diségno 17 / 2025

Dimensioning and Geometric Patterns in Hadrianic Architecture: the Case of the Temple of Venus at Baiae

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Abstract

The so-called Temple of Venus at Baiae (2nd century A.D.) is one of the most extensive and complex surviving Hadrianic composite vaulted architecture. Although traditionally identified as a temple, the building was in fact part of the Baian thermal complex. Its spatial configuration reflects the experimental character typical of Hadrianic design.

This study, based on an integrated survey, investigates the geometrical logic underlying its plan and elevation. The analyses focus on whether the composition was governed by a modular grid in plan and elevation, with diameters set as multiples of seven and articulated through the ad quadratum scheme. Reverse modelling protocols and best-fitting algorithms were applied to the polygonal model of the rotunda to test these hypotheses. The results confirm a design diameter of 91 pedes*, with a modular subdivision of 13* pedes*, consistent with other Hadrianic domes. In elevation, the vault appears as composite "umbrella" dome made up of alternating cylindrical segments and trikentron surfaces, creating a coherent vaulted system. The unusually slender proportions (1:8.86 diameter-to-thickness ratio) highlight the structural audacity of the monument. The research demonstrates how Hadrianic architecture employed flexible geometric tools, –multiples of seven, ad quadratum, and modular grids– not only for design efficiency but also to generate innovative spatial solutions. These findings contribute to the broader understanding of Hadrianic experimentation.*

Keywords: Hadrianic domes, modular grid design, trikentron, reverse modelling, Roman vaulted structures.

Introduction

Among the surviving examples of Hadrian's composite vaulted architecture (2nd century A.D.), the so-called Temple of Venus in Baiae, Naples, is one of the largest structures, although the vault has only partially survived the centuries.

The architecture of the complex [De Angelis d'Ossat 1977; Rakob 1988] is dominated by the large volume of the main hall, with a central plan and covered by a monumental composite vault (figs. 1, 2). Around this nucleus, a series of small subsidiary volumes defines an approximately square basement, today mostly underground. On the western side, two additional volumes are attached, reduced in scale and architecturally subordinate to the central body. The function and configuration of these spaces remain uncertain, and their legibility is compromised not only by the overall poor state of preservation but also by the construction of a modern road that has obliterated part of the original layout (fig. 3).

Although traditionally referred to as the 'temple', the building was in fact a thermal facility. The improper designation as a temple is misleading, as its architectural configuration reflects the experimental character typical of constructions commissioned by Emperor Hadrian and possibly partly designed by him, where conventional typologies were frequently reinterpreted. The present study is based on data acquired through integrated surveying, aimed at producing a high-resolution three-dimensional model to be used as the basis for the geometrical analysis of the design.

https://doi.org/10.26375/disegno.17.2025.9

The research forms part of a broader research project, focusing on the architectural and structural peculiarities of Hadrianic domes [Cipriani et al. 2020, Eramo, Fantini 2024; Roca et al. 2024]. Within this framework, the authors have developed a methodological approach that begins with an analysis of the building's overall planimetric composition and proceeds through a progressively refined investigation of the elevations. In addition to the use of applications intended for the formal reading of the remains, the method incorporates the theoretical apparatus derived from Vitruvian exegesis with the mathematical principles articulated by Hero of Alexandria [Heiberg 1914a; 1914b], offering interpretative tools that prove particularly effective in addressing archaeological questions related to design logic, as well as the reconstruction of lost or fragmentary architectural elements.

In addition to the analyses conducted to interpret and reconstruct the sequence of steps through which the planimetric was translated into the elevation and into the definition of the intrados of the vaulted system, this study integrates the results of recent core samples carried out at the centre of the main hall (fig. 4). These data provided elements for a more accurate understanding of the original elevation and floor level. The study of the elevations indicates the presence of an articulated vaulted system composed of eight main cylindrical segments, set on the externally octagonal drum, and eight *trikentron* [1], double-curved surfaces positioned above the windows.

Notably, the dome under investigation is among the largest known in the ancient world [Sanpaolesi 1971], with a free span of 26.57 metres and a wall thickness of approximately 3 metres at the structural piers located at the corners of the external octagonal perimeter. This results in a diameter-to-thickness ratio of approximately 1:8.86, which is remarkably slender when compared to the Pantheon's dome in Rome, whose 43.56-metre span is supported by 6.2 metres thick walls, yielding a ratio of roughly 1:7.03. These proportions highlight the technical audacity of the Baian structure and reinforce its role as a paradigmatic example of architectural innovation.

Finally, the analysis of the building and vault remains helps to position the Temple of Venus within a broader architectural complex extending up the slope, representing a later expansion, not aligned with the adjoining pre-existing structures.

The following results lay the groundwork for future investigations into the full extent of the complex and its volumetric and design logic, the understanding of which is hindered by the partial ruin of the structures and by ongoing bradyseismic phenomena, opening further perspectives for broader studies on Hadrianic architectural experimentation.

Fig. 1. The monumental complex of the Temple of Venus from the western entrance (photograph by S. Bertacchi).

Fig. 2. View of the surviving portion of the dome and the openings in the drum (photograph by S. Bertacchi).

Objectives and methodology

The purpose of this study is to highlight the systems for dimensioning used by the ancient architect as design rules and constraints in both the plan and elevation of the Temple of Venus complex at Baiae. Through the analysis of reality-based data and historical sources, the authors aim to verify possible proportional relationships between buildings characterized by shapes and structural solutions comparable to those of the Temple of Venus. In particular, the aim is to verify the presence of a modular grid underlying the entire composition, and whether the diameter of the vaulted space is a multiple of 7, in line with the studies of Svenshon [Svenshon 2009], and Fuchs [Fuchs 2023].

