



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

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# 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

- Tom Hidley introduced “Non-Environment” Control Room using flush-mounted Kinoshita monitors and trapping on all surfaces, except the concrete front wall and hardwood floors
  - 10 Hz Infrasonic Control Room
  - 24 Hz “built-in” surround sound monitoring for 5.1
- Measurement of reflection thresholds and other psychoacoustical perception metrics by Haas, Pudie Rogers, Floyd Toole, Mike Barron, Bill Martens/Gary Kendall, etc.
- 1982 Muncy LEDE with all cone loudspeakers
- 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

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- 1997: RRZ Angus AES Preprint 4405
- 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 +

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- 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

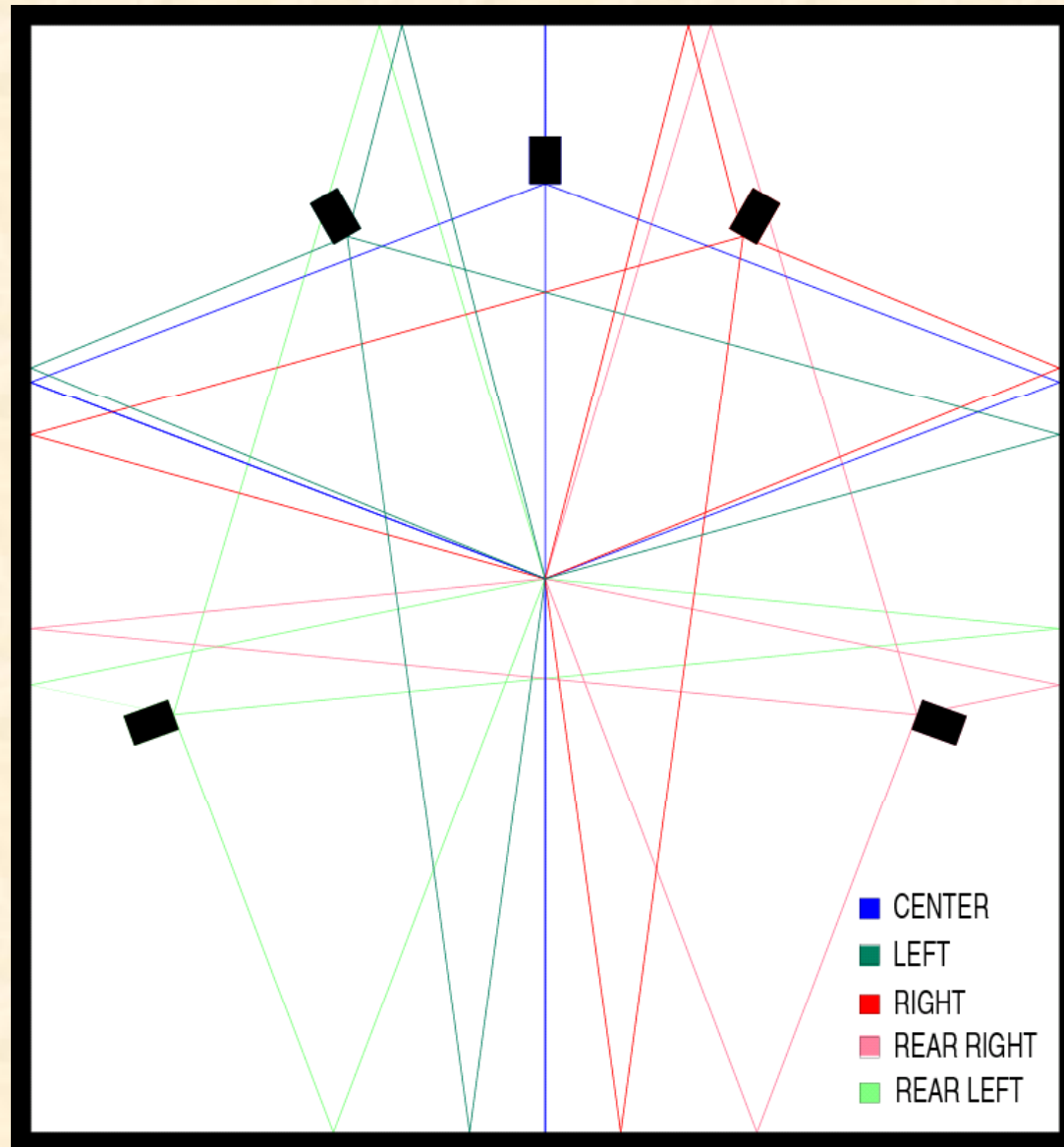


# Evolution Summary

- Early Reflections:
  - We have oscillated from being unaware of the importance of early reflections
  - to emphasizing them in Hidley's compression ceilings
  - to learning of their importance in providing envelopment from Schroeder's concert hall research
  - to removing frontal reflections completely due to comb filtering and image shift in Davis' LEDE, D'Antonio's RFZ, Hidley and Newell's non-environment approaches
  - to utilizing rear diffuse reflections for enveloping passive surround sound in D'Antonio's RPG rear wall
  - to re-evaluating the perceptual importance of specular and diffuse reflections in the work of Massenburg, Angus, D'Antonio, Toole, Martens and Moulton
- Mid and Late Reflections:
  - There has been general agreement in all designs over time that the decay time should be small
- Throughout all of this evolution, recorded music has survived... **Maybe we are irrelevant and music is what really matters!**



