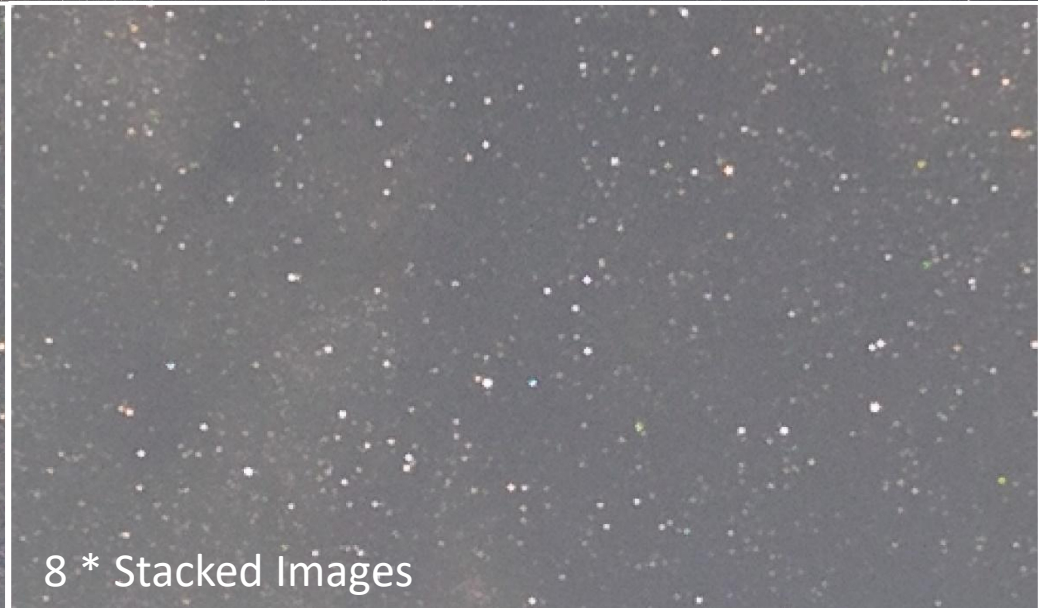


Milky Way Technique

8 * Stacked Image
Satellite trails have dissapeared



Single Image



8 * Stacked Images

Stars are aligned, but Foreground is blurred
Take separate Untracked stack for foreground.

Final Image

Combining Foreground/Sky

- In the Sky stack, the foreground is blurry.

