From Carnac to Chartres:
five thousand years of lunar sightings

A: Carnac (Er Grah)
Lat. = 47.5667° N
Long. = 2.95° W

B: Chartres (Cathedral)
Lat. = 48.4474° N
Long. = 1.4878° E

The road to Chartres

Carnac : a megalithic lunar observatory ?

A visit of the site

The theory of lunar standstills

A description of one of the alignments studied by Alexander Thom

The reassessment of Thom’s theory

Alignments

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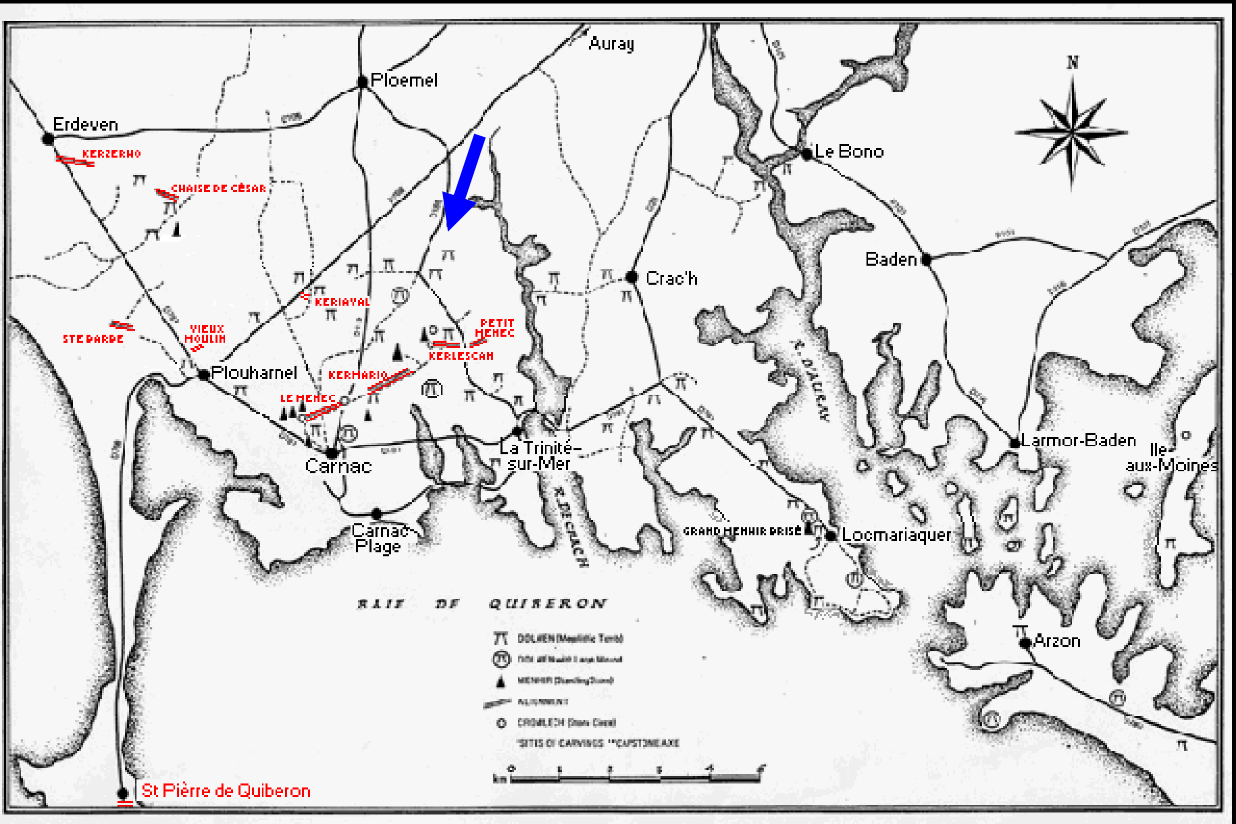
The most famous are: Le Menec, Kermario, Kerlescan (shown here) and Le Petit Menec.



Kerlescan alignment
13 lines of 560 menhirs
on half a mile

Alexander Thom
1894-1985

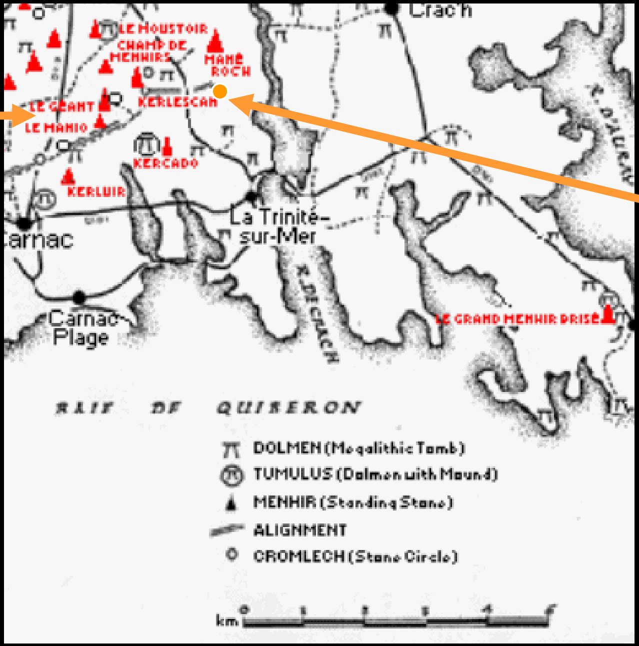
Menhir: a standing stone.

Single menhirs are widely scattered over the district.

Dolmen: a sepulture formed from large stones grouped close together.

The menhir « **le géant de Manio** » (here below) was thought by Thom to be a central sighting of a solar observatory.

The dolmen of **Kervilor** (here below) is situated near two of the backsights which, according to Alexander Thom, were Used with the Grand Broken Menhir as a foresight for lunar observations.



Most dolmens were probably covered by a mound of earth and/or stone.

Cairn: a construction made of dry rocks covering one or two dolmens

Ex. « Table des Marchand » of Locmariaquer (M)

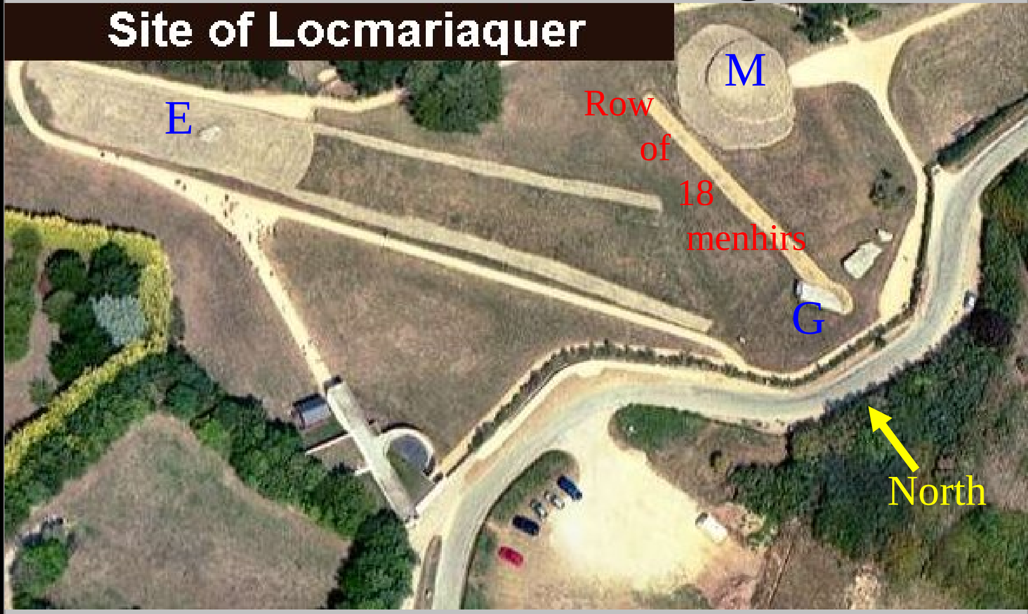
Tumulus: a mound covering a sepulture which has no access corridor

Ex. tumulus « Er Grah » in Locmariaquer (E).

The tumulus of le Moustoir is one of the few « tumulus carnacéen ».

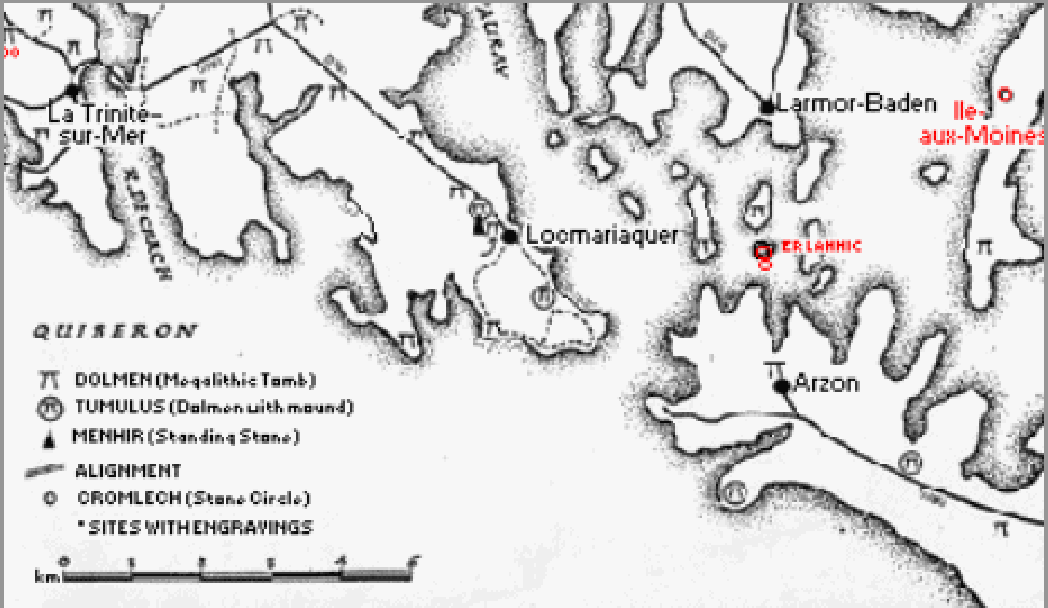
Small menhir sitting on the top of the tumulus

The grand Broken Menhir (G), the centre of the alleged lunar observatory, belonged to a row of 18 menhirs of decreasing size



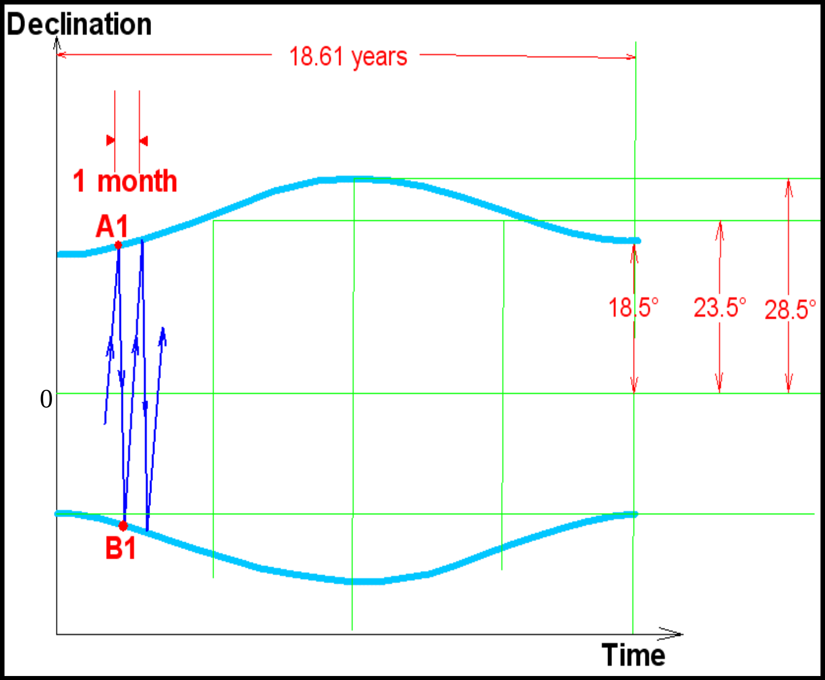
Cromlech: an enclosure of menhirs

Half of north circle and all of south circle of **Er Lannic'** s cromlech are submerged.

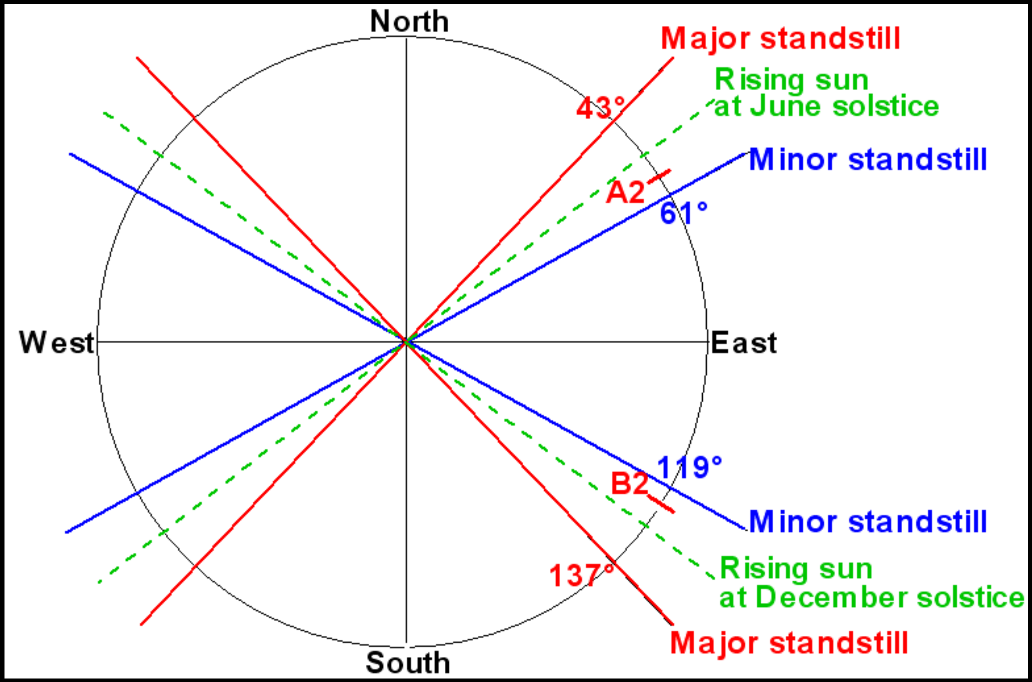


The western part of the Morbihan Gulf has been subsiding since the erection of the megaliths of Carnac about 4500 BC.

Envelope traced by the extreme declination of the moon in 18.61 years



Extreme azimuths of the moon at Carnac



The 18.61-years lunar cycle and the standstills

During the course of a lunar month of circa 27. 2 days, the moon's declination oscillates between two limits A1 and B1. An astronomer watching the horizon would see the azimuth of the rising moon oscillate between A2 and B2. Over an 18.61-years period, the northern extreme declination (and azimuth) moves from a minimum to a maximum and back to a minimum. The same is true for southern declination and azimuth.

The lunar nodal cycle

Some definitions

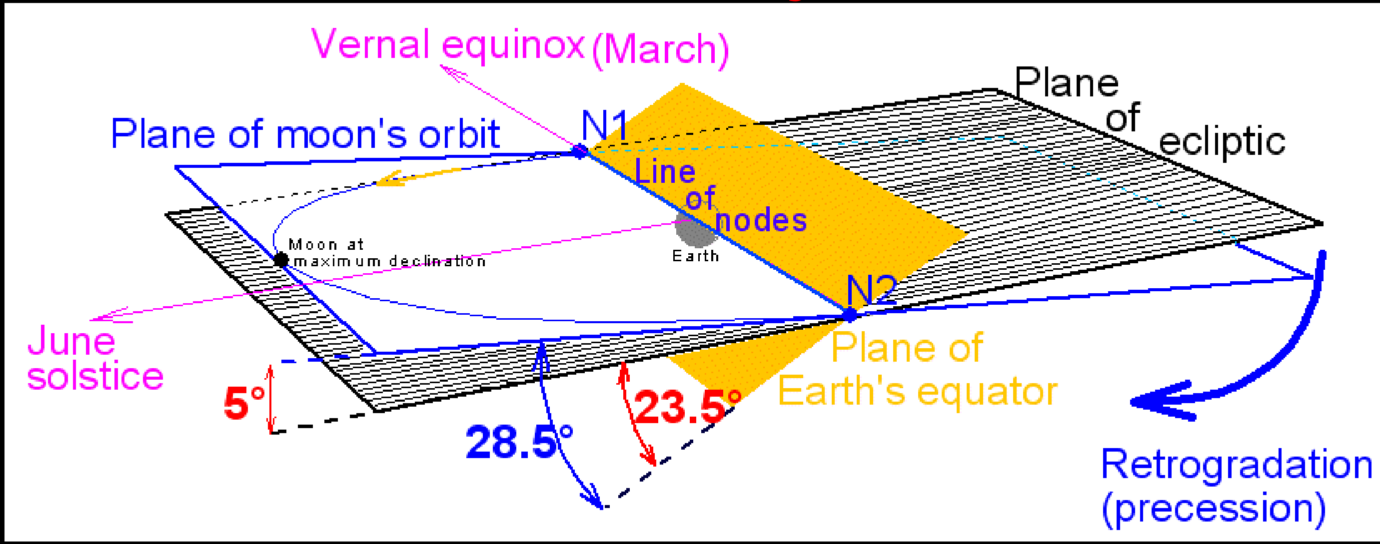
The **obliquity** of the ecliptic(ε) is the angle at which the plane of the ecliptic is inclined to the plane of the equator.
$\varepsilon = 23.5°$ at the present time.