Among the objectives of this study is the formulation of a hypothesis regarding the total height of the domed circular chamber, with the aim of verifying the ratio between the building's planimetric layout and its vertical elevation. In several Hadrianic constructions previously analysed – such as the Small Baths [Cipriani et al. 2017], the Eastern Triclinium of the Golden Court, and the *Serapeum* [Eramo, Fantini 2024] at Hadrian's Villa– a 1:1 ratio between plan and elevation has been consistently observed. However, in other cases, the vertical dimension exceeds the horizontal span due to various factors, often of a structural nature, as exemplified by the Vestibule of access to the Golden Court, where the increased height responds to specific engineering and spatial requirements [Adembri et al. 2018].

The shape of the surviving portions of the different segments composing the vault is therefore the subject of a quantitative study, which aims to hypothesize the overall geometry ruling the design of the dome. To this end, a reality-based 3D model derived from data acquired in February 2024 has been created. To ensure reliable data as a foundation for geometric analysis and interpretation, a comprehensive survey of the monument was conducted, including the surrounding area to reconnect the Temple of Venus with the upper archaeological ruins, at present obliterated by the vehicle-accessible road. The survey activities included an integrated documentation, i.e., i) a Terrestrial Laser Scanner (TLS) survey using a Leica ScanStation C5 based on Time-of-Flight (ToF) technology (80 scans at medium resolution) to create a detailed 3D digital model through standard meshing and optimizing procedures; ii) a photogrammetric survey exclusively focused on the investigated monument, consisting of 986 photos (Single Lens Reflex Camera Nikon D5200 equipped with Nikon AF-P 18-55mm f.3.5-5.6 DX VR lens) taken with X-rite Colorchecker target, to achieve colour-balanced texturing of the surfaces (fig. 5).

The acquired data were processed using a Reverse Modelling (RM) application, which represents the current state of the art in the field [2]. When properly employed, these tools align effectively with the goals of architectural design analysis. The adopted workflow protocol includes the conversion of the point cloud model into a high-resolution mesh, which serves as the analytical foundation for subsequent investigations. The resulting mesh features an average edge length of approximately 4 mm, enabling the efficient processing and interpretation of high-resolution mesh models derived from point cloud data as follows:

- interactive definition of planes, vectors, and reference points necessary for the creation of two-dimensional templates. These references are strategically positioned to identify original architectural elements and to distinguish them from later restorations or alterations resulting from human intervention or natural causes;
- geometric elements such as planes are employed in multiple analytical operations:
  - to extract sections that provide accurate documentation of the built structure;
  - to generate best-fitting 2D profiles, which serve as a basis for interpretative readings of the architectural design;
  - to derive contour lines that reveal traces of the original vaulted surfaces, particularly in areas where the intrados has suffered degradation, thus offering valuable clues for reconstructing the initial spatial configuration;
- from a carefully selected collection of points or regions –either manually defined by the operator or automatically extracted– it is possible to derive geometric primitives, such as solids or surfaces, that approximate the original vaulted system. These idealized forms serve as analytical proxies, enabling a more analytical interpretation of the remains;
- an additional functionality lies in the ability to compare idealized models and forms –based on NURBS surfaces or solids– with the corresponding original mesh, thereby enhancing the accuracy and reliability of the entire reconstruction and interpretation process.

In addition, for some of the more in-depth investigations, a dedicated process was developed, based on best-fitting algorithms for curves and quadric surfaces.

The data obtained through reverse modelling protocols are employed to test the hypothesis that ancient architects may have adopted a generalized approach to vaulted structures, as outlined in certain surviving texts attributed to Hero of Alexandria, specifically *Stereometrica I*, *Stereometrica II*, and *De Mensuris*. Although Hero's original treatise on vaults '*ta kamarika*' [Conti, Martines 2010] appears to have been lost, recent research by Roca, Juan-Vidal, Cipriani, Fantini [Roca et al. 2023] suggests that portions of its content may have survived in editions by Heiberg [Heiberg 1914a; Heiberg 1914b]. Hero builds upon Archimedean studies, simplifying them with a technical and applied focus. When reduced to their essential mathematical expressions, the formulas and methods concerning the volume (constructive material) of arches, domes and vaulted spaces can be summarized as follows:

- subtraction of volumes (extrados minus intrados): the intrados of domes/arches is often based on a diameter of seven units or its multiples;
- use of 'average' surfaces –positioned midway between the intrados and extrados of a dome– which are then multiplied by a constant thickness to estimate the volume (here too, the diameter corresponds to seven units or a multiple thereof). A comparable method is also described by Hero in his approach to calculating the number of spectators in theatres [Bianchini, Fantini 2015];
- another method involves applying rectangular elements –such as cloths– onto complex surfaces, which are then flattened onto a plane for measurement. While this approach may offer a practical means of estimating areas of irregular shapes, it appears more appropriate for sculptures or freestanding elements than for the analysis of complex vaulted systems.

One of the key aspects of the ancient architect's design method lay in reconciling a numerical dimension –what we might define as computational (*distributio*)– with a modular criterion permeating the entire building (*ordinatio*), and finally with graphic constructions of proven effectiveness and ease of execution using ruler and compass, such as the ad quadratum pattern or the dodecagon layout of the Latin theatre [3]. As a final observation, the value of π is consistently approximated as 22/7. For this reason, diameters are often set as multiples of seven, in order to simplify the calculation of the perimeter first, and subsequently of all related quantities, including surface areas and volumes.

