

# Orchestra Acoustics – what do they hear?

Stage Acoustics and Orchestra Acoustics are research fields with still many questions to be answered. In an incredibly complex sound field - what do musicians hear?

Current update: Dry-to-Room level balance, presentation of some recent results.

Please post any questions directly to the posts on LinkedIn or Facebook, or by e-mail

<mailto:msk@brekkestrand.no>

# Dry sound and Room sound

Sound at an orchestra musician's ear consists of parallel streams of  
DRY sound, from the instruments, without reflections from room surfaces  
ROOM sound, the sum of all sound reflections from the room

Dry sound consists of parallel streams of  
SELF, the dry sound from ones own instrument  
OTHERS, the dry sound from the other instruments in the ensemble

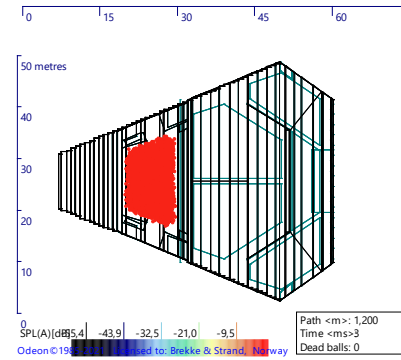
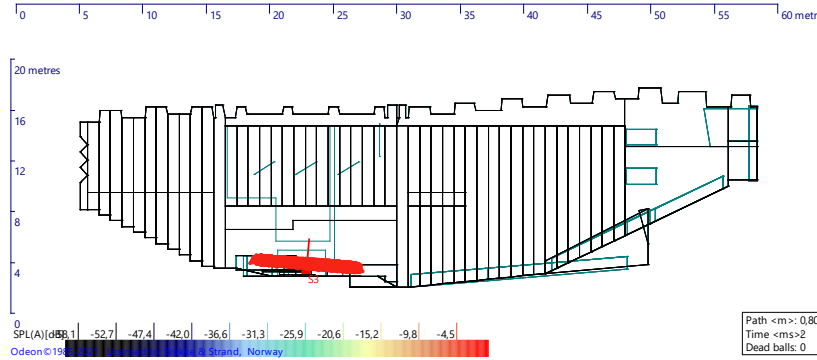
Room sound consists of 1) reflected Self and 2) reflected Others

All the above parts could be analysed further, e.g. in  
Frequencies, harmonics, frequency bands, octave bands  
Time intervals, early Room and late Room, by travel time of reflected sounds  
where early Room is reflected sound having travelled less than e.g. 100ms

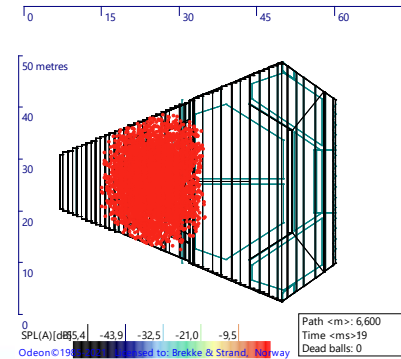
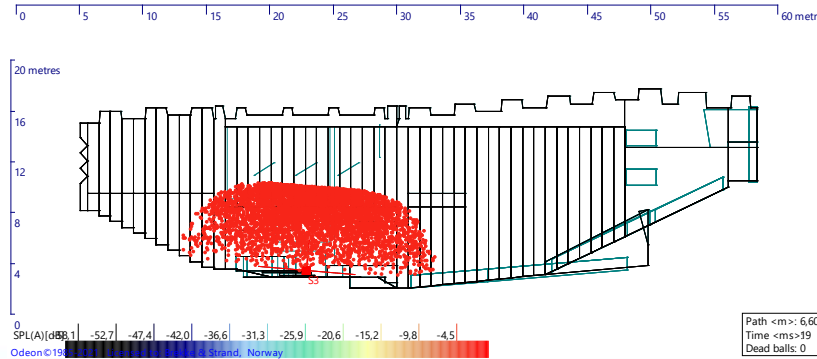
In the following review, all sounds levels are A-weighted sound in 1 second windows

