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COLORATION DUE TO REFLECTIONS, FURTHER INVESTIGATIONS

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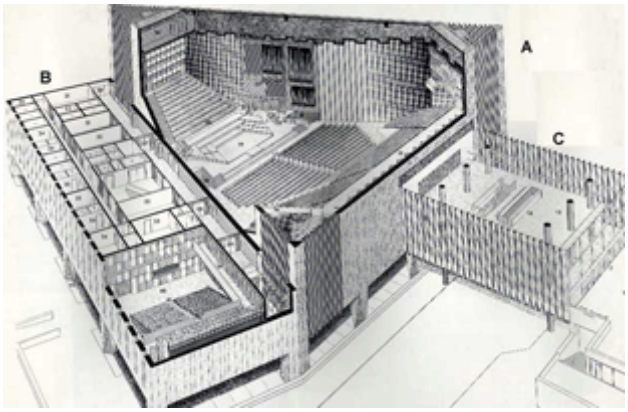
ABSTRACT
Close Reflections might give audible Coloration, both on Orchestra Platforms and in Recording Studios/Sound Control Rooms. This paper gives an overview of Coloration from such close reflections. To investigate the stage acoustics of an Orchestra Hall, one needs to do measurements with the orchestra on the platform, Trough Orchestra impulse Responses (TOR). The question is: *"When will discrete reflections give clear, audible comb-filtering?" ("Box-Klangfarbe")*? This paper presents new measurements of TOR-impulse responses, and a practical case study, showing how the TOR-impulse responses have changed due to improved design of an over-orchestra reflector in a concert hall.

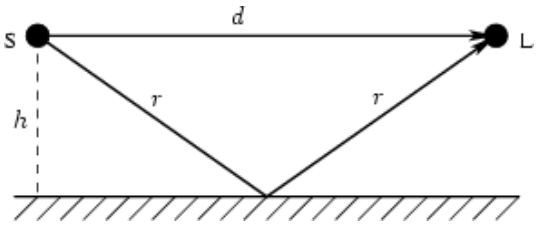
INTRODUCTION
ORCHESTRA PLATFORM ACOUSTICS
My first interest in podium acoustics came from playing on the stage of the Oslo Concert Hall.

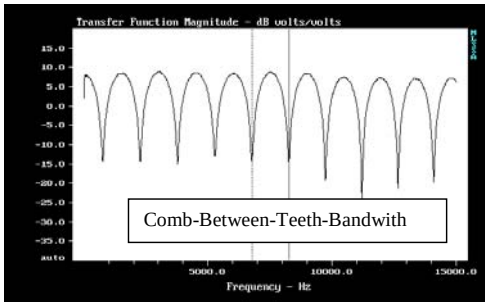


Most reference data and measurements regarding podium acoustics are given for empty stages. The orchestra is often, for practical/economical reasons, not in included when measuring stage acoustic parameters like ST. My measurements for the Oslo Phil./Mariss Jansons in several high profiled concert houses showed that the orchestra has a mayor influence on the acoustics on stage.

Stage Acoustics should be measured with the musicians present on stage.

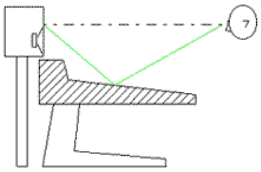
COLORATION DUE TO REFLECTIONS
A distinct/discrete reflection arriving after the direct sound will always give a Comb-filter. For investigations of Comb-filters **Comb-Between-Teeth-Bandwidth** is defined as the distance in Hz between two successive dip's of a comb-filter FFT.