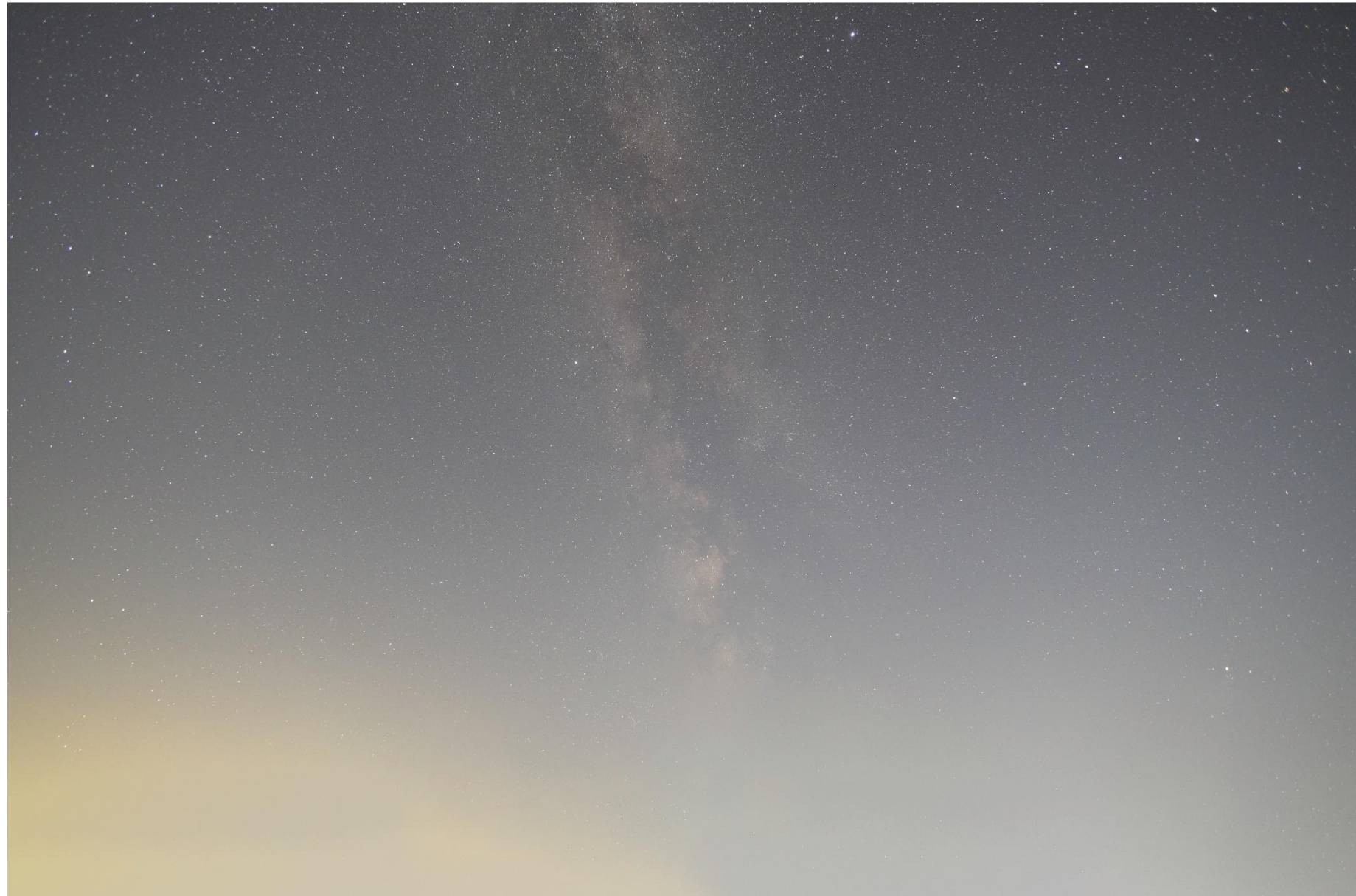


Exposure: 4 Minutes, F2.8, ISO3200

Final Image

Combining Foreground/Sky

- In the Sky stack, the foreground is blurry.
- Delete the foreground then fill the space with a Content Aware Fill.

