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Abstract In early 1669, the Jesuit missionary astronomer Ferdinand Verbiest (1623—1688, Nan Huairen 南怀仁 in Chinese) was ordered by the Kangxi emperor (r. 1662—1722) to take part in a test of his abilities to make accurate astronomical predictions, principally those needed to construct a luni-solar calendar of the type used by all literate members of the population of Imperial China, lay or official, for planning their daily activities. He was to do this in competition with the Muslim astronomer Wu Mingxuan 吴明烜. In his account of that competition, Verbiest states repeatedly that Wu based his predictions on the 'Muslim [astronomical] system' (*Hui hui li* 回回历). This essay is an initial investigation of the methods used by Wu Mingxuan to make astronomical calculations, with the aim of finding the extent to which his results really were based on the system to which Verbiest refers. This investigation indicates that Verbiest's characterisation of Wu Mingxuan's methods is incorrect. Wu Mingxuan was in fact using a version of the Ming dynasty's Great Concordance system *Da tong li* 大统历, that had been restored to use by the Astronomical Bureau (*Qin tian jian* 钦天监) after Jesuit astronomers and their Chinese colleagues were deprived of their offices in 1665 as a result of the accusations made by Yang Guangxian 杨光先. The reasons why Verbiest nevertheless described Wu's methods as 'Muslim' are best understood in the context of the Jesuits' struggle to re-establish themselves as astronomical experts at the Qing court.

Ⅰ. The rise, fall and restoration of Jesuit astronomy: retrospect from 1644 to 1668 [1]

In 1644 the Qing dynasty began its rule over the former empire of the Ming dynasty. That same year, they gave responsibility for overseeing the state Astronomical Bureau (*Qin tian jian* 钦天监) to a Jesuit astronomical specialist, Johann Adam Schall von Bell (Tang Ruowang 汤若望, 1592—1666). Thereafter the annual luni-solar calendar that symbolized the dynasty's success in maintaining harmony between the human and the natural orders was produced using the western astronomical methods

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[1] The opening section of this article recapitulates events that are traced in detail with full references and citations of textual evidence in Cullen and Jami (2020); for the wider context see also Jami (2012), particularly chapters 2 and 3.

that the Jesuits had brought to China in the closing years of the Ming.[2] But in 1665 Schall and a number of his Chinese colleagues were sentenced to death after being convicted of serious errors in their work, principally in wrongly deciding the most auspicious time for the funeral of a child of the Shunzhi emperor (r. 1644—1661) and thus allegedly causing the emperor's death.[3] Schall's sentence was later commuted to house arrest, but several of his Chinese colleagues were executed. Jesuit missionaries working in the provinces were exiled to Canton.

The Jesuits' principal accuser, Yang Guangxian 杨光先 (1597—1669) was appointed as Director (*Jian zheng* 监正) of the Astronomical Bureau, and despite his repeated protestations that he lacked the necessary technical astronomical knowledge, the regents who ruled during the emperor's minority insisted on his assuming office, which he finally did in October 1665. Once in office, he ordered the readoption by the Bureau of the Great Concordance astronomical system (*Da tong li* 大统历)[4] which had been the official system of the Ming dynasty, and the Qing dynasty's official calendar was henceforward calculated on this basis rather than using the Jesuit's western methods.[5] His tenure of the Directorship was not widely seen as successful. The staff of the bureau had not used the old system since 1644, and in 1666 Yang was obliged to recruit Wu Mingxuan 吴明烜, the disgraced former director of the Astronomical Bureau's Muslim section (*Hui hui ke* 回回科), which had been abolished during Schall's period in office, in order to have access to the skills in predicting planetary motions, in which the Muslim section had traditionally specialised. Yang did this in the face of complaints from some officials that Wu was a convicted criminal who had escaped a death sentence for misleading the emperor only because he was lucky enough to be covered by a general amnesty to celebrate the recovery of a member of the imperial family from a serious illness.

Yang Guangxian was by his own admission quite unable to carry out calendrical computations, which he therefore entrusted to his subordinates in the Bureau. Instead, he began a project to restore an alleged ancient method known as *hou qi* 候气 'watching for the *qi*', for experimental determination

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[2] These astronomical methods were set out in the multi-authored collection of explanatory texts, calculation procedures and tables of data compiled under the supervision of Xu Guangqi 徐光启 (1562—1633), the *Chong zhen li shu* 崇祯历书 (Texts on astronomical systems [compiled in] the Chongzhen reign), and submitted to the throne between 1630 and 1635. In 1644 a new version of this collection, which continued to be modified thereafter, was issued by Schall under the title *Xi yang xin fa li shu* 西洋新法历书 (Texts on astronomical systems according to the new western methods). The words *Xi yang* 'western' were later dropped from the title to give *Xin fa li shu* 新法历书 (Texts on astronomical systems according to the new methods). The collated edition of Shi and Chu (2017) includes all the material added to the text under the early Qing.

[3] It was a routine part of the Bureau's work to compile the annotations to the imperially issued annual calendar, indicating which days were favourable or unfavourable for certain activities; see the account of the criticisms levelled against Schall by some of his fellow Jesuits for taking part in such 'superstitious' activities in Jami (2012), 38—40. It was a natural extension of such activities for the Bureau to choose appropriate times for important state activities such as an imperial funeral.

[4] In the texts referred to in this article, the word *li* 历 is used to refer to two things whose names demand different English translations. It may refer to a text in pamphlet form such as the 'People's *li*' *Min li* 民历, promulgated annually by imperial authority and used by all literate households, giving information relating to each day of the lunar months of the year: here the translation 'calendar' is appropriate. Elsewhere, as in 'Great Concordance *li*' (*Da tong li* 大统历) it refers to a complex document specifying the astronomical calculations and tabulated data which, amongst other functions, enable such documents as the annual lunisolar calendar to be produced. Here the words 'system' or 'astronomical system' are more appropriate. On this issue, see the discussion in Cullen (2017), 24.

[5] By the time Yang took office, it was too late for calendars based on the Great Concordance to be produced for Kangxi 5, 1666, and those already calculated under the Jesuits for that year had to be used: see note 84.

of the initial moments of the 24 subdivisions of the seasons of the year.[6] This supposedly worked by constructing pitch pipes whose lengths would enable them to resonate with the different cosmic *qi* 气, associated with each season. These 24 subdivisions, themselves called *qi*, sometimes *jie qi* 节气, were crucial reference points in deciding whether the months were in step with the seasons, or whether an intercalary month needed to be inserted in the calendar to restore their correct relations. Despite devoting considerable time and official funds to his project, Yang was unable to report any success, and by the end of 1668 a number of high ministers, and even the young Kangxi emperor himself (1654—1722, then aged 14, having formally assumed personal rule since August 1667), had begun to display impatience with Yang's procrastination.

Around this time, the emperor became aware of the presence of the group of Jesuits still under house arrest in Beijing, of whom three remained after the death of Schall two years earlier. One of the group, Ferdinand Verbiest (Nan Huairen 南怀仁, 1623—1688), was expert in astronomy and had served as Schall's assistant in the work of the Astronomical Bureau. The others were Lodovico Buglio (Li Leisi 利类思, 1606—1682, the superior of the group), and Gabriel de Magalhães (An Wensi 安文思, 1609—1677). Early in the morning of Christmas Day, 25 December 1668 (Kangxi 7/11/28), a group of four senior officials were sent to the Jesuit residence by the emperor, and asked for comments on the calendar prepared by the Astronomical Bureau for Kangxi 8, 1669,[7] which had been issued a few weeks earlier (see note 14). Verbiest responded with a number of trenchant criticisms which evidently impressed the visitors, since they returned later in the day to convey to the Jesuits a summons to appear at the palace early on 26 December. There, together with Yang Guangxian and Wu Mingxuan, they were closely questioned on astronomical matters, first by high ministers, and then by the emperor himself, who had previously sent a message urging Yang, Wu, and the Jesuits to discuss calendrical matters in a cooperative and non-contentious spirit. Despite this injunction, Yang claimed that the Jesuits were engaged in plotting rebellion against Qing rule, and should therefore play no role in calendrical reform. The emperor rejected as implausible the suggestion that a small number of missionaries could pose any danger to the dynasty, and angrily rebuked Yang as a 'petty and venal person' (*xiao ren* 小人) for having concealed the presence of the Jesuits in Beijing when the emperor had, earlier in the year, issued a call for astronomical experts to be located and sent to the capital.

In contrast, the emperor questioned Verbiest and his colleagues (who were probably the first Europeans with whom he had had any significant contact) with friendly interest. When the emperor asked Verbiest to suggest some test that would enable anybody to see whether the Jesuits' astronomical methods were or were not correct, Verbiest suggested the simple experiment of asking for predictions of the length of the noon shadow of a gnomon of any given length on any day that might be assigned. On the emperor asking Yang and Wu whether this was a fair test, they agreed that it was, and the emperor ordered that the shadow prediction trial should begin the next day, 27 December. When it came to the day itself, Yang and Wu admitted that they were in fact unable to make the re-

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[6] On this see Huang and Chang (1996). Like many sinologists, we prefer to leave the word *qi* untranslated, since none of the English translations proposed, such as 'pneuma', 'vapor' or 'ether' seem to capture its range of meanings to an adequate degree.

[7] During the Ming and Qing periods, a regnal year began on the first day of the first lunar month, which typically fell during February, or sometimes in late January. Thus, Kangxi 8 began on 1 February 1669, and Kangxi 9 on 21 January 1670. In this article, we give the Gregorian year in which a given regnal year begins, and during which most of its months fall.

quired predictions, and Verbiest alone was tested on that and the two subsequent days. He was held to have completed the trial with a high degree of success.[8]

As a result of Verbiest's criticisms of the official calendar, for which Yang Guangxian was formally responsible even if others had actually produced it, added to his failure in the 'watching for the *qi*' project and his incapacity to meet the shadow prediction challenge, Yang appears to have lost all credit in the emperor's eyes, although he was not formally dismissed until March 1669. Wu Mingxuan, however, was apparently seen by the emperor as a competitor against whom Verbiest still needed to prove himself further, despite Wu's failure in the shadow trial. To see why this was, and what it entailed, we need to look back at events earlier in 1668.

Ⅱ. Wu Mingxuan as a contender in the project of astronomical reform

As already mentioned, it was Yang Guangxian who had rescued Wu Mingxuan from obscurity and disgrace by bringing him back into the Astronomical Bureau in 1666. But by 1668 it seems that Wu's sense of gratitude was wearing thin, since in August of that year he launched a major attack on the competency of the Bureau as an organization, and thus by implication attacked the management of the Bureau by its Director Yang Guangxian:

> 康熙七年 … 七月 … 壬子。钦天监监副吴明烜疏言、见用古历、不无差谬。如五官正戈继文等所进历、暨回回科七政历三本、互有不同。宜令四科知历之官、详加较正、以求至精。然推历以黄道为验。黄道以浑仪为准。今观象台浑仪损坏、亟宜修整。又地震方向、各有所占。请造滚球铜盘一座。并设台上。仪器备、则占验始为有据。
>
> 得旨、历法甚为精要。如何而使大备。永远可行。著礼部确议具奏
>
> Kangxi 7 … 7th month … (15th day) *renzi*. 49 (22 August 1668):[9]
>
> The memorial of the Deputy Director of the Astronomical Bureau, Wu Mingxuan, states:
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> The way the old astronomical system [i. e. the Great Concordance system], is being used is not without errors. As for the calendar submitted by the Supervisor of the Five Offices Ge Jiwen and his colleagues,[10] and the three versions of the Planets Calendar of the Muslim section, they are not consistent with one another. It would be appropriate to order those officials of the Four Sections [of the Bureau][11] who understand astronomical systems to go into this in detail and make corrections, in order to arrive at the greatest accuracy.
>
> Now in making predictions with an astronomical system, the ecliptic is the reference, and the ecliptic uses an armillary sphere as its standard. But the armillary sphere on the Ob-

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8 A detailed analysis of the calculation methods used by Verbiest to make these predictions, and of the circumstances that led him to adopt them is given in Cullen and Jami(2022).

9 The number 49, not given in the original, is the number in the 60-day cycle of the sexagenary day labelled *renzi*, added here and elsewhere for the reader's convenience. For a tabulation of the whole cycle, see Cullen (2017), 57, Table 2. 3. The day of the month, added here for clarity, is not normally given in the *Shi lu*. All Western dates given in this article are in the Gregorian calendar.

10 From the context, and what is said in the report of the Board of Rites that follows, it appears that this is not the 'People's Calendar' for general distribution, but the 'Planets Calendar' giving daily positions of the sun moon and planets, that was only circulated to the officials of the capital bureaucracy.

11 These were the Calendar Section (*Li ke* 历科), the Observatory [Literally 'Celestial signs'] Section (*Tian wen ke* 天文科), the Clepsydra Section (*Lou ke* 漏科), and the Muslim Section (*Hui hui ke* 回回科).

servatory platform is damaged, and it should be repaired as a matter of urgency. Further, the directions of earthquakes all have divinatory significance. I therefore request that there should be made a bronze 'ball-rolling plate',[12] to be set up on the observatory. When the instruments are complete, then for the first time divination will have something to serve as a basis.

A Rescript was received [from the emperor] in response: Astronomical systems are a matter of vital importance. How can their completeness be assured, so that they will work permanently? Let the Board of Rites come to a definite decision on this, and memorialize accordingly.[13]

The concern that this attack caused to the emperor and his advisors is evident from the words of the rescript, which asked in effect how, if the restored 'old system' (the Great Concordance system) was problematic, the dynasty was to find a system that could be guaranteed to work in the long term. The Board of Rites took over a month to reply, an interval which suggests that they had investigated this problem with considerable care:

康熙七年 … 八月 … 丙申。礼部等衙门、议覆五官正戈继文等、所算七政历、金水二星、差错太甚。主簿陈聿新七政历、未经测验、亦有差错。监副吴明烜之七政历。与天象相近、理应颁行。但陈聿新推算己酉年民历、已经颁行各省、不便更换、止于本年暂用。其七政经纬躔度、月五星凌犯等历、及日月交食。既据吴明烜自认、务求合天。应自康熙九年以后。俱交吴明烜推算。仍令钦天监堂官、公同四科官员每日上台。昼测晷影。以定节气。夜测日月五星。以定行度。四年之内修正。务期合天。著成历书。得旨、著吴明烜将康熙八年历日、七政历日、推算进览。余依议

Kangxi 7 … 8^{th} month … (30^{th} day) *bingshen*. 33 (5 October 1668):

The Board of Rites and other offices report on their deliberations:

[As for] the Planets Calendar calculated by the Supervisor of the Five Offices Ge Jiwen and others, there are very large errors in relation to the two planets Venus and Mercury. The Planets Calendar of the Recorder Chen Yuxin has not yet been subjected to observational testing, and it may also have errors. The Planets Calendar of the Deputy Director Wu Mingxuan is close to the celestial phenomena, and in principle it ought to be promulgated for use. But the People's Calendar calculated by Chen Yuxin for the *jiyou*. 46 year [Kangxi 8, 1669] has already been promulgated to every province,[14] and since it would be inconvenient to make a change, it should be used for that year only. As for the calendars giving the degrees of the orbits of the planets in celestial longitude and latitude, and the approaches and

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[12] This device used the direction in which a ball rolled from a central position on a horizontal plate as an indication of the location of the earthquake causing the disturbance.

[13] *Da Qing li chao shi lu* 26, 16b—17a.

[14] This had taken place, as was the custom, in the fourth lunar month to enable provincial officials to print a sufficient number of copies for general distribution to the population on the first day of the tenth month, which in 1668 was 4 November. See the account in Verbiest (1687), ch 8, translated and commented in Verbiest and Golvers (1993), 71—73.

invasions of the moon and five planets[15], together with solar and lunar eclipses, Wu Mingxuan is resigned to having to work to seek agreement with the heavens. It would be proper to order Wu Mingxuan to make calculations for the years from Kangxi 9 [1670] onwards. Accordingly, the chief officers of the Astronomical Bureau, with the officials of the Four Sections, should be ordered to go up to the observatory every day, to measure the [gnomon] shadow during the daytime, in order to determine [the times of] the *qi*, and at night to observe the (sun)[16] moon and five planets, in order to determine their motions. They should carry out [this work of] revision and correction for four years, with the aim that during that time they will achieve agreement with the heavens, and can then compose [a new] treatise on the astronomical system.

