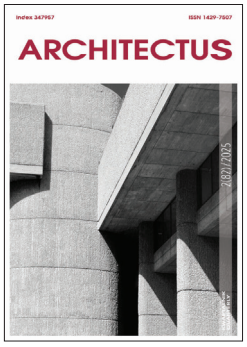

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A hidden history in the Burgos Cathedral (Spain): virtual reconstruction of the lighting effects generated in the 15th century Chapel of the Conception or Saint Anne

Abstract

Special lighting effects, popularly known as "the miracles of light", take place at the solstices or equinoxes in three medieval churches located in the Spanish city of Burgos and its surroundings. These hierophanies can be observed in religious buildings whose design and construction were carried out by medieval architects associated with what is known as "taller de los Colonia". The underlying assumption of the research is that the same effects were also generated in the Conception Chapel of Burgos Cathedral and were visible until the Chapel of Santa Tecla was built in the 18th century. This paper virtually reproduces these lighting effects using solar simulation software tools and analyses the methods used to generate them.

Key words: lighting effects, workshop of Juan de Colonia, Burgos cathedral, conception chapel, solar simulation software

Introduction

In the late Gothic phase of the construction of the Burgos Cathedral, the figure of Juan de Colonia (c. 1410–c. 1479) stands out above all. This *magister operis* architect of German origin revolutionized the architectural panorama of Burgos in the mid-15th century. According to the traditional historiographical account, he arrived in Burgos at the beginning of 1440 with the help of Bishop Alonso de Cartagena, who brought him back from the Council of Basel with the task of finishing the cathedral towers with two openwork spires following Central European models.

In the main church in Burgos he built the spires of the towers (1442–1458) and a spectacular dome in dialogue with them (c. 1470). This last construction collapsed in 1539, being replaced by the Renaissance dome that we see today. He is also credited with the chapel of the Visitation (c. 1440–1442) in the same cathedral, the parapet of the triforium (from 1450) and the design and beginning of the chapel of the Conception (c. 1477). He also designed and began the works on the Cartuja de Miraflores and was possibly involved in the renovation of the churches of the monasteries of San Juan and San Pedro de Cardeña and in the construction of the church of San Nicolás de Bari in Burgos.

Juan de Colonia made a decisive contribution to renewing a local architecture anchored in the Gothic tradition of the 13th and 14th centuries. His main contributions were improvements in construction technology, innovations in vault systems and the introduction of a new spatial model based on spaciousness, openness and the elevation of the height of buildings (Menéndez-González 2022).

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Fig.1. The Cathedral of Burgos, Spain.
View of the entrance to the Chapel of the Conception of the Virgin
(photo by J.A. Gárate-Alcalde)

Il. 1. Katedra w Burgos, Hiszpania.
Wnętrze – widok na wejście do kaplicy Poczęcia NMP
(fot. J.A. Gárate-Alcalde)

Two of the six children of the German architect, Simón and Diego, were also *magister operis* architects, and the former achieved a relevance comparable to that of his father. Simón de Colonia (c. 1450–1511) is a key figure in late Gothic architecture in Burgos. His production is characterized by the introduction of innovative ribbed-openwork vaults and by the great prominence of sculptural decoration. He trained in his father's workshop, succeeding his father as master builder of the cathedral from 1481 onwards and taking charge of completing the projects that the latter had begun before his death, such as the chapel of the Conception in the Cathedral of Burgos or the church of the Cartuja de Miraflores (Justi 1913).

Between 1482 and 1494 he built what is considered his great masterpiece, the Chapel of the Purification or the Constable. In it he executed a spectacular openwork vault that would be widely imitated in Burgos architecture well into the 16th century.

In the city of Burgos he also built the Casa del Cordón (the urban palace of the Constables of Castile), and worked on the churches of San Nicolás and San Gil. Outside Burgos, the cloister of the monastery of San Salvador de Oña and the façades of the churches of Santa María de Aranda de Duero and the convent of San Pablo in Valladolid stand out (Payo-Hernanz, Matesanz del Barrio 2015).

The architects of the so-called Colonia workshop are particularly known for their ability to incorporate surprising lighting effects into their works (Sánchez-Ameijeiras 2001). The phenomenology of light was of great importance in the medieval Christian imagination. In this sense, the Colonia workshop has bequeathed to posterity the hierophanies visible in the churches of San Juan de Ortega, Santa María de Miraflores and San Nicolás de Bari, all of them located in the city of Burgos and/or its surroundings. These lighting effects, popularly known as "miracles of light", always occur on specific dates in the liturgical-astronomical calendar.

The chapel of the Conception of the Virgin of the cathedral of Burgos

The premise of this research is that, in addition to the three churches mentioned, these same lighting effects were produced in the Chapel of the Conception of the Virgin (Fig. 1) of the cathedral of Burgos until the chapel of Santa Tecla was built in the 1st half of the 18th century, attached to its southwest side, and, as a consequence, the source of natural light that caused them was blinded, an oculus located in the highest part of the southwest wall, just in front of the main altarpiece of the chapel (Figs. 2a, b, 3)[1].

As we have demonstrated using solar simulation software, before the oculus was blinded in the 18th century, a beam of sunlight penetrated through it during the spring and autumn equinoxes and travelled diagonally across the main altarpiece, from left to right and from bottom to top, briefly illuminating its main theme, the embrace of Saint Joachim and Saint Anne, the parents of the Virgin Mary, before the Golden Gate of Jerusalem.

