Dating Methods for the Ancient Chinese Star Charts

[Appendix: SHIBUKAWA Harumi's star charts]

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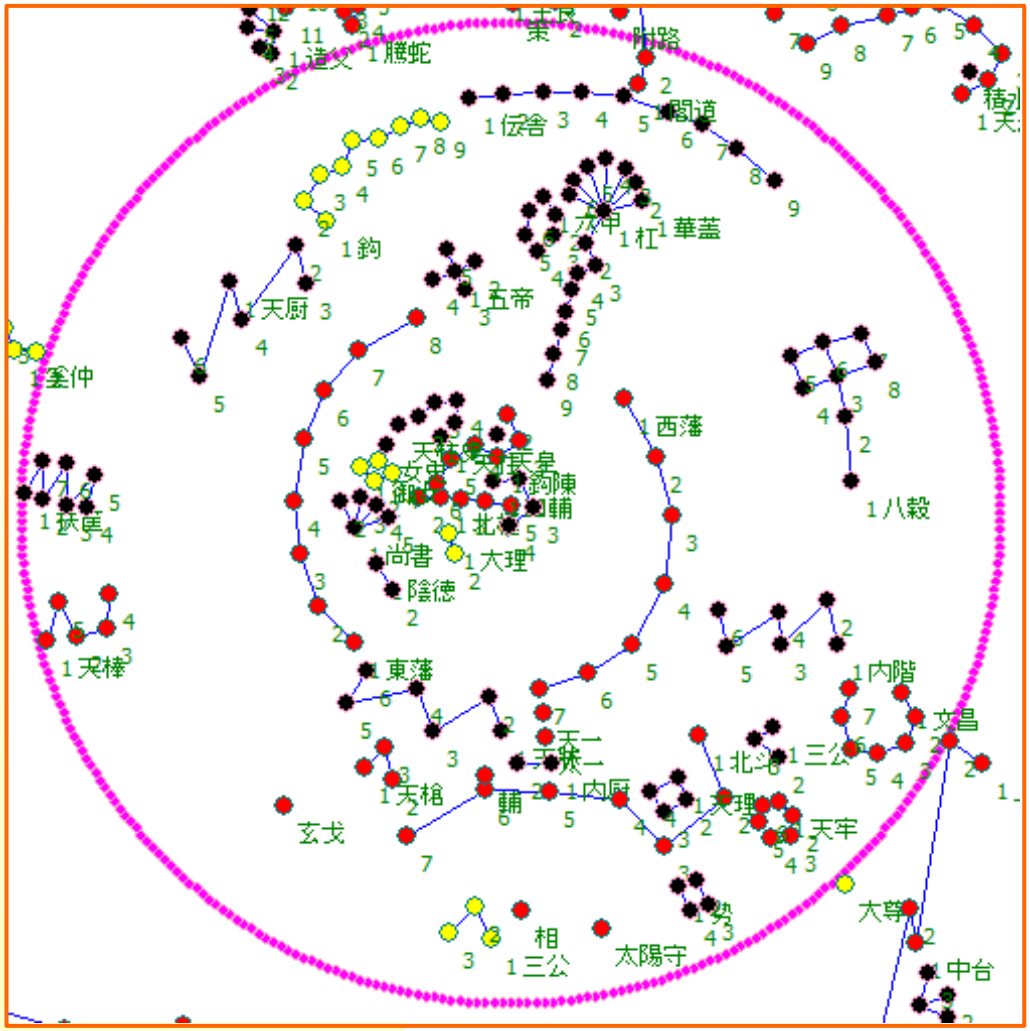

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2023年1月21日
第24回 天文文化研究会

[格子月進図(3 colored)]

Contents

This presentation summarizes the following papers and some new findings.

- 『中国古代星図の年代推定の研究』数学史研究 (228号) p.1-21(2017)
- 『最小二乗法による古代星図の年代推定』数学史研究 (232号)p.1-22(2019)
- 『『格子月進図』の原図となった星図の年代推定』数学史研究(III期 第1巻1号)(2022)
- 『渋川春海の星図の研究』数学史研究 (231号)p.1-48 (2018)

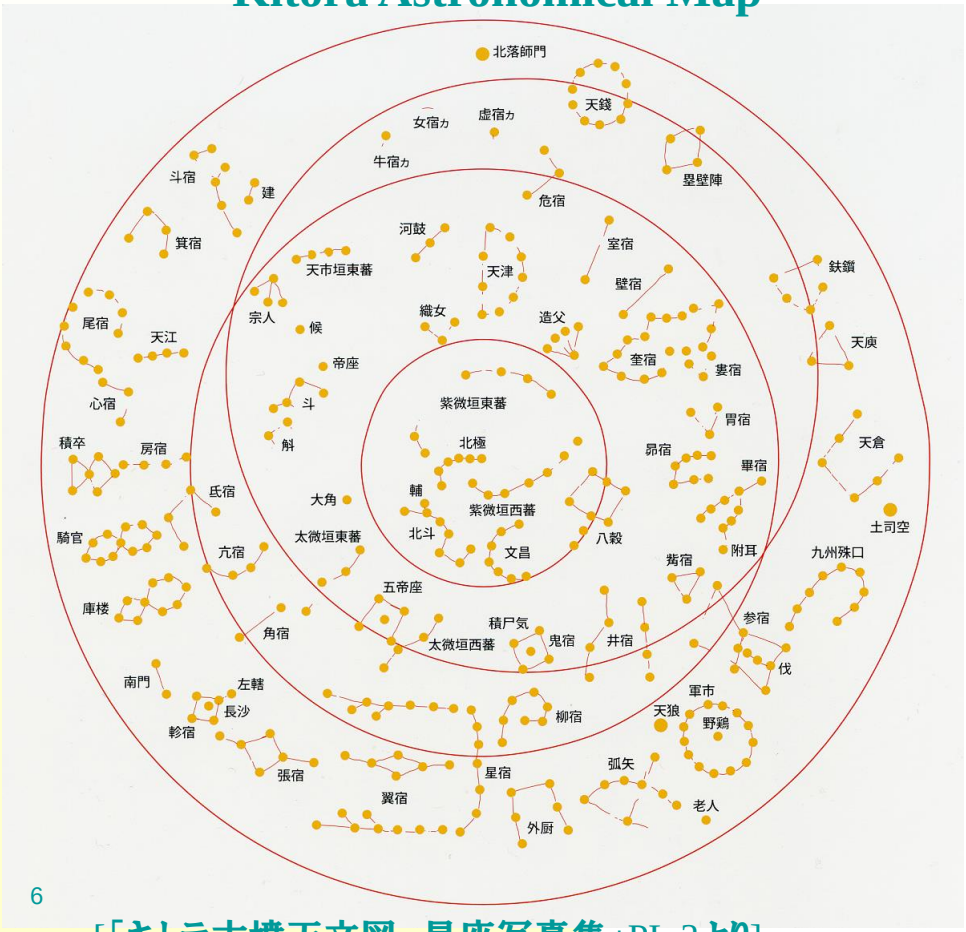
I. Overview of the ancient Chinese star charts

1. Overview of Dating Methods for Ancient Star chart

Date of「キトラ天文図」(Kitora Astronomical Map) is not yet confirmed

An astronomical map drawn on the Kitora Tumulus. Discovered in 1998 and excavated in 2004. More than 350 stars in 74 constellations are depicted, centering on the North Pole.

Kitora Astronomical Map



[「キトラ古墳天文図　星座写真集」PL.3より]

Dating by M. Soma(2015)

Date：AD300±90 years

Place：Latitude 33.9 ± 0.7°

Dating by T. Nkamura(2015)

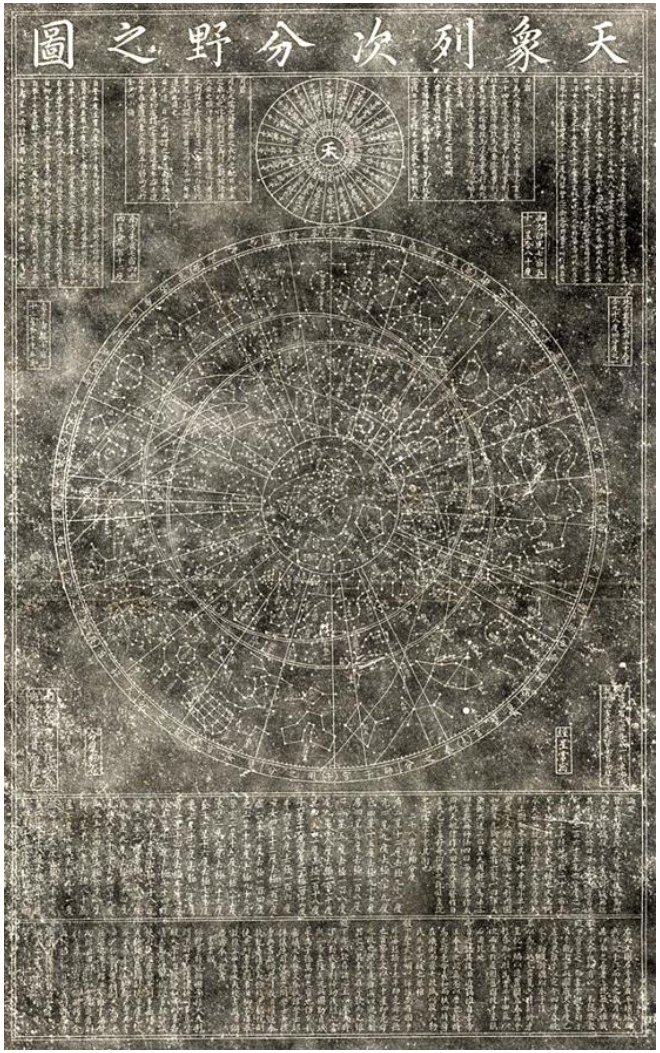
Date：BC80±aprox. 40 years

Place：There is no necessity to regard the latitude calculated from the internal and external circle as the latitude of the star observation site.

There was no dating method for the ancient Chinese star charts

- **『天象列次分野之図』** is a star chart carved in stone that was created in the 4th year of King Taejo and the 28th year of Hongmu (1395) of Yi Dynasty Korea (1392-1897).
- According to the inscription, the original star map is believed to be from the Goguryeo period (668 AD).⇒As a result, it was thought to be the original map of the Kitora astronomical chart(700AD).
- The tale inscribed on the inscription reads, "`When Goguryeo was attacked by the allied forces of Tang and Silla and fell, the stone carved star map was sunk in the Taedong River. However, a rubbed copy was handed down, and there was one that was presented to Taejo when he was enthroned, and that rubbed copy was used as the original drawing"

➢ Some researchers suspected it was a fiction based on political background, but until now there was no way to ascertain the date of the original star chart.



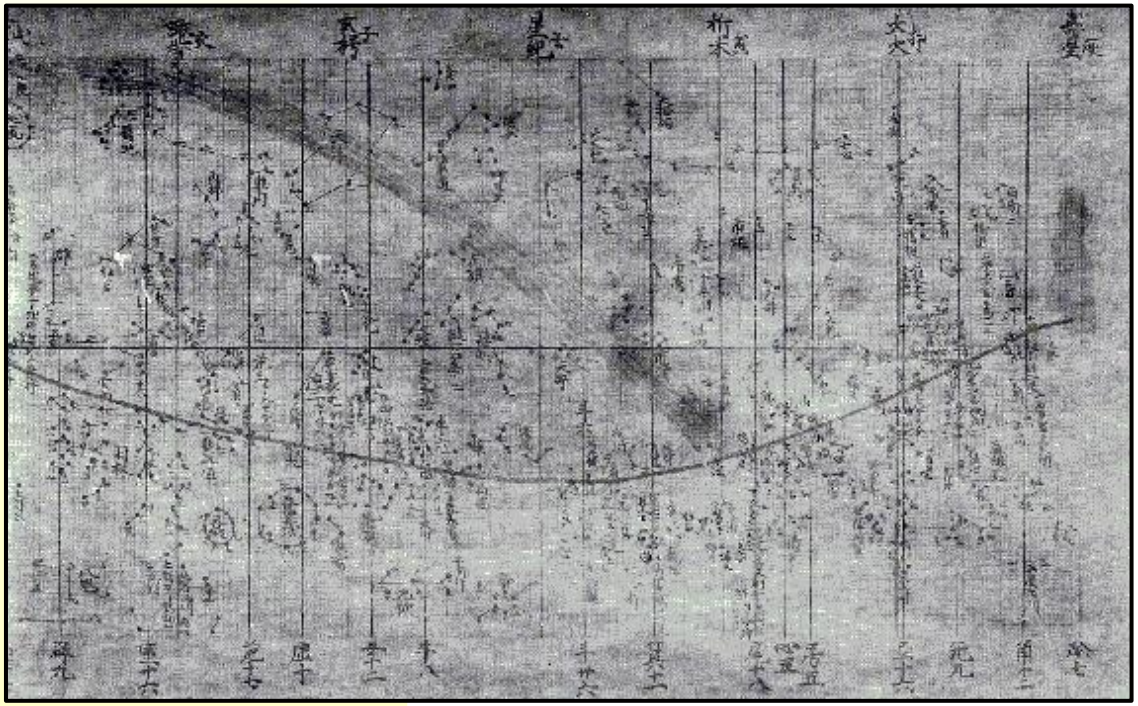
『天象列次分野之図(再刻)』
(京都大学附属図書館所蔵)

Incorrect dating of「格子月進図」(Koshi Gettshins)

『格子月進図』(Koshi Gettshins) End of Kamakura - Northern and Southern Courts period Private collection.
This is Japan's oldest star chart, created around AD 1100, and consists of two charts: the North Pole chart and the Middle sky chart. This manuscript is from the first half of the 14th century and is a copy of a star chart handed down in the family of Yasuyo Tsuchimikado, who worked as a professor of Yin and Yang. This painting was stored in Tokyo Tennichikan, but it was destroyed by fire in the Tokyo air raid on April 25, 1945, and only a few photographic prints remain. The grid refers to graph paper made from longitude and latitude lines, and the title includes the Japanese, "A chart showing the movement of the moon at night."
(from "Bessatsu Taiyo" No. 73 (1991) p.39 including the figure below,)

Mr.Imoto*：average 1101AD (Vernal(奎5.9°):1548 Autum(角3.9°):654) Corrected 330AD (Vernal:620 Autum:39)

*：Without correction. However, the average year remains the same.

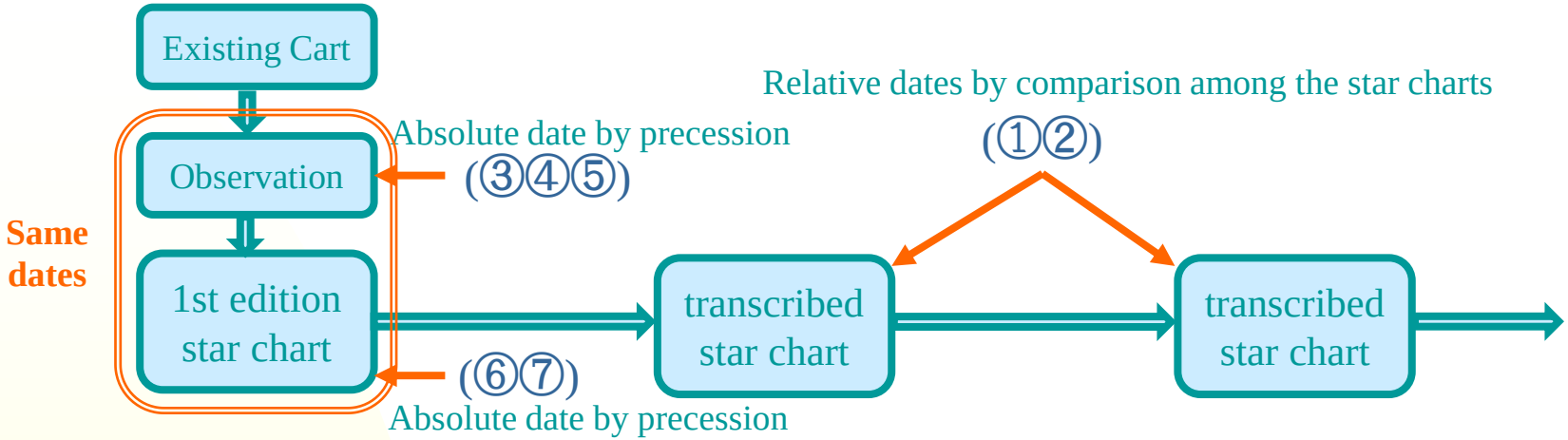


Dating by equinox

奎宿(Kui xiu) (HR215　34ζ An)		
Year	RA(°)	Vernal equinox
1548	5.9	奎宿 -5.9°
1088	0.0	
620	354.1	奎宿 +5.9°

角宿(Jiao xiu) (HR5056　67α Vir)		
Year	RA(°)	Autumnal equinox
654	183.9	角宿 -3.9°
347	180.0	
39	176.1	角宿 +3.9°

Dating methods of ancient star charts and targets

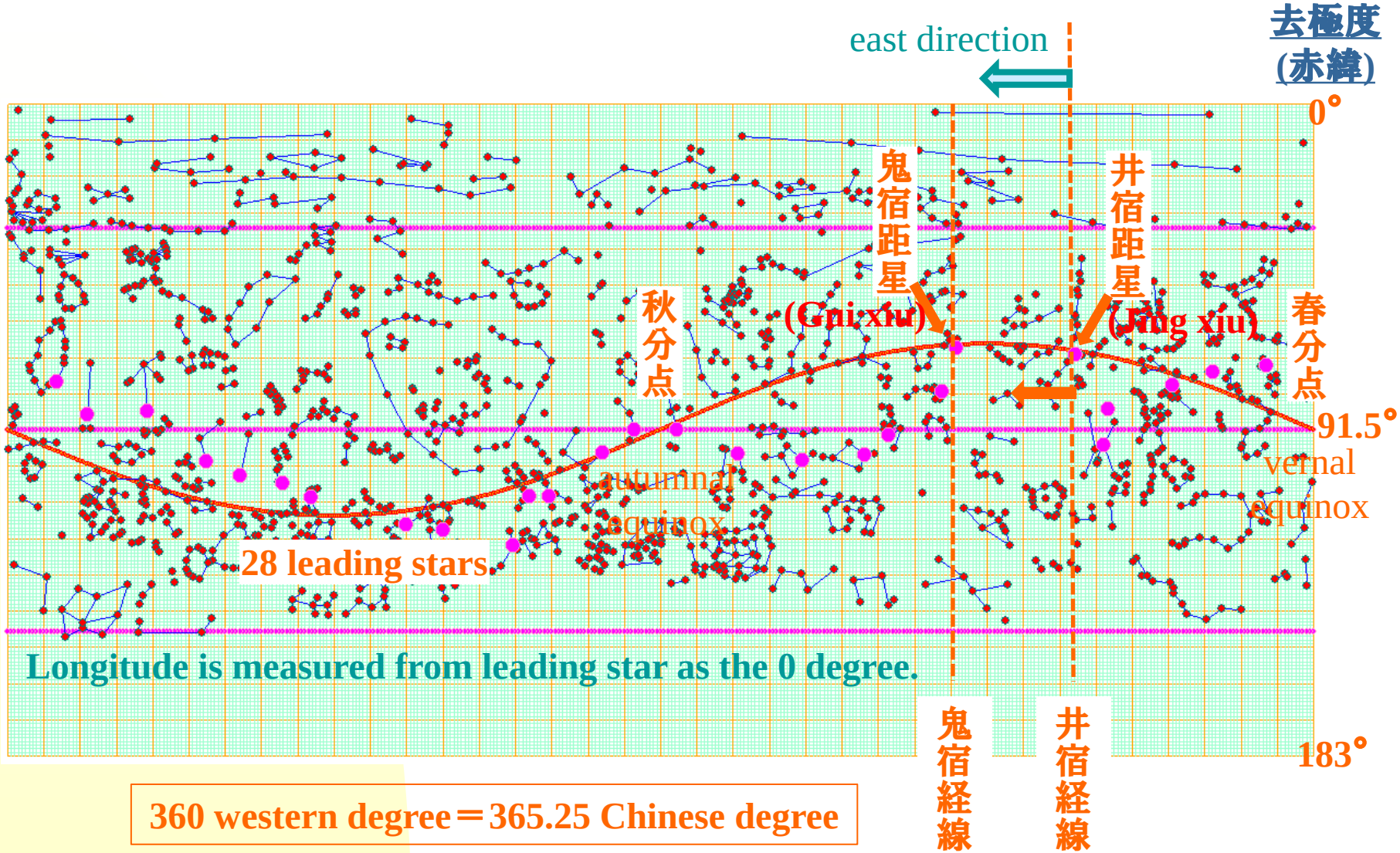


	Target	2017'paper	2018'paper	2022'paper
①Shape of the constellation	Date of the transcribed star chart	○		
②Name of the constellation		○		
③Position of star (right ascension)	Date of the Observation for the position of the stars		○	
④Position of star (declination)			○	
⑤Position of star (both)				○
⑥Vernal & autumnal equinoxes	Date of 1st edition of chart	△(w/o correction)		○(w correction)
⑦12th order (12 signs)				○

Each star chart has two dates.

2. Style of Chinese star charts

Measurements of star positions in China



360 western degree＝365.25 Chinese degree

Chinese constellation system

Han 漢/後漢 | 三国 | Jin 晋/南北朝 | Tang 隋/唐 | 五代 | Song 宋 | 元/明

3 systems

- **石氏**
- **石氏星経(星表)**
- **甘氏**
- **巫(フ)氏**

Upper limit of the observation

Integration of 3 system and made star chart (**呉/晋・陳卓**)

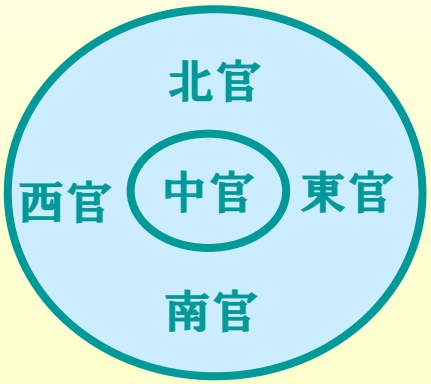
(283constellations 1464stars)

『格子月進図』
『天象列次分野之図』
『敦煌天文図』

太史令:in charge of astronomy, calendars, rituals, the drafting of national document.

From『歩天歌』

五官



中官・28宿・外官

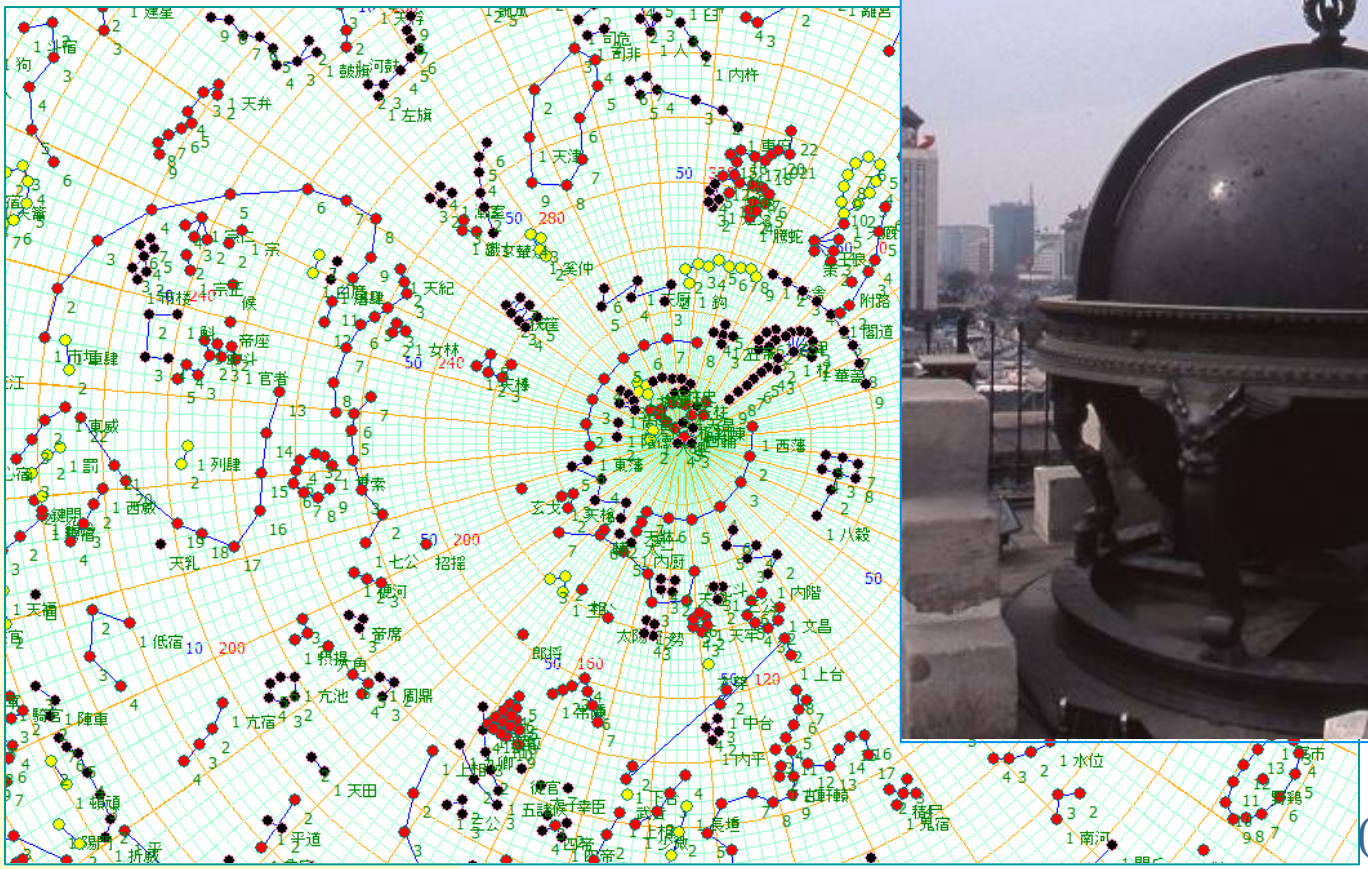
唐宋

三垣・28宿

Organization of constellations

錢楽之(Senrakshi) in the 5th century [Northern and Southern Dynasties] made copper celestial globe

「宋元嘉中(424-453)、太史令・錢楽之(センラクシ)所鋳渾天銅儀、以朱・黒・白三色、用殊三家、而合陳卓之数。」(「隋書」天文志)

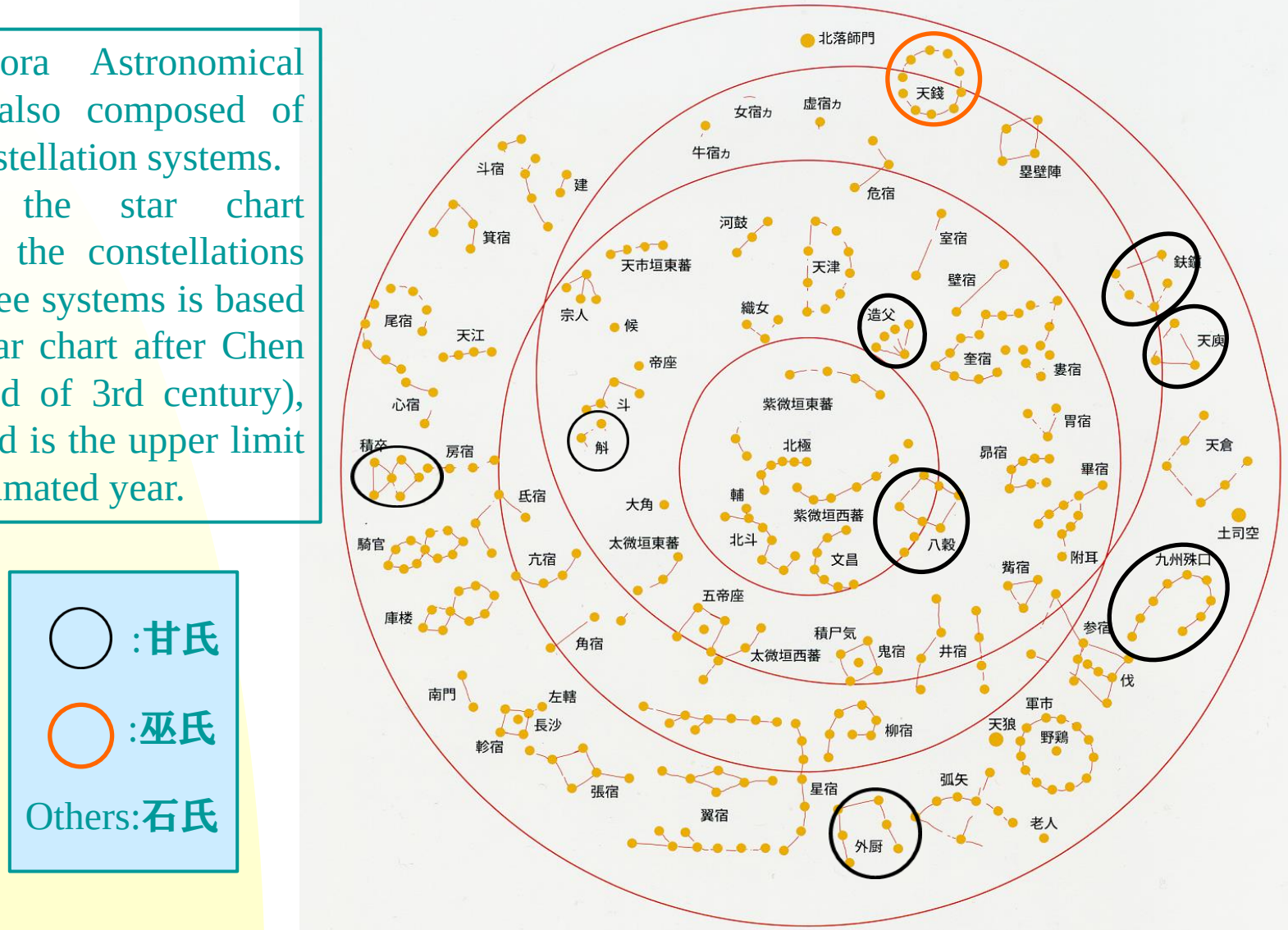


『格子月進図』(赤・黒・黄で彩色)

渾天儀
(明・北京古観象台)

「キトラ天文図」(Kitora Astronomical Map) is also a star map after the integration of the three systems

The Kitora Astronomical Map is also composed of three constellation systems.
⇒Since the star chart depicting the constellations of the three systems is based on the star chart after Chen Zhuo (end of 3rd century), this period is the upper limit of the estimated year.



:甘氏

:巫氏

Others:石氏

[「キトラ古墳天文図　星座写真集」PL.3に加筆] 2023/01/21

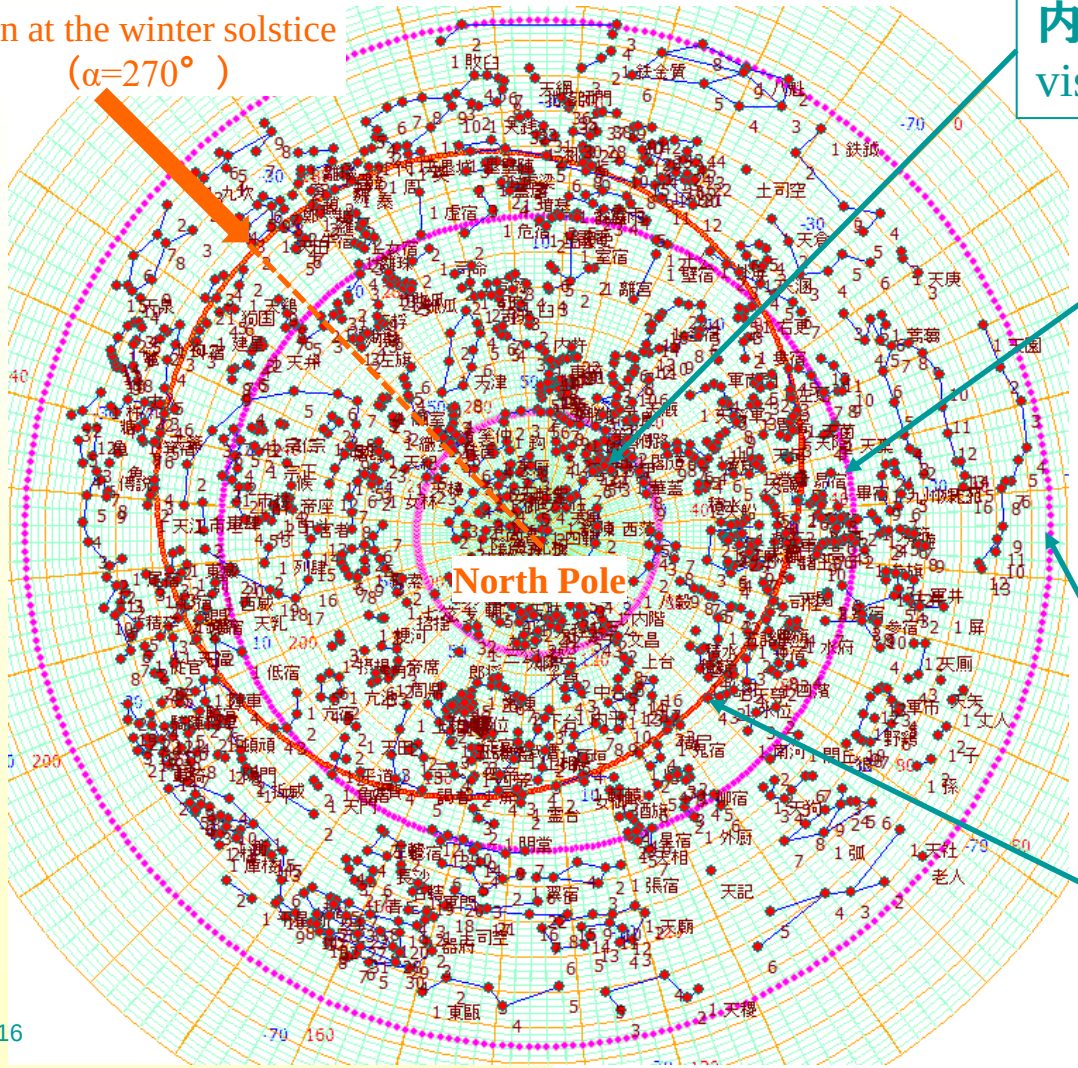
Differences Between Chinese and Western Star chart

- Features of Chinese Chart：
  - Many constellations and stars.
  - no classification by star magnitude
  - many faint stars of 5 to 6th magnitude
- No bright star near the Pole, the ancient Pole Star is a faint star.

