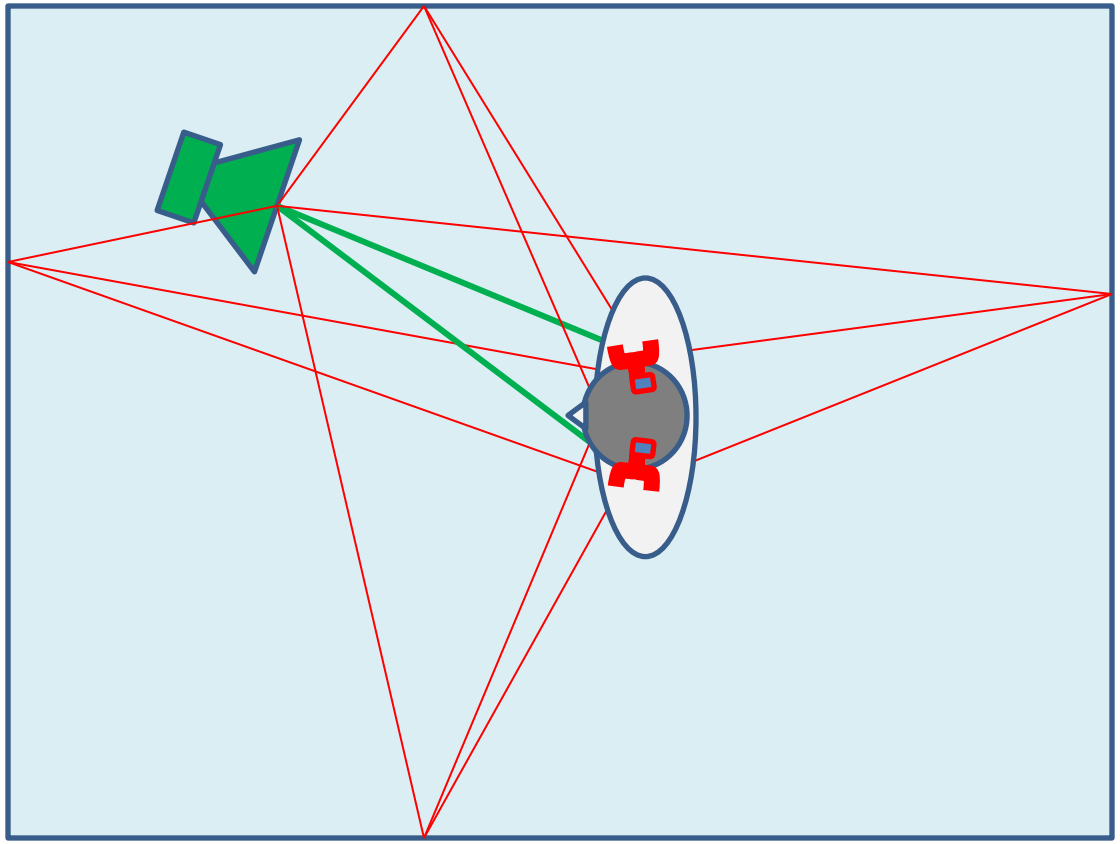
LINKWITZ LAB

Sensible Reproduction & Recording of Auditory Scenes

What are the On-axis & Off-axis Frequency Response Requirements for Stereo Loudspeakers?

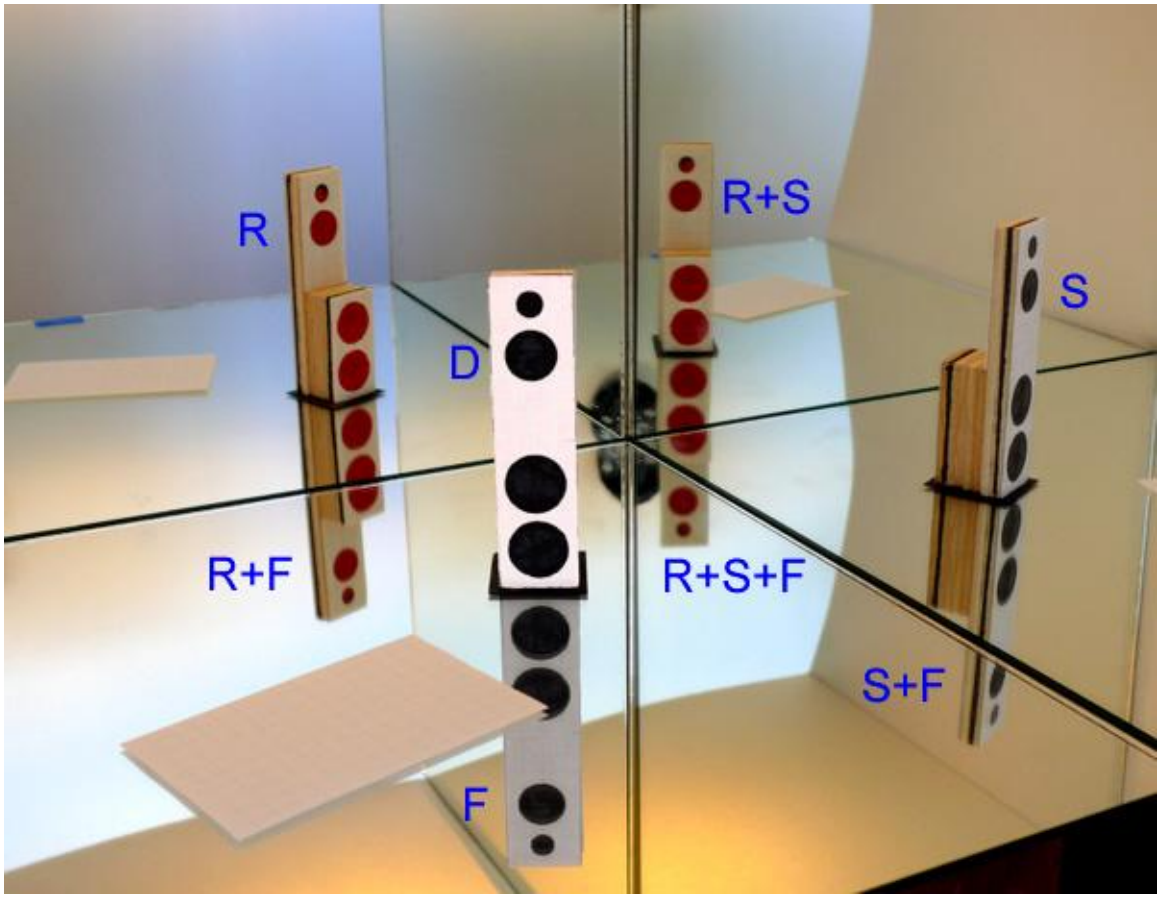
A single loudspeaker in a room



HEARING:

- Direction
- Distance
- Room
- Tonality
  lateral shift
  angular shift
- Intelligibility
- Gestalt
- Auditory Horizon

A ~~single~~ loudspeaker in a room

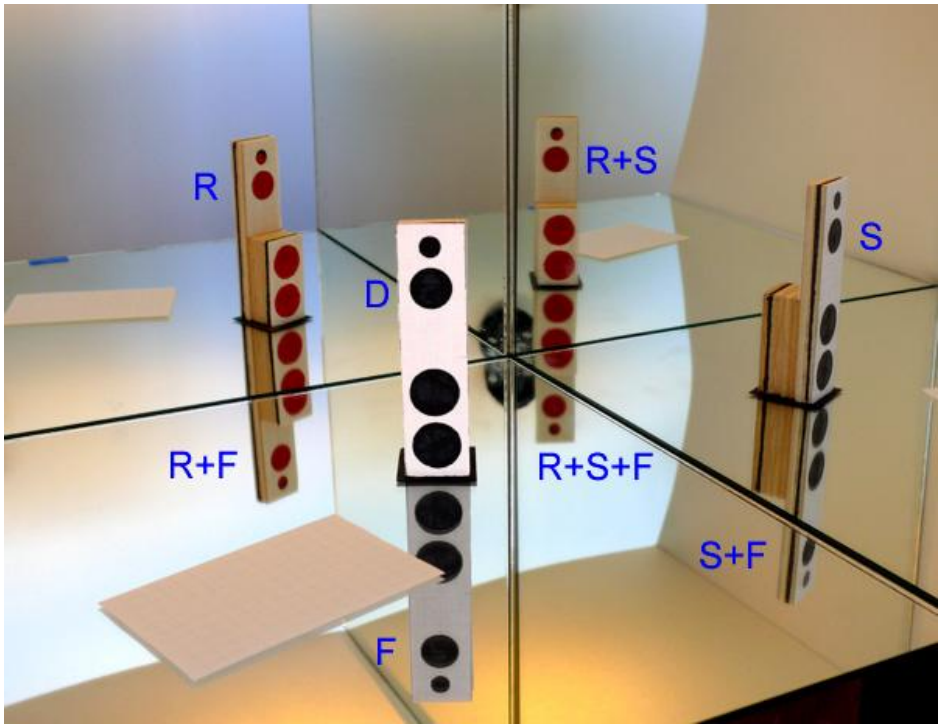


Dipole loudspeaker near a room corner

HEARING:

- Direction
- Distance
- Room
- Tonality
  lateral shift
  angular shift
- Intelligibility
- Gestalt
- Auditory Horizon

