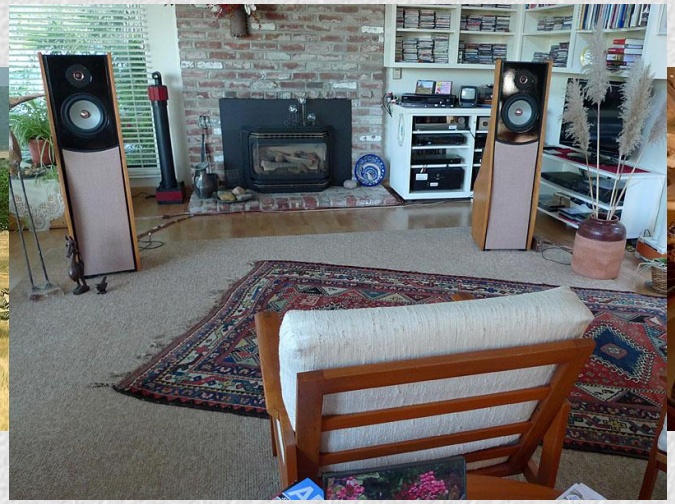
Recording and Reproduction over Two Loudspeakers as Heard Live

Part 1: Hearing, Loudspeakers and Rooms

Siegfried Linkwitz & Don Barringer

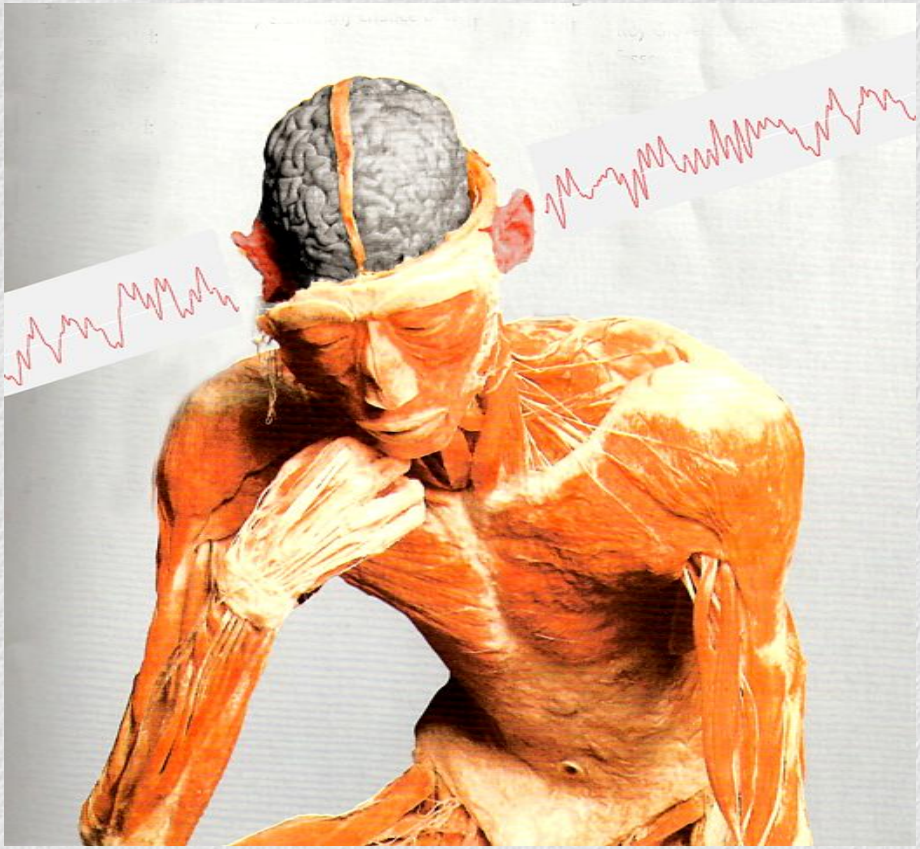


Hearing for survival in an environment with multiple sources and reflections

- Direction
- Distance
- Size

- Tracking
- Meaning
- Attention

Hearing happens between the ears



We employ:

- ❖ **Intensity differences**
- ❖ **Arrival time differences**
- ❖ **Envelope variations**
- ❖ **Spectrum masking**

- ❖ **Stream segregation**
- ❖ **Pattern recognition**
- ❖ **Attention**
- ❖ **Learning**

