

Imaging with *SPIRIT*- Choosing celestial objects to view

Celestial motion, target planning and timing

There are a number of factors that affect successful target planning and imaging with *SPIRIT*. An understanding of *SPIRIT*'s location in Perth and the apparent motion of astronomical objects across the sky as seen from this location is important.

The Earth completes one rotation on its axis every 24 hours. It rotates from west to east and as a consequence, astronomical objects appear to *rise* in the east and move westwards across the night sky.

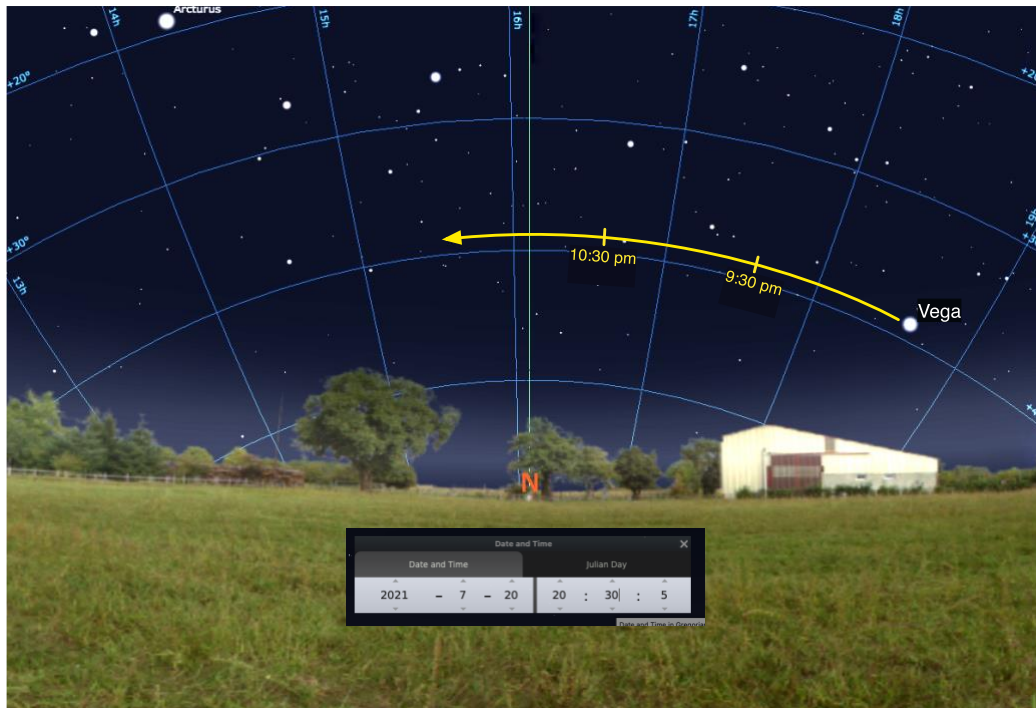


Figure 1: Star trails show the apparent motion of astronomical objects across the sky caused by the Earth's rotation.
(Image credit: Gemini Observatory/AURA)

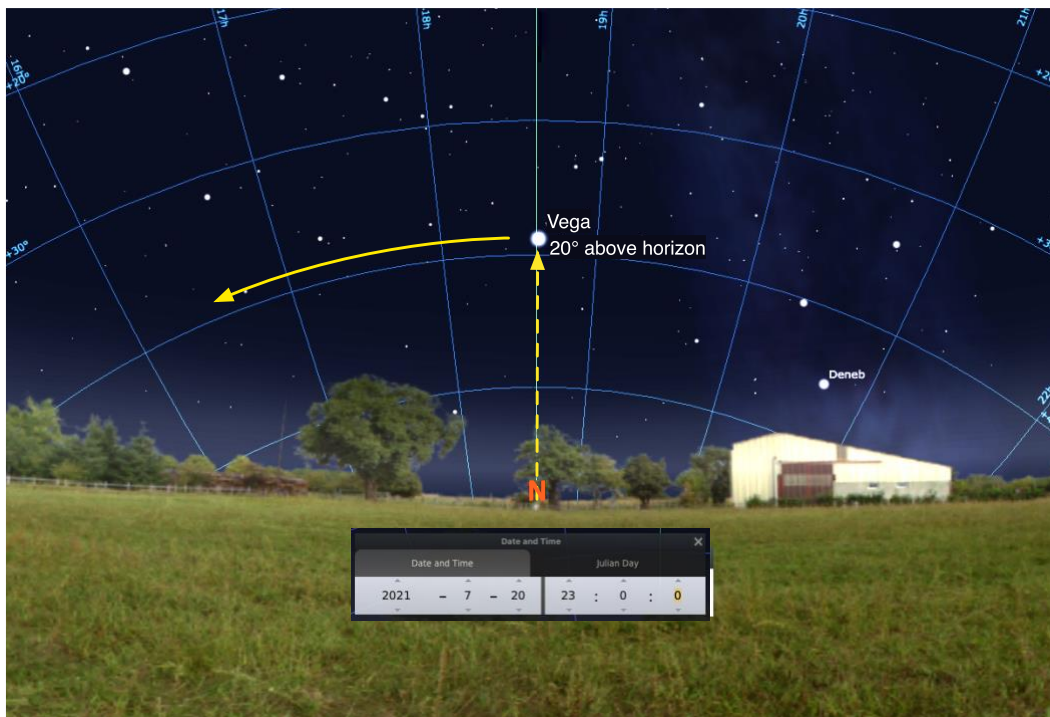
However, Perth's location 31° south of the equator means astronomical objects do not move uniformly across the sky from east to west.

