

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

Siegfried Linkwitz

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Sensible Recording and Rendering of Acoustic Scenes

Directional Hearing

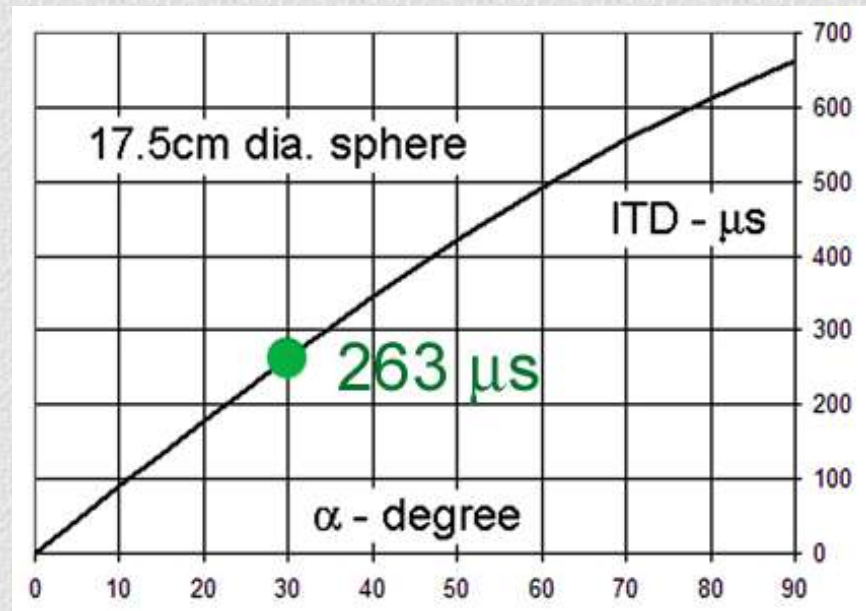
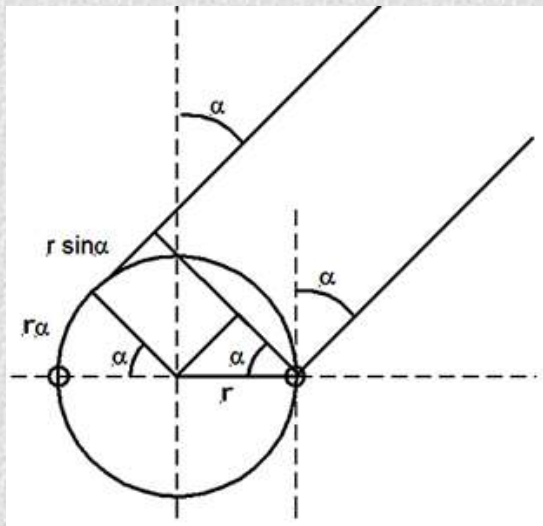
HRTF - Head Related Transfer Function

ITD - Inter-aural Time Difference below 800 Hz

ILD - Inter-aural Level Difference above 2 kHz

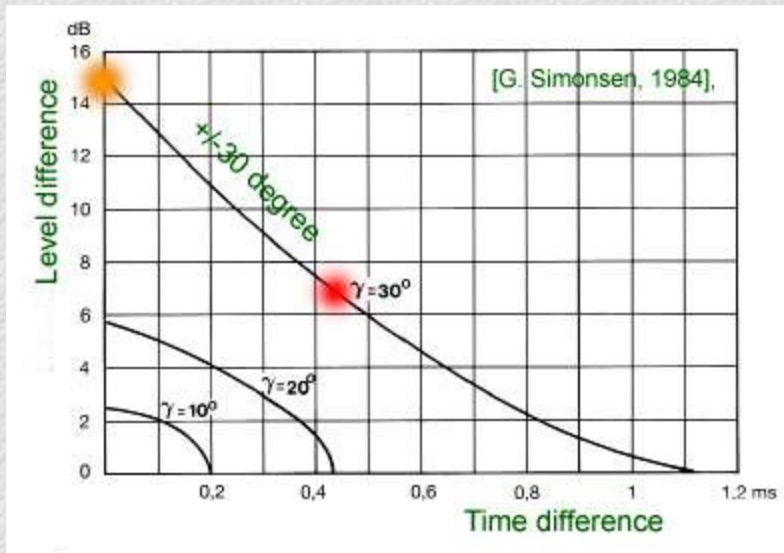
HRTF change with head movement

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

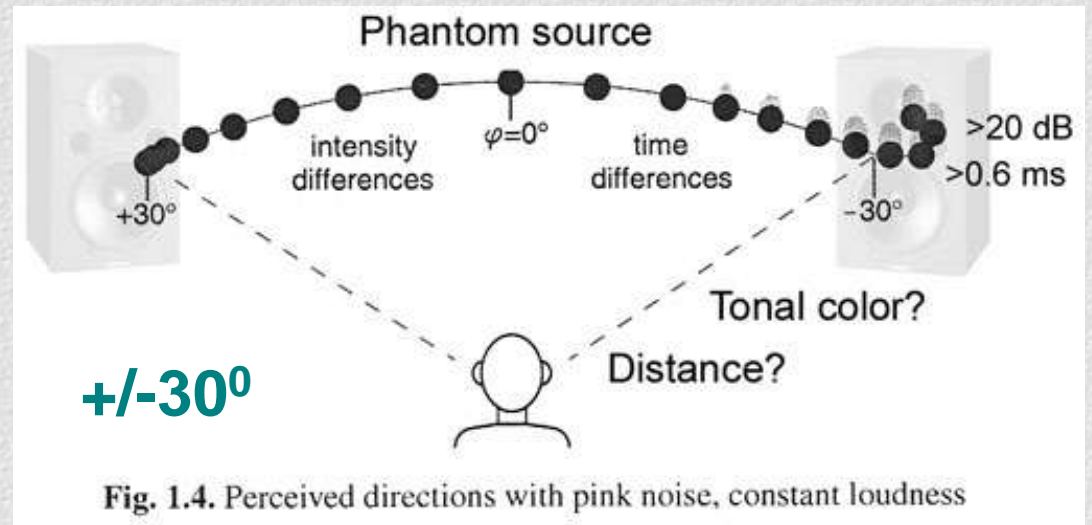
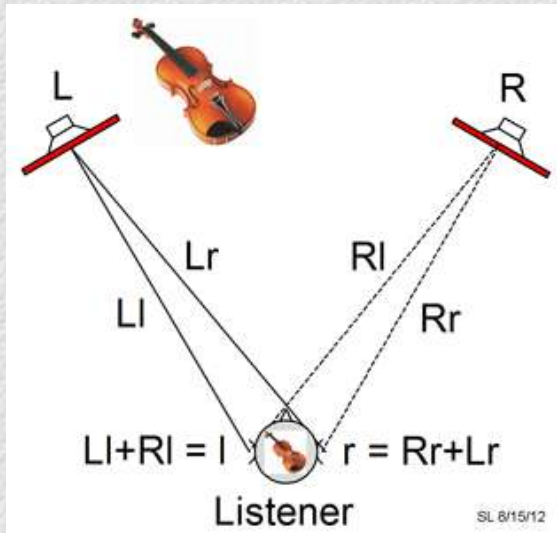


