Die Basics der Raumakustik

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

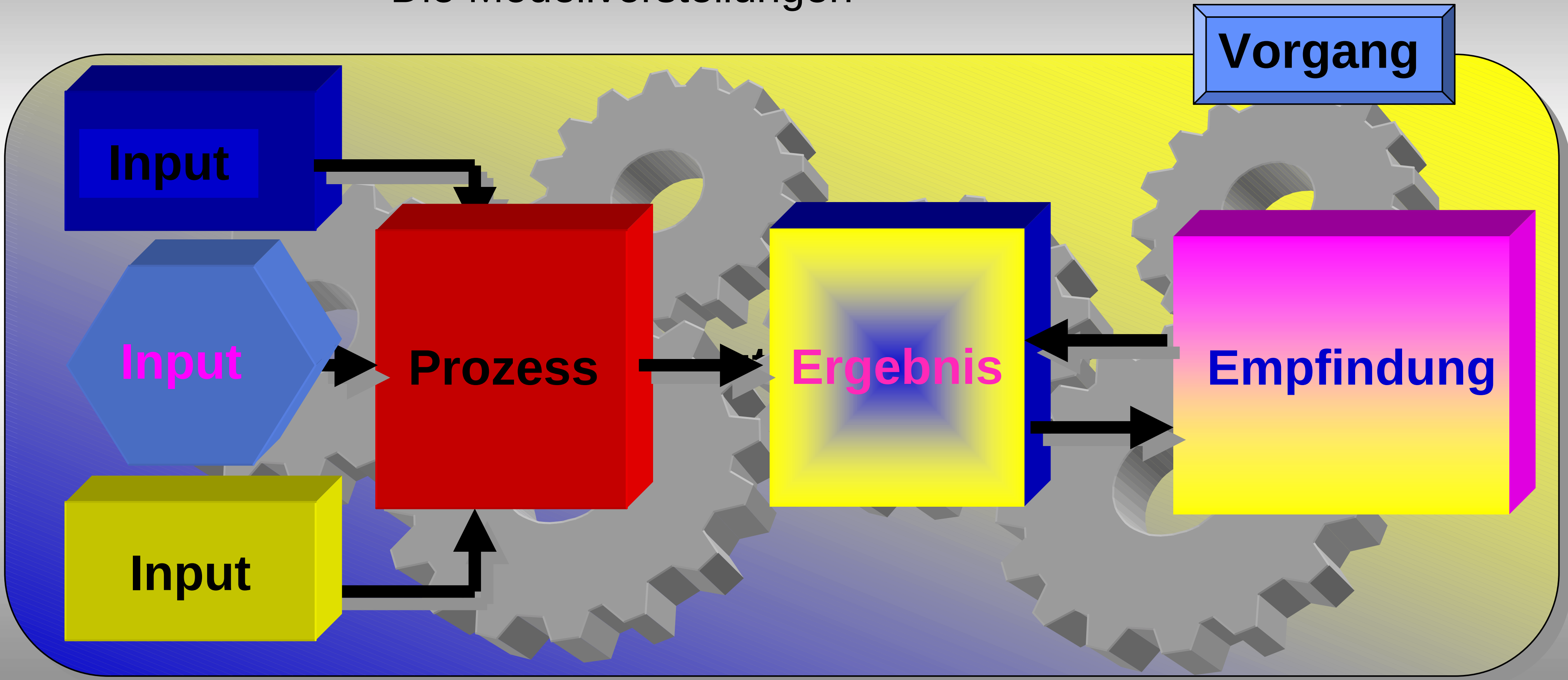
Referent: Volker Löwer, IFBconsulting

Grundlagen der Schallausbreitung

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

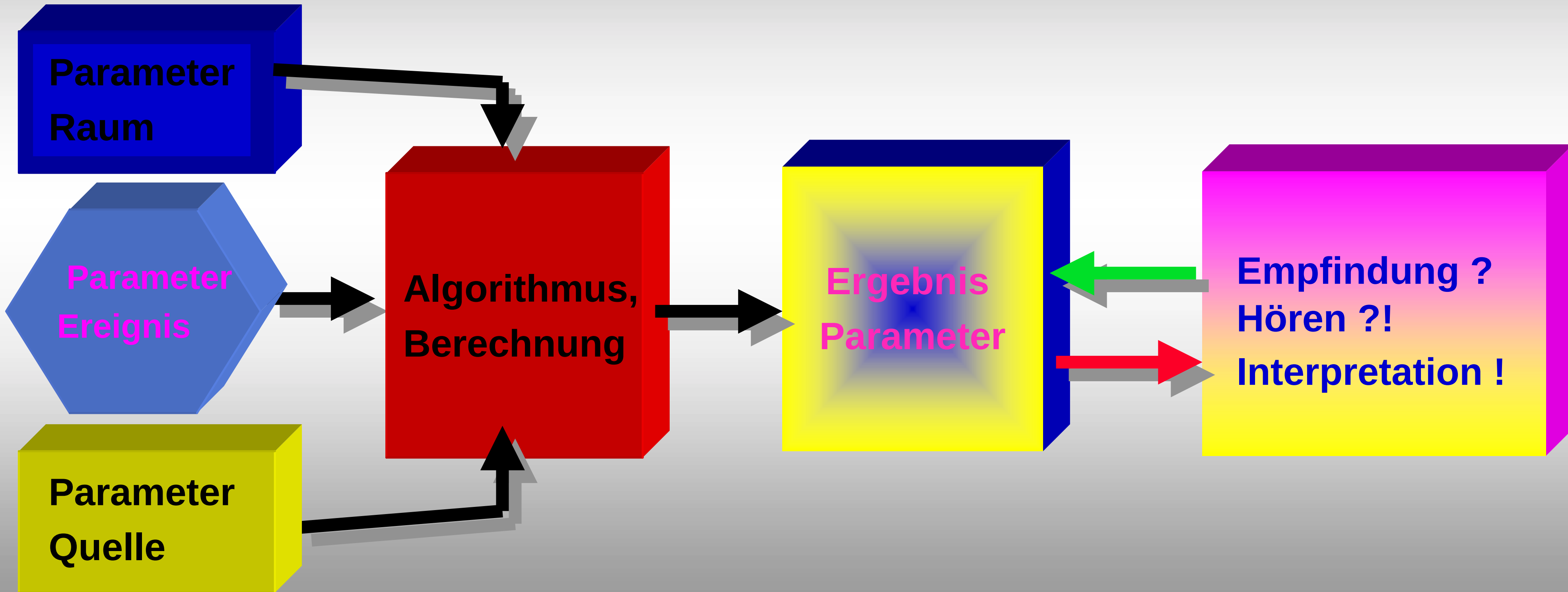
Vorbemerkungen

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

