Reverb Design
acoustical & aesthetical Concepts

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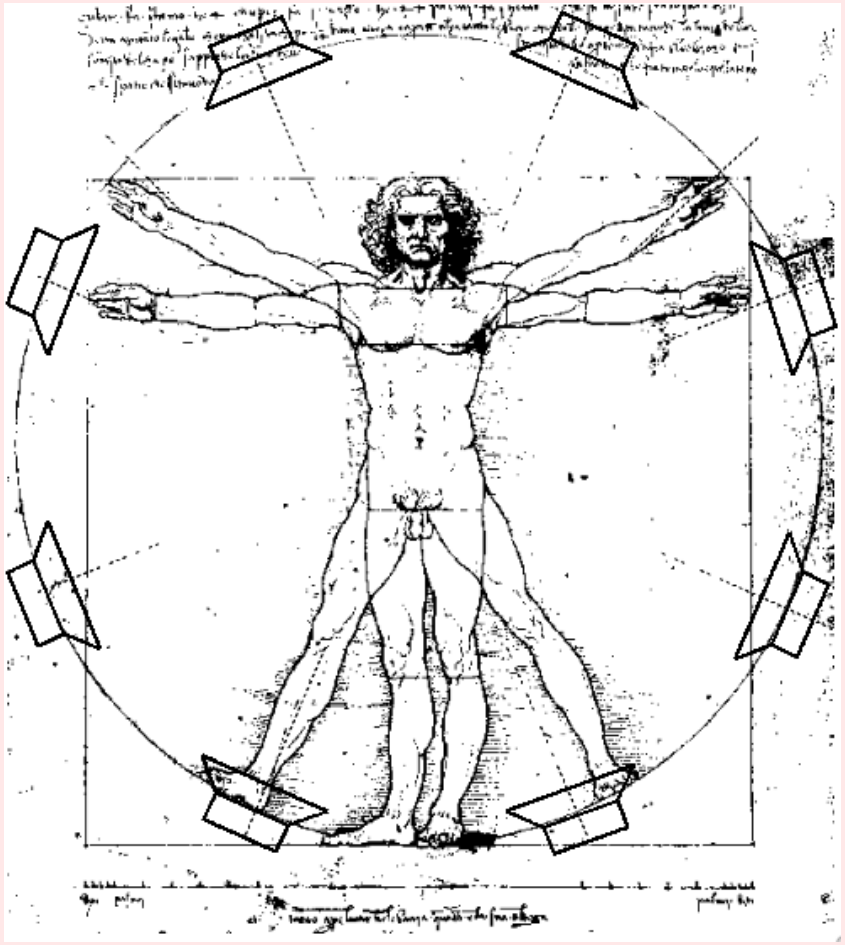
Reverb Design: An Interdisciplinary Topic