	Chinese constellation (「格子月進図」)	Western Constellation (「Almagest」)
Number of constellation	283(+235)	48
Number of stars	1467(+532)	935
1st mag. (>1.5 mag.)	16	20
2nd mag.	61	62
3rd mag.	149	159
4th mag.	352	359
5th mag.	518(west+220)	299
6th mag.(<5.5mag.)	371(west+330)	36

Style of Ancient Chinese Star Chart (1/2)
Circular Star Chart

Circular Star Chart Centered on Pole Star



内規(Naiki, Inner Circle):Range always visible from the observation point

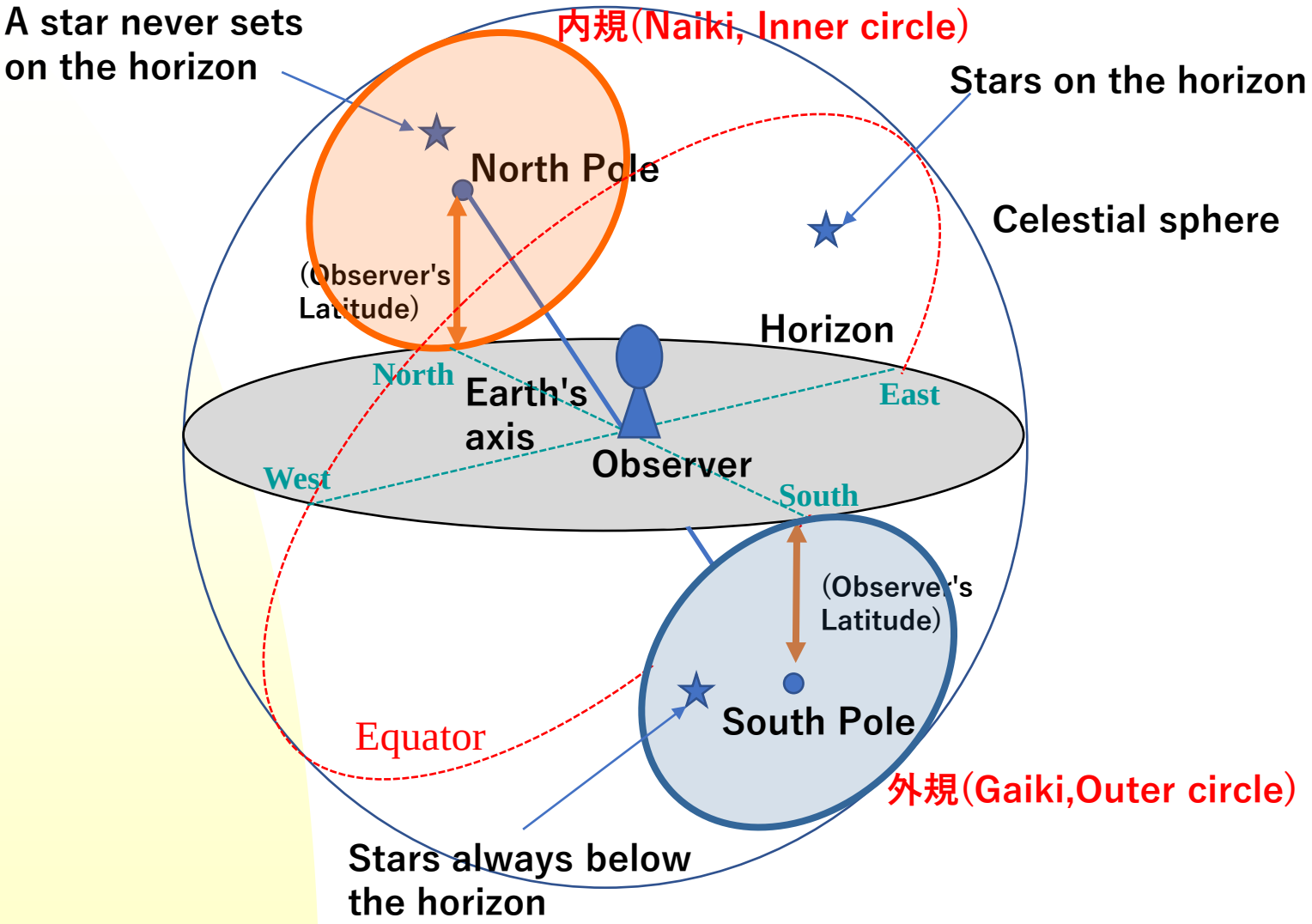
Equator

No classification by star magnitude in the Chinese star chart.

外規(Gaiki, Outer Circle):
The southernmost point visible from the observation site

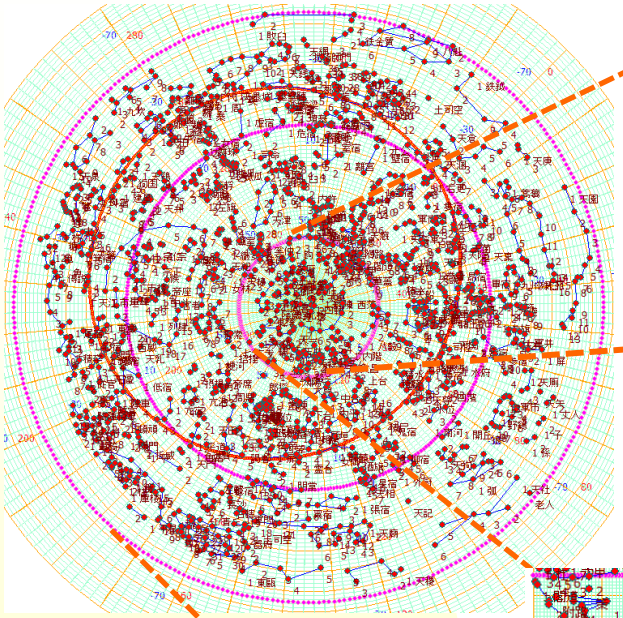
Ecliptic: path of the sun

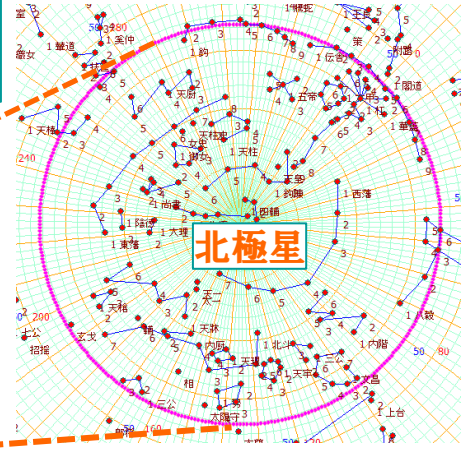
Explanation of inner and outer circles



Style of ancient Chinese star chart (2/2)
Square star chart

内規 Naiki
(Inner Circle)

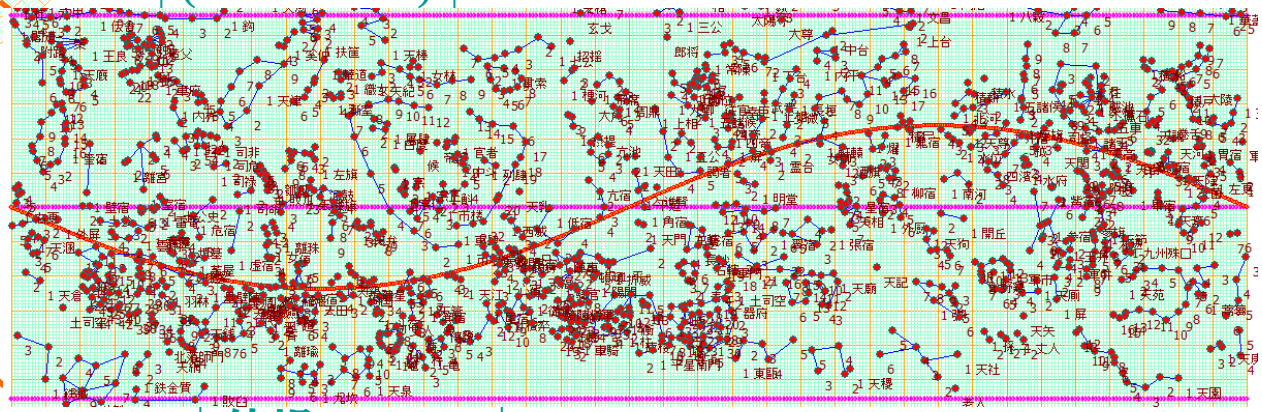




Circular chart inside the internal circle

内規 Naiki
(Inner circle)

Square chart from internal circle to external circle

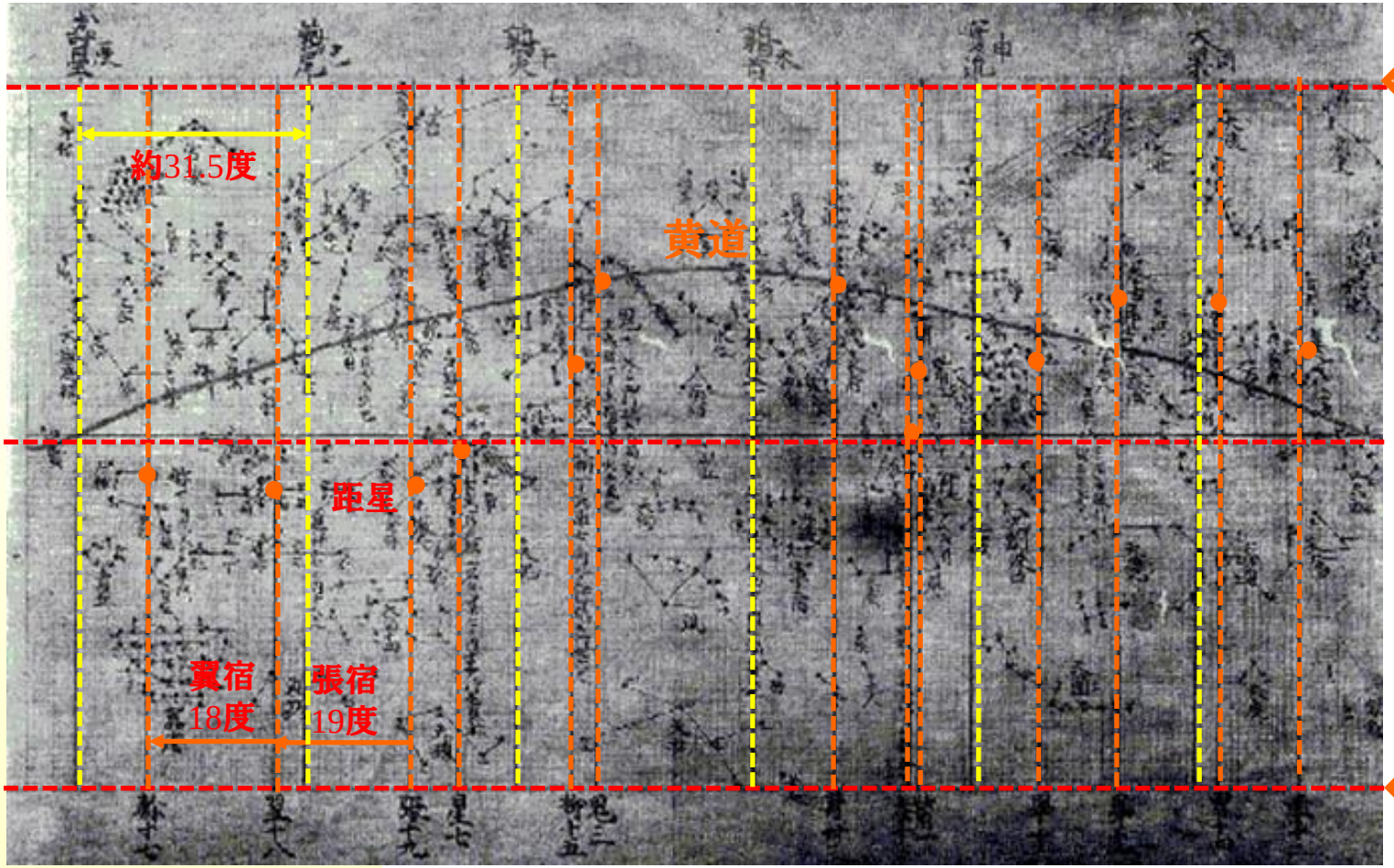


外規 Gaiki
(Outer circle)

Example of Square star chart「格子月進図」

12th order line (every 31.5 degrees)：Based on season, later changed.

The angle from the North Pole



⇐ 内規 (35°) Inner Circle

Equator 赤道 (91.5°)

Outer Circle ⇐ 外規 (148°)

28 constellation line：angel from leading star ⇒ Little influence of precession

(Total lange is 366 degrees in this chart.) Observation site：35x360/366=34.43°

[画像は『別冊太陽』73号(1991)p.39より]

2023/01/21

陽城(Yangcheng, Reference site of Calendar)

Observatory of Yuan Dynasty
at Yangcheng (34.4° N, 113.1° E)

[http://www.kamakura-worldheritage.com/?cat=1 より]

Instrument for measuring shadows
at Beijing Ancient observatory

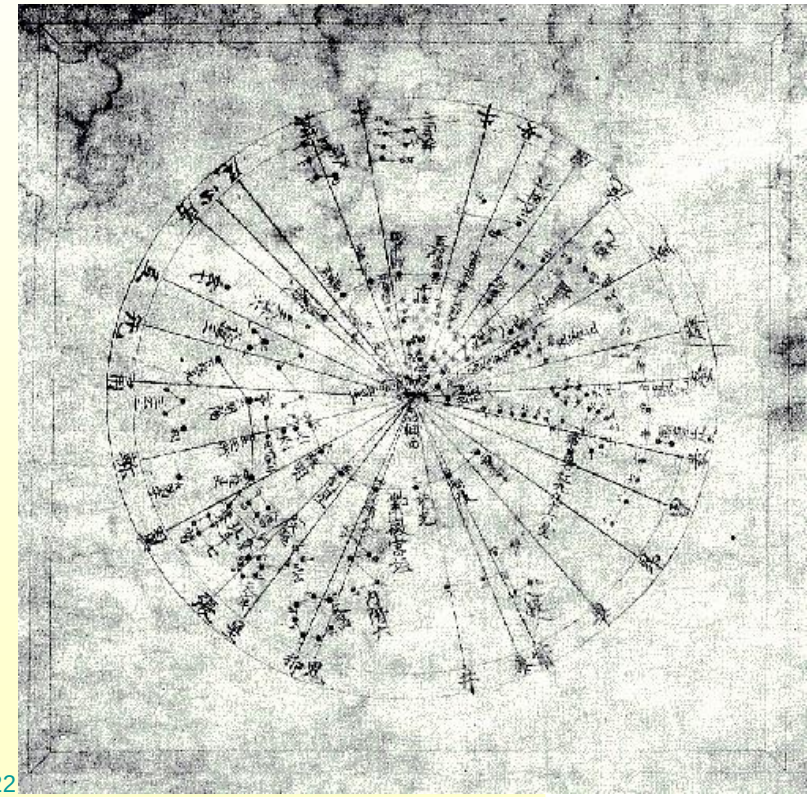
[https://zh.wikipedia.org/wiki/圭表 より]

陽城:河南省登封市告成鎮
(About 60km southeast of Luoyang)

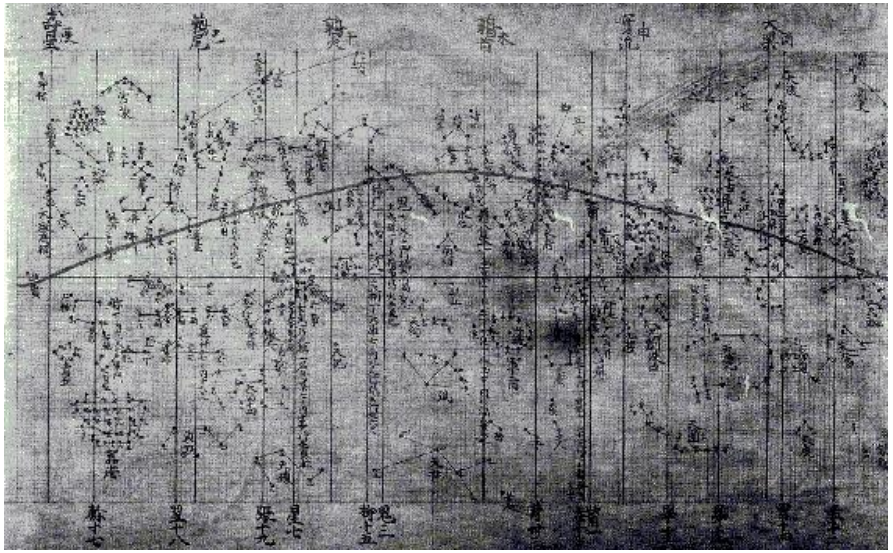
3. Introduction of ancient Chinese star charts

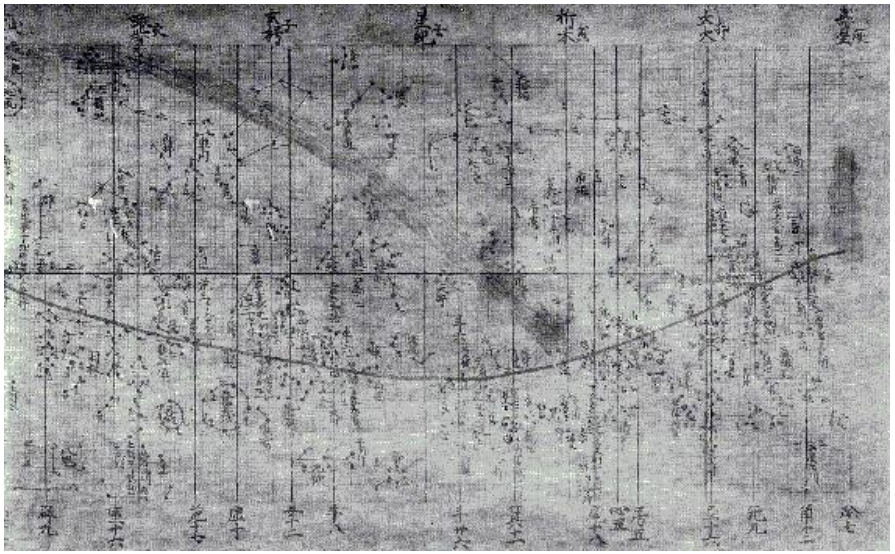
「格子月進図」(Koshi Gettshins)

『格子月進図』is a star chart handed down in the Tsuchimikado family. It was transcribed from the original by Abe Yasuyo around 1317. It was destroyed in an air raid in 1945 when it was on display, but the photographs remain. It is a star map that remains as it was at the time of introduction.



[『別冊太陽』73号(1991)p.38-39より]





Pei Xiu (224-271) of the Jin Dynasty produced a grid map.

2023/01/21

「高松塚古墳星宿図」
(Constellation map of Takamatsuzuka Tumulus)

28 constellation map drawn on the Takamatsuzuka Tumulus. Excavated in 1972. 28 constellations are drawn around the constellation of North Pole and the 四補.

Maybe trash

Cross

[「キトラ古墳天文図　星座写真集」PL.5より]

No figure in the left map

Should be 3 parts

North-south reverse

Square

No horizontal bar in Tang's map

[高松塚壁画館パンフレットより]

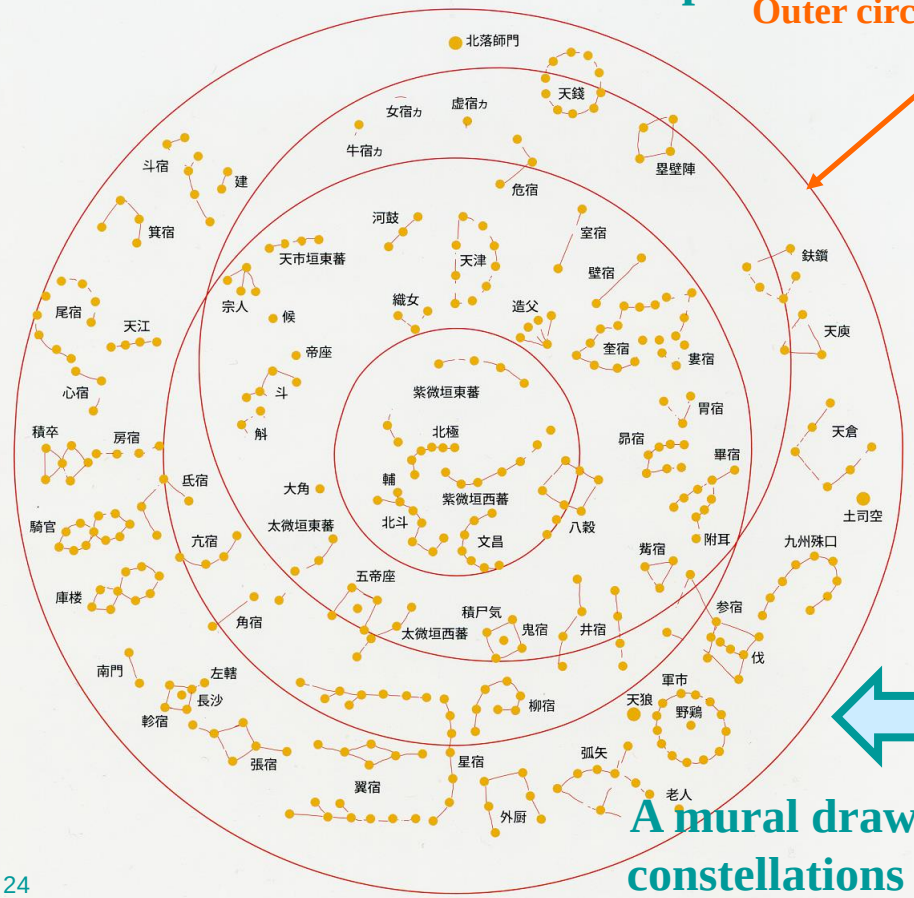
2023/01/21

「キトラ天文図」(Kitora Astronomical Map) (1/2)

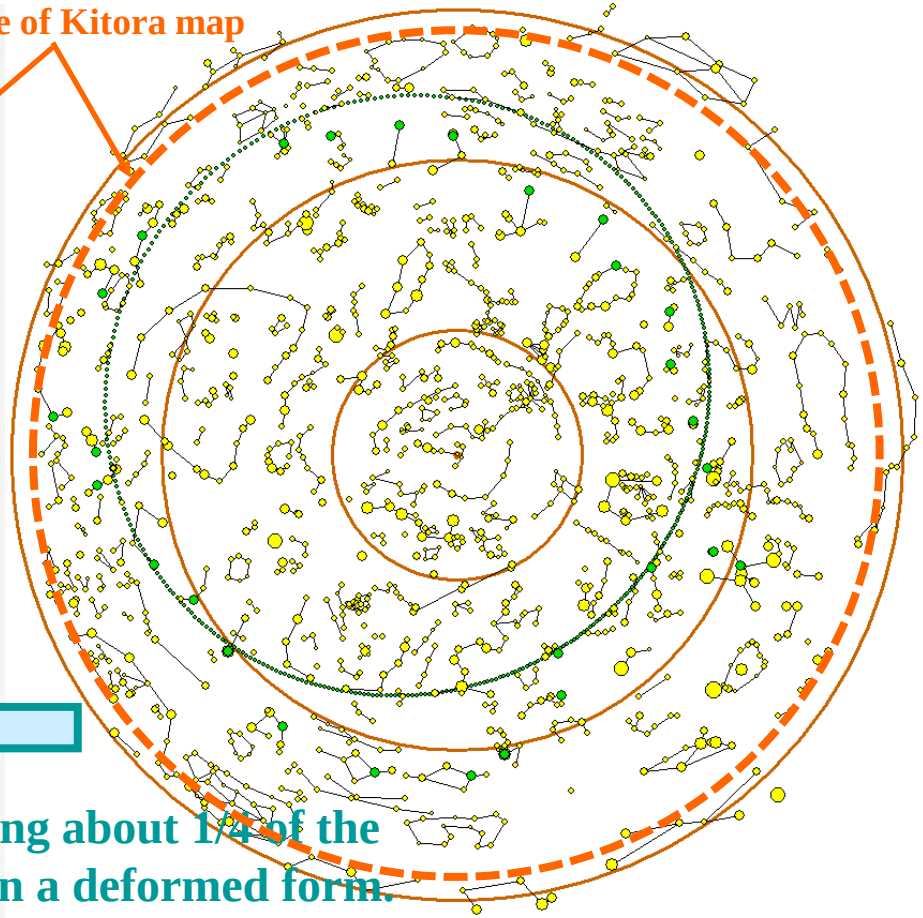
An astronomical map drawn on the Kitora Tumulus. Discovered in 1998 and excavated in 2004. More than 350 stars in 74 constellations are depicted, centering on the North Pole.

Circular star chart drawn based on「格子月進図」. (It is drawn reflecting the grade of brightness) (283 constellations, 1464 stars)

Kitora Astronomical Map



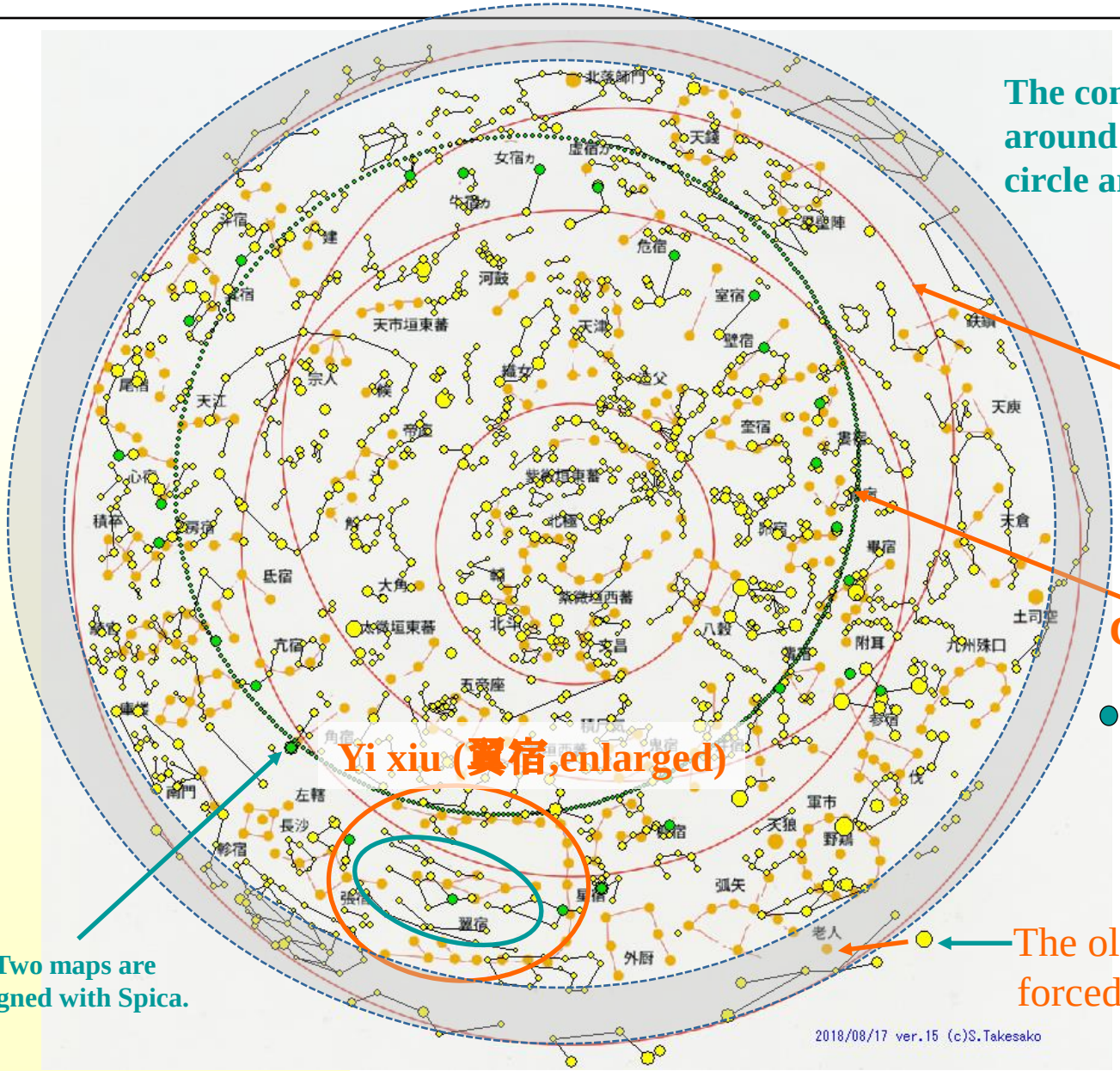
Outer circle of Kitora map



A mural drawing about 1/4 of the constellations in a deformed form.

[「キトラ古墳天文図　星座写真集」PL.3より]

「キトラ天文図」(Kitora Astronomical Map) (2/2)



Yi xiu (翼宿,enlarged)

The constellations around the outer circle are not drawn.

In-correct ecliptic

Correct ecliptic

● :Leading stars of 28 constellations

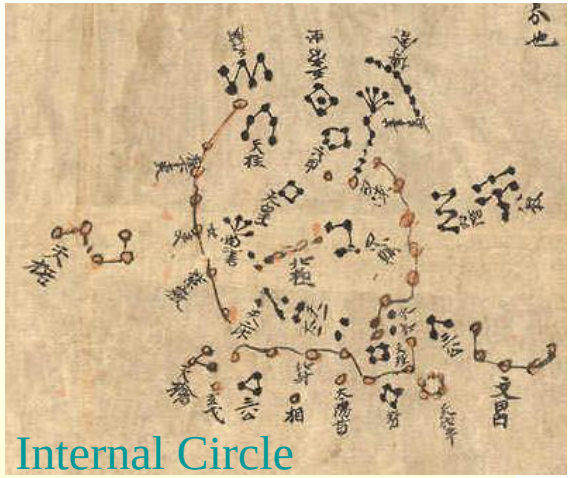
Inner:38.1°
Outer:44.5°

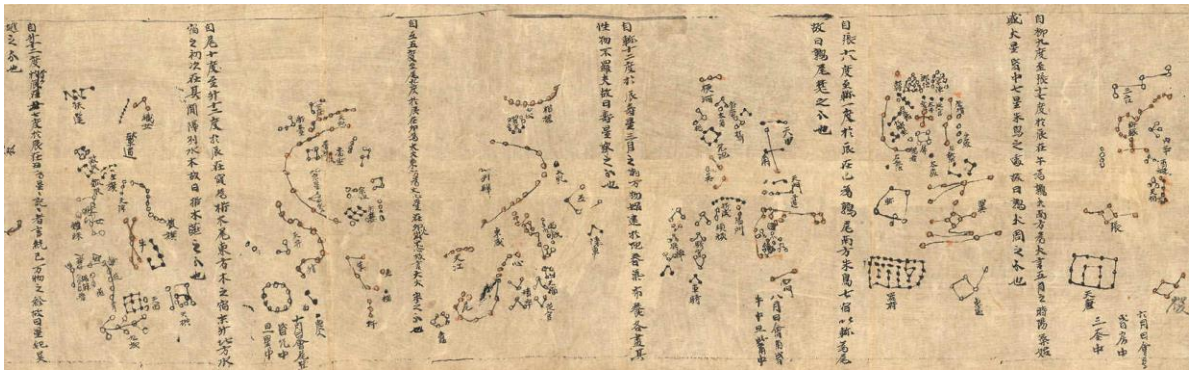
The old man's star is forced into the map.

Two maps are aligned with Spica.

「敦煌天文図」(Dunhuang astronomical map)

In 1900, a large number of documents were discovered in the Dunhuang Mogao Grottoes (17 caves), and British explorer Stein bought some of them and brought them back to the British Museum (1907). This map was included in these document. It is a celestial map of a square star chart similar to 「格子月進図」, and is divided into 12 degrees according to field theory(分野説). Needham, who discovered and introduced this star map, estimated that it was made around 940AD, but he did not show no evidence.





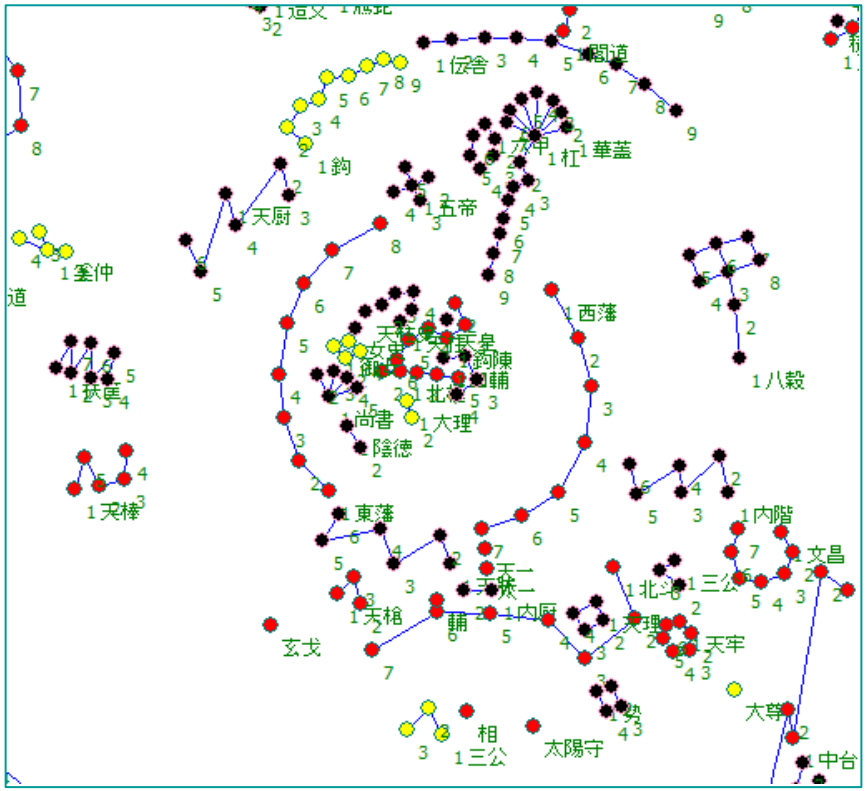
[http://www.atlascoelestis.com/Dunhuang%20VII%20sec%20base.html より]

[https://www.youtube.com/watch?v=gOy6x6CfL7M&t=216 より]

「敦煌天文図」is similar to「格子月進図」

『敦煌天文図』

『格子月進図』(3家彩色)

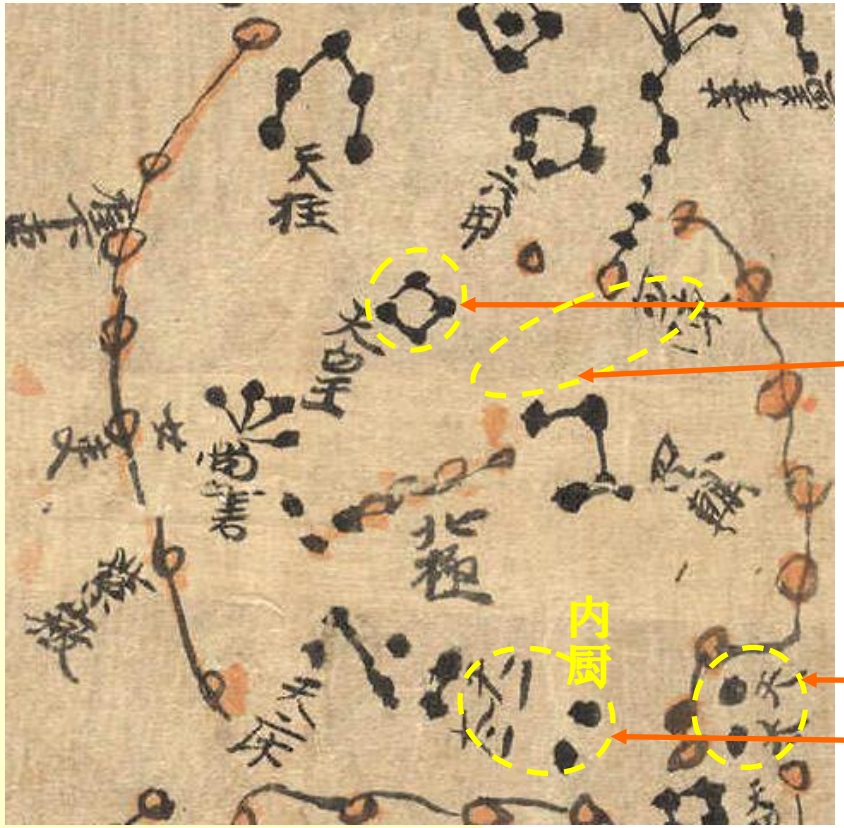


[http://www.atlascoelestis.com/Dunhuang%20VII%20sec%20base.htmlより]

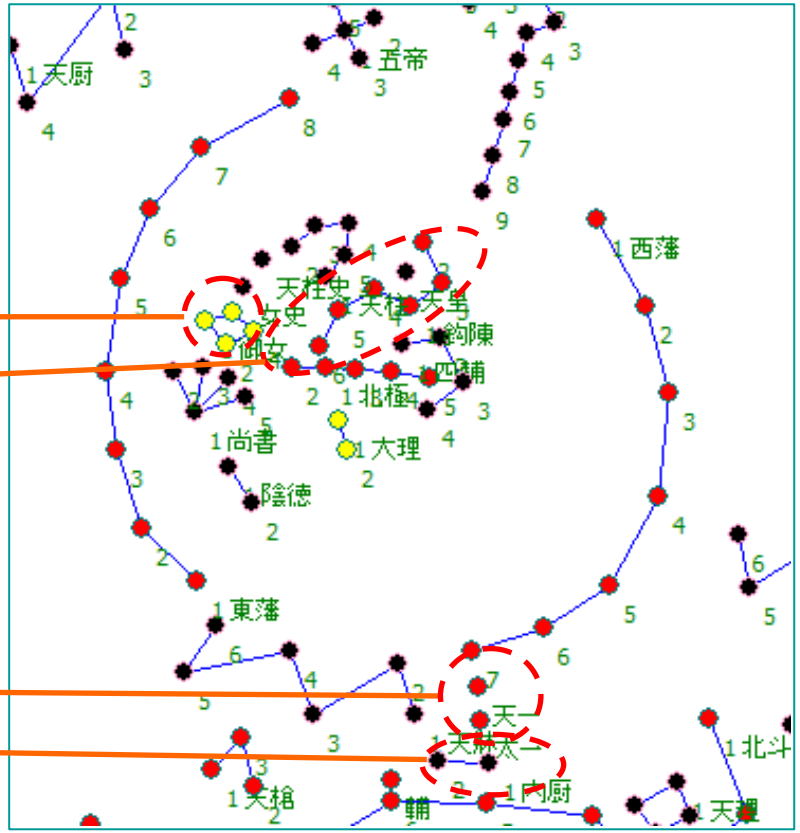
Wrong Constellations in「敦煌天文図」

- The constellation of「天皇」is「御女」.
- There is name of「勾陳」, but constellation figure is missing.
- The constellation of「天一・太一」is「内厨」.

