AVAA ACTIVE VELOCITY ACOUSTIC ABSORBER

PSI AUDIO PRECISION SOUND IMAGE SWISS MADE

ACTIVE LOW FREQUENCY SOUND ABSORPTION
Dynamo Zürich

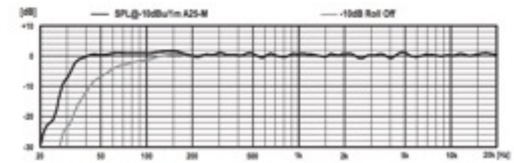
7 Septembre 2021

Roger Roschnik - Relec SA / PSI Audio

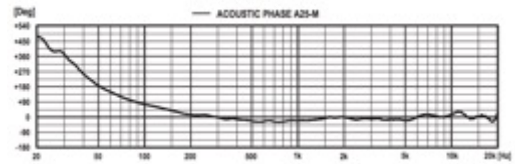
TBZ

Monitor’s jobs in sound reproduction

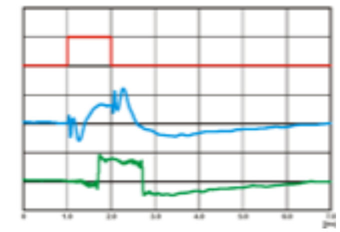
- Flat frequency response



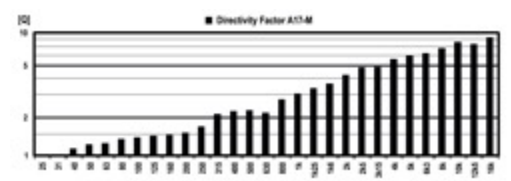
- Linear phase response
  between 200 and 4000 Hz at least



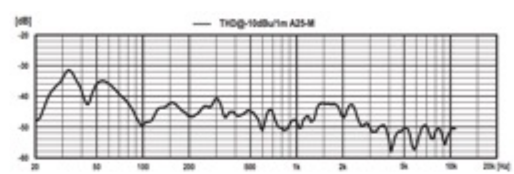
- Impulse behaviour



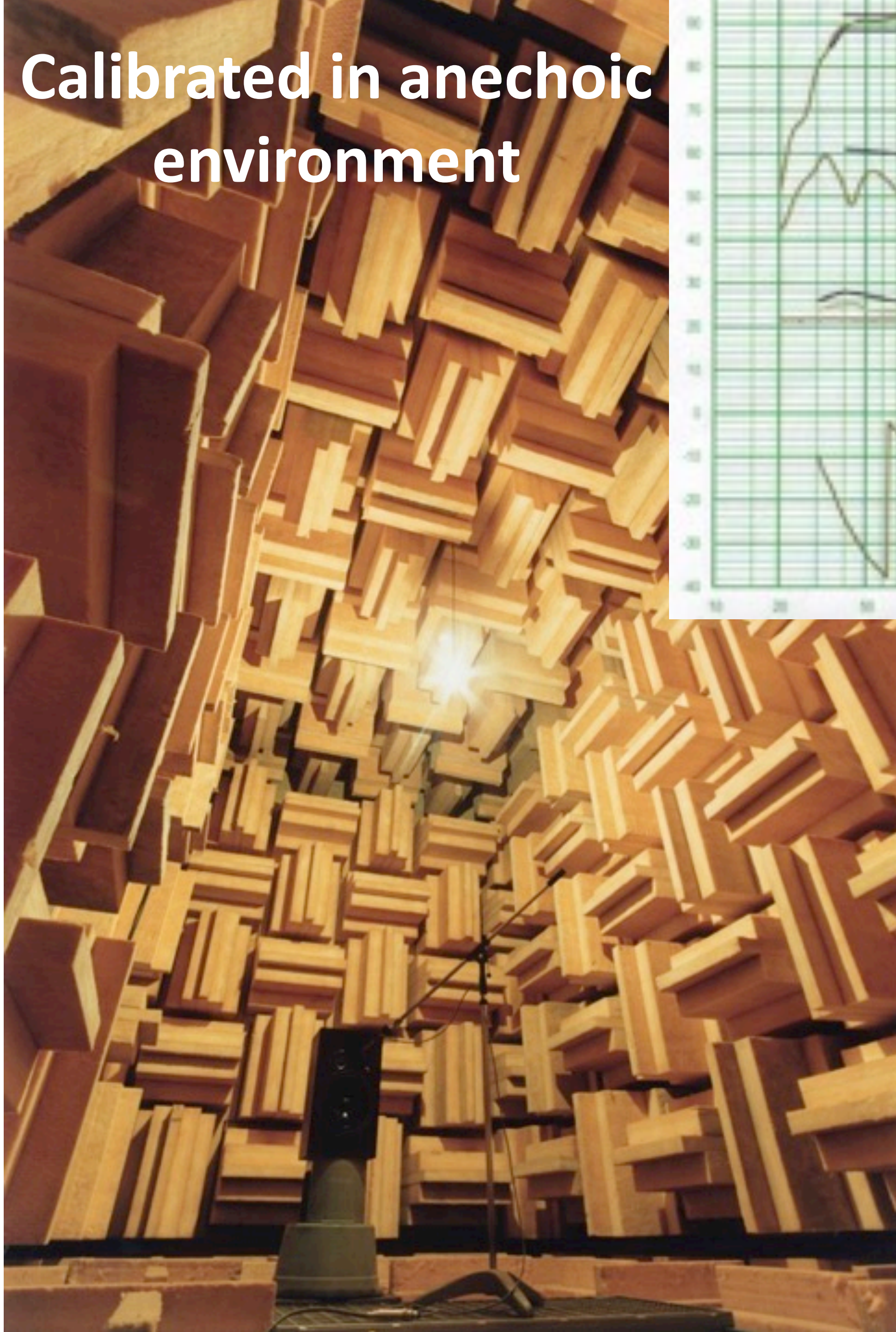
- Natural directivity

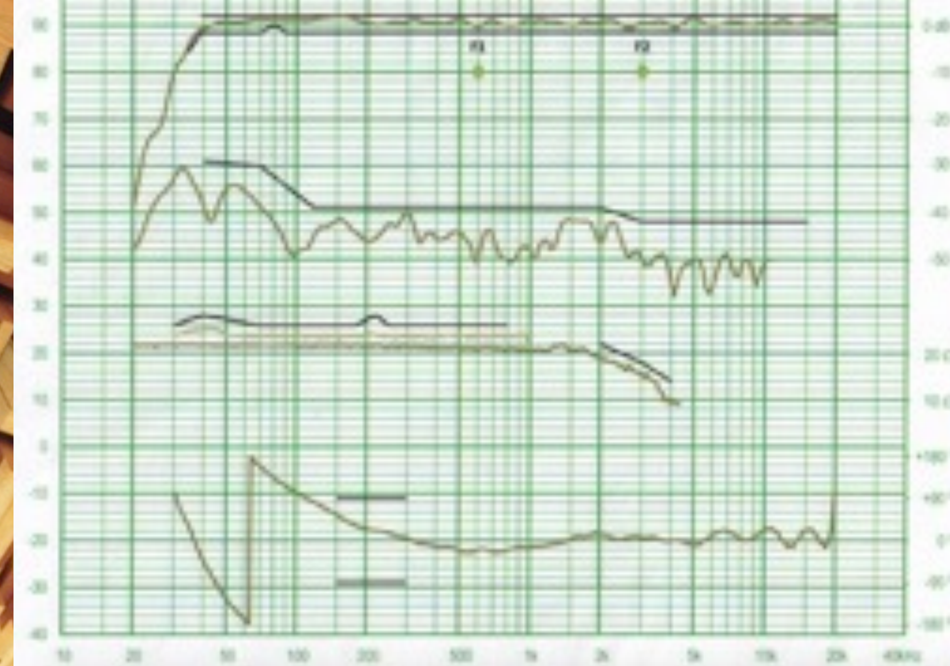


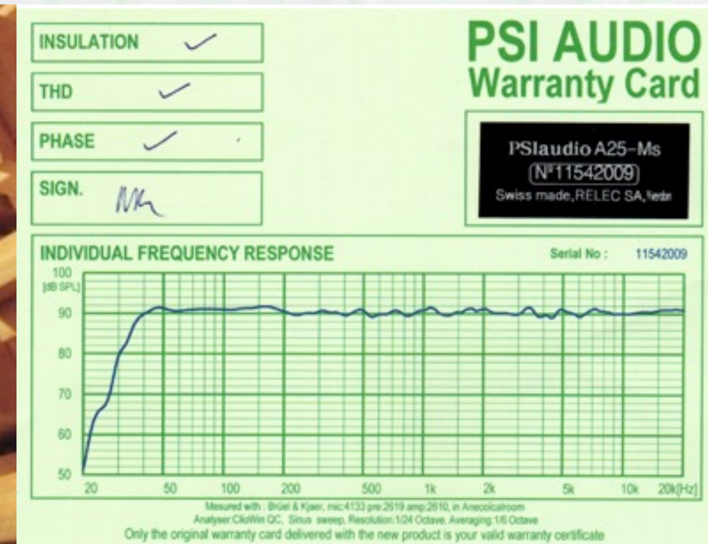
- Minimal distortion (harmonic dependant!)



