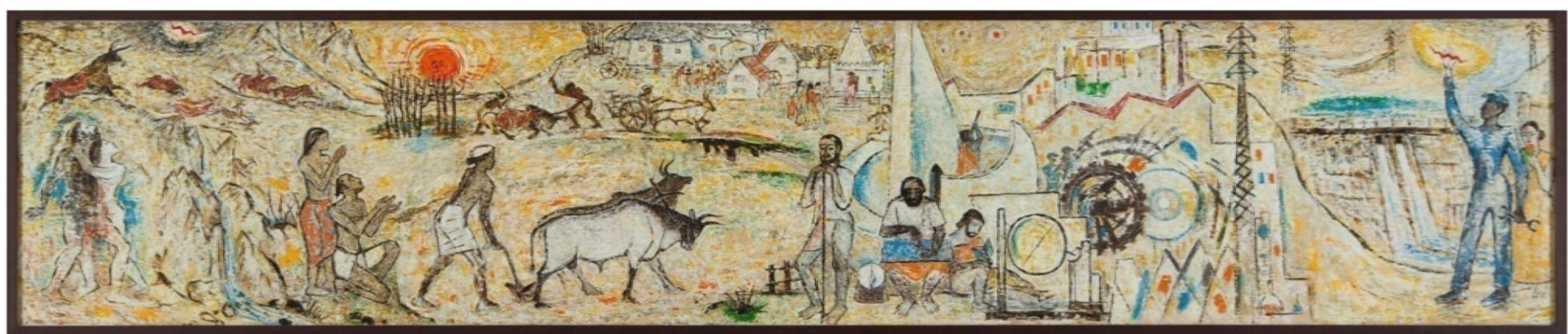


# Origin and growth of Astronomy in India

(A programme supported by Sir Jamsetji Tata Trust)



Civilisation by Hebbler ©TIFR.

Oil on paper pasted on canvas, 1963, 61 x 304.9 cm

Mayank Vahia

*Tata Institute of Fundamental Research, Mumbai, INDIA*

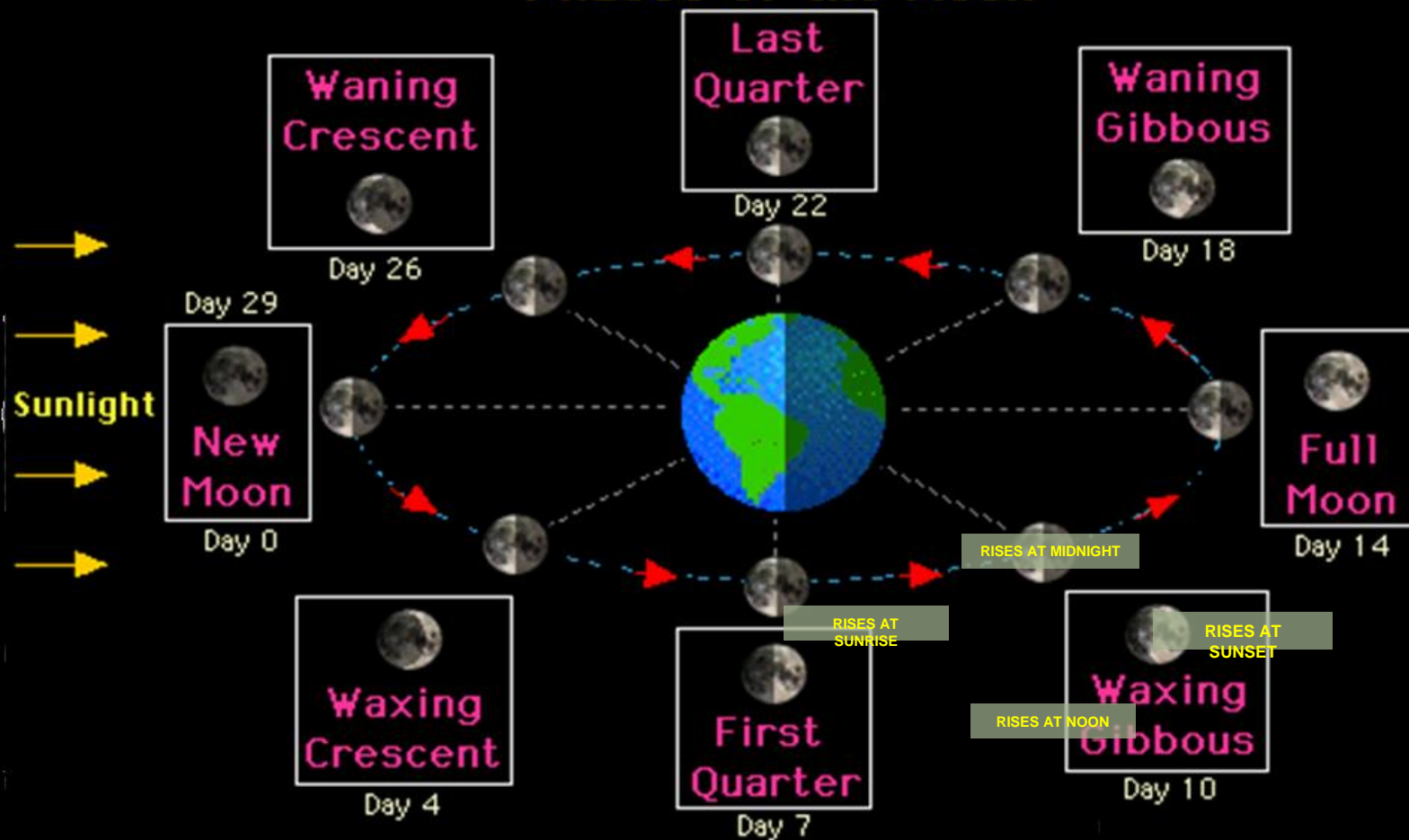
# Understanding a culture

- Archaeological data can give the *technological sophistication* of a culture.
- *Intellectual growth* is in the form of myths, religion, literature, astronomy, mathematics etc.



# Basic Astronomical Concepts

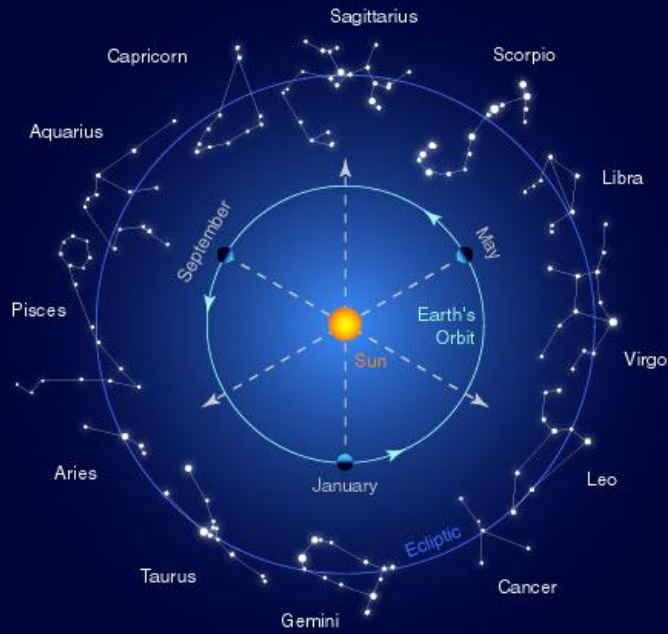
## Phases of the Moon



(a)

Copyri

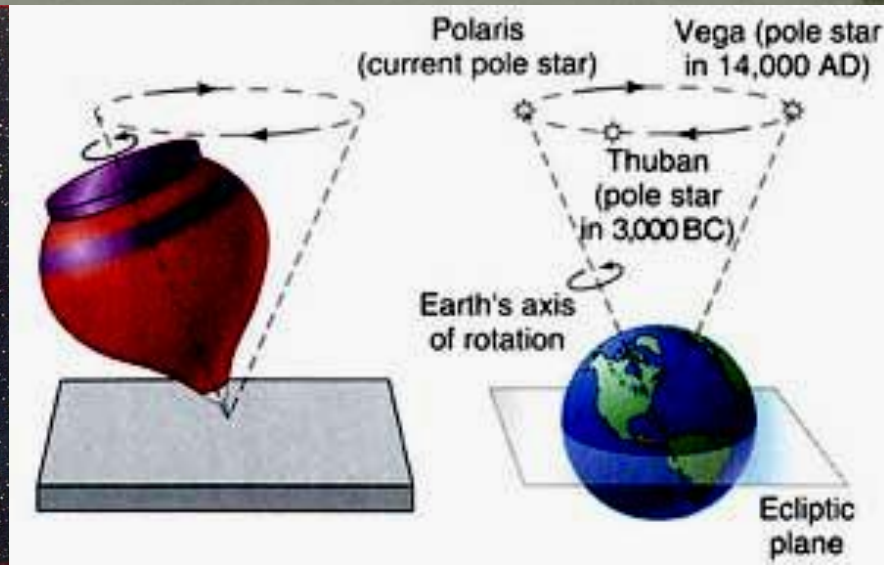
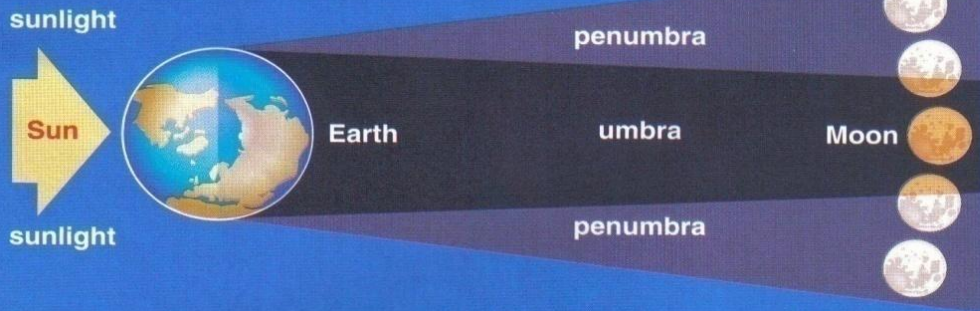
# Some more



## eclipse of the Sun

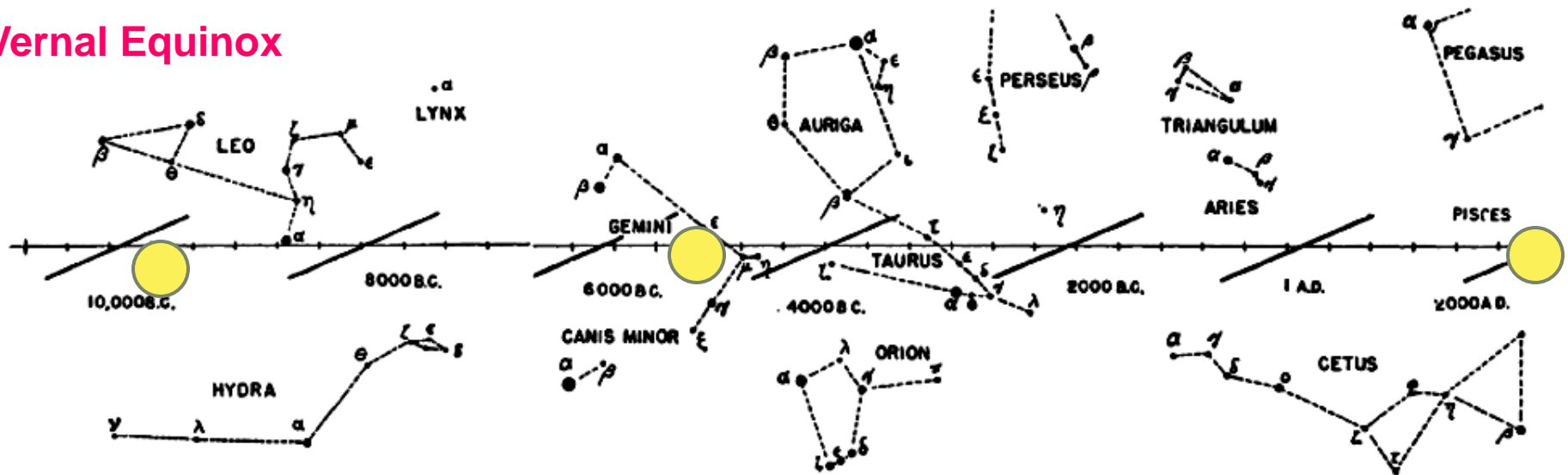


## eclipse of the Moon





## Vernal Equinox



In 6000 BC in Canis Major

Today it is in Pisces

# Astronomy Provides Many Clocks

Hours (Sun and Moon)

[Week (Moon)]

Month (Sun and Moon)

Days (Sun)

Fortnight (Moon)

Year (Sun)

---

Five to Nineteen year (Eclipse cycle)

Sixty years (Jupiter and Saturn)

Hundreds of years (Precession)



# Study in Indian Context

- In most parts of the world, the original 'pagan (?)' religions have been replaced by later more abstract ideas. This has produced a degree of discontinuity of ideas.
- In India the same religion has dominated, even if it has been greatly modified over a period of time.
- While this has produced a rather complex mix of religious ideas, the continuity of ideas over 4000 years allows a more detailed study of the growth of ideas.

# Intellectual challenge

- Acquiring this knowledge of the Heavens requires enormous expenditure of time, resources, intellect and technology.
- Cultures require to mature to various levels to develop different types of technologies.



# Origin of Astronomy

Four distinct stages in evolution of astronomy can be identified:

1. Initial steps: Noting the relation between Sunrise and seasons.
2. Settlement Astronomy: Tracking seasons and marking of stars for astronomy.
3. Astronomy of civilisation: Development of astrology and cosmogony.
4. Technology based, state supported astronomy: Modern astronomy with all its trappings.

By knowing how sophisticated a culture's astronomical work is, it is possible to determine its general intellectual and socio-cultural level.

# Stage 1: Initial astronomy

Summer  
Solstice



Equinox



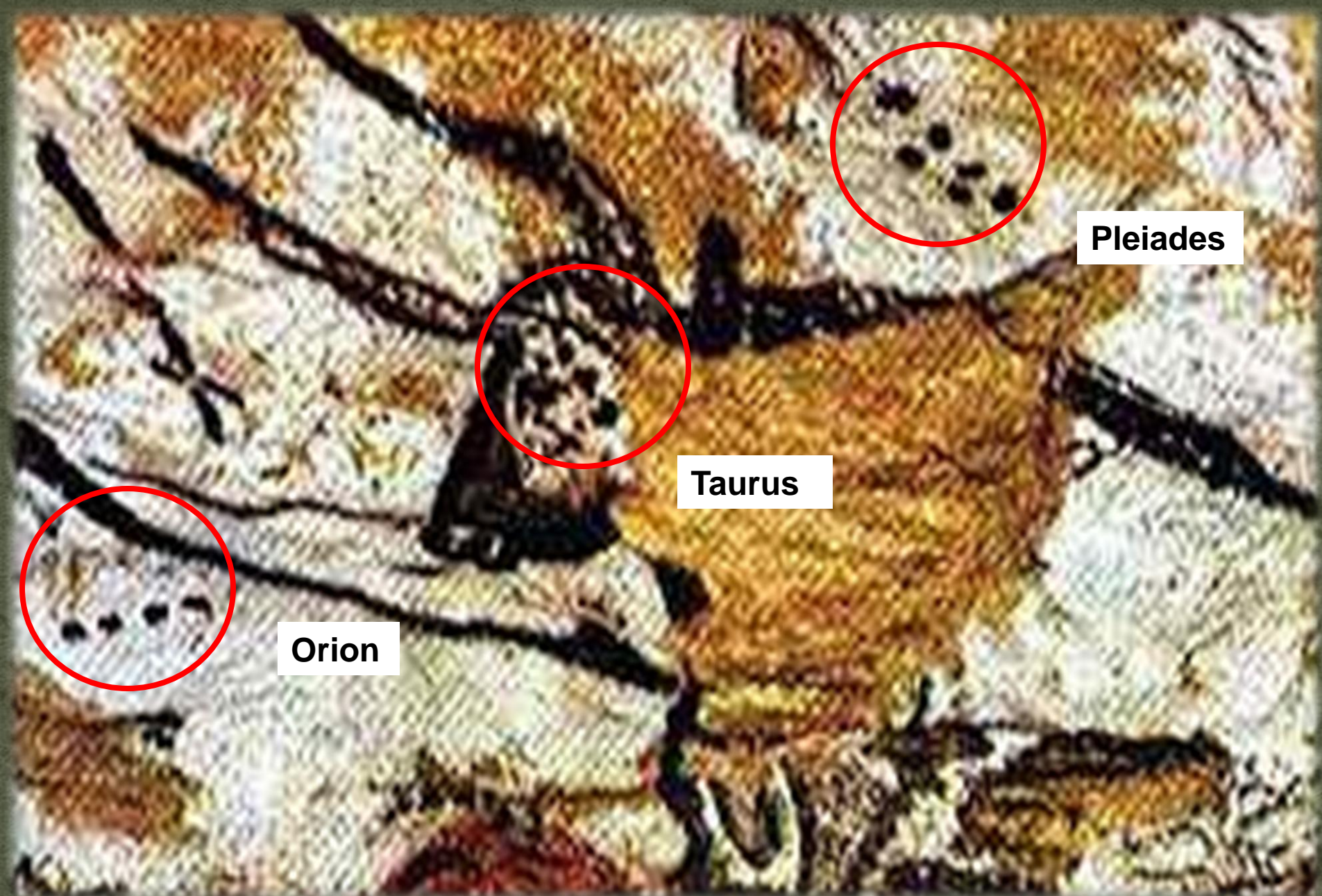
Winter  
Solstice





- Identifying Sun as the source of warmth, life and light.
- Rains, Sun and Sky are identified as crucial life givers. Sky rejuvenates the Earth. This becomes an everlasting image in human (even Neanderthal?) mind.
- Because of its elegance and importance, the sky becomes the abode for the gods.
- Arrival of first art often implies astronomical observations are marked on stones.
- Settling down will bring in first generation astronomy – to the level of defining seasons and their relation to Sunrise points.





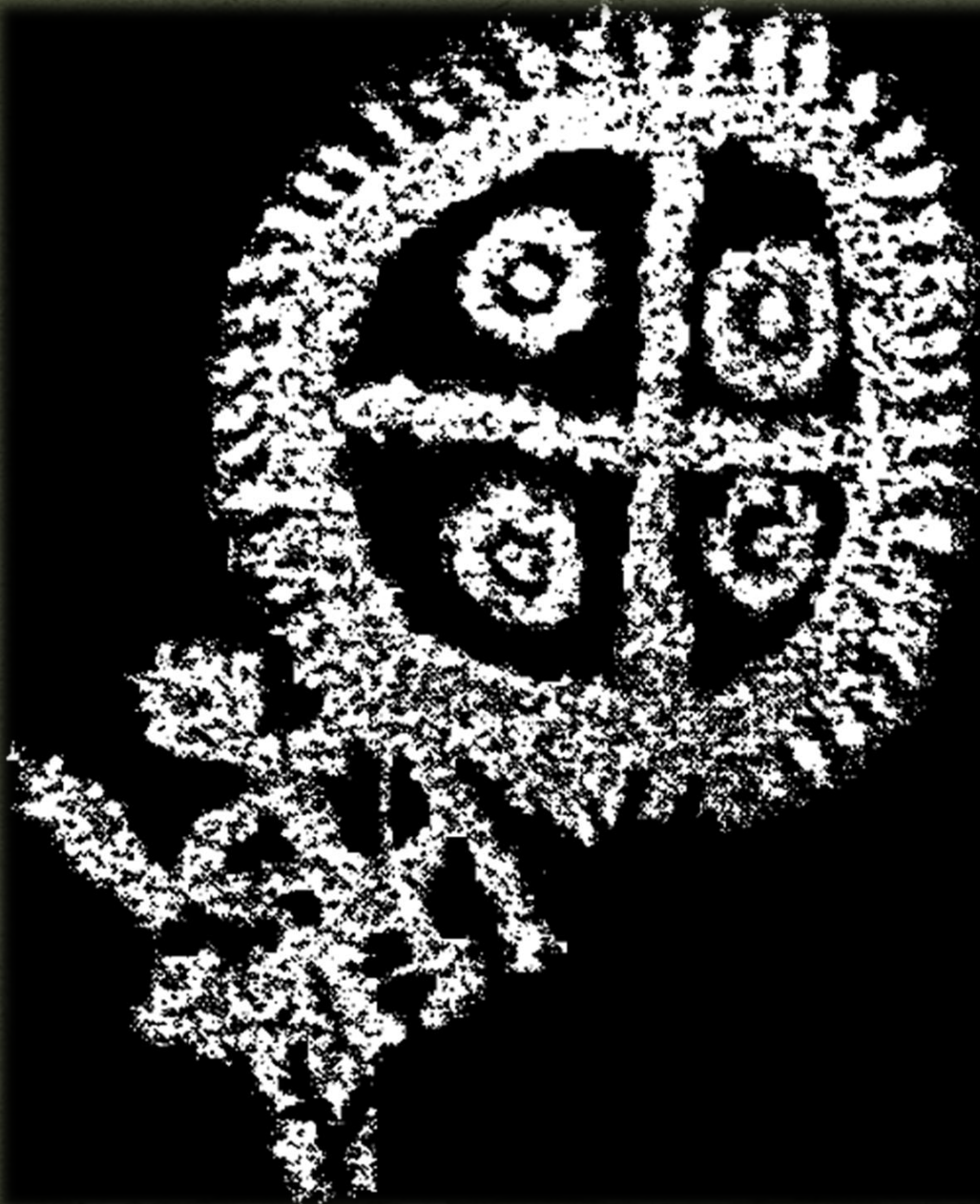
**Pleiades**

**Taurus**

**Orion**

**Prehistoric caves at  
Lascaux in France.**





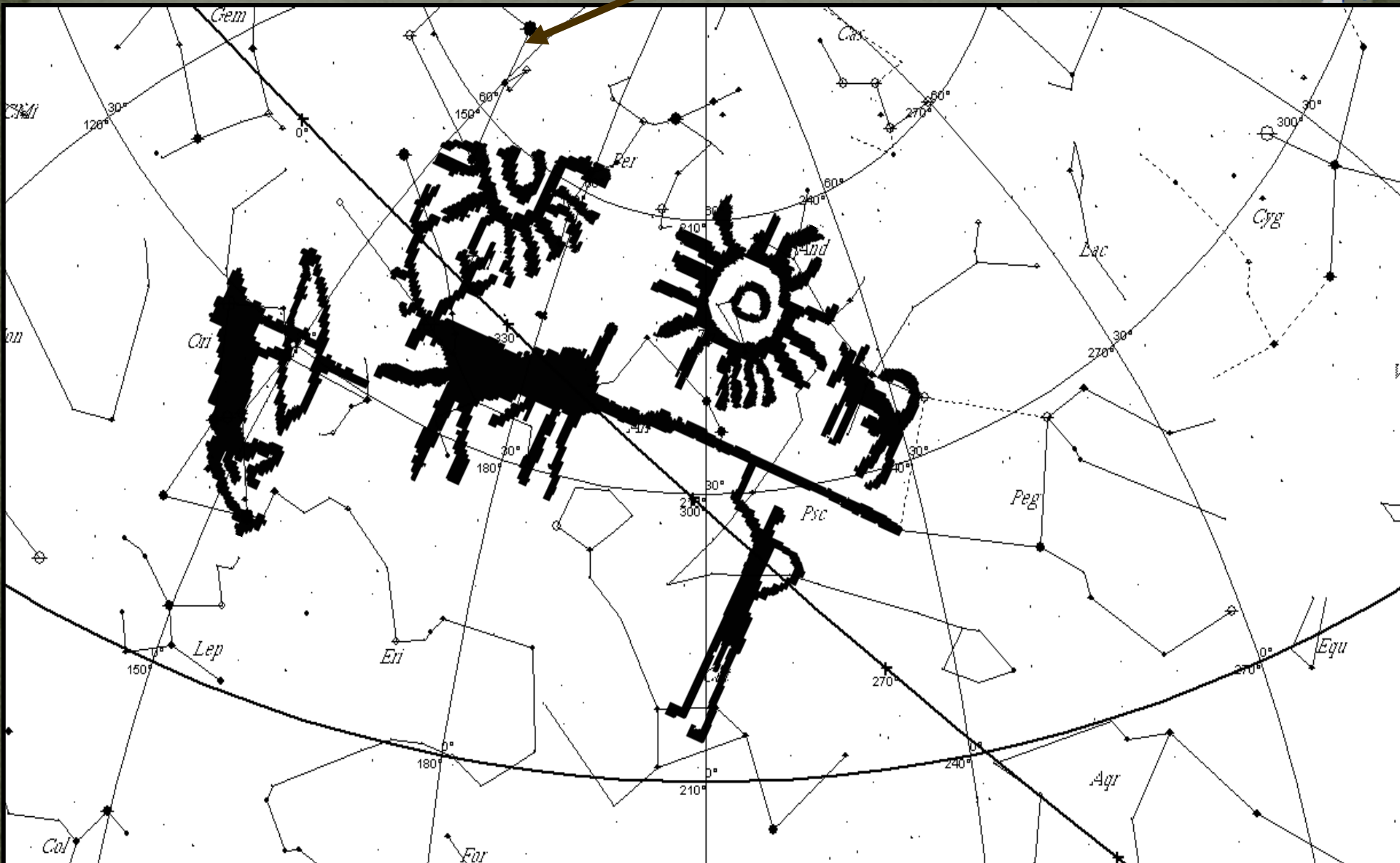
A beautiful image,  
possibly of Sun God  
with indications of 4  
seasons (Winter,  
Spring, Summer,  
Autumn) from Chillas