『敦煌天文図』



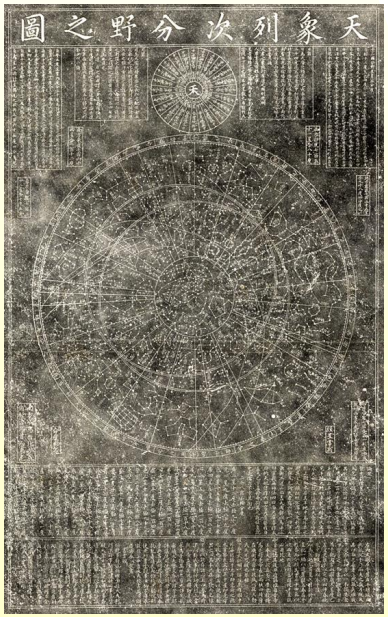
『格子月進図』

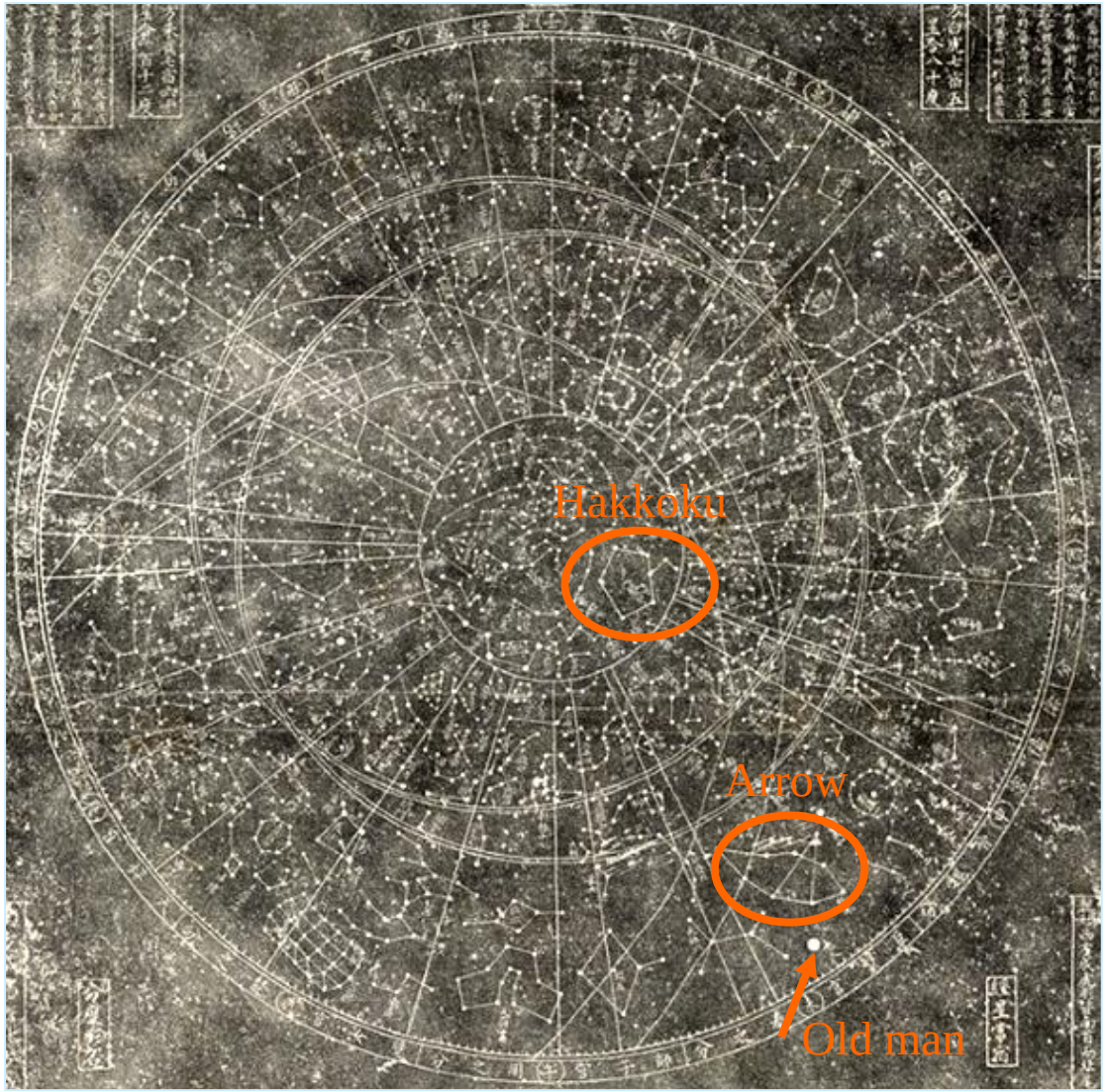


[http://www.atlascoelestis.com/Dunhuang%20VII%20sec%20base.htmlより]

「天象列次分野之図」(Tenshou retsuji bunyanozu)

A stone carved star map made in the 28th year of Hongmu (1395AD) in the 4th year of King Taejo of Yi Dynasty Korea.
According to the inscription,"When Goguryeo was attacked by the allied forces of Tang and Silla and fell to ruin (668AD), the star map was sunk in the Taedong River. However, a rubbed copy was handed down, and there was one that was presented to Taejo when he was enthroned, and that rubbed copy was used as the original drawing".





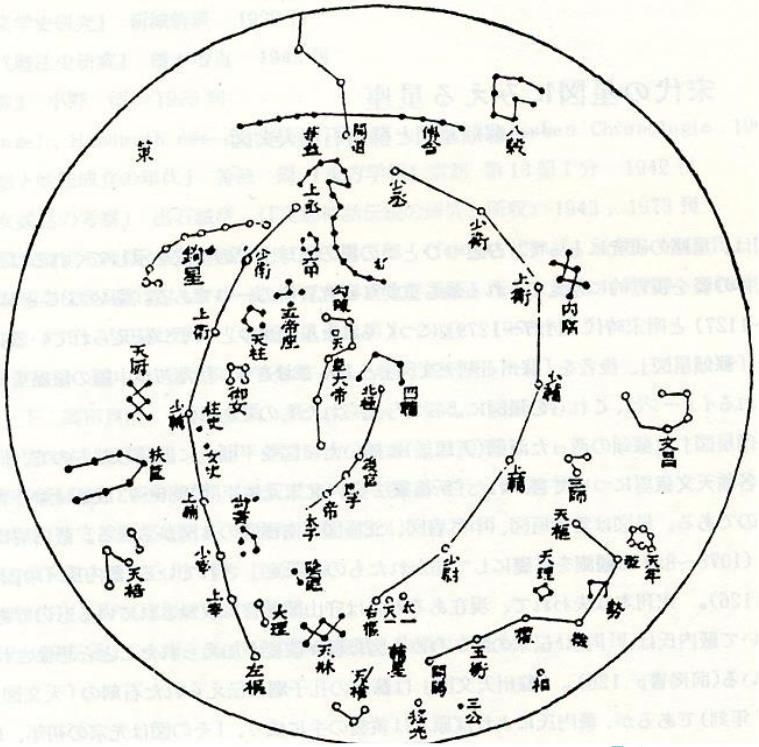
Inner：37.7°
Outer：33.1°

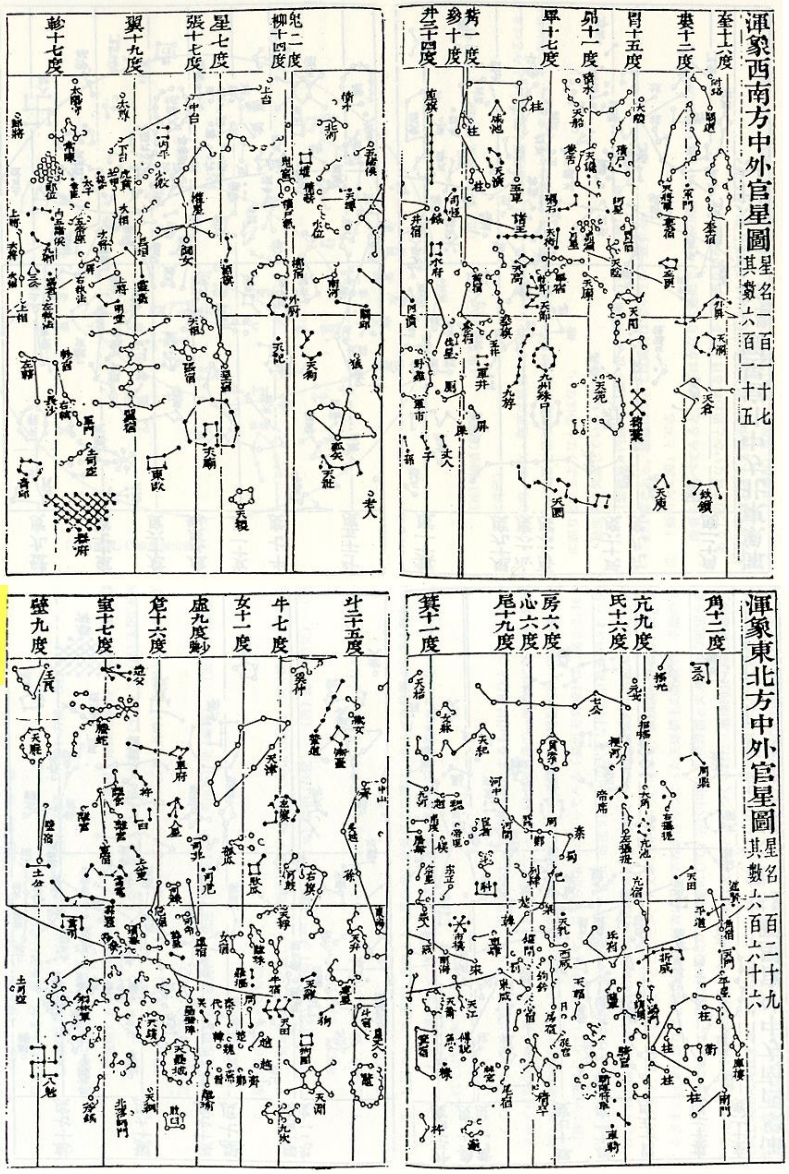
[『天象列次分野之図(再刻)』(京都大学附属図書館所蔵)及び
千葉市立郷土博物館『東西の天球図』(2002)p.18 より]

2023/01/21

「蘇頌天文図」(Su Song Star chart)

『蘇頌天文図』is a square star chart created by Su Song, an astronomer from the Northern Song dynasty of China, and was published in the book 『新儀象法要』published in the Tianyu era around 1090. It is said to have been drawn based on observations made during the Yuanfeng era (1078-85).



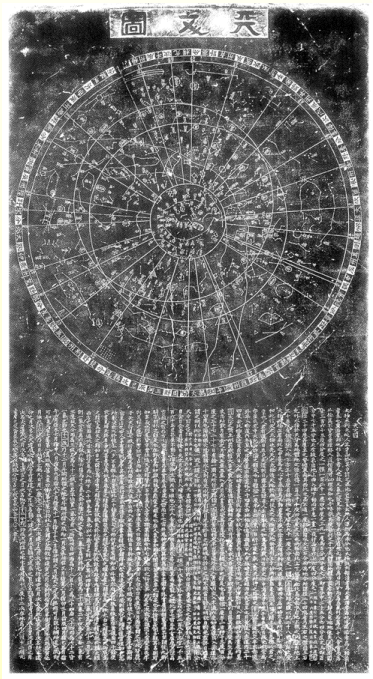


[『中国の星座の歴史』雄山閣出版 (1987) p.232-234より]

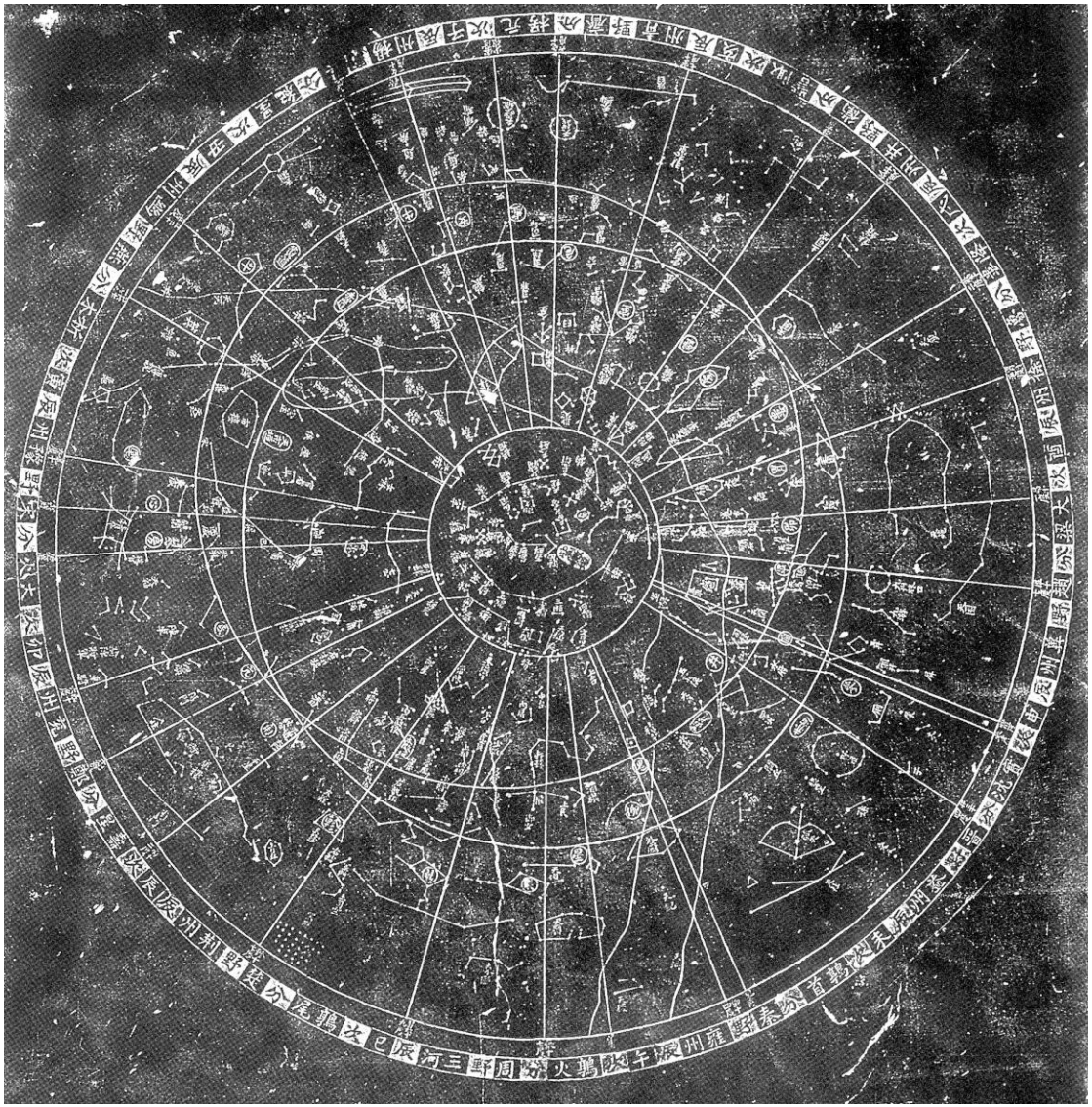
2023/01/21

「蘇州天文図」(淳祐天文図)
(The Suzhou Astronomical chart)

Based on a star map produced by Huangsu of the Northern Song dynasty around 1190, this star map was created by Wang Zhiyuan in the 7th year of **淳祐** era(1247). It is also estimated to be based on stellar observations made during **元豊**era(1078-1085).



Inner：33.9°
Outer：34.3°



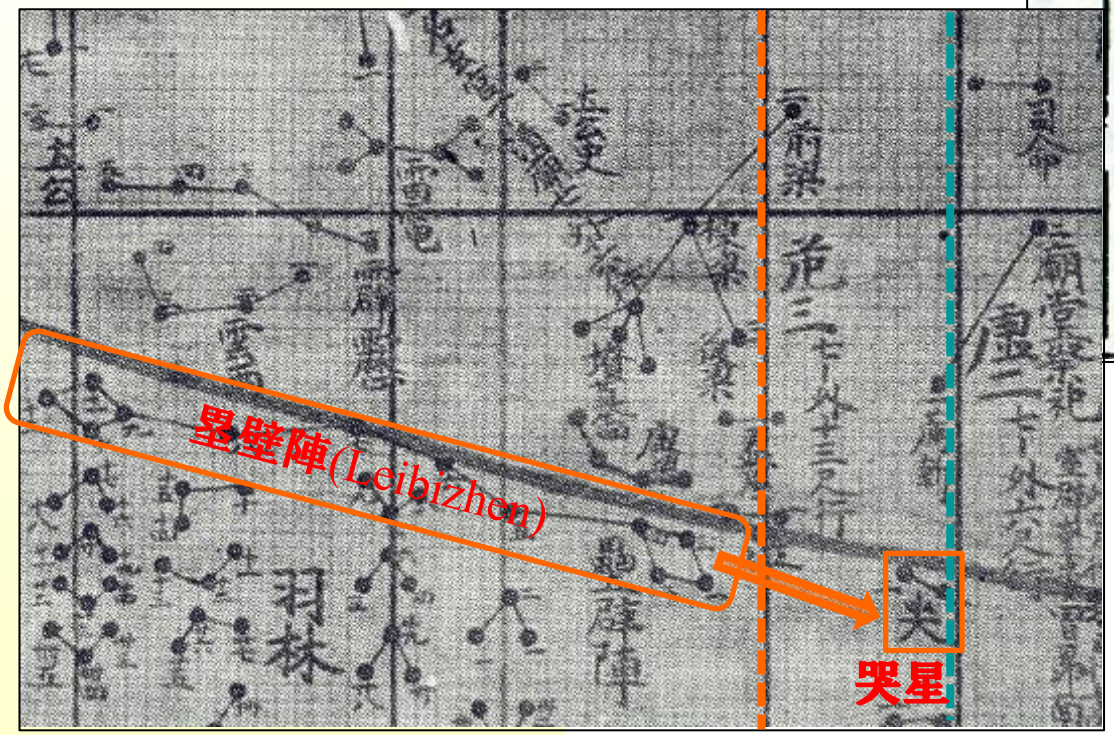
[『東西の天球図』千葉市郷土博物館(2002)p.15より] 2023/01/21

Ⅱ. Dating of original star chart

4. Dating by constellation shapes and names

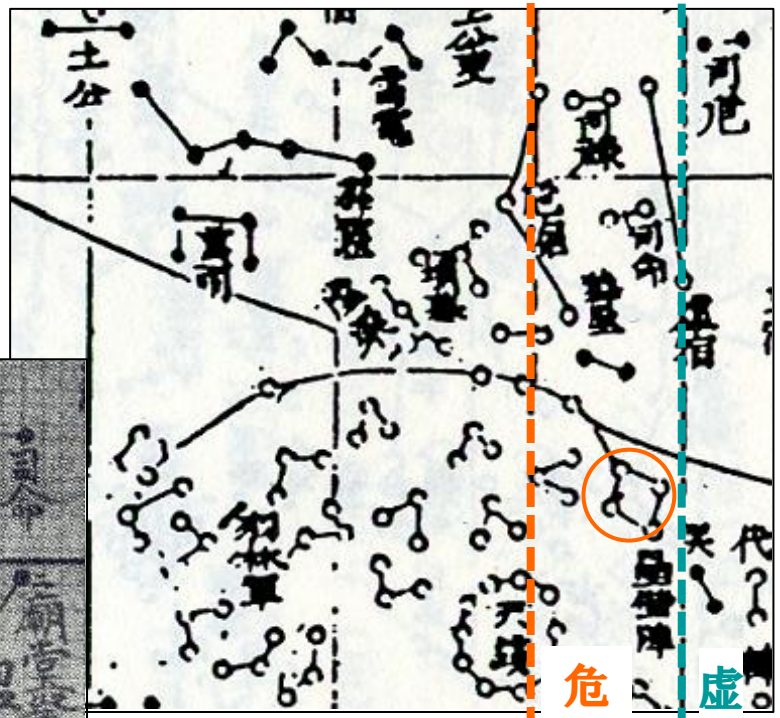
Dating by constellation「墨壁陣」(Leibizhen) (Tang dynasty or Song dynasty) (1/3)

The feature of the star charts after the Sung dynasty is that the「墨壁陣」extends to the 虚宿(Xu xiu). Discovered by Mr. Kiyohiko Ogawa (1932) by verifying the records of star occultations.



『格子月進図』(唐)

危Wei 宿 xiu　虚 Xu 宿 xiu



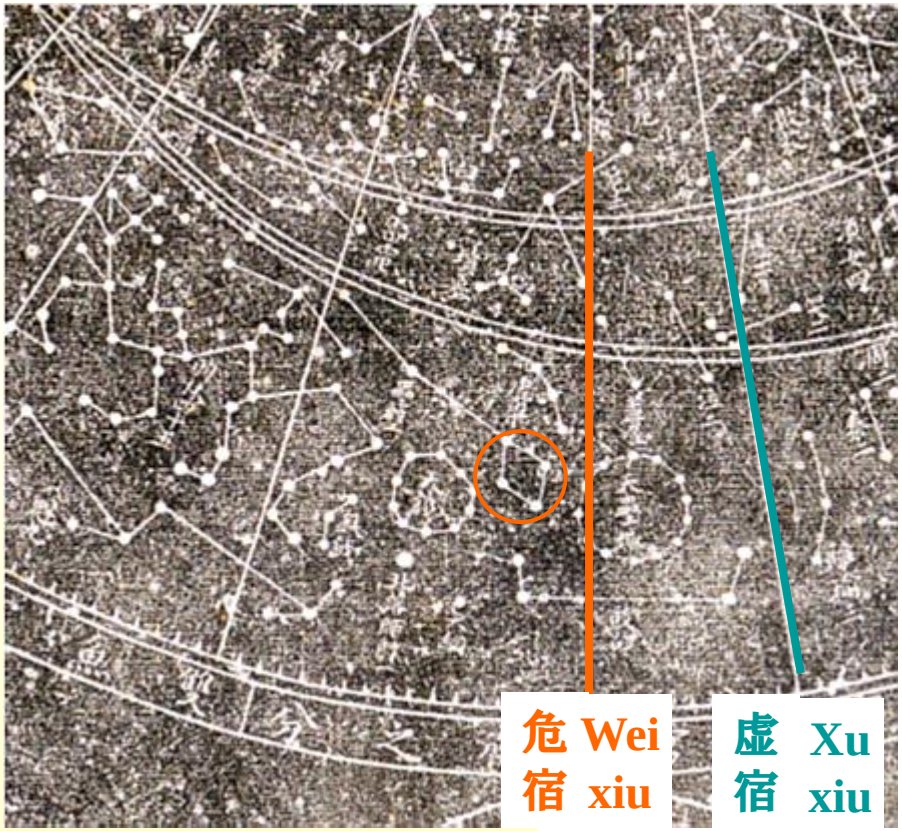
『蘇頌星図』(宋)

From the 11th century onwards, the "哭星" replaced the "墨壁陣" in Chinese records of occultation of star crimes. The record in Japan remains "Crying Star". Goryeo records contain a mixture of both.

2023/01/21

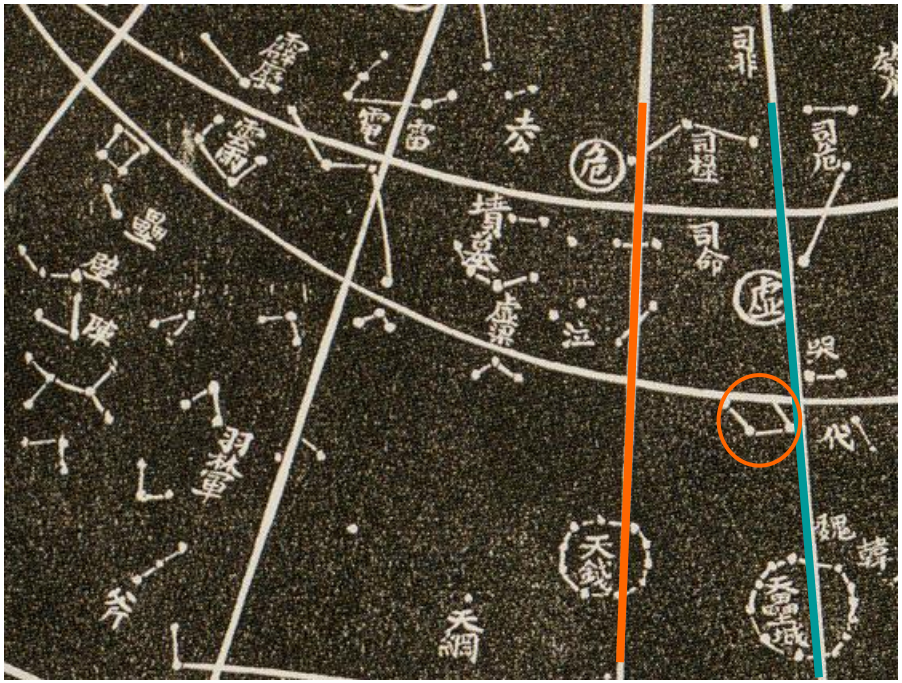
Dating by constellation「墨壁陣」 (Tang dynasty or Song dynasty) (2/3)

『天象列次分野之図』(唐)



Tang Dynasty star map
because it is in the Wei xiu.

『蘇州天文図』(宋)

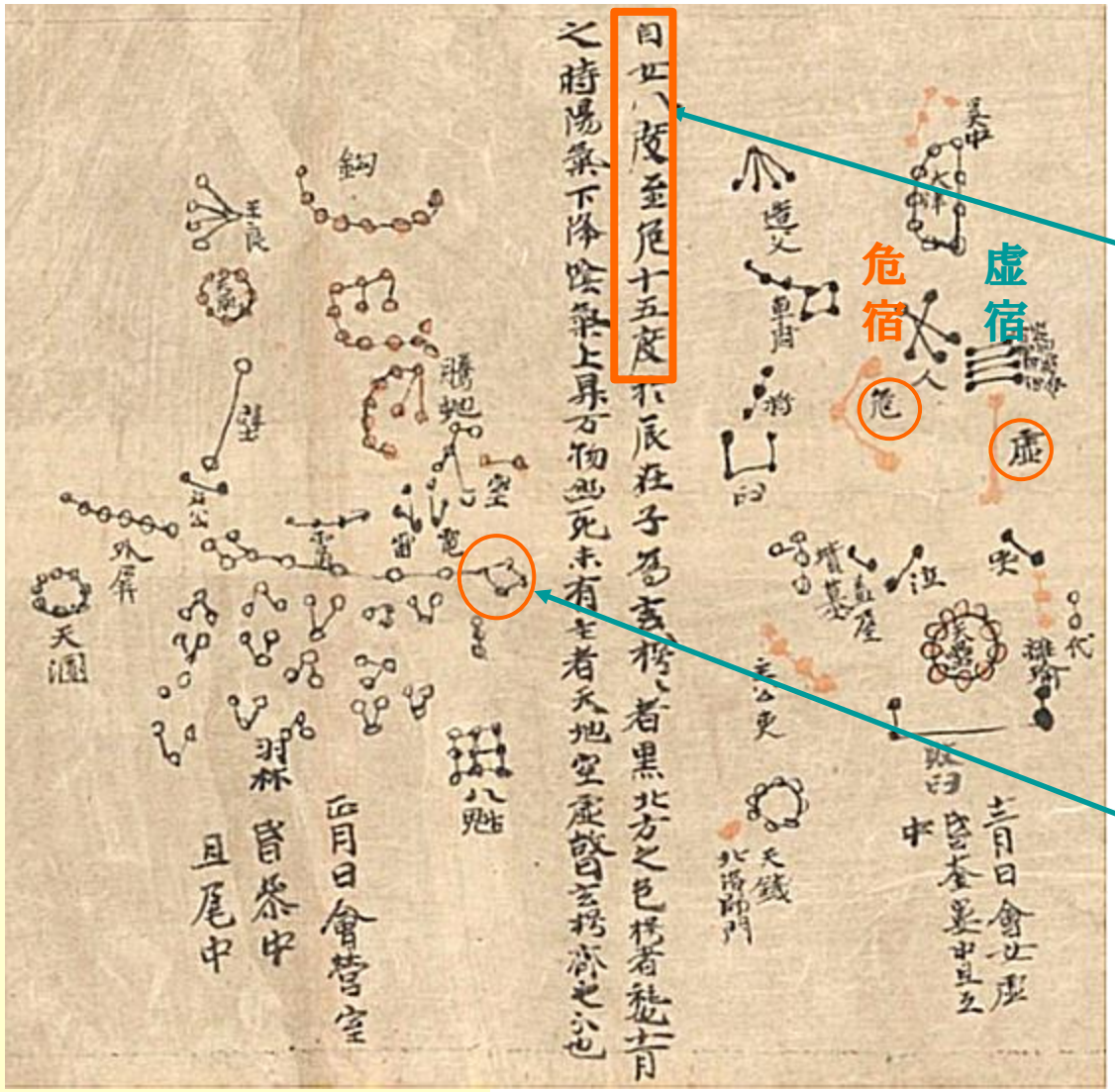


危 Wei 虚 Xu
宿 xiu 宿 xiu

Song Dynasty star map
because it extends to Xu xiu.

Dating by constellation「墨壁陣」 (Tang dynasty or Song dynasty) (3/3)

『敦煌天文図』(唐) (The Dunhuang Astronomical map)



The range of 12 order in the figure on the right is "8 degrees of **女宿**(Nu xiu)" to "15 degrees of **危宿**(Wei xiu)". The range of the 12th order of this star chart is the same as the value of **『開元占経』**.

It is unknown how far the 墨壁陣 extend. But since the shape of the constellations is similar to 『格子月進図』, it is judged to be a chart of the Tang Dynasty.

「敦煌天文図」の12次の範囲の比較

The 12th order of the "Dunhuang Astronomical Map" is based on field theory (**分野説**) and is similar to the 12 signs in the West. Also, its range is the same as the value of **『開元占経』**. It differs from the value in older documents.
⇒It is presumed that this map is after the Tang/Kaiyuan period (713-741) when **『開元占経』** was written.

月	12次	季節	十二支	敦煌天文図		開元占経(8世紀前半)		晋書天文志(7世紀)		乙巳占(7世紀)	
				始点	終点	始点	終点	始点	終点	始点	終点
11	星紀	冬至	丑	斗12度	女７度	斗12度	女７度	斗12度	女７度	斗12度	女７度
12	玄枵	大寒	子	女８度	危15度	女８度	危15度	女８度	危15度	女８度	危15度
1	娵訾	雨水	亥	危16	奎４度	危16	奎４度	危16	奎４度	危16	奎４度
2	降婁	春分	戌	奎５度	胃６度	奎５度	胃６度	奎５度	胃６度	奎５度	胃６度
3	大梁	穀雨	酉	胃７度	畢11度	胃７度	畢11度	胃７度	畢11度	胃７度	畢11度
4	実沈	小満	申	畢12度	井15度	畢12度	井15度	畢12度	井15度	畢12度	井15度
5	鶉首	夏至	未	井16度	柳８度	井16度	柳８度	井16度	柳８度	井16度	柳８度
6	鶉火	大暑	午	柳９度	張17度	柳９度	張17度	柳９度	張16度	柳９度	張16度
7	鶉尾	処暑	巳	張18度	軫11度	張18度	軫11度	張17度	軫11度	張17度	軫11度
8	寿星	秋分	辰	軫12度	氐４度	軫12度	氐４度	軫12度	氐４度	軫12度	氐４度
9	大火	霜降	卯	氐５度	尾９度	氐５度	尾９度	氐５度	尾９度	氐５度	尾９度
10	析木	小雪	寅	尾10度	斗11(2)度	尾10度	斗11度	尾10度	斗11度	尾10度	斗11度

Same as **『開元占経』**

Differ from 7th century document.

