# *DESIGN DEL PRODOTTO INDUSTRIALE*

FISICA TECNICA PER IL DESIGN

*AA 2019-20*

## *ACUSTICA IN CAMPO LIBERO A.02*

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# *PROPAGAZIONE IN AMBIENTI APERTI*

$$L_P = L_W - \sum_i A_i$$

$$\sum_i A_i = A_g + A_b + A_t + A_a$$

$A_g$ attenuazione geometrica

$A_b$ attenuazione di una barriera

$A_t$ attenuazione dovuta al terreno

$A_a$ attenuazione atmosferica

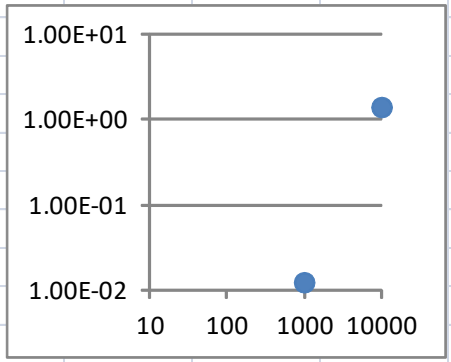
$A_t + A_a$ sono dette "attenuazioni in eccesso"

# *Attenuazione atmosferica*

$$A_a = \alpha \cdot \frac{d}{100}$$

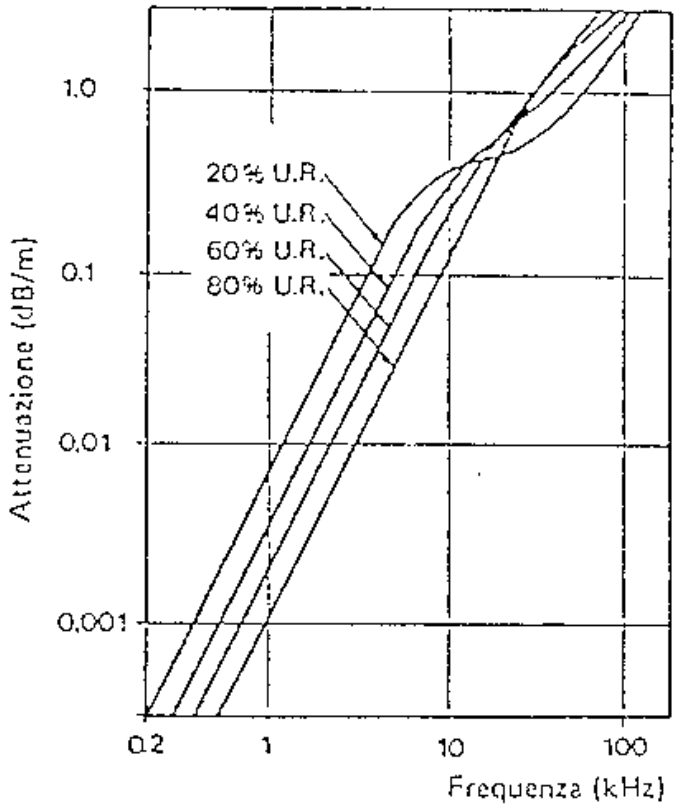
$$\alpha = 10^{\left(2.05 \cdot \log\frac{f}{1000} + 1.14 \cdot 10^{-3} T - 1.92\right)}$$

