Edge diffraction: rounding vs. chamfer

contents

motivation

In the case of a loudspeaker, the edges of the baffle create a diffraction and thus a secondary sound source, which is superimposed with the direct sound and creates an interference pattern. This interference pattern influences, among other things, the radiation behavior. This is usually counteracted with rounding or a bevel.

Rounding and chamfer are usually treated equivalent. This document is about the modes of action of both measures and compares them.

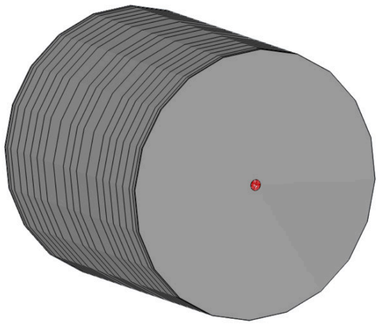
To illustrate the effects, a small sound source in the middle of a circular baffle with a radius of 10 cm was simulated by BEM. The small sound source has the advantage that it has no directional effect in the transmission range. The circular baffle ensures that the interference effects fall on the same frequencies from all directions, which makes viewing a lot easier.

The amplitude response below 0 ° and the radiation behavior at an infinite distance are shown in each case.

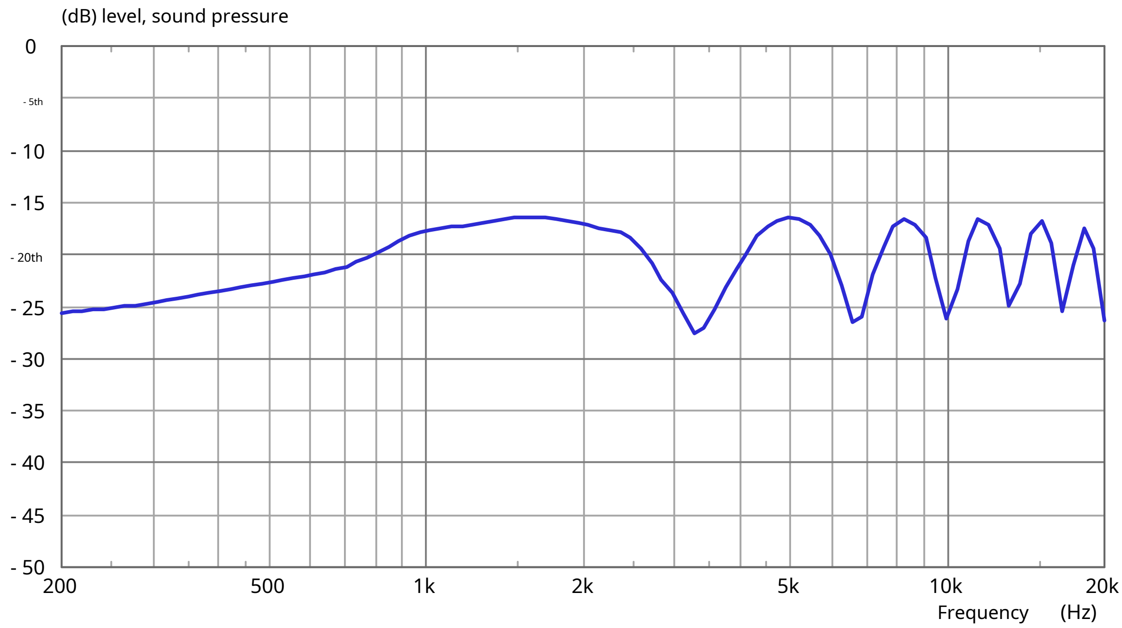
Simulations

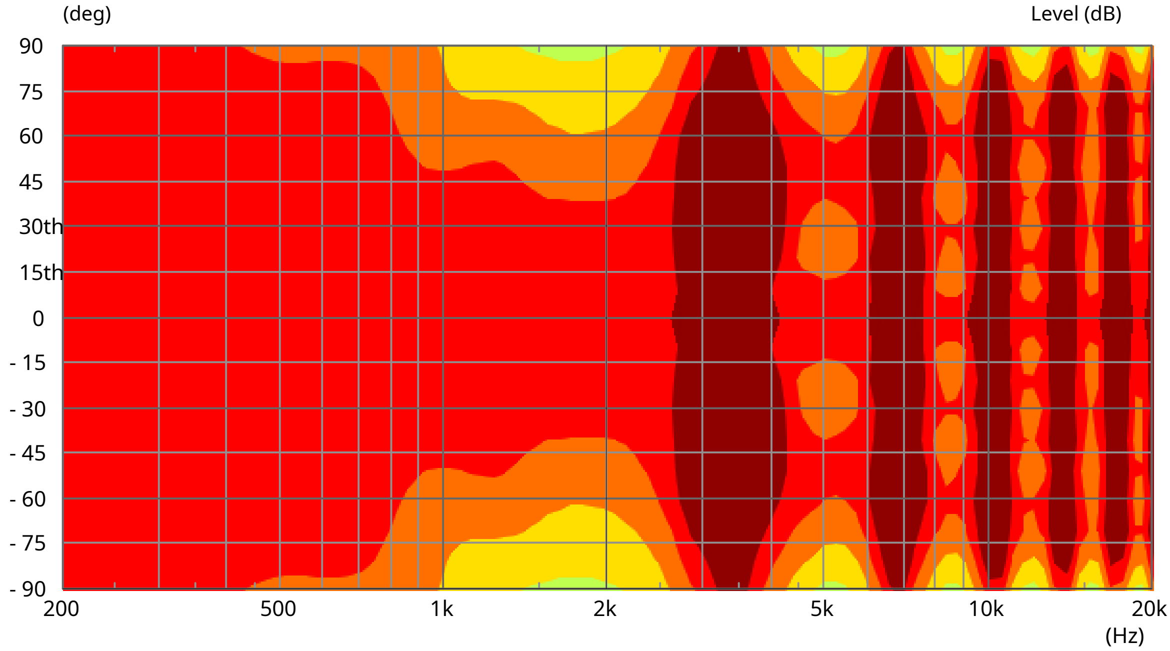
Hard edge

The hard edge creates a strong interference pattern. The secondary sound source is superimposed on the direct sound below 0 ° so that the sum fluctuates by +/- 6 dB.



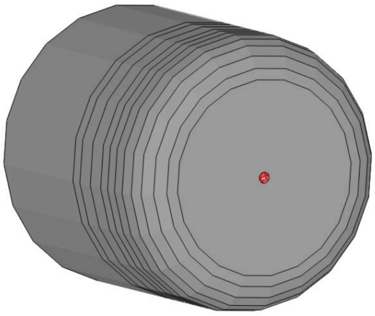
The first increase occurs in the frequency range whose half wavelength corresponds to the distance between the center of the sound source and the edge (i.e. the radius of the baffle).



