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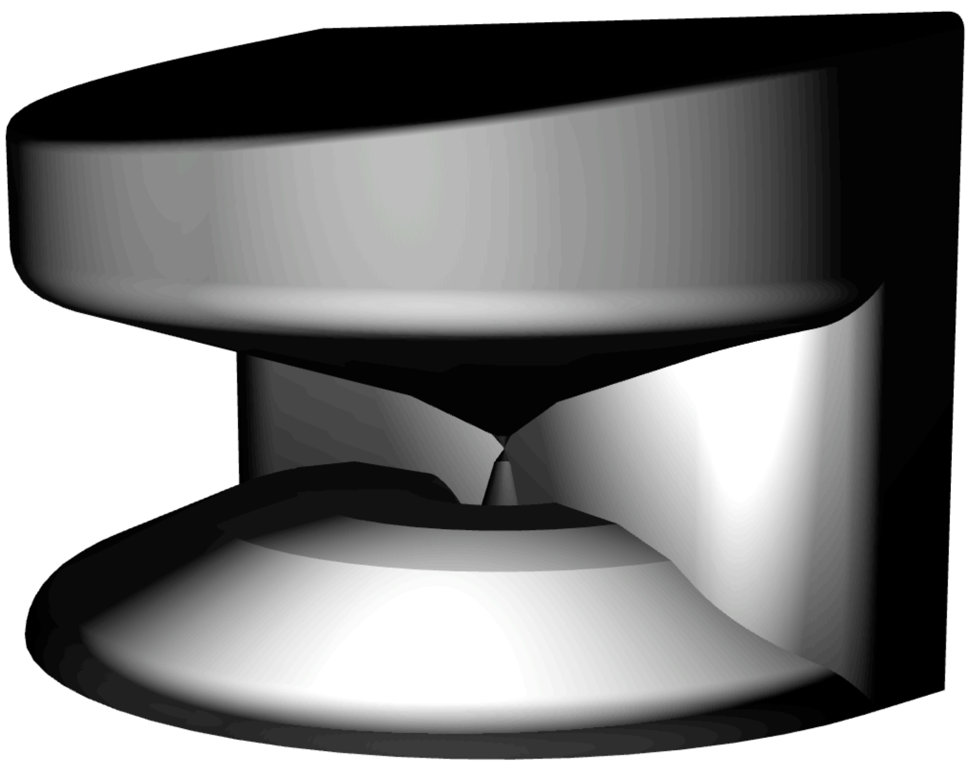
Engineering Brief: Conic Section Array™ Waveguides

By Manny LaCarrubba



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Conic Section Array™ waveguides are described in US patent # 9,208,768 “Acoustical Transverse Horn for Controlled Horizontal and Vertical Sound Dispersion”.

Visually, perhaps the principal defining feature of the CSA is that the sound radiating element mounts orthogonally to the main output axis of the waveguide. Fundamentally, the waveguide trades off some control of the output wave front in the vertical plane for remarkably wide and consistent dispersion in the horizontal plane.

