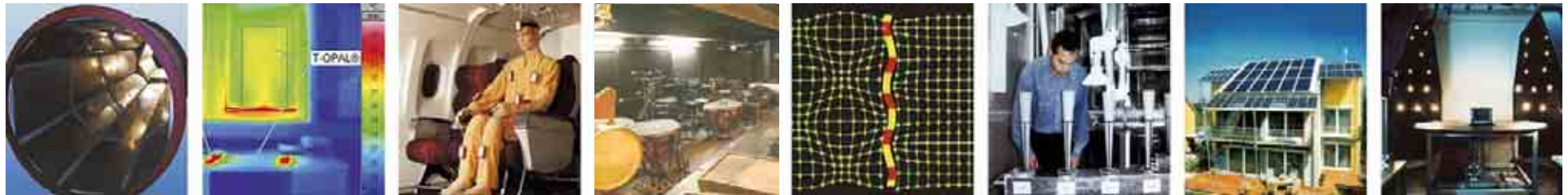

Room acoustic design of orchestra pits

Horst Drotleff, Michael Leistner





- Acoustic problems in pits
- Subjective and objective tests
- Room acoustic approach
- Refurbished pits
- Summary

- Staatstheater Stuttgart, Großes Haus
- S-H Landestheater, Stadttheater Flensburg
- S-H Landestheater, Stadttheater Rendsburg
- Stadttheater Duisburg
- Staatstheater Mainz, Großes Haus
- Aalto Theater Essen
- Stadttheater Koblenz
- Theater Aachen
- Stadthalle Biberach
- Hippodrome Theatre, Birmingham
- The Royal Opera House, London
- Stadttheater Regensburg





Acoustic load

	L_{eq} dB(A)	L_{max} dB
Strings	~ 83 – 90	up to 110
Woodwind	~ 86 – 95	up to 117
Horn /Trumpet /Trombone	~ 83 – 96	up to 120
Percussion / Kettledrum		up to 130 (?)

Billeter, T. et al: Gehörbelastung von Orchestermusiker

Fearn, R. W.: Hearing loss in Musicians, 1992

Funk, D.: Lärmbelastung von Orchestermusikern

Laitinen, H. M. et al: Sound exposure among the finnish national opera personnel, 2003

Lee, A. et al: Musician's noise exposure in orchestra pit, 2005

Kwiatkowski, A. et al: Schalldruckpegel im Orchestergraben eines Opernhauses, 1986

Mikl, K.: Orchestral Musik: An assessment of risk, 1995

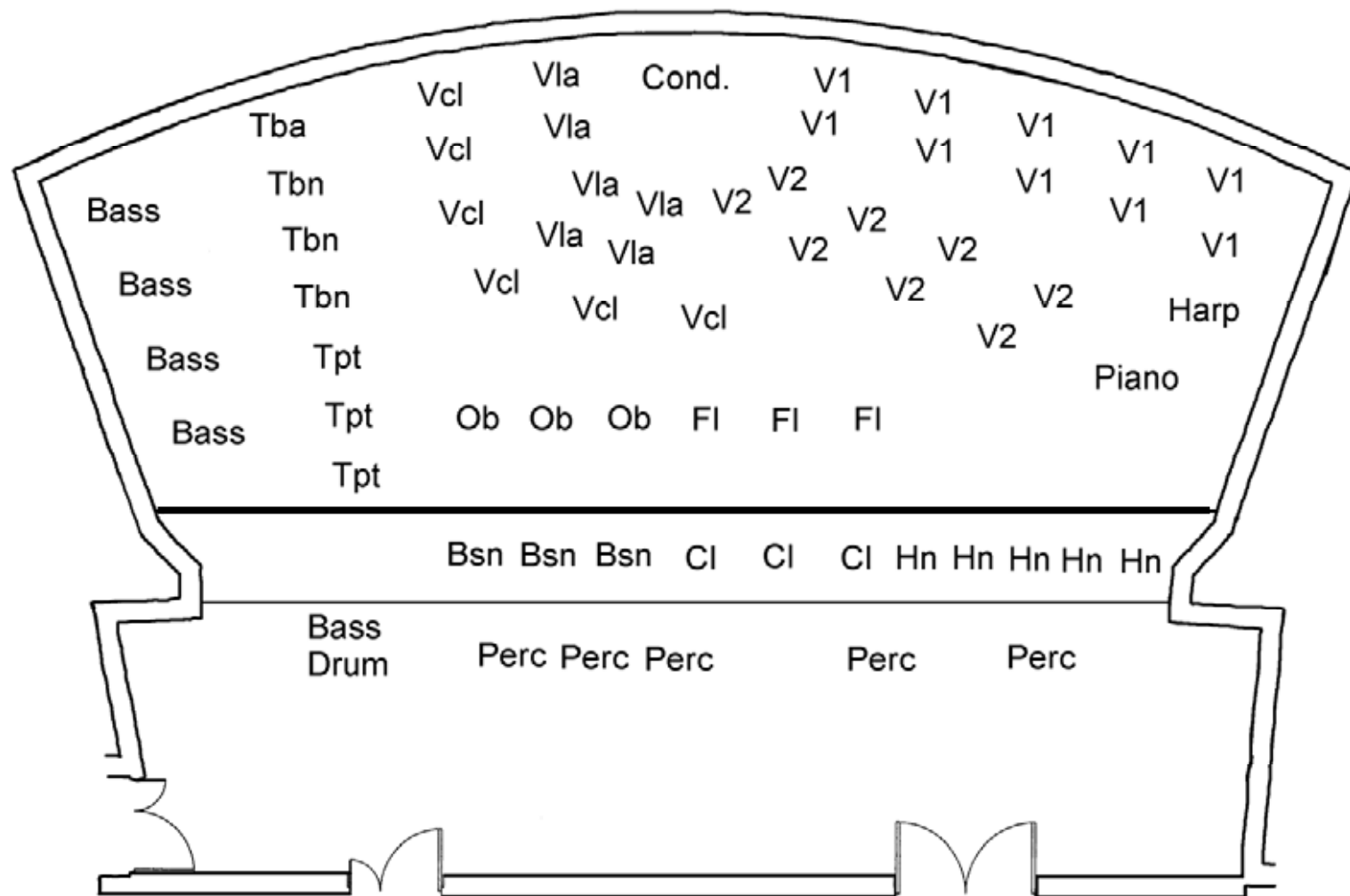
Naylor, G.M.: Problem and priorities in orchestra pit design, 1985

Vogt, J. et al: Schallbelastungen im Orchestergraben und potentielle Schutzmaßnahmen

“Nutcracker” in Hippodrome Theatre, Birmingham

	whole event Leq	8-hour Leq (ONE perf)	8-hour Leq (TWO perf)	highest peak dB (C)
In front of main Percussion desk	90	85	88	129
2nd violin music stand nearest Piccolo	92	87	90	122
Bass clarinet, by ear in front of trumpets	91	86	89	123
Cor Anglais in front of trumpets	91	86	90	125
2nd bassoon in front of timpani	90	85	88	126
double basses on music stand	90	85	88	120
In front of conductor on viola music stand	88	83	86	116
French horns on 2nd desk music stand	95	90	93	124

Subjective survey, Hippodrome Theatre, Birmingham



1. Is the orchestra pit of Birmingham Hippodrome especially bad?

Yes: 6

No: 25

2. Key problem

Related to overhang	12
Non acoustic / no problem	7
Too little room between instrument groups	5
Other instruments are hard to hear	5
Too loud, not overhang related	4

3. Other problems

Non acoustic / no problem	7
Too loud, not overhang related	5
Too dry	4
Related to overhang	3

5. Overall acoustic impression

Very good	Good	Satisfactory	Fair	Poor
0	2	14	12	4

6. Overall acoustic impression, compared to other pits

a lot better	better	Same	worse	a lot worse
1	12	10	11	0

7. How loud in forte?

Painfully loud	Too loud	Suffic. loud	Soft	Too soft
6	12	18	0	0

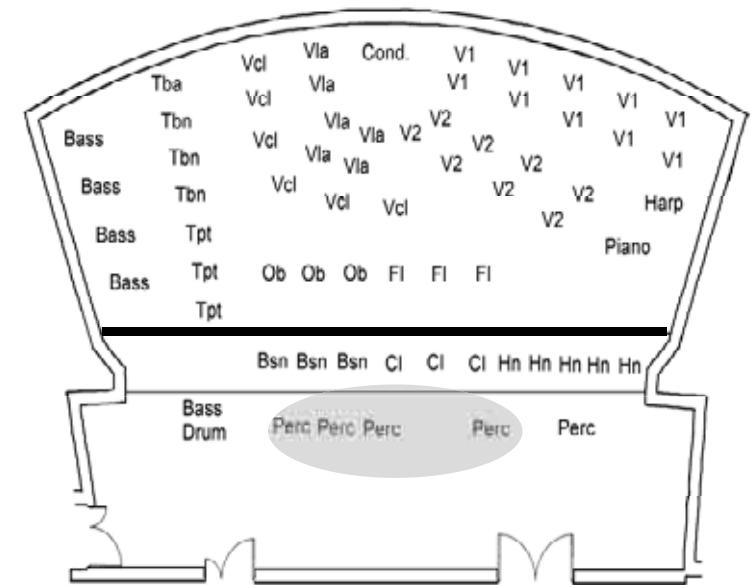
8. How loud in forte, compared to other pits?

a lot louder	louder	Same	softer	a lot softer
1	11	9	8	0

Subjective survey, Hippodrome Theatre, Birmingham

How loud is it at your position in *forte*?

