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DISEÑO ACÚSTICO DE LA SALA DE CONFERENCIAS EN LA BIBLIOTECA DE VIIPURI: UN ESPACIO POLIVALENTE

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Resumen
La sala de conferencias de la Biblioteca de Viipuri de Alvar Aalto (1935) es uno de los ejemplos más citados de la unión entre acústica y arquitectura, además de ser uno de los principales ejemplos del Movimiento Moderno.
A lo largo de las últimas décadas se han llevado a cabo múltiples investigaciones comparando este espacio con otras salas de lectura y estudiando en particular la curvatura de su techo. Nuestro trabajo recoge los estudios más recientes, introduce nuevas herramientas de diseño y muestra las distintas configuraciones espaciales que este espacio podría ofrecer en función de la actividad desarrollada. El objetivo de esta investigación es retomar la denominación original dada por Alvar Aalto de “sala de discusión”, donde múltiples oradores en distintos puntos de la sala podrían obtener una inteligibilidad a la palabra adecuada para el resto de la audiencia.

Palabras-clave: sala de conferencias, inteligibilidad, espacio aural.

Abstract
The Lecture Hall in Alvar Aalto´s Viipuri Library (1935) is one of the most cited examples of the link between acoustics and architecture, besides being one of the main examples of the Modern Movement. Over recent decades there have been multiple researches comparing this space with other lecture halls and studying the curvature of its roof. Our work includes recent reviews, introduces new design tools and shows the different spatial configurations that this space could offer depending on the activity. The aim of this research is to return to the original name given by Alvar Aalto “discussion room” where multiple speakers in different positions of the room could provide a proper Speech Intelligibility for the rest of the audience.

Keywords: lecture hall, intelligibility, aural space.

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1 Introduction

The Viipuri Library, a project based on a competition entry from 1927 and built by Alvar Aalto between 1934 and 1935, soon became an icon of Functionalism and of the Nordic approach to Modern Movement. During the Finnish-Russian war in 1939-44 the building was severely affected by degradation and abandonment but it managed to survive, and after undergoing a humble refurbishment post World War II it continued acting as the (now Russian) Vyborg municipal library.

