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Research

Architecture and Archaeoastronomy in Hadrian's Villa near Tivoli, Rome

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Abstract. Built by the emperor Hadrian starting in 117 A.D., the villa is a masterpiece of ancient Roman architecture. Our Accademia Pilot project studied and surveyed the Accademia Esplanade, the highest artificial terrace of the villa, discovering that it was astronomically oriented along the solstitial axis, as were its main buildings, Accademia and Roccabruna. From 2009 to 2011 we photographed a series of light phenomena. In the Accademia at dawn of the winter solstice or at sunset of the summer solstice (opposed by 180°) the sun shines through the main axis of the building, creating spots of light in the Temple of Apollo. In Roccabruna at the summer solstice the sun creates a blade of light inside the dome. Archaeoastronomy provided a new key for understanding the meaning and function of those buildings, which were probably dedicated to the cult of the Egyptian goddess Isis, linked to the seasons.

1 Accademia and Roccabruna

1.1 Introduction

Built by Emperor Hadrian starting in 117 A.D., Hadrian's Villa near Tivoli, outside Rome, is a masterpiece of ancient Roman architecture. Larger than Pompeii, it is the most important Roman villa – one of the World Heritage Monuments – with forty buildings set on different levels and artificial terraces. After centuries of neglect, the villa was rediscovered by Biondo Flavio in 1450,[1] then excavated and studied for more than five hundred years.[2] The antiquarian studies mainly focused on statues and mosaics found during 'treasure hunting' excavations; until the end of the nineteenth century architectural features were almost completely ignored. In recent decades there has been a renewed interest in the villa, with the publication of several articles and books striving to understand its architecture, function and meaning.[3] There is still an enormous amount of work to do in this outstanding archaeological site.

Archaeoastronomy is a comparatively recent field of study [Magli 2009; Krupp 1994]. For Etruria and Rome the starting point is usually Vitruvius (first century B.C.): in Book I of his *De Architectura* he gave precise rules for the foundation of cities and centuriations. In theory the main vertical and axial road of the towns – the *cardo maximus* – was oriented north-south, and the horizontal one – the *decumanus maximus* – was oriented east-west.

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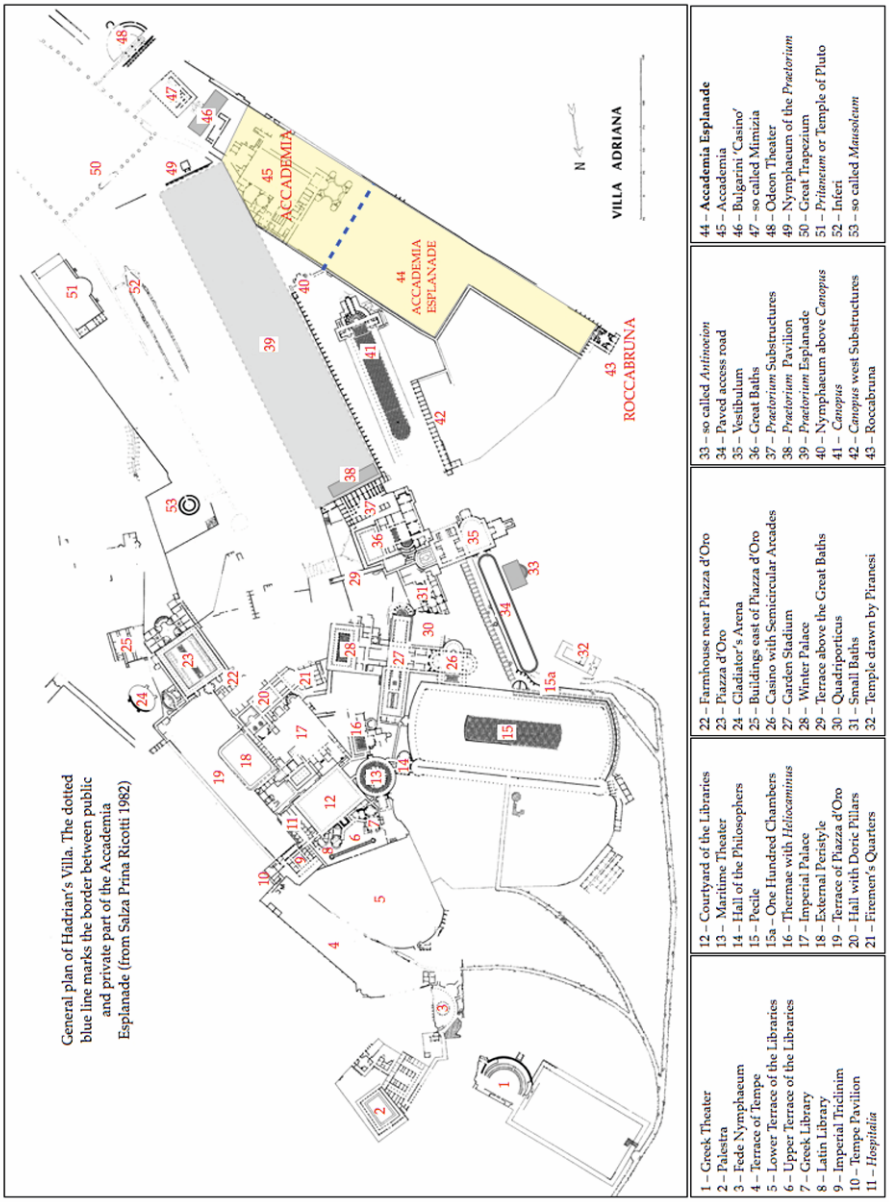

Fig. 1. General plan of Hadrian's Villa. The dotted blue line marks the border between public and private part of the Accademia Esplanade (after [Salza Prina Ricotti 1982])

The *decumanus* could also be oriented towards the point where the sun rose on the day of the foundation of the town itself: so it should be possible to determine the date of its foundation – *dies natalis* – from the position of the rising sun. Recent studies on Etruscan and Roman towns – Marzabotto, Alatri [Magli 2006; Magli 2009: 227-229], Augusta Bagiennorum (today Bene Vagienna, in the province of Cuneo [Barale et al. 2001] and Pompeii [Vitale 2000] – proved that towns did not have a geographical

orientation towards the cardinal points. Some towns, instead, had roads and gates astronomically oriented towards the solstice or the equinox [Romano 1991, 1992, 1995], or the most significant constellations and stars. Centuriations usually followed the orientation of the main consular roads along which they were built. This field of study is at the beginning and will surely give interesting results.

Only three astronomically-oriented Roman buildings have been thoroughly studied: all of them are in Rome. The first is the Horologium Augusti [De Franceschini and Veneziano 2011: 64-72; Moretti 1946; Rodriguez-Almeida 1980; Buchner 1982, 1994; Rakob 1987; Schütz 1990; Coarelli 1997; Severino 1997; Musilli 1999; Gallia 2002; Rehak 2006; Rossini 2006; Heslin 2007; Hannah 2009], built by the emperor Augustus as a giant sundial, dedicated to the sun and linked to other Augustan buildings in the Campus Martius area: Ara Pacis and Mausoleum Augusti. The second is the Domus Aurea [De Franceschini and Veneziano 2011: 72-77], a palace encrusted with gold and precious stones built by Emperor Nero, who proclaimed himself to be Neos Helios (the new sun god). The third is the Pantheon [De Franceschini and Veneziano 2011: 78-83; Hannah and Magli 2011], built by Emperor Hadrian in the same years when he was building his villa in Tivoli; it probably worked as a sundial, oriented towards the equinox and the *dies natalis* of Rome (21 April).

In Hadrian's Villa, archaeoastronomy is a brand new field of study, which gave us a new and different key for understanding and interpretating the site.

1.2 The Accademia Pilot Project

The Accademia Pilot Project is focused on one of the lesser known buildings of Hadrian's Villa, the Accademia at the southwestern end of the complex, on the Accademia Esplanade, which is the highest and most secluded one.[4] The greater part of it belongs to the Bulgarini family and is not open to the public;[5] in the State-owned area of the Esplanade, the building of Roccabruna is open to visitors (fig. 1).

Fig. 2. Accademia, 11 June 2006: a rectangle of light perfectly illuminating one of the wall panels of the Temple of Apollo. Photo: Marina De Franceschini

During our survey of the Accademia, on 11 June 2006, Marina De Franceschini happened to photograph a rectangle of light perfectly illuminating the center of a wall panel in the circular hall called Temple of Apollo (fig. 2). She immediately realized that it could not be a coincidence: the light was probably marking the hours within the Temple; she thought that perhaps the rising sun was shining at the center of the door opposite the entrance from the porch.

