WHEN IS A CONCERT

HALL TOO QUIET?

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Sound level in auditoria

Sound level, G, also called Strength, is measured relative to direct sound at 10 m from an omni-directional source, typical values 0 – 8 dB

Common criterion for concert halls, $G \geq 0$ dB

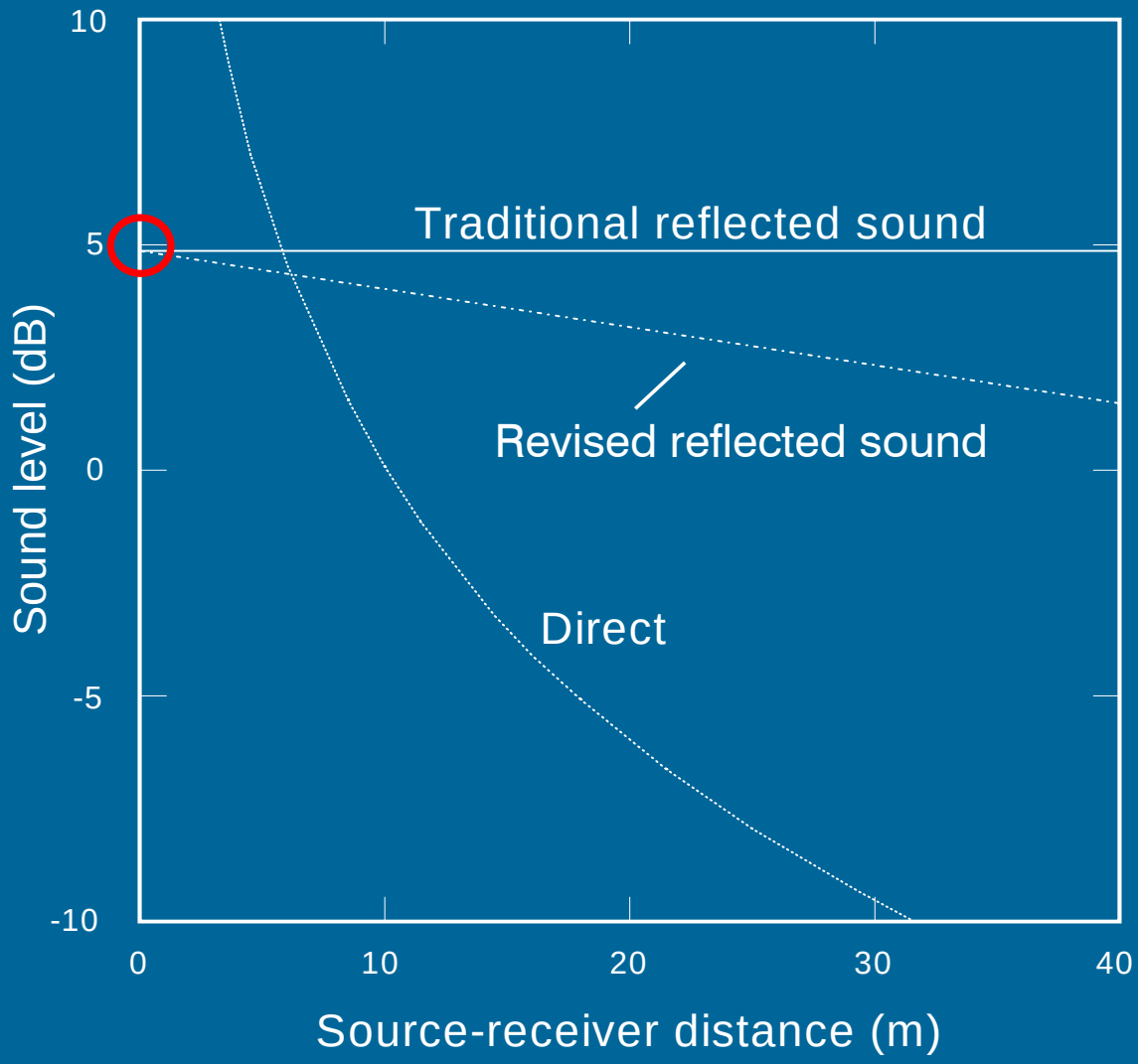
Frequency range: 500 – 2000 Hz octaves ?