Supernova HG9, ~5000 BC

STAGE - 1

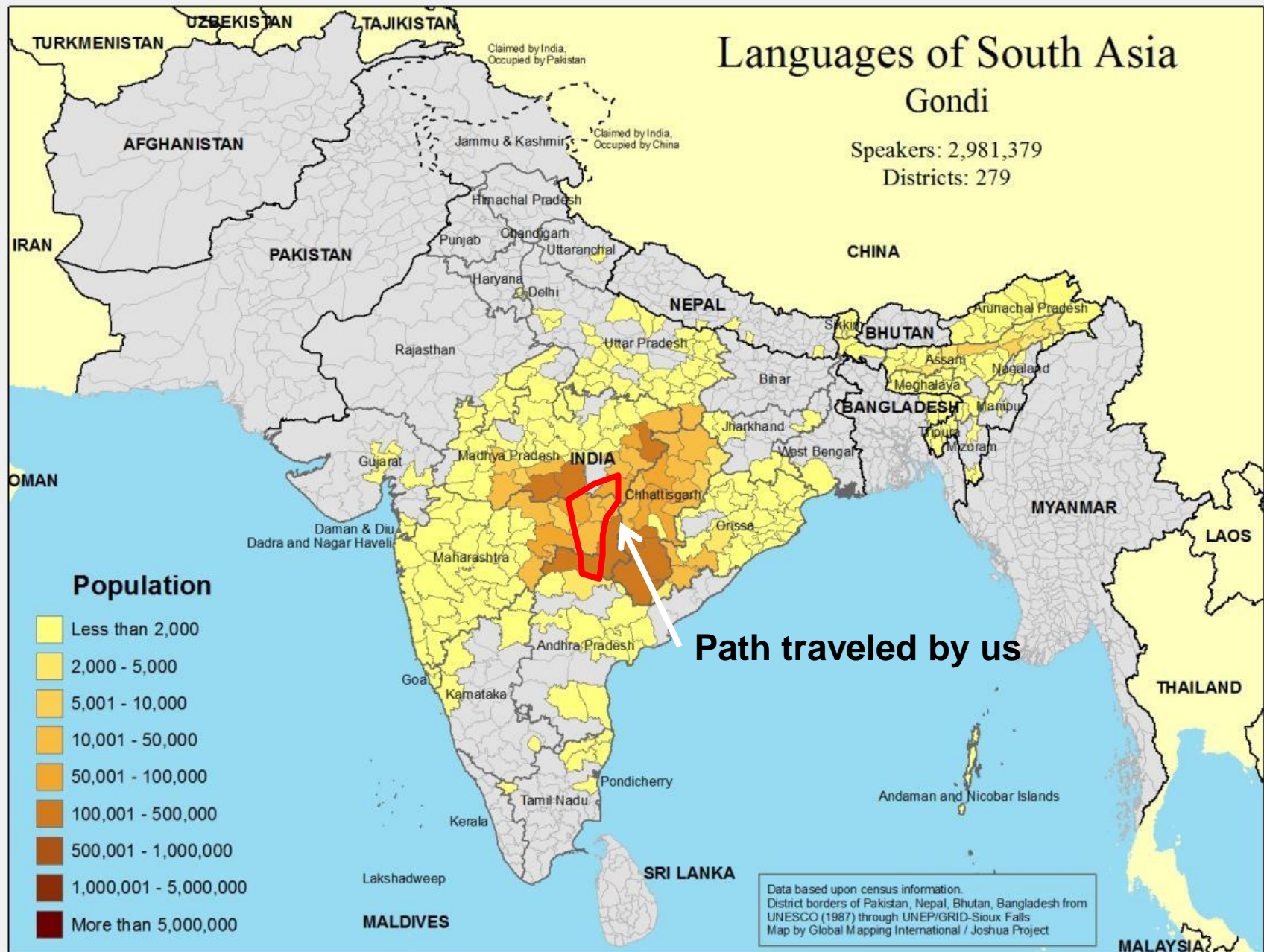


# Languages of South Asia

## Gondi

Speakers: 2,981,379

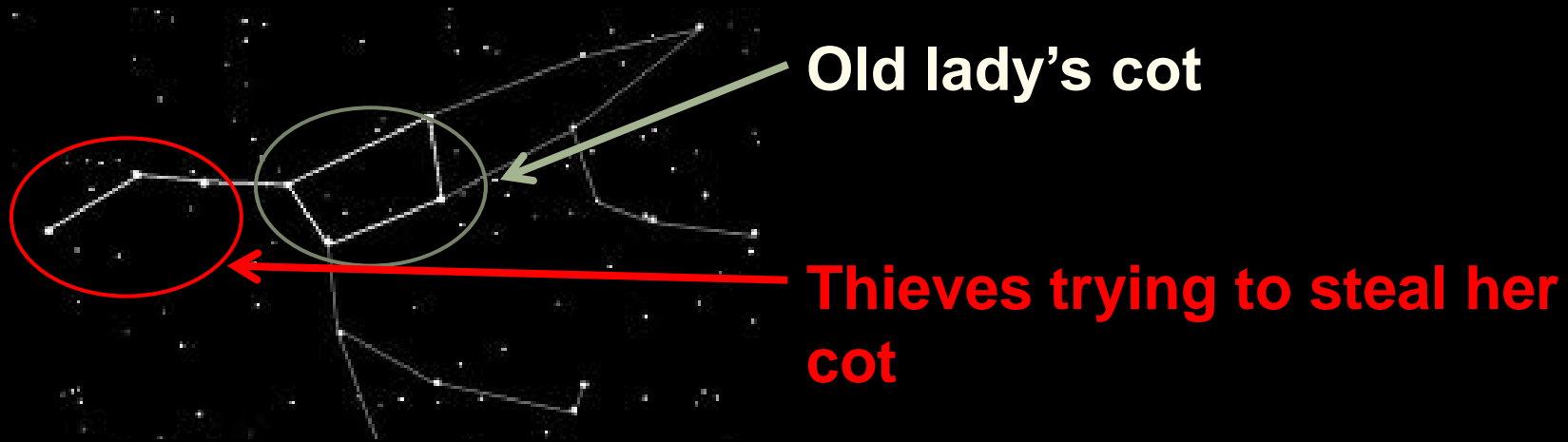
Districts: 279





# Their interesting myths

- They believe that Ursa Major represents an old lady on a mat with 3 thieves.



**The lady is therefore not allowed to sleep and hence Ursa Major must remain circumpolar (dating the observation to 1000 BC after which UM was not circumpolar).**

# Other beliefs

- The calendar is lunar with 1 month added every three years and somewhat *ad hoc* synchronisation of solar and lunar calendars.
- Around Orion they can see the entire farming sequence.
- North is considered inauspicious.
- Milky way is called the path of the animals.
- Comets are considered to be brooms of god that have come to clean up the sins of the Earth and are therefore a good omen.
- Shooting stars are called star excreta.
- Their counting system is octal with 9 and 10 adopted later from the local languages



## *Stage 2: Settlement astronomy*



Burzoham, Kashmir, India



- Large structures are created with astronomy in mind. Megaliths seem to have been used for forecasting seasons.
- Various aspects of Moon (and planets?) get studied.
- Constellations, Zodiacs and Nakshatra etc. are defined.
- Eclipses are noticed and attempts are made to determine their periodicity.
- Transient events such as comets are recorded.
- New myths are created to explain these observations.
- Cosmogonical ideas emerge.



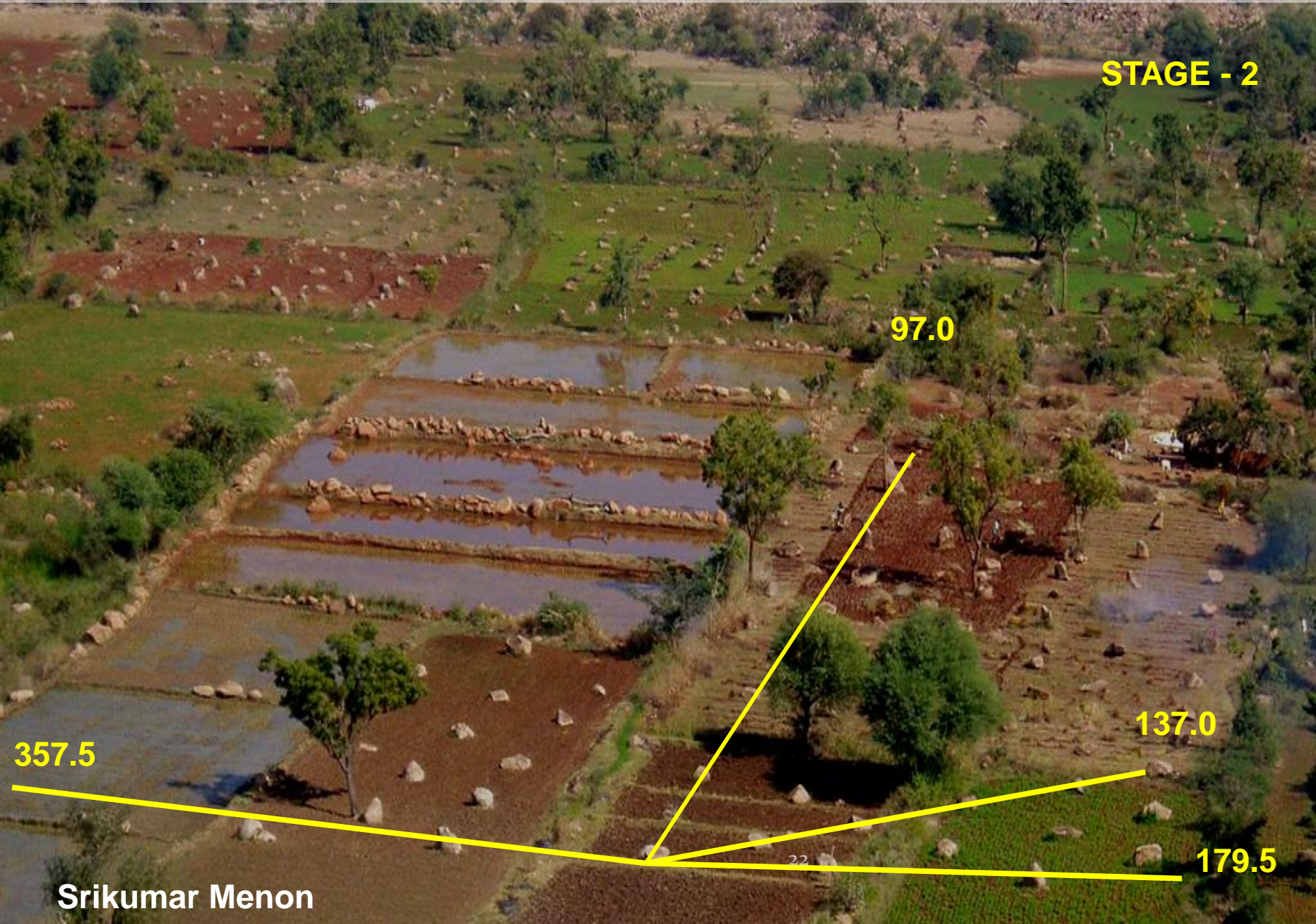
# Megaliths



- Large structures are created to study the sunrise patterns. Megaliths become essential for calendrical purposes.
- These megalithic structures are gigantic in size and are clearly made with great care and diligence.
- In western context, they have been shown to be for astronomical use.
- In India more than 2000 such structures have been catalogued but not studied.



# A portion of the stone alignment at Hanamsagar





# Importance of Astronomy

यथा शिखा मयूराणां नागानां मणयो यथा ।

तद्वद् वेदाङ्गशास्त्राणां ज्योतिषं मूर्धनि स्थितम् ॥

(RV-VJ 35)

Just like the combs of peacocks and the crest jewels of serpents, so does Jyotiṣa (astronomy) stand at the head of the auxiliaries of the Veda.

# Basic astronomical ideas in Vedas

- Both Ṛg Veda and Yajur Veda have their own aspects of Astronomy that have been compiled in Vedanga Jyotisha.
- They are accurate to a great extent in defining the duration of year and its division into seasons etc.
- They are aware of the discrepancies between Lunar and Solar months and the need for intercalary month for synchronising the two. It recommends 2 intercalary months in 5 years.



## VEDIC COSMOGONY

1. *At first was neither Being nor Non-being.*

*There was not air nor yet sky beyond.*

*What was its wrapping? Where? In whose protection?*

*Was water there, unfathomable and deep?*

2. *There was no death then, nor yet deathlessness;  
of night or day there was not any sign.*

*The One breathed without breath, by its own impulse.*

*Other than that was nothing else at all.*

....

6. *Who really knows? Who can presume to tell it?  
Whence was it born? Whence issued this creation?*

*Even the Gods came after its emergence.*

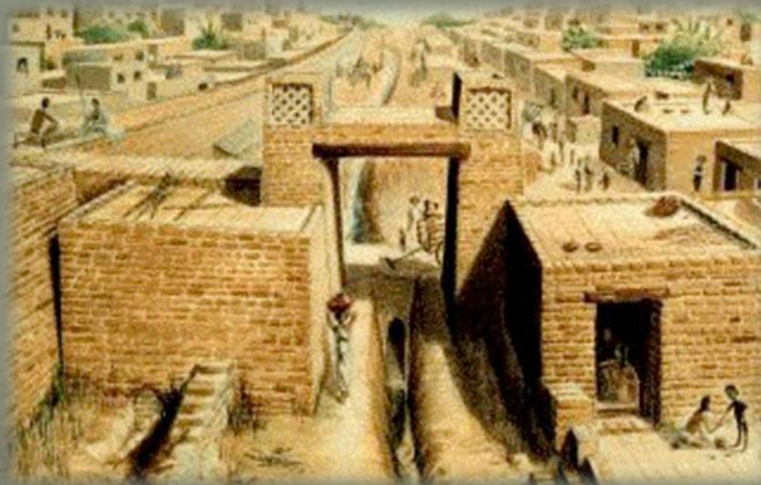
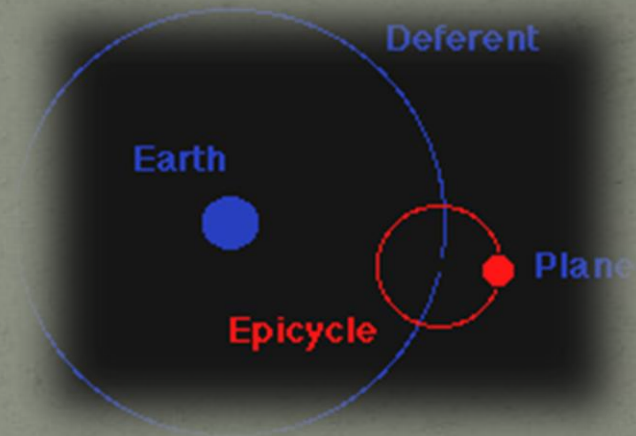
*Then who can tell from whence it came to be?*

7. *That out of which creation has arisen,  
Whether it held it firm or it did not,  
He who surveys it in the highest heaven,  
He surely knows – or **maybe He does not!***

*Rig Veda X, 129*



# *Stage 3: Astronomy of civilisation*





- At this stage the society can support speculations
  - Astronomical mythology
  - Astrology
  - Cosmogony
- In the absence of other knowledge, such activities would have certain respectability.
- These include *re-interpretation* of old scattered ideas or creation of new ideas. Sophisticated speculations emerge.
- An interesting mixture of religious beliefs, astronomy and architecture emerge, reflecting the cosmogony of the period.
- Some amount of mathematical astronomy also arises at this stage.

# Indus Astronomical Seal?



About 7 astronomical patterns can be identified.

There are several seals with 7 humans and other motifs on them that are similar to the motifs here.

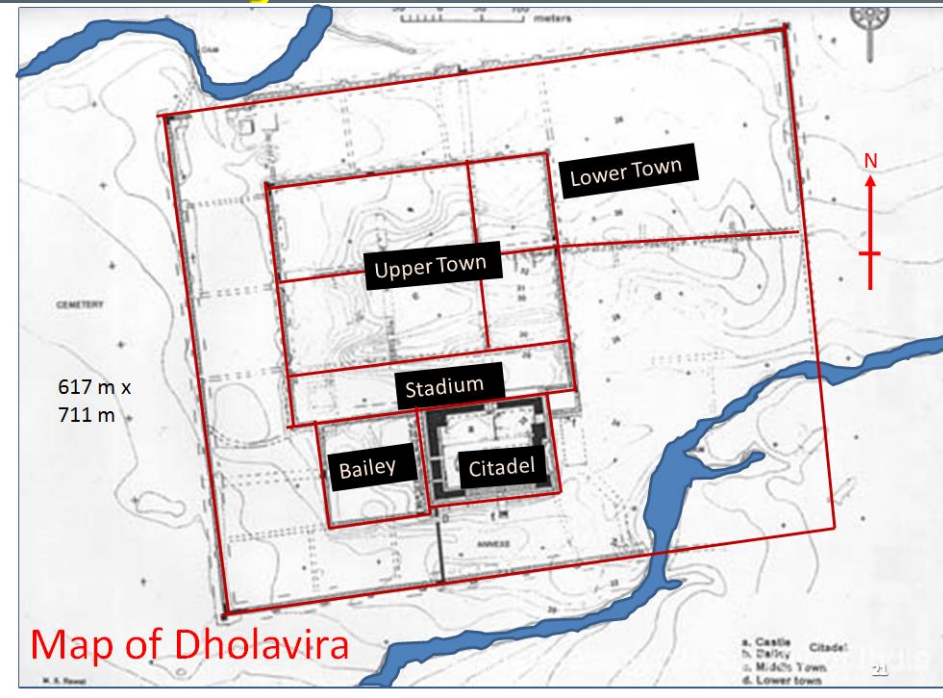


# Structures in Dholavira

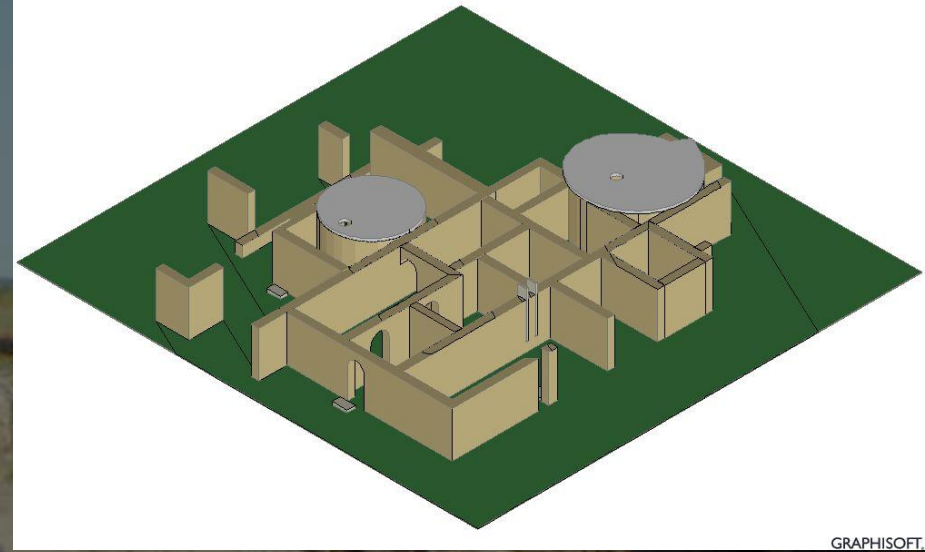
- Dholavira is one of the largest towns in the Civilisation.
- It has many different types of structures.
- It has two types of circular structures:
  - Crude ones on the top of the Citadel
  - More complex ones in the Bailey.
- We suggest that that the ones in Bailey were contemporaneous to the peak of the civilisation *in spite of its interlocking with other structures inside it.*



# Bailey

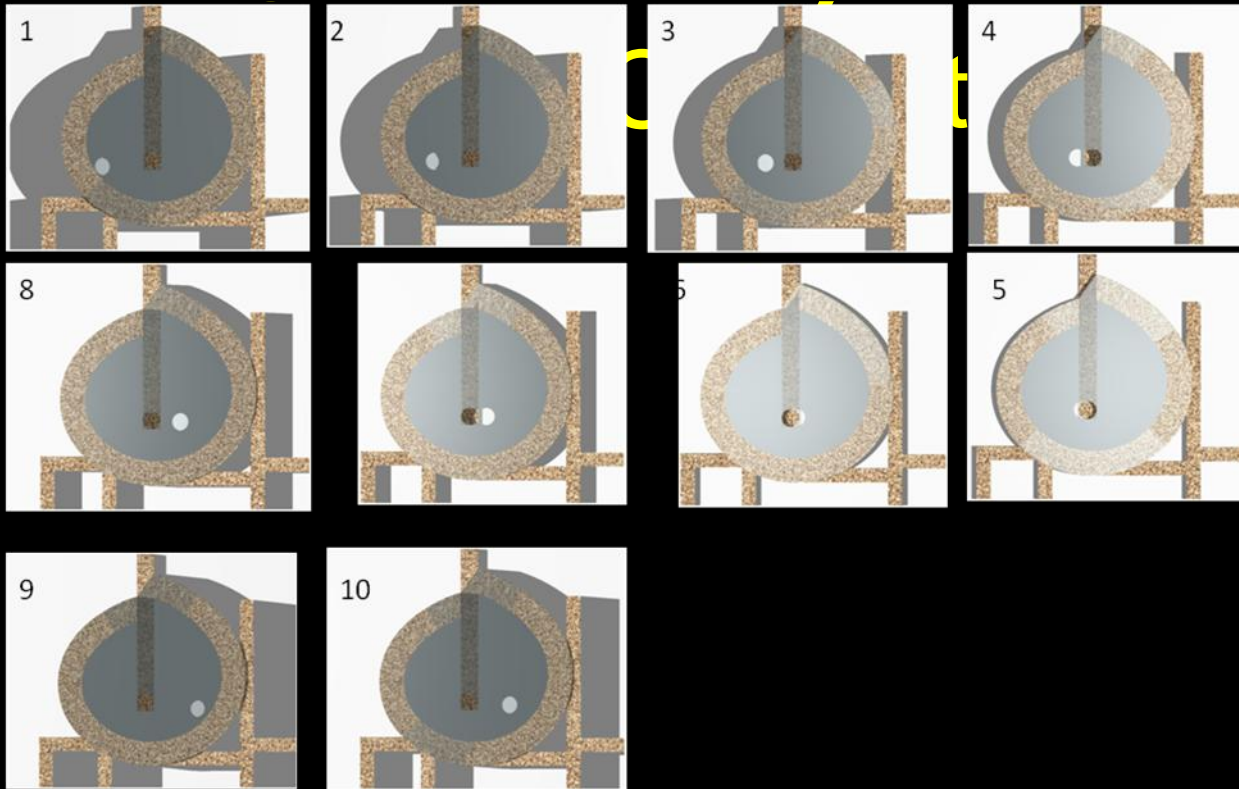


ArchCAD Student version, not for resale. Courtesy of Graphisoft.



