



Sun and Moon movement

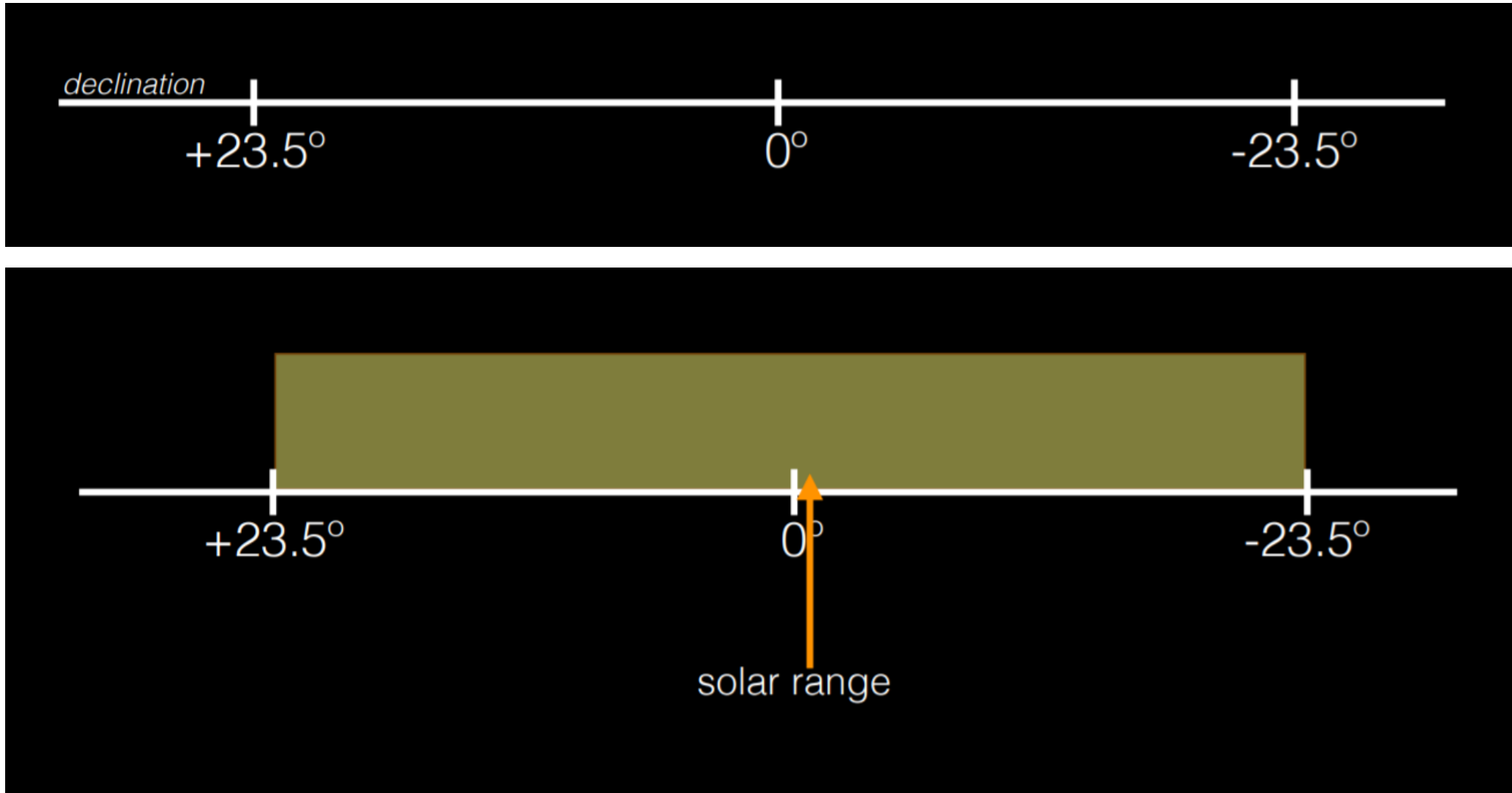
Week 2 – Sacred Skies

Bernadette Brady

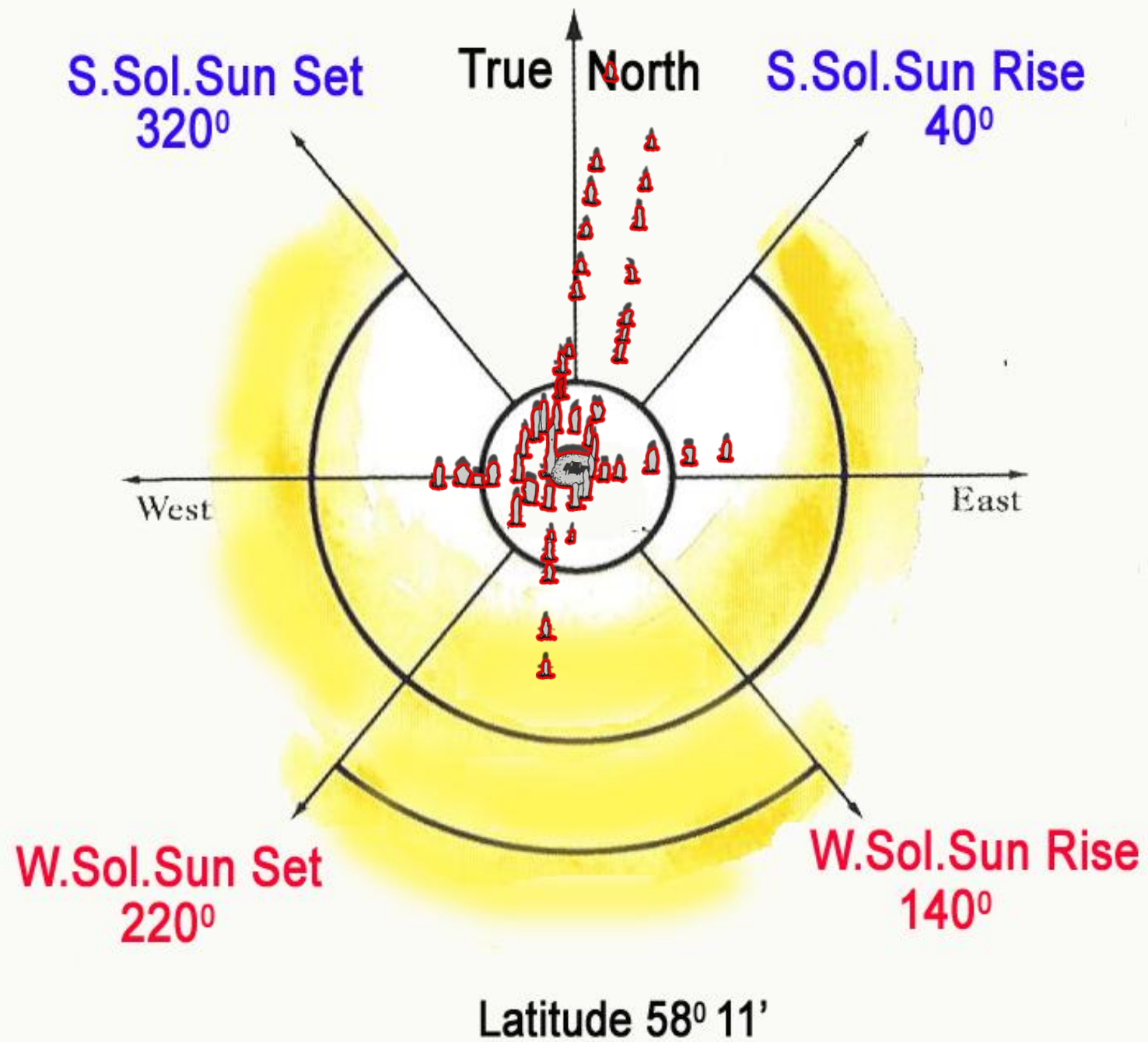
University of Wales Trinity Saint David

The solar range of an orientation

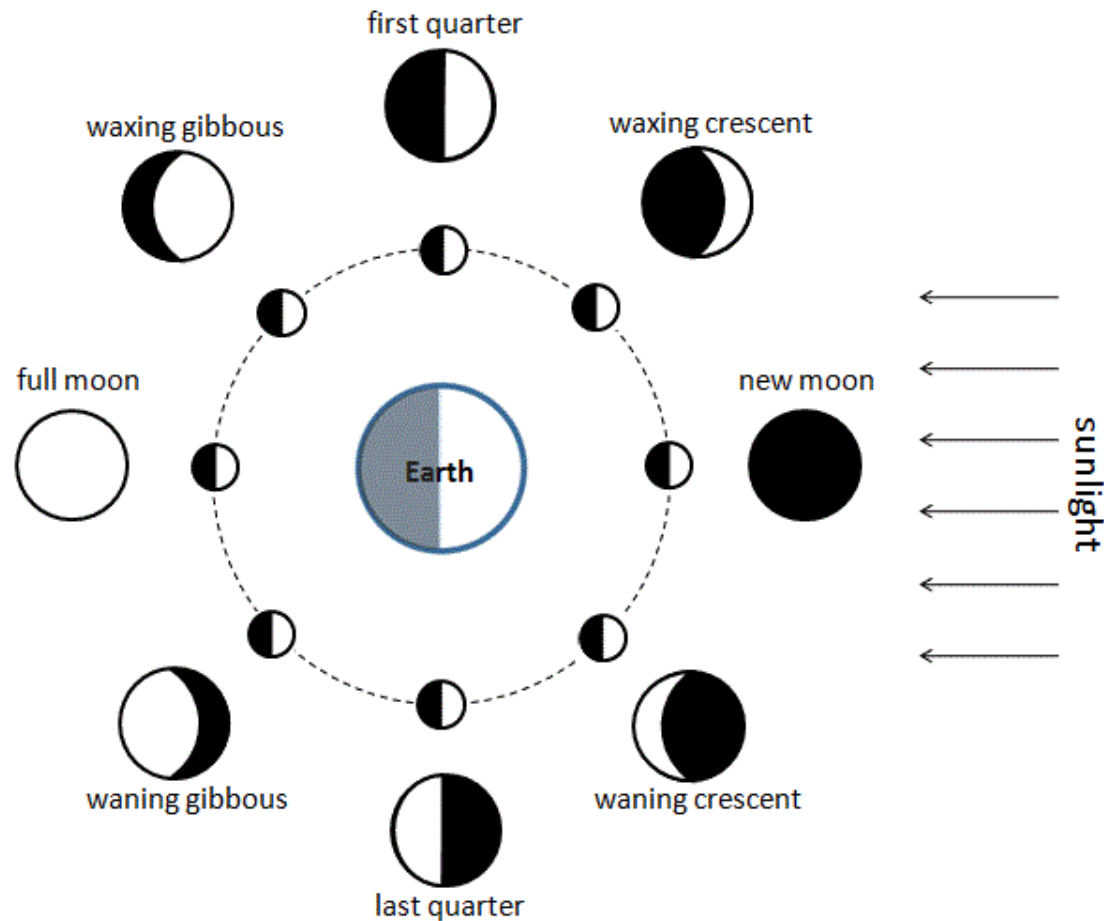
Images: Fabio Silva







The Phases of the Moon