# Current Challenge





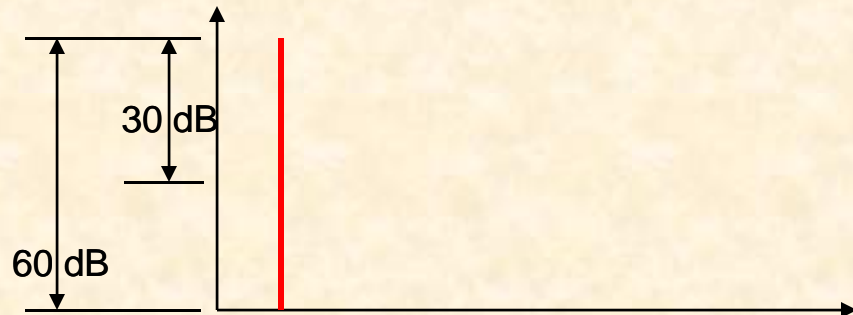
# Acoustic Distortion

FREQUENCY	ACOUSTIC DISTORTION	
	PROBLEM	SOLUTION
Below 200 Hz		
	Modal Resonances	<ol style="list-style-type: none"><li>1. Room Dimensions</li><li>2. Speaker/Listener Placement</li><li>3. Absorption</li></ol>
	Speaker-Boundary Interference	<ol style="list-style-type: none"><li>1. Speaker/Listener Placement</li><li>2. Absorption</li></ol>
Above 200 Hz		
	Comb Filtering	<ol style="list-style-type: none"><li>1. Absorption</li><li>2. Diffusion</li><li>3. Surface Treatment Placement</li></ol>
	Poor Diffusion	<ol style="list-style-type: none"><li>1. Diffusion</li><li>2. Reflection</li><li>3. Placement</li></ol>

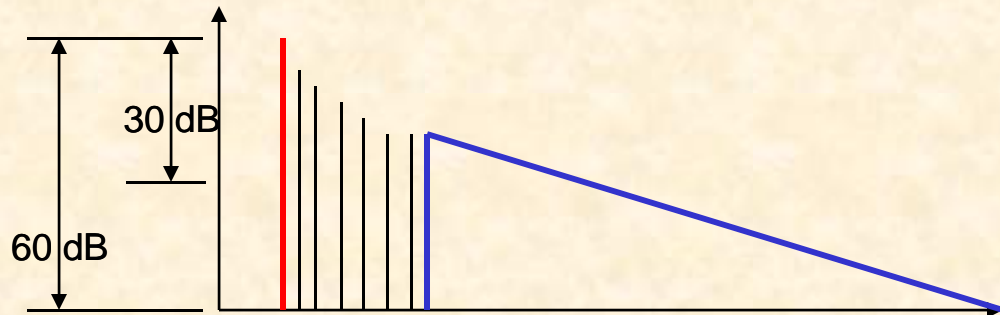


# Room Design Options

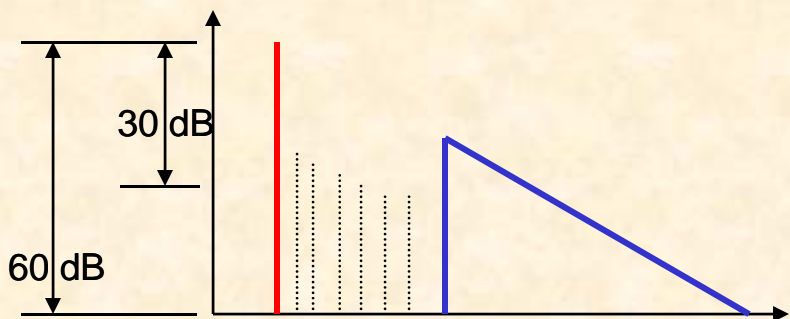
## Anechoic Chamber



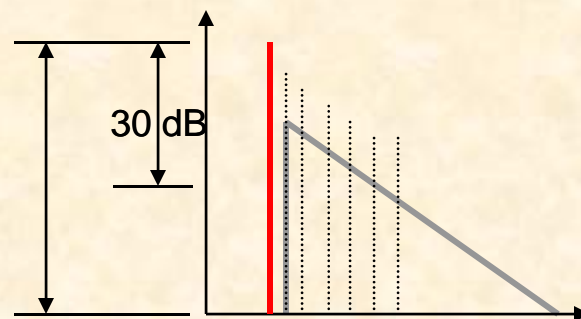
## Reverberation Chamber



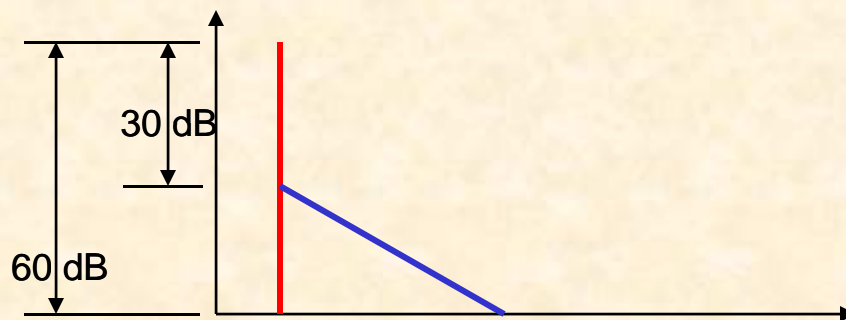
## Reflection Free Zone



## Reflection Rich Zone



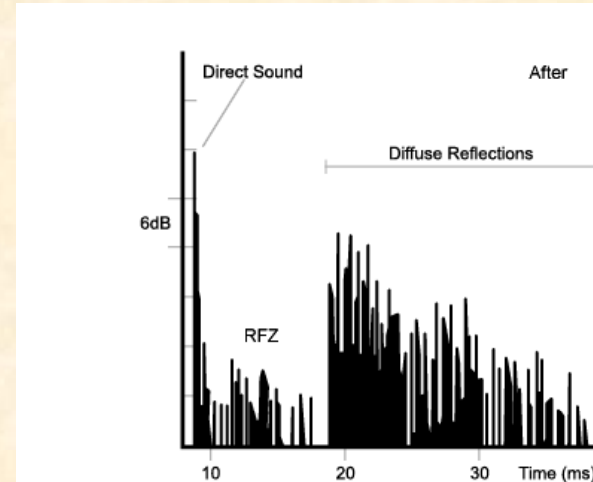
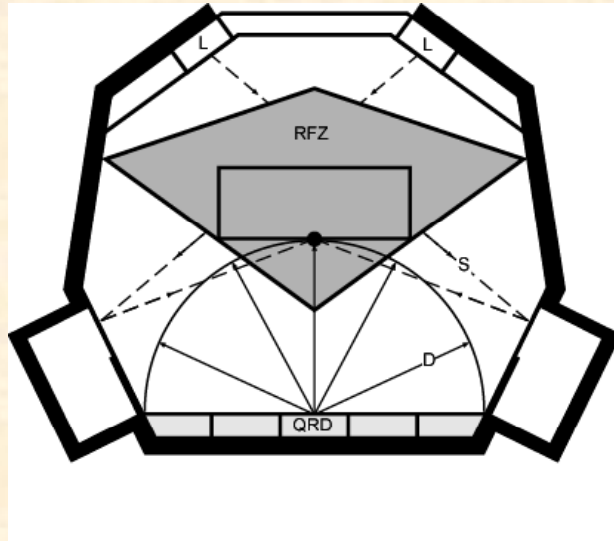
## *Ambient Anechoic- Ambechoic*







