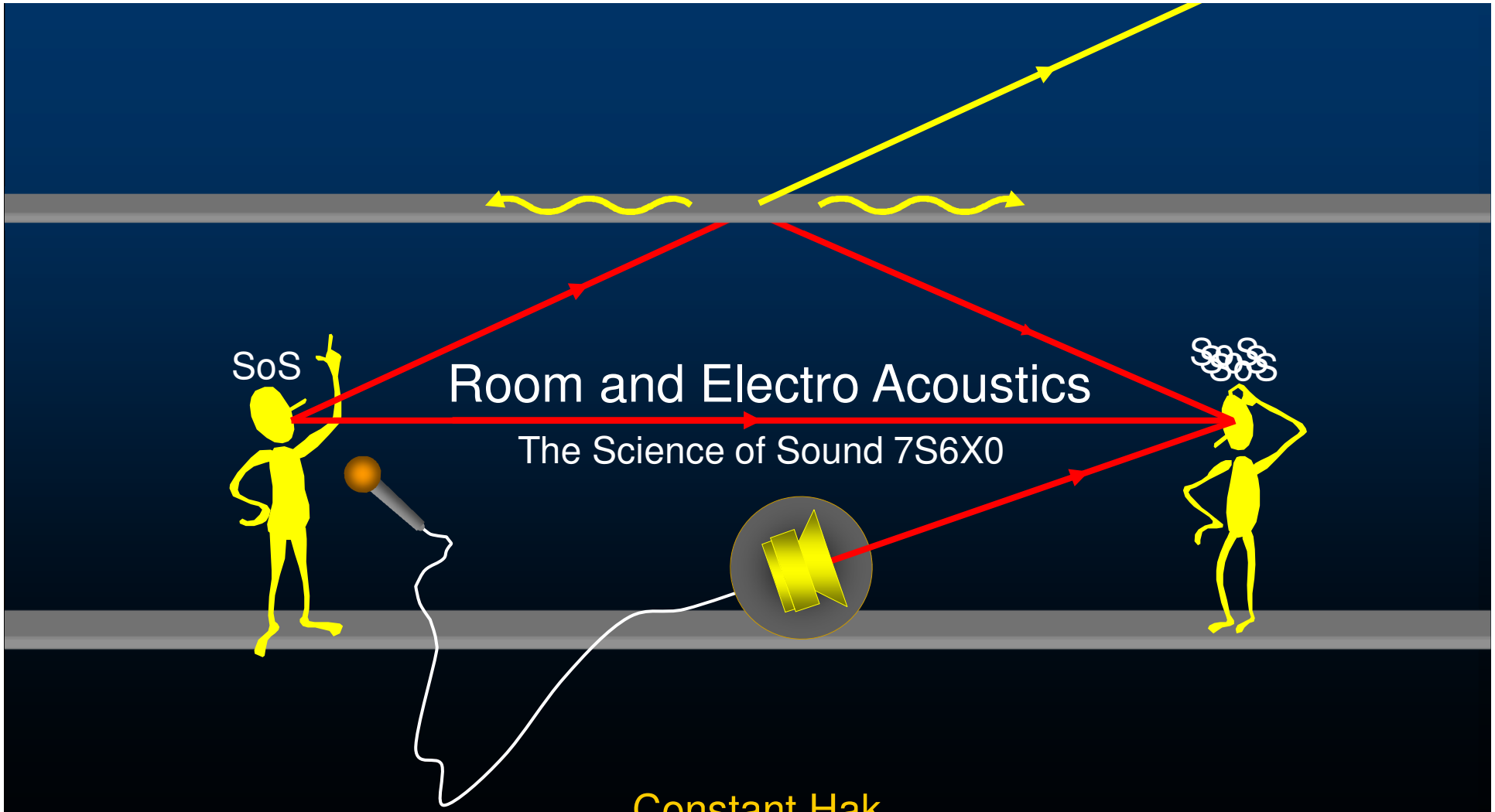

Room and Electro Acoustics

The Science of Sound 7S6X0

Constant Hak

Eindhoven University of Technology
Department of Architecture, Building and Planning
Unit Building Physics and Services

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Introduction

Room and Electro Acoustics

"The Science of Sound" Rossing Moore and Wheeler (Addison-Wesley, 2001)

Detailed information:

Auditorium Acoustics	Chapter 23
Electro Acoustics	Chapter 24
Acoustics of small rooms	Chapter 25.1

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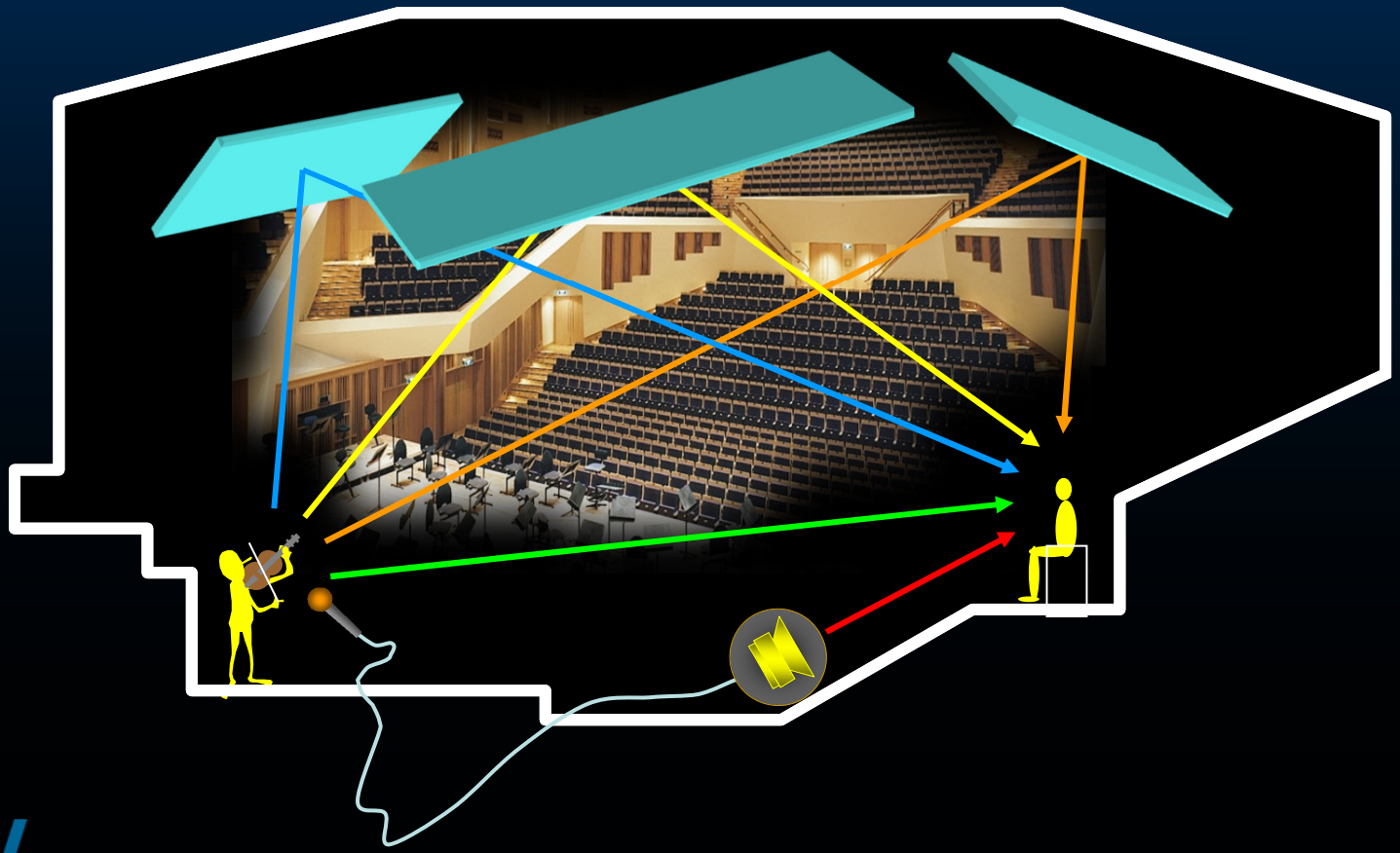
Electro Acoustics

Feedback



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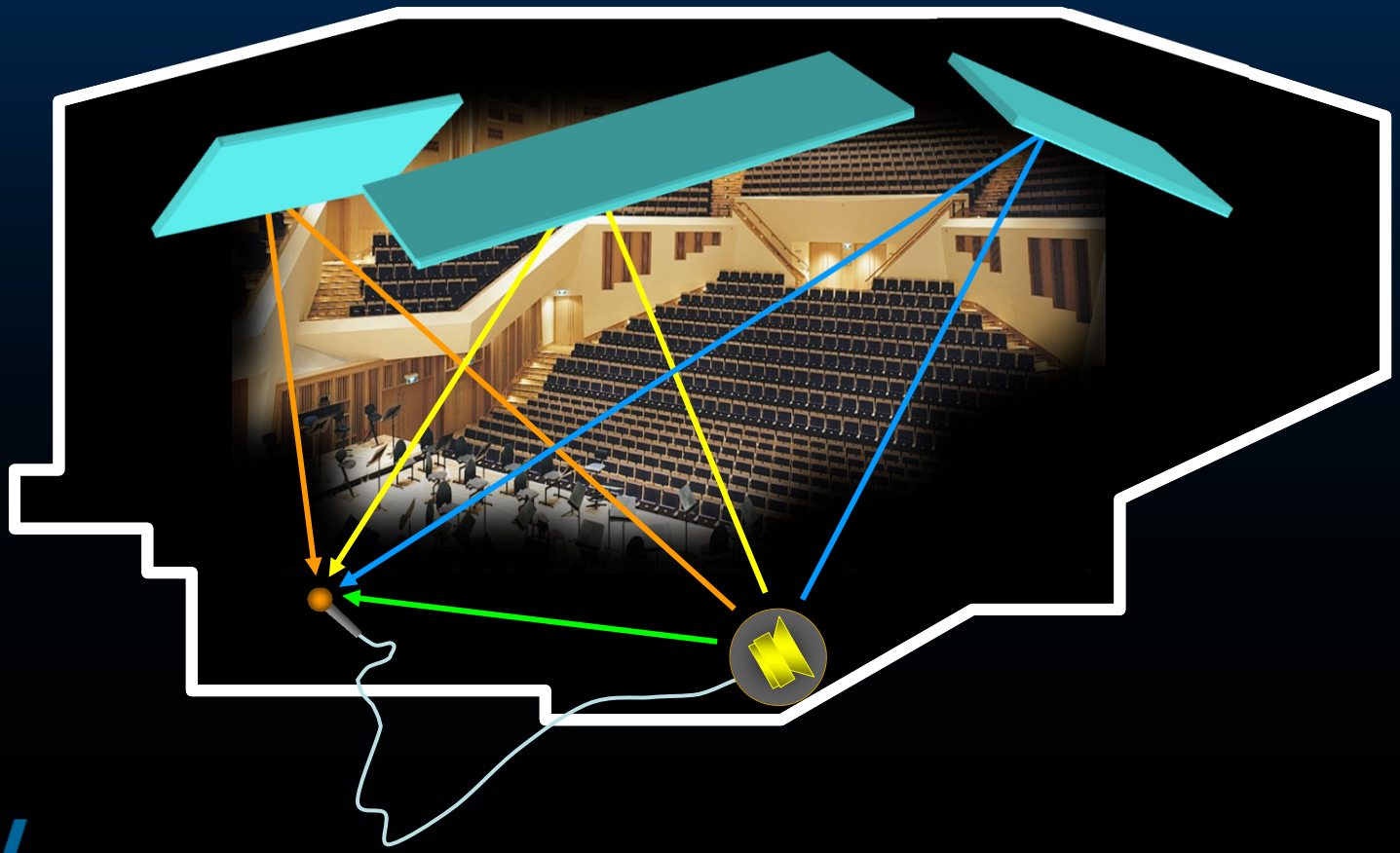
Electro Acoustics

Feedback



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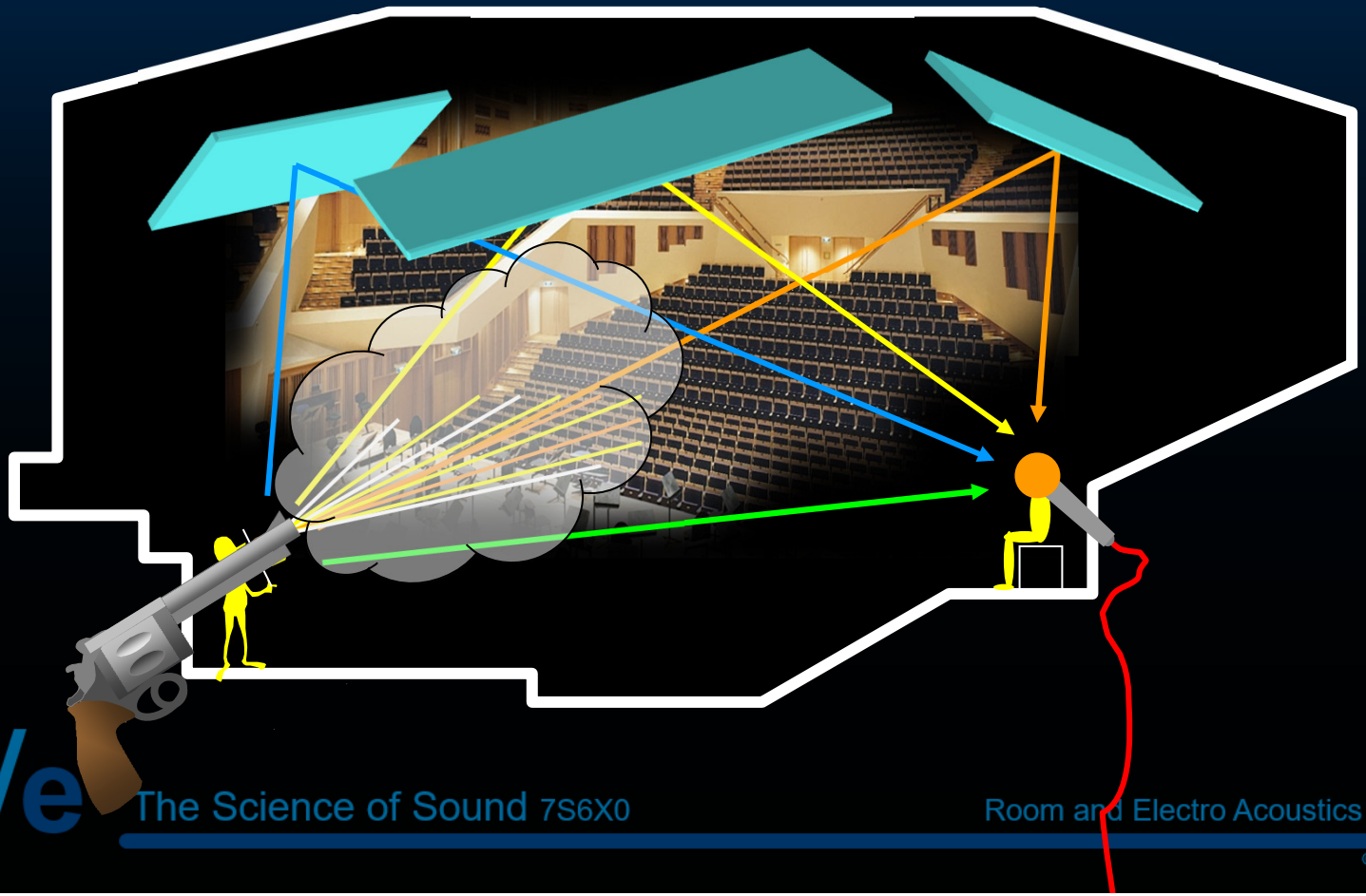
Room Acoustics

Concert hall



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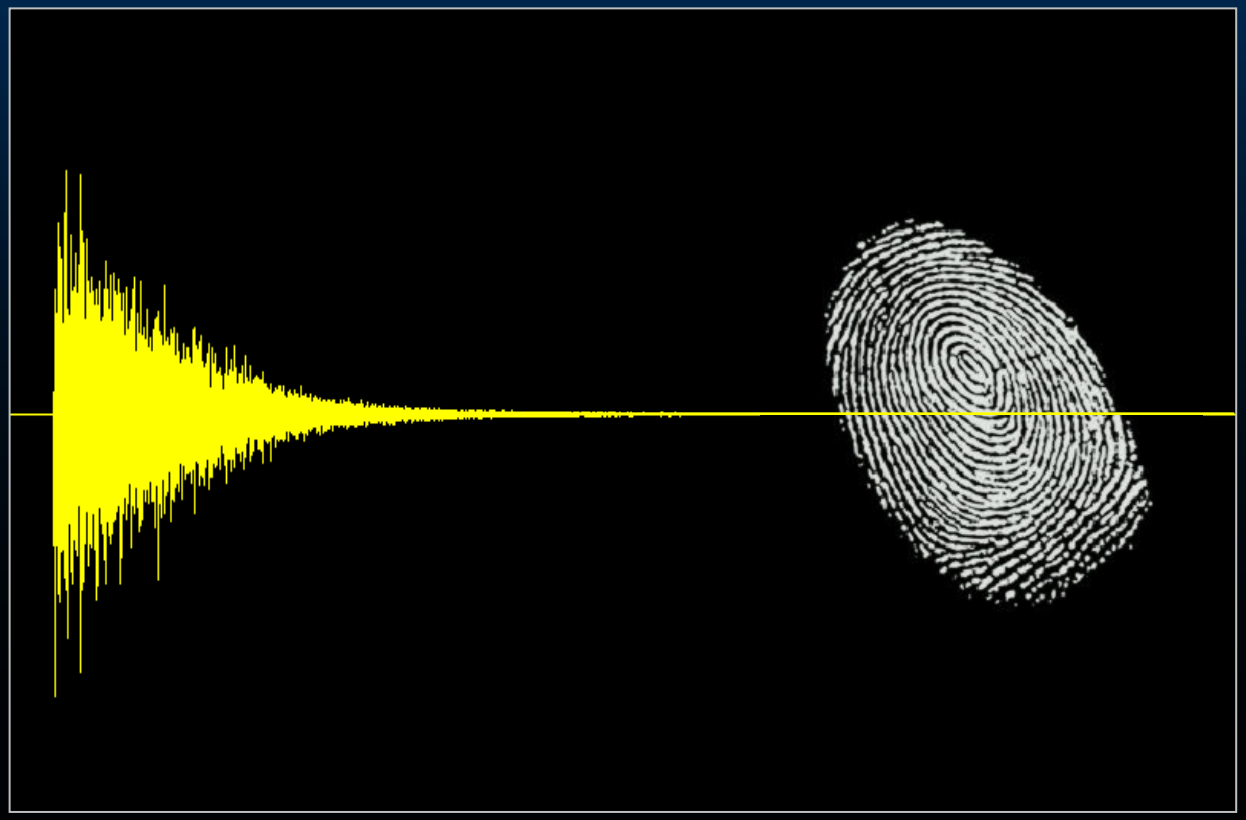
Room Acoustics

Fingerprint(s) of the hall



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Room Acoustics

What about:

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Room Acoustics

Answers:

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Room Acoustics

Describe the Fingerprint(s) of the Room

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Room Acoustics
Total number of Fingerprints

Concert hall:

1200 listeners + 80 Musicians
> 100.000 Fingerprints

Practically approx. 25
to describe a concert hall

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Acoustics Design

Reflection of sound

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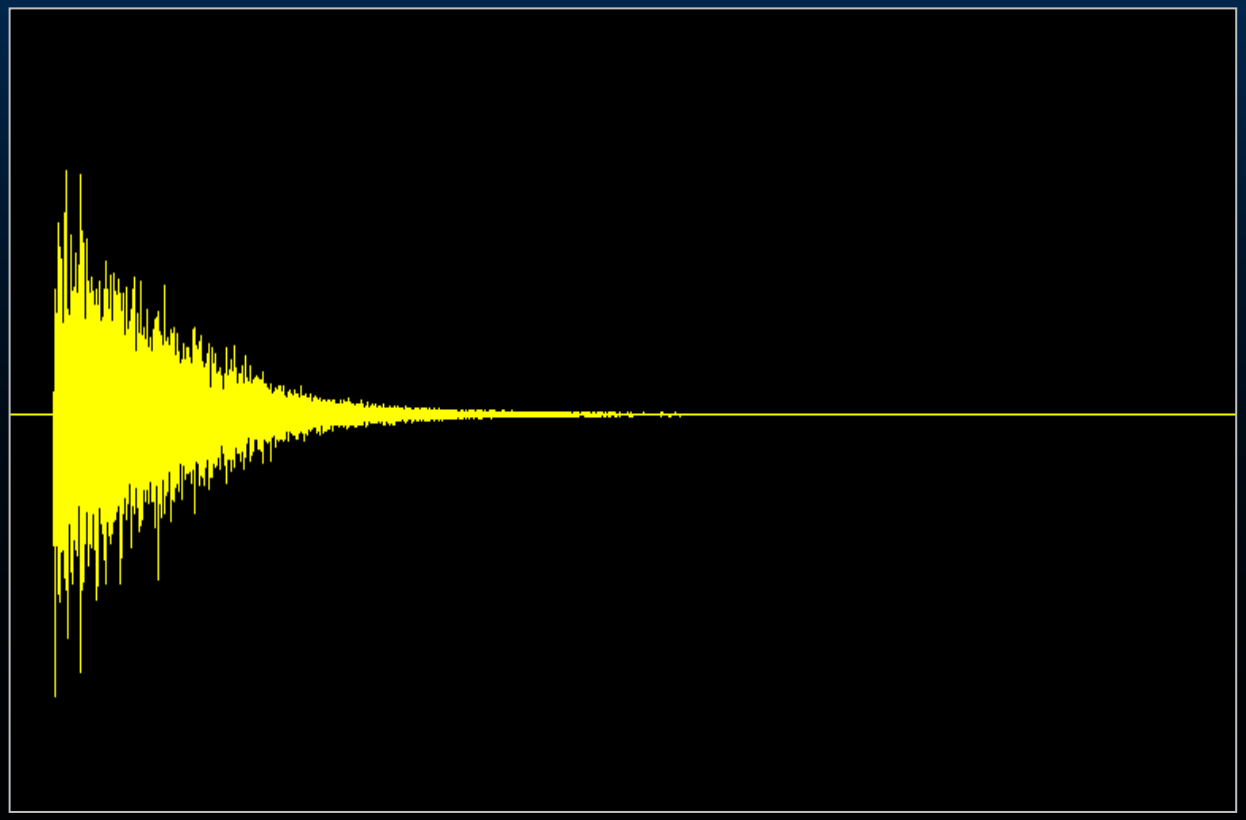
Room Acoustics

Room Impulse Response (RIR)



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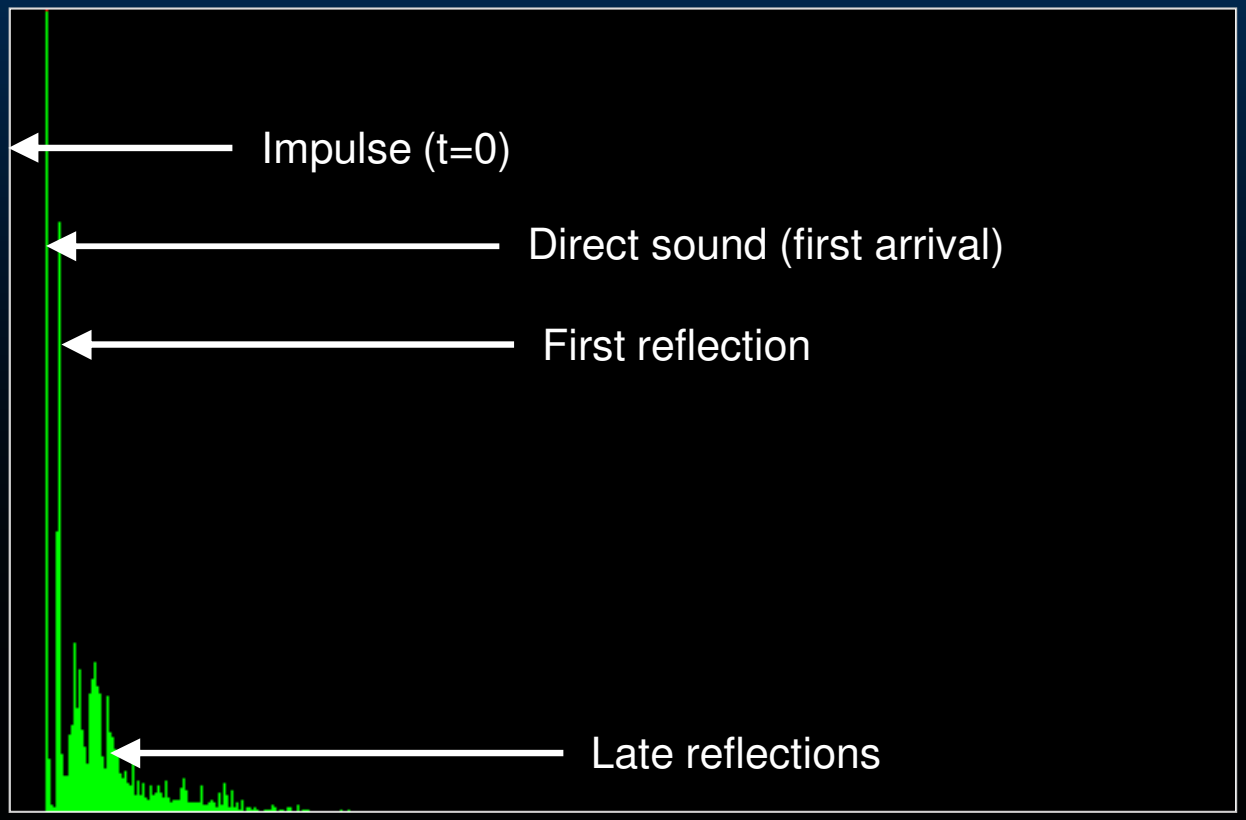
Room Acoustics
Reflectogram