Fig. 1.4. Perceived directions with pink noise, constant loudness

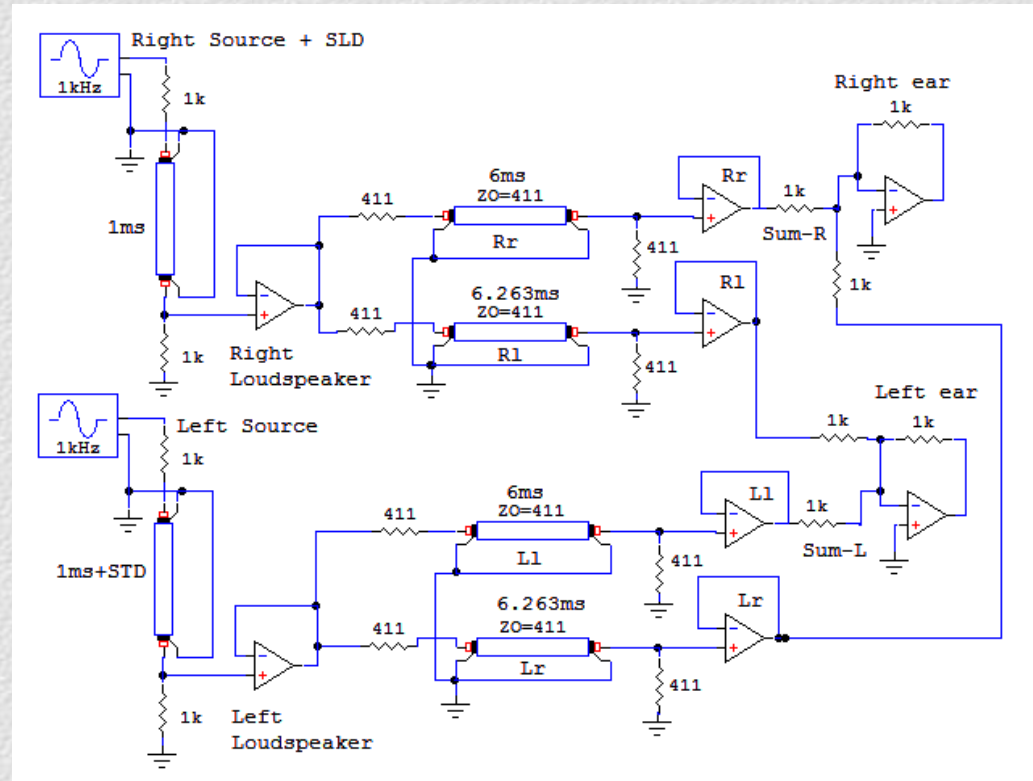
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Model for Phantom Source Placement in the ITD-Range of Hearing



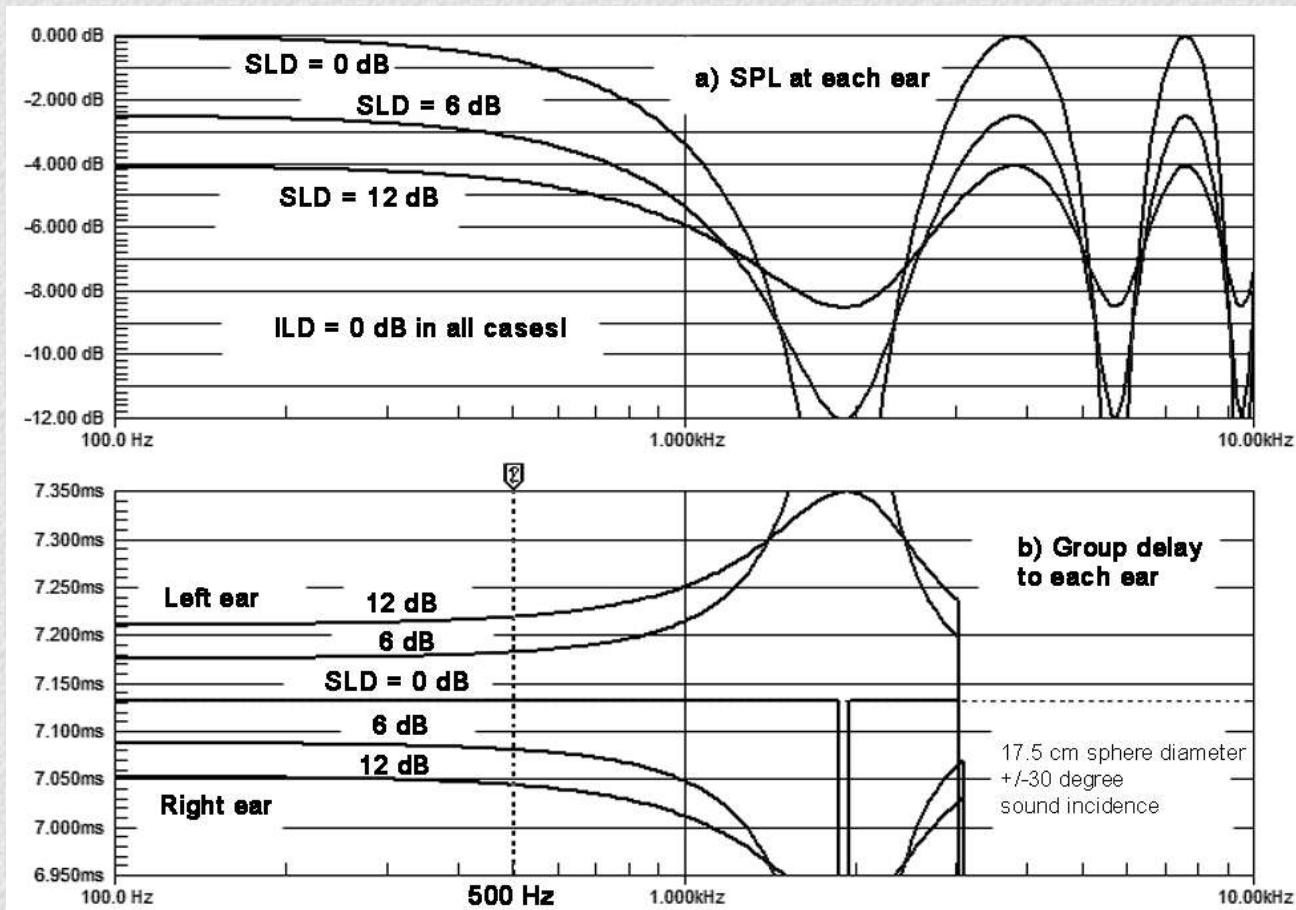
- * Sphere model of head
- * No head shading
- * ITD = $263\mu\text{s}$ @ 30°



