The Magic in 2-Channel Sound Reproduction

Why is it so rarely heard?

Siegfried Linkwitz

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Hearing under anechoic conditions

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The room response

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Typical stereo reproduction

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Two loudspeaker design examples

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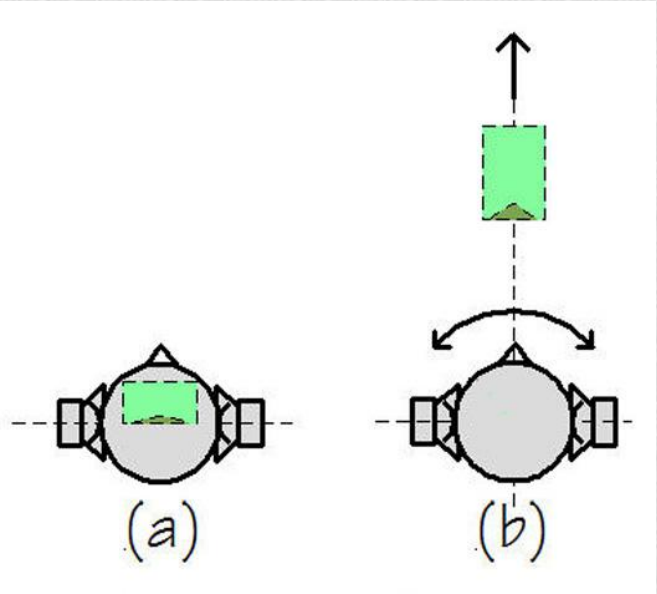
Two loudspeaker design examples

