

The Mathematics of the Chinese Calendar

Helmer Aslaksen

Department of Mathematics
National University of Singapore

aslaksen@math.nus.edu.sg

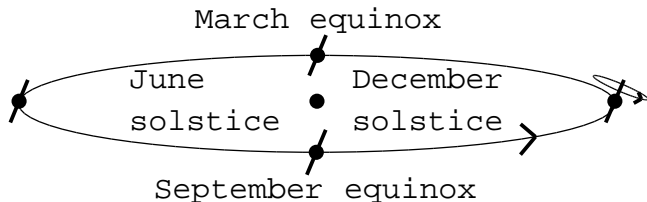
www.math.nus.edu.sg/aslaksen/
www.chinesecalendar.net

Adam Schall (汤若望 [湯若望], Tāng Ruòwàng,
1592-1666)



A Quick Course in Astronomy

- ▶ The Earth revolves counterclockwise around the Sun in an elliptical orbit. The Earth rotates counterclockwise around an axis that is tilted 23.5 degrees.



- ▶ In the northern hemisphere, the day will be longest at the June solstice and shortest at the December solstice. At the two equinoxes day and night will be equally long. The equinoxes and solstices are called the seasonal markers.

The Year and the Month

- ▶ The tropical year (or solar year) is the time from one March equinox to the next. The mean value is 365.2422 days.
- ▶ The synodic month is the time from one new Moon to the next. It ranges from 29.27 days to 29.84 days with a mean of 29.53 days.
- ▶ $12 \times 29.5 = 354$, so a lunar year consisting of 12 lunar months is about 11 days short of a solar year

$$365 - 12 \times 29.5 = 11.$$



$$365/11 \approx 33.$$

The Metonic Cycle

- ▶ 19 solar years is almost exactly 235 lunar months.

$$\begin{aligned}235 \times 29.53 &= 6939.6884, \\19 \times 365.2422 &= 6939.6018.\end{aligned}$$

The difference is about two hours.

- ▶ This is called the Metonic cycle (432 BCE). It was known in China by about 600 BCE and was called the zhāng (章) cycle.
- ▶ The Metonic cycle is used in the Jewish calendar, in the computation of Easter, and was used in the Chinese calendar before 104 BCE.

Classification of Calendars

solar Gregorian calendar. Basic unit is day. Approximates the tropical year by adding leap days. Ignores the Moon. The year is 365 or 366 days.

lunar Islamic calendar. Basic unit is lunar month. Ignores the Sun. The year is 12 months or 354 (sometimes 353 or 355) days.

lunisolar Chinese and Jewish calendars. Basic unit is lunar month. Approximates the tropical year by adding leap months. The year is 12 or 13 months. A 12-month year is 354 (sometimes 353 or 355) days. A 13-month year is 384 (sometimes 383 or 385) days.

- ▶ The Chinese calendar is NOT a lunar calendar!

Alternative Classification of Calendars

- ▶ **Arithmetical:** Gregorian and Jewish calendars. Based on arithmetical formulas. Prediction and conversion between different arithmetical calendars is simple.
- ▶ **Astronomical:** Islamic, Indian and Chinese calendars. Based on astronomical data. Prediction and conversion is hard.

The Chinese Calendar

- ▶ The goal is to approximate the solar year by adding leap months. Since 12 lunar months are 11 days too short we will need to add a leap month a little bit more than every third year.
- ▶ In ancient times, this was done by observing nature.
- ▶ Since $235 = 19 \times 12 + 7$, we can use the Metonic cycle and get a decent lunisolar calendar by having 7 leap years in every 19-year cycle.

Chinese New Year

- ▶ It can be shown that Chinese New Year will always fall between Jan 21 and Feb 21.
- ▶ Most of the time Chinese New Year will fall 11 (or 10 or 12) days earlier than the previous year, but if that would take us outside of the Chinese New Year range of Jan 21 to Feb 21, we must add a leap month, so Chinese New Year jumps 19 (or 18 or 20) days later.