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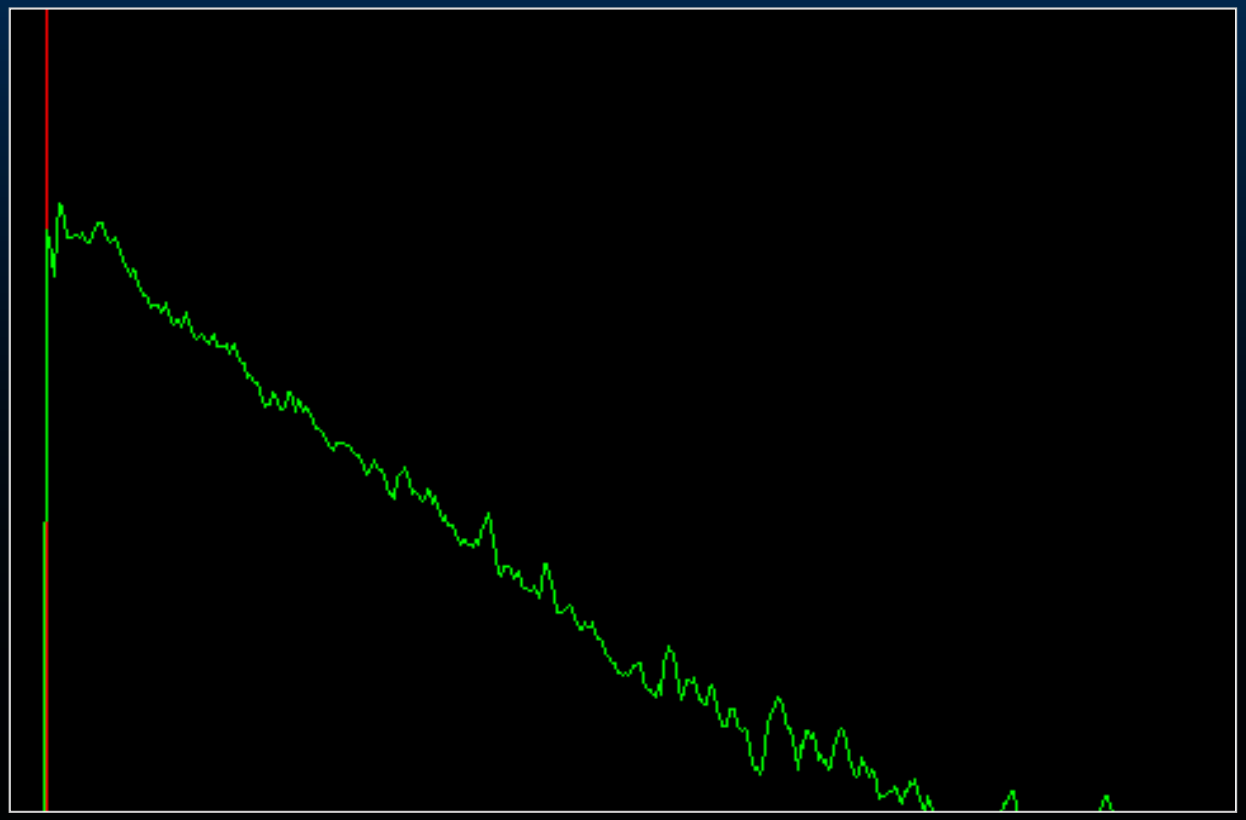
Room Acoustics

Energy Time Curve



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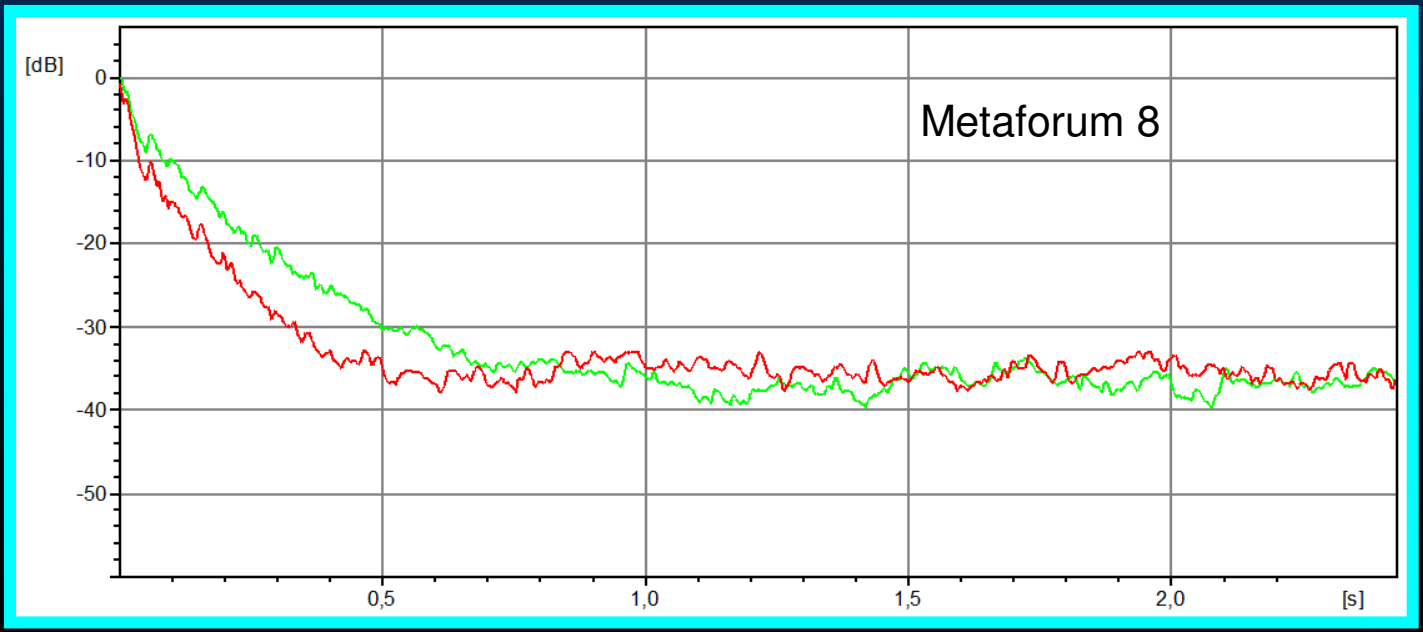
Room Acoustics

Energy Time Curve



zonder studenten: T_{gem} : 0,94 s
met studenten: T_{gem} : 0,49 s

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Reverberation Time RT

Sabins decay formula

$$w(t) = w_0 e^{\frac{-cAt}{4V}} \; for \; t > 0$$

$$RT = \frac{24 \ln 10}{c} \cdot \frac{V}{A}$$

$$\boxed{RT = 0.163 \frac{V}{A}}$$

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Reverberation Time RT
Sabins decay formula

$$w(t) = w_0 e^{\frac{-cAt}{4V}} \; for \; t > 0$$

$$RT = \frac{24 \ln 10}{c} \cdot \frac{V}{A}$$

$$RT = 0.163 \frac{V}{A}$$

$$\boxed{RT = 0.163 \frac{V}{A + 4mV}}$$

If air absorption is significant

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Reverberation Time RT
Sound absorption (coefficient)

$$A = \sum_{i=1}^{n} \alpha_i S_i$$

total sound absorption [m^2 O.R.]

sound absorption coefficient of partial surface I [-]

partial Surface i [m^2]

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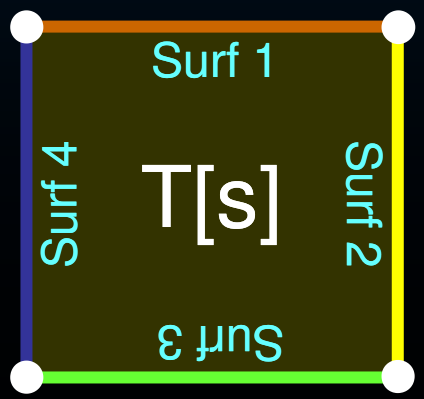
Intermezzo

Reverberation Time RT

Sound absorption

$$RT = \frac{V}{6A}[s]$$

$$A_{tot} = \sum_{surf\ i=1}^{surf\ i=n} Opp_i \cdot \alpha_i \ [m^2 O.R.]$$



tabels
manufacturers
internet
readers
books
etc.

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Reverberation Time RT
Eyring's formula

$$w(t) = w_0 e^{\frac{-cSt}{4V}\ln(1-\bar{\alpha})-mct}$$

$$\boxed{RT = 0.163\frac{V}{4mV - S\ln(1-\bar{\alpha})}}$$

$$for\ \alpha << 1 \quad \ln(1-\bar{\alpha}) \approx -\bar{\alpha} \rightarrow Sabin$$

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Sound Absorption

Contents

- Introduction/definitions
- Porous materials
- Panel constructions
- Helmholtz resonators

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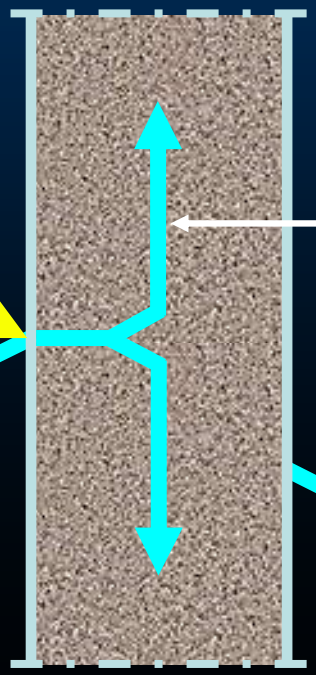
Sound Absorption

Absorption coefficient definition



$$I_i = I_r + I_a + I_d$$

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Sound Absorption

Absorption coefficient definition

$$I_i = I_r + I_a + I_d$$

(dividing by I_i)

$$1 = \rho + \delta + \tau$$

- τ — transmission coëfficiënt
- δ — dissipation coëfficiënt
- ρ — reflection coëfficiënt

Absorption coefficient α:

$$\alpha = \delta + \tau = 1 - \rho$$

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Sound Absorption

Porous materials

Absorption depends on:

- porosity (flow resistance)
- pore structure
- thickness
- frequency

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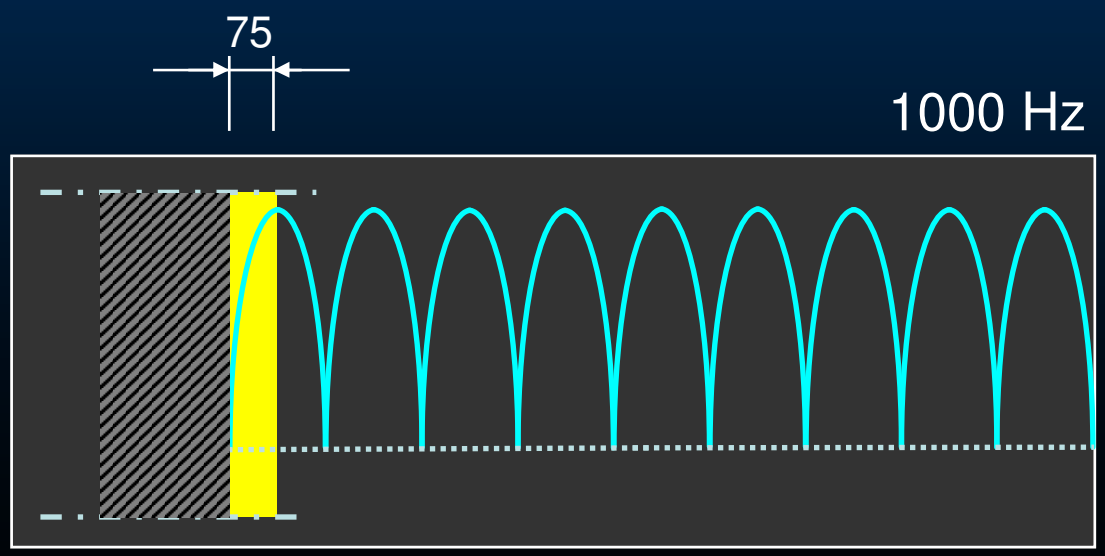
Sound Absorption

Porous materials: thickness & placement



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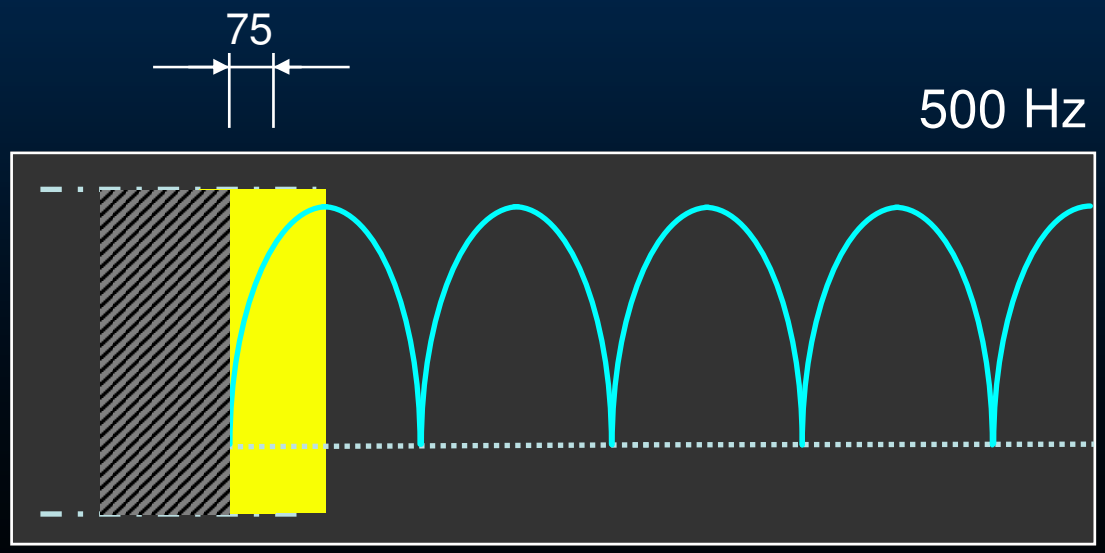
Sound Absorption

Porous materials: thickness & placement



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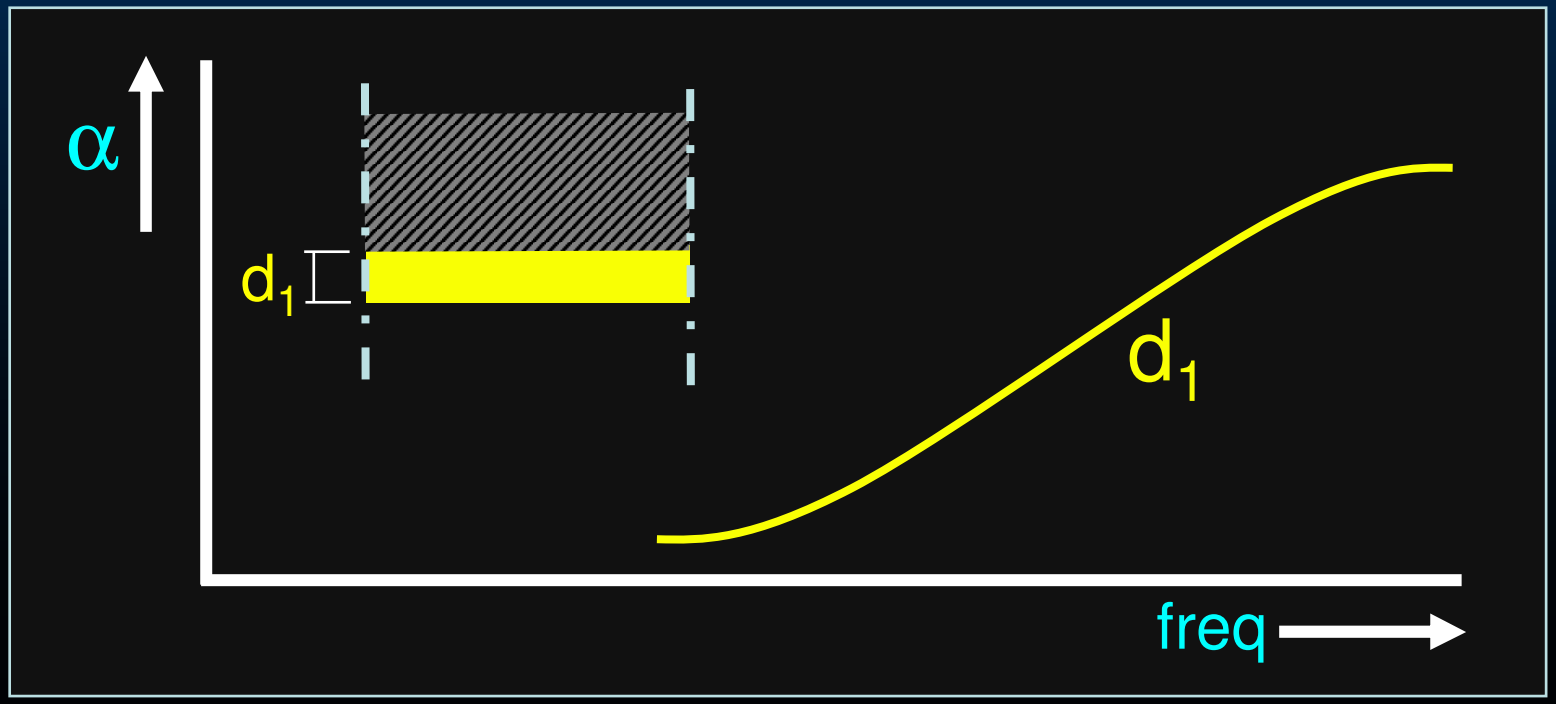
Sound Absorption

Porous materials: thickness & placement



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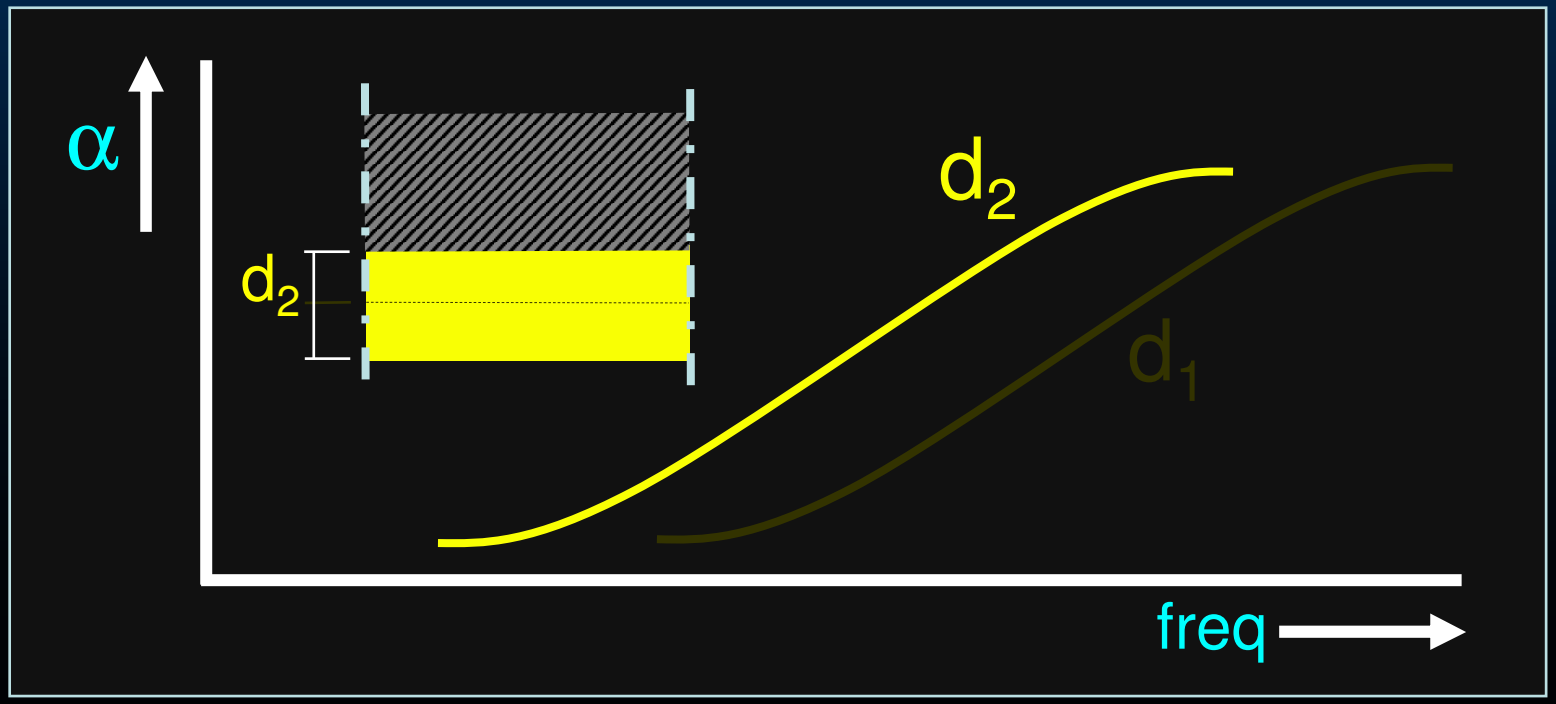
Sound Absorption

Porous materials: thickness & placement



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Sound Absorption

Panel constructions

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1{,}4 \cdot P_s}{m \cdot d}} \quad [\mathrm{Hz}]$$

f_0	= resonance freq.	[Hz]
P_s	= static air pressure	[Pa]
m	= panel density	[kg/m^2]
d	= cavity depth	[m]

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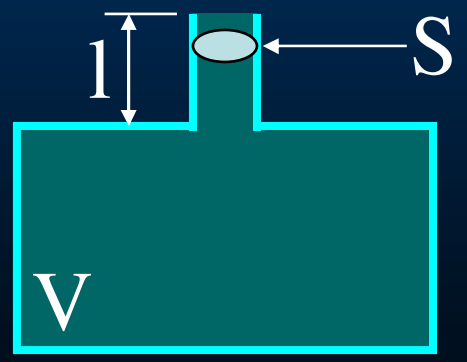
Sound Absorption

Helmholtz resonator (single)



$$f_0 = \frac{c}{2\pi}\sqrt{\frac{S}{l \cdot V}} \; [\mathrm{Hz}]$$

f_0	= resonance freq.	[Hz]
c	= speed of sound	[m/s]
S	= cross section	[m²]
l	= channel length	[m]
V	= Volume	[m³]

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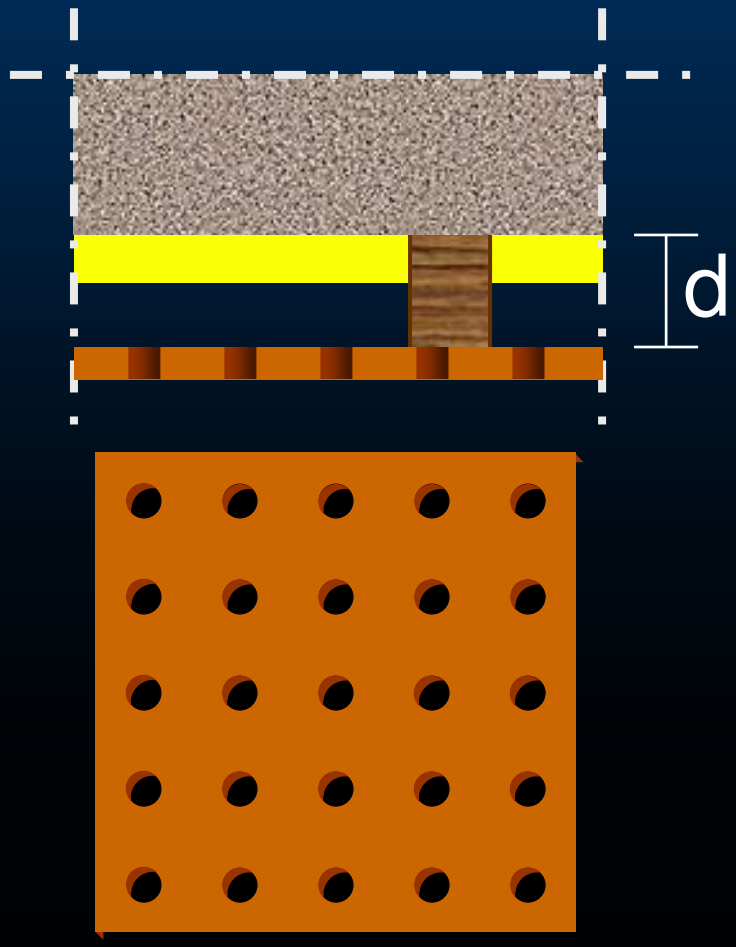
Sound Absorption

Helmholtz resonators (perforated panel)



$$f_0 = \frac{c}{2\pi}\sqrt{\frac{P}{(t+1{,}6r)\,d}}\ [\mathrm{Hz}]$$

f_0	= resonance freq.	[Hz]
c	= speed of sound	[m/s]
P	= perforation rate	[-]
t	= plane thickness	[m]
r	= hole radius	[m]
d	= cavity depth	[m]

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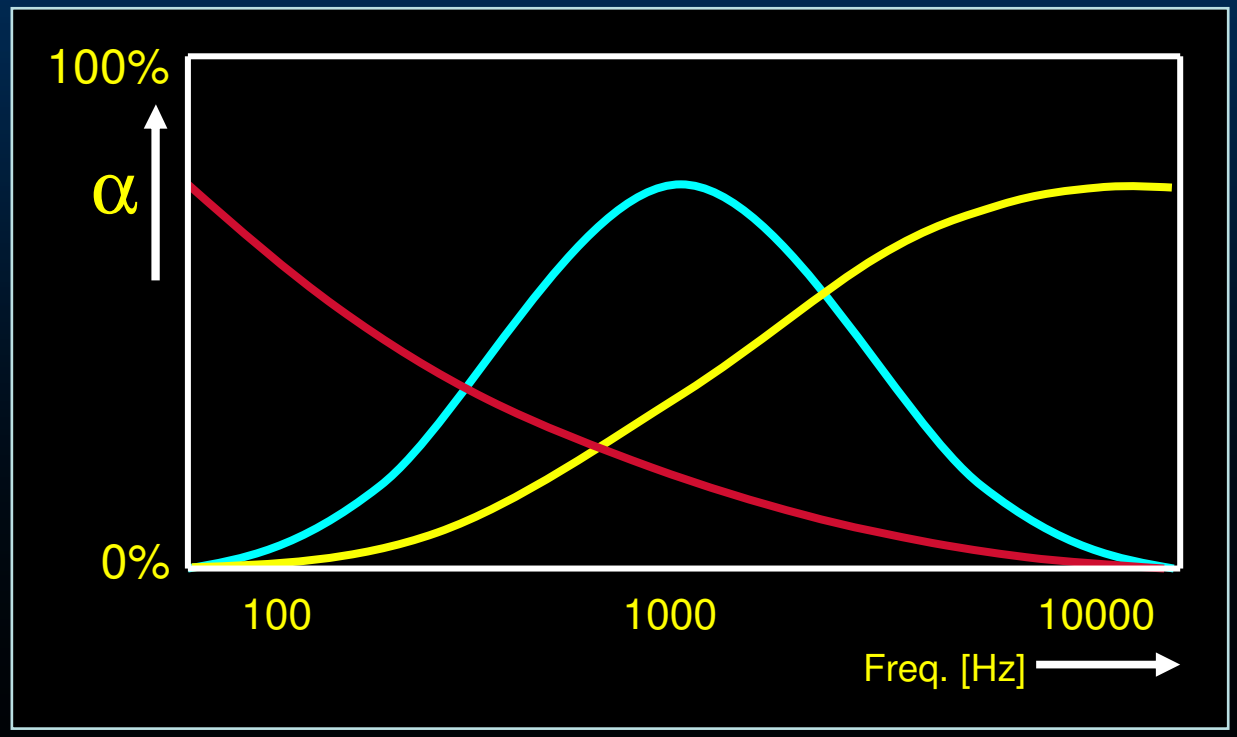
Sound Absorption

