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PREVIOUS TRADITION? COINCIDENCE? DESIGN? HOW IT WAS POSSIBLE TO CREATE THE ILLUMINATION EFFECTS AT THE CATHEDRAL OF SAINT JAMES (GALICIA, SPAIN)?

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ABSTRACT

In a previous work based on different oral traditions collected at the beginning of the XX Century we verified that inside the cathedral of Saint James different illumination effects take place over the figure of Saint James located at the main altar, in particular at important dates related with Christianity and the own Saint. However, despite the fact that illumination effects occur and therefore suggest that they were sought and not a coincidence, we should ask how the builders of the cathedral could "create" them during the baroque reform of the cathedral. This is precisely the objective of this paper, to show how they could create this project of illumination or how they readapt a previous tradition that took place in the Romanesque building.

To do that we count with different primary sources such as texts, drawings, ethnographic resources and cross-references. On a more methodological level, this is a study that deals with very different methods from diverse disciplines, such as archaeoastronomy or cultural astronomy, archaeology, architecture and ethnography. It is important to take into account, that the cathedral is an architectural project where the builders thought and planned a structure suitable for people in which the Christian imaginary had to be present, and therefore this illumination effects would play a very important role. However, such project was a living organism that evolved through time by the different reforms. Such reforms not only involved changes in the architectural styles but also in the concepts behind such styles. In particular it is important for our study how the concept and use of light within the temples changed along these centuries and how the light phenomenology was incorporated with a different meaning in the subsequent reforms. Finally, we recreate the possible method that the builders used based on architectural treatises.

KEYWORDS: Church Orientation; Illumination effects; Baroque Architecture; Light use.

1.
1. INTRODUCTION

In a previous article (Vilas-Estévez and González-García, 2016) we pointed out the existence of a series of light phenomena in the cathedral of Saint James (Galicia) that are related to the festivities of the Apostle Santiago (table 1). It should be noted that, at the time of publication of that work, we had been unable to contrast the illumination of the Santiago Apostle statue for the dates of May 23rd and July 25th (practically complementary in the solar cycle) due to the repair and conservation works of the cathedral of Saint James. But we can now confirm that this illumination takes place through one of the windows of the dome (Figures 1 and 2).

Moreover, in our previous article, we commented that, fortunately, we knew about these illumination effects, thanks to the works by Ramón Otero Pedrayo in 1926 and Celestino Sánchez Rivera in 1945. However, we recently discovered that a collection by Jose Maria Castroviejo in 1960 (p 85) contained the last recollection of the illumination events.

Therefore, once all these illumination effects were verified, we asked ourselves whether this illumination was due to a mere, although fascinating and incredible coincidence later noticed by the local population and highlighted by the abovementioned authors, or whether on the other hand the architect had a master plan for which we could find references.

In addition, after the resolution of this question lies the falsifiable demonstration of the paradigm proposed by Juan Antonio Belmonte (2006) *Testis unus testis nullus*, since at the moment the multiple illumination of the Apostle Santiago supposes a *unicum.*

Table 1 Saint James Cathedral (latitude 42 º 30′). The columns show the structure measured, the azimuth (A) and horizon altitude (h) measured with a precision compass (error estimated to be ½°), and the calculated astronomical declination (δ). The last column gives the date for the illumination event (Vilas-Estévez and González-García, 2016)

Structure	A	h	δ	Date
Rosette Inner part down	262	7½	−0¾	18th Mar/25th Sep
Rosette Inner part up	262	9	0¼	21st Mar/22nd Sep
Rosette Upper part down	262	10	1	23rd Mar/21st Sep
Rosette Upper part up	262	11½	2	25th Mar/18th Sep
Window at the dome	262	39	20¼	21st May/22nd Jul
Window at the transept	220	13	−23¼	15th Dec/30th Dec