The **inclination** (i) is the angle at which the plane of the moon's orbit is inclined to the plane of the ecliptic.
$i = 5°$

The **nodes** (N1 and N2) are the intersections of the moon's orbit with the ecliptic's plane

The line of nodes N1- N2 retrogrades (precesses) with a period of 18.61 years.

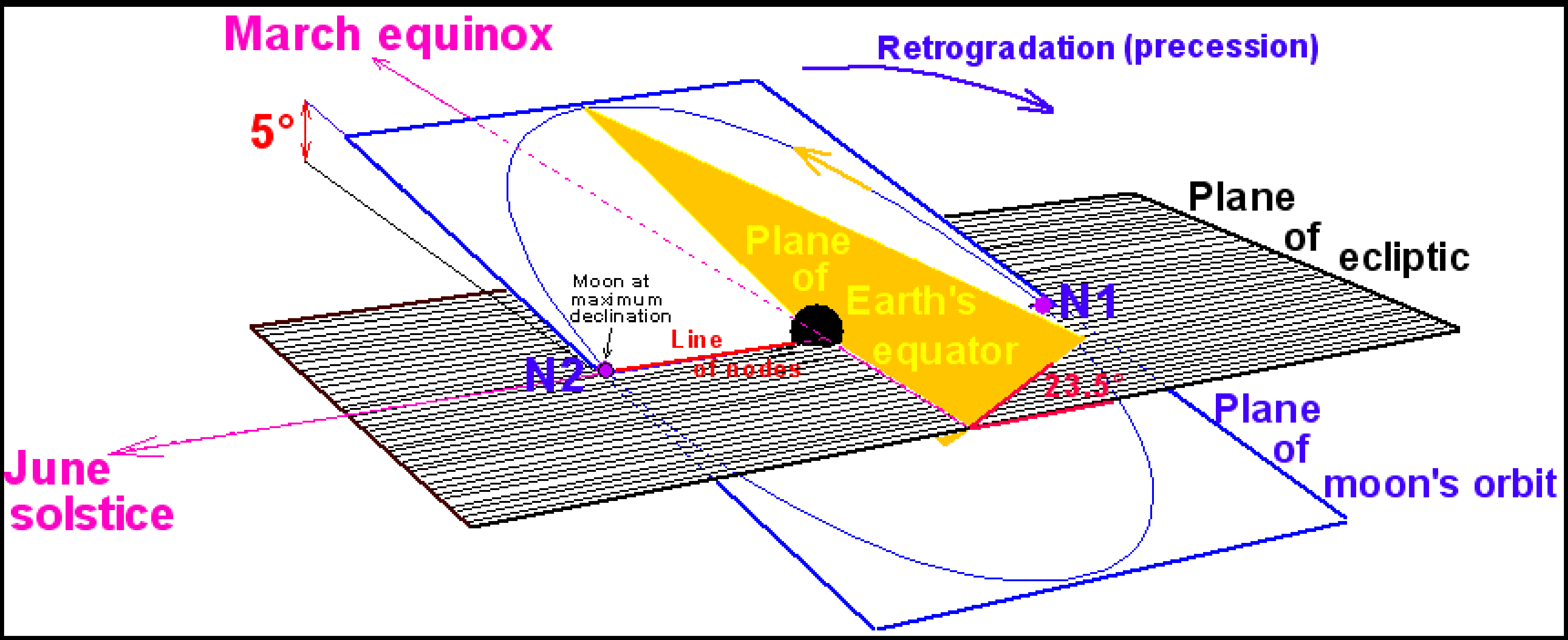
0 and 18.6 years : major standstill



The plane of the Earth's equator (brown) and the plane of the moon's orbit (blue) are tipped on opposite sides of the ecliptic's plane (hatched area)

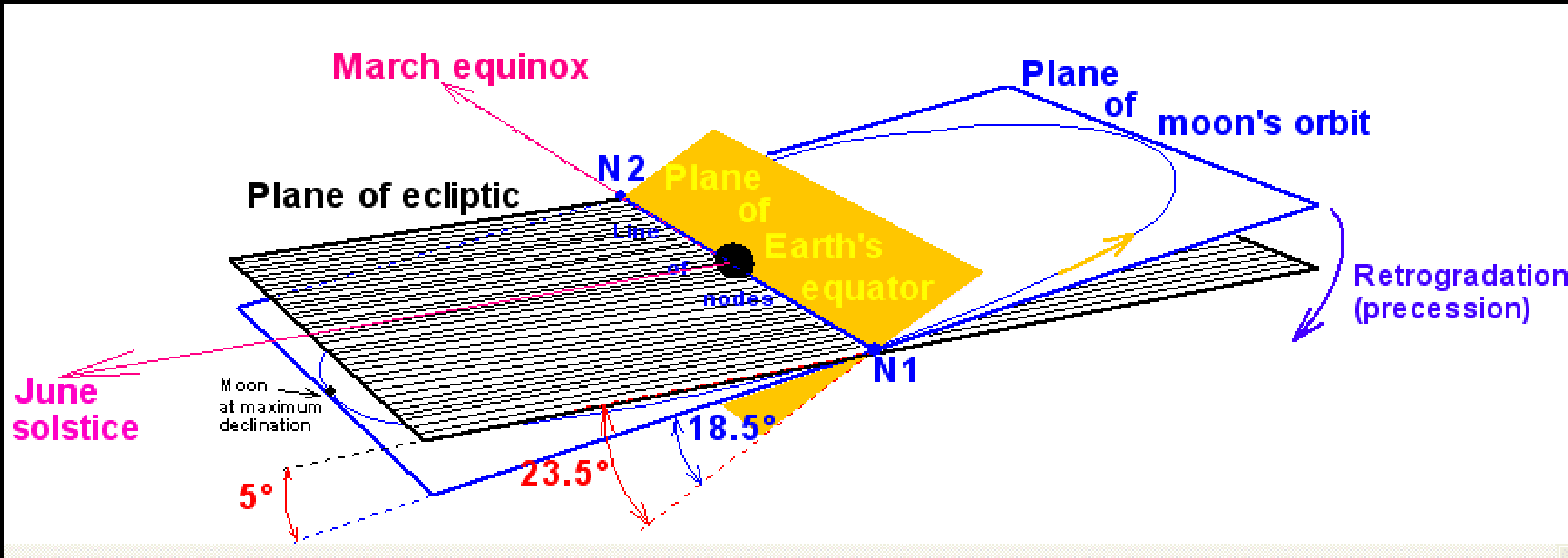
The nodes coincide with the equinoxes.
Extreme declination of the moon = $\varepsilon + i = 28.5°$ (or $-28.5°$)

4.7 years after major standstill



The line of nodes coincides with the solstices.
Extreme declination of the moon = 23.5°
(or – 23.5°)

9.3 years after major standstill: minor standstill



The plane of the Earth’s equator and the plane of the moon’s orbit are both tipped on the same side of the ecliptic.

The nodes coincide again with the equinoxes.
Extreme declination of the moon = ε - i = 18. 5°
(or - 18.5°)

Sun at solstice: observation of the full moon

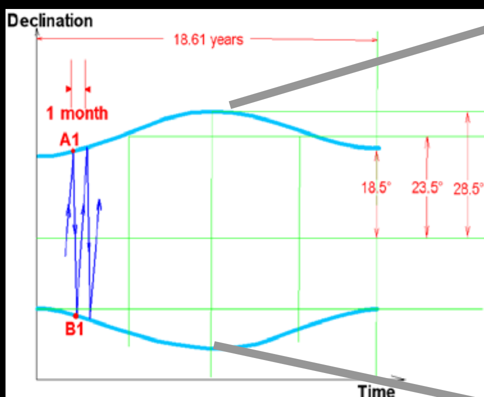
Sun at **equinox**: observation of the first or third quarter moon. It is the **true standstill** because the inclination’s perturbation is maximum (next slide)

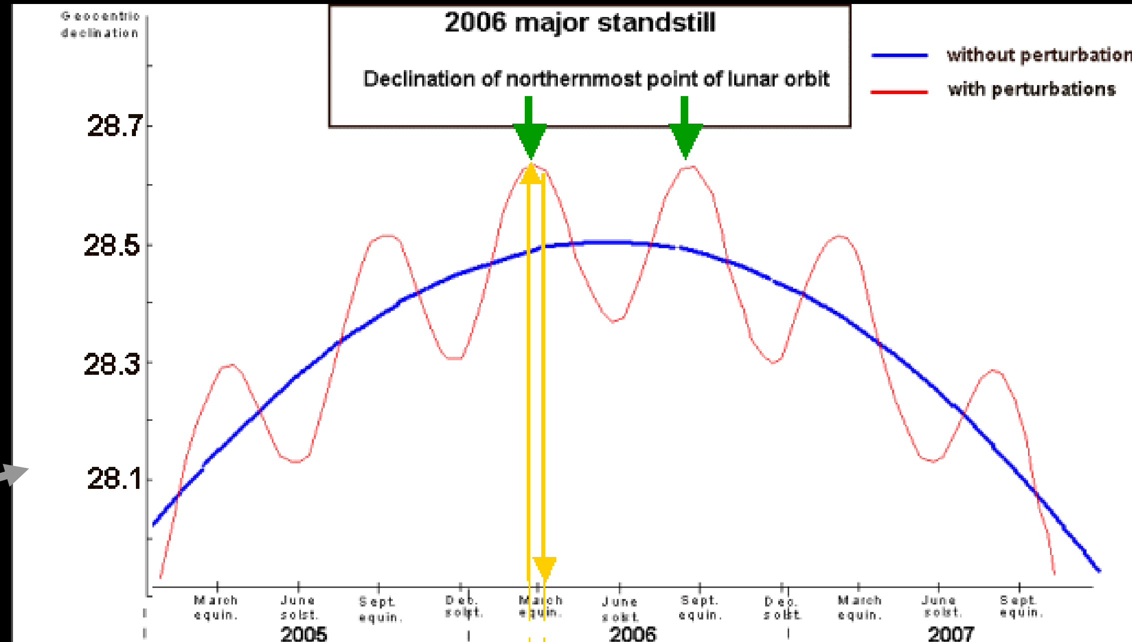
TRUE FOR MAJOR AND MINOR STANDSTILLS IN BOTH HEMISPHERES

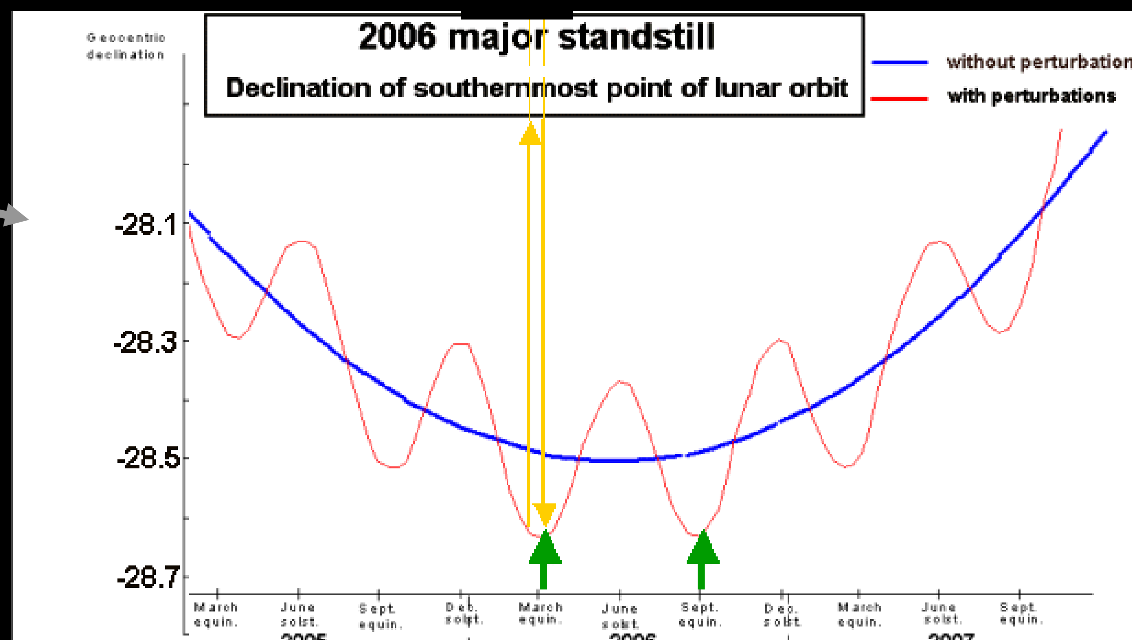
The inclination perturbation

The lunar motion is complicated by a small wobble that causes the moon's declination to oscillate plus or minus **9 arc minutes** on top of the expected cyclical variations. The slight oscillation is called the « inclination perturbation »

This perturbation is at its maximum positive value **when the sun is at a node**.







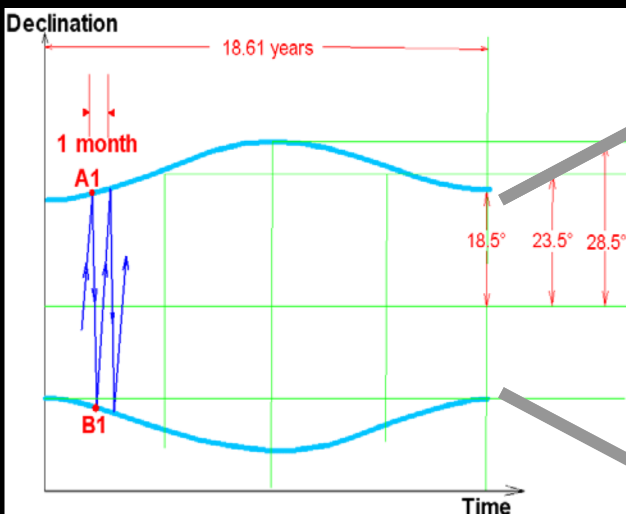
During a standstill year, the nodes coincide with the equinoxes.

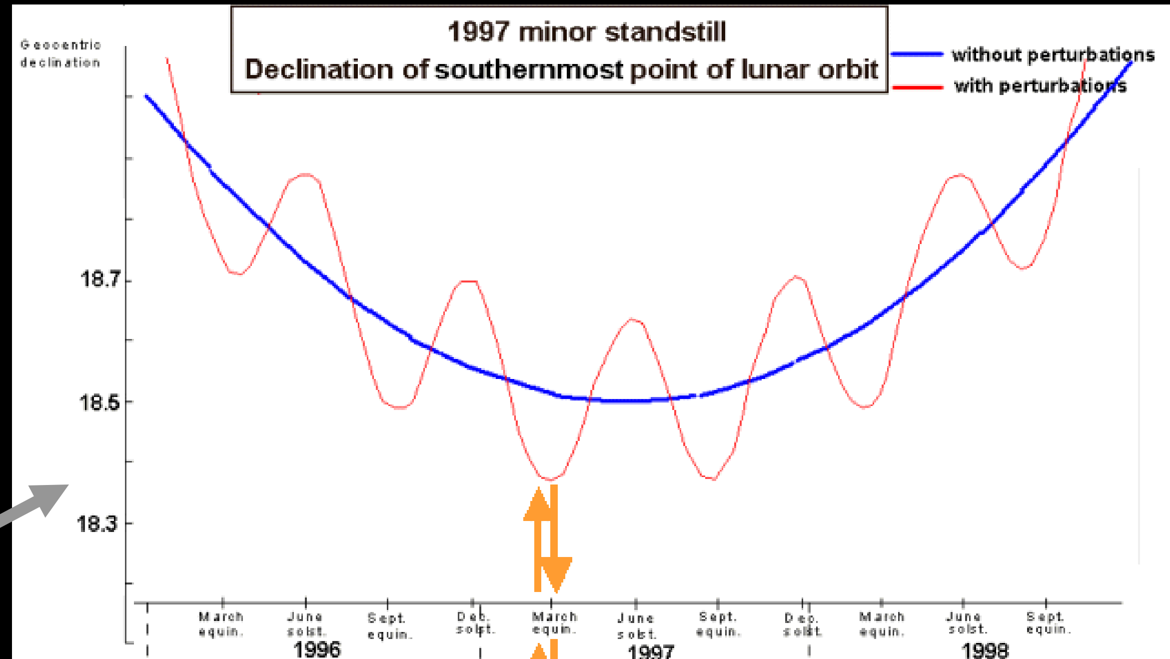
As a consequence, the greatest monthly declination's variation (orange arrows) is observed at the equinoxes (green arrows) **during a major standstill year**.