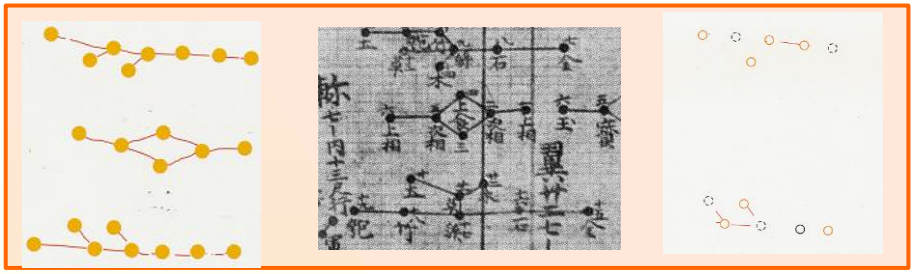
Changes of constellation shapes over time(1/4)

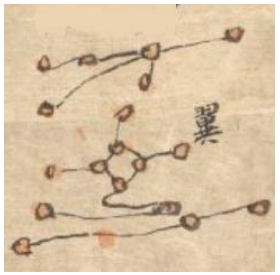
Shape of「翼宿」(Yi xiu)

Same shaped (3 divisions)

Middle of change (3 divisions)

Same shape (3 connected)



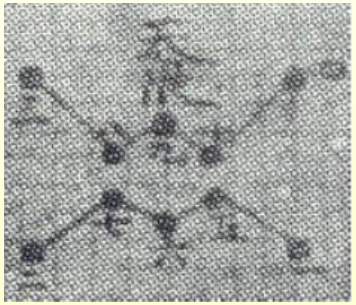


『キトラ天文図』　『格子月進図』『高松塚星宿図』『敦煌天文図』『天象列次分野之図』『蘇頌星図』

Shape of「天淵」(Tian Yuan)

Middle of change

Same shape



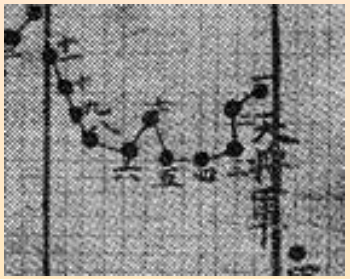
『格子月進図』　『敦煌天文図』　『天象列次分野之図』　『蘇頌星図』

Direction of change

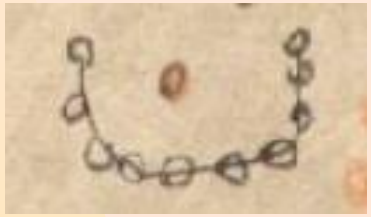
Changes of constellation shapes over time(2/4)

Shape of「天将軍」(Tian jiangjun)

Same shape(horizontal direction)

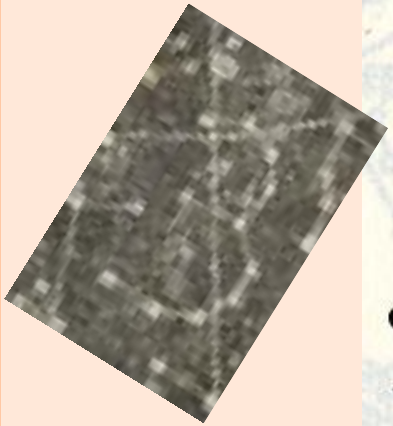


『格子月進図』

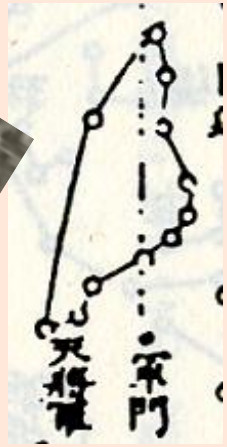


『敦煌天文図』

Same shape（Vertical direction)



『天象列次分野之図』



『蘇頌星図』

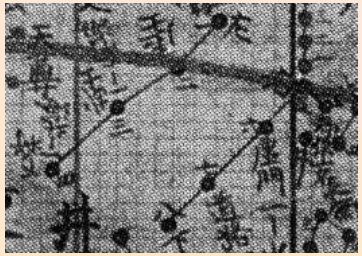
『蘇州天文図』

Direction of change

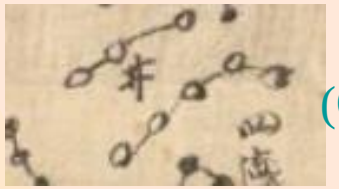
Changes of constellation shapes over time(3/4)

Shape of「井宿」(Jin xiu)

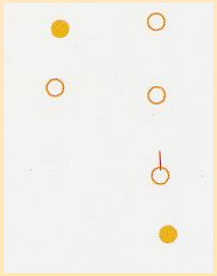
Same shape (No Horizontal line)



『格子月進図』

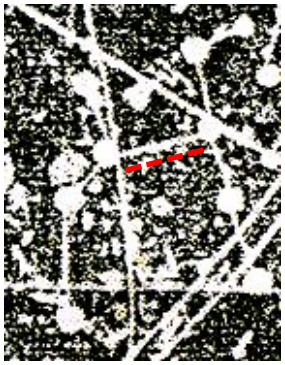


『敦煌天文図』



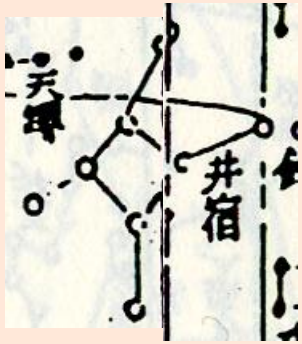
『高松塚古墳星宿図』『キトラ天文図』

Middle of change
(One Horizontal line)

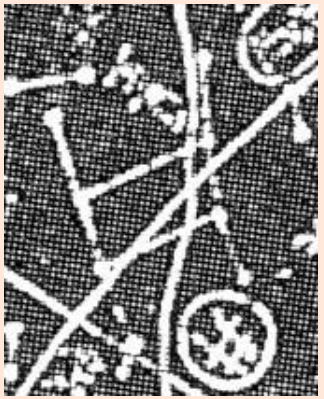


『天象列次
分野之図』

Same shape (Two Horizontal lines)



『蘇頌星図』



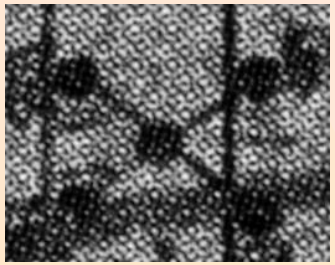
『蘇州天文図』

Direction of change

Changes of constellation shapes over time(4/4)

Shape of「鬼宿」(Gui xiu)

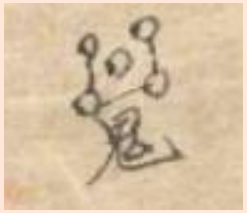
Same shape (Cross)



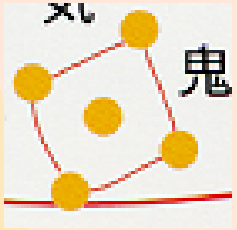
『格子月進図』

『高松塚古墳
星宿図』

Same shape (Square)



『敦煌天文図』



『キトラ天文図』

『天象列次分野之図』

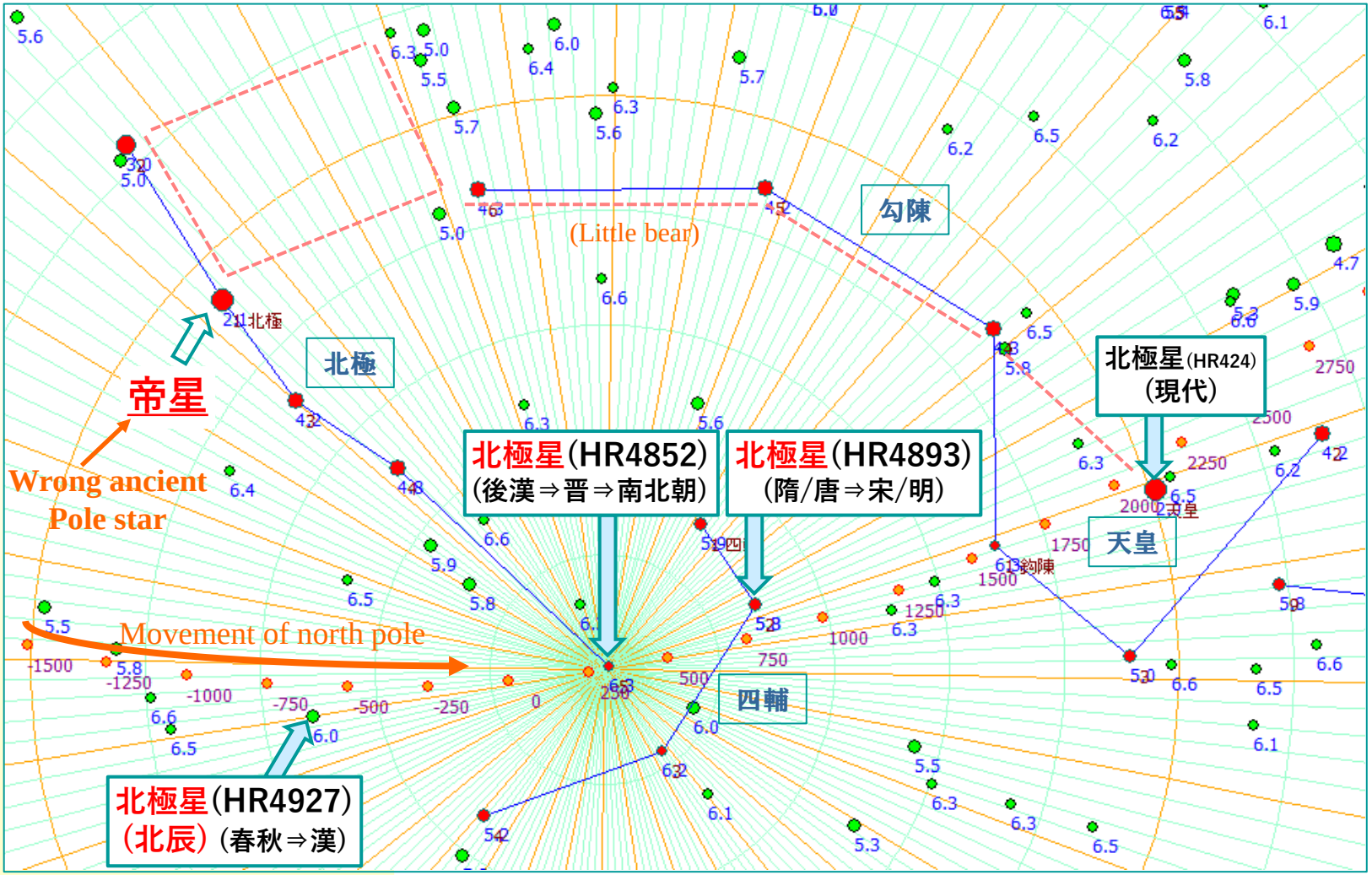
『蘇頌星図』

『蘇州天文図』

Direction of change

Dating by the shape of constellation North Pole(1/3)

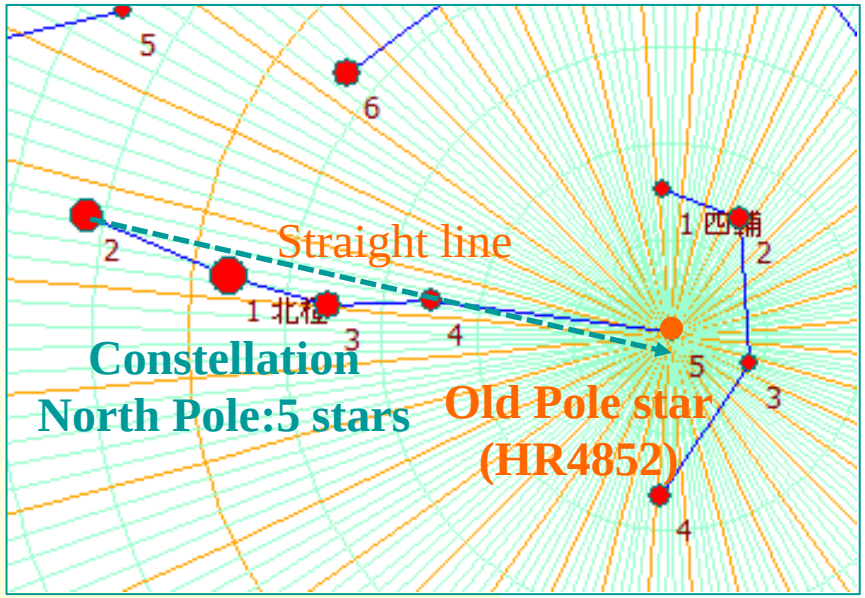
The Pole Star was not ”帝星”, but changed along with the movement of the North Pole.



Note：Base of star table of「SKY2000 Master Catalog、Version 5」(2006). up to 6.6 magnitude。
Sky at AD300. Number on the star is magnitude. Orange points are place of pole at that year.
Declination scale interval is 2°. HR number is number of「Bright Star Catalogue」.

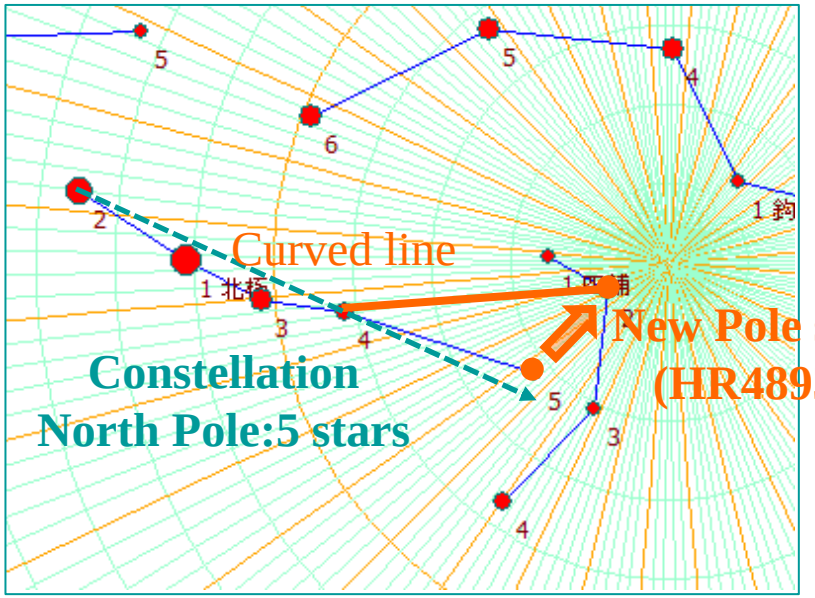
Dating by the shape of constellation North Pole(2/3)

North pole at 300AD(晋)



The 5 stars of constellations North Pole are in a straight line.

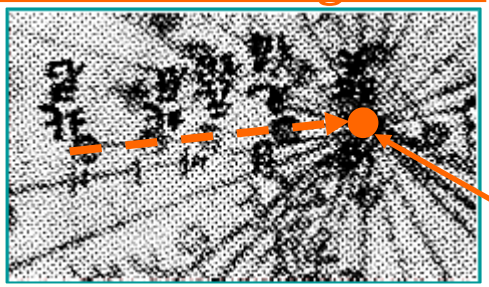
North Pole at 1100AD(宋)



The 5 stars of constellations North Pole are aligned in a curved line.

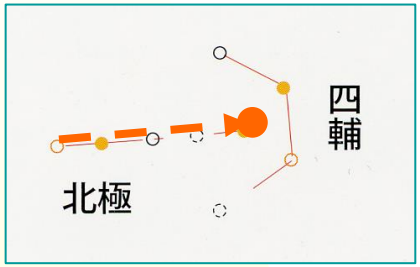
Dating by the shape of constellation North Pole(3/3)

5 stars in straight line

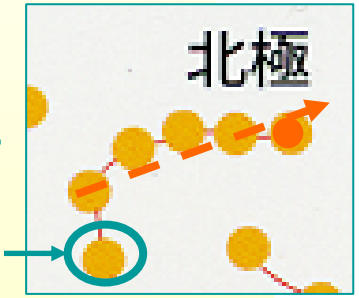


『格子月進図』

HR4852



『高松塚星宿図』

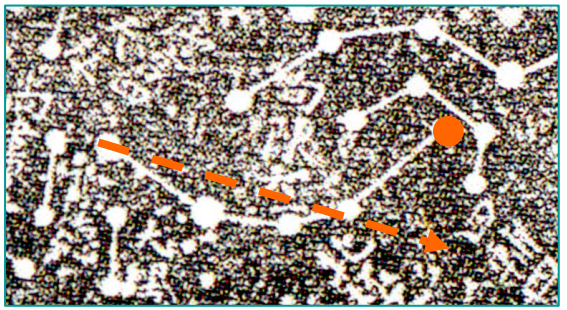


『キトラ天文図』

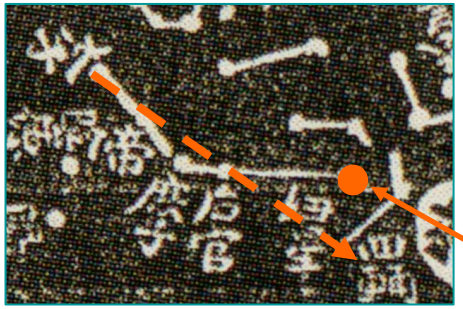
Not a star of constellation North Pole

『敦煌天文図』

5 stars in curved line

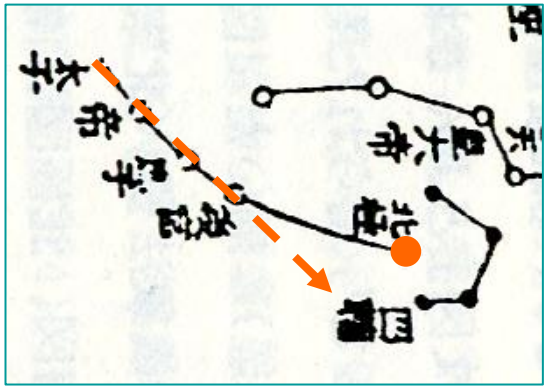


『天象列次分野之図』



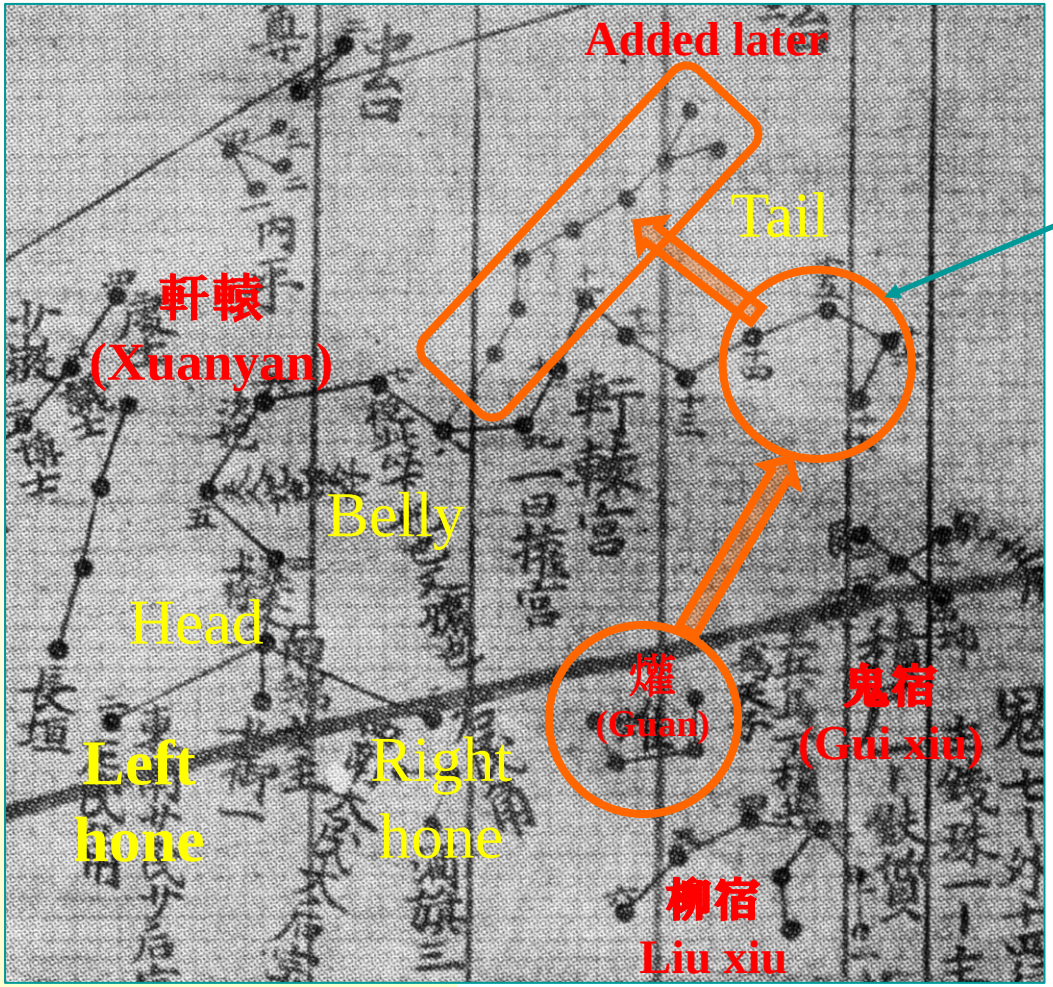
『蘇州天文図』

HR4893



『蘇頌星図』

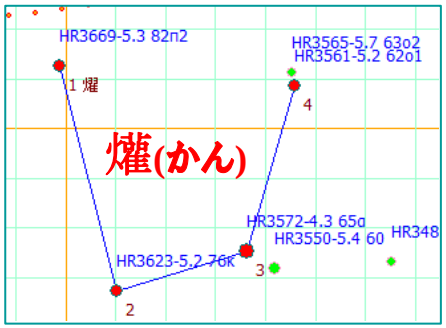
Tail of 軒轅(Xuanyan) and 爟(Guan) of「格子月進図」



爟 on other star charts are at this position

The composition of『格子月進図』consistent with the description in『開元占経』

爟 in the modern chart.



[『別冊太陽』73号(1991)p.38-39より]

唐開元占経(718～726)「爟星旧図軒轅腹内，今測軒轅尾南近柳宿北四星」(reference[43]p.767)
「軒轅，舊尾漸斜向上，今測其尾勢迤邐向西」(reference[43]p.764)

Changes in constellation shapes over time

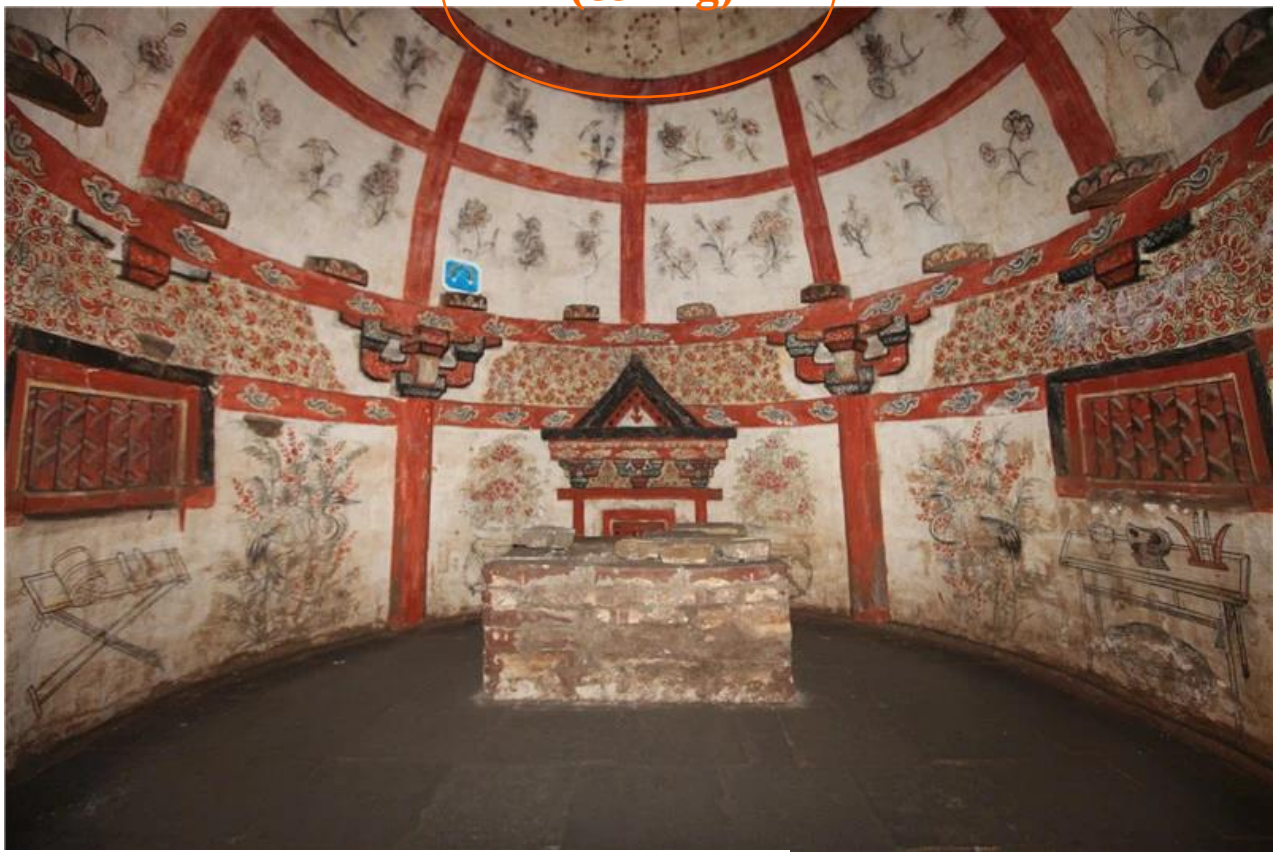
Charts in Tang Dynasty → | Charts in Song Dynasty →

Constellation	格子 月進図	高松塚 星宿図	キトラ 天文図	敦煌 天文図	天象列次 分野之図	蘇州 天文図	蘇頌星図
垒壁陣 (Leibizhen)	Kisyuku	(Around 700AD)		kisyuku	kisyuku	kyosyuku	kyosuku
翼宿 (Yi xiu)	3parts	(3parts)	3parts	3parts (tentacles)	Integrated	Integrated	Integrated
天淵 (Tian Yuan)	W＋M	–	–	Hexagonal ＋square	Hexagonal with 4line	Hexagonal with 4line	Hexagonal with 4line
大将軍 (Tian jiangjun)	Horizontal	–	–	Horizontal	Vertical	Vertical	Vertical
井宿 (Jing xiu)	Non	(None)	None	None	1 line	2 lines	2 lines
鬼宿 (Gui xiu)	cross	cross	square	square	square	square	square
北極 (North Pole)	line (HR4852)	line (HR4852)	line (HR4852)	line (HR4852)	curve (HR4893)	curve (HR4893)	curve (HR4893)
爟 (Guan)	North of 柳宿	–	–	Northeast of 鬼宿	Northeast of 鬼宿	Northwest of 鬼宿	Northwest of 鬼宿

Orange：Beginning of Tang,　Yellow：Tang,　Green：Song

The shape of the constellation of the Chinese Grave Chamber Constellation Map

Constellation figure (ceiling)



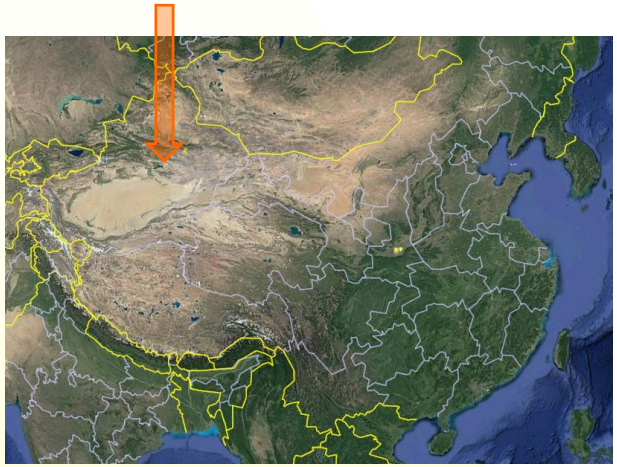
[The Grave Chamber is underground down the stairs]

【遼・張世卿墓室】(1116, refer to p.53)

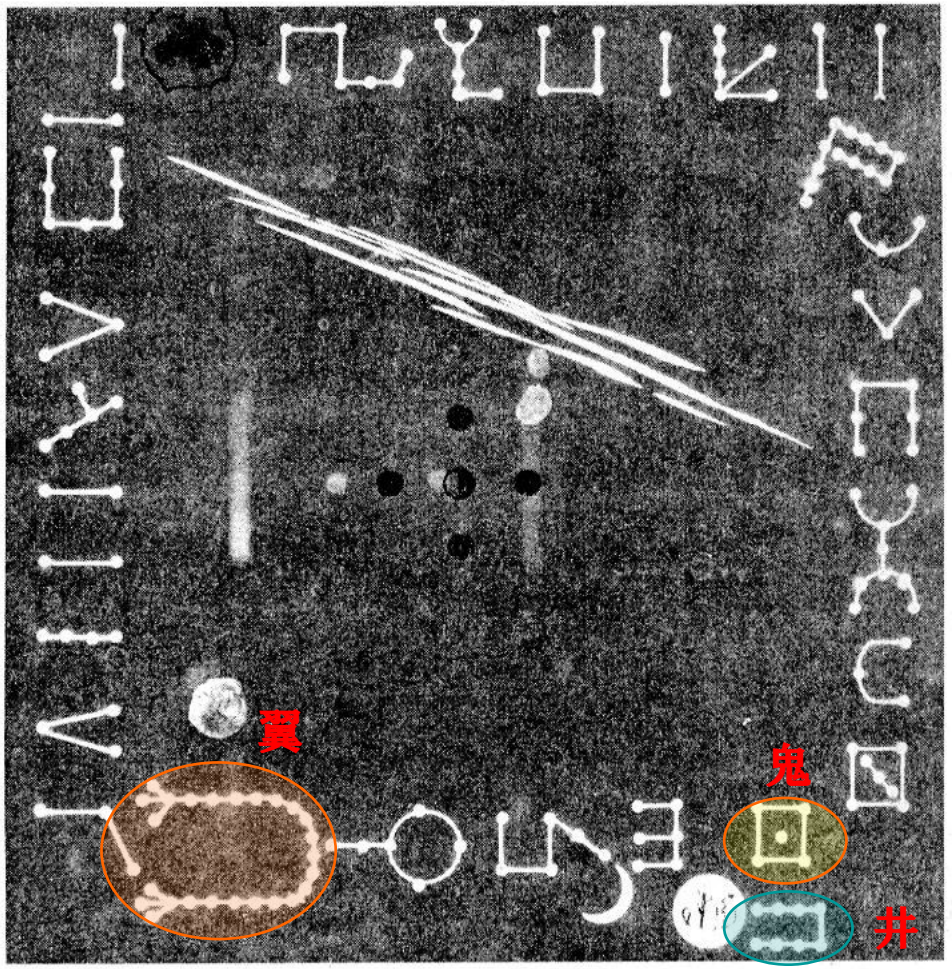
[https://new.qq.com/omn/20211210/20211210A00LMN00.htmlより]

Grave Chamber Constellation Map (1/6)

Astana Burial Mounds in Turpan
65TAM38 (Middle of 8 century)



- **翼宿:** letter U
- **井宿:** 1 Horizontal line
- **鬼宿:** Square



[潘鼎著『中国古天文図録』p.42より]

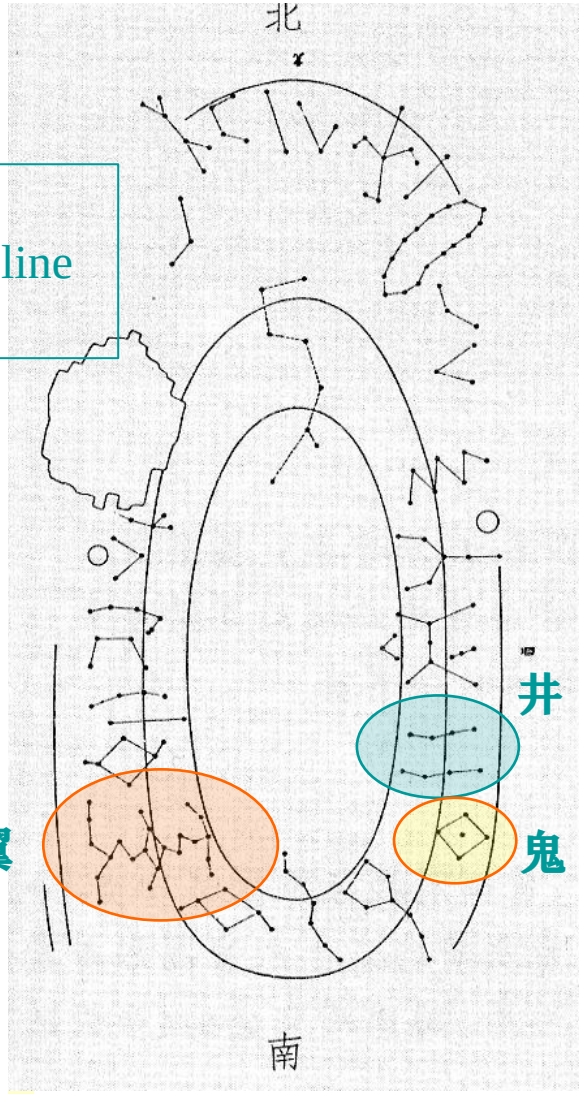
Grave Chamber Constellation Map (2/6)

吳越王家族墓室星図
吳越国(907-978)

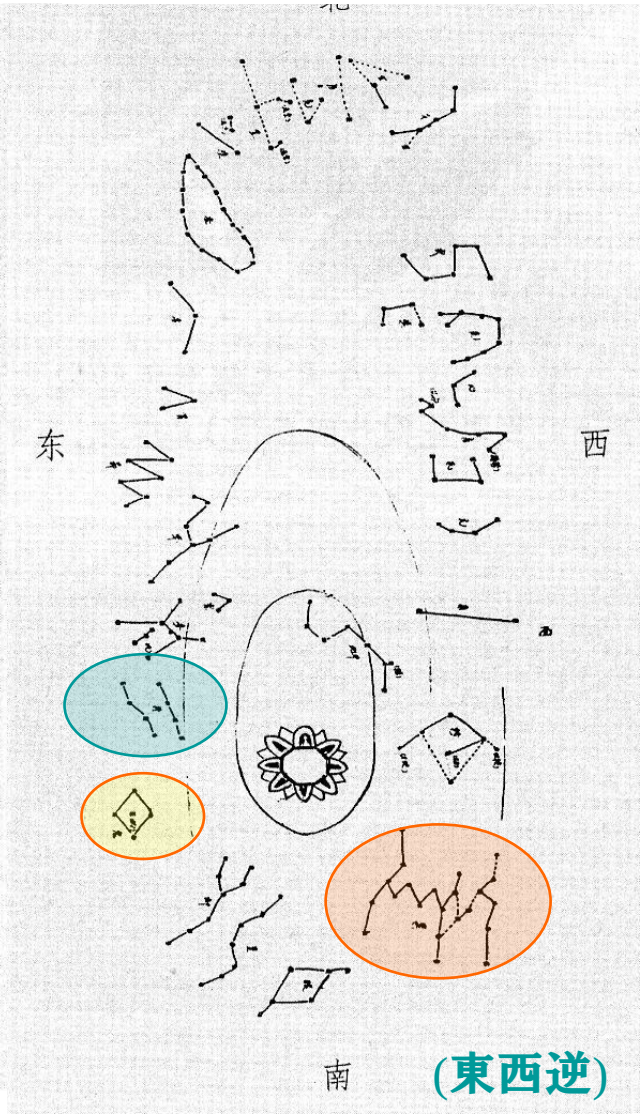
- **翼宿:** Integrated
- **井宿:** No Horizontal line
- **鬼宿:** Square

A slightly older than
『天象列次分野之図』

【銭寛墓星図】(900)



【水邱氏墓星図】(901)



(東西逆)

[潘鼎著『中国古天文図録』p.47より]

Grave Chamber Constellation Map (3/6)

呉越王家族墓室星図
呉越国(907-978)

【銭元瓘墓星図】(942)　**【銭元瓘馬王后星図】**(940)　**【銭元次妃・呉漢月墓星図】**(952)

- **翼宿:** 3parts
- **井宿:** No horizontal line
- **鬼宿:** square

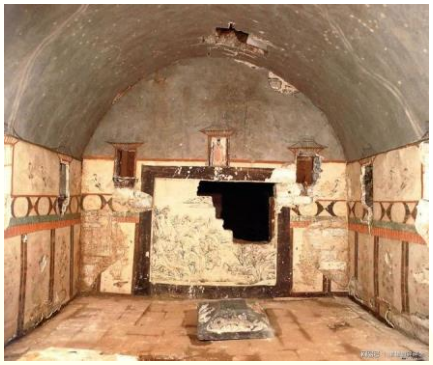
[潘鼎著『中国古天文図録』p.48より]

北極・五星
(North Pole)

Grave Chamber Constellation Map (4/6)