| | |
|---|---|
| 20 | |
| 10 | 1.01E-06 |
| 100 | 1.13E-04 |
| 1000 | 1.27E-02 |
| 10000 | 1.42E+00 |




$$A_a^{20^\circ} = \alpha \cdot \frac{d}{100}$$

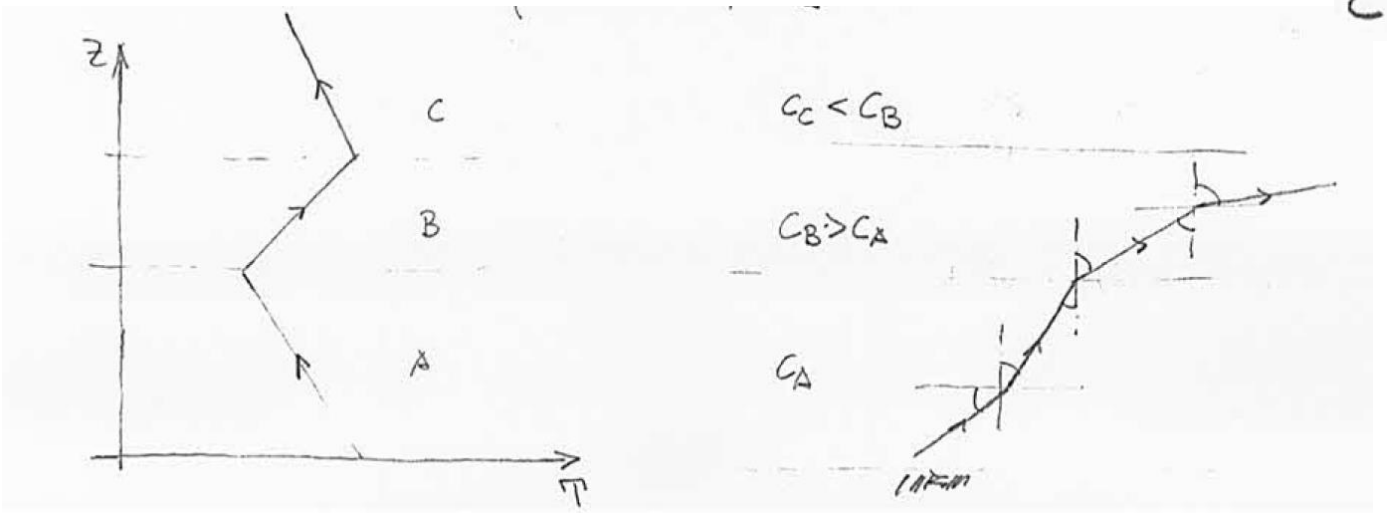
$$\alpha = 7.4 \cdot 10^{-6} \cdot \frac{f^2}{UR}$$



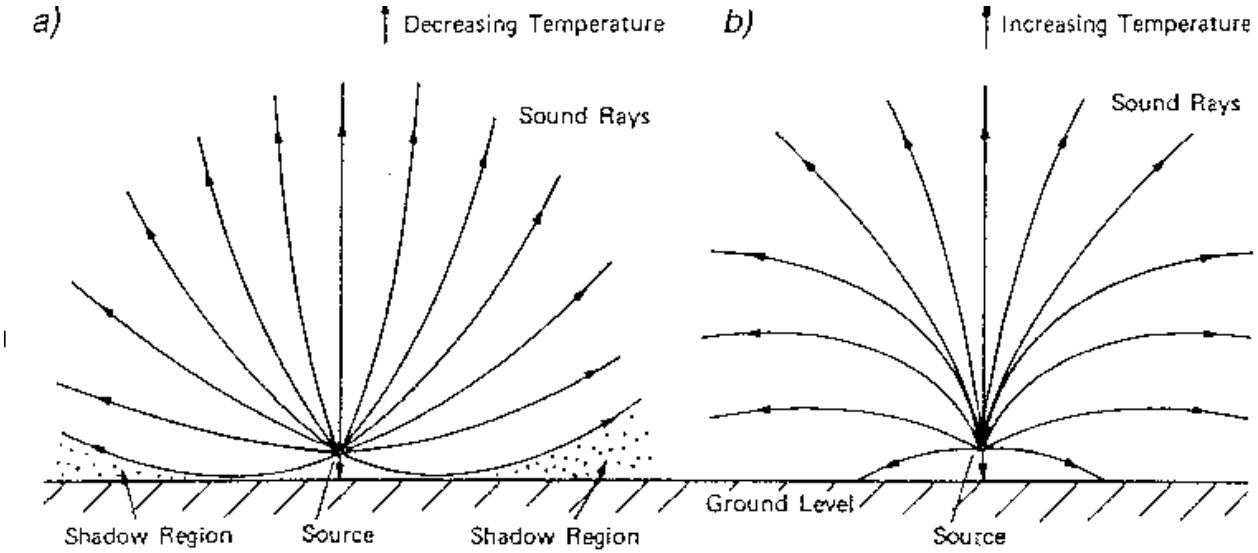
# *Attenuazione atmosferica*

$$c = \sqrt{\gamma R T}$$

$$\frac{\operatorname{sen}\theta_1}{\operatorname{sen}\theta_2} = \frac{c_1}{c_2}$$