The Moon takes 27.3 days to orbit the Sun but the lunar phase cycle – because the sun moves in that 27 days – takes an average of 29.53 days.

This phase cycle does vary in length by a few hours, due to the moon's orbit elliptical shape.

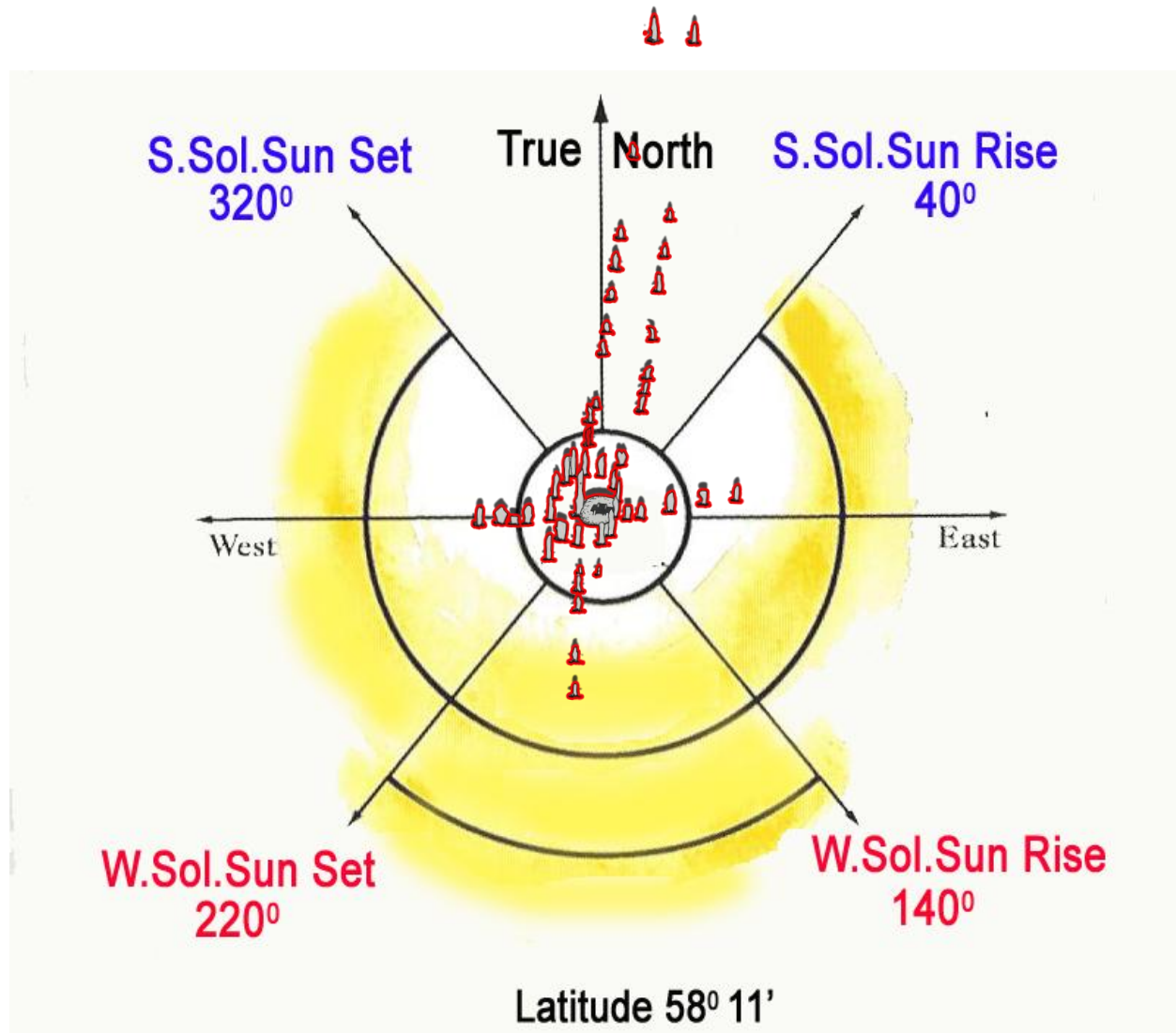
The Moon is **WAXING** when it is moving from New to Full and **Waning** when Full to New.



