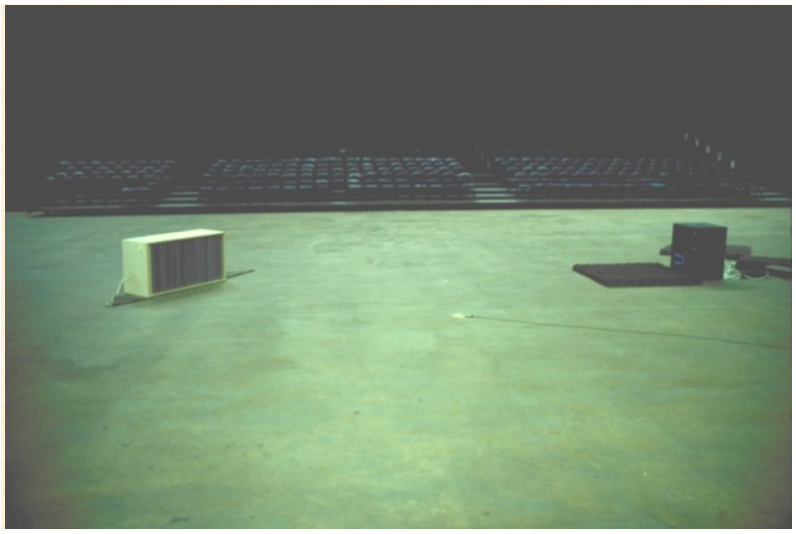
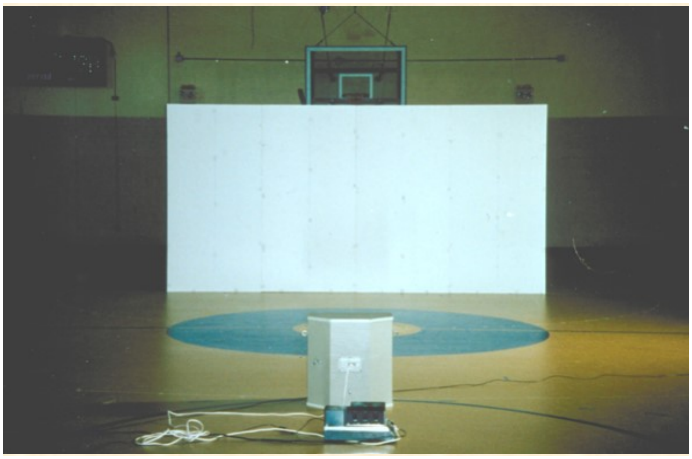
After introducing the first commercial reflection phase grating (RPG) in 1983, RPG had the obligation to compare experimental measurements with theoretical predictions. The problem was that there was no existing method to measure the uniformity of the scattered sound from these RPGs. My background in diffraction physics, using an x-ray diffractometer, suggested a way to measure the diffracted sound at various angles with a goniometer. And so, the word was enshrined into the lexicon of architectural acoustics.

In 1984, the first attempt was to measure the scattered sound from an RPG outdoors, by moving a single mic around a semicircle at 5 degree angular increments. Because of wind, thermal gradients, uneven ground, noise, and intrusions, this soon proved to be the wrong approach.

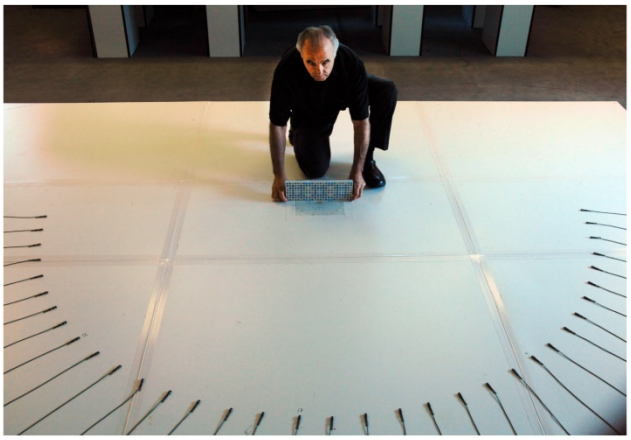
We then moved indoors to local sports arenas (the old Capital Center in Landover, MD) very close to my home, where RPG started. Using chalk on a string, we drew a 15' radius semicircle on the arena floor and marked 5 degree angular increments with a protractor. We then manually moved a pressure zone mic to each of the 37 locations and measured the impulse response, using a TEF analyzer. We also drew a concentric 30' radius semicircle with similar angular steps for the loudspeaker, so that we could measure the polar scattering for different angles of incidence. Needless to say, this was a physical and tiring process, because we also had to move ourselves out of the area of detection, so we were not in the measurement. These measurements also had to be done very late at night when the arena was not being used. Soon, the owner lost patience and we had to find another venue. With the help of my friend Charles Bilello, we moved to the Kaufmann Astoria Studios Stage H in Astoria, New York for a few measurements, but this remote location proved too difficult to transport product and gear.

