

# Astronomy in the City

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# ORIENTATION OF THE PYRAMIDS

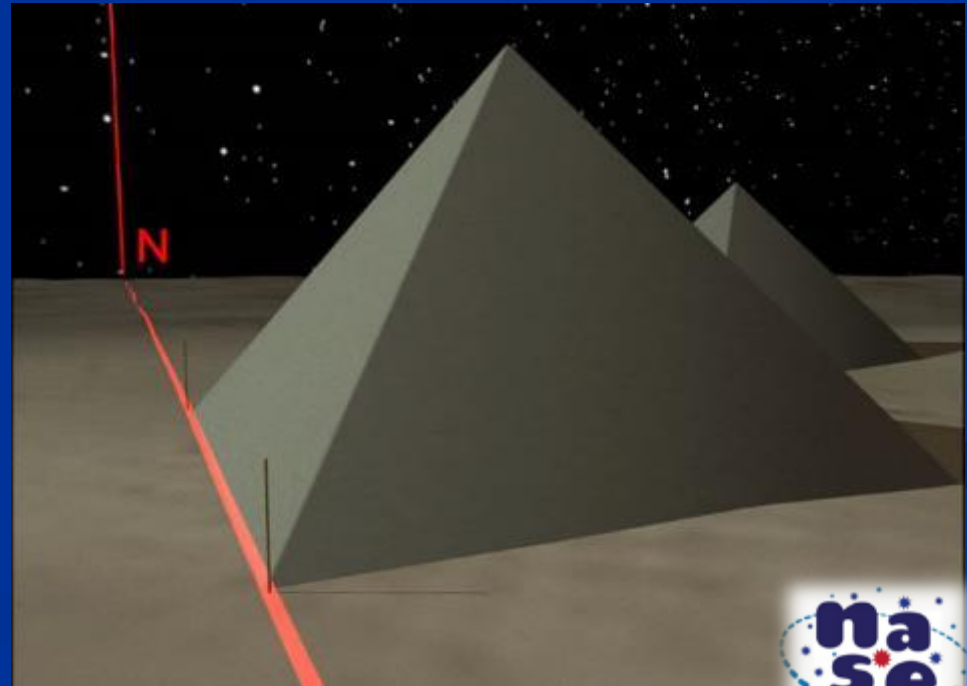
Giza, Egypt, Africa  
2500 BC



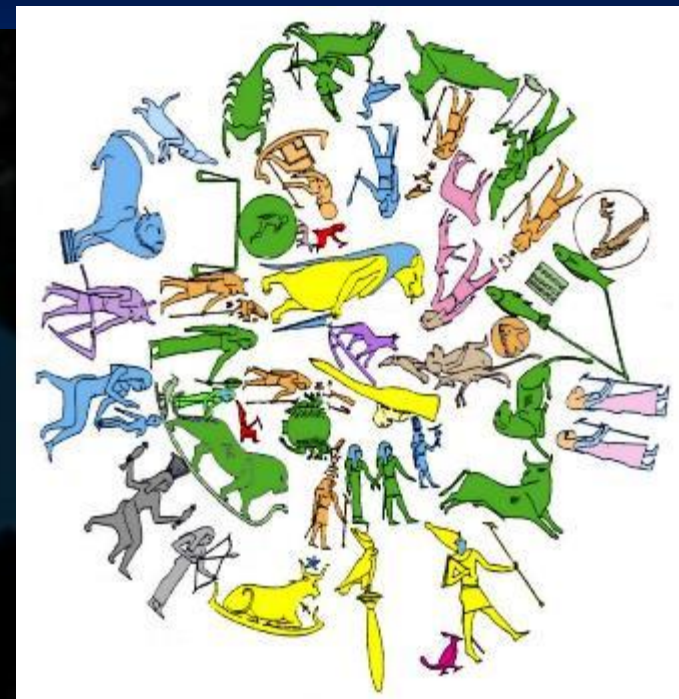
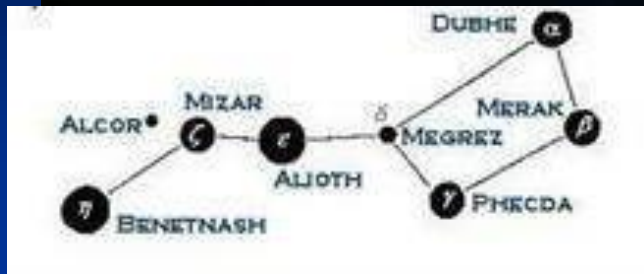
Not all of Egypt's pyramids are correctly oriented; in fact, only a few of the more than sixty well known have a precise orientation.

The pyramids of the pharaohs of dynasty IV in Dahshur and Giza are the best oriented, with errors of 15' or less.

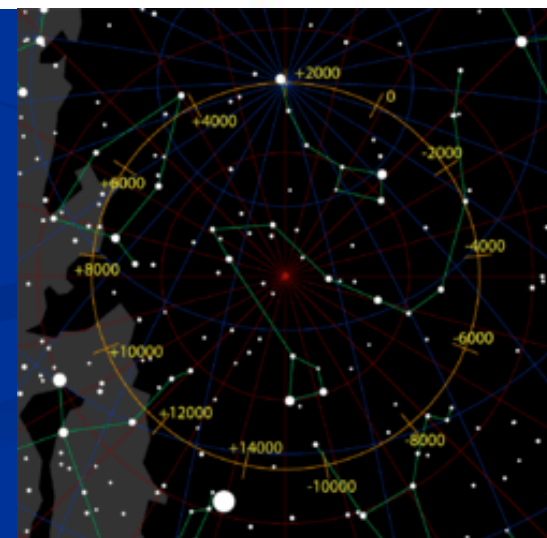
Astronomical alignment of the pyramid of Kefren (around 2545 BC) towards the meridian transit of Megrez and Phecda of the constellation Meskhetyu (The Leg of the Bull), equivalent to Ursa Major partially



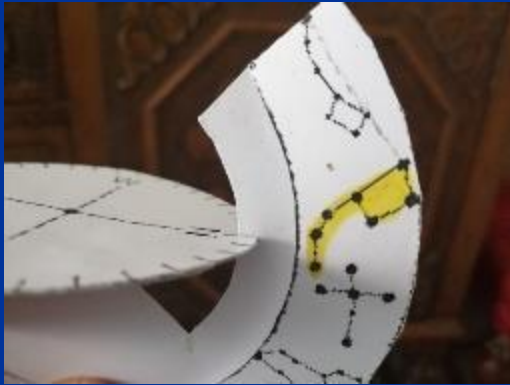
# "Imperishable" constellation of the **Bull's Leg**



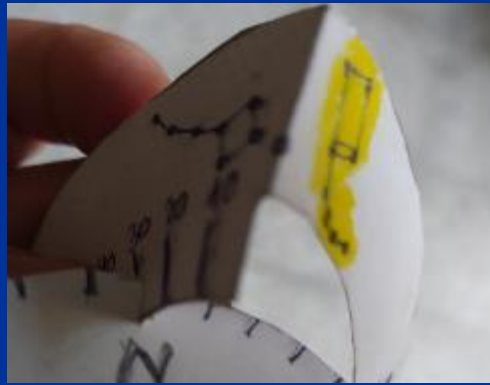
Currently Merak and Dubhe indicate the position of the polar at  $2^\circ$  from the pole. Formerly Megrez and Phecda determined the situation of Thuban that in 2787 B.C. which was only  $2'$  from the pole



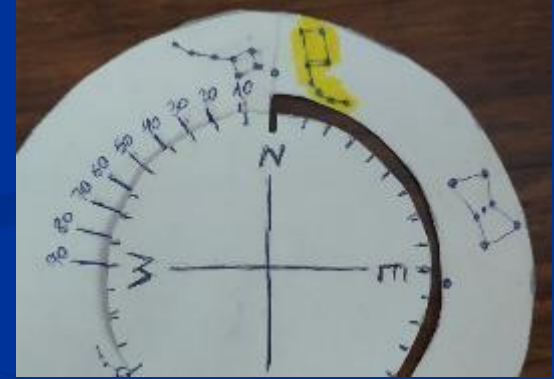
The placement of the pyramids responds to religious motivations. The Egyptians believed that the stars disappeared and reappeared, allowed to transcend death. **"The ducts of the pyramids face north because there were the stars that never disappeared from the sky, the circumpolar stars, which never died"**