- ❖ **Head movements**
- ❖ **Tactile & visual inputs**

Drift thresholds for one and two reflections

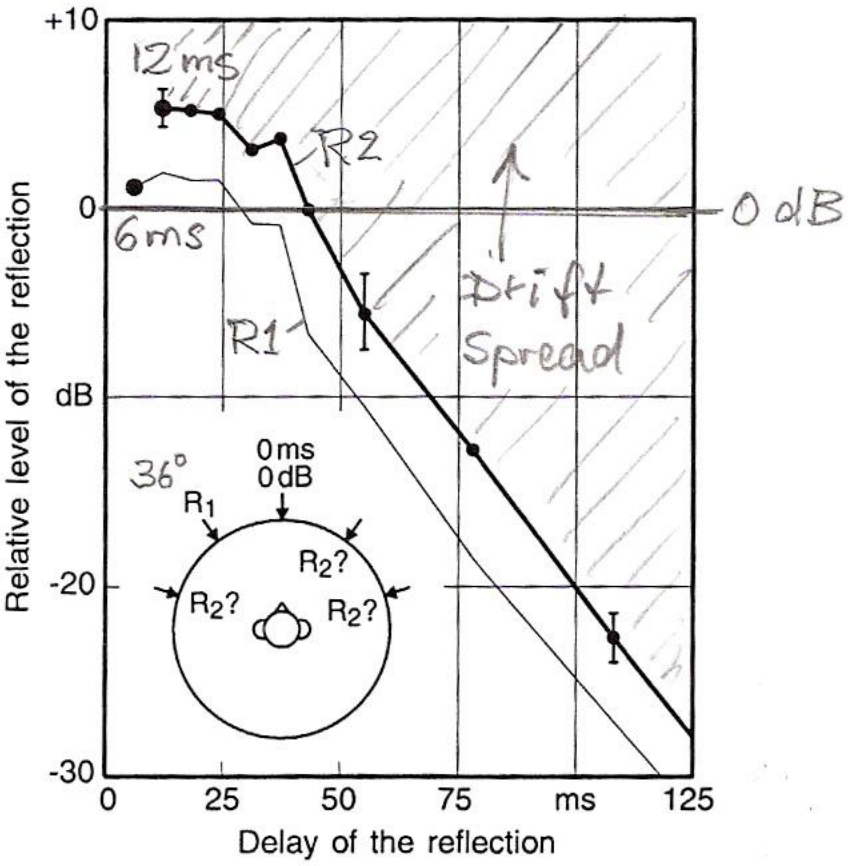


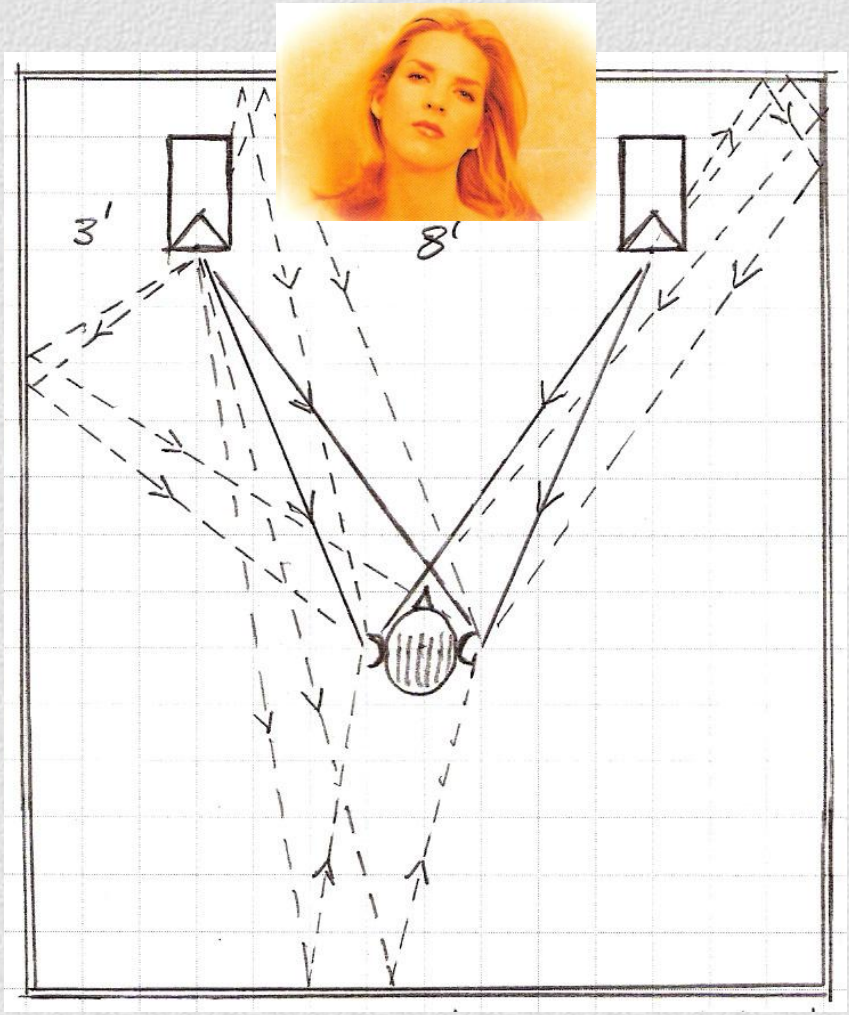
Fig. 2.6. Drift threshold (DT) of a second reflection R_2, continuous speech

