LINKWITZ LAB

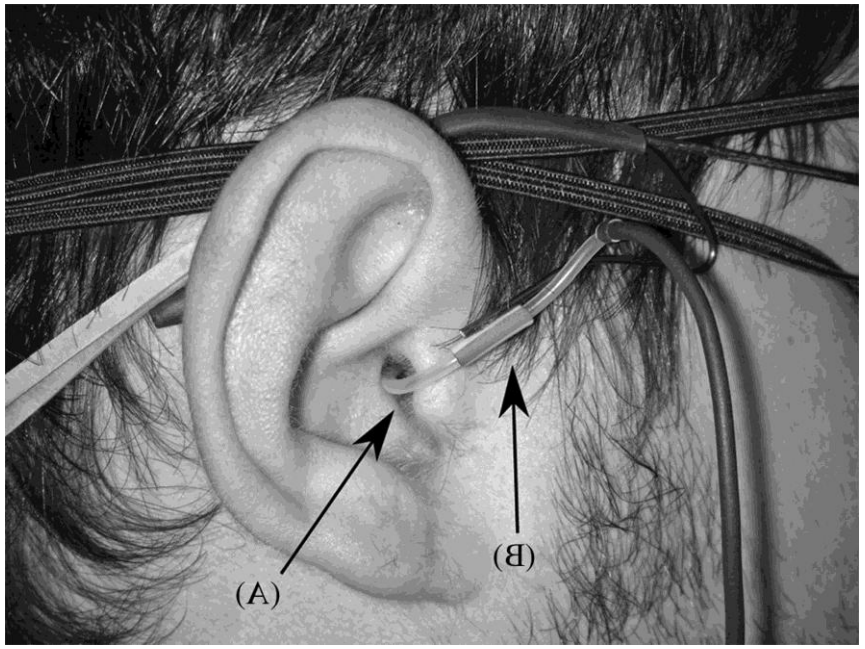
Sensible Reproduction & Recording of Auditory Scenes

Hearing Spatial Detail in Stereo Recordings

From the perspective of a Loudspeaker Designer & Audiophile

Recording the Eardrum Signal

Multiple
Sound Streams
in Time & Space



Ear signal = Sum of:

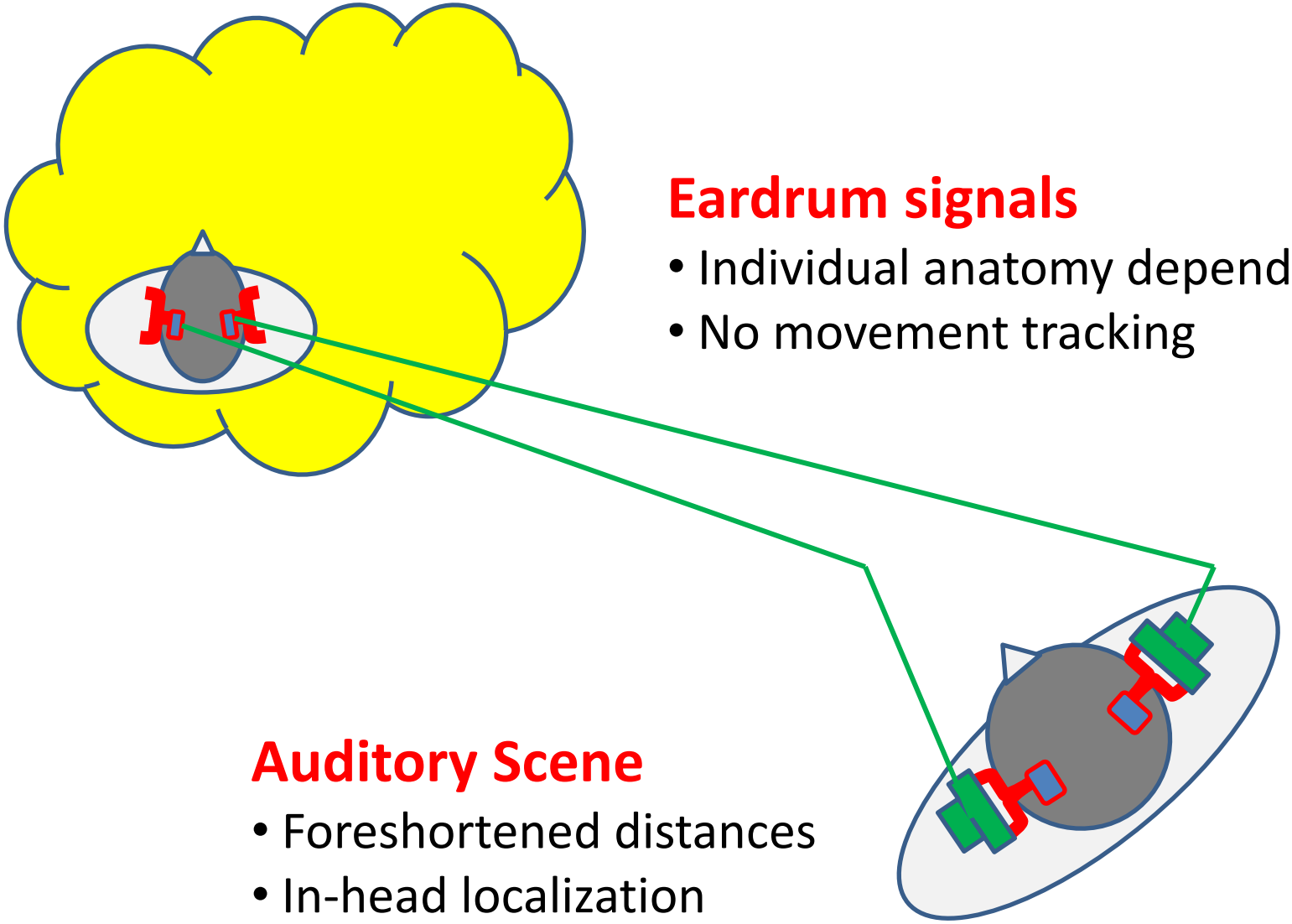
- **Instruments**
- **Voices**
- **Noises**
- **Hall reflections**