The Lunar Calendar

Easier to use, followed the same path as the sun but did so every month.

Full Moon rise
54N. 2013,
(top) January,
(middle)
March and
(bottom) May



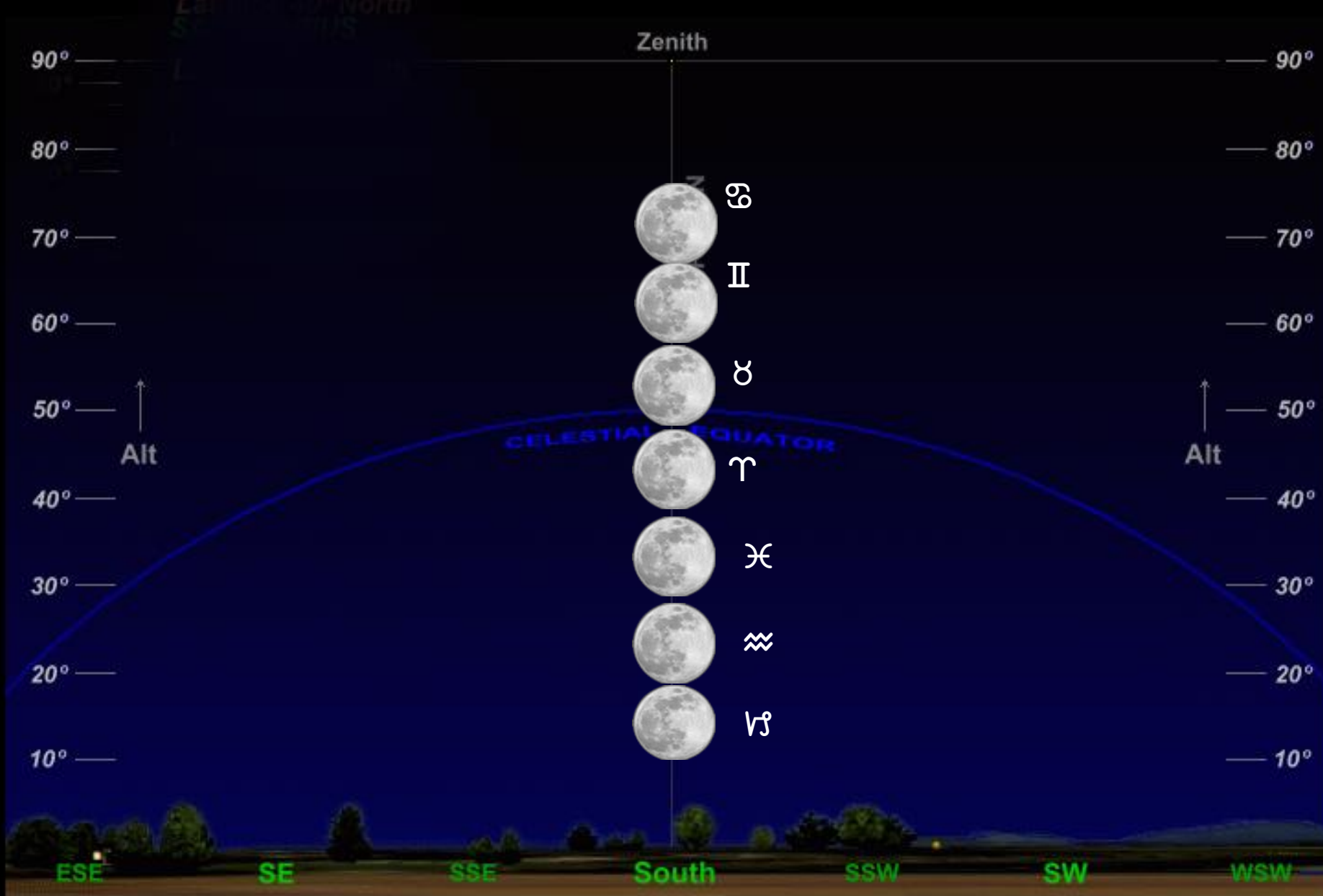
The sun takes a year to move from Summer Solstice to Winter Solstice and back again.

The Moon will do this journey of rising or setting on the horizon in ONE lunar month.



The Lunar month is based on the lunar phase and is close to $29 \frac{1}{2}$ days in length and will sweep along the horizon back and froth between the solstice points.

Its phase as it rises or sets will vary.



The Full Moon will change in height each month, also reflects the Sun's change of height during the years.

When the Full Moon was high the Sun was dark and low and vice-versa

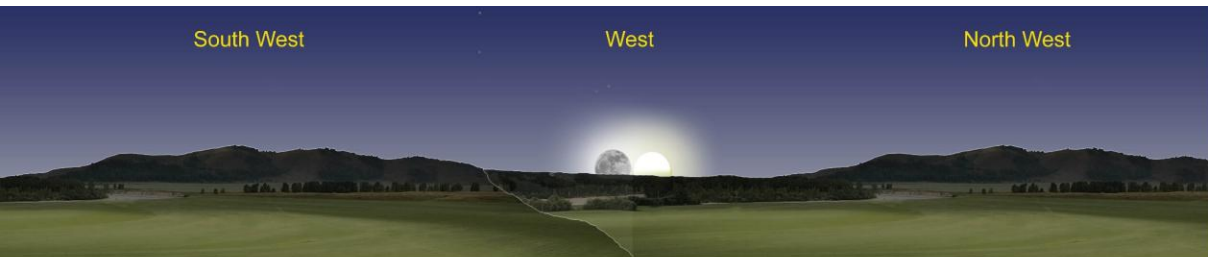
Thus the two heavenly Lights were balanced and equal.

