Scaling up: Making point-source multichannel content work for large listening areas

A project report from previous VDT International Conventions

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reverberant sound - depends on room ***and*** speaker patterns, usually strong coloration

(We cannot EQ this independent of the direct sound.)

First problem: tone colour

Speakers do not radiate uniformly.

Low frequencies are emitted in all directions.

Directivity increases with frequency.

Nominal coverage is usually reached at 1 kHz.

Coverage in the treble range is narrower.

→ The diffuse field can become bass-heavy.

→ Bass buildup gets worse the more speakers are used.

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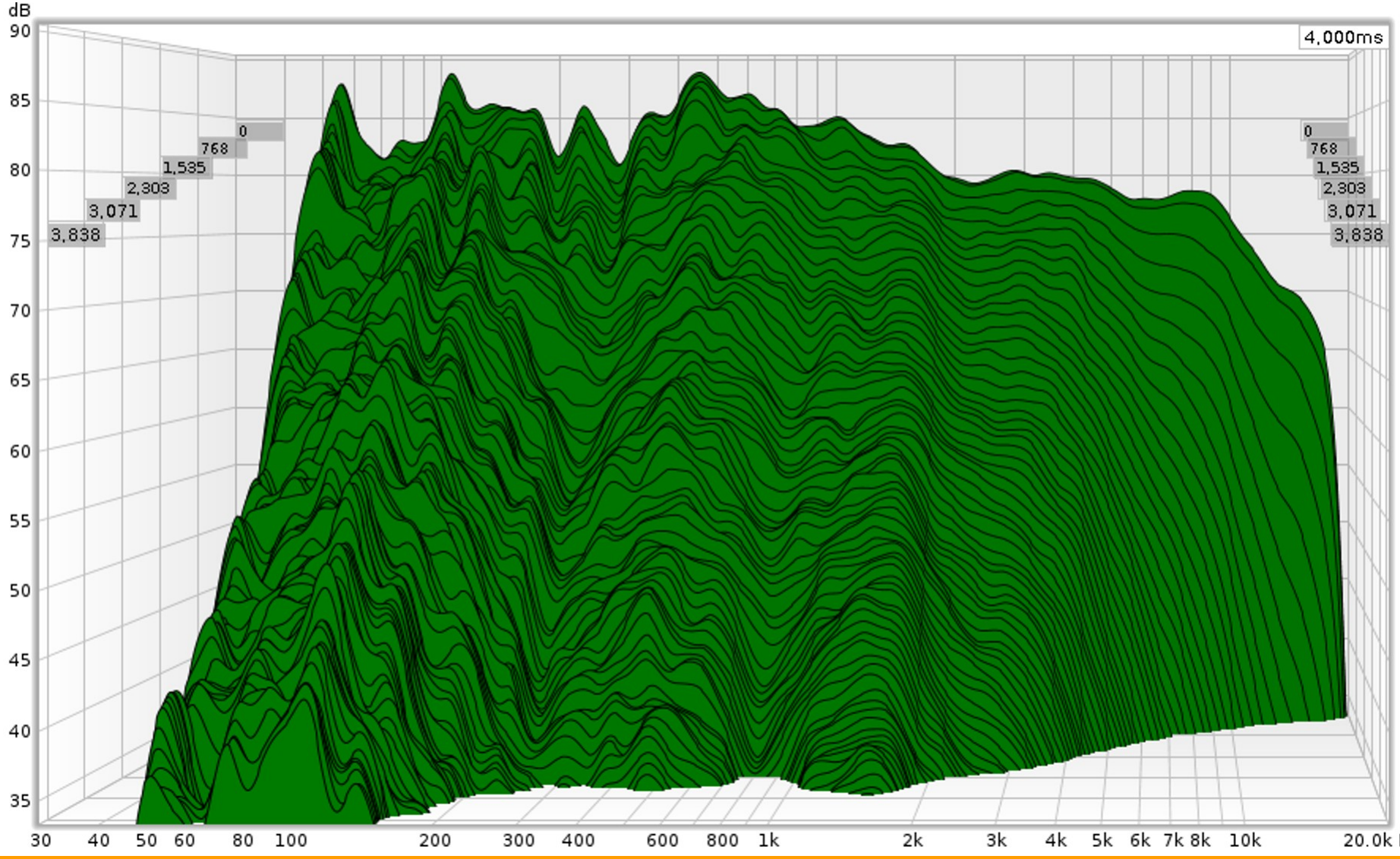
In a reverberant room, wide-dispersion speakers might lead to a more natural tone color, even though they excite the room more.

First problem: tone colour

Typical rooms have very non-uniform decay:



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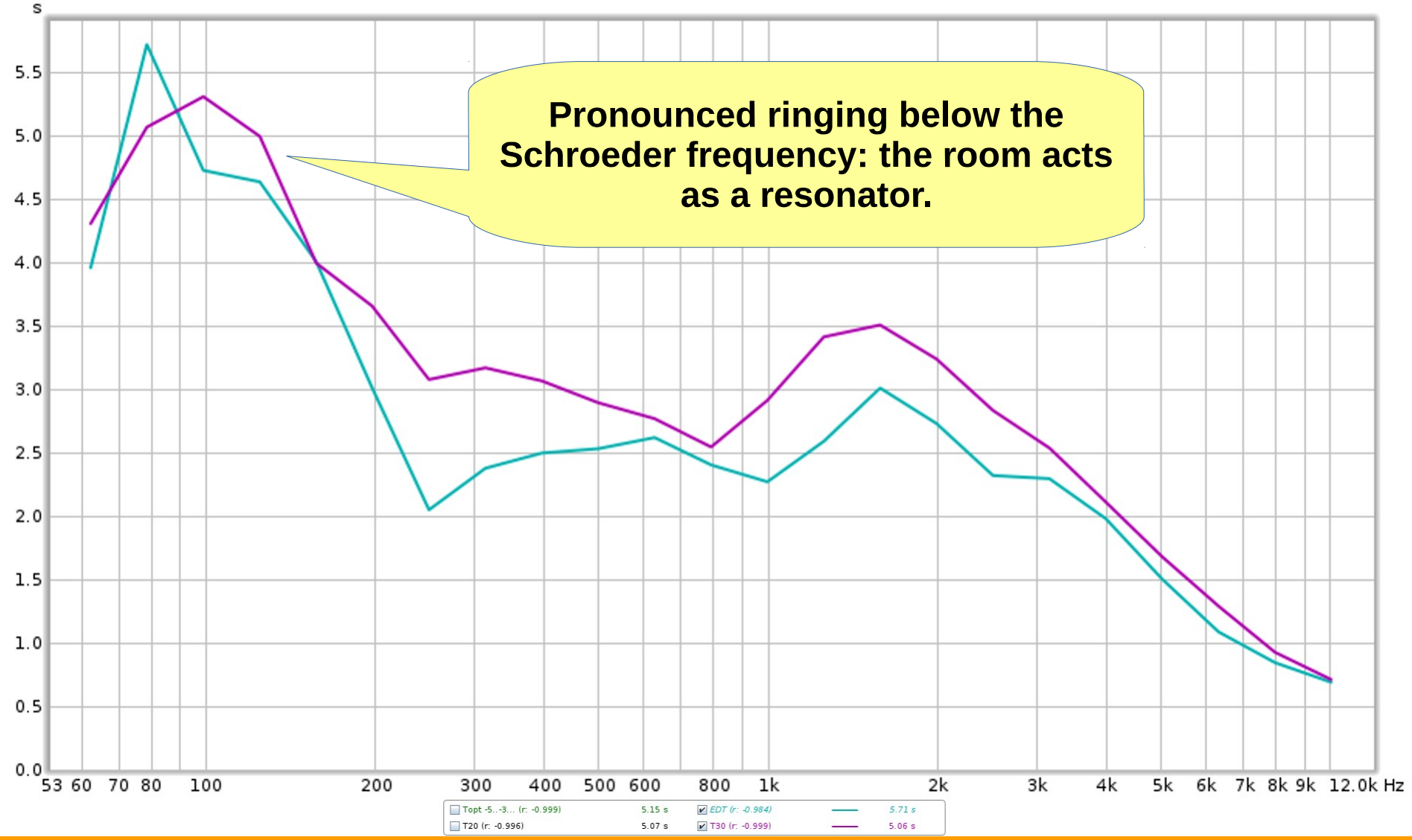

