

Kann man Akustik wirklich ausrechnen?

Wie beeinflusst die Akustik eines Raumes den Klang der Lautsprecher?

Referent: Volker Löwer, IFBconsulting

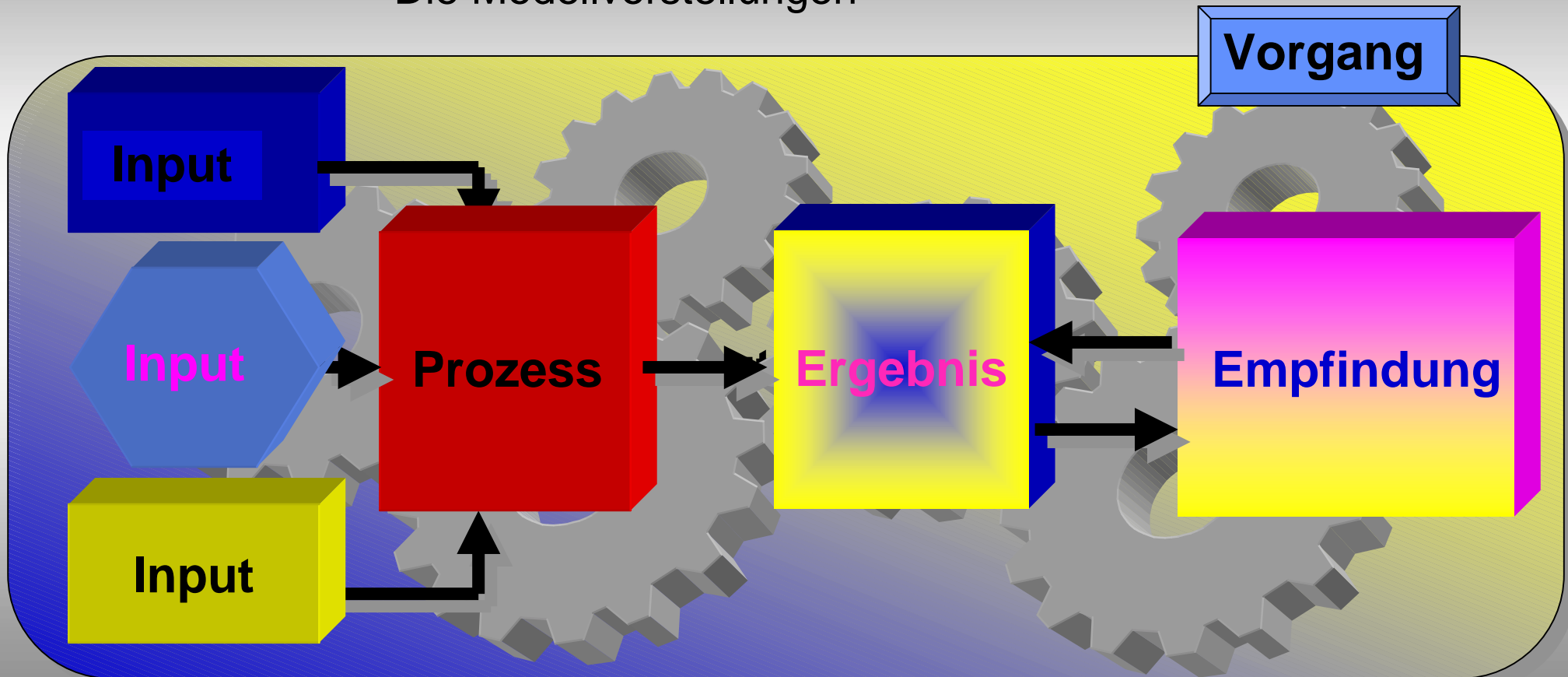


Grundlagen der Schallausbreitung

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

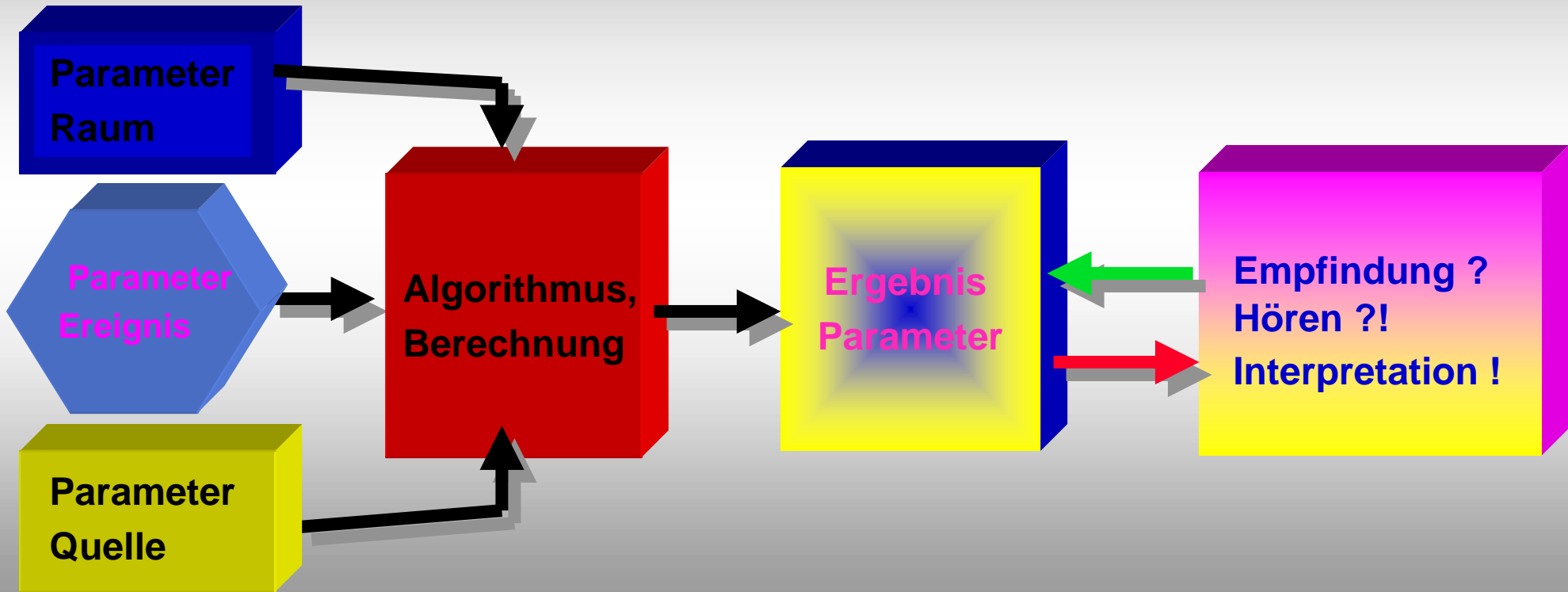
Vorbemerkungen

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

