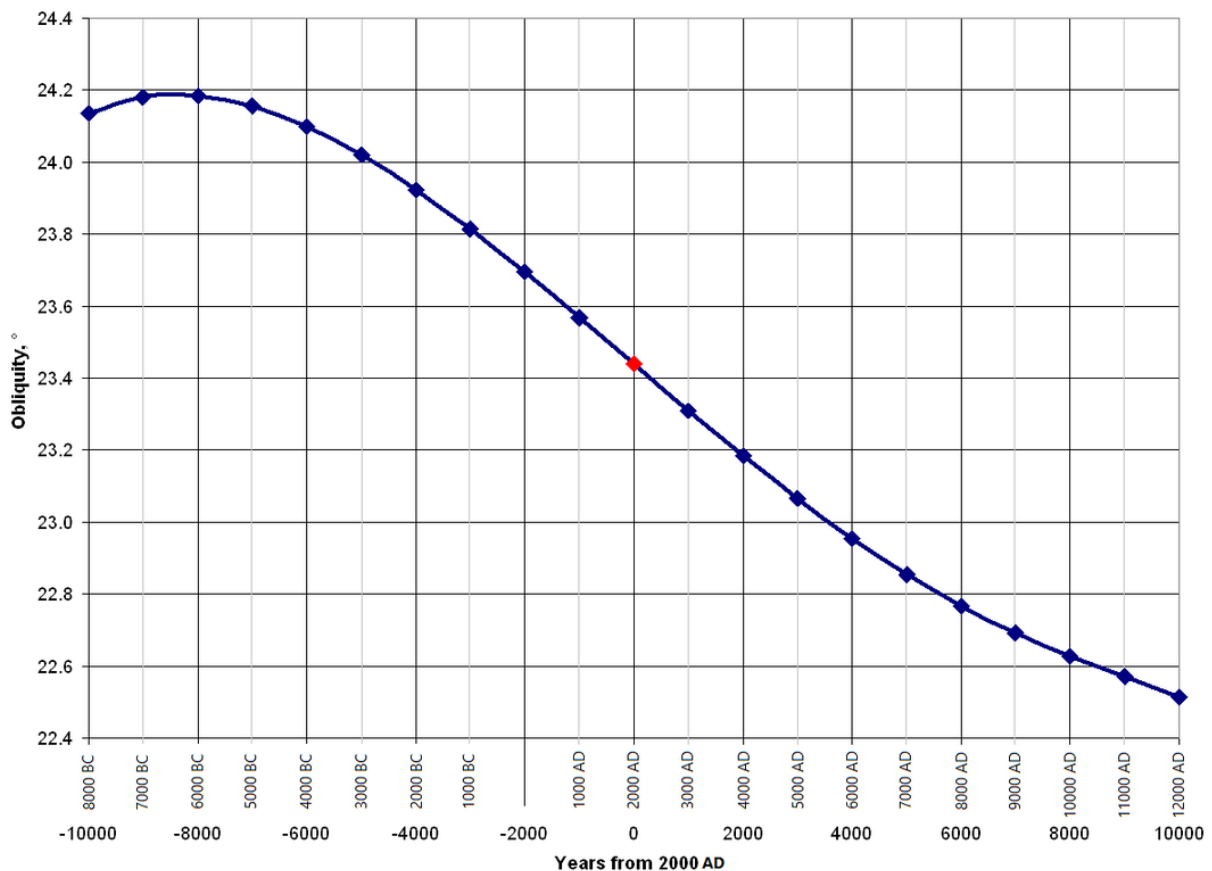


Observation of Moonrise in the Passage at Newgrange as Proxy for Neolithic Winter Solstice Sunrise

Tyrel Loertscher

The orientation of the passage at Newgrange to the position of the rising sun at the winter solstice is widely accepted and much discussed. It is also known that the tilt of the Earth on its axis is less today than in the past. Currently the tilt of the Earth is 23.43667° and decreasing. In 3200 BC when Newgrange was built the value was just beyond 24° and this resulted in the sun rising further to the south than it does today.