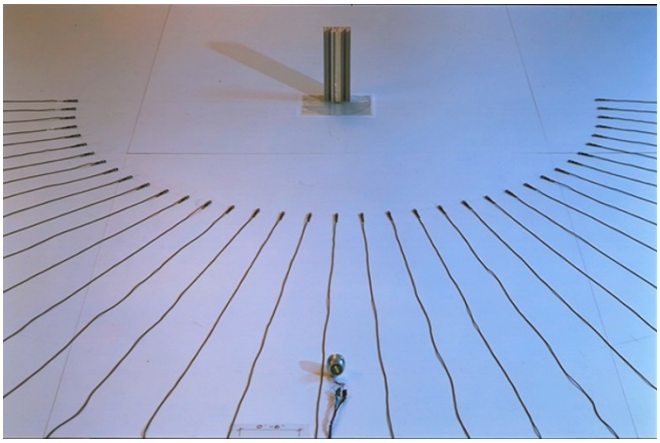


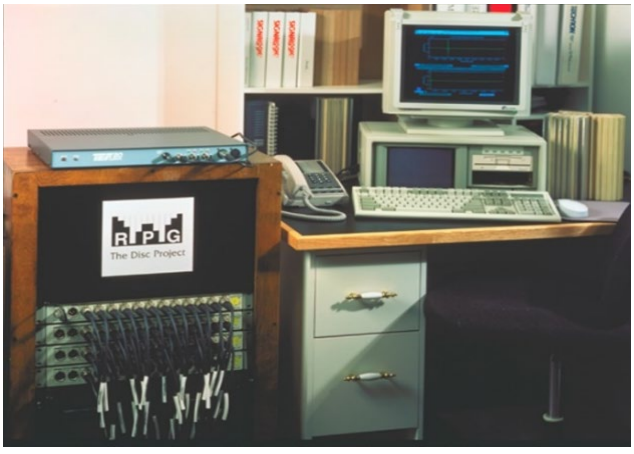
We then began using the gymnasium at Queen Anne high school in Upper Marlboro, MD, where my son was attending. On close examination, you can see the microphone arc crossing the center of the lion mascot. Between wearing out our welcome and physically transporting all of the product and measurement gear, we began to think of exploring scale model measurements.



In 1991, the first 1:10 scale model measurements were made on a platform in RPG's new corporate office in Upper Marlboro, MD. While this was infinitely more convenient than full scale remote locations, the frequency bandwidth was limiting. So, in 1995 we developed a 1:5 scale goniometer with automatic data collection.

