Room Acoustic for Multipurpose Halls

proAV Consulting
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Room Acoustic for Multipurpose Halls

multipurpose halls and different room acoustic demands

The typical multipurpose hall is used for:

- Speech
- Pop-Music, reinforced concerts
- theatre
- different genres of acoustic music (jazz, chamber, symphonic)

The room should have:

- high speech intelligibility
- relatively dry acoustic without strong reflections for reinforced concerts
- acoustic to support natural voices without sound reinforcement
- acoustic to support non-amplified musical instruments
- acoustic to support classical instruments and orchestras with rich reverberation

All at the same time is impossible ….. **there is no ‚good' or ‚bad' acoustic!**

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multipurpose halls and different room acoustic demands

The main objective should be always SPEECH !

- room acoustic design for speech
- sound reinforcement for speech
- resulting high speech intelligibility

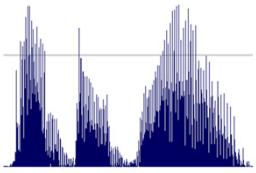
But …. all demands for other performances should be taken in consideration from the beginning !

Room Acoustic for Multipurpose Halls

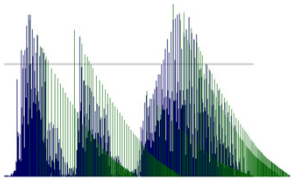
multipurpose halls and different room acoustic demands

Why doesn't the ‚good' acoustic work well for all purposes ?

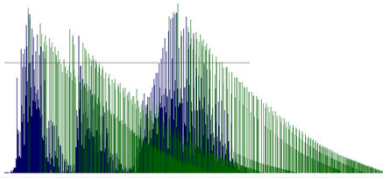
Reverberation masks sound signals, resulting in low speech intelligibility



outdoor, free field



short reverberation



long reverberation

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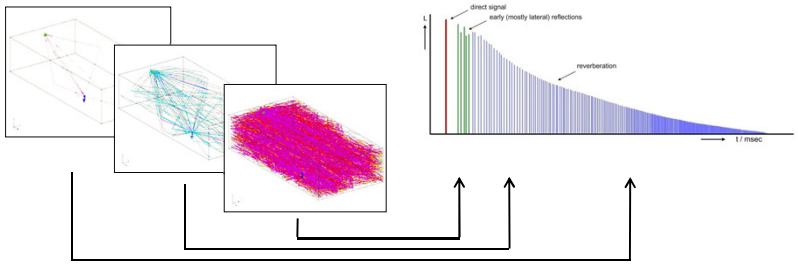
reflections as the basic of hearing in rooms

Reflections and - reflections of reflections ….

- first 150 ms of energy decay are the most important for the perceived room impression



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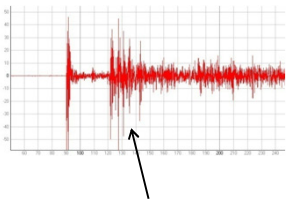
reflections as the basic of hearing in rooms

Why don't we **hear** these reflections?

- In an average concert hall only **5%** of the audible sound energy is direct sound,
  95% are reflections !



Strong early reflections in the range up to 100 msec are not perceived as disturbing but as supporting – why ?

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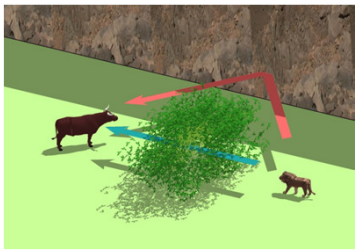
reflections as the basic of hearing in rooms

Complex direction detection



- A large part of our direction detection is based on the processing of reflected sounds
- developed very early in the evolution

Detection of noise directions and immediate decision for escape or assault are one of the basic principles for survival !

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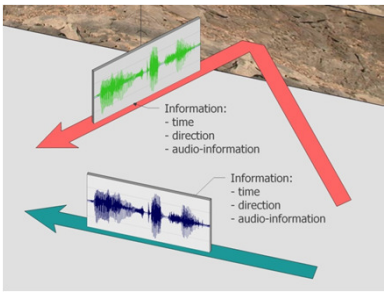
reflections as the basic of hearing in rooms

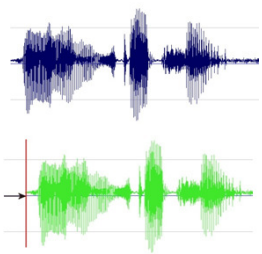
Immediate analysis of time and direction information

-> first arrival must be ‚original'

-> similar later arrivals must be ‚reflections'

through Interaural Intensity Differences (IIDs) and Interaural Time Differences (ITDs)





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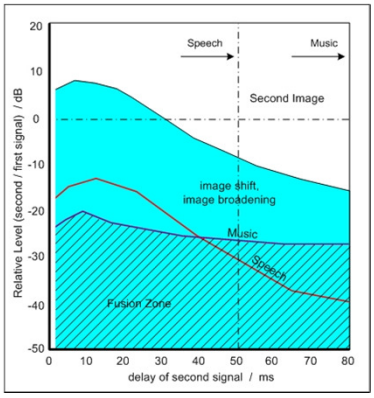
reflections as the basic of hearing in rooms

Precedence Effect

- first research by Haas, 1949
  often too trivial interpretation !
- **Fusion Zone**: second sound will not be noticed, but supports signal strength
- **Image Shift Area:** image shift, source broadening > ASW
- **Second Image is audible:** both signals can be heard individually



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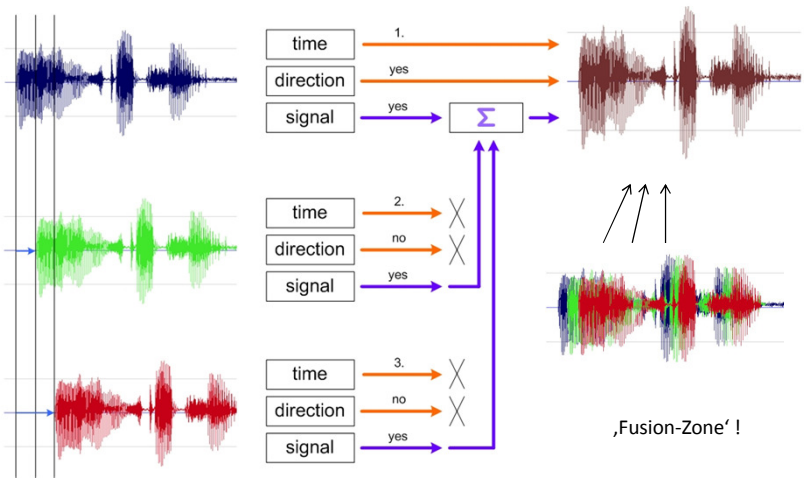
reflections as the basic of hearing in rooms

Precedence Effect > no signal distortion or suppression but signal enhancement



‚Fusion-Zone' !

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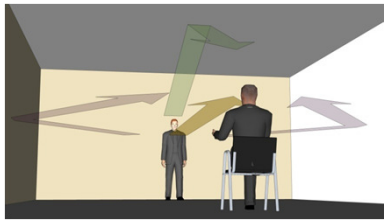
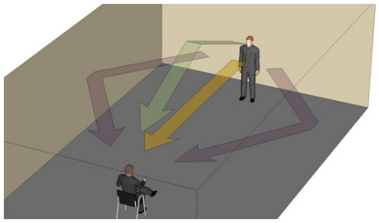
reflections as the basic of hearing in rooms

Daily experience

- original signal with directional information
- enhancing reflections without additional directional information
- in-audible but supportive

perception is different from person to person, musicians, conductors, sound engineers hear different





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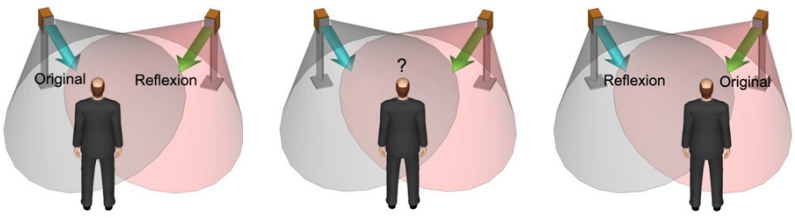
reflections as the basic of hearing in rooms

Another daily experience

- loudspeakers are no natural sound sources
- they resemble rather reflections because of their focused radiation
- psychoacoustic analysis very difficult, changing from one second to the next

> **"Sweet" Spot - but heavy work for our brains !!**



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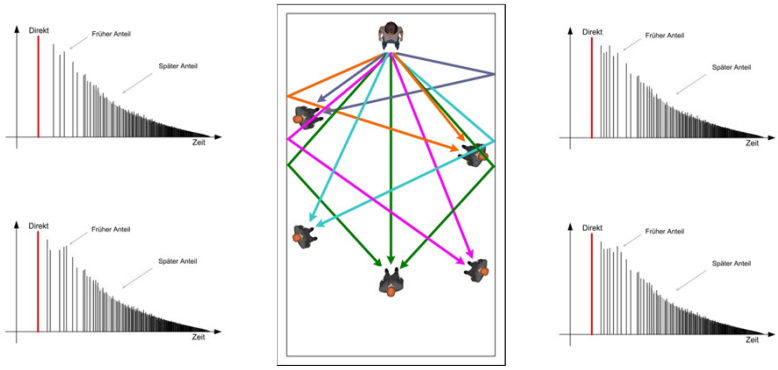
reflections as the basic of hearing in rooms



- Early reflections: single reflections, every position in the room is different ('sounds' different) !
- Later reflections: high conformity, statistical reverberation field, distributed randomly

Room Acoustic for Multipurpose Halls

room acoustic - standards

Standards:

ISO 3382-1	room acoustic parameters in performance spaces
ISO 3382-2	reverberation time in ordinary rooms

acoustic quantities grouped according to listener aspects (ISO 3382-1):

subjective level of sound	G		
perceived reverberance	EDT		
perceived clarity	C80		
apparent source width	ASW	early lateral energy	(LF)
listener envelopment	LEV	late lateral sound level	(LG)

Room Acoustic for Multipurpose Halls

room acoustic - standards

Standards:

DIN 18041 for rooms up to 5000 m³

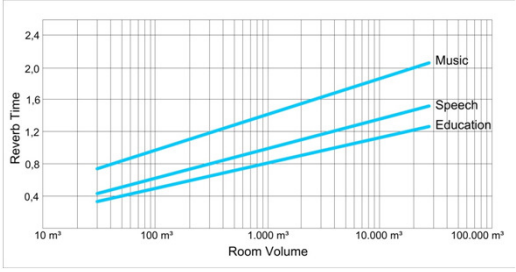
could be used for theaters and concert halls up to 30.000 m³

the Swiss **SGA guidelines** for class rooms and rooms for speech are based on the DIN 18041

Music: $T_{target} = (0{,}45 \lg \frac{V}{m^3} + 0{,}07)$ sec

Speech: $T_{target} = (0{,}37 \lg \frac{V}{m^3} + 0{,}14)$ sec

Education: $T_{target} = (0{,}32 \lg \frac{V}{m^3} + 0{,}17)$ sec

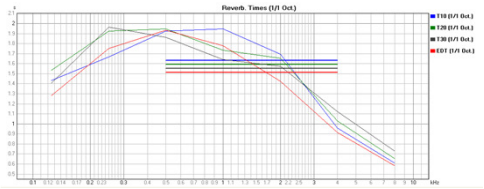


Room Acoustic for Multipurpose Halls

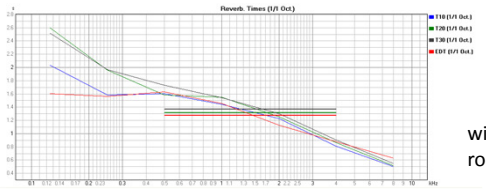
room acoustic - standards

Standards:

DIN 18041



- with ‚equal' reverberation times very different frequency responses are possible



with the 'same' reverberation time rooms can sound very different !

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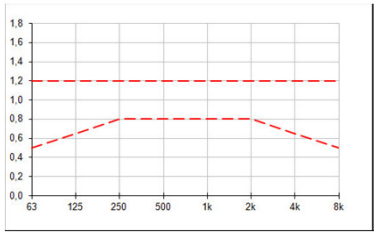
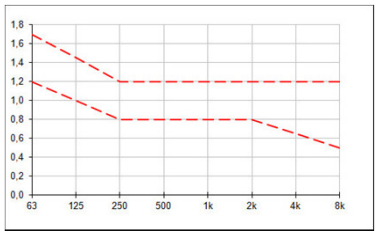
room acoustic - standards

Standards:

DIN 18041



rooms for speech and education



rooms for music performance

- tolerance fields for reverberation time and frequency response is important, defined for regular rooms
- In concert halls reverberation vs. frequency could be different from the tolerance field of DIN 18041

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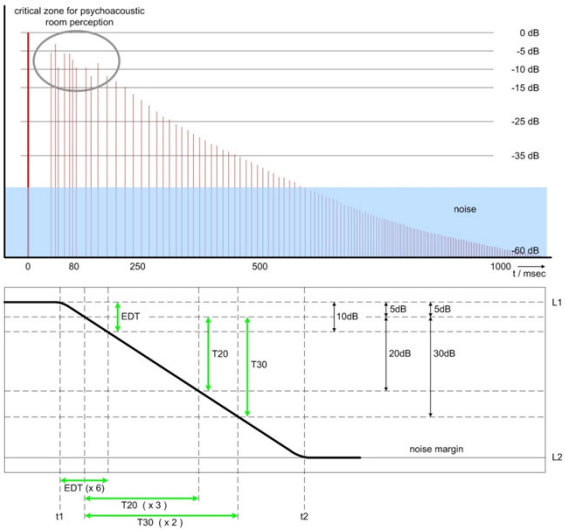
room acoustic parameters

Reverberation Time



First 150 msec is the most important part of the energy decay

defines the subjective perception of the room

Early Decay Time is the more decisive reverberation parameter than T30 (or „RT60“)

Room Acoustic for Multipurpose Halls

room acoustic parameters

Clarity C80 ‚Intelligibility' of music

Relationship between early energy (0-80ms) and late energy (80-∞ms)

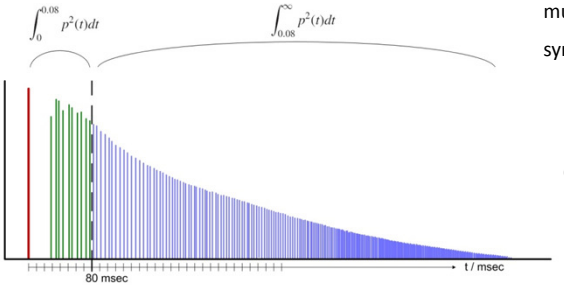
defines the subjective perception of the room, more than reverberation time !

80 ms equals a path difference of about 27m

speech: 5dB .. 10dB

musical rehearsal: about 5dB

symphonic concerts: - 2dB bis +1dB



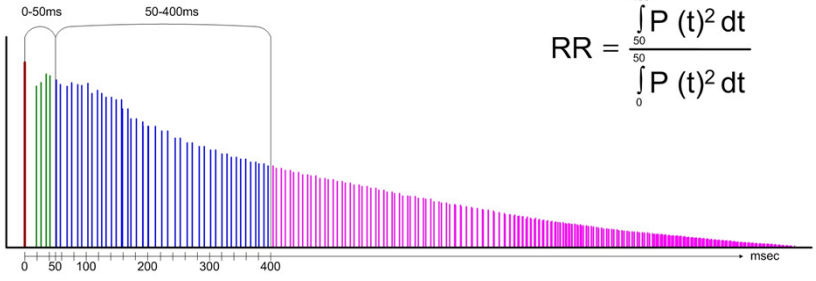
$$C_{80} = 10 \lg \frac{\int_0^{80} p^2 dt}{\int_{80}^{\infty} p^2 dt} [dB]$$

Room Acoustic for Multipurpose Halls

room acoustic parameters

„Running Reverberation" (RR)

the ratio of early reverberant sound (50-400ms) to the direct and early reflected sound (0-50ms)



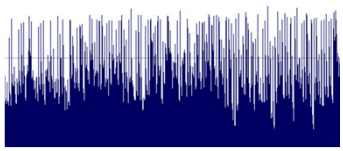
$$RR = \frac{\int_{50}^{400} P(t)^2 dt}{\int_{0}^{50} P(t)^2 dt}$$

Room Acoustic for Multipurpose Halls

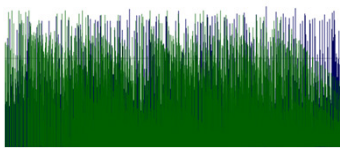
room acoustic parameters

„Reverberation Level"

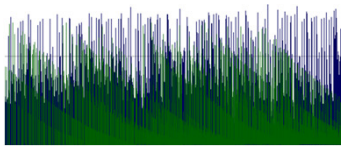
reverberation with the same reverberation time can have different level (amount of energy), what is heard while music is playing
- music can mask reverberation -



outdoor, free field



high reberberation level



same reverberation time - but low reberberation level

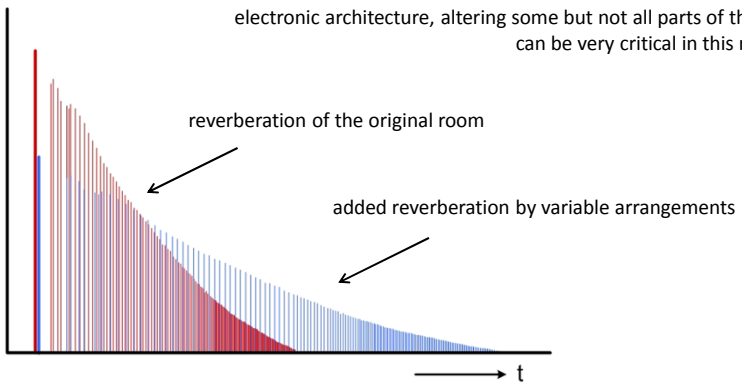
Room Acoustic for Multipurpose Halls

room acoustic parameters

EDT, T30 and C80 give a clear indication of the room's acoustical condition *only* in perfect rooms

the analysis of the energy decay of the first 350 to 380 msec is more conform to the subjective perception than the first 10dB of EDT (David Griesinger)

electronic architecture, altering some but not all parts of the room, can be very critical in this respect !

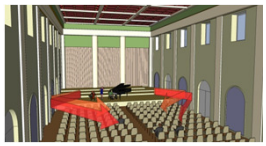


Room Acoustic for Multipurpose Halls

room acoustic parameters

Apparent Source Width ASW

Early Lateral Energy Fraction (LF) and IACCE



Interaural Cross Correlation IACC

comparing sounds arriving from both sides

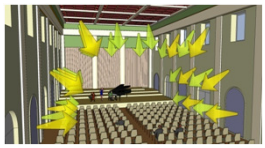
both sides equal: IACC=1

both sides totally different: IACC=0

$IACC_{A}$ t_1 $0ms \rightarrow t_2$ $1000ms$

$IACC_{E(arly)}$ t_1 $0ms \rightarrow t_2$ $80ms \rightarrow$ ASW

$IACC_{L(ate)}$ t_1 $80ms \rightarrow t_2$ $1000ms \rightarrow$ LEV

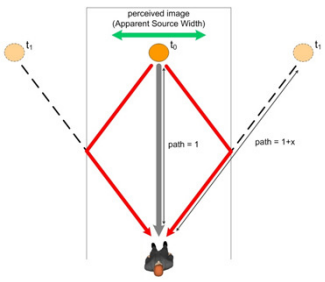


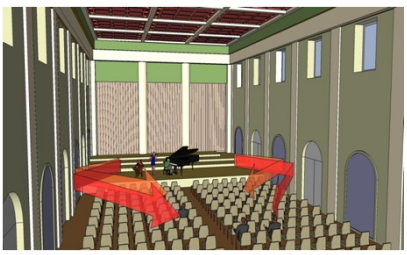
Listener Envelopment LEV

Late Lateral Sound Level (LG), spatial room sensation

Room Acoustic for Multipurpose Halls

room acoustic parameters





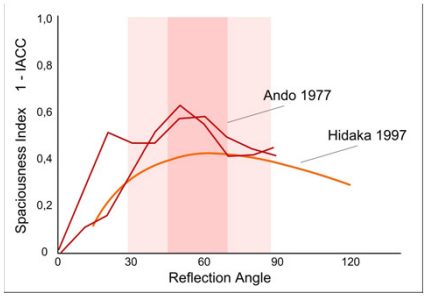
- side reflections create mirror images
- mirror images are delayed (path length)
- causing image broadening, wider than reality – higher Apparent Source Width (ASW)