Playback of the Recording

The response to the stimulus

- **The Auditory Scene**

Issues with Binaural



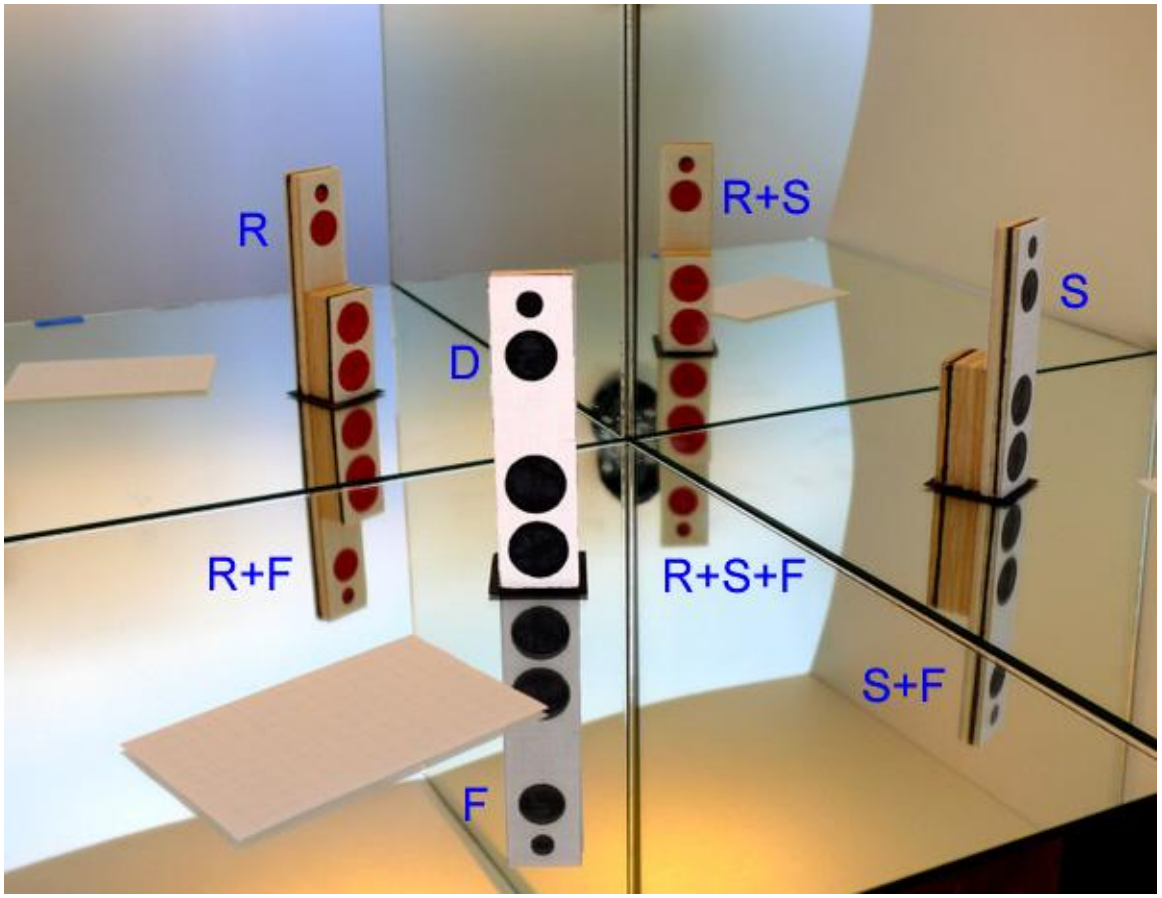
Eardrum signals

- Individual anatomy dependent
- No movement tracking

Auditory Scene

- Foreshortened distances
- In-head localization

A ~~single~~ Loudspeaker in a Room

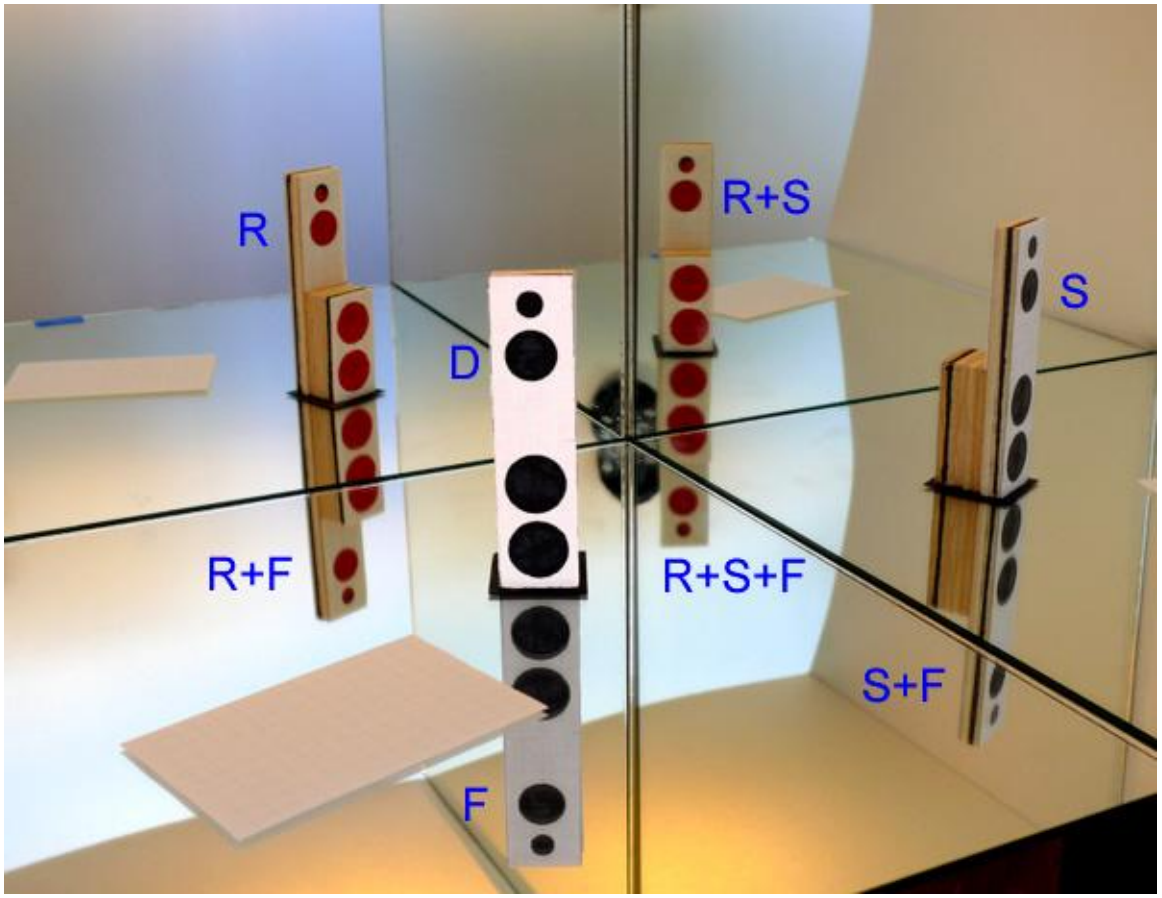


Dipole loudspeaker near a room corner

ACOUSTICS

- Direct sound
- Reflected sound
- Reverberation

A ~~single~~ Loudspeaker in a Room