Looking due north, objects appear to move from east to west across an arc in the sky. Objects in the far northern sky may be visible for a few hours only each night, and most don't reach a sufficiently high enough altitude for imaging with *SPIRIT*. The pictures on the following page illustrate movement of objects in the northern sky:

At 8:30pm on July 20, the star Vega is low in the north eastern sky. Over the next two hours, Vega will rise and move westwards across the sky following an arc on the celestial sphere.



At 11pm, Vega crosses the meridian—the highest point it reaches in the sky. At only 20° above the horizon, objects in this part of the northern sky are not suitable targets for *SPIRIT*.



From this point onwards, Vega's altitude above the horizon will decrease until it sets in the north western sky and disappears entirely.

Some northern objects—such as those routinely observed by north American astronomers—are never visible from Perth. They are *below* our northern horizon limit. Furthermore, obstacles such as buildings and trees, together with atmospheric and light pollution dictate a *practical minimum observing altitude* of approximately 35° above the horizon.

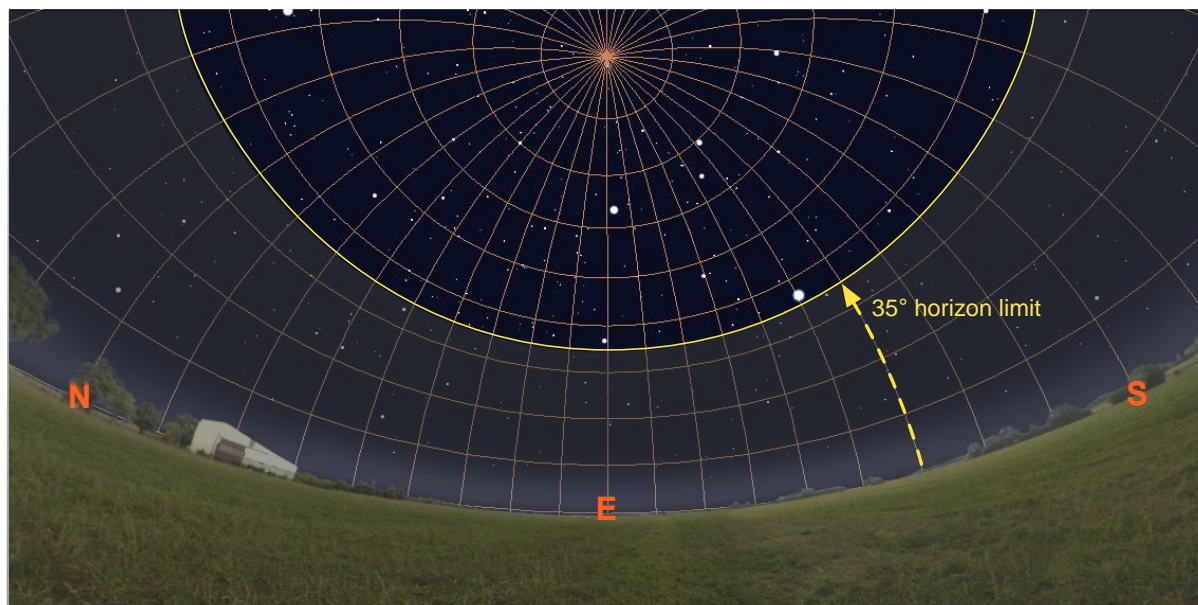


Figure 2: The suggested minimum observing limit for *SPIRIT* is 35° above the horizon.

Pay careful attention to the published declination when choosing a target for *SPIRIT*. It is best to avoid objects with northern declinations of +22° and greater. These objects never rise much higher than 35° above the horizon and can only be imaged when they are near the meridian.



Figure 3: The Dumbbell nebula (M27) is found in the northern sky. It is a 'borderline' choice of target for *SPIRIT* as it never rises much higher than 35° above the horizon.

The location of *SPIRIT* in Perth makes it best for observing southern hemisphere astronomical objects (those with southern declinations). Fortunately, most of the really impressive astronomical objects are located in the southern hemisphere!

Looking due south, objects appear to revolve around a point in the sky known as the *south celestial pole*. Objects close to the pole are referred to as *circumpolar* objects—objects that never set, continually revolving around the south celestial pole in the opposite direction to the Earth's rotation.