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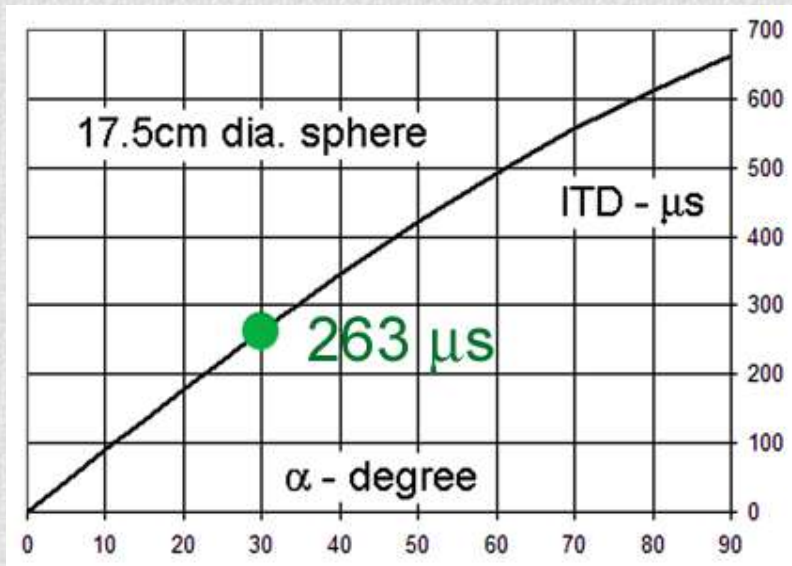
Level Panned Mono Source



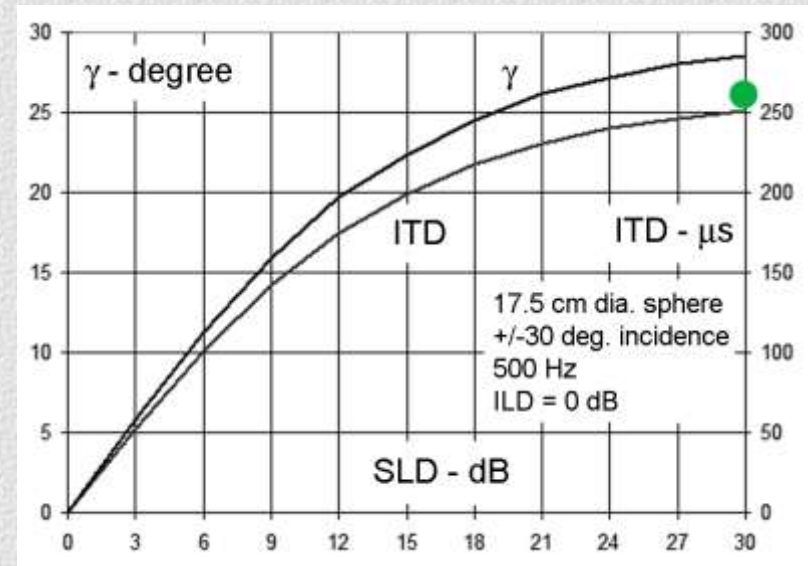
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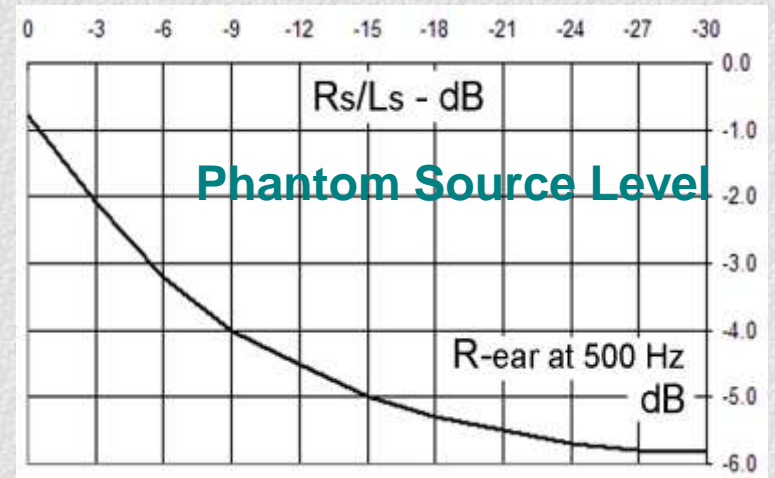
Real Source ITD