The Chapel of the Conception of the Virgin, located in the Gospel nave of the cathedral, next to the north arm of the transept, began to be built in 1477 by order of Luis de Acuña y Osorio, Bishop of Burgos between 1456 and 1495, with the intention of converting it into his funeral chapel, just as his predecessor, Alonso de Cartagena, had done a few years earlier in the south arm of the transept with the Chapel of the Visitation (Martínez-Sanz 1866).

Although there is no documentary evidence to confirm this, the construction of the chapel of the Conception has traditionally been linked to Juan de Colonia, who is said to have been in charge of the works until his death. Later, his son Simón, after redesigning the initial project was responsible for completing it (Menéndez-González 2009).

The chapel has an irregular rectangular floor plan covered by two sections of complex tierceron vaults. The construction had to adapt to the peculiarities of a space that was highly conditioned by the presence of the buttresses of the side nave and the northern arm of the cathedral transept, as well as by the layout of the current Fernán González Street. The chapel opens onto the gospel nave through two large pointed arches, which in turn are closed with two railings from the period. The space was illuminated through three openings to the outside, two pointed windows to the northwest and southeast and the aforementioned oculus to the southwest.

But this chapel is best known for its extraordinary altarpiece, the work of Gil de Siloe (sculpture) and Diego de la Cruz (polychromies), who executed it between 1483 and 1486 (Fig. 4). It is a very novel altarpiece for Castile at the time, both for its structure and its iconography. It features the monumental Tree of Jesse, or genealogical tree of Christ, located in the central street, whose branches ascend the altarpiece surrounding the large rectangle that frames the main theme, the Embrace before the Golden

[1] To build the chapel of Santa Tecla, four small medieval chapels that faced the gospel nave of the cathedral and the parish church of Santiago de la Fuente, which was located behind them, were demolished.

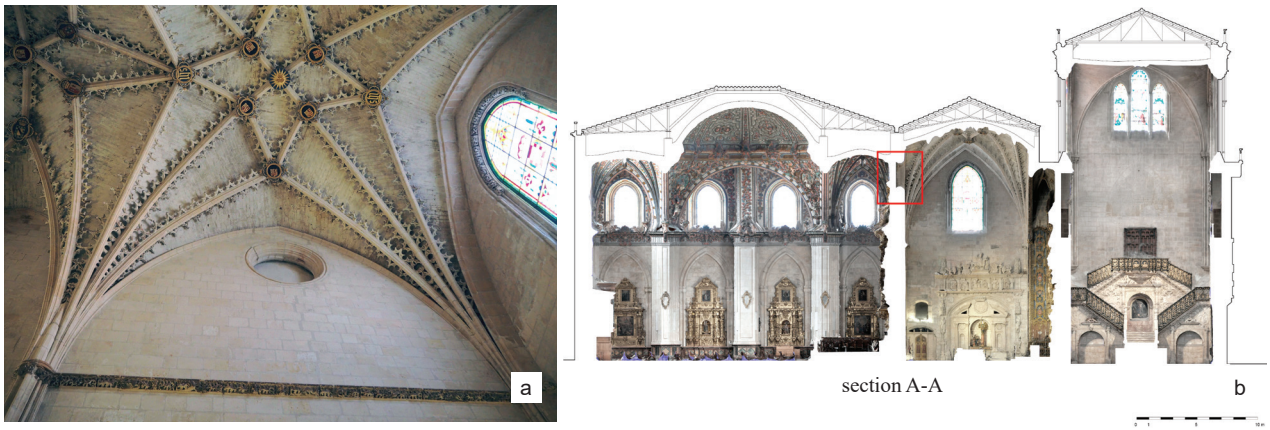

Fig. 2. The cathedral of Burgos, Spain:
a) image of the blinded oculus of the Chapel of the Concepcion as it appears today,
b) section showing the Chapel of the Conception (15th century) between the Chapel of Santa Tecla (18th century) and the northern arm of the cathedral transept (13th century) with the position of the blinded oculus framed in red (elaborated by V. Jørgensen)

Il. 2. Katedra w Burgos, Hiszpania:
a) zaślepiony okulus kaplicy Poczęcia NMP, stan obecny,
b) przekrój ukazujący kaplicę Poczęcia NMP (XV w.) pomiędzy kaplicą pw. św. Tekli (XVIII w.) a północnym ramieniem transeptu katedry (XIII w.) z pozycją zaślepionego okulusu obramowanego na czerwono (oprac. V. Jørgensen)

