A Model for Rendering Stereo Signals in the ITD-Range of Hearing

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LINKWITZ LAB

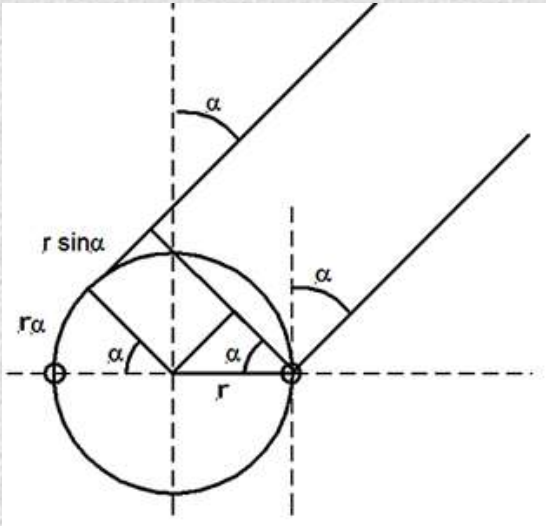
Sensible Recording and Rendering of Acoustic Scenes

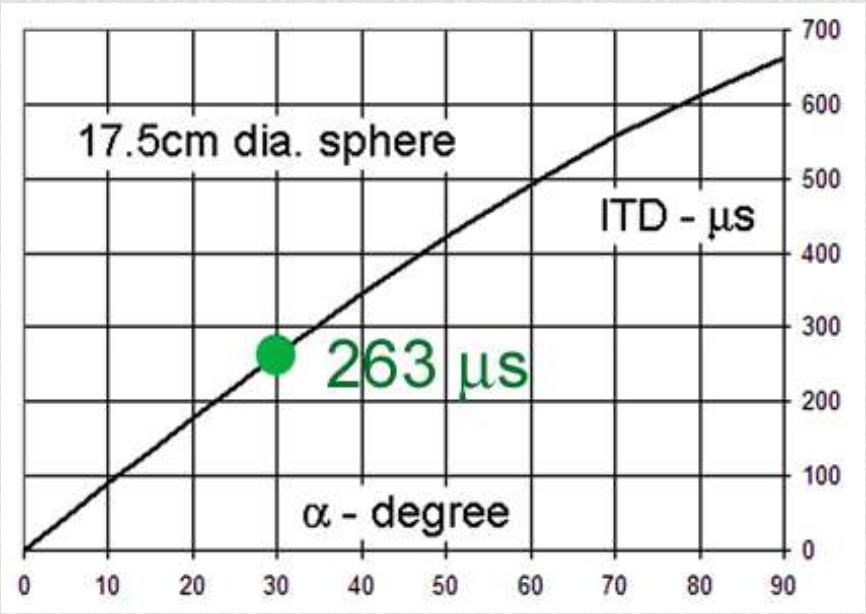
Directional Hearing

HRTF - Head Related Transfer Function
ITD - Inter-aural Time Difference below 800 Hz
ILD - Inter-aural Level Difference above 2 kHz

HRTF change with head movement

Horizontal plane for loudspeaker stereo





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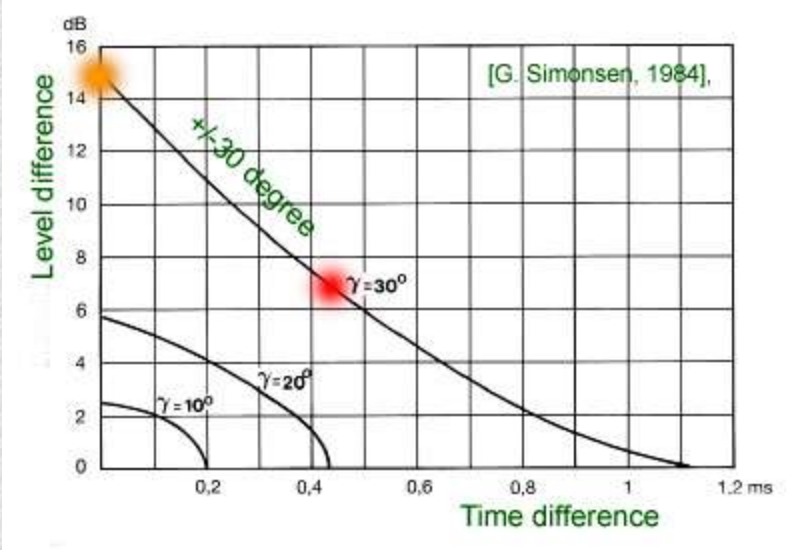