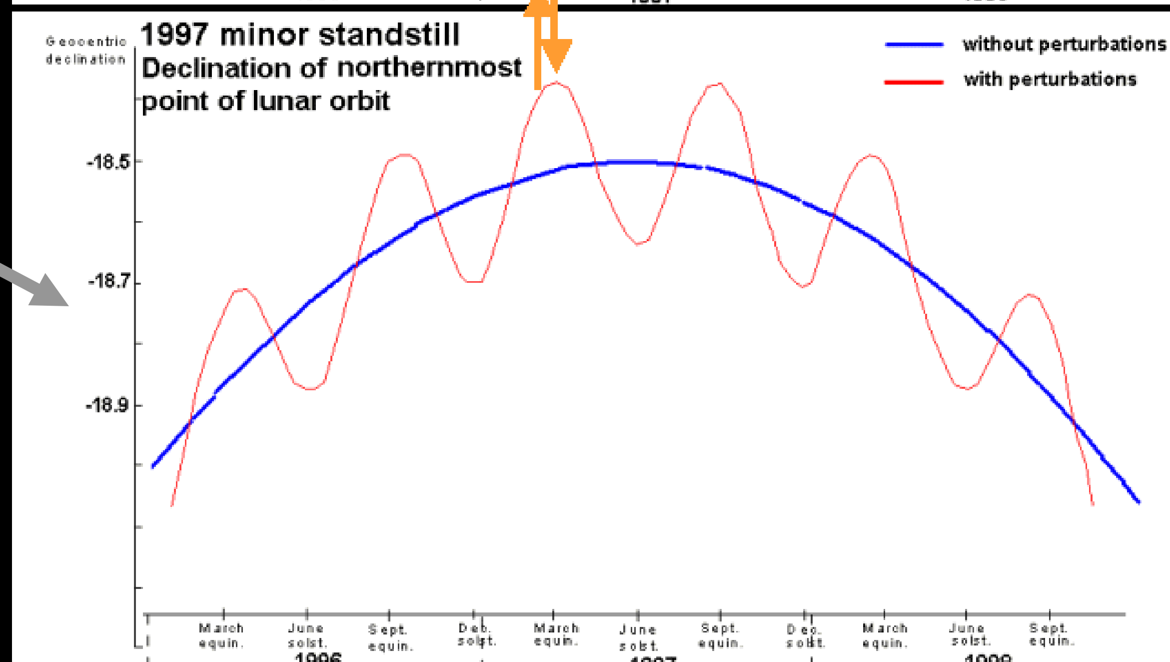
The observed phases are the first and last quarters.

During a minor standstill year, the smallest monthly declination's variation (orange arrows) is also observed at the equinoxes.

The observed phases are also the first and last quarters.

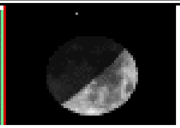
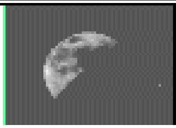
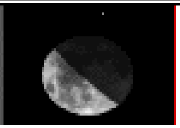
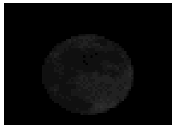
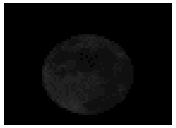
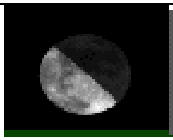
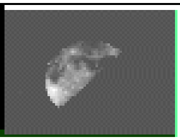
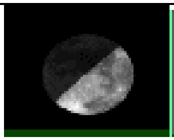
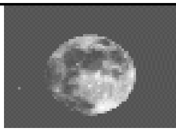
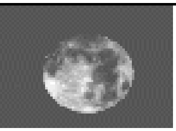


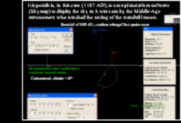




Near solar events during a standstill year

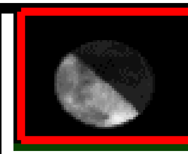
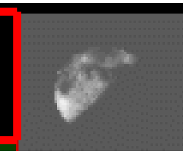
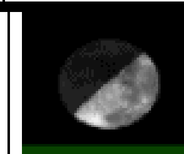
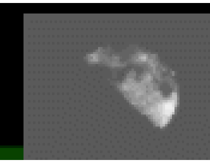
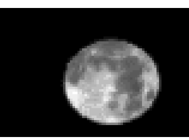
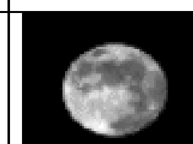
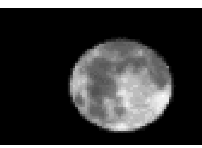
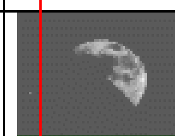
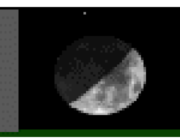
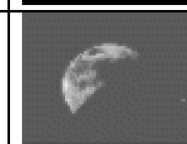
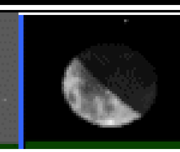
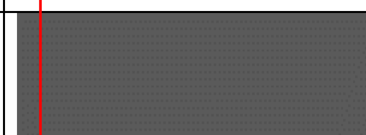
Extreme northern declinations

ε = obliquity (24.1419° in 4500 BC) i = inclination Δ=perturbation of inclination δ = declination	Extreme declination at major standstill (δ)	Extreme declination at minor standstill (δ)	Corrected inclination $\beta = i + \Delta$ i = 5.145° Δmin = -0.145° Δmax= 0.145°	Near solar event	Northern hemisphere Rising	 Setting	Southern hemisphere Rising	 Setting
Northern	$\varepsilon + \beta$ 29.4319°	$\varepsilon - \beta$ 18.8519°	Δ maximum $\beta = i+\Delta = 5.29°$	March equinox First quarter				
Northern	$\varepsilon + \beta$ 29.1419°	$\varepsilon - \beta$ 19.1419°	Δ minimum $\beta = i+\Delta = 5°$	June solstice New				
Northern	$\varepsilon + \beta$ 29.4319°	$\varepsilon - \beta$ 18.8519°	Δ maximum $\beta = i+\Delta = 5.29°$	September equinox Third quarter				
Northern	$\varepsilon + \beta$ 29.1419°	$\varepsilon - \beta$ 19.1419°	Δ minimum $\beta = i+\Delta = 5°$	December solstice Full				



Near solar events during a standstill year

Extreme southern declinations

ε = obliquity (24.1419° in 4500 BC) i = inclination Δ=perturbation of inclination δ = declination	Extreme declination at major standstill (δ)	Extreme declination at minor standstill (δ)	Corrected inclination β = i + Δ i = 5.145° Δmin = -0.145° Δmax= 0.145°	Near solar event	Northern hemisphere Rising	Northern hemisphere Setting	Southern hemisphere Rising	Southern hemisphere Setting
Southern	$-(\varepsilon + \beta)$ -29.4319°	$-(\varepsilon - \beta)$ -18.8519°	Δ maximum β = i+Δ = 5.29°	March equinox Third quarter				
Southern	$-(\varepsilon + \beta)$ -29.1419°	$-(\varepsilon - \beta)$ -19.1419°	Δ minimum β = i+Δ = 5°	June solstice Full				
Southern	$-(\varepsilon + \beta)$ -29.4319°	$-(\varepsilon - \beta)$ -18.8519°	Δ maximum β = i+Δ = 5.29°	September equinox First quarter				
Southern	$-(\varepsilon + \beta)$ -29.1419°	$-(\varepsilon - \beta)$ -19.1419°	Δ minimum β = i+Δ = 5°	December solstice New				

Figures of the moon: web page of Victor Reijs
http://www.iol.ie/~geniet/eng/majorstandstills.htm#Favored

Not easy to observe in the case of a minor standstill

R azimuth Chartres

R azimuth Carnac (major) R azimuth Carnac (minor)

Carnac: a megalithic lunar observatory ?

According to Alexander Thom, « the Grand Menhir Brisé may have been used as a universal lunar foresight from several standstill backsights .

Er Grah (the Grand Broken Menhir) as a universal lunar foresight

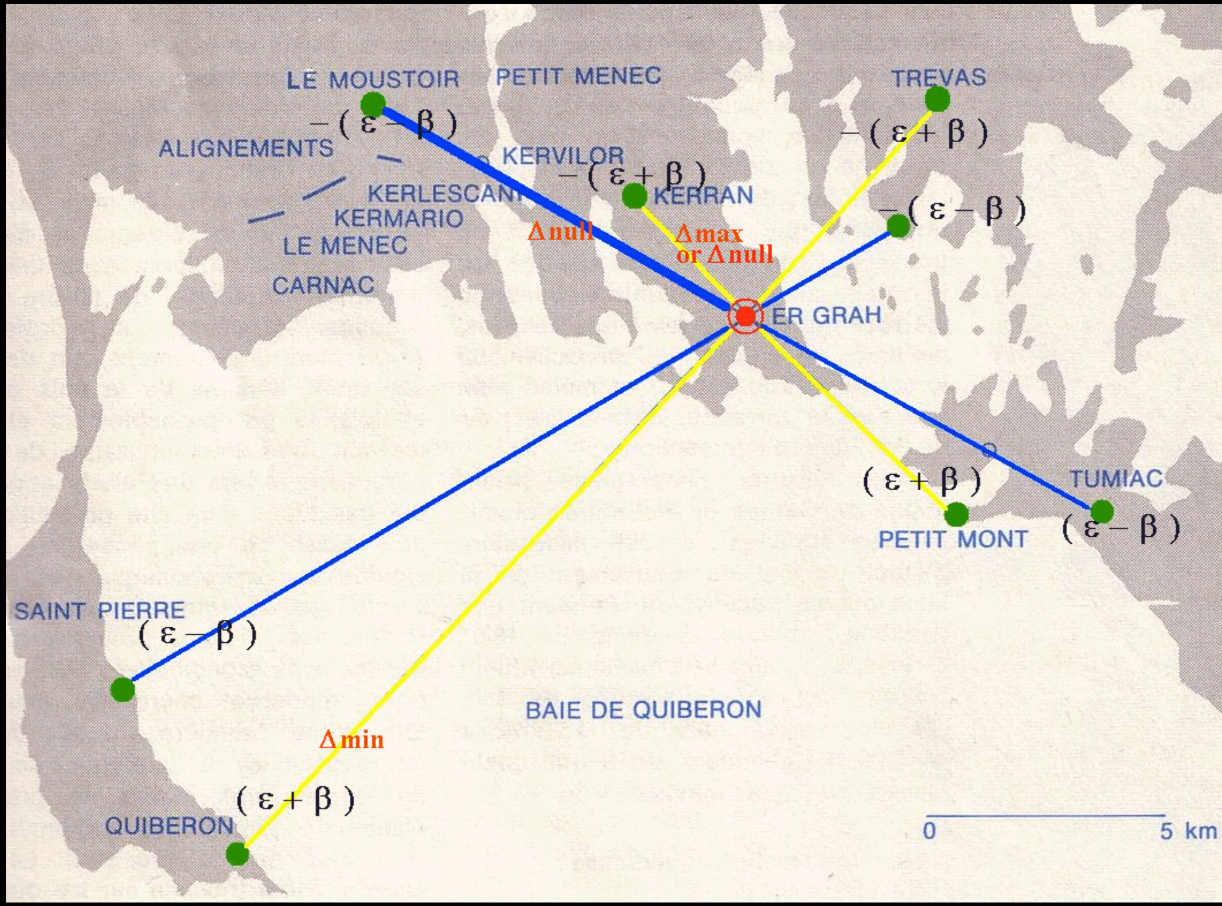
Backsights

Minor standstills

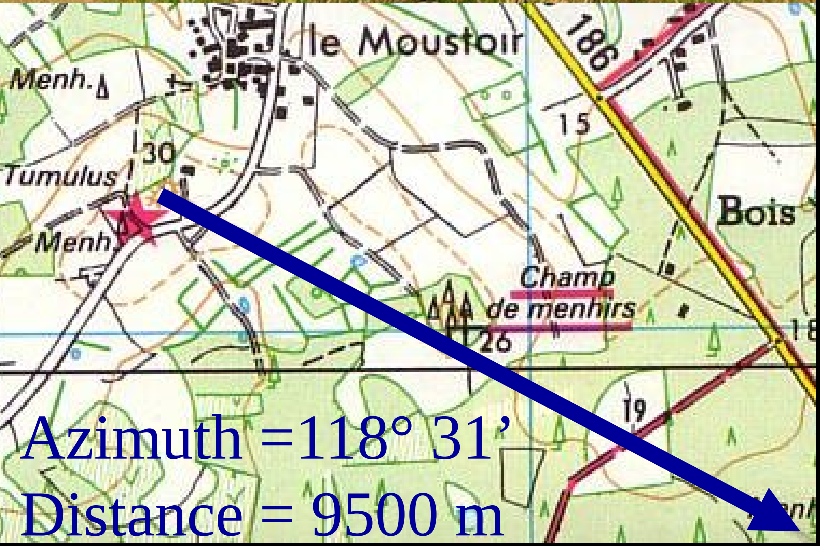
Thick line: next slide

Major standstills

ε = obliquity
According to Thom, ε = 23.897° (1700 BC)
β = i + Δ
i = inclination = 5.145°
Δ = perturbation
MAX.(+ 0.145°),
or NULL
or MIN. (– 0.145°)

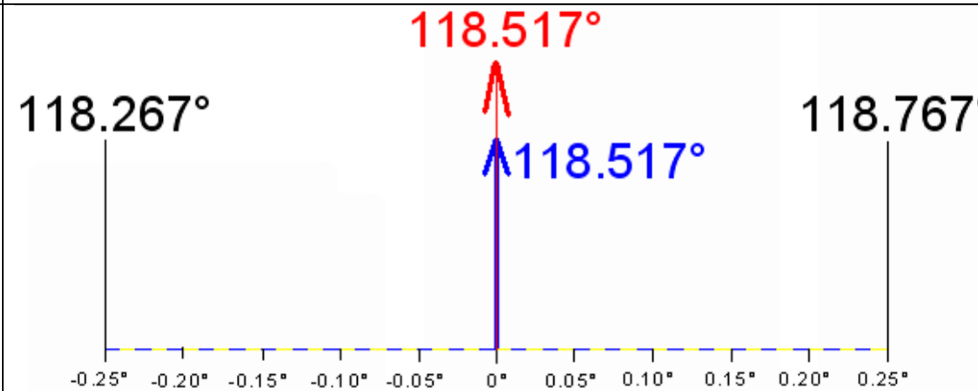
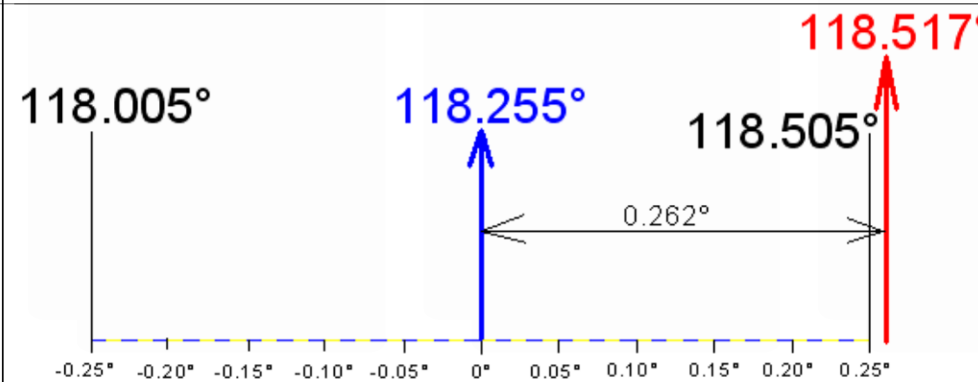


Δ min, null or max : Thom's hypotheses

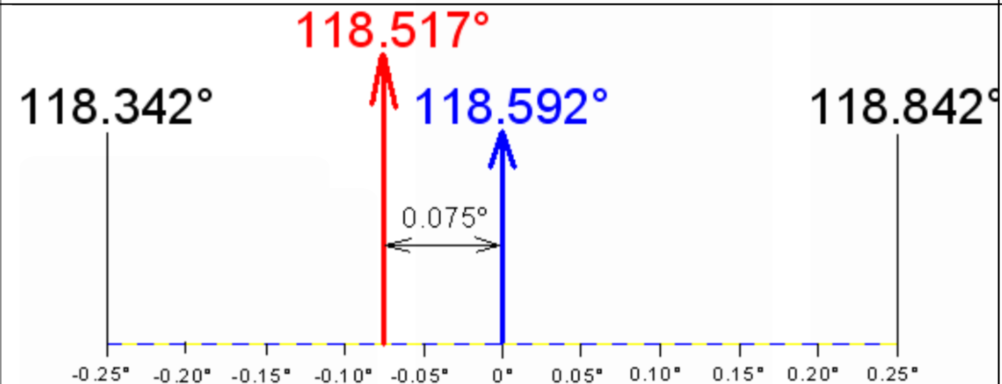
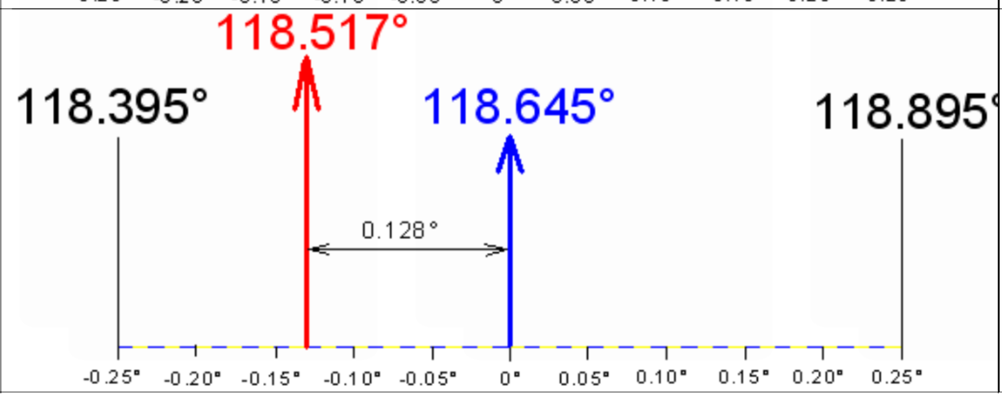


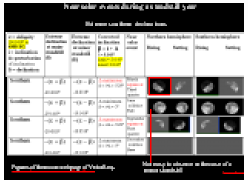
Minor standstill's rising moon seen from le Moustoir

Minor standstill : southern rising moon seen from le Moustoir

Dates (BC)	**Calculated Azimuths (°)**	**inclination's perturbation (°)**	**Accuracy of the calculated azimuth** taking into account a possible variation of 30% of the nominal value of refraction (NVR). Blue: calculated azimuth with NVR (variation = 0°) Black: extreme calculated azimuths with variation of 30% of the NVR (plus or minus 0.25° of azimuth at Carnac's latitude) Red: observed azimuth	**Comments**
1700	**118. 517**	**0**		Thom's hypothesis Incorrect date. Correct azimuth because perturbation is ignored.
1700	**118. 255**	**+ 0. 145 (Maximum)**		Incorrect date. Incorrect azimuth.