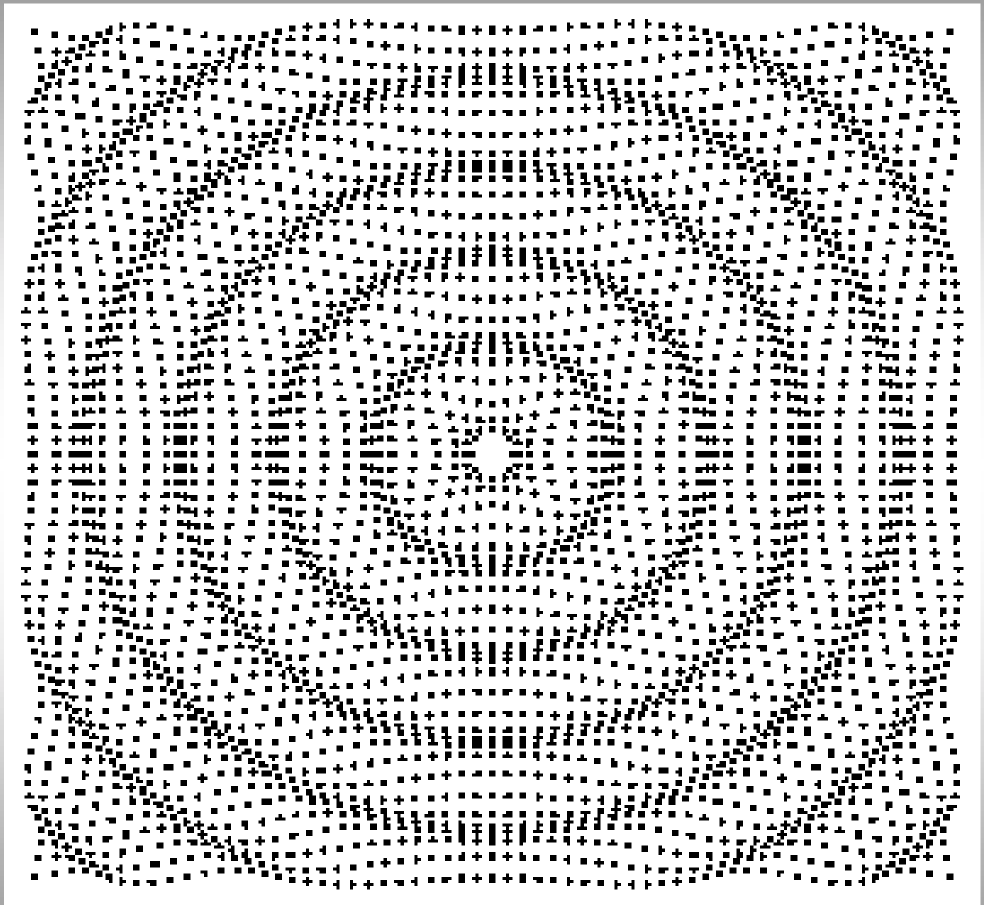


Modelle, Algorithmen

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

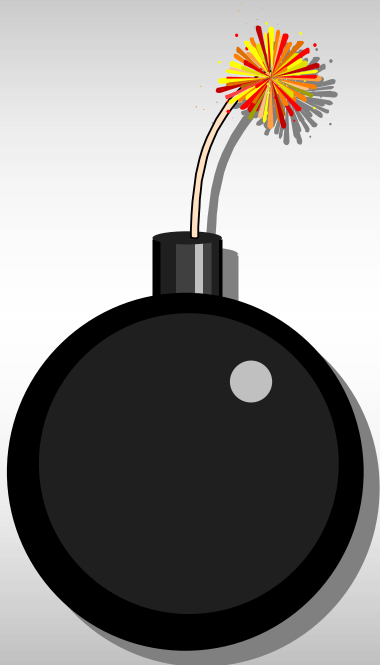


Was ist Schall ?



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

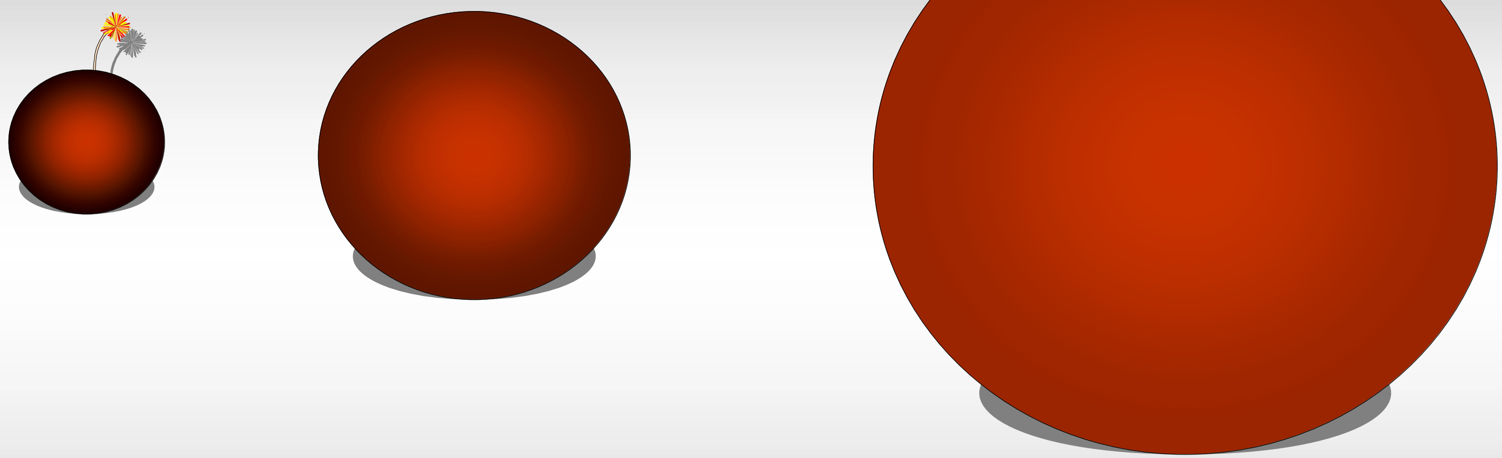
Abstandsgesetz



Impuls-Schallquelle, omnidirektional ...