*Willebrord Snel van Royen*



## *Attenuazione del terreno*

1- In generale

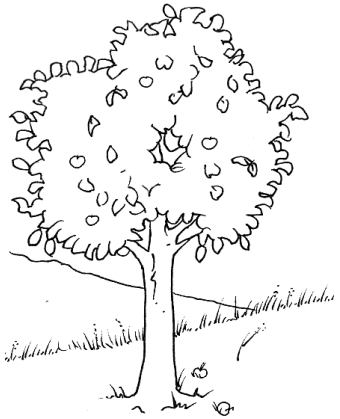
$$A_t = 4.8 - 2\frac{h_m}{d} \cdot \left(17 + \frac{300}{d}\right)$$

2- In presenza di arbusti ($f$>50 Hz)

$$A_t = (0.18 \cdot \log f - 0.31) \cdot d$$

3- In presenza di alberi densi ($f$>500 Hz)

$$A_t = f^{\frac{1}{3}} \cdot \frac{d}{100}$$



# *Attenuazione per divergenza geometrica*

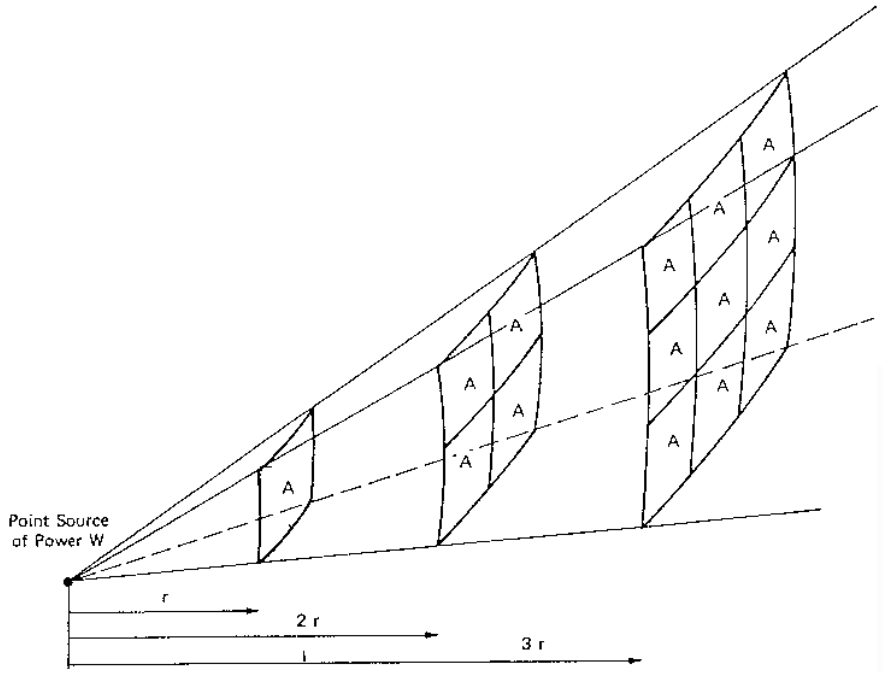
$$L_W = L_I + 10 \lg S/S_0 \quad \Rightarrow \quad L_I = L_W - 10 \lg S$$

