Die Basics der Raumakustik

Kann man Akustik wirklich ausrechnen?
Wie beeinflusst die Akustik eines Raumes den Klang der Lautsprecher?

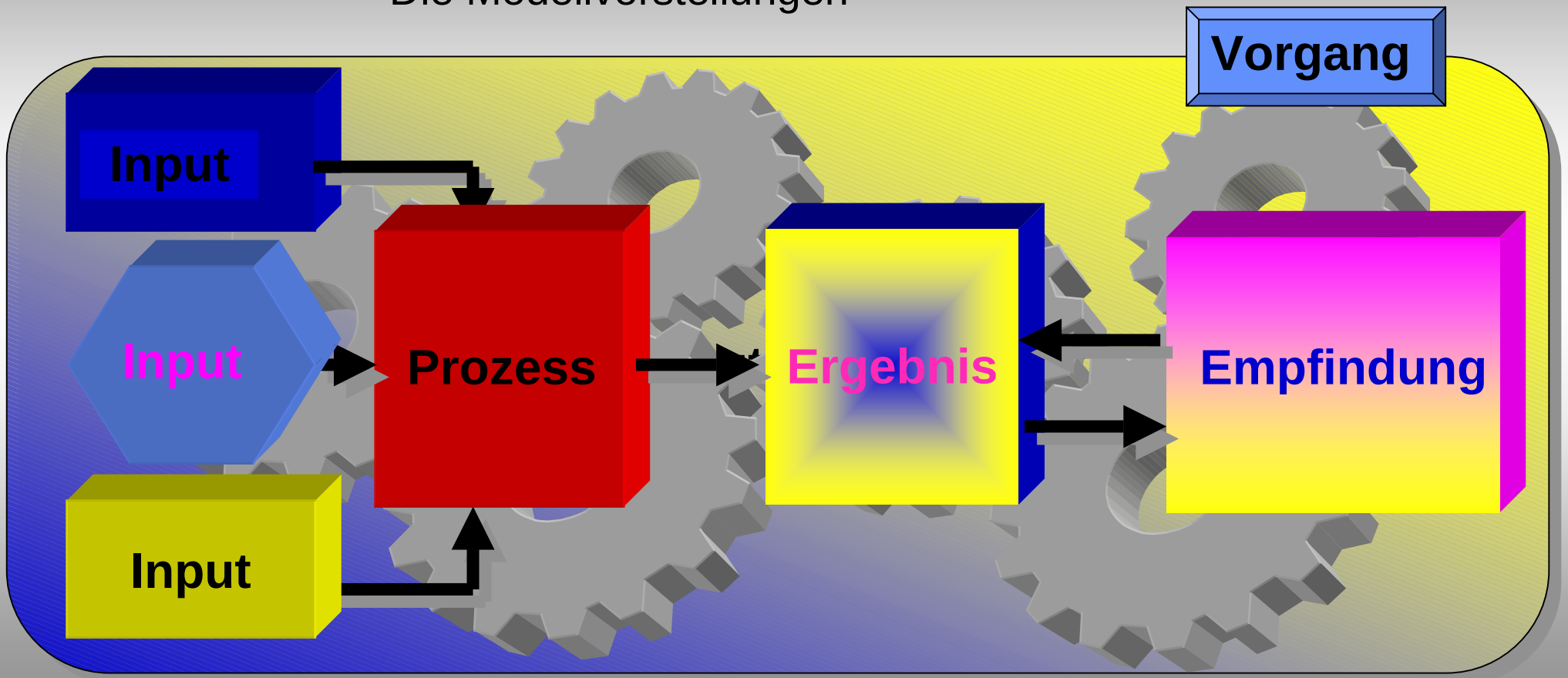
Referent: Volker Löwer, IFBconsulting

Grundlagen der Schallausbreitung

- Direktschall, Abstandsgesetz
- Signal/Noise
- Raumakustik
- Direktschall und Nachhall
- Gesamtes Schallfeld