t = 0 ms

Abstandsgesetz

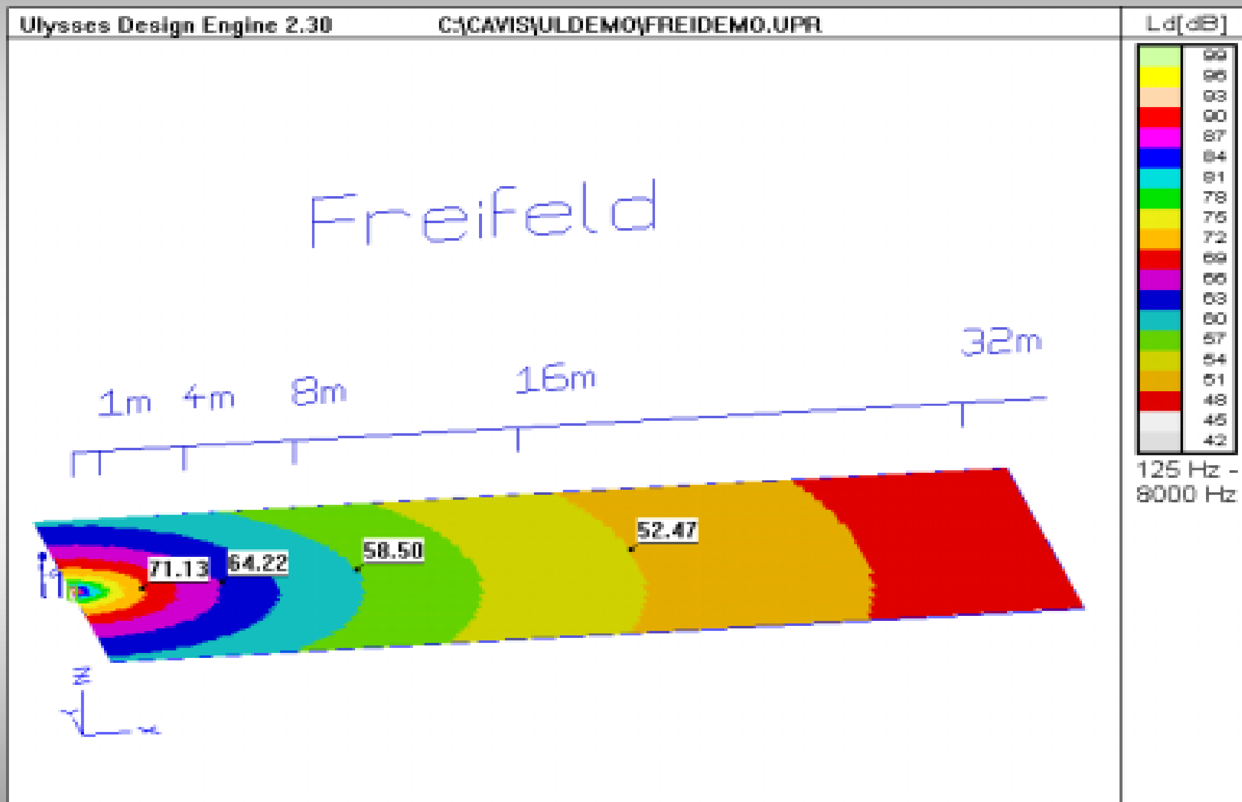


Ld = 0 dB
R = 1m

Ld = -6dB
R = 2m

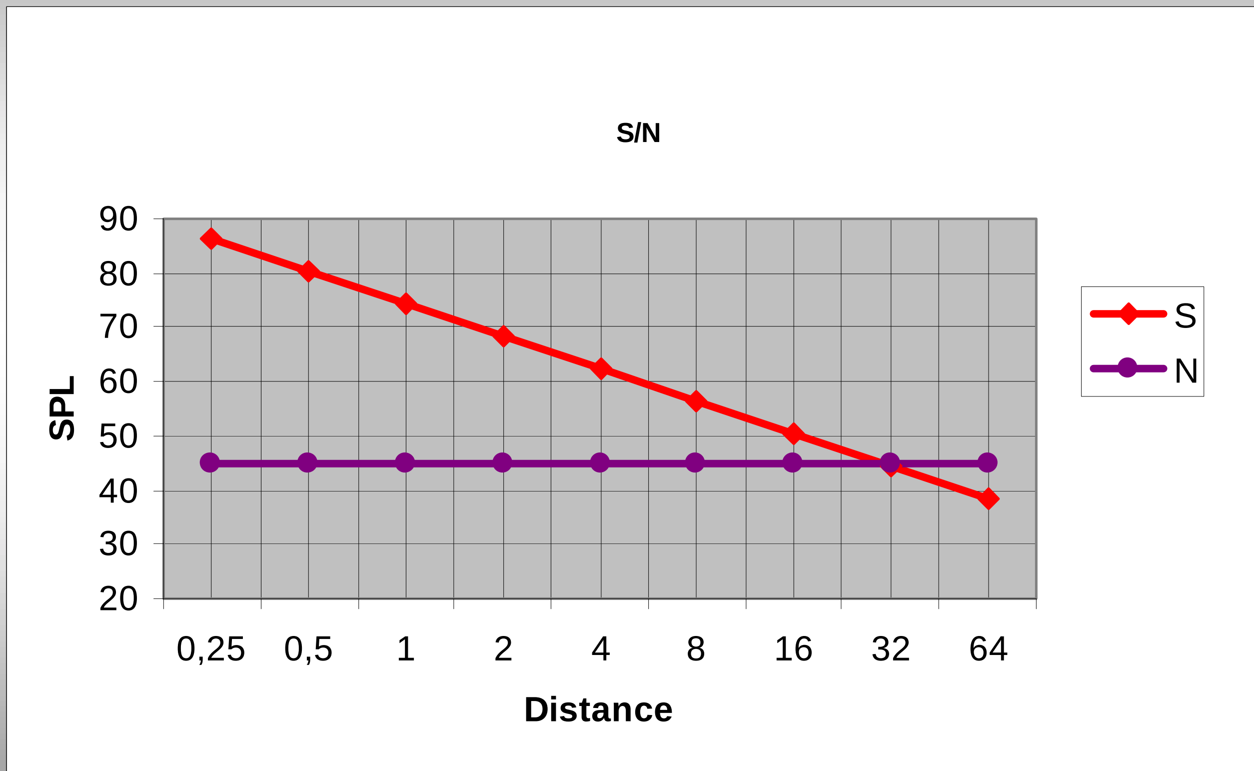
Ld=-12dB
R = 4 m

Freifeld

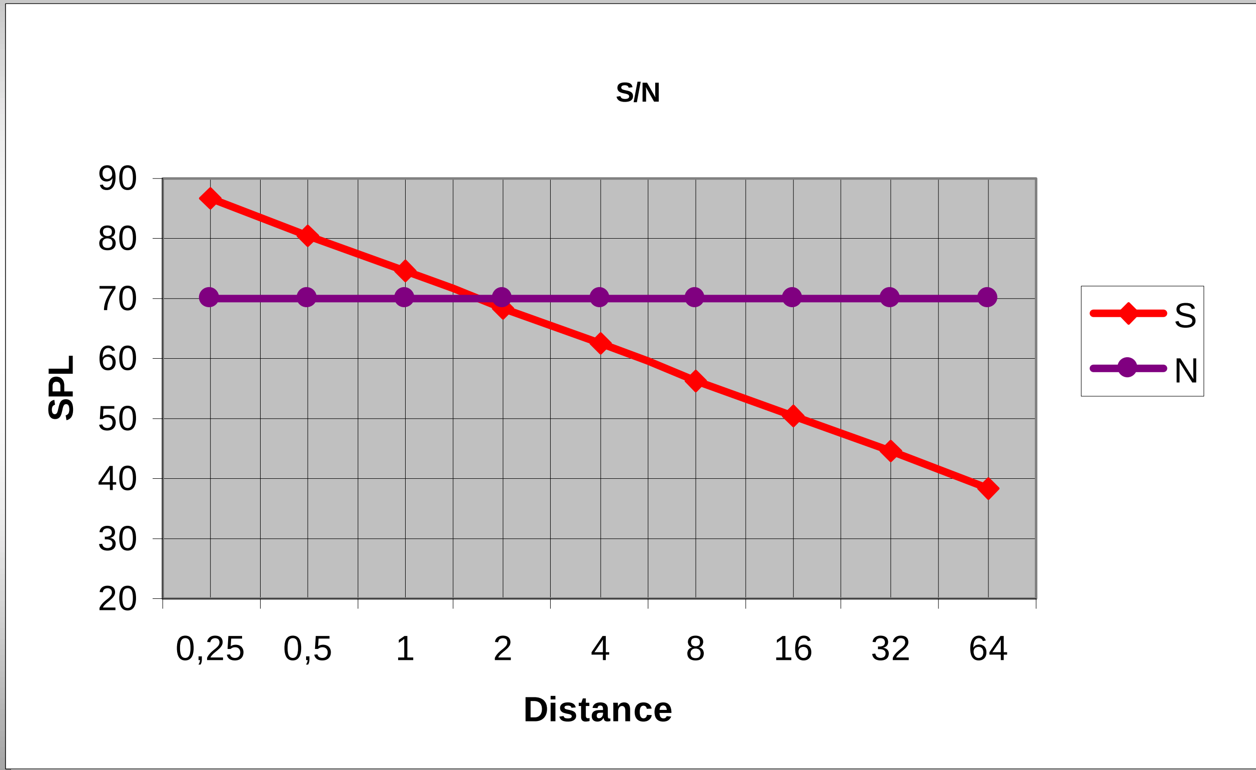


Ulysses Design Engine 2.30
C:\CAVIS\ULDEMO\FREIDEMO.UPR
Ld[dB]
99
96
93
90
87
84
81
78
75
72
69
66
63
60
57
54
51
48
45
42
125 Hz -
8000 Hz
Freifeld
1m
4m
8m
16m
32m
71.13
64.22
58.50
52.47