North East

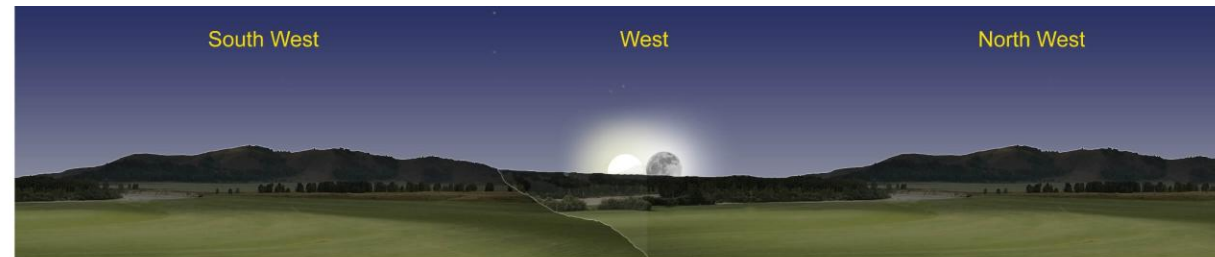
East

South East

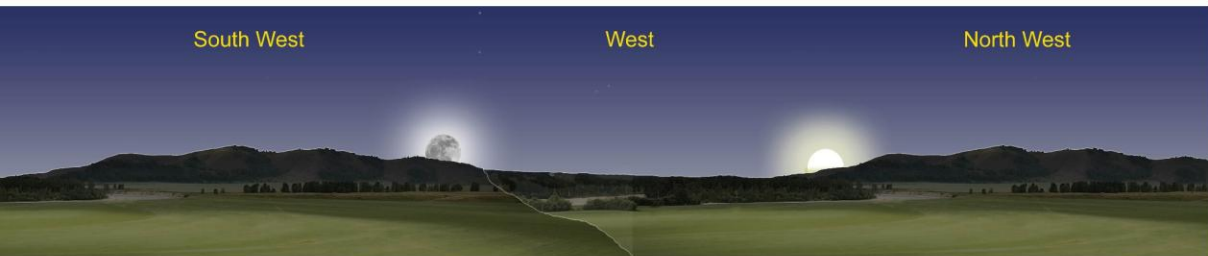




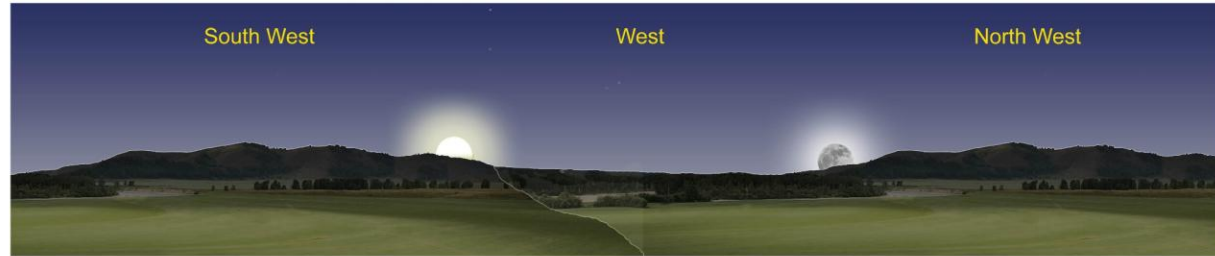
Equinox (March)
Full Moon Set Sunset



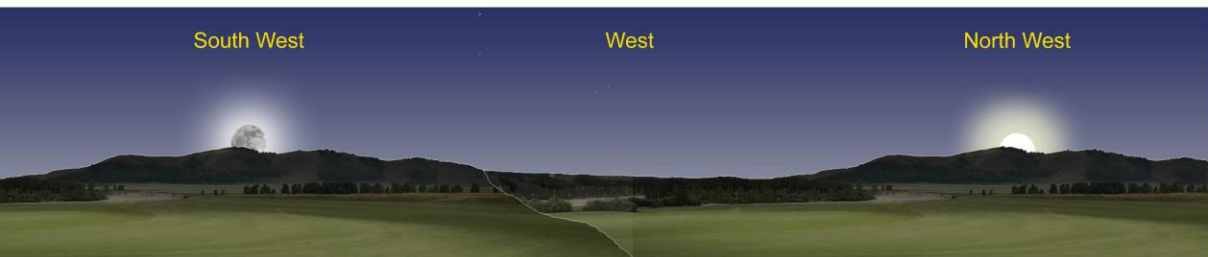
Equinox (September)
Full Moon Set Sunset



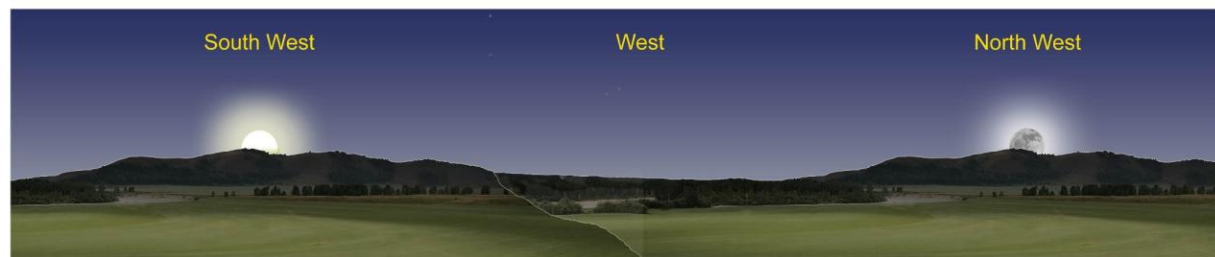
Cross Quarter (May)
Full Moon Set Sunset



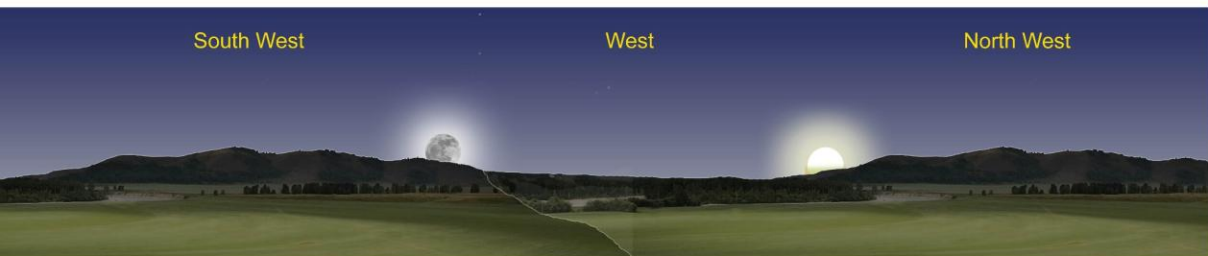
Cross Quarter (Oct/Nov)
Sunset Full Moon Set



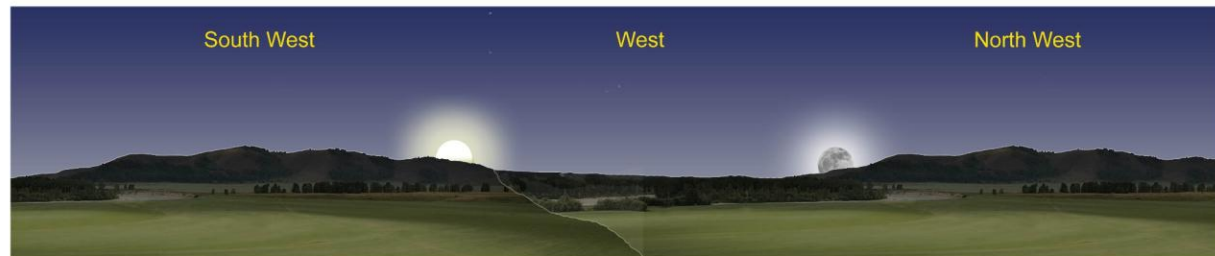
Summer Solstice
Full Moon Set Summer Solstice (June)
Sunset