Now 2000



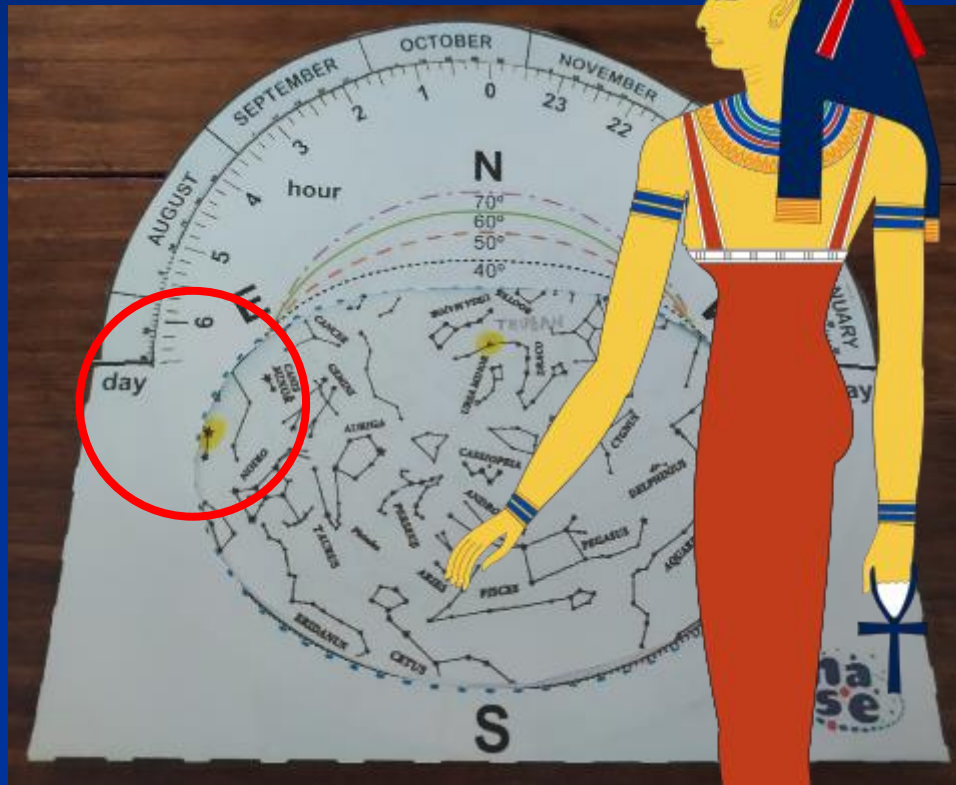
Before 2500 BC



Cairo latitude 30°N

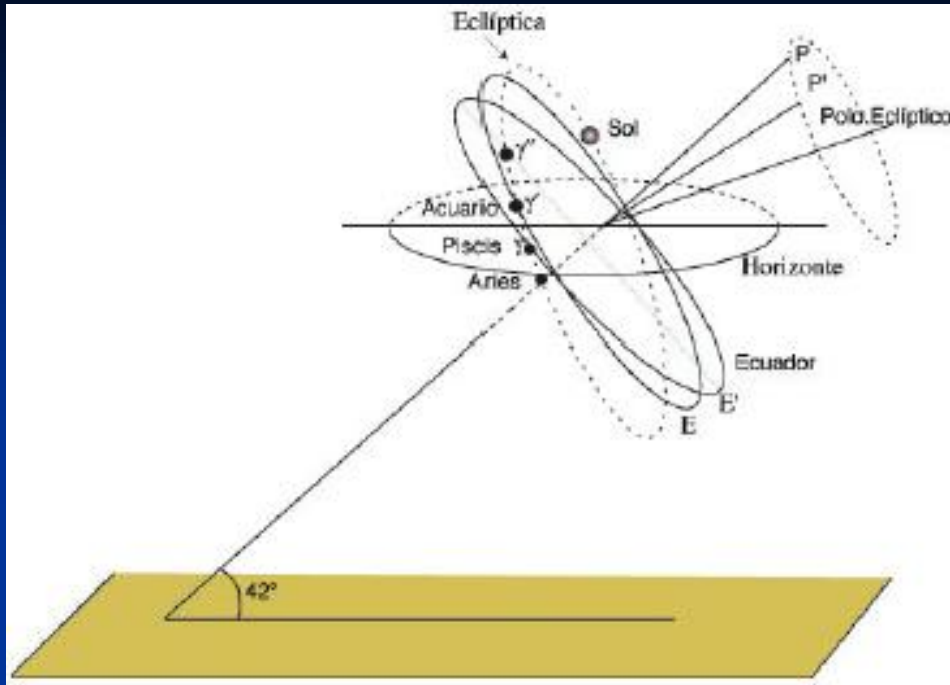
The access corridors were built with a slope such that this would facilitate the king's ascension to the northern skies, domain of the "undying stars".

The Sirius star, called Sopdet by the Egyptians, announced the arrival of the flood of the Nile, with its first annual appearance at dawn, the so-called heliacal rising (the first day it becomes visible just before sunrise) and this moment of great importance in Egypt.

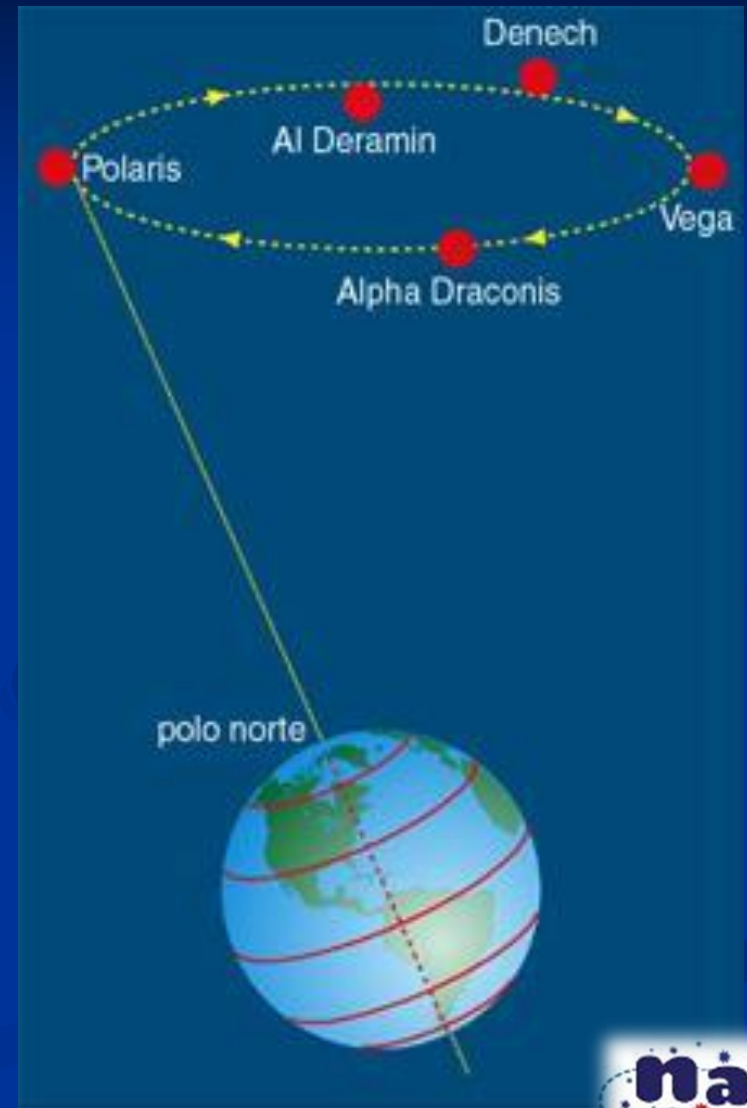


The star Sirius remained invisible for 70 days, the same time as in the mummification process, the bodies were immersed in natron salts to dehydrate them for 70 days and the body was subsequently removed.



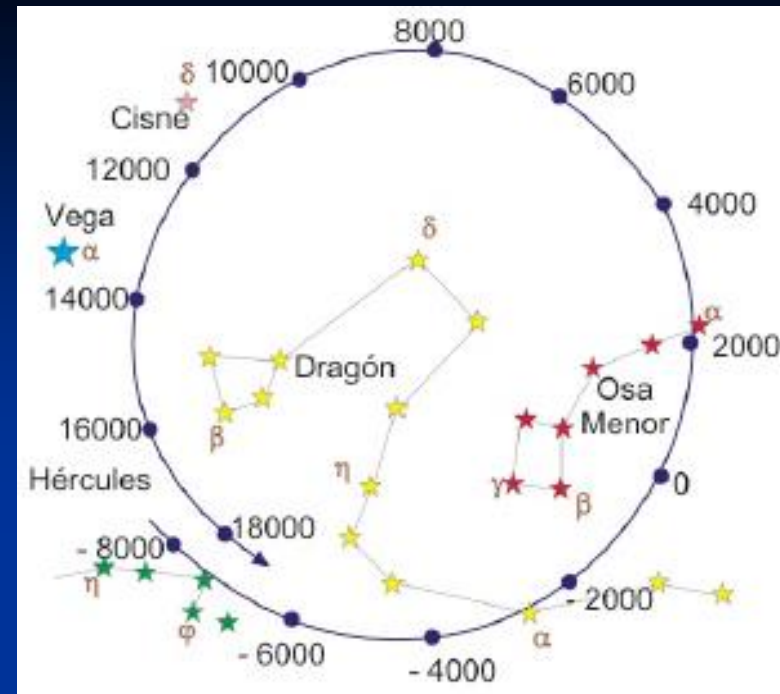


Due to the Precession of the Equinoxes, the point of intersection between the equator and the ecliptic, called the Aries point (because it was in this constellation) has moved to the constellation of Pisces.





Precessional motion of the Earth's axis of rotation (change of direction of the axis describing a circumference like a spinning top) takes place  $50.29''$ /year (it turns in 25776 years). The celestial equator also wobbles and its intersection with the ecliptic varies.



Hipparchus observed it between 147 and 127 BC, (about 2000 years ago). Then the point named Aries point (because it was in that constellation) has moved to the constellation of Pisces and the north pole has changed.

$$50.29'' \times 2000 = 100580'' = \text{approx. } 28^\circ \text{ a zodiac sign}$$

**For example, now the North Pole is on the Polaris of Ursa Minor and 2000 years ago it was Thuban in the Draco.**



# ROMAN CITIES

## Barcelona, Spain, Europe

### 10 BC



Barcelona was founded by the Roman Empire in the 1st century BC. (it was called Iulia Augusta Faventia Paterna Barcino) on a small hill called "Mons Taber".

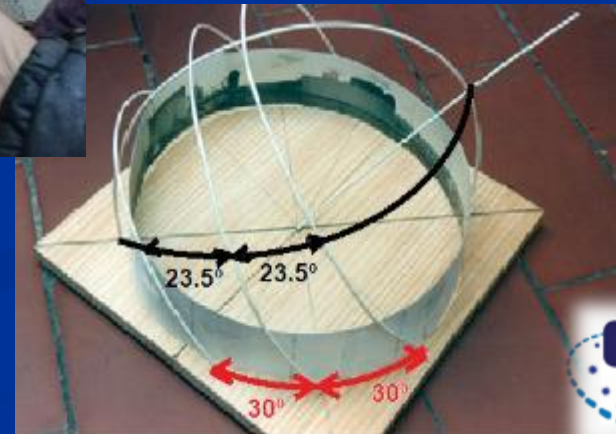
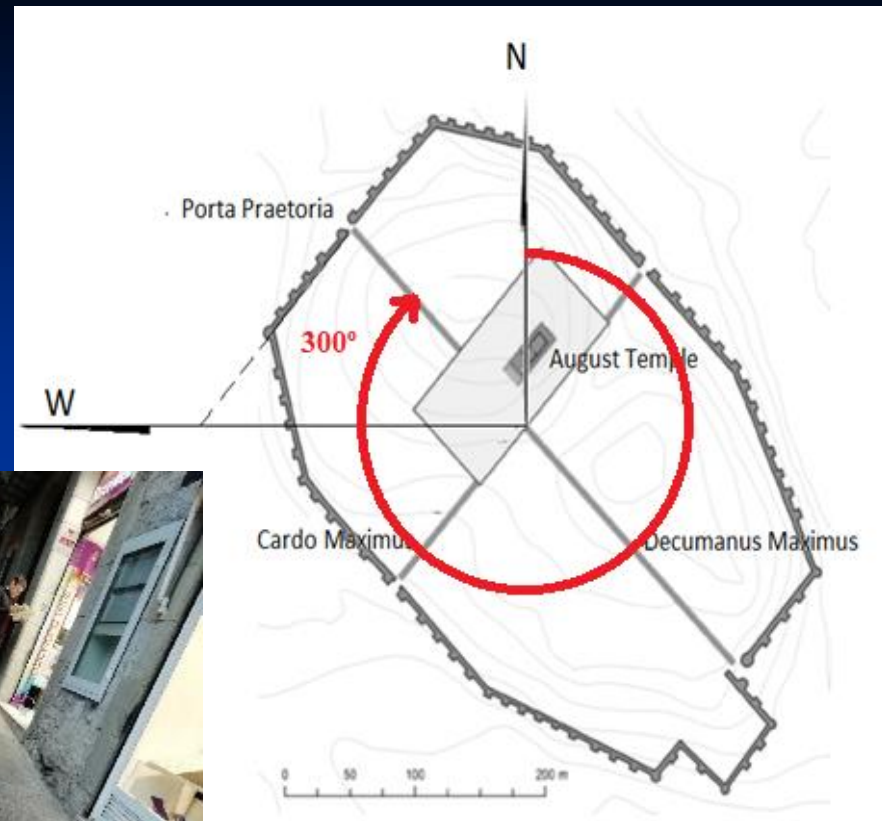
The Temple of Augustus was located at the highest point of Mons Taber



Barcino was crossed by the Decumanus maximus (main street with approximate orientation from East to West), and the Cardus maximus (from North to South) which crossed the city.