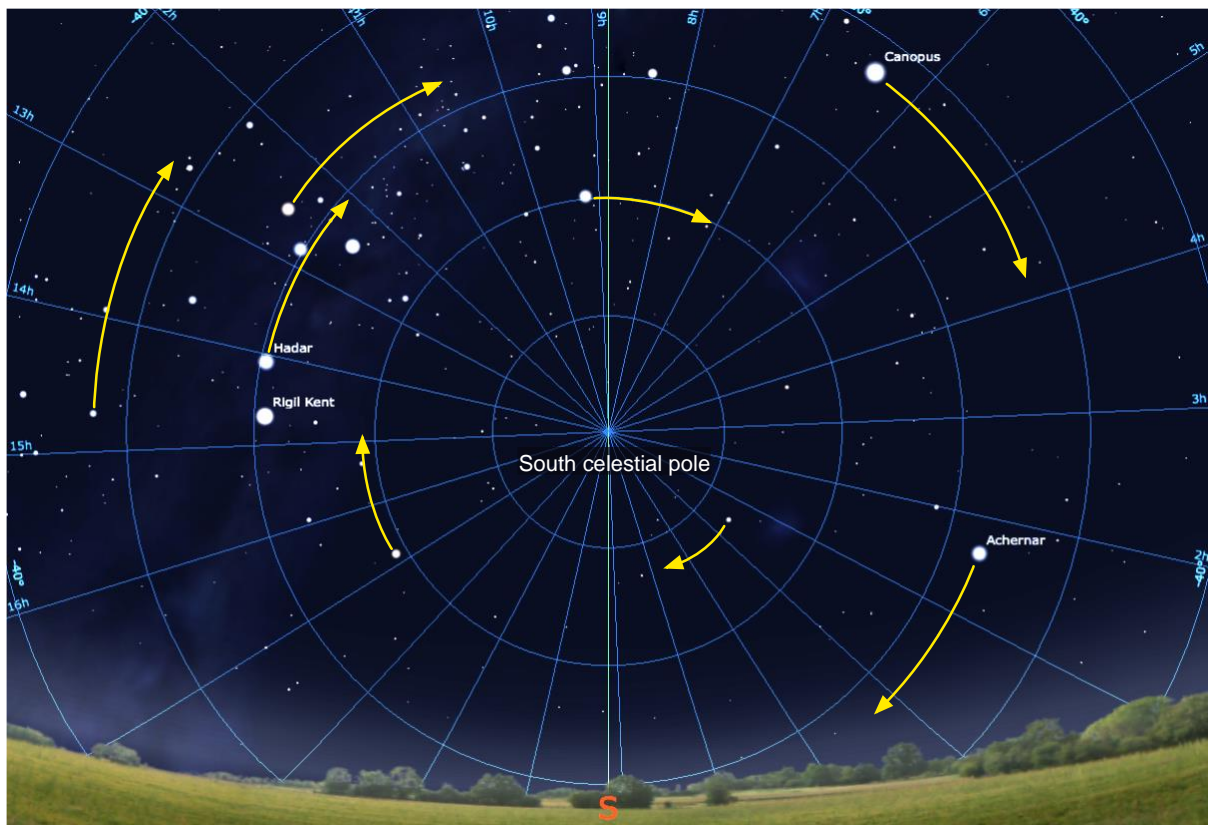
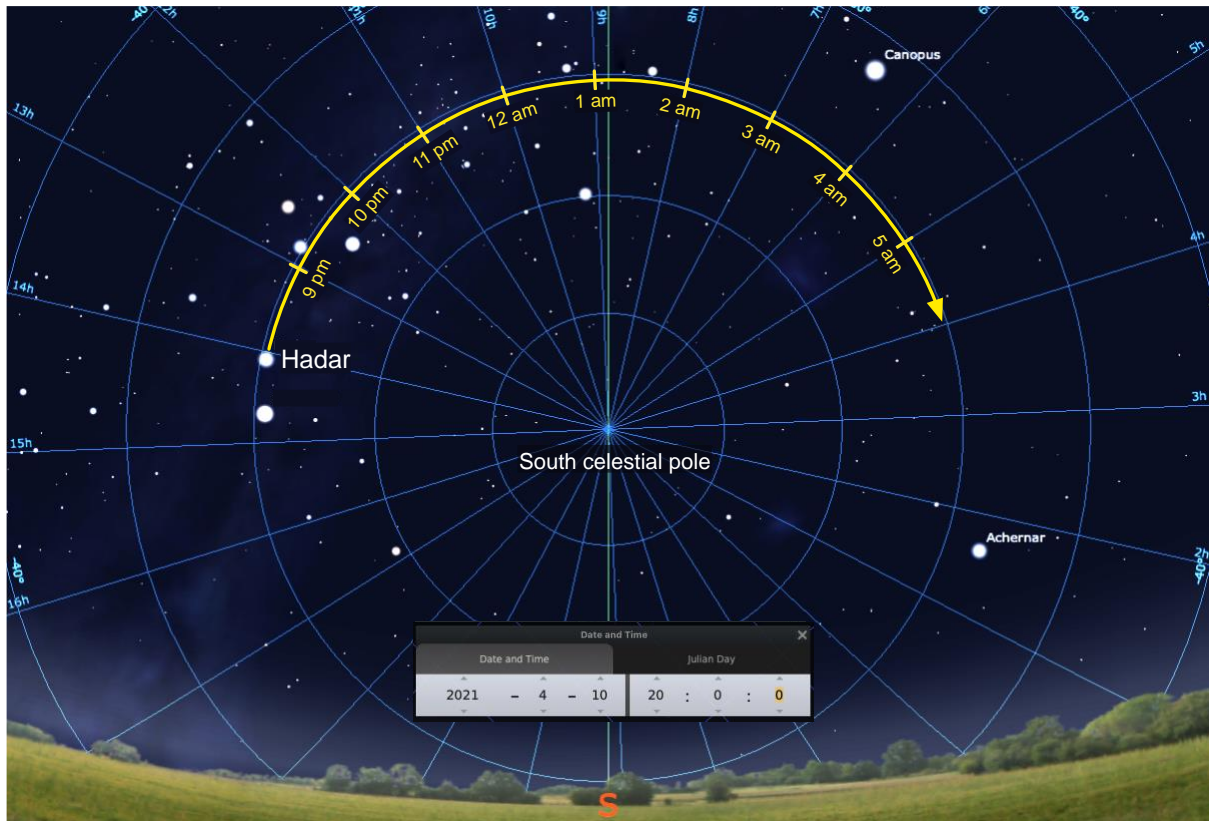


Figure 4: The southern sky as viewed from the location of *SPIRIT*.