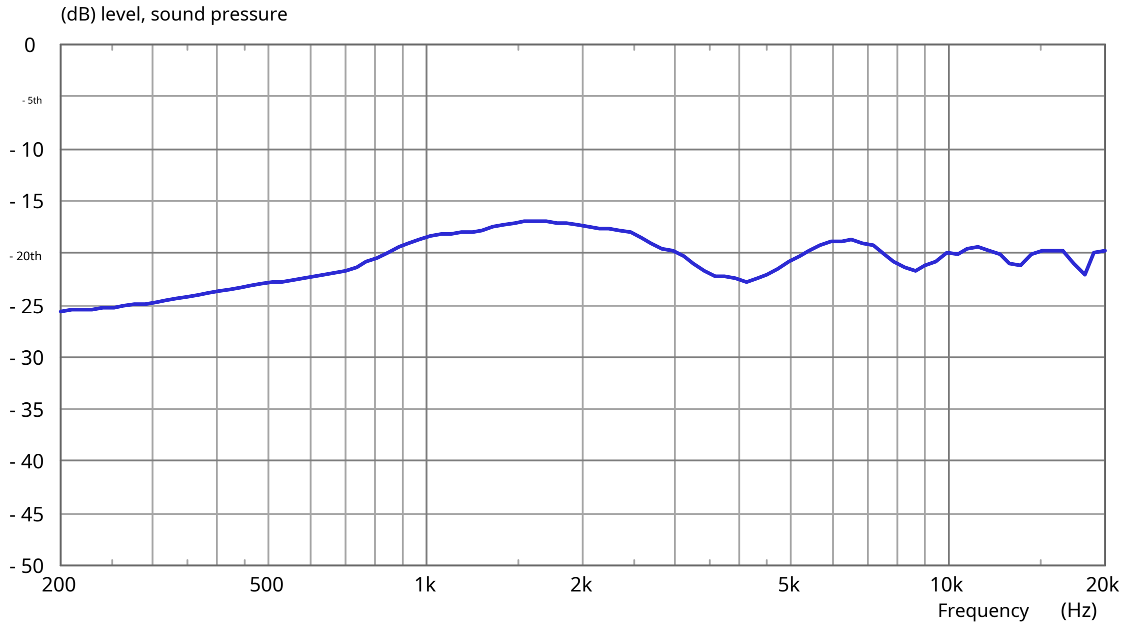


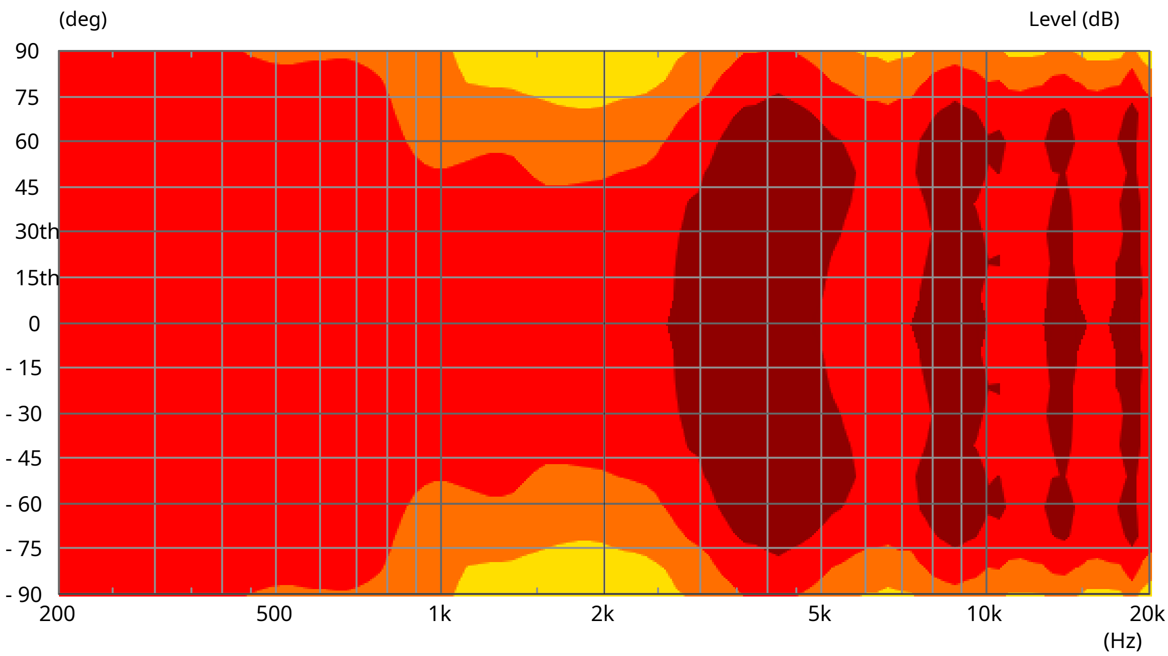
Rounding off

The first thing you notice is that the rounding shifts the secondary sound sources slightly upwards in the frequency range. The baffle is thus made smaller with regard to the interference.



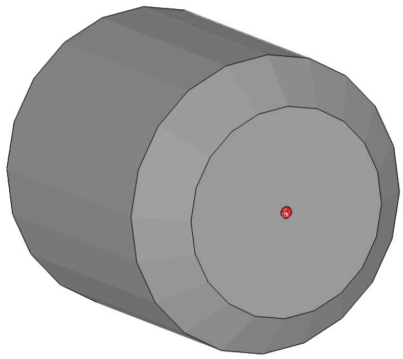
Furthermore, the amplitude of the secondary sound sources is greatly weakened, especially in the upper frequency range. The attenuation is less in the lower area because the radius of the rounding is too small in relation to the wavelength. That the secondary sound source is not complete in the treble is eliminated, it could have its cause in the approximated rounding of the 3D model. That was not investigated further.



