iRoom:

The Next Generation Media Room

Dr. Peter D'Antonio

RPG Diffusor Systems, Inc.

Contents

- Acoustic Tools
  - Absorbers
  - Diffusors
- Room Design Evolution

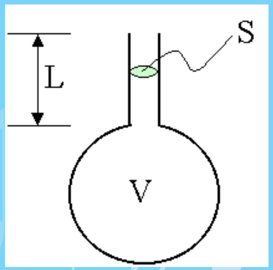
Types of Absorbers

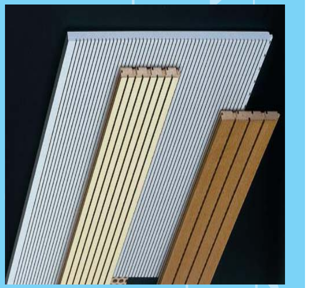
Porous Absorber

Contains interconnected voids and sound is absorbed by conversion to heat due to friction

Resonator Absorber

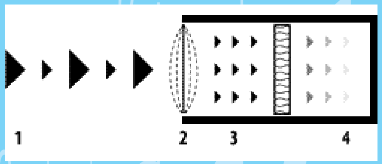
The Helmholtz resonator is a vibrating mass of air in the neck against the volume of air in the larger volume acting as a spring.

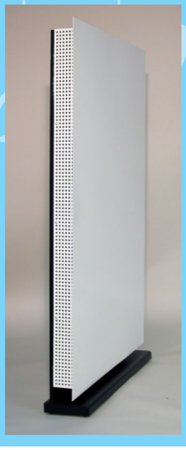




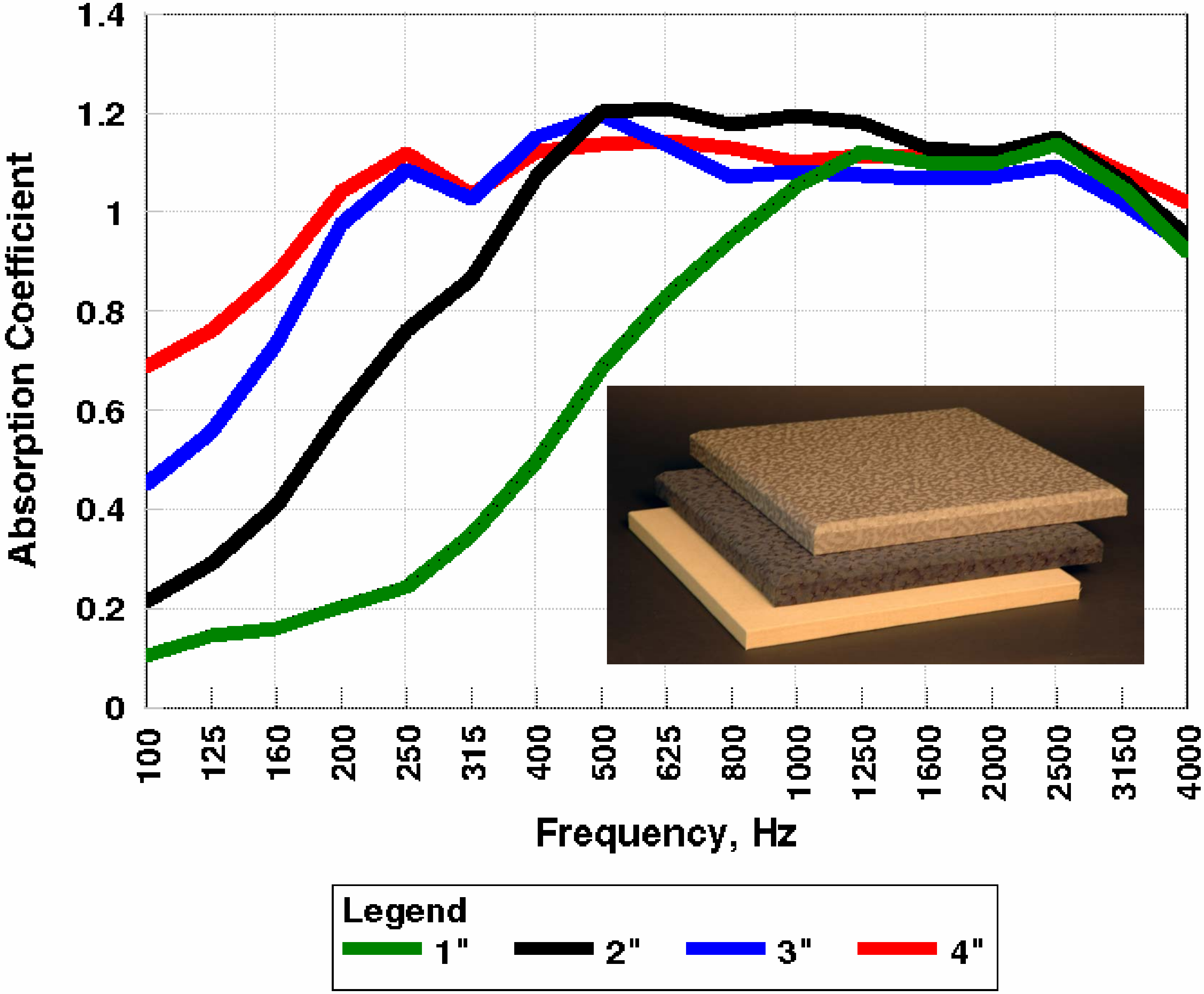
Membrane Absorber

The membrane absorber is a limp mass that vibrates at a specific frequency and moves air through a porous panel converting sound into heat.

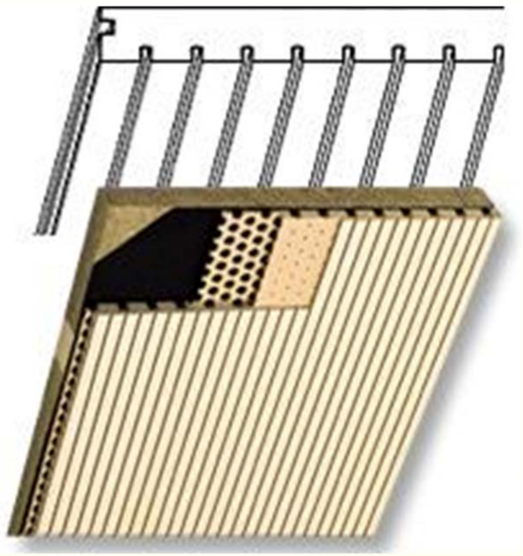


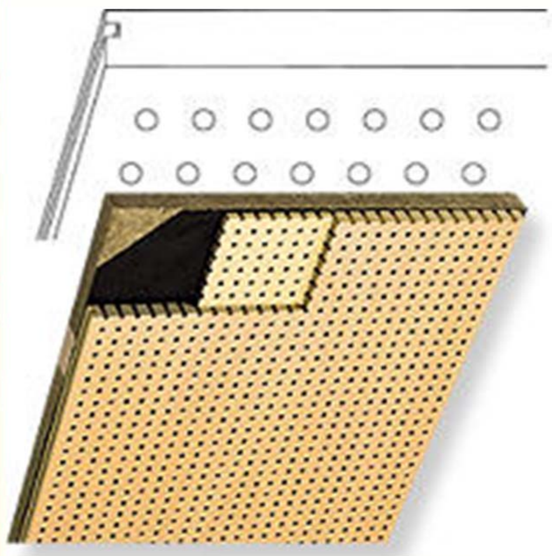


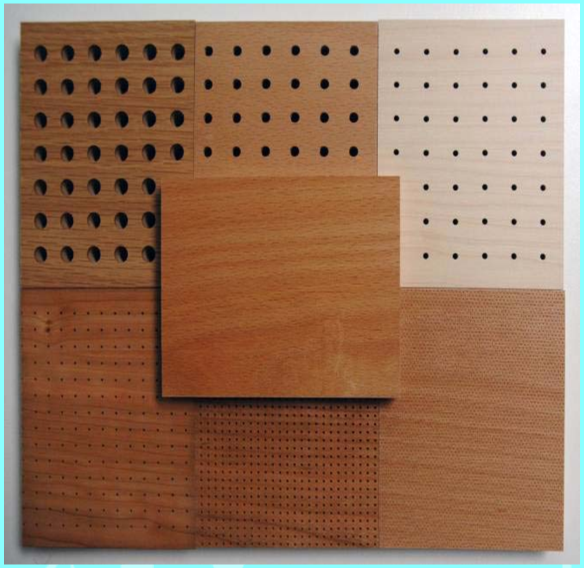
Textile Facing

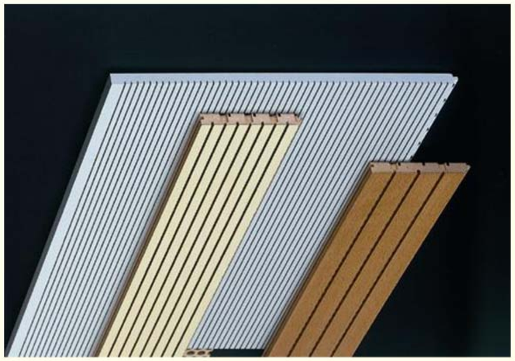


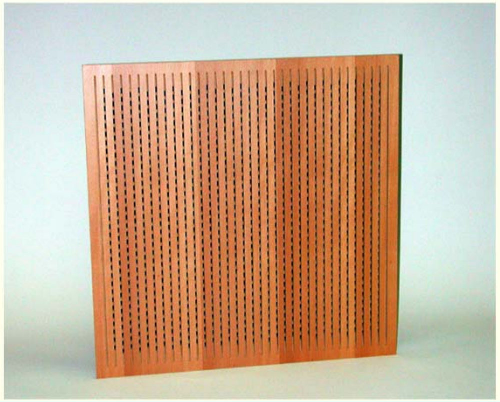
Absorptive Wood



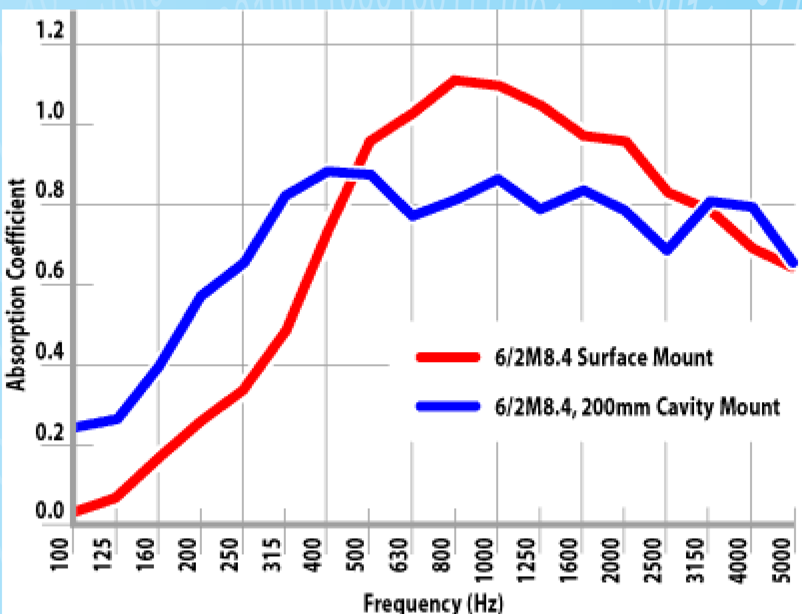


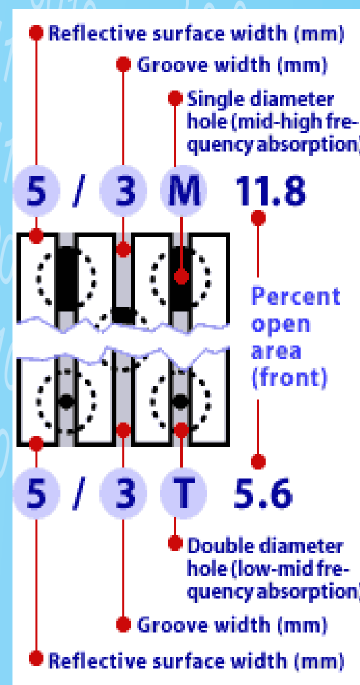


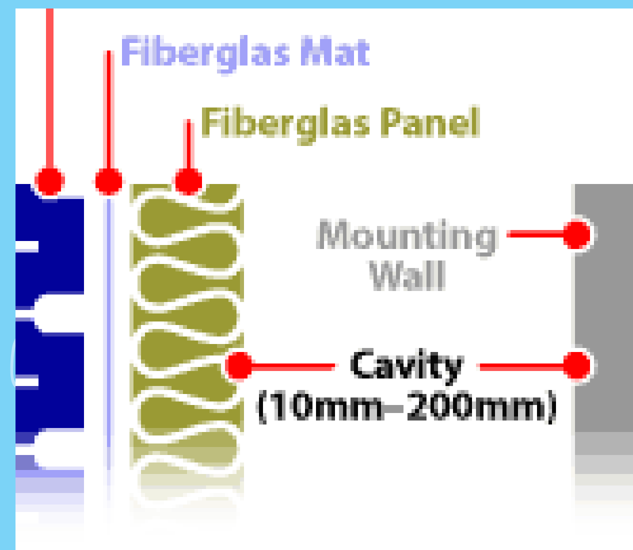




Performance



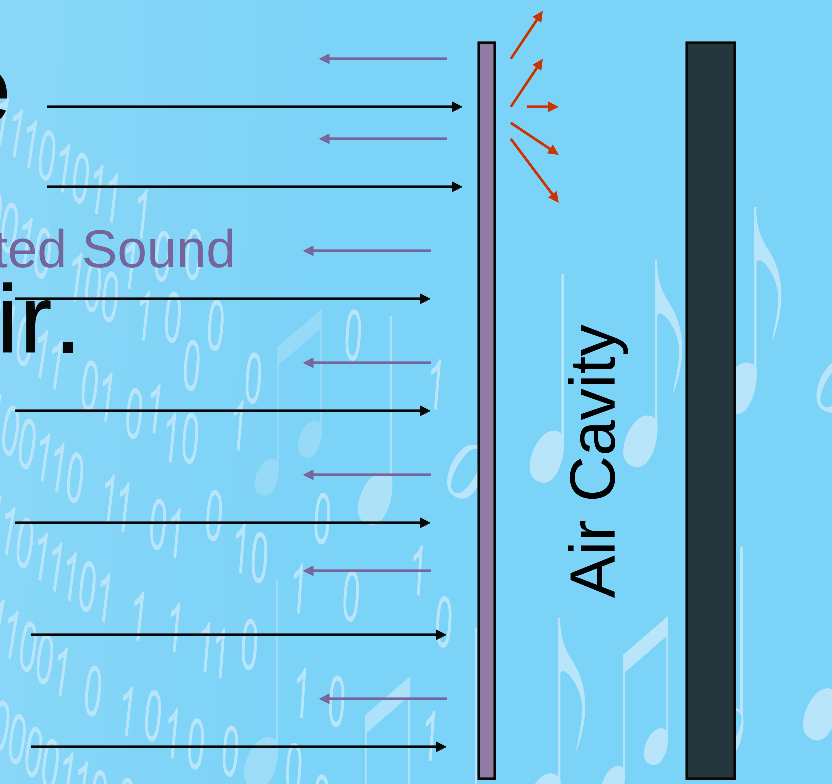




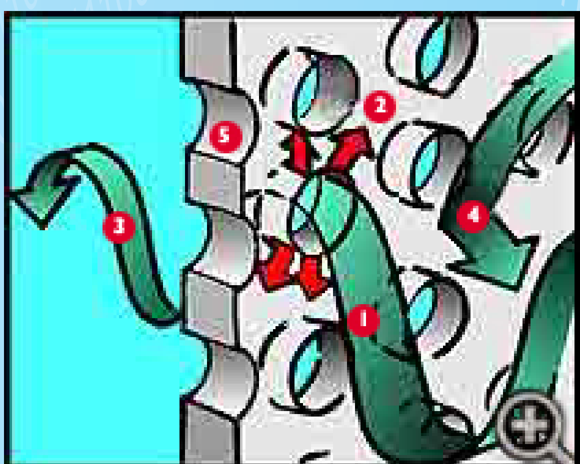
Absorption Mechanism

NEW

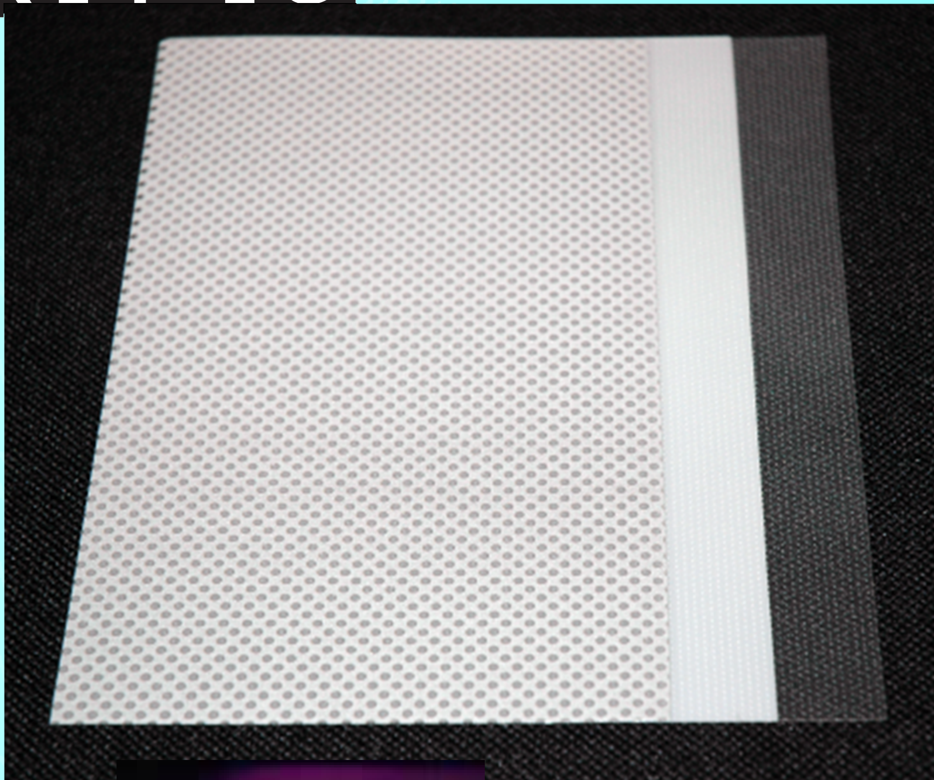
When surface perforations are the same size as a boundary layer of air.