My challenge to Loudspeaker Designers

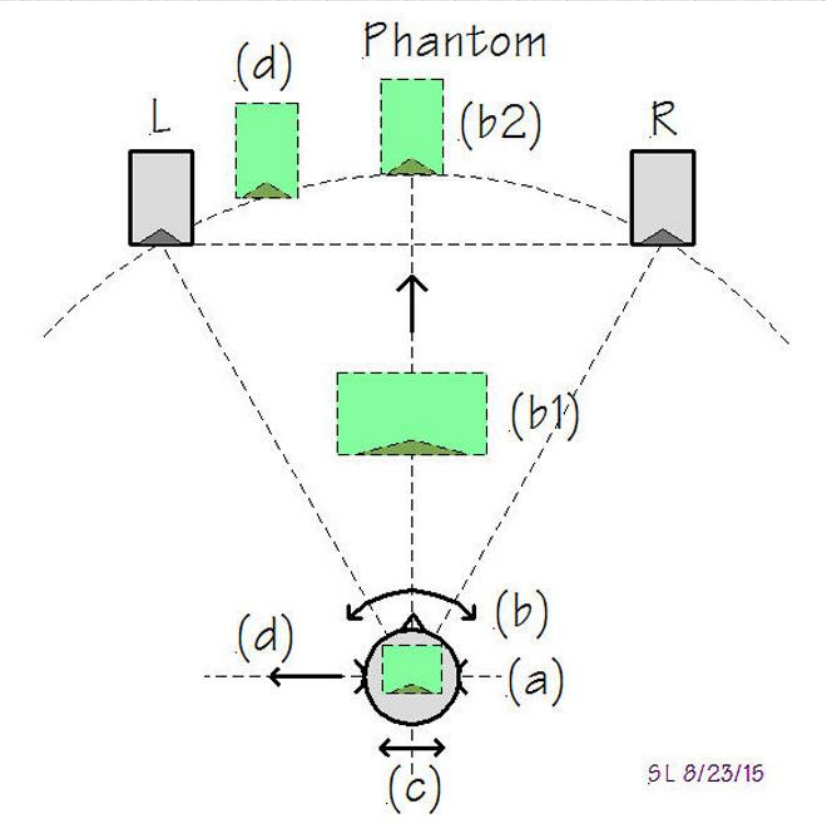
Hearing under anechoic conditions

A - Headphone Stereo



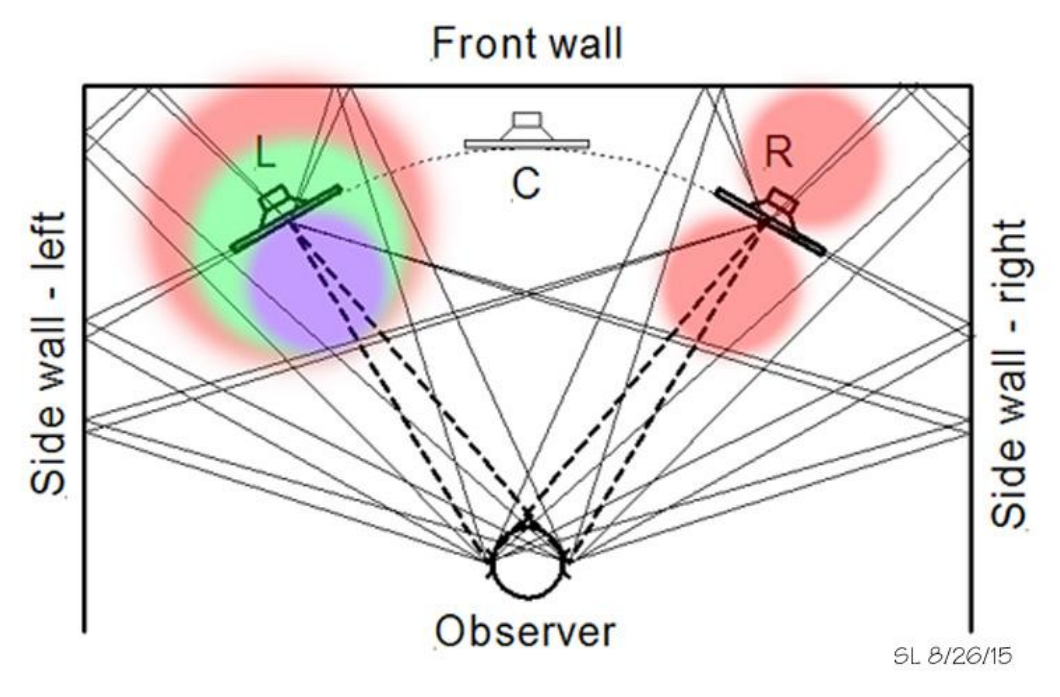
Hearing under anechoic conditions

B - Loudspeaker Stereo



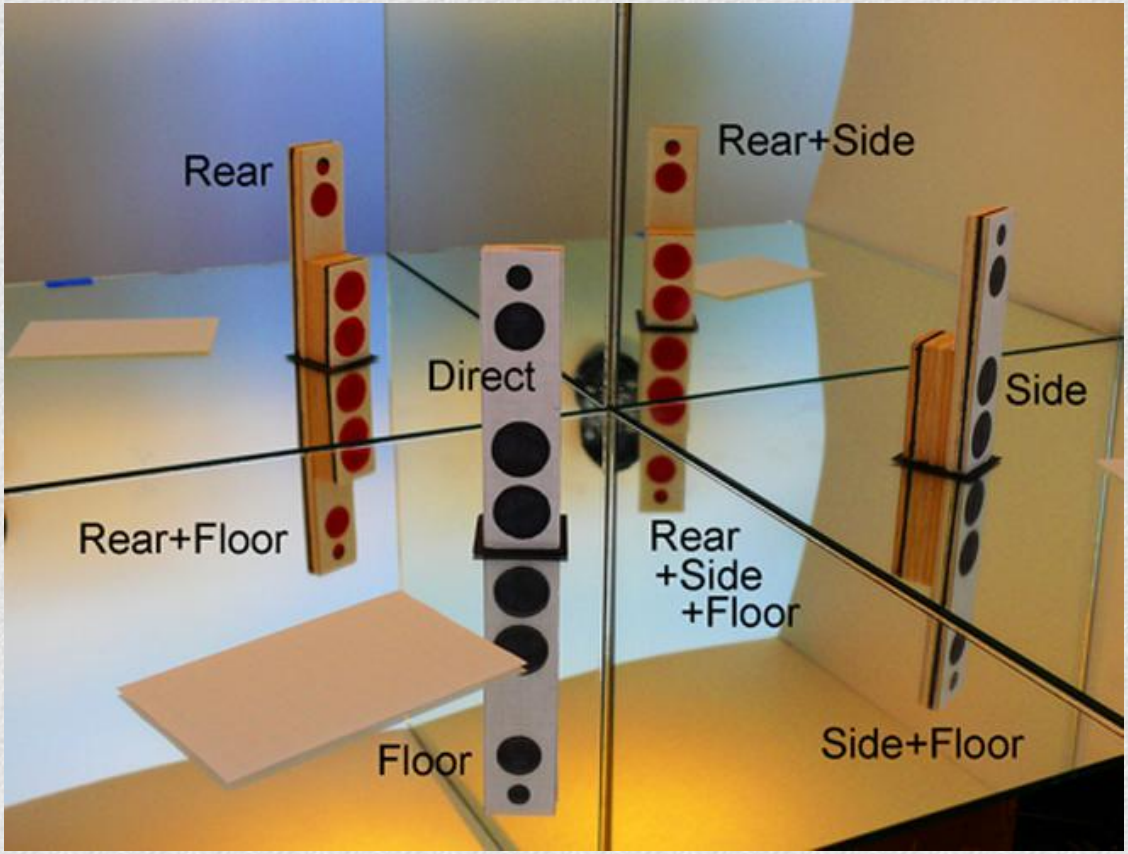
The Room Response

R1 - Reflections



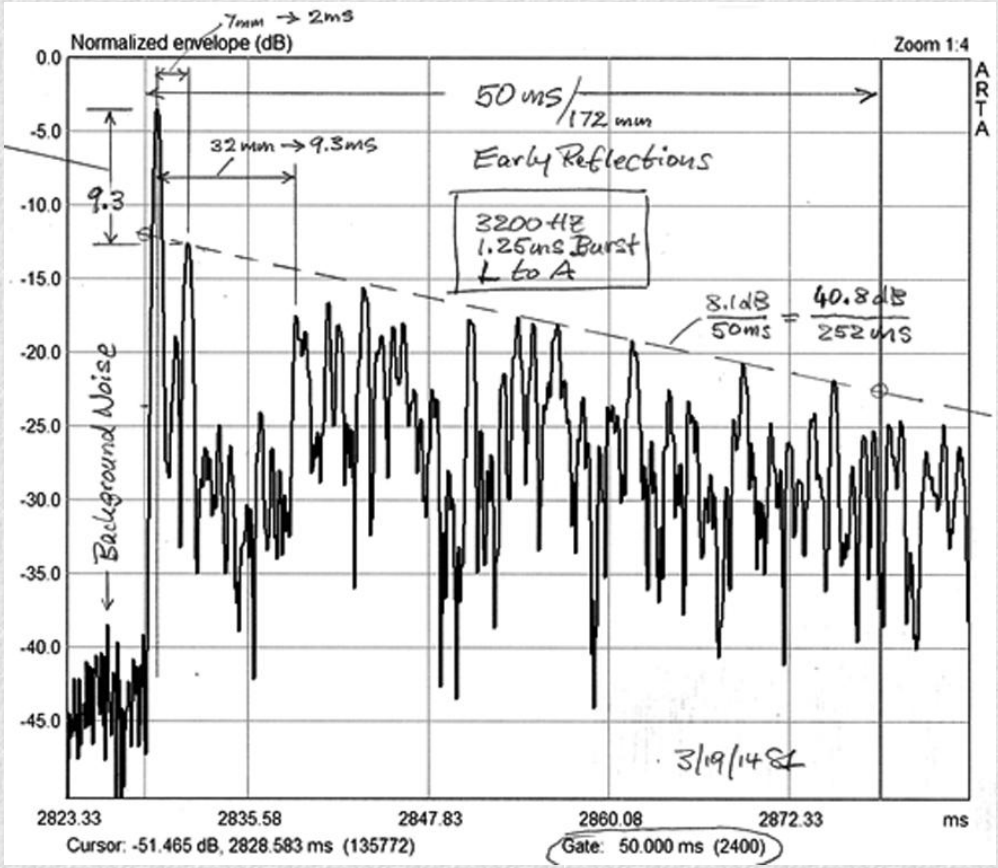
The Room Response

R2 - Reflections



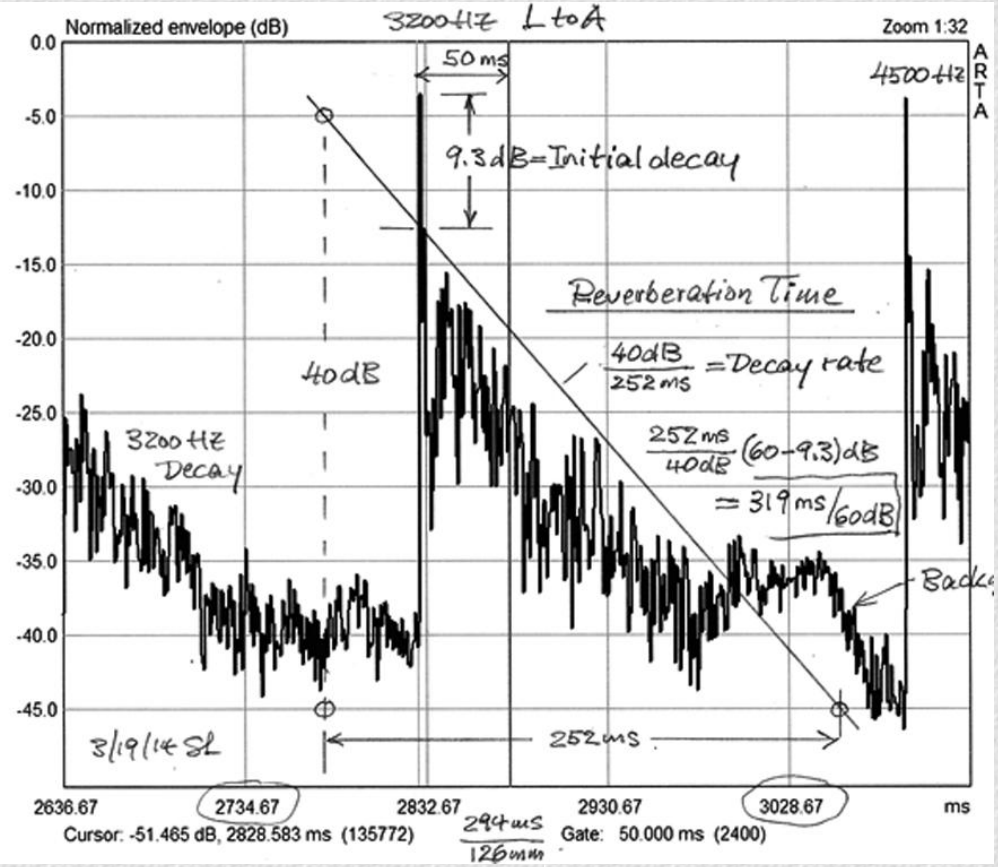
The Room Response

R3 - Reflections



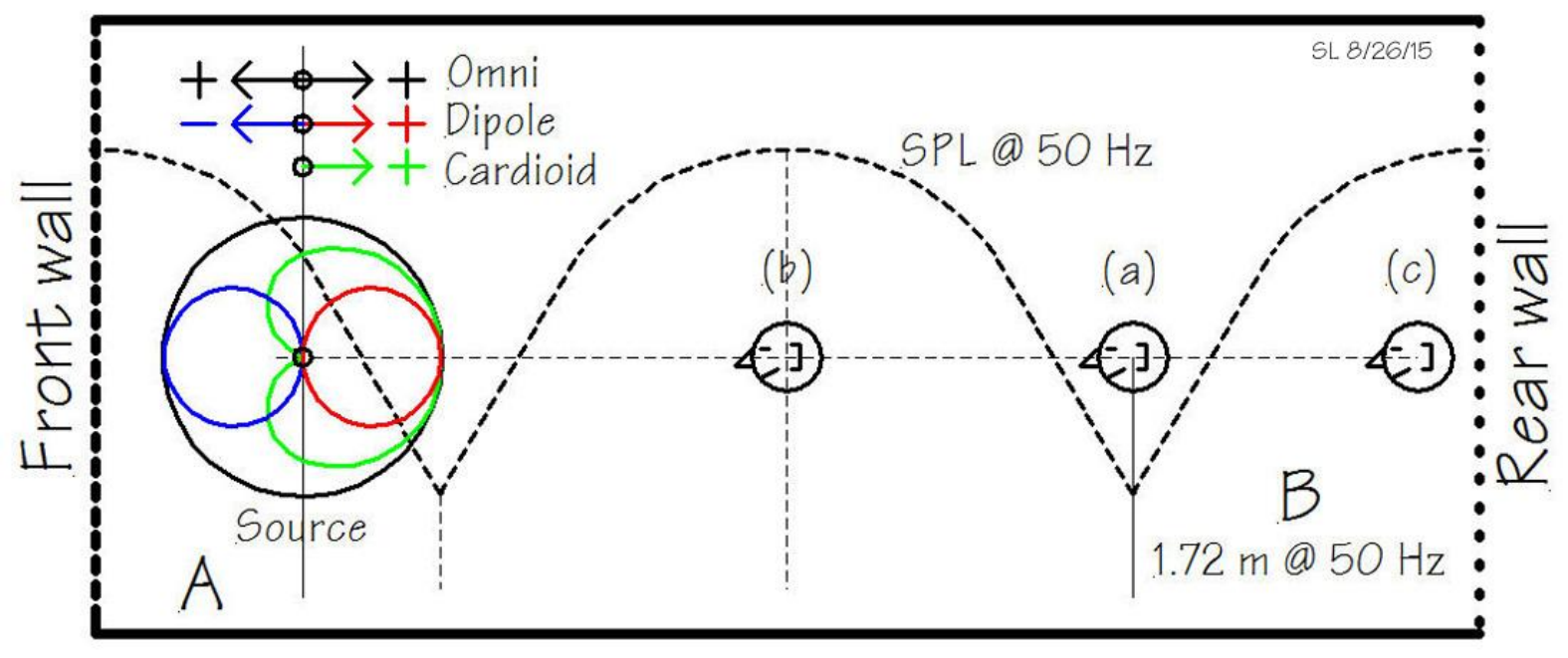
The Room Response

R4 - Reflections



The Room Response

R5 - Resonance modes



The Room Response

R6 - Reverberated sound field

a) Room dimensions		
L =	22.6 ft	6.88 m
W =	16.0 ft	4.88 m