Should the criterion be independent of source-receiver distance?

We need to look at behaviour of sound level in a room

AND

appreciation of loudness in a room



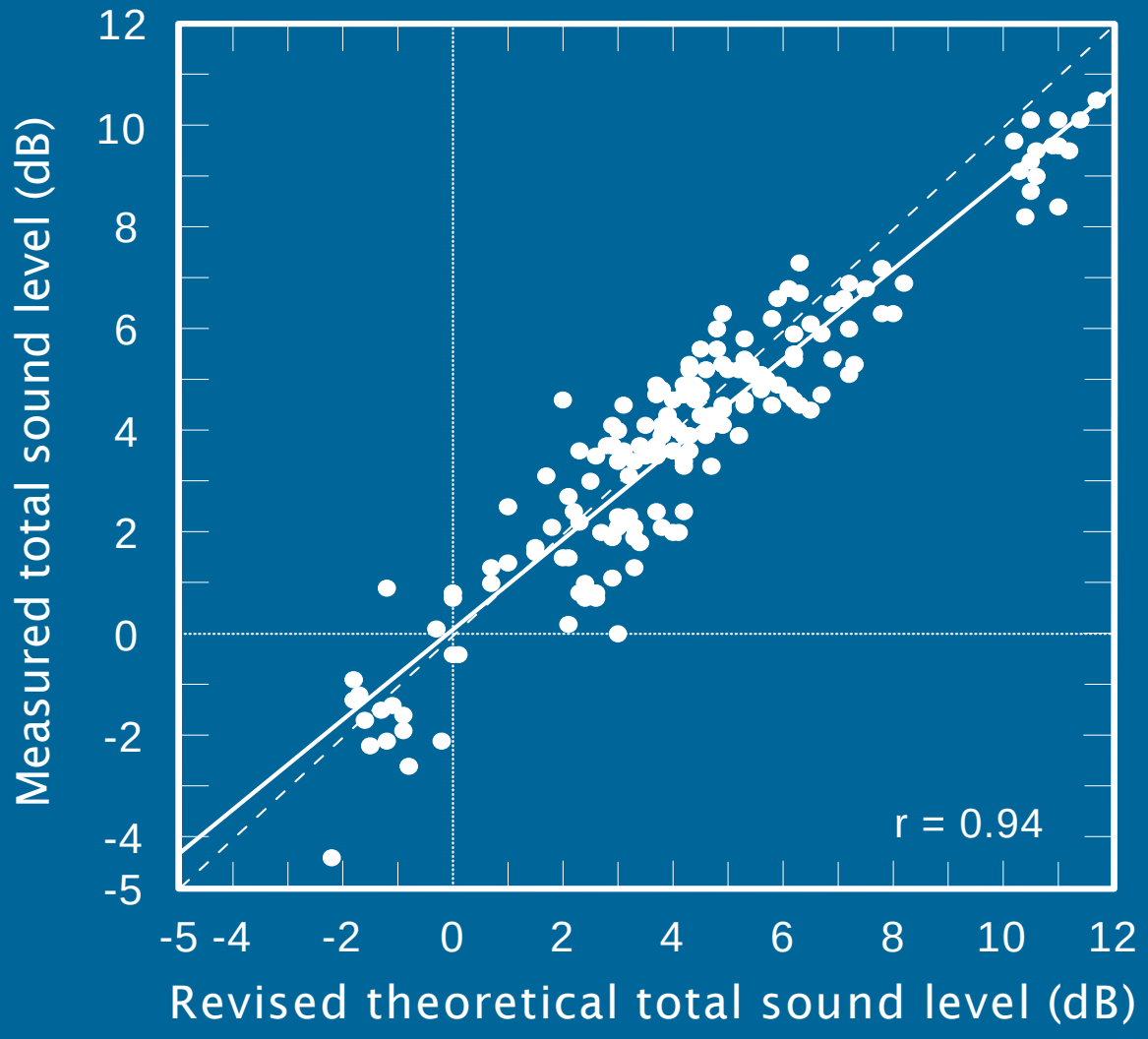
Behaviour of sound level G in a room – revised theory