Winter Solstice
Sunset Winter Solstice
Full Moon Set



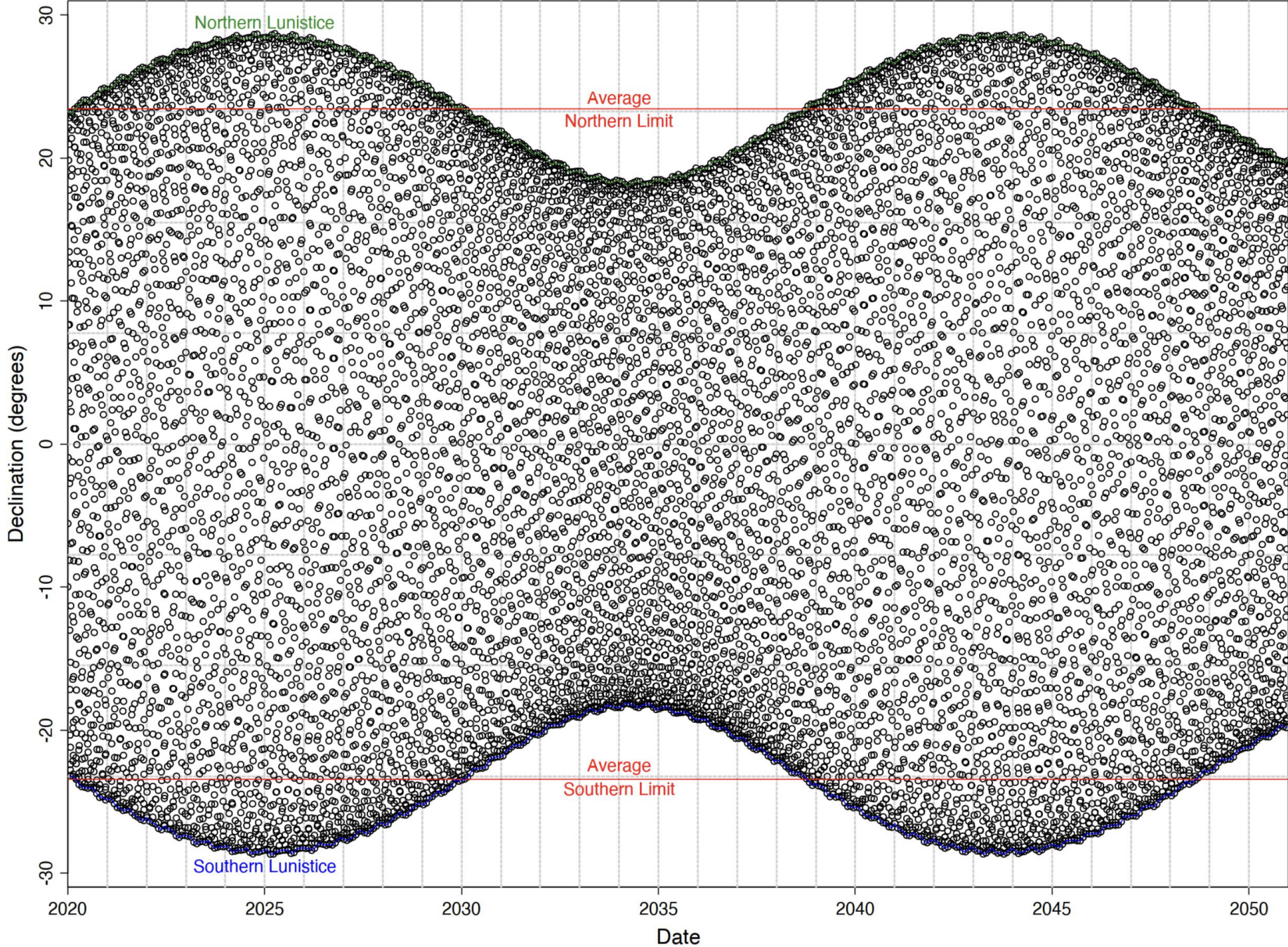
Cross Quarter
Full Moon Set Cross Quarter (August)
Sunset



Cross Quarter (February)
Sunset Cross Quarter (February)
Full Moon Set

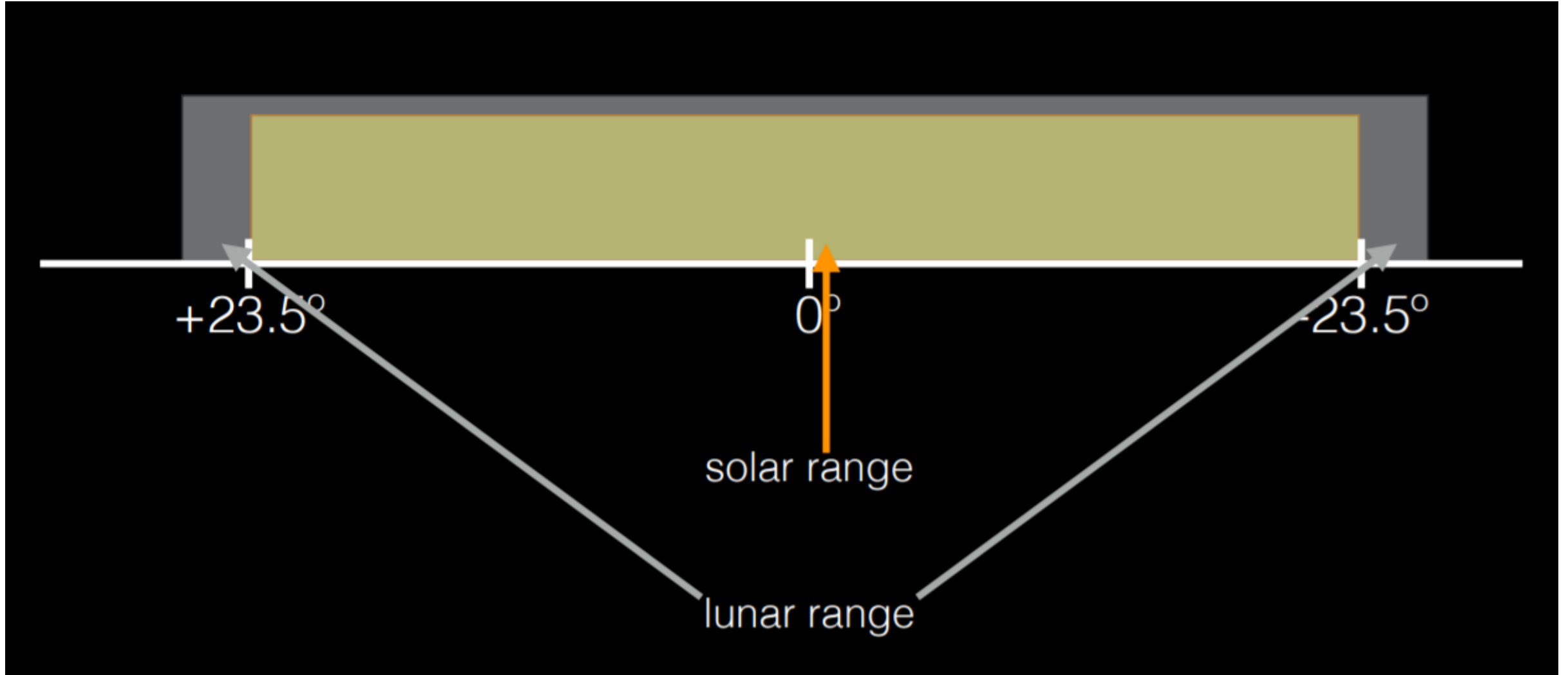
Daily Position of the Moon Relative to Center of the Earth at 0h UT

