

# Variants of the Double Bass Array

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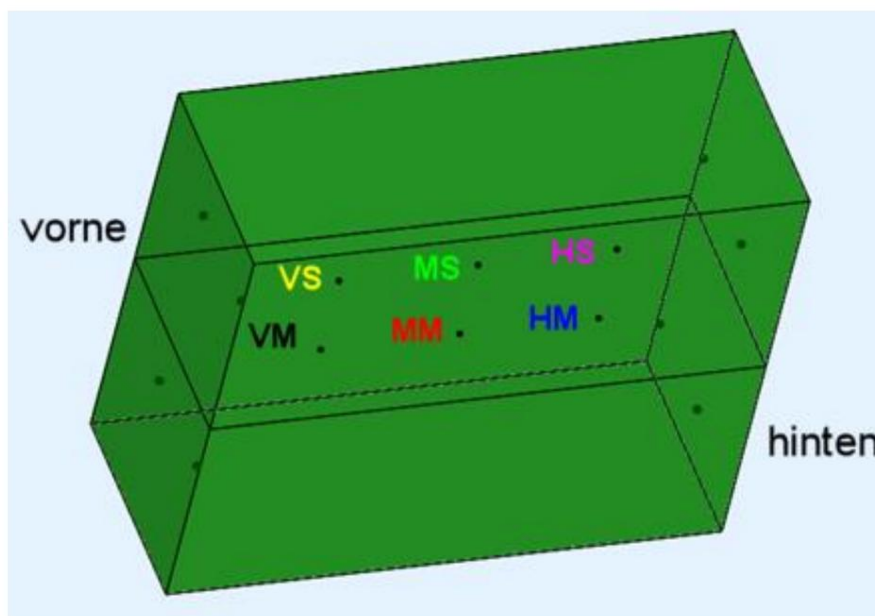
## 2. Motivation

The aim is to investigate whether a double bass array can be reduced in such a way that its function is only minimally affected. The goal is to find alternative arrangements that save costs and can be integrated into non-optimal spaces. For example, if a door is the ideal position of a driver blocked.

## 3. Simulation

The simulations were performed with ABEC. The virtual room measures 6 x 4.8 x 2.2 m.

The measurement positions were 1.5, 3 and 4.5 m from the front wall and doubled again at 1 m from the center towards the side wall. So there are a total of six measuring points.



Colors of the measurement positions in the amplitude response:

- **Black:** Front center
- **Yellow:** Front side
- **Red:** center center
- **Green:** mid-page
- **Blue:** Center back
- **Purple:** Back side

Room modes (up to 120 Hz):

- **Length:** 29 Hz, 57 Hz, 86 Hz
- **Width:** 36Hz, 71Hz, 107Hz
- **Treble:** 71Hz

A front bass grille and a rear bass grille are modeled from ideal point sound sources.

The rear is inverted and delayed. The delay corresponds to the transit time of the sound

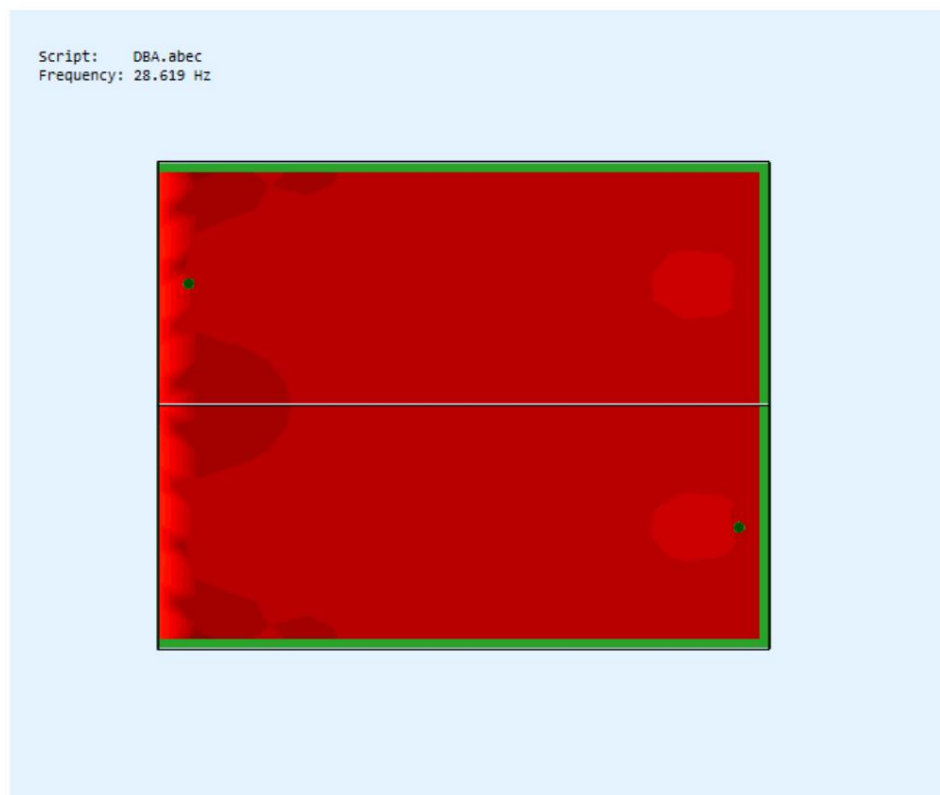
needed to pass the room length. Furthermore, the signal from the rear grille is slightly attenuated to compensate for the low wall attenuation.

In the following, the two grids will not always be symmetrical. In these cases, the sound pressure level of the rear grille has been adjusted to match that of a symmetrical arrangement. If, for example, only half as many drivers are working at the rear as at the front, they are fed with twice the signal level.

In addition, a flat high pass was connected in front of all woofers, which simulates the drop of a closed subwoofer. This compensates for the strong increase to low frequencies of the interface reinforcement ("pressure chamber effect") and produces amplitude responses that are relatively close to reality.

In each simulation, it was checked whether the 1st longitudinal mode really no longer has any effects in the entire room. For this purpose, the sound pressure level was shown as a sonogram (top view).

In the following, this diagram is not published for every simulation because differences were practically non-existent. The variances are extremely small across the entire space.



**Figure 1: 28 Hz for a double bass array**

For comparison, a sonogram in which only the front grid is active. The strong expression of the 1. Longitudinal mode is clearly visible. This is also noticeable as an increase in the amplitude response.

Script: DBA.abec  
Frequency: 28.619 Hz

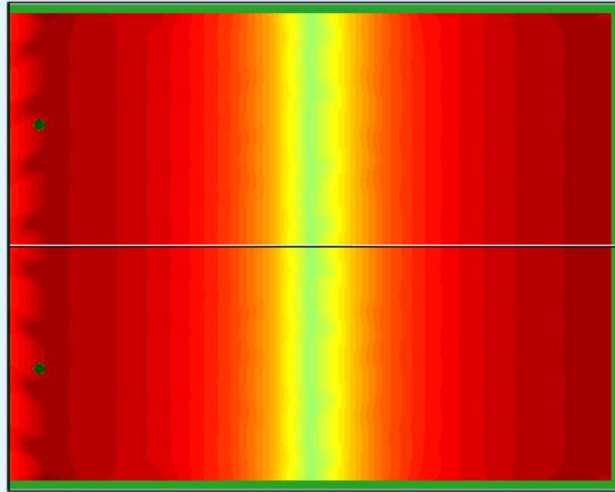
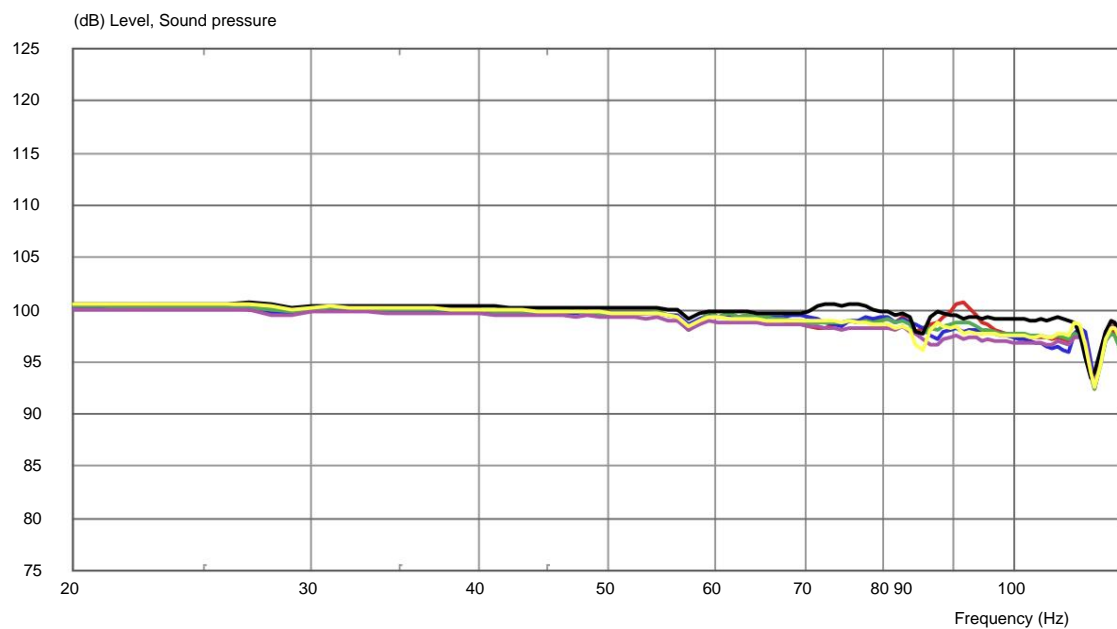
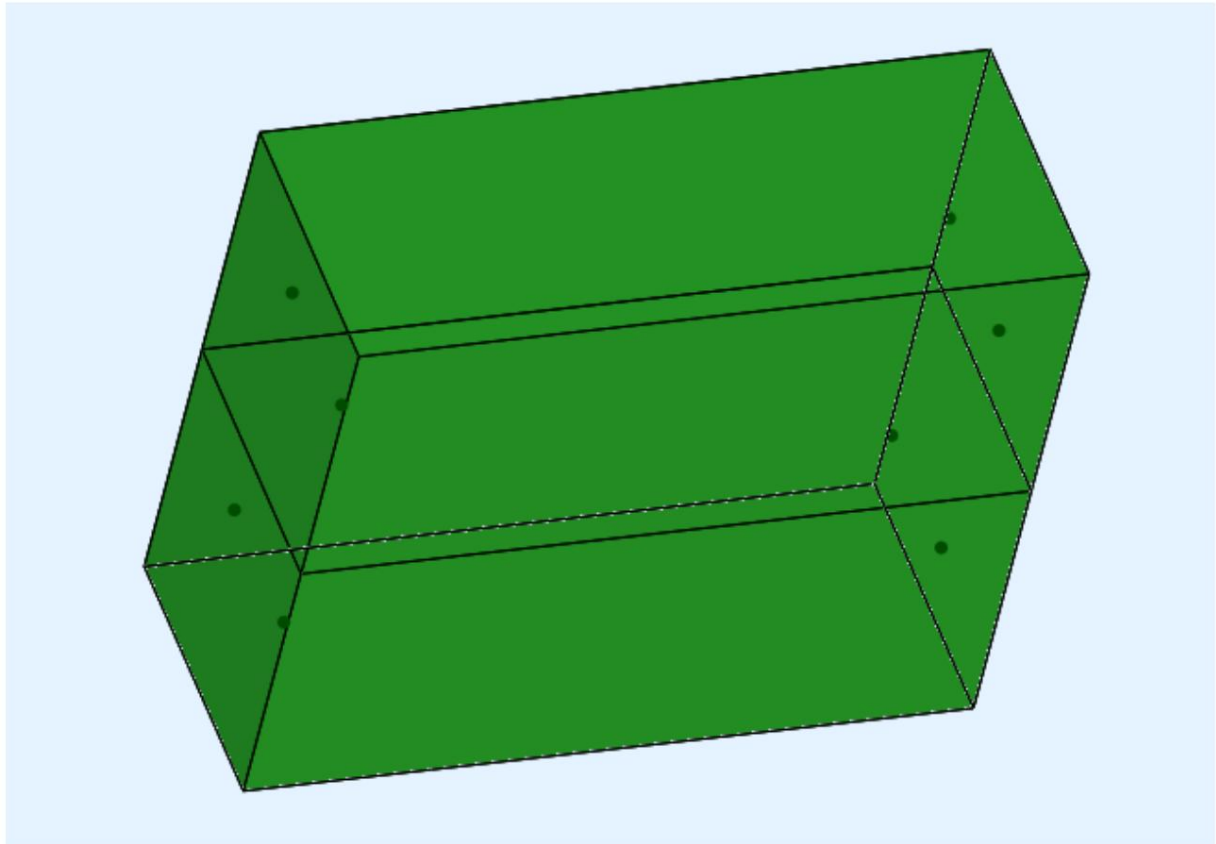