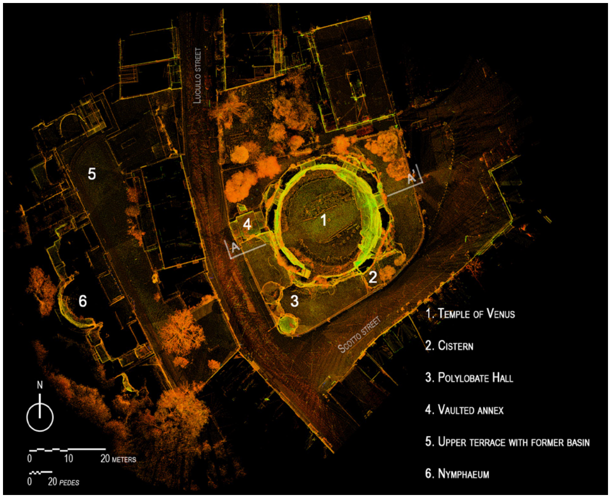


Fig. 3. Plan view of the TLS point cloud of the complex at the Archaeological Park of the Thermal Baths of Baiae, showing the main archaeological remains (point cloud registration and processing by S. Bertacchi).

Plan analysis

Regarding the interpretation of the plan design (*ichnographia*), the rotunda appears to be generated by its inner circle, which follows the same design logic as other buildings from Hadrian's time, namely the use of a diameter multiple of the number seven. This can be observed in well-known buildings at Hadrian's Villa, particularly in two domes that are still in a good state of preservation within the so-called Golden Court complex. In the case of the Eastern Triclinium, the intrados of the hemispherical semi-dome displays a diameter corresponding to seven modules of 5.5 *pedes*. A second example, also within the same pavilion, is the vestibule that provides access to the large portico (fig. 6). Here, the recurrence of the number seven is less explicit: while the *triclinium* expresses it through the number of modules, the vestibule measures six modules of 5.5 *pedes* (33 *pedes*), to which an additional 2 *pedes* –corresponding to the distance between intrados and extrados– must be added, reaching a total of 35 *pedes*. A similar recurrence is found in the semi-dome of the *Serapeum*, where the plan reveals eight modules of 7 *pedes*, again suggesting a compositional logic based on multiples of seven (fig. 7).

Once the diameter of the inner structure (26.57 m at +9 m from the ground level) was obtained through reverse modelling tools, it was divided by the standard *pes*

(1 *pes* = 0.2956 m), yielding a measurement of approximately 90 *pedes* (89.88 *pedes*) for the best-fitting diameter (D_{BF}) (fig. 8A). Assuming this rounding, and considering π = 22/7, the following module (M) is derived:

$$M = 90/7 = 12.86\ \textit{pedes} \approx 13\ \textit{pedes}\ (1)$$

It is not unexpected that the result does not return a whole number, likely due to the precautionary principle that the Roman engineer consistently employed when designing innovative structures, such as the great vaulted space of the Temple of Venus. In fact, the calculation to determine the design diameter (D_D), carried out at the initial dimensioning stage, could have been as follows (fig. 8B), where the design circle (in red) can be subdivided into seven modules of 13 *pedes* each:

$$D_D = 7 \times 13 = 91\ \textit{pedes}\ (2)$$

This value may have been reduced to 90 *pedes* to allow for greater wall thickness. Considering the masonry along the sides of the octagon, the thickness varies by a few centimetres; nevertheless, the value fits with the modular grid, namely half a module ($M/2$ = 1.921 m = 6.5 *pedes*). The building's layout in plan is also based on the *ad quadratum* scheme, within which a circle of eight modules is inscribed: the drum is defined with a side length of S_{AQ} = 104 *pedes* (8 modules of 13 *pedes*) (fig. 8B). As previously observed by Rakob [1988], the width of the buttresses also relates to the modular grid of 13 *pedes* that guides the building's sizing. In fact, the flat sides of the external octagonal structure between the buttresses measure an average width of 26 *pedes*, while the windows measure 13 *pedes*, further confirming the modular logic (fig. 8C).

At the corners, the vertices of the octagon are reinforced by angular masses (amplitude ca. 17°), which increase the resistant thickness to about 10 *pedes* (fig. 8D). Their curvilinear silhouette further emphasizes the structural role of these reinforcements, compared to the 6.5 *pedes* of the walls consistent with the modular scheme.

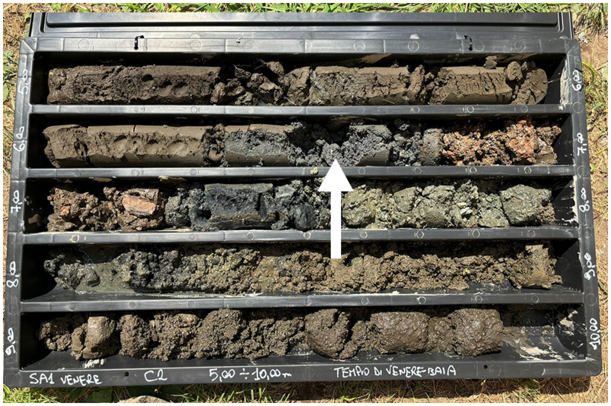
Elevation analysis

Regarding the elevation design, the vault exhibits features closely comparable to other Hadrianic examples conceived on circular plan layouts, notably the *Serapeum* of Hadrian's Villa and the *Horti Sallustiani* in Rome [Eramo, Cinque 2024; Eramo, Fantini 2024]. In all these cases, the overall design conception is based on the definition of a governing form, usually recognizable in the shape of the simplest segments, generically referred to as 'coves', and subsequently elaborated through the addition of the *trikentron* and other smaller elements that regularize and soften the final built shape. In line with this design approach, the investigation of its geometrical conception was carried out through the analyses discussed below, with a focus on the overall configuration. The surviving structure, however –especially its intrados surface– is highly degraded and smoothed by erosion phenomena, making a reconstruction of its original shape an inevitably interpretative process, albeit grounded in objective and verifiable data (fig. 10).