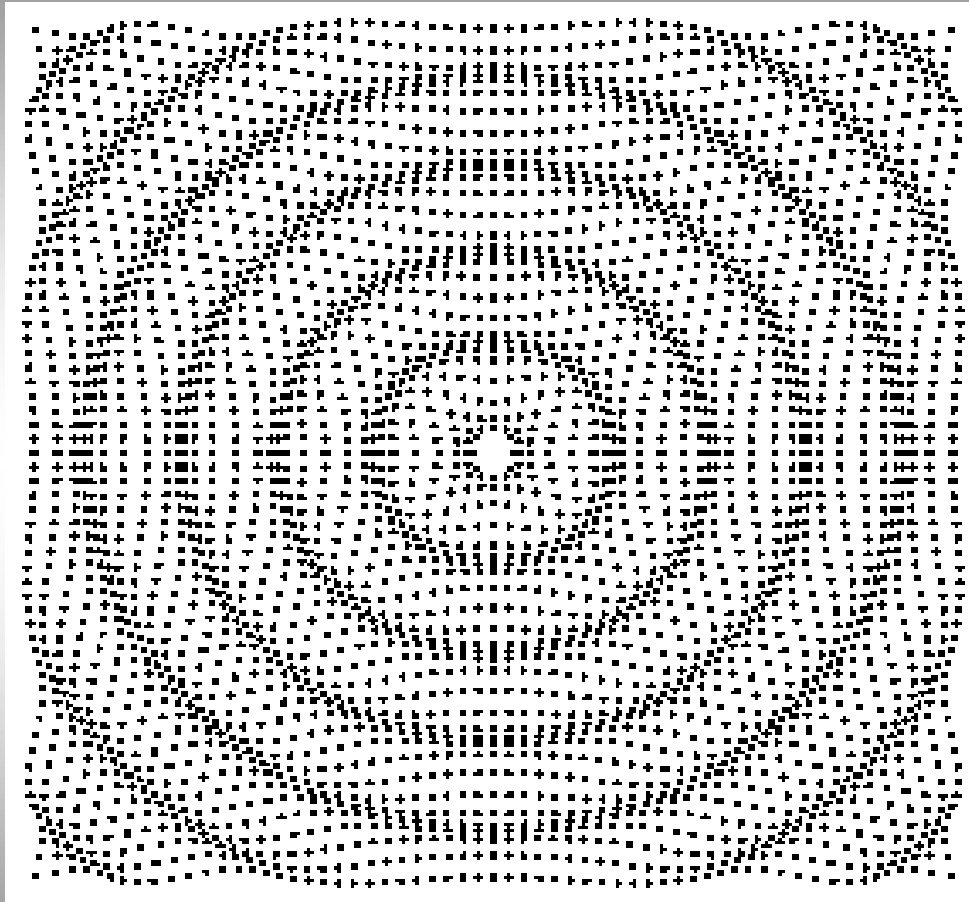


Modelle, Algorithmen

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

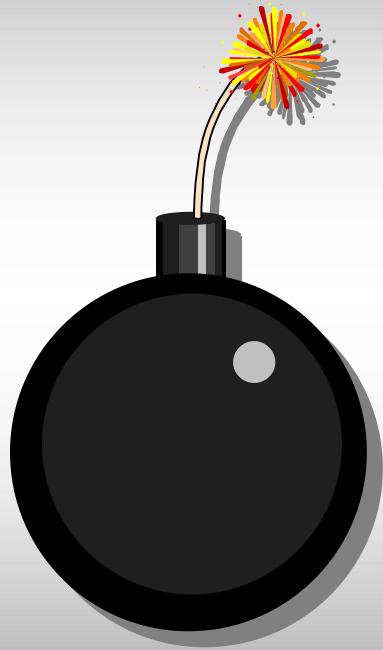


Was ist Schall ?



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

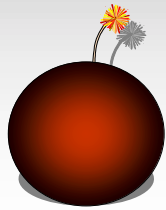
Abstandsgesetz



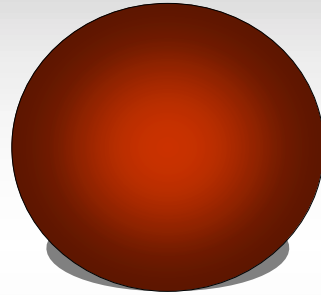
**Impuls-Schallquelle,
omnidirektional ...**