Calibrated in anechoic environment







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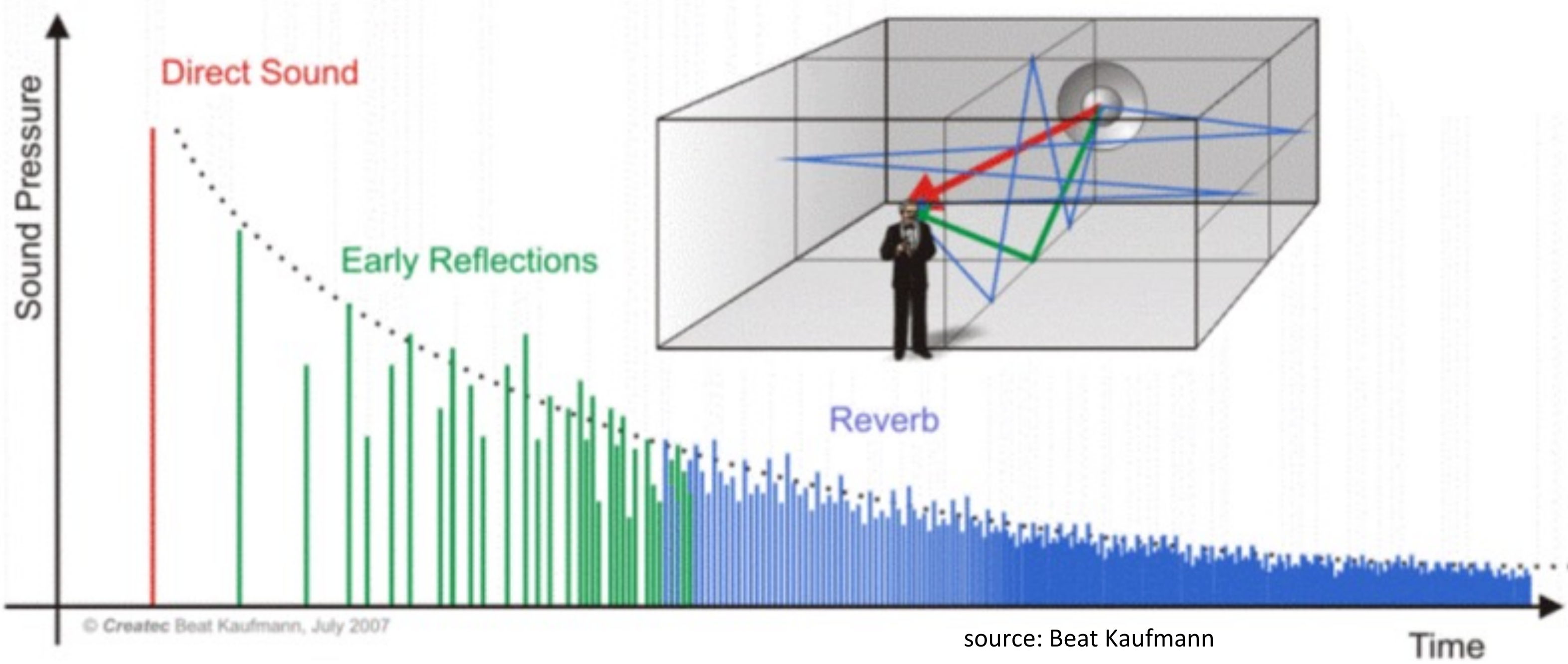
But then, in a room…

THE ROOM:

THE SECOND
BIGGEST CONTRIBUTOR
TO SOUND QUALITY

Direct and indirect sound



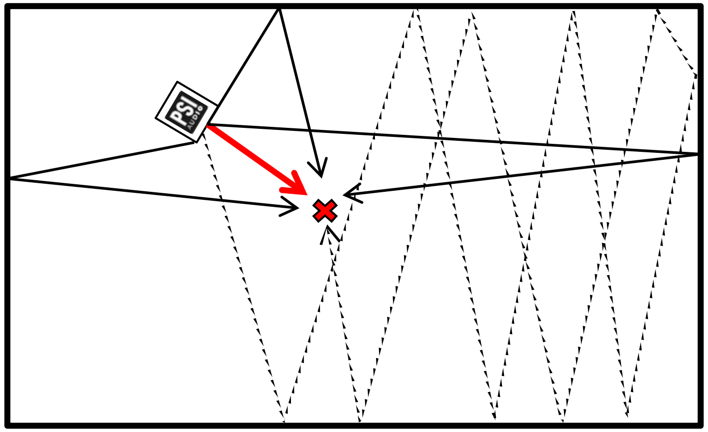
source: Beat Kaufmann

Perception: direct sound + early reflections + reverb

Give info on: source space material

- Monitor:
- Room:

Direct and indirect sound



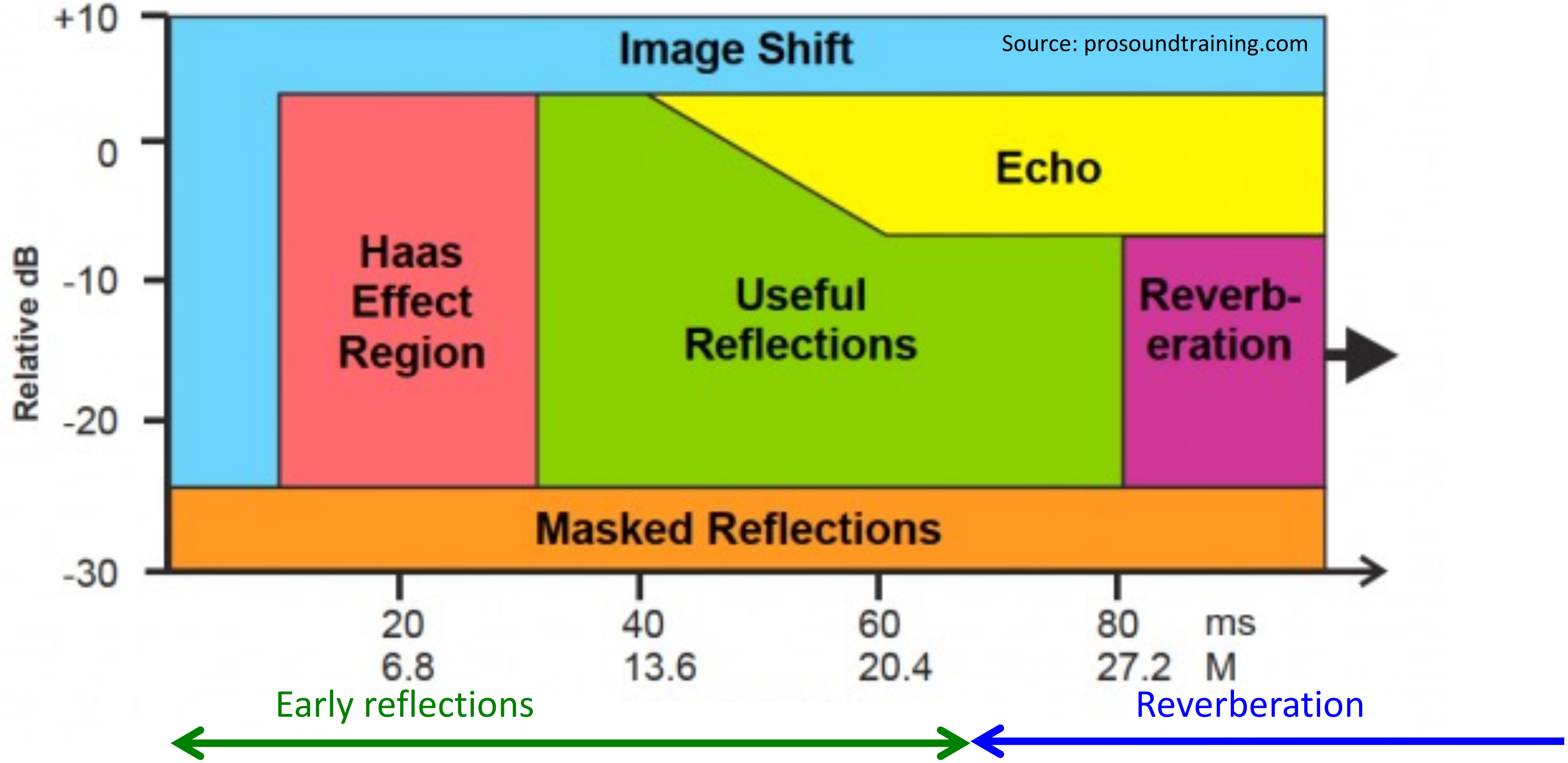
Direct sound:

- Enables to identify the sound source, qualitatively as well as locate the origin in space
- **Must be as accurate as possible**

Indirect sound:

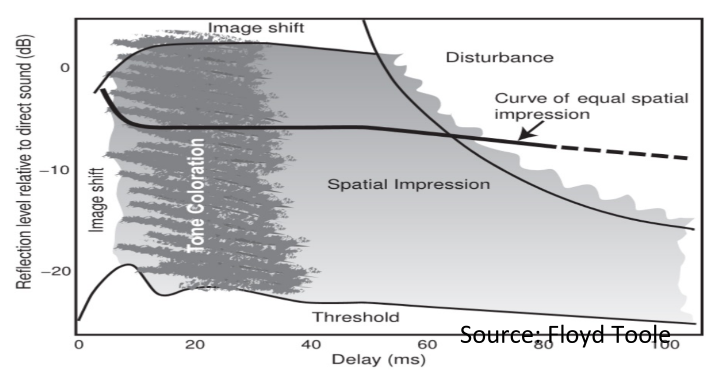
- **Enables to understand the environment**
  - Sum of all reflected sounds
  - Little impact on direct sound if it is close enough in time (Haas effect)
  - Decreases with each reflection and absorption factor
- **Reverberation time: RT_{60}**
  - RT_{60} = 0.16 * room volume / equivalent absorption area (with α = 1)
  - Depends on type of audio message:
    Church : 5 to 10 seconds
    Studios: 0.2 to 0.5 seconds
  - **Must be "similar" over all frequencies for good listening conditions**

Direct and indirect sound



Remember:

- You have 2 ears and a brain
- They don't work like a microphone
- You don't listen to sweeps (continuous)



THE PROBLEM:

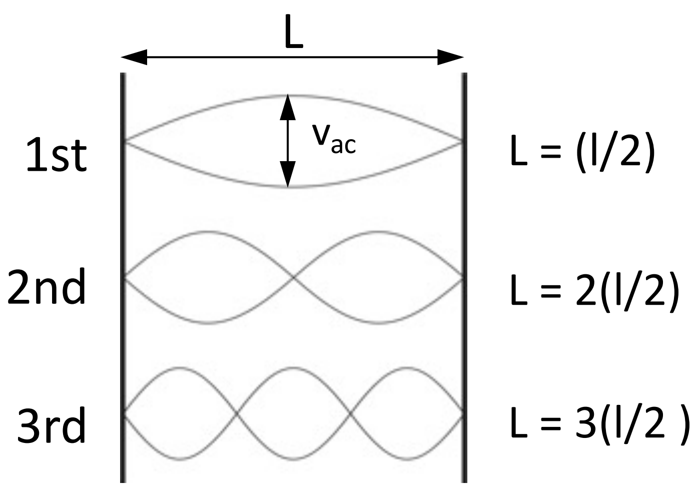
ROOM MODES,
THE BIGGEST DISTURBANCE

Room modes

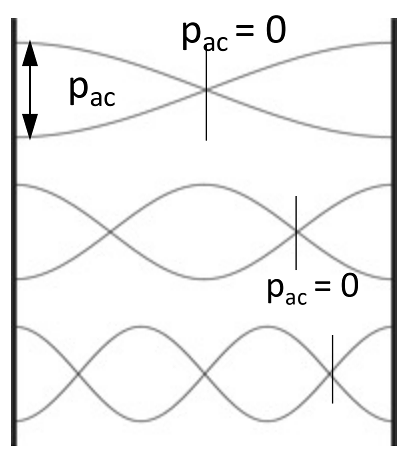
Room modes:

- Room dimension = x (wave length/2)
- Standing wave with little diffusion
- Peaks and null always at the same place
- Long reverberation time, long RT_{60}

