STATSBYGG

Hvorfor låter det sånn?

Akustisk forskning i(inni)mellom

Tor Halmrast
Akustiker, Statsbygg
(1.ammanuensis UiO/Musikkvitenskap)

NAS 2015

FoU-satsningsområder i STATSBYGG

1. Kostnadseffektive bygg og kortere gjennomføringstid
Areal-effektivisering

2. Effektiv og miljøriktig drift

3. Konseptutvikling og rådgivning

4. På vei mot 0-utslippsbygg

+ Øvrige mindre prosjekter:
Samfunnssikkerhet, Klimagassregnskap,
Metodikk for innhentning av eiendomsdata

BIM (**B**ygnings**I**nformasjons**M**odellering)

STATSBYGG Tilbud for studenter

Sommerjobber
Hvert år 10-20 studenter (1-2 i akustikk!!)

Summer Internship
Statsbygg har et eget Summer Internship-program som
studenter med ulik fagbakgrunn relevant arbeidserfaring.


Martin Ervik (24)
Studerer akustikk ved NTNU

Hva er det morsomste med å være intern i Statsbygg?
Det morsomste har faktisk vært at vi ble kas
tet ut i et prosjekt fra starten av, og at vi ha
måttet løse reelle problemstillinger vi ikke ha
vært borti før. I tillegg er alle de sosiale sam
menkomstene med de andre internsene veld
hyggelig. Sommeravslutningen før fellesferie
var et høydepunkt.

Hva er ditt favoritt-Statsbygg og hvorfor?
Som akustikkstudent må jeg si Operaen i Bjø
vika. Det er få bygg i Norge, om ingen, som ha
en like gjennomført akustikk som det. Der ha
ingenting blitt overlatt til tilfeldighetene. I ti

Det morsomste har faktisk vært at vi ble kastet ut i et prosjekt fra starten av.
MARTIN ERVIK (24), STUDERER AKUSTIKK VED NTNU

Masteroppgave
Statsbygg er opptatt av forskning og utvikling, og ønsker å samarbeide med studenter om master- og diplomoppgaver innen våre satsingsområder.

Psychomusicology: Music, Mind, and Brain © 2015 American Psychological Association
Special issue in the honor of Leo Beranek 100 year

Tor Halmrast:

Acoustics in Between: Perception of Sound in Rooms Beyond Standard Criteria

1 Between Time

(How early reflections are distributed in time and the possibility of comb filter coloration)

2 Between Musicians

(How musicians on stage influence the acoustics, and how distinct, strong reflections on stage create comb filters)

3 Between Our Mouth and Ears

(How persons who are blind “see” with their ears: Echolocation in both time domain and frequency domain)

4 Between Measurements

(How musicians and actors perceive reverberation and room acoustic details not covered by the standardised criteria, and how one can investigate this by one’s own hand claps and tongue drops recorded with “in-ear”- microphones)

5 Between Echoes

(How “An echo is not an echo”, but is highly dependent on the type and duration of the signal, masking by other sounds (music and noise), and masking by the signal itself),

6 Between Walls

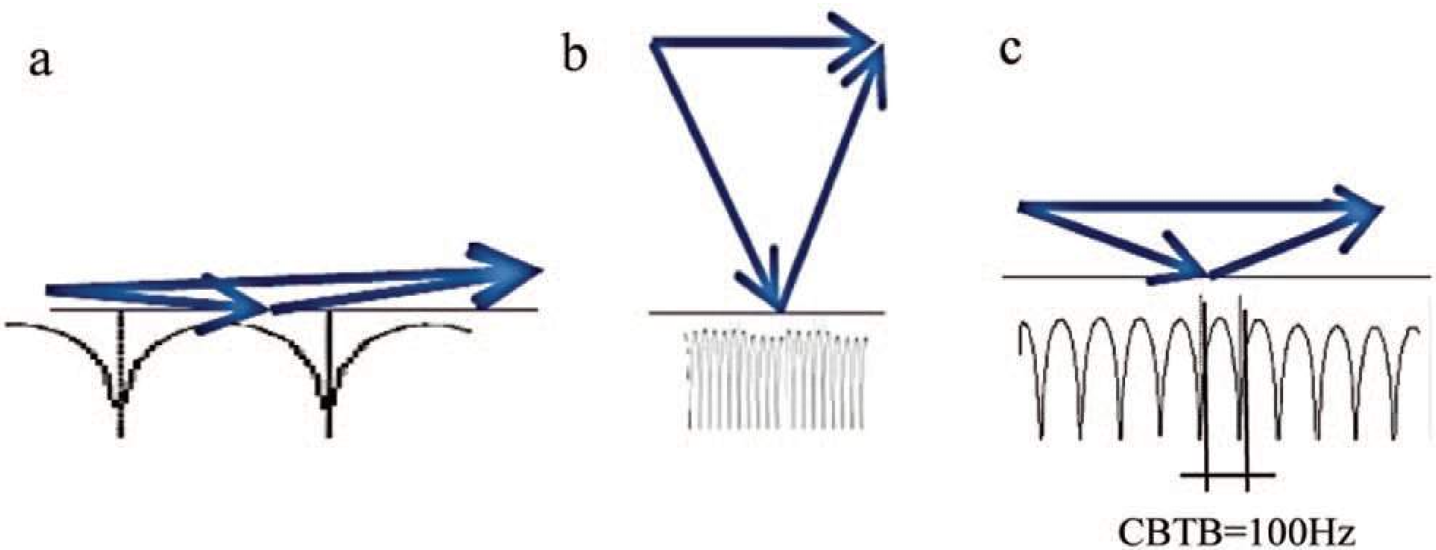
(How details like room resonances and “shimmering” treble are more important for the perceived acoustics of (too) small rehearsal rooms than common reverberation time and sound pressure level criteria).

7 Between Conclusion and the Future

Inexpensive and handy measuring equipment, such as “in-ear”- microphones, handheld wav-recorders, laptops, smart phones and apps, makes it possible to measure impulse responses in many acoustic situations

1-BETWEEN TIME

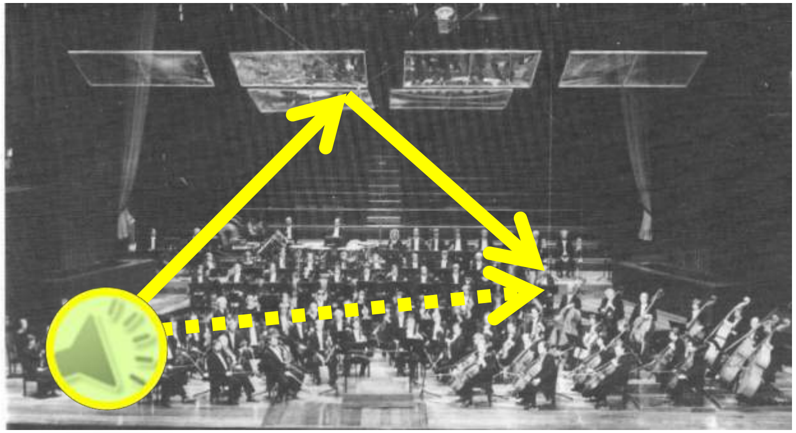
Kamfiltre pga. korte refleksjoner

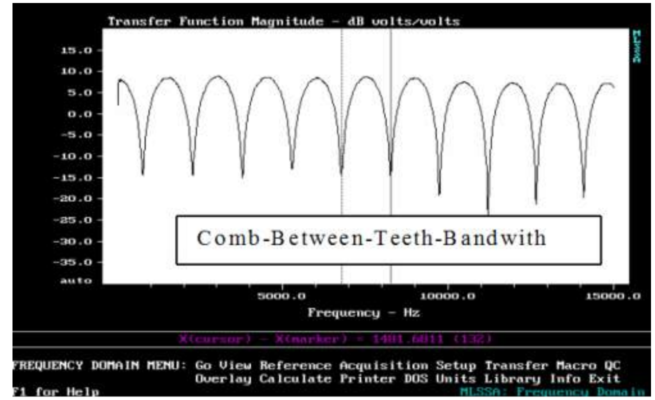


2 BETWEEN MUSICIANS

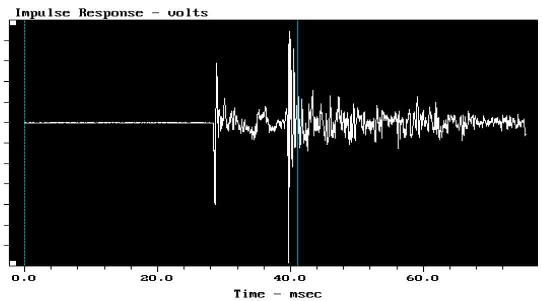
Test, reflektorer

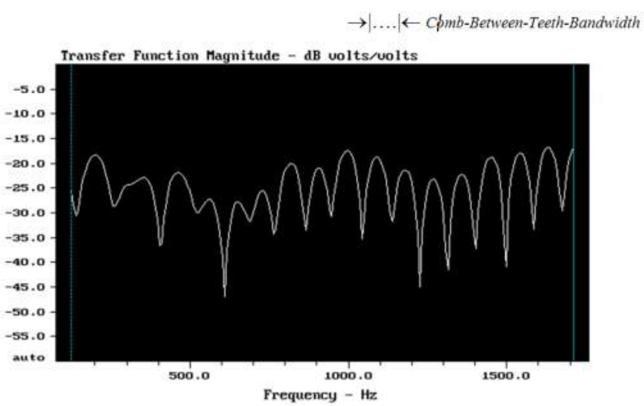
Journal of Sound and Vibration 2000(1) 352
JASA, ICA Madrid 2007



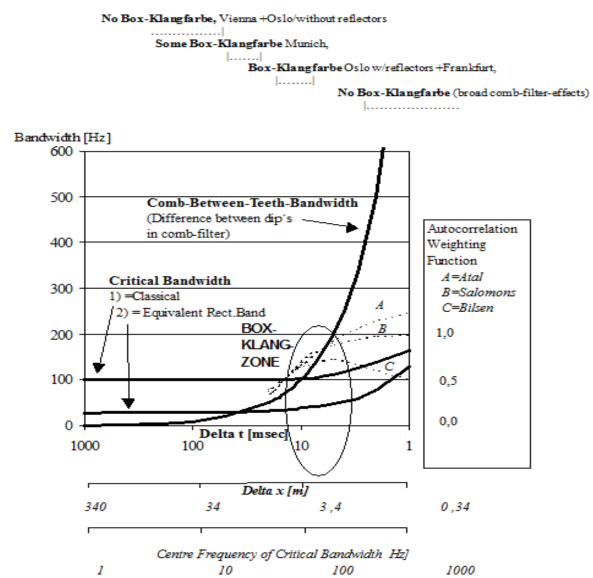


TOR =
Through
Orchestra Impulse
Response

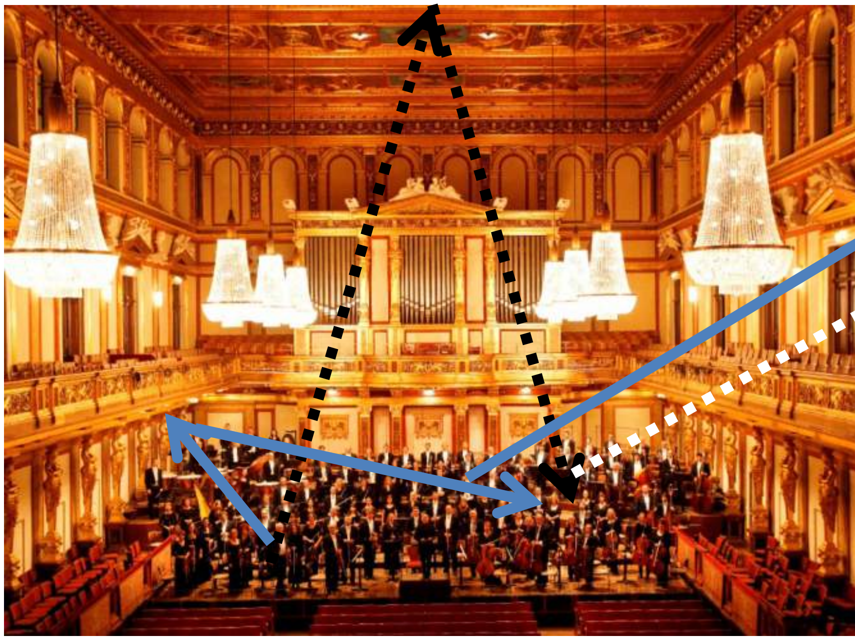




BOX-KLANGFARBE når
Comb-Between Teeth≈Critical Bandwidth



TH: Own Measurements in Musikverein



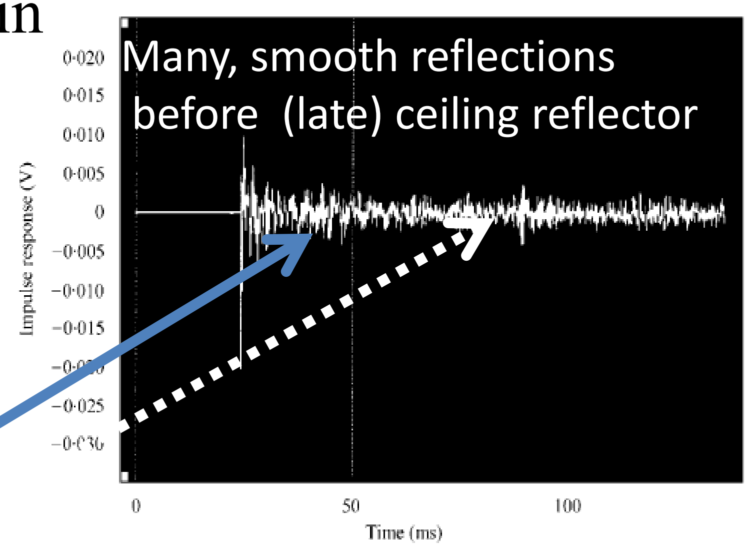
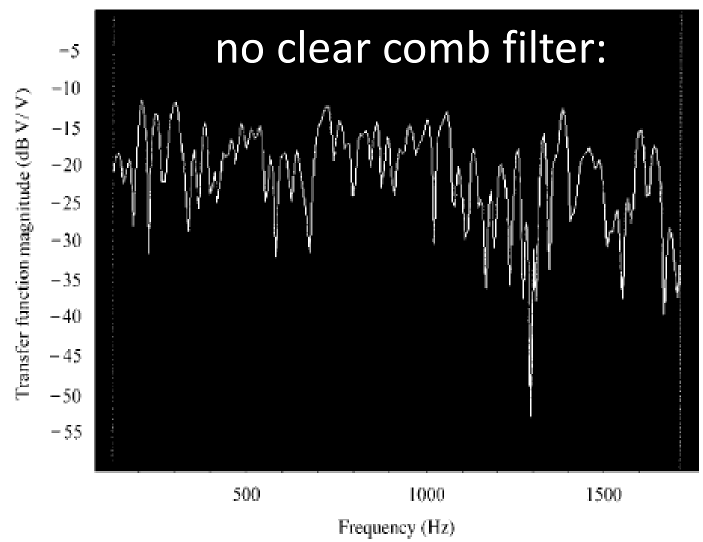
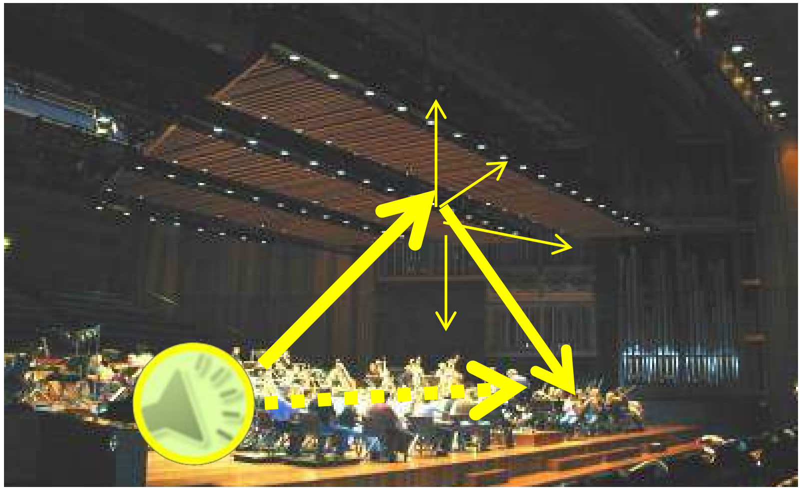


Figure 8. TOR-impulse response, Vienna.

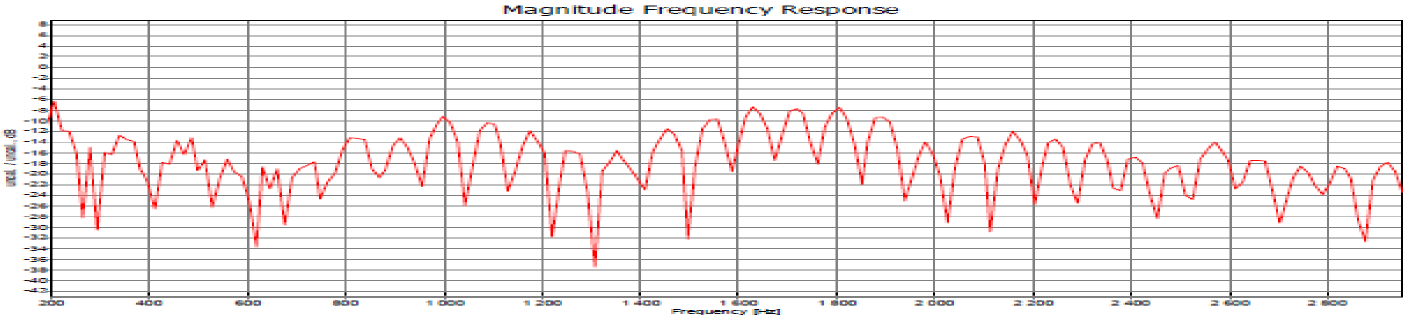


PS! Hvorfor er dette ikke et EKKO
(for symfonisk musikk)???

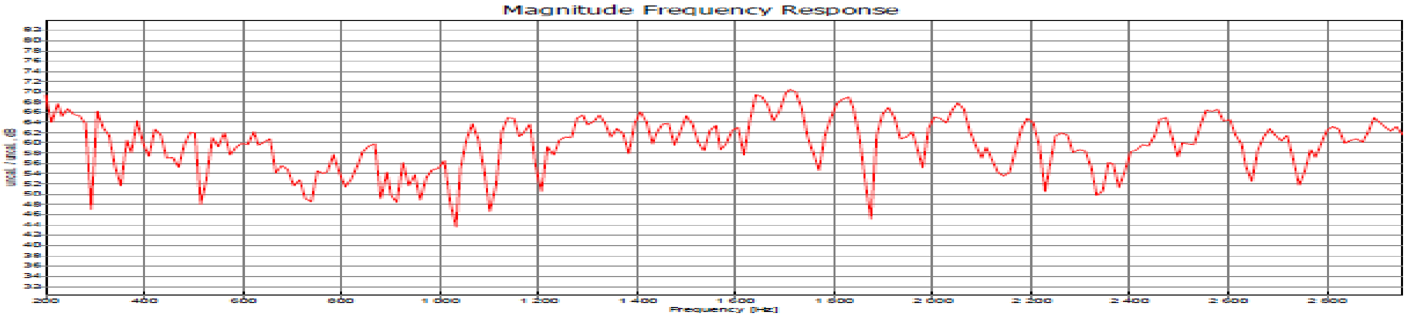
Løsning (BrekkeStrand/Skålevik):



OLD/TEST-REFLECTOR:



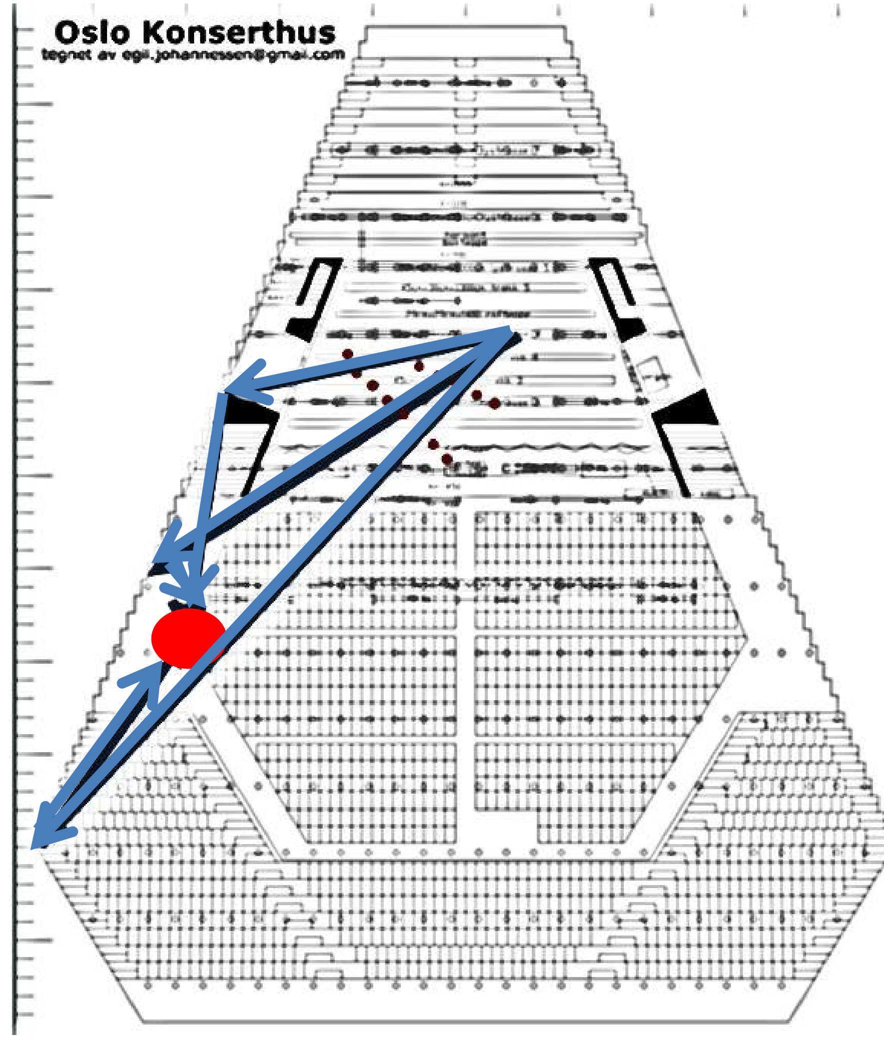
NEW/DESIGNED REFLECTOR:



SISTE NYTT!

Through Orchestra (TOR)-skjerming også for publikum!

Antydninger til «Delayed Phantom»



The Delayed Phantom of the Opera

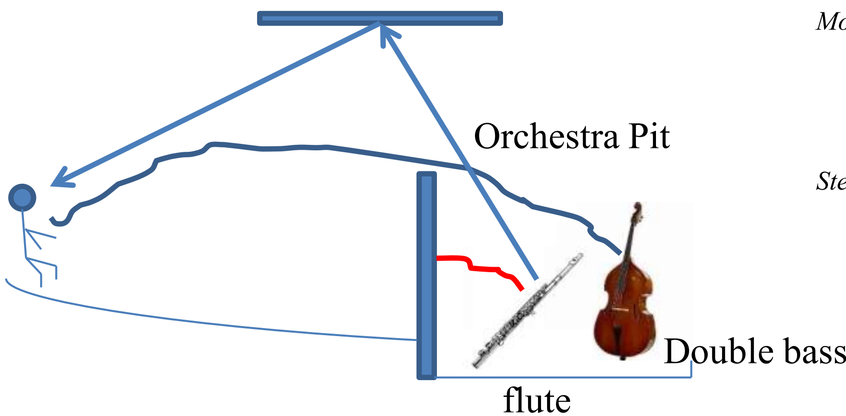
Bayerische Staatsoper, München

«Image Shift»/«False localisation»

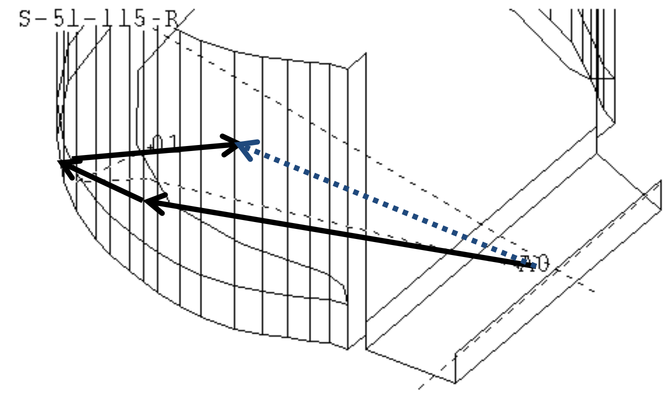
Orig.

