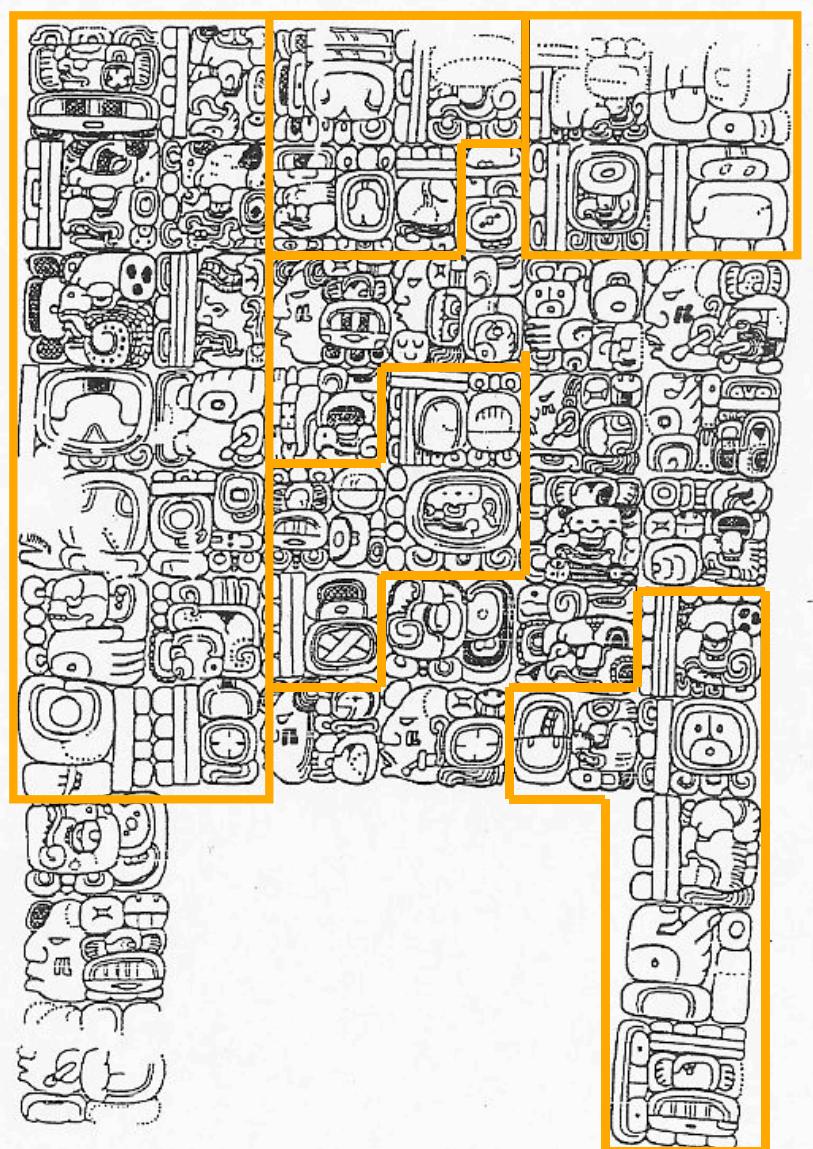


# The Age of Things: Sticks Stones and the Universe

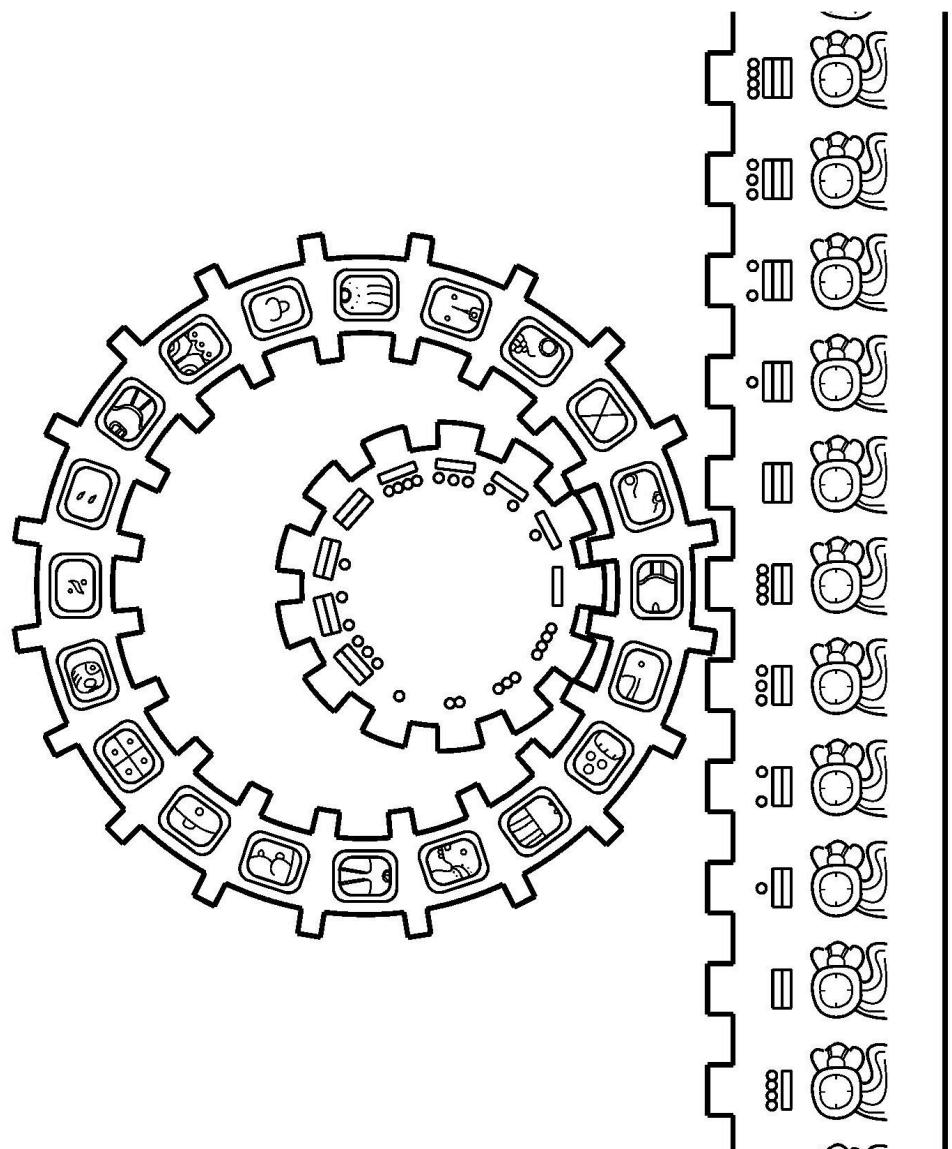
Precession, Polaris, and the  
Pyramids of Egypt

<http://cfcp.uchicago.edu/~mmhedman/compton1.html>

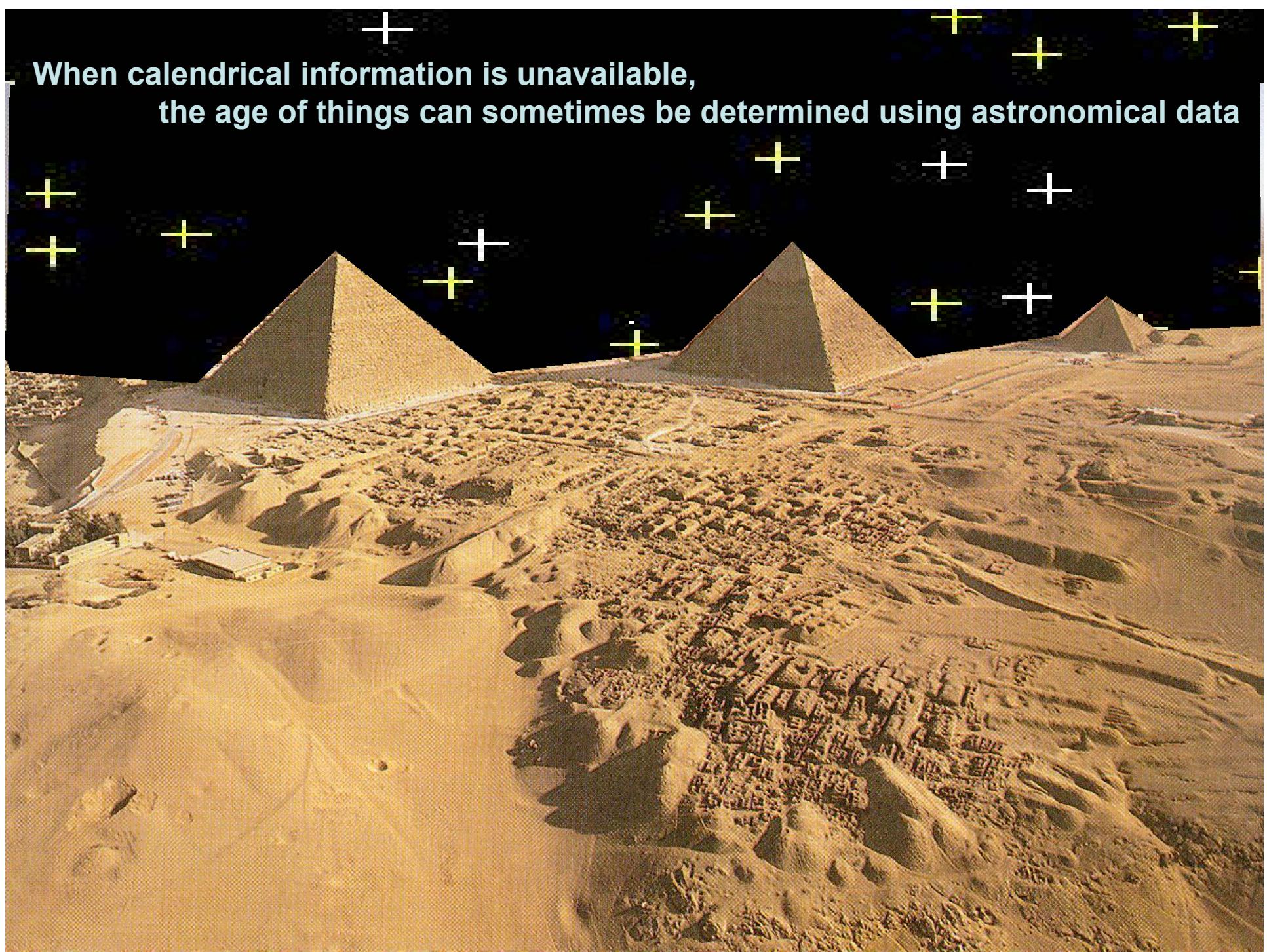
## Last Time: Calendars are the Key to Mayan History



Piedras Negras Stela 3, Drawn by Linda Schele

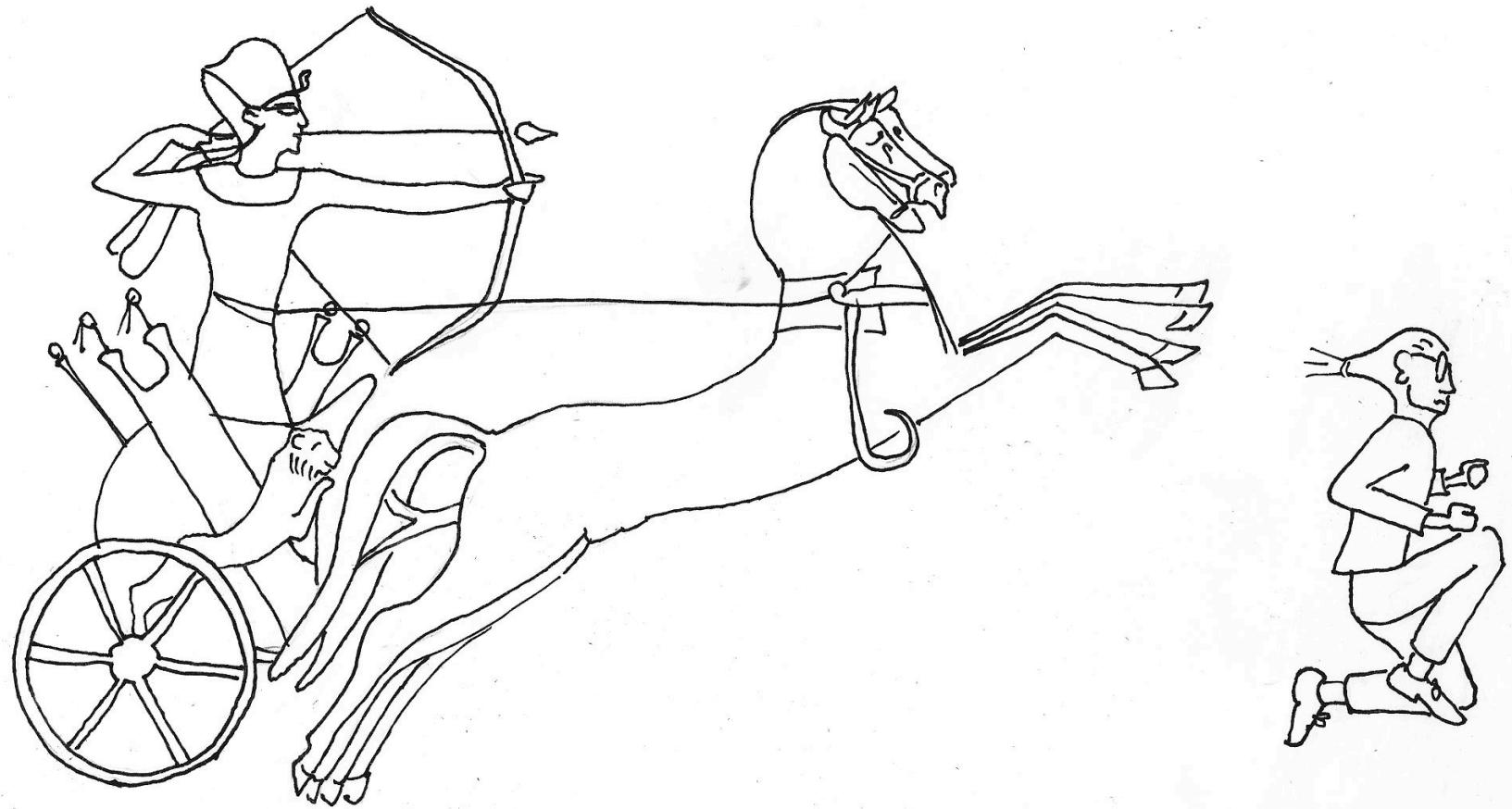


When calendrical information is unavailable,  
the age of things can sometimes be determined using astronomical data



# **Warning!**

## **Astrophysicist talking about Egyptology!**

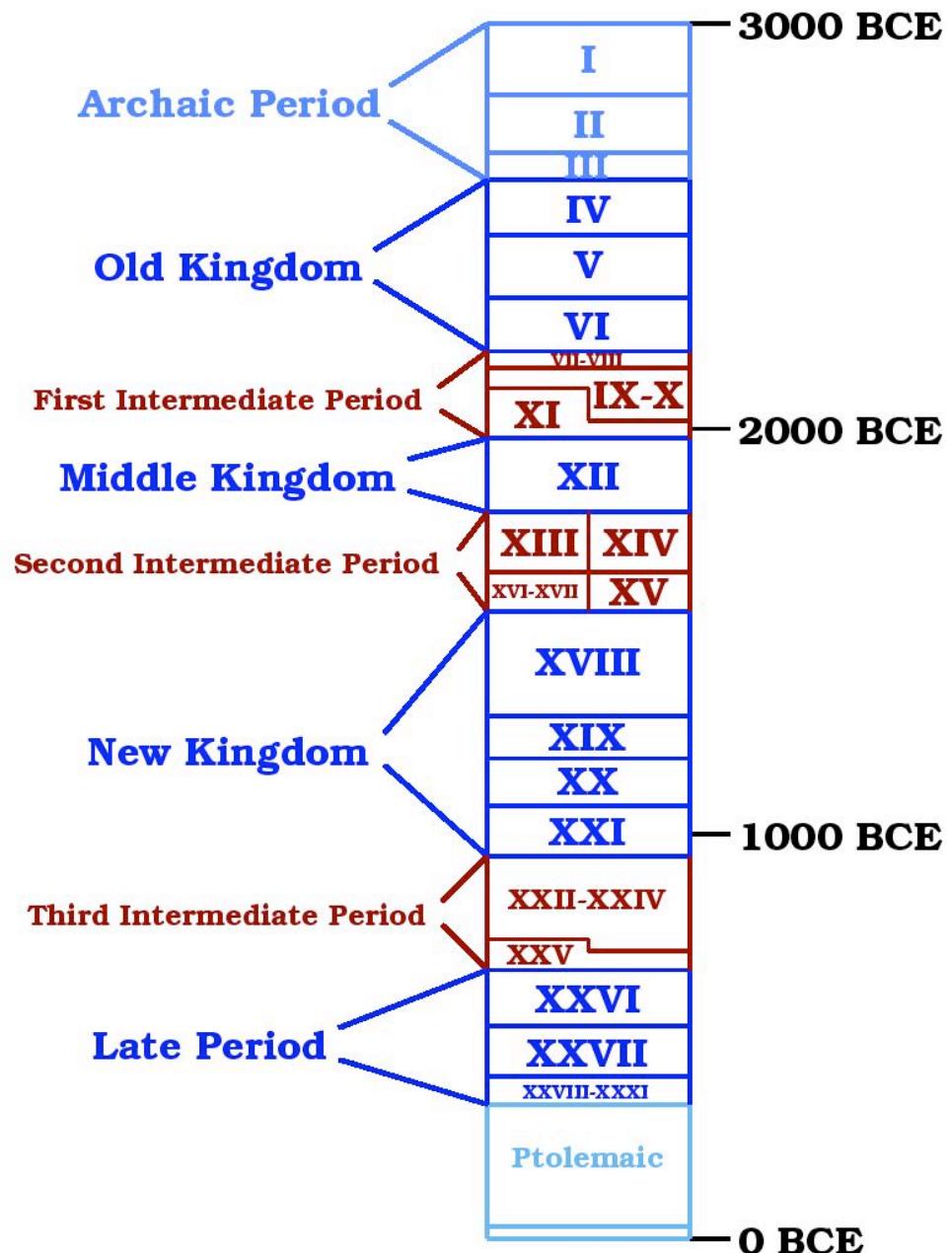


# The Ages of Ancient Egypt

The General Structure of Egyptian History Is well established

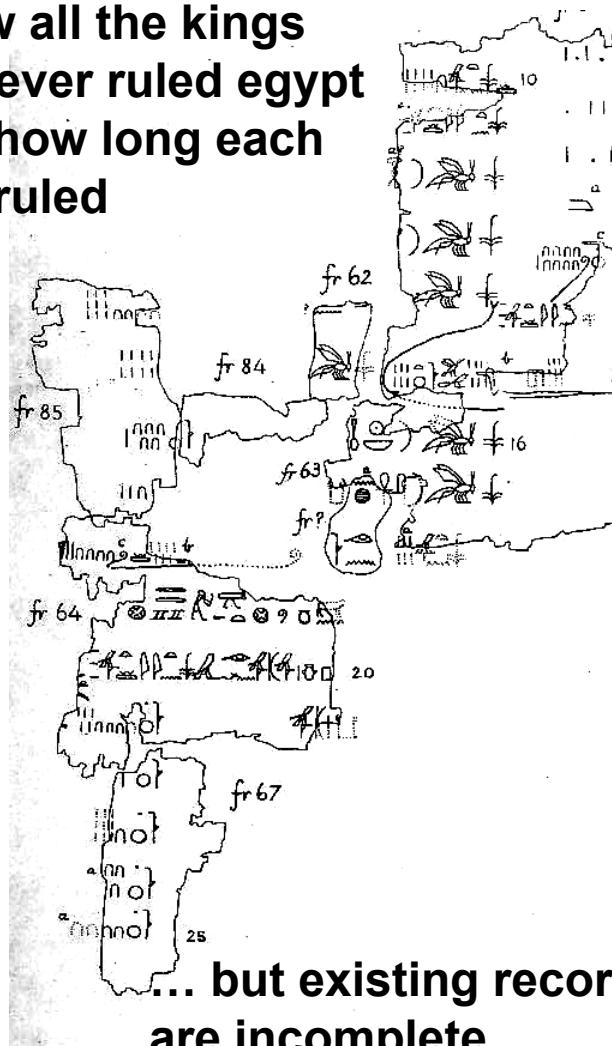
However, the Egyptians did not have a calendar that counted years from a fixed point in the past

Years were instead counted From the time the last king came to power.

