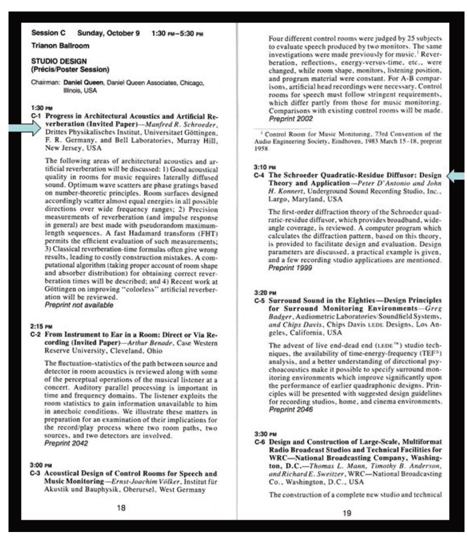
Dr. Peter D’Antonio celebrates his 40th year in the Recording Industry

The history of every career or company is a captivating narrative. My formal education was in chemistry and diffraction physics, not acoustics, however this prior background proved immensely valuable in the pursuit of my passion for music performance and recording.

1.0 Prequel

My recording studio career began in 1983, but its roots can be traced back to 1972 when I completed a personal recording space for my musical compositions. Over time, this space evolved into Underground Sound Recording Studio, Figure 1, with separate control, isolation, and live rooms. As I ventured into designing the control room, I scoured the scientific literature, but found no prior research. However, I stumbled upon an article by Don and Carolyn Davis of Syn-Aud-Con that introduced me to the Live End Dead End (LEDE) approach to control room design. Inspired by this concept, I aimed to create a design that combined the characteristics of both acoustical boundary conditions, namely an anechoic chamber and a reverberant space, within a small room to replicate the experience of a larger performance venue. To minimize interfering early reflections, I created a temporal and spatial reflection free zone, RFZ, by splaying and absorbing the surfaces between the speakers and mix position, to create the Dead End. The challenge then lay in introducing a diffuse reverberant Live End. Fortunately, my search led me to an article by Manfred Schroeder in Physics Today's October 1980 issue. It described reflection phase grating (RPG) diffusors that were capable of uniformly scattering sound in concert halls. Delving deeper, I surprisingly discovered that these diffusors remarkably were 2-dimensional periodic versions of the 3-dimensional periodic crystal lattices I had been studying as a diffraction physicist at the Naval Research Lab, using x-ray crystallography. My familiarity and interest in these designable and quantifiable uniformly scattering diffusers led me to further research. Since these surfaces were a new addition to the acoustical palette, I decided to make a presentation on what was then called a Schroeder diffusor, at the 74th AES Studio Design Session C in October of 1983 in New York. To my surprise, Manfred Schroeder presented the leadoff invited presentation (C-1 Arrow). The original Session C Program is shown in Figure 2, where there is an arrow for C-1 for Manfred Schroeder, and another arrow at C-4 for Peter D’Antonio. Following the presentation, I met several people in the audio community including Syn-Aud-Con founders Don and Carolyn Davis and Bob Todrank, owner of Valley Audio. Don and Carolyn Davis invited me to the first LEDE Studio Design Workshop, where the first TEF measurements were made using TDS, which was developed by Richard Heyser, and incorporated into a TEF analyzer by Crown. This *first* measurement can be seen in Figure 3.

Figure 1. Underground Sound Studio, Largo, MD.



Session C **Sunday, October 9** **1:30 PM–5:30 PM**
Trianon Ballroom

STUDIO DESIGN
(Précis/Poster Session)

Chairman: **Daniel Queen**, Daniel Queen Associates, Chicago, Illinois, USA

1:30 PM
C-1 **Progress in Architectural Acoustics and Artificial Reverberation (Invited Paper)**—*Manfred R. Schroeder*, Drittes Physikalisches Institut, Universitaet Göttingen, F. R. Germany, and Bell Laboratories, Murray Hill, New Jersey, USA

The following areas of architectural acoustics and artificial reverberation will be discussed: 1) Good acoustical quality in rooms for music requires laterally diffused sound. Optimum wave scatters are phase gratings based on number-theoretic principles. Room surfaces designed accordingly scatter almost equal energies in all possible directions over wide frequency ranges; 2) Precision measurements of reverberation (and impulse response in general) are best made with pseudorandom maximum-length sequences. A fast Hadamard transform (FHT) permits the efficient evaluation of such measurements; 3) Classical reverberation-time formulas often give wrong results, leading to costly construction mistakes. A computational algorithm (taking proper account of room shape and absorber distribution) for obtaining correct reverberation times will be described; and 4) Recent work at Göttingen on improving "colorless" artificial reverberation will be reviewed.
Preprint not available

2:15 PM
C-2 **From Instrument to Ear in a Room: Direct or Via Recording (Invited Paper)**—*Arthur Benade*, Case Western Reserve University, Cleveland, Ohio

The fluctuation-statistics of the path between source and detector in room acoustics is reviewed along with some of the perceptual operations of the musical listener at a concert. Auditory parallel processing is important in time and frequency domains. The listener exploits the room statistics to gain information unavailable to him in anechoic conditions. We illustrate these matters in preparation for an examination of their implications for the record/play process where two room paths, two sources, and two detectors are involved.
Preprint 2042

3:00 PM
C-3 **Acoustical Design of Control Rooms for Speech and Music Monitoring**—*Ernst-Joachim Völker*, Institut für Akustik und Bauphysik, Oberursel, West Germany

18

Four different control rooms were judged by 25 subjects to evaluate speech produced by two monitors. The same investigations were made previously for music.[1] Reverberation, reflections, energy-versus-time, etc., were changed, while room shape, monitors, listening position, and program material were constant. For A-B comparisons, artificial head recordings were necessary. Control rooms for speech must follow stringent requirements, which differ partly from those for music monitoring. Comparisons with existing control rooms will be made.
Preprint 2002

[1] Control Room for Music Monitoring, 73rd Convention of the Audio Engineering Society, Eindhoven, 1983 March 15–18, preprint 1958.

3:10 PM
C-4 **The Schroeder Quadratic-Residue Diffusor: Design Theory and Application**—*Peter D'Antonio and John H. Konnert*, Underground Sound Recording Studio, Inc., Largo, Maryland, USA

The first-order diffraction theory of the Schroeder quadratic-residue diffusor, which provides broadband, wide-angle coverage, is reviewed. A computer program which calculates the diffraction pattern, based on this theory, is provided to facilitate design and evaluation. Design parameters are discussed, a practical example is given, and a few recording studio applications are mentioned.
Preprint 1999

3:20 PM
C-5 **Surround Sound in the Eighties—Design Principles for Surround Monitoring Environments**—*Greg Badger*, Audiometric Laboratories/Soundfield Systems, *and Chips Davis*, Chips Davis LEDE Designs, Los Angeles, California, USA

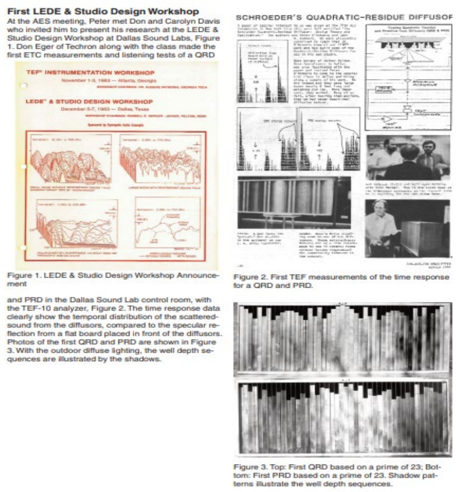
The advent of live end-dead end (LEDE™) studio techniques, the availability of time-energy-frequency (TEF®) analysis, and a better understanding of directional psychoacoustics make it possible to specify surround monitoring environments which improve significantly upon the performance of earlier quadraphonic designs. Principles will be presented with suggested design guidelines for recording studios, home, and cinema environments.
Preprint 2046

3:30 PM
C-6 **Design and Construction of Large-Scale, Multiformat Radio Broadcast Studios and Technical Facilities for WRC—National Broadcasting Company, Washington, D.C.**—*Thomas L. Mann, Timothy B. Anderson, and Richard E. Sweitzer*, WRC—National Broadcasting Co., Washington, D.C., USA

The construction of a complete new studio and technical

19

Figure 2. First AES Presentation.