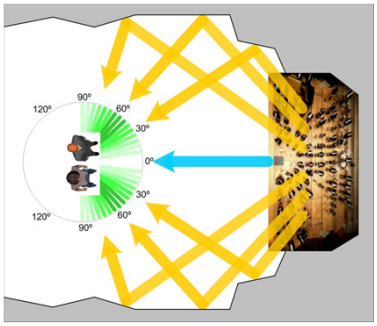
Room Acoustic for Multipurpose Halls

room acoustic parameters

angles of reflections are important for the perception of Apparent Source Width (ASW)

several tests showed that preferred side reflection angles are between 30 and 90 degrees

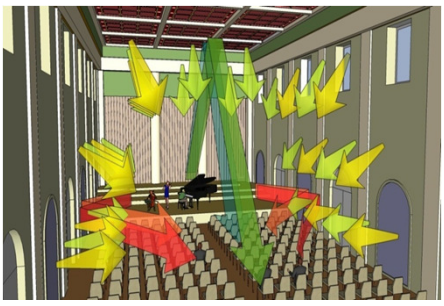




preferred angles of side reflections

Room Acoustic for Multipurpose Halls

room acoustic parameters



- early lateral reflections > ASW + IACC
- ceiling reflections (should arrive always later than first lateral reflections)
- late diffuse reverberation field > LEV

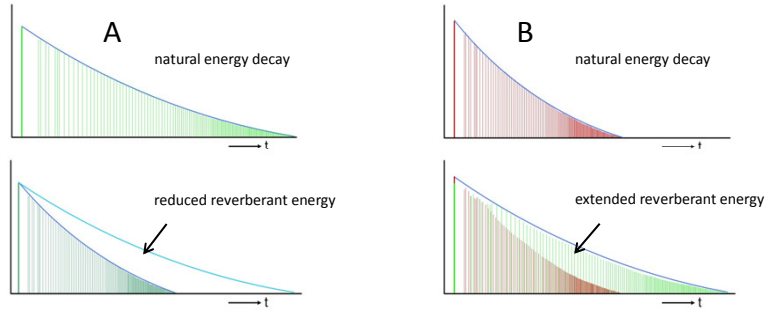
Room Acoustic for Multipurpose Halls

multipurpose halls and variable room acoustic

Changing room acoustic in two ways:

A adding absorptive material to reduce reverberation time,
less reflective surfaces, more absorption

B adding reverberation chambers and reflective surfaces to extend the
reverberation time, more room volume, more reflective surfaces

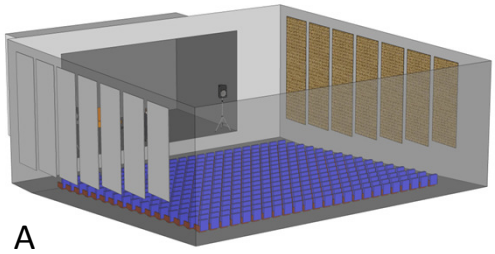


Room Acoustic for Multipurpose Halls

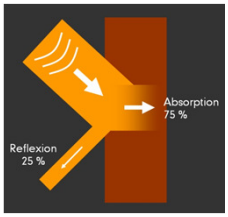
variable room acoustic

Approach "A"

- Since the late 19th century variable room acoustic was designed by movable walls, movable ceiling parts, curtains and drapery
- designing a room with **rich acoustics** for symphonic conditions,
  adding absorptive material to shorten the acoustics for opera and theater



A



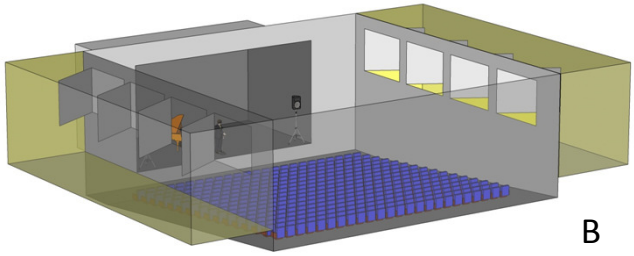
Room Acoustic for Multipurpose Halls

variable room acoustic

Approach “B”:

- designing a hall with a **short reverberation** for speech, theatre, opera,
  adding volume creating to increase the energy in the room, creating a richer acoustic
  for symphonic concerts or other musical performances

  > using additional reverberation chambers



B

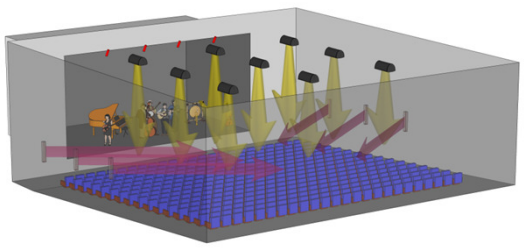
Room Acoustic for Multipurpose Halls

variable room acoustic

Approach “B”:

- designing a hall with a **short reverberation** for speech, theatre, opera,
  adding an active system to increase the energy in the room, creating a richer acoustic
  for symphonic concerts or other musical performances

  > using an **active** system



B

Room Acoustic for Multipurpose Halls

variable room acoustic

Moving ceilings and variable absorption by drapery and curtains

thick movable absorptive screens on the side walls (electric screens)

designing a room with **medium** for symphonic conditions,

- **adding absorptive material** to shorten the acoustics for opera and theater
- **adding an active room acoustic system** to enrich the acoustic

A + B

Granada Theatre Santa Barbara

variable room acoustic with and without electronics

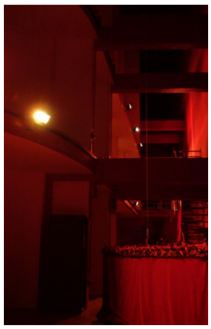
(absorptive drapery and VRAS system, McKay Conant Hoover Inc., Arizona)

Room Acoustic for Multipurpose Halls

variable room acoustic

- designing a hall with a **short reverberation** for speech, theatre, opera, adding volume creating a richer acoustic for symphonic concerts
- using additional reverberation chambers
- problems: difficult to design, expensive to built

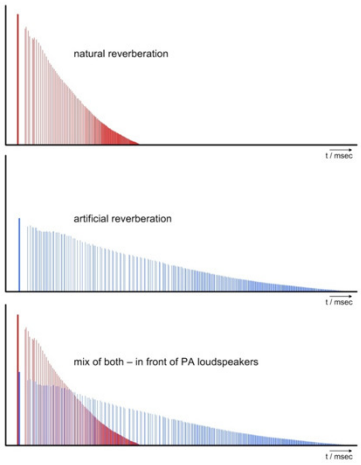
B



KKL Luzern, large Concert Hall

Room Acoustic for Multipurpose Halls

electronic architecture ?? - ‚artificial' reverb ??



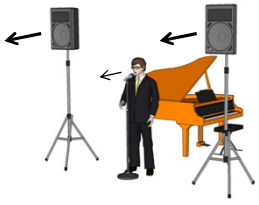
‚one dimensional' reverb through sound reinforcement
but ... no real, three-dimensional room sound

Room Acoustic for Multipurpose Halls

electronic architecture - ‚artificial' reverb

- acoustic energy from a talking person

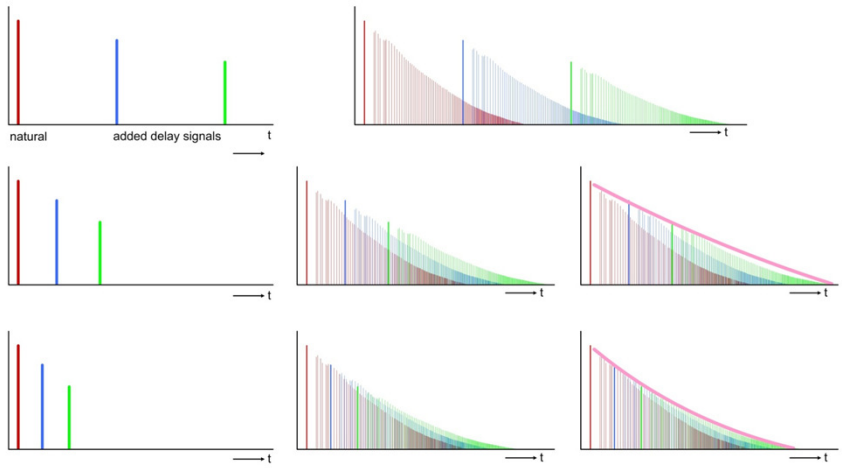
- acoustic energy from a talking person
  AND from a loudspeaker system



- **but:** both will not change the acoustic parameters of the room !

Room Acoustic for Multipurpose Halls

electronic architecture - ‚artificial' reverb



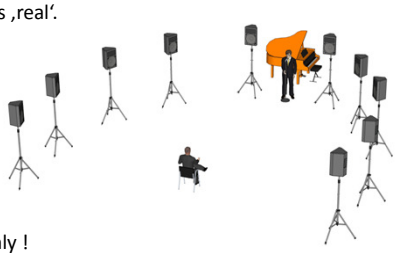
delayed signals add energy – and create three-dimensional room feeling

Room Acoustic for Multipurpose Halls

electronic architecture - ‚artificial' reverb

- The more speakers are used
  the better the artificial reverb
  mixes with the natural reverberation !

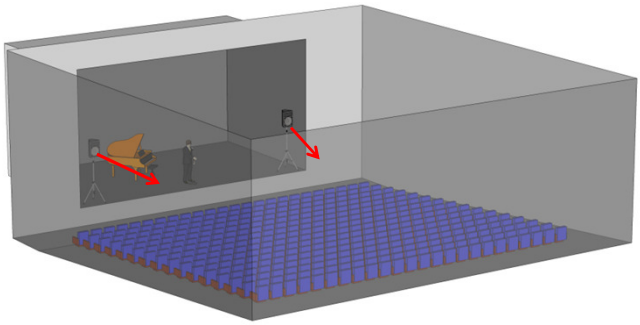
- With enough loudspeakers the ‚effect' becomes ‚real'.