$S_0 = 1\,m^2$

$S = 4\pi r^2$ (sfera) con $r$ = distanza sorgente – ricettore

$$\Rightarrow \quad L_I = L_W - 10 \lg 4\pi r^2$$

$$\approx L_W - 20 \lg r \underline{-11}$$




$$L_W = 10 \lg \frac{W}{W_0}$$

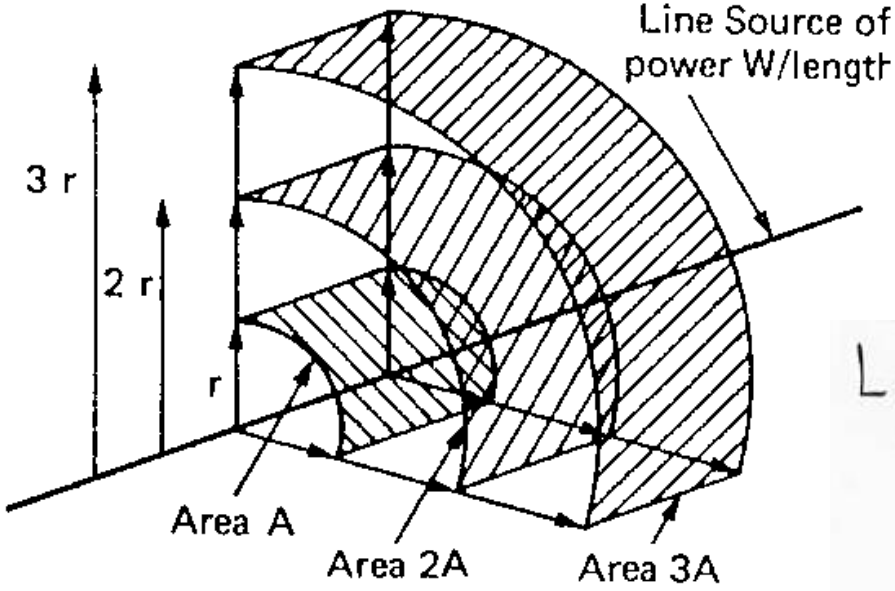
$$= 10 \lg \frac{I S}{I_0 S_0}$$

$$= 10 \lg \frac{I}{I_0} + 10 \lg \left( \frac{4\pi r^2 m^2}{1 m^2} \right)$$

$$= L_I + 10 \lg 4\pi + 10 \lg r^2$$

$$= L_I + 11 + 10 \lg r^2$$

$$\Delta L^{\text{Sferico}} = 10 \lg \frac{r_2^2}{r_1^2}$$




$$L_W = 10 \lg \frac{W}{W_0}$$

$$= \;\vdots$$

$$= 10 \lg I/I_0 + 10 \lg \frac{2\pi r \cdot \ell}{1 \cdot \ell}$$

$$= L_I + 10 \lg 2\pi + 10 \lg r$$

$$= L_I + \text{☁} + 10 \lg r$$

$$\Delta L^{\text{cilindrico}} = 10 \lg \frac{r_2}{r_1}$$

# *Direzionalità*

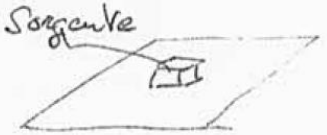
Se non sono nello spazio libero, ma la sorgente è posta su un piano:

$$S = \frac{4\pi r^2}{2} = 2\pi r^2 \Rightarrow L_I = L_W - 20 \lg r - 8$$

- Il valore -8 origina da -11+3, in cui il +3 è dovuto alla attenuazione per direzionalità della sorgente (D)

In generale il fattore di direzionalità può essere espresso come

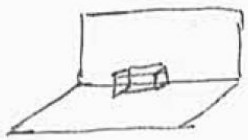
$$D = 10 \lg 2^n \quad \text{dove} \quad n = 1$$



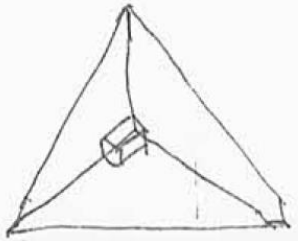

con $n$ = numero dei piani limitanti

La direzionalità di una sorgente è anche funzione della frequenza che in generale si evidenzia per frequenze medio alte (> 500 ÷ 1000 Hz)