Overview



- Porous materials f > 1000 Hz
- Panel constructions 50 Hz < f < 500 Hz
- Perforated panels 300 Hz < f < 1500 Hz

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Concert Halls

Concertgebouw Amsterdam

Year built: 1887
Volume [m^3]: 18.700
Seats: 2200

RT [s] :

125	500	2000
2.2	2.1	1.8

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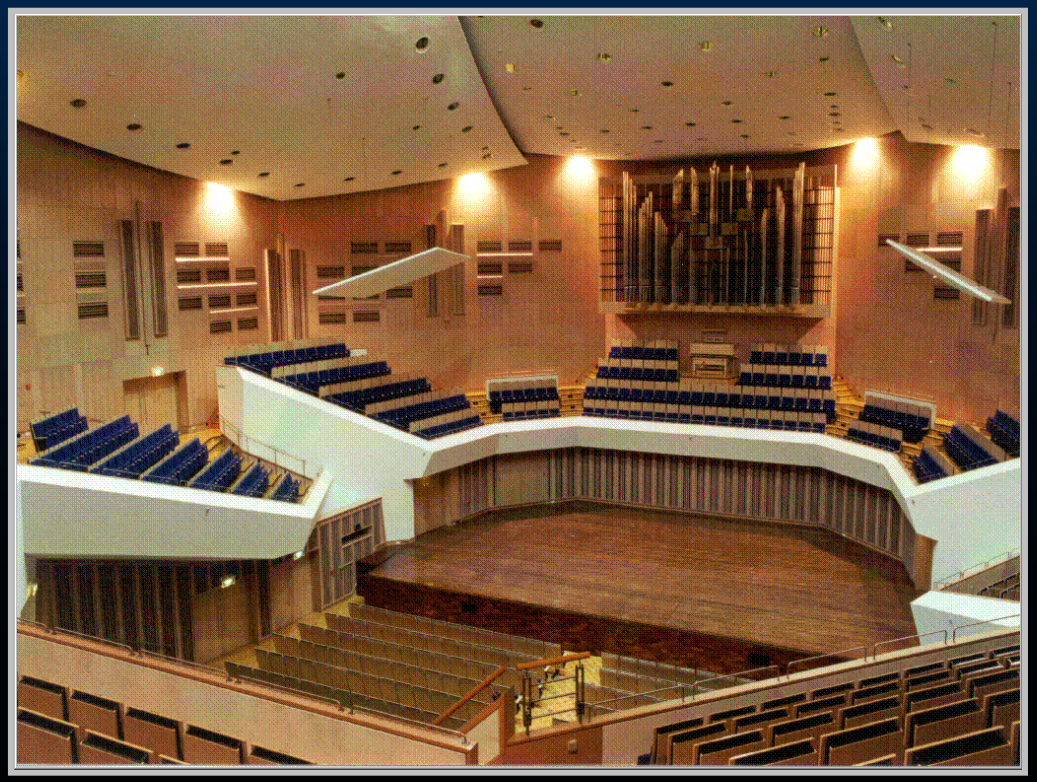
Concert Halls
Muziekgebouw Eindhoven



Year built: 1992
Volume [m^3]: 14.400
Seats: 1300

RT [s] :

125	500	2000
1.9	2.0	2.0

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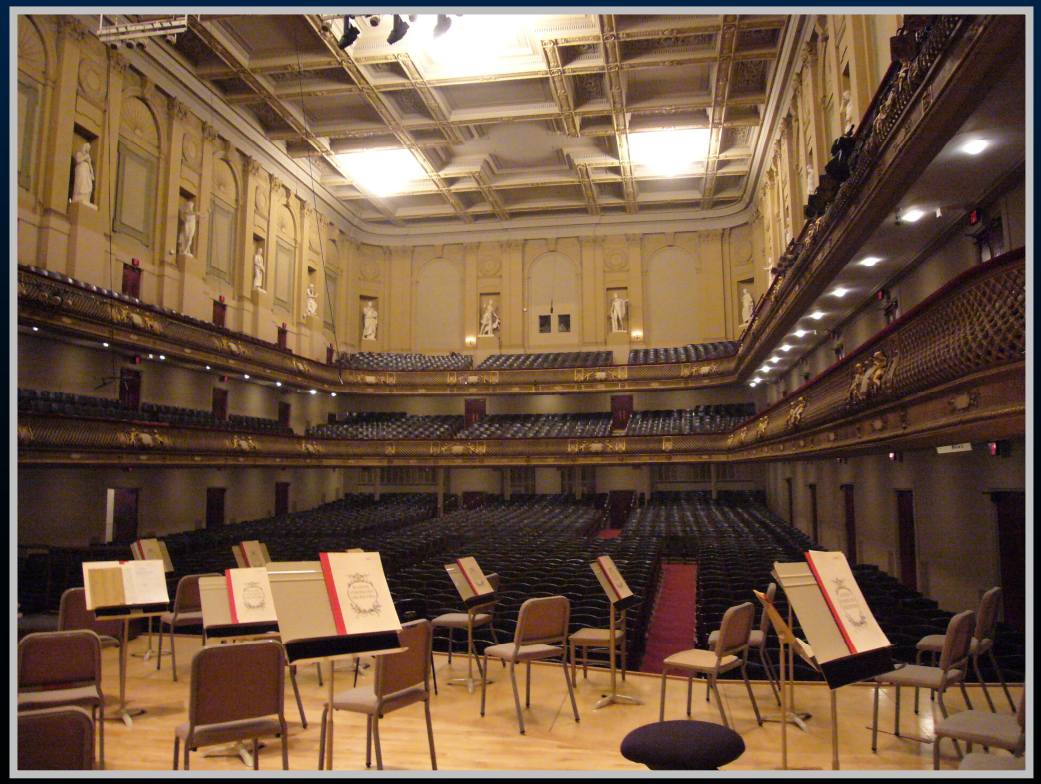
Concert Halls
Symphony Hall Boston



Year built: 1900
Volume [m^3]: 18.740
Seats: 2580

RT [s] :

125	500	2000
2.2	1.8	1.7

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Sound Fields
Theoretical

- Direct Sound Field
- Diffuse Sound Field

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Sound Fields
Practical

- Direct Sound Field
- Direct/Diffuse Sound Field
- Diffuse Sound Field

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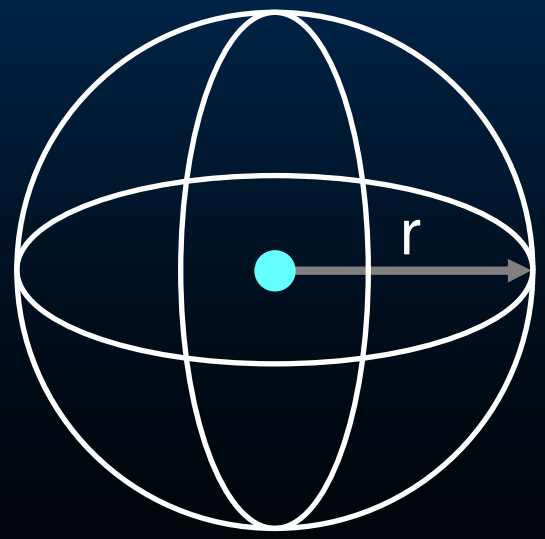
Direct Sound Field

Theoretical free field



Point Source

(Omnidirectional)

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Direct Sound Field

Theoretical free field

$$L_p = L_w + 10 \cdot \lg\left(\frac{1}{4\pi r^2}\right) \quad [\mathrm{dB}]$$

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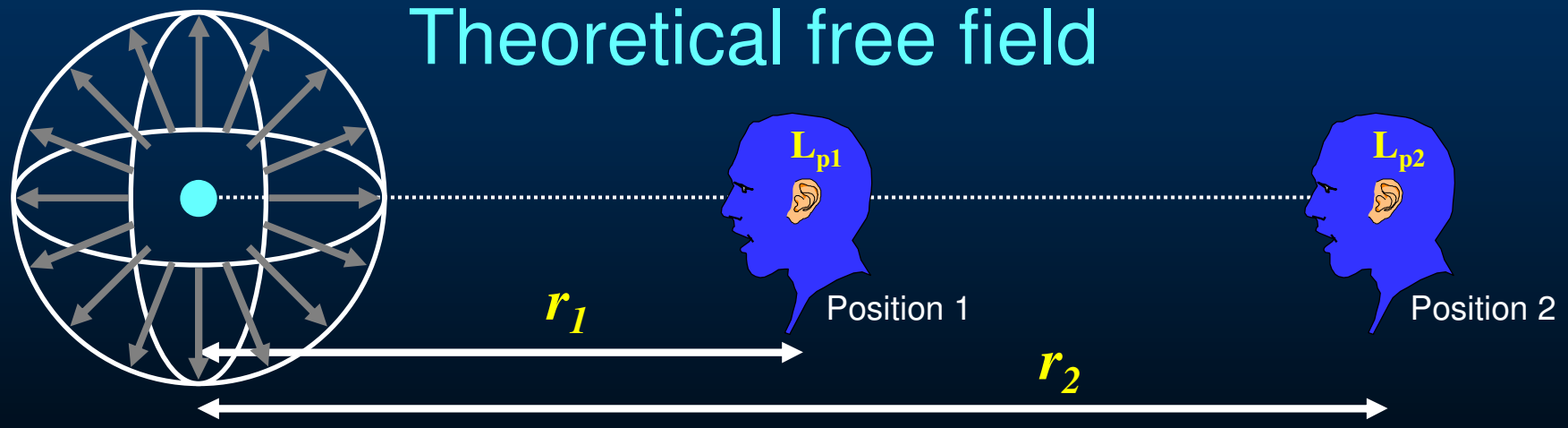
Direct Sound Field

Theoretical free field



$$L_{p1} - L_{p2} = 10 \cdot \lg\left(\frac{r_2^{\,2}}{r_1^{\,2}}\right)$$

If $r_2 = 2r_1$: $L_{p1} - L_{p2} = 10 \lg 4 = 6$ dB

- 6 dB per distance doubling !

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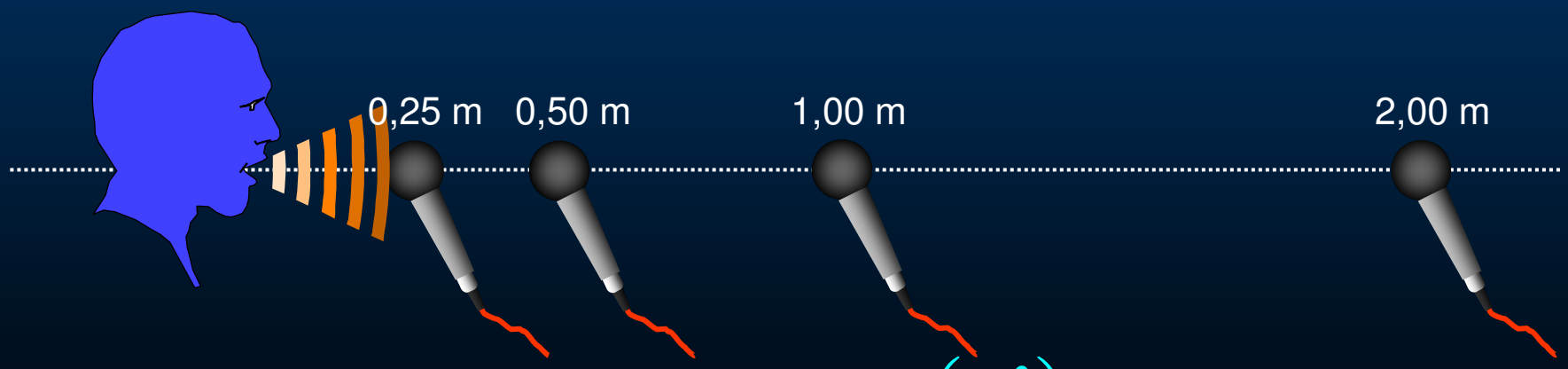
Direct Sound Field

Theoretical free field



$$L_{p1} - L_{p2} = 10 \cdot \lg\left(\frac{r_2^{\,2}}{r_1^{\,2}}\right)$$

Dus als $r_2 = 2r_1$: $L_{p1} - L_{p2} = 10 \lg 4 = 6$ dB

r [m]	0,25	0,5	1,0	2,0
L_p [dB]	0	-6	-12	-18

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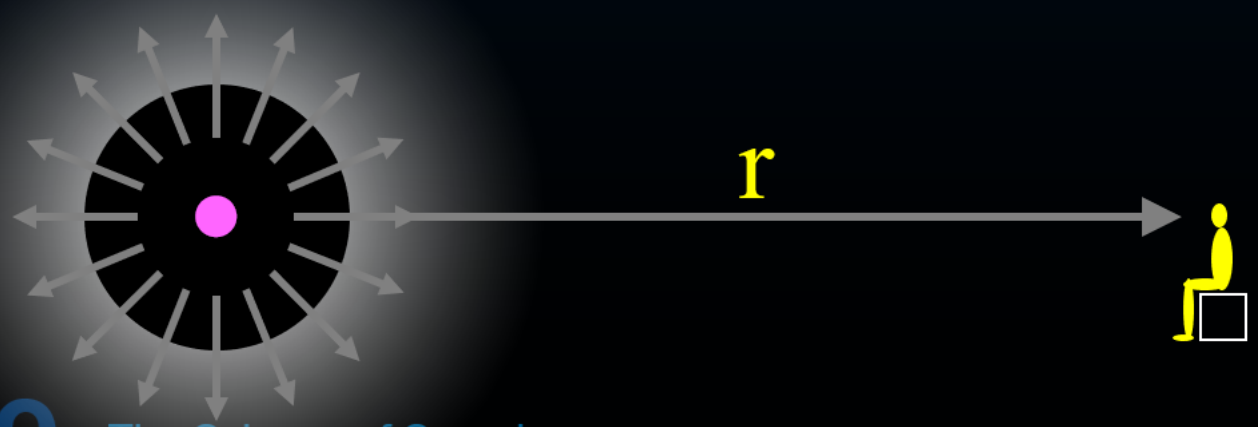
Direct Sound Field

Source in free field

- Sphere
- Q = 1
- + 0 dB

$$L_p = L_w + 10 \cdot \lg\left(\frac{Q}{4\pi r^2}\right)$$



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Direct Sound Field

Source on reflective surface

- 1/2 sphere
- Q = 2
- + 3 dB

$$L_p = L_w + 10 \cdot \lg\left(\frac{Q}{4\pi r^2}\right)$$

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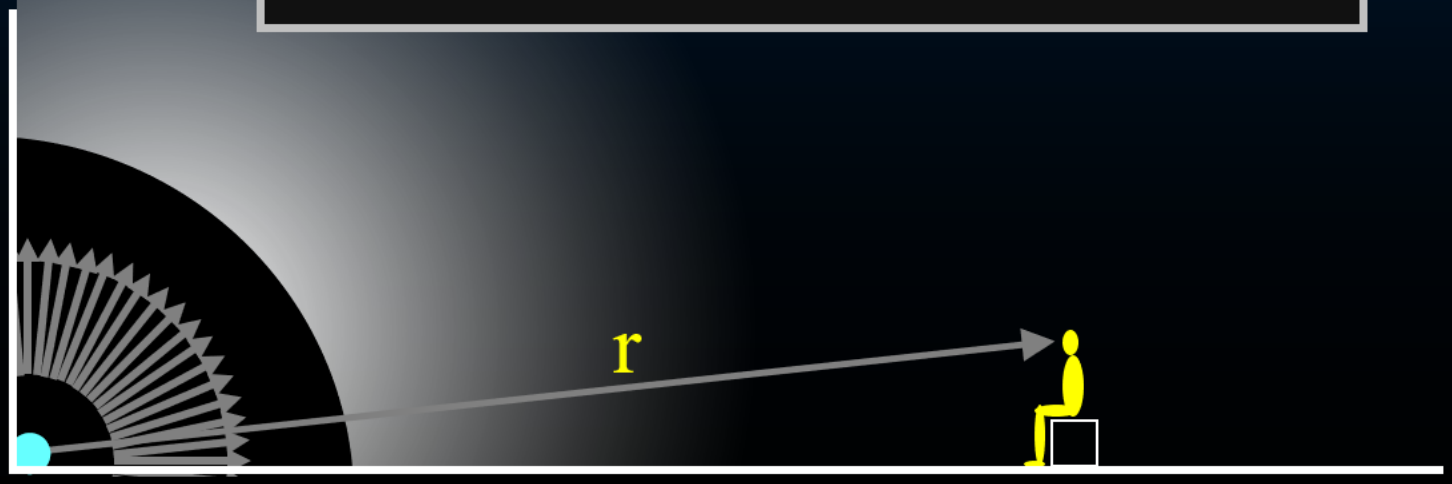
Direct Sound Field

Source in 90° corner

- 1/4 sphere
- Q = 4
- + 6 dB

$$L_p = L_w + 10 \cdot \lg\left(\frac{Q}{4\pi r^2}\right)$$



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Diffuse Sound Field

Reverberant room

$$L_p = L_w + 10 \cdot \lg\left(\frac{4}{A}\right)$$

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Direct/Diffuse Sound Field

Normal room

$$L_{p_{dir}} = L_W + 10\lg\frac{Q}{4\pi r^2}$$

$$L_{p_{diff}} = L_W + 10\lg\frac{4}{A}$$

$$\boxed{L_{p_{dir+diff}} = L_W + 10\lg\left(\frac{Q}{4\pi r^2} + \frac{4}{A}\right)}$$

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Sound Field

Source and receiver directivity

$$Q = Q_s \cdot Q_r$$

$$L_p = L_w + 10 \cdot \lg\left(\frac{Q_s \cdot Q_r}{4\pi r^2} + \frac{4}{A}\right)$$

Q *directivity factor* [–]

$q = 10 \lg Q$ *directivity index* [*dB*]

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Sound Field

Direct field / Diffuse field

direct field $$L_{p_{direct}} = L_w + 10\lg\left(\frac{Q}{4\pi r^2}\right)$$

diffuse veld $$L_{p_{diffuus}} = L_w + 10\lg\left(\frac{4}{A}\right)$$

dir. + diff. field $$L_{p_{dir+diff}} = L_w + 10\lg\left(\frac{Q}{4\pi r^2} + \frac{4}{A}\right)$$

Critical distance $$L_{p_{dir}} = L_{p_{diff}} \quad \Rightarrow \quad r_k = \sqrt{\frac{QA}{16\pi}}$$

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Loudpeaker

Onmi versus high directivity

Rule of thumb:

$$Q = \frac{lengte\,[m] \cdot freq\,[Hz]}{100}$$

$$Q = \frac{1\,m \cdot 1000\,[Hz]}{100} = 10$$

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‘Small’ Rooms

Introduction

Small rooms	⟷	Large rooms/halls
Listening rooms		Concert halls
Sound studios		Theaters
Recording studios		Auditoriums
Audiometry rooms		Lecture halls

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‘Small’ Rooms

Introduction

- Music transfer
- Speech transfer
- Sound assessment
- Measurements

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‘Small’ Rooms

Introduction

Small rooms ⟷ Large rooms/halls

‘Large room condition’:

$$f > f_s = 2000\sqrt{\frac{T}{V}}$$

(f_s = Schroeder frequency)

V = 25 m^3
T = 1 s
f_s = 400 Hz

V = 13000 m^3
T = 2 s
f_s = 25 Hz

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‘Small’ Rooms

Introduction

$V = 3 \times 4 \times 2{,}5 = 25\ m^3$

$T = 1\ s$

$f_s = 400\ Hz$

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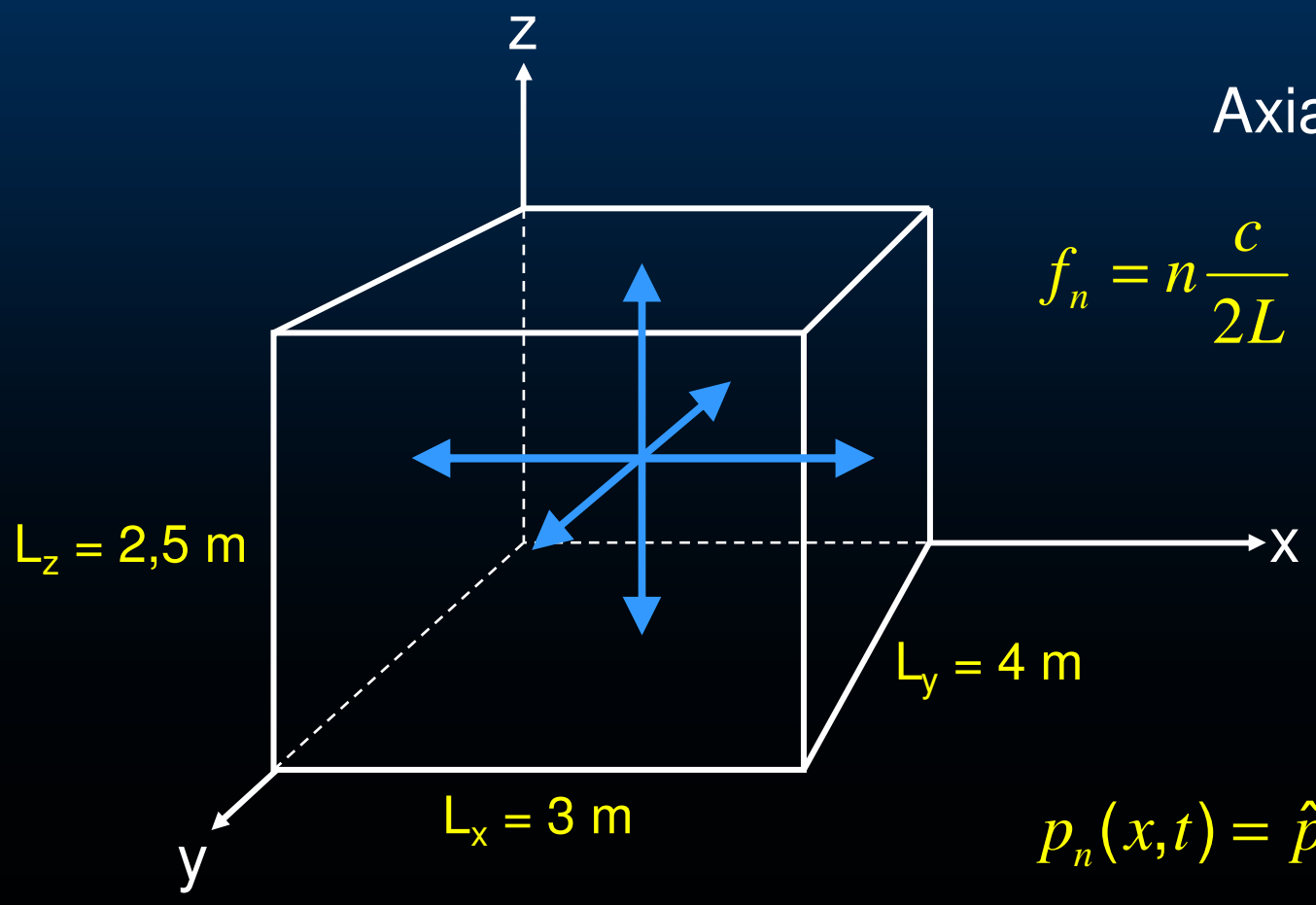
‘Small’ Rooms

Normal modes in small (rectangular) rooms



Axial modes:

$$f_n = n\frac{c}{2L} \quad (n = 0, 1, 2, \ldots)$$

$$p_n(x,t) = \hat{p}\cos\left(\frac{n\pi x}{L}\right)e^{j\omega_n t}$$

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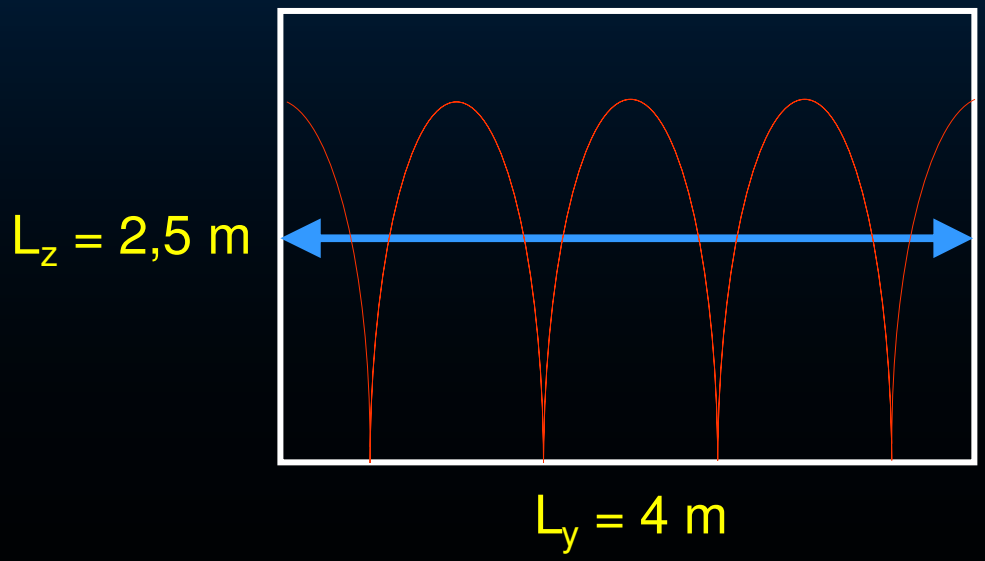
‘Small’ Rooms

