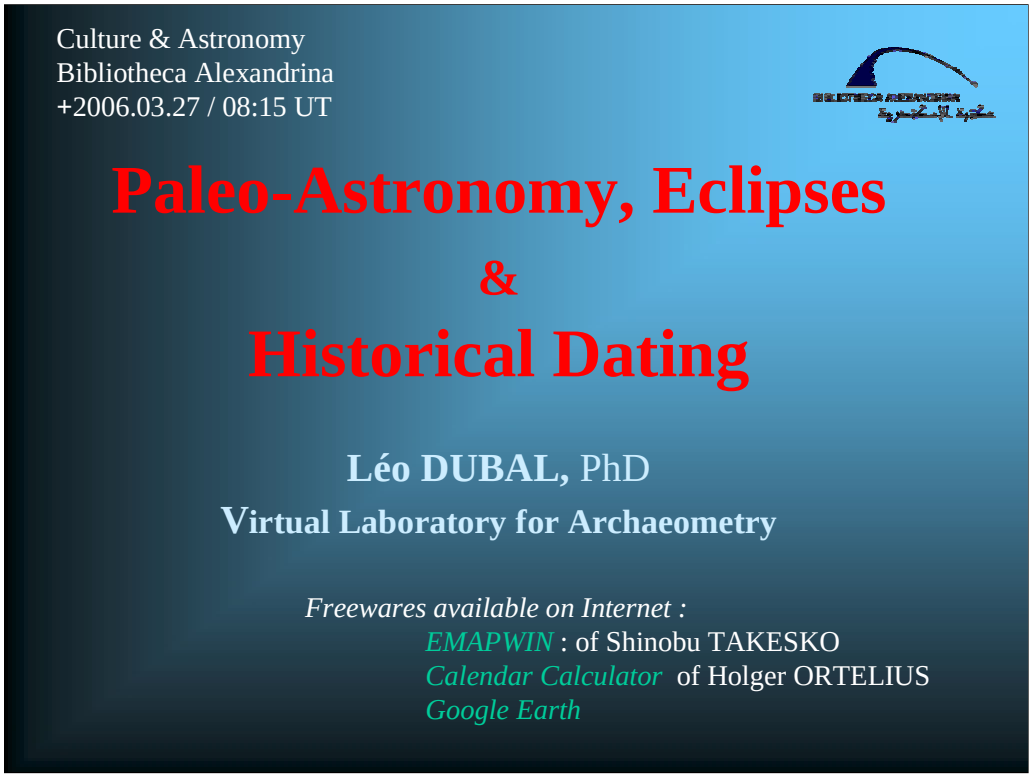
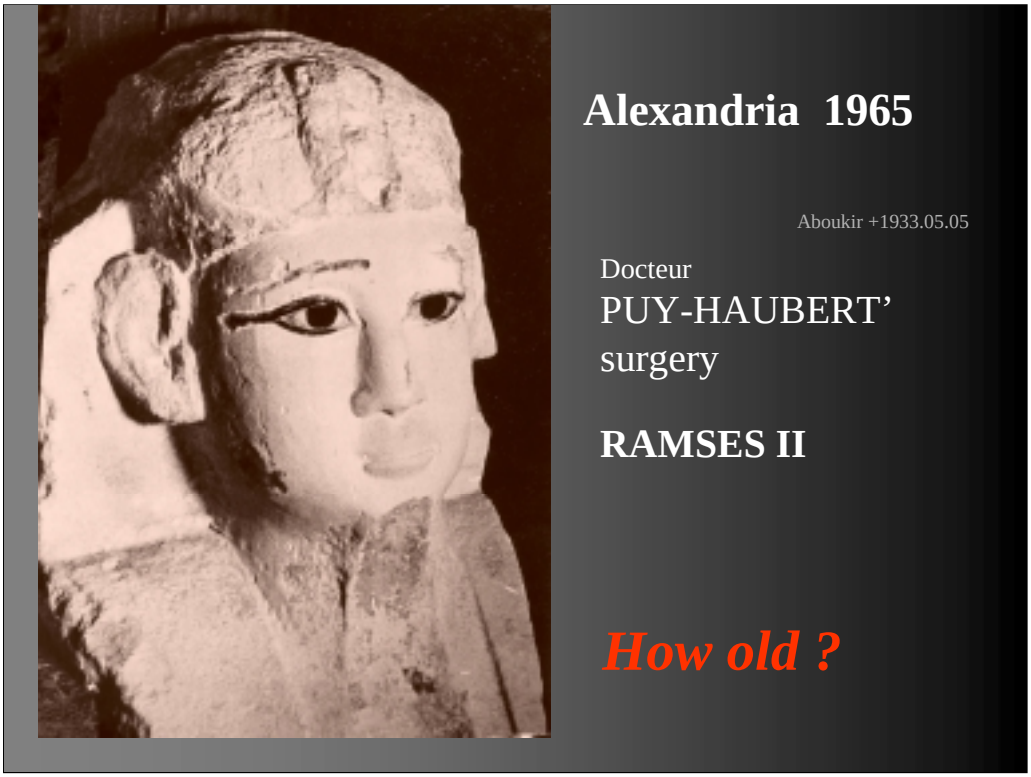
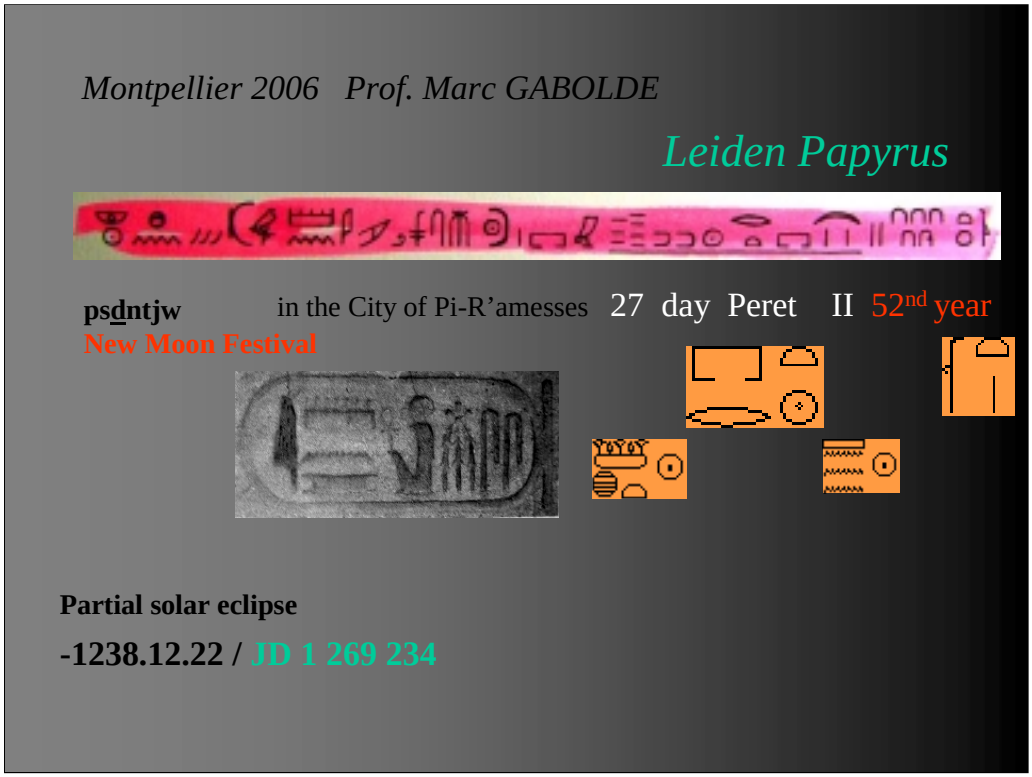