$t = 0$ ms

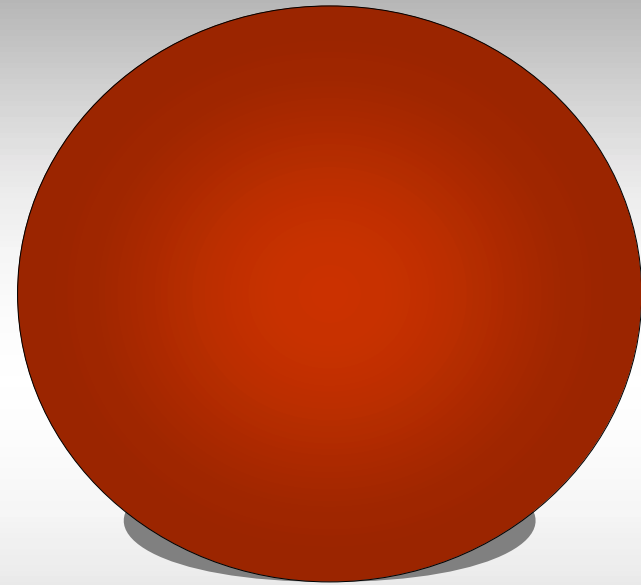
Abstandsgesetz



Ld = 0 dB
R = 1m

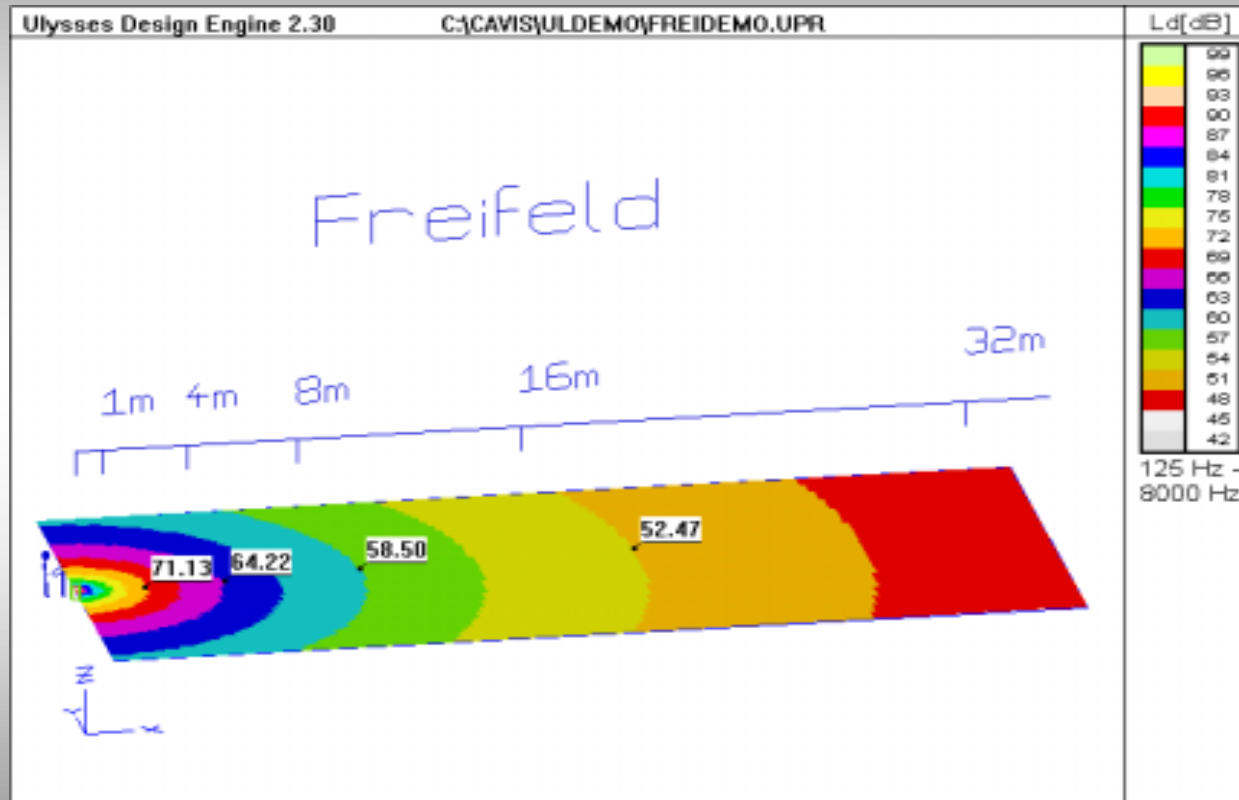


Ld = -6dB
R = 2m

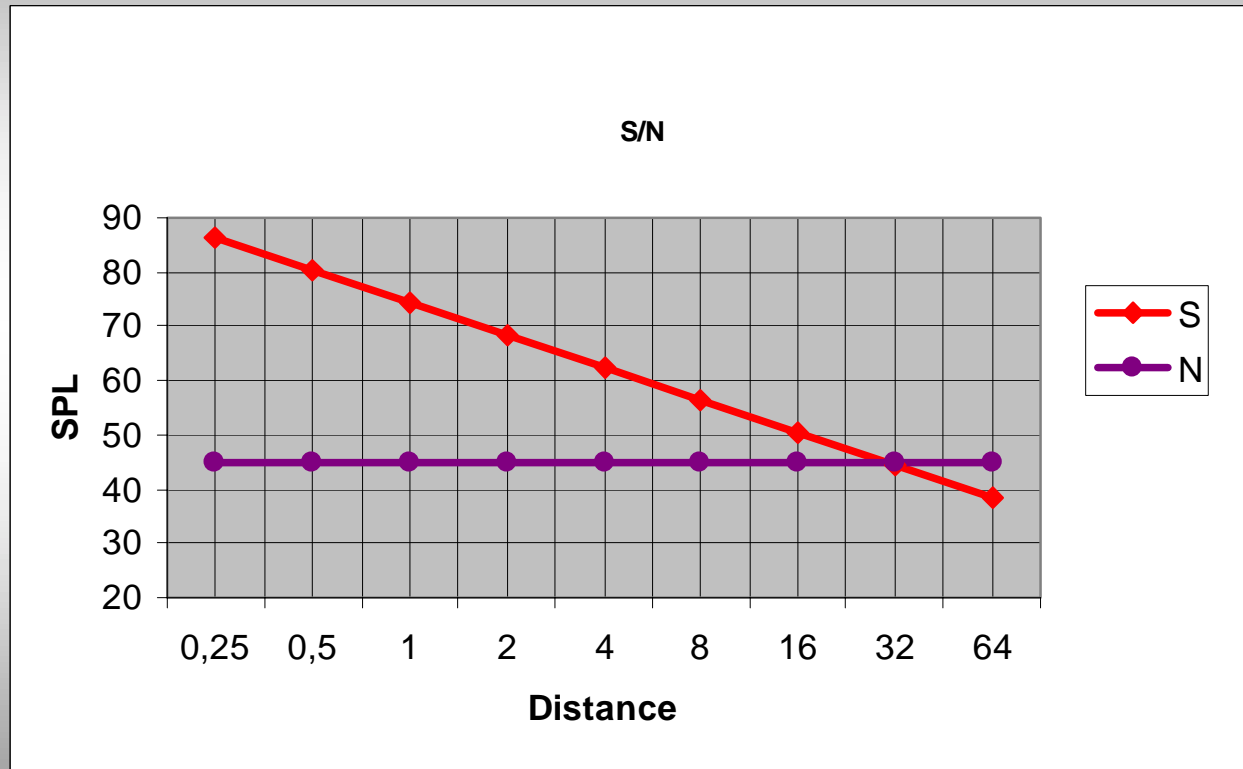


Ld = -12dB
R = 4 m

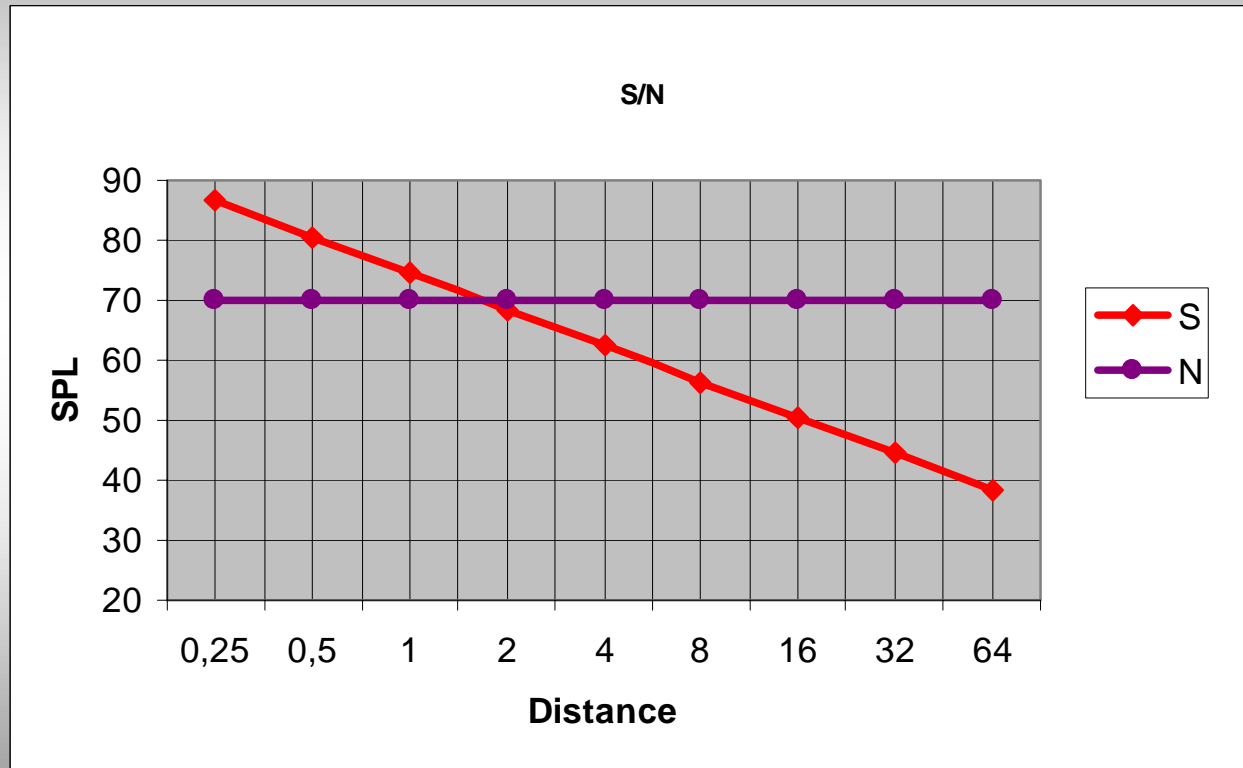