The Decumanus Maximus (East-West) is easy to find in present-day Barcelona and it is not difficult to calculate its angle to the West  $300^\circ - 270^\circ = 30^\circ$  and compare the result obtained with the results of professional archaeoastronomers.



For example, the table summarizes the result of a study carried out by J. A. Belmonte on 270 urban structures and military settlements measured

Declination	Festivity	Zone
+23,5°	Sunset, Summer solstice June, 21st <i>Sol invictus, Appolus</i>	Cartago Nova Mediterranean Zone Galia and Germania
+7 °	Sunrise and Sunset March, 1st <i>Mars Festivity</i>	Britania, Limes Arabicus Limes Germanicus
0°	Equinox March, 21st September, 21st	Iberic origin North of Africa and nest to the East Berberes Group
-23,5°	Sunset, Winter solstice December, 21st <i>Saturnalias</i>	East and West of Rome

Documanus maximum is 30° from the West which in Barcelona (latitude 41°) corresponds to the summer solstice 23.5°

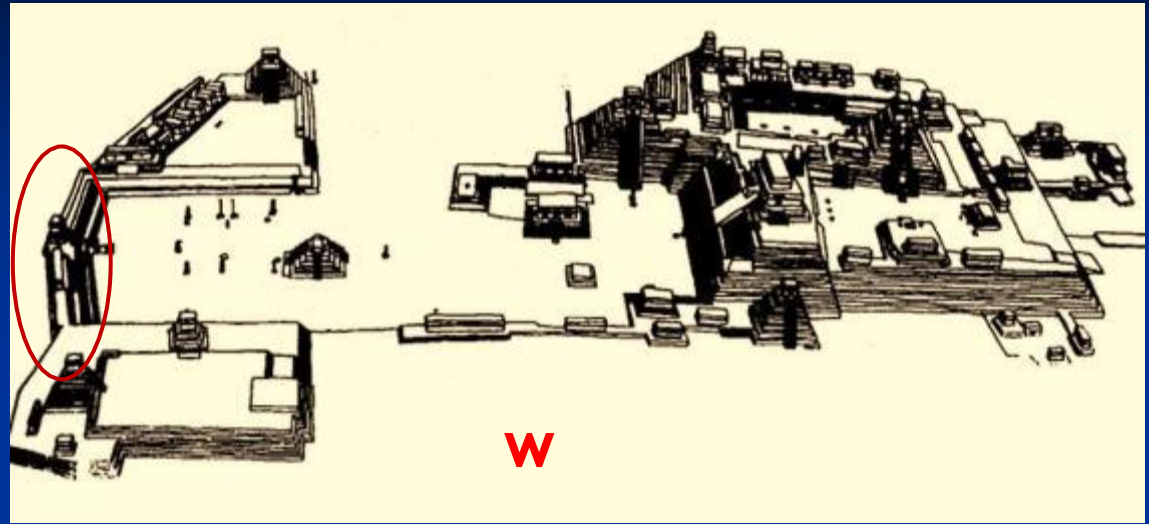


**SUNDIAL AT COPAN**  
**Copan, Honduras, América**  
**700**



# Copan archeological site

From 695 at 738 d.  
C., Copan was ruled  
by Waxaklaju'n U  
'B'aah K'awiil ("18  
Rabbit") in late  
Maya times.



