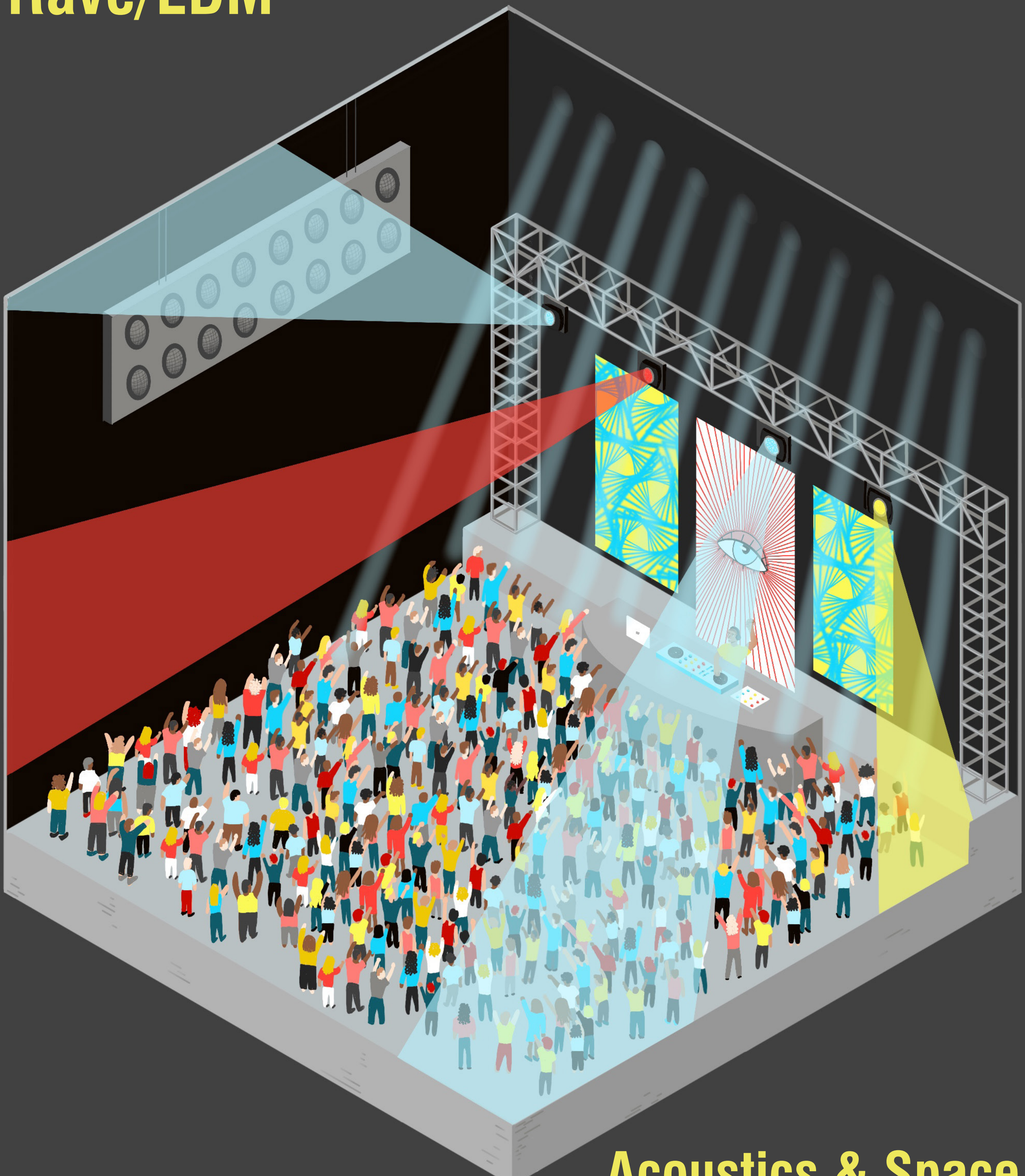
The Ideal Environment:
Rave/EDM



Acoustics & Space

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RESEARCH REPORT

A Study of The Ideal Acoustical/Spatial Environment for Rave/EDM Performance Spaces

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By examining the types of space raves inhabited, from the predominate 90's anarchist grass-root origins of the urban undergrounds to today's contemporary youth in vast landscapes of commodified festivals and clubs, as well as their generational socio-cultural implications, I question: what would the ideal 21st century rave space be? This is my overarching thesis question on a broad level, where for this journal research study, I break it down into a smaller area of focus, such as acoustics and space. This study involves identifying the ideal architectural acoustical and spatial characteristics of rave performance spaces, focusing on a diverse range of past and present exemplar performance spaces and their physical, mental and emotional perceptual experiences – both objectively and subjectively.

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Introduction

The system of inquiry for this research is both a quantitative-deductive process and qualitative-inductive, combining both overall to test my theories of the ideal acoustical spatial environment for Rave/EDM performances and their changing phenomena. I will approach my theories from the bottom up, gathering the info I need, that will give me the generalizable knowledge to help design and simulate the ideal space. People's perceptions and experiences of the space, whether old abandoned warehouses, underground clubs, or festivals are important as I require empirical input, to inform design ideas, to evaluate through simulation.

The qualitative research methodology is inductive, collecting non-numerical evidence of the participants reactions to a diverse range of rave environments and their preferred conditions spatially and acoustically. This qualitative analysis will investigate the verbal (oral, written), experimental (film- actions/reactions of people in the space), and artificial (the space itself) implications of the users and the space, in order to evaluate the preferred conditions(Groat, 2013, p. 69). The quantitative research methodology will be a deductive process, taking the observed qualitative architectural implications of the past and present spaces, fragmenting and articulating them through experimentation, then testing them through simulations. The simulations will experiment with a diverse range of acoustical and spatial environments, where data will be collected by testing an array of acoustical variables in relation to spatial implications.

By synthesizing these two methods together, I can test multiple theories to determine how the physical environment can enhance the sound and space sensibilities of the users in a holistic manner. This combined method relies on the empiricist outlook, where I depend on people's sensual experiences within these environments to gain the knowledge that I need in order to test my theories by simulation. The simulations are reconfigurable, meaning as I find out more information, I can easily input it into the simulation software program to adjust the spaces for specific goals and optimal decisions. The software used for testing my theory is specifically designed for spatial audio simulation, where I can simulate the ideal space through virtual audio environments. The goal here is to simulate the optimal solution by exploring options and evaluating what works and what doesn't. Referring to Plato's philosophy, the nature of reality is deceptive, aiming to represent how the spaces could be not how spaces are, especially as the phenomena is constantly changing with time and today's innovative technologies.

My motivations for this study fall under both personal interests and practical interests. My personal interest that sparked this study is my handful of experiences at raves, which have been incredible and inspiring, both indoors in clubs as well as outdoors for festivals. The amorphous blending of sound, light, space, and bodies is what really inspired me to study the diverse range of rave performance spaces from their historic to contemporary times - to theorize the ideal acoustical and spatial environment.

My practical reason for this study is to practice my research skills in a more organized fashion, to which I can generate new knowledge and hypothesize and test new ideas. With this, it opens my horizons to different practices in architecture, such as the pursuit of research, which is becoming more common within firms. One last unifying motivation for this study is that it helps lead me into my thesis project which will be taking these solutions of performances spaces and incorporating them under one roof as an architectural whole, that provides people with a diverse range of rave performances spaces that are linked together. Overall providing the ideal acoustical space to be in for raves that helps to amplify the users physical, emotional, and spiritual responses.

The intended audience of this study and my findings sits at both a micro and macro levels. The micro level audience consists of the NDSU architectural community such as professor, Ganapathy Mahalingam, and my classmates who I will be updating on my status and findings. Also sitting at this micro level is other fields of study within the NDSU institution, who may be able to access my work through the libraries database. The intended audience on a macro level consists of specialty areas, such as acoustical specialists, set designers, and any other architects or engineers interested in performance spaces. The rave audience is also intended, as the study is formed around them, so as much as the consumers themselves, the producers (DJ's), and the organizers of the venue (promoters).

Methodology

For my methodology, simulations of the ideal rave performance space will be my primary strategy, but it is combined with qualitative research to find out the preferred acoustic and spatial variables for the space. In order to start the qualitative research method, I need a space, or multiple spaces, to gather the verbal and experimental data from the users in the space itself. Applying research into both historical and contemporary dance/night clubs will help me find this space, where I can then proceed with my qualitative research of gathering and analyzing people's perceptions and experiences of the space. This qualitative research will need to produce enough information for me to articulate the ideal space, model it, then input it into the simulation and evaluate its output.

The tasks I will pursue to find the optimal solution will be to establish my findings of the conditions of the ideal space – informed by prior qualitative research – then creating a variety of 3D models that represent the ideal space. The spaces will be modeled in SketchUp, then transferred into the programs EASE 4.4 and Audio 3D which are spatial audio simulation systems. Once in EASE 4.4 or Audio 3D, I can replicate all the relevant variables in a holistic manner, listen to the sound feedback of the space (through software Audacity), adjust the spaces for specific goals and optimal decisions, then test and analyze the results.

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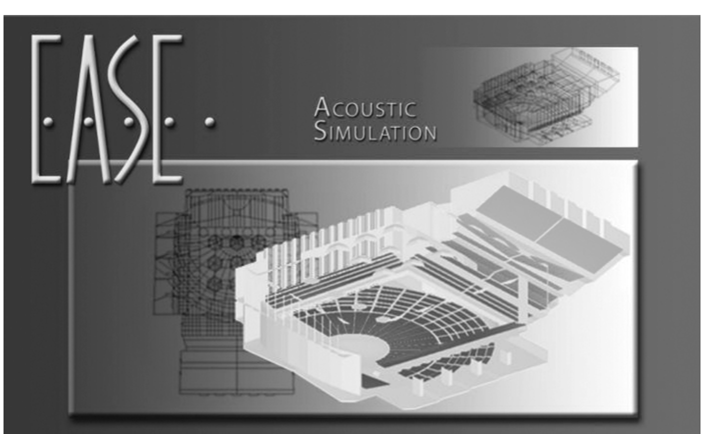
EASE 4.4 - Intoduction to Simulation

The EASE software program provides system designers and consultants with a valuable tool set for many sectors of professional practice. These range from detailed, realistic modeling and simulation of venue acoustics and sound system performance to informative and engaging client presentations as well as professional data assessment and verification (AFMG, 2019). Simulations are an architectural research strategy that takes the guesswork out of the system design where preliminary design ideas can be imported and programmed so the spaces can be experienced and tested virtually – helping to eliminate costly mistakes and reducing installation time in the real world.

The strength of simulations for my case allows me to learn about the ideal acoustical performance space and its properties for a variety of my preliminary ideas, where I can then adjust my design ideas for specific goals and optimal solutions. As I generate more knowledge about acoustical properties and the sound/space relationship, I can go back to the main model and reconfigure it overtime. To help me learn more about this relationship, I produce qualifiable reenactments of past venue spaces (replication of real-world settings) and their audio-visual implications, which will help aid my theory building as I analyze and test their designs through simulation. This historical research also allows me to investigate the technical advances in such buildings overtime, understanding the trends in performance spaces and the cutting-edge acoustical treatments. Overall, simulations are the representation of behavior or characteristics of one system, through the use of another system, which in turn make envisioned realities real ones.



[Fig. 1]: EASE 4.4 Acoustical Software

Strengths:
- Used as a tactic in research strategies
- Data can be triangulated with data yielded by other means for more robust results
- Support for theoretical claims and supplementing the findings, helping to prove either true or false

Weaknesses:
- Can’t be real life environments
- Determining what amount of input data will lead to outcomes at best satisfice

Introduction to General Step procedures:
The next section will outline my generalized steps taken in order to start producing the acoustical outputs of the space. First you need a model, where you can either construct one using EASE software or through a SketchUp file. After importing the model, you set up the acoustical variables of the space, such as setting surface materials, positioning desired speaker locations as well as the positioning of individual listener seats or grouped audience areas. This sets up the key relationship between sound sources and specific listener areas which is the main step in order to start producing simulations of the space. The first general simulation procedures I examined were Ray Tracing, Ray Tracing Impacts, and Auralization. I will further briefly introduce what these are and what they show before listing the steps to produce them.

RayTracing: The EASE software uses RayTracing to study the propagation of all sound rays and their relation to the sound source and the unifying space. Here, rays are released into the room where each ray path is traced until it reaches predetermined limits. The idea of RayTracing revolves around the understanding of reflection patterns within the room by emitting rays whose reflection paths ca be viewed and investigated.

RayTracing Impacts: RayTracing impacts are viewed through the Trace File, which is computed following the RayTracing itself. In a click of a button, you can see all the rays or just the bounce points of the space. It also allows you to examine certain loudspeakers and their impacts by turning them on and off individually, enabling you to study the reflection pattern of each loudspeaker reflection pattern.

Auralization: Auralization is the process of converting the acoustic and electro acoustic data generated by EASE into an audio signal that can be listened to and evaluated through EARS (a binaural auralization program). It adds subjective listening to the evaluation process.

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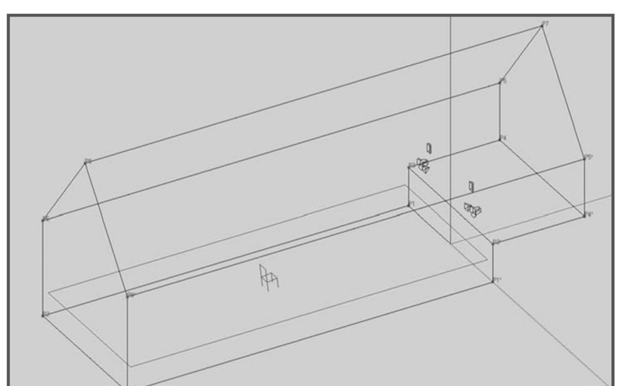
EASE 4.4 – General Step Procedures

1. **Importing Model**
    a. Open EASE 4.4
    b. Main screen window will open
    c. File – Create new project
    d. (Note: changing scale units from Meters Squared) File – options – settings – Set to Feet Squared before Import
    e. File – Import/Export – Opens new window
    f. Tools – Import DXF file – Pop-up window (Data of project? – yes – Cleans project up)
    g. Locate Project (SKP file) – OK
    h. Main screen window opens again – Select Room Edit folder – Select Modify Data folder
    i. (Small pop-up windows – assign Wall materials – Click ok)
    j. Asks to save file – Save as FRD file
    k. (pop-up – reopen import/export window? – No)
    l. Reopen minimized tab to EASE main screen
    m. Main screen window opens again – Select Room Edit folder – Select third folder – Opens modeled project – Maximize screen
    n. Tools – Check for holes – OK
2. **Getting Materials**
    a. Edit – Select Project Database – Select wall materials
    b. (pop-up window) – Full – Global Materials – Select all – Add – Done
3. **Getting Speakers**
    a. Edit – Select Project Database – Select Speaker Models
    b. Click on Speakers (Choose any type of manufacturer – Ex, Yamaha)
    c. Select all speakers within manufacturer – Add – Done
4. **Surface Materialization**
    a. Start applying materials to planar elements (walls, floors, ceilings, etc.)
    b. Click Plane – Right click – Properties – Select Material - Apply
        Ex.) Ceiling: Reflective: Gypsum Board – OK
        Floor: Absorber: Heavy Carpet – OK
        Rear/Front walls: Absorber: Curtain – OK
        Stage: Reflective/Absorber: Wood Floor – OK
        Side Walls: Reflective: Perforated Panels – OK
5. **Placing Listener Seats**
    a. Insert – Listener Seat – Place
    b. (Note: Positioning and orientation of listener seat to be double checked within all views – 3D, Plan, Elevation)
    c. To adjust the placement or orientation – click on chair – Right click – Properties – Adjust X, Y, Z variables for preferred location
6. **Placing Speakers**
    a. Insert – Speaker – Place
    b. (Note: Positioning and orientation of speaker to be double checked within all views – 3D, Plan, Elevation)
    c. To adjust the placement or orientation – click on chair – Right click – Properties – Adjust X, Y, Z variables for preferred location



[Fig. 2]: Listener/Speaker Placement

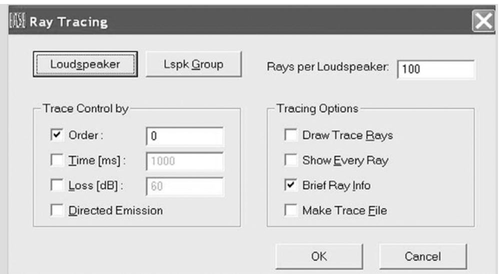
7. (Note: Check Holes and Check Data/Room Data at Interval Times – Making sure model is acting properly)

8. **Ray Tracing**
   a. return to the Main menu - open the Calculations pull down menu - Selecting Ray Tracing will open the Prompt shown to the right.
   b. Click Yes for View Project
   c. This will open two windows, the main Ray Tracing control window and the Ray Tracing View Project window
   d. Select the Rays pull down menu in the Ray Tracing Control window - Click on Ray Tracing. This will open the Ray Tracing setup
   e. Check – Order: 10 Reflections for Each Ray
   f. Check – Time: 5,000 (ms) – 5 Seconds
   g. Check – Draw Trace Rays
   h. Check – Make Trace File
   i. Rays per Loudspeaker: 900
   j. Select Loudspeaker – OK – Save Trace File – Once saved, it runs the file
   k. (Note: Check for holes, check scale, check data/room data)
   l. (Check orientation of surface faces: a white outline on a picked face means that you are looking at the outside (the non-exposed side) of that face. Yellow means you are looking at the inside of that face (the reflective side), the side that should be facing into the room.

9. **Viewing Ray Tracing Impacts**
   a. Select Loudspeaker
   b. Select Seat
   c. Time: 5,000 (ms) – 5 Seconds
   d. Check: Draw impact File
   e. Check: Read Trace File
   f. Check: Make Impact File
   g. Click OK
   h. Pick Trace File for Reading (TRC) – Open
   i. Save Impact File (MPC)
   j. Rays - Save as a Response File (RSP)
   k. Close Out of Windows

10. **Auralization**
   a. Go back to EASE main screen – Click on Auralization Tab
   b. File – Open Response File (RSP)
   c. Edit – Make Binaural Response
      - (pop-up – Leave everything as Default)
      - Show filter info -Yes
      - Provides an impulse response file for that seat – Save
   d. Tools – Auralization
      - Check: Convolve
      - Load it
      - Play it
      - Evaluate
      - To Save: File – Open Filter File – Select (BIR) File - Output audio folder - save

8.d



[Fig. 3]: Ray Tracing

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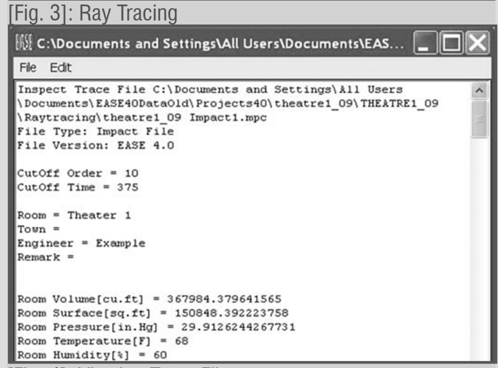

[Fig. 4]: Viewing Trace File

9.a

[Fig. 5]: Finding Impacts

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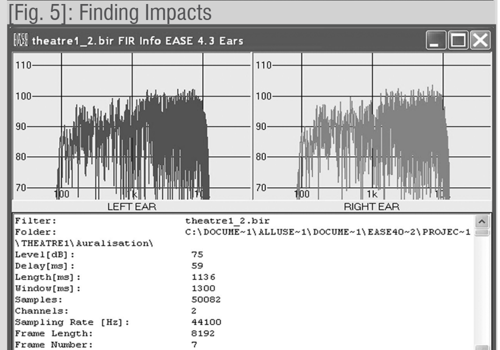


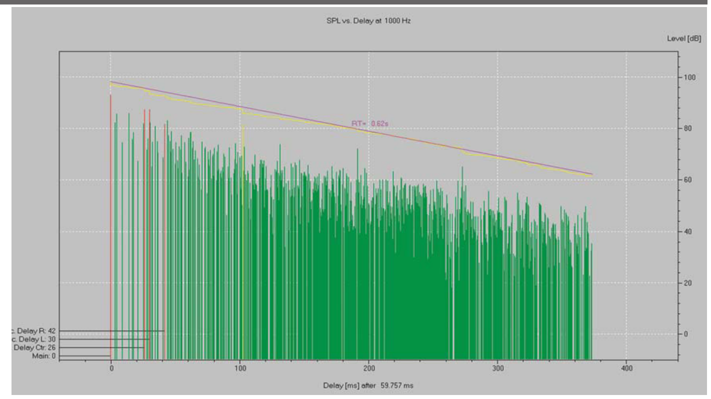
[Fig. 6]: Auralization

EASE 4.4 - Acoustical Probe Displays

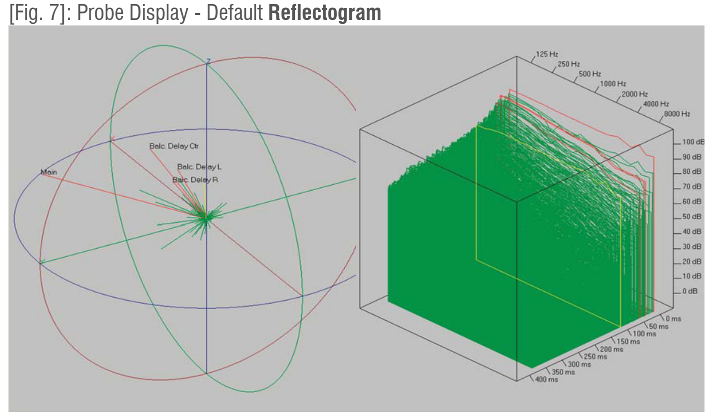
The steps described on the previous pages go over the generalized steps taken to set up the 3D model and to start the simulation process, gathering the required data that is produced through the steps of raytracing and auralization. These two data collecting steps provide different methods of analyzation; auralization involves the analyzation through listening to the simulated sound in the space whereas raytracing provides a variety of acoustical graphic representations for analyzing, which is done through the acoustical probe option. This option includes a wide range of acoustical analysis tools where you can pick any speaker-seat pair, or multiple pairs, and analyze them graphically. The probe option appears at the step of viewing the impact file, two dialog boxes give you the opportunity to select the desired loudspeakers and listening seats, to execute push invoke probe which will generate the graphical reflectogram. The process of generating a reflectogram may take some time to appear as it's a lot of data to compute, so be patient. Once finished, the default reflectogram will appear with the graphically simulated data, this is shown on the first diagram to the right. Within the reflectogram you can move your cursor to select one of the shown impact pulses which provides a readout on the screen displaying the exact arrival of that reflection (ms) and its exact level (dB).

As stated previously, the probe option offers many different types of displays for the simulated data where you're not only limited to the default reflectogram. Probe takes that information and generates it into other graphical displays which may better represent the desired information for analysis and documentation. Some of these displays are shown to the right: waterfall, 3D hedgehog, impulse response and energy time curve - and will be explained further below.

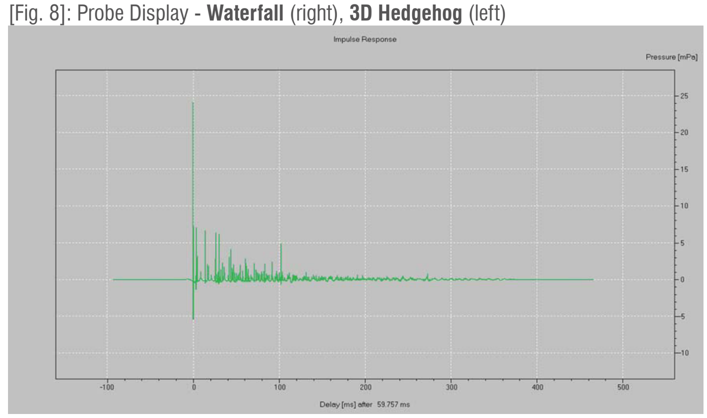
- **Waterfall:** Representation that shows at a glance the energy level and arrival time for each impact at each of the 21 frequencies. You can access this display through the graph pull down menu or its tool bar icon, where you'll find it under the time response option.
- **3D Hedgehog:** Representation that shows the pulse directionality in a unique fashion. This display can also be viewed in horizontal or vertical oriented views for whichever preferred. The hedgehog and its different views can be accessed by the same steps as the waterfall but instead it will be under the pulse directionality option.
- **Impulse Response (IR):** The impulse response is calculated by convolving all 21 of the 1/3 octave reflectograms with a unity sphere, which produces a monaural IR you could measure in real life with an omni spherical microphone (EASE, 220). To access the IR, click on the IR (impulse response) icon in the tool bar and select time response/impulse response.
- **Energy Time Curve (ETC):** This representation is developed by squaring and transforming the IR signal, which overall shows how sound energy decays in a room with relation to reflected and direct sound and the time it takes to decay. To access ETC, click the graphs pull down and select time response.



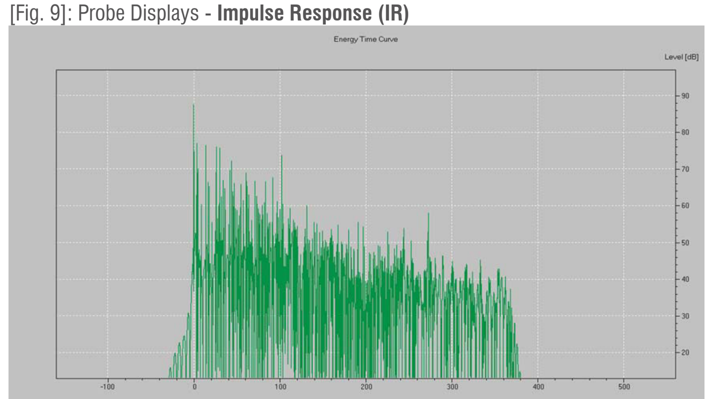
[Fig. 7]: Probe Display - Default **Reflectogram**



[Fig. 8]: Probe Display **- Waterfall** (right), **3D Hedgehog** (left)



[Fig. 9]: Probe Displays **- Impulse Response (IR)**



[Fig. 10]: Probe Displays **- Energy Time Curve (ETC)**

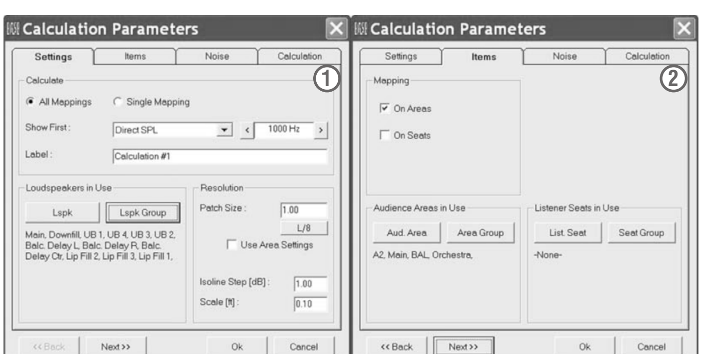
EASE 4.4 - Room Investigation Procedures:

This next section investigates the many ways EASE 4.4 can simulate and display acoustical performances of the room and its loudspeaker configurations. These mappings require the insertion of an audience area plane for the mapping functions to produce desired results, opposed to the more generalized first section procedures which was focused on the relationship between one speaker/ one listener seat pair. My area mappings investigate the space and its surfaces (audience area, walls/ceiling/floor) in relation to all speakers playing in unison. For example, A space with six speakers will map their response within the boundaries of one/or multiple audience areas. Stated previously, there are many mapping functions which can be produced for one model, they can be categorized by either speech intelligibility or music acoustical performances, where for my project I look at the musical performance of the space. Following will be a brief introduction to the five main mappings I will be using for this section of simulation, these are: Clarity Calculation (C80), D/R Ratio, Pressure Levels (L80), Total SPL (SUM), and ITD Gap. Also introduced is an important setting for all these mappings: The Split Time Setting.