I would like to thank the organizers of this Lecture series to have extended to me the hospitality of this Mythical Library & given to me the opportunity to present some new results in Paleo-Astronomy, Eclipses & Historical Dating.
As my lecture deals with Chronology, let me introduce the time format I will be using:
first the year with the sign + for Common Era, or minus for years Before Common Era.
Then the month. Then the day. Then the hour, expressed as Universal Time.
The results presented here, have been obtained thanks to three freewares now available on Internet:
1) EMAPWIN to retro-predict solar eclipses
2) Ortelius Calculator to convert a date from a given calendar into another, and
3) Google Earth to obtain the GPS coordinates of any observation sites in the world.



During my 1st trip to Alexandria, forty years ago,
I stayed by Dr Puy Haubert, who belonged to the team who discovered, in 1933, the under sea-water ruins in Aboukir.
The Doctor had in his clinic this beautiful head, which he claimed to be the one of Ramses II.
At this time,
as a young High energy Physicist,
I was already curious about how to date Ramses II.



Surprisingly, I found early this year a satisfactory answer to this. Professor Marc Gabolde, from University of Montpellier, made me aware of a ship Log Book on recycled Papyrus, called the "Leiden Papyrus".
It mentions: 52nd regnal year, Season Peret, 27th day.
Let's say there are 3 seasons in the Ancient Egyptian Calendar: Akhet, Peret & Shemu.
Further, the City of Pi-Ra-meses is mentioned. This points out to a Pharaoh of the Rameses' Dynasty. But only Ramses II reigned long enough to be a candidate.
And, *last but not least*, a New Moon Festival is mentioned. New Moon might of course coincide with a solar eclipse. In fact, a partial eclipse did occur over Kamchamka on -1238.12.22.
This date is a good candidate for this most precious Log-book.
This date could also be expressed as
Julian Day **1 269 234.**

Linear vs Cyclic Time Scales

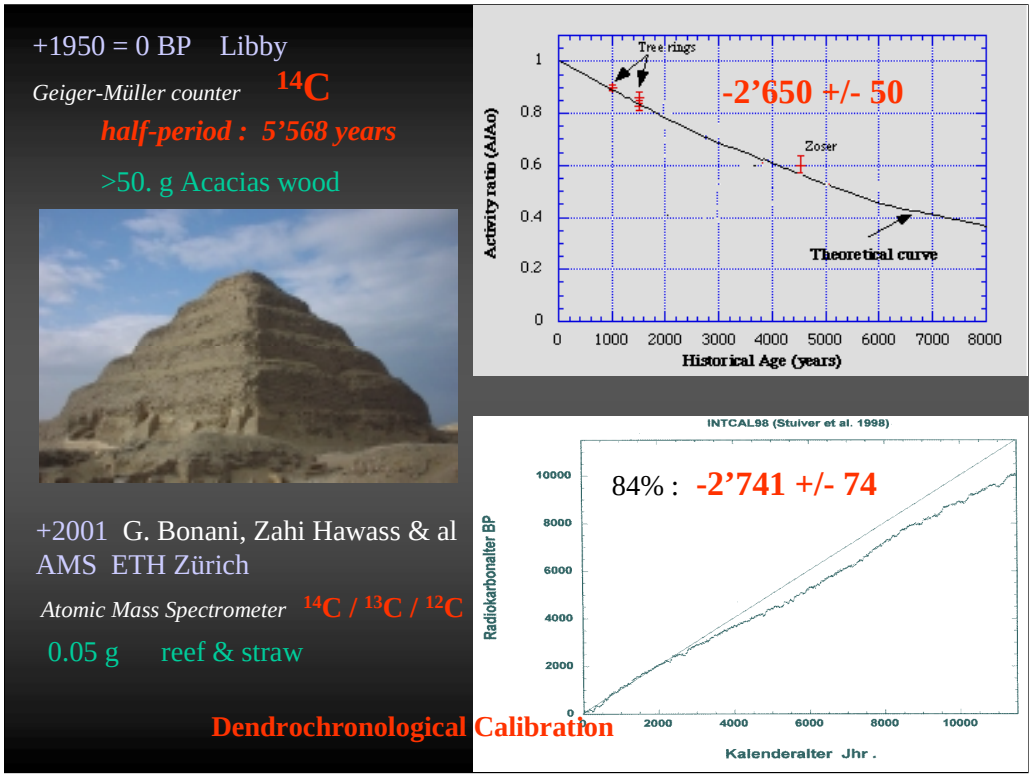
1. Linear time scales :

