Astronomical Observations from the Temple of the Sun

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"Dawn"

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During the solstices, equinox, zenith and nadir passages over the past four years, the authors observed distinctive patterns of sunlight inside the Temple of the Sun at Palenque. This article describes the recorded phenomena in detail and presents new evidence on the astronomical orientation of the temple. The second section puts forth a possible methodology for the architectural layout and design of the Temple of the Sun. The geometric proportions and angles of the temple appear to correspond with the astronomical alignments of the temple. The final section discusses astronomical references in the text and in the iconography of the Tablet of the Sun.

INTRODUCTION

Maya architecture is a repository for ancient astronomical knowledge. Investigating the celestial alignments of Maya architecture, archeoastronomers have identified dozens of structures that were oriented to the sun, stars, and planets rising and setting on the horizon Astronomical observations formed the basis of the Classic Maya calendar, which eventually integrated the cycles of the sun with the movements of the moon and five visible planets. The calendar supported a religious system that linked the heavens with seasonal cycles and the agricultural rituals associated with them (Milbrath 1999:1). Decipherments of carved inscriptions reveal that royal ceremonies and accessions also were timed to coincide with significant stations of the sun or with rare planetary conjunctions (Aveni 2001:163-214). The role of astronomy in agriculture, politics, and religion exemplifies the Maya penchant for interweaving nature, human society, and the divine. The night sky, with its infinite population of souls, gods, and monsters, presented a mirror image of the hidden underworld below. Alignments to celestial bodies expressed the bonds between earth and the many levels of the cosmos.

The ancient Maya exhibited their scientific and spiritual understanding of the cosmic realms through astronomical hierophanies (Aveni 2001:220-221). As defined by the religious historian Mircea Eliade (1958:11), a hierophany is the manifestation of the sacred in an object or event in the material world. Archaeoastronomers have adopted the term to describe phenomena of sunlight and shadow that play across architectural features during important stations of the sun. If accompanied by public ceremonies, these dazzling displays must have generated awe and religious fervor among the populace, and confirmed the power of the divine ruler.

Such spectacles rely on the alignment of monumental buildings with the sun. In the Maya region the most renowned example takes place at Chich'en Itza during equinox when, in a dramatic play of light and shadow, the triangular pattern of a serpent appears on the balustrade of the pyramid, El Castillo. Other hierophanies depend on the position of the sun as seen from a meaningful vantage point. At Dzibilchaltun, the rising sun at equinox, when viewed from the main causeway, fully illuminates the central door of the Temple of the Seven Dolls (Chan Chi and Ayala 2003). Both Yucatecan sites demonstrate the precise interplay between monumental architecture and the sun during key stations of the year (Figures 1 and 2).

Figure 1 C. Powell

Figure 2 F. Chan Chi

Precedents for solar-oriented structures exist at Early Classic Maya sites. Known as "Group E" complexes, after the architectural complex identified as Group E at Waxaktun, numerous examples have been found throughout the Maya area (Aveni 2001; 288-292). Characteristically, the Group E complex contains a single temple, used for sighting, that stands directly west of three buildings, each of which mark winter solstice, summer solstice, and equinox, the midpoint between those two solar extremes. Because Group E complexes were primarily used to record the known positions of the sun, rather than to obtain new astronomical information, they cannot be considered genuine observatories. Instead, the complexes served as stages for "ritual observation" that may have been the focus of public ceremonies (Krupp 1981:249).

Calendrical observations were closely tied to religious observances among the ancient cultures of the American Southwest. Pueblo sun priests still conduct solar observations prior to the solstices, which are crucial phases in the tribes' agricultural and religious cycles. In fact, the main responsibility of the Pueblo sun watchers is to anticipate the exact days of the solar stations in order to set the dates for major rituals (Zeilik 1985:S3).

At Palenque, Aveni (1980:284; 2001:295) sees a subtle distinction between astronomically oriented structures designed for ritual purposes and structures that served a symbolic function—to manifest astronomical hierophanies. To date, archaeoastronomers (Carlson 1976; Aveni and Hartung 1978) have identified the celestial orientation of a number of buildings; namely, the alignment of the Temple of the Count to Sirius; the Temple of the Foliated Cross to Capella; and House A and the east side of the Palace to the moon at maximum elongation. Considering the solar alignments of major buildings at the site, Aveni and Hartung (1978) noted that Temple XIV is aligned with the winter solstice and that the west side of the Palace is aligned with the setting sun at zenith passage. John Carlson (1976) was the first to hypothesize that the Temple of the Sun is oriented to face the rising sun at winter solstice, a theory supported by other scholars (Aveni and Hartung 1978; Milbrath 1999; and Aveni 2001). Following the discovery of these alignments, only a few researchers have witnessed hierophanies at the site.

Neil S. Anderson, Alfonso Morales, and Moises Morales (1981) documented a series of solar events that occurred in the Tower of the Palace. Standing inside the Tower, the three investigators noticed that at sunset on 30 April, the sun's rays passed directly through the T-shaped window on the western façade and struck an interior wall of the viewing chamber. With the approach of summer, the image of the T-shaped window moved progressively to the east. On 22 June, the investigators saw the complete image of the T glowing on the wall. After the summer solstice, as the northerly position of the sun decreased, the projected image shifted until only a fraction appeared on the wall. By 12 August, a few days after zenith passage at Palenque, the sun's rays were aligned perpendicularly with the west wall of the Tower; consequently the light entering the window did not project an image on the angled wall. For the three investigators, these observations demonstrated the existence of specially designed interior spaces, oriented with extreme precision, which made it possible for Maya astronomers and calendar keepers to monitor the sun at solstice and zenith passages.

At the sites of Monte Albán and Xochicalco, zenith passages were observed through zenith sighting tubes. At Palenque, where no zenith tubes have been found, the Tower evidently served this purpose and thus functioned as a working observatory. Anderson, Morales, and Morales suggest that observations made from the Tower allowed astronomers to divide the solar year into two periods: the 105-day agricultural cycle and the 260-day ritual cycle. In reality, the 105-day period, from zenith passage on 30 April to zenith passage on 12 August, only occurs at 15° latitude. At higher latitudes, this inter-zenith period was more symbolic than practical, an ideal cycle designed by the Maya hierarchy to fix the length of the relatively arbitrary growing season, from the first sprouting of corn to its maturity, as well as to commemorate the anniversary in the solar year of the date of Creation, 13.0.0.0.0 4 Ahaw 8 Kumk'u. As we have recently discovered, alignments to zenith passage may be seen in the relationship between the Temple of the Sun and the Temple of the Cross, where its importance is bound up with the recorded creation myth and dynastic history.

Three hierophanies, witnessed during the solstices**,** have been associated with rites of divine kingship. While standing in the Tower of the Palace, Linda Schele (in Carlson 1976:107) observed that the "dying" sun at winter solstice, setting over the ridge directly behind the Temple of the Inscriptions, appeared to enter the earth through the royal tomb of Janahb Pakal. Schele interpreted this solar event as an annual re-enactment of Janahb Pakal's descent into the underworld, as depicted in the iconography on the sarcophagus lid (Figure 3).

Figure 3 A. Mendez

The second hierophany described by Schele (in Carlson 1976:107) also occurred during winter solstice. Seen from the Tower, the sun setting behind the Temple of the Inscriptions sent a shaft of light that slowly mounted the terraces of the Temple of the Cross, and as the base of the pyramid sank into shadow, a final beam of light entered the temple and illuminated God L, portrayed on the eastern doorjamb of the sanctuary. Schele speculated that this phenomenon symbolized the transfer of royal power from Janahb Pakal to his son and heir Kan B'ahlam II, an event that occurred under the aegis of God L.

Another dynamic relationship between the Temple of the Inscriptions and the Temple of the Cross has been described by Anderson and Morales (1981). At sunset during summer solstice, they noted that the light entering the western window of the anterior corridor of the Temple of the Inscriptions aligned with the eastern window directly across the corridor and then highlighted the upper platform of the Temple of the Cross, where a major stela once stood. The researchers suggest that Stela I, believed to be a portrait of Janahb Pakal or Kan B'ahlam, marked a solar observation point. Anderson and Morales's report reveals not only the longitudinal orientation of the Temple of the Inscriptions to the summer solstice, but also its remarkable alignment to the Temple of the Cross. Their observation also reinforces Schele's theory that the visual effects seen at summer solstice represented the transfer of royal power from Janahb Pakal to Kan B'ahlam.

Schele's theory begins to address the metaphysical connection between astronomical phenomena and historical events recorded in the hieroglyphic inscriptions. In fact, her on-site observations helped confirm her readings of two great historical moments: the heir-designation ceremony of the young prince, Kan B'ahlam, held during summer solstice of A.D. 641 and the death and burial of his father, Janahb Pakal, some forty years later. As it turns out, Schele's winter solstice observation requires some correction; the Tower where she was standing was not erected until the eighth century (Hartung 1980:76) and was therefore not the correct stage for watching the setting sun. House E of the Palace, where Pakal was crowned, is the proper vantage point for viewing the winter solstice sun sink behind the Temple of the Inscriptions where Pakal is buried (See Figure 3). The great pyramid was completed by Kan B'ahlam and dedicated on 9. 12. 16.12.19 10 Kawak 7 Pax, 23 December 688 (Stuart 2005 pers. comm.), two days after winter solstice. We still see the drama of birth, death, and royal succession written in light, for the last rays of the winter solstice sun illuminate the Temple of the Cross, built by Kan B'ahlam to commemorate his accession to the throne. Years after his father designated him as heir on the summer solstice, Kan B'ahlam continued to honor his father's interest in solsticial alignments.

Father and son also shared an intense preoccupation with the planets. Aldana's reading (2001:131-132) of the texts in the Temple of the Inscriptions suggests that Janahb Pakal's fascination was largely oracular. Many scholars (Lounsbury 1989:253-254**;** Aveni and Hotaling 1996; Aldana 2004**)** have noted that Pakal's katun-ending ceremonies were synchronized with multiple astronomical events, particularly the appearance of Venus at maximum elongation. As will be seen in the final section of this paper, the moon and major planets also played a role in the timing of rituals conducted by Kan B'ahlam. Moreover, sometime during his reign, astronomers perfected the 819-day calendar, which took into account the cycles of Saturn and Jupiter (Lounsbury 1978**;** Powell 1996**;** Aldana 2004). Given the numerous allusions to astronomical phenomena in the art and literature, considerable speculation has gone into equating the rulers and patron gods of Palenque with specific planets (Kelley 1980; Lounsbury 1985; Schlak 1996).

In sum, on-site observations comprise a small part of the multi-disciplinary inquiries into the astronomical knowledge buried in the inscriptions, art, and architecture of Palenque. Aside from studies made by Milbrath (1988), little recognition has been given to the role of the anti-zenith, or nadir, passages in the Maya calendar. Venus, Jupiter, and Saturn have received enormous attention, but the moon has been mysteriously slighted. Progress has been made in identifying the orientations of major buildings and their possible ritual and calendrical significance, but there has been little headway in discovering the overall cosmological scheme of the ceremonial center. Numerous observations from a significant vantage point are needed for a fuller appreciation of the alignments at Palenque. Our ongoing investigations show that the Cross Group, the Temple of the Inscriptions, and the Palace exhibit astronomical alignments that are fundamental to understanding their design, function, and interrelationships.

OBSERVATIONS IN THE TEMPLE OF THE SUN

The Temple of the Sun is the westernmost building in the Cross Group, a complex of three temples erected on three hills rising above a small plaza (Baudez 1996:121-124) (Figure 4). Completed by Kan B'ahlam in A.D. 692, the Temples of the Cross, Foliated Cross, and Sun represent shrines to the three patron deities of Palenque, GI, GII, and GIII, respectively. Each temple contains tablets with texts that tie the history of Kan B'ahlam's lineage to those gods of Creation. Each temple also commemorates major events in Kan B'ahlam's reign. With the Temple of the Cross on the tallest hill to the north, the Foliated Cross nestled at the base of the eastern mountain, and the Sun on a low mound in the west, the temples represent a cosmogram of the Upper, Middle, and Lower Worlds. At the same time, the temples represent the three "hearthstones of creation" located at the center of the universe in the constellation of Orion (Schele, Freidel, and Parker 1993:65-69). Sharing architectural and artistic styles as well as textual cross-references, the temples of the Cross Group are also interrelated in their alignments to the sun and moon and to one another.