H =	9.0 ft	2.75 m

Floor area A =	361 ft^2	33.6 m^2
Volume V =	3253 ft^3	92 m^3
Surface area S =	1417 ft^2	132 m^2
Edge length Le =	190 ft	58 m

b) Acceptable room if:		
1.1*(W/H) < (L/H) < 4.5*(W/H)-4		
2.0	2.5	4.0
(R. Walker, BBC, 1996)		

c) Below frequency fm =	150	Hz
Total number of modes N =	55	
Avg. mode spacing df =	1.6	Hz at fm

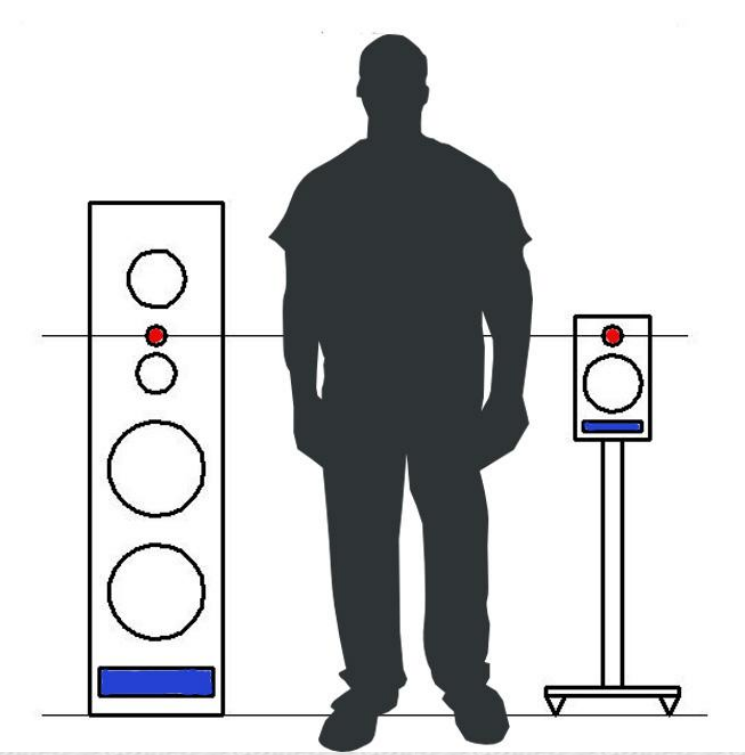
d) Estimated avg wall absorption a =	25%	
Reverberation time T60 =	456	ms

e) Estimated reverberation time T60 =	456	ms	
Resonance bandwidth bw =	4.8	Hz	
Rise time Trise =	146	ms	
Schroeder frequency fs =	134	Hz	
Monopole reverb distance Rm =	0.80	m	2.6 ft
Dipole reverb distance Rd =	1.39	m	4.6 ft
Avg wall absorption a =	25%		