Frequency Response for a mono loudspeaker in a room



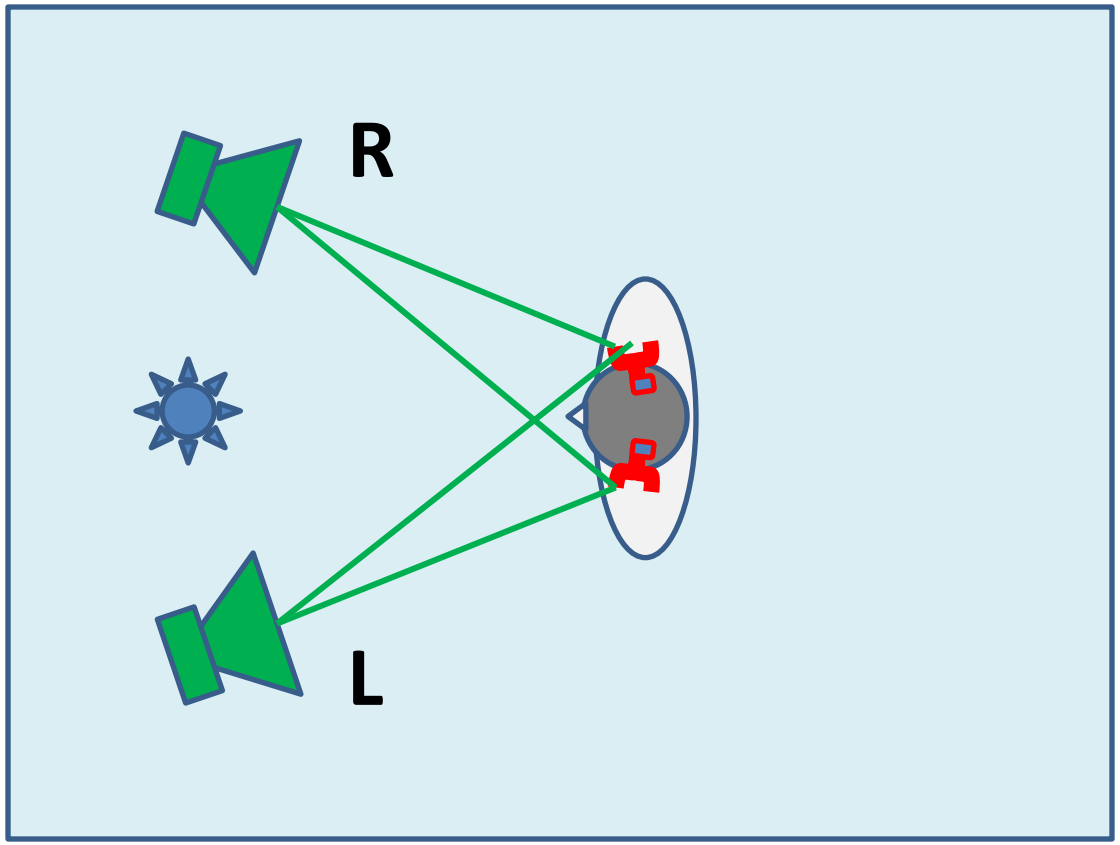
On-axis: <u>Flat</u>

Off-axis:
<u>Frequency independent at every angle</u>

- acoustically small
- point source

Room:
<u>Flat reverberation</u>

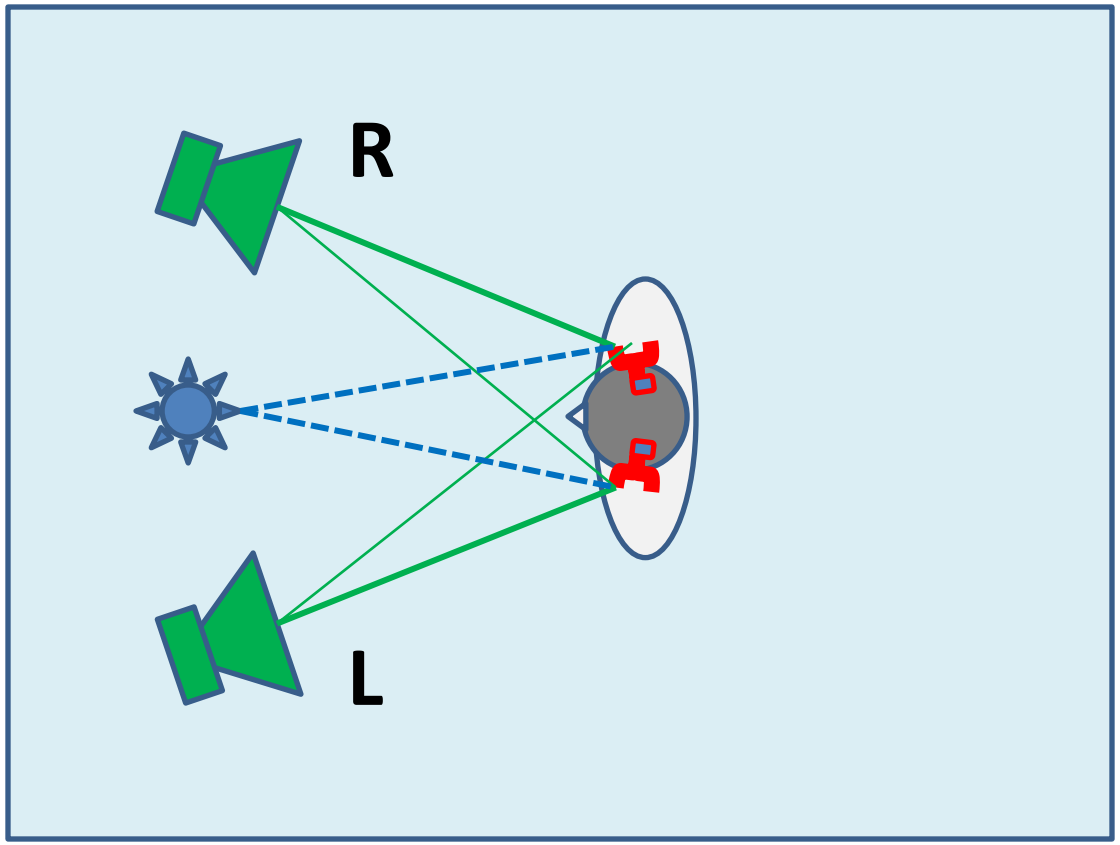
Monaural Phantom Source from two loudspeakers



HEARING:

- Unnatural phenomenon
- Direction?
  Lateral shift?
  Angular shift?
- Distance?
- Size?
- Tonality?
- Gestalt?

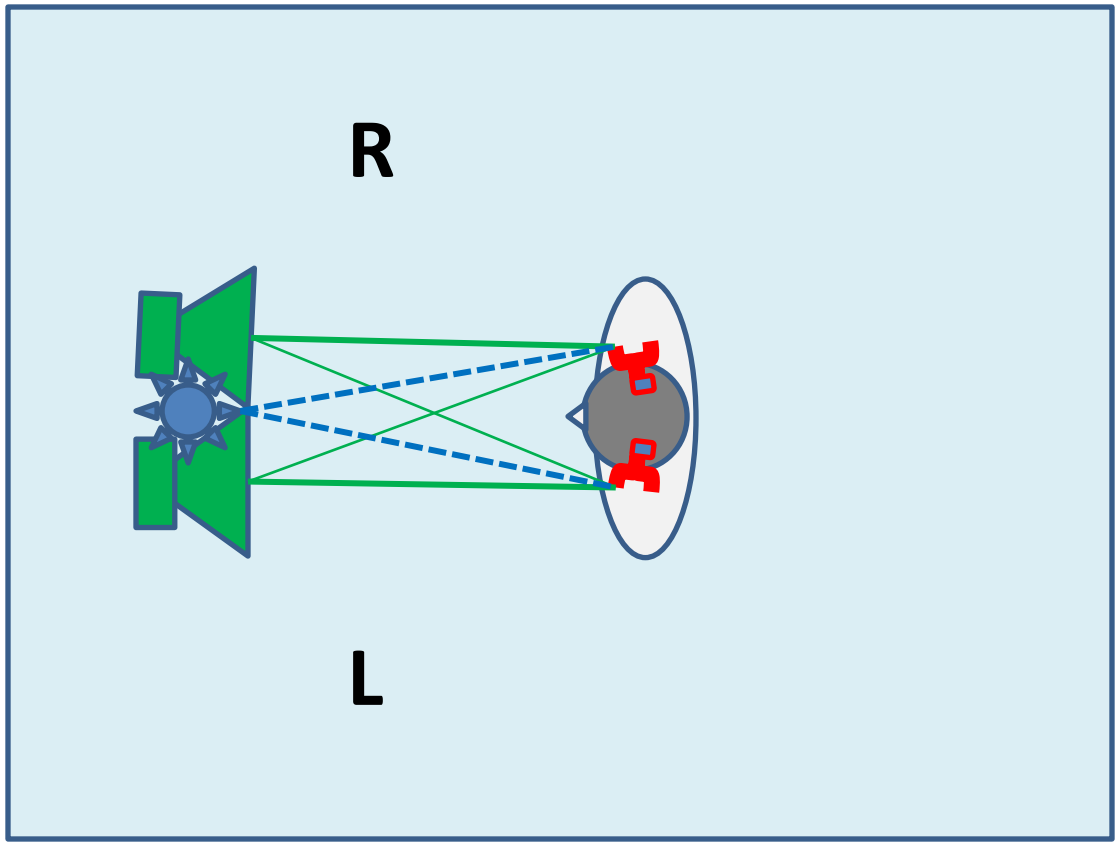
Monaural Phantom Source from two loudspeakers