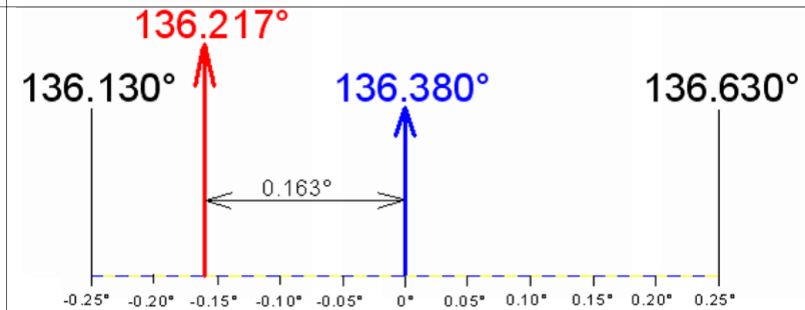
Minor standstill : southern rising moon seen from le Moustoir

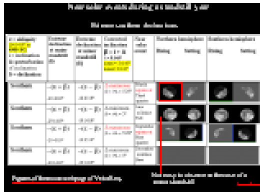
Dates (BC)	Calculated Azimuths (°)	Inclination's perturbation (°)	**Accuracy of the calculated azimuth** taking into account a possible variation of 30% of the nominal value of refraction (NVR). Blue: calculated azimuth with NVR (variation = 0°) Black: extreme calculated azimuths with variation of 30% of the NVR (plus or minus 0.25° of azimuth at Carnac's latitude) Red: observed azimuth	Comments
4000	**118. 592**	**+ 0. 145 (maximum)**		Approximate date of the Grand Menhir's destruction. Acceptable Azimuth. Third quarter moon of March equinox
4500	**118. 645**	**+ 0. 145 (maximum)**		Approximate date of the Grand Menhir's erection. Acceptable Azimuth. Third quarter moon of March equinox



Major standstill : southern rising moon seen from Kerran

The backsight is the "small menhir" of Alexander Thom. This menhir is situated near two passage graves and, according to Hadingham, there was "a third passage grave that formerly stood to the S of the surviving pair, and this may have blocked the sight-line to Er Grah". I suggest that this dolmen could have been used as a sighting platform.

Dates (BC)	Calculated Azimuths (°)	Inclination's perturbation (°)	**Accuracy of the calculated azimuth** taking into account a possible variation of 30% of the nominal value of refraction (NVR). Blue: calculated azimuth with NVR (variation = 0°) Black: extreme calculated azimuths with variation of 30% of the NVR (plus or minus 0.25° of azimuth at Carnac's latitude) Red: observed azimuth	Comments
4000	136. 380	- 0. 145 (minimum)		Approximate date of the Grand Menhir's destruction. Acceptable Azimuth. **Full moon of June solstice**



Minimum perturbation of inclination : full moon of june solstice.

It is easy to observe this event during a major standstill (sun below the horizon)

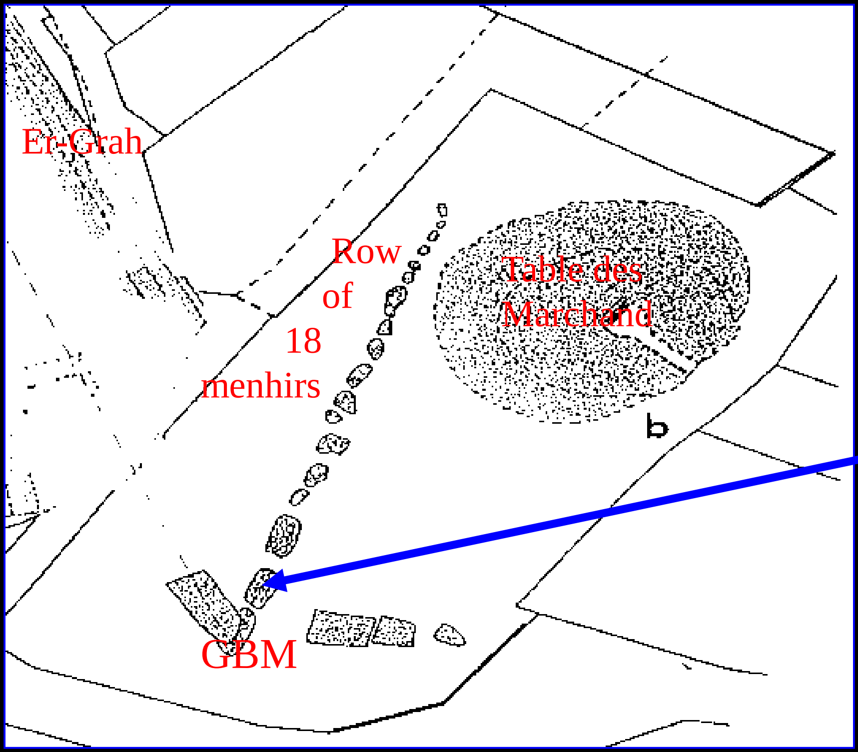
Carnac : rising full moon around summer solstice at standstills

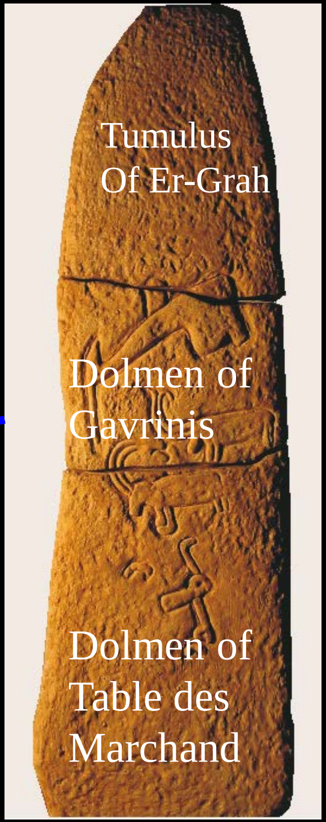
20th and 21th centuries ; not very different in megalithic time

Date	Standstill	Moon's altitude	Moon's phase	Sun's altitude
10-06-1979	minor	- 0° 14'	0.997	+ 1°
29-06-1988	major	- 0° 14'	0.998	- 4° 23'
20-06-1997	minor	- 0° 14'	0.998	+ 3° 46'
11-06-2006	major	- 0° 14'	0.998	- 4° 55'

The 18 menhirs of Locmariaquer

Excavation has shown that the Grand Broken Menhir (GBM) was one of a row of 18 menhirs of decreasing size represented now only by the holes in which they were once placed. One of them is the stone known to have been broken into three parts.





Height = 14 m ; mass = 65 tons

Does symbolism confirm calculations ?

According to Frank Edge (« Aurochs in the Sky: Dancing with the Summer Moon, A Celestial interpretation of the Hall of Bulls from the cave of Lascaux ») :

« *the moon/bull symbol was carried forward at least as far as the goddess cultures and agricultural communities of 6,000 B.C. I see a direct link between the crescent moon and the horns of the bull.* »

Quoted from « ANCIENT STAR PICTURES » by Laura Lee
http://www.lauralee.com/index.cgi?page=articles/lascaux.htm

Moon / bull symbols

I suggest that :

-the oversized bull's horns observed on the broken stele are **lunar symbols**.

-the 18 menhirs, including the broken stele, correspond to the 18 years of the **lunar cycle**.

“The lunar observatory at Carnac: a reconsideration”
Evan Hadingham *Antiquity*. Vol LV, 1981.

According to Evan Hadingham:

1. «It should be noted that no definite proof exists that the Great Broken Menhir was ever successfully erected» (p 36)

The archaeologers working now in Locmariaquer are convinced that the Great Menhir was erected circa 4500 BC and destroyed voluntarily some centuries later.

2. « ... then Le Grand Menhir represents not a unique scientific endeavour, but instead the extraordinary elaboration of an established architectural and religious tradition. » (p 40)

We have seen that the presence of 18 menhirs of decreasing size in Locmariaquer and the lunar symbols engraved on one of them confirm the astronomical theory of Alexander Thom.

3. « ... it is common sense to expect standing stone backsights of an appropriate size and permanence… » (p40)

A big stone is not necessary as a backsight. Moreover, a large size would not be appropriate because the parallax would create an azimuthal shift when the astronomer makes a sighting from one side of the a big stone and afterwards from the other side.

However, it would be logical to erect a small backsight-menhir in a particular place. It is the case for the menhir of le Moustoir which was erected on a giant tumulus called « tumulus carnacéen » (Carnac-type mound).
There are only two such tumuli in Carnac and two other ones in Locmariaquer. They were build in the middle of the 5th millenium (erection’s epoch of the 18 menhirs of Locmariaquer) .

He wrote about the earthen long mounds and Carnac-type mounds:
4. «Both type of monuments are now put back in roughly the mid-fourth millenium BC… This is about 2,000 years earlier than the period around 1700 BC that the Thoms have assumed to be the heyday of the lunar observatories … » **(p40)**

We have seen that this problem has been solved in the case of the alignment le Moustoir-Grand Menhir. The giant tumulus of le Moustoir and the Grand Menhir have been built in the middle of the 5th millenium and the lunar alignment could have been established at the same epoch.

5. « There are several reasons why a statistical approach to the significance of the Grand Menhir lines is unsatisfactory. »

This would be good news for Alexander Thom since the statistical approach of the British sites is a real threat for the lunar standstill theory.

I would like to add that we have no reason to take into account, in a statistical approach, all the megaliths of le Moustoir’s area since the involved menhir is the only one which has been erected on the only giant tumulus of that zone.

Anyway, it would be interesting to study a « clear-cut » site to dodge the issue of the statistical approach: we will see that the Cathedral of Chartres provides such an alignment.

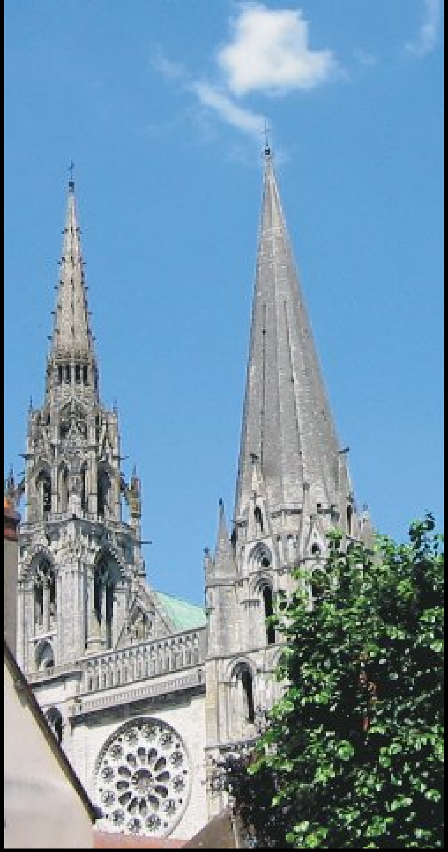
The road to Chartres:

There are megaliths in the country around Chartres

For almost a thousand years looms the incomparable
Silhouette of a great vessel of stone and light, above
an ocean of wheat as expressed by the poet Charles Péguy :

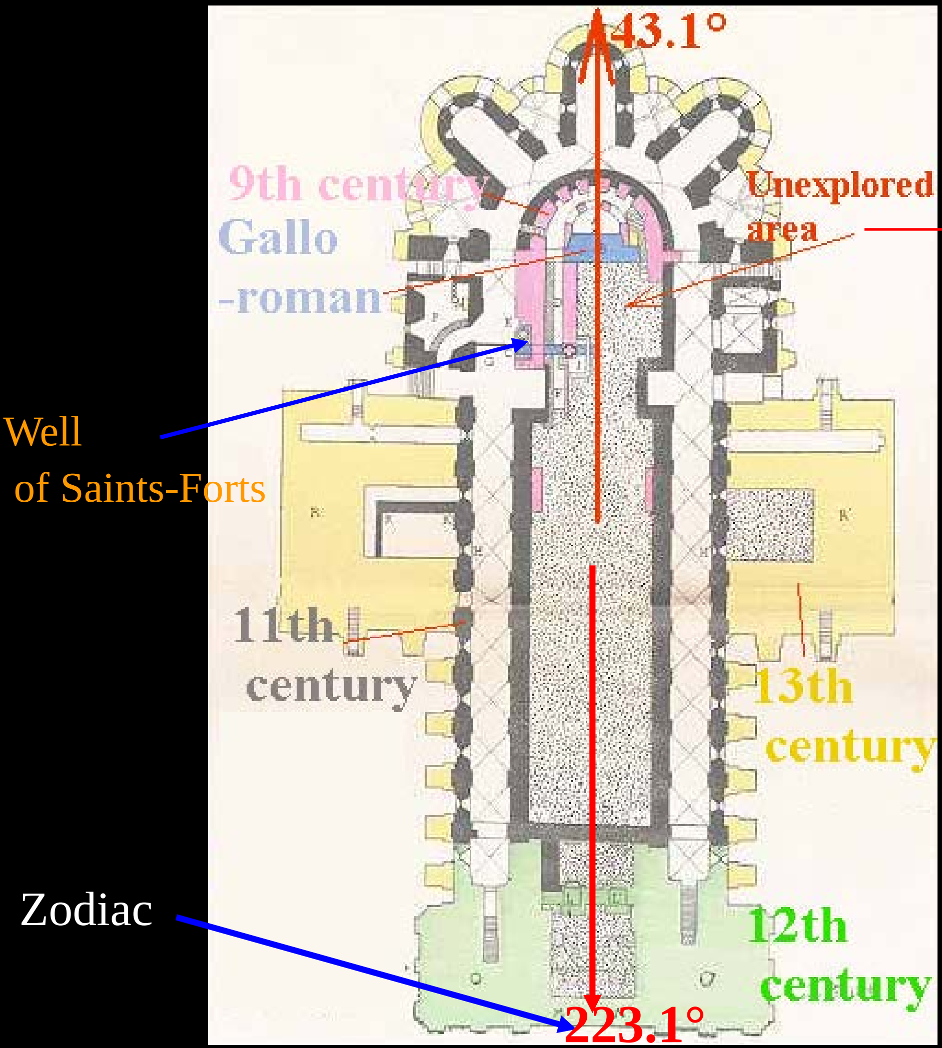
the cathedral of Chartres.