SL 5/27/15

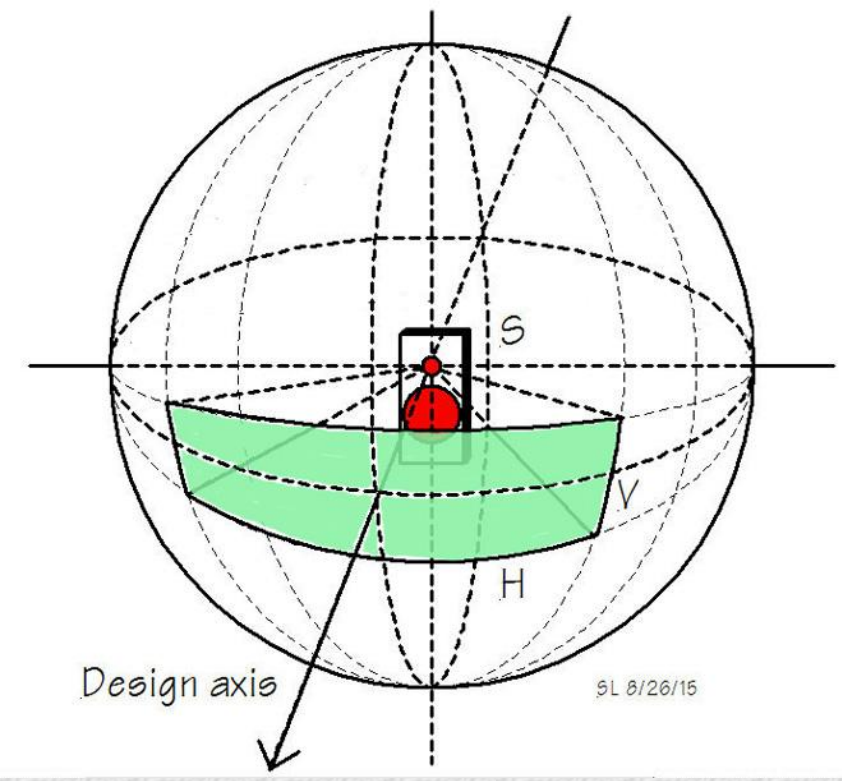
Typical Stereo Reproduction

Generic box loudspeakers



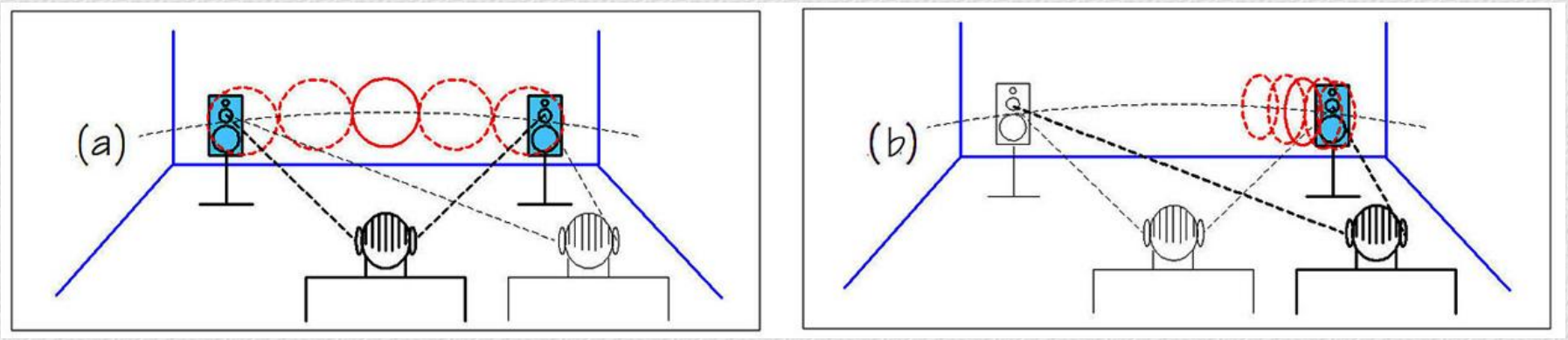
Typical Stereo Reproduction

Design axis/window



Typical Stereo Reproduction

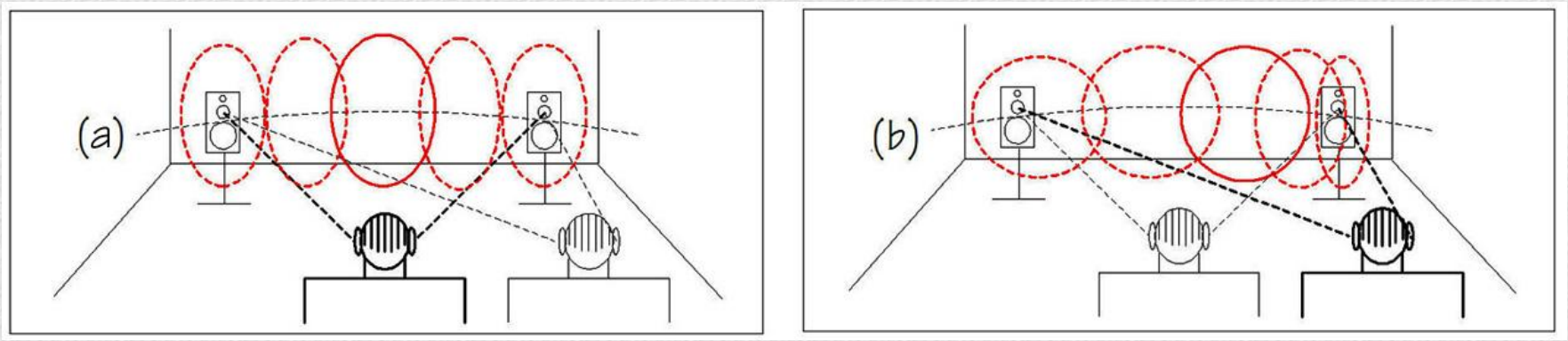
Auditory scene



Focused lateral imaging. Depth?
Height of scene = Height of speaker boxes
Auditory scene is hard-bounded by the speakers
Like listening to headphones at a distance
Scene collapses into nearest speaker
Aware of listening to 2 speakers in a room

Optimal Stereo Reproduction

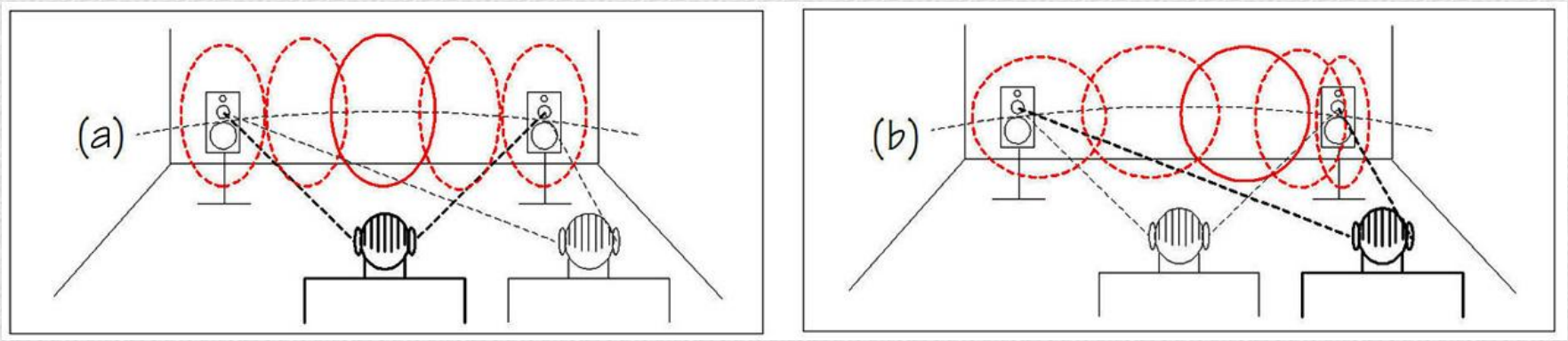
Auditory scene



Focused lateral imaging. Depth
Height of scene much greater than Height of speaker boxes
Auditory scene is soft-bounded by the speakers
Like being at the performance venue
Scene is viewed from off-center seat without collapsing
Not aware of listening to speakers in a room

Optimal Stereo Reproduction

Loudspeaker & Setup Requirements



1 – Speaker's 4π power response similar to on-axis response
2 – Speakers free of audible non-linear and linear distortion
3 – Speakers set up >1 m from large reflecting surfaces
4 – Space behind speakers is diffusive & absorptive behind listener
5 – Comfortable living space with RT60 around 450 ms