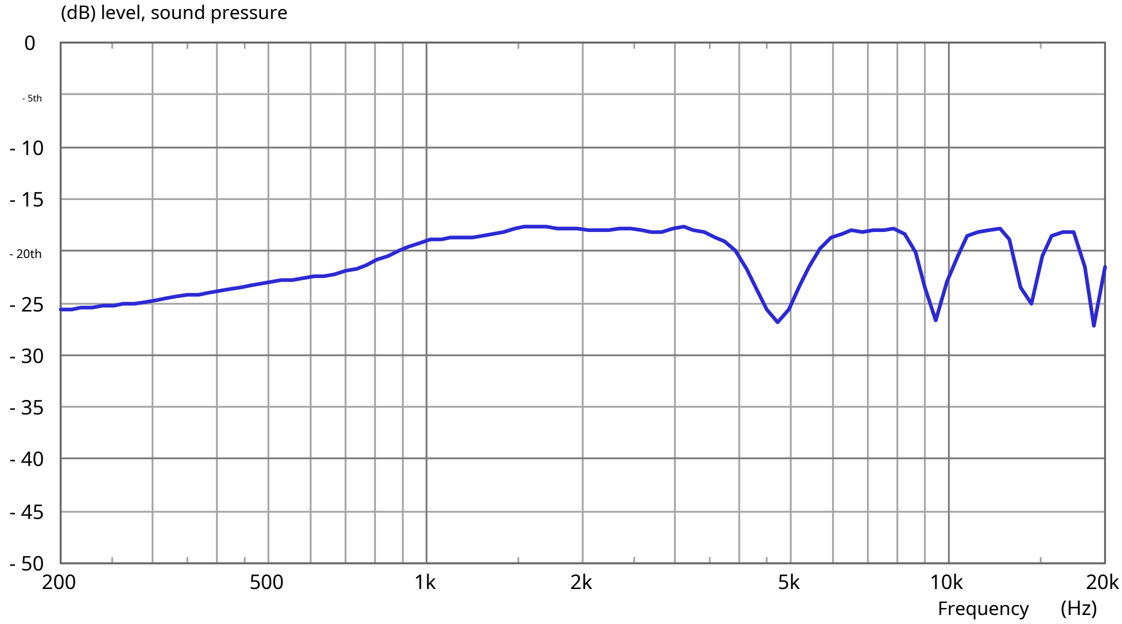


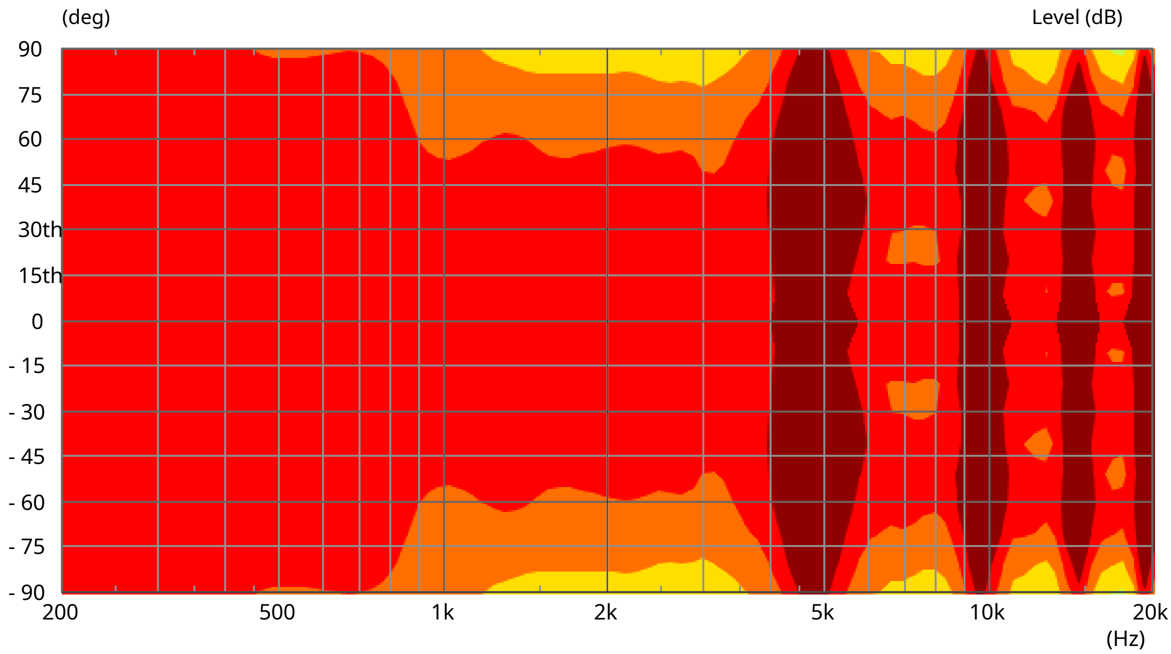
chamfer

With the bevel, on the other hand, the amplitude of the secondary sound sources is not weakened. The bevel ensures that the baffle is reduced to the inner edge (r1). This has the consequence that the interference pattern shifts upwards in the frequency range.



Farther generated the outer Edge (r2) one Tertiary sound source. So a secondary sound source of the secondary sound source, which in turn is superimposed with the direct sound.





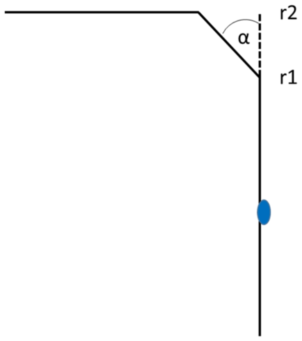
If r1 and r2 are chosen so that the transit times of the secondary and tertiary sound sources are identical to their primary sound sources, the peaks take on the form of a plateau. This creates a relatively large frequency range (almost three octaves) in the area of the first cant, which has an almost constant radiation behavior. This is at a ratio of

$-_{-} = \frac{}{\sqrt{}}$ the case.

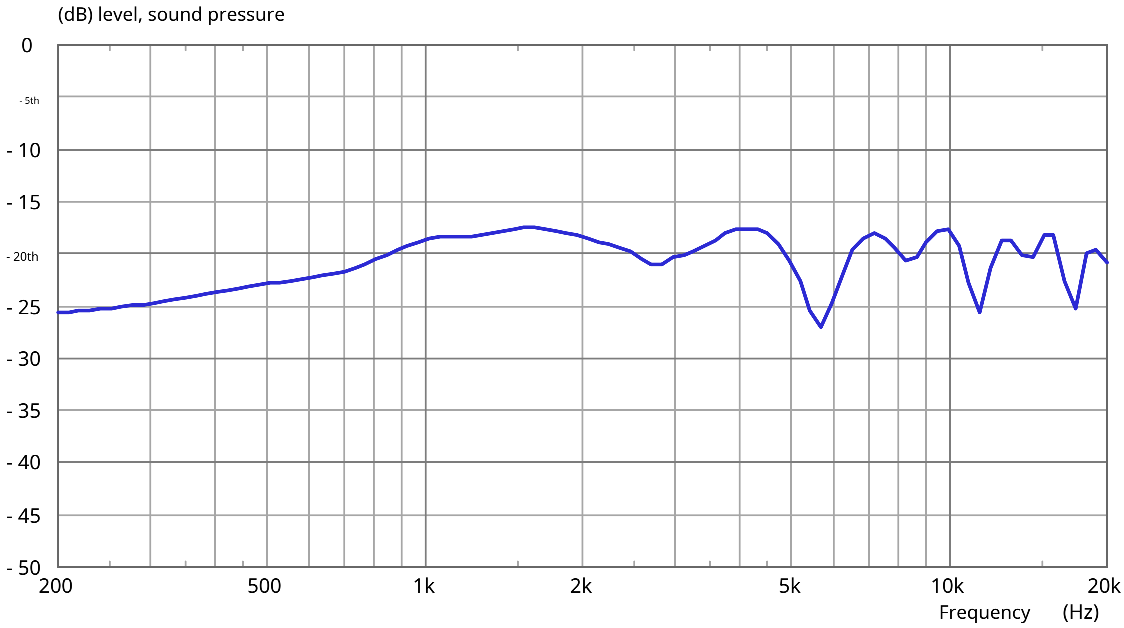
This particularly favorable ratio can also be transferred to rectangular baffles with a centrally placed sound source, although it is less pronounced. With more complex baffles and acentric driver positions, on the other hand, this no longer works so trivially.