Phantom source placement by Level panning and/or Time panning

Left to right spatial rendering control

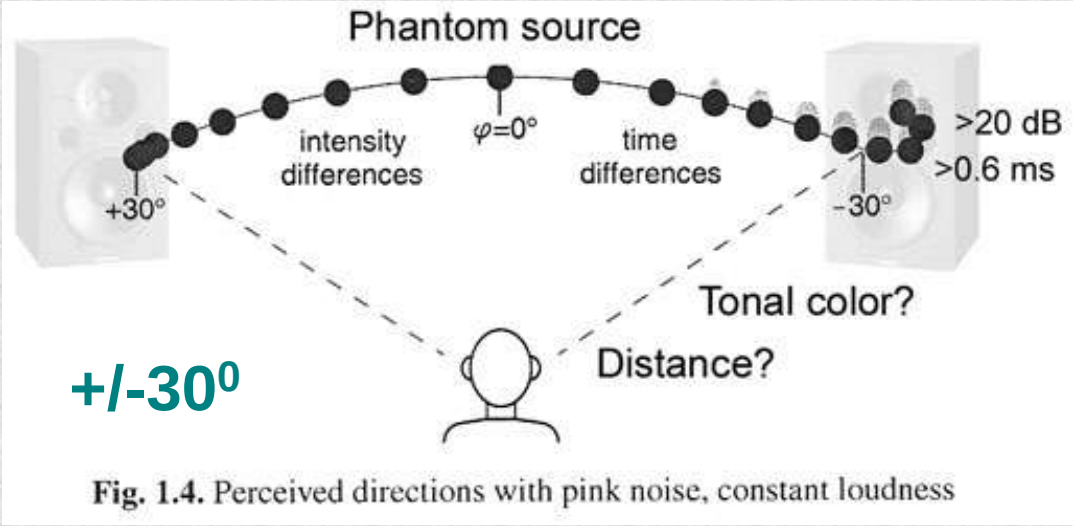
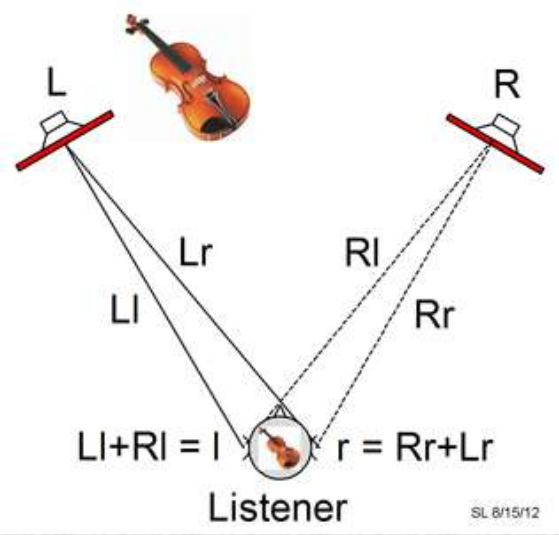
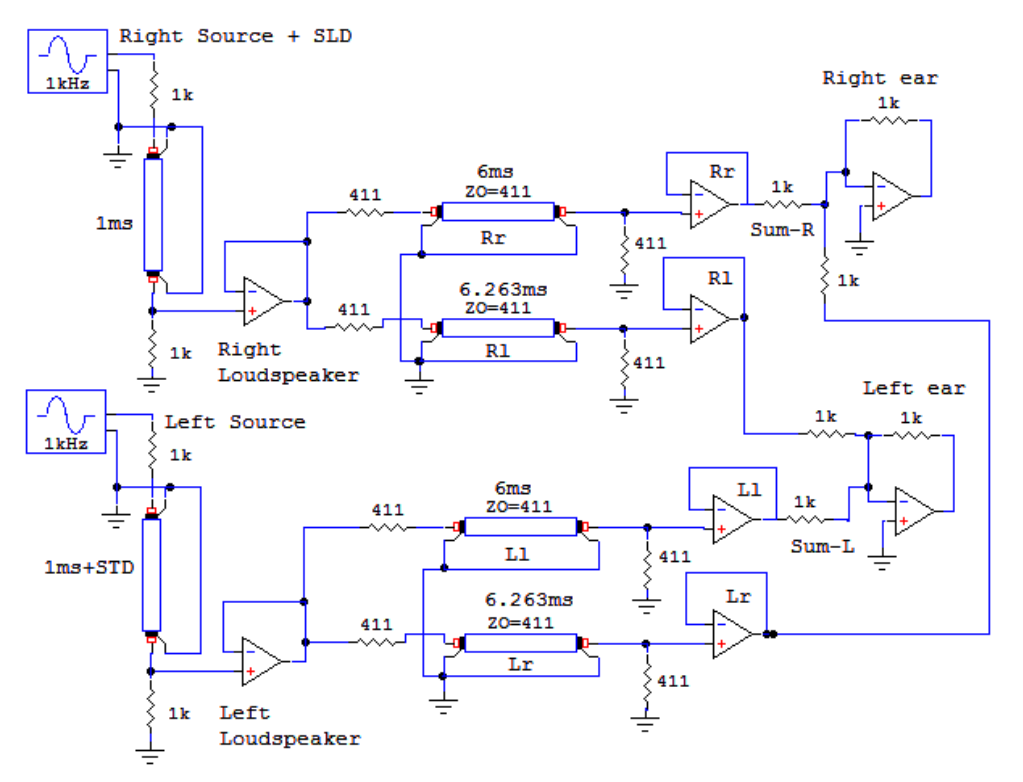


Fig. 1.4. Perceived directions with pink noise, constant loudness

Model for Phantom Source Placement in the ITD-Range of Hearing





* Sphere model of head
* No head shading
* ITD = 263μs @ 30^0

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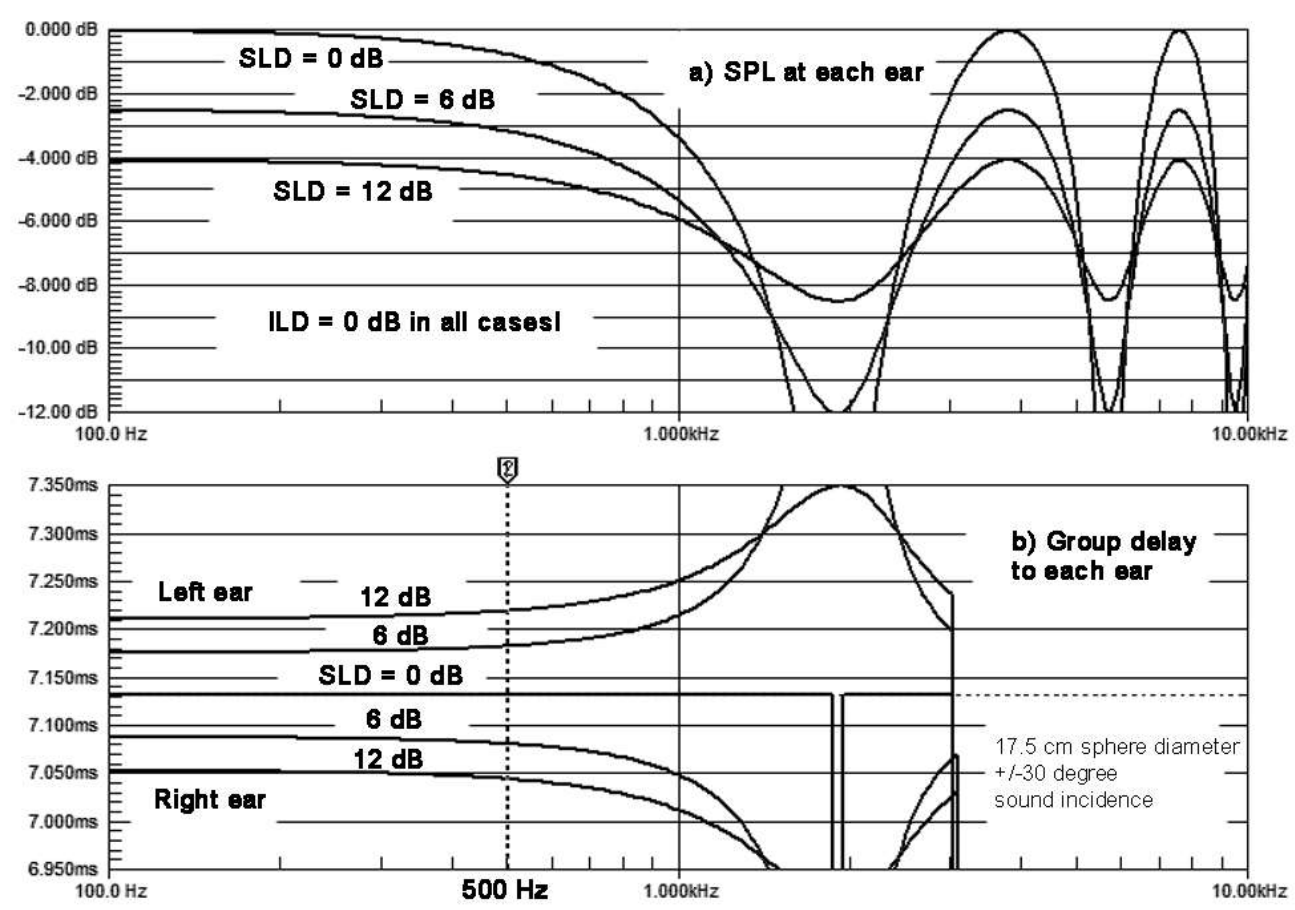
Level Panned Mono Source