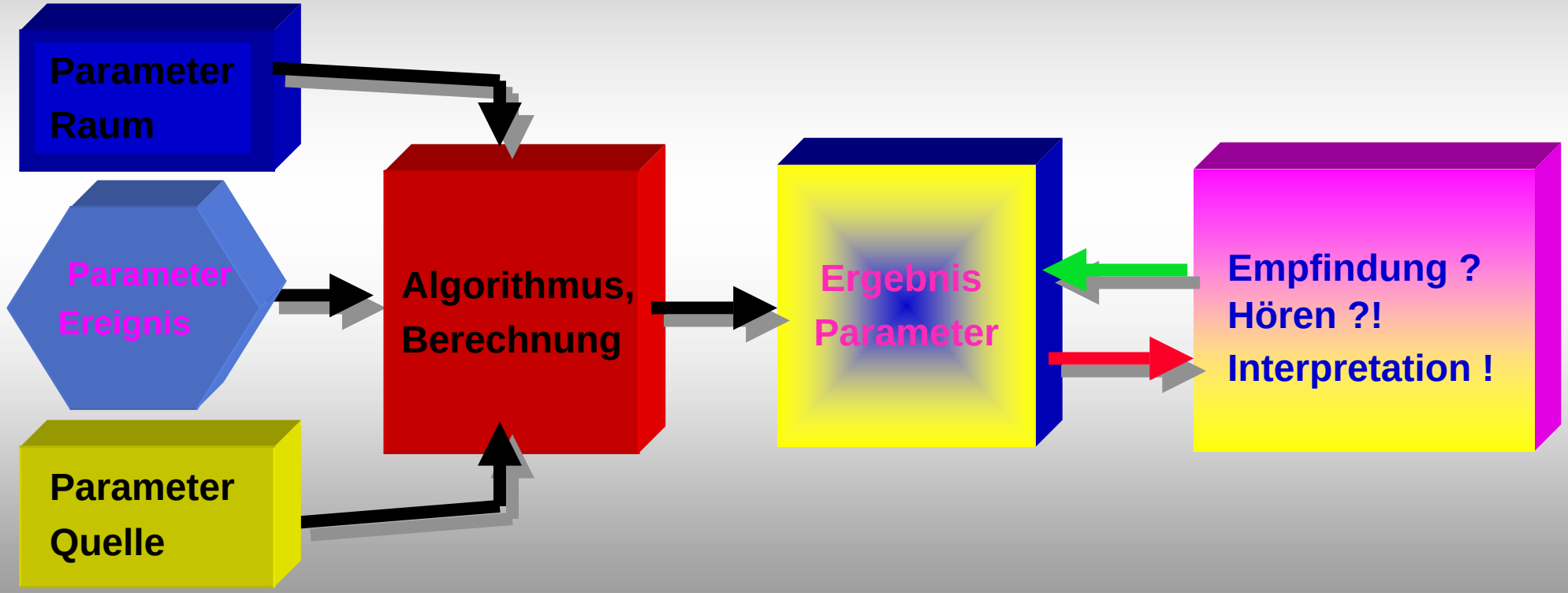
Vorbemerkungen

- Die Vorgänge der Natur
- Das subjektive Empfinden
- Die Modellvorstellungen

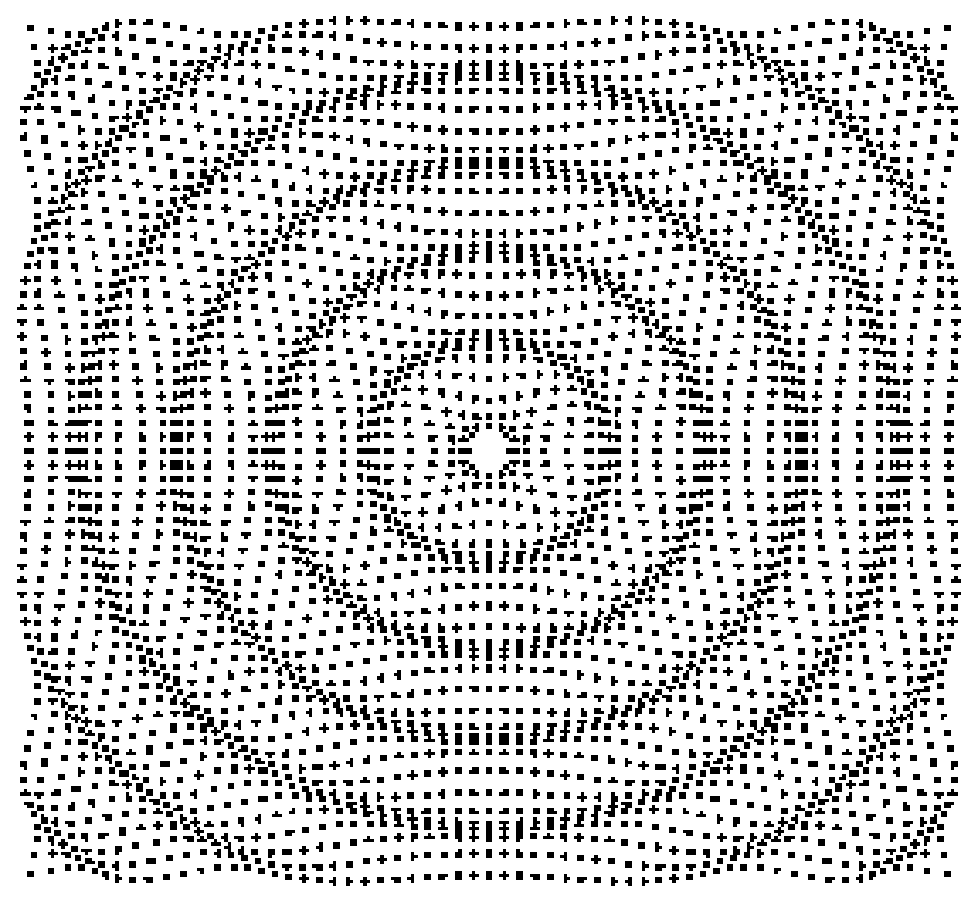


Modelle, Algorithmen

- Die Vorgänge der Natur vereinfachen
- Abhängigkeiten verstehen und erkennen
- Ergebnisparameter berechnen

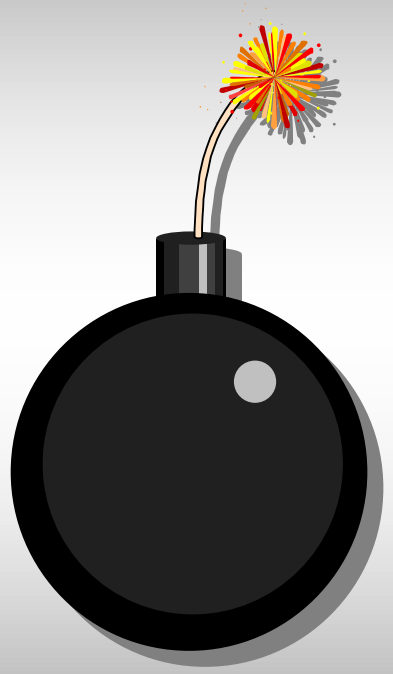


Was ist Schall ?



- Schalldruck, p
- Schallschnelle, v
- Schallgeschwindigkeit, c

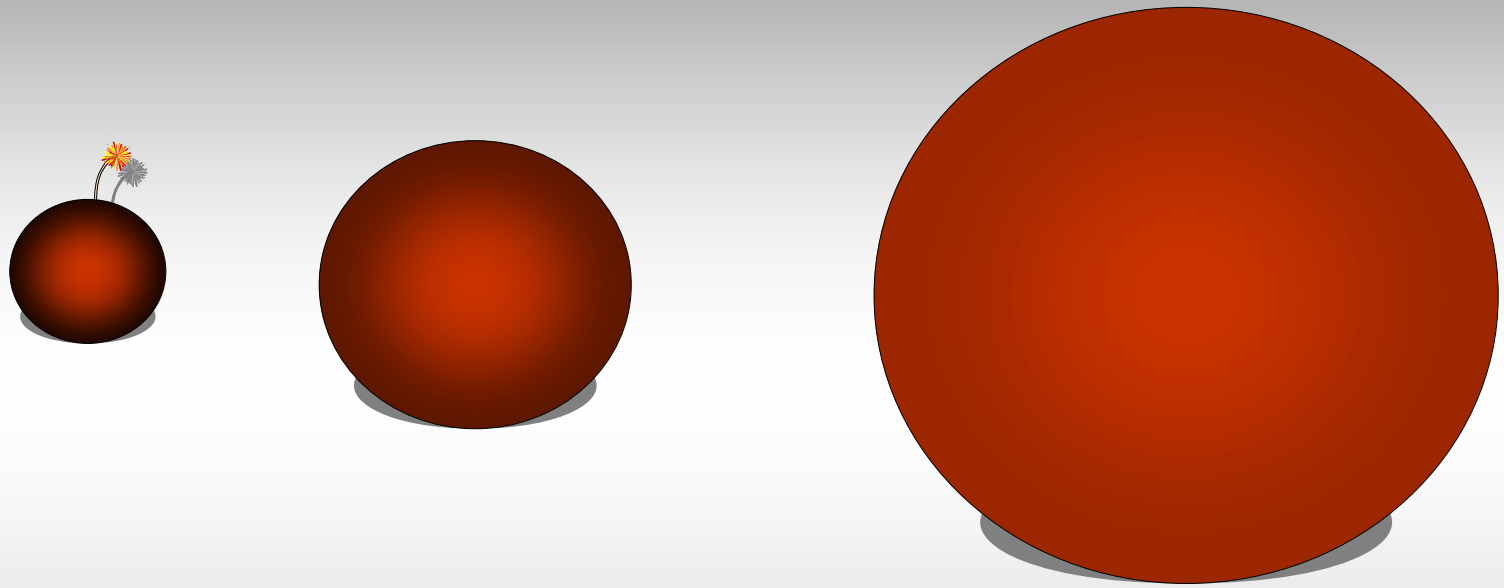
Abstandsgesetz



Impuls-Schallquelle, omnidirektional ...