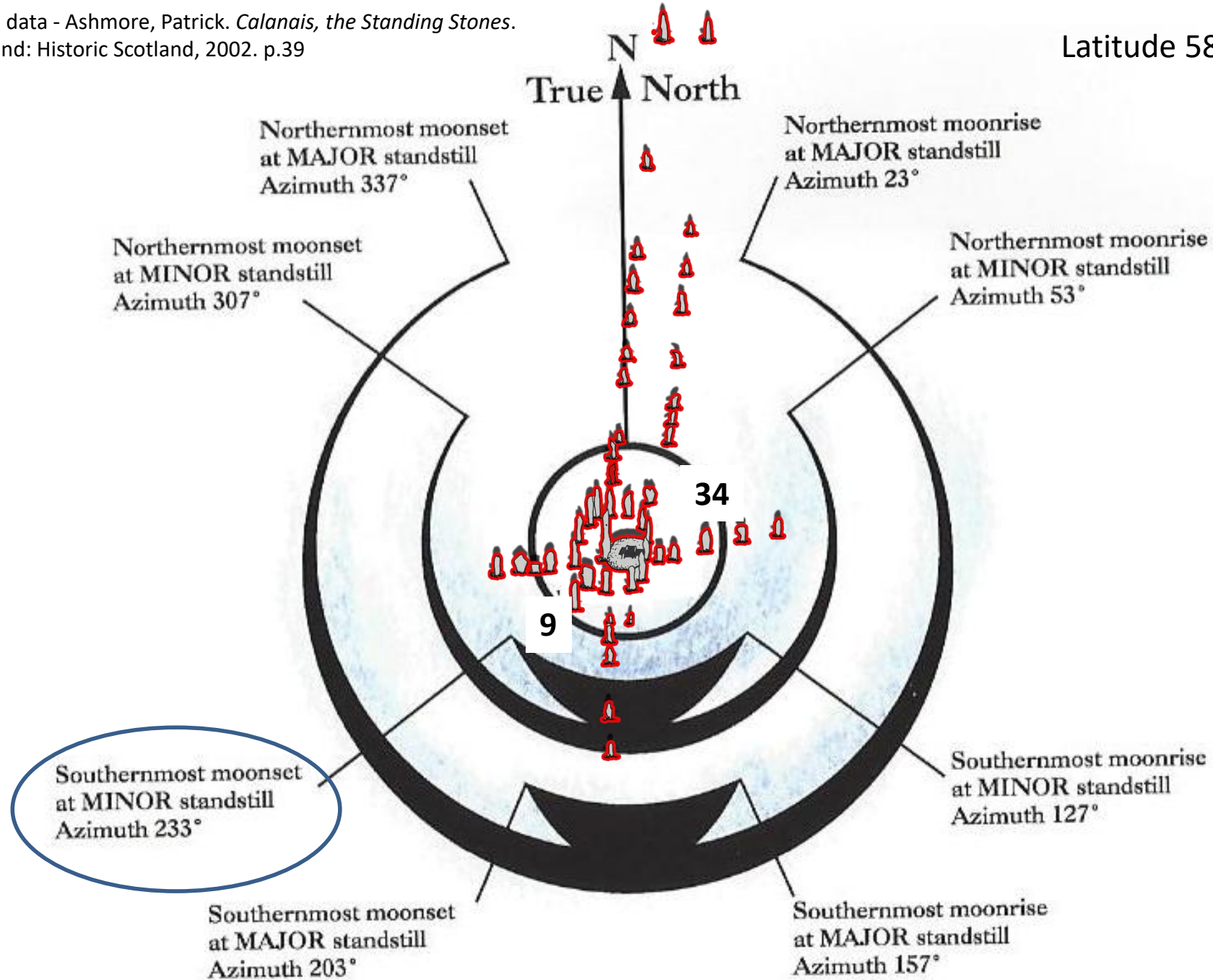
Rice University



Expand this range a little to consider the possible major lunar standstills

Images: Fabio Silva







Using the
moon as a
calendar

The Lunar Calendar



Different ways of beginning a lunar month. The dominant method which Islam adopts is the first day of the month being counted from the first appearance of the **crescent moon** in the **west at sunset**.

Sunset and the **first visible crescent** of the new moon.

Note for the northern hemisphere the horns of the crescent moon point south -you are looking west in this picture – and they are not forming the letter ‘C’.

This is the beginning of the Islamic lunar month.

The Ancient Egyptian Lunar Month



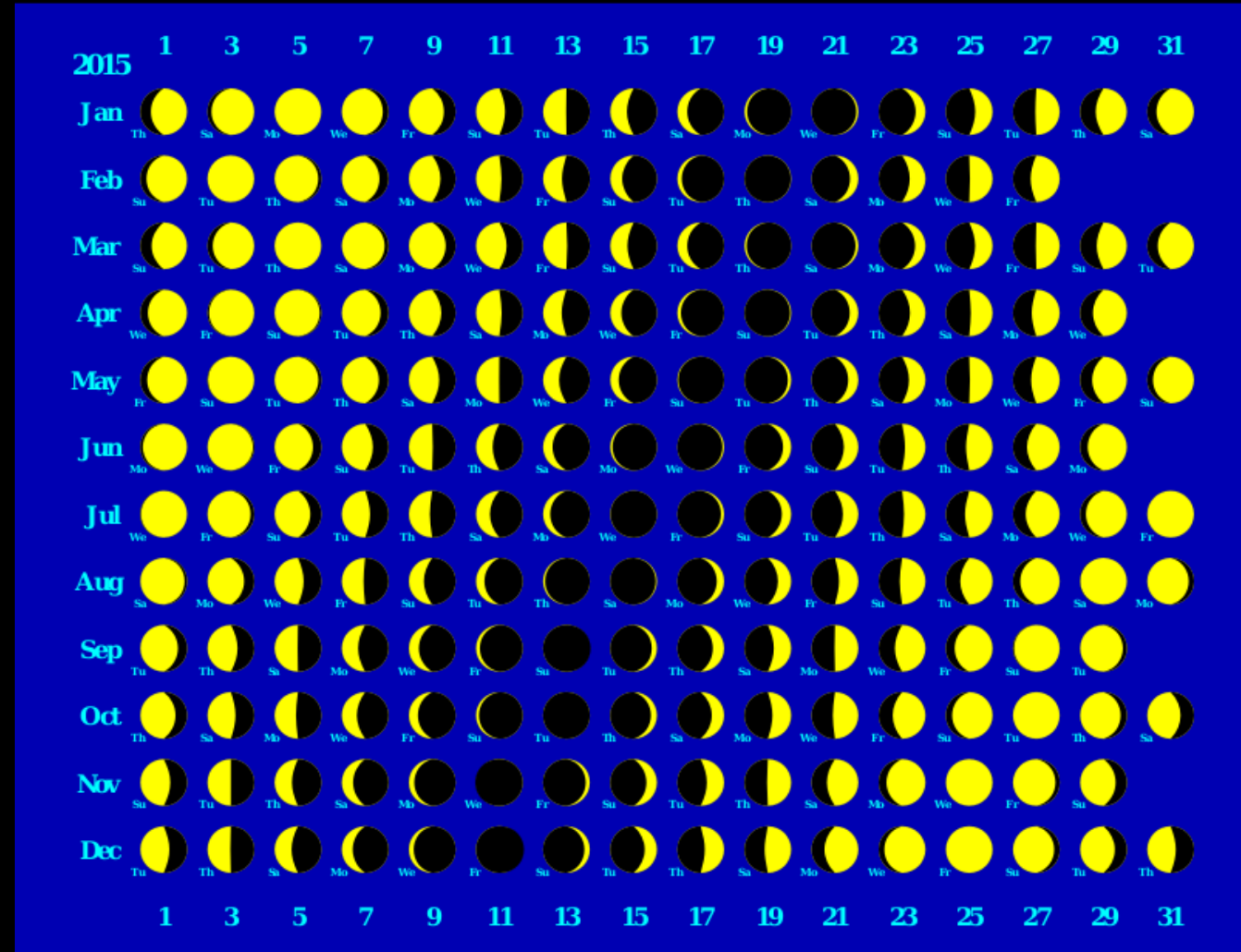
Sunrise, last visibility of the **balsamic moon** – the next day at sunrise you will not see the moon. That is the first day of the Egyptian lunar month.