Freifeld



Signal / Noise



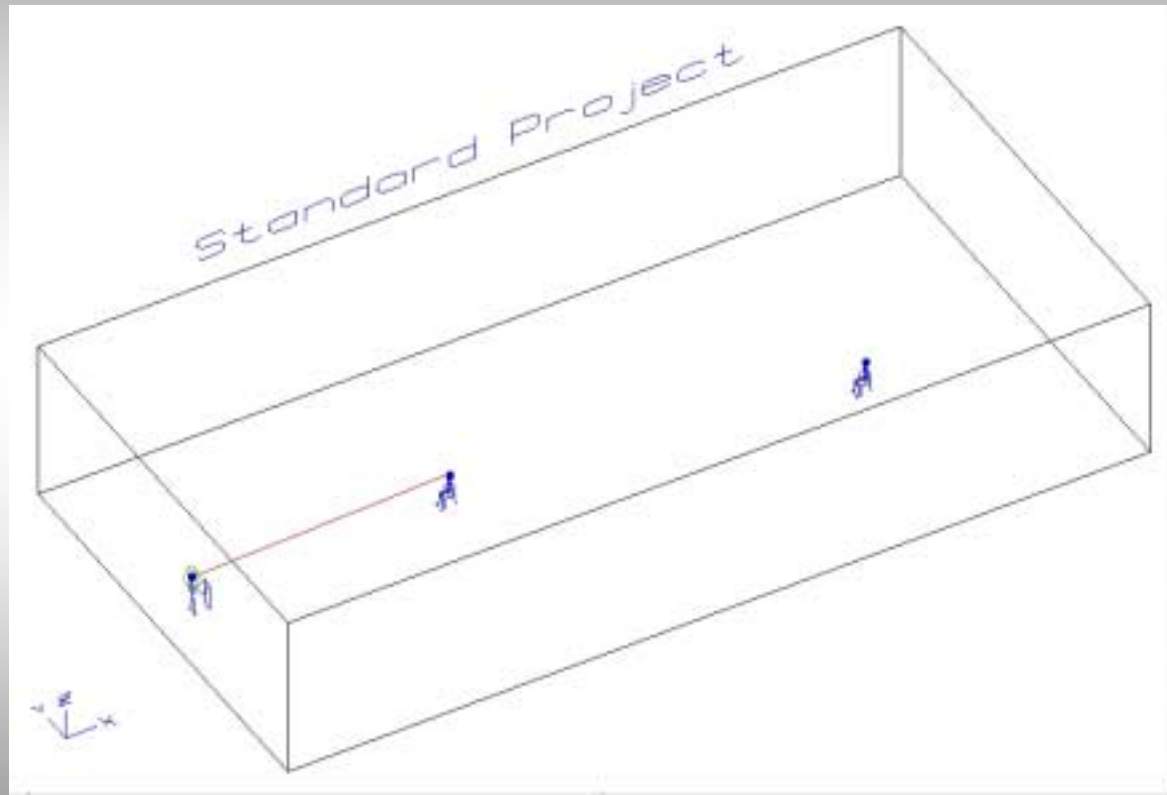
Signal / Noise



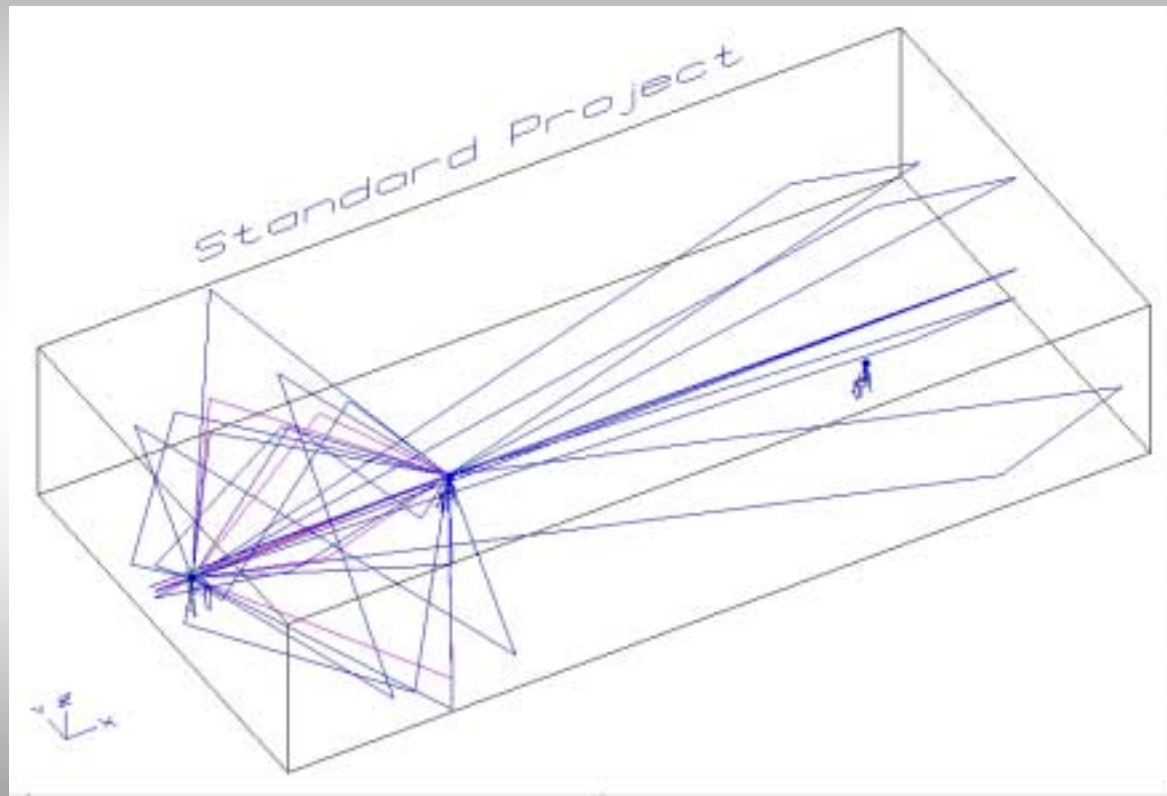
Der Raum



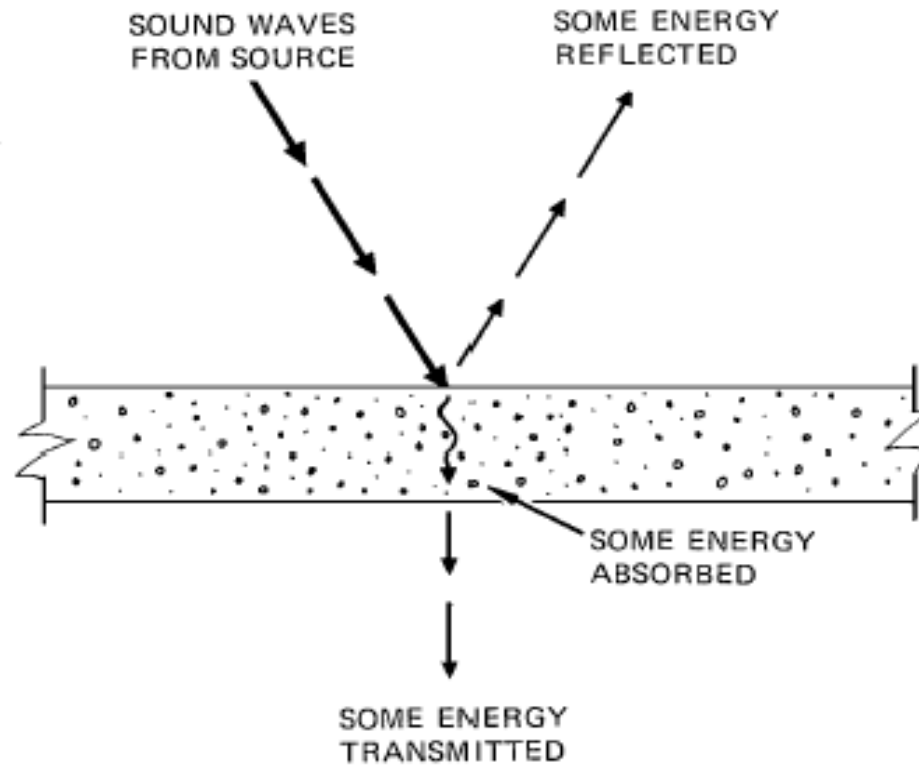
Direktschall Ld



Reflektionen