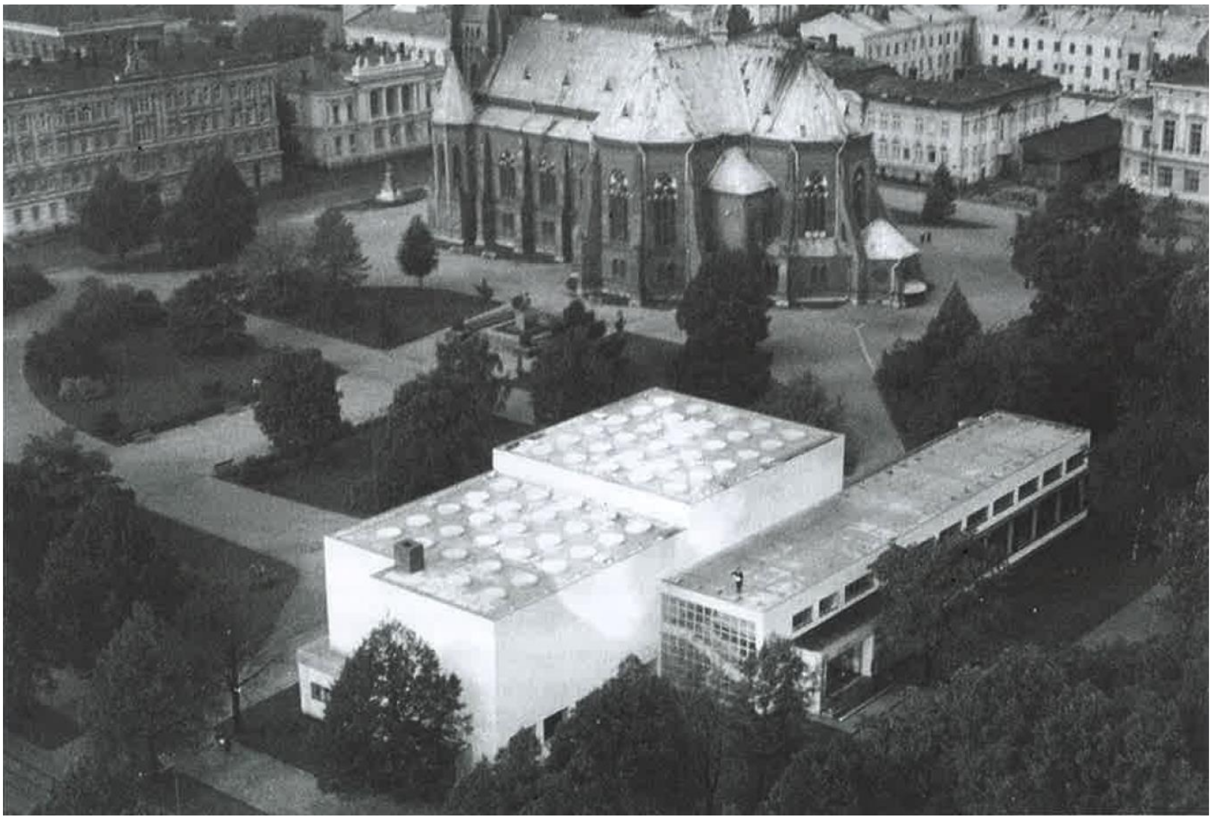


Figure 1 – North-East aerial view, 1935.

The legacy of the building would pervade and once recovery works started in the early 1990s it has become a new icon, now as an example of restoration of and respect for modern architecture.

Figure 2 – North view through trees, 2012.

This paper, in a sense, aims at redefining one of several myths the building has fed since the early days: that of the "scientific reasoning" that could "prove through acoustic diagrams" the high sound performance of the lecture hall.

The myth was reinforced by none other than Sigfried Giedion in his Bible of Modern Movement, *Space, Time and Architecture* [1]:

> *In the intimate hall of the Viipuri Library the irrational curves of the ceiling glide through space like the serpentine of a Miró painting. Of course, the architect himself can prove, with meticulous acoustic diagrams, that the undulating form he gave the ceiling enables sound to reach the human ear more perfectly. Here, therefore, scientific reasoning and artistic imagination have merged to free architecture from that rigidity which is today an ever-present menace.*

But, accepting Aalto's honest interest in improving the acoustic performance of the discussion room in Viipuri, a space otherwise long, short and straight, the fundamental question remains: was it achieved? Recent scholars as Mortensen (2003), and Blundell Jones / Kang (2003) think the short answer is no. The last two authors have an interesting remark [2]:

> *The wavy ceiling might not have been entirely useless in acoustic terms, however, for the curves covered up a series of downstanding structural beams that would have made acoustic compartments with unwanted resonances. (…) Thus if the ceiling is less than credible as a positive acoustic measure for the reflection paths it creates, it is at least effective as a negative measure, for preventing other acoustic problems that might otherwise have arisen.*

Our research continues upon this line and provides a twist not yet analysed: the possibility that the acoustic design was intended by Aalto to allow for the double use of a single space: sometimes as a lecture hall and others as a discussion room. The name of the space in Aalto's project drawings appears as "Kerhohuoneita" that can be translated as Club Rooms. The plural is relevant: this space is not univocal but multiple, adaptable, as the compartment curtains between columns and the use of different chair furniture seem to show.