Normal modes in small (rectangular) rooms



Axial mode:

$$f_4 = 4\frac{c}{2L} \quad (m = 4)$$

$$p_4(y,t) = \hat{p}\cos\left(\frac{4\pi y}{L}\right)e^{j\omega_4 t}$$

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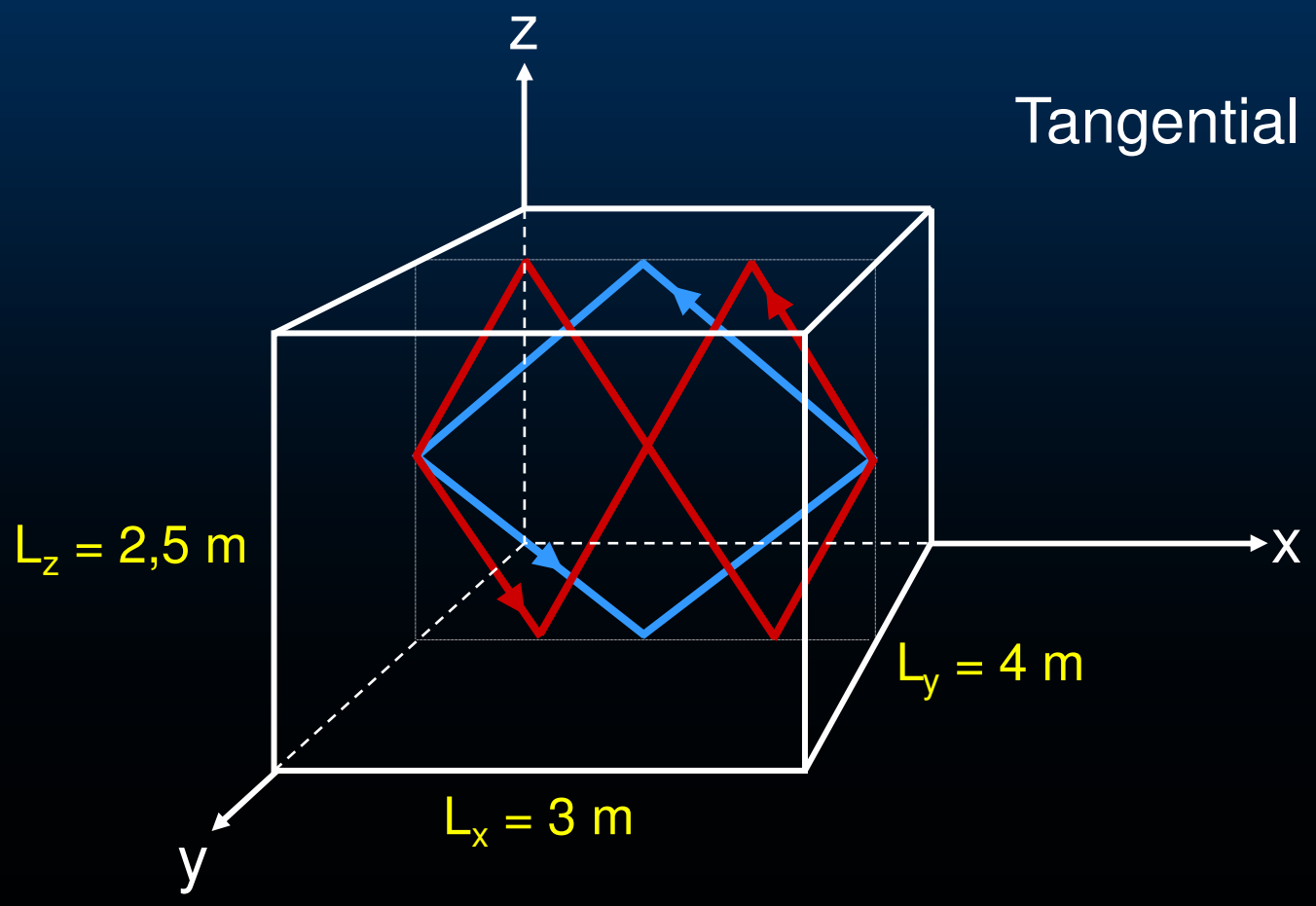
‘Small’ Rooms

Normal modes in small (rectangular) rooms

Tangential modes:



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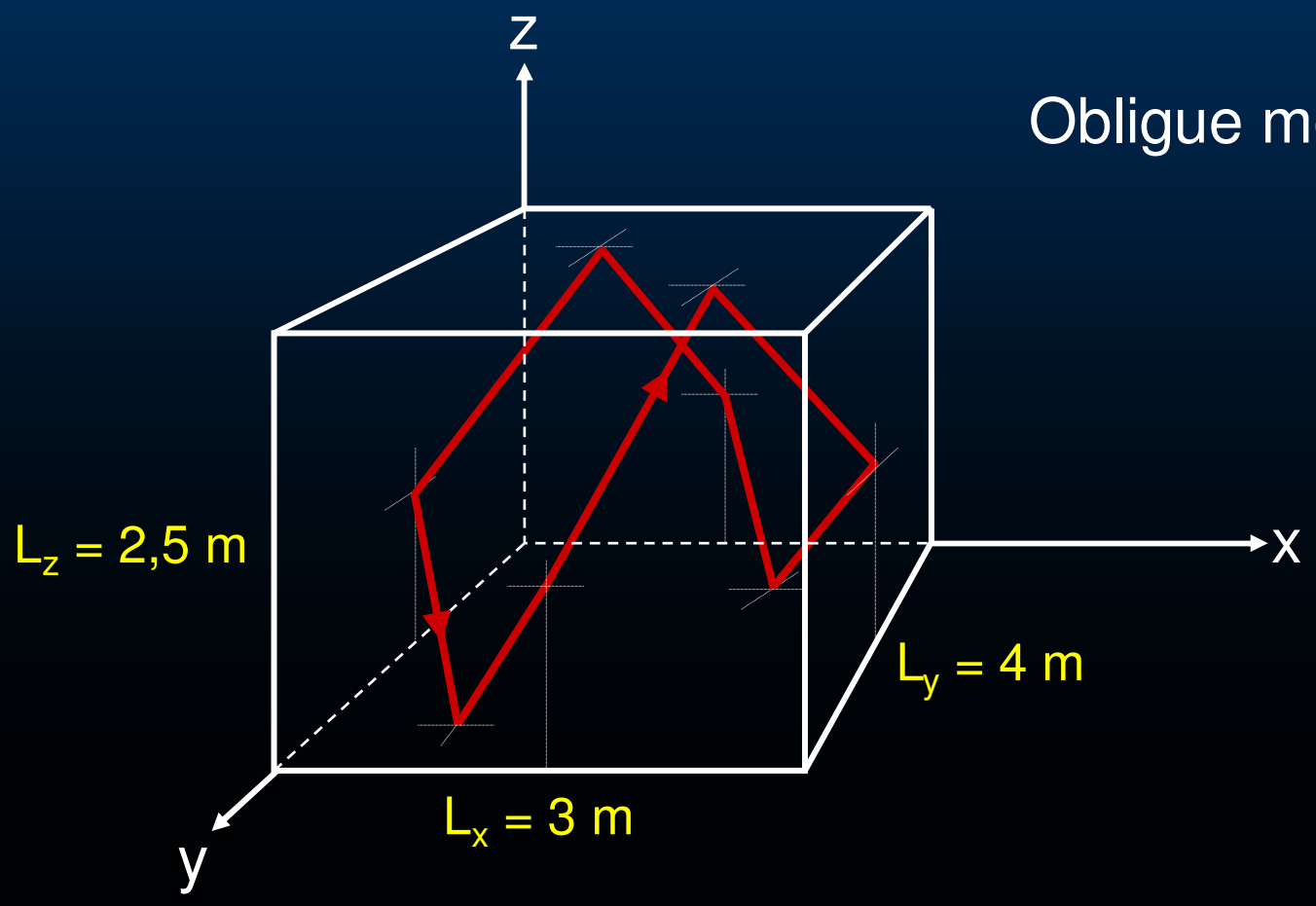
‘Small’ Rooms

Normal modes in small (rectangular) rooms

Obligue mode(s):



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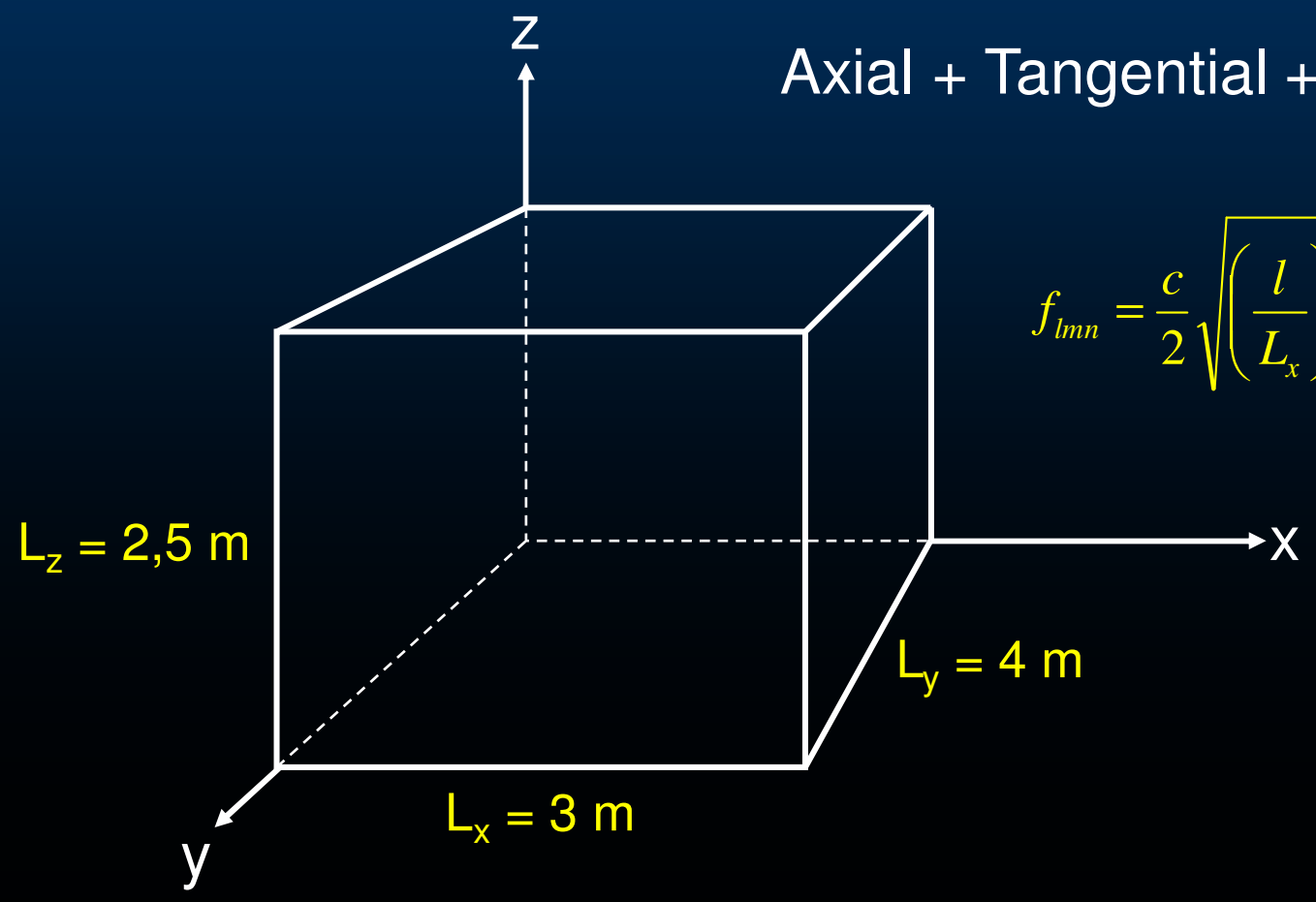
‘Small’ Rooms

Normal modes in small (rectangular) rooms

Axial + Tangential + Obligue:

$$f_{lmn} = \frac{c}{2}\sqrt{\left(\frac{l}{L_x}\right)^2 + \left(\frac{m}{L_y}\right)^2 + \left(\frac{n}{L_z}\right)^2}$$



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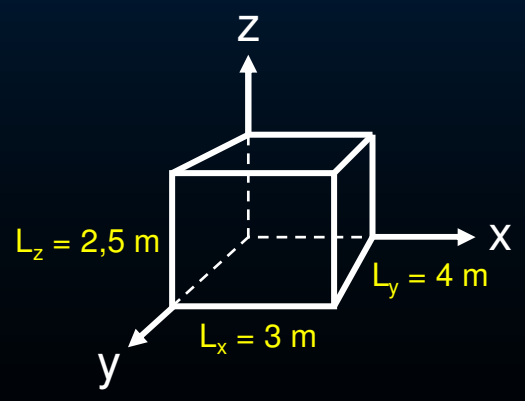
‘Small’ Rooms

Normal modes in small (rectangular) rooms

Axial + Tangential + Obligue:

http://amroc.andymel.eu/



1	42.9	0-1-0	ax	11	114.3	2-0-0	ax
2	57.2	1-0-0	ax	12	122.1	2-1-0	tan
3	68.6	0-0-1	ax	13	123.8	1-2-1	obl
4	71.5	1-1-0	tan	14	128.6	0-3-0	ax
5	80.9	0-1-1	tan	15	133.3	2-0-1	tan
6	85.8	0-2-0	ax	16	137.2	0-0-2	ax
7	89.3	1-0-1	tan	17	140.1	2-1-1	obl
8	99.1	1-1-1	obl	18	140.8	1-3-0	tan
9	103.1	1-2-0	tan	19	142.9	2-2-0	tan
10	109.8	0-2-1	tan	20	143.7	0-1-2	tan

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‘Small’ Rooms

Literature

Bolt	(1946)	1 : 1.25 : 1.6
Louden	(1971)	1 : 1.4 : 1.9
Gilford	(1979)	stronger weighting axial modes
Bonello	(1981)	increasing number of modes over 1/3 octave bands
Walker	(1996)	$1.1L_y \le \frac{L_x}{L_z} \le \frac{4.5L_y}{L_z} - 4$

$$L_x < 3L_z$$

$$L_y < 3L_z$$

Cox and D'Antonio (2000) flattest possible modal frequency response

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‘Small’ Rooms

Literature

[1] R.H.Bolt. Note on the normal frequency statistics in rectangular rooms. J.Acoust.Soc.Am. 18(1) 130-133. (1946).

[2] M M Louden. Dimension ratios of rectangular rooms with good Distribution of eigentones. Acustica. 24. 101-104 (1971).

[3] C.L.S.Gilford. The acoustic design of talk studios and listening rooms. J.Audio.Eng.Soc. 27. 17-31. (1979).

[4] O. J. Bonello. A New Criterion for the Distribution of Normal Room Modes. JAES Volume 29 Issue 9 pp. 597-606; (1981).

[5] R. Walker. Optimum Dimension Ratios for Small Rooms. Preprint 4191. 100th Convention of the AES. (5/1996).

[6] Trevor J Cox and Peter D'Antonio. Determining Optimum Room Dimensions for Critical Listening Environments: A New Methodology. Proc 110th Convention AES. paper 5353 (2000)

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Acoustics Design

Dimension: volume

hall function

concert hall
cinema
etc.

m^3/pp

# of persons

volume

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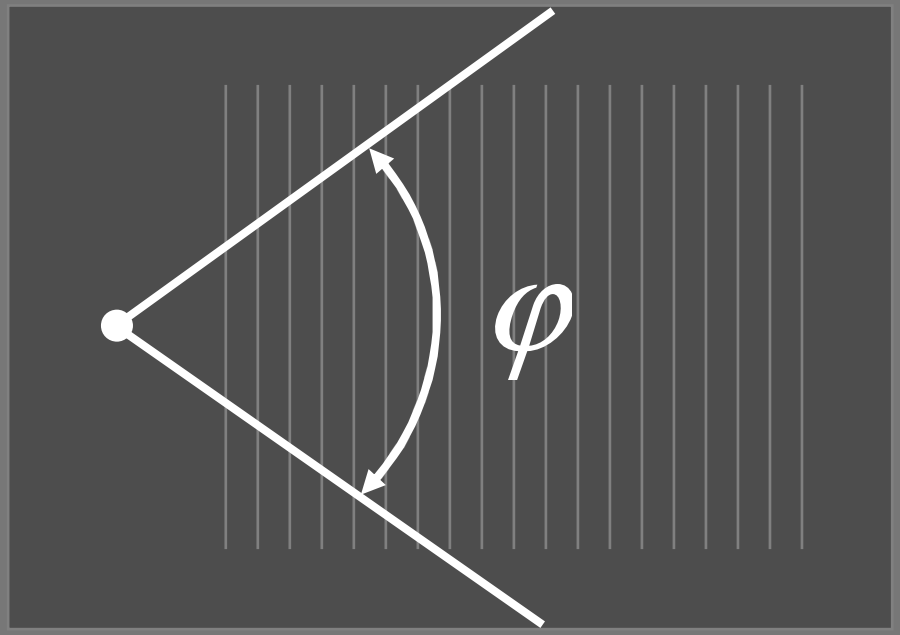
Acoustics Design

Shape/dimensions

directivity



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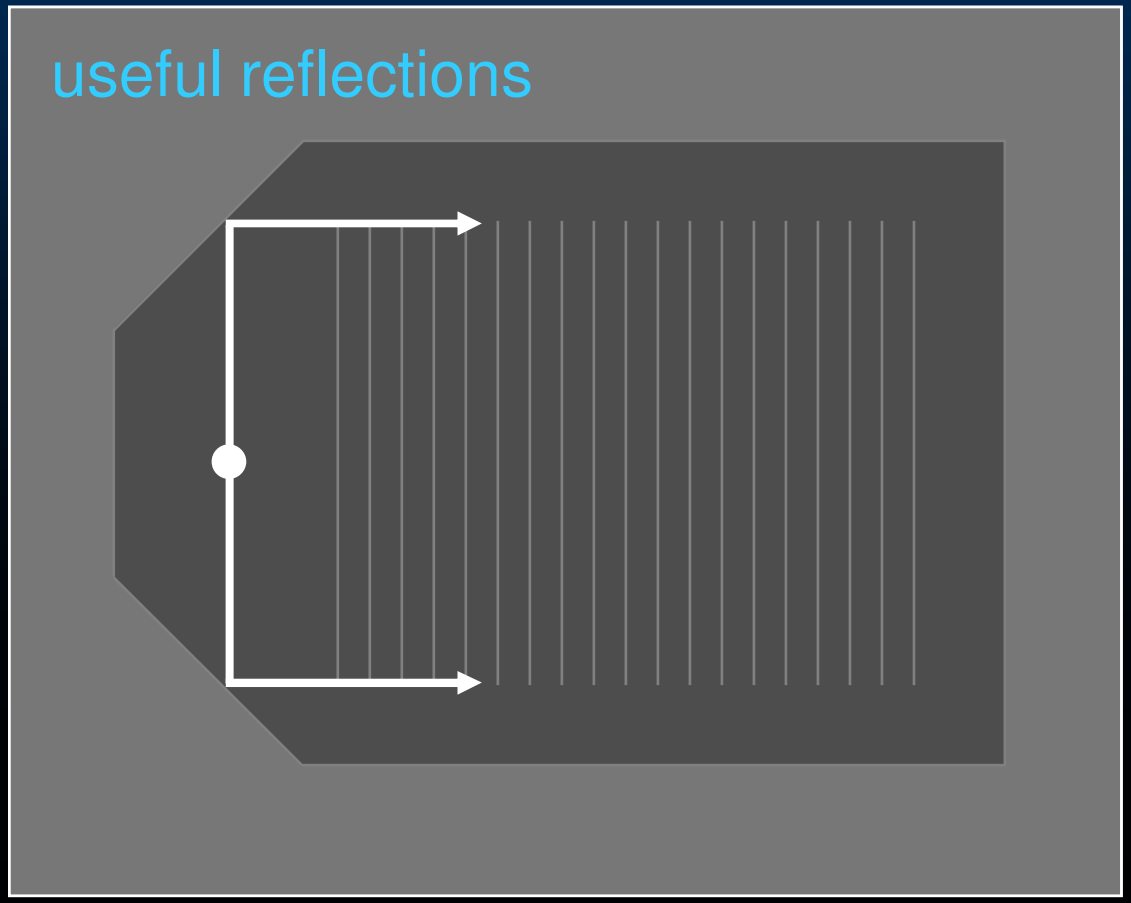
Acoustics Design

Shape/dimensions



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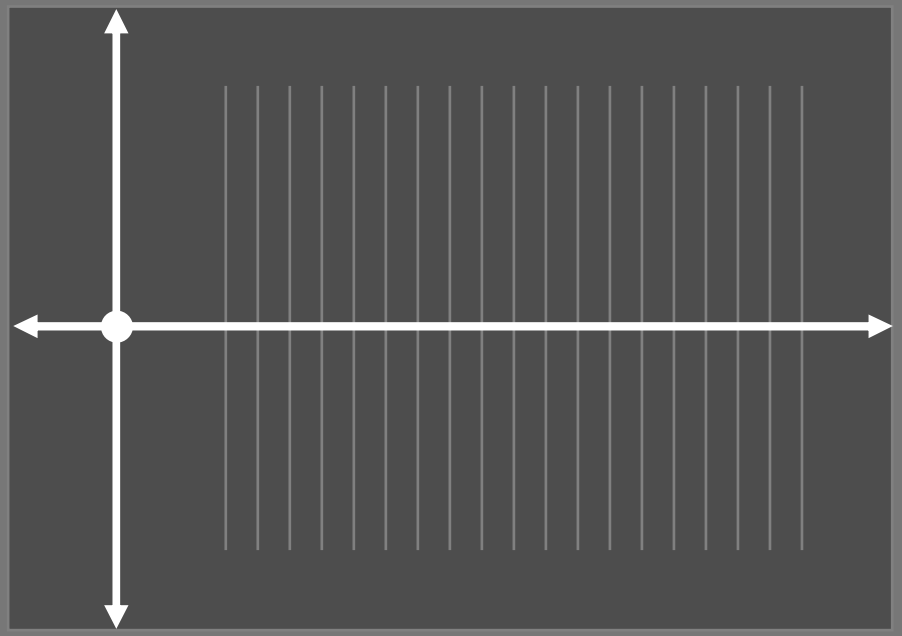
Acoustics Design

Shape/dimensions

flutter echo's



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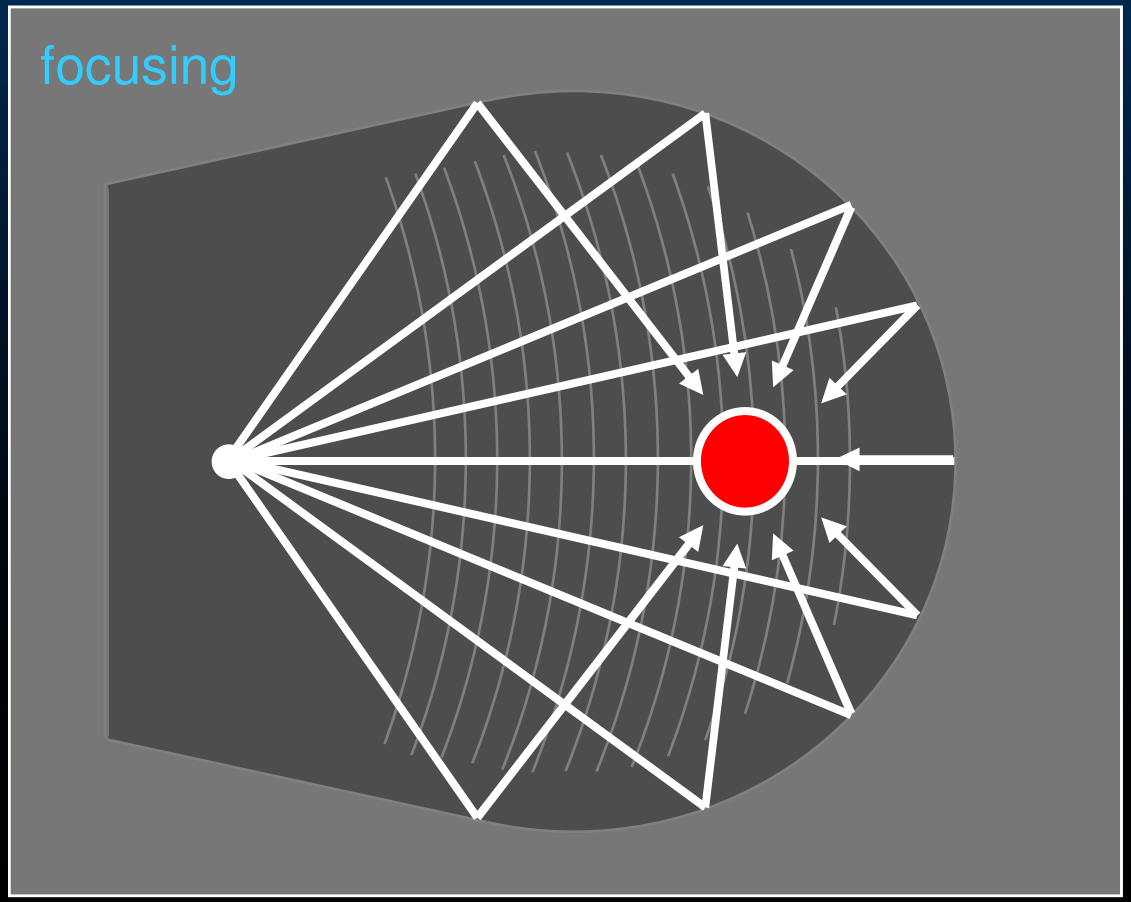
Acoustics Design