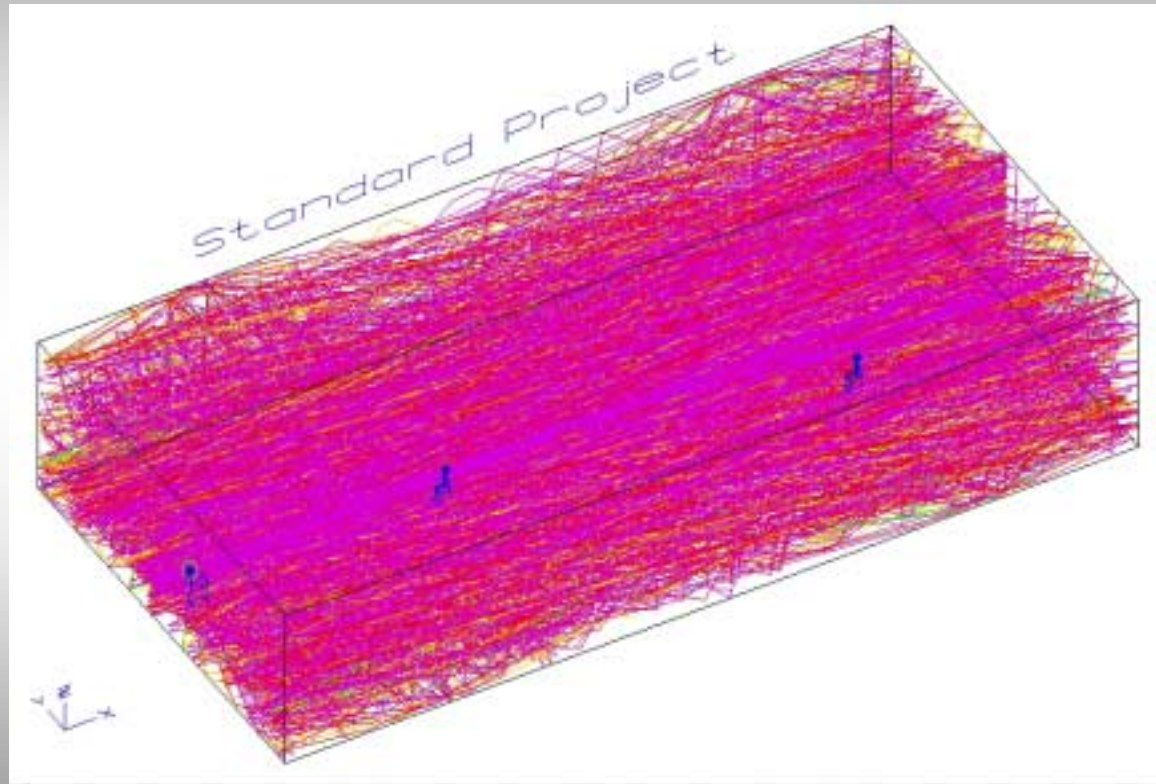


Absorption, Reflexion, Transmission

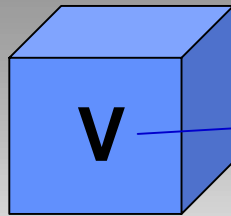


ALL THREE EFFECTS MAY VARY WITH FREQUENCY AND ANGLE OF INCIDENCE.
THEY DO NOT VARY WITH INTENSITY IN TYPICAL SITUATIONS.

Diffusfeld oder Nachhallfeld, L_r



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



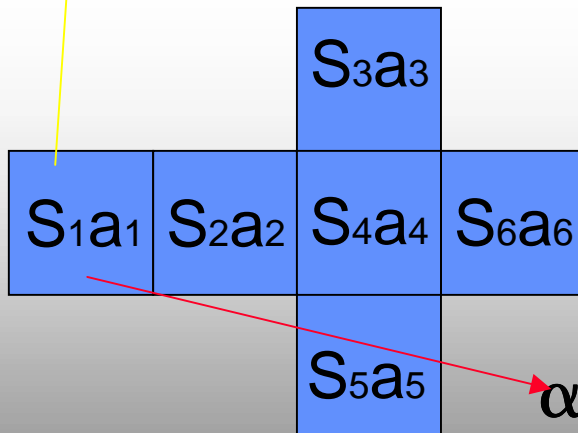
Volumen

V

$$RT_{60} = 0.163$$

$$\frac{V}{\sum S_i a_i}$$

S = Oberfläche



(äquivalente Absorptionsfläche)