Peter Damaske, Acoustics and Hearing, Springer 2008

Hearing for pleasure in a room with two sources and multiple reflections

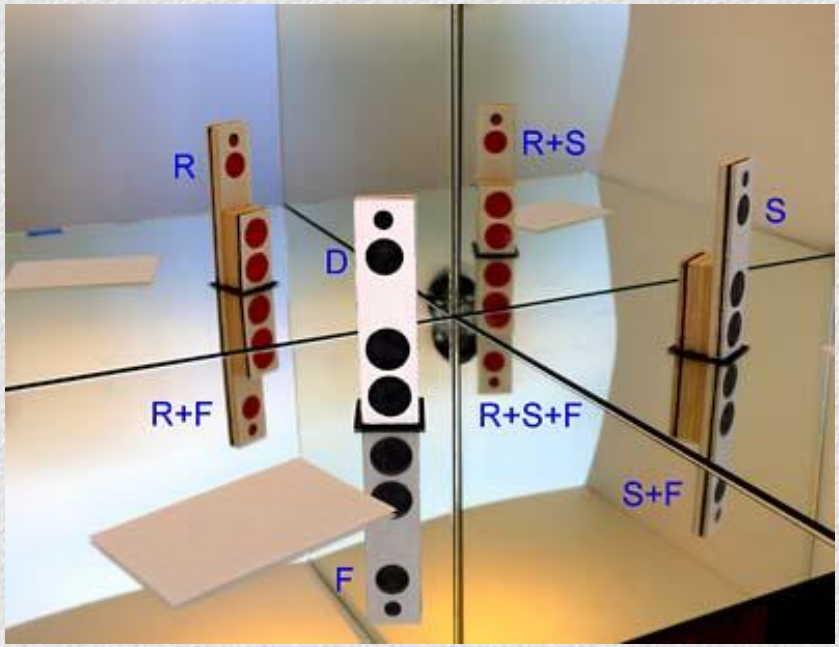
- Same hearing processes as for survival
- Two real sources with room reflections
- Multiple phantom sources with recording venue reflections