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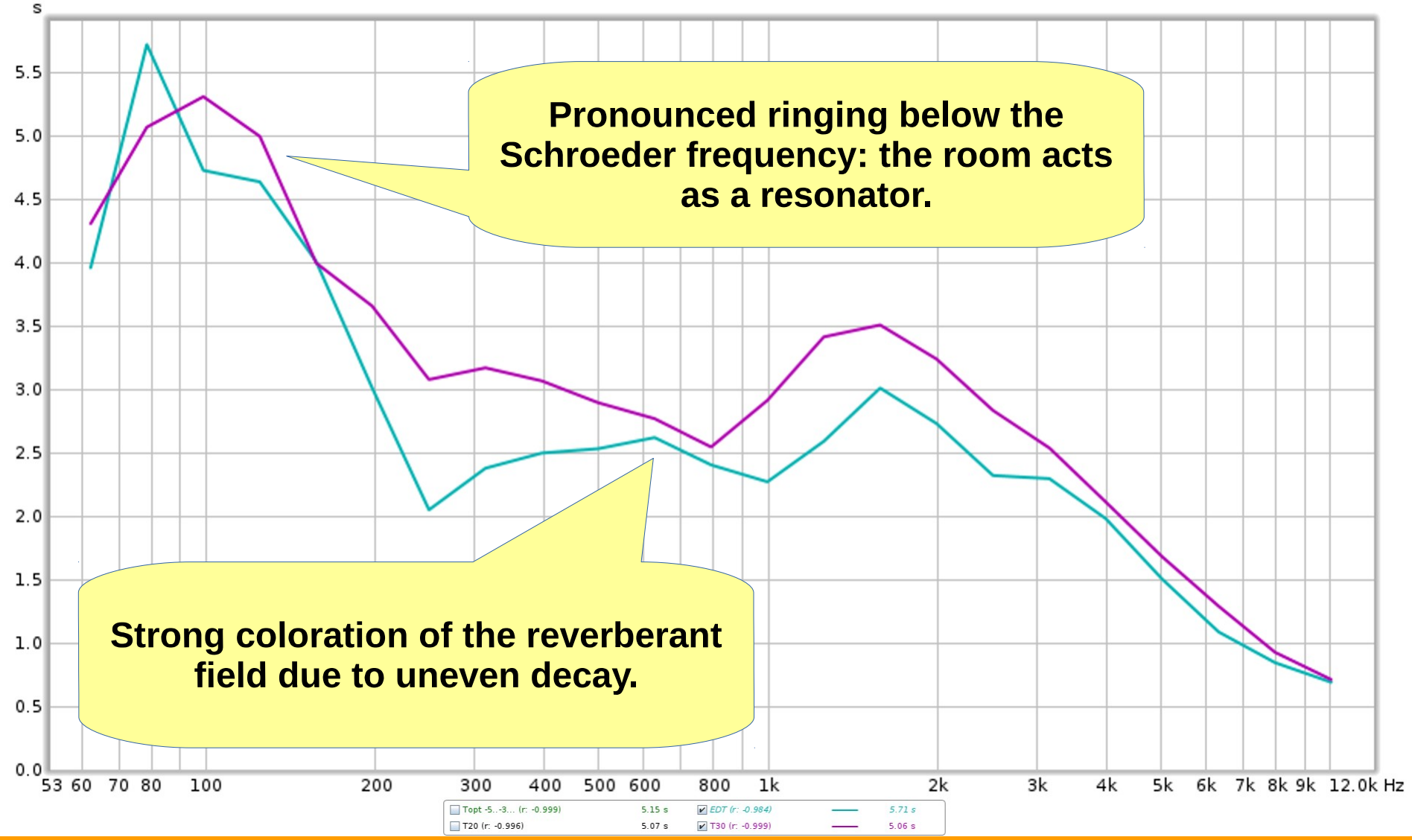

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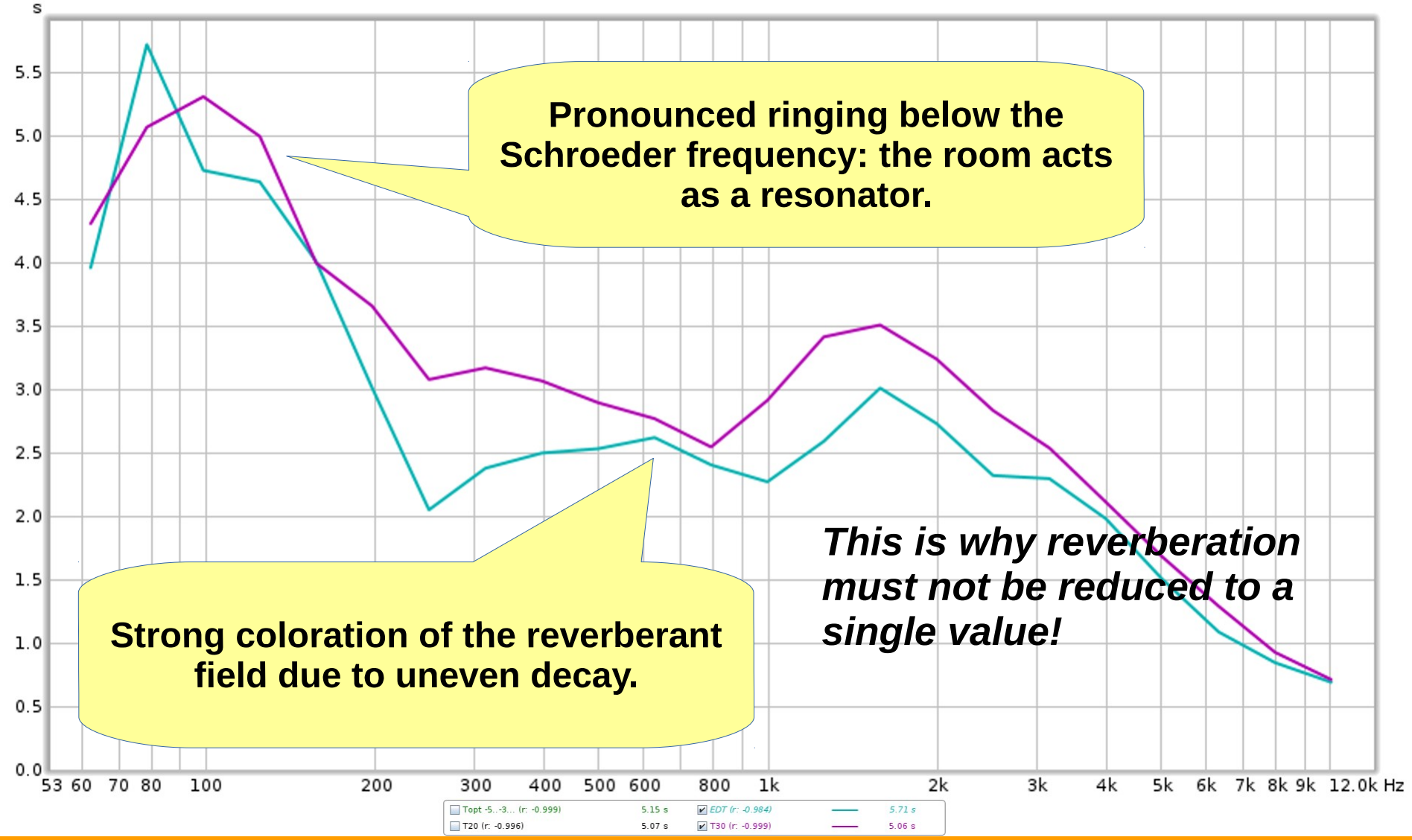

Pronounced ringing below the Schroeder frequency: the room acts as a resonator.