Figure 2: 28 Hz with active front grid (undamped SBA)

## 4. Mono-DBA

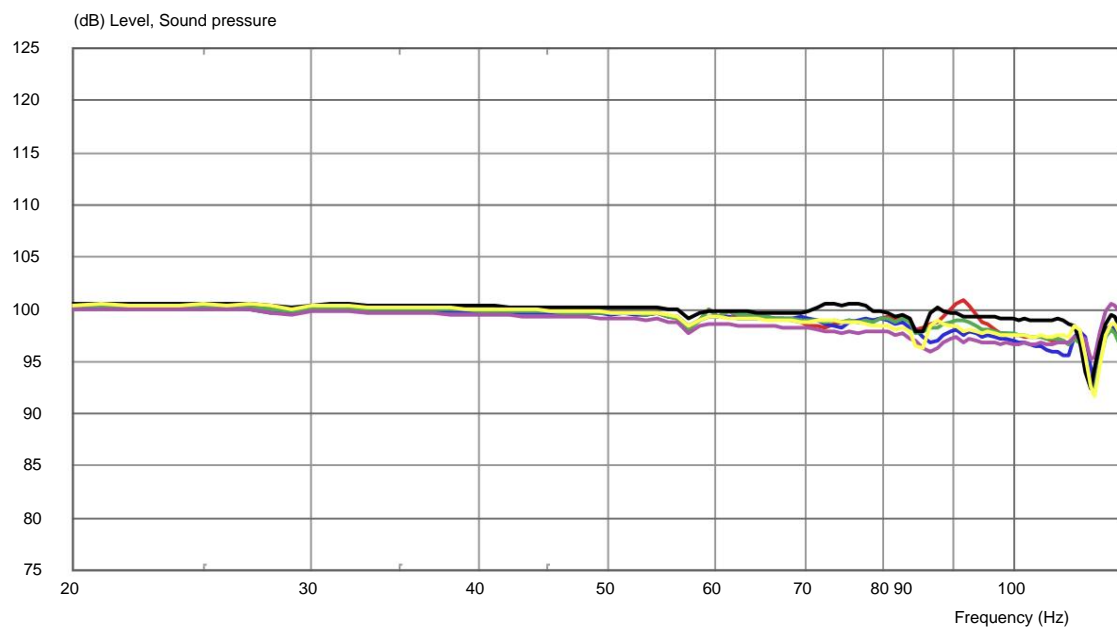
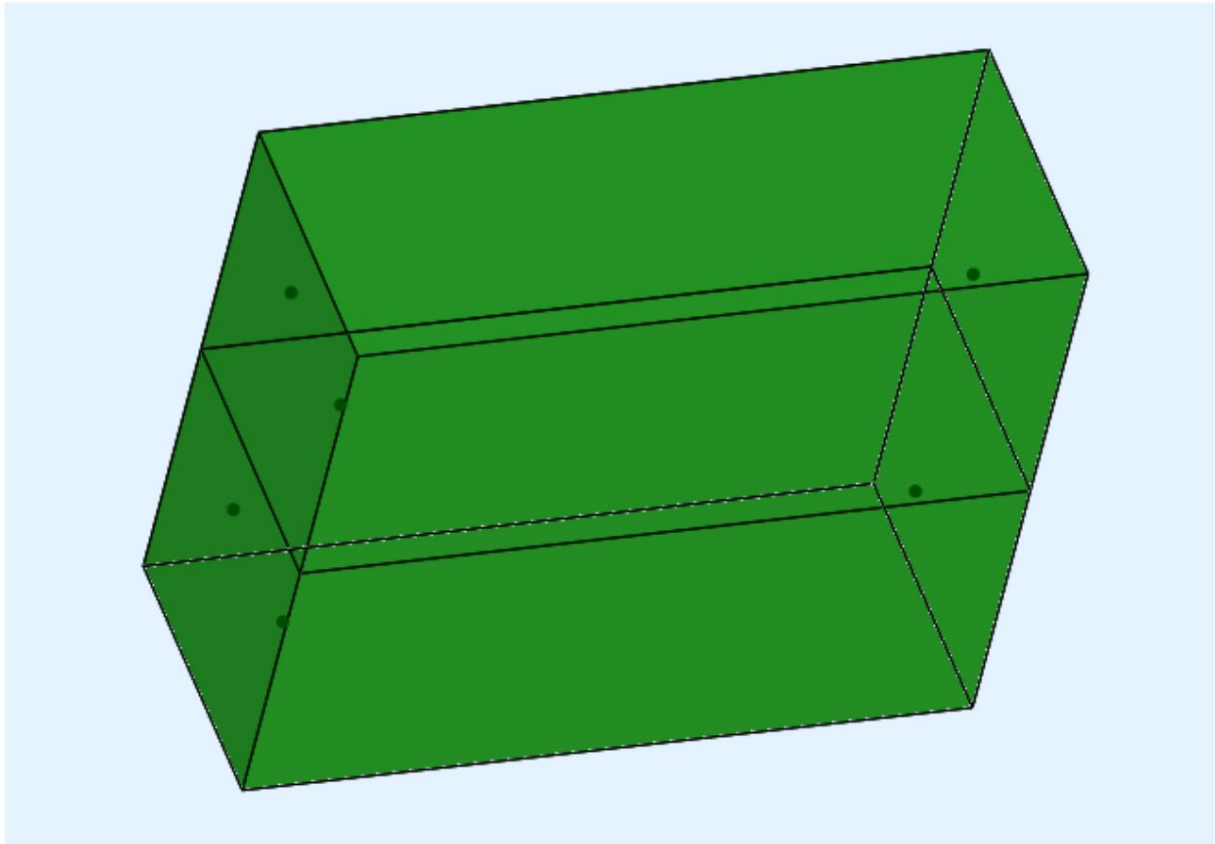
### 4.1. 4 drivers per grid

This simulates the typical DBA arrangement with four drivers per grid at  $\frac{1}{4}$  and  $\frac{3}{4}$  of the width Height.



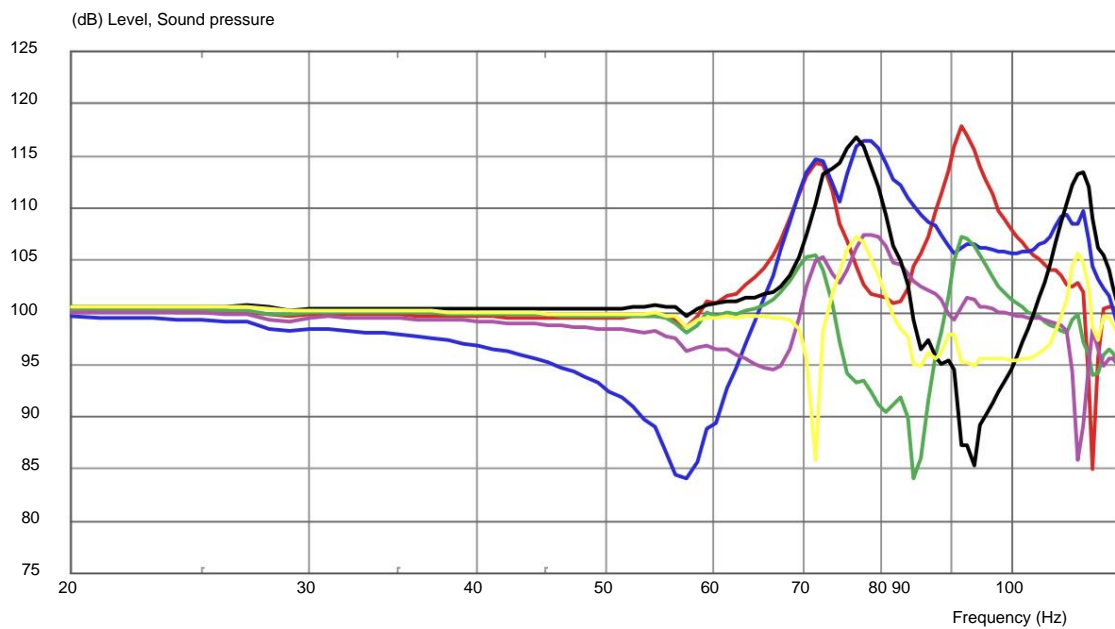
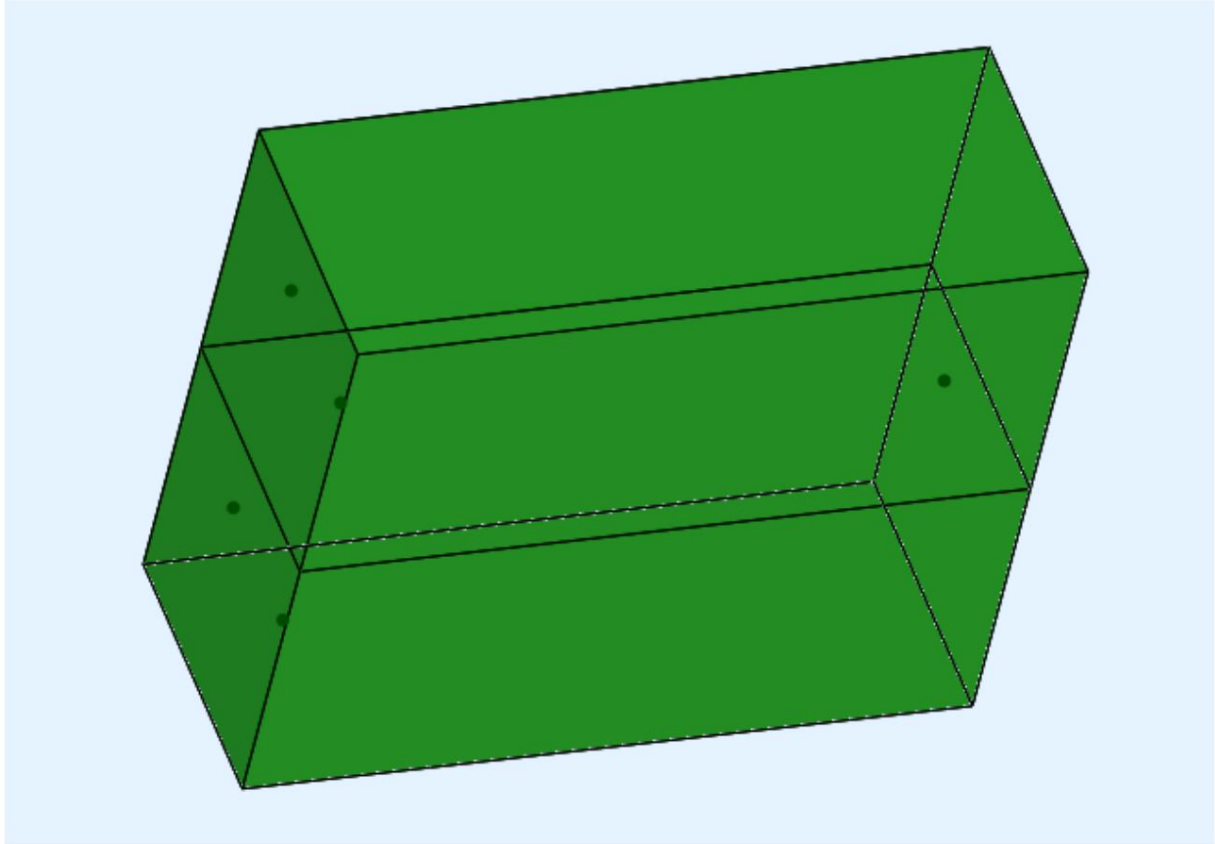
#### 4.2. 4 drivers at the front, 2 drivers at the back

The rear grille was halved and the subwoofers positioned at  $\frac{1}{2}$  the height of the room.