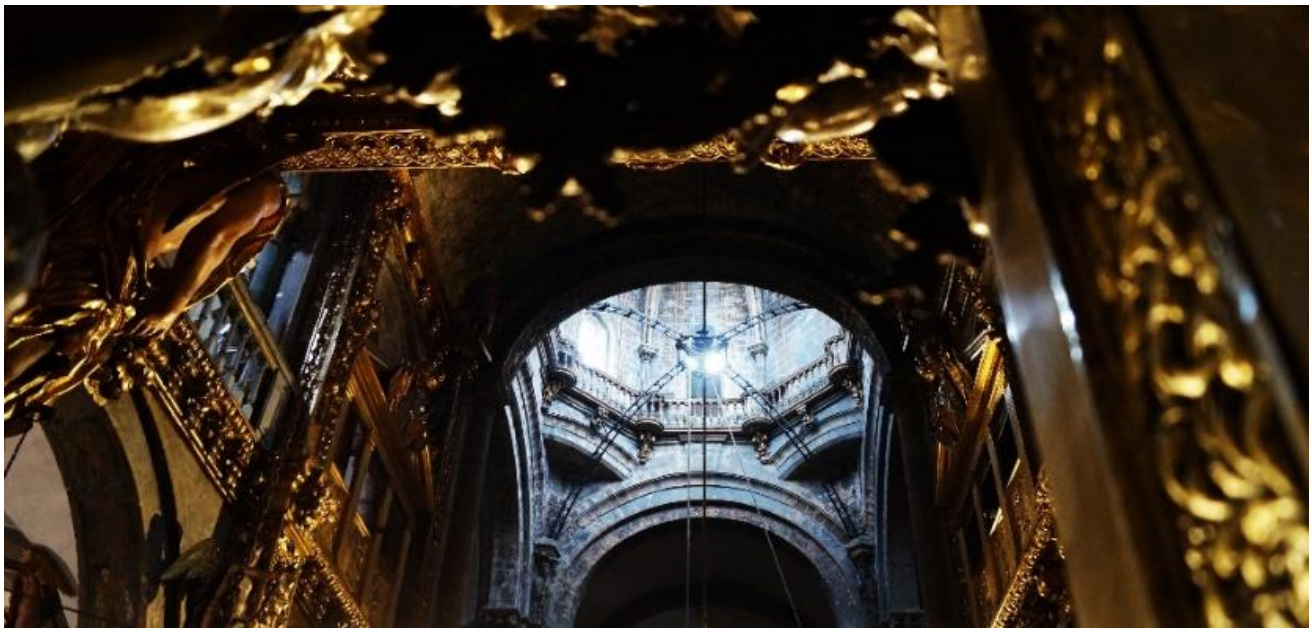

Figure 1. Photograph that was taken on May 23 (2017) from inside the apostle's chapel, where Saint James´s statue is located. Note the sunlight entering through the west window at the dome. ©Benito Vilas-Estévez