Fortunately she asked the advice of Pietro Planezio, former director of the Astronomical Observatory of Genoa. She hoped that by looking at the plan of the Temple of Apollo, he could detect the logical time sequence of the rectangles of light on the wall panels, of which there were originally twenty, a number that does not correspond to hours, seasons or months, nor to the Zodiac. After measuring the angle between the longitudinal main axis of the building and north (27°), Planezio told her: 'The sun will never shine through that door. But the Accademia is oriented towards winter and summer solstices!' He explained to her the concept of astronomical orientation towards the main astronomical events of the year (solstices and equinoxes), and introduced her to archaeoastronomer Giuseppe Veneziano: they started to study the site together, and in 2011 they published the first book on archaeoastronomy in Hadrian's Villa [De Franceschini and Veneziano 2011].

1.3 Archaeoastronomy in the Accademia

The Accademia Esplanade is the highest and most secluded artificial terrace of the villa, its true Acropolis (fig. 3). To reach it, one must follow a winding path: pass nearby the Canopus, go to Roccabruna, climb the monumental ramp leading up to the Accademia Esplanade and then walk for about 350 meters to the Accademia.

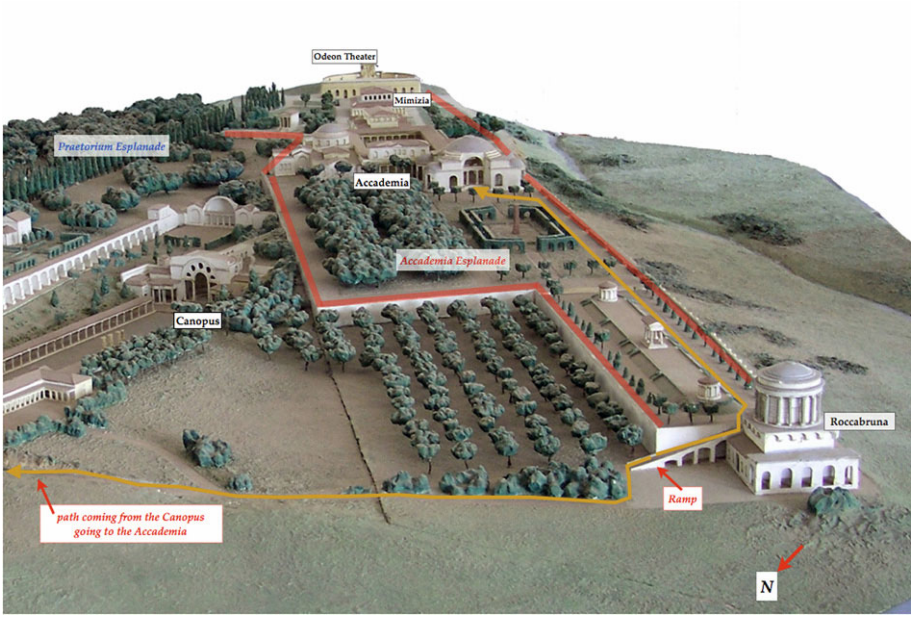

Fig. 3. Model of Hadrian's Villa, Gismondi 1956. The Accademia Esplanade (outlined in red) and its buildings. Photo: Marina De Franceschini

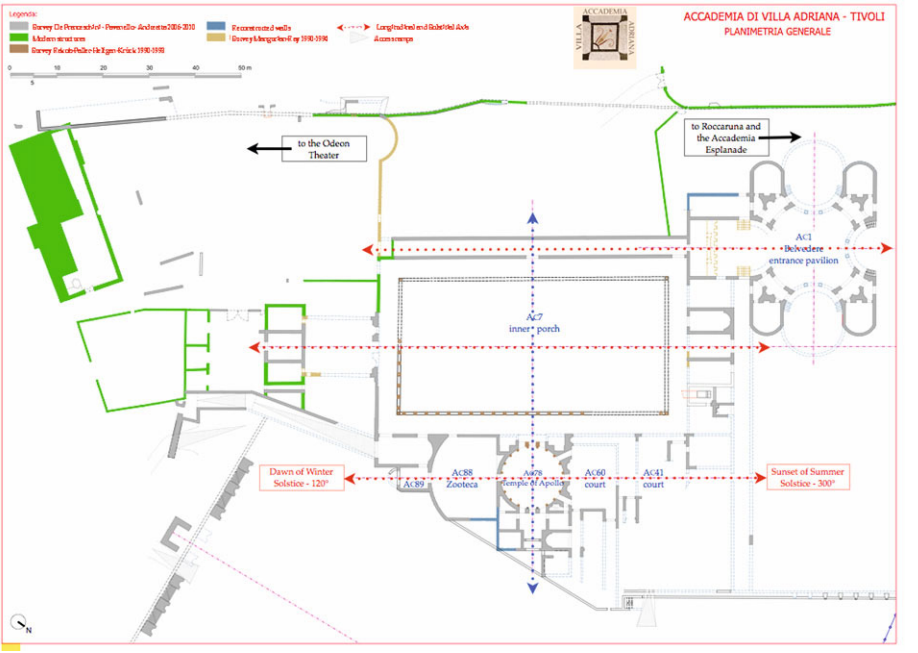

Fig. 4. Accademia, general plan with the longitudinal axis and main rooms. From the Accademia Pilot Project, plan by De Franceschini-Pavanello-Andreatta 2005-2010

Fig. 5. Accademia, Temple of Apollo: in the lower floor doors alternate with panels, in the upper floor are niches for statues and windows. Photo: Marina De Franceschini

Fig. 6. Accademia. See-through perspective of the rooms aligned along the longitudinal and solstitial axis of the building, from southeast to northwest. Photo: Giuseppe Veneziano

Fig. 7. Accademia. See-through perspective of the rooms aligned along the longitudinal and solstitial axis of the building, from north-west to south-east. Photo: Giuseppe Veneziano

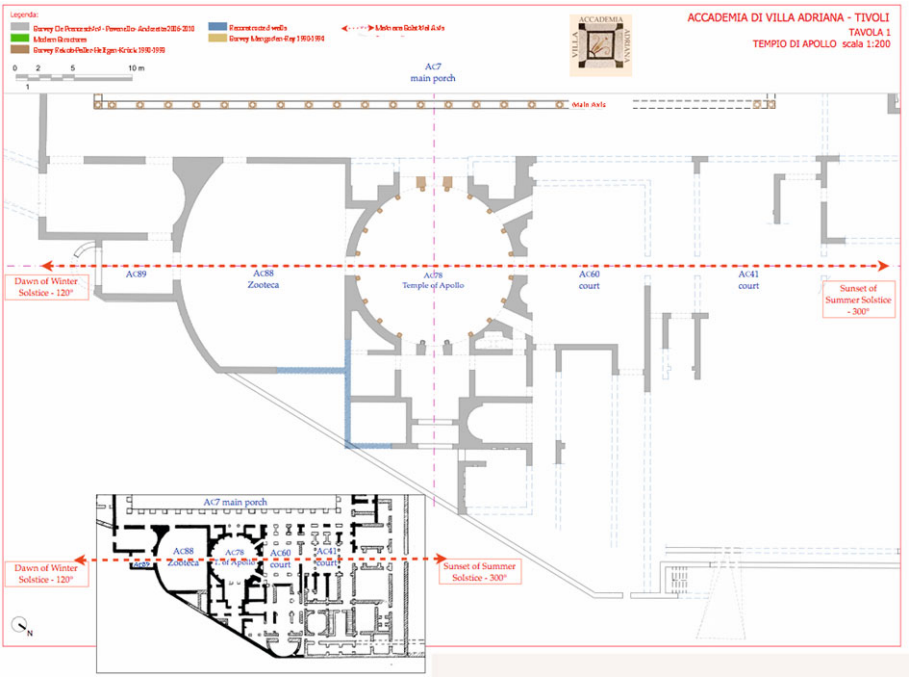

Fig. 8. Plan of the Accademia with the solstitial axis coinciding with the longitudinal axis of the building. From the Accademia Pilot Project, De Franceschini-Pavanello-Andreatta 2005-2010. Box on lower left, the same axis in the plan by Winnefeld [1895]

Only 40% of the building is still standing (fig. 4): it consists of an entrance pavilion, the so-called Belvedere (Ac1), leading to a large rectangular inner porch (Ac7) with a central garden surrounded by columns. On the eastern side of the porch lies the main group of rooms with the monumental circular hall of the Temple of Apollo (Ac78): its diameter is more than 13 meters, the walls – as we said – were originally divided into twenty panels, thirteen of which are still standing (fig. 5).[6]

Our Accademia Project produced a new and updated plan of the building,[7] showing a series of rooms whose doors are aligned on the main longitudinal axis, with a see-through perspective (figs. 6, 7). This axis coincides with the solstitial axis, an ideal line connecting the point where the sun rises on the winter solstice and the point where it sets on the summer solstice (fig. 8).