For a single reflection with a time delay of Δt msec, this "Comb-Between -Teeth-Bandwidth is $1/\Delta t$. A "short reflection" will give a very broad combfilter, and reflections arriving "late" will give only small "ripples" in the FFT, (but probably echoes in the time domain). [1,12]

Coloration due to reflections are important for the correct positioning of loudspeakers, both in halls an in sound control rooms. [12]

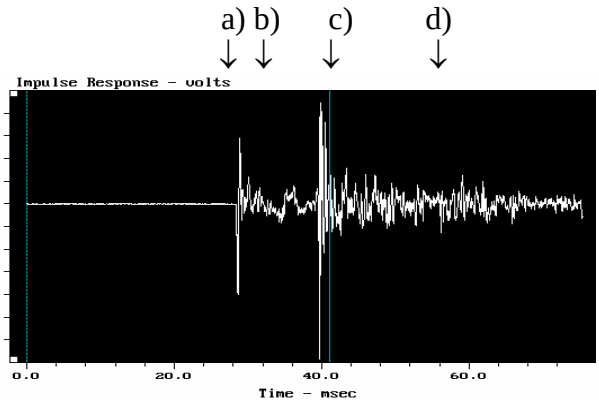


This paper concentrates on Orchestra Platforms. Measurements for details of stage acoustics should be done with a loudspeaker giving a more "directional" sound than for overall room acoustic measurements. For our earlier measurements, a Fostex SPA-11 was used. For the new measurements in Oslo Concert Hall, a smaller Monitor-speaker was used. For all measurements MLS was used as signal (MLSSA and WINMLS).

Measurements of podium acoustics with the orchestra on stage were named TOR-measurements: Trough Orchestra impulse Response. (for me to remember), [1,2,12]. TOR-measurements should be performed between many as many positions on the stage as possible. Understanding that orchestra rehearsal time is expensive, it has been shown, that, for a typical Symphony Orchestra, measurements between the left-most violin1 and the rear-most bassoon might give an overall idea of typical podium acoustics. [1,2,3]

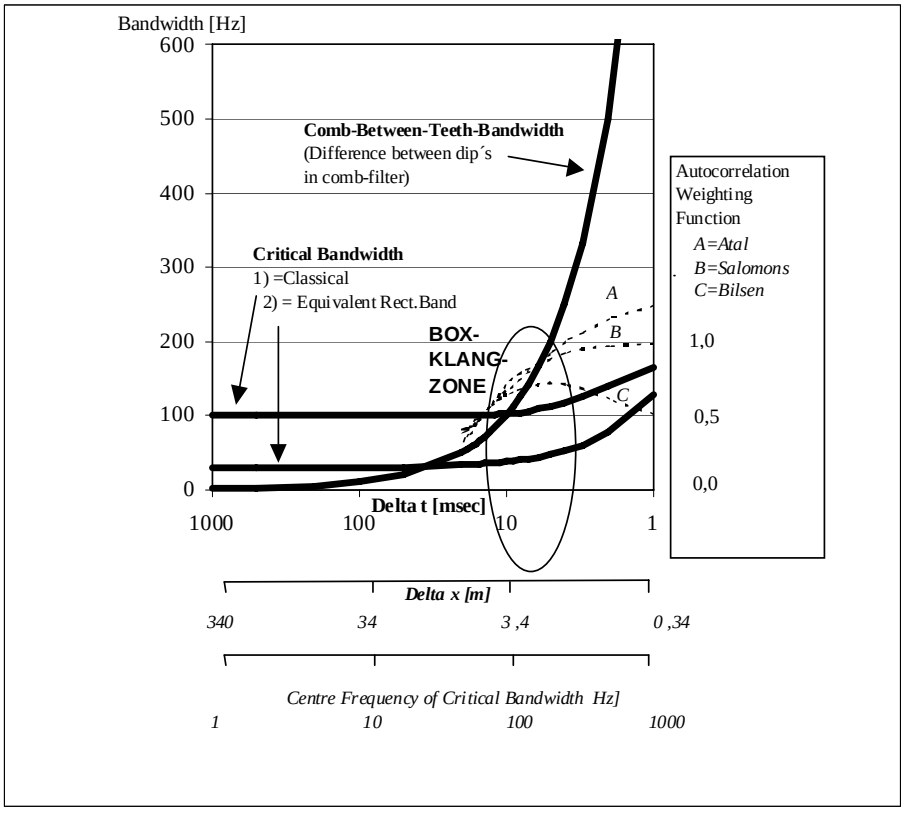
TYPICAL IMPULSE RESPONSES with/ORCHESTRA