Note, for the northern hemisphere, the horns of the **balsamic moon** are a 'C'.

You are looking east in this picture, thus the horns of the moon are still pointing south.

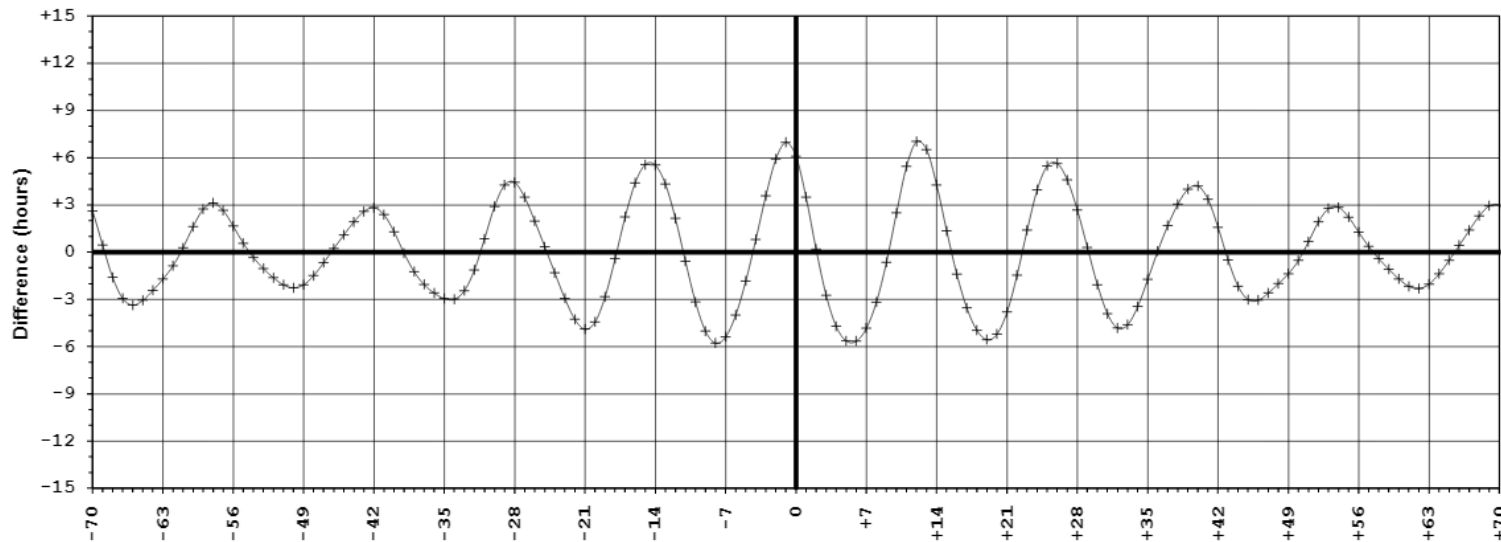
The Lunar Calendar and the seasons

The lunar year, twelve new moons, is on average 11 days short of the solar year of $365 \frac{1}{4}$ days. This means that every second to third year a thirteenth month needed to be included in the calendar otherwise the seasons would drift through the year. However, this method over five years, produces an excess of 7-8 days.



SOLEX Lunar Cycle Duration minus Mean Synodic Month (atomic time)
by Lunation Number relative to Zero = January 6, 2000 AD at 14:20:44 TT

Short-term periodic variability repeats at intervals of about 412 days (almost 14 lunar months), due to lunar orbital perigee advance.
The maximum positive peaks occur when Earth is near perihelion (moving fastest) and Moon is near apogee (moving slowest).
The maximum negative peaks occur when Earth is near aphelion (moving slowest) and Moon is near perigee (moving fastest).



The length of a lunar phase cycle

The longest waxing or waning cycle is 15 days 14 hours 30 minutes, the shortest is 13 days 22 hours and 30 minutes.

Hence the length of a lunar phase does vary by around 13.5 hours from one cycle to the next.

Graph from: <http://individual.utoronto.ca/kalendis/lunar/#trend>

Description	Assumed Lunar Cycle Length (exact days)	Decimal Month (days) overscored groups repeat	Time in excess of 29 days
Orthodox Easter <i>computus</i>	$(365+\frac{1}{4}) \times \frac{19}{235} = 29+\frac{499}{940}$	≈ 29.530851	12:44:25+ $\frac{25}{47}$ s
Hebrew calendar molad	$29+\frac{12}{24}+\frac{44}{1440}+\frac{1}{25920} = 29+\frac{13753}{25920}$	29.530594135802469...	12:44:03+ $\frac{1}{3}$ s
Yerm Lunar calendar	$\frac{25101}{850} = 29+\frac{451}{850}$	29.530588235294117647...	12:44:02+ $\frac{14}{17}$ s
Hindu <i>Surya</i> calendar (modern)	$29+\frac{7087771}{13358334}$	≈ 29.530587946	$\approx 12:44:02.8$
Mean Synodic Month (2000 AD, mean solar days)	$29+\frac{82517}{155520}$	≈ 29.53058770576	12:44:02+ $\frac{7}{9}$ s
Tibetan <i>Phugpa</i> calendar	$29+\frac{3001}{5656}$	29.530586987270155...	12:44:02+ $\frac{506}{707}$ s
Gregorian Easter <i>computus</i>	$\frac{2081882250}{70499183} = 29+\frac{37405943}{70499183}$	≈ 29.53058690056	$\approx 12:44:02.7$
Cycle of 49 yerms	$\frac{25101}{801} = 29+\frac{425}{801}$	29.530588235294117647...	12:44:02+ $\frac{62}{89}$ s
Cassidy-Dee Easter <i>computus</i>	$\frac{48091470}{1628531} = 29+\frac{864071}{1628531}$	≈ 29.530583083773	$\approx 12:44:02.4$
25 Saros cycle	$29+\frac{2958}{5575}$	$\approx 29.5305829596412556$	12:44:02+ $\frac{82}{223}$ s
Hindu <i>Arya</i> calendar (old)	$\frac{1577917500}{53433336} = 29+\frac{2362563}{4452778}$	≈ 29.53058180758	$\approx 12:44:02.3$
Fixed Islamic calendar	$\frac{(30 \times 6 \times 59 + 11)}{(30 \times 12)} = 29+\frac{191}{360}$	29.5305...	12:44:00

Different methods of trying to find a fixed method for the calculation for a FIXED lunar calendar.