Shape/dimensions



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Acoustics Design

Shape/dimensions

Concert Hall
Eindhoven

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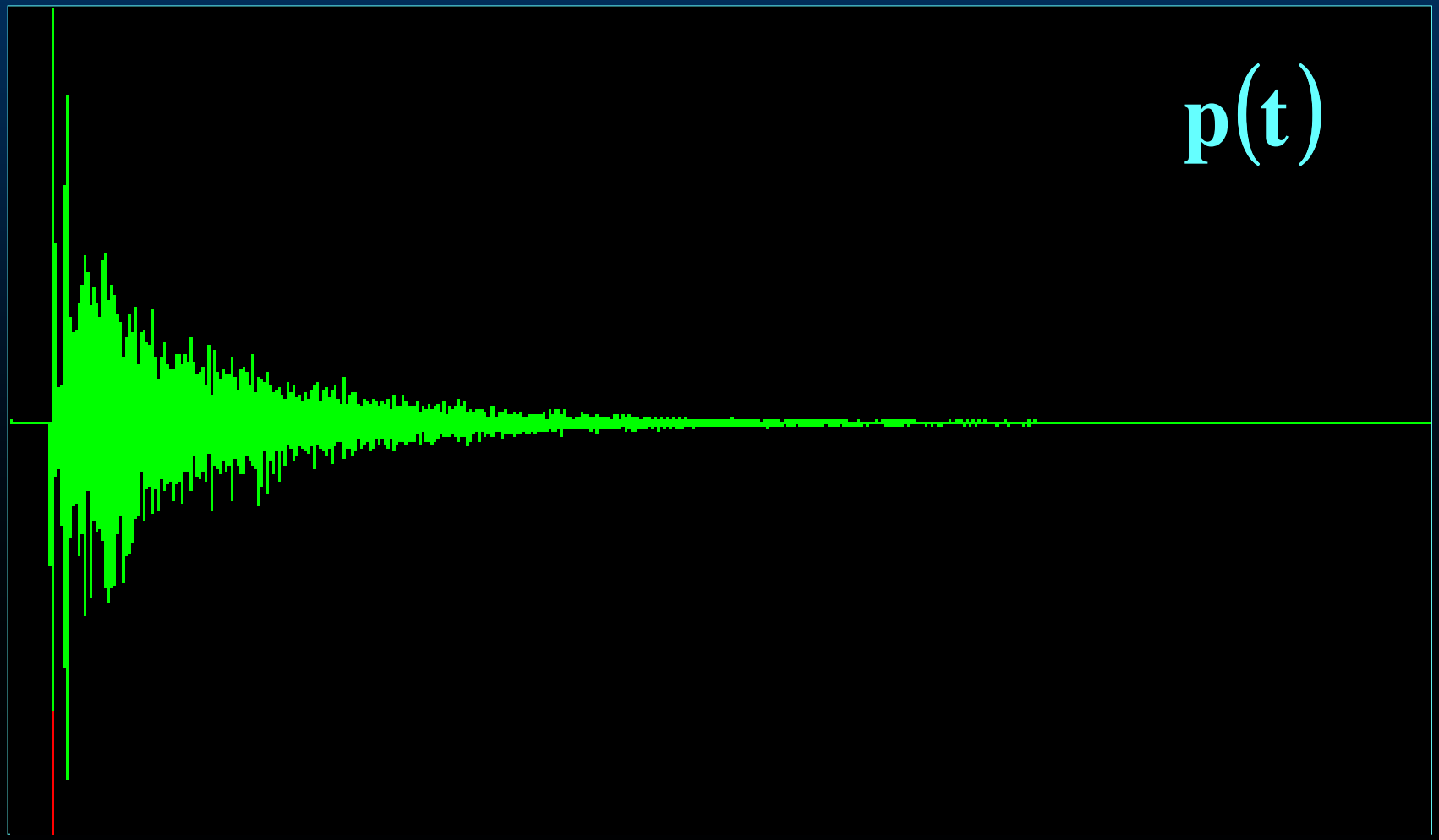
Room Impulse Response (RIR)



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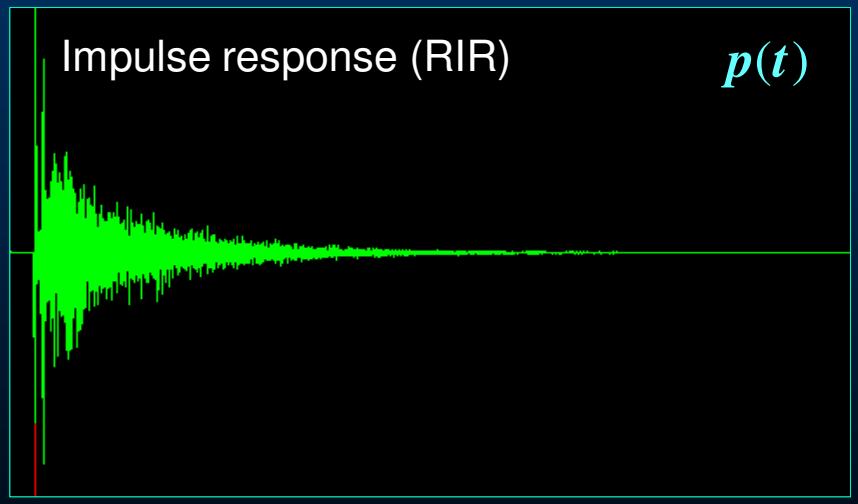
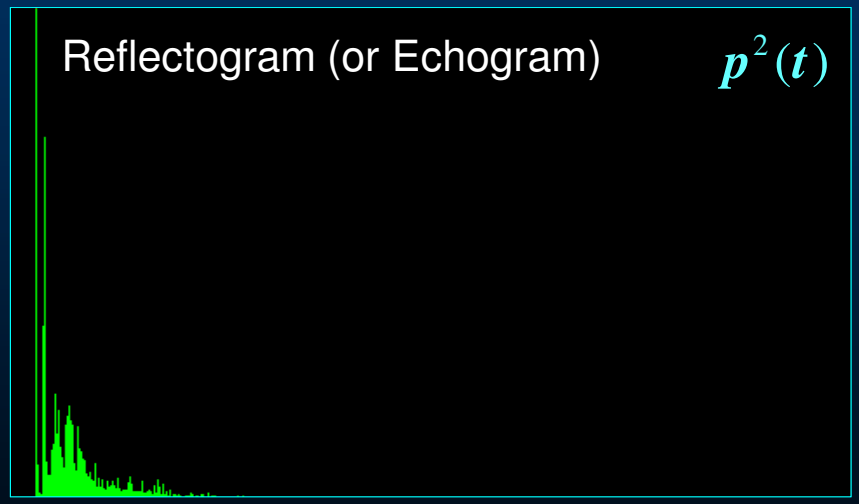
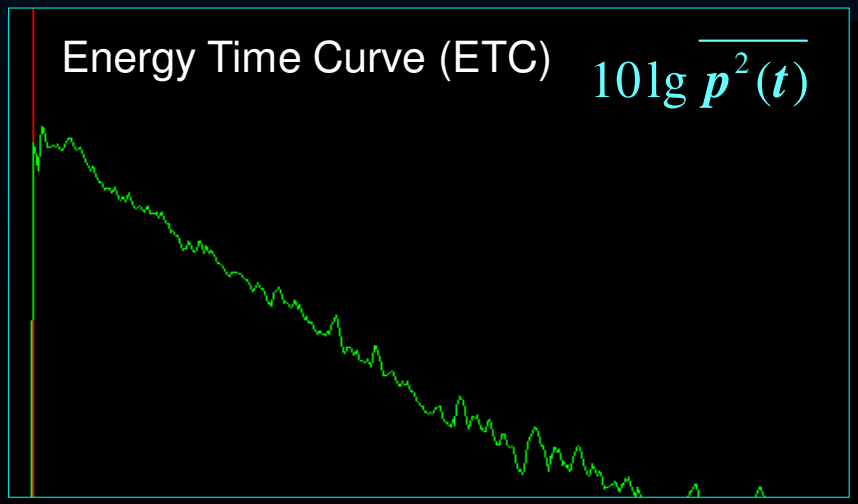
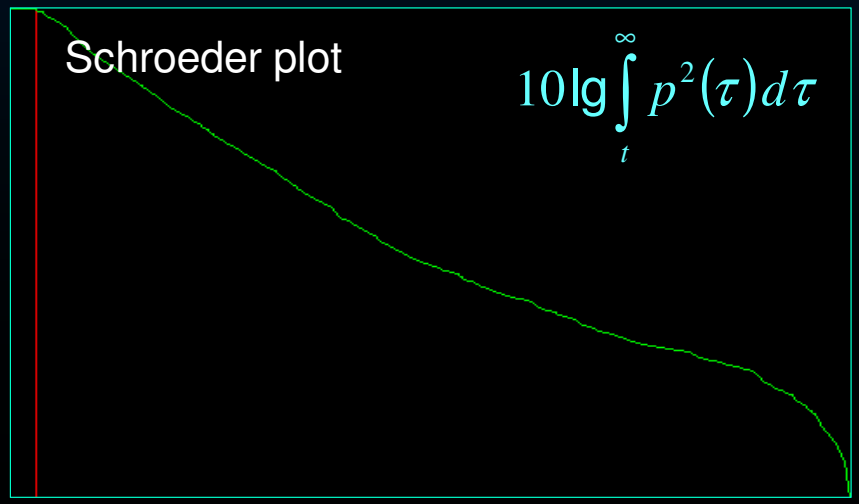
Time-domain









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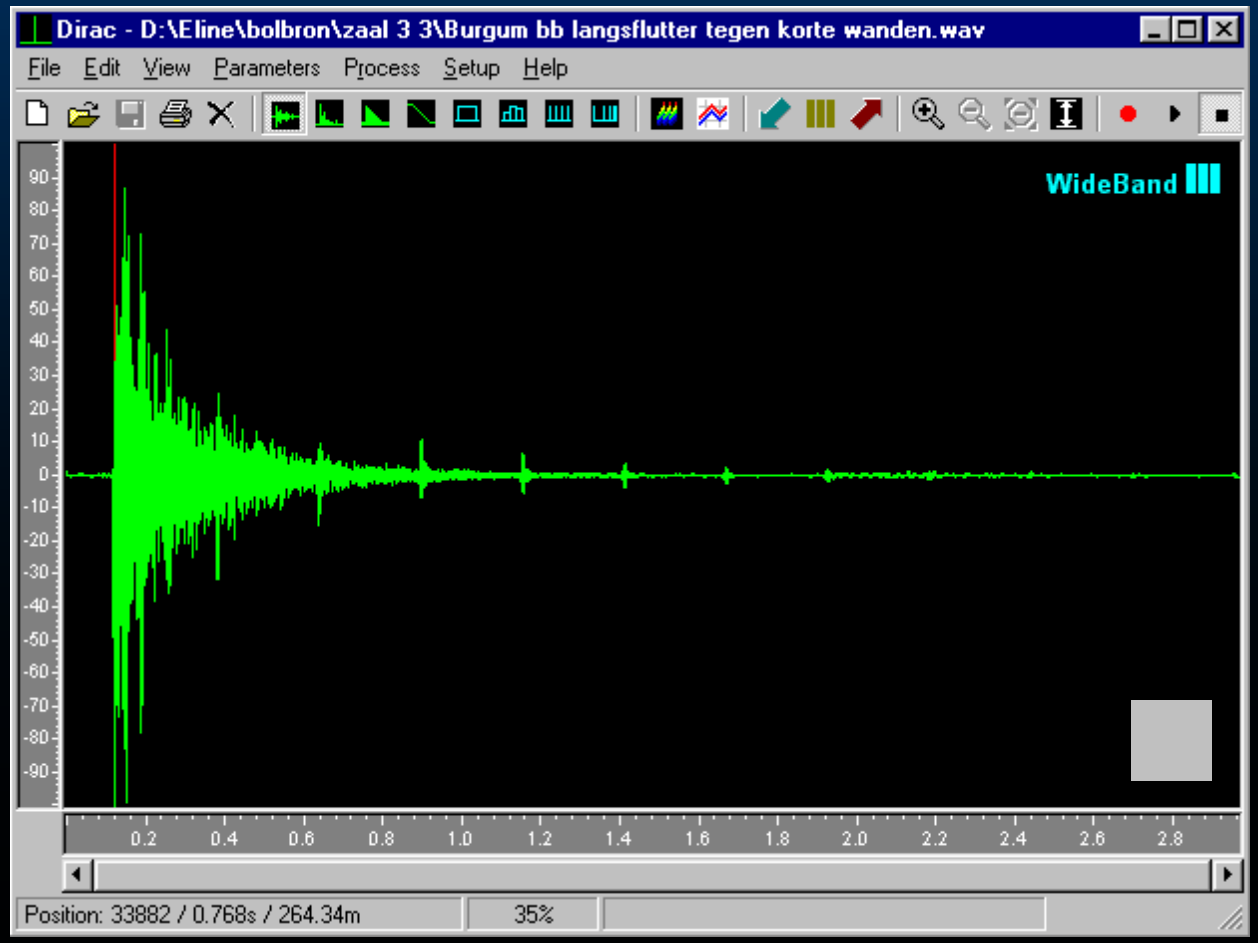
RIR measurement

Flutter



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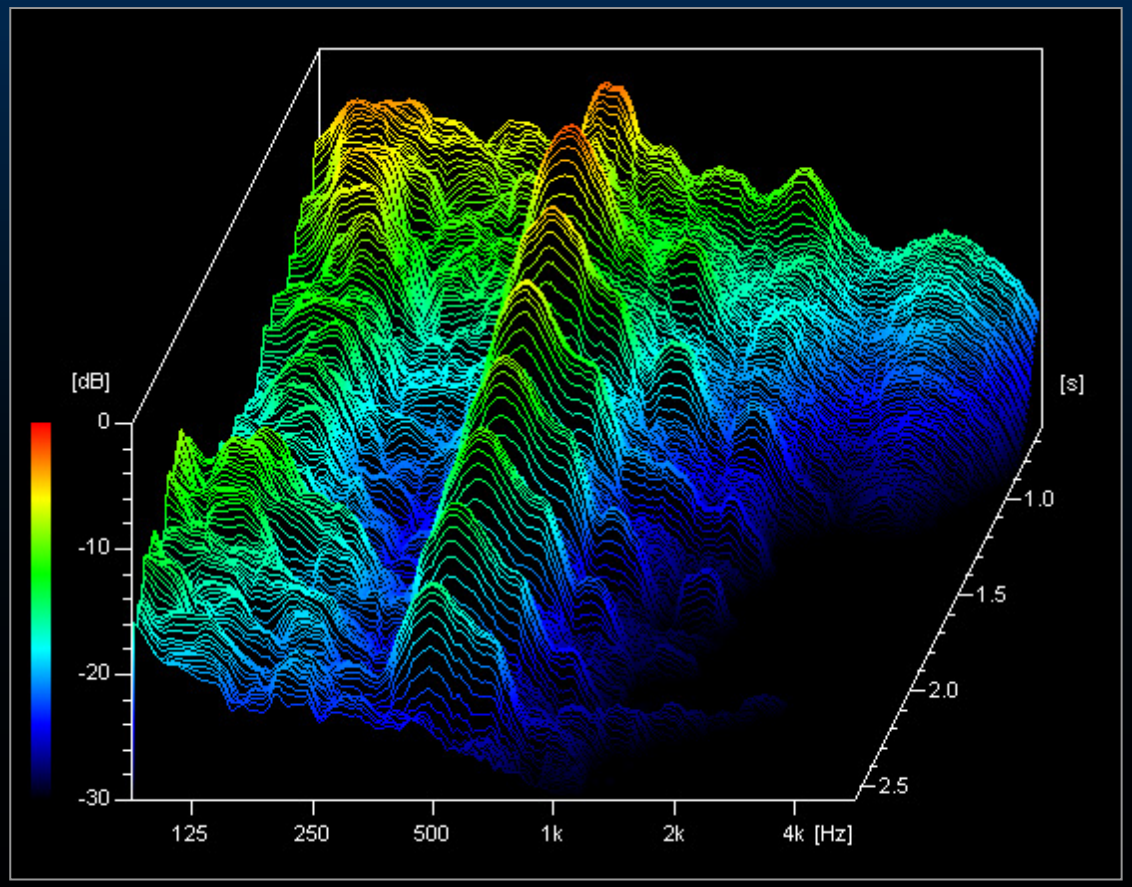
RIR measurement

Waterfall plot



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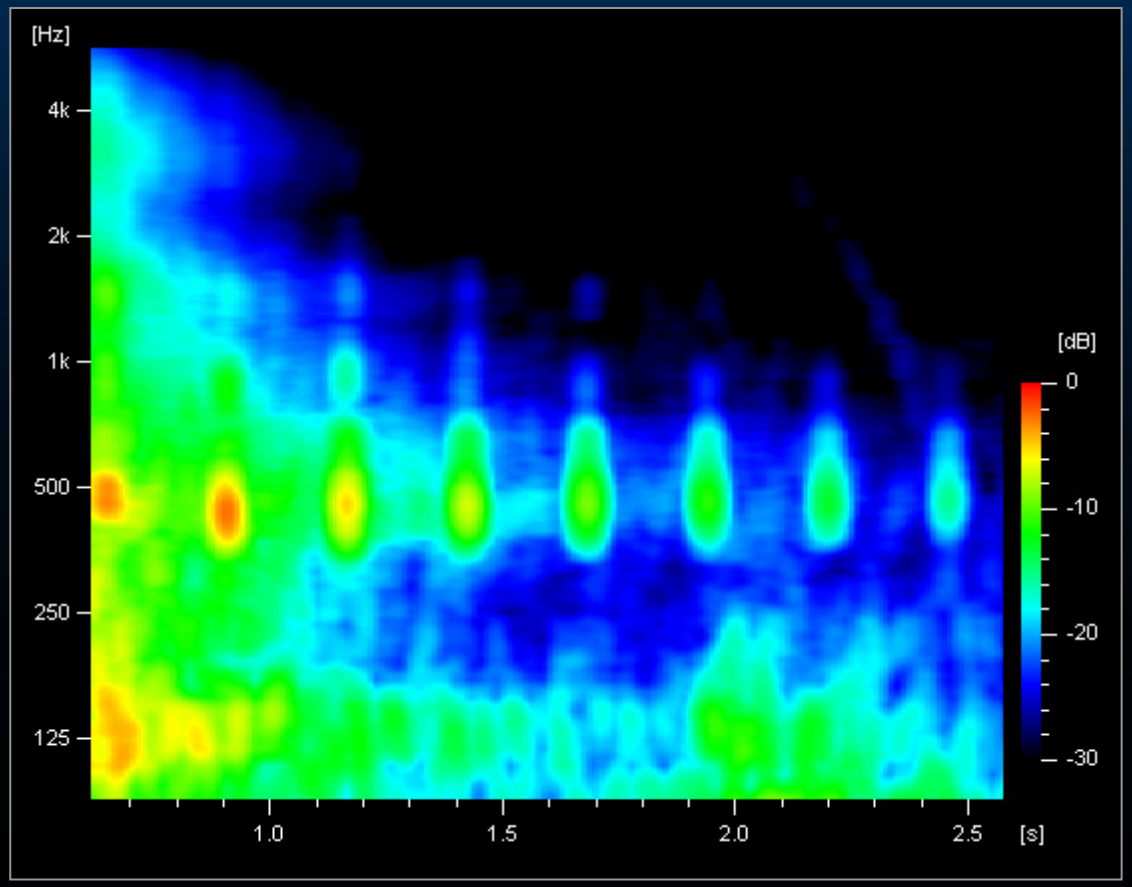
RIR measurement

Spectrogram



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Room Acoustic Parameters

Room
ISO 3382

- G [dB]
- EDT [s]
- T_{20} [s]
- T_{30} [s]
- C_{80} [dB]
- D_{50} --
- T_S [ms]
- LF --
- IACC --
- STI

Stage
Gade

- ST early [dB]
- ST late [dB]
- ST total [dB]

Quality

- INR [dB]
- SNR [dB]
- cc --

Reflection

- RI --
- Q_w --

Speech
ISO 60268-16

- STI --
- STI male --
- STI female --
- STITEL --
- RASTI --
- ALC [%]

Level

- Grel [dB]
- Magnitude --
- SPL [dB]

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Room Acoustic Parameters

Strength G

- ✓ G [dB]
- EDT [s]
- T20 [s]
- T30 [s]
- C80 [dB]
- D50 --
- T_S [ms]
- LF --
- IACC --
- STI

ISO 3382-1

$$G = L_p - L_W + 31\,[dB]$$

$$G = L_p - L_{p(10m\,dir)}[dB]$$

1

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Room Acoustic Parameters

Strength G

- ✓ G [dB]
- EDT [s]
- T20 [s]
- T30 [s]
- C80 [dB]
- D50 --
- T_S [ms]
- LF --
- IACC --
- STI

ISO 3382-1

$$G = 10 \lg \frac{\int_0^\infty p^2(t)\,dt}{\int_0^\infty p_{10,dir}{}^2(t)\,dt} [dB]$$

2

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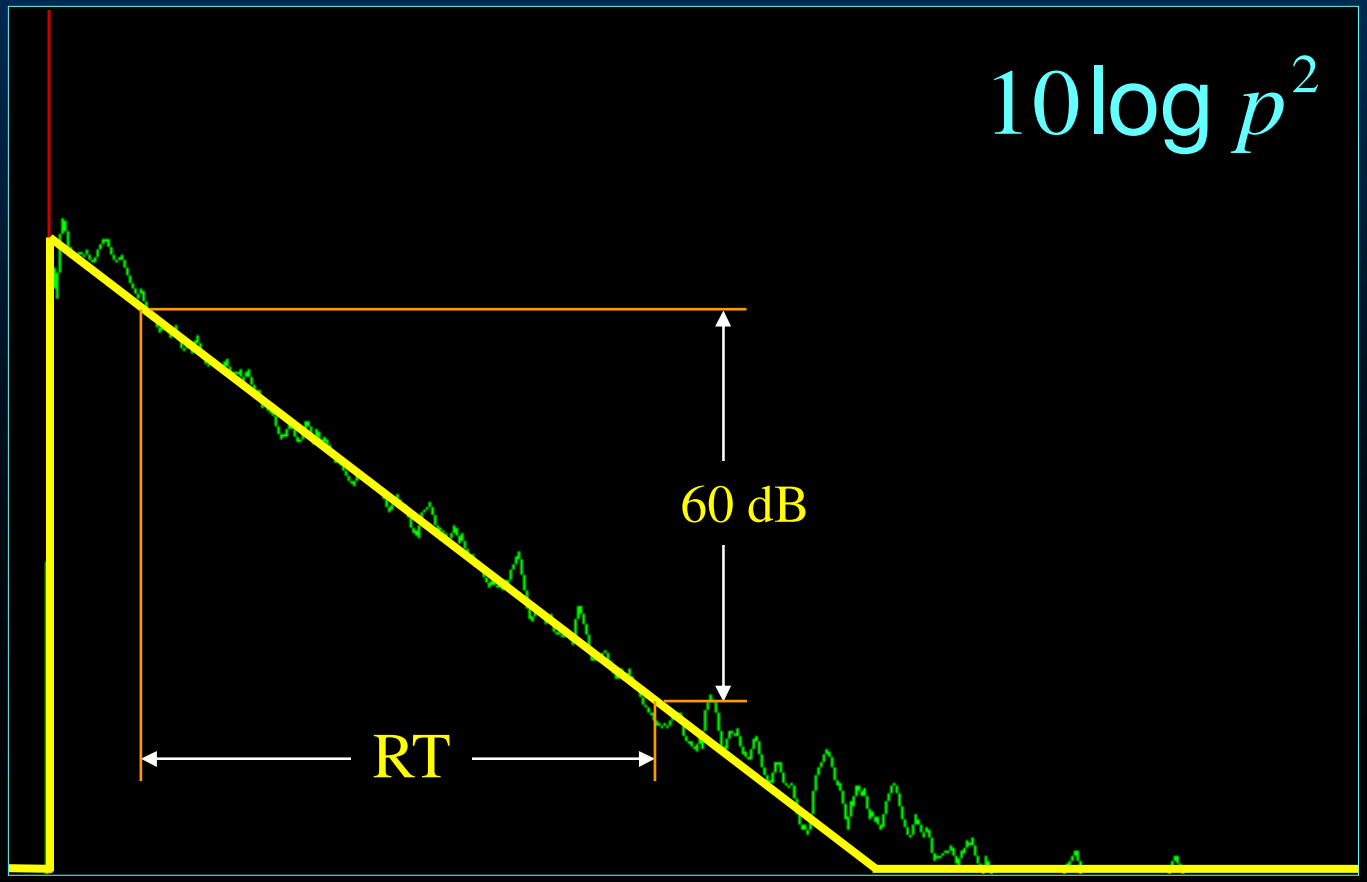
Intermezzo

Room Acoustic Parameters

Reverberation time RT

ISO 3382-1

- G [dB]
- EDT [s]
- T20 [s]
- T30 [s]
- C80 [dB]
- D50 --
- T_S [ms]
- LF --
- IACC --
- STI