Signal / Noise

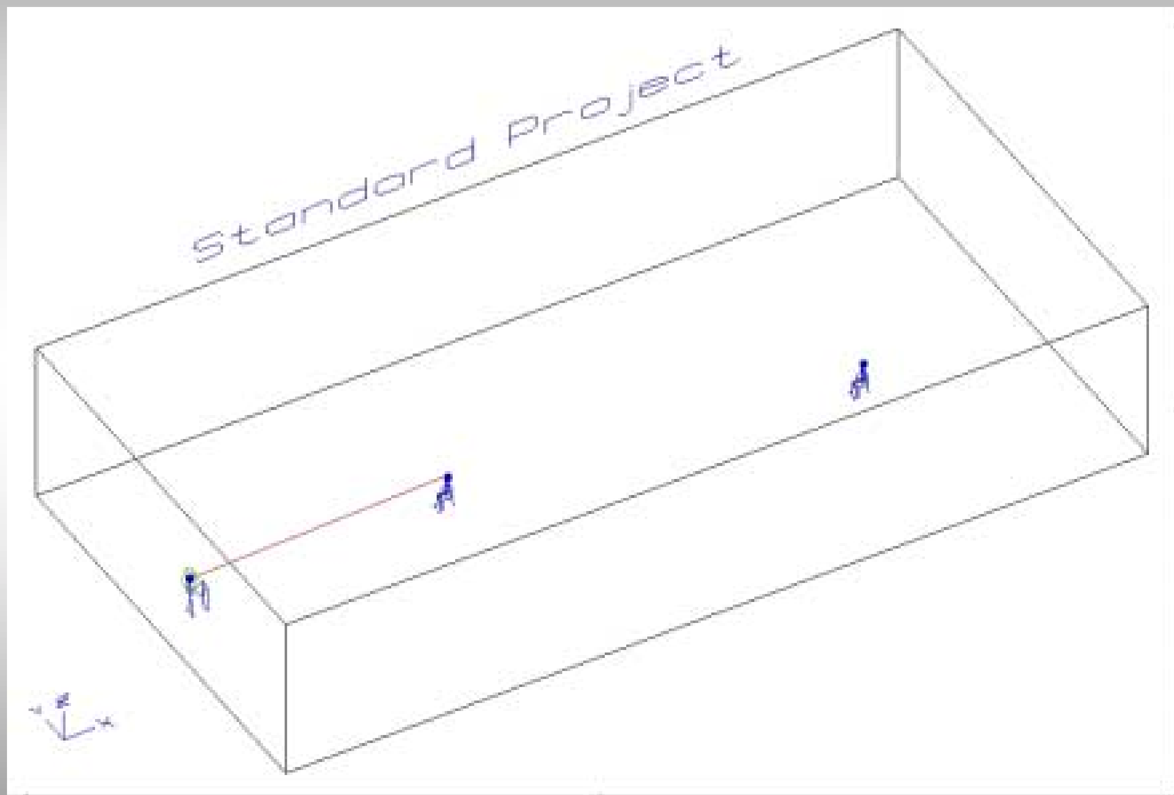


Signal / Noise

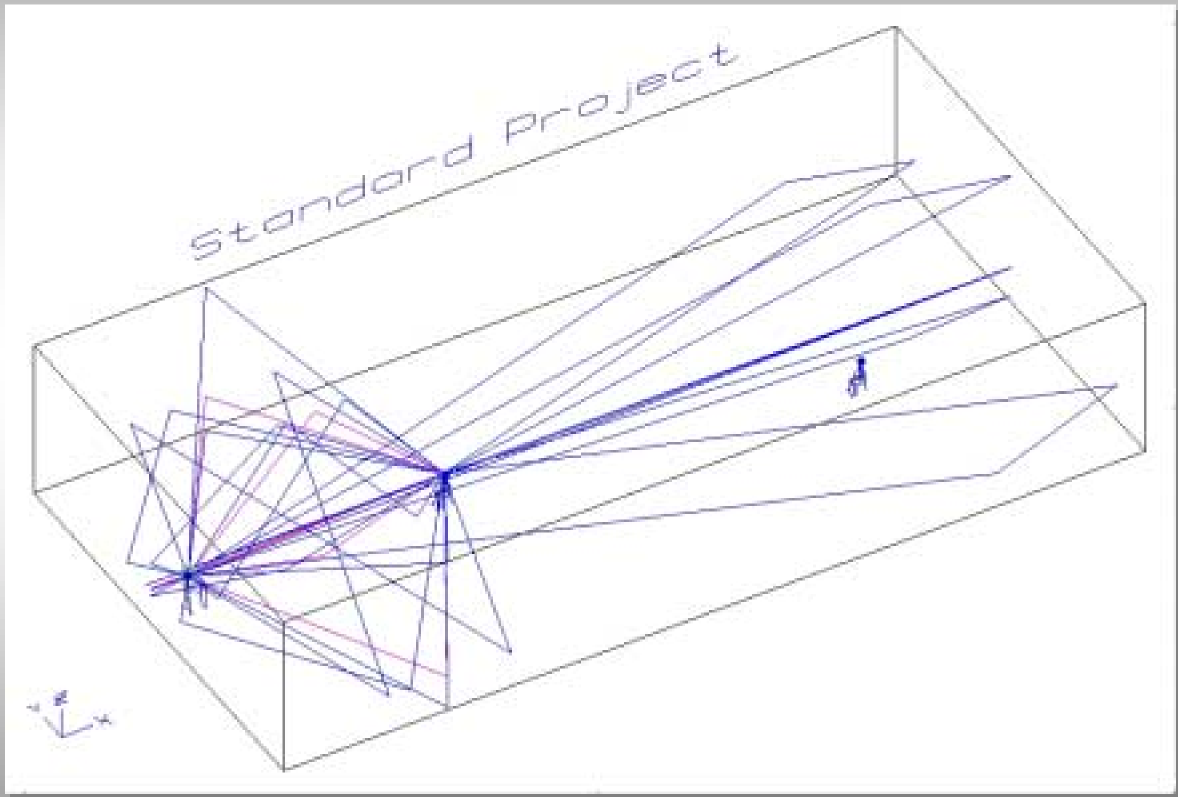


Der Raum

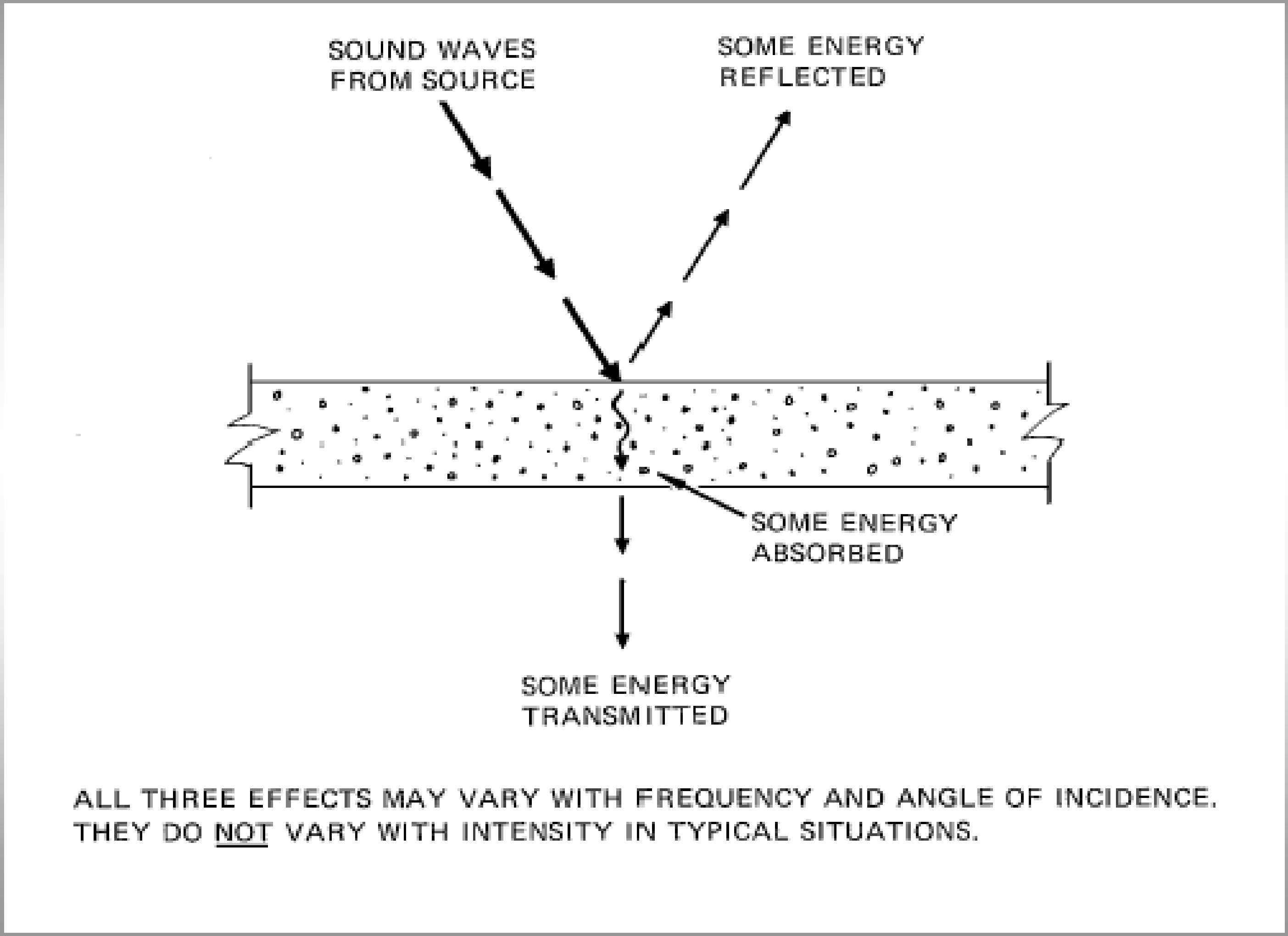
Direktschall Ld



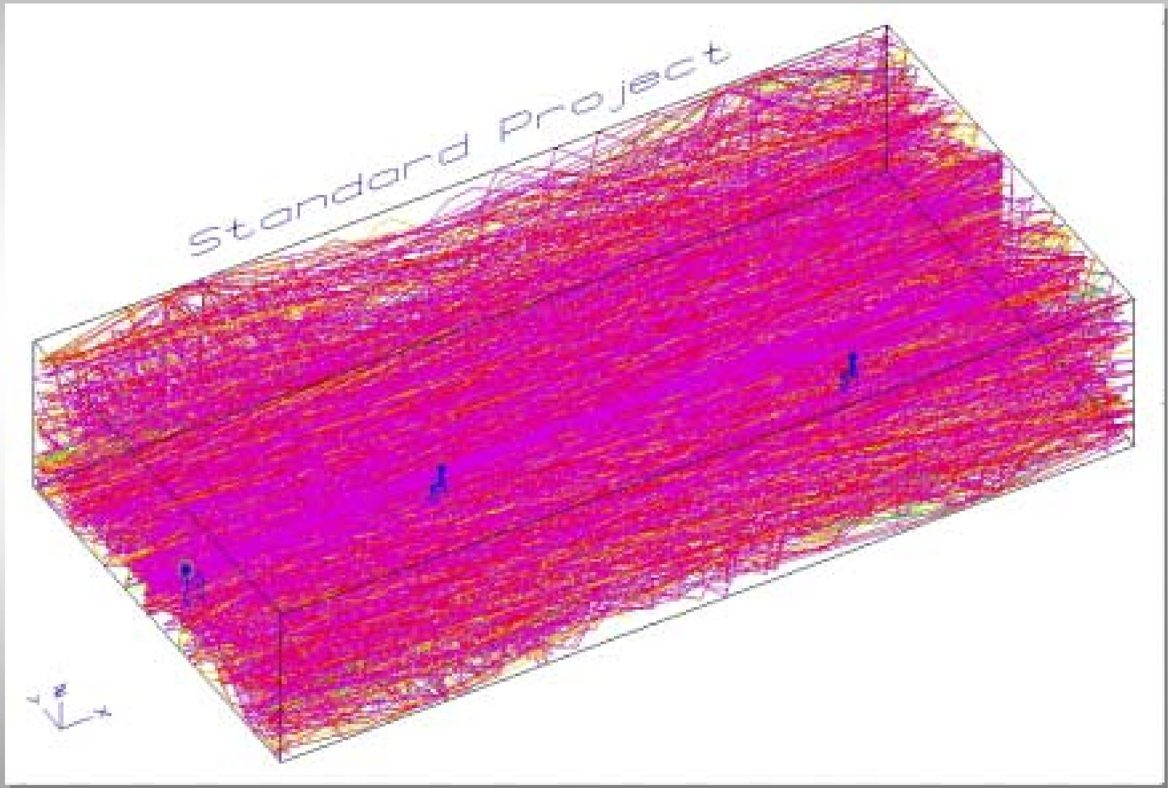
Reflektionen



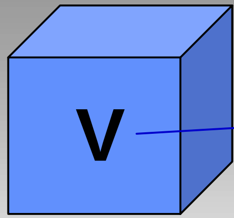
Absorption, Reflexion,Transmission



Diffusfeld oder Nachhallfeld, Lr



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

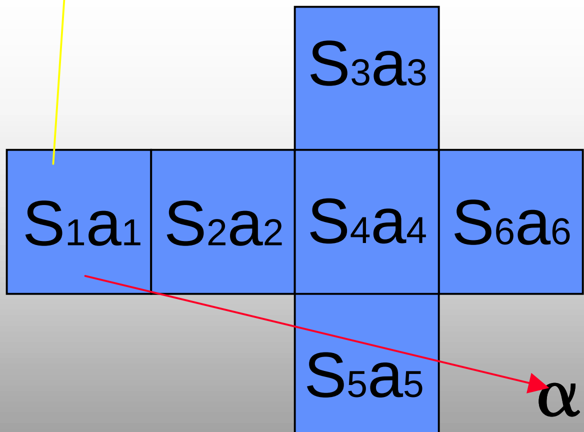


Volumen

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

S = Oberfläche

(äquivalente Absorptionsfläche)