Painfully loud	
Too loud	✓
Sufficiently loud	
Soft	
Too soft	

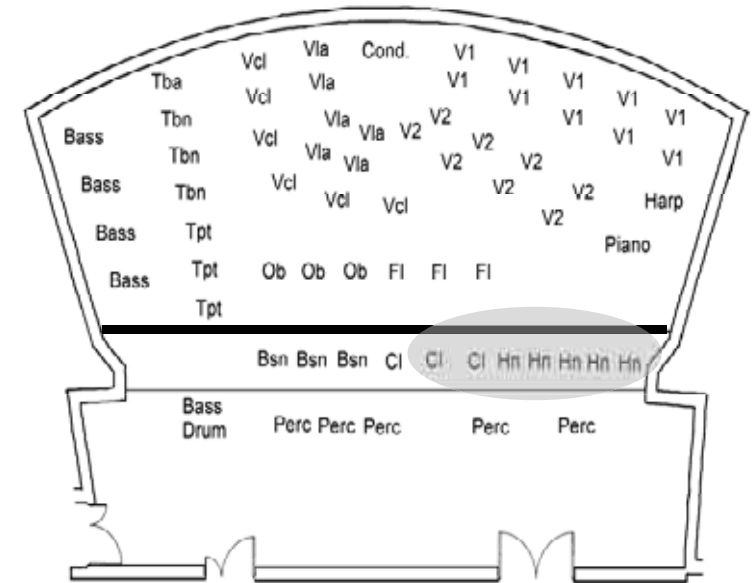


Remarks: MADE WORSE BY THE USUAL BARRICADE
OF SCREENS PLACED IN FRONT OF US - REFLECTING
OUR ~~OWN~~ SOUND BACK AT US.

Subjective survey, Hippodrome Theatre, Birmingham

How loud is it at your position in *forte*?

Painfully loud	
Too loud	
Sufficiently loud	
Soft	
Too soft	



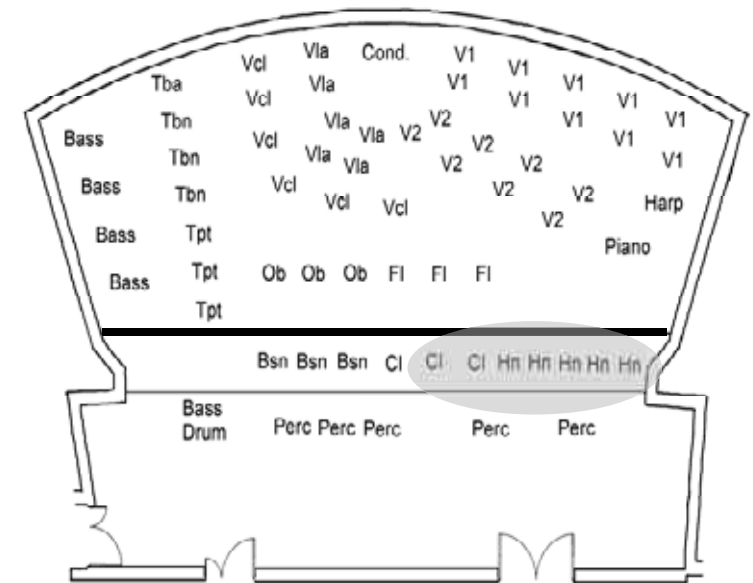
Remarks:

Then under the low ceiling, the pipe and general high woodwind can be piercingly loud.

Subjective survey, Hippodrome Theatre, Birmingham

How loud is it at your position in *forte* compared to other orchestra pits?

A lot louder	
Louder	✓
Same	
Softer	
A lot softer	



Remarks:

A more open pit / higher ceilings makes the noise situation more comfortable for everyone.

9. Instruments that are too loud

Percussion	22
Piccolo	9
Brass	9
Horns	8
Timpani	5
Woodwind	5

10. Instruments that are hard to hear

Strings	19
Bass	8
Woodwind	8

11. Opinion to screens

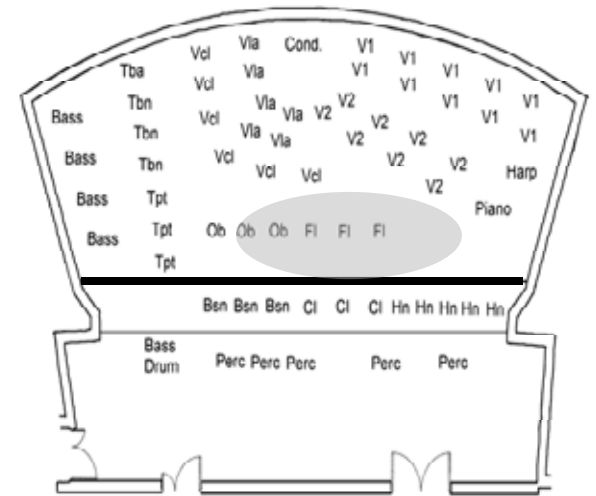
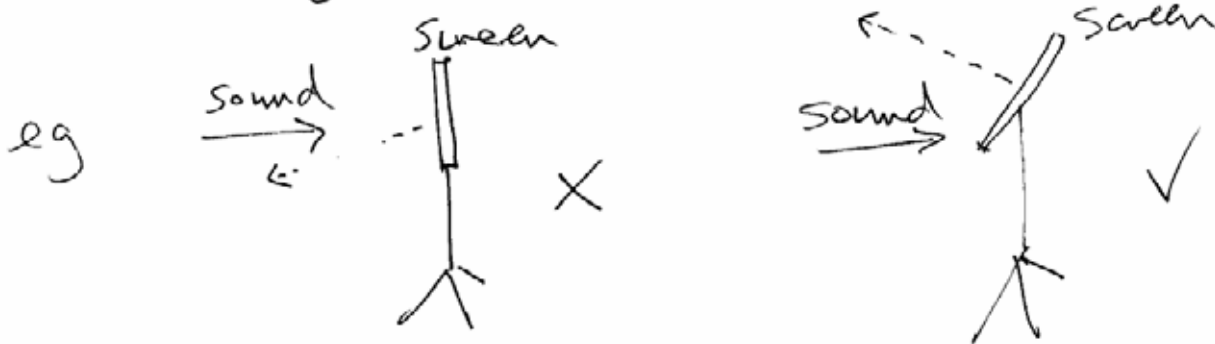
Positive	9
Neutral	5
Negative	13

Subjective survey

What is your opinion about the protective screens which are being used in the Birmingham Hippodrome orchestra pit?

Useless. They should have a dampening material on them instead of perspex which just reflects the sound in a different direction. I realise this would cause visual problems for the player behind but that should be a lesser issue than damaging peoples hearing!!

Also the angle of the screens is just left to chance. If you think about it the angle should be carefully considered!