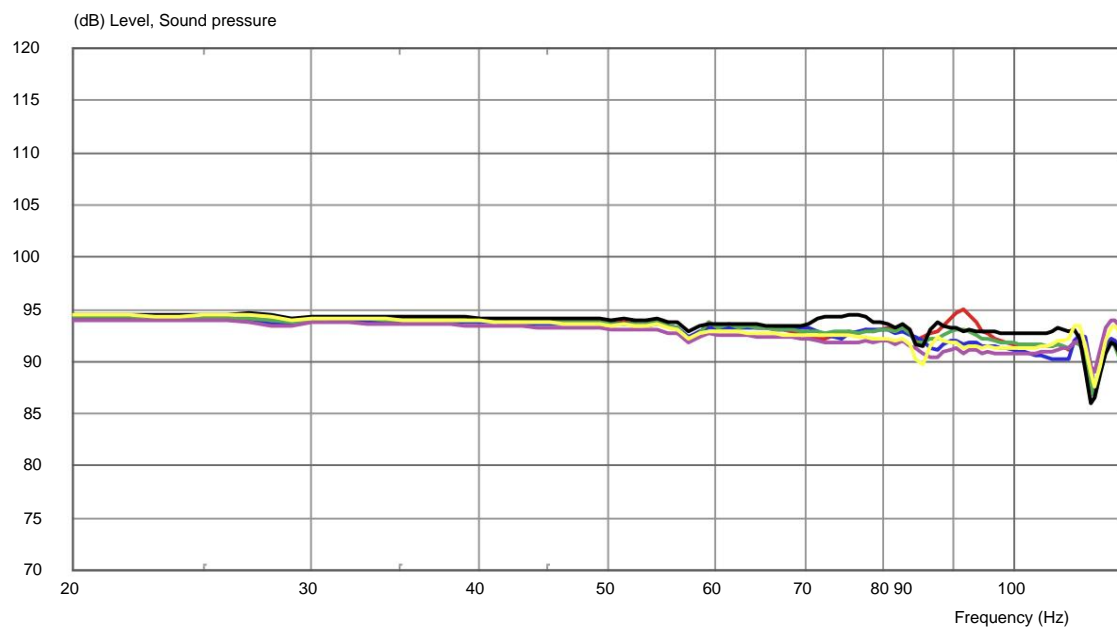
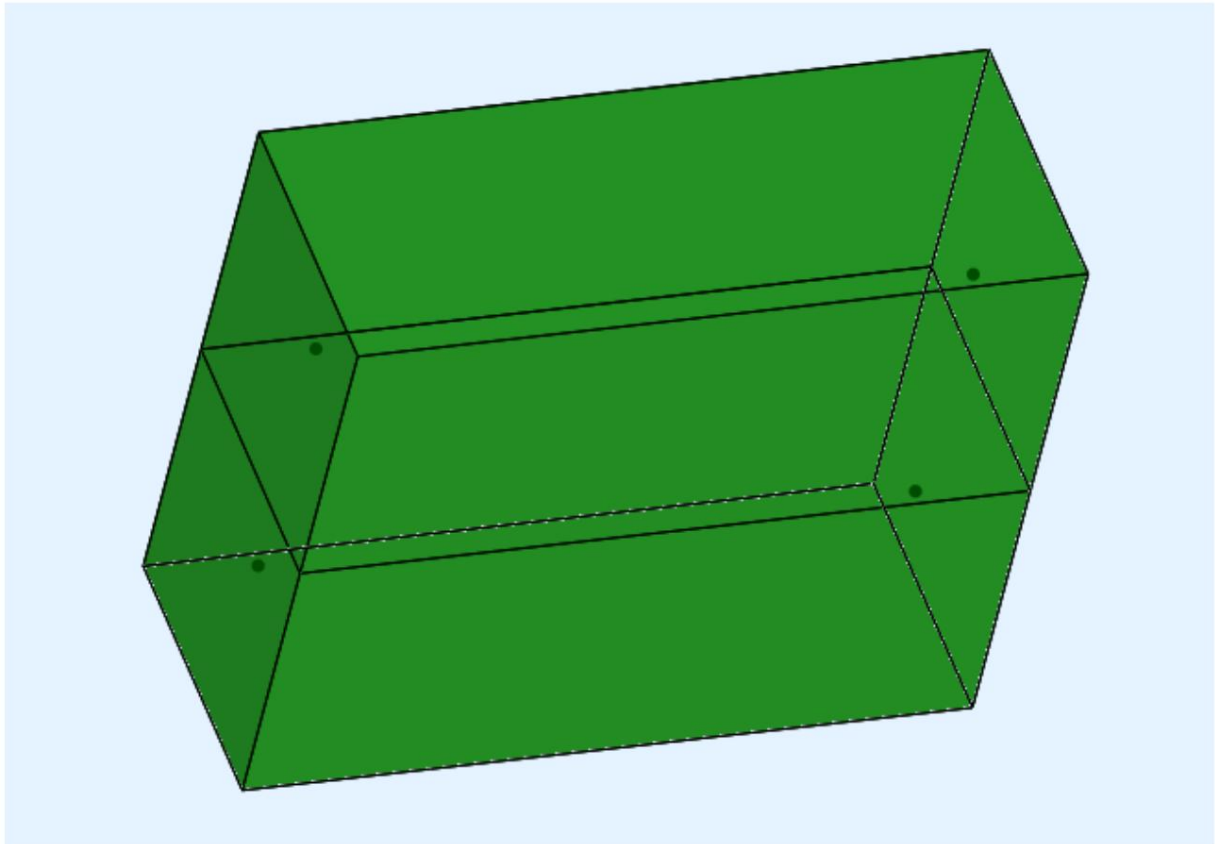
#### 4.3. 4 drivers at the front, 1 at the back

The rear grille has been further reduced to a driver that expands to  $\frac{1}{2}$  the wall width and – height.



#### 4.4. 2 drivers per grid at $\frac{1}{2}$ the height

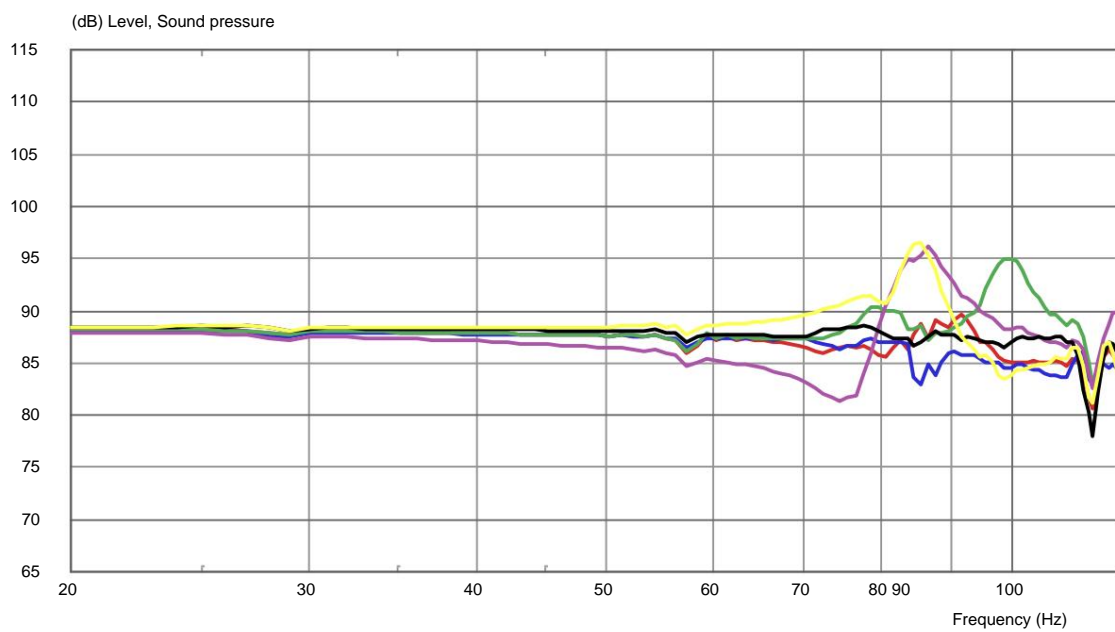
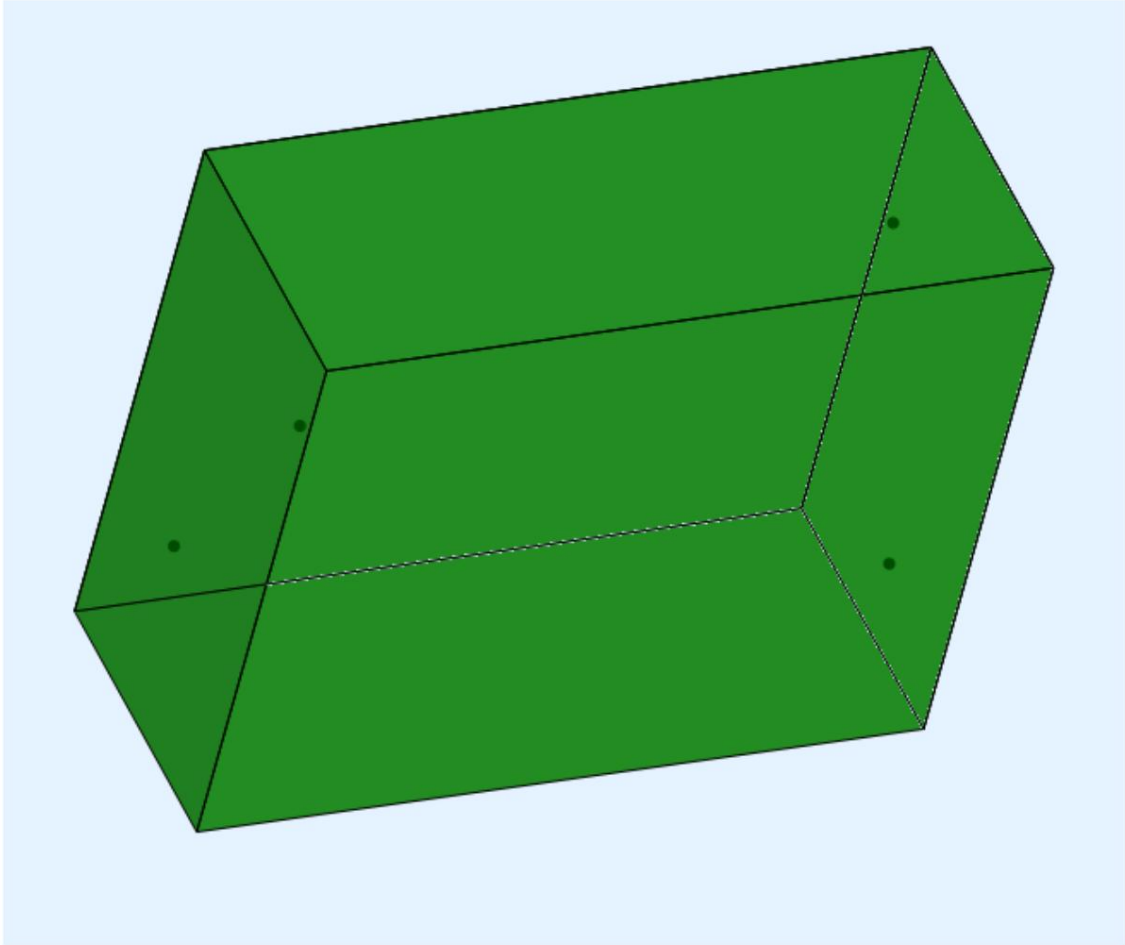
Both grilles were halved and the drivers positioned at  $\frac{1}{2}$  the height of the room.