$S_1 a_1 + \ldots S_i a_i = \sum S_i a_i)$

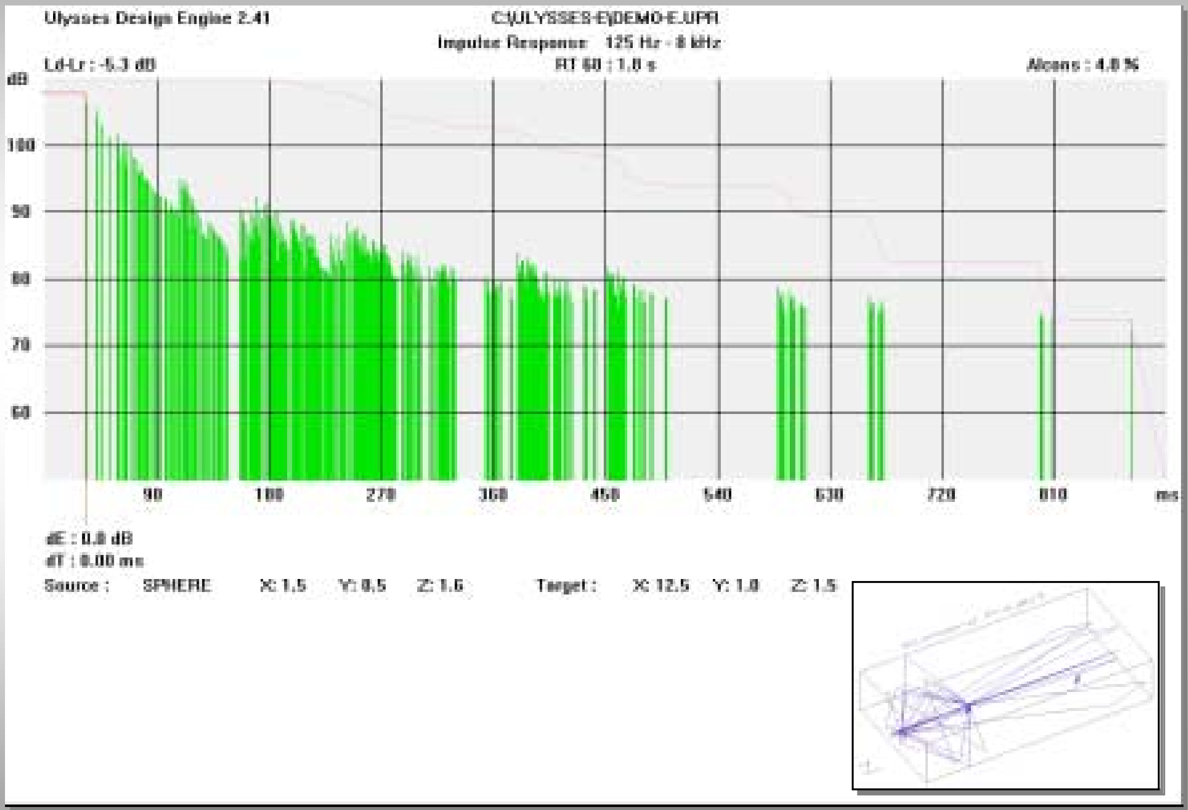
α = Absorptions-Koeffizient

Sabine, Eyring und Fitzroy Ansatz

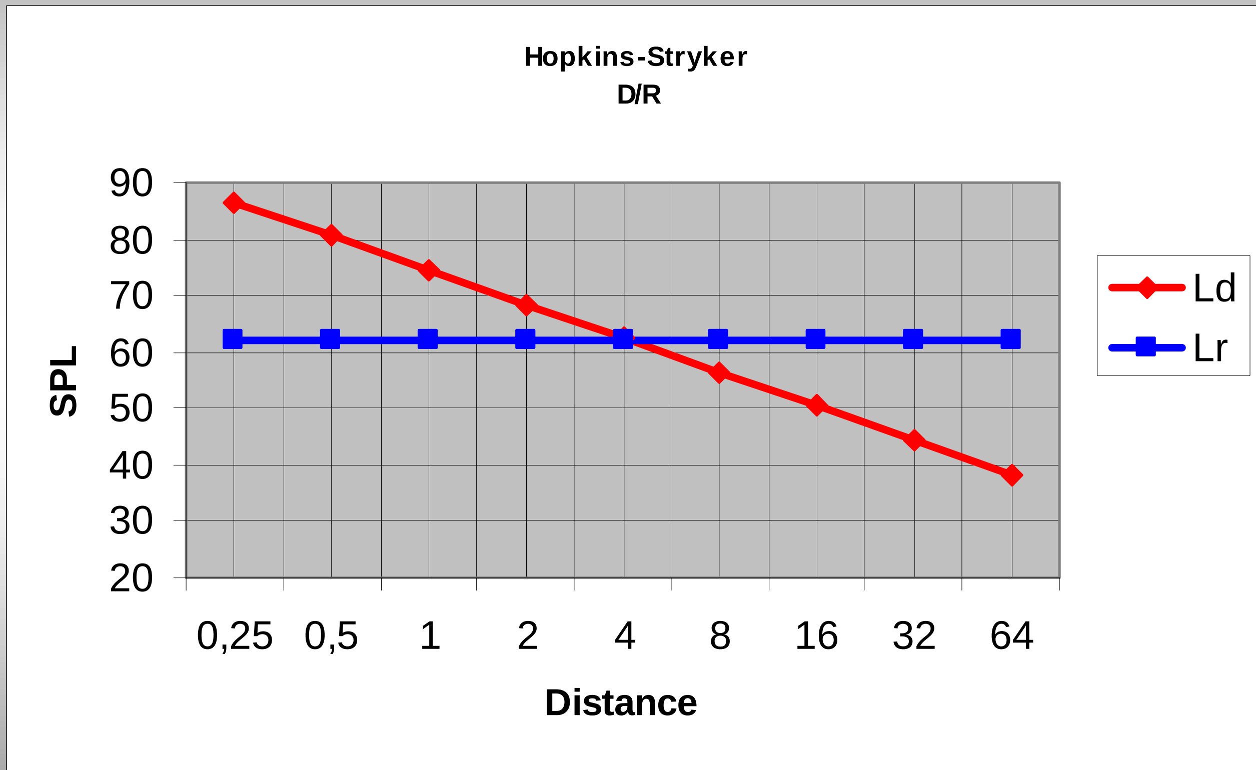
REVERBERATION TIME EQUATIONS: T = 60 dB DECAY TIME IN SECONDS		
EQUATION:	ENGLISH UNITS: S = SURFACE AREA IN FT^2 V = VOLUME IN FT^3	SI UNITS: S = SURFACE AREA IN m^2 V = VOLUME IN m^3