Rescript [from the emperor]: Let Wu Mingxuan take in hand the [People's] Calendar for Kangxi 8 and the Planets Calendar, and submit his calculations for inspection. Let the rest be in accordance with the report.[17]

The internal situation of the Astronomical Bureau revealed here is very striking, and appears to indicate that Yang Guangxian was failing to control his subordinates' activities — a not unexpected state of affairs given his confessed lack of technical understanding. There were apparently several conflicting versions of the Planets Calendar for 1669 in existence, one prepared by Ge Jiwen, another by Chen Yuxin and another prepared by Wu Mingxuan, together with perhaps up to three others from the Muslim section. It is not clear how the Board of Rites had decided that Ge Jiwen's calendar was in error in its predictions for Mercury and Venus, and that Wu Mingxuan's calendar was relatively accurate: it may simply be that Wu had more supporters in the Bureau than Ge. The fact that Chen Yuxin's People's Calendar had already been promulgated to provincial governments may explain why his Planets Calendar was spared serious criticism — although it had not yet been released to the senior officials who would normally receive this document, it would have caused difficulties if a different Planets Calendar had been substituted that was not consistent with those parts of its data (such as the times of luni-solar conjunctions marking the first days of months) that had already been used in the People's Calendar. But although Wu Mingxuan's Planets Calendar was not selected for immediate use in Kangxi 8, 1669, the Board still recommended that he should be given responsibility for the Planets Calendar in subsequent years. The Board also took up Wu's suggestion that the officers of the whole Bureau should cooperate in work to improve the astronomical system — and not only proposed that this work should extend over several years but also laid stress on observation as a basis for the elaboration of a body of theory. Finally, the explicit reference to determining the times of *qi* by observation may well be intended as a veiled criticism of Yang Guangxian's contention that such observational

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15 This last document, *the Ling fan li* 凌犯历, was in principle submitted only to the emperor, in manuscript form. It contained detailed calculations of the close approaches of the moon and five planets to one another, and to astrologically significant stars.

16 This word is clearly out of place here, since the sun is not observable at night; it has probably slipped in by way of a reminiscence of the conventional phrase *ri yue wu xing* 日月五星.

17 *Da Qing li chao shi lu*, 26, 25b—26a.

work was unnecessary if his 'watching for the *qi*' method was put into practice.[18]

The emperor's response expressed approval of these proposals, but also revealed his desire to make more immediate progress with astronomical issues by insisting that Wu Mingxuan should go ahead immediately with the production of trial versions of a People's Calendar and a Planets Calendar for Kangxi 8, 1669, so that his abilities could be judged on that basis in advance of his being given responsibility for the calendars that would, if all went according to plan, be prepared for Kangxi 9, 1670. It appears that if Wu succeeded, the emperor was prepared to give him the main responsibility for the project of producing an astronomical system for the dynasty that could be used in the long term. Under those circumstances, it was unlikely that the emperor would abandon these plans purely because of Verbiest's success in predicting gnomon shadows, a matter that was decidedly peripheral to the imperative need for the dynasty to produce a reliable calendar.

So, far from giving Verbiest any responsibility for astronomical matters, or even any reward for his success, the emperor simply set him a heavy task to perform, as set out in the imperial response dated 29 December to the report of the officials who had supervised the shadow trial:

> 知道了。将吴明烜所造。七政及民历。着南怀仁验看差错之处写出。俟报部之日。尔等议奏钦此。
>
> Acknowledged. Take the Planets and People's Calendars made by Wu Mingxuan, and let Verbiest[19] examine them. If he sees any errors he is to point them out in writing. You shall wait for the day when he reports back, and then you shall deliberate and report.[20]

Verbiest was no doubt well aware of the fact that he was being given an opportunity to prove that he should replace Wu Mingxuan as the person responsible for producing a calendrical system that would be 'capable of working permanently' (*yong yuan ke xing* 永远可行), as the emperor had demanded in his rescript on Wu Mingxuan's memorial of the preceding August. Unsurprisingly he made full use of this opportunity to attack Wu Mingxuan's astronomical competence. It appears that Verbiest spent most of January 1669 on this task. The copy of his memorial to the emperor that he prepared to accompany his detailed report is dated to Kangxi 7/12 (which ran from 2—31 January 1669), but the day of the month is blank. However, in the copy given in the documents collected in *Xi chao ding an* 熙朝定案 (*Cases decided during the* [*Kang*]*xi reign*, hereafter abbreviated as *XCDA*), the emperor's rescript in response is dated to Kangxi 7/12/26, 27 January 1669. Given the brevity of the rescript it is likely that the report was received at most a day or two before that date. In his manuscript Latin account, written seven years later, Verbiest tells us that the emperor responded *statim*

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[18] He had first made this claim during the Jesuit's trial in 1665, when he said that it was not necessary to go up to the observatory to make observations (*fei deng tai guan xiang* 非登台观象), so long as the 'watching for the *qi*' procedure was properly followed: An (2015), 116—117, report of trial proceedings submitted Kangxi 4/1/29, 15 March 1665.

[19] In translating Chinese texts in which Verbiest's Chinese name, Nan Huairen 南怀仁 occurs, we commonly render it as 'Ferdinand Verbiest', 'Verbiest', or when the term is used self-referentially by Verbiest 'I', 'me' 'my' or 'mine' as appropriate.

[20] *CYJL* 6b—7a.

('immediately'). [21] In his rescript, the emperor ordered that the report should be passed to the Deliberative Council *Yi zheng wang da chen hui yi* 议政王大臣会议 for discussion. [22] Two days later, the Deliberative Council, headed by Prince Giyešu, responded by declaring their incapacity to evaluate Verbiest's report, and suggesting a way of proceeding that might satisfactorily resolve the issue between Verbiest and Wu:

> 南怀仁所称吴明烜推算历日种种差错之处。皆系精微。其是非一时据难定议。必须差委测验大臣。同钦天监马祜等。将南怀仁吴明炫推算历日内可以测验之数欵。谁人合天象不合天象之处测看。完日再议具题。
>
> The different kinds of errors and inaccuracies in Wu Mingxuan's calendars set out by Verbiest are all very precise and subtle, and it is difficult to come to any overall conclusion as to whether [Verbiest's criticisms] are correct or not. What should be done is to send some high officials to observe, together with Mahu[23] and his colleagues from the Bureau of Astronomy, so that they can take all the numerical data by Verbiest and Wu Mingxuan capable of being tested by observation, and see whose [predictions] match the heavens and whose do not. When this has been done a further report should be made. [24]

The emperor responded on the same day with a list of twenty names of suitable officials to be delegated to carry out the required observations. These included the Presidents and other senior officials of the Boards of Works, Personnel, Rites, Punishments and War, together with two Censors. It was agreed that observations should take place on the third and eighteenth days of the first month of Kangxi 8 (3 and 18 February 1669), which were the days on which Verbiest had predicted that the two *qi* associated with the first month, Establishment of Spring and Rain Waters, should fall. As well as checking when these events actually occurred, there were also to be observations to check predictions of the positions of Mars and Jupiter on the first occasion and of the Moon on the second occasion. [25]

Verbiest and Wu made their predictions in advance of the dates fixed, and the designated officials attended the subsequent observations by which those predictions were checked. Finally, the officials jointly signed a detailed report on the 22nd day of the month, in which they set out the results of their observational evaluation of the predictions made by Verbiest and Wu Mingxuan, and attested that in every instance Verbiest's predictions were correct and Wu's were wrong. [26] Two days later Giyešu

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21 *Xi chao ding an*, 4a-6b, Verbiest (1687), IV,12 and Golvers and Nicolaidis (2009), 128—129. The collection of memorials and imperial pronouncements in *XCDA* appears to have been initially assembled in 1669, but continued to be added to and modified in later editions.

22 This was composed of Manchu princes and ministers, and was the major advisory body for emperors in early Qing. On its role and development see Oxnam (1975), 70—76 and elsewhere.

23 This is the Manchu who was co-president (*Jian zheng* 监正)of the *Qin tian jian* 钦天监 with Yang Guangxian.

24 *XCDA*, 7a—7b.

25 In both the 1676 manuscript and in *Astronomia Europaea* eleven years later, Verbiest indicates that he and Wu Mingxuan were summoned to a meeting by the Board of Rites (the ministry to which the Astronomical Bureau was then subordinate), at which it was decided what predictions were to be made and tested. He seems to suggest that he had an influential voice in this choice; there is no record of this meeting in Chinese. See Golvers and Nicolaidis (2009), 129—131 and Verbiest and Golvers (1993), 67.

26 *CYJL*, 43a—38b.

summarised their report for the emperor in a memorial on behalf of the Deliberative Council, and recommended that Verbiest should be appointed to an office in the Bureau of Astronomy and put in charge of calendrical calculation for the following year, Kangxi 9, 1670. Wu Mingxuan, on the other hand, should be investigated by the Board of Personnel. At this point we shall conclude our narrative and look more closely at the calculations and predictions that have been central to the story.

Ⅲ. Verbiest's criticism of Wu Mingxuan and the 'Muslim system *Hui hui li* 回回历' in early 1669

On what basis had Wu Mingxuan produced his two calendars for Kangxi 8, and made his predictions for the observational tests of February 1669? As we shall see below, in Verbiest's criticisms of the calendrical writings that Wu Mingxuan had produced, he repeatedly refers to Wu's calculations as resulting from the *Hui hui li* 回回历 'Muslim astronomical system'. Taken with the fact that Wu was indeed a Muslim, and had previously headed the Muslim section of the Astronomical Bureau, it would indeed be no surprise to find that Wu's work actually was based on Muslim astronomical techniques.

Astronomical theory and practice from the Islamicate world, which Dror Weil has characterised as 'Arabo-Persian astronomy', was first introduced into East Asia under the patronage of the Yuan dynasty.[27] The Chinese texts nowadays associated with the title *Hui hui li* originate from the early years of the Ming dynasty (1368—1644), when translations of astronomical texts from the imported system were first produced, and Muslim specialists in their use were given a place in the Astronomical Bureau of the new dynasty. The origins and subsequent history of this material has been studied by a number of scholars, based on detailed descriptions of its methods of calculation in a number of extant sources from the 15th century onwards.[28] The *Hui hui li* is, ultimately, a descendant of the system set out in the second century CE *Almagest* of Ptolemy of Alexandria, transmitted and modified over the centuries by astronomers working in the Islamicate world, before it was finally embodied in a Chinese language version. It may thus be regarded as a distant cousin of Verbiest's methods, which ultimately go back to the same Hellenistic roots, via the modifications of Copernicus and Tycho Brahe, who in turn drew on work by astronomers in the medieval Islamicate world.[29]

But was there any connection between tables and calculation procedures set out in the various extant documents associated with the title *Hui Hui li*, and Wu Mingxuan's Planets and People's Calendars for Kangxi 8, 1669, together with the predictions of lunar and planetary positions he was ordered to submit for observational testing in February 1669?

Verbiest criticises the predictions of Wu Mingxuan's draft People's and Planets calendars at length and in great detail. His report is preserved as part of the document collection relating to his

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27 See Weil (2018).

28 See for instance Yabuuti and van Dalen (1997) and van Dalen and Yano (1998), also Shi (2003). We have made use of these and other sources in our work towards understanding the *Hui hui li*, and are grateful to Benno van Dalen and Shi Yunli for their personal responses to queries, which have been of great assistance.

29 In his 1676 manuscript Verbiest specifically stated that Wu's methods were 'according to the tables of Ptolemy [*secundum Ptolem<a>ei tabulas*], which he had inherited from his ancestors': Golvers and Nicolaidis (2009), 126—127. This is the only point at which Verbiest refers by implication to the common ancestry of Wu's methods and his own.

conflict with Yang Guangxian and Wu Mingxuan that was assembled, apparently by Verbiest himself in response to an imperial command, under the title *Qin ding xin li ce yan ji lue* 钦定新历测验纪略 (*A summary of observations in accordance with the new astronomical system, imperially commissioned*), abbreviated as *CYJL*. He opens the collection with the following introduction:

> 奉旨查对杨光先吴明垣所造各历,并测念诸差纪略。治理历法极西耶稣会士南怀仁述。
>
> In response to a Rescript commanding him to examine and report on the various calendars produced by Yang Guangxian and Wu Mingxuan, and on their discrepancies with observation, Ferdinand Verbiest from the Far West, member of the Society of Jesus, Managing Calendrical Methods reports as follows.[30]

This text of *CYJL* is thus likely to have been composed at some time after Kangxi 8/3/15 (15 April 1669), the date of the first memorial by Verbiest in which he described himself as 治理历法 'Managing Calendrical Methods', the title used in his opening.[31] It is a fairly lengthy text, taking up 84 single pages counted in the western manner, printed on 42 centre folded sheets in the normal Chinese book design. At three points in the text, the sequence of *CYJL* pages pauses to allow the insertion of pages containing documents taken from the woodblock print of the *Xi chao ding an* (*XCDA*) collection of memorials and other official documents, of which the first version was also assembled in 1669. After each of these three documents (which preserve the *XCDA* pagination and were clearly printed from the *XCDA* woodblocks), the *CYJL* page sequence resumes. These insertions add another 6 folded sheets. Verbiest's discussion of Wu Mingxuan's work on the People's and Planets Calendars for Kangxi 8 takes up pages 11a—28b of the main text.

We do not however have to wait until that point for Verbiest to make it clear on what basis he thinks that Wu Mingxuan performed his calendrical calculations. On the very first page of his report, he states:

> 仁当查对吴明烜所用回回历法诸差者。缘奉特旨。
>
> The reason for my taking responsibility for examining and reporting on all the errors in the Muslim astronomical methods used by Wu Mingxuan was that I received a special edict.[32]

And later:

> 先是杨光先保用大统授时诸历。以为较之回回历法。远天特甚。故康熙七年。奉旨谓历交吴明烜推算。及至仁查对明烜所用回回历法。仍复大谬。与大统授时诸历无异。
>
> The origin [of this affair] was that Yang Guangxian treated the Great Concordance and

[30] *CYJL* 1a.

[31] See *XCDA*, no 7, 15a—16a. Although *li fa* usually refers to the methods embodied in astronomical systems, the 'calendrical' rendering reflects the way that Verbiest probably expected his skill-set to be viewed in this context.

[32] *CYJL*, 1a.

Season Granting systems as precious heirlooms.[33] It was considered that compared with the *Hui hui* system methods these erred greatly from [the phenomena seen in] the heavens. Thus in the 7th year of the Kangxi period, a Rescript was issued that the calendar should be handed over to Wu Mingxuan to calculate. When I came to check and report on the methods of the *Hui hui* system, thereupon [I found] further major errors, no different from those in the Great Concordance and Season Granting systems.[34]

Here Verbiest is evidently referring to the events of August and October 1668, Kangxi 7, when Wu Mingxuan criticised the official calendars for the coming year Kangxi 8, which was to begin in early 1669. Wu's memorial was given in full in the preceding section of this article, followed by the memorial of the Board of Rites suggesting that he should be given responsibility for a long-term project of astronomical reform, as well as for calculating the calendars for Kangxi 9, 1670. It will be recalled that while agreeing to this proposal, the emperor demanded that Wu should also produce draft calendars for Kangxi 8. However, if we look again at Wu's memorial of 22 August 1668 cited above, his only reference to the work of the Muslim section was to include it in a note referring to officials whose work was inconsistent:

> 如五官正戈继文等所进历、暨回回科七政历三本、互有不同。
>
> As for the calendar submitted by the Supervisor of the Five Offices Ge Jiwen and his colleagues, and the three versions of the Planets Calendar of the Muslim section, they are not consistent with one another. (See above for full text)

And Wu's reform project was not to be based solely on the Muslim section, but was inclusive of all qualified persons in the entire Bureau:

> 宜令四科知历之官、详加较正、以求至精。
>
> It would be appropriate to order those officials of the Four Sections [of the Bureau] who understand astronomical systems to go into this in detail and make corrections, in order to arrive at the greatest accuracy. (See above for full text)

Verbiest himself, when writing for a European readership some years after the events of 1669, indicated that the connection between the 'Muslim system' and Wu Mingxuan's predictions embodied in his two calendars was by no means as straightforward as he had indicated in *CYJL*:

> Mahumetanus ille, quàm temerarius in loquendo, tam ignarus in calculando, & rudis in

[33] The expression in the text, *bao yong* 保用 literally means 'preserve and use'. The translation given here is based on the role of this expression as a variant of the common phrase *bao yong* 宝用 'treasure and use', found in inscriptions on ancient bronze vessels, in such phrases as *zi sun yong bao yong* 子孙永宝用 'May sons and grandsons treasure and use this for ever': for one example amongst many, see Shaughnessy (1991), 8. The variant form occurs in early texts, such as *Hou Han shu* 23, 817, and is used on a seal of the Qianlong period on a Southern Song dynasty scroll in the British Museum, *Illustrations to the Odes of Chen*, Museum number 1964, 0411,0.1. Yang Guangxian certainly regarded the Chinese tradition of calendrical astronomy as a precious heritage to be preserved at all costs against foreign encroachments: see his memorial in *XCDA*, no 26, 52a—54b.