Delayed Mono

Stereo



Reflection from underneath balconies and curved wall arriving almost from behind:

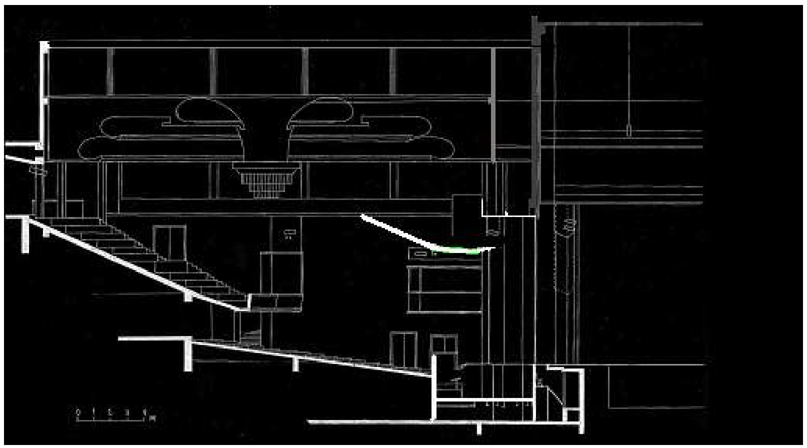


Treble instruments delayed 1/16-note due to delayed «phantom» reflection:

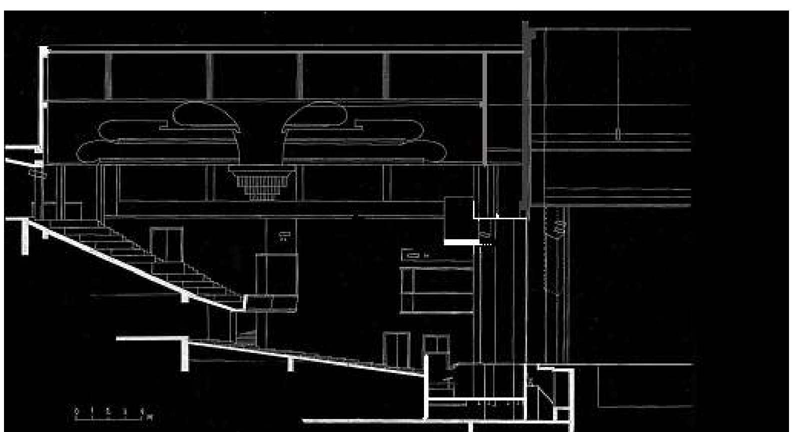
Bizet: Trubadour-March from Carmen

THE INFLUENCE OF A LARGE REFLECTOR OVER THE ORCHESTRA PIT IN AN OPERA HOUSE

Halmrast, Buen, Ihlen, IoA, London

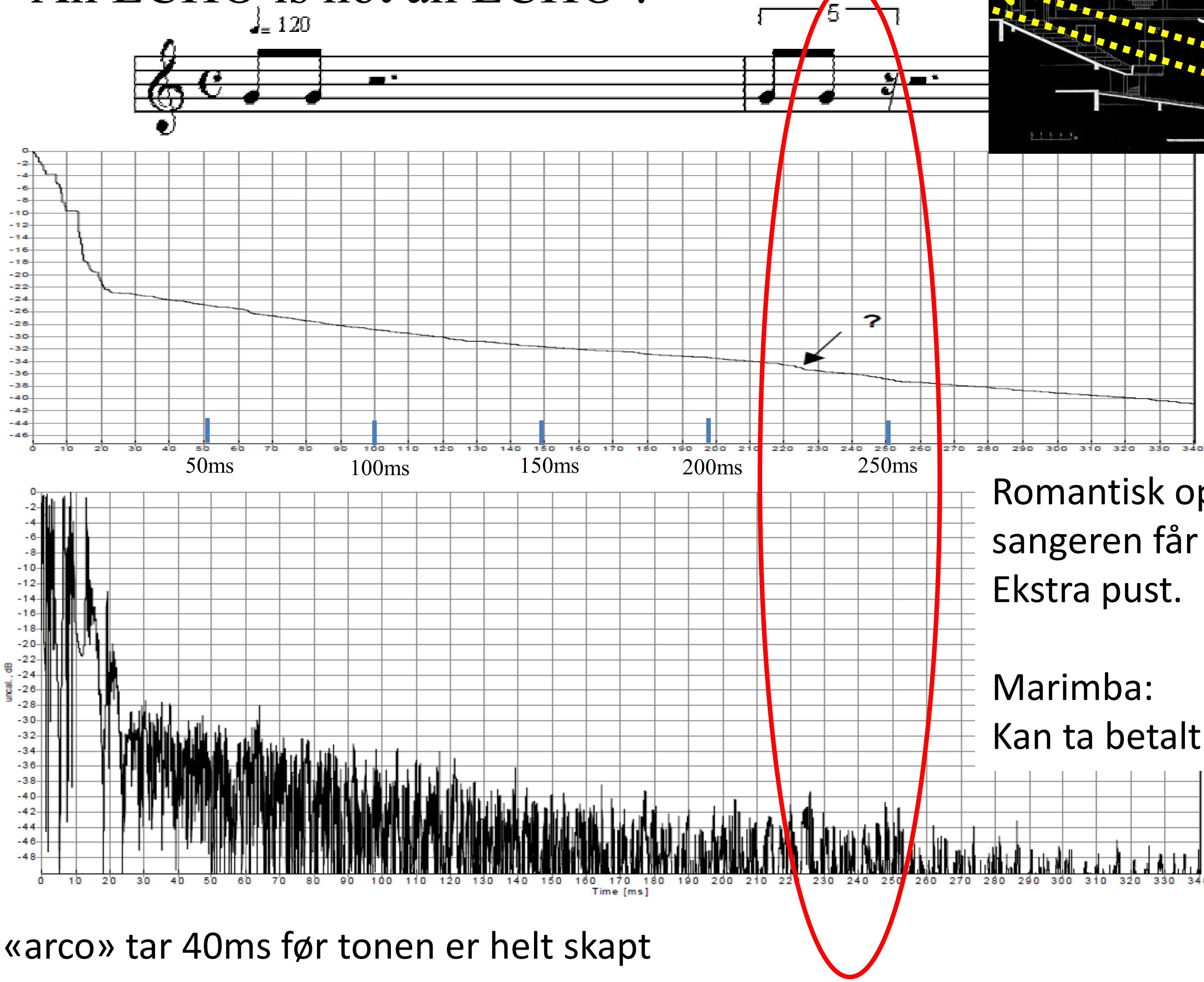


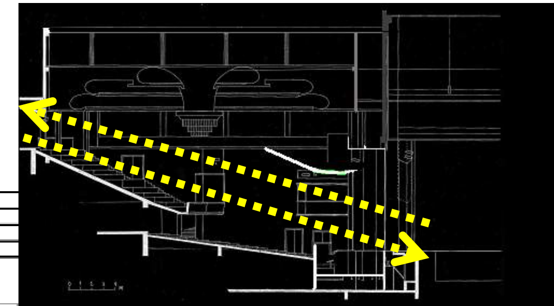
Gml. Operaen/Folketeateret



Referenced in Barron:
«Auditorium Acoustics and Architectural Design

An ECHO is not an ECHO !





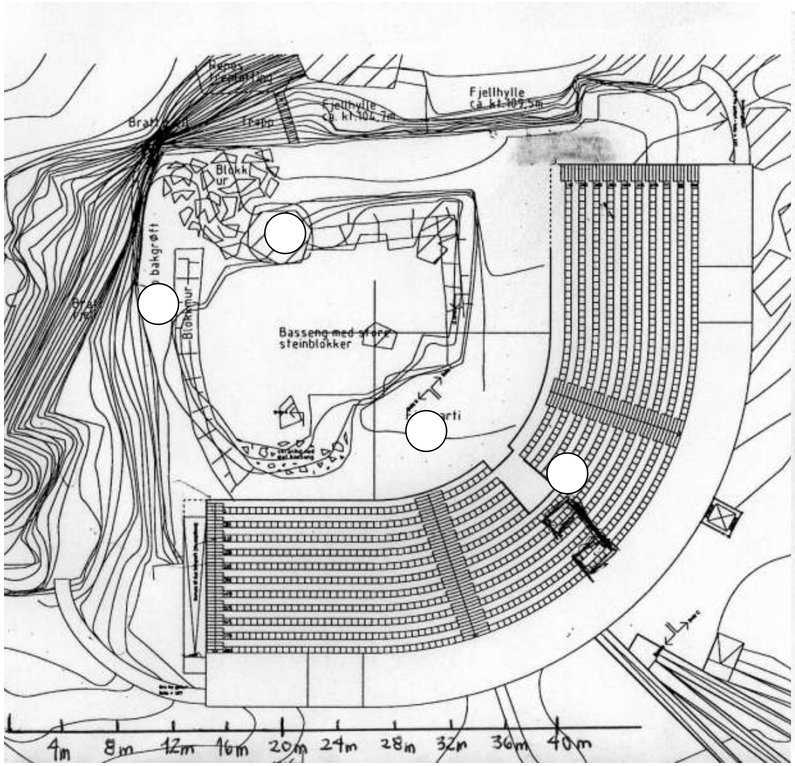
Romantisk opera:
sangeren får «løft».
Ekstra pust.

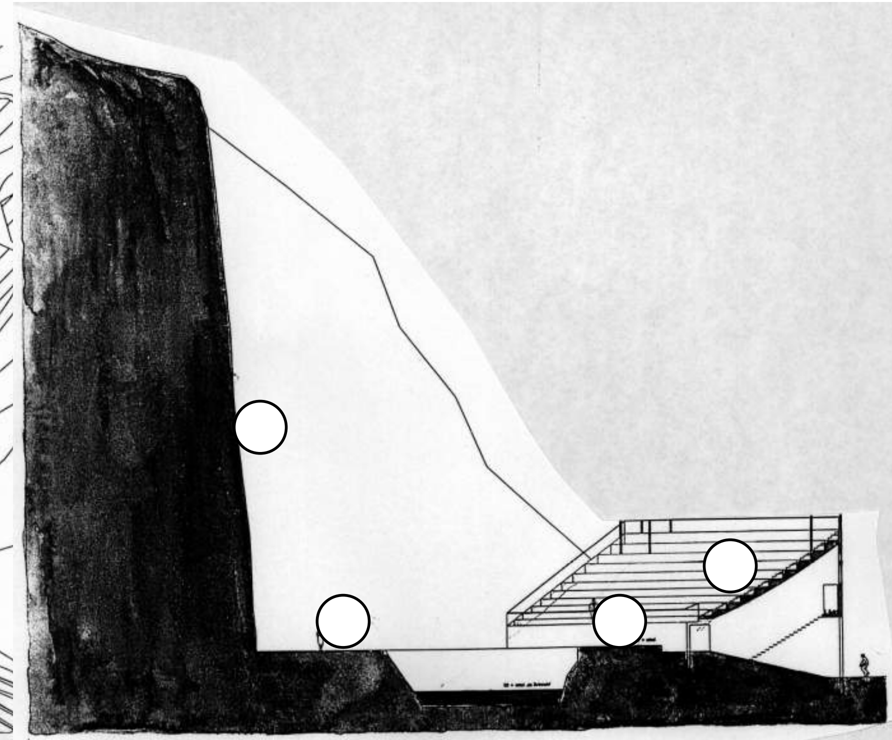
Marimba:
Kan ta betalt for 2 musikere

Fiolin «arco» tar 40ms før tonen er helt skapt

+ Ekko-Prosjekt med ***Hugu Fastl****: Techn.Univ. München*

Taletydelighetens avhengighet av nære refleksjoner





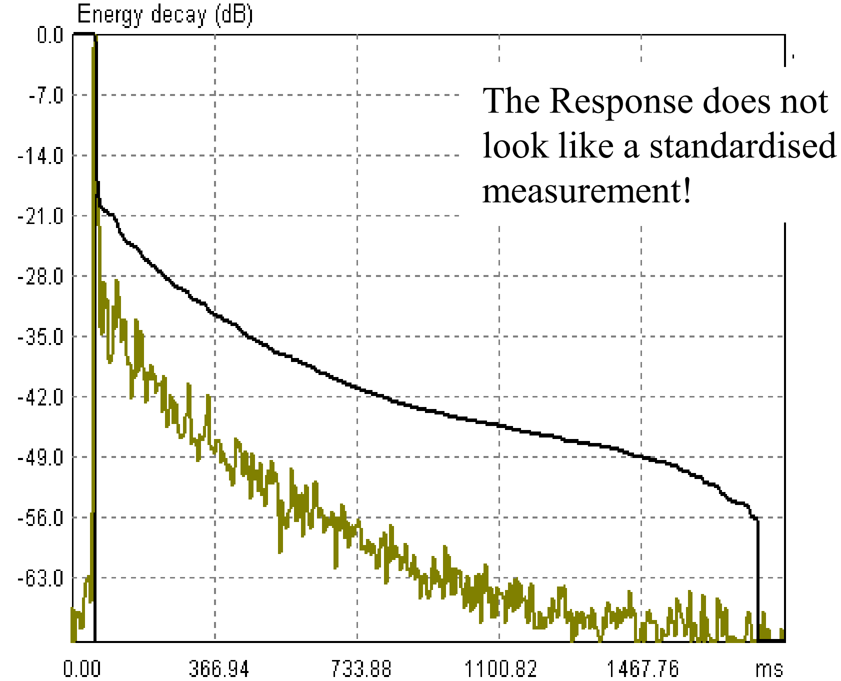
Fjæreheia, Grimstad
Agder Teaters frilufscene i «Hitlers» Steinbrudd

3- BETWEEN OUR MOUTH AND EARS

"WHEN SOURCE IS ALSO RECEIVER"

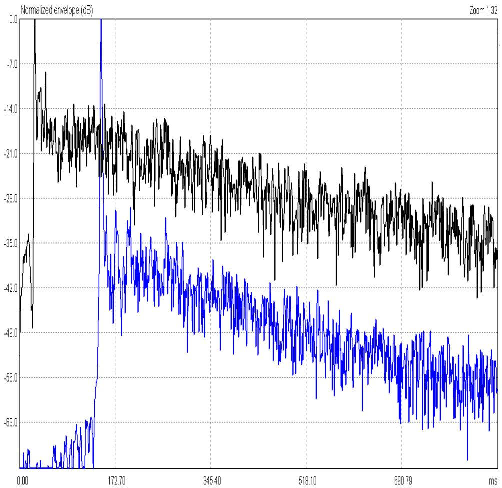
How are we able to judge room acoustics
by listening to our own Handclaps and Tongue-drops?

Own Handclap and "In-Ear" -mic:

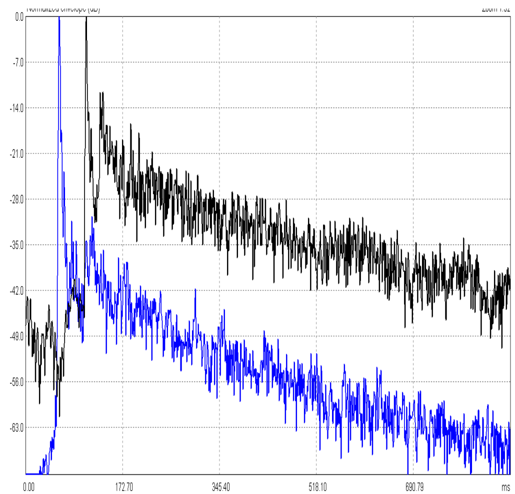


The Response does not look like a standardised measurement!

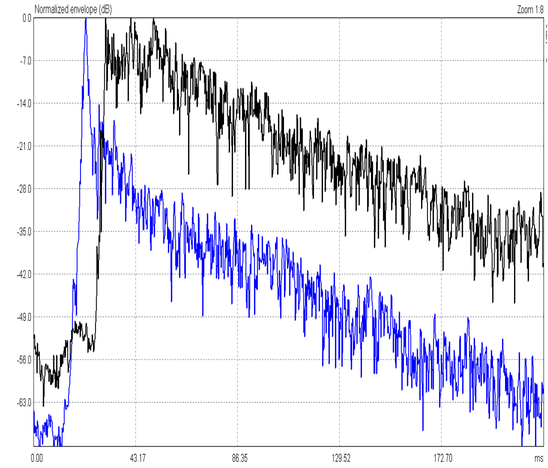
BIG FOYER



CONCERT HALL

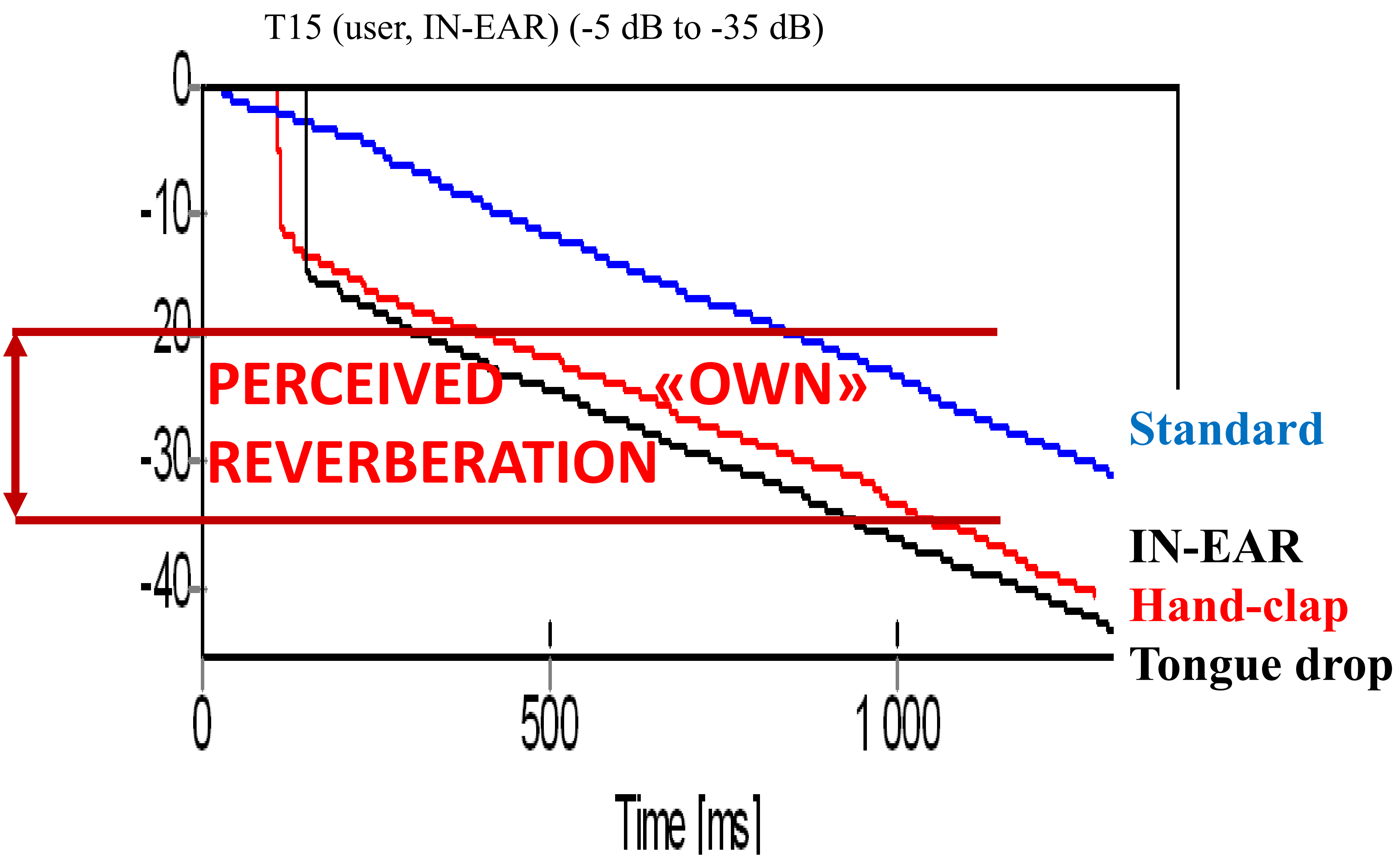


LIVING/MUSIC ROOM



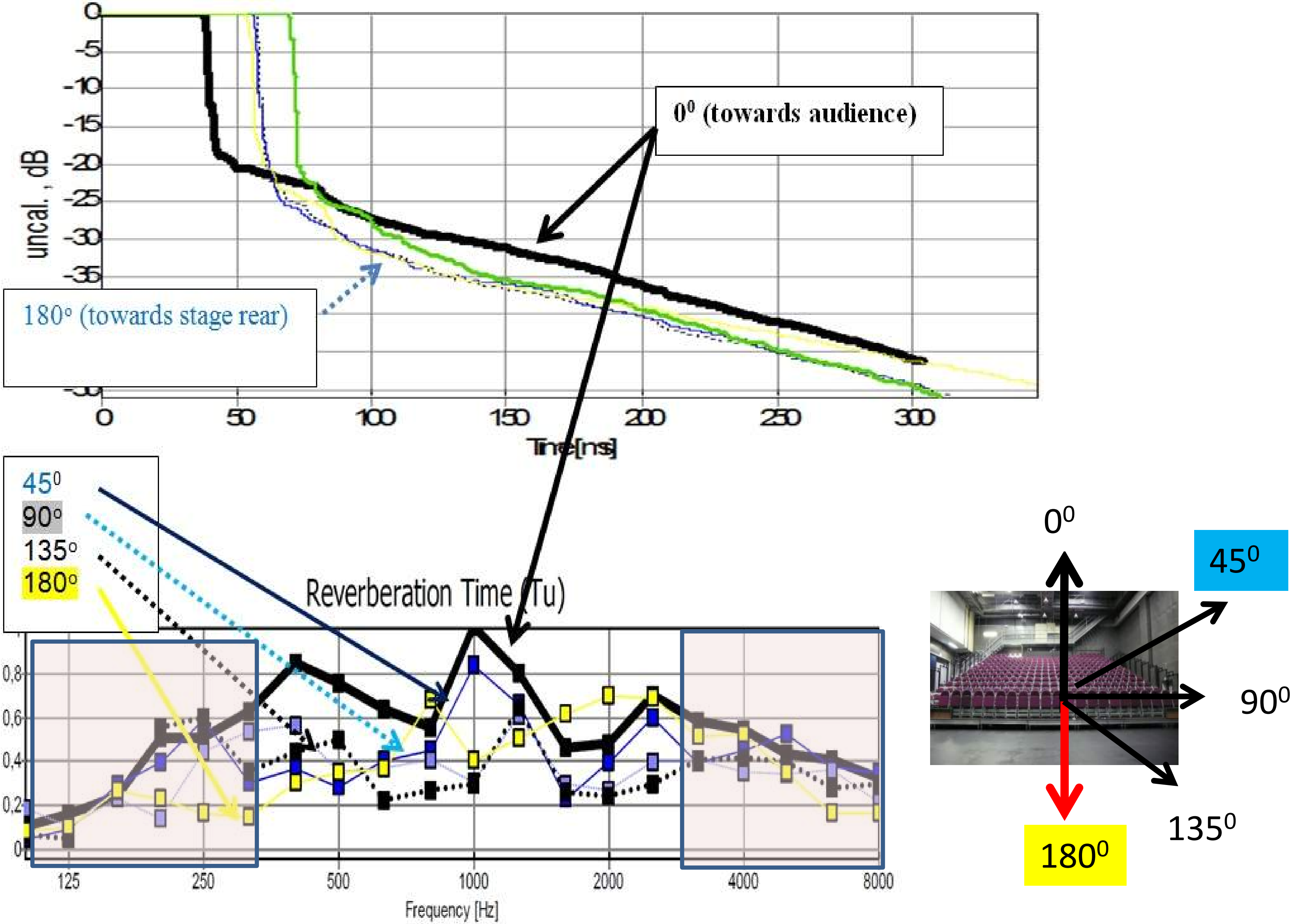
BLACK= Standardised

BLUE= Clap, In Ear Mic



We judge the reverberation time in a room by ***eliminating the direct sound*** *when listening to our own handclap.*

DIFFERENT DIRECTIONS:



3) ECHOLOCATION,
How the Blind «see» with the ears

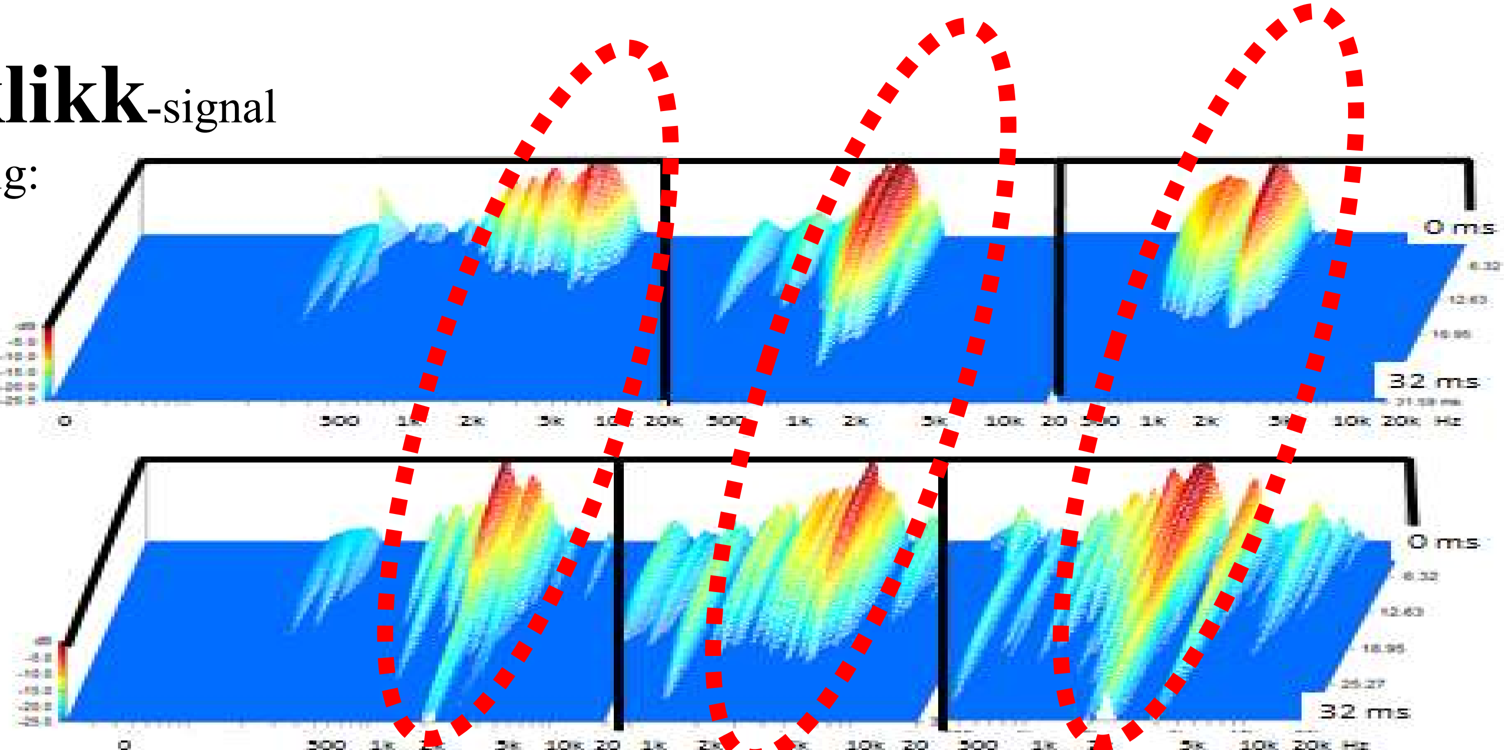
Daniel Kish «World Access for the Blind»

Huseby Kompetansesenter/Statped

EAA Forum Acusticum Aalborg 2011 + IoA + Psychomusicology
Lite Statsbygg FoU-prosjekt med Jens Jørgen Dammerud (NISS/Rikshospitalet)
Anders Buen (BS-akustikk) og Huseby Kompetansesenter.