Revised equation for reflected sound level

Traditional theory ‘Slope’

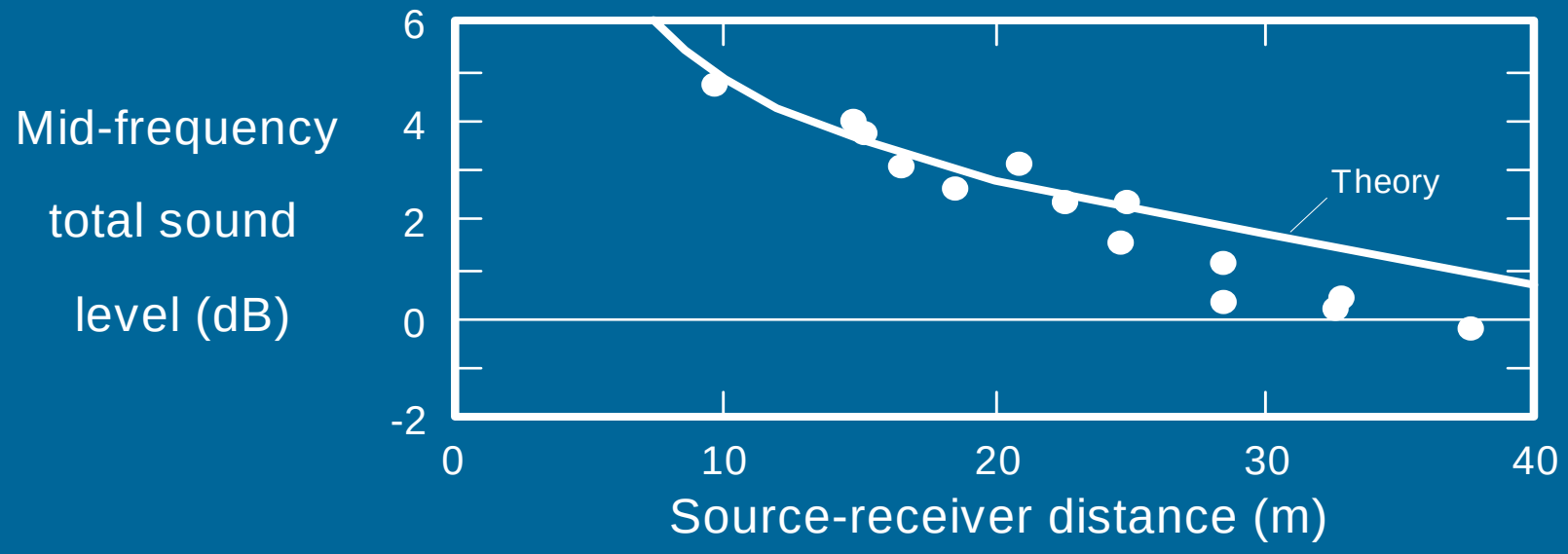
$$L_{refl} = 10 . \log\left(\frac{31200 . T}{V}\right) - \frac{0 \cdot 174 . r}{T} \quad dB$$