# 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

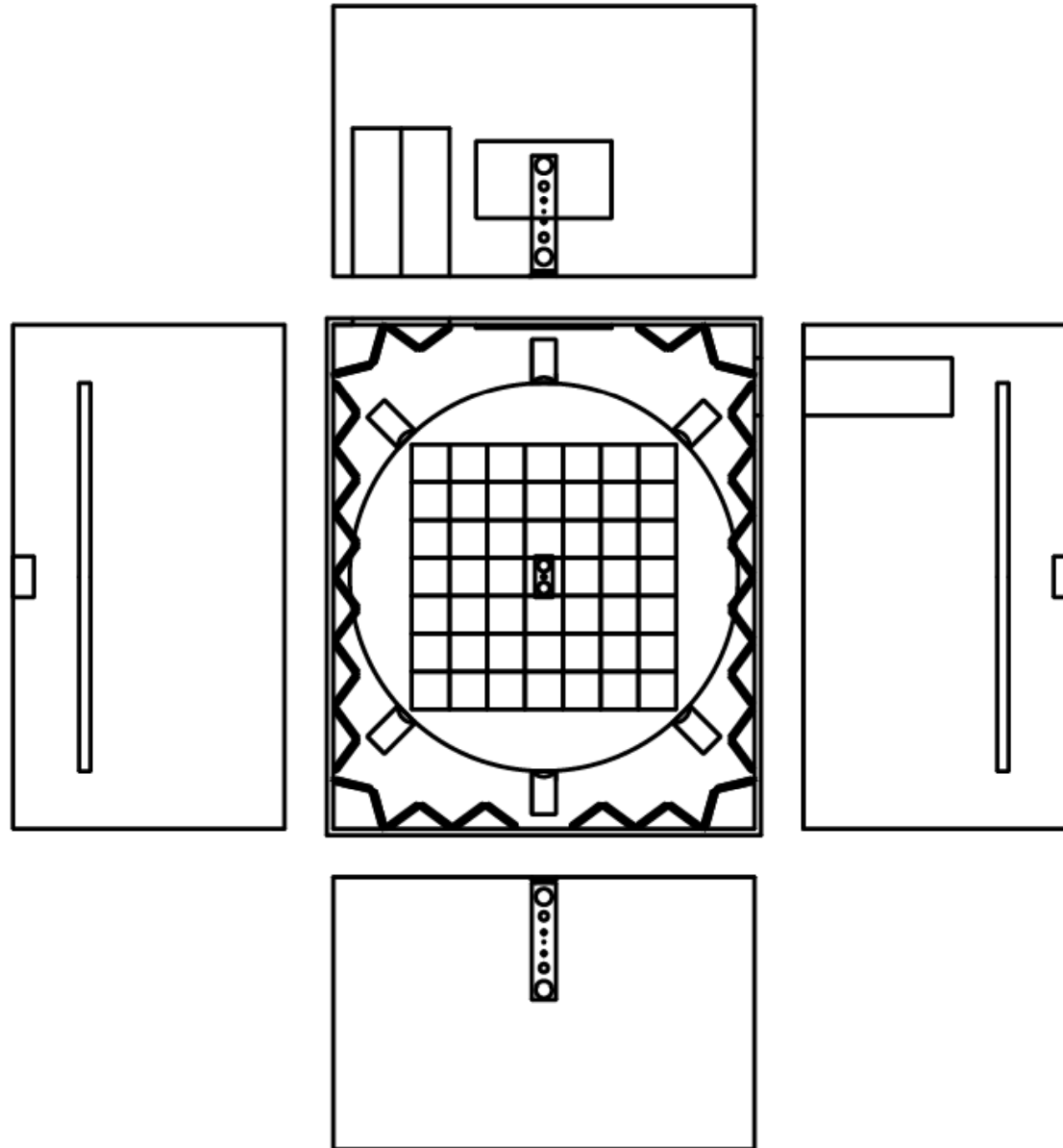


- Skywalker Sound Scoring Stage in 1989





# Widescreen Review







# Widescreen Review



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



# Blackbird Studios

- The original single-room studio on site, Creative Recording, was the home of many Gold and Platinum records including artists such as Kenny Rogers, Shelby Lynn and, most notably The Judds.
- The studio was purchased by John McBride in 2002 and was christened Blackbird Studio. An extensive renovation was initiated that will eventually encompass 3 tracking rooms, 6 controls and 4 edit suites.
- Their client list is a who's who not only in country music, but also rock, jazz, acoustical and classical. Think Sheryl Crow, R. Kelly, Kid Rock, Michael Buble, and Hiromi Uehari.
- John McBride approached George Massenburg with a mission to craft the most advanced monitoring space he could imagine. George, in turn, approached RPG to collaborate on the design of a completely unique concept in critical listening environments, namely a...