- Each loudspeaker distributes a small portion only !

Room Acoustic for Multipurpose Halls

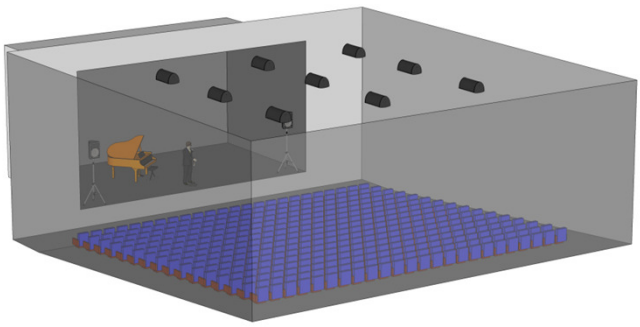
electronic architecture - ‚artificial' reverb



simple ‚one dimensional' additional reverb through loudspeaker system

Room Acoustic for Multipurpose Halls

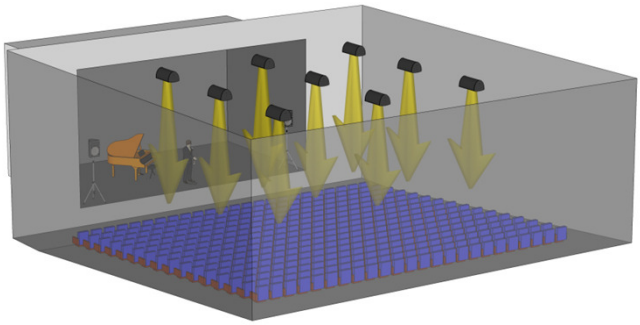
electronic architecture - ‚artificial' reverb



multi-channel reverb through distributed loudspeaker system

Room Acoustic for Multipurpose Halls

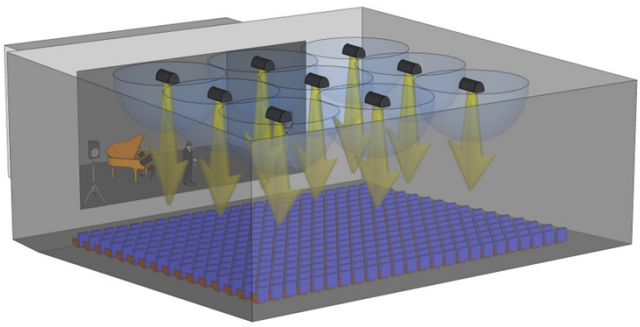
electronic architecture - ‚artificial' reverb



multi-channel reverb through distributed loudspeaker system

Room Acoustic for Multipurpose Halls

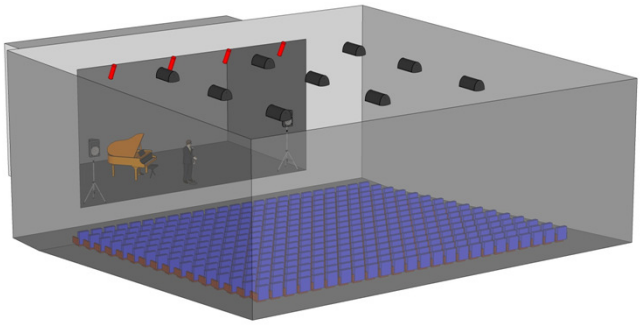
electronic architecture - ‚artificial' reverb



audience out of reverberation radius and out of loudspeakers' critical distance,
but loudspeakers must be correctly time aligned to be "in-audible" (precedence effect)

Room Acoustic for Multipurpose Halls

electronic architecture - ‚artificial' reverb

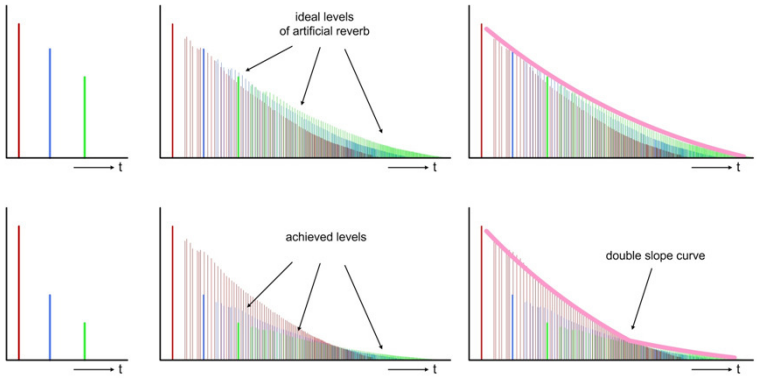


microphone - loudspeaker distance should be out of reverberation radius !

but: directional microphones are off-axis not linear !

Room Acoustic for Multipurpose Halls

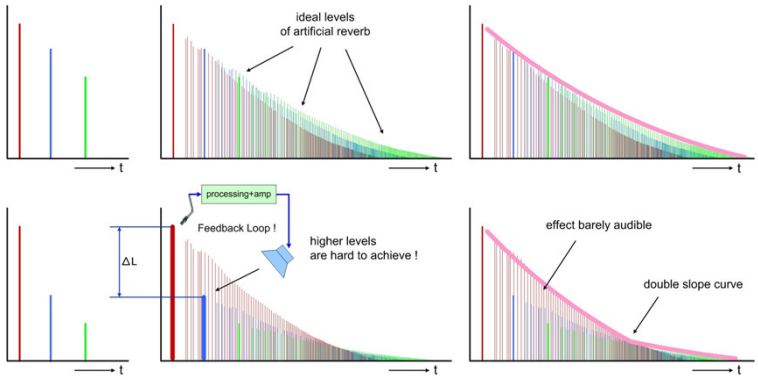
electronic architecture - ‚artificial' reverb



.... achievable levels are usually too low

Room Acoustic for Multipurpose Halls

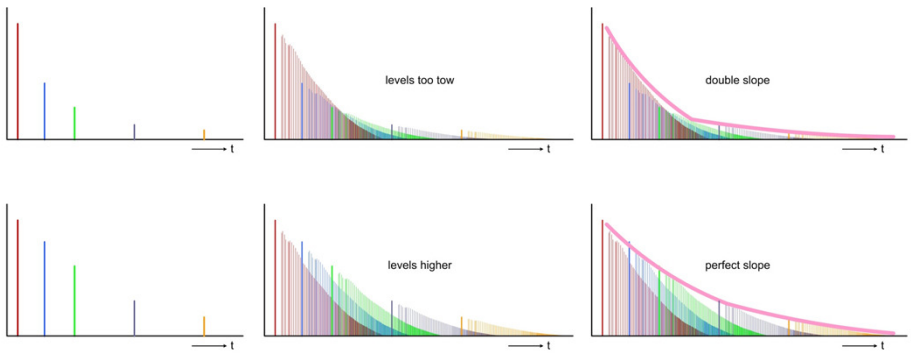
electronic architecture - ‚artificial' reverb



.... achievable levels are usually too low

Room Acoustic for Multipurpose Halls

electronic architecture - ‚artificial' reverb

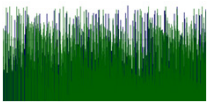


additional reverb level is critical !

too low signals resulting in a double slope curve !
>> low EDT, low Running Reverb, high C80

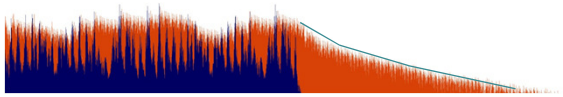
Room Acoustic for Multipurpose Halls

electronic architecture - ‚artificial' reverb

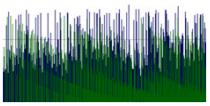


high reverberation level

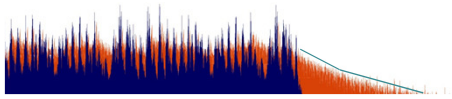
1



high reverberation, high reverberation level, natural condition

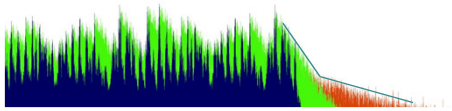


same reverberation time
but low reverberation level



low reverberation level (only artificial reverb)

2



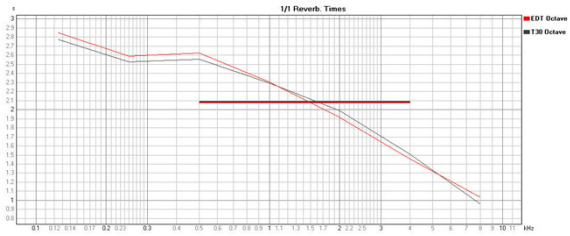
real situation: natural reverb and low artificial reverb - double slope !

2: measured parameters reverberation T30 high, but EDT too low and C80 too high

Room Acoustic for Multipurpose Halls

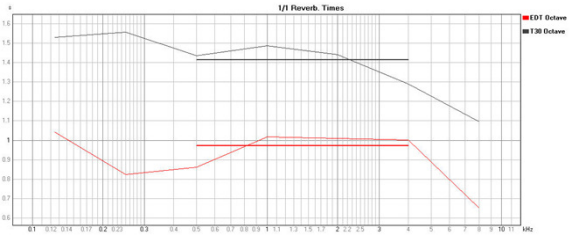
electronic architecture - ‚artificial' reverb

1



measurement of EDT and T30 similar

2



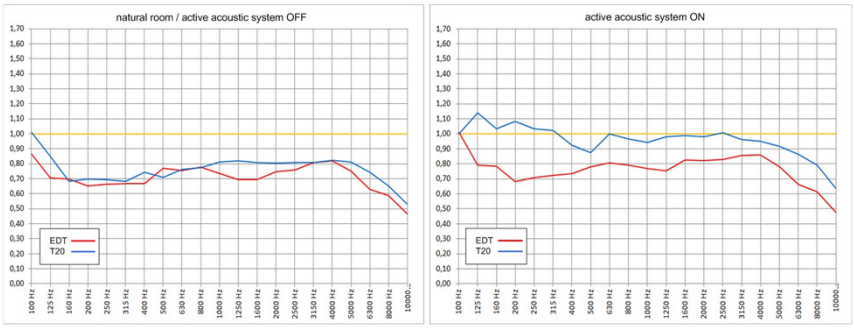
measurement of EDT and T30 very different, high T30 but too low EDT (double slope !)