The Temple of the Sun is the most intact structure in the Cross Group. After reconstruction in the 1950s, and the replacement of the lintels, the temple is now the most reliable focus for on-site observations. The hierophanies that occur inside the temple are characterized by thin rays of light that cross the temple floor at well-defined angles which, we propose, were determined by architectural features and by the position of the sun.

The following descriptions of these solar events are based on naked-eye observations, corroborated by topographical measurements from the latest map of Palenque (Barnhart 2000) (See Figure 4). Data for building azimuths are taken from Carlson (1976) and Aveni and Hartung (1978), solar azimuths and lunar information for Palenque's latitude from Starry Night Deluxe (Andersen, Hanson, and Leckie 1997).

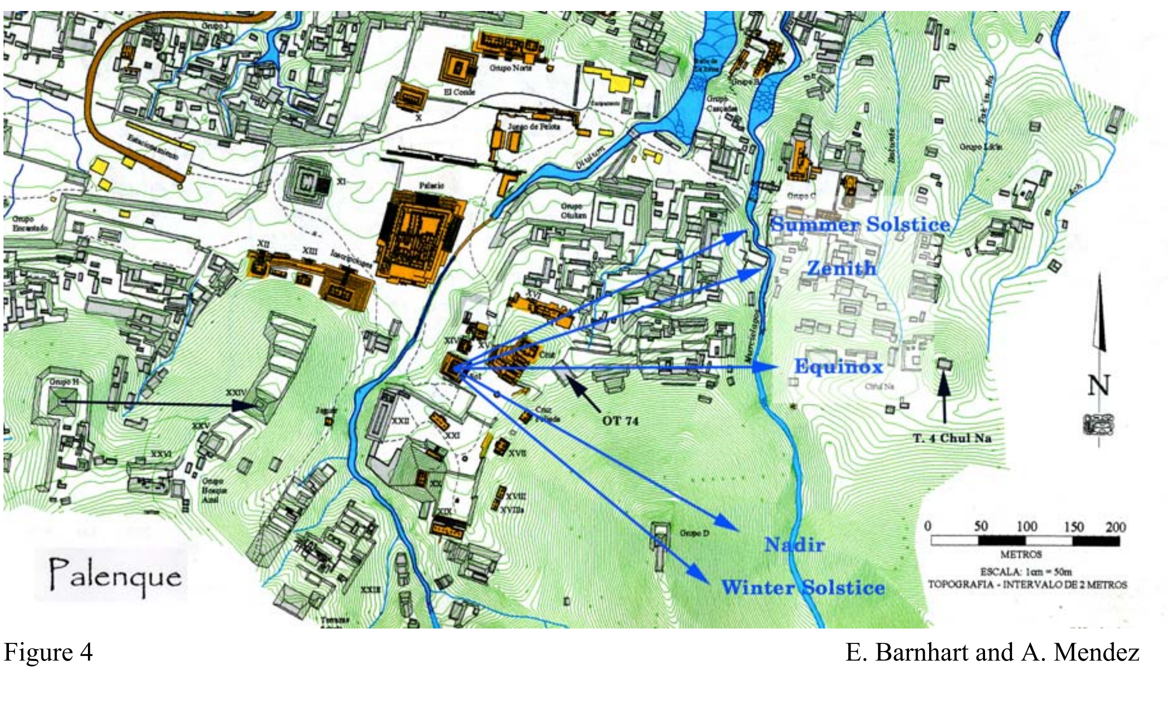

Figure 4 E. Barnhart and A. Mendez

WINTER SOLSTICE

It has long been held that the Temple of the Sun was oriented to face the rising sun on the morning of the winter solstice (Carlson 1976; Aveni and Hartung 1978:175; and Milbrath 1999:69). John Carlson (1976:110) recorded the winter solstice orientation of the Temple of the Sun as 119° 46’. Estimating a horizon line of 9° altitude, Carlson predicted that on winter solstice the first rays of sun would enter the central doorway of the temple at a “directly perpendicular” angle.

Our eye-witness observations did not confirm Carlson’s hypothesis. At 9:23 A.M. on 21 December, the rising sun broke the horizon at approximately 130° azimuth directly above El Mirador, the mountain under which the Cross Group was built (Figure 5). At a vertical angle

Figure 5 A. Mendez

of 30°, the first rays shone through the central doorway of the temple at an angle 10° south of the transversal axis of 119°46’ (Figure 6). At that moment the light lined up along the back edges of the medial walls (Figure 7). That is the farthest the sunlight now reaches into the temple’s interior during winter solstice.

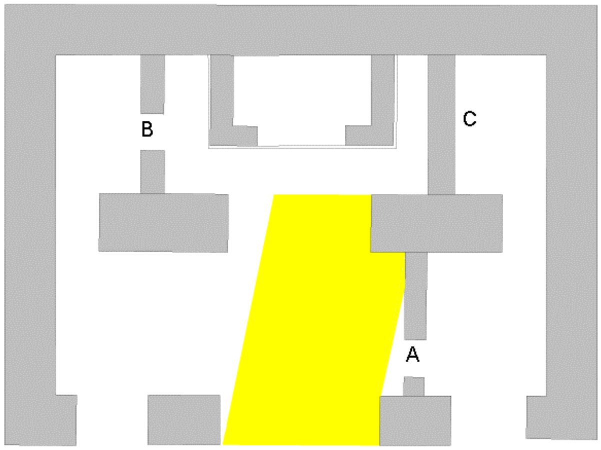

Figure 6 A. Mendez

Figure 7 A. Mendez

On a flat horizon at Palenque's latitude of 17.28° N, the winter solstice sunrise occurs at an azimuth of 114°23'E and sunset at 245°36'W. As noted, the observed sunrise emerging over the peak of El Mirador is closer to 130°. The mountain completely blocks the sun's visibility at a 9° altitude and prevents the early morning rays from entering the temple at a perpendicular angle. However, the fact that the sun breaks from the peak of El Mirador is consistent with a recognized pattern of solstice orientations seen at numerous Mesoamerican sites with prominent topographical irregularities such as mountains or clefts between mountains (Malmström 1997).

The problem remains: how do we account for the 119° 46'E-299° 46'W alignment of the Temple of the Sun? One possible explanation is that the transverse axis of the temple closely matches the maximum elongations of the moon. Like the sun, the moon has its maximum northern and southern rising and setting points. Called lunar standstills, they occur on the solstices, at full or new moon, and repeat every 18 2/3 years (Aveni 2001:72-73). At Palenque's latitude, the moon at its maximum southern extreme rises at 120° and at its maximum northern extreme sets at 300° on a flat horizon. The moon rising at its maximum southern extreme on the eastern horizon would not have been visible from the central doorway of the Temple of the Sun; however, from the Temple of the Foliated Cross, the moon at its maximum northern extreme would have been seen setting over the roofcomb of the Temple of the Sun (Figure 8).

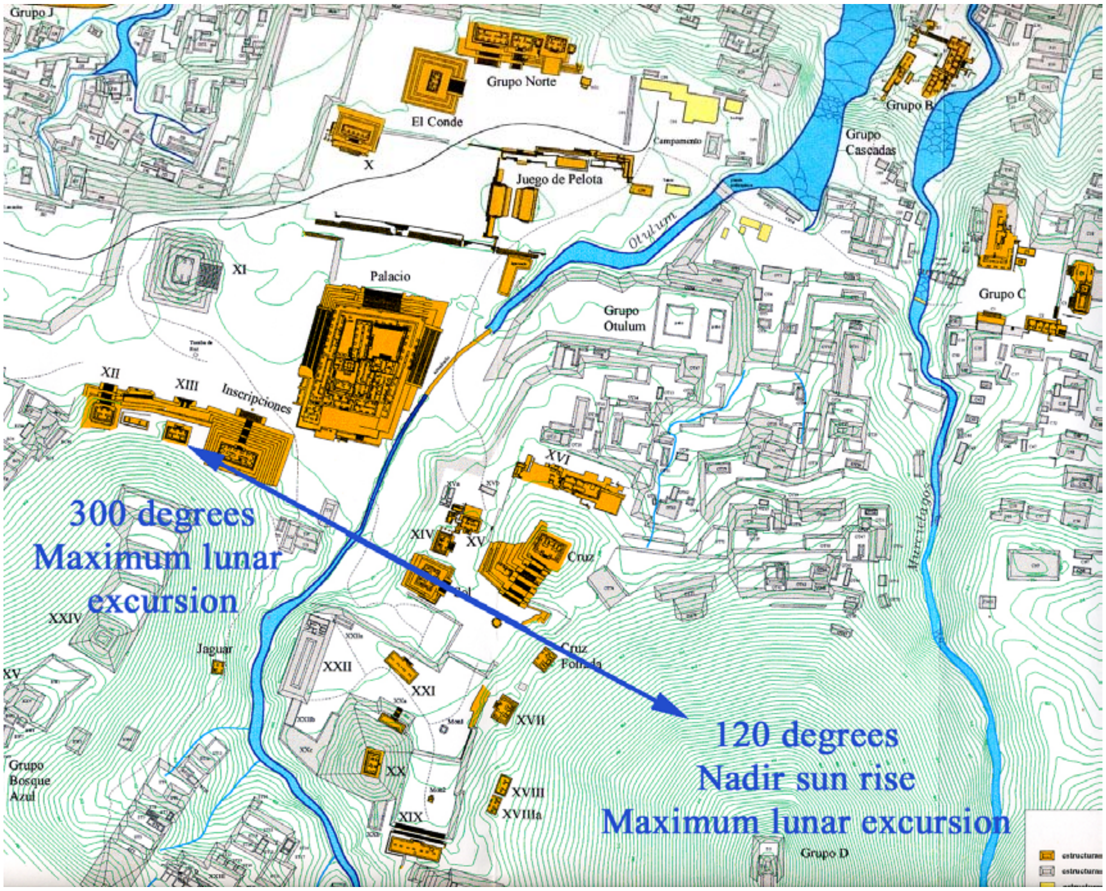

Figure 8 E. Barnhart and A. Mendez

This correlation between the Temple of the Sun and the moon lends weight to lunar interpretations of the iconography in the Tablet of the Sun (Bassie-Sweet 1991:192-198). But as we shall see, sunrise at nadir passage provides a decisive answer regarding the solar orientation of the temple.

EQUINOX

Equinox marks the midpoint between the solstices and corresponds to the time of year when the sun rises and sets on the celestial equator. As a result, the length of the day is equal to the length of the night. During vernal equinox, on 21 March, the sun passes from the southern to the northern hemisphere; at autumnal equinox, on 20 September, the sun retreats to the southern hemisphere. Sunrise on both days occurs at an azimuth of 90° due east and sunset at 270° due west.

Viewed from the Temple of the Sun on 21 March, the sun rises at a low point on the horizon, between El Mirador and the Temple of the Cross, at an azimuth of 91° (Figure 9). At 6:50 A.M., sunlight enters the middle doorway of the temple at an oblique angle of 29° north of the transverse axis. The medial wall and sanctuary wall narrow the first ray until it becomes a thin knife of light reaching into the southwest corner of the central posterior chamber (Figures 10 and 11). The light then retreats from the corner, and by 7:30 A.M., it disappears completely.

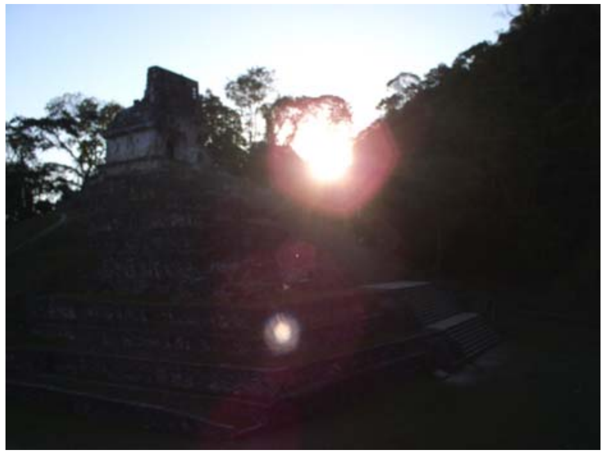

Figure 9 E. Barnhart

This corner, formed by secondary wall B and the back wall (Figure 11), was apparently added to define the angle of sunlight at equinox. By observing the alignment of diagonal shafts of light in the far corner of the Temple of the Sun, Maya astronomers would have been able to recognize the exact days of vernal and autumnal equinoxes. This knowledge may have served to fix the dates for agricultural activities in the solar calendar (Aveni 2001:293-294).