<u>Cross-talk cancellation</u>

- 30 degree HRTF
- Sweet spot size
- Off-center sound

Monaural Phantom Source from two loudspeakers



Cross-talk cancellation

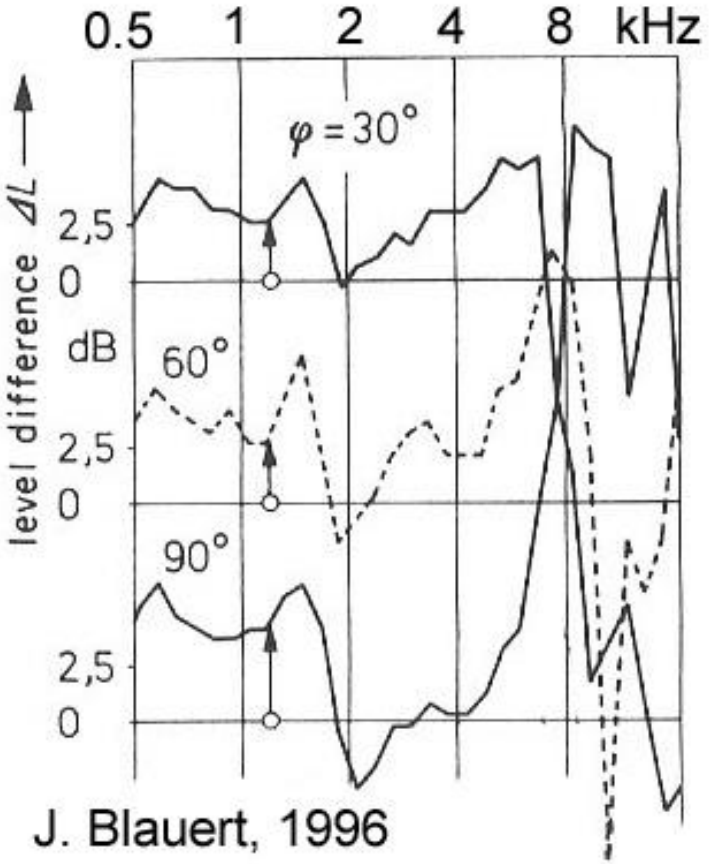
- Stereo Dipole
- HRTF
- Sweet spot size
- Phantom source width
- Off-center sound