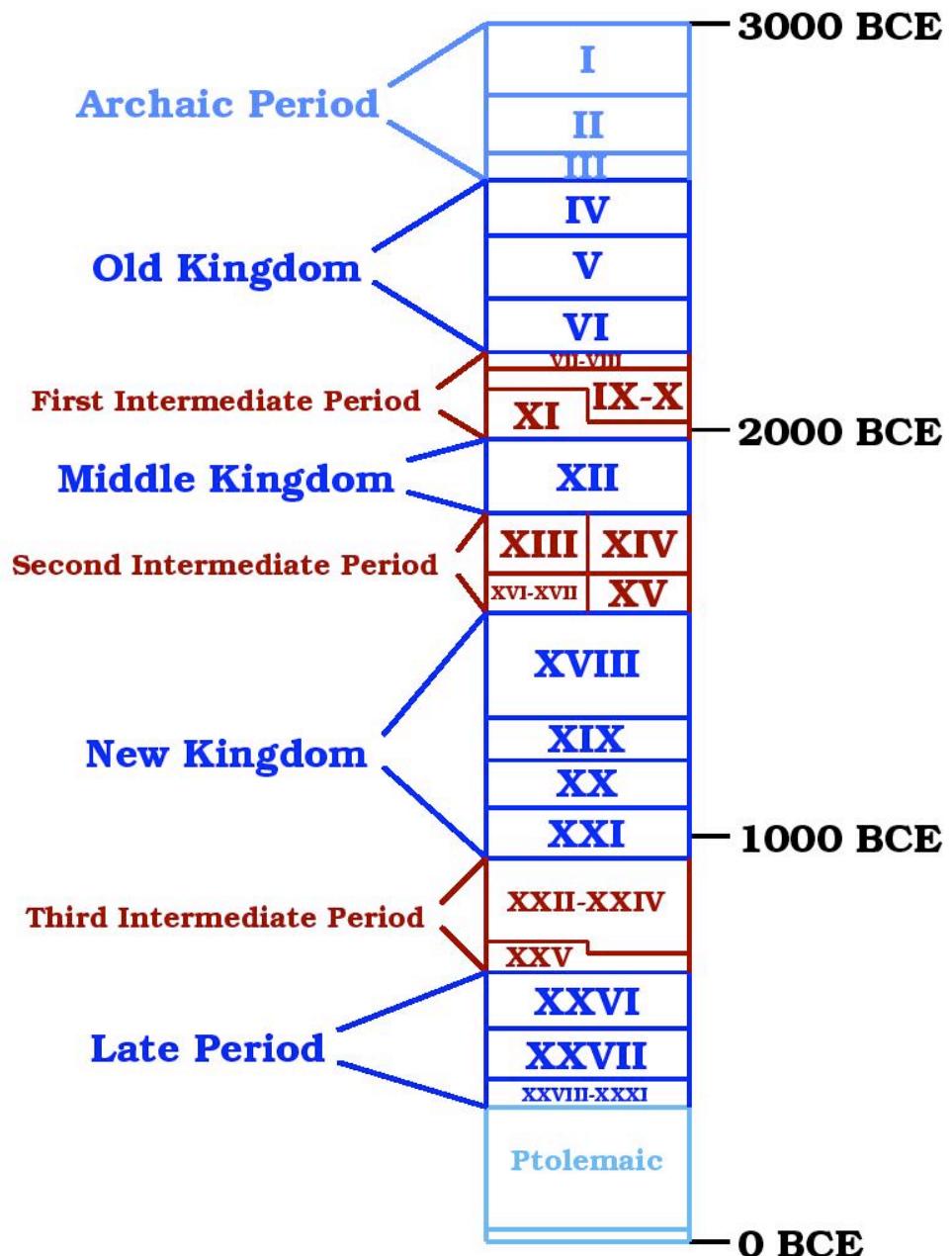


# The Ages of Ancient Egypt

To figure out exactly when events occurred in time, we need to know all the kings that ever ruled egypt and how long each one ruled



... but existing records are incomplete



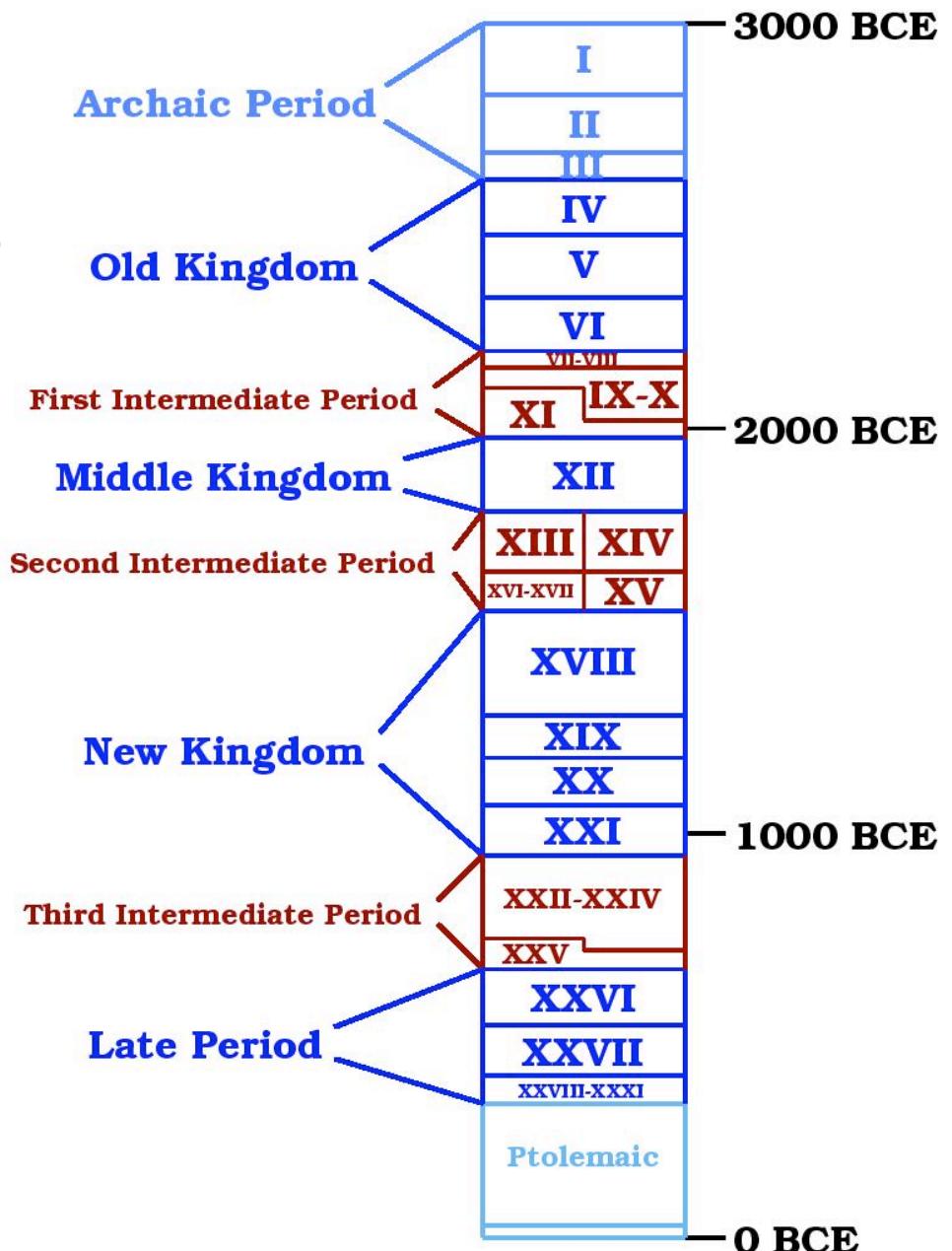
# The Ages of Ancient Egypt

Historical records from each kingdom are abundant enough that events can be well located relative to each other in time.

But records from the intermediate periods are sparse, so the length of time occupied by these periods is quite uncertain.

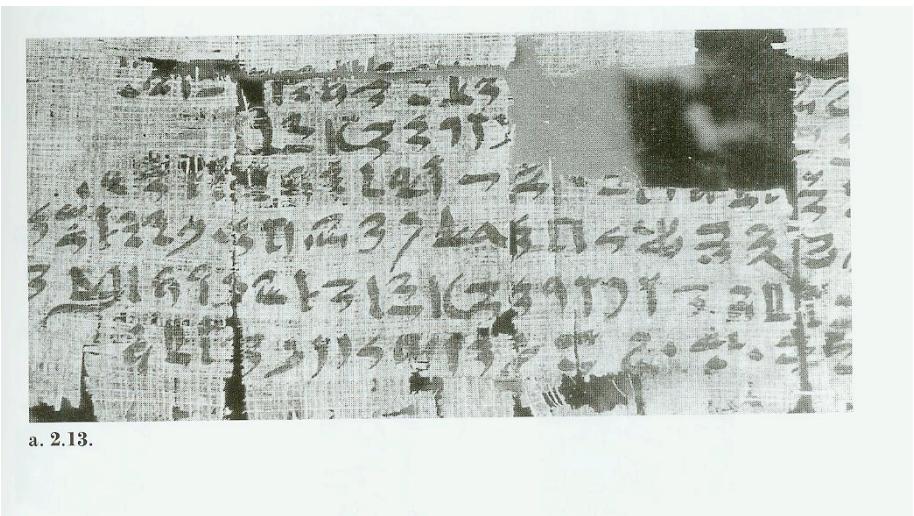


or?

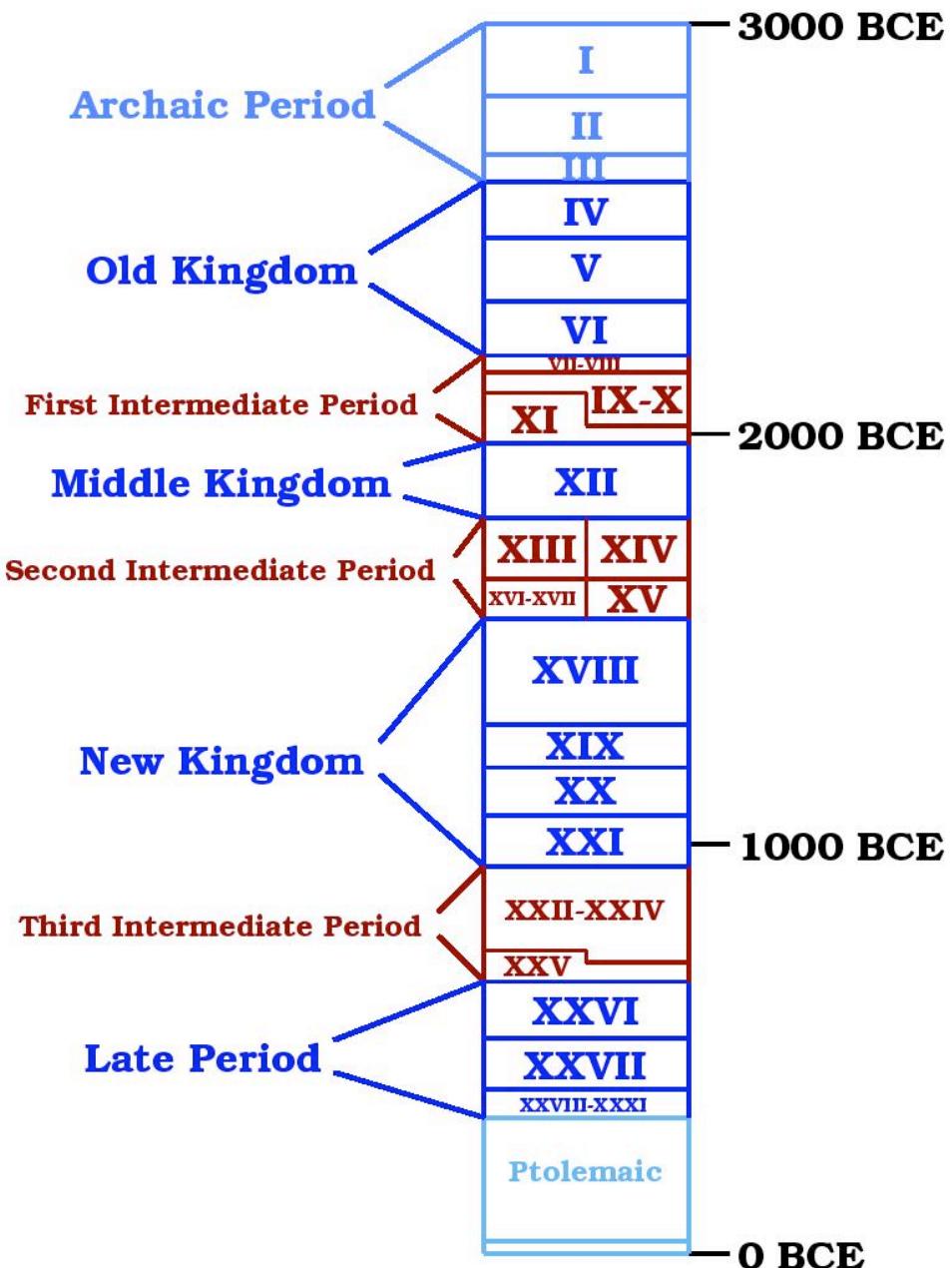


# The Ages of Ancient Egypt

The Middle and New Kingdoms are anchored in time by written texts that mention astronomical events



No such text exists for the Old Kingdom, so this period can “float” in time over a few hundred years



**In 2000, K.E. Spence suggested the Pyramids themselves could provide the key to anchoring the Old Kingdom in time**

**articles**

# Ancient Egyptian chronology and the astronomical orientation of pyramids

**Kate Spence**

*Faculty of Oriental Studies, University of Cambridge, Sidgwick Avenue, Cambridge CB3 9DA, UK*

**The ancient Egyptian pyramids at Giza have never been accurately dated, although we know that they were built approximately around the middle of the third millennium BC. The chronologies of this period have been reconstructed from surviving lists of kings and the lengths of their reigns, but the lists are rare, seldom complete and contain known inconsistencies and errors. As a result, the existing chronologies for that period (the Old Kingdom) can be considered accurate only to about  $\pm 100$  years, a figure that radiocarbon dating cannot at present improve. Here I use trends in the orientation of Old Kingdom pyramids to demonstrate that the Egyptians aligned them to north by using the simultaneous transit of two circumpolar stars. Modelling the precession of these stars yields a date for the start of construction of the Great Pyramid that is accurate to  $\pm 5$  yr, thereby providing an anchor for the Old Kingdom chronologies.**

The pyramids of the middle of the third millennium in Egypt (the Old Kingdom), built as tombs for the kings of the period, were oriented to the cardinal points with extraordinary precision. The most accurately aligned is the Pyramid of Khufu (Cheops) at Giza, also known as the Great Pyramid, the sides of which deviate from true north by an average of less than 3 minutes of arc<sup>1</sup>. Ever since modern survey techniques revealed this achievement in the late nineteenth century<sup>2</sup>, the question of how the ancient Egyptians achieved such accuracy has been widely debated.

