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ASTRONOMY AND SOLAR SYMBOLOGY IN THE BASILICA OF SAN MINIATO AL MONTE AND IN THE BAPTISTERY OF SAN GIOVANNI IN FLORENCE

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ABSTRACT

The Basilica of San Miniato al Monte is one of the oldest churches in Florence: its construction began in 1018 by the Bishop Hildebrand who wanted to celebrate St. Minias, the patron Saint of the city. The Basilica is one of the finest examples of Romanesque in Tuscany and presents intriguing astronomical and symbolic allusions that, however, largely remain undiscovered. This article presents the study on the relationship between architecture, religious symbols and astronomical elements of the church of San Miniato al Monte.
In order to identify possible correlations between the position of the Sun and the decorative components of the Basilica that are illuminated by sunlight, we adopted the GNSS methodology and a Total Station. We found that the figures of Christ and the Virgin Mary on the apse mosaic are illuminated by the Sun during the Easter period, and the crypt altar, containing the relics of Saint Minias, is brightened on the day of his martyrdom.
The preeminent symbolic/astronomical element is certainly the marble zodiac, similar to that of the Baptistery, which Capricorn-Cancer axis coincides with the axis of the Basilica. At the summer solstice a fascinating light phenomenon occurs: the sunlight perfectly illuminates the Cancer sign, thereby confirming the astronomical function of the marble zodiac. Furthermore the sunbeams coming from the windows of the right wall of the nave design a path of light on the ideal axis of the Basilica.
The re-discovered astronomical role of this zodiac led us to hypothesize that the marble zodiac of the Baptistery of Florence was originally placed adjacent to the basement of the columns in front of the northern door of the Baptistery. In this way, on summer solstice day the light beam coming from the central opening of the dome, would have illuminated the Cancer sign, similarly to what happens for the zodiac of San Miniato.

KEYWORDS: San Miniato al Monte, Baptistery of Florence, zodiac, Cancer sign, Capricorn sign, summer solstice, winter solstice, gates of heaven.

1. INTRODUCTION

The history of the Basilica of San Miniato al Monte in Florence dates back to the time of the martyrdom of Minias (A.D. 250). The hagiography tells us that Minias, an Armenian prince, was tortured and beheaded in the presence of the Roman Emperor Decius: Minias then picked up his head and walked on the Mons Florentinus, the hill where the present church was built, where he was buried.

The figure of Saint Minias is very important to the Florentine people: in fact, he his venerated as the first Christian martyr of Florence and for some centuries he was considered the only patron saint of the city. Later, both Saint Minias and Saint John were deemed to be the patron saints of the Church of Florence, as mentioned in a certificate of King Berengar of April 25, 899 (Manetti, 2009). It is then not a coincidence that the two most important Romanesque churches of Florence are dedicated to Saint Minias (San Miniato al Monte) and to Saint John (the Baptistery). Documents of donations from various emperors, between VIII and X century, including Charlemagne, confirms the existence of a place of worship dedicated to Saint Minias, perhaps a Paleochristian Basilica, in the site of the resting place of the martyr (Loris Pegna, 1974). However, as reported by Moreni, in the following decades "*o per l'incursione dei barbari, o per l'antichità, o per altro accidente era ridotta in pessimo stato*" [1] (Moreni, 1794): Bishop Hildebrand then proposed to build a large Basilica dedicated to St. Minias. After Pope Benedict VIII and Emperor Henry II had approved the project, on April 27, 1018, Hildebrand issued a document, the *charta ordinationis* (Pratesi, 1995), which declared the foundation of the Basilica of San Miniato and the subsequent beginning of the construction works, which took almost two centuries to complete. Francesco Gurrieri (Gurrieri, 1988) identified the four construction phases as follows:

- 1018-1068: the wall of the crypt in the apse area;
- 1070-1093: the walls of the side aisles and choir, the first order of the façade;
- 1128-1150: the Colonnade, the wall of the nave, the second order of the façade;
- 1175-1207: the pediment and the floor of the nave.