Direct signals, reflections, crosstalk



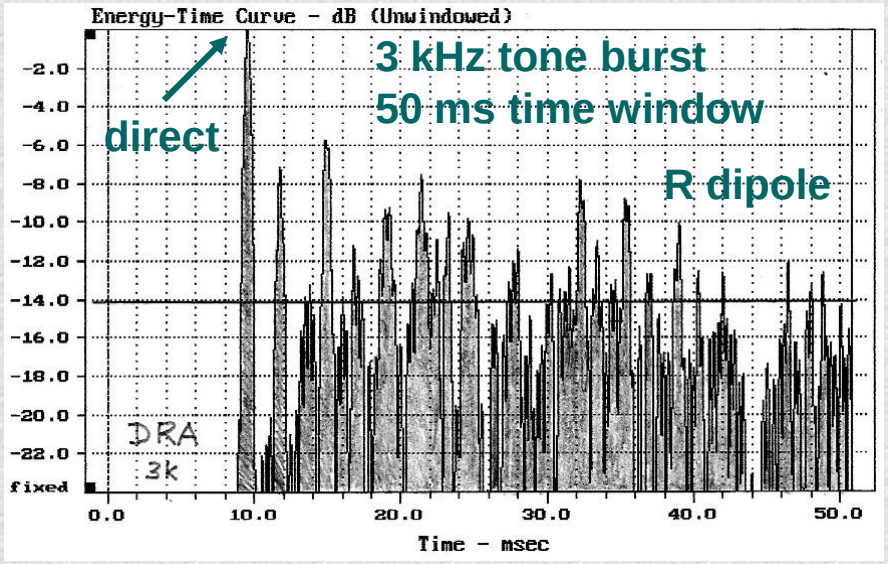
Phantom image placement,

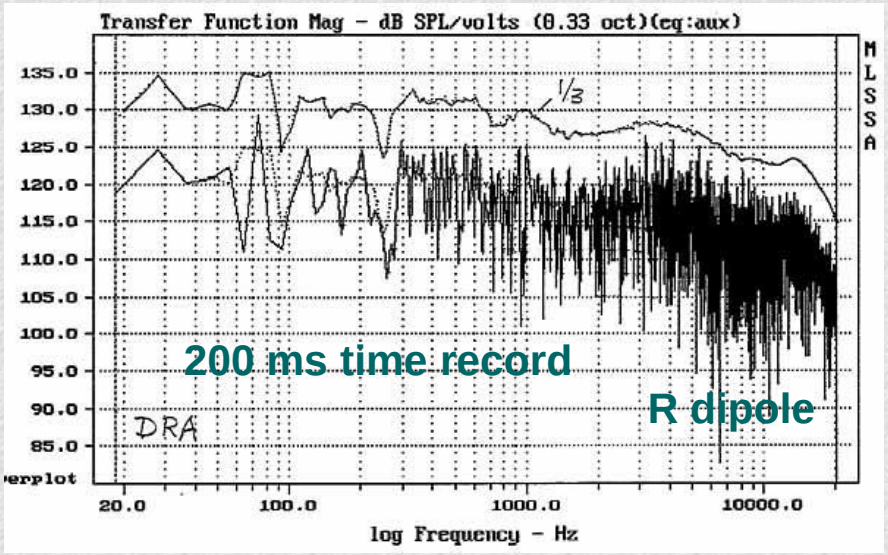
spread & diffuseness



Room reflections & perceived frequency response

- Direct & reflected sounds determine in-room response at the listener
- L - R symmetry of reflections for phantom image positioning
- Loudspeakers >1 m from reflecting surfaces (>6 ms delay)
- Each reflection with same spectral content as the direct sound (= delayed copies)
- Listener's brain can safely blank out the room & focus on the direct sound
- Below 150 Hz use dipole bass.
  A few room modes can be equalized parametrically





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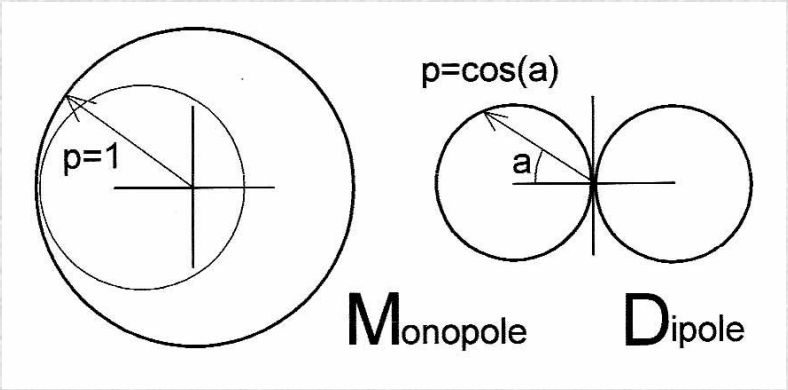
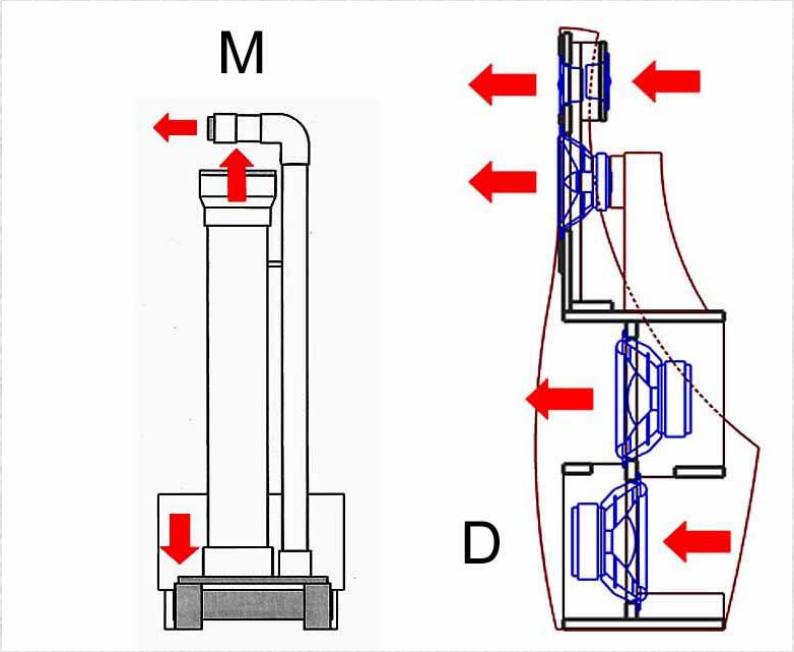
Loudspeaker requirements