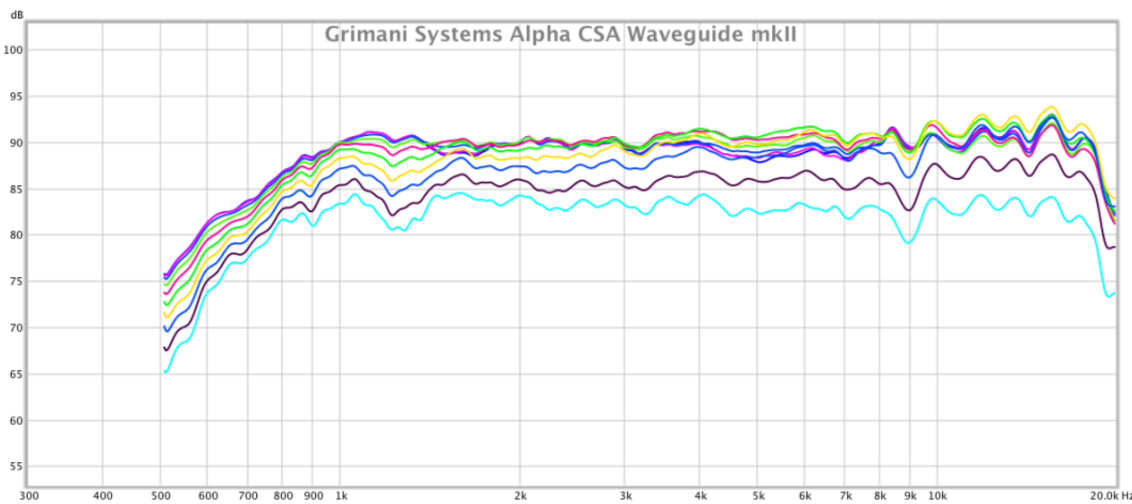

Figure 1: This chart shows a family of frequency response curves taken from the CSA used in a commercially available product. The data are taken at 10° increments from 0°- 90° in the horizontal plane.

Of special note in the Fig. 1 chart is the fact that the curves do not converge at the low end of the passband. In fact, they tend to converge at the high end of the pass band. This behavior makes it easier, when mating the high frequency waveguide to a properly sized midrange unit, to achieve well-behaved off-axis performance through the crossover region.

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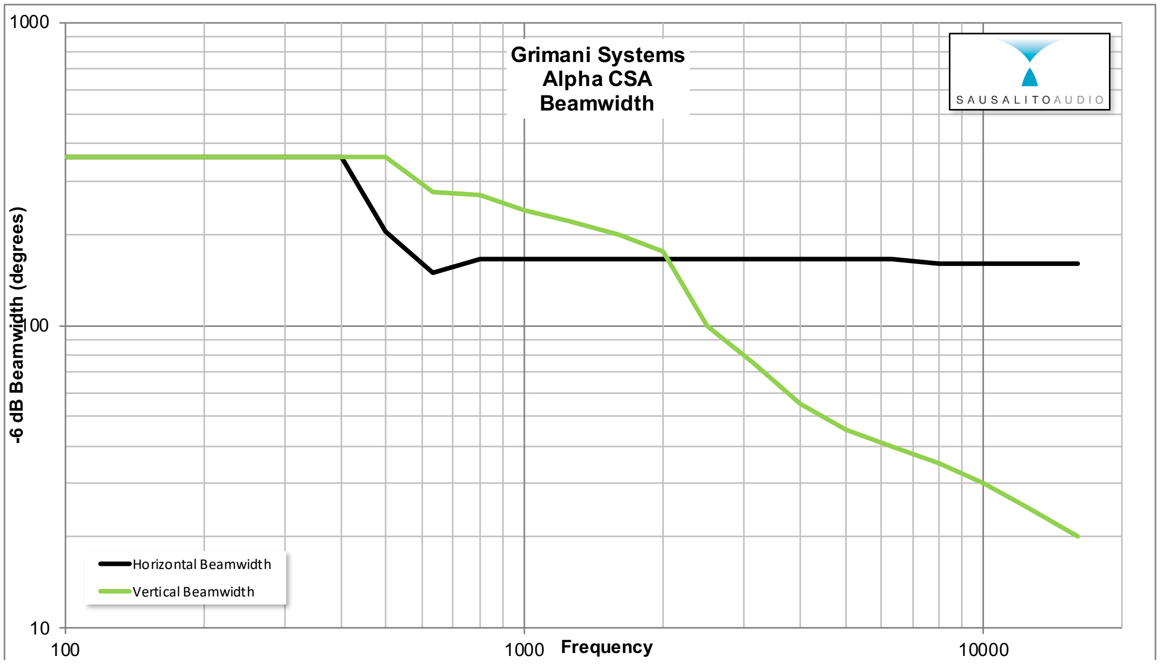

Figure 2: This is the same waveguide as used in fig 1. The chart shows the -6dB point as function of frequency and angle for both the horizontal and vertical planes.