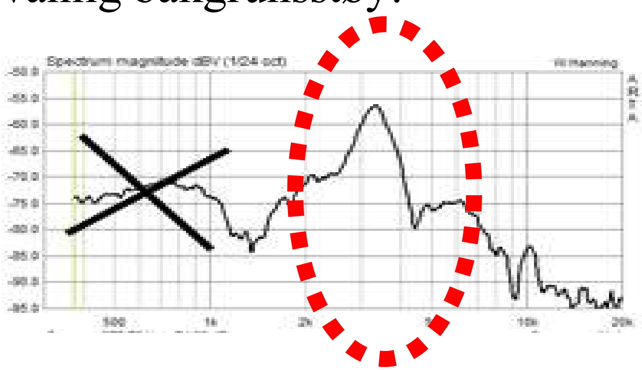
Blindeklikk-signal

Personavhengig:

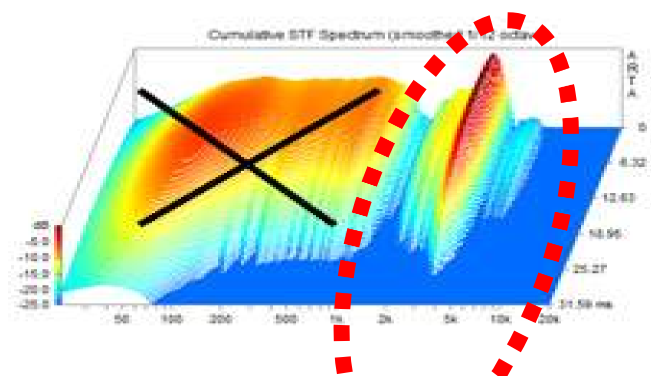


Ca. (1)-**2 -**(4)**kHz**

«utenfor» vanlig bakgrunsstøy:



Daniel Kish



CLICKS/FORMANTS?

Shape your mouth/tongue so as to pronounce «K»

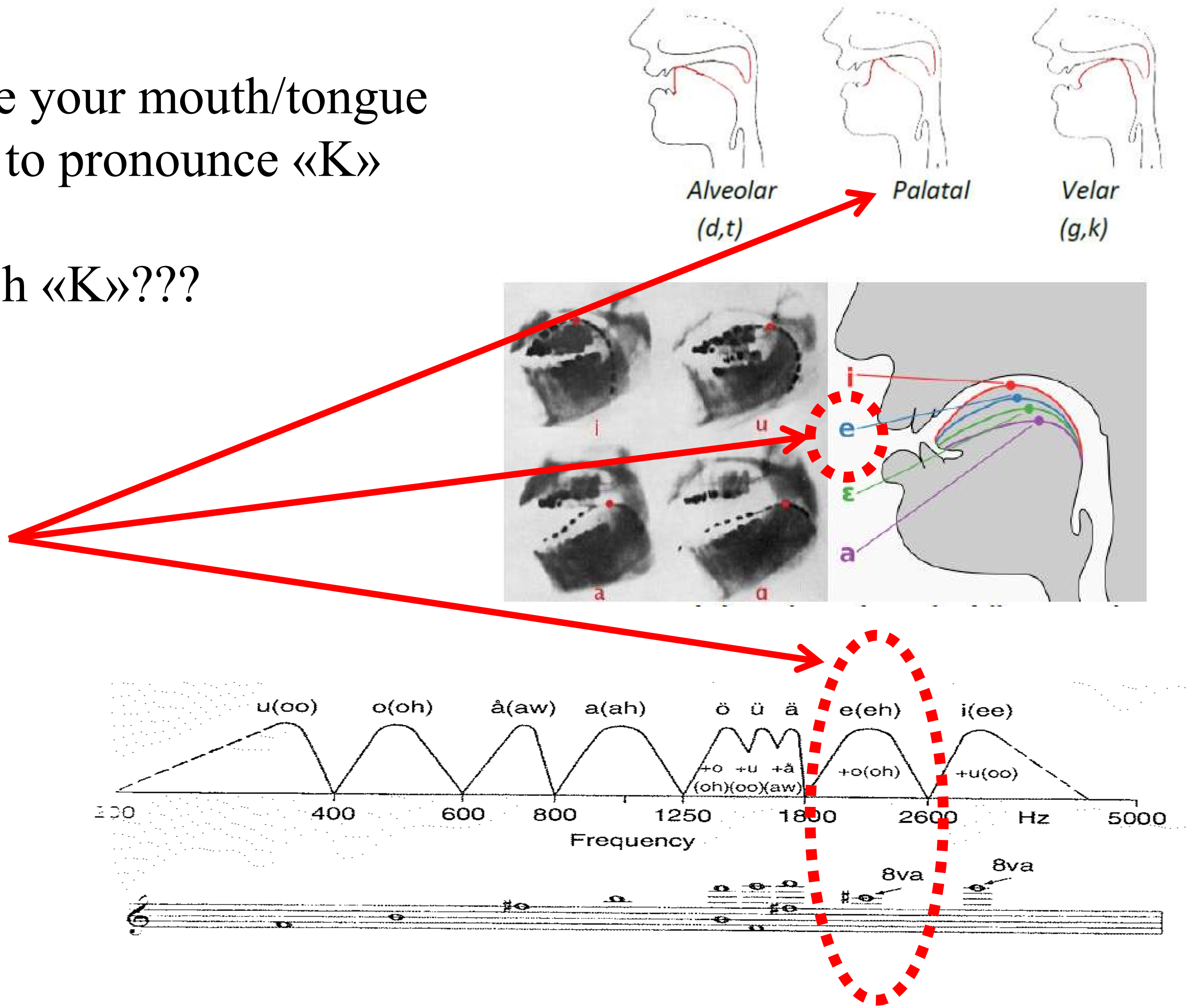
Which «K»???

Ka?

Kå?

Ki?

Ke?



CONCLUSIONS, HUMAN ECHOLOCATION

BROAD FREQUENCY/SLOW BACKGORUND NOISE

Localisation in Frequency Domain (Timbre/Comb Filter)

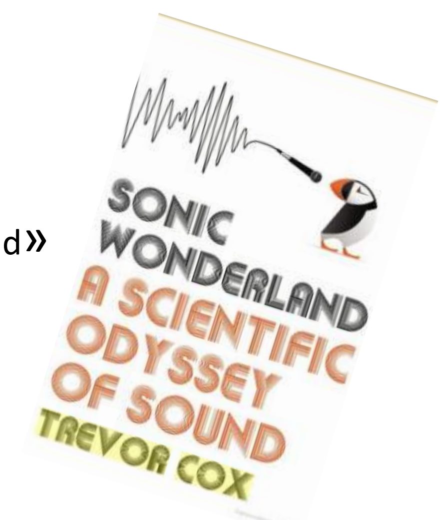
SHORT CLICKS

both Freq. and Time Domain («Echo»)

Easier to detect the reflections when performing the clicks yourself in «real time», compared to listening to them afterwards

Turn the head/ «zoom-in» on the objects/surfaces

Referenced in: Trevor Cox: «Sonic Wonderland»



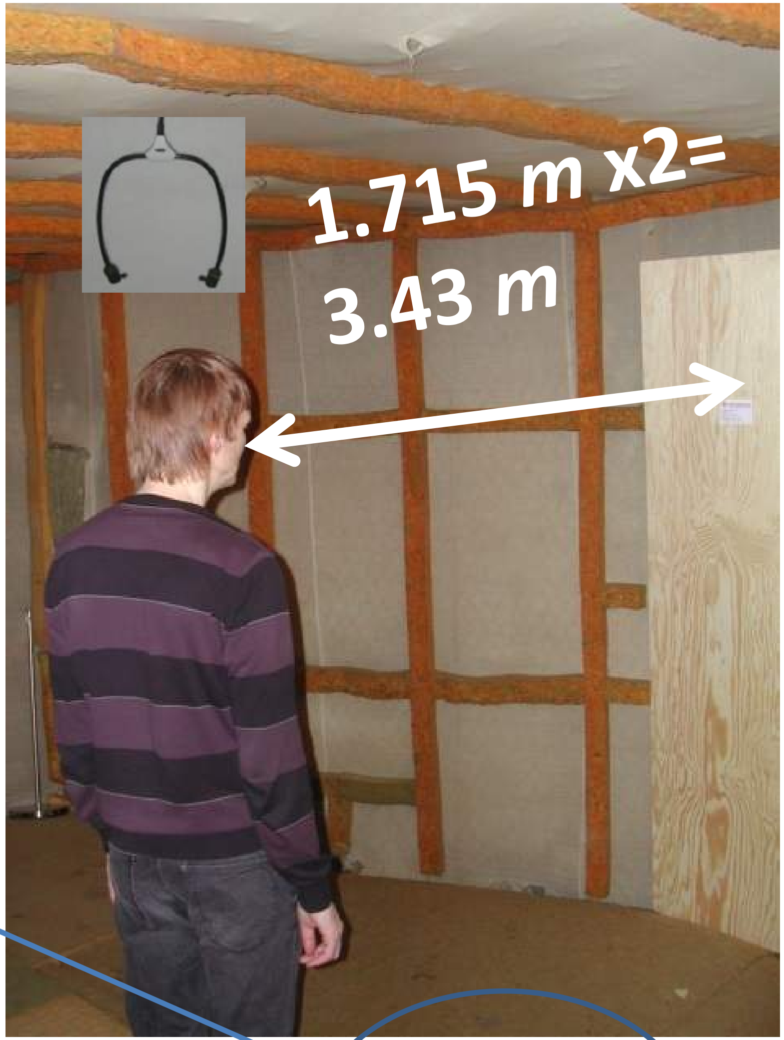
Motstridende ønsker mhp Universell Utforming mellom Blinde og Døve

ANECHOIC CHAMBER

University Oslo, Physics

with/without reflecting plate

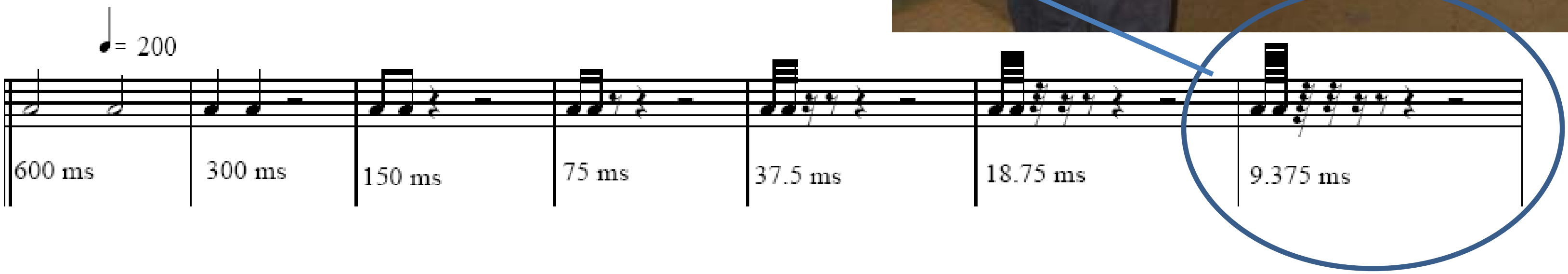
«in-ear»-microphones



$\Delta x = 3.43\ m$

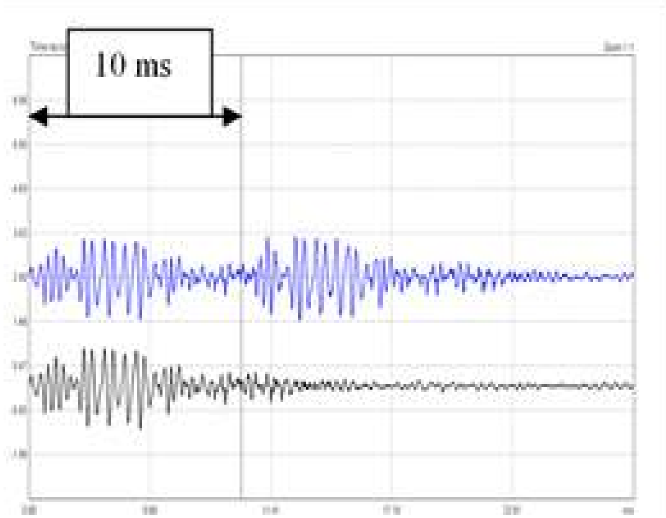
$\Delta t = \frac{3,43\ m}{343 m/s}$=0.01 s = 10 ms

$CBTB = \frac{1}{0,01}$ = 100 Hz

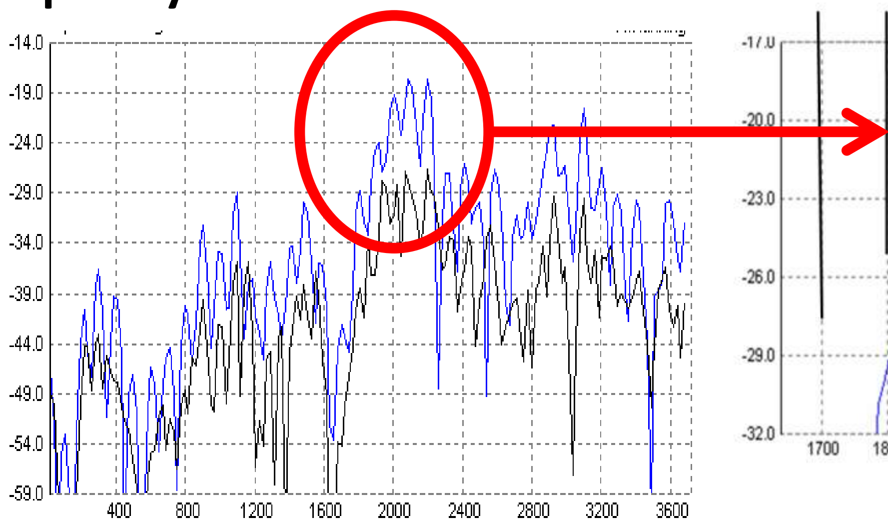


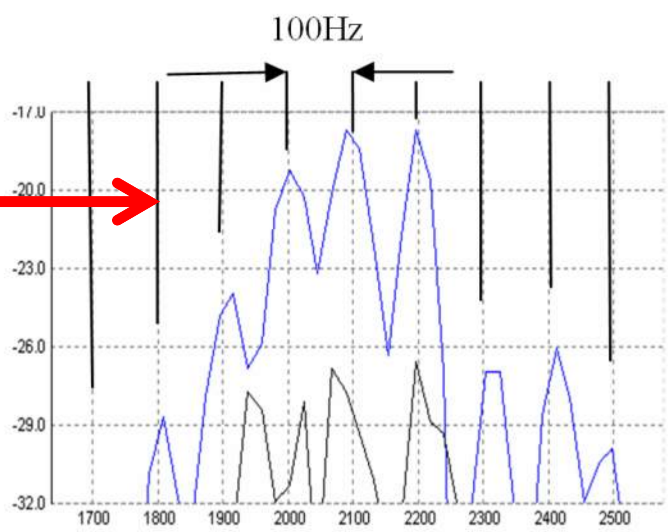
Long/»juicy» (amateur) click:

Combined with a delayed reflection gives



COMB FILTER in the Frequency Domain

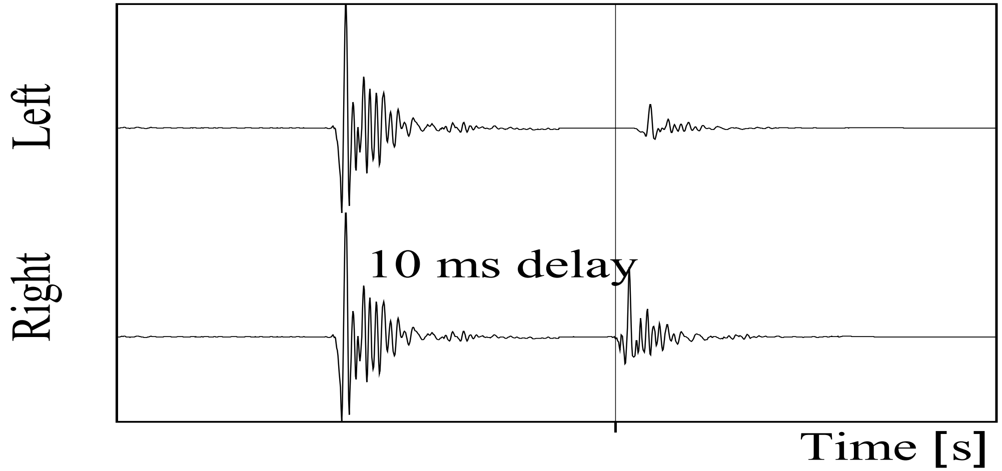




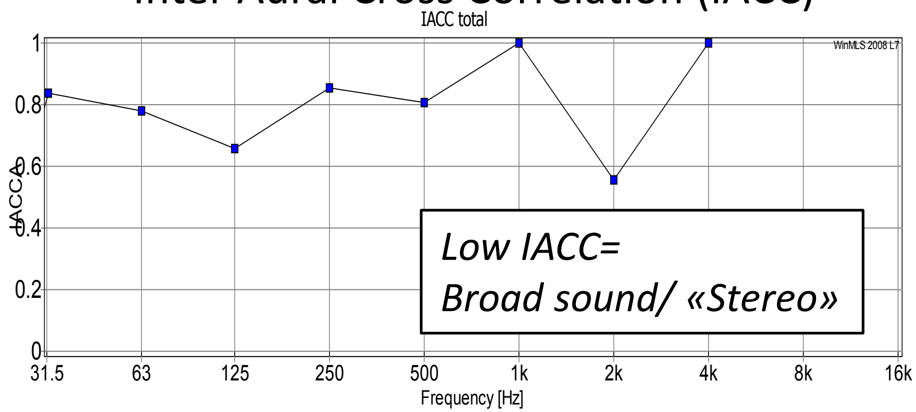
BINAURAL

Mouth forwards

Reflecting plate to the Right (90 degrees)



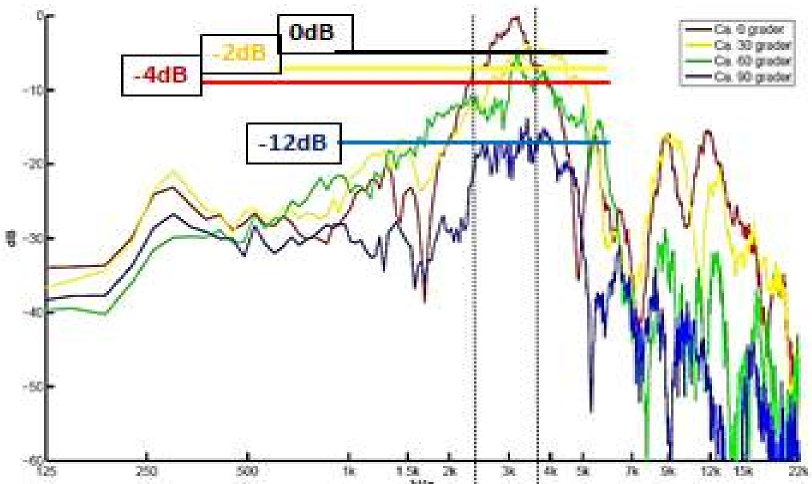
Inter Aural Cross Correlation (IACC)

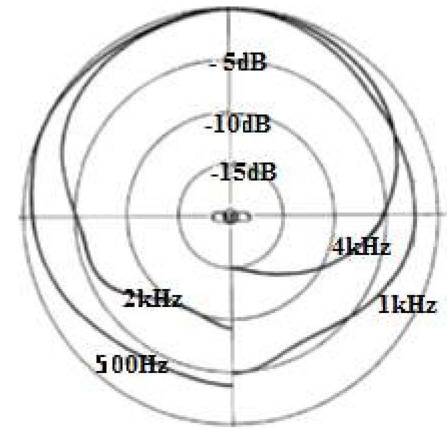


DIRECTIVITY

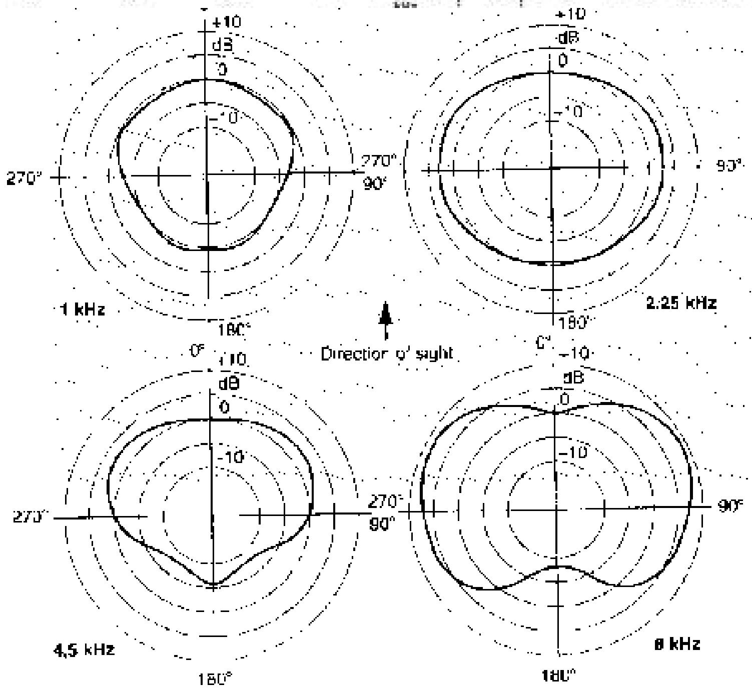
Clicks more directive than Speech:

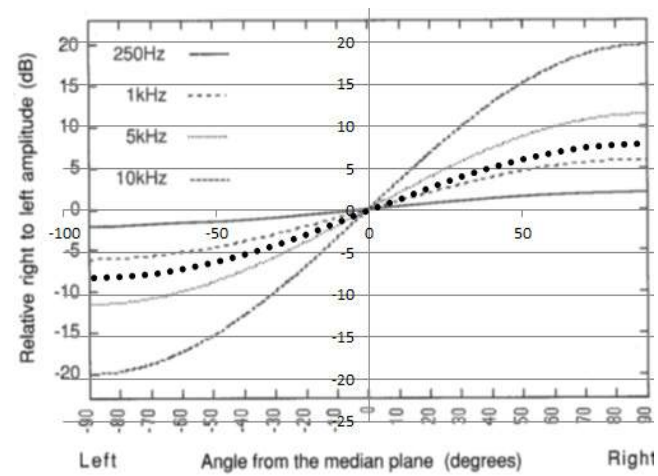
MOUTH



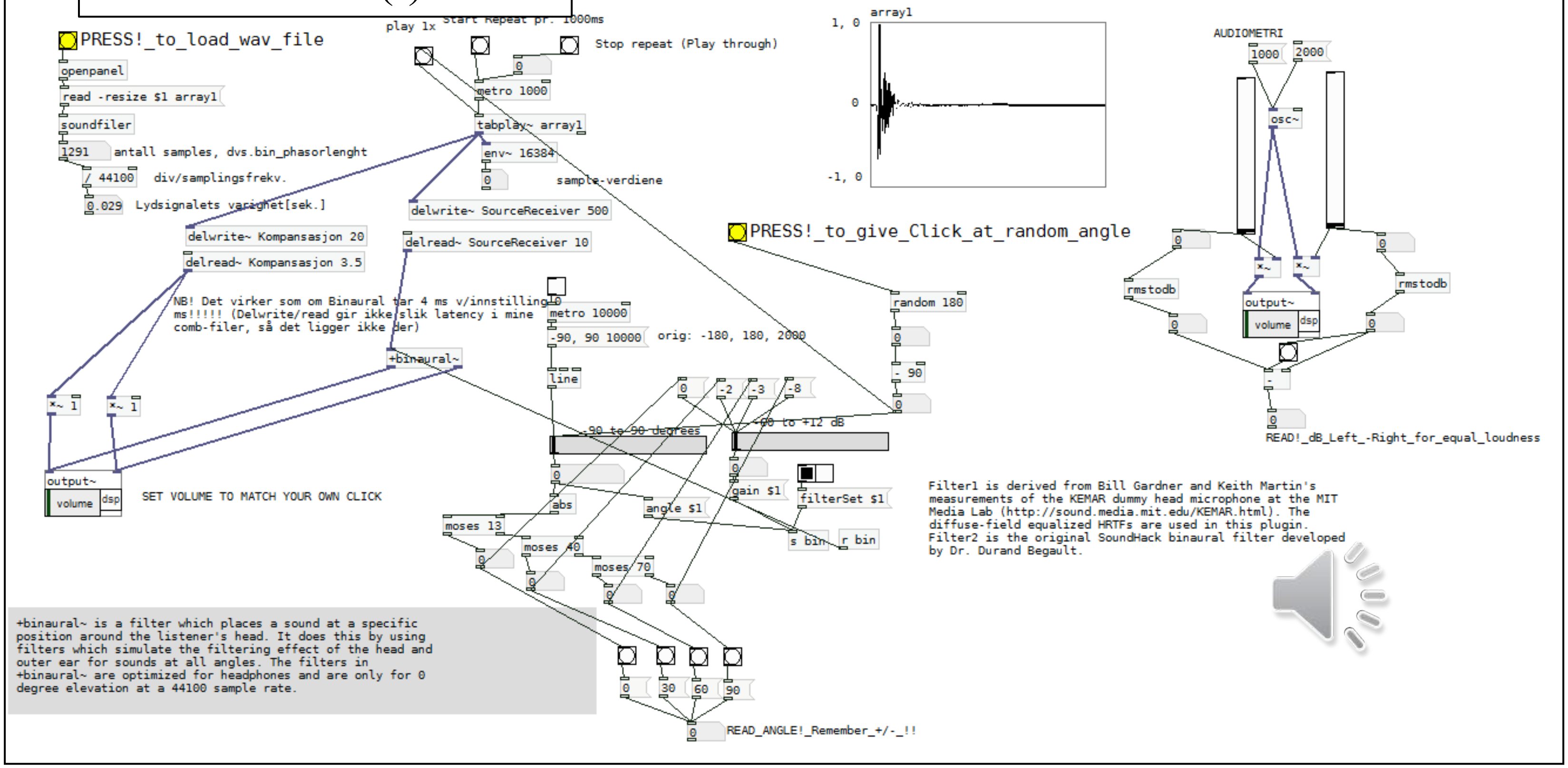


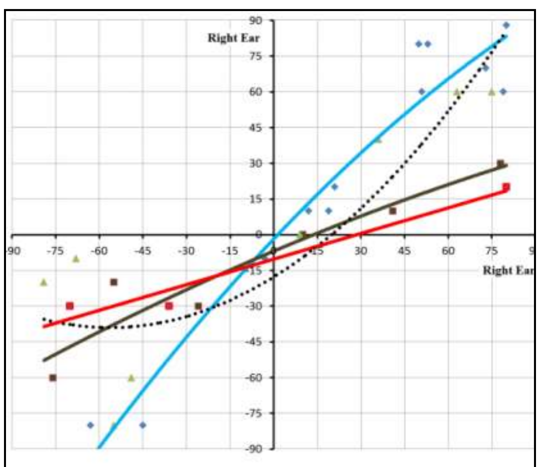
EAR
(Binaural
HRTF)