t = 0 ms

Abstandsgesetz

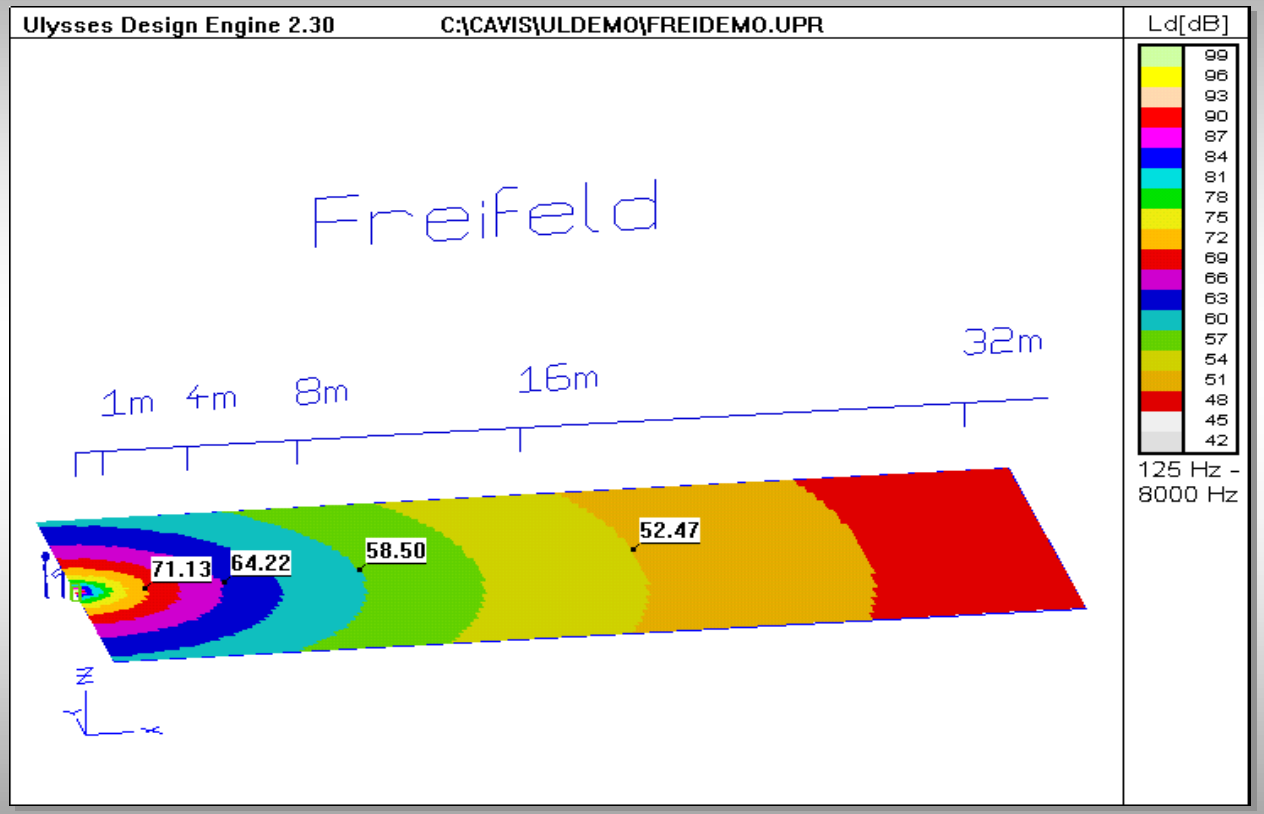


Ld = 0 dB
R = 1m

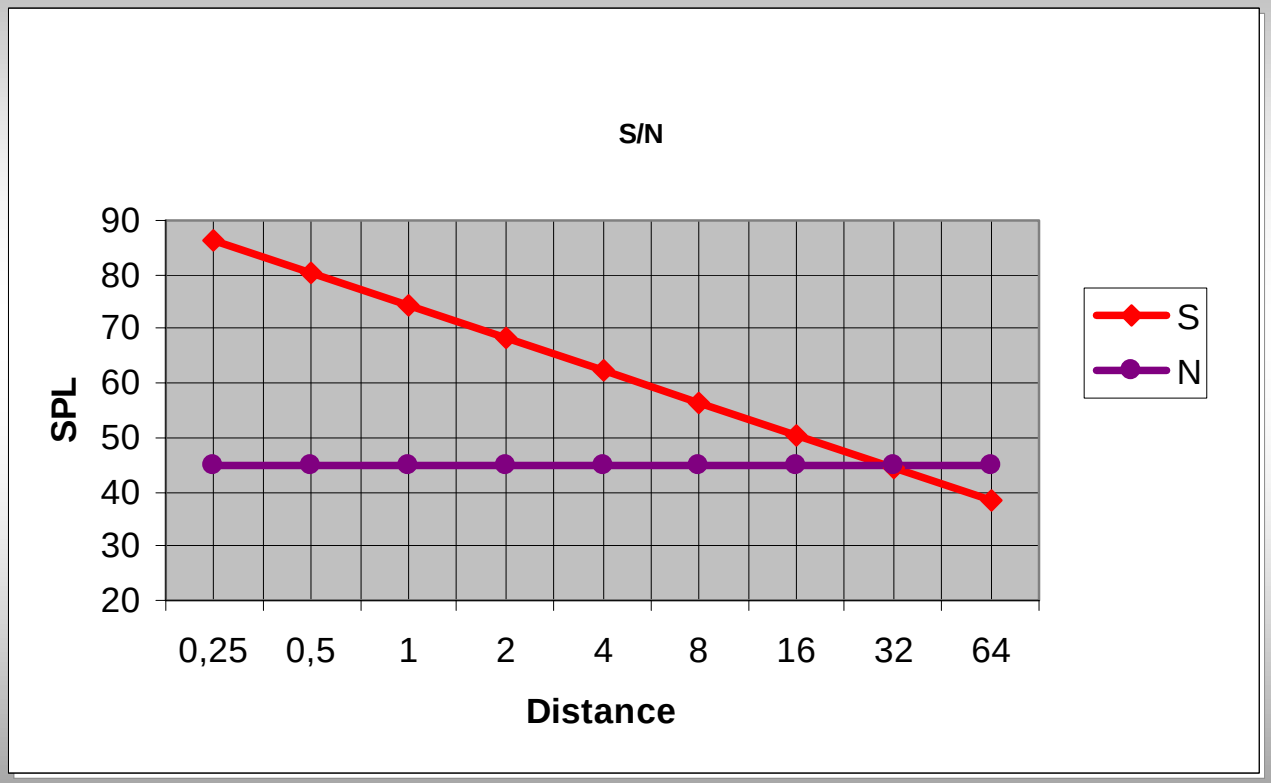
Ld = -6dB
R = 2m

Ld=-12dB
R = 4 m

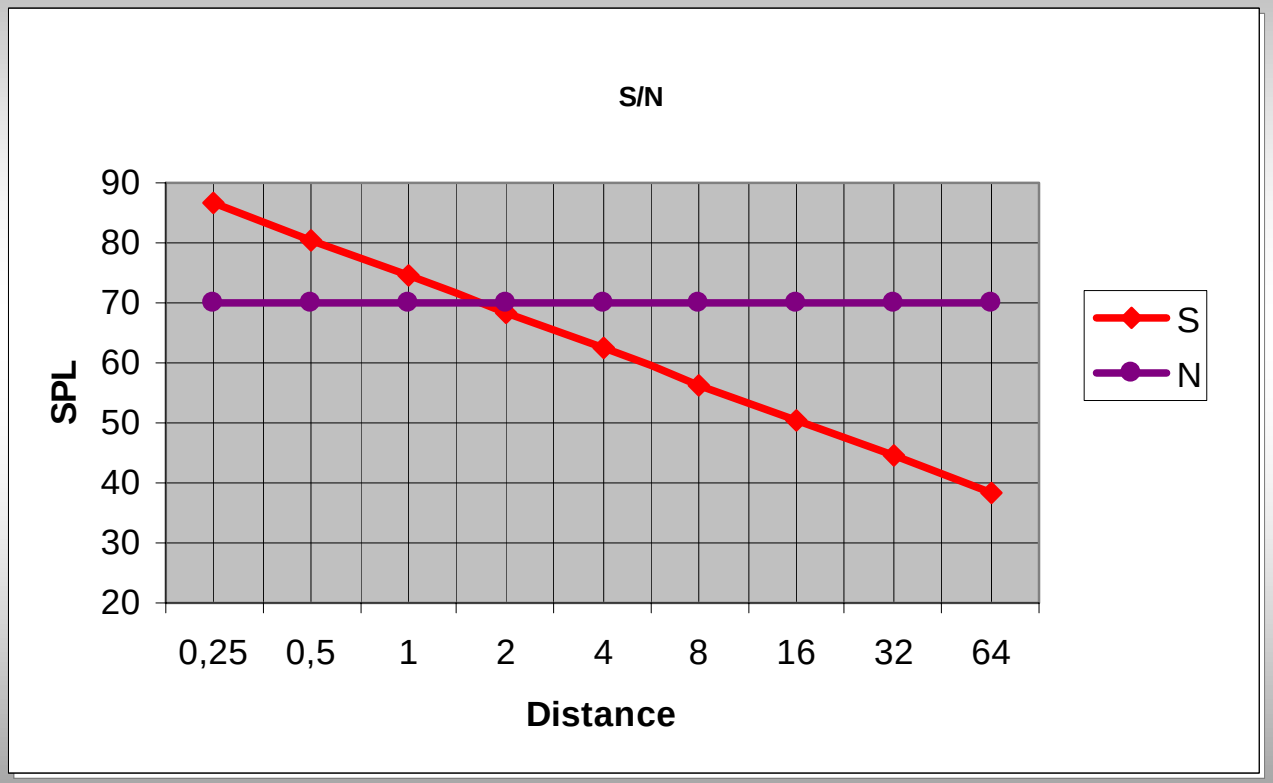
Freifeld


Ulysses Design Engine 2.30
C:\CAVIS\ULDEMO\FREIDEMO.UPR
Ld[dB]
99
96
93
90
87
84
81
78
75
72
69
66
63
60
57
54
51
48
45
42
125 Hz - 8000 Hz
Freifeld
1m
4m
8m
16m
32m
71.13
64.22
58.50
52.47
N