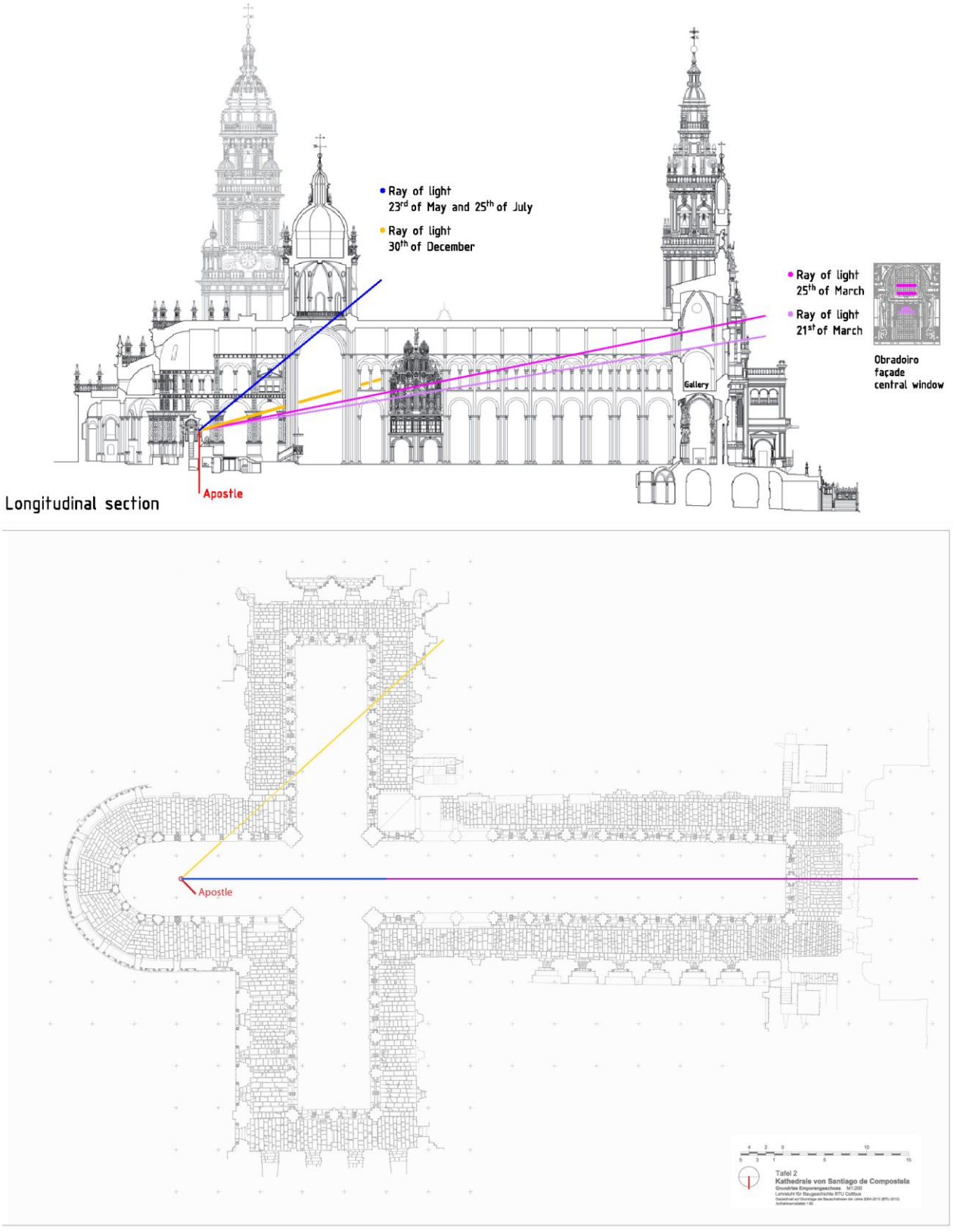

Figure 2 Longitudinal section and floor plan of the main nave of the Cathedral of Saint James. The figure indicates the entrance holes that allow the light rays to illuminate the statue of the Santiago Apostle on various days. Violet line: 21st and 25th of March. Blue Line: 23rd of May and 25th of July. Yellow line: 30th December (Upper image, Franco Taboada, J.A; Tarrío Carrodeaguas, S.B and Departamento de Representación e Teoría Arquitectónica da Universidade da Coruña ETSAC, 1999w. Lower image, Münchmeyer, A 2016). The red stroke indicates the location of the apostle statue.

2. THE BAROQUE DESIGN AND THE LIGHT

Our previous article was based entirely on the empirical verification of the tradition, presenting as our framework the Baroque remodelling of the cathedral where one of its functions was to provide light to the interior of the cathedral, since this building was at that time a darkened Romanesque monument because of the different reforms and constructions that had altered its illumination through time. Several windows had been walled, whereas many other beams of light were set back. What had qualified as direct illumination was converted into twilight (Rosende Valdés, 1996, p 530).

After all, as José Ramón Alonso Pereira (2005) indicated, natural light and Baroque architecture are two inseparable concepts, because if baroque architectural reality has a determining factor, it is that the use of light is a design element that can constitute a drastic change of style. Light was used in this case as a mechanism to lead the gaze of the faithful towards the main altar (where the statue of Apostle Santiago is located in Saint James cathedral) without major distraction. It is worth recalling the instructions of 1577, dictated by the Council of Trent, that were mentioned by Cardinal Carlos Borromeo in his book "*Instructiones Fabricae*" (1985), in which he specified how windows should be adapted to the liturgy.

The Baroque architectural projects therefore study light, in its physical and symbolic component and establish where light sources should be and how the architectural elements that make up the luminous devices must be designed.