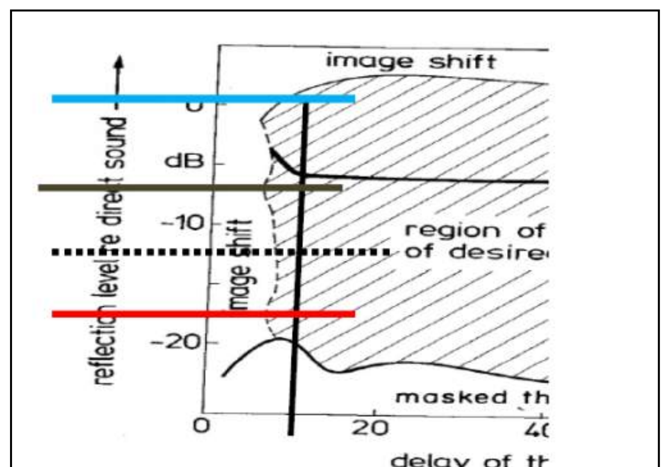




«BLINDFOLD(!)-TEST







Motstridende ønsker mhp Universell Utforming mellom **Blinde og Døve**

Begge liker lave/moderate etterklangstider, men:

-Veggabsorbenter er for blinde=tomrom (fare?)
-Blinde elsker hjørner
(Hjørneabsorbenter jmf Døve=FORBUDT!)
-Blinde vil ha noe midt-frekvens/diskant-lyd/«støy» (til og med VVS) for å høre vegger/objekter.
- Blinde elsker harde sko på grus

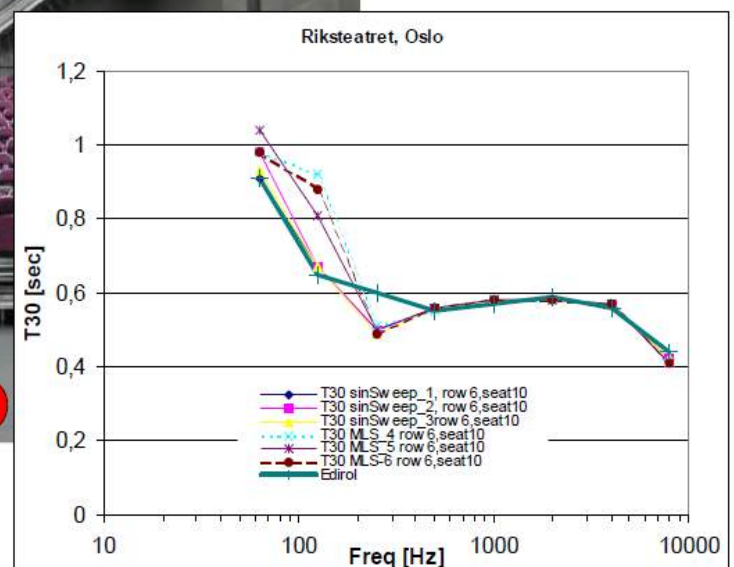
FORENKLEDE måle-metoder

1) Halmrast, Gade, Winsvold (Norsonic)

2) Tor Halmrast/Anders Buen

Riksteateret, Oslo

One Position
- Several Sweeps
- Several MLS
- 1 wav-recording



Musician´s Perceived Timbre and Strength in (too) Small Rooms

EAA Acoustics in Practice (ref. i NS 8178, Musikkrom)
BNAM

«NON-DAMPENED»

Gypsum: All walls and ceiling *Curtain*: one long wall

Forsvarets Musikk Korps, Nord Norge
Kulturhuset, Harstad

«DAMPENED»

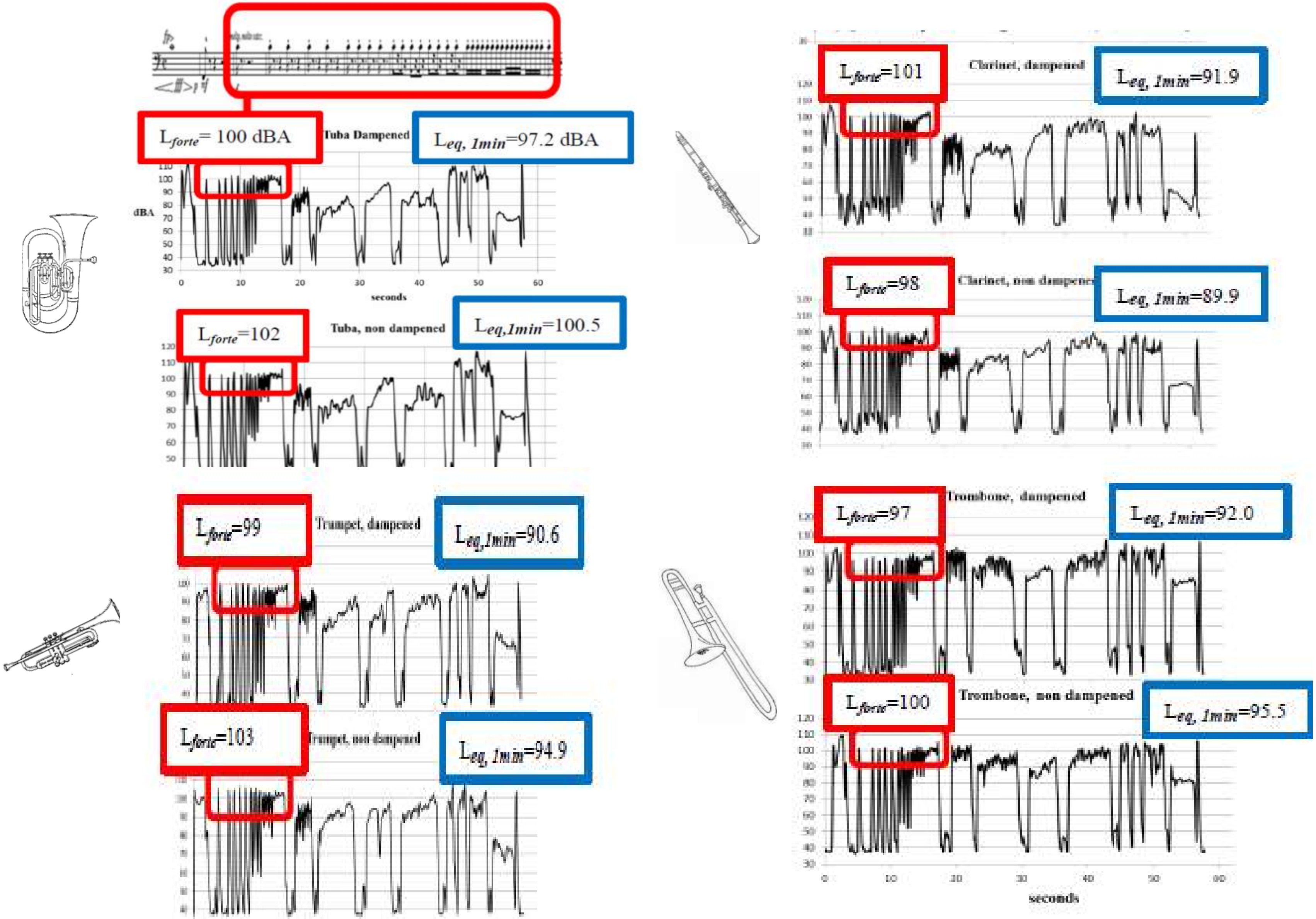
Corner/ «Bass»- Absorber

4 Wall-Absorbers, 10 cm Cosmos

Rehearsal Room Test

Tor Halmrast

Flute
Clar. B*b*
Alto Sax E*b*
Trpt B*b*
Trbn
Tuba



L_{forte}= 100 dBA
Tuba Dampened
$L_{eq,\ 1min}$=97.2 dBA
dBA
seconds
L_{forte}=102
Tuba, non dampened
$L_{eq,1min}$=100.5
L_{forte}=99
Trumpet, dampened
$L_{eq,1min}$=90.6
L_{forte}=103
Trumpet, non dampened
$L_{eq,\ 1min}$=94.9
L_{forte}=101
Clarinet, dampened
$L_{eq,\ 1min}$=91.9
L_{forte}=98
Clarinet, non dampened
$L_{eq,\ 1min}$=89.9
L_{forte}=97
Trombone, dampened
$L_{eq,\ 1min}$=92.0
L_{forte}=100
Trombone, non dampened
$L_{eq,\ 1min}$=95.5
seconds

Conclusion, Sound Pressure Level MUSICIAN as SOURCE:

Measured reduction in sound pressure level at the musician´s ear when introducing the extra absorbers is

1-2 dB less

than the reduction measured with a constant loudspeaker source.

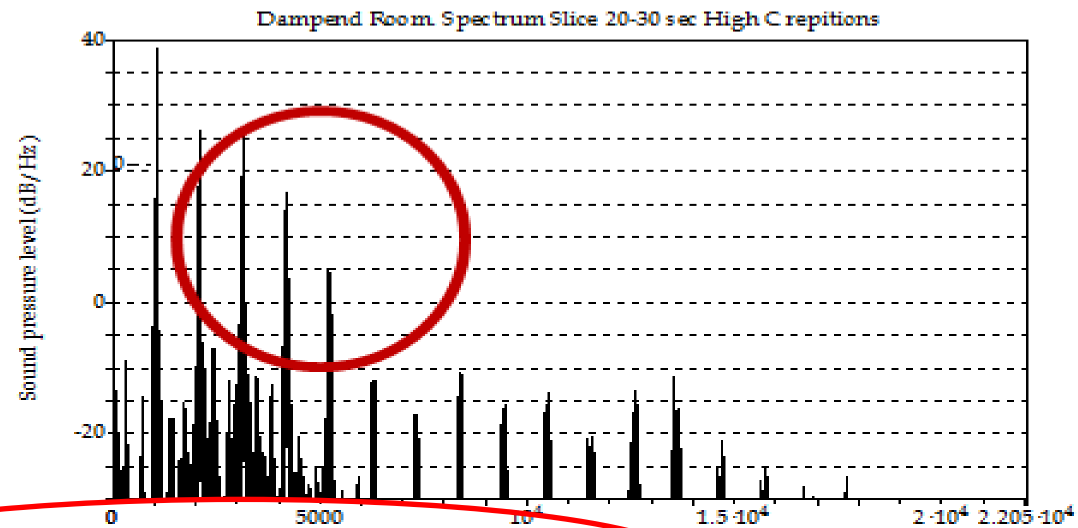
Even if the sound pressure levels are “dangerous”/high:

Musicians compensate for the reduced “answer” from the room.

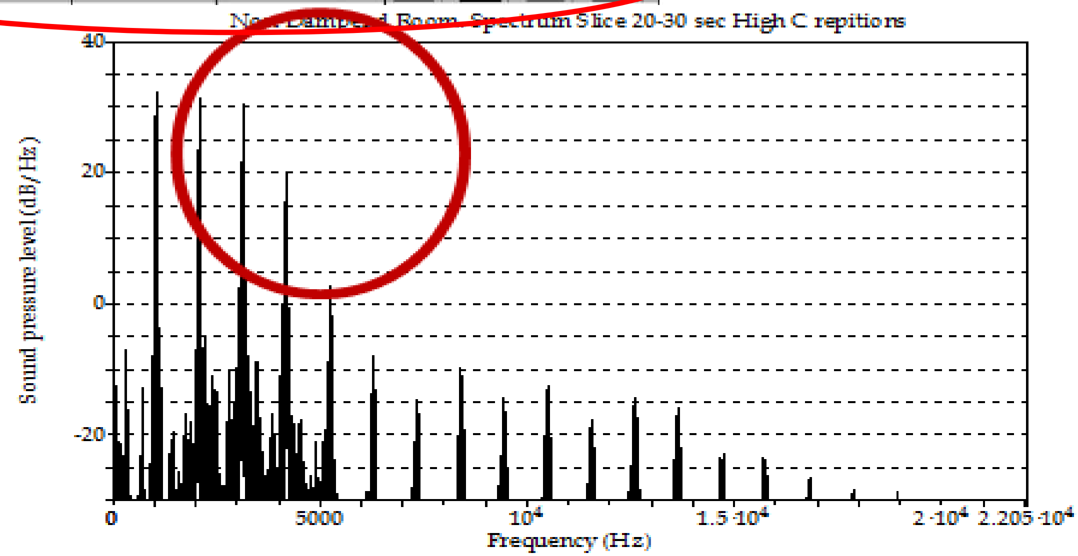
The clarinet plays/sounds louder in the dampened room!!!!

CLARINET
Spectrum Slice

10 sec
High C –repetitions
~ 1000 Hz



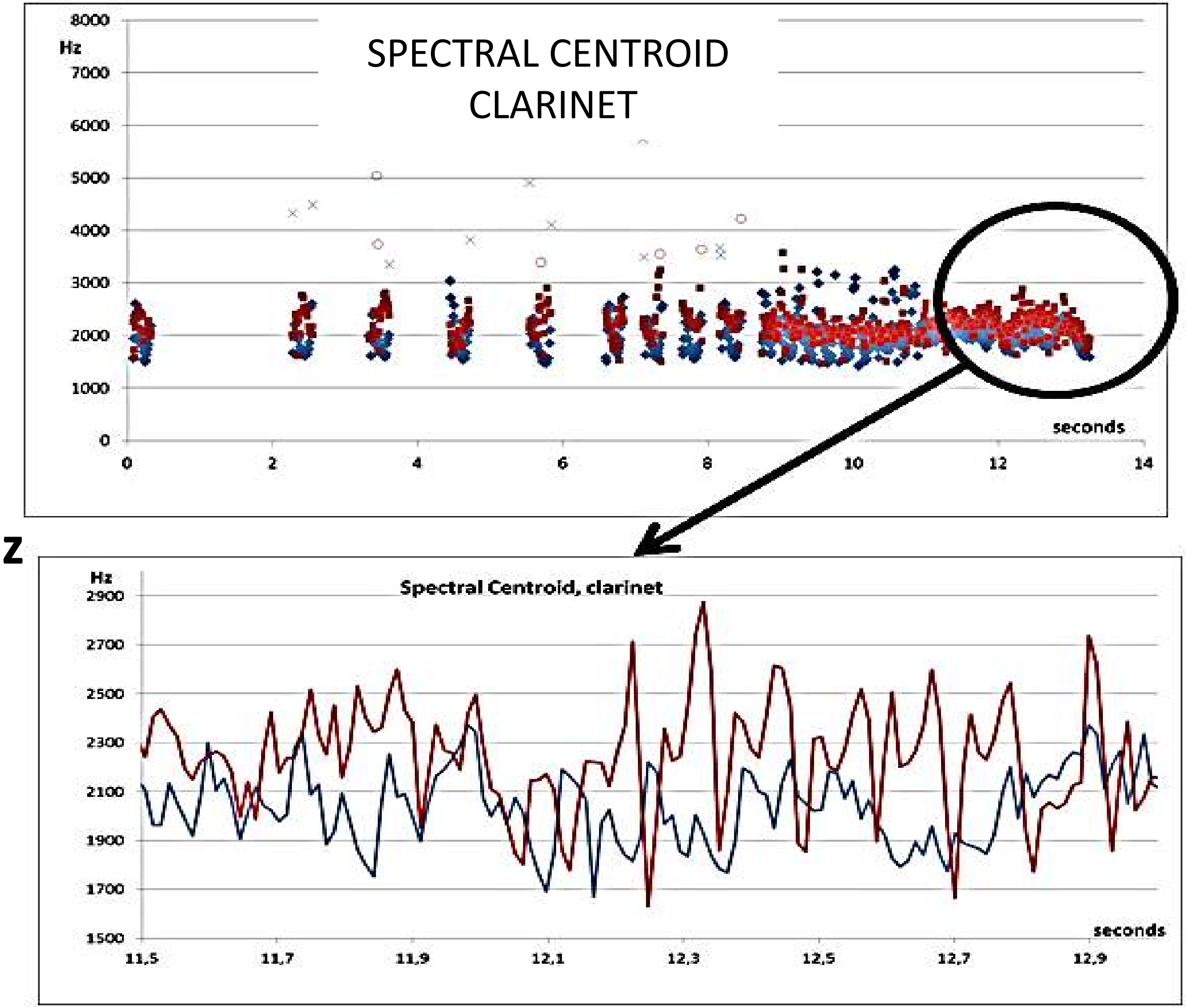
Linear freq. axis



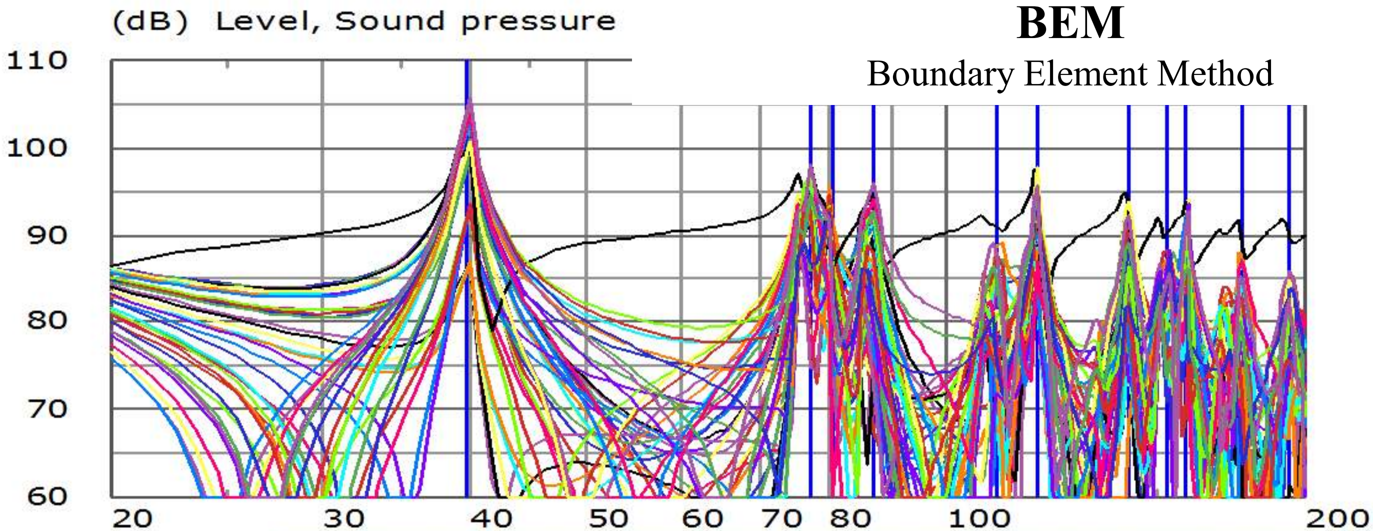
Spectr. Centroid

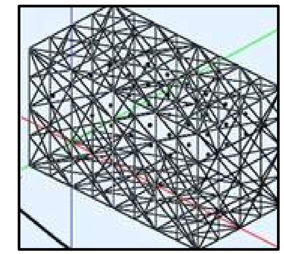
reduced 200 Hz

when dampening the room

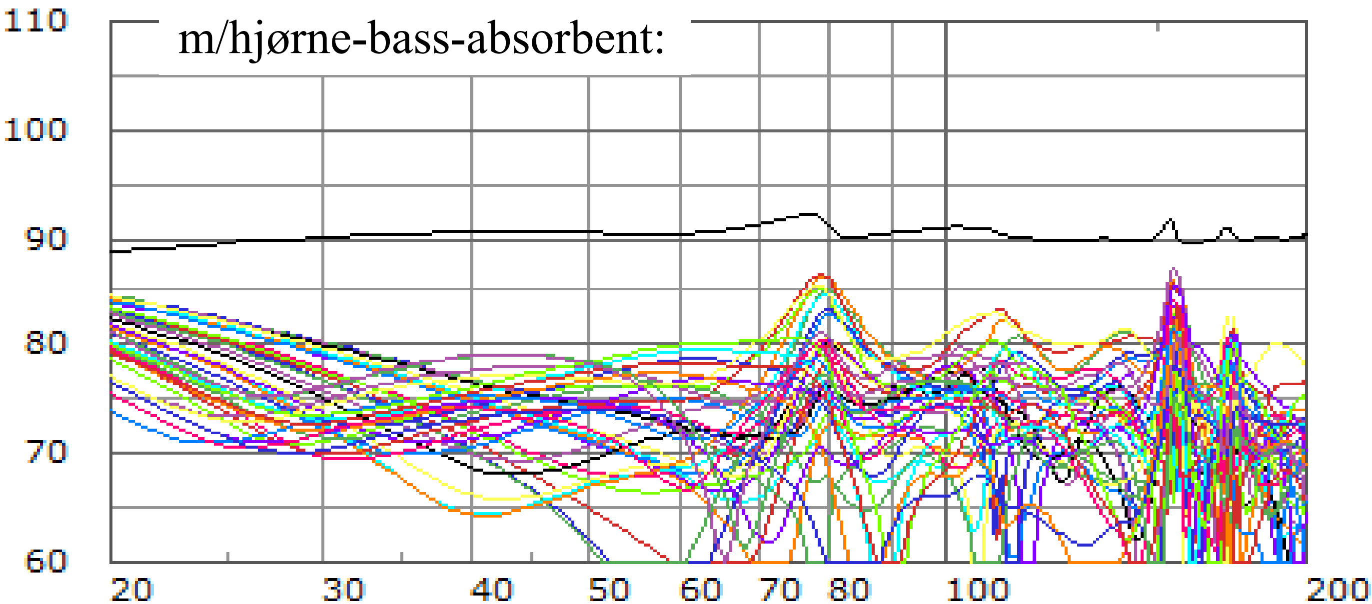


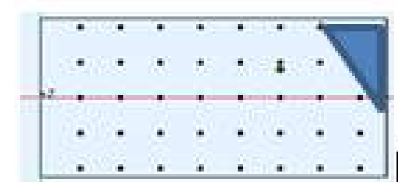
BEM
Boundary Element Method





m/hjørne-bass-absorbent:





The main effect of a well absorbed room in practice is to:

1)Reduce «SHIMMERING» of high frequencies

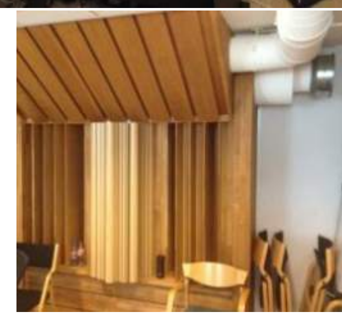
2)Dampen (some) room (bass)-RESONANCES

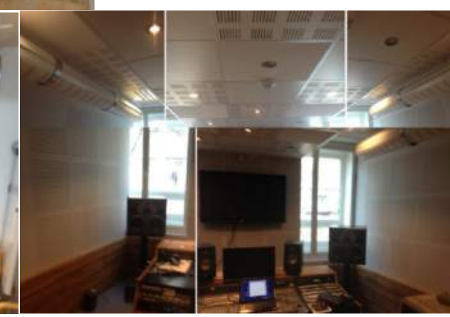
These issues are
more important than
Reverberation Time and dBA
when designing (too) small rooms for music

(SMÅ) LYDKONTROLLROM

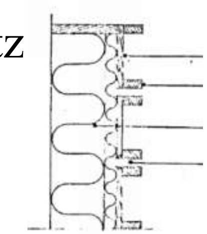
Griegakademiet

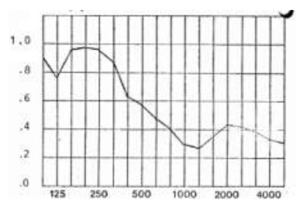
UiO
Musikkvitenskap
Erik Asheim
↓



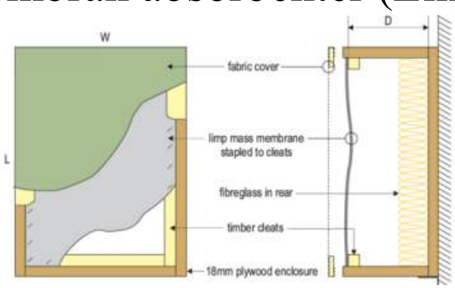


-Mineralull/Helmholtz



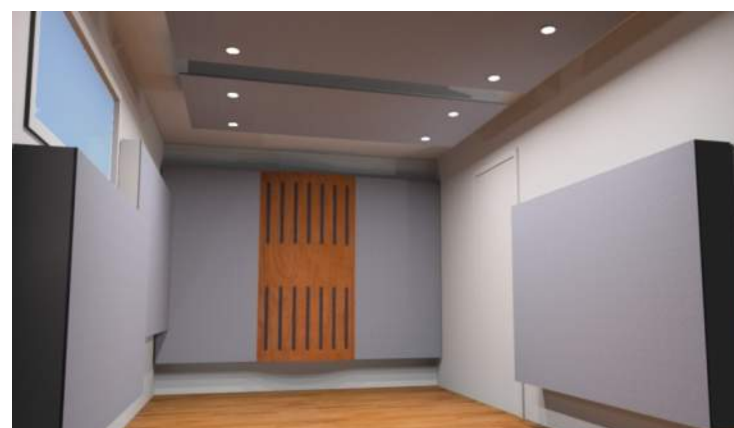


kontra
-Membran absorbenter (LimpMass)



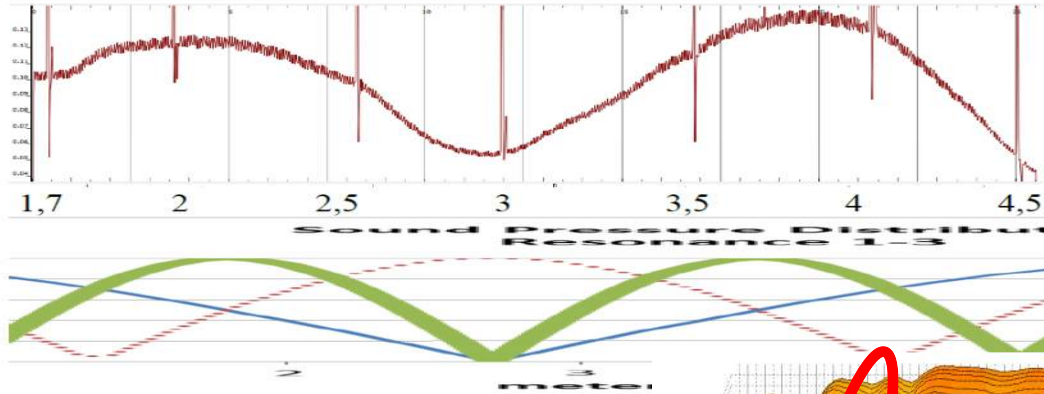
Res.Freq:Equation
Abs.koeff.? m2 Sab?