Acoustics

DSP Design

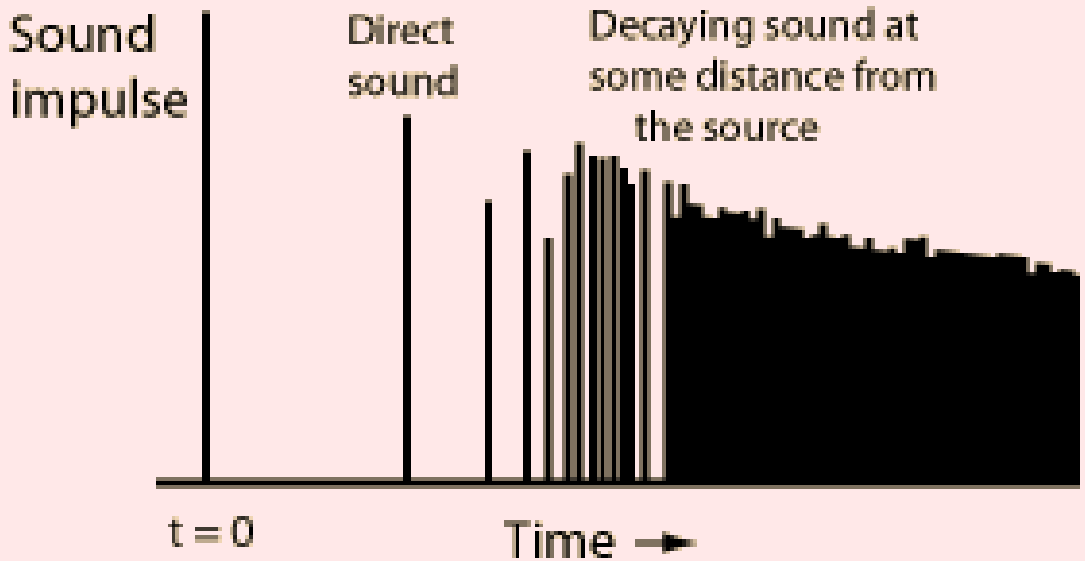


Human Perception

Recording Practice

Human Perception: Multimodal and Cognitive Aspects

- McGurk effect
- Cocktailparty effect
- The "irrelevant sound effect"
- Precedence effect



Perceptual approach: Auditory Scene Analyses

Bregman (1990)

- Auditory events are grouped into perceptional streams based on similarity

Implications for Reverb Design

- early echos are copies of direct sound