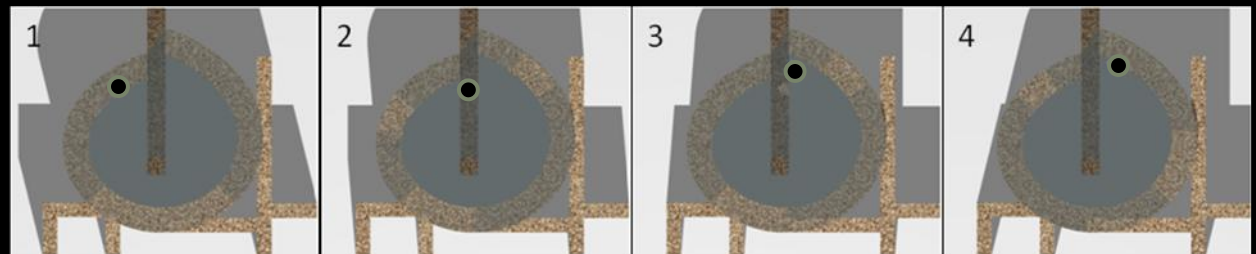


# Observatory of Harappan



Summer Solstice

Winter Solstice



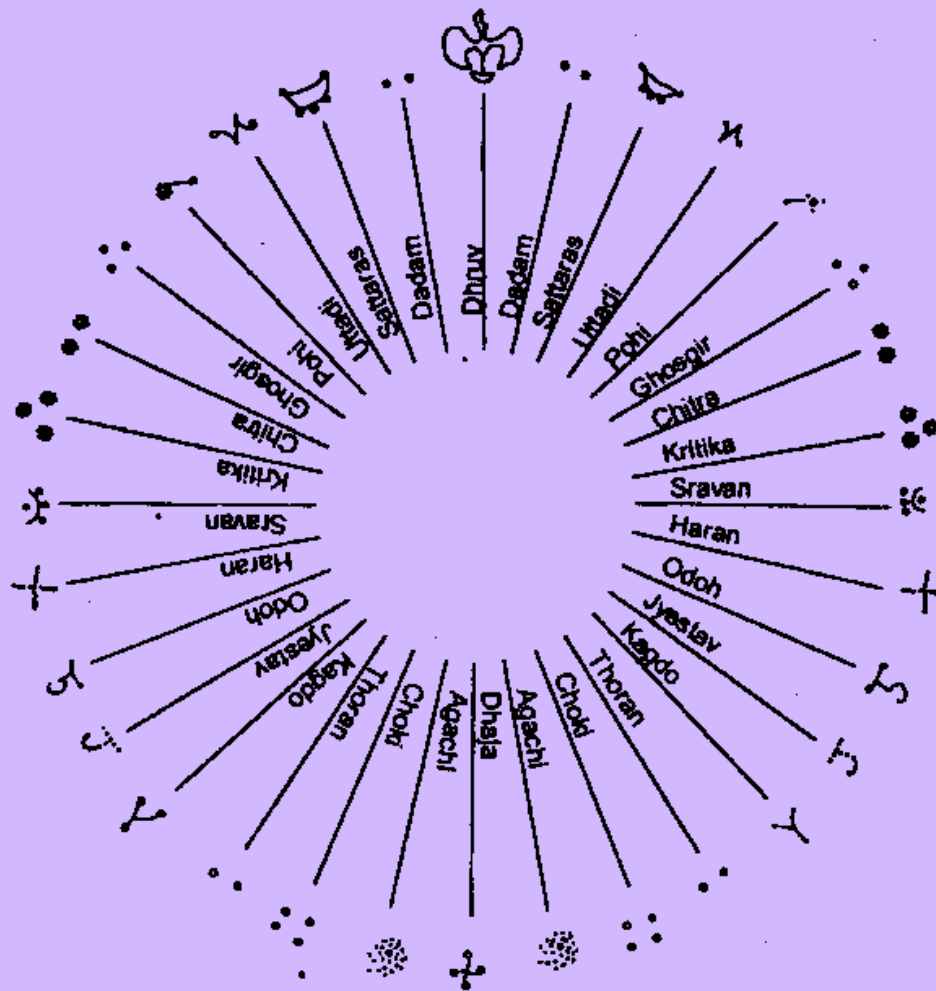
# Issues with the interpretation

- Nothing is known about Harappan astronomy or their calendar and hence any attempt to identify an observatory is a speculation.
- It needs to be established that the building was contemporaneous to the Castle.
- The bailey has no view of the Eastern sky.
- Similar structures should also be seen in other Harappan sites.



# Navigation by Star

- 1  $\alpha$  UMi
- 2  $\beta, \gamma$  UMi
- 3  $\zeta$  UMa
- 4  $\alpha, \beta$  Cas
- 5  $\alpha$  Aur
- 6  $\alpha$  Lyr
- 7 Perseus
- 8 Pleiades
- 9 Altair
- 10 Orion
- 11 Sirius
- 12  $\delta$  Sco
- 13  $\alpha$  Sco
- 14  $\alpha, \beta$  Cen  
[and Crux]
- 15  $\alpha$  Carina
- 16  $\alpha$  Eridani
- 17 LMC



Navigational chart from around 1500 AD in north Gujarat

These location based lotuses were used to define direction of travel based on the stars at setting time.

# Junapani and the village of the dead







Image © 2010 DigitalGlobe  
© 2010 Europa Technologies  
© 2010 Google

©2009 Google

Date: Apr 21, 2009

21°11'49.33" N 78°59'55.40" E elev 346 m

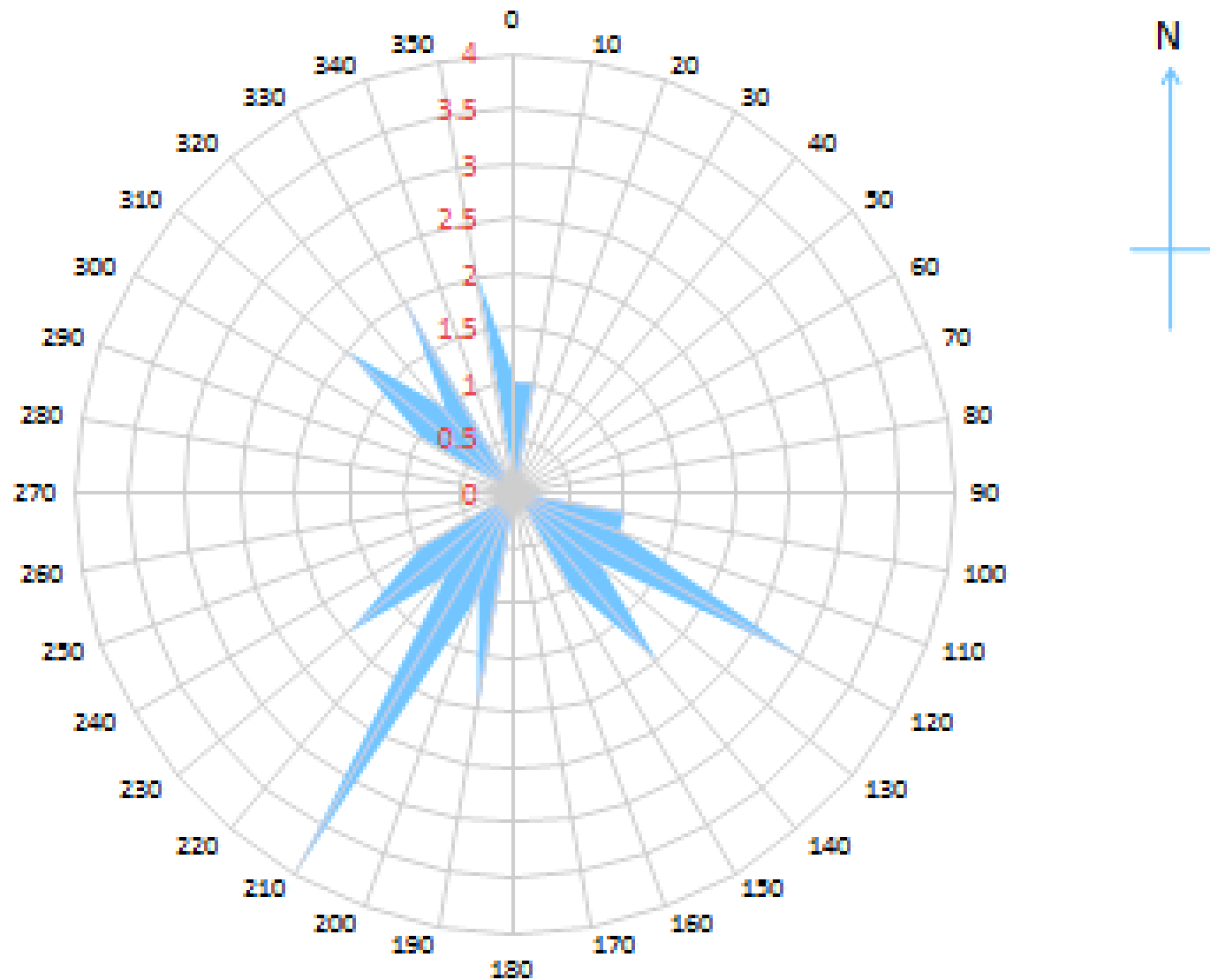
Eye alt 557 m

# Site summary

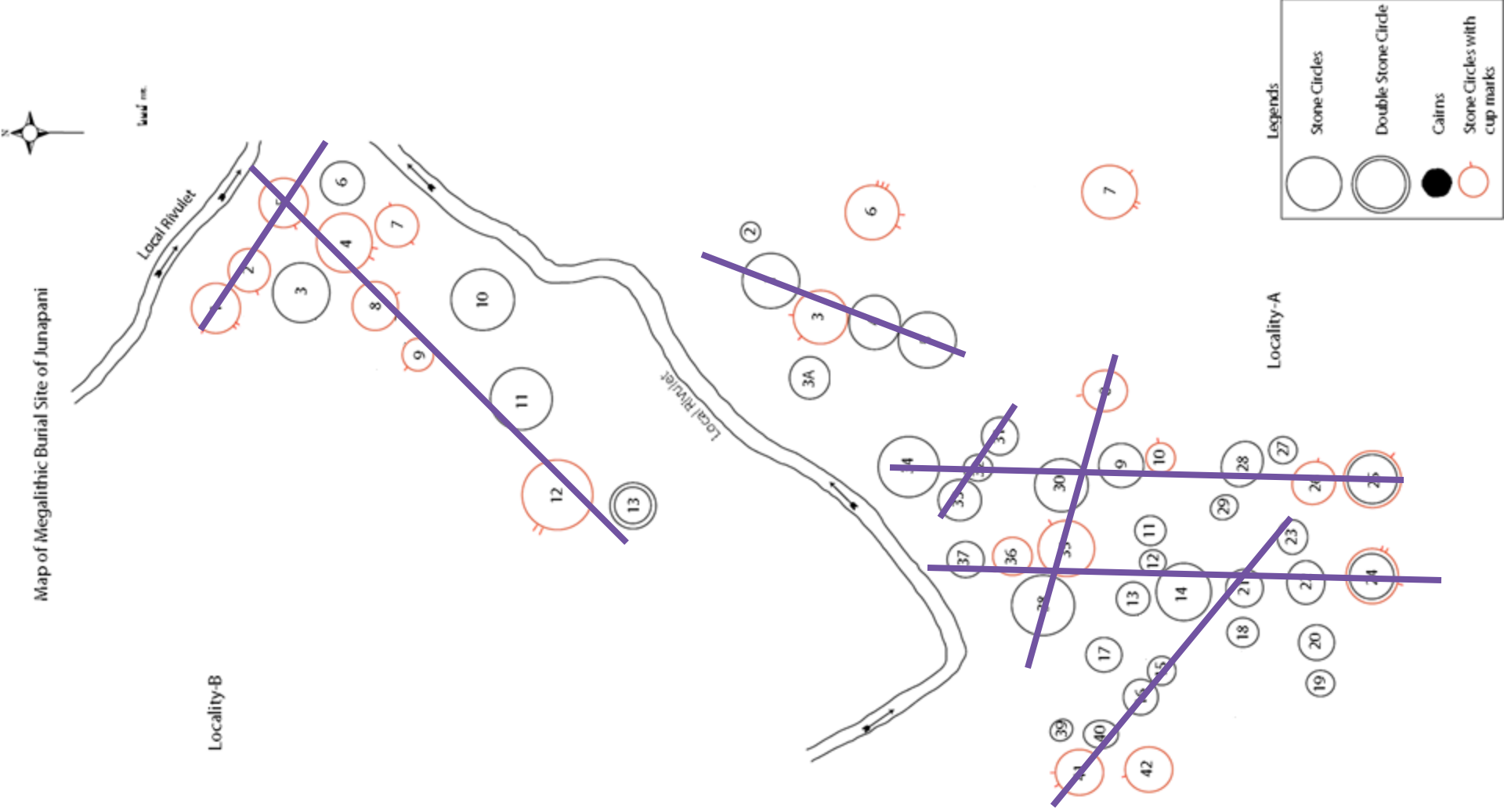
- The stone circles of Junapani seem to be sepulchral in nature.
- They seem to be of iron age and later period.
- They are in a region of flat landscape.
- We have surveyed and mapped 56 circles and another 50 cairns.
- Of these 20 circles had cup marks (36%).



# Angular distribution of cup marks



# Village of the dead





# Cosmogony of Upanishads

In Brihadaranyaka Upanishad (6<sup>th</sup> Brahmana) Yagnavalkya describes Universe to Gargi in the following terms:

1. Everything on earth is wrapped in **water**
2. Water is wrapped in **air**
  
1. Air is wrapped in **sky**
2. Sky is wrapped in the world of **Gandharvas** (planets?)
3. Worlds of Gandarvas is wrapped in Aditya (**Sun**)
4. The world of Sun is wrapped in the world of Chandra (**Moon**)
5. The world of Moon is wrapped in the world of **Nakshatra**
  
1. The world of Nakshatra is wrapped in the world of **Deva's**
2. The world of Deva's is enclosed in the world of **Indra**
3. The world of Indra is wrapped in the world of **Prajapati**
4. The world of Prajapati is wrapped in the world of **Brahman**

# The Yugas

- The Original idea of Yuga exists in the Rig Veda and the Rig Vedic Vedanga Jyotisha.
- But it is in the form of a 5 year cycle designed to synchronise the Sola and Lunar Calendars by adding *adhikamasa*.
- Subsequently this idea is expanded to include time periods of planets so that they can complete an integral number of rotation within a *Kalpa*.
- Eventually it expanded to the much larger time frame by going from *Versha* to *Daivik Varsha* and then creating 4 yugas etc.





## Cosmogony of Gods and process of life

The cycle of life is  
handled by 3 gods of  
creation, sustenance  
and destruction



**Minakshi temple in  
Madurai in classical  
Dravidian Style**

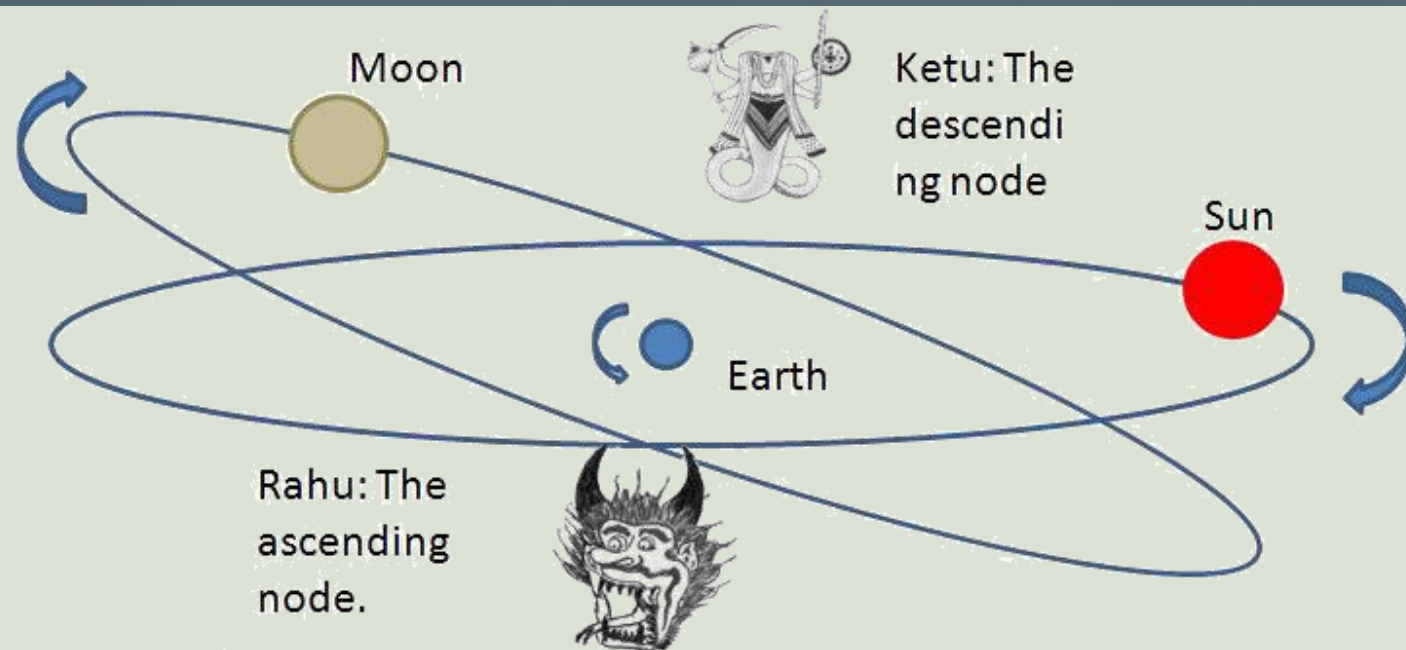
**Somnath Temple, Gujarat in  
Nagara Style**





# Rahu and Ketu

- Rahu and Ketu are one of the *navagrahas*, but a dark one that engulfs the Sun or the Moon.
- They then evolve as the head and body of a demon who managed to get a bit of the divine nectar during *Samudramanthan*. This is a line of mythology common to several cultures.
- Later, in the Sidhantic period, they are identified as the two nodes of the Earth-Sun line whose location can be calculated.
- If Sun and Moon come close to the node simultaneously, an eclipse occurs.