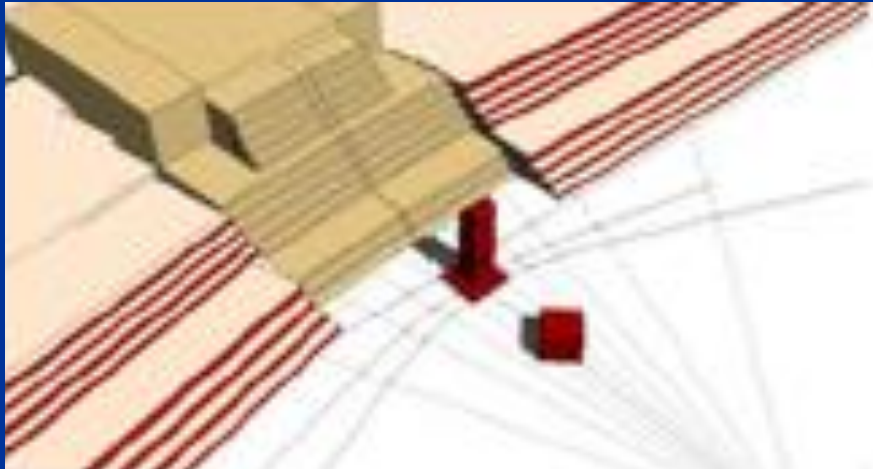
Acropolis



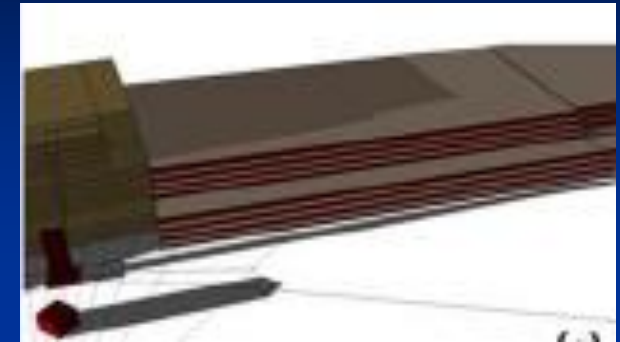


# Winter Solstice December 21st

Shadow at noon



# Spring Equinox March 21st

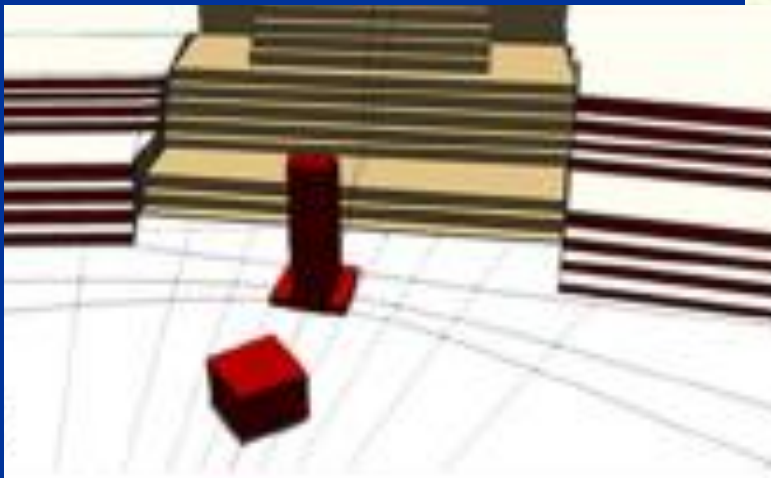


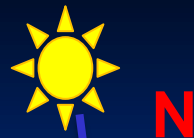
## 1st Zenit Sun Passage 30th April



# Summer Solstice June 21st

Shadow at noon





N

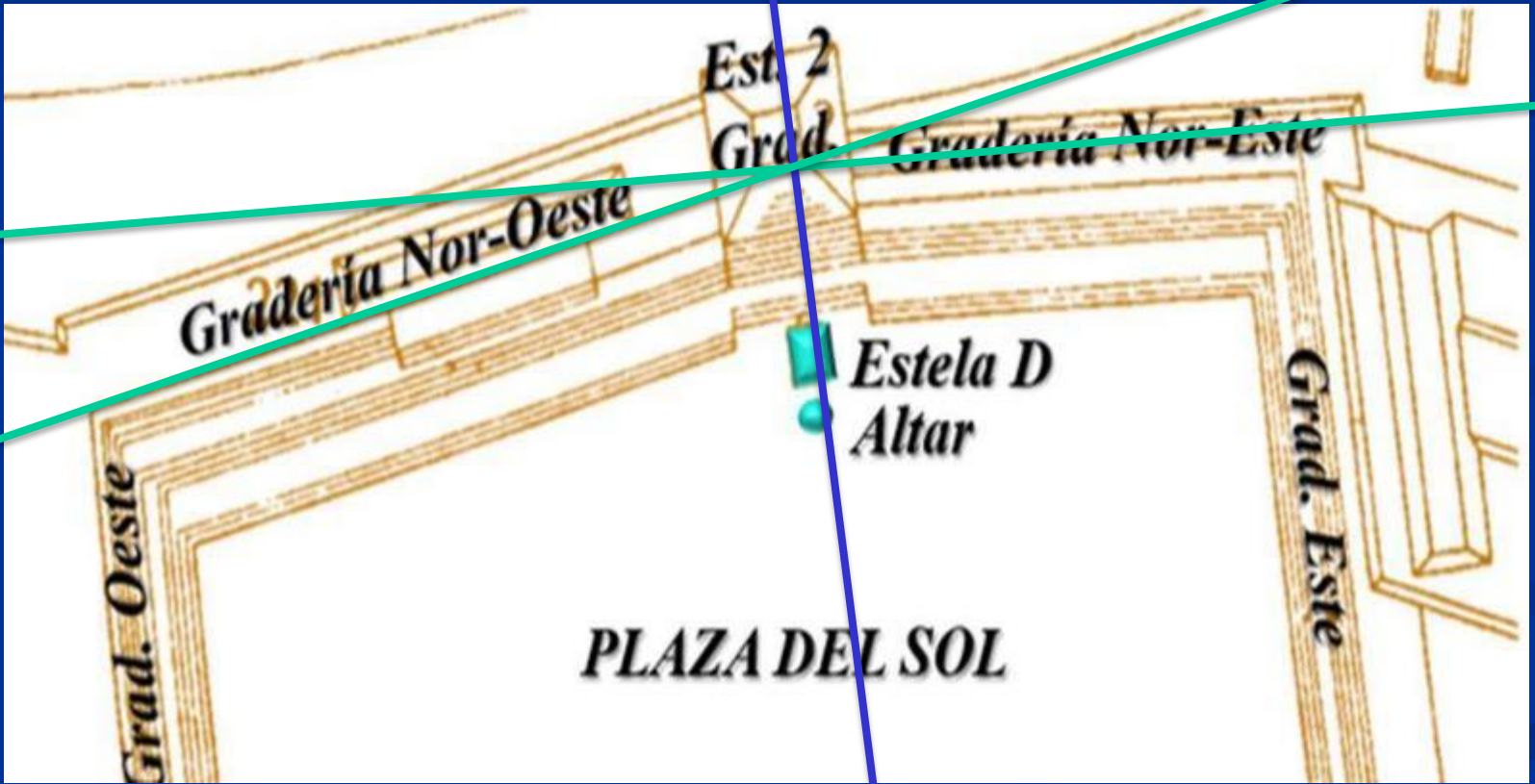
Sunrise on Zenith Passage

Local meridiiane

Sunset on Equinoxes



E



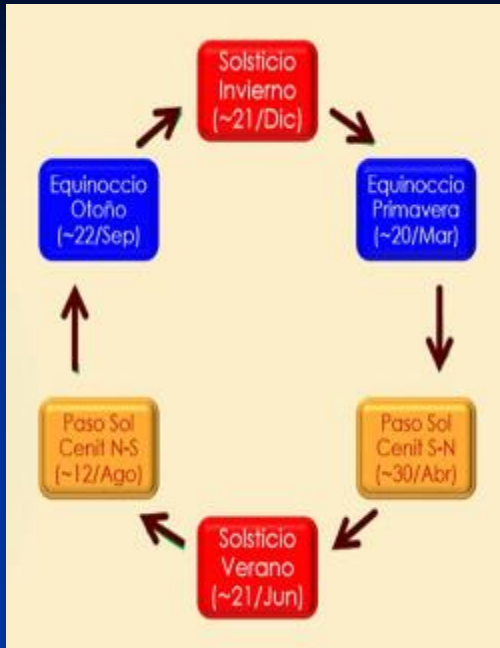
W



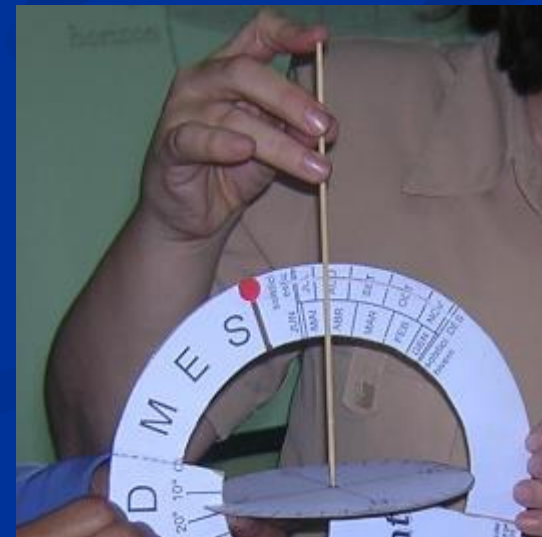
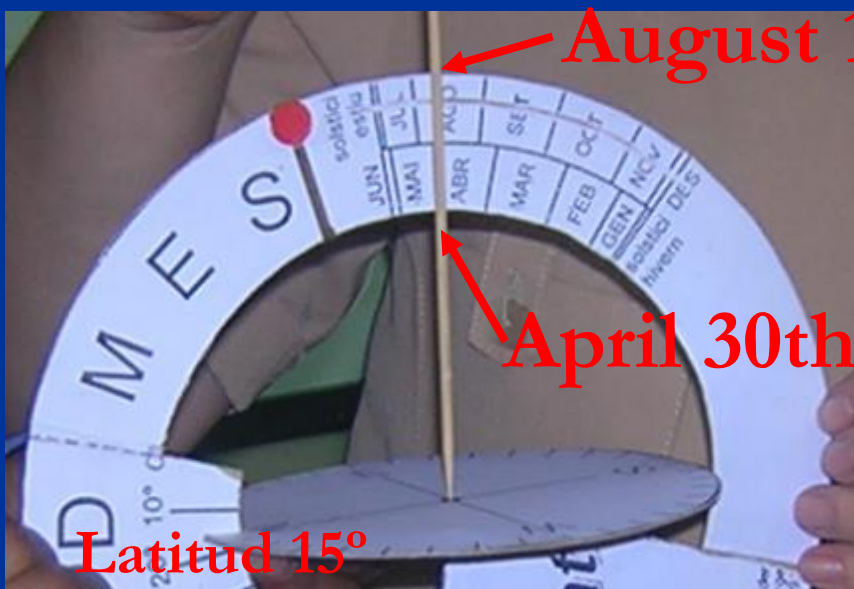
S

Local meridiiane





**Winter Solstice December 21st**  
**Spring Equinox March 21st**  
**1st Zenit Pass April 30th**  
**Winter Solstice June 21st**  
**2nd Zenit Pass August 12nd**  
**Autumn Equinox September 23rd**  
**Winter Solstice December 21st**



The colored glyph represents the Sun in the sky. Shadows move, like "bodies of Snakes." The head towards the Sun and the shadow in the opposite direction to the Sun.

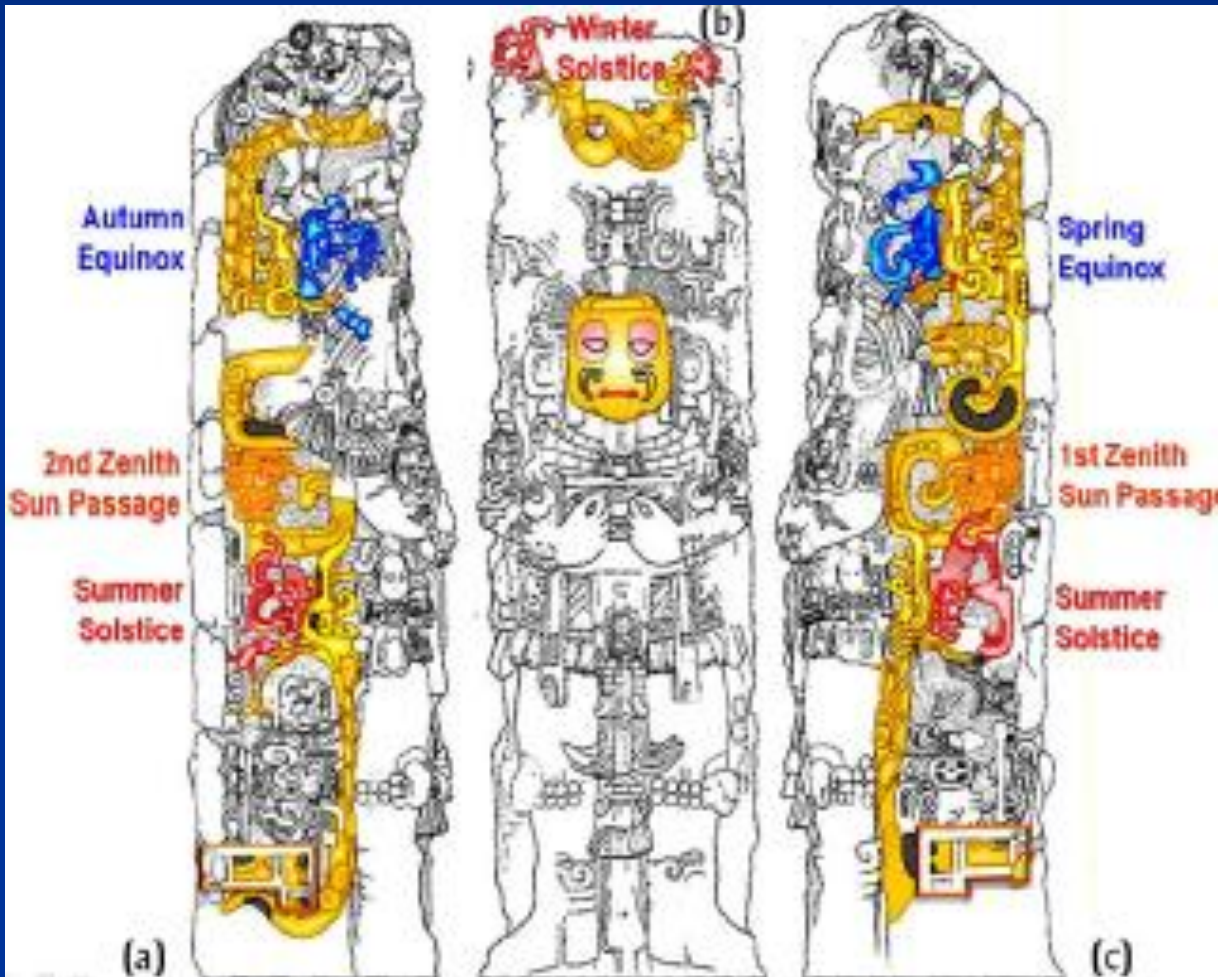
Snakes are intertwined to the north in the king's headdress. The solar year ends and begins

N

The Snake is to the North because the Sun is to the South, and the head also to the South

There are no shadows, the Snake is very small and looks up, because the Sun is at the zenith

The Snake is to the south and is buried in the stairway, because the Sun is to the north



W

E

S



**KUKULKAN**

**Chinchén Itzá, México, América  
1100**

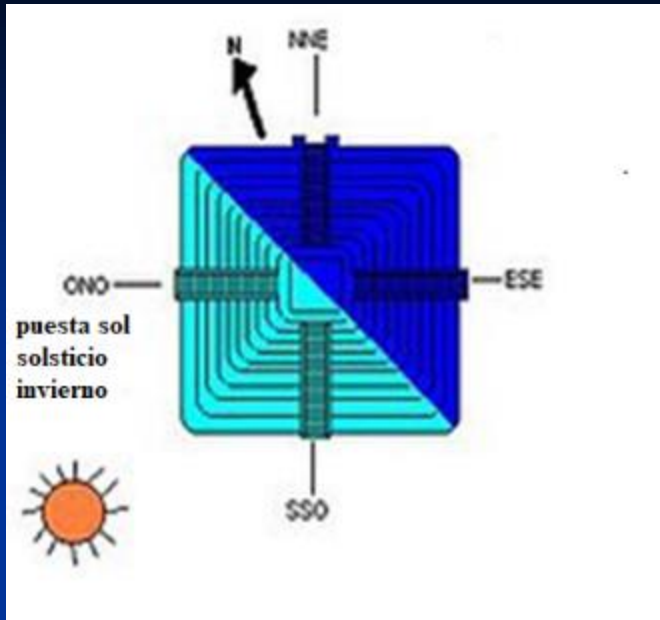


# The temple of Kukulcán

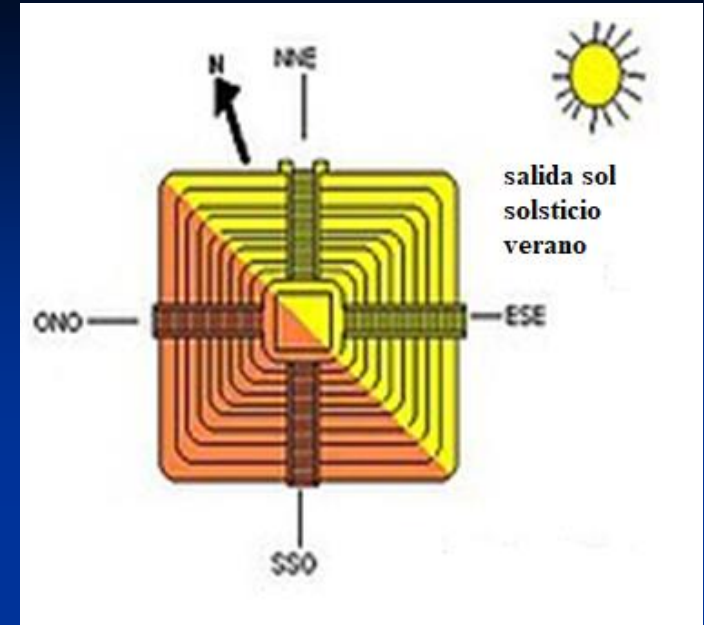


The Temple of Kukulcán, or “El Castillo”, was built by the Mayans in the city of Chichén Itzá in the 12th century to worship the feathered serpent at Kukulcán. The construction of the pyramid allows observing various phenomena of light and shadow due to its orientation during the solstices and equinoxes.