Figure10 E. Barnhart

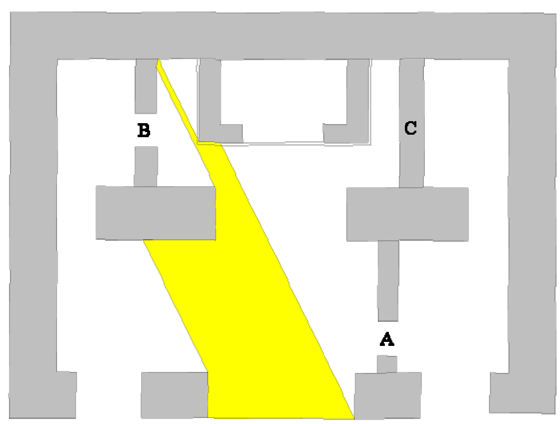

Figure 11 E.Barnhart

As mentioned earlier, equinox sightings have been documented at sites with flat horizons, such as Chich'en Itza, Dzibilchaltun, and the Group E architectural complexes found at Waxaktun and numerous other sites throughout the Maya area. The Cross Group at Palenque does not fit the Group E pattern. From the Temple of the Sun, the low notch between El Mirador and the Temple of the Cross defines the horizon at equinox. Our topographical surveys indicate that much of this low notch was manmade. Pending further exploration, structure OT74 and the terraces of the Otolum Group could prove to be the true markers for equinox sightings from the

Temple of the Sun (See Figure 4). Because they are related to the Cross Group and show alignments to equinox, these structures may eventually illustrate a concerted effort by Palencano builders to establish corridors of sightings.

Given the hilly terrain, it is likely that astronomers made initial long-distance sightings of the sun from high observation points. On the peak of El Mirador, the platform of Group D has a cardinal orientation, possibly toward equinox, but the buildings are too badly deteriorated to say with any confidence. Smaller hills crowned with standing structures do show definite equinox orientations to one another (e.g., between the Temple of the Cross and Temple IV in the Ch'ul Na Group and between Temple XXIV and Group H. See Figure 4). Such long-distance sightings would have decreased any margin of error in reading the slight differences in azimuth during the two successive days of equinox (Aveni 2001:65-66). Established readings taken from lofty elevations could then be transferred to plazas or groups lacking clear views of the horizon. This was probably the case for the Temple of the Sun; modifications were made to the low notch as well as the interior of the temple so that the building would better interact with the sun at equinox. Future excavations as well as further investigations of ancient surveying techniques will no doubt shed light on the complex interrelationship between elevated sightings and plaza orientations.

SUMMER SOLSTICE

Summer solstice corresponds to the time of year when the sun rises and sets at its maximum position in the north. At Palenque's latitude of 17°. 28 N, sunrise on a flat horizon occurs at an azimuth of 65° 14'E and sets at 294° 44'W.

At 7:00 A.M. on 21 June, the sun, when viewed from the interior of the Temple of the Sun, rises from its northernmost point on the horizon, grazing the northwest corner of the Temple of the Cross (Figure 12). Light enters the Temple of the Sun at an oblique angle of 50° north of the transverse axis, or approximately 70° azimuth (Figure 13).

The diagonal light entering the northeast doorway continues to steal across the temple floor. As it pierces the dark interior, the broad ray, blocked by consecutive wall edges, grows increasingly narrow until it becomes a thin beam of light striking the corner of the southwest chamber (Figure 14). By 7:30 A.M. the rays recede from the temple.

The angle of light seen within the temple appears to be the direct result of significant architectural details, which suggest that this solstice alignment was intentional. The northeast corner is set back 10cm. from the rest of the façade, a notable difference that allows the sun to penetrate the interior at the desired angle.

Because the temple faces El Mirador mountain, early morning rays can only enter the front doorway at azimuths between 90° and 65°. The ancient architects left evidence that implies close attention to those particular angles of sunrise. Their concern is apparent in the addition of two interior walls (A and B) with doorways that precisely frame the light. Given the fact that the

Figure 12 A. Mendez

Figure 13 A. Mendez

Figure 14 A. Mendez

other secondary wall (C) does not have an opening, we must assume that the architects chose to capture the light that radiates from the northern part of the horizon. Careful alignment of the doorways to the medial wall permitted the ray of light to pass through the temple. By capturing sunlight through doorways at a diagonal, observers were also able to confirm the position of the sun on the horizon on significant dates with greater precision.

A final point needs to be made concerning the intentionality of design as well as the function of the temple. While the diagonal of the temple (66° 14') is only one degree off the true azimuth for summer solstice sunrise (65° 14'), it is the *visible light* entering the temple at 70° and its relationship to the transverse axis that mark the angle of the summer solstice (Figure 15). This indicates knowledge of the solsticial azimuth prior to the construction of the temple; later design modifications reaffirm this knowledge both visually and conceptually. Based on these factors, we conclude that the temple functioned as a space for ritualized astronomical observations.

Observations of the sun deep inside the temple would have been conducted by priests, astronomers, or rulers, whereas the diagonal light entering through the northeast doorway would have been visible to a larger group of observers. A person standing directly in the center of the building is fully illuminated by the dazzling morning rays (Figure 16). This powerful lighting effect may have been employed during public rituals that took place during summer solstice.

On the evening of the summer solstice, at 6:18 P.M., we made our principal observation from the small "altar stone" near the base of the stairway of the Temple of the Cross. At an azimuth of 290°, the sun sinks behind the Inscriptions Prospect, and the last rays of light pierce the center of the roof comb of the Temple of the Sun (Figure 17).

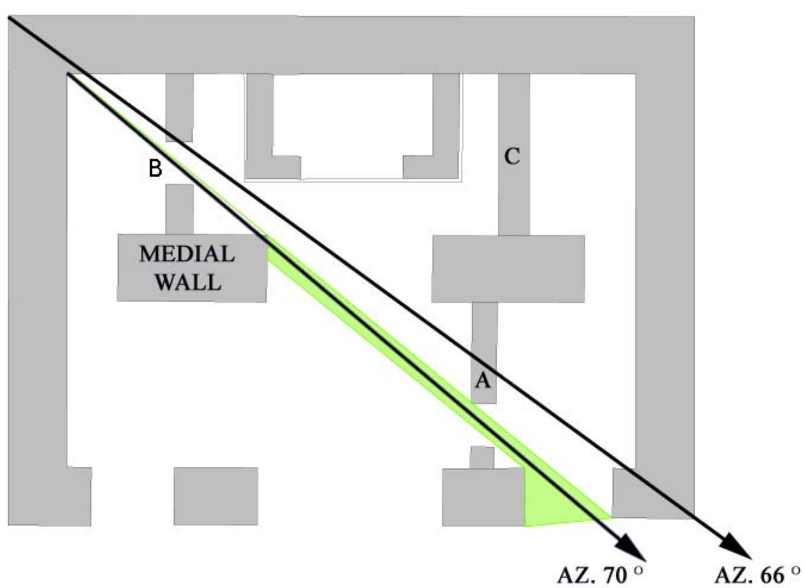

Figure 15 A. Mendez

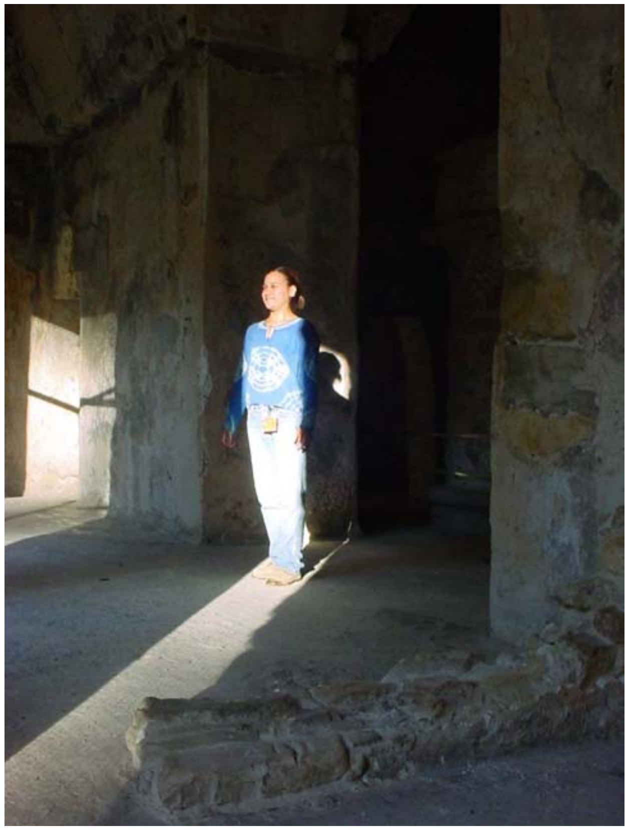

Figure 16 C. Powell

Figure 17 S. M. Prins

Although our observation point was not on the transverse axis of the temple (119° 46'E-299° 46'W), there is nevertheless a noteworthy relationship between the setting sun at summer solstice and the temple as viewed from the plaza. With an unobstructed horizon, the visual effects of this alignment may have been more striking.

In a reconstructed drawing of the roofcomb (Robertson 1991:47-48), a seated stucco figure, surrounded by a double-headed serpent and sky bands, holds a double-headed serpent bar (Figure 18). Four *Bacabs* support the sky serpents.

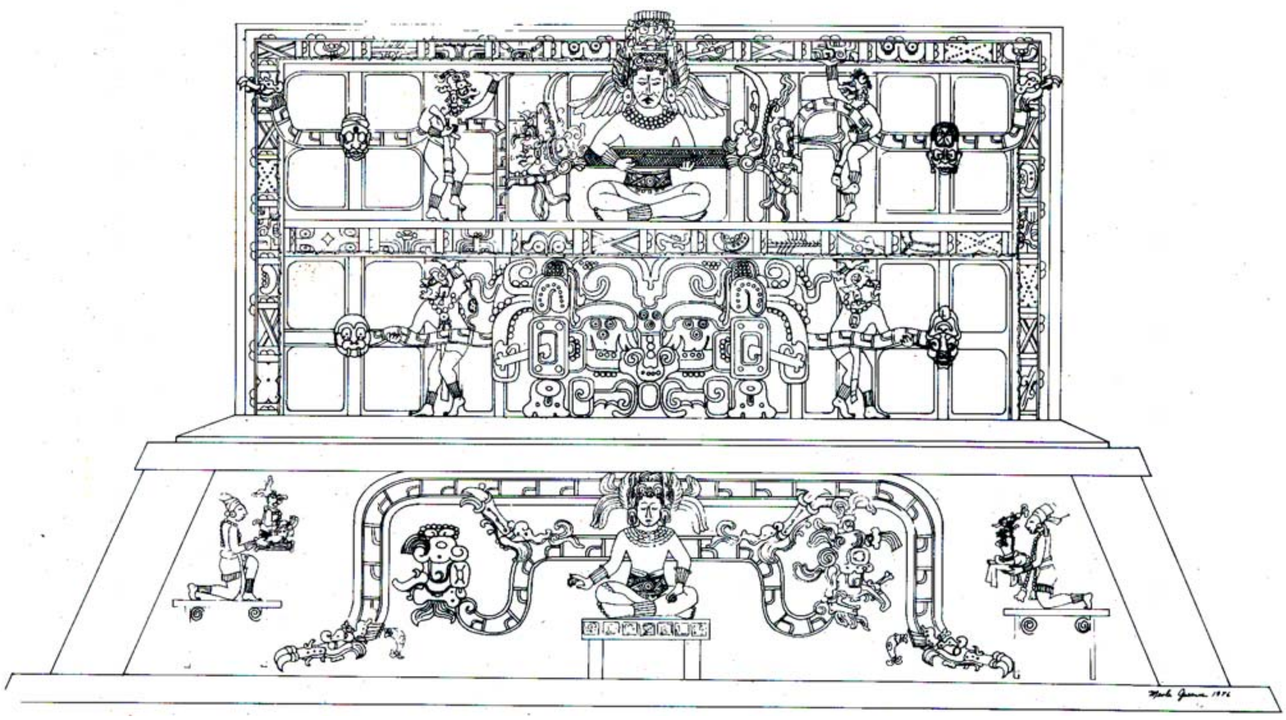

Figure 18 M.G. Robertson

The figure is seated on a *Kawak*, or Earth Monster (Robertson 1991:47), perhaps an implicit reference to the sun setting over the mountain behind the Temple of the Sun (Milbrath 2004, pers. comm.).