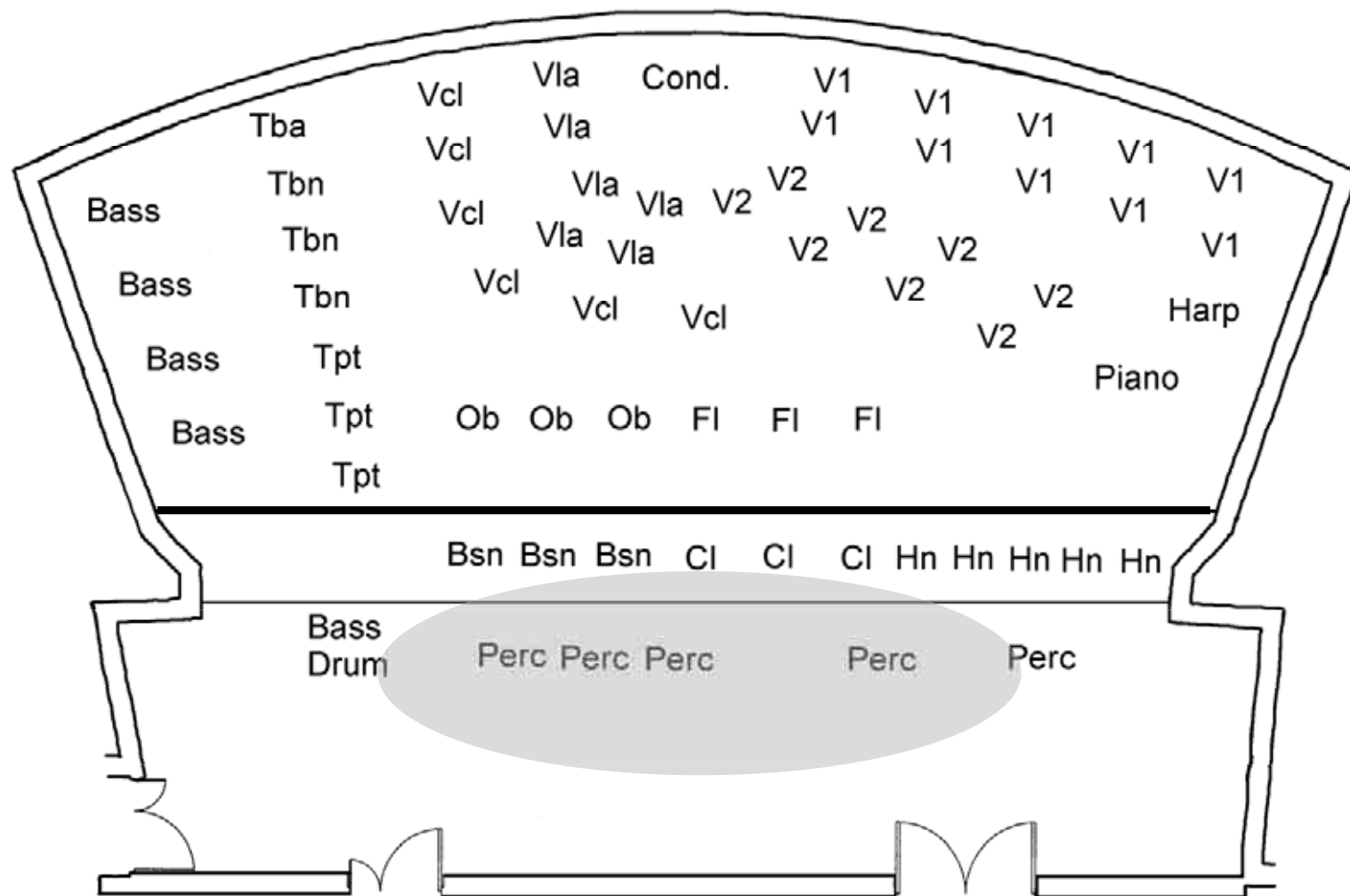
12. Clarity of sound

Very good	Good	Satisfactory	Fair	Poor
0	6	14	8	2

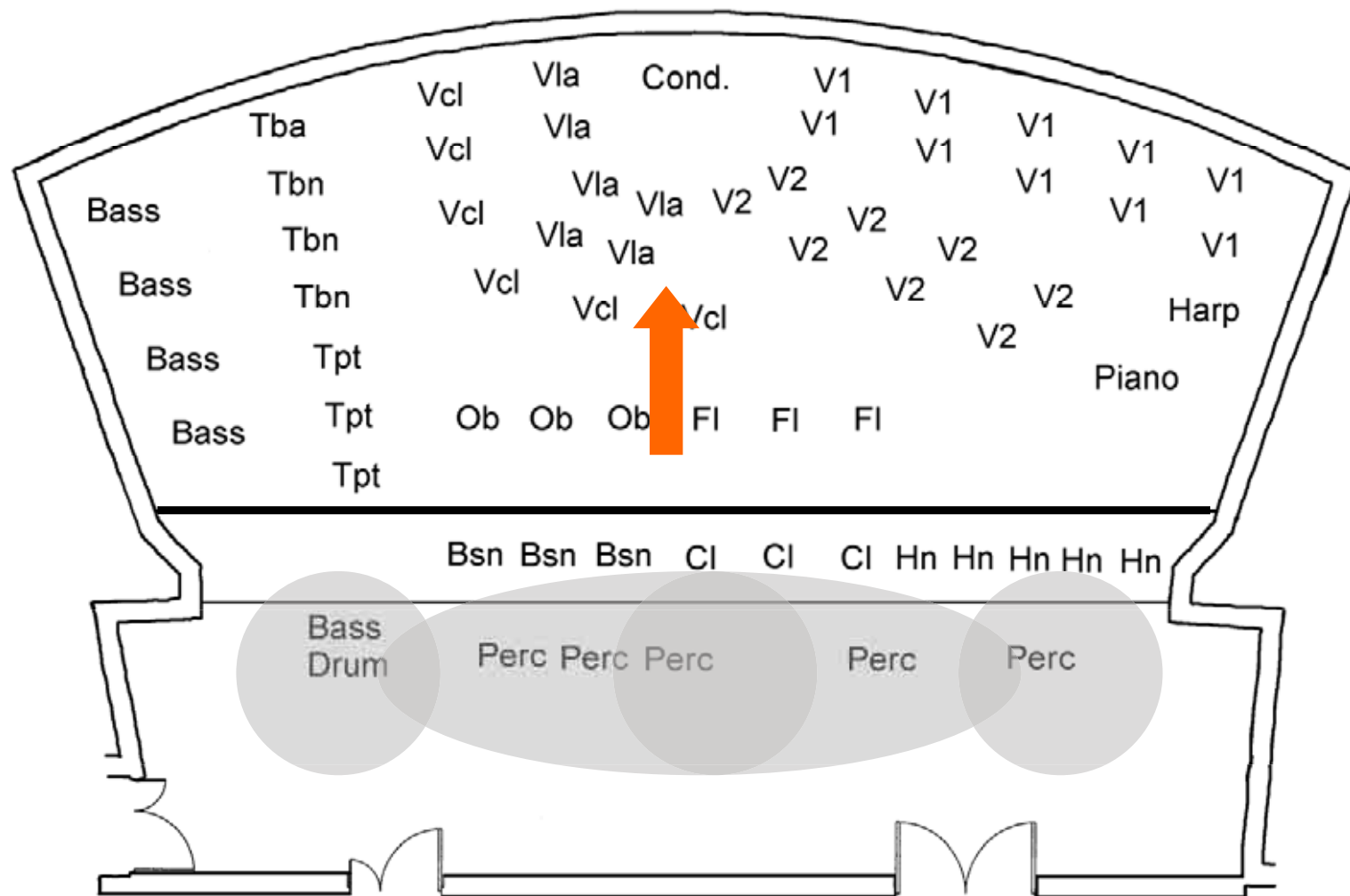
13. Merging of sound

Very strong	Strong	Good	Little	Very little
0	3	11	8	1

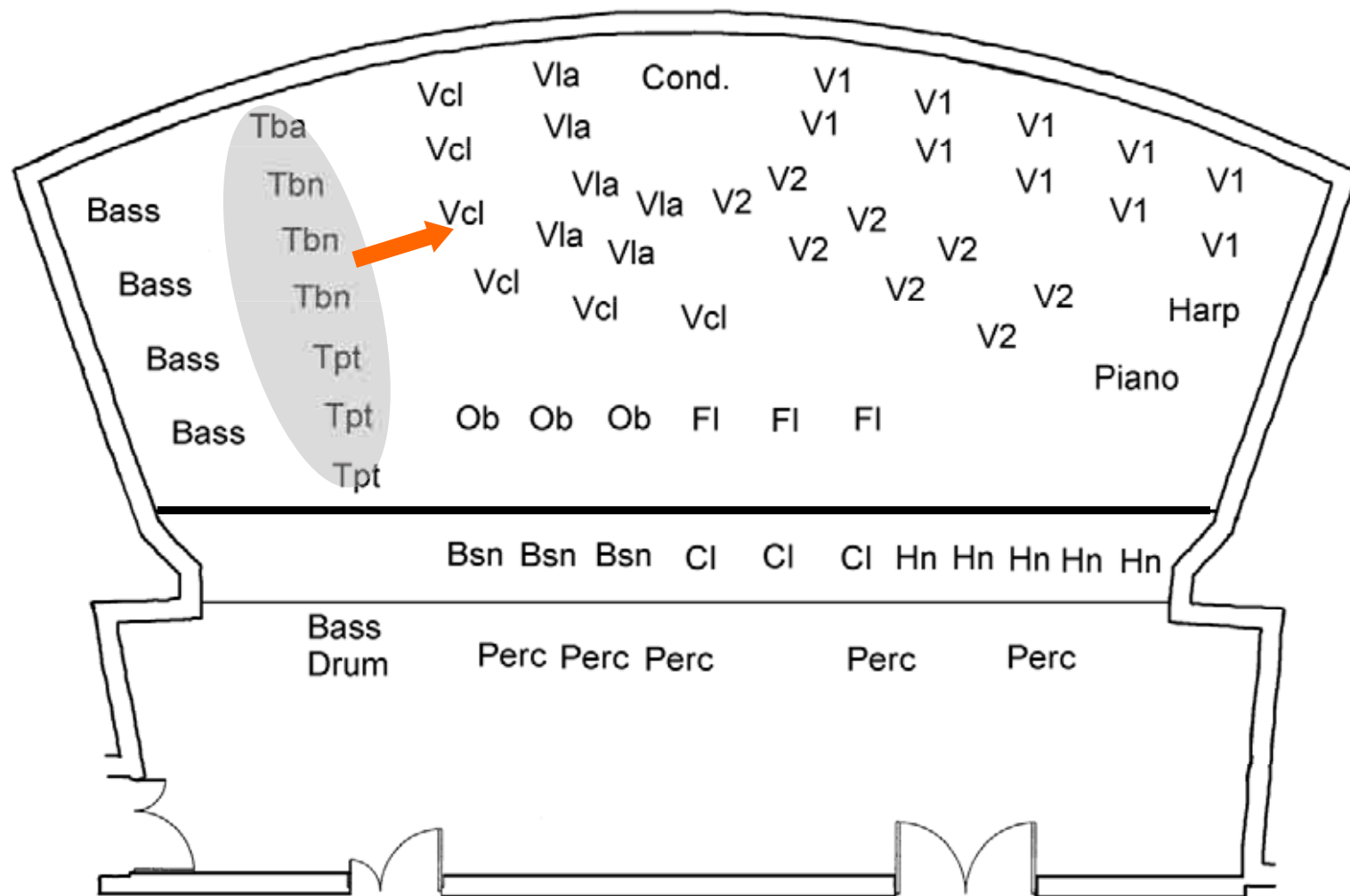
Summing up subjective survey

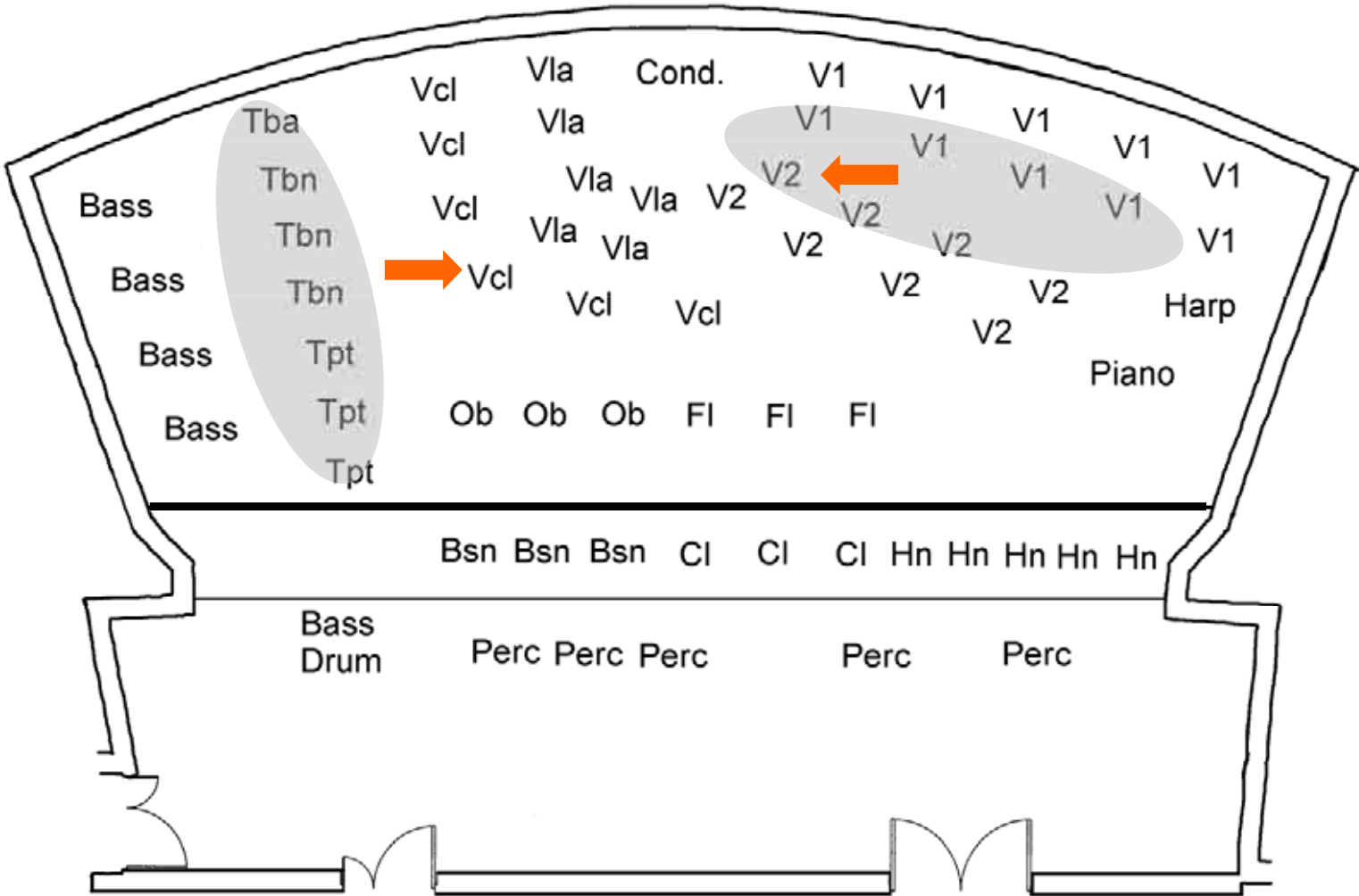


Summing up subjective survey



Summing up subjective survey





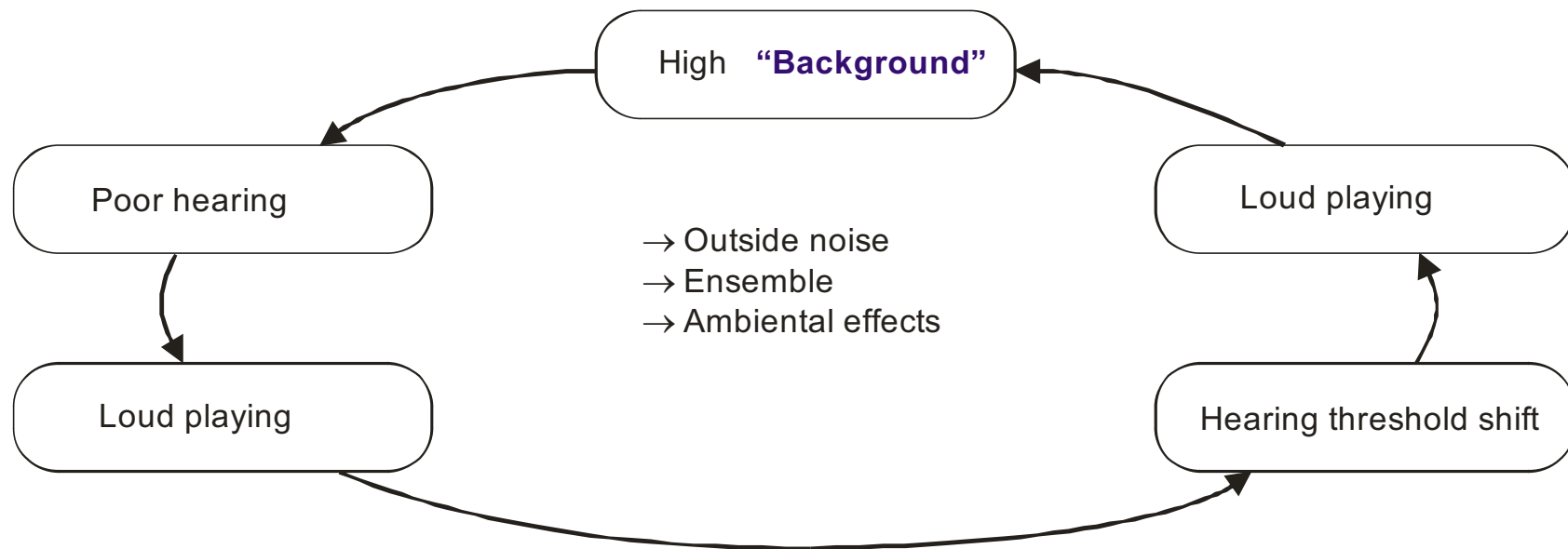