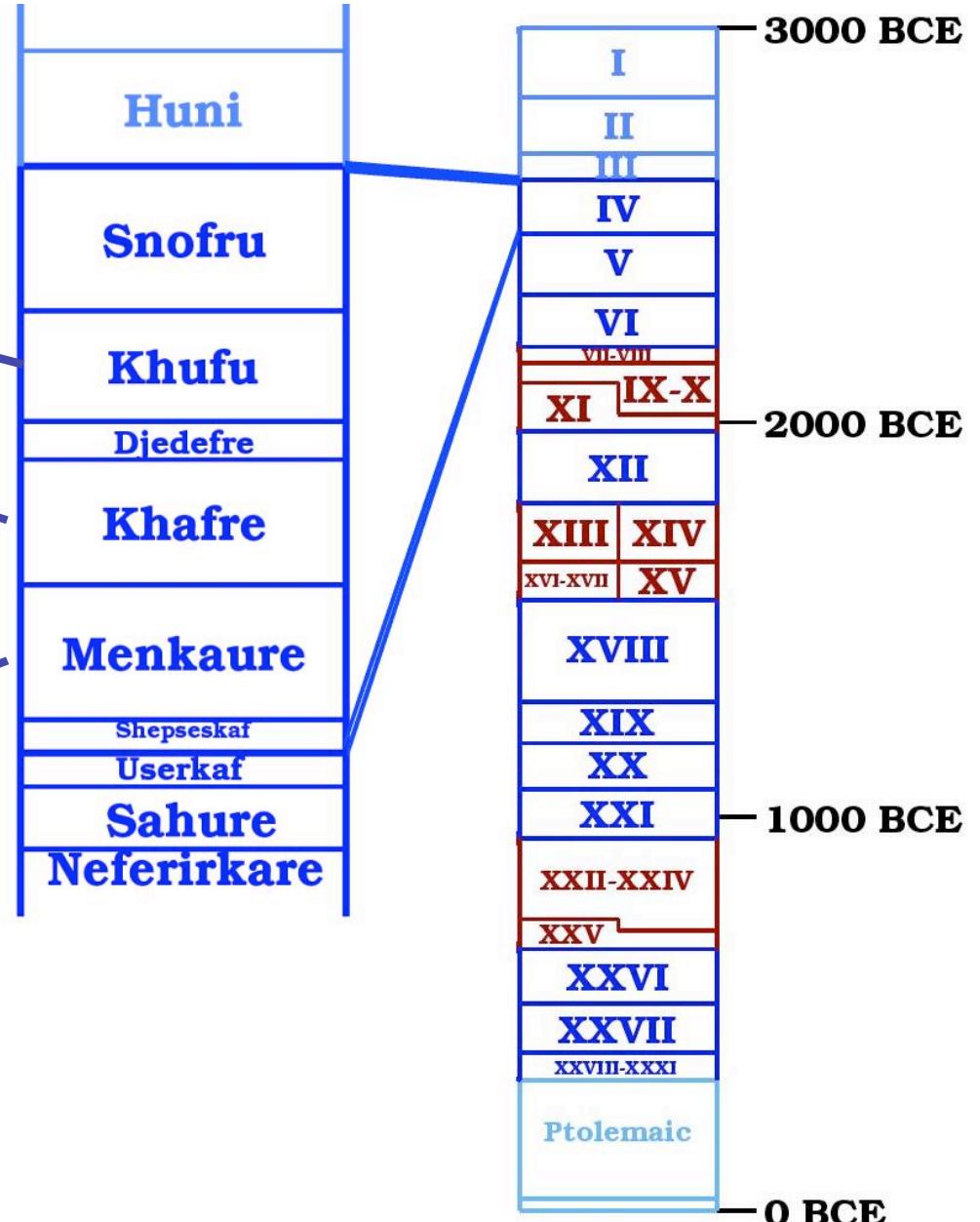
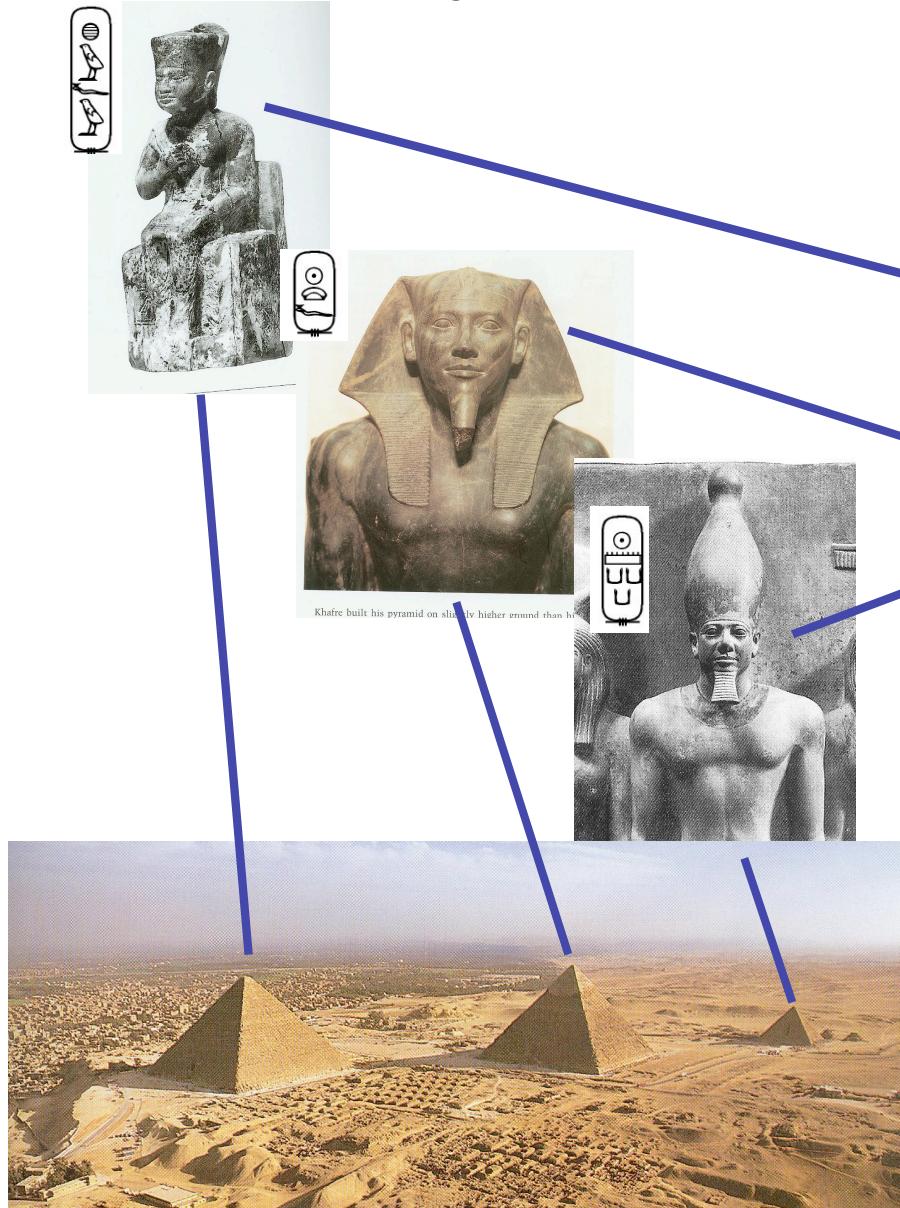
The absence of contemporary source material accounts for the range of possible orientation methods that have been proposed over the years. There are no relevant texts or representations from this period and discussions have therefore relied either on much later textual or representational evidence or on considerations of potential accuracy<sup>3</sup>. Although for many years it has been accepted on the grounds of accuracy that a stellar method was used<sup>3,4</sup>, recent research has revived the possibility of solar alignment<sup>5</sup>.

the pyramid of Khufu represented a peak of accuracy which was not maintained in subsequent reigns. In fact, after Khufu's reign the alignment of pyramids became increasingly inaccurate. If the Egyptians had mastered a method of exceptionally accurate orientation, they should have been able to reproduce the results in subsequent generations. Nor can the accuracy of the Khufu alignment be considered coincidental when overall trends in pyramid orientation are examined in detail.

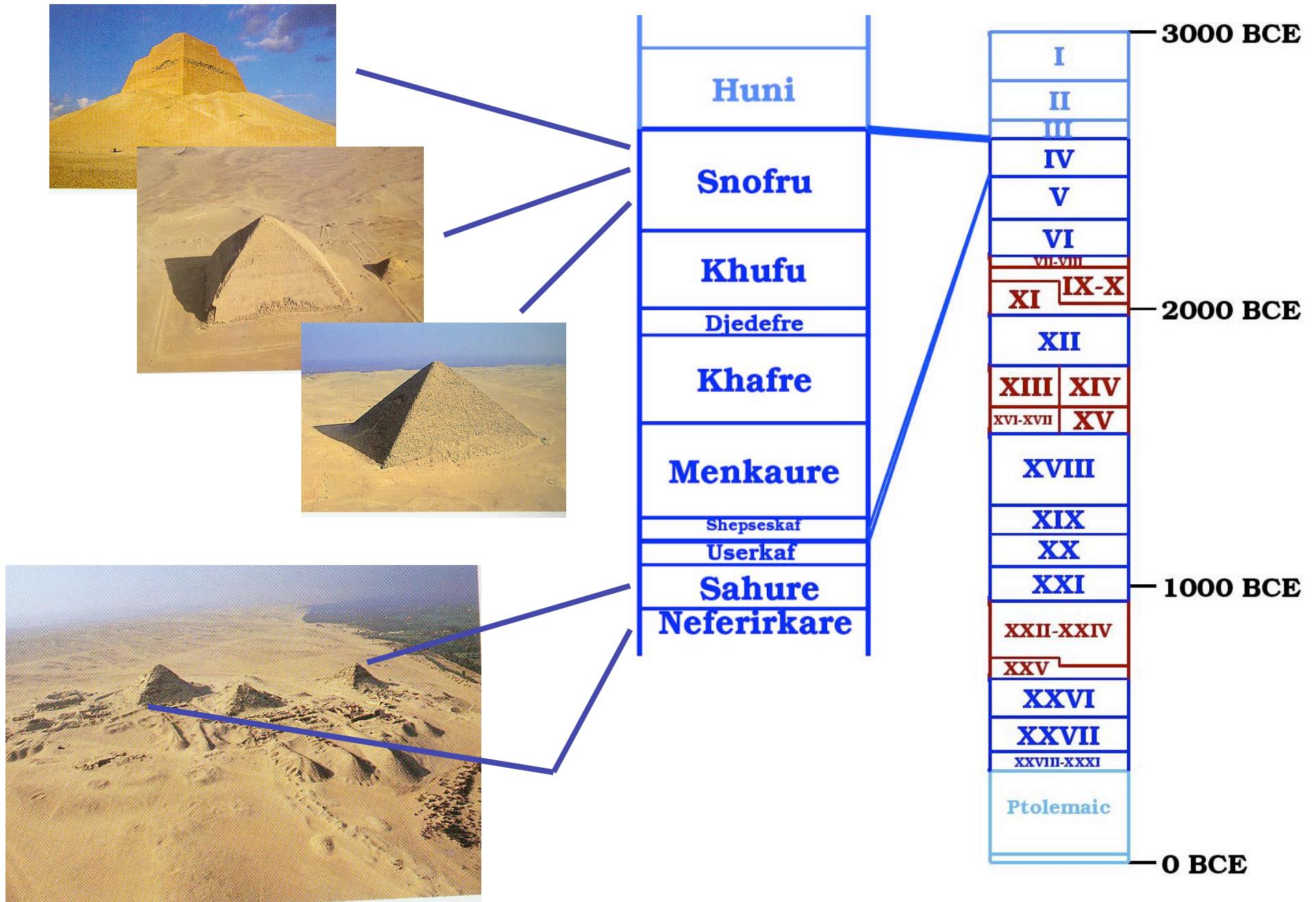
Table 1 lists the pyramids for which accurate measurements of orientation are available together with the accession dates of the kings for whom they were constructed. As a result of differences in reconstructions of the historical data, several chronologies of the period are available<sup>7</sup>; here I follow the lower range of dates given in von Beckerath's recent chronology<sup>8</sup>, with the exception of the reign of Snofru. Stadelmann's proposed 46-year reign of Snofru is followed here<sup>9</sup>, and the start dates for Snofru's construction of Meidum and the Bent and Red pyramids also follow his chronology

# The Old Kingdom: The Age of Pyramids

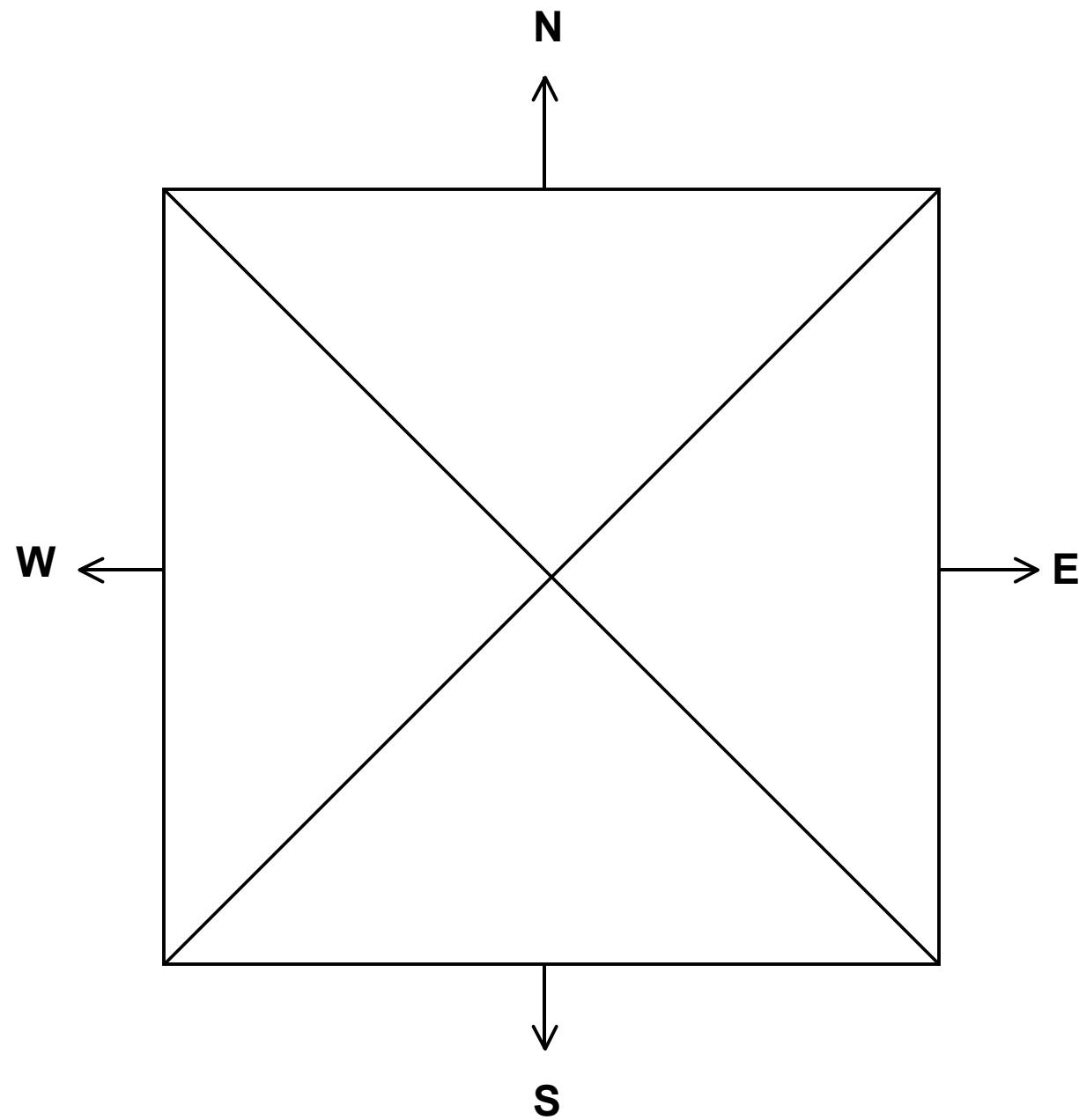
## The Great Pyramids at Giza



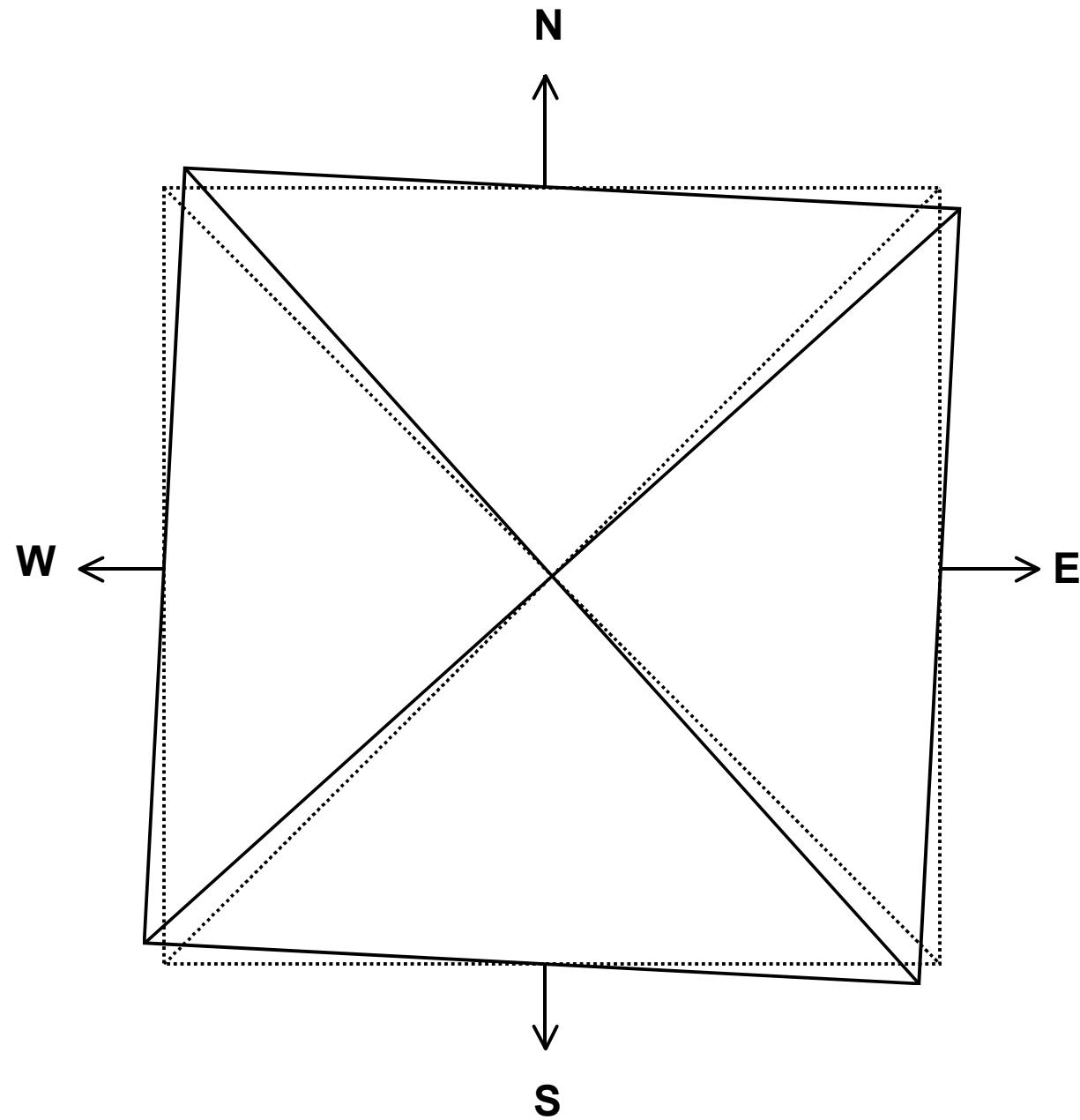
# The Three Pyramids of Snofru and the pyramids of the Fifth Dynasty