As reported by the date engraved on the inlaid marble floor near the main entrance of the Basilica, construction works were finalized in 1207, although in later centuries the church underwent renovation. Because of its harmonic architectural proportions, the Basilica of San Miniato al Monte is considered one of the finest examples of Florentine Romanesque. This church is also characterized by an intriguing religious and solar symbolism and complex astronomical allusions that are related to architectural and decorative details, which make this monument unique in its genre. Although the solar/astronomical symbolism of San Miniato al Monte has fascinated numerous scholars in recent decades (Gettings, 1987; Incerti, 2011; Shrimplin, 2011), many aspects still remain undisclosed. In this article we present the study on the relationship between architecture, religious symbols and astronomical features of the church of San Miniato al Monte.

2. SOLAR SYMBOLISM OF THE BASILICA OF SAN MINIATO

The relationship between architecture and astronomy is almost as old as mankind itself. In his treatise "De Architectura" (15 B.C. circa) Vitruvius highlighted the importance of astronomy in art and architecture. During the medieval period, architects widely employed astronomical orientations and sunlight in the construction of religious buildings in order to link the humanity to the celestial realm (Shrimplin, 2011). The illumination of architectural and decorative details by the sunlight evidenced the sacred space circumscribed by the church, the house of God, which is the point of contact between Earth and Heaven (Hani, 1996).

Because little is known about the actual astronomical features of the Basilica of San Miniato al Monte, we investigated the possible correlation between architecture and religious symbols of San Miniato with the path of the Sun.

2.1. Astronomical survey

In order to perform a rigorous investigation to verify solar and astronomical correlation within the Basilica of San Miniato, we carried out precise measurements with Total Station Theodolite on the square in front of the façade. In particular, using static GNSS methodology[2], we determined the coordinates of a point in front of the entrance of the Basilica. We then measured a traverse within the Basilica itself in order to detect the coordinates and heights of architectural and decorative elements of symbolic and interest, such as:

- the single-lancet windows on the right wall of the main nave and the apse windows;
- details of Christ, the Virgin Mary and Saint Minias depicted in the apse mosaic;

[1] "Perhaps because of barbarian incursions, or aging, or any other accident [the church] was almost destroyed".

[2] GNSS is the global navigation satellite system based on the US system GPS, the Russian system GLONASS and the European system GALILEO.

- the Cancer and Capricorn signs on the inlaid marble zodiac;
- the edges of the base plate of the columns of the main nave, from which we determined the azimuth of the Basilica's axis, which is 131.5°.

Furthermore, we determined the position of the altar of the crypt with respect to the central single-lancet-window[3] of the crypt to shed light on possible solar-symbolic connections.

2.2. *The altar of the crypt*

During the construction of the crypt, Bishop Hildebrand decided to place the relics of Saint Minias at the centre of the altar, which became the founding and distinctive element of the entire Basilica for its symbolic importance. It is therefore crucial to verify a possible connection between the position of the altar with the sunlight, like it has been observed in other churches (Spinazzè, 2015).

Using a laser distance-meter, we measured the inclination of the sunbeams that would filter through the central window of the crypt[4] with respect to the altar: we observed that the central part of the altar would be illuminated when the Sun is 17° to 24° high over the horizon (see Figure 1) and it is on the axis of the Basilica. From such data we computed the declination values of the Sun and the days of illumination of the altar (Table I).

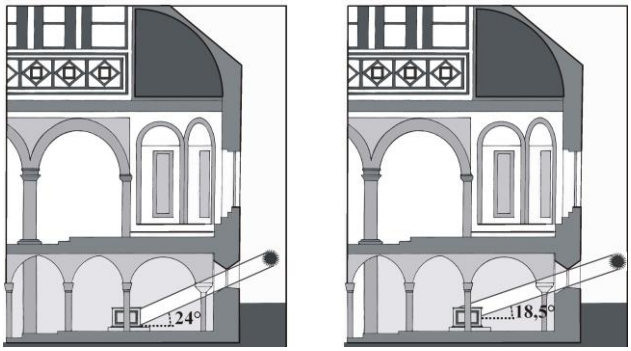

Figure 1. The illumination of the crypt altar containing the relics of Saint Minias.