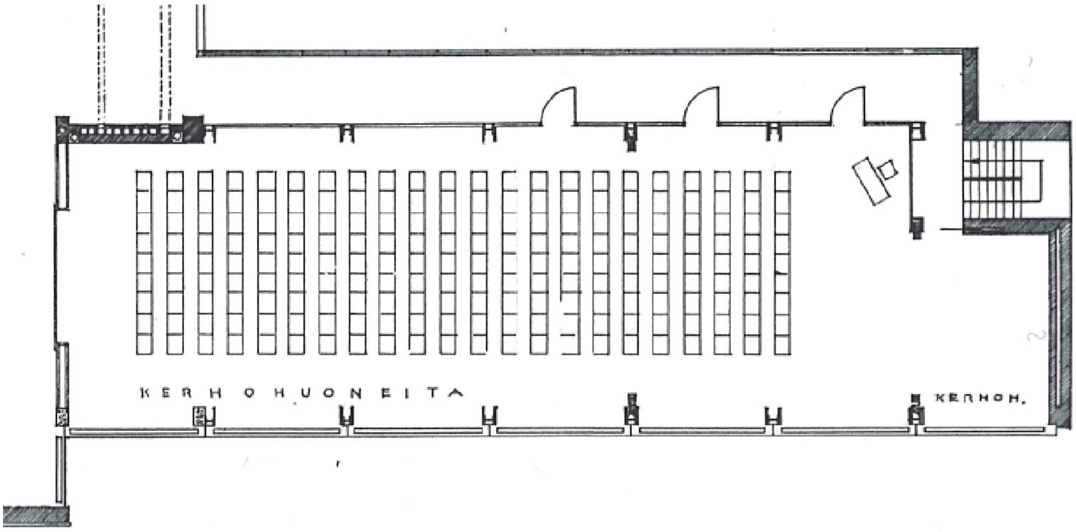


Figure 2 – Plan of the *Kerhohuoneita*, Finnish word for "Club Rooms"

One thing is for certain: the undulating ceilings would become, with better or worse visual results, equivalent to acoustically improved spaces; and have been used many times by architects along the 20th century. Starting with Viipuri Alvar Aalto would focus on the matter of acoustic treatment of inner spaces in his future work, paving the way to many other architects.

2 Acoustical analysis of Viipuri discussion room

In the Modern Movement there are existing examples where acoustic design and architecture are shown as a successful match. One of these buildings is the Viipuri Library (Finland, 1935) designed by Alvar Aalto including a discussion and lecture room. This space would become one of the most celebrated acoustic designs in the early 20th century due to its wave shaped ceiling, designed to enhance the acoustic of the space. In the last decade, numerous publications and papers have been written discussing this space, in particular related to its shape [2] and its corrugated ceiling [3]

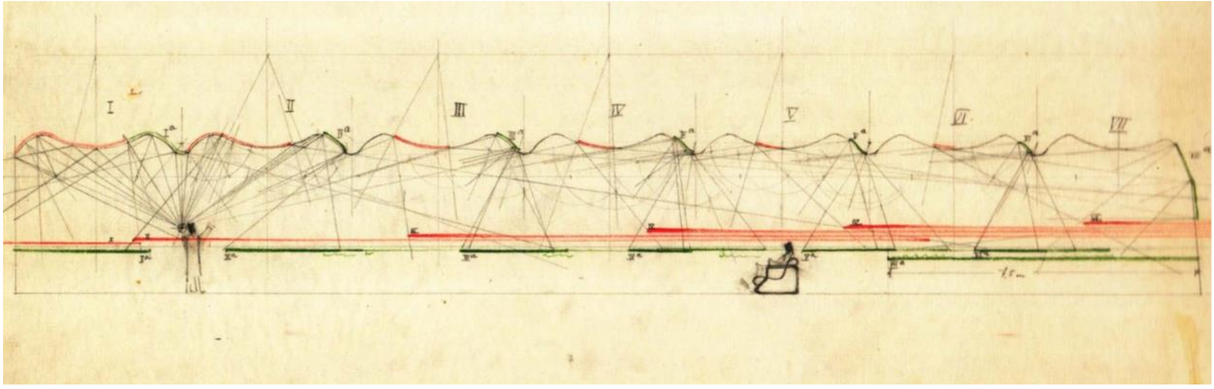


Figure 3 – Discussion room handmade section

Most of the published information related to the Viipuri lecture hall analyze the acoustic behavior of the internal enclosure as a whole. In general, most of the acoustic studies show a position of receivers and transmitter in the same place for both situations; lecture hall and discussion space.