Room Acoustic for Multipurpose Halls

electronic architecture - ‚artificial' reverb

„Early to Late Enhancement " (EL_{20})
ratio of achieved gain at EDT to achieved gain at T20
at the average between 500Hz and 1kHz

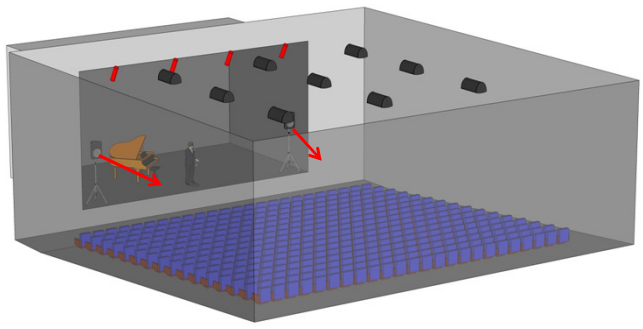
$$EL_{20,\,mid} = \frac{EDT_{gain,\,mid}}{T20_{\,gain,\,mid}}$$



Room Acoustic for Multipurpose Halls

electronic architecture - ‚artificial' reverb

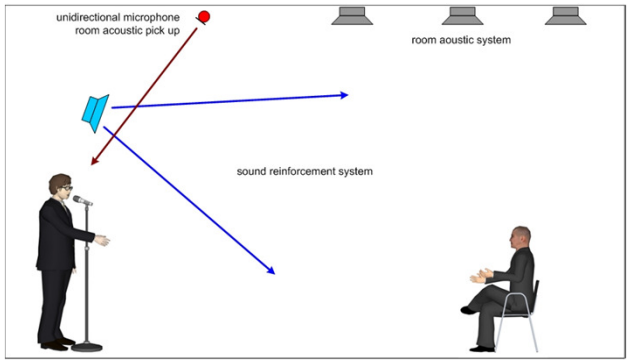
What is the sound source ?

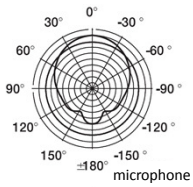


sound source not a natural instrument or voice but a loudspeaker itself … ?

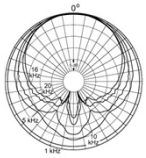
Room Acoustic for Multipurpose Halls

electronic architecture - ‚artificial' reverb





microphone



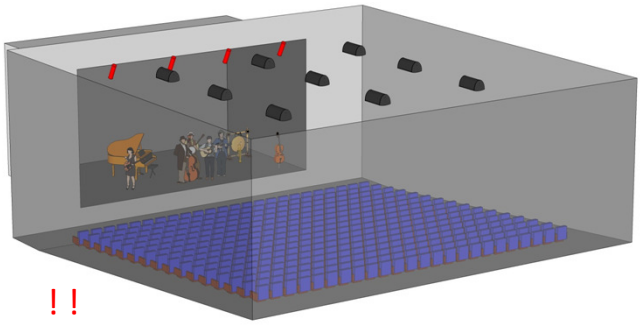
loudspeaker

microphones need to have narrow directivity to enable gain before feedback

loudspeakers have directional distribution pattern

Room Acoustic for Multipurpose Halls

electronic architecture - ‚artificial' reverb



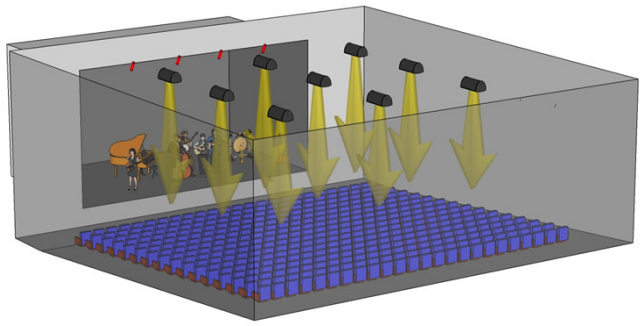
! !

overhead stage microphones work only well for natural instruments and voices

(wide and even dispersion)

Room Acoustic for Multipurpose Halls

electronic architecture - ‚artificial' reverb



overhead stage microphones work only well for natural instruments and voices
(wide and even dispersion)

Room Acoustic for Multipurpose Halls

electronic architecture - first approaches

- Historical Review -

electronic architecture from the beginnings until today

Room Acoustic for Multipurpose Halls

electronic architecture - first approaches

Philadelphia Academy of Music, 1930

- first known approach to electronic manipulation of room acoustic parameters
- RCA installed loudspeakers in the room fed with microphone signals picking up stage signal
- the goal: to extend reverberation time

Room Acoustic for Multipurpose Halls

electronic architecture - first approaches

Milano, La Scala, 1955

- R. Vermeulen developed a stereo enhancement system to produce artificial reflections Philips Laboratories installed the system at the La Scala opera house in Milano
- it uses tape machines as 'echo processors' delivered the room acoustic signals fed to the distributed loudspeaker system

1 recording head fed by microphones in the hall (stage pick up)

8 playback heads, each for a group of loudspeakers

Room Acoustic for Multipurpose Halls

electronic architecture - first approaches

Jahrhunderthalle Hoechst / Frankfurt, 1963

- system design by Heinrich Kuttruff und Erwin Meyer
- chamber reverberator of 144 m³ with an additional reverb plate was installed in a dedicated room, it was the largest reverberation chamber at this time
- signal pickup by microphones near stage
  signal playback though a large number of loudspeakers
- problems: low gain, coloration

Room Acoustic for Multipurpose Halls

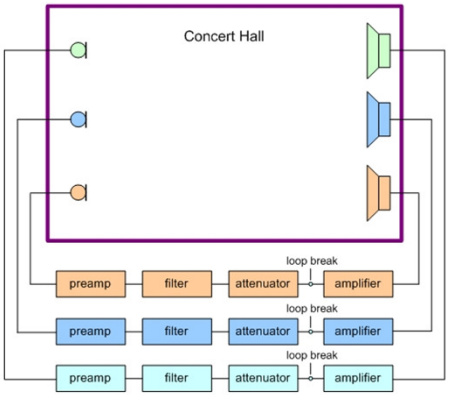
electronic architecture - Assisted Resonance

Assisted Resonance, 1964

- developed by P. H. Parkins (Building Research Station, England)
- first installed at the Royal Festival Hall, London in 1964

regenerative system

- reverberation time could be extended from 1.4 to 2.5 seconds
- large number of very narrow band channels with controlled feedback
- At the Royal Festival Hall : 172 channels used, in the range of 58–700 Hz, channel spacing by a few Hz only

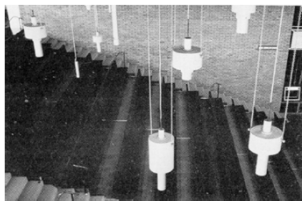


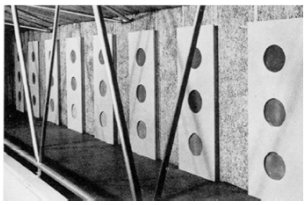
Room Acoustic for Multipurpose Halls

electronic architecture - Assisted Resonance

Assisted Resonance

- the technology was used for thousands of concerts in the 1960s and 1970s !
- another large installation: the Central Hall of the University of York, installed 1974 overhault in 1985, multipurpose hall with 1200 seats





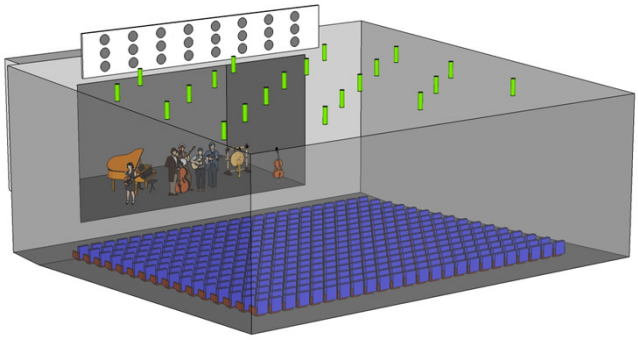
Microphones and Loudspeakers

Photographs from the article ‚Assisted Resonance' by Berry and Crouse, 1974

Room Acoustic for Multipurpose Halls

electronic architecture - Assisted Resonance

Assisted Resonance



extended reverberation time by using a large number of very narrow-band channels with controlled feedback

Room Acoustic for Multipurpose Halls

electronic architecture - Assisted Resonance

Assisted Resonance - nothing new: Ancient Theatres

- resonators used by Greek stone-built theatres
- resonating jars distributed in semicircles around the auditorium, reinforcing certain pitches
- Romans studied the technology very well and found that it doesn't work well in wooden theatre buildings, but very well in stone amphy theatres
- smaller Greek theatres had only one row and larger theatres had three rows tuned to enhance the entire spectrum of chromatic and diatonic scales
- the rows were arranged: first row harmonia, second row chromatic, third row diatonic

described by Virtruvius (Roman author)

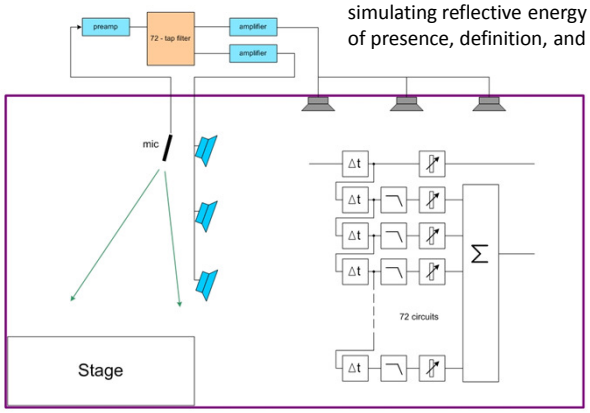
Room Acoustic for Multipurpose Halls

electronic architecture - ERES

Electronic Reflected Energy System ERES, 1970

In 1971 Christopher Jaffe (Jaffe Acoustics, US) started working on generating ‚artificial' reflections, patented in 1977

simulating reflective energy to enhance perception of presence, definition, and warmth