Two Loudspeaker Design Examples

D - Full-range dipole loudspeaker

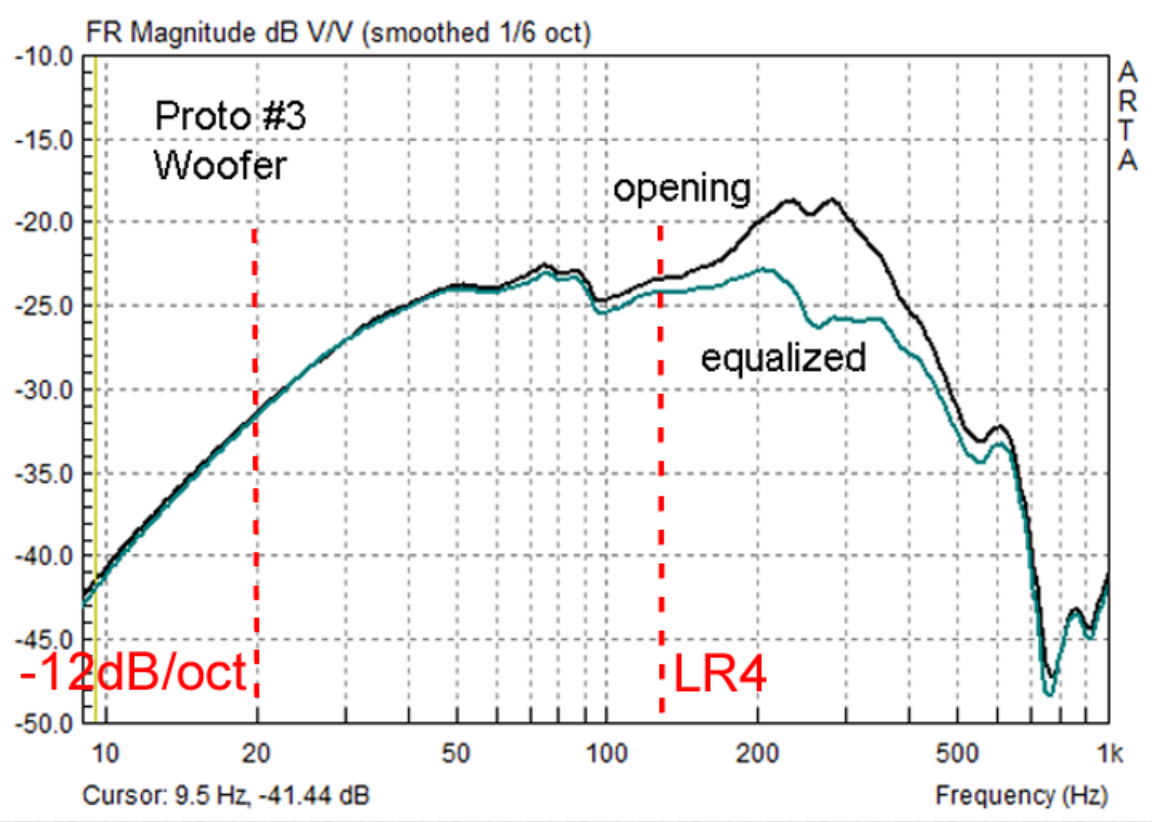
H - Hybrid loudspeaker

Two Loudspeaker Design Examples

D1 – Open-baffles

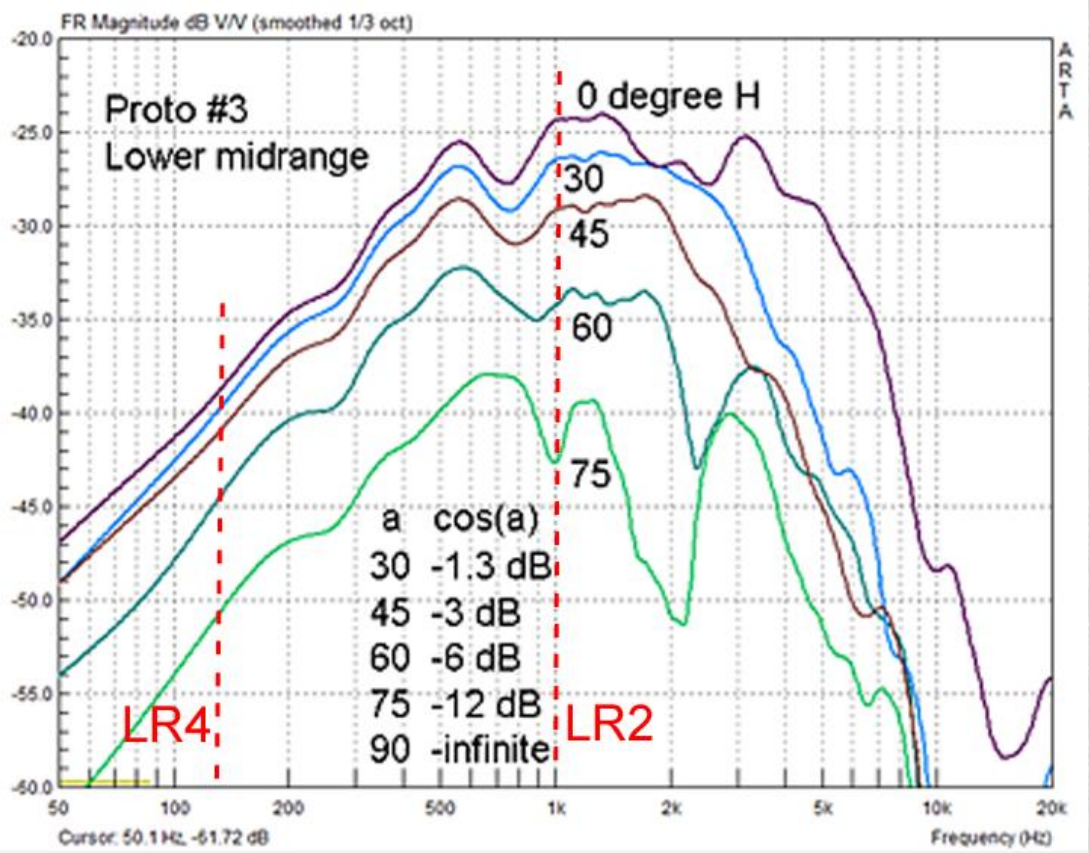
Two Loudspeaker Design Examples

D2 – Woofer response at baffle opening



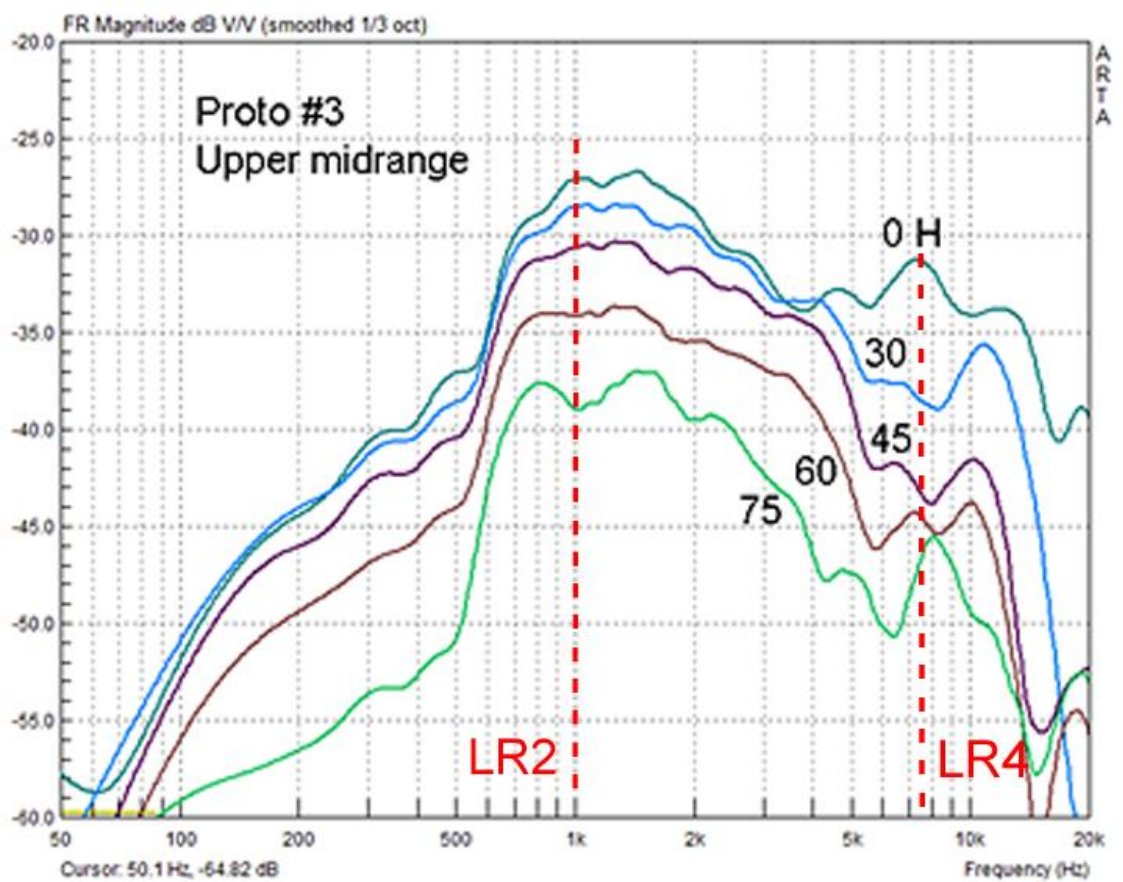
Two Loudspeaker Design Examples

D3 – Lower midrange polar response



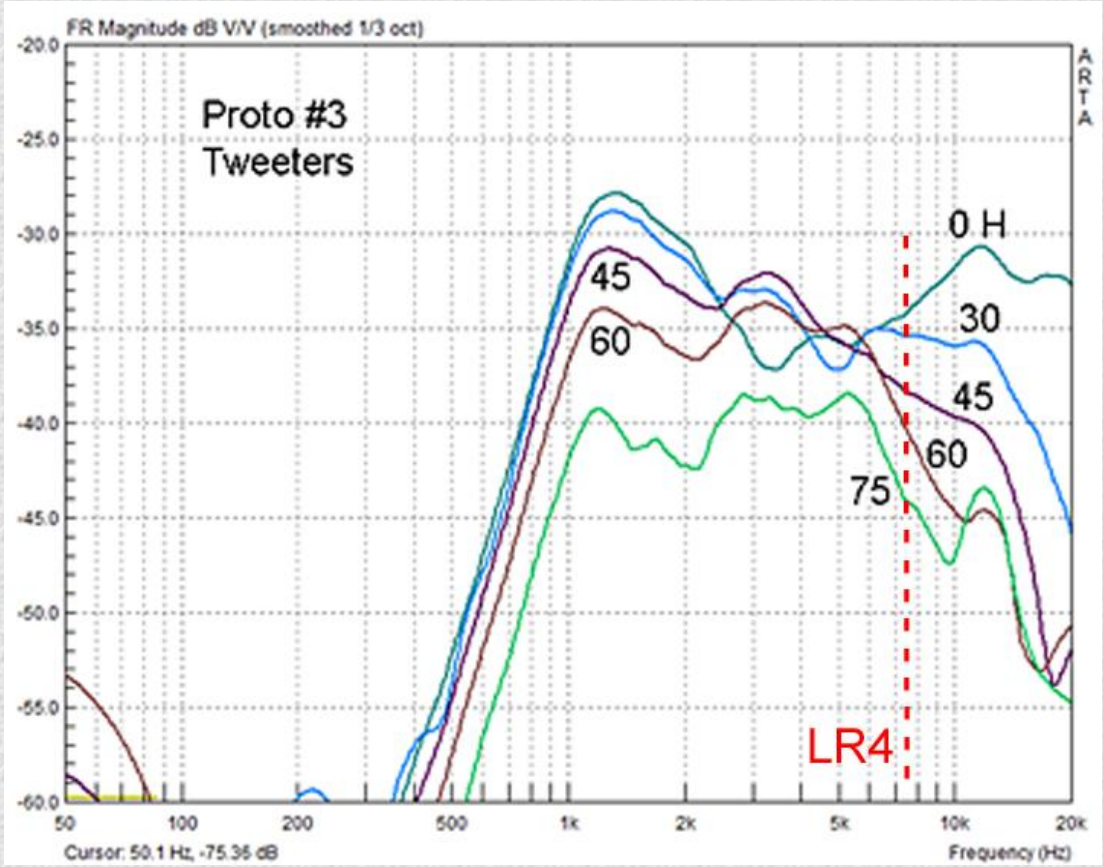
Two Loudspeaker Design Examples