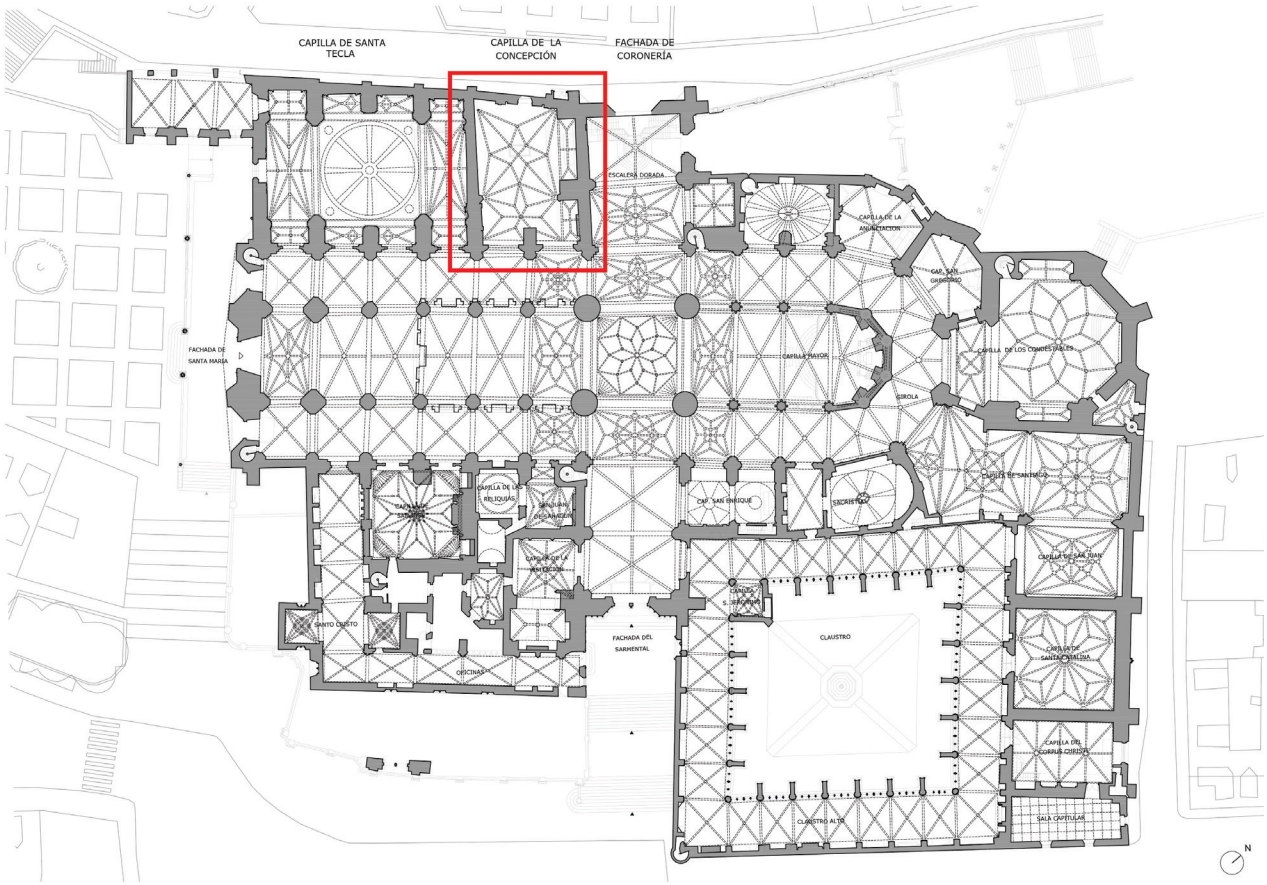

Fig. 3. The cathedral of Burgos, Spain.
Plan – the Chapel of the Concepcion framed in red (elaborated by V. Jørgensen)

Il. 3. Katedra w Burgos, Hiszpania.
Rzut – kaplica Poczęcia NMP zaznaczona na czerwono (oprac. V. Jørgensen)