[34] *CYJL*, 1a—1b.

Astronomia，sibíque plane inconstans & contrarius，pleraque Calendariis suis sine ordine ponebat，id est Sinica Arabicìs，& Arabica Sinicis miscebat，atque ita Calendarium. Arabico-Sinicum dici poterat.

The Muslim，as bold in speech as he was ignorant in calculating，and unskilled in astronomy，while openly inconsistent and contradictory to himself，put many things into his calendars[35] without any order，that is，he mixed Chinese materials with Arabic and Arabic with Chinese，so that it might be called an Arabic-Chinese calendar.[36]

Moreover，a detailed analysis of the calculations that Wu Mingxuan performed，and Verbiest's criticisms of them，show that it was probably not Wu's intention to attack the Great Concordance system in itself，or to replace it by a new system based on the Muslim tradition，but rather to criticise the way that the Great Concordance system was being applied by the officials of the Astronomical Bureau.[37] To that analysis we now turn.

Ⅳ. Wu Mingxuan's calculations of *qi*

In pages 14a—18a of *CYJL*，Verbiest compares his own and Wu Mingxuan's predictions of the moments of inception of the two *qi* 气 contained in each month of the coming civil year Kangxi 8，1669. Thus，for the first month，we read：

一正月初四日。戌初一刻。回回历为立春。臣等所推历法。正月初三日。巳初二刻八分为立春。则回回历后天一日零三十八刻有余。

一正月二十日。子正二刻。回回历为雨水。臣等所推历法。正月十八日。卯初三刻二分为雨水。则回回历后天一日零七十四刻有余。

Item：On the 4th day of the 1st month，1 mark into the first half of [the period] xu (19：00—21：00) [*i. e.* 19：15][38]，the Muslim system makes it [the *qi*] Establishment of Spring. The astronomical system calculated by me and my colleagues makes it Establishment of Spring on the 3rd day of the first month，2 marks into the first half of [the double-hour] *si* (09：00—11：00) and 8 minutes [*i. e.* 09：38]. So the Muslim system lags behind heaven by 1 day，38 marks and a fraction.

Item：on the 20th day of the 1st month，2 marks into the second half of [the period] *zi* (23：00—01：00) [*i. e.* 00：30]，the Muslim system makes it [the *qi*] Rain Waters. The astronomical system calculated by me and my colleagues makes it Rain Waters on the 18th day of the 1st month，3 marks into the first half of [the period] *mao* (05：00—07：00) and 2 mi-

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35 Despite this translation，a *calendarium* in an astronomical context was considerably more than a simple calendar in the modern sense；see for instance the great variety of astronomical information given in Regiomontanus (1485).

36 Verbiest (1687)，IV，12，translated with commentary in Verbiest and Golvers (1993)，65.

37 Huang(1993)，60，65，66 and 68 appears to have been the first modern scholar to make the assumption that Wu Mingxuan's calculations were based on the Muslim system. In this he was followed by Chu (1997)，29. We made the same assumption when referring to Wu's project in Cullen and Jami (2020)，13. But in the light of the analysis discussed in this paper，this view must be abandoned.

38 An explanation of how these pre-modern Chinese time notations can be translated into the modern 24-hour clock is given below.

nutes [05:47]. So the Muslim system lags behind heaven by 1 day, 74 marks and a fraction. [39]

Although Verbiest consistently refers to his opponent's results as having been calculated according to the *Hui hui li* 回回历 'Muslim system' (and we shall discuss the accuracy of that characterisation later in this article), he does not give any formal title to what he calls "the astronomical system calculated by me and my colleagues". The astronomical system introduced by the Jesuits has sometimes been referred to by modern scholars as the *Shi xian* 时宪 'Timely modelling' system. This is however not strictly accurate. While a full account of this question will require a longer discussion elsewhere, the essential point is that we must distinguish between the official title given to all calendrical publications issued with Qing imperial authority, and the methods by which they were calculated. A document issued by the Board of Rites in the first months of the Qing makes this explicit. It notes that the Ming dynasty used the title *Da tong* 大统 'Great concordance' for its calendars, and that the new dynasty needed to change this for a title of its own. For this reason, it tells us, an order from the regent on Shunzhi 1/7/4 (5 August 1644) had defined the title *Shi xian* for the Qing calendar. [40] However, in referring to the systems used for calculating calendars, the methods used under the Ming dynasty and the methods advocated by Schall are distinguished by the Board as the *jiu fa* 旧法 'old method' and the *xin fa* 新法 'new method'. Accordingly, the title *Shi xian li* 时宪历 'Timely modelling calendar' appears on the cover of all available calendrical documents produced during the period when Schall was in charge, when Yang Guangxian had taken over the bureau, and after Verbiest was given responsibility for calendar production.

Turning to the actual data given by Verbiest, the figures in square brackets in the above translation, e.g. [19:15], represent the time in the modern 24-hour clock equivalent to that given in Chinese. At this point, it is necessary to explain the time units used by Verbiest and his opponent. Both take as their largest unit of time the 'period' *shi* 时, of which there are twelve in a day, so that each period contains two modern hours (nowadays called *xiao shi* 小时 'small periods'), for which reason some scholars refer to a *shi* period as a 'double-hour'. These periods were named using the standard 12-fold sequence of cyclical characters, beginning with *zi* 子 and ending with *hai* 亥. For timekeeping purposes, each two-hour period was divided into halves of one modern hour each, the first designated as *chu* 初 'beginning' and second as *zheng* 正 'regular'; the hour designated as *zi zheng* 子正 began at midnight, so that the first half of the period zi began at 23:00 at the end of the preceding day. In referring to the time 23:00 on a given day, the term *ye zi chu* 夜子初 'the start of the period *zi* in the evening' is commonly used.

For the convenience of the reader, in this discussion, we shall convert periods into modern hours counted from midnight. Both Verbiest and Wu Mingxuan use the *ke* 刻 'mark' (literally 'cut' representing a graduation cut into the indicator rod of a float clepsydra) as their next smaller unit below the period. Verbiest's marks are each worth 1/96 day (a quarter of a modern hour), and the *fen* 分 'parts' into which he divides his marks are each 1/15 mark, a modern minute. In Verbiest's system, each half period (1 hour) is divided into four equal intervals, as shown in Table 1; the *fen* are, like the

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39 *CYJL*, 14a—14b.

40 See Tang (after 1661, 1993 repr.), 10a—11b, 8:863—864. The term *shi xian* 时宪 was drawn from the text of the ancient Book of Documents *Shu jing* 书经, as were the titles *da tong* 大统 and *shou shi* 授时 used under the Ming and Yuan dynasties.

marks *ke*, numbered according to the whole *fen* elapsed at the moment they begin.

Table 1 Subdivisions of the half-period (1 hour) according to Verbiest's system using 96 *ke* in 1 day

	Instant when interval begins	Instant when interval ends
Chu ke 初刻 'beginning of marks'	Start of the hour	15 complete minutes after start of hour
Yi ke 一刻 'one [elapsed] mark'	15 complete minutes after start of hour	30 complete minutes after start of hour
Er ke 二刻 'two [elapsed] marks'	30 complete minutes after start of hour	45 complete minutes after start of hour
San ke 三刻 'three [elapsed] marks'	45 complete minutes after start of hour	60 complete minutes after start of hour.

So to the nearest minute, the latest time period within an hour that can be recorded in Verbiest's terms without using smaller time divisions is *san ke shi si fen* 三刻十四分 'three marks and 14 minutes', a designation which applies to the whole of the last minute of an hour, beginning when $3 \times 15 + 14 = 59$ minutes have elapsed. The start of the next minute is the first instant within the *chu ke* 初刻 'beginning of *ke*' for the next hour. A time specified in Verbiest's system can thus never include *si ke* 四刻 'four marks'.

Wu Mingxuan, on the other hand, follows Chinese tradition in using marks equal to 1/100 day, equal to 14.4 modern minutes each. Each mark was divided into 100 *fen* 分 'parts', each of which was thus 0.144 modern minutes or 8.64 seconds. For all but the most precise purposes, if Wu Mingxuan gives a time in (elapsed) marks within an hour as, say, *er ke* 二刻 'two elapsed marks', the difference from the moment designated by the same expression used by Verbiest is inconsiderable —in this case only 30 min－28.8 min＝1.2 min, 62 s. Of course, Wu's 'parts' are much smaller than Verbiest's minutes. But there is one significant difference: In Wu's system, when four completed marks have passed, the total time elapsed is only 400 parts. But an hour (or half a 'period') contains more parts than that, since there are $100 \times 100 = 10000$ parts in a day, and

$$10000 \text{ parts}/24 = 416\frac{2}{3} \text{ parts}$$

As a result, the hour does not end after 4 complete marks have elapsed, since there are still $16\frac{2}{3}$ hundredth parts of the hour left to expire. We may therefore, relatively rarely, see examples of timing such as that for *qi* 15, 'Great Heat', which Wu gives as 'four marks' in the relevant hour, as he also does for *qi* 19, 'Autumn Equinox'. The fact that Verbiest reproduces Wu's predictions in these cases shows that he has not converted Wu's original figures based on 100 *ke* into his own 96 *ke* system; however, since the differences noted by Verbiest between Wu's predictions and his own are in all cases at least several hours, no question of importance arises. The problem of *fen* conversion need not be considered, since all Wu's predictions are given in periods and *ke* alone.

Predictions such as those given by Wu Mingxuan and Verbiest were not merely technical matters of concern to astronomical specialists. They were crucially important in the construction of the People's Calendar by which all the subjects of the Qing empire, from high officials down to the mass of the population, were expected to regulate their daily lives. That is because the placement of *qi* within a month determines whether the month belongs in the normal sequence of months from 1 to 12, or whether it is an anomalous 'intercalary' month, an extra month inserted in the series without a number of its own, but labelled as 'intercalary Nth month' *run N yue* 闰N月, where N is the number of the normal month preceding it, so that the year in question has 13 months rather than 12. The decisive factor is that each normal month must contain a 'medial *qi*' (*zhong qi* 中气), *i.e.* one of the twelve odd-numbered *qi* beginning with winter solstice as number 1. A month that does not contain a medial *qi* is counted as intercalary. Thus if a medial *qi* fell near the midnight separating two months, a small shift in the prediction of that *qi* could change which month was counted as intercalary.[41] Verbiest had already referred to such an issue in the first part of his report in *Ce yan ji lue*. There he stated that, according to his calculations, *qi* number 5 Rain Waters *yu shui* 雨水 fell in the month following the twelfth month of Kangxi 8, which would normally have been designated as the first month of Kangxi 9.

本月二十九日午初二刻六分。

On the 29th day of that month, at 2 marks 6 minutes into the first half of the period *wu* (11:00—13:00) [*i.e.* 11:36].[42]

That month (which contained 30 days) therefore contained a medial *qi*, and was a normal month, being the first month of the next year, Kangxi 9. But, Verbiest notes, Wu Mingxuan made this an intercalary twelfth month, because Wu's time for the *qi* in question was so late compared with Verbiest's that it fell on the first day of the month *after* the month following the twelfth month. As Verbiest notes, the delay was 1 day and 71 marks (41 hours and 45 minutes in Verbiest's units), so that the *qi* in question as determined by Wu fell 21 marks into the first day of the next month, at around 05:15.

A disagreement about the placing of an intercalary month raised issues with an impact far outside the concerns of professional astronomers. If Verbiest was correct, then nor only was Wu Mingxuan's calendar for Kangxi 8 incorrect, but so was the already promulgated official calendar for that year, which also had an intercalary 12th month. It was no doubt because he realised the importance of this issue that Verbiest made it the subject of an experimental test during his observation made during the first lunar month of Kangxi 8, which coincidentally began on 1st February 1669.

Verbiest had already predicted that Rain Waters early in Kangxi 8 would fall on the 18th day of the 1st month (18 February 1669), 3 elapsed marks and 2 minutes into the first half of [the period] *mao* (05:00—07:00) [i.e. 05:47]. When on that day his predictions were, he claimed, verified by observation, then since the 'New Western' value used by Verbiest for the interval between *qi* in successive years was then 365 days, 23 marks, 3 minutes and 33 seconds (365d 5h 48m 33s, =365.24205d),[43] no more than simple addition was needed in order to predict that the Rain Waters of Kangxi 9 should fall on day 29 of the first month (18 February 1669), at a time given by:

05:47 +5 h 49 min (to the nearest minute) = 11:36, as he had predicted.

In his *Astronomia Europaea*, Verbiest makes the connection with intercalation explicit:

... observavi Solis ingressum in signum piscis, à quo tanquam fundamento pendebat illa quaestio, num scilicet mensis ille intercalaris, de qua supra, ex Calendario illo tam Sinico, quàm Arabica expungendus effet: certè expungendum esse altitudo & declinatio Solis, eo die

41 Since Verbiest and Wu did not disagree about the days when months of Kangxi 8 began and ended, the discussion is simpler than it might otherwise have been.

42 *CYJL*, 11a.

43 See Shi and Chu (2017), 893.

in meridie observata, clarissimè demonstrabat.

> . . . I observed the entry of the sun into the sign Pisces [longitude 330°, when Rain Waters began according to Jesuit reckoning], on which depended the fundamental question of whether the intercalary month referred to earlier should be deleted from the calendar, [which was] as much Chinese as it was Arabic: the altitude and declination of the sun as observed at noon on that day showed very clearly that it should be deleted.[44]

As Verbiest indicates, a critical observation for him was that of the sun's noon altitude, from which, in combination with the known altitude of the north celestial pole the sun's declination at that instant could be deduced. Hence by the use of a table of obliquity, the celestial longitude of the sun at noon could be found, and compared with the longitude corresponding to Rain Waters (as defined by Verbiest), which was 330°. While this is not the place for a detailed examination of Verbiest's observations, with the apparatus we know Verbiest to have used it should have been possible for him to check the day of entry of the sun into Pisces by a noon observation of the sun's altitude, as well as verifying that his timing of that event within the day was broadly correct. He also used a sextant zeroed on the noon altitude of the celestial equator to determine the declination of the sun directly.[45]

The predictions of both Verbiest and Wu Mingxuan for all 24 *qi* of Kangxi 8 are shown in Table 2, where they occupy the two main central divisions of the table. In each case the Chinese civil month and day of the month appear first, in the columns labelled 'Chinese lunar month, day', followed in the next columns to the right by the month and day of the month in the Gregorian calendar. Next follow three columns showing the units as recorded by Verbiest in his report, followed by the corresponding hour and minute of the day in the 24-hour clock. The next division shows the corresponding predictions of Wu Mingxuan.

44 Verbiest (1687), V, 14 tr. and comm. in Verbiest and Golvers (1993), 68.

45 In *CYJL* 36b—37a, Verbiest states that the noon altitude of the sun observed on the day in question was 38° 38′, and that the altitude of the pole was 39° 55′. This would imply that the sun's noon declination was 90°—38° 38′—39° 55′ =11° 27′, whereas the declination he gives is 11° 25′, which is in fact the value implied by calculation from the tables in the *XFLS* and the stated timing of the *qi* (see a forthcoming publication). However, since he tells us that the altitude was observed using a quadrant *xiang xian yi* 象限仪 which from *CYJL* fig 5 we know was based on a circle of diameter 5.2 *chi* 尺, and 1 *chi* was 32 cm, the difference of two minutes of arc would only amount to half a millimetre on the quadrant scale, below the limits of visual accuracy. The change in solar declination between the true moment of Rain Waters at 05:47 and noon on the same day would have been about 16 minutes of arc, corresponding to a 4 mm shift on the scale. If we may rely on the illustration in *CYJL*, the smallest division marked on the scale corresponded to 20 minutes, about 5 mm. It would therefore have been possible for Verbiest to verify that his *qi* timing was right to within an hour or so. In this context, it is worth noting that the observational procedure did not involve reading values off a scale, but checking whether the sighting device appeared to align with the sun when the diopter was adjusted to match the line previously marked on the instrument according to Verbiest's calculations. Similar remarks apply to Verbiest's use of a sextant with a 10 *chi* circle radius, which he used to measure declination directly (*CYJL* fig 6).