The acoustic analysis of any building must take into consideration the function of its spaces as the starting point of its design. As shown in the acoustical study of larger spaces as Cathedrals and their liturgical configurations [4], inner spaces can be clasiffied according to several categories:

-Architectural space: corresponds to the physical space limited by the enclosures. It could be linked to a purely visual experience.

-Liturgical / functional space: It is the space were different events take place inside the architectural space and it usually corresponds to the area where the listeners are located.

-Aural space: also known as "acoustic space"; it is the part of the architectural space in which a sound event is perceived according to the aural expectations, characterized by the interaction between sound and room properties. The boundaries of the aural spaces are delimited by the acoustic horizon, the maximum distance allowed in which the sound event is heard. The region centered in a sound event where attendants are part of a community of listeners is defined as the acoustic arena.

With this range of spaces clasiffication, we can find the case where an architectural space is divided into different aural spaces. This in the case of the Viipuri Library, where a defined architectural space has two contiguous aural spaces: the lecture hall and the discussion room.

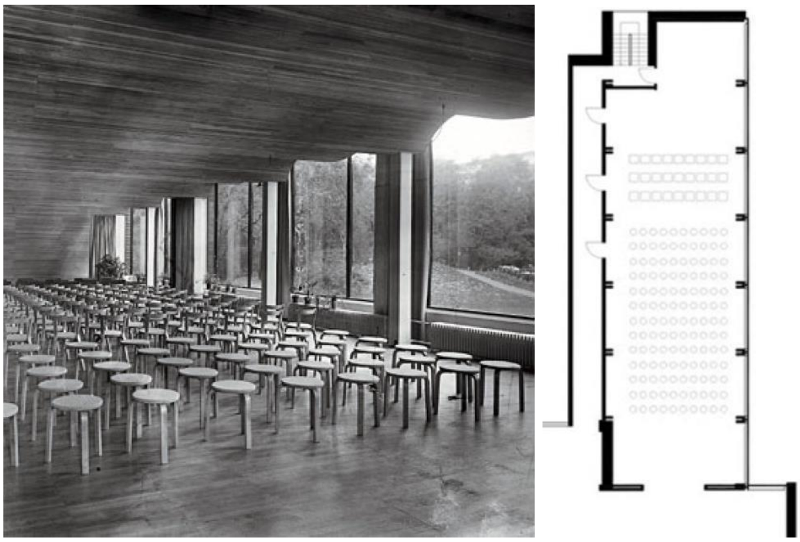


Figure 4 – Discussion room furniture selection

As shown in the figures and in the initial design of Alvar Aalto, elements as the chairs identify these two spaces, modifiying its finish and materiallity according to the aural space to whom they are linked. Padded chairs with a clear seat direction were used for events with a sound source in one position, using the space as lecture hall. Chairs without backrest and no clear seat direction were used for the discussion room aural space.

In recent photographs taken after the last architectural refurbishment, previously lost elements such as drapes appear that could have been used to separate both spaces, while changing the acoustic conditions of the discussion room. This approach seems to have gone unnoticed so far, probably due to the lack of information and visual references.

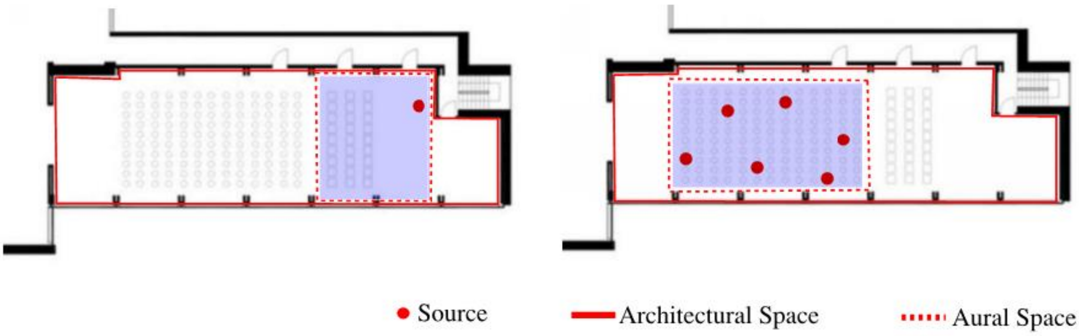


Figure 5 – Proposed aural spaces: left image, lecture hall; right image, discussion room