We decided to make on-site surveys during the solstices to verify our theory: the easiest way is still to 'go there and see what happens'; calculations and 3D reconstructions can come afterwards.

1.3.1 Winter solstice

In 2009, during the very cold days of the winter solstice (18-22 December) archaeoastronomer Giuseppe Veneziano and archaeologist Elena Salvo went to the Accademia at dawn, to find out if our theory was correct.

The first step was to verify the solar movements: as foreseen, the sun enters from the main door of room Ac89 (fig. 9), passing through several doors and rooms set along the longitudinal axis (Ac88 – where the photograph in fig. 9 was taken – Ac78, Ac60 and

Ac41); the rays illuminate the whole building for all its surviving length. When the Accademia was intact, the row of rooms and the see-through perspective was much longer (see the reconstructed plan by Winnefeld, box in fig. 6). The effect was similar to what happens at Abu Simbel in Egypt or at Newgrange in Ireland: the rays of the sun shine inside a long corridor or sequence of rooms, gradually elongating on the floor.

Fig. 9. Accademia, door between Ac88 and Ac89, winter solstice 2009. The rays of the sun shining through at dawn, 18 December. Photo: Giuseppe Veneziano

Fig. 10. Accademia, Temple of Apollo, 2009: measuring true north versus magnetic north. Photo: Giuseppe Veneziano

The second step was measuring true north (fig. 10) compared to magnetic north [De Franceschini and Veneziano 2011: 177 and fig. 158]: this was done to verify the correctness of the orientation of the plan that we used for our astronomical survey. The plan (unpublished; see fig. 16 below) was drawn by professor Friedrich Rakob and architects Faller, Helfgen and Krück.[8]

The third step was measuring the orientation of the Accademia: its longitudinal axis is oriented 120°/300°, which corresponds to the solstitial axis connecting the points where the sun rises on the winter solstice (122°) and sets on the summer solstice (302°).

The fourth step was the calculation of azimuths, using a dedicated software: Starry Night Pro Plus 6.0 [De Franceschini and Veneziano 2011: 197-199]. In 2010 the azimuth of the sun at dawn of the winter solstice was 122°19.5′, at sunset of the summer solstice it was 302°19.5′; at the time of Emperor Hadrian (125 A.D.) it was 122°40.5′ on the winter solstice, and 302°40.5′ on the summer solstice. The difference is very small and the position of the sun has not changed much: this is why the light phenomena still occur.

1.3.2 Summer solstice

From 19 to 22 June 2010 Giuseppe Veneziano went to the Accademia to see the light phenomena of the summer solstice, focusing once more on the Temple of Apollo. What he saw was not simply the reverse of what happened on the winter solstice (azimuth 120°). The sun obviously set on the opposite side (azimuth 300°) illuminating the see-through perspective of rooms in reversed sequence. But the light effects were more complex, with two different phases: the first one created by the sun entering from the windows of the upper floor (the 'window phase') and the second by the sun entering from the main northwestern door on the lower floor (the 'door phase').

In the first window phase at the beginning, the sun's rays pass through a window of the upper floor creating a rectangle of light on the wall panel on the opposite side (fig. 11-12), confirming what we had seen in 2006. But all of a sudden a second rectangle of light appears (fig. 13), and both start to move slowly from left to right, with an arched motion. When the second spot of light hits the next panel, the first one is reaching the wall near the (axial) door of room Ac88 (fig. 14).

Fig. 11 (left). Accademia, Temple of Apollo, summer solstice 2010. The sun's rays enter from window F2 illuminating the center of panel S13 on the opposite side. Photo: 20 June, 18:18 – 18:29, by Giuseppe Veneziano

Fig. 12. Accademia, Temple of Apollo, summer solstice 2010: the sun enters from windows F1 and F2 creating two rectangles of light on wall panels S11 and S13 on the opposite side. Photo: 20 June at 18:34, by Giuseppe Veneziano

Fig. 13. Accademia, Temple of Apollo, summer solstice 2010. The rectangles of light move towards the right, illuminating panel S12 and the wall of room AC88 (Zooteca) left of the axial door towards AC89. Photo: 20 June at 19:26, by Giuseppe Veneziano

Fig. 14. Accademia, Temple of Apollo, summer solstice 2011: final moments of the 'window phase' of the light phenomena: the rectangle of light hits the door between of room AC88 (Zooteca) and room AC89. Photo: 20 June at 19:49, by Giuseppe Veneziano

Fig. 15. Accademia, Temple of Apollo, summer solstice 2011. Door phase of the light phenomena: the sun shines through the axial door between the Temple of Apollo and court AC60, starting to illuminate the floor. Photo: 20 June at 19:59, by Giuseppe Veneziano

The spot of light moves further right, towards the same door from which we photographed the sun's rays entering at dawn of the winter solstice (fig. 14).

Then begins the second door phase: near sunset, the sun shines through the series of axial doors, entering from the door towards Ac60 (fig. 15) and slowly moving on the pavement, until it reaches the door of Ac89 (reversed sequence compared to the winter solstice).

Unfortunately several olive trees block the way, and it is not possible to see the phenomenon in full as it was originally planned: the light of the sun would slowly advance on the floor, illuminating the whole building for all its length.

It is very likely that on the winter solstice as well, after the door phase there was a window phase with double light spots on the wall panels: this cannot be seen anymore because half of the temple has collapsed. After the survey and the calculations we were able to draw an archaeoastronomical plan of the Temple of Apollo, with the azimuths of the astronomical events (fig. 16).

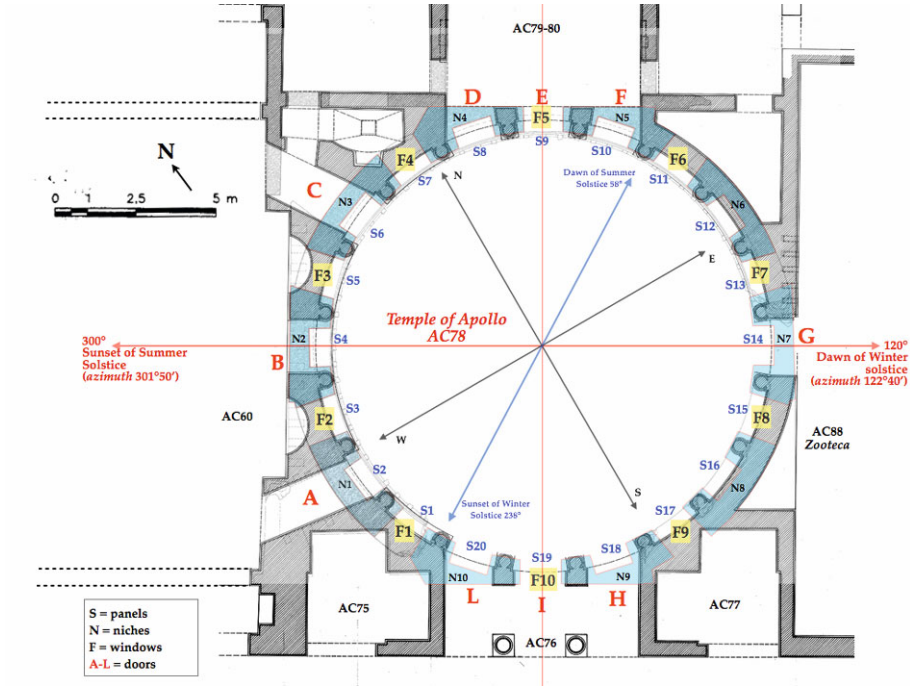

Fig. 16. Accademia, Temple of Apollo, astronomical azimuths and events superimposed on the plan drawn by professor Friedrich Rakob and architects Faller, Helfgen and Krück. Courtesy of architect Edmund Faller

1.3.3 Further research in the Accademia

Since, as we said, half of the Temple of Apollo has collapsed, some of its light phenomena can only be reconstructed with a 3D model and virtual reality. We plan to simulate the course of the sun and verify a series of hypotheses.