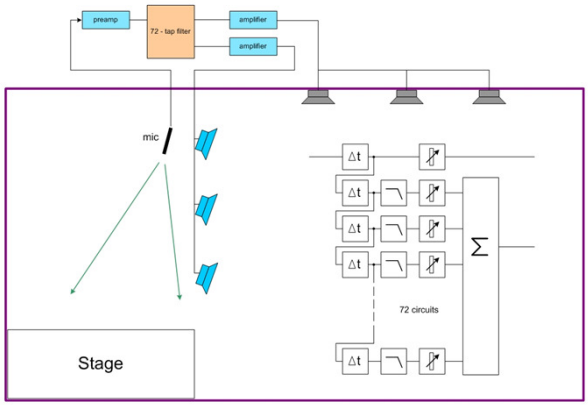


Room Acoustic for Multipurpose Halls

electronic architecture - ERES

Electronic Reflected Energy System ERES 72 channel delay tap filter

first reflections over proscenium speakers, later reflections low-pass filtered over ceiling speakers



Room Acoustic for Multipurpose Halls

electronic architecture - RODS

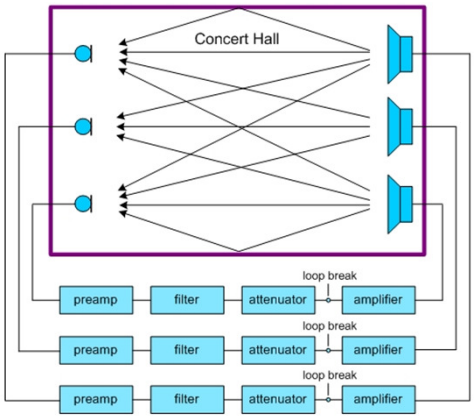
Reverberation on demand system RODS, 1985

- from 1982 Jaffe Acoustics and Acoustic Management Systems, Ltd. worked together and 1985 the RODS system was developed by Peter Barnet
- RODS was an add-on to the ERAS system, using an additional reverberation processor
- individual switching of channels, to avoid feedback, regulated by levels

Room Acoustic for Multipurpose Halls

electronic architecture - MCR

Multiple-Channel Reverberation MCR, 1968



developed 1968 by Franssen (Philips Laboratories) development based on Assisted Resonance System

regenerative system

large number of broadband channels, controlled feedback

the higher the number of channels, the higher the achievable gain

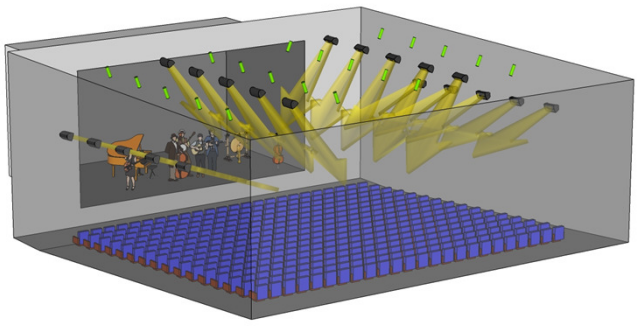
to double the energy density at least 50 channels are necessary

each microphones feeds one channel with one loudspeaker

Room Acoustic for Multipurpose Halls

electronic architecture - MCR

Multiple-Channel Reverberation MCR



room microphones to pick up the reverberant field
maximum distance between microphones and loudspeakers

Room Acoustic for Multipurpose Halls

electronic architecture - MCR

Multiple-Channel Reverberation MCR

"increasing the energy density" equivalent to "decreasing the absorption"

- microphone placed in the reverberant field
- amplified loudspeaker outside the reverberation radius

  > the reverberant energy in the room will increase

- increase by each loudspeaker is added to the total energy increase
- the number of channels can be calculated by the required energy enhancement

- MCR enhances EDT and decreases C80, but doesn't create an artificial ‚reverberation tail'
- works very well in larger rooms but not in smaller ones !

Room Acoustic for Multipurpose Halls

electronic architecture - MCR

Multiple-Channel Reverberation MCR

- in den 1980s further development on the system by S.H. de Koning (Philips)
- many high level installations all over Europe

problem: each channel individually tuned short before acoustic feedback
with analog circuitry long-time stability was hard to achieve !

large improvements in the 2000s by
Peutz B.V. and Cees Mulder,
using digital signal processing
(Peavey Mediamatrix)

MCR installation (2005)
Tonhalle Duesseldorf, Germany

Room Acoustic for Multipurpose Halls

electronic architecture - MCR

MCR installation (2005): Kursaal in Oostende, Belgium

lines of loudspeaker s on the rear and side walls

Room Acoustic for Multipurpose Halls

electronic architecture - ACS

Acoustical Control System ACS, 1987

- developed by Prof. Berkhout, University Delft, Netherlands

non-regenerative system

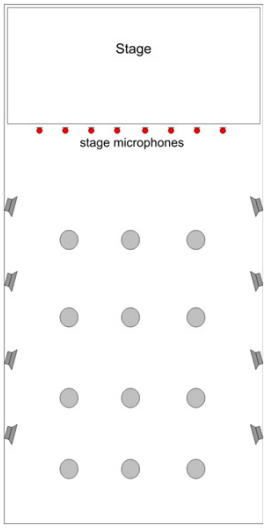
- each loudspeaker is fed with an individual ‚impulse response' according to the needs of the designed room
- theoretically based on wave field synthesis
- the existing hall is ‚overlaid' with an artificial hall image

Room Acoustic for Multipurpose Halls

electronic architecture - ACS

Acoustical Control System ACS, 1987

- 8 to 24 directional microphones
- processor: early reflection module, reverberation module
- as much loudspeaker channels as possible are used
- developed with analog circuitry, later transformed to digital



Room Acoustic for Multipurpose Halls

electronic architecture - LARES

Lexicon Acoustic Reinforcement and Enhancement System LARES, 1988

- developed by David Griesinger and Steve Barbar at Lexicon, Inc. later LARES Associates

non-regenerative system

- the first installation at the Elgin Theatre, Toronto, using 2 microphones and 116 loudspeaker channels
- LARES uses the so-called „time variant processing“:

  special algorithm for delay changes and minimized pitch shift,
  compromise between coloration-free gain and audible pitch problems

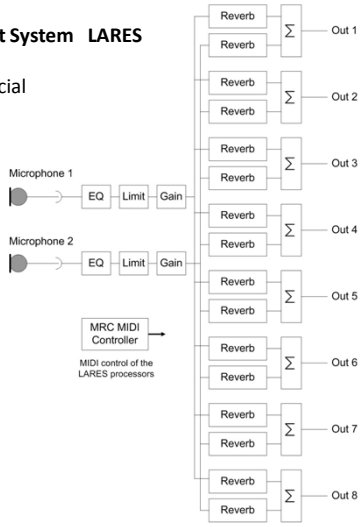
LARES

Room Acoustic for Multipurpose Halls

electronic architecture - LARES

Lexicon Acoustic Reinforcement and Enhancement System LARES

- natural reverberation of the room and full artificial reverberation is mixed in the room
- LARES increases lateral energy and increases the reverberant field
- 2 - 4 cardioid microphones as close to the stage as possible
- 2 LARES processors provide 16 independent reverberation channels
- 1992 a patent was issued for LARES entitled "Electroacoustic system"



Room Acoustic for Multipurpose Halls

electronic architecture - LARES

Lexicon Acoustic Reinforcement and Enhancement System LARES

German Staatsoper Berlin
Reverberation time 1.2s, with LARES up to 1.9s

The system is still in use, now moved to the temporary location
Schiller Theatre in Berlin

Room Acoustic for Multipurpose Halls

electronic architecture - LARES

Lexicon Acoustic Reinforcement and Enhancement System LARES

Perfectly suited for open air performance
(short microphone distance)

Vienna Festival (Open Air)

Supporting system for the Vienna Philharmonic Orchestra

Room Acoustic for Multipurpose Halls

electronic architecture - LARES

Lexicon Acoustic Reinforcement and Enhancement System LARES

Crystal Palace Festival (UK)

orchestra support on stage

Room Acoustic for Multipurpose Halls

electronic architecture - SIAP

System for Improved Acoustic Performance SIAP, 1991

- developed by Wim Prinssen

non-regenerative system

- 4 - 8 supercardioid microphones close to the stage, 8 - 10m above front edge of stage
- time-constant de-correlation of the individual microphone channels (time-variance available)
- with a large number of de-correlated signal paths / loudspeaker channels usually about 30 loudspeaker channels
- retains acoustical character of the hall, but fills missing reflections
- system should not have acoustic feedback between loudspeakers and microphones
- uses sophisticated reverb algorithms

Room Acoustic for Multipurpose Halls

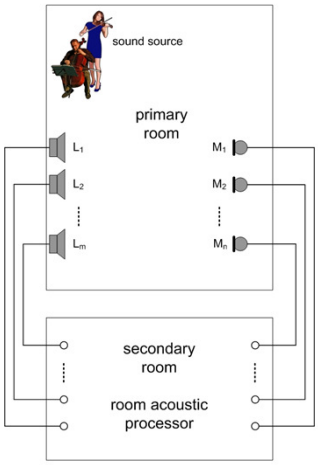
electronic architecture - VRAS

Variable Room Acoustic System VRAS, 1994

- developed by Mark A. Poletti, New Zealand

regenerative system

- using the acoustic feedback between loudspeakers and microphones
- omnidirectional microphones
- full-range loudspeakers with very wide dispersion pattern
- multichannel unitary reverberator maintaining a constant power gain with frequency
- system is creating an electro-acoustically coupled room

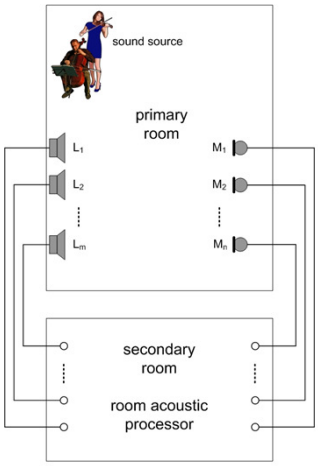


Room Acoustic for Multipurpose Halls

electronic architecture - VRAS

Variable Room Acoustic System VRAS

- reverberator is time - **in**variant
- microphone signals are mixed with a special mix-algorithm to generate a summed microphone mix feeding reverberator modules, these feeding the loudspeaker channels
- additional ‚in-line' early reflection module working with directional close-stage microphones
- patent issued in 1993



Room Acoustic for Multipurpose Halls

electronic architecture - VRAS

Variable Room Acoustic System VRAS

Stadttheater Kempten, Germany
a province theatre renovated and renewed to a multifunctional hall for theatre, opera, chamber music and full-size symphonic concerts

system is used nearly daily !!