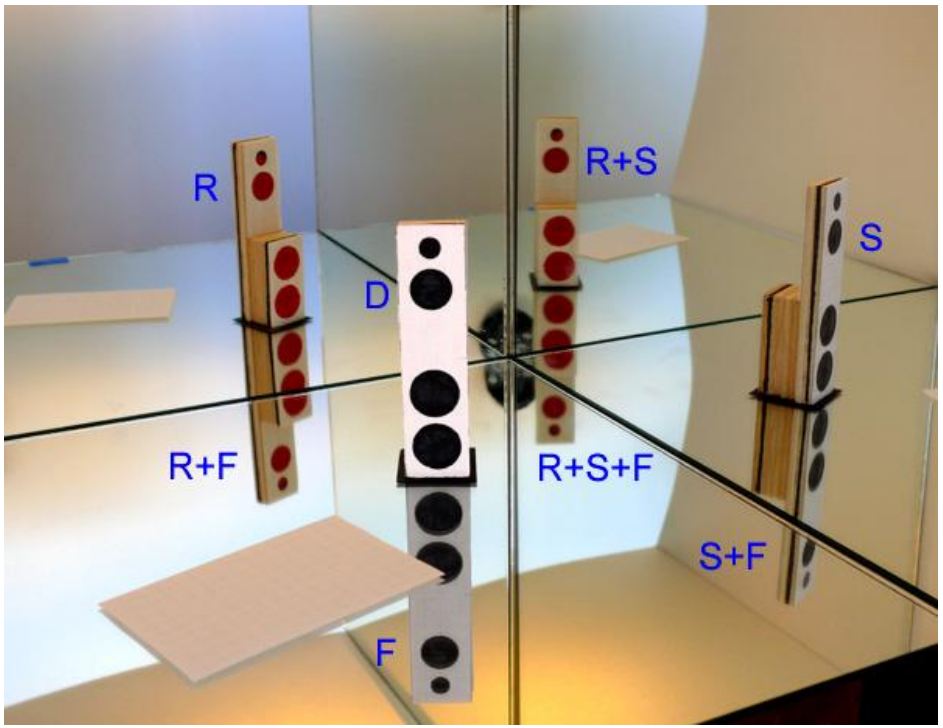
Dipole loudspeaker near a room corner

HEARING

- Direction
- Distance
- Room
- Tonality versus head movement
- Pattern recognition
- Intelligibility
- Gestalt
- Horizon

- **Spatial Hearing**
- **Sound Streams**

Frequency Response
for a single Loudspeaker in a Room



On-axis

Flat

Off-axis

Frequency independent
at every angle

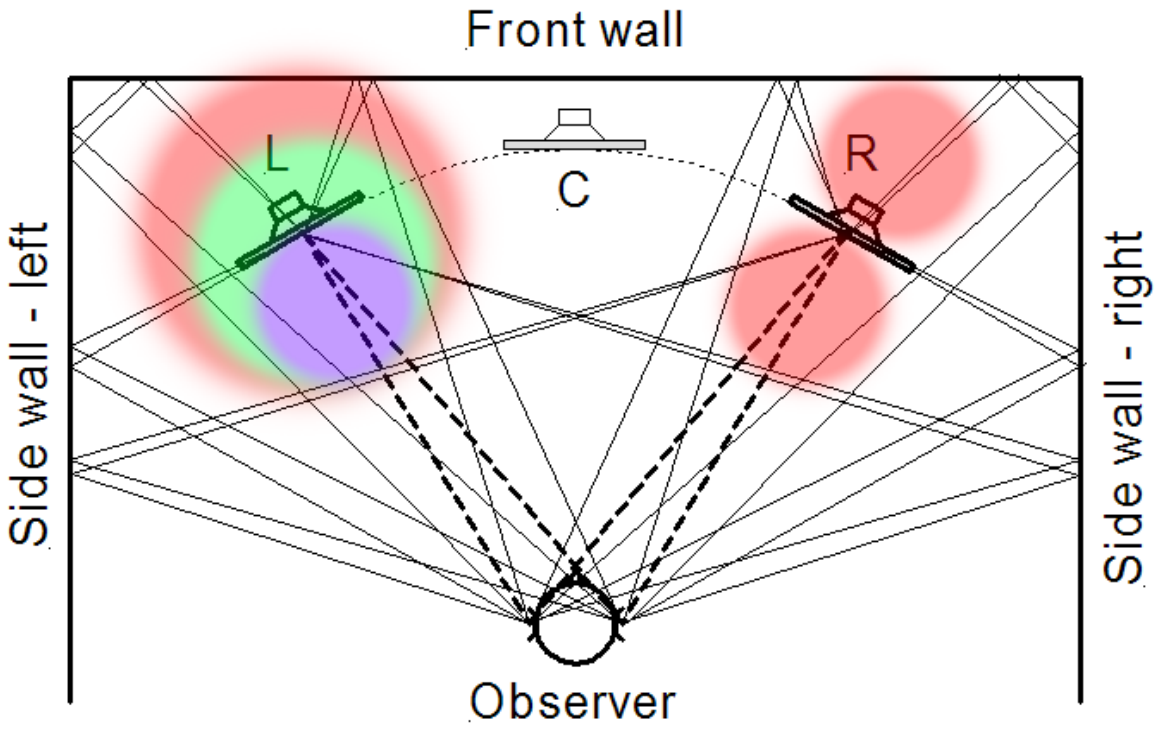
-> acoustically small source

Room response

Anechoic <–> Reverberant

Frequency independent?