1998	1999	2000	2001	2002	2003
Jan 28	Feb 16	Feb 5	Jan 24	Feb 12	Feb 1
19	11	12	19	11	

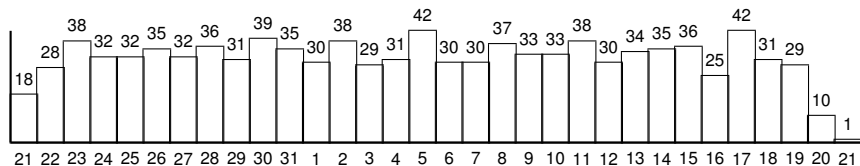


	2004	2005	2006	2007	2008	2009
	Jan 22	Feb 9	Jan 29	Feb 18	Feb 7	Jan 26
10	18	11	20	11	12	

The 19-year Cycle

- ▶ Because of the Metonic cycle, there is almost a 19-year cycle in the Chinese calendar.
- ▶ I was born on April 16, 1960. This was the 21st day in the 3rd month in the Chinese calendar. Normally my birthday will fall on different days in the Chinese calendar, but my 19th birthday fell on the 20th day in the third month. The same goes for my 38th and 57th birthday. So we see that the 19-year cycle is close but not exact.
- ▶ There are two reasons for this. First of all, the Metonic cycle is off by about two hours.
- ▶ But more importantly, we are now comparing the Chinese calendar not with the tropical year, but with the Gregorian calendar, which is just an approximation to the tropical year. In particular, since 19 is not a multiple of 4, different cycles will contain different numbers of leap years.

Dates of Chinese New Year Between 1645 and 2644



The 24 Jiéqì

A fundamental concept in the Chinese calendar is the 24 solar terms or jiéqì (节气). They are a generalization of the solstices and equinoxes. The even ones are called major solar terms or zhōngqì (中气).

List of the 24 Jiéqì

J1	Lìchūn	立春	Beginning of spring	February 4
Z1	Yǔshuǐ	雨水	Rain water	February 19
J2	Jīngzhé	惊蛰	Waking of insects	March 6
Z2	Chūnfēn	春分	Spring equinox	March 21
J3	Qīngmíng	清明	Pure brightness	April 5
Z3	Gǔyǔ	谷雨	Grain rain	April 20
J4	Lìxià	立夏	Beginning of summer	May 6
Z4	Xiǎomǎn	小满	Grain full	May 21
J5	Mángzhòng	芒种	Grain in ear	June 6
Z5	Xiàzhì	夏至	Summer solstice	June 22
J6	Xiǎoshǔ	小暑	Slight heat	July 7
Z6	Dàshǔ	大暑	Great heat	July 23
J7	Lìqiū	立秋	Beginning of autumn	August 8
Z7	Chǔshǔ	处暑	Limit of heat	August 23
J8	Báilù	白露	White dew	September 8
Z8	Qiūfēn	秋分	Autumnal equinox	September 23
J9	Hánlù	寒露	Cold dew	October 8
Z9	Shuāngjiàng	霜降	Descent of frost	October 24
J10	Lìdōng	立冬	Beginning of winter	November 8
Z10	Xiǎoxuě	小雪	Slight snow	November 22
J11	Dàxuě	大雪	Great snow	December 7
Z11	Dōngzhì	冬至	Winter solstice	December 22
J12	Xiǎohán	小寒	Slight cold	January 6
Z12	Dàhán	大寒	Great cold	January 20