Room Acoustic for Multipurpose Halls

electronic architecture - VRAS

Variable Room Acoustic System VRAS

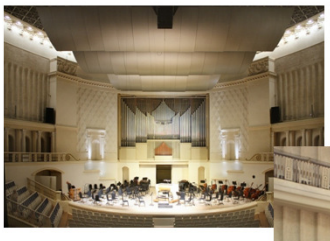
Opera Tel Aviv, Israel
the opera house is used additionally for symphonic concerts

- system is used daily !!

Room Acoustic for Multipurpose Halls

electronic architecture - VRAS

Variable Room Acoustic System VRAS



Moscow Philharmony
Tchaikowsky Hall

„repair of deficits“: additional reflections, increasing low frequency energy density

- system is used daily !!

Room Acoustic for Multipurpose Halls

electronic architecture - Carmen

CARMEN, 1998

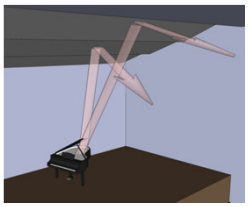
developed by Vian, France

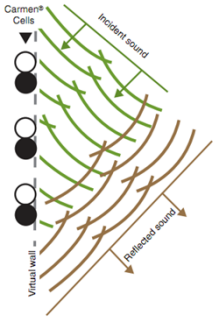
regenerative system - active wall principle

- each unit is equipped with microphone, processor/amplifier and loudspeaker
- a quantity of units is used to built an „active wall“

- each cell captures and renders
- sounds in real time

- a digital processing unit handles the signals in real time



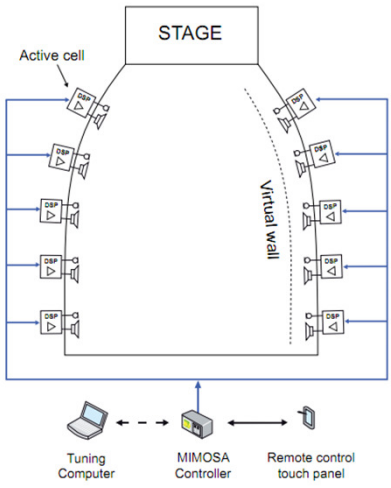


Carmen®

Room Acoustic for Multipurpose Halls

electronic architecture - Carmen

CARMEN, 1998



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Room Acoustic for Multipurpose Halls

electronic architecture - AFC

Active Field Control AFC, 2003

- developed by Yamaha Corp.

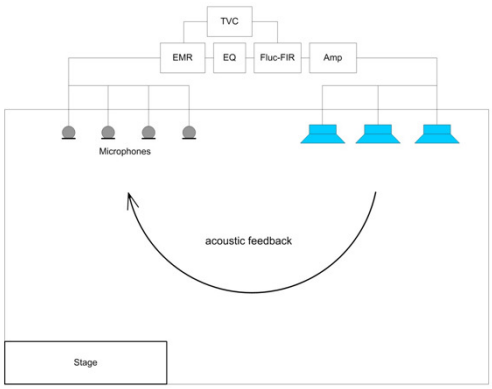
regenerative system

- uses an array of 4 or 8 omnidirectional microphones, installed outside reverberation radius
- microphone spacing should be at least half the wave length of the lowest reproduced frequency
- signals are fed to a so-called „microphone rotator“ that changes input and output combinations periodically every 1/3 second to 2 seconds
- FIR filtering (fluc FIR) is used to control feedback further by moving each FIR tap periodically
- Two systems are used: early reflections and reverberation field

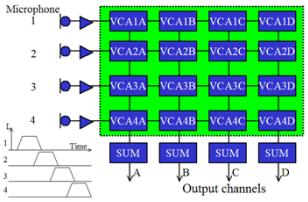
Room Acoustic for Multipurpose Halls

electronic architecture - AFC

Active Field Control AFC

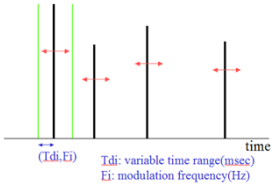


EMR electronic microphone rotator



Fluc-FIR Filter

Each FIR tap moves periodically on time axis



Tdi: variable time range(msec)
Fi: modulation frequency(Hz)

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Room Acoustic for Multipurpose Halls

electronic architecture - LARES - VIVA

Virtually Invisible Voice Amplification LARES VIVA, 2004

- developed by LARES Associates
- room acoustics system incorporating microphones, loudspeakers, and signal processing
- lifts the acoustic level in a conference room, to improve speech levels without visible microphones
- creates a natural room acoustic feeling
- microphones are located in ceiling and walls, even close to loudspeakers
- systems are custom designed, loudspeakers can also be used for sound playback (DVD)

image from LARES VIVA website

Room Acoustic for Multipurpose Halls

electronic architecture - VRAS

Meyer Sound, Constellation, 2005

- Meyer Sound entered the market of electronic architecture in 2005 after acquiring LCS Audio
- the former VRAS system is further developed and now called “Constellation”
- packaged system with certified Meyer Sound loudspeakers and certified microphones
- Each system is programmed and tuned only by certified Meyer Sound personnel

Constellation
ACOUSTIC SYSTEM

Room Acoustic for Multipurpose Halls

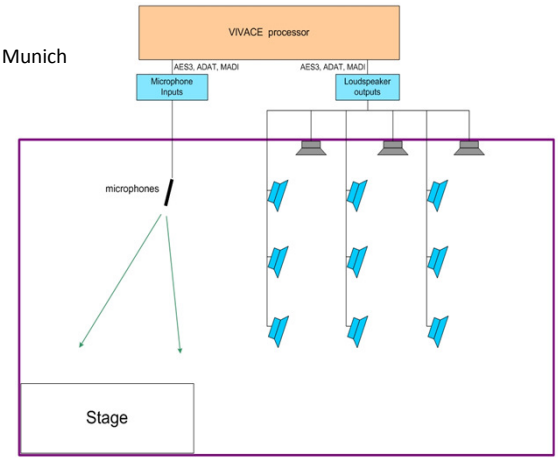
electronic architecture - VIVACE

Vivace, 2008

- developed by Mueller BBM, Munich
- marketing by Stagetec

non-regenerativ

- convolution algorithm
- input/output matrix in combination with sound reinforcement
- claim:
  "can recreate almost any environment in a low-reverberant space"



Room Acoustic for Multipurpose Halls

electronic architecture

All is perfect ??

.. some general problems

Room Acoustic for Multipurpose Halls

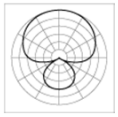
electronic architecture - microphones

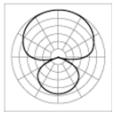
Problems with directional stage microphones in non-regenerative systems

- proximity effect
- different on-axis / off-axis frequency response
- different on-axis / off-axis pick-up levels

- pick-up area on stage must be defined !
- walking in and out of the preferred area on stage will change the sound


cardioid


supercardioid

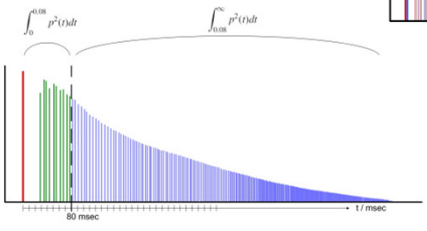

hypercardioid

Room Acoustic for Multipurpose Halls

energy deficits with non-regenerative systems

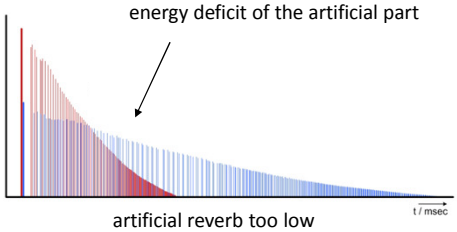
Energy deficits in non-regenerative systems

because of insufficient gain before feedback the reverberation is not effective enough



$$C_{80} = 10 \log\left(\int_0^{0.08} p^2(t)dt \Big/ \int_{0.08}^{\infty} p^2(t)dt\right)$$

energy deficit of the artificial part



artificial reverb too low
= low EDT + high C80

if too low:

it doesn't combine with the natural acoustic, sounds like an effect

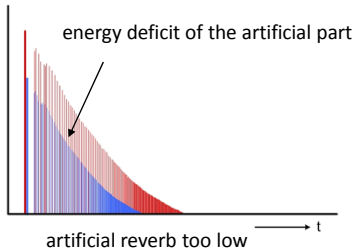
it cannot increase EDT and cannot decrease C80

Room Acoustic for Multipurpose Halls

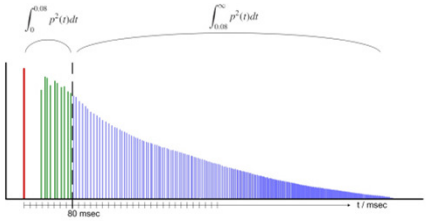
energy deficits with regenerative systems