**The pyramids are very accurately aligned with the cardinal directions**

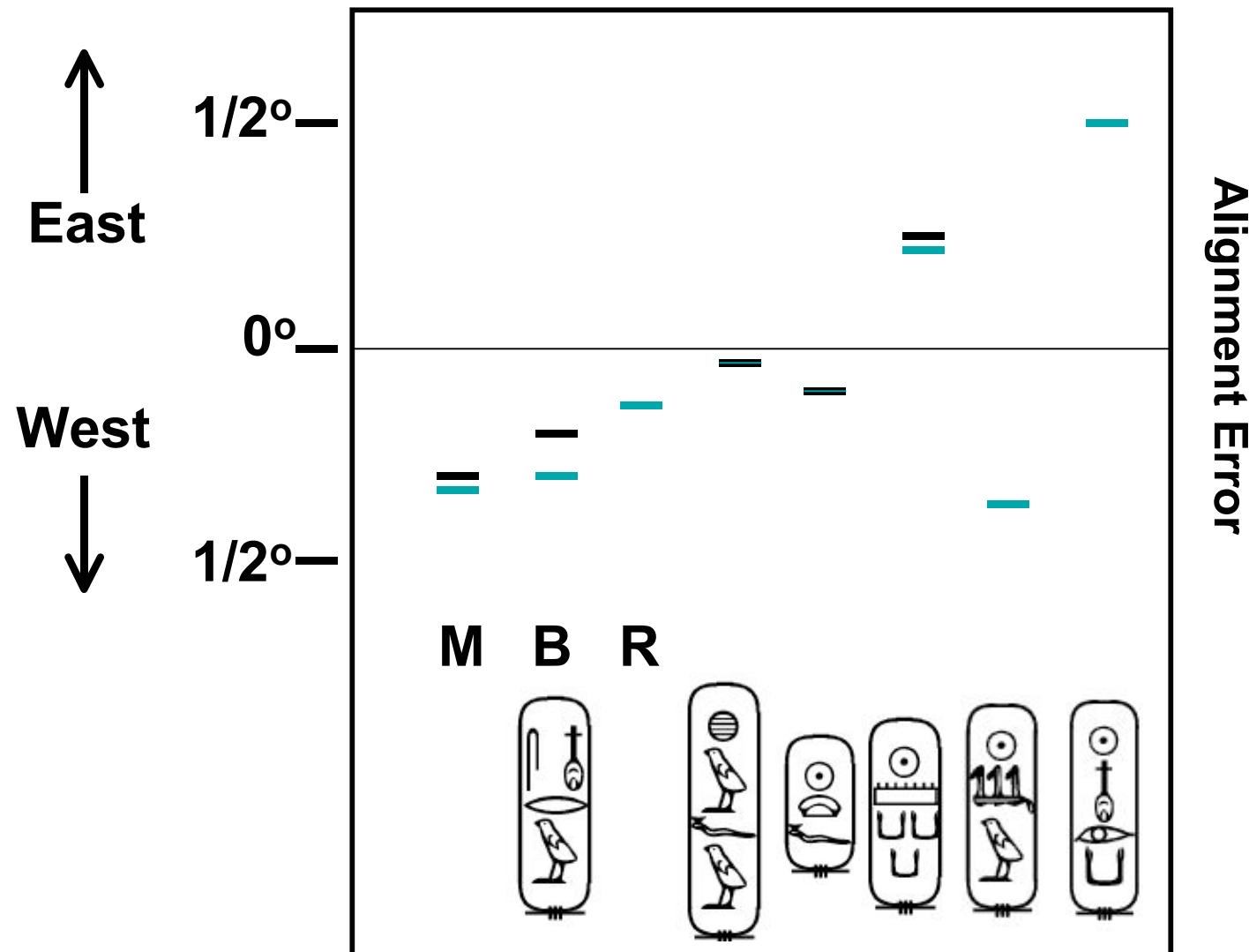


**There are slight alignment errors in all the pyramids**

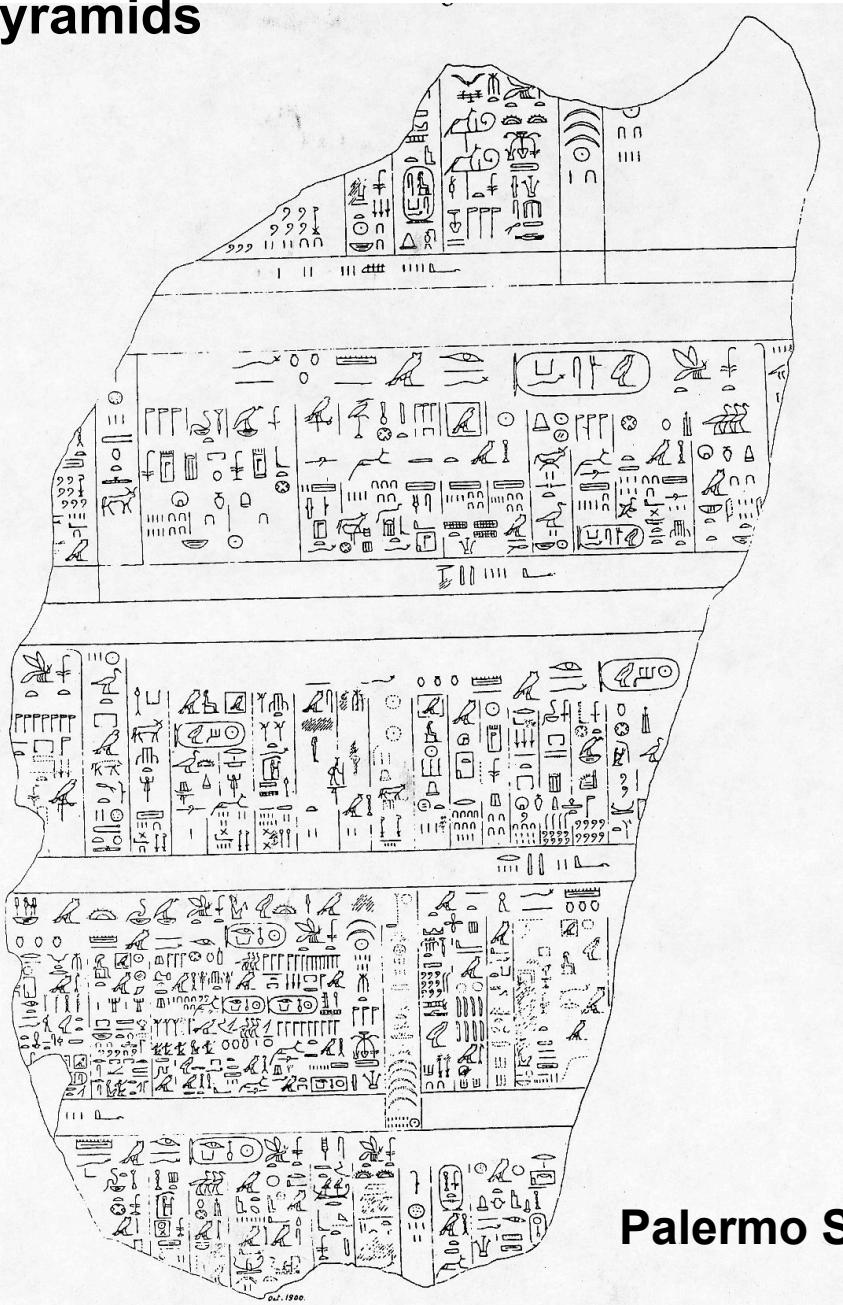


# A Curious Pattern in the Pyramids

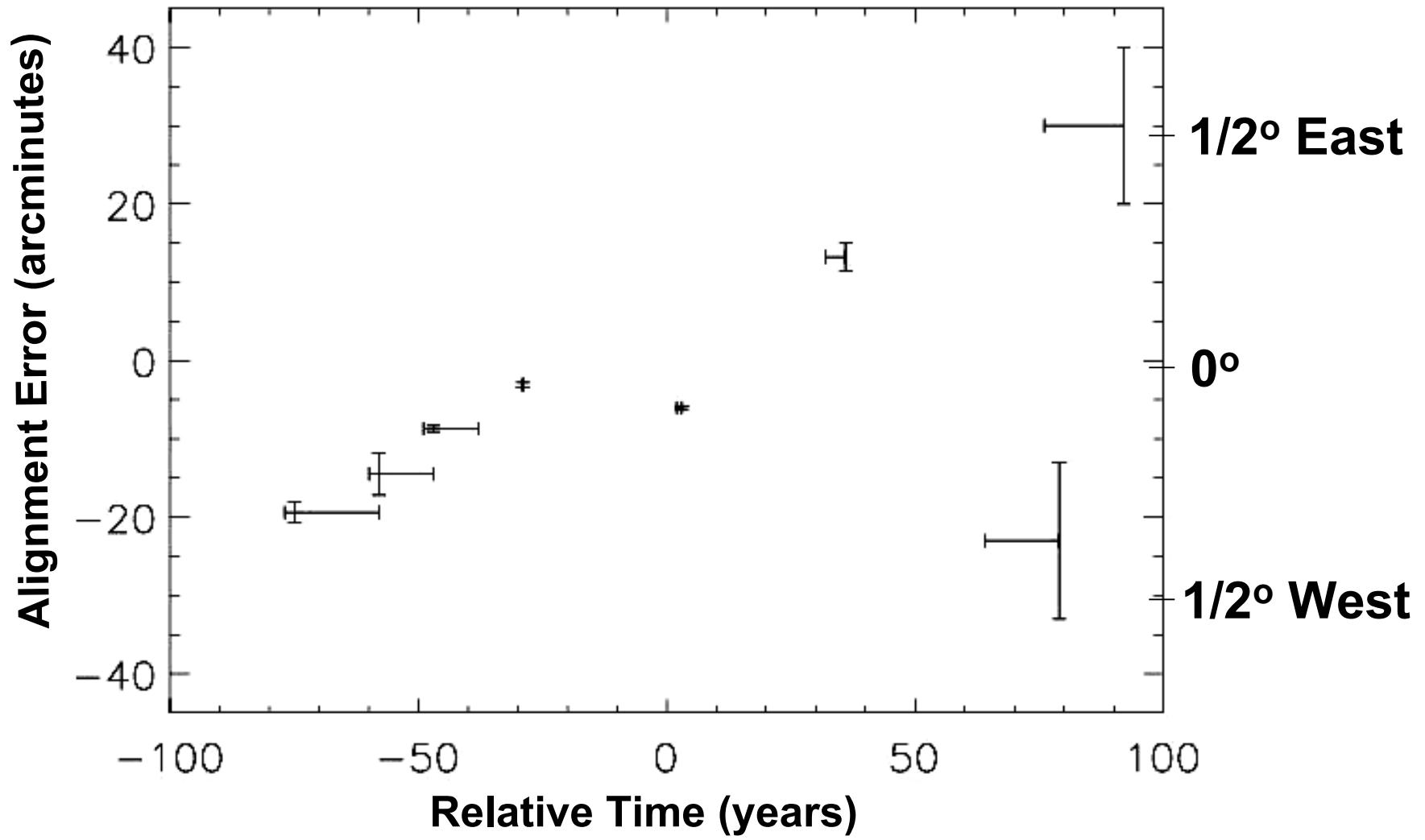
— West Side  
— East Side



# Timing the Construction of the Pyramids

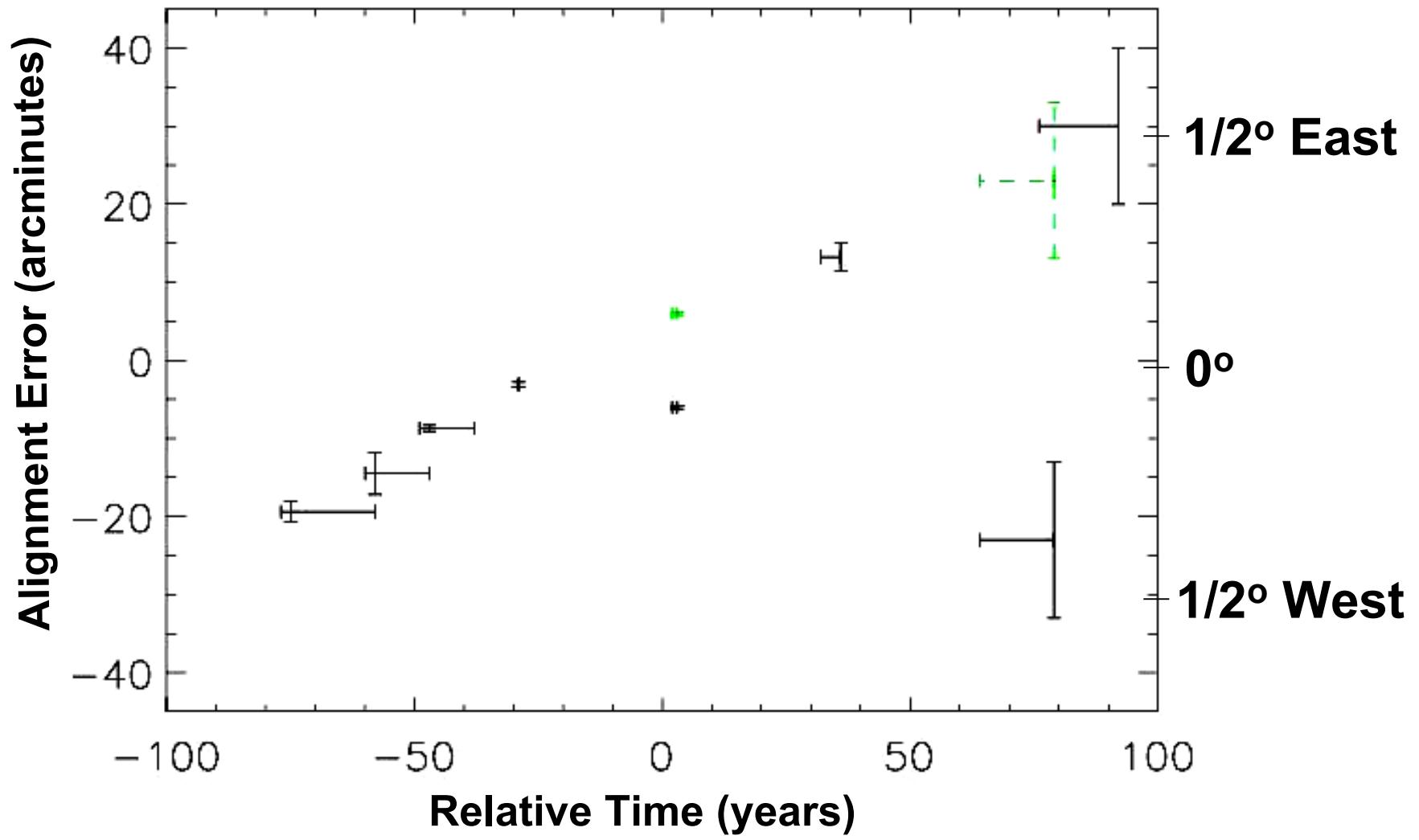


# A Curioser Pattern in the Pyramids



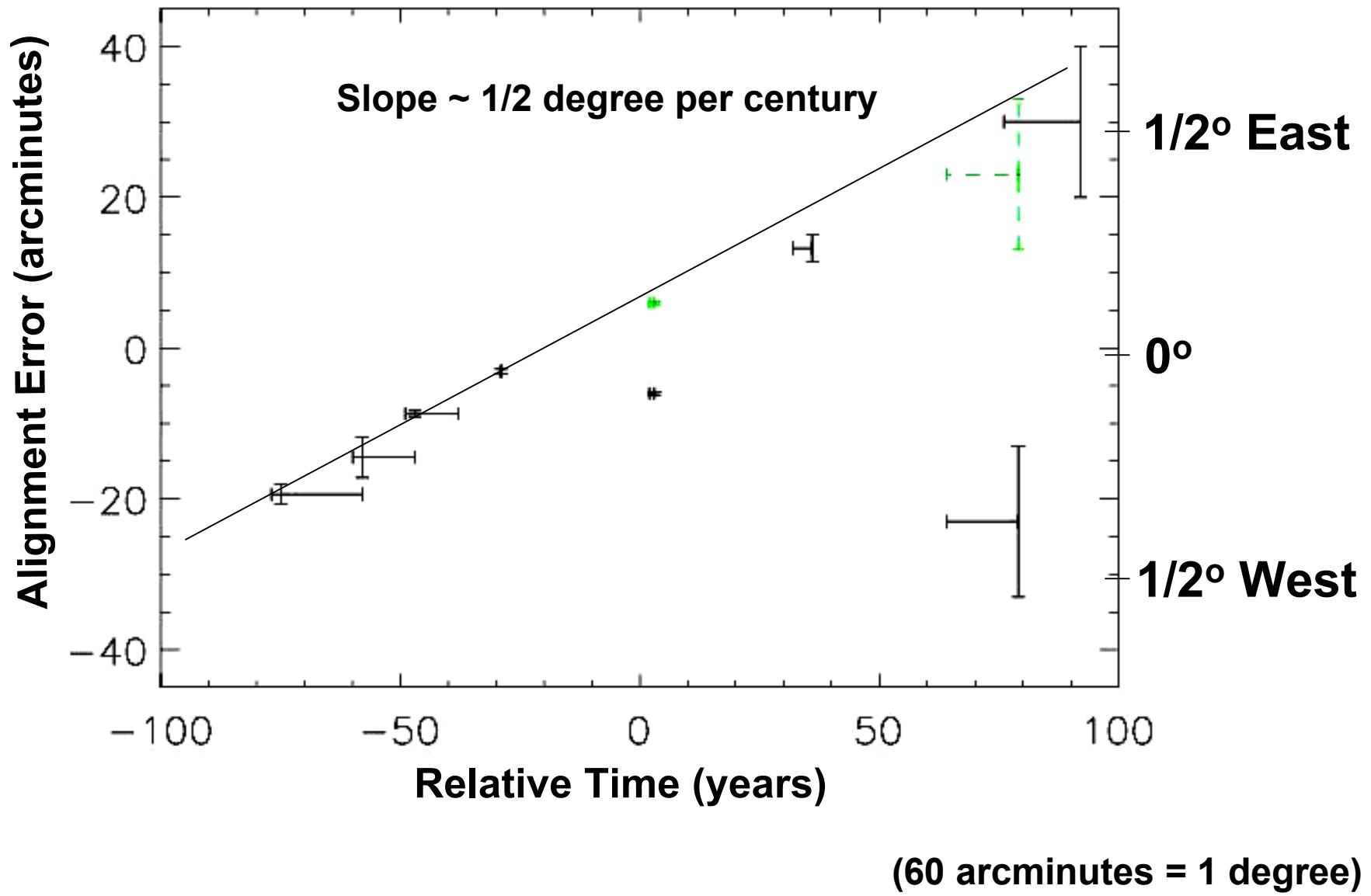
(60 arcminutes = 1 degree)