- **Split Time Setting:** Determining which reflections are direct sound and which ones are reverberant sounds (early/late reflections)
  - Helps to figure out **D/R ratio** (direct sound/reverberant sound) which is a key factor in determining intelligibility as well as other aspects of system performance

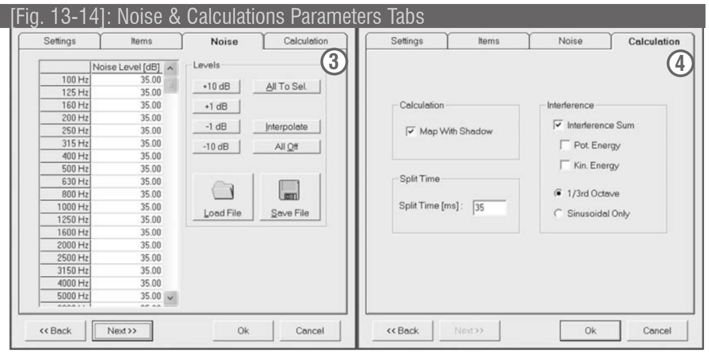
The mapping procedure starts with the settings dialog box which includes the parameters you need to set up before the simulation. They are categorized into four tabs: settings, items, noise, and calculation.

1. The Settings tab is where you set the frequency of the simulation, choose the loudspeaker(s) to be used as well as the desired output resolution of the map.
2. The Items tab is where you choose what listener seats or audience areas will be used in the simulation.
3. The Noise tab allows you to set the noise levels that will be used in intelligibility calculations.
4. The Calculations tab allows you to make further adjustments to the default settings that were established in room data.



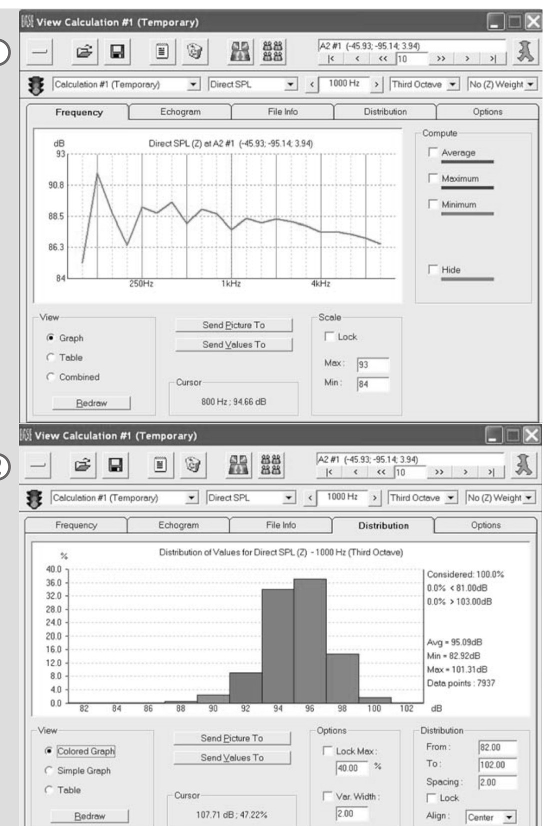
[Fig. 11-12]: Settings & Items Parameters Tabs

[Fig. 13-14]: Noise & Calculations Parameters Tabs



The next two diagrams are numerical/graphical representations of the simulation, they pop up in the view calculations window once the mapping simulation is finished (the simulation starts once preferred parameters are set in the settings dialog tabs). The view calculations box has five tabs, but for my project I focus on two of them: Frequency and Distribution. Whatever mapping option chosen (C80, L80, D/R Ratio, ITD Gap, etc.):

1. The Frequency tab will display its values for all frequencies for the set location. It also allows you to look at the average, minimum and maximum levels for area scanned.
2. The Distribution tab displays a graphical representation of the selected parameters in the mapping option chosen. This allows you to quickly determine what percentage of the mapped areas fall within certain criteria. This window is key to the specifications that call for coverage to be "flat within +/-__dB" (EASE, pg. 189).



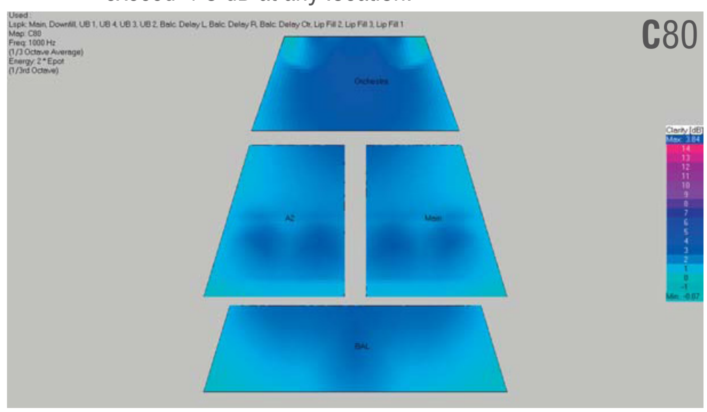
[Fig. 15-16]: Frequency & Distribution Diagramic Representations

EASE 4.4 - Room & Area Mappings

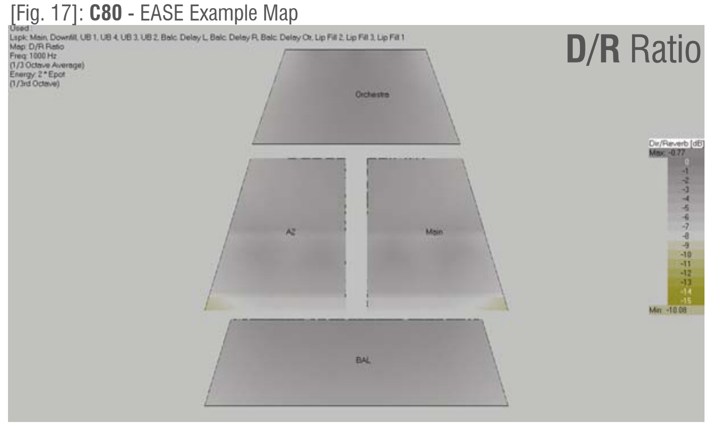
This page displays the simulated mapped surfaces on a variety of different audience areas. The diagrams shown are just a few examples of the different simulation mapping options (C80, D/R Ratio, ITD Gap). These mappings have various display methods other than the default shown called color patches, others include patch grid/painted and isobars. The display methods also allow you to view the simulated mapped surfaces in 3D perspective where you can see the mappings within its confined context, helping you to visually understand the relationship between the overall space and the audience area/s. Just a reminder that the two previous diagrams are numerical graphic representations of this mapped simulation, allowing you to evaluate the space through numerical graphics like tables and graphs where you can then relate it to the visual colored mappings. Both types of representations can be easily saved with the Send Picture To button, which gives you the option to save them to the clipboard as an electronic file or sending it to the EASE Page Designer.

Next, I will examine the different types of simulated mappings that EASE has to offer. The different types of maps are used depending on the desired information you need to gather for the simulation. For example, the STI (Speech Transmission Index), ALCons (% Articulation Loss of Consonants) and the C50 (Clarity Calculation: 50ms) maps are typically used for measuring speech intelligibility within a space. Since my project is investigating the ideal acoustical space for rave electronic music, I will not be using the speech measuring maps explained above. The maps I will be using are specifically programmed to measure the rooms musical performance. The following will define the types of maps I will be using along with desired parameters and outcomes.

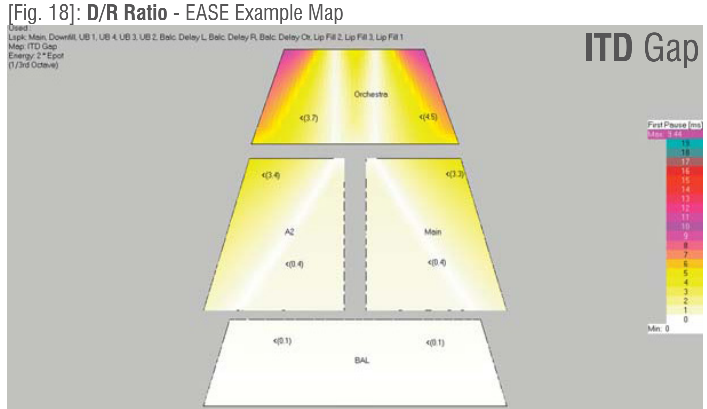
1. **D/R Ratios** - Show the ratio of direct to reverberant sound in terms of dB.
   - Zero dB indicates the sound levels are the same.
   - Numbers less than 0 indicate the reverberant sound level is higher than the direct sound level.
   - Numbers greater than 0 indicate the direct sound level is higher.
2. **Pressure Level L80** - Allows you to look at the sum of the direct and reverberant sound energy within the specified time
   - In other words, Pressure Level simulations are similar to C80 calculations, except they show you the total sound during the specified period.
3. **Total SPL (SUM)** - Displays the sum of the Direct and Reverberant sound energy in dB.
   - In other words, it displays the total sound level.
   - Don't be surprised at the small variation between the mini mum and maximum levels. It's normal.
4. **ITD Gap** - Displays the difference in arrival times between the first two direct sound arrivals.
   - This information is useful in determining the proper placement of loudspeakers and the delay times needed in distributed loudspeaker systems.
5. **Clarity Calculations C80 -** is often called a clarity ratio. It uses an 80 ms Split Time to predict the articulation (clarity) of different types of music. In other words, it provides a look at the room's musical performance.
   - Type of musical intrument: Percussive instruments (ex, piano, drums, electronic instruments, xylophone etc.) These instruments have a quick attack and a quick decay.
   - Scale for interpreting C80 (Percussive Instruments): 6 +/-2 dB is ideal for percussive instruments. This can be described best as Rock and Roll. In churches this would be known as Full Contemporary.
   - For good musical performance: the number should not exceed +8 dB at any location.



[Fig. 17]: **C80** - EASE Example Map



[Fig. 18]: **D/R Ratio** - EASE Example Map



[Fig. 19]: **ITD Gap** - EASE Example Map

Audacity - Digital Audio Editor/Rec. Software

The next and final step of the overall simulation involves the use of Audacity. Audacity is an open source digital audio editor and recording application software that overall allows users to both record and edit single or multi-track audio clips. Other common uses include converting tapes and records into digital recordings, adding effects to a recording such as changing the pitch or speed, as well as cutting, copying, splicing and mixing sounds together ("About Audacity", 2019). For my project, I will be mixing all auralization .wav files (speaker-seat pairs) together to render into one track. This allows me to be in the listeners seat, where I can listen and evaluate how the space reacts to the sound in relation to the seat and speaker locations. Next, I will walk through the steps taken to produce this final mixed track, including the last auralization steps in EASE, how to import your own music for the simulation, and the quick and easy process of mixing the individual speaker-seat tracks in Audacity.

To start, Audacity requires the auralization (.wav) files that were created previously in the EASE acoustical simulation. For example, one of my simulation projects has one positioned listener seat and surrounding it are six individual speakers – for which I auralized each pair to produce six different output .wav files. These files all contain the same audio output containing a snip it of an EDM techno track, this had to be inputted prior to saving the .wav file as the default is set to a male voice which doesn't pertain to my area of study. The EDM .wav file that I used also had to also be converted from its default binaural .wav format to a monaural .wav format. This is done by opening the binaural .wav file in Audacity, where you go to the Tracks menu item, under that go to Mix, and then execute Mix Stereo down to Mono. This should be done prior to the EASE auralization process of each speaker-seat pair so that the music and pair link together to produce one output .wav file (ex, speaker-seat1.wav, speaker-seat2.wav, speaker-seat 3.wav…).

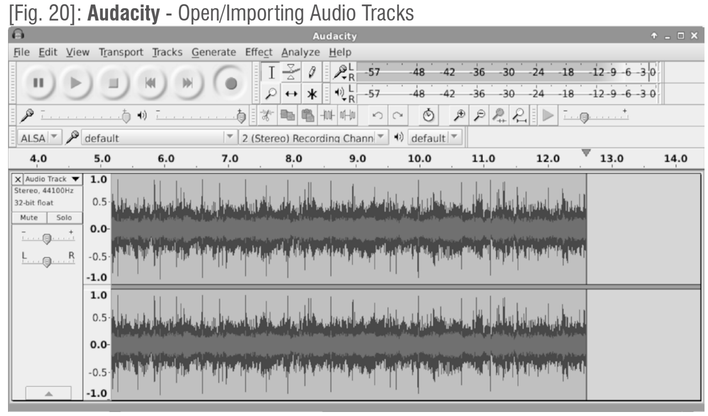
Once all speaker-seat pair .wav files are computed, they should be saved to a specific location such as a folder on the desktop. The next step is to open the Audacity software, which can be downloaded through their website free of cost. Once opened you can start placing the tracks (.wav files):

- **Opening First Track:** Go to the File menu item, under that go to open, find the desired track .wav file, and press OK to open (the first track should then be loaded as seen in the second diagram to the right)
- **Importing Remaining Tracks:** Go to the File menu item, under that go to Import, on the extended options list pick Audio, find the desired track .wav file, and press Ok to import (Multiple tracks should be loaded as seen in the third diagram on the right)

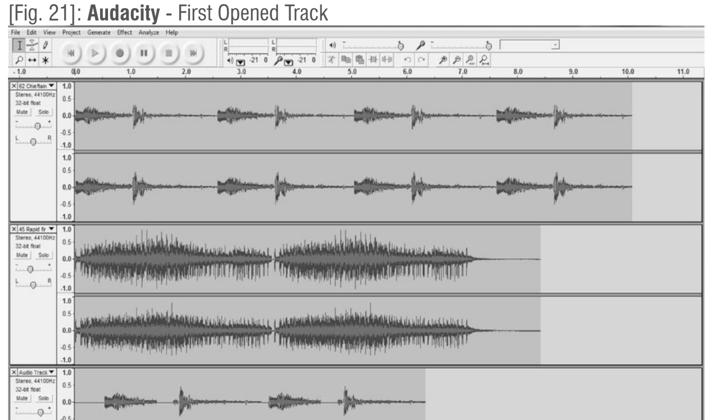
(Note: There are two ways of placing tracks as seen above, the first track should be opened using the Open option, whereas the remaining tracks (if any) are opened using the Import-Audio option)

After all desired tracks are placed, the next step is to combine them together to produce one overall output .wav file. This is done by pressing the Ctrl key and selecting each of the tracks. All the tracks now should be highlighted in a light purple, procced by going to the Tracks menu item, under that go to Mix, on the extended options list pick Mix and Render to One Track. All tracks are now combined into one track where you are then able to play the track, at this point you should also save the track to a .wav file for future examination.

[Fig. 20]: **Audacity** - Open/Importing Audio Tracks



[Fig. 21]: **Audacity** - First Opened Track



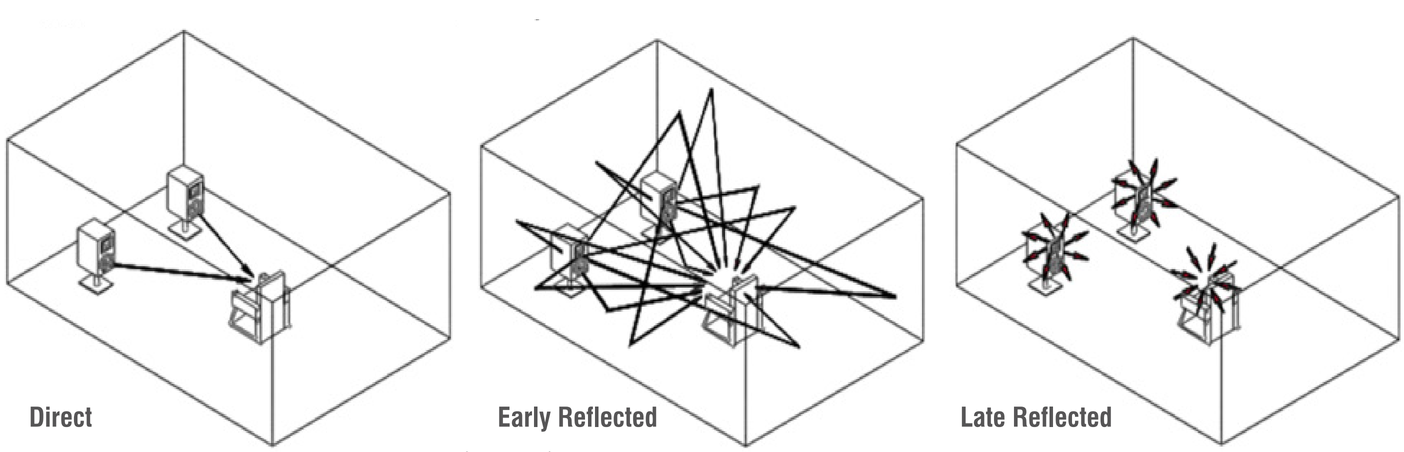
[Fig. 22]: **Audacity** - Importing Multiple Tracks

RESEARCH REPORT

Conclusion: Simulation Methodology

Previously in this section, I briefly introduced the research methodology of simulations, specifically the acoustical simulation software of EASE 4.4, highlighting its uses, capabilities, strengths and weaknesses. I then introduced the generalized steps taken to initialize the simulation process, such as importing a model from SketchUp and selecting the desired materials and speakers for the project, where you can then apply materialization to the surfaces along with placing the speakers and listener seats in relation to the space. Following the initial set up of the model, I run through the basic simulation process of raytracing (investigating propagation of all sound rays and their relation to the sound source and the unifying space) for each speaker-seat pair, which then allows you to start the auralization process (converting the acoustic and electro acoustic data generated by EASE into an audio signal that can be listened to and evaluated through EARS). After laying out the basics to get started with the simulation of the room, I introduced more advanced room investigations such as the acoustical probe displays which generate the simulated data into a variety of graphical representations. Continuing with the advanced room investigations, I described simulated mappings and the many different types EASE has to offer, where I then highlighted the maps of interest for my project that focuses on percussion musical instruments that characterize EDM. The last step described is the mixing of the auralization files created in EASE which is done in the recording/editing audio software of Audacity, with the end result being one mixed file of all speaker-seat pairs, allowing you to listen to all sound sources and how they behave in the space.

This simulation methodology and the graphical/analytical data representations produced from it will provide me with an efficient amount of information needed to start analyzing and evaluating the space and its acoustical performance. The analysis isn't only pursued through visual graphical/analytical representations, but also through the listening process from the simulated produced track and the real-life subjective responses. I plan to analyze both the audio and numerical data simultaneously for a space, say for example when I hear a strong reflection or a direct first hit I can look at the data generated for that specific time or level of dB to understand its behavior more. By understanding its behavior in the space, it will allow me to examine and determine the good vs. bad reflections, the percentage of absorber/reflective coverage, acoustical material/treatment, the shape of the space (height, width, length, volume), the speaker positioning and orientation, etc. The characteristics just listed are key factors in determining the ideal acoustical performance for any type of musical space and any type of sound, the only difference is the preferred performance values of reverberation time, strength of direct sound, instrument attack/decay times, ratio of direct to reverberant sound, etc., - which explains why EASE allows for many different types of simulation methods and representations. Overall, the focus of this simulation process aims to understand sound and its ideal parameters for electronic music within a space; seeing the propagation of it, how it behaves, how it moves, how it gets absorbed by the structure it is contained in. This then brings me to the next section of this report that introduces the two exemplar performance spaces in which I will be analyzing through this simulation process.



[Fig. 23]: **Audacity** - Importing Multiple Tracks

CASE STUDIES

Introduction: Case Studies

The two exemplar performance spaces I will be studying are both “legendary” nightclubs with positive subjective responses regarding the overall sound and spatial qualities, these spaces are London’s Ministry of Sound main venue space ‘The Box’, and Berlin’s Berghain main dance floor. I choose these two spaces for their unique differences in size, shape, materials, and sound experience, whereby modeling these spaces and running simulations I can determine the ideal acoustical and spatial qualities of each space with further guidance through subjective responses. To briefly introduce, ‘The Box’ was designed specifically for an amazing sound experience with majority of the budget going to acoustical treatments and the sound system. Berghain was a was a large concrete power plant prior to its restoration, but the restoration was minimal as they kept the raw, industrial feel of the 60’ voided dance floor, resulting with a space that’s scientifically not ideal for acoustics. With these distinctive acoustical differences between the two physically, the subjective responses to the space and sound all remain positive but differ in their preferred attributes. ‘The Box’ is preferred for its crisp, clean, almost perfect sound and spatial intimacy whereas as Berghain is preferred for its cathedral like sound with very long prominent reverberation times that are known to invoke a spiritualized uplifting experience. It is these main distinctions of subjective responses to such spaces and their produced sounds that motivates me to examine them more thoroughly through simulation with the goal of finding idealities. The following studies examine these spaces more in depth.

1 Ministry Of Sound

[Fig. 24]: Ministry of Sound Logo

2 Berghain

[Fig. 25]: Berghain Logo

1 MINISTRY OF SOUND

Audio / Visual / Spatial

[Fig. 24]: Ministry of Sound Logo

The Project Type: Nightclub
Location: London, UK
Size: <u>6 Event Spaces - Over 2 Floors</u>

- The Box: 3067 SF (98' x 54') Capacity: 600
- The 103: 3046 SF (44' x 79') Capacity: 500
- The Baby Box: 818 SF (36' x 22') Capacity: 100
- Courtyard: 3562 SF (72' x 50') Capacity: 400
- The Lounge: 1323 SF (45' x 56') Capacity: 86
- The Loft: 1323 SF (45' x 56') Capacity: 150

Distinguishing Characteristics:

- Inspired by New York's 'cavernous' house venues
- The prior structure was a derelict bus garage in south London
- The worlds first nightclub with a room built purely for exceptional sound quality
- Performance spaces designed to be multi-purpose: seated dinners, conferences and award ceremonies, standing receptions, exhibitions, team building, event breakouts, VIP use, etc
- Featuring award-winning audio-visual systems.
- Recognised for its technological innovation and production.

Research Findings:

<u>Common findings:</u>

- One large main dance space acting as a gateway to other flanking subspaces such as smaller dance event spaces,bathrooms, bar, lounge area, etc.
- Consisting of wrap around mezzanines with high ceilings inside a large volumetric space
- Spaces for large communal gatherings and small intimate gatherings

<u>Uncommon findings:</u>

- Ourdoor courtyard acting as a performance space, ideal for concerts, summer parties and car launches

Ministry of Sound Context:
(environmental, social, cultural, political)

To begin, I want to inform that this Club is the built club of Ministry of Sound, not the unbuilt commissioned design by OMA, titled Ministry of Sound II. To reintroduce, the Ministry of Sound is a multi-media business, being dynamically involved in the industries of nightclubs, music, entertainment, events, and lifestyles. (To learn more about the context of this club – look at case study number 2). The company's nightclub titled "Ministry of Sound" first opened its doors in 1991, where it quickly developed into a popular multi-media brand. This project was a remodel of an existing derelict bus garage in South London, which the design was inspired by New York's 'cavernous' house venues such as the Paradise Garage. The element that sets this music venue out from the rest is that the spaces and the technology used were purely dedicated for exceptional sound quality. The designer Justin Berkmann states: "My concept for Ministry was purely this: 100% sound system first, lights second, design third (in that order); the reverse of everyone else's idea."

The first night in which the club opened, they served no alcohol, consisted only of three flashing lights, a strict door policy where exclusivity was determined by authentically knowing the music and the DJ's. Besides the bizarreness of the first opening night, it was a success, and as the weeks passed, so did the networking of news that Ministry of Sound is the new modern curator of London's nightlife club scene. This club was not only dedicated for exceptional acoustical qualities, but also as the first club dedicated strictly to house music and the first club to 'pick up the gauntlet laid down' by the second summer of love. The Ministry of Sound today is still thriving and transcending as a clubbing venue within London's center, where acoustics and high-quality sound remains at the forefront. The club maintains the attraction of around 300,000 clubgoers per year and has won the IDMA 'Worlds Best Sound System' award within these past four years. "Put simply, there is no better place on earth to hear the worlds greatest DJ's play the world's best music" (Berkmann, 1997). As a music venue, London's Ministry of Sound functions as three weekly club nights, where Fridays are generally for Trance music and Saturdays – which host many club nights – are generally House music, where the third day falls within a week night, such as on Tuesdays the club entertains a student session named 'milkshake', which was established in 2002.

Conceptual Underpinnings Perspective:

This project serves as the center of London's nightlife, highlighting their musical origins by providing London with a variety of performance spaces which are built for exceptional sound quality. This is the first case study in which the main priority of the design was acoustics, where visuals and the design of the space followed. Music and sound is the key element of nightclub venues, as it acts as a curator for the other key element: Dance. Where the architecture is the host of these elements, and in this project, there are many hosts, or separate performance spaces that create diverse sensibilities.

1 MINISTRY OF SOUND

Audio / Visual / Spatial

[Fig. 26-31]: Event Spaces Interior Perspec-

[Fig. 32]: Spatial Configuration Diagram

6 Event Spaces - Over Two Floors

1.	**The Box:** 3067 SF (98' x 54')	Capacity: 600
2.	**The 103:** 3046 SF (44' x 79')	Capacity: 500
3.	**The Baby Box:** 818 SF (36' x 22')	Capacity: 100
4.	**Courtyard:** 3562 SF (72' x 50')	Capacity: 400
5.	**The Lounge:** 1323 SF (45' x 56')	Capacity: 86
6.	**The Loft:** 1323 SF (45' x 56')	Capacity: 150

The Box:

- Ultimate space for live production
- Award winning audio-visual equipment
- Large duel entranced space
- Benefits from uninterrupted floor plan
- Space is overlooked by glass windows
- In-House AV
- Rigging points
- Flexible staging

The 103:

- Located in the center of the venue
- Acts as a gateway to all other event spaces
- Benefits from a mezzanine and high ceilings
- Ideal for intimate or larger central hub gatherings
- In-House AV
- Fitted Bar
- Rigging points

The Baby Box:

- A dynamic space
- Inimitate and ideal for smaller events
- High ceiling with rigging available
- Fitted bar
- DJ booth
- AV facilities

The Courtyard:

- Unique addition to venue
- Outside container bar and kitchen
- offers a heated canopy
- Interchanging sound and lighting
- Ideal for summer parties, car launches & concerts
- In-House AV
- Partial covering
- Ability to drive into

The Lounge:

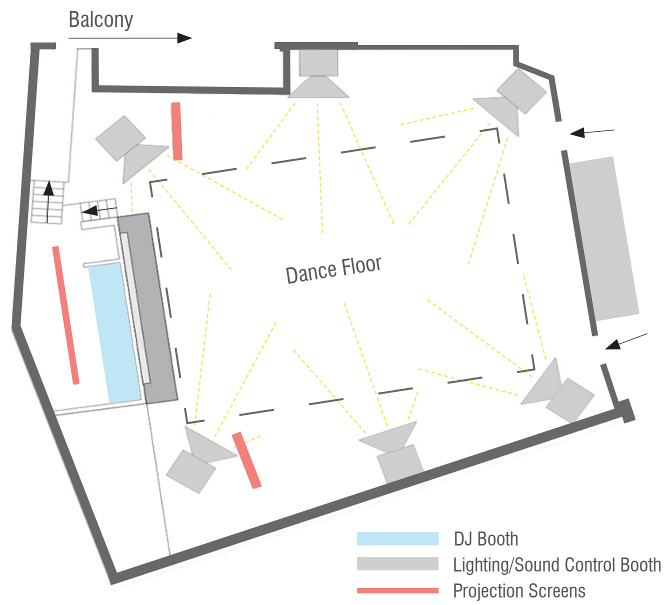
- Located on upper level of venue
- Overlooks The 103
- Features its own bar and facilities
- Glass windows overlooking The Box
- Access to The Box balcony
- Ideal for conferences, event breakouts, and VIP use
- LED lighting
- Toilets

The Loft:

- A contemporary space overlooking The 103 through its glass wall
- Offering fixed seating, fixed bar, DJ booth, mezzanine balcony, and high ceilings with rigging available
- Ideal as a break out for main venue or intimate cocktail lounge
- AV facilities

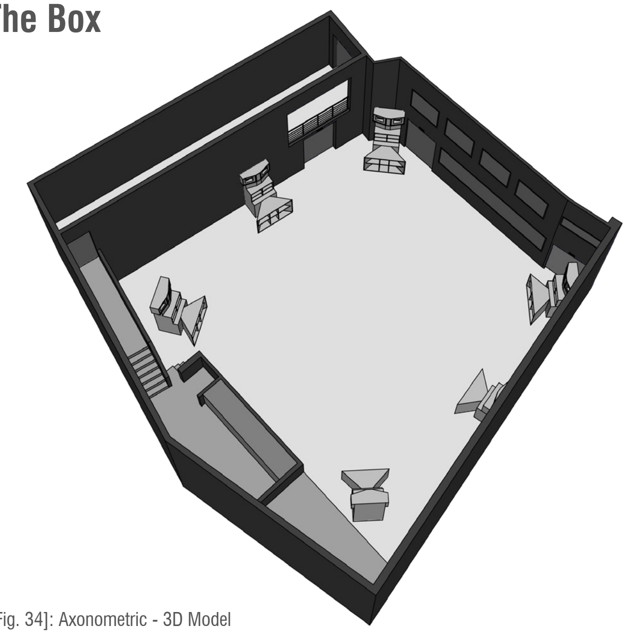
1 MINISTRY OF SOUND

Audio / Visual / Spatial



[Fig. 33]: Audio/Visual/Spatial Diagram

The Box



[Fig. 34]: Axonometric - 3D Model

The Box

Out of the six event spaces configured within The Ministry of Sound, The Box is the main room, with its iconic sound system and award-winning audio-visual equipment. The Box is a five-sided room with no parallel facing walls and a ceiling plane/roof that's slopes down towards the DJ booth. The room shape, wall treatments, and sprung dance floor (accentuates and absorbs bass) all work together to provide the ideal acoustical environment for music and dance. This design of the space also works to minimize sound reflections and reverberations, emphasizing that each sound you hear within the Box should be coming direct from a speaker, not bouncing off any surfaces or echoing in a hollow 'cavernous' space, resulting in a crisp and clean sound that doesn't leave people with their ears ringing.