Given the poor present state of conservation of the vault, a preliminary step of the analysis consisted of manually segmenting the polygonal model to isolate the best-preserved portions that still correspond to the original intrados surface.

Then, three complementary methods were used to analyse the model. The first consisted of identifying vertical sections of the coves, traced along radial planes significant in relation to the symmetry of the plan design (fig. 10A). The best-fitting circumferences ($C_{BF}V$) for these sections were then evaluated. The resulting circumferences

Fig. 4. Core samples from the current floor level at the center of the temple reveal the presence of an ancient pavement at approximately –6.6 m (samples by E. Gallocchio).



exhibited a marked variability in radius (ranging from 13.93 m to 15.52 m) and displacement of their centres from that of the drum (ranging from 0.6 m to 1.2 m). Nevertheless, they share relevant features: they are consistently very close to tangency with the impost best-fitting circle ($C_{BF}H$), which corresponds to the vertical rotation of the drum's horizontal section. Moreover, their radii are systematically larger than that of the impost circle (fig. 9B). Concurrently, the same portions of the model were subjected to a comprehensive analysis using a custom-developed shape recognition tool, based on a Matlab function for best-fitting generic quadric surfaces [Petrov 2015].

Fig. 5. A. Polygonal mesh model of the temple (digital elaboration by S. Bertacchi); B. Photogrammetric model with texture (digital elaboration by E. Eramo).

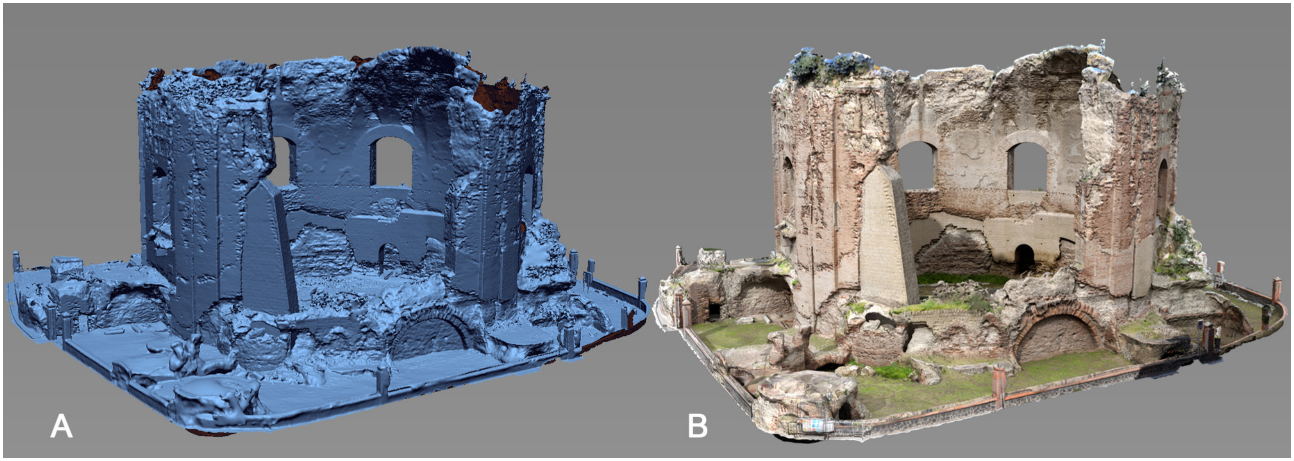
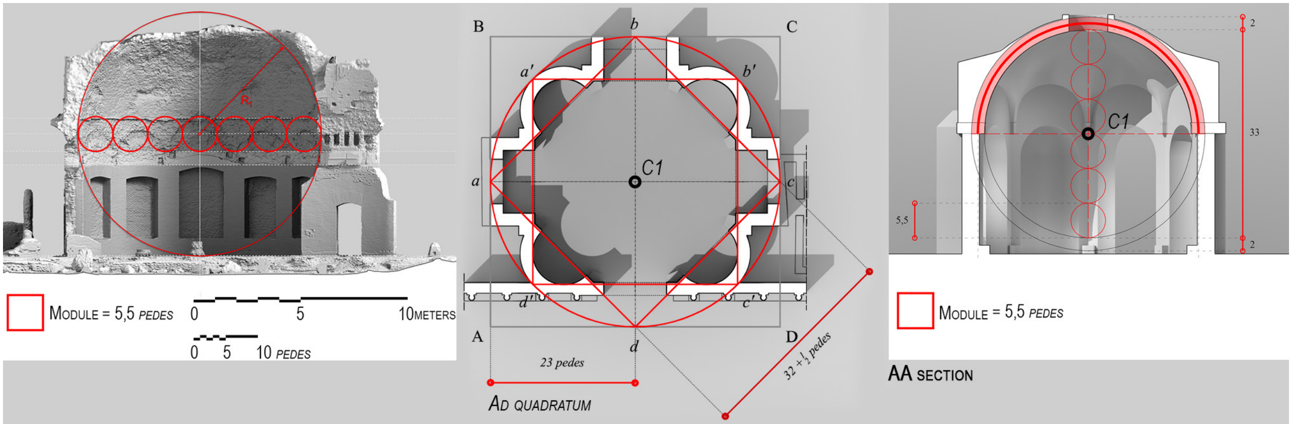


Fig. 6. East triclinium at the Golden Court, Hadrian's Villa: intrados of hemispherical dome with modularity of seven units (module = 5.5 pedes), (digital elaboration by F. Fantini).