Variation of the angle

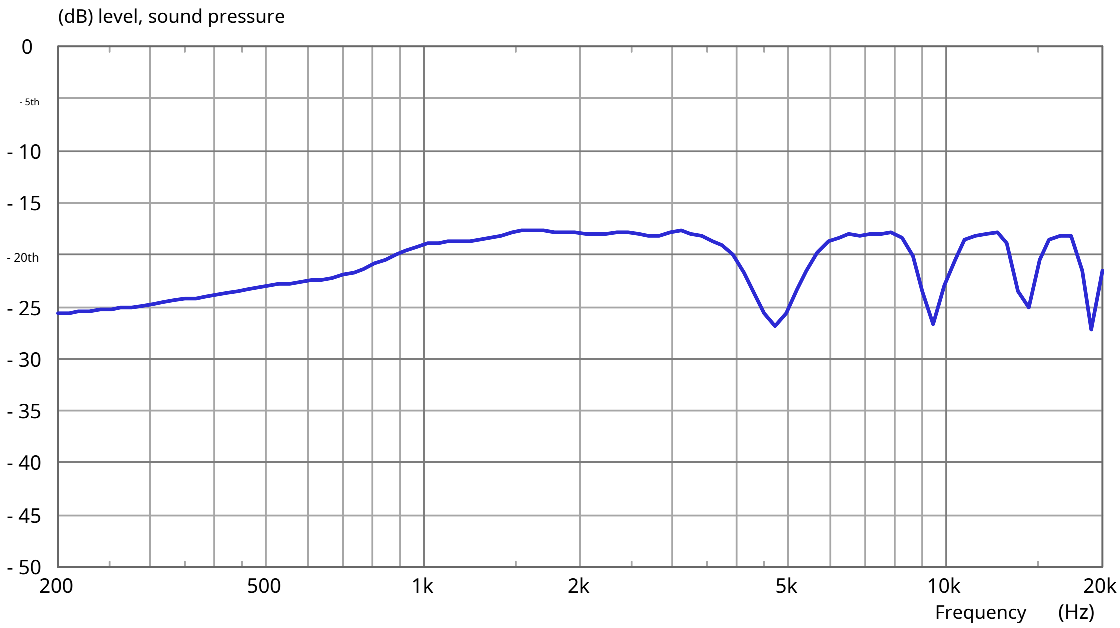
In the following it was examined whether the angle has an influence on the radiation behavior. For this, the outer radius (r2) and the difference in transit time between the secondary and tertiary sound sources were kept constant. As a result, the inner radius (r1) varies. The transit time difference was set so that it is identical to the transit time between the primary and secondary sound source.



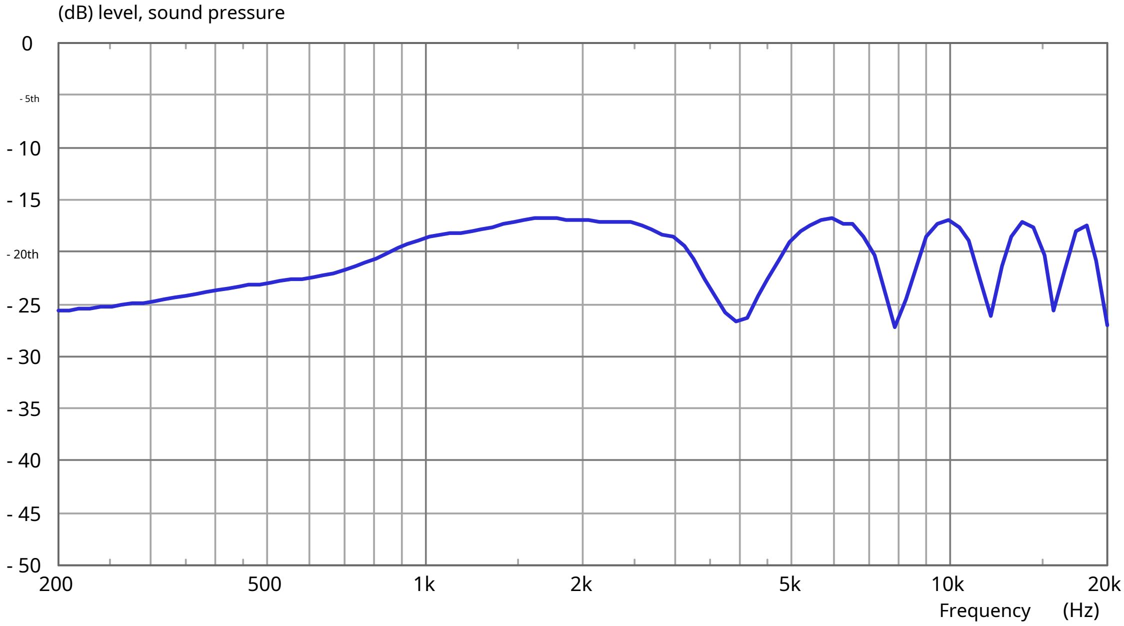
α = 20 °, r1 = 58.8 mm:



α = 45 °, r1 = 70.7 mm:



α = 70 °, r1 = 85 mm:



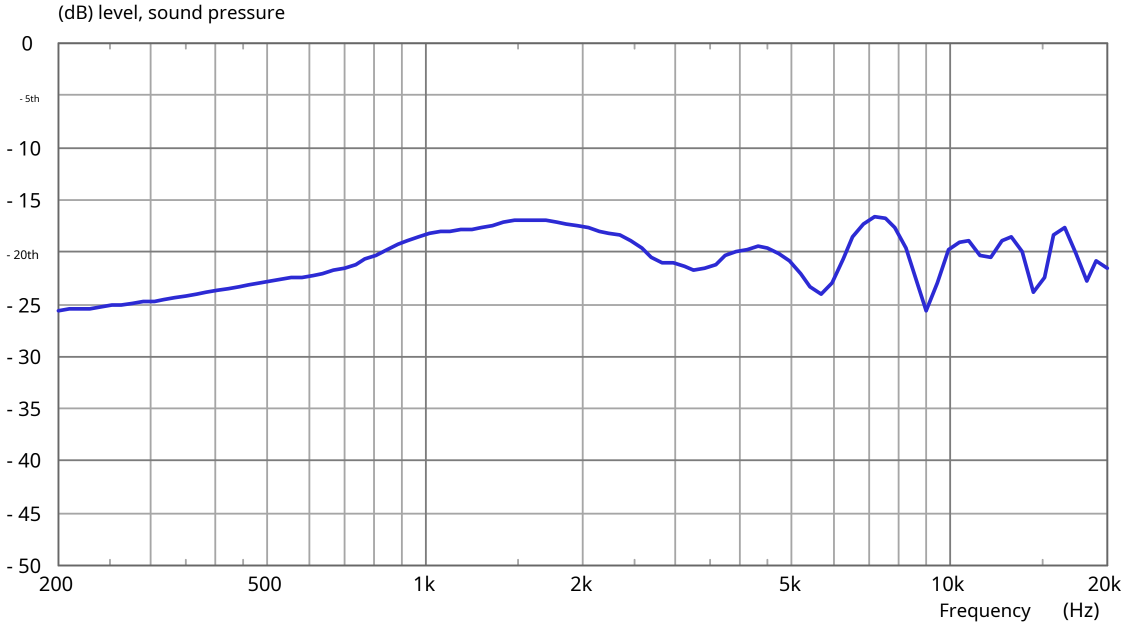
The interference pattern is practically equally pronounced at all angles. There is no weakening. This means that the angle itself has no significant effect on the amplitude of the secondary sound source. However, in these examples the ratio between the radii r1 and r2 and thus the wavelengths at which the minima and maxima occur changes.

There seems to be an ideal relationship between the radii. The largest area of an almost constant radiation behavior is at approx. 45 °. Larger distances (flatter angles) produce a dip below 0 ° (i.e. a widening of the radiation behavior) and smaller distances (steeper angles) have the opposite effect.