A Chinese Calendar

公元 1982 年——壬戌年

公历日期	1 月	2 月	3 月	4 月	5 月	6 月
	农日 星期	农日 星期	农日 星期	农日 星期	农日 星期	农日 星期
1	初七	初八	初七	初八	初八	初八
2	初八	初九	初八	初九	初九	初九
3	初九	初十	初九	初十	初十	初十
4	初十	十一	初十	十一	十一	十一
5	十一	十二	十一	十二	十二	十二
6	十二	十三	十二	十三	十三	十三
7	十三	十四	十三	十四	十四	十四
8	十四	十五	十四	十五	十五	十五
9	十五	十六	十五	十六	十六	十六
10	十六	十七	十六	十七	十七	十七
11	十七	十八	十七	十八	十八	十八
12	十八	十九	十八	十九	十九	十九
13	十九	二十	十九	二十	二十	二十
14	二十	廿一	二十	廿一	廿一	廿一
15	廿一	廿二	廿一	廿二	廿二	廿二
16	廿二	廿三	廿二	廿三	廿三	廿三
17	廿三	廿四	廿三	廿四	廿四	廿四
18	廿四	廿五	廿四	廿五	廿五	廿五
19	廿五	廿六	廿五	廿六	廿六	廿六
20	廿六	廿七	廿六	廿七	廿七	廿七
21	廿七	廿八	廿七	廿八	廿八	廿八
22	廿八	廿九	廿八	廿九	廿九	廿九
23	廿九	三十	廿九	三十	三十	三十
24	三十	初一	三十	初一	初一	初一
25	初一	初二	初一	初二	初二	初二
26	初二	初三	初二	初三	初三	初三
27	初三	初四	初三	初四	初四	初四
28	初四	初五	初四	初五	初五	初五
29	初五	初六	初五	初六	初六	初六
30	初六	初七	初六	初七	初七	初七
31	初七	初八	初七	初八	初八	初八
节	小寒: 6日	立春: 4日	惊蛰: 6日	清明: 5日	立夏: 6日	芒种: 6日
气	大寒: 20日	雨水: 19日	春分: 21日	谷雨: 20日	小满: 21日	夏至: 22日

公元 1982 年——壬戌年

公历日期	7 月	8 月	9 月	10 月	11 月	12 月
	农日 星期	农日 星期	农日 星期	农日 星期	农日 星期	农日 星期
1	十一	十二	十一	十二	十一	十二
2	十二	十三	十二	十三	十二	十三
3	十三	十四	十三	十四	十三	十四
4	十四	十五	十四	十五	十四	十五
5	十五	十六	十五	十六	十五	十六
6	十六	十七	十六	十七	十六	十七
7	十七	十八	十七	十八	十七	十八
8	十八	十九	十八	十九	十八	十九
9	十九	二十	十九	二十	十九	二十
10	二十	廿一	二十	廿一	二十	廿一
11	廿一	廿二	廿一	廿二	廿一	廿二
12	廿二	廿三	廿二	廿三	廿二	廿三
13	廿三	廿四	廿三	廿四	廿三	廿四
14	廿四	廿五	廿四	廿五	廿四	廿五
15	廿五	廿六	廿五	廿六	廿五	廿六
16	廿六	廿七	廿六	廿七	廿六	廿七
17	廿七	廿八	廿七	廿八	廿七	廿八
18	廿八	廿九	廿八	廿九	廿八	廿九
19	廿九	三十	廿九	三十	廿九	三十
20	三十	初一	三十	初一	三十	初一
21	初一	初二	初一	初二	初一	初二
22	初二	初三	初二	初三	初二	初三
23	初三	初四	初三	初四	初三	初四
24	初四	初五	初四	初五	初四	初五
25	初五	初六	初五	初六	初五	初六
26	初六	初七	初六	初七	初六	初七
27	初七	初八	初七	初八	初七	初八
28	初八	初九	初八	初九	初八	初九
29	初九	初十	初九	初十	初九	初十
30	初十	十一	初十	十一	初十	十一
31	十一	十二	十一	十二	十一	十二
节	小暑: 7日	立秋: 8日	白露: 8日	寒露: 8日	立冬: 8日	大雪: 7日
气	大暑: 23日	处暑: 23日	秋分: 23日	霜降: 24日	小雪: 22日	冬至: 22日