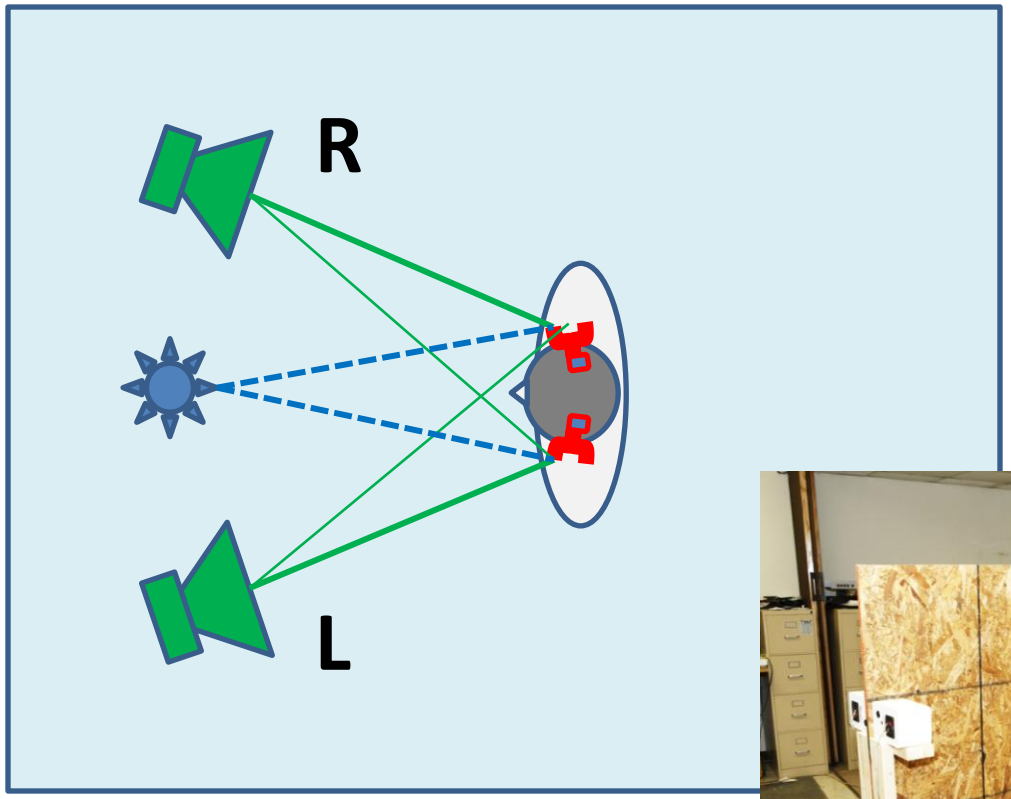
Monaural Phantom Source between two Loudspeakers



HEARING

- Unnatural phenomenon
- Localization versus head movement
- Distance
- Size
- Tonality versus head movement

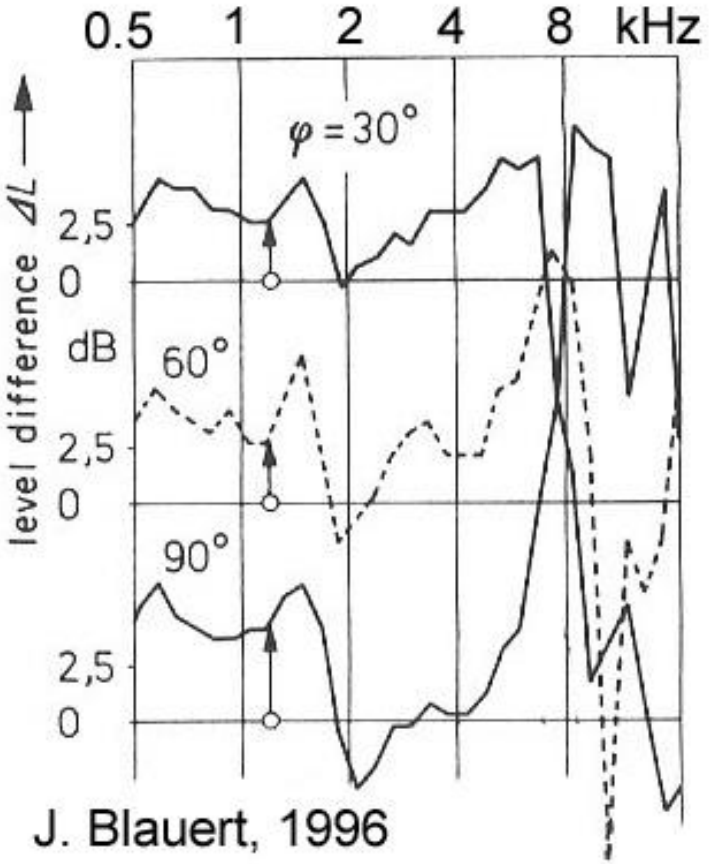
Optimizing the Phantom Source between two Loudspeakers