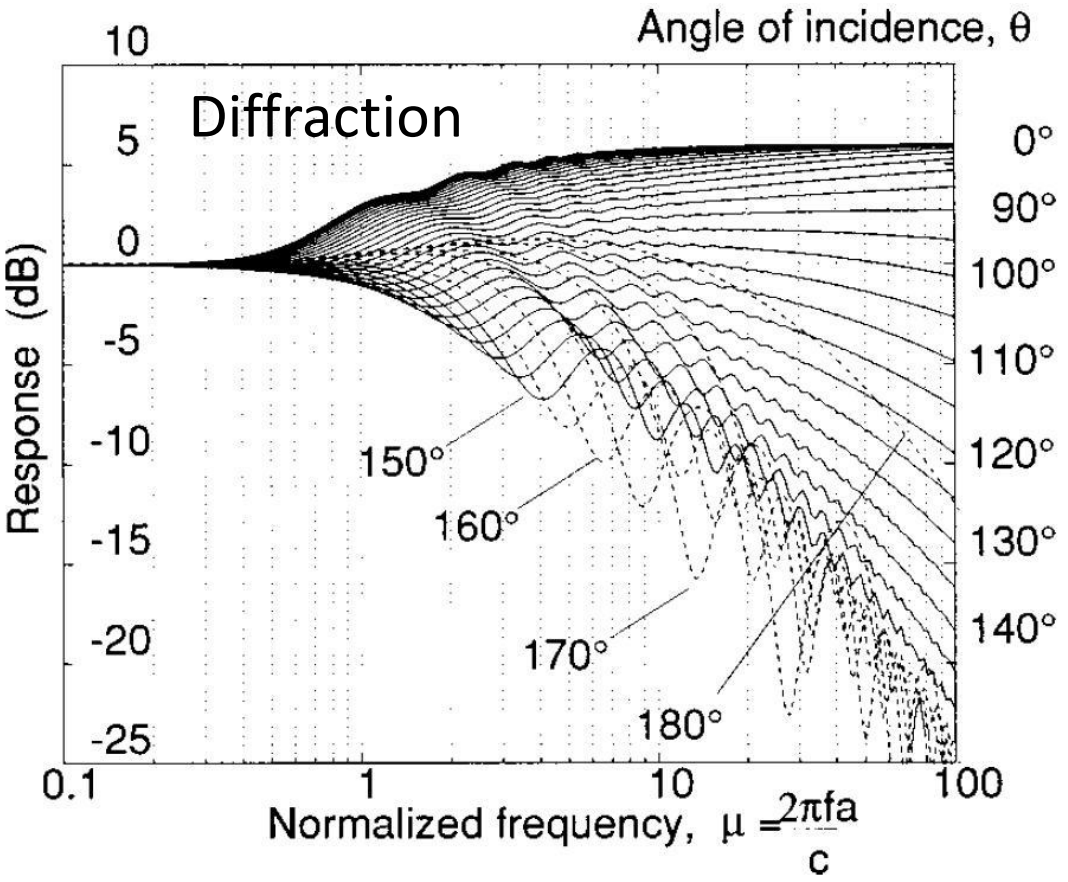
Phantom Source from two loudspeakers

Cross-talk cancellation

- Stereo Dipole

Head-Related-Transfer-Functions



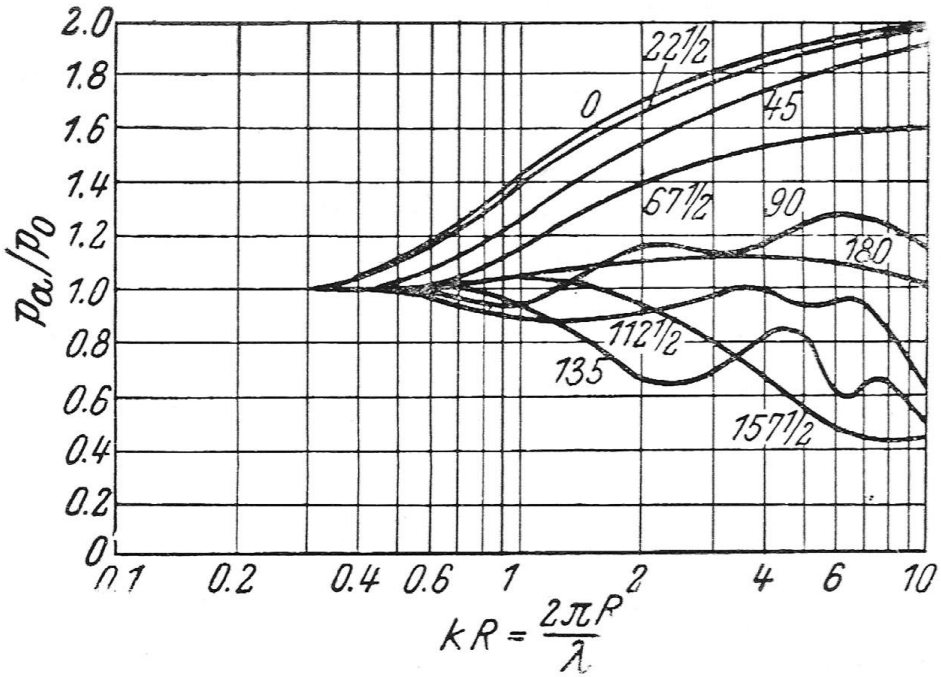


Level at eardrum relative to frontal incidence at 0^0

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

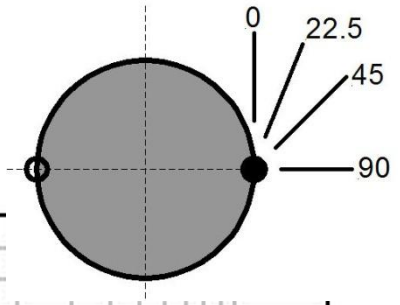
Duda & Martens, 1998

Sphere-Related-Transfer-Functions

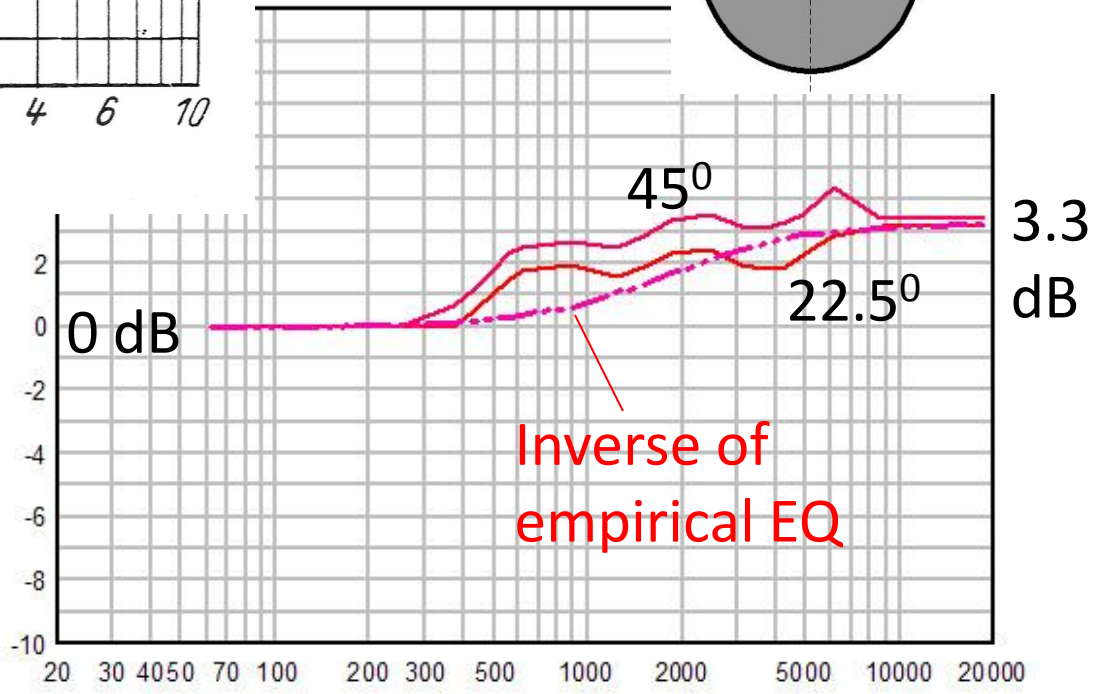


(22.5^0)