# Sound emission from orchestra

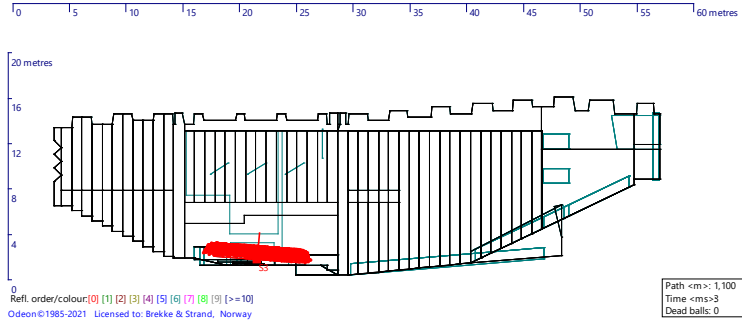
If every little vibration, every atom of music, emitted tiny sound particles in all directions, this is what it would look like, in long section and plan



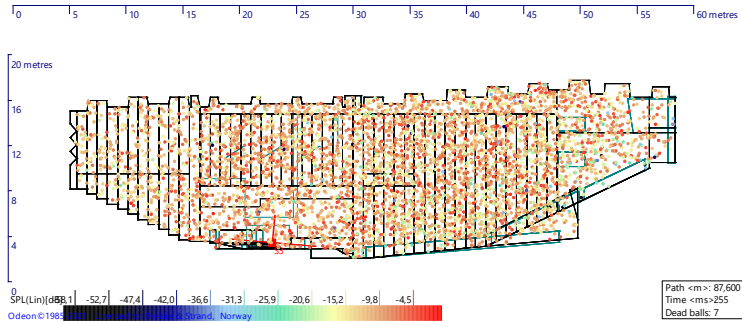
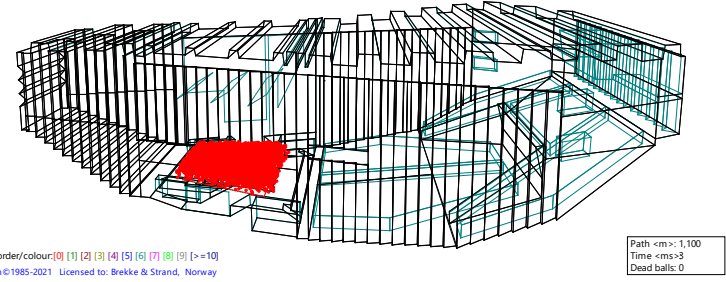
After 20ms, i.e. 1/50 second, the sound particles have reached the nearest walls



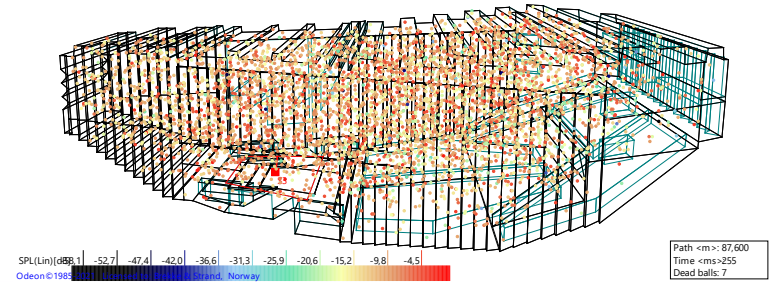
# Dry sound and Room sound



DRY



ROOM



# Parallel streams

Unlike the common temporal analysis known as the Impulse Response, investigating the progress of the emitted sound from each «atom of music», the actual sound heard by musicians is a stream of Dry and Room, sounding at once.

In this review we measure A-filtered sound levels in a sequence of 1 second windows.