Table from: <http://individual.utoronto.ca/kalendis/lunar/#trend>

Celtic struggle with the Lunar Calendar

The **Coligny Calendar** considered to be a Celtic (Druidic calendar) from the third century BCE. Reveals the astronomical challenge of correctly aligning the solar year with the lunar calendar.

This was essential as the correct full moon needed to fall in the correct season of the year.

Garrett Olmsted, *The Gaulish calendar : a reconstruction from the bronze fragments from Coligny with an analysis of its function as a highly accurate lunar/solar predictor as well as an explanation of its terminology and development*, (Bonn: Habelt, 1992), pp. 73-75.

Adolfo Zavaroni, *On the structure and terminology of the Gaulish calendar*, (Oxford: Archaeopress, 2007), p. 18., 89.

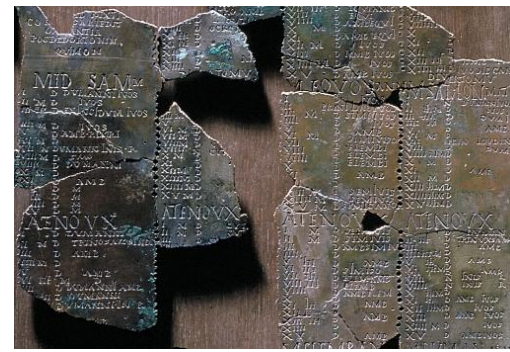


The Coligny Calendar is a Celtic calendar found in bronze fragments at Coligny, France in 1897.

The Coligny calendar is one of the earliest examples of the struggle to deal with the astronomical puzzle of aligning the lunar and solar cycles.

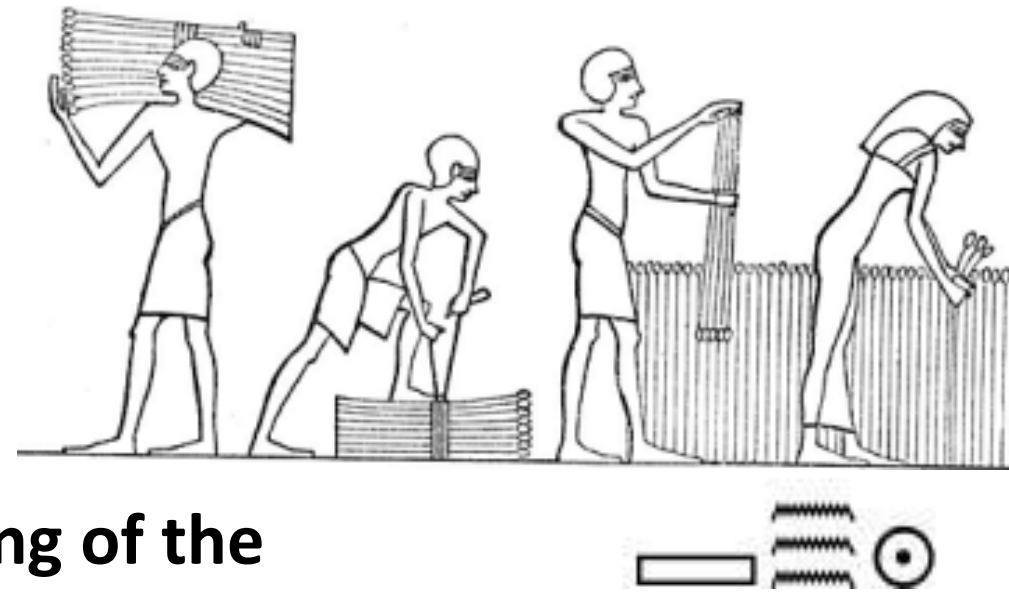
The process.....

- Adding a **leap month every third year** was not sufficient as the length of the lunar cycle cannot be evenly fitted into the length of a solar year.
- Using a **five solar year period is the best fit**, but this still gave a calendar that would be **seven to eight days** too long against the solar year. Hence leap days had to be removed!
- Added to this problem the moon does not move at a consistent rate and thus a five year block of lunar /solar years can be established by observation **but it cannot be tabulated**.
- The ONLY way to link the two calendars was by **direct observation of the sky**.
- This can be done in two ways. Link a particular part of the **lunar phase to a solar event** or to a **lunar event** or to a **solar/lunar/stellar event**.



Brady, Bernadette.
"The Afon Cynfael- a River's Part in the Cosmology of the Mabinogi." In Rivers, Mountains, Sky and Sea - the Materiality of Spirit and Place edited by Luci Attala, 117-30. Ceredigion, Wales: Sophia Centre Press, 2023.

The Ancient Egyptian Solution Lunistellar Calendar



Egyptians solved the problem by using **the rising of the bight star Sirius**. If Sirius rose in the last 11 days of the **fourth month of the third season** then an extra month was added to the year to ensure that Sirius, in the following year, did not rise out of its month.

This tied the lunar calendar to the seasons and ensured that the beginning of the new year was always linked to the heliacal rising of Sirius and thus also the inundation.



Depicting
the Lunar
Calander



Khnum Temple. Esna

Initial construction began under King Tuthmosis III of the 18th Dynasty (c. 1479–1425 BC).

The temple was expanded, decorated, and completed between 40 and 250 A.D. under Ptolemaic rulers and Roman emperors such as Claudius, Trajan, and Hadrian.



Lunar Cycles can be hard to recognise

The Lunar
Phases at Esna –
Temple of
Khnum -
Ptolemaic Egypt

New to Full
moon.





Thoth offering the full moon – the complete eye – to the setting sun

Dendera – the new moon at sunrise.
The moon being snatched from the waters of the Nile by Thoth in the 'covered basket'



Calendars – Lunar and Solar

Lunisolar calendars – where the lunar calendar is readjusted through adding intercalary months to the solar year with or without the removal of leap days.

Hebrew

Buddhist

Hindu

Burmese

Bengali

Tibetan

Traditional – Chinese

Japanese

Vietnamese

Mongolian

Korean

Hellenic

Coligny

Babylonian

The **Islamic calendar is lunar**, it is not a lunisolar calendar because its date is not related to the sun.

The **Egyptians used a lunar +stellar** calendar so sunrise on the horizon was not linked to a particular calendar date.