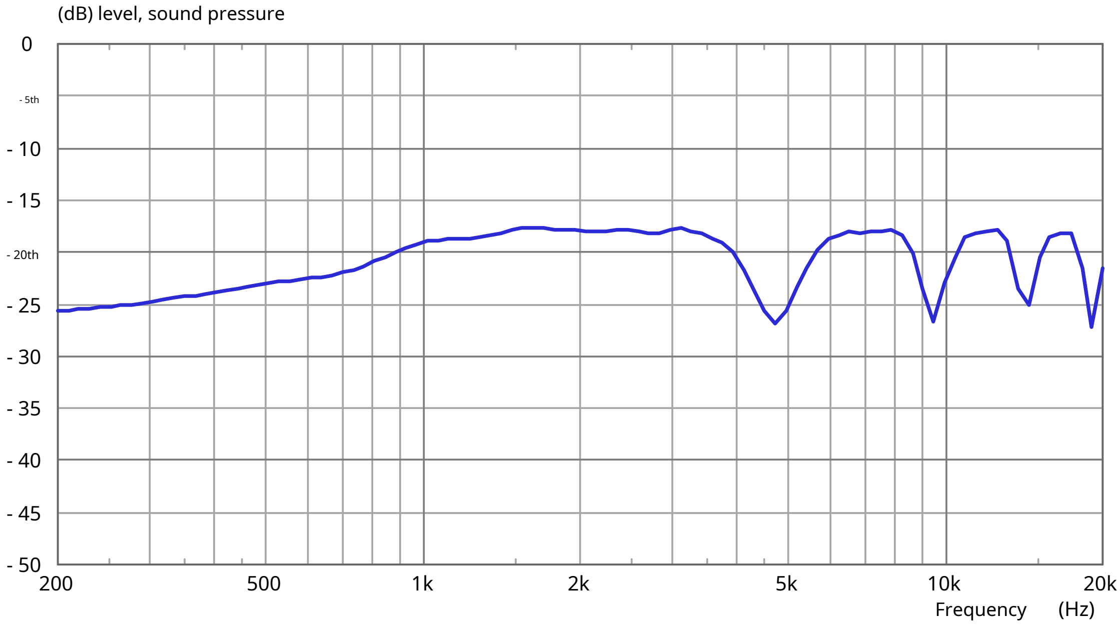
Variation of the running time

In the following, the radii r1 and r2 were kept constant and only the angle was changed. As a result, the difference in transit time between the secondary and tertiary sound sources varies. For the Ratio between the radii was -- = $\sqrt{}$ chosen.

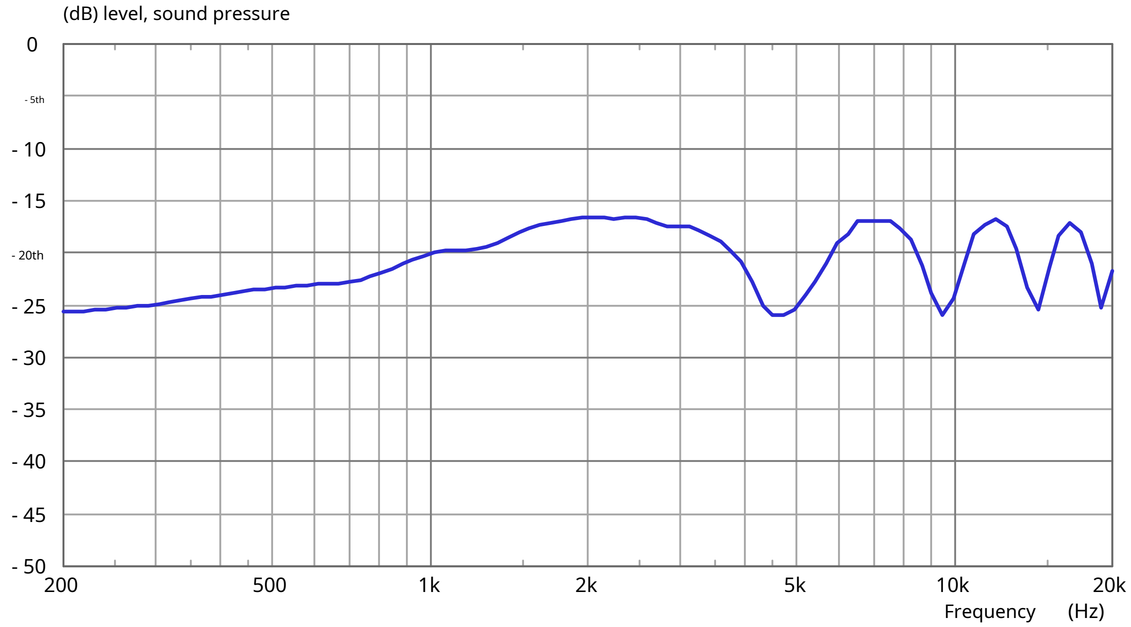
α = 20 °, t12 / t23 = 1.7:



α = 20 °, t12 / t23 = 1:



α = 70 °, t12 / t23 = 0.43:



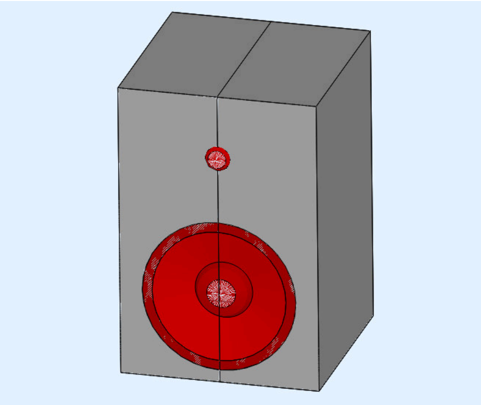
An optimal ratio seems to exist with identical runtime differences.

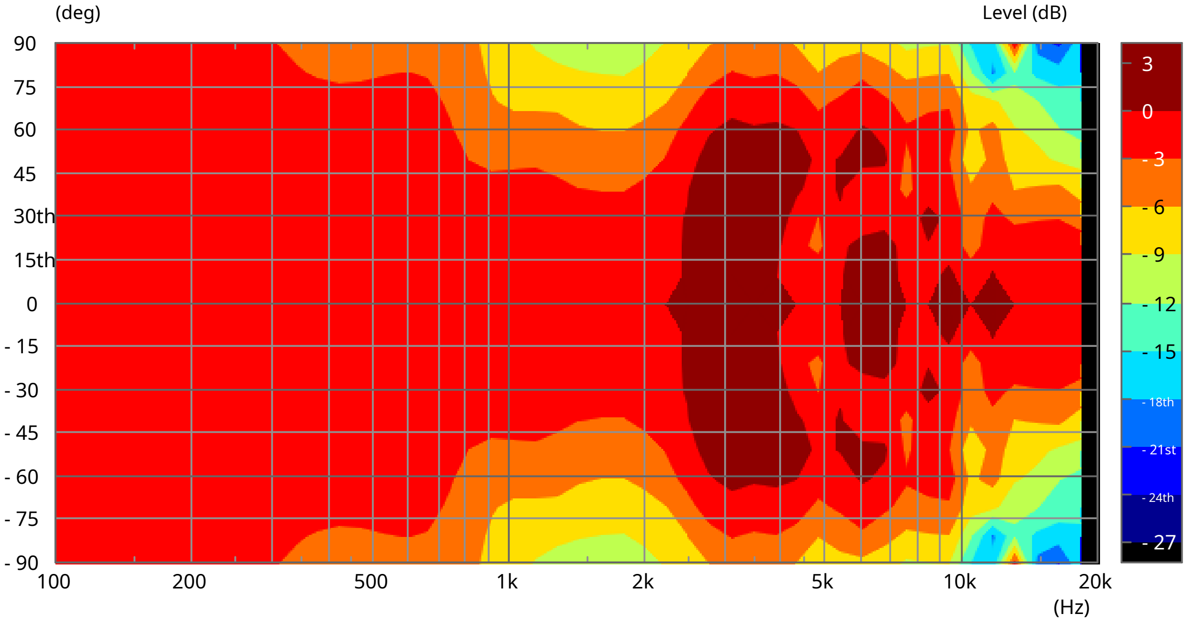
Example based on a 2-way

In the following, a 2-way driver with 6 "woofers and 1" tweeter was simulated. The housing dimensions were 20 x 30 x 20 cm (WxHxD). The crossover frequency was 1.8 kHz. The filter characteristic was Linkwitz-Riley 4th order.