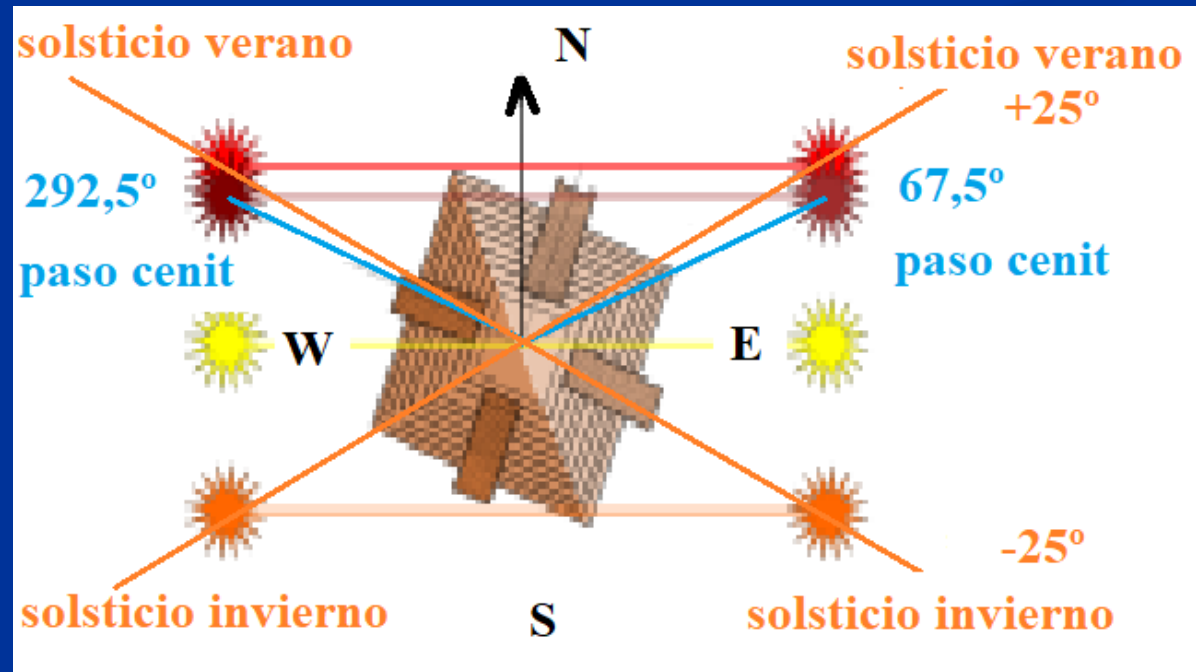


## Orientation with the solstices



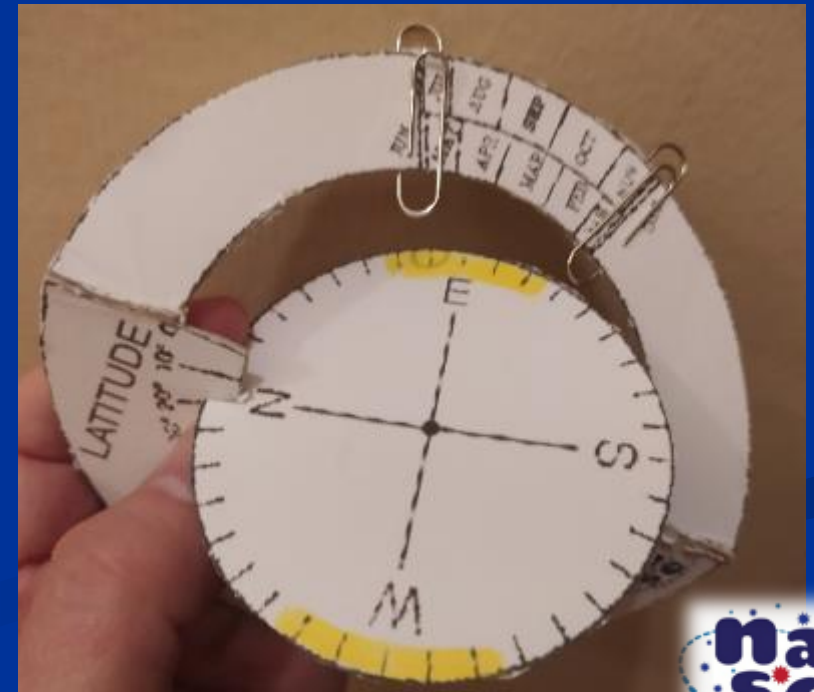
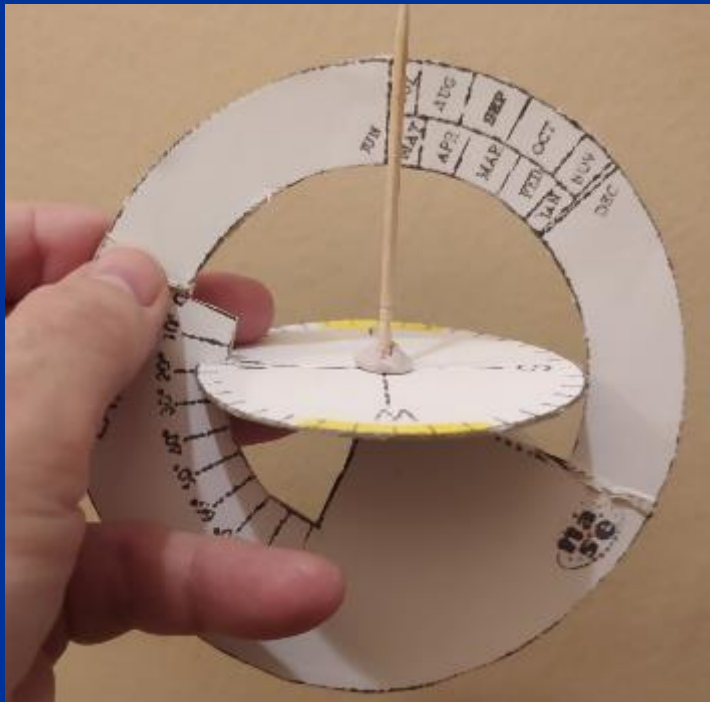
Passage through the zenith

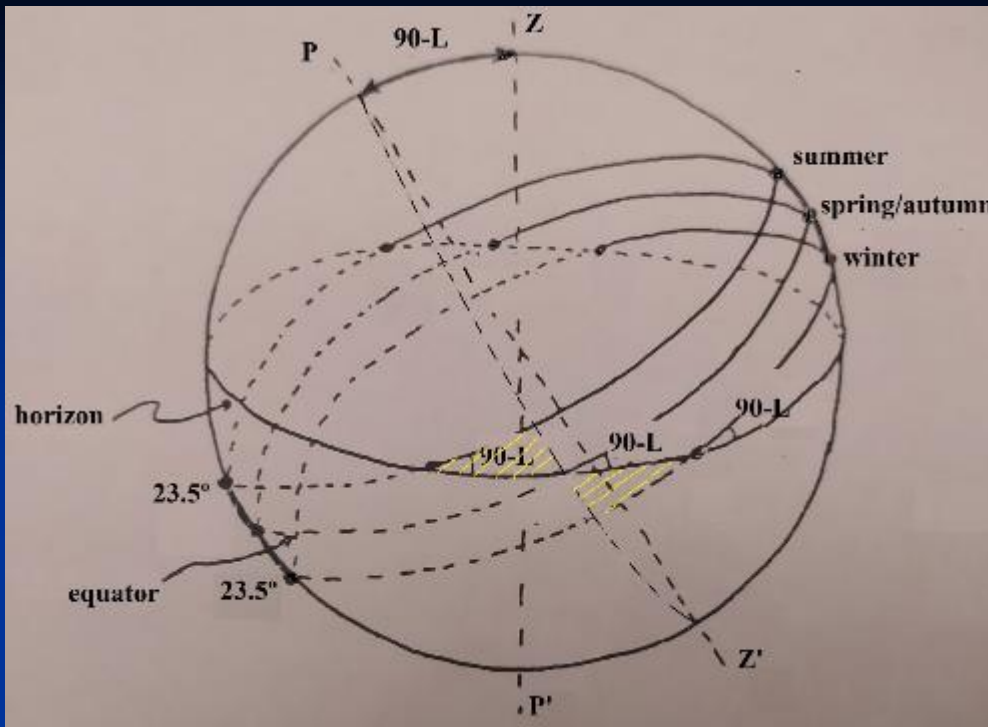
May 23rd and July 19th



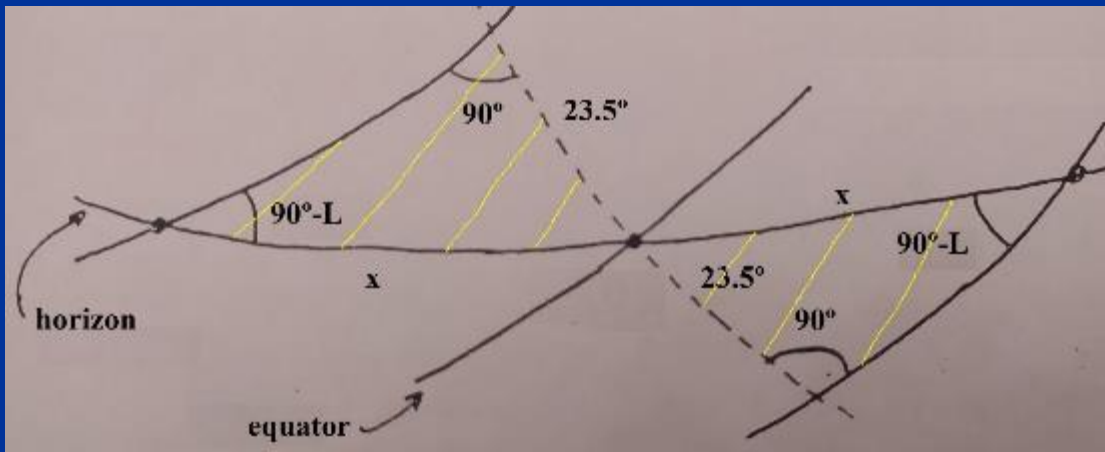
# The latitude of Chichén Itzá is $20.5^\circ$ which gives rise to:

- The passage through the zenith corresponds to two days: May 23 and July 19
- The angle between sunrise and sunset for the solstices is  $25^\circ$





$$\sin x = \sin 23.5^\circ / \cos L$$



Latitude L	X°
0°	23,5°
10°	24°
20°	25°
30°	27°
40°	32°
50°	40°
60°	53°

$$\sin x / \sin 90^\circ = \sin 23.5^\circ / \sin (90^\circ - L)$$

# Kukulkan at sunset of the equinox

The shadow that is projected gives the impression of a serpent, the God Quetzalcoatl, descending to Earth with the head at the end of the staircase.