Combining the acoustical treatments of the space with the top of the line sound system is what makes The Box so paramount. Located around the perimeter of the dance floor are 6 Martin Audio ground stack speakers that kick out 25,000 W, that's running at less than 50% or less of its capacity "ensuring no part of the system is stressed, no speaker drivers blow, and the sound is of much higher quality than a system running continuously near its limit"(Walton, 2016). Walton also states that a speaker can be acoustically amazing, but if it's located in a poor space it wont sound good. The Ministry of Sound placed top priority on sound and acoustical treatments, with service coming second and design being third, which is the complete opposite compared to other nightclubs.

Standing at about 8' tall, the 6 paramount speaker stacks consist of 2 x ASX subwoofers, 2 x AS118 subwoofers, and 2 W8C top boxes, a custom flare on the lower section, and custom cabinet housing to hide cabling, and what people don't see are the 16 speakers placed in the wall in between each speaker stack, allowing for undistorted sound to reach every part of the dance floor. All these speakers are put to use with the innovative Dolby Atmos DJ software, which allows the engineer to direct sounds to specific speakers during specific parts of the song, or where speakers are designated for bass and drums and others are for synths, overall creating a more immersive acoustical performance. "With Atmos, sounds are object based, meaning that the sound is given a specific XYZ coordinate within a 3D space, and the system figures out which speaker array to pump it through, no matter how many (up to 64) or few (as low as two) there are"(Walton, 2016). Another cool function is the pan, where sounds move in a path through each individual speaker, producing a twirling 3D surround sound.

Sound

12 x MoS Custom Martin Audio W8C
12 x MoS Custom Martin Audio AS118
12 x Martin Audio Custom ASX active subs
2 x BSS Soundweb London Blu-320
1 x BSS Soundweb London Blu-800
3 x Lab Gruppen Martin Audio MA 4.2s Amplifier
3 x Lab Gruppen Martin Audio MA 2.8s Amplifier
3 x Lab Gruppen Martin Audio MA 1.6s Amplifier
3 x Lab Gruppen Martin Audio MA 1.3s Amplifier
3 x Crown CTS-600 Amplifier
3 x Crown CTS-1200 Amplifier (stage wedges)
4 x Martin Audi Blackline F12 (stage wedges)
4 x BSS - AR133 DI
1 x Soundcraft Vi3000 FOH Console

DJ Booth

4 x Martin Audio Blackline F12
1 x Martin Audio CDD15
1 x Martin Audio S218 Blackline
3 x Crown Itech HD 5002 Amplifier
2 x BSS Soundweb London Blu-800
1 x Rane Serato SL4 interface c/w psu
4 x Technics SL - 1210 mk5G c/w cust. Isonoe isolation feet
4 x Pioneer CDJ 2000NXS2
4 x Pioneer CDJ 2000 Nexus
2 x Pioneer DJM - 900NXS2
1 x Allen & Heath XONE:92
1 x Allen & Heath DB4
1 x Rane MP2015
1 x Pioneer EFX - 1000

Lighting

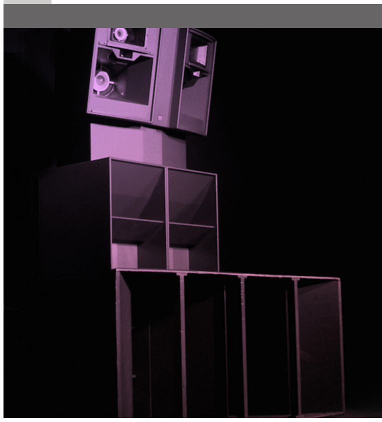
12 x Robe Pointe
5 x Martin Rush MH3 Beam
12 x Martin Mac 101
2 x Martin Atomic 3000 Strobes
6 x SGM XC-5
5 x Martin Rush MH6 Wash
8 x Showtec Sunstrips
3 x Colourband Pix
6 x Par 56
2 x Jem Hydra Smoke Head
1 x Jem Hydra Base Unit
2 x Martin AF2 Fans
1 x Martin M6 Lighting Cont.
2 x 2w Green/Blue Lasers
1 x 3w RGB Laser

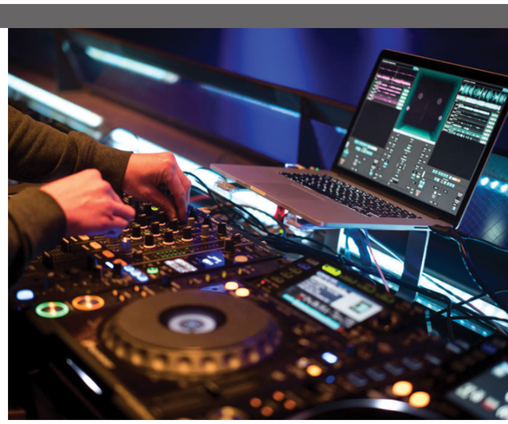
Video

Box LED Wall: 2.6mm pitch / 1536x672px / 4x1.75m
Processor: Nova Ctrl660
1 x Mac Pro Resolume Arena 5 Video Server w/ Livid Instraments OhmRGB
1 x Blackmagic Smarthub 12x12 matrix switcher
3 x Projection Screens
2 x Benq Projectors
1 x Optoma ZH510T Full HD 16:9 Projector

1 MINISTRY OF SOUND

Audio / Visual / Spatial



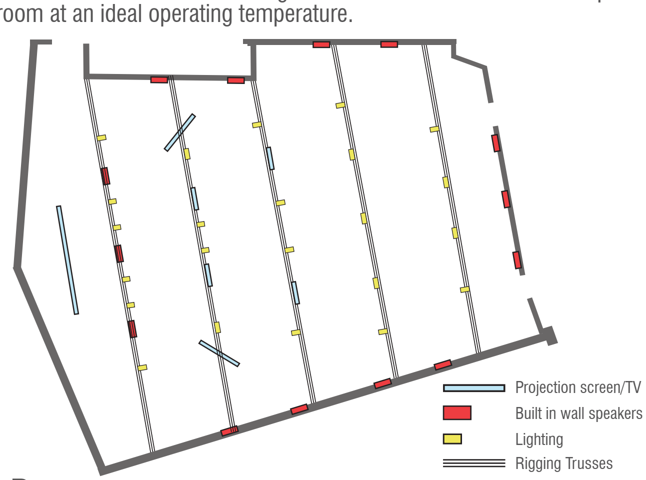


[Fig. 35-37]: Sound/DJ Booth/Video/Lighting

DJ Console/Booth: The DJ Booth places hierarchy on itself, elevating 4 feet about the dance floor, in this case it sits inside of a manipulated shipping container. This shipping container is 17' wide and has a depth of 10', and within that contains the 14' wide DJ booth, leaving lots of room for added equipment (synths, controllers, laptops). This setup is a modular design allowing two different DJ setups, making it easy and quick for the transfer between DJ's. Each setup is equipped with 3-4 Pioneer CDJ-2000NXS2 players, and a Pioneer DJM-900NXS2 mixer. Turntables are also no longer fitted as standard, but the club makes them available upon request. Most DJ's prefer the right-hand setup, which allows more of a centralized view of the room. (Note: the middle picture above shows the DJ Booth)

Sound/Light Control Booth: The sound and light control booth is located at the back wall of the room, accommodating space for a lighting engineer, sound engineer, and video or laser engineer. The positioning of the equipment allows for easy and comfortable reach between these different engineers. This booth contains everything needed to make this famous Soundsystem and lightshow work, containing a lot of flashing buttons such as faders, switches, touchscreens, etc., and featuring video, sound and networking 'patch points' for extra equipment, touring Vj's and custom setups.

Amp Room: Located behind the Control Booth is the engine room that runs the whole operation. This room consists of an air-conditioned cupboard that is filled with the essential kit of amps and processors. It is housing three 28U racks of amps, processing, lighting and video control servers and systems. All acoustical equipment is powered on a singular phase from a main local distribution board, along with an armored cable providing power to DJ booth directly from amp room – 'alleviating grounding issues and buzz'. Air conditioning units mounted within the wall keep the amp room at an ideal operating temperature.



The Box

[Fig. 38]: Sound/Light/Video Configuration

Conclusion:

This study focused more on the audio-visual-spatial design of a performance space, opposed to other case studies where I study the architectural principles and elements of the overall club. The Ministry of Sound was an ideal club to study as it is designed for exceptional sound quality, especially The Box, which is analyzed by itself rather than analyzing all 6 event spaces. By focusing on The Box, I was able to analyze all its components that makes it the best acoustical sound performance space.

What I will take from this study is placing high priority on acoustical design, focusing on the acoustical wall, floor, ceiling treatments, proportions and shape of the space, which allows reverberation and reflection of sound to be at a minimum. The configuration and orientation of perimeter walls will be focused on as well, which not only makes it desirable for acoustics, but also a different experience for the user, getting away from the plain box. For example, this project contains 5 walls, with each wall oriented different than another, with no parallel facing walls.

This study also shows the technical components of the space, which is important for the engineering to run smoothly. The technical specifications of the DJ booth, control booth and amp room, along with their placement in the space will contribute to my design, where I will study the newest trends in innovative audio and visual technology, such as Dolby Atmos App which allows for a more immersive audience experience by providing artists the power to control where certain sounds are sent throughout the space. The variation in sound system products is very diverse with different types of speakers serving different purposes depending on where their located.

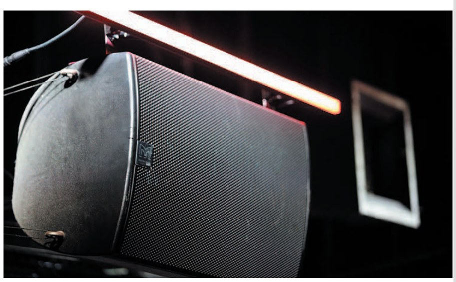
By looking at the Club as a whole (6 event spaces) and not just The Box, I notice the same trends in other nightclubs, such as one centralized main space (The 103) that transition into other smaller dancefloor spaces, lounges, courtyards, etc. I will incorporate this diverse performance space configuration, which each performance space being unique, such as The Box being the best acoustical experience, the Baby Box being a more intimate dance space, or the lounge providing a quieter atmosphere.

But the most important aspect from this study is acoustics, which has the power to unite audiences with exciting sounds creating shared memories that delve into the communal consciousness of the audience. The materialization and spatial qualities of the space allows that sound to be crisp and clean, where reverb and reflection time held to a minimum. The orientation of and placement of speaker sources are key within the space too. With my research involving acoustical simulation experimentation, I will model this space like how it is in real life and be able to analyze this space even more through hearing what it sounds like at different locations of the space.

1 MINISTRY OF SOUND

Audio / Visual / Spatial

[Fig. 39-40]: Sound/Light/Video Perspective



[Fig. 41-42]: Additional Speakers-Rigged Ceilings

Perceptions of 'The Box'
(DJ's, Audience, Promoters, Sound Engineers)

This section will continue investigating Ministry of Sounds premier production space, 'The Box'. Previously, I investigated the objective elements of the space, how it is arranged, its uses, and its technical specifications. Here I will investigate the subjective components of the space, examining people's perceptions of the space including their very own co-founders, resident DJ's, promoters and the regular Ministry of Sound clubgoers. These perceptions are found on a 20:20 Exhibition Documentary found online, where the people are asked questions on their experiences and thoughts of the space.

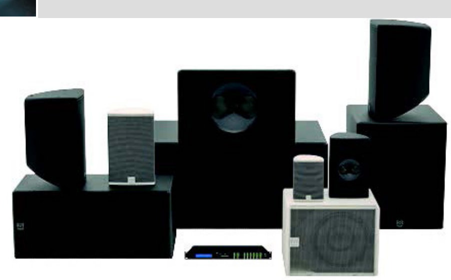
Most of the responses revolve around 'The Box' and its legendary sound system, seeking much interest from the resident DJ's that perform there. Jim Masters, a resident DJ states "when I walked into the main room 'The Box' I was blown away by it, if there ever was a room made for house music, that was it". Another DJ, Judge Jules explains "playing there was like flying in a spaceship, much like Star Wars". When thinking about a club space, you would think that most if the attention is directed toward the consumers of the music – the ones who pay to participate and dance – but Ministry of Sound focused just as much on the experience of the DJ's that play there as they did on the consumers. "all the money went into the dance experience" says Co-founder Justin Berkman, meaning the money was spent on the sound system which facilitates the dance experience. CJ mackintosh states "if it wasn't for the sound system, I don't think the club would be as successful".

The success of the space cant be produced only by a good sound system, the space also needs to be designed to enhance the quality of the sound system, such as the rooms acoustical treatments, its reverberation time, direct sound rays versus reflected sound rays in relation to listener position etc. Berkman the co-founder adds to this, "the box itself is part of the sound system, not just the speaker stacks you see on the floor, the fact that the whole room is one giant box as if it were a speaker in itself, providing a lot of the characteristics of sound". The six speaker stacks couldn't do what they do it you put a 'mad' roof on it – which would distort the clarity of the sound and would increase the reverberation and reflection time. It was as close to sonic perfection as you could get, explains a regular clubgoer. Another clubgoer states the 'feel' of the space: "big, warm, lovely, huggable, love machine, like a big teddy bear". It was all about spreading the vibe and curating the atmosphere of the room for the audience. Club promoter, Matt White explains "The difference back then it was all about the music, quality of music, sound of music, person playing the music. It was about collective of atmospheres – not a place to go to see or be seen".

The overall success of the club can be devoted to the quality of the sound, cutting edge equipment, and the acoustical treatments of the space. "Designing the club is the art of designing a black room, a brilliant black room" says Berkman. The club was diversified, not afraid of doing something different but also changing and evolving with times. As for the future, Berkman states "people are not going to stop wanting to dance, jump around with friends to the best

Products
Martin Audio

[Fig. 43]: **Blackline X**-Passive Indoor Loudspeakers/Subs



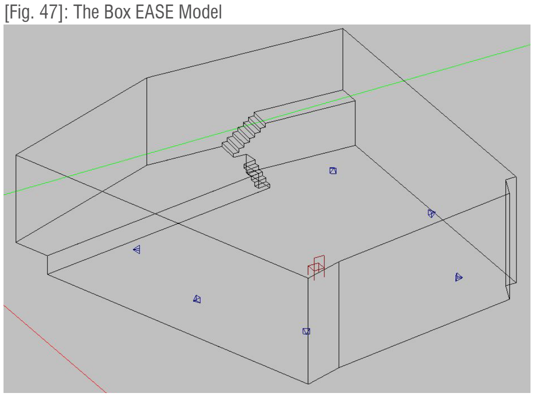
[Fig. 44]: **CDD**-Passive Indoor Loudspeakers/Subs

[Fig. 45]: **MLA**-Multi-Cellular Loudspeaker Arrays

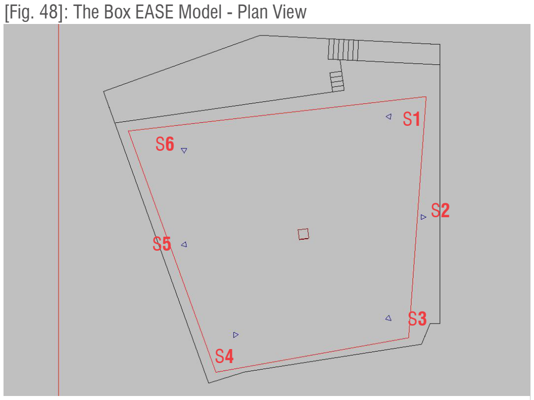
[Fig. 46]: **Wavefront**-Line Arrays

1 'THE BOX' SIMULATION

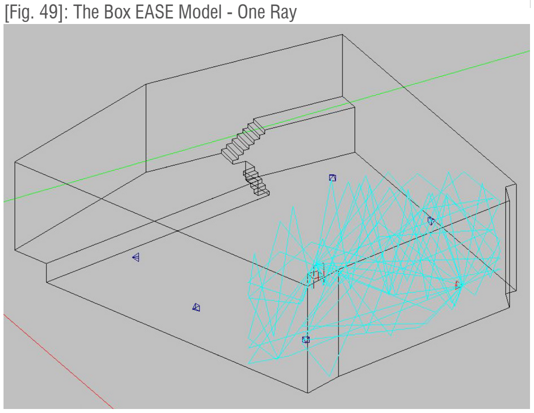
[Fig. 47]: The Box EASE Model



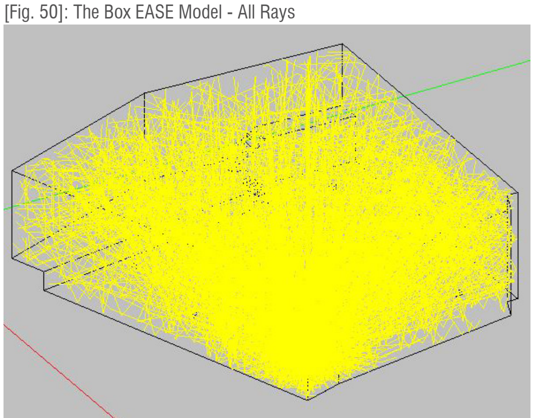
[Fig. 48]: The Box EASE Model - Plan View



[Fig. 49]: The Box EASE Model - One Ray



[Fig. 50]: The Box EASE Model - All Rays



Room Volume:	59529 cu. ft.
Room Surface:	10709 sq. ft.
Audience Area:	2,305 sq. ft.
Room Capacity:	600 standees
Average Room Height:	20 ft.
Average Room Width:	54 ft.
Average Room Length:	50 ft.
Stage Area:	430 ft. sq.
Average Stage Depth:	10 ft.
Average Stage Width:	40 ft.
Mean Ceiling Height: (above stage area)	15 ft.

Surface Materialization:

- **Floor:** Floating Sprung Dance Floor: Plywood
  - W/ dual density shock dampening elastomer blocks at predetermined intervals
- **Side Walls:** (Absorbers)
  - Exterior Side: Triple thick absorbing walls
  - Interior Side: Perforated panels
- **Rear/Front Walls:** (Absorbers)
  - Exterior Side: Triple thick absorbing walls
  - Interior Side: Perforated panels
- **Ceiling:** Sound Absorption Acoustical Ceiling Panels
- **Stage:** Floating Floor Assembly: Plywood
  - Reflective/absorptive

Loudspeakers:

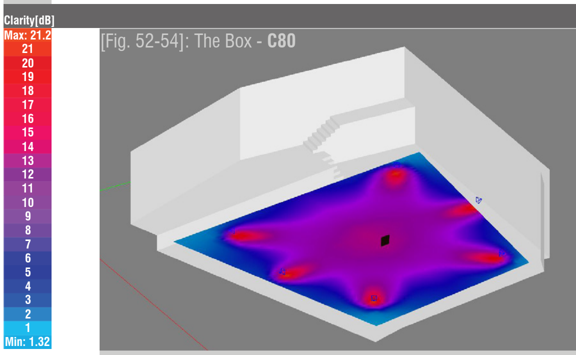
- **Martin Audio Sound System**
  - (6) x VRS1000

(Note: One VRS1000 loudspeaker represents one of the six large speaker stacks - Each speaker stack consists of:
2 x ASX subwoofers, 2 x AS118 subwoofers, 2 W8C top boxes)

SCAN TO LISTEN

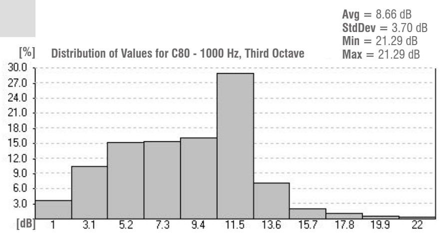
[Fig. 51]: QR Code - The Box Audio Wav File

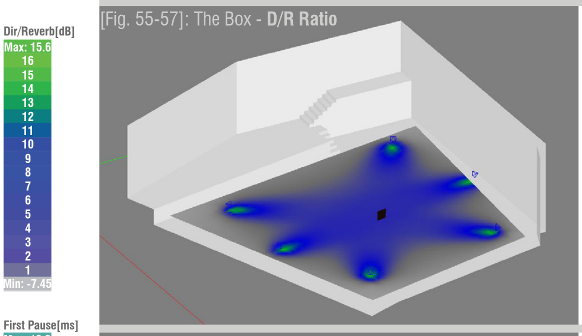
1 THE BOX SIMULATION



[Fig. 52-54]: The Box - **C80**

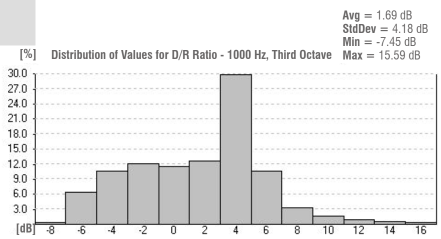
Map: C80
Project: 'The Box' Simulation
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6
Freq: 1000 Hz (1/3 Octave Avg.)

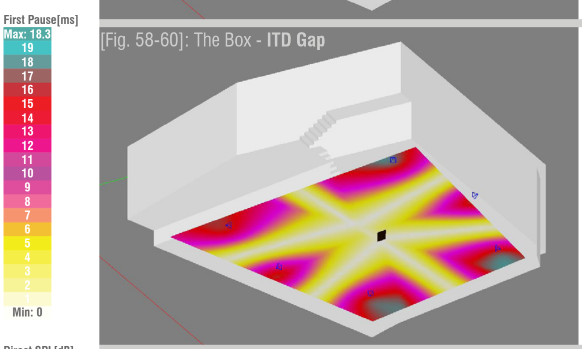




[Fig. 55-57]: The Box - **D/R Ratio**

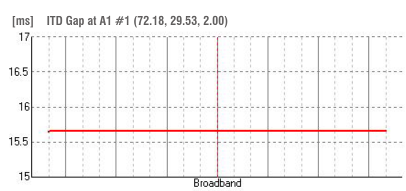
Map: D/R Ratio
Project: 'The Box' Simulation
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6
Freq: 1000 Hz (1/3 Octave Avg.)

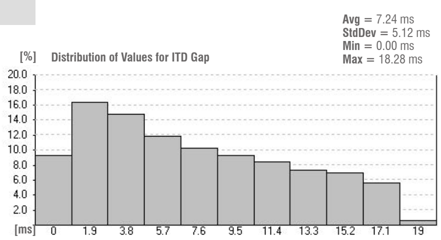


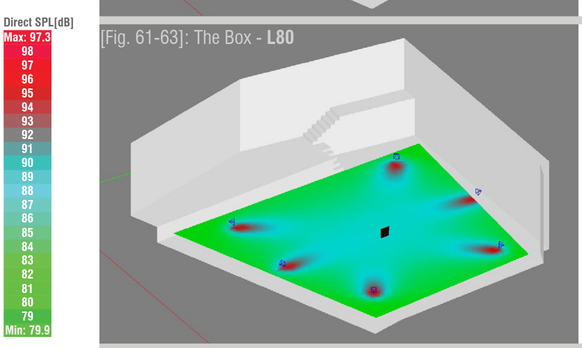


[Fig. 58-60]: The Box - **ITD Gap**

Map: ITD Gap
Project: 'The Box' Simulation
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6

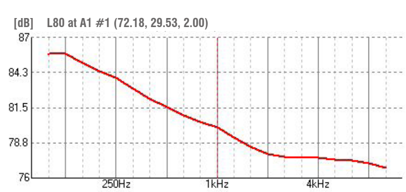


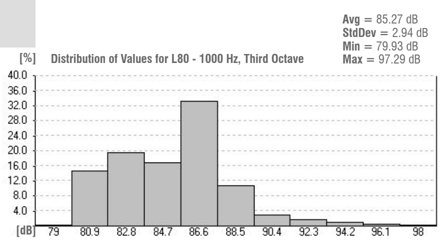


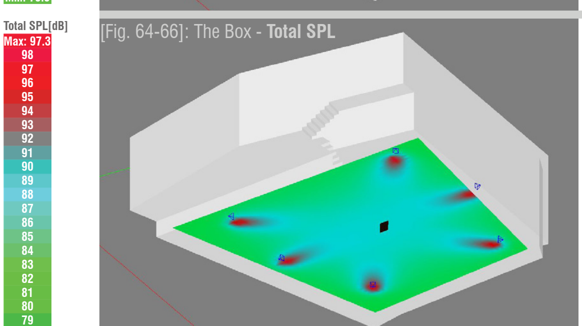


[Fig. 61-63]: The Box - **L80**

Map: L80
Project: 'The Box' Simulation
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6
Freq: 1000 Hz (1/3 Octave Sum)

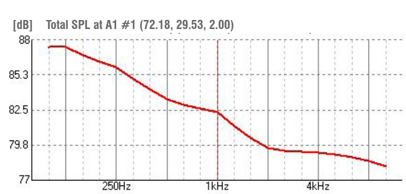


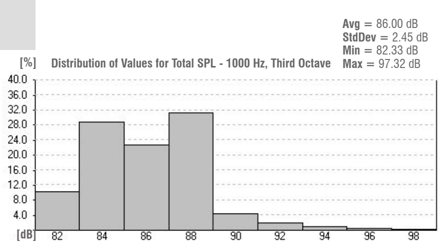




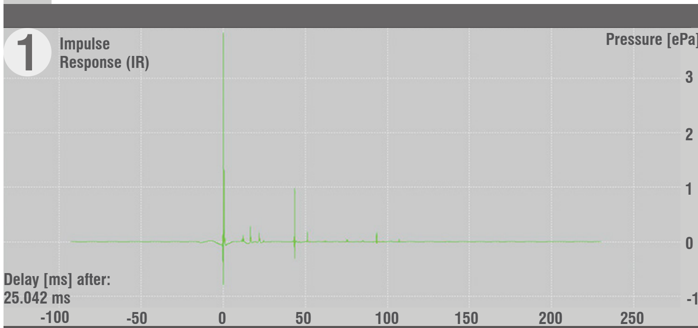
[Fig. 64-66]: The Box - **Total SPL**

Map: Total SPL
Project: 'The Box' Simulation
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6
Freq: 1000 Hz (1/3 Octave Sum)





1 'THE BOX' SIMULATION

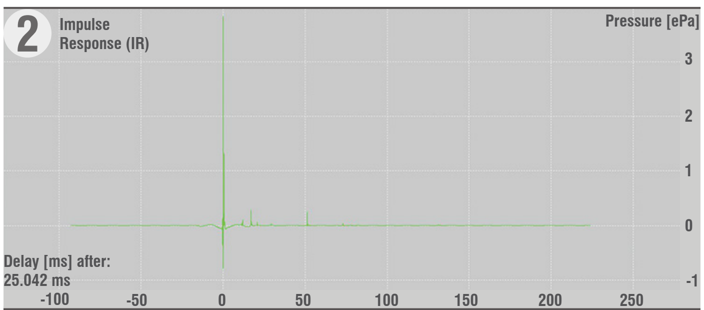


Project:	THE BOX SIMULATION	Filter:	THE BOX
Volume:	59529 cu.ft.	Level[dB]:	62
Surface:	10709 sq.ft.	Delay[ms]:	25
Humidity:	60 %	Length[ms]:	317
Air Temp:	20 °C	Window[ms]:	372
		Samples:	13984
		Channels:	2
Listener:	1	Sampling Rate [Hz]:	44100
Position[ft]:	X = 45.9 Y = 45.9 Z = 3.7	Frame Length:	8192
Orientation:	Hor = -83 ° Ver = 2 °	Frame Number:	2