First LEDE & Studio Design Workshop
At the AES meeting, Peter met Don and Carolyn Davis who invited him to present his research at the LEDE & Studio Design Workshop at Dallas Sound Labs, Figure 1. Don Eger of Techron along with the class made the first ETC measurements and listening tests of a QRD

TEF® INSTRUMENTATION WORKSHOP
November 1-3, 1983 — Atlanta, Georgia

LEDE™ & STUDIO DESIGN WORKSHOP
December 5-7, 1983 — Dallas, Texas

Figure 1. LEDE & Studio Design Workshop Announcement

and PRD in the Dallas Sound Lab control room, with the TEF-10 analyzer, Figure 2. The time response data clearly show the temporal distribution of the scattered-sound from the diffusors, compared to the specular reflection from a flat board placed in front of the diffusors. Photos of the first QRD and PRD are shown in Figure 3. With the outdoor diffuse lighting, the well depth sequences are illustrated by the shadows.

SCHROEDER'S QUADRATIC-RESIDUE DIFFUSOF

Figure 2. First TEF measurements of the time response for a QRD and PRD.

Figure 3. Top: First QRD based on a prime of 23; Bottom: First PRD based on a prime of 23. Shadow patterns illustrate the well depth sequences.

Figure 3. First measurement of an RPG.

Bob Todrank and I discussed the application of these new diffusers in a studio he was designing, and our collaboration led to the first RPG installation on the rear wall of the Oak Ridge Boys' Acorn Sound Recorders, in Henderson, TN. Figure 4 shows the published announcement in August 1984. Following the installation, a Syn-Aud-Con Workshop was held at Acorn Sound Recorders in the summer of 1984, with many of the present and future recording studio designers. In Figure 5, we see a photo from that workshop with the class, the first RPG in the background and the Oak Ridge Boys, with engineer Jimmy Tarbutton.


'Come On In'

Valley Audio invites you inside ACORN SOUND RECORDERS' new control room.

When the Oak Ridge Boys wanted a new control room for their Acorn Sound Recorders in Hendersonville, Tn., they entrusted their chief engineer, Jimmy Tarbutton, with the responsibility of contracting the best services available for the job. He chose Bob Todrank and Valley Audio.

"I wanted the latest in control room technology with a large functional space. Since we were building from the ground up, it had to be right. I chose Bob to completely design the room and oversee the construction. I wanted Valley Audio's technical services to do our equipment interface because of their more than ten years' experience in audio installations, and selected the new Harrison MR-4 32-24 console based on its flexibility and innovative design. We then selected a long term associate, Jim Aanderud of Viking Enterprises as our contractor."

Todrank says, "Since Jimmy wanted a large, open room with a very "live" feel, I designed a control room incorporating the latest *LEDE (Live End/Dead End) concepts. I chose a rear wall diffuser system designed by Peter D'Antonio of RPG Diffusor Systems, Inc., to accomplish a widely dispersed sound field around the console. We built and installed the very first of its kind anywhere and I was thrilled with the results. I also used our TECRON TEF equipment to place the final room interior treatments. The proper implementation of the LEDE design theory along with the use of on-axis monitoring, correct room geometry and accoustical equalization (selective diffusion/reflection/absorption techniques) has resulted in a room I'm very proud of."

The Oaks are proud of it too. Duane Allen's reaction...."*It's like a dream come true.*"

VALLEY AUDIO
2821 Erica Place • P.O. Box 40743 Nashville, TN • 37204-3111 • 615-383-4732
Circle #048 on Reader Service Card

AUGUST 1984

75

Figure 4. Acorn Sound Recorders' announcement.

My involvement with Syn-Aud-Con led to my meeting many of the present and future recording studio designers, who enthusiastically incorporated the RFZ/RPG control room design in recording studios around the world and each played a key role in embracing and employing my research. I especially like this photo from the workshop, because so many attendees have become important names in studio design: Russ Berger, Steve Blake, Chips Davis, Neil Grant, Doug Jones, Steve Langstaff, Neil Muncy, Lennert Nilsson, Bob Richards, Bob Skye, Bob Todrank and Charles Bilelllo.

Figure 5. Syn-Aud-Con workshop at Acorn Sound Recorders.

1.1 The First RFZ/RPG Control Room Design

In 1984 I published a peer reviewed paper of my research in JASA (P D'Antonio, J Konnert (1984) "The reflection phase grating diffusor: design theory and application," J. Audio Eng. Soc., Vol. 32 (4), 228-238) and presented the RFZ/RPG design concept at the 76th AES Convention, with the original illustration shown in Figure 6 (left) and eventually a more explanatory illustration evolved in Figure 6 (right).

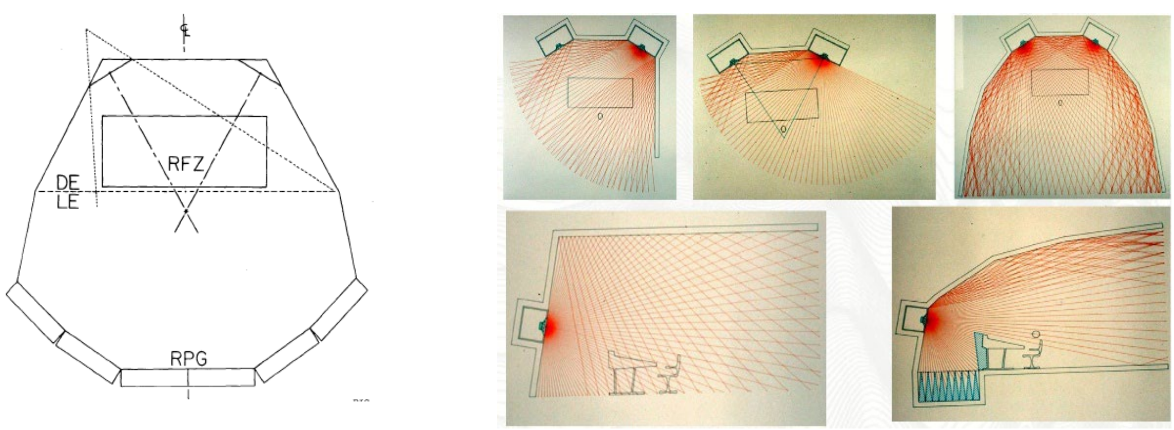


Figure 6. Left: Original RFZ/RPG drawing; Right: Plan and section ray drawing of the RFZ

2.0 RPG Diffusor Systems, Inc.: Pioneering the sound diffusion industry

The level of excitement and interest in these diffusers essentially led me to form RPG Diffusor Systems, Inc. in December 1983 to meet the demand and set up manufacturing in my carport and backyard, Figure 7, which was problematic when it rained. Like my entry into the field of acoustics, starting a manufacturing company was completely foreign to me.