Table I. The illumination of the crypt altar.

azimuth	height	declination	enlightening days
131.5°	17° to 24°	-9° 02' to -14° 52'	Oct 17 to Nov 3

The period of the illumination of the relics of Saint Minias, at the centre of the crypt altar, comprises the day of martyrdom of Minias, October 25. It should be pointed out, however, that in the XI century, when Hildebrand ordered the construction of the Basilica, the Julian calendar was in use. That this calendar was slightly inaccurate, as it considered the year to be about 12 minutes longer: therefore, the day of October 25 in the first half of the XI century corresponded in actuality to 30-31 October. On these dates, at about 8.50 am, the Sun is about 18°-18.5° high on the Basilica's axis and the sunbeams would brighten the centre of the altar. This event would confirm the hypothesis that the Basilica was conceived with astronomical implications, as the sunlight celebrates Saint Minias illuminating its relics on the day of his martyrdom.

2.3. *The apse and the orientation of the apse windows*

The apse, in Christian architecture, represents the spiritual fulcrum of a church the very place where man meets God. The apse of San Miniato presents many religious symbols and elements of solar and astronomic significance: in fact, the hemispherical semi-dome symbolizes the vault of heaven, and the mosaic, completed in the XIII century, depicts Christ the Pantocrator together with the Virgin Mary and Saint Minias. In addition to the symbolic significance, the apse also presents interesting astronomical implications: in fact, the first window on the left is directed towards the sunrise at the summer solstice (azimuth 56.5°), while the second is oriented towards the sunrise on the day of the equinox (azimuth 90°): the altar and the apse would be flooded[5] with light in these two particular astronomical moments.

2.4. *Solar and lunar illumination of the apse mosaic*

The apse mosaic presents other intriguing connections with the position of the Sun. In particular, the sunbeams filtering through the two windows to the right of the presbytery of the main nave (labelled I and II in Figure 2 a and b) illuminate the figures of Christ and the Virgin Mary in the late afternoon of the months of March and September, especially near the equinoxes (Table II, III and IV).

Because of the inaccuracy of the Julian calendar, in the XIII century the period of illumination of the figures of Christ and the Virgin Mary was delayed of about 6-7 days with respect to the actual Sun position. The illumination of the apse mosaic is particularly evident during the Easter period, when the two sunbeams precisely illuminate the figures of Christ and the Virgin Mary. The figure of Christ the Pantocrator flooded with light reminds us of the resurrection and the victory of light over darkness.

[3] From now on we will refer to "single-lancet-window" as "window".

[4] It should be remembered that while the two lateral windows are closed with glass windows, the central window of the crypt is closed with a slab of alabaster.

[5] The sunlight does not illuminate the altar because the apse windows are closed with alabaster slabs.

Finally, it is worthy of note the wonderful light effect already observed by Gettings (Gettings, 1987). During the period 11-25 April and from 19 August to 2 September (Table V) the sunbeams coming from the first window to the right of the presbytery shines first under the right foot of Christ (see *Figure 2c*) and then moves toward the left foot, where the light disappear. This fascinating light effect may symbolize the greatness of Christ the Pantocrator as the sovereign of all things, including the Sun.

Carrying out additional calculations concerning the position of the Moon in the sky during the year, we observed that, when the Moon is in the phase between the first quarter and the full moon, the moonlight would illuminate the feet of the Virgin Mary through the first window to the right of the presbytery (indicated by I in *Figure 2a*). This would happen when the Moon is 12° to 15° high over the horizon and with azimuth 249°-253°. Such event reminds us of the verse 12.1 in the Book of Revelations: "and there appeared a great wonder in heaven: a woman clothed with the Sun, with the Moon under her feet and on her head a crown with twelve stars". Indeed, for about four months of the year (Table III and IV) the Virgin Mary depicted in the mosaic, who has a crown of stars, represented by the nacres set around her head, is illuminated by the sunlight just before the sunset (see *Figure 2d*). In addition, she would have "the Moon under her feet", which is the lunar light one day a month.