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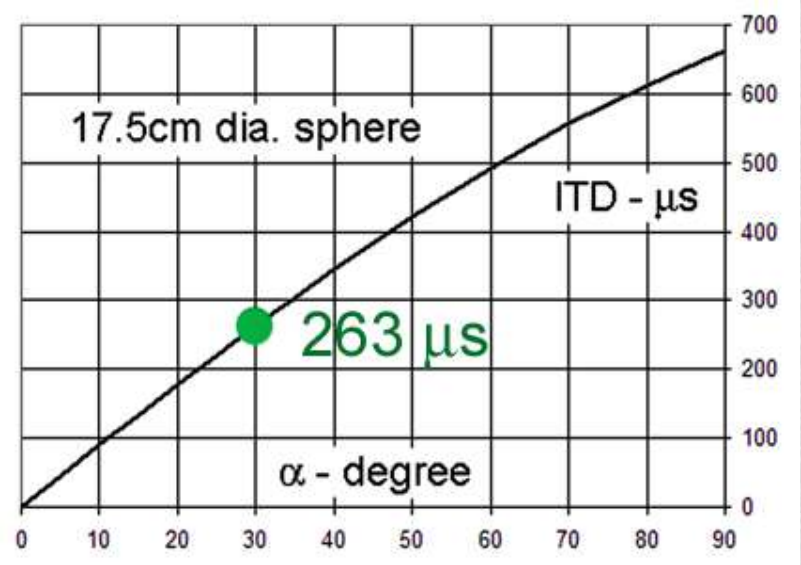
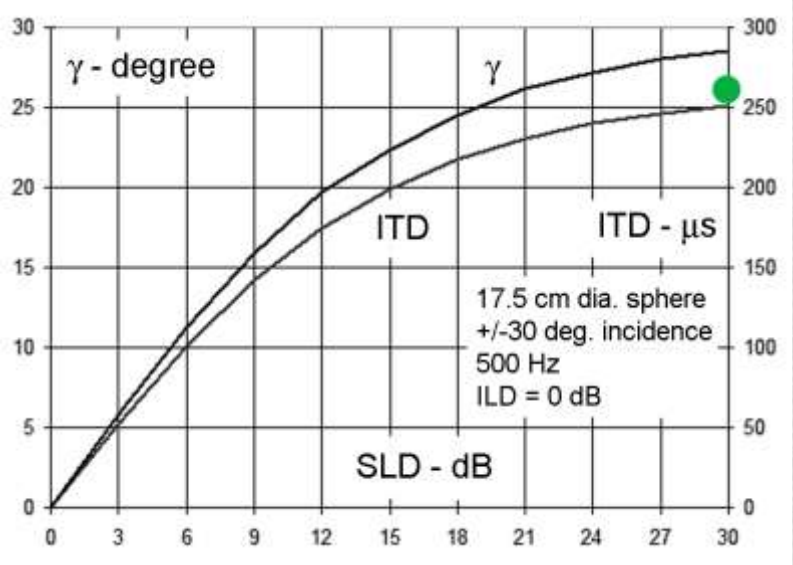
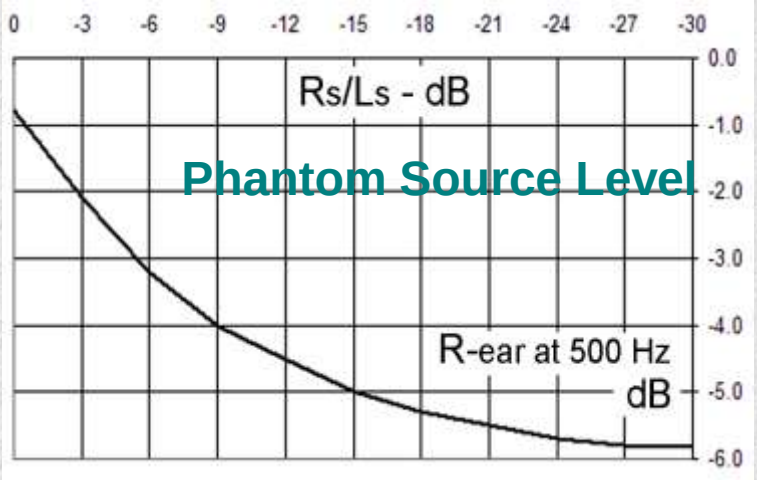
Real Source ITD