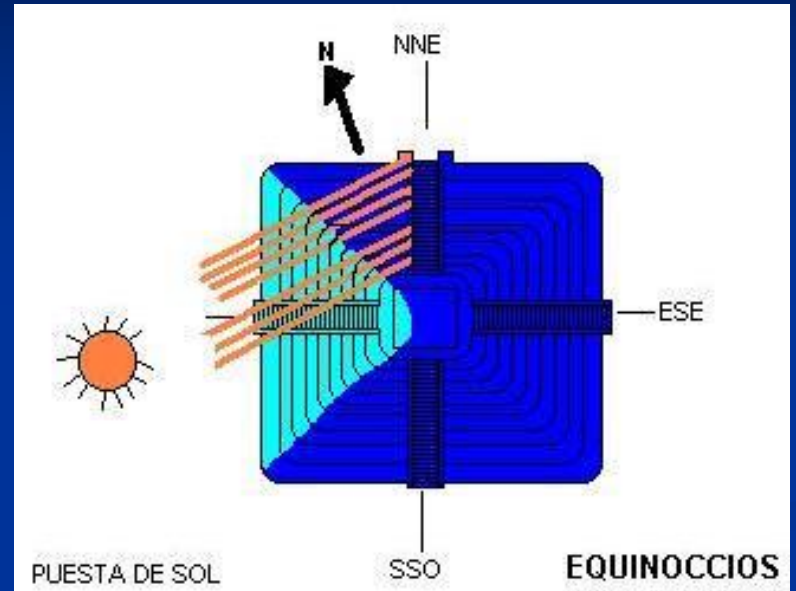


This phenomenon occurs about five days in March and September and the triangles are seen for ten minutes.

# Kukulcan at sunset of the equinox

The **NNE** wall of the pyramid is inclined  $20^\circ$  with to the **N**

At sunset on the spring and autumn equinoxes, a projection of seven inverted triangles of light is observed on the **NNE** staircase, the result of the shadow that



the nine platforms of **ONO** are projected and the image of the serpent of triangles of light appears on the **NNE** staircase and at the end it is projected on the head.

Due to the fact that the **SSW** and **ESE** walls are deteriorated, a similar phenomenon is not observed in the sunrises of the equinoxes.

# DARK CONSTELLATIONS

Cuzco, Perú, América

1100 - 1500



The Milky Way is present in the astronomical traditions of various aboriginal cultures. Many groups view the Milky Way as a river and identify dark clouds or nebulae as animals.





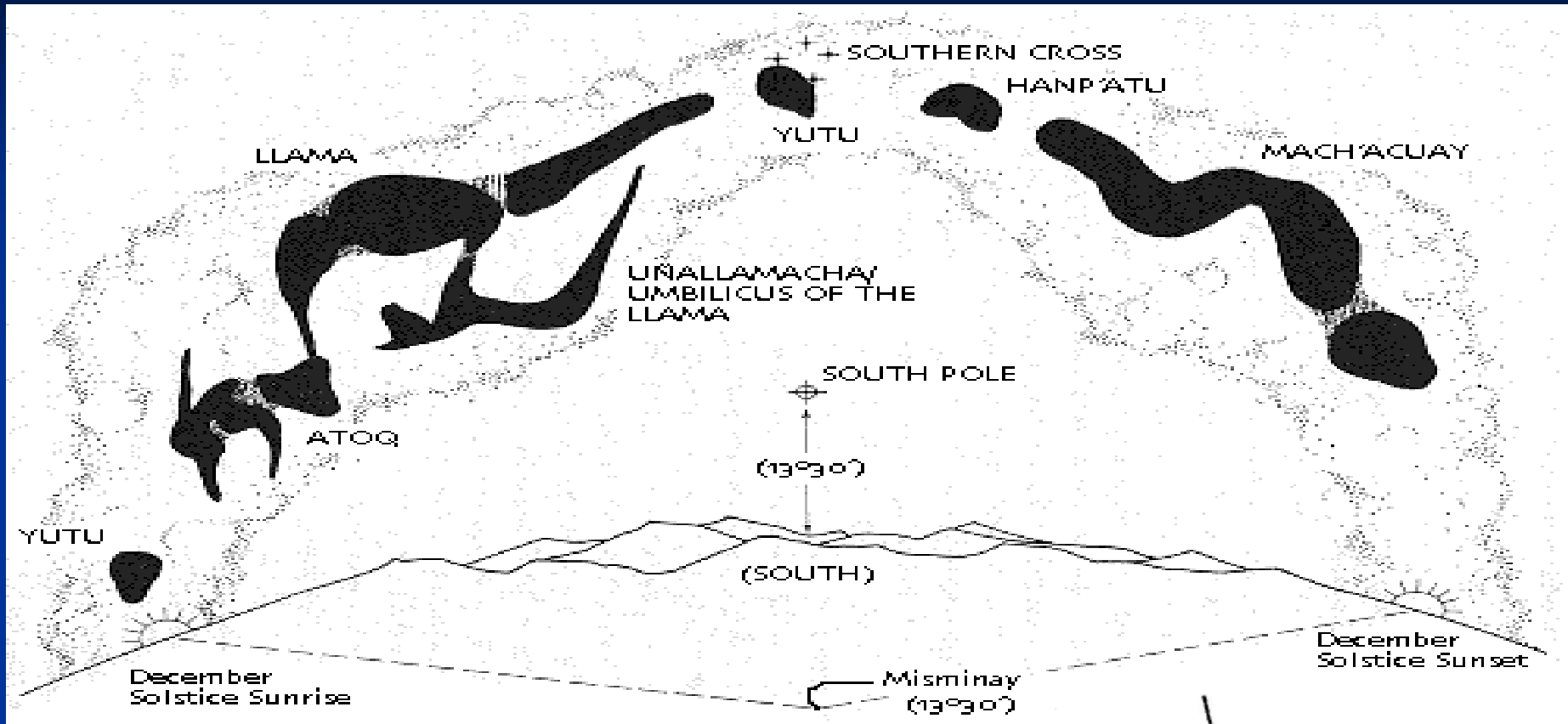
The Incas, with significant astronomical knowledge, named the stars forming constellations and had a unique type of "constellation" the dark clouds (yana phuyu) that draw the arms of the Milky Way.



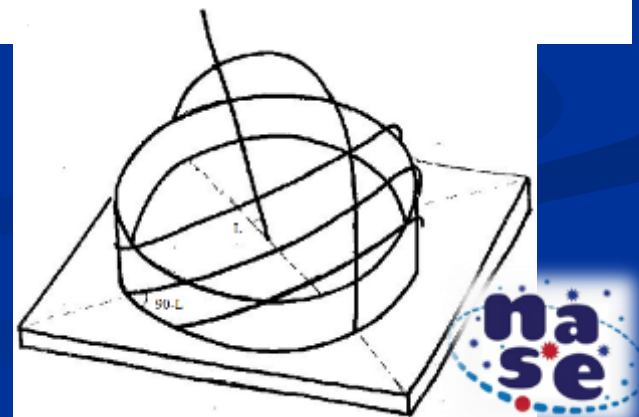




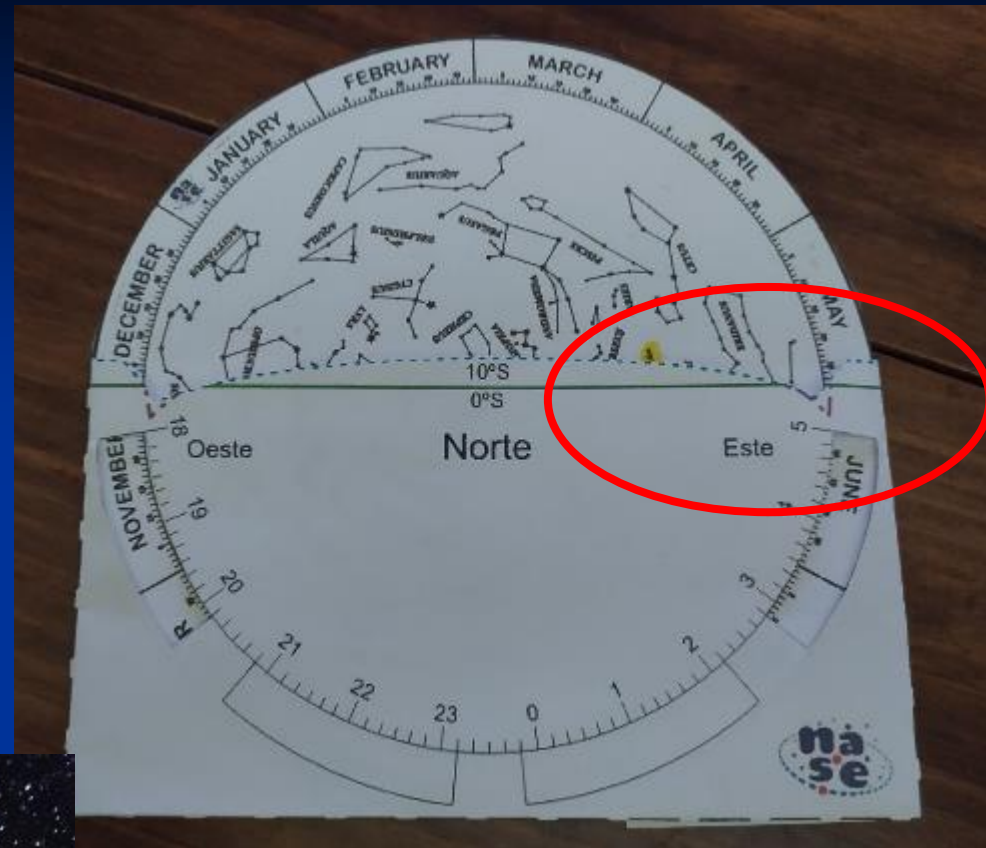
# The Chakana was identified with the Southern Cross.



Note the position of the Milky Way on the December solstice



Inti Raymi has been and still is celebrated beginning at the time of the June solstice (June 21st). The heliacal rise of the Pleiades is earlier in **June around the 8th or 9th** and is used to forecast crop success for the year.