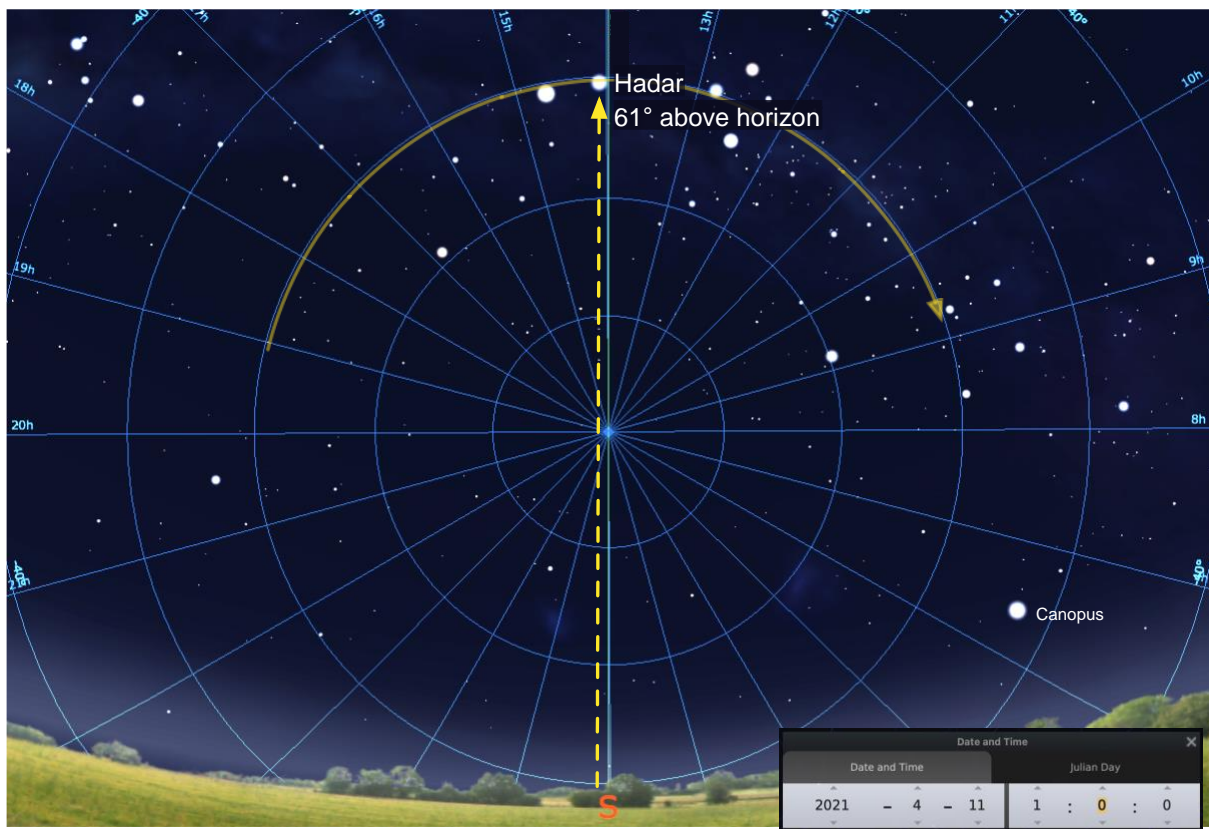
Compare the visibility of stars in the south, with stars in the north. Objects in the southern sky are visible for much longer periods during the night and, in general, provide better targeting opportunities for *SPIRIT*.

The pictures on the following page illustrate movement of objects in the southern sky.