Sound at 10 musicians ears is measured with dosimeters

Additional measurements with 5 distributed microphones

Room sound is analysed from all 15 microphone positions, with an algorithm

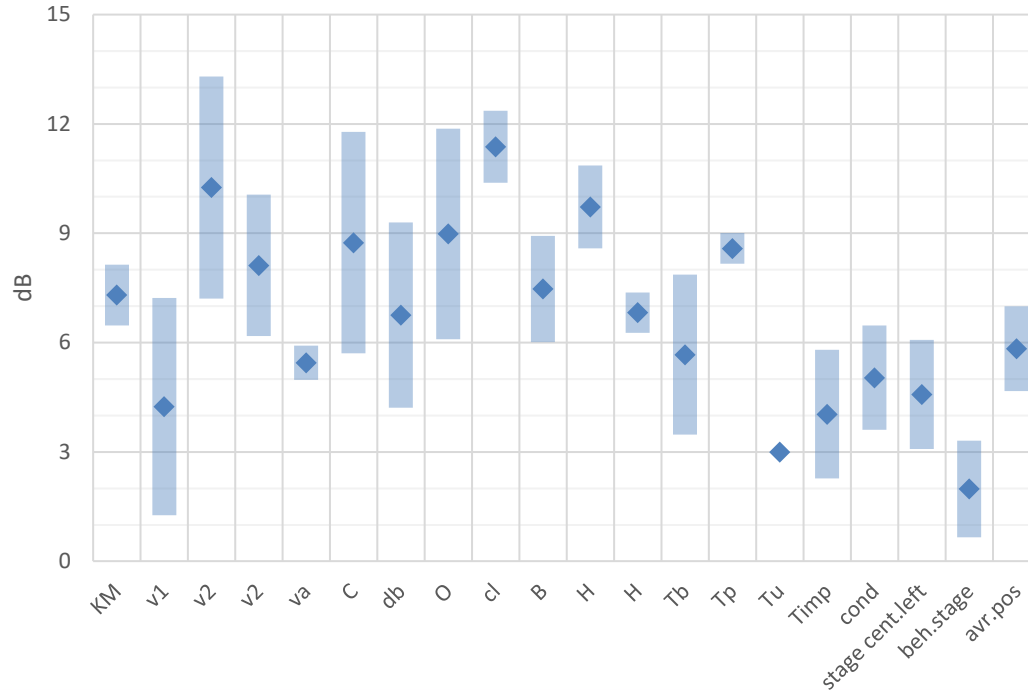
Dry energy is calculated by subtracting Room energy from total energy at each dosimeter, in each 1s window.

We are curious – what is the balance between Dry and Room? Is it constant, is it varying?

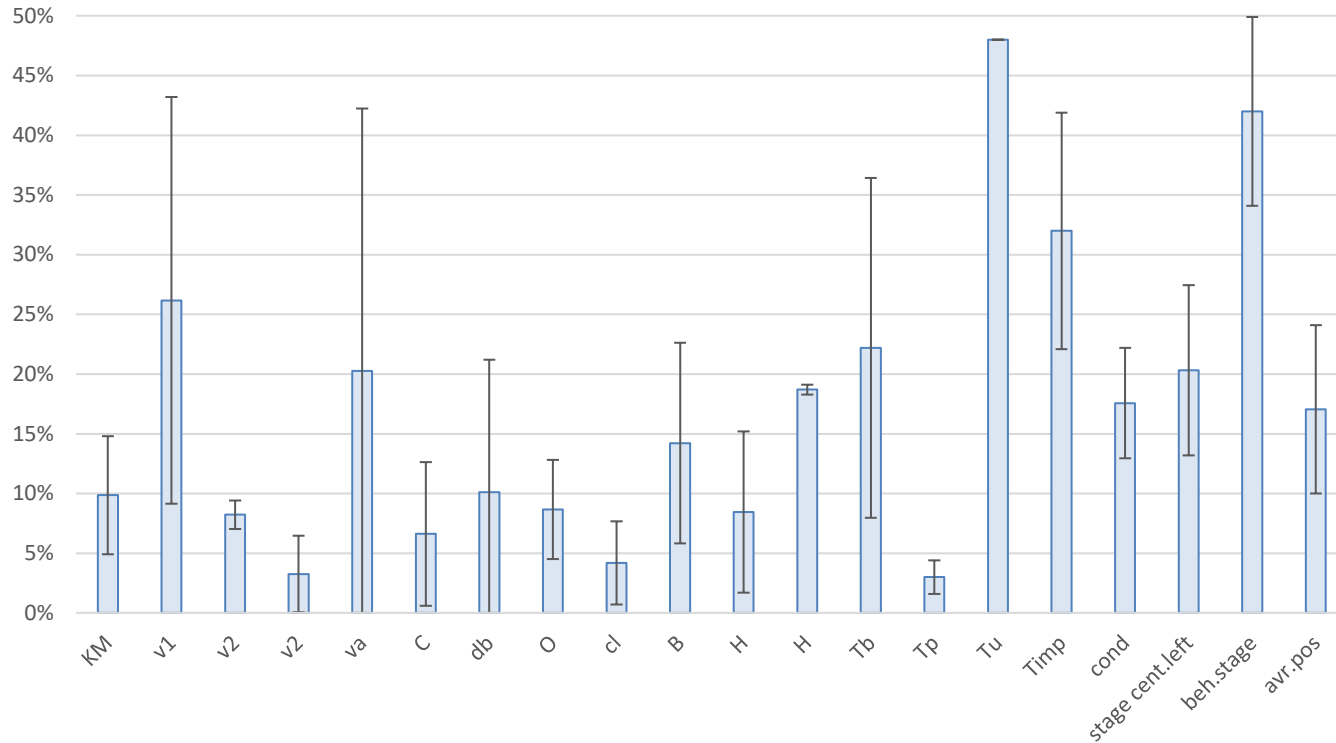
Answer: The D-R balance fluctuates, on average 4dB from one 1s-window to the next. Details follow.