Signal / Noise

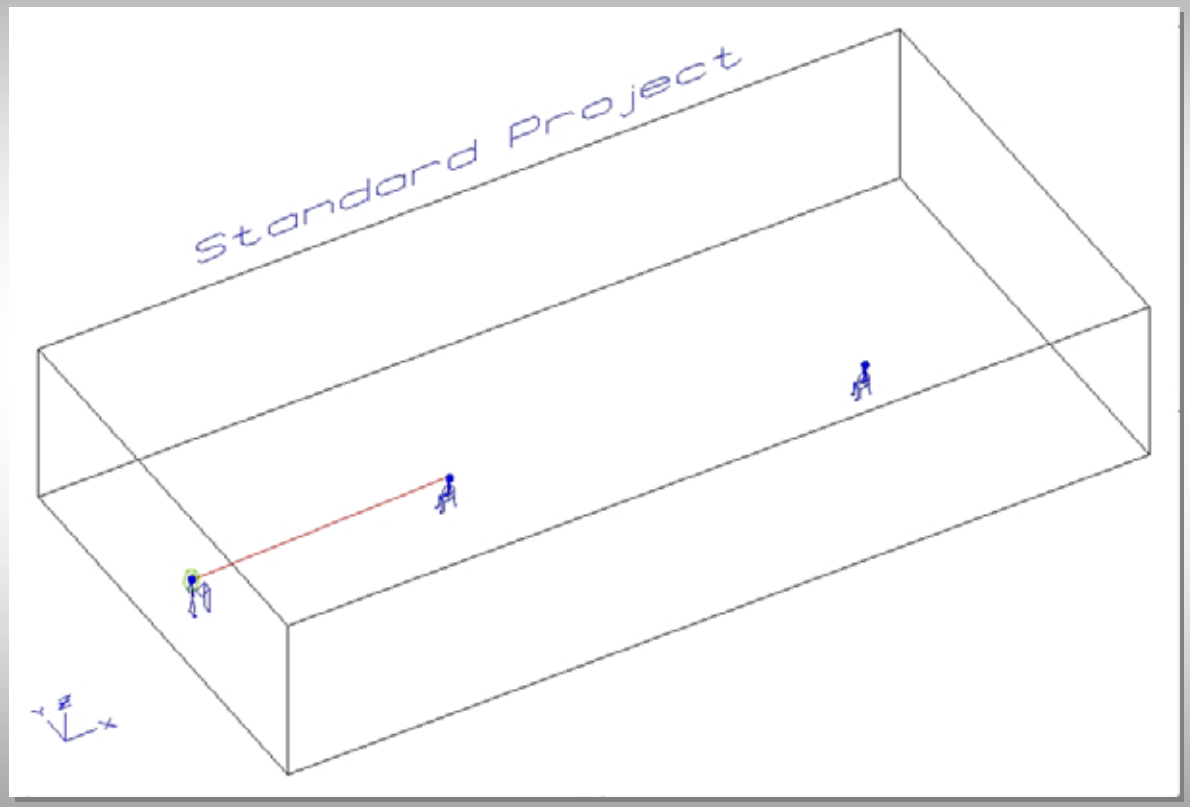


Signal / Noise

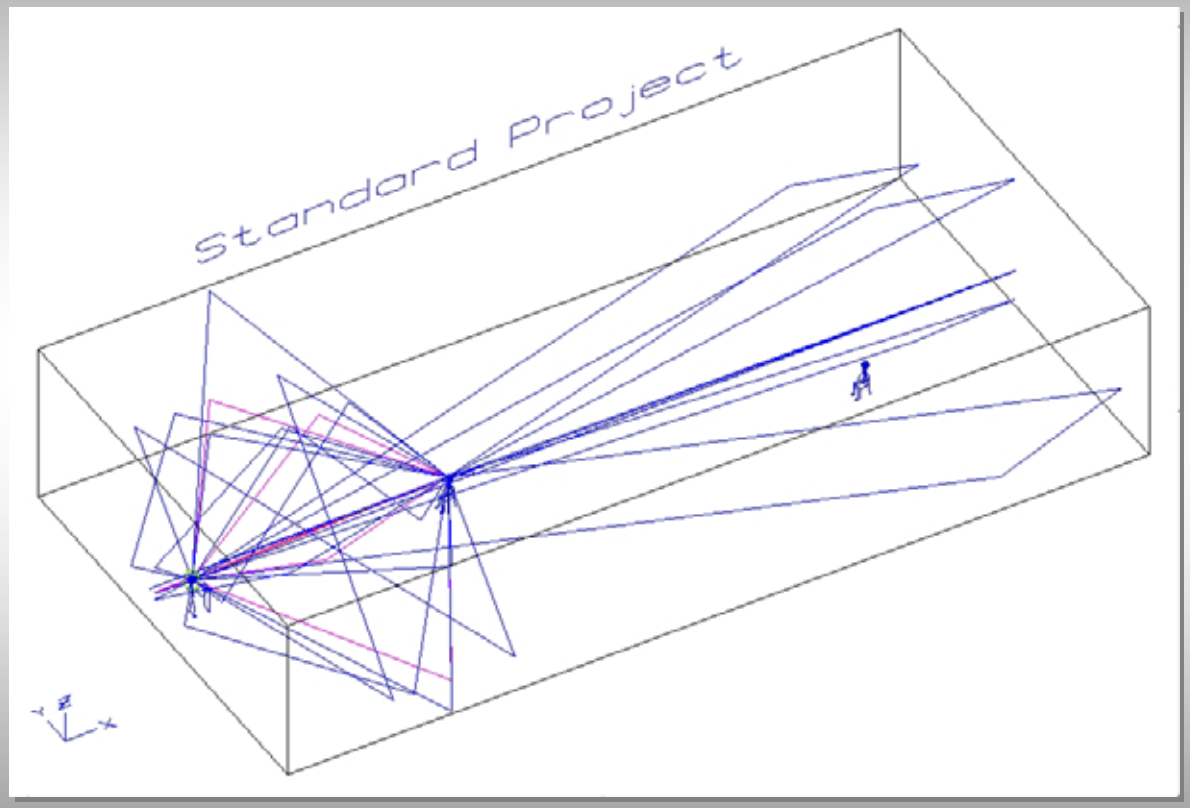


Der Raum

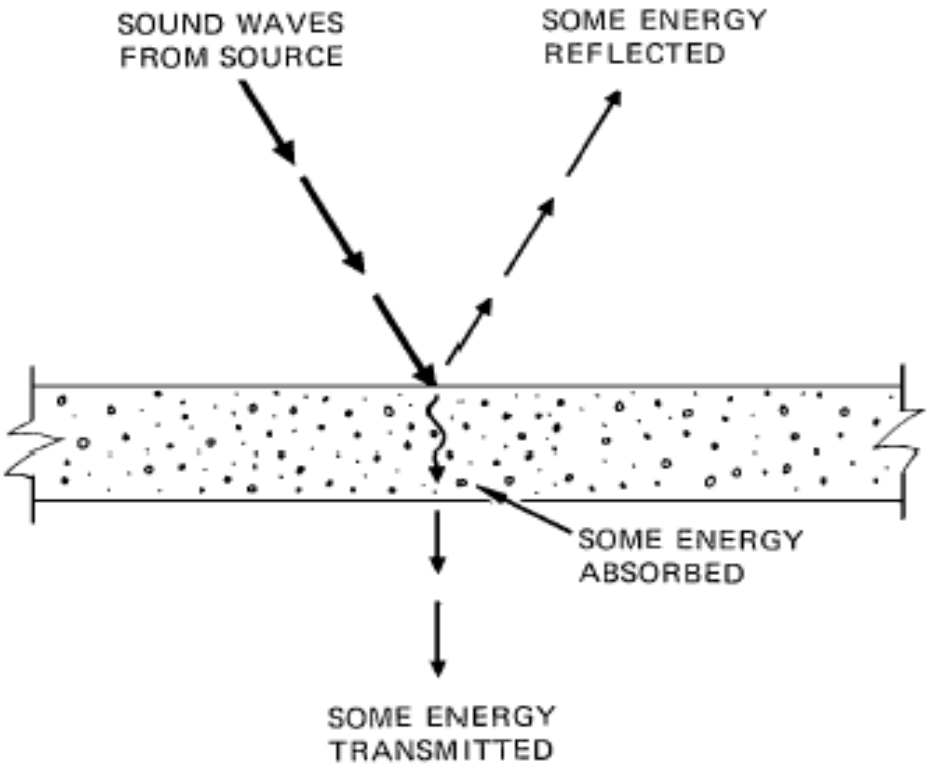
Direktschall Ld



Reflektionen

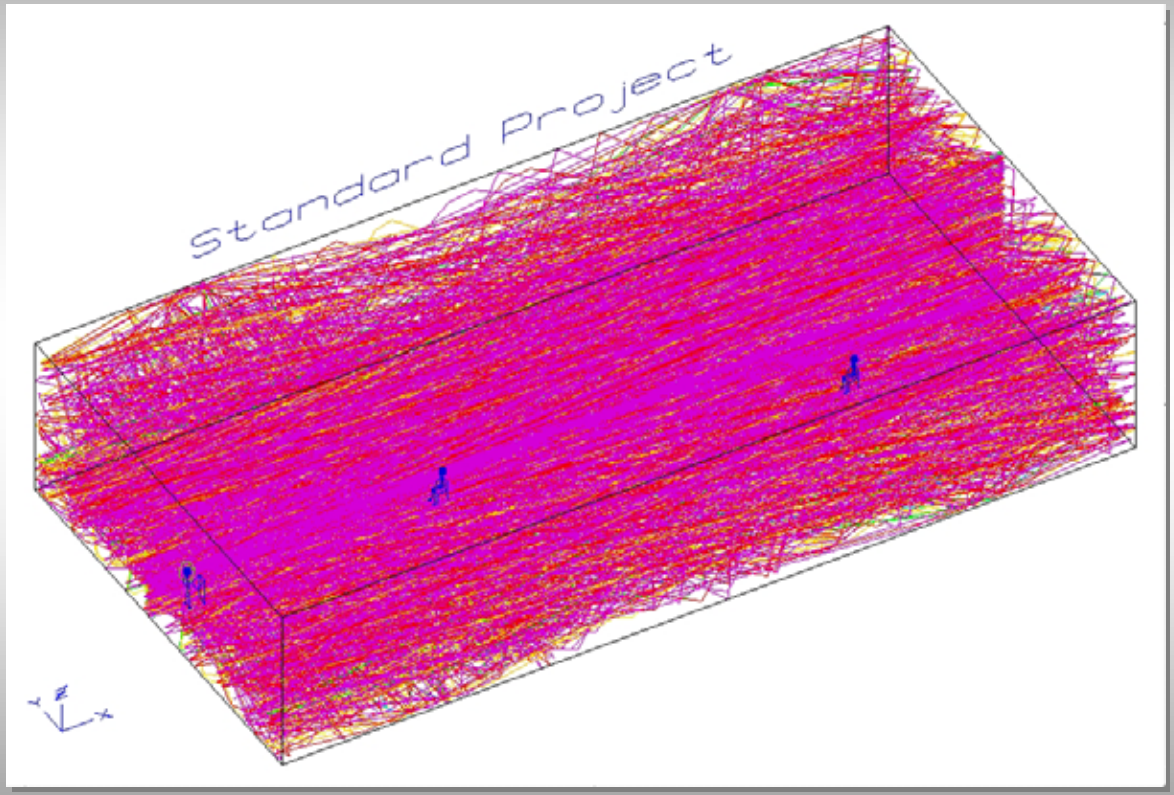


Absorption, Reflexion,Transmission

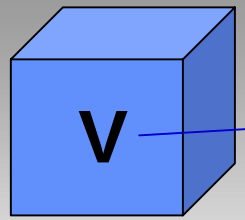