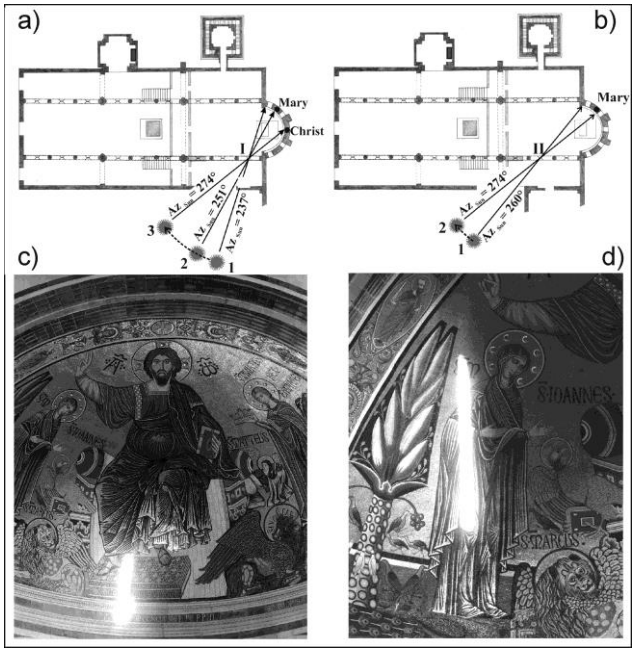

Figure 2. a), b) The sunlight filtering through the windows I and II on the right wall illuminate the apse (see text). c) The sunlight filtering through the window I shines under the foot of Christ the Pantocrator. d) For about four months a year the Virgin Mary is illuminated just before the sunset.

Although this would allow the hypothesis of a cosmic symbology associated to the Virgin Mary, the illumination of Mary's feet by the moonbeams seems more a coincidence that a planned effect, since the day of illumination varies from month to month.

Table II. Illumination of Christ by window I is from Mar. 26 to Apr. 5 - from Sep. 8 to 18

Days of illumination	Solar hour	Azimuth	height	decl.
March 26 and September 18	from 17.12 to 17.30	from 263.1° to 266.2°	from 10° to 6.8°	2°
April 5 and September 8	from 16.55 to 17.12	from 263° to 266°	from 15.9° to 12.9°	6°

Table III. Illumination of Mary by window I is from Feb. 21 to Mar. 15 – from Sep. 30 to Oct. 23

Days of illumination	Solar hour	Azimuth	height	decl.
February 21 and October 23	from 16.46 to 17.08	from 249° to 252.9°	from 5.3° to 1.9°	-11°
March 15 and September 30	from 16.22 to 16.38	from 250.8° to 253.8°	from 15.5° to 13°	-2.5°

Table IV. Illumination of Mary by window II is from Mar. 21 to Apr. 16 - from Aug. 28 to Sep. 23

Days of illumination	Solar hour	Azimuth	Height	decl.
March 21 and September 23	from 17.45 to 17.52	from 267.5° to 269°	from 3° to 1.5°	0°
April 16 and August 28	from 17.12 to 17.42	from 269° to 274.1°	from 15.6° to 10.2°	10°

Table V. The Sun under the foot of Christ by window I from Apr. 11 to 25 - from Aug. 19 to Sep. 2

Days of illumination	Solar hour	Azimuth	Height	decl.
April 11 and September 2	from 17.02 to 17.17	from 265.8° to 268.5°	from 16° to 13.2°	8°
April 25 and August 19	from 16.40 to 16.55	from 266° to 268.6°	from 23.4° to 20.5°	13°

2.5. *The marble zodiac of San Miniato al Monte*

To our knowledge, no historical document somehow reports of a possible astronomical meaning of the marble zodiac of San Miniato al Monte (made in 1207), while it is known that the zodiac of the Baptistery was built with astronomical implications. Even Leonardo Ximenes, in his treatise on astronomical culture in Tuscany (Ximenes, 1757), did not mention the zodiac of San Miniato, while he examined in depth the astronomical significance of zodiac of the Baptistery. Therefore, the zodiac of San Miniato appears to be a mere, though marvellous, decorative element full of cosmic symbology. Only recently, Manetti has hypothesized an astronomical function of this zodiac (Manetti, 2009).