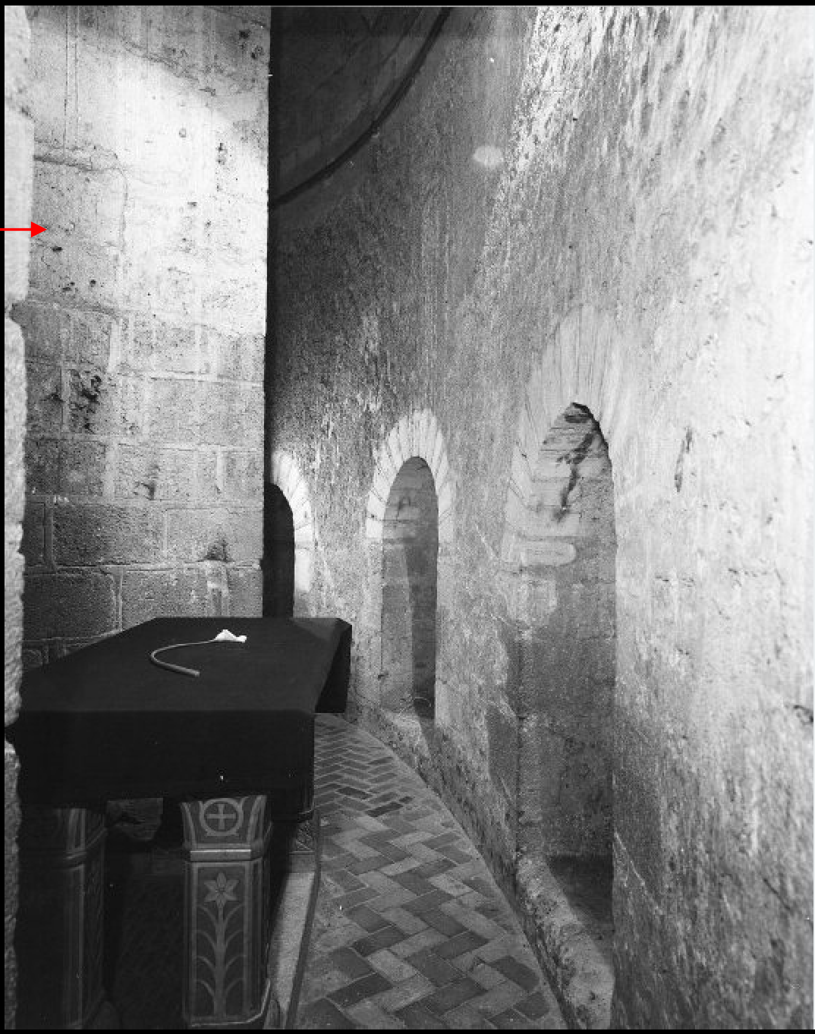
The first church was undoubtedly erected during the time of religious peace brought about by the Emperor Constantine at the beginning of the 4th century. It was established on the place of the well of Saints-Forts, a miraculous source and probably the site of Druidic worship. Fire devastated this first church in 743.



Four other churches have been standing on this very spot previous to the enormous building we can still admire today and all four had been destroyed by fire. The present cathedral was built after the previous church had burned down in 1194 A.D

The site on which the present building stands has been a place of worship since megalithic times, starting out probably with a dolmen.





A large filled-in space between the two galleries of the crypt is yet to be explored. The dolmen is probably located there.

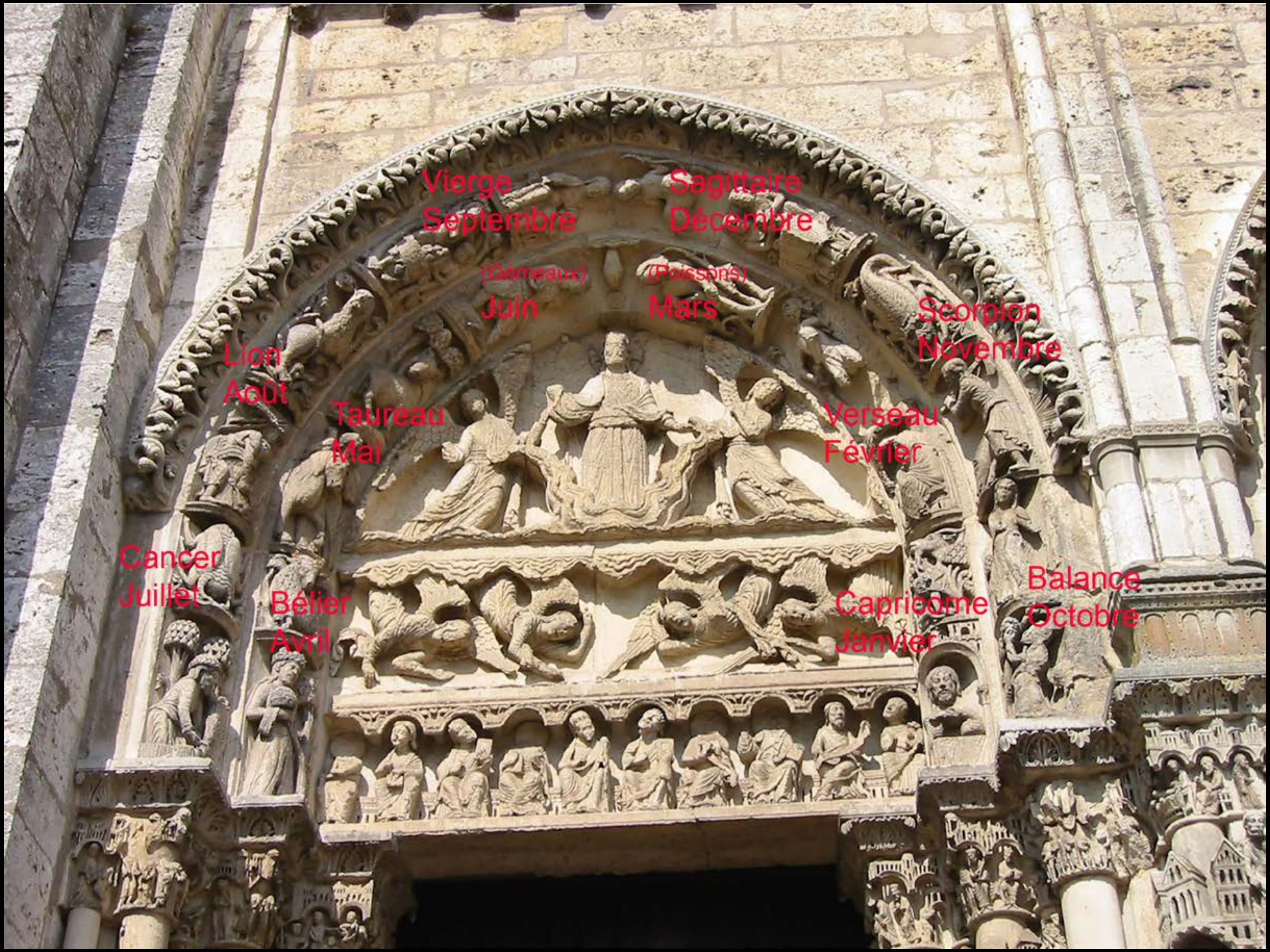
From the very beginning, Chartres owes the main part of its influence to its sanctuary. Before the Roman invasion, the Carnutes, a Celtic tribe, made Chartres their principal Druidic centre.

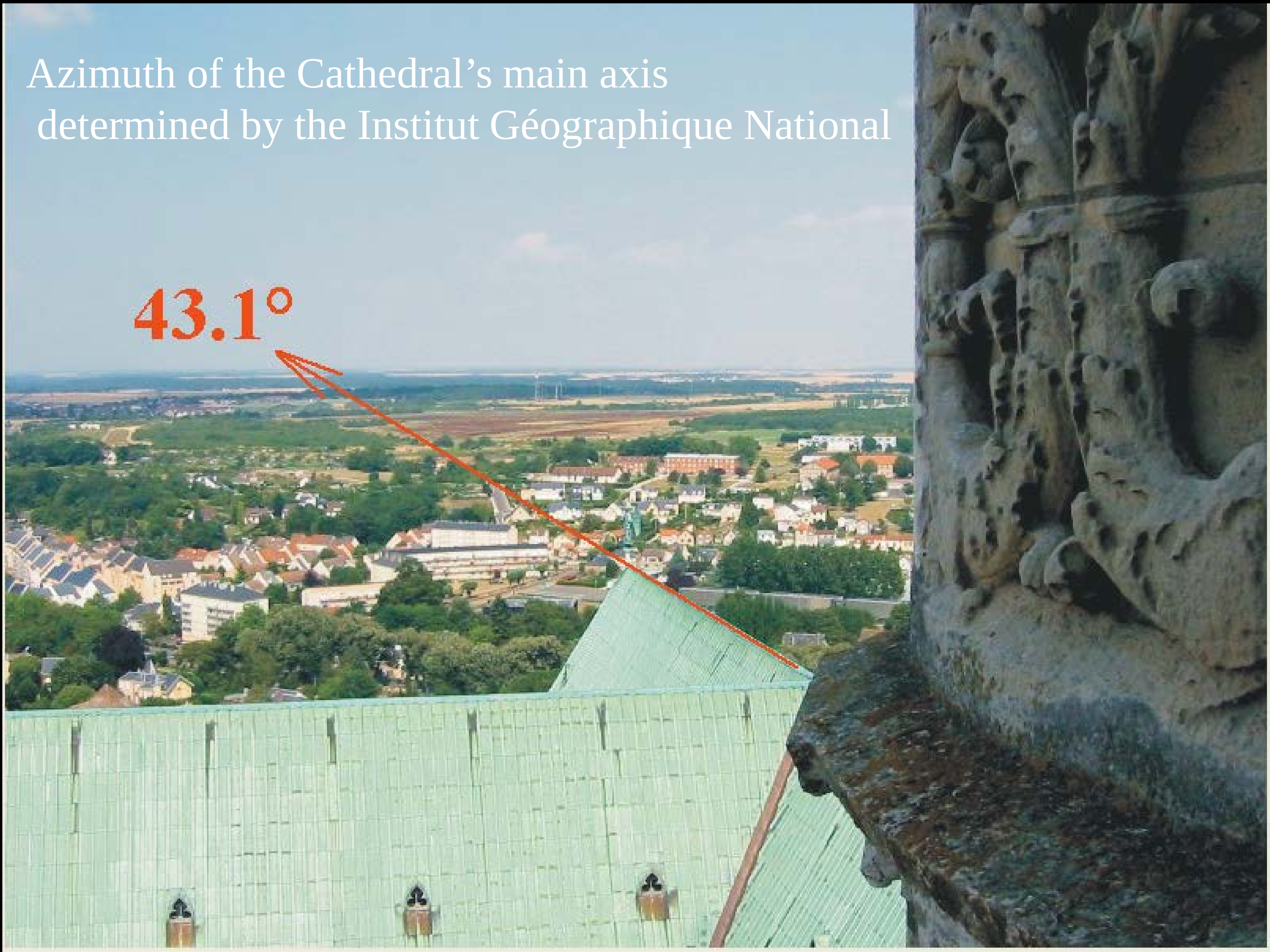
The figure of the Virgin had preceded Christianity. Even before the time of the birth of Christ, Chartres had its altar and its statue in honour of a mother goddess, the " Virgin who must give birth ", that texts from the Middle Ages call the Virgo paritura

This Druidic goddess became the black Virgin at the onset of christianity. We can see her statue at the end of the crypt gallery

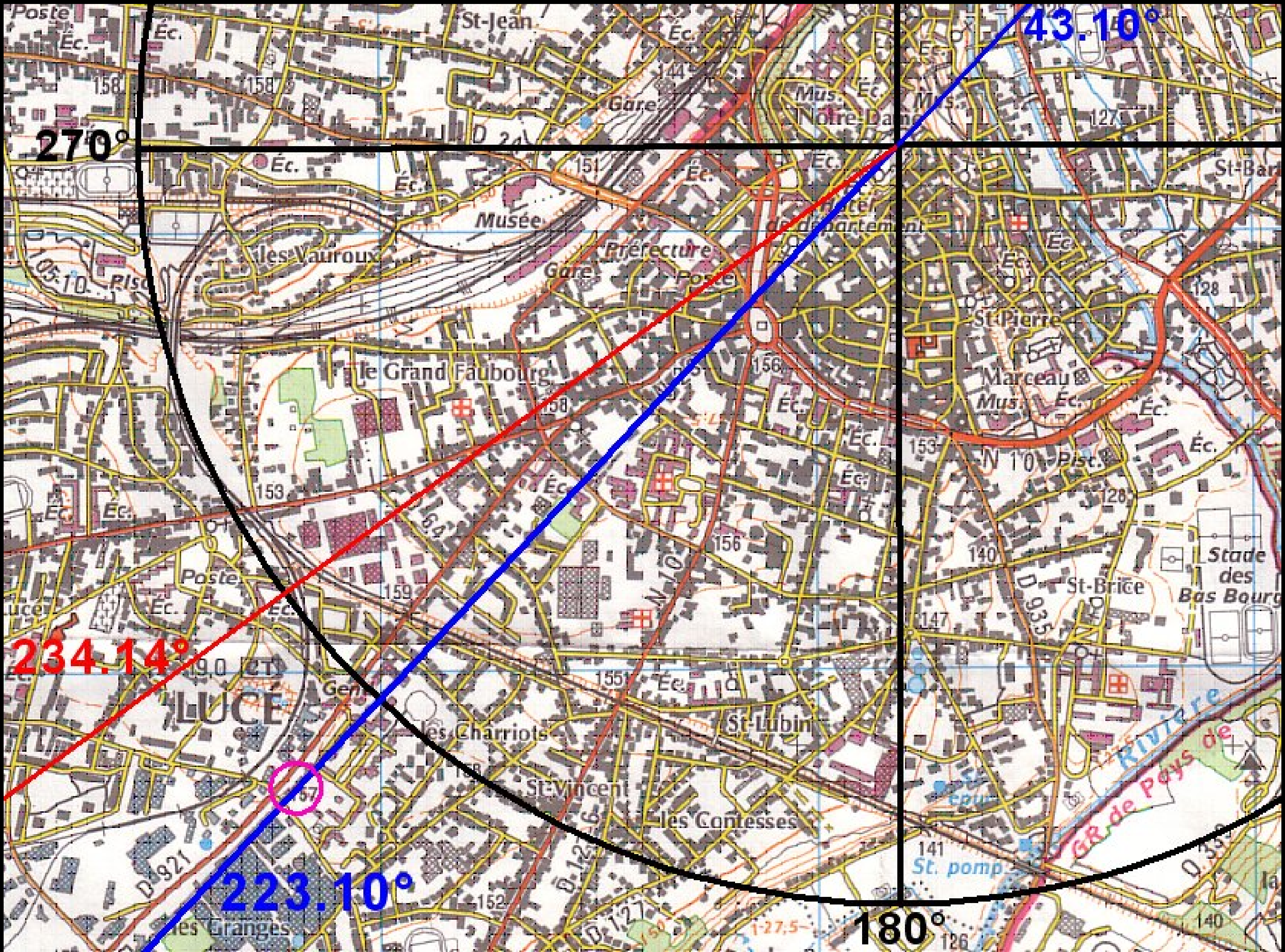
We can count approximately 4 000 sculpted figures at Chartres, but above all it's the portals which hold ones attention by their incomparable quality. To the south-west, on the lunar axis which I will describe shortly, we see the royal portal (three doorways), which was one of the few parts salvaged from Fulbert's earlier cathedral, and was built between 1145 and 1155.

On the left, the tympanum features Christ's Ascension. The archivolts displays the signs of the zodiac with their appropriate monthly activities.