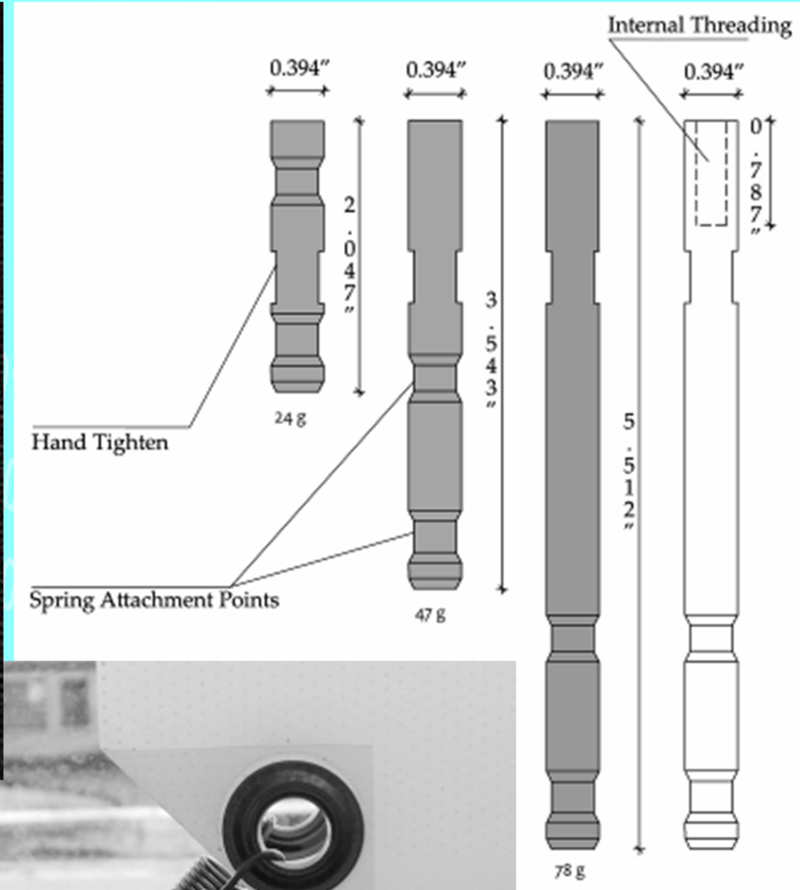


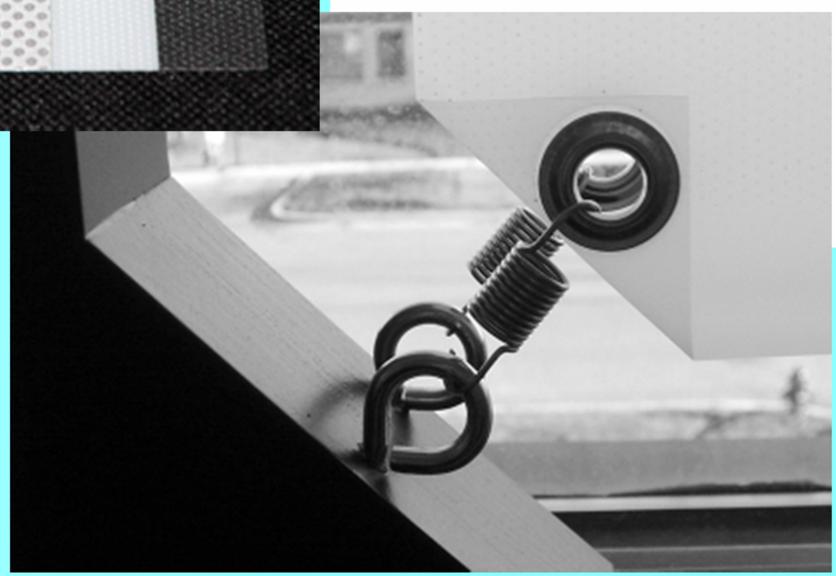
0.2 mm diameter holes



Foil & Mounting







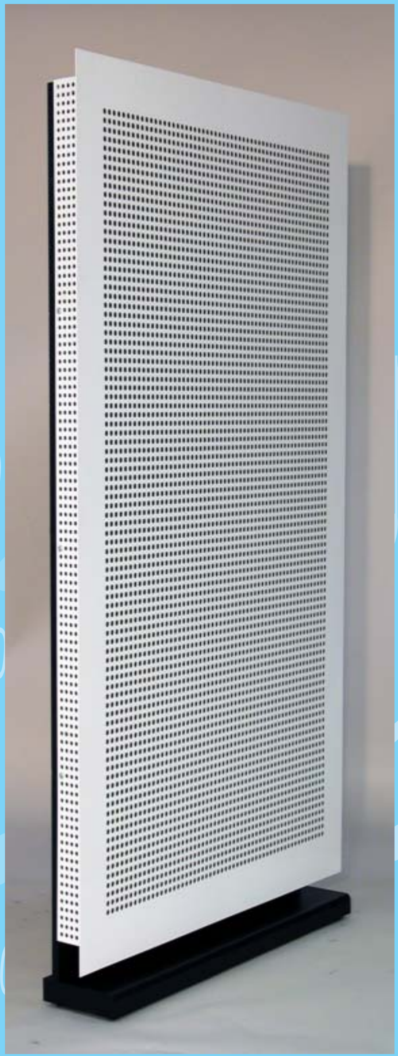
Roller Blind Functionality

Laser Micro-Slotted Panels

Scenery

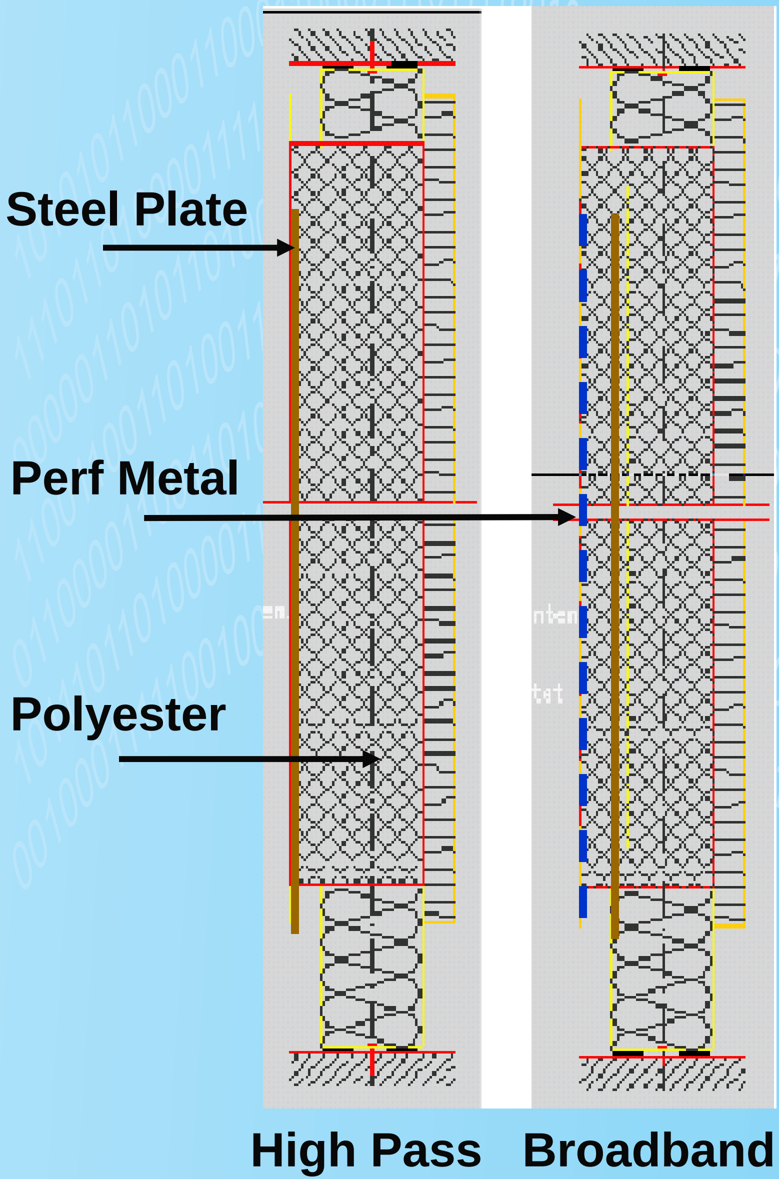
Plate Resonators

High Pass



Broadband

Plate Resonators



Mechanisms

Pistonic Resonance

$$f_R = \frac{c_d}{2\pi}\sqrt{\frac{\rho_d}{\rho_t t d}}\,(Hz)$$

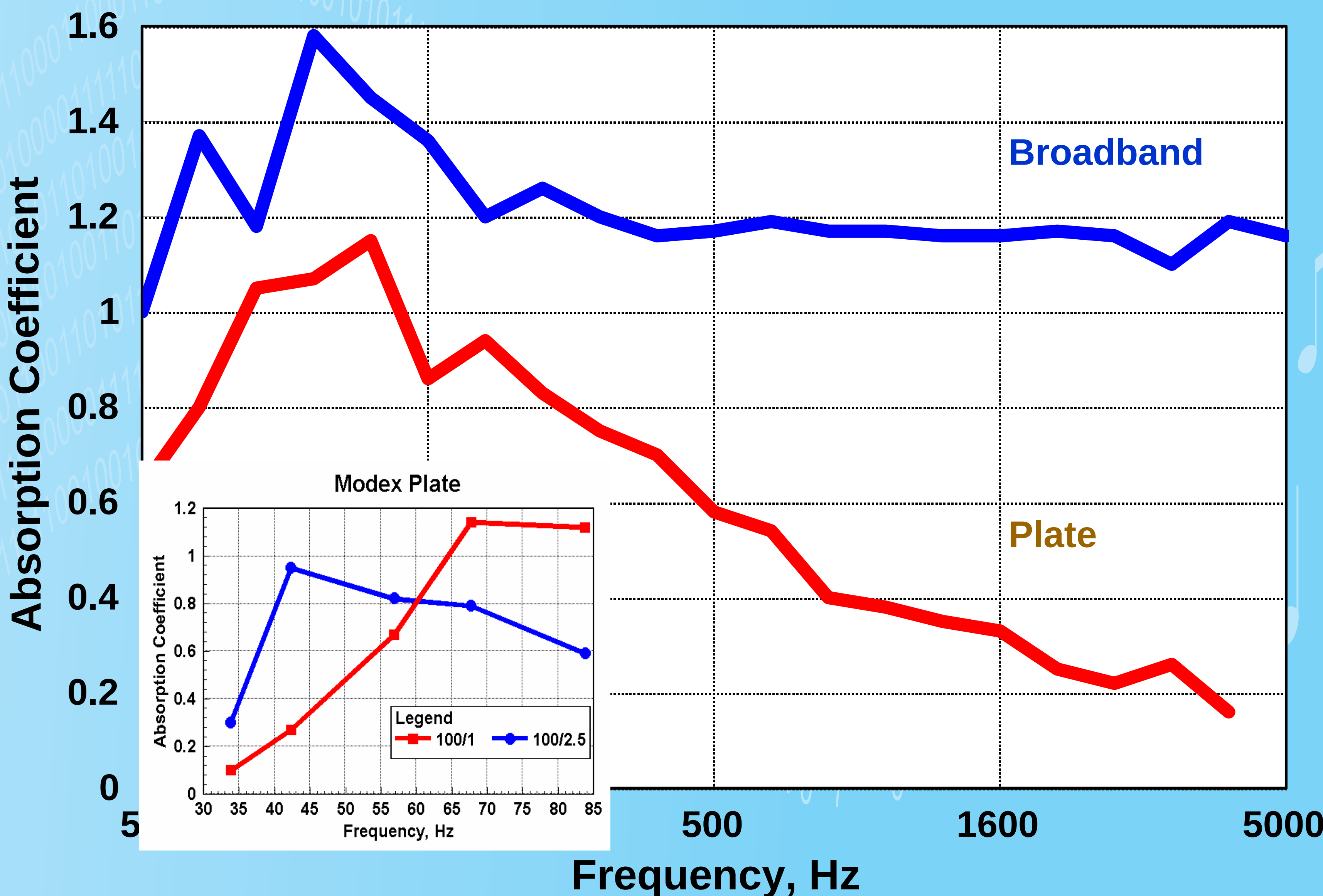
Damp Bending Modes

$$f_{n,m} = \frac{\pi}{2} t \sqrt{\frac{E}{12(1-\mu^2)\rho_t}}\left[\left(\frac{n}{l_n}\right)^2 + \left(\frac{m}{l_m}\right)^2\right](Hz)$$

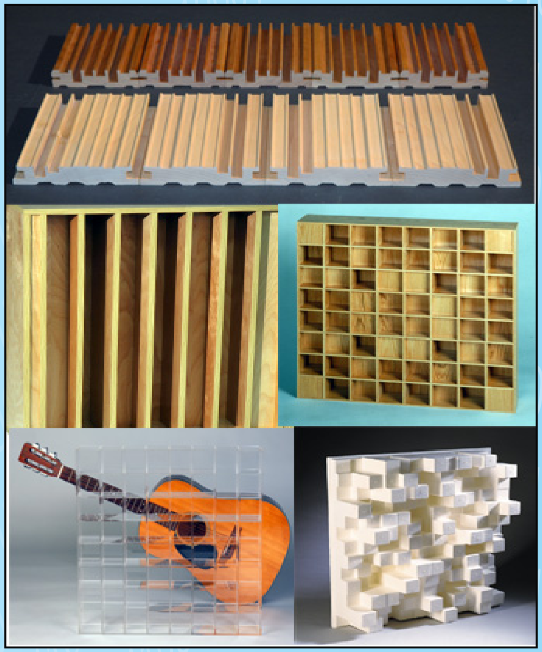
Diffraction

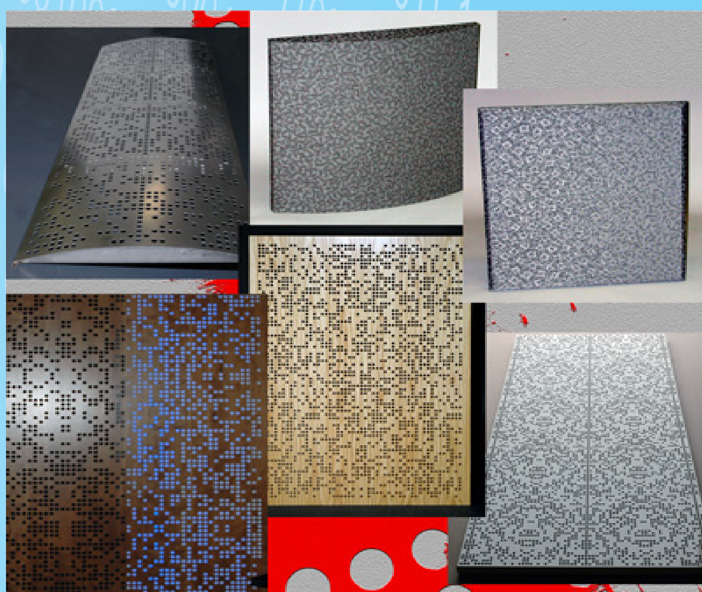
Above these frequencies absorption occurs from diffraction of the sound around the plate into the porous absorber

Performance



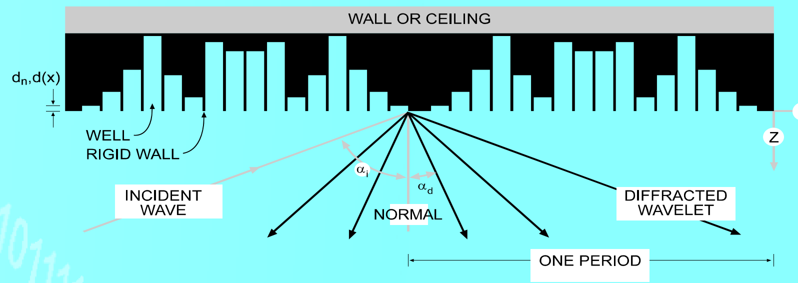
The RPG Diffusor System



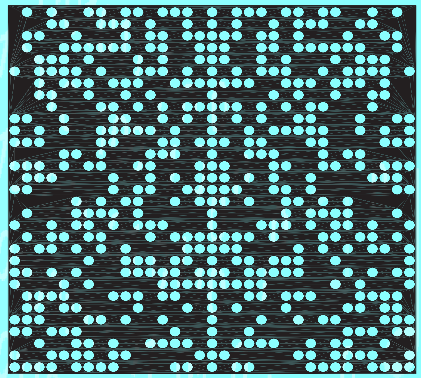


Design Theory of Diffusors

Reflection Phase Grating diffusors were first introduced in the early 1980s. They consisted of divided wells, whose depths were based on quadratic residue number theory



Binary Amplitude Diffsorbers were created to provide diffusion through a variable impedance surface consisting of holes distributed according to an optimal binary sequence