The two zodiacs look remarkably alike: indeed, they might have been designed and manufactured in the same workshop. Both zodiacs are enclosed in a circle which is inscribed in a square and the centre of both is decorated with an inlaid sun. In medieval symbology the circle represented the cosmos and the celestial sphere (the "vault of heaven") whilst the square represented the earth with the implied reference to the four elements (earth, air, water and fire) and the four cardinal points (Incerti, 2011).

The Basilica of San Miniato is oriented to the south-east. We observed that the signs of the two solstices on the marble zodiac lie on the ideal axis of the Basilica: entering the church we can see the Capricorn sign first and then Cancer sign. Therefore, the Gemini sign, and not the Taurus (Gettings, 1987), is oriented to the East (see Figure 3b). This observation led us to hypothesize that the zodiac might have an astronomical significance linked to the solstices.

Although Manetti (Manetti, 2009) suggests that the Capricorn sign would be illuminated early in the morning of the winter solstice, we determined that the sunlight that would filter through the central window of the apse (now closed with a slab of alabaster), would actually light up the bottom of the central door of the Church at 8.25 hours (solar time) of the winter solstice, when the Sun is about 7° high and has an azimuth of 131.5° (see Figure 3a). Therefore, anyone who entered the church prior to the XV Century[6] early in the morning on winter solstice day would have been bathed in sunlight, and walking towards the presbytery would have found the inlaid marble Capricorn sign, which is associated of Christ's birth that in the first centuries of Christianity coincided with the winter solstice.

We then wondered if there was a more consistent link with the summer solstice. Because this astronomical event is linked with the Cancer sign, we speculated that the inlaid Cancer of the zodiac might be illuminated on the summer solstice day.

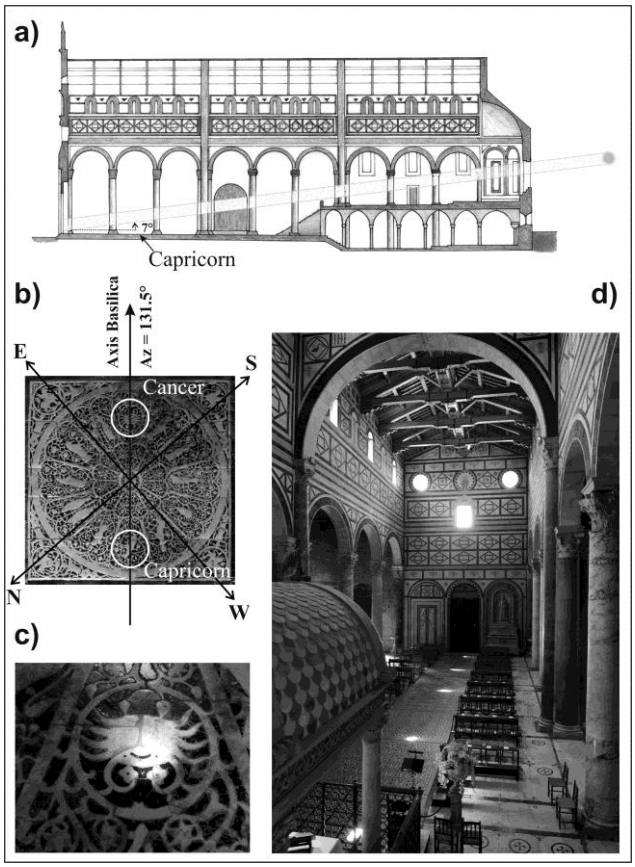

Figure 3. a) The sunbeams filtering through the central window of the apse central window would illuminate the bottom of the central door on winter solstice day. b) The orientation of the marble zodiac. c) The Cancer sign is illuminated by the sunlight at 12.36 (solar time) on summer solstice day. d) The sunlight shines from the windows of the right wall of the main nave (entering the church) to create a path of light.