Chinese Seasons

- ▶ A useful rule of thumb is that Chinese New Year is the new Moon closest to the beginning of spring (立春, lìchūn). This rule is correct most of the time, but it failed in 1985 and will fail again in 2015.
- ▶ Since the beginning of spring falls around Feb 4, this helps explain why Chinese New Year will always fall between Jan 21 and Feb 21. It also helps explain why Chinese New Year is called the spring festival.
- ▶ In Western astronomy, spring begins at spring equinox. In Chinese astronomy, spring begins midway between winter solstice and spring equinox.

The Chinese Meridian

- ▶ Calculations are based on the meridian 120° East.
- ▶ Before 1929 the computations were based on the meridian in Beijing ($116^{\circ}25'$), but in 1928 China adopted a standard time zone based on 120° East. This change corresponds to about 14 minutes.

1978 in Hong Kong

- ▶ Before 1978, many calendars in Hong Kong and Taiwan were still based on the old imperial calendar from 1908, the year in which the last Qīng emperor ascended the throne.
- ▶ The new Moon that marked the start of the 8th month in 1978 would occur just before midnight at 23h 53m on September 2, 1978, making the 7th month a short month. The astronomers at the Purple Mountain Observatory in Nanjing had computed that the new Moon would occur after midnight at 0h 07m on September 3, 1978, making the 7th month a long month.
- ▶ The Mid-Autumn Festival is celebrated on the 15th day of the 8th month. Because of this, the Mid-Autumn Festival was celebrated on different days, causing a lot of confusion.
- ▶ After 1978, both Hong Kong and Taiwan have followed the same calendar as China, so at least when it comes to calendars, everybody agrees on a “one-China” policy.

The Vietnamese Calendar

- ▶ Traditionally, the Vietnamese used the Chinese calendar, even though the longitude of Hanoi is $105^{\circ}55'$ East.
- ▶ However, on August 8, 1967, the North Vietnam government approved a lunar calendar specifically compiled for the UT+7 time zone.
- ▶ The following year, the Chinese New Year new Moon occurred on Jan 29 16h 29m. That meant that in the new North Vietnamese calendar, Chinese New Year, known as Tet in Vietnam, would be celebrated on January 29, while in South Vietnam it would be celebrated on January 30.

The Tet Offensive of 1968

- ▶ The North Vietnamese Army and the Vietcong guerillas were preparing for what would be known as the Tet Offensive. The instructions were to attack in the early morning of Tet.
- ▶ The units in Da Nang and other Central Vietnamese cities had closer links to North Vietnam and were aware of the calendar change, so they attacked on the morning of January 30, the day after the new Tet.
- ▶ However, in Saigon and other cities to the South, everybody was using the traditional calendar, and the attack started on the morning of January 31, the day after the traditional Tet.

The Length of a Chinese Month

- ▶ The day on which a new Moon occurs is the first day of the new month.
- ▶ The length of the months are determined astronomically. The lunar month can vary between about 29.25 and 29.75 with a mean of 29.53.
- ▶ Suppose a month is 29.5 days.

New Moon	Next new Moon	Length
May 1 13h	May 31 1h	30 days
May 1 1h	May 30 13h	29 days

- ▶ There can be four long months or three short months in a row.

The Mid-Autumn Festival

- ▶ If the 1st month marks the beginning of spring, autumn should start with the 7th month.
- ▶ This explains why the Mid-Autumn Festival is celebrated on the 15th day of the 8th month.

The Chinese Solar Calendar

- ▶ It is important to understand that the Chinese calendar is a combination of two calendars, the usual lunisolar calendar and a solar calendar that follows the 24 jiéqì.
- ▶ The solar calendar is traditionally called the farmer's calendar (农历). Unfortunately the term farmer's calendar has come to include the lunisolar calendar.
- ▶ The Chinese solar calendar follows the tropical year closely, so it is perfect for farming purposes, but the lunisolar calendar is not at all suitable for farmers.