- late reverb sounds like decaying noise for impulsive sounds
- pure tones + the slow onset (eg. organ): late reverb still resembles direct sound

- *At least two perceptional streams evolve from reverberation.*

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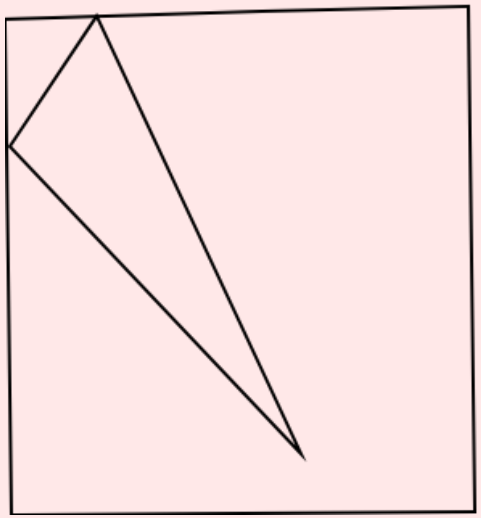
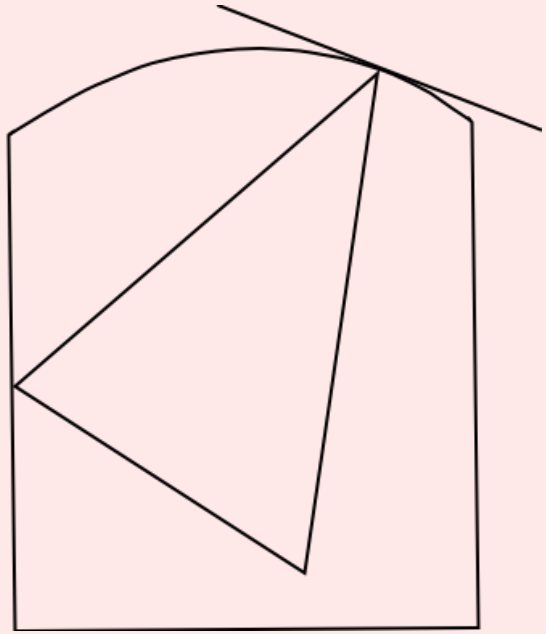
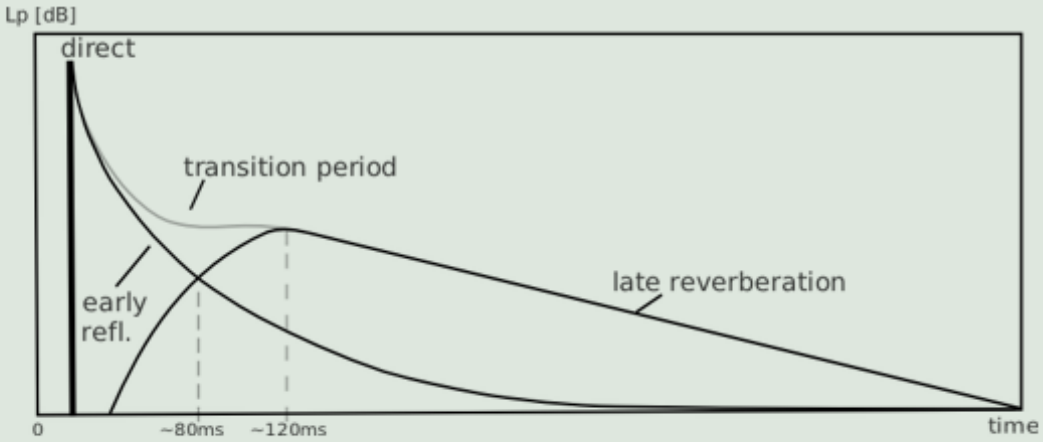
Salient properties of good sounding concert halls