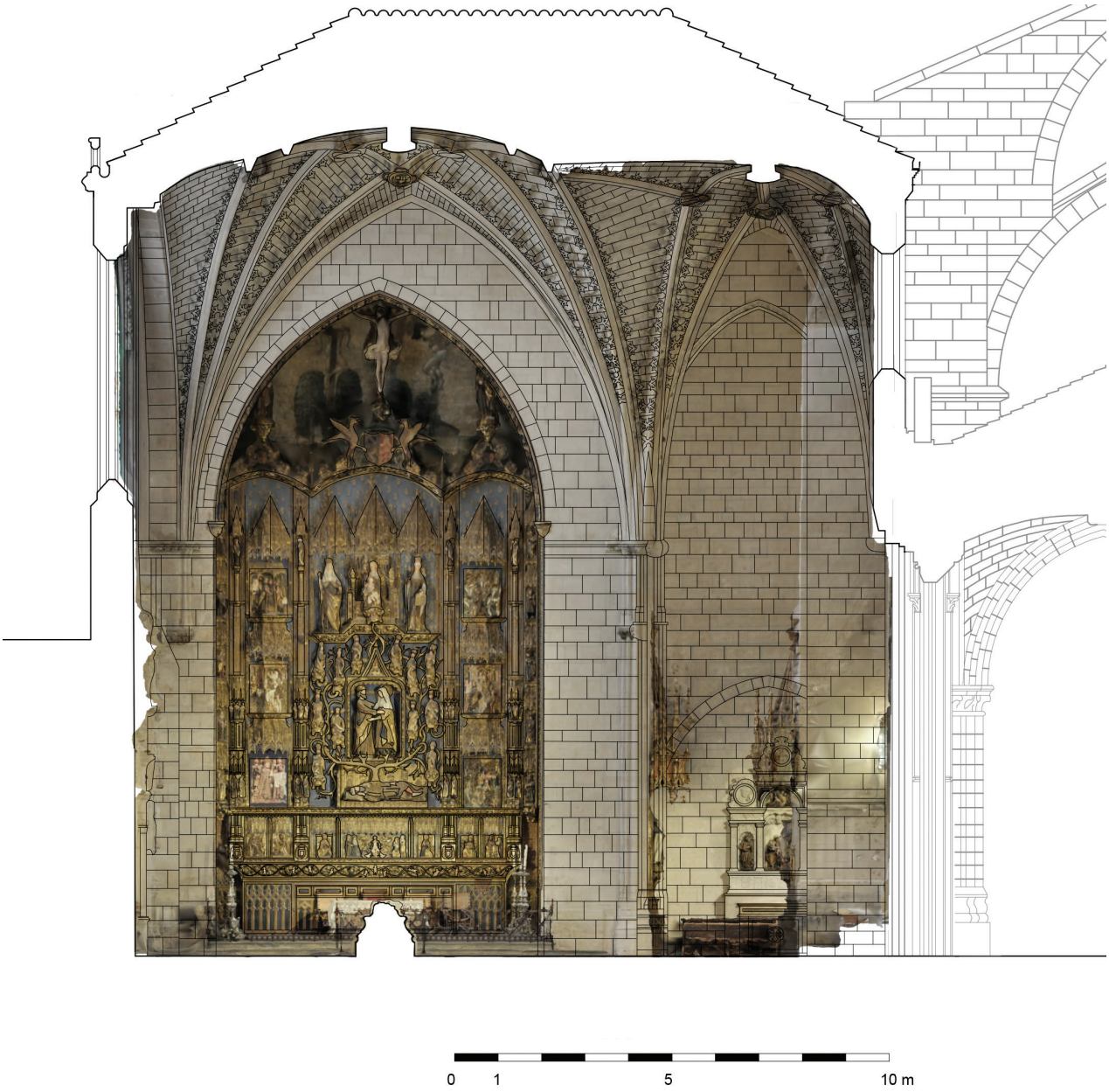

Fig. 4. The cathedral of Burgos, Spain. Image of the northeast side of the Chapel of the Conception in which the altarpiece by Gil de Siloe can be seen with the sculptural group of the embrace of St. Joachim and St. Anne located in its centre (elaborated by V. Jørgensen)

Il. 4. Katedra w Burgos, Hiszpania. Północno-wschodnia ściana kaplicy Poczęcia NMP z ołtarzem autorstwa Gila de Siloe z rzeźbiarską grupą obejmujących się św. Joachima i św. Anny przy bramie Jerozolimy umieszczoną w jego centrum (oprac. V. Jørgensen)

Gate of Jerusalem. This unusual theme, which comes from the apocryphal gospels, is a reference to the immaculate condition of the Virgin Mary, a mystery that was debated in those final years of the 15th century and to which Bishop Luis de Acuña dedicated the Chapel (Yarza-Luaces 2000, pp. 42, 43 and 80, 81).

Generation of lighting effects in medieval Christian temples

The lighting effects that occur on certain days of the liturgical-astronomical calendar in religious buildings in the Burgos area are not an isolated event.

Numerous cases of surprising lighting effects have been documented in medieval European ecclesiastical architecture, which can be concluded to be no coincidence. Well-known similar examples include those that occur at the summer solstice in the Abbey of Chiaravalle della Colomba (1135), Abbey of Pomposa (1026), Basilica of Santa Maria Magdalena in Vezelay (1140), in the Baptistery of Parma (1196) (Incerti 2013, 2015) and at the equinoxes in the pulpit of Strasbourg Cathedral (1493) (Becker 2021).

These lighting effects always occur on special dates in the astronomical calendar of pagan origin. This can be explained by the fact that the Christian calendar contains a cycle of four festivals that became the solstice and equinox

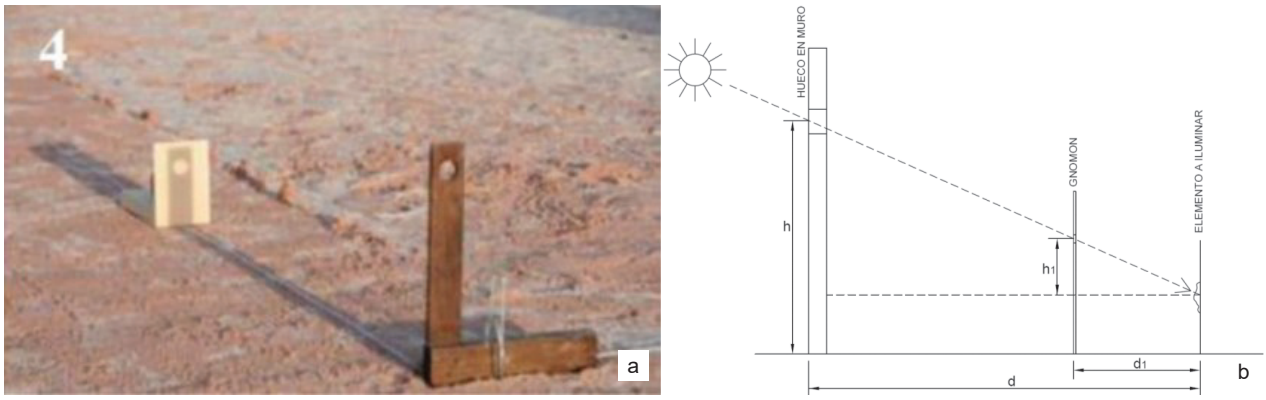

Fig. 5. Determining the position of openings using the gnomon: a) determination of the height of the opening using Thales' theorem (source: Vilas-Estevez, Varela and Gonzalez-Garcia 2018), b) diagram (elaborated by E. Uson)

Il. 5. Określenie pozycji kąta padania promieni za pomocą gnomonu: a) określenie wysokości z użyciem twierdzenia Talesa i wykorzystaniem otworów gnomonu (źródło: Vilas-Estevez, Varela i Gonzalez-Garcia 2018), b) diagram (oprac. E. Uson)

dates with theological and cosmological symbolism. These four days, located next to the astronomical solstices and equinoxes, celebrate the Annunciation on March 25th, the birth of Christ on December 25th (Christmas), and the conception and birth of Saint John on December 24th and June 24th. In his sermons, Saint Augustine makes clear the contrast between the pagan cult of the visible Sun and the cult of Jesus Christ, the Christian creator of the sun, *the sun of justice* (McCluskey 1993).