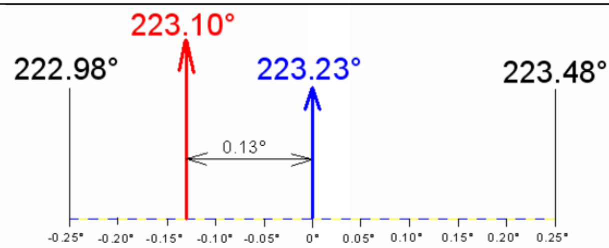
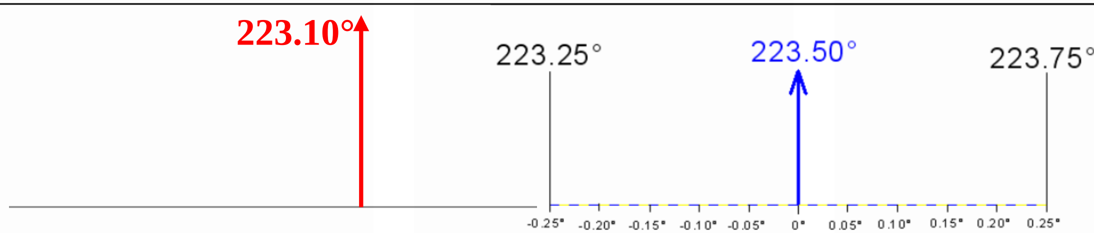
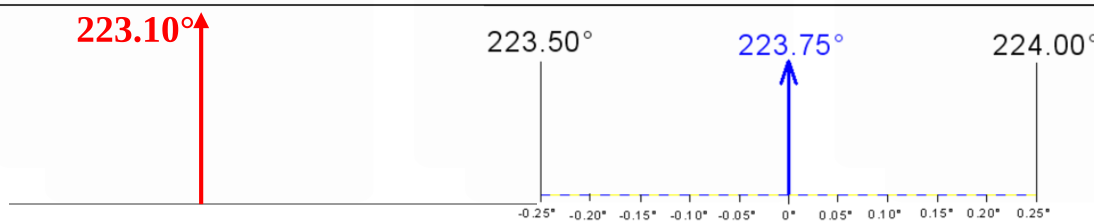



Azimuth of the Cathedral’s main axis
determined by the Institut Géographique National
43.1°

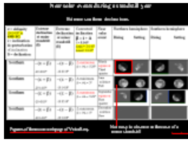
Blue: main axis of cathedral ; Red : setting sun of winter solstice



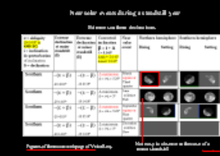
Major standstill of 1187 AD, some years before the last re-construction

Dates (AD)	Calculated Azimuths (°)	Inclination's perturbation (°)	**Accuracy of the calculated azimuth** taking into account a possible variation of 30% of the nominal value of refraction (NVR). Blue: calculated azimuth with NVR (variation = 0°) Black: extreme calculated azimuths with variation of 30% of the NVR (plus or minus 0.25° of azimuth at Chartres latitude) Red: observed azimuth	Comments
1187	**223. 23**	**+ 0. 145**		First quarter moon of September equinox
1187	**223. 5**	**0**		Crescent approx. halfway between equinox & solstice
1187	**223. 75**	**- 0. 145**		Full moon of June solstice

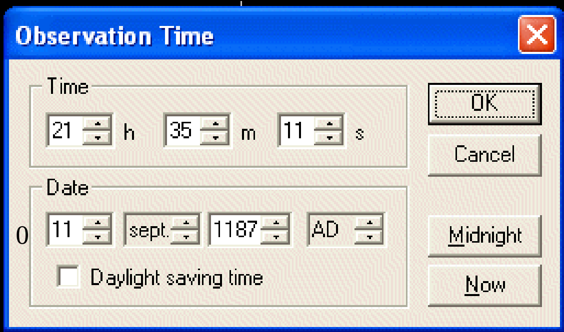
The axis of the cathedral was probably determined by the azimuth of the setting southern first quarter moon of september equinox.

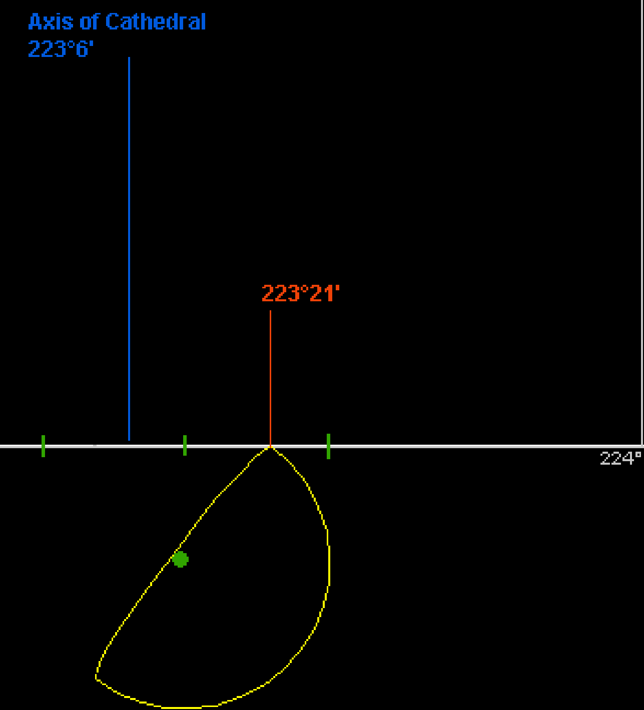


It is possible, in this case (1187 AD), to use a planetarium software (Skymap) to display the sky as it was seen by the Middle-Age astronomers who watched the setting of the standstill moon.



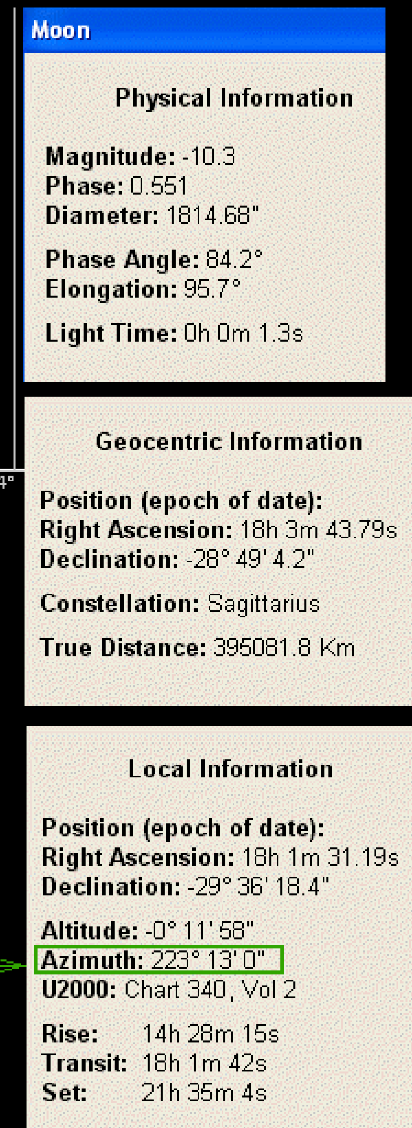
Standstill of 1187 AD ; southern setting of first quarter moon



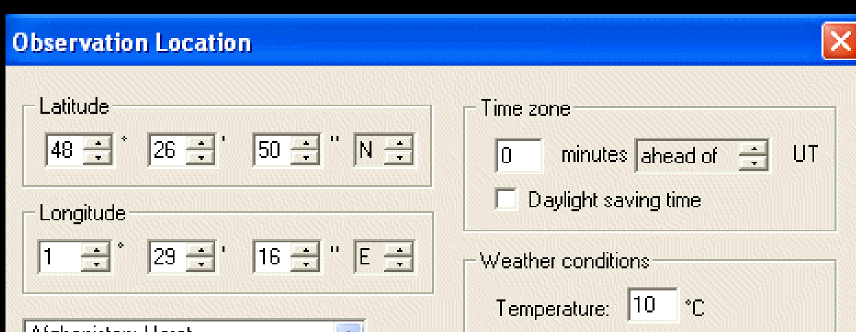


Maximum error due to refraction's variation = moon's radius

Culmination's altitude = 12°



Centre →



The « Skymap » program provides the same results than the theoretical calculations because the moon was reaching its maximum southern declination when it set.

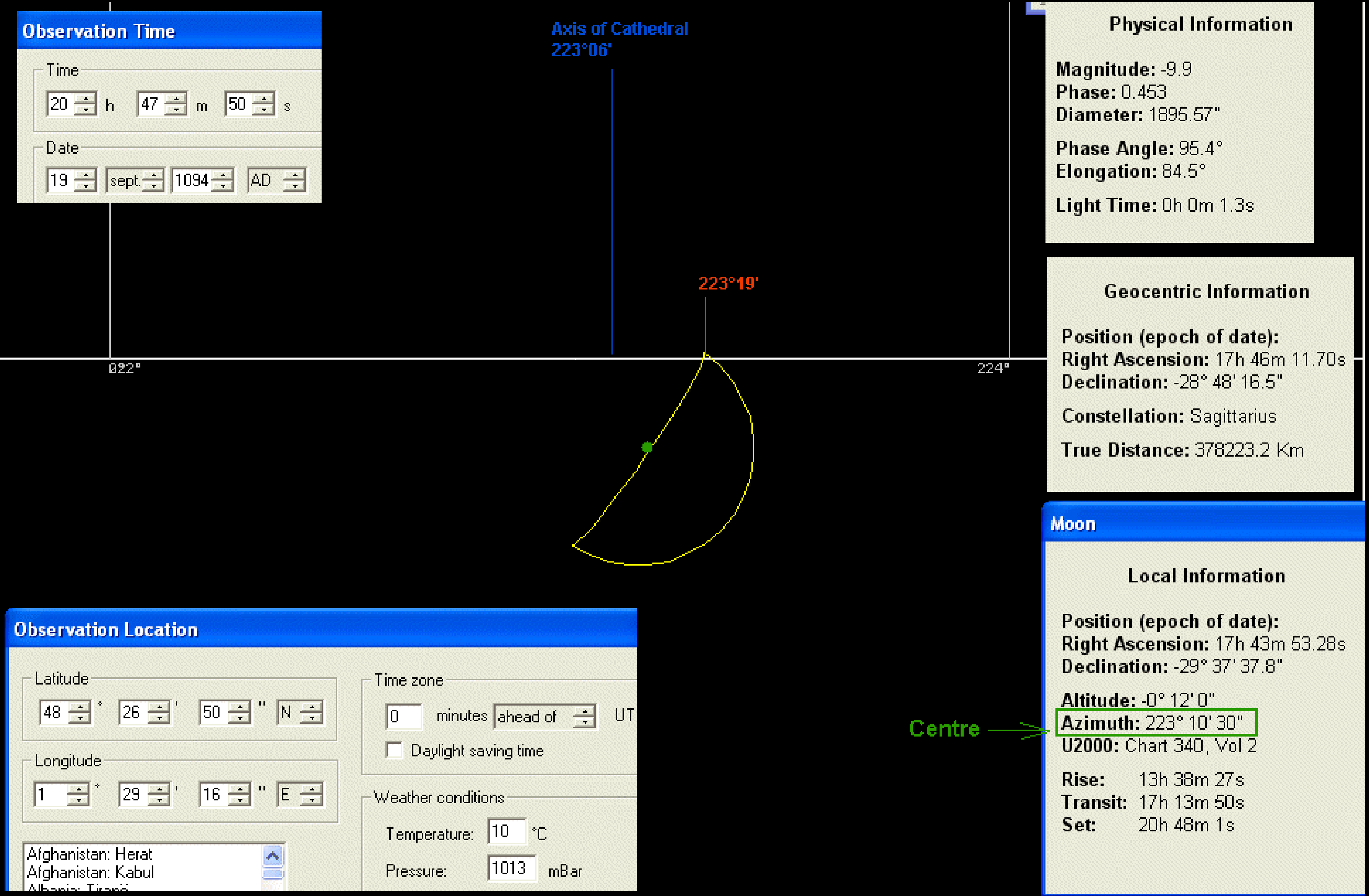
++ True Geocentric Lunar Coordinates ++

11-Sep-1187 in time zone: 0 with daylight saving: 0

DATE		LOCAL CIVIL TIME	RIGHT ASCENSION HMS	DECLINATION DMS
11-Sep-1187		18 0 26.000	17 55 8.916	- 28 49 44.087
11-Sep-1187	Maximum	19 0 26.000	17 57 30.764	- 28 49 45.385
11-Sep-1187		20 0 26.000	17 59 52.467	- 28 49 37.424
11-Sep-1187	Setting	21 0 26.000	18 2 14.019	- 28 49 20.233
11-Sep-1187		22 0 26.000	18 4 35.416	- 28 48 53.841
11-Sep-1187		23 0 26.000	18 6 56.651	- 28 48 18.281
12-Sep-1187		0 0 26.000	18 9 17.720	- 28 47 33.583
12-Sep-1187		1 0 26.000	18 11 38.618	- 28 46 39.780
12-Sep-1187		2 0 26.000	18 13 59.338	- 28 45 36.905
12-Sep-1187		3 0 25.999	18 16 19.877	- 28 44 24.994

The same azimuth could be observed during the standstill of 1094 AD

Standstill of 1094 AD ; southern setting of first quarter moon



During the major standstill of 1094 AD, the first quarter moon of september equinox was also setting at maximum southern declination.

++ True Geocentric Lunar Coordinates ++

19-Sep-1094 in time zone: 0 with daylight saving: 0

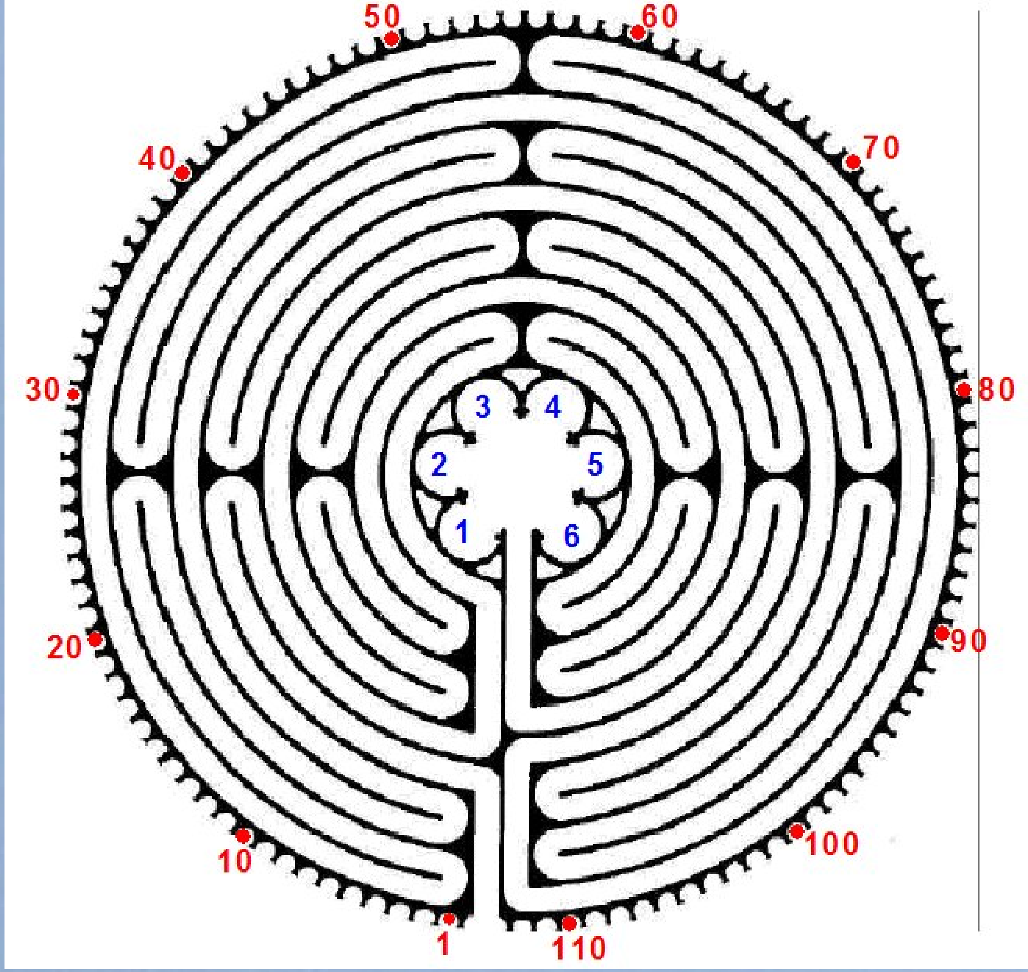
DATE		LOCAL CIVIL TIME	RIGHT ASCENSION HMS	DECLINATION DMS
19-Sep-1094		18 0 26.000	17 38 52.736	- 28 45 38.281
19-Sep-1094		19 0 26.000	17 41 26.707	- 28 46 44.435
19-Sep-1094		20 0 26.000	17 44 0.883	- 28 47 39.721
19-Sep-1094	Setting	21 0 26.000	17 46 35.255	- 28 48 24.096
19-Sep-1094		22 0 26.000	17 49 9.815	- 28 48 57.520
19-Sep-1094		23 0 26.000	17 51 44.554	- 28 49 19.954
20-Sep-1094		0 0 26.000	17 54 19.464	- 28 49 31.359
20-Sep-1094	Maximum	1 0 26.000	17 56 54.536	- 28 49 31.700
20-Sep-1094		2 0 26.000	17 59 29.761	- 28 49 20.944
20-Sep-1094		3 0 26.000	18 2 5.132	- 28 48 59.058

If we don’t take into account the entrance, there are 112 notches around the maze .

There are 6 « petals » in the central part.

112 / 18.61 = 6.018

There are almost exactly 6 lunar cycles of 18.61 years in 112 years.