SABINE — GIVES BEST CORRESPONDENCE WITH PUBLISHED ABSORPTION COEFFICIENTS WHERE $\bar{\alpha}$ IS LESS THAN 0.2	$T = \frac{.049V}{S\bar{\alpha}}$	$T = \frac{.16V}{S\bar{\alpha}}$
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

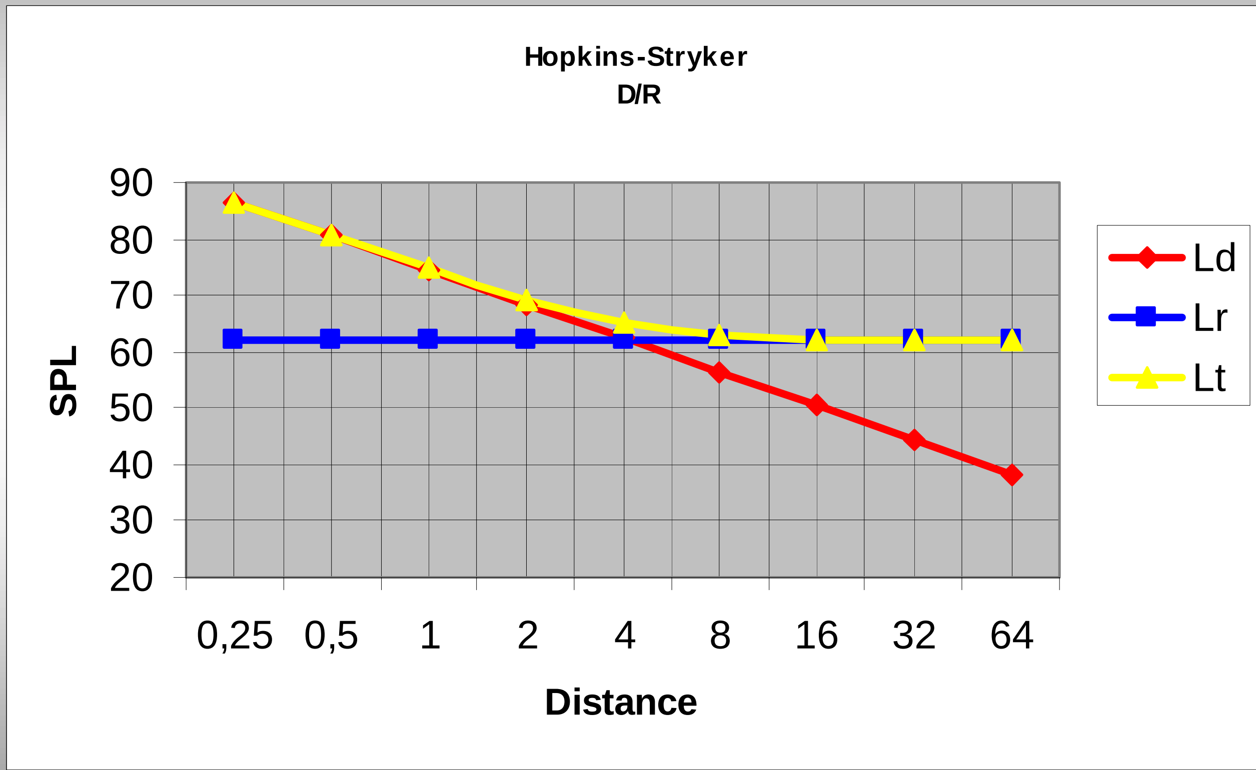
Energie vs. Zeit, Reflektogramm, Nachhall