Table 2 *Qi* predictions for Kangxi 8，1669

			Qi dates and from times found using *Hui hui li* solar longitudes at 15° intervals			*Qi* dates and times predicted by Verbiest，from *CYJL*								*Qi* dates and times predicted by Wu Mingxuan，from *CYJL*								Interval from Verbiest to Wu Mingxuan predictions
Qi number			Gregorian Month Day		Time of day	Chinese Lunar Month Day		Gregorian Month Day		Hours	Marks=Day/96	Mins=Mark/15	Time of day	Chinese Lunar Month Day		Gregorian Month Day		Hours	Marks=Day/100	Parts=Mark/100	Time of day	hours
4	Establishment of spring	立春	Feb	3	9:35	1	3	Feb	3	9	2	8	9:38	1	4	Feb	4	19	1		19:14	−33.60
5	Rain waters	雨水	Feb	18	5:56	1	18	Feb	18	5	3	2	5:47	1	20	Feb	20	0	2		0:29	−42.70
6	Emerging insects	惊蛰	Mar	5	4:57	2	4	Mar	5	5	0	10	5:10	2	6	Mar	7	5	3		5:43	−48.55
7	Spring equinox	春分	Mar	20	7:06	2	19	Mar	20	7	0	10	07:00	2	21	Mar	22	11	0		11:00	−51.83
8	Clear and bright	清明	Apr	4	12:34	3	4	Apr	4	11	3	6	11:51	3	6	Apr	6	16	1		16:14	−52.38
9	Grain rains	谷雨	Apr	19	21:20	3	19	Apr	19	21	1	11	21:26	3	21	Apr	21	21	2		21:29	−48.05
10	Establishment of summer	立夏	May	5	9:09	4	6	May	5	7	2		7:30	4	8	May	7	2	3		2:43	−43.22
11	Grain fills	小满	May	20	23:36	4	21	May	20	23	0		23:00	4	23	May	22	8	0		8:00	−33.00
12	Grain in ear	芒种	Jun	5	16:01	5	7	Jun	5	15	3		15:45	5	8	Jun	6	13	1		13:14	−21.48
13	Summer solstice	夏至	Jun	21	9:41	5	23	Jun	21	9	2		9:30	5	23	Jun	21	18	2		18:29	−8.98
14	Little heat	小暑	Jul	7	3:43	6	10	Jul	7	4	1	7	4:22	6	9	Jul	6	23	3		23:43	4.65
15	Great heat	大暑	Jul	22	21:15	6	25	Jul	22	22	0		22:00	6	25	Jul	22	4	4		4:48	17.03
16	Establishment of autumn	立秋	Aug	7	13:28	7	11	Aug	7	15	0		15:00	7	10	Aug	6	10	0		10:00	29.00
17	Limit of heat	处暑	Aug	23	3:36	7	27	Aug	23	5	1	8	5:23	7	25	Aug	21	15	2		15:29	37.90
18	White dew	白露	Sep	7	15:03	8	13	Sep	7	16	3	8	16:53	8	11	Sep	5	20	3		20:43	44.17
19	Autumn equinox	秋分	Sep	22	23:25	8	29	Sep	23	1	0	9	1:09	8	27	Sep	21	1	4		1:48	47.18
20	Cold dew	寒露	Oct	8	4:25	9	14	Oct	8	6	0		6:00	9	12	Oct	6	7	0		7:00	47.00
21	Frost-fall	霜降	Oct	23	6:09	9	29	Oct	23	7	2		7:30	9	27	Oct	21	12	1		12:14	43.27
22	Establishment of winter	立冬	Nov	7	4:49	10	14	Nov	7	6	0	5	6:05	10	12	Nov	5	17	2		17:29	36.60
23	Little snow	小雪	Nov	22	0:51	10	29	Nov	22	2	2		2:30	10	27	Nov	20	22	3		22:43	27.78
24	Great snow	大雪	Dec	6	18:55	11	14	Dec	6	20	0		20:00	11	14	Dec	6	4	0		4:00	16.00
25	Winter solstice	冬至	Dec	21	11:45	11	29	Dec	21	12	3		12:45	11	29	Dec	21	9	1		9:14	3.52
26	Little cold	小寒	Jan	5	4:11	12	14	Jan	5	3	3		3:45	12	14	Jan	5	14	2		14:29	−10.73
27	Great cold	大寒	Jan	19	21:08	12	28	Jan	19	21	3		21:45	12	29	Jan	20	19	3		19:43	−21.97

As can be seen from the table，Verbiest only specifies minute in eleven out of the 24 *qi*，and Wu Mingxuan does not specify parts at all.[46] The rightmost column in the table gives the differences be-

[46] In this essay we shall concentrate on how Wu Mingxuan's predictions were made，and it will be shown that they can be reproduced precisely by relatively simple calculations. For Verbiest's *qi* predictions，the situation is more complex. One of us (Cullen) has constructed an Excel workbook that follows the step by step instructions for calculation from the tabulated data in the *Xin fa li shu*. The dates of the *qi* in Kangxi 8 thus found match those given by Verbiest，as well as those calculated in Liu (2018－2022) using modern trigonometrical expressions taken from or constructed on the basis of publications such as Chu and Shi (2012). However，neither method succeeds in reproducing Verbiest's stated times of day for the *qi* of that year. This topic will be discussed further in later publications.

tween the two sets of predictions in hours, with a negative value meaning that Wu Mingxuan's predictions are later than Verbiest's, as they were in the example quoted above. Verbiest has earlier in his report insisted that his success in the shadow trial proved that the Jesuits' system represented the true state of the heavens[47]— hence his confident statement above that if Wu Mingxuan's 'Muslim system' made a prediction later than his own, it was 'lagging behind heaven'. While not all the discrepancies Verbiest lists are as large as those noted in the example, in only three cases are they less than ten hours, whether lagging behind 'the heavens' or in advance of them, and in 16 cases they are greater than a day.

Discrepancies of this size cannot be blamed on any essential defect in the historical 'Muslim system' set out the *Hui hui li* texts. The historical texts of the *Hui hui li* make no attempt to predict the moments of inception of the 24 *qi* as equal divisions of time, which are an East Asian reference framework absent from the astronomical systems descended from the Ptolemaic tradition.[48] The same was however true of the European systems used by the Jesuits, which traced their origins to the same roots. But the Jesuits could not ignore the 24 *qi* if they wished to win responsibility for managing the Chinese state calendar; they dealt with the problem by simply redefining the *qi* as equal intervals of solar longitude measured along the ecliptic, or as they put it, calculating the true *qi*, rather than the mean *qi* defined according to Chinese custom as falling at equal intervals of time.[49] Had the practitioners of 'Muslim methods' wished to do likewise, the *Hui hui li* was well able to produce values of solar longitude based on mean ecliptic motion of the sun, corrected to true motion by the addition or subtraction of an 'equation of centre' *tai yang jia jian cha fen* 太阳加减差分 (literally 'solar additive or subtractive difference parts'), whose magnitude, given in tables, depends on the position of the sun in its orbit relative to its apogee, the point where the sun-earth distance is greatest.[50] If therefore Wu Mingxuan had wished to compete with Verbiest in computing *qi* based on the moments when the sun's longitude passed through a multiple of 15° using the 'Muslim system', he could have done so with reasonable success.

Thus, to take two examples, Verbiest complains that Wu Mingxuan's calculations for the *qi* 'Establishment of Spring' *li chun* 立春, and 'Autumn Equinox' *qiu fen* 秋分 are both more than a day wrong (that is, they differ by more than a day from his own predictions). Verbiest takes Establishment of Spring as marking the moment when the sun passes through 315° longitude. Now the longitudes of the sun computed according to the *Hui hui li* for two successive noons when the sun's lon-

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47 Given the very slow rate of change of noon solar altitude during the three days of the trial shortly after winter solstice (6.7 minutes of arc from noon on 27 December to noon on 29 December), and the poor precision of shadow observations, Verbiest had a somewhat limited scientific basis for this claim.

48 See Huang (1993), 61 & 63. Lu Dalong 鲁大龙 also made this point in a comment during a brief presentation of the material of this paper at the online 26th International Congress of History of Science and Technology in July 2021.

49 See Shi and Chu (2017), 893.

50 See *Chiljeongsan oepyeon*, 14a—31b.

gitude is near this value are:[51]

1669, 2 February: 314.089°

1669, 3 February: 315.102°

Linear interpolation between these two values suggests that the sun will pass through 315° (corresponding to 'Establishment of Spring') at 09:35 on 3 February; Verbiest's prediction was that this *qi* will occur at 09:38, so the difference is inconsiderable.

For Autumn Equinox (180° longitude), the two successive noon longitudes from *Hui hui li* are:

1669, 22 September: 179.533°

1669, 23 September: 180.515°

which predicts that the sun will pass through 180° at 23:25 on 22 September; Verbiest's prediction is for 01:09 on 23 September, 1 hour 44 mins later. But as Verbiest notes, the actual predictions made by Wu Mingxuan for these two *qi* are respectively more than 33 hours later and 47 hours earlier than his own.

If we compare the complete set of *qi* timings computed using the longitudes predicted by the *Hui hui li* (given in the leftmost division of Table 2) with Verbiest's, there are certainly differences. However, the predicted days are identical, and although the differences in time of day may be as large as two hours, in many cases they are no more than a few minutes. But if the comparison is made with Wu Mingxuan rather than Verbiest, the differences of his predictions from those using the *Hui hui li* are so large — at times as much as two days — that it is clear that whatever Wu Mingxuan was doing, he was not using the *Hui hui li* to make *qi* predictions using equal intervals of longitude in the way that Verbiest had done. Indeed, it is in any case not very likely that he would have attempted to do so, since the Jesuit redefinition of the *qi* as 24 equal shifts in longitude, each one 360°/24 =15°, rather than as equal divisions of the time interval between winter solstices was one of the innovations that their opponents had denounced as a dangerous departure from Chinese tradition.[52] So let us instead try to find a method to reproduce Wu Mingxuan's predictions that would have been less revolutionary than using the *Hui hui li* as described above. Thus, for instance, how do Wu Mingxuan's predictions compare with the *qi* times listed in the official calendar, issued for Kangxi 8 by the Astronomical Bureau under the leadership of Yang Guangxian, and calculated according to the Great Concordance system?[53] The result of the comparison is shown in Table 3.

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[51] These values have been computed using an Excel workbook developed by Christopher Cullen, incorporating specially created VBA functions, whose structure follows step by step the instructions for calculation and worked examples set out in the 15th century Korean text *Chiljeongsan oepyeon jeongmyonyeon ilsig galyeong* 칠정산외편정묘년일식가령 七政算外篇丁卯年日食假令 (Reckoning [the positions of] of the Seven Governors [sun, moon and five planets], part 2: the example of the solar eclipse in sexagenary year 4 [1447]). (abbr. *CJSOPGY*). The resulting system has been tested using the example of the 1447 eclipse, which it computes precisely as in the original text. As a cross-check, calculations of sun and moon longitudes at noon on the day of spring equinox for 1432 and 1910 made using the workbook agree closely with those made by Shi (2003), 46 'calculated with the methods of the CCSOP [*Chiljeongsan oepyeon*, 1447]', and in general Excel calculations support Shi's conclusion that the *Hui hui li* remained capable of predicting these quantities with an absolute error of less than a degree up to recent times.

[52] See for instance the exchanges recorded in the secret Manchu records of the trial of the Jesuits, where both Schall and Yang Guangxian are questioned on this matter, translated in An (2015), 19—20 as part of a report of proceedings submitted on Kangxi 3/11/11 (27 December 1664); see An (2015), 37 for the date. Yang Guangxian's complaint on this point was first submitted on Shunzhi 17/12/3 (3 January 1661) without any official response; see Chen (2000), 35—38.

[53] The relevant data for Kangxi 8 and all other years discussed in this paper are taken from copies of the Planets Calendars for those years preserved in the National Palace Museum, Taibei. We are grateful to Professor Guan Yuzhen 关瑜桢 and Yang Boshun 杨伯顺 at the University of Science and Technology of China, Hefei, for helping with technical problems in accessing the file format of this material.

Table 3 *Qi* predicted by Wu Mingxuan and the Kangxi 8 Planets Calendar

			Qi dates and times for Kangxi 8 predicted by Wu Mingxuan, as found in *CYJL*							*Qi* dates and times predicted by Kangxi 8 Planets Calendar						
			Chinese Lunar Month	Day	Gregorian Month	Day	Hour	Marks=Day/100	Parts=Mark/100	Chinese Lunar Month	Day	Gregorian Month	Day	Hour	Marks=Day/100	Parts=Mark/100
4	Establishment of spring	立春	1	4	Feb	4	19	1		1	4	Feb	4	19	1	63
5	Rain waters	雨水	1	20	Feb	20	0	2		1	20	Feb	20	0	2	64
6	Emerging insects	惊蛰	2	6	Mar	7	5	3		2	6	Mar	7	5	3	65
7	Spring equinox	春分	2	21	Mar	22	11	0		2	21	Mar	22	11	0	49
8	Clear and bright	清明	3	6	Apr	6	16	1		3	6	Apr	6	16	1	50
9	Grain rains	谷雨	3	21	Apr	21	21	2		3	21	Apr	21	21	2	52
10	Establishment of summer	立夏	4	8	May	7	2	3		4	8	May	7	2	3	53
11	Grain fills	小满	4	23	May	22	8	0		4	23	May	22	8	0	37
12	Grain in ear	芒种	5	8	Jun	6	13	1		5	8	Jun	6	13	1	38
13	Summer solstice	夏至	5	23	Jun	21	18	2		5	23	Jun	21	18	2	39
14	Little heat	小暑	6	9	Jul	6	23	3		6	9	Jul	6	23	3	40
15	Great heat	大暑	6	25	Jul	22	4	4		6	25	Jul	22	5	0	24
16	Establishment of autumn	立秋	7	10	Aug	6	10	0		7	10	Aug	6	10	1	25
17	Limit of heat	处暑	7	25	Aug	21	15	2		7	25	Aug	21	15	2	27
18	White dew	白露	8	11	Sep	5	20	3		8	11	Sep	5	20	3	28
19	Autumn equinox	秋分	8	27	Sep	21	1	4		8	27	Sep	21	2	0	12
20	Cold dew	寒露	9	12	Oct	6	7	0		9	12	Oct	6	7	1	13
21	Frost-fall	霜降	9	27	Oct	21	12	1		9	27	Oct	21	12	2	14
22	Establishment of winter	立冬	10	12	Nov	5	17	2		10	12	Nov	5	17	3	15
23	Little snow	小雪	10	27	Nov	20	22	3		10	27	Nov	20	22	4	16
24	Great snow	大雪	11	14	Dec	6	4	0		11	14	Dec	6	4	1	0
1	Winter solstice	冬至	11	29	Dec	21	9	1		11	29	Dec	21	9	2	2
2	Little cold	小寒	12	14	Jan	5	14	2		12	14	Jan	5	14	3	3
3	Great cold	大寒	12	29	Jan	20	19	3		12	29	Jan	20	19	4	4

One difference is immediately obvious: as already noted, Wu Mingxuan's predictions are made to the nearest mark (1/100 day), without parts, whereas the Planets Calendar values are in every case given to the nearest part (1/100 mark). In two cases, *qi* 23 and 3, parts are given after 4 elapsed marks; in the first case, 16 parts are given, so that only 2/3 part is left before the next hour begins. Wu Mingxuan's hours and marks match those of the Planets Calendar for the first 11 *qi* of the calendar (numbers 4 to 14, beginning the numbering from winter solstice). *Qi* numbers 15 and 16 disagree, however, as do *qi* numbers 19 to 3 of the next cycle. Another point worthy of notice is that where Wu Mingxuan's marks do agree with those of the Planets Calendar, they have not been produced by rounding up marks in accordance with the parts where these are greater than 50 (out of 100), as is the case for *qi* numbers 4, 5, 6, 9 and 10. The parts are simply ignored. We shall return to this point below.

What kinds of calculation lie behind the figures we see here? There is a full specification of the calculation methods of the Great Concordance system in the *Ming shi* 明史.[54] The specified procedure begins by finding the day of the winter solstice that fell in the 11th month of the civil year preceding the year for which we wish to find the dates and times of *qi*. Before we carry out the calculations for Kangxi 8, it will be helpful for comparative purposes if we first carry out the calculation for the preceding year, Kangxi 7, 1668—1669.