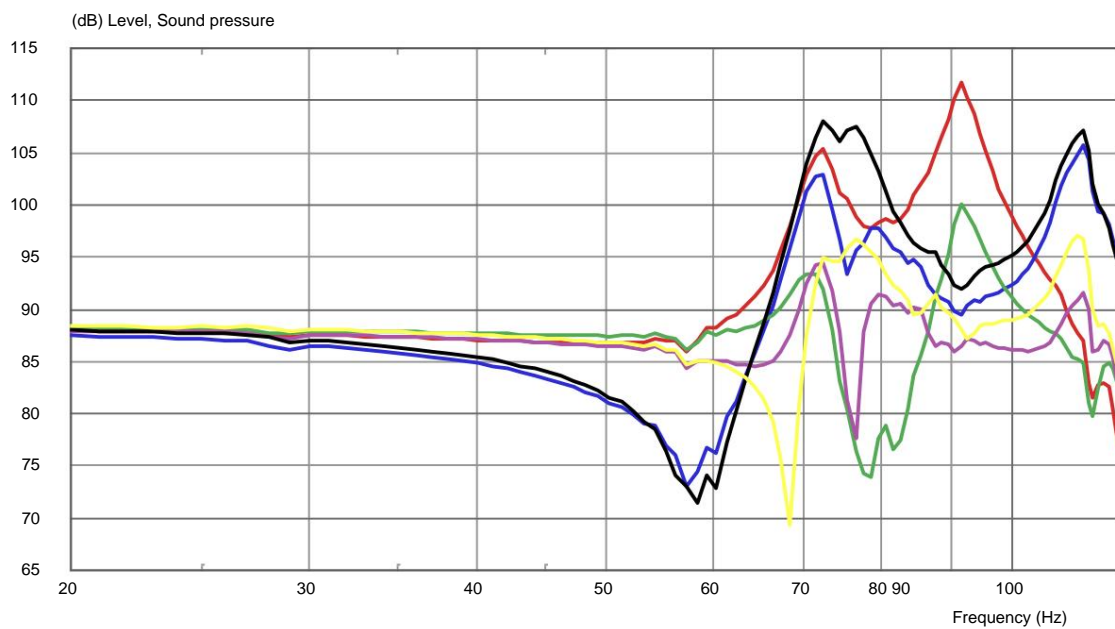
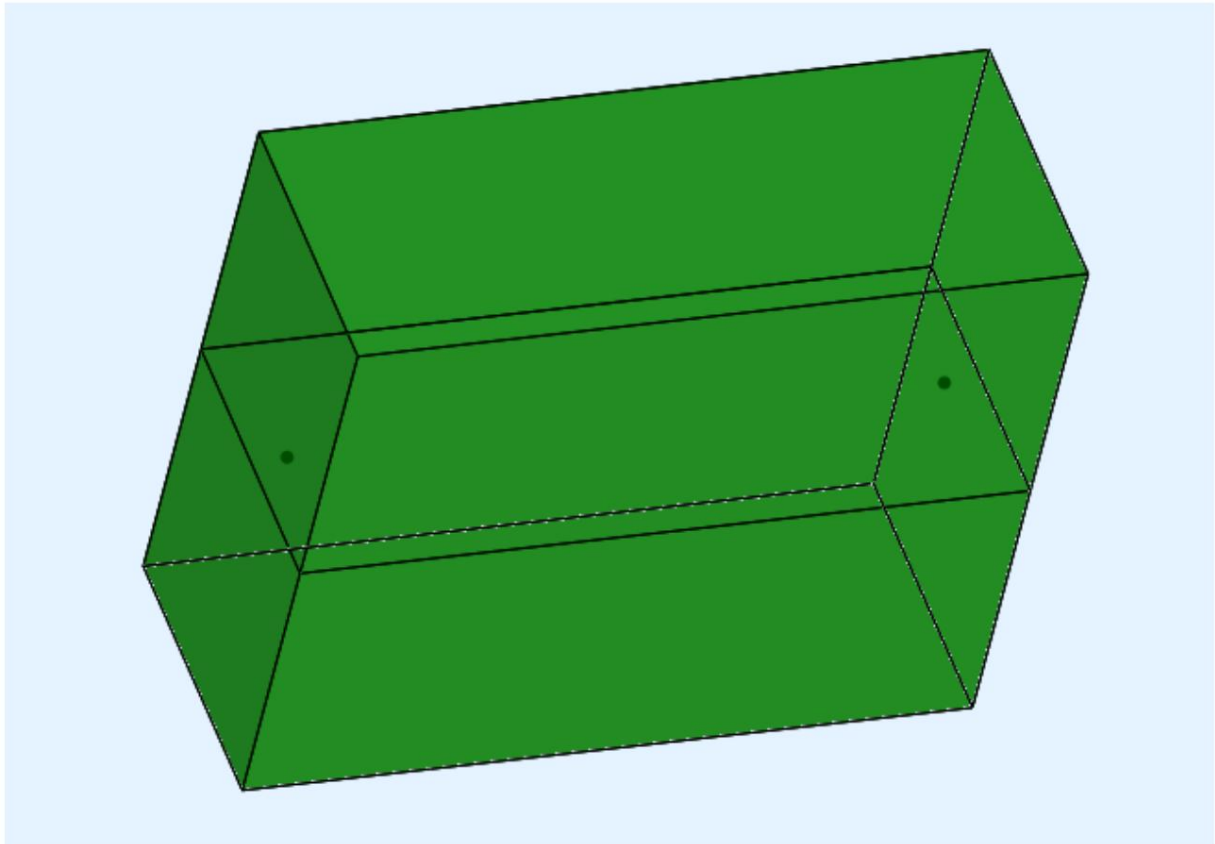
#### 4.5. 2 drivers per grid on $\frac{1}{4}$ and $\frac{3}{4}$

The drivers are now installed at  $\frac{1}{4}$  and  $\frac{3}{4}$  of the room width and height. The rear grid is point-symmetrical to the front one.



#### 4.6. 1 driver per grid in the middle of the wall

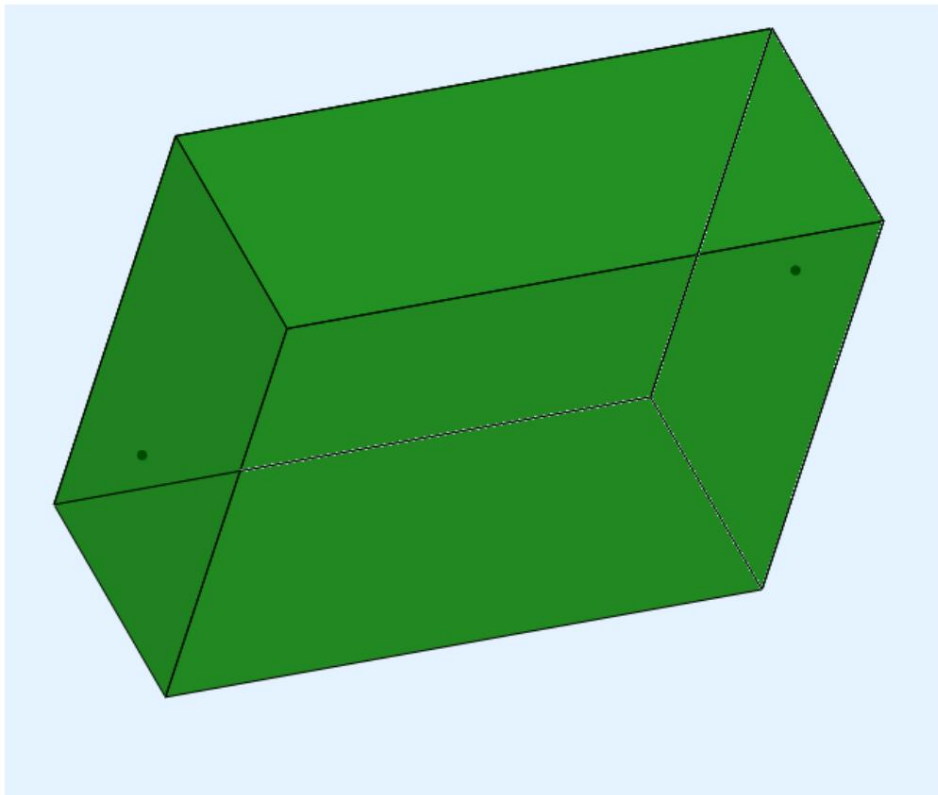
Both grilles have been reduced to one driver located at  $\frac{1}{2}$  the wall width and height.

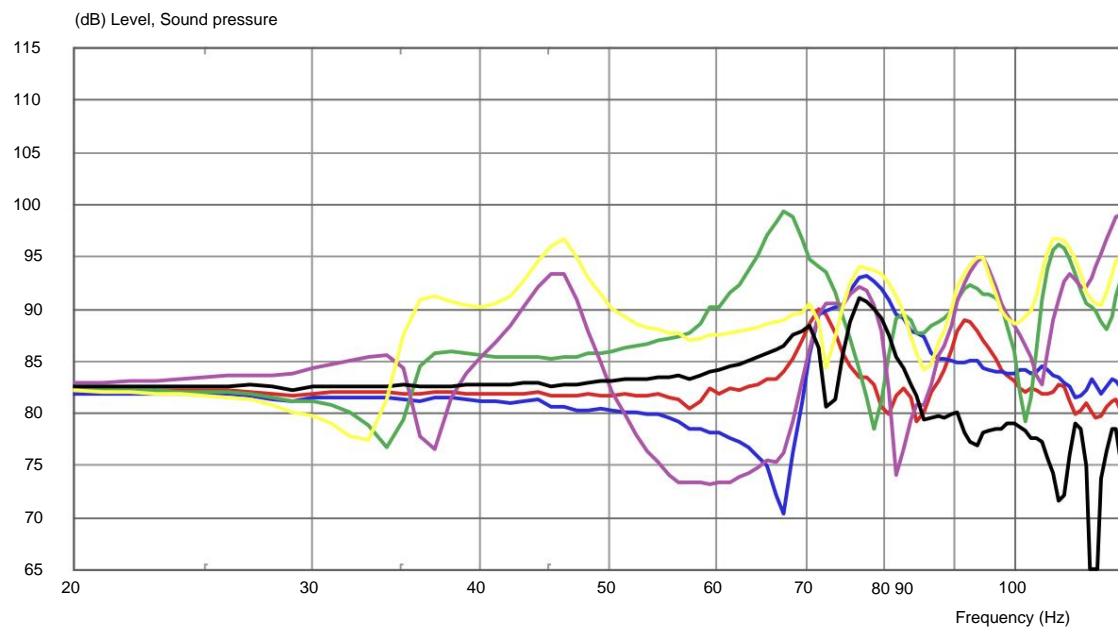


## 5. Stereo-DBA

For stereophony it can make sense to also reproduce the bass in stereo. This is not possible with the arrangements that are optimized for monaural bass. The following simulations each contain only one driver per grid, arranged on one side in terms of width.