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



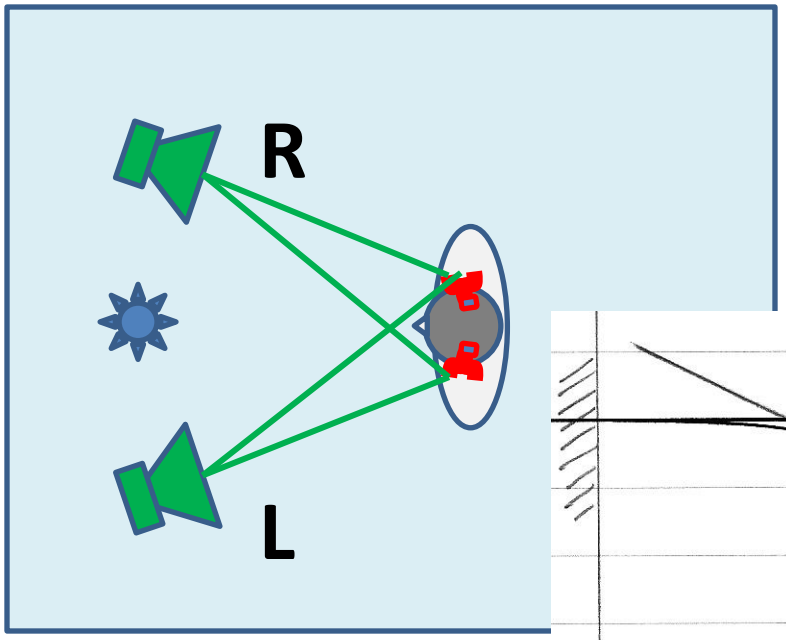
17.5 cm diameter



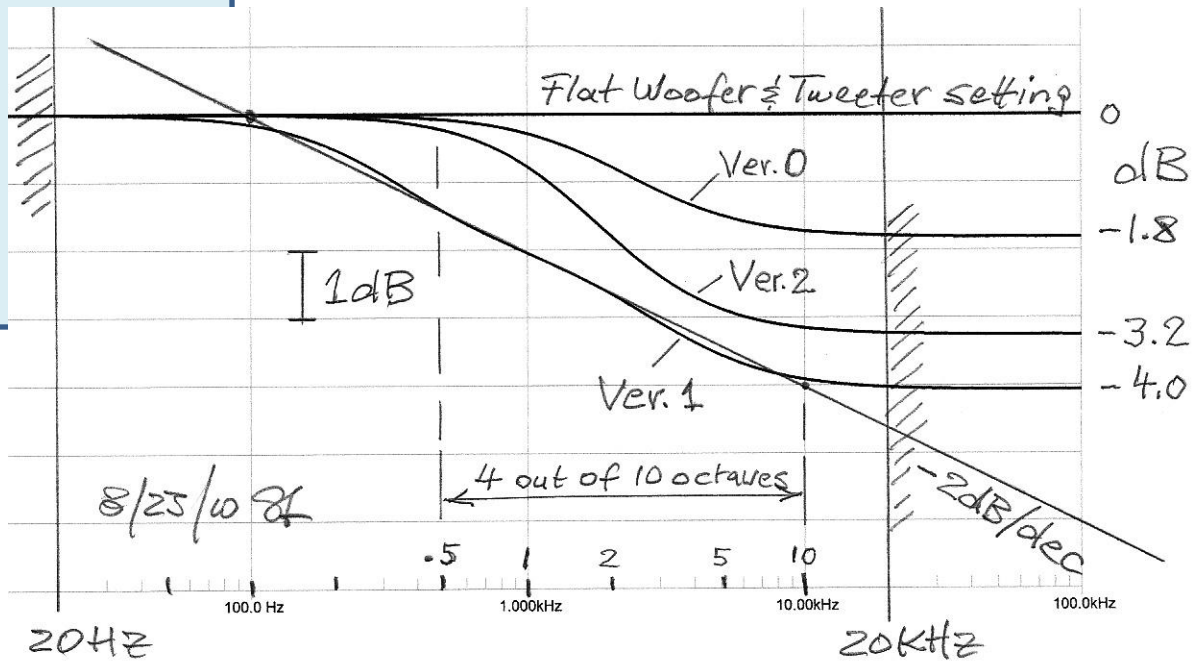
Level at a point on a rigid sphere relative to the level at the center without the sphere

Shaw, 1974

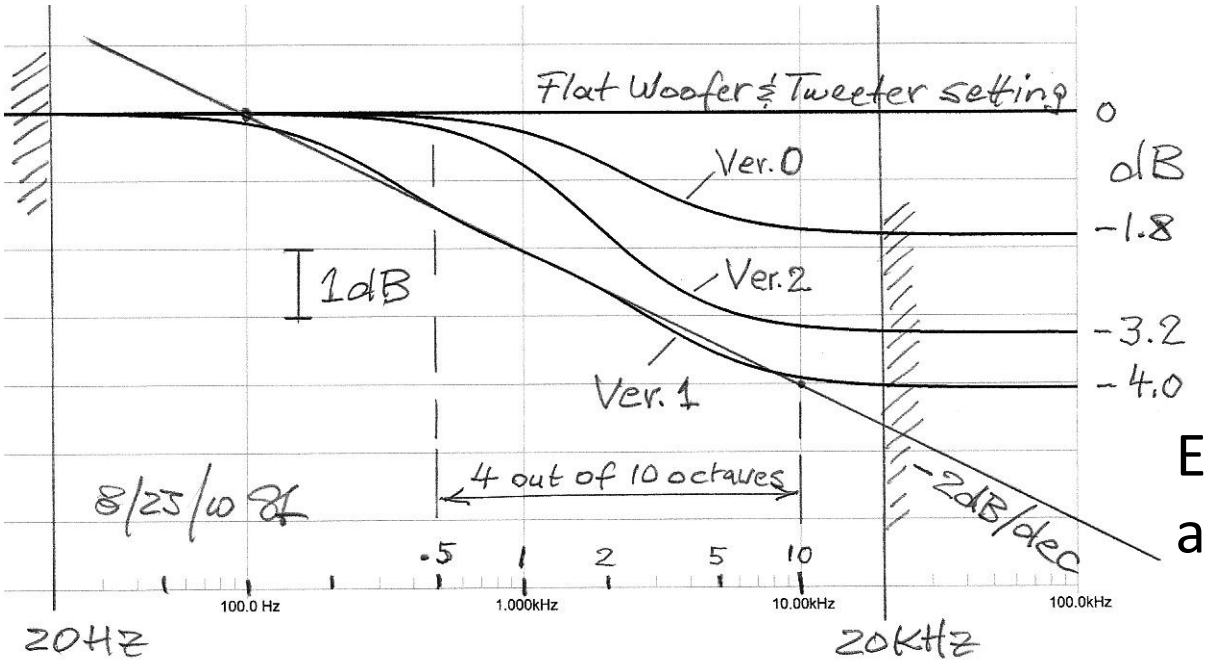
On-axis Frequency Response of stereo loudspeakers