On the roof frieze below, a smaller figure, whom Robertson identifies as Kan B'ahlam in the guise of God K, is seated on a throne in the company of two kneeling figures holding what appear to be the Jester God/*Tok Pakal* and God K manikin. The related image depicted on the Tablet of the Sun shows the "sun shield" looming above a more elaborate throne. In both the roof frieze and the tablet, the 7 and 9 gods flank the central image, another parallel between this seated figure and the shield on the tablet.

ZENITH PASSAGE

Zenith passage occurs only within the limits of the Tropics of Cancer and Capricorn and corresponds to the days when the sun reaches a 90° vertical position from the horizon. At midday the sun is directly overhead in the center of the sky. If a gnomon were planted in the earth, an observer would notice the total absence of a shadow at noon. Zenith passage had major significance in ancient Mesoamerican calendars, mainly marking the ideal beginning of the 105-day agricultural cycle in early May and harvest in early August. At 15° latitude, the second zenith passage corresponds with the mythical day of creation, 13 August 3114 B.C. (Freidel, Schele, and Parker 1993:97; Coggins 1996:21; Malmström 1997:52).

Zenith varies according to latitude. At Palenque, the first zenith passage takes place on 7 May and the second on 5 August, when the sun rises at an azimuth of 72°2' and sets at an azimuth of 287°7'.

On the day of zenith passage, sunrise at Palenque occurs at about 6:30 A.M., but direct light is not visible from the Temple of the Sun until 8:00 A.M. Seen from the central doorway of the temple, the sun rises directly over the roof comb of the Temple of the Cross in a spectacular display of architectural alignment between the two buildings (Figures 19 and 20).

Inside the Temple of the Sun, a wide beam of light enters the northeast doorway, as it does during summer solstice. Originally, doorway A had a lintel that limited the maximum extension of the morning light. With the aid of a plumb rod marking the edge of the doorway and approximating the height of the door, we were able to observe a thin ray of light, defined by the width of the door and the angle of entry (approximately 45° north of the transverse axis), advancing toward the southeast corner of the sanctuary (Figures 21 and 22).

Figure 19 A. Morales

Figure 20 A. Mendez

Figure 21 A. Mendez

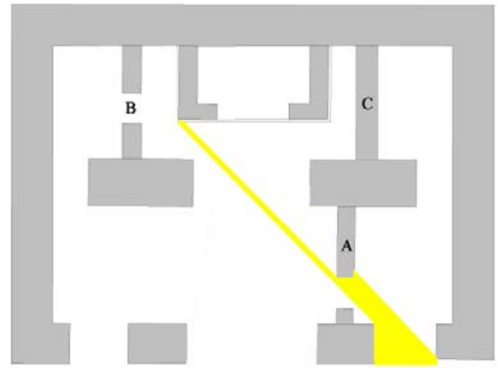

Figure 22 A. Mendez

NADIR PASSAGE

Nadir is the opposite of zenith. Like zenith passage, nadir passage varies according to latitude; the higher the latitude, the closer the distance between winter solstice and nadir passage, summer solstice and zenith passage. At the equator, nadir and zenith coincide with the equinoxes. At the 23° latitude of the Tropics, nadir and zenith correspond with the solstices. At Palenque's latitude of 17.28° N, nadir passage occurs at midnight on 29 January and 9 November, when the sun passes at 90° below the horizon (Figure 23).

The nightly passage of the sun under the earth is described in contemporary cosmology and folk tales (Gossen 1974:34; Karasik 1996:232, 273). Additionally, ethnographers have found that modern Maya languages equate our cardinal directions of north and south with zenith, "up" or "above," and nadir, "down" or "below" (Tedlock, B. 1992:19-24). According to Coggins, the same was true for the ancient Maya (Tedlock, B. 1992:19).

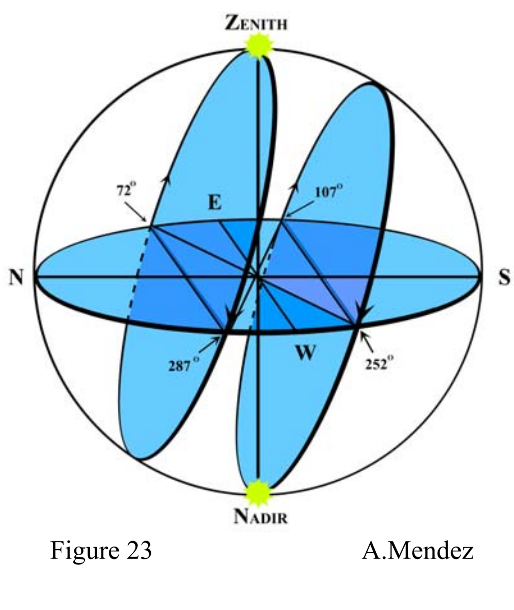

Figure 23 A.Mendez

How did the ancient Maya determine the times of year when the sun reached what they considered to be the center of the underworld? Nadir can be arrived at geometrically by measuring the angle between summer solstice and zenith sunrises and then transposing that angle to the known winter solstice azimuth and the presumed azimuth of nadir. Alternately, a straight line can be extended from the point on the horizon line where zenith sunrise occurred through the observer's location to a point opposite on the western horizon. The arithmetical solution is as simple. Astronomers at Palenque may have counted the number of days from summer solstice to zenith and then counted the same number of days from winter solstice to nadir. The results would have been fairly accurate. Astronomers could then correlate their findings by observing bright stars on the horizon. Sirius, the brightest star in the sky, would have been the logical marker for nadir passage. During the Late Classic period, Sirius rose at 106°26' and set at 253°33', remarkably close to the azimuths for the rising and setting nadir sun (107°45'E-252°5'W) in the seventh century. Aveni and Hartung (1978:176) have already noted that Palenque's Temple of the Count faces Sirius. It is possible that the temple also faced the rising sun at nadir passage. The Pleiades passing through the zenith of the night sky also presaged the solar nadir passage, but only in November (Milbrath 1988:27; Krupp 1983: 205-208).

Milbrath's (1988:26-28) identification of the east/west axis of El Castillo at Chich'en Itza is perhaps the first recognition of the relationship between zenith and nadir as seen in the alignment of a Maya temple. At Chich'en Itza's latitude of 20°, the temple's western façade is aligned to the zenith sunset on 25 May and 20 July, while its eastern face is oriented to the nadir sunrise on 22 November and 21 January. Milbrath mentions that the November nadir marked the beginning of the dry season while the January nadir marked the commencement of the agricultural season. In addition to its calendrical significance, Milbrath proposes that the November nadir announced the period of warfare.

At Palenque, the nadir sun now rises and sets at an azimuth of 107°18'E - 252°32'W. Viewed from the Temple of the Sun at 9:15 A.M. on 9 November, the sun rise breaks the horizon at a vertical angle of 23° and a horizontal azimuth of 120°. Light floods the temple at a direct perpendicular angle, illuminates the room to the south of the sanctuary (Figures 24 and 25), and reaches the entrance to the inner sanctuary (Figure 26). The photograph in Figure 27, taken from the threshold of the sanctuary, shows the centering of the sun below the lintel of the middle doorway.

This is the effect that Carlson had predicted for winter solstice. Our observations establish that the transverse axis of the temple is oriented to the rising sun at nadir.

As mentioned earlier, the transverse axis of the temple also marks the southern maximum extreme of the rising moon as well as the northern maximum extreme of the setting moon (300°), events which occur during the solstices every 182/3 years. Although the moonrise at 120° is not visible from the Temple of the Sun, the alignment of the temple with the lunar standstills merits attention (See Figure 8).

Figure 24 A. Mendez

Figure 25 A. Mendez

Figure 26 A. Mendez

Figure 27 A. Mendez

AN ASTRONOMICAL BLUEPRINT

FOR THE LAYOUT AND DESIGN OF THE TEMPLE OF THE SUN

This section presents a hypothetical discussion of surveying methods that may have been employed during the Classic period. Our experience during the Palenque Mapping Project (1998-2000) gave us some practical insights into the challenges the ancient Maya faced when they were laying out and designing the Temple of the Sun, and the Cross Group as a whole.

A nucleus of bedrock lies at the core of the Cross Group and forms the mass of the temples' substructures. The ground-penetrating radar survey, conducted by the Proyecto de las Cruces, along with accompanying test pits that explored the terraces, revealed that the Temple of the Cross, northeast of the Temple of the Sun, rests on solid bedrock as far up as the sixth terrace (Hanna 1996:5). This natural configuration of bedrock salients also lined the ravine that would become the Cross Group Plaza.

First the deep ravine that ran between the major hills had to be leveled. Topsoil was removed in order to reach the bedrock carved by millennia of rains rushing down the mountainside. Then thousands of cubic meters of clay were laid down to insure that later flooding would never undermine the foundation of the Cross Group Plaza. Upon this foundation, construction of the Temples of the Sun, Cross, and Foliated Cross began. In this case, it was not necessary to move mountains but to "dress" them.

The builders of the Cross Group must have recognized the advantages of raising temples on natural elevations, one of which would face the rising sun. While standing on the foundation for the future Temple of the Sun, the builders had observed the major stations of the sun in relation to El Mirador mountain. During winter solstice, the sun rose directly over the peak; at equinox the sun rose from the cleft between El Mirador and the ridge that would become the Temple of the Cross; at zenith the sun rose directly above that same ridge; and at summer solstice, just north of the ridge. This information was all the builders needed for their preliminary design (Figure 28). The goal was to build two terraced platforms. The Temple of the Sun would eventually serve as the solar observation point; the Temple of the Cross would serve as the back-sight for those observations.

Initially the taller platform of the Temple of the Cross was used for taking sightings that would orient the entire group. From this high vantage, surveyors were afforded a clear view of the eastern and western horizons. The primary observation was made during summer solstice to establish the extreme northern position of the sun. The surveyors drove a gnomon into the center of the stucco floor of the platform. Sunrise observations were recorded on the floor by tracing the shadow of the gnomon and connecting that painted line to a sighting stick aligned to the first rays of the sun. The surveyors then waited until the sun set in the west. A second line painted over the evening shadow of the gnomon ran toward a sighting stick aligned to the last rays of the sun. In one day of observations, the surveyors had drawn two intersecting lines that crossed at approximately 50°, the angle of the solstices. By dividing these angles in half they established the line of the equinox. This alignment was preserved in the diagonal orientation of the Temple of the Cross, which is less than one degree off due east/west (Figure 29).