1. Winter solstice in the Temple of Apollo: to see if after dawn and a first 'door phase', there was a second 'window phase', with the sun illuminating the wall panels on the northwestern side of the temple (fig. 17).

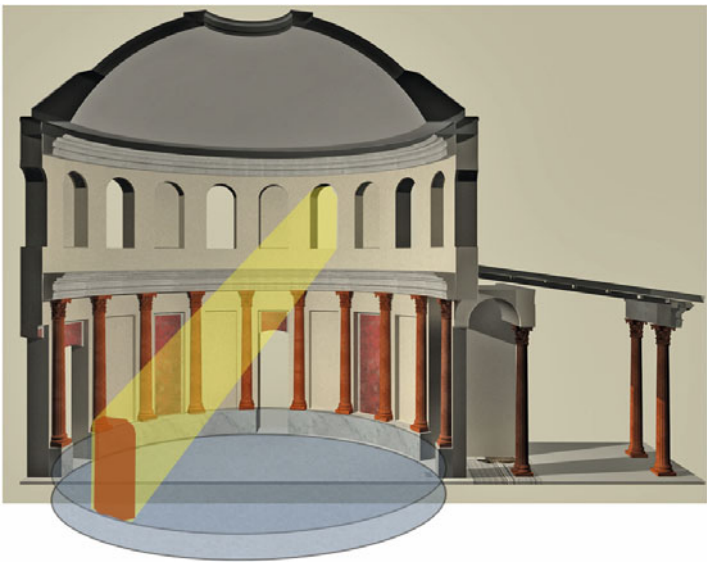

Fig. 17. Accademia, Temple of Apollo, 3D reconstruction with a possible 'window phase' light phenomena on winter solstice. Drawing: Brigitta Casieri

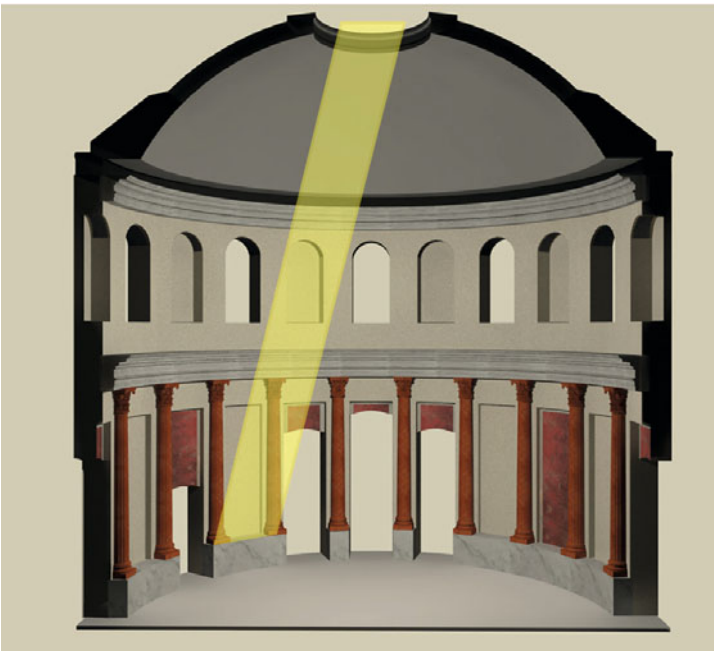

Fig. 18. Accademia, Temple of Apollo, 3D reconstruction with a possible light phenomena originated by the oculus of the dome. Drawing: Brigitta Casieri

2. Was the sunlight marking the hours within the temple? Could each panel correspond to a different hour of the day?[9]
3. Could the dome of the Temple of Apollo work as a sundial, as in the Pantheon in Rome? Nothing is left of the dome, but since the preserved height of the walls almost equals its diameter, the dome was probably built over an imaginary perfect sphere, as in the Pantheon. Therefore we reconstructed a dome 13 meters high, and its oculus was given the same proportion that we see in the Pantheon.[10]
4. Could the light coming from the oculus or the windows create signals of light during special dates? Examples of such important dates might be the anniversary of Hadrian's enthronement (*dies imperii*, 11 August), the *dies natalis* of Rome (21 April), the equinox or the solstice (fig. 18).
5. What was happening in the Belvedere (Ac1) during solstices? It was the main entrance of the Accademia, a monumental and curvilinear pavilion which is almost completely destroyed; just three of its four main pillars and small parts of the elevation survive. We drew a new plan of it: the main axis coincides with the solstitial axis, and it is oriented towards the sunset of the summer solstice (fig. 19). The sun was shining through its main door and the axial door of room Ac3 (fig. 20; see also fig. 4) reaching inside the porch Ac6, with the same effect of light slowly advancing on the floor that we saw in the Temple of Apollo and surrounding rooms.
6. Another longitudinal and solstitial axis centers the inner porch and its main rooms, as can be seen in an aerial picture (fig. 21).

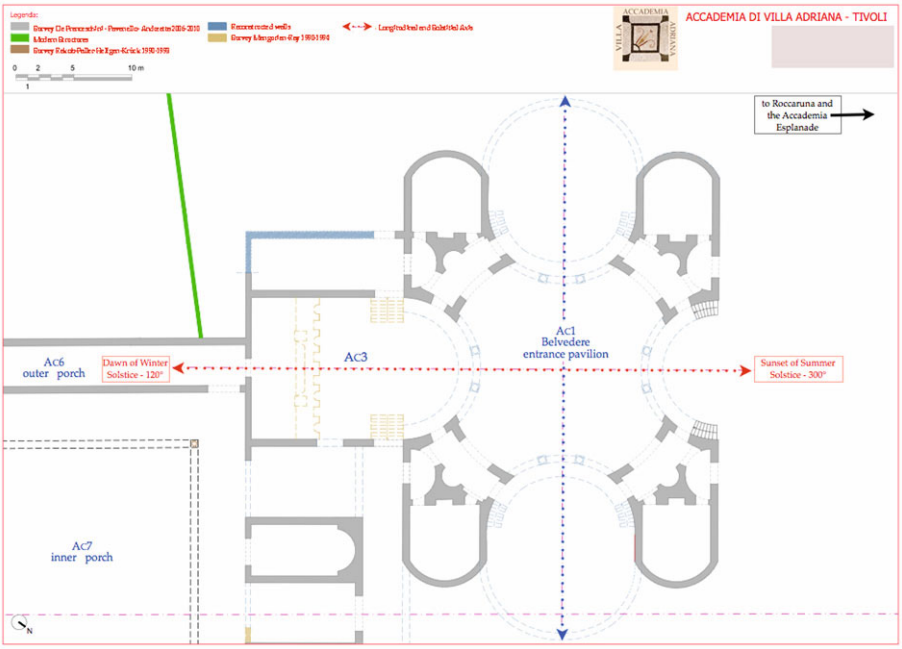

Fig. 19. Accademia plan of Belvedere Ac1, entrance pavilion, whose longitudinal axis coincides with the solstitial axis. On the summer solstice the rays of the sun reach inside the outer porch Ac6. From the Accademia Pilot Project, plan by De Franceschini-Pavanello-Andreatta 2005-2010

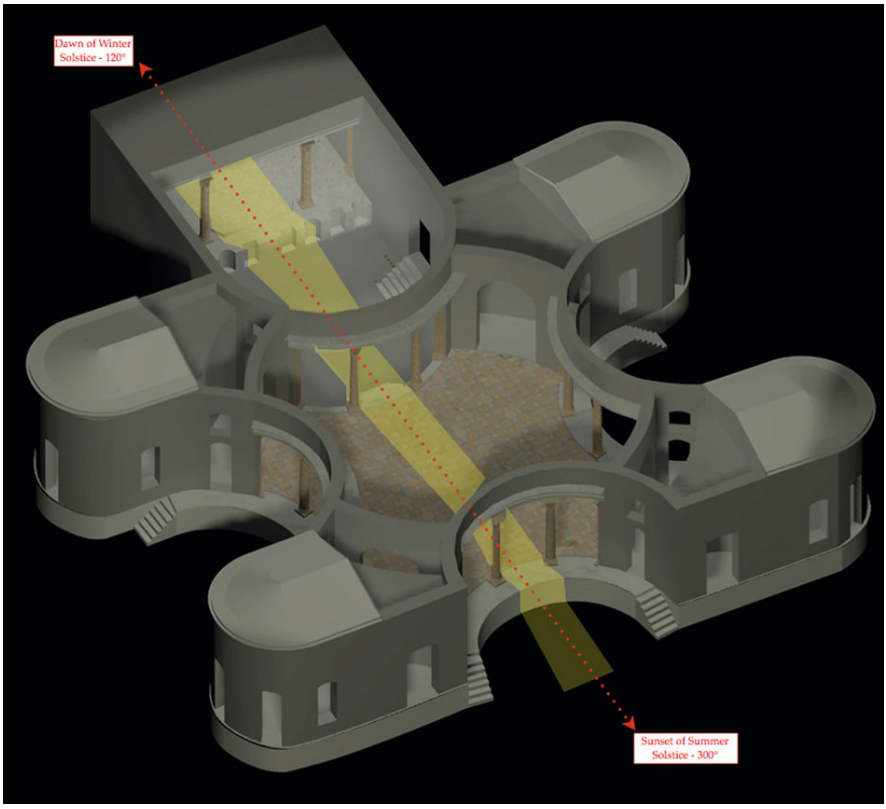

Fig. 20. Accademia, Belvedere AC1 entrance pavilion. 3D reconstruction with light phenomena at sunset of the summer solstice. Drawing: Brigitta Casieri