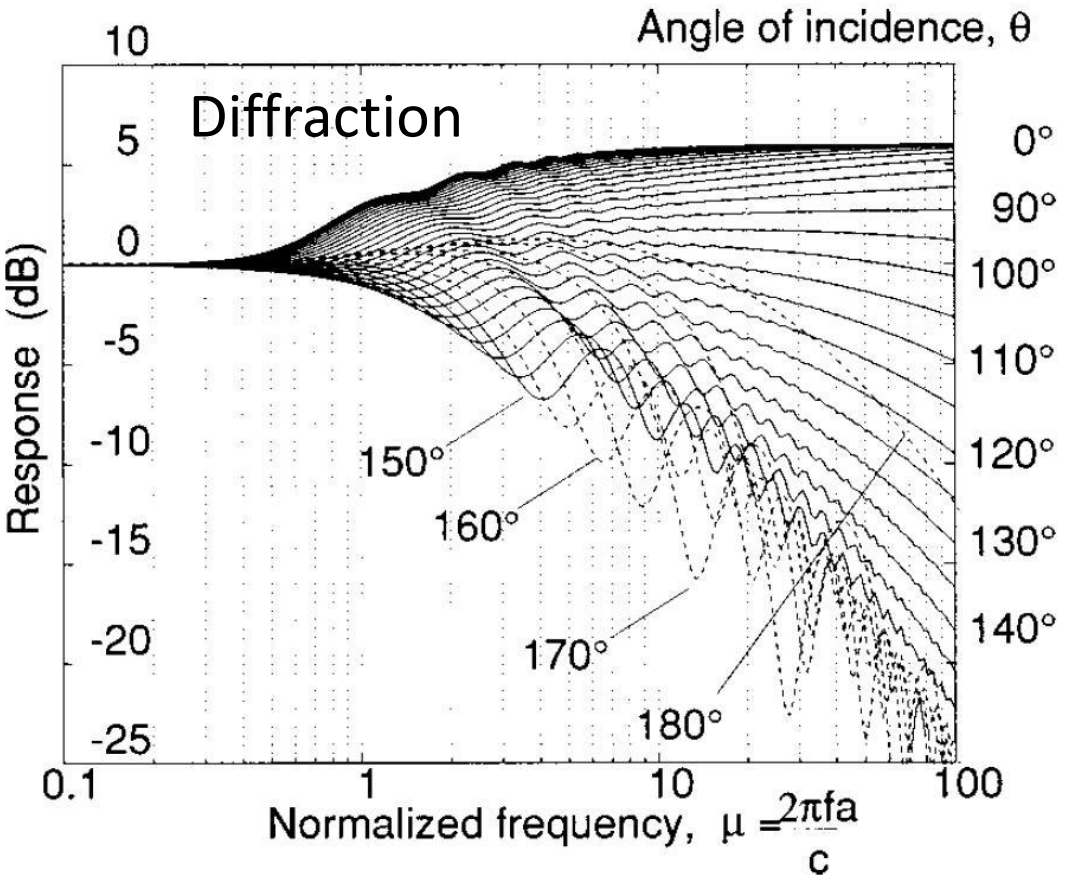


Cross-talk cancellation

- 30 degree HRTF
- Sweet Spot size
- Reverberant sound
- Naturalness

Head-Related-Transfer-Functions



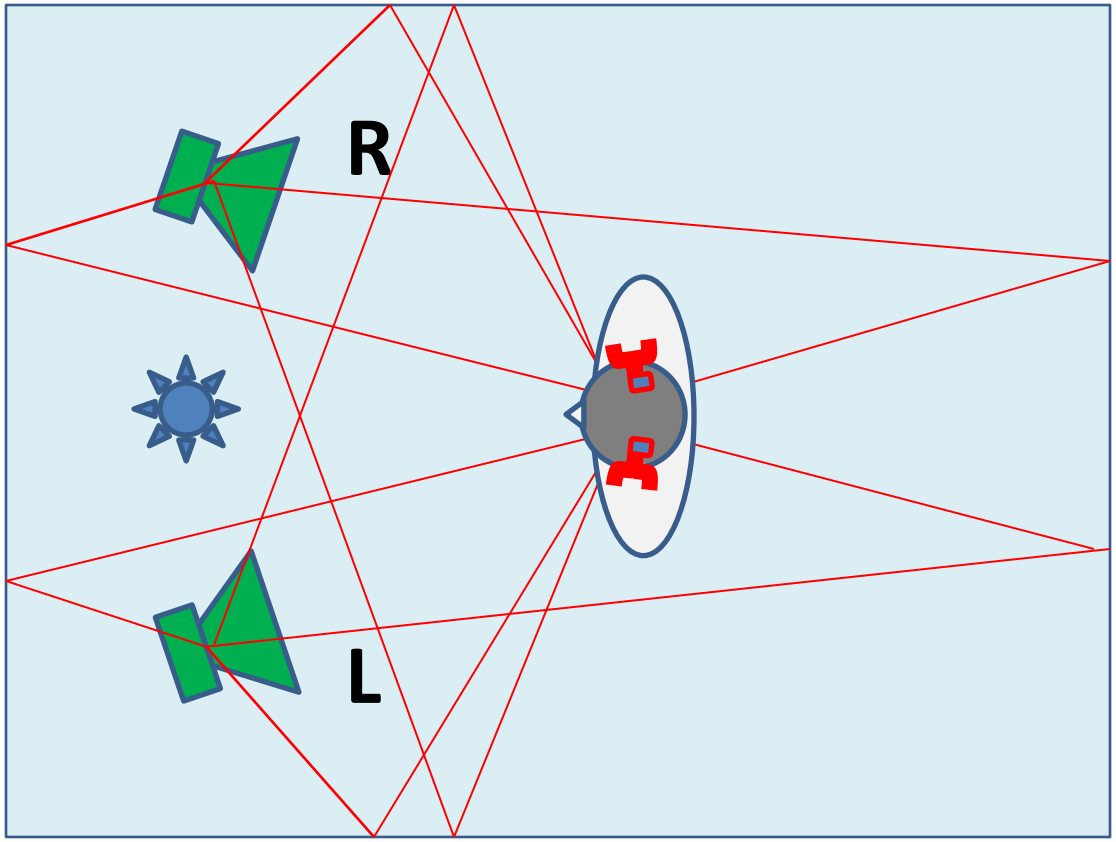


Level at eardrum relative to frontal incidence at 0^0

Level at a point on a rigid sphere relative to the level without the sphere

Duda & Martens, 1998