Phantom Source ITD



Phantom Source Angle γ as Function of Source Level Difference



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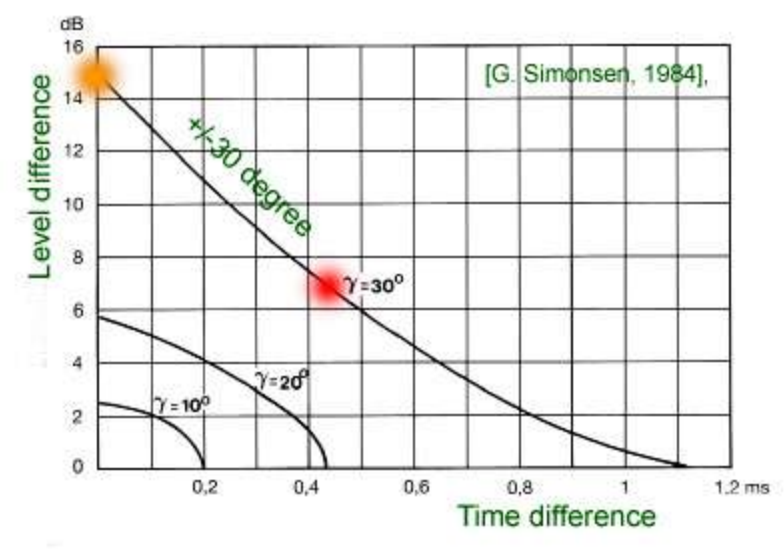
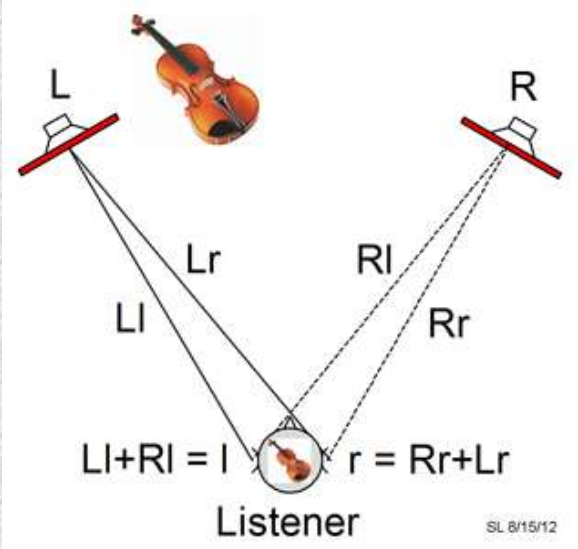
A level panned source signal produces Time Differences between the ears, but no level differences





The time differences at the ears determine the phantom source angle γ

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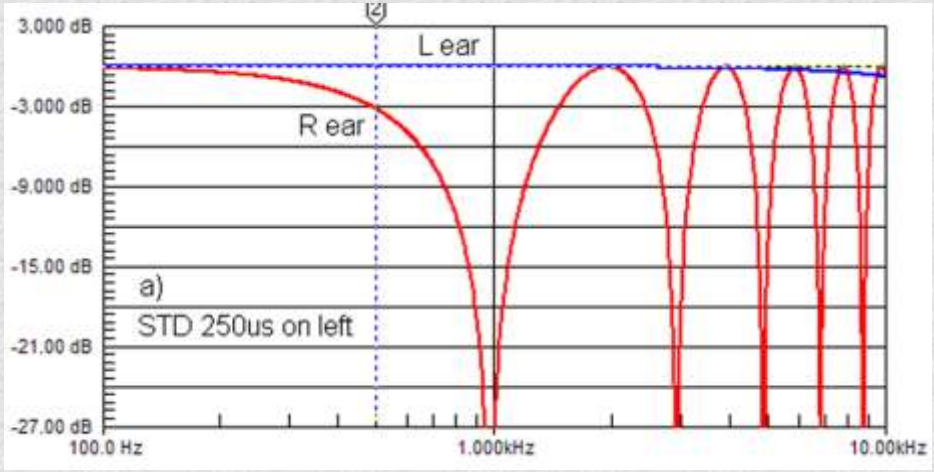
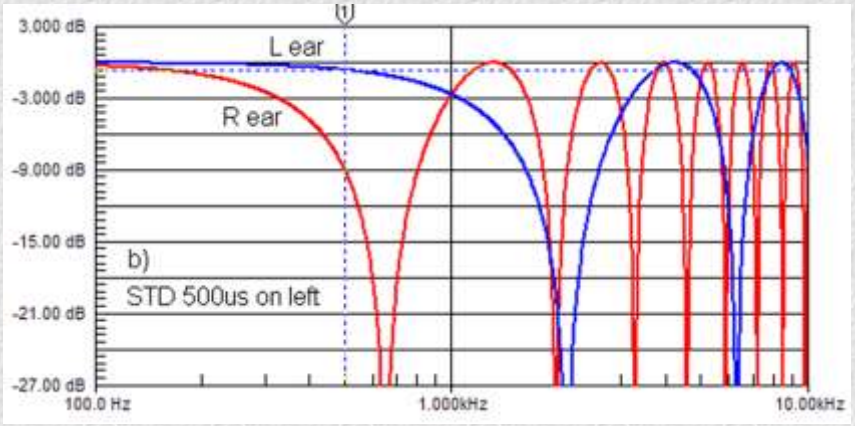
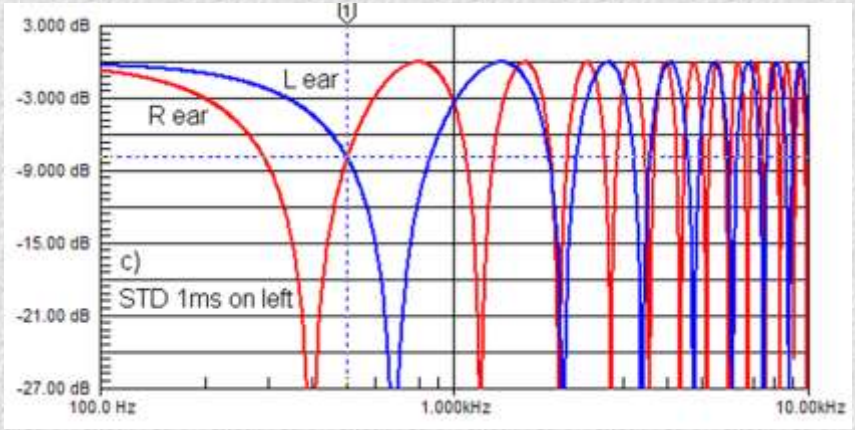
Time panned mono source