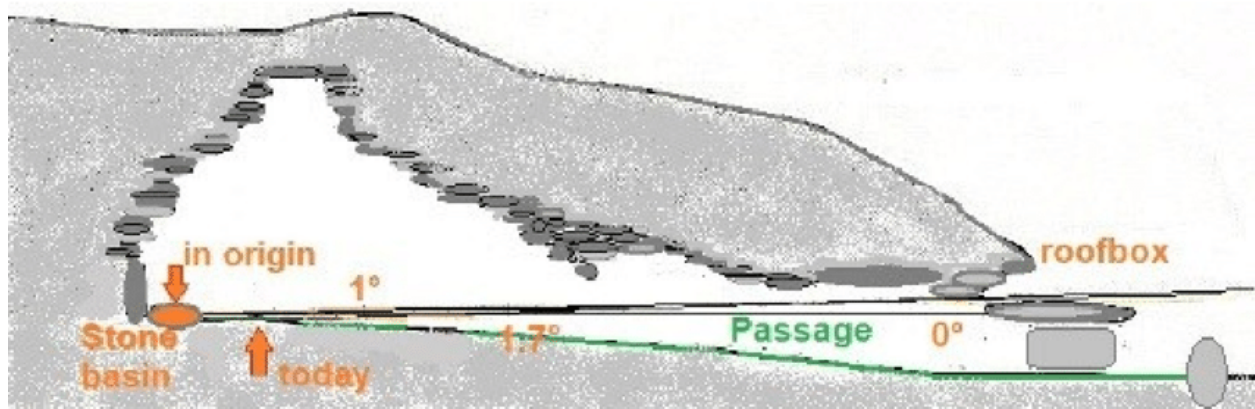


Graph of obliquity of the ecliptic vs time for +/- 10,000 years

https://commons.wikimedia.org/wiki/File:Obliquity_of_the_ecliptic_laskar.PNG

Graph: After Laskar, J. (1986), "Secular Terms of Classical Planetary Theories Using the Results of General Relativity" (date labels added)

At solstices the declination of the sun is equal to the angle of the tilt of the Earth's axis and this determines the position where it rises on the horizon. The sun no longer rises at the same point on the horizon at Newgrange so there is a delay while it climbs higher in the sky before it comes in line with the passage horizontally. At that point it has increased in altitude and is not aligned perfectly with the roof box in the vertical plane. This only allows the beam of sunlight to reach the floor in the center of the main chamber while in the past it would have reached all the way to the back of the chamber.



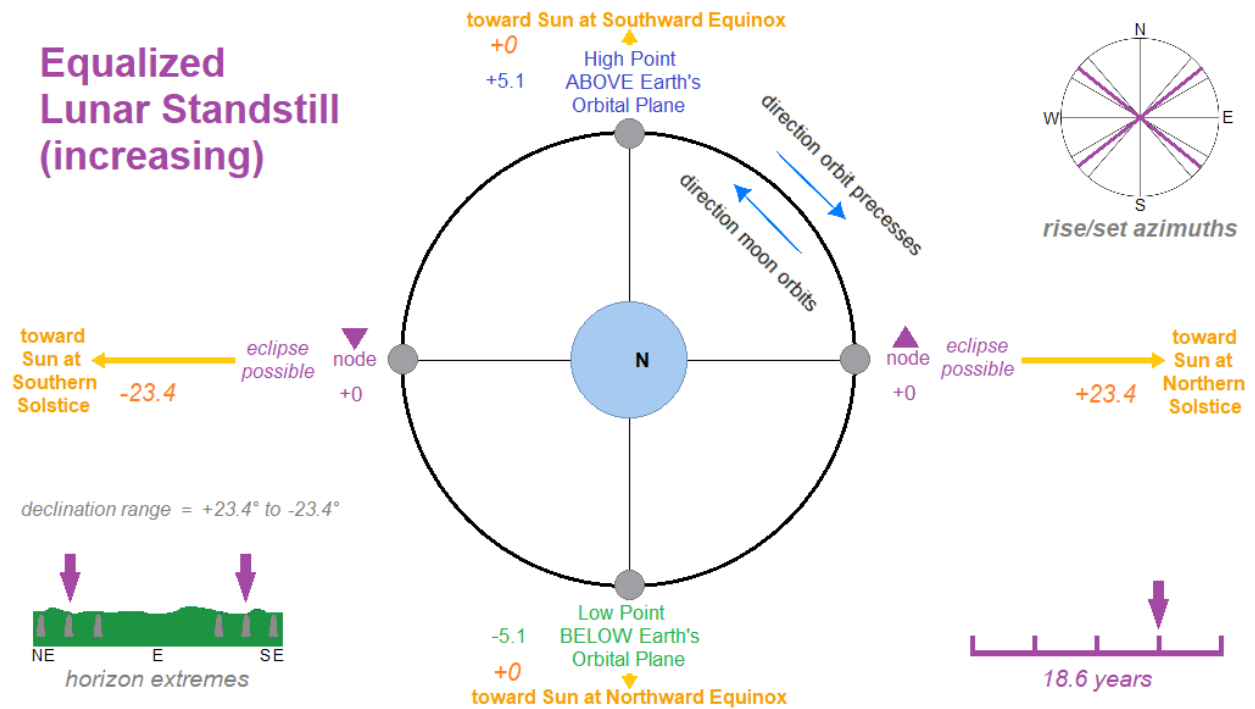
<https://www.researchgate.net/publication/323510746> Exercises in Archaeoastronomy -2 -The passage mound of Newgrange