Fig. 21. Aerial view of the Accademia with its longitudinal and solstitial axis. Courtesy Microsoft Virtual Earth

1.4 Archaeoastronomy in Roccabruna

After discovering the astronomical orientation of the Accademia, Marina De Franceschini realized that the retaining walls of the Accademia Esplanade and Roccabruna had the same solstitial orientation: 120°/300° (see general plan fig. 1 and model fig. 3). Therefore she decided to study Roccabruna, which was supposed to be an astronomical observatory.[11]

The orientation of Roccabruna towards the sunset of the summer solstice and its light phenomena were discovered in 1988 by American architects Robert Mangurian and Mary-Ann Ray, during their survey of Hadrian's Villa within the Atelier Italia project (years 1985-1994). When they met in 2009, Robert told Marina that only during the days of the summer solstice at sunset the light enters through a special 'light conduit' on top of the main door of Roccabruna, creating a slot of light inside its dome (fig. 22). This light blade moves from left to right and upwards, then fades as if there were a 'dimmer switch'. Unfortunately they never published their important discovery,[12] which confirmed our own in the Accademia.

Fig. 22. Composite photograph of the front façade of Torre Roccabruna on 21 June 1988, showing the rays of the setting sun on the summer solstice passing through the central door opening, and the 'solstice' window above, on the back wall of the inside rotunda space. Photo: Mangurian and Ray

Once again it was important to go to the site and see what was happening, and so we did.

1.4.1 Summer solstice

The first step was to verify the solar movements. Marina De Franceschini went to Roccabruna in 2009 a week before the summer solstice, and saw that there was no light blade. On summer solstice in 2009 (19 June) and again in 2011 (19, 21 and 22 June) the light phenomenon was exactly as Robert Mangurian had described.

Roccabruna originally had two levels. The lower floor (still standing) is a squared building with a large circular hall inside, covered by a dome. It has three façades, each with a central door or window, on top of which is the large rectangular opening of a pyramid-shaped conduit (A-B-C), whose inner end opens inside the dome with a small slot (fig. 23). The conduits have been variously interpreted as devices for ventilation or holes for large beams [De Franceschini and Veneziano 2011: 128-133].

At 19:30 the sun's rays enter the 'light conduit' above the main door, and a rectangular spot of light appears inside the dome (fig. 24).

Fig. 23. The main façade of Roccabruna with the entrance door and the rectangular opening of conduit B on top. On the left, the ramp leading up to the Accademia Esplanade. Photo: Marina De Franceschini

Fig. 24. Roccabruna, summer solstice 2011. Inside the dome, the light enters from conduit B on the left, creating a spot of light on the opposite side. Photo: 19 June at 20:12, by Marcello Ranieri

Fig. 25. Roccabruna, summer solstice 2009: a, left) the sun centers the main door, June 19th, 20:28; b, right) the spot of light is under the Y-shaped opening of conduits D-E.
Photo: 19 June at 20:28, by Marina De Franceschini

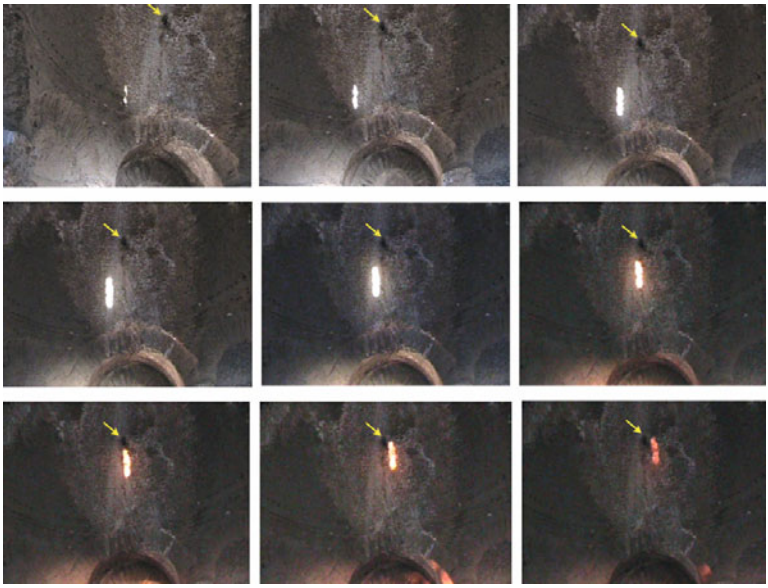

Fig. 26. Roccabruna, summer solstice 2011. Series of pictures showing the movement of the spot of light on the dome; yellow arrows indicate the Y shaped opening of conduits D-E.
Photos: 19 June, 19:30 – 20:45, by Marina De Franceschini

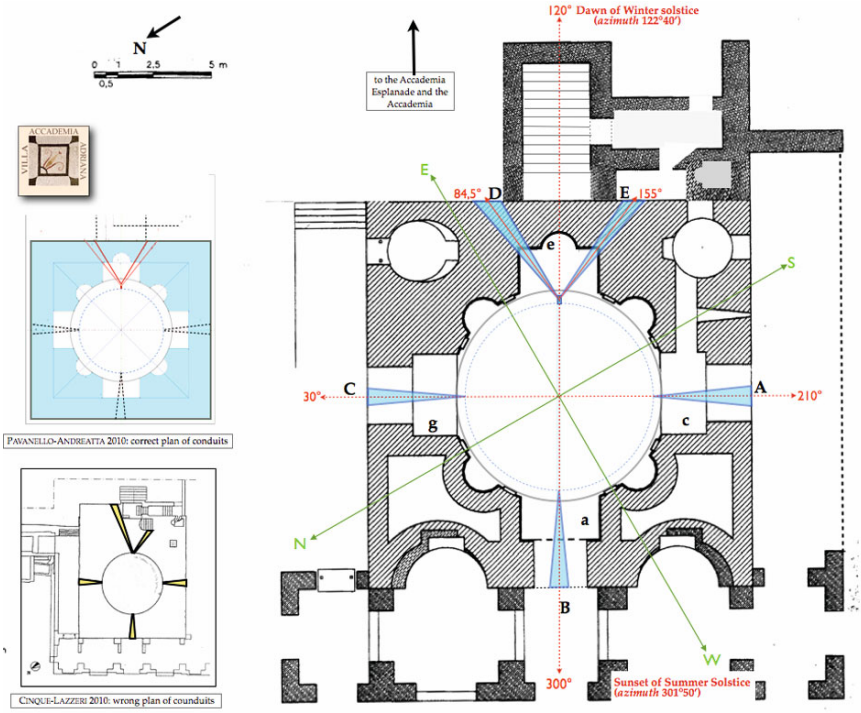

Fig. 27. Roccabruna, plan of the lower floor and of the five conduits: A-B-C on the façades and D-E on the two sides of the stair, with astronomical alignments and azimuths (elaboration of plan by architect Sergio Sgalambro, Soprintendenza Archeologica del Lazio 1995, dis. 3729).
Box: correct position of the conduits in the plan by Pavanello-Andreatta 2010 and wrong position in [Cinque and Lazzeri 2010]

After a few minutes it becomes larger and brighter, and it starts moving from left to right with an arched movement. At 20:28 the sun is at the center of the door, and the spot of light is aligned with the opening in the dome where two other conduits (D-E) converge from the southern side of the building (fig. 25). Then the spot of light moves further upwards, becoming red and slowly fading away (fig. 26).

The second step was measuring the orientation of Roccabruna. Its main longitudinal axis coincides with the solstitial axis, as in the Accademia. For the first time, using GPS and Total Station, we acquired precise data on the position and orientation of the conduits, proving that previous plans were inaccurate or wrong (fig. 27).