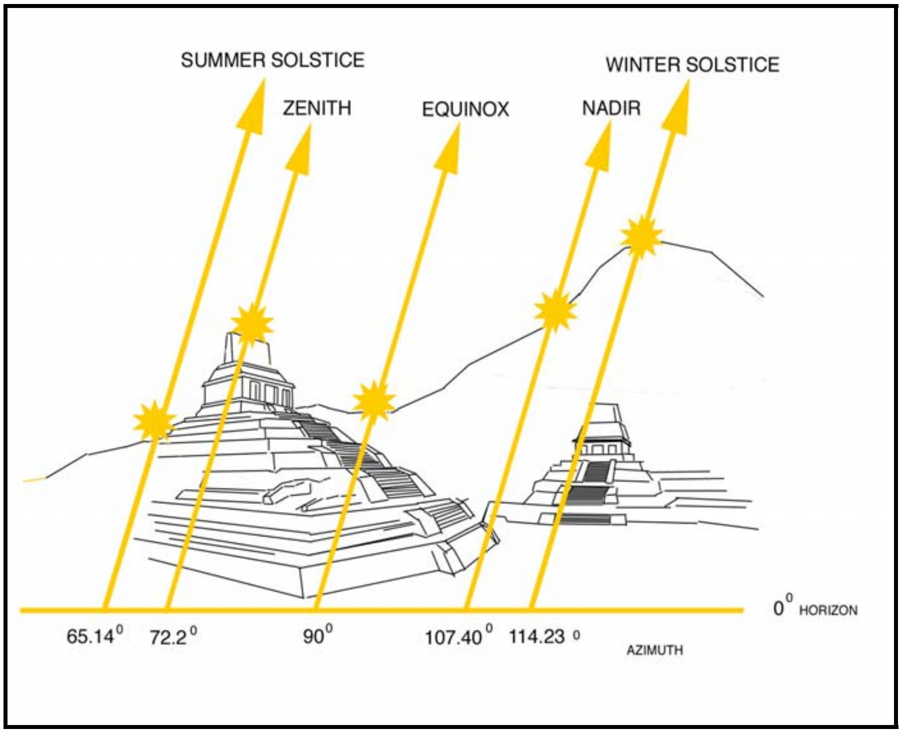

Figure 28 A. Mendez

Solar alignments as seen from the Temple of the Sun

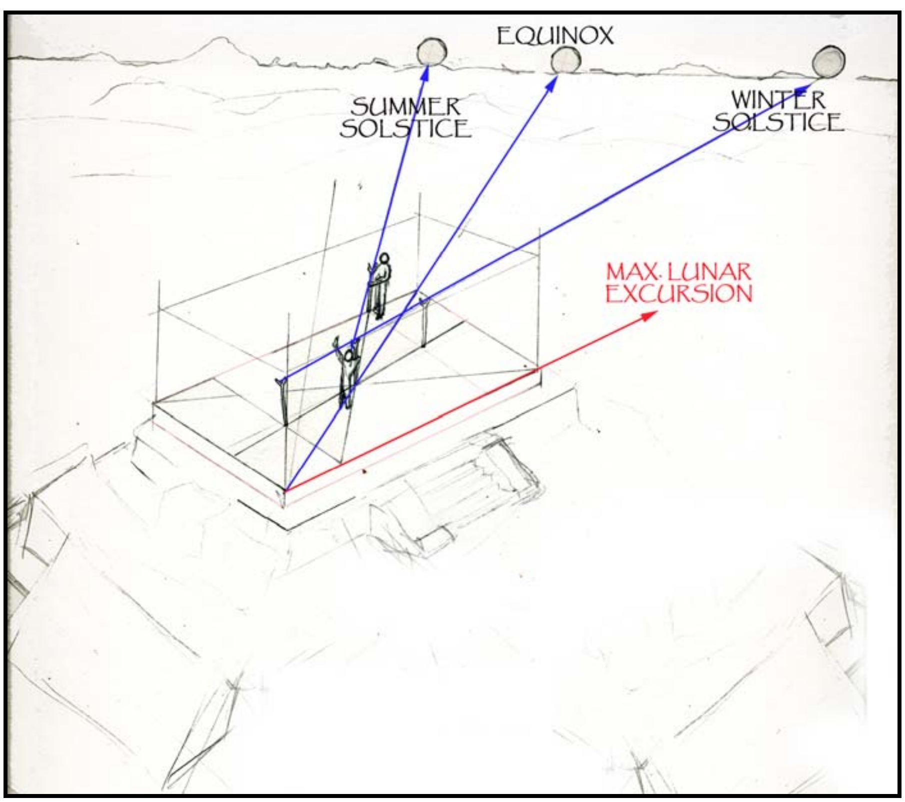

Figure 29 A. Mendez

The longitudinal axis of the Temple of the Cross (119°E-301°W) coincides with the maximum excursions of the moon. On a flat horizon at Palenque's latitude, the moon, at its maximum southern position, rises and sets at an azimuth of 120°E-240°W and at 60°E-300°W at its maximum northern position. The lunar azimuths also match the transverse axis of the Temple of the Sun (119° 46'E-299° 46'W).

It was possible to project the measurements down to the platform of the Temple of the Sun with the aid of plumb bobs and sighting rods**.** Two crossed wooden sticks may have served as a rudimentary surveyor's transit. With this device, surveyors could project desired angles either vertically or horizontally (Aveni 2001:65). Adjustments could then be made to the height of the platform, to bring the future temple into alignment with El Mirador, the low notch, and the Temple of the Cross.

After the solar angles were drawn on the platform of the Temple of the Sun, the builders began to lay out the geometric proportions of the temple. They probably relied on the same methods and the same tools traditionally employed in measuring houses made of wattle and daub (Anderson 2004, pers. comm.). Braided henequen rope and wooden stakes were used for squaring the building from corner to corner. In effect, the temple builders repeated the actions of the Maker, Modeler who laid out the cosmos:

> The fourfold siding, fourfold cornering,
> measuring, fourfold staking,
> halving the cord, stretching the cord
> in the sky, on the earth,
> the four sides, the four corners, as it is said,
> by the Maker, Modeler…(Tedlock 1985:72)

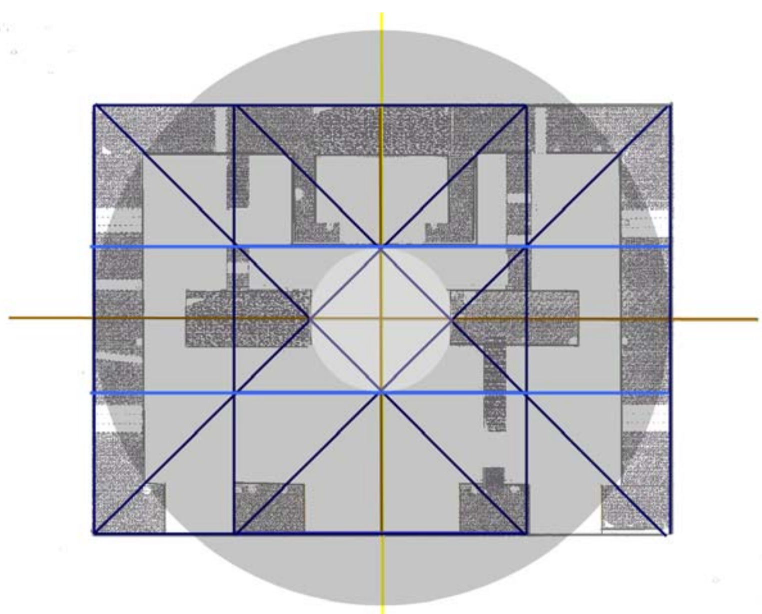

Figure 30 A.Mendez

The repetitive measurements of halving the cord, then stretching or "doubling" the cord, suggest that the Creators, like modern Maya house builders and farmers, began with a square (Vogt 1990:17-18; Christenson: 2003:65). Next, the sides of the initial square were extended to produce a double square. This double square defined two larger squares, which, overlapping, produced a rectangle with a 3:4:5 ratio. The overlapping squares marked the two main piers of the temple façade, the width of the medial doorway, the façade of the sanctuary, and the secondary walls that framed the sanctuary. For the width of the walls, the builders stretched a cord from the center of the initial square to the outer rectangle and made a circle. The points where the radius intersected the major diagonals marked the interior corners of the temple. Three inner doorways eventually would allow sunlight to travel along the original sight lines that defined the interior space. Thus, a formula of progressive squares and rectangles produced a beautifully proportioned floor plan that also was in keeping with the principal solar orientations of the temple (Figure 30).

The exterior dimensions of the temple were based on an integral right triangle with 3:4:5 proportions and interior angles of 90º, 53º, and 37° (Figure 31).

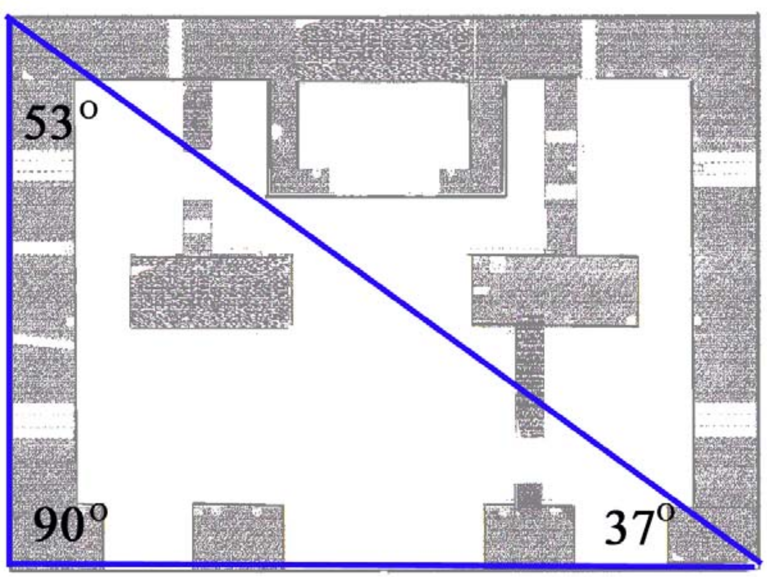

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Figure 31 A. Mendez

The 90º angle was inherent in the initial square, whose 45º diagonal was the angle between the observed sunrise at zenith and nadir passages. The 53º angle was the angle between summer solstice and nadir passage/maximum lunar excursion (Figure 32). The observed sunlight entering the temple during summer solstice created a 50° angle with the transverse axis (See Figure 16).

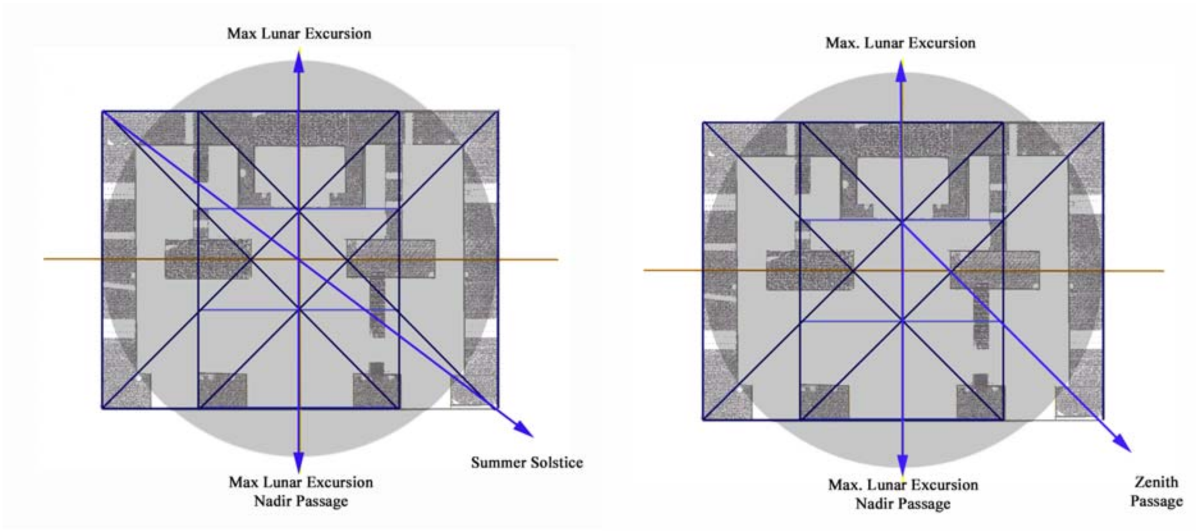

Figure 32 A.Mendez

When the walls and vaults were raised, the roof comb was added. The side elevations conformed to the 3:4:5 principal proportion of the temple (Figure 33).

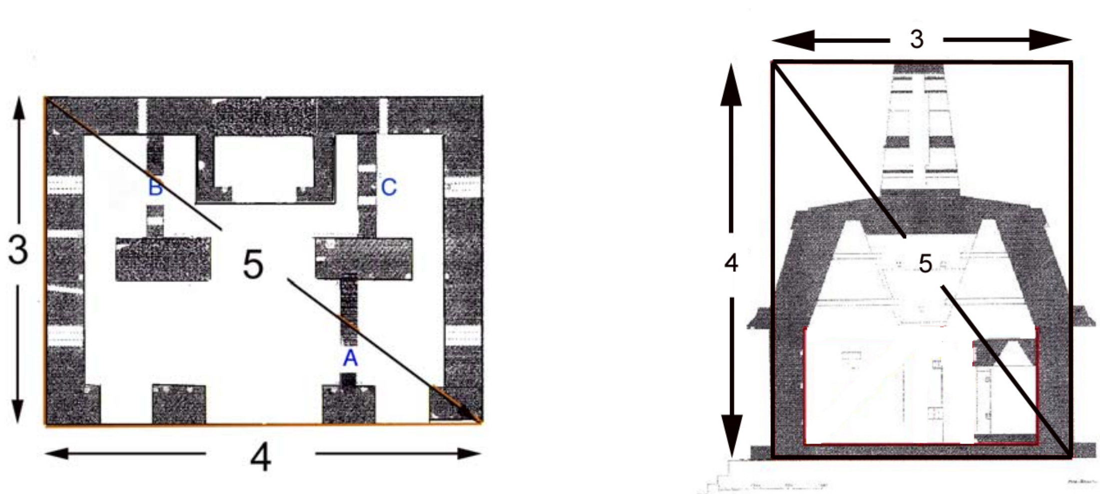

Figure 33 After M.G.Robertson

During excavations conducted by M.A. Fernández (1991: 239-241) between 1942 and 1945, three offerings were discovered in the floor of the temple. Offering One (a cist containing two lidded vessels) and Offering Two (a lidded vessel accompanied by jaguar phalanges) were buried on the transverse axis of the temple; Offering Three, a stucco mask representing a solar deity, aligned with Offering Two along the 70° degree azimuth where the solstice light enters the building (Figure 34).