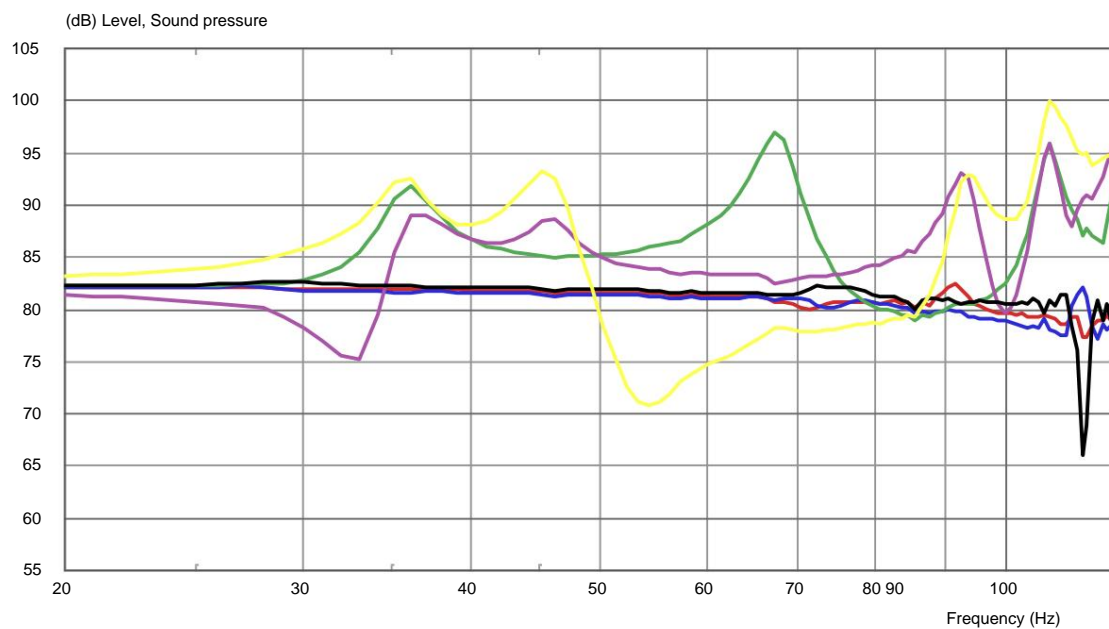
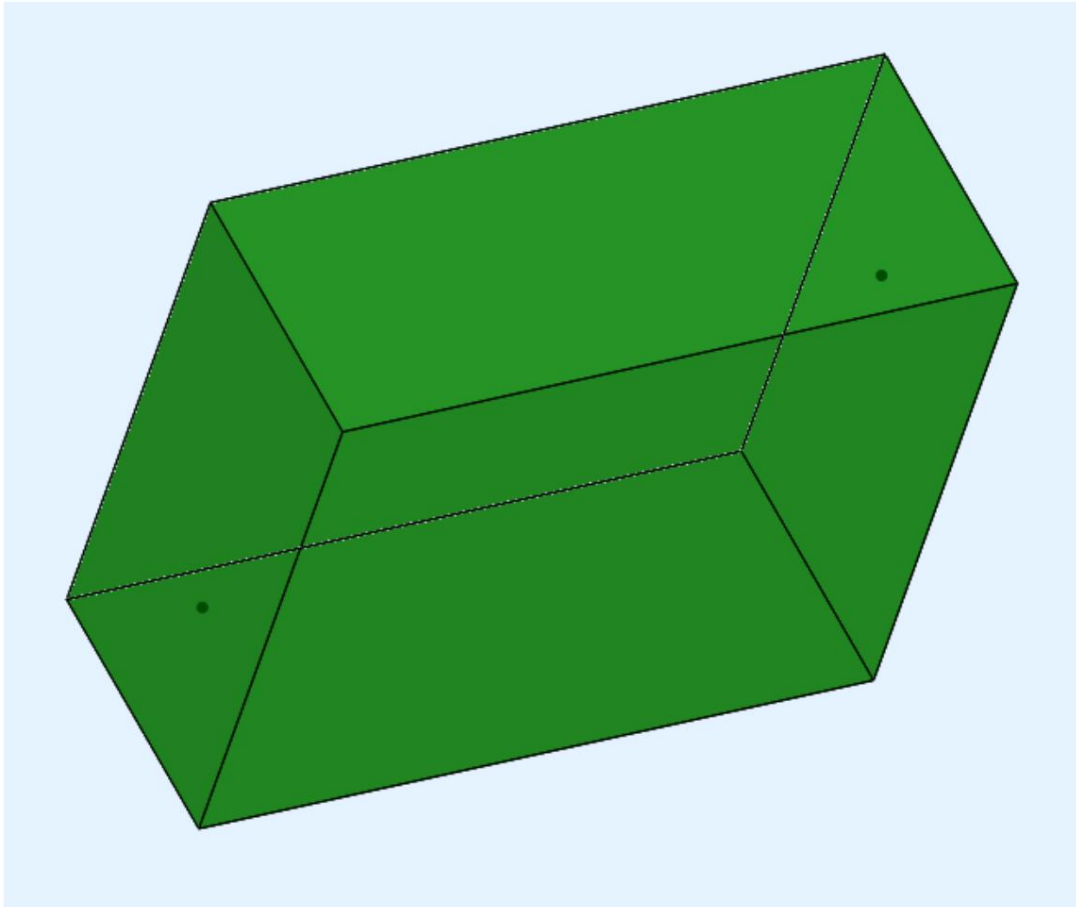
**5.1. 1 driver per grid at  $\frac{1}{4}$  and  $\frac{3}{4}$**  The two drivers are positioned at  $\frac{1}{4}$  and  $\frac{3}{4}$  of the room width and height. The rear grille is point-symmetrical to the front one.





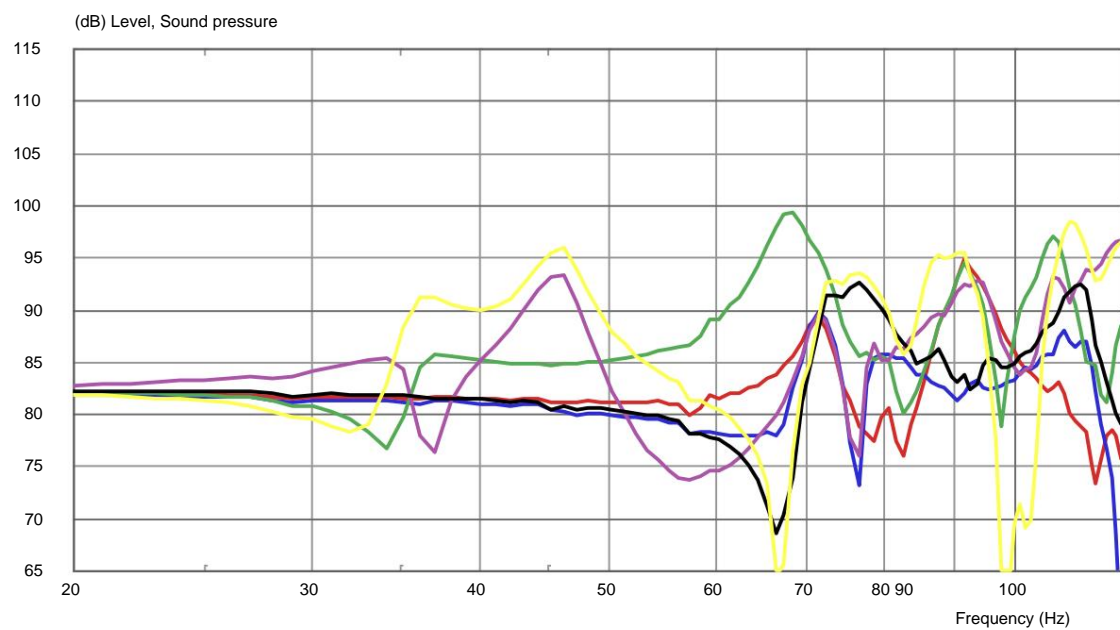
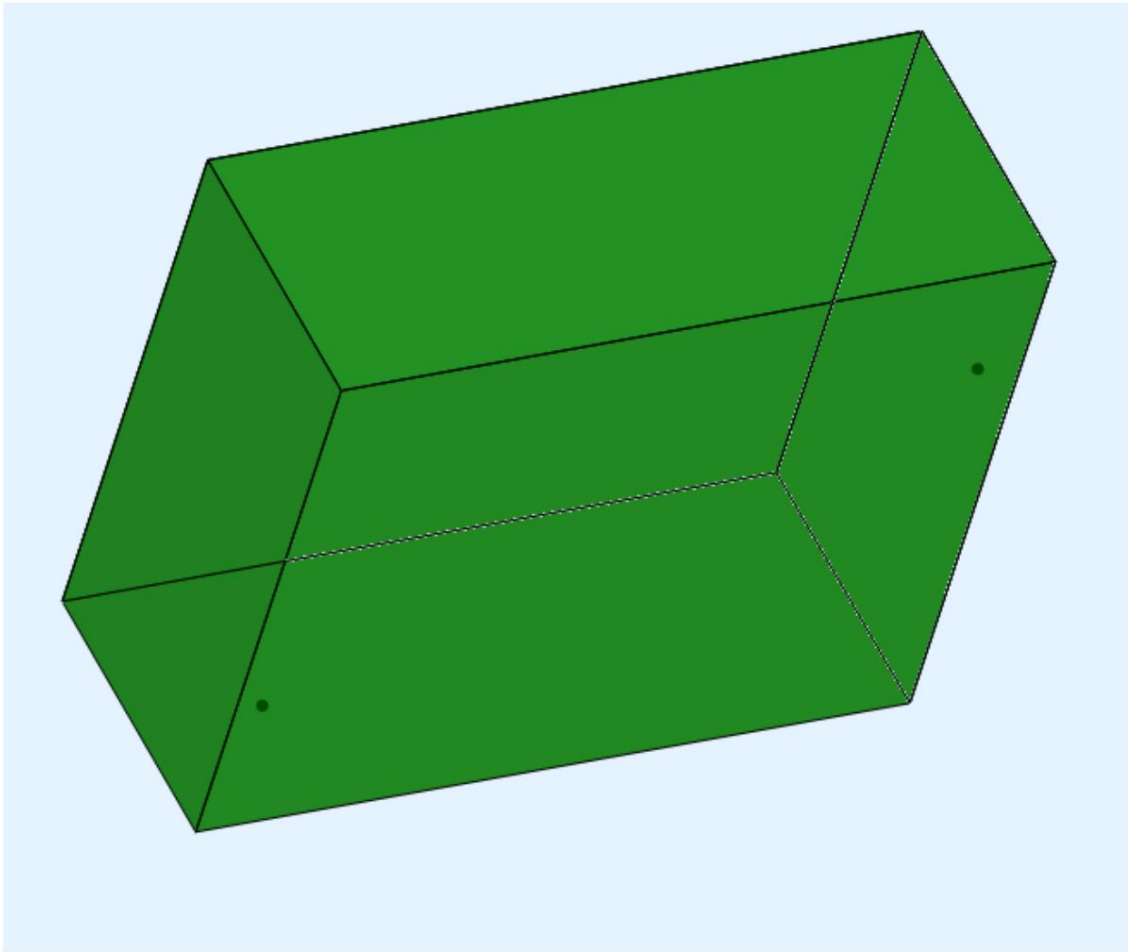
## 5.2. 1 driver per grid at $\frac{1}{2}$ the height

The two drivers are positioned at  $\frac{1}{4}$  and  $\frac{3}{4}$  of the room width and at  $\frac{1}{2}$  the room height. So there is point symmetry with respect to the width. The corridor in which the DBA functions is relatively narrow. Outside the longitudinal axis, the linear distortions increase sharply.