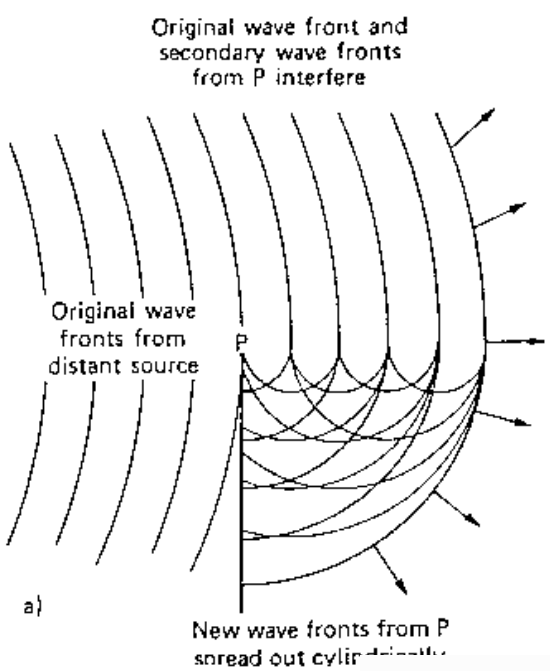
$n = 2$

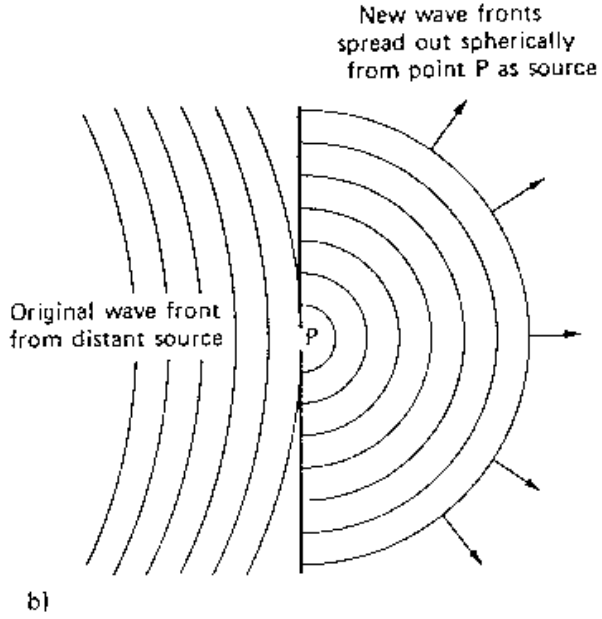


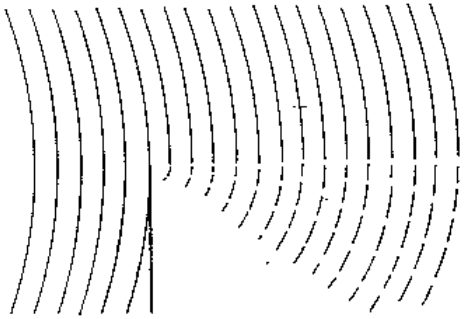
$n = 3$

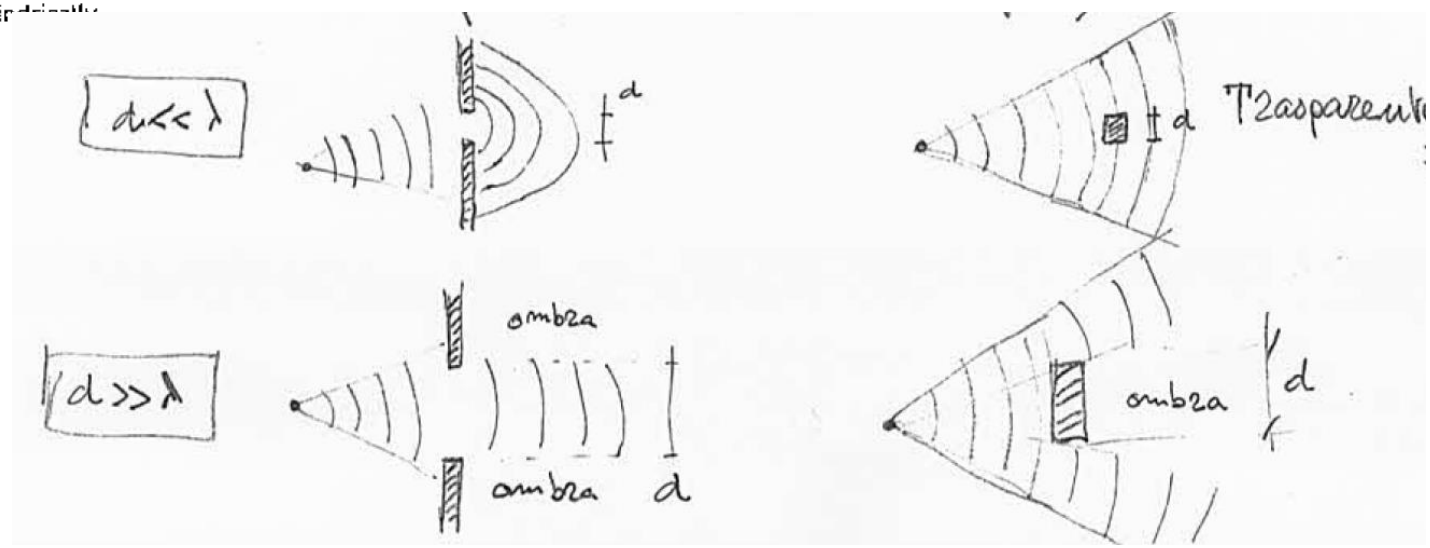


# *Schermi acustici*



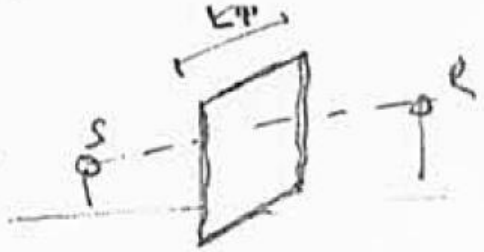



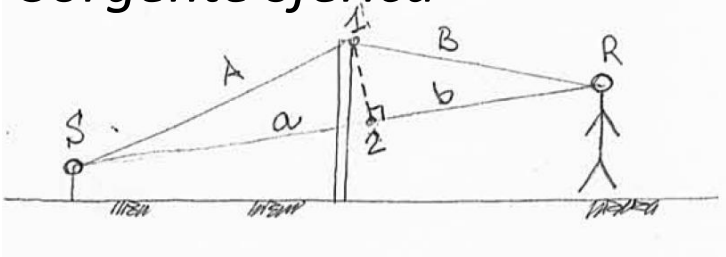


## *Schermi acustici*

**Barriera Acustica:**
- $\rho_{superficiale} > 10\ kg/m^2$
- nasconde la sorgente al ricevente
- $L_\pi > \lambda$
- non ha fori




## *Sorgente sferica*




$N = 2\frac{\delta}{\lambda} = 2\frac{\delta}{c}f$

$\delta$ → differenza tra A+B e a+b

$\lambda$ → lunghezza d'onda

$f$ → frequenza

Secondo Fehr: $A_b^D = 10\lg(10 \cdot N) = 10\lg(20 \cdot \delta/\lambda)$

Maekawa: $A_b^D = 10\lg(20 \cdot N + 3)$ con $N > 1$

Kurze-Anderson (1971): $A_b^D = 5 + 20\lg\frac{\sqrt{2\pi|N|}}{\tanh\sqrt{2\pi|N|}}$ $\forall N$

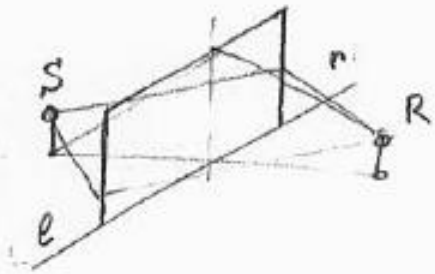
# *Schermi acustici*

Nel caso il fenomeno sia ipotizzabile anche sui bordi:

$$\Delta L = \Delta L_{\text{bordo singolo}} - 10\log\left(1 + \frac{N}{N_r} + \frac{N}{N_e}\right)$$