Illustration: After Sparavigna 2018

The position of the moon on the horizon is also affected by the tilt of the Earth's axis, but as it orbits in a plane that is tilted 5.1° beyond the ecliptic, it can reach monthly maximum declination values both higher and lower than that of the sun and the range of these values changes slowly over the 18.6 year cycle between major lunar standstills when the most extreme declination values are attained. At two points in the cycle the values match the declination of the sun, and just before or after this the values will be slightly higher or lower.

This effect can create a situation where the moon can be used as a proxy to simulate the exact position of the sun in the past. Because the declination of the moon changes very quickly as it orbits the Earth, the monthly standstill positions when a maximum or minimum declination

is reached before reversing are the best times to observe the moon at a specific declination. At these times there is relatively little change during a short observation, such as when the moon is at the horizon and rising. Although these conditions are met in general at two points in each 18.6 year cycle (separated by approximately 9.3 years), complexities in the lunar orbit can affect what declination values are passed through quickly and which values remain with little change over multiple months. Also the phase of the moon during which any value is reached can vary widely making certain moonrise or moonset events more difficult to observe when they occur in daylight as opposed to when the sun is below the horizon.



http://www.explorelobe.net/uploads/5/7/9/2/5792627/high-low-4-equalized-increase_orig.png

Diagram: After Loertscher 2020, description of how the position of the lunar nodes over the 18.6 year lunar cycle affect the declination of the moon during monthly standstills.

The points in the 18.6 year cycle when the moon reaches positions that match the sun at the solstices could be termed *equalized lunar standstills*, one with values *increasing* towards

major lunar standstill, and another will values *decreasing* toward the minor lunar standstill. The year 2020 will see the moon matching modern values at various latitudes in turn due to lunar parallax, and then slowly attaining declination values comparable to periods in the past. The parameters for this year happen to allow for multiple opportunities to observe the moon at monthly standstill positions from March to July at declinations very close to the value for the Neolithic period. Further, some of these events occur during brightly illuminated phases of the moon that rise at night at the southerly position that corresponds to the rising of the sun at Winter Solstice around 3200 BC when Newgrange was built.

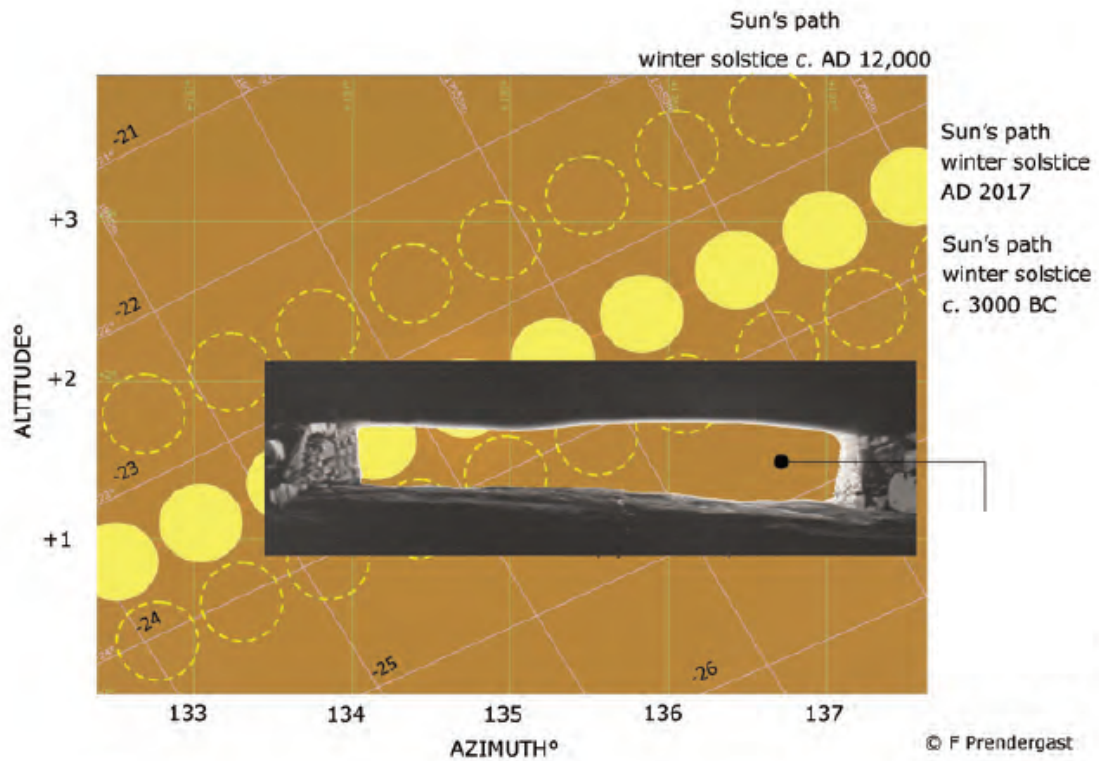
**2020 Southern Standstill Moonrise Events
corresponding to Winter Solstice Sunrise circa 3200 BC**