1583 *Publication in Geneva:* "De emendatione temporum" Breakthrough in Chronology
Joseph-Juste Scaliger's **Julian Day** Scale
Correspondances with Sosigene's *Julian calendar*
JD 1 = - 4'712.01.01/12:00 UT
and *Common Calendar* **JD 2 453 822** = +2'006.03.27/12:00 UT

1968 Atomic Clock ^{133}Cs hyperfine transition:
AT **second SI** **1 sSI = 9.**192 631 770 GHz

1950 **^{14}C** radioactive decay rate *half-period : 5'568 years*
0 BP (**Before Period**) = 1950

Let us explain what are those JD and other time scales.
Times scales are of two types: linear or cyclic.
In a *linear time scale y*ou just pile-up one time element onto the next one.
The first linear time scale has been invented only 483 years ago, in Geneva, my home town. Joseph-Juste SCALI**GER** is the one to be thanked for this major breakthrough in Chronology. He named his reformist time scale JULIAN DAY, in honour of his father Julius Caesar de L'Esqualle, said Scaliger. Julian Day ONE is defined at noon time, January 1st, 6'718 years ago, and today, at lunch time it will be **JD2 453 822**. *Another linear time scale* is generated by atomic clocks.
The 2nd is… the *second* which is defined as the time interval for 9 Billions transitions between energy level of Caesium-133, a very stable Atomic clock.
A 3rd linear time scale is the decay of a radioactive chemical element: 14C. Its half-period is 5'568 years long.

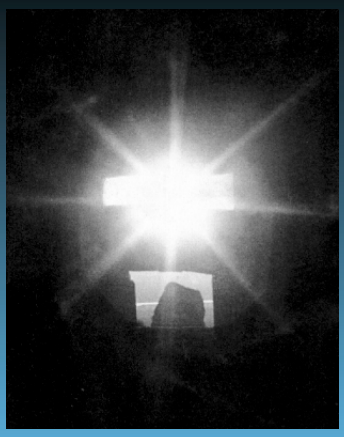


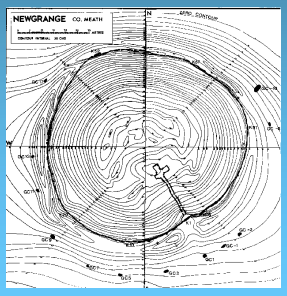
In 1950 took place the 1st test of 14C-datation method.
With 50 g of acacia wood found in the Zoser' Pyramid, the date obtained was year –2'650.

This method improved tremendously over the last 50 years. In 2001, Dr Zahi Hawass, the Chief of the Egyptian Antiquities and former colleagues of mine, in Zürich,
used samples of reef and straw from adobe bricks from the 3rd tier of the Pyramid, in the amount of 50 mg,
i.e. only one thousandth of the weight used before.

Those researchers found a date older by nearly one hundred years to all the previous datation attempts.

Let's look at 2 other *linear time scales*.
Previously, the "Length of the Day" was defined as 86'400 seconds long. Therefore a period must occur when the second, defined as one part of a day in 86'400, matches exactly the second defined by an Atomic clock. A convenient choice for this date is **JD 2 339 200**.
The next question is: When does a day begin? It's a matter of taste. JD starts at noon, but there are alternatives ranging from sunrise to midnight.
Another important time scale is the yearly circumsolar journey of the Earth.
Already in year –230, Ptolemy Euergetes tried to introduce a calendar year of "365 days and a quarter".
But one had to wait for two more centuries, until Sosigenes and Julius Caesar succeeded to introduce the
so-called Julian Calendar but this Calendar, obviously, has nothing to do with Julian Day.
Now, the next question is: When does a year begin?





Newgrange

Winter solstice

5’200 BP

In the Northern Hemisphere, 5’250 years ago, in Newgrange, in Ireland, the year was beginning at sunrise on winter solstice day. There is a tumulus, there, with a 19 meters long corridor, a kind of sight-telescope, allowing the sun to illuminate the engravings at the bottom of this light-guide at winter solstice dawn.

Under the tropics another feature dominates.
Let me come back to a topic already mentioned yesterday by Jean-Yves Daniel and Hoda Elmikaty.

Here the students of the School Naguid Mahfouz in Assouan demonstrate, how, on June 21st, at twelve fifty local time, there is no more shadow around.

On summer solstice day, in Assouan, on the Elephantine Is., the bottom of the mythical Eratosthene's well is illuminated. Here is the story of the *most impressive Paleo-astronomical measurement ever achieved:*

2'080 years ago, Eratostene had the genial idea to correlate this absence of shadow with the shortest shade in Alexandria. Here, at local noon, on summer solstice day, the shade is one fiftieth of a full circle.

On the other hand, Elephantine is located 50 caravanning days southern from here. If you take, 16 km as the daily average of a dromedary ride, you end up with 40'000 km for the Earth's circumference. In fact, this figure has been taken by the geometers of Napoleon to define what we call nowadays the meter.

2. *Mnemotechnical Cyclic Time Scales :*

- **1** **Jia** - **Zi** period
  5x12 = 6x10 = 60 days

  6x60 = 360 days

- 1 **week** period = 7 days : ***SUN***, ***MOON***, MARS, MERCURY~ *Mittwoch*, JUPITER, VENUS, SATURN
- 4 weeks period = 28 days ~ 1 lunar month
- 52 weeks period = 364 days ~ 1 solar year

Now let's examine Cyclic Time Scales.
Since 40 centuries, the Chinese use the Jia-Zi period, a 10 by 12 matrix. 60 combinaisons of two ideograms serve as a mnemotechnical way to remember a 60 days long period. Unfortunately, the Jia-Zi cyclic period does not represent well neither lunar month nor solar year.

The 7 days weekly period, in comparison, appears to allow a far better match.