Note, slope is an inverse function of reverberation time



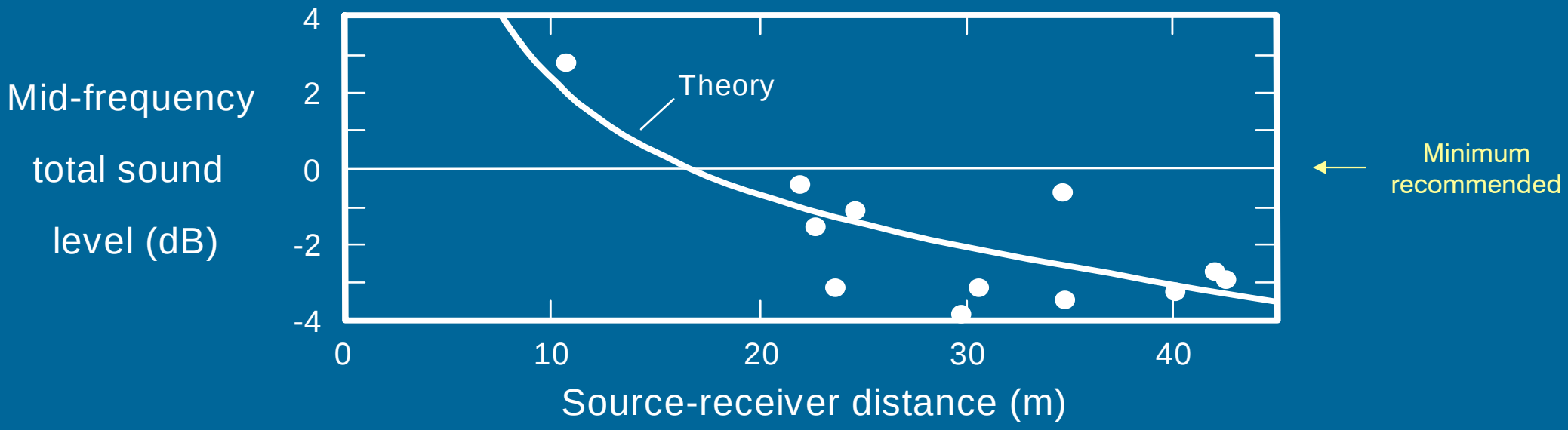
Measured vs. revised theoretical sound level

Mid-frequency values without overhung locations



Sound level behaviour in a typical large concert hall

Royal Albert Hall, London (measured 1982)



Predicted and measured sound levels are low because total acoustic absorption is large in this hall (audience capacity > 5000)