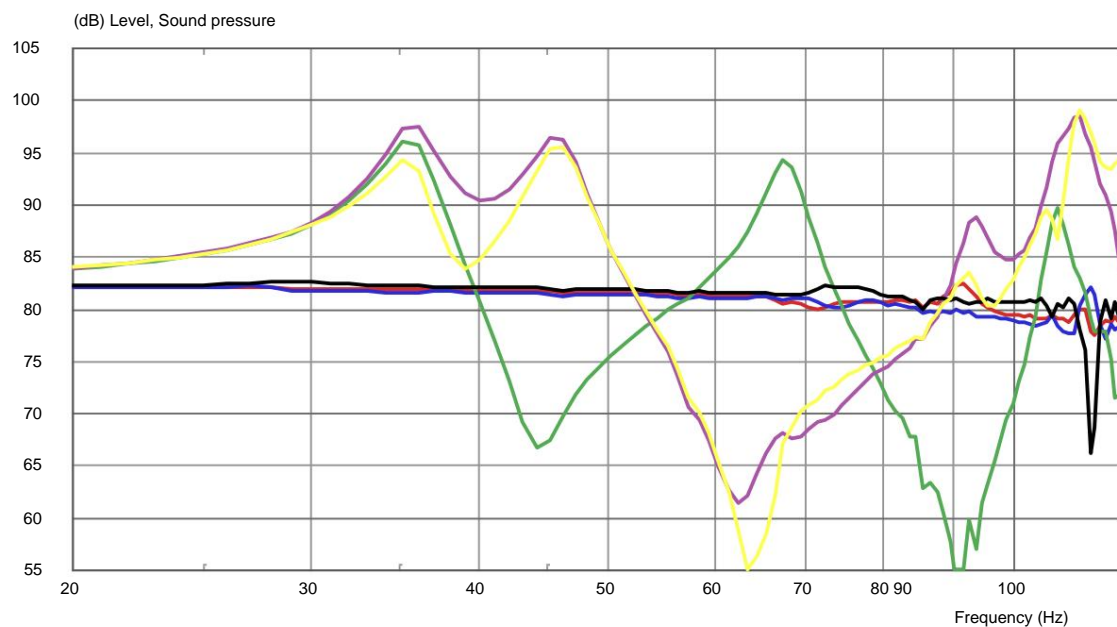
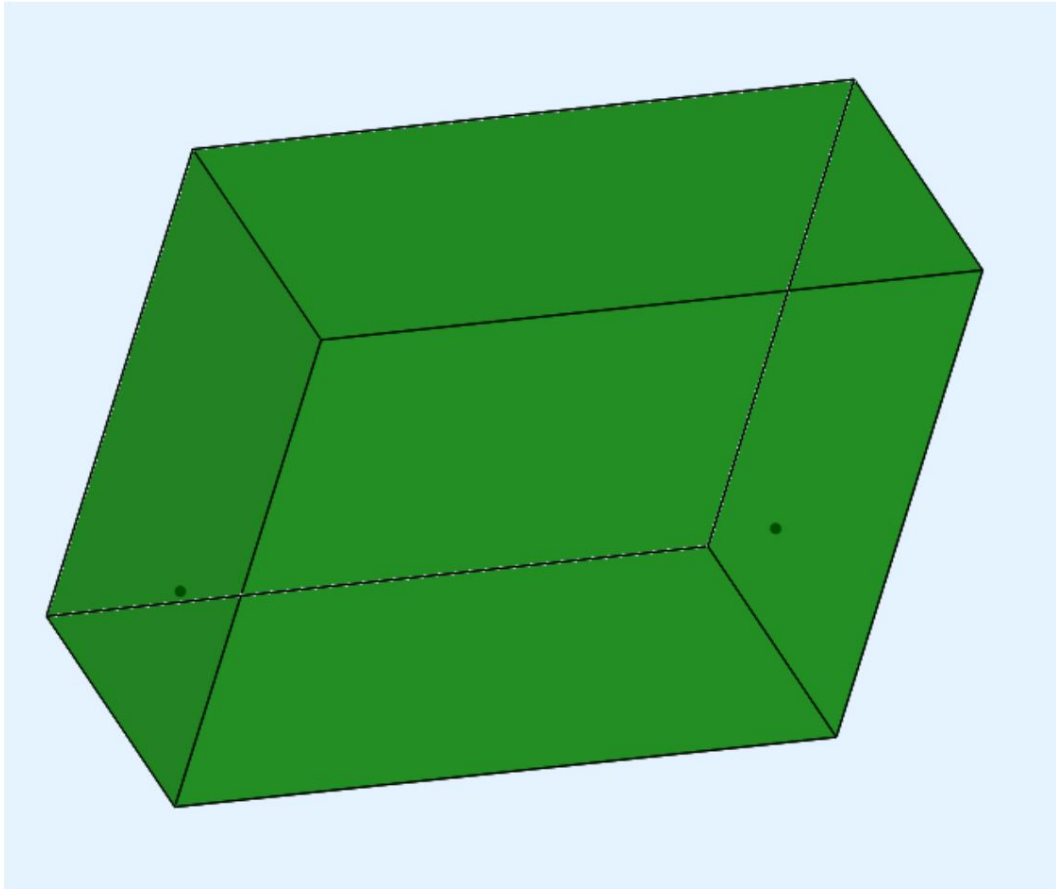
### 5.3. 1 driver per grid on the floor

Here both drivers are on the floor and  $\frac{1}{4}$  and  $\frac{3}{4}$  of the room width.



#### 5.4. 1 driver per grid on $\frac{1}{4}$ and $\frac{1}{2}$

Here both drivers are located at  $\frac{1}{2}$  the room height and  $\frac{1}{2}$  the room width. Both drivers are placed in the same half with respect to width. The corridor in which the DBA functions is relatively narrow. Outside the longitudinal axis, the linear distortions increase sharply.