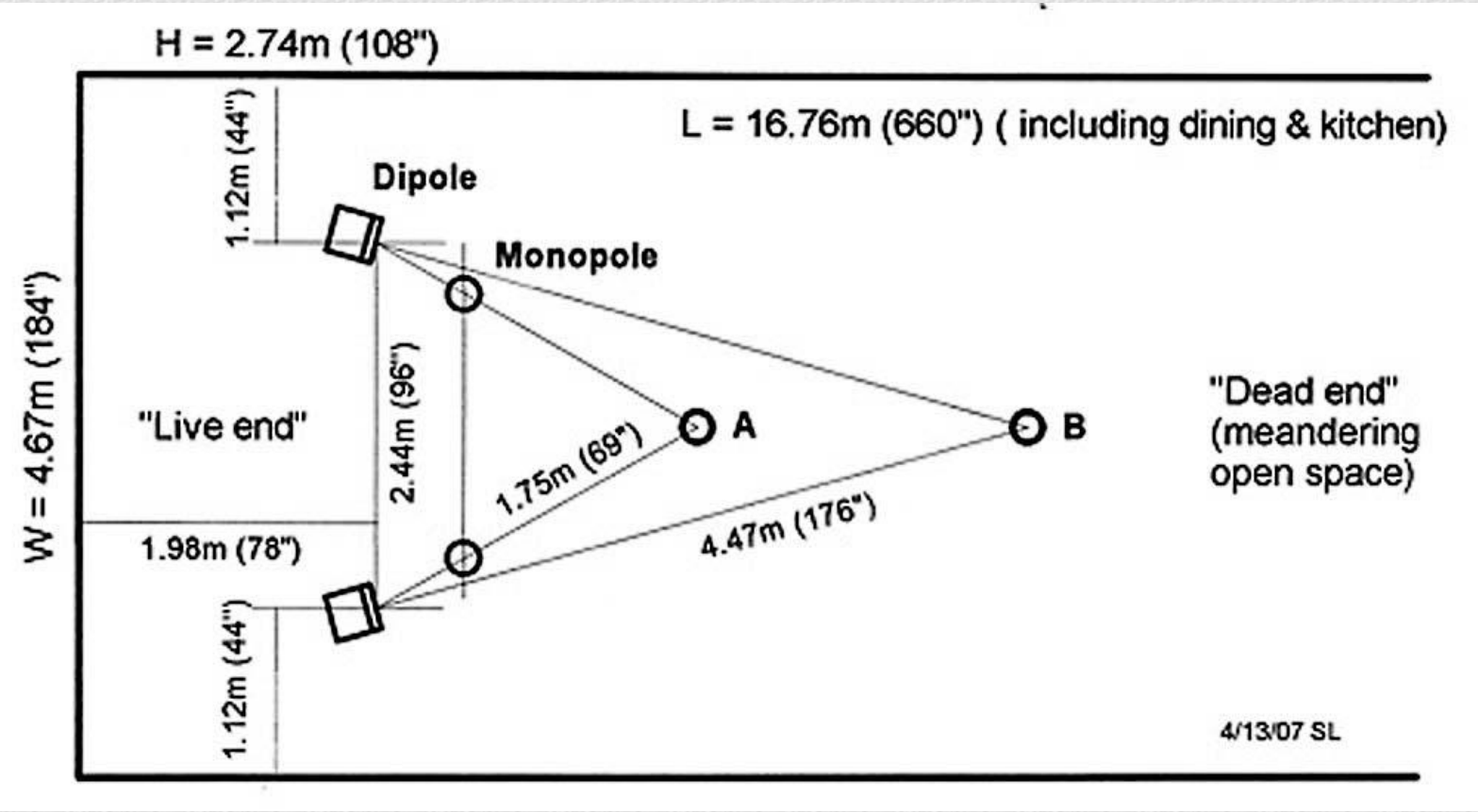
- Flat on-axis response in free-field (20 Hz – 20 kHz)
- Frequency independent polar response
- Acoustically small size (λ = 34 cm @ 1kHz)
- Low cabinet edge diffraction
- Low stored energy (resonances)
- Low non-linear distortion (new sounds, intermodulation)
- Large dynamic range, high SPL