Qīngmíng (清明)

- ▶ There are two Chinese holidays that are determined by the solar calendar, namely Qīngmíng (清明) around Apr 5 and winter solstice Dōngzhì (冬至) around Dec 22.
- ▶ Notice that lunar dates can fall within a range of about one month in the solar calendar and conversely. Chinese New Year can fall between Jan 21 and Feb 21.
- ▶ Qīngmíng can fall between the 13th day of the 2nd month and the 17th day of the 3rd month.

The Chinese Year

- ▶ There are several years in the Chinese calendar. The most important are the suì (岁) and the nián (年).
- ▶ A suì is the solstice year from one winter solstice to the next. This is the same as the tropical year.
- ▶ A nián is the Chinese year from one Chinese New Year to the next. Since a Chinese year can contain 12 or 13 lunar months, and they can have 29 or 30 days, it can be shown that the length of a nián can be 353, 354, 355, 383, 384 or 385 days long.
- ▶ Just like we can think of the Gregorian year as an approximation to the tropical year, we can think of the nián as an approximation to the suì.
- ▶ The Chinese astrological year runs from the beginning of spring (立春, lìchūn) around Feb 4, not from Chinese New Year.

Buddha's Birthday (Vesak Day)

- ▶ Traditionally, Buddhists have observed Buddha's Birthday (Vesak Day) on the 8th or 15th day of the fourth month.
- ▶ Since the 1950's the Singapore Buddhist Federation celebrates it on the first full Moon in May.

Deepavali

- ▶ Deepavali falls on the last day of the lunar month Asvina, called Purattasi in Tamil. Like the Chinese calendar, the Tamil calendar consists of a solar calendar and a lunisolar calendar.
- ▶ The solar month Asvina runs from around Sep 16 to around Oct 17. The lunar month Asvina starts with the first new Moon within this solar month.
- ▶ It follows that Deepavali can fall between Oct 15 and Nov 15.

The Sexagenary Cycle

Heavenly Stems	天干	tiāngān	Element
1	甲	jiǎ	Wood
2	乙	yǐ	Wood
3	丙	bǐng	Fire
4	丁	dīng	Fire
5	戊	wù	Earth
6	己	jǐ	Earth
7	庚	gēng	Metal
8	辛	xīn	Metal
9	壬	rén	Water
10	癸	guǐ	Water

The Sexagenary Cycle 2

Earthly Branches	地支	dìzhī	Animal
1	子	zǐ	Rat
2	丑	chǒu	Ox
3	寅	yín	Tiger
4	卯	mǎo	Rabbit
5	辰	chén	Dragon
6	巳	sì	Snake
7	午	wǔ	Horse
8	未	wèi	Goat
9	申	shēn	Monkey
10	酉	yǒu	Chicken
11	戌	xū	Dog
12	亥	hài	Pig

The Golden Dragon

- ▶ Let us denote both the stems and the branches by their numbers. We denote 1 by (1, 1) or (甲, 子), 2 by (2, 2) or (乙, 丑) and so on up to (10, 10) or (癸, 酉).
- ▶ Now we have run out of stems, so we denote 11 by (1, 11) or (甲, 戌) and 12 by (2, 12) or (乙, 亥). Now we have run out of branches, too, so 13 becomes (3, 1) or (丙, 子).
- ▶ We continue in this way through 6 cycles of stems and 5 cycles of branches up to 60, which is (10, 12) or (癸, 亥).
- ▶ The next number is then (1, 1) or (甲, 子), which starts a new sexagenary cycle.
- ▶ Notice that each branch, or animal, occurs five times in each 60-year cycle. An animal corresponding to an odd number, will meet the stems that correspond to the odd numbers.
- ▶ Year 2000 is the 17th year in the current cycle (see below), so it corresponds to (7, 5) ($17 = 10 + 7 = 12 + 5$) or (庚, 辰). So we see that it is a metal dragon year, or a golden dragon.