The resulting surface is an ellipsoid (E_{BF}) whose principal radii, although rotated with respect to the symmetry axes of the complex, are still comparable to them. The rotation is attributable to the asymmetrical extension of the remaining portions of the coves between the west and east sides of the complex (see fig. 3). The quasi-horizontal radii, specifically, measure 13.31 m and 13.38 m, values very close to the radius of the dome impost circumference (13.28 m). In contrast, the approximately vertical radius is greater in size, measuring 13.69 m (fig. 9C).

The results of the first two analyses indicate that the overall geometry of the vault clearly deviates from a spherical form, such as in the case of the *Horti Sallustiani*. Moreover, the outcome of the quadric fitting must be interpreted differently from the case of the *Serapeum*, where the underlying geometry coincides precisely with an ellipsoid. In the case of the Temple of Venus, the best-fitting procedure did not yield a shape exactly matching the vault. Nevertheless, it is still useful as qualitative evidence that the overall development of the structure was more elongated in the vertical direction than a simple spherical surface.

Finally, the results of the previous analyses become clearer when examined considering the contour lines study. For the complete model of the vault, contour lines were extracted at 0.5 m intervals. As shown in fig. 9A, the horizontal sections display, in correspondence with the circular sectors of the coves, a linear rather than curvilinear pattern, with a decreasing slope in the radial direction. In addition, within the sectors corresponding to the window openings at the impost, distinct curved and steeper portions of the *trikentron* can be identified. Lastly, narrow areas can be observed between the two groups of segments, where the contour lines follow straight paths with varying horizontal inclinations. These areas, which narrow towards the summit, clearly denote a connecting function between the two main groups.

These findings confirm, in accordance with Rakob's proposal [Rakob 1988], that the covering of the Temple of Venus was conceived as a large umbrella vault. The dome was in fact formed by eight cylindrical segments with an increased radius compared to the impost drum, bearing down on the corner reinforcements. The segments above the windows, shaped by the double-curved surfaces of the eight *trikentron*, were connected to the former through transitional surfaces that softened the intersection edges. These findings highlight the refinement of the design strategy. In contrast to the above-mentioned comparative cases, where a circular plan corresponds to a geometry defined by a convex double-curved surface, the roofing of the Temple of Venus was conceived through geometrically simpler segments. Owing to the large impost diameter, these segments can approximate the curvature of the drum with sufficient accuracy. They are connected through local adjustments to the drum and alternated with the *trikentron*, whose original design remains to be clarified. Between the two groups of segments, transitional surfaces –generated from straight elements following the boundary curves of the adjacent portions– resolved the intersections and softened the intrados, producing a continuous and sinuous surface.

Finally, the results of the analyses were compared with the modular scheme identified for the plan, with the primary aim of verifying whether it also finds correspondence in the elevation design, thereby allowing the data to be interpreted within a unified and coherent framework of the

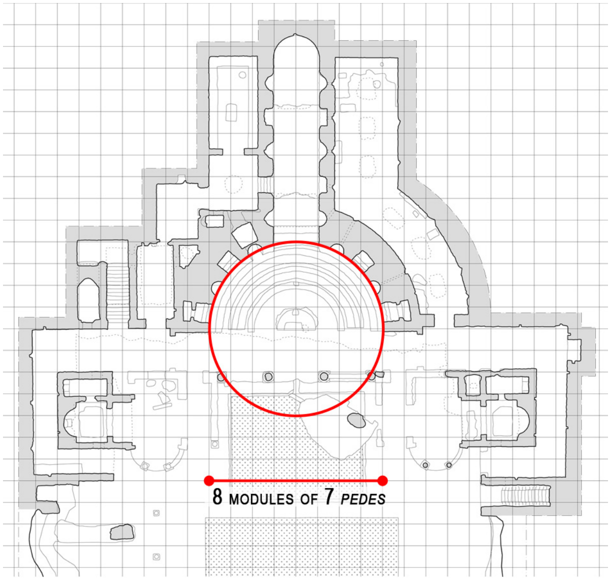


Fig. 7. Plan of the Serapeum-Canopus complex. The intrados measures 56 pedes, confirming modular logic based on multiples of seven (graphic elaboration by F. Fantini).