**Massively Diffuse, Ambient Space**



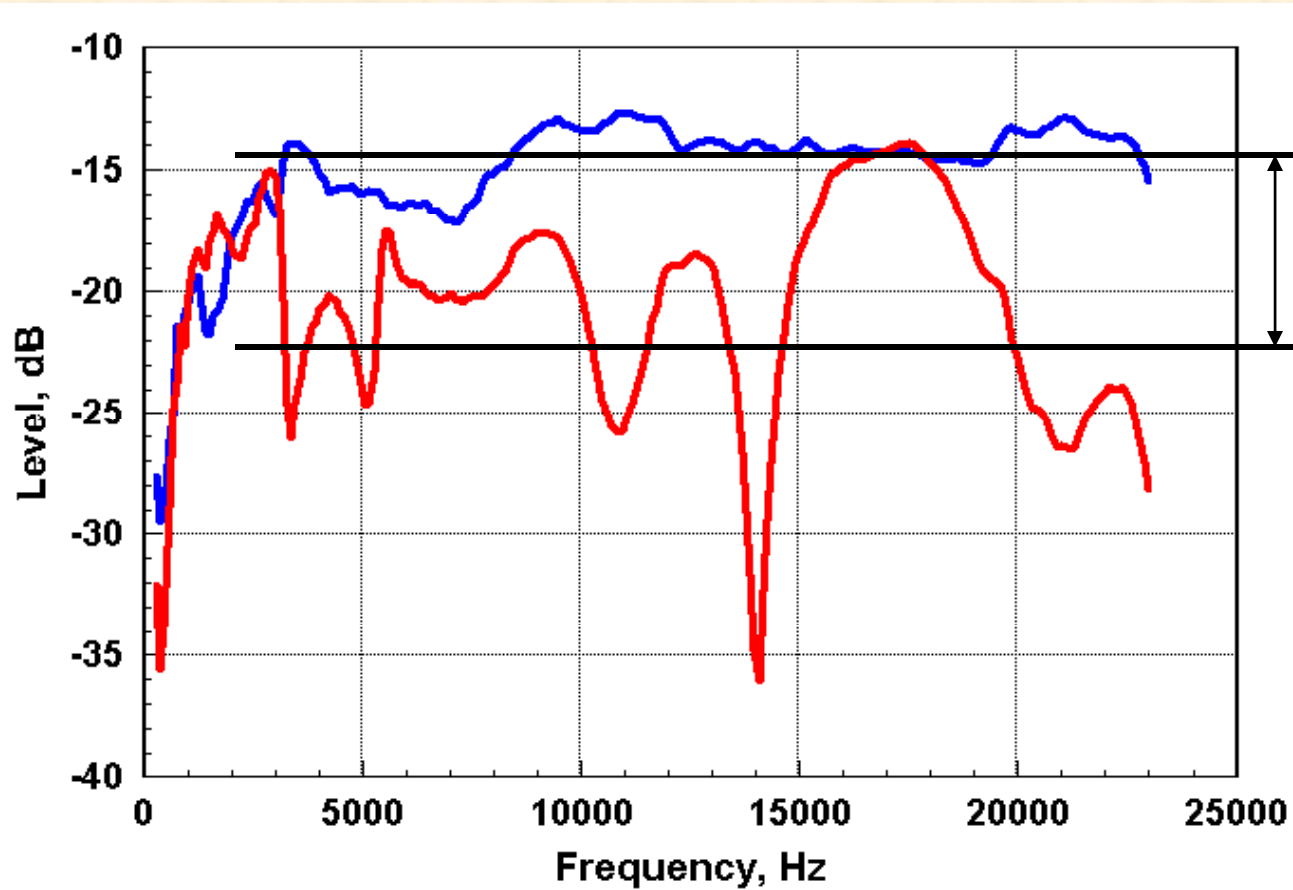


# Proof of Concept

- 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



Legend  
— QRD1A — QRR1A

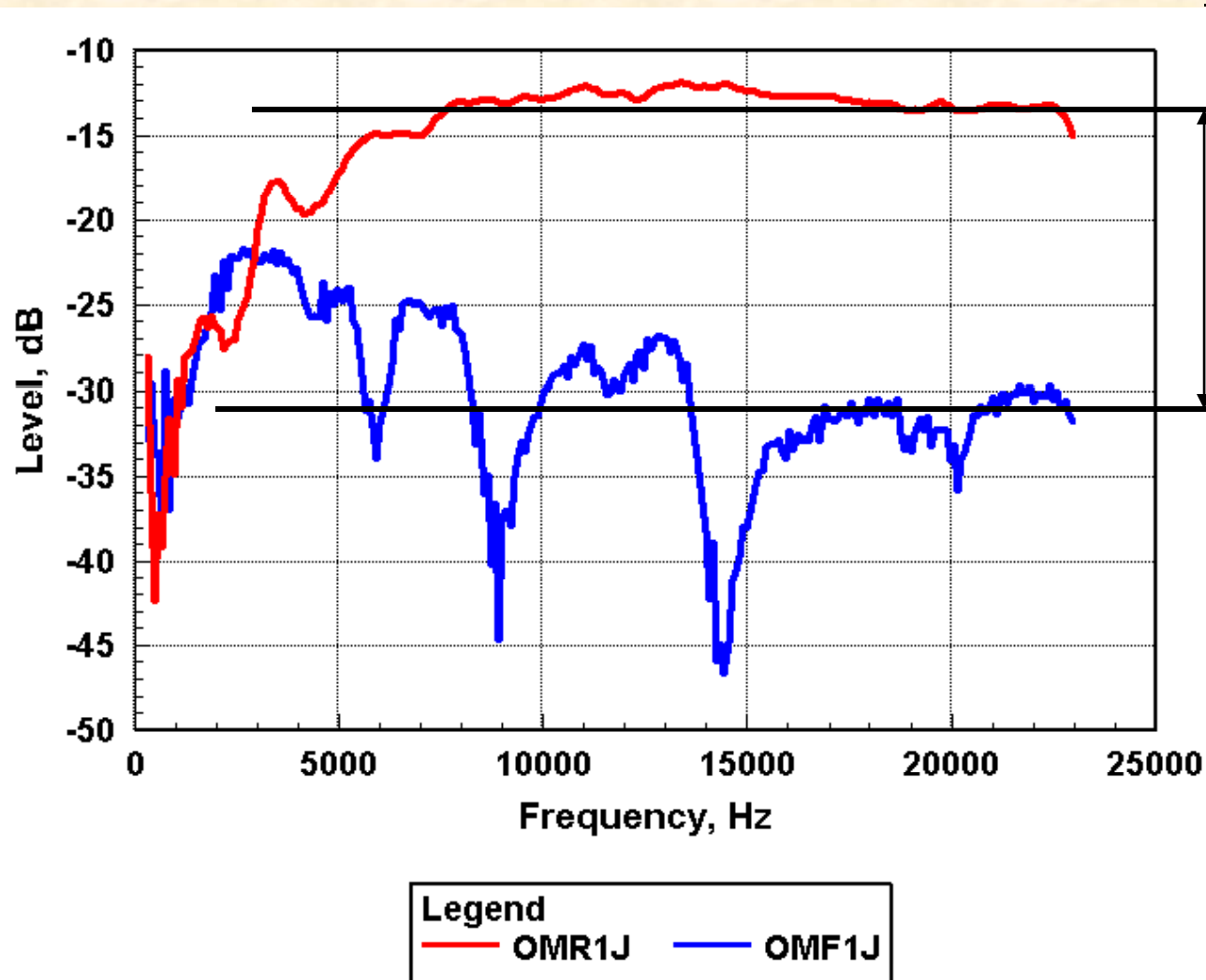
Attenuation:

$$10\text{Log}(1/7) \\ = -8.5 \text{ dB}$$



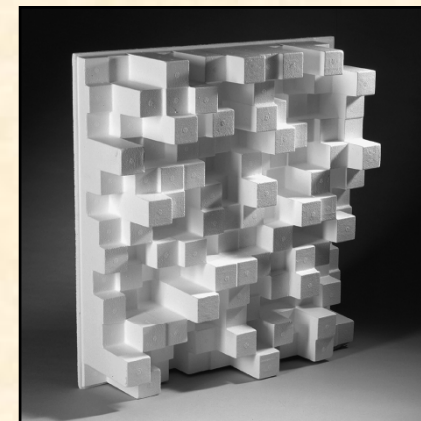


# Attenuation from a 2D QRD



Attenuation:

$$10 \cdot \log(1/49) \\ = -17 \text{ dB}$$



Attenuation Blackbird:

$$10 \cdot \log(1/(181 \times 769)) \\ = -51 \text{ dB}$$

Based on amplitude modulated prime 181 and 769 1D primitive root sequences, using modulus 953.



# Blackbird Design Elements



studio c

## Walls:

3' deep amplitude modulated prime 181 and 769 1D primitive root sequences, using modulus 953.

138,646 block heights!

## Ceiling:

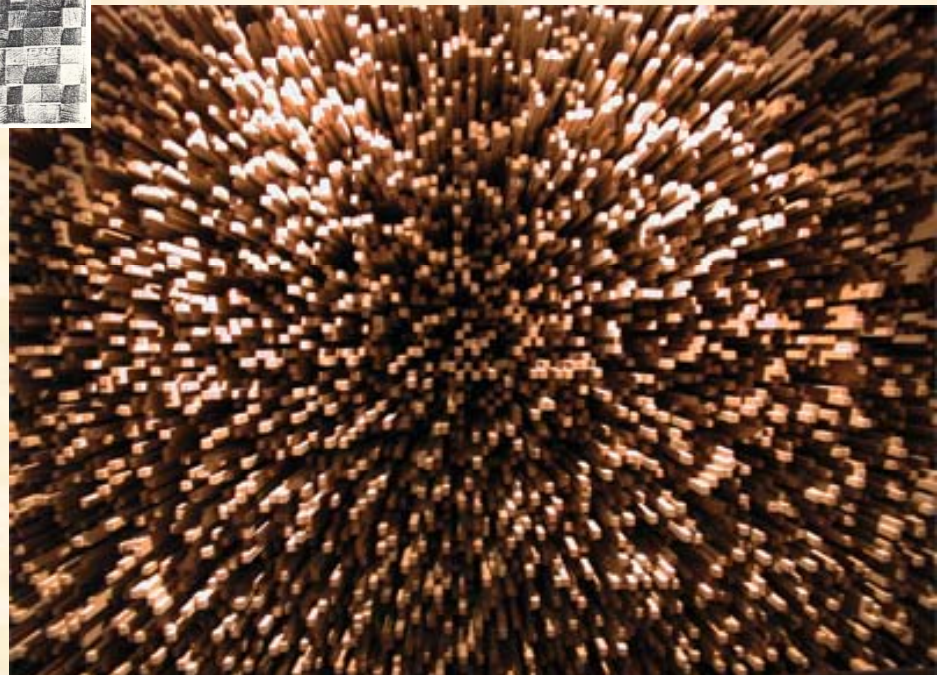
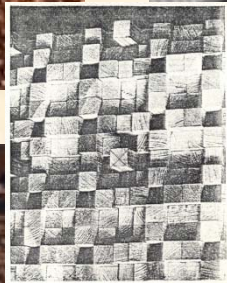
7' deep 12 x 13 primitive root Diffractal, based on  $N=157$ .

24,336 block heights!