[Fig. 67]: The Box - **Impulse Response 1**

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	97	5	1	100	0.48	0.435
2	125	97	5	2	125	0.48	0.435
3	160	97	6	3	160	0.49	0.431
4	200	97	6	4	200	0.49	0.428
5	250	97	7	5	250	0.50	0.425
6	315	97	7	6	315	0.49	0.434
7	400	97	8	7	400	0.47	0.443
8	500	97	9	8	500	0.46	0.452
9	630	97	10	9	630	0.50	0.427
10	800	97	10	10	800	0.54	0.402
11	1000	97	11	11	1000	0.58	0.377
12	1250	97	12	12	1250	0.53	0.402
13	1600	97	12	13	1600	0.49	0.427
14	2000	97	13	14	2000	0.45	0.452
15	2500	97	13	15	2500	0.45	0.451
16	3150	97	13	16	3150	0.45	0.451
17	4000	97	13	17	4000	0.44	0.450
18	5000	97	13	18	5000	0.42	0.452
19	6300	97	13	19	6300	0.40	0.454
20	8000	97	13	20	8000	0.38	0.456
21	10000	97	13	21	10000	0.34	0.456

Loudspeaker:	S1	Aiming:	Hor =55 ° Ver = 0 ° Rot = 0 °
Active:	True	Delay:	0 msec
Position[ft]:	X = 22.9 Y = 62.3 Z = 3.28	Speaker:	VRS1000

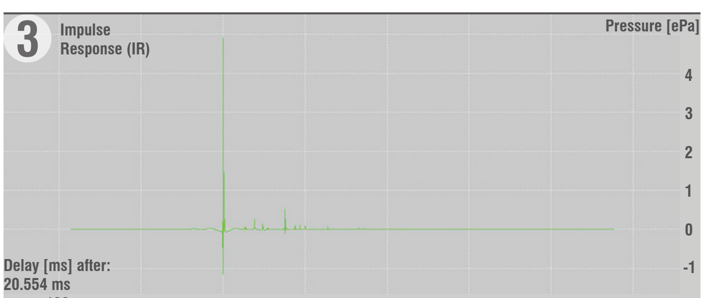


Project:	THE BOX SIMULATION	Filter:	THE BOX
Volume:	59529 cu.ft.	Level[dB]:	67
Surface:	10709 sq.ft.	Delay[ms]:	21
Humidity:	60 %	Length[ms]:	186
Air Temp:	20 °C	Window[ms]:	372
		Samples:	8193
		Channels:	2
Listener:	1	Sampling Rate [Hz]:	44100
Position[ft]:	X = 45.9 Y = 45.9 Z = 3.7	Frame Length:	8192
Orientation:	Hor = 270 ° Ver = 0 °	Frame Number:	2

[Fig. 68]: The Box - **Impulse Response 2**

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	97	5	1	100	0.48	0.435
2	125	97	5	2	125	0.48	0.435
3	160	97	6	3	160	0.49	0.431
4	200	97	6	4	200	0.49	0.428
5	250	97	7	5	250	0.50	0.425
6	315	97	7	6	315	0.49	0.434
7	400	97	8	7	400	0.47	0.443
8	500	97	9	8	500	0.46	0.452
9	630	97	10	9	630	0.50	0.427
10	800	97	10	10	800	0.54	0.402
11	1000	97	11	11	1000	0.58	0.377
12	1250	97	12	12	1250	0.53	0.402
13	1600	97	12	13	1600	0.49	0.427
14	2000	97	13	14	2000	0.45	0.452
15	2500	97	13	15	2500	0.45	0.451
16	3150	97	13	16	3150	0.45	0.451
17	4000	97	13	17	4000	0.44	0.450
18	5000	97	13	18	5000	0.42	0.452
19	6300	97	13	19	6300	0.40	0.454
20	8000	97	13	20	8000	0.38	0.456
21	10000	97	13	21	10000	0.34	0.456

Loudspeaker:	S2	Aiming:	Hor = 0 ° Ver = 0 ° Rot = 0 °
Active:	True	Delay:	0 msec
Position[ft]:	X = 42.65 Y = 68.9 Z = 3.28	Speaker:	VRS1000



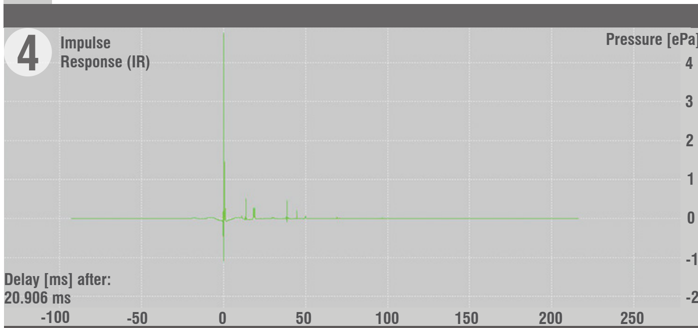
Project:	THE BOX SIMULATION	Filter:	THE BOX
Volume:	59529 cu.ft.	Level[dB]:	63
Surface:	10709 sq.ft.	Delay[ms]:	21
Humidity:	60 %	Length[ms]:	332
Air Temp:	20 °C	Window[ms]:	372
		Samples:	14628
		Channels:	2
Listener:	1	Sampling Rate [Hz]:	44100
Position[ft]:	X = 45.9 Y = 45.9 Z = 3.7	Frame Length:	8192
Orientation:	Hor = 270 ° Ver = 0 °	Frame Number:	2

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	97	5	1	100	0.48	0.435
2	125	97	5	2	125	0.48	0.435
3	160	97	6	3	160	0.49	0.431
4	200	97	6	4	200	0.49	0.428
5	250	97	7	5	250	0.50	0.425
6	315	97	7	6	315	0.49	0.434
7	400	97	8	7	400	0.47	0.443
8	500	97	9	8	500	0.46	0.452
9	630	97	10	9	630	0.50	0.427
10	800	97	10	10	800	0.54	0.402
11	1000	97	11	11	1000	0.58	0.377
12	1250	97	12	12	1250	0.53	0.402
13	1600	97	12	13	1600	0.49	0.427
14	2000	97	13	14	2000	0.45	0.452
15	2500	97	13	15	2500	0.45	0.451
16	3150	97	13	16	3150	0.45	0.451
17	4000	97	13	17	4000	0.44	0.450
18	5000	97	13	18	5000	0.42	0.452
19	6300	97	13	19	6300	0.40	0.454
20	8000	97	13	20	8000	0.38	0.456
21	10000	97	13	21	10000	0.34	0.456

Loudspeaker:	S3	Aiming:	Hor =-40 ° Ver = 0 ° Rot = 0 °
Active:	True	Delay:	0 msec
Position[ft]:	X = 62.3 Y = 62.3 Z = 3.28	Speaker:	VRS1000

[Fig. 69]: The Box - **Impulse Response 3**

1 ‘THE BOX’ SIMULATION



Project: THE BOX SIMULATION
Volume: 59529 cu.ft.
Surface: 10709 sq.ft.
Humidity: 60 %
Air Temp: 20 °C

Listener: 1
Position[ft]: X = 45.9 Y = 45.9 Z = 3.7
Orientation: Hor = 270 ° Ver = 0 °

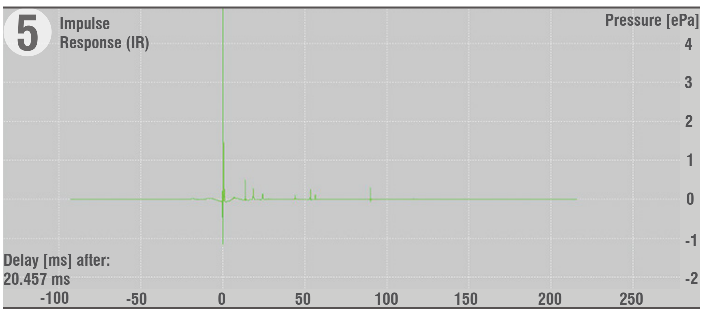
Filter: THE BOX
Level[dB]: 60
Delay[ms]: 21
Length[ms]: 309
Window[ms]: 372
Samples: 13648
Channels: 2
Sampling Rate [Hz]: 44100
Frame Length: 8192
Frame Number: 2

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	97	5	1	100	0.48	0.435
2	125	97	5	2	125	0.48	0.435
3	160	97	6	3	160	0.49	0.431
4	200	97	6	4	200	0.49	0.428
5	250	97	7	5	250	0.50	0.425
6	315	97	7	6	315	0.49	0.434
7	400	97	8	7	400	0.47	0.443
8	500	97	9	8	500	0.46	0.452
9	630	97	10	9	630	0.50	0.427
10	800	97	10	10	800	0.54	0.402
11	1000	97	11	11	1000	0.58	0.377
12	1250	97	12	12	1250	0.53	0.402
13	1600	97	12	13	1600	0.49	0.427
14	2000	97	13	14	2000	0.45	0.452
15	2500	97	13	15	2500	0.45	0.451
16	3150	97	13	16	3150	0.45	0.451
17	4000	97	13	17	4000	0.44	0.450
18	5000	97	13	18	5000	0.42	0.452
19	6300	97	13	19	6300	0.40	0.454
20	8000	97	13	20	8000	0.38	0.456
21	10000	97	13	21	10000	0.34	0.456

Loudspeaker: S4
Active: True
Position[ft]: X = 65.6 Y = 32.8 Z = 3.28

Aiming: Hor = -120 ° Ver = 0 ° Rot = 0 °
Delay: 0 msec
Speaker: VRS1000

[Fig. 70]: The Box - **Impulse Response 4**



Project: THE BOX SIMULATION
Volume: 59529 cu.ft.
Surface: 10709 sq.ft.
Humidity: 60 %
Air Temp: 20 °C

Listener: 1
Position[ft]: X = 45.9 Y = 45.9 Z = 3.7
Orientation: Hor = 270 ° Ver = 0 °

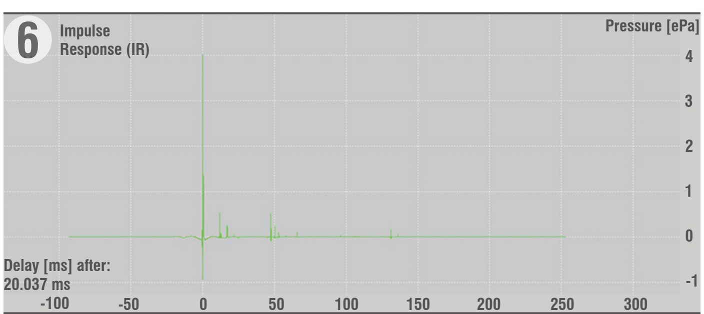
Filter: THE BOX
Level[dB]: 66
Delay[ms]: 20
Length[ms]: 309
Window[ms]: 372
Samples: 13626
Channels: 2
Sampling Rate [Hz]: 44100
Frame Length: 8192
Frame Number: 2

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	97	5	1	100	0.48	0.435
2	125	97	5	2	125	0.48	0.435
3	160	97	6	3	160	0.49	0.431
4	200	97	6	4	200	0.49	0.428
5	250	97	7	5	250	0.50	0.425
6	315	97	7	6	315	0.49	0.434
7	400	97	8	7	400	0.47	0.443
8	500	97	9	8	500	0.46	0.452
9	630	97	10	9	630	0.50	0.427
10	800	97	10	10	800	0.54	0.402
11	1000	97	11	11	1000	0.58	0.377
12	1250	97	12	12	1250	0.53	0.402
13	1600	97	12	13	1600	0.49	0.427
14	2000	97	13	14	2000	0.45	0.452
15	2500	97	13	15	2500	0.45	0.451
16	3150	97	13	16	3150	0.45	0.451
17	4000	97	13	17	4000	0.44	0.450
18	5000	97	13	18	5000	0.42	0.452
19	6300	97	13	19	6300	0.40	0.454
20	8000	97	13	20	8000	0.38	0.456
21	10000	97	13	21	10000	0.34	0.456

Loudspeaker: S5
Active: True
Position[ft]: X = 48 Y = 22.9 Z = 3.28

Aiming: Hor = -170 ° Ver = 0 ° Rot = 0 °
Delay: 0 msec
Speaker: VRS1000

[Fig. 71]: The Box - **Impulse Response 5**



Project: THE BOX SIMULATION
Volume: 59529 cu.ft.
Surface: 10709 sq.ft.
Humidity: 60 %
Air Temp: 20 °C

Listener: 1
Position[ft]: X = 45.9 Y = 45.9 Z = 3.7
Orientation: Hor = 270 ° Ver = 0 °

Filter: THE BOX
Level[dB]: 64
Delay[ms]: 25
Length[ms]: 346
Window[ms]: 372
Samples: 15259
Channels: 2
Sampling Rate [Hz]: 44100
Frame Length: 8192
Frame Number: 2

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	97	5	1	100	0.48	0.435
2	125	97	5	2	125	0.48	0.435
3	160	97	6	3	160	0.49	0.431
4	200	97	6	4	200	0.49	0.428
5	250	97	7	5	250	0.50	0.425
6	315	97	7	6	315	0.49	0.434
7	400	97	8	7	400	0.47	0.443
8	500	97	9	8	500	0.46	0.452
9	630	97	10	9	630	0.50	0.427
10	800	97	10	10	800	0.54	0.402
11	1000	97	11	11	1000	0.58	0.377
12	1250	97	12	12	1250	0.53	0.402
13	1600	97	12	13	1600	0.49	0.427
14	2000	97	13	14	2000	0.45	0.452
15	2500	97	13	15	2500	0.45	0.451
16	3150	97	13	16	3150	0.45	0.451
17	4000	97	13	17	4000	0.44	0.450
18	5000	97	13	18	5000	0.42	0.452
19	6300	97	13	19	6300	0.40	0.454
20	8000	97	13	20	8000	0.38	0.456
21	10000	97	13	21	10000	0.34	0.456

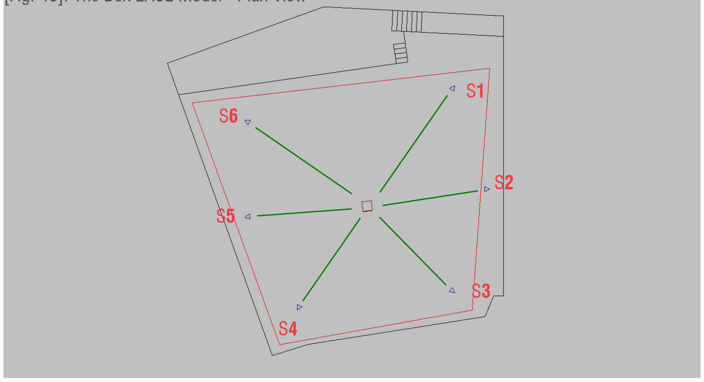
Loudspeaker: S6
Active: True
Position[ft]: X = 29.5 Y = 22.9 Z = 3.28

Aiming: Hor = -210 ° Ver = 0 ° Rot = 0 °
Delay: 0 msec
Speaker: VRS1000

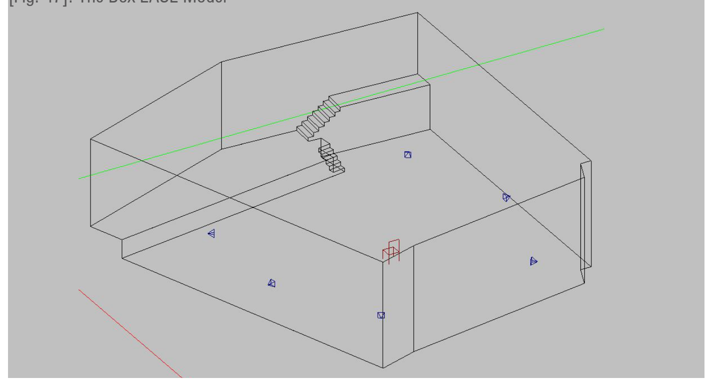
[Fig. 72]: The Box - **Impulse Response 6**

1 'THE BOX' SIMULATION

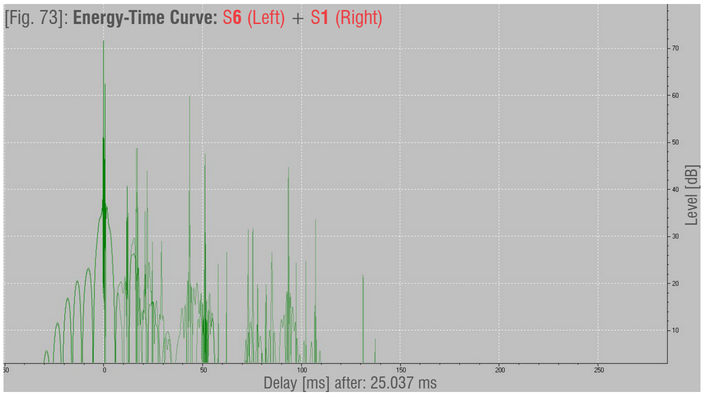
[Fig. 48]: The Box EASE Model - Plan View



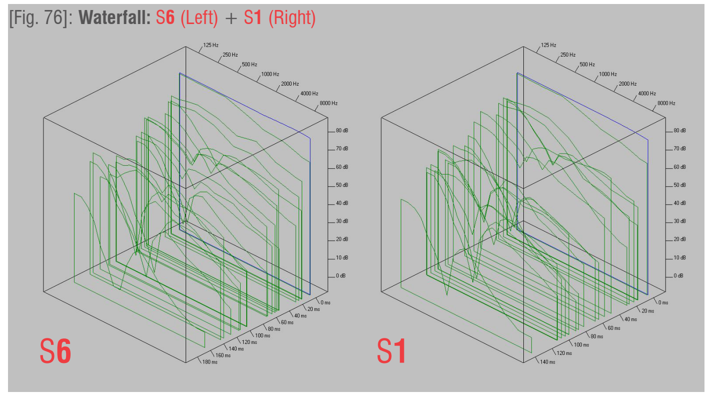
[Fig. 47]: The Box EASE Model



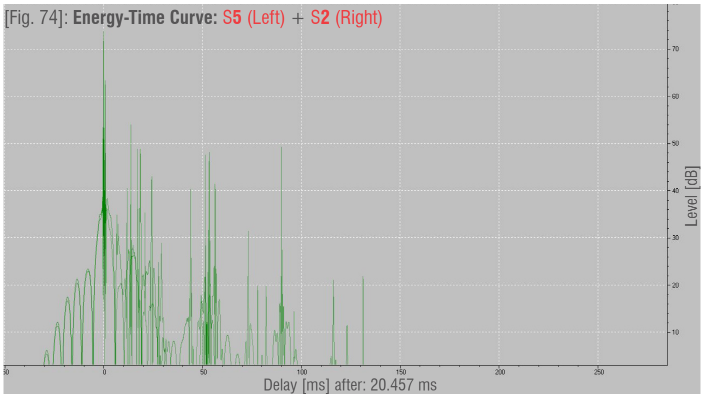
[Fig. 73]: **Energy-Time Curve:** S6 (Left) + S1 (Right)



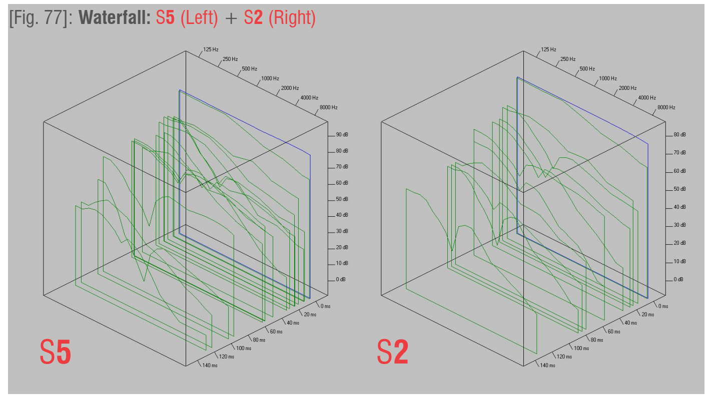
[Fig. 76]: **Waterfall:** S6 (Left) + S1 (Right)



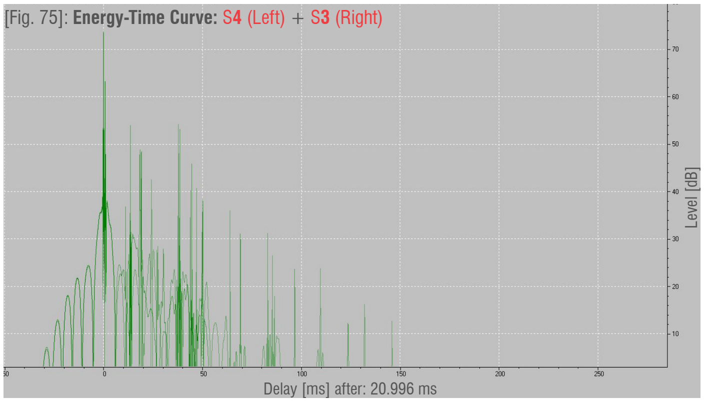
[Fig. 74]: **Energy-Time Curve:** S5 (Left) + S2 (Right)



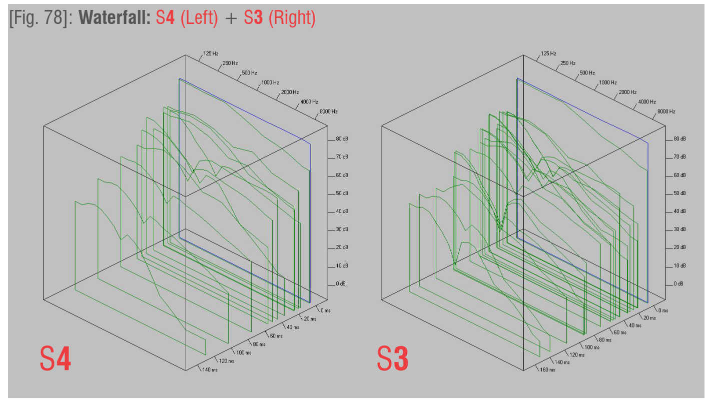
[Fig. 77]: **Waterfall:** S5 (Left) + S2 (Right)



[Fig. 75]: **Energy-Time Curve:** S4 (Left) + S3 (Right)



[Fig. 78]: **Waterfall:** S4 (Left) + S3 (Right)



1 'THE BOX' SIMULATION

Simulation Findings: 'The Box'

The Box was acoustically designed and treated for minimal reflections and reverberations. The five-sided shape, sloped ceiling plane, sprung dance floor and acoustical wall treatments all work together to accentuate and absorb the bass, allowing for a crisp and clean sound that doesn't leave people with their ears ringing.

ITD Gap - Displays the difference in arrival times between the first two direct sound arrivals.

- This information is useful in determining the proper place ment of loudspeakers and the delay times needed in dis tributed loudspeaker systems

[Figures 58-60: The Box – Total SPL Map]: Positioned at the center of The Box's audience area, the maximum difference between the first two direct sound arrivals is around 18.3 ms, which fits the ideal ITDG preference of less than 25 ms. Within the 5-sided pentagon shape, the loudspeaker sources are distributed at almost equal spacing around the center position, allowing for decreased difference in arrival times between any configuration of loudspeakers.

Energy Time Curve (ETC): Acoustic measurement tool for examining reflections and their amplitude over time but gives no insight into the spectrum of that energy (Hedback, 2011)

- Each peak on an ETC after the direct sound is a reflection
- ETC by itself is not enough to tell you if a space is acousti cally good or bad

[Figures 73-75: The Box - Energy Time Curves] are simulated energy time curves showing 3 sets of speaker's pairs where each pair contains a left and right speaker (ex, S6 left & S1 right). The speaker pair images (left and right) are overlaid to get a better understanding of their reflection peaks and decay patterns, whereas the figures to the right are acoustical waterfall representations of each speaker individually, analyzing the reflections through spectral information such as time, energy and frequency. Hedback's criteria for the ETC of both left and right speakers states that it should:

- Be visually identical (with only minor deviations) from 0-40 ms
- Show that peaks are down to at least -10 dB by 40 ms to prevent breakdown of the precedence effect
- Clearly show a decrease in the amplitude of energy over 0-40 ms. The decay pattern may or may not be continuous
- Show the consecutive peaks of the highest amplitude reflections viewed across the time axis to be relatively smooth in pattern and density

In analysis of the 3 ETC's (figures 73-75), each show a ragged profile appearance worthy of further investigation in a zoomed in representation from 0-40 ms instead 0-250 ms. This ragged profile in turn shows to be visually un-identical with noticeable deviations regarding reflection peak and decay points. On the other hand, The ETC's do hit the criteria of showing a decrease in amplitude of energy over 0-40 ms, as well showing that the peaks are down at least -10 dB by 40 ms. But like I stated earlier, the ETC by itself is not enough to tell you if a space is acoustically good or bad and should be considered in conjunction with other acoustical targets and measurements.

D/R Ratio - Shows the ratio of direct to reverberant sound in dB

- Zero dB indicates the sound levels are the same.
- Numbers less than 0 indicate the reverberant sound level is higher than the direct sound level.
- Numbers greater than 0 indicate the direct sound level is higher.

[Figures 55-57: The Box – D/R Ratio Map]: With all six speakers activated at a frequency of 1000 Hz (1/3 Octave Avg), the simulated mapping of the audience area (2,305 SF) indicates a maximum of 15.59 dB and a minimum of -7.45 dB. This shows that the ratio of direct sound level is about twice as much higher than the reverberation time for 1000Hz, which proves to be accurate considering the design intention was to minimize reverberation times for a direct clean sound.

Clarity Calculations C80 - Often called a clarity ratio. It uses an 80 ms Split Time to predict the articulation (clarity) of different types of music. In other words, it provides a look at the room's musical performance.

- Type of musical instrument:
  Percussive instruments (ex, piano, drums, electronic instruments, xylophon etc.) These instruments have a quick attack and a quick decay.
- Scale for interpreting C80 (Percussive Instruments):
  6+/-2 dB is ideal for percussive instruments.
- For good musical performance:
  the number should not exceed +8 dB at any location.

[Figures 52-54: The Box – Clarity C80 Map]: With reverberations decreased, the clarity of the sound increases, meaning that the energy of the early direct sounds are greater than those of reverberant sounds within 80 msec after the first direct hit from loudspeaker. This indicates that the room is very dead where the music will be very clear and C80 will produce a large positive value in decibels (Beranek, 2004). According to the simulation for C80, a large positive value was produced, showing a maximum of 21.2 dB and a minimum of 1.3 dB. The average comes to 8.6 dB which slightly exceeds the preferred level of 8 dB for good musical performance whereas the standard deviation of 3.7 dB sits well within the scale of ideal levels for percussive instruments.

Total SPL (SUM) - Displays the sum of the Direct and Reverberant sound energy in dB (displays the total sound level)

- Don't be surprised at the small variation between the mini mum and maximum levels. It's normal.

[Figures 64-66: The Box – Total SPL Map]: This simulated mapping compares well with L80 where instead of looking at the energy sum at a specified time it looks at the energy sum in dB. This space is not small like a listening room (where sound pressure of reflected sounds is greater than direct sounds) or big like a concert hall (sound pressure of direct sounds in greater than reflected), but sits in the middle as medium sized space where sound pressure is intermediary between direct and reflected. Both Total SPL and L80 fit the normal standards of little variation between maximum and minimum levels. For example, the distribution of values for Total SPL has a max. of 97 dB and a min. of 82 dB at the frequency of 1000 Hz (1/3 Octave Sum).