Loudness perception in concert halls

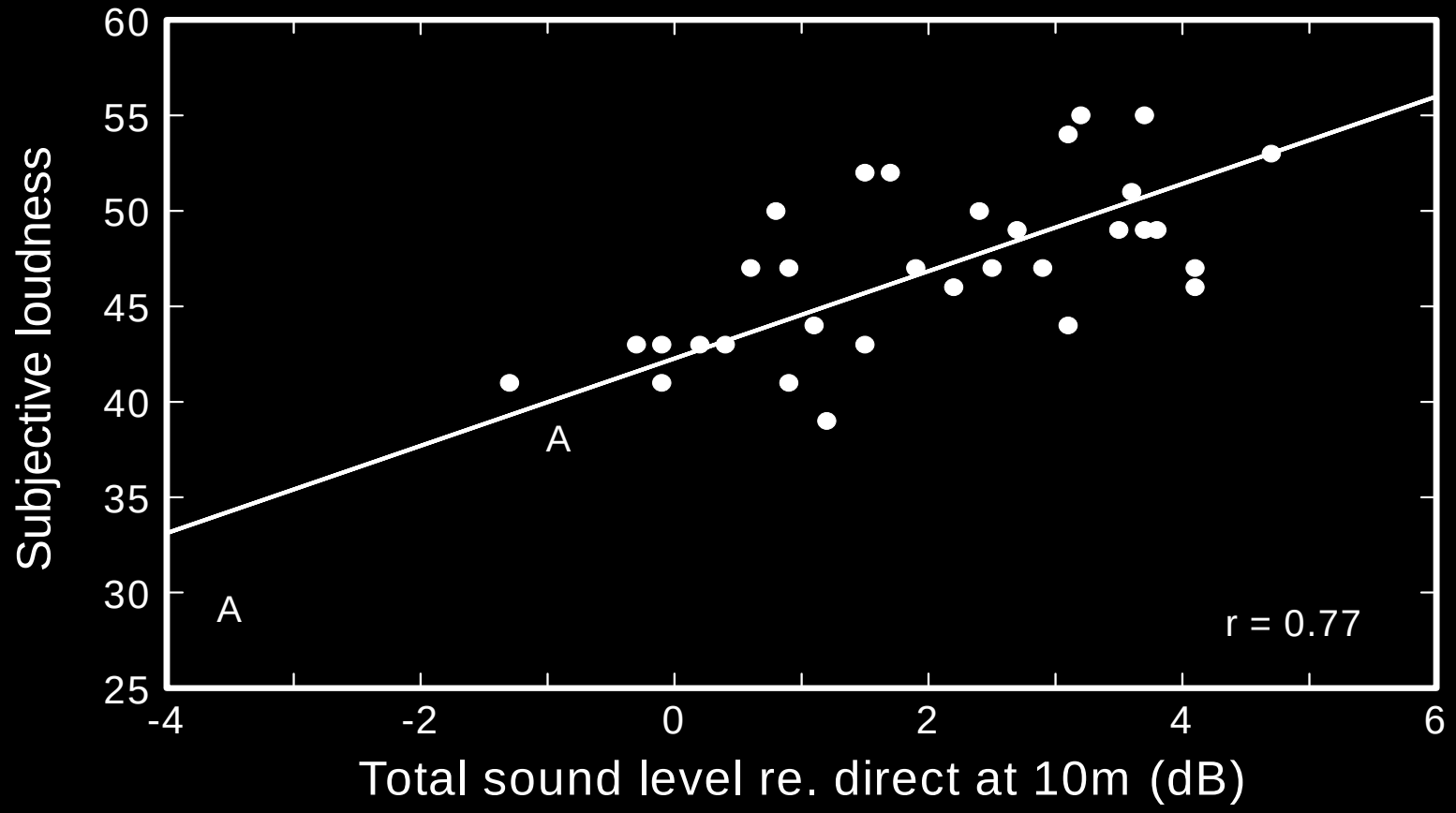
Two German studies (~1970):

- Göttingen (Gottlob and Siebrasse): sound level subjectively very important
- Berlin (Lehmann and Wilkens): 'loudness' found to be one of three important subjective dimensions
  - 'Loudness' highly correlated with total sound level (r = 0.82)

Objective/subjective survey of British concert halls (1982 – 84)

- Data from 11 large British concert halls, 34 positions in total
- Subjective scale:

Loudness in British concert halls



Correlation between subjective loudness and measured sound level

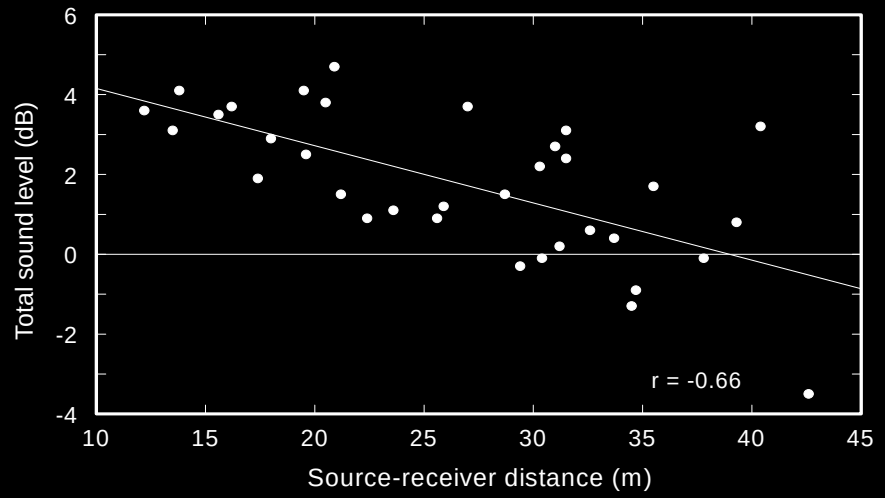
Sound level for 125 – 2000Hz. (r = 0.70 for mid-frequency only.)