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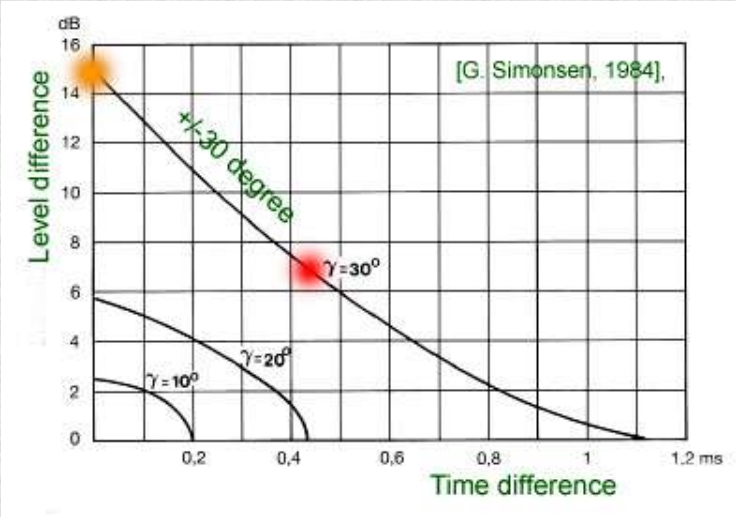
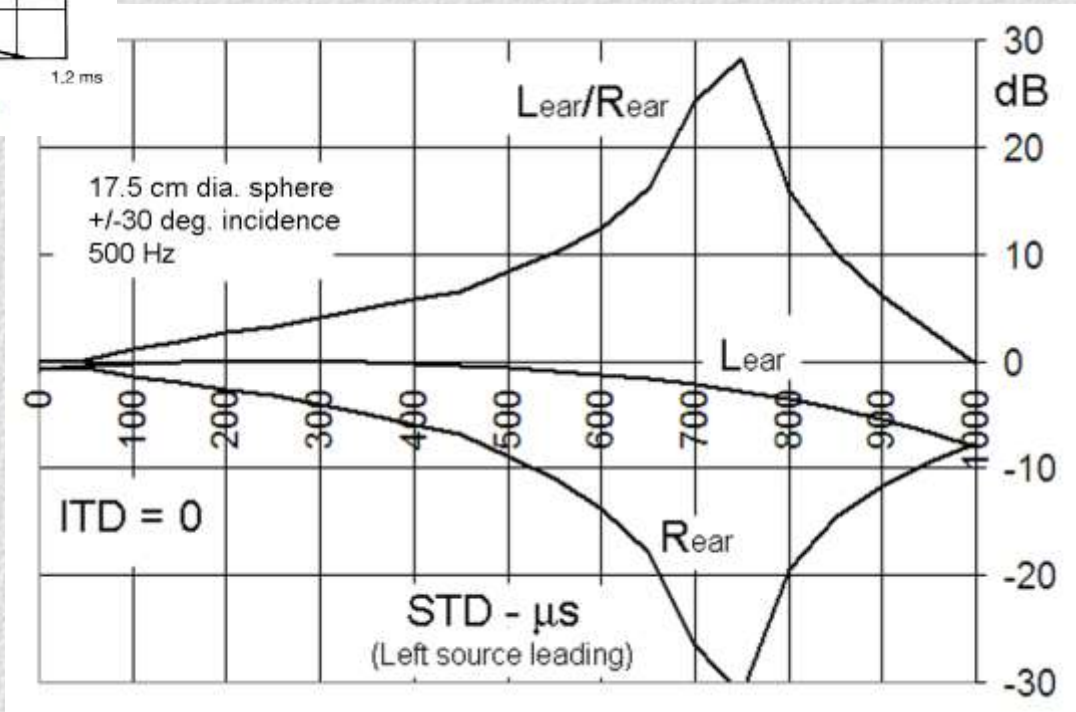


A time panned source signal produces Level Differences between the ears, but no time differences

The level differences at the ears pull the phantom source towards the leading loudspeaker but depending upon frequency



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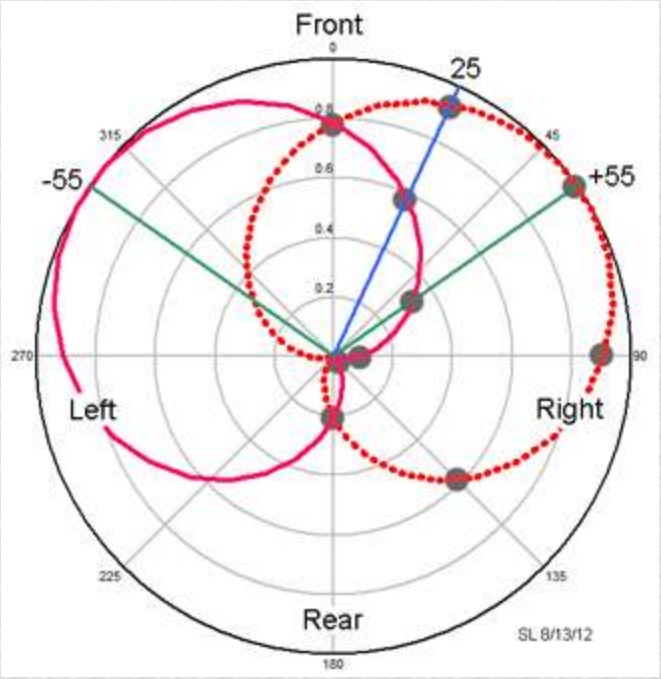
Automatic Level and Time Panning with Microphone Pairs