Lawo plateselskap, Oslo

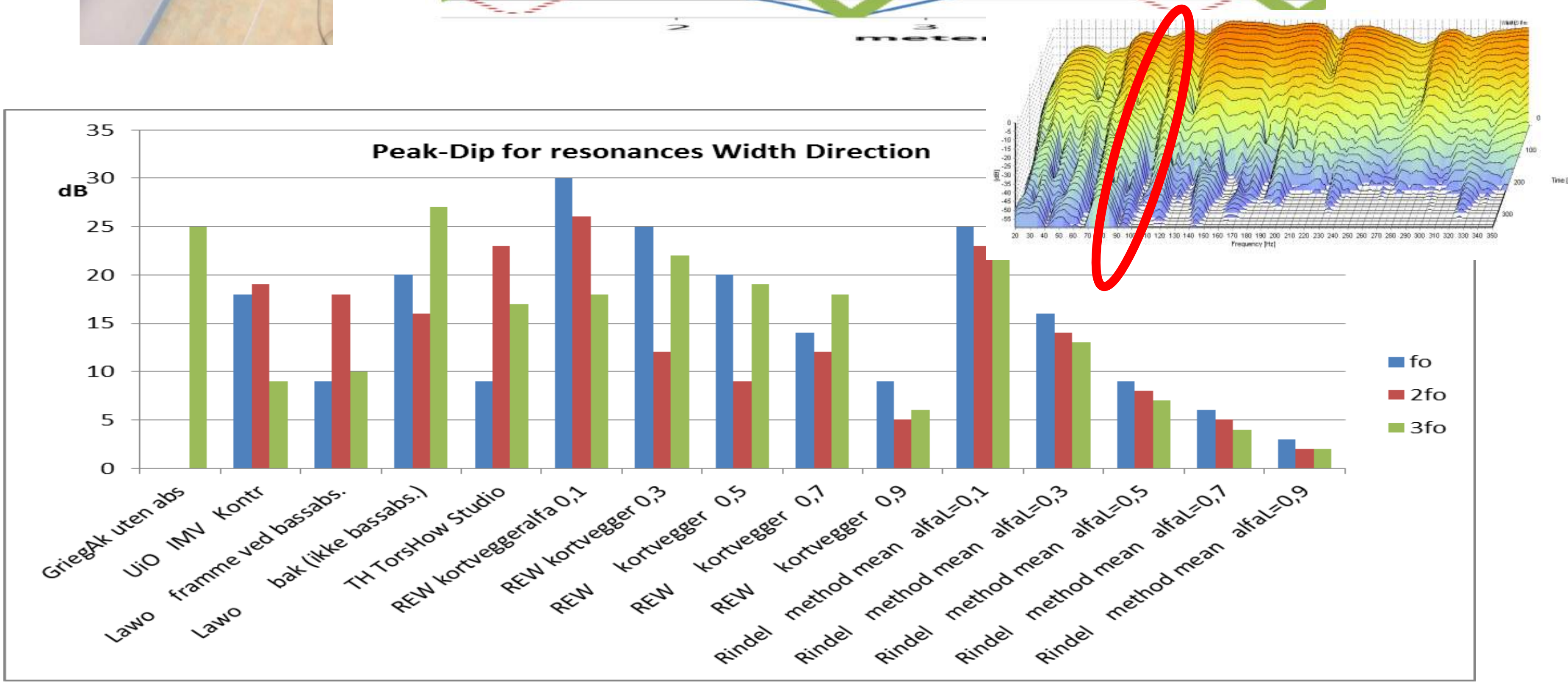


Overharmoniske av romresonanser!!

100Hz Length



meter→

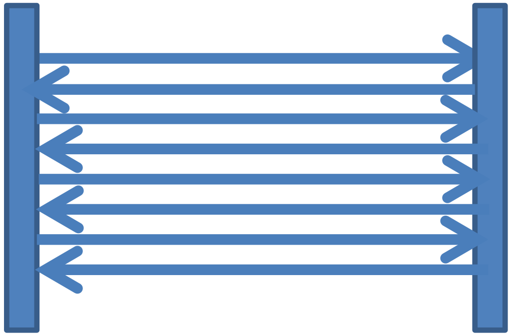


Grunnresonans viktig for Rock, 2-3 «overtone-resonans» viktig for Klassisk?

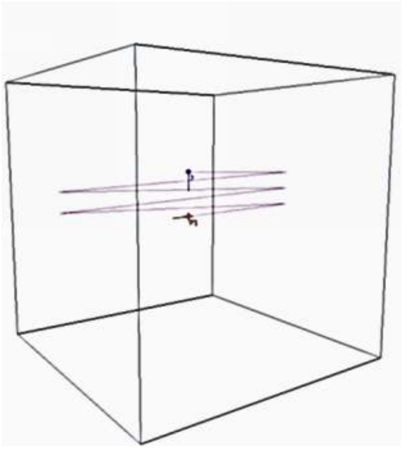
Membran ***Min.ull/Helmholtz***

7) FLUTTER-ECHO

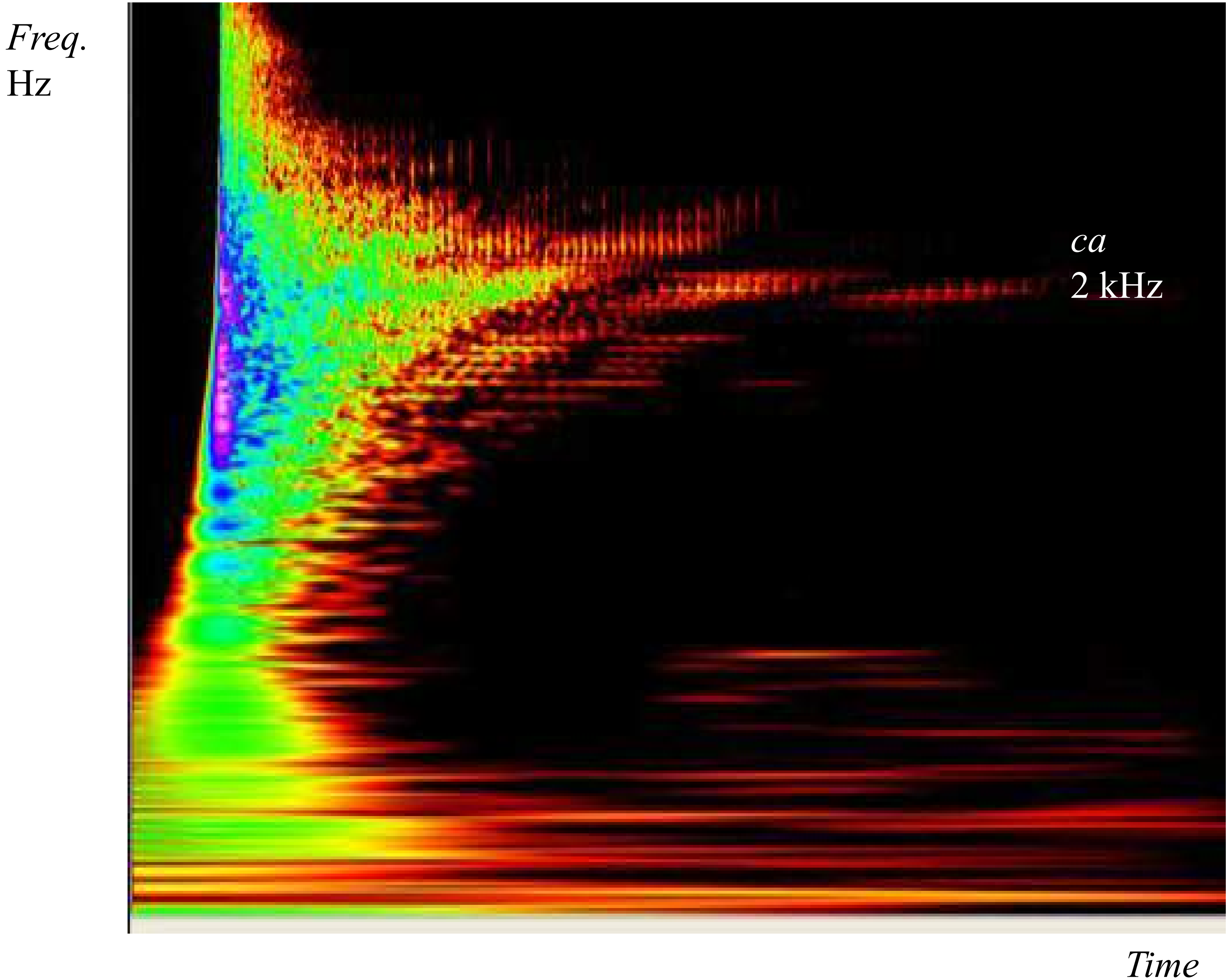
Inst. of Acoustics: Room Acoustics, Paris, oct-nov2015



Repetition Frequency→ Tone?

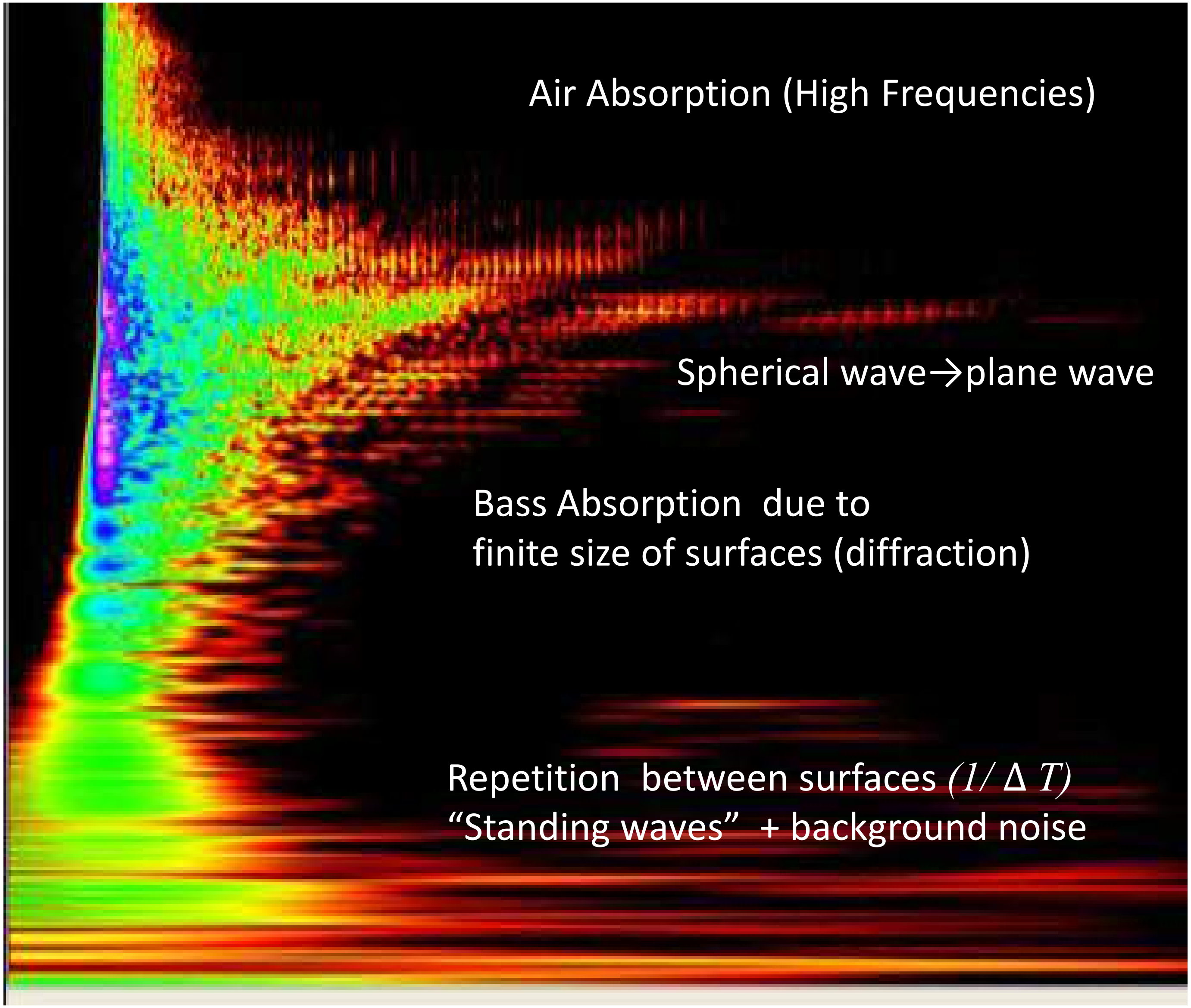


Wavelet-analyse



To spoil the CONCLUSION:

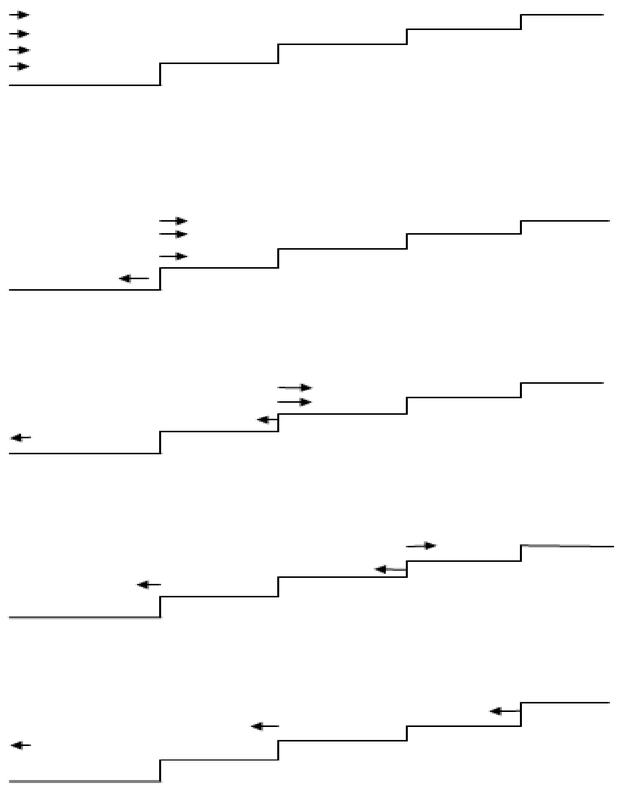
Freq.
2 kHz

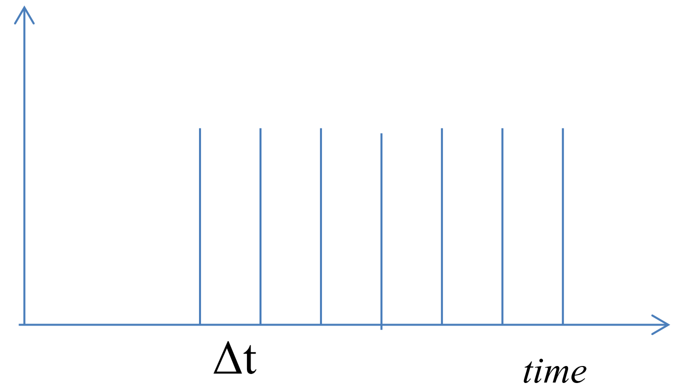


Time

REPETITION PITCH

Stairs: *(Huygen/Bilsen)*



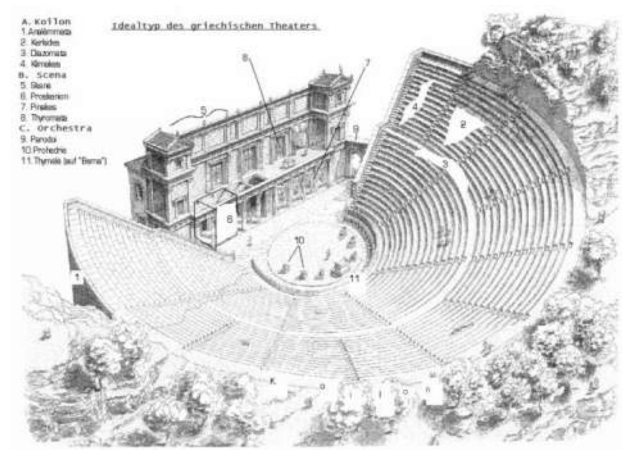


Oslo Konserthus:
Sagtann-vegg og
Reflekterende parti over stolryggen
Tonehøyde (uten personer)

REPETITION TONALITY

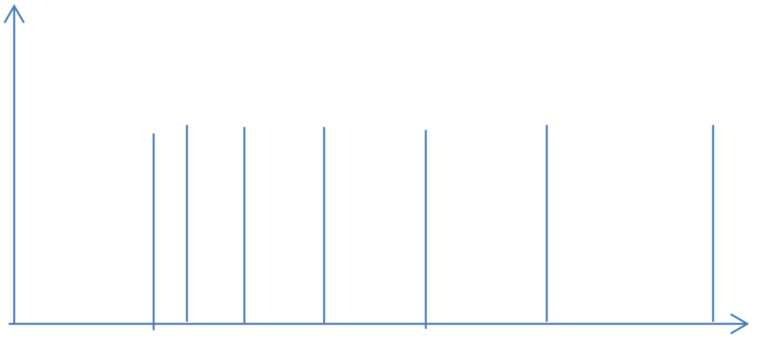
***fo*=1/Δt** [Hz] *2fo*, *3fo* NB! Her er **Δt** meget liten!!!

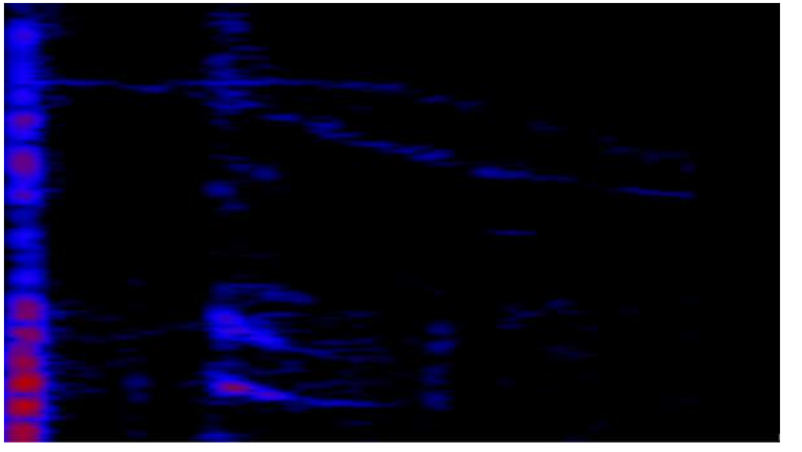
(also in Greek «amphitheatres»…
……..unoccupied)



STEEP/HIGH STAIRS

Chichen Itza Pyramiden i Mexico.





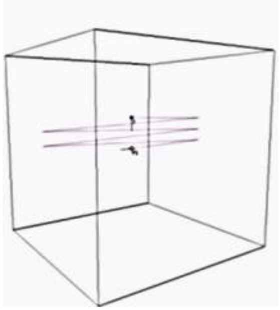
Height increases for each step,
Effective step depth increases
GLISSANDO downwards! *Clap1x*

2 **Quetzal bird** chirps (recorded in a rain forest)
+ 2 chirped echoes stimulated by a handclaps at the pyramid

TYPICAL ROOMS in dwellings:

Δt longer than for pitched fences etc: : f_o<ca 100 Hz

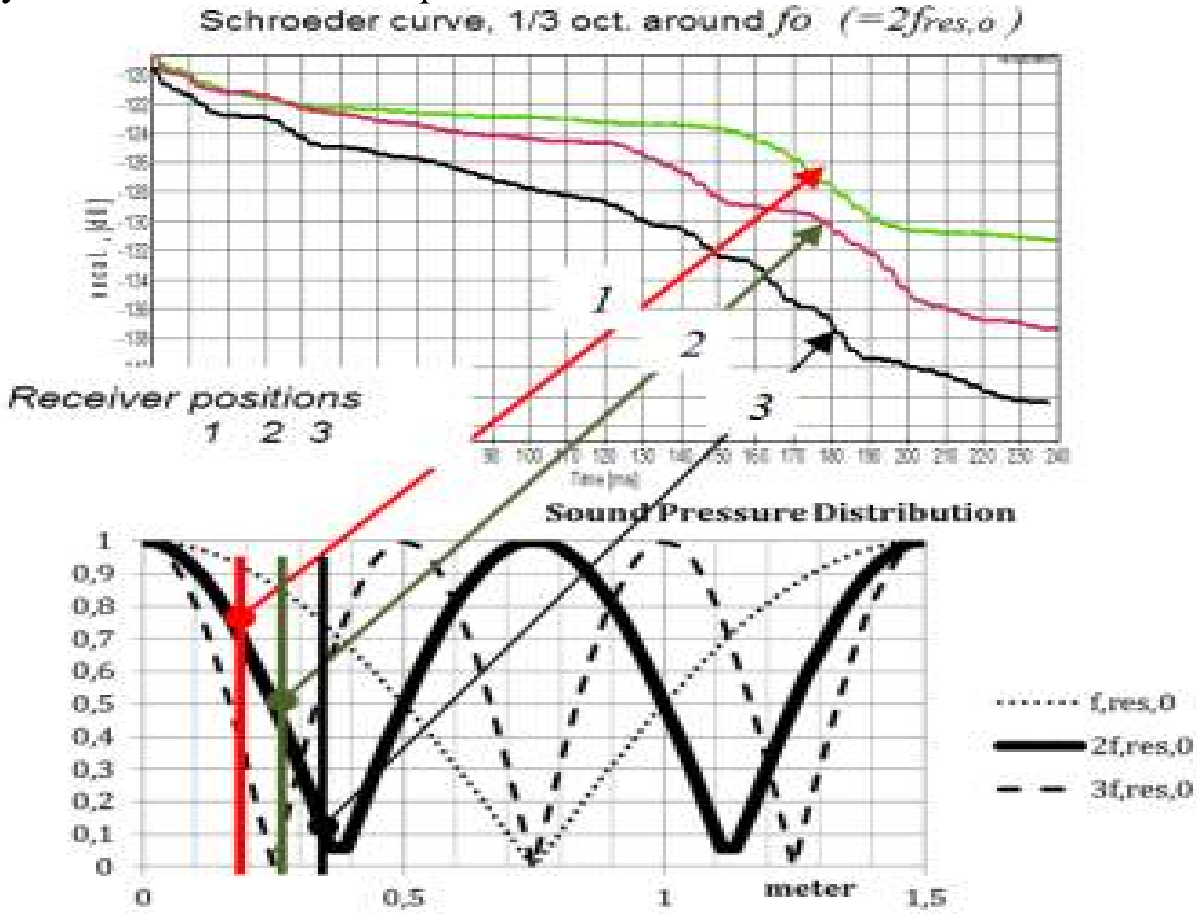
so: It is NOT f_o (by itself) that gives the characteristic flutter timbre



It its also NOT the ROOM RESONANCES/STANDING WAVES

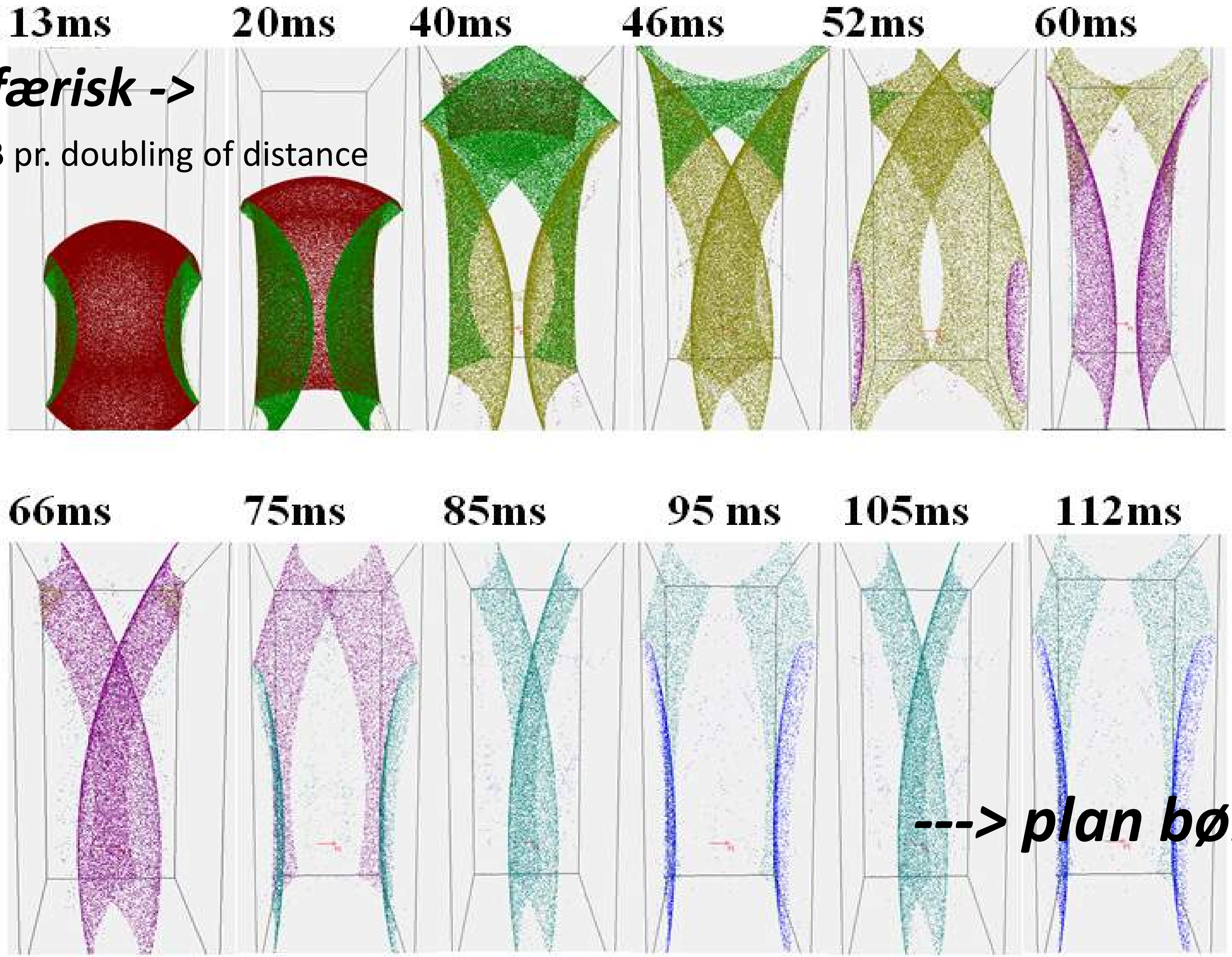
f_o and Room Resonances ($f_{res,o}=1/2 f_o$)

influence only for sender+receiver at pressure max.