# A Curioser Pattern in the Pyramids

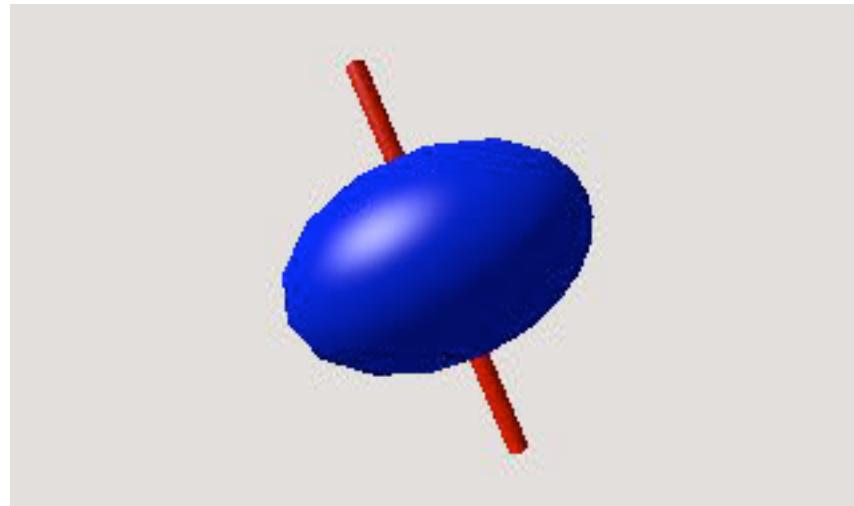


(60 arcminutes = 1 degree)

# A Curioser Pattern in the Pyramids

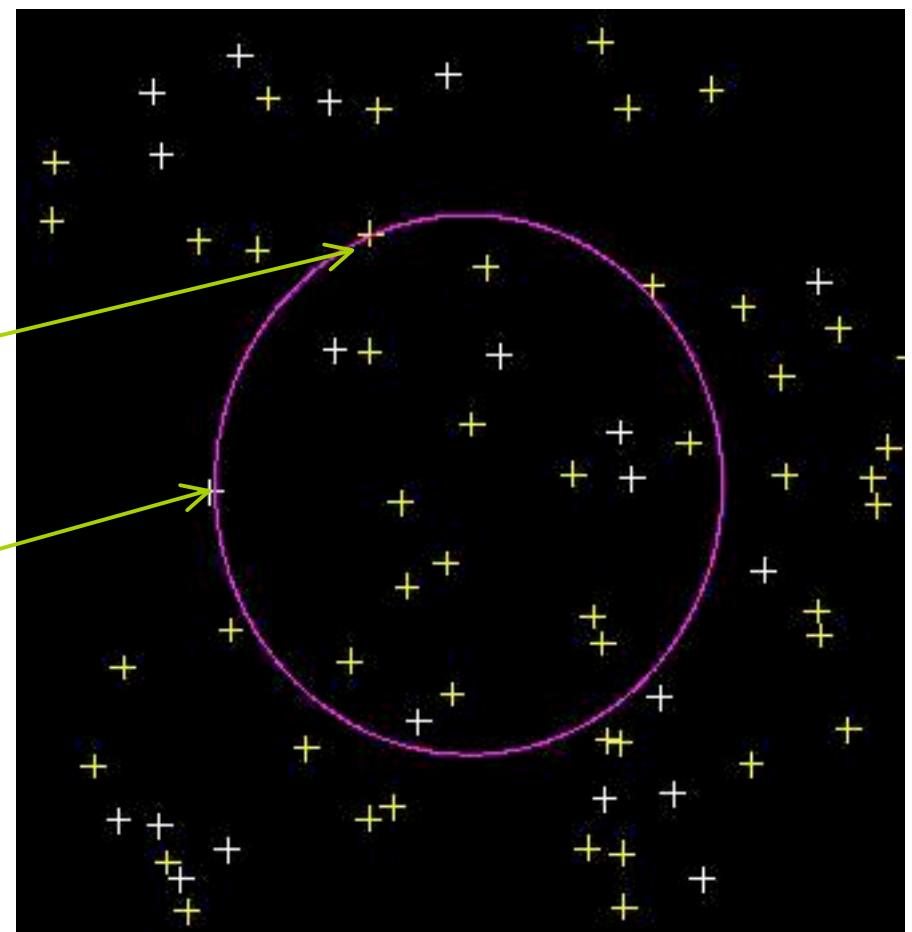


# Precession of the earth



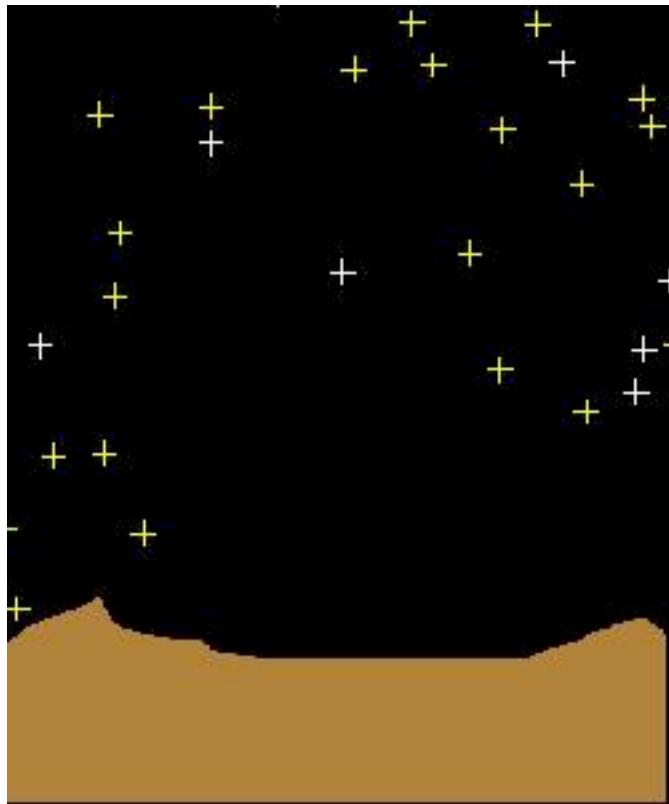
Celestial Pole in 2500 BCE

Celestial Pole Today



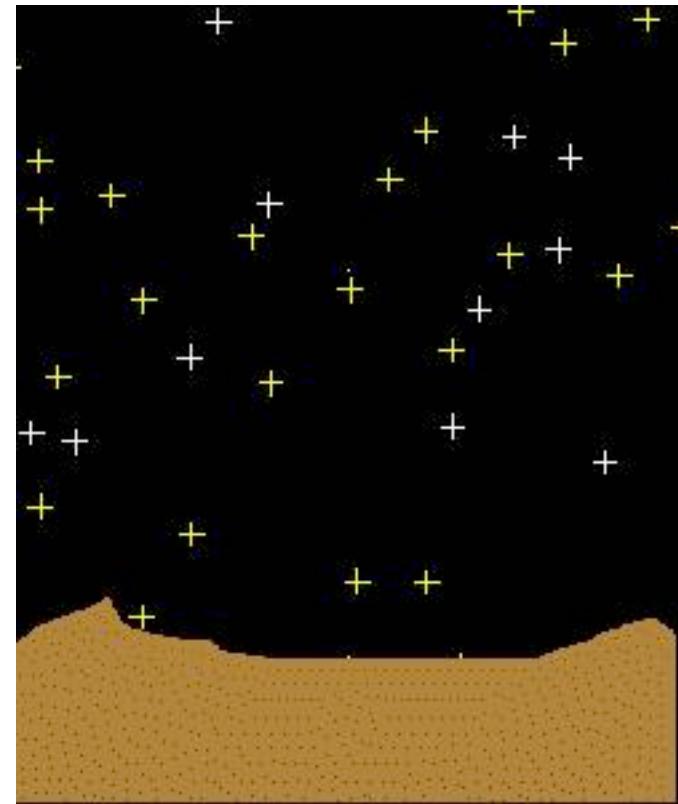
# The Precession of the Earth affects the night sky

The Northern Sky Today



N

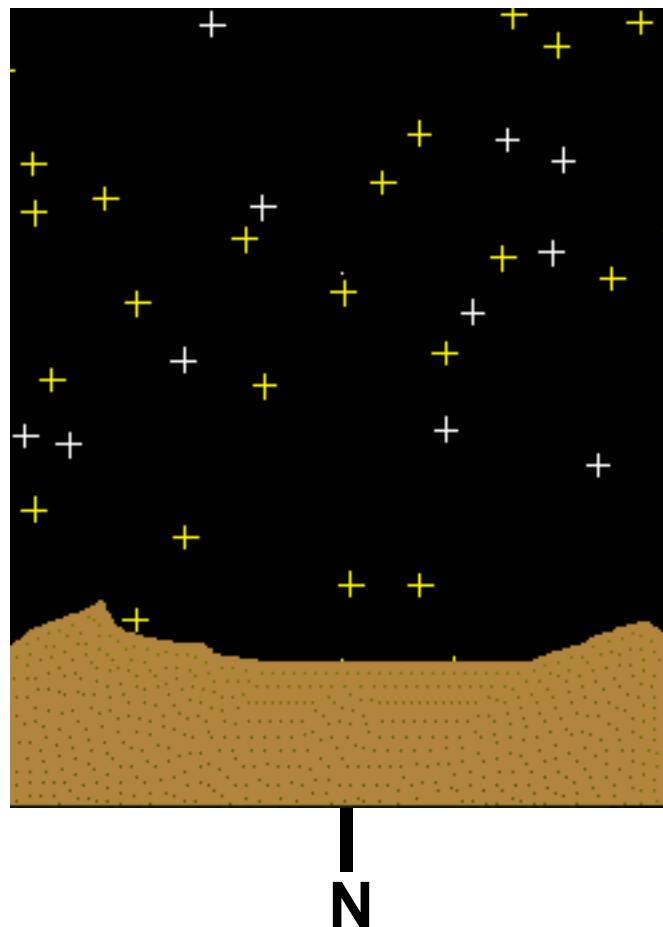
The Northern Sky in 2500 BCE



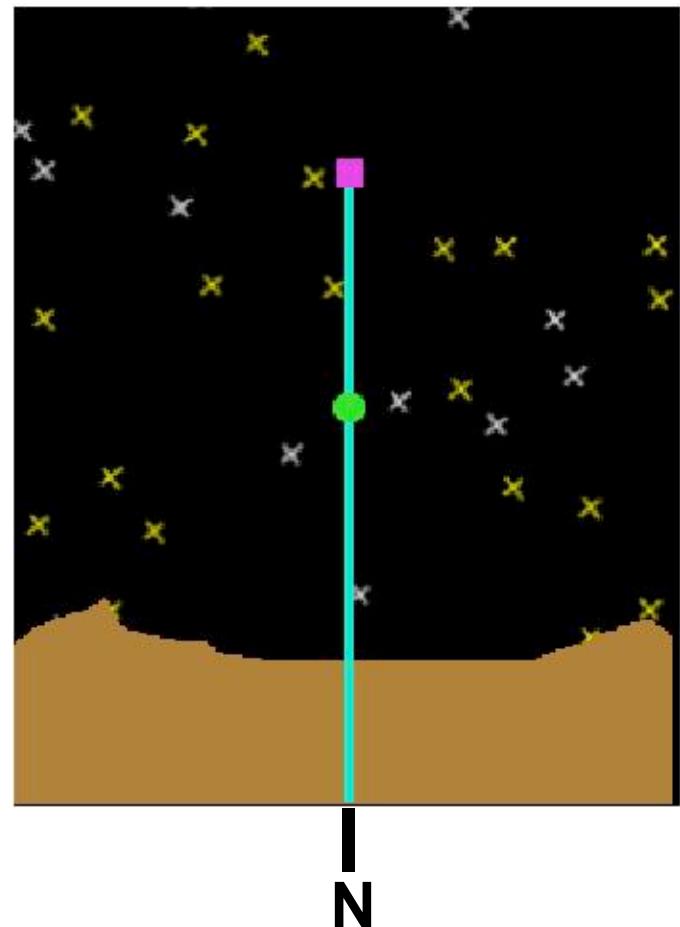
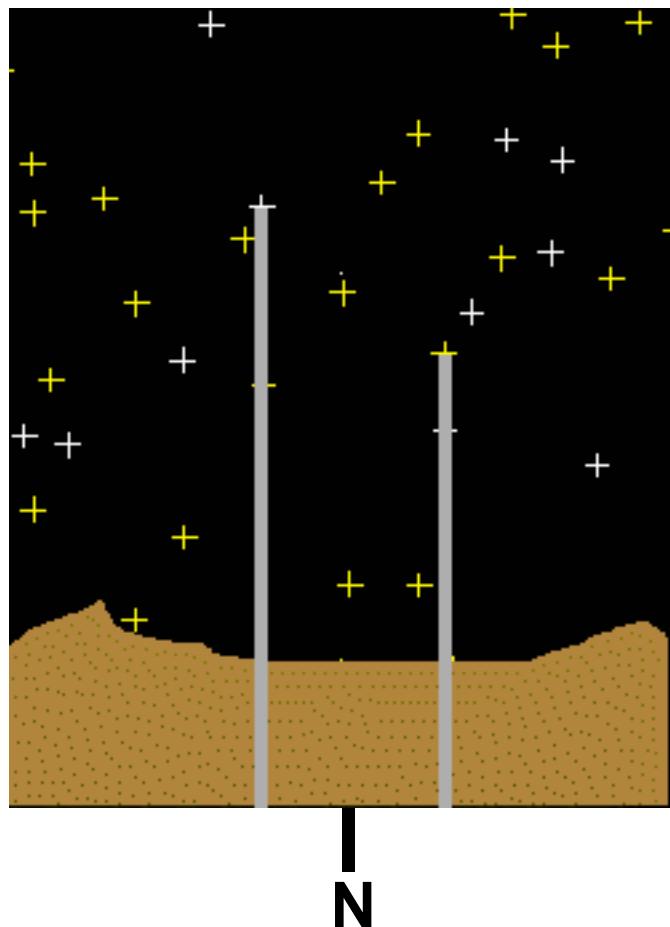
N

Precession causes the stars to move with respect to North at a rate of about 1/2 degree per century