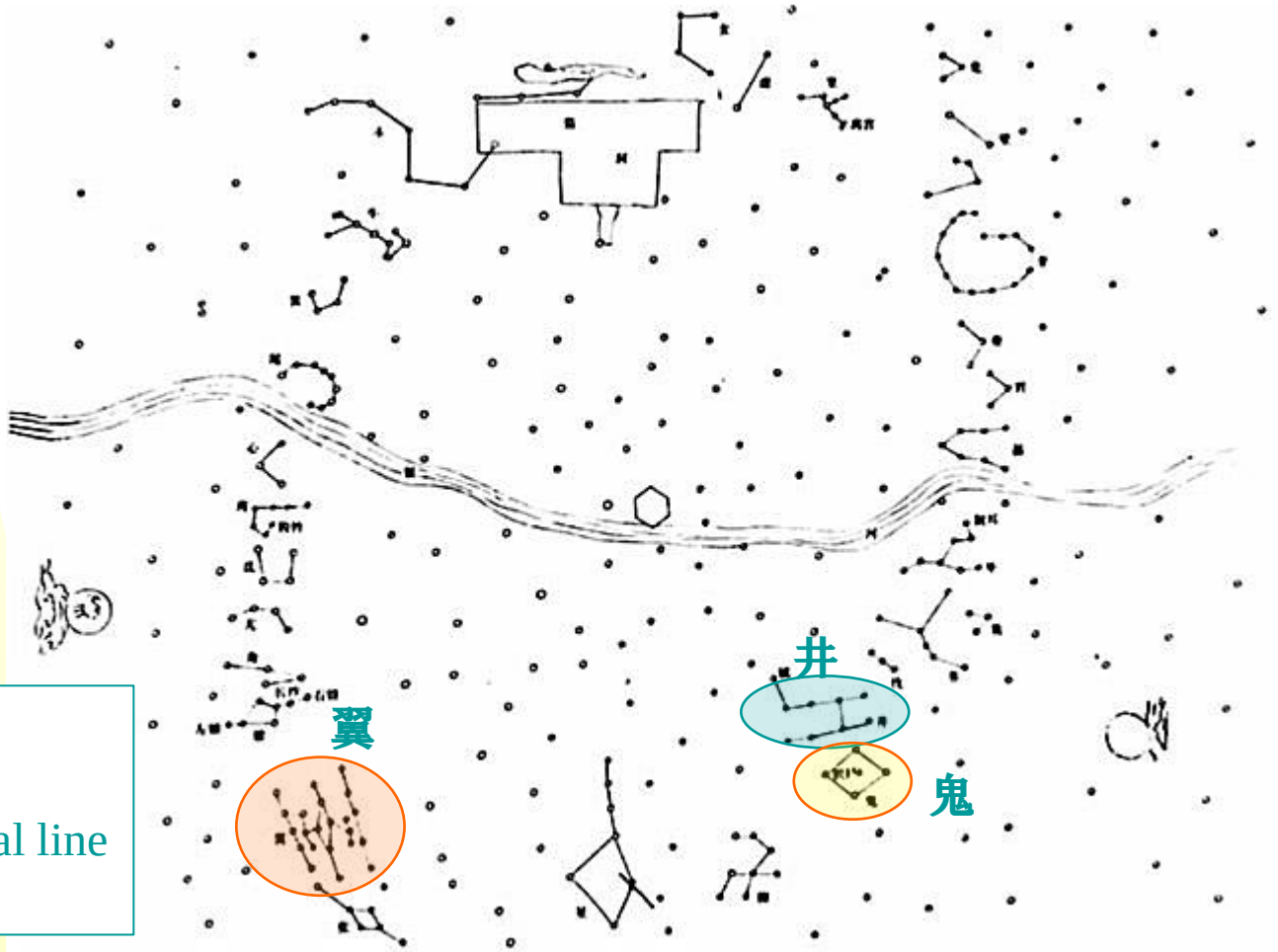
五代・後梁(907-923)・王処直墓(924)

唐朝末年和五代後梁・義武軍節度使・王処直(863年—923年)之墓。



https://www.163.com/dy/article/DVA6F2HV0523G0SJ.html

河北省曲陽県
西燕川村付近



- **翼宿:** 3parts (with tentacles)
- **井宿:** One Horizontal line
- **鬼宿:** Square

[庄蕙芷『再論日本奈良的両座壁画墓及其天象図』p.208より]

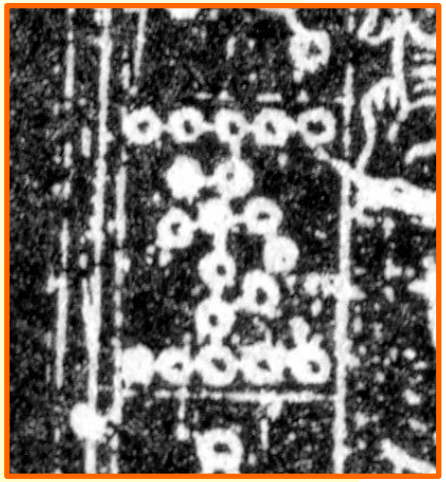
Grave Chamber Constellation Map (5/6)

五代・南唐(937-975)初期
墓誌函蓋に描かれた星宿図

- **翼宿：** Integrated
- **井宿；** 3 Horizontal lines
- **鬼宿：** Square

墓誌函蓋の例

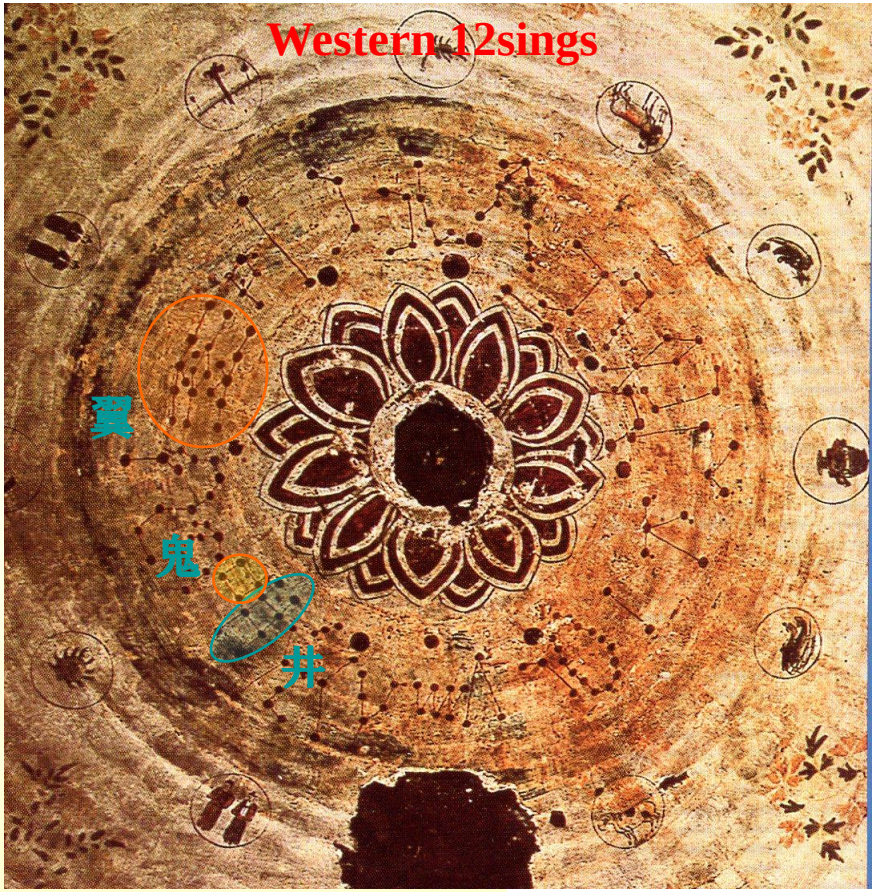
翼宿



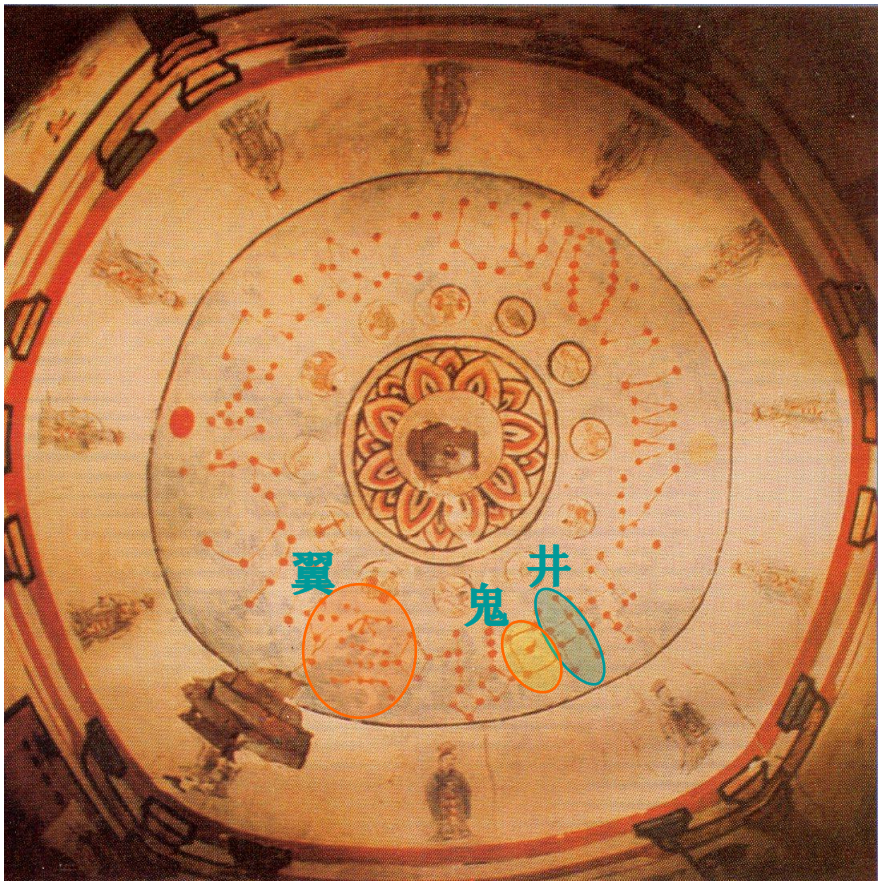
[潘鼎著『中国古天文図録』p.46より]

Grave Chamber Constellation Map (6/6)

【張世卿墓星図】(1116)



【張恭诱墓星図】(1117)



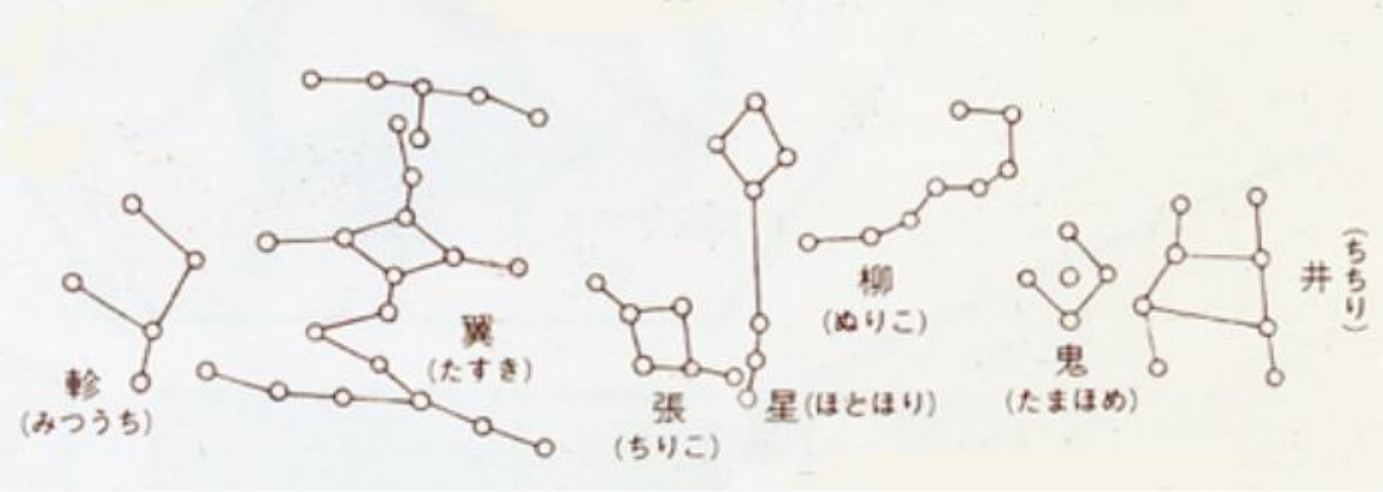
- **翼宿:** 3parts
- **井宿:** 2 Horizontal lines
- **鬼宿:** Square
- Western 12 signs

河北・宣化遼墓室星図

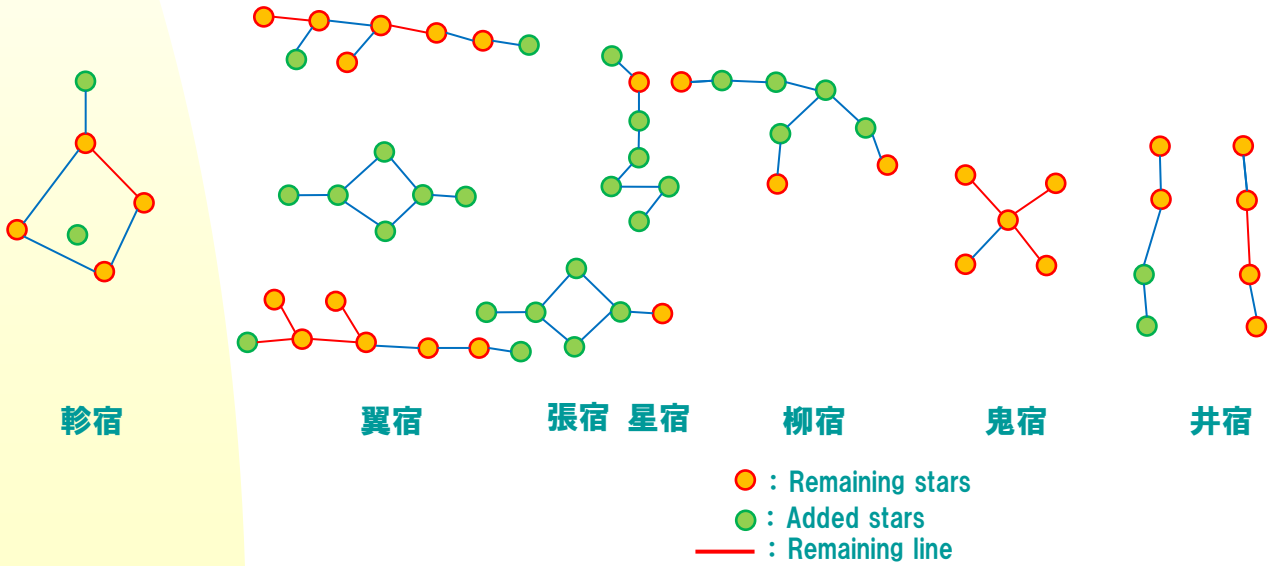
[星図は潘鼎著『中国古天文図録』口絵p.7より]

Tentative restored map of 高松塚古墳

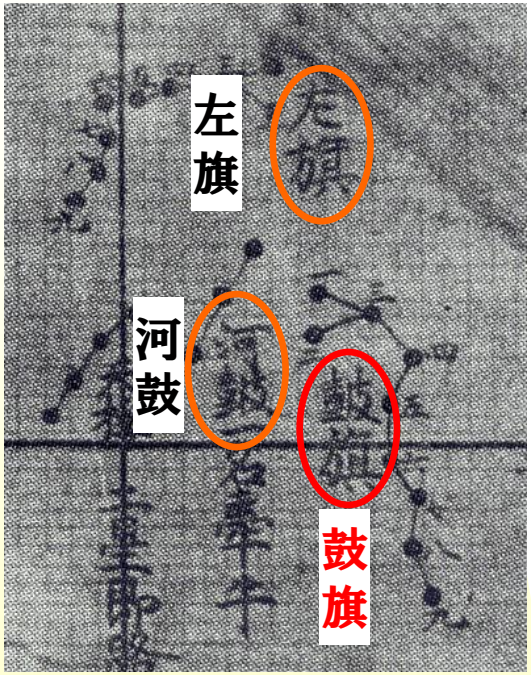
[Current]



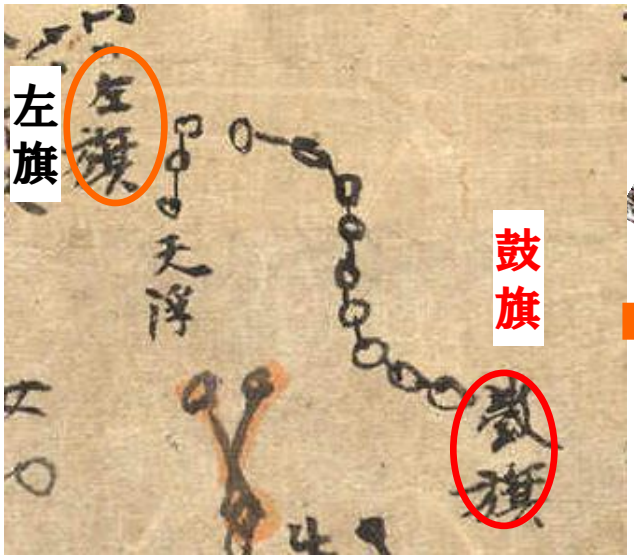
[Restored map]



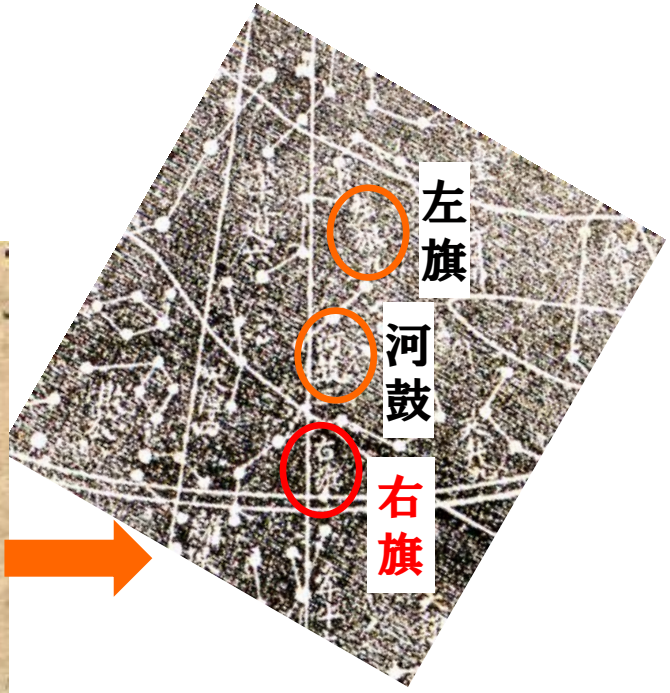
Changes in constellation names
「鼓旗」(Gu qi)⇒「右旗」(You qi)



『格子月進図』

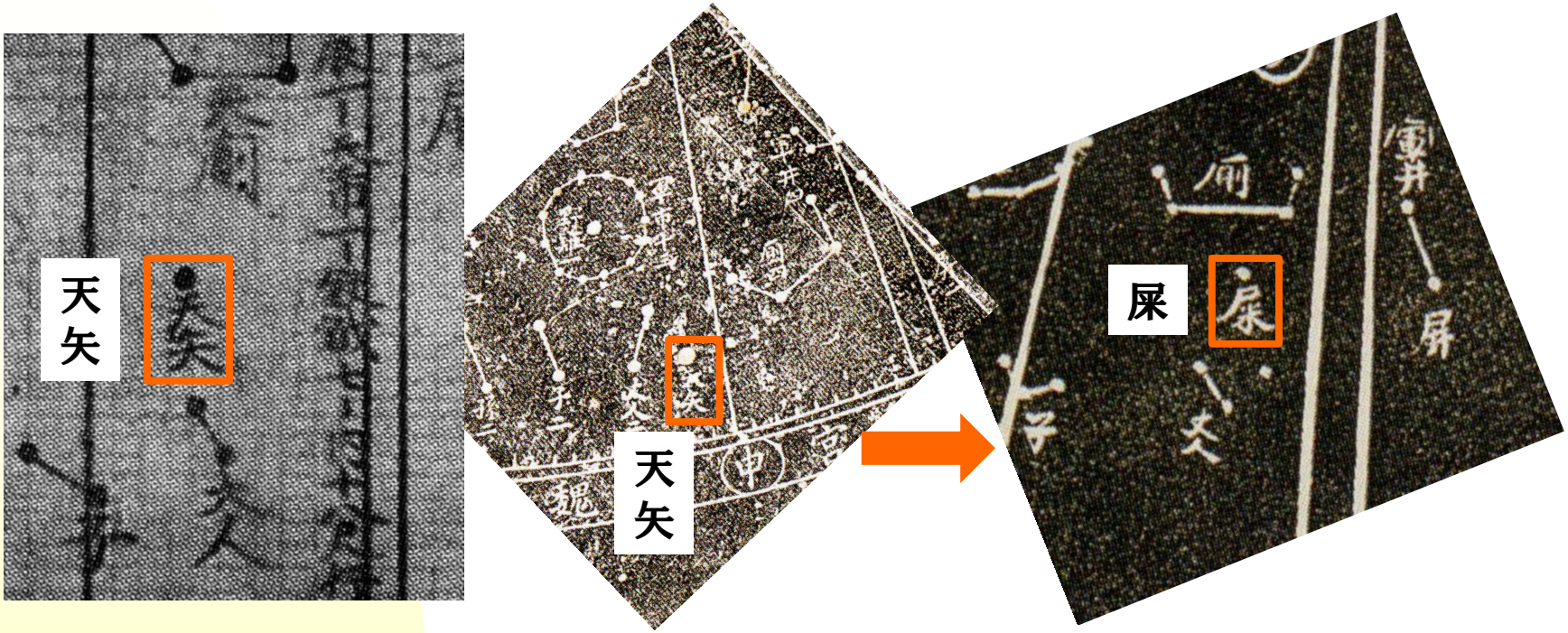


『敦煌天文図』



『天象列次分野之図』

Changes in constellation names
「天矢」(Tian shi)⇒「屎」(Shi)



『格子月進図』　『天象列次分野之図』　『蘇州天文図』

Chronological changes in constellation names

Star Charts and Documents in Tang Dynasty ⟷ In Song Dybasty

星座名称	格子月進図	隋書 晋書 (648編纂)	開元占経 (718～726)	敦煌天文図	天象列次分野之図	唐 歩天歌	蘇州天文図	蘇頌天文図
鼓旗	鼓旗	河鼓/旗	河鼓並旗	鼓旗	右旗	右旗	右旗	右旗
天矢	天矢	天矢	天矢	–	天矢	天屎	屎	屎
虎賁	武賁 (character replacement by 避諱*)	武賁	虎賁	虎賁	虎賁	虎賁	虎賁	虎賁
天淵	天泉 (character replacement by 避諱*)	天池	天淵	天淵	天淵	天淵	天淵	天淵

(Changes corresponding to 左旗)

(Pronunciation is same)

*避諱(taboo): Prohibit the use of the personal names of the emperor and his relatives.

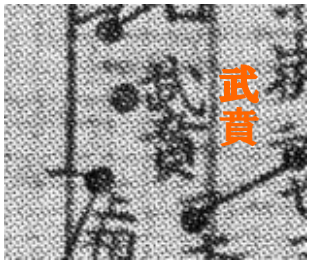
taboo related to「格子月進図」

- **避諱(taboo): Prohibit the use of the personal names of the emperor and his relatives.**
- **避諱 is an important factor in the dating of ancient Chinese documents.**

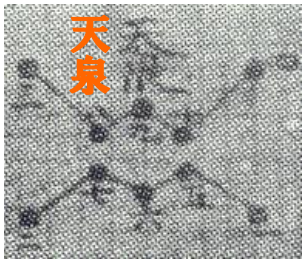
「晋書」「隋書」compiled at the same time, has replacement to「武賁」「天池」.

status of taboo of『格子月進図』

虎賁⇒武賁



天淵⇒天泉



右民角

唐代皇帝

- 李虎
- 李昞
- 高祖・李淵(618～626)
- 太宗・李世民(626～649)
- 高宗・李治(649～683)

「虎」と「淵」are prohibited.「民」is not prohibited.

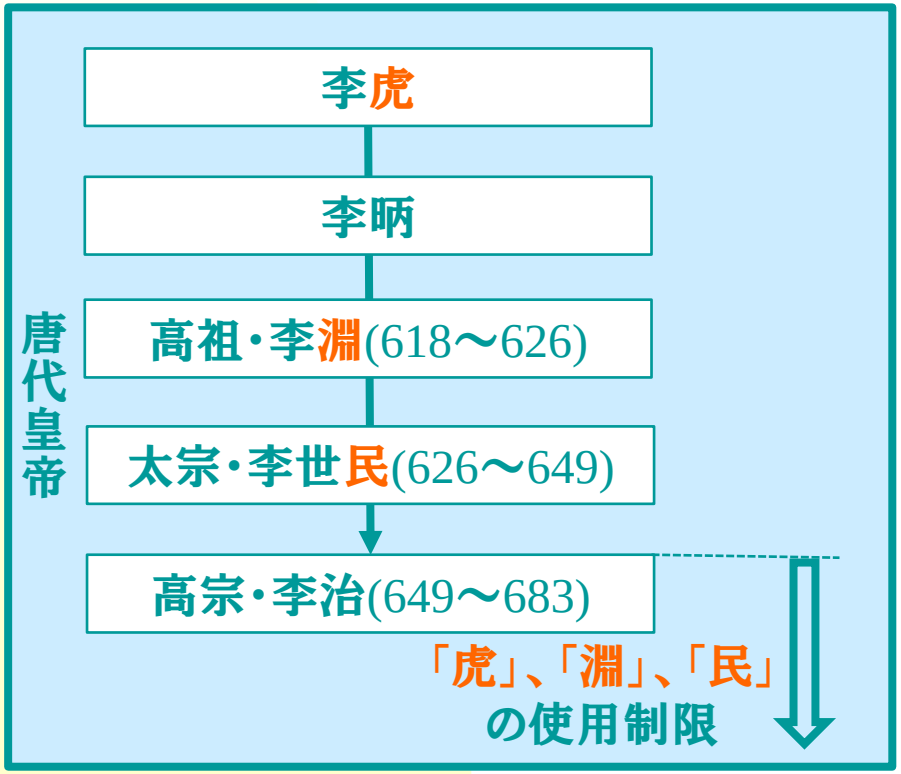
『格子月進図』was transcribed during this period.(618～649)

「虎」、「淵」、「民」All prohibited.

taboo related to「敦煌天文図」

The "Dunhuang Astronomical Map" is also presumed to have been written in the period of King Gojong (649-683), based on the character of the "**民**" (reference [46]). However, the character that is avoided is not the star map, but the cloud (weather) forecast part.

⇒ "**虎**(Tiger)" and "**淵**(Yuan)" are used in star charts, I think that they were copied from different originals.



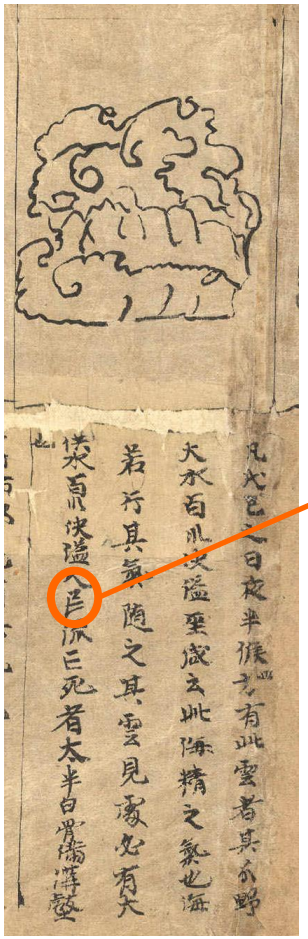
[http://www.atlascoelestis.com/Dunhuang%20VII%20sec%20base.htmlより]

『星図』

虎賁(誤字)

天淵(誤字)

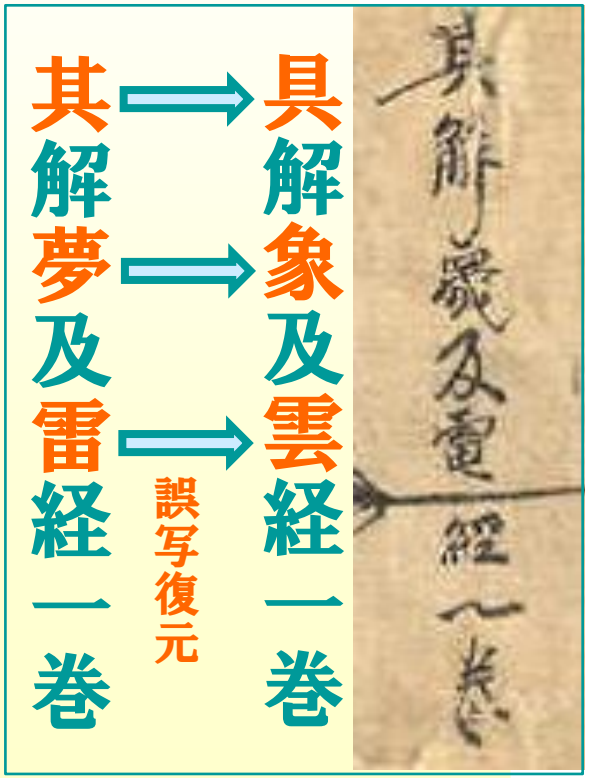
『雲(気象)占い』



民の一画を欠いている。(避諱の方法の一つ)

The scroll containing「敦煌天文図」consists of two parts

The Dunhuang Astronomical Map has a title that has not yet been deciphered. In the paper (Reference [45]), for example, it is read as "The interpretation of the dream and thunder sutra one volume, and there is an interpretation of "The interpretation of dreams and the book of lightning".
⇒The person who copied "Dunhuang Astronomical Map" did not speak Chinese as their native language, and made many mistakes. The title of the book can be read as**『具解象及雲経一巻』**(Detailed Interpretation of Celestial Phenomena and Cloud Divination). The first half and the second half are connected without any context, and are probably copies from two books.



Recovery from the error

Second half:
Forecast by heaven

First half:
Forecast by Cloud

[http://www.atlascoelestis.com/Dunhuang%20VII%20sec%20base.html**より**]

Date Estimation Results Based on Constellation Shapes and Names

Related document

晋書・隋書天文志(648)

開元占経(718～726)

Value of 12 order is same

唐・歩天歌(唐末)

The author is said to be "Tan Yuanzi" of the Sui Dynasty, but the name of the constellation was around the end of the Tang dynasty.

Ancient Chinese Star Chart

格子月進図(618～649)

Based on taboo.

高松塚星宿図/キトラ天文図(700頃)

敦煌天文図(800頃)

天象列次分野之図(900頃)

Similar to chart of Song Dynasty

蘇頌天文図(1086～93頃)

蘇州天文図(1190頃)

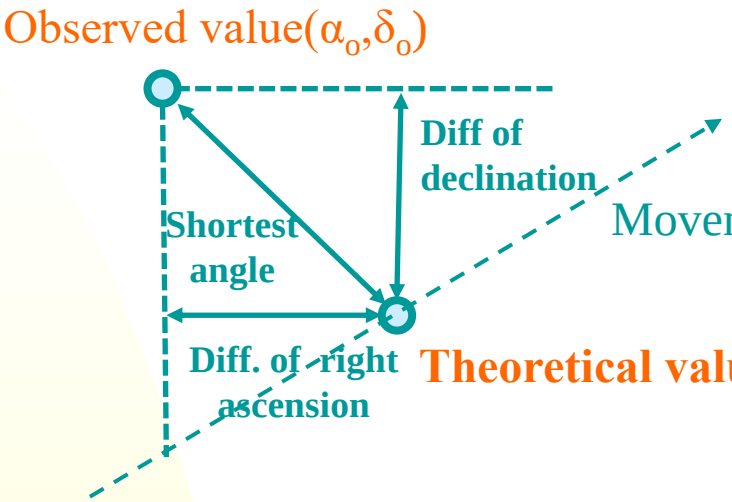
Chart of Tang Dynasty

Chart of Song Dynasty

Ⅲ. Dating of the Observations and 1st Chart

5. Dating by the star positions

How to use the least squares method for the Western star catalog



Movement of stars by precession

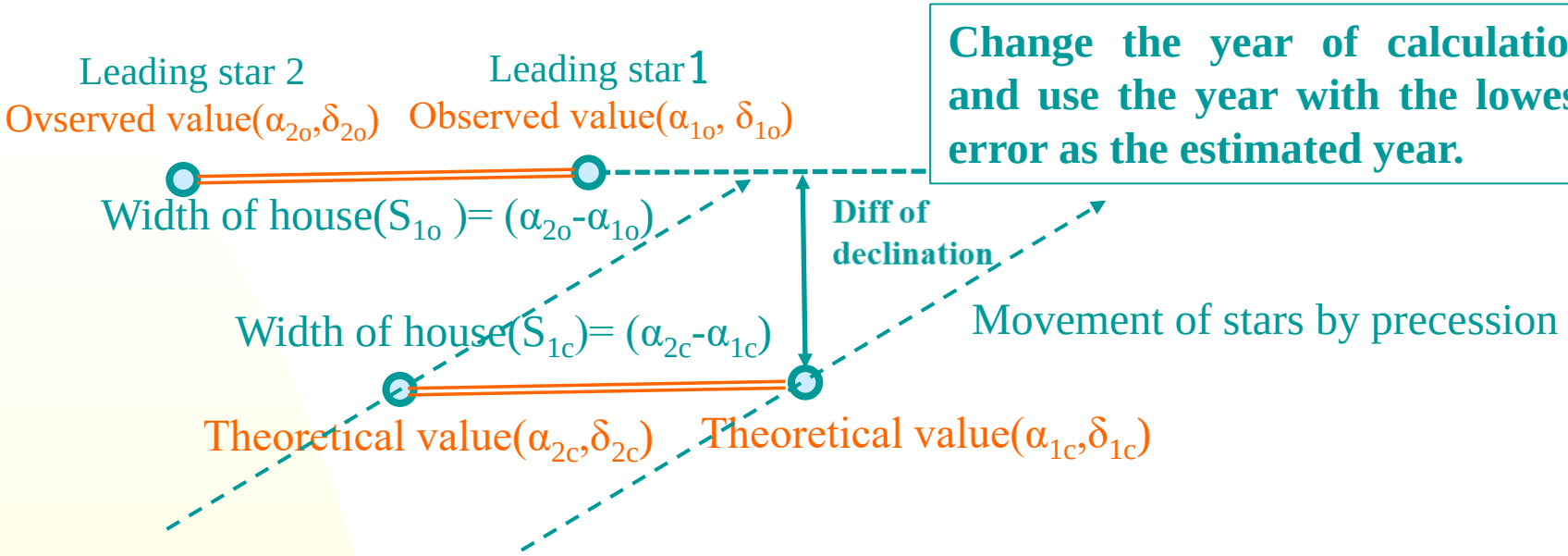
Change the year of calculation and use the year with the lowest error as the estimated year.

α：right ascension
δ：declination

In the case of the Western star catalog, since the right longitude is the absolute value from the vernal equinox, the year that minimizes the error in the following formula is the estimated central year.