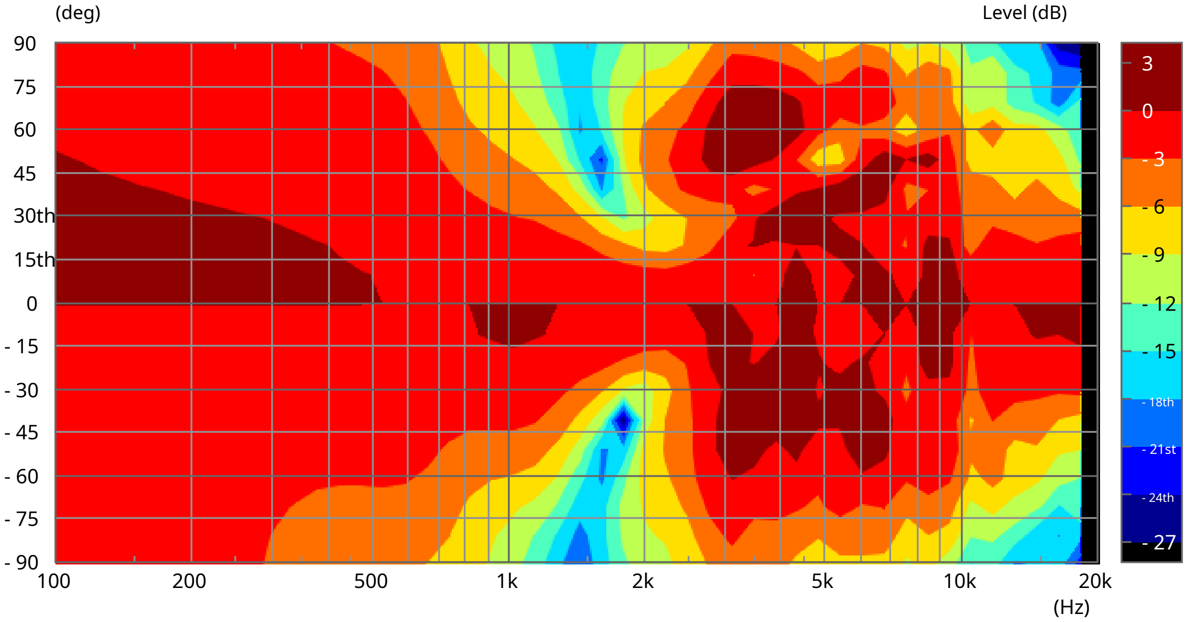
The horizontal and vertical radiation behavior is shown in each case.

Simple edge



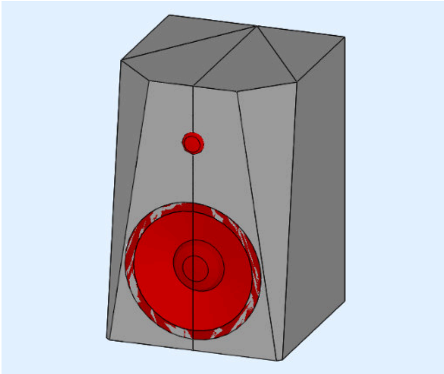


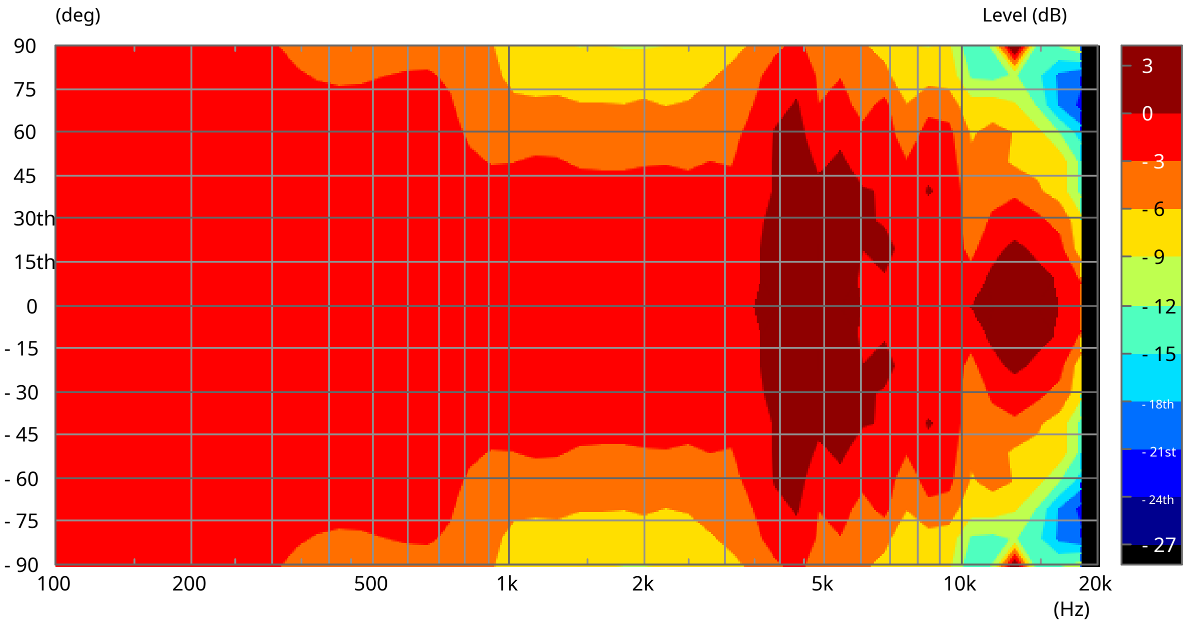
(deg)
Level (dB)
90
75
60
45
30th
15th
0
- 15
- 30
- 45
- 60
- 75
- 90
100
200
500
1k
2k
5k
10k
20k
(Hz)
3
0
- 3
- 6
- 9
- 12
- 15
- 18th
- 21st
- 24th
- 27