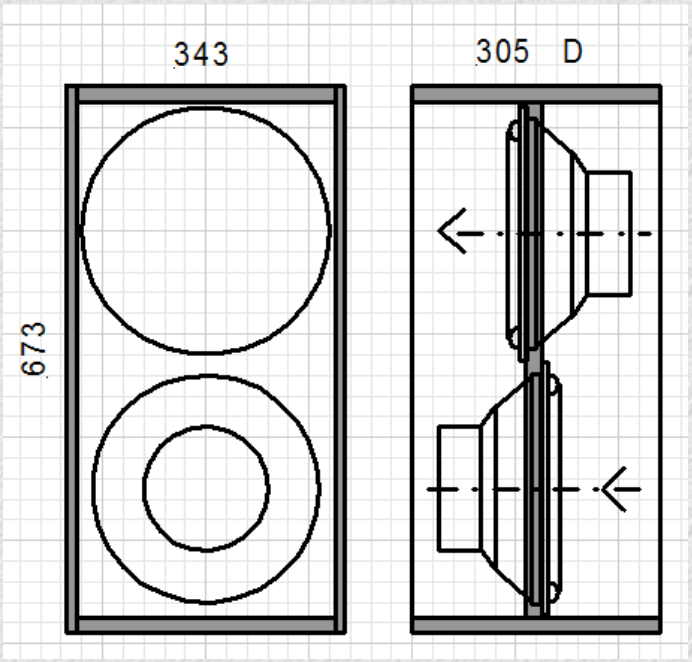


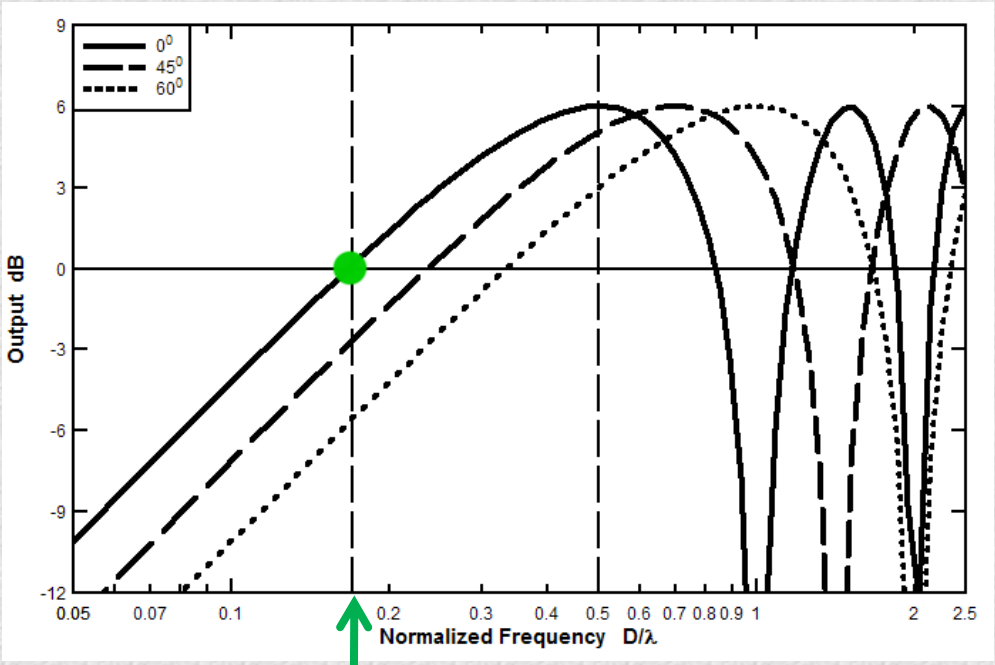
Room requirements

- Loudspeaker & listener setup symmetrical and >1 m from walls
- Lively acoustics (RT60 = 400 – 600 ms above 200 Hz)



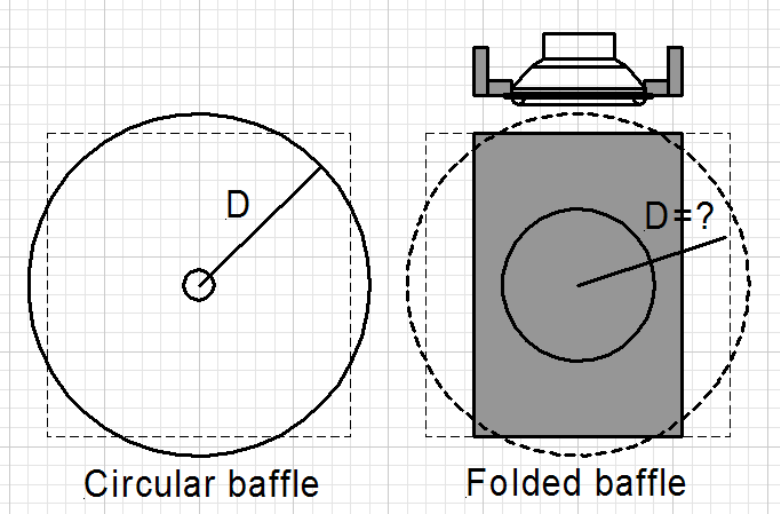
Practical dipole source
-- Bass frequency range --