The Eight Characters

- ▶ The sexagenary cycle is used for keeping track of years, months, days and (double) hours in Chinese astrology. Your date and time of birth is determined by the “Eight Characters” (八字) formed by the pair of cyclical characters for the year, month, day and hour.
- ▶ The 60-day cycle has been used for keeping track of days since ancient times. During the Hàn (汉) dynasty, the 60-year cycle was also introduced.

What is Year 2000 in the Chinese Calendar?

- ▶ The Chinese do not have a continuous year count. They started counting from one again with each new emperor.
- ▶ some scholars tried to reconstruct ancient Chinese chronology by adding up years of reigns, much the same way some westerners in the past tried to reconstruct Biblical chronology.
- ▶ Some claim that the calendar was invented by the Yellow Emperor, Huángdì (黃帝), in 2637 BCE during the 61st year of his reign.
- ▶ Some people prefer to start the count with the first year of his reign in 2697 BCE.
- ▶ Since these years are 60 years apart, it follows that 1984 was the first year of either the 78th or 79th 60-year cycle. Using this as a starting point, Chinese New Year in 2000 marks the beginning of the Chinese year 4637 or 4697.
- ▶ Some people write 2636 BCE, but they really mean -2636, using the astronomical year count, where 1 BCE is year 0, 2 BCE is -1, etc.

Sun Yat-sen

- ▶ To add to the confusion, some authors use an epoch of 2698 BCE. I believe this because they want to use a year 0 as the starting point, rather than counting 2697 BCE as year 1, or that they assume that the Yellow Emperor started his year with the Winter solstice of 2698 BCE.
- ▶ In particular, this system was used by Sun Yat-sen (孫逸仙, Sūn Yìxiān or 孫中山, Sūn Zhōngshān, 1866–1925). He and other political activists wanted to use a republican and “modern” year numbering system.
- ▶ This system actually won some acceptance in the overseas Chinese community, and is for example used occasionally in San Francisco’s Chinatown. (At least around the time of Chinese New Year!)

The continuous year count is not an integral part of Chinese culture

- ▶ The continuous year count is not an integral part of the Chinese calendar, but rather an afterthought. While there isolated incidents of Chinese scholars who have used it, it only gained popularity with the Jesuit missionaries.
- ▶ Most of the people who use it are Westerners who refuse to believe that it is possible to have a “civilized” society without a continuous year count.
- ▶ While Chinese chronology is fairly reliable going back to 841 BCE, and oracle bones with date inscription go back to the 13th century BCE, modern scholars consider the Yellow Emperor to be a mythological figure.

Kāngxī (康熙)

- ▶ Beginning in the Hàn dynasty, emperors would adopt era name or reign names (年号 [年號], niánhào), which together with the 60-year cycle would fix the year.
- ▶ In the past, the emperors often changed their era names during their reign, but by the time of the Míng and Qīng dynasties, the emperors used the same era name for their whole reign.
- ▶ This system worked well most of the time, but the Kāngxī Emperor (康熙) ruled more than 60 years. He ruled from February 7, 1661 to December 20, 1722. Since Chinese New Year fell on January 30 in 1661, the first year of his reign started on February 18, 1662, and the last year of his reign ended on February 4, 1723.
- ▶ Since both 1662 and 1722 are rényín years, the term Kāngxī rényín (康熙壬寅) is ambiguous.

Qiánlóng (乾隆)

- ▶ This is the only such problem in Chinese history. The Qiánlóng Emperor (乾隆) ruled from October 18, 1735, to February 8, 1796. The first year of his rule started on February 12, 1736, but he chose to retire on February 8, 1796, as a filial act in order not to reign longer than his grandfather, the illustrious Kāngxī Emperor.
- ▶ Despite his retirement, however, he retained ultimate power until his death in 1799.