Phantom Source ITD



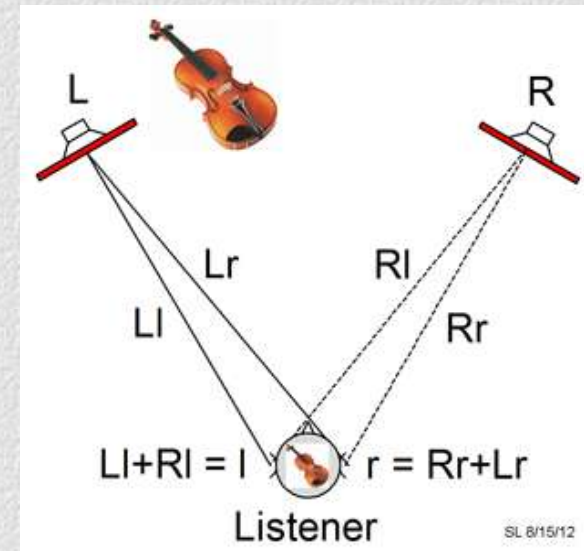
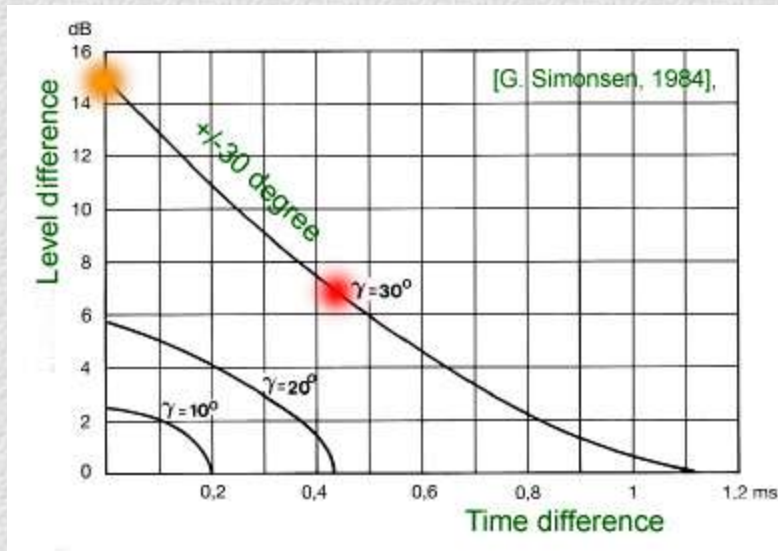
Phantom Source Angle γ
as Function of
Source Level Difference



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

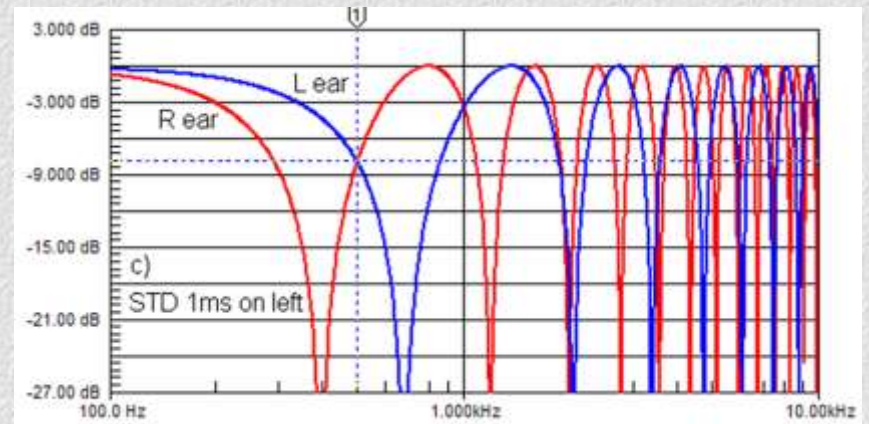
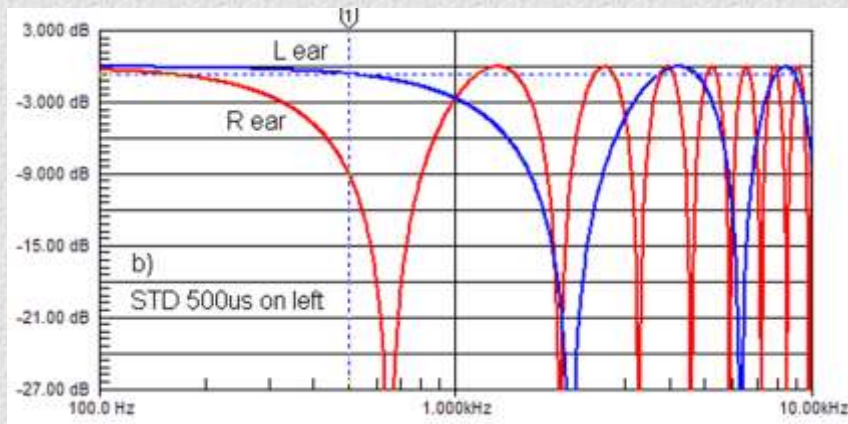
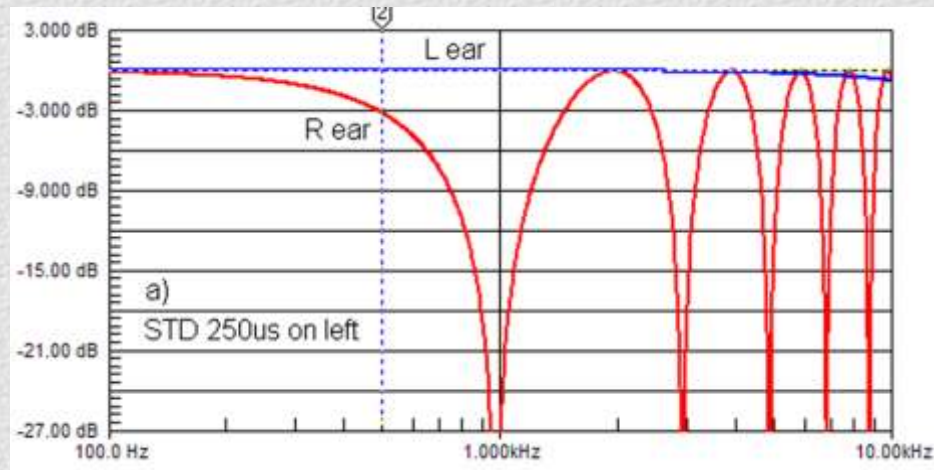