Spaced

Coincident



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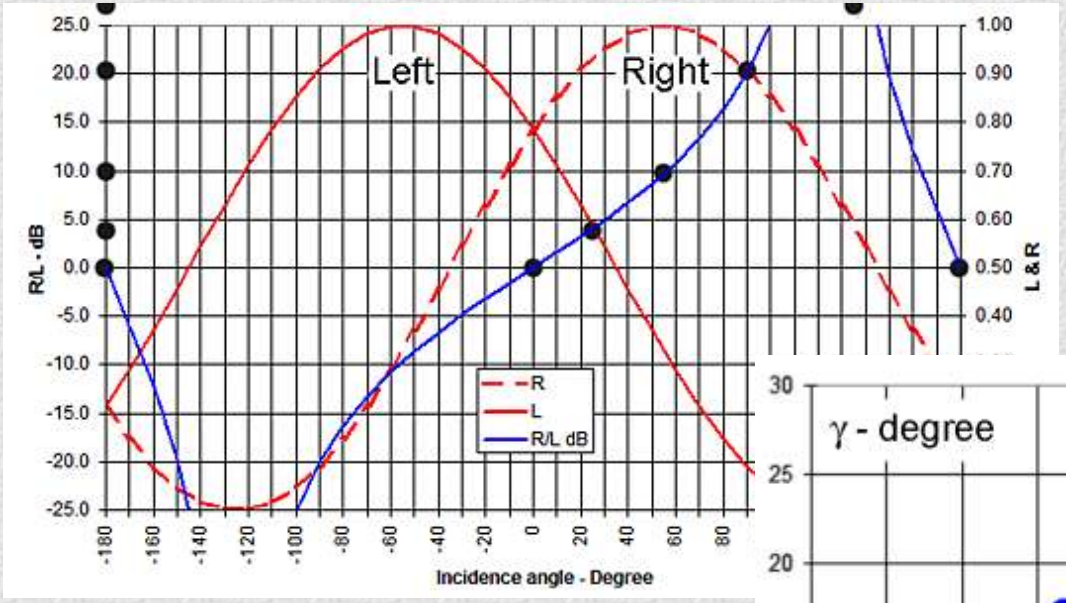
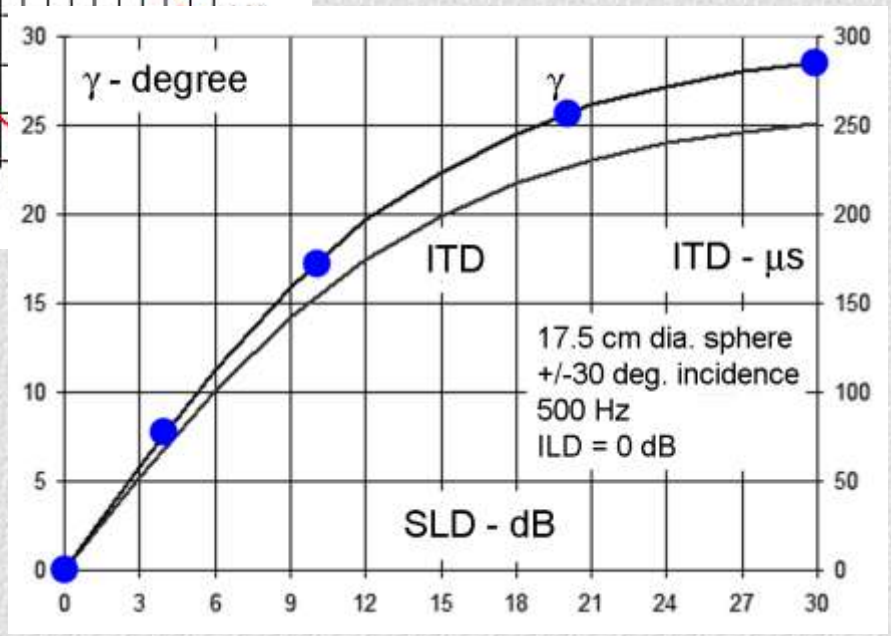
Coincident Microphone Pair





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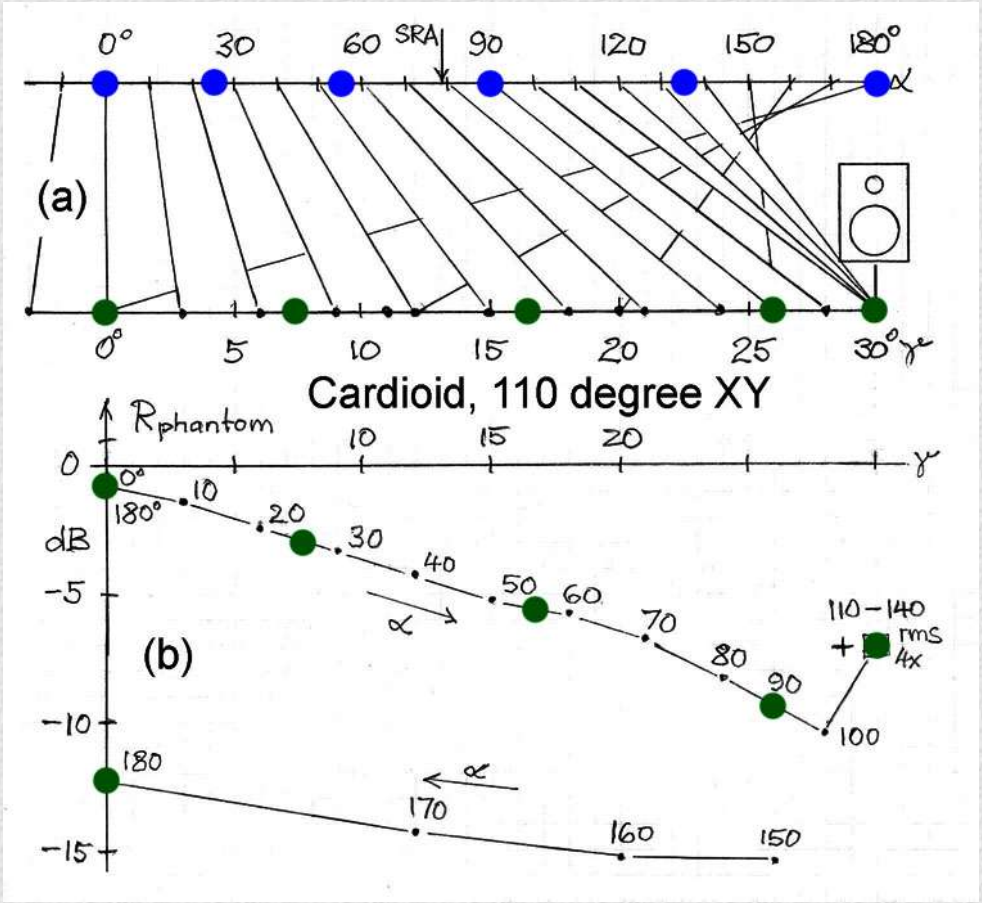
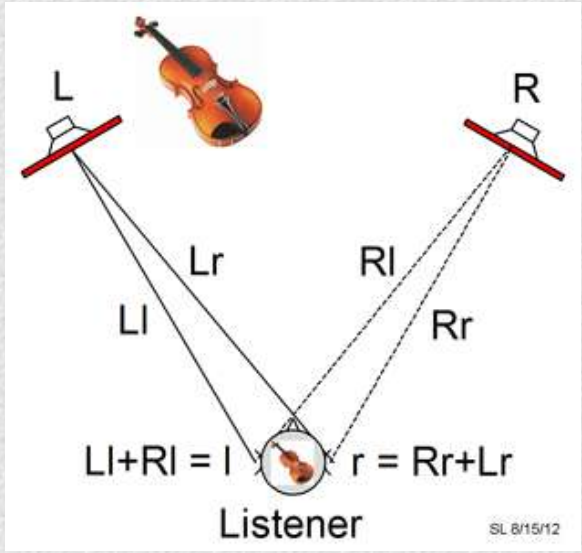
Coincident Microphone Pair