(deg)
Level (dB)
90
75
60
45
30th
15th
0
- 15
- 30
- 45
- 60
- 75
- 90
100
200
500
1k
2k
5k
10k
20k
(Hz)
3
0
- 3
- 6
- 9
- 12
- 15
- 18th
- 21st
- 24th
- 27

chamfer




(deg)
Level (dB)
90
75
60
45
30th
15th
0
- 15
- 30
- 45
- 60
- 75
- 90
100
200
500
1k
2k
5k
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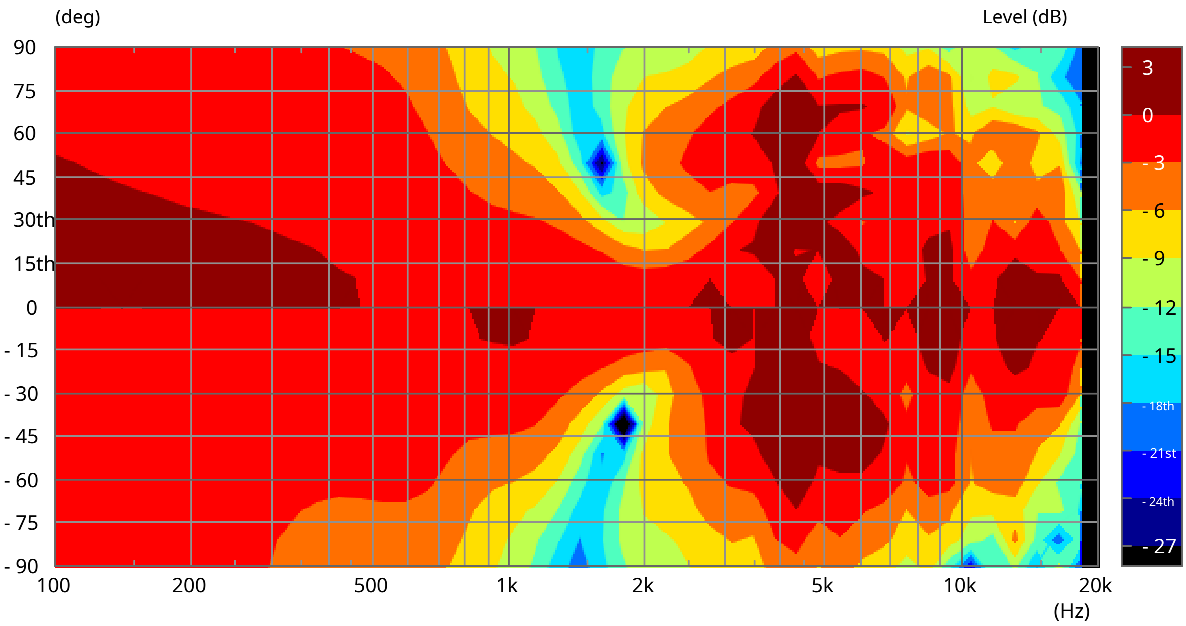
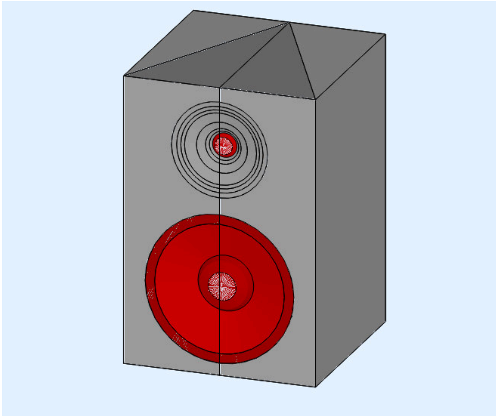
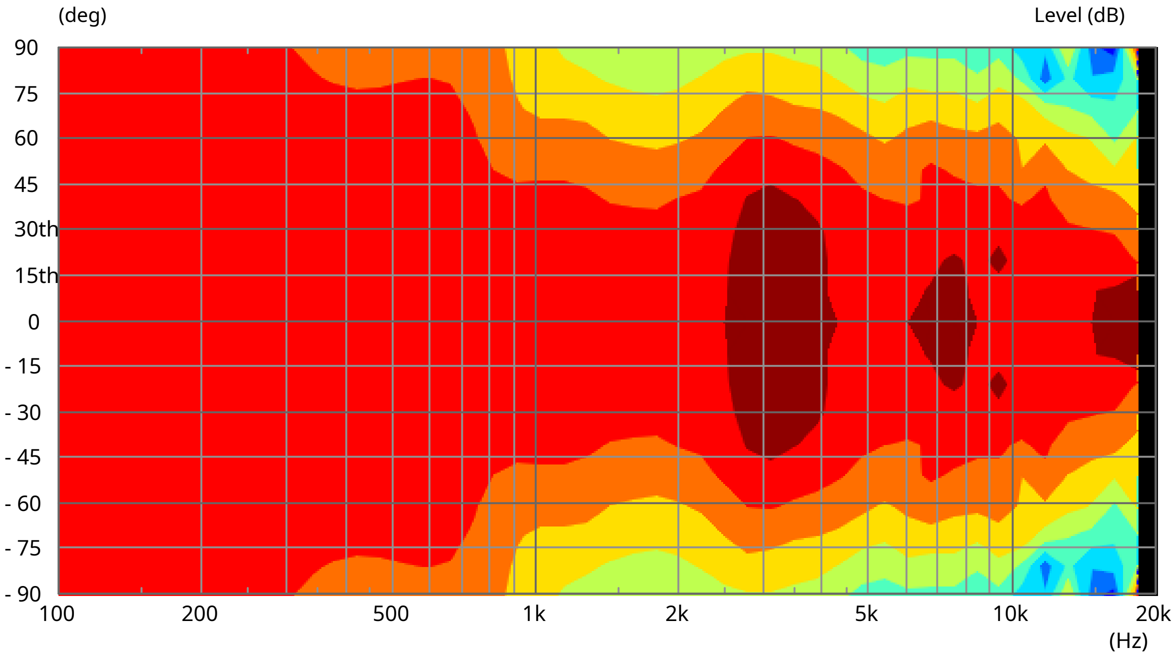
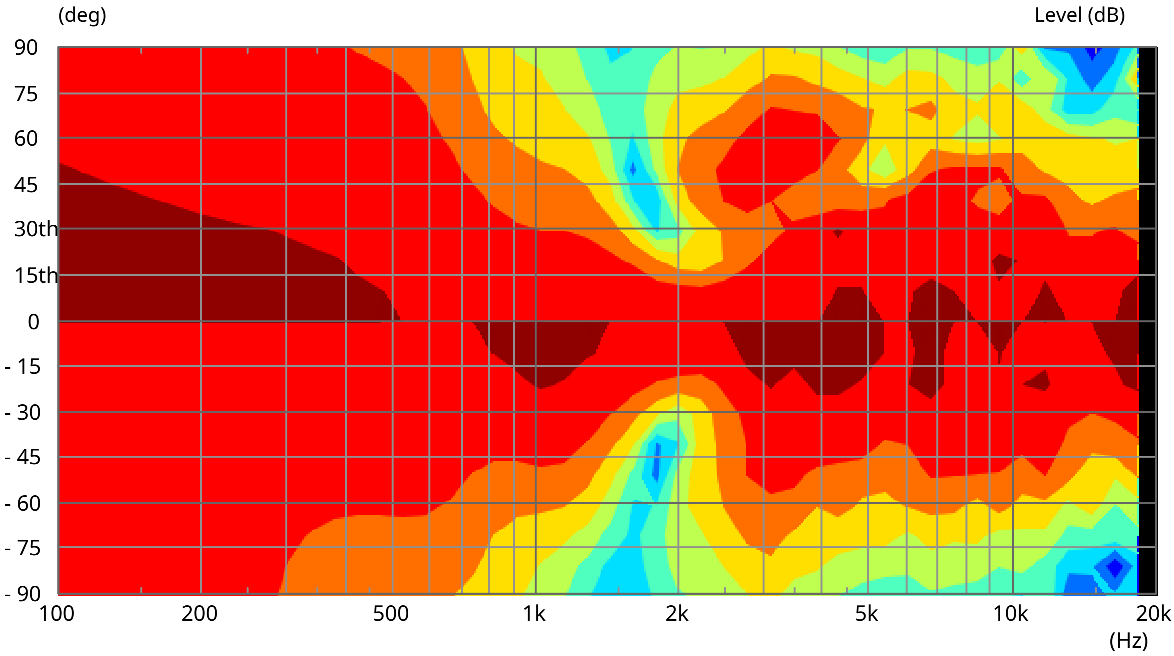
20k
(Hz)
3
0
- 3
- 6
- 9
- 12
- 15
- 18th
- 21st
- 24th
- 27