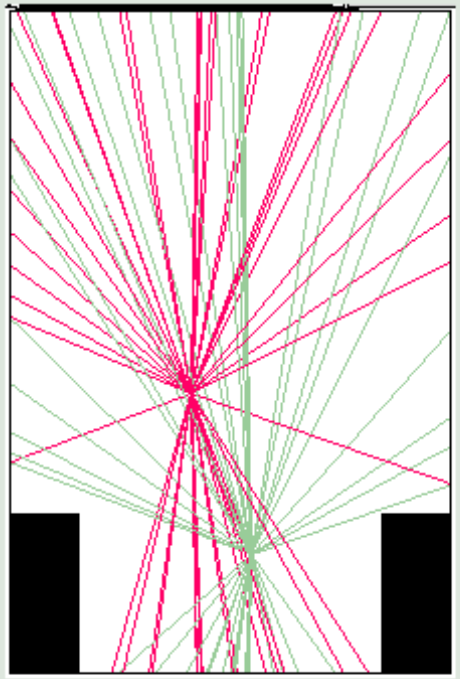
- stage housing with convex front, medium structures (organ)
- concave ceiling, small structures
- balcony overhangs, columns
- balcony in the rear of the hall acts like a "bass trap" or diffusor for very low frequencies





Early Reflections: Spacial & Temporal Distribution





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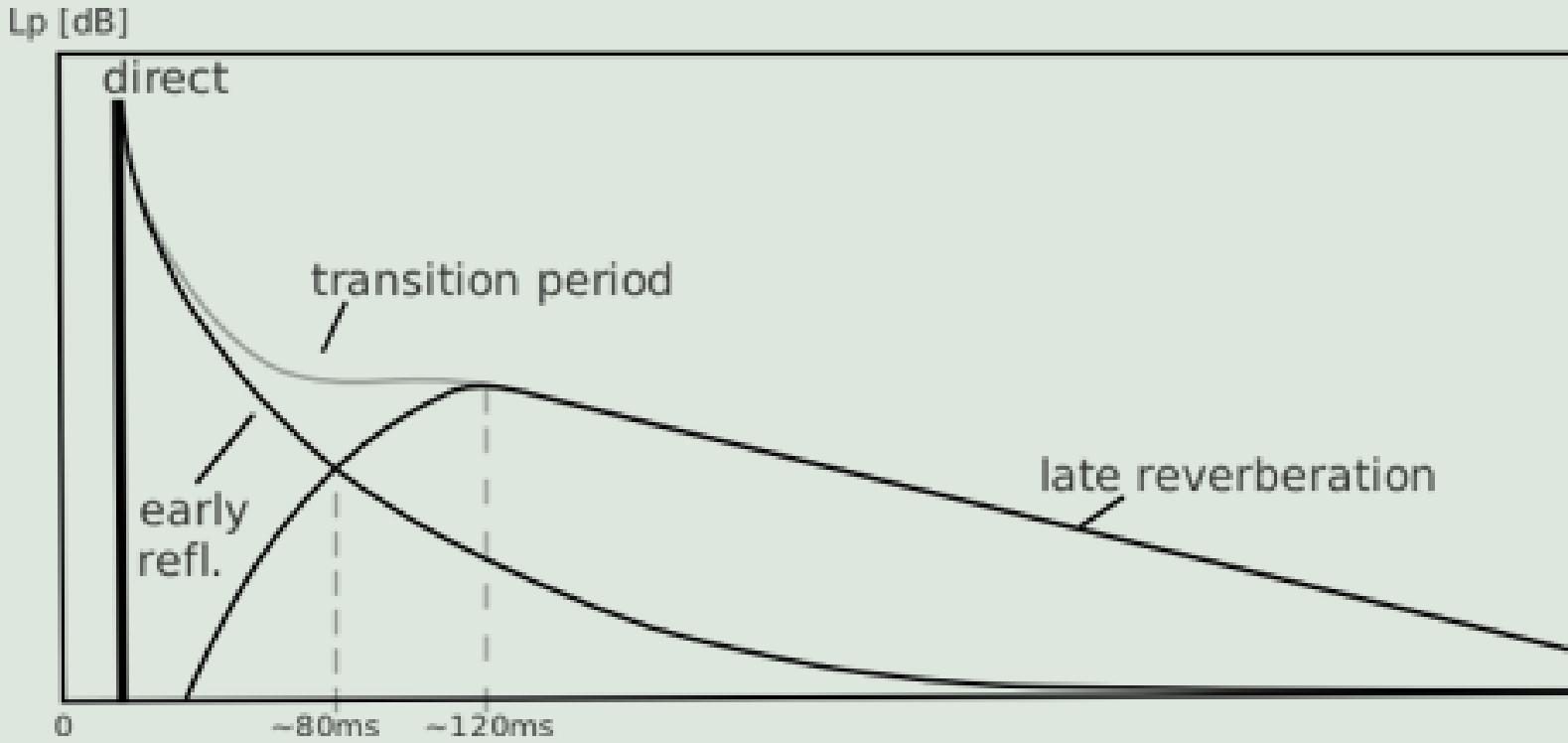