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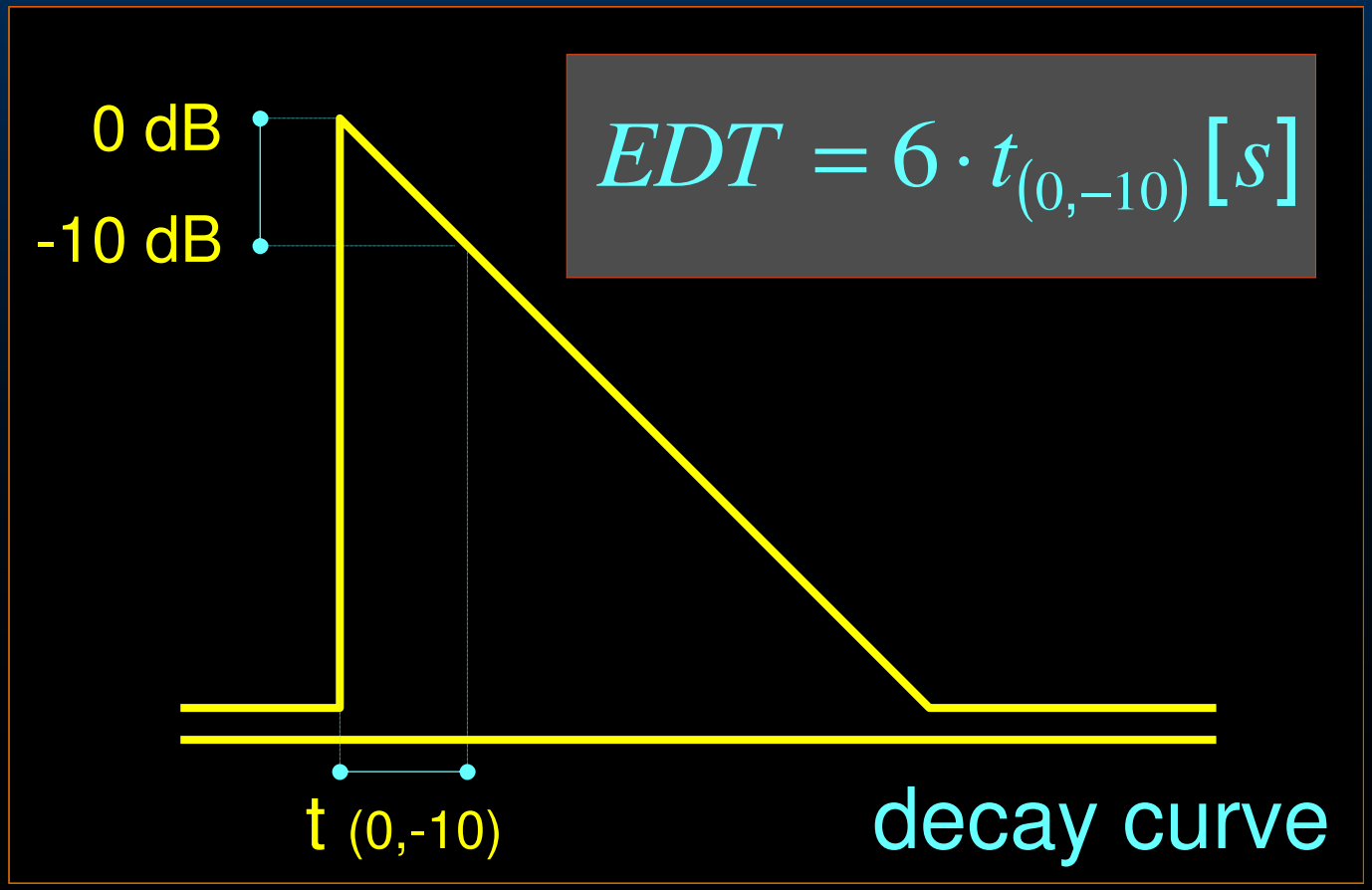
Room Acoustic Parameters

Early Decay Timed EDT

ISO 3382-1

- G [dB]
- ✓ EDT [s]
- T_{20} [s]
- T_{30} [s]
- C_{80} [dB]
- D_{50} --
- T_S [ms]
- LF --
- IACC --
- STI



$$EDT = 6 \cdot t_{(0,-10)} [s]$$

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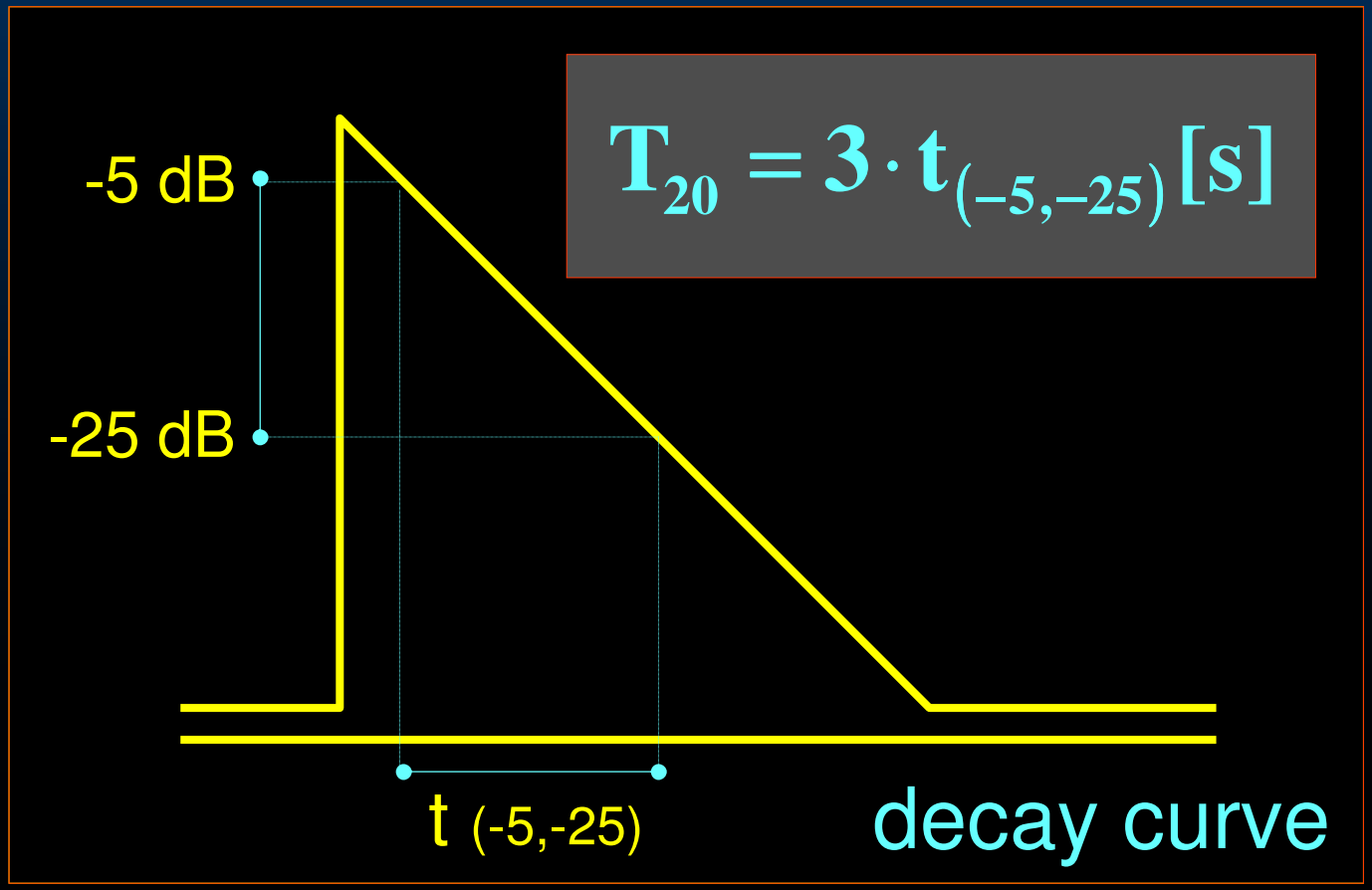
Room Acoustic Parameters

Reverberation time T_{20}

ISO 3382-1

- [ ] G [dB]
- [ ] EDT [s]
- [x] T20 [s]
- [ ] T30 [s]
- [ ] C80 [dB]
- [ ] D50 --
- [ ] T_S [ms]
- [ ] LF --
- [ ] IACC --
- [ ] STI



$$T_{20} = 3 \cdot t_{(-5,-25)} [s]$$

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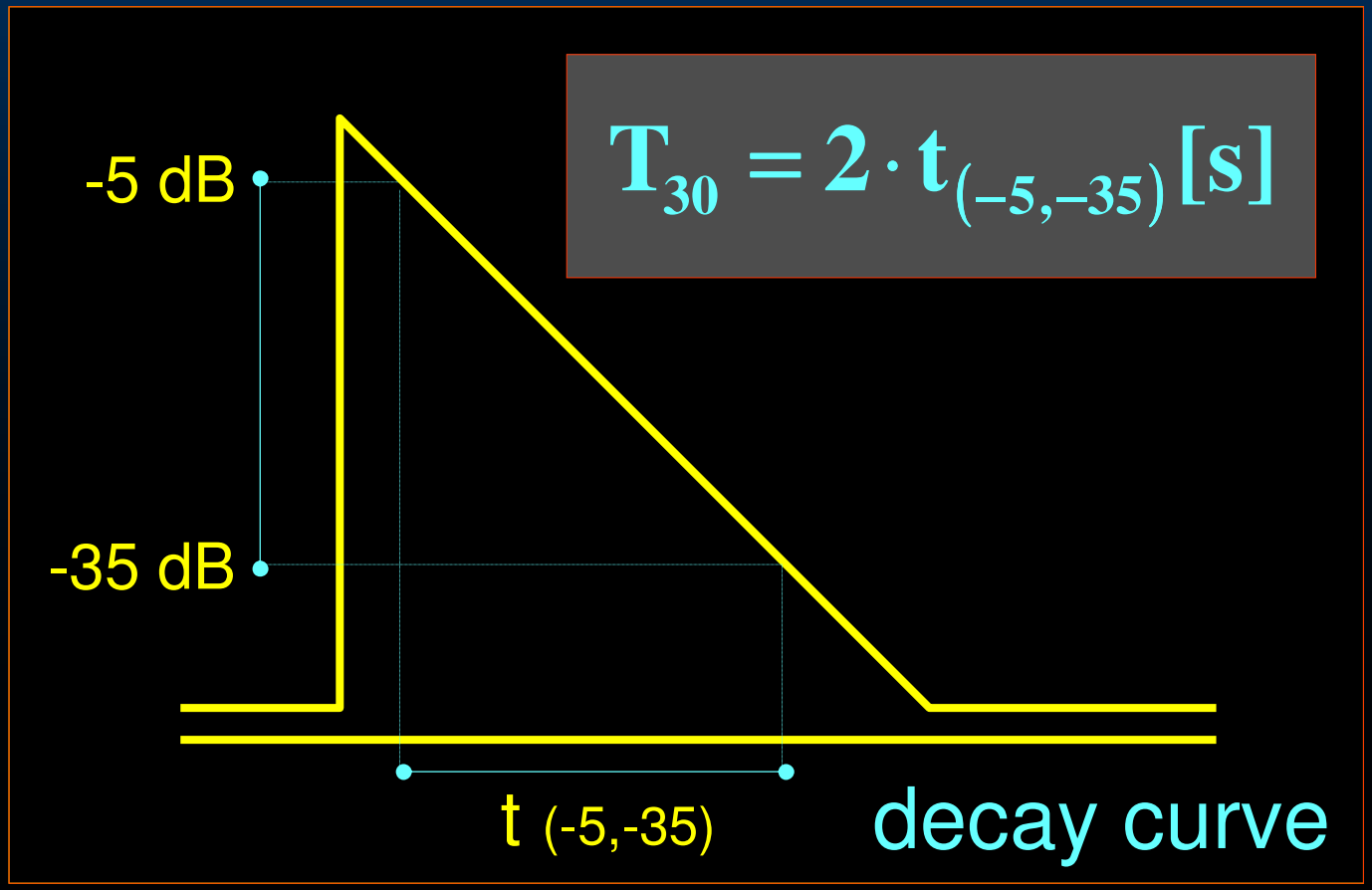
Room Acoustic Parameters

Reverberation time T_{30}

ISO 3382-1

- G [dB]
- EDT [s]
- T20 [s]
- ✓ T30 [s]
- C80 [dB]
- D50 --
- T_S [ms]
- LF --
- IACC --
- STI

$$T_{30} = 2 \cdot t_{(-5,-35)} \, [s]$$



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Room Acoustic Parameters

Clarity C_{80}

- [ ] G [dB]
- [ ] EDT [s]
- [ ] T20 [s]
- [ ] T30 [s]
- [x] C80 [dB]
- [ ] D50 --
- [ ] T_S [ms]
- [ ] LF --
- [ ] IACC --
- [ ] STI

ISO 3382-1

$$C_{80} = 10\lg \frac{\int_{0}^{0.080s} p^2(t)\,dt}{\int_{0.080s}^{\infty} p^2(t)\,dt} \quad [dB]$$

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Room Acoustic Parameters

Definition D_{50}

- G [dB]
- EDT [s]
- T20 [s]
- T30 [s]
- C80 [dB]
- ✓ D50 --
- T_S [ms]
- LF --
- IACC --
- STI

ISO 3382-1

$$D_{50} = \frac{\int_0^{0.050s} p^2(t)\,dt}{\int_0^{\infty} p^2(t)\,dt} \quad [-]$$

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Room Acoustic Parameters

Center time T_S

- G [dB]
- EDT [s]
- T20 [s]
- T30 [s]
- C80 [dB]
- D50 --
- ✓ T_S [ms]
- LF --
- IACC --
- STI

ISO 3382-1

$$T_S = \frac{\int_0^\infty t \cdot p^2(t)\,dt}{\int_0^\infty p^2(t)\,dt} \quad [s]$$

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Room Acoustic Parameters

Early Lateral Energy LF

- G [dB]
- EDT [s]
- T20 [s]
- T30 [s]
- C80 [dB]
- D50 --
- T_S [ms]
- ✓ LF --
- IACC --
- STI

ISO 3382-1

$$LF = \frac{\int_0^{0.080s} p_{\oplus}^2(t)\,dt}{\int_0^{0.080s} p_{\oplus}^2(t)\,dt} \quad [-]$$

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Room Acoustic Parameters

Inter Aural Cross Correlation IACC

- ☐ G [dB]
- ☐ EDT [s]
- ☐ T20 [s]
- ☐ T30 [s]
- ☐ C80 [dB]
- ☐ D50 --
- ☐ T_S [ms]
- ☐ LF --
- ☑ IACC --
- ☐ STI

ISO 3382-1

$$IACF_{t1,t2} = \frac{\int_{t1}^{t2} \left| p_L(t) \cdot p_R(t+\tau) \right| dt}{\sqrt{\int_{t1}^{t2} p_L^{\,2}(t)\,dt \cdot \int_{t1}^{t2} p_R^{\,2}(t)\,dt}}$$

$$IACC_{t1,t2} = \max \left| IACF_{t1,t2}(\tau) \right| \quad \begin{matrix} \tau > -1\,ms \\ \tau < +1\,ms \end{matrix}$$

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Room Acoustic Parameters

Modulation Transfer Function MTF *(Schroeder)*

- G [dB]
- EDT [s]
- T20 [s]
- T30 [s]
- C80 [dB]
- D50 --
- T_S [ms]
- LF --
- IACC --
- ✓ MTF

$$m(F) = \frac{\int_{-\infty}^{\infty} p^2(t) \cdot e^{-j2\pi Ft} dt}{\int_{-\infty}^{\infty} p^2(t) dt} [-]$$

(Speech Intelligibility: IEC 60268-16)

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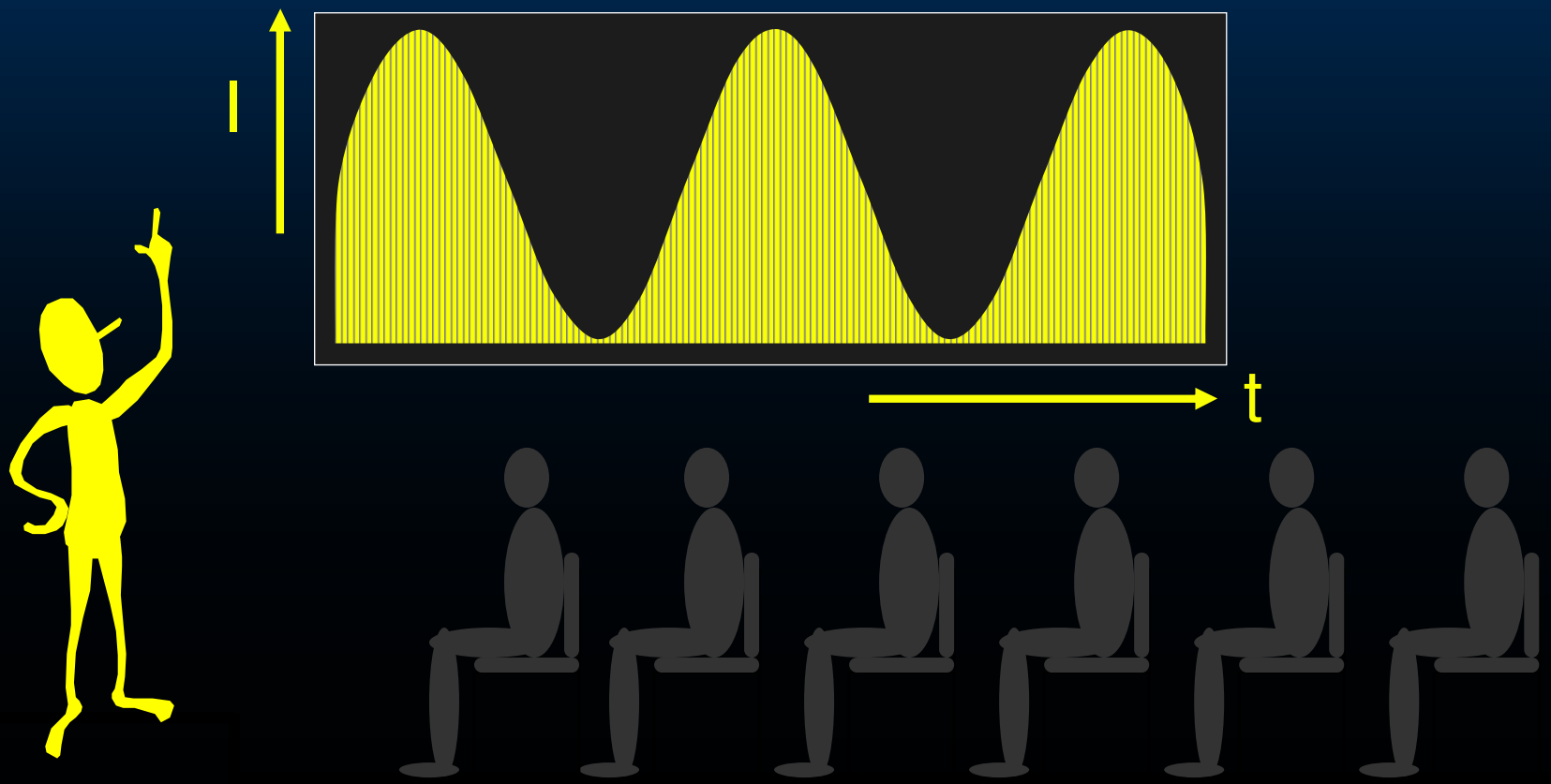
Speech Transmission

Signal modulation reduction



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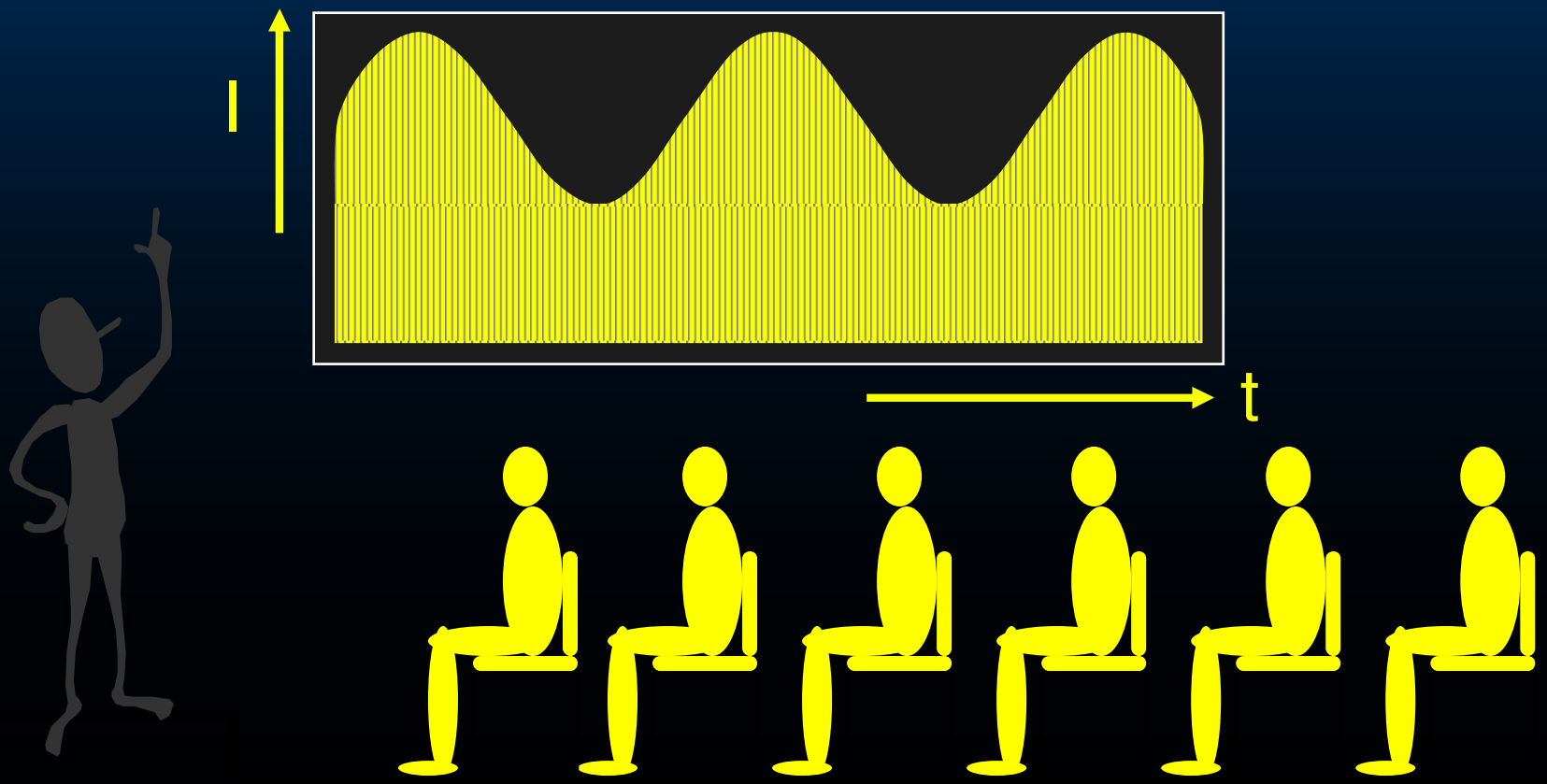
Speech Transmission

Signal modulation reduction



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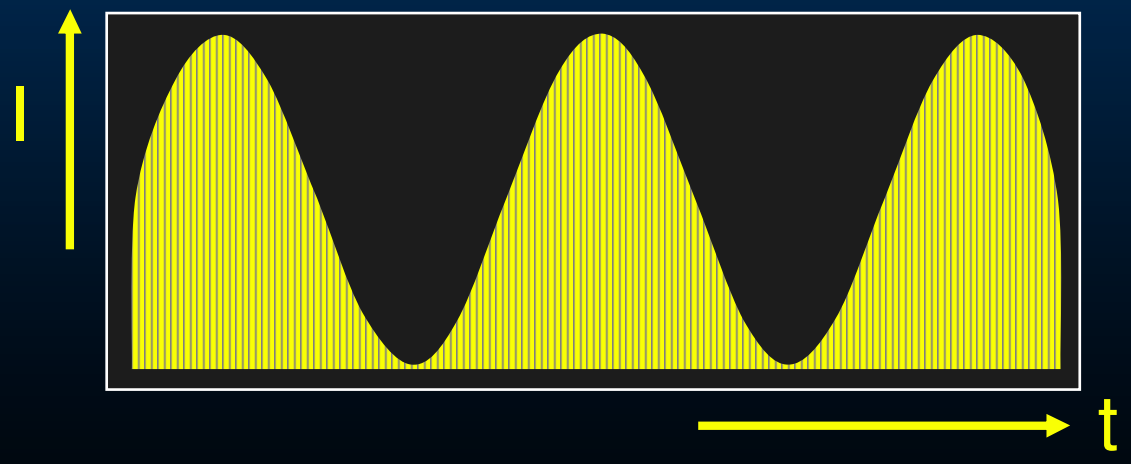
Speech Transmission

Signal modulation reduction



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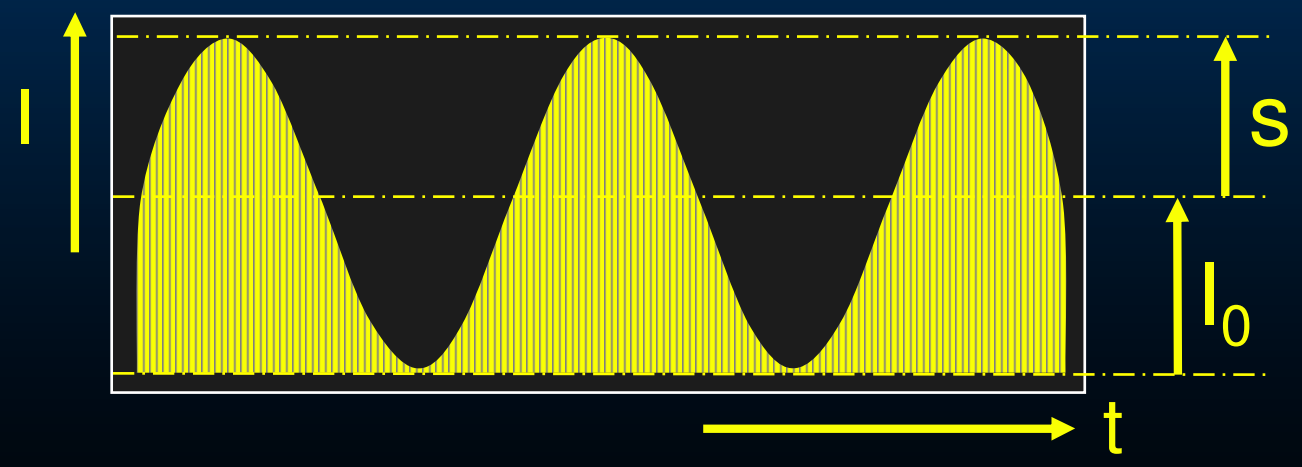
Speech Transmission