Strong coloration of the reverberant field due to uneven decay.

This is why reverberation must not be reduced to a single value!

Second problem: clarity

Clarity is defined as

> the ratio of initial sound energy versus remaining sound energy, that is, the „early sound“ versus the late reverberation.

Clarity is an indicator for speech intelligibility, musical precision, directness, and hence emotional „impact“.

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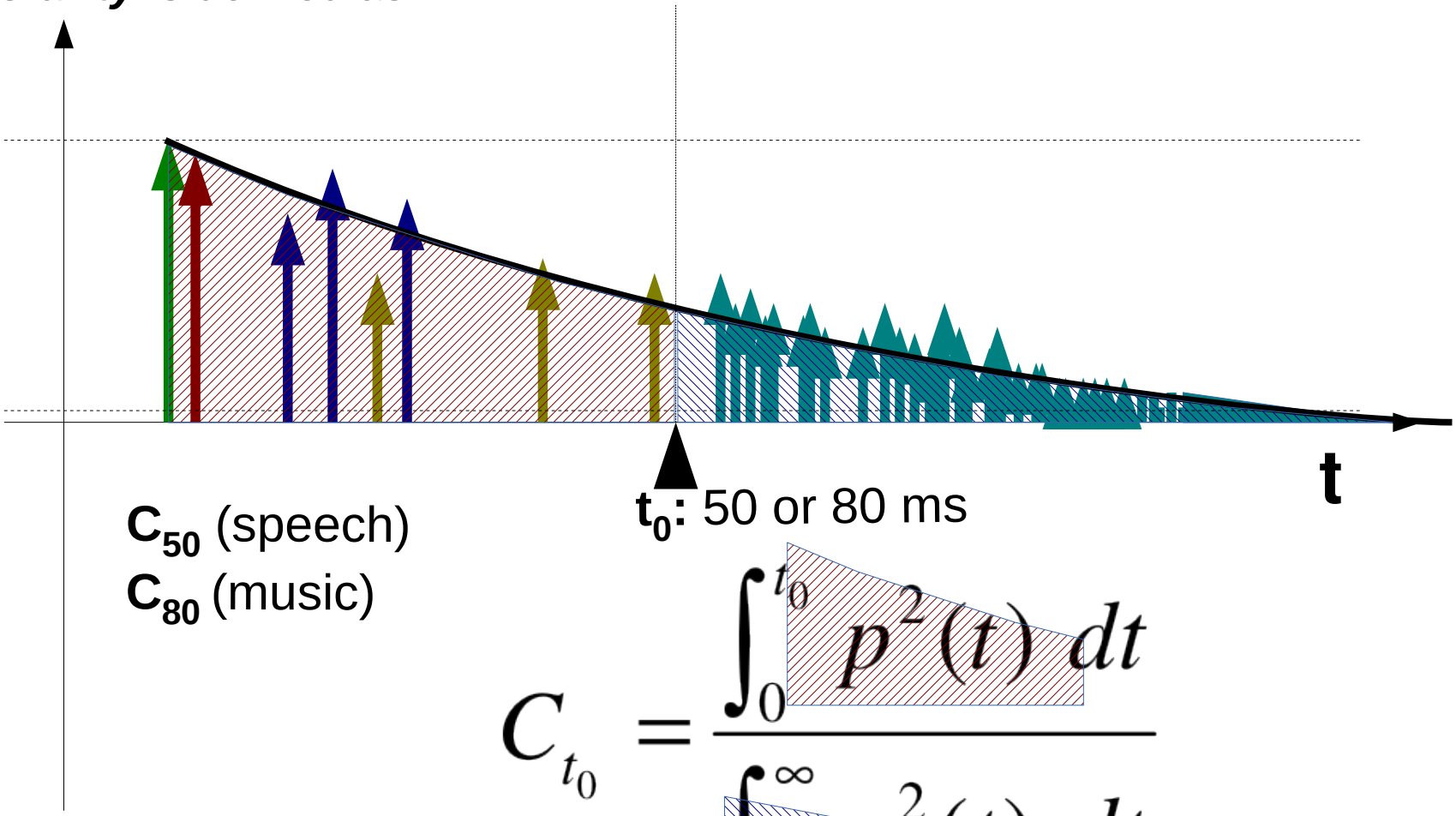


t_0: 50 or 80 ms

C_{50} (speech)
C_{80} (music)

$$C_{t_0} = \frac{\int_0^{t_0} p^2(t)\,dt}{\int_{t_0}^{\infty} p^2(t)\,dt}$$

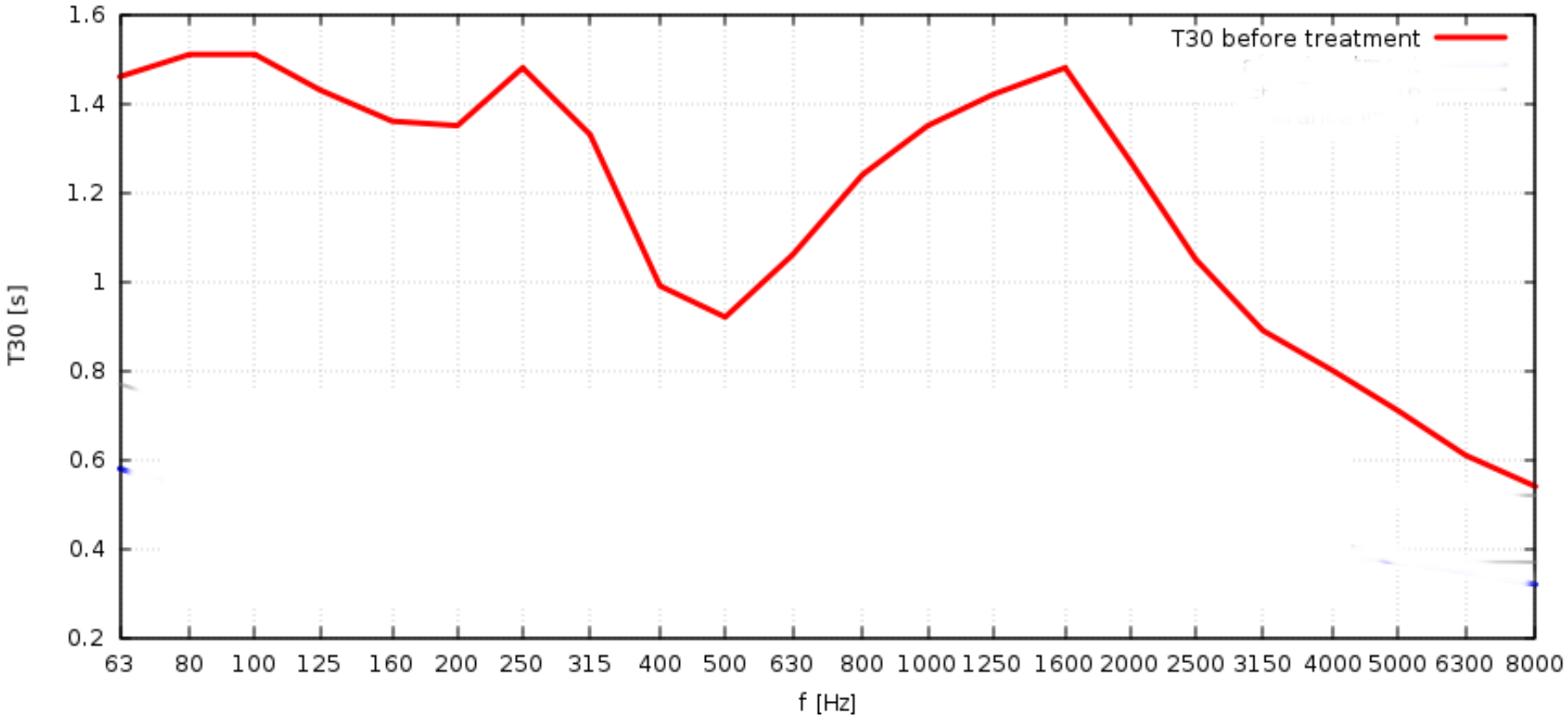
Room treatment

Tone colour and clarity are determined by the diffuse sound field.