Figure 7. The first RPG factory!

2.1 The First Goniometer

While we had the capability to simulate the performance of the RPGs, I needed to develop an experimental method to measure and document their performance, so they could be specified by acousticians and added to the acoustical palette. I began a systematic program of experimental measurements, using the TEF analyzer. Full scale experiments began in large sports facilities, then my son's high school gymnasium and when we outlived our welcome in these spaces, we developed a new scale-model measurement system called a Goniometer, which was another example of how my experience in crystallography led to a development in acoustics, Figure 8. This research eventually led to the current ISO 17497-2 diffusion coefficient measurement standard published in 2012. The data reduction used to extract the diffusion coefficient from the measured polar responses is shown in Figure 9.

To introduce these new diffusing surfaces, we created an illustration depicting the temporal and spatial response differentiating a reflector, absorber, and a diffuser, seen in Figure 10.

Figure 8. Left: Full scale measurements in a sports arena; Right: First scale model goniometer

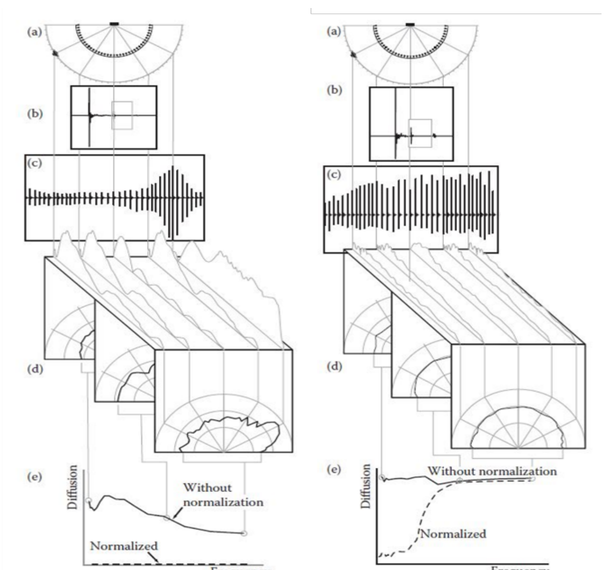


Figure 9. Left: Calculation of the diffusion coefficient of a flat panel; Right: diffuser under test, with and without normalization.

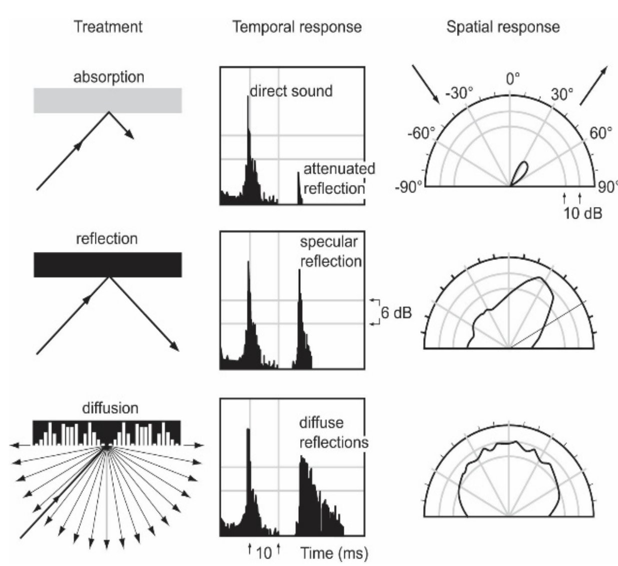


Figure 10. Temporal and spatial responses for an absorber, reflector, and diffuser.

2.2 Early Milestone Projects

The *first* publication announcing RPG Diffusor Systems was in Mix Magazine 1984, Figure 11.

Following the positive reaction to Acorn Recorders, I began collaborating with workshop attendees like Russ Berger, Charles Bilello, Chips Davis, and Neil Grant, implementing the new RFZ/RPG control room design, which was published in October 1984 in an AES Preprint for the 76th Convention in New York. In 1985, Russ Berger incorporated RPG diffusers into his design of Tele-Image studios in Dallas TX, Figure 12, and many others. Charles Bilello incorporated RPG diffusers in Master Sound Astoria studios in NY, Figure 13.

Figure 11. First announcement of the RPG Diffusor to the recording industry.

Figure 12. Tele-Image, Dallas, Texas, Russ Berger.

Figure 13. Master Sound Astoria, New York, Charles Bilello.

My collaboration and friendship with Neil Grant was growing rapidly and continues to this day, with several studios like Red Bus, Chipping Norton, and Swan Yard, in England, Hitokuchizaka, in Tokyo, and a milestone project for Peter Gabriel's Real World Studios, Box, UK, Figure 14, which began in 1986 and ended in 1989. Also noteworthy was The Hit Factory in NY, Figure 15, and Starstruck, Nashville, TN, Figure 16.

Figure 14. Real World Studios, Box, UK, Neil Grant.

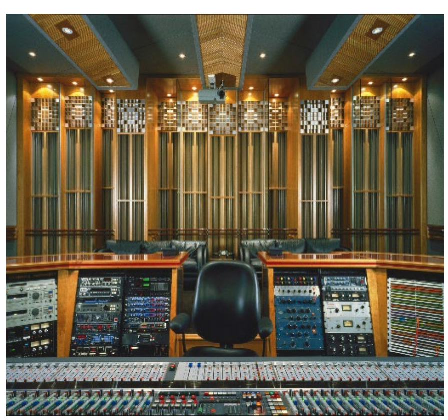


Figure 15. Hit Factory, New York, Neil Grant.

Figure 16: Starstruck, Nashville, TN, Neil Grant

In the 1980s, I also began a successful collaboration with Martin Pilchner, Pilchner Schoustal Designs, Figure 17, Fran Manzella, FM Design, Figure 18, and Chris Pelonis, Pelonis Sound and Acoustics, Figure 19, where several products were incorporated into the live room.

Figure 17. Winfield Sound, Toronto, ON Canada, Martin Pilchner.

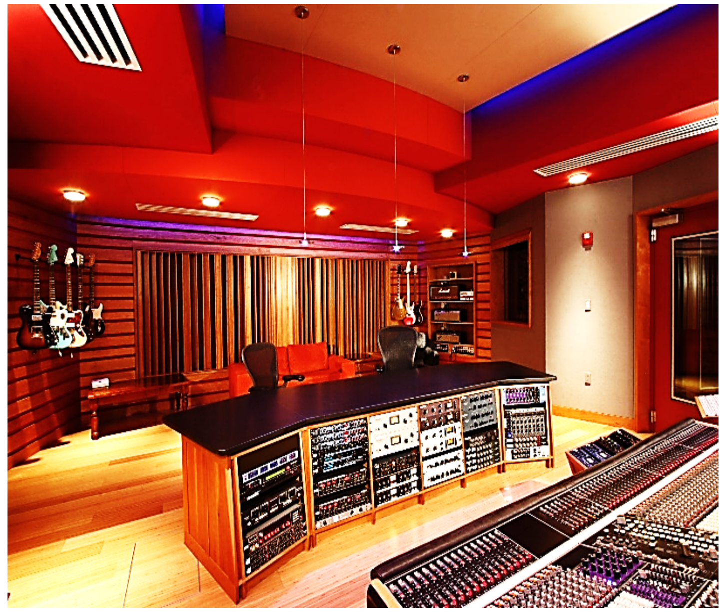


Figure 18. Guilford Sound, Guilford, VT, Fran Manzella.