Surya the Sun



Chandra the Moon

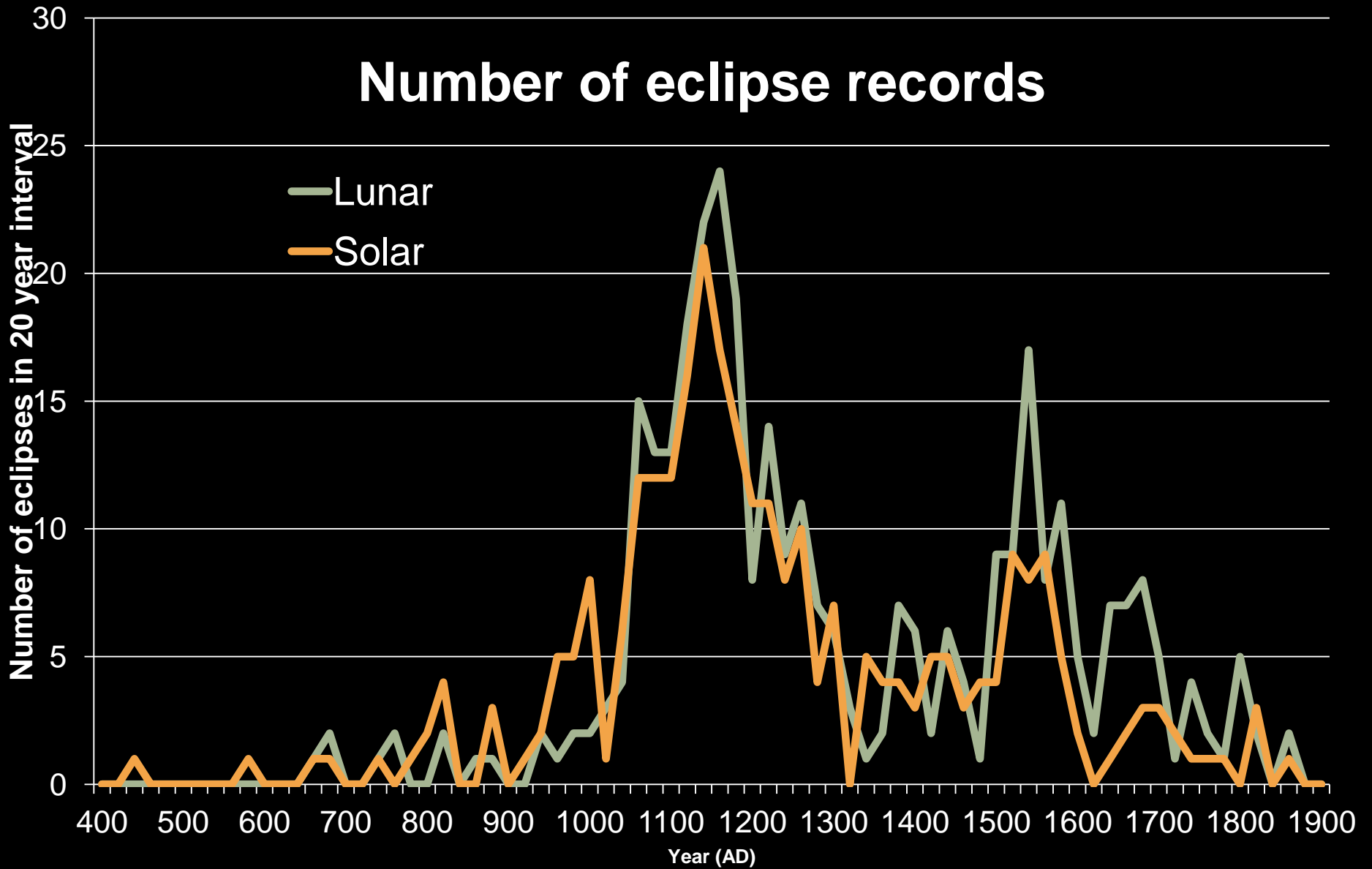


Rahu



Ketu





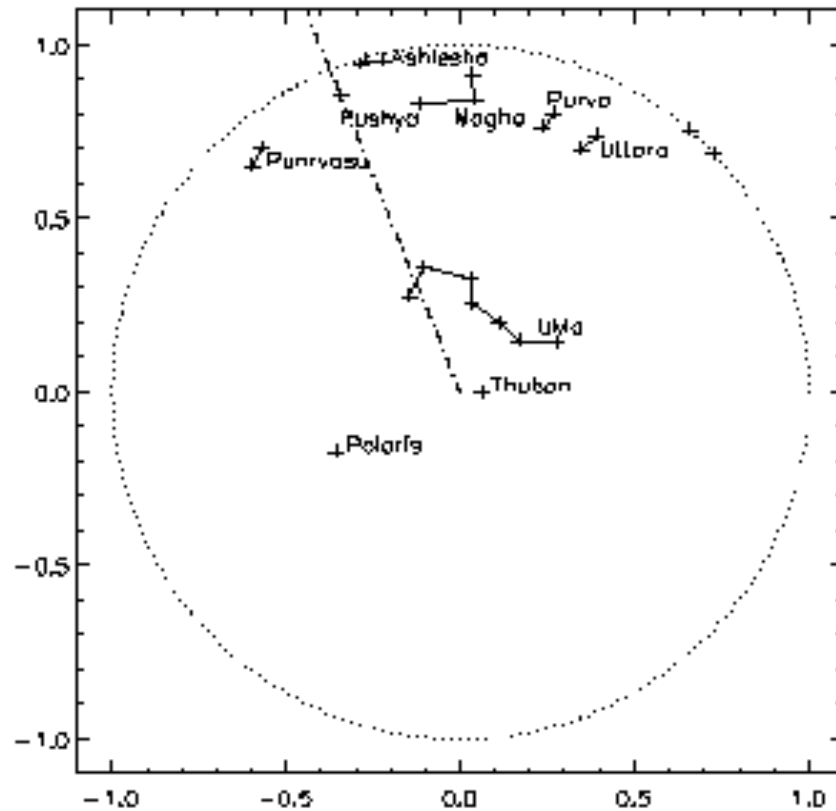
Subbarayappa

## Calendar based on Ursa Major (UMa)

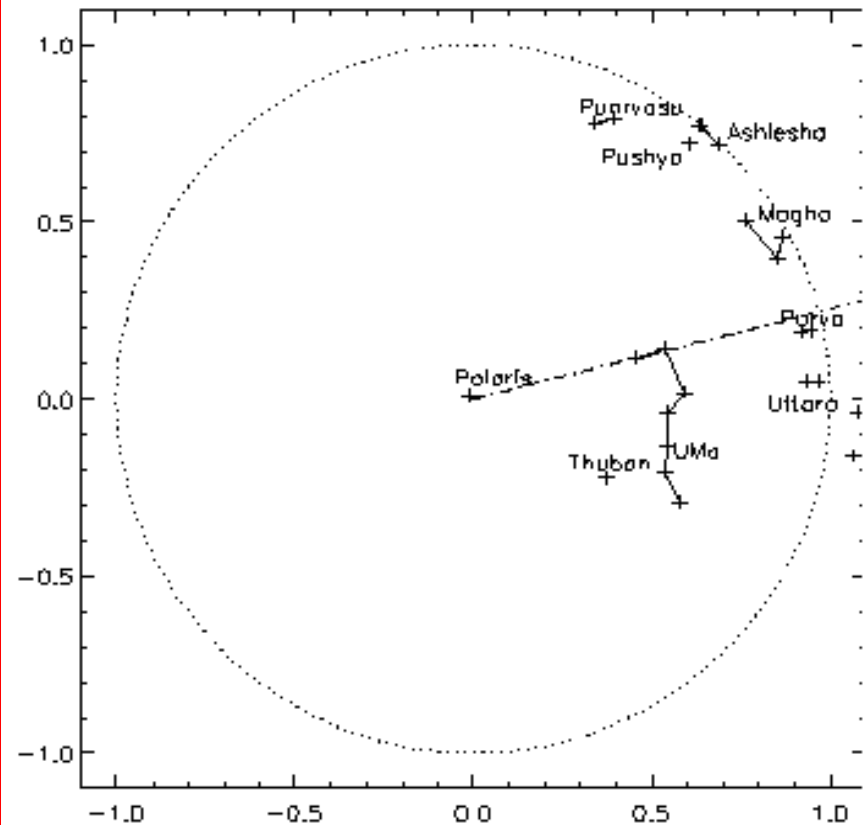
- An interesting time line in the post Vedic literature is a calendar that is based on UMa.
- It states that the UMa constellation visits different Lunar Mansions giving different eras.
- It was generally assumed to be wrong.



# Calendar for UMa



**2100 BC**



**2000 AD**

# Astronomical observations of the past can give interesting clues

	Document	Date (BC)	Comments	Reference
1	<b>Brihat Samhita</b> (Prob a memory of earlier event)	5284	<b>Rohin Shakata Bheda</b>	Mahajani, Vahia et al.
2	Yajur Veda	2350	Vernal Equinox in Kritika	Vedang Jyotisha translated by T S K Sastry
3	Yajur – Vedanga Jyotisha	1370	Summer Solstice in Aslesha	
4	Period of Lagadha	1340	Polar latitude of Sravishtha	
5	Mahabharata	1200	Saptarshi Calendar	Sule, Vahia et al.
6	Parashara Samhita	1100-1300	Description of seasons and constellations	Iyengar R N



*Stage 4: Technology based, state sponsored astronomy*

[illegible][illegible][illegible][illegible]



- Beyond a certain level of sophistication, a culture begins to specialise tasks and not everyone will be required to be proficient in all aspects of life.
- This translates into specialised education programme that comes in a variety of forms. However, a common feature of most of these is the state patronage.
- Depending on the capability, development of astronomy will be driven by mathematical and technological developments. Interaction with neighbouring cultures can also spur the growth.
- From here on, the growth of astronomy follows the same growth plan as the rest of the society.



# Siddhantic Astronomy

- In the Indian context, this phase begins around 500 AD with the advent of Siddhantic Astronomy and great astronomers like Aryabhatta.
- Pre-occupation of Indian astronomers for the next millennium was the calculation of geocentric planetary orbits.
- They developed algorithms for solving mathematical equations.
- This included concepts of trigonometry and limiting value of functions – the first steps of differential calculus.

# Mathematical formulations

- At this stage, the exact mathematical equations covering the movement of Sun, Moon and Planets are parameterised.
- Important functions like sine functions are tabulated.
- Eclipses are calculated based on angular movements of the Sun and the Moon per day and their relative vertical and horizontal displacements.
- Planetary locations are calculated and Astral Charts are created for astrological purposes.



# Temples and Angkor Wat

- The climax of Temple architecture is reached in the Great Temple of Angkor Wat in Cambodia (Kampuchia).
- This gigantic complex is an accurate mapping of the Hindu Cosmogony in every detail and aspect.
- Every stone, stone step and dimension is carefully synchronised to the Hindu view of the cosmos.
- Architecturally it is a very smooth blending of Nagar and Dravidian style to create a harmonious cosmos on Earth.

# Epitome of Temple Architecture: ANGKOR WAT, CAMBODIA



802 meters

1025 m

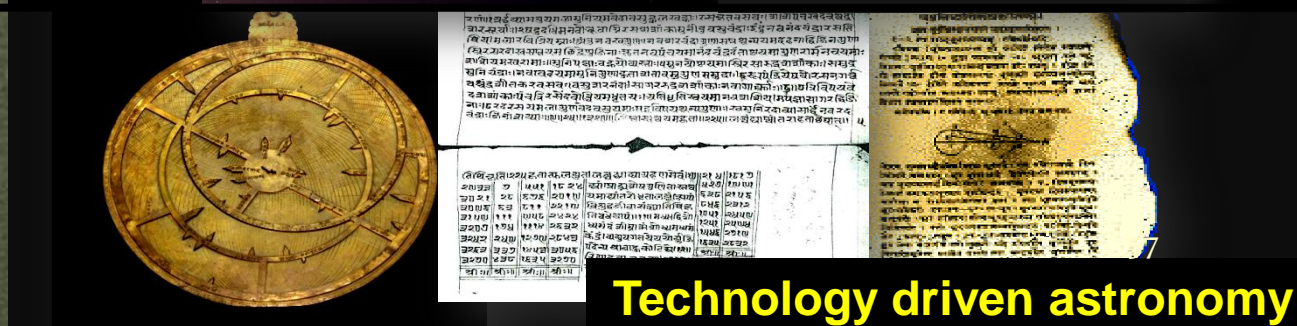
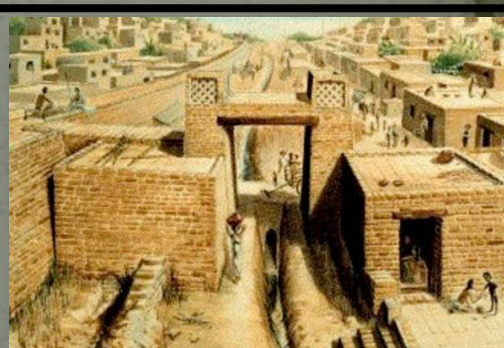




# Astronomy of today

- This path leads to Astronomy as we understand it today. Following stages appear here:
  - Invention of telescope and other instrumentation
  - Realisation of multi wavelength astronomy
  - Advances in physics and other fields
  - Satellite astronomy
- Together they produce the comprehension of the cosmos that we call Astronomy and Astrophysics today.





# Mapping to time periods

• Astronomy allows us to define the four major phases of intellectual growth as:

1. Initial steps: 50,000 BC to about 5,000 BC (7,000 YBP)
2. Settlement Astronomy: 5,000 to 2,500 BC for Harappans and up to 1,500 BC or later for Vedic and other cultures in the Subcontinent.
3. Astronomy of civilisation: 2,500 to 1,900 BC for Indus Civilisation and 1,500 BC to 500 AD – Upanishad/ Purana period.
4. Technology based, state supported astronomy: 500 AD Aryabhata onwards



# Summary

- It is possible to create a map of the intellectual growth of a culture using astronomy as a probe.
- The growth of astronomy occurs in distinct stages that are dramatically different from each other.
- These stages can be considered analogous to phase transitions of the evolution of cultures.
- Often the archaeological evidence does not show these dramatic transitions.
- Astronomy therefore provides an excellent window to the past.

Thank you



# Undated rock art from Likitse in Kashmir

Courtesy, Indira Gandhi  
National Centre for the Arts,  
New Delhi

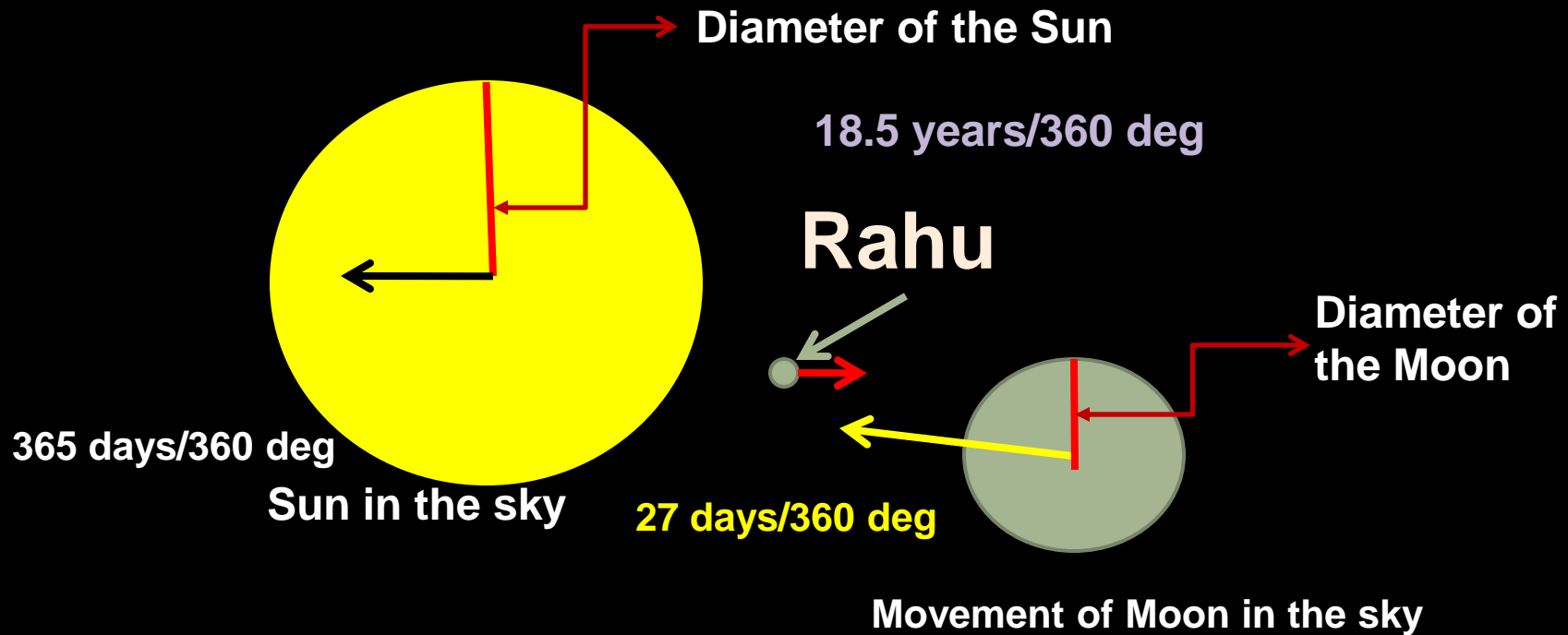


# Temples

- Temples arose in India around 500 BC in the time frame when Buddhism spread in India.
- They are essentially a representation of cosmos in a microcosm.
- They have specific orientation and entrance windows for sunlight.
- Architecturally temples seem to be a natural extension of megaliths.
- They are in two basic styles:
  - Nagara style: The tower is beehive shaped.
  - Dravida: The tower consists of progressively smaller storeys of pavilions.



# Diagram of calculation of Eclipse details



- To calculate the eclipse possibility and parameters, the coordinates of Sun and Moon are tracked and compared with those of Rahu and Ketu to decide when an eclipse is likely.
- The point of closest approach of the centres of the two objects and their diameter are considered to determine the nature of the eclipse.

Site: Juniperi  
Locality-A  
Stone circle no. JNP-A-42

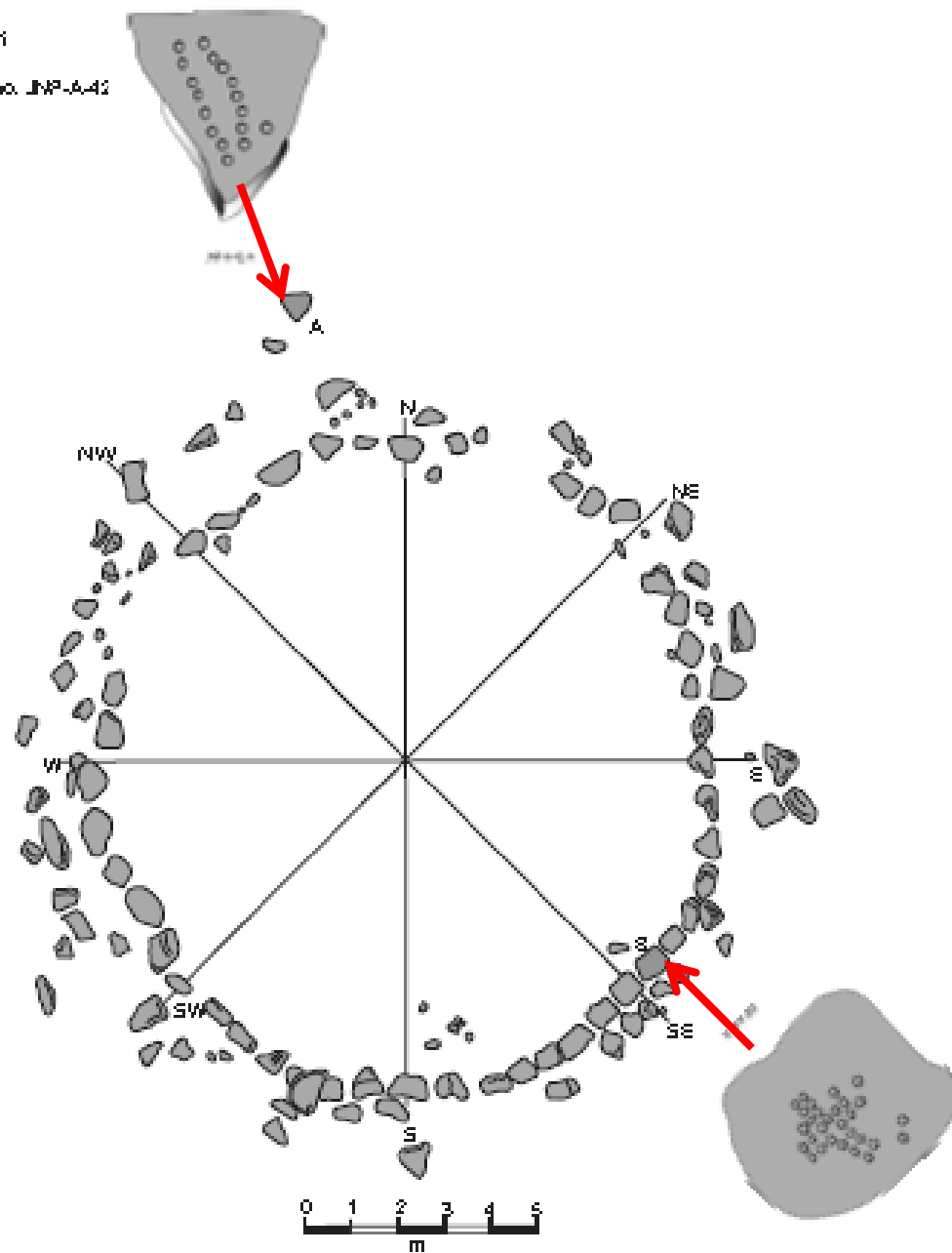


Figure 47





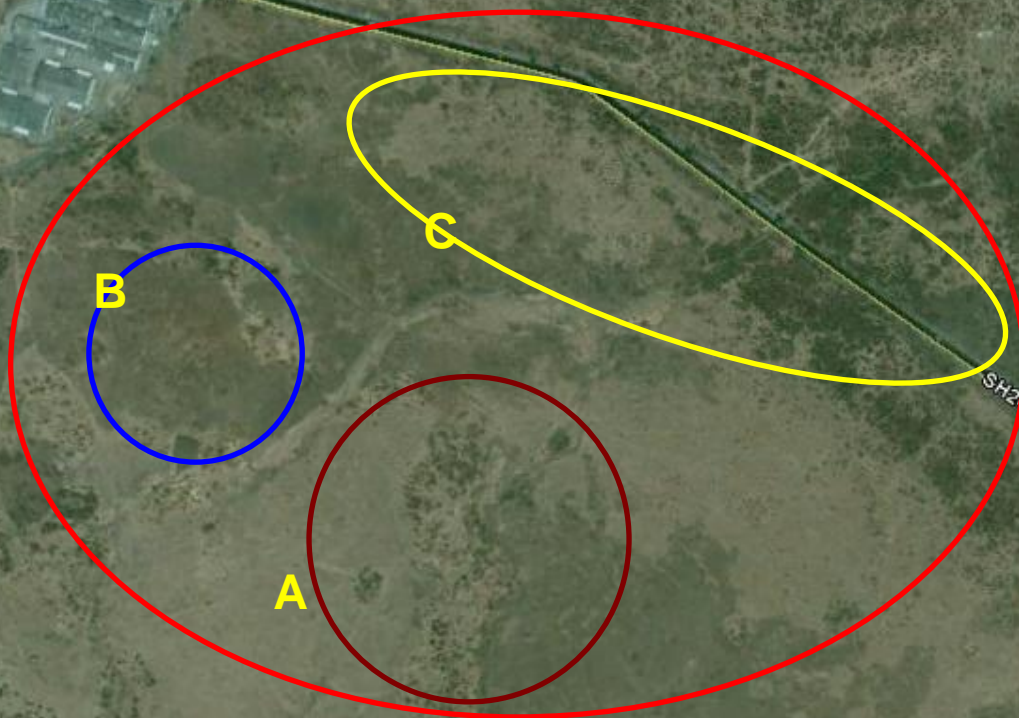
# Astronomy and Navigation at Sea





Village Fetri

Godown



## Junapani Stone Circles

© 2010 Google

© 2009 Google

Image © 2010 DigitalGlobe

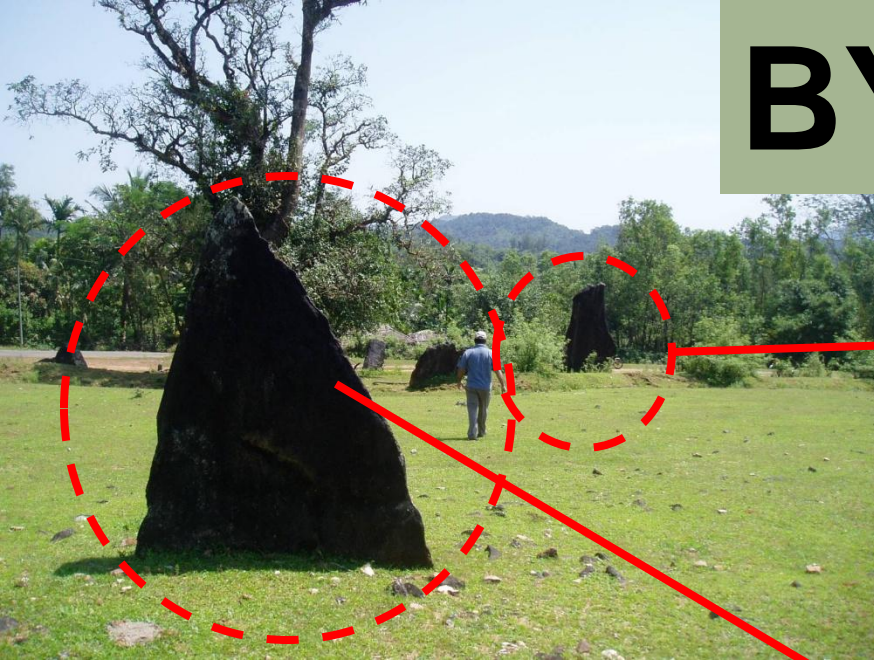
Imagery Date: Apr 21, 2009

21°11'51.65" N 78°59'51.10" E elev 1142 ft

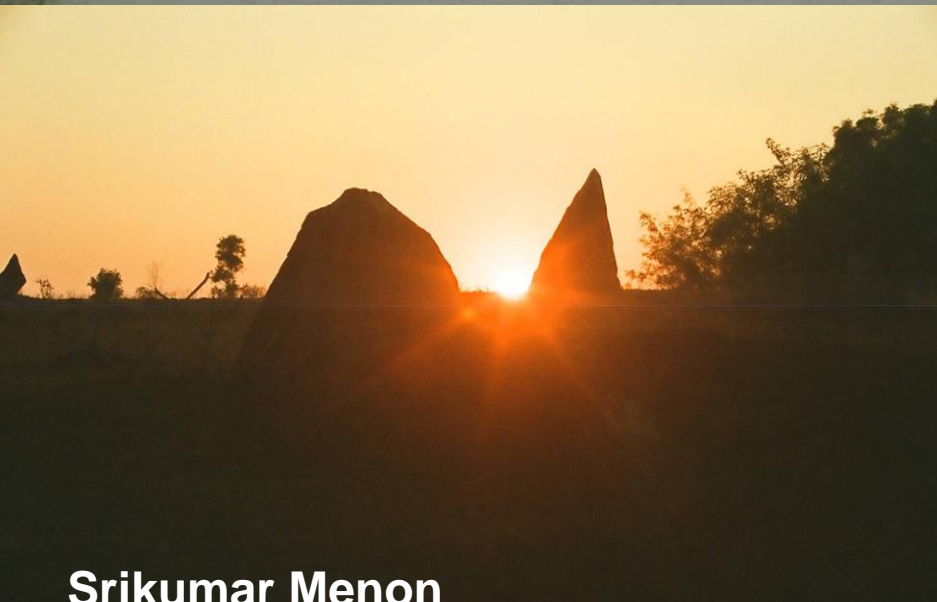
Eye alt 8041 ft



# BYSE

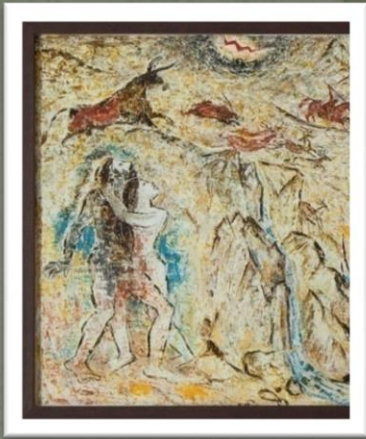


*Looking westwards at sunset, 28 Dec, 2008 from E of stone N16*  
*Nilaskal –  $294.2^\circ$  to  $245.8^\circ$*