The identification of light with the sacred in medieval art and architecture reinforces the thesis that these phenomena are not the result of chance, but were intentionally generated in order to emphasize the story represented in certain sculptural groups inside these buildings.

Now, in order to attribute an astronomical intention to these light phenomena that occur in some medieval churches, it is important to carefully assess the knowledge that these architects possessed:

To generate these effects, three types of problems must be solved in the design and construction of the building.

– An astronomical problem: the alignment of the building with visible points on the horizon that coincide with the rising or setting of a celestial body (sun, planets, stars or moon) on significant dates of the year.

– A geometric problem: the position of the openings and their relationship to the floor plan and elevation of the building so that the entry of sunlight at specific times illuminates certain sculptural groups inside.

– An ornamental problem: the design and position of the sculptural elements so that a certain image would be reached by the ray of light on a specific day of the astronomical calendar (Incerti 2015).

Geometry and astronomy in the training of medieval architects

Although we do not know exactly all the geometric canons that were used to generate these lighting effects, it is clear that some medieval architects had the necessary knowledge of astronomy and geometry to do so. Their training, acquired first in monastic and cathedral environments and later in universities, was based on two blocks of disciplines, the *trivium* (grammar, rhetoric and dialectics) and the *quadrivium* (arithmetic, music, geometry and astronomy), which, in turn, came from the "seven liberal arts" taught in the classical world and were transmitted to the medieval world through successive translations and reproductions of ancient texts.

The knowledge of geometry of the architects of the "Colonia workshop" is evident in their buildings, especially in their vaulting systems. The vaults they built in some chapels of the Burgos Cathedral are based on complex geometric figures that are impossible to design without a minimum knowledge of Euclidean geometry. This can be seen above all in the star-shaped and openwork vault of the chapel of the Purification or of the Constable (De la fuente-Martínez, García-Velasco and Gordillo-Alonso 2021).

Geometrical tools and procedures supposedly used by medieval architects to produce lighting effects

In order to determine the trajectory of the ray of sunlight with simple geometric operations and to transfer the results to the full-scale layout on the ground, medieval architects had tools such as the gnomon, the astrolabe, the Vitruvian analemma and the Ptolemaic analemma. These tools allowed them to determine the azimuth of sunrise on any day of the year and the celestial coordinates throughout the hours. With these instruments, knowledge of Euclidean geometry and the help of scale models or, much more simply, very basic and simplified graphics, using Thales' theorem and laying out two similar right triangles, they could measure any height simply by using a gnomon[2] (Fig. 5a, b).

[2] The height of the opening in the exterior wall of the building is obtained by applying the formula $h=dxh1/d1$, whit $d1$ being the distance between the gnomon and the shadow cast, $h1$ the height of the perforation of the gnomon and d the distance between the shadow cast and the wall in which the opening is to be made. This method may have originated with Fibonacci, whose treatise *De Practica Geometria* (1220) was studied in medieval schools (Hughes 2008).

Thus, a good architect could choose the exact position of those openings that, placed at topologically significant points, would guarantee surprising lighting effects.

A recent study on the lighting effects produced in the cathedral of Santiago de Compostela demonstrates the validity of the method that could have been used by medieval architects to create them (Vilas-Estévez, Varela and González-García 2018). Using the gnomon, they possibly solved it empirically with some ease. However, although the issue of determining the position of openings and ornamental elements to be illuminated can be resolved theoretically with relatively simple graphic calculations, achieving the illumination of a certain sculptural group inside the temples on a certain day of the year and at a certain time of day is a much more complex issue.

With a gnomon, the position of the sun and its trajectory can be determined, and once the position of the image of the interior of the temple to be illuminated has been established, the position of the opening through which the ray of sunlight will penetrate on the dates on which the lighting effect is to be produced can also be established. To do this, it will be necessary to calculate, in addition to the altitude and azimuth, the basic data of the opening: its position from the ground and its dimensions. A second possibility would be to establish the position and size of the opening and move the decorative element until the correct position is found. And all this, as is usual in architectural construction, can be verified empirically during the layout phase of the building in its final location.

In relation to this methodology, it is important to draw attention to a peculiarity of the Chapel of the Conception in Burgos Cathedral. If we look at the oculus on the southwest wall, it is centred with respect to the arch of the main vault. However, the large niche that houses the altarpiece of the chapel appears clearly off-centre with respect to the arch of the vault. This asymmetry could be related to the elaboration of the lighting effect that was produced in the chapel.

Virtual reconstruction of the lighting effect of the Chapel of the Conception of the Virgin of Burgos Cathedral

To virtually recreate the lighting effects that occurred in the chapel of the Conception of the Virgin of the Cathedral of Burgos, an original methodology has been used, already used in other previous investigations (Uson-Guardiola 2023), which is based on the use of solar simulation software tools and whose phases are described below.

1. Survey of the chapel with 3D digital scanning and subsequent restoration carried out from the point cloud with the SketchUp 2023 Extension Trimble Scan Essentials program (Fig. 6) (SketchUp. 2024).

2. Positioning of the chapel with marking of the azimuth of the main axis of Burgos Cathedral and determination of its geographical coordinates (Fig. 7). Obtaining from Google Earth the geographical coordinates of Burgos Cathedral (42°20′26″N 3°42′16″W) and the orientation of the main axis of the Chapel of the Concepcion (221° measured from the north in a clockwise direction) (Fig. 7).