ALL THREE EFFECTS MAY VARY WITH FREQUENCY AND ANGLE OF INCIDENCE.
THEY DO NOT VARY WITH INTENSITY IN TYPICAL SITUATIONS.

Diffusfeld oder Nachhallfeld, Lr



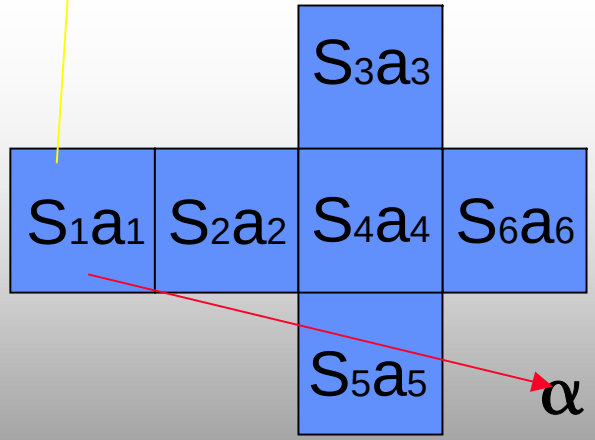
Nachhallzeit RT_{60} (W.C. Sabine) (SI metrisch!)



Volumen

$$RT_{60} = 0.163 \frac{V}{\sum S_i a_i}$$

S = Oberfläche



(äquivalente Absorptionsfläche)