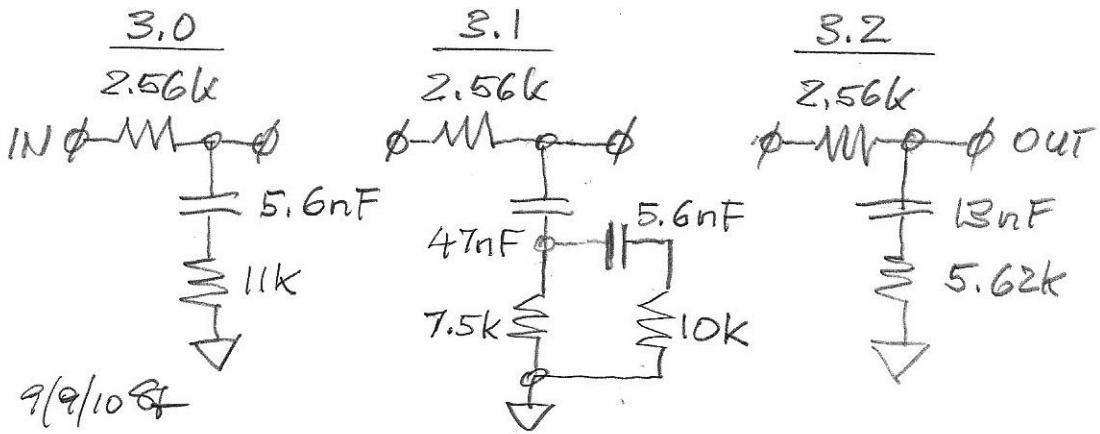
Rolled-off towards high frequencies



Experimental equalization networks

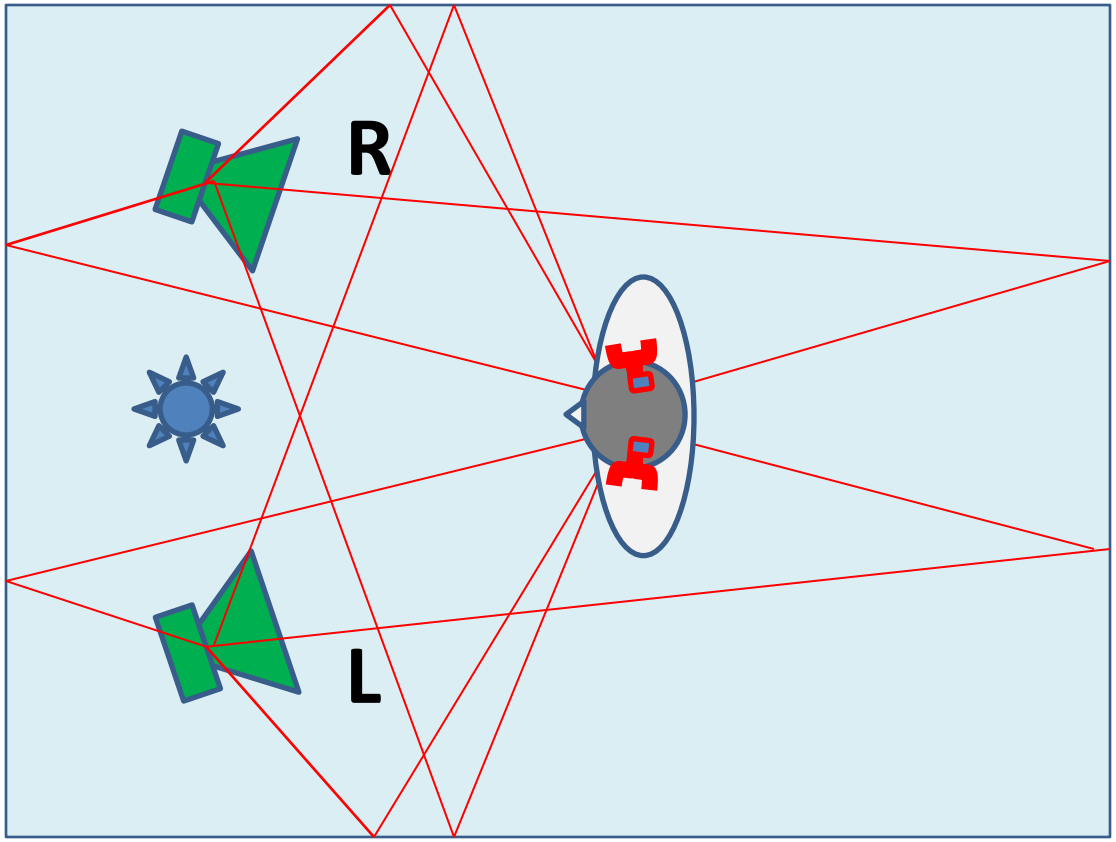


Equalization curves arrived at by listening



Circuit detail from ORION Revision 3

Off-axis Frequency Response & Room Reflections



Response:

- As on-axis
- Independent of angle except for amplitude

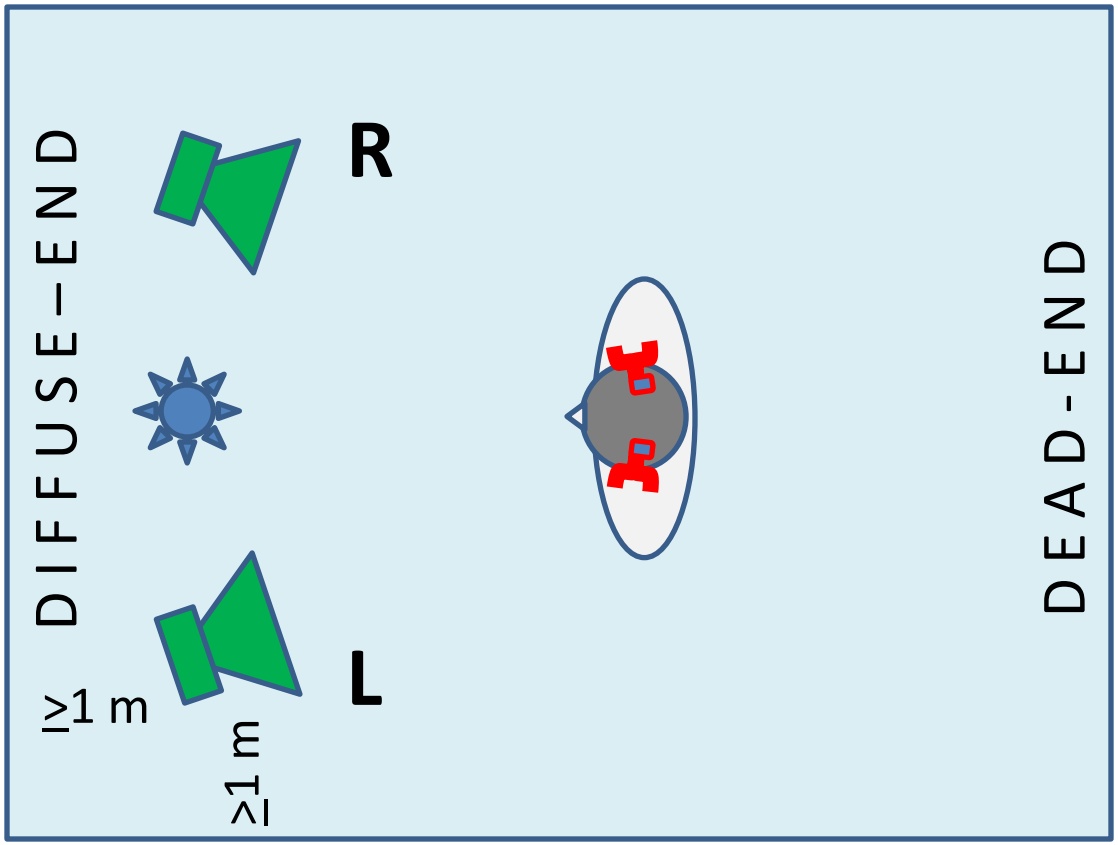
Reflections:

- Symmetrical
- Delayed

Source types:

- Omni
- Dipole
- Cardioid

Stereo setup in the room



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

Phantom Source placement horizontally by channel differences

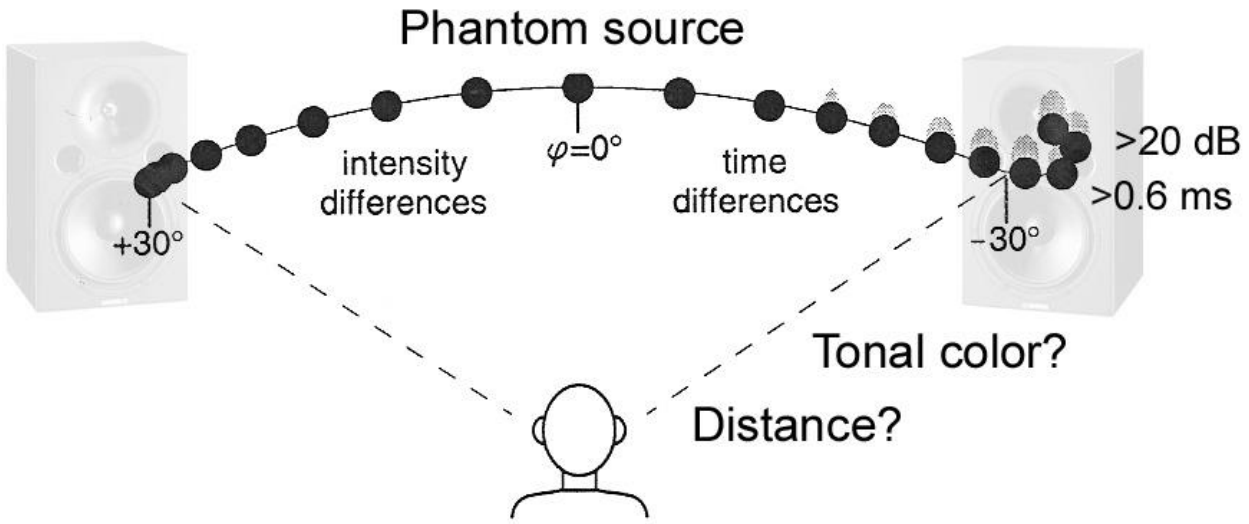
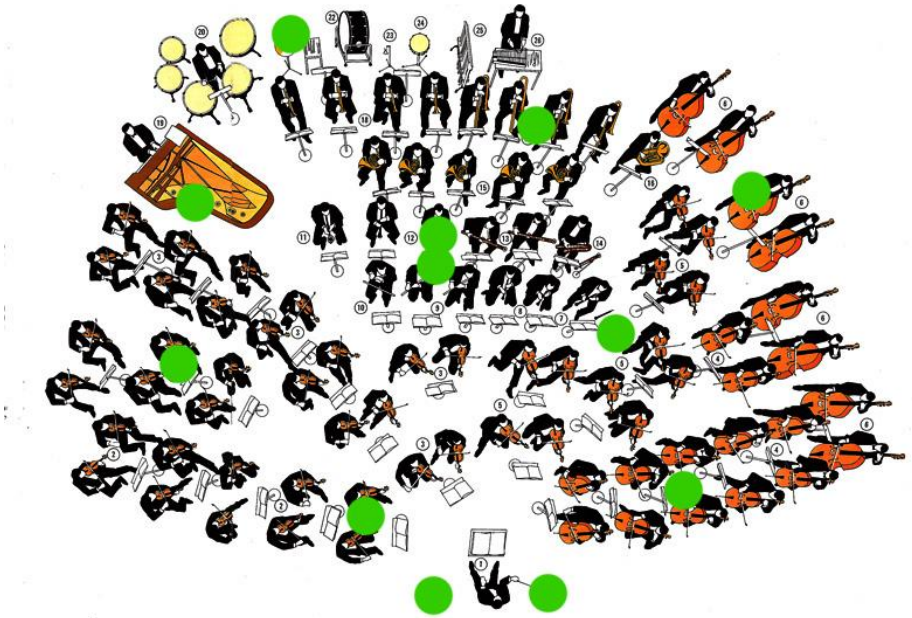


Fig. 1.4. Perceived directions with pink noise, constant loudness

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

Source size
Perspective
Distance
Timbre

The optimum frequency response
and setup of loudspeakers in the room
are essential
to Phantom Source Creation
and to experience Stereo
at its full capability

STEREO System = ILLUSION Engine

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