More mnemotechical cyclic time scale

1 *Ancient Egyptian Year* period

3 Seasons x ***4 months*** x ***30 days = 360 days***
+ 5 additional days = 365 days



Osiris
Horus
Seth
Isis
Nephthys

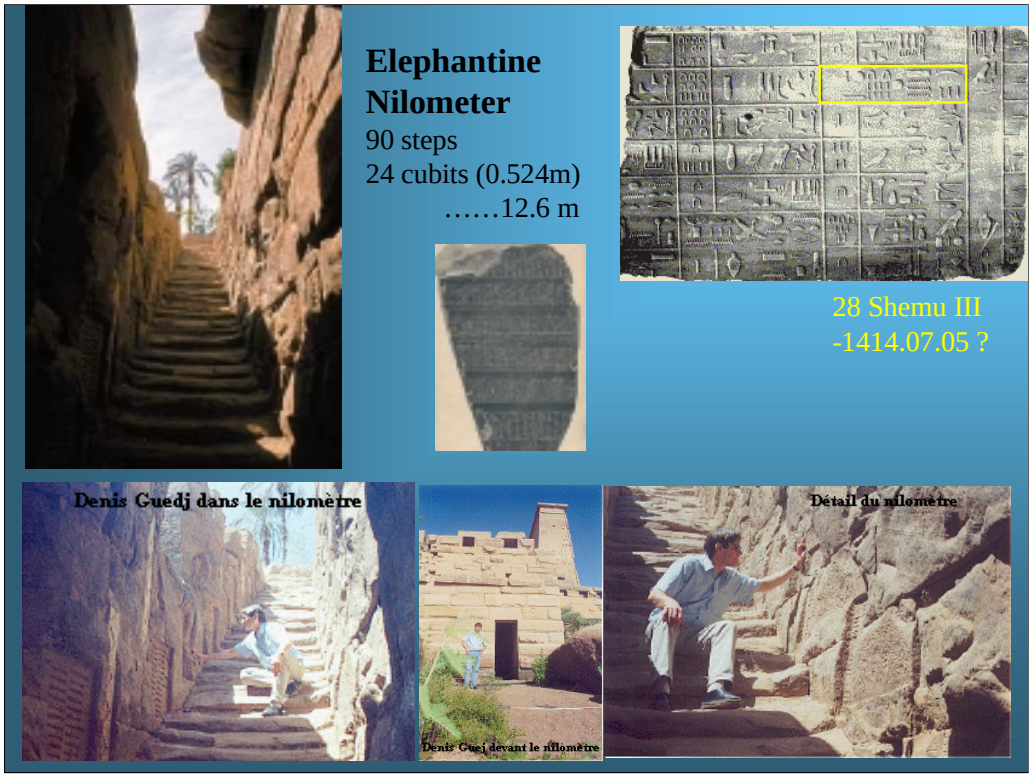
Akhet		Proyet		Shomu		epagomena
(Inundation)		(Sowing)		(Low Water)		
I	Thoth	V	Tybi	IX	Pachons	5
II	Phaophi	VI	Mechir	X	Payni	days
III	Athyr	VII	Phamenoth	XI	Epiphi	
IV	Choiak	VIII	Pharmuthi	XII	Mesore	only

Initially: **1 Akhet I** *(Thot1) had something to do with inundation….*

When ?

Starting of the flood of the Nile : Summer Solstice in Elephantine

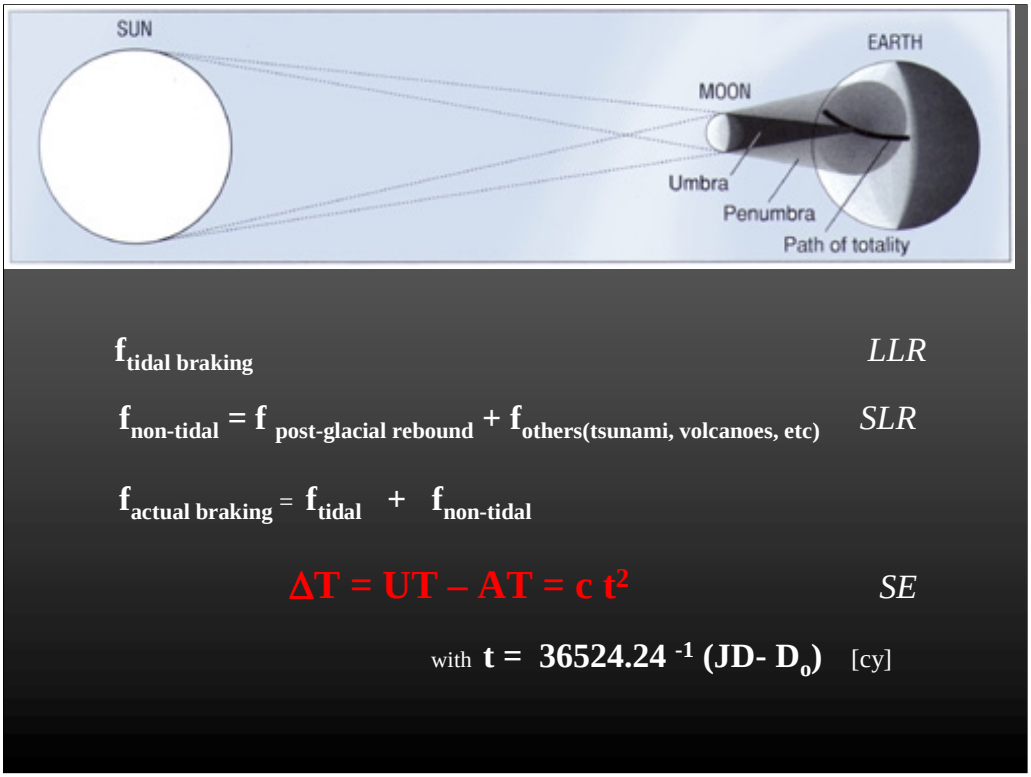
Another cyclic period, particularly relevant to our topic, is the Ancient Egyptian Calendar. The name of each season is an help in understanding the genesis of this calendar.
The first season AKHET means inundation. When does the flood begin in Upper-Egypt?
In Elephantine, this just occurs at the time of the year, when the shadow disappears….



No surprise to find there the largest Nilometers to measure the level of the Nile's waters.