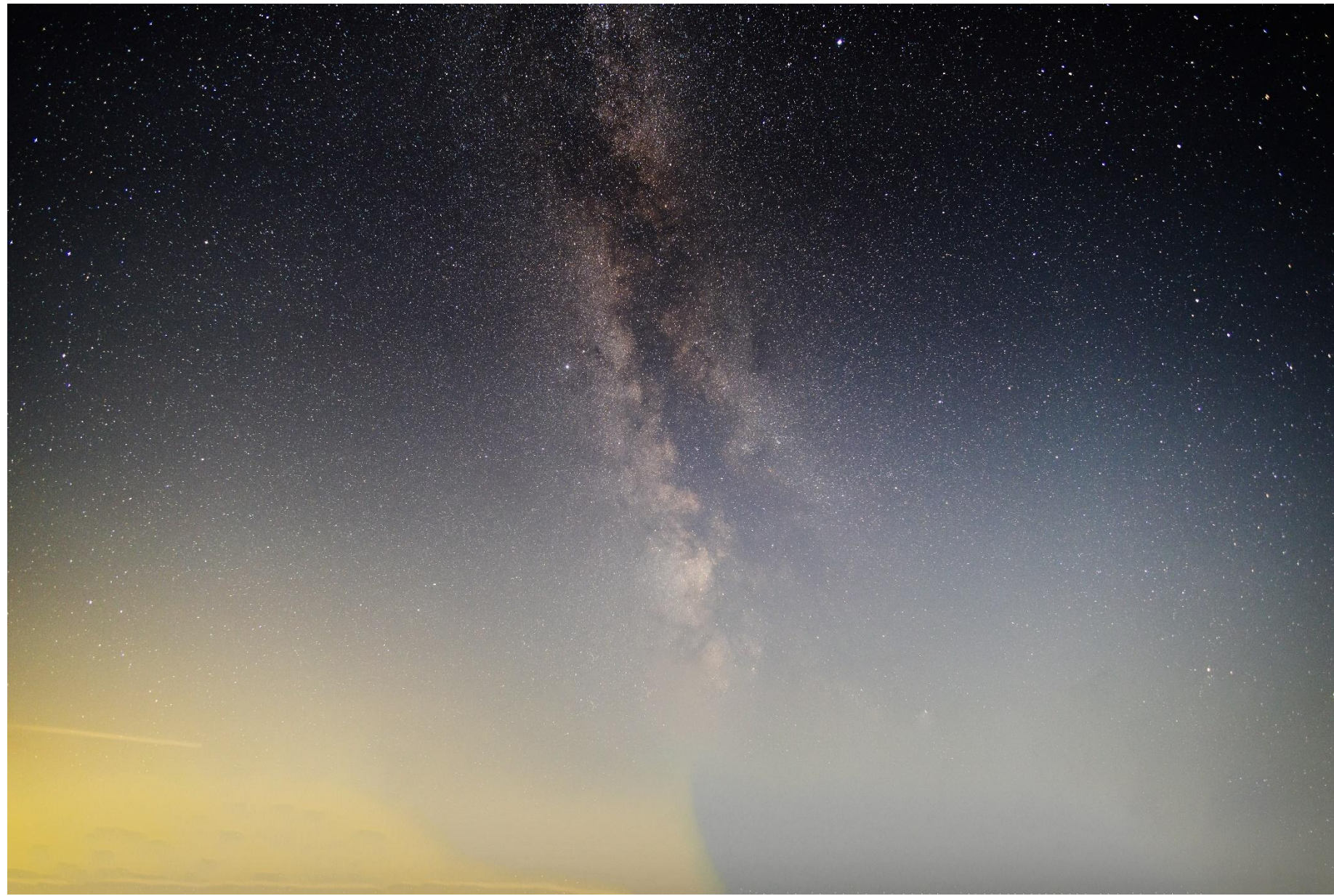


Exposure: 4 Minutes, F2.8, ISO3200

Final Image

Combining Foreground/Sky

- In the Sky stack, the foreground is blurry.
- Delete the foreground then fill the space with a Content Aware Fill.
- Use Camera Raw Clarity slider, and saturation to gradually increase 'local' contrast in the sky.



Exposure: 4 Minutes, F2.8, ISO3200

Final Image

Combining Foreground/Sky

- In the Sky stack, the foreground is blurry.
- Delete the foreground then fill the space with a Content Aware Fill.
- Use Camera Raw Clarity slider, and saturation to gradually increase 'local' contrast in the sky.
- Overlay the static foreground stack with a Darken blend mode.



Exposure: 4 Minutes, F2.8, ISO3200

Final Image

Combining Foreground/Sky

- In the Sky stack, the foreground is blurry.
- Delete the foreground then fill the space with a Content Aware Fill.
- Use Camera Raw Clarity slider, and saturation to gradually increase 'local' contrast in the sky.
- Overlay the static foreground stack with a Darken blend mode.
- Adjust colour temperature, boost saturation and lighten top part of image with a curves adjustment and graduated mask.
- Reduce star impact using a 'Minimum' Filter.
- (Filter→Other→Minimum)