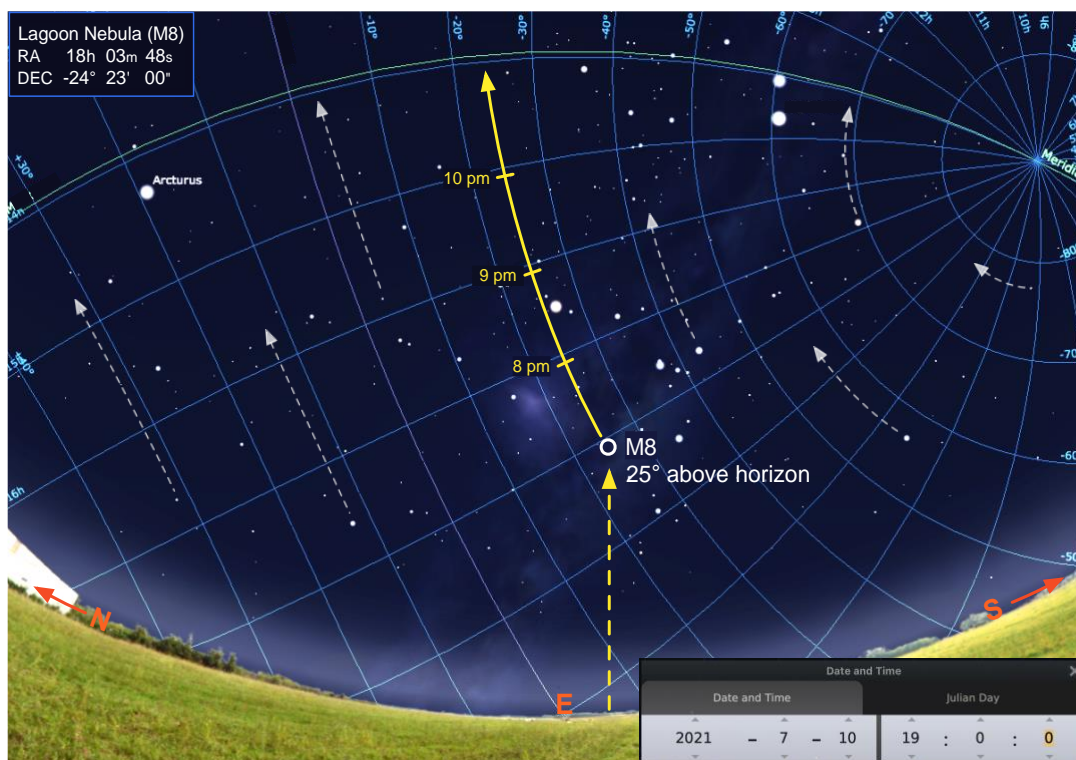


On April 10, the star Hadar is visible above an altitude of 35° from about 8 pm until dawn.

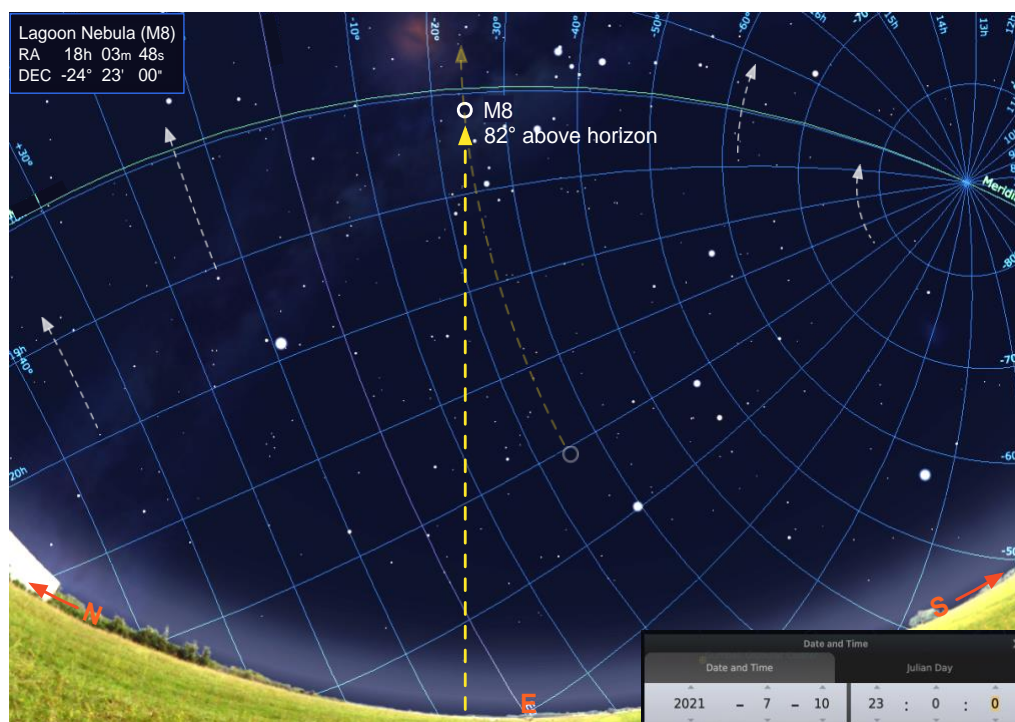
It reaches a maximum altitude of 61° above the horizon at about 1am.



Objects with southern declinations make the best targets for *SPIRIT*. A target with a declination of -31° will pass directly overhead, i.e. it will reach an altitude approaching 90° .



At 7pm on July 10, the Lagoon Nebula (M8) is about 25° above the eastern horizon. It rises to an altitude of 82° , virtually overhead, as it approaches the meridian 4 hours later at 11pm—a great time for imaging M8 on that night.



Astronomical objects with declinations between +10° and -70° will rise to altitudes greater than 50° above the horizon. These present excellent targets for imaging with *SPIRIT*, particularly as they approach the meridian. It's no accident that the “*SPIRIT* Top Twenty” (<http://spirit.icrar.org/2014/05/01/imaging-challenge-the-spirit-top-20/>) comprise objects that fall within this range of declination.