In accordance with the Great Concordance system as specified in the *Ming shi*, the process starts by finding the time elapsed since the beginning of the first year with the sexagenary number *jiazi*. 1 during the Hongwu reign period (1368—1398, when the first Ming emperor was on the throne). That year was Hongwu 17, 1384, during which the winter solstice fell on the first day of the 11th month (13 December in the Julian calendar), which was a *jiazi*. 1 day. In fact, however, the process of calculating the calendar for any given civil year begins by finding the winter solstice near the end of the preceding civil year. For Hongwu 17, this fell on the 14th day of the 11th civil month of the preceding year, a *jiwei*. 56 day (14 December 1383).

In the calculations below (Box 1), days are shown at a scale of 10000—so that the quantity 'Year Cycle' (*sui zhou* 岁周), 3652425, represents 365.2425 days, the interval between one winter solstice and the next, the functional equivalent of the modern 'tropical year'. '*Qi* Correspondence' (*qi ying* 气应), 550375, represents 55.0375 days, the interval between the moment of winter solstice on 14 December and the midnight beginning Hongwu 16/9/24 (20 October 1383), which is the *jiazi*. 1 day preceding the winter solstice. '[Sexagenary] Sequence Factor' (*ji fa* 纪法), 600000, represents 60 days, the length of a completed sexagenary cycle.

Box 1 Finding the winter solstice of 1667 using the Great Concordance system from the *Ming shi*

Text from *Ming shi* 35, 689	Translation of text	Calculation specified
推天正冬至置距洪武甲子积年减一	To predict the winter solstice in the first celestial month. Set out the accumulated years[55] from Hongwu [17] *jiazi*. 1, and subtract 1	Accumulated years: 1384 … 1668 inclusive = 1668−1383=285 years 285−1=284 (Or simply: 1668−1384 =284)
以岁周乘之为中积	Multiply it by Year Cycle [3652425] to make Accumulated Medial *Qi*	3652425×284=1037288700
加气应为通积	Add *Qi* Correspondence [550375] to make Overall Accumulation	1037288700+550375=1037839075
满纪法去之，至不满之数，为天正冬至	Cast Out what fills [Sexagenary] Sequence Factor [600000]. When you come to the number that does not fill, that makes the winter solstice in the first celestial month	1037839075−1729×600000=439075
以万为日	Take 10000 for a day	43
命甲子算外，为冬至日辰	Then count off from *jiazi*. 1, and outside the count is the sexagenary day of winter solstice.	*jiazi*. 1+43 =*dingwei*. 44

[54] *Ming shi*, chapter 35.

[55] 'Accumulated years' is not simply the difference in the year dates, but includes the first year, so that the count begins at 1. By subtracting 1, we simply obtain the difference in the year numbers.

The prediction is thus that the winter solstice near the end of regnal year Kangxi 6, *qi* number 1, which serves to define the starting point for calculating the calendar for Kangxi 7, 1668, will fall on a *dingwei*. 44 day in the 11th civil month of Kangxi 6, i. e. 21 December 1667.

Later in the text we are told how to find the other *qi* of the civil year following this winter solstice. '*Qi* Reckoning' (*qi ce* 气策), 152184. 375, is 1/24 of 'Year Cycle', 3652425, and thus represents the constant interval of 15. 2184375 days from the beginning of one *qi* to the next. [56]

Box 2 Finding subsequent *qi* from the time of winter solstice

Text from *Ming shi* 35 690	Translation of text	Calculation specified
推各恒气 置天正冬至,加三气策	To predict the regular *qi*, set out the winter solstice and add three times *Qi* Reckoning [152184. 375]	439075+3×152184. 375=895628. 125
满纪法去之,即得立春恒日	Cast out what fills [Sexagenary] Sequence Factor [600000], and you get the day of Establishment of Spring [*qi* number 4]	895628. 125−600000=295628. 125
以气策累加之,去纪法,即得二十四气恒日	Add *Qi* Reckoning [152184. 375] in succession, casting out the [Sexagenary] Sequence Factor [600000], and you obtain the days of all 24 *qi*	

To find the sexagenary day on which each successive *qi* falls, we treat the numbers found here as we did the 439075 that defined winter solstice. Thus the 295628. 125 found for Establishment of Spring is a number of days scaled up by 10000, representing 29. 5628125 days. Adding the 29 whole days to *jiazi*. 1, we find *guisi*. 30 as the day of Establishment of Spring. This is the 23th day of the 12th lunar month of Kangxi 6, 5 February 1667.

If we wish to find the first *qi* of the regnal year Kangxi 7 that began in early 1668 (which is number 5, 'Rain Waters' *yu shui* 雨水), we need to add four *Qi* Reckonings to the original quantity found for winter solstice, *qi* number 1:

$$439075+4\times152184.375=1047812.5$$

Casting out [Sexagenary] Sequence Factor to eliminate repetitions of the 60-day cycle, we obtain:

$$1047812.5-600000=447812.5$$

This is 44. 78125 days, so this *qi* will fall on sexagenary day:

44 + *jiazi*. 1 = *wushen*. 45, the 9th day of the first month of Kangxi. 7, 20 February 1668. The fractional part of the day is 0. 78125 days; rather than working in 2-hour 'periods' *shi* 时. we may simply find the number of modern hours directly, multiplying the fractional part of the day by 24 to find:

24 hours/day × 0. 78125 days =18. 75 hours, so we have 18 whole hours

0. 75 hour =0. 03125 days, which is 3 marks and 12 parts.

And so Rain Waters is predicted by the Great Concordance system as falling on Kangxi 7/1/9, 18

56 Here we see that unlike the Jesuit system which reckoned *qi* as falling at equal intervals of solar longitude, the Great Concordance followed the traditional Chinese practice of placing *qi* at equal time intervals.

hours, 3 marks (3/100 day) and 12 parts (12/100 mark) after midnight. In the modern 24-hour clock this is equivalent to 18:45, to the nearest whole minute.

This result and the results of the *qi* calculations for the rest of the year are set out in Table 4, compared with the times given in the Planets Calendar for that year. As we can see, for this year the Kangxi 7 Planets Calendar gives its data in the same style as the predictions of Wu Mingxuan in Kangxi 8: unlike the Kangxi 8 Planets Calendar, after the period (here shown in terms of hours) only whole marks are given, without any indication of parts. What is more, as seemed to be the case with Wu Mingxuan in Kangxi 8, parts are ignored completely, even in a case like *qi* number 8 'Clear and Bright' where calculation yields 10 hours, 1 mark and 98 parts, just 2 parts short of 2 marks. If and only if we adopt this practice, we may say that using the Great Concordance method set out in the *Ming shi* we have successfully reproduced all the official Planets Calendar predictions for the regnal year Kangxi 7, which runs from early 1668 to early 1669.

Table 4 *Qi* in Kangxi 7 Planets Calendar, and calculated using Great Concordance System

			Qi dates and times predicted by Kangxi 7 Planets Calendar							*Qi* times predicted for Kangxi 7 by *Da tong li*, using *Qi* counterpart 550375		
			Chinese Lunar Month	Day	Gregorian Month	Day	Hour	Marks=Day/100	Parts=Mark/100	Hour	Marks=Day/100	Parts=Mark/100
5	Rain waters	雨水	1	9	Feb	20	18	3		18	3	12
6	Emerging insects	惊蛰	1	24	Mar	6	23	4		23	4	13
7	Spring equinox	春分	2	10	Mar	22	5	0		5	0	97
8	Clear and bright	清明	2	25	Apr	6	10	1		10	1	98
9	Grain rains	谷雨	3	11	Apr	21	15	3		15	3	0
10	Beginning of summer	立夏	3	26	May	6	20	4		20	4	1
11	Grain fills	小满	4	12	May	22	2	0		2	0	85
12	Grain in ear	芒种	4	27	Jun	6	7	1		7	1	86
13	Summer solstice	夏至	5	13	Jun	21	12	2		12	2	87
14	Little heat	小暑	5	28	Jul	6	17	3		17	3	88
15	Great heat	大暑	6	13	Jul	21	23	0		23	0	72
16	Beginning of autumn	立秋	6	29	Aug	6	4	1		4	1	73
17	Limit of heat	处暑	7	14	Aug	21	9	2		9	2	75
18	White dew	白露	7	29	Sep	5	14	3		14	3	76
19	Autumn equinox	秋分	8	15	Sep	20	20	0		20	0	60
20	Cold dew	寒露	9	1	Oct	6	1	1		1	1	61
21	Frost-fall	霜降	9	16	Oct	21	6	2		6	2	62
22	Beginning of winter	立冬	10	2	Nov	5	11	3		11	3	63
23	Little snow	小雪	10	17	Nov	20	17	0		17	0	47
24	Great snow	大雪	11	2	Dec	5	22	1		22	1	48
1	Winter solstice	冬至	11	18	Dec	21	3	2		3	2	50
2	Little cold	小寒	12	4	Jan	5	8	3		8	3	51
3	Great cold	大寒	12	19	Jan	20	14	0		14	0	35

We might expect that the *Ming shi* method would be equally successful in reproducing the *qi* times given in the official Planets Calendar predictions for Kangxi 8. The comparison is shown in Table 5, which also includes Wu Mingxuan's predictions for that year. Surprisingly, the predictions of the *Ming shi* method just described differ in every instance in the parts column from those of the Planets Calendar, in eleven instances in the marks column, and in two cases even in the hours column. On the other hand, the hours and marks of the *Ming shi* method match those of Wu Mingxuan (who gives no parts) in every case. It seems that Wu Mingxuan made his predictions using exactly the same *Ming shi* method as did the official Planets Calendar of Kangxi 7, even to giving hours and marks only, while ignoring partsbut the Planets Calendar of Kangxi 8 is no longer using that method.

There is, however, one small adjustment to the *Ming shi* calculation method that produces perfect concordance between the calculated *qi* times and those given in the Kangxi 8 Planets Calendar. If we work out the time difference between the *Ming shi* results for Kangxi 8 and the *qi* timings given in the Planets Calendar, we see that in every case the Planets Calendar timings are 27 parts later than the *Ming shi* calculation. All that is necessary to eliminate the discrepancy is to increase the value of *Qi* Correspondence, 550375, by 27 to 550402, which amounts to shifting the instant of every *qi* 0.0027 day =3.888 minutes later. With this exact adjustment, neither more nor less, we find that all the calculations made using the adjusted Great Concordance system produce precise agreement, to the nearest part, with the predictions in the Planets Calendar for that year.

Since the changing value of the *Qi* Correspondence is key to explaining what happened in 1668—1669 in relation to the way basic calendrical calculations were carried out, it is helpful to look at the origins of the value of this constant. The Great Concordance system used under the Ming was, as we know, an adaptation of the Yuan dynasty Season Granting system *Shou shi li* 授时历 produced in 1280 by Guo Shoujing 郭守敬 and his collaborators.[57] The basic constants used in the calculations above were common to both systems—Year Cycle [3652425], *Qi* Reckoning [152184.375] and [Sexagenary] Sequence Factor [600000].[58] The origins from which *qi* were reckoned were however different, as a result of which the values of *Qi* Correspondence in the two systems also differed.

Thus, for the Season Granting system, the initial point for *qi* calculations was the winter solstice of late 1280, which was assumed to fall on 14 December 1280 (Julian calendar), at 01:26, 0.06 day after midnight, or 600/10000 day. The day of the solstice was sexagenary day *jiwei*.56, so the interval to the moment of the solstice from the beginning of the preceding *jiazi*.1 day was 55.06 days, or 550600 at a scale of 10000, which is the value of *Qi* Correspondence. As we have explained above, the *Qi* Correspondence value 550375 for the Great Concordance system simply reflects the fact that it counts its *qi* from a different starting point, the winter solstice of 14 December 1383, which fell at 0.0375 of a day after midnight on sexagenary day *jiwei*.56, and hence was 55.0375 days from the midnight beginning Hongwu 16/9/24 (20 October 1383), which is the *jiazi*.1 day preceding the winter solstice, thus giving 550375 for the *Qi* Correspondence to be used. At the beginning of the description of the Great Concordance system, the *Ming shi* explains how to calculate the Great Concordance

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57 See the detailed analysis of this work and its background in Sivin (2009).

58 [Sexagenary] Sequence Factor in the Season Granting system was given in terms of days, 60, rather than in units of 1/10000 day, 60000, but these values are functionally identical.

value for *Qi* Correspondence from the Season Granting value:

Box 3　How to calculate *Qi* Correspondence

Text from *Ming shi* 35, 686	Translation of text	Calculation in text
洪武十七年甲子岁为元。上距至元辛巳一百〇四算。	Hongwu 17, *jiazi*. 1 [1384] is the system origin Back to Zhiyuan [18] *xinsi*. 18 [1281] is 104 counts	Counting both 1281 and 1384 and all intervening years, we obtain 104.
岁周三百六十五万二千四百二十五分	The Year Cycle is 3 652 425 parts [1 part =1/10000 day]	This is in effect a value for the length of the tropical year, given at a scale of 10000
置距算一百〇四	Set out the separation count, 104	[See above]
求得中积三亿七千六百一十九万九千七百七十五分	One obtains Accumulated Medial *Qi* 376199775 parts [1 part =1/10000 day]	3652425×103[59]=376199775
加辛巳气应五十五万〇六百分,得通积三亿七千六百七十五万〇三百七十五分	Add the *xinsi*. 18 [year, 1281] *Qi* Correspondence [550600], to obtain the Overall Accumulation 376750375 parts	376199775+550600 =376750375
满纪法六十去之,余为大统气应。	Cast out what fills [Sexagenary] Sequence Factor 60 [600000 parts], and the remainder is the *Qi* Correspondence for the Great Concordance. (*Ming shi* 35,686)	376750375−627×600000=550375

This explains how the 550375 value is to be obtained. But what about 550402, the value used in calculating the official calendar for Kangxi 8, 1669? Could this value of *Qi* Correspondence simply be the result of a third change of origin for *qi* calculations? The problem immediately arises that this number can never be the result of a process such as that outlined about, which, since the calculation necessarily involves multiplying Year Cycle [3652425] by some integer, then adding 550600 and subtracting multiples of 600000. Those processes can only result in number that is a multiple of 5, which 550402 is not. A second possibility is that the change might result from a desire to shift predicted times of *qi*, perhaps to accord with what might have been held to have been a more accurate observation of the time of a winter solstice. But the change involved is very small, only 0.0027 day =3.888 minutes, and we have no indication of related observations and calculations having taken place before early Kangxi 7, 1668, when the calculations for the Kangxi 8, 1669 calendar would have had to have taken place. On the other hand, Wu Mingxuan's memorial in Kangxi 7 certainly indicates that there was at that time considerable dissension in the Astronomical Bureau, which might have been the result of a decision by the Recorder Chen Yuxin to make adjustments to the Great Concordance system in calculating his People's Calendar. It may well have been that change that motivated Wu's state-

59　In the calculation that follows, we need to know the numbers of years (103) between 1281 and 1384, which are those from which the two systems begin their calculations. It is therefore essential, though not stated explicitly, that we should subtract 1 from the inclusively reckoned 'separation count' of 104 before proceeding; if we do not do so, we fail to obtain the result 550375 said to result from the calculation.

ment (quoted above) on 22 August 1668 that 'the way the old astronomical system [i. e. the Great Concordance system], is being used is not without errors' (*jian yong gu fa*, *bu wu cha miu* 见用古法不无差谬). Had there been any such adjustment, it is unlikely that it could have won the support of Yang Guangxian, who had argued that the 'old system' was worthy of adoption in its original form: but his name is not mentioned in this connection, and in any case it does not seem that he was ever involved in such technical matters. At the time of writing, it is not therefore possible to reconstruct with any certainty the thinking that led the staff of the *Qin tian jian* to take the step of changing the *Qi* Correspondence value by 27 as they seem to have done.

Ⅴ. Wu Mingxuan's calculation of the position of the moon and planets

So far, Verbiest's exposition has used a system of astronomical coordinates equivalent to that still in use today. To follow his discussion of the positions of the moon and planets, we shall need to take into account a somewhat different system, the Chinese system of lodges, *xiu* 宿, by which the circuit of the heavens is divided into 28 unequal intervals, each named after an asterism (a group of stars). The beginning of each lodge is, in principle, defined by a 'determinative star' *ju xing* 距星, which is the star that first crosses the observer's meridian as a lodge rises in the east and moves westwards to its setting. The lodges are normally enumerated in a sequence from west to east, reflecting the order in which they cross the meridian in the course of a day and a night, commonly beginning with the lodge named 'Horn' *Jiao* 角,[60] whose determinative star is Spica, α Virginis — not to be confused with the quite different star named 'Great Horn' *Da jiao* 大角, which is Arcturus, α Bootis. Both stars will be mentioned shortly.