Example of room modes:
Room length 7 m: modes at **25, 50, 75 Hz**
Room width 5 m: modes at **35, 70, 105 Hz**
Room height 2.5 m: modes at **70, 140 Hz**



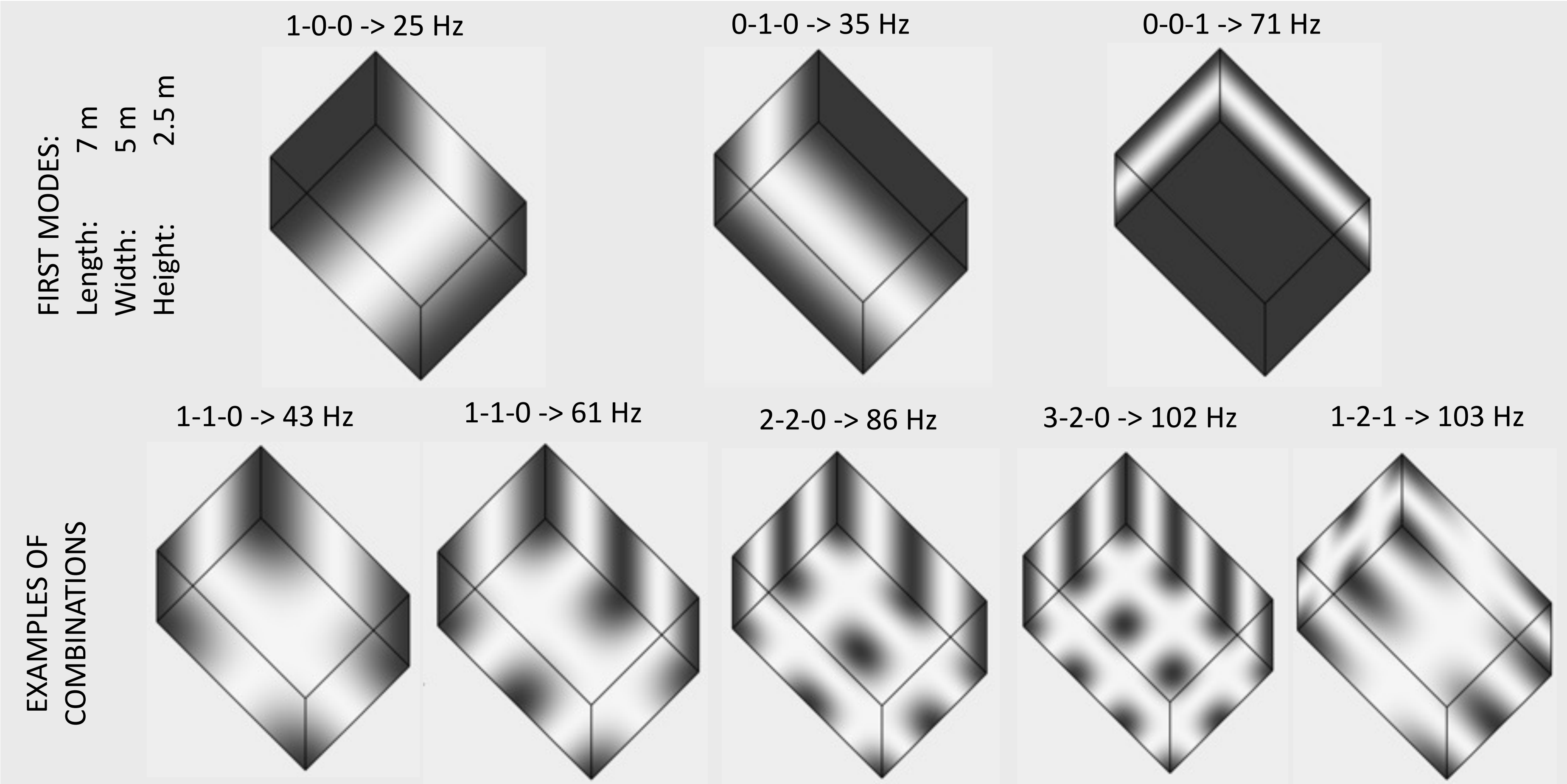
acoustic velocity



acoustic pressure

Against a (rigid) wall, acoustic pressure is highest and acoustic velocity is lowest

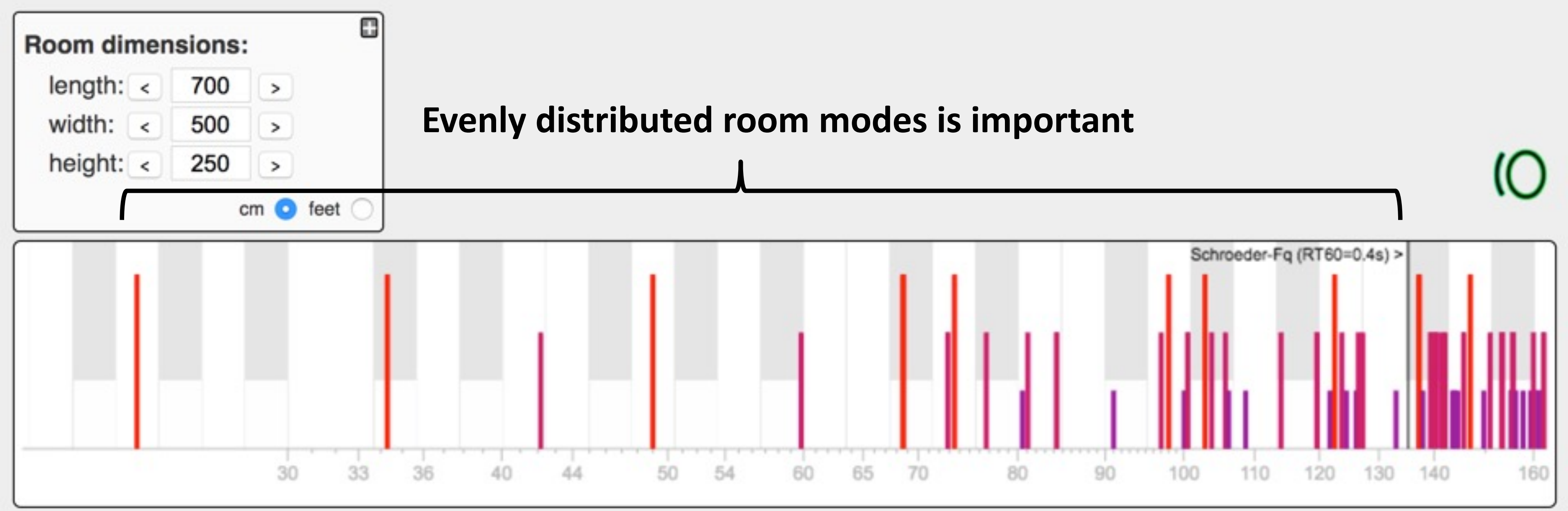
Room modes pressure distribution



- Rigid corners always have high pressure and contribute to room modes
- In general over 50 modes below Schroeder frequency
- Regular and computable modes? Only in simulations of perfect rooms!

Standing modes of room 7 x 5 x 2.5 m

> 30 standing modes to treat:



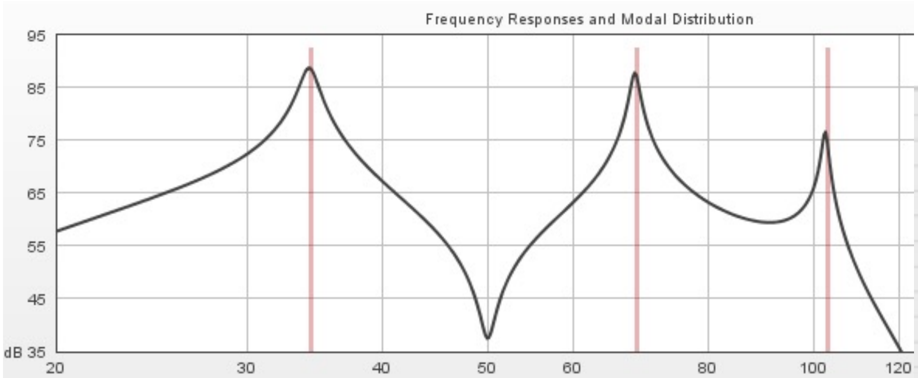
Outil: AMROC http://amroc.andymel.eu/

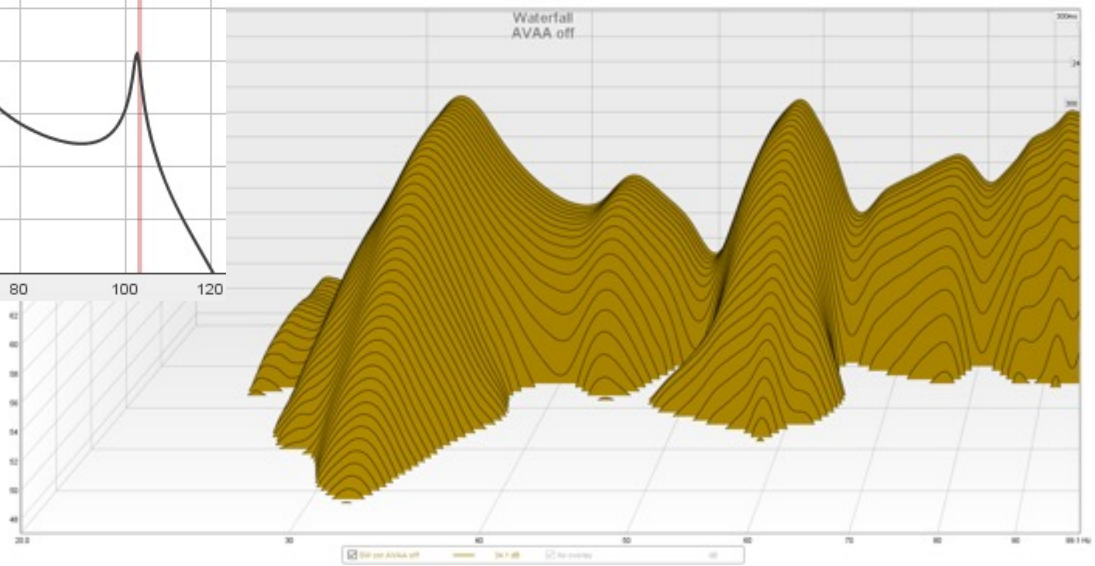
Limit between diffusion and modal behaviour :

$$\text{Schroeder frequency} = 2000 \times \sqrt{RT_{60} / \text{room volume}}$$

Room modes are a real pain

- Create peaks and nulls in frequency response
- Resonate longer than other frequencies in the room long RT_{60}
- Mask higher frequencies (muddy masking effect)
- Very difficult to control (generally between 20 and150 Hz)
- Cause errors for the sound engineer