$$S_1a_1 + \dots S_i a_i = \sum S_i a_i$$

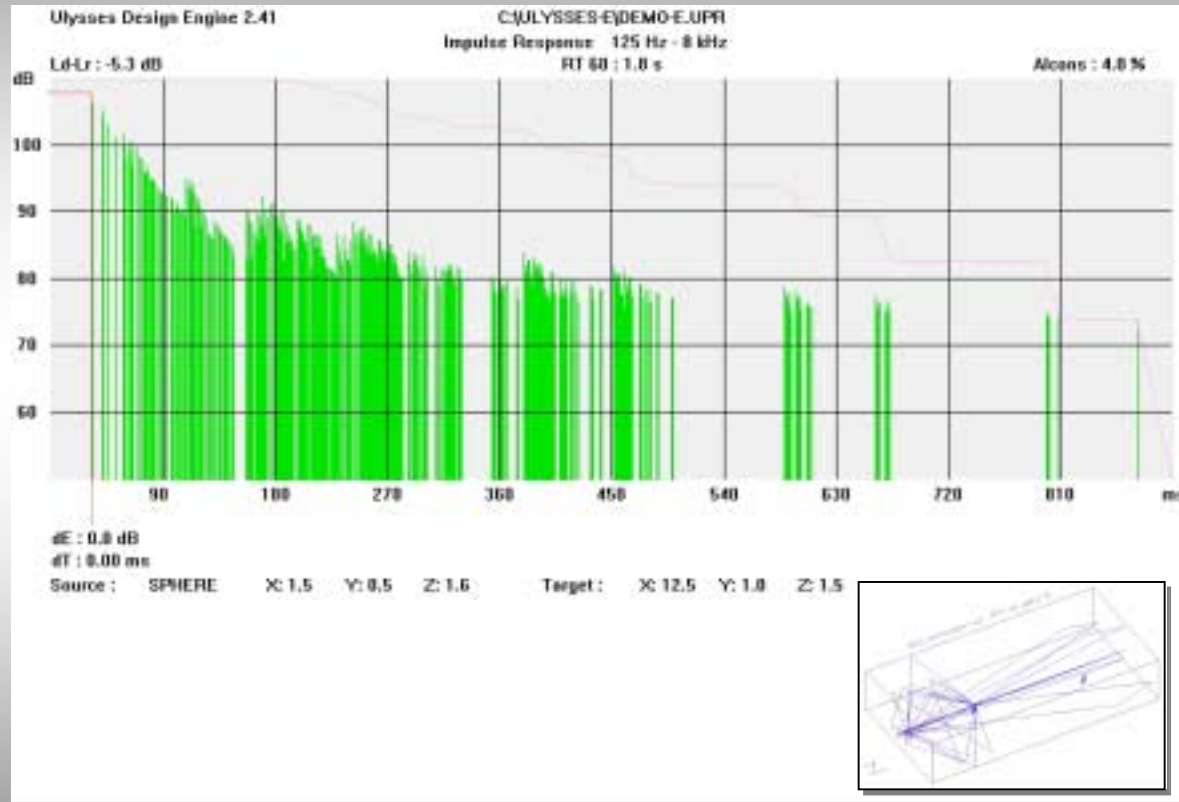
α = Absorptions-Koeffizient

Sabine, Eyring und Fitzroy Ansatz

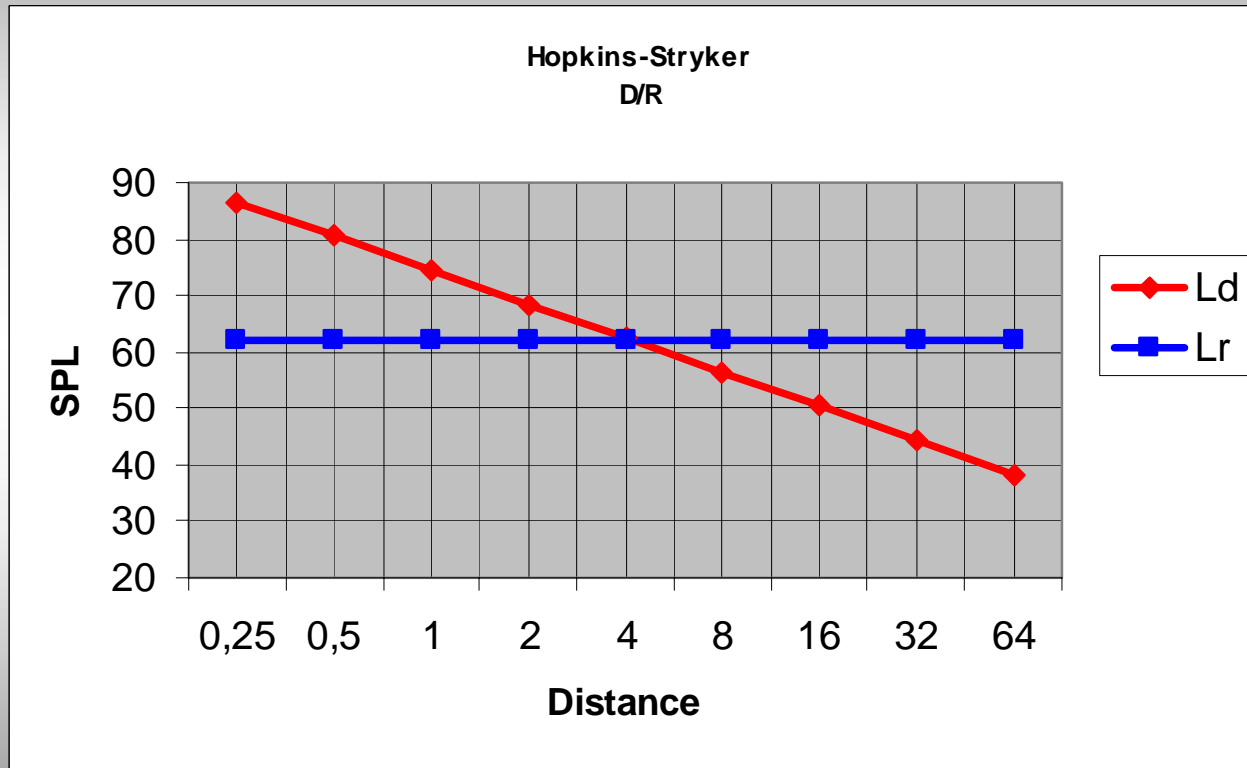
REVERBERATION TIME EQUATIONS: T = 60 dB DECAY TIME IN SECONDS		
<u>EQUATION:</u>	<u>ENGLISH UNITS:</u> S = SURFACE AREA IN FT ² V = VOLUME IN FT ³	<u>SI UNITS:</u> S = SURFACE AREA IN m ² V = VOLUME IN m ³
SABINE – GIVES BEST CORRESPONDENCE WITH PUBLISHED ABSORPTION COEFFICIENTS WHERE $\bar{\alpha}$ 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.	$T = \frac{.049V}{S^2} \left(\frac{x^2}{x\alpha_x} + \frac{y^2}{y\alpha_y} + \frac{z^2}{z\alpha_z} \right)$	$T = \frac{.16V}{S^2} \left(\frac{x^2}{x\alpha_x} + \frac{y^2}{y\alpha_y} + \frac{z^2}{z\alpha_z} \right)$
α_x , α_y , AND α_z ARE AVERAGE ABSORPTION COEFFICIENTS OF OPPOSING PAIRS OF SURFACES WITH TOTAL AREAS x, y, AND z.		

Figure 5-9. Reverberation time equations

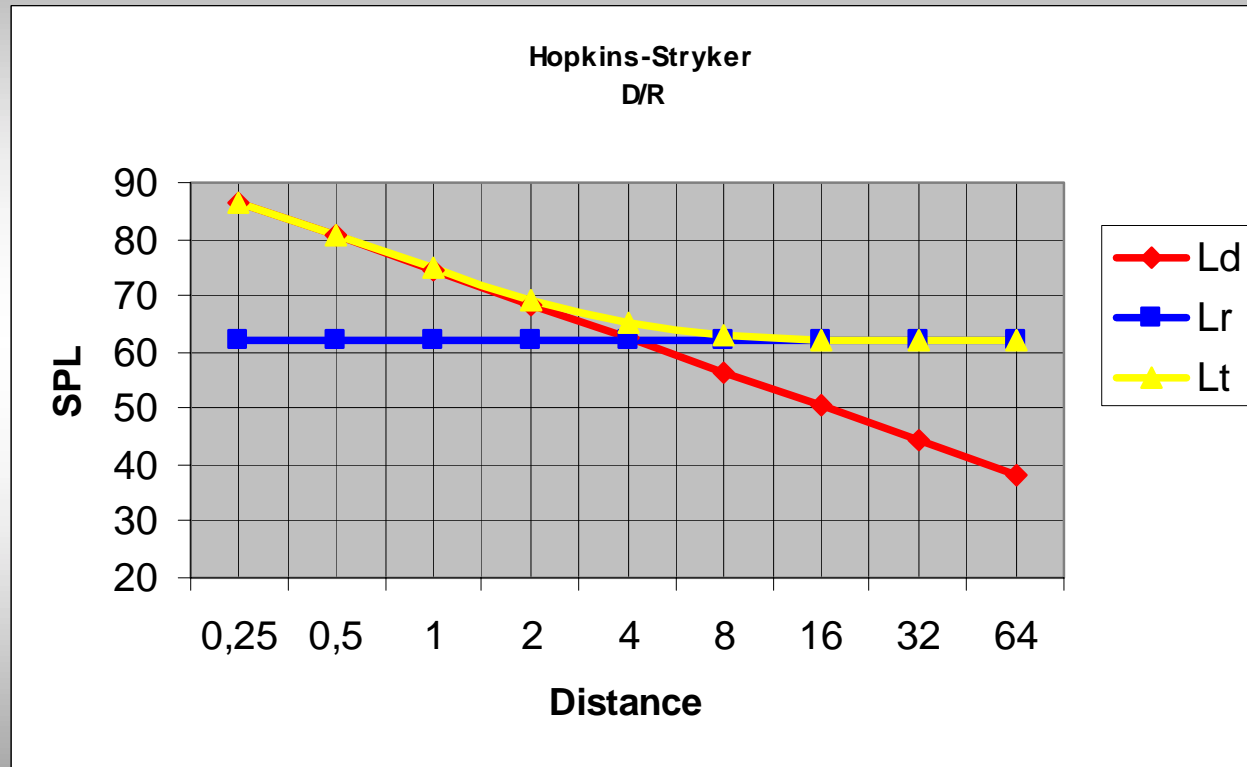
Energie vs. Zeit, Reflektogramm, Nachhall