Loudness and distance

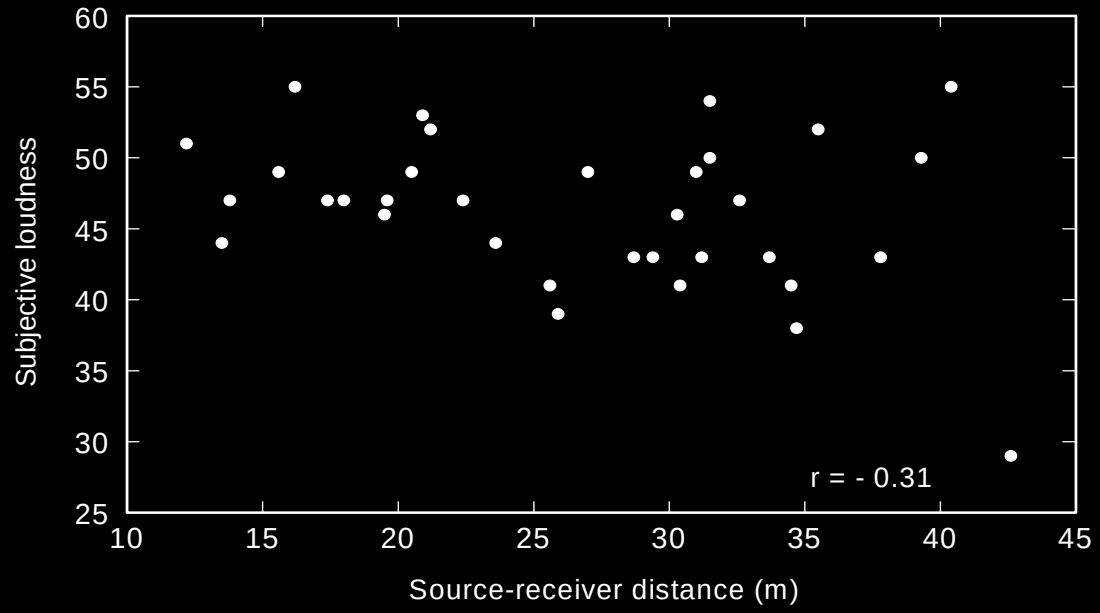
Perceived loudness is related to sound level

Sound level is related to source-receiver distance (r = -0.66)

Is loudness related to distance?



No!



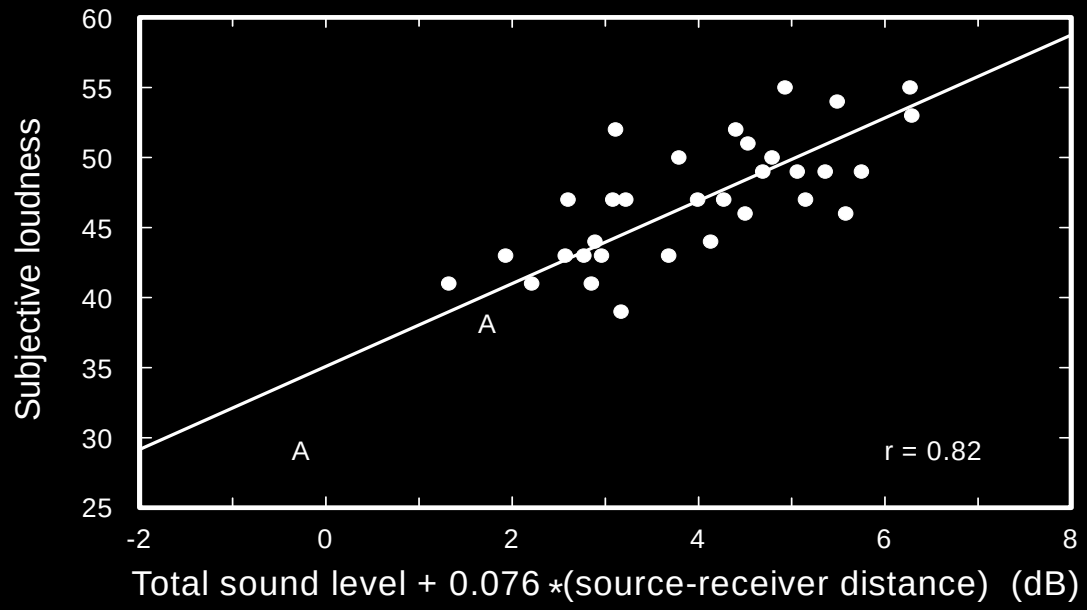
Loudness and distance (2)