Figure 19. Sony PlayStation, The Reserve, Playa del Rey, CA, Chris Pelonis.

At this point, the RFZ/RPG control room design was becoming a de facto standard. I met John and Beth Storyk in 1988 and began a friendship lasting to this day with innumerable studio*s* around the world, like Crawford Productions, Atlanta, GA, Figure 20, Jungle City, NY, Figure 21. and in 2023 Rue Boyer for Mix with the Masters, in Paris, France, Figure 22.

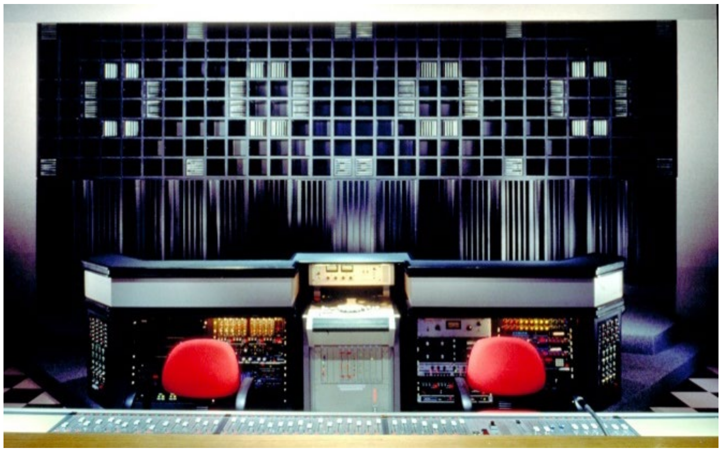


Figure 20. Crawford Productions, Atlanta, GA, John Storyk.

Figure 21. Jungle City, New York, John Storyk.

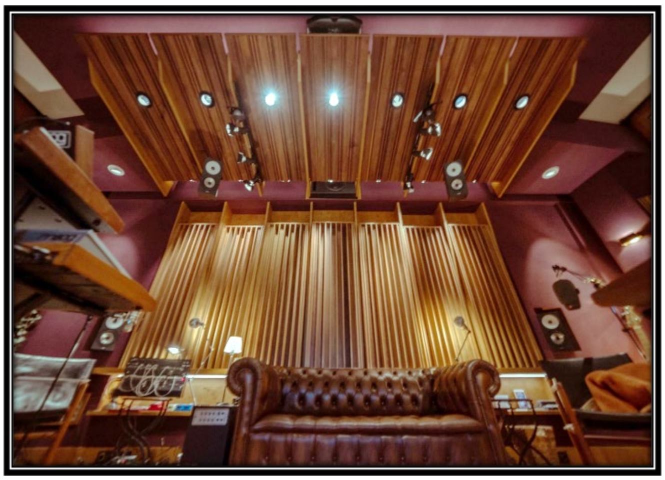


Figure 22. Rue Boyer, Paris, France, John Storyk.

Figure 23. Gateway Mastering, Portland, ME, Bob Ludwig.

In 1992, we collaborated with Bob Ludwig in optimizing the location of his free-standing Duntech speakers and the installation of a large 3rd generation Diffractal on the rear wall of his new Gateway Mastering studio, in Portland, ME, Figure 23. In 2006, George Massenburg contacted me to collaborate on the design of a new surround studio in Studio C, at Blackbird Studios, Nashville, TN, Figure 24. This collaboration yielded the first Ambient Anechoic (Ambechoic) massively diffusive environment, which continues to work well with today's immersive concepts. Our collaboration continued with many more current control room designers, like Wes Lachot's innovative design at Manifold Studios,

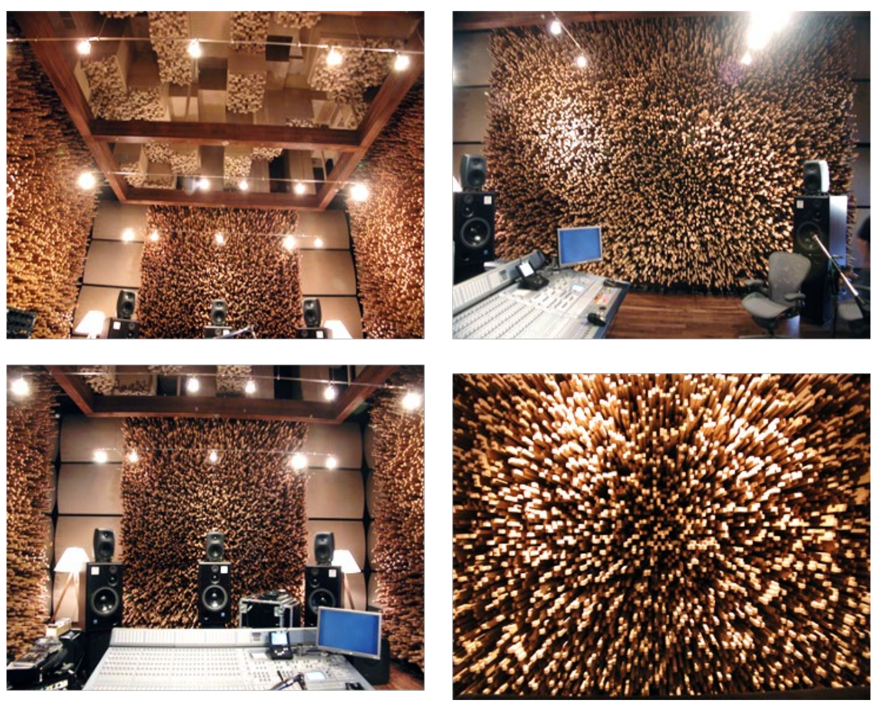


Figure 24. Studio C, at Blackbird Studios, Nashville, TN, George Massenburg.

Pittsboro, NC. If Figure 25 (Left) we see the control room using DiffusorBlox and in Figure 25 (Right) we see the Studio Annex control room, using an optimized Waveform concept.

Figure 25 (Left): Manifold Control Room; (Right): Manifold Studio Annex, Wes Lachot.

3.0 Evolution beyond reflection phase gratings

3.1 Evolving the venerable QRD

While the QRD was revolutionary when introduced by RPG Diffusor Systems in 1983, there were three limitations that RPG methodically eliminated to improve performance through fractal geometry, modulation, and shape optimization, shown in Figure 26.

These include:
- Extending the bandwidth with the introduction of the Diffractal;
- Eliminating the quantized well depth effect, which results in a specular reflection at the frequency where all wells scatter in phase, by optimization;
- Minimizing the effect of grating lobes, i.e., making the response uniform, through modulation.