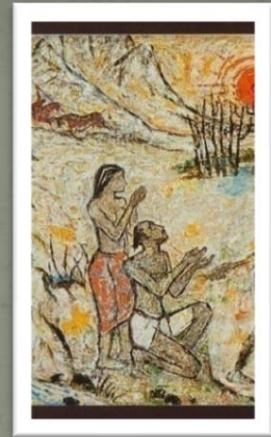


**Srikumar Menon**





**Myths**

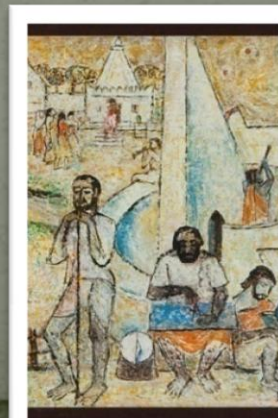
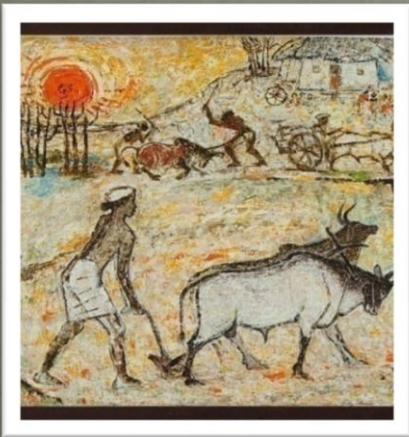


**Astronomy  
(and other science)**

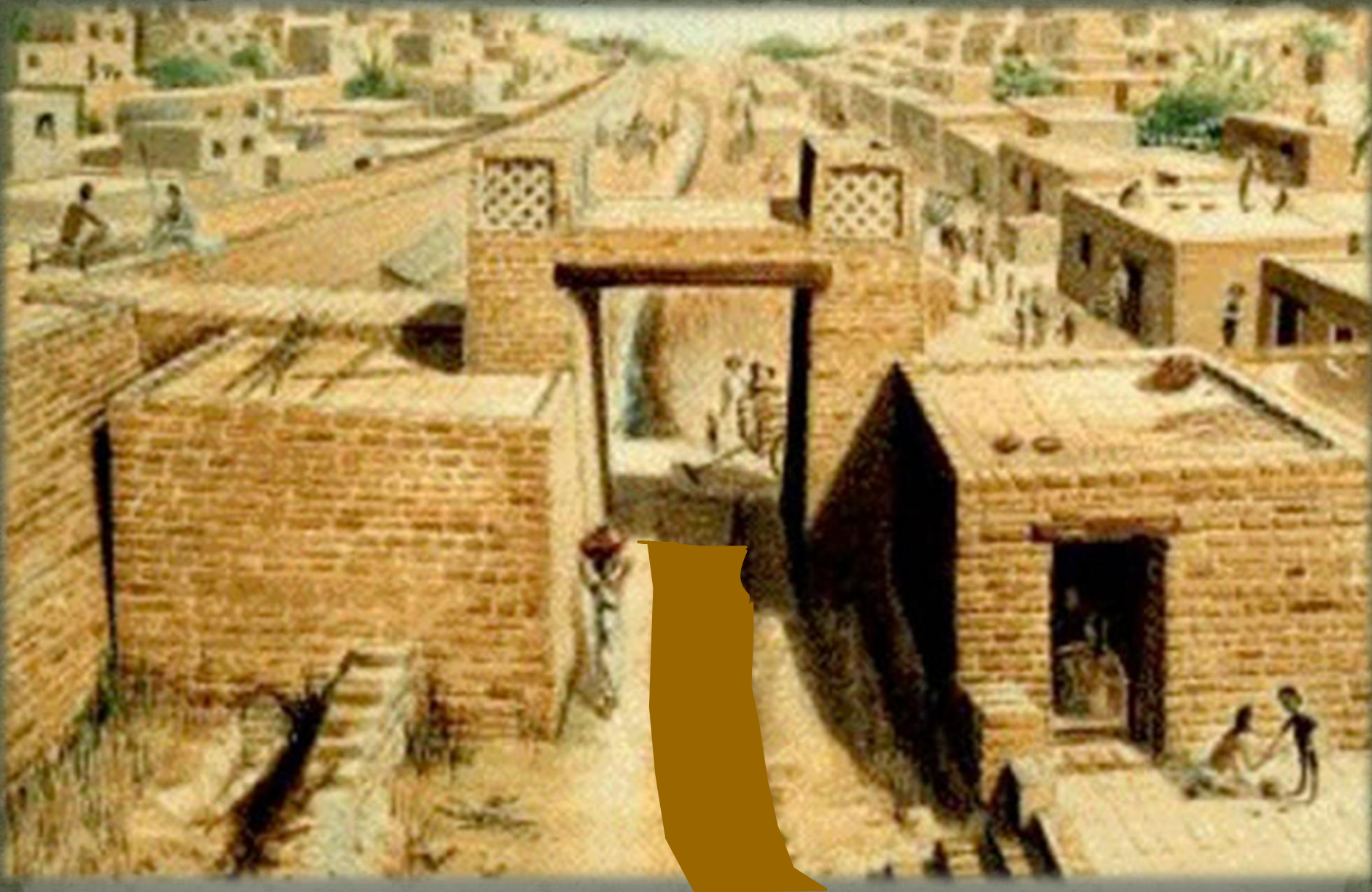
**Human  
intellectual  
growth**

**Religion**

**Megaliths**







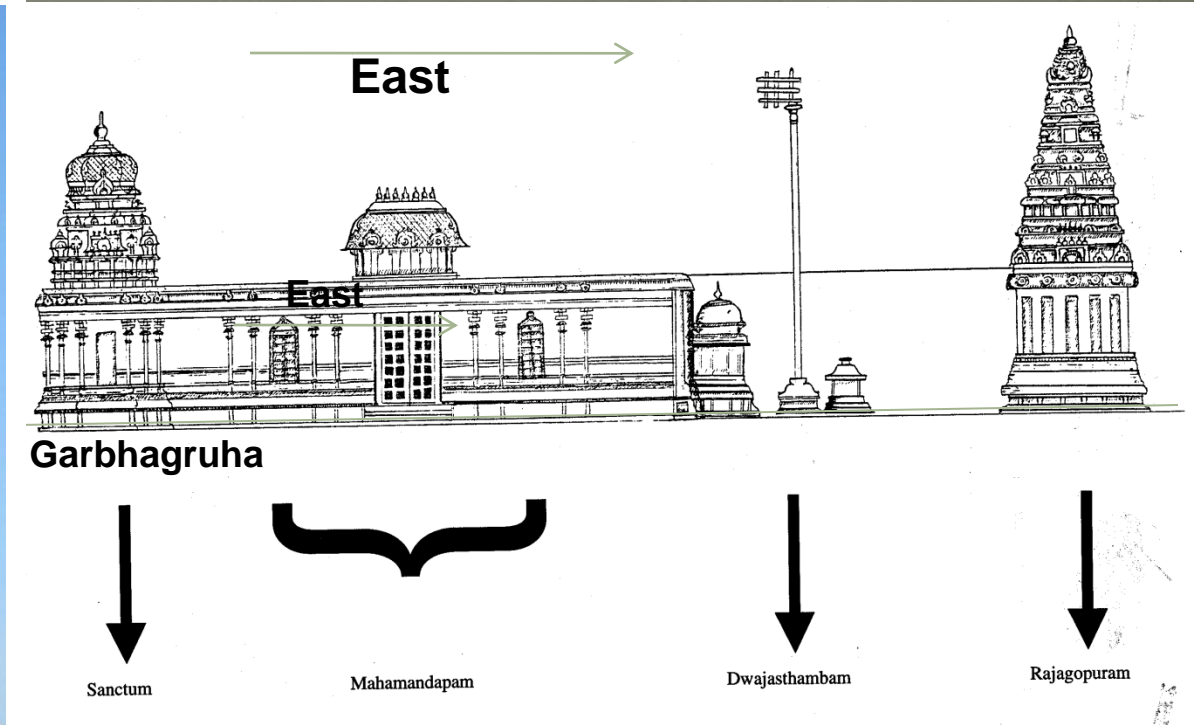




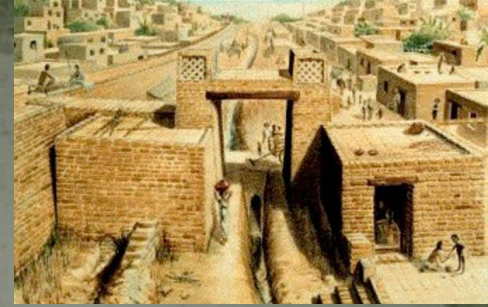




# Typical Dravidian Style temple lay out and Gopuram of Minakshi Temple, Madurai

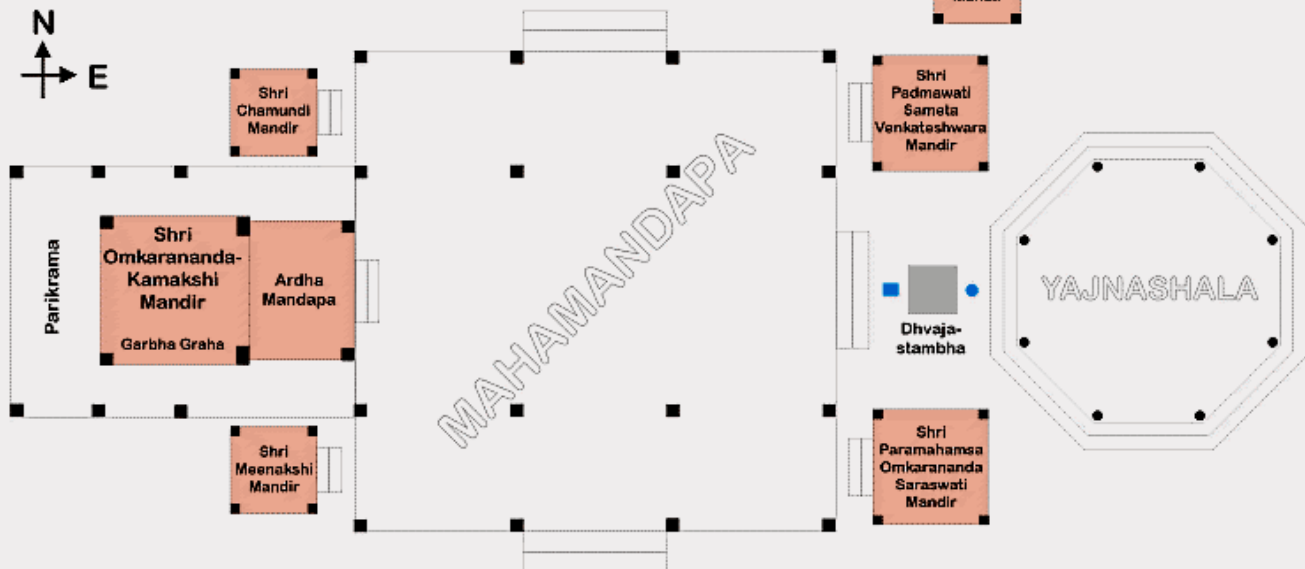






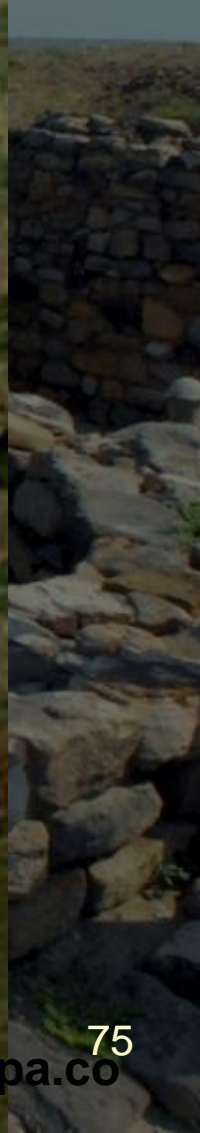
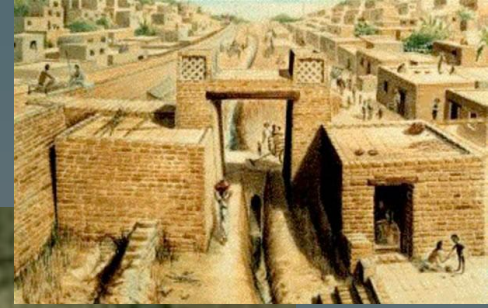
## Cosmogony of Nagara Temples

### Omkananda Kamakshi-Devi Mandir MUNI-KI-RETI, RISHIKESH, INDIA





# Ring stone of Mohenjo Daro



# Who can be an astronomer?



According to Brihad Samhita of Varahamihira (505 AD) an astronomer should be a man of great personal strength and should be able to do the following:

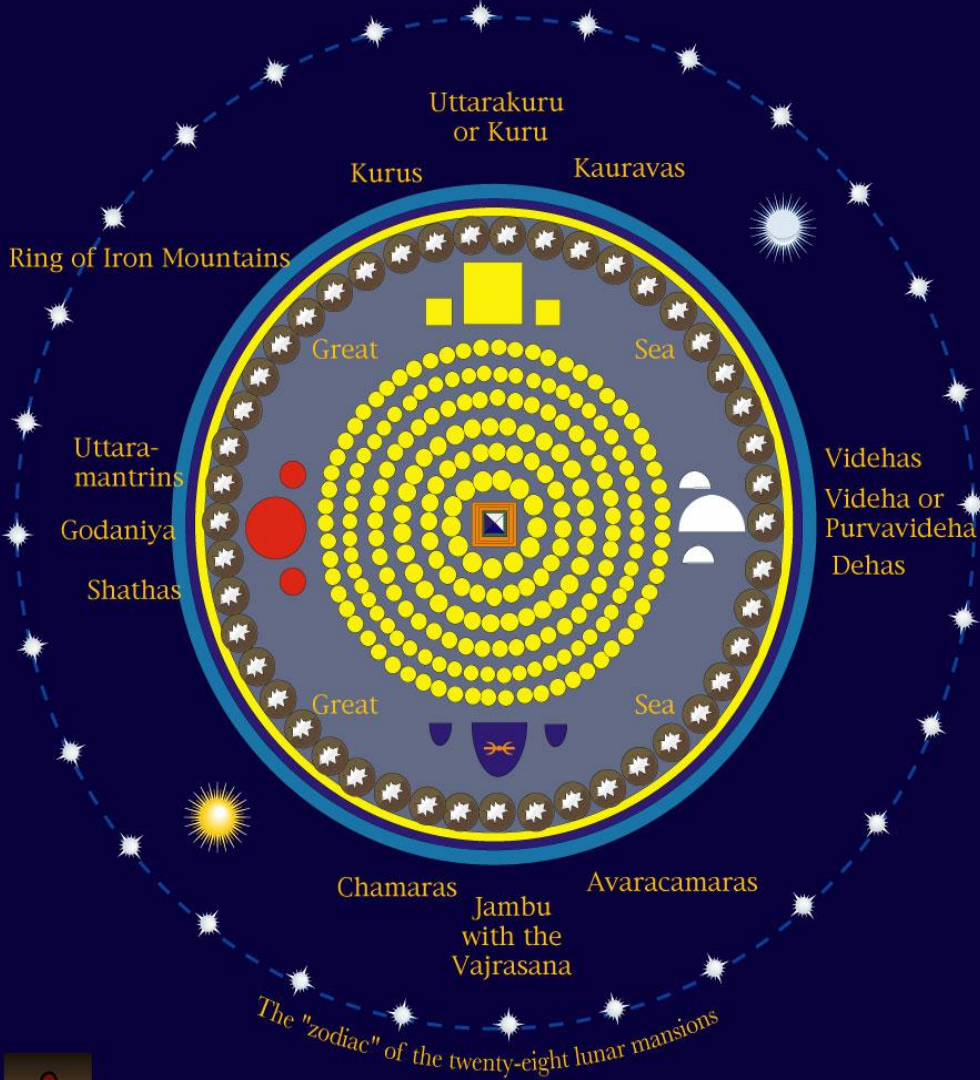
- Time division of Yuga, year, solstice, seasons, month, fortnight, day, night, yama (90 min), mahurta (48 min), nadi (24 min), prana, truti and calculate their starting and ending times
- Saura (planetary calendar including the retrograde motion of planets and their different speeds in the sky),
- Savana (terrestrial calendar)
- Understand and calculate solstices
- Calculate times of eclipses
- Sun's daily and annual motion and revolution including concepts of difference in the length of day and night
- Calculate latitude and longitude of a place (from Ujjain)
- Understand Nakshatras and Zodiacs and show them in the sky
- Teach this to a learned person

NOTE THAT KNOWLEDGE OF ASTROLOGY IS NOT A REQUIREMENT



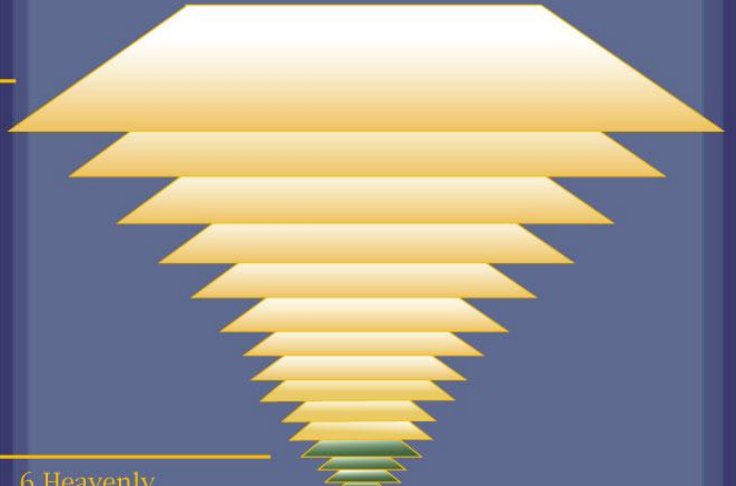
# The World System and Continents Surrounding Mount Meru

Seven Rings of Gold Mountain surround Mount Meru in the center



4 "No Place"  
Formless  
(Arupa)  
Realms

Raalsms of Form



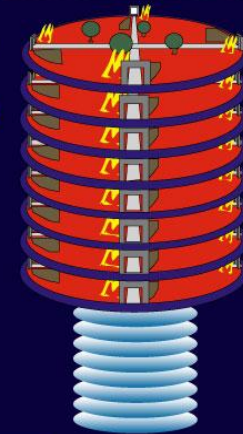
6 Heavenly  
Kamadhatu  
Realms

Trayastrimsha  
(Heaven of 33 Gods)

Gold Disk  
Water Disk  
Air Disk

Realms of Desire

Preta Loka  
(in the world  
plane)



8 Hot Hells

8 Cold Hells





Sirius

Betelgeuse

Aldebaran

Rigel



Arrangement of  
dropping the  
the wind so  
basket  
letting

Sirius

## Betelgeuse

Aideparan

Rigel

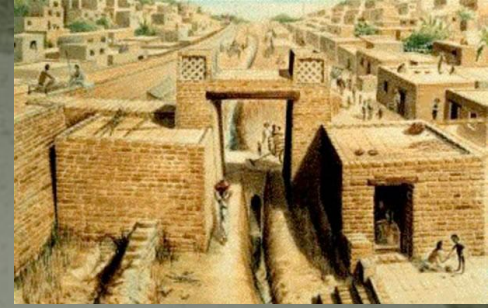
# Region between Aquarius and Scorpio







# Mix of mathematics and Philosophy – the play of infinities



- *One of the most fascinating aspects of Indian mathematics is the play with large numbers and infinities.*
- *The Idea of infinity seems to have so fascinated the philosophers from early period that there are a variety in Infinities found in the literature.*
- *There are several different kinds of Infinities –*
  1. *Numbers: They use numbers as large as  $10^{17}$  from very early times. This idea arises in terms of the amount of wealth which is defined as the incomprehensible large number of cows etc.*
  2. *Time:*
    - a. *Time has a beginning when Bramhan created the universe out of pure thought. However, it then becomes periodic with Yuga's and maha-yugas which are cyclic but there is no end of time.*
    - b. *There is another set of ideas of relative time in terms of human time, time looping as an illusion etc. However, even within this, time loops do not violate causality!*



3. *Space:*
  - a. *Space: Space is defined to be infinite in early literature but that is without relation to the cosmos.*
  - b. *Size scales: From infinity to infinitesimal, - from infinitely large to infinitely small.*
  - c. *Cosmos : In later literature the idea of infinity of space is extended to cosmos and its layered structure.*
4. *Duration of 'life': This idea arises in the form of rebirth and related ideas and eventually the goal of life is defined in terms of working to end this eternal cycle of birth and death through living life according to Dharma.*
5. *Number of gods: There are infinite Gods and whenever a specific God is worshiped all important virtues and names are assigned to that god.*
6. *Meditation: Meditation is supposed to provide us internal knowledge of mind and soul which is essentially infinitely deep.*
7. *Brahman: Brahman is essentially abstract and infinite – only he existed when even time did not!*

**THE ONLY EXCEPTION TO THIS RULE OF CAUSALITY IS IN GODS WHO OFTEN EMERGE FROM EACH OTHER.**



# Harappan Civilization



[www.harappa.com](http://www.harappa.com)