+/-180^0

Spatially detailed rendering

+/-30^0



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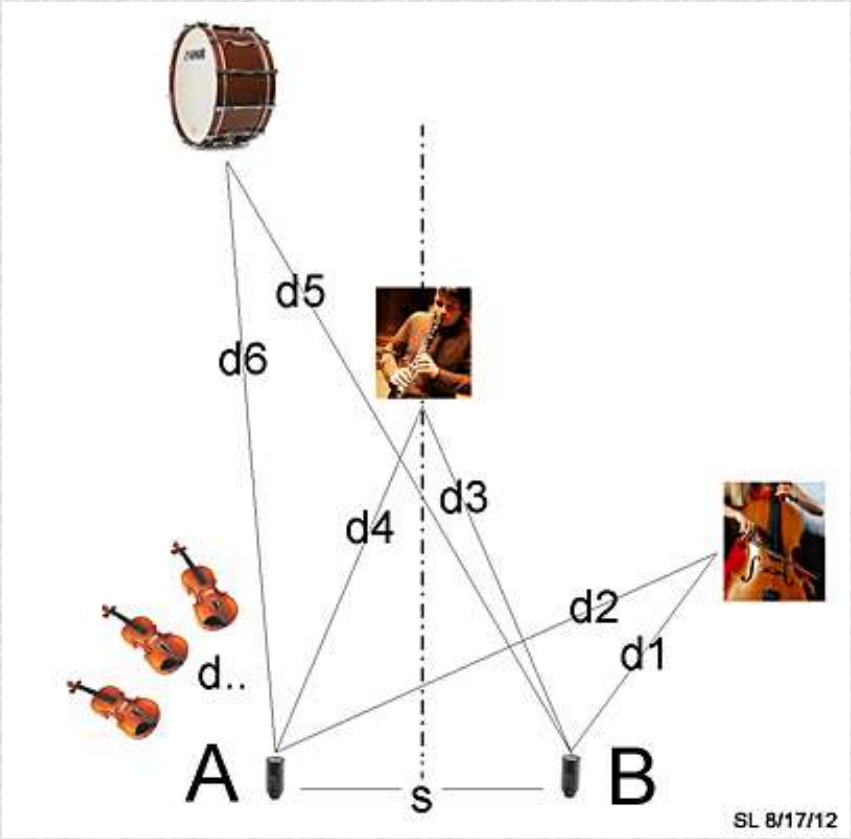
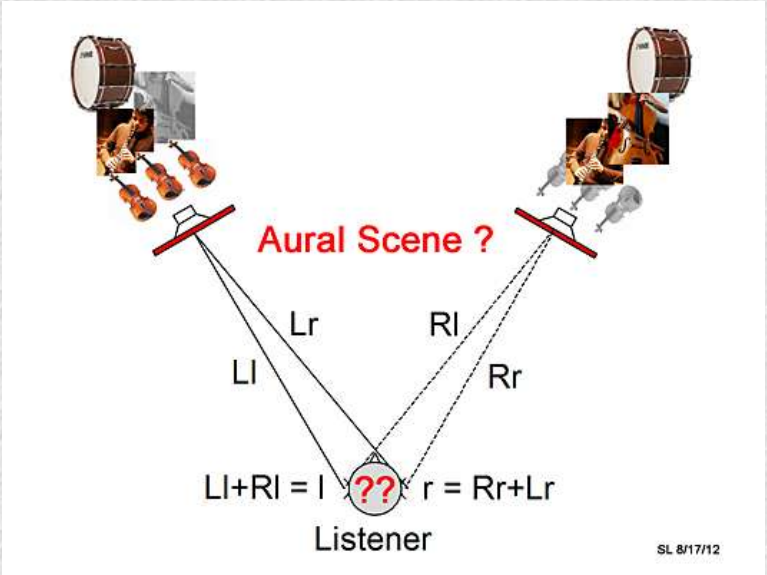
Spaced Microphone Pair