Sfærisk ->

6dB pr. doubling of distance



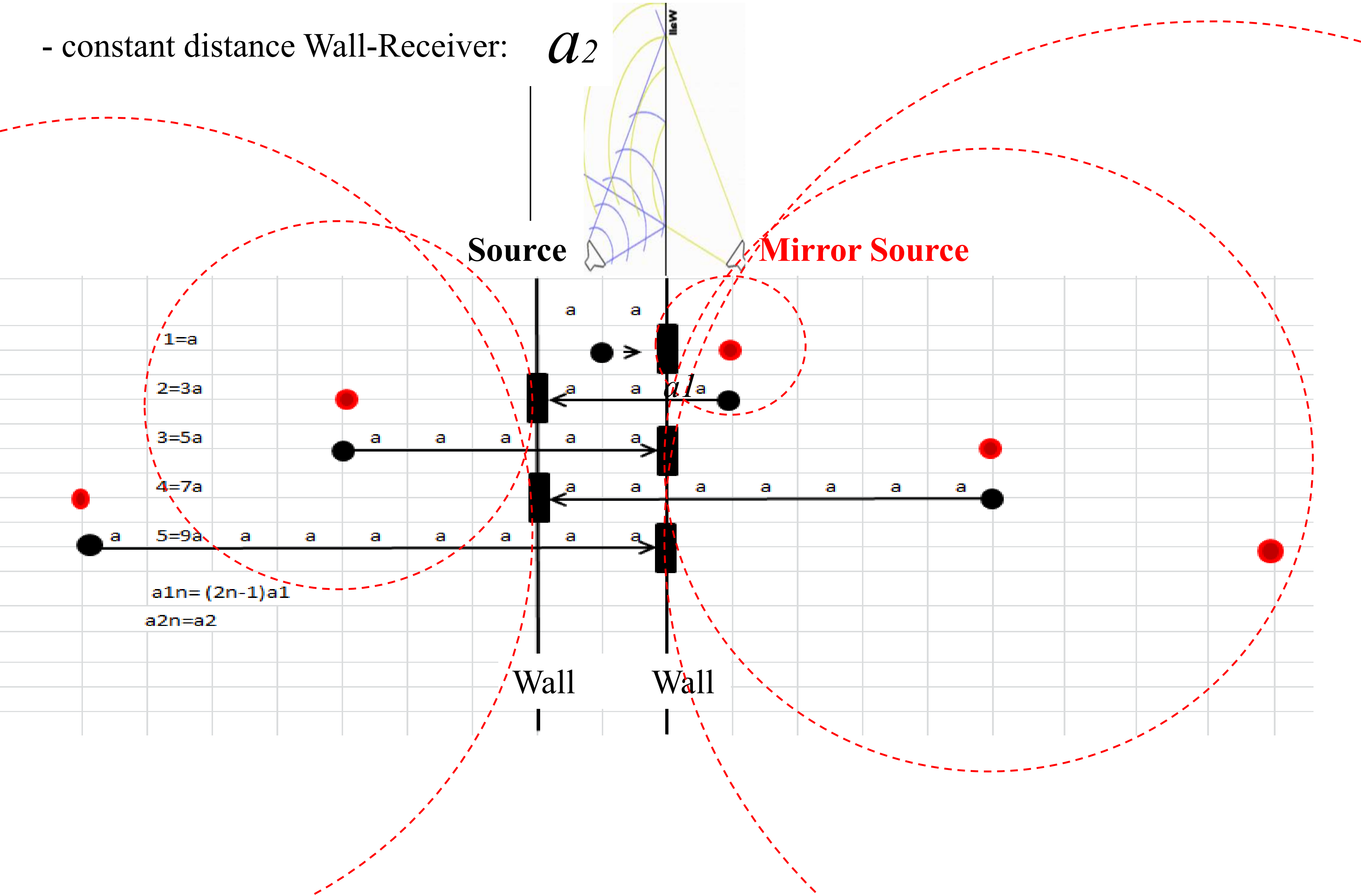
---> plan bølge

Only the absorption
in of the air and at surfaces

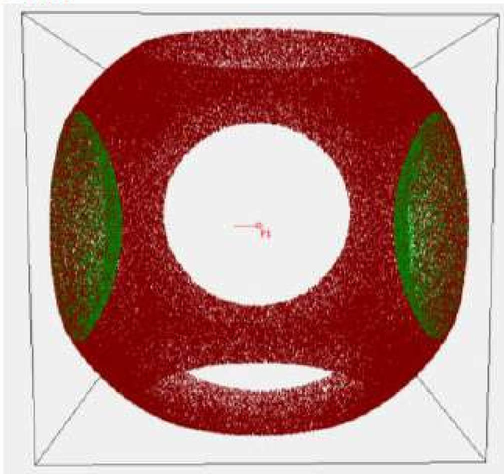
Higher order Mirror Source

- increasing distance Source-Wall: $a_{1,n}=(2n-1)\ a_{1,0}$

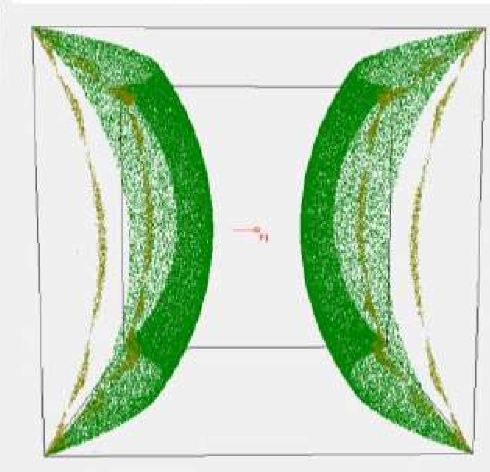
- constant distance Wall-Receiver: a_2



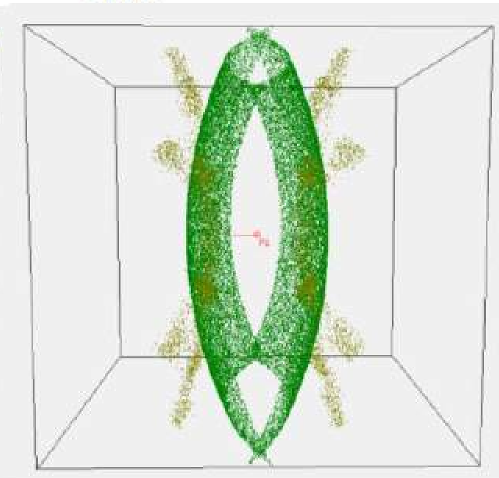
3ms



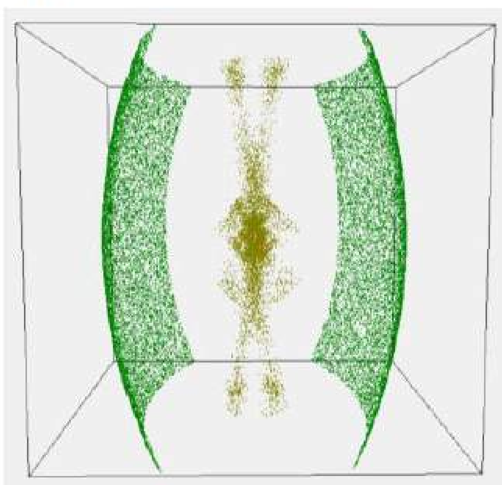
4ms:



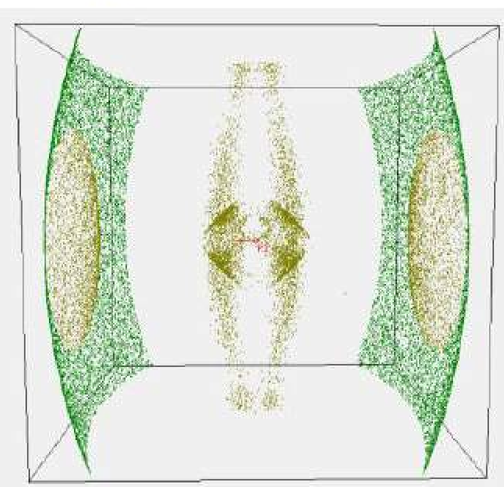
5ms:



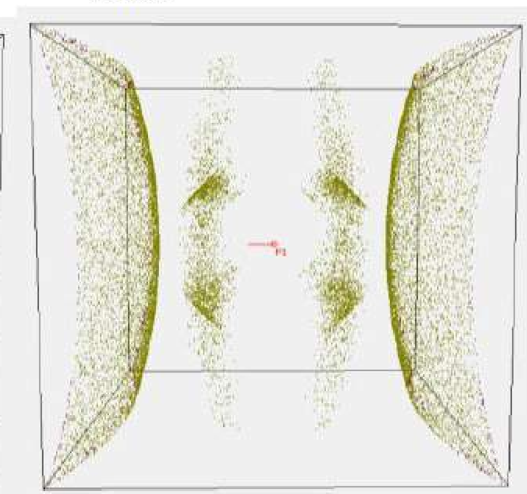
6ms:



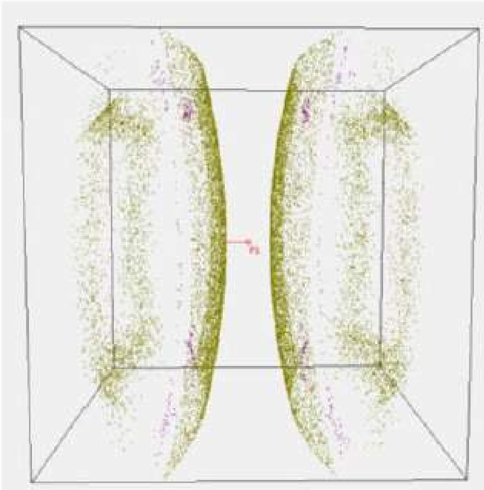
7ms:



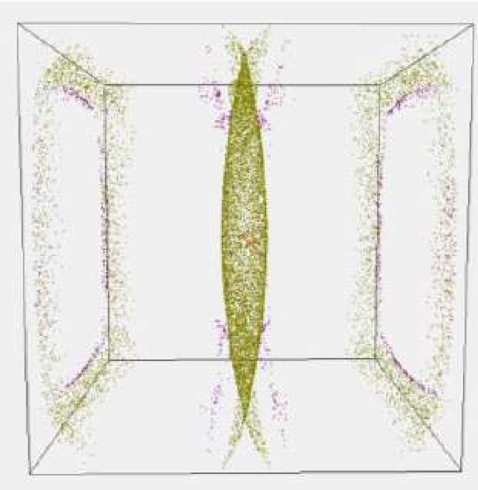
7ms:



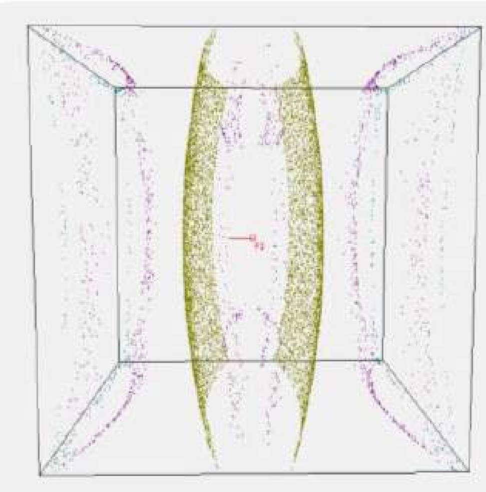
8ms:



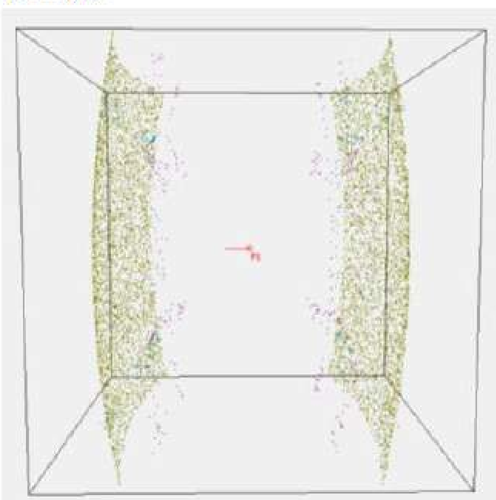
9ms:



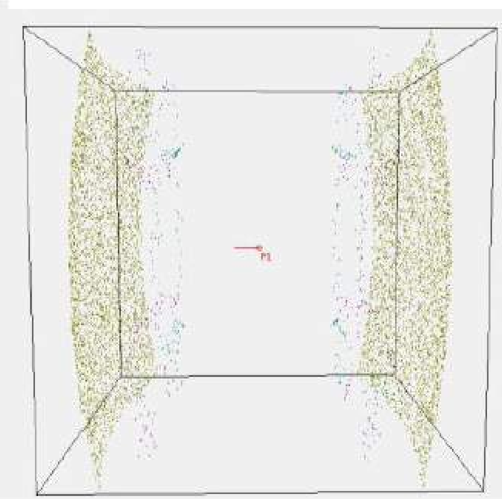
10ms:



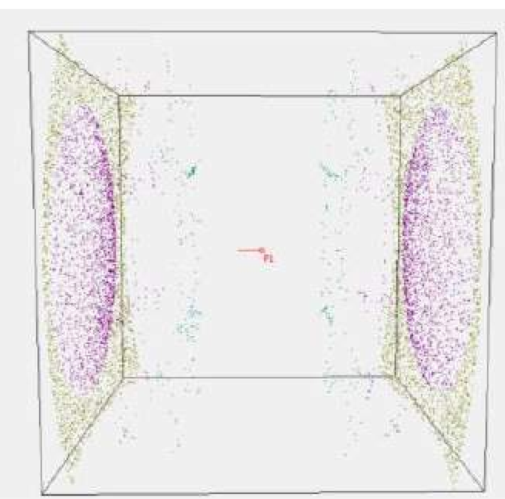
10ms:



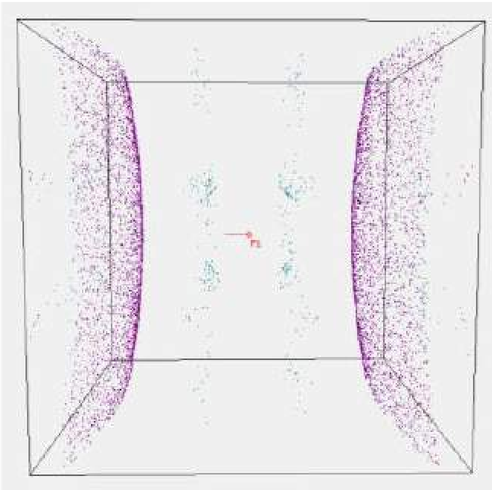
11ms:



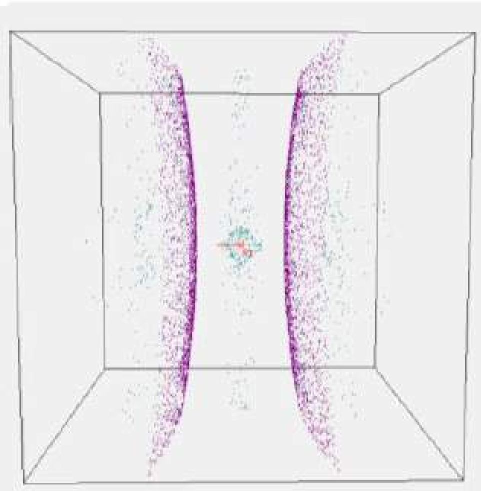
11ms:



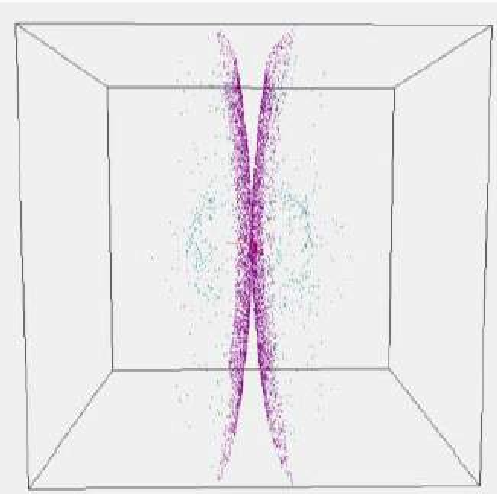
12ms:



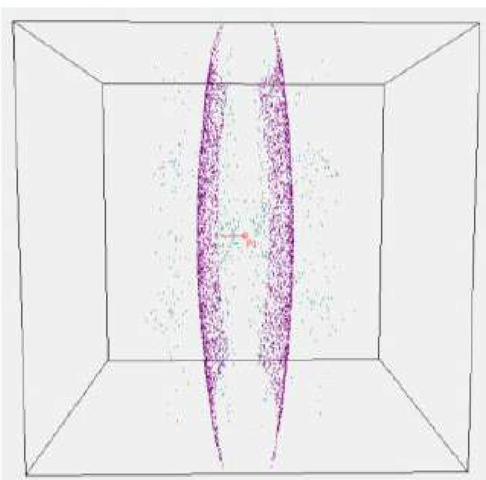
12ms:



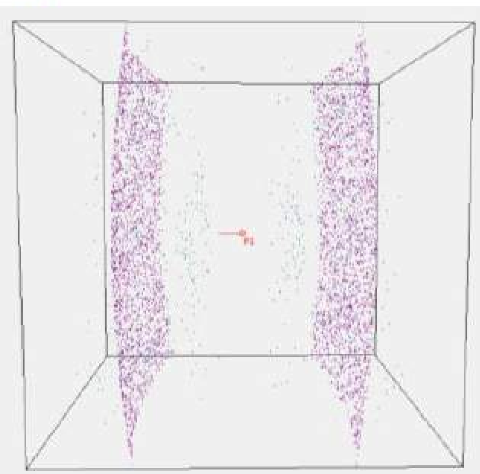
13ms:



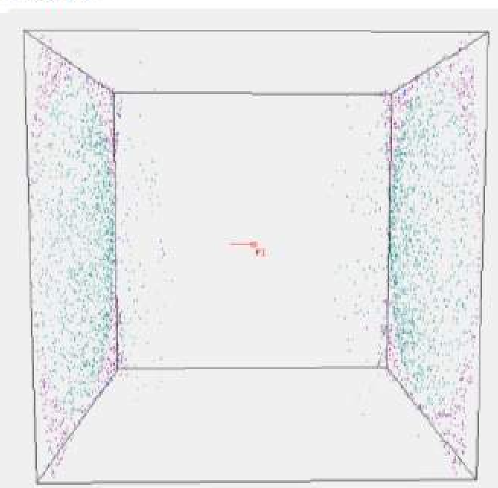
14ms:



15ms:



15ms:



APPROACH 1: Kuhl´s equation(s)

“Sum” of three reverberation “asymptotes” for the reverberation time versus frequency:

1. Low Frequency damping due to finite surface areas: ***As mirror source goes further and further away, the surface “seems” smaller and smaller compared to wavelength***

$$T_1 = \frac{0.041 \times 2fS}{c}$$

2. (Possibly) Damping ,absorption on the surfaces:

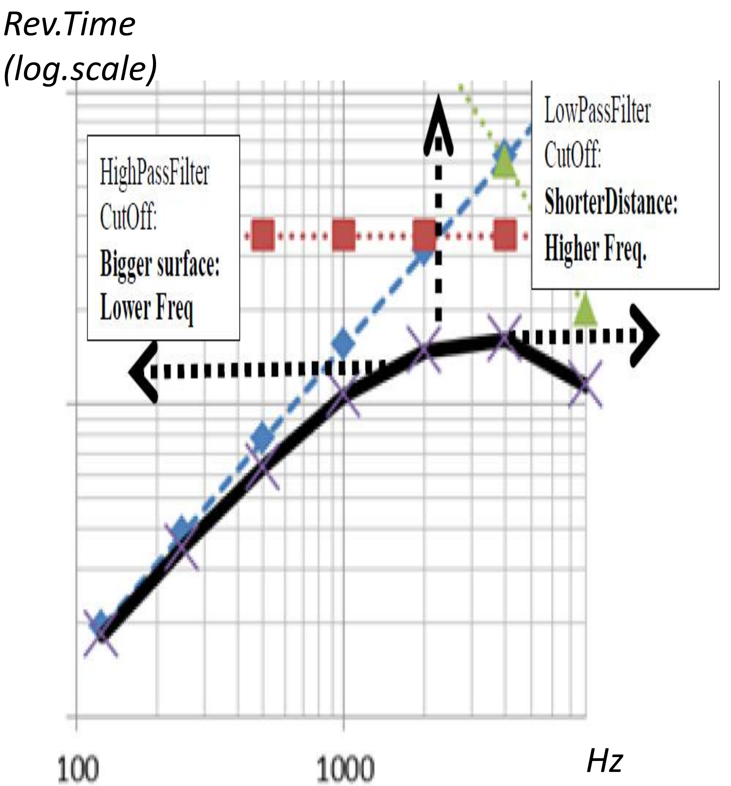
$$T_2 = \frac{0.0041 \times l}{\alpha}$$

3. High Freq. Damping in the air (dissipation):

$$T_3 = \frac{0.0041}{m}$$

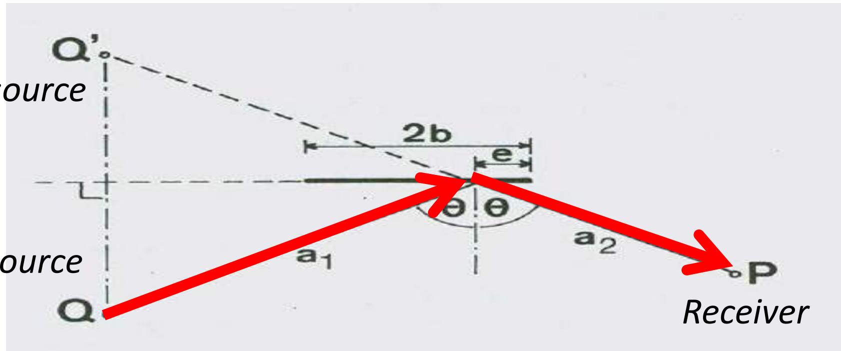
The total reverberation time can be re-written as:

$$\frac{1}{T_{FL}} = \frac{1}{T_1} + \frac{1}{T_2} + \frac{1}{T_3}$$



APPROACH 2: Fresnel/Kirchoff approx.Rindel

(Rindel, BNAM): Spherical Wave (to start with)

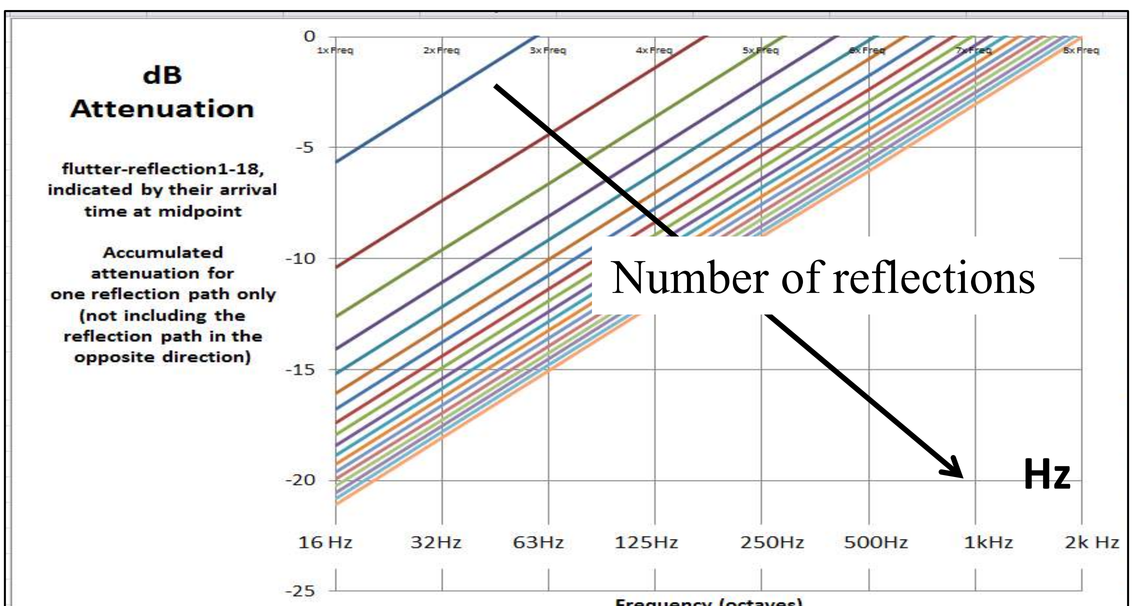


Bass is reduced (High Pass Filter), for

$$f < f_{lim} = \frac{1}{2} \times \frac{\frac{a_1 a_2}{a_1 + a_2}}{(2b\cos\theta)^2}$$

For $f < f_{lim}$

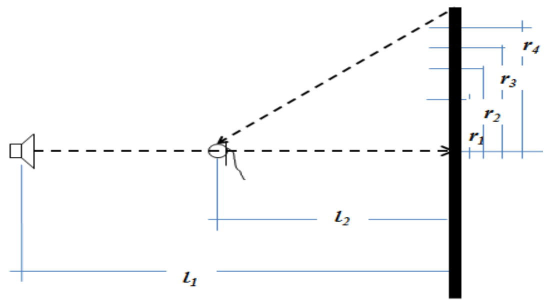
Dampening /re. infinite surface:

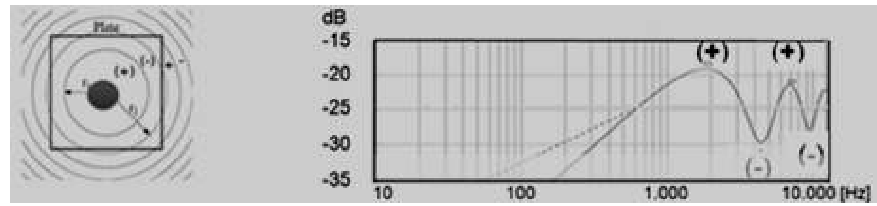


$$\Delta L = 10\log\left(\frac{2b\cos\theta}{\sqrt{\lambda\frac{a_1 a_2}{a_1 + a_2}}}\right)^2$$

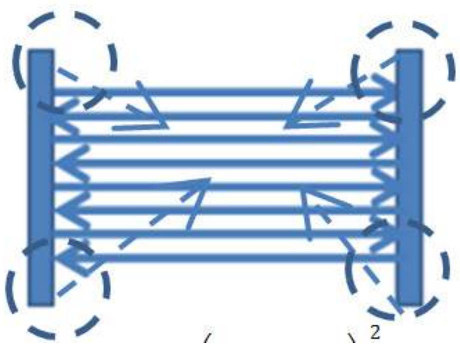
Gives bass reduction,
but not as much as measured?