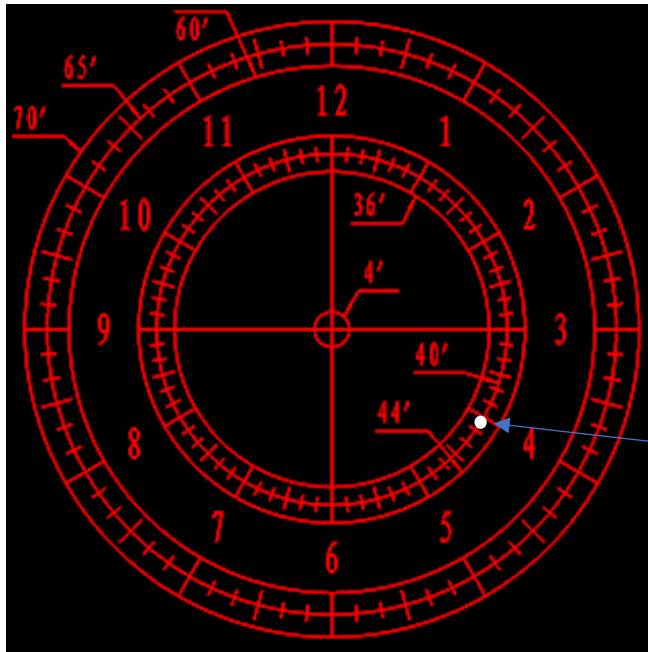
Exposure: 4 Minutes, F2.8, ISO3200

Spring Arc - Panorama

- Tracker not useful due to difficulty in horizontal panning - use 3-Way Geared Head if available.
- Frame shots vertically and overlap by ~50%.
- Either take several images per frame (Say 8x15sec = 90sec each frame), or single shots at ~30sec.
- **Processing**
- Apply lens profiles in Lightroom and save images as Tiffs.
- Align stars for each panel, using Sequator → Star Panels.
- Stack and average foreground images in Photoshop → Foreground Panels.
- Combine Foreground and Star panels into separate panoramas in Lightroom, then combine Sky/Foreground panoramas in Photoshop.
- Process Sky and Foreground separately using masks.
- Camera Raw Clarity will draw out Milky Way detail.

Astro Trackers

- Astro Trackers allow increased exposure times by tracking the night sky rotation.
- The axis of the tracker is aligned to the celestial pole.
- Once aligned, the stars are tracked by rotation of the tracker.



Polaris Aligned

iOptron SkyGuider Pro ~ £300



Astro Tracker



Milky-Way Setup.
Tracker with Tripod Head, Camera
and Wide Angle Lens.



Deep Space Setup.
Tracker with Bar and Counterweight. Camera
and Tele-photo Lens.
A red dot finder helps locate objects in space.

Deep Space Astro-Photography

Unprocessed Image

Andromeda Galaxy -

Bortle 4 skies

Canon EOS80D + 300mm Lens on
iOptron SkyGuider Pro.

F4, ISO400.

Total Exposure time – 43 Minutes.



Deep Space Astro-Photography

Andromeda Galaxy -

Bortle 4 skies

Canon EOS80D + 300mm Lens on
iOptron SkyGuider Pro.

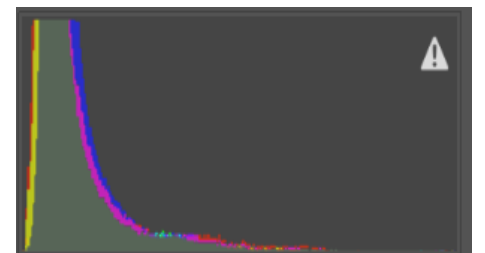
F4, ISO400.

Total Exposure time – 43 Minutes.

2 million years in the making!