## Corners:

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

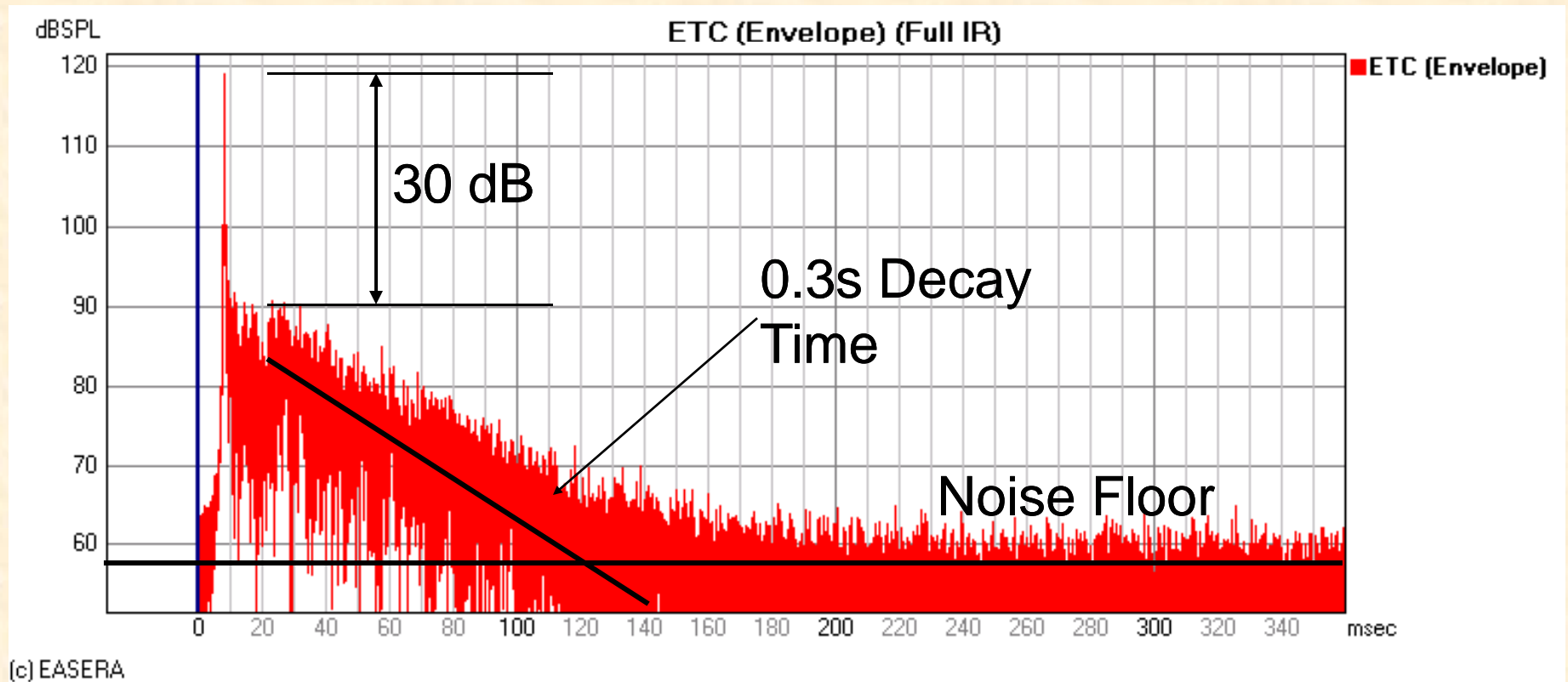








# ETC At Mix Position



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



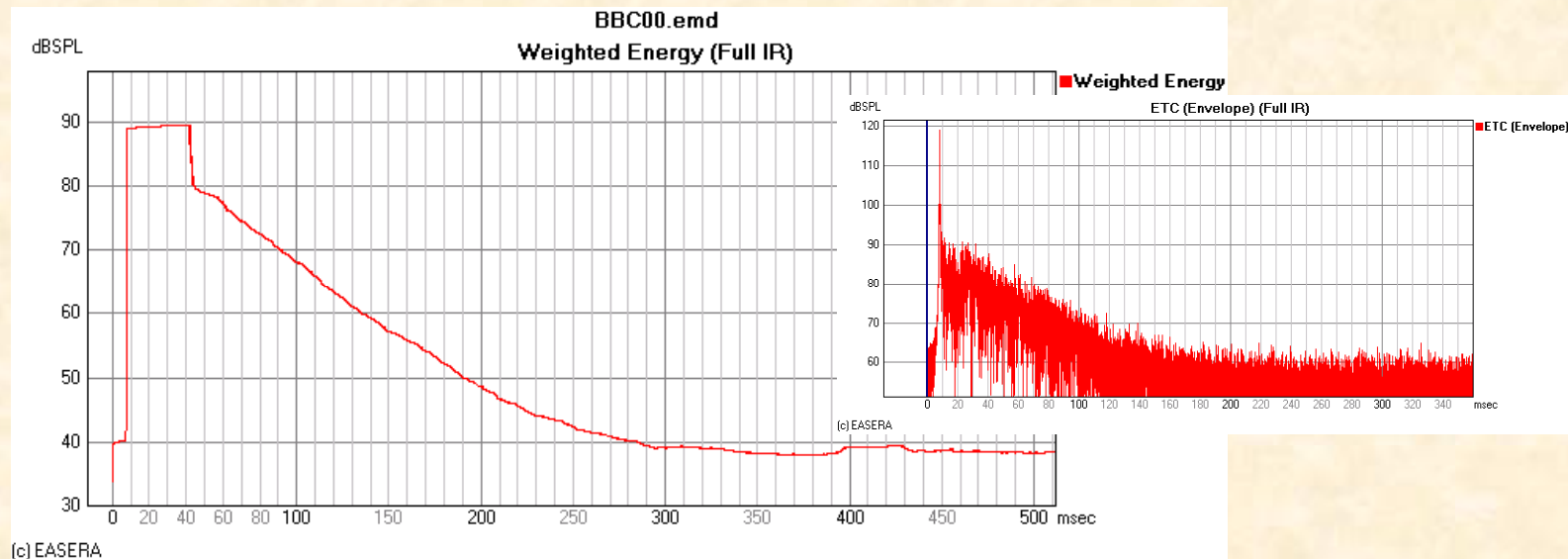
# Early Subjective Impressions

- 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 <math><85-95\text{dB SPLA}</math>, lower than typical <math>100-110\text{dB SPLA}</math> 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.