The rigorous survey and the precise calculation we performed led us to identify the third window of the right wall of the main nave (as we enter the church) as the possible solstice Gnomon from which the sunbeams can illuminate the sign of Cancer. Indeed, on June 21st near to solar noon, at 12:36 of solar time (13:53 civil time), the first sunbeam that filters in the Church through the window mentioned above, illuminates the Cancer sign (Bartolini, 2013). Within 2-3 minutes the light spot, initially only a few centimetres wide, expands progressively and become as big as the inlaid crab shape (see Figure 3c). The precision with which the sunbeam illuminates the Cancer sign does not leave any doubt: the zodiac has been carefully positioned to indicate the summer solstice. This phenomenon is observable for a very

[6] In the first half of the XV century Michelozzo built the Chapel of the Crucifix, so the sunlight could no longer reach the main door.

short period of time, about four days before and after the summer solstice. Finally, it may be argued that the marble zodiac also assumes a religious function: in fact the illumination of the Cancer sign at summer solstice announces the feast of St. John, the patron Saint of Florence, on June 24. With the rediscovery of the astronomical function of the zodiac of San Miniato, we can add this solstice sundial (the oldest sundial still working!) to the list of the other eight ancient monumental sundials built in Florence.

In order to complete the astronomical study of marble zodiac, we computed the apparent position that the Sun had in early XIII century, when the pavement was completed. In fact, because of the precession of Earth's rotation axis, back in the early centuries of the second millennium AD the Sun appeared higher in the sky: in particular, at noon on the summer solstice the Sun was about 6' of arc higher. Based on the height of the window, we computed that the disc of light illuminating the Cancer sign would be shifted about 2 cm towards the window, an acceptable accuracy for the purpose that could have the marble zodiac.

The illumination of the Cancer sign is a wonderful event that is part of a fascinating light phenomenon occurring at the summer solstice. In fact, at about 12.30 (solar time) the first spot of light appears just under the Chapel of Crucifix; three minutes later another spot of light shines at the centre of the nave floor about six meters away from the preceding one and subsequently a third spot illuminates the Cancer sign. Then, two other spots of light shine every three minutes from one another on the ideal axis of the Basilica, giving the impression that a path of light is taking us towards the main door (see Figure 3d).

3. THE MARBLE ZODIAC OF THE BAPTISTERY OF SAN GIOVANNI

The marble zodiac of San Miniato and the zodiac of the Baptistery of San Giovanni are very similar. Although the one of the Baptistery is more elegant and refined, the two zodiacs might have very well been created in the same workshop. The zodiac of the Baptistery is positioned near the Gates of Paradise, the eastern doors in front of the Duomo, and has a precise cardinal orientation: the sign of Aries is oriented to the East, the Libra to the West, the Capricorn to the North and the Cancer to the South.

The astronomical function of the zodiac of the Baptistery is confirmed by Giovanni Villani, a Florentine diplomat and chronicler of the XIV century who, in a passage of his "Nuova Cronica" ("New Chronicles", one of the first histories of Florence) writes: "And we find, from ancient records, that the figure of the sun carved in mosaic, which says: "En giro torte sol ciclos, et rotor igne," was done by astronomy, and when the sun enters into the sign of Cancer, it shines at mid-day on that place through the opening above, where is the turret"[7].

This clearly suggests that the "sun carved in mosaic" is the centre of the astronomical function of the marble zodiac, because at the summer solstice ("when the sun enters into the sign of Cancer"), the inlaid marble sun "shines at mid-day". In fact, it should be point out that the dome of the Baptistery was originally open, similarly to the Pantheon in Rome, and the sunlight could filter from there.

However, according to Villani, the opening on the dome was closed with a lantern (called "turret" by Rose E. Selfe) built in 1150: therefore, on June 21st ("when the sun enters into the sign of Cancer") of the XIV century the sunlight could no longer filter through the opening to illuminate the inlaid sun on the marble zodiac (Degl'Innocenti, 1994). The zodiac is placed on the floor in proximity of the eastern doors, but according to our calculations, even if the lantern was removed, the sunlight would not illuminate the zodiac because this is not on the meridian of the Baptistery. In another edition of Villani's Cronica of 1729, the phrase reported above is slightly different: "... and when the sun enters into the sign of Cancer, and not in other periods of the year, shines at mid-day the *spera* on that place through the opening above, where is the lantern".