Hypothesis

Ambience
Reverberation,
sound reflection

Acoustic Transparency
Hearing, Self-control

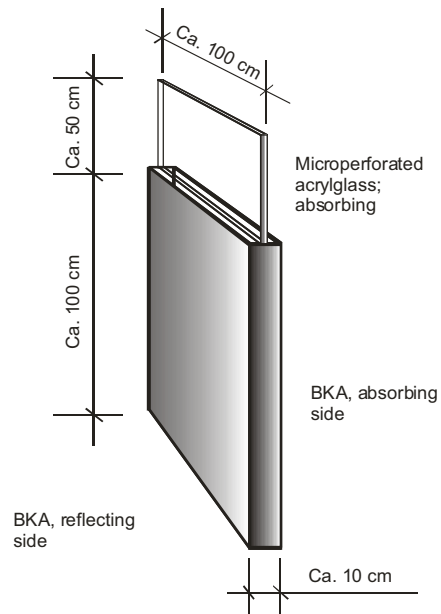
Dynamic Range
Max. Level - **“Background”**

Cause / Effect- Spiral



Various approaches

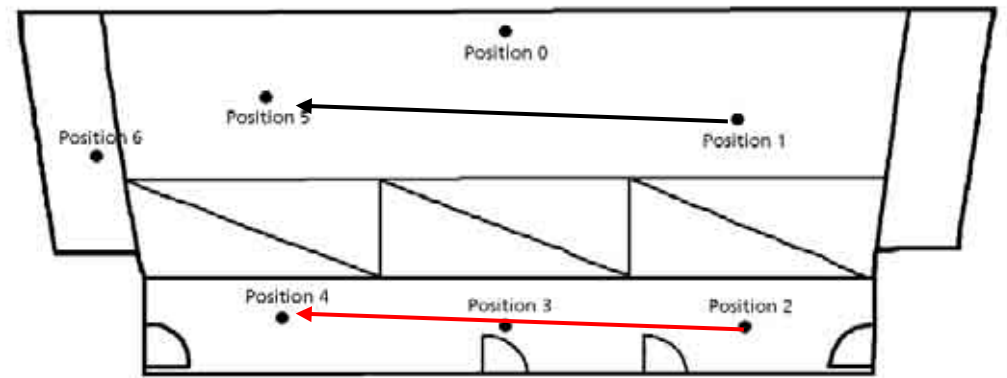
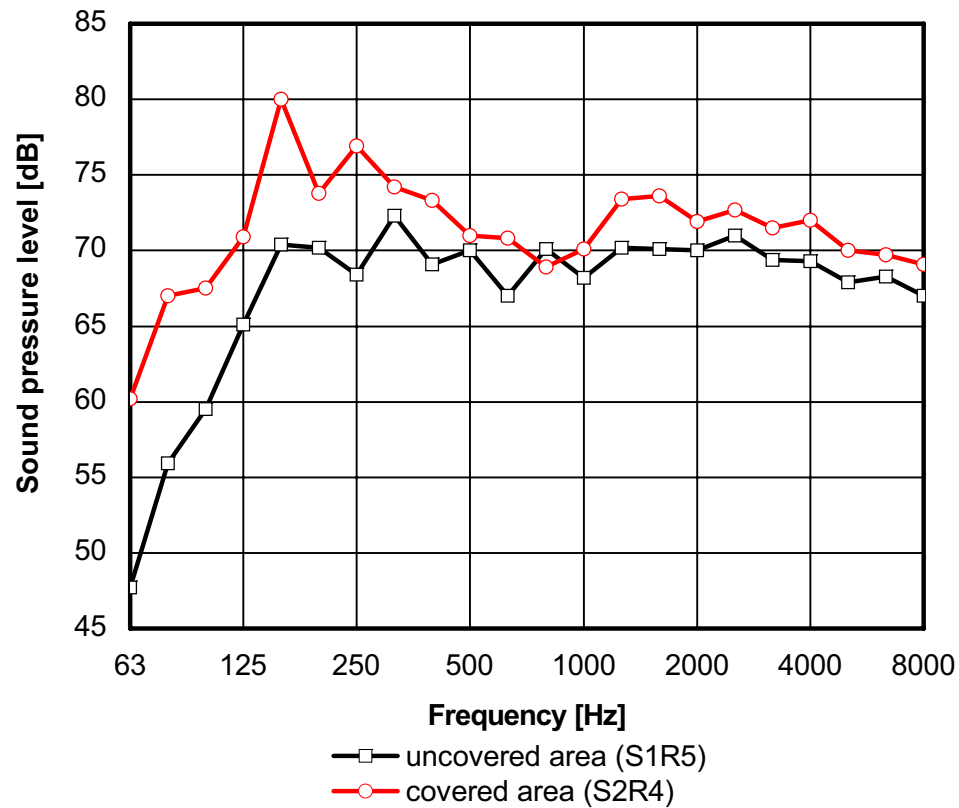
- Individual ear protection
- Shielding measures
- Room acoustic measures



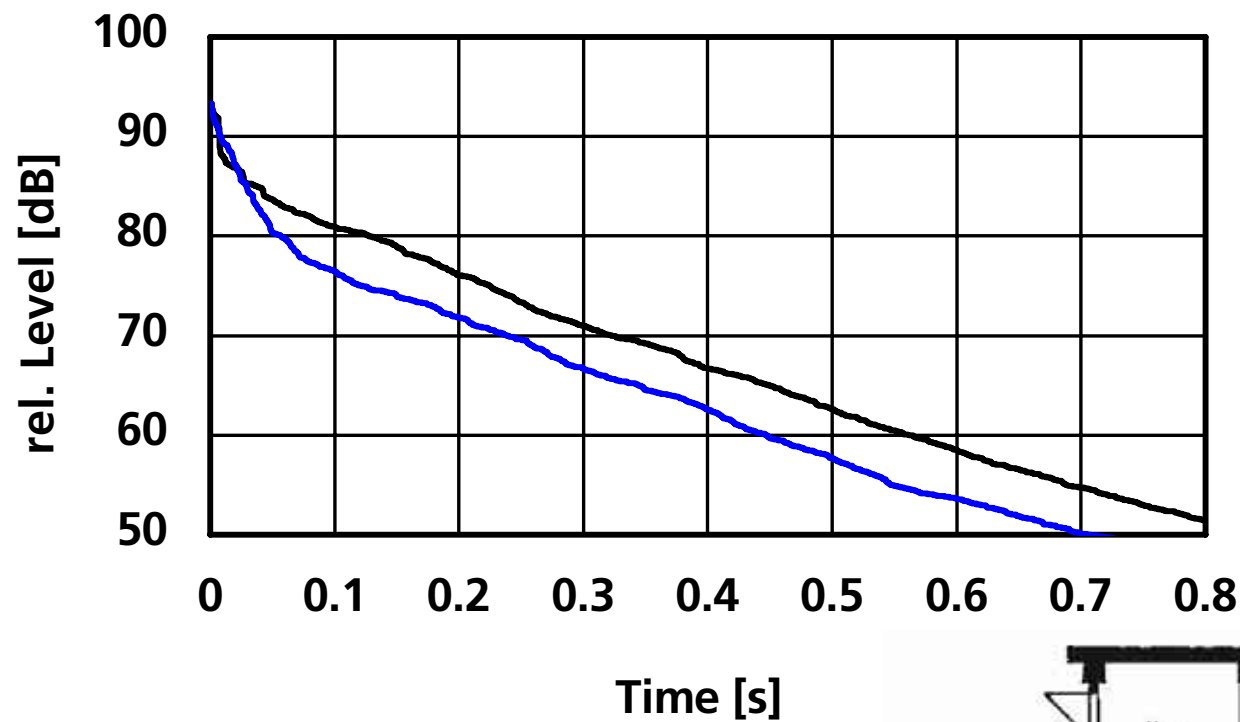
- **Geometry** optimisation
 - 1.5 m² / Musician (Naylor 1985, Mackenzie 1985)
 - Area ratio covered / open (Barron 1993)
 - Height below the overhang; 2.5 ~ 3.5 m (Barron 1993)
- **First reflections** via proscenium surfaces (Tennhardt 2002)
- Sensible **positioning** of instruments (Tennhardt 2002)
- Accentuated **sound field** at **low frequencies** (Tennhardt 2002)
- **High frequencies** over-damped (Tennhardt 2002)
- Absorption **desirable**, but not too much (Barron 1993)