Thus, in order to ascertain the intentionality and intent of the promotors of the reform during the XVII and XVIII centuries we consulted the historical documents of the baroque remodeling of the cathedral that are kept at the archives of the cathedral and were not taken into account in our previous work. We analysed the documentation, and although we could not find the exact sentence that mentioned these phenomena, we found a highly interesting document which indirectly points to the fact that the illumination of the saint is an intentional act as light is studied in detail at the cathedral, where some experts were elected to carry out this task.

In such document, dated in 1661 (which is translated in López Ferreiro, 1907), D. Juan de Mondragón denounced that the works conducted at the cathedral removed the light from the Chapel of La Piedad or Santa Cruz. This is a small chapel located in the ambulatory to the back of the main altar. The complaint was solved in 1663 when the cathedral chapter instructed four experts (Melchor de Velasco, Bartolome Gutierrez, Juan de Bar and Fray Juan Plata) to analyse the light in the chapel from the windows and examine how the new works were going to affect the solar illumination. We are therefore aware that, during the construction of the baroque reform of the cathedral, a number of experts were responsible for analysing how solar light was distributed through the windows and how it affected different elements of the cathedral.

At a European level, we can see that light was important in baroque design, both for religious purposes as well as for other purposes as it stands out in the letter that Leibniz sent to the Count of Sinzendorf in 1716. In this letter, the philosopher insisted on Kepler's idea of using the great churches for an astronomical and ecclesiastical design, drawing in them a meridian from a gnomon to be able to determine with great precision the place of the sun, and consequently to accurately show the time of Easter and other mobile feasts according to the regulations of the Council of Nicaea. In this same letter, Leibniz stated that Cassini (Cassini, 1695) had already made this design in Bologna and that, at that time, Pope Clement XI ordered the building of such a gnomon in the church of Santa Maria Alli Angeli in Rome (Alcan, 1861, pp 109-111).

This fact that Leibniz related was not strange at the time, as John L. Heilbron (1999) demonstrated through the study of the architecture of different European cathedrals built between 1650 and 1750, many of which served (and still serve today) as authentic solar observatories.

We do not claim that the illumination events at Saint James were design to accurately follow the seasons. However, if baroque design and natural light are inseparable concepts (especially at the liturgical level, as ordered by Borromeo), and we count with some experts on illumination that gave their opinions on the cathedral of Saint James, and given the European climate that encouraged the incorporation of the solar cycle into the design of the cathedrals, then there is no doubt that, if at some point in history the illumination of the Apostle Santiago could be carried out intentionally on its significant liturgical dates it had to be at this time. However, we must now question how the apostolic illumination was achieved from such different angles and at a same time that worked for all of them.

3. THE EXPERIMENT

Although one could think that the solution to this issue should be rather complex, the truth is that the method that could have been used to perform the empirical tests on the ground is surprisingly "simple". The question corresponds to an equation of multiple unknowns, but thanks to the use of the gnomon, the initial data, the transit and the position

of the sun can be known, and therefore these data can be contrasted with dates on which the illumination of the apostle is desired.

On a practical note, once the date we are interested in is set with the aid of a gnomon, two possible methods can produce the desired effect. The first possibility would be to fix the position of the apostle and thus obtain the position of the hole through which the light must enter. A second possibility would be to set the position and size of the hole and move the apostle until the correct position is found. In the first option, it is necessary to calculate, in addition to the altitude and the azimuth, the basic data of the hole: its position in the floor, height, and width as well as the flare of the intrados. All these calculations can be performed without problems with simple geometric operations, such as projections, turns, and / or plane changes, but also, as is usual in the architectural discipline, all these calculations would be verified empirically at the definitive emplacement. For the second option, which would be the most plausible for dealing with the illumination on December 30th, it starts from a preexisting hole that admits fewer modifications -in general only partial closings when this is required- and the solution to the problem would consist of making the necessary adjustments to the position of the apostle.

At first, the dates related to March 21st and 25th, May 23rd and July 25th do not represent a major problem for geometric calculations, since the ray of light that illuminates the apostle enters perpendicular to the axis of the façade, through the Baroque/Romanesque facade for the March dates and the west side of the dome for the dates in the remaining two months. In this way the angles of altitude and azimuth measured with the gnomon can be directly transferred with true magnitude to the plant and the interior section of the cathedral.