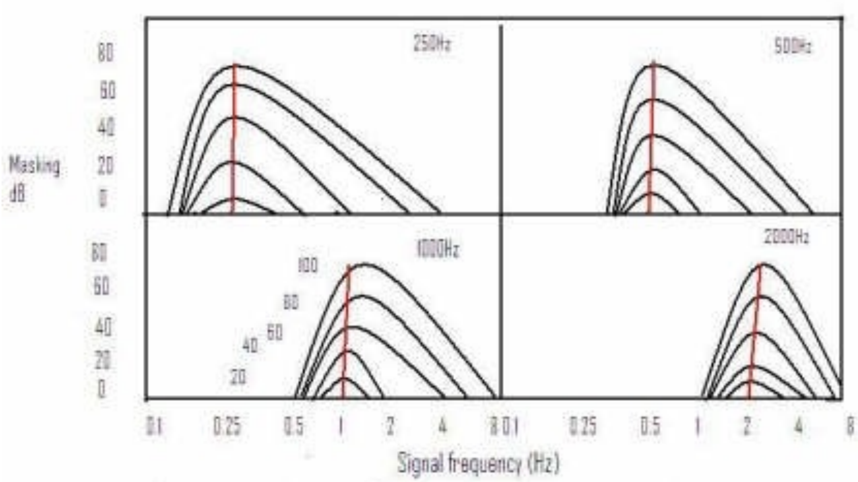


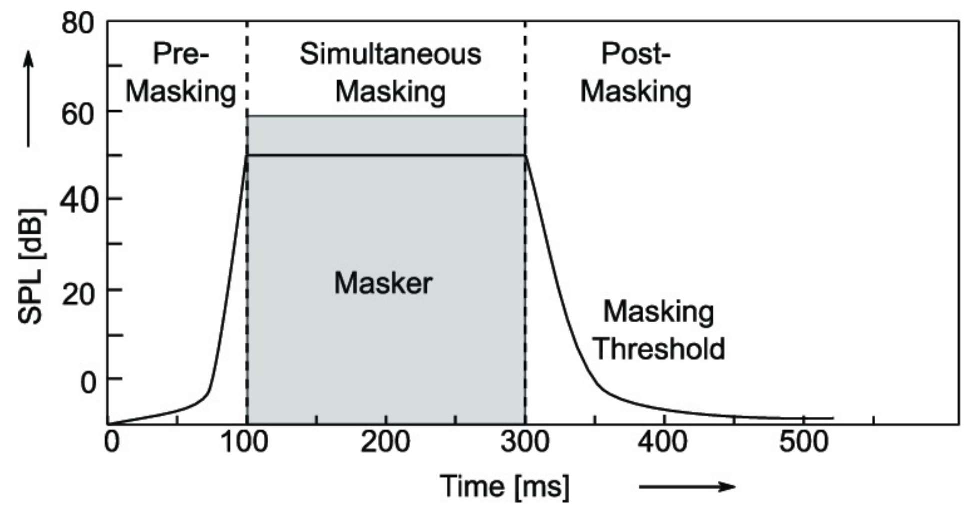


Masking effect

Frequency masking

Temporal masking





source: www.researchgate.net

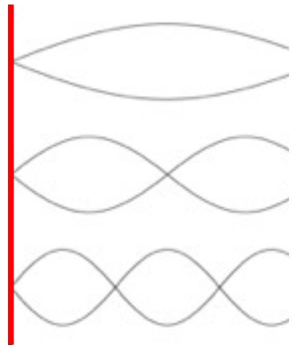
source: wikipedia

PASSIVE SOLUTIONS

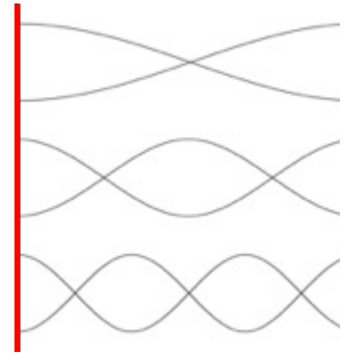
Mechanism of sound reflection

- Against a rigid wall: acoustic velocity = 0
- Kinetic energy from acoustic velocity
  is transformed into potential energy (pressure)
- Creates high pressure and acceleration in opposite direction: **reflection**

$V_{ac} = 0$



P_{ac} = Max -> reflection



Mechanism of sound reflection

Controlling reflections

1. **Modify wall geometry (angle of incidence):**

   - Diffusion but **doesn't remove energy**

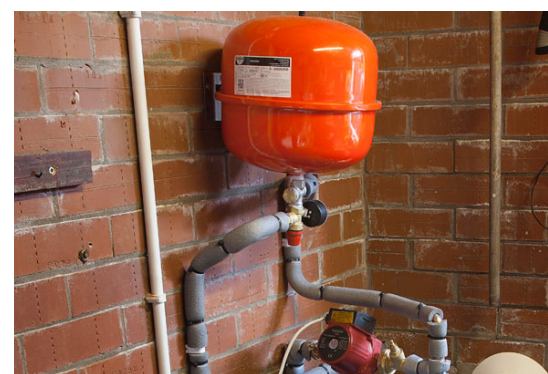
2. **Slow down velocity in front of wall:**

   - Porous material, passive absorption

3. **The wall (or part) moves:**

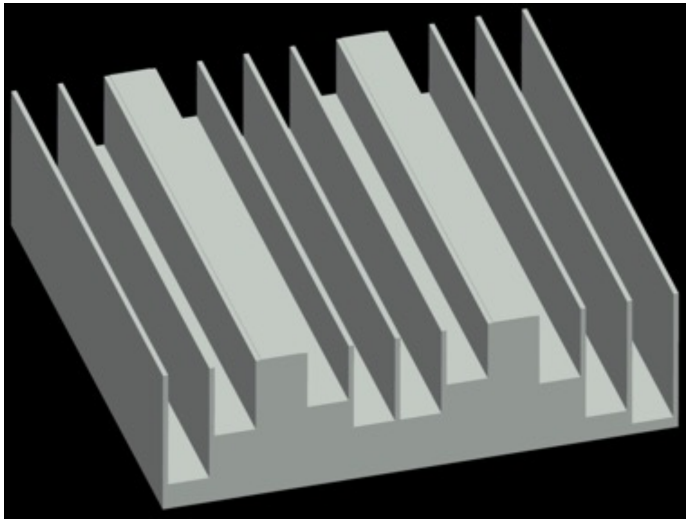
   - Moves passively: **resonators**

   - Moves actively: **active absorption**



Diffusion

Diffusion:



Reflection with phase shift

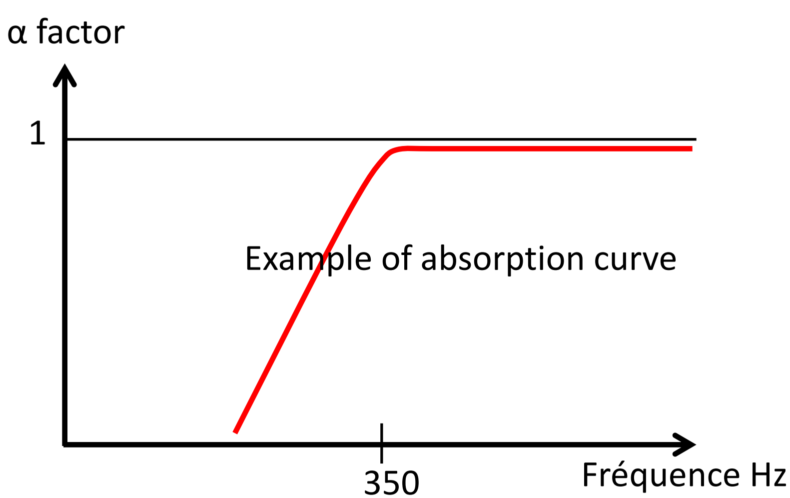
Diffraction

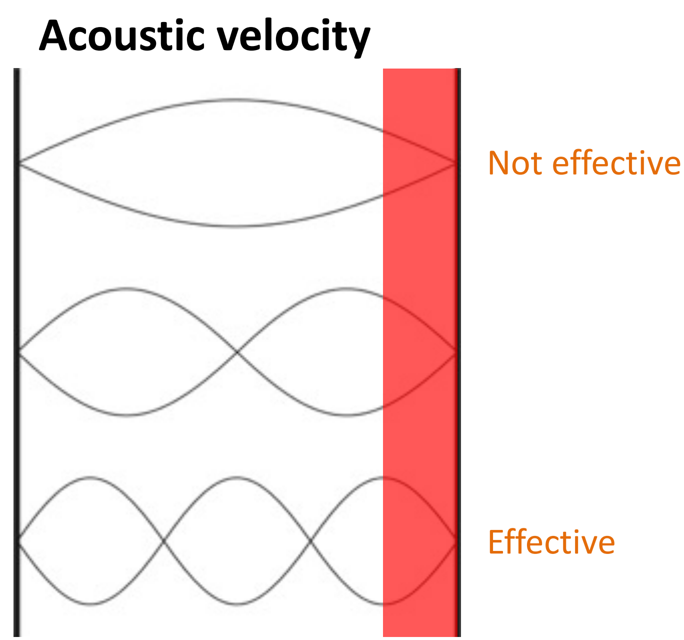
Need to be large compared to wave length

Doesn’t remove energy

Porous Absorber

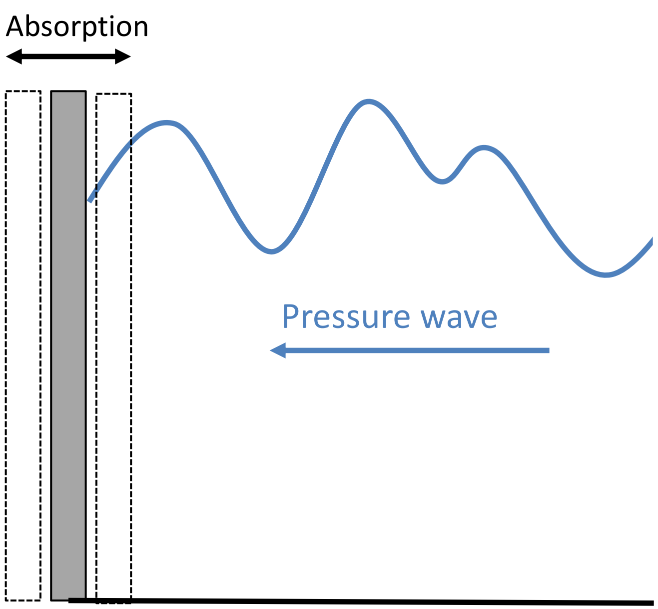
- Transforms **velocity into heat** through friction
- Important to **slow down velocity where it is highest**
- A thickness equivalent to **¼ of wave length** is needed:
  - 20’000 Hz wave : 1.7 cm thickness: 4 mm
  - 350 Hz wave: 1 m thickness: 25 cm
  - 100 Hz wave: 3.4 m thickness: **85 cm**
  - 20 Hz wave: 17 m thickness**: 4 m**