2 BERGHAIN

Audio / Visual / Spatial

[Fig. 25]: Berghain Logo

The Project Type: Nightclub
Location: Berlin, Germany
Size: 30,000m (322,917 Square Feet)
Capacity: 1,500
Distinguishing Characteristics:

- Known as the "best club in the world"
- Enormous existing power plant transformed into a club
- Monumental composition
- 18 m-high(60') cavernous main dance floor
- Minimalist interior of derelict concrete and steel
- Unique club restrictions: strict door policy and not allowed to take pictures IF you get inside.
- Place of Unlimited hedonism and permissiveness
- The club is built so there are no dead ends, allowing for free circulation with minimal obstruction

Research Findings:

Common findings:

- One large main dance space with flanking subspaces such as smaller dance spaces,bathrooms, bar, lounge area
- Compared to a 'sancturary', or 'Shrine of Techno', so its also known for people to have a religous experience.
- Containing spiritually/psychologically transformative powers through architectural implications
- Qualities of spaces act as a catalyst for identity dissolution, inverted social structure, communitas, optionality, and a sacred sense of play
- Berghain and the underground community is anti-structural, proposing alternatives to the dominant cultural and socio-political norms

Uncommon findings:

- Berghain is composed of three seperate operational establishments under one roof: Berghain main dance floor, Panorama Bar, and Lab.Oratory Club
- 'Dark Rooms' - More intimate, closed off spaces where both gay and straight sexual activities occur
- Berghain operates as a heterotopic "other place" where visitors disappear for days at a time
- Selectivity or the strict door policy for people entering preserves the sense of sacredness and community

Berghain Context: Social, Political, Cultural, Environmental

Berlin was and still is known for their legendary clubbing experience and strong relationship with electronic dance music, mostly known for the genre 'techno'. Techno was created in the 70's in Detroit, and almost simultaneously worked its way across the globe, landing most notably in Berlin, amplifying popular clubs such as Tresor, E-Werk, and laying the foundations for future clubs: Ostgut and Berghain. Berlin, Germany is known for its hectic past of the 20th century, but saw some light with the Berlin Wall coming down in the 1990's, where techno saw a shift in outlook and attitudes from the citizens 'sociologically trapped' by the wall, especially the youth of Germany. It created a new subcultural movement, which has evolved with techno to make Berlin a 'clubbing paradise' for DJ's, producers and masses of ravers.

Berghain was inherited by a prior club Ostgut which opened in 1998, being the one location for Snax – "a gay sex fetish night". This club was a fulcrum for the partygoers of Berlin as it helped rejuvenate the techno scene in the back end of the 90's. In 2003, the Ostgut was shut down and demolished, repurposing the space for a new development. After the clubs short lived years, a step towards revitalizing techno and its foothold with Berlin was taken into effect by the gay crowds and parties who lost their only place where they could live their lives and express themselves through music and dance. The legacy of Ostgut paved the way for Berghain as a club and a culture, which soon became the new home of the flourishing 21st century raver subculture.

The large 322,917 square foot empty floor space plan of the Berghain had the prior use of a combined heat and power station, erected in 1953-1954 as a socialist neo-classical architectural style, which became abandoned due to the 'inevitable obsolescence' of these power stations at the time. The plant was filled with generators, turbines, and other types of equipment which were removed after going out of service, leaving a large raw concrete structure from the 50's in the creative hands of club promoters Michael Teufele and Norbert Thormann. Berghain got its name through the location of which the structure stands, flanking two neighborhoods named Kreuzberg (BERG) and Friedrichshain (HAIN), which in German means "Mountain Grove".

Conceptual Underpinnings Perspective:

Berghain is another example making use of the cities found spaces, which was an enormous existing powerplant on the outskirts of Berlin. The transformation into Berghain nightclub was in honor of a legendary past Berlin club whose doors were shut due to a redevelopment project. It was a site of freedom, experimentation, unraveling, and excess, especially at a time when the community was socio-logically impacted from the trappings of the Berlin Wall. People wanted their space back, which was sacred in their mind, describing it as a religious experience when in the space of EDM. The fall of the wall in the 1990's changed this, as it changed the overall outlook and attitudes of Techno and what it brings to the underground community and its culture. The story of Techno in Berlin is a true testament to the powerful effects of dance music. The sound evolved into a global force yet maintained resistance to commercialization while uniting people of all types racially, sexually and culturally – and Berghain was the curator for it.

2 BERGHAIN

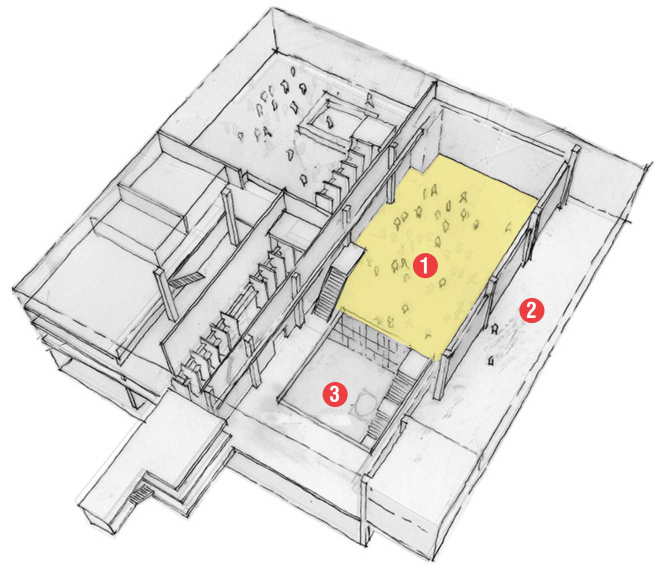
Audio / Visual / Spatial

Fig. 79: Berghain Dance Floor Perspective

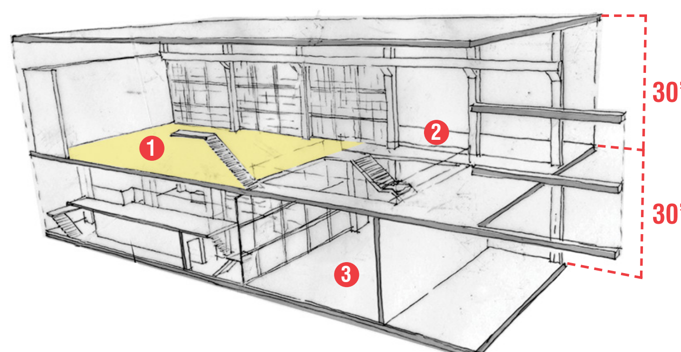
Berghain-Techno: Dance Floor - Spatial

The space of Berghain (The main dance floor) acts as the club's main hierarchical component with great importance and focus on the double height rectangular void that is centralized within the space as a whole, serving as the club's heart. Other spaces, or 'subspaces' such as other dancefloors, bars, lounges, bathrooms, etc., are radially directed outward from the centralized void with no dead ends and minimal obstruction, allowing for free circulation - which is ideal for the mass amounts of bodies. The transition between the main dance floor and its subspaces is 'loose' and open, serving as a threshold from space to space. Circulation is also emphasized vertically with suspended sets of industrial steel stairs transitioning to the level above and below the main dance floor. These stairs are pushed off to the perimeter walls of the space which also help with easier circulation as well as less congestion.

The Berghain dance floor itself takes the place of the old turbine room, hence the massive scale and the industrial, cavernous, cathedral like 'feel' of the space. The dance floor can hold up to 500 people with approximate dimensions of 45' x 65', which extends back to a double height void of 60' with a mezzanine wrapping around the perimeter. The club essentially has three levels, each level being about 30' in height where some areas are half that for a more intimate feel. The space is constructed around five existing bays of structural concrete columns extending from the ground floor to the roof. Filling in between the bays are concrete walls, which take up three sides of the rectangular space, with the fourth side being glass storefronts that separates the dance floor and the adjacent bar.

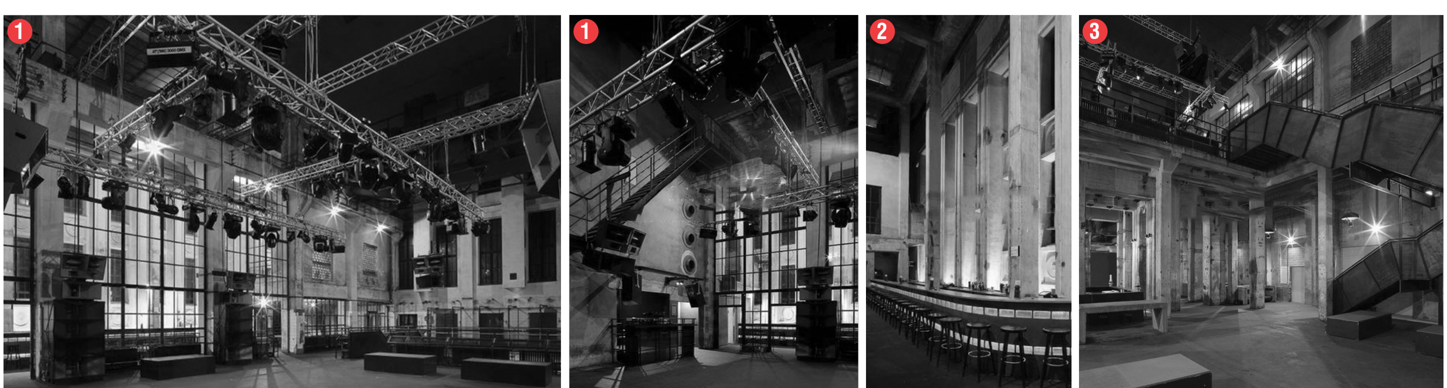


[Fig. 80]: Berghain Section Perspective Diagram 1

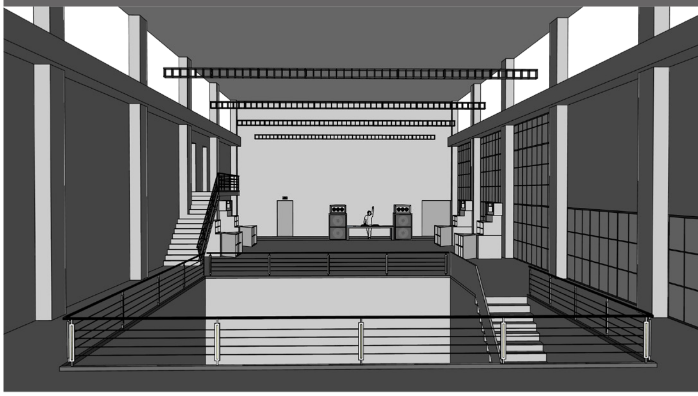


[Fig. 81]: Berghain Section Perspective Diagram 2

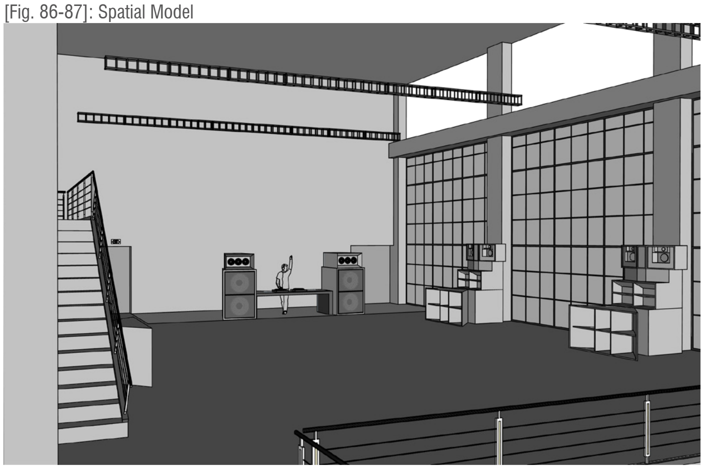
1. Berghain Main Dance Floor
2. Rough Bar Room
3. Dark Room 1



[Fig. 82-85]: Interior Perspectives: Berghain + Adjacent Spaces

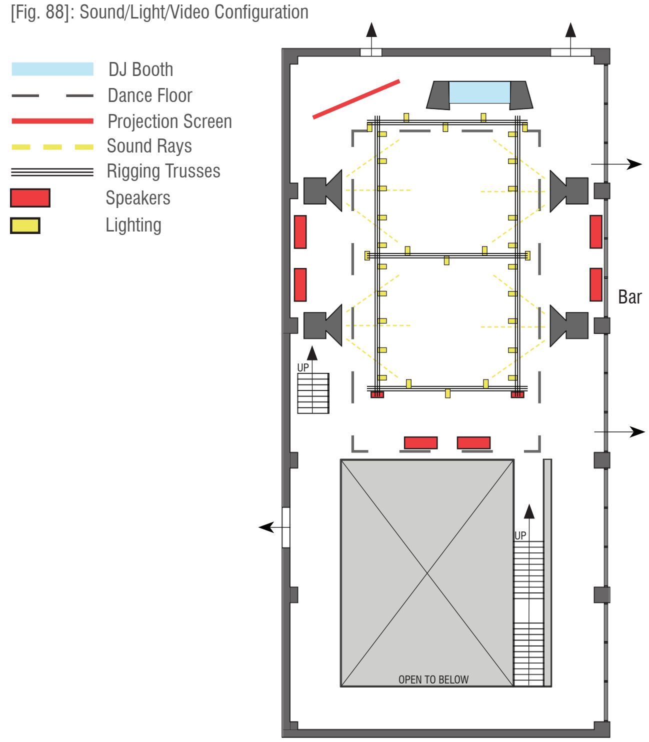


[Fig. 86-87]: Spatial Model



Berghain - Main Dance Floor: Sound / Lighting / Video

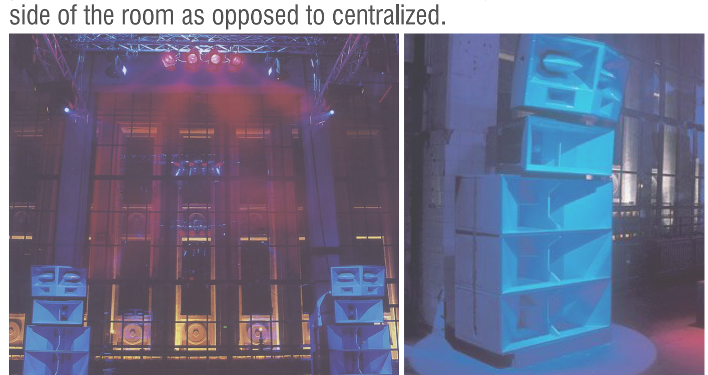
[Fig. 88]: Sound/Light/Video Configuration



Sound / Lighting / Video:

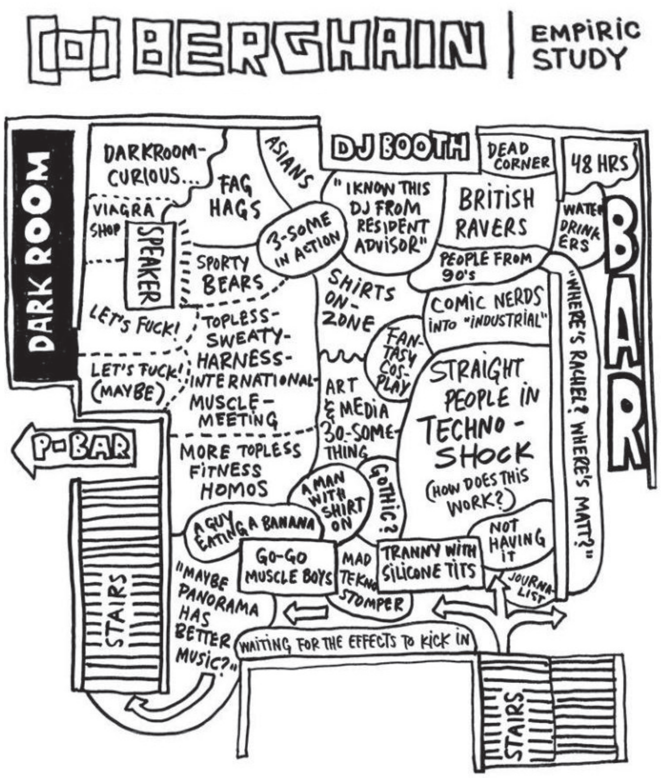
Berghain kept the 'feel' of the existing structure for many good reasons, but with that comes a massive cathedral like space with its surfaces consisting of concrete, glass and steel – which maximize reflections and echo of the sound which is not ideal for reverberation times of music, especially the fast paced booming bass of techno EDM. Due to this, Berghain installed good isolation material that made an 80% improvement regarding the acoustical sound of the space. It also helps that they invested in a good sound system: Funktion One(F1), where there are seven 8' tall speaker stacks configured 360 degrees around the dance floor. Smaller F1 speakers fill in the gaps creating an immersive, powerful and clear sound. With all this sound, you are still able to hold a conversation with a person near you as "the sound of F1's is smooth and free of distortion for very long periods of time" explains the founder of F1: Tony Andrews. He also stresses high quality sound and making it as translucent as possible, when its clean and clear it's like having an invisible landscape of sound around you, stating that it creates an uplifting and spiritual experience which is essential for music and sound. Berghain acoustics is explained well by a resident DJ, stating " In this place [Berghain], the acoustics can be quite restrictive, because it's very loose in there, and part of the appeal is this cathedral effect that you get on the music that you play. It enhances some things, and it has the opposite effect on other things"(Kirn, 2019).

Opposite of Berghains legendary sound system and its wide array of informative resources, the technical specifications of lighting and video fixtures was no where to be found, so I will analyze them by modeling the space. The 60' ceiling space of the dance floor is split by an array of rigging trusses, which are suspended from the ceiling rather than having its structure obstruct the ground surface. Mounted on the trusses are various types of lighting fixtures like lasers, strobe lights, sun strip lights, etc. The trusses commonly host smaller speakers, sending sound from above the audience, but here its minimal with majority of the sound sources coming from 8 feet or less above the ground surface. Berghain has one large video projection screen angularly situated at the front of the dance floor, parallel with the DJ Booth/table – which is oddly offset towards one side of the room as opposed to centralized.



[Fig. 89-90]: Sound System: FunktionOne Speaker Stacks

[Fig. 91]: Berghain - Spatial Empirical Study



Perceptions of Berghain:

The perceptions of Berghain, just like any nightclub setting, are as diverse as the people that inhibit the spaces, where Berghain was a curator for all types of races, cultures, sexuality etc., to dissolve together into oneness and equality, through techno and dance.

Starting with the perceptions of berghains sound, I will examine both the producers (DJ's) and consumers (audience) viewpoints. A resident DJ of Berghain named Barker explains the nice and even acoustical response of the sound is due to the classic shoebox concert hall shape, adding its just a very long and very prominent reverb. Due to this, it takes some working with during sound checks where he describes the process as 'glorious' in a way because it taps into the working of deep historical responses to acoustics. "David Byrne talks about how caves were spiritual places for early humans, because they represented shelter and safety, and this feeling was then exploited in how churches and cathedrals were designed. So, this response to reverb is deeply programmed into our DNA" (Kirn, 2019). Some describe the sound reverberation as hearing the room speaking back to the music, adding that there is something somewhat spiritual about it. Andi Baumecker, another resident DJ states that the space has a call and response to it, further commenting that "sometimes great music that I really love falls totally flat in there and sounds like a mess".

DJ Nick Hoppner provides his viewpoint on EDM sound in cathedral like spaces, presenting the fact that most of these spaces are concrete halls which means there is significant reverberation, which means if the sounds are played too fast (which EDM usually is) then the reverberation covers too much of the silence, where he emphasizes the need for silence (the silence he is referring to is the softer parts of tracks usually between the booming kicks of bass). He further interprets that "The ups and downs are pleasing to us, whether its on a bigger or smaller scale, so if you play in an environment like that – you risk losing your dynamics to reverberation".

Stemming from the more technical perceptions of the sound, I will examine the overall perceptions of the Berghain dance floor from the audience point of view – an empirical study of the space relating to sound, visuals and spatial qualities. I start with Grant Taylor's experience whose main interest in going to Berghain is the sound, stating "it is entirely about the music and the people there. Everyone there, no matter race, age, gender, sexual orientation…, are all there for the music and to have a great time together. This was a common viewpoint for many of Berghain's clubgoers – music and togetherness on the dance floor. Taylor adds that everything was so intimately designed to enhance the experience all while keeping the sound of the music the primary focus, revealing the rareness to find that in other clubs.

The spatial sequence to the main dance floor is also a popular experience among them as well, some describing the vertical ascension through the 60' void as a spiritual sacred threshold, others like Irfan Kubiak describe the anticipation of it: "We began our ascent on the metal stairs, buzzing to the bass. As we rose, so did the volume. I'm getting goosebumps just remembering first setting eyes on the dance floor. You start climbing the stairs towards the outside of the club, halfway up, the stairs U-turn to face the dance floor". The massive space of the dance floor hall is likened for the headroom, leaving little room for the claustrophobic sensation, even in the middle of the crowd, with no need to grab fresh air outside. I also found that this large space invokes a sense of relaxation, which is needed with the constant chaos. The raw, industrial, and minimal character is also a pleasing architectural attribute – where you can see the historic remains of the existing power plant. One last key spatial perception is the positioning of the DJ Booth, already noted earlier for its odd offset rather than centralized hierarchy, Chris Moger adds another dimension: "the DJ booth is right on the dance floor, not on some pedestal above the crowd. I hate that, it has turned DJing into such a spectacle, when at the end of the day, its all just about getting together for the music".

With not a lot of technical information on the lighting and visuals, there are some common desirable perceptions of them and their effect on the space and the users. Taylor makes clear the spectacular incorporation of visuals around the dance floor, stating that often times during music buildups, the less used lights hanging from the ceiling would turn on to light up the crowd so you could see the entire floor – "combining visual energy with audio".

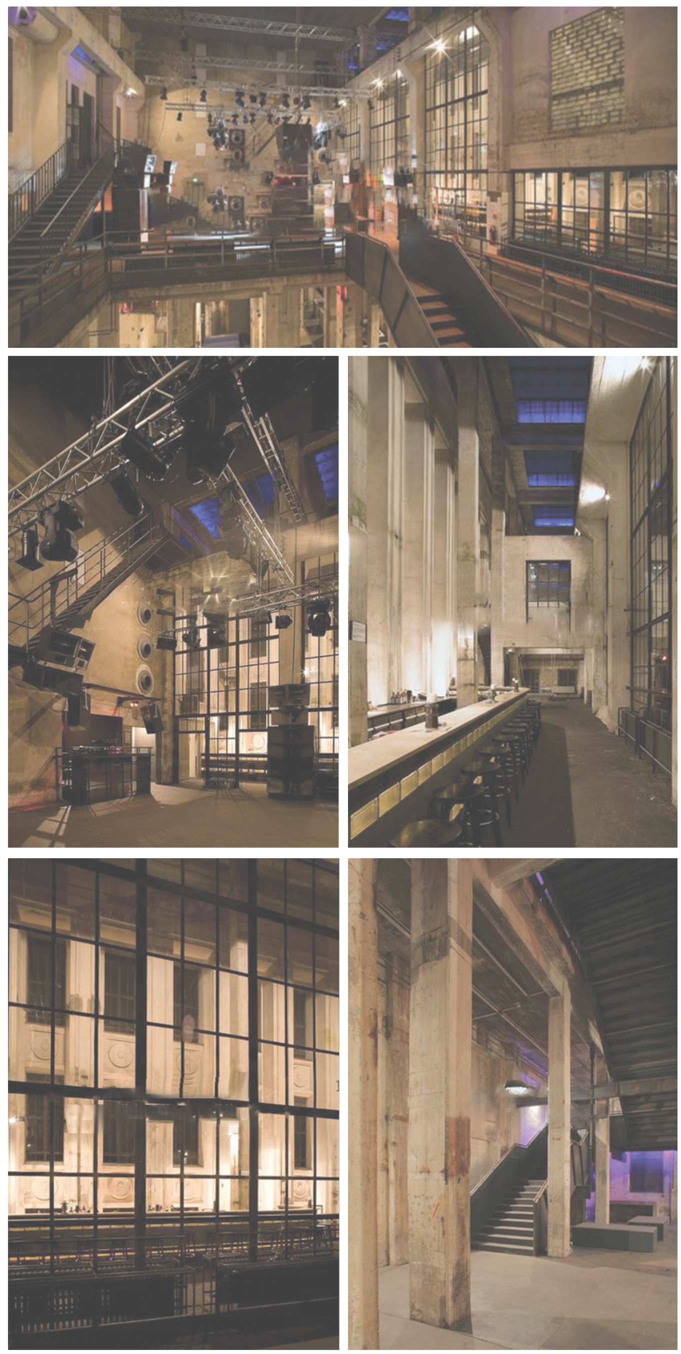
Taylor adds that in other instances, the music drops and would cause the strobe lights to turn on every other beat – "as if time had slowed down or completely froze". The music and sound are one dimension, and when you add the perfectly syncopated lasers, strobes and light squares with it, you get a timeless dimension', "an all-out perfect interaction through music" Kubiak adds.

Conclusion:

I picked the massive Berghain dance floor space to study as an exemplar case for the very own reason of it being a massive, 'cathedral like' space that kept a lot of the existing powerplants architectural elements and their industrial materialization of concrete, glass and steel – all of which should lead to miserable acoustical quality. They've done some work with acoustical isolation material which has said to help, but its still a 60' tall rectangular void with just less exposed reflective material, still resulting in long and prominent reverberation time. Which then comes down to the sound system, one of the best with the seven funktion One speaker stacks placed around the dance floor with even distribution. The placement and knowing how and where to send the music are key, especially within a massive concrete void, where DJ's are known to mess around with the system during sound checks to understand the acoustical quality of the space. Its these acoustical implications that made me want to simulate the sound of this legendary club in the acoustical software EASE, aiming to understand how the non-ideal acoustical space of Berghain attracts people from all over the world, with the biggest component being the sound of the music.

Berghain is not a perfectly acoustical treated room such as 'The Box' at the Ministry of Sound, but that's what makes Berghain's sound so desirable and different – the historic cathedral effect to it, enhancing somethings like the raw, industrial, massive feel of the space – but also having the opposite effect on other things such as the reverberation time which distorts the clarity of the sound. Some people prefer this reverberation produced by the cavernous space, pointing out the natural and spiritual effects of it. David Byrnes statement further explains this desired effect by talking about how caves in early human times were spiritual places, representing safety and shelter, where this feeling informed how churches, temples and cathedrals were designed, concluding that the response to reverberation effects is deeply rooted and programmed into our DNA(Kirn,2019). With that, I conclude that there are many perceptions of the ideal sound within Rave/EDM dance spaces, but what makes this sound stand out is the context in which it is played, Berghain's sound follows and resembles the natural, large industrial space of the building itself – linking the memories of sound with the physical place.

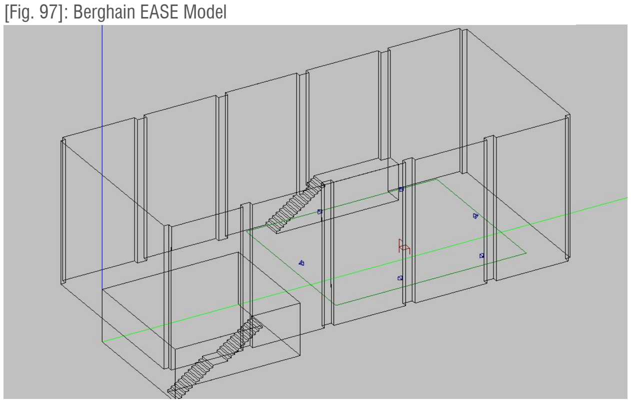
The physical space of the club and people's experiences about it is also another reason why I studied Berghain. People like big spaces, and some like smaller intimate spaces – Berghain combines both with its centralized double height voided dance floor space which then flank to more intimate spaces with minimal obstruction to circulation, both horizontal and vertical. I appreciate the fact that Berghain is a found space of the city that was converted into a nightclub but did so in a very nonchalantly minimalistic way by preserving the 'feel' of the existing historical power plant with its industrial, cavernous spatial characteristics.