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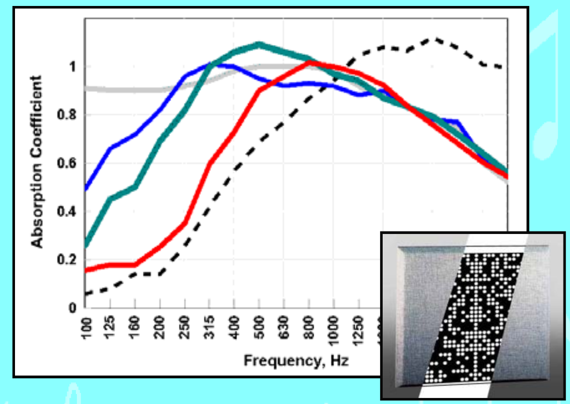
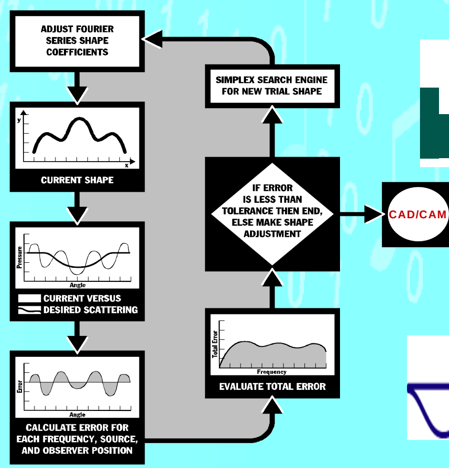
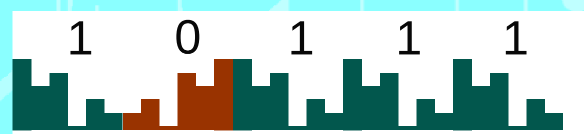
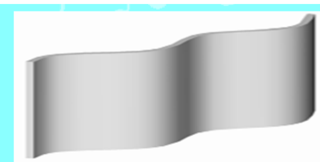


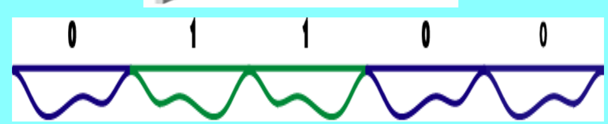
Today, state-of-the-art Waveform diffusors are designed using:

- **Shape Optimization, which couples boundary element multi-dimensional optimization techniques**
- **Aperiodic Modulation, using optimal binary codes**

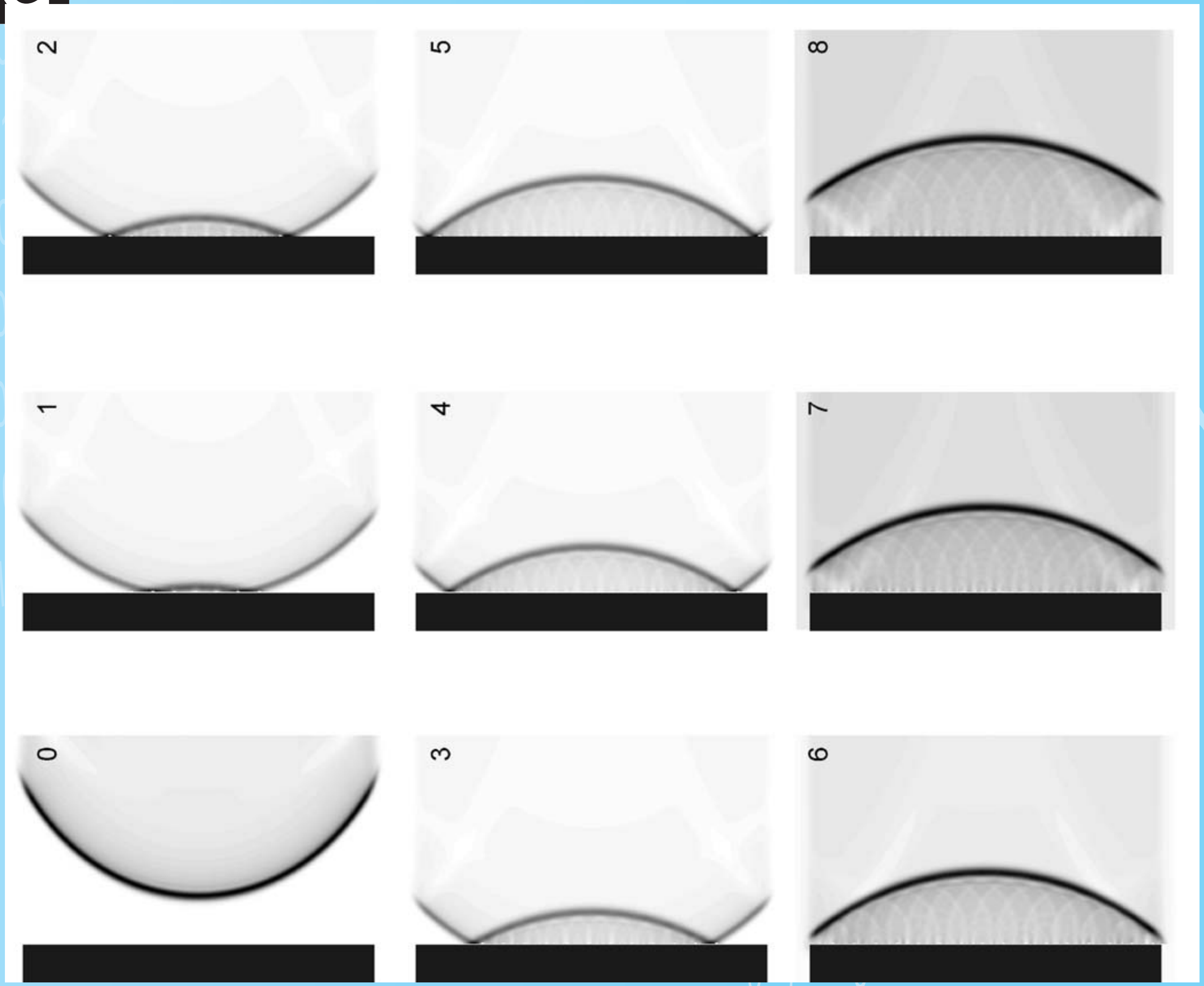






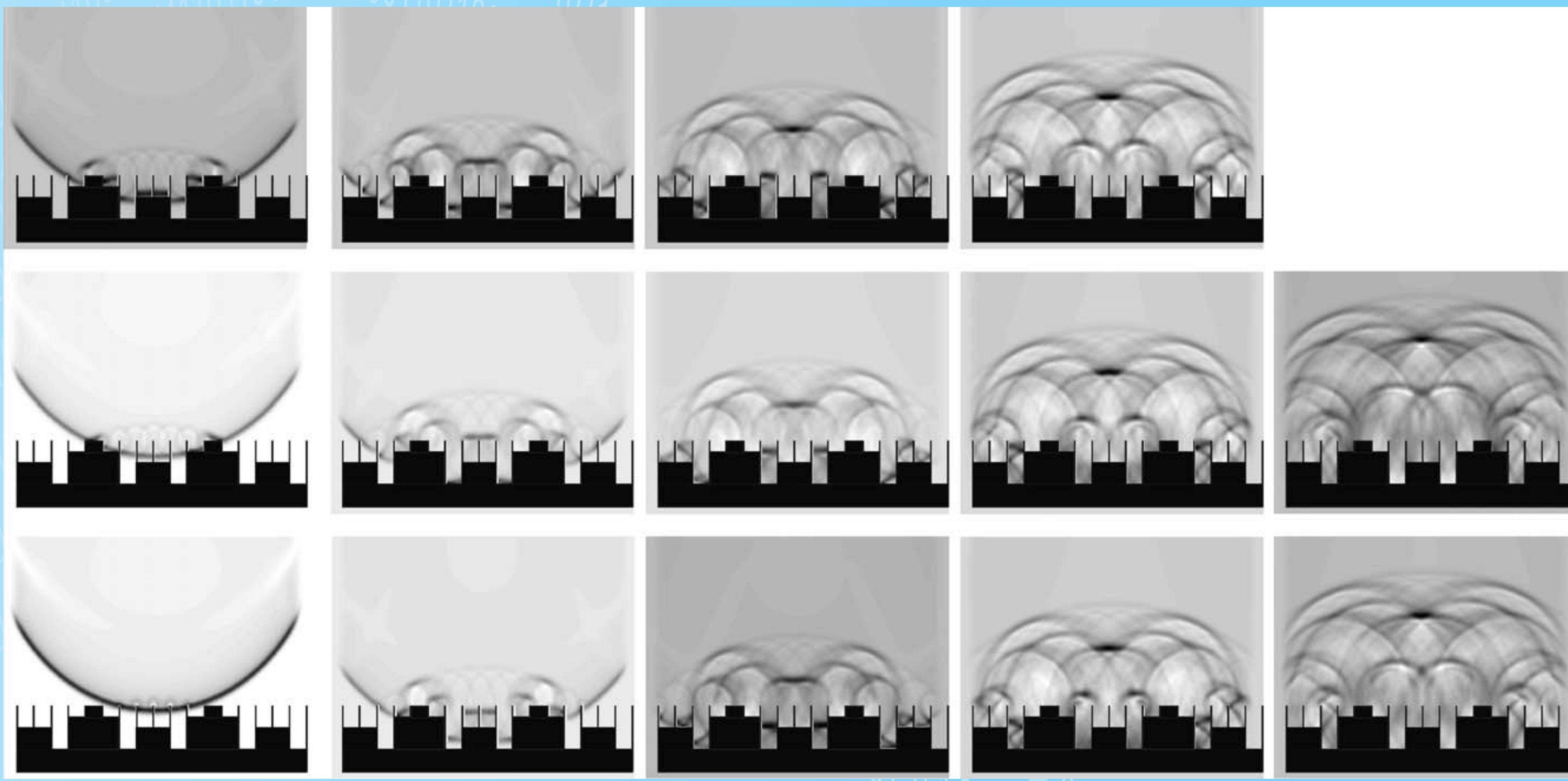


Specular Reflection

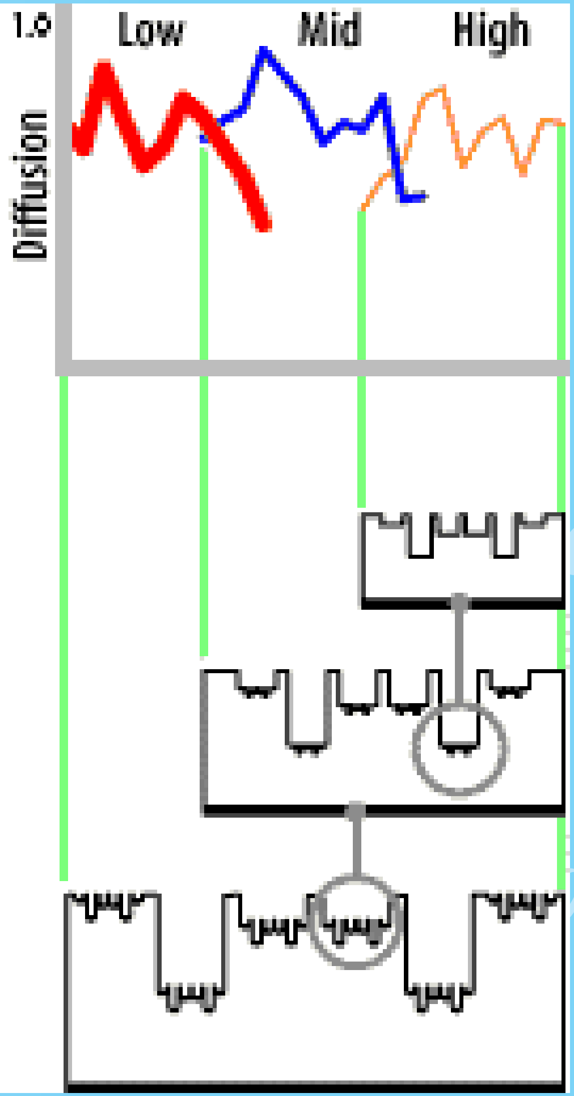


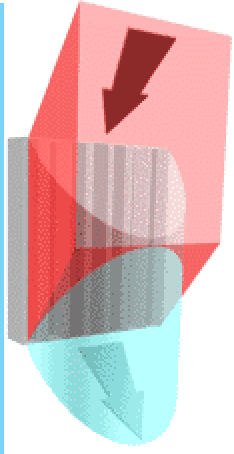
Finite Difference Time Domain (FDTD) model