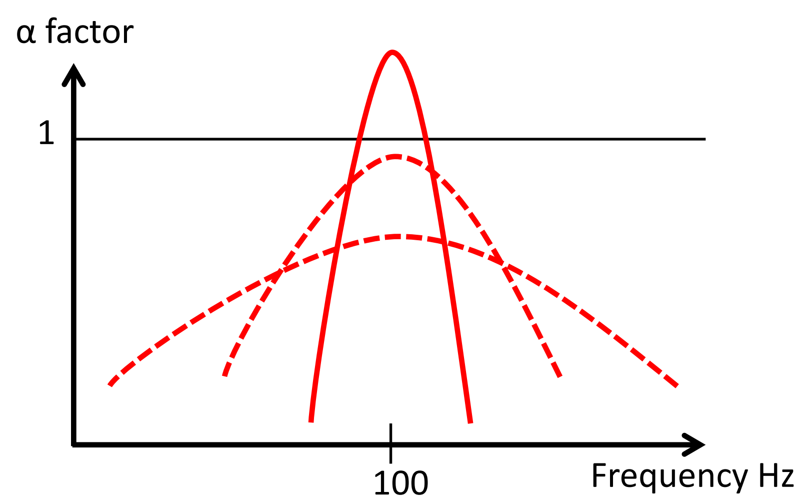




Passive resonators: let the wall move

- The wall (or part of it) moves to **dampen or absorb the acoustic velocity**
- A resonator will move easier on frequencies that correspond to its own **natural mode**
- Can be a window, membrane, Helmholtz, etc.





Passive resonators

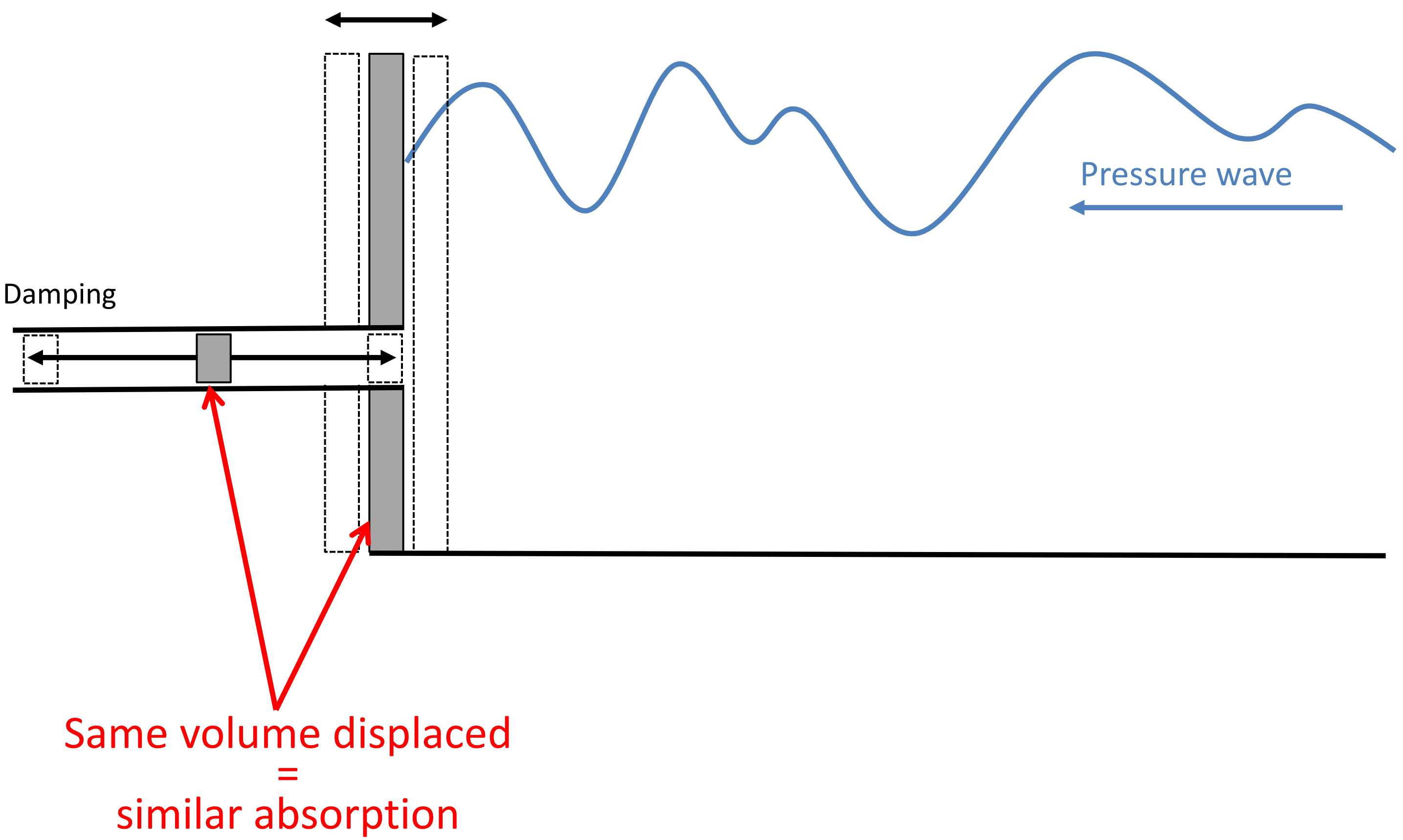
Helmholtz resonator

Panel, membrane resonator

ACTIVE SOLUTION

Active absorption: make the wall move

- **Make the wall** (or part of it) **move**
  to **absorb velocity** and avoid pressure build-up



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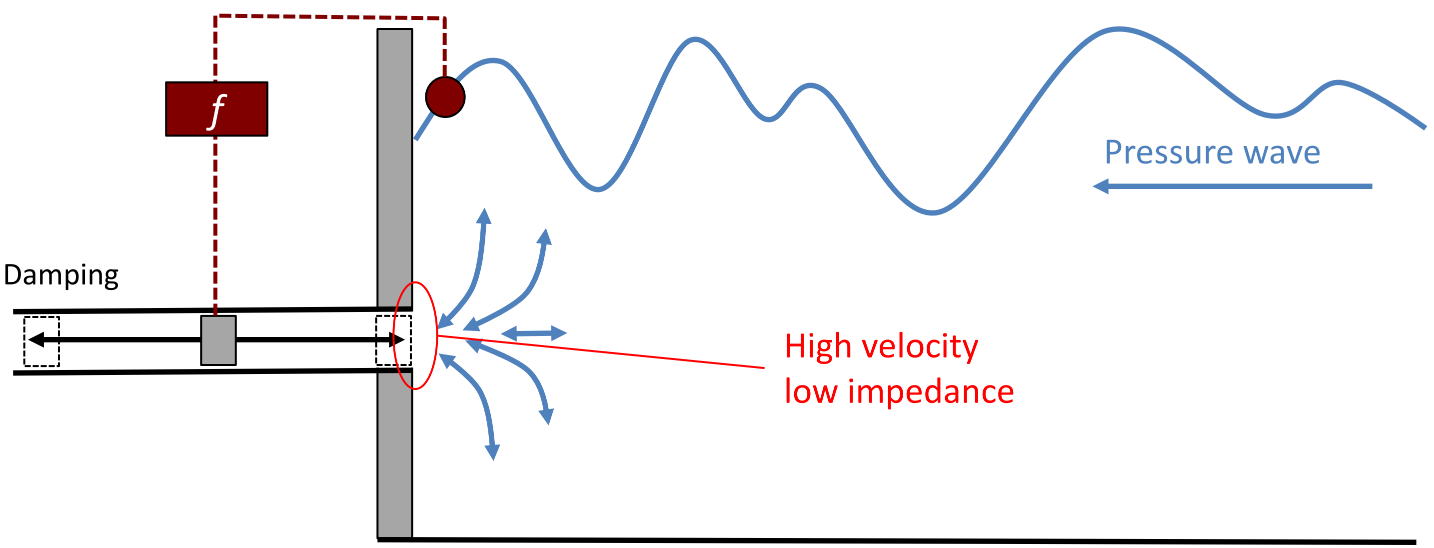
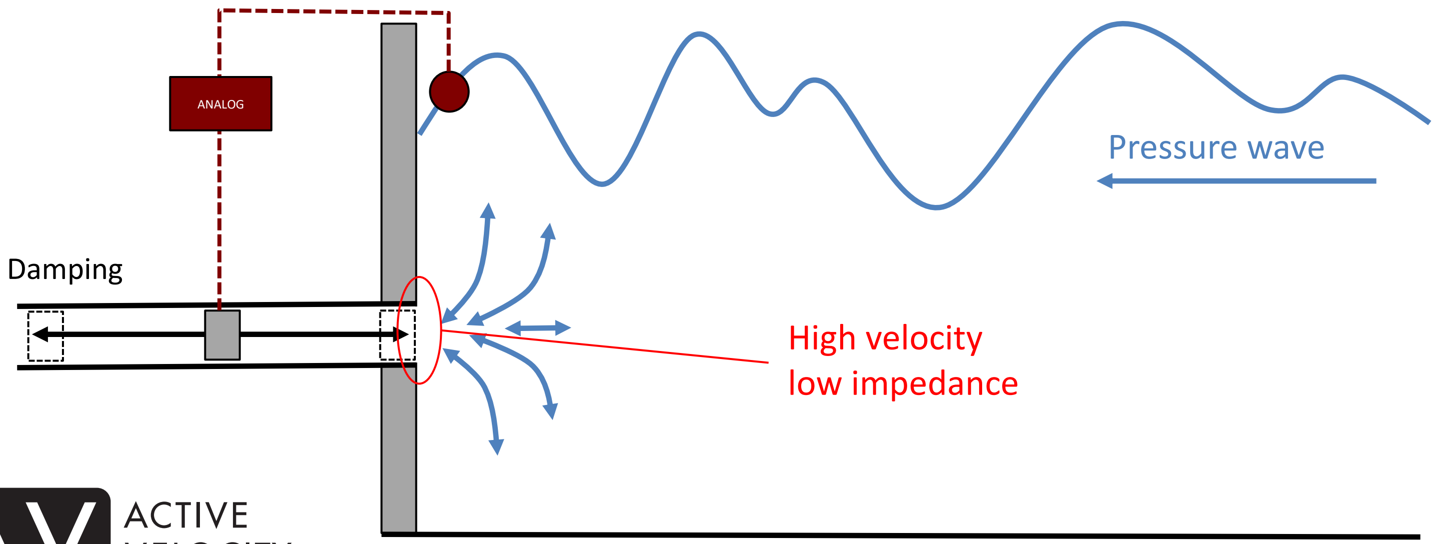


$$\text{Acoustic impedance (Pa s/m)} = \frac{\text{Acoustic pressure (Pa)}}{\text{Acoustic velocity (m/s)}}$$