Here again, the 1st Megaton monument. Its AMS Dating overlapps year –2'767. The 1st day of the Egyptian year was 1AkhetI, the 1st day of the Inundation Season. It means the great Imhotep might be the one who launched the Egyptian Calendar 4'772 years ago.
After a few decades, the season Akhet was no longer in phase with the inundation cycle. Nevertheless this mnemotechnical time scale was like divine words and survived 30 centuries.

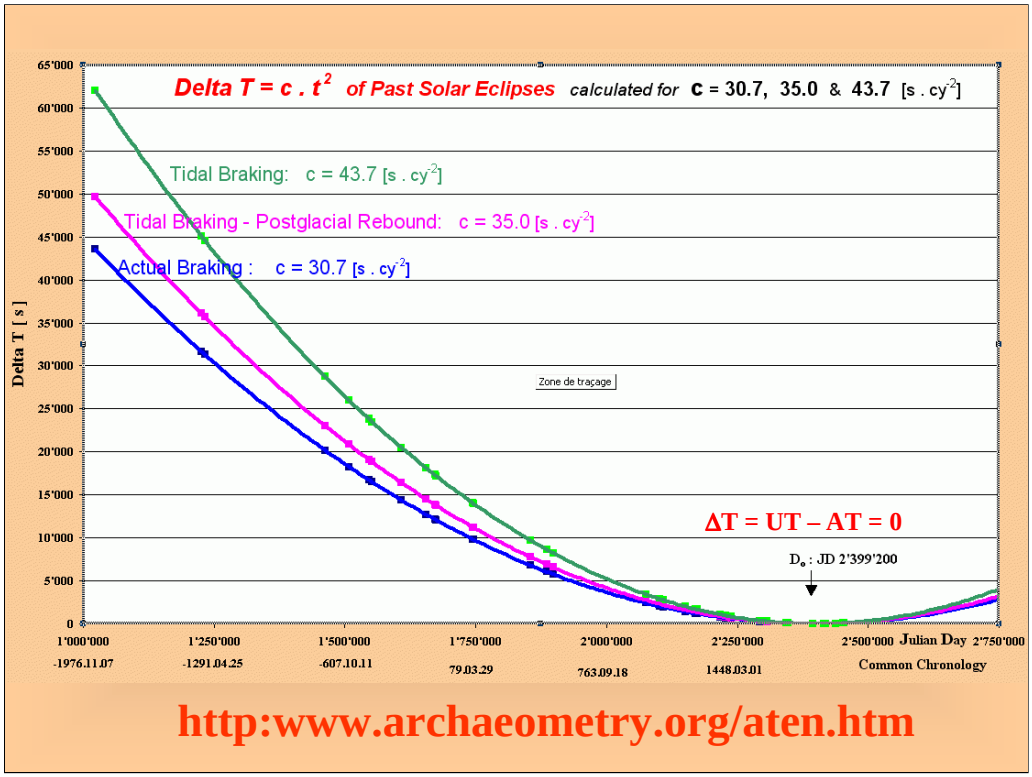
Now, how do solar eclipses & ephemeredes could be used for datation. On this picture of the Earth taken from a Russian satellite VOSTOK, one sees the shadow of the Moon which the SUN is casting onto the Earth. As the Earth is rotating a narrow shadow path is generated.
To retro-predict an ancient eclipse, one should not only know the position of the Moon relative to the Sun & the Earth, but also the changes in the speed of rotation of the Earth.



Galileo today would say: "…*and still it slows down*". The Moon induces ***tides*** which slow down the Earth by rubbing the bottom of the oceans. With Lunar Laser Ranging, LLR, one can measure this tidal braking force.

There are also non-tidal effects. The most important one is the so-called post glacial rebound: 10'000 years ago, the Earth was compressed by huge polar ice caps. As this ice melts away, the Earth looses steadily some of its extra belt and recovers a more spherical shape. The effect is the same as when you sit on a rotating chair. If you fold your arms, you will spin faster. It's the Satellite Laser Ranging, SLR, which gives us information on the changes in Earth's oblateness.

Finally Solar Eclipses, SE, provide data showing the existence of other non-tidal effects. The sensitive parameter is Delta T, the cumulated difference between Universal Time and Atomic Clock Time.