RPG: Diffuse Reflection



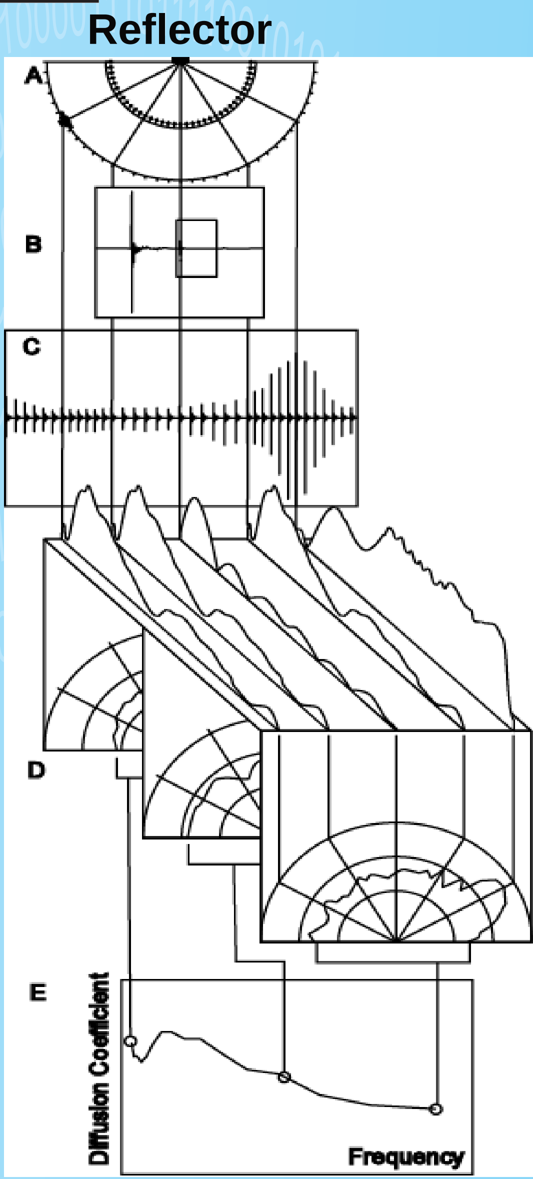
Broadband Diffusors

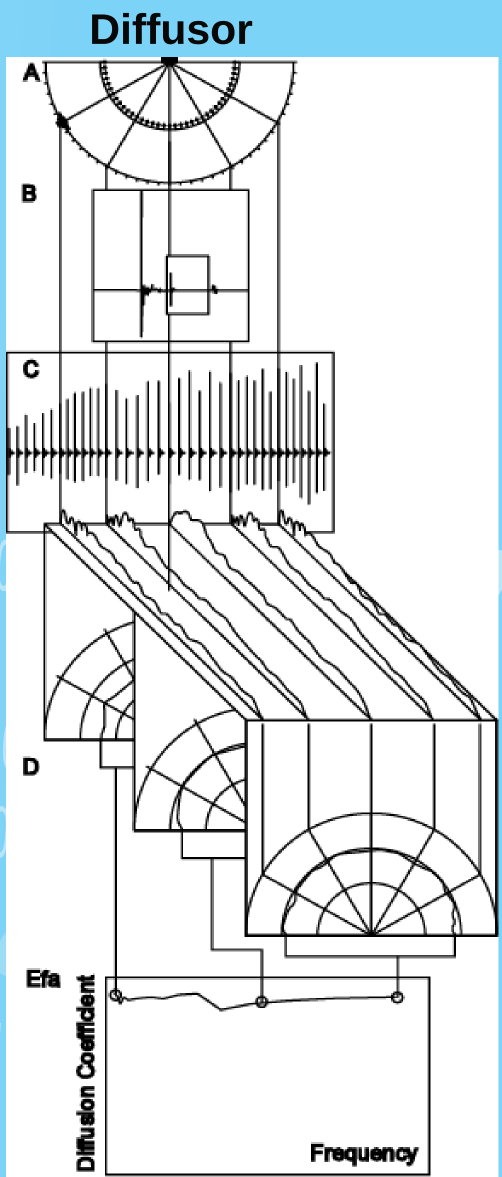




1D Diffusion

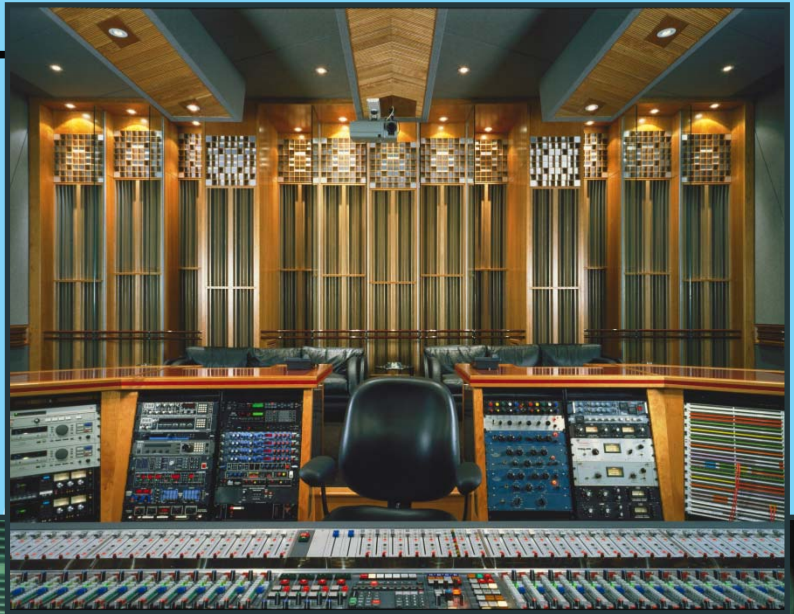
Data Reduction

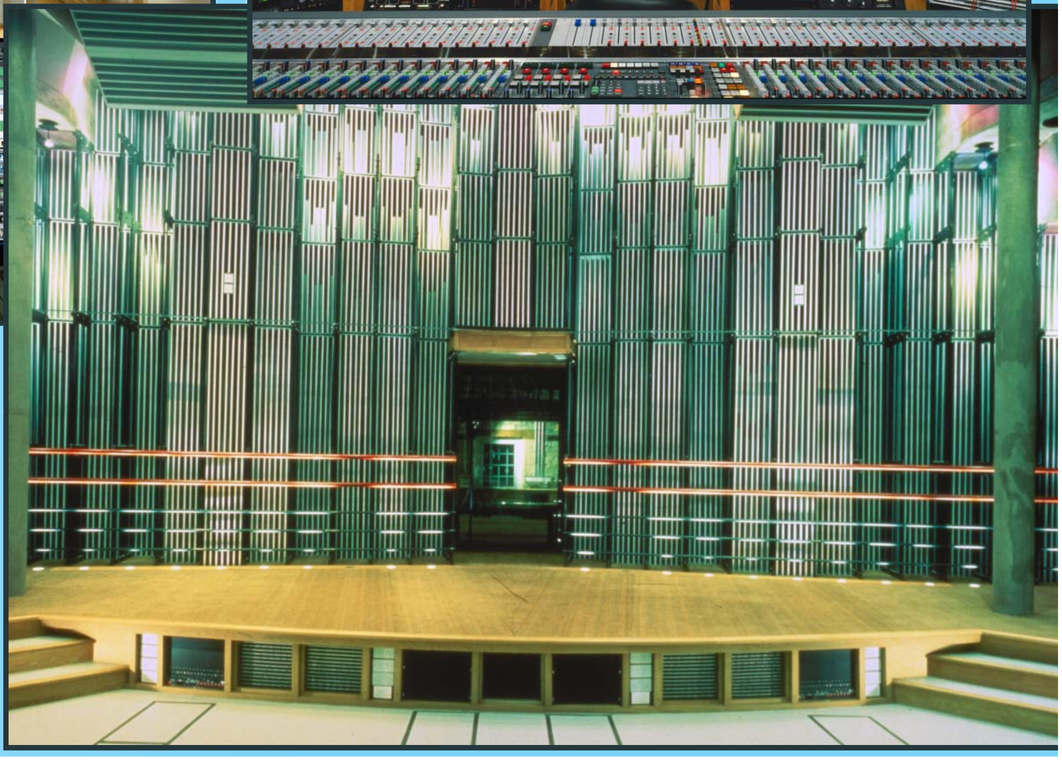




RPG

Celebrity Recording

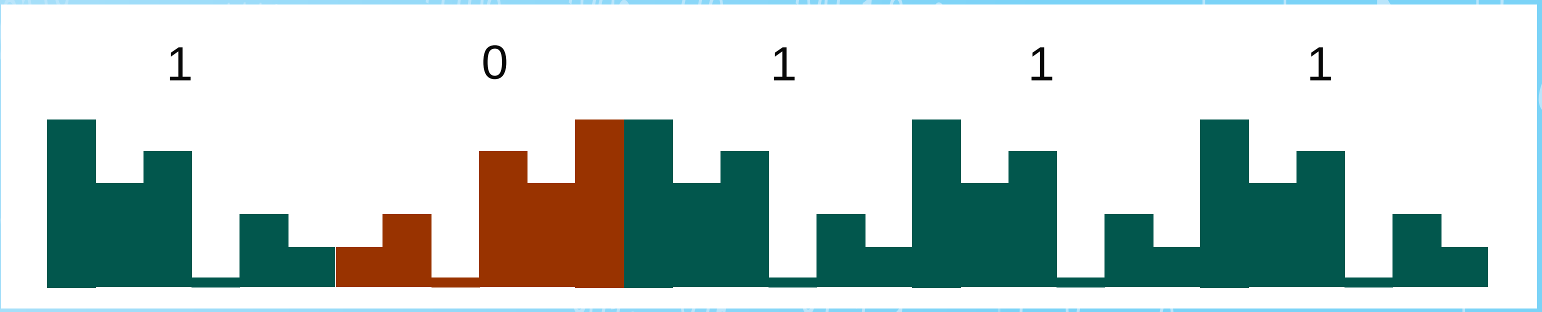




OPTIMIZING PHASE GRATINGS

This acoustical milestone is made possible by two new patented technologies known as:

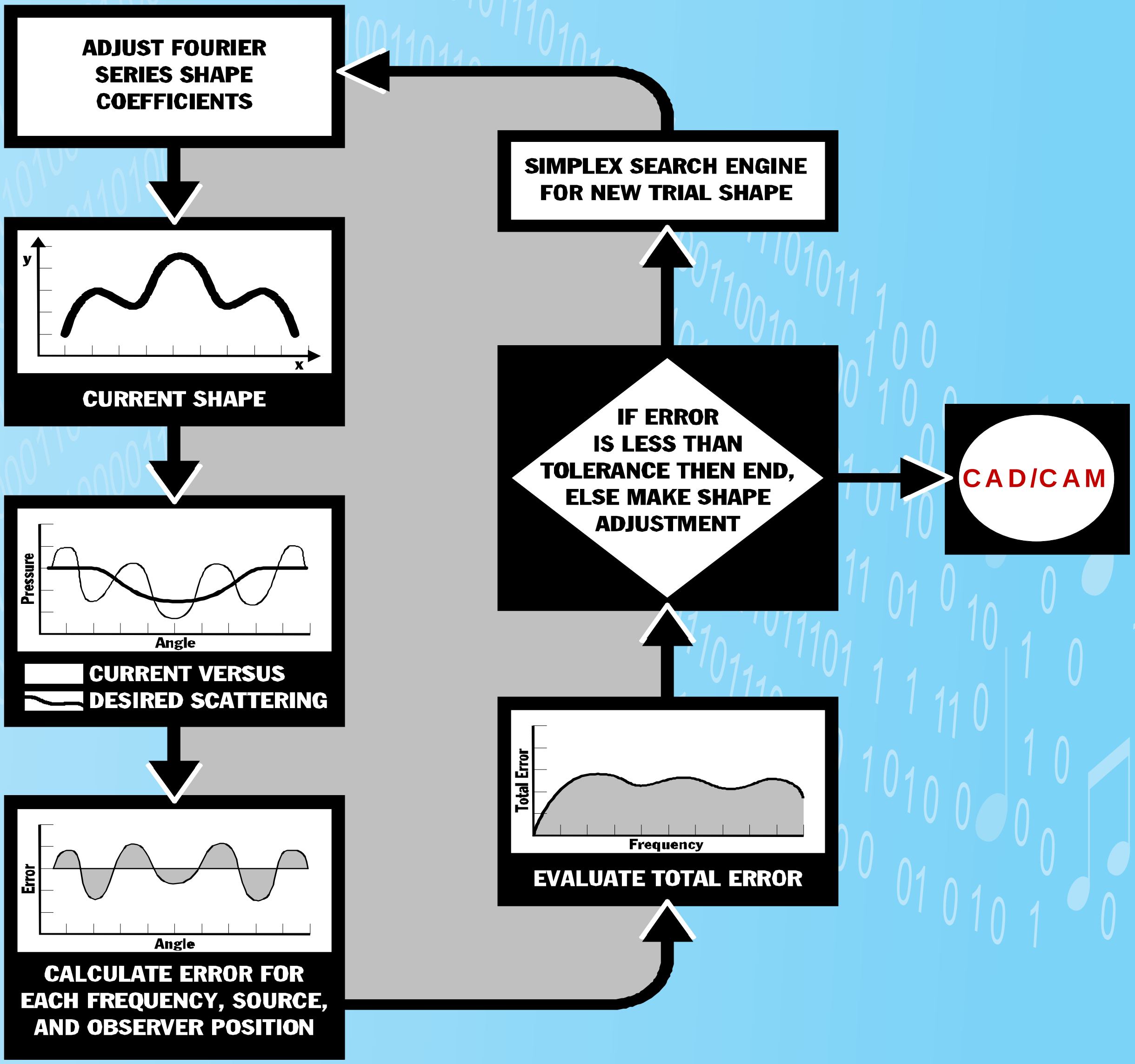
1. Shape Optimization



2. Aperiodic Modulation of a Single Asymmetric Base Shape

1011000101000111000001110101001110110110001101110100100101001001111

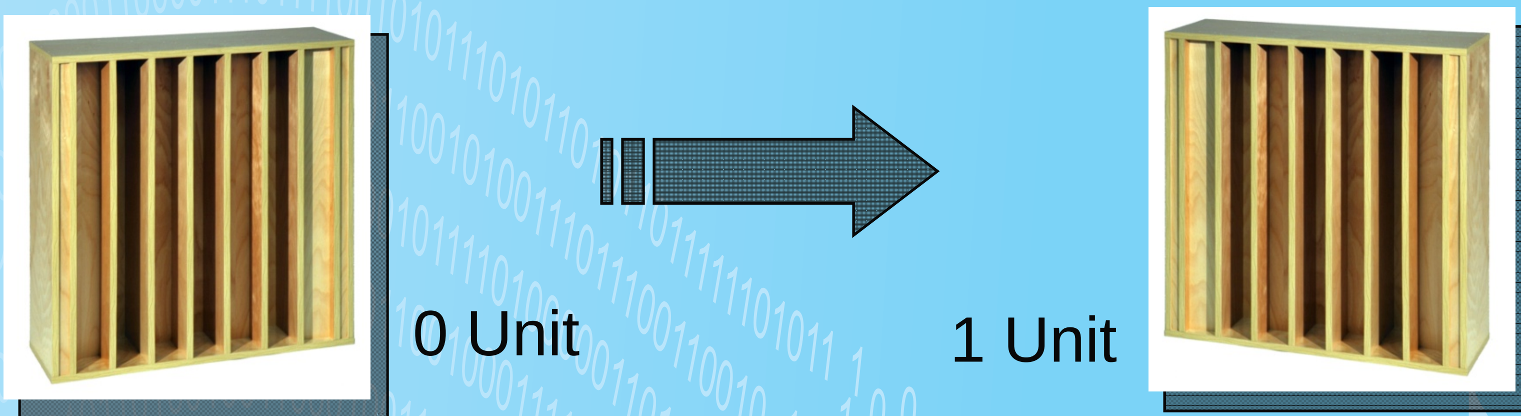
Shape Optimization

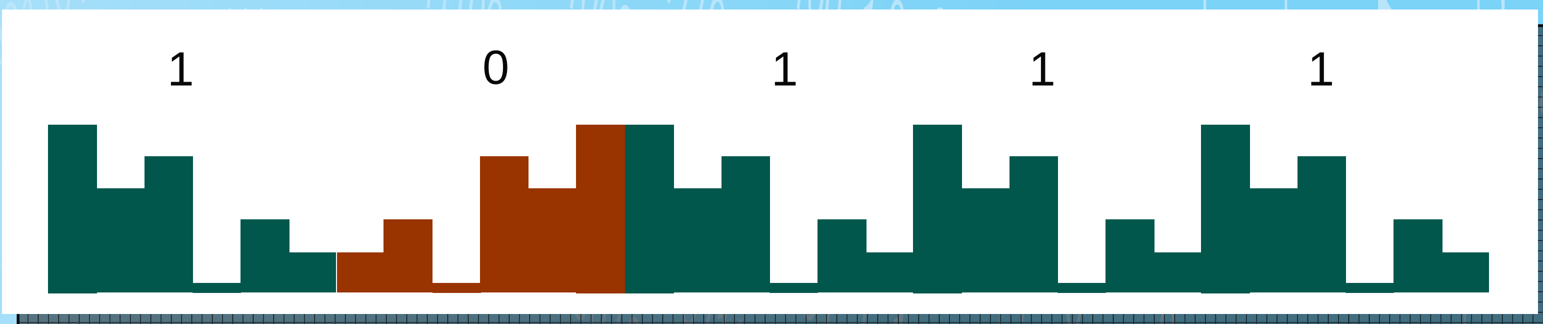


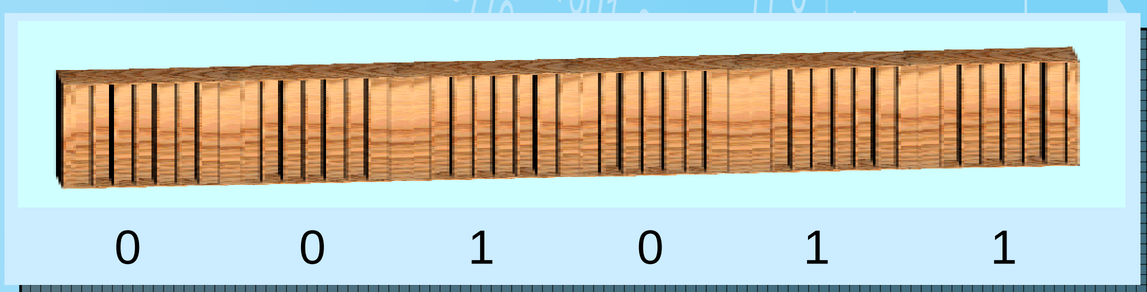
The Shape Optimizer has recently been upgraded to also include stage canopy arrays, where we can optimize the cloud density, size, shape, tilt, depth, using the Support objective measure as an optimization metric.

Also using Aperiodic Modulation discussed later.

2 Modulated Phase Gratings







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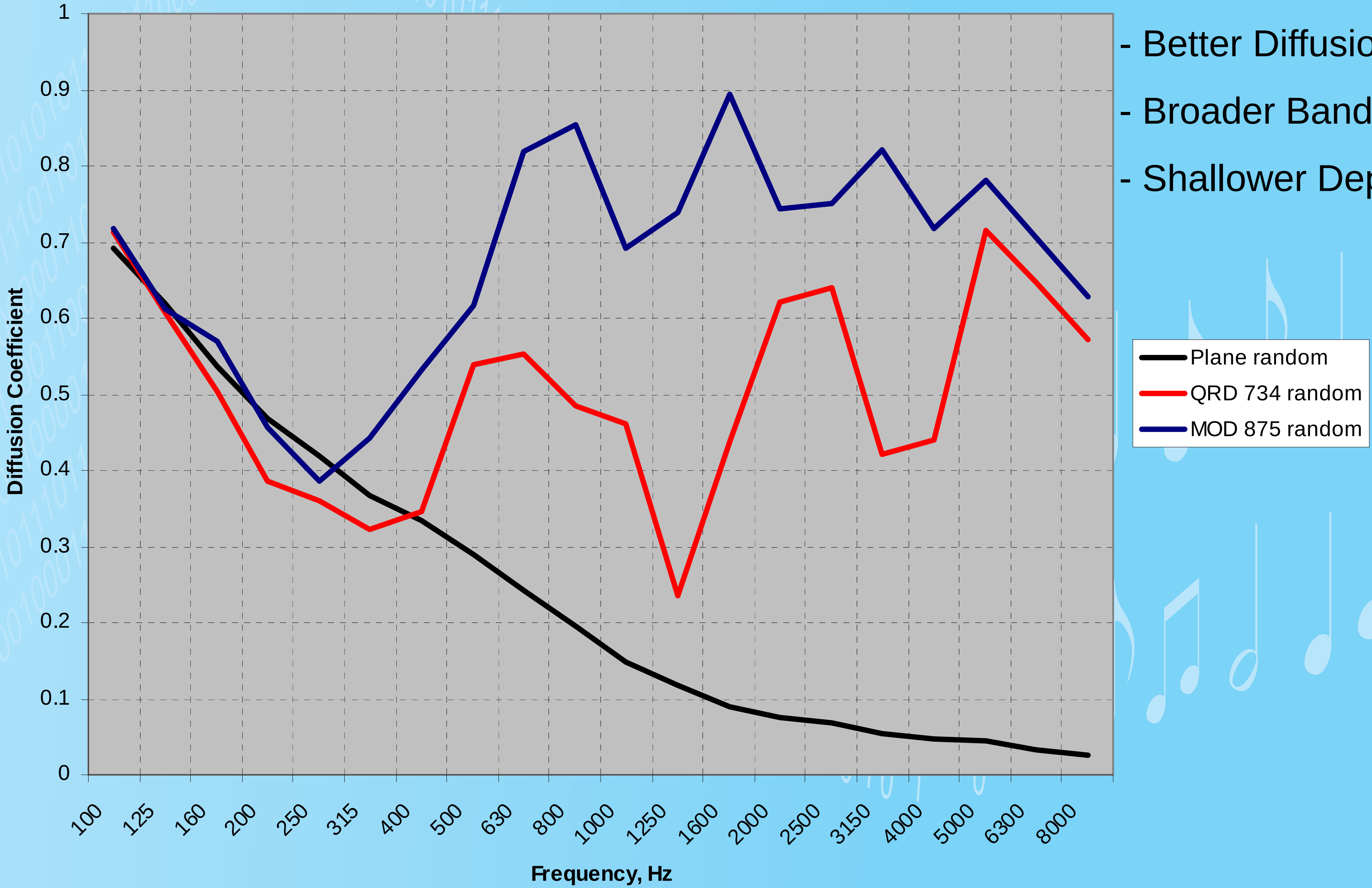
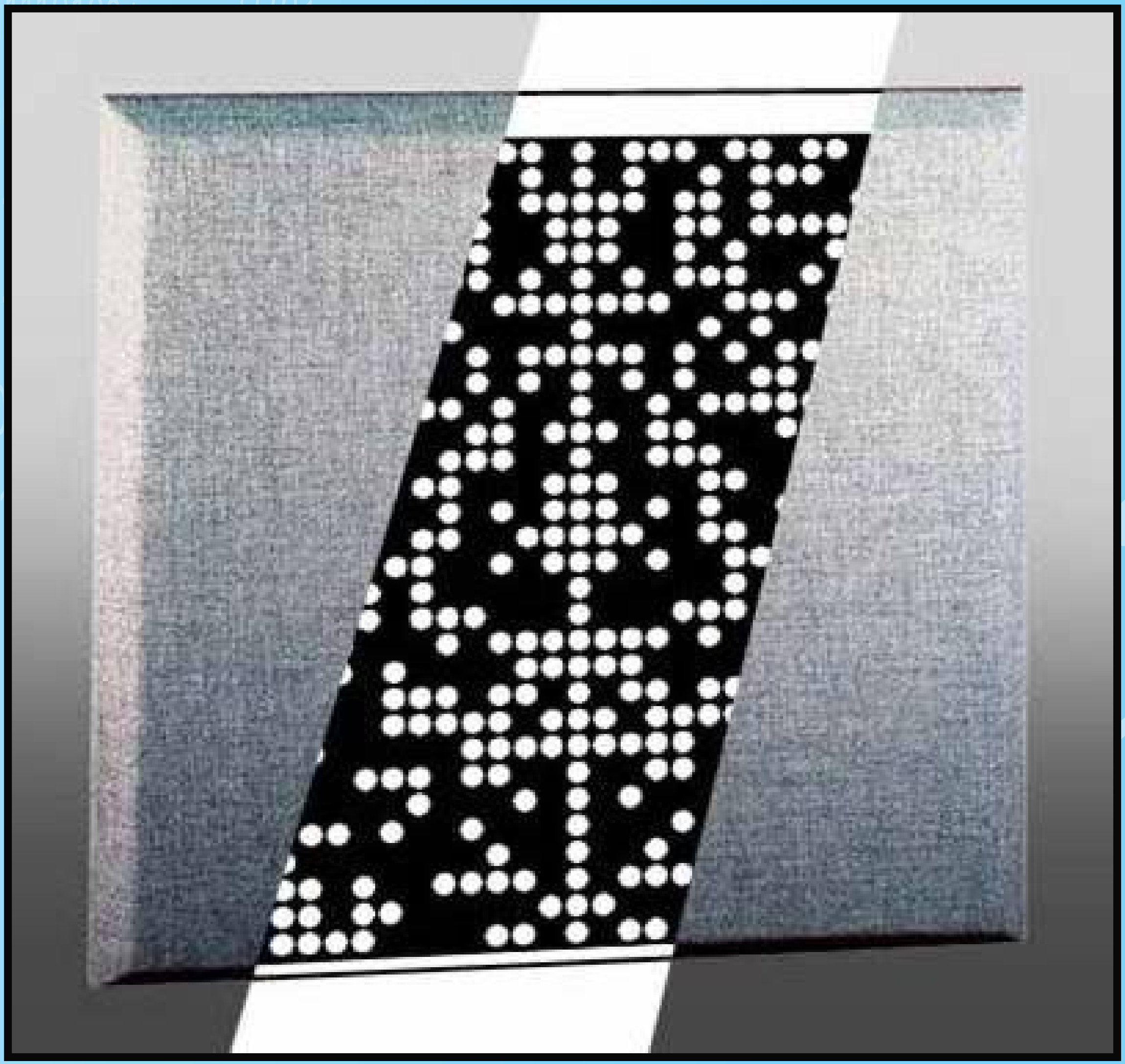
Old QRD vs. Optimized/Modulated