Like all constant directivity devices, the CSA requires equalization to achieve a flat axial frequency response. For this reason, Conic Section Array™ waveguides are best suited for active loudspeakers with digital signal processing.

CSA waveguides are scalable. The image on the title page is of the largest CSA built so far. The data in the charts of Figs. 1 & 2 are derived from this waveguide. The size of the waveguide most dramatically effects the vertical dispersion. This larger waveguide is 18" wide and the mouth is approximately 5.5" tall. Fig.3 shows the beamwidth chart for a somewhat smaller waveguide that is 12" wide with a mouth approximately 4" tall. As one would expect, the narrower mouth yields less beaming in the vertical plane. In the horizontal plane, the response characteristics are essentially identical what is shown in Fig. 1.

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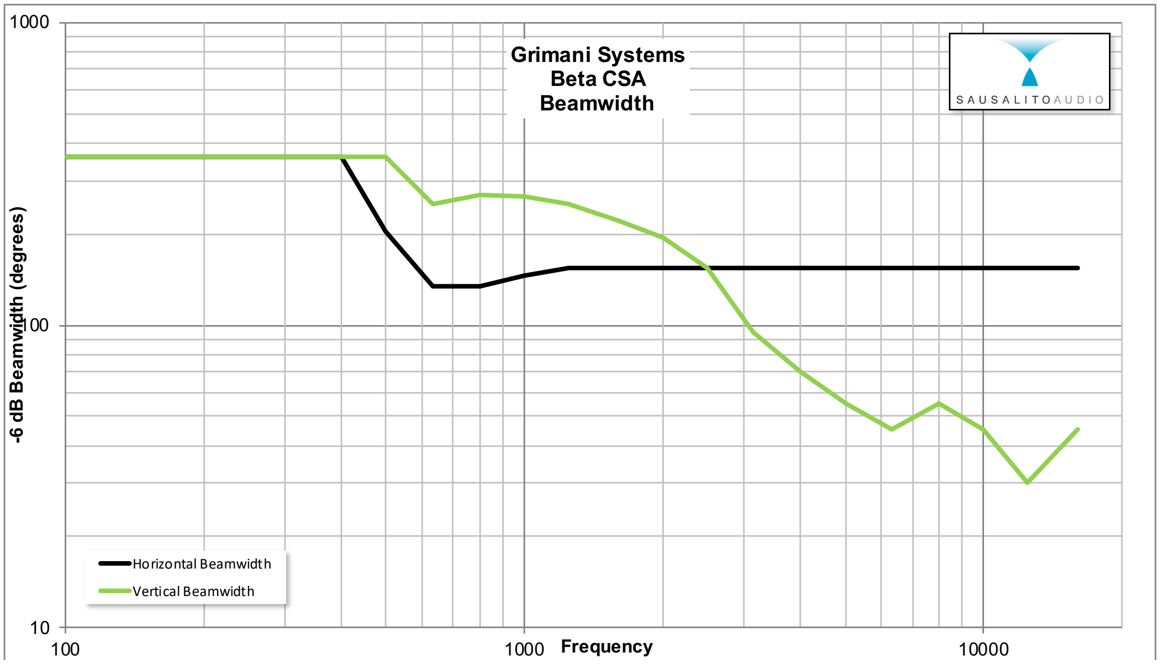

Figure 3: This is a smaller waveguide than the one used to produce the chart in fig. 2. The smaller device has a wider vertical dispersion characteristic especially in the top two octaves.

Scaling the CSA down even further, Fig. 4 shows a small 6" two-way loudspeaker.

Figure 4: This is the 6" bookshelf speaker prototype that produced the data for figs. 5 & 6.

Notable in the CSA used here is the squared-off lower portion of the waveguide. This was done for aesthetic purposes and ease of construction. Performance is only slightly degraded as a result.