The most ancient usages of the lodge system for quantitative measurements of positions of the sun, moon and planets were equivalent in modern terms to measuring differences in the right ascensions of celestial bodies.[61] Right ascension, as its name implies, was originally conceived in the western tradition to indicate how long it would take for various intervals on the celestial equator to rise above the horizon as the heavens rotate about the celestial axis in the course of a day and a night; it is therefore measured in hours, but can be converted to degrees at the rate 24 hours $=360°$. Right ascension is conventionally measured from zero at the spring equinox, where the sun moving on the ecliptic crosses the celestial equator from south to north.

Although right ascension is measured with reference to the celestial equator, the asterisms of the lodges do not however lie neatly along the line of the celestial equator on the celestial sphere; they were in any case defined and used well before the concept of the celestial sphere came into use. By the first century CE, by which time the celestial sphere was widely adopted by astronomers, Jia Kui gave the first time a listing of the extents of the lodges in terms of what we would nowadays call celestial longitude, measured along the ecliptic circle of his armillary instrument.[62] From this time on, and up to the time of the conflict between Verbiest and Wu Mingxuan, when someone tells us that a given celestial body is, for example '3 *du* into lodge X', we need to ask ourselves first whether this is an equatorial or an ecliptic measurement — and then we need to know where the beginning of lodge X is located in terms of (equatorial) right ascension or (ecliptic) longitude.

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[60] This is now the common pronunciation; the more 'literary' form *jue* is also found.

[61] For a discussion see Cullen (2017), 186—207.

[62] Cullen (2017), 251—255.

Table 5 Qi for Kangxi 8, 1669 as given by Wu Mingxuan, the Planets calendar, and calculated using the Great Concordance System with different values of Qi Correspondence

			Qi dates and times for Kangxi 8 predicted by Wu Mingxuan, as found in CYJL							Qi dates and times predicted by Kangxi 8 Planets alendar							Qi times for Kangxi 8 predicted by Da tong li, using Qi correspondence 550375			Qi times for Kangxi 8 predicted by Da tong li, using Qi correspondence 550402		
			Chinese Lunar Month	Day	Gregorian Month	Day	Hour	Marks= Day/100	Parts= Mark/100	Chinese Lunar Month	Day	Gregorian Month	Day	Hour	Marks= Day/100	Parts= Mark/100	Hour	Marks= Day/100	Parts= Mark/100	Hour	Marks= Day/100	Parts= Mark/100
4	Establishment of spring	立春	1	4	Feb	4	19	1		1	4	Feb	4	19	1	63	19	1	36	19	1	63
5	Rain waters	雨水	1	20	Feb	20	0	2		1	20	Feb	20	0	2	64	0	2	37	0	2	64
6	Emerging insects	惊蛰	2	6	Mar	7	5	3		2	6	Mar	7	5	3	65	5	3	38	5	3	65
7	Spring equinox	春分	2	21	Mar	22	11	0		2	21	Mar	22	11	0	49	11	0	22	11	0	49
8	Clear and bright	清明	3	6	Apr	6	16	1		3	6	Apr	6	16	1	50	16	1	23	16	1	50
9	Grain rains	谷雨	3	21	Apr	21	21	2		3	21	Apr	21	21	2	52	21	2	25	21	2	52
10	Establishment of summer	立夏	4	8	May	7	2	3		4	8	May	7	2	3	53	2	3	26	2	3	53
11	Grain fils	小满	4	23	May	22	8	0		4	23	May	22	8	0	37	8	0	10	8	0	37
12	Grain in ear	芒种	5	8	Jun	6	13	1		5	8	Jun	6	13	1	38	13	1	11	13	1	38
13	Summer solstice	夏至	5	23	Jun	21	18	2		5	23	Jun	21	18	2	39	18	2	12	18	2	39
14	Little heat	小暑	6	9	Jul	6	23	3		6	9	Jul	6	23	3	40	23	3	13	23	3	40
15	Great heat	大暑	6	25	Jul	22	4	4		6	25	Jul	22	5	0	24	4	4	14	5	0	24
16	Establishment of autumn	立秋	7	10	Aug	6	10	0		7	10	Aug	6	10	1	25	10	0	98	10	1	25
17	Limit of heat	处暑	7	25	Aug	21	15	2		7	25	Aug	21	15	2	27	15	2	0	15	2	27
18	White dew	白露	8	11	Sep	5	20	3		8	11	Sep	5	20	3	28	20	3	1	20	3	28
19	Autumn equinox	秋分	8	27	Sep	21	1	4		8	27	Sep	21	2	0	12	1	4	2	2	0	12
20	Cold dew	寒露	9	12	Oct	6	7	0		9	12	Oct	6	7	1	13	7	0	86	7	1	13
21	Frost－fal	霜降	9	27	Oct	21	12	1		9	27	Oct	21	12	2	14	12	1	87	12	2	14
22	Establishment of winter	立冬	10	12	Nov	5	17	2		10	12	Nov	5	17	3	15	17	2	88	17	3	15
23	Little snow	小雪	10	27	Nov	20	22	3		10	27	Nov	20	22	4	16	22	3	89	22	4	16
24	Great snow	大雪	11	14	Dec	6	4	0		11	14	Dec	6	4	1	0	4	0	73	4	1	0
1	Winter solstice	冬至	11	29	Dec	21	9	1		11	29	Dec	21	9	2	2	9	1	75	9	2	2
2	Little cold	小寒	12	14	Jan	5	14	2		12	14	Jan	5	14	3	3	14	2	76	14	3	3
3	Great cold	大寒	12	29	Jan	20	19	3		12	29	Jan	20	19	4	4	19	3	77	19	4	4

To convert such measurements as referred to by Verbiest into modern terms, we may use the convenient tables provided in Jesuit sources such as the *Chong zhen li shu* and its successors. Turning first to the ecliptic (relative to which the separations of stars do not change as the centuries pass), the widths of the lodges are given in the table headed 'The degrees of each lodge on the ecliptic' *Ge xiu huang dao ben du* 各宿黄道本度.[63] The degrees of each lodge are given twice, in the upper register of the table in terms of the western style degrees and minutes used by the Jesuits, with 360° to a complete revolution and 60 minutes to each degree, and below in Chinese *du*, with $365\frac{1}{4}$ *du* to a complete revolution and 100 'parts' *fen* 分 to each *du*. On the page preceding that table is another table listing the *du*, but this time giving 'The accumulated degrees for [the starts of] lodges on the ecliptic' *Huang dao xiu ji du* 黄道宿积度; this is the distance in longitude along the ecliptic from the defined starting point of the spring equinox to the start of the given lodge. Here the two registers contain 'ancient' *gu* 古 and 'modern' *jin* 今 values, which differ because the position of the spring equinox moves slowly round the ecliptic from east to west, completing a circuit in about 26000 years. The 'ancient' values are calculated for the late third millennium BCE, the time when the mythical emperor *Yao* 尧 was traditionally believed to have laid down the first systematic relation between the stars, the seasons, and the lengths of day and night.[64]

Similarly, if we convert equatorial lodge measurements into degrees of right ascension, we may use the two tables 'The degrees of each lodge on the equator' *Chi dao ge xiu du* 赤道各宿度 and 'The accumulated degrees for [the start of] each lodge on the equator' *Chi dao ji xiu du* 赤道积宿度.[65] Both tables include both 'ancient' and 'modern' values; in the first case the modern values are given both in 360° notation and in $365\frac{1}{4}$ *du* notation.

The officials appointed by the emperor to supervise the observational tests reported the answer given by Verbiest to their request for a statement of his observations of the moon on Kangxi 8/1/18 (18 February 1669):

> 问南怀仁正月十八日。测太阴以何时何仪器为凭。南怀仁供称。正月十八日。角宿离天中之西。二十五度时。即寅正二刻。(见第八图)据明烜黄道算太阴。于本时刻。在翼宿十度二十三分有余。依南怀仁在翼宿一度二十三分。相差九度。依南怀仁所算太阴。于本时刻。在秋分前九度二十七分。而轸宿在秋分后。六度零十分。则彼此相距十五度三十七分。(见第九图)依吴明烜相距不过七度。则差八度三十六分。依怀仁算。大角星在秋分后十九度三十七分。而太阴在秋分前九度二十七分。则彼此相距二十九度四分。依吴明烜相距四十二度二十分。则差十三度十三分。
>
> 至期公测太阴。正与南怀仁所定黄赤仪上界限。脗合无差。
>
> We asked Verbiest: On the 18th day of the first month, at what time and in reliance on what instrument did you observe the moon? Verbiest submitted this statement:
>
> On the 18th day of the first month, at the time when the lodge Horn was 25° to the west of the meridian, that is, at 2 marks of the middle of the period *yin* (03:00—05:00) [*i.e.*

63 Shi and Chu (2017), 448.

64 On this story and its astronomical implications, see Cullen (2017), 20—27.

65 Shi and Chu (2017), 441—443.

04:30—04:45] (see the 8th diagram)[66] then according to Wu Mingxuan's calculation of the Moon's [position] on the ecliptic, at that time it was at slightly over 10° 23′ of the lodge Wings. According to my calculation it was at 1° 23′ of the lodge Wings, a difference of 9°. According to my calculation of the Moon's [position], at that time it was 9° 27′ before the autumn equinox, while the lodge Axletree was 6° 10′ after the autumn equinox. So these two points were 15° 37′ apart (see the 9th diagram).[67] According to Wu Mingxuan they were no more than 7° apart, so the difference was 8° 37′.[68] According to my calculations, the star Great Horn [Arcturus, alpha Bootis] was 19° 37′ after the autumn equinox, and the moon

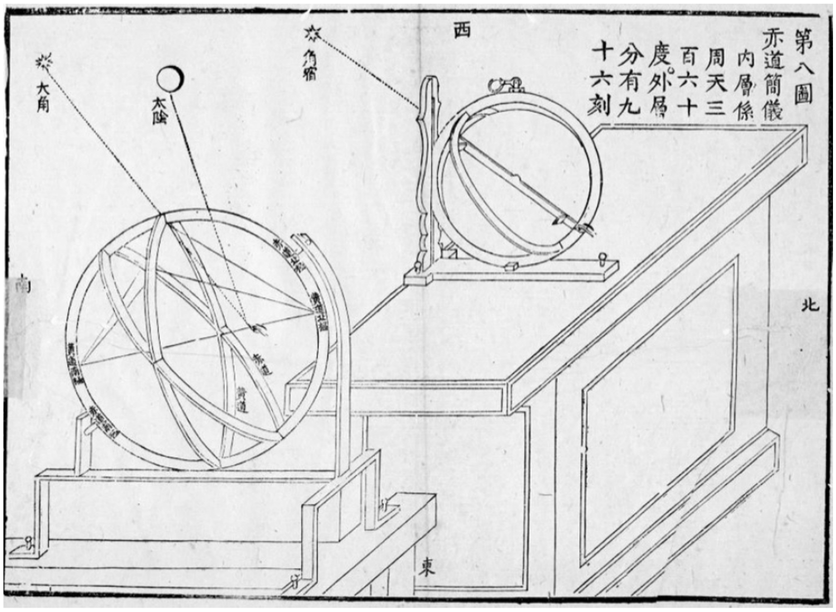

Figure 1: Measuring the position of the moon 1 February 1669 (*Ce yan ji lue*, figure 8). Source: gallica. bnf. fr /Bibliothèque nationale de France, Chinois 4992.

was 9° 27′ before the autumn equinox. So they were 29° 4′ apart. According to Wu Ming-

66 Shown here as Figure 1. The draughtsman does not seem to have understood exactly how the instruments in question were used, so his drawing fails to represent the situation accurately The moment when the azimuth of Spica (alpha Virginis) the defining star of the lodge Horn (Sun and Kistemaker (1997), 52, Table 3. 1) was 205°, making it 25° to the west of the meridian, was Julian Date 2330698. 367, which corresponds to 4 hours 19 minutes after local midnight at Beijing, 4 minutes into the second mark after the middle of the period *Yin* 寅 (03:00—05:00) — close to the time stated by Verbiest. Julian Date (JD) is a common time reference used by astronomers, representing the time counted in days from Greenwich mean noon on 1 January 4713 BCE.

67 Shown here as Figure 2. Unlike the previous figure, this diagram shows the situation fairly accurately. The distance between the Moon's position and gamma Corvi, the defining star of Axletree (Sun and Kistemaker (1997), 52, Table 3. 1) was 15° 39′ of longitude rather than Verbiest's stated 15° 37′.

68 For consistency with the previous stated 9° difference of the stated positions of the Moon in Wings, this figure should also have been 9°, making the distance from Wu Mingxuan's lunar position to the start of Axletree 6° 37′, which for some unknown reason has been expressed as 'no more than 7°'.

xuan they were 42° 20′ apart, a difference of 13° 13′.[69] When the time came, all the gentlemen observed the moon, and it was exactly in accordance with the line that I had marked on the ecliptic-equatorial instrument, without the slightest discrepancy.[70]

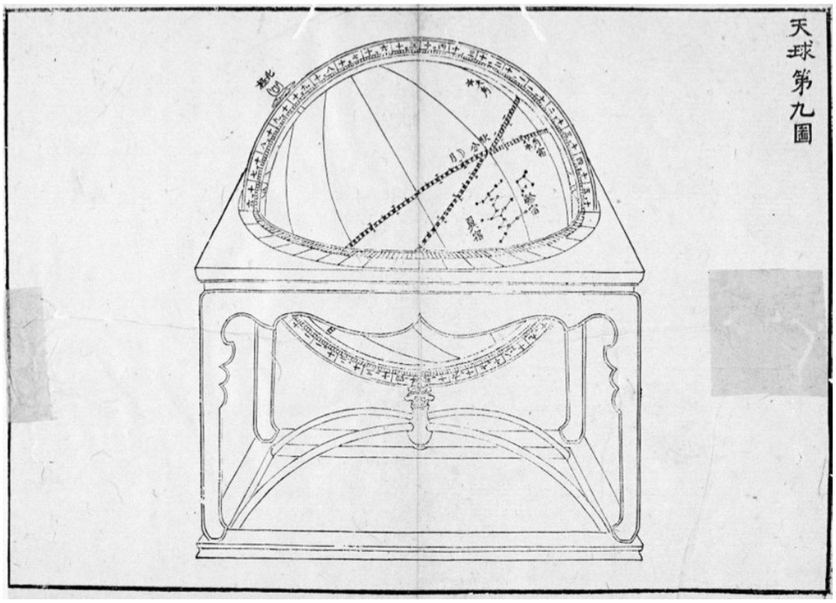

Figure 2: Celestial globe, showing the Moon in relation to the autumn equinox and the stars mentioned in the text (*Ce yan ji lue*, figure 9). Source: gallica. bnf. fr /Bibliothèque nationale de France, Chinois 4992.

Measured on the ecliptic, as stated, the lodge Wings (whose determinative star is α Crateris) begins at longitude 168° 36′ according to the tables referred to above. So the moon's position at 10° 23′ in Wings according to Wu Mingxuan equates to a longitude of:

$$168° 36' + 10° 23' = 178° 59'$$

Similarly, Verbiest's position of 1° 23′ in Wings[71] equates to a longitude of 169° 59′, which is 10°1′ before the autumn equinox at 180°, not 9° 27′ as he states. This appears to show that Verbiest had updated the longitudes of the start of the lodges to account for the effect of precession of the thirty years since the tables were calculated, whether by observation or by recalculation. In February 1669, the longitude of α Crateris was in fact 169.1355° = 169° 8′ rather than the tabulated 168° 36′, so the

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69 Since 42° 20′ − 29° 4′ = 13° 16′, the 13′ 十三分 here seems to be a typographical error for 16′ 十六分. The distance between the Moon's position at the stime stated and gamma Corvi, the defining star of Axletree (Sun and Kistemaker (1997), 52, Table 3.1) was 15° 39′ of longitude rather than Verbiest's stated 15° 37′, and the distance between the Moon and the star named Great Horn *Da jiao* 大角, alpha Bootis, see (Sun and Kistemaker (1997), 147, *App*. 1.2), was 29° 9′ in longitude rather than Verbiest's 29° 4′. Following the previous logic, we would have expected Wu Mingxuan's result to be 29° 4′ − 9° = 20° 4′ in longitude. It seems likely that the 42° 20′ figure ascribed to Wu Mingxuan does not represent the difference in longitude between the Moon and alpha Bootis, but is an attempt at finding their angular separation on the celestial sphere, which was 39° at the instant considered. The 3° discrepancy is not surprising, given that we do not know precisely where Wu placed the Moon in relation to the ecliptic (its latitude at the relevant instances was close to 3° 20′) and that Wu would have had to make the measurement manually on the surface of a celestial globe on which the position of the two bodies had been marked.