QRD vs MOD

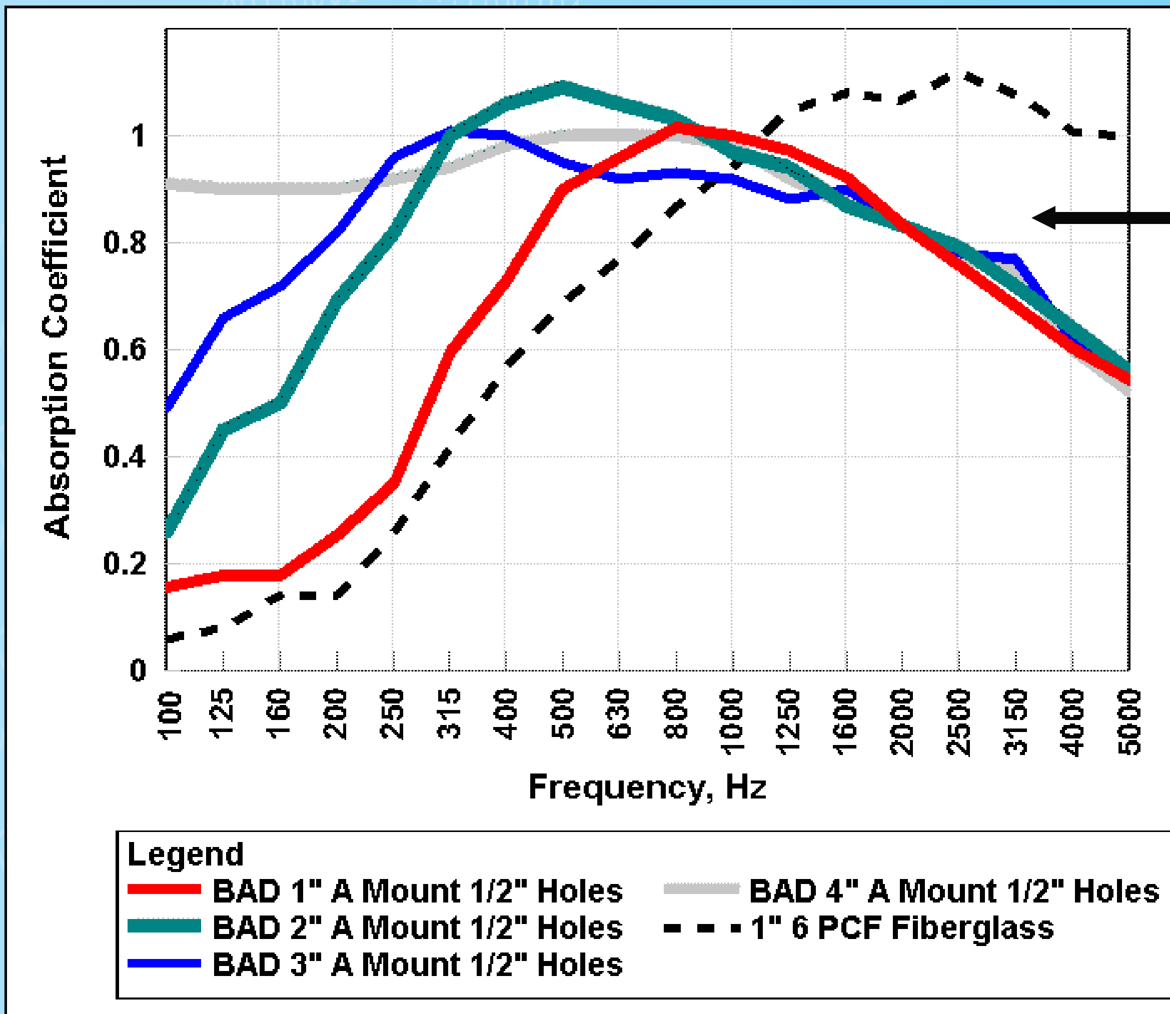


- Better Diffusion
- Broader Bandwidth
- Shallower Depth

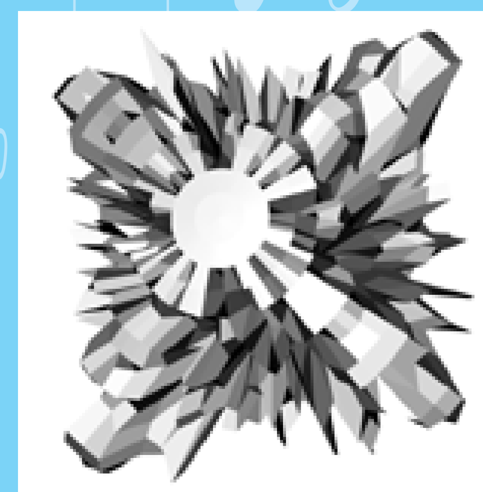
Hybrid Diffsorbers



Binary Amplitude Diffsorber (BAD)



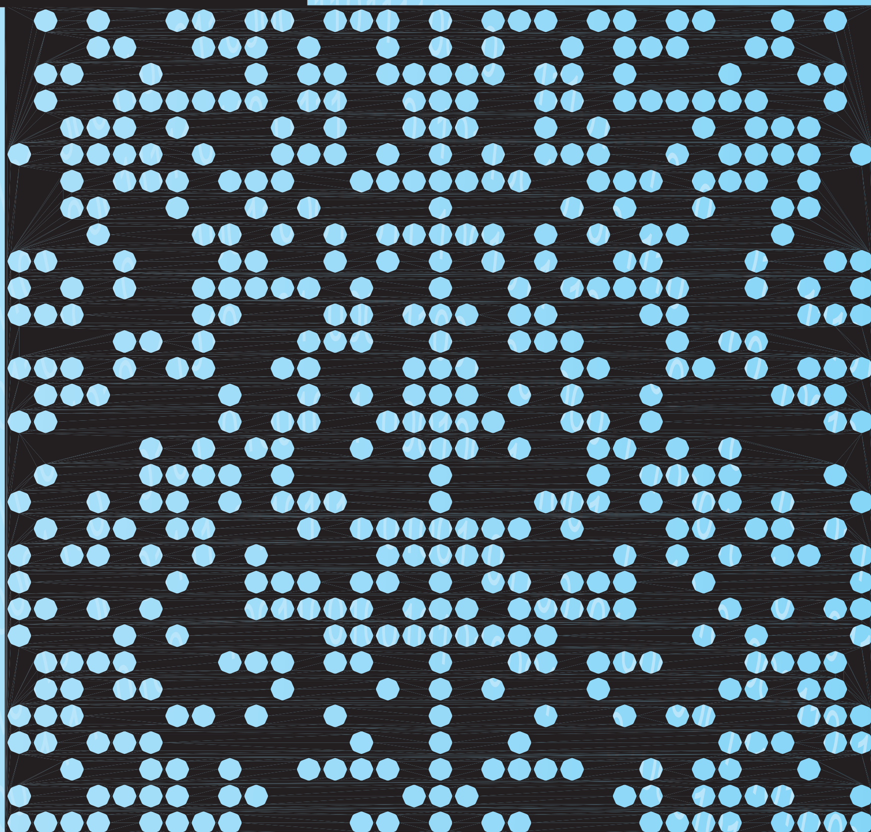
Diffusion



Reflection

Better Low Frequency Absorption as Thickness Increases

2D Unipolar MLS Sequence



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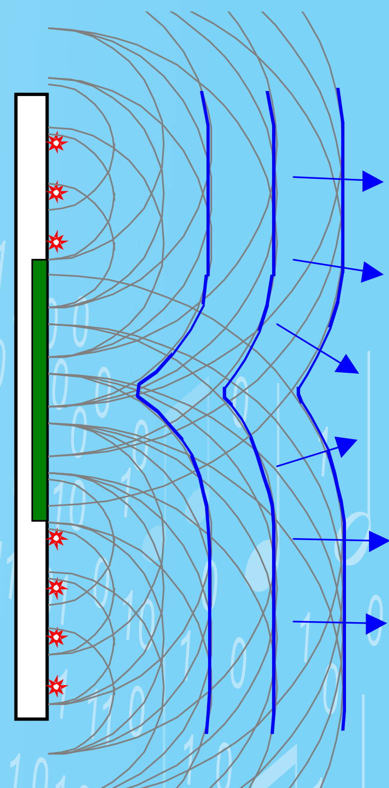
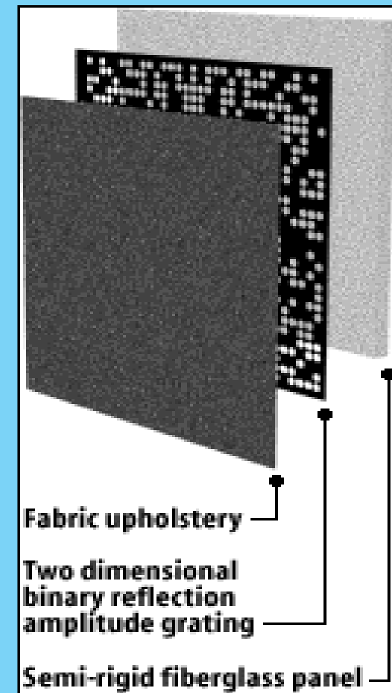
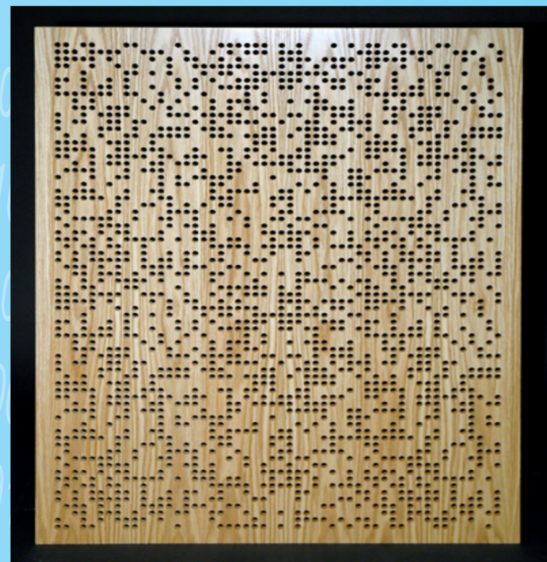
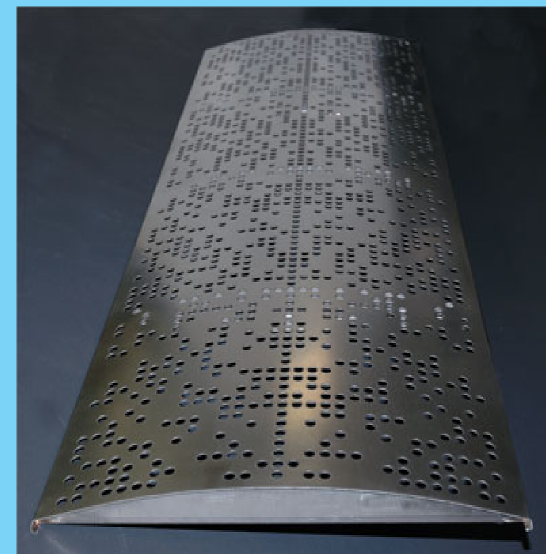
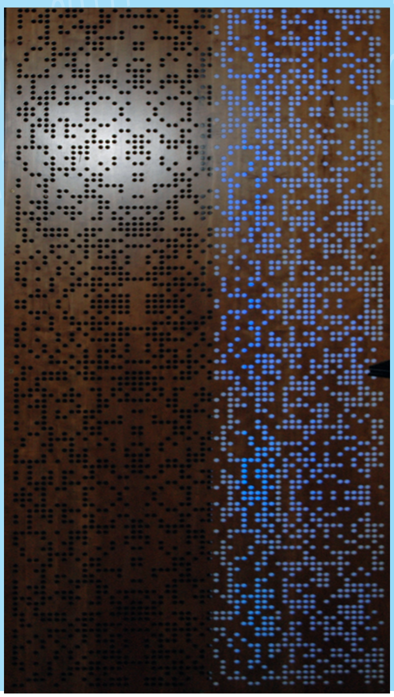


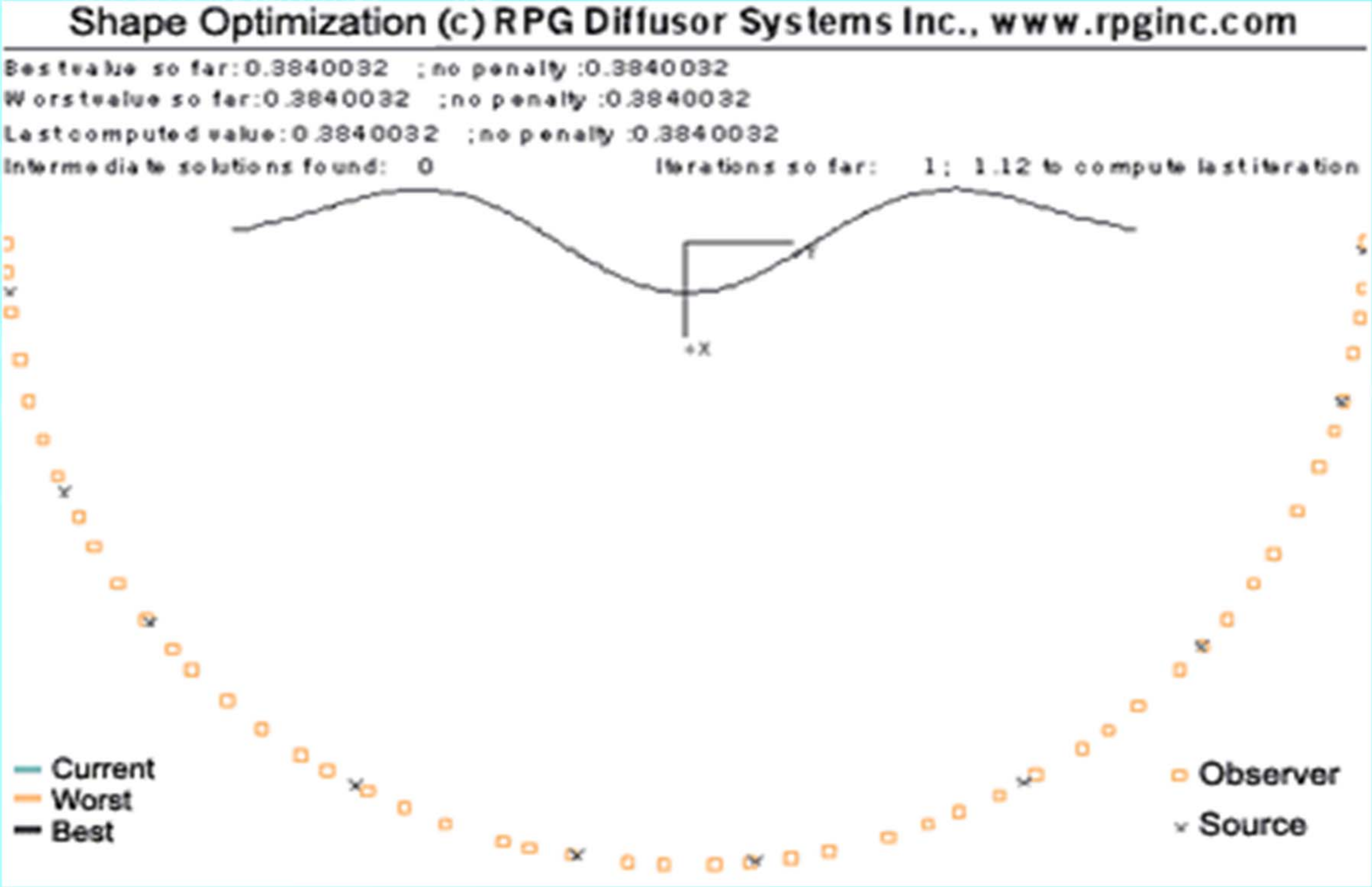


Optimal 2D binary sequence of holes can be formed with the Chinese Remainder Theorem.