- Minimizing the pit influence
 - Reducing the size of overhang
 - **Selective absorption** → uniform decay times
 - Kettledrum / percussions → **broad band** absorption
- Uncovered area → only **low frequency** absorption
- Transparent, absorbing screen elements
- 1. and 2. Violins → on podiums

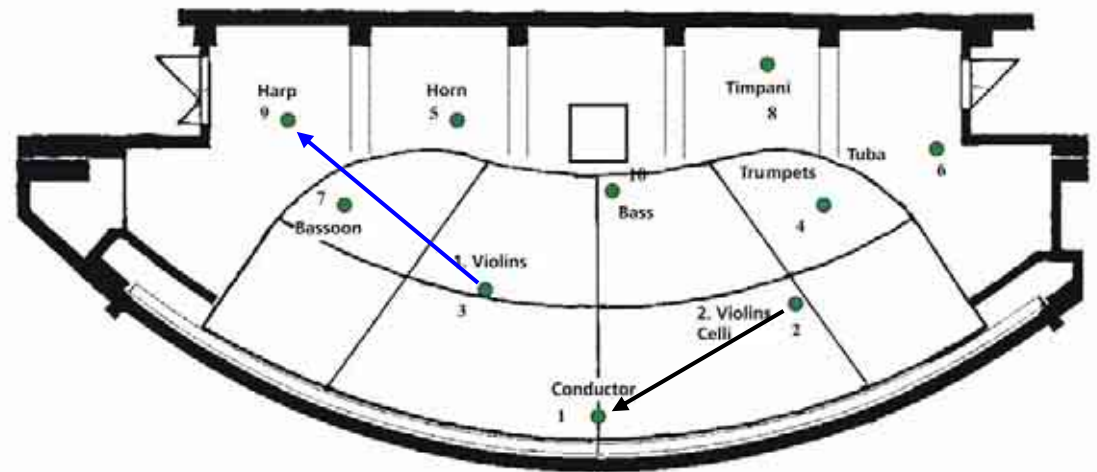
Sound levels covered vs. uncovered



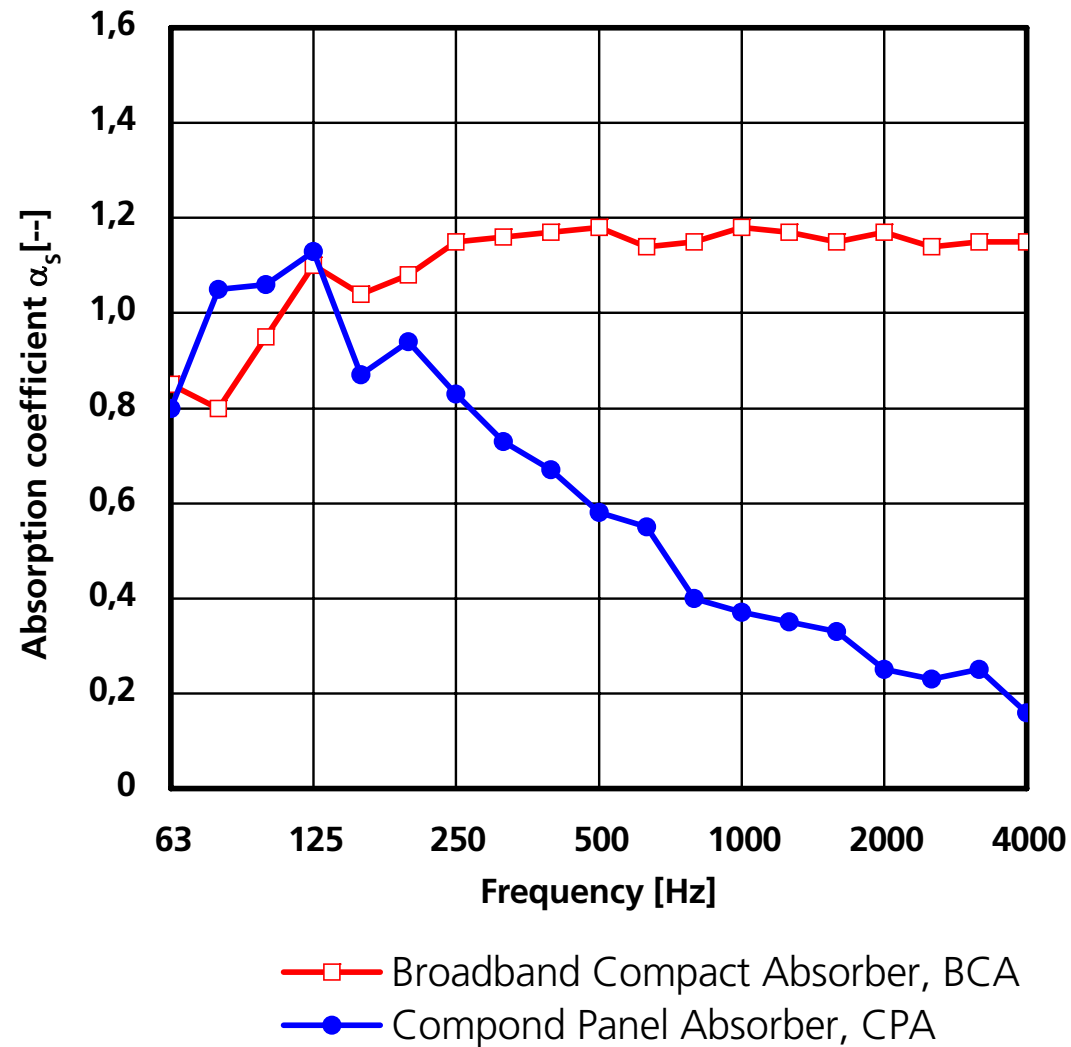
Decay times



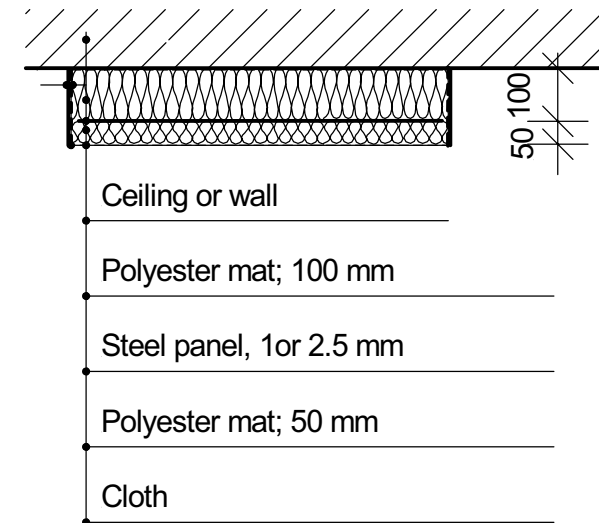
1.0 kHz Octave



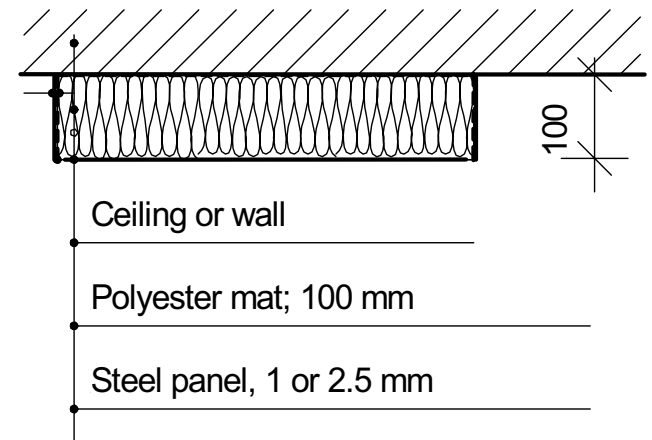
Absorbers