Direktschall und Nachhall, Ld & Lr



Totales Schallfeld $L_t = L_d + L_r$



Hopkins Stryker Gleichung

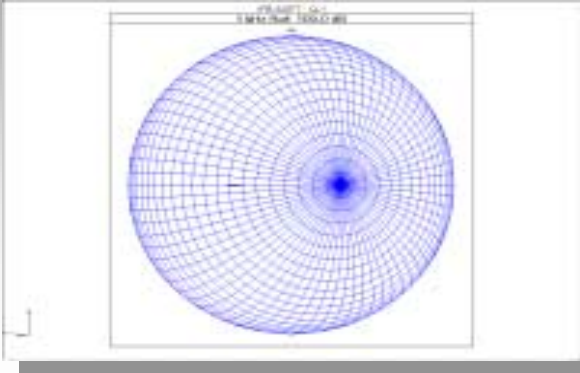


$$\Delta L_D = 10 \log \frac{Q}{4 \pi r^2}$$

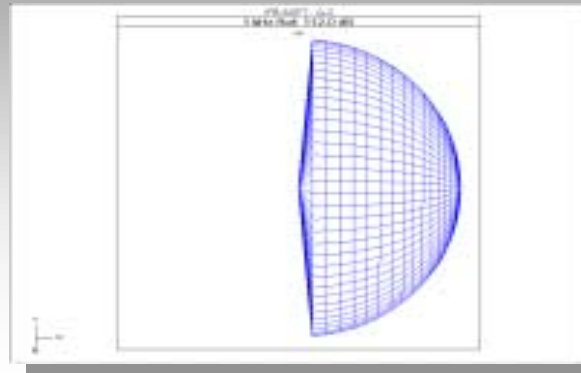
$$\Delta L_R = 10 \log \frac{4}{S \alpha}$$

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

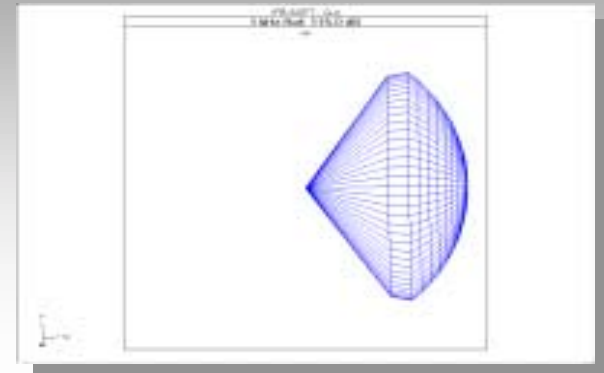
Bündelung Q & DI, Directivity, Q & DI



$Q=1$
 $DI=0\text{ dB}$



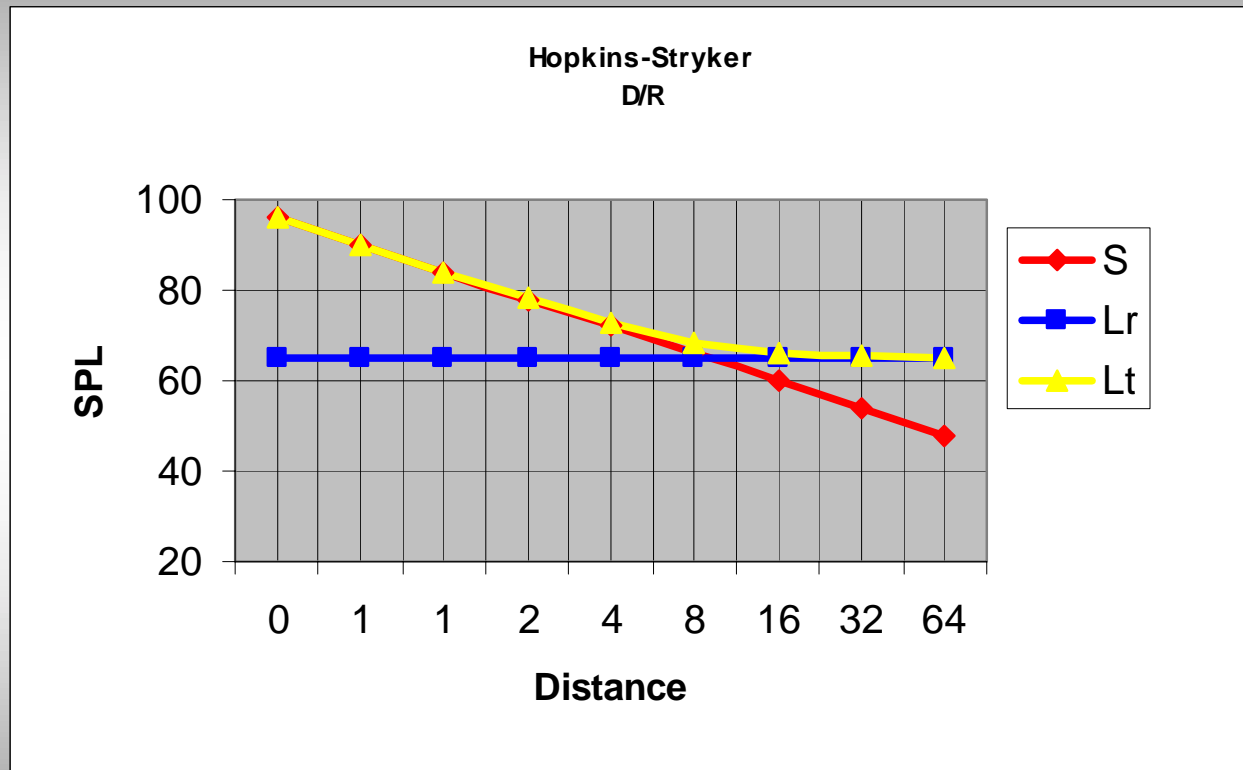
$Q=2$
 $DI=3\text{ dB}$



$Q=4$
 $DI=6\text{ dB}$

$$DI = 10 \log Q$$

Totales Schallfeld $L_t = L_d + L_r$, $Q= 8$, $D_l= 9$ dB



- Jede Frage ist willkommen ...



Vielen Dank für Ihre Aufmerksamkeit !