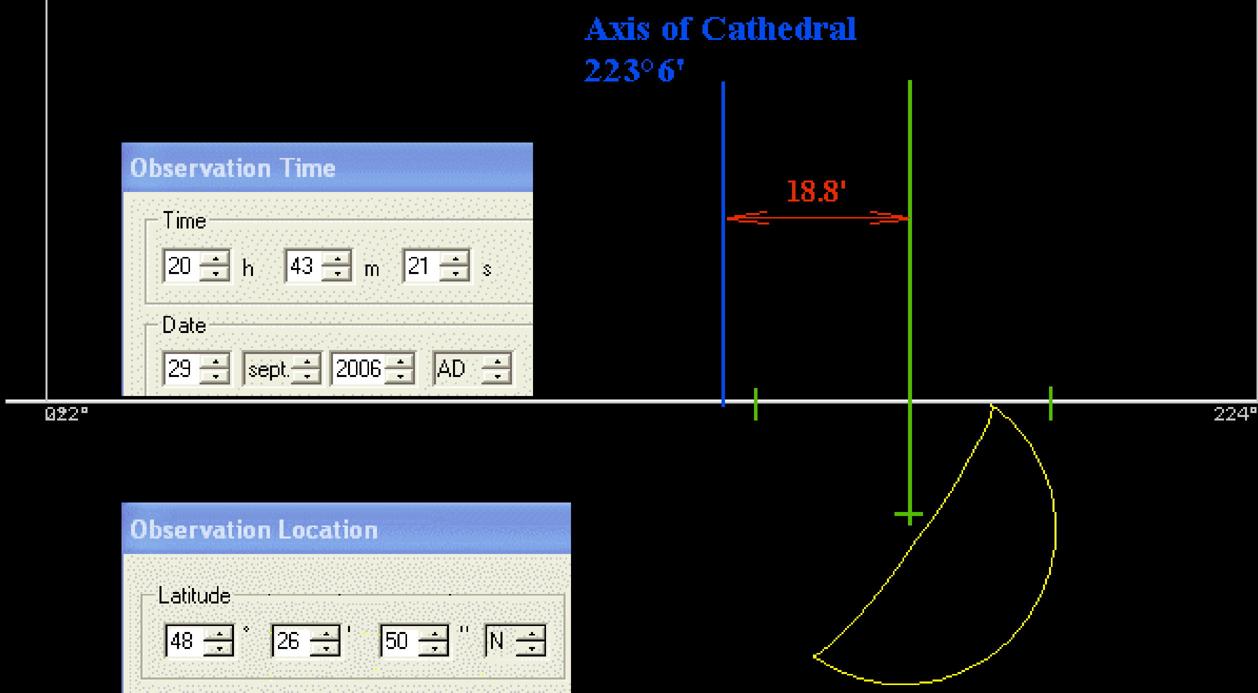


In Stonehenge, the 56 holes of Aubrey provide the same kind of information

The structure of the labyrinth confirms the lunar meaning of the site.

In conclusion, it seems that the tradition of lunar sightings has perpetuated in western France for five thousand years

Standstill of 2006 AD 29-09 20:43
Southern setting of first quarter moon



Observation Time

Time: 20 h 43 m 21 s

Date: 29 sept. 2006 AD

Observation Location

Latitude: 48° 26' 50" N

Longitude: 1° 29' 16" E

Physical Information

Magnitude: -9.8
Phase: 0.438
Diameter: 1857.45"
Phase Angle: 97.1°
Elongation: 82.8°
Light Time: 0h 0m 1.3s

Geocentric Information

Position (epoch of date):
Right Ascension: 17h 56m 49.66s
Declination: -28° 42' 38.1"
Constellation: Sagittarius
True Distance: 385985.0 Km

Local Information

Position (epoch of date):
Right Ascension: 17h 54m 33.70s
Declination: -29° 30' 56.1"
Altitude: -0° 12' 44"
Azimuth: 223° 24' 46"
U2000: Chart 339, Vol 2
Rise: 13h 33m 34s
Transit: 17h 8m 43s
Set: 20h 43m 21s

Obliquity = 23° 26' 28"
(23° 32' 50" in 1187)

Difference between 2006 and 1187 = 6.37 arc minutes

The moon will reach its maximum southern declination when it will set. The same event occured during the standstills of 1094 and 1187.

++ True Geocentric Lunar Coordinates ++

29-Sep-2006 in time zone: 0 with daylight saving: 0

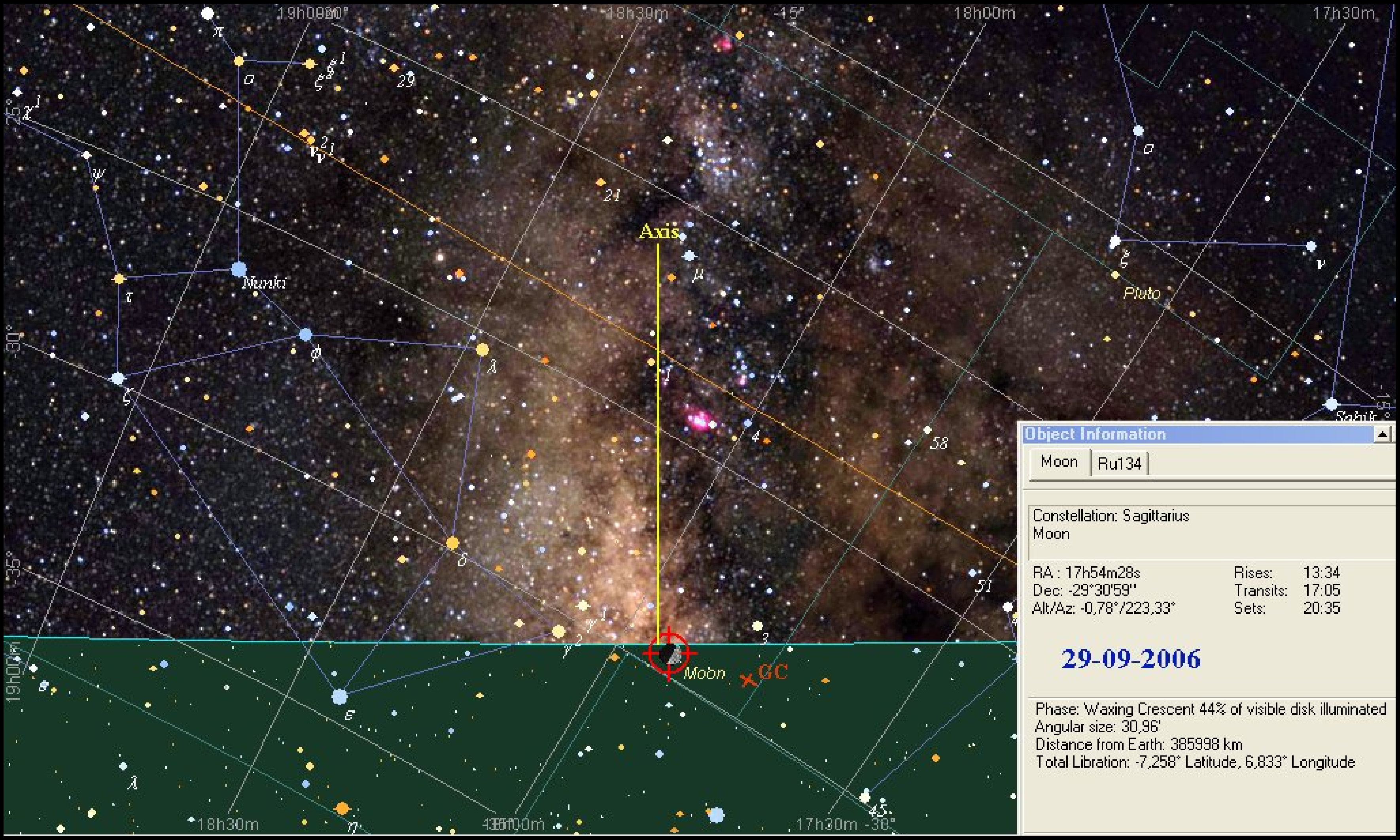
DATE	LOCAL CIVIL TIME	RIGHT ASCENSION HMS	DECLINATION DMS	
29-Sep-2006	15 43 0.000	17 44 25.976	- 28 40 40.965	
29-Sep-2006	16 43 0.000	17 46 53.216	- 28 41 24.532	
29-Sep-2006	17 43 0.000	17 49 20.649	- 28 41 58.168	
29-Sep-2006	18 43 0.000	17 51 48.270	- 28 42 21.834	
29-Sep-2006	19 43 0.000	17 54 16.073	- 28 42 35.493	
29-Sep-2006	20 43 0.000	17 56 44.050	- 28 42 39.109	MAX
29-Sep-2006	21 43 0.000	17 59 12.195	- 28 42 32.646	
29-Sep-2006	22 43 0.000	18 1 40.500	- 28 42 16.072	
29-Sep-2006	23 43 0.000	18 4 8.960	- 28 41 49.354	
30-Sep-2006	0 43 0.000	18 6 37.567	- 28 41 12.461	

Again (Y or N) .... ? Y

Previous

Chartres 29-09-2006

Southern setting of first quarter moon



1) Calculation of the hour angle (H)

Cos(H) = [sin(h0) - sin(phi)*sin(delta)] / [cos(phi)*cos(delta)]

H = hour angle
phi = latitude
In this case (Carnac): phi = **47.6°**
sin(phi) = 0.7384
cos(phi) = 0.6743
delta = declination
In the case of a southern minor standstill circa 1700 BC:
delta = -(23.897° - 5.145°)
= - 18.752°
sin(delta) = -0.3215
cos(delta) = 0.9469

The inclination's perturbation was not taken into account (Thom's method)

h0 = P – R – r – C1 – C2

P = parallax = 57' = **0.95°** (mean horizontal parallax of the moon)

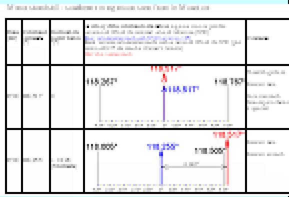
R = refraction
In this case, R = 0.62°. It is the refraction applied to an object situated at 0.25° below the horizon. It is the altitude of the moon's center when the upper limb is on the horizon

r = radius of the moon (0.25°)

C1 is calculated from the altitude of the observer
C1 = 0.032° * square-root(A)
With A = altitude (meters) of the observer with respect to the sea level
= altitude of the little menhir on le Moustoir tumulus
According to the topographic map, this altitude is equal to 30 m but Thom uses an altitude of about **18 m** because he takes into account the curvature of the Earth decreased by the curvature of the refracted rays.
Thus, CI = **0.1358°**

C2 is calculated from the altitude of the observer's horizon (it is not the horizontal plane of reference which is the basis of all astronomical calculations).
Tg(C2) = D / l
D = altitude of the observed area.
= 14 m (more or less the altitude of the basis of Locmariaquer's GBM)
l = distance between backsight and foresight = 9900 m
Thus, C2 = **0.081°**
A check: according to Thom, "the altitude of the distant high ground is probably about –3' " . I'll call this value the "dip" (word used by the sailors)
Now: -C1 + C2 = -0.1358° + 0.081° = -0.0548° = -3.29'

So: cos(H) = 0.2378 / 0.6385 = 0.3725
H = 68.1301°
tg(H) = 2.4914 (used here below)



2) Calculation of the azimuth (a) of rising

tg(a) = - sin(phi)*tg(H)
tg(a) = -0.7384*2.4914 = -1.8396
a = -61.4717°
We have to remove the ambiguity which arises from taking the inverse tangent
a = -61.4717° + 180° = 118.5283° = 118° 31.7'

It is exactly the azimuth calculated by Thom (118° 31') and the azimuth giving, in the program of Victor Reijs (http://www.iol.ie/~geniet/eng/decli.htm), the correct declination (next slide).

With a pocket calculator:

Azimuth from le Moustoir
to Grand Broken Menhir = 118° 31.7'
According to Thom: 118° 31'

BUT: 1) perturbation (Δ) = 0

The calculated azimuth is not the extreme monthly azimuth of the minor standstill (118° 16')
It is the azimuth of a crescent or gibbous rising moon observed between an equinox and a solstice.

2) The date (1700 BC) is wrong.

The Grand Broken Menhir was erected circa 4500 BC and destroyed circa 4000 BC.

I suggest that this problem of date can be solved by taking into account the perturbation.

With the program of Victor Reijs (http://www.iol.ie/~geniet/eng/decli.htm)

Return

Same results … and same problems.

Calculating the declination and azimuth

On this web site we always talk about geocentric declination (if topocentric declination is meant it will be explicitly mentioned). Browser should support **JavaScript**

For some useful conversion see below

General parameter

Air pressure: 1013.25 [mbar] (at ◉ eye or ○ sea height reference)

Temperature: 10 [°C] (using same height reference as *Air pressure*)

Time of day: ◉ night time ○ sun set/rise ○ day time

Celestial object: ◉ moon ○ sun and others

Astronomical date: -1700 (positive for CE and negative for BCE) **Date chosen by Thom**

Latitude: 47.6 [°] +/- 0.01 [°]

Azimuth: 118.516 [°] +/- 0.2 [°] **Azimuth from le Moustoir to Er Grah**

Eye height: 0 [m]

Distance to distant object: 1 [km]

Distant (object) height: 0 [m]

○ distant object

○ vast plain horizon

◉ given apparent altitude: -0.3 [°] +/- 0.2 [°]

radius of moon (0.25°)
+ "dip" (0.05°) calculated by Thom

Calculate apparent altitude: -0.3 [°]

○ given altitude: 0 [°] +/- 0.25 [°]

Altitude (without refraction)
used to calculate the declination

Calculate altitude -0.9417 [°] +/- 0.25173 [°]

declination -18.7712 [°] +/- 0.23304 [°] **Calculated declination = declination of 1700 BC**

Azimuth, in 1700 BC, taking into account the inclination perturbation: not correct

Calculating the declination and azimuth

On this web site we always talk about geocentric declination (if topocentric declination is meant it will be explicitly mentioned). Browser should support **JavaScript**

For some useful conversion see below

General parameter

Air pressure: 1013.25 [mbar] (at ◉ eye or ○ sea height reference)

Temperature: 15 [°C] (using same height reference as *Air pressure*)

Time of day: ○ night time ◉ sun set/rise ○ day time

Celestial object: ◉ moon ○ sun and others

Astronomical date: -1700 (positive for CE and negative for BCE)

Latitude: 47.6 [°] +/- 0.01 [°]

Azimuth: 118.27 [°] +/- 0.2 [°] → Too small

Eye height: 1.5 [m]

Distance to distant object: 1 [km]

Distant (object) height: 0 [m]

○ distant object

○ vast plain horizon

◉ given apparent altitude: -0.3 [°] +/- 0.2 [°]

Calculate apparent altitude: -0.3 [°]

○ given altitude: 0 [°] +/- 0.25 [°]

Declination in 1700 BC taking into account the perturbation

(extreme positive value)

Calculate altitude -0.9305 [°] +/- 0.25083 [°]

declination -18.608 [°] +/- 0.23240 [°]

Azimuth, in 4500 BC, taking into account the inclination perturbation: OK

Return

Calculating the declination and azimuth

On this web site we always talk about geocentric declination (if topocentric declination is meant it will be explicitly mentioned). Browser should support **JavaScript**

For some useful conversion see below

General parameter

Air pressure: 1013.25 [mbar] (at ◉ eye or ○ sea height reference)

Temperature: 15 [°C] (using same height reference as *Air pressure*)

Time of day: ○ night time ◉ sun set/rise ○ day time

Celestial object: ◉ moon ○ sun and others

Astronomical date: -4500 (positive for CE and negative for BCE)

Latitude: 47.6 [°] +/- 0.01 [°]

Azimuth: 118.66 [°] +/- 0.2 [°] ← Error = 0.14°

Eye height: 1.5 [m]

Distance to distant object: 1 [km]

Distant (object) height: 0 [m]

○ distant object

○ vast plain horizon

◉ given apparent altitude: -0.3 [°] +/- 0.2 [°]

Calculate apparent altitude: -0.3 [°]

○ given altitude: 0 [°] +/- 0.25 [°]

for refraction a variation of 18% of nominal value is assumed
So, the error in calculated azimuth is around 0.2°