The only way to correct that is room treatment.

A good starting point is a measurement of the room's decay properties.

Room treatment



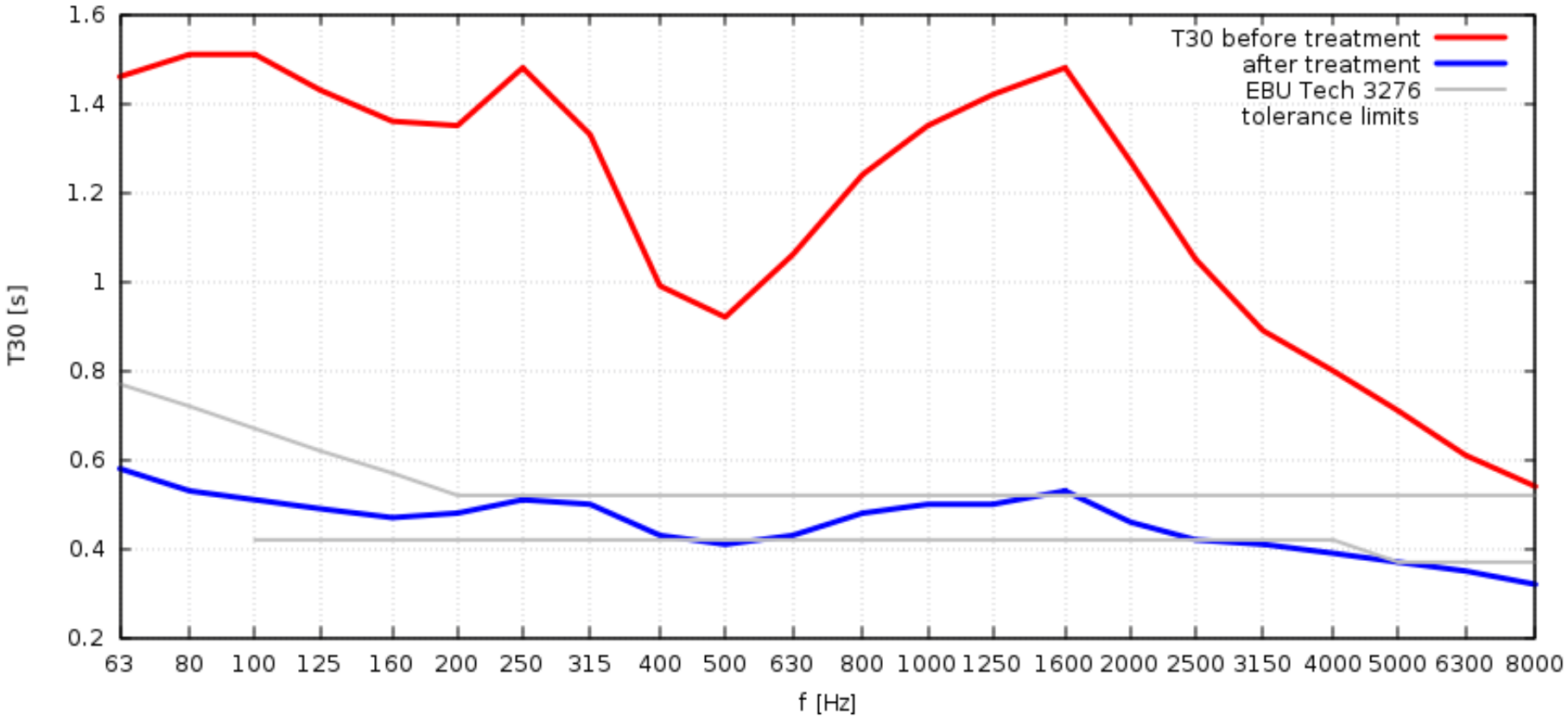
This is the T_{30} of room R3 at Tonmeistertagung 2012, empty and untreated.

Room treatment

Room treatment

- three layers of stage cloth
- wideband absorbers along room edges
- wideband absorbers in corners

Room treatment



This is room R3 after treatment.

We are within the limits of EBU Tech 3276 (recommendation for control room acoustics), extrapolated for room size.

Electronic correction

After room treatment, consider EQ:

→ notch remaining room modes

→ low-shelf bass buildup

→ fine-tune subjective tone color

When measuring the room frequency response, look at longer integration windows (up to the reverberation time).

Third problem: stereophonic localisation

Stereophonic localisation cues:

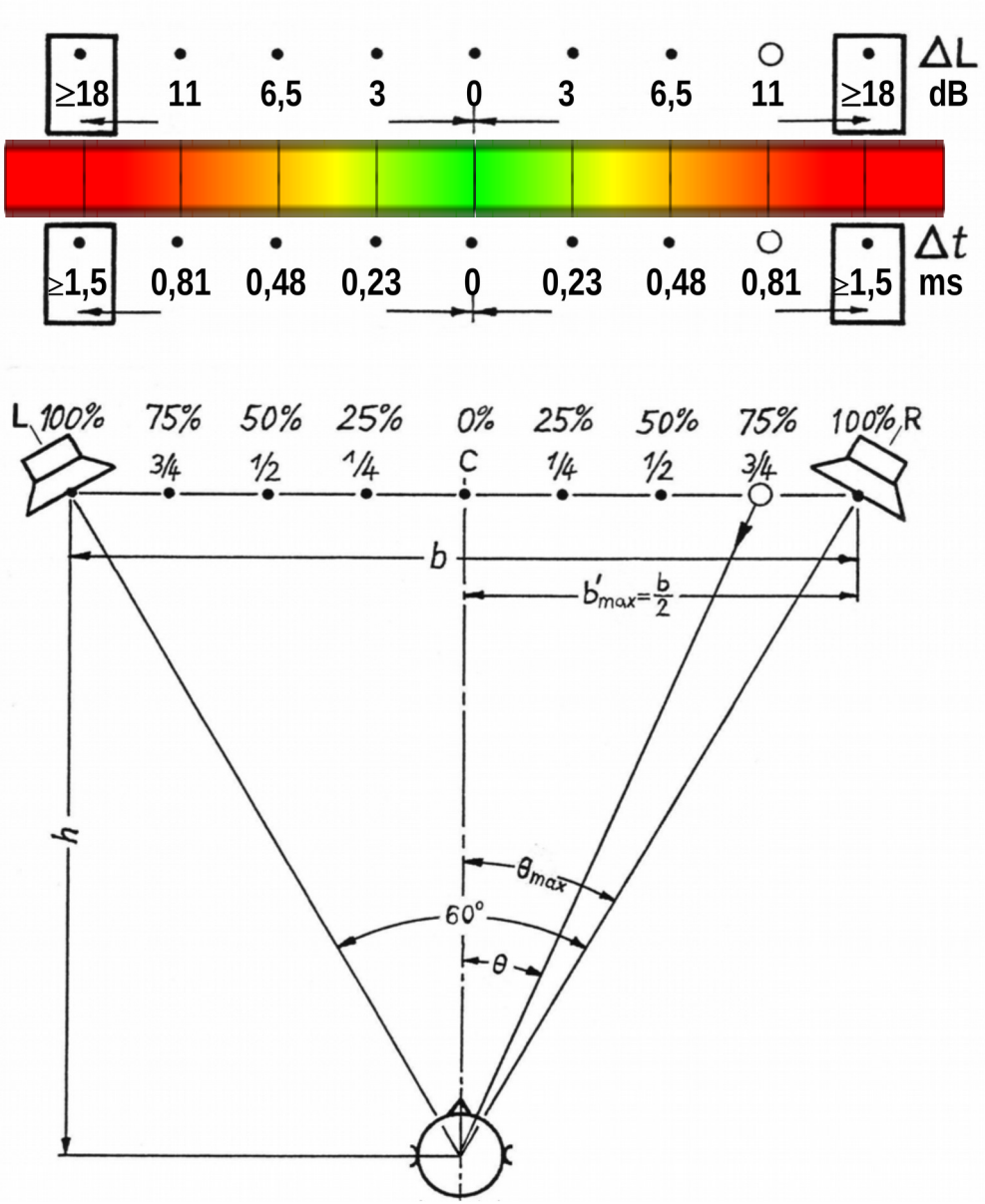
inter-aural level difference ***(ILD)***

inter-aural time difference ***(ITD)***

Working ranges:

ΔL: 0 .. 18 dB

Δt: 0 .. 1.5 ms



(illustration and table by Eberhard Sengpiel)

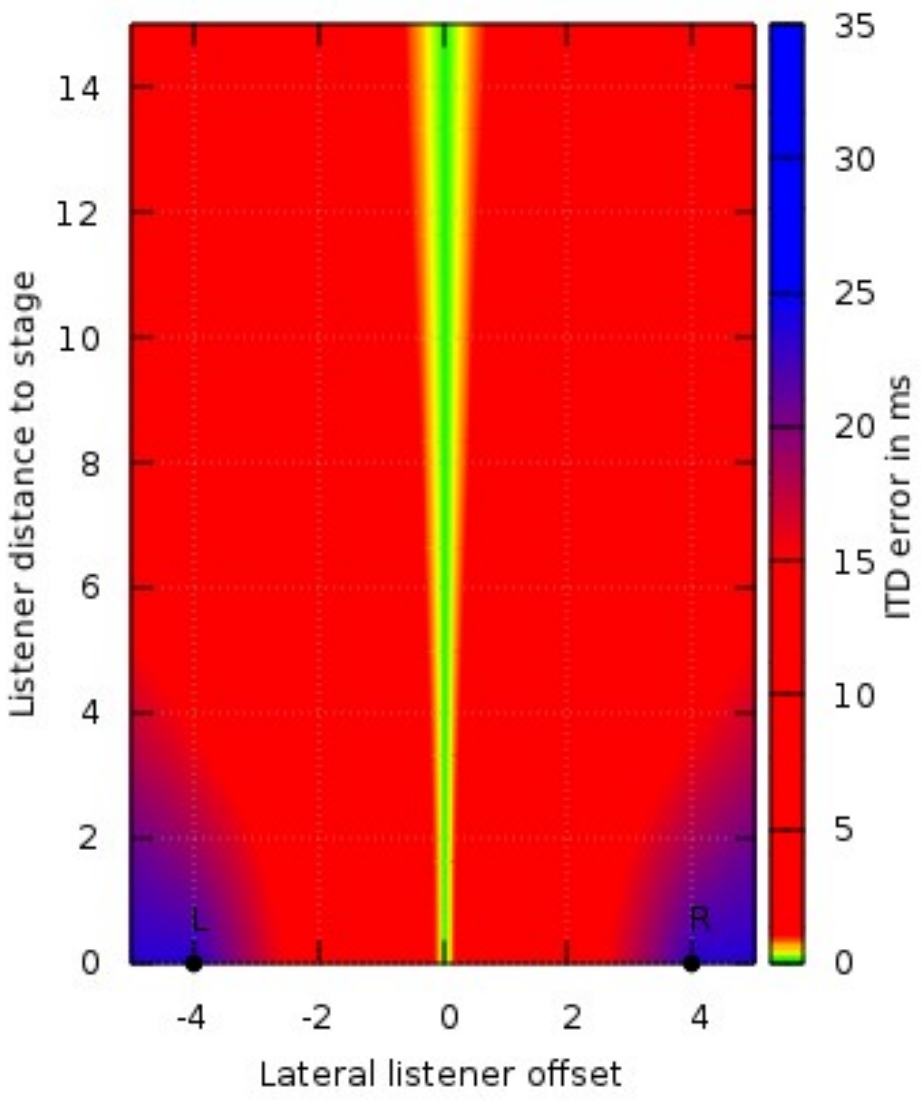
Third problem: stereophonic localisation

A 10 x 15 m auditorium, with stereo loudspeakers spaced 8 m apart (black dots at bottom).

Green areas denote less than 50% ITD localisation error.

In red areas, ITD imaging collapses to nearest speaker.

In blue areas, spill from opposite speaker may reach the echo threshold.



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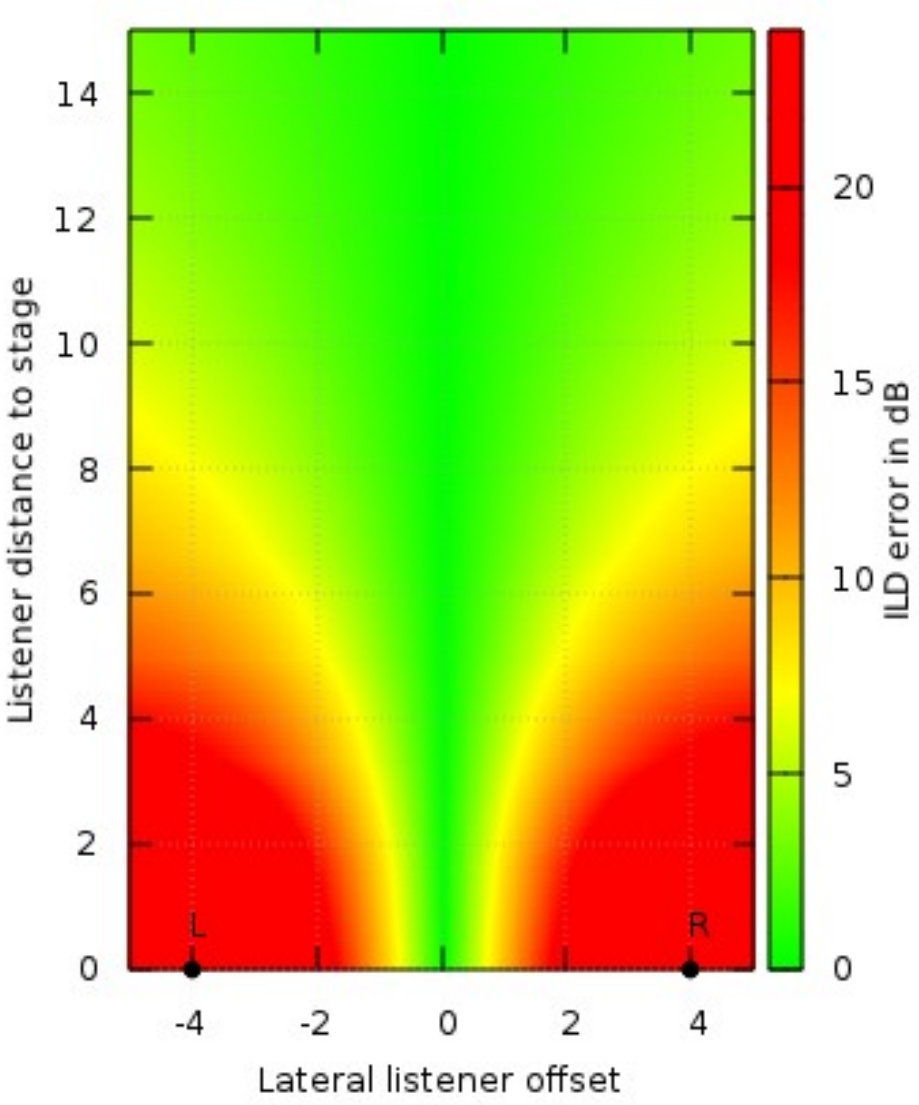

ILD cues are more robust in comparison.