[Fig. 92-96]: Berghain - Interior Perspectives

2 BERGHAIN SIMULATION

[Fig. 97]: Berghain EASE Model



[Fig. 98]: Berghain EASE Model - Plan View

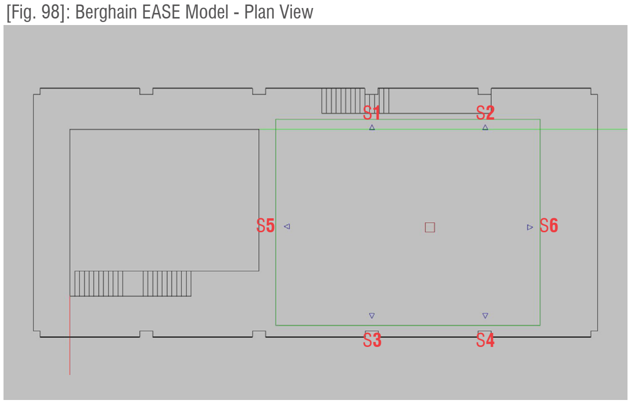
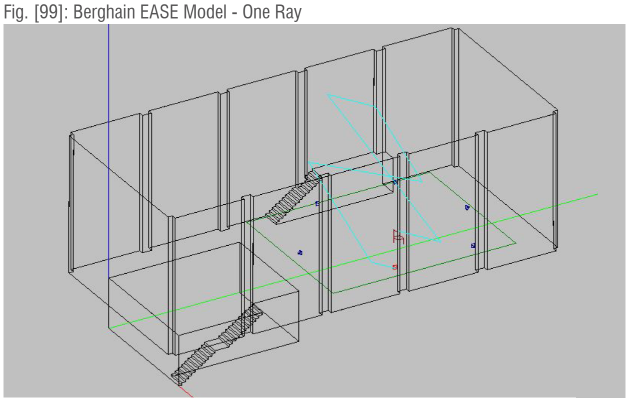
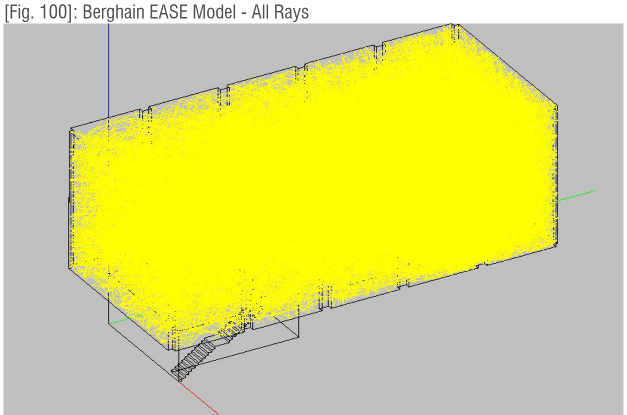


Fig. [99]: Berghain EASE Model - One Ray



[Fig. 100]: Berghain EASE Model - All Rays



Room Volume:	229450 cu. ft.
Room Surface:	86209 sq. ft.
Audience Area:	2155 sq. ft.
Room Capacity:	500 standees
Average Room Height:	40 ft.
Average Room Width:	50 ft.
Average Room Length:	108 ft.
Stage Area:	400 ft. sq.
Average Stage Depth:	10 ft.
Average Stage Width:	40 ft.
Mean Ceiling Height: (above stage area)	40 ft.

Surface Materialization:
- **Floor:** One-Way Concrete Slab
- **Side Walls:** (Reflectors)
  - Side wall one: concrete walls w/ indented columns
  - Side wall two: floor-ceiling glass storefronts
- **Rear/Front Walls:** (Reflectors)
  - Front wall: concrete wall
  - Back wall: concrete wall w/ punched window openings
- **Ceiling:** concrete w/ corrugated steel
- **Stage:** concrete slab (no fixed elevated stage)

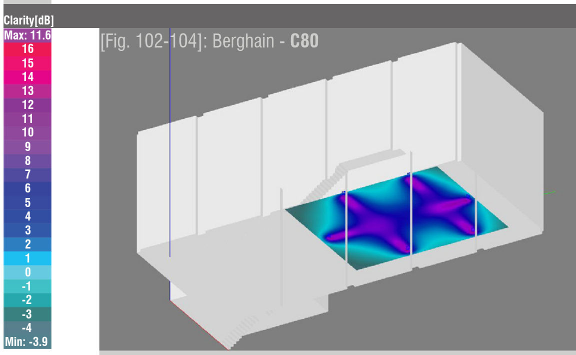
Loudspeakers:
- Funktion One Sound System
  - (6) x AX88

(Note: One AX88 loudspeaker represents one of the six large speaker stacks - Each speaker stack consists of:
2 x F221 bass enclosures, 2 x DS15 speakers, 2 x DS210 loudspeaker enclosures)

SCAN TO LISTEN

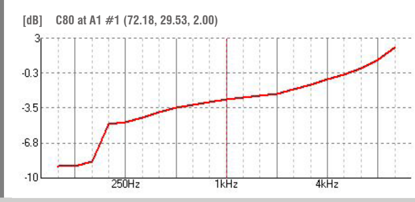
[Fig. 101]: QR Code - Berghain Audio Wav File

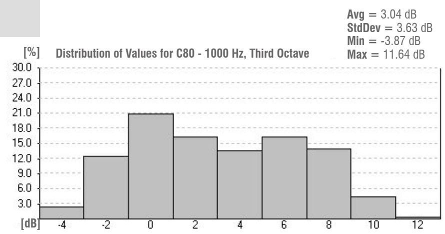
2 BERGHAIN SIMULATION

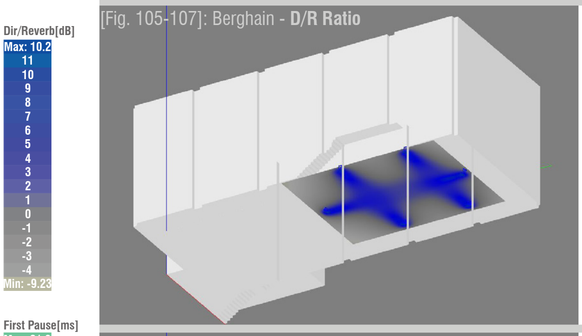


[Fig. 102-104]: Berghain - **C80**

Map: C80
Project: Berghain Simulation
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6
Freq: 1000 Hz (1/3 Octave Avg.)

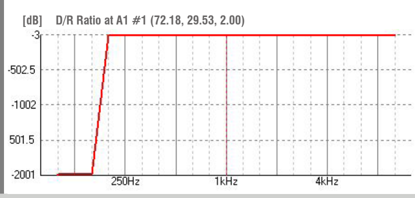


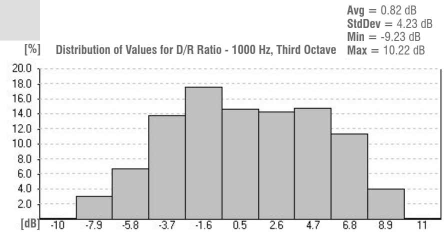


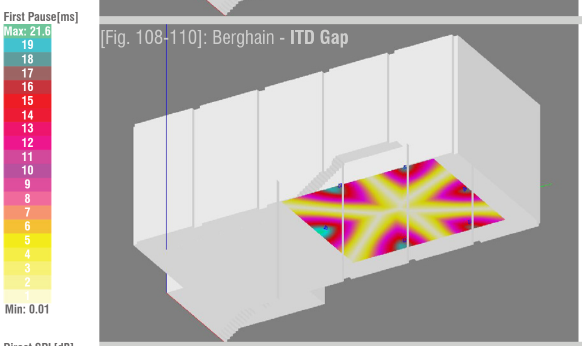


[Fig. 105-107]: Berghain - **D/R Ratio**

Map: D/R Ratio
Project: Berghain Simulation
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6
Freq: 1000 Hz (1/3 Octave Avg.)

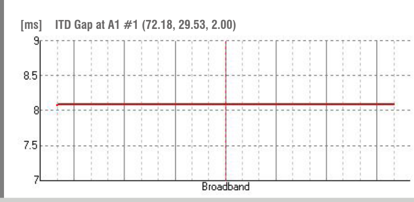


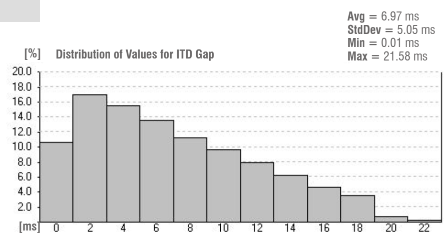


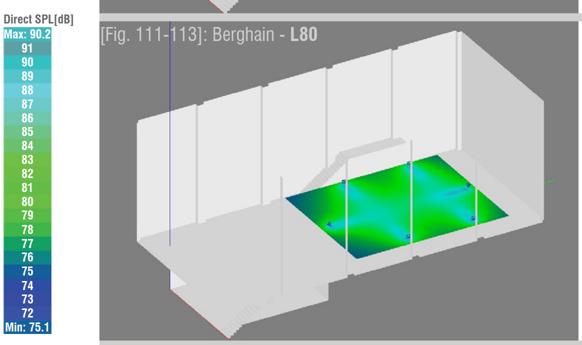


[Fig. 108-110]: Berghain - **ITD Gap**

Map: ITD Gap
Project: Berghain Simulation
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6

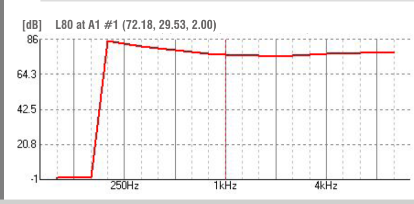


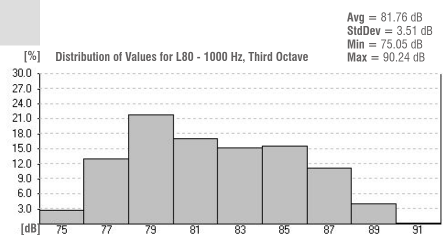


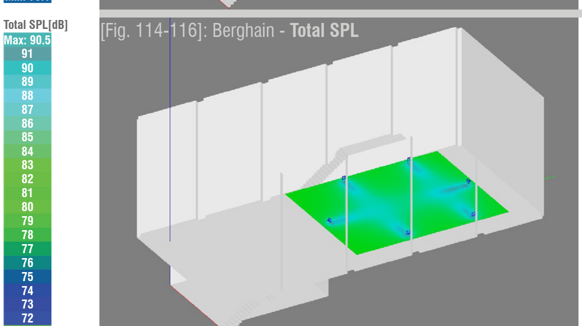


[Fig. 111-113]: Berghain - **L80**

Map: L80
Project: Berghain Simulation
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6
Freq: 1000 Hz (1/3 Octave Sum)

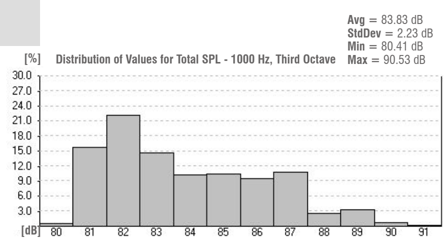




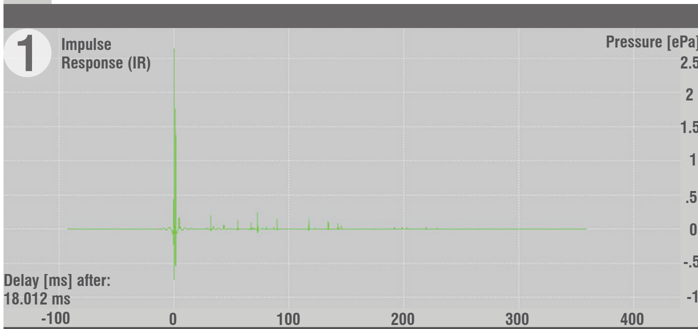


[Fig. 114-116]: Berghain - **Total SPL**

Map: Total SPL
Project: Berghain Simulation
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6
Freq: 1000 Hz (1/3 Octave Sum)



2 BERGHAIN SIMULATION



Project: BERGHAIN - SIMULATION MODEL
Volume: 229451 cu.ft.
Surface: 26277 sq.ft.
Humidity: 60 %
Air Temp: 20 °C

Filter: Berghain
Level[dB]: 60
Delay[ms]: 19
Length[ms]: 452
Window[ms]: 557
Samples: 19938
Channels: 2
Sampling Rate [Hz]: 44100
Frame Length: 8192
Frame Number: 3

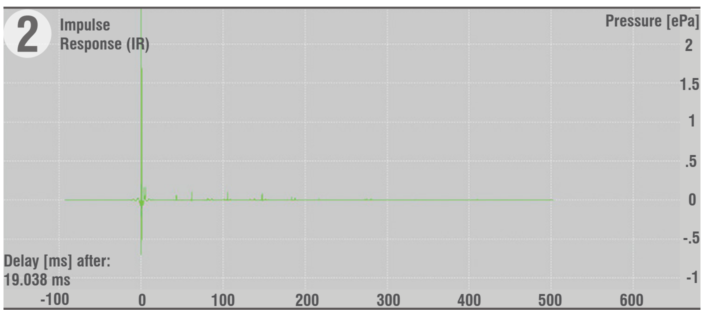
Listener: 1
Position[ft]: X = 19.69 Y = 68.9 Z = 18.3
Orientation: Hor = 180 ° Ver = 0 °

[Fig. 117]: The Box - **Impulse Response 1**

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	0	0	1	100	4.27	0.097
2	125	0	0	2	125	4.27	0.097
3	160	0	3	3	160	3.94	0.104
4	200	97	6	4	200	3.66	0.112
5	250	97	7	5	250	3.42	0.119
6	315	97	9	6	315	3.15	0.128
7	400	97	10	7	400	2.92	0.137
8	500	97	11	8	500	2.72	0.147
9	630	97	12	9	630	2.63	0.151
10	800	97	13	10	800	2.54	0.155
11	1000	97	15	11	1000	2.45	0.159
12	1250	97	15	12	1250	2.36	0.164
13	1600	97	15	13	1600	2.26	0.169
14	2000	97	15	14	2000	2.14	0.173
15	2500	97	15	15	2500	1.99	0.180
16	3150	97	14	16	3150	1.83	0.187
17	4000	97	13	17	4000	1.64	0.194
18	5000	97	13	18	5000	1.47	0.196
19	6300	97	12	19	6300	1.26	0.199
20	8000	97	11	20	8000	1.04	0.201
21	10000	97	11	21	10000	0.82	0.201

Loudspeaker: S1
Active: True
Position[ft]: X = 38 Y = 79.5 Z = 19.69

Aiming: Hor = -90 ° Ver = 0 ° Rot = 0 °
Delay: 0 msec
Speaker: AX88



Project: BERGHAIN - SIMULATION MODEL
Volume: 229451 cu.ft.
Surface: 26277 sq.ft.
Humidity: 60 %
Air Temp: 20 °C

Filter: BERGHAIN
Level[dB]: 58
Delay[ms]: 19
Length[ms]: 596
Window[ms]: 743
Samples: 26301
Channels: 2
Sampling Rate [Hz]: 44100
Frame Length: 8192
Frame Number: 4

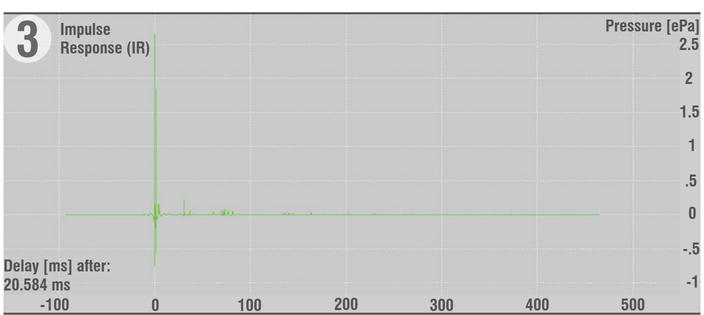
Listener: 1
Position[ft]: X = 19.69 Y = 68.9 Z = 18.3
Orientation: Hor = 180 ° Ver = 0 °

[Fig. 118]: The Box - **Impulse Response 2**

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	0	0	1	100	4.27	0.097
2	125	0	0	2	125	4.27	0.097
3	160	0	3	3	160	3.94	0.104
4	200	97	6	4	200	3.66	0.112
5	250	97	7	5	250	3.42	0.119
6	315	97	9	6	315	3.15	0.128
7	400	97	10	7	400	2.92	0.137
8	500	97	11	8	500	2.72	0.147
9	630	97	12	9	630	2.63	0.151
10	800	97	13	10	800	2.54	0.155
11	1000	97	15	11	1000	2.45	0.159
12	1250	97	15	12	1250	2.36	0.164
13	1600	97	15	13	1600	2.26	0.169
14	2000	97	15	14	2000	2.14	0.173
15	2500	97	15	15	2500	1.99	0.180
16	3150	97	14	16	3150	1.83	0.187
17	4000	97	13	17	4000	1.64	0.194
18	5000	97	13	18	5000	1.47	0.196
19	6300	97	12	19	6300	1.26	0.199
20	8000	97	11	20	8000	1.04	0.201
21	10000	97	11	21	10000	0.82	0.201

Loudspeaker: S2
Active: True
Position[ft]: X = 38 Y = 57.8 Z = 19.69

Aiming: Hor = -90 ° Ver = 0 ° Rot = 0 °
Delay: 0 msec
Speaker: AX88



Project: BERGHAIN - SIMULATION MODEL
Volume: 229451 cu.ft.
Surface: 26277 sq.ft.
Humidity: 60 %
Air Temp: 20 °C

Filter: BERGHAIN
Level[dB]: 59
Delay[ms]: 21
Length[ms]: 621
Window[ms]: 743
Samples: 27393
Channels: 2
Sampling Rate [Hz]: 44100
Frame Length: 8192
Frame Number: 4

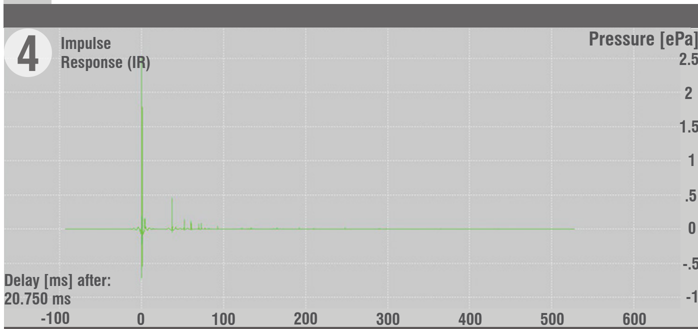
Listener: 1
Position[ft]: X = 19.69 Y = 68.9 Z = 18.3
Orientation: Hor = 180 ° Ver = 0 °

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	0	0	1	100	4.27	0.097
2	125	0	0	2	125	4.27	0.097
3	160	0	3	3	160	3.94	0.104
4	200	97	6	4	200	3.66	0.112
5	250	97	7	5	250	3.42	0.119
6	315	97	9	6	315	3.15	0.128
7	400	97	10	7	400	2.92	0.137
8	500	97	11	8	500	2.72	0.147
9	630	97	12	9	630	2.63	0.151
10	800	97	13	10	800	2.54	0.155
11	1000	97	15	11	1000	2.45	0.159
12	1250	97	15	12	1250	2.36	0.164
13	1600	97	15	13	1600	2.26	0.169
14	2000	97	15	14	2000	2.14	0.173
15	2500	97	15	15	2500	1.99	0.180
16	3150	97	14	16	3150	1.83	0.187
17	4000	97	13	17	4000	1.64	0.194
18	5000	97	13	18	5000	1.47	0.196
19	6300	97	12	19	6300	1.26	0.199
20	8000	97	11	20	8000	1.04	0.201
21	10000	97	11	21	10000	0.82	0.201

Loudspeaker: S3
Active: True
Position[ft]: X = -0.9 Y = 79.5 Z = 19.69

Aiming: Hor = 90 ° Ver = 0 ° Rot = 0 °
Delay: 0 msec
Speaker: AX88

[Fig. 119]: The Box - **Impulse Response 3**



Project: BERGHAIN - SIMULATION MODEL
Volume: 229451 cu.ft.
Surface: 26277 sq.ft.
Humidity: 60 %
Air Temp: 20 °C

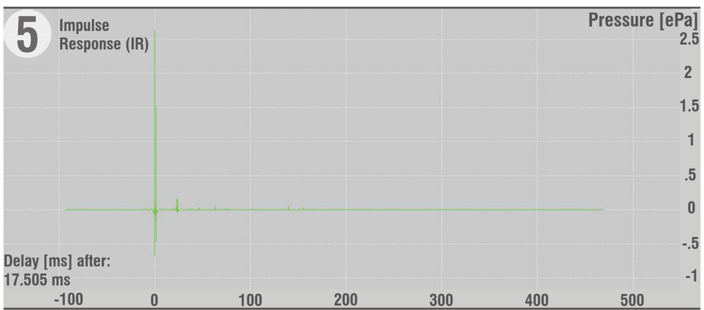
Listener: 1
Position[ft]: X = 19.69 Y = 68.9 Z = 18.3
Orientation: Hor = 180 ° Ver = 0 °

Filter: BERGHAIN
Level[dB]: 58
Delay[ms]: 18
Length[ms]: 562
Window[ms]: 743
Samples: 24797
Channels: 2
Sampling Rate [Hz]: 44100
Frame Length: 8192
Frame Number: 4

[Fig. 120]: The Box - **Impulse Response 4**

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	0	0	1	100	4.27	0.097
2	125	0	0	2	125	4.27	0.097
3	160	0	3	3	160	3.94	0.104
4	200	97	6	4	200	3.66	0.112
5	250	97	7	5	250	3.42	0.119
6	315	97	9	6	315	3.15	0.128
7	400	97	10	7	400	2.92	0.137
8	500	97	11	8	500	2.72	0.147
9	630	97	12	9	630	2.63	0.151
10	800	97	13	10	800	2.54	0.155
11	1000	97	15	11	1000	2.45	0.159
12	1250	97	15	12	1250	2.36	0.164
13	1600	97	15	13	1600	2.26	0.169
14	2000	97	15	14	2000	2.14	0.173
15	2500	97	15	15	2500	1.99	0.180
16	3150	97	14	16	3150	1.83	0.187
17	4000	97	13	17	4000	1.64	0.194
18	5000	97	13	18	5000	1.47	0.196
19	6300	97	12	19	6300	1.26	0.199
20	8000	97	11	20	8000	1.04	0.201
21	10000	97	11	21	10000	0.82	0.201

Loudspeaker: S4
Active: True
Position[ft]: X = -0.9 Y = 57.8 Z = 19.69
Aiming: Hor = 90 ° Ver = 0 ° Rot = 0 °
Delay: 0 msec
Speaker: AX88



Project: BERGHAIN - SIMULATION MODEL
Volume: 229451 cu.ft.
Surface: 26277 sq.ft.
Humidity: 60 %
Air Temp: 20 °C

Listener: 1
Position[ft]: X = 19.69 Y = 68.9 Z = 18.3
Orientation: Hor = 180 ° Ver = 0 °

Filter: BERGHAIN
Level[dB]: 56
Delay[ms]: 25
Length[ms]: 791
Window[ms]: 929
Samples: 34868
Channels: 2
Sampling Rate [Hz]: 44100
Frame Length: 8192
Frame Number: 5

[Fig. 121]: The Box - **Impulse Response 5**

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	0	0	1	100	4.27	0.097
2	125	0	0	2	125	4.27	0.097
3	160	0	3	3	160	3.94	0.104
4	200	97	6	4	200	3.66	0.112
5	250	97	7	5	250	3.42	0.119
6	315	97	9	6	315	3.15	0.128
7	400	97	10	7	400	2.92	0.137
8	500	97	11	8	500	2.72	0.147
9	630	97	12	9	630	2.63	0.151
10	800	97	13	10	800	2.54	0.155
11	1000	97	15	11	1000	2.45	0.159
12	1250	97	15	12	1250	2.36	0.164
13	1600	97	15	13	1600	2.26	0.169
14	2000	97	15	14	2000	2.14	0.173
15	2500	97	15	15	2500	1.99	0.180
16	3150	97	14	16	3150	1.83	0.187
17	4000	97	13	17	4000	1.64	0.194
18	5000	97	13	18	5000	1.47	0.196
19	6300	97	12	19	6300	1.26	0.199
20	8000	97	11	20	8000	1.04	0.201
21	10000	97	11	21	10000	0.82	0.201

Loudspeaker: S5
Active: True
Position[ft]: X = 19.69 Y = 88.58 Z = 19.7
Aiming: Hor = 0 ° Ver = 0 ° Rot = 0 °
Delay: 0 msec
Speaker: AX88

Project: BERGHAIN - SIMULATION MODEL
Volume: 229451 cu.ft.
Surface: 26277 sq.ft.
Humidity: 60 %
Air Temp: 20 °C

Listener: 1
Position[ft]: X = 19.69 Y = 68.9 Z = 18.3
Orientation: Hor = 180 ° Ver = 0 °

Filter: BERGHAIN
Level[dB]: 56
Delay[ms]: 25
Length[ms]: 791
Window[ms]: 743
Samples: 34868
Channels: 2
Sampling Rate [Hz]: 44100
Frame Length: 8192

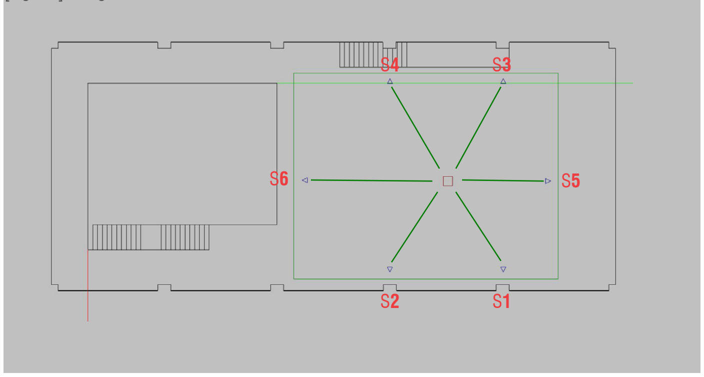
No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	0	0	1	100	4.27	0.097
2	125	0	0	2	125	4.27	0.097
3	160	0	3	3	160	3.94	0.104
4	200	97	6	4	200	3.66	0.112
5	250	97	7	5	250	3.42	0.119
6	315	97	9	6	315	3.15	0.128
7	400	97	10	7	400	2.92	0.137
8	500	97	11	8	500	2.72	0.147
9	630	97	12	9	630	2.63	0.151
10	800	97	13	10	800	2.54	0.155
11	1000	97	15	11	1000	2.45	0.159
12	1250	97	15	12	1250	2.36	0.164
13	1600	97	15	13	1600	2.26	0.169
14	2000	97	15	14	2000	2.14	0.173
15	2500	97	15	15	2500	1.99	0.180
16	3150	97	14	16	3150	1.83	0.187
17	4000	97	13	17	4000	1.64	0.194
18	5000	97	13	18	5000	1.47	0.196
19	6300	97	12	19	6300	1.26	0.199
20	8000	97	11	20	8000	1.04	0.201
21	10000	97	11	21	10000	0.82	0.201

Loudspeaker: S6
Active: True
Position[ft]: X = 19.5 Y = 41 Z = 19.69
Aiming: Hor = 180° Ver = 0 ° Rot = 0 °
Delay: 0 msec
Speaker: AX88

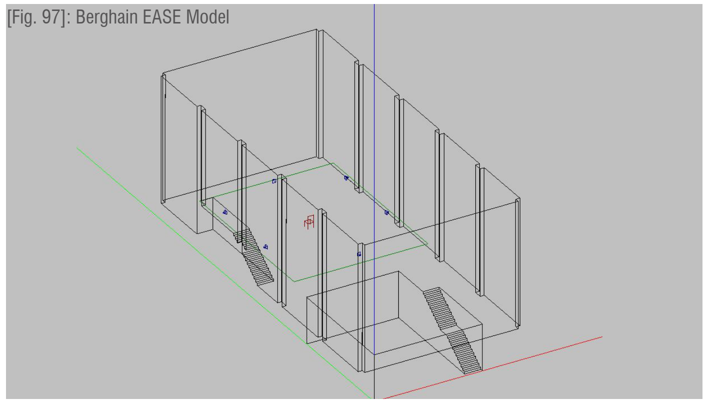
[Fig. 122]: The Box - **Impulse Response 6**

2 BERGHAIN SIMULATION

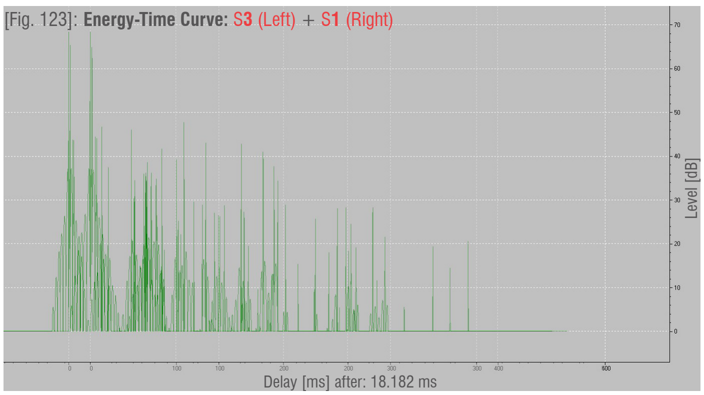
[Fig. 98]: Berghain EASE Model - Plan View