The third step was calculating the azimuths of the conduits, and their relationship with astronomical events. Roccabruna has five conduits: A-B-C on the three façades, D-E on the back side towards the Accademia Esplanade. Which was their function?

Conduit B has an archaeoastronomical function and meaning: it is oriented towards the sunset of the summer solstice to capture its rays only during those five days of the year. It is important to point out that the difference between its azimuth (300°) and the sun's azimuth at sunset (302°19.5′) is neither coincidental nor due to a mistake: it was intentionally aimed at obtaining a longer lasting light phenomenon (from 19:30 to 20:45); had it been oriented exactly as the setting sun, it would have lasted just a few minutes.

Every day the sun is passing in front of conduit A, but we have to figure out when its rays can get inside it: usually the sun is too high, also in the days of the equinox. Conduit C, instead, is 180° opposite to conduit A, and the rays of the sun never reach it. Thus their function and meaning remain unclear.

The other two conduits D-E are opening at the two sides of the stair once leading to the temple on top of Roccabruna; they join together into a Y-shaped opening, visible inside the dome of Roccabruna (fig. 28). The rays of the sun can reach both of them, but the outer opening of conduit E was originally set inside a 'secret room' (partially destroyed by the Jesuits in the eighteenth century) (fig. 29).

Fig. 28. Roccabruna: left) Conduit E; right) Giuseppe Veneziano measuring the azimuth of conduit D. Photo: Marina De Franceschini

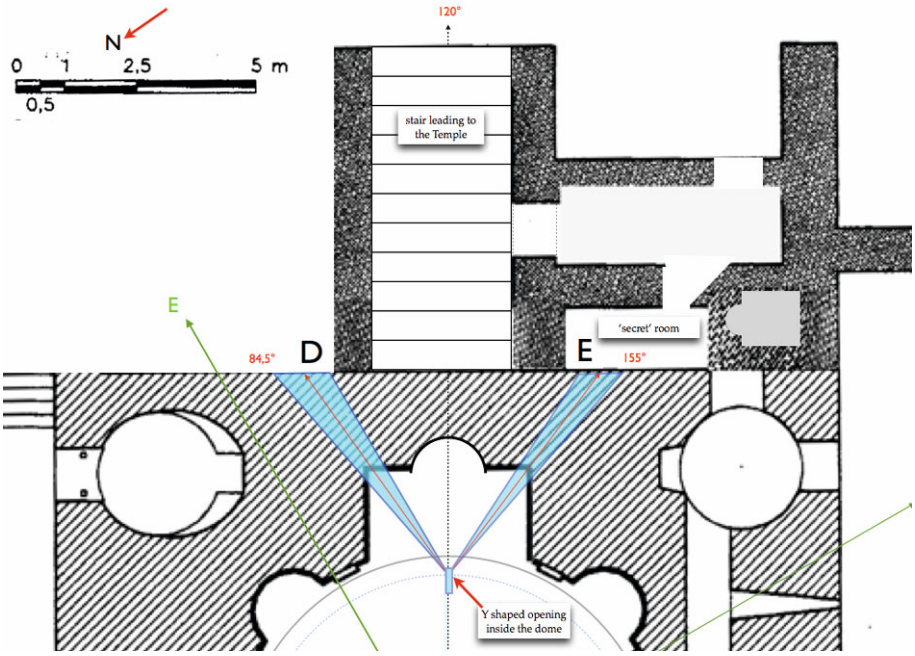

Fig. 29. Roccabruna, plan of conduits D-E and related 'secret room' (elaboration of fig. 27)

During our survey we discovered that from conduits D and E can be heard the voices of people standing in the domed hall of Roccabruna, and vice-versa. Therefore it is quite likely that conduits D and E were 'acoustic conduits' used to achieve 'magic sound effects' connected with the light phenomena of the solstice: people gathering in the hall for the sacred ceremonies on the summer solstice could magically hear music or voices (perhaps oracles) without seeing anyone [De Franceschini and Veneziano 2011: 139-143].

1.4.2 Winter solstice

Roccabruna once had a second floor with a circular temple (reconstructed from the marble fragments scattered on the ground) (fig. 30).

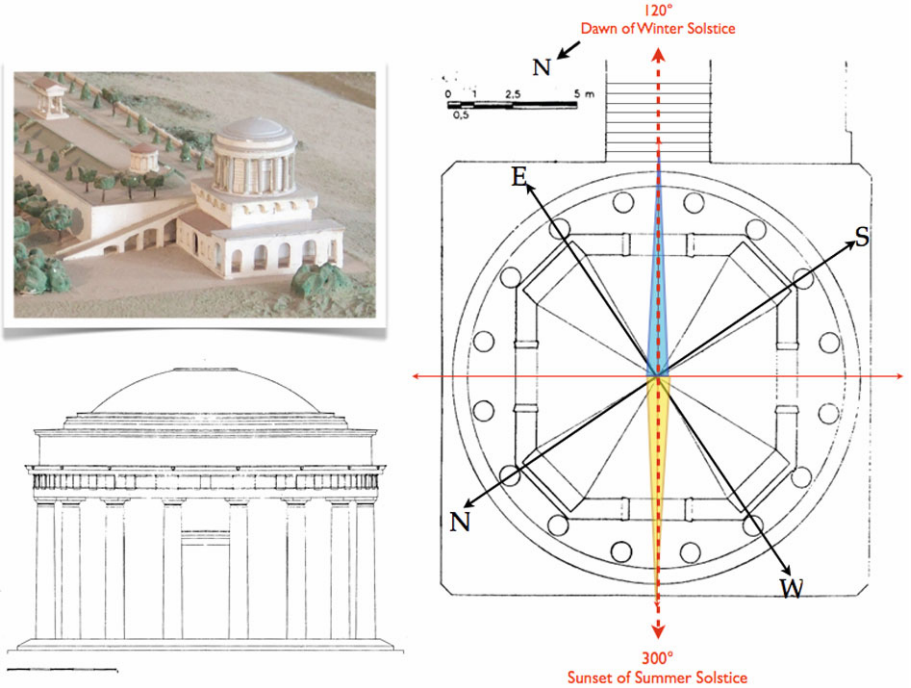

Fig. 30. Roccabruna: above left) Model; below left) drawing of the elevation of the Doric temple on top of Roccabruna; right) plan with astronomical alignments (elaboration from [Lugli 1940]. Photo: Marina De Franceschini

It had sixteen Doric columns and an inner octagonal chamber with one door and three large windows. The door and the window in front of it were aligned on the main axis of the temple, once again coinciding with the solstitial axis. On the summer solstice the rays of the sun entered through the window at sunset; on the winter solstice they entered from the main door at dawn.

1.4.3 Further research in Roccabruna

1. When did the sun enter conduit A? We plan to find out on which days the sun is low enough to send its rays inside conduit A. The date might be related to some astronomical or historical event (such as the *dies imperii*).

2. What light effects were created by the oculus of the dome covering the temple of the upper floor? The oculus was reconstructed in 1940 by Lugli and Bonelli [Lugli 1940], using the architectural fragments still visible on the ground (fig. 31). It is likely that the oculus created light phenomena as in the Pantheon of Rome: it could have been a giant sundial, signaling hours and seasons; or it could be related to special dates such as solstices, equinoxes, the *dies imperii* (11 August), or the *dies natalis* of Rome (21 April) and so on.