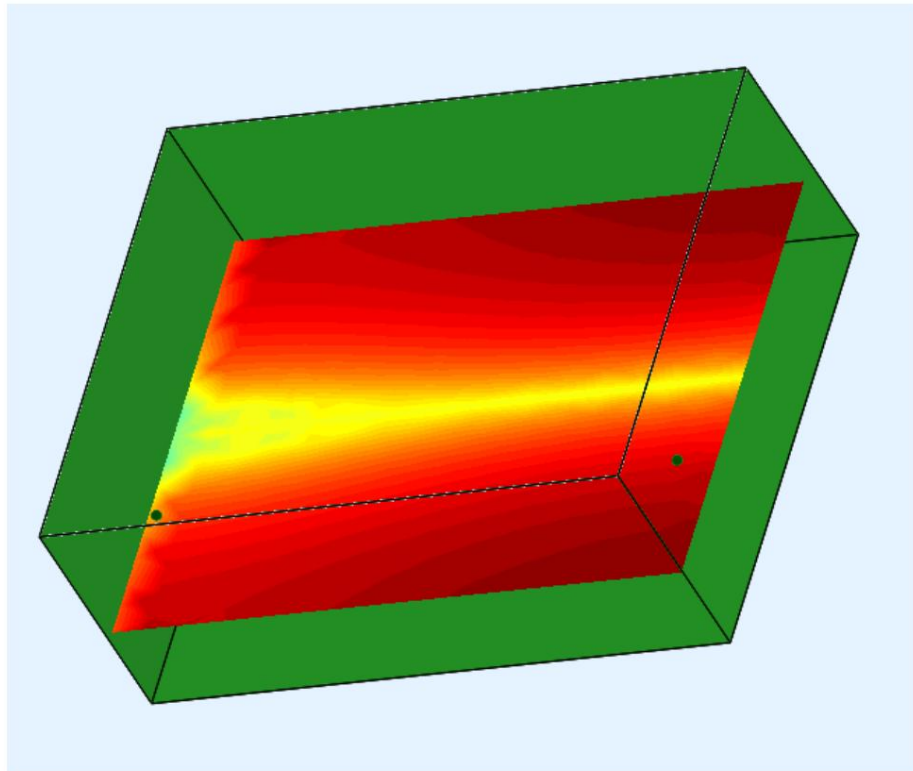


Figure 3: Sound pressure level at 35 Hz

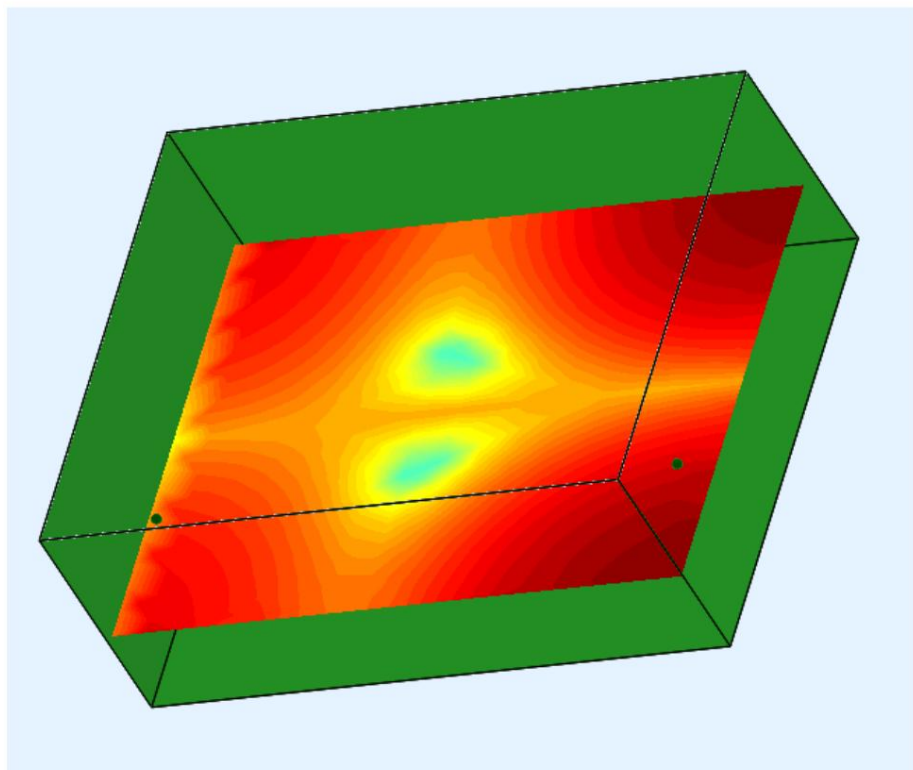


Figure 4: Sound pressure level at 40 Hz

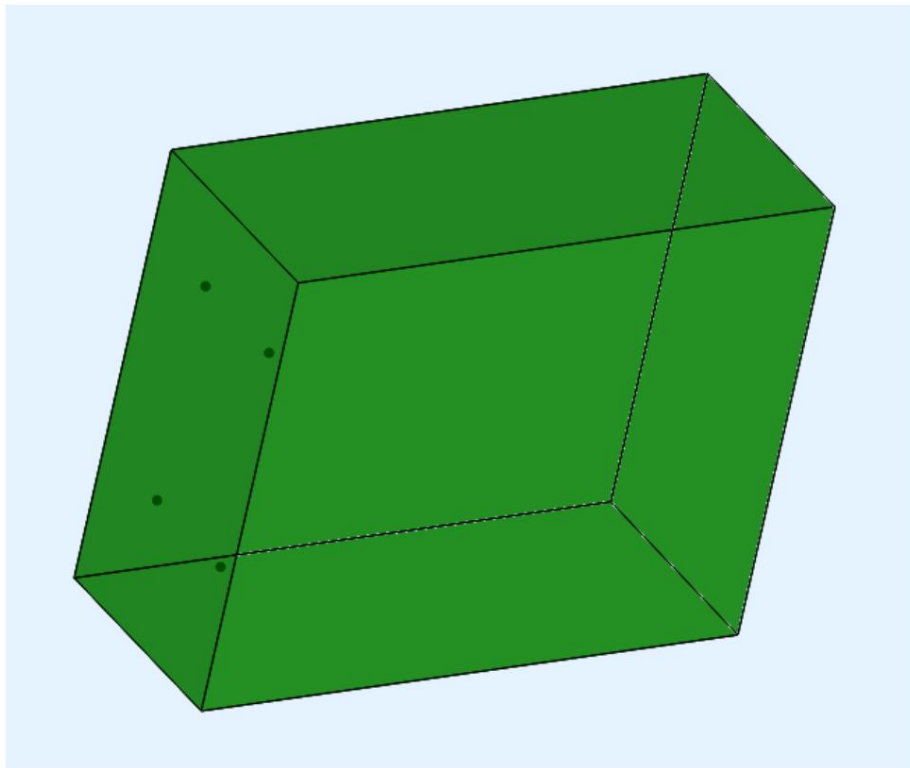


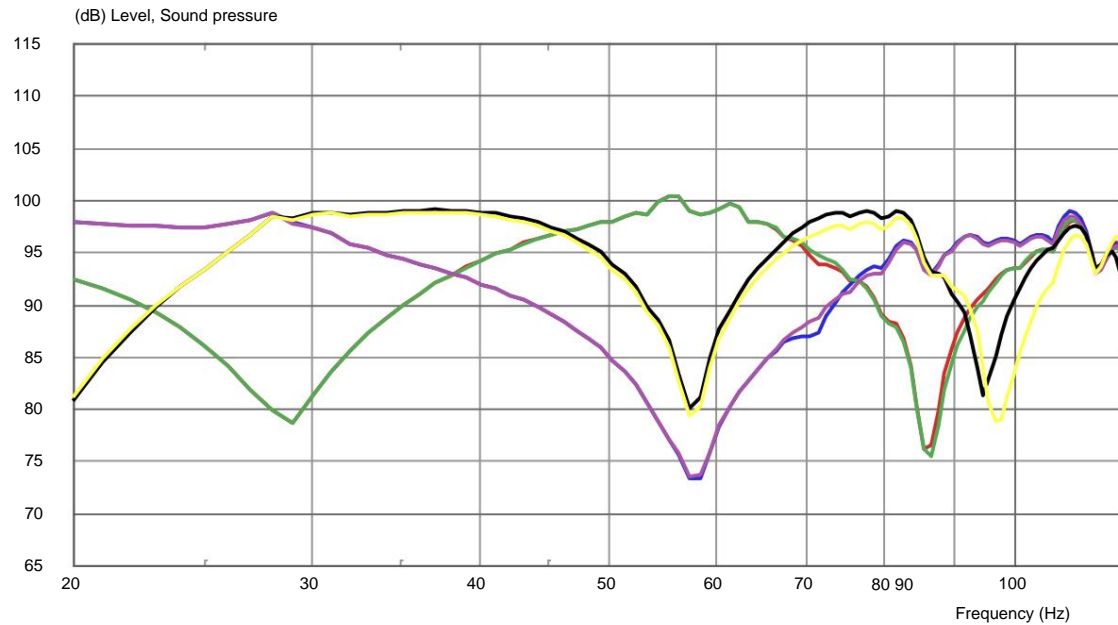
## 6. Pseudo-DBA with only one grid

### 6.1. Delay = 2 x room length

In the following, only a bass grid is used that cancels out the signal reflected on the back wall when it arrives at the front again. This means that the second, inverted signal is reproduced with a delay that corresponds to twice the length of the room.

The idea is to save half of the drivers. Unfortunately, this doesn't work as hoped, since the reflected sound passes through the listening position once and thus interferes with the direct sound. The amplitude response is strongly dependent on the sitting position in the longitudinal direction.





In the following, an additional measuring point was placed on the rear wall. As can be seen, the principle works here, since the non-existing transit time difference means that a comb filter cannot form between the direct sound and the reflection.

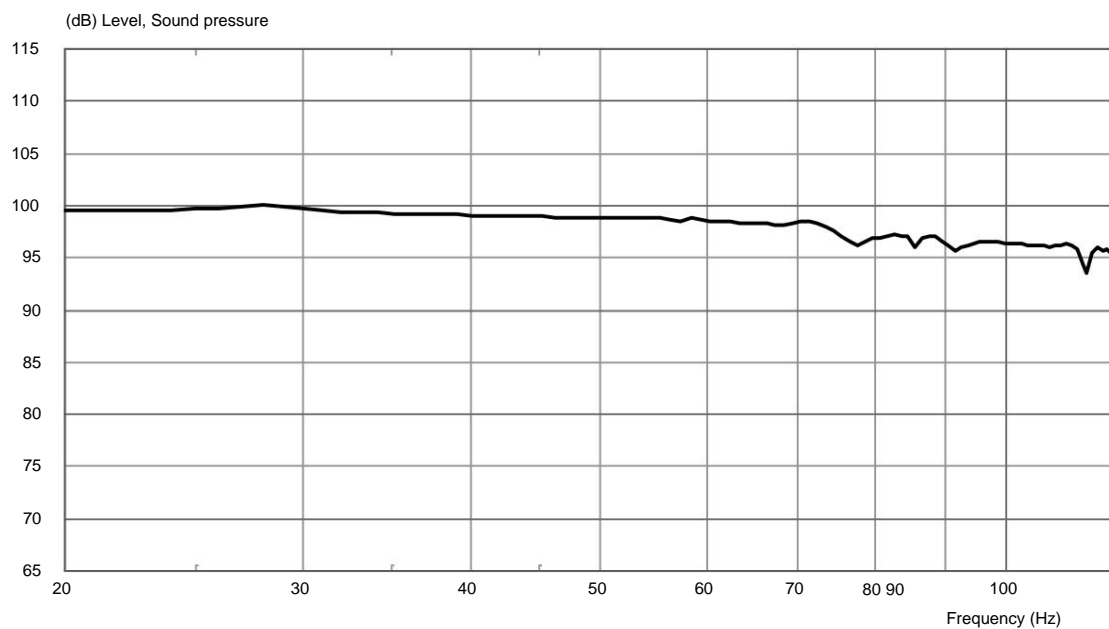
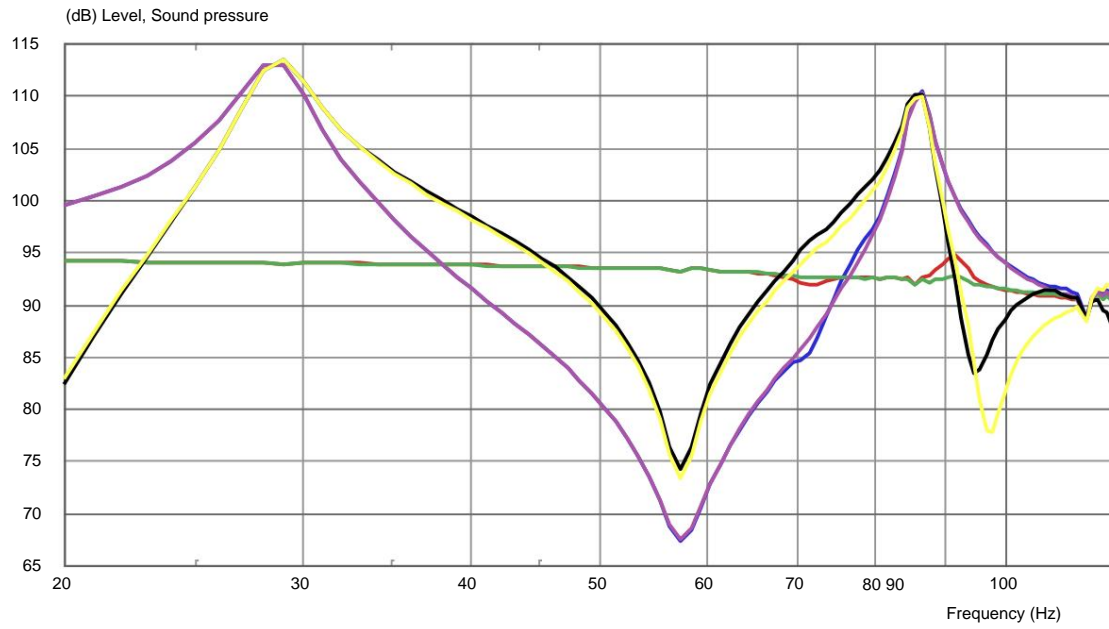


Figure 5: Measuring point on the rear wall

## 6.2. Delay = 1 x room length

If the delay only corresponds to the simple room length, all modes cancel out in the longitudinal center. In the rest of the room, on the other hand, they are maximally pronounced.



## 7. Efficiency-optimized DBA

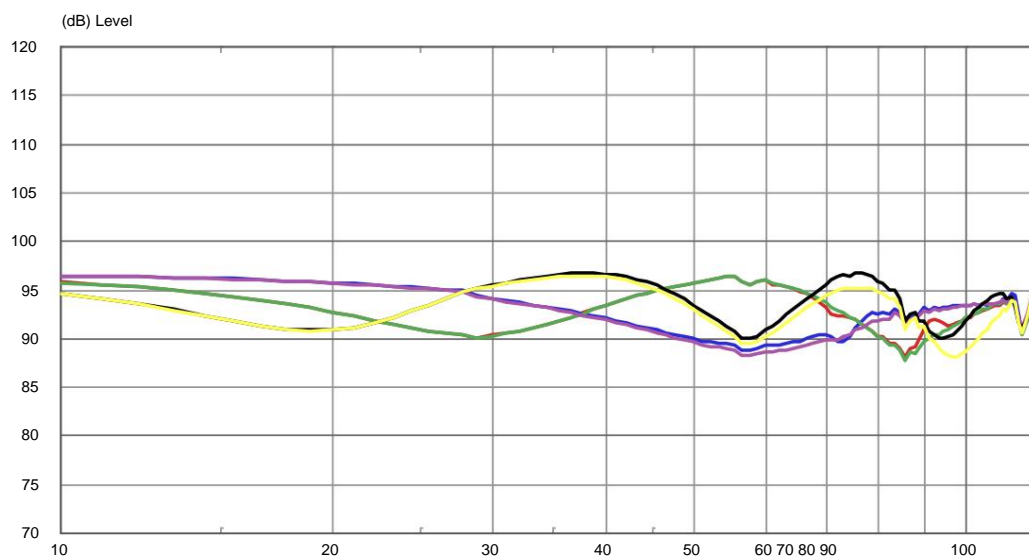
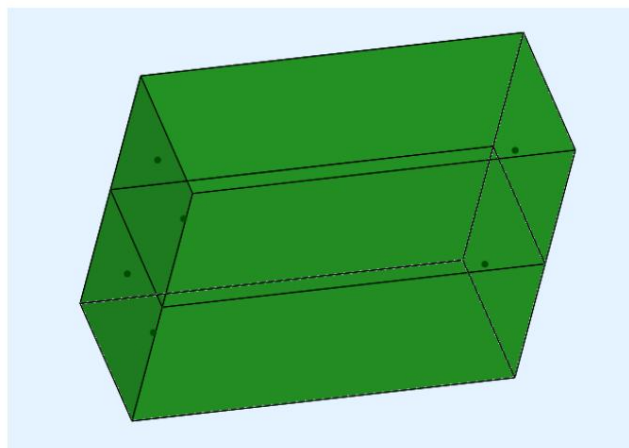
In the following, the reduced DBA arrangement from 4.2 is simulated and both grids are assigned compensation signals. So it is a mixture of DBA and pseudo-DBA. The rear grid only partially compensates for the modes. The front compensates for the rest.

Front Grille (4 Drivers):

- Useful signal (0 dB)
- Compensation signal (level: -6 dB, delay: 2 times the room length)

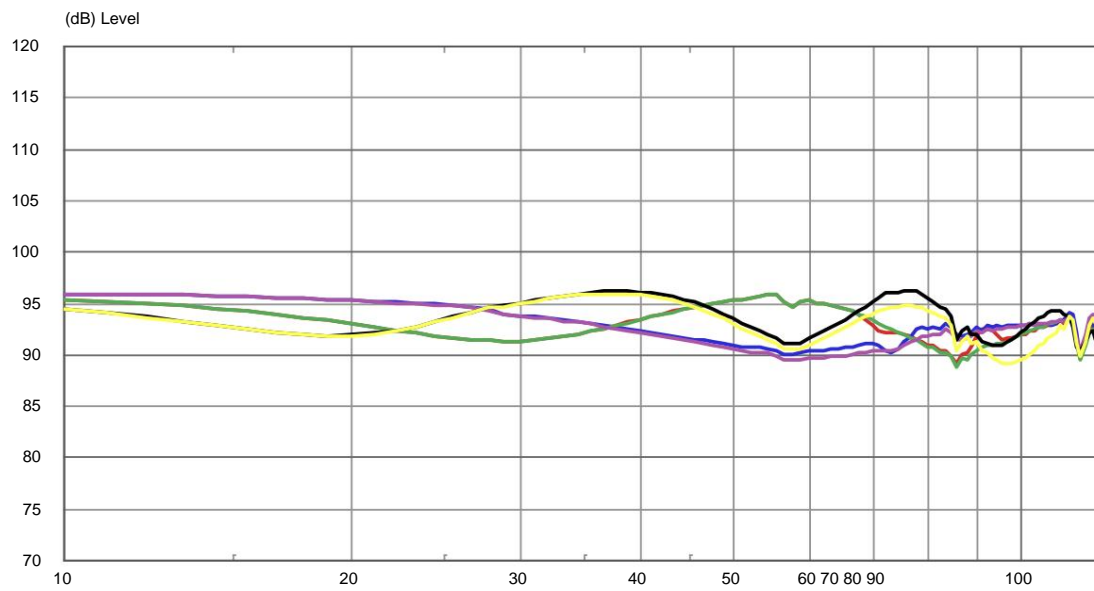
Rear grille (2 drivers):

- Compensation signal (level: 0 dB, delay: 1x room length)



With this arrangement, the comb filter of the pseudo-DBA is greatly weakened, but remains present. The front grille must reserve up to 3.5 dB of the maximum level (limited by the excursion) for the compensation signal. This makes it more efficient than the reduced DBA from 4.2, where the maximum level is reduced by up to 6 dB through the rear grille. However, the values can be slightly lower in real rooms due to the attenuation.