The authors have not been able to conduct in-situ measurements in the original space to determine its acoustic performance, but numerous acoustic models and simulations have been carried out in the last few years. Several acoustic 3D models have been developed by Arup for this research, with different sound source positions to study the space acoustic performance taking into consideration the two aural spaces.

In order to study the Speech Intelligibility, STI (Speech Tranmission Index) is evaluated. STI predicts the likehood of sillables, words and sentences that a receiver can comprehend. Its expresion is a numeric scale representation (from 0 to 1)

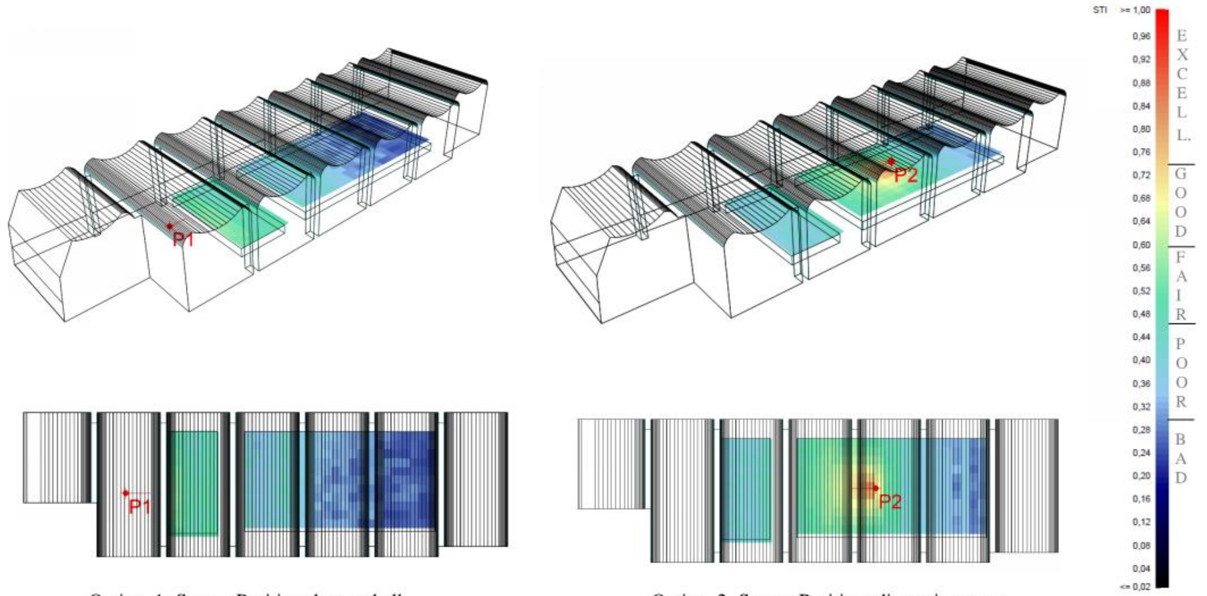
Table 1 – STI values

STI Value	Subjetive scale
0.00-0.30	Bad
0.30-0.45	Poor
0.45-0.60	Fair
0.60-0.75	Good
0.75-1.00	Excellent

2.1 Results and discussion

The analysis of the values for the room acoustic parameters with the sound source in the *lecture hall position*, show that according to the STI values, the optimum (Good/excellent) positions are near the speaker position. In farther away positions the STI classification would be considered as “fair-poor”

When the sound sources are located in several positions in the mentioned *discussion room position*, the STI values vary noticeably, obtaining a clasiffication of “good-Excellent” in an wider area



Option_1- Source Position- lecture hall

Option_2- Source Position- discussion room

Figure 6 – STI graphical values

These values reinforce our hypothesis of an architectural space with two aural spaces, supporting the architect’s intention of having a space with different uses. If we combine the obtained results with the proposal of aural spaces, we observe a clear correlation.