ER Simulation: Directivity and Time Variance

- Bad news: directivity seems to be a perceived attribute (Ottondo 2005)

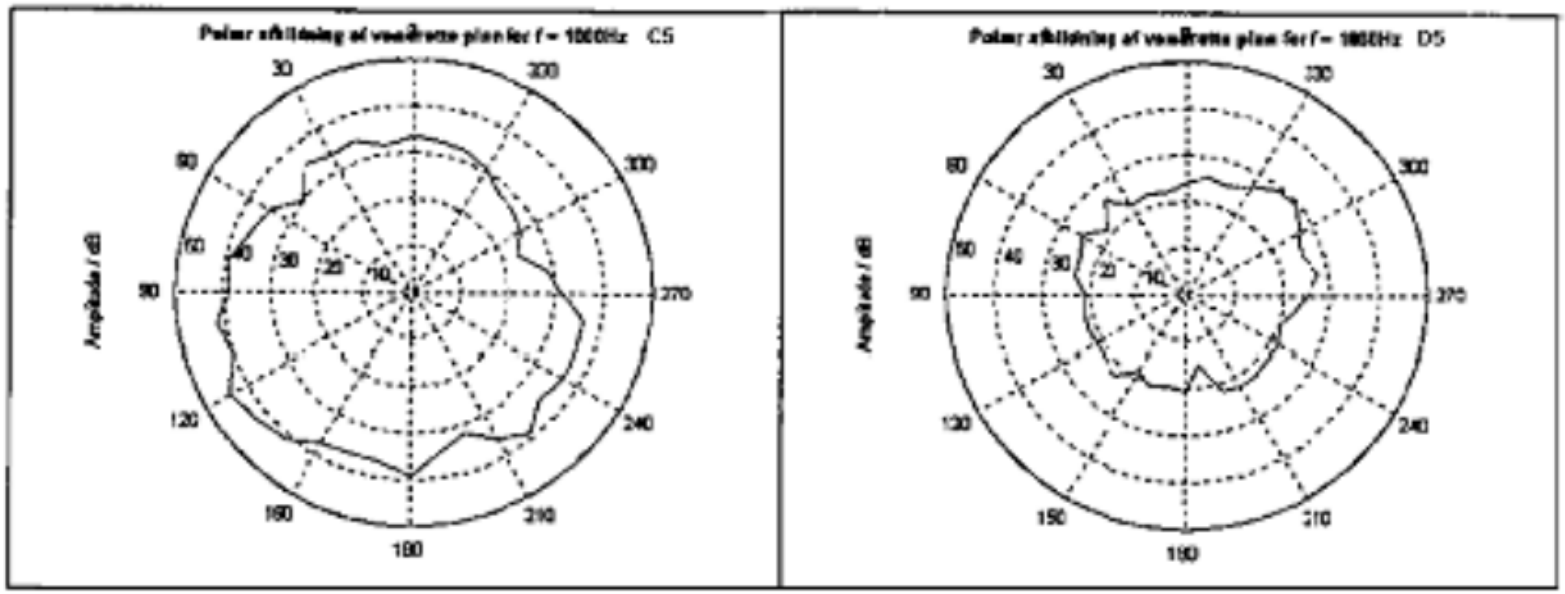
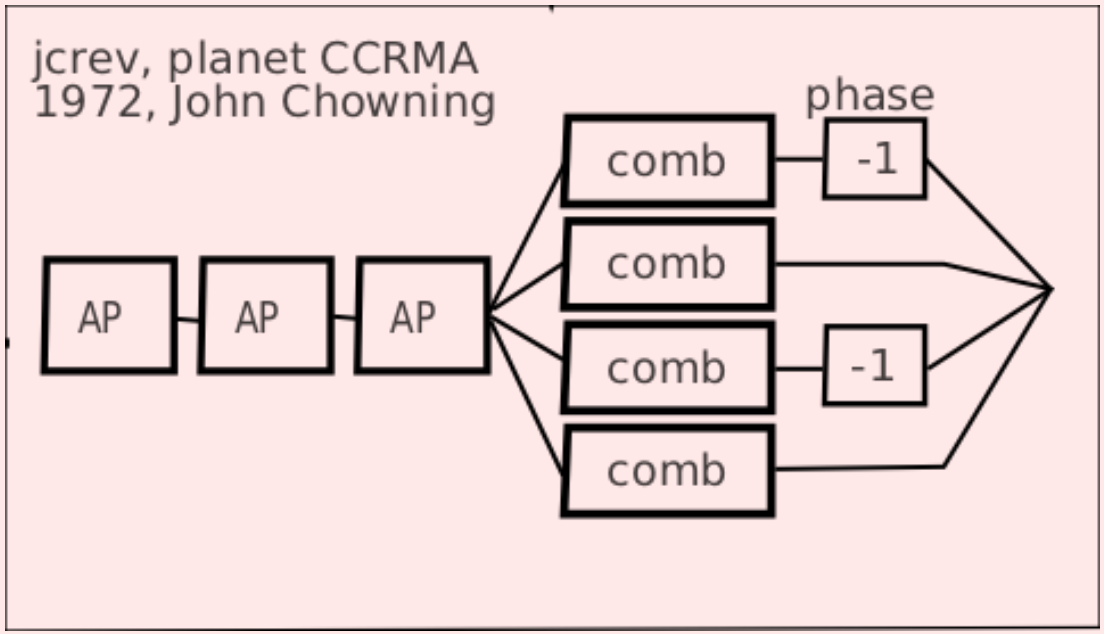