The time differences at the ears determine the phantom **source angle γ**

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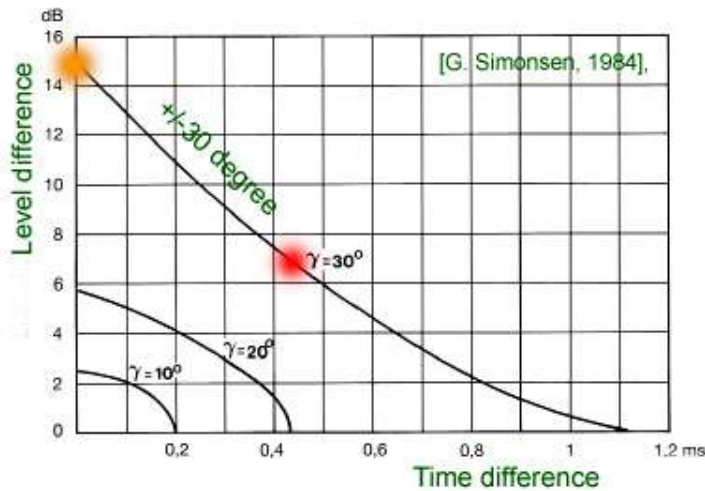
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Time panned mono source



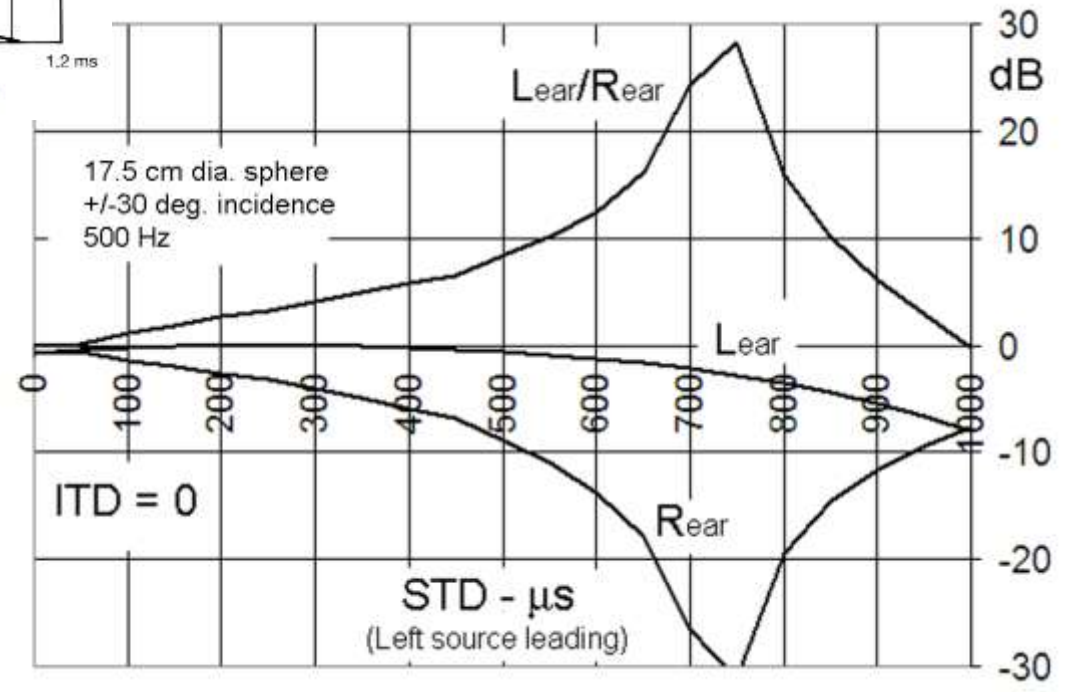
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A time panned source signal produces Level Differences between the ears, but no time differences

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



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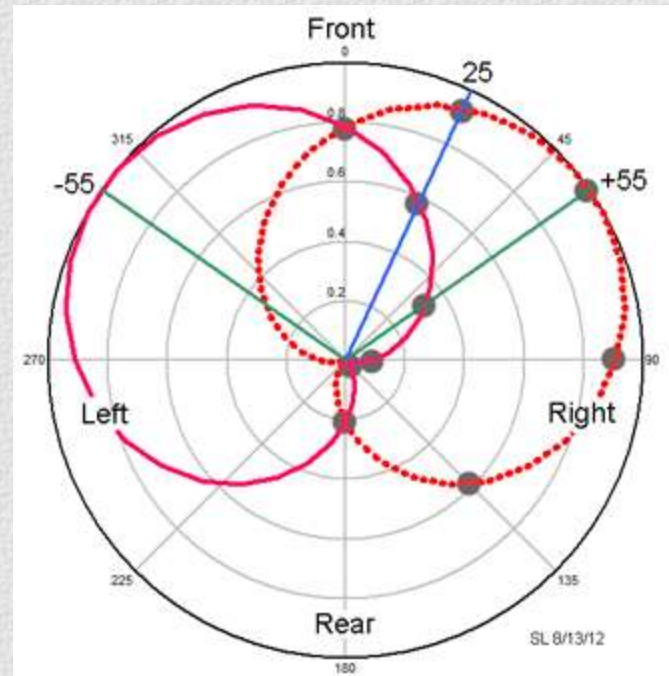
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Automatic Level and Time Panning with Microphone Pairs