AVAA: Active Velocity Acoustic Absorber

- **Imposed acoustic impedance: 100 Pa s/m** between **15 et 150 Hz**
- Pressure sensor (microphone) dictates the counter-reaction
- Counter-reaction must be:
  - Immediate (analogue technology works best)
  - Accurate in frequency
  - Accurate in phase

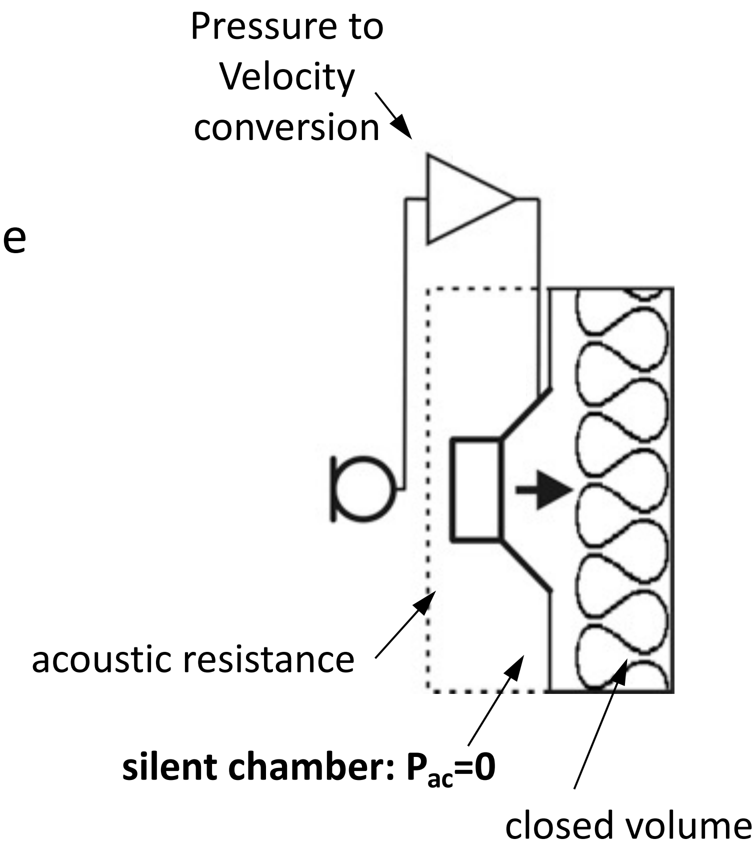


How does the AVAA work?

- A microphone measures the acoustic pressure in front of an micro perforated sheet with specific acoustic resistance

- A electronic treatment uses this pressure to drive velocity through the acoustic resistance

- The transducer's acoustic velocity is set to achieve zero acoustic pressure behind the fabric, i.e. in the “silent chamber”.



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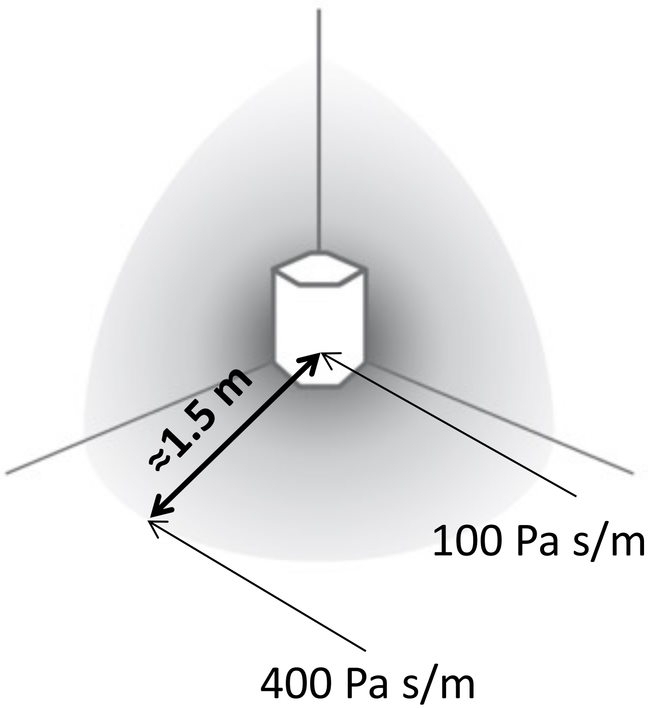
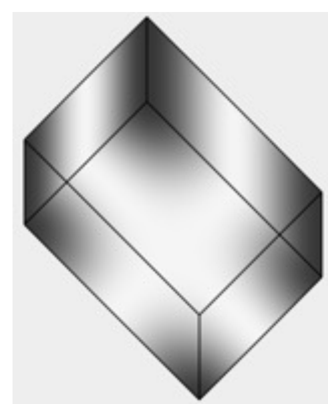
How does the AVAA work?

$$\text{Acoustic impedance (Pa s/m)} = \frac{\text{acoustic pressure (Pa)}}{\text{acoustic velocity (m/s)}}$$



- The AVAA imposes a low acoustic impedance on its surface (between 15-150 Hz)
- It sucks in low frequencies over 1 to 1.5 m
- The equivalent absorption area is up to 25 times the surface of the AVAA



AVAA
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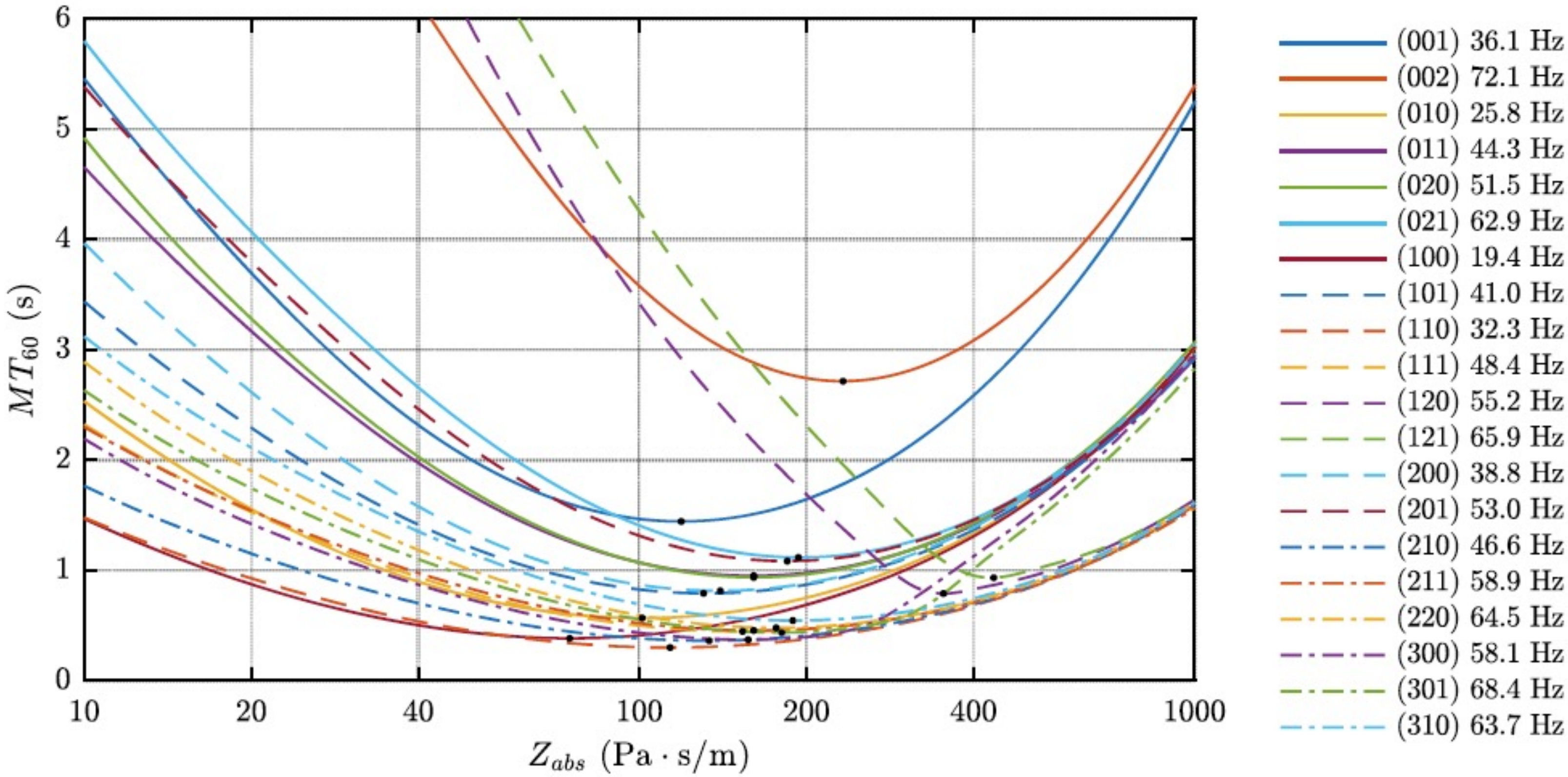
VELOCITY
ACOUSTIC
ABSORBER

Target Acoustic Impedance

- Target impedance for the first 20 modes in room: 100 to 200 Pa s/m



AVAA absorption efficiency

- Starting from measured and simulated extinction time of the natural modes, we computed the equivalent absorbent area A_{ae} using Sabine's formula
- **Result:** One AVAA, with an acoustic resistance of **0.2 m²** represent an equivalent absorption area of **0.6 to 4 m²** i.e. **factor 3 to 20** depending on frequency and position**.**