A typical Impulse Response from TOR-measurements on an occupied stage with suspended reflectors or a low ceiling over the orchestra is: [1]

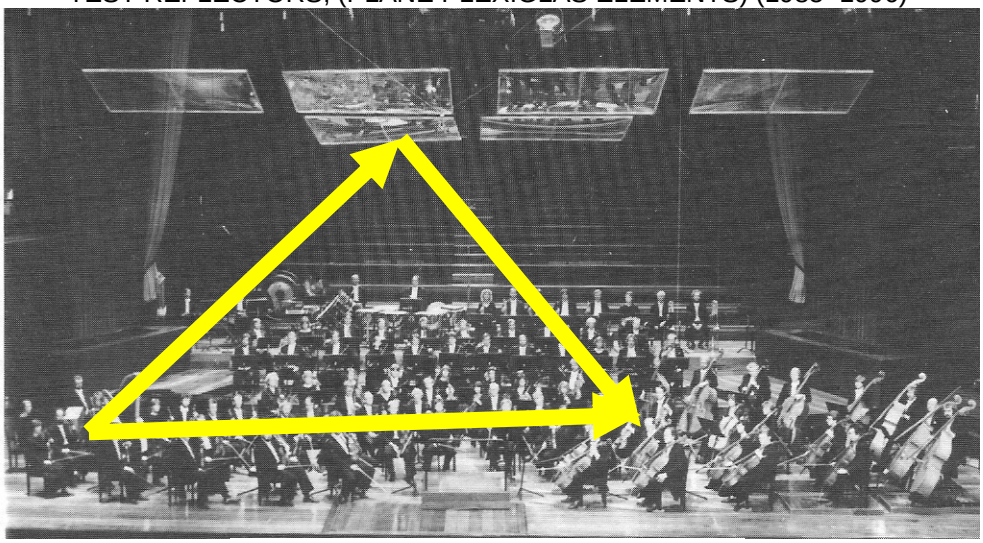


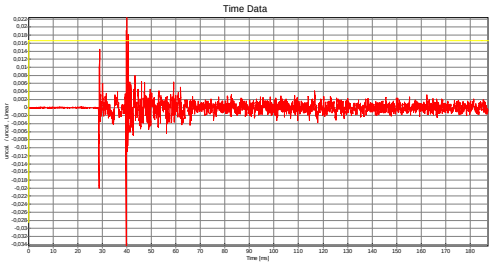
a) Direct Sound
b) Very Early Reflections
c) **Reflection from Ceiling/Suspended Reflectors**
Note that with the orchestra on the platform, this reflection is stronger than the direct sound.
d) **Late Early-Reflections**
(> 25 msec after the direct sound)

Taking the FFT of the whole measuring time (app.2 sec.), gives no visual indication of the coloration-effect reported [1]. We must use shorter time-windows for the FFT to visualise the "colorating" comb-filters. This agrees with psycho-acoustic studies that gives that the "Timbre/Klangfarbe" is given in the earlier part of the sound. [1,2,4,5,6,7]
Investigations of TOR-measurements in several well-known Concert Halls such as Musikverein/ Vienna, compared to Gasteig/Munich and the tests for Oslo Concert Hall, gave that that "Box-klangfarbe" might appear if district/distinct reflections give comb filtering in the region of the Critical Bandwith. The following figure gives an overall picture of how discrete reflections might influence the "klangfarbe"/timbre. Included are some results from psychoacoustics studies from Bilsen et al., which will not be discussed in detail. see [1,5,6,7]