# Baise Site map



TIFR





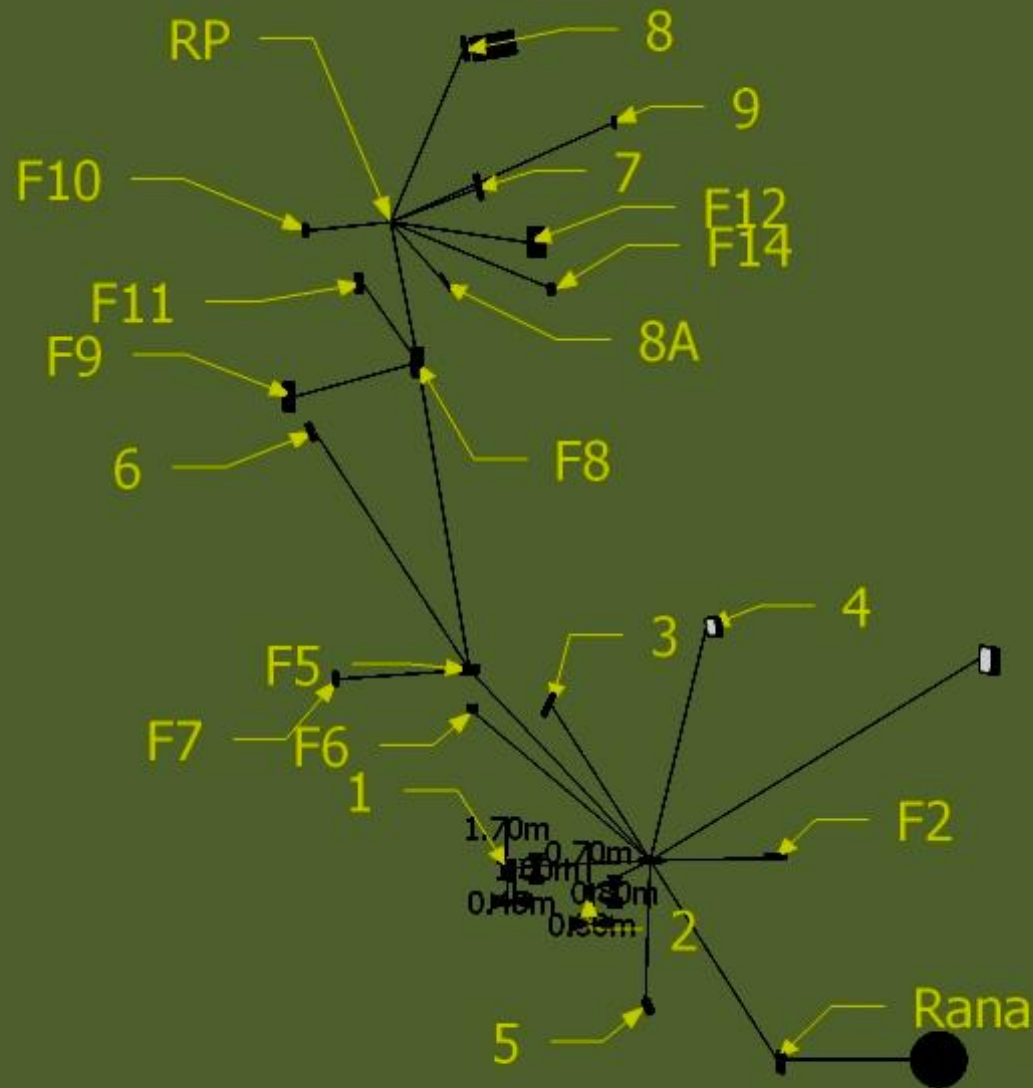


**Worshipped Stone 1 –  
Bhoota Raya in Baise**

**Worshipped Stone 2 –  
Rana in Baise**



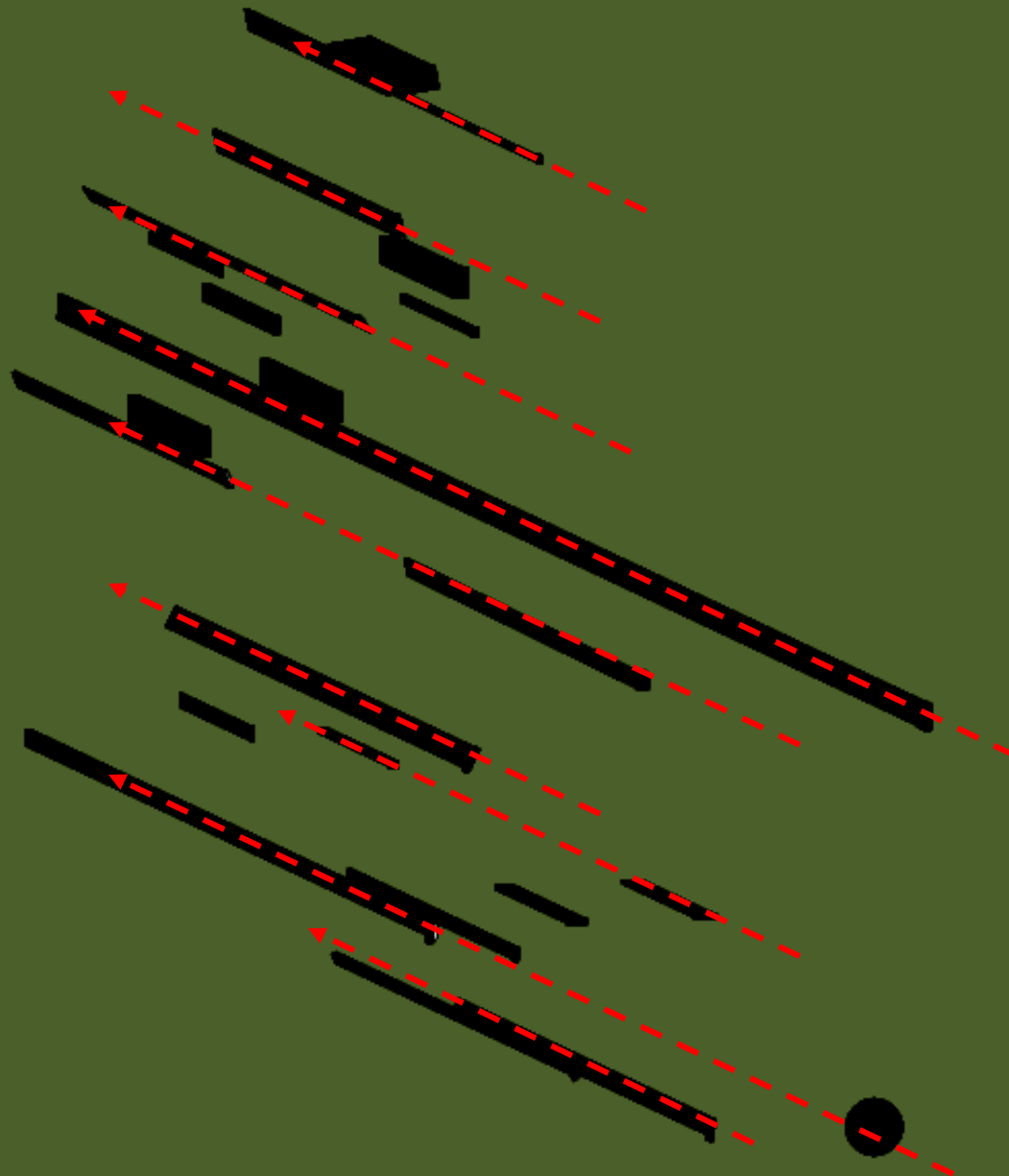




Menon and Vahia, 2009, in press

# **Baise – top view of the menhirs**

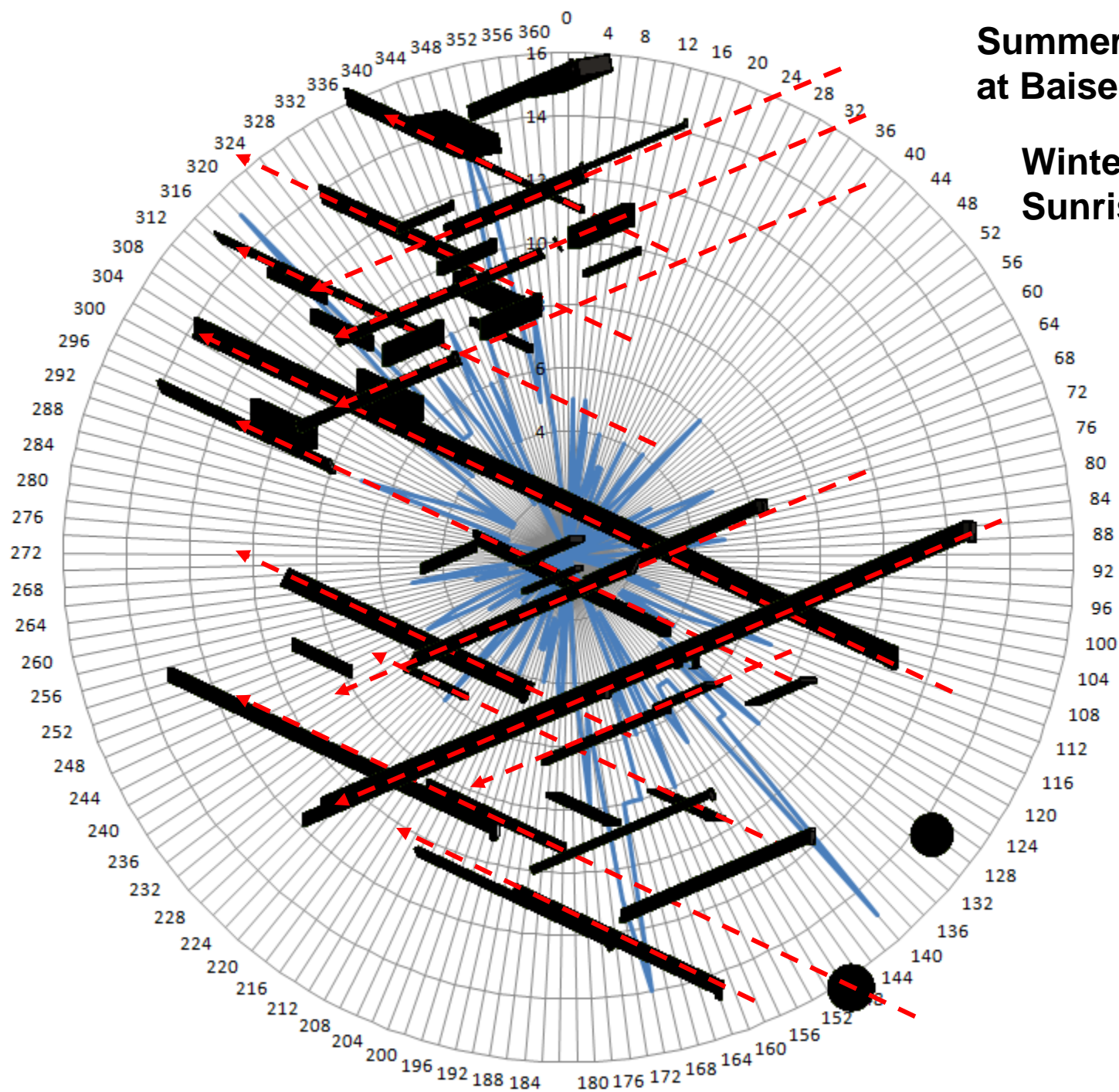
## Winter Solstice Sunrise at Baise





**Summer Solstice Sunrise  
at Baise**

**Winter Solstice  
Sunrise at Baise**



I should have stopped long back!



# Vedic religion and cosmogony



- There are about 30 Gods mentioned in the Vedic religion.
  - Five are **Human like**: Indra, Ribhus (artisan), Vishnu, Yama, Manyu (gods of war)
  - Fifteen refer to **Natural forces**: Agni, Soma, Vayu, Apas, Dyaus – Prithivi, Varun, the Maruts, Ushas, Savitr, Pushan, Surya, Sarasvati River, Parjanya, Vac, Kapinjala, Dadhikas
  - Four refer to **Water**: Varuna, Apas, Sarasvati River, Parjanya
  - Six are **Abstract**: Vishvadevas, Brhaspati, Brahmanaspati, Rudra, Vastospati, Vishvakarman
  - Eight **overlap with Avesta**: Indra, Mitra, Agni, Soma, Vayu, Apas, Dyaus-Prithivi
  - The **Trimurti** appears in weak formalism with Bramha as the Guru of the Gods, Shiva as Rudra and Vishnu more as a benevolent entity.

# Structure of the religion

- There are some notable omissions – No moon, star (or constellation) or planet is worshipped and feminine form is missing even though all religions begin with Mother Earth and Father Sky.
- The religion itself is a Tripartite Contract between the Gods, Ancestors and Humans.









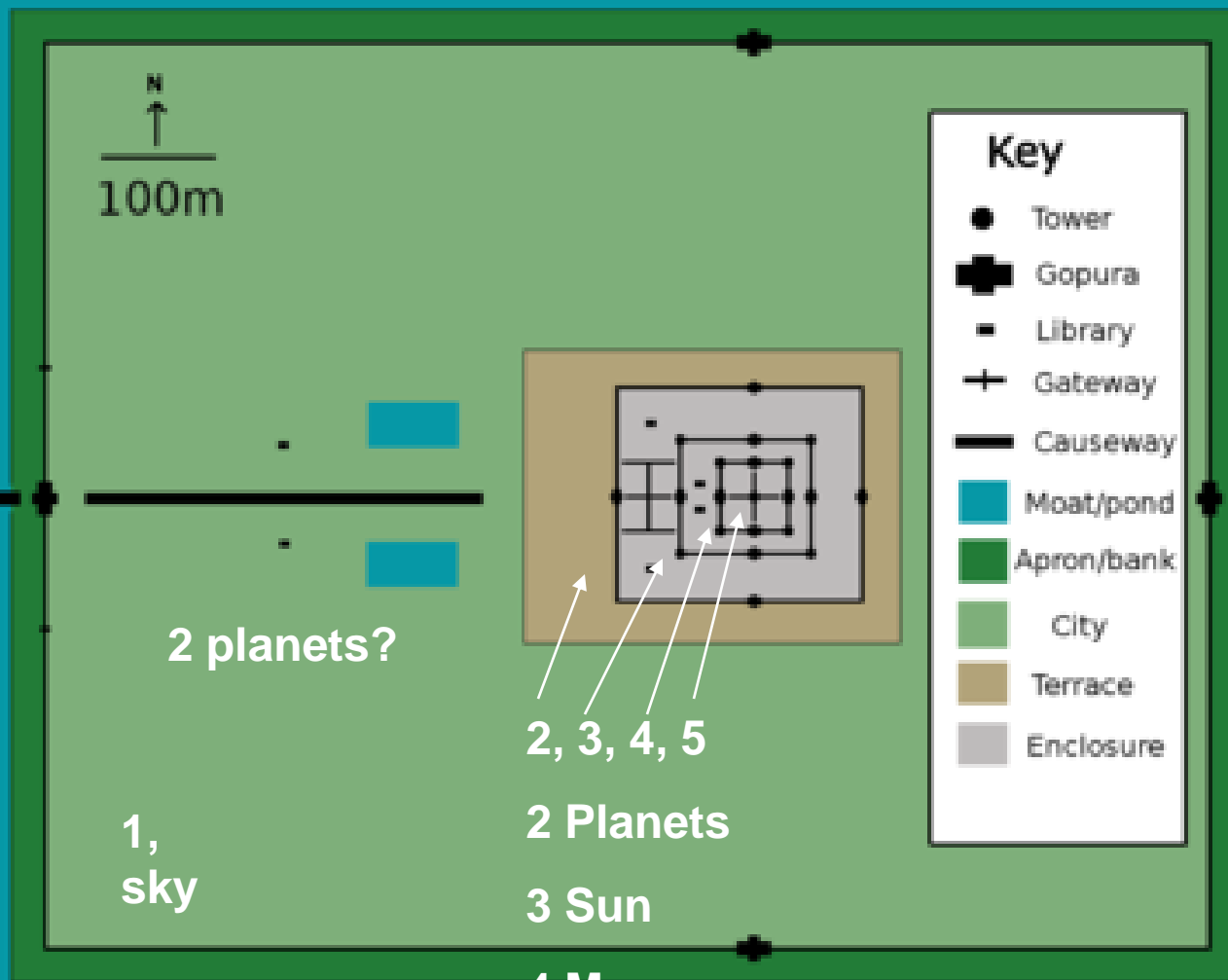












# Dashavatara – Cosmogonic ideas?

(Vishnu Puran around 1 century BC)



**Dashavatar: (from left) Matsya, Kurma, Varaha, Narasimha, Vamana, Parashurama, Rama, Balarama, Buddha, Kalki.**

**Fish Tortoise Boar Human-lion Dwarf Human**



	<b>Name</b>	<b>Discretion</b>	<b>Period</b>
1	Matsya	Fish	Satya Yuga.
2	Kurma	Tortoise	Satya Yuga.
3	Varaha	Boar	Satya Yuga.
4	Narasimha	Man-Lion	Satya Yuga.
5	Vamana	Dwarf	Treta Yuga.
6	Parashurama	Warrior Bramhin	Treta Yug.
7	Rama	King of Ayodhya	Treta Yuga.
8	Krishna	God incarnate in Mahabharata	Dwapara Yuga.
9	Buddha	The 9th Incarnation of Vishnu	Kali Yuga
10	Kalki	The Destroyer of foulness	expected at the end of Kali Yuga

# Quantification of Stages

Stages	Scales (1 to 4, with 4 being the best)										
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Total
Nomadic	0	1	1	2	0	0	0	2	1	1	8
Barbarian	0	2	2	2	1	1	1	2	1	2	14
Rural	1	3	3	3	2	2	1	3	2	3	23
Urban	3	4	4	4	4	3	3	4	4	4	37
Post Vedic	1	3	3	2	2	2	2	2	2	2	21
2 <sup>nd</sup> Urbanisation	4	4	4	4	4	3	4	4	4	4	39

Scale 1: Writing and Records;    Scale 2: Fixity of Residence;    Scale 3: Agriculture;  
 Scale 4: Urbanization;    Scale 5: Tech. Specialisation;    Scale 6: Land Transport;  
 Scale 7: Money;    Scale 8: Density of Population;    Scale 9: Level Integration;  
 Scale 10: Social Stratification

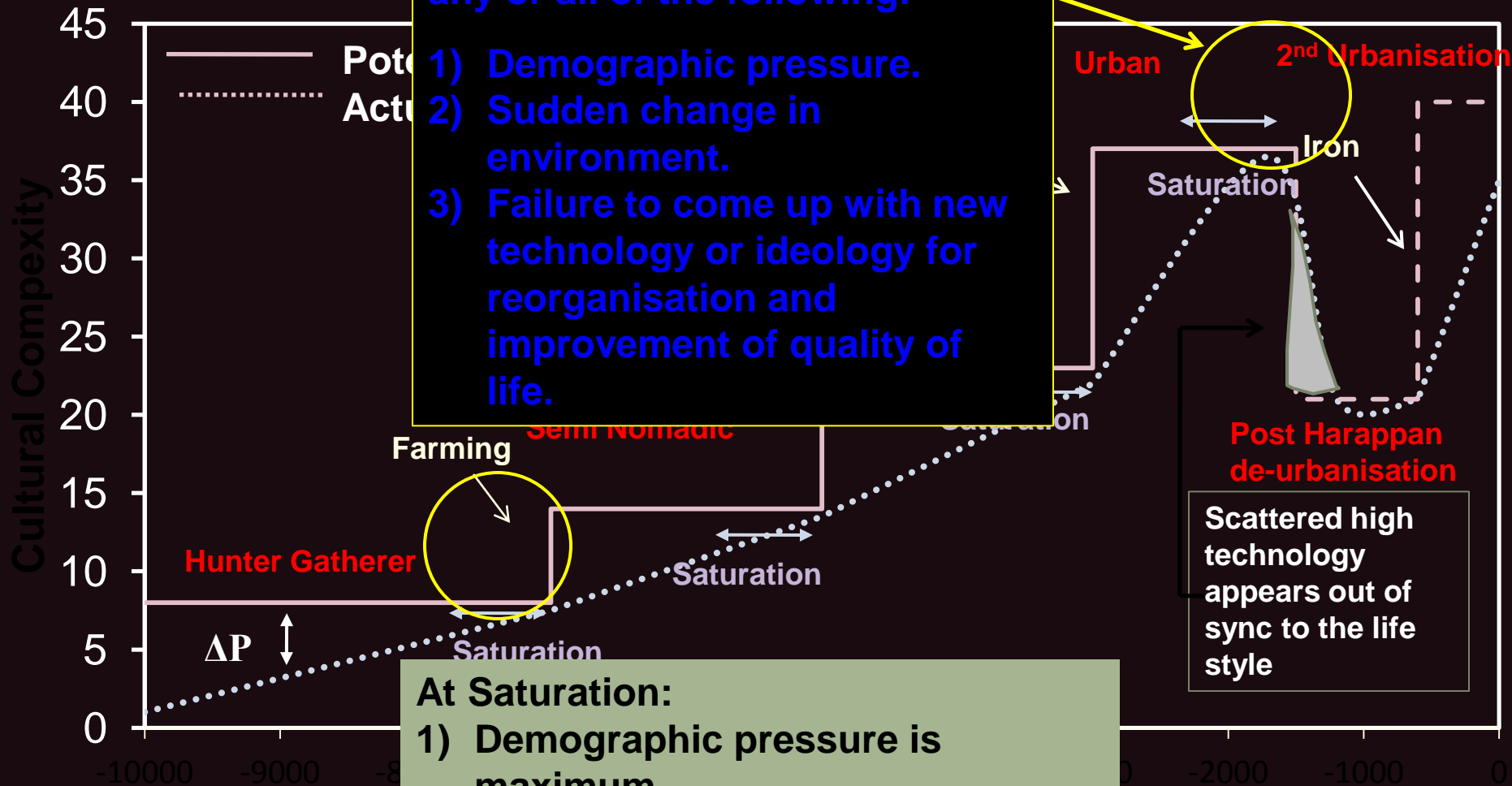
**BASED ON THE WORK OF MURCOCK AND PROVOST (1973)**



# Evolution of Harappan Civilisation

This could have been a result of any or all of the following:

- 1) Demographic pressure.
- 2) Sudden change in environment.
- 3) Failure to come up with new technology or ideology for reorganisation and improvement of quality of life.



At Saturation:

- 1) Demographic pressure is maximum
- 2) Resource availability is maximum
- 3) Demand on available technology

OLUTION IS

# Enigma of Harappan Astronomy

- Largest civilisation of pre-iron age.
- Must have used a lot of astronomy for calendars, seasons, festivals etc.
- Must have had 'astronomers' and some locations dedicated to observations. Yet, we have no idea where they are!



- The culture is so enigmatic that its script is also unknown and only now we have shown that it is **at least a formal language writing.**



# Rotation of earth

- Aryabhata (around 500 AD) had even proposed that the Earth may be rotating:  
  
“just as a moving boat perceives the trees moving backwards, so also the Earth perceives the stars going east to west.”
- He was severely criticised for this idea by later astronomers since it contradicted many prevailing beliefs.