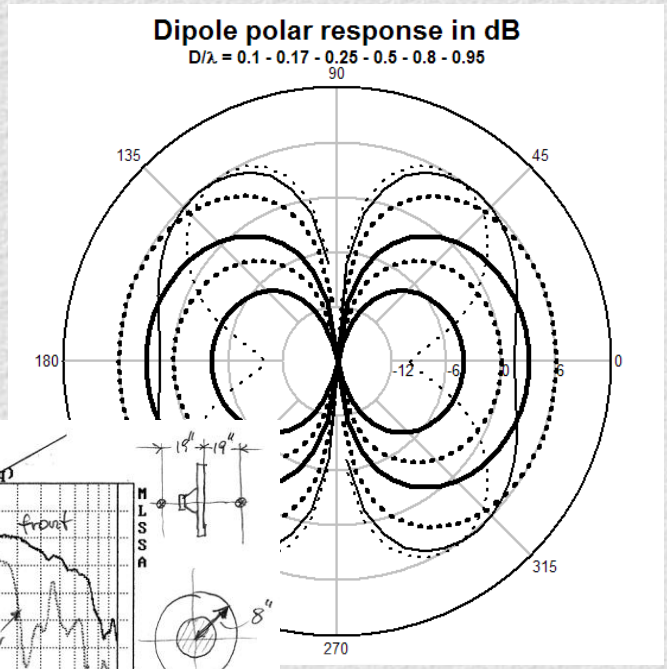


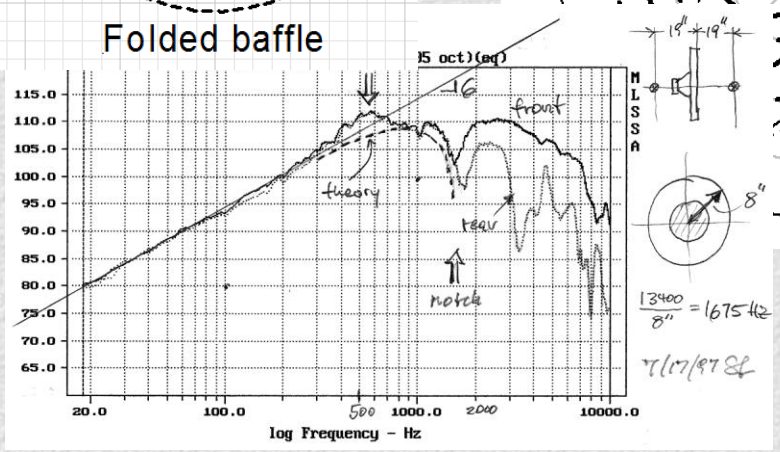


Fequal @ D = λ/6

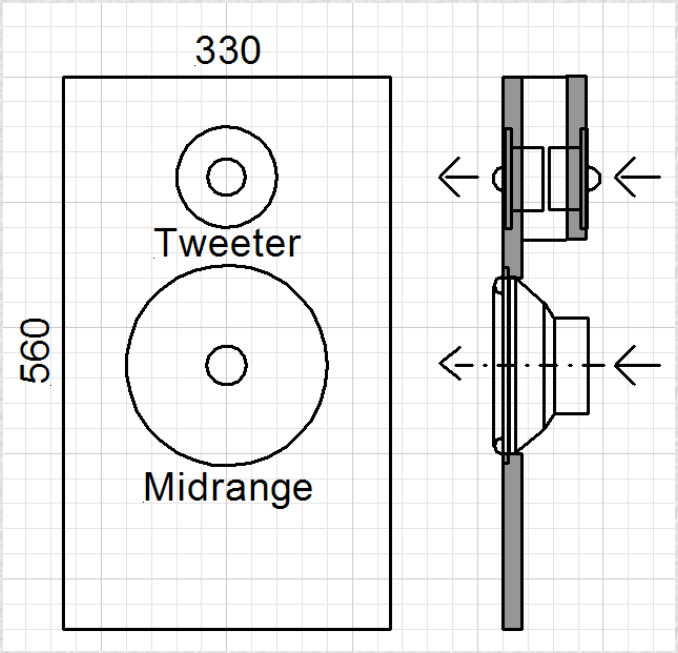
Practical dipole source
-- Mid frequency range --