Planisphere of Northern Hemisphere is better than the Southern Hemisphere because below the equator there is a big distortion.



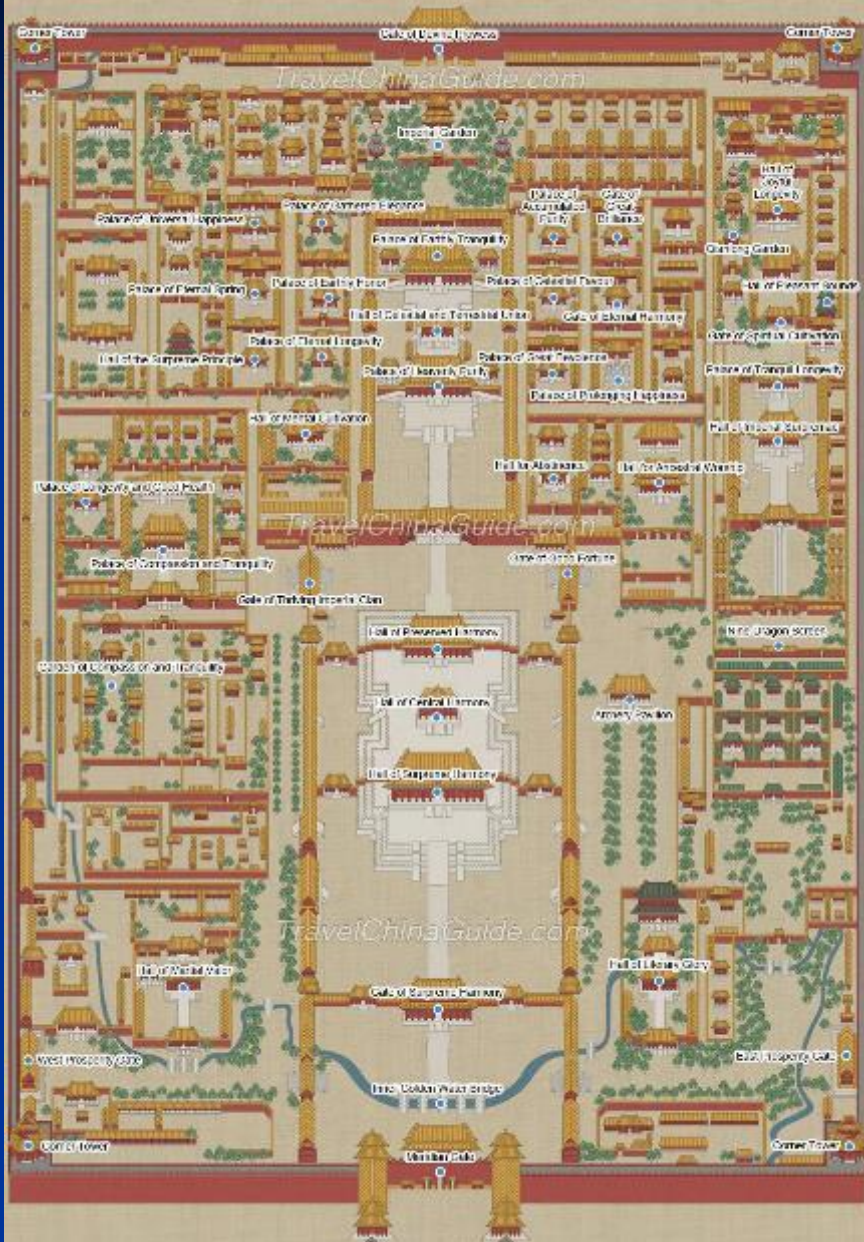
# FORBIDDEN CITY

## Beijing, China, Asia

### 1420



A Full Map of the Forbidden City



The full map is oriented  
North-South  
according the local meridian.

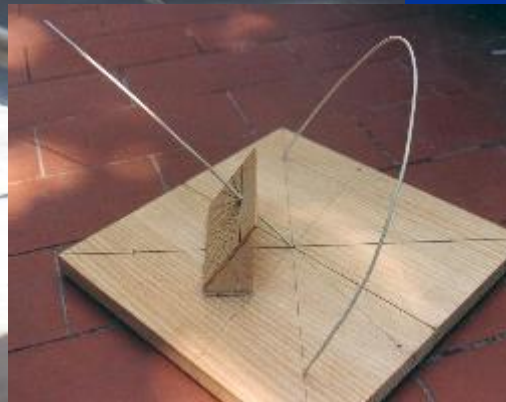
Location Map of Forbidden City and Tiananmen Square



There is a collection of equatorial sundials aligned with the local meridian



The plane of sundial is parallel to the equator and the gnomon is according the terrestrial rotation axe



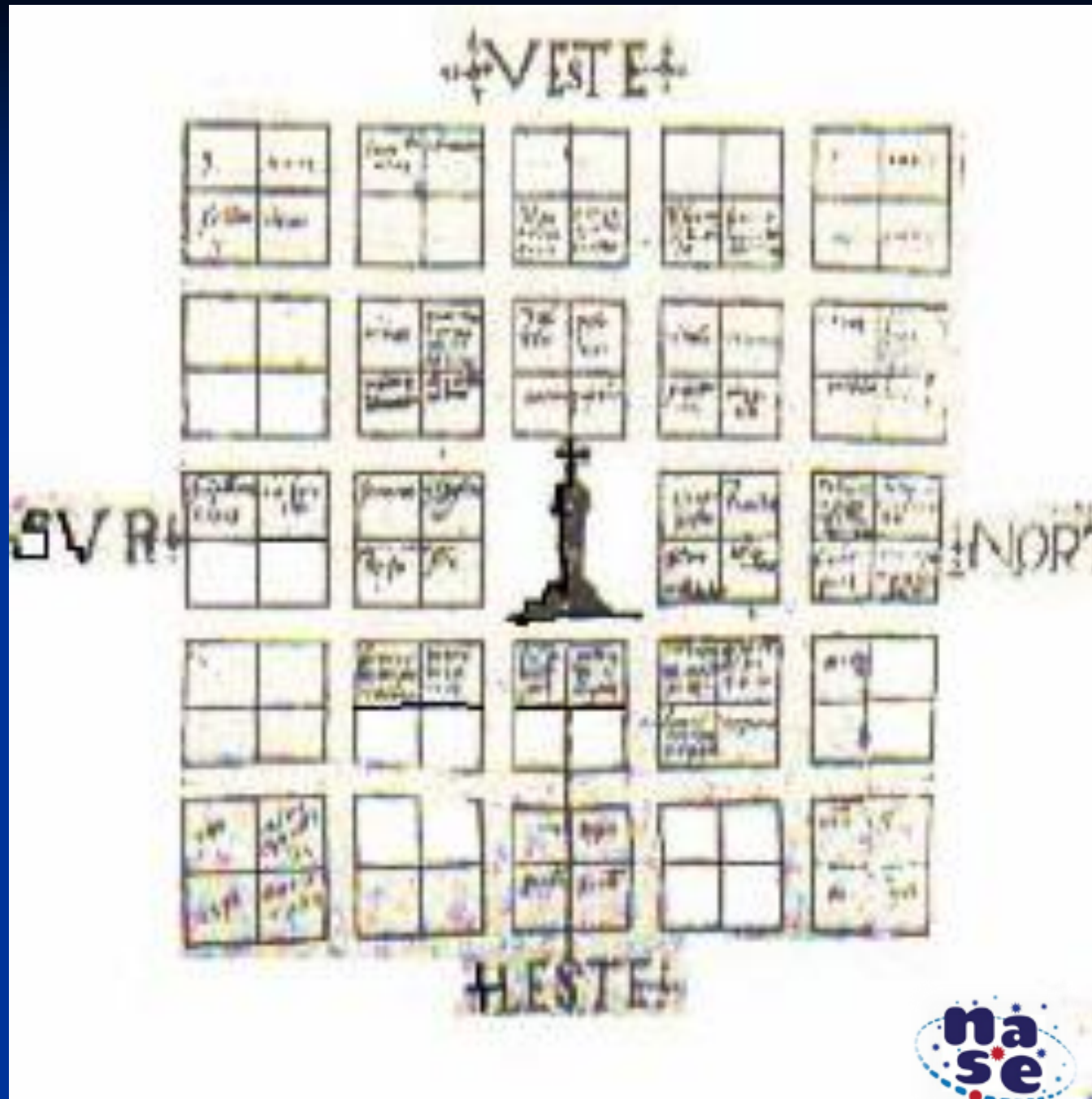
**PLAZA DE ARMAS**  
**Mendoza, Argentina, América**  
**1562**



# Foundation

1561 Pedro del Castillo  
1562 Juan Jufré

1562 plan of Plaza de Armas, that was oriented North-South and East-West as was usual