$$S_1a_1 + \ldots S_ia_i = \sum S_ia_i)$$

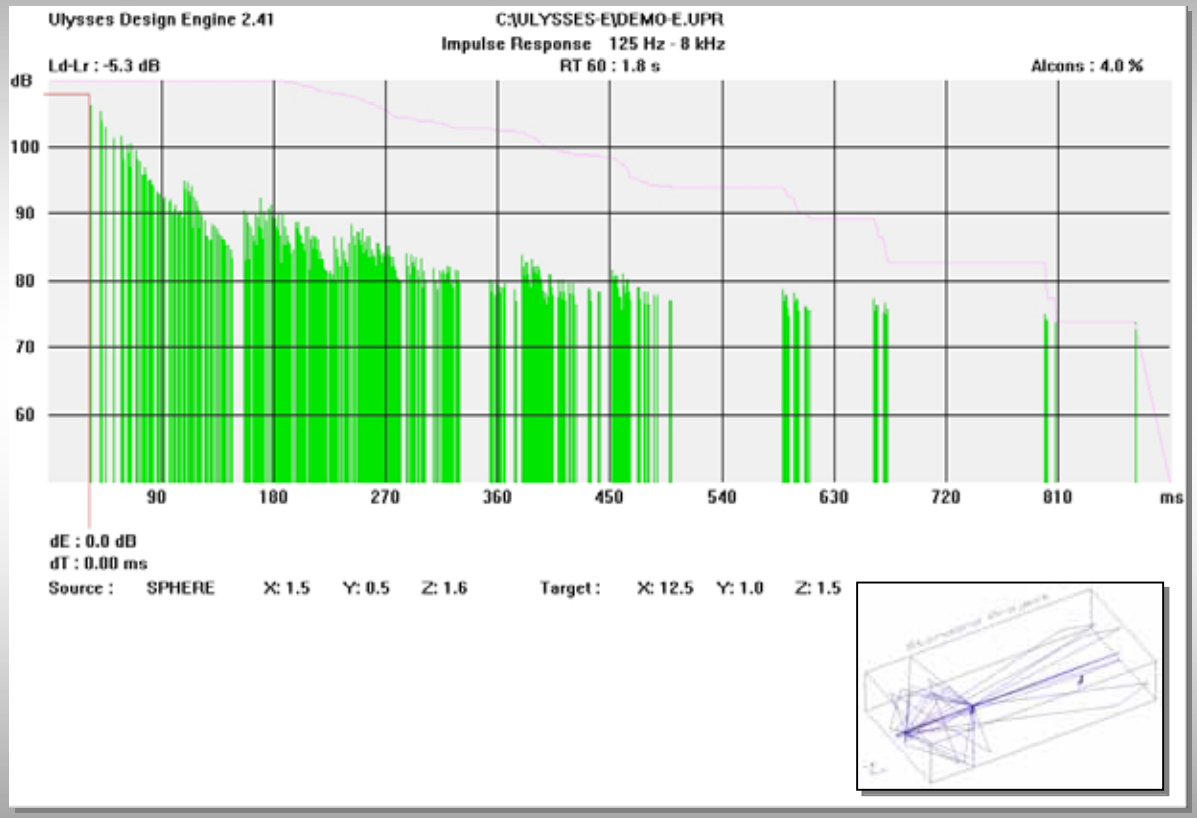
α = Absorptions-Koeffizient

Sabine, Eyring und Fitzroy Ansatz

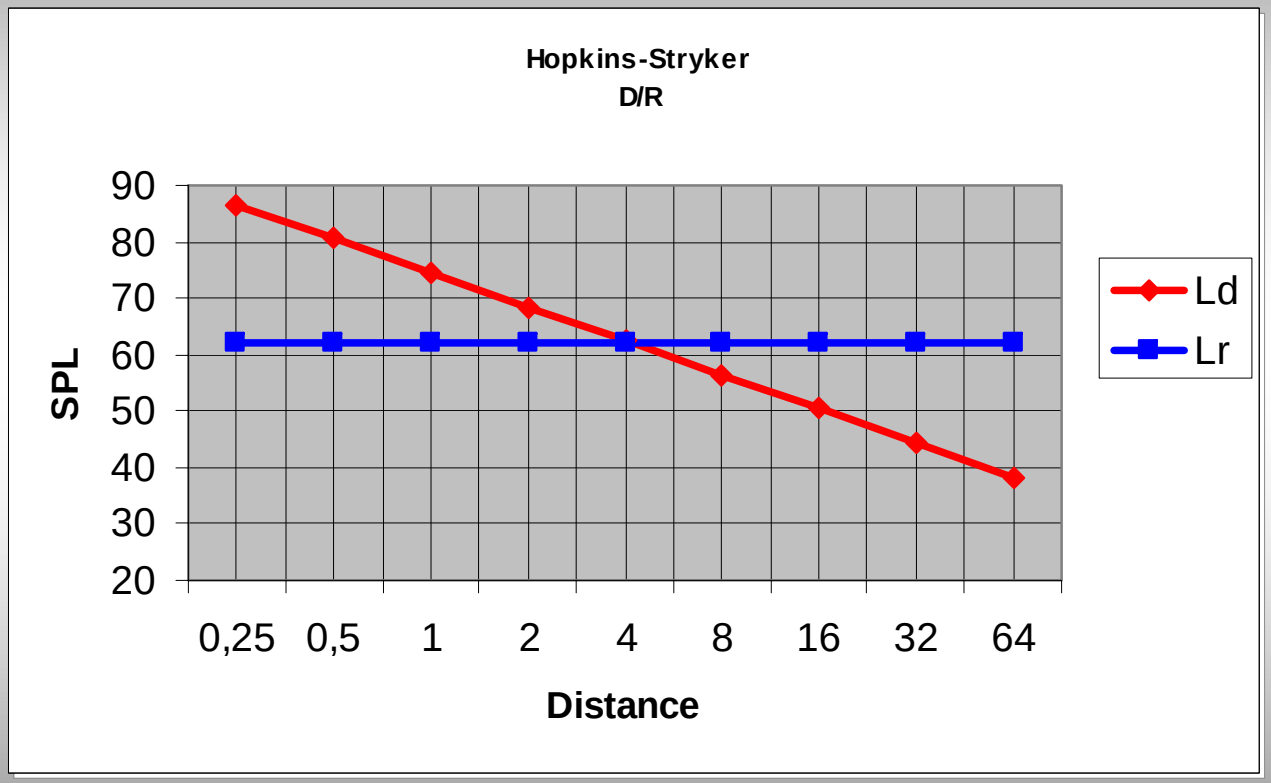
REVERBERATION TIME EQUATIONS: T = 60 dB DECAY TIME IN SECONDS		
EQUATION:	ENGLISH UNITS: S = SURFACE AREA IN FT^2 V = VOLUME IN FT^3	SI UNITS: S = SURFACE AREA IN m^2 V = VOLUME IN m^3
SABINE — GIVES BEST CORRESPONDENCE WITH PUBLISHED ABSORPTION COEFFICIENTS WHERE $\bar{\alpha}$ IS LESS THAN 0.2	$T = \frac{.049V}{S\bar{\alpha}}$	$T = \frac{.16V}{S\bar{\alpha}}$