Green area denotes less than 50% ILD localisation error.

The red areas where the image collapses into the nearest speaker are much smaller.

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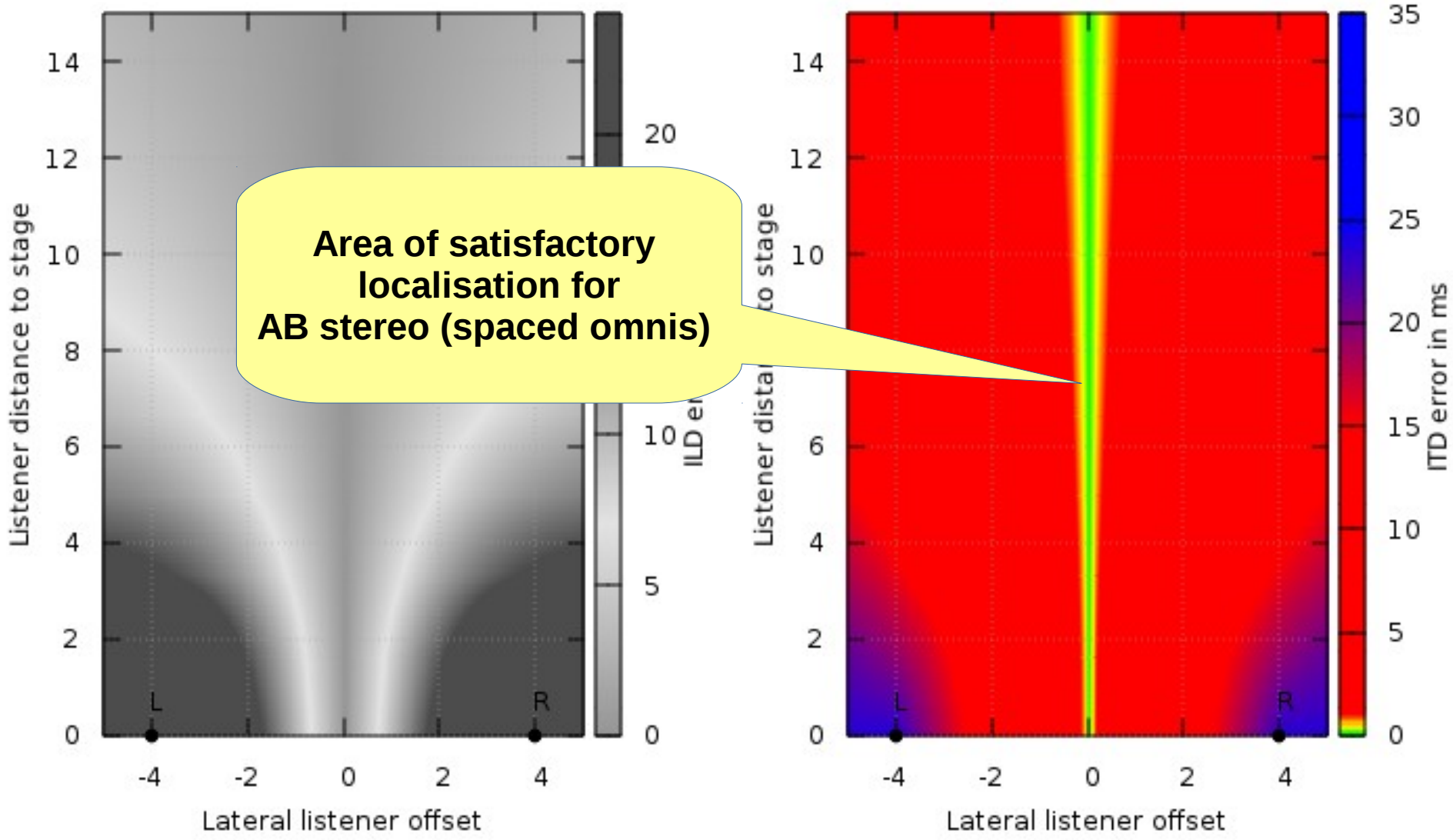

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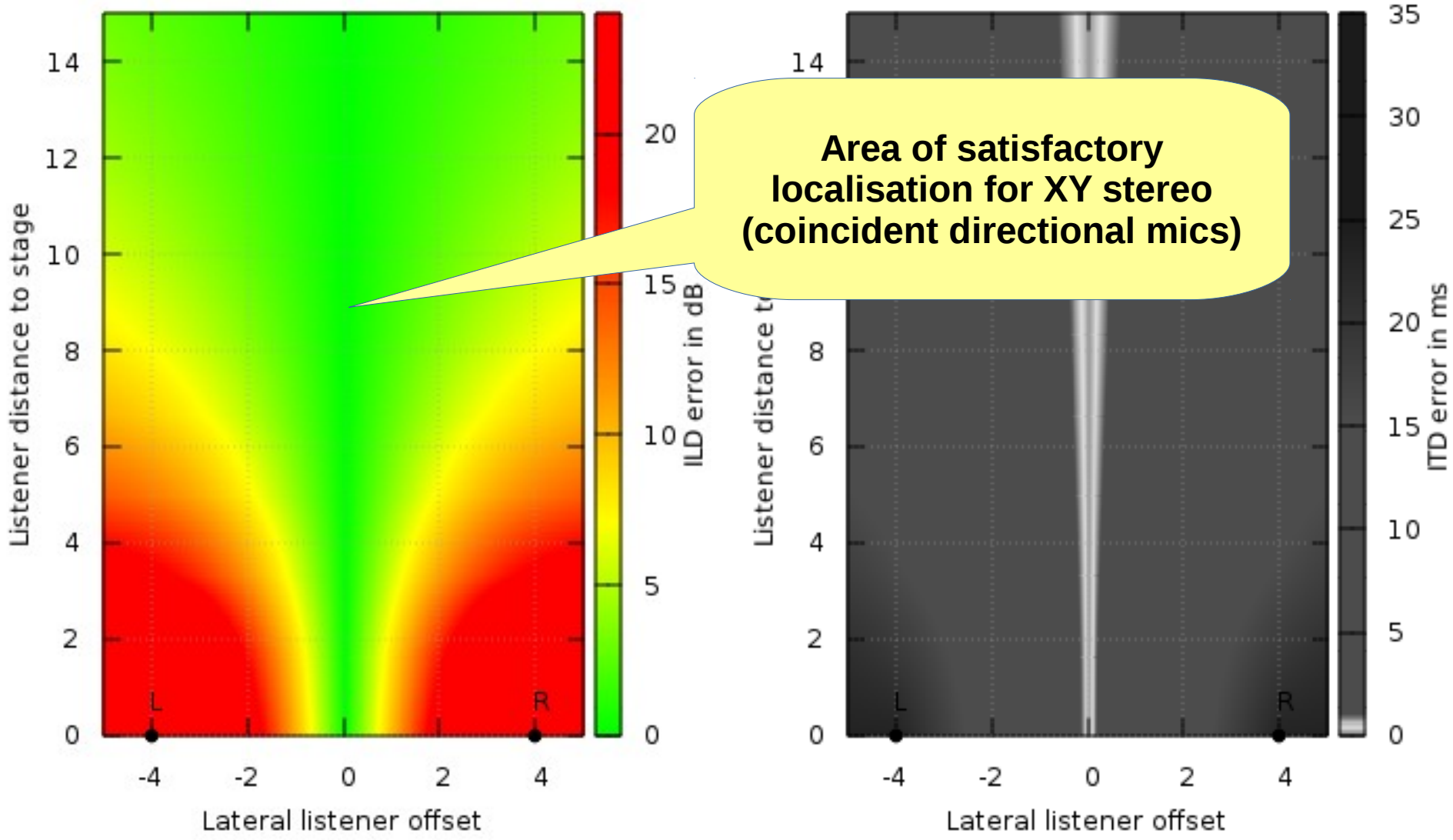