Spaced



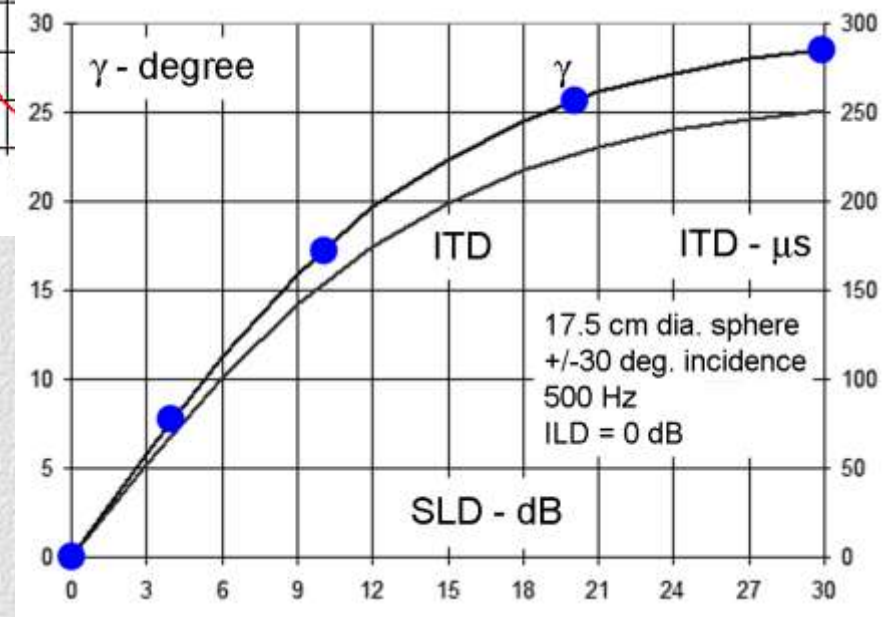
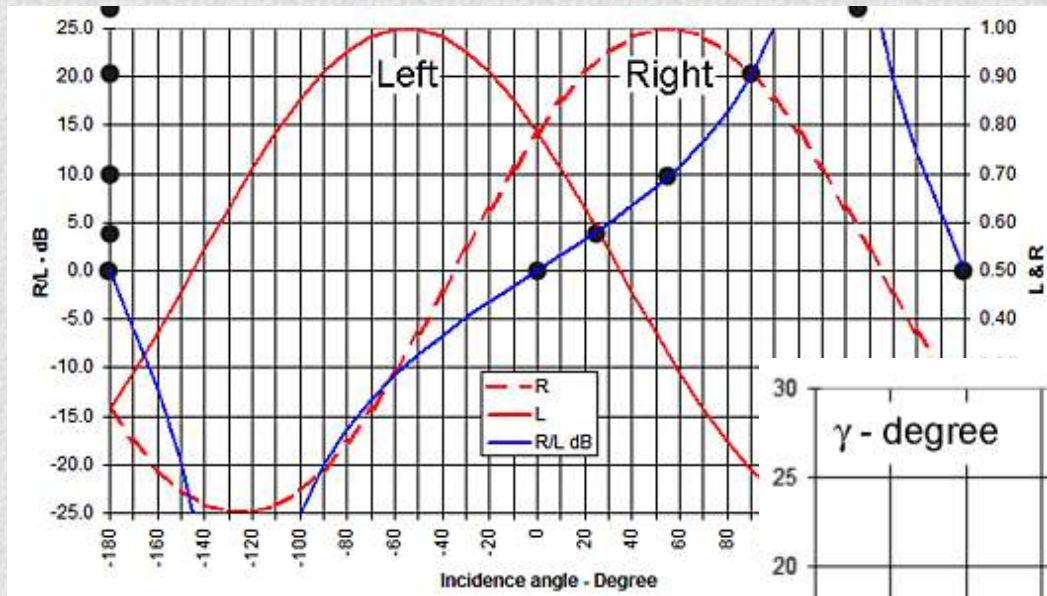
Coincident



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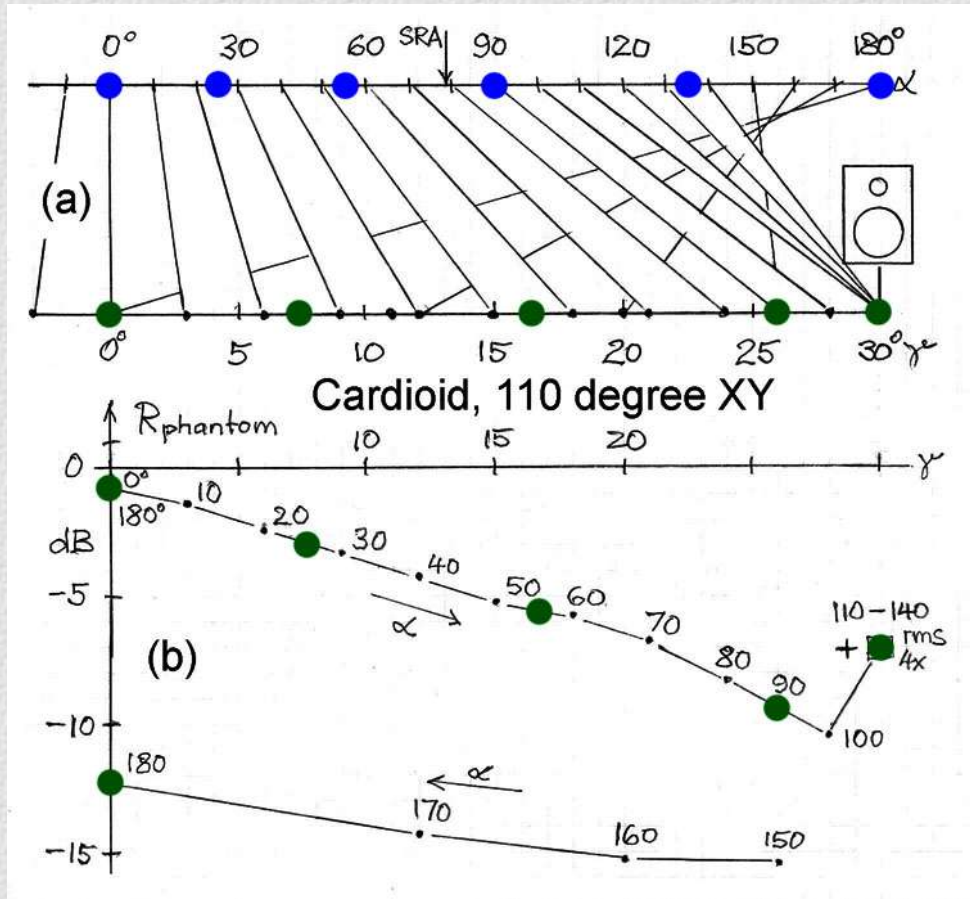
Coincident Microphone Pair