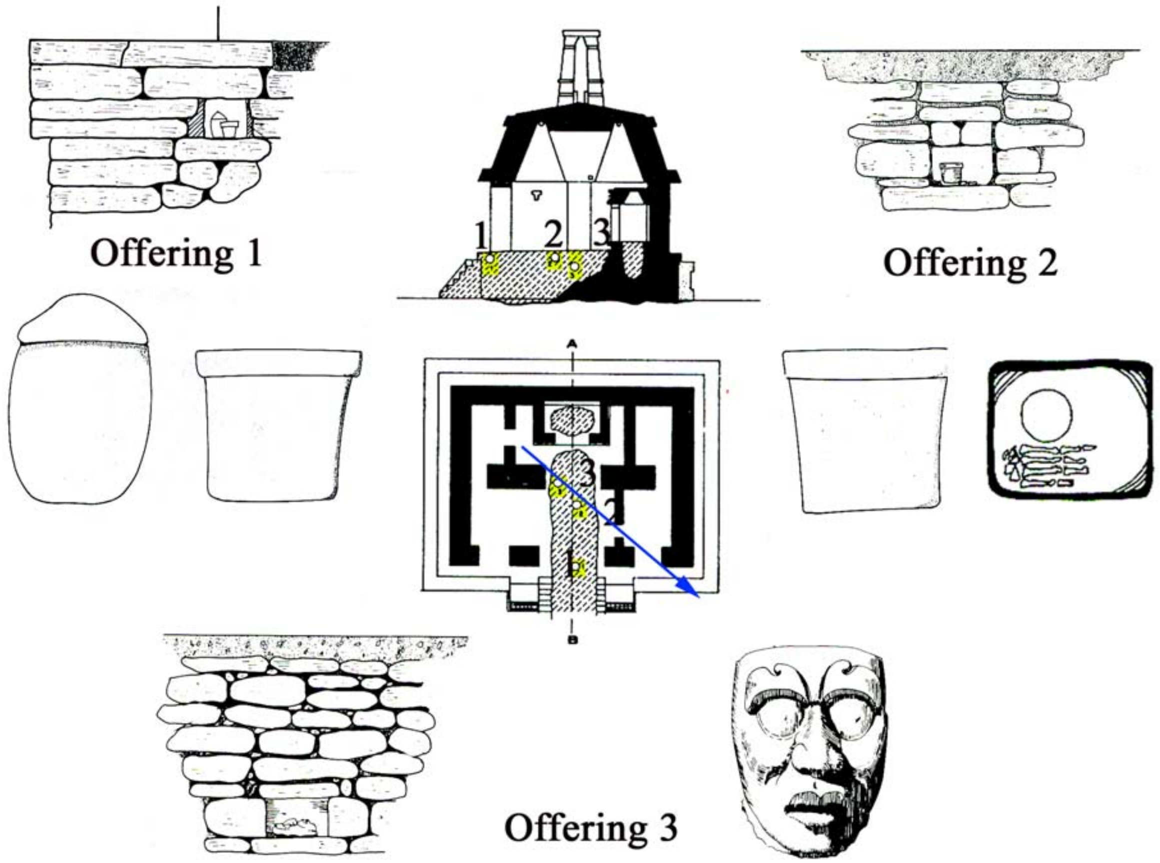

Figure 34 After M.A. Fernández

After the temple was built, the hieroglyphic texts tell us that two dedicatory rites were held, one celebrating the completion of the temple on 9.12.18.5.17 3 Caban 15 Mol (A.D. 24 July 690), the second celebrating the completion of the inner sanctuary on 9.12.19.14.12 5 Eb 5 Kayab (A.D. 10 January 692). Sometime during those two years, walls B and C (See Figure 11) were added to define the space of the sanctuary so that it would better interact with the diagonal light at equinox; doorway A defined summer solstice and zenith (See Figures 15 and 22).

The Cross Group raised Kan B'ahlam's royal lineage above previous dynasties and rooted his legitimacy in the mythology of creation (Freidel, Schele, and Parker 1993:283; Baudez 1996:126**;** Aldana 2004). Charged with religious symbolism, the Cross Group also embodied the movements of the sun and moon. The Temple of the Sun, with its back to the Plaza of the Inscriptions, became the new vantage for witnessing the repeating cycles of hierophanies that would convey the spiritual and intellectual message of the new ruler.

ASTRONOMICAL ELEMENTS IN THE TEXT AND ICONOGRAPHY OF THE TEMPLE OF THE SUN

The Temple of the Sun was originally named for the prominent "sun shield" displayed on the carved tablet in its inner sanctum (Figure 35). In addition to the imagery, the hieroglyphic inscriptions on the tablet and *alfardas* contain numerous direct, and oblique, astronomical references (See Table 1). Floyd Lounsbury (1978; 1989) has provided brilliant mathematical insights into the Jupiter-Saturn periods related to the 819-day count, the Venus and Mars cycles, and the 108- year tropical year drift cycle. Given the orientation of the temple, this section focuses on the transits of the sun and moon alluded to in the Tablet of the Sun. (For correlations between calendrical data and astronomical phenomena we used the 584,285 GMT+2 standard and the Maya Date–Maya Calendric Calculator (Bassett 1999).

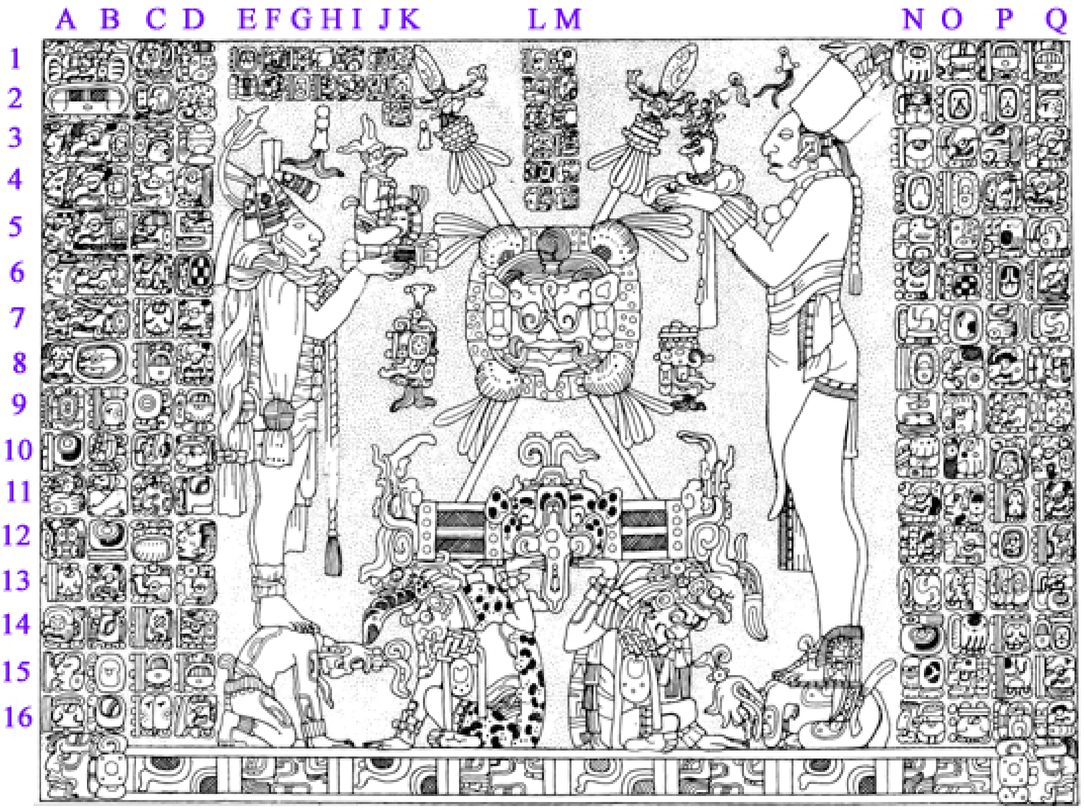

Figure 35 Tablet of the Sun   L. Schele

The text of the tablet begins with the birth of GIII on 1.18.5.3.6 13 Cimi 19 Ceh (A1-D6) (25 October 2360 B.C.). The second born of the Palenque Triad, GIII is named in the text as *Ahaw Kin*, "Lord Sun" (Lounsbury 1985:50-51), though he is currently called *K'inich Ahaw*, "Sun-Faced Lord" (Miller and Taube 1993:130; Wald 1999:93; Montgomery 2002:28). Long considered a solar deity, he is often associated with the sun in the underworld (Kelley1976:6). Dennis Tedlock (1985:368**;** 1992:264) identifies GIII with the younger Hero Twin, Xbalanque, or “little jaguar sun,” and equates him with the full moon. It is interesting to note, however, that a new moon rose on his birthday.

The later passages of the tablet cite important dates in Kan B’ahlam’s life; those events are keyed to major astronomical phenomena. The first historical date, 9.12.18.5.16 2 Cib 14 Mol (D16-06) (A.D. 20 July 690), corresponds to a rare Jupiter/ Saturn/Mars conjunction. This major astronomical event, related to the dedication of the Cross Group, is also referenced in the texts of the Temples of the Cross and Foliated Cross. That night, Mars set at 252°45’, less than a minute off the sun’s nadir position on the western horizon; Jupiter, and Saturn set at 254°; and the moon set at 250° 22’. In other words, this conjunction was amplified by the fact that the major planets entered the underworld through the portal of the nadir sun.

Kan B’ahlam dedicated the *K’inich B’ahlam Kuk Nah* building (Houston 1996), the Temple of the Sun, on 9.12.18.5.17 3 Caban 15 Mol (N7-N8) (A.D. 24 July 690). That evening, Venus rose within 3° of the sun’s summer solstice position. Like the sun at that time of year, Venus would have been visible through the northeast doorway of the Temple of the Sun.

Following the dedication of the temple, Kan B’ahlam performed a blood-letting rite to the gods, on 9.12.19.5.19 5 Cauac 17 Mol (N13-N16) (A.D. 27 July 690). The night before, the full moon passed through the sun’s nadir position, rising at 106° 9’ and setting at 251° 43’.

Apparently Kan B’ahlam had waited for the moon to reach its southern extreme and to begin its northern journey before conducting the blood-letting ritual. The anniversary of Janahb Pakal’s accession to the throne, 29 July, fell immediately after the full moon and five days before the sun’s zenith passage. Aveni and Hotaling (1996:363) mention that Jupiter, Saturn, and Mars, which had come within 10° of longitude the night before the dedication of the Cross Group, were even closer (within 4°) on the anniversary of Janahb Pakal.

The inscriptions then moves back in time to record Kan B’ahlam’s heir designation ceremony. The celebration, which began on 9.10.8.9.3 9 Ak’bal 6 Xul (A.D. 17 June 641), culminated five days later on the summer solstice. As the text states (Q5-Q10), *i-u-ti bolon Ak’bal wak Xul k’alwani u-ho’tal Ok-te K’in K’inich Kan B’ahlam B’aakel Wayal yi-chi-nal* GI: “After the fifth changeover [day] [he became] the Pillar of the Sun, the Sun-Faced Kan B’ahlam, the Bone Spirit, in the presence of GI” (Stuart 2005:48)**.** The heir-designation ceremony, culminating on the summer solstice, is perhaps the most critical of the solar allusions in the text as it defines the transfer of divine status from Janahb Pakal to his son Kan B’ahlam.

Just prior to the ceremony, on 14 June, a new moon (Milbrath 1999:102)**,** in conjunction with the sun, set midway between the solstice and zenith at an azimuth of 292°. On 18 June the moon, 3.8 days before first quarter, passed through the zenith. By 22 June the moon had moved away from the sun to join Mars and Jupiter in a conjunction that set directly on the sun’s equinox position.