Optimizing the Phantom Source without XTC & in a Room



Off-axis Response

- As on-axis
- Lower level

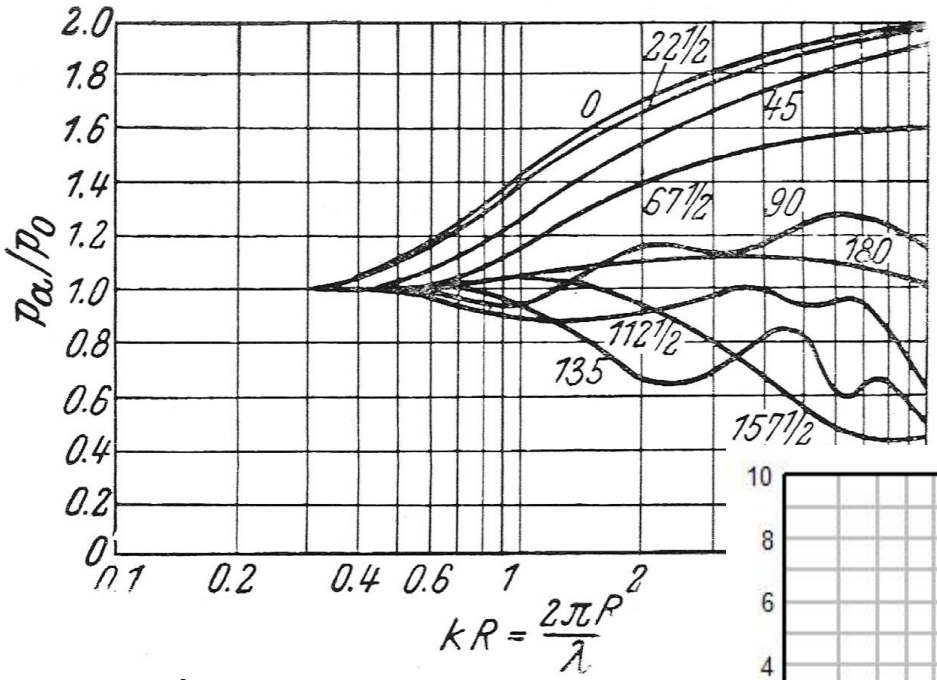
Reflections

- Symmetry
- Delay

Source types

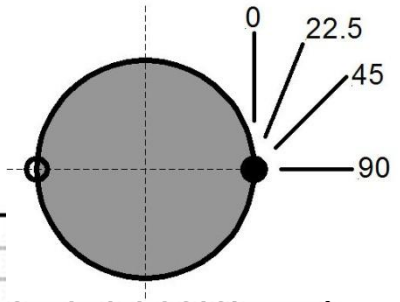
- Omni
- Dipole
- Cardioid
- Other?

On-axis Frequency Response ?

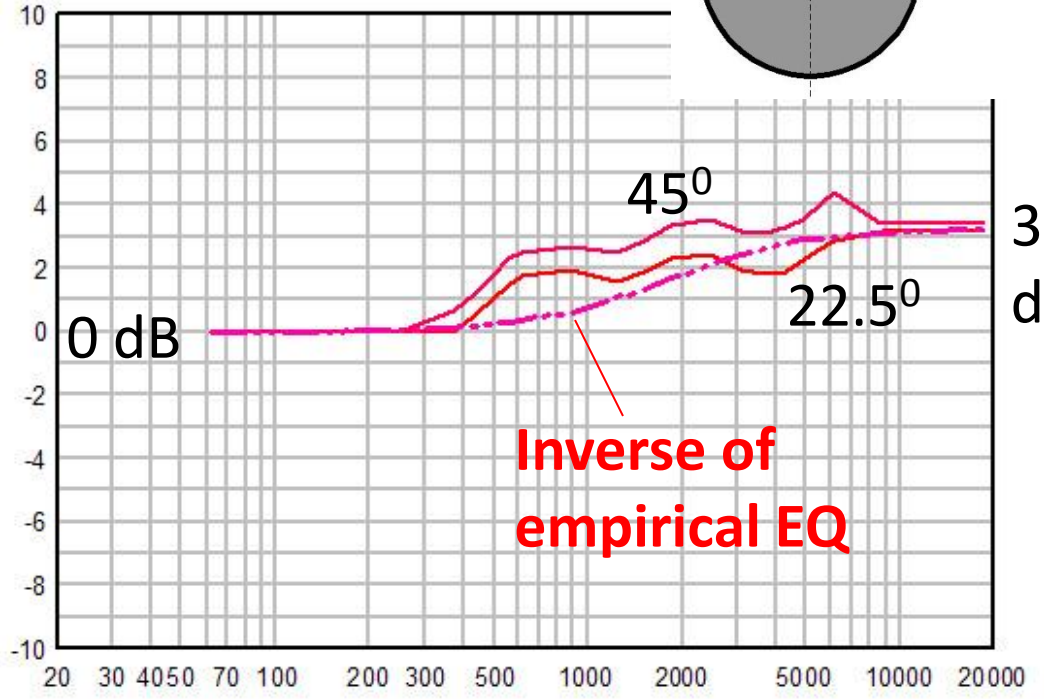


(22.5^0)