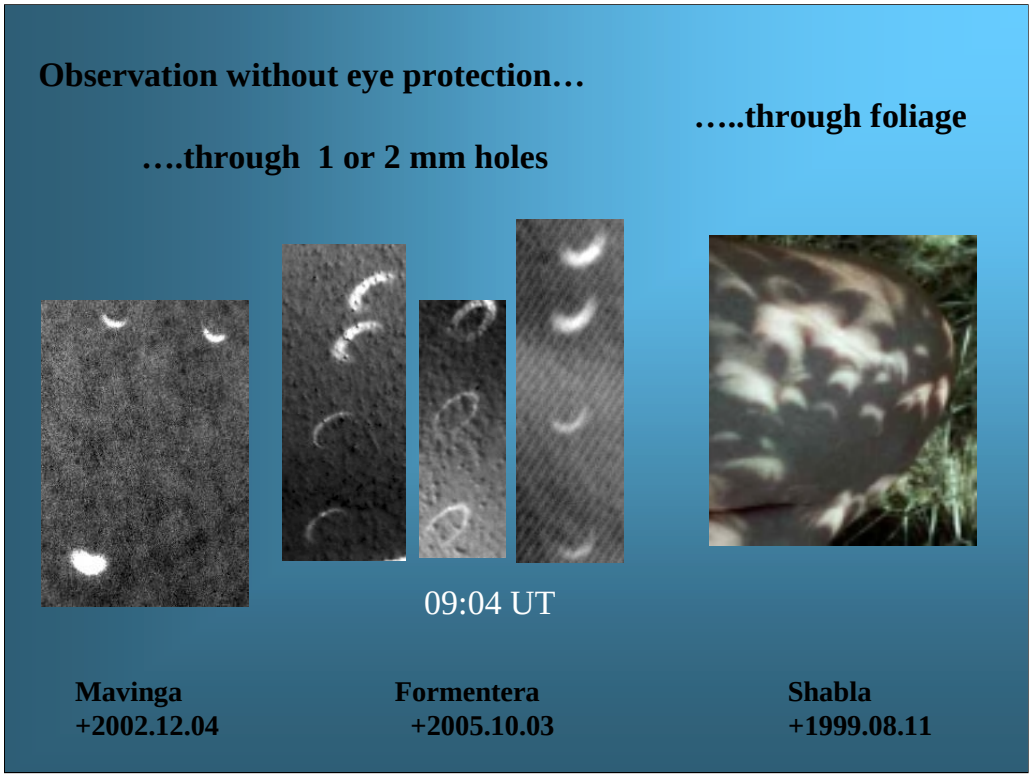


http:www.archaeometry.org/aten.htm

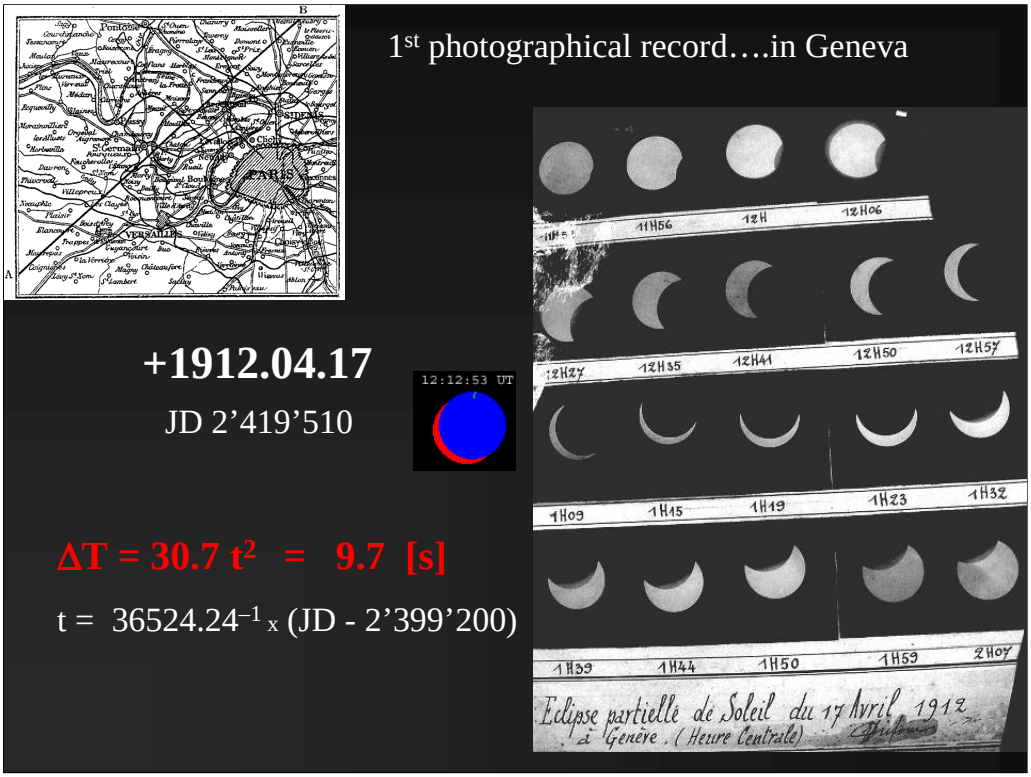
On this chart of the Time variation of DeltaT, the *top curve* shows the cumulative retardation effect expected from tidal braking only. The *2nd curve* shows the partial compensation to tides, due to the post glacial rebound.
And, finally, the *lowest curve* shows what represents the *actual* slowing down of Earth's spin.
My web-paper http://www.archaeometry.org/aten.htm discusses how such a simple quadratic Model allows to explain 38 solar eclipses, spread over the last 4'000 years. The origin of the curve on the time axis is JD 2 399 200, namely when the *Length of the Day* is of 86'400 seconds in both,
the Ancient AND Modern definition of the second.

How could have one, in Ancient times, managed to observe solar eclipses without eye protection?

This picture I took last October, in Formentera, 14 minutes before the maximum of the eclipse, demonstrates how, by cloudy weather, naked eye observations are sometimes possible.



Another way to look at a solar eclipse without eye protection is through foliage.
In 1999, in Shabla, e.g., I used my knee as a projection screen for the inverted image of the crescent-like, solar light source.
In Formentera, at the time of maximum annularity,
I used tiny holes in an opaque foil: the brightness reflects the diameter of the hole, 1 or 2 mm.



The size of the shadow of the Moon of the pearled eclipse of 1912 was only 3.5 km wide. It has been very well documented by Camille Flammarion.
The predicted path of the Bureau des Longitudes was 1 Lunar shadow diameter too far South. They have the excuse that EMAPWIN was not yet available, at the time.

This full diaporama of the eclipse is due to Dufour, in Geneva, where the maximum occultation was 89%. Those pictures confirm the predictions of EMAPWIN: the maximum is predicted at 12:12:53 UT i.e;: 1H13 central time.