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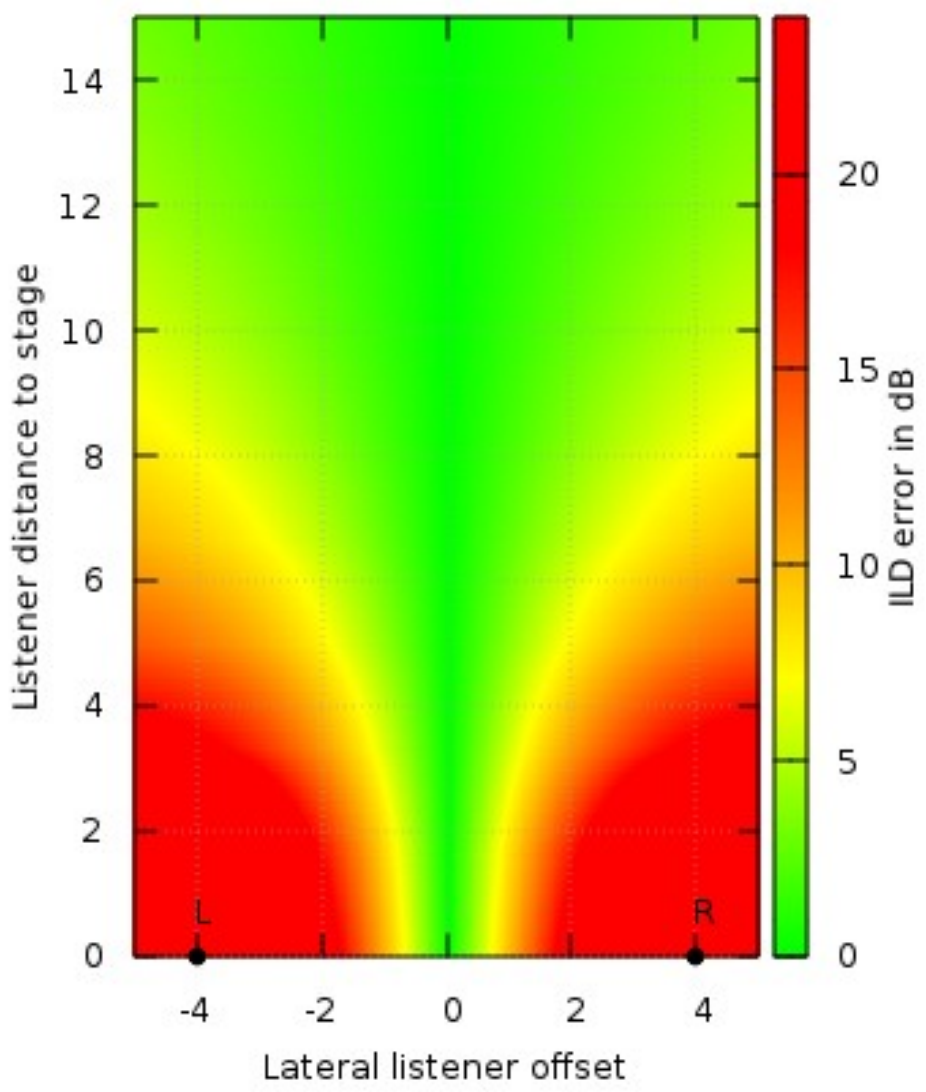
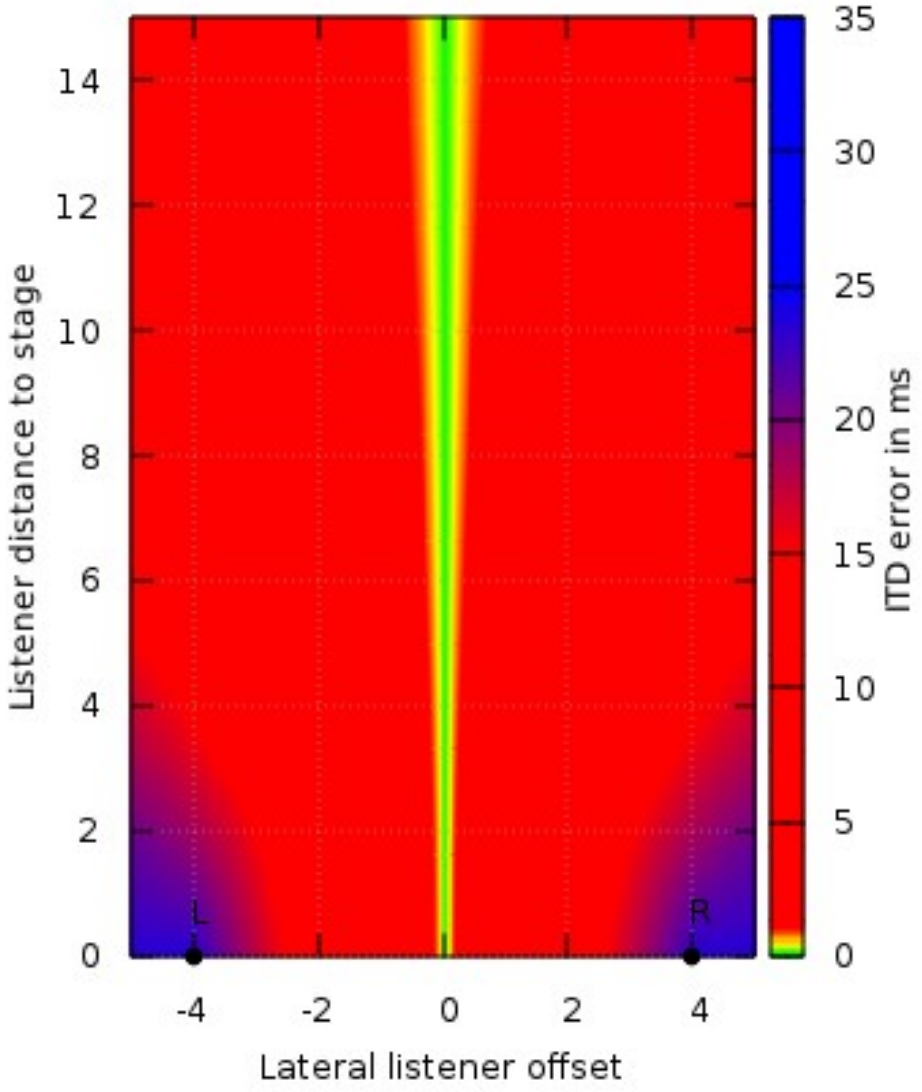




Third problem: stereophonic localisation

Stereo localisation does not scale.

Different stereo techniques exhibit wildly different localisation behaviour.

The only way to handle it is to communicate the limitations to presenters and audience.

Third problem: stereophonic localisation

With an added center speaker (and a suitable signal set), scalability improves dramatically:

The frontal stereo bases are only half as wide. We have perfect center stability.

Moving to 5.1, the challenge is to balance front and rear speakers.

The rears must be loud enough to provide satisfactory envelopment, and not too loud to not disturb the frontal image. The tolerance range is often less than 3 dB.