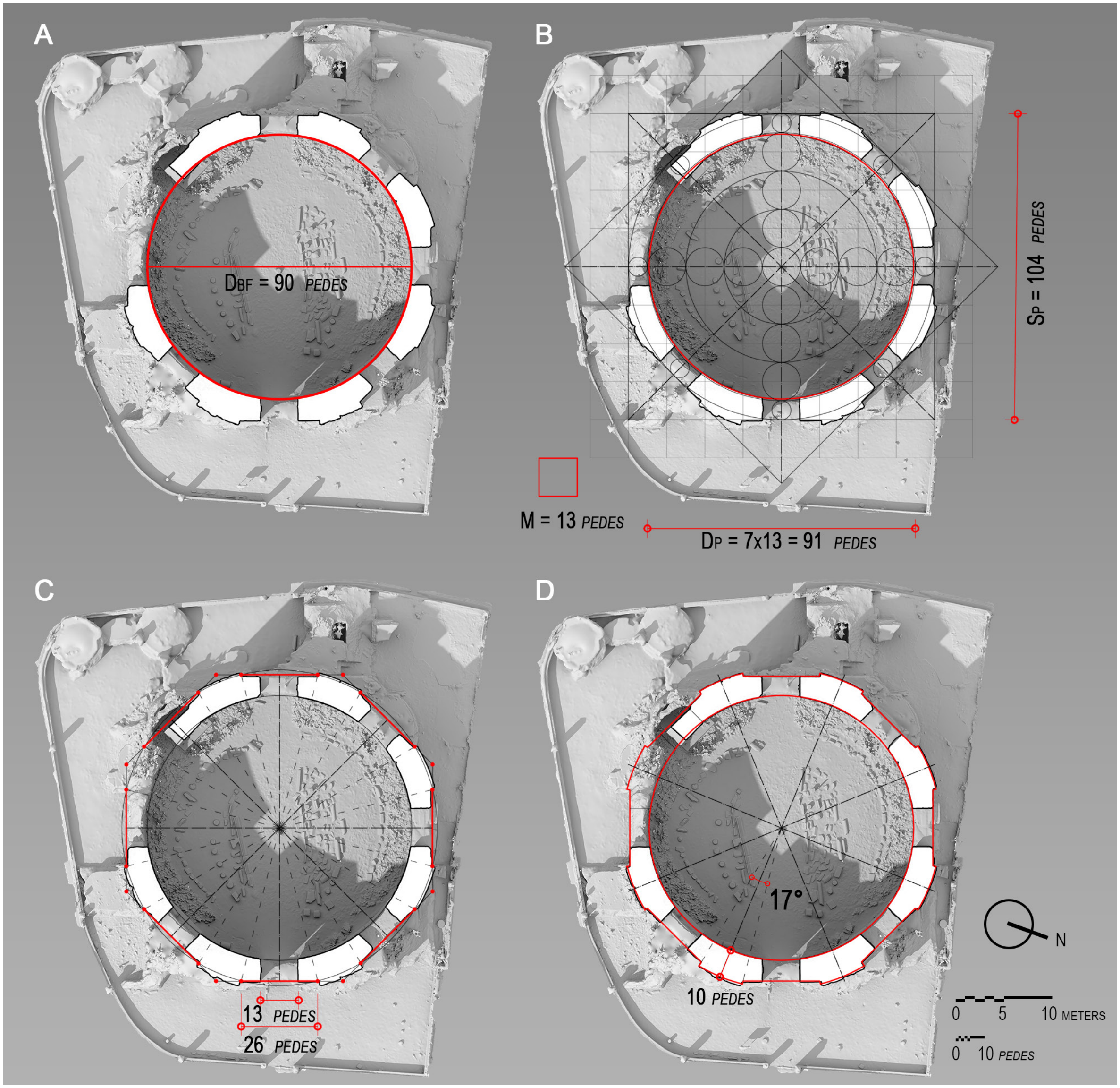


Fig. 8. Geometric analysis of the plan. A. DBF circle, ca. 90 pedes; B. Design circle equal to a diameter of 91 pedes with ad quadratum scheme; C. Dimensional layout of the external sides of the octagonal rotunda; D. Angular reinforcements at the corners (geometric analysis by F. Fantini, S. Bertacchi).

overall geometric project. To this end, the evidence provided by the core samples (fig. 4) was considered: these indicated a possible level of the original floor at approximately -6.6 m, as shown in fig. 10, consistent with that of nearby submerged structures.

Based on the evidence that the width of the windows in the drum corresponds to one module *M* (13 *pedes*), it was observed that the height of their jambs also coincides with the same measure. Moreover, the centre of the circle inscribed in the window coincides with the springing level of the cylindrical segments of the vault and was therefore assumed as the compositional centre of the elevation (fig. 11A). This choice provided preliminary positive evidence: the presumed ancient floor would in fact be located about -4.5 *M* from the identified centre, while the external façades, from the floor up to the level where the extrados of the dome begins to spring, would reach a height of 7 *M*.

Concerning the maximum height of the intrados of the vault, for which no direct evidence is available, the quantitative analyses suggest a greater vertical elongation, which does not appear to be consistent with the 8×8 *M* modular grid adopted for the plan design. A possible interpretation of the relationship between this elongation and the modular scheme was developed by hypothesizing a modular construction of the guiding arches of the cylindrical segments of the vault. A circumference of ½ *M* in diameter –the same measure that defines the wall thickness of the drum– was used to identify, along a radial direction, two eccentric points (C_1, C_2 in fig. 11A). Using these points as centres, arcs tangent to the drum on the side opposite the grid centre were traced, in accordance with the characteristics already identified in the best-fitting circumferences of the coves.