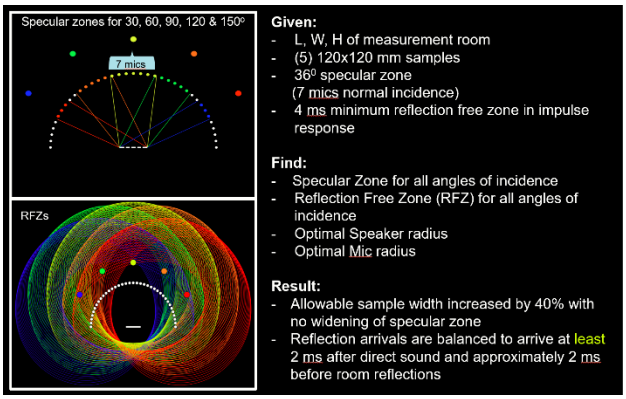


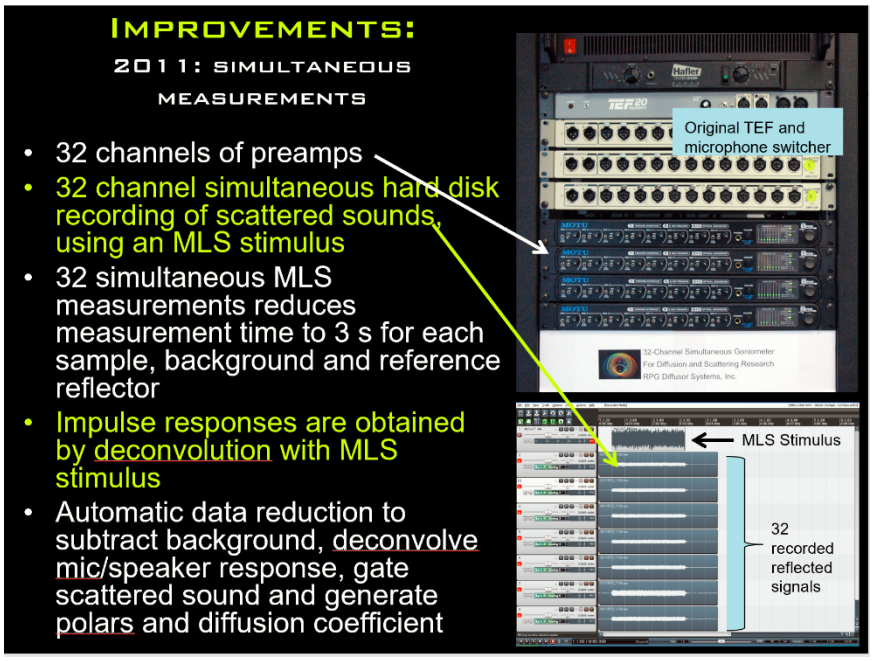


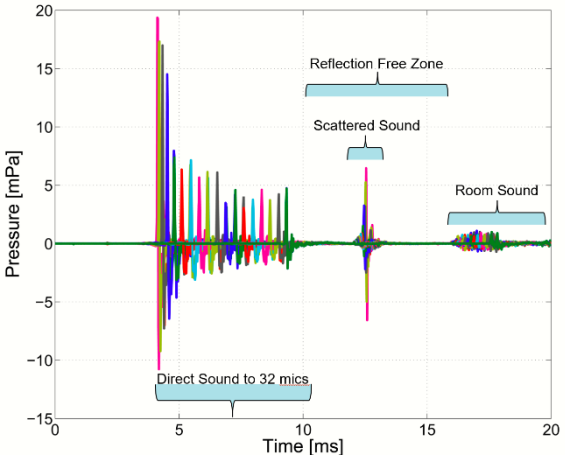


To accomplish this, we used 5, 8 channel microphone switchers and a computer controlled program that automatically and sequentially selected a mic position and emitted a test signal sine sweep, until all 37 receiver positions were collected. Then the process was repeated for all angles of incidence. This simply meant moving the loudspeaker to a new angle of incidence.

In 2011, we developed software to optimally design the 1:5 goniometer to minimize the specular zone and began collecting all of scattered sound (not the impulse response) at each mic simultaneously, using a digital audio workstation called REAPER. Each mic was connected to a MOTU preamp channel. We then deconvolved the reflected wav file with the stimulus to extract the impulse response. This significantly reduced data collection time. We simply had to physically move the loudspeaker to different angles of incidence. The data was then automatically processed in a goniometer suite software program.