Try multiple regression:

$$\text{Loudness} = 2.96 \times (\text{Full-freq. sound level} + 0.076 \times \text{Distance}) + 35$$

Note sign

Perceived loudness increases with distance, as people move back they compensate for distance



Correlation coefficient, r, increases from 0.77 to 0.82

Loudness and distance (3)

From multiple regression, trade-off between sound level and distance is 0.076 dB/m

From earlier equation, similar rate of reflected level drop-off in halls with 2 s reverberation time is 0.087 dB/m

The accuracy of the first of these numbers is not high due to its origin in subjective data

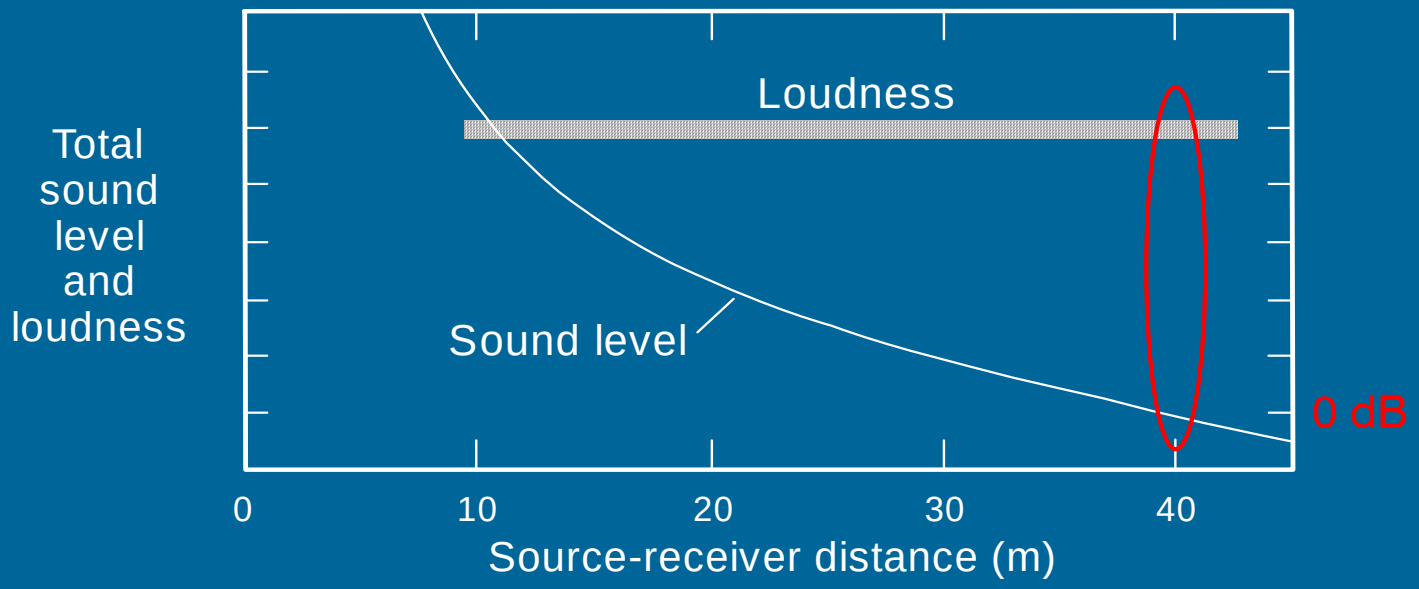
Reasonable to assume that perceived loudness is constant throughout a ‘typical concert hall’