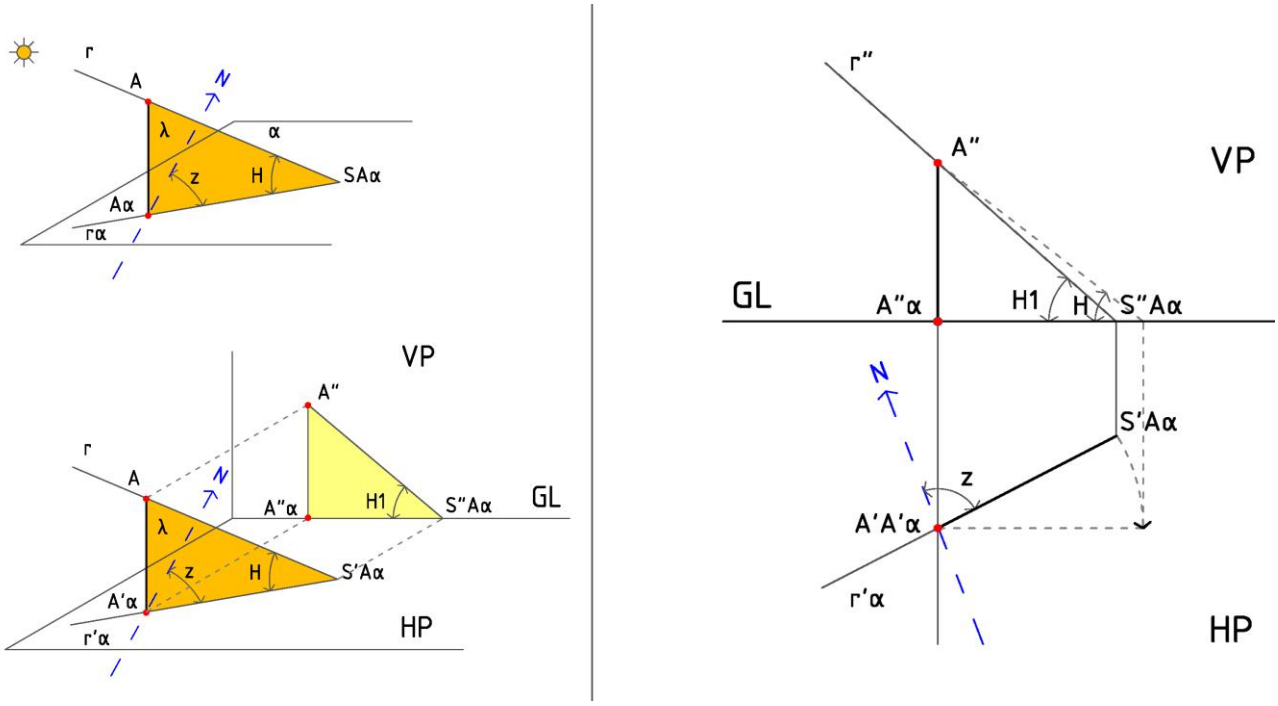

Figure 3. In these three schemes, it could be seen, step by step, the main graphic calculations to geometrically obtain the trajectory followed by a ray of sunlight that is not coplanar to the main axes of a given building; in this case the Cathedral of Saint James. Left top: The dark yellow triangle presents the light beam (r) as entering with a given height (H) for an azimuth (z). We could see that the ray of light and its projection on a horizontal plane define a triangle of light ($A/A_\alpha/SA_\alpha$); painted in dark yellow. Left bottom: we could see this same scheme represented in axonometry in the dihedral system. In this axonometry it is possible to see the horizontal projection (HP) and the vertical projection (VP) of this triangle of light. It should be considered in this axonometry that the ground line (GL) coincides with the longitudinal axis of the main nave of the Cathedral of Saint James, where the statue of the Apostle is located. The case of the triangle of light painted in dark yellow represents the situation in which the ray of light is not coplanar to the longitudinal axis of the Cathedral of Saint James; as it happens on the date of December 30. But when the ray of light is coplanar, as happens for the rays of light of March 21 and 25, May 23 and July 25, the triangle of light would be inscribed in the vertical plane (VP) itself and would be equivalent to the one painted in light yellow. At the right: we could see that the triangle of light ($A"/A"_\alpha/S"A_\alpha$) which is equivalent to the one painted in light yellow in the figure on the left, it is in true magnitude and therefore the height H1, can be measured directly on that vertical plane (VP). However, in order to know the height H of the triangle of dark yellow it is necessary to rotate the plane according to the axis of vertical rotation (A/A'_α) until it is supported on a plane parallel to the Vertical Plane (VP). Image redrawn by Ruth Varela from the originals drawings by Daniel González and Diego Cortinas in Carlos Pantaleón, 2010 (pp 7-8)