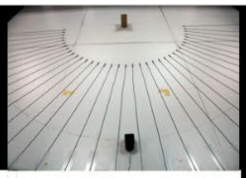


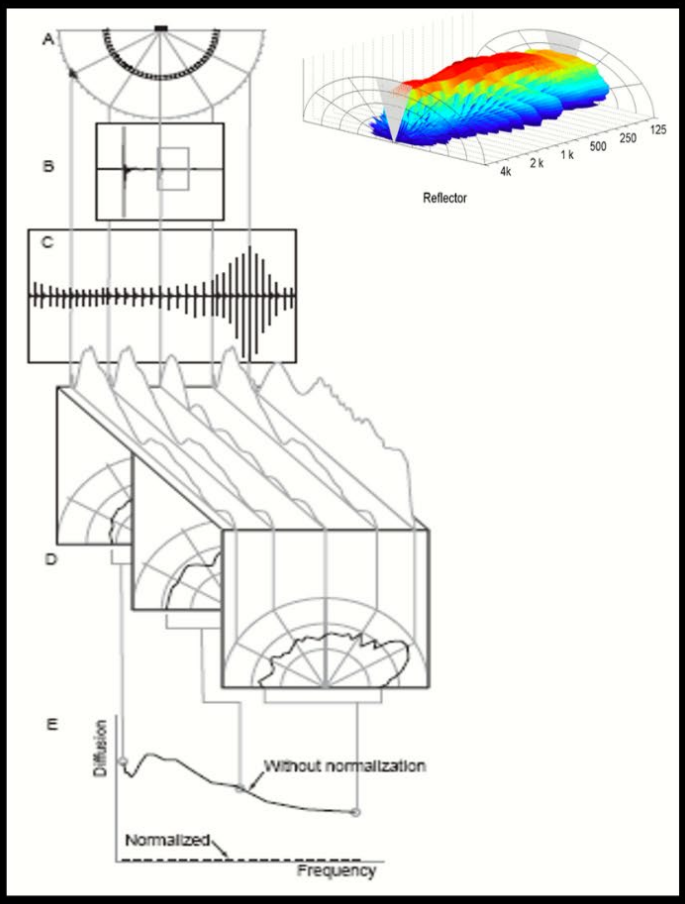


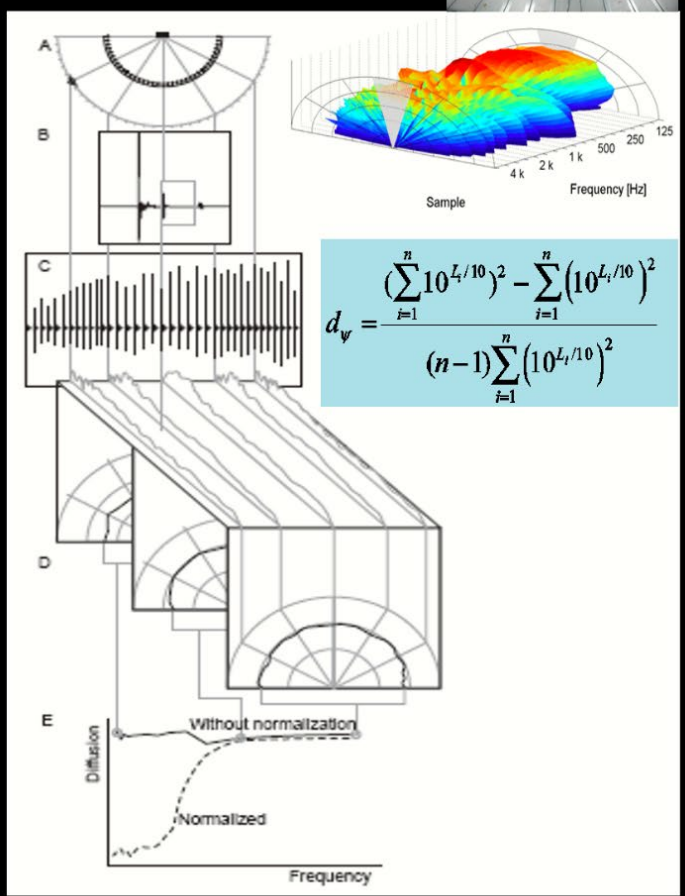
This process of using a goniometer to measure the polar responses and diffusion coefficient, which is graphically illustrated below, is now enshrined in the ISO 17497-2 international standard. So, what started in a noisy outdoor field and eventually wound up in a 1:5 scale measurement goniometer is now the procedure to determine the diffusion coefficient.

There is a link to a published paper that describes the process in detail.

Diffusion Coefficient: ISO 17497-2







$$d_\psi = \frac{(\sum_{i=1}^{n} 10^{L_i/10})^2 - \sum_{i=1}^{n} \left(10^{L_i/10}\right)^2}{(n-1)\sum_{i=1}^{n} \left(10^{L_i/10}\right)^2}$$