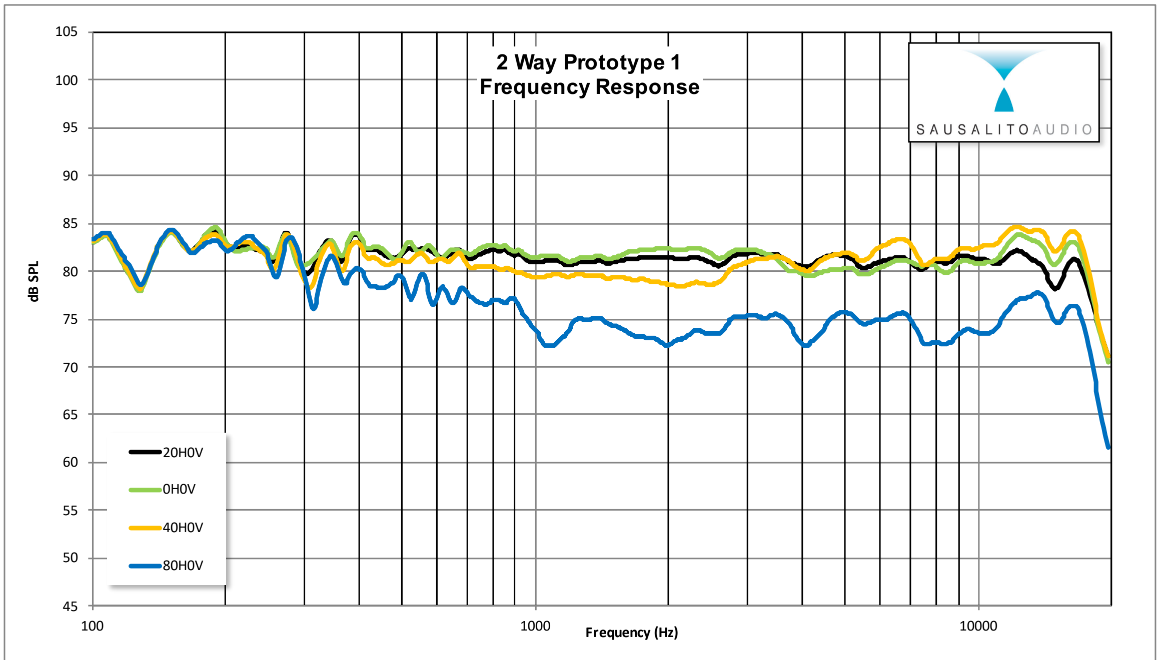

Figure 5: The CSA used in this speaker is 7" across and the mouth is approximately 3" tall. The crossover point is 1100Hz. Data is shown for 0°, 20°, 40° & 80° in the horizontal plane.

Also noteworthy here is the difference in the type of high frequency drive unit. The larger waveguides profiled above were designed for high SPL, high-end cinema loudspeakers and use a good quality 1" throat compression driver as would be appropriate for that application. This bookshelf speaker uses a standard 1" dome tweeter and much more modest DSP.

It is possible to mount the same 1" tweeter in the larger waveguides and get substantially identical frequency response behavior to that shown. The only caveat is that the construction of many tweeters do not lend themselves to this manner of mounting. Also, it has been my experience that certain types of tweeters perform better than others with CSA's. The point here is that CSA waveguides are applicable to a wide array of loudspeakers at vastly different price points. I am currently working on an even smaller CSA for use in wireless speakers and soundbars.