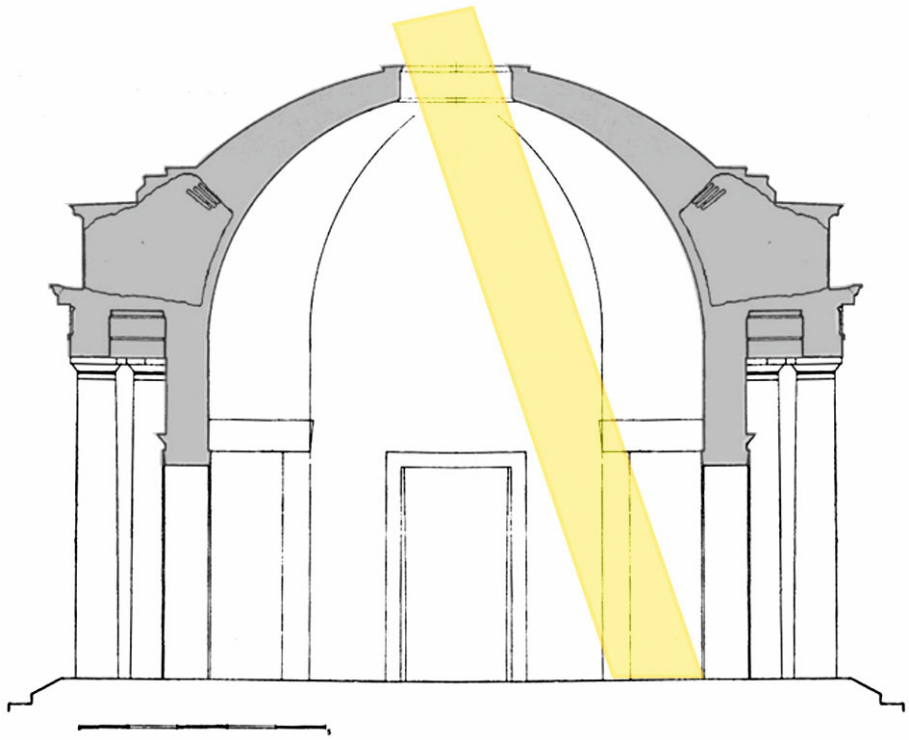

Fig. 31. Roccabruna. Possible light phenomena originated by the oculus of the temple on top of Roccabruna (elaboration of [Lugli 1940])

1.5 Archaeoastronomy in the Accademia Esplanade

The Accademia Esplanade is surrounded by retaining walls that have the same orientation of Accademia and Roccabruna, 120°/300°, corresponding to the solstitial axis. Once again, this is not a coincidence: we think that the Esplanade was a 'sacred landscape' [De Franceschini and Veneziano 2011: 110, 165-166] dedicated to the religious rituals and processions that were performed during the five days of the summer and winter solstices, when the light phenomena were taking place both in Accademia and Roccabruna. Elizabeth Lewis, who is currently studying and reconstructing the gardens of Hadrian's Villa, proposed a reconstruction of the landscape of the Esplanade considering the Solar alignments (fig. 32).

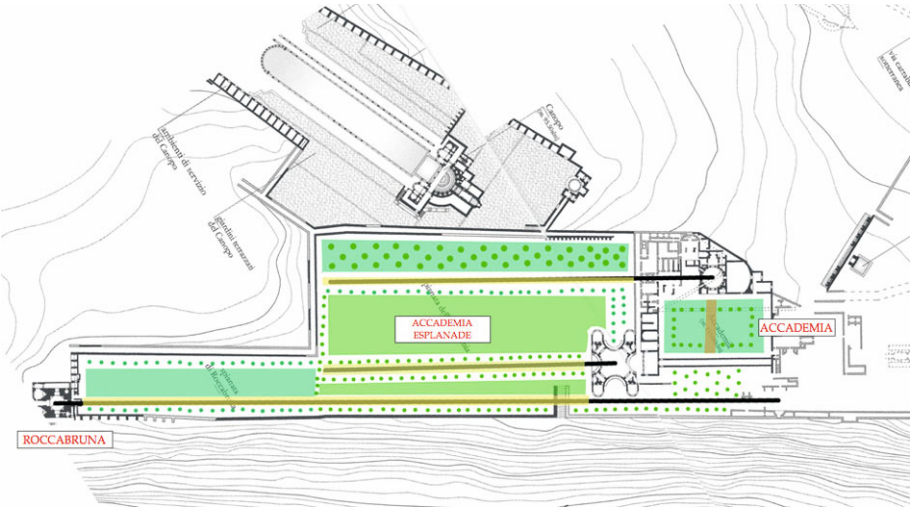

Fig. 32. Accademia Esplanade. reconstructive drawing of the gardens and Solar alignments. Courtesy of Elizabeth Lewis

1.6 Symbolic meaning

Archaeoastronomy gave us a new and effective key for the interpretation of Accademia, Roccabruna and the Accademia Esplanade. Modern and 'rational' science often ignores the sacred and spiritual aspect of the ancient world, underestimating its importance under the label of 'superstition'. But the Sacred is a key element for understanding the meaning and function of ancient buildings, to reconstruct the events that they were once hosting, bringing them back to life [De Franceschini and Veneziano 2011: 151, 169].

In Roman times, the solstices marked the most important feasts and religious ceremonies of the year. On the summer solstice there was the feast of Fors Fortuna, an ancient goddess who was later identified with Isis. In Roccabruna was found the base of a candelabrum [De Franceschini and Veneziano 2011: 162] decorated with the symbols of Isis. Isis was the most powerful Egyptian goddess, whose cult spread throughout the whole Mediterranean world: the queen of the sun and the stars, commanding cosmic events, destiny, seasons, crops [De Franceschini and Veneziano 2011: 162].

Taking place during the winter solstice, the Saturnalia was the most significant feast of the whole year. Its rituals partly survive in our Christmas tradition: banquets, candles, gifts and night vigil. It was the celebration of the end of the time cycle and of the old year, and propitiated the rebirth of the sun after its apparent death during the shortest days of the year. Originally dedicated to the ancient god Saturn, Saturnalia was later linked to the cult of Dionysus. Several Dionysian sculptures have been found in the Accademia: a young Dionysus, a Red Satyr and two Centaurs (fig. 33) [De Franceschini and Veneziano 2011: 160-161].

Fig. 33. Red Satyr and Young Centaur found in the Accademia. Photos: Marina De Franceschini

How can we bring together Isis/Fors Fortuna in Roccabruna and Saturn/Dionysus in the Accademia? The answer is Roman syncretism, which 'mixed' and joined different cults and divinities: the goddess Isis was the common denominator of all these symbols [De Franceschini and Veneziano 2011: 143-145, 164], since her husband Osiris was identified with Dionysus.

The winter solstice was connected with Dionysos/Osiris, the summer solstice with Isis/Fors Fortuna: Accademia and Roccabruna were astronomically aligned with both events. Isis and Osiris were related to the seasons, and to the positive/negative symbols of the universe: life and death, light and darkness, summer and winter. The sun was also a symbol of the imperial power, a tradition dating back to the pharaohs of Egypt and to the Hellenistic kingdoms, which was imported in Rome. Roman emperors identified with the sun [De Franceschini and Veneziano 2011: 158], becoming a medium between mankind and divinity. As Pontifex Maximus (an ancient religious figure), the Emperor supervised the Calendar, setting the dates of religious feasts, ceremonies and rituals, in all of which he played the most important role.[13]

This is why the Accademia Esplanade – the secluded Acropolis of Hadrian's Villa, whose height alone signified closeness to divinity – can be considered a 'sacred landscape' [De Franceschini and Veneziano 2011: 165].

The light phenomena of the solstice days in Roccabruna and Accademia signalled that the right moment had arrived for the religious ceremonies: there were probably ritual processions going from one building to the other, as described by Apuleius in his *Metamorphoses*.

2 Astronomical orientation of Accademia and Roccabruna

After the first pictures taken by Marina De Franceschini in June 2006 in the Accademia, in the Temple of Apollo, where a wall panel in the lower floor was illuminated by the rays of the sun shining from a window of the upper floor, our studies started from the orientation towards the sunset of the summer solstice given by professor Vittorio Castellani [Castellani 2006]. Thanks also to the discoveries of the American architects Robert Mangurian and Mary-Ann Ray – who first saw the light phenomena occurring in Roccabruna on the summer solstice – we understood that the Accademia Esplanade and its buildings all had an astronomical orientation.

We organized several surveys and inspections on the spot, which confirmed that during the solstices there were very significant light phenomena in the two buildings that we studied: Roccabruna (in the state-owned area) and Accademia with the Temple of Apollo (on the Bulgarini private estate).

The two buildings are located at about 350 meters apart from each other, and their geographical coordinates are the following (source: Google Earth):

Roccabruna:	41° 56′ 16.63″	North latitude
	12° 46′ 23.13″	East longitude
	100 m.	Height above sea level of lower floor
	110 m.	Height above sea level of upper floor

Accademia:	41° 56′ 12.32″	North latitude
	12° 46′ 39.56″	East longitude
	114 m.	Height above sea level

We then estimated the 'real' rising and setting points of the sun, as seen from the two buildings, during two of the most significant astronomical events of the year: the winter and summer solstices.

We also estimated the present azimuth of the points where the sun rises and sets today, considering the latitude of the two buildings, and we obtained the following data. On the winter solstice, the upper part of the sun rises at an azimuth of 122°19.5′ and sets at an azimuth of 237°19.4′; during summer solstice, the sun rises at an azimuth of 58°40.5′ and sets at an azimuth of 302°19.5′. According to the program Planetario 2.0 by Piero Massimino (Observatory of Catania, Italy), in year 125 A.D. – the year Hadrian's Villa was completed – the astronomical spring equinox was on 22 March, the autumn equinox on 24 September, the summer solstice on 23 June 23 and the winter solstice on 22 December.