However, for the date of December 30th the geometric calculation is slightly more complex than the other calculations because the light does not enter perpendicularly, but rather passes over to the facade through a window of the transept (see Figure 2). In this case, it is possible to determine the angle corresponding to the height of the sun by turning the plane of the light formed by one of the light rays that enter through that window and the projection on the ground of that ray, or azimuth, according to an axis of the vertical rotation until supporting it in a plane parallel to the vertical plane. This involves working from right triangles to obtain the full contour of the illuminated surfaces, although it would be enough to work with the central ray and the most significant points of the basic geometric figure that defines the contour of the light (Figure 3)

Depending on the procedure, determining the position of the apostle or of the holes, is achieved by the intersection of three triangles with their respective azimuths and altitude angles. Each triangle is defined by a hypotenuse, i.e ray of light and a vertical leg in relation to the height of the hole that corresponds to the altitude at the time indicated and by another horizontal leg, which corresponds to the azimuth of the main beam of light for each of the hours and dates indicated.

In turn, all this would be checked by the architect during the project and the execution of the work.

An element that confirms our idea that all lighting phenomena were sought is the fact that after making measurements with a rope and laser inside the cathedral to verify the relative positions of the different elements, we made a highly striking discovery; that the position of the saint in the main altar is located slightly outside the off-axis with respect to the main nave (and therefore to the Romanesque rose window and the baroque window). This position might be off the main axis by less than 50 cm, although we have not yet been able to fully verify the deviation, but this sufices to ensure that the illumination effect through the side window on December 30th. This fact could then be a key element in the support of the intentionality of the illumination, because although the slight change is unnoticeable due to the visuals corrections from the main nave as it presents a centred appearance with respect to the main altar, it is not, and therefore the lighting effect of December 30th could be maximized without losing those of March, May and July.

However, to be able to test the methodology proposed, we decided to carry out an experiment, an empirical verification that the method is reliable and precise. For this purpose, on March 21, 2017, almost the equinoctial date (in 2017 the equinox was on March 20), we decided to move to scale, an idealization of the rosette of the Baroque/Romanesque façade, represented by a circular hole in a wooden surface, and the plane of illumination of the apostle, represented by a smooth wooden tablet. To trace the azimuth on the horizontal plane of the ground, a rethinking was performed with the Pythagorean triangle technique, which was very often used at the time for its simplicity, using rope in which we simply tied three separate knots at a distance of 3, 4 and 5 metres (Figure 4).

Figure 4 Realization of the initial stakeout using the Pythagorean triangle. Experiment carried out at the football pitch of the University of Santiago de Compostela on March 21, 2017. © Ruben Vuelta-Santín

Once the azimuth was laid out, we placed on the ground, previously smoothed with a level, a wooden carpenter´s square with the aforementioned circular hole, acting like the cathedral's rose window. Next, at the distance proportional to the one that would be located at the Apostle's chapel measured on the ground plane (which would be equivalent to the level of the finished pavement in the cathedral) we placed a vertical wooden board. The rope that joins the square and the table is in line with the azimuth of 262º, which determines the position of the sunbeam perpendicular to the facade of the cathedral and illuminates the apostle directly. From here, we just had to wait for the shadow of the sun to be placed on this rope that marked the azimuth to measure the height of the sunbeam on the wooden board. This simple operation allowed us to verify in a simple way that the sunbeam illuminates the apostle as we had previously calculated through other methods, and it also allowed us to obtain the contour of the light on the ground, and with all of its basic geometric points, measure the altitude (Figure 5).