Level at 22.5^0 & 45^0 incidence relative to 0^0 incidence



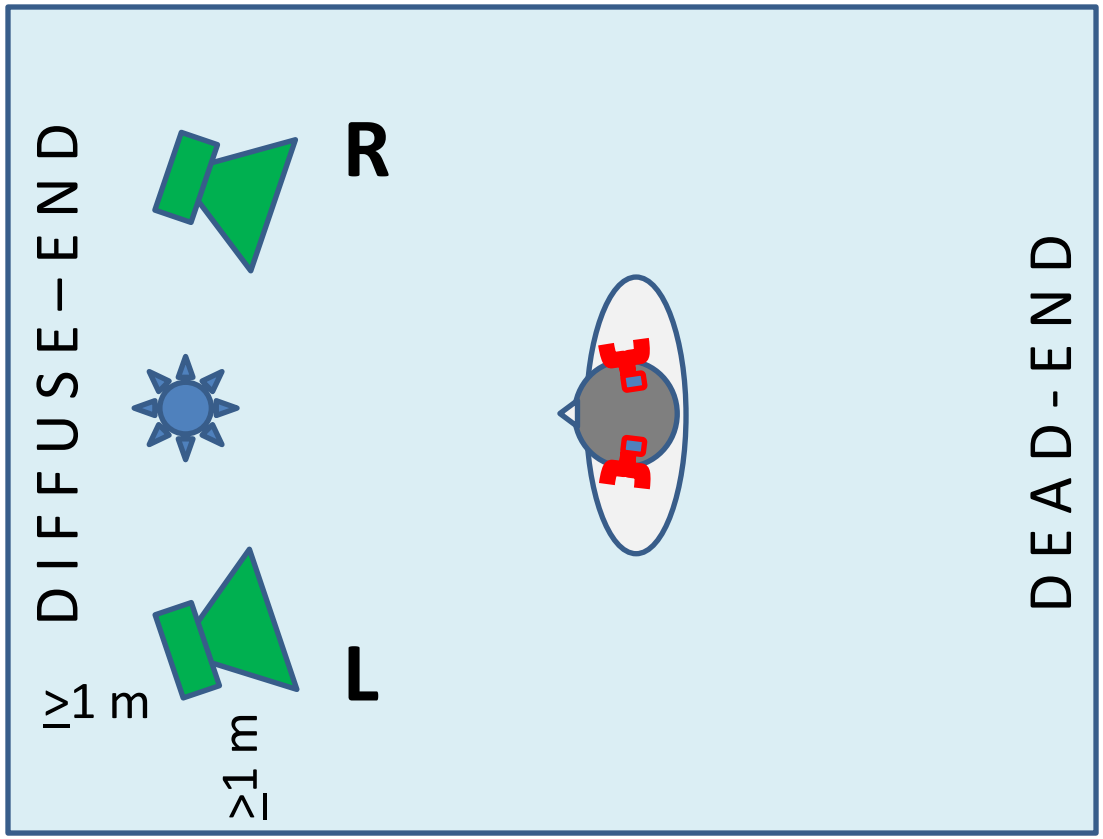
17.5 cm diameter



Level at a point on a rigid sphere relative to the level at the center without the sphere

Shaw, 1974

Optimizing the Room Setup



- Loudspeaker-Listener triangle
- Symmetry to reflective surfaces
- Loudspeakers out in the room
- Lively room
- Diffuse End
- Dead End

Perceptually hiding Loudspeakers & Room

Phantom Source Placement horizontally by channel differences

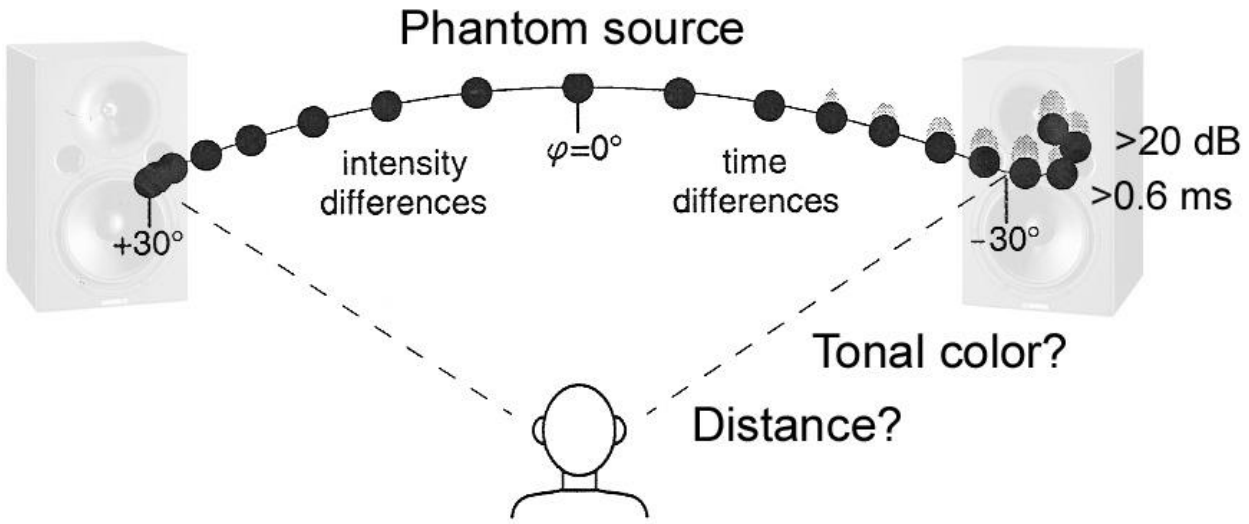
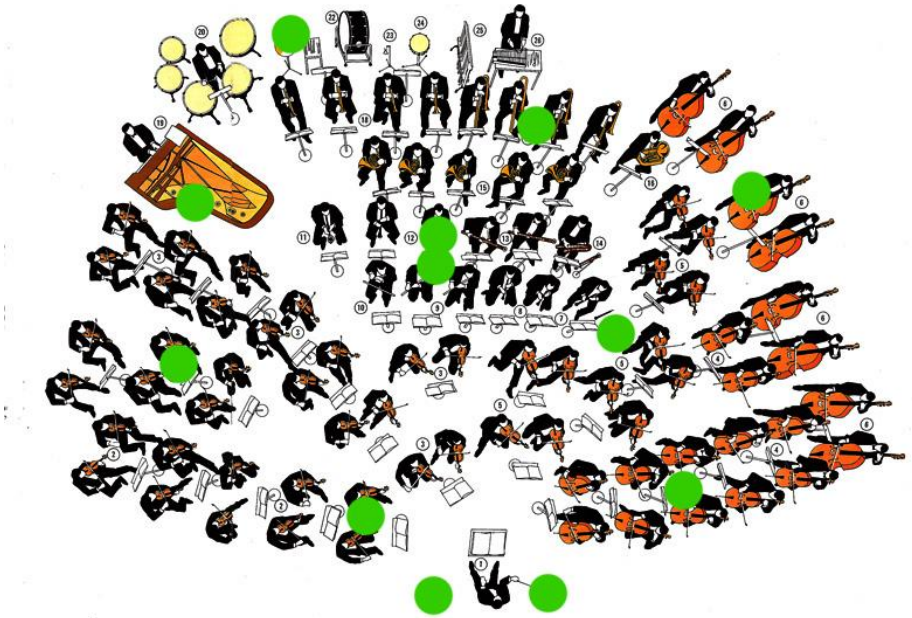


Fig. 1.4. Perceived directions with pink noise, constant loudness

Damaske, 2008

Duplex Theory of Directional Hearing:
Inter-aural Time Differences (ITD) at low frequencies
Inter-aural Level Differences (ILD) at high frequencies
(Ignoring HRTF changes)