# The Night Sky in the Age of the Pyramids

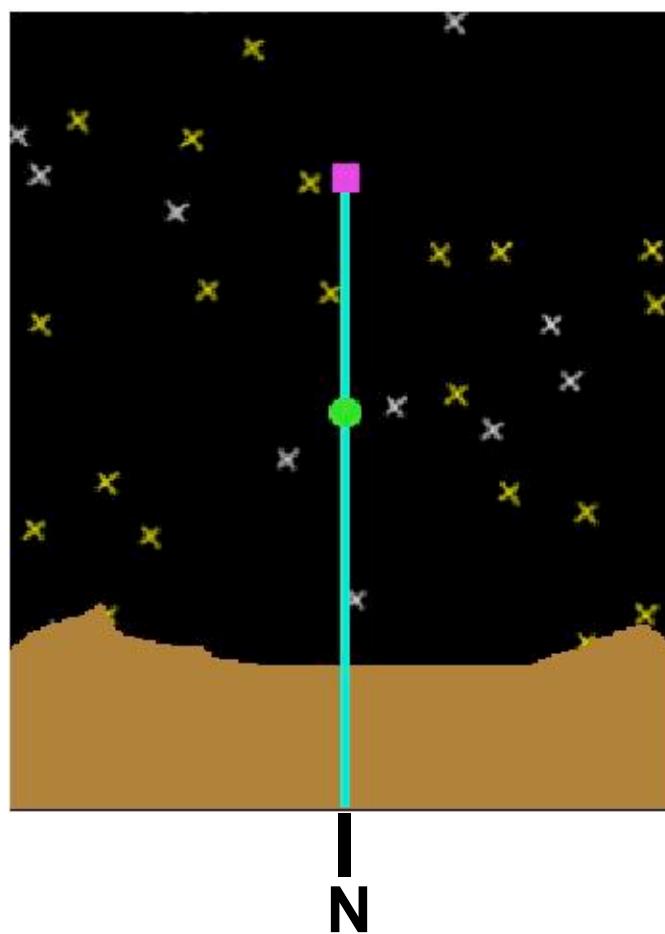


# Using Two Stars to find True North

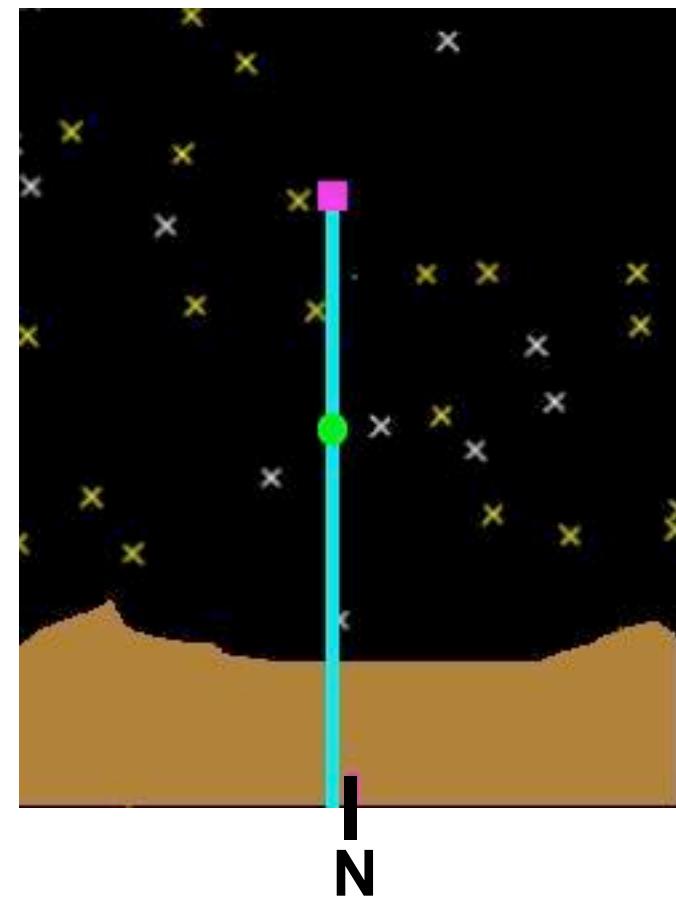


**This method has an error that changes with time**

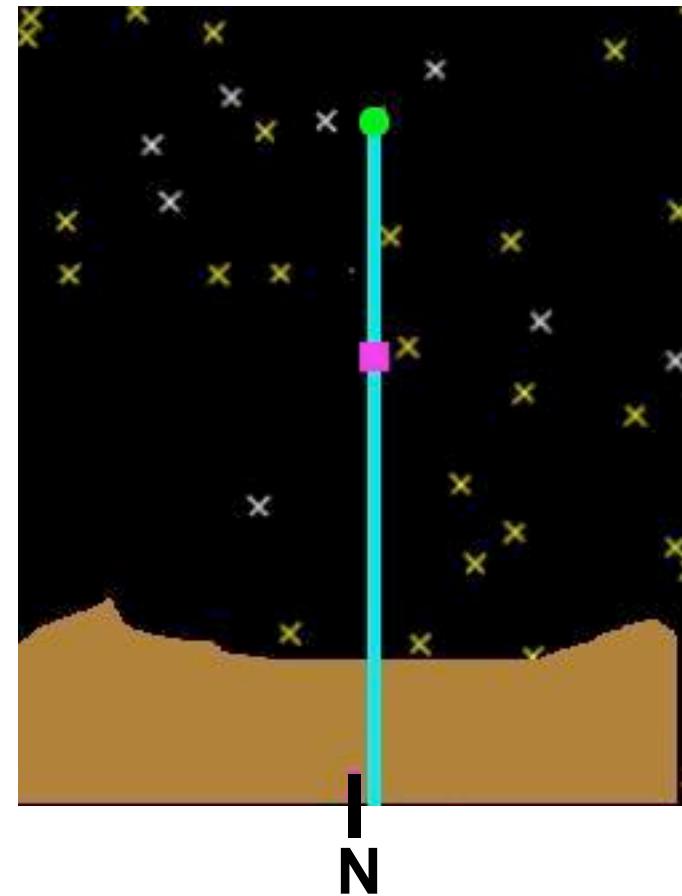
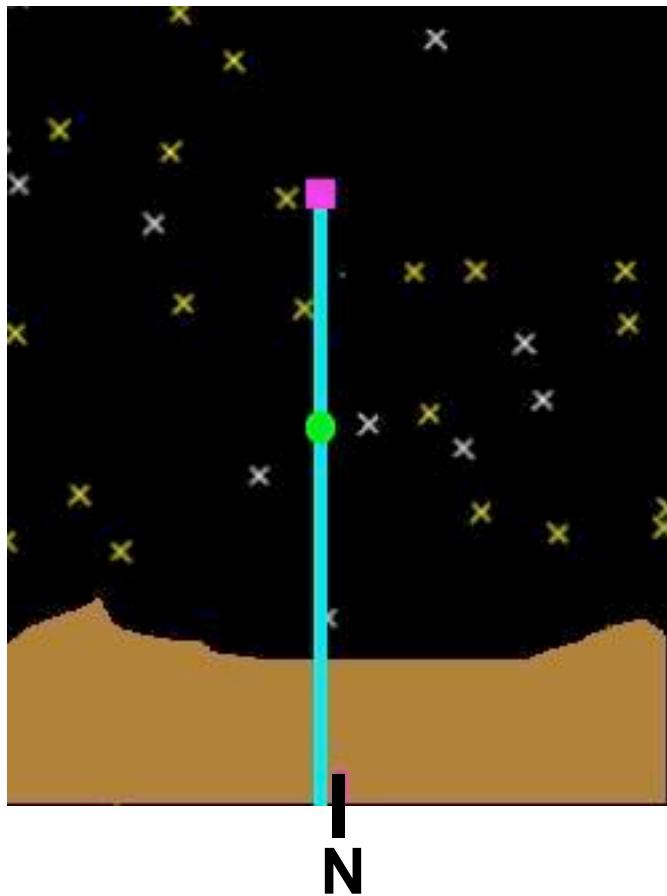
**2500 BCE**

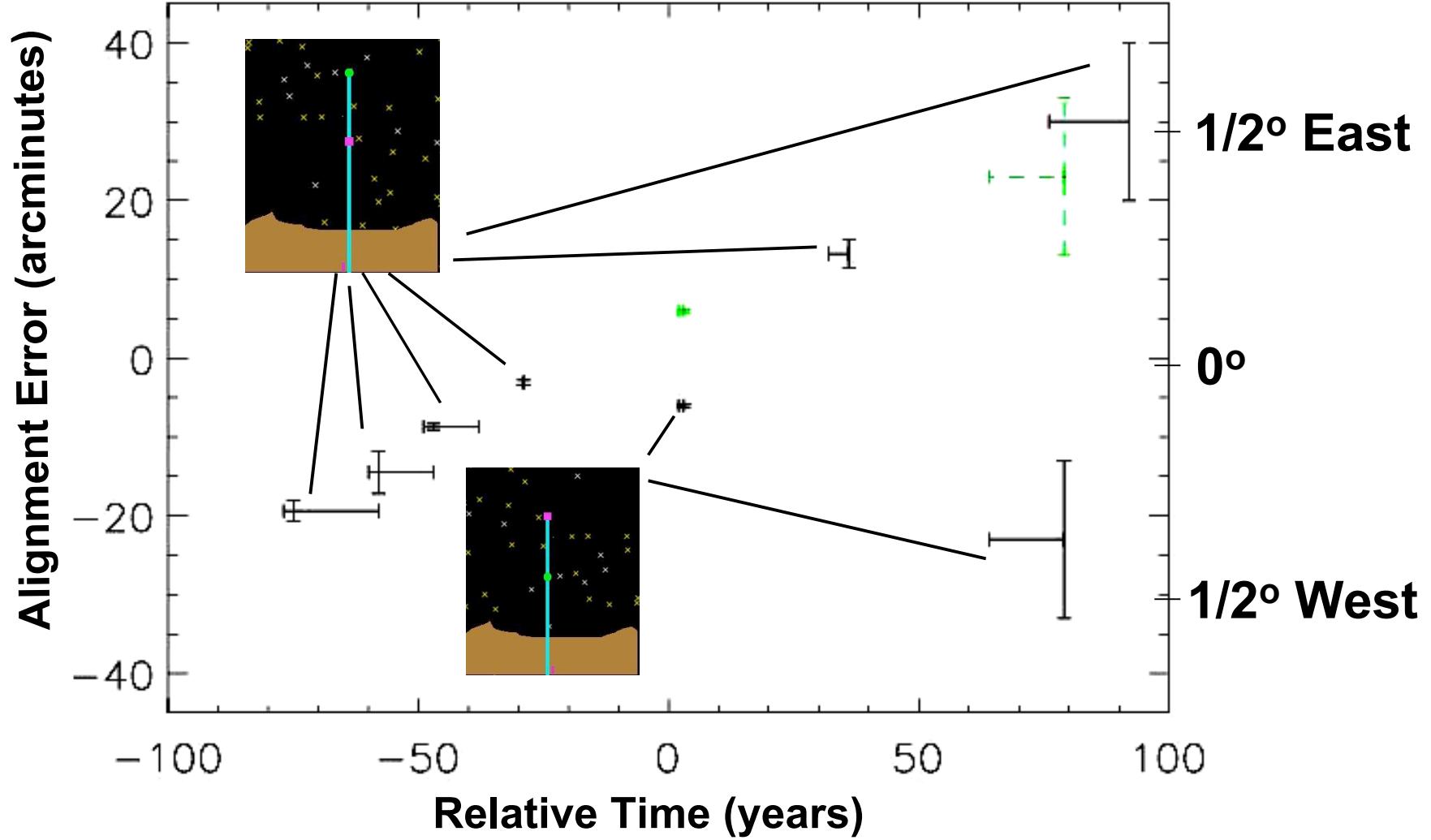


**2000 BCE**



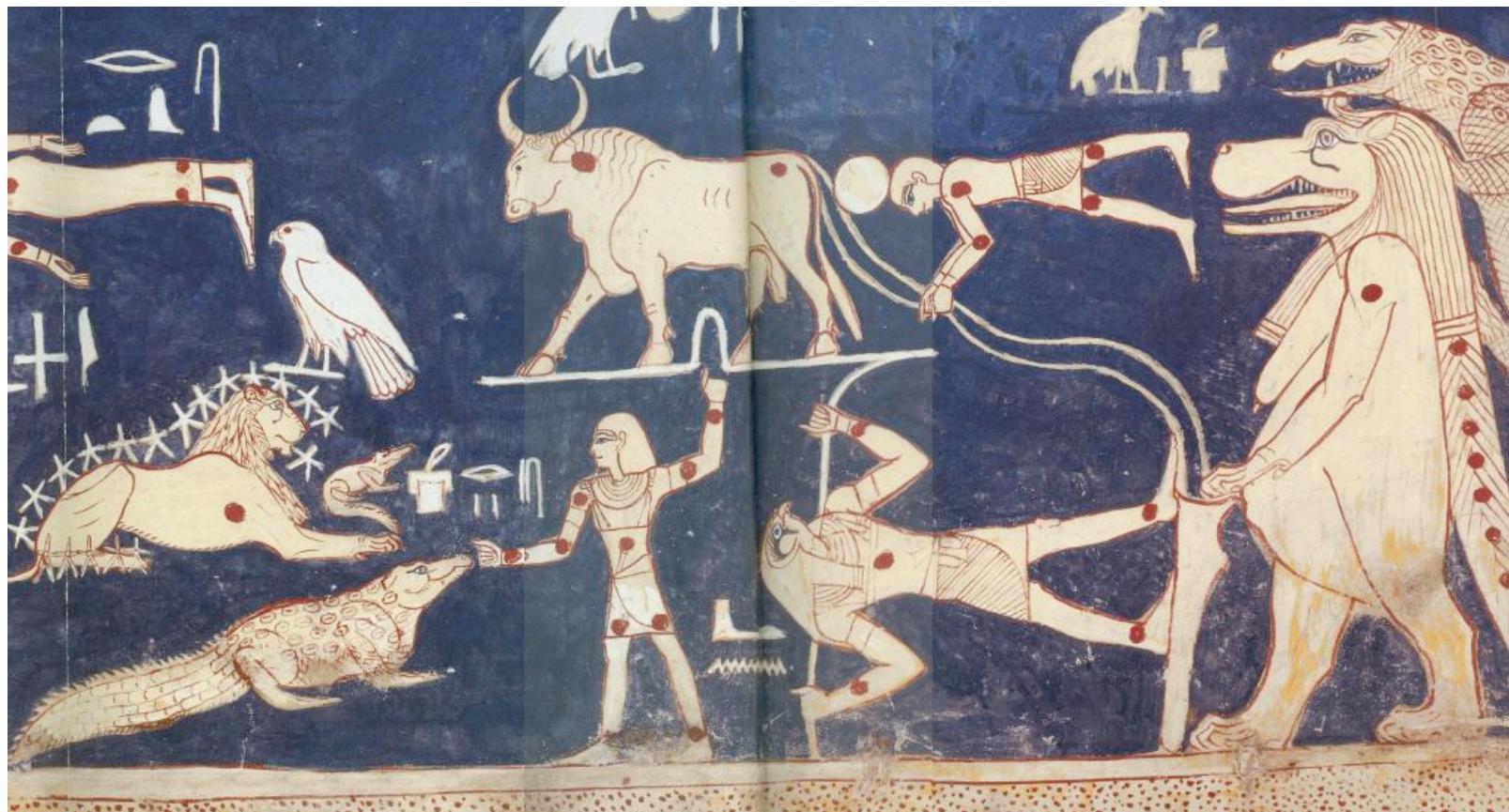
**The Sign of the alignment error depends on which star is higher in the sky**





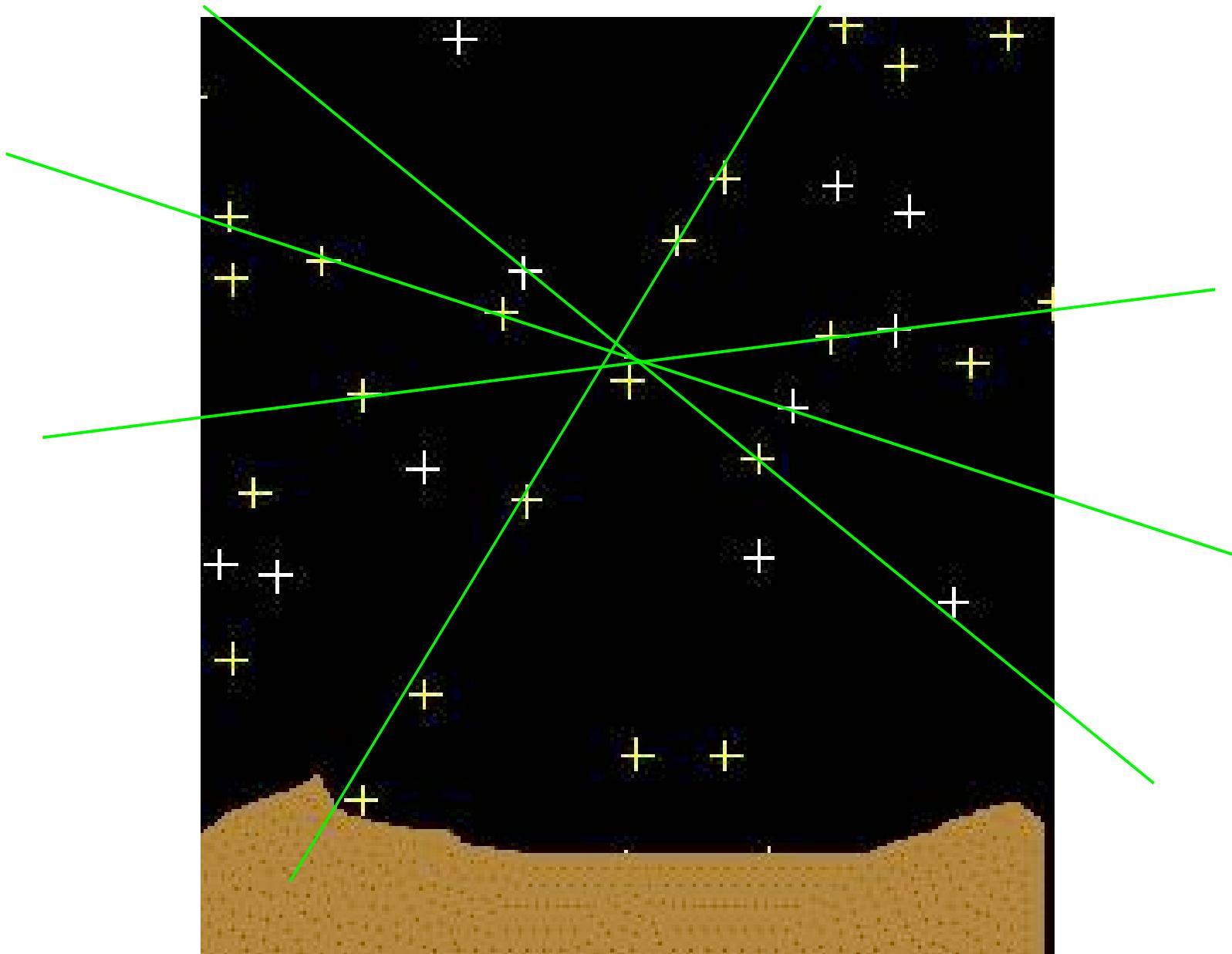
**The Northern Stars were important to the Egyptians:**