D4 – Upper midrange polar response



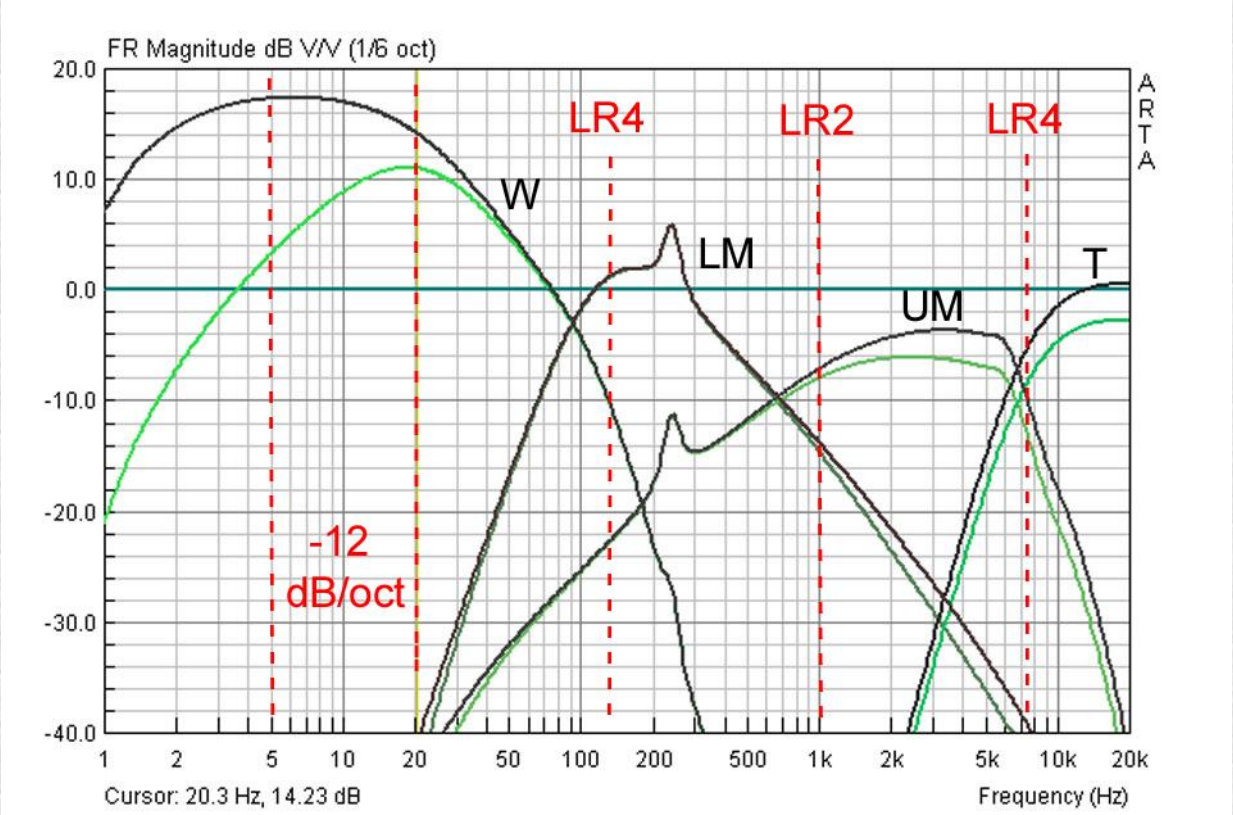
Two Loudspeaker Design Examples

D5 – Tweeter polar response



Two Loudspeaker Design Examples

D6 – Equalization & Crossovers

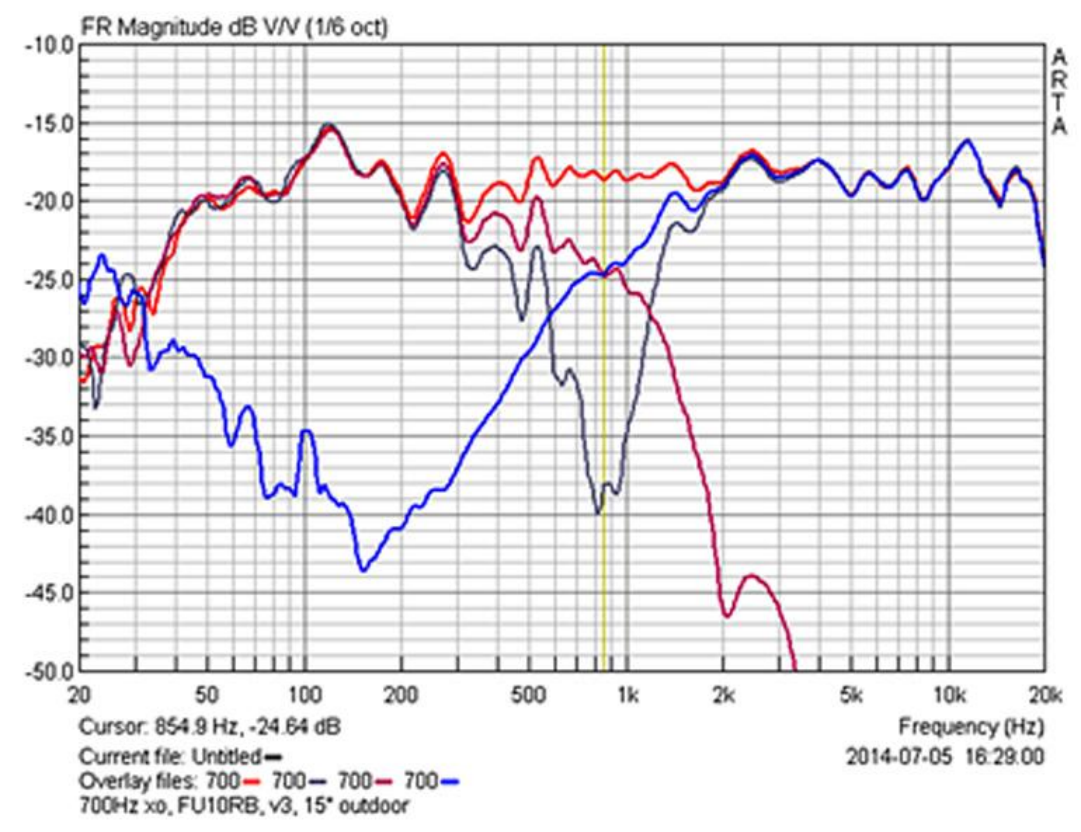


Two Loudspeaker Design Examples

H1 – Hybrid loudspeaker

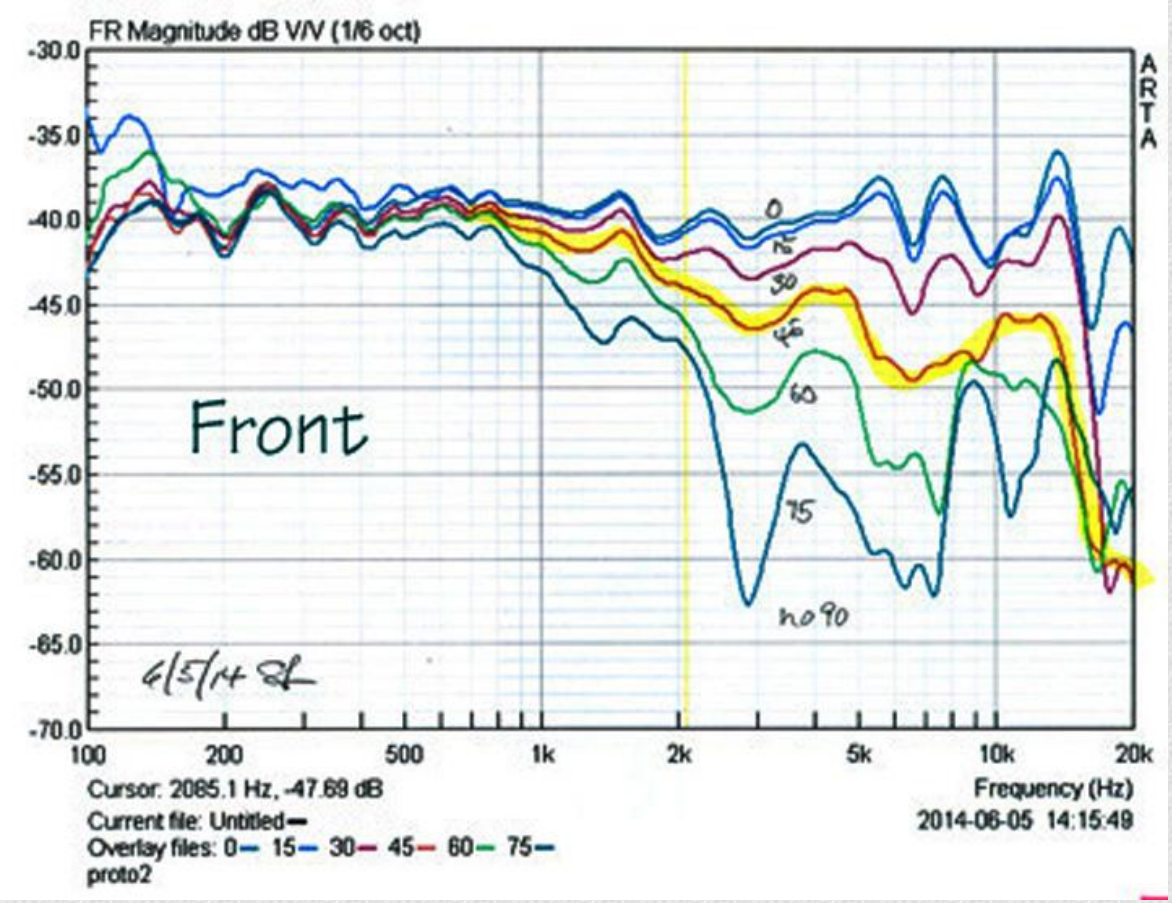
Two Loudspeaker Design Examples

H2 – On-axis response



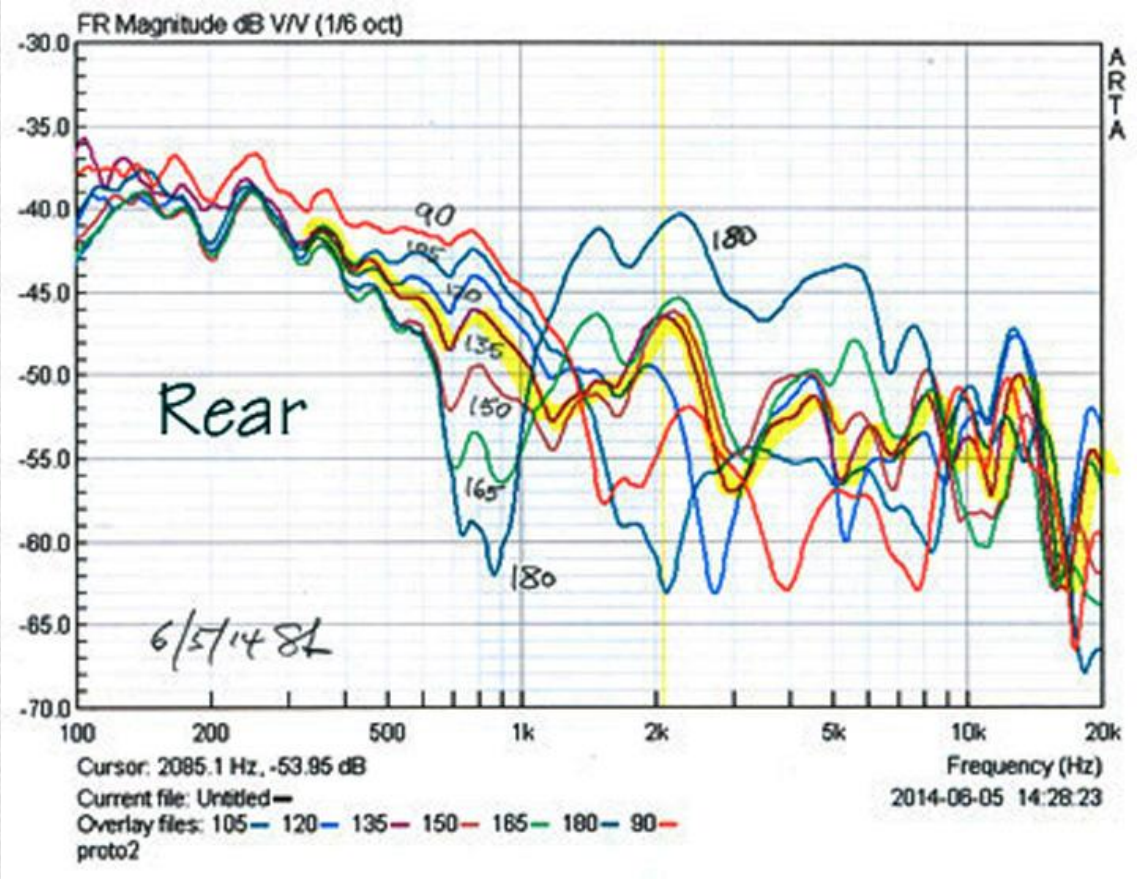