Figure 1 Polar diagram for 1000 Hz of an alto saxophone playing a C5 (left) and a D5 (right).

- Good news: any difference in frequency response will do (Schlemmer 2006)

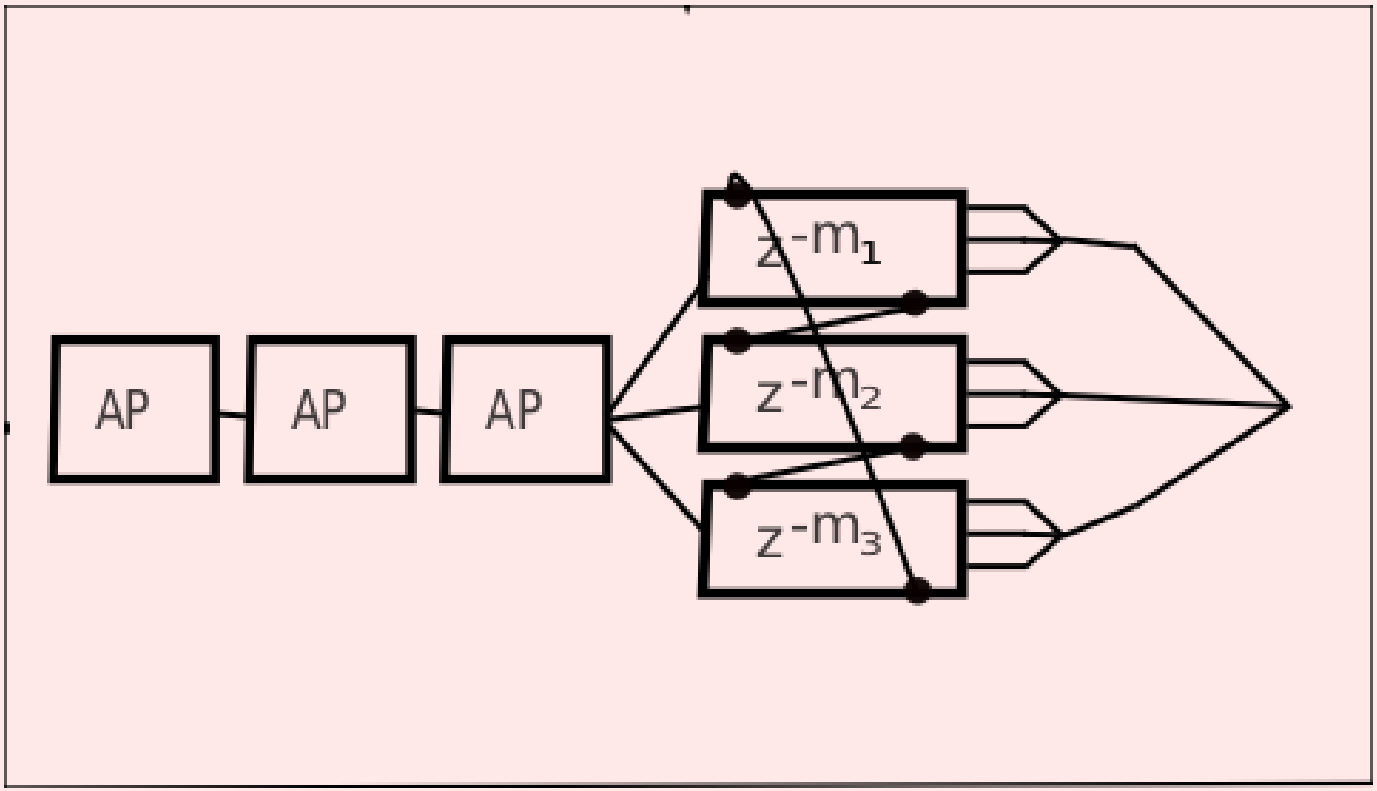
Evolution of diffuse algorithms: Schroeder's "Natural sounding artificial reverberation"

- Schroeder describes two fundamental different techniques: nested structures...
- ...and this one:



Evolution of algorithms: EMT250

- looks like a tapped delay line, but in fact it's a simple FDN



Feedback Delay Networks

- Gerzon (1969): energy preserving matrixes. Puckette: efficient implementation for n^2 delay lines in PD