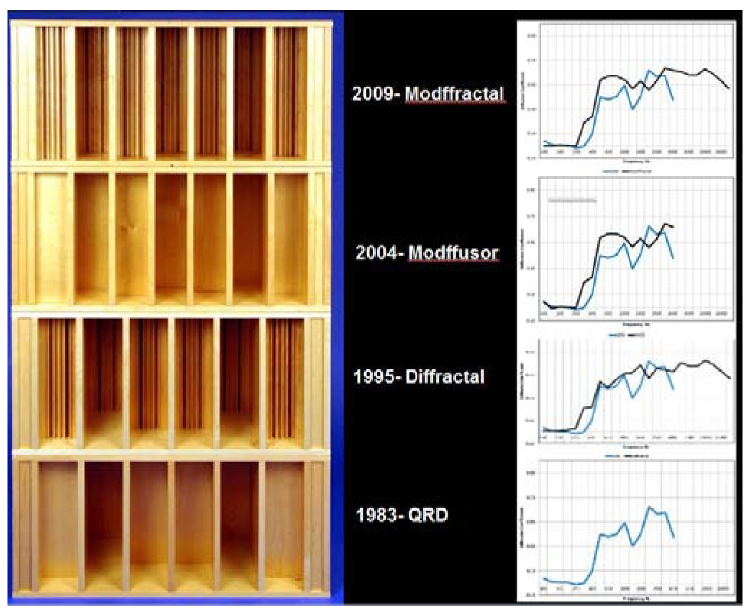


Figure 26. Evolving the QRD to improve bandwidth, flat plate frequency and periodicity issues.

In addition, many other diffusing devices were also introduced, significantly expanding the acoustical palette, Figure 27.

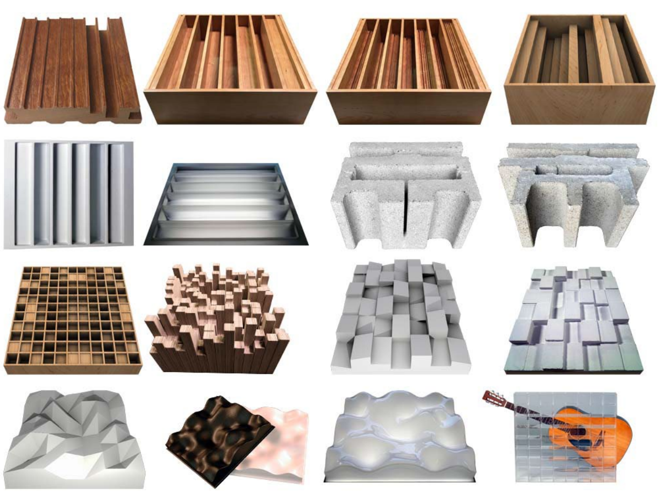


Figure 27. The evolving acoustical palette of diffusers.

3.2 The First Wave-based Shape Optimization Software

As the RPG Diffusor System began expanding from use in recording studios, to home theaters, worship spaces, performance venues, etc. there was a call from the architectural community to offer more shape profiles that provided similar diffusive performance. To solve this problem, we created a wave-based optimization software called the Shape Optimizer, to optimize surface treatment, stage and audience canopies and concave surfaces, Figure 28. The goal was to take a curvilinear shape desired by the design team and acoustically optimize it, while maintaining the original motif, to satisfy both the architect and the acoustician. This proved very successful and has led to countless projects in a wide variety of environments. In Figure 28 (Left), we show a collage of Glass Reinforced Gypsum (GRG) Waveform applications and in Figure 29 (Right), we show a collage of Waveform wooden applications.

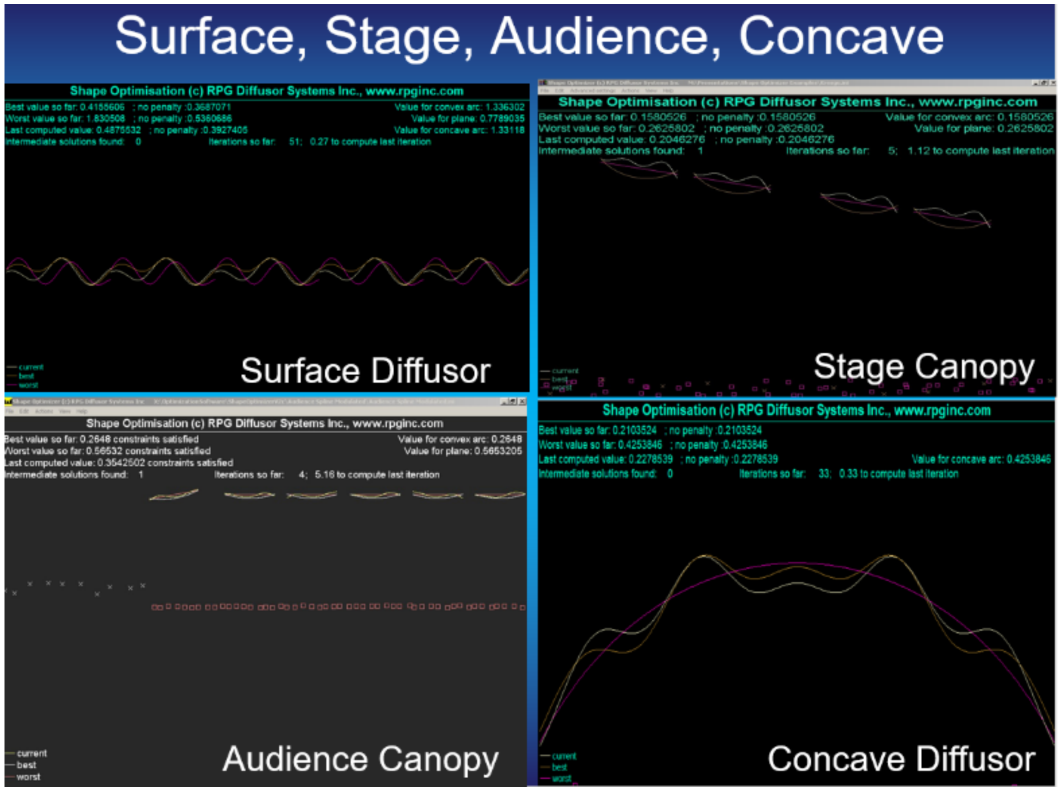


Figure 28. The Shape Optimization Software.

Figure 29. Left: we show a collage of Glass Reinforced Gypsum (GRG) Waveform applications; and Right: Waveform wooden applications.

4.0 Pioneering the Consumer Pro Audio Acoustic Tools Market

In the 1990s, there was a growing interest in what were called project studios. Professional control rooms at this point had good acoustical design and professional recording equipment. As higher end recording equipment and eventually digital workstations because available to smaller studios, they still lacked professional acoustics. To solve this problem, RPG developed a series of affordable *Studio in a Box™, Figure 30, and AcousticTool* packages, Figure 31, as well as the first iterative room optimization programs called the Room Sizer, Figure 32, which optimized the room's dimensional ratios to control room modes and the Room Optimizer, Figure 33, to optimize the location of speakers and listening positions for surround sound. This was the beginning of the Pro Audio professional acoustical products market.