The comparison with the best-fitting ellipsoid E_{BF} shows that this construction yields a maximum height consistent with the results of the analyses, while further quantitative evidence reinforces its coherence: the arches in fact present a radius of 3¾ *M* and a displacement of ¼ *M* from the centre (i.e., about 14.40 m and 0.95 m), values approximately intermediate between those determined

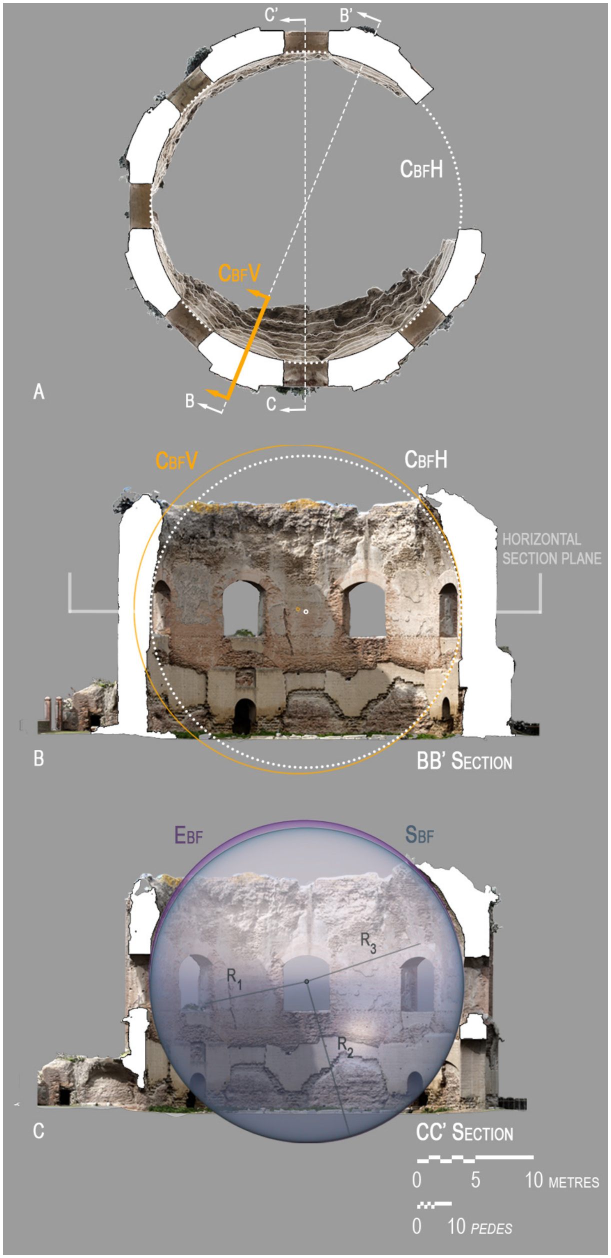


Fig. 9. A. Hypographic view with contour lines and impost best-fitting circumference (CBFH). B. Best-fitting circumference (CBFV) for the median section of the NE cove. C. Best-fitting ellipsoid (EBF) and best-fitting sphere (SBF) for the intrados of the coves (geometric analysis by E. Eramo).

through quantitative analysis. In the case of the best-preserved cylindrical segment, on the NE side, this generating arc offers a reliable approximation of the best-fitting circumference of its section (fig. 11B).

Conclusions

The monument as a whole recalls recurring themes found in other examples; notably, the alternation of coves and *trikentron*

Fig. 10. Section AA' (see fig. 3) showing the relationship between the upper terrace, the Temple of Venus, and the level of the ancient pavement (–6.6 m), (digital elaboration by S. Bertacchi).

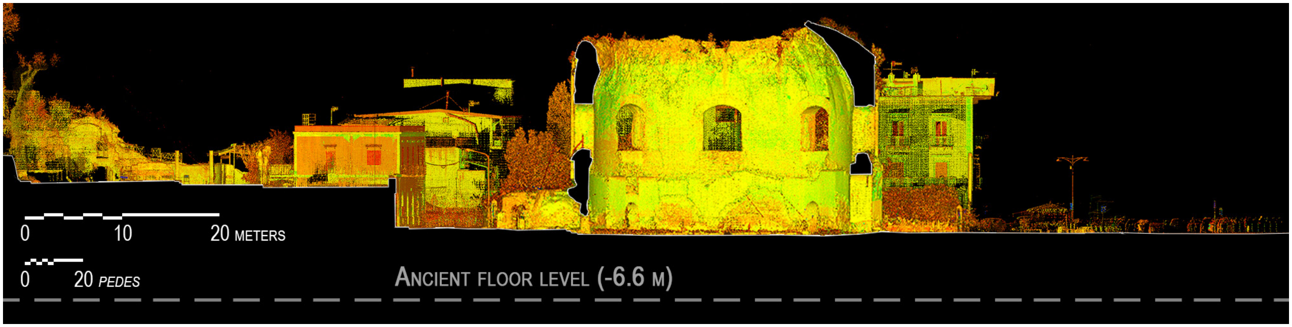
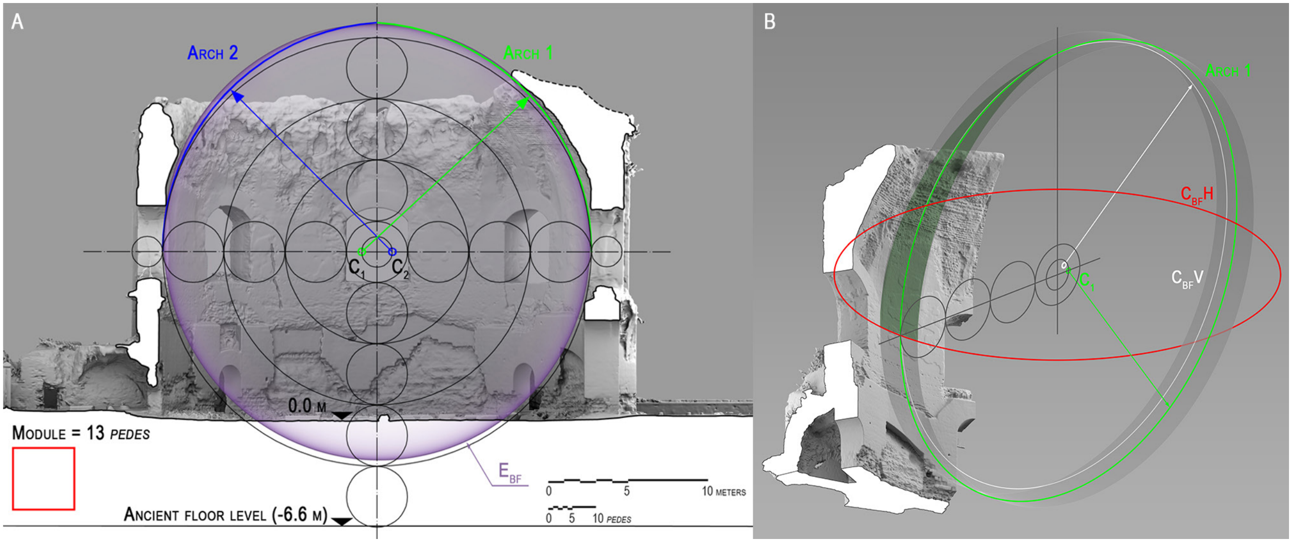