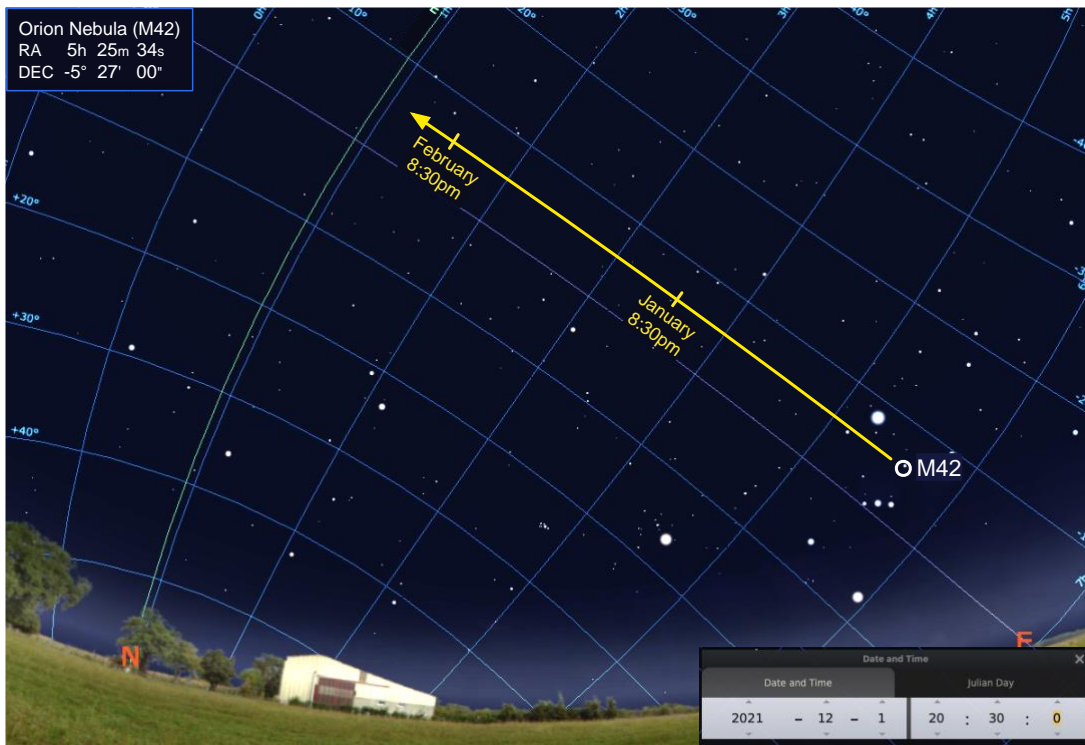
Figure 5: A sample 8 objects from the ‘*SPIRIT* top 20’.
They all sit within the range declination most suitable for targeting with *SPIRIT*.

Choosing the best time to image targets

Together with rotating on its axis, the Earth also orbits the sun. It moves $\frac{1}{365}$ th of its orbit around the sun each day. As a consequence, astronomical objects appear slightly displaced from their previous position at the same time the night before. In practical terms, the stars appear to ‘rise’ approximately 4 minutes earlier each night. Over the course of several weeks, a target of interest will continue to rise, appearing higher in the sky at the same time each night. As the weeks continue, the target will move westwards, eventually overtaking and setting before the sun. In essence, the orbit of the Earth around the sun accounts for the changing constellations over the course of a year.

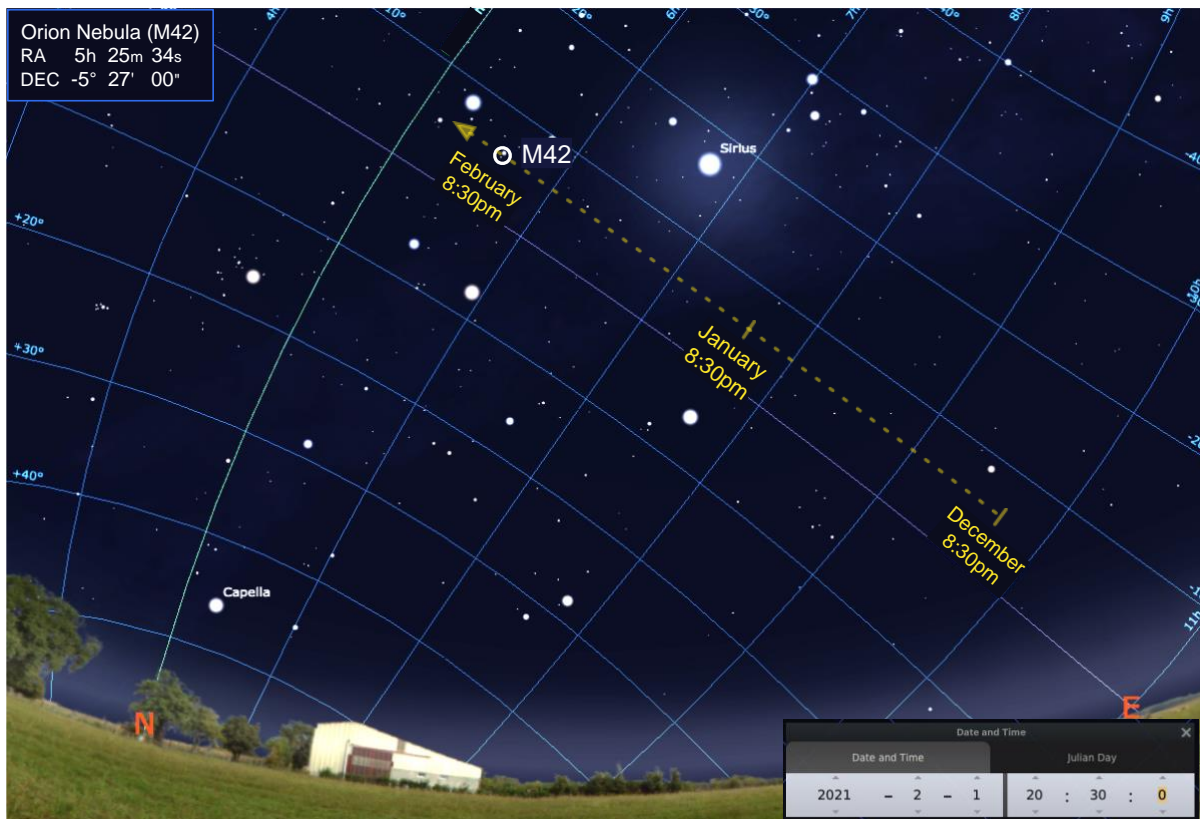
The pictures on the following two pages illustrate the change in position of a target at the same time each evening over the course of 4 months.