This version provides us additional information, but at the same time adds questions. Certainly, it is more accurate than the previous one because it tells us that the sunlight filtering through the opening on the dome illuminated the floor only in the period of the summer solstice, but it is not clear about the meaning of the word *spera*. This term may refer to an opening, a sphere or a mirror: depending on the meaning we assign to *spera* we have three different interpretations that lead to us very different assumptions.

If we consider *spera* as referred to an opening, according to our calculations when the sun is at noon on the summer solstice the light filtering from the dome would illuminate the north gate of the Baptistery (*Figure 4a*), but not the zodiac.

If the word *spera* refers to a sphere (Degl'Innocenti, 1994), we might assume the presence of a sphere at the centre of the opening on the dome. Accordingly, when the sunlight filtering through the opening casted its shadow on the inlaid sun symbol in the centre of the zodiac it indicated that was the summer solstice day.

7 Villani's Chronicle being selections from the first nine books of the Croniche Fiorentine of Giovanni Villani translated by Rose E. Selfe and edited by Philip H. Wicksteed M.A. London Archibald Constable & CO. LTD. 1906 second edition carefully revised.

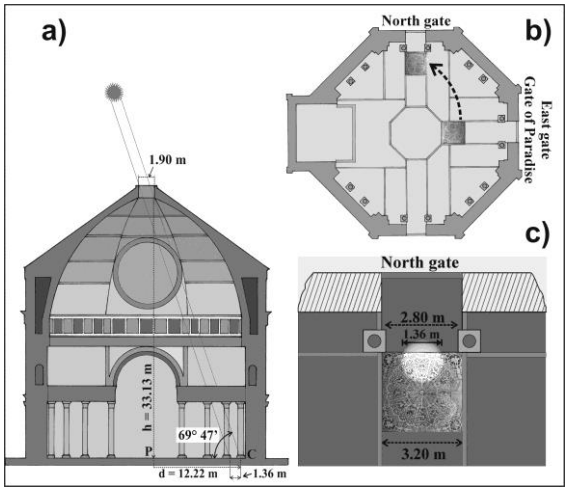

Figure 4. a) Section of the Baptistery of San Giovanni with the solstitial light filtering through the opening. b) Plan of the Baptistery with the hypothesized original position of the marble zodiac. c) In this simulation, the Cancer sign on the marble zodiac is illuminated at noon on the summer solstice in the first half of the XII century.

Filippo Camerota speculates that *spera* could actually stand for mirror. Therefore, he hypothesizes, if a mirror was positioned at the centre of the opening on the dome, the sunlight could have been reflected on the marble carpet despite the occlusion caused by the lantern. In this way, the sunlight would have illuminated the inlaid Sun symbol on the summer solstice day.

It is worthy of note that the floor of the Baptistery underwent renovation in 1351 (Strozzi, 1892) and Camerota himself reports that some works were made in 1200 (Camerota, 2007). At that time, as reported by Villani, the lantern on the dome already existed, and that perhaps the sunlight could no longer filter through the opening. This may suggest that the marble zodiac had been moved from its original position. Based on this information and consistently with our observation on the zodiac of the Basilica of San Miniato al Monte, we propose a new hypothesis about the astronomical role of the marble zodiac of the Baptistery. Although the target of the solstitial sunlight has always been considered the inlaid Sun symbol, Villani, might actually have referred to the Cancer sign. Therefore, considering the Cancer sign and not the Sun symbol on the zodiac as the target of the solstitial light, we can speculate about the original position of the marble zodiac. If in fact the Cancer sign was conceived to be illuminated on the summer solstice day - or to be obscured by a sphere - then the squared zodiac might have been positioned with one side along the base of the columns, rotated of 180° and then with the Cancer sign oriented to the Northern Gate (*Figure 4b*).