3 New simulation tools developed by Arup

Back in 1970 Sir Ove Arup spoke to his partners, in response to the changes the company was facing as the founding partners were retairing. This is known as the “Key Speech” [5]. One of the most relevant topics is the term *‘Total Architecture’* which implies that all relevant design decisions have been considered together and have been integrated into a whole by a well organised team empowered to fix priorities. This is an ideal which can never - or only very rarely - be fully realised in practice, but which is well worth striving for, for artistic wholeness or excellence depends on it, and for our own sake we need the stimulation produced by excellence.

One of the challenges of architects and engineers is to understand how they can deal with the different variables and issues that take part in the design process. This challenge can be identified briefly on the following complexity sources [6]:

- Geometrical Complexity
- Human Complexity
- Technological Complexity
- Constraint Complexity

The digital transformation that the design practice has been undergoing for the last decades has opened oportunities to develop more integrated tools which are able to cope with many variables and issues, allowing designers to strive for the aim of “Total Architecture”.

The tools being developed at Arup over the last years focus mainly in the ability to reduce the geometrical complexity of a project by the use of parametric modeling techniques. There is now the opportunity to have a clear understanding of the bounce of sound on multiple surfaces from different sources.

As we are able to encapsulate the logic behind, we can test many different cases. The internal “MultiBouncer patch” tool allows designers to interact with the geometry of the space and the source point in order to be able to understand, almost in “real time”, the implications of any design decision and how the sound is being reflected.