At 8:30pm on December 1, the Orion Nebula (M42) is only 20° above the eastern horizon. It

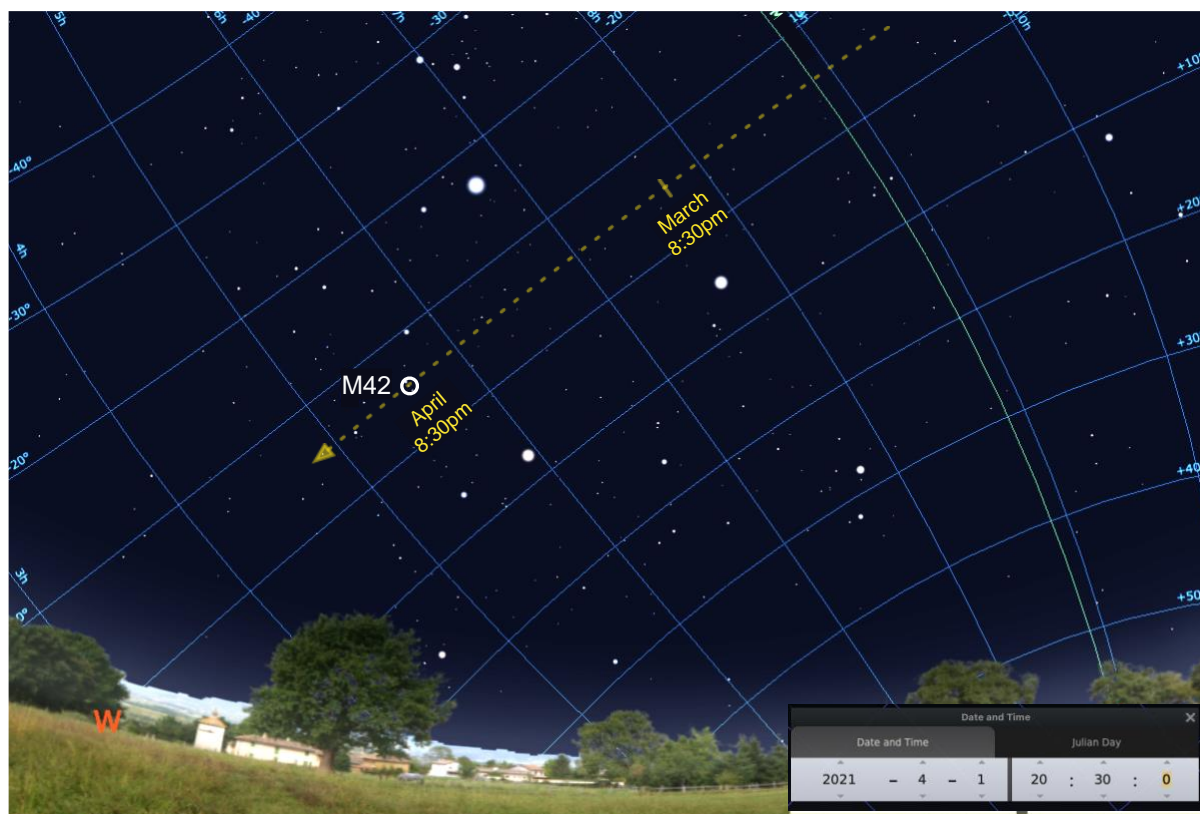


will rise steadily over the summer months, appearing slightly higher in the sky each evening.

At 8:30pm on February 1, M42 is now 62° above the horizon and in a much better position for imaging with *SPIRIT* early in the evening.



By Autumn, M42 has passed the meridian and is in the western sky at sunset. At 8:30pm on



April 1 it is only 37° above the western horizon and no longer a viable target for *SPIRIT*.

An important factor that can affect target planning is the location of *SPIRIT* with respect to the city of Perth. Located close to the central business district, the skies above UWA are worst in the east. The glow of city lights together with atmospheric pollution can make imaging of faint objects below an altitude of 40° difficult. High quality imaging should only be undertaken when targets have risen higher, or appear in the western sky. In addition, local ambient light pollution reduces later in the evening and after midnight, creating more favourable conditions for imaging faint targets.

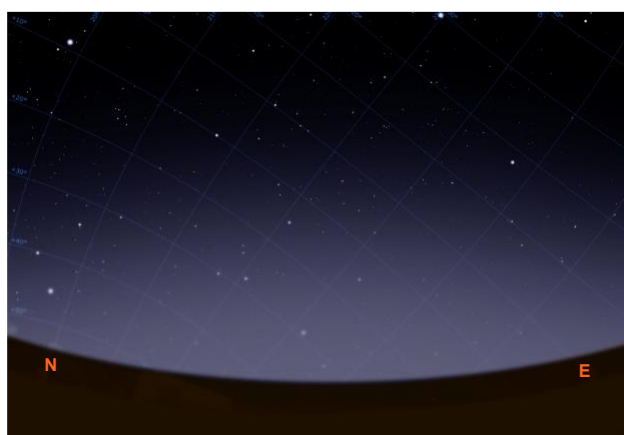


Figure 6: Light

Summary

On any given night, the best time to image faint objects is when they are highest in the sky. This is because light from the object travels through less atmosphere, providing a clear image with improved resolution. The location of *SPIRIT* close to the city of Perth also affects image quality, particularly objects located in the eastern sky.

For long exposure astrophotography, e.g. where 2 hours or more might be needed to gather sufficient data to create a detailed colour image, it is common to select targets that sit within a range of 1 to 2 hours from the meridian.

This is illustrated in planetarium programs such as *Stellarium* by viewing the overhead sky and examining an area near the meridian bounded by the suggested declination limits for *SPIRIT*.