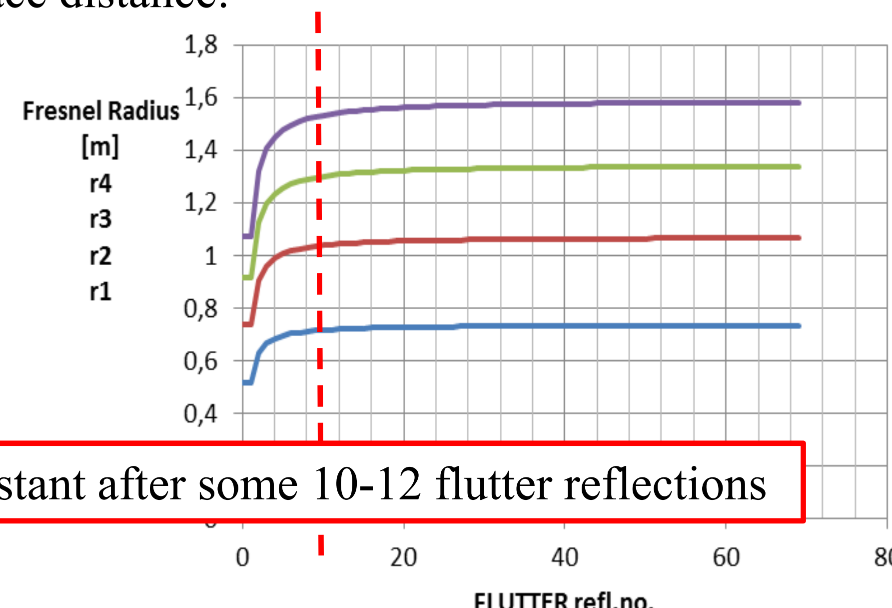
APPROACH 3: Fresnel Zones





For repetitive «flutter»-reflections between surfaces
and increasing (mirror)Source-Surface distance:





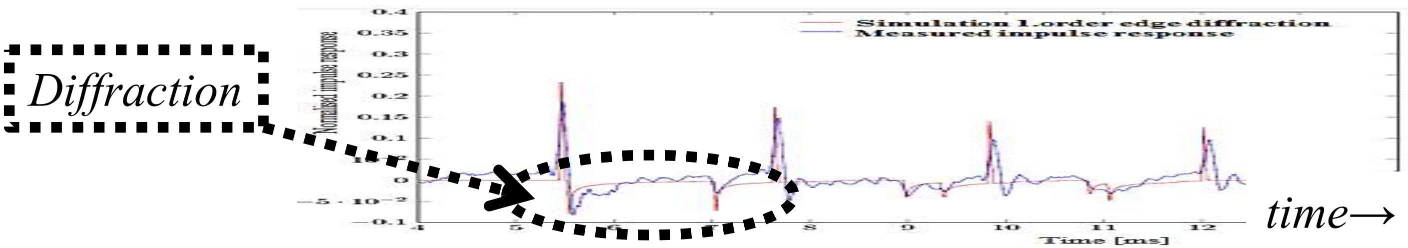
Fresnel radii constant after some 10-12 flutter reflections

(=> spherical wave)

APPROACH 4 MatLab

EDB (Edge Diffraction ToolBox/Peter Svnesson, NTNU

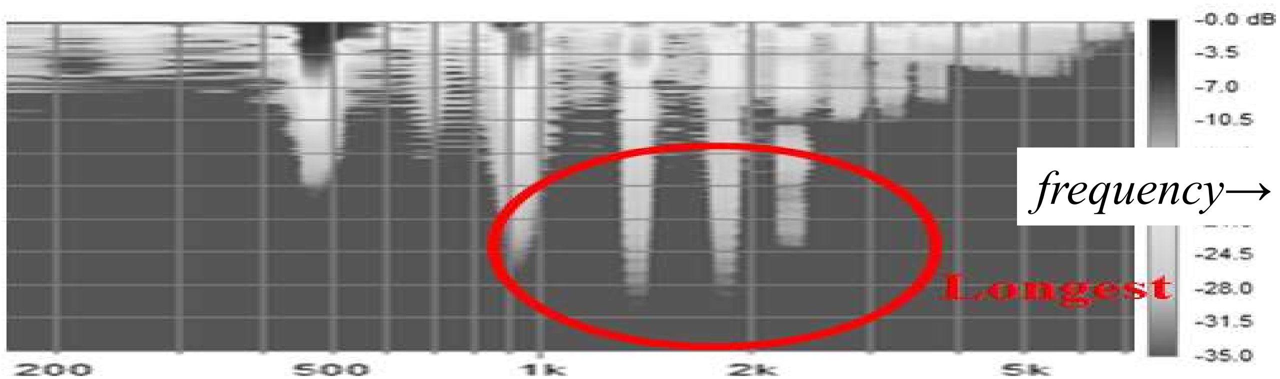
Master Thesis:
Harald Skjong
NTNU/Norconsult



MatLab

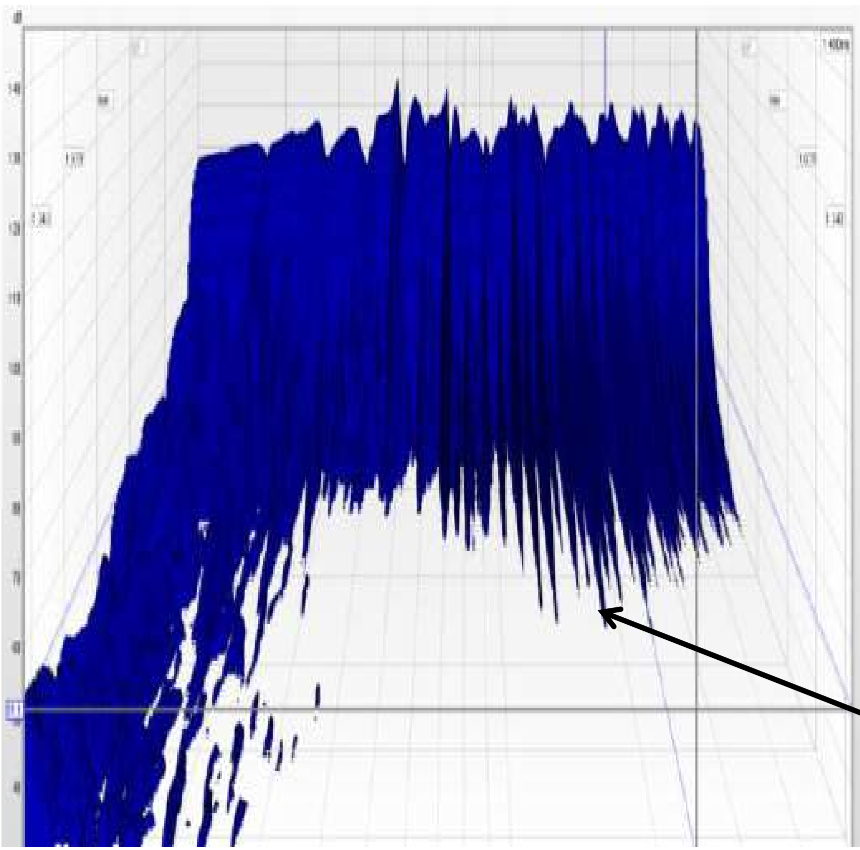
Correct frequencies, but does not include more than 13 flutter reflections so the longest «tail» is not shown as in the measurement

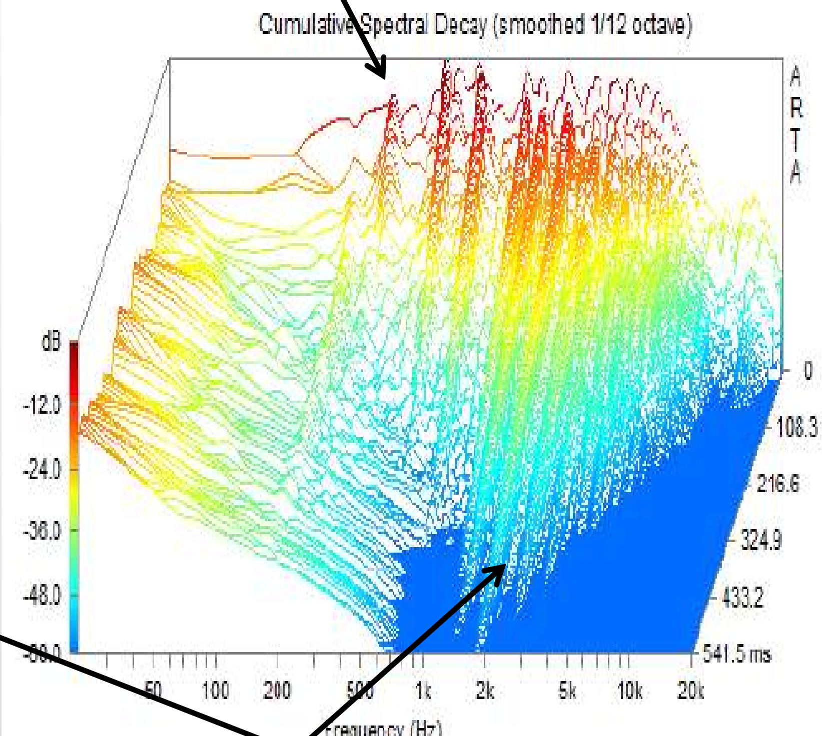
Measurement



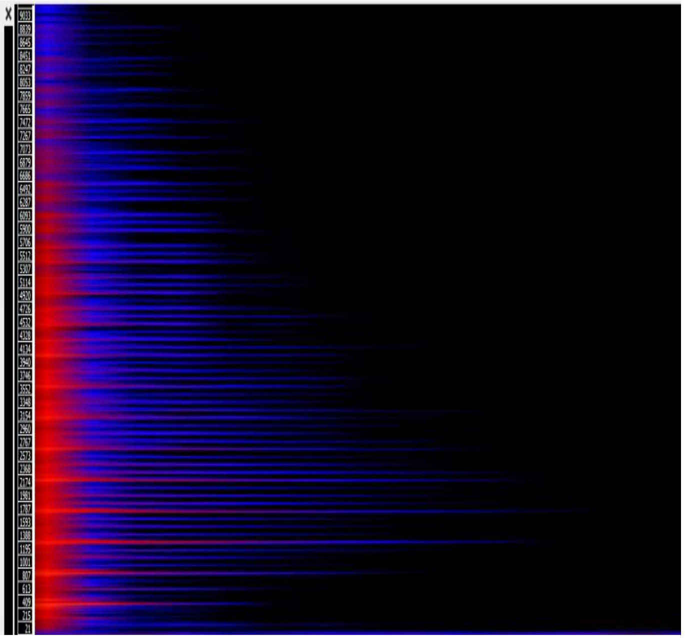
CONCLUSION FLUTTER

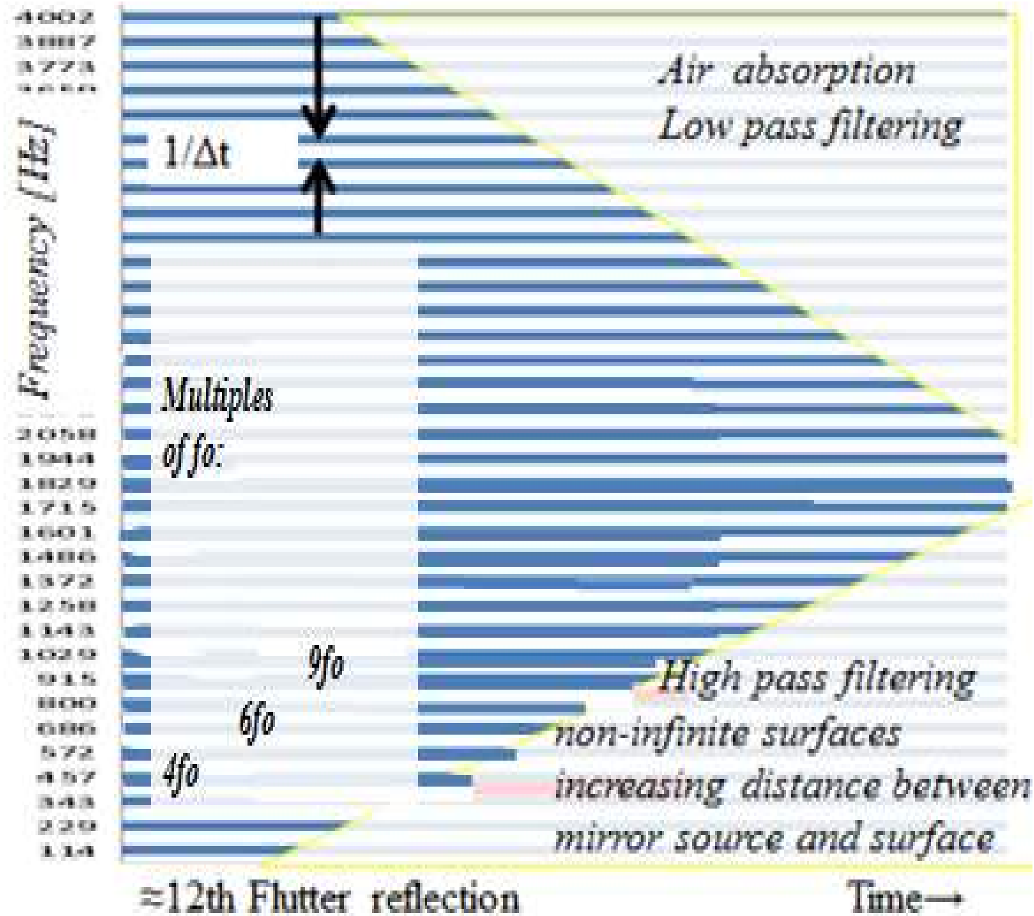
Repetition Pitch between the surfaces f=1/Δ T





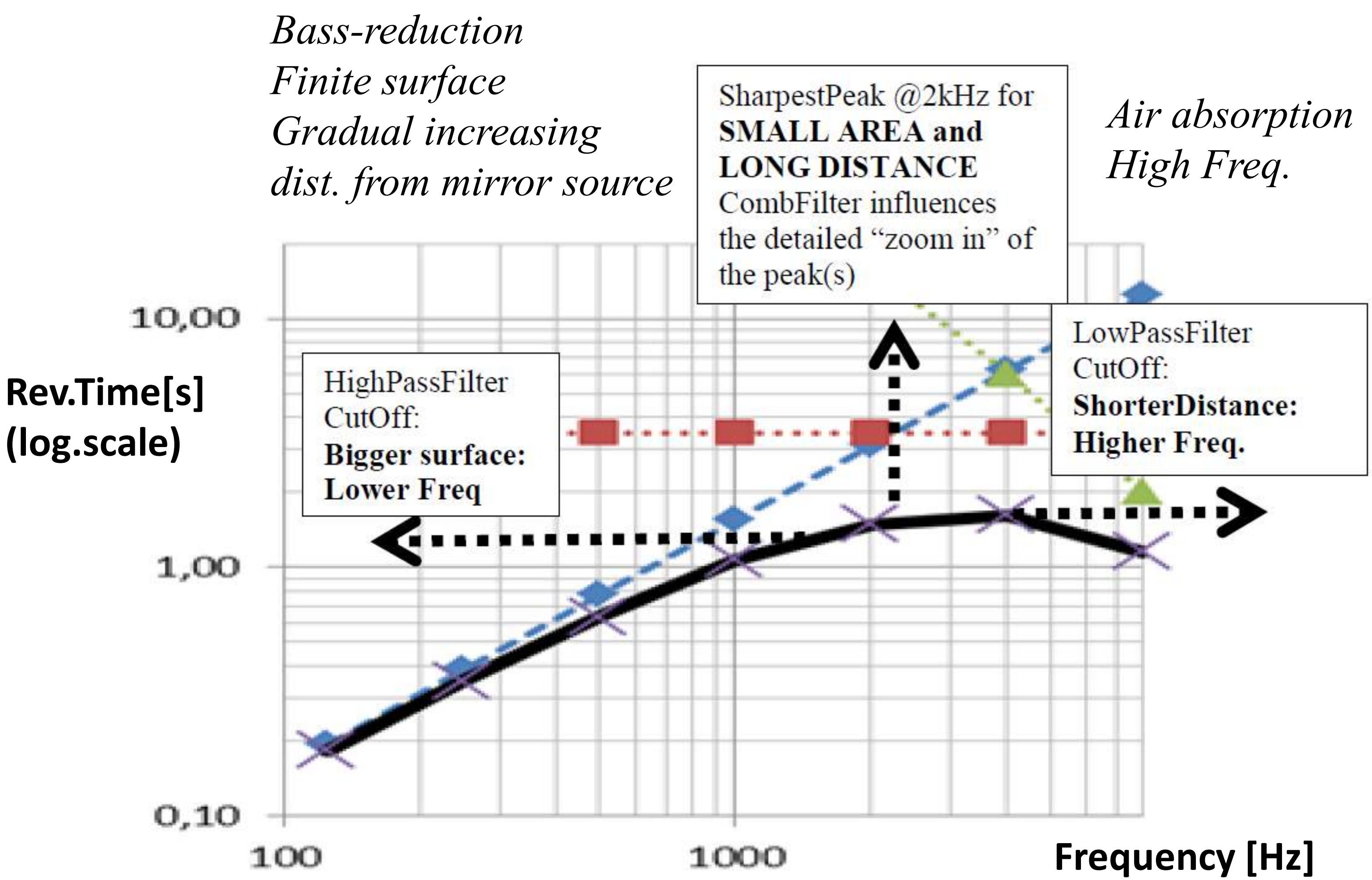
«Tail» due to diffraction, non-infinite surfaces Spherical-Plane waves



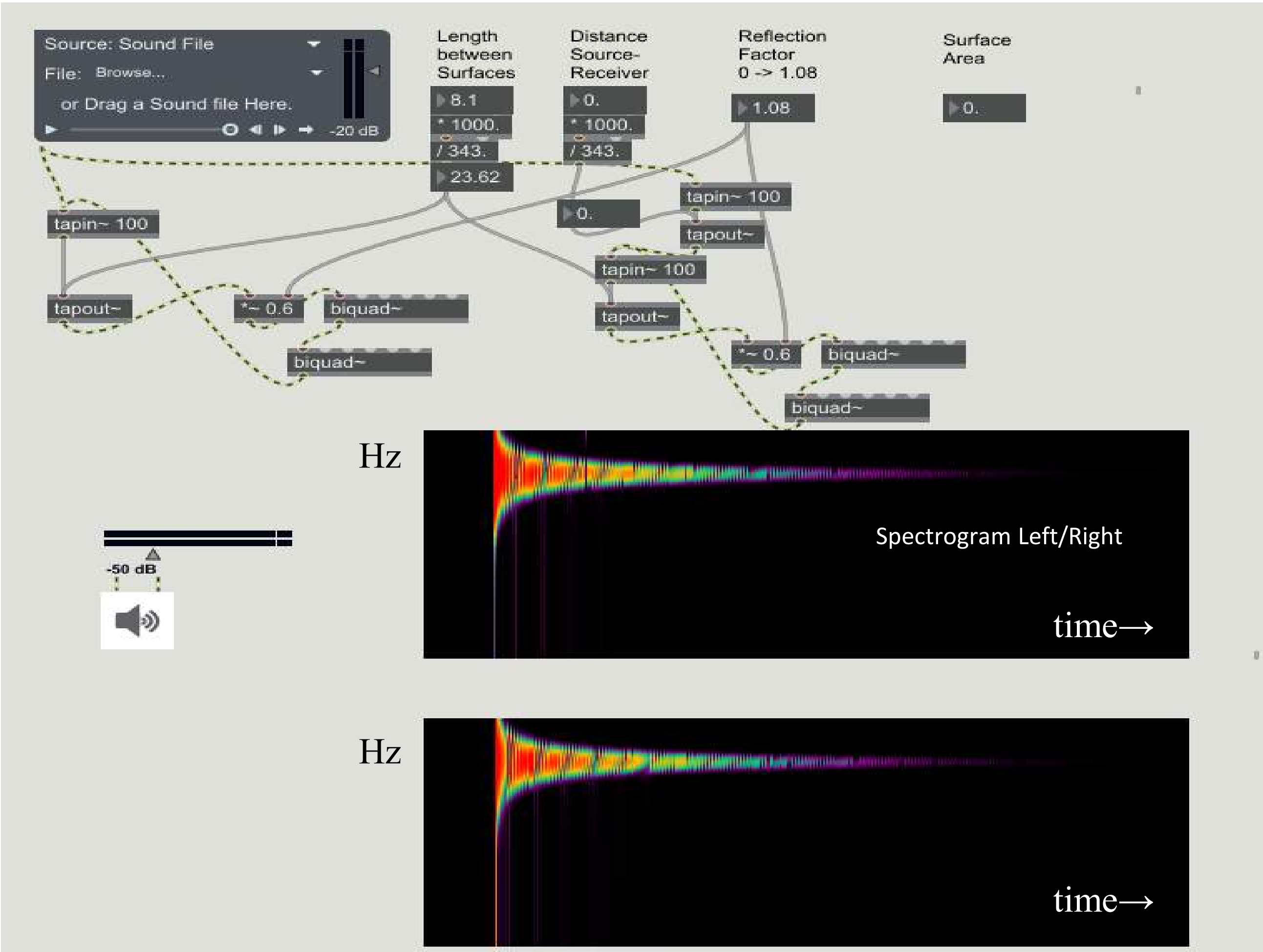


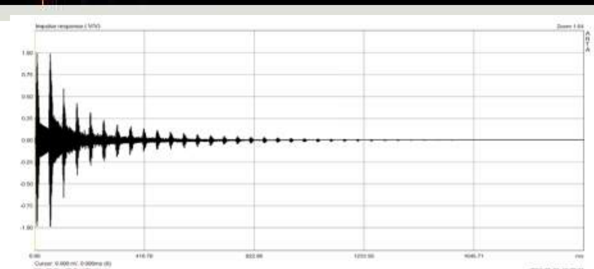
4002
3887
3773
Frequency [Hz]
2058
1944
1829
1715
1601
1486
1372
1258
1143
1029
915
800
686
572
457
343
229
114
Air absorption
Low pass filtering
1/Δt
Multiples of fo:
9fo
6fo
4fo
High pass filtering
non-infinite surfaces
increasing distance between
mirror source and surface
≈12th Flutter reflection
Time→

Always 1-2 kHz??