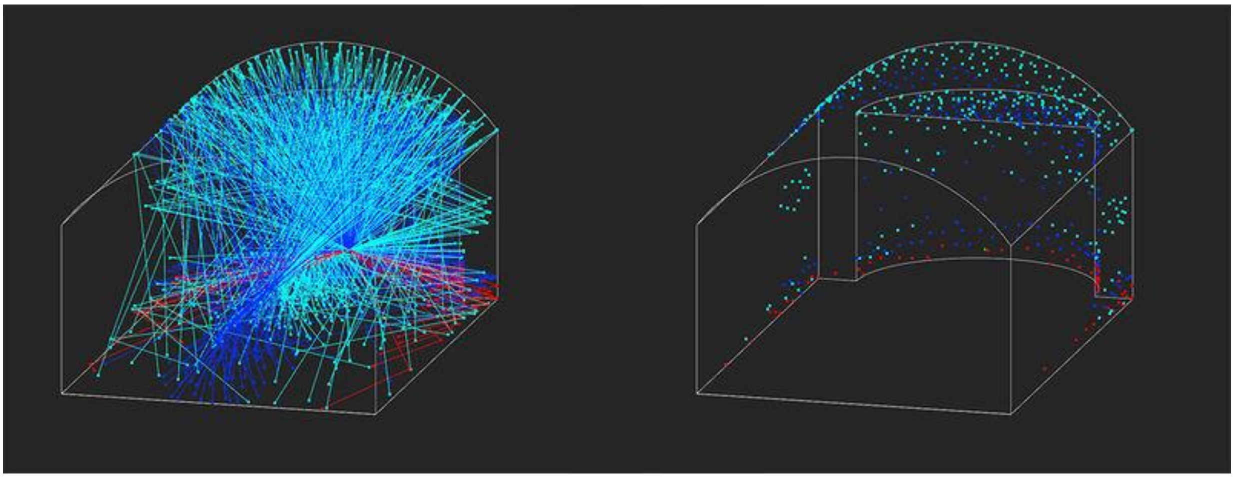


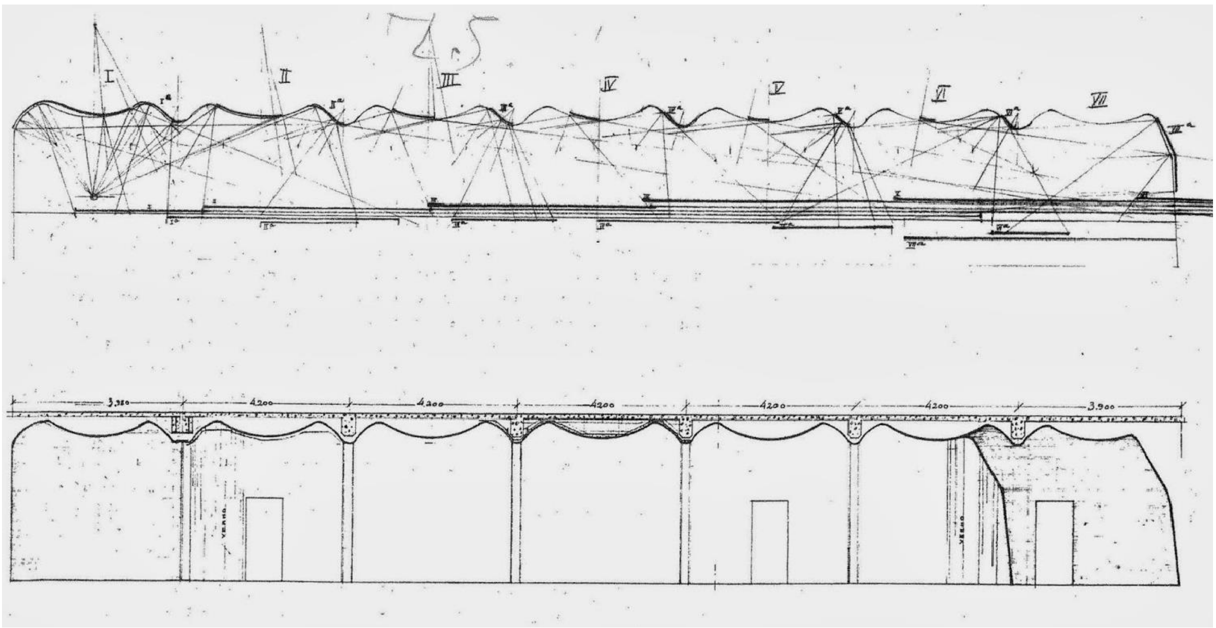
Figure 7 - Static Display in time window mode with all components shown (l) and bounce points only shown (r)

This tool has been developed with a visual programming tool like Grasshopper3d which allows the user to layout the logic behind the problem we would like to solve. The use of these visual tools and similar ones have allowed to improve the workflow in design, allowing us to take more informed decisions on the design or understandig better the implications of those.

4 Conclusions

The Viipuri library has become an architectural icon and one of the most celebrated acoustic designs in the early 20th century due to its wave-shaped ceiling, one of the first examples where acoustic design and modern architecture are shown as a successful match.
The results obtained and the existing information reinforce our hypothesis that Alvar Aalto designed the Viipuri Lecture hall / discussion room as a unique architectural space with two aural spaces, making our assumption reasonable.

This space has been historically attributed with “geometrical” acoustic qualities that the building does not have. This situation was mainly caused due to the lack of information and the powerful visual impact of the curved ceiling. As Blundell and Kang remarked, the curved ceiling was not created as an acoustic measure to control the reflection paths.The architectural plan sections show that the ceiling design responds to an architectural problem of small free height and as an unique solution to hide the structural beams. A comparison of the acoustic performance of this space with undulating ceiling and without it was carried out by Bo Mortensen [7], showing that the acoustic performance in both situations could be considered similar.



Alvar Aalto’s design does not control the reflection paths but it improves significantly the acoustic performance of the room, avoiding unwanted reflections and resonances that the concrete beams may have caused. This design concept is one of the first examples of architectural approaches to design room shapes in order to avoid unwanted sound reflections using geometry in modern architecture.

This design example enhances the importance of creating new design tools, as the ones being developed by Arup, which will help designers and researchers to take more informed design decisions for a better understanding of their acoustic options.

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