(deg)
Level (dB)
90
75
60
45
30th
15th
0
- 15
- 30
- 45
- 60
- 75
- 90
100
200
500
1k
2k
5k
10k
20k
(Hz)
3
0
- 3
- 6
- 9
- 12
- 15
- 18th
- 21st
- 24th
- 27

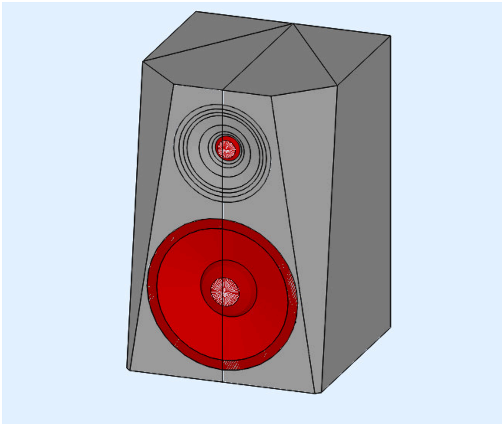
Waveguide and simple edge

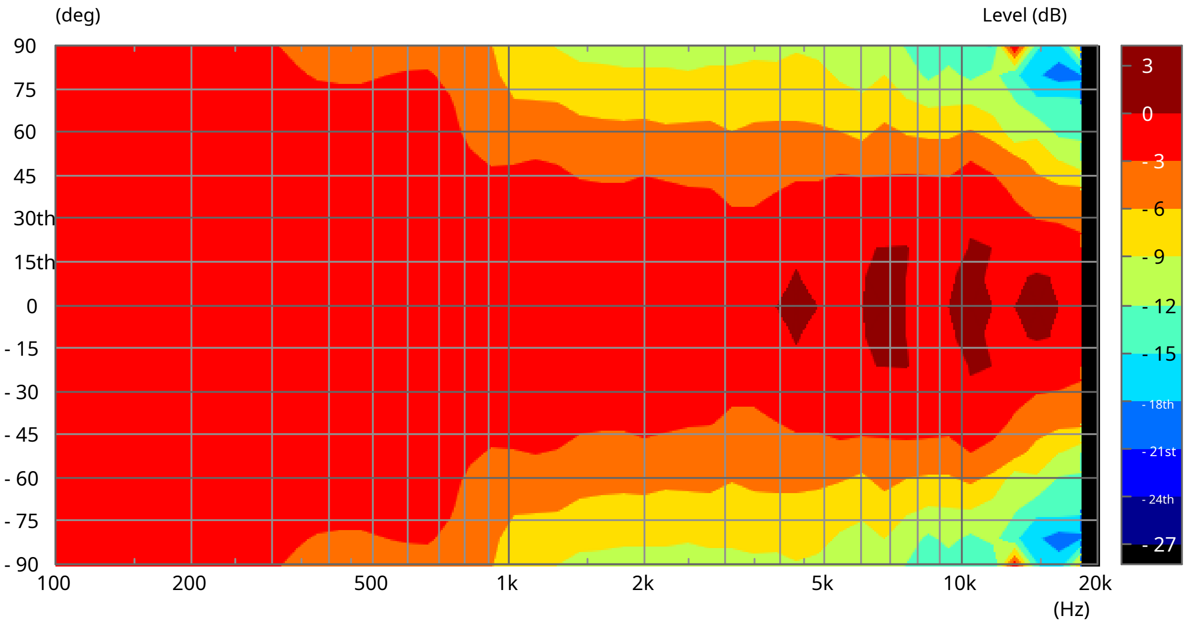


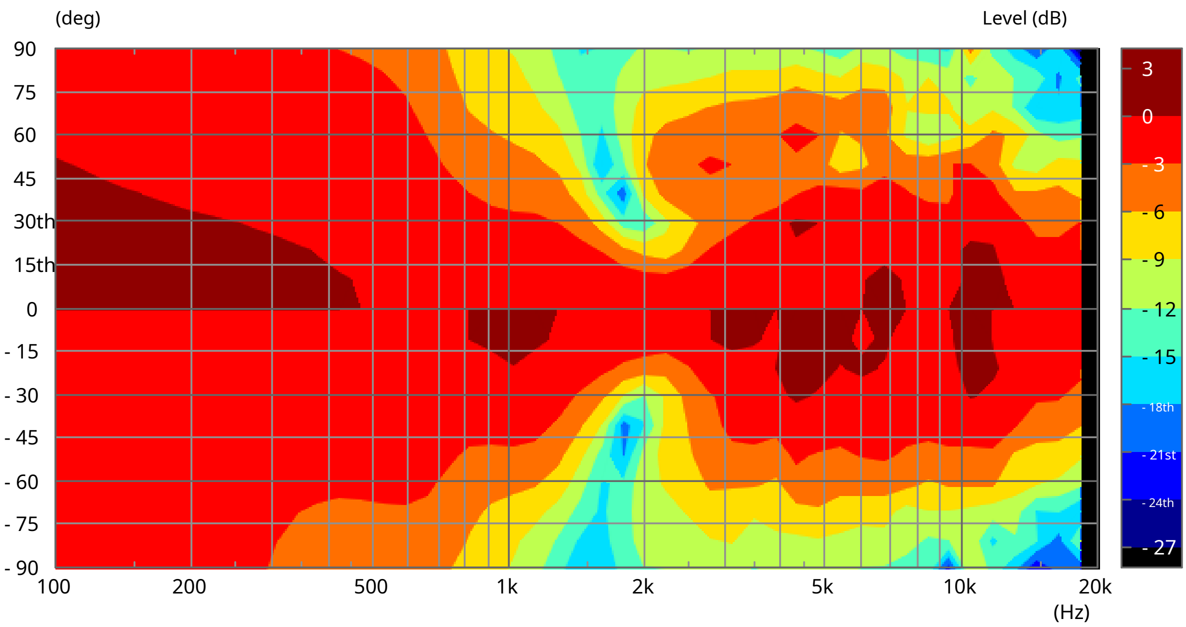




Waveguide and bevel







Conclusion

While both the rounding and the bevel reduce the effective baffle, this effect is much more pronounced with the bevel. Furthermore, only the rounding weakens the amplitude of the secondary sound sources and thus the interference. It is therefore always necessary to investigate precisely which measure is better for a particular concept.

The effects of sound sources which themselves have a directional effect (large membrane or horn / waveguide) were not considered in this document. It should be noted, however, that these are very effective in attenuating secondary sound sources.