- **Declination method：** $\Delta L = \sum (\delta_o - \delta_c)^2$
- **Right ascension method：** $\Delta L = \sum (\alpha_o - \alpha_c)^2 \cos^2 \delta_c$
- **Declination and ascension method：** $\Delta L = \sum ((\delta_o - \delta_c)^2 + (\alpha_o - \alpha_c)^2 \cos^2 \delta_c)$

How to use the least squares method for the Chinese star catalog (1/2)

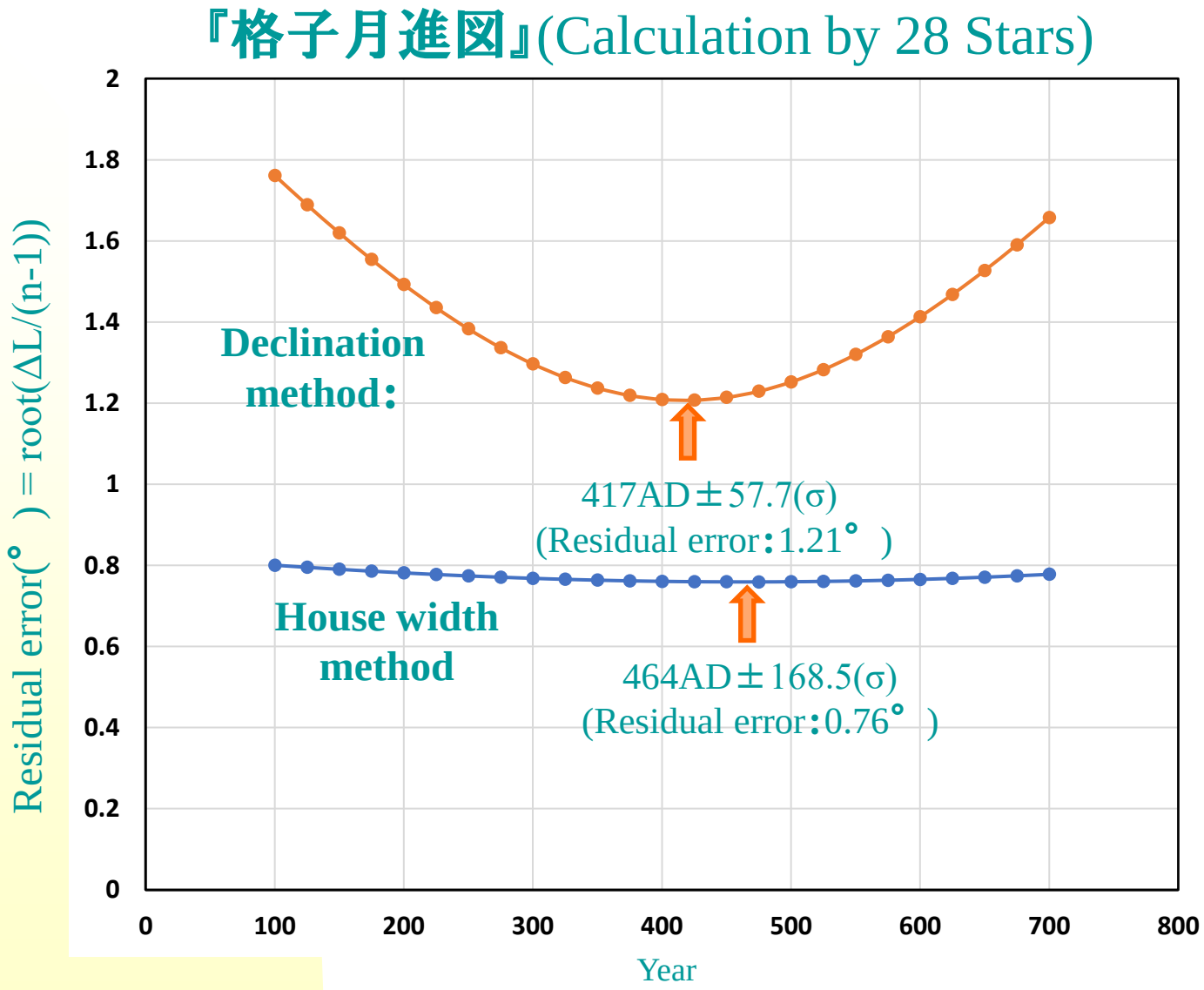


Change the year of calculation and use the year with the lowest error as the estimated year.

In the case of the Chinese star catalog, the right ascension is the angle from the leading star, so the absolute position in the right ascension direction is not determined. The right ascension direction is compared by the width of house, which is from leading star to next leading star. Declination is the same.
The year that minimizes the error in the following formula is the estimated central year.

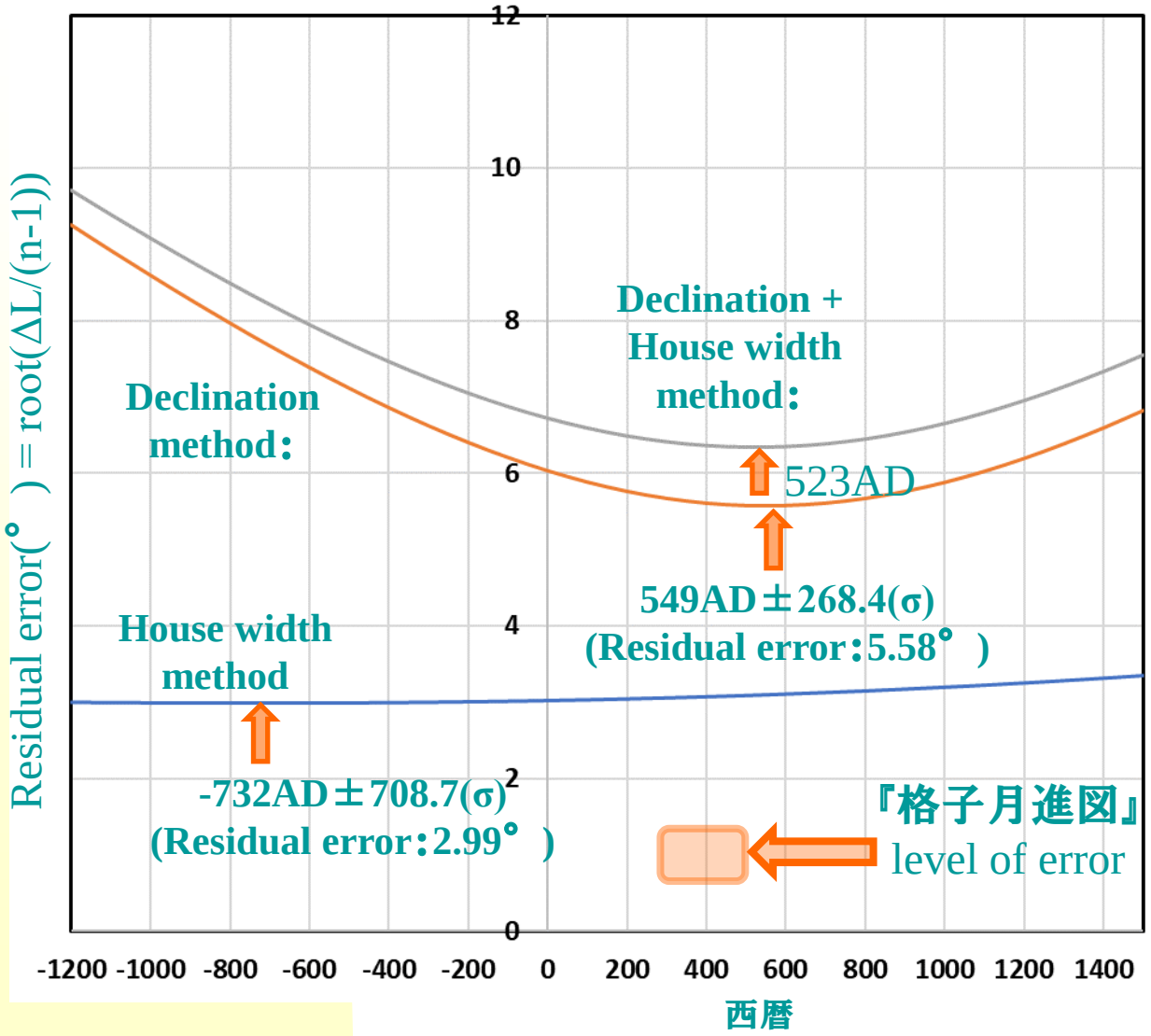
- **Declination method: $\Delta L = \sum (\delta_o - \delta_c)^2$**
- **House width method: $\Delta L = \sum (S_o - S_c)^2$**

Example of least squares simulation (1/2)



Example of least squares simulation (2/2)

『キトラ天文図』(Calculation by 28 Stars)



How to use the least squares method for the Chinese star catalog (2/2)

Even in the case of the Chinese star catalog, if the right ascension can be assumed, the year that minimizes the error of the following formula will be the estimated central year.

Declination and ascension method: $\Delta L = \sum ((\delta_o - \delta_c)^2 + (\alpha_o - \alpha_c)^2 \cos^2 \delta_c)$

Method of MR. Tsugo Nakamura (28 constellations bootstrap method)

①First, assuming that the right ascension of the first star is 0 degrees (reference star), calculate the right ascension of each star. Let $Year_1$ be the year that minimizes ΔL_1.

②Next, let $Year_2$ be the year that minimizes ΔL_2 with the right longitude of the next stellar leading star at 0 degrees (datum star).

③After calculating 28 constellations, the average of $Year_1$ to $Year_{28}$ is taken as the estimated central year.

Since the bootstrap method is not used as a calculation method here, it is called the declination/estimated right ascension method.

Note: The right ascension of the reference star has a true value of 0 degrees, so the error is 0.

Example of virtual right ascension(「格子月進図」)

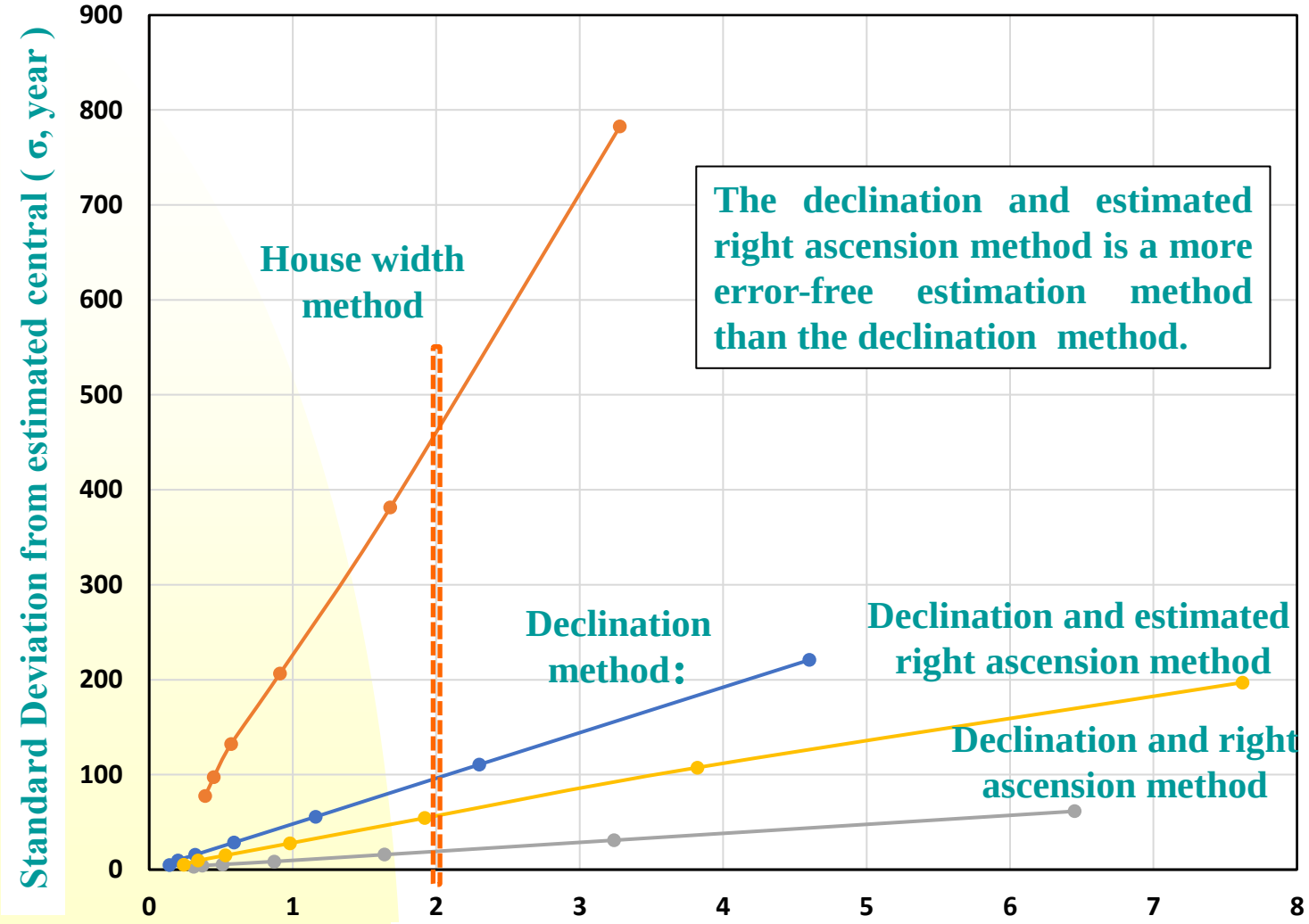
Size of house Declination

宿名	HR	距星	宿広度	去極度	仮定赤経(1)	仮定赤経(2)	仮定赤経(3)
角	5056	67 α Vir	12.00	93.00	0	354.00	345.00
亢	5315	98 κ Vir	9.00	90.50	12.00	0.00	357.00
氐	5531	9 α 2 Lib	16.00	97.25	21.00	9.00	0.00
房	5944	6 π Sco	5.00	109.00	37.00	25.00	16.00
心	6084	20 σ Sco	5.00	110.00	42.00	30.00	21.00
尾	6247	μ 1 Sco	18.00	123.00	47.00	35.0	
箕	6746	10 γ 2 Sgr	11.00	120.00	65.00	53.0	
斗	7039	27 φ Sgr	26.00	117.00	76.00	64.00	55.00
牛	7776	9 β Cap	8.00	108.75	102.00	90.00	81.00
女	7950	2 ε Aqr	12.00	105.50	110.00	98.00	89.00
虚	8232	22 β Aqr	10.00	101.00	122.00	110.00	101.00
危	8414	34 α Aqr	17.00	98.50	132.00	120.00	111.00
室	8781	54 α Peg	16.00	83.25	149.00		
壁	39	88 γ Peg	9.00	82.75	165.00		
奎	215	34 ζ And	16.00	71.25	174.00	162.00	153.00
婁	553	6 β Ari	12.00	76.00	190.00	178.00	169.00
胃	801	35 Ari	14.00	71.00	202.00	190.00	181.00
昴	1142	17(b) Tau	11.00	72.00	216.00	204.00	195.00
畢	1409	74 ε Tau	16.00	75.00	227.00	215.00	206.00
觜	1876	37 φ 1 Ori	1.00	83.00	243.00	231.00	222.00
参	1852	34 δ Ori	10.00	92.50	244.00	232.00	223.00
井	2286	13 μ Gem	33.00	68.00	254.00	242.00	233.00
鬼	3357	31 θ Cnc	3.00	67.00	287.00	275.00	266.00
柳	3410	4 δ Hya	15.00	81.00	290.00	278.00	269.00
星	3748	30 α Hya	7.00	95.00	305.00	293.00	284.00
張	3903	39 υ 1 Hya	19.00	100.75	312.00	300.00	291.00
翼	4287	7 α Crt	18.00	101.00	331.00	319.00	310.00
軫	4662	4 γ Crv	17.00	98.00	349.00	337.00	328.00

Second reference star

First reference Star

Simulation results using each estimation method



Estimated years of ancient star charts by various estimation methods

Star chart with the smallest error

The error is large and cannot be used for estimation.

Charts	Declination			House width			Declination & estimated right ascension		
	Center year	Σ (year)	error (°)	Center year	σ (year)	error (°)	Center year	σ (year)	error (°)
格子月進図	417	57.7	1.2	464	168.5	0.8	336	62.5	2.33
天象列次分野之図	472	182.8	3.8	-18	459.9	2.0	375	118.8	4.49
キトラ天文図(*)	549	268.4	5.6	-732	708.7	3.0	445	191.5	7.29
蘇州天文図	1108	114.9	2.4	1018	501.7	2.2	1124	88.6	3.33
蘇頌星図	1087	149.1	3.1	947	95.2	0.4	1080	83.8	3.15

Song Dynasty star charts are consistent with the presumption of "observations during the Yuanfeng era (1078-85)

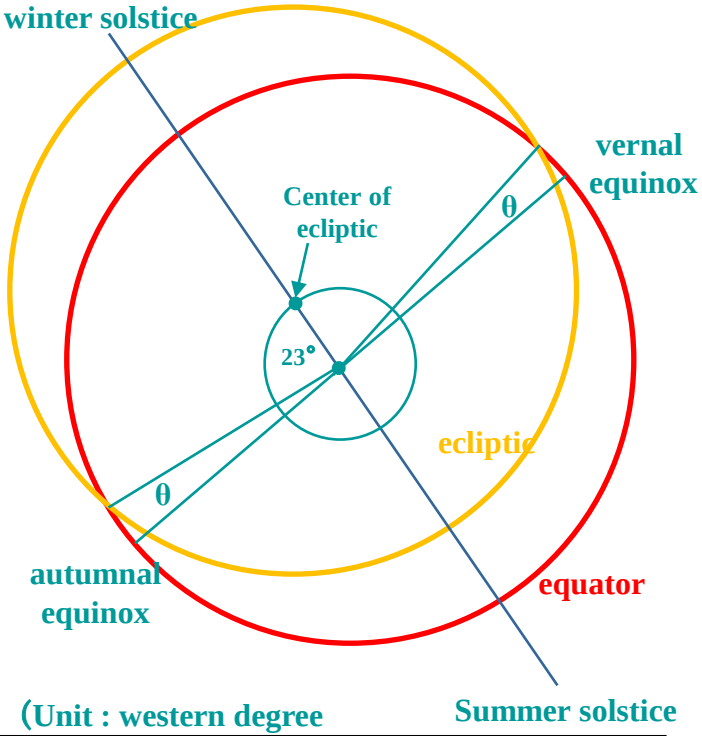
Note : *For the Kitora astronomical chart, 3-range stars with large errors have been corrected. See the papers for the data used.

6. Dating by the vernal and autumnal equinox (ecliptic)

Dating by the vernal and autumnal equinox (ecliptic)

The eccentric circles in Chinese star charts are drawn with the same diameter as the equator, so the vernal and autumnal equinoxes are not 180 degrees apart. (θ) must be shifted for correction.

(*Note: Kazuhiko Miyajima (2019) points out that the ecliptic in the Suzhou astronomical map may be in 300s AD.)



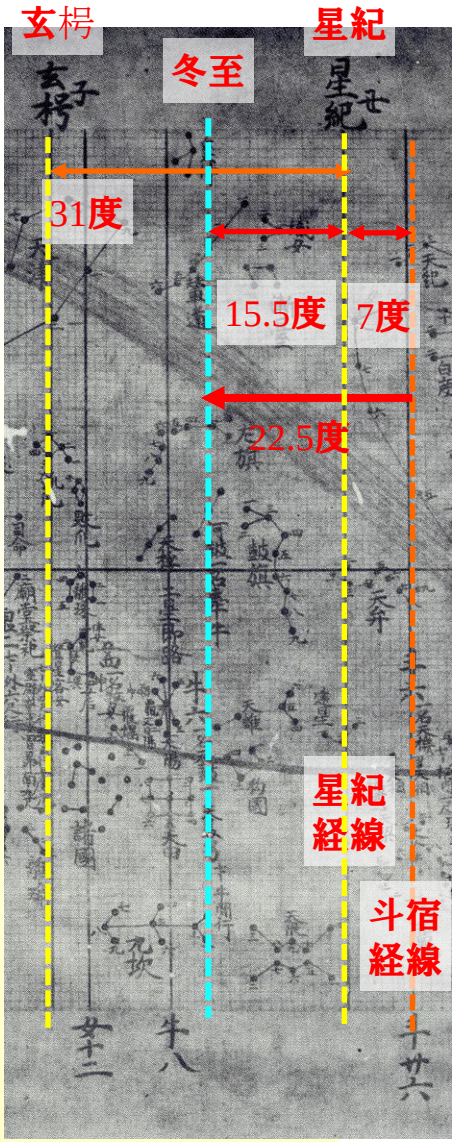
(Unit : western degree

星図	Vernal 奎宿	Autumn. 角宿	Diff. (°)	Correction (°)	vernal equinox 奎宿	vernal equinox year	Autumnal equinox 角宿	Autumnal equinox year	average year
蘇州天文図(*)	3.6	5.4	168.2	5.9	9.5	331	−0.5	386	359
天象列次分野之図	3.7	5.1	169.2	5.4	9.1	363	−0.3	370	367
格子月進図(右秋分)	5.9	3.9	173.1	3.4	9.3	347	0.5	307	327
格子月進図(左秋分)	5.9	−7.9	184.9	−	(presumed mis transcription)				
キトラ天文図(反転)	3.7	19.6	163.2	−	(Not estimated due to large error)				

The ecliptic drawn in the 300s star charts were passed down to Song dynasty

7. Dating by 12th order (12sings)

Dating by 12th order for「格子月進図」



- Center of **星紀** is winter solstice
  - **斗宿**(Dou xiu) 22.5°
  - BC163
- Mr. Osaki's estimation
  - 12th order：BC190±21 (Including other season)
  - Declination method：AD500±50
  - Mysterious star chart which has two epochs

⇒Mystery of **『格子月進図』** There was a reason for this.

Note：**「格子月進図」**is the oldest star chart drawn in the 12th order of the seasons, and the other star charts are drawn in "field theory" and cannot be estimated.

[**『別冊太陽』**73号(1991)p.38-39**より**]

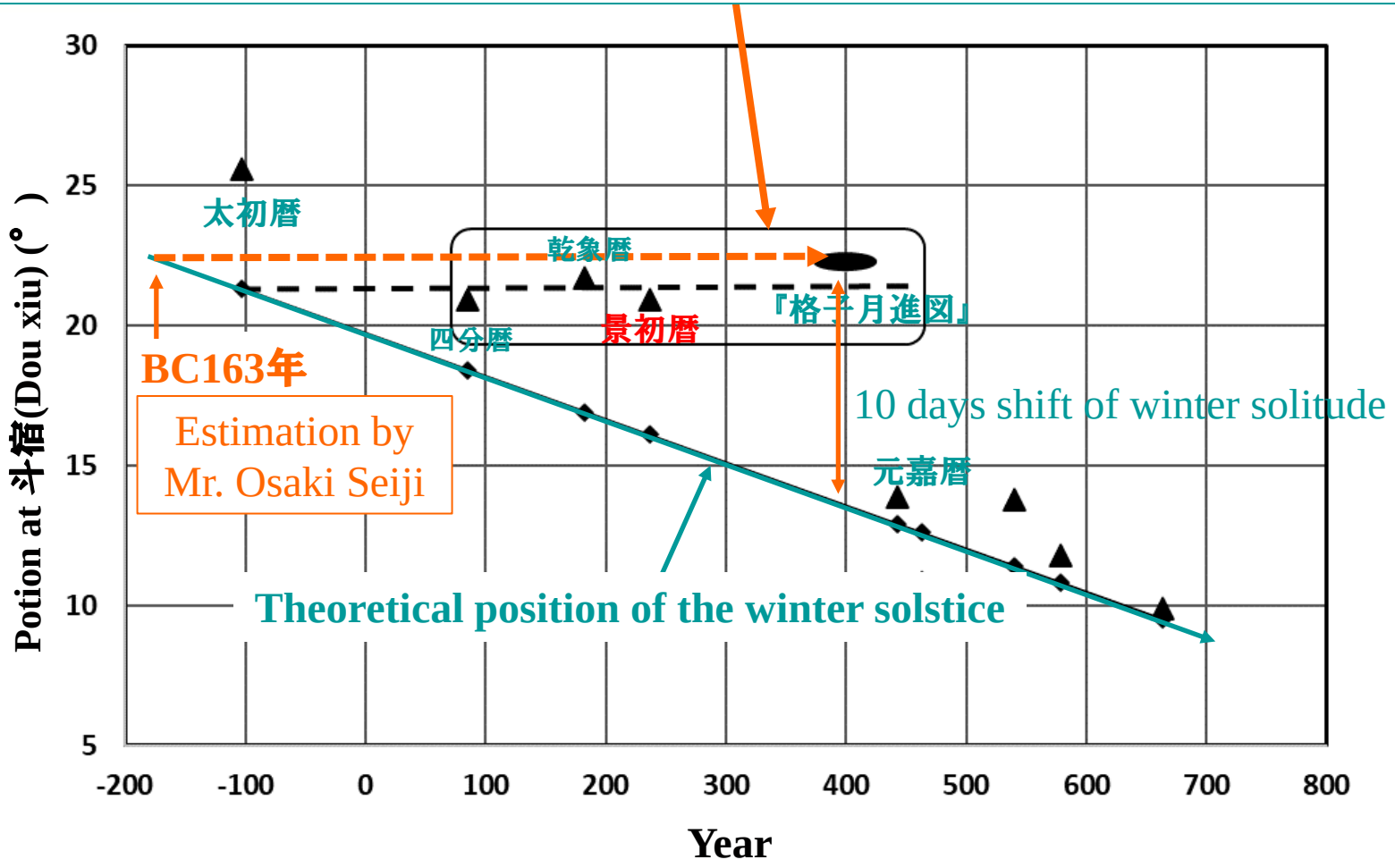
The position of the winter solstice in calendars

The position of the winter solstice at 斗宿(Dou xiu) (°)

暦法	暦法記載の値			計算値（270°との差）			大崎計算	『歴代天文律暦等志彙編』記載項
	暦修成年代	冬至の斗宿度**	西洋度(A)	斗距星赤経	斗宿度(B)	誤差(A-B)	対応年	
太初暦	-103	26(牛初)	25.6	248.7	21.3	4.3	−450	5冊p.1431
四分暦	85	21.25*	20.9	251.6	18.4	2.5	−70	5冊p.1518
乾象暦	182頃	22	21.7	253.1	16.9	4.8		5冊p.1580
景初暦	237	21少	20.9	253.9	16.1	4.9	−80	5冊p.1632
元嘉暦	443	14強	13.9	257.1	12.9	1.0	377	6冊p.1735
大明暦	463	11	10.8	257.4	12.6	-1.8		6冊p.1743
興和暦	540	14	13.8	258.6	11.4	2.4		6冊p.1843
大象暦	579	12	11.8	259.2	10.8	1.0		6冊p.1892
麟徳暦	664	10	9.9	260.5	9.5	0.4	639	7冊p.2199
月進図	−	22.5	22.2	247.8	22.2	0.0	−162	

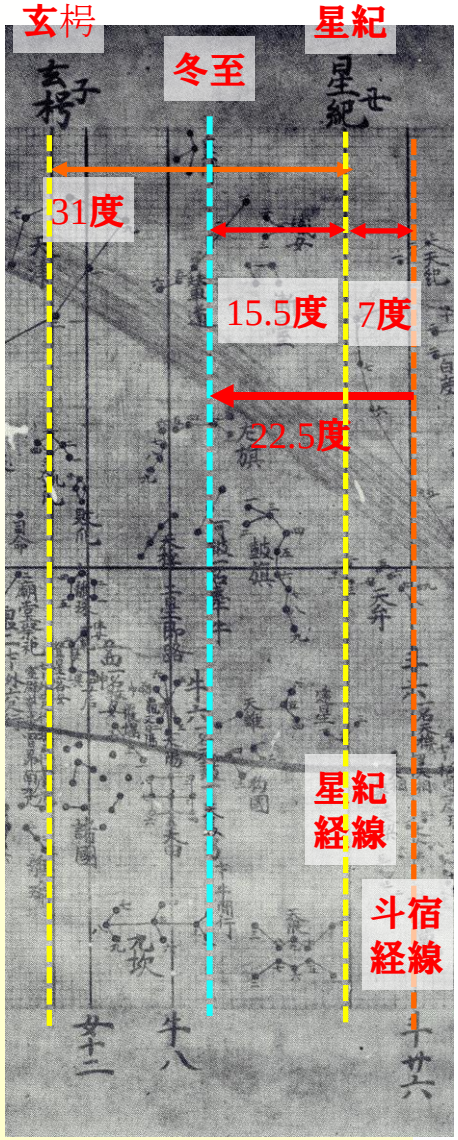
Chronological change in the position of the winter solstice in the calendar

The position of the winter solstice in the calendar was fixed at approximately 21.5 degrees of **斗宿**.
The **景初暦** was enforced until 451, and is almost consistent with the position of **『格子月進図』**.



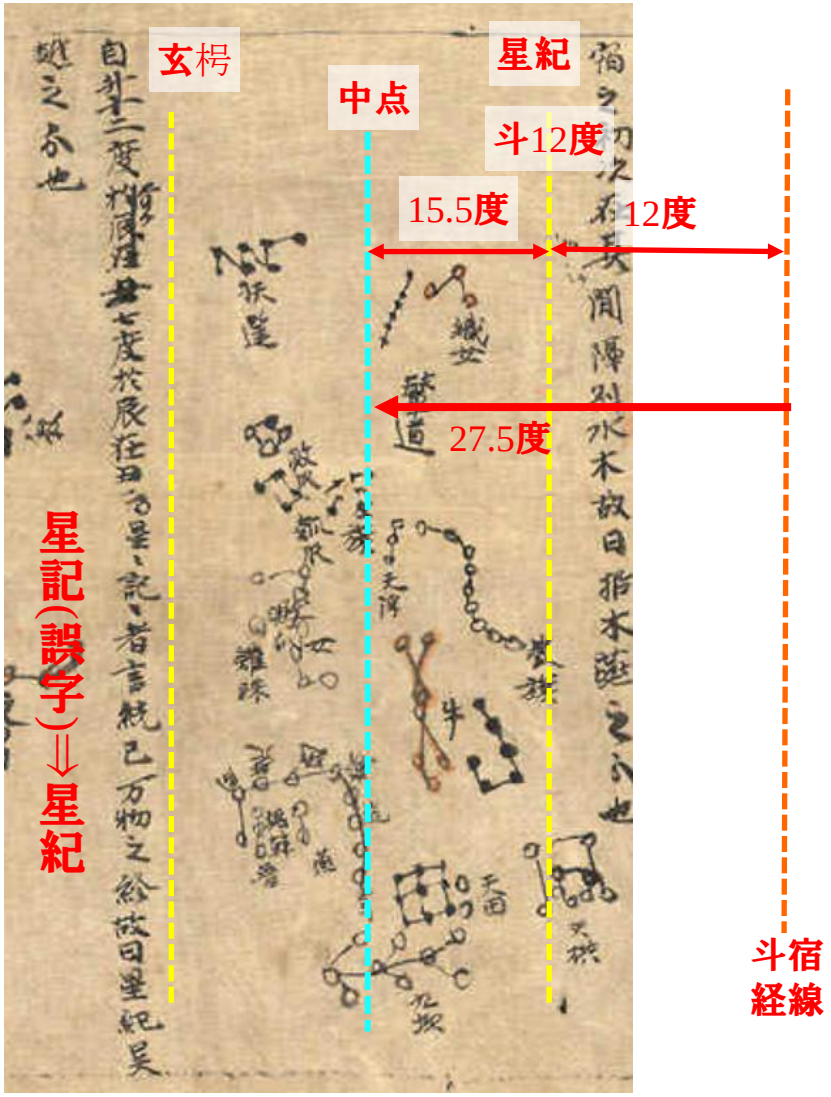
12th order after「格子月進図」

『格子月進図』Based on season



5° Difference

『敦煌天文図』Based on the astrology



[『別冊太陽』73号(1991)p.38-39より]

(It was not transcribed by Chinese)

8. Summary of dating of『格子月進図』

「格子月進図」Comparison of date of Original chart

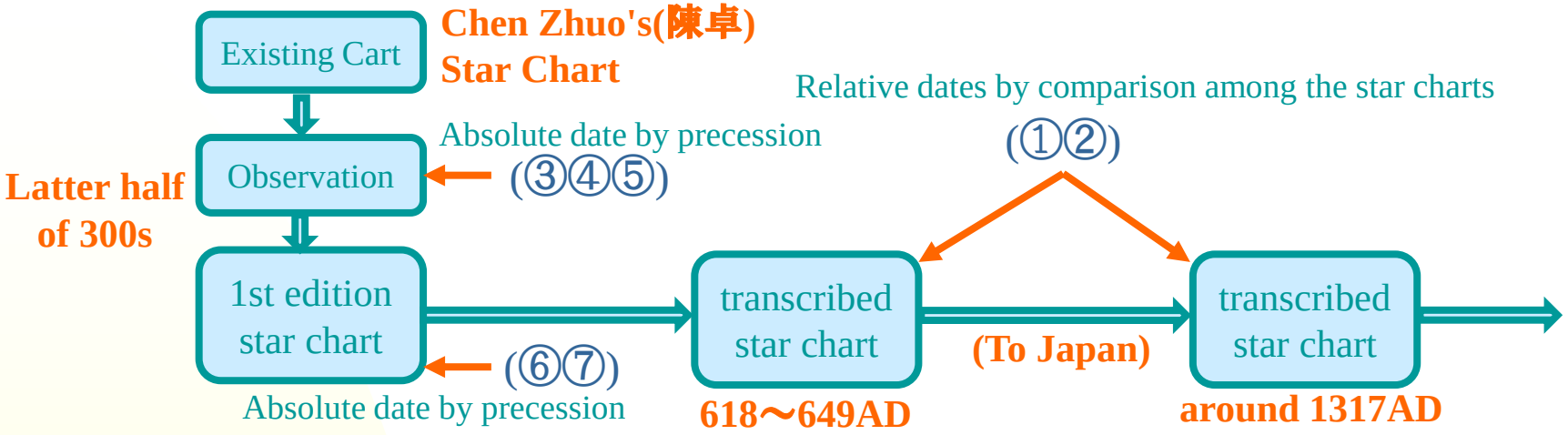
	vernal and autumnal equinox	12th order	Position of the star (the least squares method)			
			Declination method		House width	Estimated RA
			28 stars	more stars	28 stars	28 stars
Imoto (1942,1972)	1100 *1	–	–	–	After 一行(720)*2	–
Watanabe (1987)p.764	δAnd(814) ζAnd(653)*3 ηAnd(466)	–	–	–	After 一行(720)*2	–
Osaki (1987) p.270-271	**Recognized as lunar path**	BC190 ±21	AD319±58 [σ: 1.22°]	481±38 (163 stars) [σ: 1.84°]	–	–
Nakamura (2018)p.163	–	–	AD545±90 (21stars) [90%、σ: 2.1°]	–	AD485±20 (28宿) [90%、σ: 0.8°]	–
Author (2019,2022)	**AD327** (freehand drawing)	**Before AD451**	**AD417±58** [1σ] 417±18 [90%] [σ:1.21°]	**AD397±23** (1346stars) [σ: 3.12°]	**AD464±52** (28stars) [90%、σ: 0.76°]	**AD336±19** (28 stars) [90%、σ: 2.33°]

A star chart based on observation from the mid 300s to 400AD.

*1:The direction of precession was opposite. There is no correction.
*2:The estimate date of 一行 is 440AD±37。
*3:Leading star isζAnd. There is no correction.