**They were the “indestructable” stars, which never died**



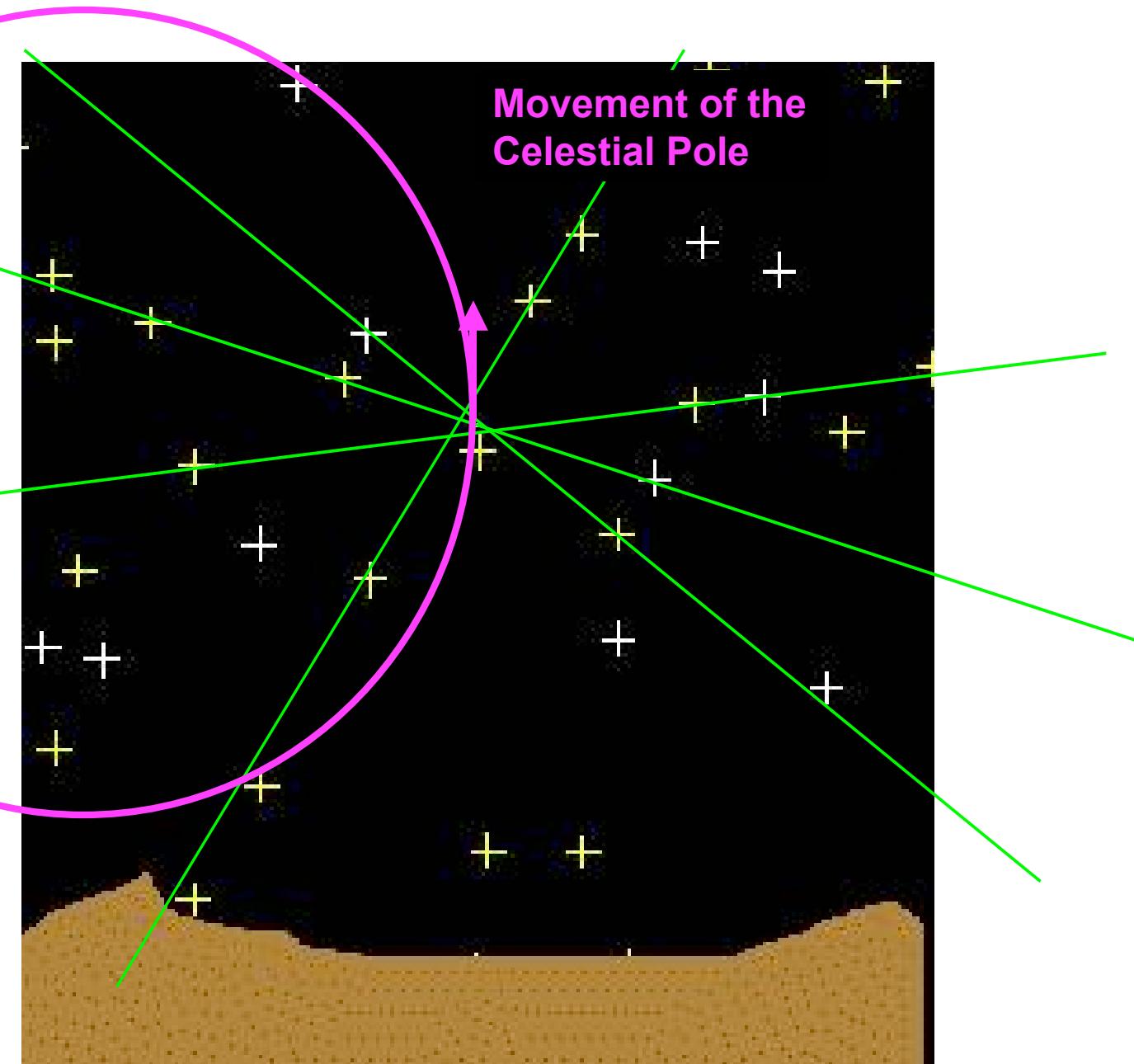
**Ceiling of the tomb of Seti I**

**Which pair of stars did the Egyptians use?**

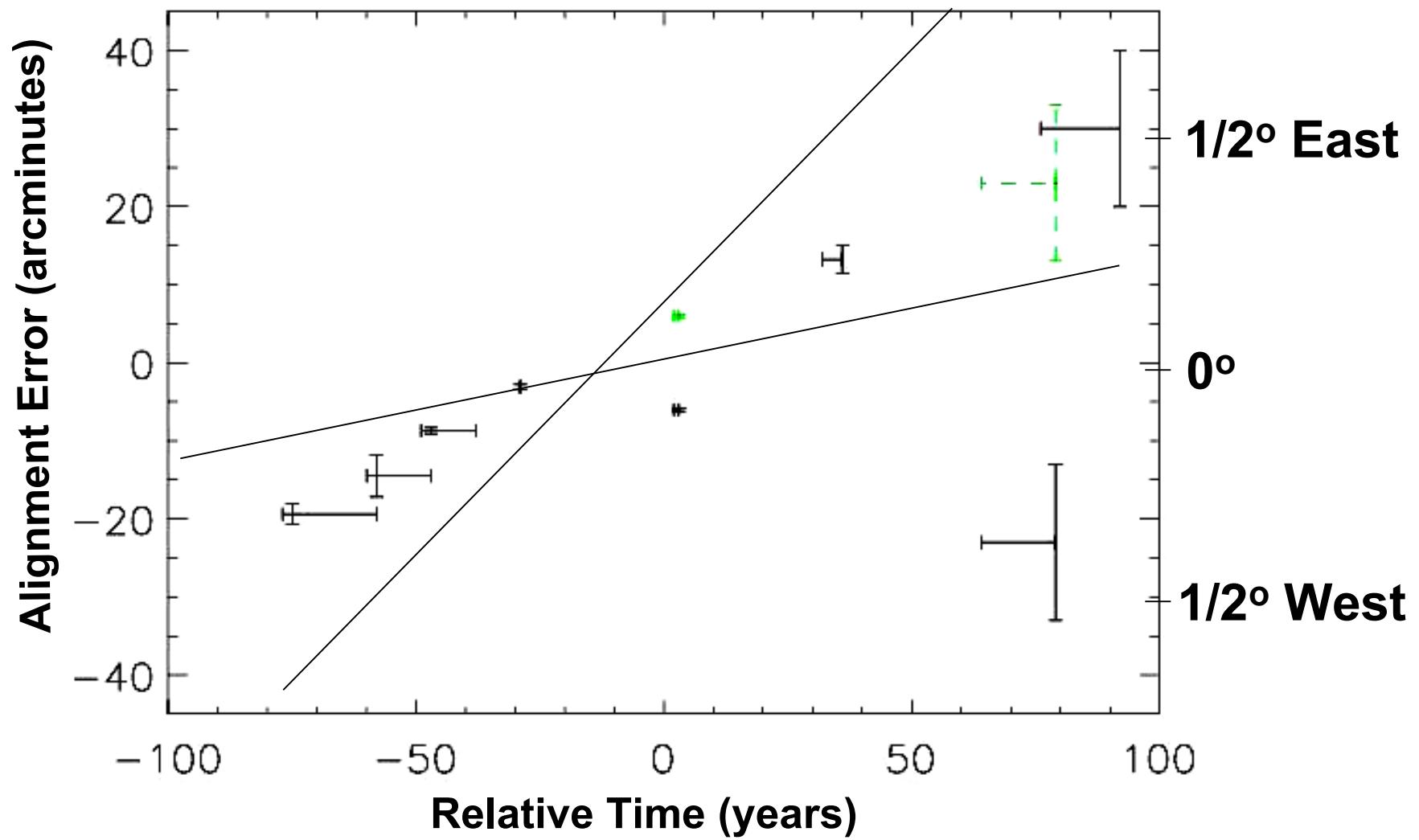


# Which pair of stars did the Egyptians use?

The celestial pole moves with respect to the line at a rate that depends on the position of the stars

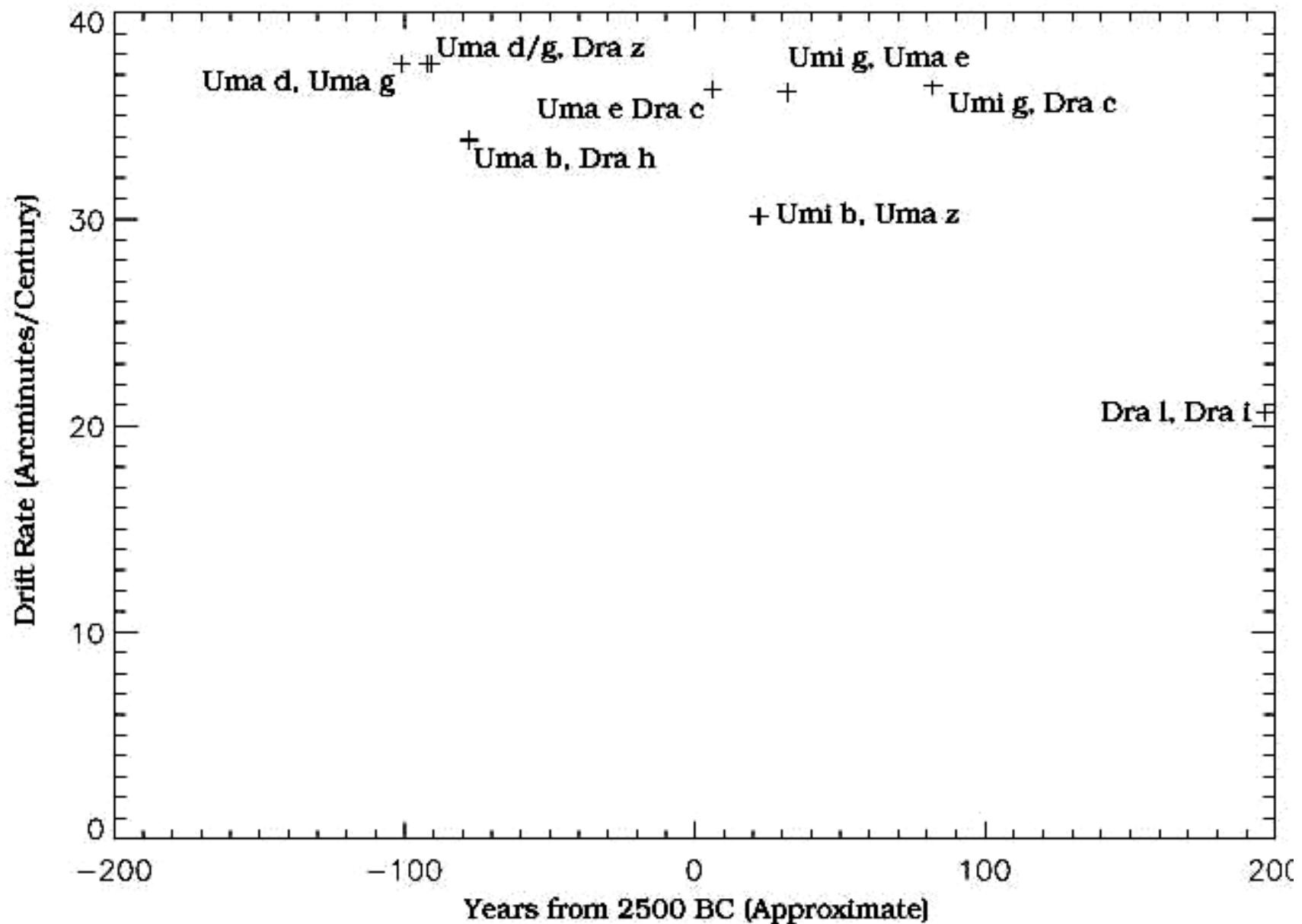


**Different Star-pairs would give different slopes**

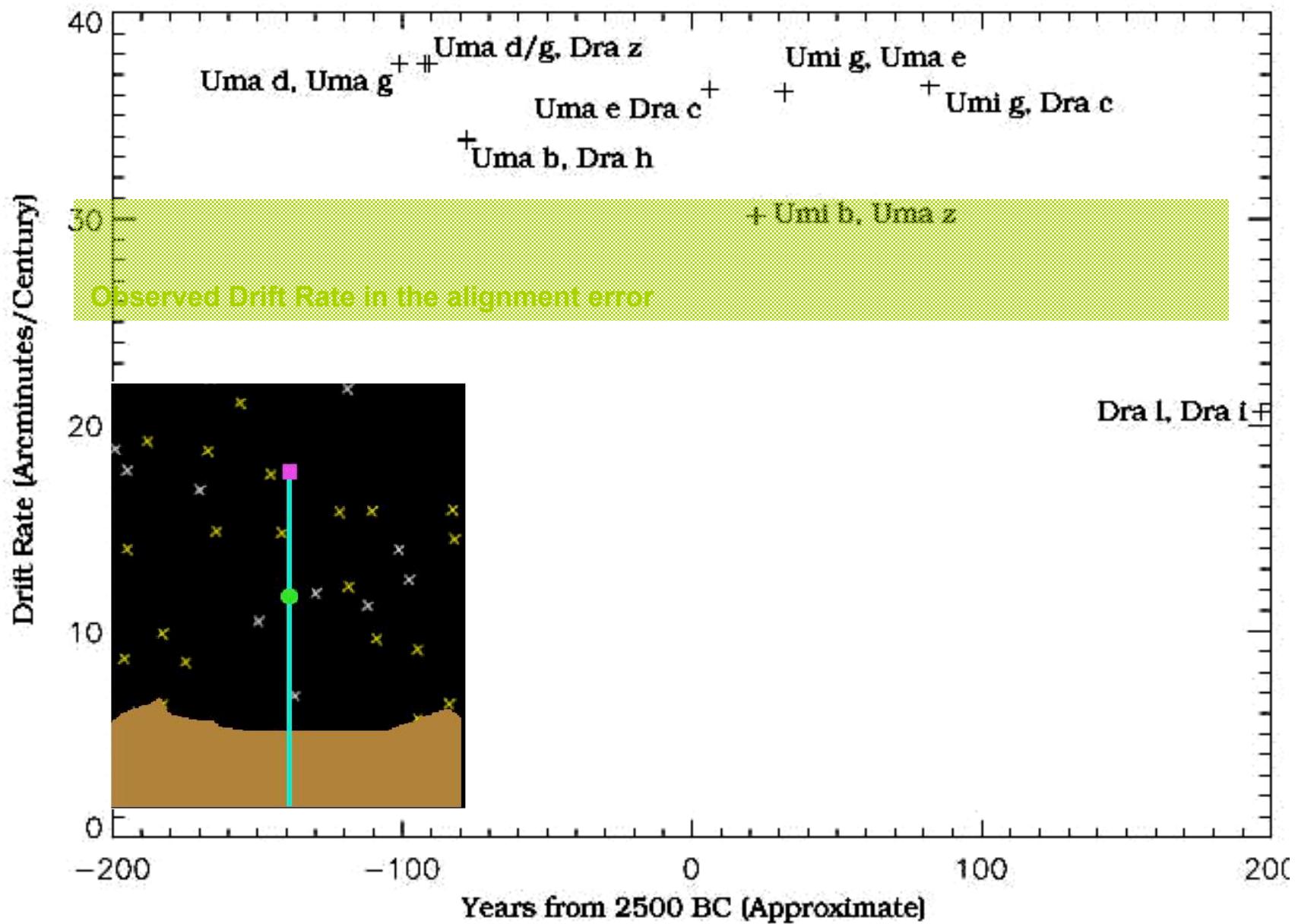


(60 arcminutes = 1 degree)

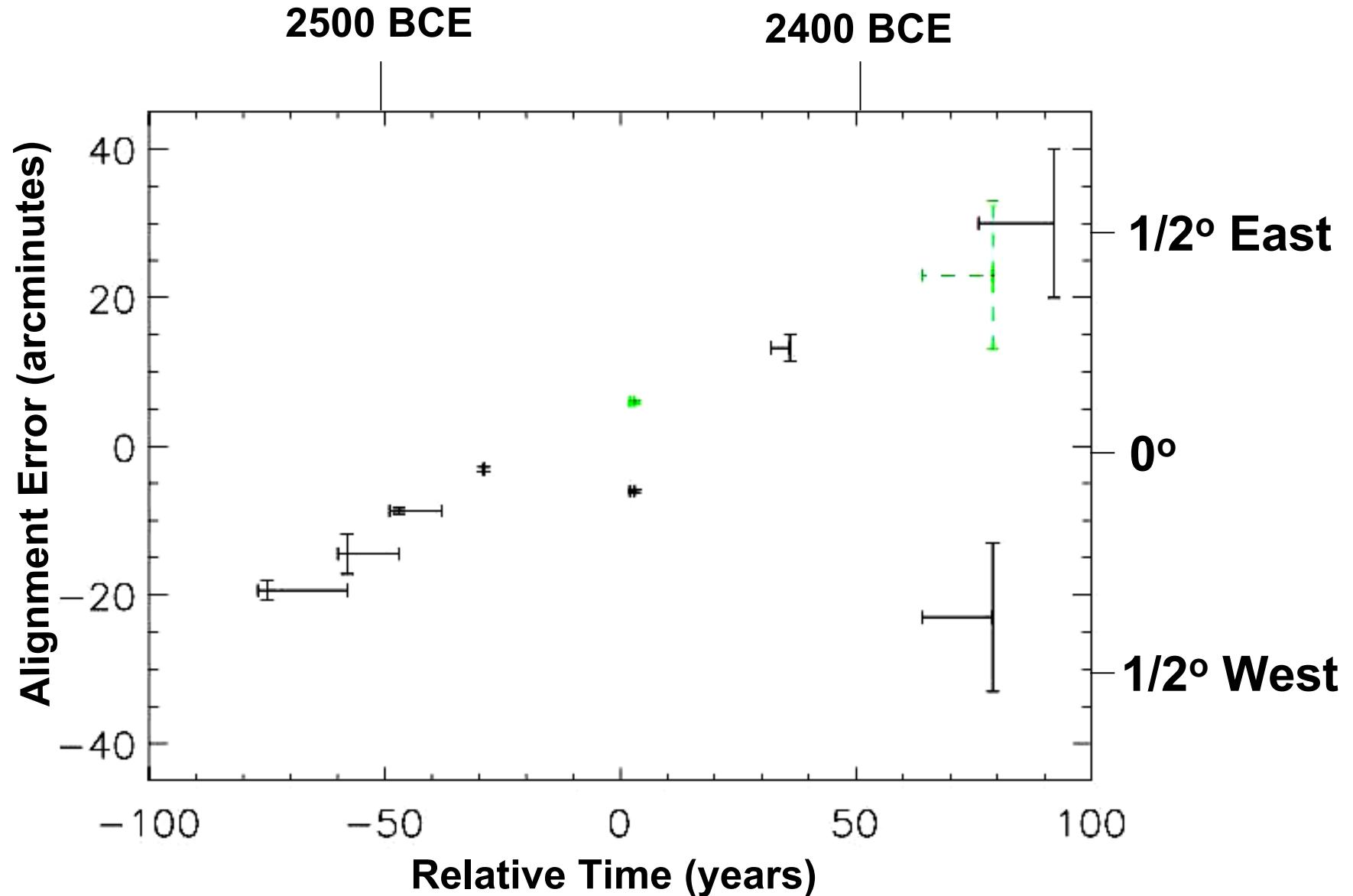
**Only nine pairs of stars give lines that pass through the NCP in a reasonable time**