The picture below shows an area of sky 2 hours either side of the meridian, bounded by $+10^\circ$ to -70° declination. As a general rule, targets located within this area are well positioned for high quality imaging.

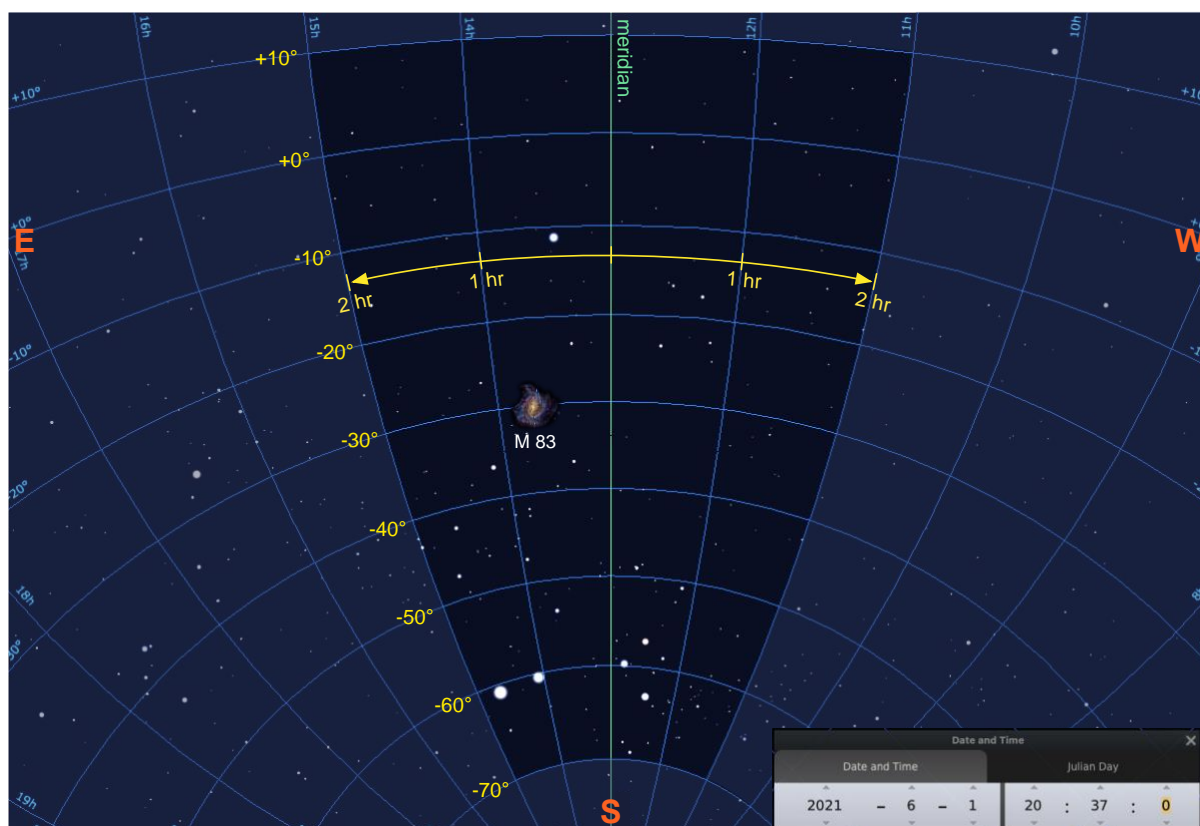


Figure 7: The spiral galaxy M83 is perfectly positioned for imaging by *SPIRIT* on June 1 at 8:37pm in the evening.

Glossary

Altitude (Alt)

How 'high' an astronomical object is above the horizon. There are 90 degrees between the horizon and the point directly over head (the zenith).

Azimuth (Az)

The bearing of an object with respect to the cardinal points on a compass. Due north is 0°, east is 90°, south is 180° and west is 270°.

Celestial Coordinates

The position of objects on the celestial sphere as points represented by right ascension and declination. Celestial coordinates are analogous to longitude and latitude on Earth.

Celestial equator

An imaginary line projected on the celestial sphere. It corresponds with the Earth's equator joining due east with due west at 0° declination.

Celestial sphere

An imaginary sphere upon which all astronomical objects are positioned and rotate with respect to the Earth. It is usually marked by lines of celestial longitude (right ascension) and celestial latitude (declination).

Circumpolar objects

Astronomical objects that appear to rotate around the celestial pole and never set, as viewed from a particular location.

Declination (DEC)

The coordinate that specifies the celestial latitude (north/south) of an astronomical object. Declination ranges from +90° in the north to -90° in the south.

Horizon

The imaginary line positioned horizontally at 0° altitude.

Horizon limit

A practical lower observing limit defined by horizon obstacles, physical telescope constraints or sky conditions and typically within 20° to 35° above the horizon.

Hour angle (HA)

The angular distance east or west of the meridian expressed in hours of right ascension.

Local sidereal time (LST)

The line of right ascension directly overhead at any particular time.

Meridian

An imaginary line connecting due north with due south and passing directly overhead. The meridian effectively divides the sky into east and west.

Right Ascension (RA)

The coordinate that specifies the celestial longitude (east/west) of an astronomical object. Right ascension is measured in increasing hours from west to east from 0hr to 24hr.

South celestial pole

The point in the sky upon which stars appear to 'rotate' around in the south. It is analogous to the north celestial pole for northern hemisphere observers.

Zenith

A point directly over head, 90° above the horizon.