Date	Rise Time	Rise Azimuth	Apparent Declination	Geocentric Declination	Phase Illumination	Sun Horizon Position	Position in Roof Box
Tue. 17 March	3:36 AM	132.402	-24.249084	-23.422156	42% waning	below	center
Wed. 18 March	4:29 AM	132.235	-24.133376	-23.317892	32% waning	below	center
Mon. 13 April	2:27 AM	132.392	-24.202623	-23.358422	70% waning	below	center
Tue. 14 April	3:26 AM	133.179	-24.606200	-23.773862	59% waning	below	right of center
Tue. 12 May	2:08 AM	132.796	-24.411218	-23.577043	75% waning	below	right of center
Sat. 6 June	10:54 PM	132.743	-24.487957	-23.630633	98% waning	just below	right of center
Fri. 3 July	8:35 PM	131.521	-23.772695	-22.920747	98% waxing	above	left of center
Sun. 5 July	10:36 PM	132.836	-24.412011	-23.573328	99% waning	just below	right of center
Sat. 29 Aug	7:10 PM	132.311	-24.132616	-23.308417	90% waxing	just above	center
Wed. 23 Sep	3:10 PM	132.470	-24.277737	-23.426775	48% waxing	above	center

Dates are for Newgrange with a range of values on/around standstills for multiple observations. Target apparent declination is -24 but for earlier in 2020 closer matches were during unfavorable phases. Difference between Apparent Declination and Geocentric Declination is due to lunar parallax.

It is proposed that the opportunities to observe moonrise during the year 2020 which correspond to the position of the sun at winter solstice during the Neolithic should be used to increase our understanding of how light passing through the roof box would have interacted with