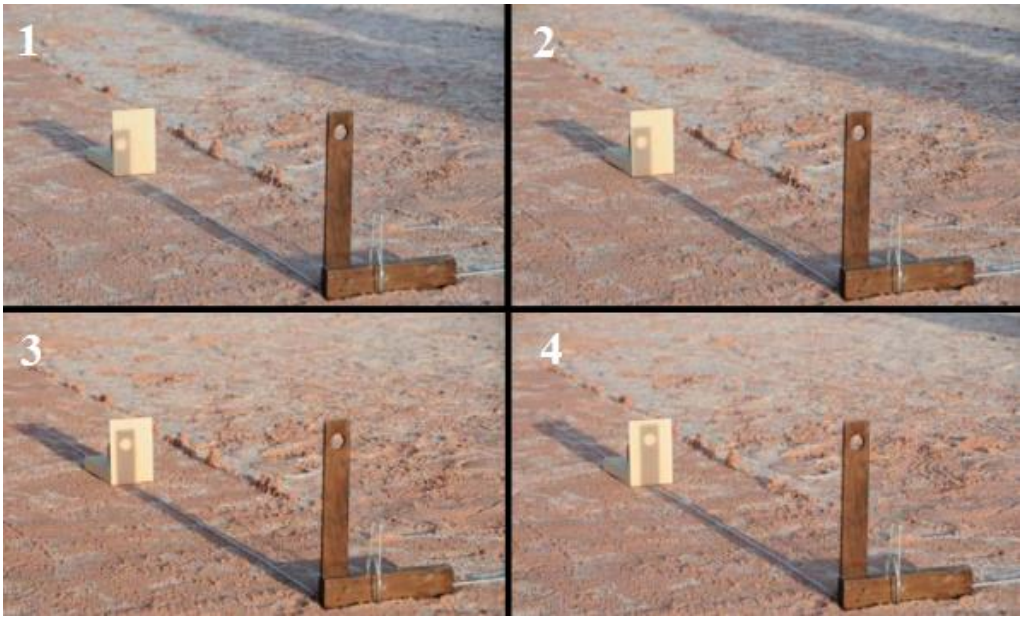

Figure 5 Experiment of the sequence of solar lighting that would reach the statue of the apostle Santiago on March 21, 2017. The position of the apostle coincides with the upper centre of the tablet; exactly with the gap illuminated in image 4. ©Benito Vilas-Estévez

Hereinafter, once we marked this outline of light (whose central point would match the face of the apostle) on the tablet we could see that indeed the method was very effective and accurate despite its simplicity.

4. CONCLUSION

Given the Baroque ambience of light used both for pure liturgical and practical uses, the existence of experts in the church to verify that works did not change the illumination inside the buildings and the treatises to calculate light beams we conclude that the illumination of St. James in his liturgical feasts could be an intentional light phenomenon. It is one that responds to a very specific way of understanding architecture during the baroque: architecture was an art of construction, but above all, architecture was a symbolic language (Milner, 2012), an expression, with a spirit of permanence, of the message, in this divine case associated with light. It is a fact that fortunately we were able to rediscover thanks to the fact that the tradition of the illumination of the apostle was reflected in different written sources, but it had disappeared since the introduction of electric lighting inside the cathedral in the mid-twentieth century.

One of the most interesting aspects of this work is precisely that this illumination phenomenon was never directly written down at a more formal level during the time of the Baroque reform (which would undoubtedly have caused it to be known for some time). In this case the primary source is extracted from the "reading" of the "primary material", the stones of the cathedral and the verification that such a phenomenon was known from the past, tracing such knowledge in the sources at least to the early nineteenth century, barely a century after the reform. The cathedral of Saint James is recognized internationally for the phenomenon of pilgrimages, but totally forgotten in the study of cathedral solar illuminations of the baroque era, despite constituting at least for the moment a unique example of how the liturgy and the sun merged, beyond a "simple" solar observatory.

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