EYRING — PREFERRED FORMULA FOR WELL-BEHAVED ROOMS HAVING $\bar{\alpha}$ GREATER THAN 0.2 OR SO	$T = \frac{.049V}{-S \ln (1-\bar{\alpha})}$	$T = \frac{.16V}{-S \ln (1-\bar{\alpha})}$
FITZROY-(SABIN) — FOR RECTANGULAR ROOMS IN WHICH ABSORPTION IS NOT WELL DISTRIBUTED.	$T = \frac{.049V}{S^2}\left(\frac{X^2}{X\alpha_x} + \frac{Y^2}{Y\alpha_y} + \frac{Z^2}{Z\alpha_z}\right)$	$T = \frac{.16V}{S^2}\left(\frac{X^2}{X\alpha_x} + \frac{Y^2}{Y\alpha_y} + \frac{Z^2}{Z\alpha_z}\right)$
αx, αy, AND αz ARE AVERAGE ABSORPTION COEFFICIENTS OF OPPOSING PAIRS OF SURFACES WITH TOTAL AREAS x, y, AND z.		

Figure 5-9. Reverberation time equations

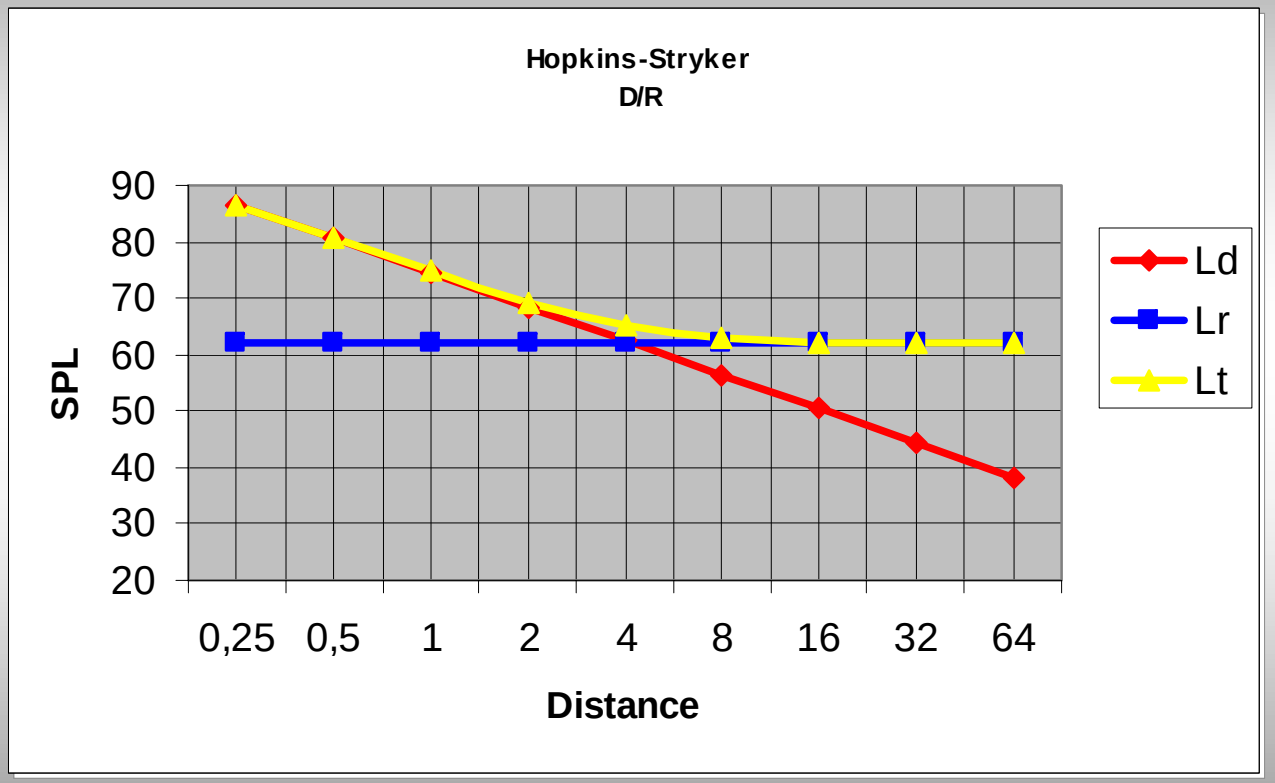
Energie vs. Zeit, Reflektogramm, Nachhall