In order to verify this hypothesis, we measured the height of the opening on the dome and the horizontal distance from the supposed position of the marble zodiac. The results that we obtained confirm the possibility that the zodiac was "done for astronomy" and, in particular, that it was positioned with the Cancer sign to the north in order to indicate the summer solstice and the upcoming feast of Saint John, the patron Saint of Florence. In *Figure 4. a)* we simulate the position of the light disk deriving from the sunbeams filtering through the opening on the dome at noon on the summer solstice of the year 1100: the sunlight illuminates the cancer sign.

Our hypothesis would be supported by the rediscovered astronomical function of the marble zodiac of the Basilica of San Miniato al Monte, which is clearly positioned with a solstitial orientation, as demonstrated by the illumination of the Cancer sign on the summer solstice day.

4. CONCLUSION

In this article we illustrate that several architectural and decorative elements of the Basilica of San Miniato al Monte are linked with the path of the sun and specific astronomical events.

The unusual orientation of the church, to the south-east instead of east, like many Romanesque churches, might have three reasons associated with three distinct astronomical moments:

- to celebrate Saint Minias, as the sun illuminates its relics on the day of his martyrdom, October 25;
- to enlight the devotees: on the winter solstice day the sunlight would have illuminated the bottom of the central door and whoever entered the church;
- it has also been proposed a connection with the northern lunistice (Incerti, 2011).

Perhaps, the most plausible hypothesis is the first one, because the crypt where the relics of Saint Minias are preserved was the first portion of the church to be built. Indeed, we computed that the sunbeams filtering through the central window of the crypt (now closed with a slab of alabaster) would illuminate the relics of Saint Minias, at the centre of the altar, in a period of the year that comprises the day of martyrdom of Minias, October 25. In addition to that, it is known that the orientation of other Romanesque churches is related with the death day of the Saint to whom the church is dedicated.

The second hypothesis may be acceptable, especially if we consider that there are two paths of light on the axis of the Basilica towards the main entrance: one for the winter solstice and the other for the summer solstice.

Because of the anomalous orientation of the axis of the Basilica, Incerti hypothesizes a connection with the northern lunistice, because the Moon azi-

muth is 311° (Incerti, 2011). However, this eventuality appears to be less probable, because a lunar orientation of the church would subvert the actual criteria applied in the Middle Ages.

Many symbolic and decorative elements of the apse are connected with the solar illumination. In fact, the sunbeams filtering through the two windows to the right of the presbytery illuminate the figures of Christ and the Virgin Mary depicted in the mosaic in the late afternoon near the equinoxes. Furthermore, during the periods of mid-April and late August the sunlight shines first under the right foot of Christ and then moves toward the left foot. This fascinating light effect may symbolize the greatness of Christ the Pantocrator as the king of all things.

The preeminent symbolic/astronomical element is the marble zodiac. Although the zodiac of San Miniato al Monte was thought to be a simple decorative element, we attested its actual astronomical function. In fact, we observed that on summer solstice day the sunbeams illuminate the inlaid Cancer sign which is the only, among the twelve signs on the marble, to be inserted in a circle, like it was a target for the sunlight. The illumination of the Cancer sign is part of a light phenomenon that occurs at the summer solstice: in fact the sunbeams filtering through the windows on the right wall of the main nave create a path of light on the ideal axis of the Basilica, which takes us towards the main door. These events confirms that the position of the windows have been carefully calculated with respect to the centre of the main nave in relation to the summer solstice. Philosophers like Plato, Porphyry and Macrobius linked these two astronomical events to the descent of souls from the stars of the celestial sphere to Earth and the ascent of souls of the virtuous to the heaven.

Our findings confirm that the Basilica of San Miniato al Monte was projected and built with astronomical significances, with a particular focus on the solstices. Furthermore, the rediscovery of the astronomical function of the zodiac of San Miniato allows us to hypothesize that the zodiac of the Baptistery, was conceived to indicate the summer solstice by way of the illumination of the Cancer sign by the sunlight. Accordingly, we speculate that the zodiac has been moved from its original position, perhaps in 1351, because, in line with our calculations, today the zodiac of the Baptistery would not be illuminated by the solstitial sunlight, even if the lantern on the dome was removed.

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