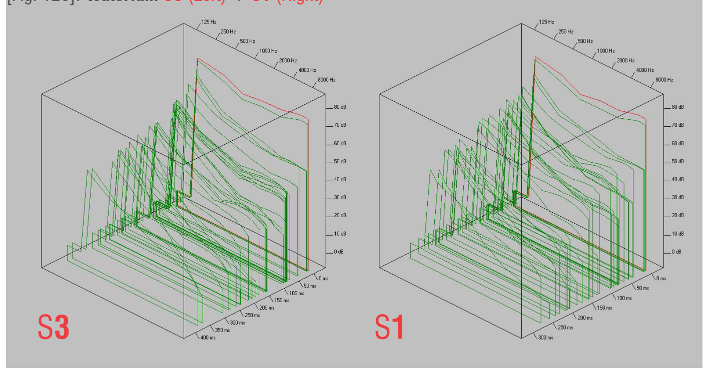
[Fig. 97]: Berghain EASE Model



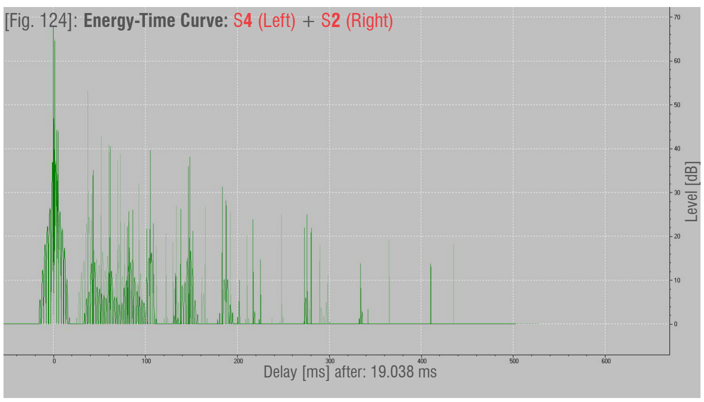
[Fig. 123]: **Energy-Time Curve:** **S3** (Left) + **S1** (Right)



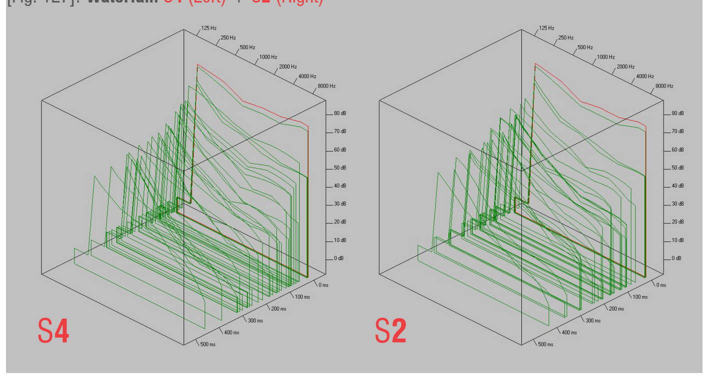
[Fig. 126]: **Waterfall:** **S3** (Left) + **S1** (Right)



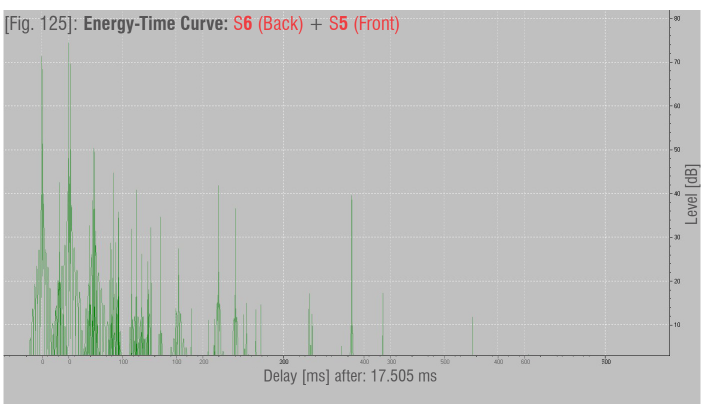
[Fig. 124]: **Energy-Time Curve:** **S4** (Left) + **S2** (Right)



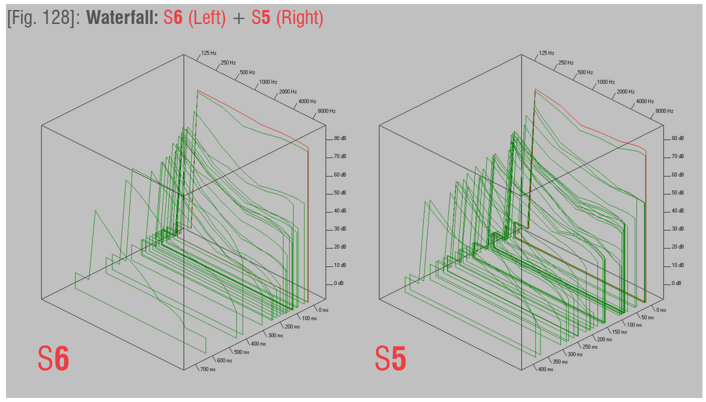
[Fig. 127]: **Waterfall:** **S4** (Left) + **S2** (Right)



[Fig. 125]: **Energy-Time Curve:** **S6** (Back) + **S5** (Front)



[Fig. 128]: **Waterfall:** **S6** (Left) + **S5** (Right)



Simulation Findings: Berghain

Berghain is not a perfectly acoustical treated room such as 'The Box' at the Ministry of Sound, but that's what makes Berghain's sound so desirable and different – the historic cathedral effect to it, enhancing somethings like the raw, industrial, massive feel of the space – but also having the opposite effect on other things such as the reverberation time which distorts the clarity of the sound. Some people prefer this reverberation produced by the cavernous space, pointing out the natural and spiritual effects of it.

ITD Gap - Displays the difference in arrival times between the first two direct sound arrivals.

- This information is useful in determining the proper place ment of loudspeakers and the delay times needed in dis tributed loudspeaker systems

[Figures 108-110: Berghain – Total SPL Map]: Positioned at the center of The Box's audience area, the maximum difference between the first two direct sound arrivals is around 21.6 ms, which fits the ideal ITDG preference of less than 25 ms. Within rectilinear concrete void, the loudspeaker sources are distributed at almost equal spacing around the center position, allowing for decreased difference in arrival times between any configuration of loudspeakers.

Energy Time Curve (ETC): Acoustic measurement tool for examining reflections and their amplitude over time but gives no insight into the spectrum of that energy (Hedback, 2011)

- Each peak on an ETC after the direct sound is a reflection

[Figures 123-125: Berghain Energy Time Curves] are simulated energy time curves showing 3 sets of speaker's pairs where each pair contains a left and right speaker (ex, S6 left & S1 right). The speaker pair images (left and right) are overlaid to get a better understanding of their reflection peaks and decay patterns, whereas the figures to the right are acoustical waterfall representations of each speaker individually, analyzing the reflections through spectral information such as time, energy and frequency. Hedback's criteria for the ETC of both left and right speakers states that it should:

- Be visually identical (with only minor deviations) from 0-40 ms
- Show that peaks are down to at least -10 dB by 40 ms to prevent breakdown of the precedence effect
- Clearly show a decrease in the amplitude of energy over 0-40 ms. The decay pattern may or may not be continuous
- Show the consecutive peaks of the highest amplitude reflections viewed across the time axis to be relatively smooth in pattern and density

In analysis of the 3 ETC's (figures 123-125), each show a ragged profile appearance worthy of further investigation in a zoomed in representation from 0-40 ms instead 0-250 ms. This ragged profile in turn shows to be visually un-identical with noticeable deviations regarding reflection peak and decay points. On the other hand, The ETC's do hit the criteria of showing a decrease in amplitude of energy over 0-40 ms, as well showing that the peaks are down at least -10 dB by 40 ms. But like I stated earlier, the ETC by itself is not enough to tell you if a space is acoustically good or bad and should be considered in conjunction with other acoustical targets and measurements.

D/R Ratio - Shows the ratio of direct to reverberant sound in dB

- Zero dB indicates the sound levels are the same.
- Numbers less than 0 indicate the reverberant sound level is higher than the direct sound level.
- Numbers greater than 0 indicate the direct sound level is higher.

[Figures 105-107: Berghain – D/R Ratio Map]: With all six speakers activated at a frequency of 1000 Hz (1/3 Octave Avg), the simulated mapping of the audience area (2,155 SF) indicates a maximum of 10.22 dB and a minimum of -9.23 dB. This shows that the ratio of direct sound level to reflected sound level is about the same, with the average being slightly above 0 at 0.82 dB. Considering Berghain is a large cavernous concrete void, the numbers should be less than 0 for the most part as the reverberant sound level is known to be higher than the direct sound level, this involves further investigation.

Clarity Calculations C80 - Often called a clarity ratio. It uses an 80 ms Split Time to predict the articulation (clarity) of different types of music. In other words, it provides a look at the room's musical performance.

- Type of musical instrument:
  Percussive instruments (ex, piano, drums, electronic instruments, xylophon etc.) These instruments have a quick attack and a quick decay.
- Scale for interpreting C80 (Percussive Instruments):
  6+/-2 dB is ideal for percussive instruments.
- For good musical performance:
  the number should not exceed +8 dB at any location.

[Figures 102-104: Berghain – Clarity C80 Map]: With the findings that the ratio of reverberation and direct sound levels are similar, that means that the energy between them are similar as well where it's the combination of both direct and reflected sound that make up the clarity, where the clarity can be described as live, vibrant and loud rather than the absorption dominant (minimal reflections) dead space of The Box. According to the simulation of C80, the maximum value is 11.64 dB and the minimum is -3.87 dB, which is slightly over the ideal criteria of being in between 6 +/-2, but when looking at the average (3.04 dB) and standard deviation (3.63 dB) of the numbers, they sit well within that ideal criteria while also not exceeding +8 dB at any location – allowing for good musical performance.

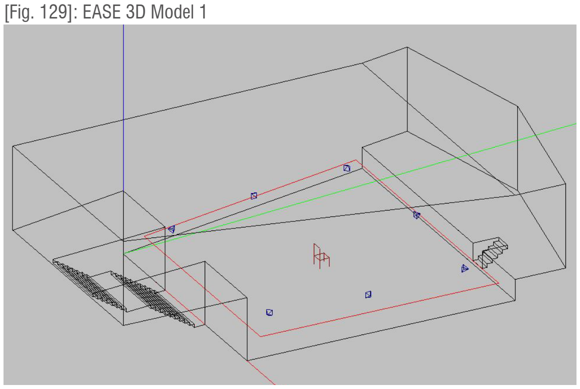
Total SPL (SUM) - Displays the sum of the Direct and Reverberant sound energy in dB (displays the total sound level)

- Don't be surprised at the small variation between the mini mum and maximum levels. It's normal.

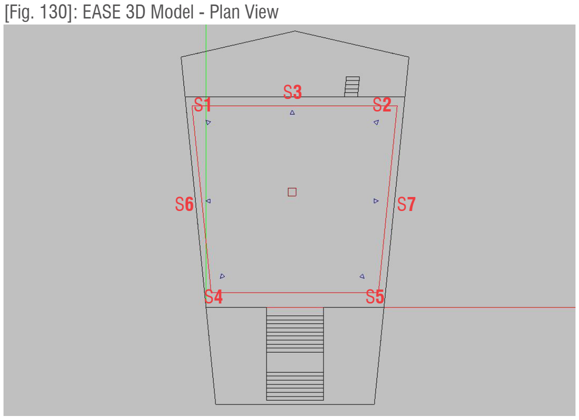
[Figures 114-116: Berghain – Total SPL Map]: This simulated mapping compares well with L80 where instead of looking at the energy sum at a specified time it looks at the energy sum in dB. This space is a large cavernous concrete hall, meaning that its more likely that the sound pressure of direct sounds will be greater than those of reflected because the reflected sounds die off quicker due to the large volume. Both Total SPL and L80 fit the normal standards of little variation between maximum and minimum levels. For example, the distribution of values for Total SPL has a max. of 90.5 dB and a min. of 80.4 dB at the frequency of 1000 Hz.

3 SIMULATION: 3D MODEL 1

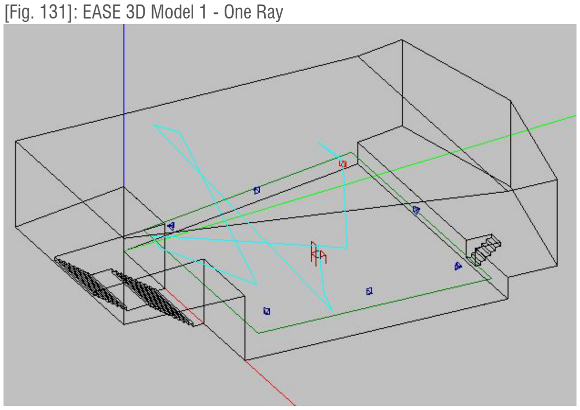
[Fig. 129]: EASE 3D Model 1



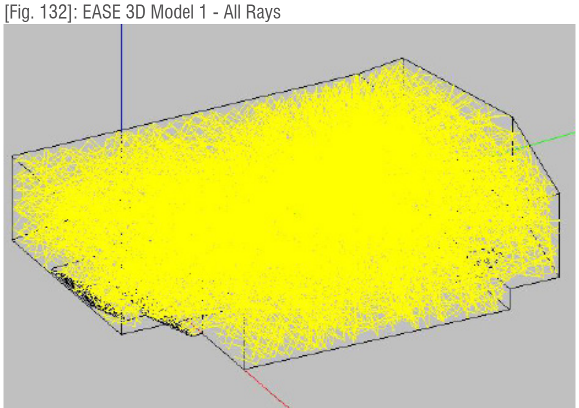
[Fig. 130]: EASE 3D Model - Plan View



[Fig. 131]: EASE 3D Model 1 - One Ray



[Fig. 132]: EASE 3D Model 1 - All Rays



Room Volume:	73590 cu. ft.
Room Surface:	42243 sq. ft.
Audience Area:	1944 sq. ft.
Room Capacity:	400 standees
Average Room Height:	22 ft.
Average Room Width:	46 ft.
Average Room Length:	48 ft.
Stage Area:	600 ft. sq.
Average Stage Depth:	12 ft.
Average Stage Width:	50 ft.
Mean Ceiling Height: (above stage area)	16 ft.

Surface Materialization:

- **Floor:** Floating Sprung Dance Floor: Plywood
  - W/ dual density shock dampening elastomer blocks at predetermined intervals
- **Side Walls:** (Absorbers)
  - Exterior Side: Triple thick absorbing walls
  - Interior Side: Perforated panels
- **Rear/Front Walls:** (Absorbers)
  - Exterior Side: Triple thick absorbing walls
  - Interior Side: Perforated panels
- **Ceiling:** (Sloped) Reflective - gypsum board - 6/8”
- **Stage:** Floating Floor Assembly: Plywood
  - Reflective/absorptive

Loudspeakers:

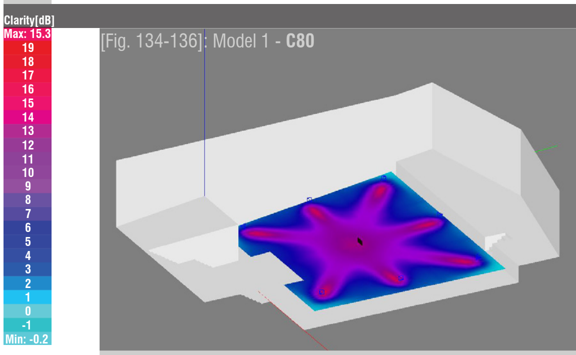
- Funktion One Sound System
  - (7) x RES9

(Note: One RES9 loudspeaker represents one of the 7 large speaker stacks

SCAN TO LISTEN

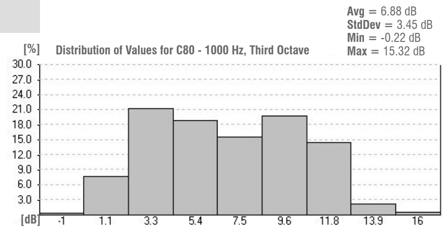
[Fig. 133]: QR Code - Berghain Audio Wav File

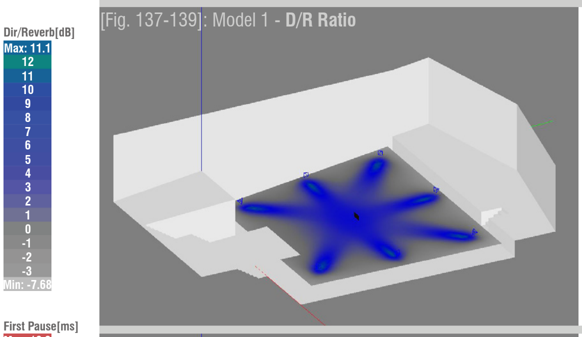
3 SIMULATION: 3D MODEL 1



[Fig. 134-136]: Model 1 - **C80**

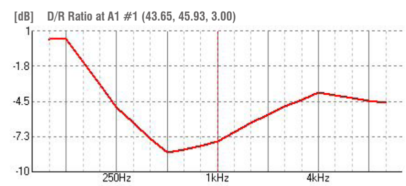
Map: C80
Project: 3D Model 1
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6, S7
Freq: 1000 Hz (1/3 Octave Avg.)

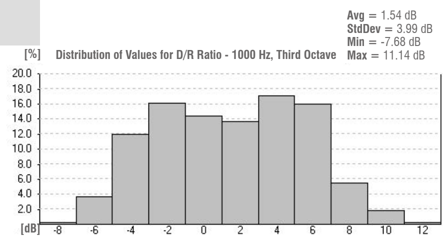


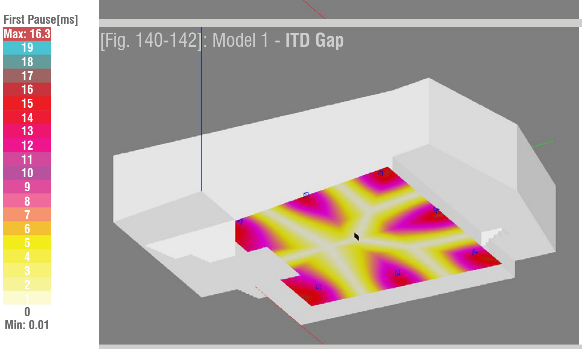


[Fig. 137-139]: Model 1 - **D/R Ratio**

Map: D/R Ratio
Project: 3D Model 1
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6, S7
Freq: 1000 Hz (1/3 Octave Avg.)

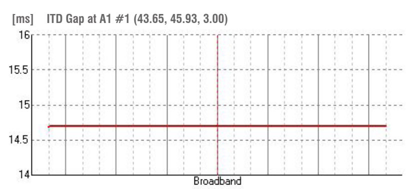


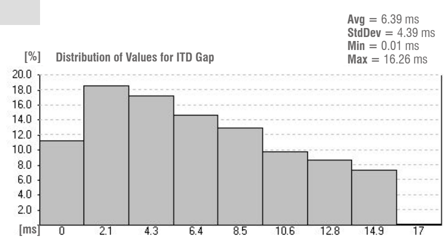


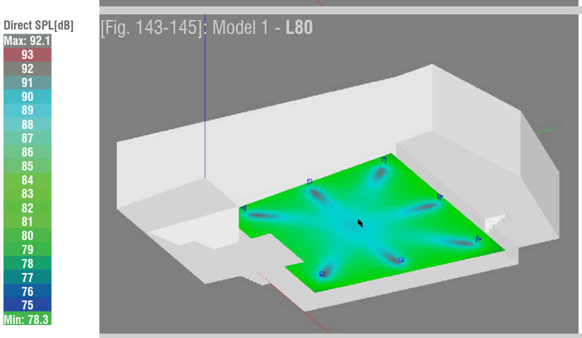


[Fig. 140-142]: Model 1 - **ITD Gap**

Map: ITD Gap
Project: 3D Model 1
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6, S7

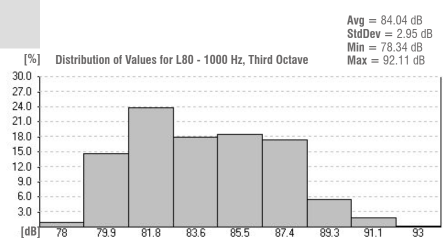


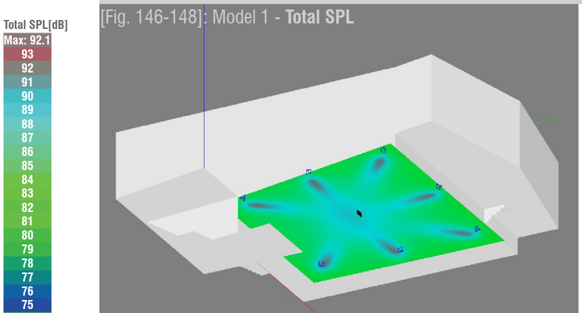




[Fig. 143-145]: Model 1 - **L80**

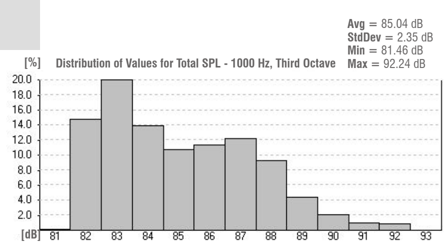
Map: L80
Project: 3D Model 1
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6, S7
Freq: 1000 Hz (1/3 Octave Sum)



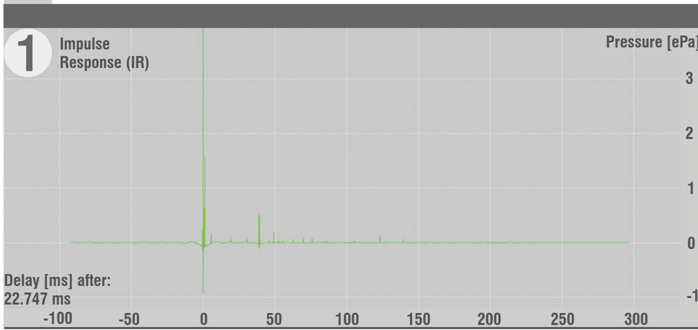


[Fig. 146-148]: Model 1 - **Total SPL**

Map: Total SPL
Project: 3D Model 1
Ver: -30° Hor: -120°
Lspk: S1, S2, S3, S4, S5, S6, S7
Freq: 1000 Hz (1/3 Octave Sum)



3 SIMULATION: 3D MODEL 1



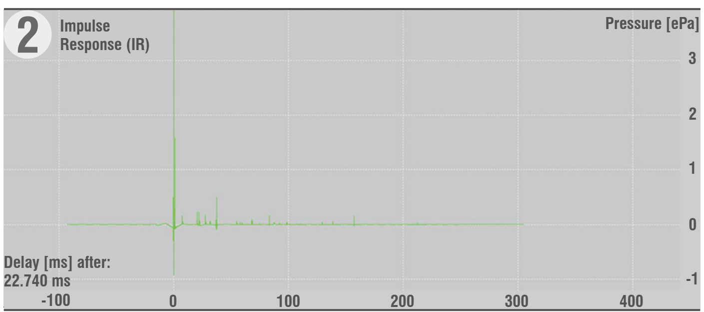
Project:	3D MODEL 1	Filter:	MODEL 1
Volume:	73591 cu.ft.	Level[dB]:	63
Surface:	12876 sq.ft.	Delay[ms]:	23
Humidity:	60 %	Length[ms]:	390
Air Temp:	20 °C	Window[ms]:	557
		Samples:	17213
		Channels:	2
Listener:	1	Sampling Rate [Hz]:	44100
Position[ft]:	X = 19.69 Y = 26.25 Z = 3.7	Frame Length:	8192
Orientation:	Hor = 180 ° Ver = 0 °	Frame Number:	3

No.	Band [Hz]	SPL(1m)	Direct. [dB]
1	100	97	6
2	125	97	6
3	160	97	6
4	200	97	6
5	250	97	7
6	315	97	8
7	400	97	9
8	500	97	10
9	630	97	11
10	800	97	13
11	1000	97	14
12	1250	97	15
13	1600	97	15
14	2000	97	16
15	2500	97	17
16	3150	97	17
17	4000	97	17
18	5000	97	17
19	6300	97	16
20	8000	97	15
21	10000	97	15

No.	Band [Hz]	RTime [s]	Absorp.
1	100	0.38	0.528
2	125	0.38	0.528
3	160	0.45	0.471
4	200	0.53	0.414
5	250	0.64	0.357
6	315	0.71	0.328
7	400	0.79	0.300
8	500	0.89	0.272
9	630	0.93	0.263
10	800	0.97	0.254
11	1000	1.00	0.245
12	1250	0.95	0.255
13	1600	0.91	0.265
14	2000	0.86	0.275
15	2500	0.86	0.271
16	3150	0.86	0.266
17	4000	0.85	0.262
18	5000	0.81	0.260
19	6300	0.75	0.258
20	8000	0.67	0.256
21	10000	0.57	0.256

Loudspeaker:	S1	Aiming:	Hor =45 ° Ver = 0 ° Rot = 0 °
Active:	True	Delay:	0 msec
Position[ft]:	X = 0 Y = 42.65 Z = 4.5	Speaker:	RES 9

[Fig. 149]: The Box - **Impulse Response 1**



Project:	3D MODEL 1	Filter:	MODEL 1
Volume:	73591 cu.ft.	Level[dB]:	58
Surface:	12876 sq.ft.	Delay[ms]:	17
Humidity:	60 %	Length[ms]:	353
Air Temp:	20 °C	Window[ms]:	372
		Samples:	15549
		Channels:	2
Listener:	1	Sampling Rate [Hz]:	44100
Position[ft]:	X = 19.69 Y = 26.25 Z = 3.7	Frame Length:	8192
Orientation:	Hor = 180 ° Ver = 0 °	Frame Number:	3

No.	Band [Hz]	SPL(1m)	Direct. [dB]
1	100	97	6
2	125	97	6
3	160	97	6
4	200	97	6
5	250	97	7
6	315	97	8
7	400	97	9
8	500	97	10
9	630	97	11
10	800	97	13
11	1000	97	14
12	1250	97	15
13	1600	97	15
14	2000	97	16
15	2500	97	17
16	3150	97	17
17	4000	97	17
18	5000	97	17
19	6300	97	16
20	8000	97	15
21	10000	97	15

No.	Band [Hz]	RTime [s]	Absorp.
1	100	0.38	0.528
2	125	0.38	0.528
3	160	0.45	0.471
4	200	0.53	0.414
5	250	0.64	0.357
6	315	0.71	0.328
7	400	0.79	0.300
8	500	0.89	0.272
9	630	0.93	0.263
10	800	0.97	0.254
11	1000	1.00	0.245
12	1250	0.95	0.255
13	1600	0.91	0.265
14	2000	0.86	0.275
15	2500	0.86	0.271
16	3150	0.86	0.266
17	4000	0.85	0.262
18	5000	0.81	0.260
19	6300	0.75	0.258
20	8000	0.67	0.256
21	10000	0.57	0.256

Loudspeaker:	S2	Aiming:	Hor =45 ° Ver = 0 ° Rot = 0 °
Active:	True	Delay:	0 msec
Position[ft]:	X = 39.4 Y = 42.65 Z = 4.5	Speaker:	RES 9

[Fig. 150]: The Box - **Impulse Response 2**

Project:	3D MODEL 1	Filter:	MODEL 1
Volume:	73591 cu.ft.	Level[dB]:	61
Surface:	12876 sq.ft.	Delay[ms]:	23
Humidity:	60 %	Length[ms]:	388
Air Temp:	20 °C	Window[ms]:	557
		Samples:	17103
		Channels:	2
Listener:	1	Sampling Rate [Hz]:	44100
Position[ft]:	X = 19.69 Y = 26.25 Z = 3.7	Frame Length:	8192
Orientation:	Hor = 180 ° Ver = 0 °	Frame Number:	3

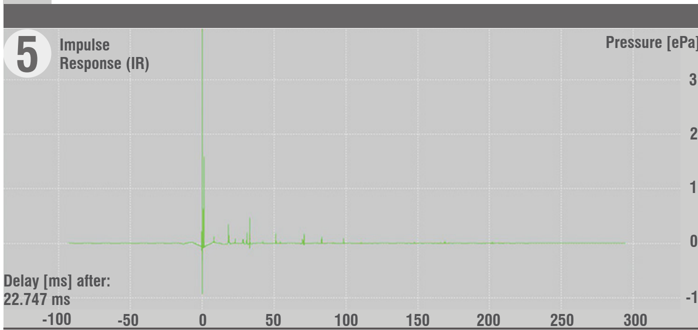
No.	Band [Hz]	SPL(1m)	Direct. [dB]
1	100	97	6
2	125	97	6
3	160	97	6
4	200	97	6
5	250	97	7
6	315	97	8
7	400	97	9
8	500	97	10
9	630	97	11
10	800	97	13
11	1000	97	14
12	1250	97	15
13	1600	97	15
14	2000	97	16
15	2500	97	17
16	3150	97	17
17	4000	97	17
18	5000	97	17
19	6300	97	16
20	8000	97	15
21	10000	97	15