# Early Subjective Impressions

- Why doesn't the room sound anechoic with room reflections 30 dB below the direct sound?
- Possible reasons:
  - The 35 ms integration time of the ear may raise the level and importance of the diffuse sound field



- The diffuse sound field is very dense and occurs without any time delay, as in a reverberant space which requires time to develop a reverberant sound field
- It's like adding reverberation with a level 30 dB below the anechoic direct sound, an interesting perception experiment to perform.

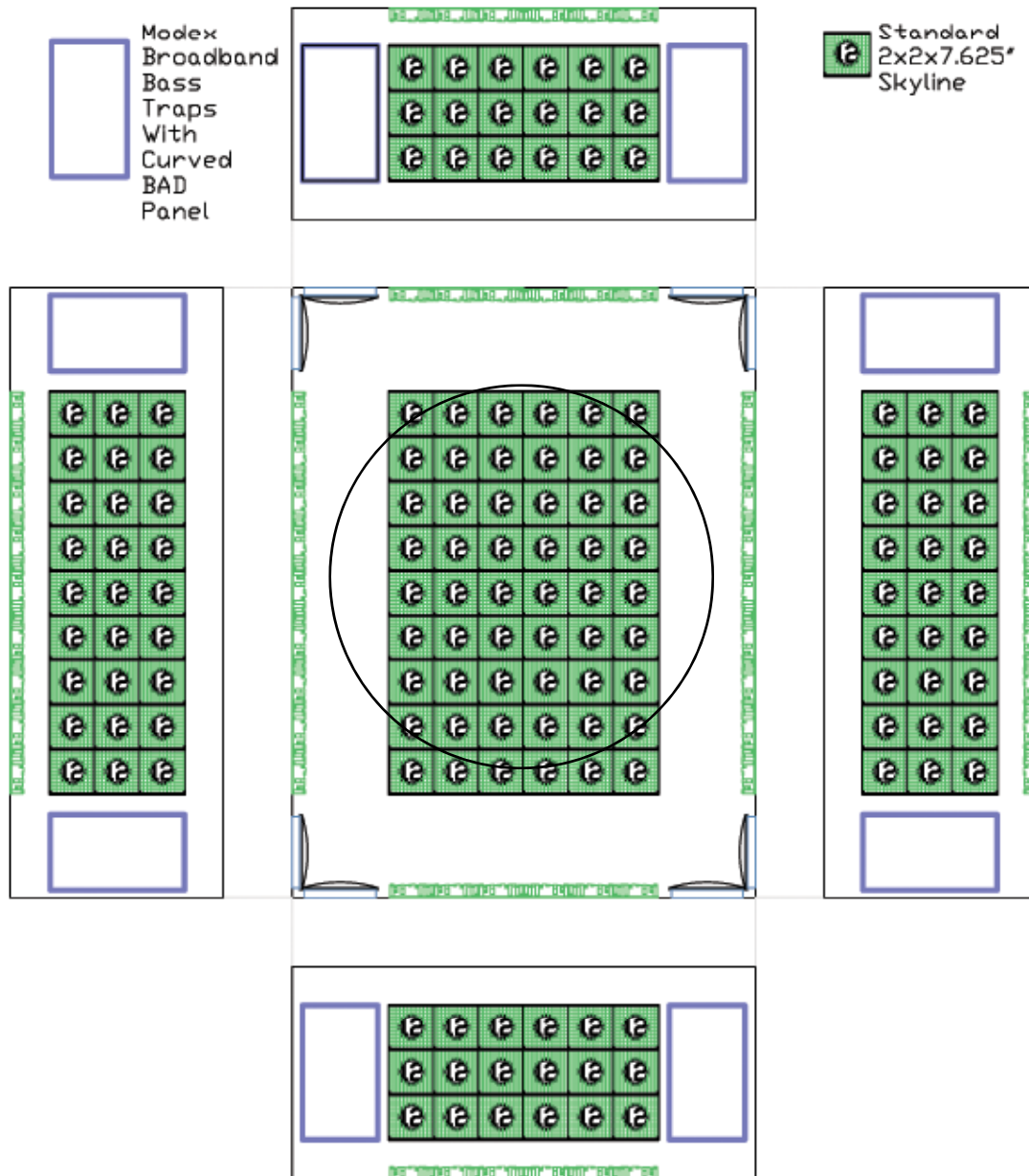
# Next Room?







