Experimental Measurement Lab: Evolution of the Diffusion Coefficient Using a Goniometer

Thus far in our Diffuse Reflections series, we have discussed the reverberation chamber, low-frequency, and the broad bandwidth impedance tubes and their applications. In 1983, when RPG introduced the first commercial reflection grating diffusor, there was no standardized procedure to measure its uniform scattering properties. Therefore, we began a research program to develop a method to measure the scattered polar response and develop a diffusion coefficient from these data to complement the absorption coefficient. This process evolved over many years and was finally enshrined as the internationally recognized standard ISO 17497-2 in 2012. In this and subsequent posts, we will describe the development of a device called a Goniometer, which enables the measurement of the scattered polar response from a sample with a given topology for any angle of incidence. We will then describe how to extract a diffusion coefficient from the data.

Since we did not have access to an anechoic chamber, we developed a device using pressure zone microphones on the ground plane to remove the boundary in a reverberant space. The initial measurements from 1983-1993 were conducted with a TEF analyzer, using a sine sweep, at full scale in local arenas and gymnasiums to minimize interfering room reflections, Figure 1 (Left). These measurements used one microphone, a source, and a diffusive sample. The microphone was physically moved 37 times along a semicircle at 5° angular increments for each source location. Yes, this was very time-consuming!

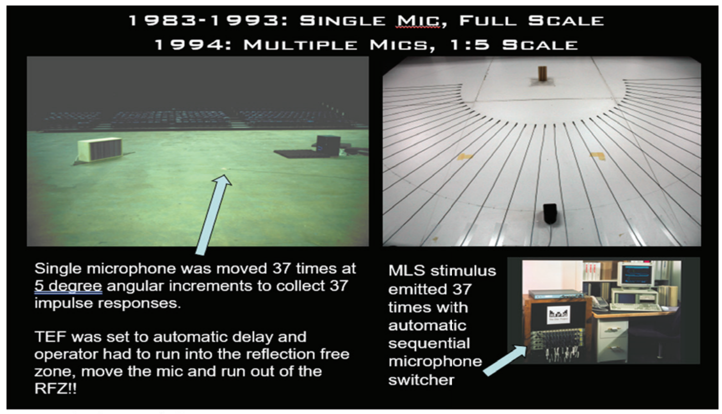

Figure 1. (Left) Original Goniometer set up in an arena at full scale; (Right) Original scale model Goniometer.

After wearing out our welcome at local entertainment venues, in 1994, we decided to explore scale model measurements in smaller rooms. These measurements were made by programming the TEF analyzer and a microphone switcher to conduct the measurements automatically for each angle of incidence. This setup is shown in Figure 1 (Right). This evolution continued, and in 2011, we began making 32 simultaneous measurements using a digital audio workstation called *Reaper*. The collected scattered signals were subsequently deconvolved with the stimulus to obtain the impulse responses. This setup used the same scale model Goniometer but different data collection, as shown in Figure 2.

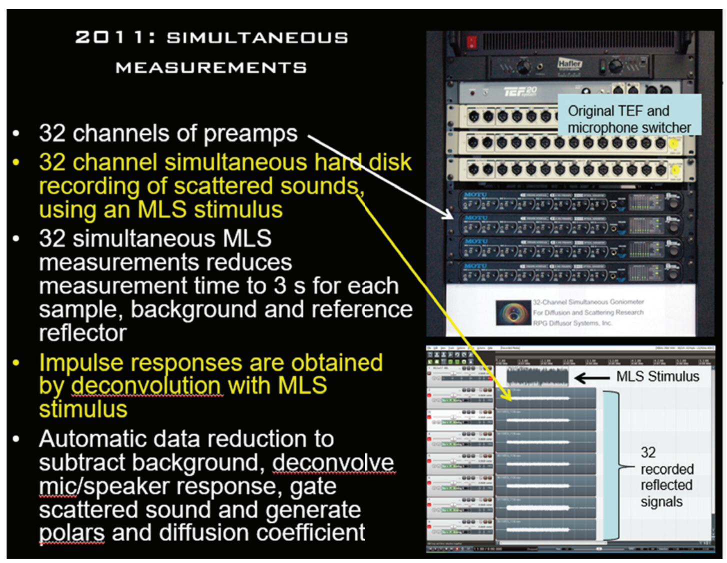

Figure 2. Simultaneous measurements using a Digital Audio Workstation and MLS stimulus.