# Ring stone of Mohenjo Daro





# Calendar Stone from Mohenjo Daro

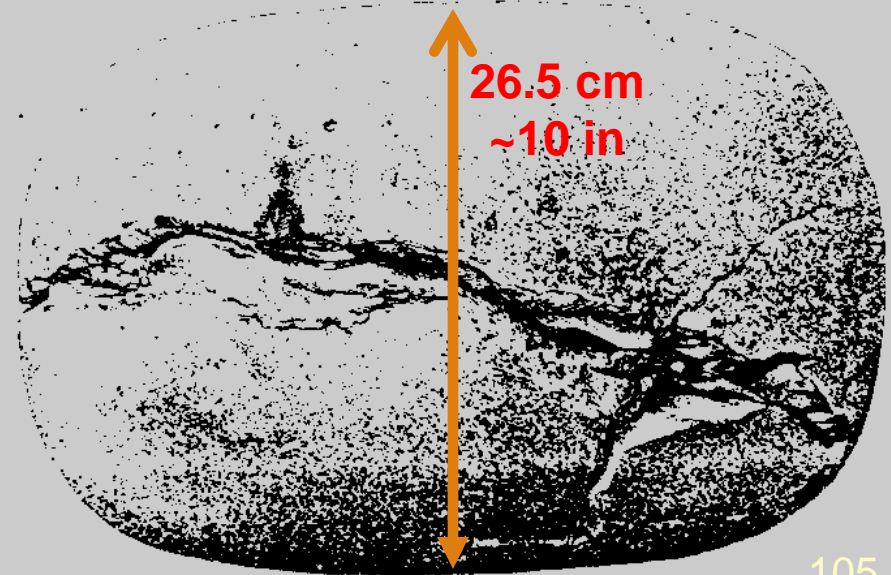
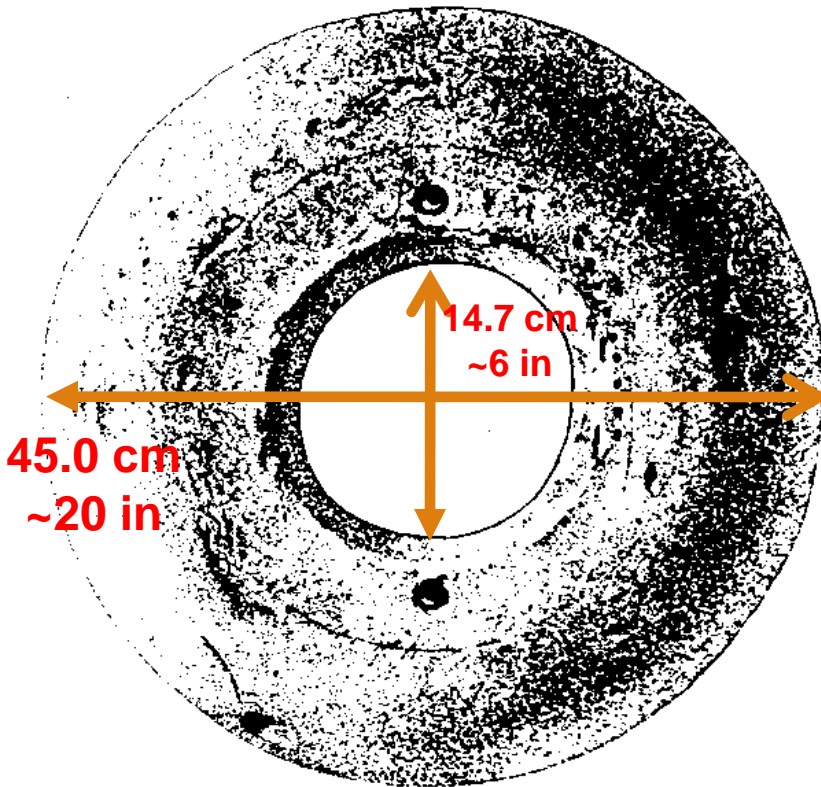
**MM 1407** Topside: 2 dowel-holes  $\phi$  16 mm, 25 mm deep, distance 20 cm, 9 little spots  $\phi$  5 mm, engraved circle  $\phi$  25.6 cm, radial scratches

Bottom side: engraved circle  $\phi$  25.8 cm.

**M1407 (HR5929)**

**Weight ~ 250 kg**

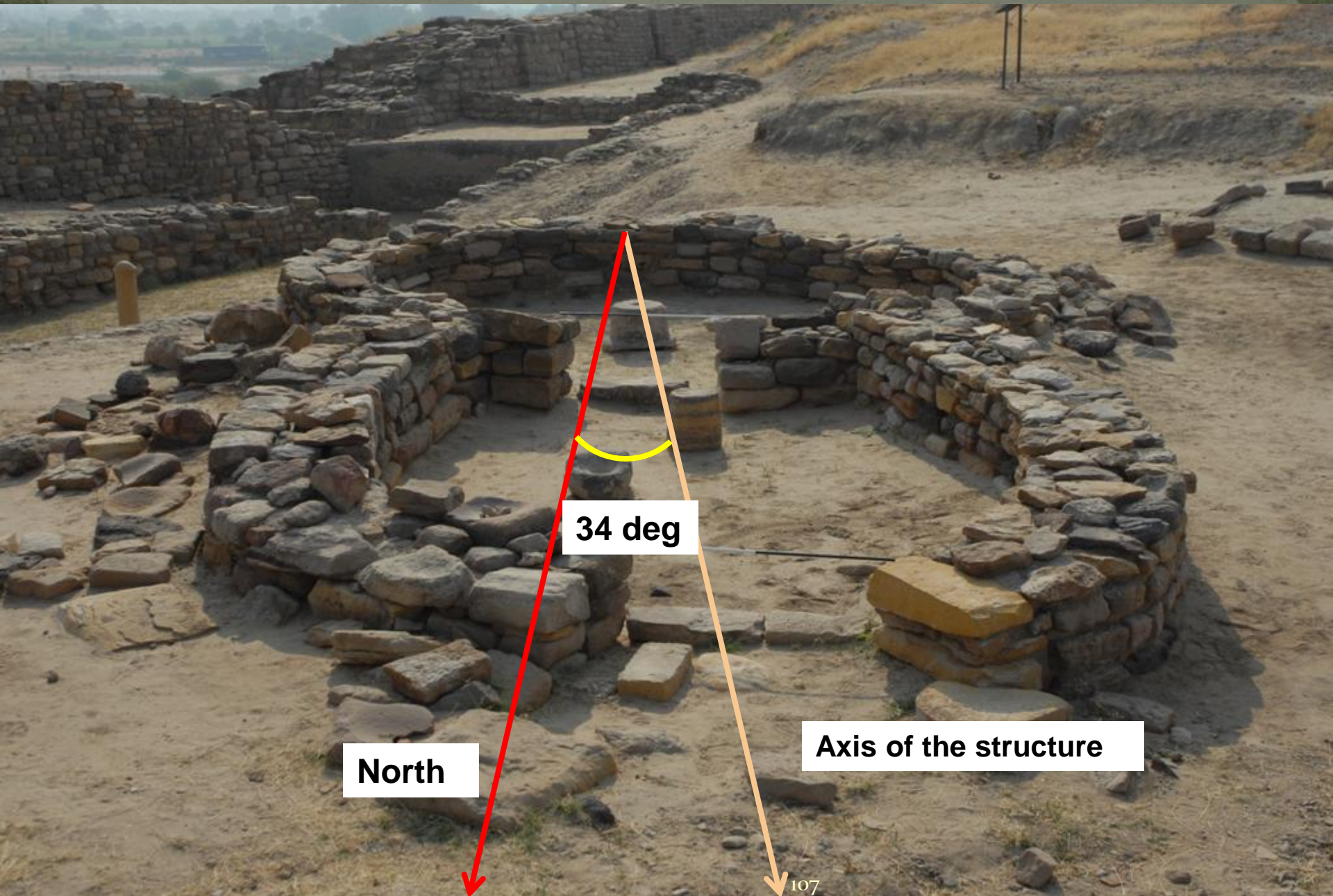
From Maula (1984), Interim report on the field work carried out in 1982 – 83  
p 159



# A strange structure in the Citadel at Dholavira







34 deg

North

Axis of the structure

107



NORTH

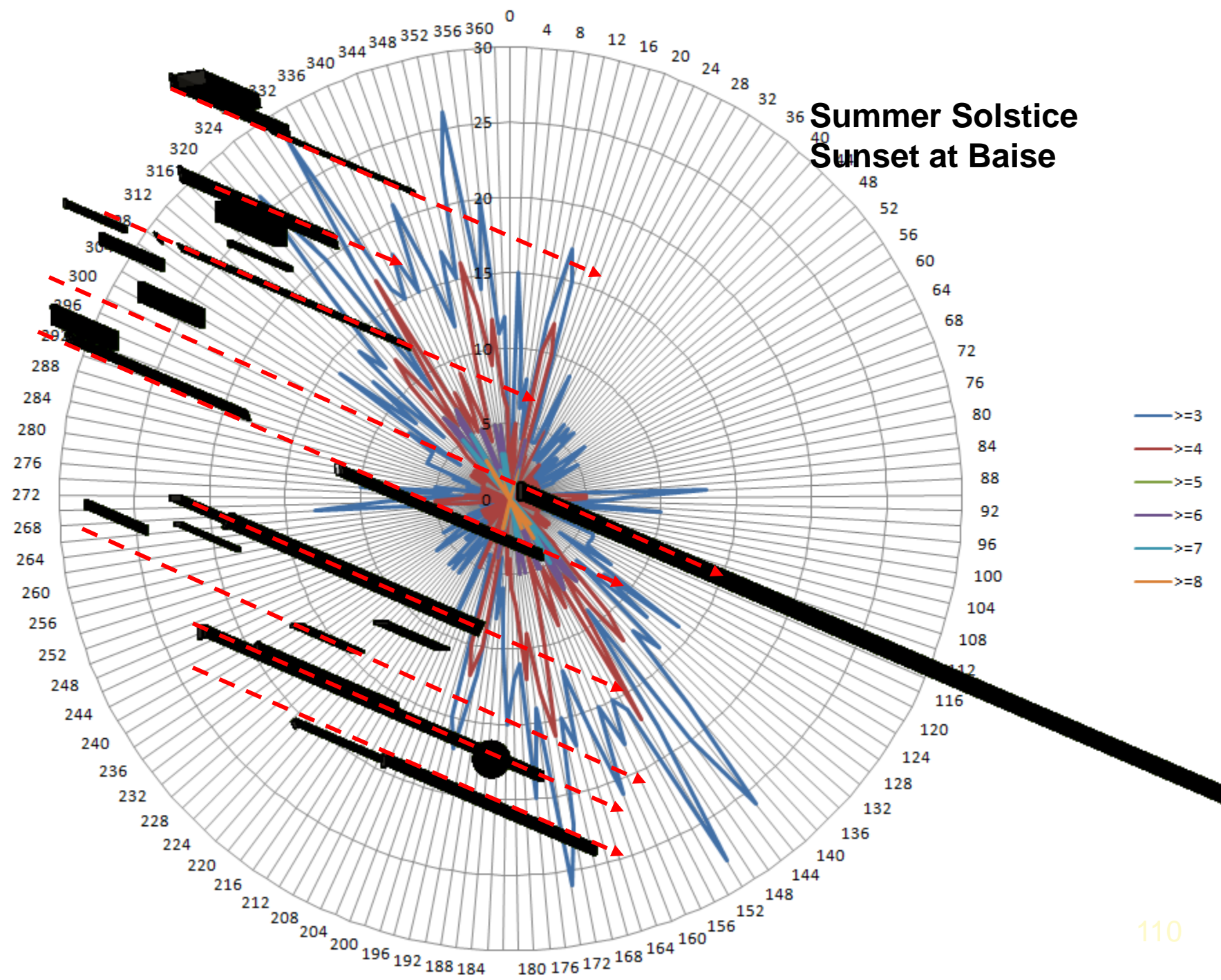




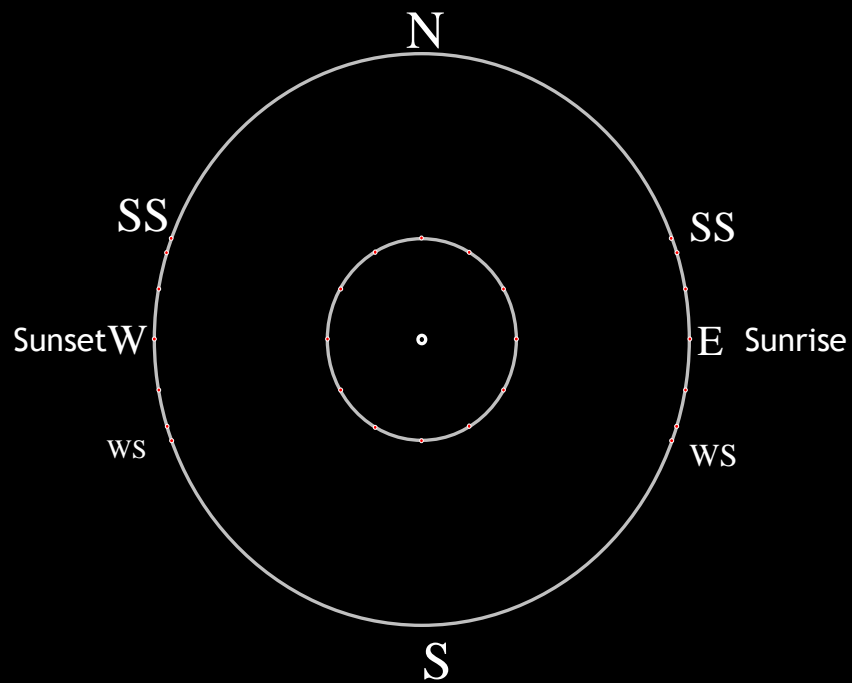
# What does it look like?

- It is built in the middle of the most important road in the Citadel of Dholavira.
- It is the only non square/non circular structure.
- It is offset from the general axis of the city.
- It points to the edge of an artificial mound within the citadel.
- The pointing is therefore intentional and towards the horizon.
- The only object at the horizon is that it marks the setting point of Vega.
- We therefore tentatively (and probably incorrectly) call it the “Temple of Vega (Abhijit)”. It could even be temple of Arcturus (Swati)
  - Vega and Arcturus are the brightest stars in the northern night sky. Arcturus sets at sunrise is on Spring Equinox day in 4000 BC.
  - Vega sets in the early morning in late July in 2000 BC that initiated the monsoon season.

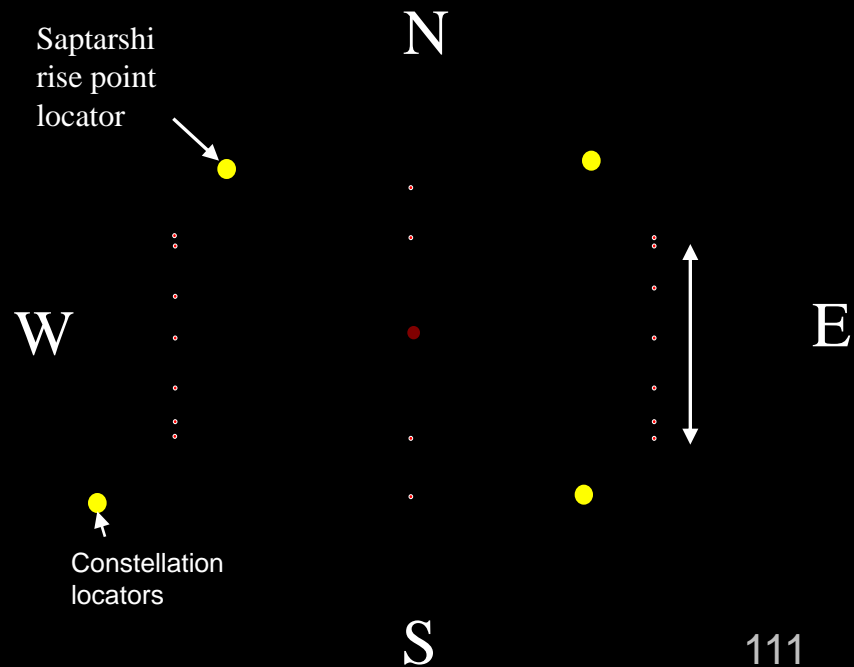
# Summer Solstice Sunset at Baise







VE = Vernal Equinox  
 SS = Summer Solstice  
 AE = Autumnal Equinox  
 WS = Winter Solstice

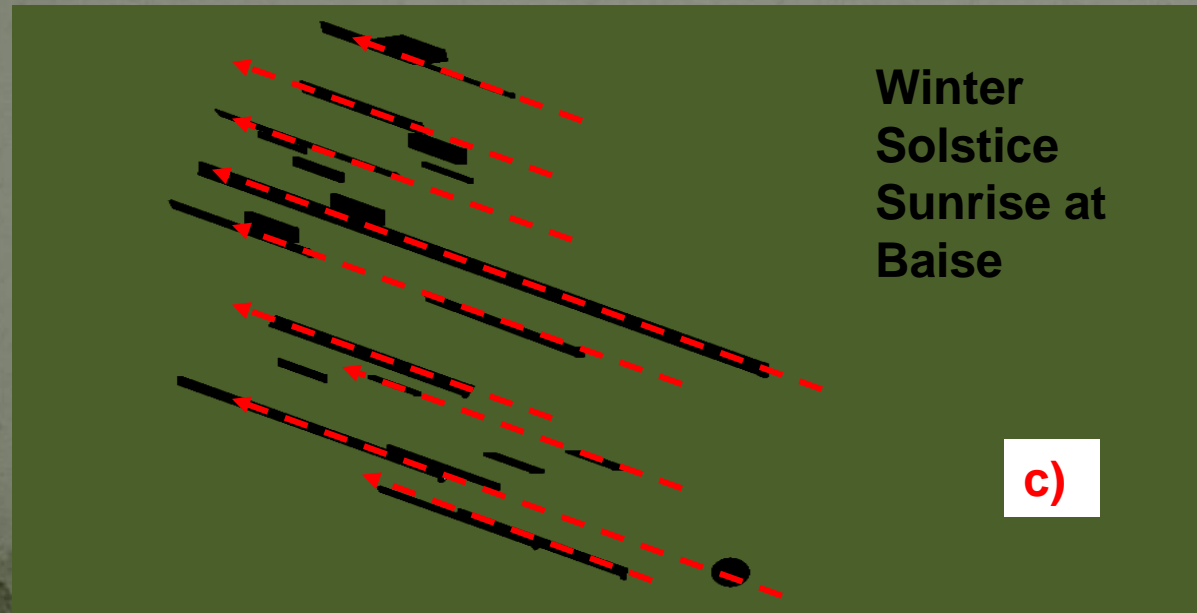




a)

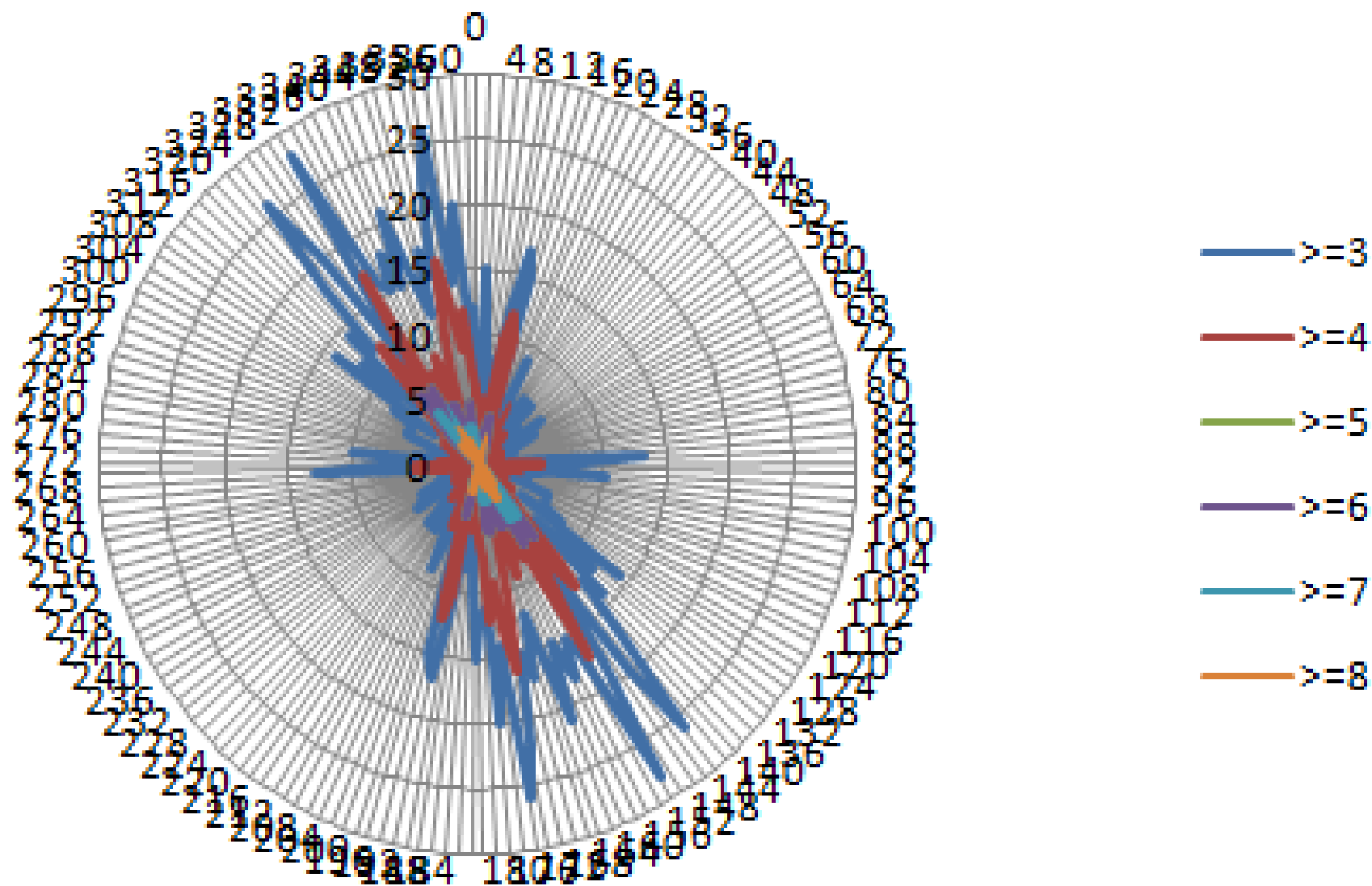


b)