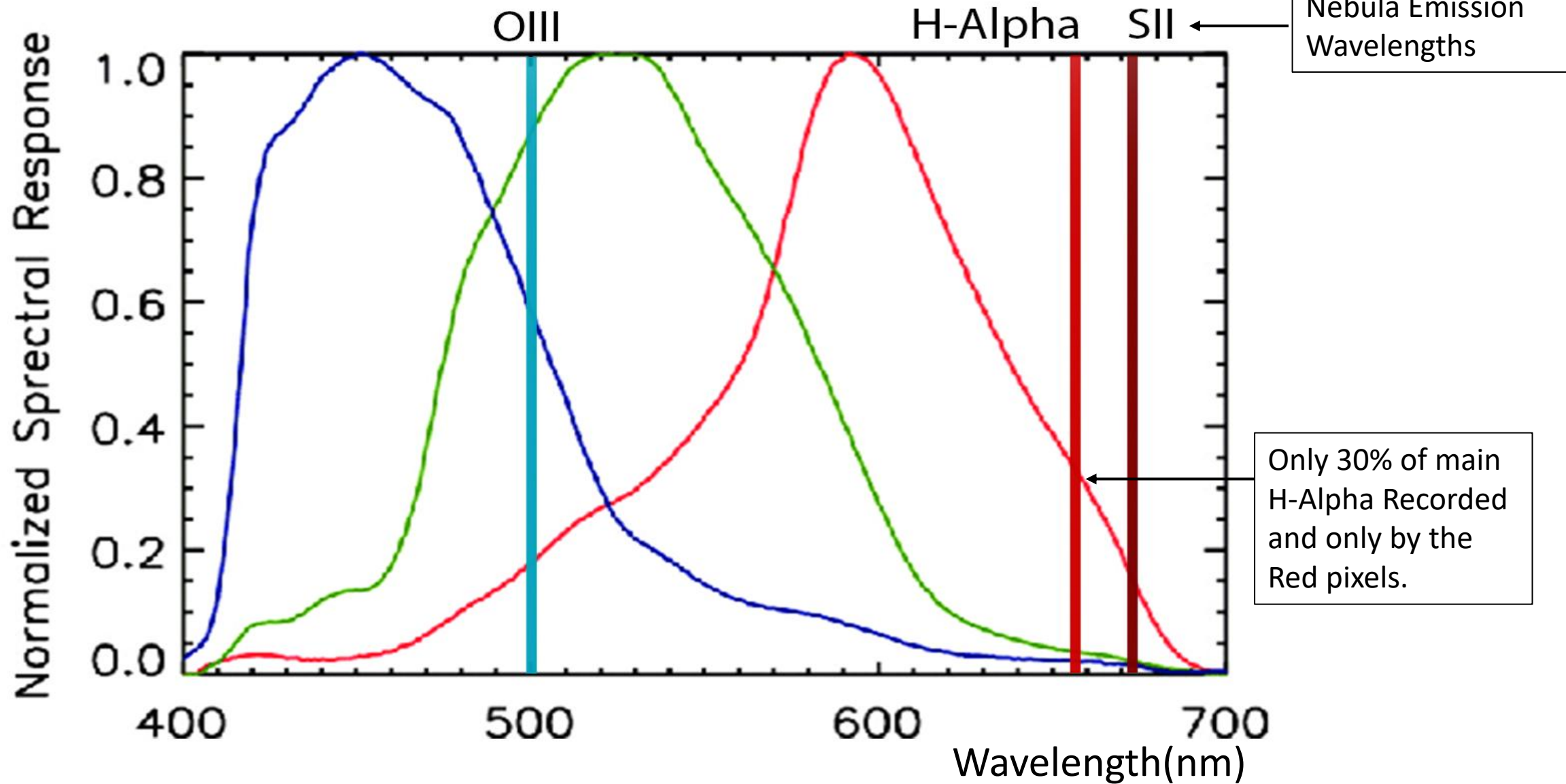
Stretch Histogram



DSLR Limitations

← UV Cut Filter

IR Cut Filter →



My Home Astro Rig

- HEQ5 GoTo Equatorial Mount
- 432mm/F6 Telescope
- Mono Cooled Astro Camera → -20°C
- Filter Wheel for Colour (RGB) and 'Narrow-Band' Filters for nebula (Hydrogen, Oxygen, Sulphur)
- Guide Scope → Locks onto a star for Guiding
- Electronic Focuser
- Power Box distributes power to equipment and dew bands
- USB hub
- Mini PC for automated operation

Guiding Accuracy < 1 Arc Second

→ Equivalent to 5p piece at 2 miles!



Night hides the world but reveals the universe.

Wishing you clear skies!
Thank-You for your attention