BAD Expo: Woodgrain & Metalik

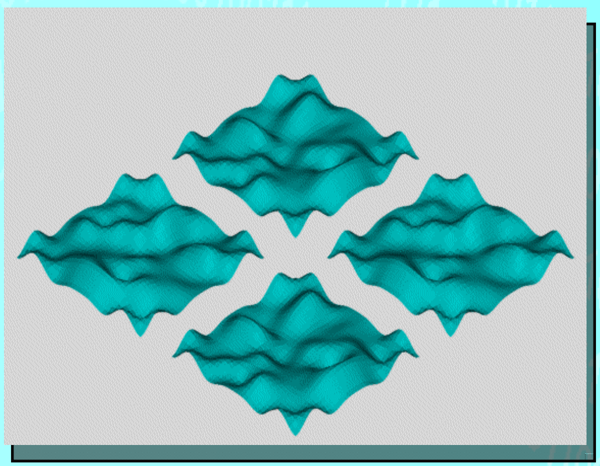
Shape Optimization

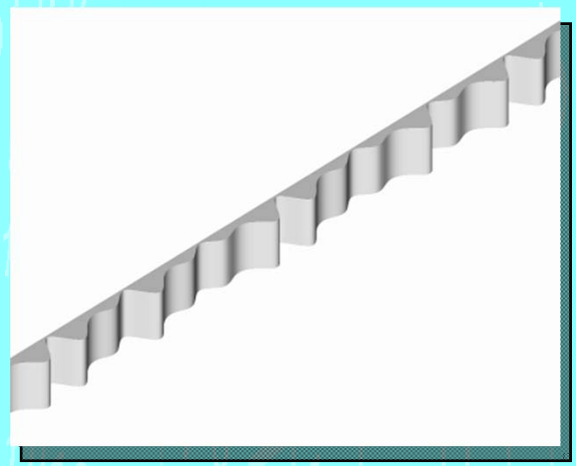


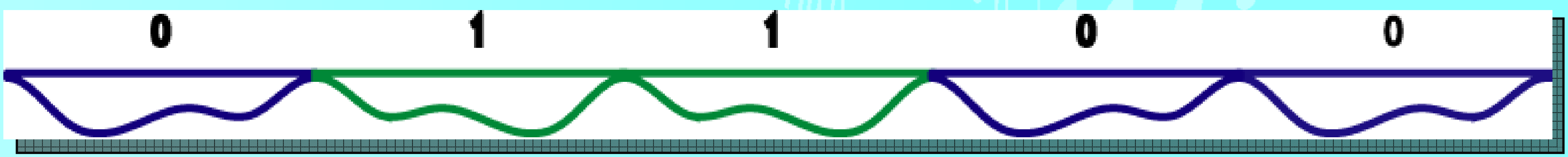
Asymmetric Tiling

0 Unit

1 Unit







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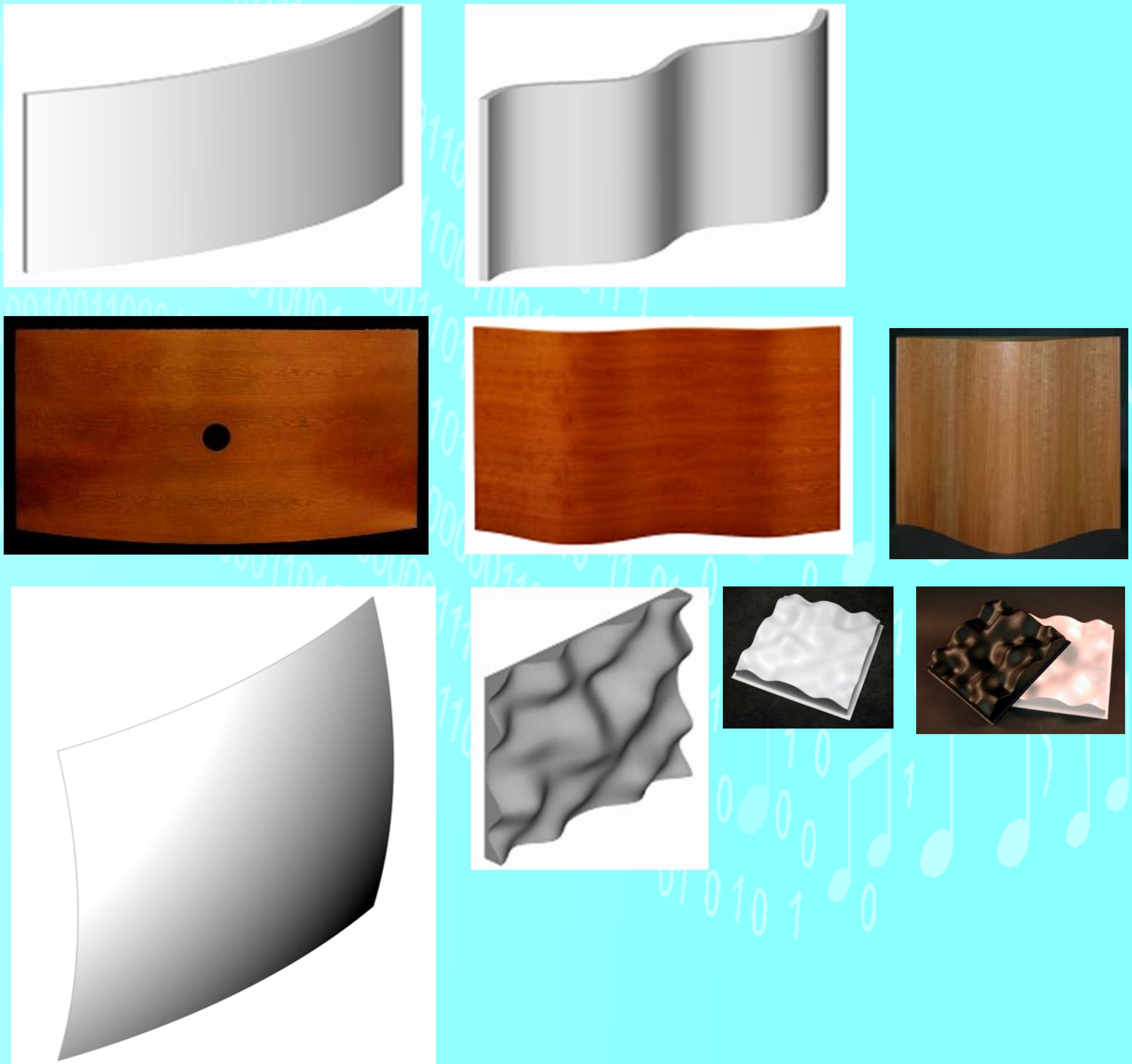
Optimized 1D and 2D Shapes in Wood and GRG

1D

2D



From Mono to Surround: A review of critical listening room design and a new immersive surround design proposal

In the beginning…….

- How did we get here?
- How have listening rooms evolved over the years?
- Let's briefly review the contributions of the acoustical pioneers and some of the milestone events in critical listening room design
- We will begin in the 1940s and progress to an immersive surround sound proposal

1940s

- Most attention to large tracking rooms, little attention to control booth
- Most recording facilities were owned by the record companies, including RCA, Columbia, Decca, Mercury, MGM and later Capitol
- 1947 Universal Recording Corp, Chicago, IL Bill Putnam (UREI). First pop recording, using live chamber Reverberation, echo sends and many current console features (47-57 Chicago years). First independent recording studio.
- Style: Big tracking rooms 15-30,000 cf and small control room booths
- Acoustic Materials:
  - Drapery, Mansville transite panels/rockwool, acoustical tile; Slat resonators and polys soon commonplace
  - No low frequency absorption
  - Scoring stages more advanced than pop studios

1950s

- Bill Putnam's moved to LA and opened United and Western Recording
- Capitol Tower, LA was designed acoustically by Michael Rettinger, who pioneered the acoustical techniques and materials in a facility designed for phonograph records. He used variable T60 and reduced LF reverberation in tracking rooms.
- New studios opened by Chess, Chicago; Rudy van Gelder in NJ; Sun in Memphis; Criteria in Miami;
- Stereo and Hi Fi emerged: CBS introduced LP 33 1/3 rpm; Classical and pop records
- Bill Putnam was sending stereo and mono feeds to separate mono control room
  - Speakers typically over the windows
  - Control room geometry and acoustics were introduced

- **Stereo Control room dilemma**
  - Acoustics and non-symmetrical geometry not satisfactory for stereo
  - Poor monitoring conditions, vis-à-vis
    - Quality of monitor speakers, Location, Power, Response
- Insufficient floor space and volume

1960s

- Stereo in the 1960s was where 5.1 is today
- Tom Hidley introduces control room design-built packages, utilizing flush mounted speakers, compression ceilings and rear wall absorbers and coined the term “Bass Trap”
  - Along with 16 Track, 2” tape recorder, dual woofer control room monitors, carpeting, hardwood, sliding glass doors and other architectural elements
- Phil Ramone A&R New York 1961
- 1969 John Storyk designed Electric Ladyland

1970s

- 1975 Philip Newell/Hidley built The Manor
  - Non-environment Room: broad band trapping everywhere except the flush mounted front wall and floor.
- 1978 Dick Heyser introduces Time Delay Spectrometry (TDS) and pioneers new approach to computerized room and speaker testing
- 1979 LEDE design proposed by Don & Carolyn Davis and executed at Las Vegas Recording by Chips Davis, following results from TDS room testing

1980s

- Measurement of reflection thresholds and other psychoacoustical perception metrics by Haas, Pudie Rogers, Floyd Toole, Mike Barron, Bill Martens/Gary Kendall, etc.
- 1983: Reflection Rich Zone (RRZ) George Massenburg, The Complex, LA
- 1984: Reflection Free Zone (RFZ) and Reflection Phase Gratings (RPG) Peter D'Antonio, Underground Sound, MD
- 1983 CD introduced

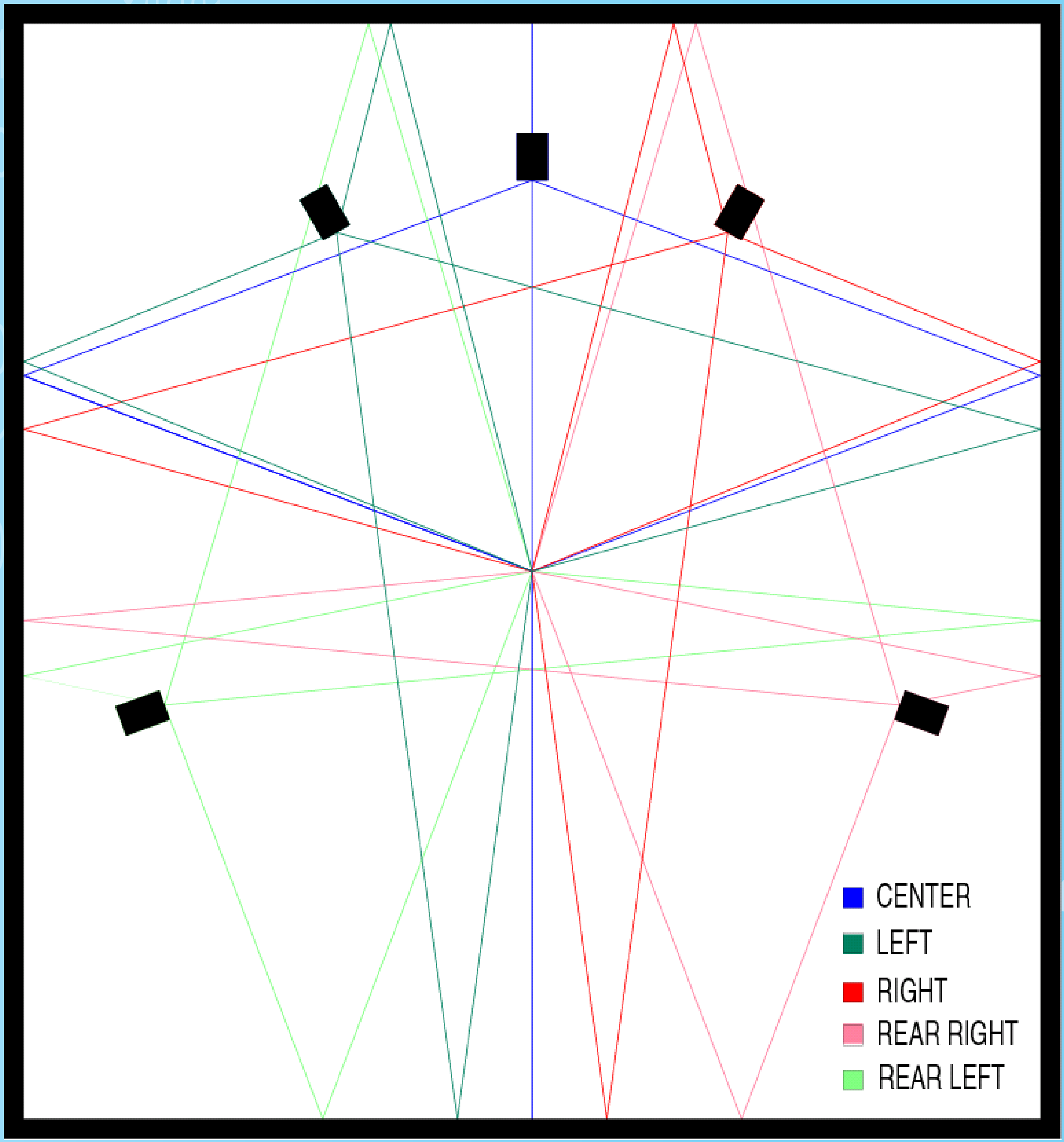
1990s

- 1997: RRZ Angus AES Preprint 4405
- 1997: D'Antonio reiterates the importance of broad bandwidth diffuse reflections in critical listening rooms
- 1997: The Moulton Room, anechoic front, reflective sides, diffusive rear/rear sides, absorptive front ceiling
- 1998: Hidley introduced 24 Hz "built in" surround sound monitoring for 5.1

2000 +

- Floyd Toole proposes that early reflections in small rooms may be beneficial to perception
- New plate resonators introduced to absorb down to 40 Hz in 4" thickness
- Blackbird Studios, George Massenburg "Ambechoic" Surround Sound environment
- D'Antonio introduces a new immersive surround sound listening room design

Current Challenge



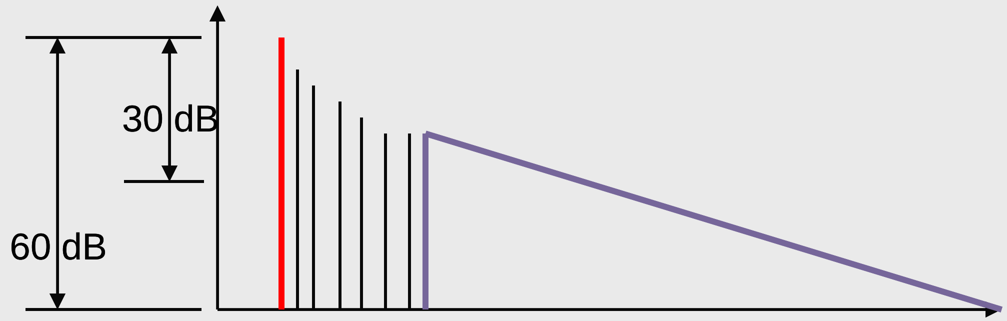
Acoustic Distortion

FREQUENCY	ACOUSTIC DISTORTION	
	PROBLEM	**SOLUTION**
Below 200 Hz		
	Modal Resonances	1. Room Dimensions 2. Speaker/Listener Placement 3. Absorption
	Speaker-Boundary Interference	1. Speaker/Listener Placement 2. Absorption
Above 200 Hz		
	Comb Filtering	1. Absorption 2. Diffusion 3. Surface Treatment Placement
	Poor Diffusion	1. Diffusion 2. Reflection 3. Placement