Direktschall und Nachhall, Ld & Lr



Totales Schallfeld Lt = Ld + Lr



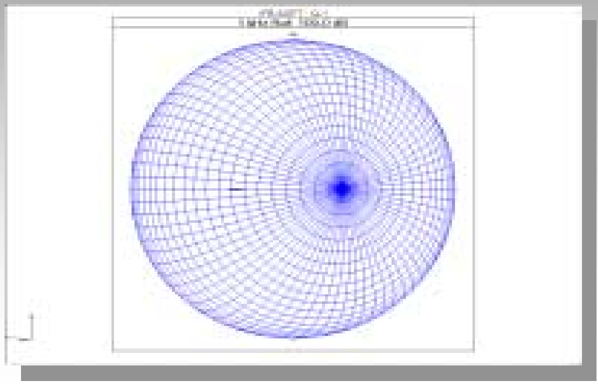
Hopkins Stryker Gleichung

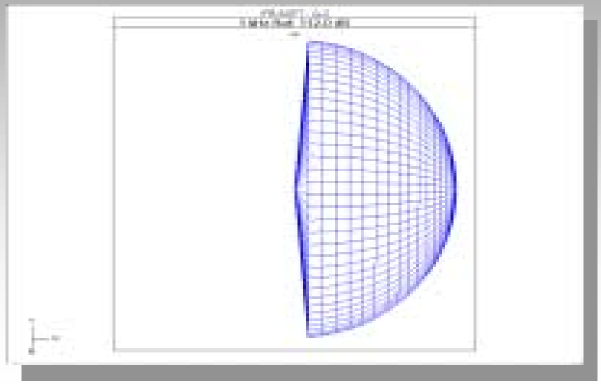
$$\Delta L_D = 10 \log \frac{Q}{4 \pi r^2}$$

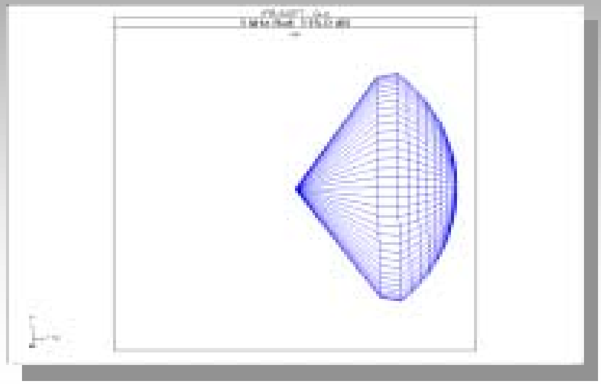
$$\Delta L_R = 10 \log \frac{4}{S \alpha}$$

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

Bündelung Q & D_I, Directivity, Q & D_I







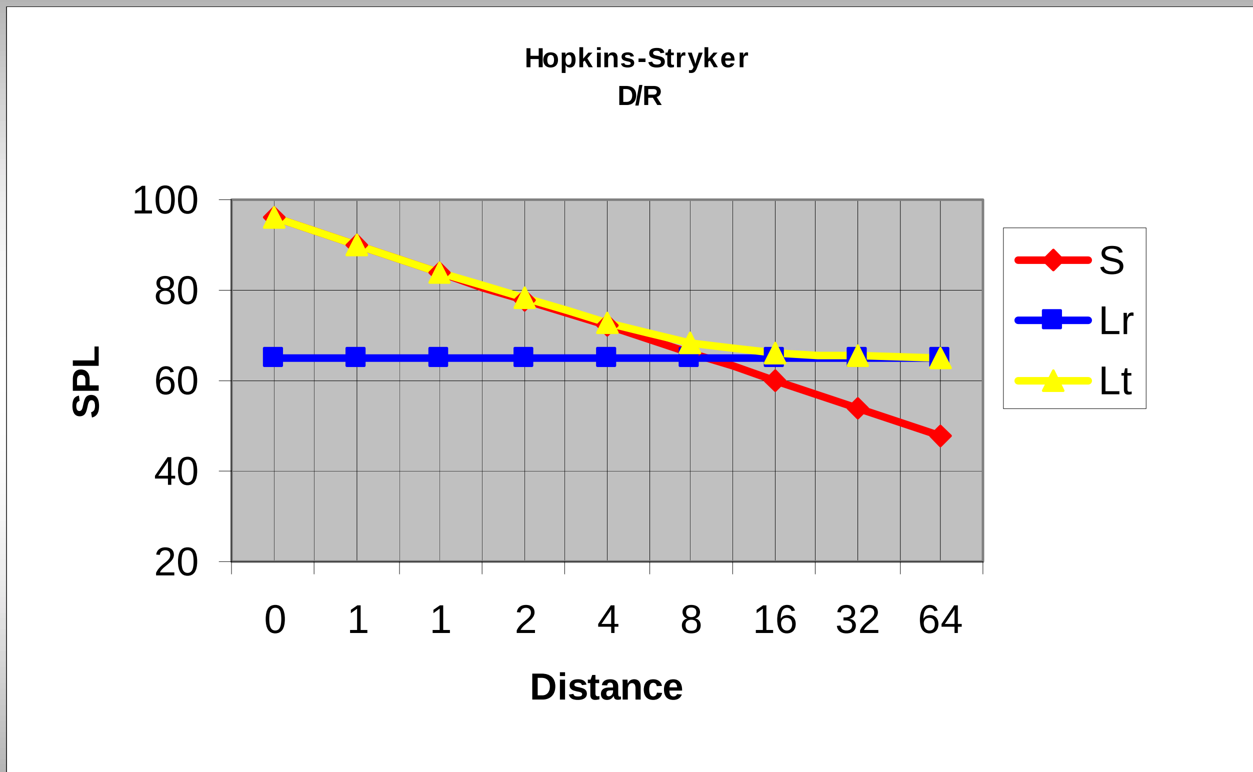
Q= 1
DI= 0 dB

Q= 2
DI= 3 dB

Q= 4
DI= 6dB

$$D_I = 10 \log Q$$

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



Diskussion

- Jede Frage ist willkommen ...

Die Basics der Raumakustik

Vielen Dank für Ihre Aufmerksamkeit !