It becomes even more efficient if both grids produce the same overall level, i.e. limit at the same time. This is achieved by increasing the level of the rear grid by 1.75 dB and correspondingly reducing the level of the front compensation signal by 1.75 dB. This results in a total loss of maximum level of up to 3 dB. The comb filter is reduced somewhat by this measure.



## 8. Direction-optimized DBA for multi-channel systems

In multi-channel systems (surround) with speakers in “small” mode (i.e. redirection of the bass to the subwoofer), a DBA leads to the problem that the localization of the bass is always perceived from the direction of the primary grille. So usually from the beginning. This matches the localization direction of the three front speakers, but not that of the surround speakers.

To improve this, a second DBA can be created using the existing bass grids.

In this case the primary grid is the rear and the front provides the cancellation. The direction thus correlates much more strongly with that of the surround loudspeakers.

Note: the following drawings for a 7.1 system do not include the bass grilles, only the direction of the sound they produce.

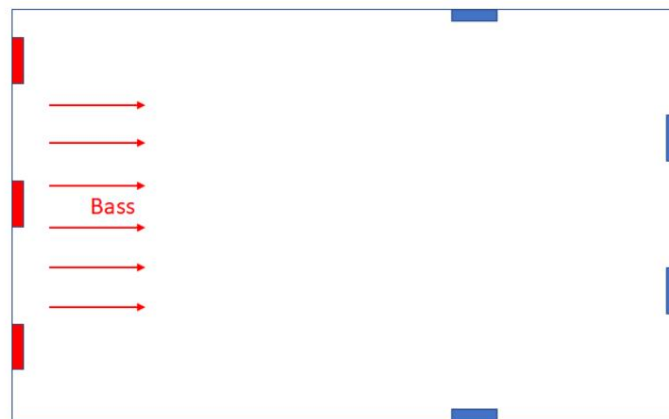


Figure 6: Direction of the low frequency signal from the front channels



Figure 7: Direction of the bass tone from the surround channel signal

The signals for both DBAs can be generated and added in a freely configurable DSP.

At the end, the summed signals are placed on the two woofer grids.

**Routing for the front DBA: L, C, R, LFE**

**Routing for the rear DBA: SL, SR, SBL, SBR**

Since two DBAs can be active in the room at the same time with the appropriate source material, the problem arises that the addition is purely constructive on one level only. This is typically placed on the 1st row of seats in a home theater via adjustment of delays.

For all other levels, the two plane waves also produce destructive interference.

However, the problem is rather negligible since the surround channels rarely contain high-level low frequencies. The advantage of the improved localization of the surround channels clearly outweighs this.

## 9. Dual DBA

The idea came up to use both DBAs from Chapter 8 for the entire bass to achieve a higher maximum level. However, the idea is subject to a flaw. Because with a conventional DBA, the drivers in the rear grille have to produce practically the same deflection as those in the front. This means that the mechanical limit regarding deflection is reached at the same time. A reserve does not exist. If the signal from the second DBA is now added, the deflection also increases accordingly. In the worst case it is an addition of +6 dB, which means a doubling of the deflection. The maximum level cannot therefore be increased.

Furthermore, two opposing DBAs only produce purely constructive interference in one plane. In a home theater this would correspond to exactly one row of seats. Before and after there are obliterations. Below are two examples of different rear DBA delays.

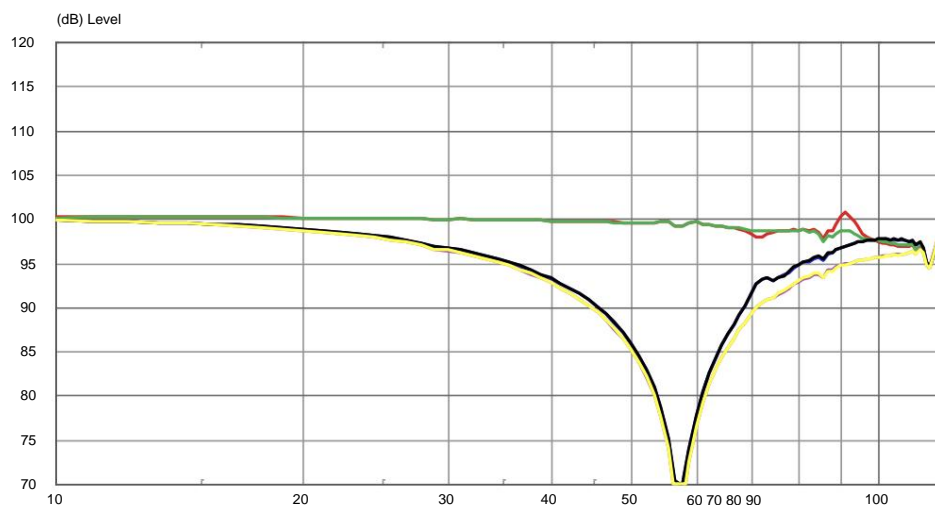


Figure 8: Delay for  $\frac{1}{2}$  the room length

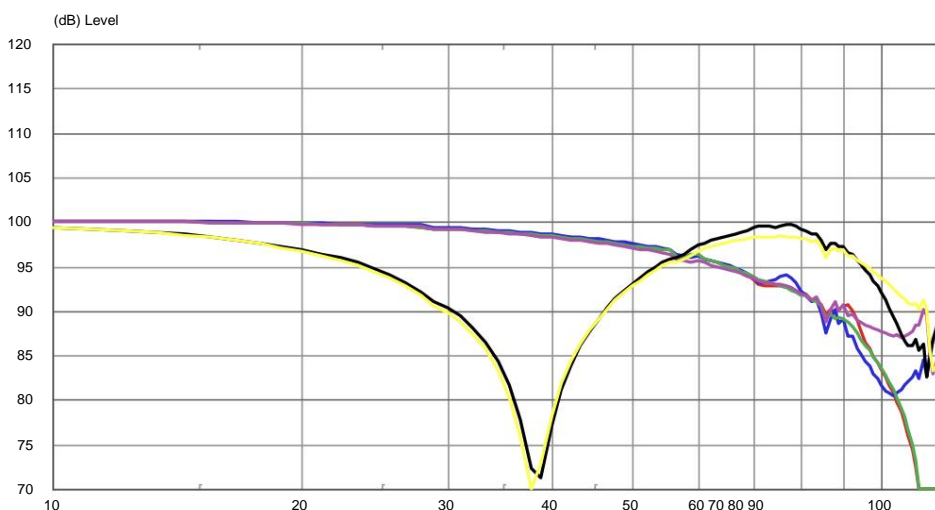


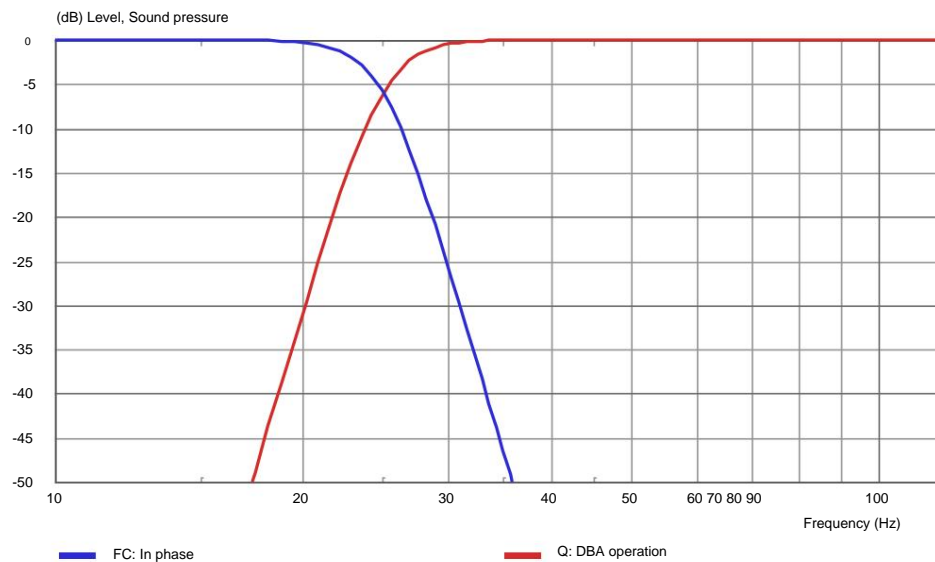
Figure 9: Delay for  $\frac{3}{4}$  of the room length



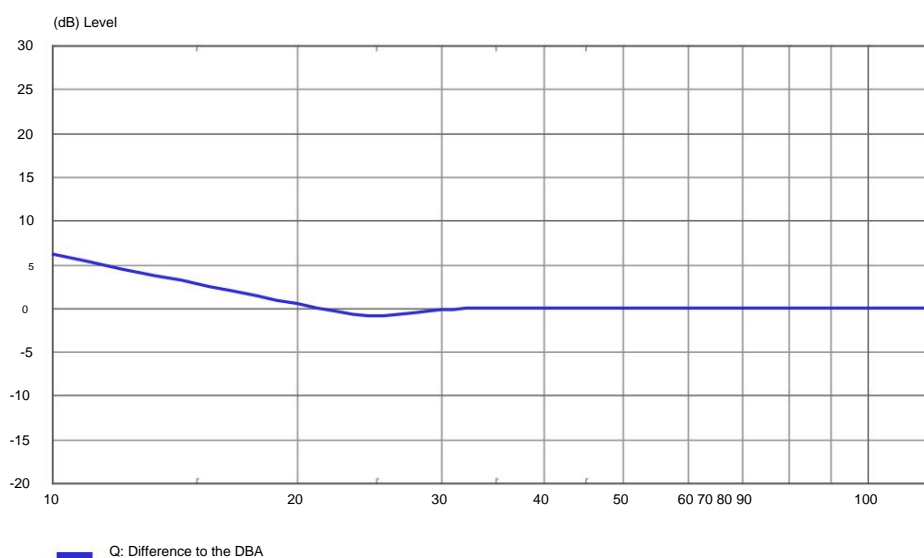
## 10. Optimized control below the 1st longitudinal mode

Below the 1st longitudinal mode, active extinction on the rear wall is no longer necessary. The rear bass grille can be operated in phase and without delay in this frequency range. This has the advantage that the maximum level increases.

In the following it was simulated that the rear bass grid is controlled in phase and without delay below 25 Hz and serves for active cancellation above 25 Hz. Both signals were summed and placed on the back grid. The separation occurs with 8th order.



Then the difference curve to the full DBA was generated at one of the measurement points. It turns out that the gain in sound pressure level only starts from around 20 Hz and increases towards lower frequencies. At 10 Hz approx. +6 dB is achieved compared to the full DBA. The benefit in the relevant transmission range is therefore limited.



## 11. Conclusion

The 1st longitudinal and latitudinal modes are completely canceled by all arrangements.

The reduced arrangements 4.2 and 4.4 work almost as well as the complete DBA arrangement. This means that very good results can be achieved with just two drivers per grid can.

Very good results can already be achieved with 2 drivers for stereophony and a single seat along the longitudinal axis of the room. Here 5.2 seems to produce the smallest deviations outside the longitudinal axis.

For multi-channel systems, a possibility was demonstrated for localization in small operation improve.

Furthermore, the rear grid density can be lower than the front one. Since in many real living spaces the level of the rear grille can be lowered anyway, the costs of the overall arrangement can be optimized.