Fig. 11. Geometric analysis of elevation. A. Section AA' with modular grid, hypothesized tracing method of the cylindrical segments (blue and green), and best-fitting ellipsoid. B. Axonometric view of the NE cove with the design arch (green) compared to the best-fitting circumference (geometric analysis by E. Eramo).



draws parallels between this dome (diameter 26.57 m) and the previously mentioned domes of the *Horti Sallustiani*, albeit smaller (diameter 11.20 m), and that of the *Serapeum* (diameter 16.55 m), which lacks polar symmetry since it is projected towards the front of the building [Eramo, Fantini 2024].

Two noteworthy parallels can be observed in the planimetric design of the main rotunda of the Temple of Venus and the octagonal hall of the Small Baths at Hadrian's Villa. The first concerns the use of a diameter corresponding to seven modules for the sizing of these interior spaces (with a module of 5 *pedes* at the Small Baths and 13 *pedes* at the Baian building); the second relates to the wall thickness, which in both cases equals half a module. In both buildings, the use of the *ad quadratum* scheme is evident and appears to be a recurring feature that links domed spaces in Hadrianic architecture [Fletcher 2019], whether based on octagonal or circular plans, despite clear typological and constructional differences between the two forms [De Angelis d'Ossat 1936].

These geometric schemes may be regarded as general-purpose tools –scalable and flexible– designed to facilitate calculations, particularly those involving circular areas. Diameters that are multiples of seven simplify the computation of circular surfaces, while the *ad quadratum* scheme allows for straightforward doubling of such areas. Comparable considerations, although based on different *ichnographia* patterns, underpin the generation of both Latin and Greek theatre plans (*De Architectura*, V, 5 and 7), and, as demonstrated by Lara Ortega [Lara Ortega 1992], they can be adapted to both new constructions and the modification of existing buildings. Beyond this approach, based on philological analysis applied to surveyed buildings, recent archaeological evidence has also provided significant insights into the history of architectural design, as in the case of the slab bearing the carved plan of Galerius' Octagon at Thessaloniki [Savvides 2021]: this 'drawing' clearly demonstrates the use of the *ad quadratum* scheme and was found near the well-known building constructed towards the end of the third century AD. It also demonstrates the reception and continued use of graphic tools analogous to those employed in Hadrianic architecture, even in later historical phases.

The results obtained open the way for further research perspectives. In particular, the small mixtilinear extension of the Temple of Venus should be investigated in greater depth, since it represents another interesting example of experimentation in the context of other Hadrianic buildings, i.e., the Small Baths, the Mixtilinear Atrium [Ottati 2022] and the southern hall of Golden Court [Adembri et al. 2014] at Hadrian's Villa. Moreover, the complex at Baiae was not limited to the building of the Temple of Venus but extended to the slope behind it [De Angelis d'Ossat 1977], where there was a series of descending terraces, and to the area facing the sea. Future research should extend the analysis of the modular grid underlying the entire complex to investigate its design within a unified compositional framework.

Credits and Acknowledgements

All authors contributed to the study and approved the final manuscript. The research was conducted under the scientific coordination of FF and EG. Authors of the sections are as follows: *Introduction* (FF); *Objectives and methodology* (SB); *Elevation analysis* (EE); *Plan analysis* (SB); *Conclusions:* FF and EG. The authors would like to thank Parco Archeologico dei Campi Flegrei.

Notes

[1] The term *trikentron*, as used by Hero of Alexandria (*Stereometrica I*, 96), refers to a surface portion defined by three arcs of circles whose centres lie on different planes [Roca et al. 2023].

[2] The RM software used is 3D System Geomagic Design X.

[3] A crucial aspect in the planimetric design of the Latin theatre –and, by extension, of other buildings with a circular ground plan– consists in identifying a principal circle (*perimetros imi*), whose diameter must be divided into modules. From this foundational geometry, the well-known Vitruvian construction is developed [Salvatore 2007].

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