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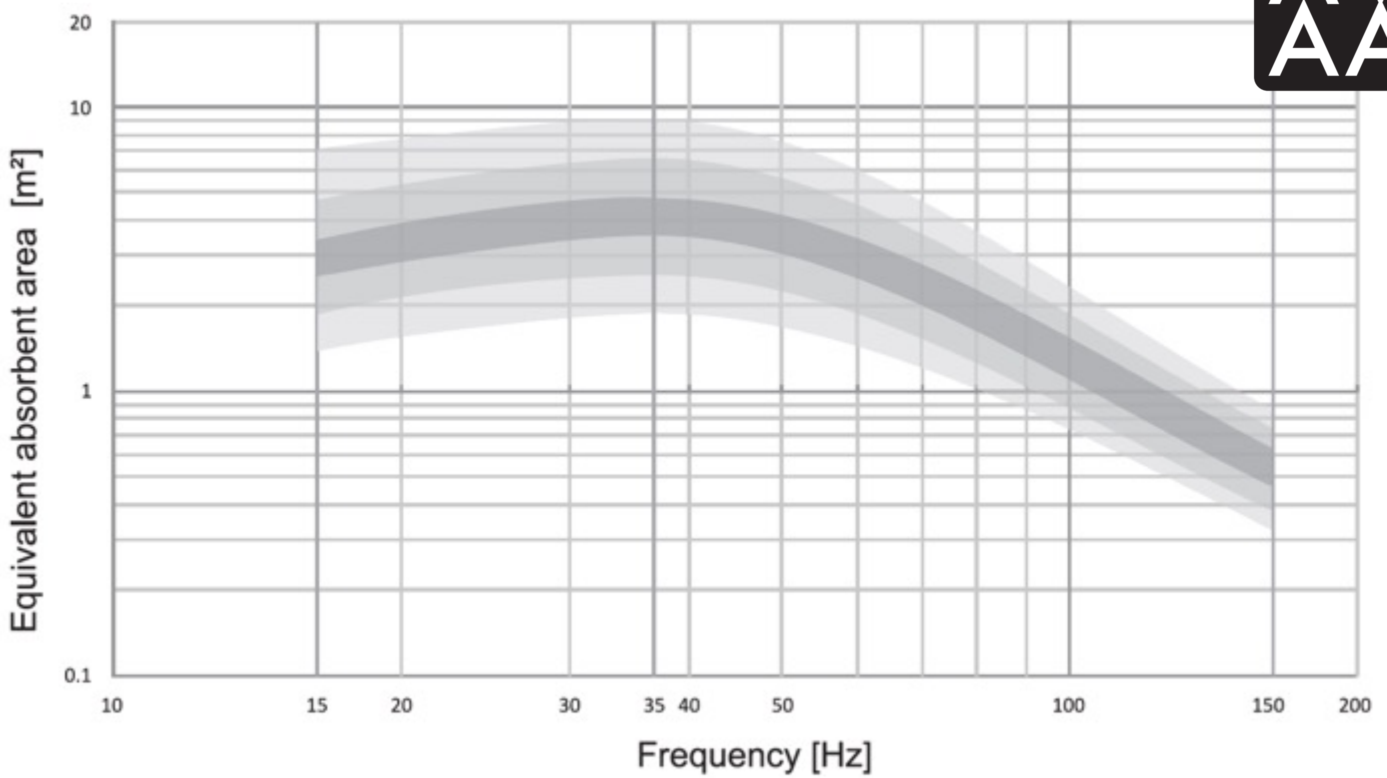
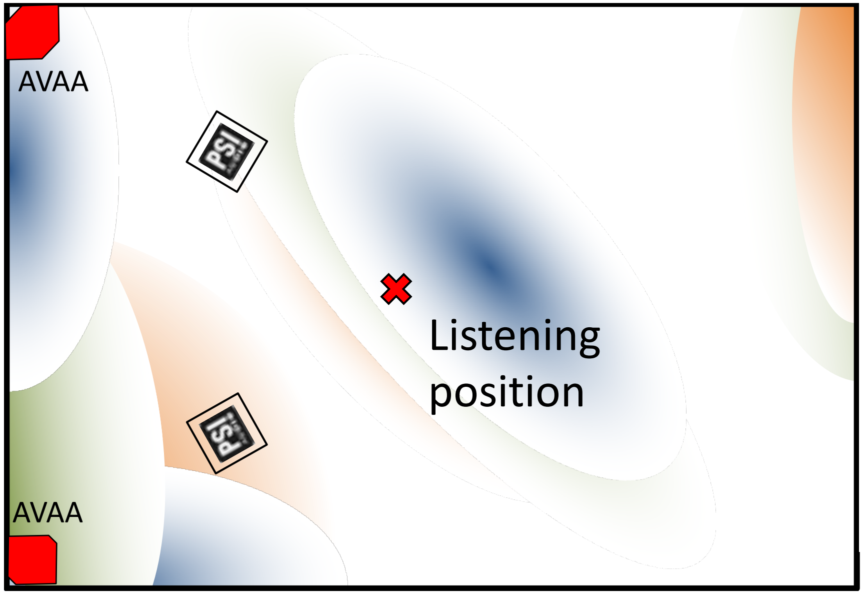


Positioning the AVAA

- Position in **high pressure** areas
- Position in **most rigid corners** (highest pressure)
- Keep room **symmetry** (position AVAAs in **pairs**)
- AVAA **behind monitor** will act earlier
- **Easy to test** and identify most effective position

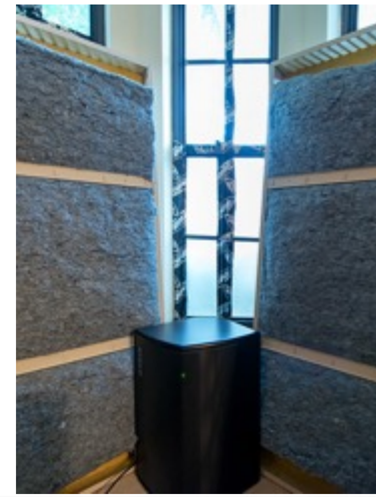


RESULT:

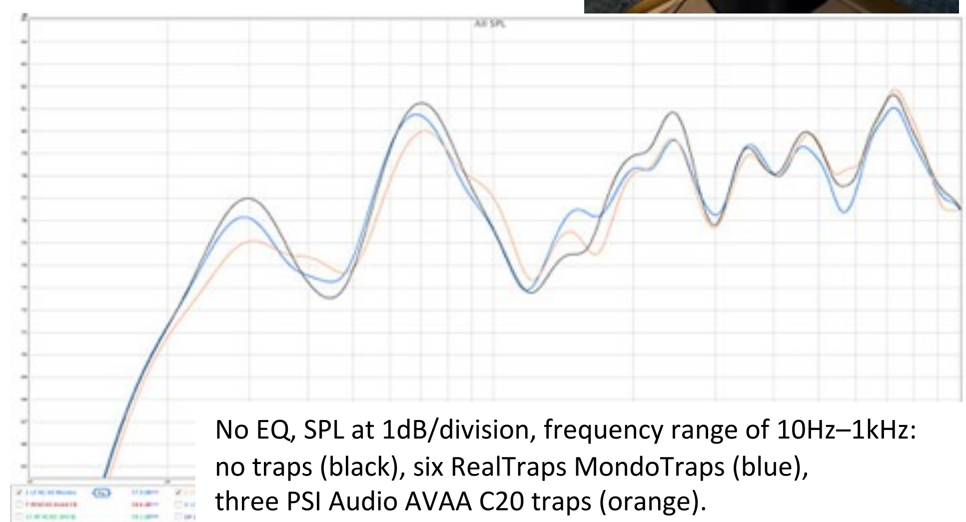
- Shorter room mode decay time
- Clearer mids and highs
- Smoother frequency response
- All over the room

Bob Katz, USA - Mastering room

- Mastering room:
  - Concrete floor, solid walls, sloping ceiling 7 m high at rear, bay window
  - Problems @: 29, 46, 70, 125, 145 Hz and dip @ 125 Hz
  - Issue: traditional basstrap overdamp the room when trying to fix the bass
  - For each frequency: play sine waves and walk around room to identify pressure areas (i.e. best location for AVAA)
  - Solution: 3 AVAA (2 in corners and 1 in middle) and 4 passive traps

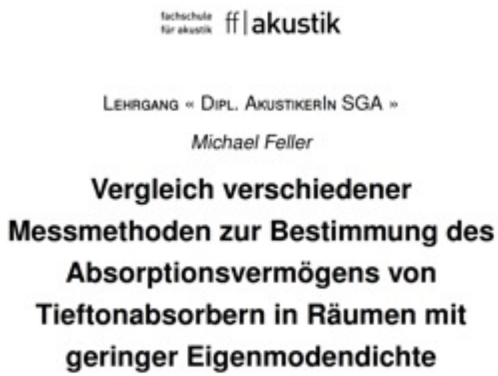


“Sonically it has taken my room to a level of sonic accuracy that I never thought could be attained without some serious compromise usually an overdamped room in the mid and high-frequency”



No EQ, SPL at 1dB/division, frequency range of 10Hz–1kHz: no traps (black), six RealTraps MondoTraps (blue), three PSI Audio AVAA C20 traps (orange).

Michael Feller Diploma – Non treated room



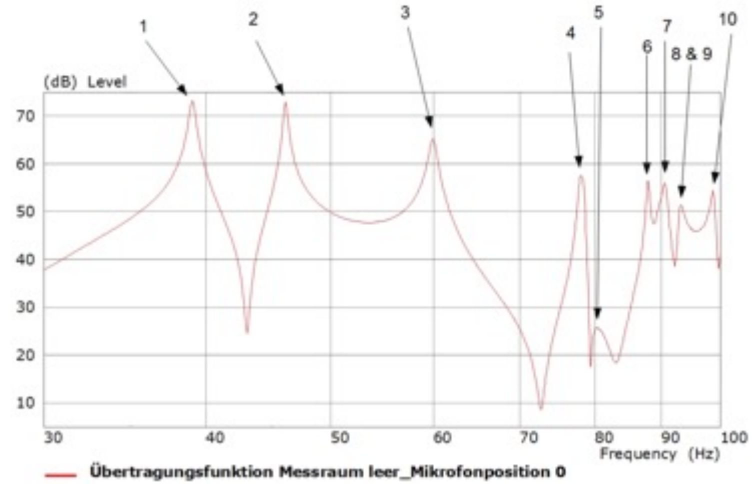
fachschule für akustik ff|akustik

Lehrgang « Dipl. AkustikerIn SGA »

Michael Feller

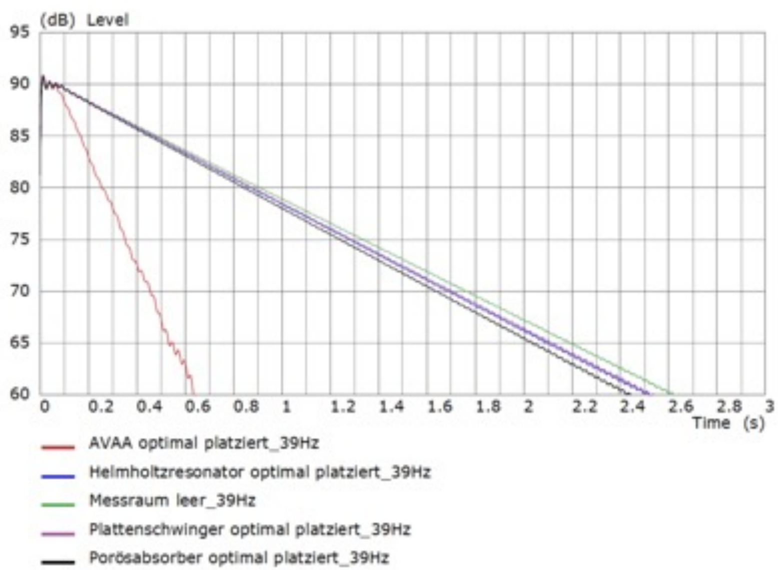
Vergleich verschiedener Messmethoden zur Bestimmung des Absorptionsvermögens von Tieftonabsorbern in Räumen mit geringer Eigenmodendichte