Max/Msp SIMULATION of Flutter





OdeonClapSkarp

Dr+Bass

Flute

RomeoFoster

Sabine

SabineHP

SabineHP8va

U-SCHZ

KANTINER/RESTAURANTER

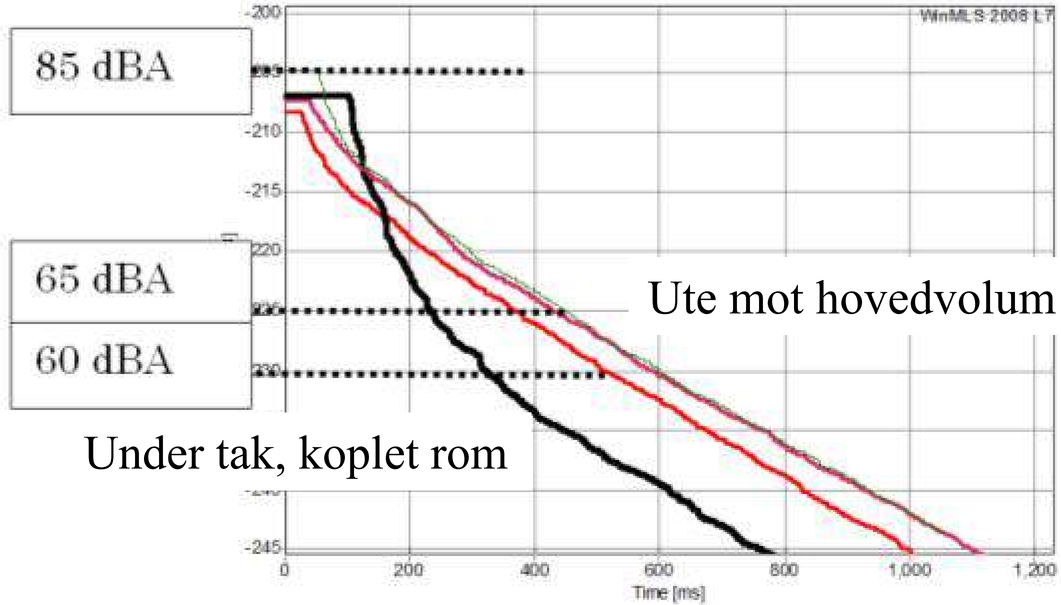
-Ikke fullgod absorberende himling, og
-Lyd mellom bordene speiles i glasset
-Liten avstand fra støyende kjøledisker
og folk som skravler i kassa

For kort avstand til naboer vi ikke vil høre:

Naturlige samtalegrupper:
<5(6) personer, selv utendørs!!!
Langre avstand, og
Telle antall reflekterende flater fra folk vi ikke vil høre?

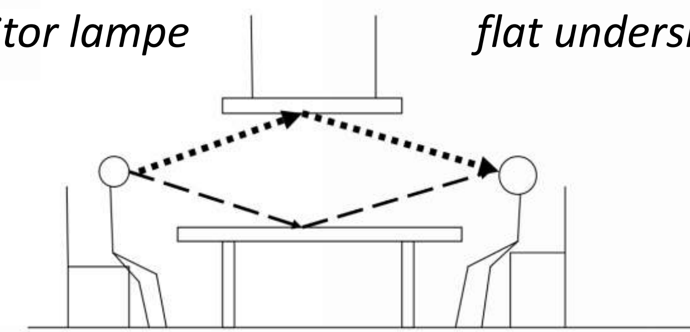
Sosiale aspekter:
Ikke flaut å sitte alene uten
å prate hvis det er mye støy.
Discoteque:
Støy maskerer sosial angst

T<0,2 x H ?????



Her kunne vi tenkt motsatt tankegang:
Ikke (bare) dempe og skjerme, men:
Bedre refleksjonene mellom dem vi vil høre:

Stor lampe *flat underside*



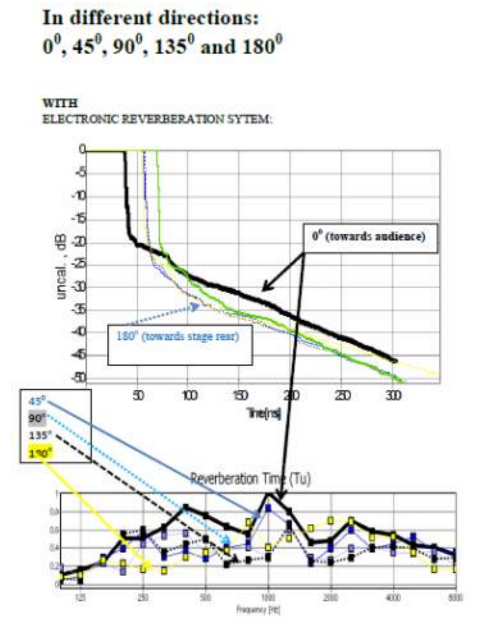
ELEKTRONISK ETTERKLANGSANLEGG

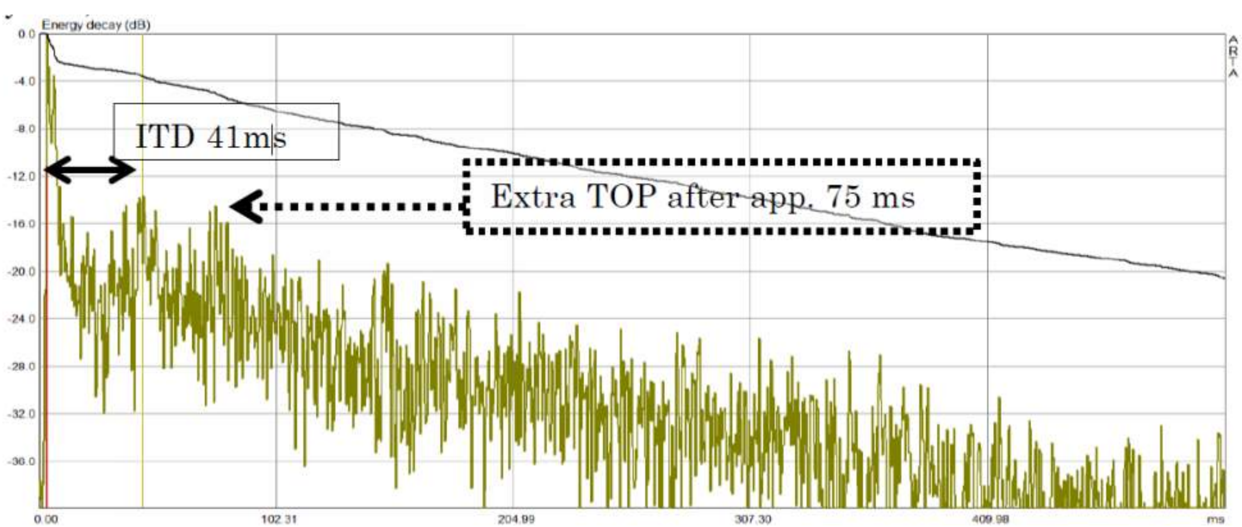
Yanaha (Lørenskog, Riksteatret, Nydalen)
Shure/Fraunhofer
Constellation (Tallin, Fosnavåg)

Må se på IMPULSRESPONSENE,
ikke bare ETTERKLANGSTID!!!

Viktigheten av tidlige refleksjoner tilbake til utøverne
(Problematisk hvis både mic´er og høyttalere skal være
utenfor romradius)
«Eget anlegg» for sceneområdet?!

Måling med klapp/klikk til eget øre,
i forskjellige retninger:

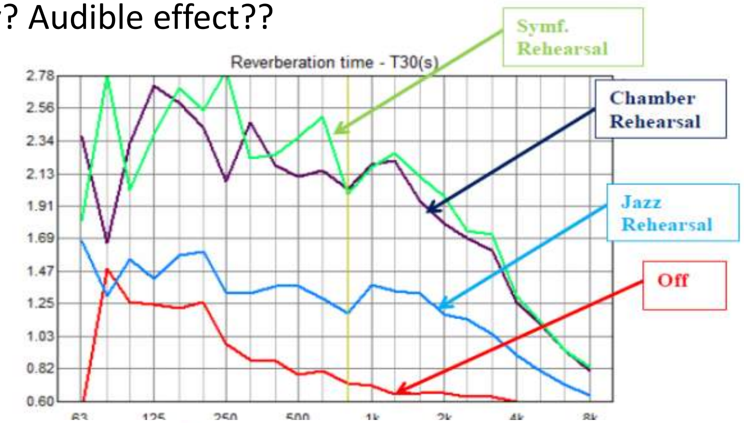




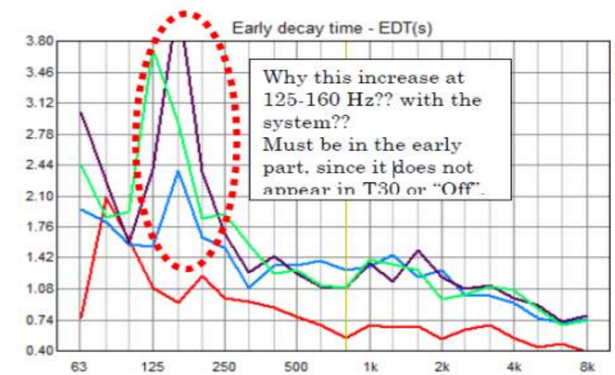
Meyer Sound (Constellation) Fosnavåg

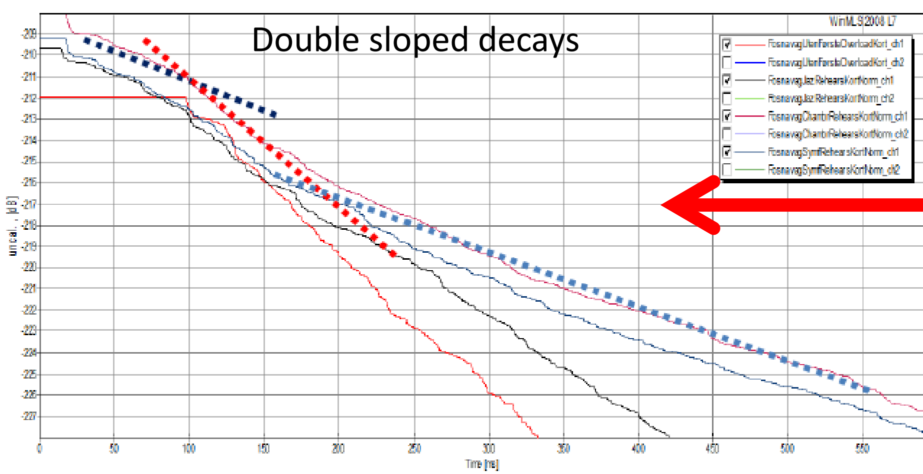
DeCorrelation: - varying phase and/or frequency? Audible effect??
Does that give “smoothing”?
Phase response??

T30



EDT





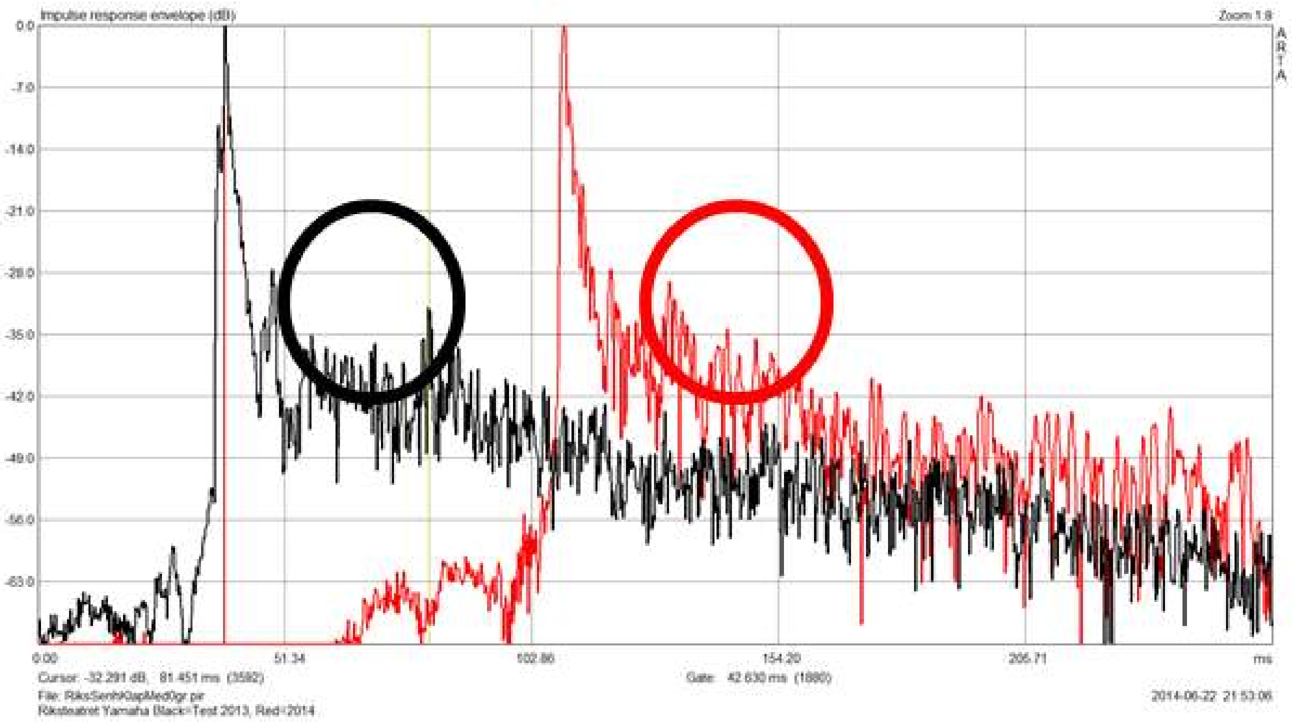
VIKTIGERE:
SE PÅ IMPULSRESPONSENE!!!!

Krumme kurver:
KOPLEDE «ROM»
(slik også Klangkamre/Artec gir)

Tilbake til musiker/taler på scenen:

Viktig med nære refleksjoner

(Problematisk dersom mic+høyttaler må være utenfor romradius)



Målingen viser at det "tomrommet" i utsvinget som ble observert med det lille testanlegget, er "fylt" med fine refleksjoner for den ferdige installasjon i 2014. Målingene viser dog ikke om dette er pga anlegget eller pga de fine akustiske egenskapene ved dekorasjonen i 2014.

Den skumle unnskyldning for å ikke montere reflektor over/foran taler i auditorier

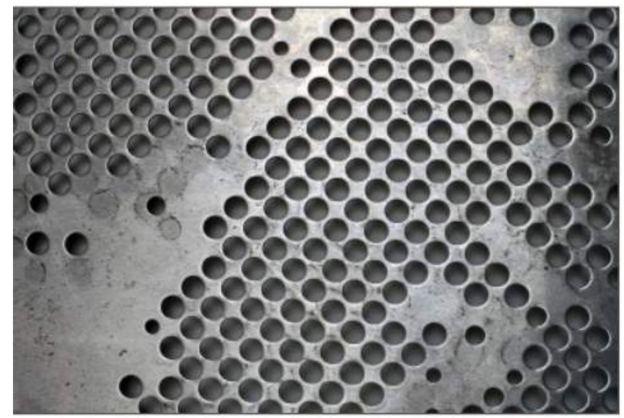
Statens bygningstekniske etat
(tidl. Direktoratet for byggkvalitet)

§ 13-10
"I byggverk for publikum og i rom i arbeidsbygning skal det være **lyd- og taleoverføringsutstyr** med mindre det kan dokumenteres at dette er unødvendig for å oppnå god taleforståelse. "

«SYNGING» I PERFORERTE FASADEPLATER?

Erfaring fra P-hus ved Kilden i Kr.sand: Vinden «synger» i perforerte plater.

For Høgskolen i Bergen:
Brekke & Strand: Utredning. Gikk OK!



Perforerte plater som er en del av kunstprosjektet. Disse skal pryde fasadene. Kunstneren er Anne-Gry Løland. Foto: Mauricio Paves/Høgskolen i Bergen

MUSIKKBASIS

Nytt Introduksjonskurs for ALLE studenter:

dB, Hz, Spektrogram, FFT-vindusstørrelser, Etterklangstid, Romresonanser, Overtoner, Renstemt/temperert, Formanter

LYDLÆRE 1&2

LYDANALYSE

Musikk og bevegelse

Lokaliserer lydkilde vha f.eks. 4 mikrofoner

Interaktiv musikk

Studio-design (Master/NTNU/Musikkteknologi, Marius D. Letnes)

Arkeologisk Akustikk

veiledet Master P.Snekkestad: «Betraktninger omkring akustisk intensjonalitet i romanske steinkirker i Norge»

Veiledning/samarbeid, andre institutter UiO:

Informatikk

Logopedi/Lingvistikk (-> pedagoger Teaterhøgskolen)

Psykologi

Samarbeid Arkitekthøgskolen (Lydinstallasjoner)

ACOUSTICS IN BETWEEN

Akustikere MÅ:

Måle IMPULSRESPONS, ikke bare T30 etc!!

Inspisere hva som skjer når!!

LYTT på Impulsresponsen!!!

Se på FFT av første del av Impulsresponsen for å finne evt. farging etc.

Heller måle mange rom med enklere utstyr (wav-opptak ballong etc.) enn noen få rom etter standarden

De fleste rom er IKKE diffuse!

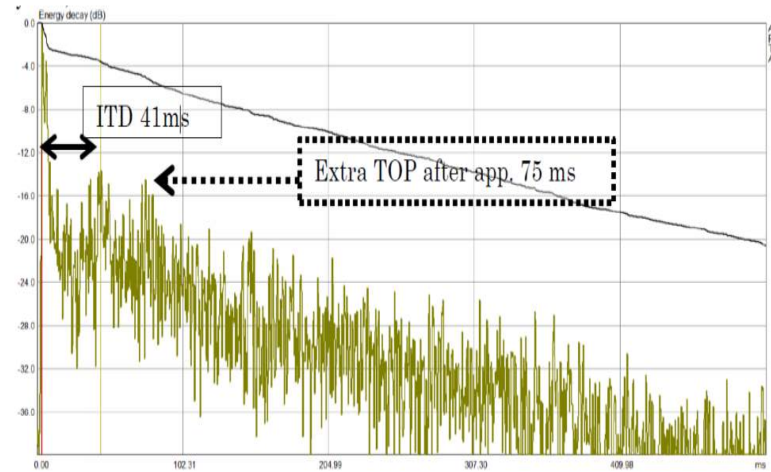
Noen flutter-ekko er OK (Univ. Aula, verneverdig)

Noen flutter-ekko er forferdelige

Noen ekko er farlig for NOEN typer musikk

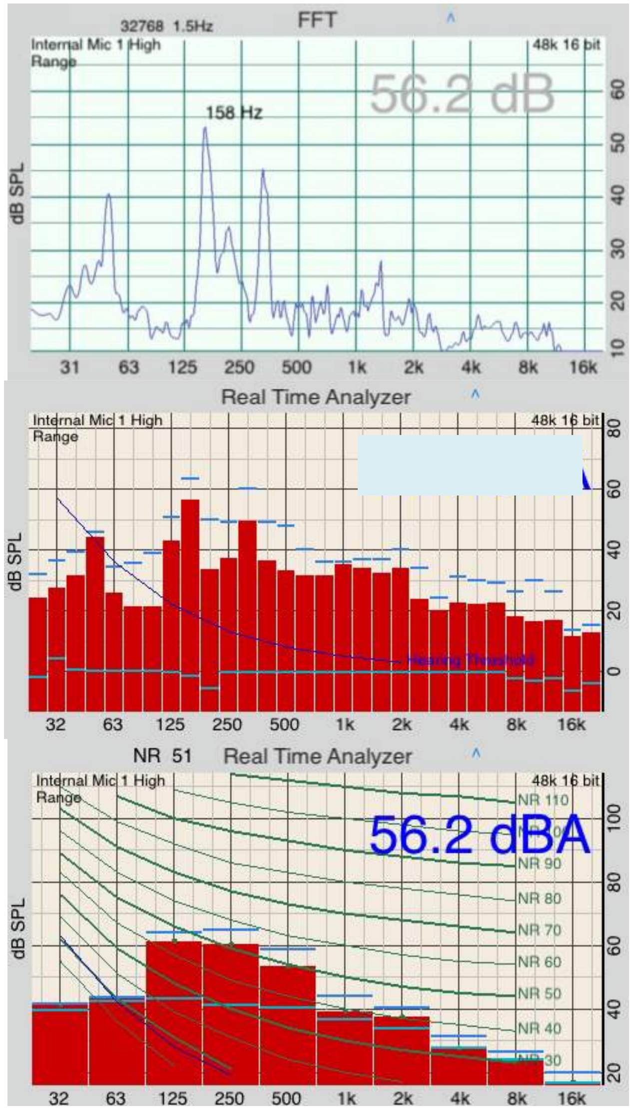
(og verre for høyttalere, med færre kildeposisjoner)

Akustikere må inspisere
Ren RT dempning hjelper ikke
nødvendigvis mot resonanser og flutter



FFT

iPhone



Tankerekke:
Ideell etterklangskurve=diffus=
kjedelig Reverb-box, syntetisk

Gode rom har ikke lineært decay (ITDG etc)
(PS! Sjekk mot Flutter planbølge etc!!)

Lydstudio/CD: Klarhet vha. korte refleksjoner.
Lang klang. Samme trend i saler: Operaen/St.v.

Men: Innføring av etterklangsanlegg gir enda
«rarere» utsving, «koplede rom»
som ikke likner på gode, reelle rom
(likner noe på klangkamre)

Hva det bør forskes på:

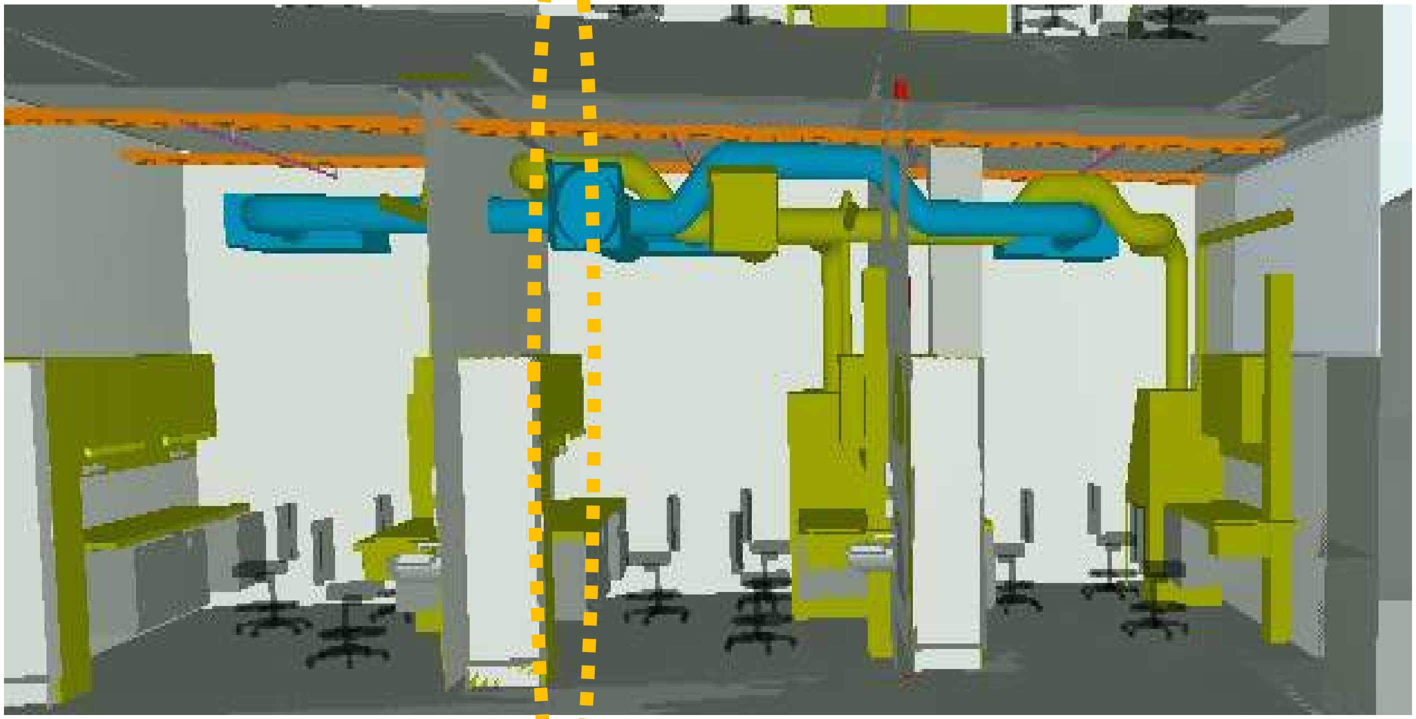
Enkel signalgiver for G [dB] i mellom-frekvens
(korreksjon mot bassen kan gjøres via T30 kurve)

Bedre karakteristika for Støyens frekvensinnhold (NR er fremdeles «best»)
FFT på iPhone!! Rentoner/Harmonisk?/SpectralCentroid

MER KONTAKT MUSIKKTEKNOLOGI/Psykoakustikk/Kognisjon
STUDIO/LYDKONTROLL
Bassresonanser/Membran-absorbenter (reportoire)
ET EKKO ER IKKE ET EKKO
ROMAKUSTISKE MÅLINGER i AMBISONICS el.lgn.

BIM-Akustikk
(integrering dRofus/Solibri/Romakustikkprogrammer/Flanketransmisjon)
(sikre at det ikke blir for enkle løsninger)
Problemer: BIM etc. tenker ofte hvert rom som selvstendige Lego-klosser
Flanketransmisjon/Nøyaktighet i romakustikk-simuleringer/
Lydisolasjonskrav kan ikke settes før naborom er kjent.
NB! Lage implementering av Flankeberegning/knutepunkt direkte i BIM!!
Lydabsorpsjon: Himlingsklasser for «grovt» i bassen

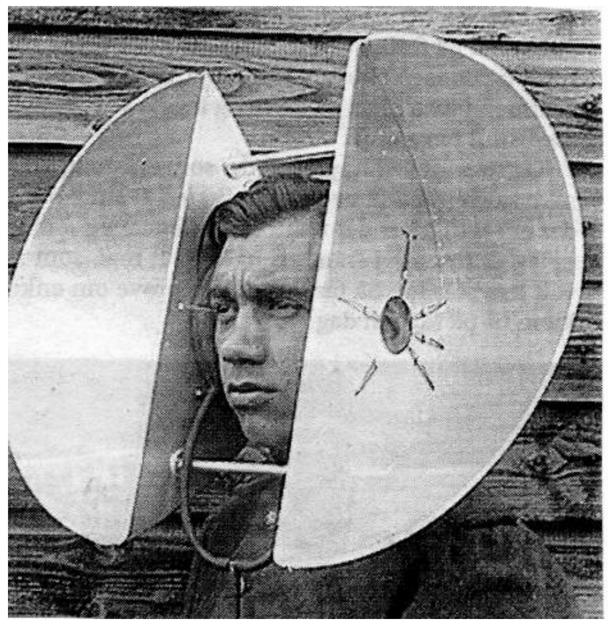
KNUTEPUNKT/ «Relation»??/ Junction



Sukk:

Har Akustisk prosjektering blitt (kun)
en oppramsing av krav fra NS (og Statsbygg BP)?

Konklusjon:
LYTT FØRST!
FORSK SIDEN!



fine del opera