SAROS 79 / 29 ….. **+71.03.20 /** 09:28
@ E23.7 / N 38.0 5 (Athens) 22 s 48°

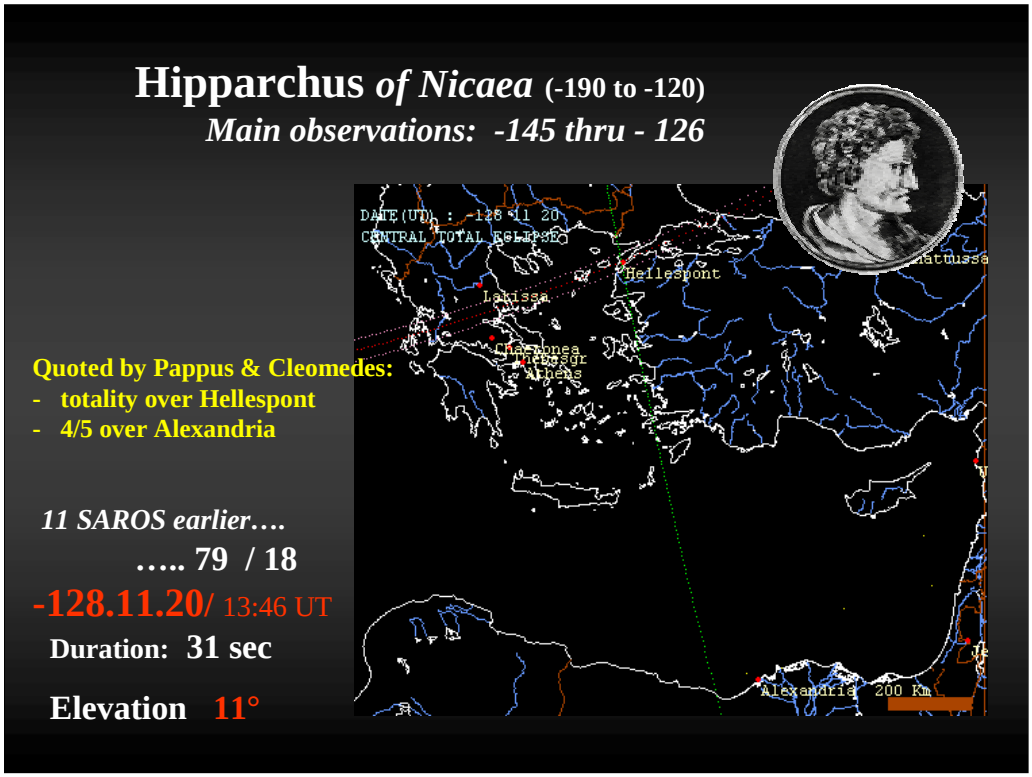
PLUTARCH : ***1st report on Solar Corona***

"...a kind of light visible about the rim,
keeping the shadow from being profound.."

Totality occurred over the city of ATHENS…….

PLUTARCH spent most of his life in his city of Chaeronea.
therefore… in **De facie in orbe lunae**
he leaves an Athenian (friend of his ?), called Lucius,
to describe a solar eclipse:
….beginning just after noonday

In year +71, the poet Plutarch wrote the 1st poetical description of a Solar Corona:
It reads: A kind of light, visible about the rim, keeping the shadow from being profound.

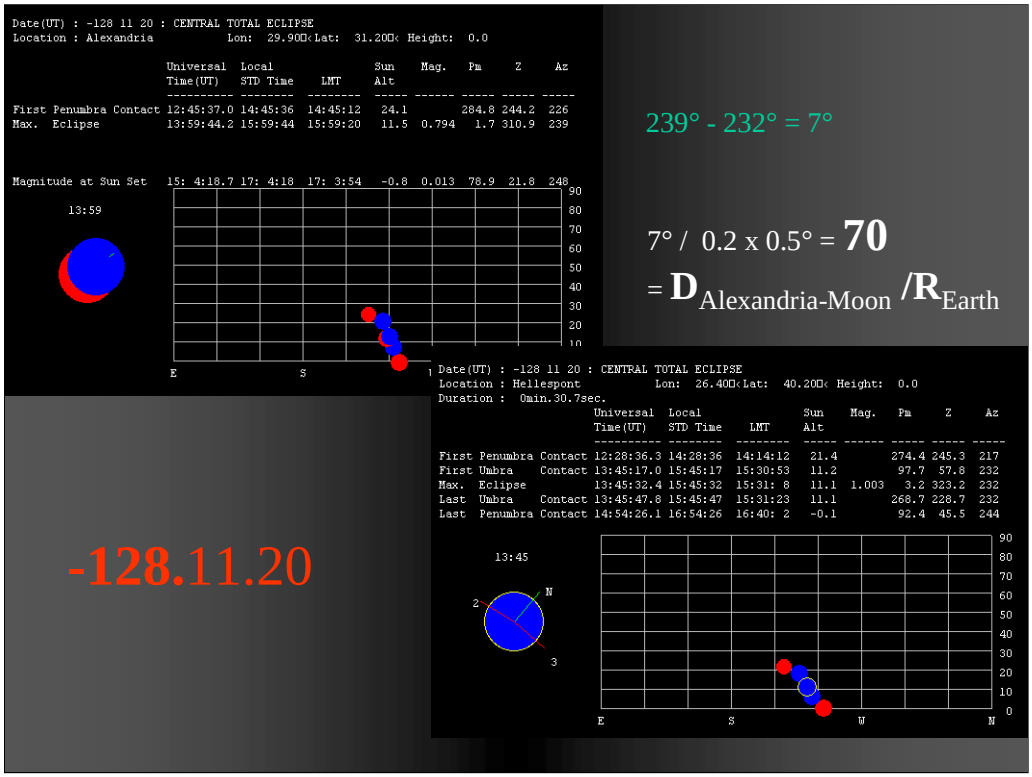


In year -128,

11 SAROS cycles *before* Plutarch's eclipse over Athens,

a partial eclipse of ***four fifth*** occurred over Alexandria.

The Astronomer Hipparchus had the genial idea to look for the place, where this eclipse might have been total….
In Hellespont, near to his home town of Nicaea, people did observe totality and remembered the azimuth angle of the Sun while it was hidden by the Moon, because its position over the skyline of the city was only 11°.



At maximum occultation, the difference of azimuth angles between Alexandria and Hellespont was 7 degrees. As the apparent diameter of the Moon is half a degree, a fifth of it, means 0.1 degree. Therefore the ratio of *the distance between Alexandria to the Moon* to the Radius of the Earth, is of the order of 70. This is *the most stupendous result in Paleo-astronomy* I know of.

Πινδαρ

Pindar (-518 / -437)

When 40 years old…

- 477.02.17/10:05UT

37°

5m 09s

ΘΗΒΑΙΣΙΣ ΕΙΣ ΙΣΜΗΝΙΟΝ

To the Thebans

Beam of the Sun !
0 thou that seest from afar, what wilt thou be devising?
0 mother of mine eyes !
0 star supreme, reft from us in the daytime !
Why has thou perplexed the power of man and the way of wisdom,
by rushing forth on a darksome track ?
Art thou bringing a sign of some war, or wasting of produce,
or an unspeakably violent snow-storm, or fatal faction,
or again, some overflowing of the sea on the plain,
or frost to bind the earth,
or heat of the south wind streaming with raging rain?
Or wilt thou, by deluging the land, cause the race of men to begin anew?
I in no wise lament whate'er 1 shall suffer with the rest !