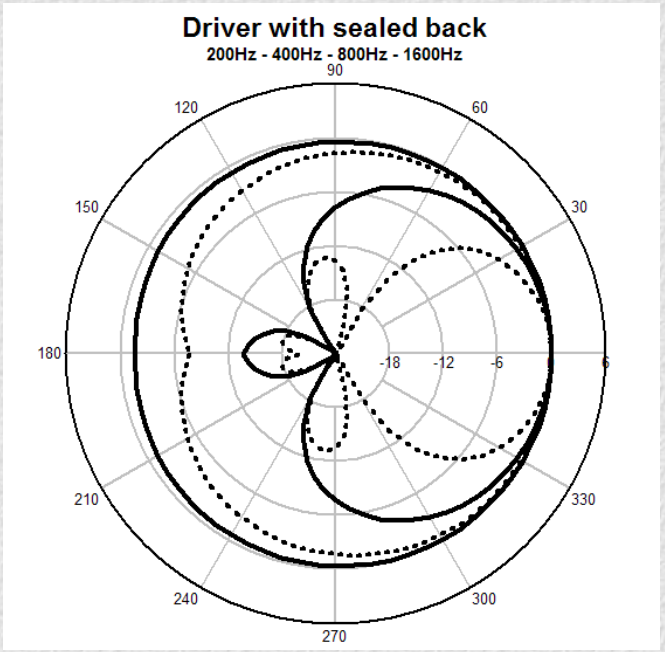






Practical dipole source
-- Tweeter frequency range --





Summary

- Natural hearing processes must be respected to optimally create auditory illusions in the absence of physically accurate wavefield reproduction

- Loudspeakers should be designed to illuminate the listening room with equal timbre for all horizontal and vertical angles

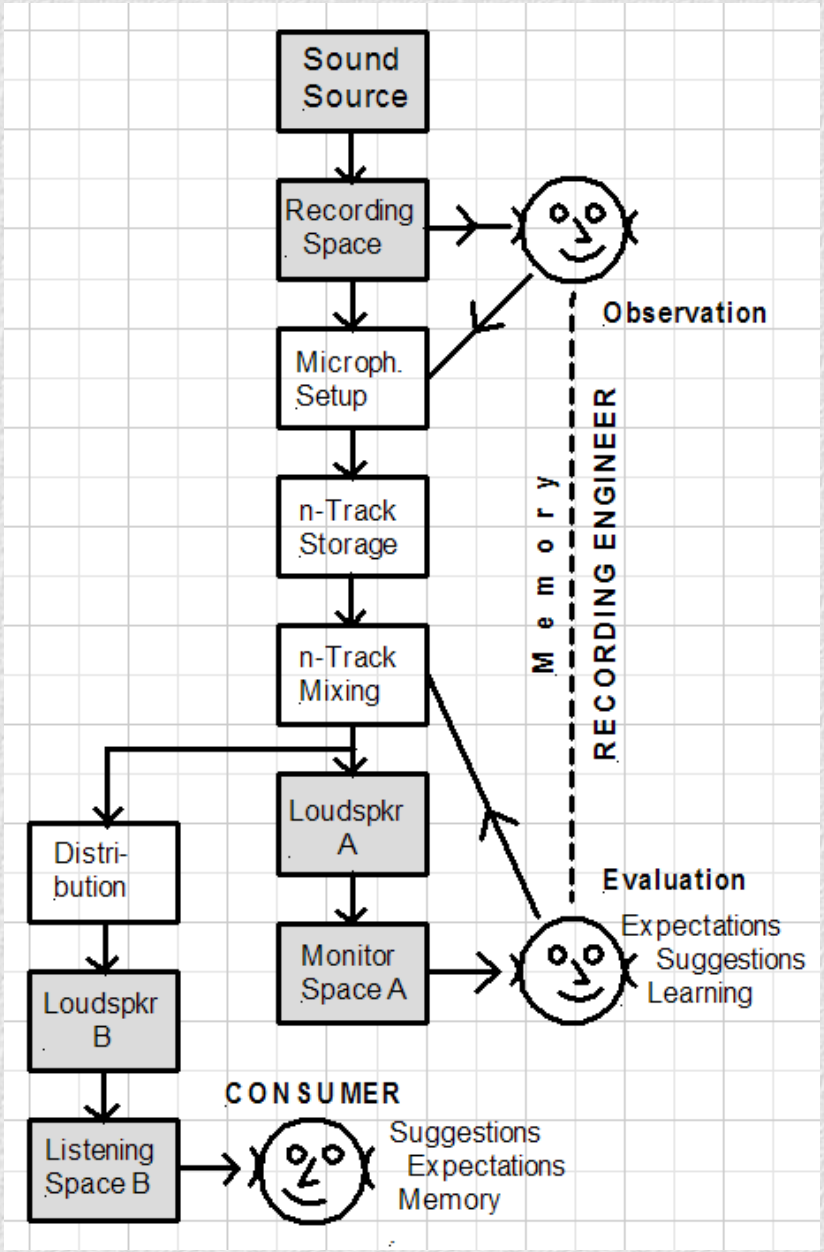
- Loudspeakers should be placed at least 1 m from the walls

- Loudspeakers and listener should be set up symmetrically relative to adjacent room boundaries

- The loudspeaker is far more problematic than the room in creating a believable auditory illusion

Recording as heard live

- The critical role of the monitor loudspeaker
- The potential for a "Circle of Confusion"



Thank you for your attention

QUESTIONS?

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