Direktschall und Nachhall, Ld & Lr



Totales Schallfeld Lt = Ld + Lr



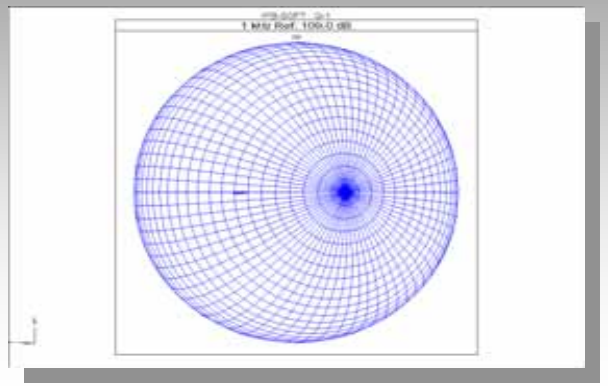
Hopkins Stryker Gleichung

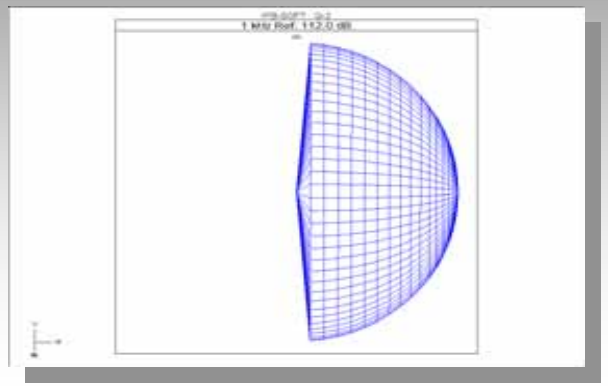
$$\Delta L_D = 10 \log \frac{Q}{4 \pi r^2}$$

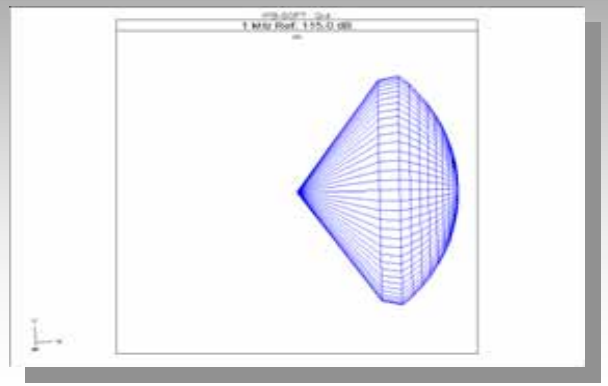
$$\Delta L_R = 10 \log \frac{4}{S \alpha}$$

$$\Delta L_T = 10 \log \left(\frac{Q}{4 \pi r^2} + \frac{4}{S \alpha} \right)$$

Bündelung Q & D_I, Directivity, Q & D_I







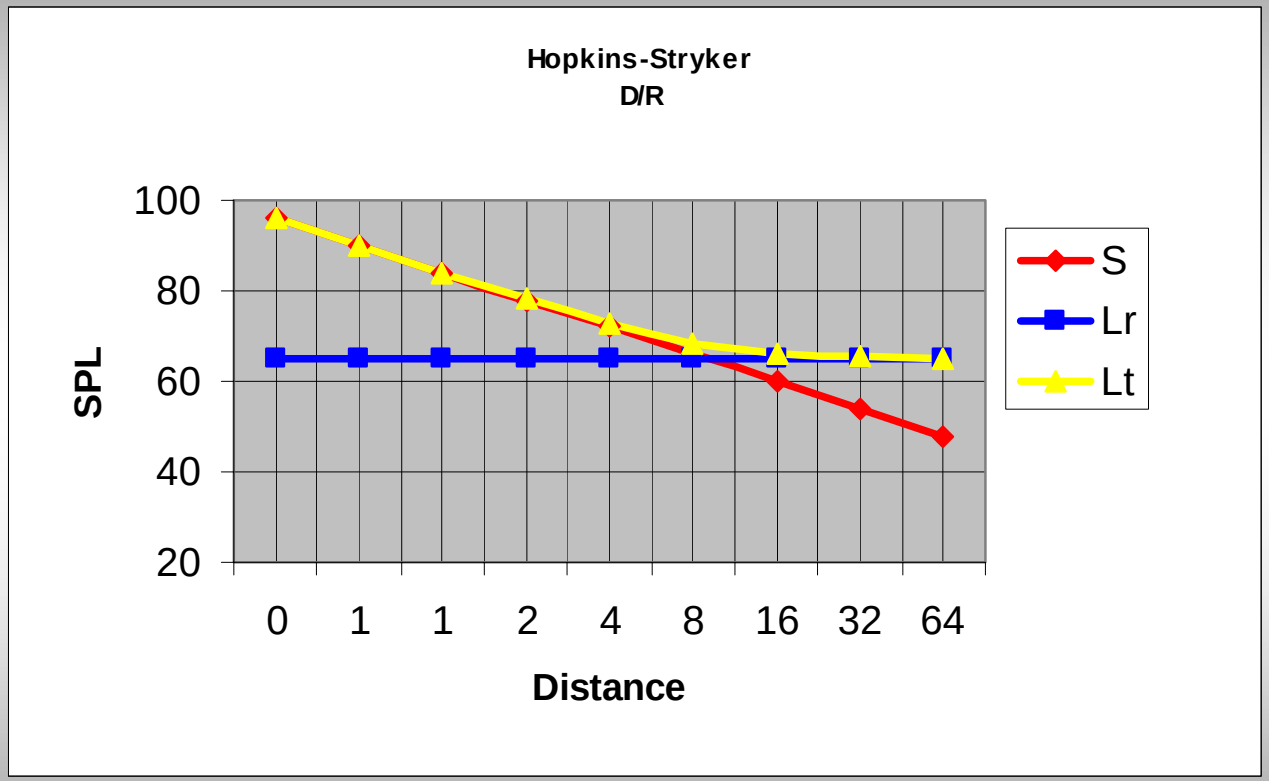
Q= 1
DI= 0 dB

Q= 2
DI= 3 dB

Q= 4
DI= 6dB

$$D_I = 10 \log Q$$

Totales Schallfeld Lt = Ld + Lr , Q= 8, D_I= 9 dB



Diskussion

- Jede Frage ist willkommen ...

Die Basics der Raumakustik

Vielen Dank für Ihre Aufmerksamkeit !