Modulation index



$$m = \frac{s}{I_0} = 1$$

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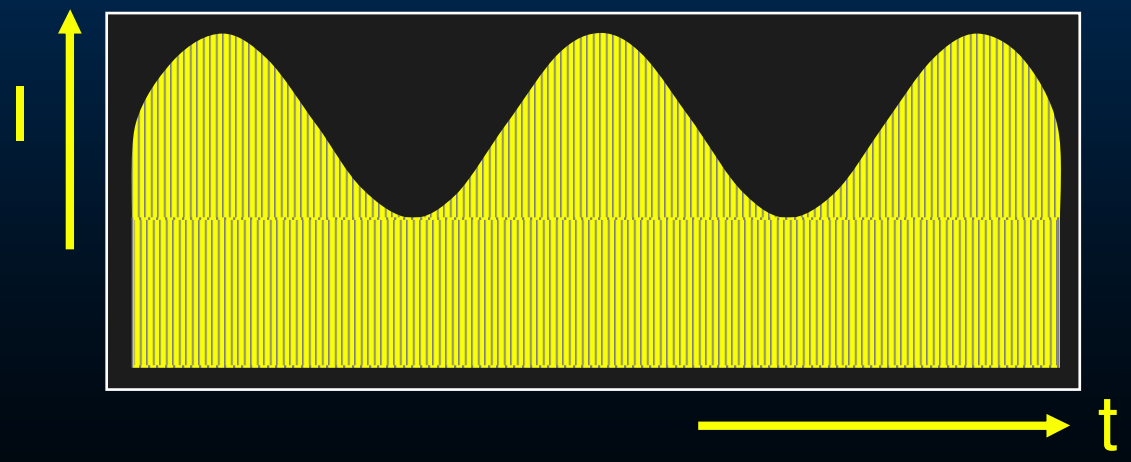
Speech Transmission

Modulation index



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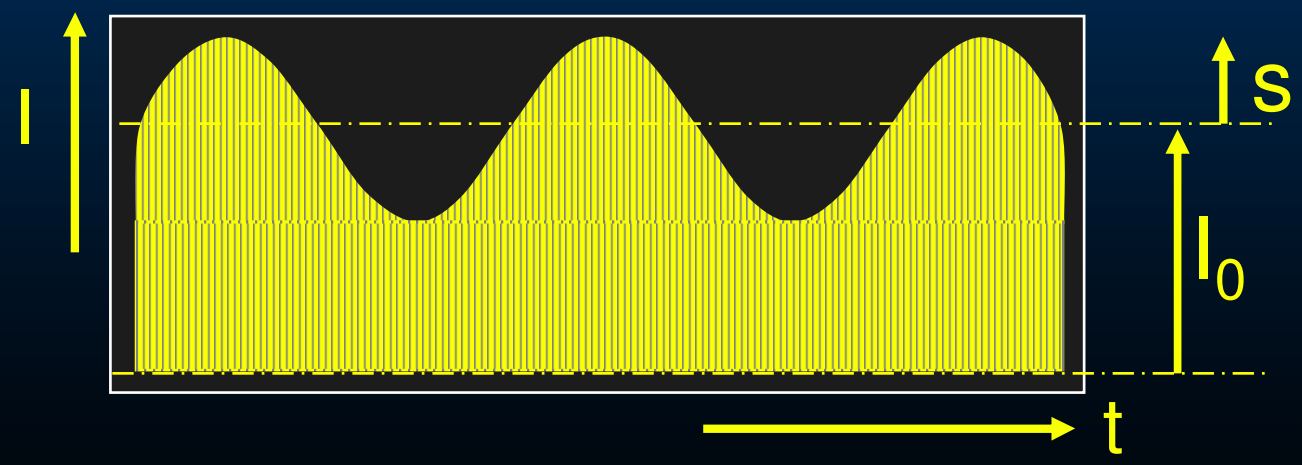
Speech Transmission

Modulation index



$$m = \frac{s}{I_0} < 1$$

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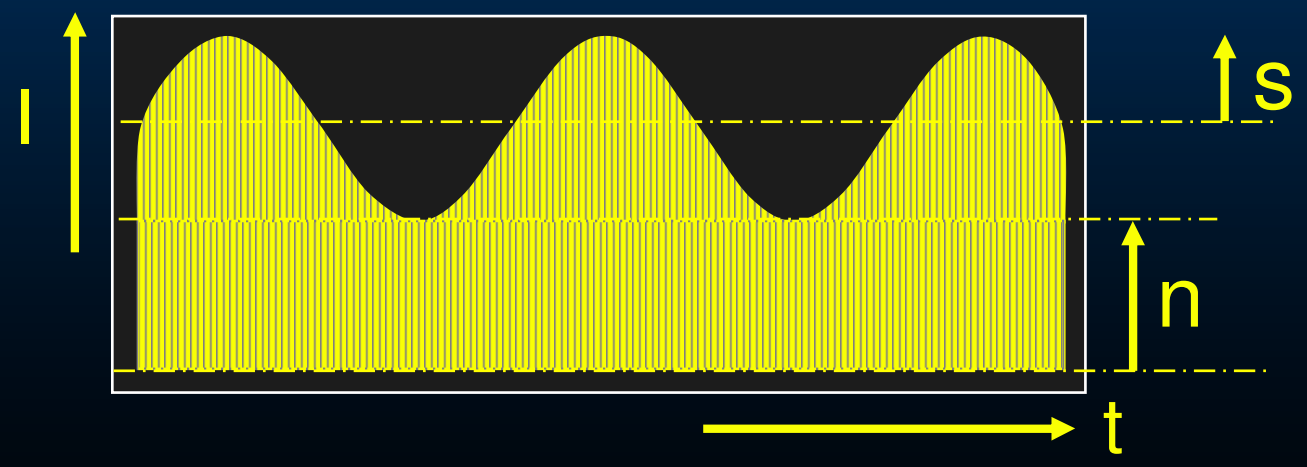
Speech Transmission

Modulation index



$$m = \frac{s}{s+n} < 1$$

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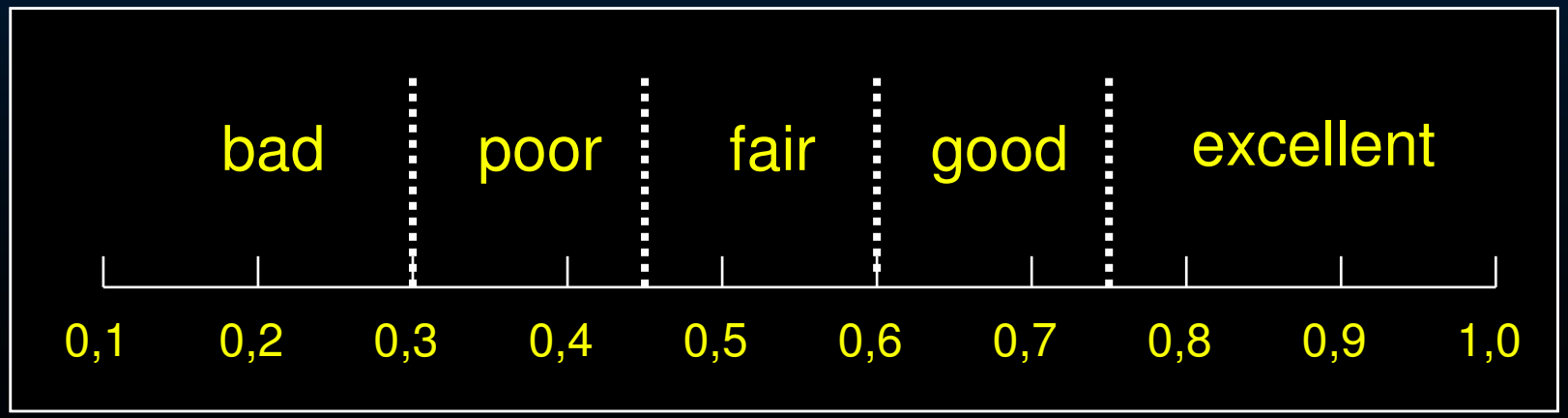
Speech Transmission

Speech Transmission Index: STI

(Speech Intelligibility)

$$0 < STI < 1$$

IEC 60268-16



$$m(F) = \frac{\int_{-\infty}^{\infty} p^2(t) \cdot e^{-j2\pi Ft} dt}{\int_{-\infty}^{\infty} p^2(t) dt} [-]$$

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Room Acoustic Parameters

Just Noticeable Differences JND

G	[dB]	1 dB
EDT	[s]	5 %
T_{20}	[s]	10 %
T_{30}	[s]	10 %
C_{80}	[dB]	1 dB
D_{50}	--	0.05
T_S	[ms]	10 ms
LF	--	0.05
IACC	--	0.075
STI	--	0.03

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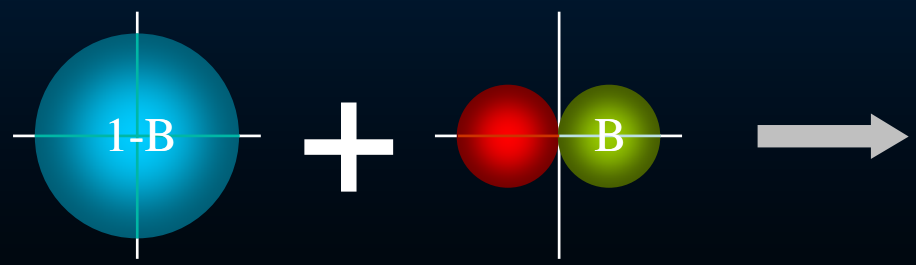
Microphone

Directivity B = ?



$$S(\varphi) = 1-B+B\cos\varphi$$

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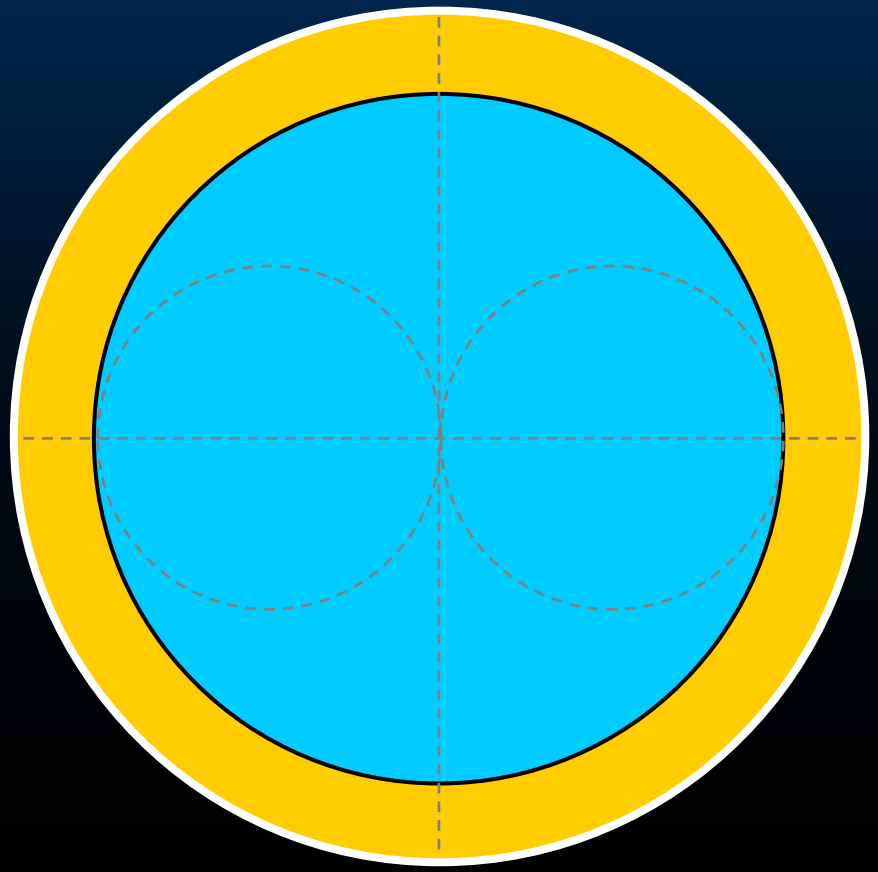
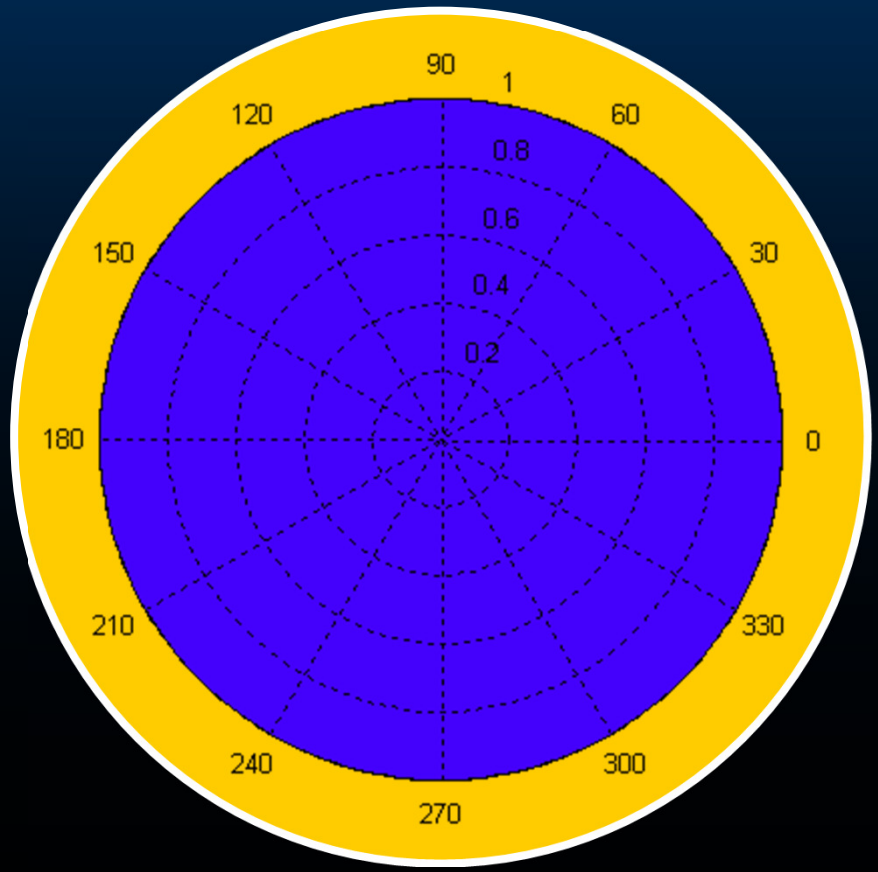
Microphone

Directivity B = 0





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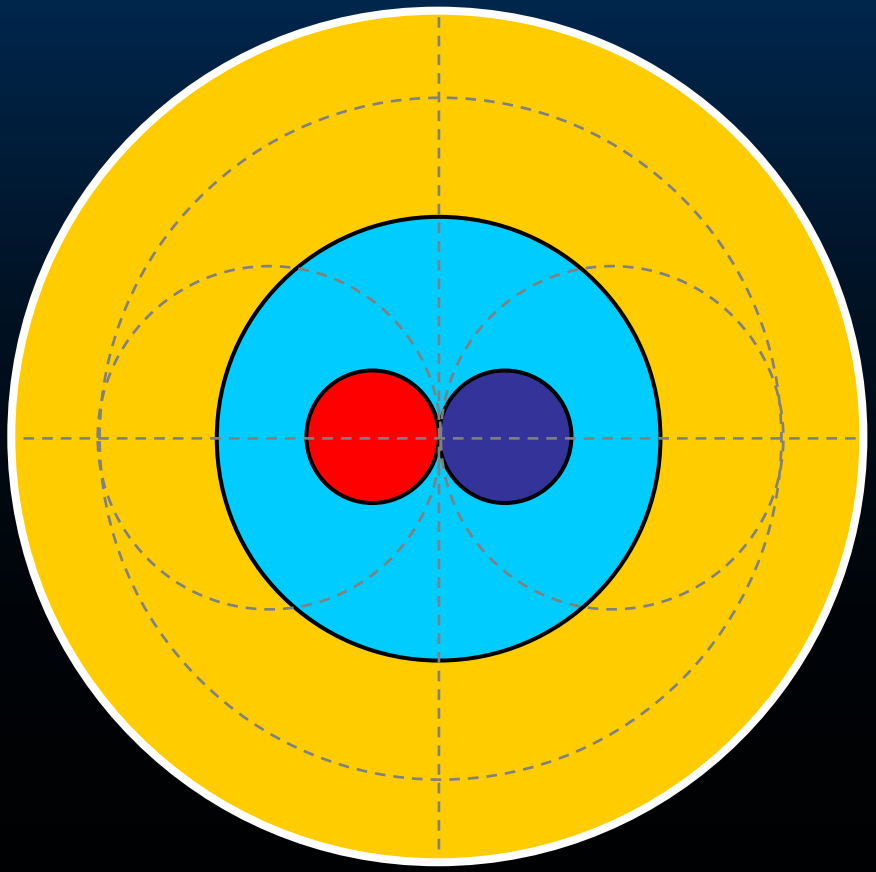
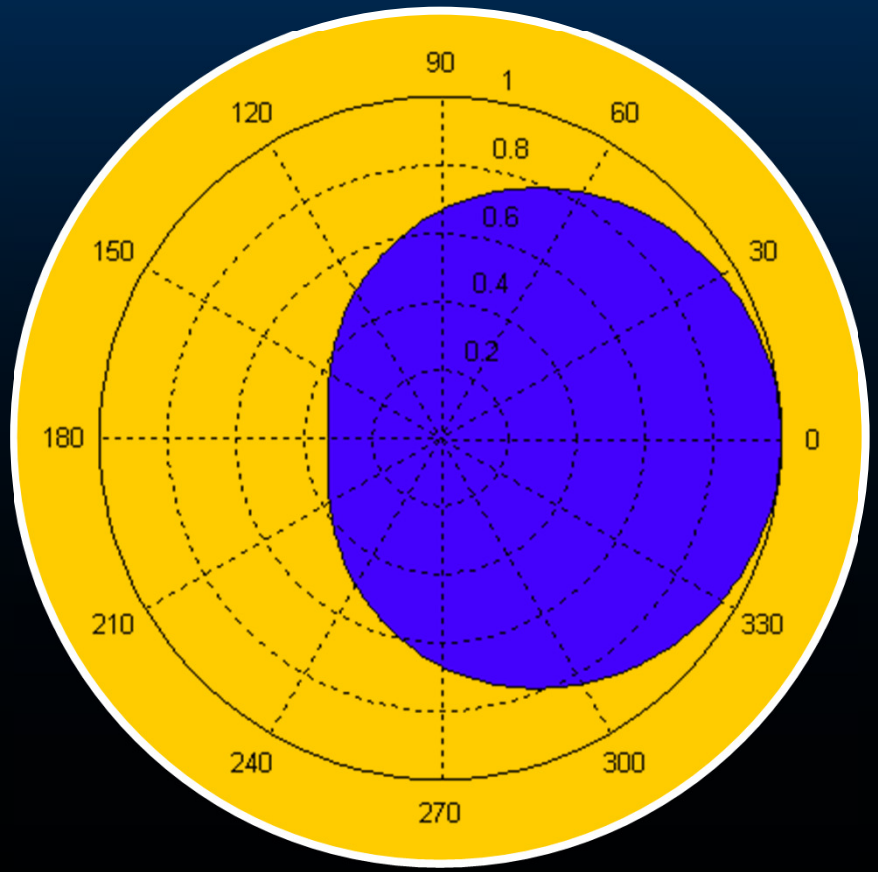
Microphone

Directivity B = 0,37





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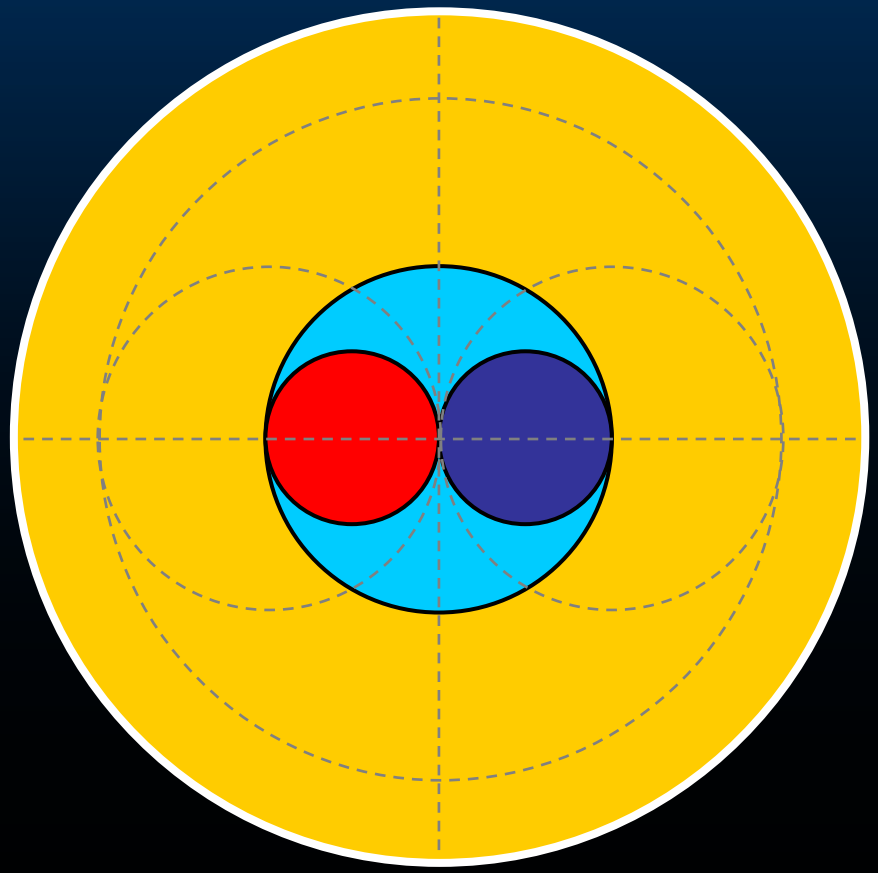
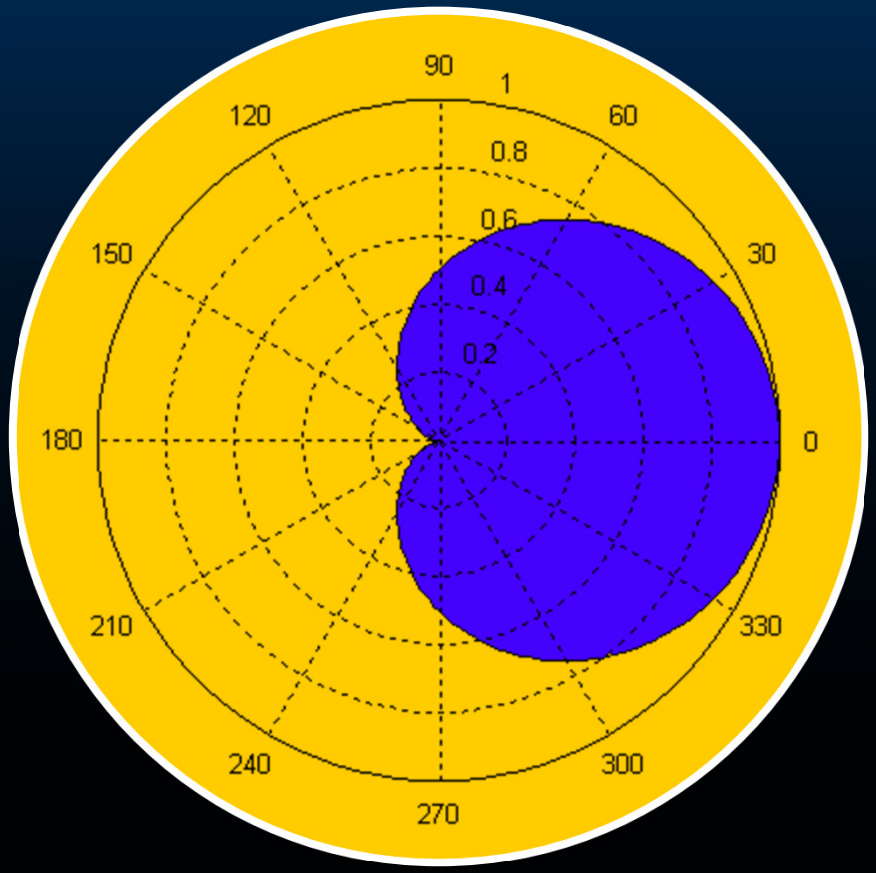
Microphone