The final date on the tablet, 9.10.10.0.0 13 Ahaw 18 Kankin (P14-Q16)(A.D. 6 December 642), relates to a war event that coincided with a ten *tun* anniversary. As was customary, the six-year-old heir designate, or his father, was required to capture and sacrifice nobles from a rival kingdom (Schele and Freidel 1990:236). On the same date, Smoking Squirrel of Naranjo and Ah

Cacaw of Tikal engaged in battle with the cities of Ucanal and Calakmul respectively (Schele and Freidel 1990:251). Why was this date so propitious for war? Astronomically, this date coincided with a full moon, which entered into a partial eclipse on 11 December, perhaps an ideal time for a beheading. That night the moon rising at 66° 40’, slightly more than one degree from the azimuth of summer solstice, seemed to be in direct opposition to the sun, which set in the southwest at 245° 37’, only ten minutes away from the azimuth of winter solstice.

A brief text prominently displayed above the center of the “sun shield” on the tablet records the accession of K’inich Kan B’ahlam II on 9.12.11.12.10 8 Oc 3 Kayab (L1-M6) (A.D. 10 January 684). At the ripe age of forty-eight, Kan B’ahlam waited 132 days after his father’s death before he came to the throne (Schele and Freidel 1990:240). A possible explanation may lie in the astronomical significance of this date. According to Lounsbury (1989), the event was timed to Jupiter’s retrograde motion. The moon was equally prominent that evening. One day before full, and in conjunction with Mars, the moon reached its maximum northern excursion, rising at 60° and setting at 299° 39’, less than one degree off the transverse axis of the Temple of the Sun. The placement of the accession text at the center of the tablet parallels the commemoration of this event in the central alignment of the temple. The visual and conceptual ramifications are profound**.** The moon not only mirrored the position of the rising sun during nadir passage, but also echoed the setting sun at summer solstice, the time of Kan B’ahlam’s heir-designation ceremony (See Figure 17).

On the eighth anniversary of Kan B’ahlam’s accession, he dedicated the sanctuary of the Temple of the Sun. According to a separate text recovered from the *alfardas* of the temple (Figure 36), this ceremony occurred on 9.12.19.14.12 5 Eb 5 Kayab (A1-G2, *alfardas*) (A.D.10 January 692). The night before**,** a full moon rose at an azimuth of 73°, only one degree from the sun’s position during zenith passage. Observed from the central doorway of the Temple of the Sun, the moon would have been seen emerging directly from the center of the roof comb of the Temple of the Cross.

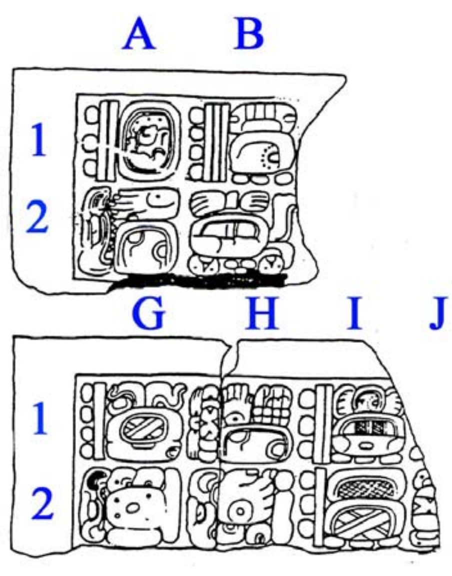

Figure 36 After Linda Schele

A few months later, Kan B'ahlam celebrated the completion of Katun 13 on the vernal equinox, 9.13.0.0.0 8 Ahau 8 Uo (H1-L2, *alfardas*) (A.D. 18 March 692). Saturn, Mars, the moon, and Jupiter rose in alignment, within 2° and within two hours of one another. The planets would have been seen rising from the peak of El Mirador at the position of the rising sun at winter solstice. Venus would have been visible from the Temple of the Sun directly centered in the doorway at 30° altitude and 120° azimuth, the sun's nadir position on the horizon.

Table 1. Dates from the Temple of the Sun and their Proposed Astronomical Significance

Glyph ID	L.C. Tzolkin and Haab	Context	GMT + 2 Correlation	Event	Proposed Astronomical Significance
A1-B9	1.18.5.3.6 13 Cimi 19 Ceh	INSG Mythological Date Tablet of the Sun	25 October 2360 B.C.	Birth of GIII	1.38 days before New Moon Mercury/Jupiter Conjunction Venus at A.M. G.E.*
D16-O6	9.12.18.5.16 2 Cib 14 Mol	Historical Date Tablet of the Sun	A.D. 23 July 690	Dedication Temple of the Sun	Jupiter/Saturn /Mars/Moon (Conjunction at Nadir azimuth) Venus rises at 67º azimuth and A.M. G.E.
N7-N8	9.12.18.5.17 3Caban 15 Mol	Historical Date Tablet of the Sun	A.D. 24 July 690	Dedication Temple of the Sun	Venus Rises at 67º azimuth (1º off diagonal of temple)
N13-N16	9.12.19.5.19 5 Kawak 17 Mol	Historical Date Tablet of the Sun	27 July 690 A. D.	Bloodletting Rite	Full Moon rises at Nadir azimuth Jupiter/Saturn/Mars conjunction at max. proximity
P6-Q6	9.10.8.9.3 9 Akbal 6 Xul	Historical Date Tablet of the Sun	17 June 641 A. D.	Heir Designation Kan B'ahlam	New Moon (14 June) Summer Solstice (21 June) Jupiter/Mars/Moon Conjunction (22 June)
P14-Q15	9.10.10.0.0	Historical Date Tablet of the Sun	6 December 642 A.D.	War Event 10 Tun Completion	Full Moon/ Partial lunar eclipse (Dec. 11)
L1-M6	9.12.11.12.10 8 Oc 3 Kayab	Historical Date Tablet of the Sun	10 January 684 A.D.	Accession Kan B'ahlam	Jupiter in Retrograde Full moon sets at 299º (max. northern excursion) Moon /Mars Conjunction
A1-G2	9.12.19.14.12 5 Eb 5 Kayab	Historical Date (*Alfardas*)	10 January 692 A. D.	Dedication Sanctuary	Full Moon at 1º from Zenith azimuth
H1-L2	9.13.0.0.0 8 Ahaw 8 Uo	Historical Date (*Alfardas*)	18 March 692 A.D.	13th Katun Celebration	Vernal Equinox Saturn/ Mars/ Moon Alignment Jupiter at Winter Solstice azimuth. Venus at Nadir azimuth

*A.M.G.E= Greatest elongation as "morning star"

Table 2. Dates for Kan B'ahlam's Life and their Proposed Astronomical Significance

L.C. Tzolkin and Haab	Context	GMT + 2 Correlation *(Julian 854285)*	Event	Proposed Astronomical Significance
9.10.2.6.6	Temple of the Cross	A.D May 23 635	Birth of Kan B'ahlam	New Moon at Zenith Azimuth
		A.D January 16 702		Moon at 2.42 days before full Completion of one 18 2/3 year cycle of Maximum Lunar excursion since Kan B'ahlam's Accession
9.13.10.1.5 6 Chichan 3 Pop	Temple of the Cross	A.D. Feb 16 702	Death of Kan B'ahlam	Moon at 1 day before full rises at Zenith Azimuth and sets at summer solstice Azimuth
9.13.13.15.0 9 Ahaw 3 Kankin	Temple XIV Tablet	A.D. Nov 2 705	Apotheosis of Kan B'ahlam	Sun at 4 nights away from Nadir Passage Moon rises at Zenith Azimuth

A series of dramatic lunar events surrounded Kan B'ahlam's death, recorded on the Zapata Panel as 9.13.10.1.5 6 Chikchan 3 Pop (A.D.16 February 702). One month earlier, on A.D. 16 January 702, the moon reached its maximum northern excursion, completing the18 2/3-year cycle that began on the date of Kan B'ahlam's accession. Rising at an azimuth of 60° and setting at 300°, the full moon would have been seen from the Temple of the Foliated Cross as it descended behind the Temple of the Sun, precisely along the line of the transverse axis. On the date of Kan B'ahlam's recorded death, the moon, one day before full, rose in the sky in the zenith position (72° azimuth) and set at the position of the summer solstice sun (285° azimuth). On A.D. 17 April 702, shortly before Kan B'ahlam's younger brother assumed office, a total lunar eclipse took place, and although it occurred just below the horizon at 103°, its red penumbra would still have been visible; by dawn the full moon set at 254°, the nadir position of the sun. Two and a half years later, Kan B'ahlam's spirit is said to have risen from the underworld, on 9.13.13.15.0 9 Ahaw 3 Kankin, or A.D. 5 November 705, (Apotheosis Panel, Temple XIV). That evening the sun set within one degree of nadir. The night before, the full moon rose directly from the zenith position on the horizon, traveled across the height of the sky, and eclipsed the Pleiades before they descended into the horizon. Kan B'ahlam's life, death, and apotheosis were circumscribed by recurring patterns of the sun and moon (See Table 2).

Considerable debate surrounds the solar and lunar symbolism of the Tablet of the Sun. But first, a description of the iconography is in order. The dominant imagery on the Tablet ostensibly refers to war, perhaps to the war event associated with Kan Ba'ahlam's heir designation or to the role of the king, upon his accession, as a warrior. On either side of the panel, two men face each other—the same two men who appear on each of the tablets in the Cross Group. The man on the right has been identified as K'inich Kan B'ahlam II. The smaller figure, draped in "winding sheets," probably represents Kan B'ahlam's dead father, K'inich Janahb Pakal (Schele and

Freidel 1990:254), although some scholars identify the figure as the young Kan B'ahlam before his accession to the throne (Martin and Grube 2000:169, Milbrath 1999:233). He offers a personified eccentric flint with flayed face shield: the *Tok Pakal*, an icon that denotes royal lineage as well as warrior status (Freidel, Schele, and Parker 1993:305). The larger figure on the right offers a God K manikin, another symbol of royal lineage (Miller and Taube, 1993:110-111) as well as blood sacrifice (Freidel, Schele, and Parker 1993:194). These same objects are offered by the two kneeling figures on the roof frieze of the temple.

Both figures stand on the backs of sun deities and pay homage to the tablet's central motif, the "war stack" (Schele and Freidel 1990:259): a shield in front of two crossed spears resting upon a platform adorned with the masks of a jaguar and two serpents. The face emblazoned on the shield has been identified as the Jaguar God of the Underworld, the Night Sun (Schele and Freidel 1990:414), or the Jaguar War God, a deity associated with the moon (Milbrath 1999:123-125). Karen Bassie-Sweet (1991:192-198) specifically associates what she calls the "Twisted Cord Jaguar" with the full moon and then proposes that the jaguar is the zoomorphic form of GIII.

Although the platform upon which the sun shield rests appears to be a flat bar, it is most likely a throne with four sides (Bassie-Sweet 1991:163). A similar throne, decorated with jaguar masks at either end, is seen in the accession scene depicted on the Palace Tablet. While the shield above the platform may represent the sun on the horizon, it may also symbolize the seating of the ruler, K'inich Kan B'ahlam, on the throne.

Like many thrones seen in Classic Maya art, it is supported by two Pauahtuns or Bacabs. The Pauahtuns support the throne with one hand and with the other hand touch the band running across the bottom register of the panel. This band is composed of alternating glyph blocks. One reads *cab* or "earth"; the second glyph block is a profile of God C, who signifies divinity or holiness (Taube 1992:27-31).

The band terminates with the faces of GIII (Milbrath 1999:102). The band of alternating "earth" and God C glyphs, terminating with the faces of GIII, may represent the nightly passage of the sun through the underworld (Baudez 1996:123). Rather than the west to east path of the sun beneath the earth, it may be more accurate to say that the band represents the horizon that lies between the points of maximum excursion. In any event, the band seems to serve as a symbol of transition. The gesture used by the Pauahtuns as they touch the band is reminiscent of the *u-pas-kab* or "hand above earth" glyph, interpreted as "to experience" or "to be born" (Lounsbury 1980:113).

The underworld is a place of death, transformation, and rebirth. The presence of the underworld deity God L, the Pauahtun on the left, tie the scene on the tablet to the underworld. The floating toponyms on either side of the shield, referring to the "7 and 9 place," denote supernatural space (Miller and Taube 1993:151; Martin and Grube 2000:194); perhaps the 7 and 9 refer more specifically to the underworld. On the roof frieze, Kan B'ahlam is identified with God K. On the tablet located in the inner sanctuary—the *pib na*, "steambath" or "underground house" of GIII (Schele and Freidel 1990:251; Houston 1996)—Kan B'ahlam is associated with the Jaguar War god, emblematic of the night sun, the full moon, and GIII seated in the underworld (Aldana 2004). Repeating a common theme in Classic Maya art, Kan B'ahlam communes with his deceased father, Janahb Pakal, who reinforces the role of Kan B'ahlam as warrior by offering him the *Tok Pakal*, a miniature "war stack." The tablet thus resonates with metaphorical associations between warfare, the moon, and the nadir sun.