# Immersive Surround Environment

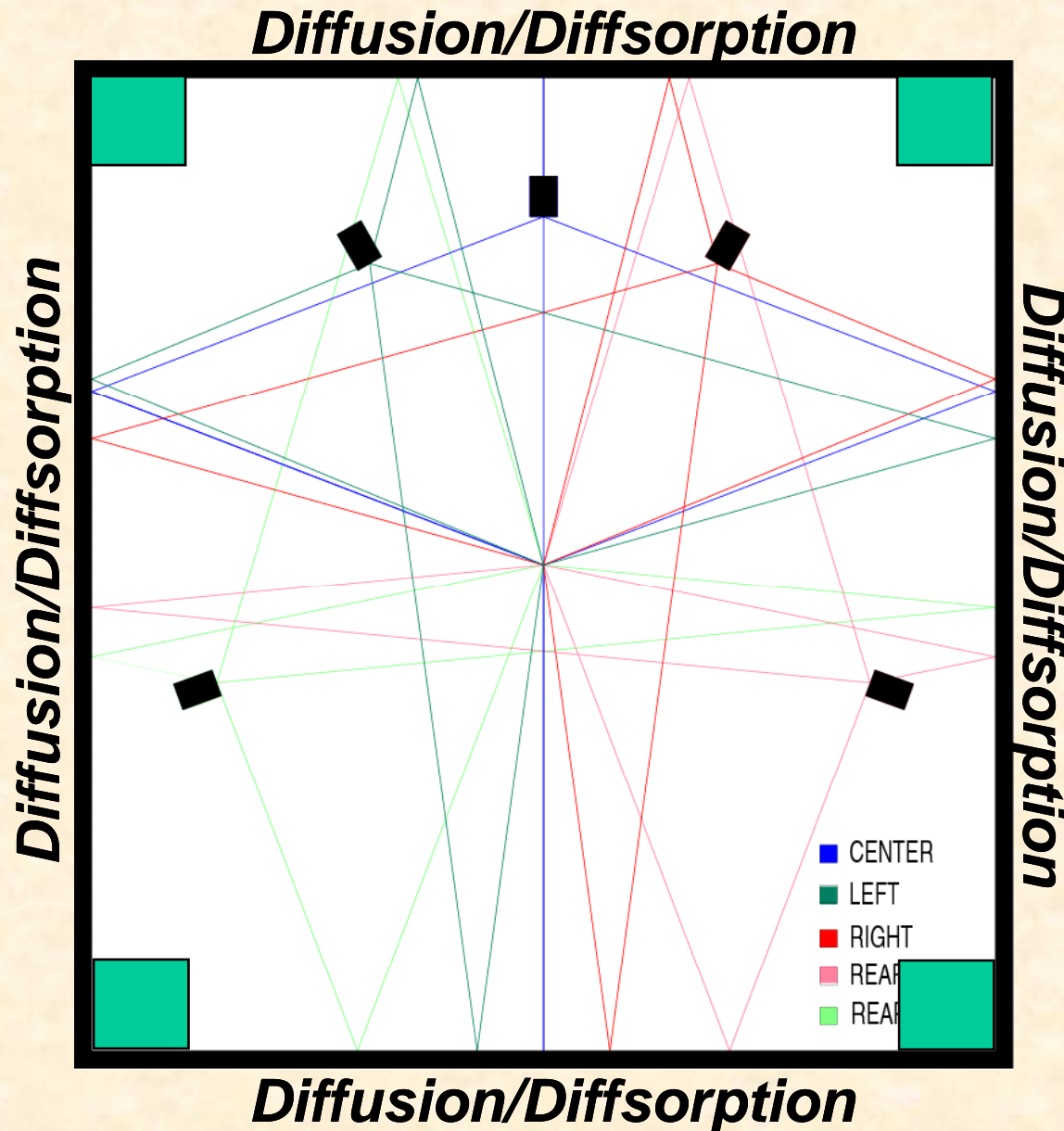


## *iRoom*™

- 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 difforsorption



# Immersive Environment



## Corner Treatment

-Plate Resonators

## Boundary Treatment

-Broadband  
Diffractals

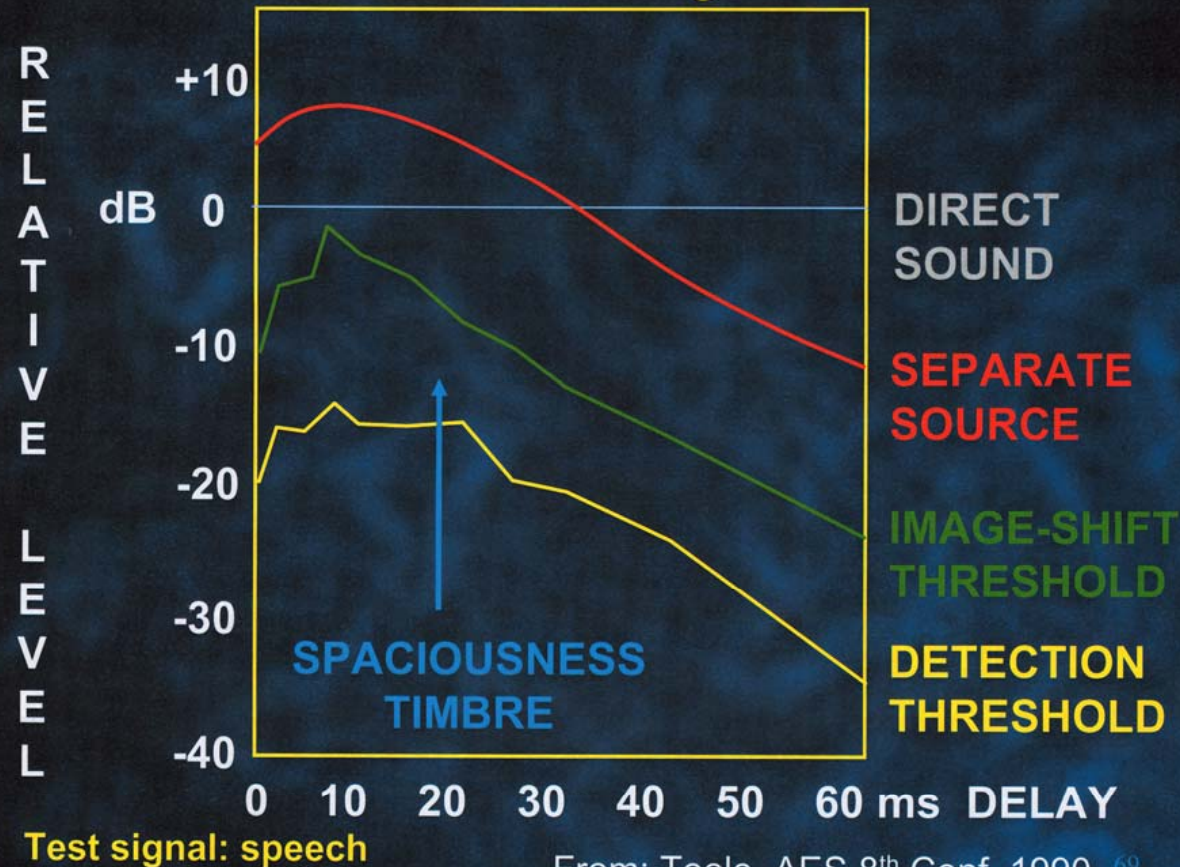
-Broadband Binary  
Amplitude Diffusors

-Broadband  
Alternating  
Reflection/Absorption



# Future Research

Factors relevant to understanding small-room acoustics:



We are beginning both objective and subjective measurements on the space (including comparison of auditory imagery in the Blackbird studio with that in a variable acoustic environment that is under construction for Dr. William Martens at McGill University).





***This is only the beginning.....***

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***Thank You***