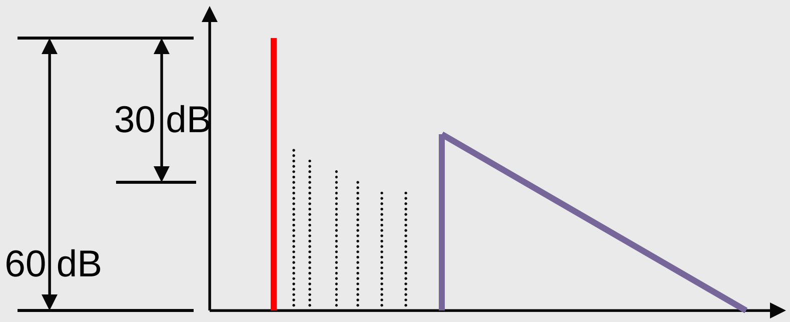
Room Design Options

Anechoic Chamber

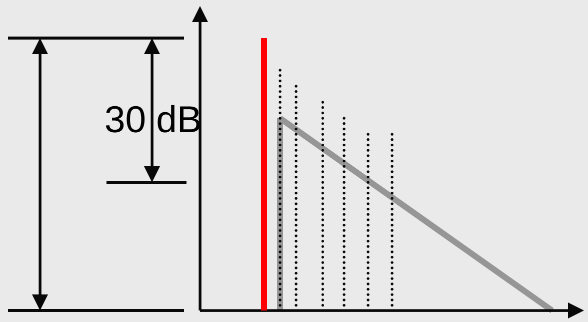
Reverberation Chamber



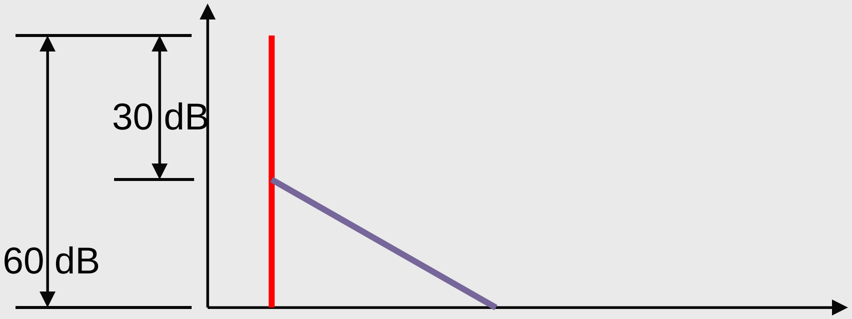
Reflection Free Zone



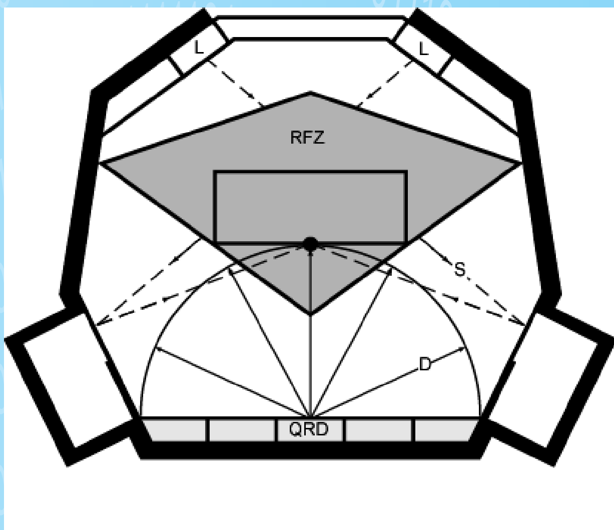
Reflection Rich Zone

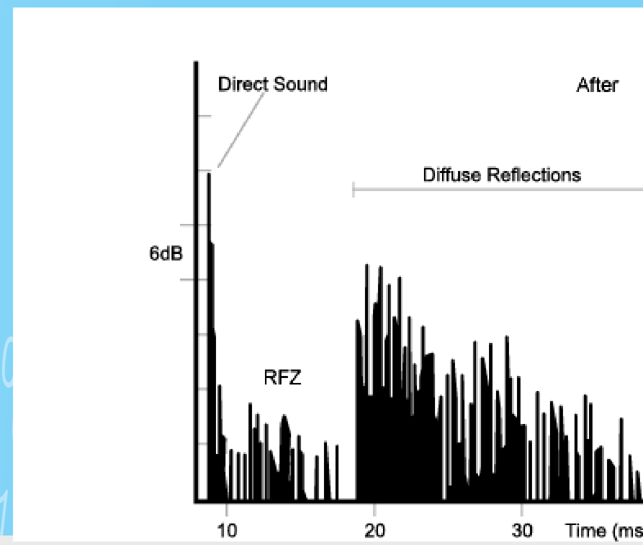


Ambient Anechoic- Ambechoic



Stereo Solution: RFZ





Spatio-temporal Reflection Free Zone can be created, using absorption or diffusion to control room reflections.

This stereo solution is being used for surround, but more is needed.

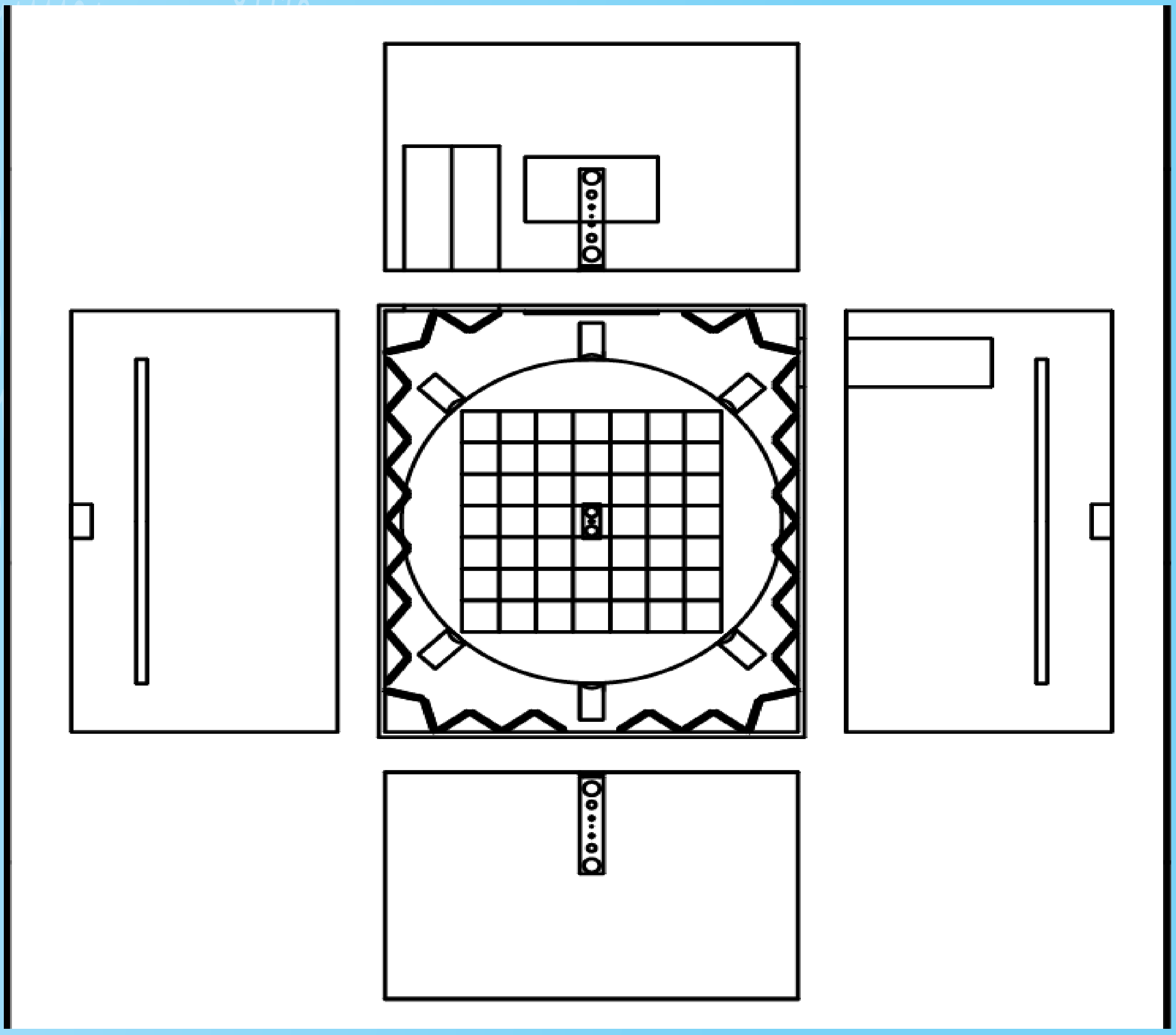
Massenburg, The Complex (1983) studied the diffusive approach
D'Antonio, AES Preprint 2157 (1984) studied the absorption approach
Angus, AES Preprint 4405, (1997) studied the diffusion approach

Early Experimentation

- The Complex in West Los Angeles in 1980

- Skywalker Sound Scoring Stage in 1989

Widescreen Review



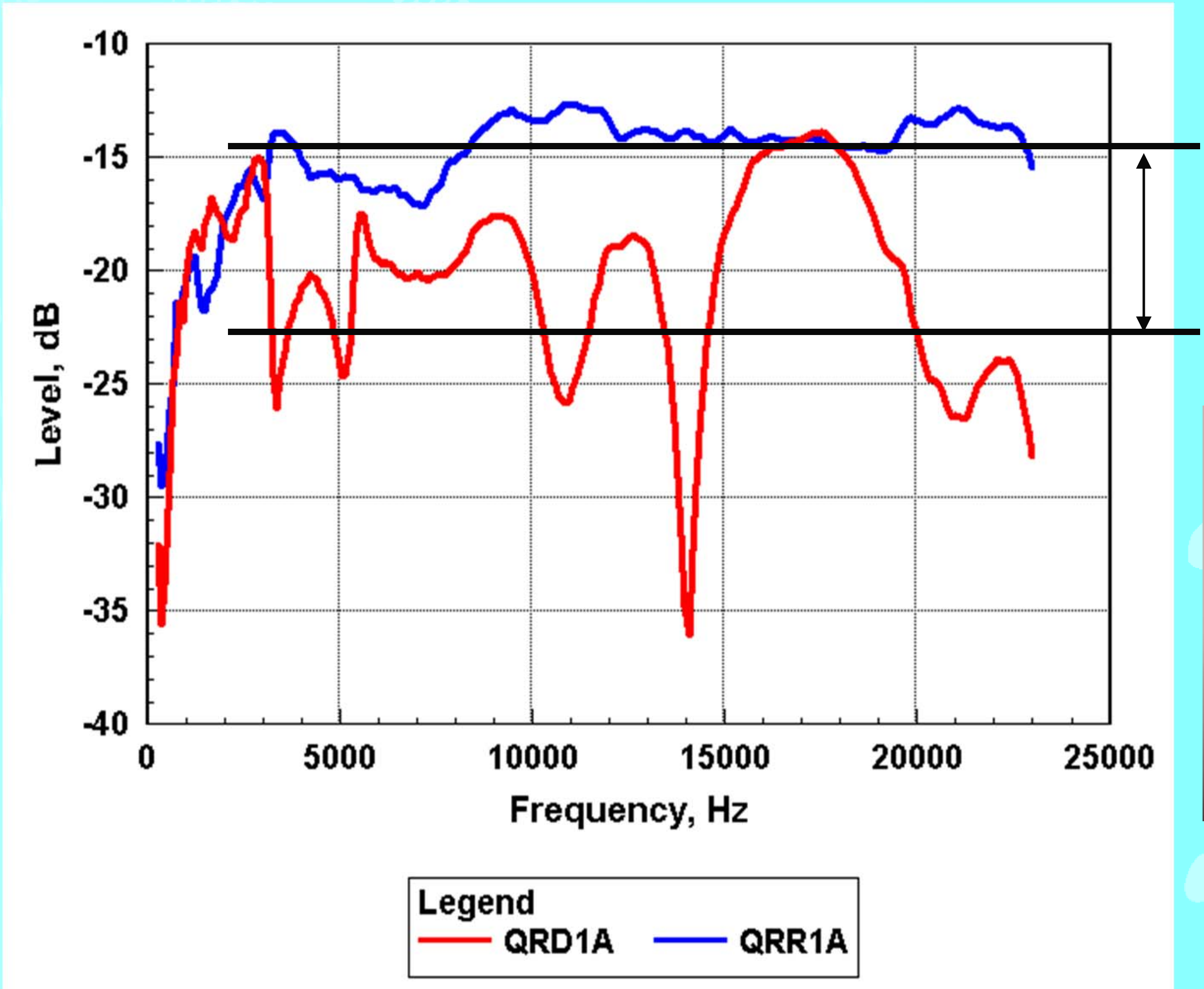
Widescreen Review

Uniform surround environment using phase grating ceiling and binary amplitude diffsorbers along walls

Proof of Concept

- After mixing in all known types of professional and experimental spaces, George Massenburg wanted to work in an environment that better supported:
  - An improved imaging of virtual sources in surround monitoring
  - A much broader "sweet-spot"
  - A room with supportive, linear ambience that has near-equal decay rates across as much of the frequency spectrum as possible.
- The experiment involved designing a combination of massively prime 2D wall diffusors extending to 100 Hz
- And ceiling Diffractals extending to 50 Hz, which surround the listener

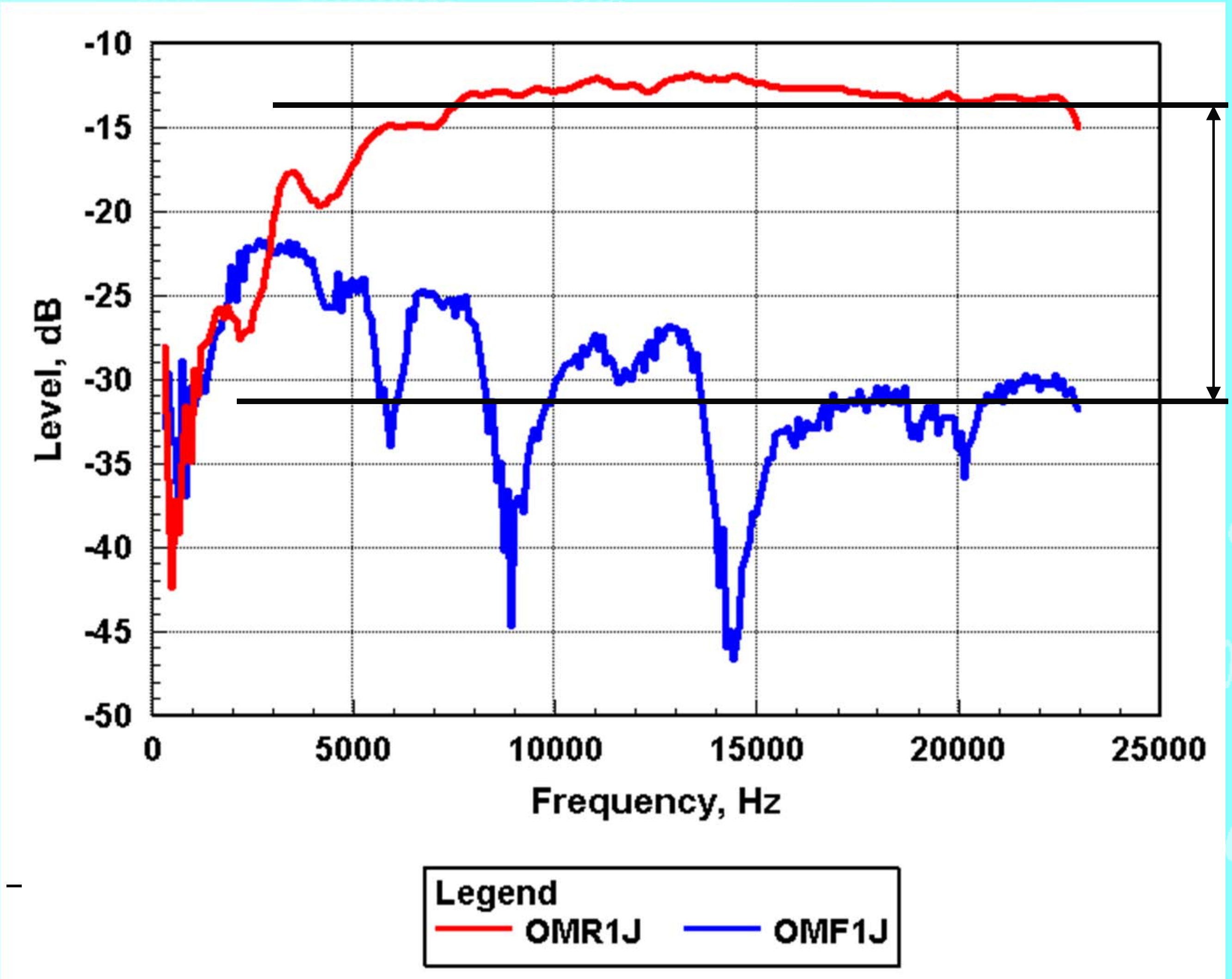
Attenuation from 1D QRD



<u>Attenuation:</u>

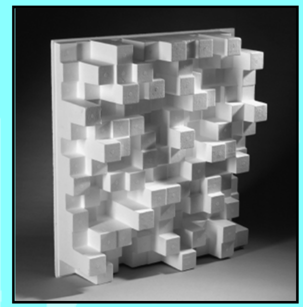
10Log(1/7)
= -8.5 dB

Attenuation from a 2D QRD



Attenuation:

10*log(1/49)
=-**17 dB**



Attenuation Blackbird:
10*log (1/(181x769)
= -51 dB
Based on amplitude modulated prime 181 and 769 1D primitive root sequences, using modulus 953.