70 *CYJL*, 36a−36b.

71 At the moment of observation stated, the Moon was then at 1° 25′ of Wings in longitude, compared with Verbiest's stated 1° 23′.

longitude corresponding to 1° 23′ in that lodge was 170° 31′, which is 9° 29′ before the autumn equinox—very close to the value that Verbiest states.[72]

Using the Excel workbook for the 'Muslim system' *Hui hui li* (see footnote 51), we obtain for the longitude of the moon:

Noon on 17 February: 162.1°
Noon on 18 February: 174.183 3°
Hence by interpolation, at 04:30 on 18 February: 170.407 3° =170° 24′

The modern calculated value found using Starry Night Pro using UT +7.8 hours for local mean time Beijing at 04:30 (JD 2330698.36250) on 18 February is 170.4309° =170° 26′. It was 170.4073° at 04:26:25. It seems that the *Hui hui li* lunar longitude value as represented by the *CJSOPGY* system is very close to the true value.

So the *Hui hui li* predicted distance of the moon before the autumn equinox at the moment specified is

$$180° - 170.4073° = 9.5927° = 9° 36'$$

Verbiest had 9° 27′. So if Wu Mingxuan really had used the *Hui hui li*, his position of the moon would have been only about 9′ closer to the equinox than Verbiest's, rather than 9°, the distance calculated by Verbiest from the difference between his position of the moon at "1° 23′ of the lodge Wings", and Wu Mingxuan's stated position at "slightly over 10° 23′ of the lodge Wings"

So if Wu's position of the Moon at 10° 23′ (10.38° or 10.53 *du*) of the lodge Wings did not come from the Muslim system, where might it have come from? If we consult the official planets calendar for Kangxi 8 (see note 53), we are told that the position of the moon at dawn (*chen du* 晨度) on the 18th day of the first lunar month (18 February) was at Wings 11 *du* 37 *fen* (11.37 *du*). Now the mean motion of the moon in one day is 13.36875 *du*.[73] To get from 11.37 *du* down to 10.53 *du* requires a displacement of 0.84 *du*, for which the time required is:

24 hours × (0.84/13.36875) = 1.508 hours, 1 hour 30 minutes to the nearest minute.

Now sunrise on that day was at 06:51; allowing the conventional value 2.5 marks =36 minutes back from sunrise to the start of dawn,[74] we get to 06:15, which is 1 hour 45 minutes from 04:30. It seems that Wu Mingxuan is using a longitude for the moon based on essentially the same methods as the Planets Calendar, and certainly not based on the *Hui hui li*.

Finally, let us consider the planetary positions on 3 February that Verbiest gives for Mars and Jupiter as predicted by himself and Wu Mingxuan. Here there are signs of some confusion; in the case of Mars this may be related to the procedural errors by his opponent cited by Verbiest in his 'Remarks at the time of observation' *Ce yan cheng yu* 测验呈语, where he complains

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[72] In the explanation of the tables referred to above, it is noted that the effect of precession is to shift longitudes by 51 seconds of arc each year: see Shi and Chu (2017), 438. Thus, since the tables were based on calculations made for Chongzhen 1, 1628, then the 32′ difference between 169° 8′ and 168° 36′ would correspond to a time interval of 32 × 60/51 years =38 years, which would take us up to 1666, the beginning of Verbiest's confinement in Beijing, during which period he might well have passed the time by updating his tables in this way.

[73] See *Ming shi* 35, 698: 月平行度一十三度三十六分八十七秒半.

[74] *Ming shi* 34, 656: 晨分加二百五十 分,为日出分。日周一万分,内减晨分为昏分。昏分减二百五十分,为日入分,又减五千分,为半昼分。故立成只列晨昏分,则出入及半昼分皆具,不必尽列也。

在依黄道推算。以赤道测验。

[Wu] makes calculations based on the ecliptic, and then uses the equator for observations.[75]

Thus for Mars, Verbiest says:

依吴明炫七政历。康熙八年正月初三日。火星在室宿十五度五十八分。依南怀仁历法。本日火星在室宿七度五十分。则吴明炫历。先天八度八分。

According to Wu Mingxuan's planets calendar, on Kangxi 8/1/3 [3 February 1669], Mars was in House, at 15° 58′. According to my astronomical system, on that day Mars was in House, at 7° 50′. So Wu Mingxuan's astronomical system was 8° 8′ ahead of heaven.[76]

Now in February 1669 the longitude of the determinative star of House, α Pegasi, was 348.8780° = 348° 53′, so if Verbiest is, as before, using the then current longitude for this star rather than its tabulated value (which was 348° 20′), his longitude for Mars would be 356° 43′ (subtracting the whole revolution).[77] At Beijing dusk (the time specified for the observation), the predicted longitude of Mars using modern planetarium software (Starry Night Pro) was 356.7603° = 356° 47′, extremely close to Verbiest's value.[78] If Wu's value for Mars was indeed an ecliptic value, then it was certainly as wrong as Verbiest says it was — and it was not far from the erroneous values for the position of Mars given by the official Planets Calendar around that time — which were 13 *du* 46 *fen* in House for midnight beginning 3 February, and 14 *du* 23 *fen* in House for the following midnight. Since we have seen that his *qi* predictions were made using a version of the Great Concordance system, the same may be true of his planetary positions. If, however he had accurately predicted the right ascension of Mars, which was 23.815 4 hours = 357.231° = 357° 14′ at Beijing dusk according to modern calculations, then using the tabulated right ascension of the start of House, 341° 34′, Mars would in equatorial terms be 15° 40′, which would be close to the value ascribed to him — which would then indicate something like the confusion referred to by Verbiest, in which equatorial and ecliptic measurements were muddled.[79] But since the *Hui hui li*, which had a common Ptolemaic ancestry with Verbiest's system, calculated planetary positions on the ecliptic, this would be a further point against the likeli-

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75 *CYJL*, 16a.

76 *CYJL*, 34a—34b.

77 See Shi and Chu (2017), 447.

78 The tabulation in Argoli (1648), vol 2, 864, gives Pisces 26° 44′, i.e. longitude 356° 44′ on this date at Rome noon, which is close to Beijing dusk. It is known that Verbiest made use of this text in his work around this period: the copy of this text in the Beijing National Library, (inspected by Cullen in May 2017), which has annotations in Verbiest's handwriting, has inked horizontal marks next to the entry rows for the ephemeris data for 27 and 28 December 1668, the first two dates for which Verbiest had to make shadow predictions. Verbiest also mentions Argoli's tables in Verbiest and Golvers (1993), 74 and the original text in Verbiest (1687), VIII, 23.

79 This point is made in Huang (1993), 65—66.

hood of Wu Mingxuan having used the Muslim system for such calculations.[80]

Turning briefly to the case of Jupiter, we read in Verbiest's account:

> 依吴明炫七政历。正月初三日。木星在昴宿七度十五分。依南怀仁历法。木星在昴宿五度五十四分。则吴明炫历。先天一度二十一分。以日计之。则差有二十三日矣。
>
> According to Wu Mingxuan's Planets Calendar, on [Kangxi 8] 1/3 (3 February 1668), Jupiter was in Mane, at 7° 15′. According to my astronomical system, Jupiter was in Mane at 5° 54′. So Wu Mingxuan's astronomical system was 1° 21′ ahead of heaven. Reckoning in days, the difference is 23 days.[81]

A modern calculation of the longitude of Jupiter at Beijing dusk on 3 February gives 61.5876°, and the observed longitude of 17 Tauri, normally taken as the determinative star of Mane (basically the Pleiades) was then 54.7931°. That would mean Jupiter was 6.7945° = 6° 48′ into Mane,[82] which makes Verbiest's value about a degree wrong, corresponding to a month's movement of the planet. The issue may of course have been a simple error on Verbiest's part — but that would be a little surprising, since he could easily have checked his prediction against Argoli's tables for that date (which we know he consulted; see note 78), which gave a Rome noon (roughly Beijing dusk) longitude of 1°15′ of Gemini or 61° 15′ = 61.25°, which would have been 6° 27′ into Mane using 17 Tauri, rather than the 5° 54′ he predicted.[83] If, however, Verbiest did not observe 17 Tauri, but (mistakenly?) observed 27 Tauri, a star of similar magnitude further to the east of the asterism, then since that had longitude 55.7372°, Jupiter would be reckoned as being at 5° 51′, very close to his stated result. From the official Planets Calendar we may compute that Jupiter would have been close to 6.33 *du* into Mane; Wu Mingxuan differs from that by about a degree. No very clear picture emerges from this comparison — in part no doubt because Jupiter moves much more slowly on the celestial sphere than does Mars, and so the differences involved are much smaller.

Ⅵ. Conclusion

On the basis of the reconstruction of Wu Mingxuan's calculations carried out in this essay, we may say that so far as the prediction of the 24 *qi* is concerned, it appears that he did not use anything that might be called the 'Muslim system' *Hui hui li* 回回历 as represented in the extensive writings setting out its methods. Instead, he simply used the 'Great Concordance system' *Da tong li* 大统历, the Ming dynasty adaptation of the Yuan dynasty 'Season Granting system' *Shou shi li* 授时历.

This was the system that had been abandoned when in 1644 the Qing gave responsibility for leading the Astronomical Bureau to Schall with his 'New Western methods', but which was restored to

80 The Excel version of the *Hui hui li* created by Christopher Cullen (see note 51) has not yet been extended to include planetary longitudes. But examples given in Shi (2003), 46, show that the *Hui hui li* produced values of the longitude of Mars from the mid 15th to the early 20th centuries that were within one or two degrees of the values found from modern methods.

81 *CYJL*, 34b.

82 As noted in Huang (1993), 63.

83 Argoli (1648), vol 2, 864.

use by Yang Guangxian after the Jesuits were removed from office in 1665.[84] What is more, in his predictions for the *qi* of Kangxi 8, 1669 Wu continued to use the original version of the Great Concordance system as applied by the Astronomical Bureau up to the time when the Kangxi 7 (1668) calendar was calculated. The Bureau itself had, as we have seen, slightly modified the system used to prepare its calendar for Kangxi 8. Wu's prediction of the position of the moon is nearly 9° different from the position predicted by the *Hui hui li*, but close to the position predicted in the official Planets Calendar, based on the Great Concordance system. Moreover, if Wu had made any use of the *Hui hui li* at all we would have expected him to use it for such a prediction, since it is well adapted for this purpose and the Muslim section had long been held to have particular skills in planetary calculations.[85] The figures for Wu's predictions of the positions of Mars and Jupiter appear somewhat confused (as may be Verbiest's prediction for Jupiter), but so far as we can make sense of them, Wu's position of Mars is certainly close to that in the Planets Calendar.

Given this state of affairs, there are two questions that present themselves:

(1) Why did Wu Mingxuan not use the *Hui hui li*?

(2) Why did Verbiest repeatedly assert that Wu was using the *Hui hui li*?

On the first question, one immediate response is that whatever his intentions might have been when he made his proposal for reforming the calculation practices of the bureau in August 1668, Wu Mingxuan was not expecting to have to produce a new system of astronomical calculation on an immediate basis. In this original memorial he set no timescale, but the report by the Board of Rites a month later, which is not likely to have been written without further consultation with him, proposed a four-year programme of observation and revision before a final result could be expected, and it would become possible to 'compose [a new] treatise on the astronomical system'. However, as we have seen, the emperor demanded that Wu should immediately produce drafts of the People's Calendar and Planets Calendar for Kangxi 8, 1669.

If Wu Mingxuan had originally planned to produce a new system for computing the calendar based in some way on the *Hui hui li*,[86] he cannot have been intending to do so within a few months of mak-

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[84] The removal of the Jesuits in Kangxi 4, 1665, did not lead to the Great Concordance system immediately becoming the basis for all calendrical documents issued for subsequent years. This is evident in the case of the Planets Calendars from the formats adopted in successive years. Because the Great Concordance did not attempt to calculate planetary latitudes, the data for each month in the Planets Calendar calculated using that system only occupied two pages rather than the six-page format used by the Jesuits, which included latitudes. The six-page format with latitudes was still used in the Planets Calendar for Kangxi 5, 1666, which must have been calculated the previous year. The first Planets Calendar generated using the Great Concordance 2-page format was that prepared for Kangxi 6, 1667, and must have been calculated in Kangxi 5, 1666. Similarly, while the last 'Approaches and Invasions' Calendar (*Ling fan li* 凌犯历 see note 15) to bear the signature of Schall (Tang Ruowang 汤若望) and his colleagues is that of Kangxi 4, 1665, the signatures of Mahu and Yang Guangxian do not appear until Kangxi 6, 1667. The *Ling fan li* for the preceding year, Kangxi 5, 1666, bore only the signature of a few officials, headed by Zhang Qichun 张其淳, who had been temporarily promoted to Director from Observatory Manager to fill the gap created by Schall's removal; he was replaced by Yang Guangxian the following year. It must have been calculated using Jesuit methods in the earlier part of Kangxi 4, 1665, although the signatures of those who had prepared it could no longer be shown for political reasons. As with the Planets Calendars, all copies of the Approaches and Invasions Calendars used in this article come from the collections of the National Palace Museum, Taibei: see note 53.

[85] It was for this reason that Yang Guangxian had brought Wu Mingxuan and before him another Muslim Ma Weilong 马惟龙, back into the Astronomical Bureau: see de Magalhães (1666 October), folios 205r and 206v.

[86] See note 37 above.

ing his original proposal. For a start, Wu Mingxuan faced the problem that, as he stated in his memorial, the Astronomical Bureau had three different and inconsistent versions of a planets calendar based on the *Hui hui li*, so his first task would have been to settle on an authoritative interpretation of the *Hui hui li* itself. And once that had been done, although the documents that set out the procedures of the *Hui hui li* enabled its users to make a large number of astronomical calculations, such as those needed to find the longitudes of the sun, moon and planets, and the precise times and circumstances of solar and lunar eclipses, considerable adaptation would have been required to use it as a basis for direct computation of a Chinese style calendar; on this, see the discussion of the 24 *qi* above. The *Hui hui li* was an astronomical system used by Muslim officials of the Astronomical Bureau, not a calendar. There was no 'Muslim calendar' usable in the Chinese context that could have been adopted directly in place of the calendar calculated using the Great Concordance system. Indeed, in order to use the *Hui hui li* for any purpose, the first task to be performed was to transform the Chinese date of interest into a date in the Muslim *hijra* calendar around which the computational machinery of the *Hui hui li* was structured.[87]

The *Hui hui li* had never previously functioned in China as the basis of an alternative official calendar but had always been restricted to supplementing and providing checks and comparisons to certain aspects of the official astronomical system. The Jesuits who worked to compose the texts in the *Chong zhen li shu* had succeeded in creating a system that enabled a Chinese calendar to be produced on a theoretical basis imported from Europe, but that task had taken the work of several astronomical specialists during the years from 1629—1635. As their patron Xu Guangqi 徐光启 (1562—1633) said, they had 'melted their [European] material and substance to cast them into the mould of the Great Concordance' (*rong bi fang zhi cai zhi ru Da tong zhi xing mo* 镕比方之才质入大统之型模).[88] To do the same with the material of the Islamicate astronomical tradition (if that had been what Wu Mingxuan intended) would have been perfectly possible — but it could certainly not have been accomplished in the few months that the emperor allowed Wu for his task of producing calendars for Kangxi 8. And quite apart from the astronomical problems involved, there would have been personal and political problems to resolve before such a new system could be accepted, given that the Director of the Astronomical Bureau, Yang Guangxian, under whom Wu now served as Deputy Director (rather than as head of the Muslim section, the role he had filled earlier in the dynasty), had already fought bitterly to banish what he saw as a "foreign" system in favour of a purely "Chinese" one. Yang would certainly have resisted any attempt to displace the Great Concordance system from use in the Astronomical Bureau.

Given all this, it is not surprising that the drafts of the People's Calendar and Planets Calendar for Kangxi 8, 1669 that Wu submitted in accordance with the emperor's command of early October 1668 appear to have been calculated using the basic methods of the Great Concordance system — though without the change in *Qi* Correspondence that appears to have been adopted by the Astronomi-

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[87] There are some signs that early in the Ming dynasty Muslim astronomers did produce calendars in the *hijra* system that were designed to meet the religious and cultural needs of the significant Muslim communities established in China. But these were not intended to replace the imperially issued Chinese-style calendars around which all official activities were structured, and which were therefore an essential reference for all the emperor's subjects. See Shi, Li and Li (2013), 161 and Shi (2014), 54. We are grateful to Professor Shi Yunli for helpful email discussions on this and related points (20—23 July 2021).