3. Creation of the EPW (Energy Plus Weather File) with the Meteonorm 8 software once the exact position of the chapel is known and the topographic horizon is determined. In this case, it is obtained that at the equinoxes. The polar coordinates at the time of sunrise would be an azimuth of 92° and a solar altitude of 2° (Meteonorm 8. 2024).

4. Preparation of the stereographic solar diagram made with Andrew Marsh's application (a first approximation) (Fig. 8).

5. To determine the days and times when the images on the altarpiece would have been illuminated by the sun's rays penetrating the interior space through the currently closed oculus, we used Andrew Marsh's Sun-Path application on the three-dimensional survey of the chapel (Andrew Marsh Software 2025).

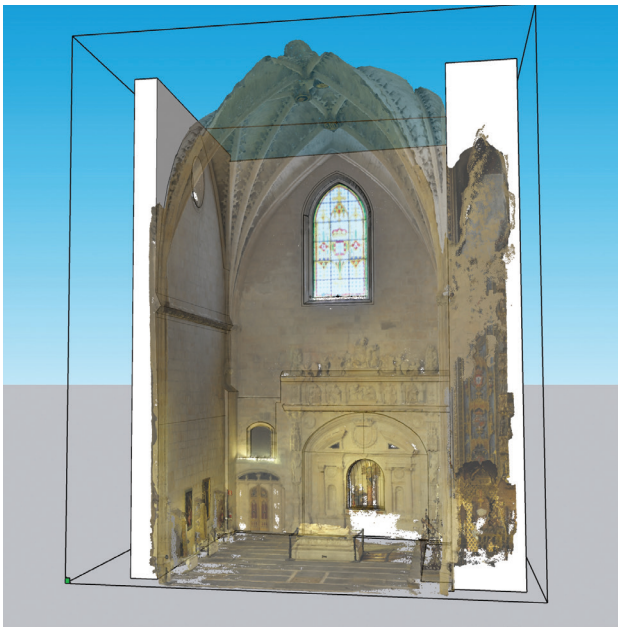

Fig. 6. Three-dimensional survey of the Chapel of the Conception from digital scanning (elaborated by E. Espuny Camacho)

Il. 6. Trójwymiarowy obraz kaplicy Poczęcia NMP utworzony na podstawie skanowania cyfrowego (oprac. E. Espuny Camacho)

Fig. 7. Location of the Chapel of the Conception from Google Earth (elaborated by E. Espuny Camacho, source: Google)

Il. 7. Lokalizacja kaplicy Poczęcia NMP – widok z Google Earth (oprac. E. Espuny Camacho, źródło: Google)

This allows us to determine the azimuth and height of the sun for the period studied. This gives us a first approximation of the day and time when the altarpiece receives sunlight. In this case, it turns out that the sculptural group of the embrace of St. Joachim and St. Anne was illuminated by solar radiation and with varying intensities for a few days around the spring equinox (the Christian feast of the Annunciation) and the autumn equinox, and that the light beam was projected with maximum intensity and more focused on the sculptural group. This it occurred specifically at the spring equinox on March 20 at 14:34 solar time (when the sun has an azimuth of 223.50° and a height of 38.19°).

6. To simulate the different times of the year when the sun passed through the oculus and to check the result obtained with the Sun-Path application, the 3D model, made from the point cloud obtained by digitally scanning the Chapel and the climate file,were imported into the *Archiwizard 2020* software (Graitec Archiwizard Software 2025). By placing a solar receiver on the sculptural group of the embrace of Saints Joachim and Anne, when simulating annual direct solar radiation, the result is also that it would receive solar radiation for a few days in the 2nd half of March and a few days in the 2nd half of September coinciding with the equinoxes (Fig. 9).

The spring equinox currently takes place in the northern hemisphere between March 20 and 21 and the autumn equinox between September 22 and 23.

7. Simulation of the light effect generated by the sun over the course of an hour (Fig. 10a) and determination of the moment when the solar radiation would be cantered on the main image of the altarpiece (Fig. 10b).

The sculpture of the embrace of Saint Joachim and Saint Anne would receive maximum radiation on March 20 between 15:00 and 16:00 UTC (winter time in the EU), which corresponds to 14:00 and 15:00 solar time. Likewise, on September 24 it would receive maximum radiation between 16:00 and 17:00 UTC (summer time in the EU), which corresponds to 14:00 and 15:00 solar time.

8. Simulation of the light effect generated by the sun on the three-dimensional image obtained from the 3D digital scan (Fig. 11a, b).

Conclusions

We believe that the lighting effects produced in medieval religious buildings designed by the architects of the Colonia workshop in the city of Burgos and its surroundings are not the result of chance, but the result of a preconceived plan, and good proof of this is the case of the chapel of the Conception of the Virgin of the Cathedral of Burgos, the subject of this research. It has been possible to verify through the use of a solar simulation methodology with *software tools* that Simón de Colonia intentionally established where the light source should be and where and how the main sculptural element of the altarpiece should be located and designed to receive spectacular lighting on certain dates of the astronomical calendar. This fact, that is, the supposed intentionality of the lighting phenomenon, would imply the dependence of the configuration of the altarpiece on the desired effect and, logically, a great rapport between architect and sculptor[3]. It is therefore worth asking whether the search for this type of effect could be be-

[3] Let us remember that Simón de Colonia and Gil de Siloe were regular collaborators. In a short space of time they worked together in the chapel of the Conception, in the Cartuja de Miraflores and in the chapel of the Purification or of the Constable. In addition, both, together with the painter Diego de la Cruz, polychromies of the main altarpieces of these constructions, belonged to the same brotherhood, that of Santiago and San Andrés of the parish of Santiago de la Fuente. On the latter (Ibáñez Pérez, Payo Hernanz 2008).