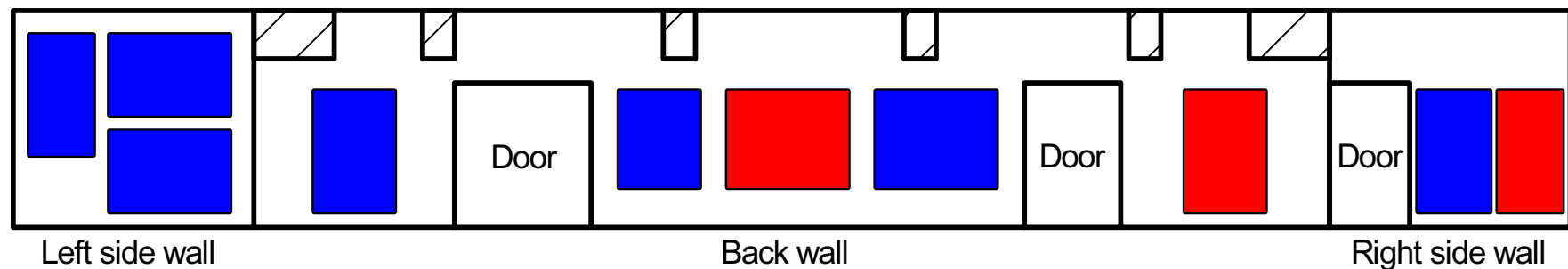
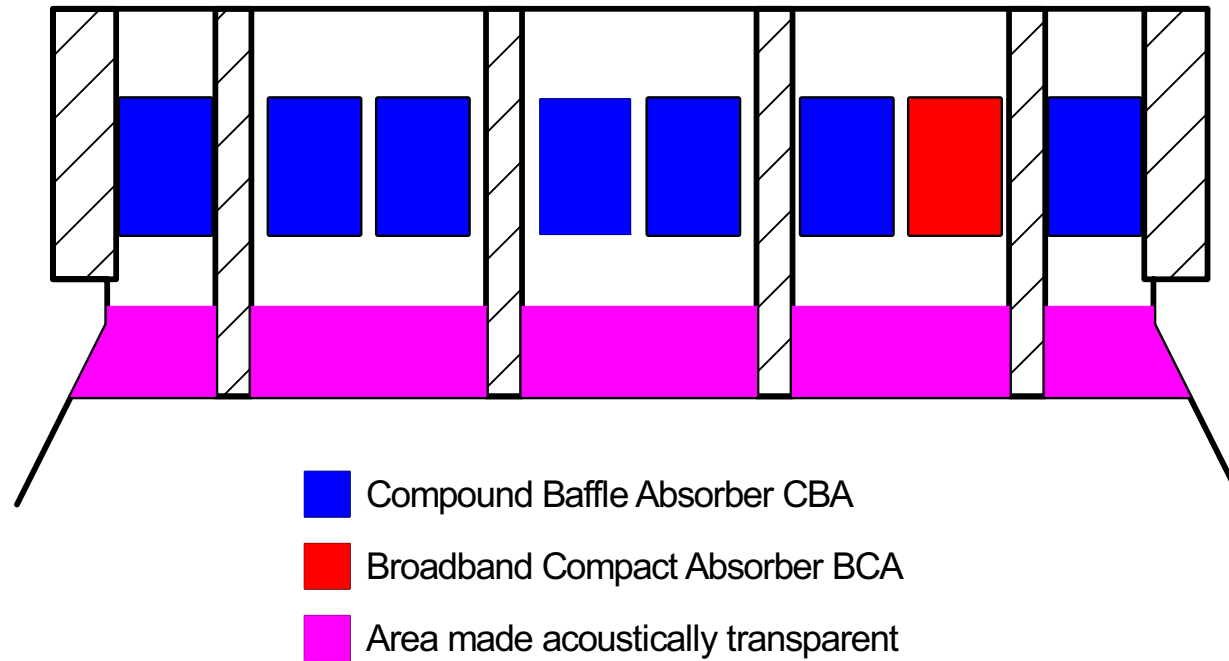
BCA



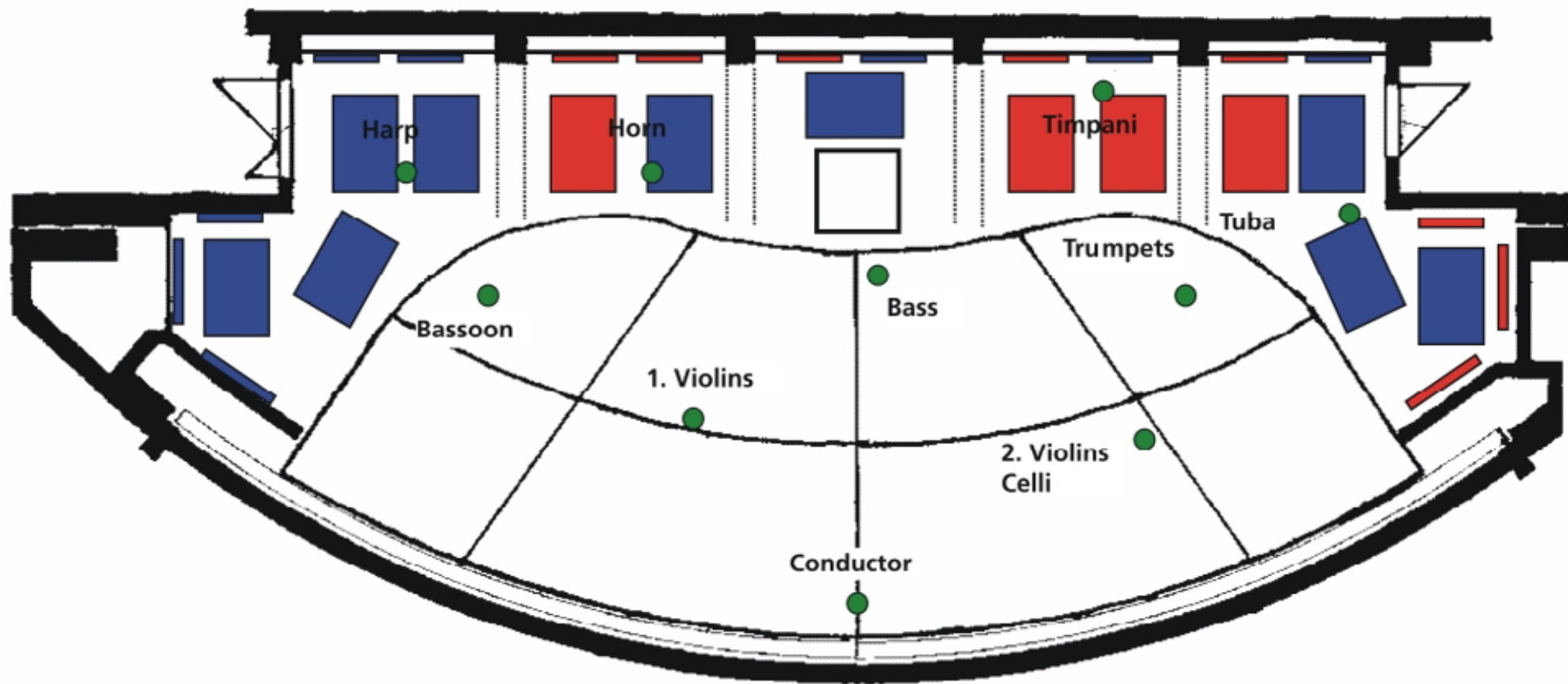
CPA



Selective absorption



Selective absorption



Examples: Landestheater Flensburg



Examples: Staatstheater Mainz, Großes Haus



Examples: Royal Opera House, London



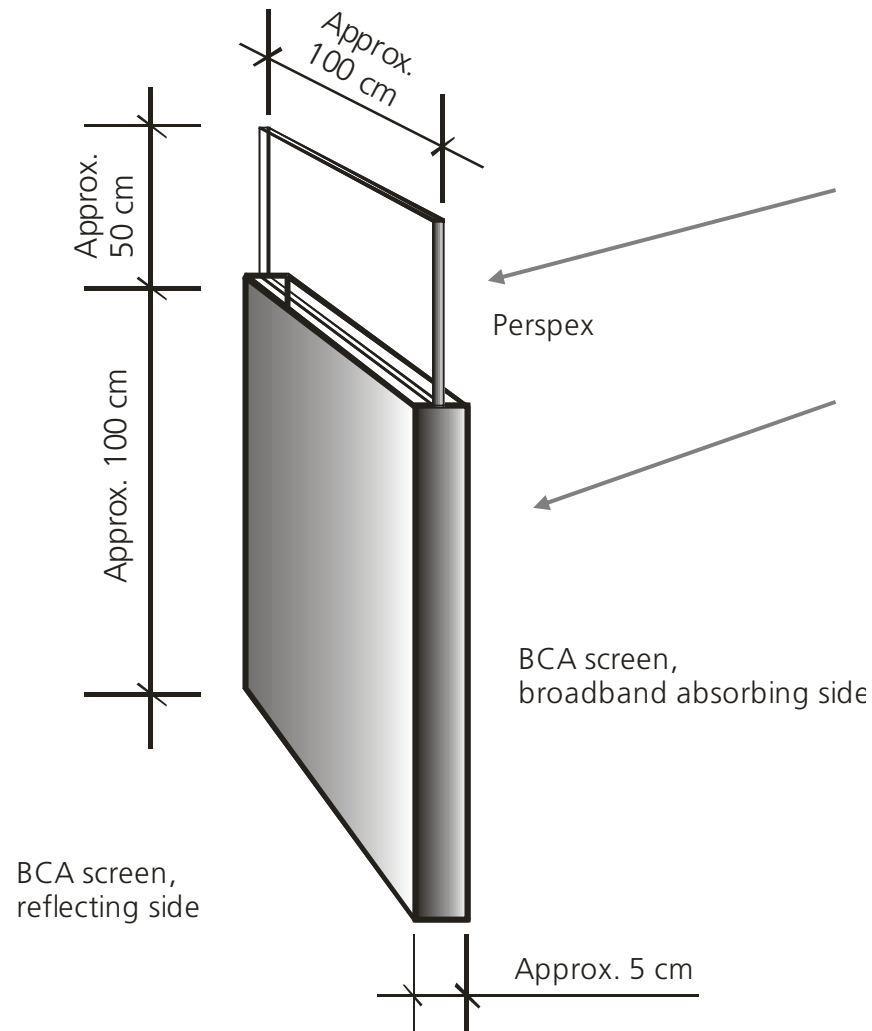
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 - Reducing the size of overhang
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- Transparent, absorbing screen elements
- 1. and 2. Violins → on podiums