No.	Band [Hz]	RTime [s]	Absorp.
1	100	0.38	0.528
2	125	0.38	0.528
3	160	0.45	0.471
4	200	0.53	0.414
5	250	0.64	0.357
6	315	0.71	0.328
7	400	0.79	0.300
8	500	0.89	0.272
9	630	0.93	0.263
10	800	0.97	0.254
11	1000	1.00	0.245
12	1250	0.95	0.255
13	1600	0.91	0.265
14	2000	0.86	0.275
15	2500	0.86	0.271
16	3150	0.86	0.266
17	4000	0.85	0.262
18	5000	0.81	0.260
19	6300	0.75	0.258
20	8000	0.67	0.256
21	10000	0.57	0.256

Loudspeaker:	S4	Aiming:	Hor =140 ° Ver = 0 ° Rot = 0 °
Active:	True	Delay:	0 msec
Position[ft]:	X = 3.28 Y = 6.56 Z = 4.5	Speaker:	RES 9

[Fig. 151]: The Box - **Impulse Response 4**

3 SIMULATION: 3D MODEL 1



Project: 3D MODEL 1
Volume: 73591 cu.ft.
Surface: 12876 sq.ft.
Humidity: 60 %
Air Temp: 20 °C

Listener: 1
Position[ft]: X = 19.69 Y = 26.25 Z = 3.7
Orientation: Hor = 180 ° Ver = 0 °

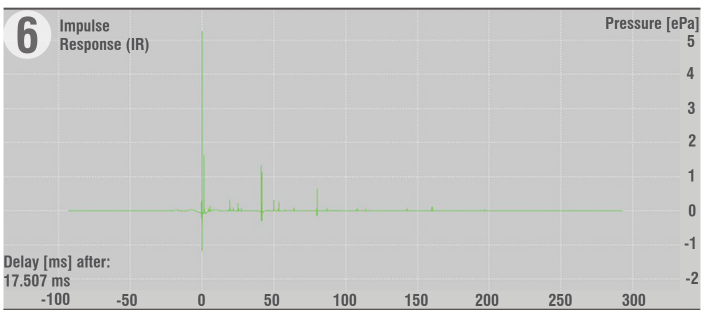
Filter: MODEL 1
Level[dB]: 66
Delay[ms]: 18
Length[ms]: 386
Window[ms]: 557
Samples: 17038
Channels: 2
Sampling Rate [Hz]: 44100
Frame Length: 8192
Frame Number: 3

[Fig. 152]: The Box - **Impulse Response 5**

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	97	6	1	100	0.38	0.528
2	125	97	6	2	125	0.38	0.528
3	160	97	6	3	160	0.45	0.471
4	200	97	6	4	200	0.53	0.414
5	250	97	7	5	250	0.64	0.357
6	315	97	8	6	315	0.71	0.328
7	400	97	9	7	400	0.79	0.300
8	500	97	10	8	500	0.89	0.272
9	630	97	11	9	630	0.93	0.263
10	800	97	13	10	800	0.97	0.254
11	1000	97	14	11	1000	1.00	0.245
12	1250	97	15	12	1250	0.95	0.255
13	1600	97	15	13	1600	0.91	0.265
14	2000	97	16	14	2000	0.86	0.275
15	2500	97	17	15	2500	0.86	0.271
16	3150	97	17	16	3150	0.86	0.266
17	4000	97	17	17	4000	0.85	0.262
18	5000	97	17	18	5000	0.81	0.260
19	6300	97	16	19	6300	0.75	0.258
20	8000	97	15	20	8000	0.67	0.256
21	10000	97	15	21	10000	0.57	0.256

Loudspeaker: S5
Active: True
Position[ft]: X = 36.09 Y = 6.56 Z = 4.5

Aiming: Hor =-135 ° Ver = 0 ° Rot = 0 °
Delay: 0 msec
Speaker: RES 9



Project: 3D MODEL 1
Volume: 73591 cu.ft.
Surface: 12876 sq.ft.
Humidity: 60 %
Air Temp: 20 °C

Listener: 1
Position[ft]: X = 19.69 Y = 26.25 Z = 3.7
Orientation: Hor = 180 ° Ver = 0 °

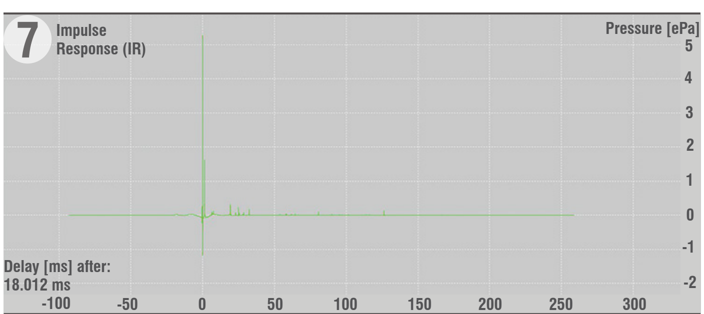
Filter: MODEL 1
Level[dB]: 66
Delay[ms]: 17
Length[ms]: 352
Window[ms]: 372
Samples: 15527
Channels: 2
Sampling Rate [Hz]: 44100
Frame Length: 8192
Frame Number: 3

[Fig. 153]: The Box - **Impulse Response 6**

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	97	6	1	100	0.38	0.528
2	125	97	6	2	125	0.38	0.528
3	160	97	6	3	160	0.45	0.471
4	200	97	6	4	200	0.53	0.414
5	250	97	7	5	250	0.64	0.357
6	315	97	8	6	315	0.71	0.328
7	400	97	9	7	400	0.79	0.300
8	500	97	10	8	500	0.89	0.272
9	630	97	11	9	630	0.93	0.263
10	800	97	13	10	800	0.97	0.254
11	1000	97	14	11	1000	1.00	0.245
12	1250	97	15	12	1250	0.95	0.255
13	1600	97	15	13	1600	0.91	0.265
14	2000	97	16	14	2000	0.86	0.275
15	2500	97	17	15	2500	0.86	0.271
16	3150	97	17	16	3150	0.86	0.266
17	4000	97	17	17	4000	0.85	0.262
18	5000	97	17	18	5000	0.81	0.260
19	6300	97	16	19	6300	0.75	0.258
20	8000	97	15	20	8000	0.67	0.256
21	10000	97	15	21	10000	0.57	0.256

Loudspeaker: S6
Active: True
Position[ft]: X = 0 Y = 25.25 Z = 4.5

Aiming: Hor =90 ° Ver = 0 ° Rot = 0 °
Delay: 0 msec
Speaker: RES 9



Project: 3D MODEL 1
Volume: 73591 cu.ft.
Surface: 12876 sq.ft.
Humidity: 60 %
Air Temp: 20 °C

Listener: 1
Position[ft]: X = 19.69 Y = 26.25 Z = 3.7
Orientation: Hor = 180 ° Ver = 0 °

Filter: MODEL 1
Level[dB]: 63
Delay[ms]: 23
Length[ms]: 390
Window[ms]: 557
Samples: 17213
Channels: 2
Sampling Rate [Hz]: 44100
Frame Length: 8192
Frame Number: 3

No.	Band [Hz]	SPL(1m)	Direct. [dB]	No.	Band [Hz]	RTime [s]	Absorp.
1	100	97	6	1	100	0.38	0.528
2	125	97	6	2	125	0.38	0.528
3	160	97	6	3	160	0.45	0.471
4	200	97	6	4	200	0.53	0.414
5	250	97	7	5	250	0.64	0.357
6	315	97	8	6	315	0.71	0.328
7	400	97	9	7	400	0.79	0.300
8	500	97	10	8	500	0.89	0.272
9	630	97	11	9	630	0.93	0.263
10	800	97	13	10	800	0.97	0.254
11	1000	97	14	11	1000	1.00	0.245
12	1250	97	15	12	1250	0.95	0.255
13	1600	97	15	13	1600	0.91	0.265
14	2000	97	16	14	2000	0.86	0.275
15	2500	97	17	15	2500	0.86	0.271
16	3150	97	17	16	3150	0.86	0.266
17	4000	97	17	17	4000	0.85	0.262
18	5000	97	17	18	5000	0.81	0.260
19	6300	97	16	19	6300	0.75	0.258
20	8000	97	15	20	8000	0.67	0.256
21	10000	97	15	21	10000	0.57	0.256

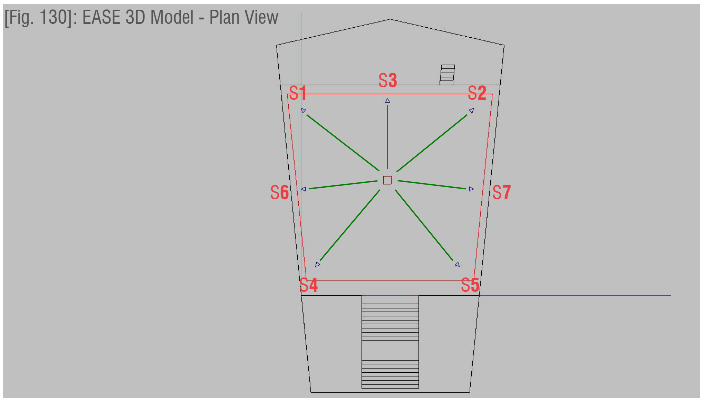
Loudspeaker: S7
Active: True
Position[ft]: X = 39.4 Y = 25.25 Z = 4.5

Aiming: Hor =-90 ° Ver = 0 ° Rot = 0 °
Delay: 0 msec
Speaker: RES 9

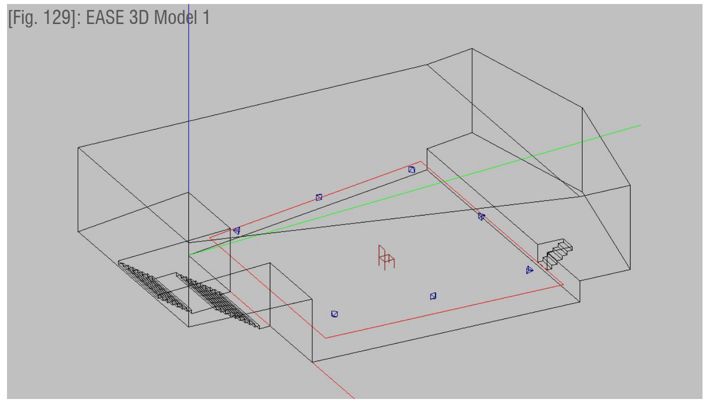
[Fig. 154]: The Box - **Impulse Response 7**

3 SIMULATION: 3D MODEL 1

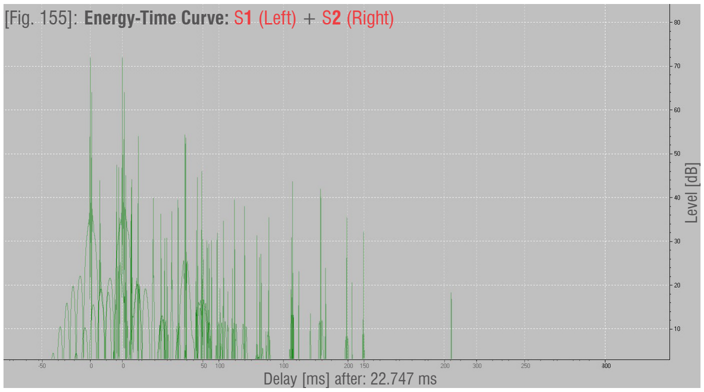
[Fig. 130]: EASE 3D Model - Plan View



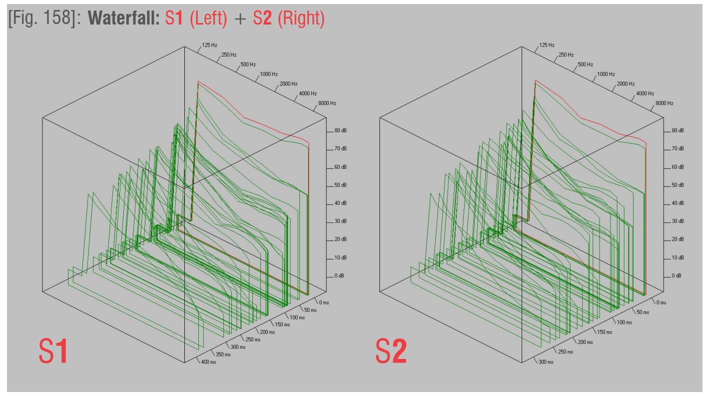
[Fig. 129]: EASE 3D Model 1



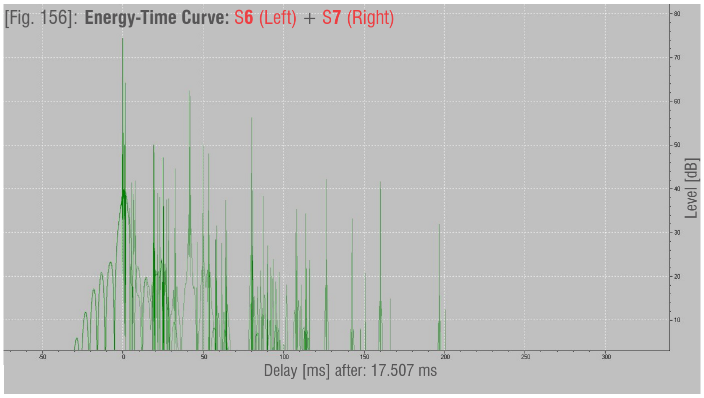
[Fig. 155]: **Energy-Time Curve:** S1 (Left) + S2 (Right)



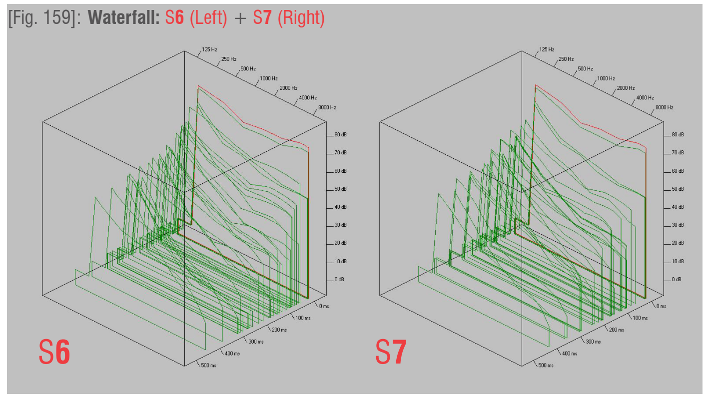
[Fig. 158]: **Waterfall:** S1 (Left) + S2 (Right)



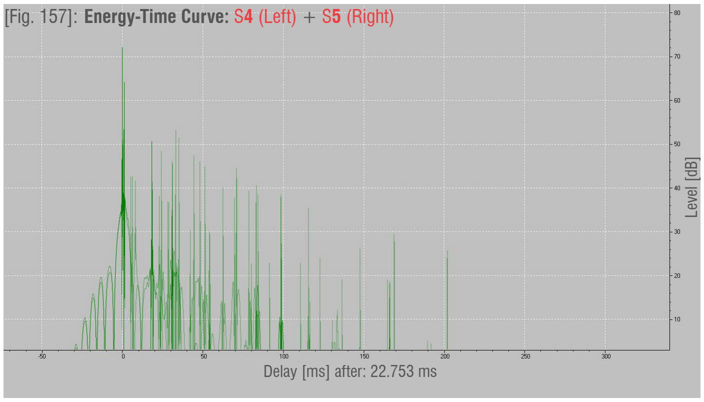
[Fig. 156]: **Energy-Time Curve:** S6 (Left) + S7 (Right)



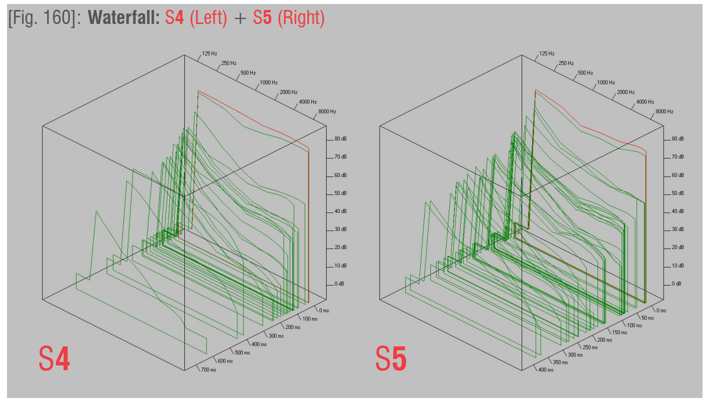
[Fig. 159]: **Waterfall:** S6 (Left) + S7 (Right)



[Fig. 157]: **Energy-Time Curve:** S4 (Left) + S5 (Right)



[Fig. 160]: **Waterfall:** S4 (Left) + S5 (Right)



3 SIMULATION: 3D MODEL 1

Simulation Findings: 3D Model 1

3D Model 1 is a design of my own, which takes preferred architectural and acoustical aspects of both Berghain and The Box and combined them into an overall design to be tested. This model contains a bigger volume allowing for more reverberation like Berghain but takes the 5-sided shape of The Box, along with a sloped ceiling towards the front stage to allow for ideal 40-60-degree sound reflection angles. A monumental stair down to the dance floor was added to enhance the inhabitants ascensional and underground senses.

ITD Gap - Displays the difference in arrival times between the first two direct sound arrivals.

- This information is useful in determining the proper place ment of loudspeakers and the delay times needed in dis tributed loudspeaker systems

[Figures 140-142: Mod 1 – Total SPL Map]: Positioned at the center of Model 1's audience area, the maximum difference between the first two direct sound arrivals is around 16.3 ms, which fits the ideal ITDG preference of less than 25 ms. Within the 5-sided pentagon shape (much like The Box), the loudspeaker sources are distributed at almost equal spacing around the center position, allowing for decreased difference in arrival times between any configuration of loudspeakers, even with an added speaker (S3).

Energy Time Curve (ETC): Acoustic measurement tool for examining reflections and their amplitude over time but gives no insight into the spectrum of that energy (Hedback, 2011)

- Each peak on an ETC after the direct sound is a reflection

[Figures 155-157 :Mod 1 Energy Time Curves] are simulated energy time curves showing 3 sets of speaker's pairs where each pair contains a left and right speaker (ex, S6 left & S1 right). The speaker pair images (left and right) are overlaid to get a better understanding of their reflection peaks and decay patterns, whereas the figures to the right are acoustical waterfall representations of each speaker individually, analyzing the reflections through spectral information such as time, energy and frequency. Hedback's criteria for the ETC of both left and right speakers states that it should:

- Be visually identical (with only minor deviations) from 0-40 ms
- Show that peaks are down to at least -10 dB by 40 ms to prevent breakdown of the precedence effect
- Clearly show a decrease in the amplitude of energy over 0-40 ms. The decay pattern may or may not be continuous
- Show the consecutive peaks of the highest amplitude reflections viewed across the time axis to be relatively smooth in pattern and density

In analysis of the 3 ETC's (figures 155-157), the profiles show to be more similar in smoothness and decay in profile when compared to Berghain's & The Box's ragged profile, yet may still warrant further investigation in a zoomed in representation from 0-40 ms instead 0-250 ms. With the profile not showing much raggedness, it hits the reflection peak and decay point criteria of being almost visually identical with minor deviations. Also, much like the earlier simulations, the ETC's hit the criteria of showing a decrease in amplitude of energy over 0-40 ms, as well showing that the peaks are down at least -10dB by 40 ms.

D/R Ratio - Shows the ratio of direct to reverberant sound in dB

- Zero dB indicates the sound levels are the same.
- Numbers less than 0 indicate the reverberant sound level is higher than the direct sound level.
- Numbers greater than 0 indicate the direct sound level is higher.

[Figures 137-139: Mod 1 – D/R Ratio Map]: With all six speakers activated at a frequency of 1000 Hz (1/3 Octave Avg), the simulated mapping of the audience area (1,944 SF) indicates a maximum of 11.14 dB and a minimum of -7.68 dB. This shows that the ratio of direct sound level is less than twice as much higher than the reverberation time for 1000Hz when compared to The Box's (15.59 dB, -7.45) dB, meaning that reverberation time was increased to due the increased volume, which was my intention.

Clarity Calculations C80 - Often called a clarity ratio. It uses an 80 ms Split Time to predict the articulation (clarity) of different types of music. In other words, it provides a look at the room's musical performance.

- <u>Type of musical instrument:</u> Percussive instruments (ex, piano, drums, electronic instruments, xylophon etc.) These instruments have a quick attack and a quick decay.
- <u>Scale for interpreting C80 (Percussive Instruments)</u>: 6+/-2 dB is ideal for percussive instruments.
- <u>For good musical performance:</u> the number should not exceed +8 dB at any location.

[Figures 134-136: Mod 1 – Clarity C80 Map]: With reverberations increased, the clarity of the sound decreases, meaning that the energy of the early direct sounds are slightly less than those of reverberant sounds within 80 msec after the first direct hit from loudspeaker. This indicates that the room is a bit more lively and energetic than The Box's, where the music will be clear but also more dynamic, and C80 will produce less positive value in decibels (Beranek, 2004). According to the simulation for C80, a less positive value was produced, showing a maximum of 15.32 dB and a minimum of -0.22 dB. The average comes to 6.8 dB which conforms to the preferred level of less than 8 dB for good musical performance whereas the standard deviation of 3.45 dB sits well within the scale of good musical performance and ideal levels for percussive instruments.

Total SPL (SUM) - Displays the sum of the Direct and Reverberant sound energy in dB (displays the total sound level)

- Don't be surprised at the small variation between the mini mum and maximum levels. It's normal.

[Figures 146-148: Mod 1 – Total SPL Map]: This simulated mapping compares well with L80 where instead of looking at the energy sum at a specified time it looks at the energy sum in dB. This space is not small like a listening room (where sound pressure of reflected sounds is greater than direct sounds) or big like a concert hall (sound pressure of direct sounds in greater than reflected), but sits in the middle as medium sized space where sound pressure is intermediary between direct and reflected. Both Total SPL and L80 fit the normal standards of little variation between maximum and minimum levels. For example, the distribution of values for Total SPL has a max. of 92 dB and a min. of 81 dB at the frequency of 1000 Hz (1/3 Octave Sum).

Conclusion

Conclusion: A Study of The Ideal Acoustical/Spatial Environment for Rave/EDM Performance Spaces

Sound Matters

Through studying a diverse range of exemplar nightclubs, not only through the case studies of Ministry of Sound and Berghain, but others like the early 60's disco clubs to todays high-tech commercial clubs, a key finding is that each nightclub design has the primary purpose of curating a sensorial immersive experience – where music is most often than not placed at the center, where sound matters in creating that experience – both subjectively and scientifically. The Ministry of Sound is a prime example (as it should with the name 'Ministry of Sound') of this intention as the concept of the design was 100% sound system first, lights and visuals second, and design third – in that order. MoS was scientifically (acoustically, spatially) designed for a specific type of music, sound and preference, that being a crisp/clean, acute/precise electronic sound and system within a dead, absorby space with the preference of hearing every single detail in the music, being pleasant for some listeners. Other listeners may prefer Berghain's lively cathedral like quality of EDM where the reverberations produced by the cavernous space bring out the natural and spiritual effects to the sound, a sound that is deeply rooted and programmed into our DNA. Therefor, subjective responses to these specific types of music, sound and space are greatly diverse with many different preferences and desires amongst listeners, concluding that the ideal acoustical/spatial environment really depends on the preference and perceptions of sound, which is where architecture and acoustical design come in. Even though music and sound aren't the only element in creating that sensory immersive experience (lights, 3D projections, communal dance, narrative/utopia, equality, connectedness etc.) – it's the primary element that curates it all and should be an absolute priority.

Running Acoustical Simulations

In the initial planning stages of any concert hall/venue, opera house, performance space, studio/listening rooms – or any space that involves acoustics (speech/music), the starting process should be creating experimental 3D models of the desired space and testing their acoustical performance through simulation software. The 3D models provide a range of alternative ideas according to their aesthetic and acoustical qualities, for example, variations of shape and form, materials that make up the space, as well as what can be done for acoustical treatments for converted spaces. The simulation process aids in the understanding how sound behaves in a certain space, examining how it moves, how it gets absorbed, and determining good vs. bad reflections, percentage of absorber/reflector coverage, speaker positioning and orientation, etc. On a more economical side, the process allows the design to be tested repeatedly virtually on a computer screen, opposed to doing so in real time after it has been constructed. An example of this is the design of the nightclub Uberhaus, where in the process of planning some said that absorbers would need to cover the entire ceiling, whereby running simulations they were able to determine that only 60% of it was needed in order to contain the sound. Another more relatable example would be the case of Berghain wanting to minimize the level of sound reverberation time, I would reopen its representational digital model and experiment with applying absorptive coverage to the 60' concrete and glass side walls that take up most surface area in its long and narrow space, as well as experimenting with sound isolators since the space is loosely connected to adjacent spaces. Simulations are overall part of the scientific process where they help to test a hypothesis, such as the ideal acoustical/spatial environment for rave performance spaces. The idealness of a space and sound can be measured objectively with regards to the preferred acoustical performance criteria of electronic music (percussive instruments: ideal ratio of reverb/direct sound, attack/decay times), but also, if not more importantly, needs to take into account the subjective responses of the listeners and their criteria for idealness.

Contributions to Theoretical Premise/Unifying Idea

My theoretical premise revolves around bringing light to the essence of rave, to bring the rave out of the cave where my unifying idea of designing the ideal 21st century rave space along with its architectural implications helps to achieve that. There are many implications that make up the ideal rave club design, but through this study I found that the most important element is the music and sound itself, acting as the main curator for the audiences sensory and sonic immersion. It is here where architecture and acoustical design come in to play which is where my case studies contributed, allowing me to understand the diversity of preference when it comes down to music, sound and space. With that, I intend on creating a variety of performance (consumption) spaces, each designed to cater to a particular type of EDM music genre, sound, feel/ 'vibe', atmosphere, etc. – almost like combining the cathedral like Berghian and the Box's acoustical perfection under one roof where each have their own autonomy. For instance, a smaller consumption space designed for a crisp, clean, warm sound; an absorption dominant space where each detail of the sound is heard directly and not reflected off any other surface; rather a space for critical listening. A larger consumption space will be that large, cavernous cathedral like feel where the sound is the most loud, vibrant and electric as absorption coverage will be less, allowing for that preferred and pleasurable reverb sound (Enhanced with the Michigan Theatre large ornamental dome). On the other side of consumption spaces brings production spaces, designing small listening/studio spaces with the art of mixing being the focus - inspired by Detroit's strong cultural narrative in the roots of electronic music; the creator of techno (explained more in hist, cult, polit, section of this book). With the intentions of designing three different types of performances spaces (consumption/production), acoustical design will be critical. The acoustical focus will be soundproofing (isolating the spaces from each other), acoustical treatments (dif. acoustic environment in each space) and the sound systems (properly positioned, oriented loudspeakers) – and will be guided by running acoustical simulations throughout the design process.

APPENDIX

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Figures & Image Credits
Simulation

EASE 4.4

EASE 4.3 User's Guide and Tutorial. (2009). EASE 4.3 User's Guide and Tutorial.
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Figure 3: Ray Tracing
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Audacity

https://www.audacityteam.org/
Figure 20: Open/Import Audio Tracks
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http://www.acousticfrontiers.com/early-reflections-101/
Figure 23: Direct/Early Reflected/Late Reflected

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https://en.wikipedia.org/wiki/Ministry_of_Sound
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https://en.wikipedia.org/wiki/Berghain

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http://www.fouroverfour.jukely.com/metro/venue-profiles/ministry-of-sound-music-fitness-classes/attachment/ministryofsound/
Figure 32: Spatial Configuration Diagram
https://www.ministryofsoundevents.com/venue/.
Figure 33: Audio/Visual/Spatial Diagram
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https://www.thelogocreative.co.uk/ministry-of-sound-brand-spotlight/
Figure 38: Sound/Light/Video Configuration
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https://martin-audio.com/downloads/casestudies/MA%20CaseStudy%20NightClubs.pdf

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https://calderwoodmedia.wordpress.com/2014/02/25/berlin-berghain-review/

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https://gramho.com/media/2107321721886569240
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