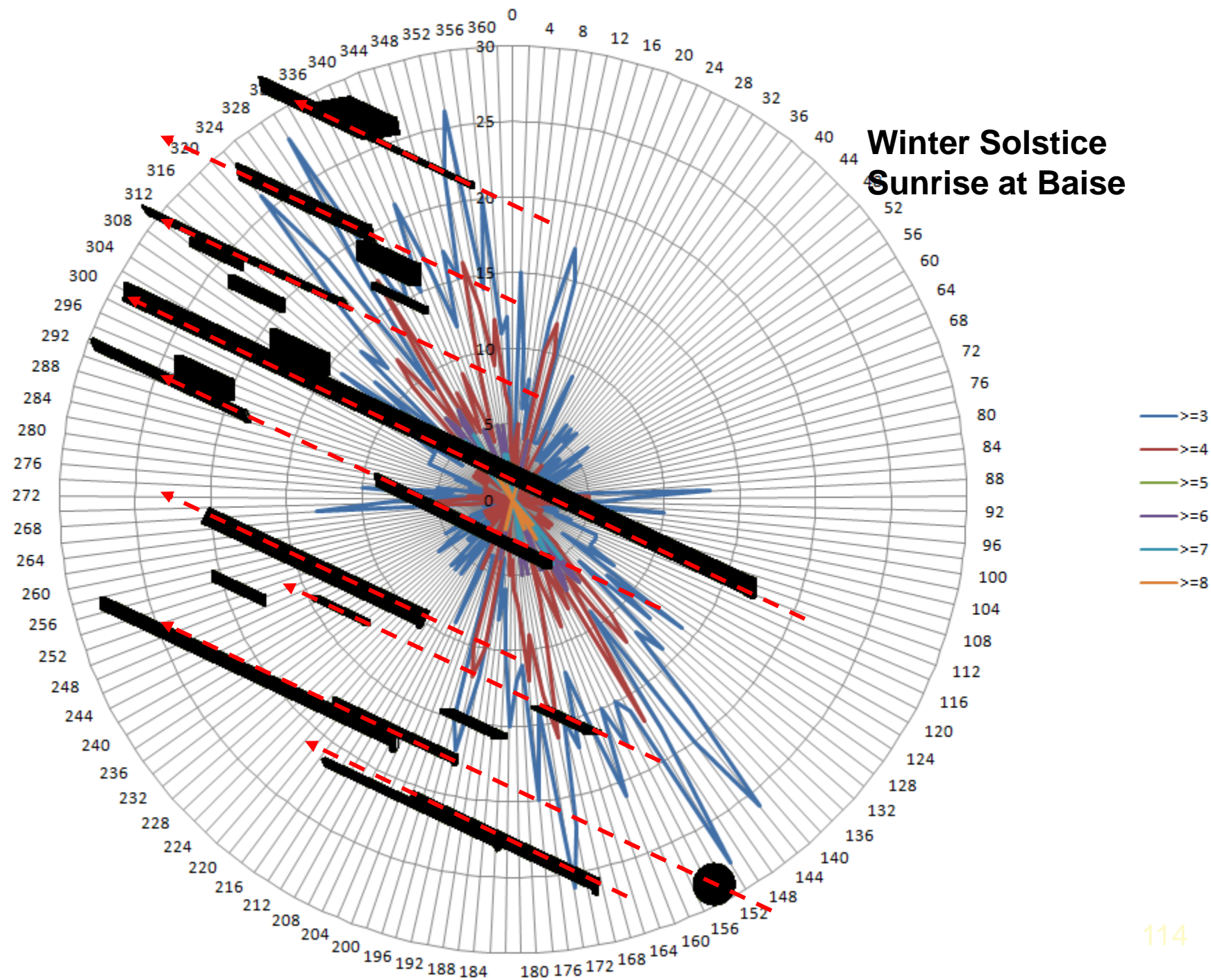


c)





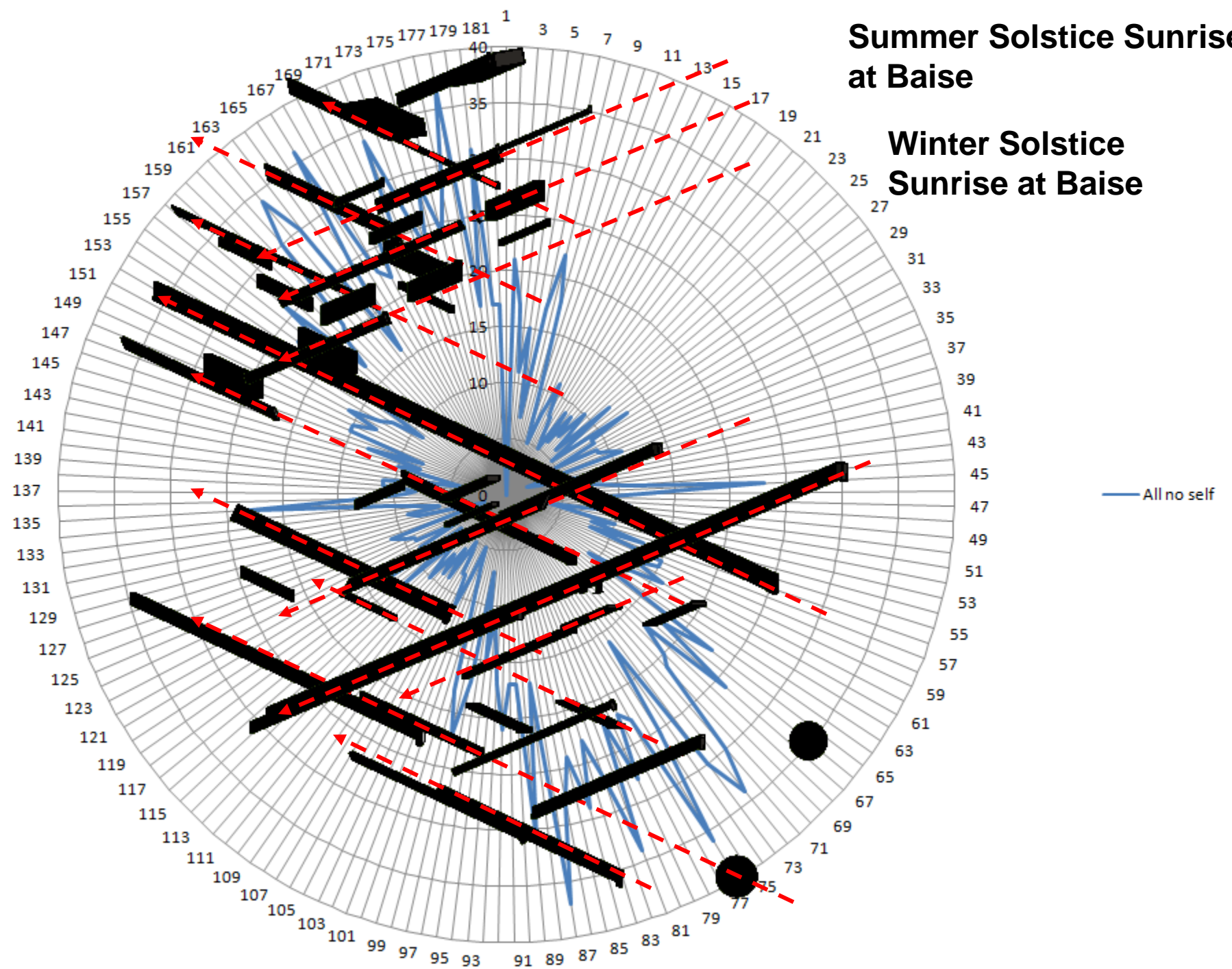
# Winter Solstice Sunrise at Baise





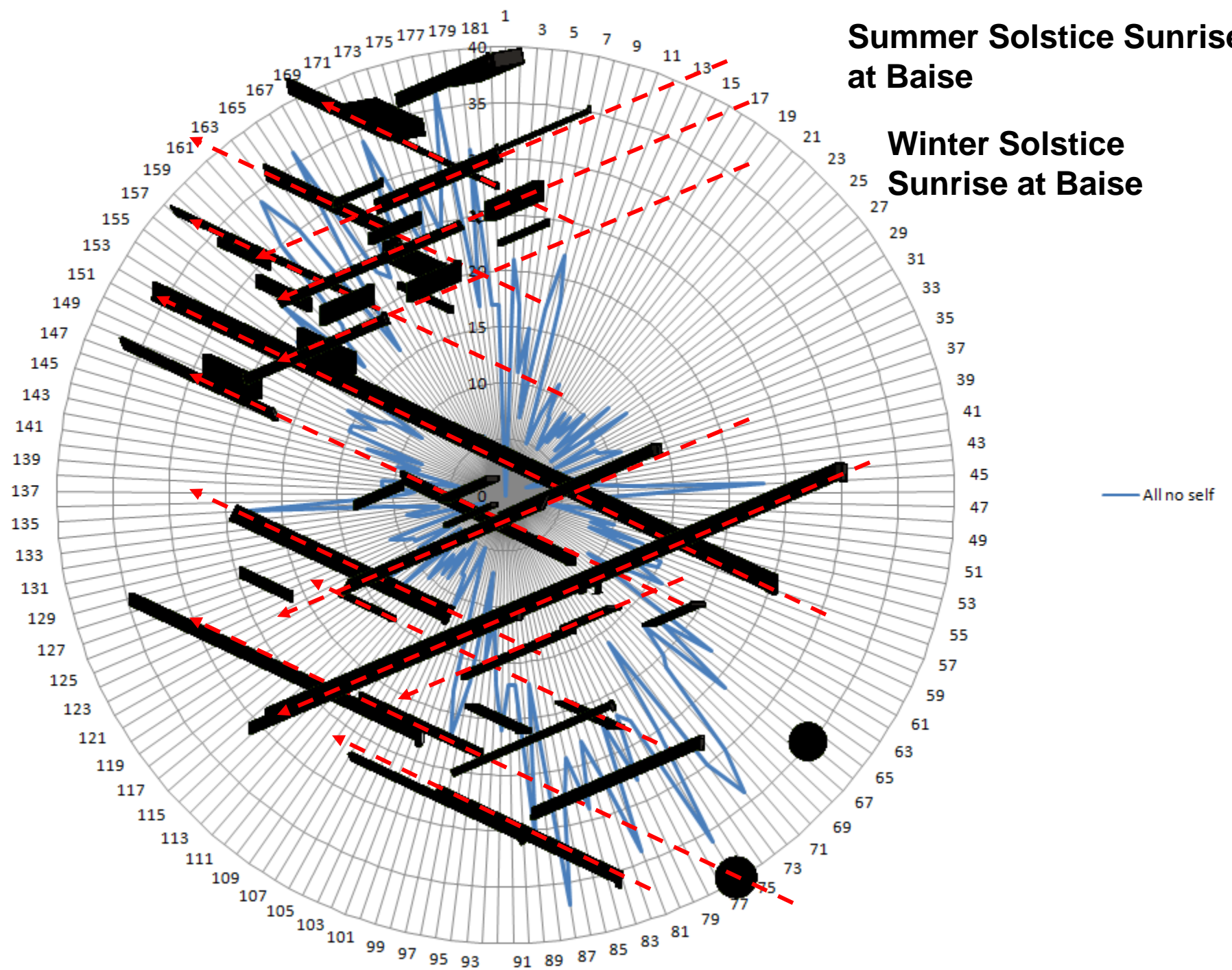
**Summer Solstice Sunrise  
at Baise**

**Winter Solstice  
Sunrise at Baise**



**Summer Solstice Sunrise  
at Baise**

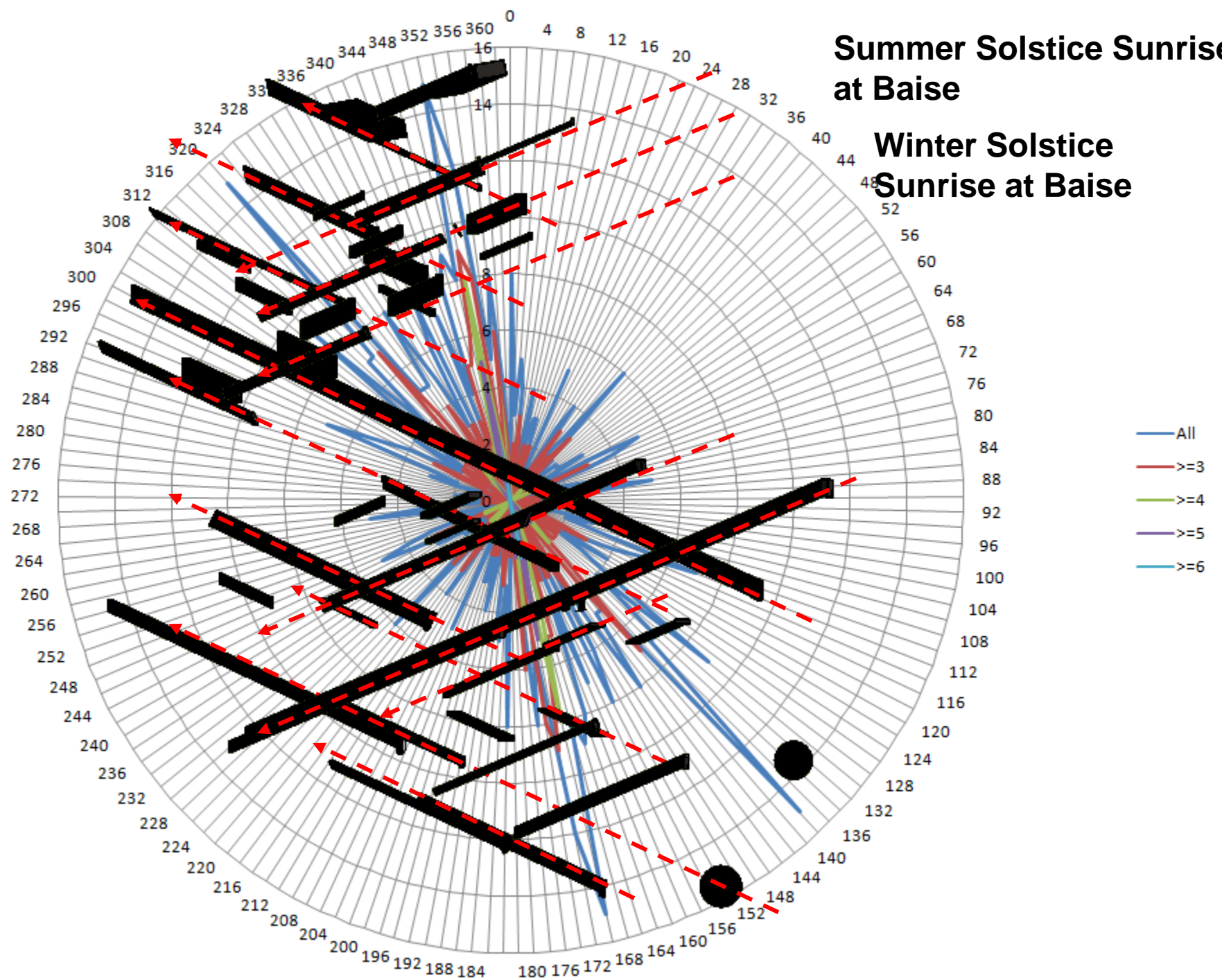
**Winter Solstice  
Sunrise at Baise**





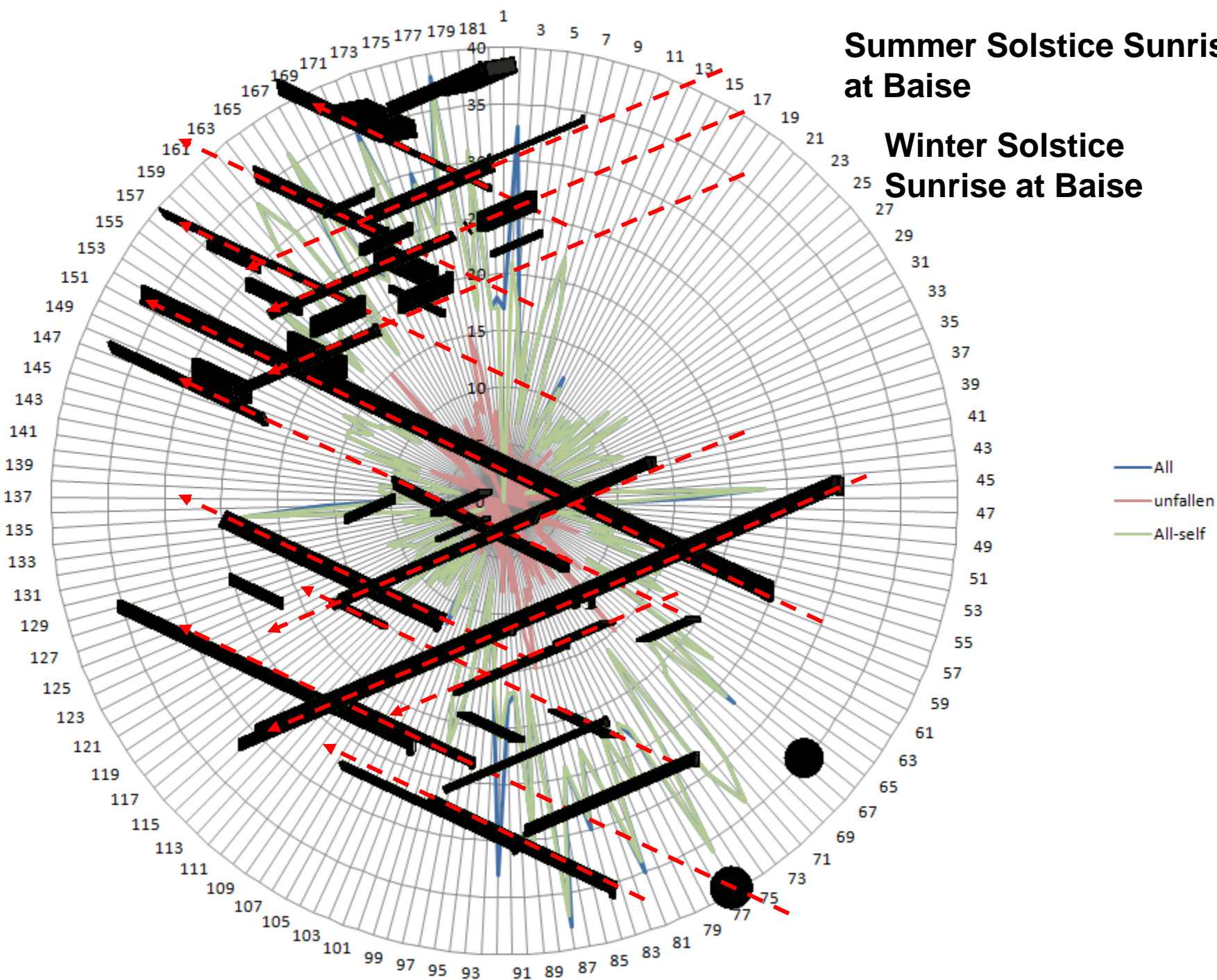
**Summer Solstice Sunrise  
at Baise**

**Winter Solstice  
Sunrise at Baise**



**Summer Solstice Sunrise  
at Baise**

**Winter Solstice  
Sunrise at Baise**

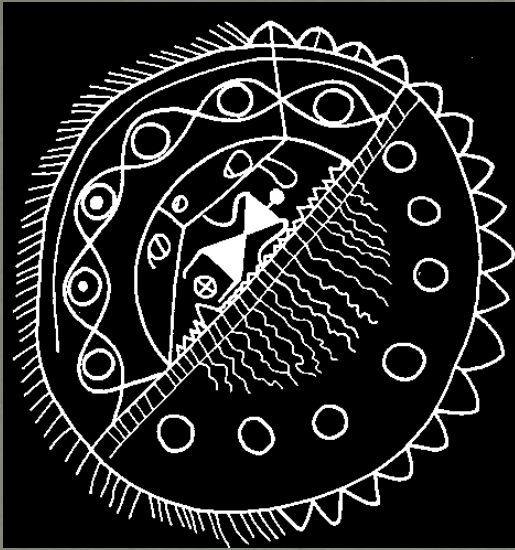




# Myths and Astronomy

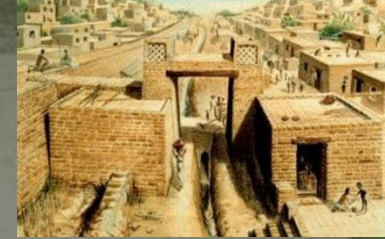
- Earth becomes the mother. She has to be seeded by father sky through rains. This interlocking relation is at the root of original myths of all cultures.
- The drama of thunderbolt, storms, moon, Sun, eclipses, rainbows, meteors and Sun all add to this fascination.
- The sky connects visual patterns from daily experience to constellations.
- The stars are given names of familiar things.

# Myths, cosmos and astronomy



- Myths and Astronomy are closely associated and their interrelation is a fascinating subject.
- However, in this talk we will deal only with astronomy.
- Evolution of Astronomy is complex and exciting enough to give new insights into our prehistoric and historic past.





Pleiades  
(Elnath)

Aldebaran  
in Taurus

Orion

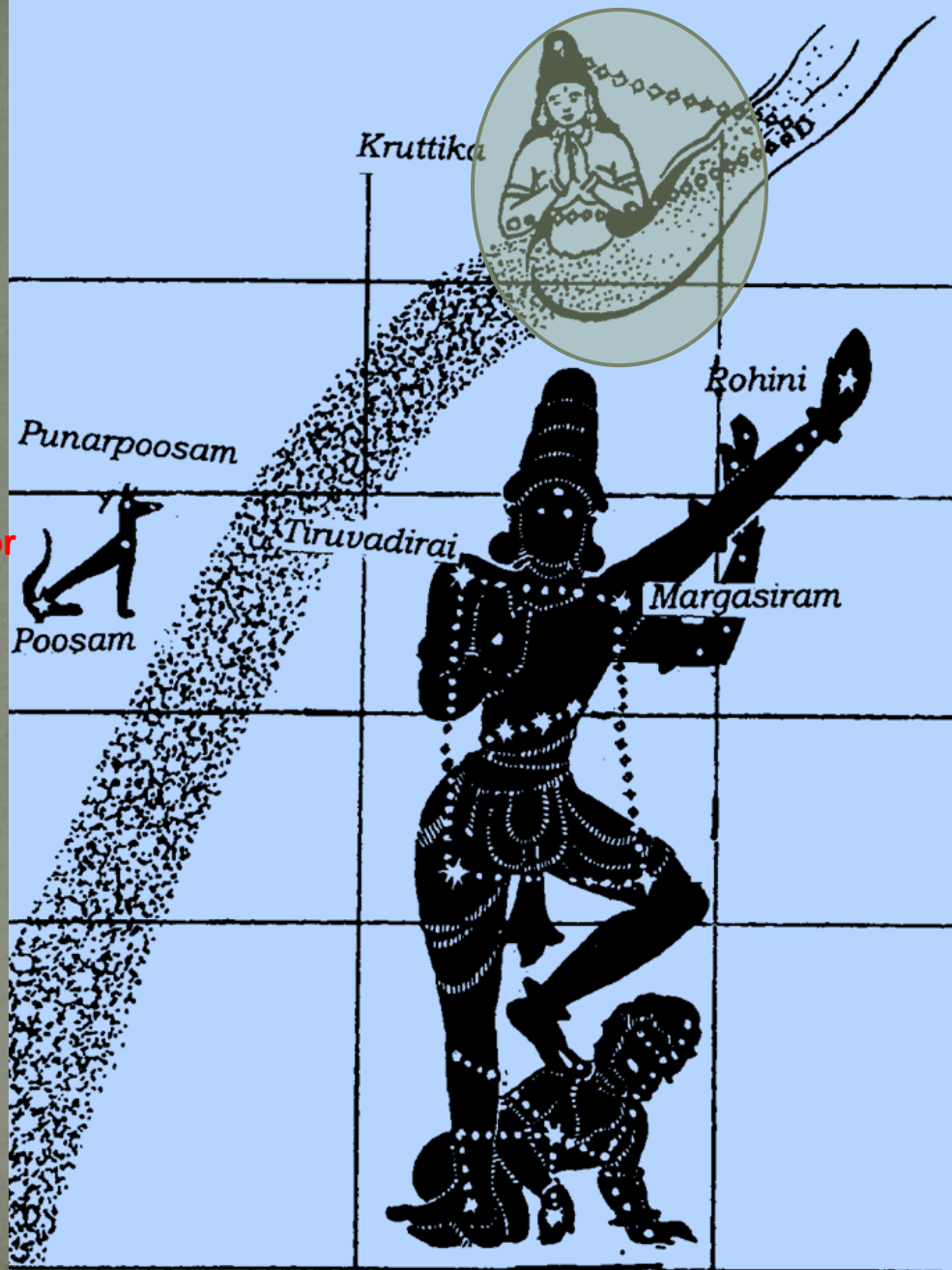
Lepus

Chola period, 9<sup>th</sup>  
century AD

Alhena

Canis Minor

Procyon



Constellation Orion seen as Gangadhara Siva

# Calendar Stone from Mohenjo Daro