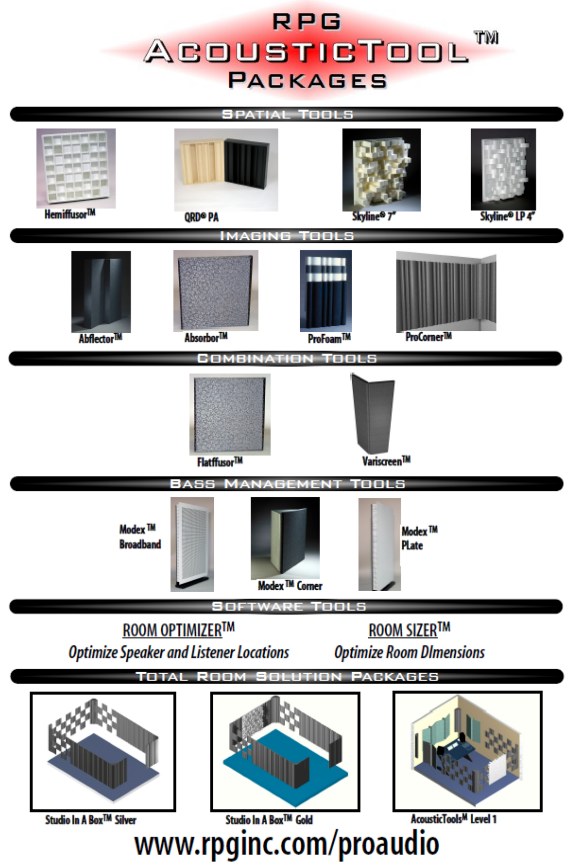


Figure 31. AcousticTools packages.

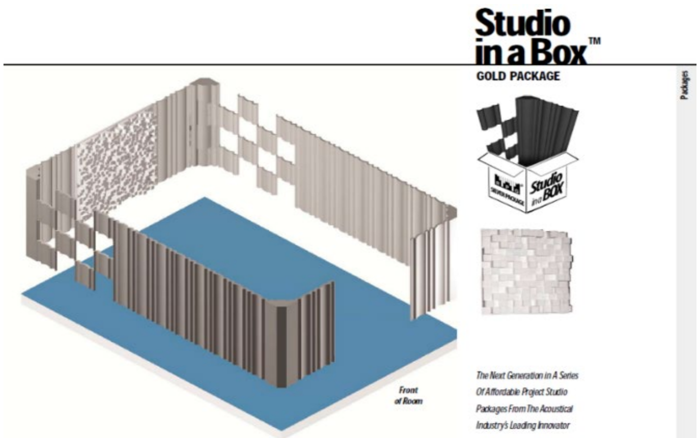


Figure 30. Studio in a Box

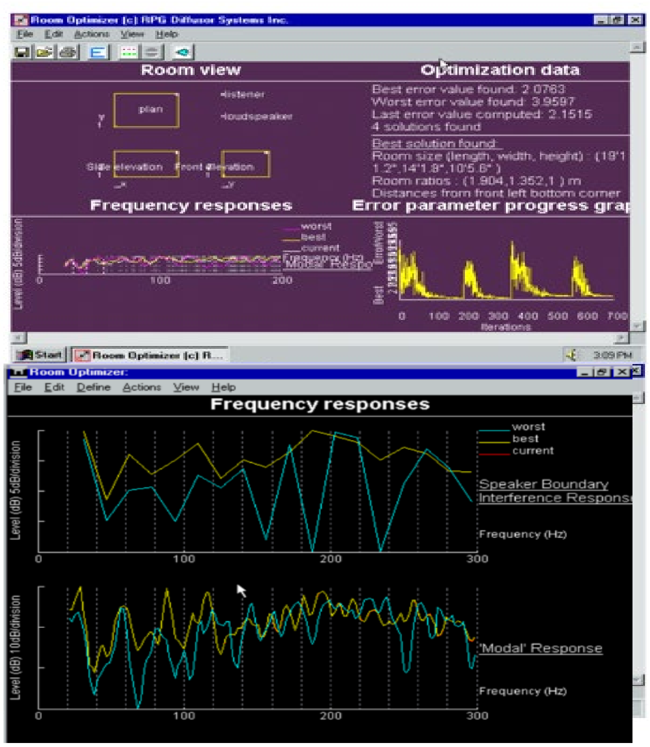


Figure 32. Room Sizer

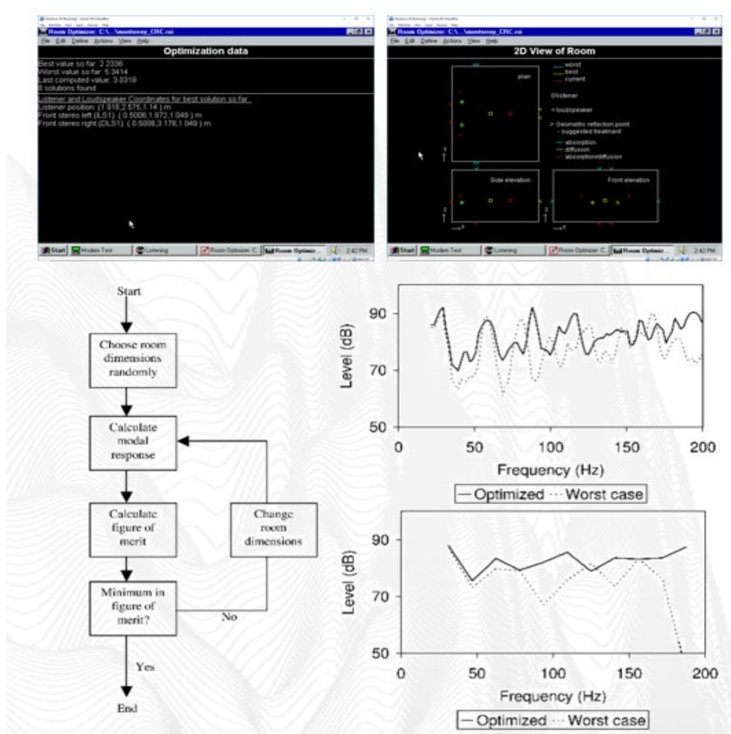
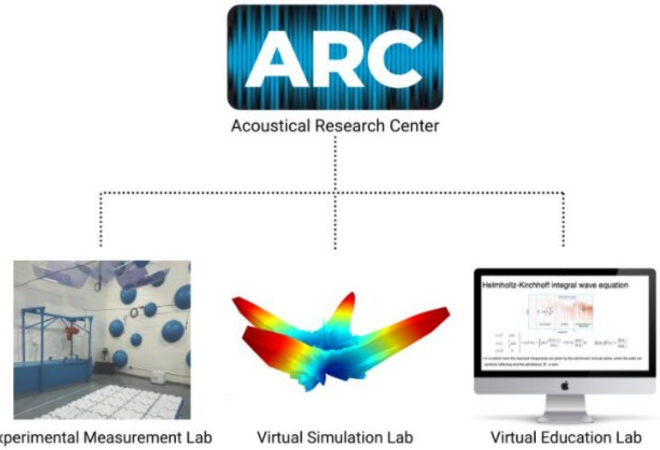


Figure 33. Room Optimizer

5.0 Sequel

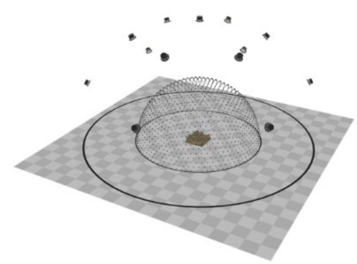
5.1 RPG Acoustical Systems. LLC



Following the sale of RPG Diffusor Systems, Inc. in 2017, a new entity called RPG Acoustical Systems, LLC was established (www.rpgacoustic.com), at which I continued on as Director of Research. To continue the commitment to fundamental acoustics research, we created a new Acoustical Research Center, ARC. (www.acousticalresearchcenter.com).