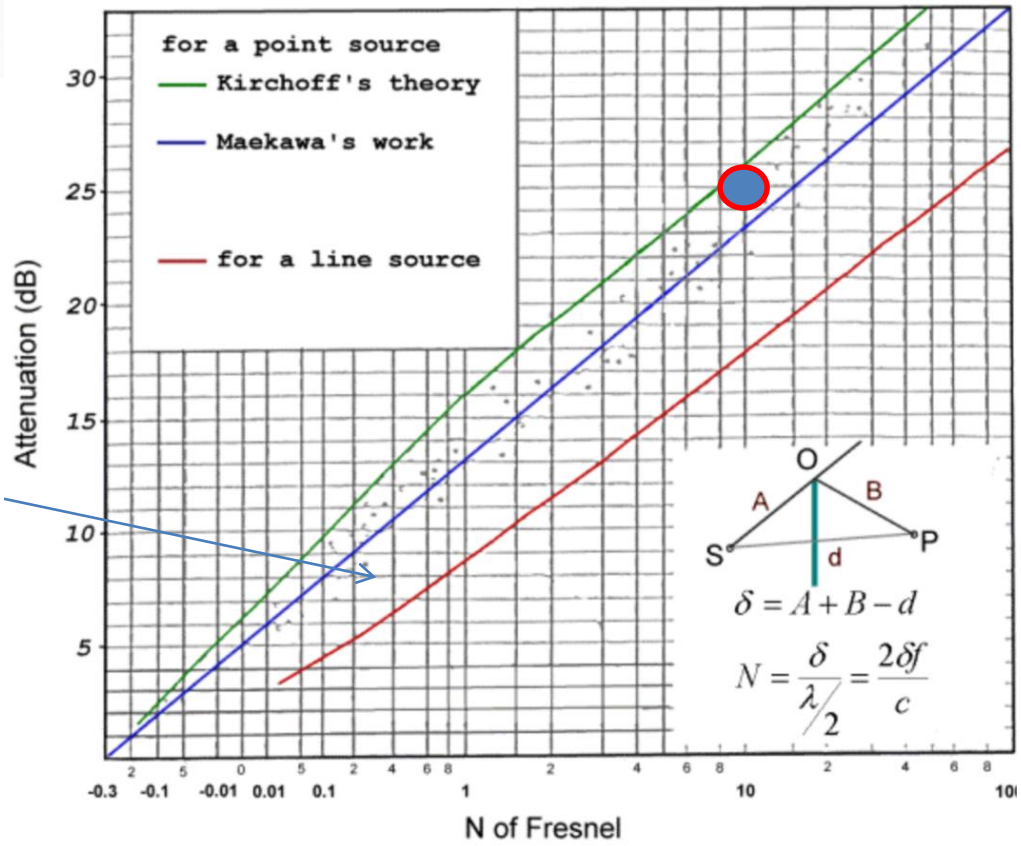
$N$: Numero di Fresnel lungo il percorso right

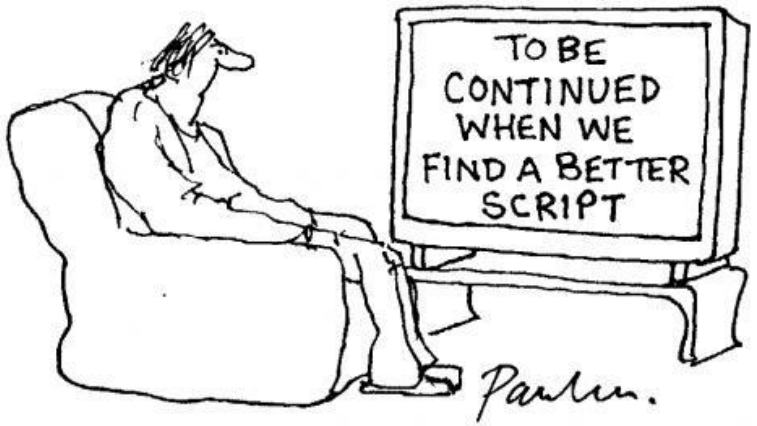
$N_e$: left path




*Sorgente lineare*

$$\Delta L = 10\log(2 + 5.5N)$$

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WHEN WE
FIND A BETTER
SCRIPT
Parker.