Examples: Staatstheater Mainz, Großes Haus



- Minimizing the pit influence
 - Reducing the size of overhang
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Transparent and absorbing screens



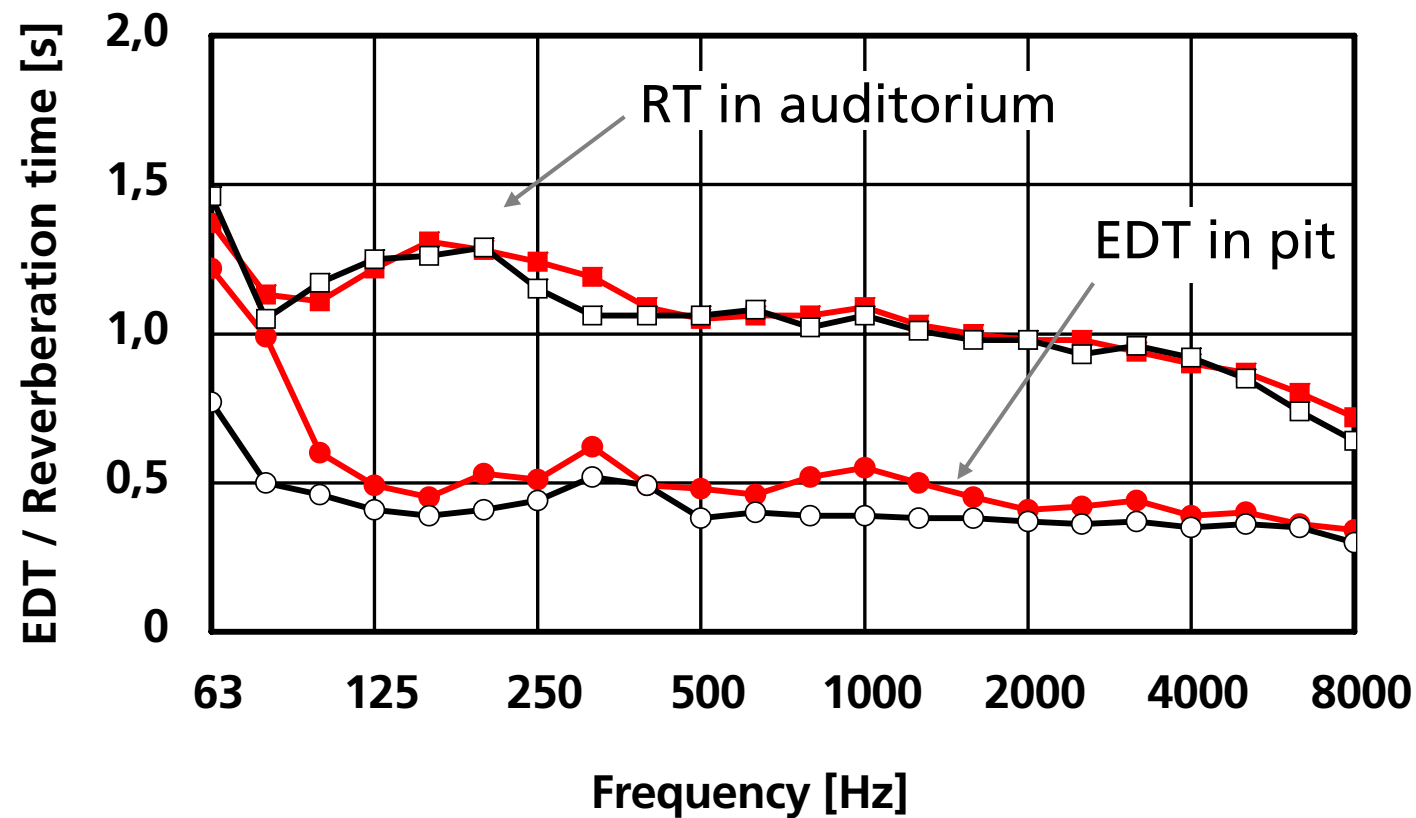
Microperforated Absorber (Perspex)

Broadband Compact Absorber, BCA
(absorbing side)

Wogram, K.: Measures against an inadmissible
sound burden within an orchestra, 2005

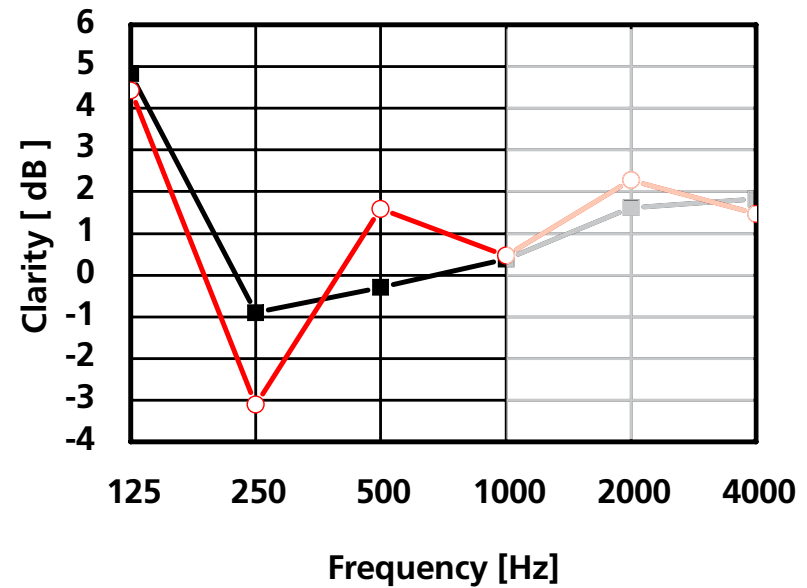
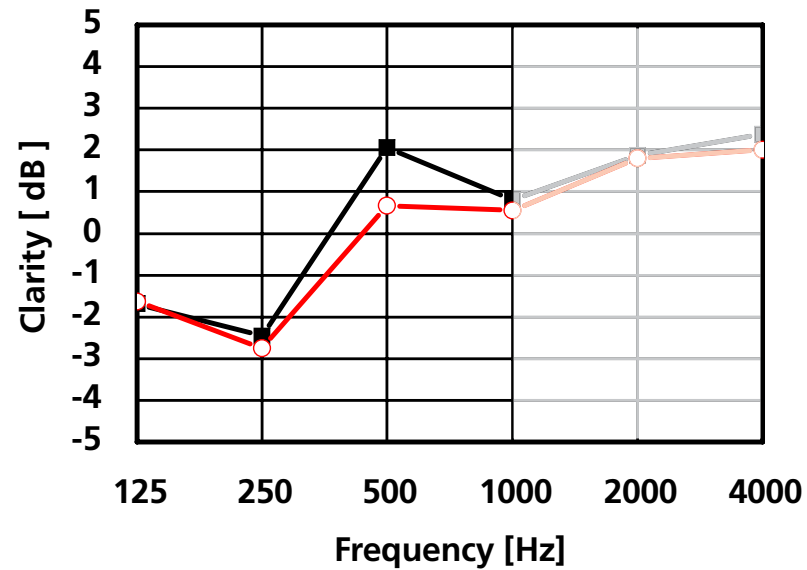
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Decay times in auditorium and orchestra pit



With (—□—, —○—) and without (—●—, —■—) measures in the pit

Clarity in auditorium



With (—■—) and without (—○—) measures in the pit

Out of 37 Musicians:

- Considerable aggravation 1
- Aggravation --
- No changes 3
- Improvement 22
- Considerable improvement 11