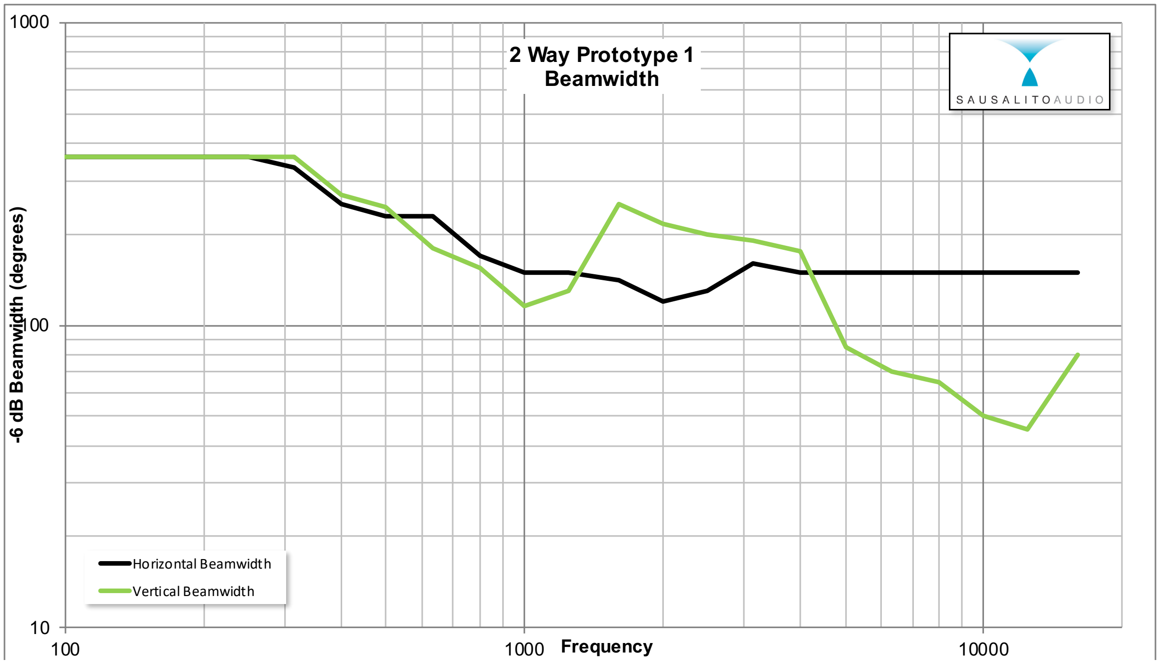

Figure 6: Once again we see that as the size of the waveguide shrinks, the vertical dispersion gets wider. Horizontal performance is largely unaffected by scale.

It is worth pointing out that the vertical dispersion pattern of these waveguides has an asymmetry to it, and, depending on the intended application, it may be advantageous to have the high frequency driver either upward firing or downward firing. Fig. 7 illustrates this behavior.

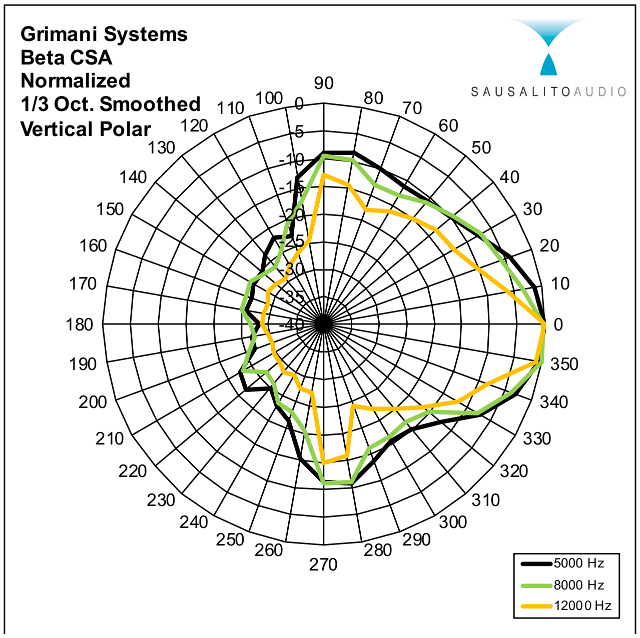

Figure 7: With the compression driver facing upward, note the downward skew of the vertical dispersion of the 12" CSA.