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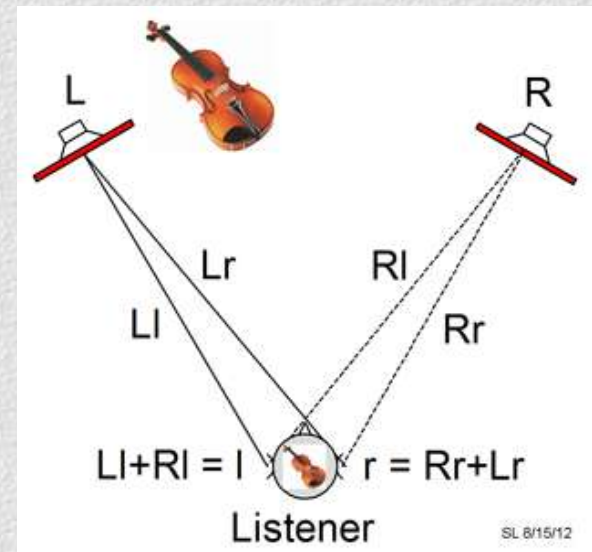
Coincident Microphone Pair



+/-180°

Spatially detailed rendering

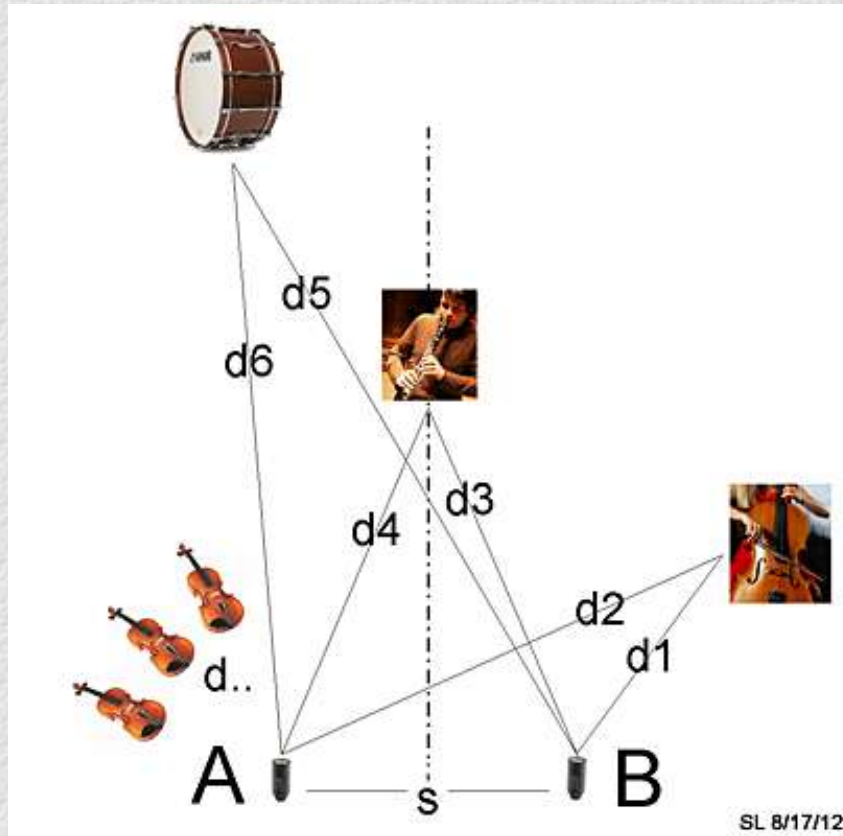
+/-30°



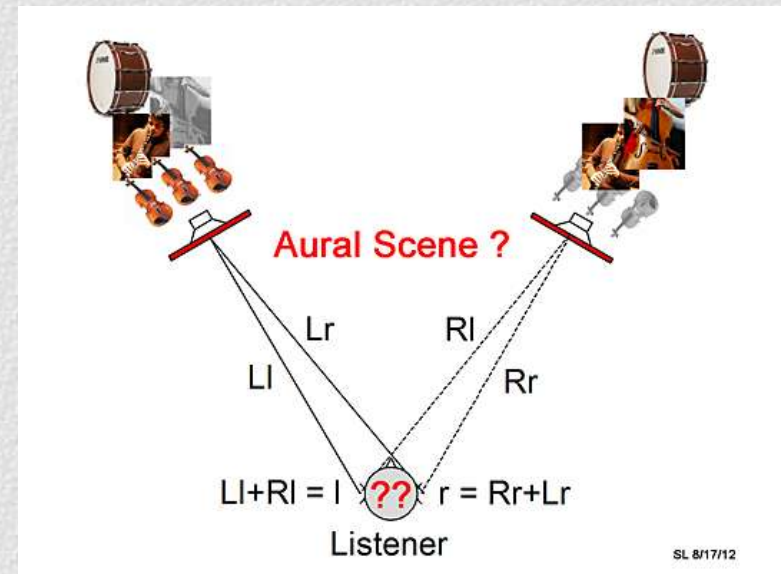
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Spaced Microphone Pair