Directivity B = 0,5





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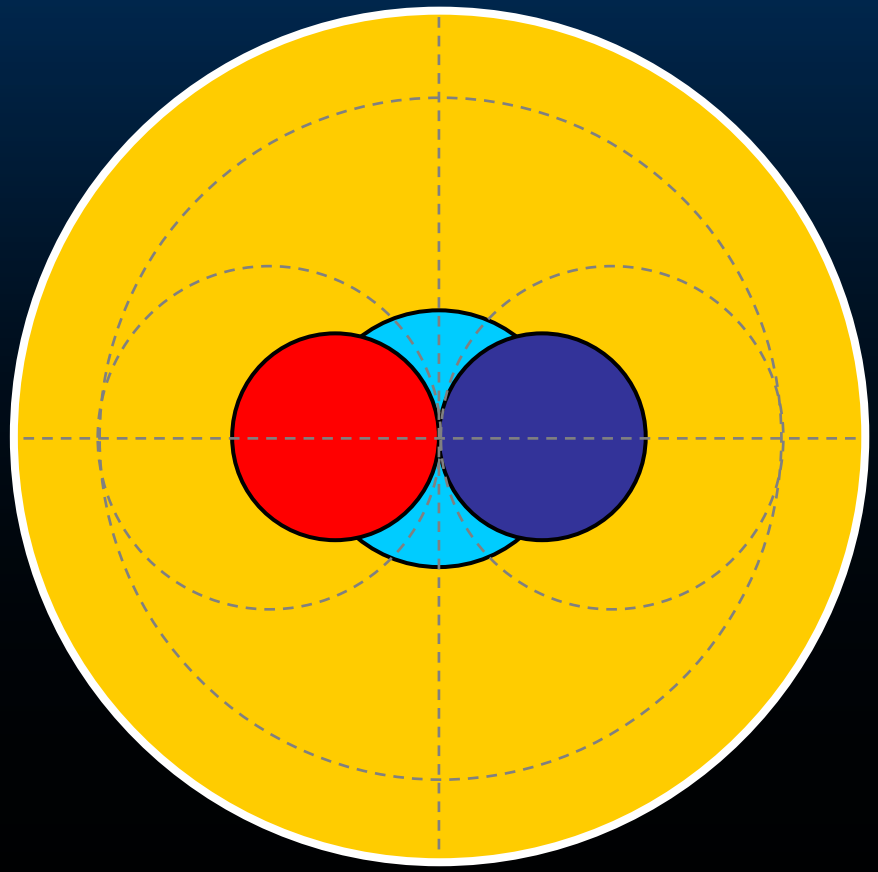
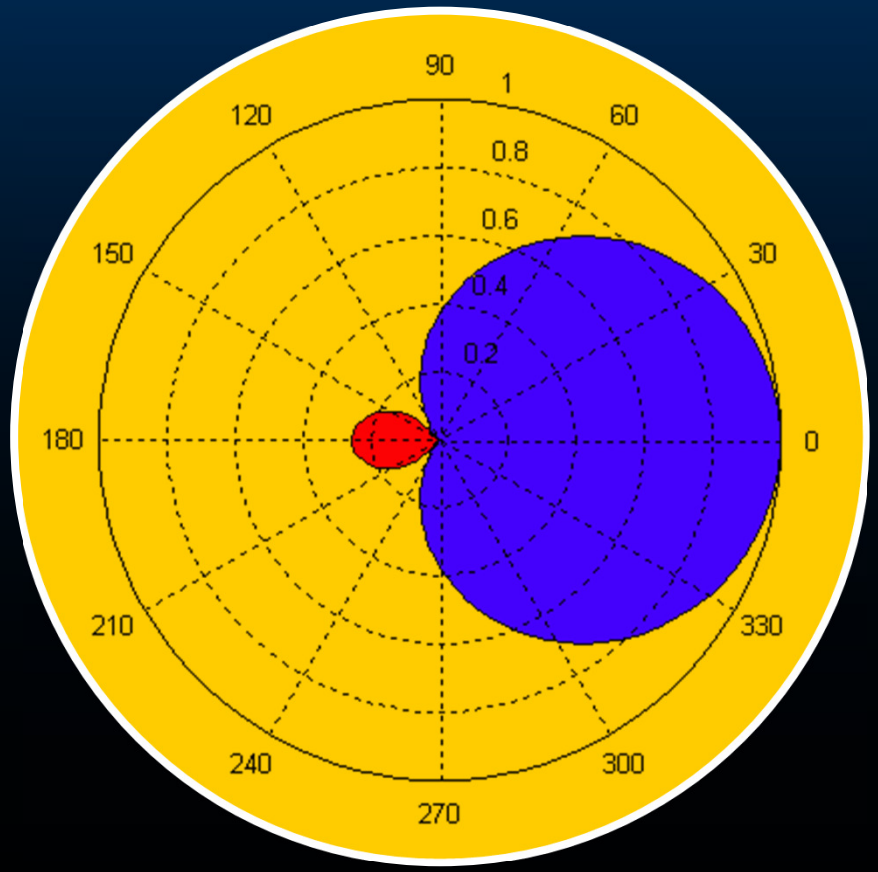
Microphone

Directivity B = 0,63





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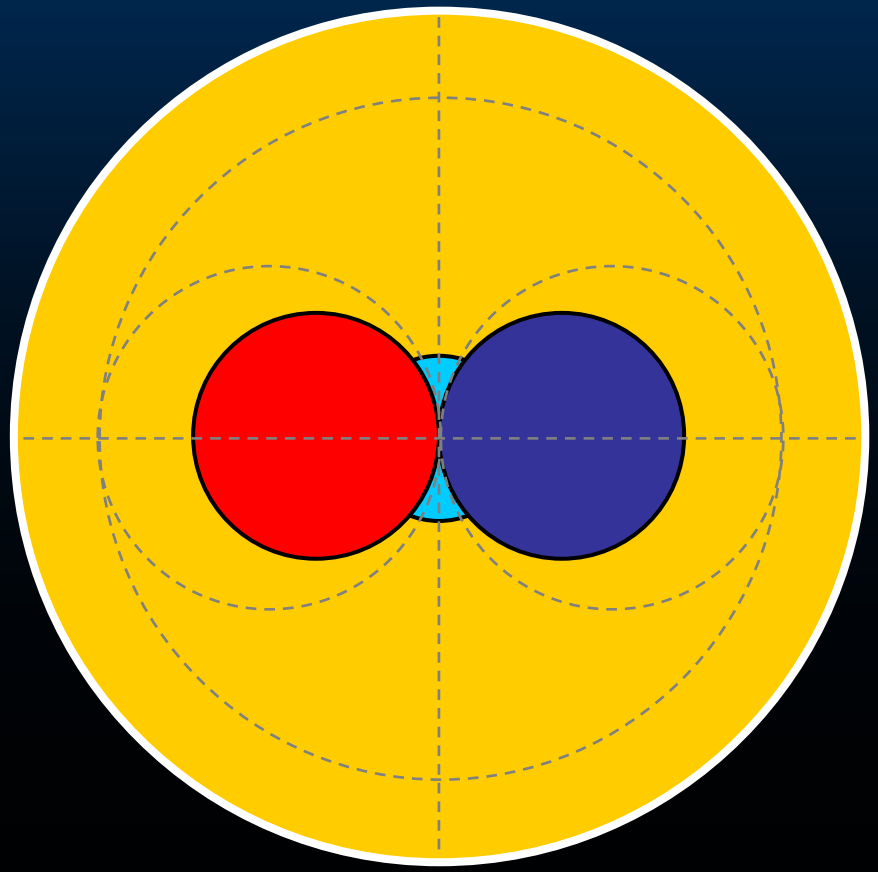
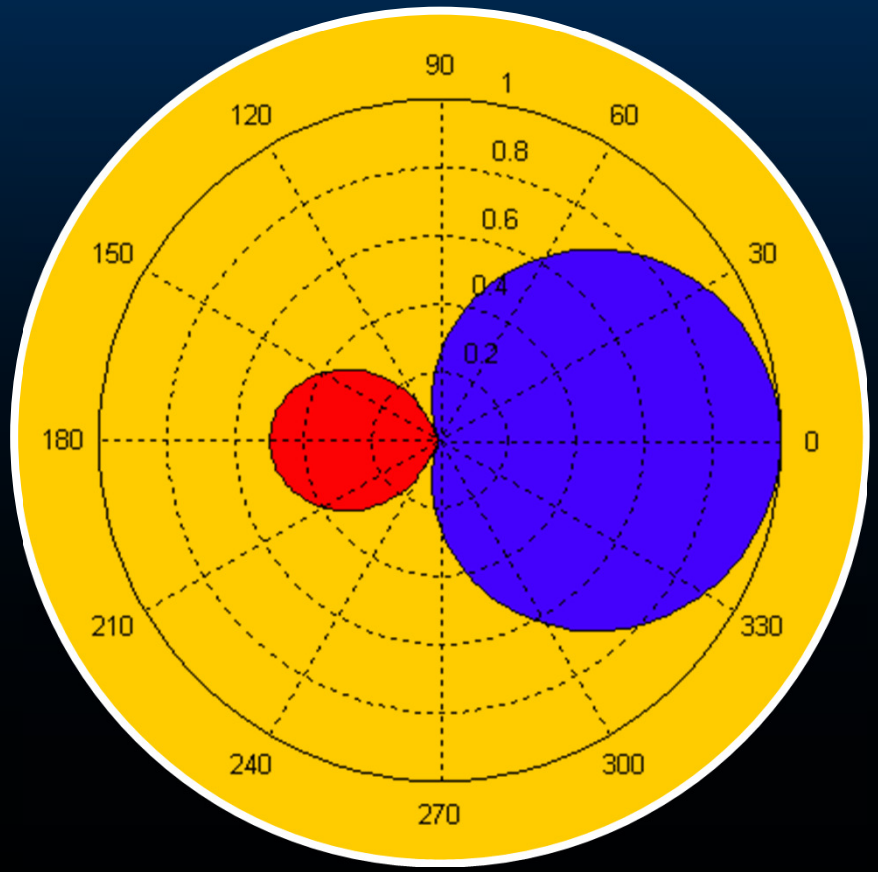
Microphone

Directivity B = 0,75





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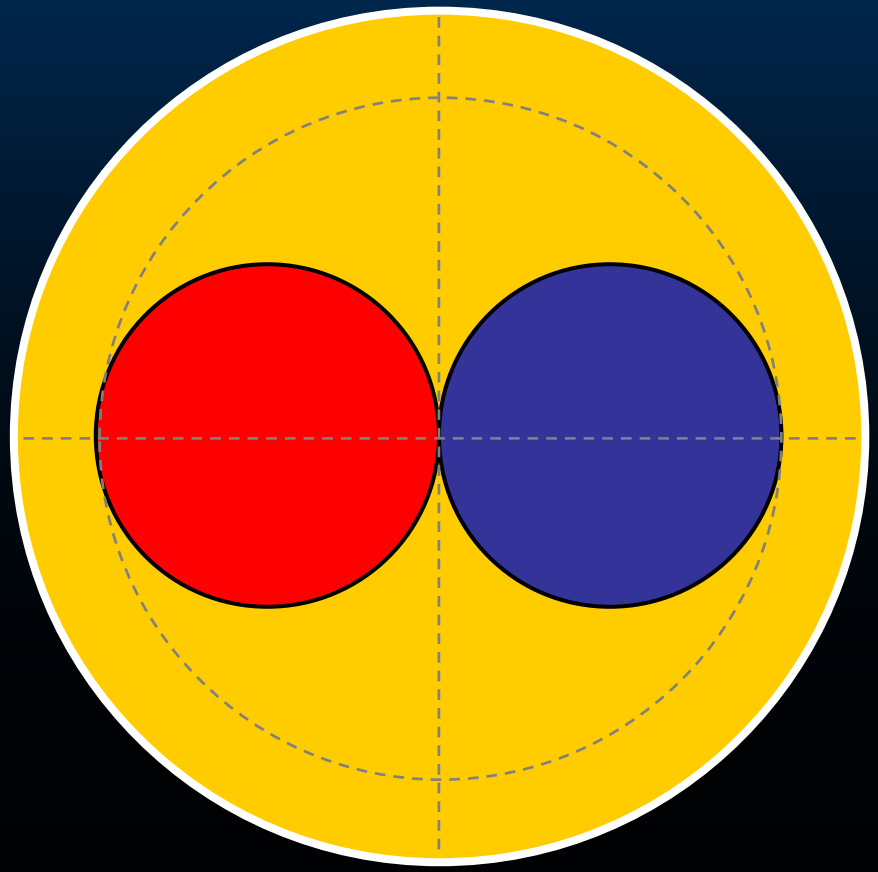
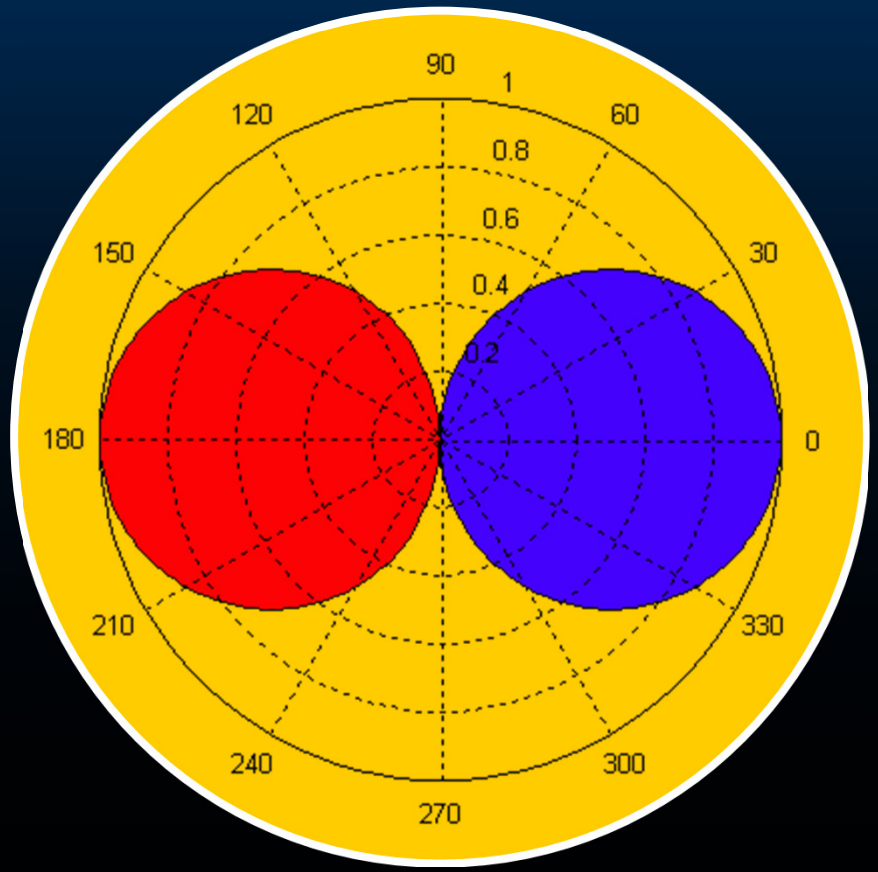
Microphone

Directivity B = 1,0





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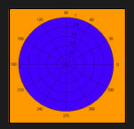
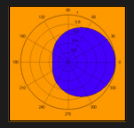
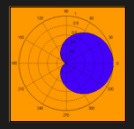
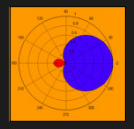
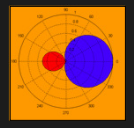
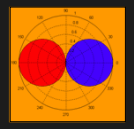
Microphones

Directivity Q_m

	B	Microphone type	Q_m	Application
	0	Omnidirectional	1,0	Measurement!
	0,37	Hypocardioid	2,2	
	0,5	Cardioid	3,0	
	0,63	Hypercardioid	3,8	
	0,75	Supercardioid	4,0	
	1,0	Bidirectional	6,0	Measurement!

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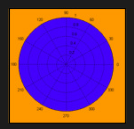
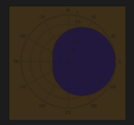
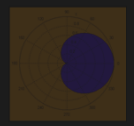
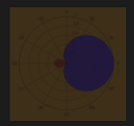
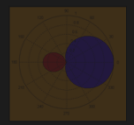
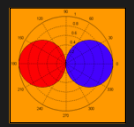
Microphones

Directivity Q_m

	B	Microphone type	Q_m	Application
	0	Omnidirectional	1,0	Measurement!
	0,37	Hypocardioid	2,2	
	0,5	Cardioid	3,0	
	0,63	Hypercardioid	3,8	
	0,75	Supercardioid	4,0	
	1,0	Bidirectional	6,0	Measurement!

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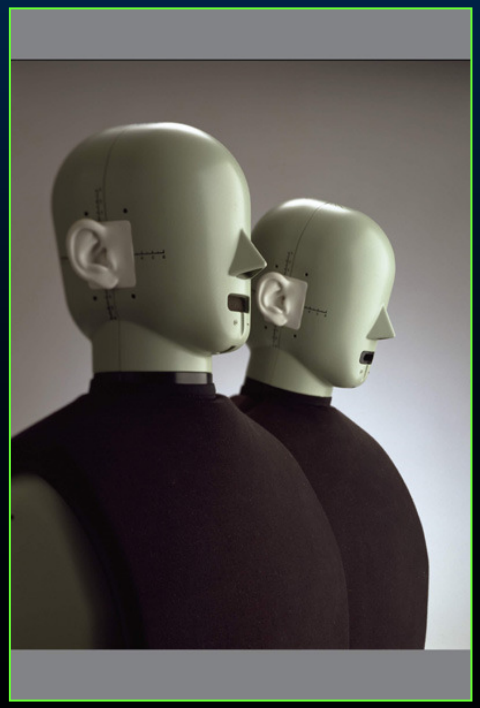
Microphones

Room acoustic measurements



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Parameters

Room
ISO 3382

- G [dB]
- EDT [s]
- T_{20} [s]
- T_{30} [s]
- C_{80} [dB]
- D_{50} --
- T_S [ms]
- LF --
- LFC --
- IACC --

Stage
Gade

- ST early [dB]
- ST late [dB]
- ST total [dB]

Quality

- INR [dB]
- SNR [dB]
- cc --

Reflection

- RI --
- Q_w --

Speech
ISO 60268-16

- STI --
- STI male --
- STI female --
- STITEL --
- RASTI --
- ALC [%]

Level

- Grel [dB]
- Magnitude --
- SPL [dB]

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Parameters

Room
ISO 3382

- G [dB]
- EDT [s]
- T_{20} [s]
- T_{30} [s]
- C_{80} [dB]
- D_{50} --
- T_S [ms]
- LF --
- LFC --
- IACC --

Stage
Gade

- ST early [dB]
- ST late [dB]
- ST total [dB]

Quality

- INR [dB]
- SNR [dB]
- cc --

Reflection

- RI --
- Q_w --

Speech
ISO 60268-16

- STI
- STI male
- STI female --
- STITEL --
- RASTI --
- ALC [%]

Level

- Grel [dB]
- Magnitude --
- SPL [dB]

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Parameters

Room
ISO 3382

- [ ] G [dB]
- [ ] EDT [s]
- [ ] T_{20} [s]
- [ ] T_{30} [s]
- [ ] C_{80} [dB]
- [ ] D_{50} --
- [ ] T_S [ms]
- [x] LF --
- [x] LFC --
- [ ] IACC --

Stage
Gade

- [ ] ST early [dB]
- [ ] ST late [dB]
- [ ] ST total [dB]

Quality

- [ ] INR [dB]
- [ ] SNR [dB]
- [ ] cc --

Reflection

- [ ] RI --
- [ ] Q_w --

Speech
ISO 60268-1

- [ ] STI
- [ ] STI male --
- [ ] STI female --
- [ ] STITEL --
- [ ] RASTI --
- [ ] ALC [%]

Level

- [ ] Grel [dB]
- [ ] Magnitude --
- [ ] SPL [dB]

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Parameters

Room
ISO 3382

- G [dB]
- EDT [s]
- T_{20} [s]
- T_{30} [s]
- C_{80} [dB]
- D_{50} --
- T_S [ms]
- LF --
- LFC --
- IACC --

Stage
Gade

- ST early [dB]
- ST late [dB]
- ST total [dB]

Quality

- INR [dB]
- SNR [dB]
- cc --

Reflection

- RI --
- Q_w --

Speech
ISO 60268-1

- STI
- STI male --
- STI female --
- STITEL --
- RASTI --
- ALC [%]

Level

- Grel [dB]
- Magnitude --
- SPL [dB]

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Parameters

Room
ISO 3382

- G [dB]
- EDT [s]
- T_{20} [s]
- T_{30} [s]
- C_{80} [dB]
- D_{50} --
- T_S [ms]
- LF --
- LFC --
- IACC --

Stage
Gade

- ST early [dB]
- ST late [dB]
- ST total [dB]

Quality

- INR [dB]
- SNR [dB]
- cc --

Reflection

- RI --
- Q_w --

Speech
ISO 60268-16

- STI
- STI male
- STI female --
- STITEL --
- RASTI --
- ALC [%]

Level

- Grel [dB]
- Magnitude --
- SPL [dB]

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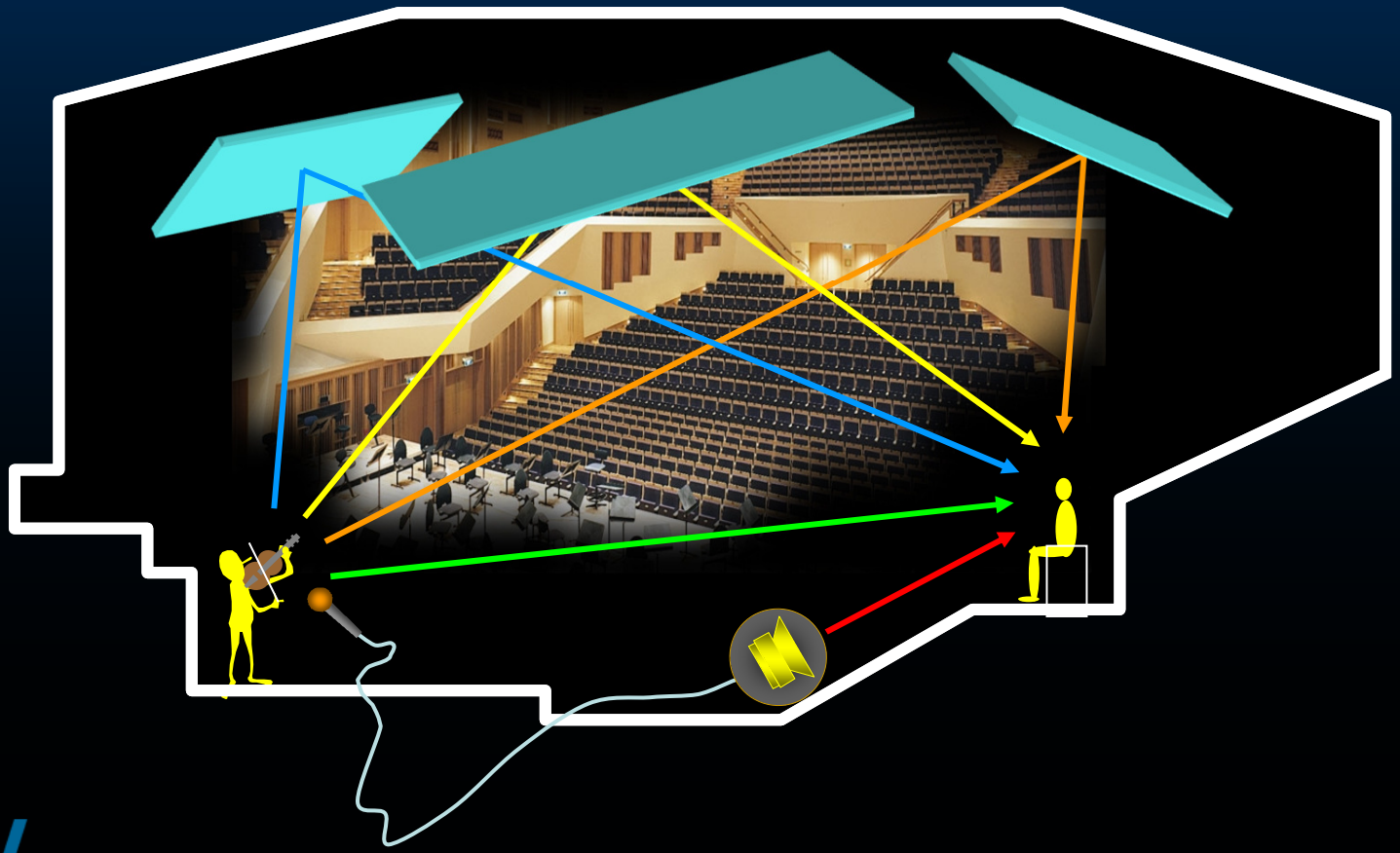
Electro Acoustics

Feedback



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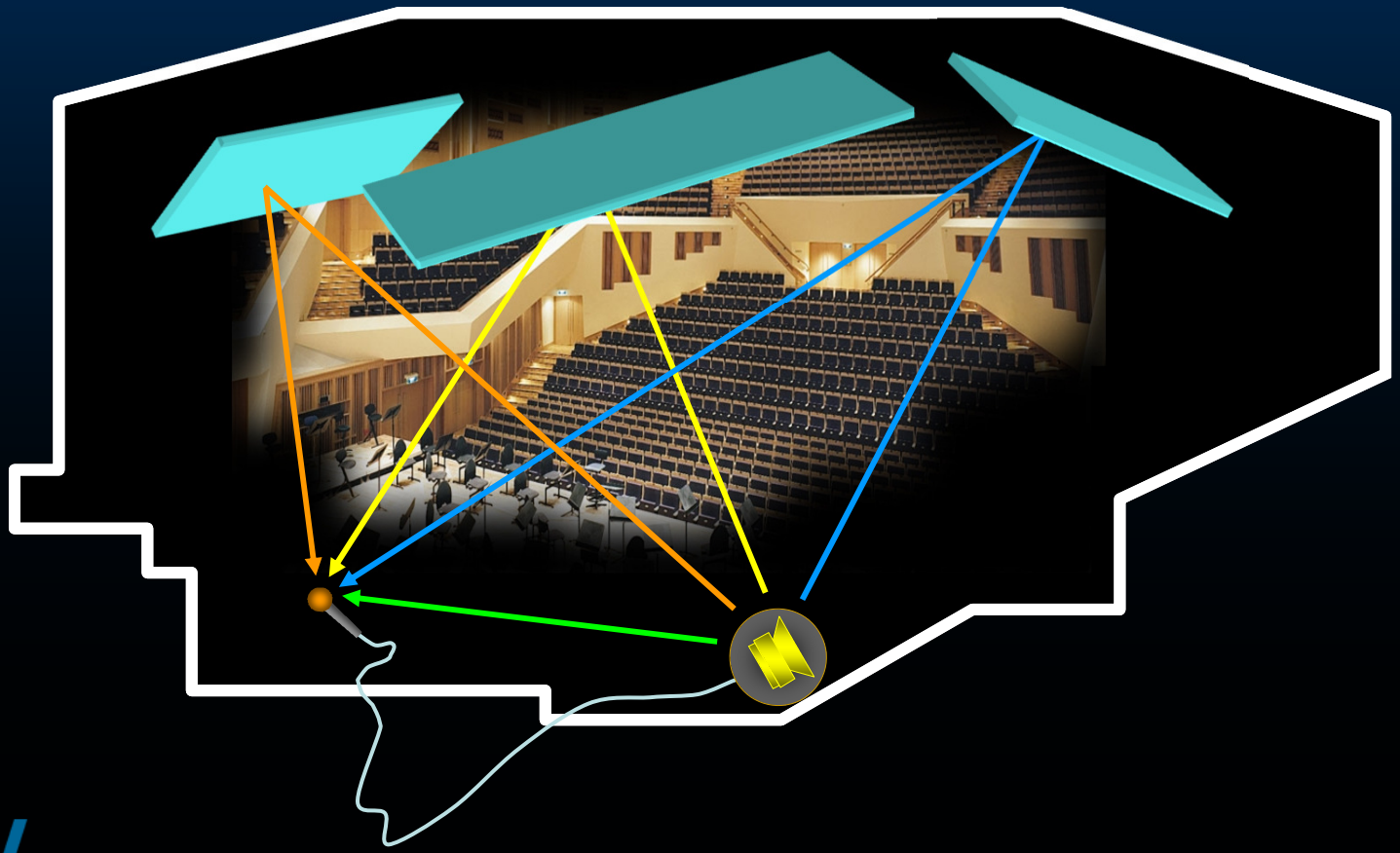
Electro Acoustics

Feedback



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Room & Electro Acoustics

Good luck !

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