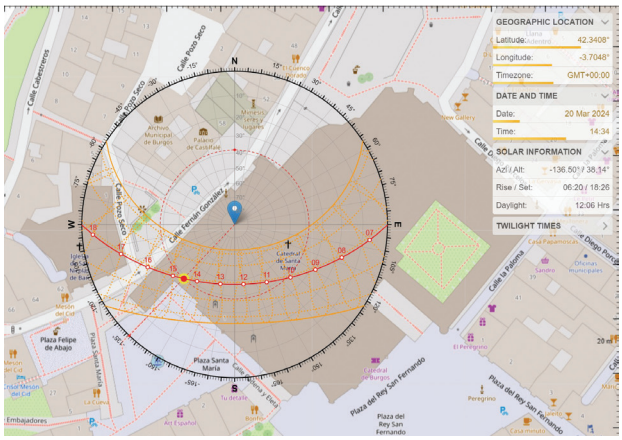

Fig. 8. Stereographic diagram made with Andrew Marsh's application at the spring equinox
(elaborated by E. Espuny Camacho, source: Andrew Marsh Software)

Il. 8. Schemat stereograficzny prezentujący obiekt w czasie równonocy wiosennej wykonany przy użyciu aplikacji Andrew Marsha
(oprac. E. Espuny Camacho, źródło: Andrew Marsh Software)

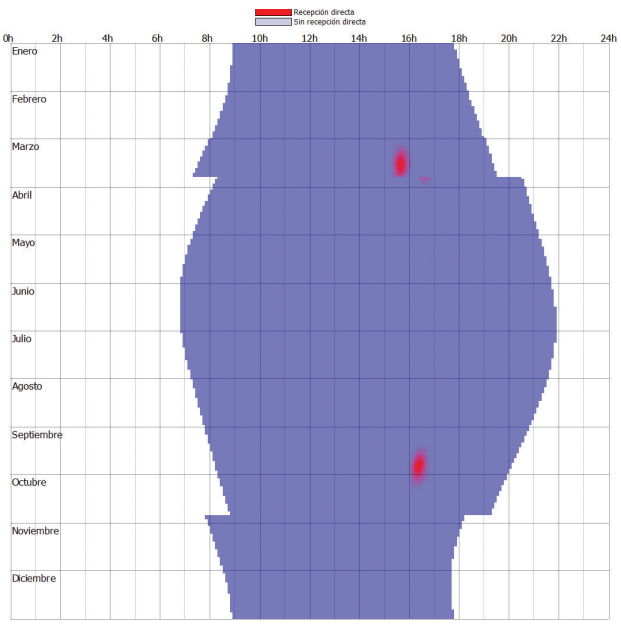

Fig. 9. Mapping of the annual direct solar reception of the sculptural group of the Embrace of St. Joachim and St. Anne
(elaborated by E. Espuny Camacho)

Il. 9. Mapowanie rocznego bezpośredniego nasłonecznienia grupy rzeźbiarskiej obejmujących św. Joachima i św. Anny
(oprac. E. Espuny Camacho)

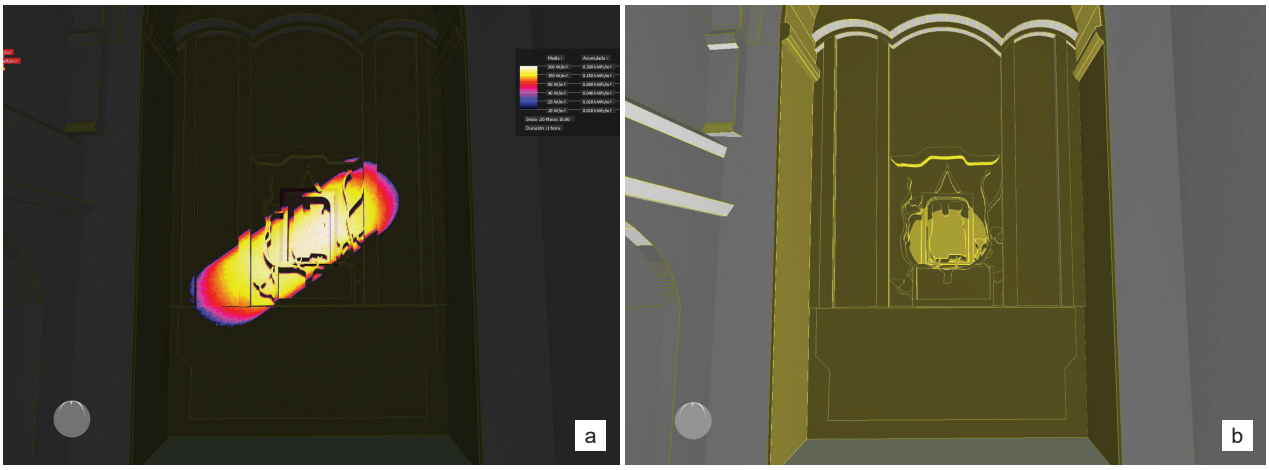

Fig. 10. Simulation of the path of solar radiation on the sculptural group
of the Embrace of St. Joachim and St. Anne:
a) (from left to right and from bottom to top) between 14:00 and 15:00. on March 20 and September 24,
b) simulation of the exact moment, 14:34 on March 20,
when the image of the embrace would be fully illuminated
(elaborated by E. Espuny Camacho, source: image obtained with the simulation carried out with the Graitec Archiwizard Software)