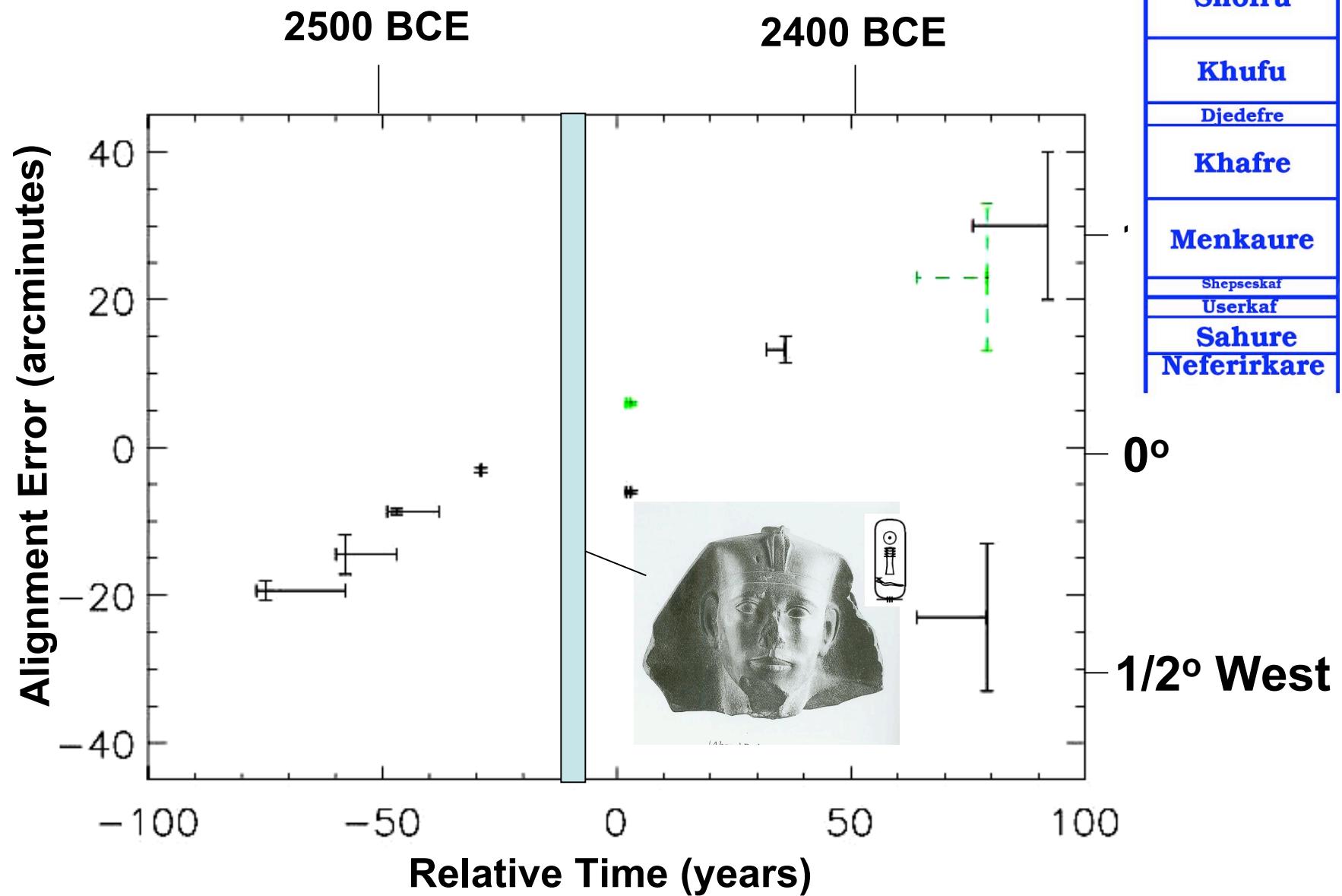
## Only one pair of stars are consistent with the observed data



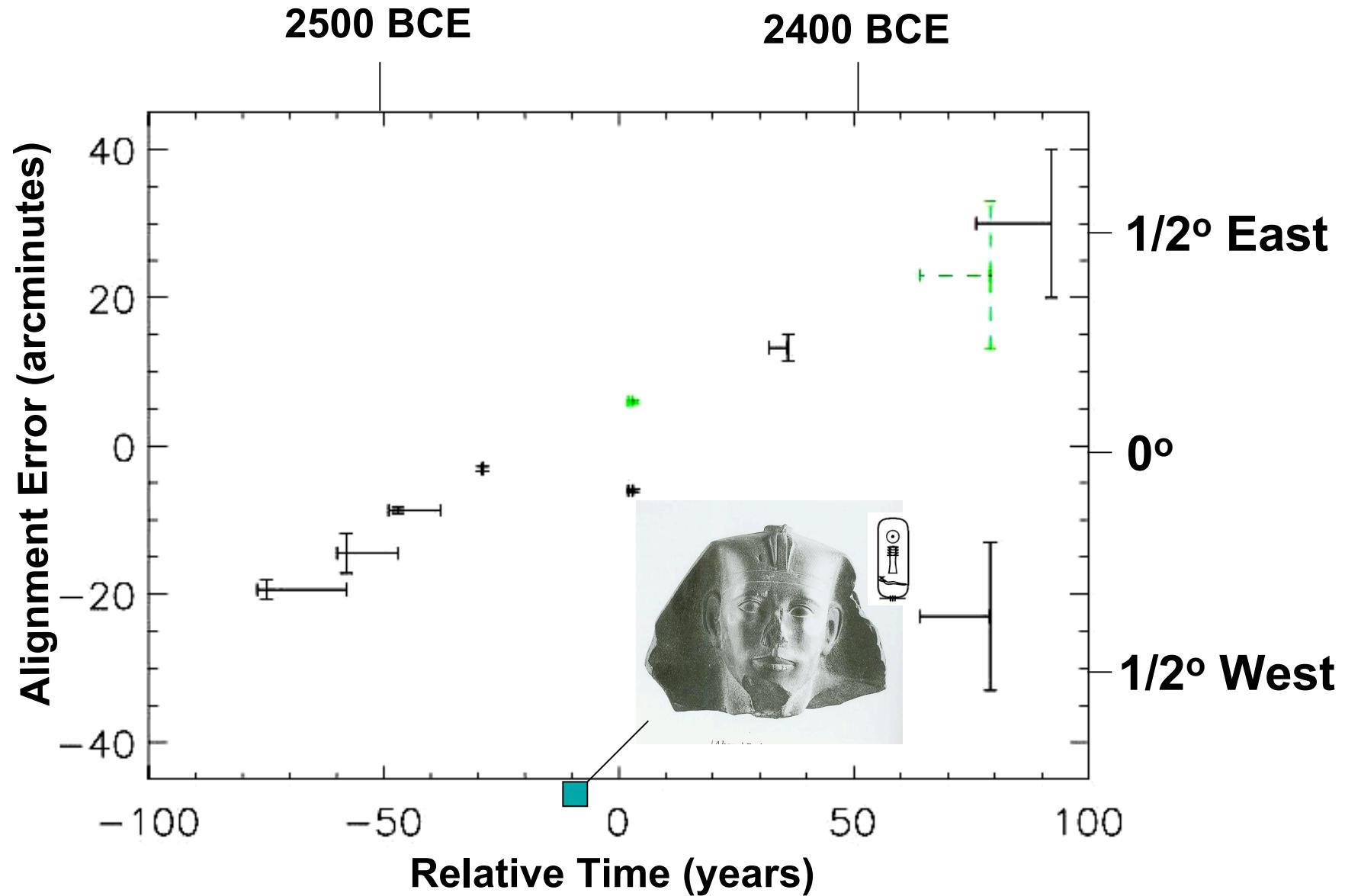
If the Egyptians used these stars,  
then we now exactly when the pyramids were built



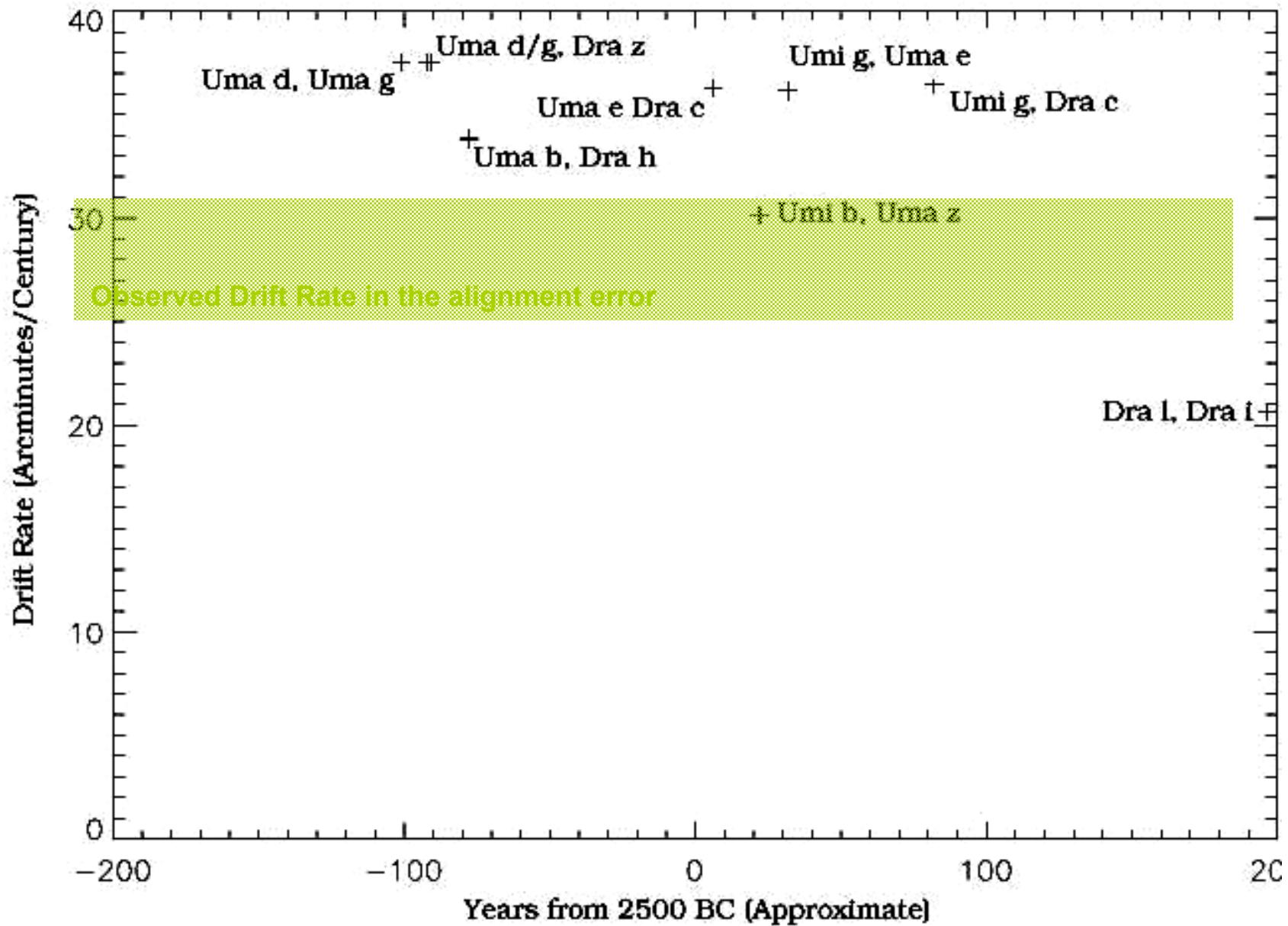
# Et tu, Djedefre?



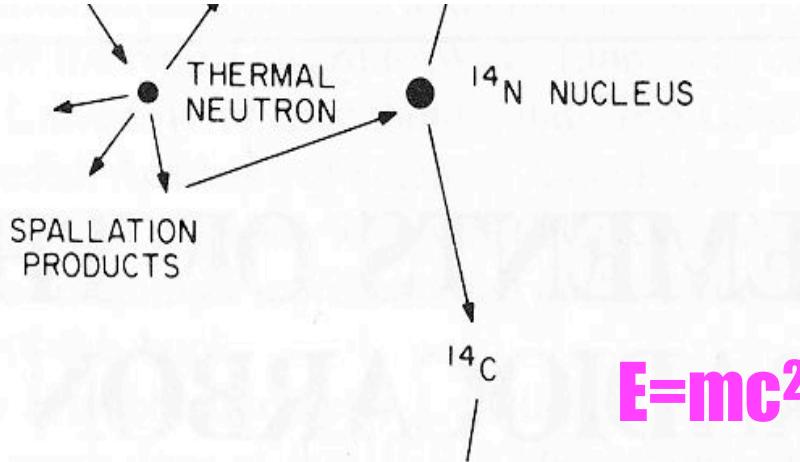
# Et tu, Djedefre?



## Only one pair of stars are consistent with the observed data

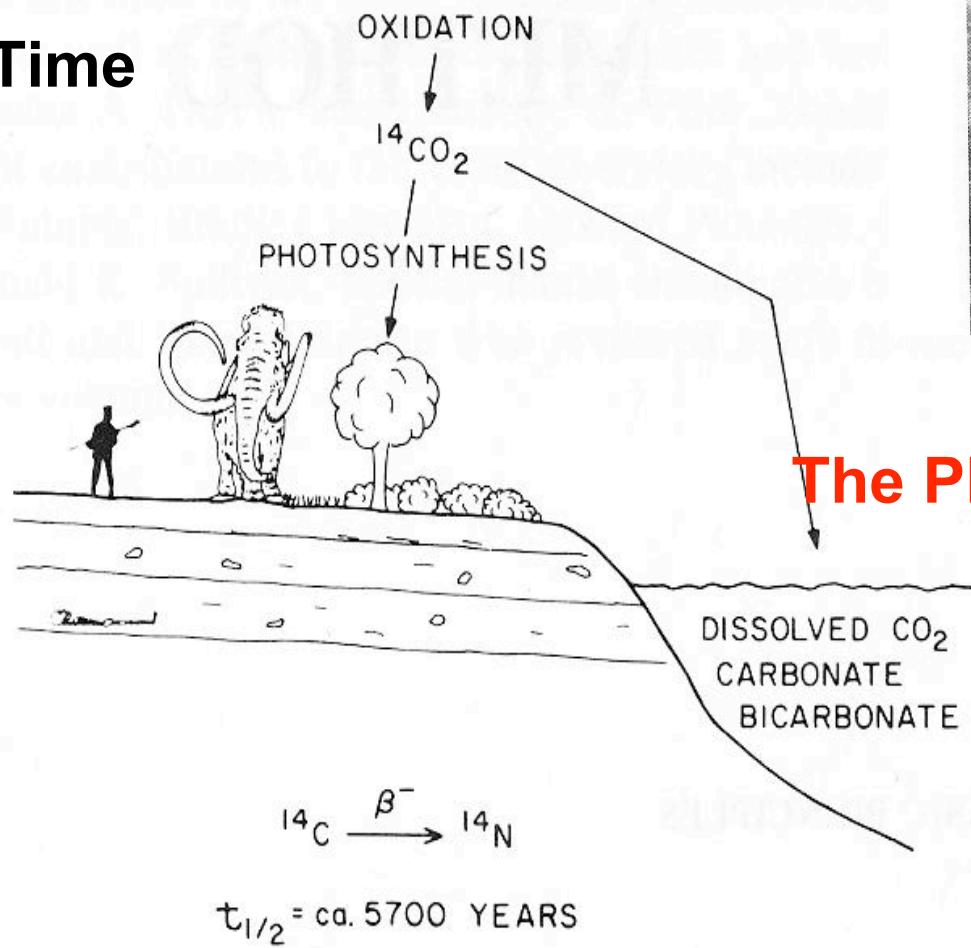


DUCTION

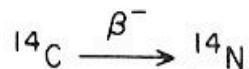


## Next Time

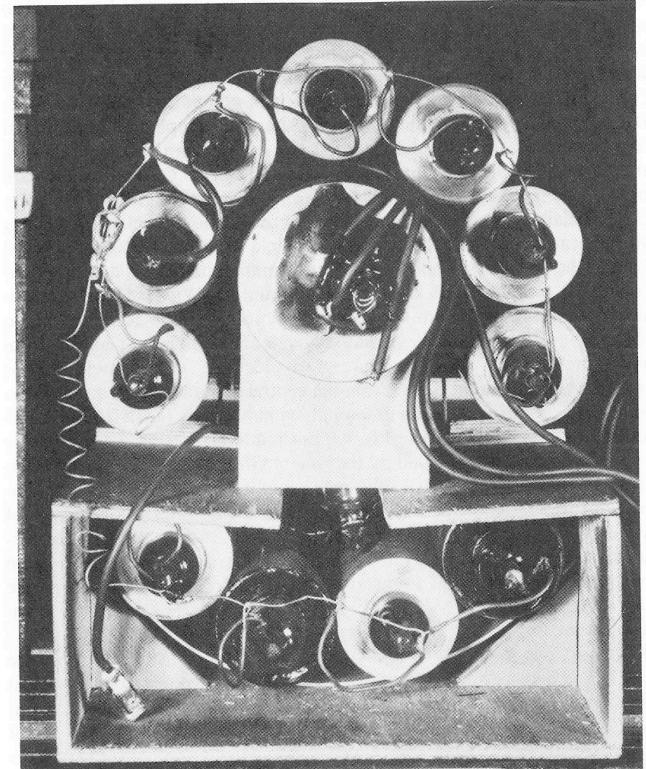
DISTRIBUTION



DECAY



$t_{1/2} = \text{ca. 5700 YEARS}$



## The Physics of Carbon 14

$$i\hbar \frac{\partial \Psi}{\partial t} = -\frac{\hbar^2}{2m} \nabla^2 \Psi + V\Psi$$