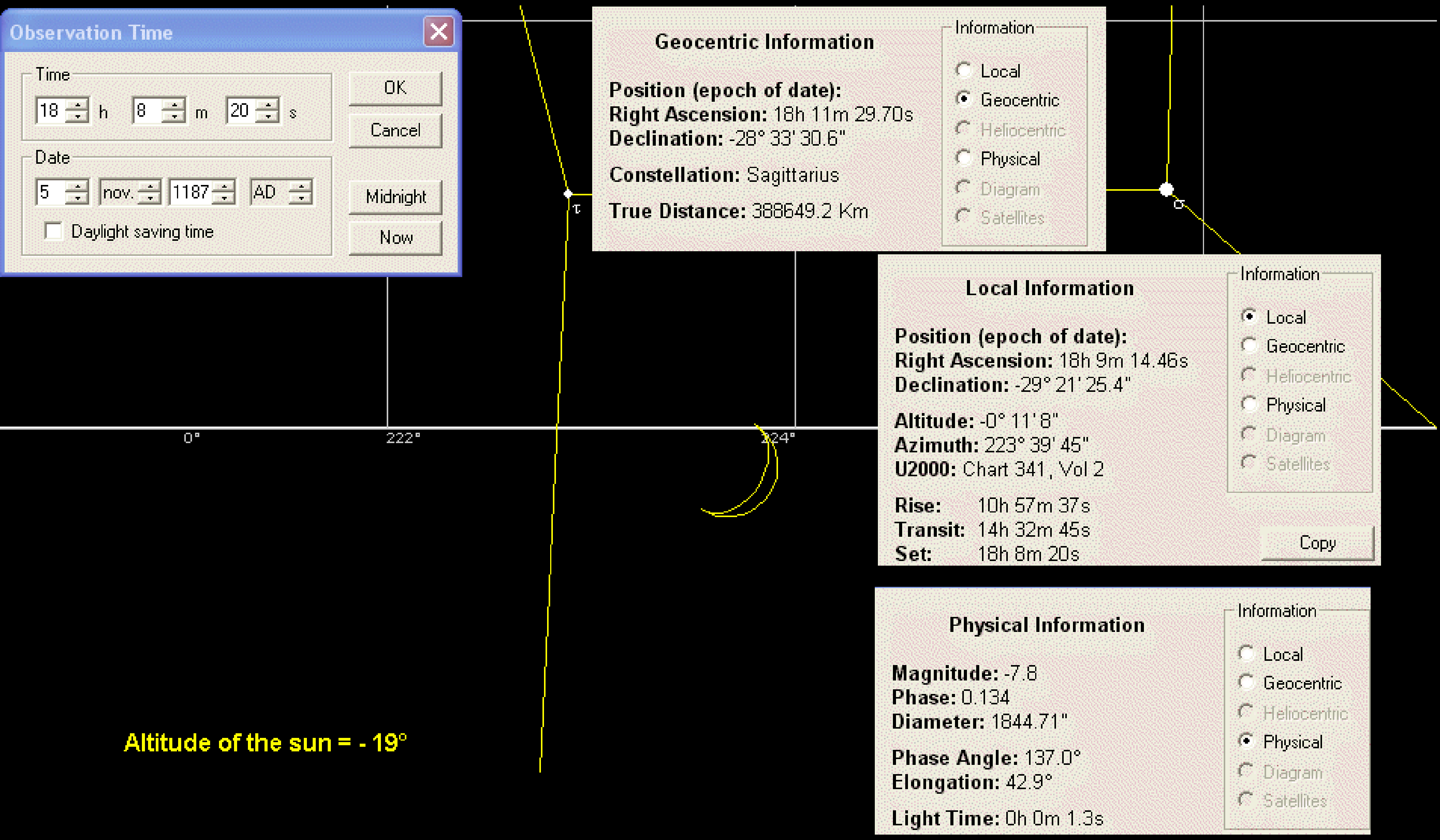
Calculate altitude -0.9305 [°] +/- 0.25083 [°]

declination -18.852 [°] +/- 0.23247 [°]

Declination of minor southern standstill in 4500 BC
Obliquity = 24.1419°

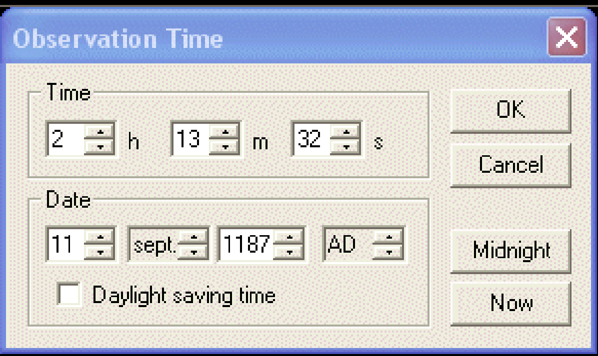
Chartres Standstill of 1187 AD

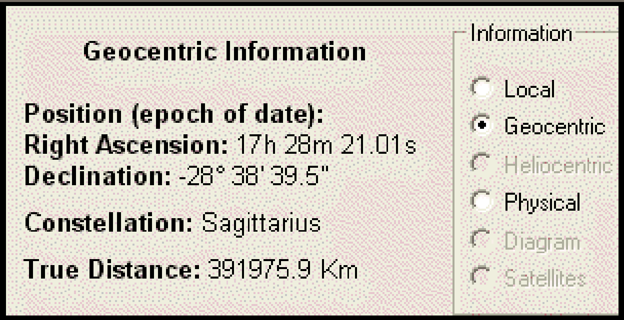
First crescent between equinox and solstice
Southern setting

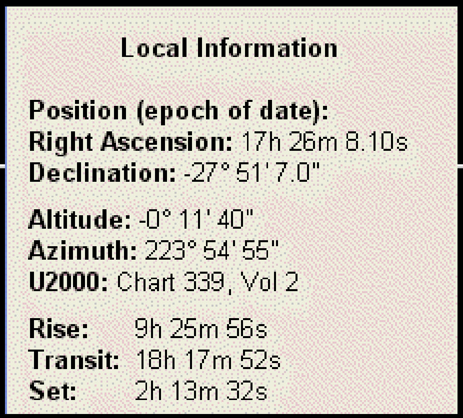


Patagonia

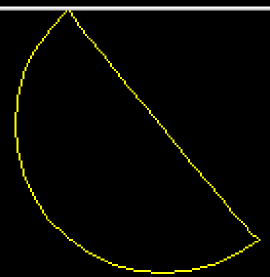
Standstill of 1187 AD ; southern setting of first quarter moon



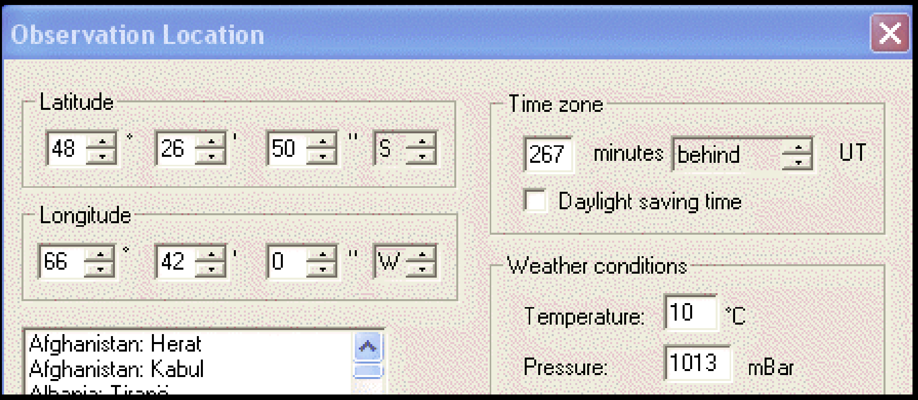


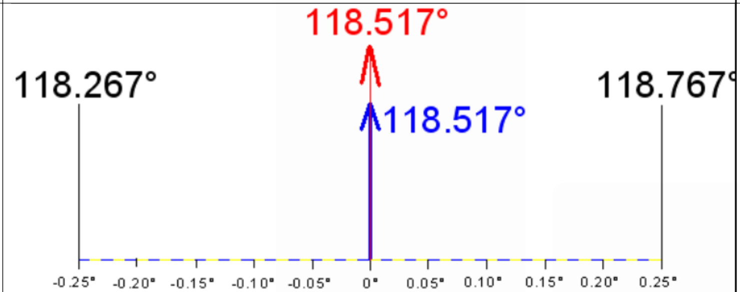
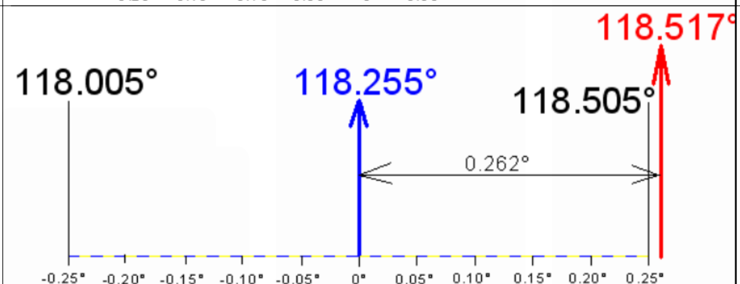
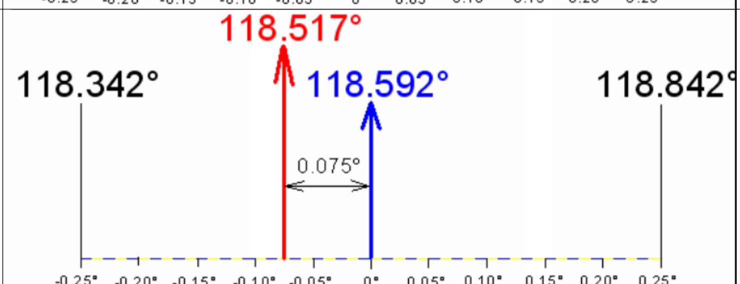
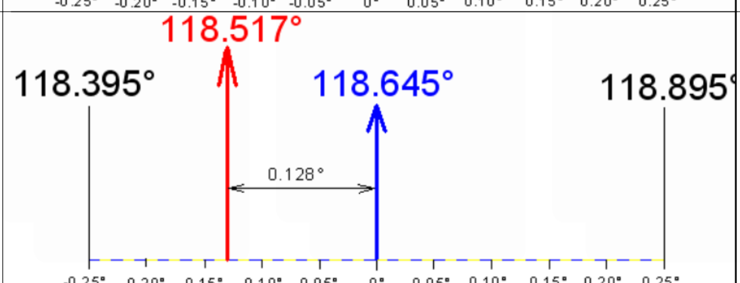


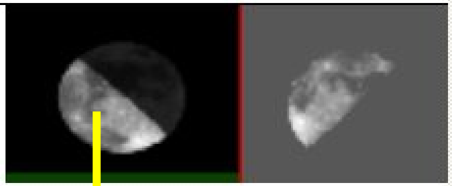
0°

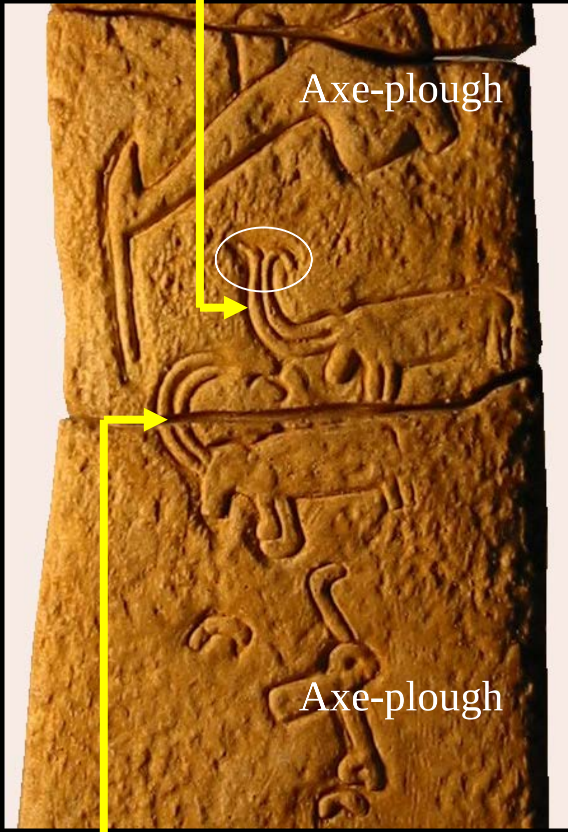


Culmination’altitude = 70°



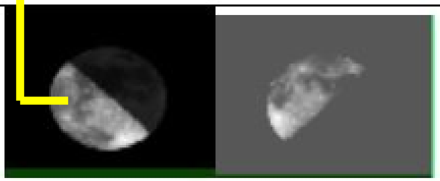
Dates (BC)	Calculated Azimuths (°)	Maximum positive value of inclination's perturbation	Accuracy of the calculated azimuth taking into account a possible variation of 30% of the nominal value of refraction (NVR). Blue: calculated azimuth with NVR (variation = 0°) Black: extreme calculated azimuths with variation of 30% of the NVR (plus or minus 0.25° of azimuth at Carnac's latitude) Red: observed azimuth	Comments
1700	118. 517	no		Incorrect date. Correct azimuth because perturbation is ignored.
1700	118. 255	yes		Incorrect date. Incorrect azimuth.
4000	118. 592	yes		Approximate date of the Grand Menhir's destruction. Acceptable Azimuth.
4500	118. 645	yes		Approximate date of the Grand Menhir's erection. Acceptable Azimuth.

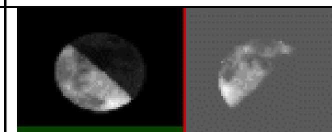
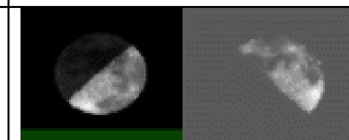
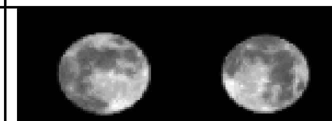
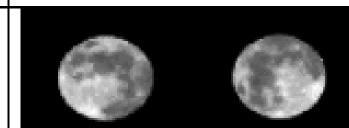
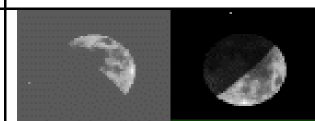
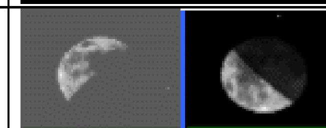
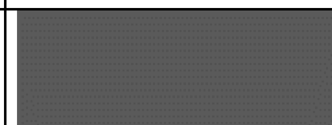
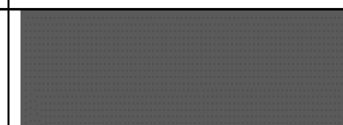
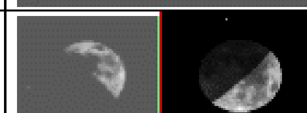
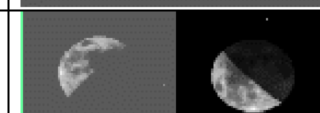
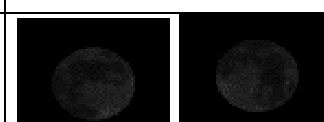
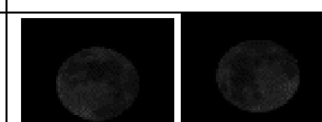
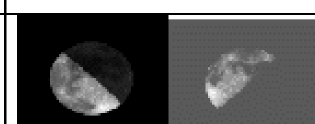
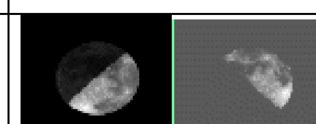
Southern	$-(\varepsilon + \beta)$ -29.4319°	$-(\varepsilon - \beta)$ -18.8519°	Δ maximum β = i+Δ = 5.29°	March equinox Third quarter	



On the broken stele, the oversized horns of the upper bull would be the third quarter southern rising moon of March equinox observed during a standstill (from le moustoir, for example). The oversized horns of the lower bull would be the third quarter northern rising moon of September equinox oberved also during a standstill. The big and small 'axe-ploughs' would indicate respectively the beginning and the end of the farmwork. The tip of the top horns (white ellipse) could be a symbol of blooming.

Between the North Cape of Norway and Gibraltar, we find only three bull's representations and all three are in Locmariaquer

Northern	$\varepsilon + \beta$ 29.4319°	$\varepsilon - \beta$ 18.8519°	Δ maximum β = i+Δ = 5.29°	September equinox Third quarter	

ε = obliquity (24.1419° in 4500 BC) **i = inclination** **Δ=perturbation** of inclination **δ = declination**	Extreme declination at major standstill **δ**	Extreme declination at minor standstill **δ**	Corrected inclination **β = i + Δ** **i = 5.145°** Δmin = -0.145° Δmax= 0.145°	Near solar event	Northern hemisphere Rising Setting	Southern hemisphere Rising Setting
Southern	$-(\varepsilon+\beta)$ -29.4319°	$-(\varepsilon-\beta)$ -18.8519°	Δ maximum $\beta = i+\Delta = 5.29°$	March equinox Third quarter		
Southern	$-(\varepsilon+\beta)$ -29.1419°	$-(\varepsilon-\beta)$ -19.1419°	Δ minimum $\beta = i+\Delta = 5°$	June solstice Full		
Southern	$-(\varepsilon+\beta)$ -29.4319°	$-(\varepsilon-\beta)$ -18.8519°	Δ maximum $\beta = i+\Delta = 5.29°$	September equinox First quarter		
Southern	$-(\varepsilon+\beta)$ -29.1419°	$-(\varepsilon-\beta)$ -19.1419°	Δ minimum $\beta = i+\Delta = 5°$	December solstice New		
Northern	$\varepsilon+\beta$ 29.4319°	$\varepsilon-\beta$ 18.8519°	Δ maximum $\beta = i+\Delta = 5.29°$	March equinox First quarter		
Northern	$\varepsilon+\beta$ 29.1419°	$\varepsilon-\beta$ 19.1419°	Δ minimum $\beta = i+\Delta = 5°$	June solstice New		
Northern	$\varepsilon+\beta$ 29.4319°	$\varepsilon-\beta$ 18.8519°	Δ maximum $\beta = i+\Delta = 5.29°$	September equinox Third quarter		
Northern	$\varepsilon+\beta$ 29.1419°	$\varepsilon-\beta$ 19.1419°	Δ minimum $\beta = i+\Delta = 5°$	December solstice Full