Il. 10. Symulacja ścieżki światła słonecznego na rzeźbiarskiej grupie
obejmujących się św. Joachima i św. Anny:
a) (od lewej do prawej i od dołu do góry) między godziną 14:00 a 15:00 w dniach 20 marca i 24 września,
b) symulacja dokładnego momentu, 14:34 w dniu 20 marca,
kiedy widok objęcia się rodziców Maryi byłby w pełni oświetlony
(oprac. E. Espuny Camacho, źródło: obraz uzyskany za pomocą symulacji przeprowadzonej przy użyciu oprogramowania Graitec Archiwizard)

Fig. 11. Simulation of the lighting effect on the 3D restoration of the Chapel of the Conception obtained from the digital scan:
a) side view with oculus,
b) altar view with the highlighted group of St. Joachim and St. Anne embracing – the moment of Conception of St. Mary
(elaborated by E. Espuny Camacho, source: Graitec Archiwizar Software)

Il. 11. Symulacja oświetlenia w modelu 3D kaplicy Poczęcia NMP opracowana na podstawie skanowania cyfrowego:
a) widok boczny z okulusem,
b) widok ołtarza z oświetloną grupą obejmujących się św. Joachima i św. Anny – momentu Poczęcia Maryi
(oprac. E. Espuny Camacho, źródło: Graitec Archiwizar Software)

hind the original compositions of some of the altarpieces on which Gil de Siloe and Simón de Colonia collaborated (the chapel of the Concepción and the church of the Cartuja de Miraflores).

To understand why the architects of the Colonia workshop created lighting effects in their religious buildings, we must take into account the importance that the "theology of light" had in the medieval Christian imagination. In medieval architecture and art, light takes on a transcendent meaning; it is used as a symbolic reference to the sacred, as a manifestation or expression of God (Nieto-Alcaide 1989). This idea, this identification of light with the sacred, is based on the numerous references existing in the gospels and will be strongly felt throughout the Middle Ages. Thus, the antagonism between light and darkness will be an ideal vehicle for the expression of religious mysteries and from the earliest times it was used to inspire devotion by contrasting the "heavenly light" with the darkness of hell.

Regarding the symbolic meaning of the lighting effect analysed, this is closely related to the meaning of the scene represented in the central element of the altarpiece. When it came to finding an image that would effectively convey the idea of the immaculate conception of Mary, the elegant theme of the embrace of her parents, Saint Joachim and Saint Anne, in front of the Golden Gate of Jerusalem, would end up prevailing in the medieval Hispanic world (Vilas-Estévez, Varela and González-García 2018).

It should be noted that the representation of divine intervention in miraculous conceptions by means of a beam of sunlight penetrating an interior space through an opening (normally an oculus) is quite common in artistic representations of the period in question. This appears, for example, in two Annunciations on the backs of the choir stalls of Burgos Cathedral itself (Fig. 12)[4].

As for the impact that the contemplation of the lighting effect would cause, if we manage to abstract ourselves from the excessive current electric lighting, very far from the lighting designed by the creators of the chapel, we can imagine the great expressiveness that would be achieved. The darkness inning in this cathedral space at dusk would intensify the beam of light that penetrated through the oculus. This, in its route through the altarpiece, would make the polychrome and gilding of the illuminated sculptural elements shine, making them stand out powerfully from the rest. In turn, the colouring of the vault, with the plinth probably painted in azure and the ribs and fringes that sprout from them gilded would further increase the visual impact of the phenomenon. And all this, surely, coinciding with the office of vespers, which is known to have been celebrated in the chapel since its foundation[5].

Fig. 12. Detail of a backrest of the choir stalls of Burgos Cathedral in which the sun's ray can be seen penetrating a room through an oculus and reaching the figure of the Virgin at the moment of the Annunciation (photo by J.A. Gárate Alcalde)

Il. 12. Fragment oparcia stalli chóru katedry w Burgos, na którym widać promień słońca wpadający do pomieszczenia przez okulus i docierający do postaci Matki Boskiej w chwili Zwiastowania (fot. J.A. Gárate Alcalde)

Translated by Malcolm Hayes

[4] The choir stalls of Burgos Cathedral were made by Felipe Bigarny and his workshop in the 1st third of the 16th century.

[5] Historical Archive of the Burgos Cathedral, ACA 52, fols. 11v–18.

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Streszczenie

Ukryta historia katedry w Burgos (Hiszpania): wirtualna rekonstrukcja efektów świetlnych wygenerowanych w XV-wiecznej kaplicy Poczęcia NMP lub św. Anny

Specjalne efekty świetlne, popularnie zwane „cudami światła", pojawiają się podczas przesileń lub równonocy w trzech średniowiecznych kościołach zlokalizowanych w hiszpańskim mieście Burgos i jego okolicach. Te hierofanie można zaobserwować w budynkach sakralnych, których projekt i konstrukcja zostały wykonane przez średniowiecznych architektów związanych z tak zwanym „taller de los Colonia". Założeniem leżącym u podstaw badań jest to, że te same efekty zostały wygenerowane również w kaplicy Poczęcia NMP w katedrze w Burgos i były widoczne do czasu zbudowania kaplicy św. Tekli w XVIII w. W niniejszym artykule wirtualnie odtworzono te efekty świetlne przy użyciu oprogramowania do symulacji oświetlenia słonecznego i zanalizowano metody ich generowania.

Słowa kluczowe: efekty świetlne, warsztat Juana de Colonia, katedra w Burgos, kaplica Poczęcia NMP, oprogramowanie do symulacji oświetlenia słonecznego