2023/01/21

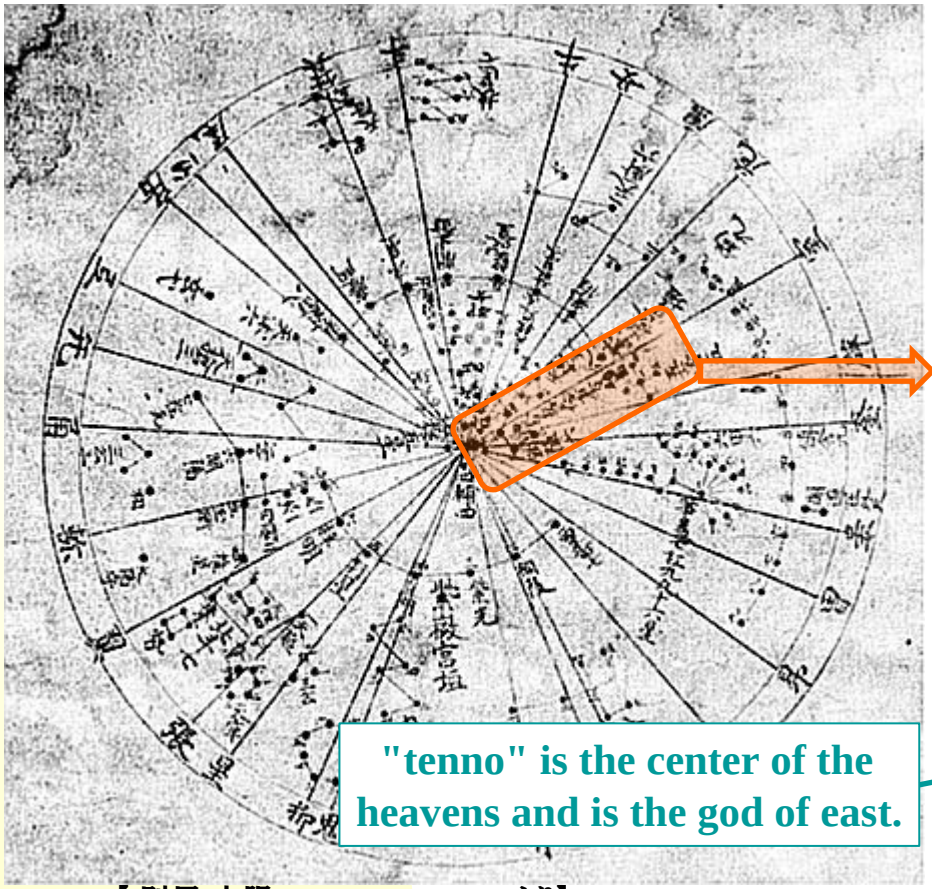
Estimated History of「格子月進図」



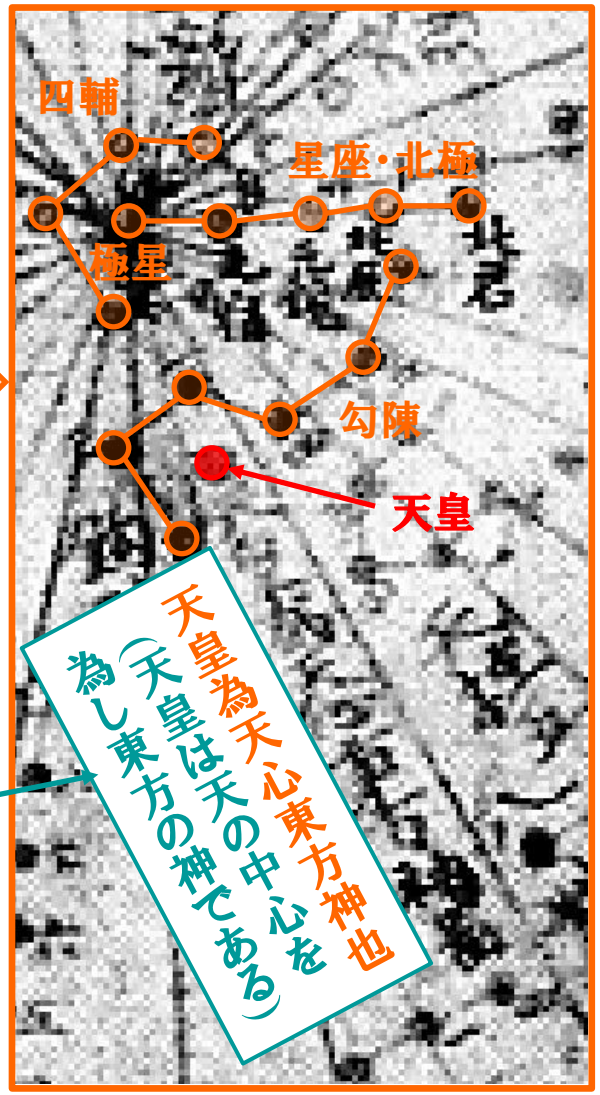
	Target	2017'paper	2018'paper	2022'paper
①Shape of the constellation	Date of the transcribed star chart	○		
②Name of the constellation		○		
③Position of star (right ascension)	Date of the Observation for the position of the stars		○	
④Position of star (declination)			○	
⑤Position of star (both)				○
⑥Vernal & autumnal equinoxes	Date of 1st edition of chart	△(w/o correction)		○(w correction)
⑦12th order (12 signs)				○

*：The vernal and autumnal equinox points and the 12th order are directly copied from the original chart.

Tenno star in『格子月進図』is origin of the name "Tenno"



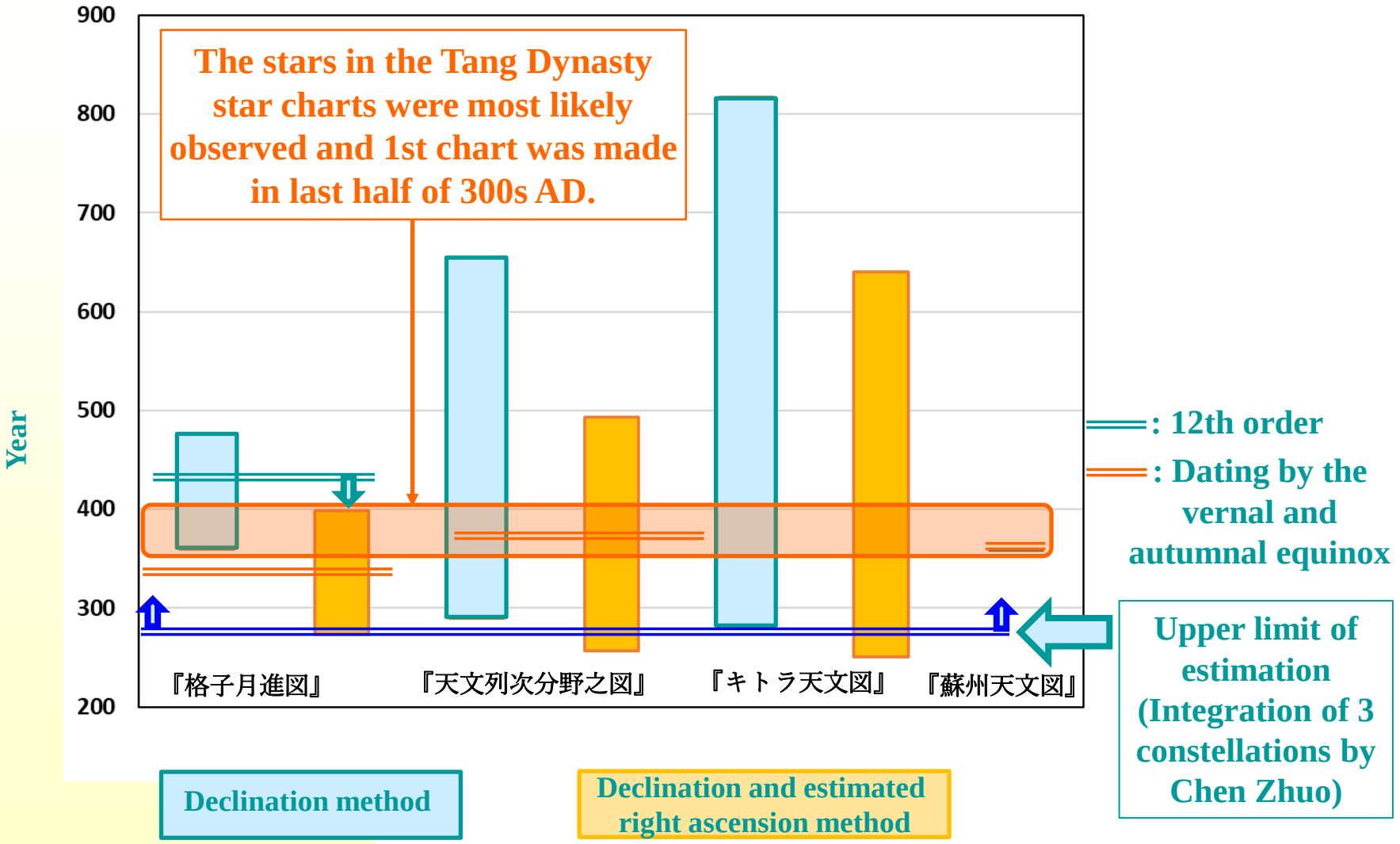
【別冊 太陽 No.73(1991) p.38より】



The star name of Great Emperor (**天皇大帝**) is in the **晋書**, but the **晋書** was completed after the 640s. So, it was not completed during the reign of Emperor Jomei (**舒明**).

9. Summary of dating of the Ancient Chinese star chart

Dates of Observation and 1st Star chart of Tang Dynasty Star Charts by precession



Summary of Dating of Ancient Chinese Star Charts

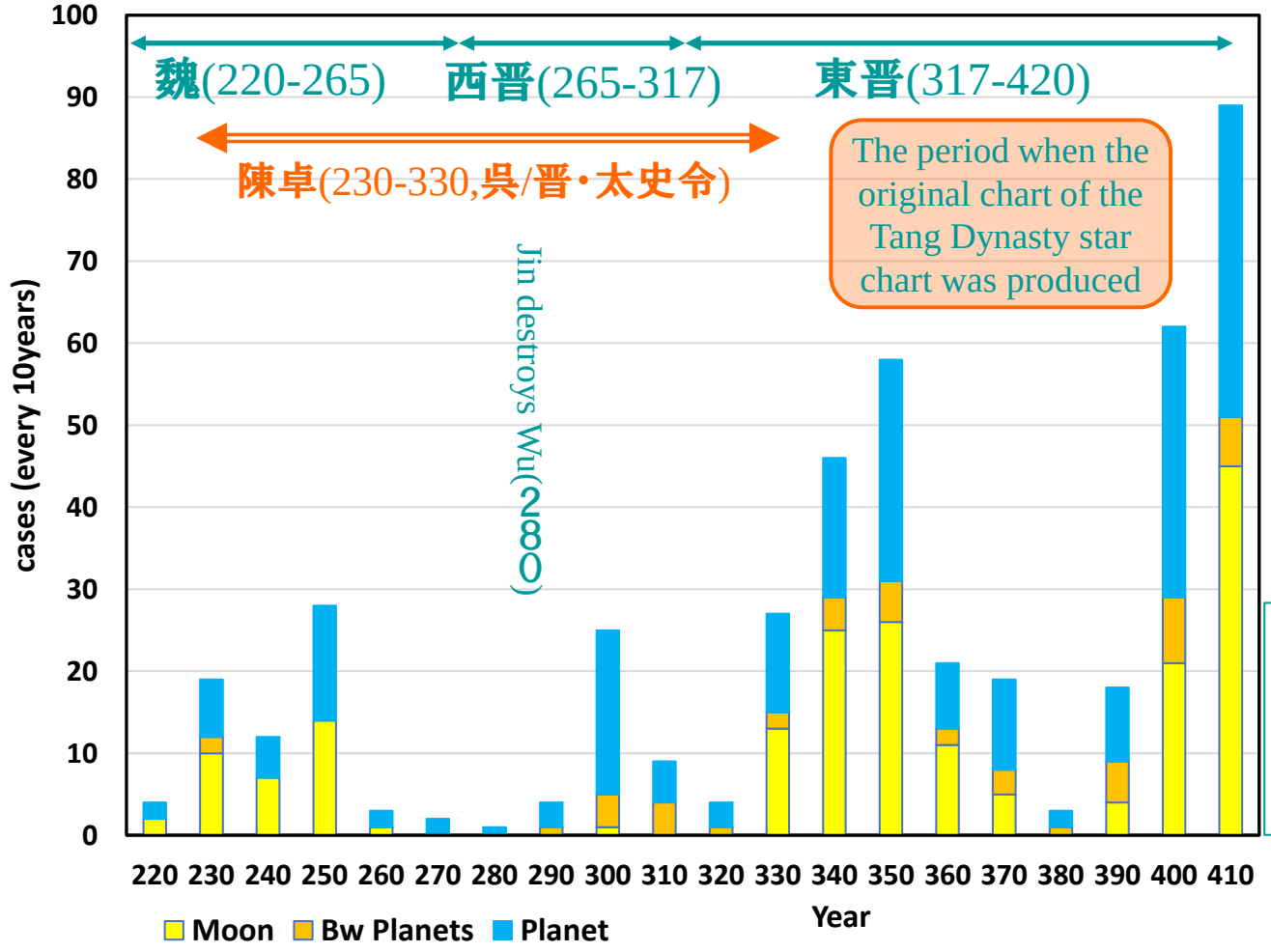
- The first edition of chart was produced based on observations in the last half of 300s AD.
- The dating by numerical calculation using precession just confirm it.
- The dating by names and shapes is important to know their position in the system of star charts.

Charts	Dating by name and shape	Dating by position of star [90%] (estimated RA)	vernal and autumnal equinox	12th order (season)	Pole Star
格子月進図	Bigging of Tang (618-649AD)	336AD±19(2.3°)	327AD	Before 451AD	HR4852
高松塚古墳星宿図	(around 700AD)	–	–	–	HR4852
キトラ天文図	(around 700AD)	445AD±59(7.3°)	–	–	HR4852
敦煌天文図	Middle of Tang (around 800AD)	–	–	(Astrology)	HR4852
天象列次分野之図	End of Tang (around 900AD)	375AD±37(4.5°)	367AD	(Astrology)	HR4893
蘇州天文図	Song (1247AD)	1124AD±27(3.3°)	359AD	(Astrology)	HR4893

Around 310AD, it was at north pole

Records of Occultations by Moons and Planets in the Book of Jin(晋書)

Accurate star charts were born from observations.



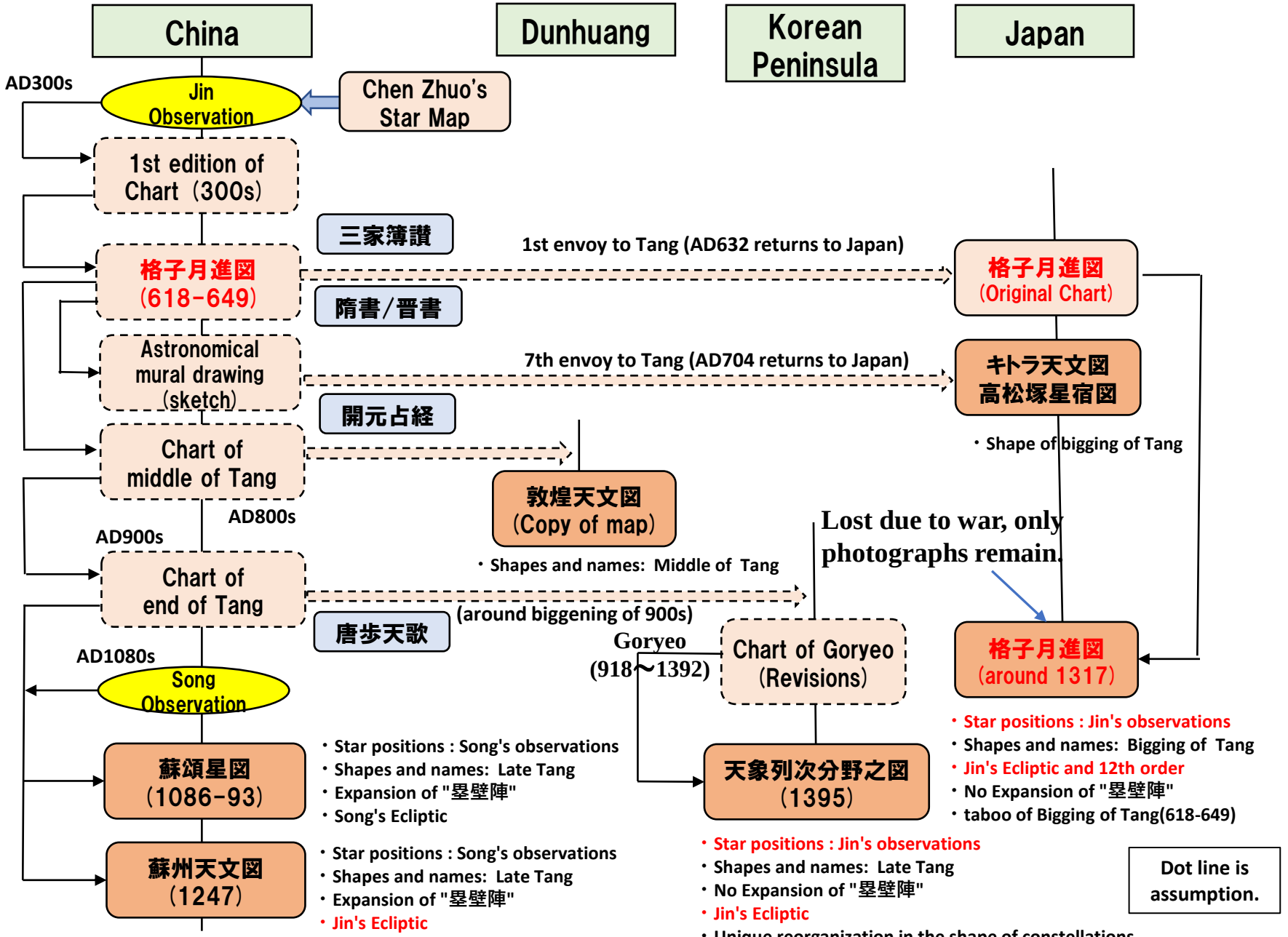
The accuracy of the records is extremely high at over 80%.

Capital of east Jin(**南京**)
Latitude：32.0°
Longitude：118.8°

太史令：in charge of astronomy, calendars, rituals, the drafting of national document.

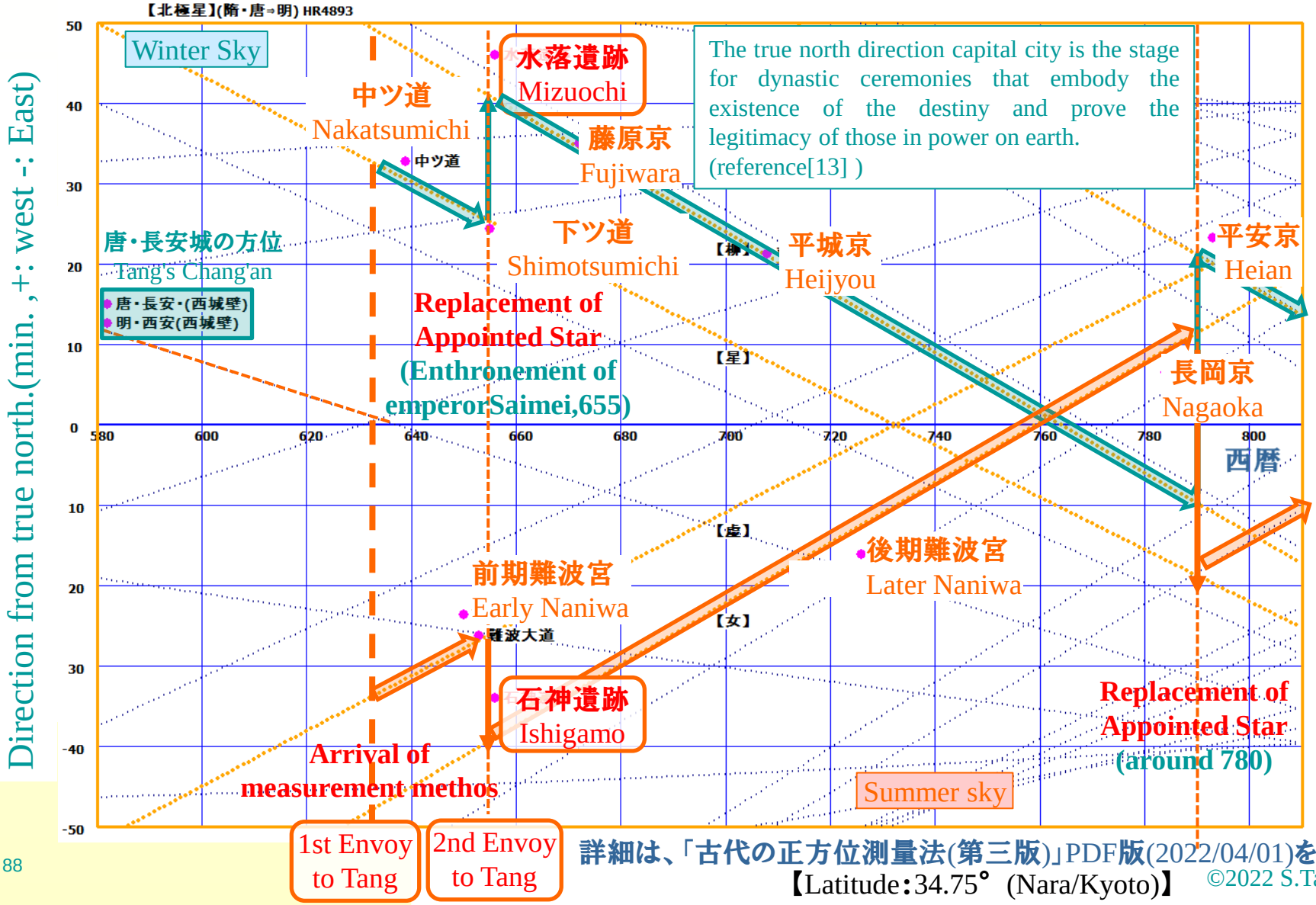
記録件数は斎藤国治/小沢賢二『中国古代の天文記録の検証』雄山閣 (1992)による

Family tree of ancient Chinses star chart



『格子月進図』was introduced along with Destiny Thought and Surveying Methods

Azimuth line by Pole star (HR4893) and direction of the ruins of Japan

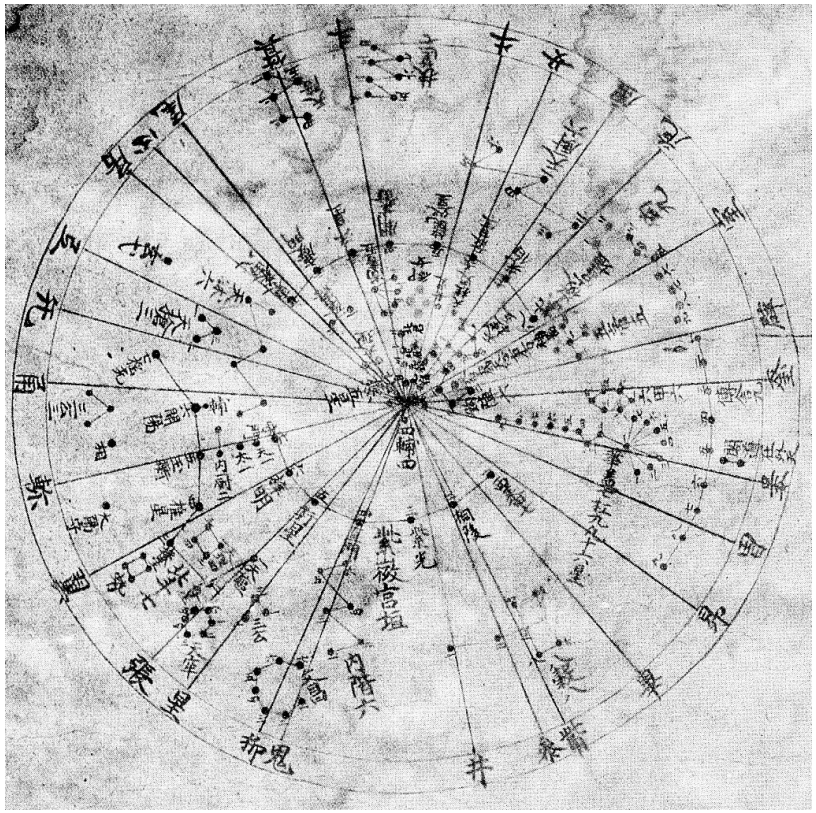


詳細は、「古代の正方位測量法(第三版)」PDF版(2022/04/01)を参照。

【Latitude：34.75°（Nara/Kyoto)】

Conclusion for the dating of ancient Chinese star charts

- The origin of the existing ancient Chinese star charts is the Jin Dynasty star chart in the 300s.
- The『格子月進図』is the oldest star chart that best conveys the characteristics of the star charts of the Jin Dynasty, and it is hoped that it will be preserved and restored as a world heritage.



【別冊 太陽 No.73(1991) p.38より】

Ⅳ. Star Chart of SHIBUKAWA Harumi

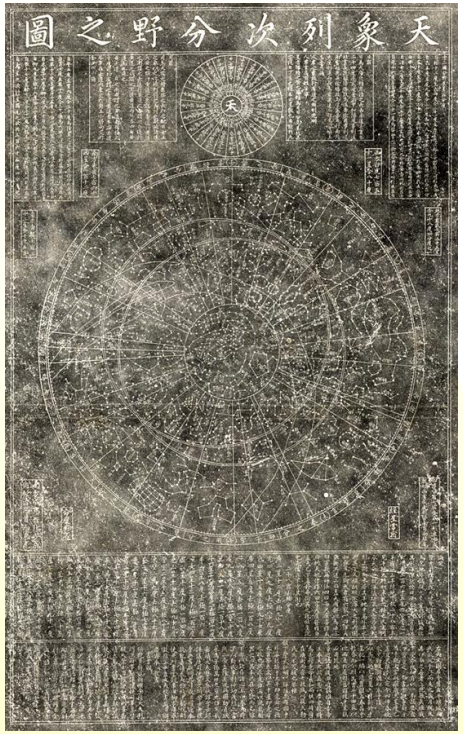
The Mystery of Harumi's Star Chart

- Compilation of the Jokyo calendar to replace the Senmyo calendar (1684).
- He also observed the stars, identified the stars in the Chinese constellations, and produced star charts and celestial globes.

⇒The star charts referred to in the observations and the creation of the star charts were unknown.

Charts of SHIBUKAWA Harumi 「天文列次之図」と「天文分野之図」

『天象列次分野之図』(1395)

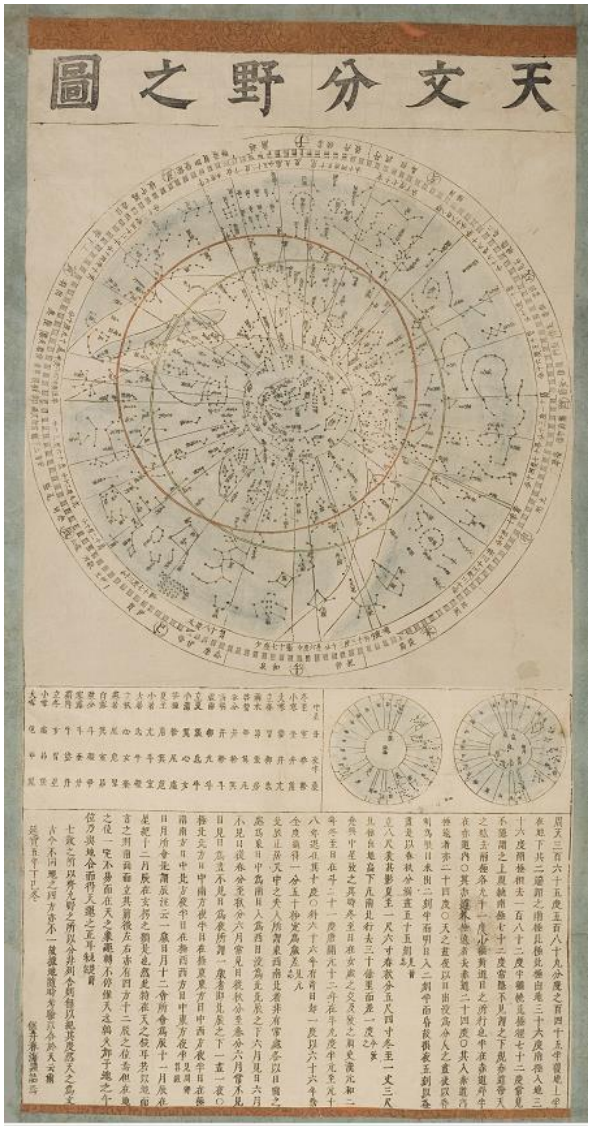


[京都大学附属図書館所蔵]

①『天文列次之図』(1670)

[国立公文書館]

②『天文分野之図』(1677)



[早稲田大学図書館]

Correction of leading stars by SHIBUKAWA Harumi

Errored Leading stars 『天象列次分野之図』 Charts of Harumi

No	宿	HR 番号	距星名	天象図 (Stone)	天象図 (Wood)	列次図	分野図	天文瓊統 (天文成象)
1	角	5056	α Vir					
2	亢	5315	κ Vir					
3	氐	5531	α Lib	ι Lib	ι Lib	ι Lib	ι Lib	
4	房	5944	π Sco					
5	心	6084	σ Sco					
6	尾	6247	μ^1 Sco					
7	箕	6746	γ Sgr					
8	斗	7039	φ Sgr					
9	牛	7776	β Cap					
10	女	7950	ε Aqr					
11	虚	8232	β Aqr					
12	危	8414	α Aqr					
13	室	8781	α Peg					
14	壁	39	γ Peg					
15	圭	215	ζ And					
16	楼	553	β Ari					
17	胃	801	35 Ari					
18	昴	1142	17 Tau					
19	畢	1409	ε Tau	δ^3 Tau	δ^3 Tau	γTau*	δ^1 Tau	
20	嘴	1876	φ^1 Ori					
21	参	1852	δ Ori					
22	井	2286	μ Gem	ν Gem	ν Gem			
23	鬼	3357	θ Cnc		η Cnc*	η Cnc	η Cnc	
24	柳	3410	δ Hya	σ Hya	σ Hya			σ Hya
25	星	3748	α Hya					
26	張	3903	υ^1 Hya	κ Hya*	κ Hya*			
27	翼	4287	α Crt	ν Hya	ν Hya			
28	珍	4662	γ Crv					
			合計	6件	7件	3件	3件	1件

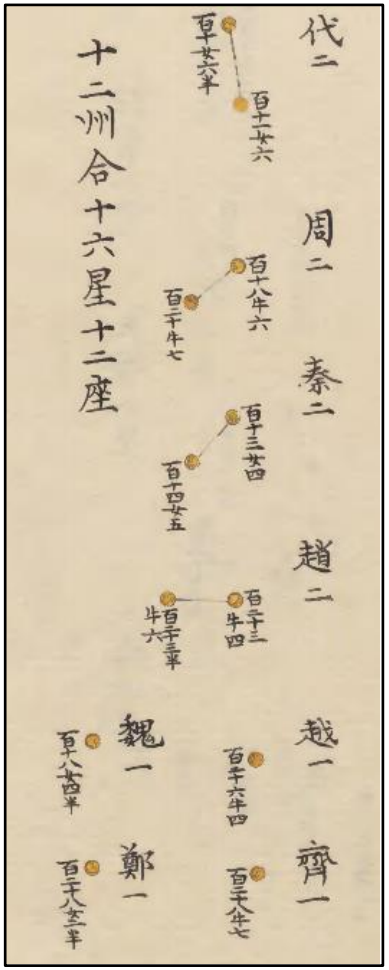
Error due to reference of woodblock chart.

Celestial globe and「天文瓊統」(chart and table)

『天球儀』(1690)

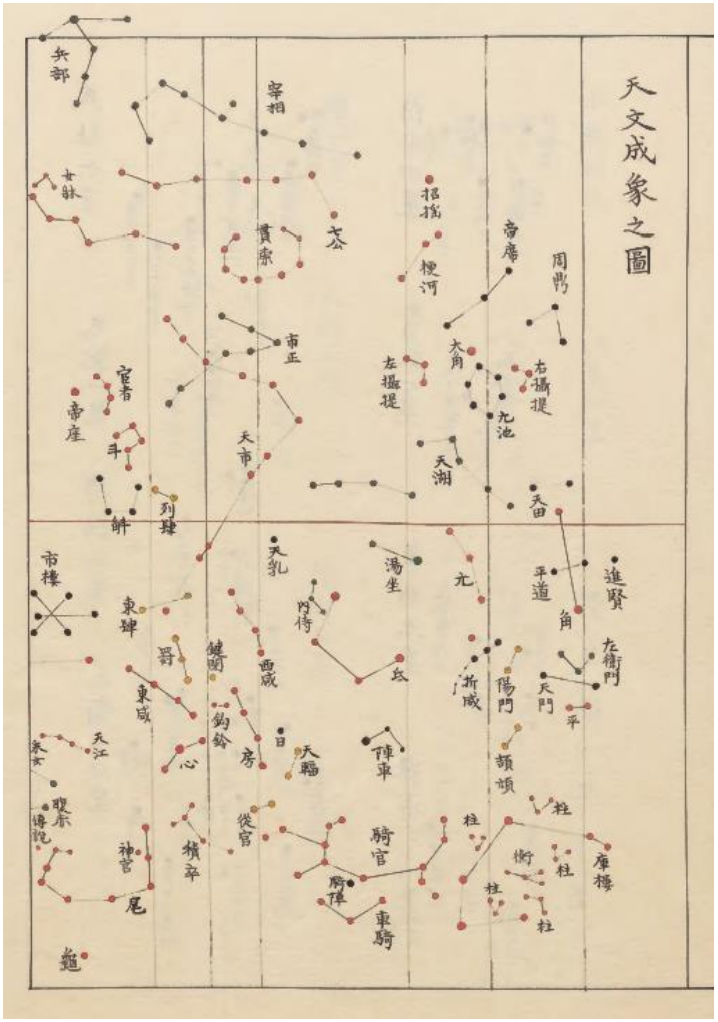
[伊勢神宮・徴古館HPより]

『天文瓊統・星表』(1698)



[国立公文書館]

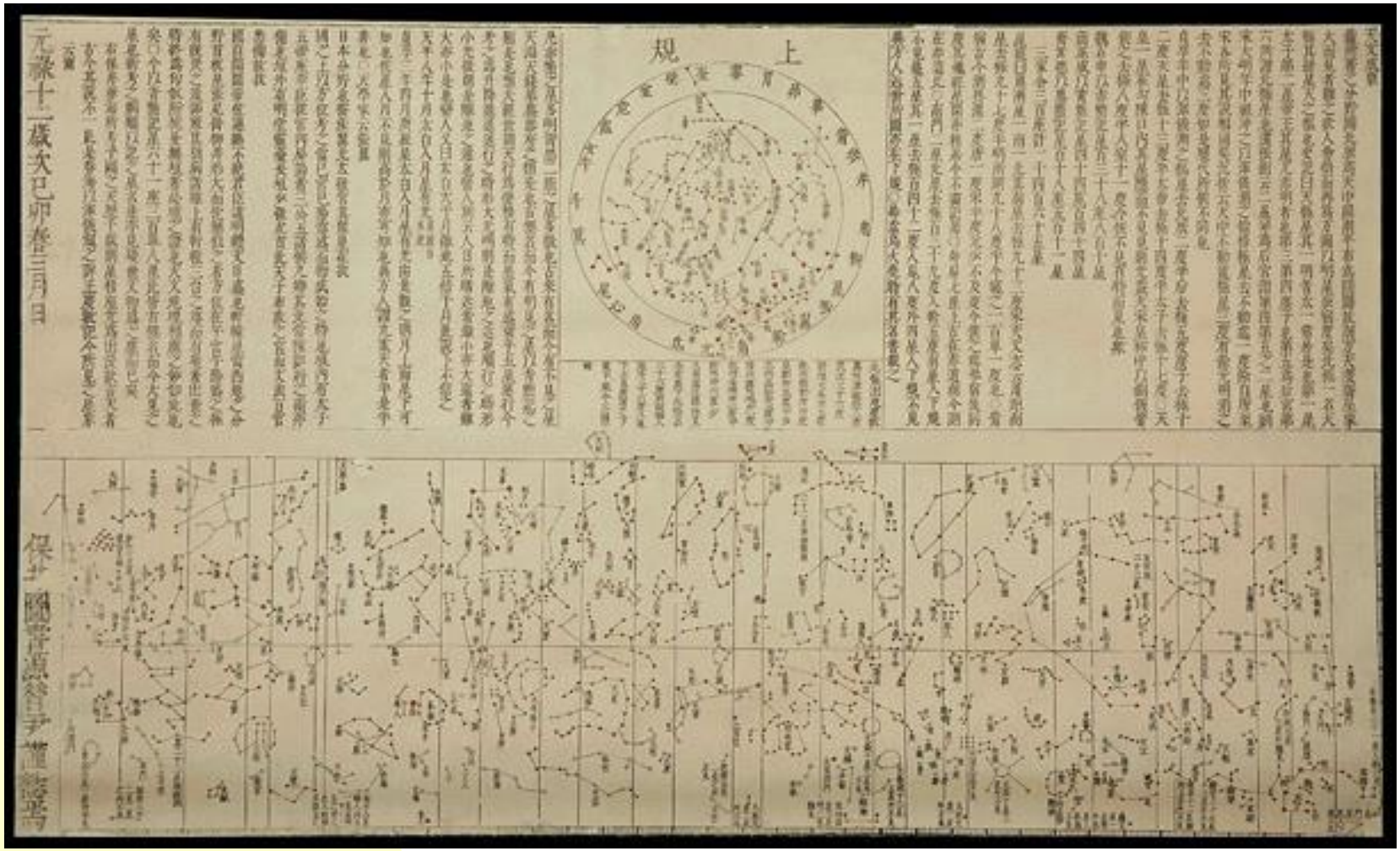
『③天文瓊統・星図』(1698)



[国立公文書館]

Charts of SHIBUKAWA Harumi「③天文成象」(1699)

Harumi's final star chart is based on a star chart of mainland China.