Two Loudspeaker Design Examples

H3 – Polar response



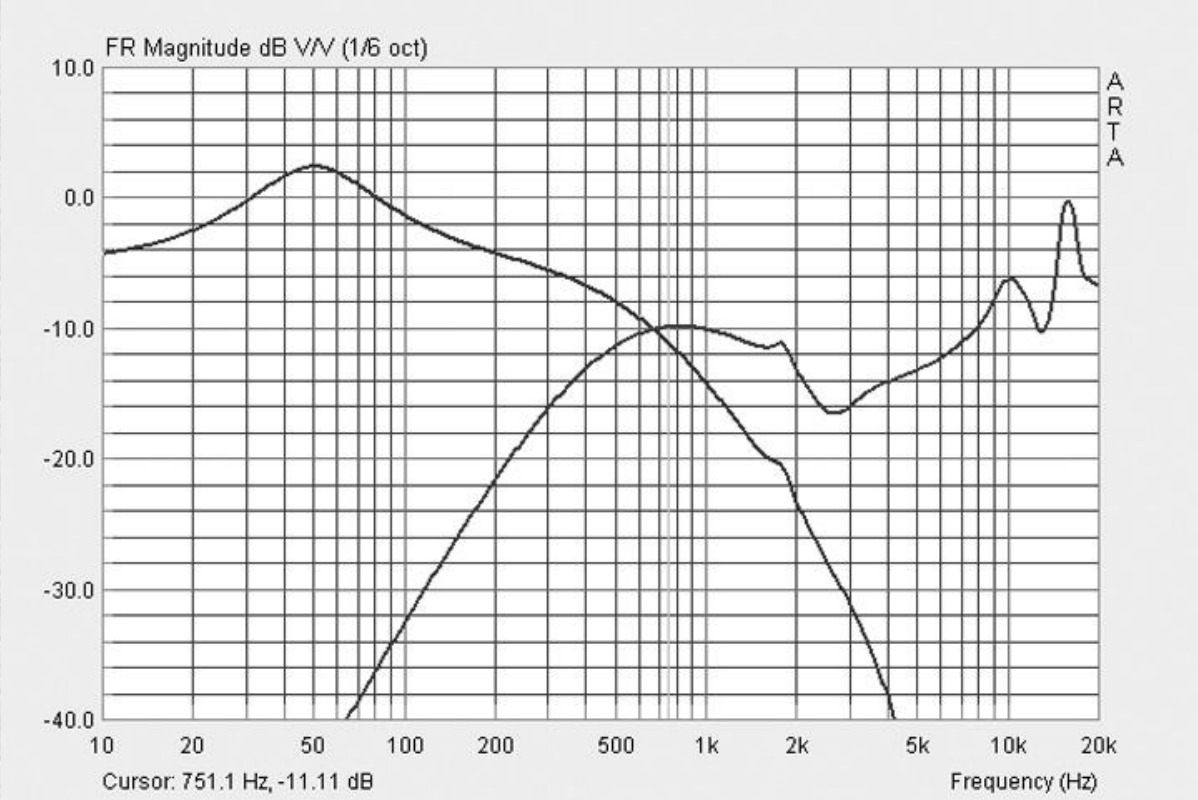
Two Loudspeaker Design Examples

H4 – Polar response



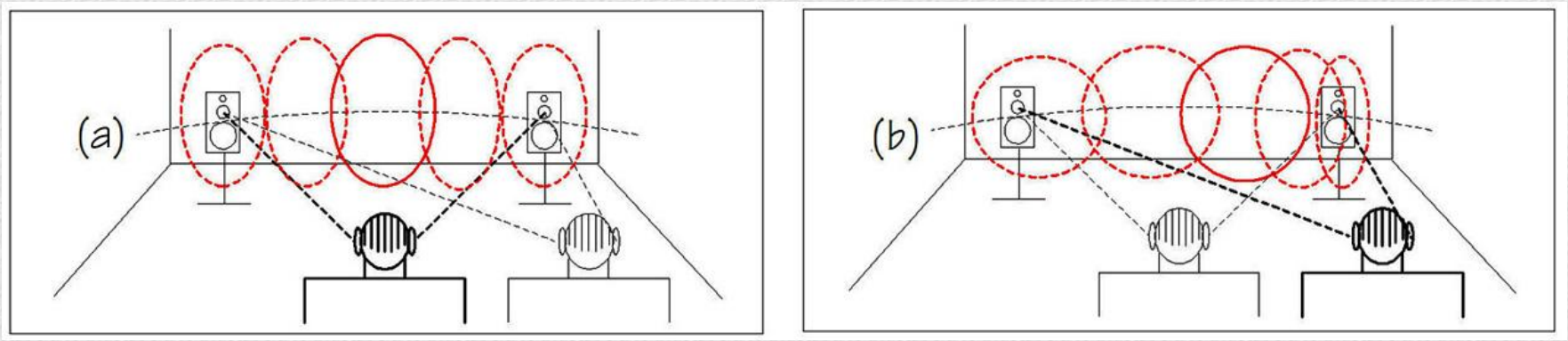
Two Loudspeaker Design Examples

H5 – Equalization & Crossover



Optimal Stereo Reproduction

e.g. Dipole or Hybrid Loudspeaker



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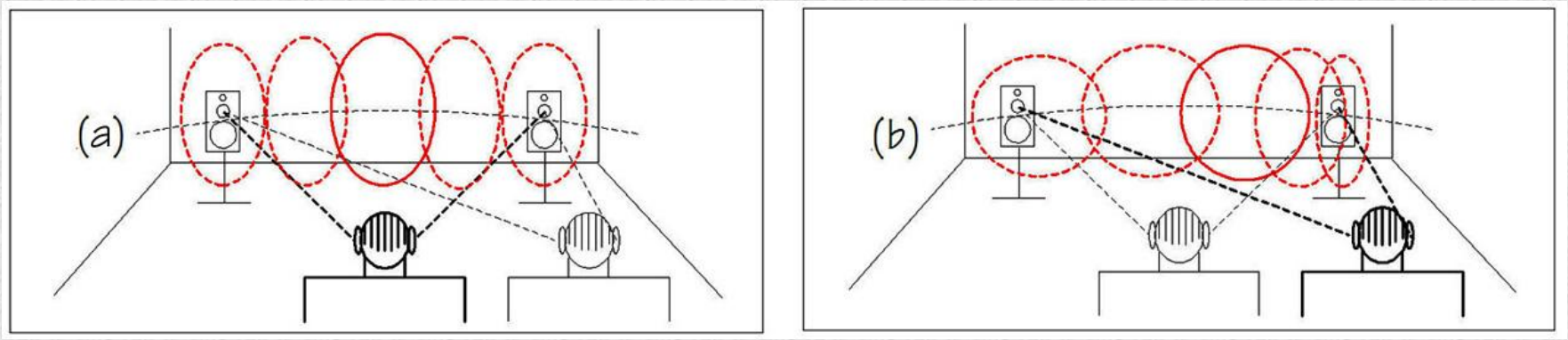
My Challenge to High-End Speaker Designers

- Recognize that the listening room is rarely the problem for sound reproduction, but how it is illuminated by the loudspeakers
- Therefore a flat on-axis frequency response is not sufficient
- Therefore reduce the variation in speaker directivity
- Reduce non-linear and linear distortions for higher SPL
- For meaningful, descriptive comparisons with other speakers designers & reviewers should own a pair of Lxmini as reference

Thank you for your attention



Please spread the message