The CSA waveguides profiled here all use substantially identical internal geometries. Other geometries are possible and would trade off different performance characteristics to achieve the desired result. I am still researching what is possible.

The question always comes up: "But how does it sound?" I address this question at length elsewhere. However, for those of you who understand the implications of these graphics, the chart in Fig. 8 should say it all. (Please look up "Interpreting Spinorama Charts" in the "Data" section of the Sausalito Audio website.)

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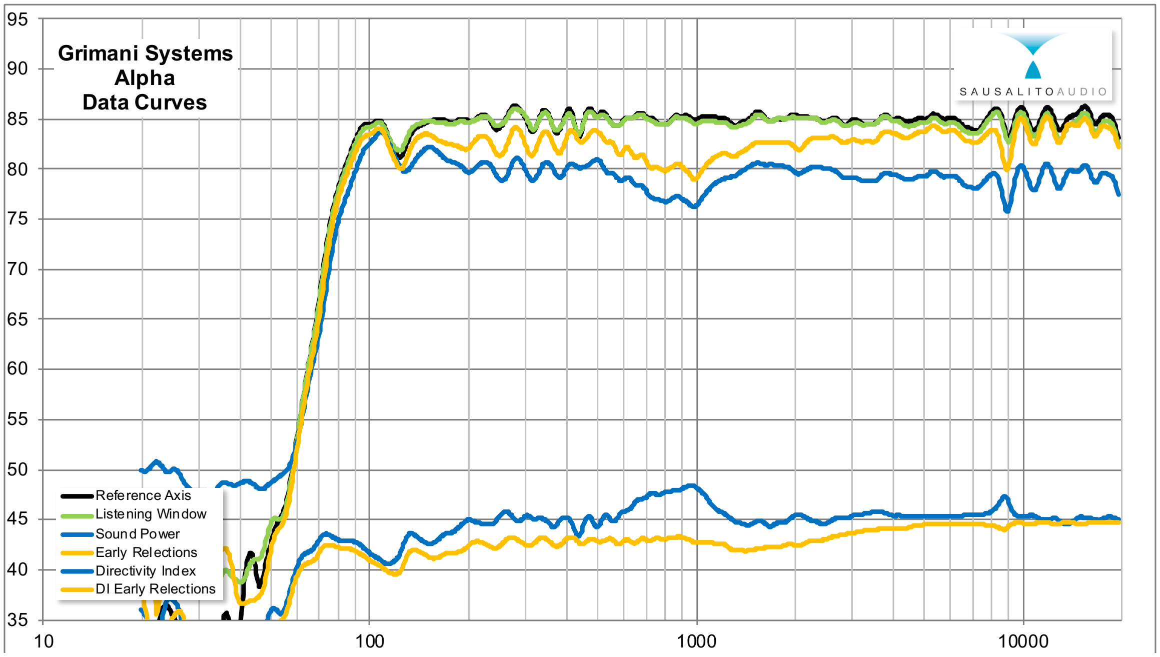

Figure 8: "Spinorama" curves for the Grimani Systems Alpha cinema loudspeaker. Data is anechoic down to ~500Hz then increasingly less so.

The data in Fig. 8 is from the flagship Conic Section Array™ loudspeaker, the Grimani Systems "Alpha". (Full disclosure: I'm a founding partner in Grimani Systems.) This is an 80 Hz, on-wall cinema loudspeaker that when mated to an appropriate subwoofer has bested every audiophile and cinema loudspeaker we have compared it to so far. While these comparisons were not formal double-blind trial, the anecdotal evidence is very compelling. It's also capable of filling a 200-seat auditorium with sound.

I have used CSA loudspeakers for live sound, home listening, professional mixing and mastering, and in private screening rooms, with outstanding results. The extraordinary coverage pattern not only gives more listeners better direct sound from the speaker, but also drives the room with much more high frequency content, making the presentation much less like "sound coming from a box".

Thanks for taking the time to read this!