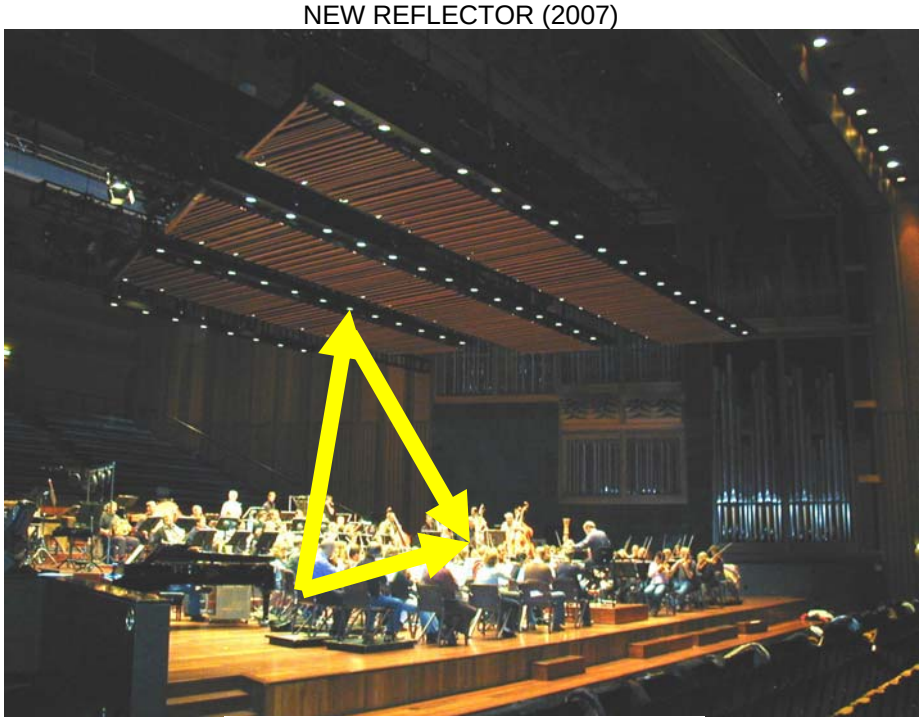


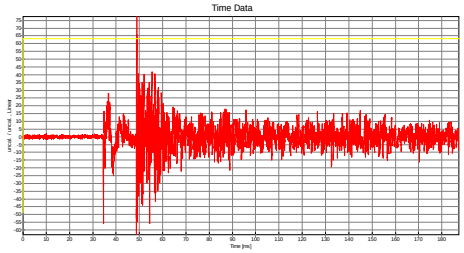
TEST REFLECTORS, (PLANE PLEXIGLAS ELEMENTS) (1985+1996)





NEW REFLECTOR (2007)