Loudness is approximately constant in a typical hall

Sound level decreases with distance

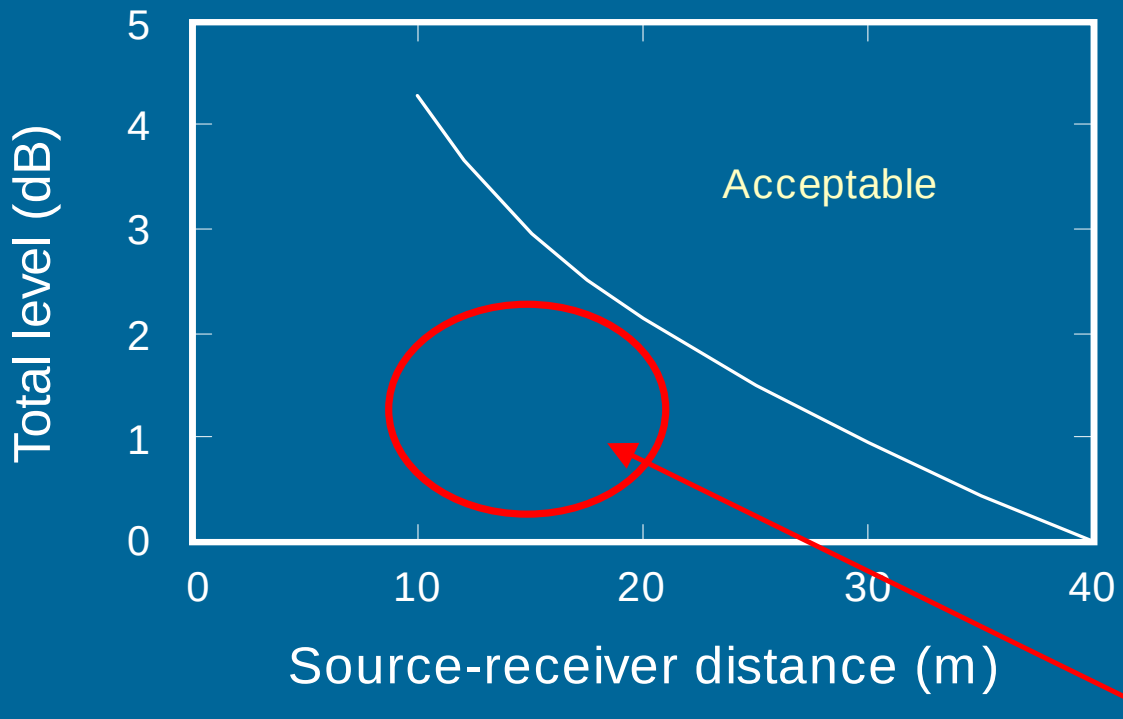
The criterion of G ≥ 0 dB most relevant to distant seats (40 m)

From revised theory equation, a hall with volume 30,000 m³, RT = 2 s gives a value of G = 0 dB at 40 m



We will need higher level sound at positions closer than 40m to sound equally loud

Boundary for acceptable loudness therefore assumed to be the average sound level for a hall with RT = 2 seconds and volume 30,000m^3



Subjective evidence needed

Equation: $L = 10.\log(100/r^2 + 2{\cdot}08.e^{-0.02r})$

CONCLUSIONS

Substantial evidence that reflected sound levels in concert halls decrease with distance from source

Evidence that perceived loudness hardly decreases with distance from the stage

This leads to the proposal that the minimum sound level for a concert hall should be greater near the stage than at seats further away