[88] Jami (2012), 32—34.

cal Bureau in its computations for Kangxi 8. The adoption of that very small change may have been what Wu complained of in his memorial of August 1668 cited above, when he wrote that the use of the Great Concordance system in the Astronomical Bureau at that time was 'not without errors'. The fact that, even without that innovation, Wu did not consider the Great Concordance system to be wholly satisfactory may have been behind his response to the questions put to him on the morning of 26 December 1668 when Wu, Yang Guangxian and the three Jesuits were questioned by high officials in the palace. In his letter of 2 January 1669 Gabriel de Magalhães recorded the following exchange between the officials and Wu Mingxuan on the subject of the calendars he had produced:

> They asked the Moor [Wu Mingxuan] if he would venture to defend his [astronomical system]? He answered, that he had not yet finished making it nor correcting it.
>
> They asked him further if the calendar that he had made for the 8th year [1669] was good? He answered, that it was adequate.
>
> "Adequate?" replied one of the four mandarins who had summoned us. "Mind what you say: does it have errors, or does it not have errors?" The Moor replied: "It still has some minor errors that need to be corrected."
>
> "So," put in another mandarin, "you really dared to give the King [i. e. the emperor] an erroneous calendar as if it was correct?" [89]

We may note that in *Astronomia Europaea*, a text written for a European readership, Verbiest stated explicitly that Wu's calendrical predictions were *tam Sinica quam Arabica* 'as much Chinese as Arabic' — something he never hints at in his writings in Chinese. [90] He was certainly correct in suggesting that Wu was using Chinese methods in his predictions — but what the 'Arabic' elements might have been, he never specifies, perhaps because he could not identify any. Indeed, it is quite possible that Verbiest had never learned anything significant about the *Hui hui li*, which was in effect the hereditary intellectual property of the families that provided the staff of the Muslim section of the Astronomical Bureau, a section which had been shut down years before Verbiest joined the Bureau under Schall. [91] But even assuming that Verbiest was ignorant in this respect, he would surely have noticed the very close resemblance between Wu Mingxuan's *qi* predictions for Kangxi 8, and those already published in the official calendar for that year, which he knew was calculated according to the Chinese system in official use up to 1644, and restored to use by Yang Guangxian after 1665. It is clear from the answers Verbiest gave to the four officials who visited the Jesuits on Christmas morning 1668 that he had not only seen the official calendar for Kangxi 8, which had been made public six weeks earlier, but had studied it in detail. [92] Why then, given all this, did Verbiest constantly refer to Wu as using the *Hui hui li* in all the texts in Chinese that he submitted by way of criticism of Wu's work?

The answer, we suggest, may perhaps be found in the rhetoric of persuasion. By the end of

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89 For the source, see, de Magalhães (1669 January 2), 270v, extract translated from Portuguese in Cullen and Jami (2020), 16—17.

90 Verbiest (1687), V, 16; compare Verbiest and Golvers (1993), 69.

91 As pointed out in Shi (2003), 35, Chinese astronomers of the Qing period complained that Muslim astronomers concealed the techniques for converting between Chinese dates and the *hijra* dates needed to operate the *Hui hui li*, thereby making the Muslim system inaccessible to them. Verbiest would naturally have shared this handicap.

92 See Cullen and Jami (2020), 11.

1668, Verbiest knew that Yang Guangxian had lost the confidence of the emperor and his court.[93] He no longer needed to mount any attacks in that direction. His target now had to be Wu Mingxuan, the person whom the emperor was clearly considering in October 1668 as a possible candidate to be entrusted with the calculations needed to prepare an official calendar — which was of course the role he wished to fill himself. It was important, however, to ensure that his attack damaged Wu's personal credibility alone, while doing as little as possible to cause unnecessary offence to others, such as the Han staff of the Astronomical Bureau, or the Han ministers who might still have been sympathetic to Yang Guangxian's project of restoring the use of the Ming dynasty's Great Concordance system. Verbiest certainly did not want to be seen at this stage as an advocate of something 'foreign' attacking a Chinese opponent: in referring to his own calculations, he simply calls them 'the astronomical calculations made by me and my colleagues' *chen deng suo tui li fa* 臣等所推历法, without any characterisation of his methods as 'new' or 'western'. In contrast, he makes continual use of the alienating characterisation of Wu Mingxuan's astronomy as 'Muslim', *Hui hui* 回回. As we have seen, this does not appear to have been an accurate description of the basis on which Wu Mingxuan was making his calculations — unless Verbiest is simply contrasting the *li* of 'me and my colleagues' with the *li* of 'the Muslim' (Wu Mingxuan was of course a Muslim), which would have been somewhat misleading, given the normal reference of the term *Hui hui li*.

But let us recall that the stakes for the Jesuits and for the future of their religion in the Qing empire were very high. As Verbiest put it, the situation was one in which

> ... res pro Dei & Religionis nostrae gloria, tam manifeste agebatur ...
> ... the honour of God and of our Religion was so clearly at stake ...[94]

Verbiest makes it clear in his writings for a European readership that it was only by completely discrediting his opponents and competitors in astronomical matters — which necessitated eliminating Wu Mingxuan from consideration — that he was eventually able to ensure that the Jesuits in exile in Canton were allowed to return to their posts throughout the empire. Without that return, the Christian mission in China would have been effectively terminated, leading to the potential consequence (in the eyes of a 17th century Catholic believer) of millions of Chinese souls remaining unredeemed for lack of baptism. That was a outcome that Verbiest must have felt bound to avoid at all costs.

Abbreviations:

CJSOPGY: see *Chiljeongsan oepyeon jeongmyonyeon ilsig galyeong*

CYJL: see *Qin ding xin li ce yan ji lue*

XCDA: see *Xi chao ding an*

Bibliography

Works cited by title

Chiljeongsan oepyeon 칠정산외편 七政算外篇 (*Reckoning* [*the positions of*] *of the Seven Governors* [*sun, moon and five planets*], *part* 2 [*the Islamic system*]). (c. 1447). Yi Sunji 李纯之 and Kim Dam 金淡.

Chiljeongsan oepyeon jeongmyonyeon ilsig galyeong 칠정산외편정묘년일식가령 七政算外篇丁卯年日

93 See Cullen and Jami (2020), 12—14 and 19—20.

94 Verbiest (1687), IV, 11 and Verbiest and Golvers (1993), 64—5.

食假令 (*Reckoning [the positions of] of the Seven Governors [sun, moon and five planets], part 2: the example of the solar eclipse in sexagenary year* 4 [1447]). (c. 1447). Jeong Heumji 郑钦之, Yi Sunji 李纯之 and Kim Dam 金淡.

Chong zhen li shu 崇祯历书 (*Texts on astronomical systems [compiled in] the Chongzhen reign*). (Compiled under the leadership of Xu Guangqi 徐光启 (1562—1633) ed., and submitted to the throne between 1630 and 1635, repr. 2009). ed. Pan Nai 潘鼐, Shanghai, Shanghai guji chubanshe 上海古籍出版社.

Da Qing li chao shi lu 大清历朝实录 (*Veritable records of the successive reigns of the Great Qing dynasty*). (1937). Anon., Xinjing 新京 (Changchun 长春), Da Manzhou di guo guo wu yuan 大满洲帝国国务院.

Hou Han shu 后汉书 (*History of Eastern Han dynasty*). (Main text completed c. 450 CE, monographs by Sima Biao 司马彪 (c. 240-c. 306 CE) added later. Punctuated edition of 1963). Fan Ye 范晔 (398-445 CE), Beijing, Zhonghua Press.

Ming shi 明史 (*History of the Ming dynasty*). (1739; punctuated edition of 1974). Zhang Tingyu 张廷玉 (1672-1755) et al., Beijing, Zhonghua Press.

Qin ding xin li ce yan ji lue 钦定新历测验纪略 (*A summary of observations in accordance with the new astronomical system, imperially commissioned*). (1669). Nan Huairen 南怀仁 (Ferdinand Verbiest).

Xi chao ding an 熙朝定案 (*Cases decided during the [Kang] xi reign*). (after 1669). Nan Huairen 南怀仁 (Ferdinand Verbiest), Rome, National Central Library, 72 C530.1.

Works cited by author

An Shuangcheng 安双成 (2015). *Qing chu xi yang chuan jiao shi Man wen dang an yi ben* 清初西洋传教士满文档案译本 (*Translations of Manchu language memorials relating to western missionaries in early Qing*). Zhengzhou 郑州, Daxiang chubanshe 大象出版社.

Argoli, Andrea (1648). *Exactissimae caelestium motuum ephemerides* … *ab anno* 1641 *ad annum* 1700. Patavii, Typis Pauli Frambotti, 3 vols.

Chen Zhanshan 陈占山, Ed., (2000). *Bu de yi, fu er zhong* 不得已, 附二种 ('*I cannot do otherwise*' [by Yang Guangxian 杨光先, 1597—1669] *and two other works*). Hefei, Huangshan shushe 黄山书社.

Chu Longfei 褚龙飞 and Shi Yunli 石云里 (2012). "Chong zhen li shu xi lie li fa zhong de tai yang yun dong li lun《崇祯历书》系列历法中的太阳运动理论 (The Theory of Solar Motions in the Chongzhen Lishu Series)." *Ziran kexueshi yanjiu* 自然科学史研究 **31** (4): 410-427.

Chu, Pingyi (1997). "Scientific dispute in the imperial court: the 1664 calendar case." *Chinese Science* **14**: 7-34.

Cullen, Christopher (2017). *Heavenly Numbers: Astronomy and Authority in Early Imperial China*. *Oxford*, Oxford University Press.

Cullen, Christopher and Catherine Jami (2020). "Christmas 1668 and after: how Jesuit astronomy was restored to power in Beijing." *Journal for the History of Astronomy* **51** (1): 3-50.

Christopher Cullen and Catherine Jami (2022). "Prediction and politics in Beijing, 1668: A Jesuit astronomer and his technical resources in a time of crisis." *Journal for the History of Astronomy* **53** (4): 422-474.

de Magalhães, Gabriel (1666 October). Letter addressed to the Fathers in Canton, October 1666: Relaçāo em que se conta o succedido na corte de Pe Kim, depois que os Padres della partirāo (An account in which is recorded what happened at the court of Beijing, after the Fathers departed from thence)(manuscript). Real Academia de la Historia, Madrid, Jesuitas, ms. Legajo 22, folio 204r-209v.

de Magalhães, Gabriel (1669 January 2). Letter addressed to Luis da Gama, Father Visitor at Macao, 2 January 1669 (manuscript). Archivum Romanum Societatis Iesu, Japonica-Sinica, ms. 162, folio 269-273v.

Golvers, Noël and Efthymios Nicolaidis, Eds., (2009). *Ferdinand Verbiest and Jesuit science in 17th century China: an annotated edition and translation of the Constantinople manuscript* (1676). Leuven Chinese studies. Athens and Leuven, Institute for Neohellenic Research and Ferdinand Verbiest Institute.

Huang Yi-Long and Chih-ch'eng Chang (1996). "The Evolution and Decline of the Ancient Chinese Practice of Watching for the Ethers." *Chinese Science* (13): 82-106.

Huang Yi-Long 黄一农 (1993). "Qing chu tian zhu jiao yu hui jiao tian wen jia jian de zheng dou 清初天主教与回教天文家间的争斗 (The struggle between Catholic and Muslim astronomers in early Qing)." *Jiuzhou xuekan* 九州学刊 **5** (3): 47-69.

Jami, Catherine (2012). *The Emperor's new mathematics: Western learning and imperial authority in China during the Kangxi reign* (1662—1722). Oxford, Oxford University Press.

Liu, Yuk Tung (2018—2022). "Conversion between Western and Chinese Calendar (722 BCE—2200 CE)." Last accessed February 2022, from https://ytliu0.github.io/ChineseCalendar/index.html? y=1670.

Oxnam, Robert B. (1975). *Ruling from horseback: Manchu politics in the Oboi Regency*, 1661-1669. Chicago, University of Chicago Press.

Regiomontanus, Joannes (1485). *Calendarium*. Venezia, Erhard Ratdolt.

Shaughnessy, Edward L. (1991). *Sources of Western Zhou history: inscribed bronze vessels*/ Berkeley, Oxford, University of California Press.

Shi Yunli (2003). "The Korean Adaptation of the Chinese-Islamic Astronomical Tables." *Archive for History of Exact Sciences* **57** (1): 25-60.

Shi Yunli (2014). "Islamic Astronomy in the Service of Yuan and Ming Monarchs." *Suhayl. International Journal for the History of the Exact and Natural Sciences in Islamic Civilisation* **13**: 41-61.

Shi Yunli 石云里 and Chu Longfei 褚龙飞 (2017). *Chong zhen li shu he jiao* 崇祯历书合校 (*Collated edition of the Chong zhen li shu*). Hefei 合肥, Zhongguo kexue jishu daxue chubanshe 中国科学技术大学出版社.

Shi Yunli 石云里, Li Liang 李亮 and Li Huifang 李辉芳 (2013). "Cong 'Xuande shi nian yue wu xing lingfan' kan hui hui li fa zai Ming chao de shi yong 从《宣德十年月五星凌犯》看回回历法在明朝的使用 (The Actual Applications of the Chinese-Islamic System of Calendrical Astronomy in the Ming Dynasty as Seen from the Encroachments of the Moon and the Five Planets in the 10th Year of the Xuande Reign)." *Ziran kexueshi yanjiu* 自然科学史研究 **32** (2): 156-164.

Sivin, Nathan (2009). *Granting the Seasons: the Chinese astronomical reform of* 1280, *with a study of its many dimensions and a translation of its records*. New York, Springer.

Sun, Xiaochun and Jacob Kistemaker (1997). *The Chinese sky during the Han: constellating stars and society. Leiden; New York, Brill.*

Tang Ruowang 汤若望 (Johann Adam Schall von Bell)(after 1661, 1993 repr.). Zou shu 奏疏 (Memorials). *Zhong guo ke xue ji shu dian ji tong hui: tian wen* 中国科学技术典籍通汇：天文 (*Comprehensive collection of classic texts of Chinese science and technology: astronomy*). Bo Shuren

薄树人 et al.，Ed. Zhengzhou，Henan jiaoyu chubanshe 河南教育出版社，**8**，857-964.

van Dalen，Benno and Michio Yano (1998). Islamic astronomy in China：two new sources for the Huihui li (“Islamic calendar”). *Highlights of Astronomy*. J Andersen，Ed. **11B**，697-700.

Verbiest，Ferdinand (1687). *Astronomia Europaea sub imperatore Tartaro Sinico Cám Hý appellato ex umbra in lucem revocata à R. P. Ferdinando Verbiest Flandro-Belga e Societate Jesu*. Dillingen，Joannis Caspari Bencard，per Joannem Federle.

Verbiest，Ferdinand and Noël Golvers (1993). *The Astronomia Europaea of Ferdinand Verbiest*，*S. J.* (*Dillingen*，1687)：*text*，*translation*，*notes and commentaries*. Nettetal，Steyler Verlag.

Weil，Dror (2018). The Fourteenth Century Transformation in China's Reception of Arabo-Persian Astronomy. *Knowledge in Translation*：*Global Patterns of Scientific Exchange*，1000-1800 *CE* (Pittsburg：Pittsburg University Press，2018)，345-370. Patrick Manning and Abigail Owen，Eds. Pittsburg，Pittsburg University Press，345-370.

Yabuuti，Kiyoshi and Benno van Dalen (1997). “Islamic Astronomy in China during the Yuan and Ming Dynasties.” *Historia Scientiarum* **7** (1)：11-43.

内容简介

2021年，适逢我国著名数学史家郭书春先生八十华诞，先生的同仁、挚友、学生和再传弟子共同撰文庆祝，结集而成本文集。文集分为“学术论文”“回忆与评价”“访谈录”3部分。“学术论文”收录论文27篇，内容涉及中国数学史、中国天文学史、数学思想与数学起源、日本数学史、朝鲜数学史等研究领域。“回忆与评价”收录文章15篇，包括对先生的回忆和为《郭书春数学史自选集》所作的序、书评等，从中可见先生指导学生、参加学术活动，与同仁、挚友交往的点点滴滴，反映了学术界对先生研究工作的认识和评价。“访谈录”收录两篇对先生的访谈，展现了先生的人生历程与学术生涯。书末附有先生的论著目录，完整地呈现了自1978年以来先生的学术成果。

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