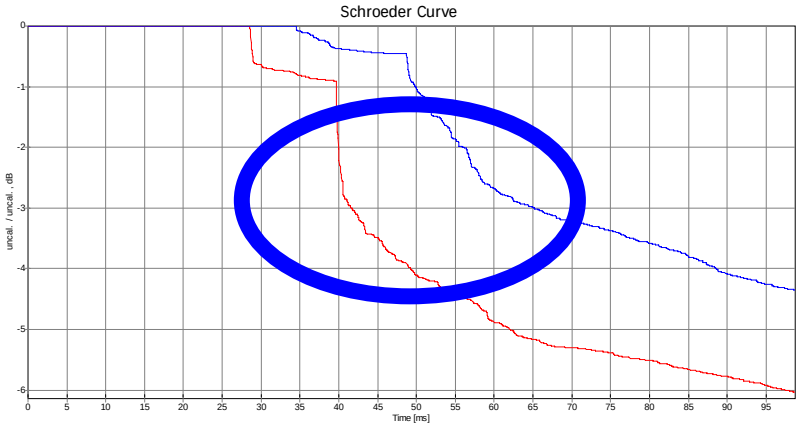




DISCUSSION

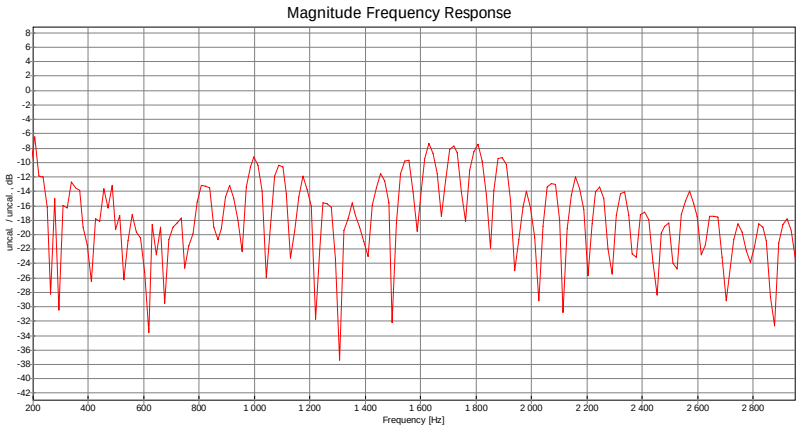
From the Impulse Responses above, we see that the old/test reflector gives a very strong and discrete reflection. The reflections from the new/designed reflector are more “smoothed”. Also, if we compare the Schroeder curves for the two reflectors, we see that, for the new reflector, the sound does not drop as quickly, due to the scattered/diffused reflections from the new designed reflector.

(The time difference is because of somewhat different measuring positions in 95 and in 07, and is not of any importance regarding coloration).

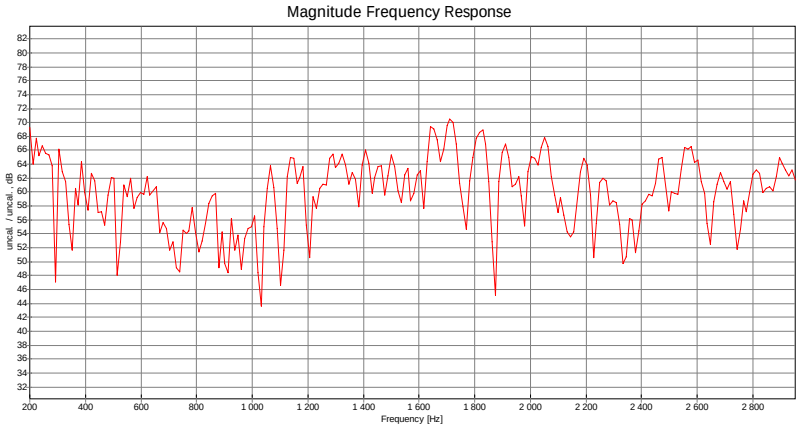


For the discussion on combfiltering, we need to compare the two “short-time” FFT analysis:

OLD/TEST-REFLECTOR:



NEW/DESIGNED REFLECTOR:



We see that the new, designed reflector gives a FFT that does not show such a clear combfilter-effect. This is due to the “diffusness” of the well-designed new reflector.

For the 1995 test, questionaries indicated “box-klangfarbe”, most clearly given from audience. This coloration was observed also just by “clapping” on the stage. With the new, well-designed diffusor/reflector, “box-klangfarbe” is now reduced, both on the stage and for audience.

CONCLUSION

We have shown results of measurements on orchestra platforms, discussing “comb-filter” effects from suspended ceilings. The measurements show that a well-designed overhanged reflector might eliminate the problems of “box-klangfarbe”/coloration earlier observed with plane reflecting surfaces for a test in this concert hall.

FURTHER WORK

There is need for further investigations of Coloration due to Short Reflections. This issue is covered in some papers regarding Sound Control Rooms, but the subject needs further investigations regarding psychoacoustics. Acousticians seem to be too involved in “How much energy is received in a certain time interval”, and somewhat forgets to study the sound arrivals within these intervals. Sound Designers use coloration from close reflections in films and computer games creating almost “Audible Reality”. Acoustic researchers and consultants should give this issue further interest.

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