Spatially diffuse rendering



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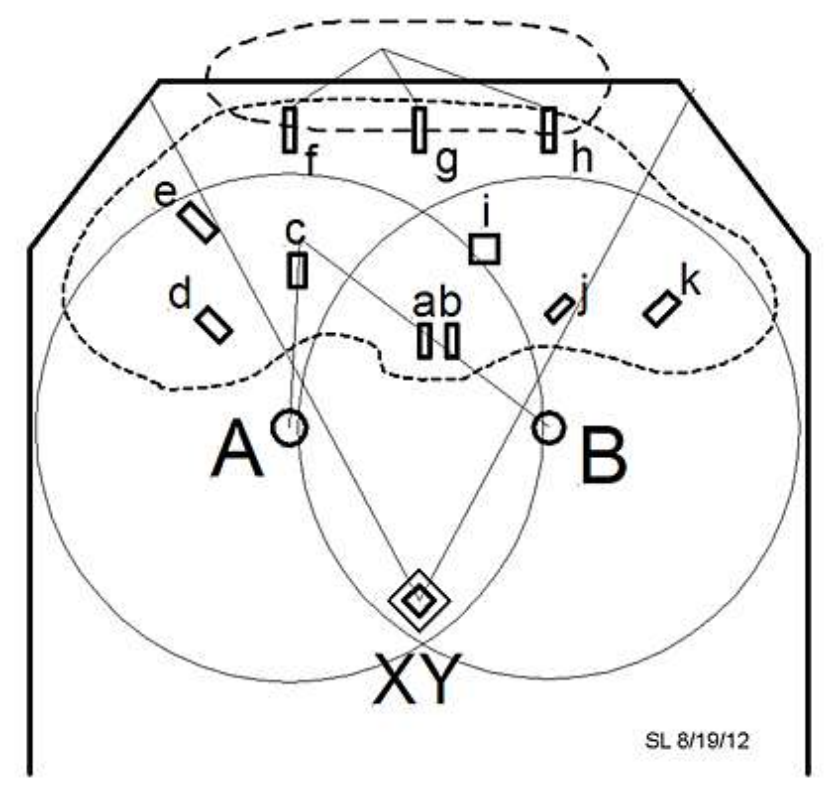
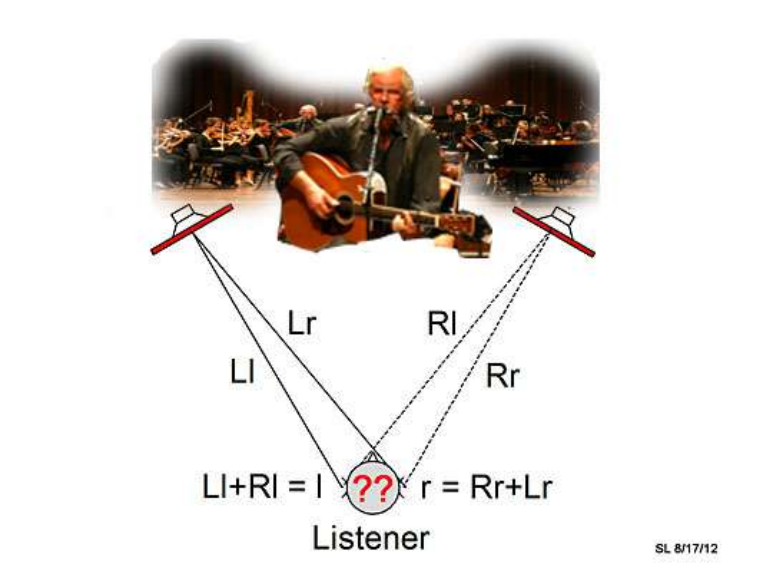
Live Recording

Coincident microphone pair
Spaced microphone pairs
Individual microphones



Spatially creative Rendering



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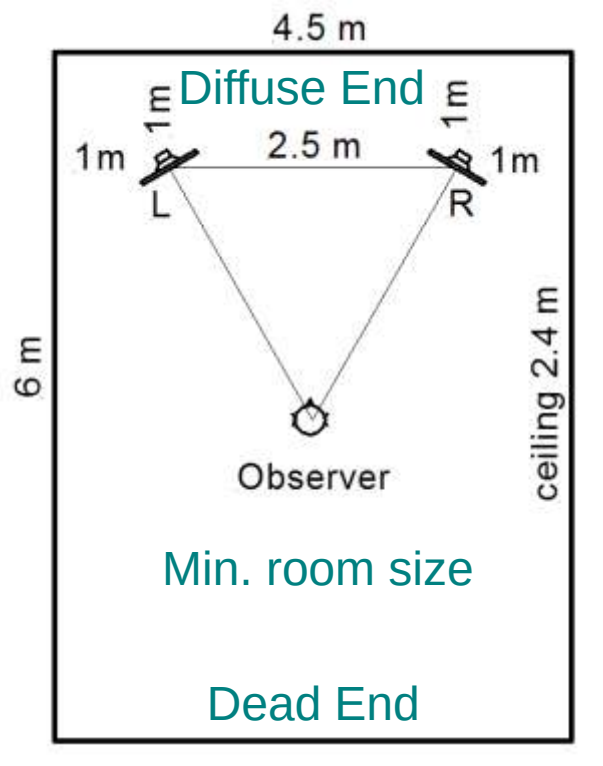
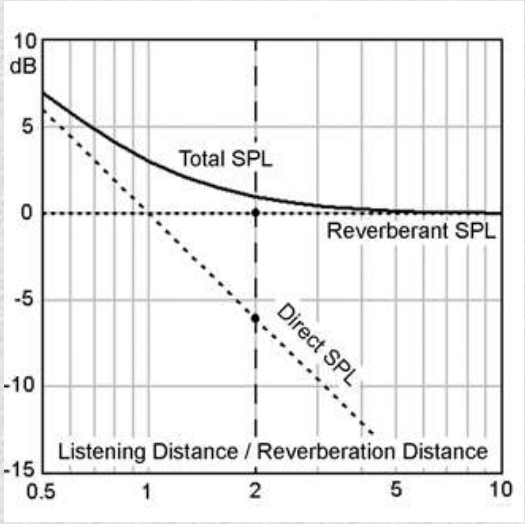
Optimum setup for rendering Stereo



- Constant directivity loudspeakers
  20Hz to 20kHz, Dipole, Cardioid, Omni
- Loudspeakers >1 m from room boundaries
- Equilateral triangle
- Symmetrical relative to room boundaries
- Listening distance < 2x Reverberation distance
- RT60 around 450 ms above $F_{Schroeder}$
- Diffuse End - Dead End



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Conclusions

Stereo recording and rendering must be considered as a unit, if communication of natural spatial relationships is important

A sphere model of the human head can provide qualitative insight into the rendering of sound over two loudspeakers in the ITD frequency range of hearing

Coincident microphone and level panned single microphone techniques yield spatially defined phantom sources

Spaced microphones and time panned single microphone techniques yield spatially diffuse phantom sources