The true inclination of the terrestrial axis on the ecliptic, as we saw before, is not consistent: within a period of about 41,000 years it spans from 22.1° to 24.5°. This variation causes a different sun declination in the sky. Using the Laskar Formula, we estimated the sun's declination at that time to be 23°40.5′. Considering these new parameters we re-estimated the azimuths of the sun,[14] shown in the following scheme:

Sun event	Azimuth in 2010	Azimuth in 125 A.D.
Dawn on winter solstice	122° 19.5′	122° 40.5′
Sunset on winter solstice	237° 40.5′	237° 19.5′
Dawn on summer solstice	57° 40.5′	57° 19.5′
Sunset on summer solstice	302° 19.5′	302° 40′

These values have been superimposed on an accurate plan of the Temple of Apollo (Ac78) measured and astronomically oriented by professor Friedrich Rakob with the German architects Faller, Helfgen and Krück during their surveys between 1991 and 1993 (see fig. 16).

The azimuths of some structures of this building showed a surprising coincidence with the azimuths of the sun. And – most important of all – we saw that at dawn of the winter solstice the rays of the sun penetrate into a series of rooms aligned along the main longitudinal axis, which passes through the geometric center of the Temple of Apollo; then the rays of light go further on, passing through the northwestern door of the Temple and the other rooms aligned on that side. The same phenomenon occurs on the summer solstice, with the rays of the sun following a reversed course, from northwest to southeast.

These two peculiar phenomena were followed (during the winter solstice) or preceded (during the summer solstice) by other striking 'light effects', when the sun, shining from the windows of the upper floor of the Temple of Apollo illuminates the panels and the doors of the lower floor, generating a 'magic' phenomenon that has a powerful symbolic meaning. Seen from the geometric center of the Temple of Apollo, these wall panels (which were framed by small columns) have a width of about 18°: if we consider that they were covered by a thick layer of plaster (still visible on the panels) their angular width could be 15°, corresponding to the angular distance covered by the sun within an hour; therefore the rays of the sun could move from one panel to the other on every hour.

Similar light phenomena were visible during the two solstices in the building of Roccabruna. The lower floor is oriented towards the sunset of the summer solstice, and during those days a rectangular spot of light appears inside the dome. The temple on the upper floor – where just the level of the pavement is preserved – was oriented towards dawn of the winter solstice; during those days, at dawn, the light entered through its main door.

3 Conclusions

Notwithstanding more than five hundred years of study, there is no complete and reliable plan of Hadrian's Villa, especially as far as orientation is concerned. Archaeologists just 'put an arrow with an N' and do not worry about accuracy, so there is a difference of several degrees comparing north in different plans. Further, previous surveys seldom used modern instruments such as GPS, Total Station or Laser Scanner.

The starting point will be drawing a new accurate and oriented plan of each building and of the whole villa, where real and precise alignments can be detected. After that, measuring and surveying on the spot is the only way to see if and how the surrounding hills interfere with the azimuth of the rising or setting sun, and to verify if other light phenomena where taking place on certain important dates.

Our archaeoastronomical survey in Accademia and Roccabruna gave such interesting results that obviously we presume that other buildings in the villa may have an astronomical orientation. We plan to survey and study the orientation of three of its most significant ones: the Maritime Theater, the Canopus and the Pecile, with the nearby complex of the Imperial Residence (Casino of Semicircular Arcades – Garden Stadium – Winter Palace – Small Baths), which is oriented east-west, and later to extend it to the whole villa.

We are certain that our research will open a new path towards new discoveries and studies, also for other scholars.

Notes

1. His book was printed a century later: Biondo Flavio, *Roma ristaurata et Italia illustrata di Biondo da Forlì. Tradotta in buona lingua volgare per Lucio Fauno. In Vinegia appresso a Domenico Giglio* (1558).
2. For a history of the excavations see [De Franceschini 1991: 5-16]; [Guidobaldi 1994: 22-43]; [MacDonald and Pinto 1995] and [Lavagne 2003: 55-62] (which refers to [De Franceschini 1991]).
3. A complete bibliography on Hadrian's Villa can be found in Marina De Franceschini's website: www.villa-adriana.net.
4. For the Accademia Pilot Project – conceived and directed by Marina De Franceschini – see her website on Hadrian's Villa: www.villa-adriana.net.
5. I am very grateful to Mrs. Daniela Bulgarini who gave me permission to survey and study the Roman buildings in her property.
6. On the lower floor there were ten panels and ten doors, but only seven doors and seven panels survive; on the upper floor were ten windows and ten niches alternating: seven windows and six niches are left.
7. Available published plans date back to 1950 [Kähler 1950] and 1982 [Salza Prina Ricotti 1982].
8. They surveyed the Accademia for the German Archaeological Institute of Rome, from 1991 to 1993 but their work was never published. I am very grateful to the late professor Friedrich Rakob and to architect Edmund Faller who generously gave me their precious documentation.
9. Giuseppe Veneziano noted that the twenty wall panels of the Temple of Apollo spanned 18° each; considering the plaster revetment, their width can be reduced from 18° to 15°, which is the arch that the sun covers in an hour.
10. The ratio between diameter of the dome and the diameter of the oculus is roughly 43.5 to 9 meters in the *Pantheon*, 13 to 2.68 meters in the Temple of Apollo.
11. There are some bizarre theories such as one of a giant armilla suspended from the dome; see [Cinque and Lazzeri 2010] and against that [De Franceschini and Veneziano 2011: 128-133, 127-128].
12. Just few lines in a brief article: [Mangurian and Ray 2008]. Robert and Mary-Ann generously gave us documentation and pictures, and wrote an Introduction about their discovery in our book [De Franceschini and Veneziano 2011: xv-xxii].
13. For the symbolic meaning of the solstice and related feasts see [De Franceschini and Veneziano 2011: 158-168].
14. Data were obtained with the dedicated program Starry Night Pro Plus 6.0; see [De Franceschini and Veneziano 2011: 197-199].

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About the authors

Archaeologist Marina De Franceschini graduated in Genoa, Italy, with professor Gioia De Luca and studied with Andrea Carandini at the University of Pisa. She also studied at Bryn Mawr College, in the United States, where her Master of Art thesis was on the mosaics of Hadrian's Villa near Tivoli (Rome). This study won the Erma di Bretschneider Prize and was published in 1991: *Villa Adriana, mosaici, pavimenti edifici*. It was the first systematic survey of the villa with room-by-room catalogue entries. In the following years she studied other Roman villas and published two other books: *Le Ville romane della X Regio Venetia et Histria* in 1999, and *Ville dell'Agro romano* in 2005. Starting in 2005 her Accademia Project (see her website www.villa-adriana.net) studied one of the lesser known areas of Hadrian's Villa, the Accademia Esplanade with the buildings of Accademia and Roccabruna. The results of these studies will be published in a series of forthcoming books. Together with archaeoastronomer Giuseppe Veneziano she published the book *Villa Adriana Architettura Celeste – I segreti dei Solstizi*. For the first time were discovered astronomical orientations in Hadrian's Villa, opening new paths to the understanding of the meaning and function of its buildings.

Giuseppe Veneziano was born in Genoa, Italy, studied Biology at the University of Genoa and presently works in a major steel industry there. For thirty years he studied astronomy, focusing on comets and stellar spectrography. He enrolled in the Popular University of Sestri (near Genoa); for many years he was secretary and is presently the director of the Astronomical Observatory of Genoa. He was one of the founders of the Associazione Ligure per lo Sviluppo degli Studi Archeoastronomici (ALSSA), one of the first in Italy for the study of archaeoastronomy; every year they have a conference on this subject. Besides being president of the ALSSA he also is a member of the Società Italiana di Archeoastronomia. His archaeoastronomical studies have led to important discoveries, such as a new hypothesis on the Bethlehem Comet and the equinox precession. He took active part in the study of the so-called Roccia del Sole (the Rock of the Sun) in Val Camonica near Brescia, Italy, together with Giuseppe Brunod and Mario Cinquetti: they discovered that it was a special sundial for keeping track of the seasons. Since 2009 he has worked with Marina De Franceschini in Hadrian's Villa, co-authoring the book *Villa Adriana Architettura Celeste – I segreti dei Solstizi*, published in 2011.