W

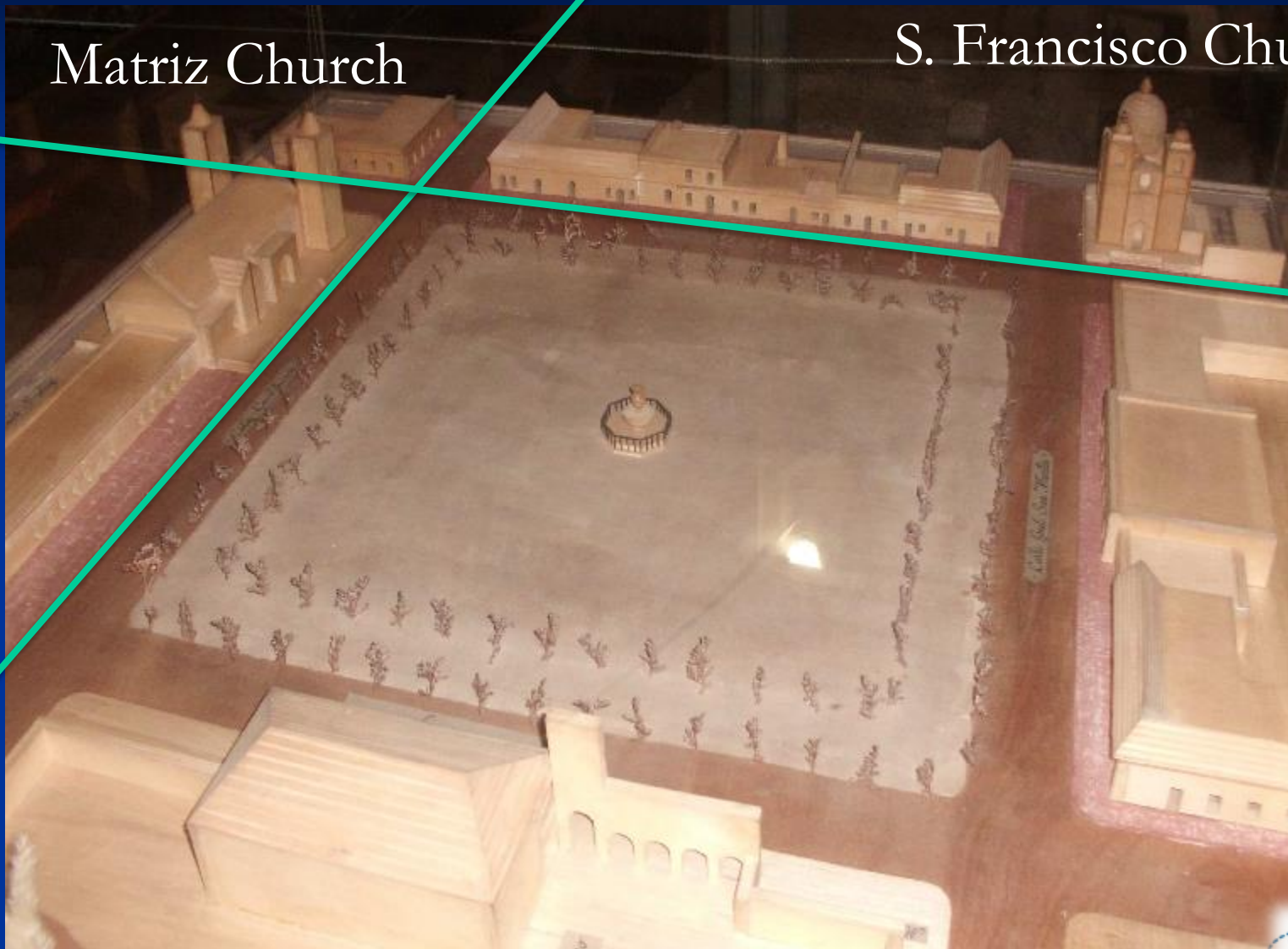
Matriz Church

S. Francisco Church

S

N

E



Main door to East, bad oriented

# San Francisco Church



S. Francisco was constructed 170 years after the Foundation, they put the door in front of the Street. It is bad oriented



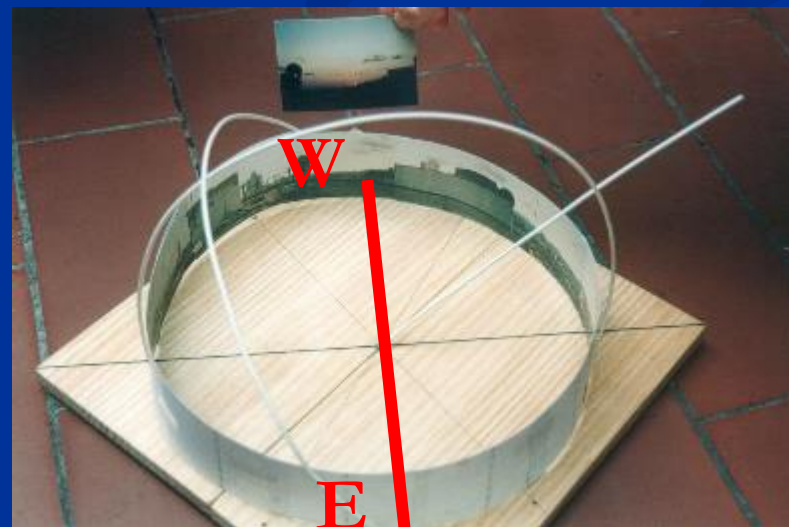
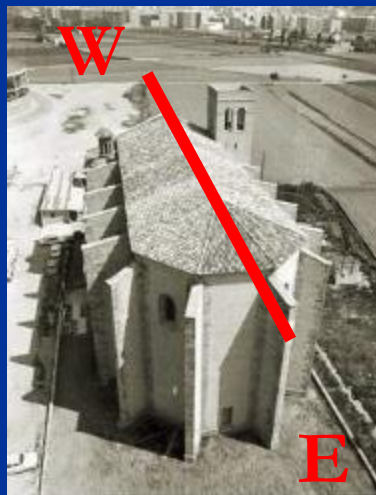


Matriz Church was constructed with the door in front of the Calle de la Cañada (currently Calle Ituzango) with the door in the West according the rules of Catholic Church. The church was destroyed in 1861 earthquake.



At the Council of Nicaea (325) it was determined that the apse was to the East and the gateway to the West so that the priest would be facing East during the services.

Thus the priest and the participants would be directed towards the East, from where Christ, the Sun of Justice, will shine at the end of time (*ecclesiarum situs plerumque talis erat, ut fideles facie altare versa orientem solem, symbolum Christi qui est sol iustitia et lux mundi interentur*)

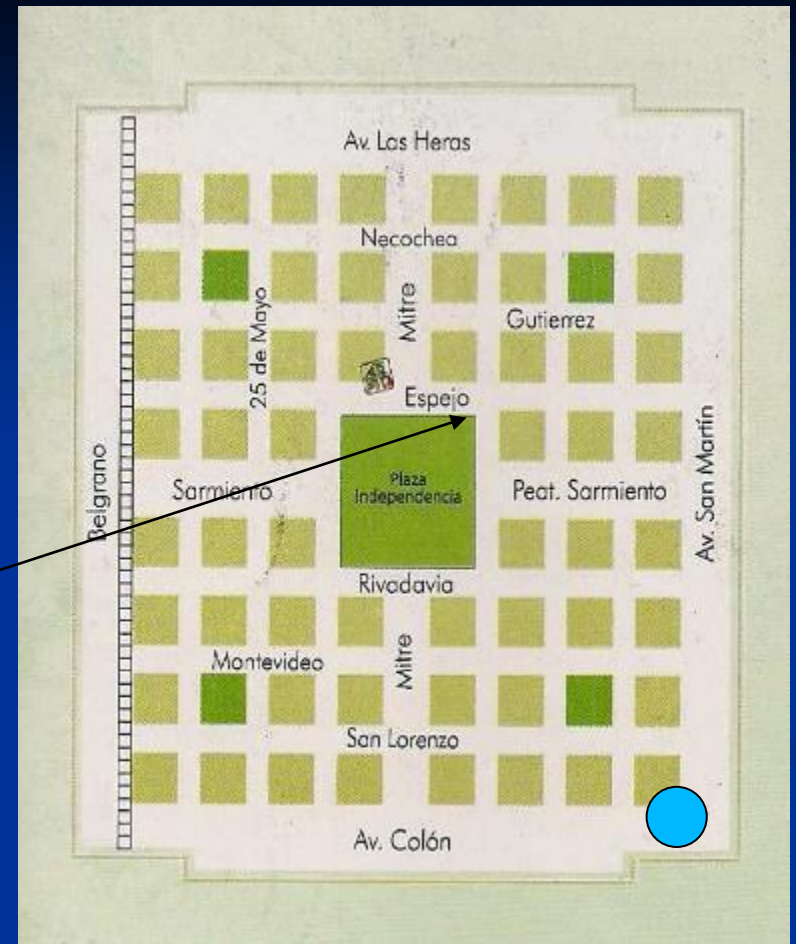


The 1861 earthquake motivated the construction of the New City of Mendoza approximately 1 km South-West of the Foundational Area.

The North-South direction of the Foundational Area and the checkerboard of the Plaza de la Independencia do not correspond

In the Plaza de España, the North-South direction forms with the line of the tiles.





The origin of the coordinates of the urban signs in Mendoza

**MONUMENT**  
**“Mitad del Mundo”**  
**Quito, Ecuador, América**  
**1992**



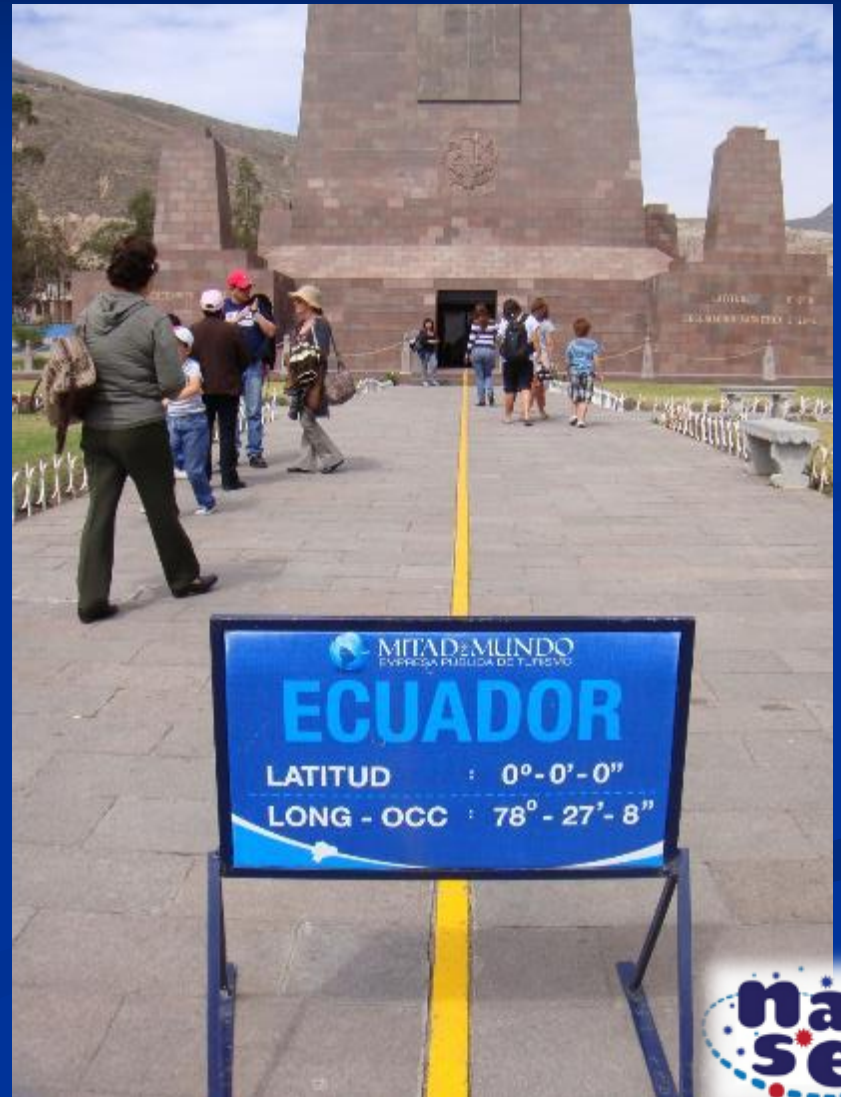
# Equator Monument in the Equator line





Parallel Earth, with the Equator line on the top

# The Equator line



# Parallel Earth? a few weeks after equinox



There is a mistake  
with the position!!!

# SOLAR PANELS

## Ulaanbaatar, Mongolia, Asia

### 2019



With solar panels ... with different orientations?



In Ulaanbaatar **ALWAYS** the same orientation according the solar path!!





Direction N-S with the inclination = site latitude



# Best sits in the Bus

From Ulaanbaatar to Tsetserleg



Sunny part on the South part  
(on the left), that is to say  
it is better to sit on the right



**Many Thanks  
for your attention !**