# Dry-Room balance at musicians' ears

Average and normal range ( $\mu \pm \sigma$ ) from 8 orchestra performances

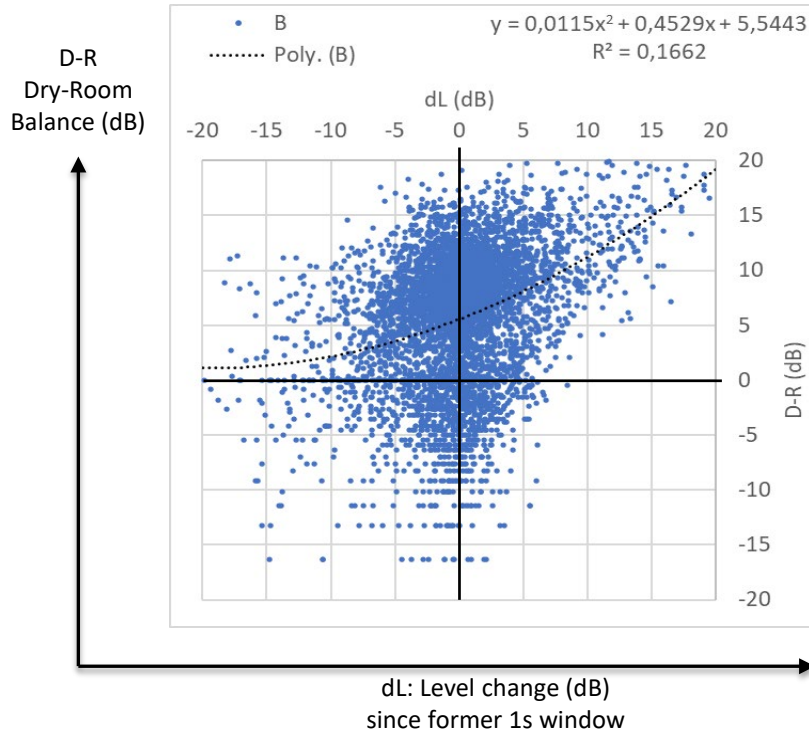


# % of time when room sound dominates

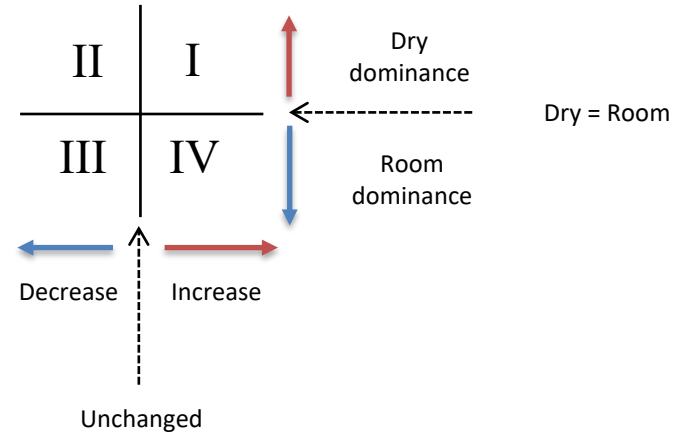


# Plot of $D-R$ versus $dL$ in 1 second windows, at musicians ear, during symphony orchestra concert

Plot example: Basson



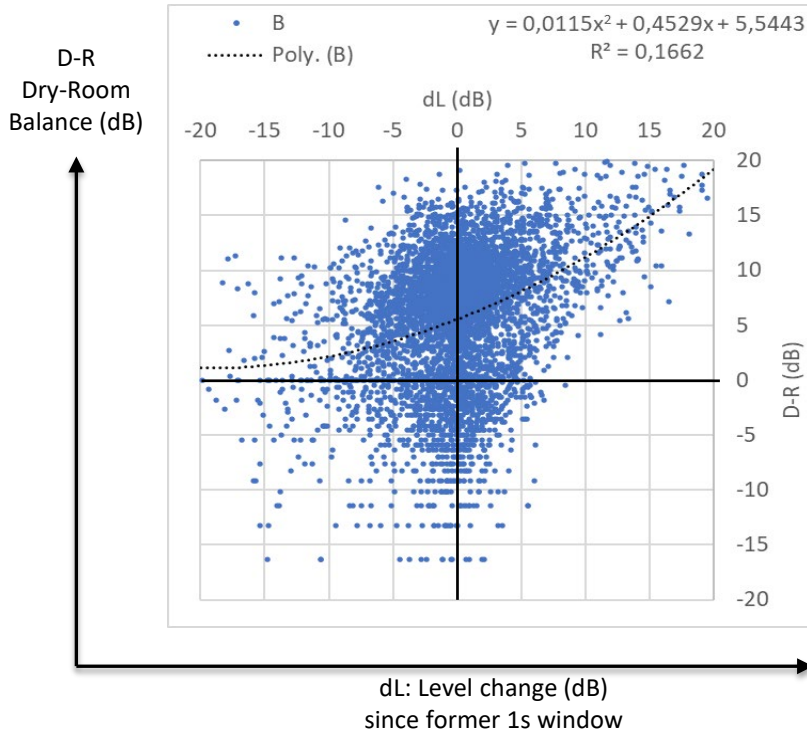
Quadrants:



I	Increased	&	Dry-dominated
II	Decreased	&	Dry-dominated
III	Decreased	&	Room-dominated
IV	Increased	&	Room-dominated



Plot example: Basson

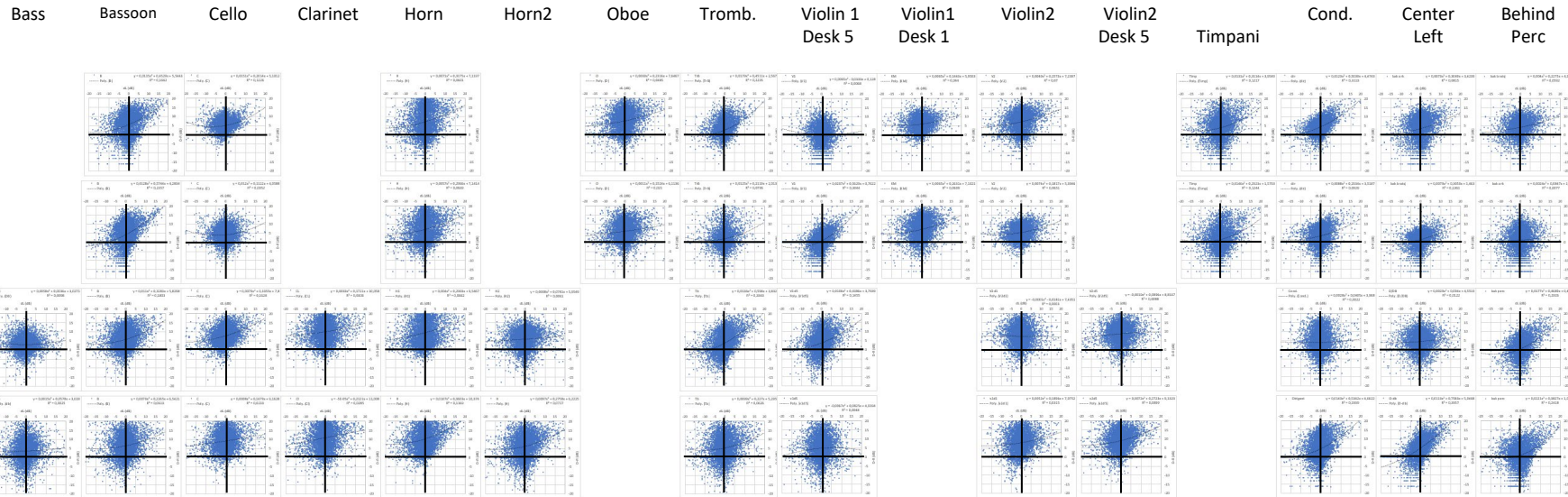


- D-R balance fluctuates heavily, even at stationary sound levels ( $dL=0$ )
- Sound is more often Dry-dominated than Room-dominated
- Room-dominated occur more often in decrease than in increase
- Higher increases  $>5$ dB are more Dry-dominated (Quadrant I)

Trends:

- D-R is sensitive to level change and the degree of change
- Average balance is 5.5dB in favour of Dry
- D-R balance changes 1dB per 2dB level change (at small changes)
- Curvature ( $x^2>0$ ): D-R sensitivity positively proportional to change

# Plots of Dry-Room Balance $D-R$ (dB) versus Level change $dL$ (dB), 2 orchestras, 4 concerts



More info ?

[www.akutek.info](http://www.akutek.info)