Blackbird Design Elements

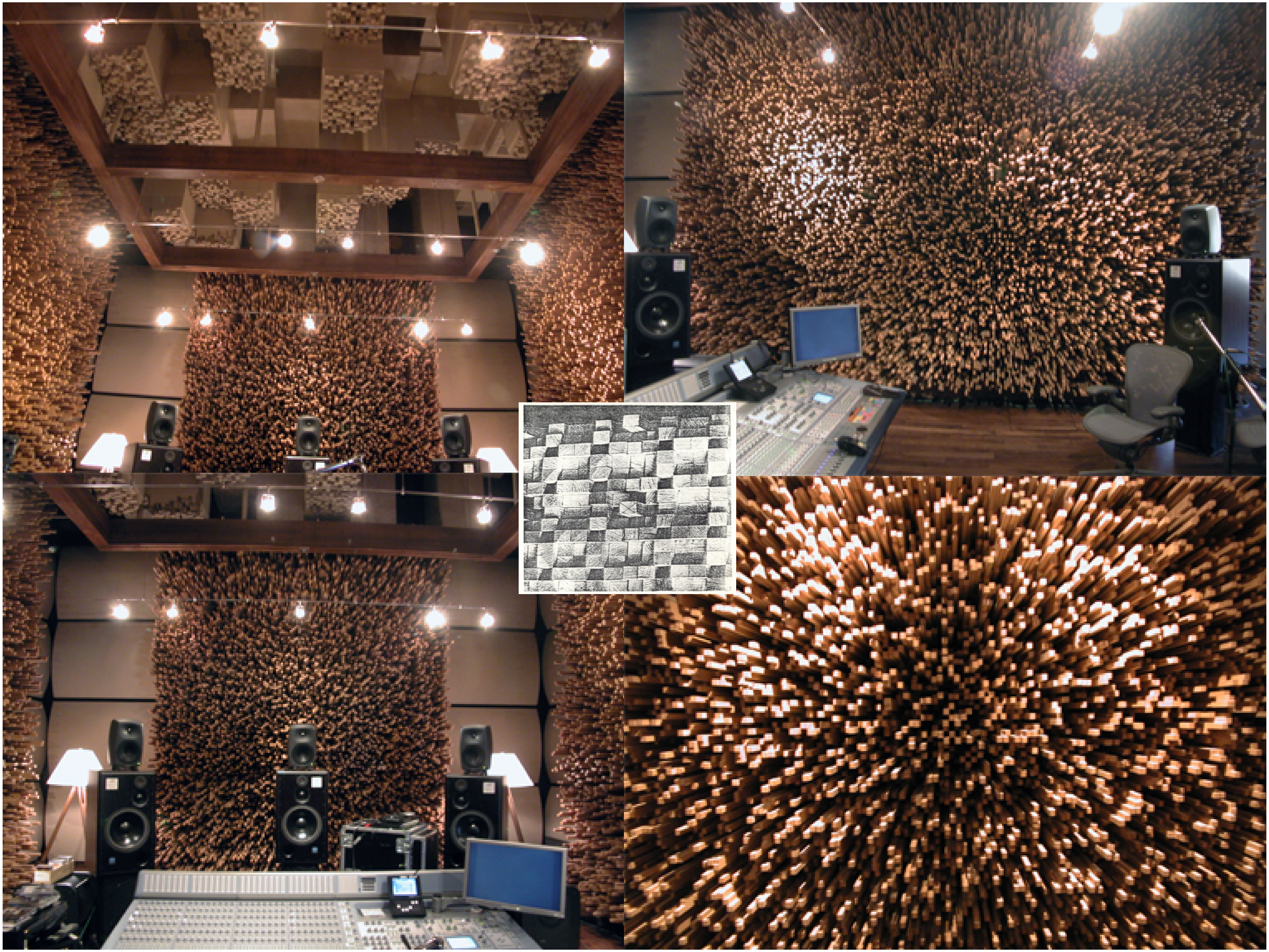
blackbird studio®

studio c

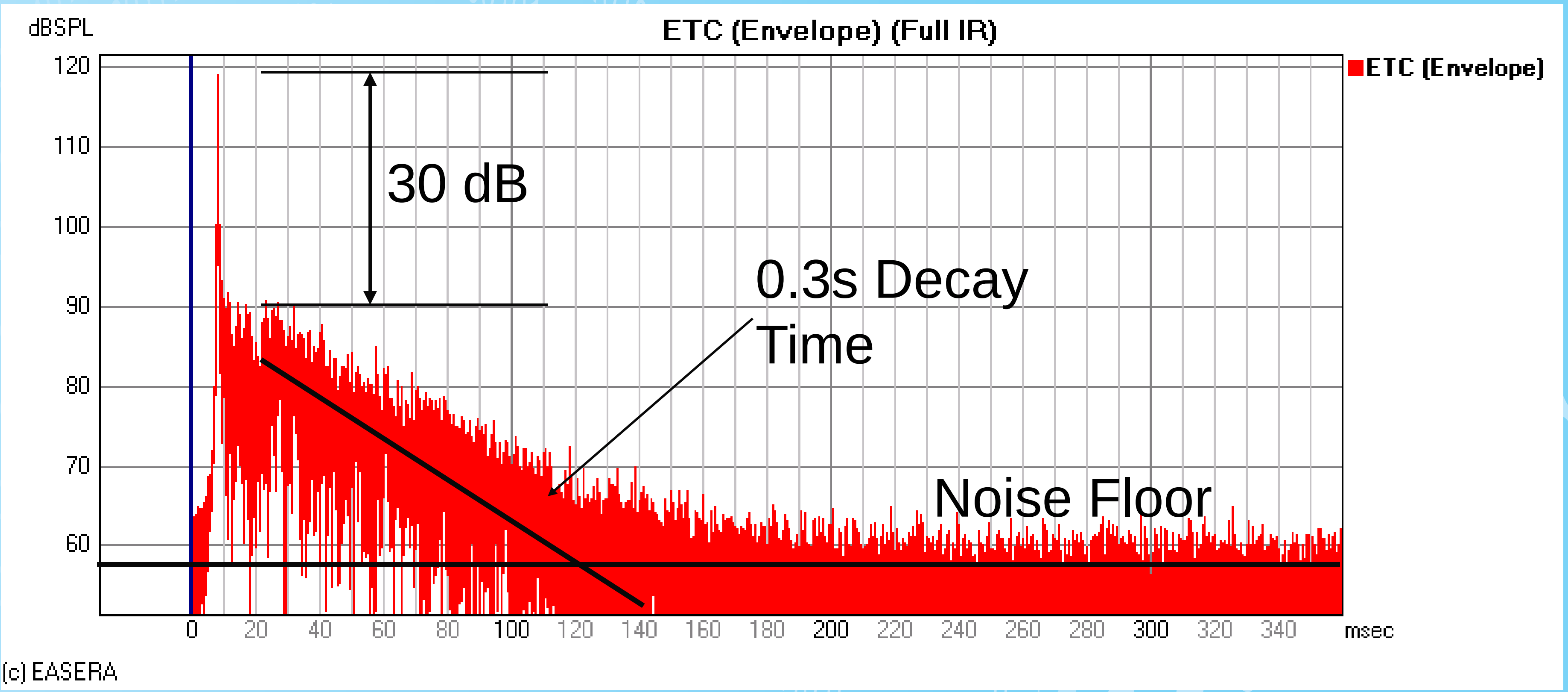
Walls:
3' deep amplitude modulated prime 181 and 769 1D primitive root sequences, using modulus 953.
138,646 block heights!

Ceiling:
7' deep 12 x 13 primitive root Diffractal, based on N=157.
24,336 block heights!

Corners:
(32) 1 x 1.5 m damped metal plate shelving resonators, covered with curved binary amplitude diffsorbers.



ETC At Mix Position

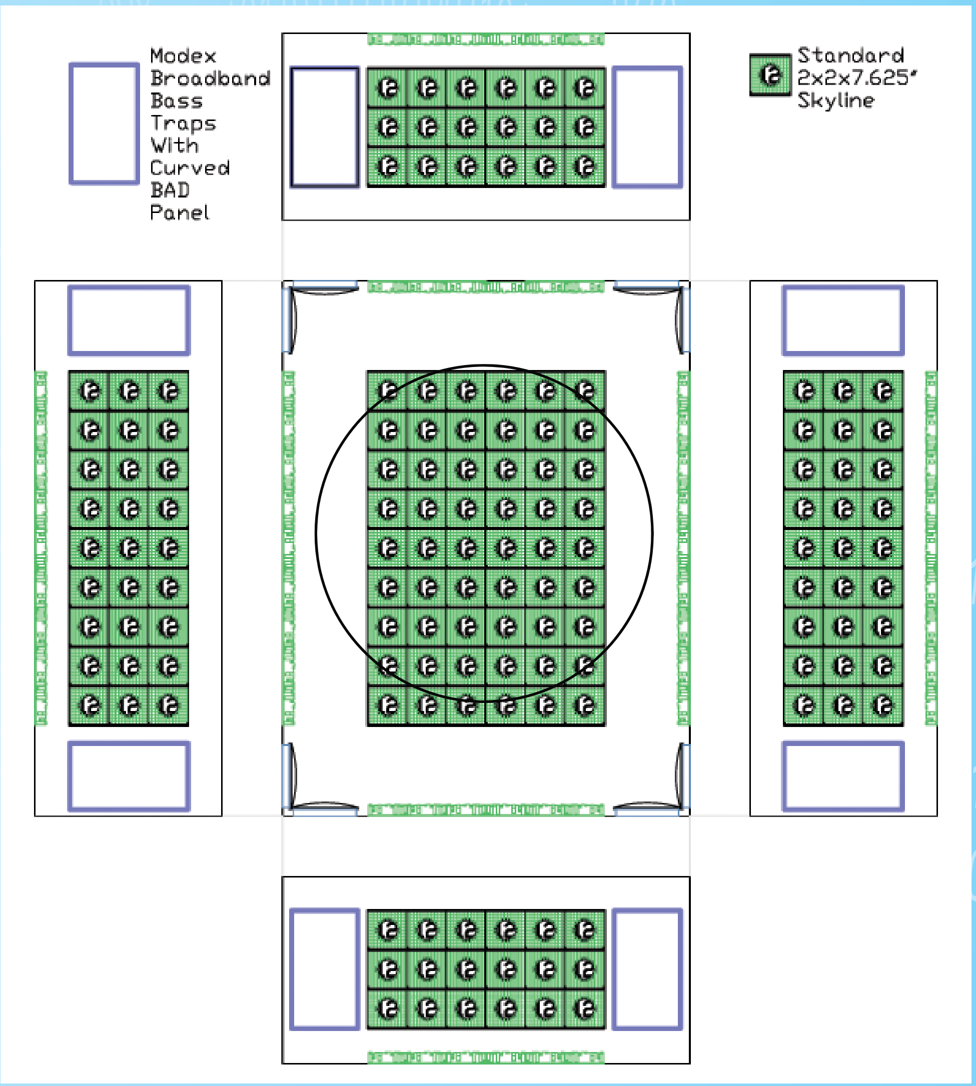


This space can be described as an "ambient anechoic space" or **Ambechoic™**, as we now describe it

Early Subjective Impressions

- The visual impact is immediate and challenging, but clients quickly forget its effect.
- Mixing engineers adapt quickly to the room and its ambience. The monitors are impressive at somewhat lower monitoring levels (generally <85-95dB SPLA, lower than typical 100-110dB SPLA control room levels).
- Imaging is startlingly precise and pan settings are repeatable from a broad range of monitoring positions.
- One can comfortably hold a conversation while listening to music in the room - the room is not “anechoic” in any way.
- The room works equally well recording live acoustic musicians. Musicians are able to hear and balance themselves without headphones or excessive amplification.

Immersive Surround Environment

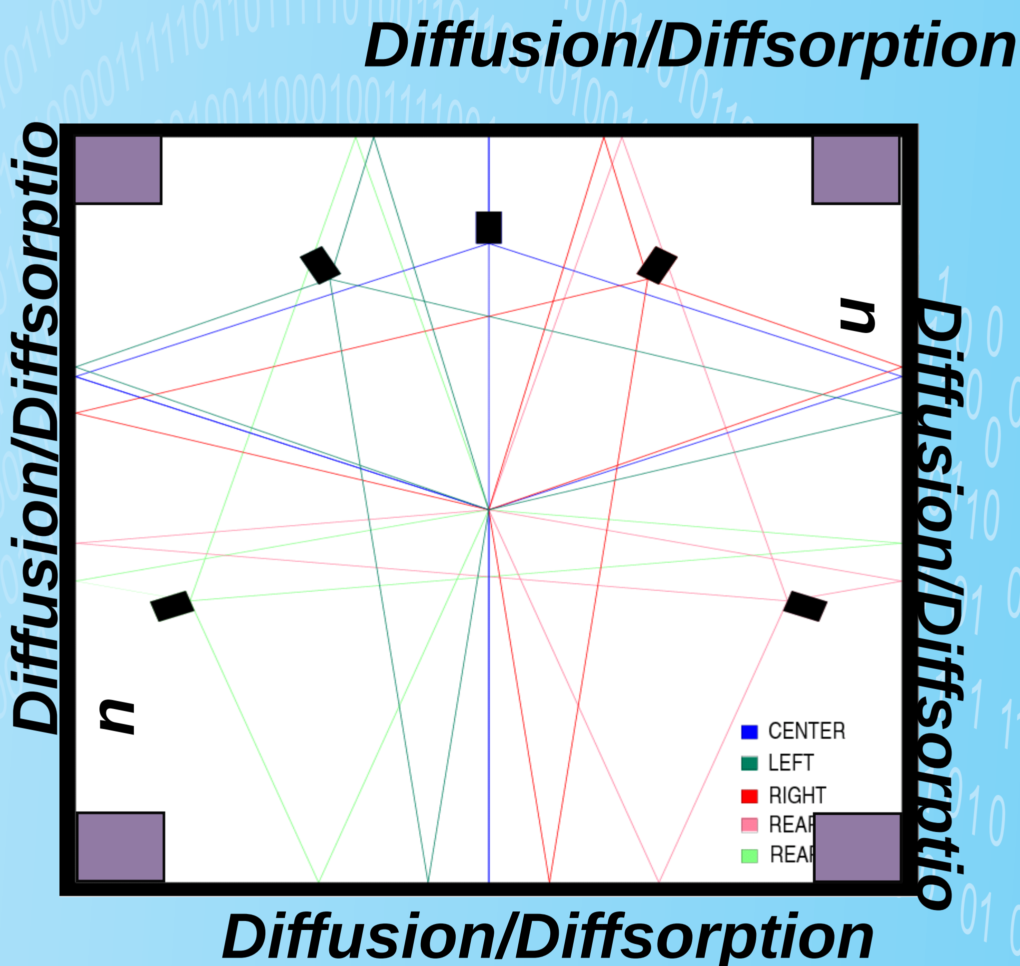


iRoom

-Complete modal control down to 40 Hz, using new plate resonators and optimal sub/listener positioning

-Uniform ambient anechoic environment in non-modal domain, using diffusion or diffsorption

Immersive Environment



***Corner** Treatment*

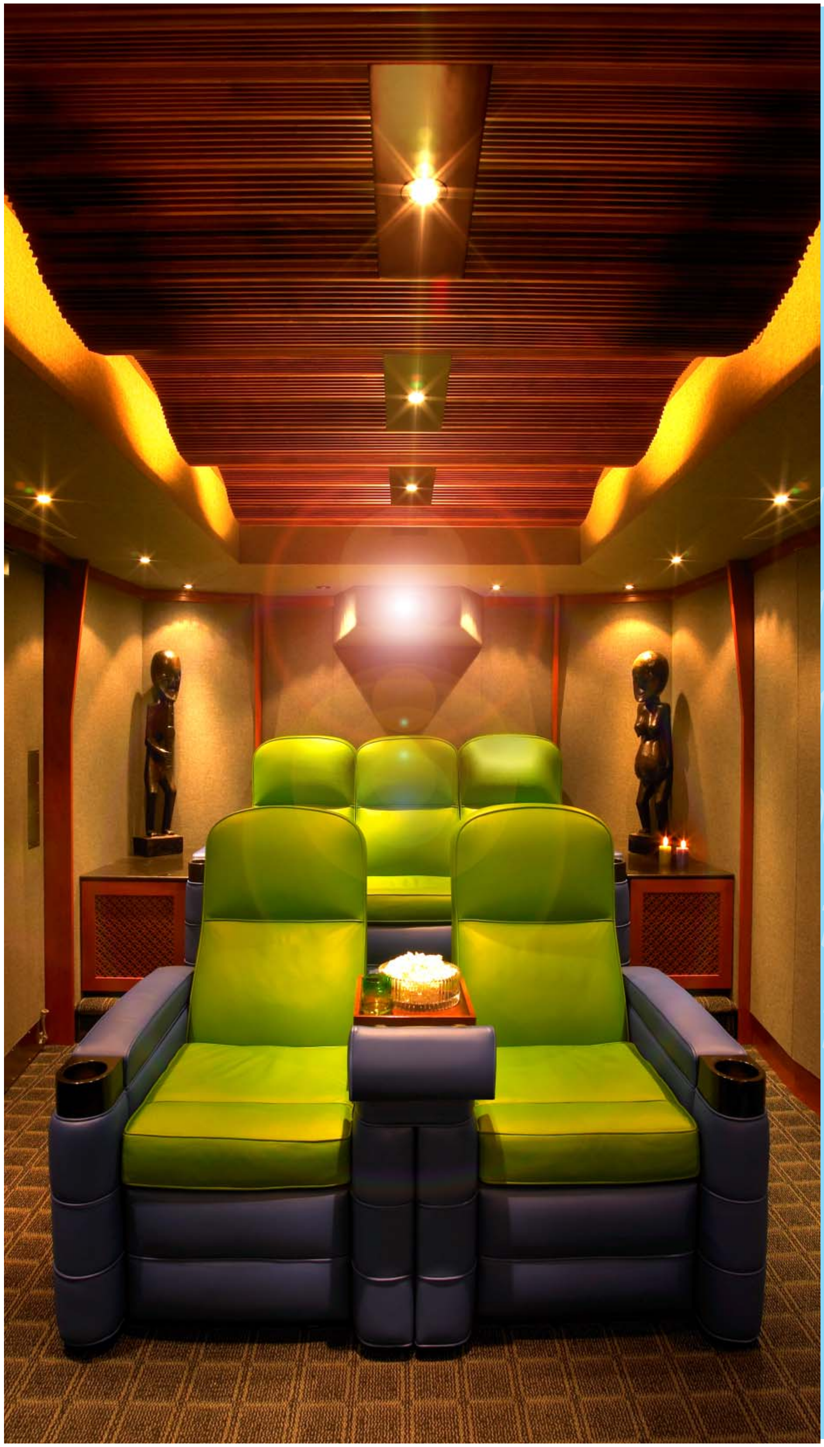
-Plate Resonators

Boundary Treatment

-Broadband Diffractals

-Broadband Binary Amplitude Diffusors

-Broadband Alternating Reflection/ Absorption



RPG

This is only the beginning......