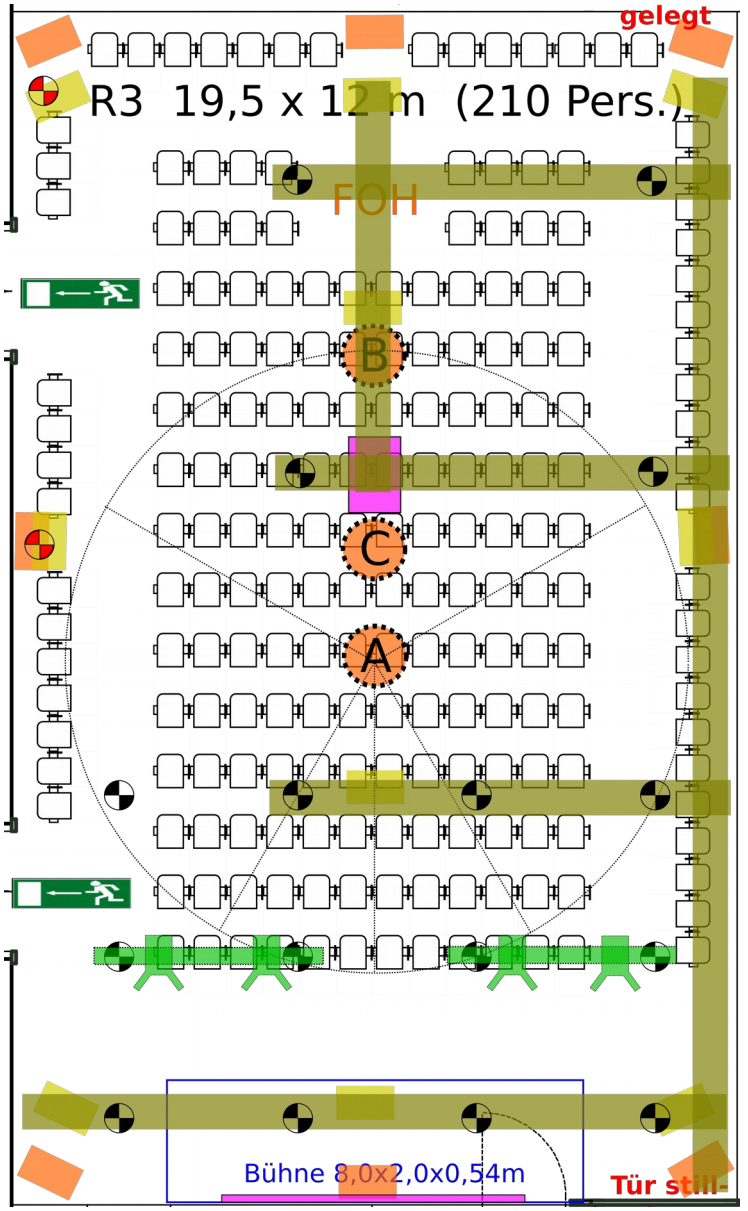
Level balance in surround systems

- move the speakers as far away from the audience as possible, EQ for boundary effects

- define a golden seat ***A***, arrange L, C, R, Ls, and Rs angles according to ITU BS R-775 and calibrate for equal loudness and arrival time in ***A***

- define the golden seat among the cheap seats ***B***, measure and average L,C, and R level and arrival times

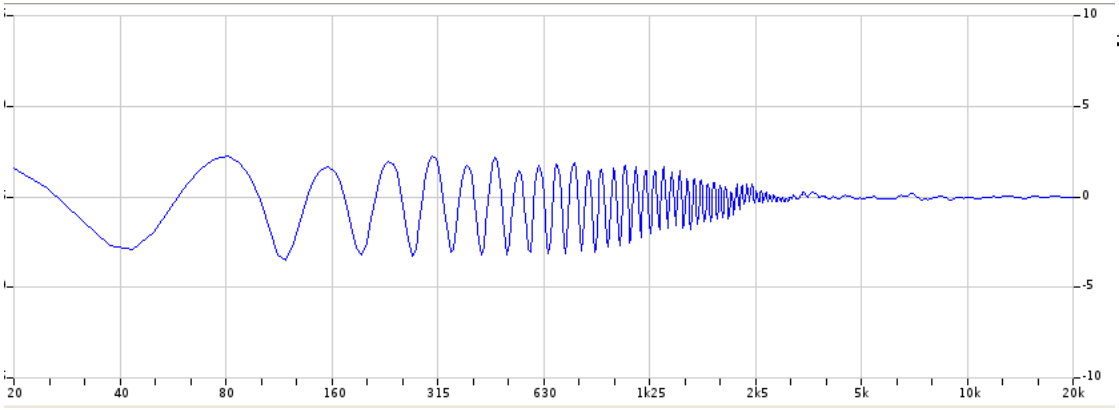
- calibrate additional surrounds Ls2 and Rs2 for correct arrival time and level in ***B***



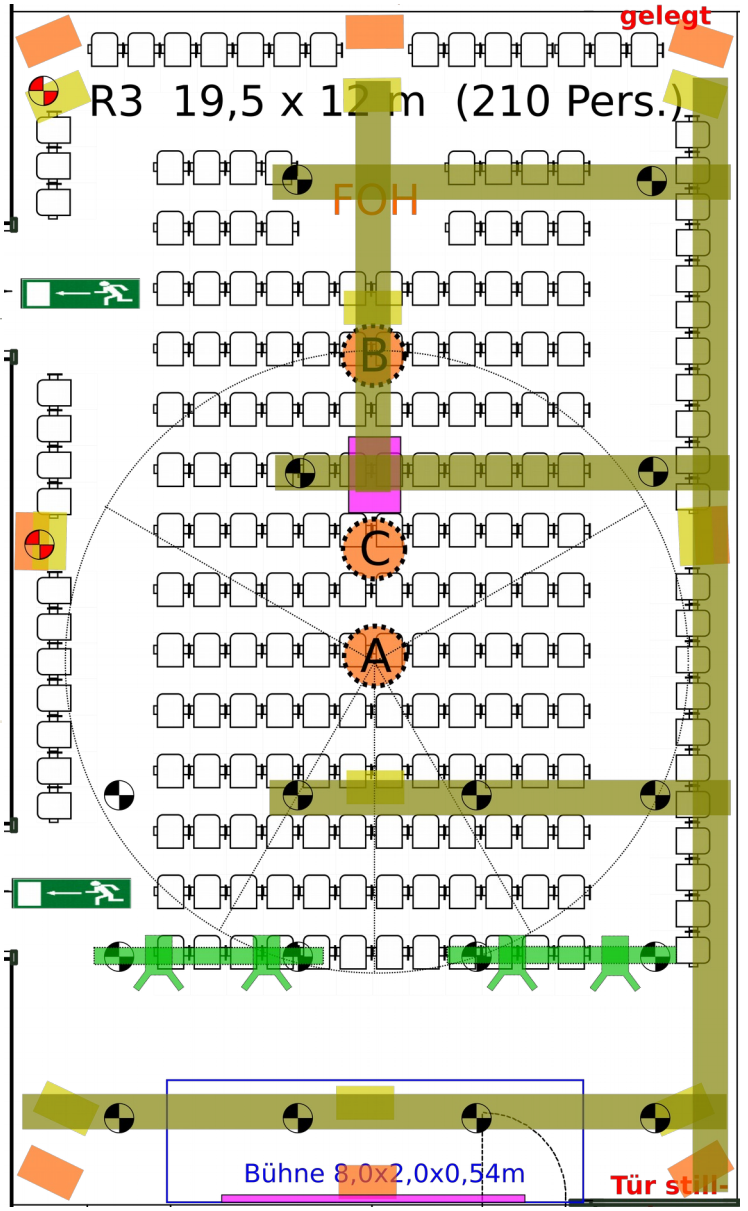
Level balance in surround systems

Consider the spill from the rear surrounds into the golden seat ***A***:

It will be late, and lower in level:



This is no worse than normal room effects. The key factor is to arrive at a spill delay that is long enough to not comb too much, and short enough to not cause an echo.



Demo

Short demo/workshop at Theater im Palais
(the building opposite the MUMUTH entrance)
at 1:50 pm.

Thanks for your attention.

Any questions?

Listening examples:

Tom Ammermann, Blug plays Hendrix: Little Wing. 5.1

Günther Wollersheim, Anton Bruckner: 5th Symphony (Köln Philharmonic). 5.1

Julien Herion, Stadtklang. 5.1

Julian Klapp, Steve Reich: Six Marimbas (Johannes Wippermann), 5.1

selected from the VDT Award winners („Goldener Bobby“) 2012