The **Experimental Measurements Lab** contains a 10,065 ft3 (285 m3) rev room, a 2'x2', 25' long, 7-ton low-frequency impedance tube, offering the capability of measuring absorption from 20-200 Hz, and a 6"x6" impedance tube to measure absorption and fabric transparency, between 63 and 4,000 Hz, using a single sample. It also contains a scale model boundary layer goniometer to measure the diffusion and scattering coefficients. The new **Virtual Simulation Lab** utilizes the first wave-based BEM virtual goniometer program, called VIRGO, to predict the diffusion and scattering coefficients of any shaped surface from a CAD file, eliminating the need to make prototypes. The new **Virtual Education Lab** allows us to provide collaboration with specifiers, as part of our ARC Associates Alliance program, and acoustical education in short LinkedIn posts with an extensive curriculum of topics derived from our 4 decades of research, publication, and books. We will describe how reflective, diffusive, and absorptive surface treatments scatter directionally and randomly incident sound and how RPG utilizes this knowledge to develop leading-edge innovative products in our Diffuse Reflections series.

Architectural acoustic shapes play a key role in acoustical spaces. Much progress has been made in evaluating shapes using geometrical acoustics in the past. However, due to advances in computational power and cloud computing wave acoustic solutions are now available to address shape optimization, diffraction, scattering and diffusion. The RPG Shape Optimization System, SOS, approach offers several services and solutions to the acoustician and architect.



VIRGO: This new wave based virtual goniometer, Figure 34, can evaluate any shape that is being considered for a project simply from a 3D CAD file. Calculation is quick and eliminates the costly and time consuming need for physical prototypes. The design team simply has to submit a 3D CAD file and VIRGO will quickly evaluate the acoustical scattering performance. the surface does not meet requirements, then the Shape Optimizer software, previously described, can optimize the shape, while maintaining its desired aesthetic motif.

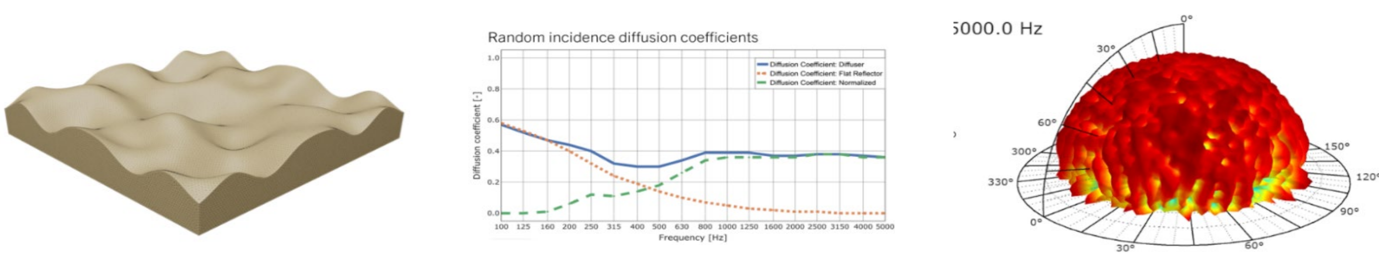


Figure 34. Top right: 3D goniometer illustration; Bottom left: 3D topology of the sample; middle: the normalized diffusion coefficient; right: 3D polar response at 1 kHz.

5.2 REDIAcoustics, LLC

Following the sale of RPG Diffusor Systems in 2017, I formed a new software company with John Storyk and PK Pandey called REDIAcoustics (Research, Education Design Initiative, www.rediacoustics.com) to complete the earlier Room Optimization software of cuboid rooms and address other challenging architectural acoustics issues, using hybrid wave and geometrical acoustics software. The first offering is called NIRO (Non-cuboid Iterative Room Optimizer).

The main issues in all critical listening recording control rooms are **transferability and creativity.** The mix must be transferable to other listening environments, and you must be able to converse, create and collaborate in comfort. Therefore, we developed two sayings to encapsulate these ideas, namely, "**Listen to the music, not the room"** and "**If you can't take the room out of the mix, you can't take the mix out of the room"**! The goal being to minimize all forms of "acoustical distortion" to create a neutral room, illustrated in Figure 35.

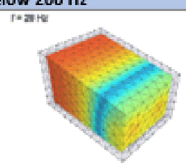
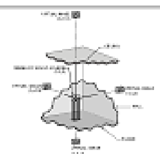
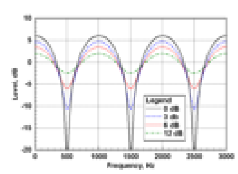
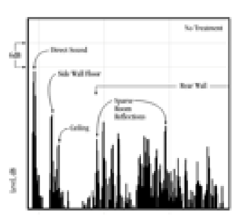
	PROBLEM	CAUSE	SOLUTION
Below 200 Hz			
	Modal Response	1. Geometry 2. Speaker/Listener placement 3. Lack of low frequency absorption	1. Wave acoustics optimization 2. Resonators/Membranes
	Speaker-Boundary Interference response	1. Omnidirectional low frequency interference with adjacent room boundaries	1. Flush/Trihedral mounting 2. Wave acoustic optimization 3. Low frequency absorption
Above 200 Hz			
	Comb Filtering	Coherent interference between a sound and a delayed specular reflection	1. Geometry 2. Absorption
	Poor Diffusion	1. Non-mixing environment 2. Too much absorption 3. Poorly designed diffusive surfaces	1. Optimize geometry 2. Strategic absorption placement 3. Broad bandwidth diffuser design, verified by experimental measurement and/or virtual BEM simulation

Figure 35. All forms of acoustical distortion.

The NIRO program uses a hybrid design in which the modal frequencies below the Schroeder frequency, fs, are optimized using the pressure based Finite Element Method, and frequencies above fs are optimized using energy based geometrical acoustics. This is illustrated in Figure 36.