[和泉市久保惣記念美術館蔵]

The influence of「天象列次分野之図」

「天象列次分野之図」

Charts of Harumi

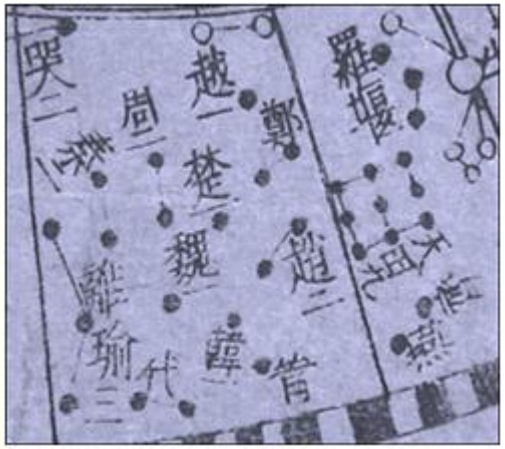
	天象図	蘇頌星図	蘇州星図	元星表	明天井図	常熟図	麟祥寺図	現代星図	列次図	分野図	神宮天球儀	天文瓊統（成象図）
作成年代	李氏朝鮮 洪武28年（1395）	北宋 天佑年間（1086～93）	北宋 淳祐7年（1247）	元朝（13-14世紀）	明朝（1453年頃）	明朝（1506）	明朝（16世紀）	清朝以降（1981）	寛文10年（1670）	延宝5年（1677）	元禄3年（1690）	元禄11年（1698）
春海の星座	無	無	無	無	無	無	無	無	無	無	無	有
「宋大夫」の有無	有	無	無	無	無	無	無	無	有	有	無	無
「弧」の形	弓と矢2本	弓と矢1本	弓と矢1本	弓と矢1本	弓と矢1本	弓と矢1本	弓と矢1本	弓と矢1本	弓と矢1本	弓と矢1本	ー	弓と矢1本
「軒轅」の形（獅子座の頭）	明確	不明確	明確	明確	明確	明確	明確	明確	不明確	不明確	不明確	明確
「軒轅」の形 中央凹部	丸型	浅い角型	角型	角型	角型	角型	角型	角型	浅い丸型	浅い丸型	浅い丸型	角型
「諸国」の形	古代図型（「代」が南）	独自（3列）	独自（2列）	蘇頌図型	蘇頌図型	蘇頌図型	古代図型	蘇州図型	古代図型	蘇頌図型	ー	蘇頌図型
「天牢」の形	六角形	六角形	六角形	米型	六角形	米型	米型	米型	六角形	米型	ー	米型
「六甲」の形	六角形	六角形	六角形	米型	米型	米型	米型	六角形	六角形	米型	ー	米型
「器府」の形	中央が大きい箱型	北が大きい台形	蘇頌図型	蘇頌図型	蘇頌図型	蘇頌図型	蘇頌図型	無	天象図型	蘇頌図型	ー	2星のみ
「文昌」の星数	7	6	6	6	6	6	6	6	7	6	6	6
「芻藁」を結ぶ線	連続	V字の重ね	V字の重ね	V字の重ね	V字の重ね	V字の重ね	V字の重ね	V字の重ね	連続	V字の重ね	（不明）	連続(独自)
珍宿(左轄右轄)	誤(左右逆)	正	正	正	ー	ー	正	正	誤(左右逆)	正	ー	正
「墓壁陣」の形・東	3星入壁度	不入壁度	不入壁度	不入壁度	不入壁度	不入壁度	4星入壁度	不入壁度	3星入壁度	3星入壁度	ー	不入壁度
「墓壁陣」の形・西	6星入危度	5星入虚度	5星入虚度	5星入虚度	4星入虚度	5星入虚度	4星入虚度	5星入虚度	6星入危度	6星入危度	ー	5星入虚度
「市楼」の形	8の字	米型	箱型	米型	米型	米型	米型	米型	8の字崩れ	8の字崩れ	米型	米型
「八穀」の形	五角形	長方形	長方形	V字の重ね	V字の重ね	V字の重ね	長方形	V字の重ね	五角形	五角形	ー	V字の重ね
「天床」の形	連続	V字の重ね	V字の重ね	V字の重ね	V字の重ね	V字の重ね	V字の重ね	V字の重ね	連続	連続	V字の重ね	V字の重ね
「天困」の形	コ型	クラゲ型原型	クラゲ型	クラゲ型	クラゲ型	クラゲ型	クラゲ型で閉じず	クラゲ型	コ型	コ型	ー	クラゲ型
「天厨」の向き	南北	東西	（4星）	南北	東西	東西	東西	（丸型）	南北	南北	東西	東西
「酒旗」の向き	東	西	西	西	西	西	西	西	東	東	西	西
「狼」の位置 「老人」の位置	井15.0度 井25.9度	井10.7度 井9.8度	井9.8度 井9.8度	井8度 ー	井7.3度 井6.3度	井8.7度 井6.2度	井13.8度 井6.2度	井5.7度 井0.8度	井18.0度 井22.0度	井15.3度 井14.6度	ー	井8.5度 井3.0度
「燈」の位置	鬼東北	鬼西北	鬼西北	ー	鬼西北	鬼北	鬼西北	鬼西北	鬼東北	鬼東北	ー	鬼西北
「積薪」の位置	積水東南	鬼西	鬼西北	鬼西	鬼西北	鬼西北	鬼西北	鬼西北	積水東南	積水東南	ー	鬼西
「列肆」の位置	斗北西	斗西	斗南西	斗南西	斗南西	斗西	斗西	斗南	斗北西	斗北西	斗南西	斗南西
「六甲」の位置	華蓋西	華蓋西	華蓋西	ー	華蓋東	華蓋東	華蓋東	華蓋東	華蓋西	華蓋西	ー	華蓋東
「哭星」の位置	虚宿線上	墓壁陣南	墓壁陣北	ー	墓壁陣南	墓壁陣北	墓壁陣南	墓壁陣北	虚宿距星線上	虚宿距星線上	ー	墓壁陣南
「外屏」の位置	全星赤道南	赤道上	赤道上	赤道上	赤道上	全星赤道南	赤道上	全星赤道北	全星赤道南	全星赤道南	ー	全星赤道北
「人」の線	直線	直線(人形)	直線(人形)	曲線	曲線	曲線	箱型	箱型	直線	曲線	ー	曲線
「羽林」と「騎官」の三角をつなぐ線	有	無	無	無	無	無	無	無	有	有	ー	有
「天記」の名称	無	天記	天紀	天記	有	有	有	天記	天紀	天紀	天紀	天記
「天阿」の名称	復刻:天阿 木版:阿	阿星	天阿	天阿	有	有	阿	天阿	天譏⇒天河 阿⇒附耳	天河	天阿	天阿
「尿」の名称	天矢	尿	尿	尿	有	有	尿	尿	天矢	尿	無	天矢
「三師」の名称	三公	三師	三師	三師	ー	有	三師	三師	三公	三師	三師	三師
円環に12宮の有無	有	ー	無	-	無	無	有	-	無	無	ー	ー

：網掛けは『天象図』と同じ特徴を示す。

2023/01/21

Evolution of constellations "諸国(Syokoku)" in Harumi's chart

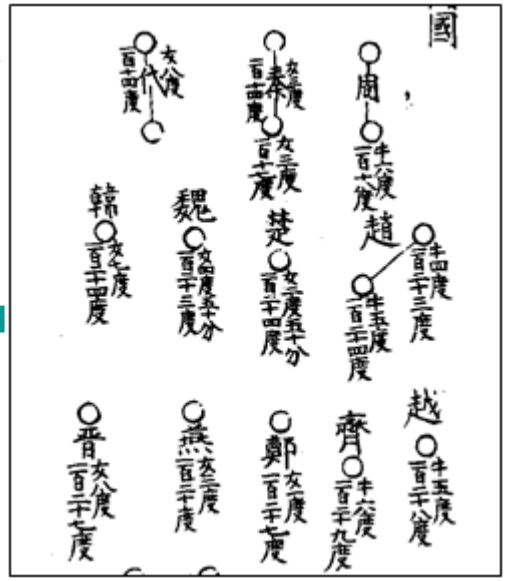
①天文列次之図(1670)



国立公文書館蔵/内閣文庫[特003-0017]

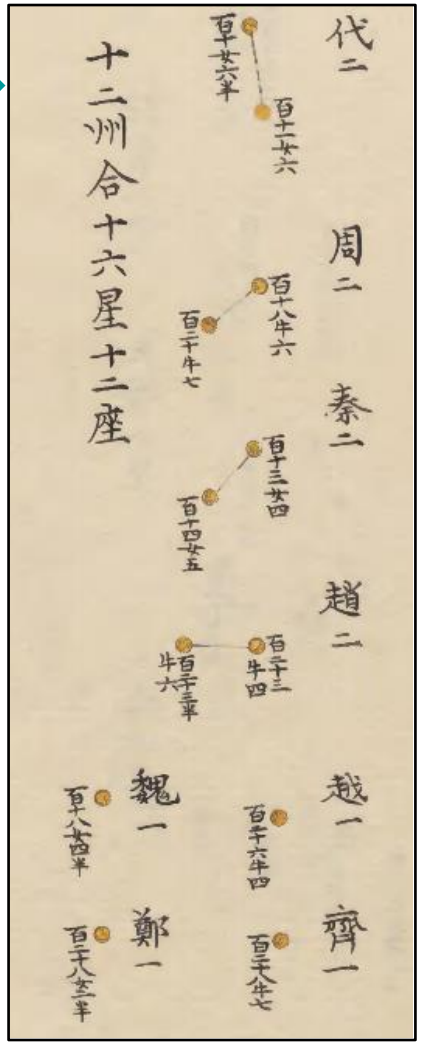
Format of the catalogue is same. (Fill in the values in the constellation chart)

Yuan Dynasty star catalogue (around 1363)



『天文匯抄十一種』
北京図書館古籍珍本叢刊78(1988) p.343

天文瓊統・星表(1698)



国立公文書館蔵/内閣文庫
[特003-000917] 2023/01/21

Revised

②天文分野之図(1677)

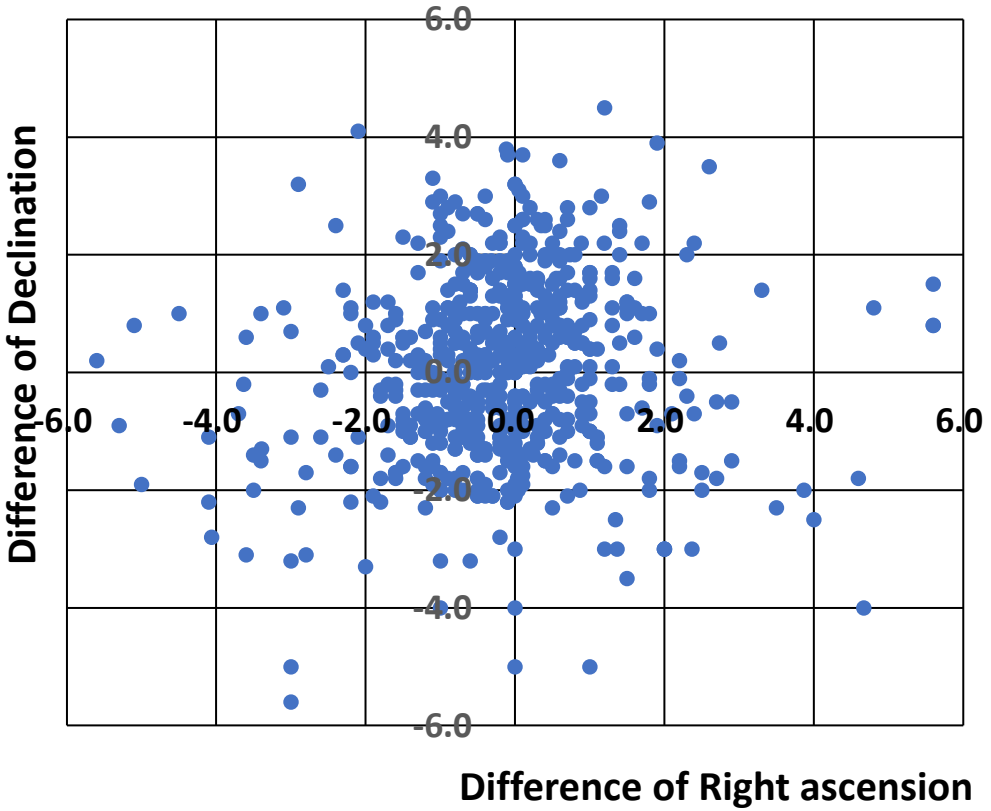
早稲田大学図書館蔵[文庫08 C0998]

Comparison results between Harumi's star catalog and Yuan Dynasty's star catalog

- The Yuan Dynasty Star Table lists the positions of about 740 stars.
- Among them, 626 stars are consistent with the Harumi's star catalog (1698).
- The display unit is 0.1° for Yuan catalog and 0.5° for the Harumi star catalog. There are 14 stars within ±0.25. 4 of them are in exactly the same position.

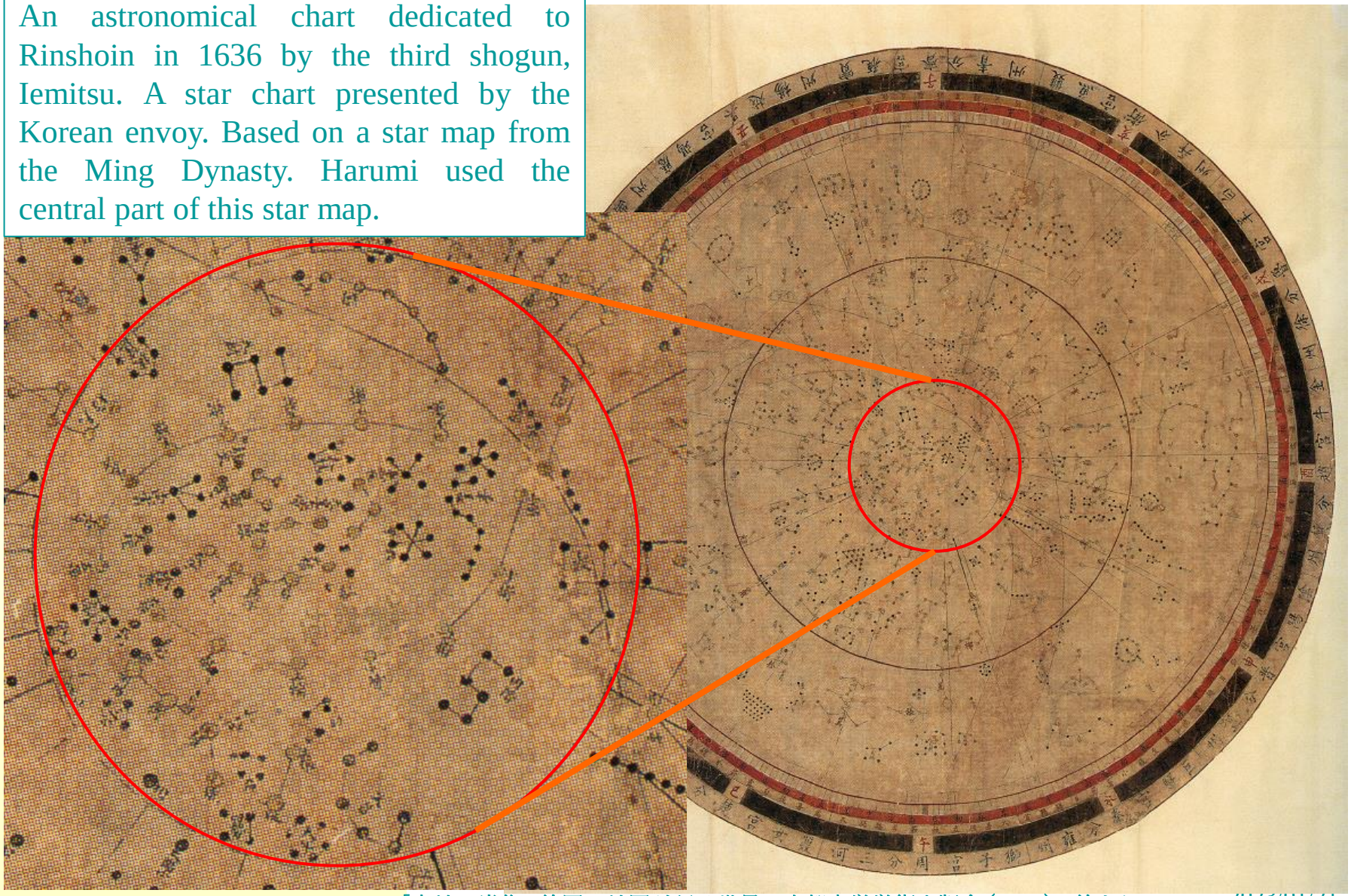
There is a strong correlation between the two catalogs.

Distribution of difference between two catalogs



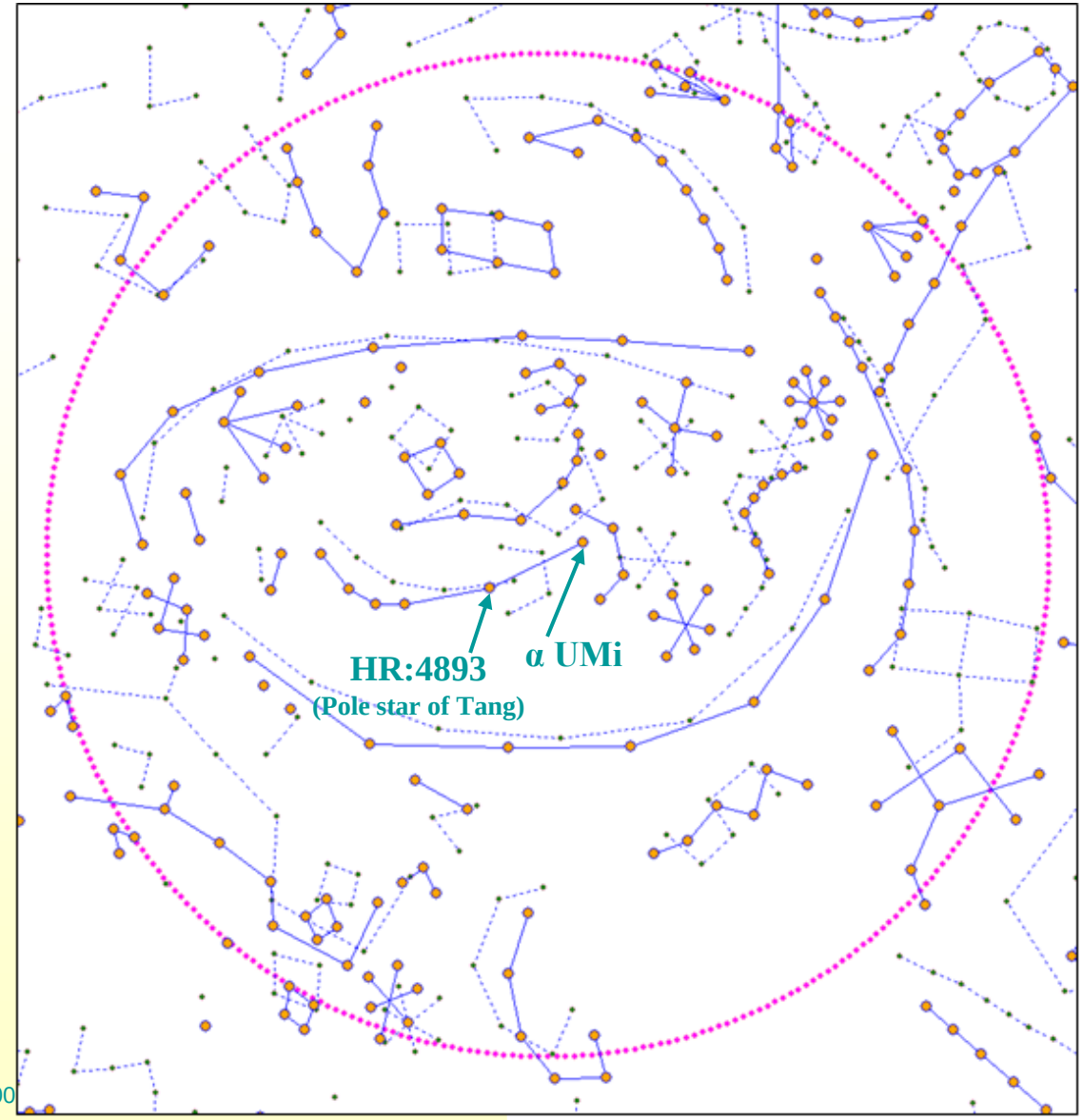
Star Chart of 麟祥院(Kyoto)

An astronomical chart dedicated to Rinshoin in 1636 by the third shogun, Iemitsu. A star chart presented by the Korean envoy. Based on a star map from the Ming Dynasty. Harumi used the central part of this star map.



「大地の肖像：絵図・地図が語る世界」京都大学学術出版会(2007)口絵より

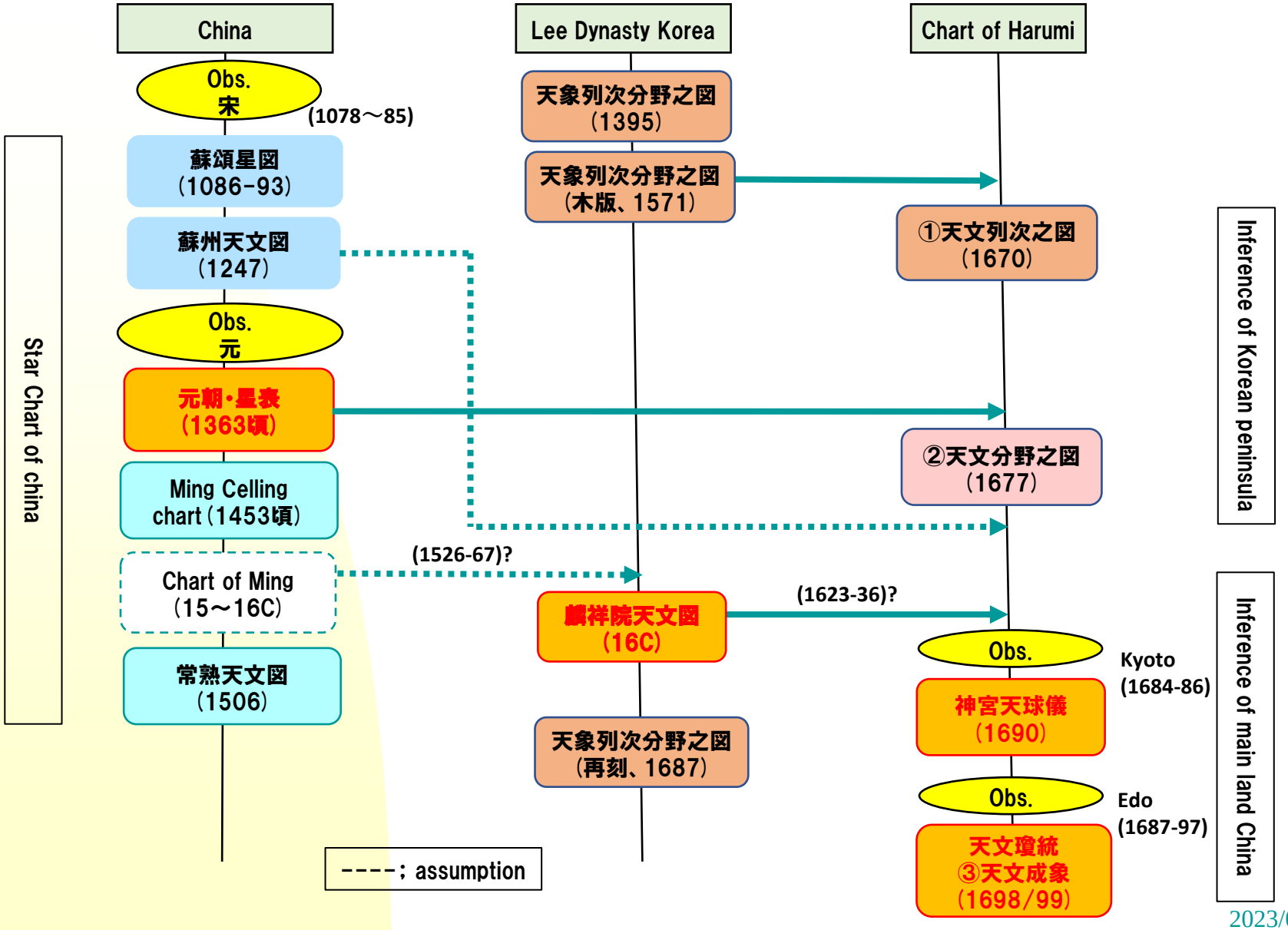
Comparison with『天文成象』and『麟祥院図』



It is believed that Harumi used this『麟祥院図』as a reference when observing the star and creating the star map for internal Circle.

Line:『天文成象』
Dot line:『麟祥院図』

Relation diagram of Harumi's star charts



Estimated Year of Observation of Star Catalog by Least Squares Method

The value of「貞享暦」(Jokyo reki). The refer value from「授時暦」(Jyujireki).

It is also possible that he had obtained Qing astronomical documents.

Star Catalogue		number	House Width	Declenation	Observation
Harumi's 『Temon Keito』 『天文瓊統』	28 stars	28	1279±28.1	1654±19.4	
	Chinese constellation	1063		1681.5±6.8	1684～86 (京都)
	Harumi's new constellation	250		1712.5±14.5	1687～97 (江戸)
『授時暦』(jyujireki)	28 stars	28	1272±15.3		
Yuan star catalog 元・星表 『三垣列舎入宿去極集』	28 stars	28		1363±6.0	
	All stars	733		1357±5.7	

(±1σ)

Harumi was actually observing the stars.
The identification of Chinese constellations is much better than that of the missionaries (16th-18th centuries)

Thanks

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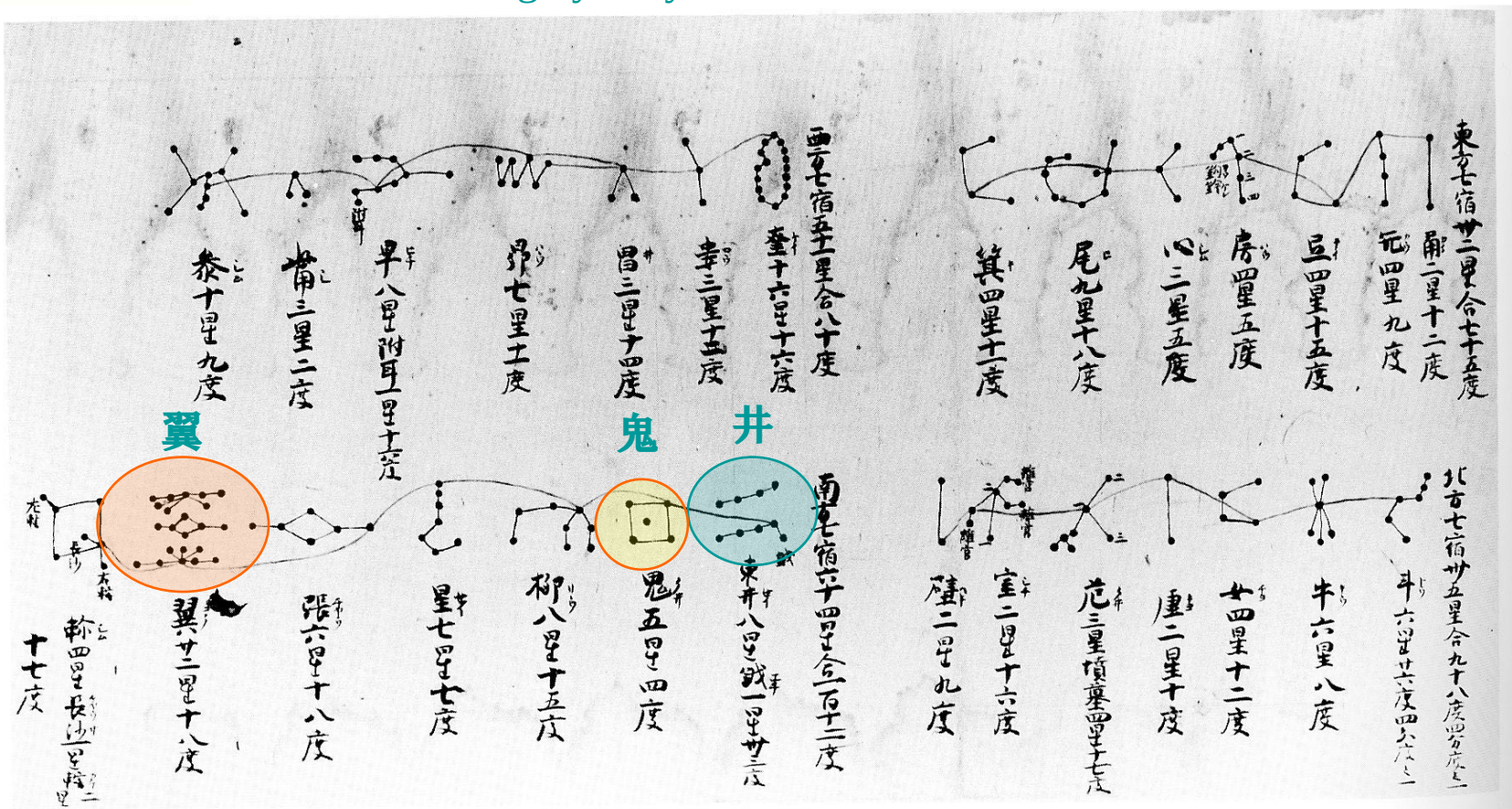
Reference material

28 constellation map in the old document

The old document in **金沢文庫** (Kanazawa bunko)
『二十八宿図并五行法』(transcribed in 1278)
(It is said to be an excerpt from the text of **六壬占**.
From the shape of the constellations, it is believed that the document dates back to the Tang dynasty.

- **翼宿**: 3 part
- **井宿**: no line
- **鬼宿**: square



24 二十八宿図并五行法

[**神奈川県立金沢文庫 『中世の占い』**(1989)p.39**より**]

黃一農, he points out that HR4852 is pole star over several centuries around 300 in his paper(1992).

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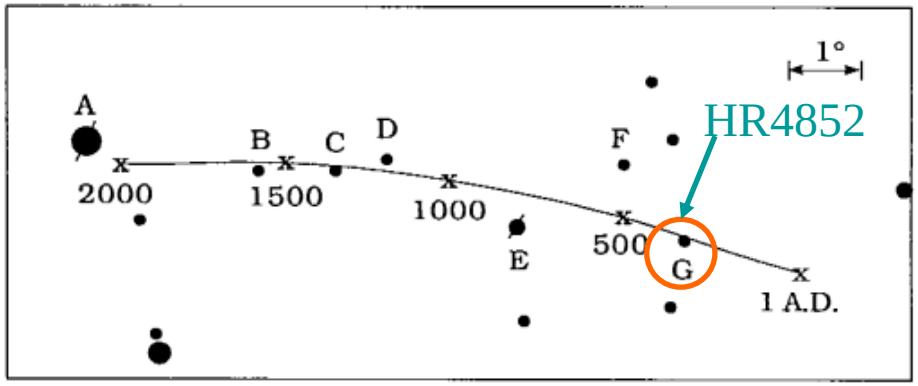
現象描述而已，因在這兩百多年間，天北極的位置已改變約3°，顯見這些學者多因循前人而未經實測。

圖五：近兩千年天北極之運行軌跡。圖中僅標示出較6.5等爲亮的星（參見表一）



經筆者推算，在第一至第五世紀間，肉眼可見星中惟 G 星最接近天北極（見圖五；爲方便起見，下文中將以英文字母爲各主要星的代號，各星的詳細資料則參見表一）。在西元310年左右，此兩者間的角距離甚且近至0.05°。此星的光度相當暗，爲6.3等，但在古代清朗且無光害的夜空中，當時的天文家應無困難覘見。故在這數世紀中，極星（亦即紐星）最可能爲 G 星。

Translation:
Estimates by the author.
From the 1st century to the 5th century, among the stars visible to the naked eye, G(HR4852) was the only star closest to the celestial pole. Around 310 A.D., the angular leading between the two was close, at 0.05° .
The star's luminosity was rather faint (magnitude 6.3), but in the clear night skies of antiquity without light pollution, astronomers of the time had no difficulty seeing it.
Therefore, in these centuries, the Pole Star (i.e., string star) is most likely the G Star.

黃一農著『極星與古度考』清華学報　第2期第22巻(1992)

Date of observation records other than star charts

星図星表	対象	宿広度				去極度			
		中心年	標準偏差	90%区間	残差	中心年	標準偏差	90%区間	残差
1. 渋川春海の星図									
渋川春海『天文瓊統』	距星	1279	28.1	8.7	0.14	1654	19.4	6.0	0.42
中国星座	1063星					1681.5	6.8		0.84
春海の新星座	250星					1712.5	14.5		0.86
授時暦	距星	1272	15.3	4.8	0.09				
元星表『三垣列舎入宿去極集』	距星					1363	6.0	1.9	0.14
全星表	733星					1357	5.7		0.58
2. 宋代の星図									
蘇頌星図	距星	947	95.2	29.5	0.44	1087	149.1	46.2	3.10
淳祐石刻天文図	距星	1018	501.7	155.5	2.16	1108	114.9	35.6	2.39
3. 宋代の観測記録									
Observation of 景祐年間	距星	370	135.6	42.0	0.62	707	55.6	17.2	1.16
皇祐(1050) (1030)	距星	864	107.3	33.3	0.49	1048	22.2	6.9	0.47
元豊(1080)	距星	952	95.2	29.5	0.44				
崇寧(1102)	距星	1079	42.8	13.3	0.21				
4. 『格子月進図』関連									
『格子月進図』	距星	464	168.5	52.2	0.76	417	57.7	17.9	1.21
『格子月進図』	1346星					397	22.7		3.12
大衍暦(720年代)	距星	363	138.5	42.9	0.63	512	39.0	12.3	0.80
5. 『キトラ天文図』	距星	-732	708.7	219.7	2.99	549	268.4	83.2	5.58
6. 『天象列次分野之図』									
星図(原図AD900年頃：筆者推定)	距星	-18	459.9	142.5	1.99	472	182.8	56.7	3.80
星図(距星の星座の星)	141星					415	106.0		4.68
星図(中緯度の明るい星)	61星					287	172.0		4.99
碑文(AD1395,『石氏星経』による)	距星	52	146.4	45.4	0.66	-45	44.7	13.9	0.94

The date of observation is around 370AD.

Dating Methods of Ancient Chinese Star Charts

[Appendix: SHIBUKAWA Harumi's star charts]