Spatially **diffuse** rendering

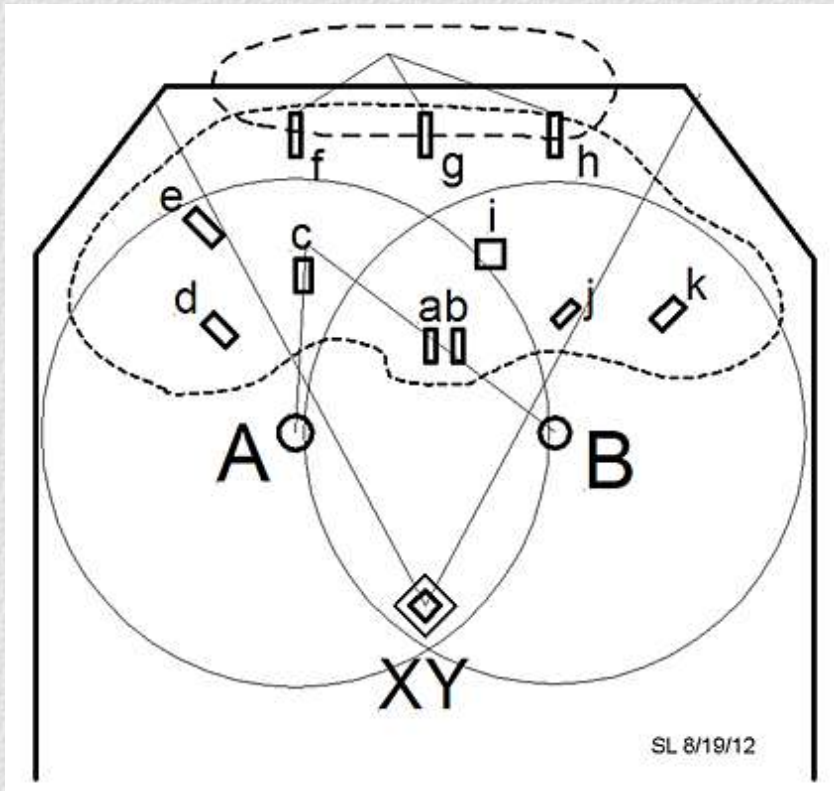


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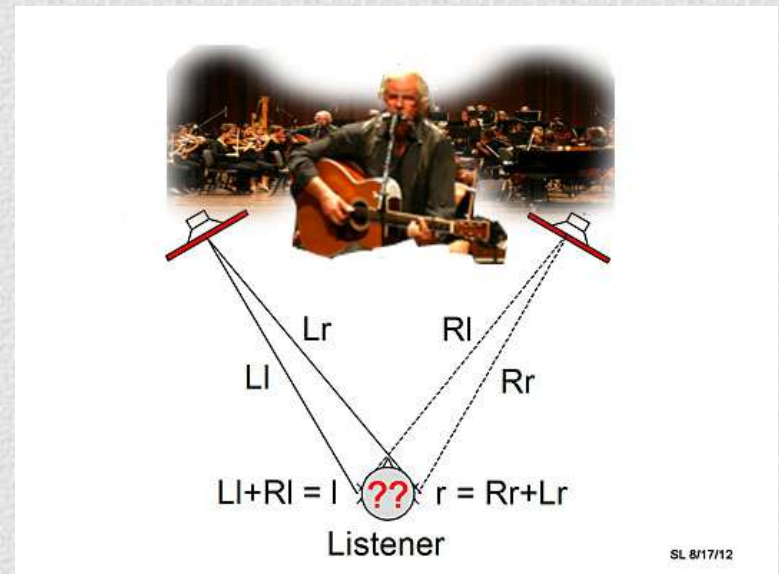
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Live Recording

Coincident microphone pair
Spaced microphone pairs
Individual microphones



Spatially creative Rendering

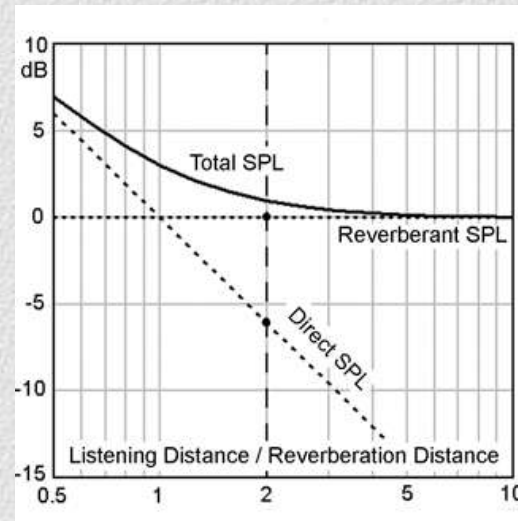
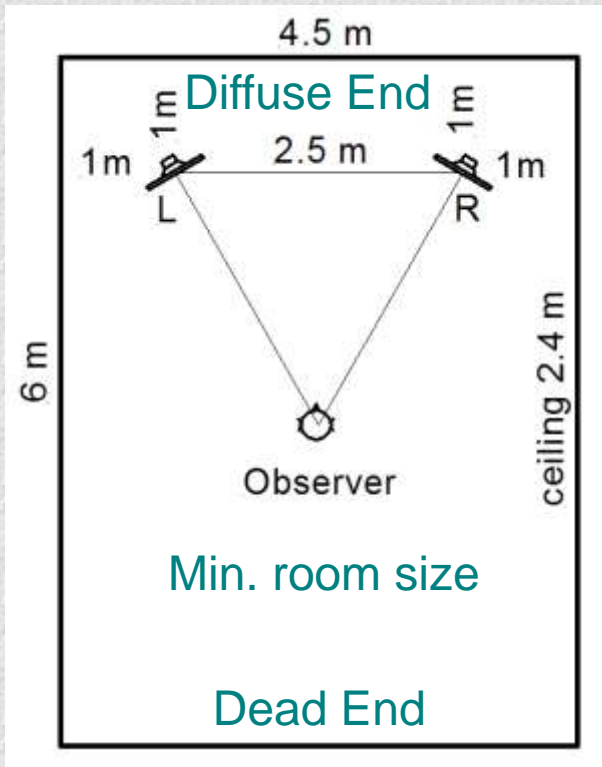


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Sensible Recording and Rendering of Acoustic Scenes

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 $F_{\text{Schroeder}}$
- 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**

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