Identification of room modes

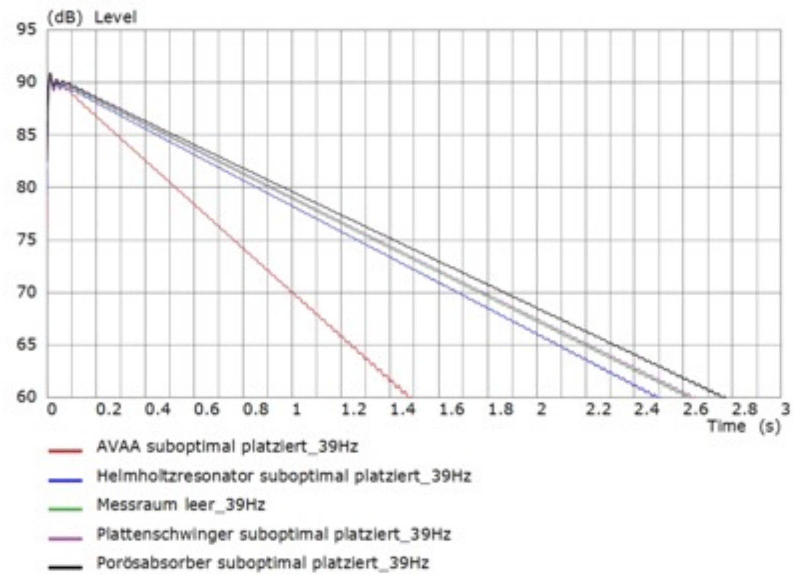


RT_{60} @ 39 Hz

Red: with 2 x AVAA in optimal position



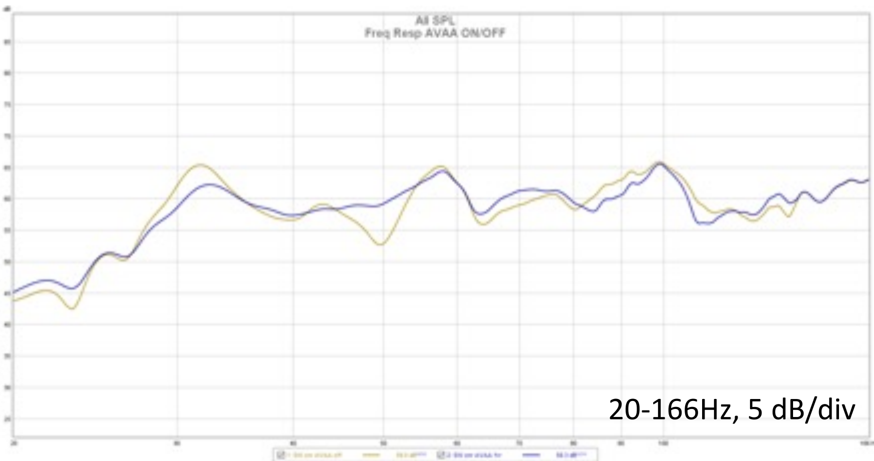
Red: 2 x AVAA in sub-optimal position



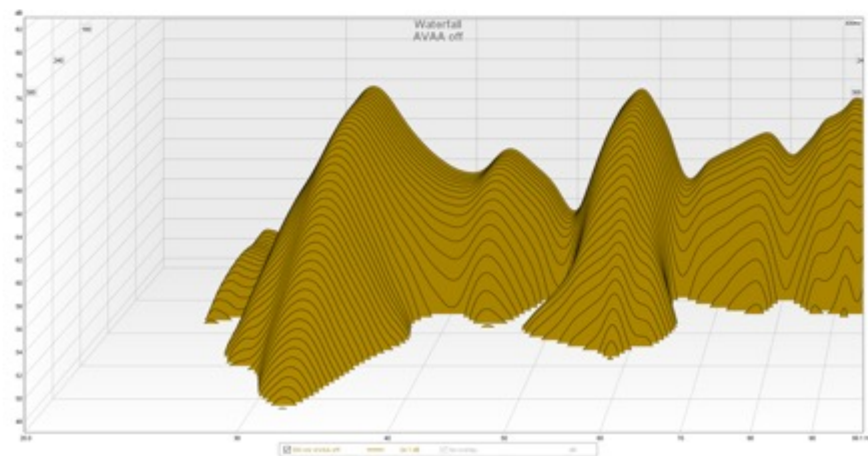
Andy Hong, USA - Studio

Frequency response and waterfall **without AVAA**

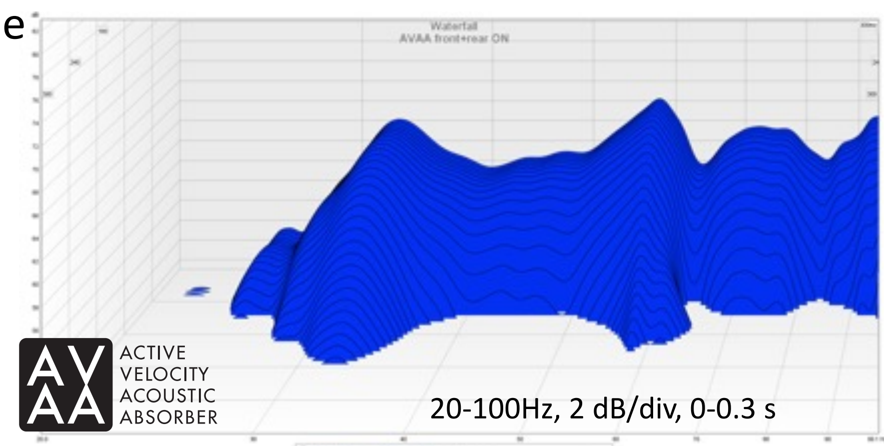
Frequency response and waterfall **with AVAA**



20-166Hz, 5 dB/div



“In short, there was not enough "**BOO..**.” in the bass — but way too much "**...OOOMMMmmmnnn**” clouding the overall image.
Once we turned on the AVAAs, we could all hear the "**BOOM**" clearly — and everything else in the mix too.”
(Andy Hong – Tape Op)



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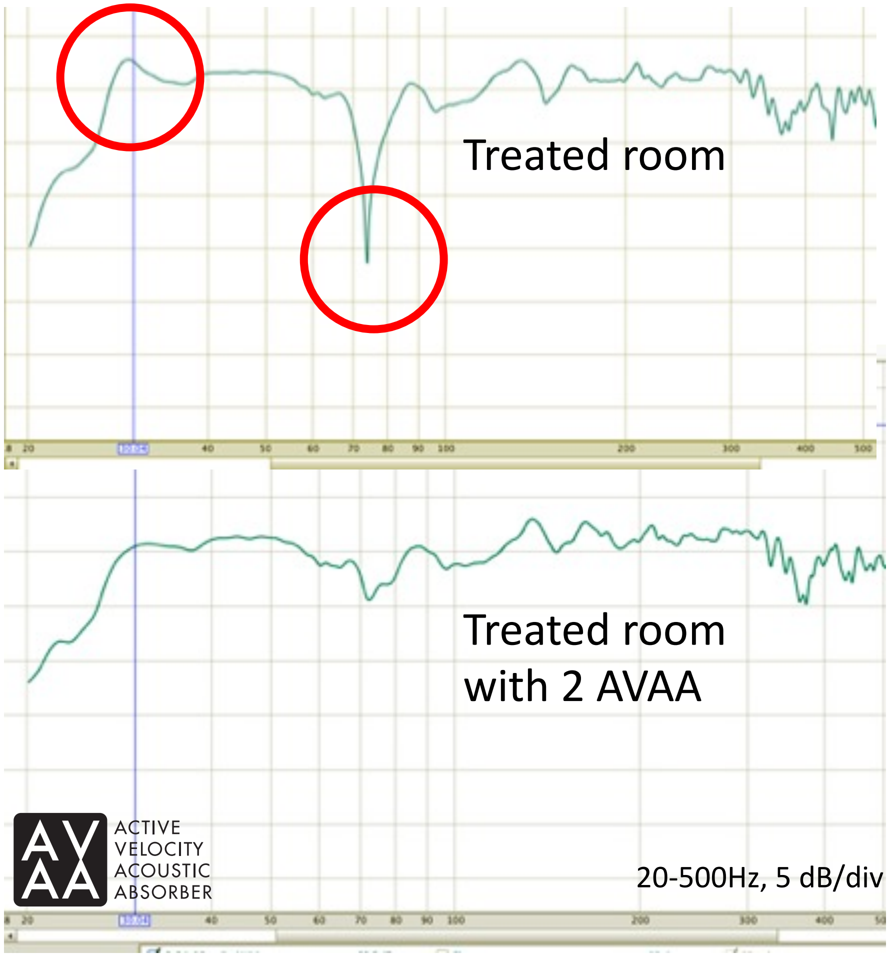
20-100Hz, 2 dB/div, 0-0.3 s

Barry Rudolph, USA - Studio



"The effect of the AVAAs is **dramatic and not subtle**! The bass became instantly **tighter**, **more defined** and **evenly balanced** throughout the entire space"

"The AVAAs **flattened** out the subsonic range from 50 Hz downward **like huge bass traps that couldn't possibly fit into my room**"

"With my two AVAAs running I arrive at **mixes faster with much less of a struggle** to get the low and low midrange frequencies correct for bass, kick and drum sounds. **Mixes translate even better now"**

Currently used in

- **Numerous music studios**
  - **Live rooms**
  - **Mixing, mastering, post production**
- **Hifi users**
- **Small concert or music rooms**
- **Anechoic rooms in laboratories**
- **Technical rooms (heat pumps, compressors, boilers)**
- **Flats built above underground (London)**
- **Car manufacturers currently testing the technology**

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Thank you for your attention!

Product range

A215-M
A25-M
A23-M
A214-M
A21-M
A17-M
A14-M Broadcast
A14-M Studio
SUB A225-M
SUB A125-M

AVAA
Active
Velocity
Acoustic
Absorber