Multiple solar positions are implied on the tablet: the rising sun at summer solstice, the sun at or below the horizon, and the sun in the underworld at nadir. The iconography of the tablet, although static, represents the myriad levels of the Maya universe.

This concept is embodied in the crossed spears poised above the throne. Milbrath (1999:272) argues that the Temple of the Sun is oriented to a cross constellation in Sagittarius seen rising in the eastern sky just before Kan B'ahlam's accession and it is this constellation which was represented by the crossed spears in the tablet. If we view the spears from a purely mathematical perspective, we discover yet another layer of interpretation. The angle of the spears is 53°degrees. This angle is repeated in the 53° interior angle of the 3:4:5 proportions of the tablet (Figure 37). The angle of the crossed spears also coincides with the angle between the transverse axis and the diagonal of the temple. In other words, the angle of the spears commemorates the angle between summer solstice and nadir and between summer solstice and the maximum lunar extreme, a deft way of depicting the polarity between sun and moon. As it turned out, this angle encompassed Kan B'ahlam's life and death.

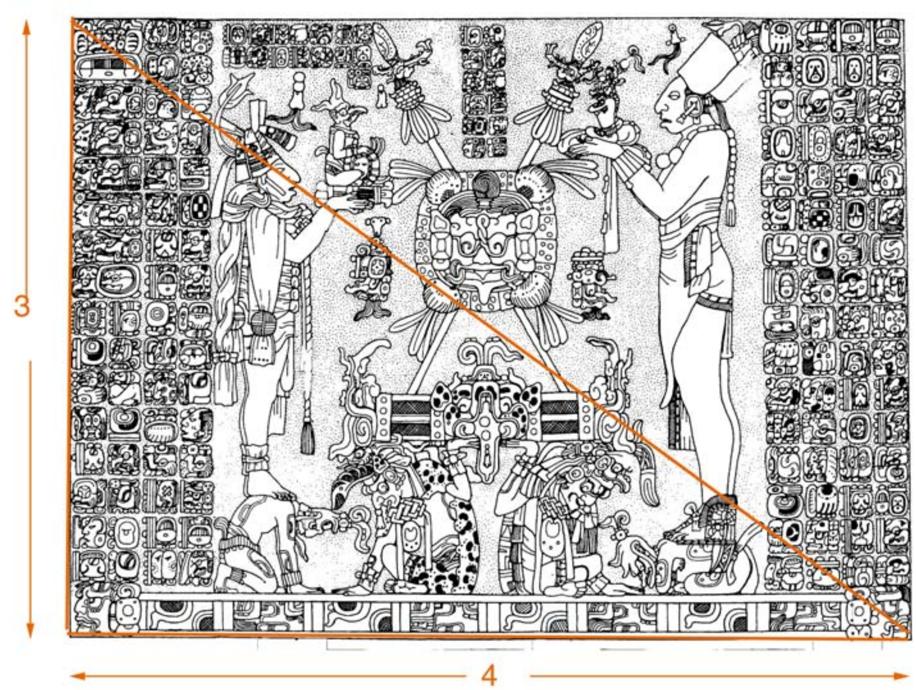

Figure 37 After L. Schele

CONCLUSIONS

The Temple of the Sun was used to track major stations of the sun as well as to mark important dates in the reign of Kan B'ahlam. Four new solar hierophanies have been identified within the temple. The morning light observed entering the temple during equinox, summer solstice, and zenith passage is characterized by diagonal rays reaching back to interior corners. The broad beam of light entering the central doorway at nadir passage indicates the transverse axis of the temple.

The diagonal rays of light recorded at equinox, summer solstice, and zenith passage were observable only to a small group of astronomers dedicated to monitoring the passage of the sun throughout the year. But at summer solstice, the dramatic morning light may have illuminated a noble personage standing in the center of the Temple of the Sun who could have been visible to a larger audience gathered in the plaza. The sun setting directly over the roofcomb that evening may also have been witnessed by a group of celebrants. Both events probably played a part in the public pageantry celebrating the anniversary of Kan B'ahlam's heir-designation ceremony. These hierophanies would have strengthened the ties between the earthly and supernatural worlds that the ruler represented.

The private hierophany within the temple would have carried a similar message, however. As we have seen, the precision of the temple's original design and subsequent modifications suggests that the Temple of the Sun functioned as a commemorative structure for ritualized astronomical observations which served to reaffirm the ruler's central place in the cosmic order.

Hierophanies, both public and private, depended on the acute harmony between scientific observations and mathematical knowledge. The precision of the architectural design is apparent in the geometry of the temple, which is founded on the proportions of an integral right triangle. The use of the integral right triangle has been proposed as a significant design element in the layout of building groups at Palenque and Tikal (Harrison 1994:243;Grube 2001:230). The same proportion is repeated in the dimensions of the Tablet of the Sun. As seen in Figures 31, 33, and 37, the geometric proportions of the tablet repeat the proportions of the temple. The patron proportion of the 3:4:5 integral right triangle contains interior angles that in turn relate to the angles of the sun and moon.

While the architecture continues to display alignments that apparently influenced the timing and expression of historical ceremonies, the iconography on the tablet is more difficult to read. The problem is that artists were trying to depict three-dimensional space on a two-dimensional field of vision. For example, the earth band and throne define dual terrestrial planes or horizon lines, while the vertical figures and "war stack" either stand on earth or in the underworld below. How space is depicted in two-dimensional art remains a subject for further investigation.

The multiple views of space depicted in the art point to certain overlapping features in the architectural design. The most complex shifts relate to the constant variations between the azimuths of the building's alignment and the visible light, especially at summer solstice and at nadir. The unique setting of the site is responsible for this multi-dimensional perspective of space. Such a feat would not have been possible on a flat landscape. The mountainous environment of Palenque encouraged, rather than hindered, a profound examination of the horizon, and more profound solutions. Just as Palencano artists stretched the possibilities of multiple spatial references in their art, the builders of the Cross Group were cross-referencing horizon events.

Inherent in the brilliant, but problematic, interplay between the “ideal” and real horizons is the Maya concept of duality. Astronomically, that duality can best be appreciated in the synchronization of the lunar and solar cycles: the 120° degree moonrise every nineteen years and the bi-annual nadir sunrise that mark the transverse axis of the Temple of the Sun; the full moon setting at the solar nadir position on A.D. 26 July 690, the night before Kan B’ahlam’s bloodletting rite; the full moon rising at the zenith passage position on A.D. 10 January 692, when Kan B’ahlam dedicated the sanctuary; and finally the full moon setting at 300°, directly opposite the nadir sunrise position on A.D. 10 January 684, when Kan B’ahlam acceded to the throne**.** (Figure 38 shows the full moon setting at its maximum northern excursion at an azimuth of 299° 40”, less than 6 minutes off the transverse axis of the Temple of the Sun. The maximum excursion, which occurred on 16 December 2005, replicates the lunar hierophany of 10 January 684.)

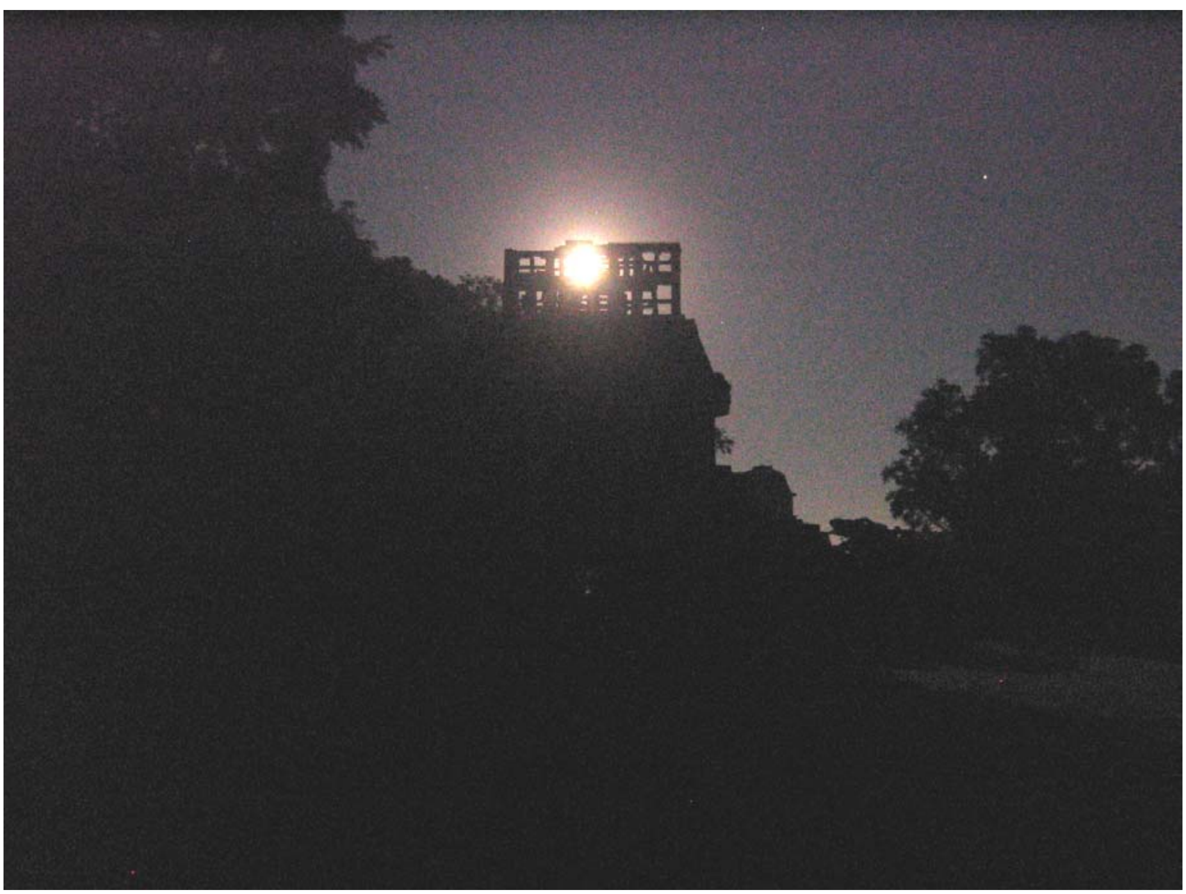

Figure 38 A. Mendez

The importance of nadir passage is now obvious in the alignment of the Temple of the Sun. Although no date is associated with the ceremony depicted on the tablet, it is possible that the central image represents the concept of nadir. At nadir, the morning sun shone directly along the central axis of the temple; that night it illuminated the center of the underworld. This may have been an auspicious moment for communication with the other world through rituals associated with sacrifice, death, and renewal.

Just as the ruler acted as a conduit between worlds, the sun's position at zenith and nadir passages served as a portal through which the moon and outer planets passed. Viewed from the Temple of the Sun, the moon and sun appeared as complementary opposites whose interwoven cycles were the basis for keeping time and giving measure to space.

The alignment between the Temples of the Sun and Cross at zenith passages may lend support to theories that identify the gods of those temples with the twin protagonists of the *Popol Vuh*; that is, GI may represent the older Hero Twin, Hunahpu, the sun, while GIII may represent the younger twin, Xbalanque, the moon. In view of the astronomical complexities described in this article and to be further explored in subsequent studies, we prefer to consider the complementary relationship empirically. The solstices, zenith and nadir passages, and maximum lunar excursions represent peak transitions in the courses of the sun and the moon. Solstices are the extreme extensions of the sun on the horizon whereas zenith and nadir are the vertical extremes. These spatial positions demarcated the boundaries of the ecliptic and defined sky, earth, and underworld. As principal actors in the creation myth recorded in the Cross Group, GI and GIII established those cosmological boundaries. In playing out this paramount role, the divine brothers, like the sun and the moon, behaved as opposite yet complementary principles.

In the text and iconography of the Temple of the Sun, Kan B'ahlam aligned himself with GI and GIII. His affinities were marked by hierophanies in the heavens and on earth. The mathematical and astronomical precision seen in the architecture replicated the "cosmic principles of hierarchical order" that formed the basis of religious thought (Aveni 1986:8). Linking the cosmos to earthly events was a powerful affirmation of the divine in a place and time.

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