Why Was the Calendar Important?

- ▶ With a lunar or lunisolar calendar, errors are much more obvious than with a solar calendar.
- ▶ A solar calendar can be off by a couple of weeks without anybody noticing. The reason why the Catholic church had to reform the Julian calendar was because the rules for computing Easter had frozen the March equinox to be March 21. That meant that Easter was drifting noticeably towards summer. Otherwise, few would have cared about the drift of the March equinox.
- ▶ With a lunar calendar, an error of even a couple of days is a serious problem. Every peasant could each month see that the new Moon was visible near the end of the previous month or that the old Moon was visible in the next month.

Foreign Talent

- ▶ Because of the importance the Chinese rulers placed on calendars, they were surprisingly open to incorporate foreign ideas into the making of calendars. The last three main calendar reforms have all been associated with foreign impulses.

The Main Calendar Reforms

- ▶ Before 621 BCE, the start of the month was based on visibility of the crescent Moon. During the Zhōu (周) dynasty, the Metonic cycle was used for determining leap months and the leap months were always placed at the end of the year.
- ▶ After the Tàichū (太初) calendar reform in 104 BCE, the no zhōngqì (无中气) rule was used for determining leap months, and the month containing the December solstice was fixed to be the 11th month.
- ▶ The Táng (唐) dynasty calendar reform in 619 switched to following the true Moon. This was inspired by Indian Buddhist astronomers.
- ▶ The Yuán (元) dynasty reform in 1280 was inspired by Muslim astronomers. It was the most accurate calendar in the world at that time.
- ▶ The last calendar reform came in 1645 during the Qīng dynasty (清) and was implemented by Jesuit missionaries. It used the true Sun.

The Jesuits

- ▶ In 1644, the German Adam Schall (汤若望 [湯若望], Tāng Ruòwàng, 1592-1666) went to the new Qīng rulers and presented his calculations for an upcoming solar eclipse.
- ▶ He challenged the Chinese and the Muslim astronomers in the Imperial Astronomical Bureau (欽天監, Qīntiānjiān), and the Jesuits' calculations were best.
- ▶ Schall was appointed director of the Bureau. The next year, he formulated the current rules for the Chinese calendar.

The Trial of the Jesuits

- ▶ A Chinese official, Yáng Guāngxiān (杨光先), had as his slogan that it was “better to have a wrong calendar than to have foreigners in China”. Yang managed to have the Jesuits arrested in 1664.
- ▶ A solar eclipse was coming up and while in prison, the Jesuits predicted it would occur at 3 p.m., Yang predicted 2:15 p.m., and the Muslim Wú Míngxuǎn (吴明炫) predicted 2:30 p.m.
- ▶ On the day of the eclipse, the Jesuits were brought into the palace in chains, and everybody watched as the eclipse occurred at 3p.m. sharp!
- ▶ Unfortunately, the regents were not impressed and the Jesuits were sentenced to death.
- ▶ However, the next day a strong earthquake struck Beijing. This was taken as a sign from Heaven that the sentence was unjust, and the sentence of the Jesuits was first converted to flogging and eventually to just house arrest.

The Kang Xi Emperor

- ▶ In 1668, the Kāngxī (康熙) emperor took over from the regents. The emperor ordered the Belgian Ferdinand Verbiest (南怀仁 [南懷仁], Nán Huáirén, 1623-1688), Yáng and Wú to compute the length of the shadow of a pole on a certain day and the position of the Sun at noon on a certain day.
- ▶ They were to leave their instruments pointing towards the predicted spot in the emperor's garden two weeks in advance. Verbiest easily won and was appointed director of the Bureau, while Yáng and Wú were arrested.
- ▶ Verbiest became personal tutor to the Kāngxī emperor, and even learned Manchu. Jesuits remained as directors of the Bureau until 1746 and it was run by other Westerners until 1826.