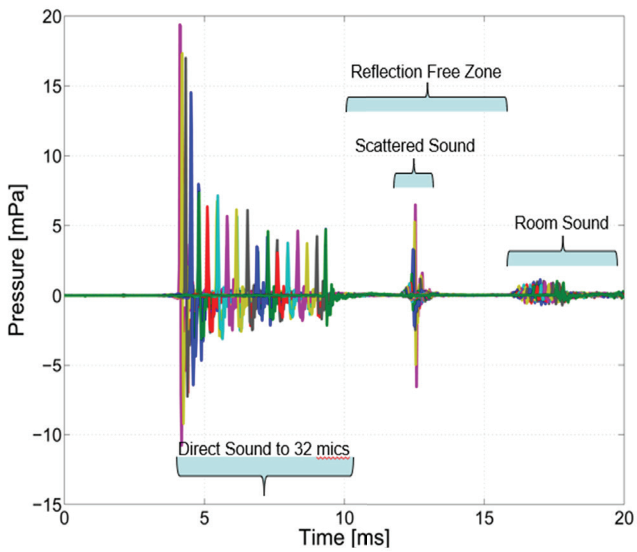

Figure 3. Scattered sound from the simultaeneous measurement at normal incidence.

In Figure 3, we illustrate the total scattered sound arriving at each microphone for a given angle of incidence. The graph shows the Direct Sound at the 32 microphones, the Scattered Sound, and the Room Sound. The Reflection Free Zone (RFZ), determined by the size of the sample and the radii of the microphones and speaker, is also shown. The output of a program called the Goniopter, Figure 4, maximized the RFZ, minimizes the Specular Zone, Figure 5, and determines the optimal speaker and mix radii in a room of a given size.

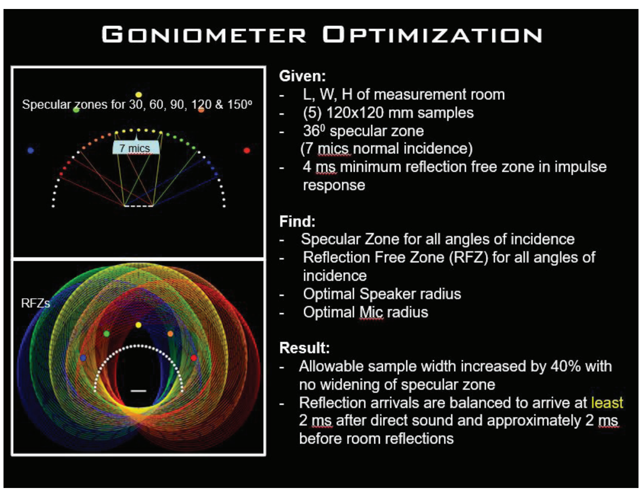

Figure 4. Results of the Goniopter program which minimizes the Specular Zone, determines the RFZ for all angles of incidence and determines the optimal speaker and mic distances from the sample for a given size room.

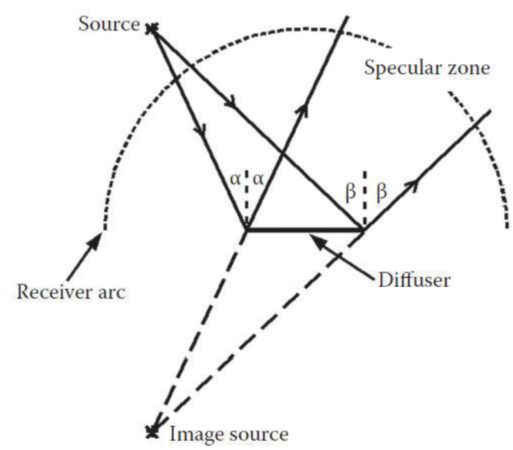

Figure 5. Specular Zone.

In the next post, we will describe how to isolate the Scattered Sound for each angle of incidence, calculate the polar responses, and determine the Diffusion Coefficient.

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