Energy deficits in regenerative systems

because of insufficient gain before feedback the inserted reverberation is not effective enough



artificial reverb too low
= low EDT + high C80



$$C_{80} = 10 \log\left(\int_0^{0.08} p^2(t)dt \Big/ \int_{0.08}^{\infty} p^2(t)dt\right)$$

if too low:

it doesn't combine with the natural acoustic, is not audible

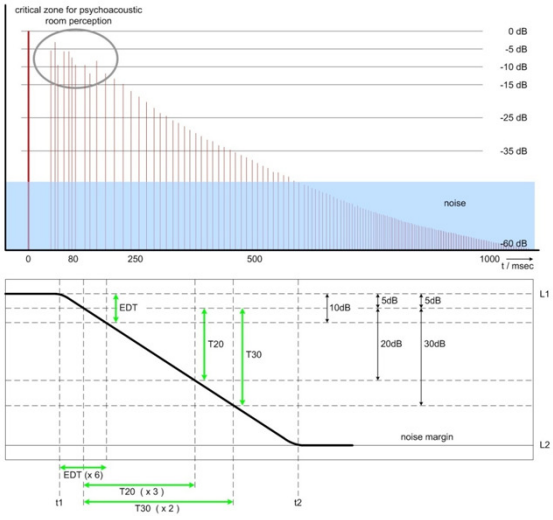
it cannot increase EDT and cannot decrease C80

Room Acoustic for Multipurpose Halls

problems with early lateral energy

Early lateral energy

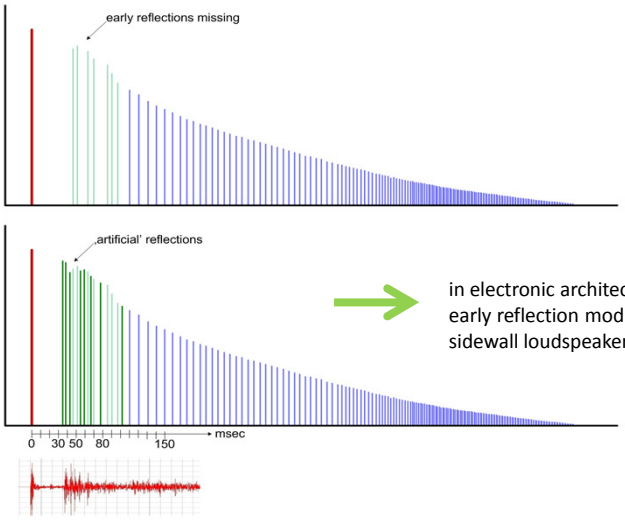
the most decisive reverberation range in electronic architecture



Room Acoustic for Multipurpose Halls

problems with early lateral energy

Early lateral energy

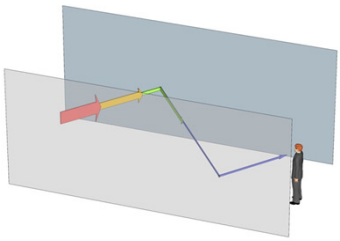


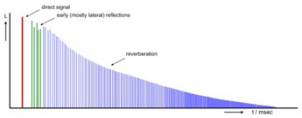
in electronic architecture:
early reflection modules +
sidewall loudspeakers

Room Acoustic for Multipurpose Halls

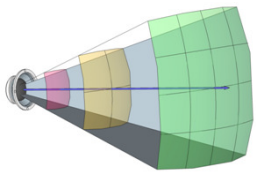
problems with early lateral energy

but ... reflections react like any other sound and follow the inverse square law !





each distance doubling = - 6dB level !



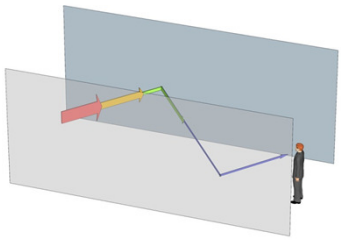
the longer the travelling path of the reflected sound is, the smaller is the relative level decrease per distance

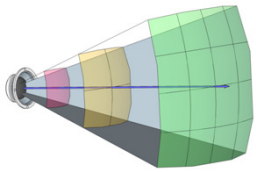
a regular loudspeaker with 6dB level reduction per doubling, imitating the later part of a reflection will create not the same energy distribution !

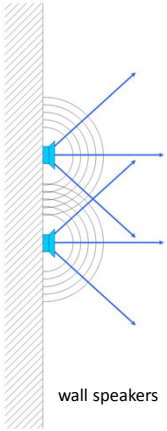
Room Acoustic for Multipurpose Halls

problems with early lateral energy

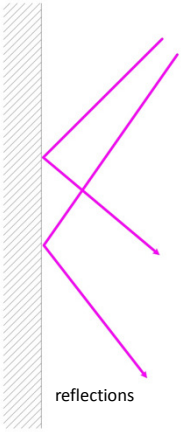
reflections must have always a longer total travelling path than a reflection simulating loudspeaker (double or more!)







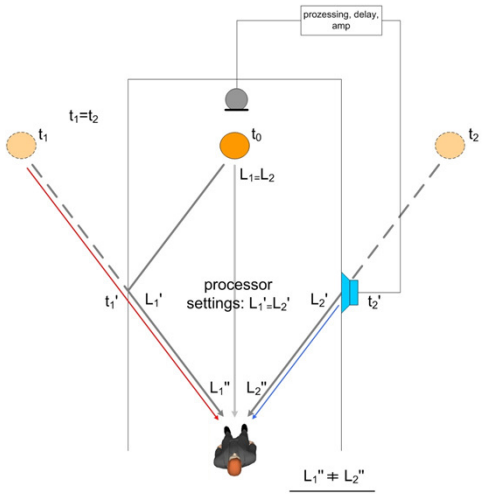
wall speakers



reflections

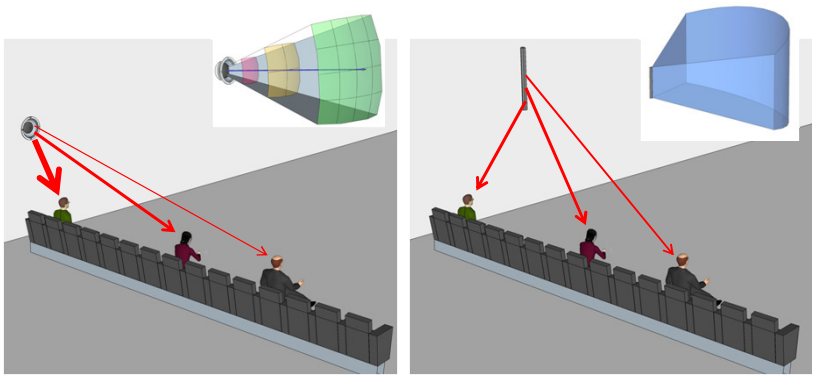
Room Acoustic for Multipurpose Halls

problems with early lateral energy



Room Acoustic for Multipurpose Halls

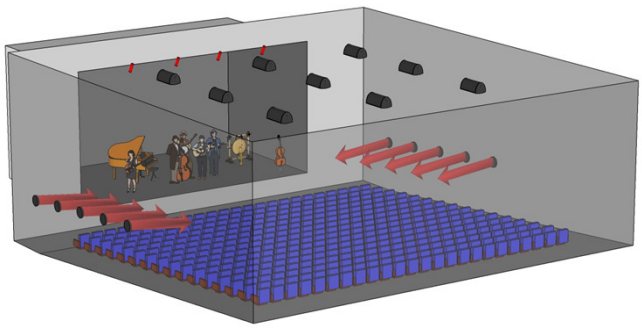
problems with early lateral energy



line source speakers can improve the situation drastically - but are still not perfect !

Room Acoustic for Multipurpose Halls

problems with early lateral energy



line source speakers can improve the situation drastically - but are still not perfect !

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Room Acoustic for Multipurpose Halls

electronic architecture

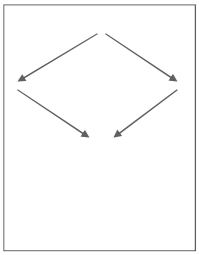
Some typical room deficits and their "repair" …

using electronic architecture

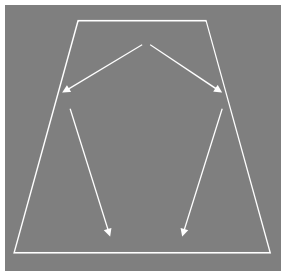
Room Acoustic for Multipurpose Halls

deficits and repairs – fan shaped rooms

The ‚Fan-Shape' form was introduced in the mid 20th century
more seats with equal distance to the stage



'Shoe Box' concept



'Fan Shape' concept

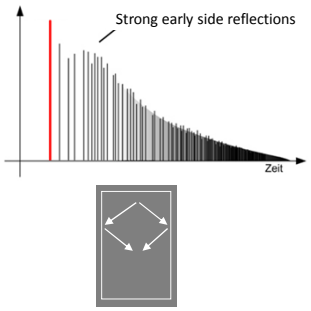
Staatstheater Darmstadt

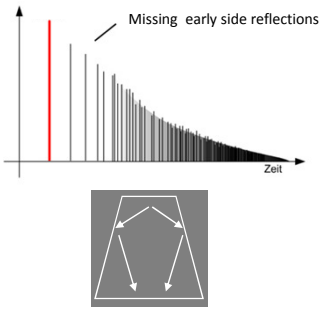
More seats, more tickets,
but less side reflections ….

Room Acoustic for Multipurpose Halls

deficits and repairs – fan shaped rooms

Too few early side reflections result in uneven and poor perception of the hall‘s acoustic

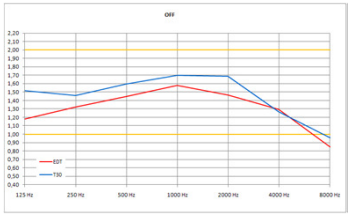


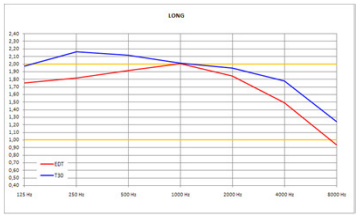


Room Acoustic for Multipurpose Halls

deficits and repairs – unbalanced absorption

Hljómahöllin Musical and Conference Centre, Keflavik / Island - variable room acoustic





adding mostly low frequency energy

Room Acoustic for Multipurpose Halls

electronic architecture

Don't we have also another problem ?

R. Vermeulen stated already in 1958:

'Under no circumstances must the public become aware of the use of loudspeakers, for their reputation has become so bad by misuse that the mere suggestion that they are present can spoil appreciation of the performance, even when they are not in use.'

As good as these systems can work, the acceptance by musicians and the audience is still not always positive !

Here **we** have something to do !!!

Room Acoustic for Multipurpose Halls

electronic architecture

Thank you very much !