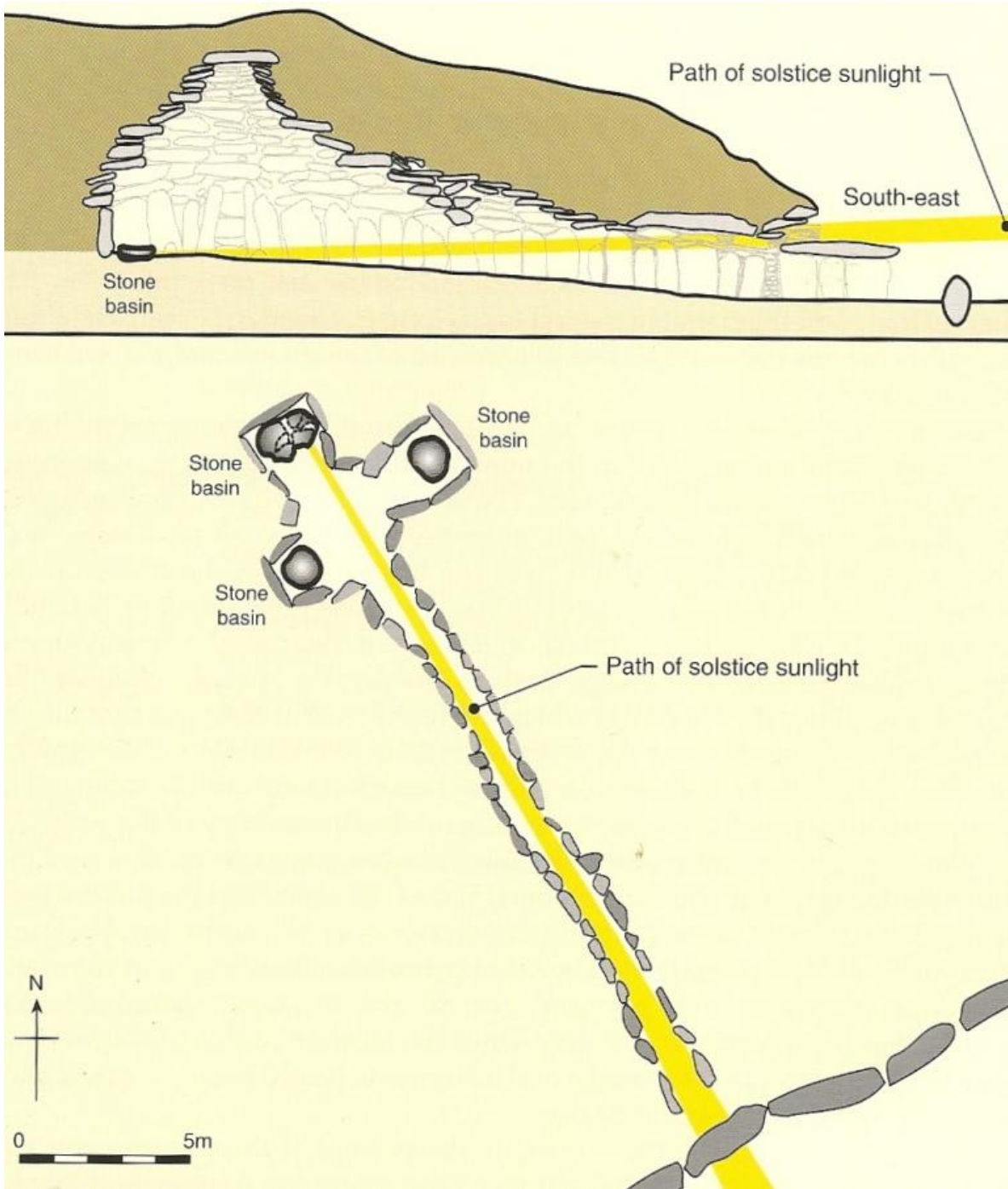
the chamber in a way much closer to the original situation than can currently be observed with sunlight in modern times. Although this phenomenon is understood and discussed, observing it in real time would add to our knowledge and increase awareness, understanding, and appreciation for this part of our ancient heritage that is Newgrange and those that built it.



<https://arrow.tudublin.ie/cgi/viewcontent.cgi?article=1008&context=arastart>

Diagram: After Prendergast 2017 (*Facing the Sun*, Fig. 9)

Note: Rising azimuth at altitude of ~ 0 is $\sim 132^\circ$ with center of Roof Box at $\sim 135.5^\circ$



<http://irisharchaeology.ie/wp-content/uploads/2011/12/Newgrange-winter-solstice1.jpg>

Illustration: After Stout & Stout 2008

REFERENCE:

<https://www.youtube.com/watch?v=ngADMns8W78>

Professor Tom Ray of Technological University Dublin, video interview giving explanation of the change in axial tilt and the effect on the sunlight entering the passage at Newgrange.

<https://arrow.tudublin.ie/cgi/viewcontent.cgi?article=1008&context=arastart>

See Fig. 9 of linked article from Prendergast, O'Sullivan, Cooney, Williams.

<https://arrow.tudublin.ie/cgi/viewcontent.cgi?article=1008&context=arastart>

Diagram: After Prendergast 2017 (Facing the Sun, Fig. 9)

https://www.researchgate.net/publication/323510746_Exercises_in_Archaeoastronomy_-2_-The_passage_mound_of_Newgrange

Amelia Carolina Sparavigna. Exercises in Archaeoastronomy -2 -The passage mound of Newgrange. Philica, Philica, 2018. <hal-01712819>

http://www.explore-globe.net/uploads/5/7/9/2/5792627/high-low-4-equalized-increase_orig.png

Diagram: After Loertscher 2020, description of how the position of the lunar nodes over the 18.6 year lunar cycle affect the declination of the moon during monthly standstills.

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