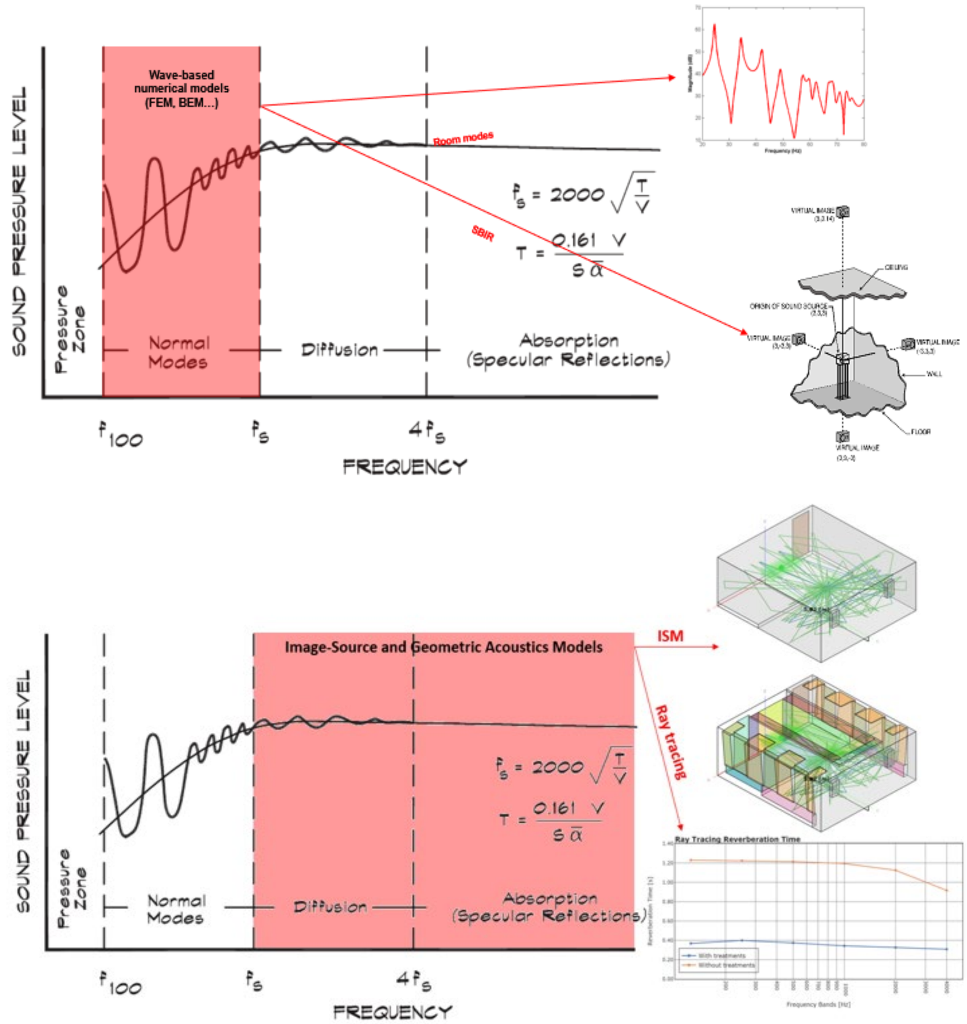


Figure 36. Top: Wave-based acoustics optimization below the Schroeder frequency, fs; Bottom: Geometrical acoustical optimization above fs.

To solve this complex problem of simultaneously and iteratively optimizing the geometry of any shaped room, the locations of free-standing or soffit mounted speakers and several listening positions, the NIRO program:

- Utilizes complex surface admittances for boundaries and acoustical treatments
- Simultaneously, optimizes the location of speakers, listeners, and the room's vertices for any shape room
- Uses a wave-based method (FEM) to evaluate the low-frequency range
- Uses the ISM and Ray Tracing to evaluate the RFZ, DFZ, and reverberation time
- Combines the methods above into a multi-objective optimization to find the best solution within the architectural constraints
- Optimizes absorbers with specific center frequency, peak absorption, and bandwidth, APEQs, to damp temporal modal ringing

An example of the final comparison between existing and acoustically treated rooms is shown in Figure 37, where we compare the frequency response, the temporal decay, and the reverberation time.

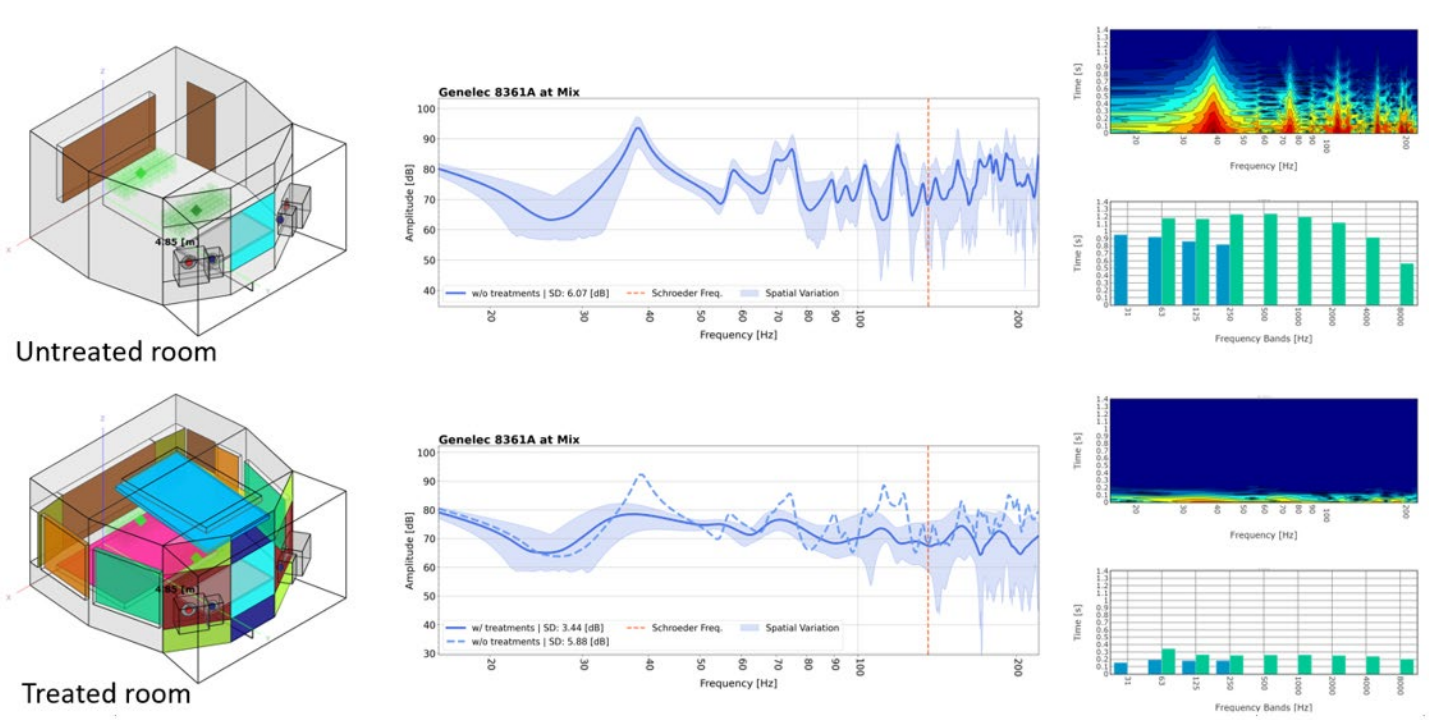


Figure 37. Comparison between Untreated and Acoustically Treated rooms. Light blue areas is the spatial deviation around the mix position.

At this time, over 100 rooms have been successfully optimized using NIRO.

6.0 Recognition

Figure 38. 2013 Music Industry's TECnology Hall of Fame Award

Figure 39. 2023 Wallace Clement Sabine Medal

In 2013, I was inducted into the TECnology Hall of Fame, Figure 38. The 40th anniversary of my career in acoustics (1983-2023) was joyously commemorated with the prestigious 20th Wallace Clement Sabine Medal, Figure 39, bestowed upon me for my *"Contributions to the theory, design, and application of diffusers"*. The Wallace Clement Sabine Medal, established by the Acoustical Society of America in 1957, celebrates individuals of any nationality who have significantly advanced the field of architectural acoustics. This recognition can be achieved through publications in professional journals or periodicals, as well as other remarkable accomplishments in the realm of architectural acoustics, as determined by the awarding body. The Wallace Clement Sabine Medal holds the distinction of being the highest honor bestowed upon acousticians specializing in architectural acoustics.

7.0 Final Thoughts;

There have been many significant accomplishments over the past 40 years. We now know how to design, predict, optimize, measure, characterize, and standardize the performance of scattering surfaces. The recording studio control room and other critical listening rooms can now be scientifically optimized. While there is still much to do, there is a general consensus in the architectural acoustics community that a solid theoretical and experimental foundation has been laid, that diffuser performance can now be quantified and standardized, and that diffusers can now be integrated into contemporary architecture, taking their rightful place along with absorbers and reflectors in the acoustical palette. This is only the beginning……….