Recording as Creation of Art

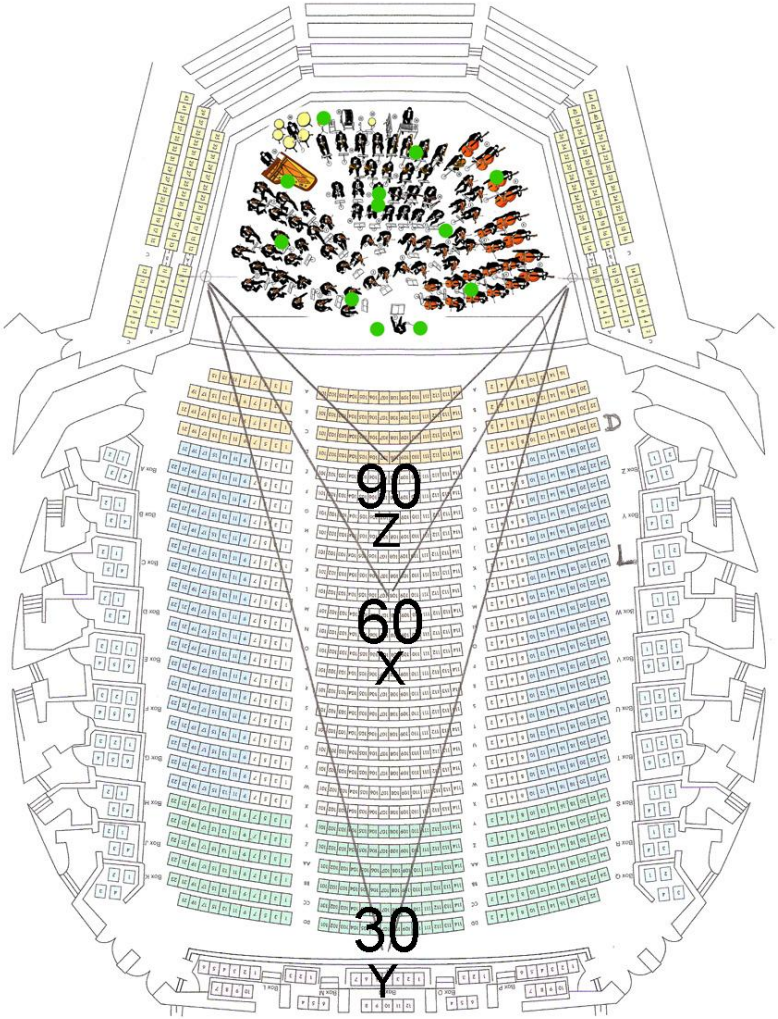


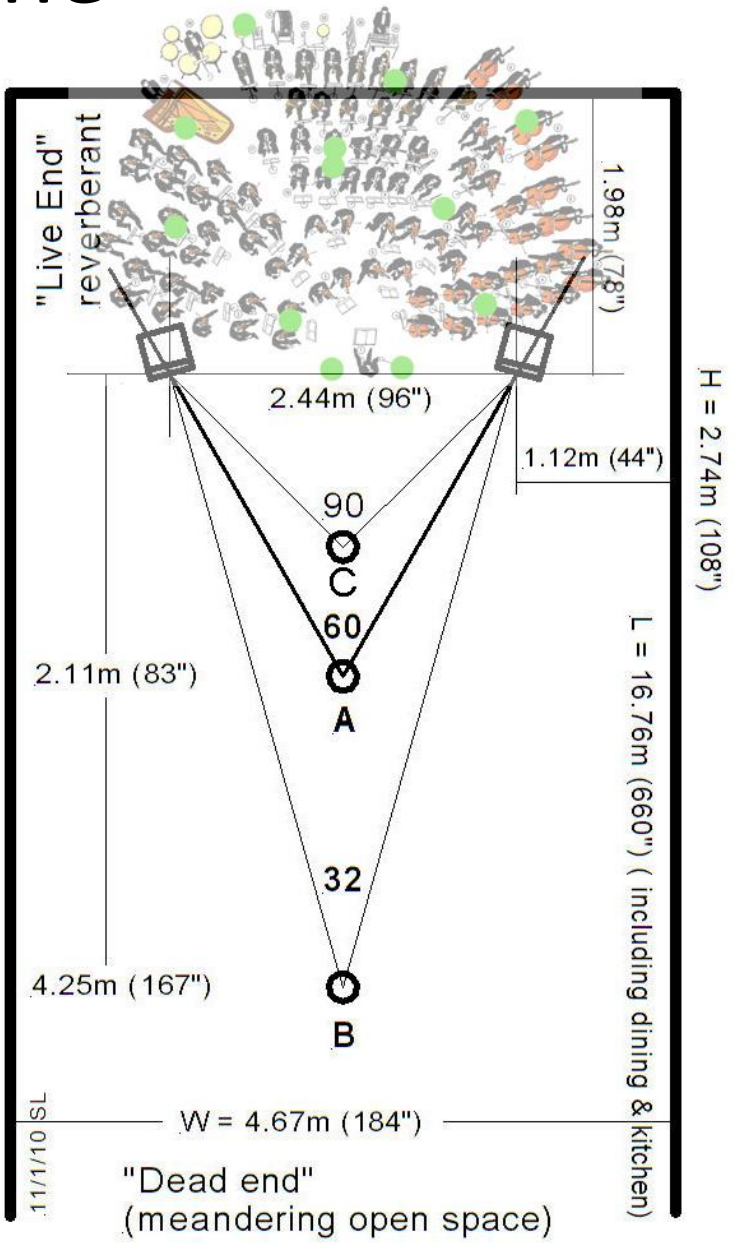
The Mix of microphone signals

Timbre
Localization
Spaciousness

Scaling the Auditory Scene

Distance - Perspective - Loudness - Size





An appropriate radiation pattern
and setup of loudspeakers
are essential
to Phantom Source Creation
and to experience Stereo
optimally in a room

STEREO System = ILLUSION Engine

LINKWITZ LAB

Sensible Reproduction & Recording of Auditory Scenes

Thank you for your attention

There will be a Demonstration of ‘Hearing Spatial Detail’
Room A, CCL Level +2
Friday, 10:00 to 19:00
Saturday, 10:00 to 19:00

Pluto-2.1 Stereo Loudspeakers will be used
(Small, active 2-way loudspeaker with
omni-directional radiation characteristics below 4 kHz)