Paean, IX

Another ancient solar eclipse has been immortalized by the poet PINDAR in his Ode to the Thebans, Not Thebes in Upper Egypt, of course, but in Greece.

Chronology Pharaoh AmenhotepIV-Akhenaten

Crowned	1Peret I ry	I	
Jubilee (& Marriage?)	1Peret I ry	IV	
Fondation of AKHET-Aten	13Peret IV ry	V	^{14}C : -1'325 +/-65 (68%)
Reception	8Peret II ry	XII	
Death	ry	XVII	

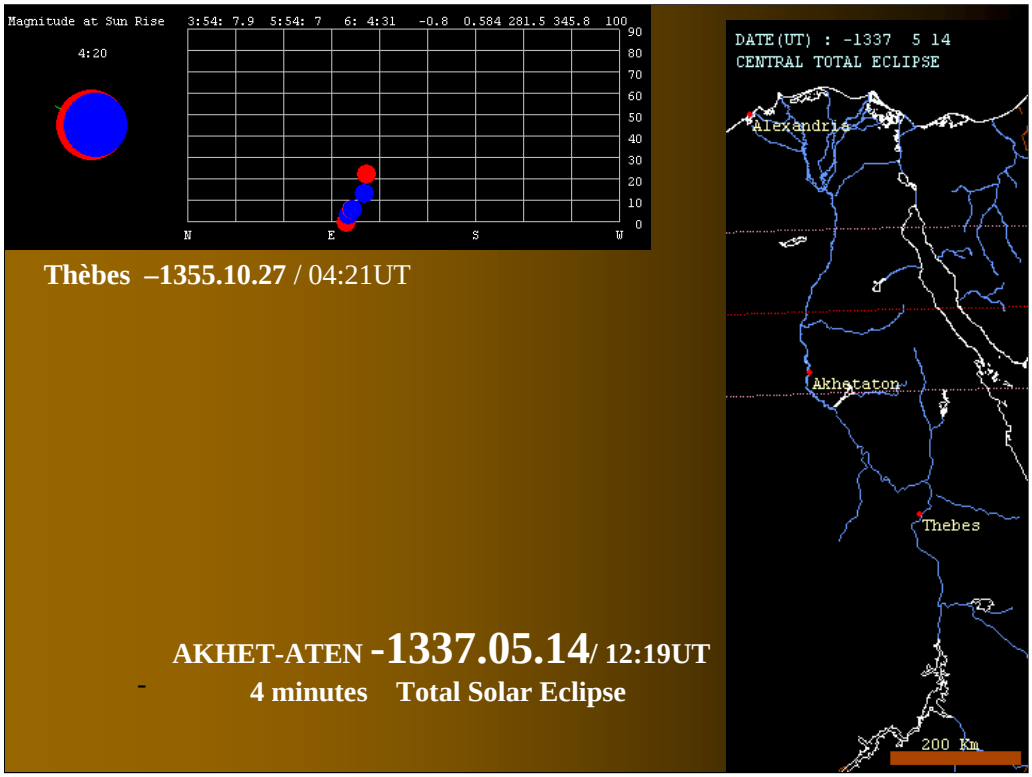
An exciting challenge is the datation of the Amarna Period.
Five dates are sure, but only the cyclic regnal years are known.
The 20 years old 14C data of Bell & Switsur,i.e.: –1'325 +/- 65 do not help too much.
AmenhotepIV was crowned when he was about 10 years old, and reigned for 17 years.
When he was about 13, he married to Nefertiti and changed his name in Akhenaton.
Here, he is depicted at 16 under the solar disk ATEN, while kissing his future heiress Merytaten.
It must be just after his moving to Akhet-Aten, the new capitol he founded 2 years earlier.

While *ATEN* means the Solar disk, Champollion deciphered the hieroglyph *AKHET* as Horizon. This picture of the *Amarna staging*, has been taken last year by Marc Gabolde just 4 weeks before the spring equinox. It is a great pleasure for me to present

to you for the 1st time this breath-taking picture.

The position of the "akhet-like" rising sun over the wadi is moving toward North, by about one diameter a day.
The point is that in this same temple, on 13 Peret IV,
in regnal year V of Akhenaton,
when this new Capitol was founded,
there occurred the same Light-show….

if one assumes the year was –1'349.



Not only the rising sun but also two solar eclipses seem to have influenced Pharaoh Akhenaton in his Amarna Heresy.
The 1st one was an annular eclipse at sunrise, easy to observe.
It occurred in year -1355, over the old capital of Thebes.
The future heir of Amenhotep III was only 9 years old.
This was 1 year before his coronation.
The 2nd solar eclipse occurred over the new capitol Akhet-Aten, in -1337. It was a 4 minutes long total eclipse.
It happened between the death of Queen Nefertiti and the one of Akhenaton…. One could then conjecture if the Pharaoh survived the event. In a culture dominated by the cult of the *Solar Disk ATEN*, a long total solar eclipse at noon time must have been considered as a dreadful omen.
What is sure is that the City of Akhet-Aten has been abandoned afterwards, and that Akhenaton's heiress, Merytaten, returned to Thebes and to the faith of the *good old gods of the past*.

Though, something unexpected, of the Amarna Heresy, remains …and this bring RamsesII back into the picture.

In Abu Simbel, there was no wadi equivalent to the one in Tell elAmarna. This absence might explain the fantastic corridor, 65 meters long like a telescope pointing to the rising sun 4 weeks before spring equinox.

It means that, the diameter of the sun, seen from the shrine, is one Egyptian cubit wide at the temple's entrance, which in turn is less than 4 cubits wide.

This *Amarna staging* provides the illumination of the shrine of the temple twice a year, a kind of hidden heritage from the heretic Pharaoh Akhenaton.