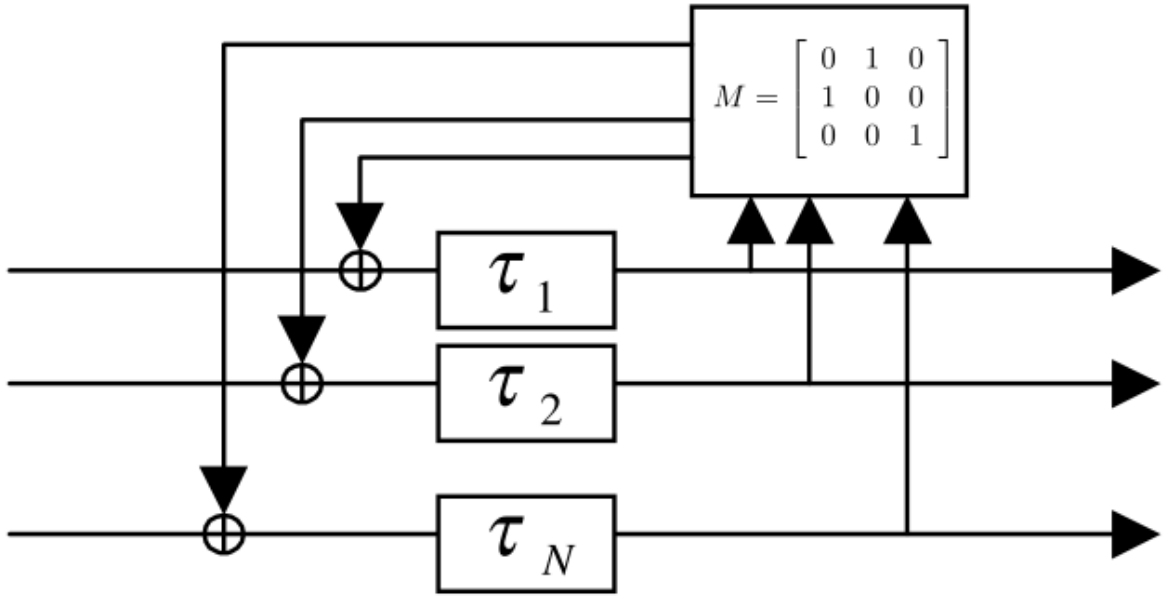
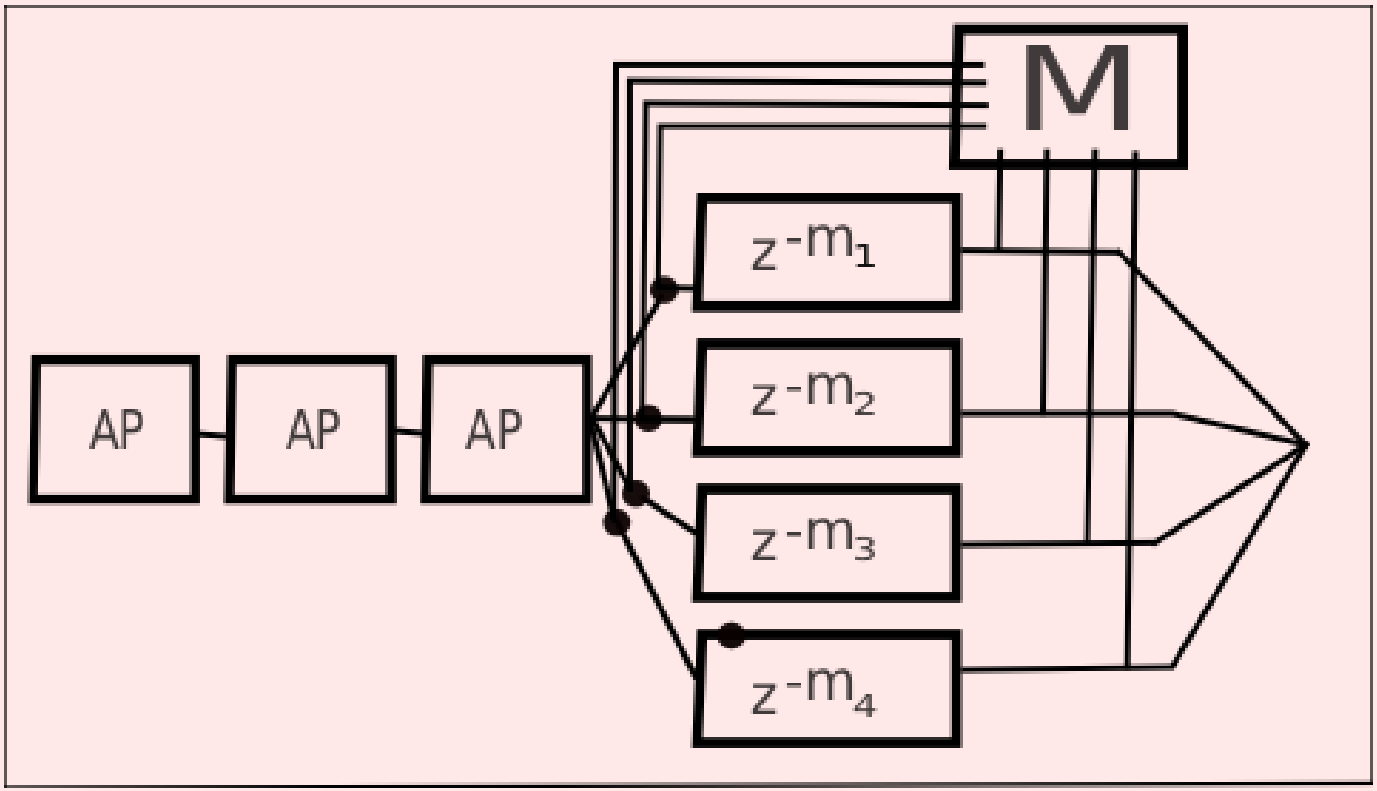


Figure 1. *'Feedback Delay Network' (FDN) topology*

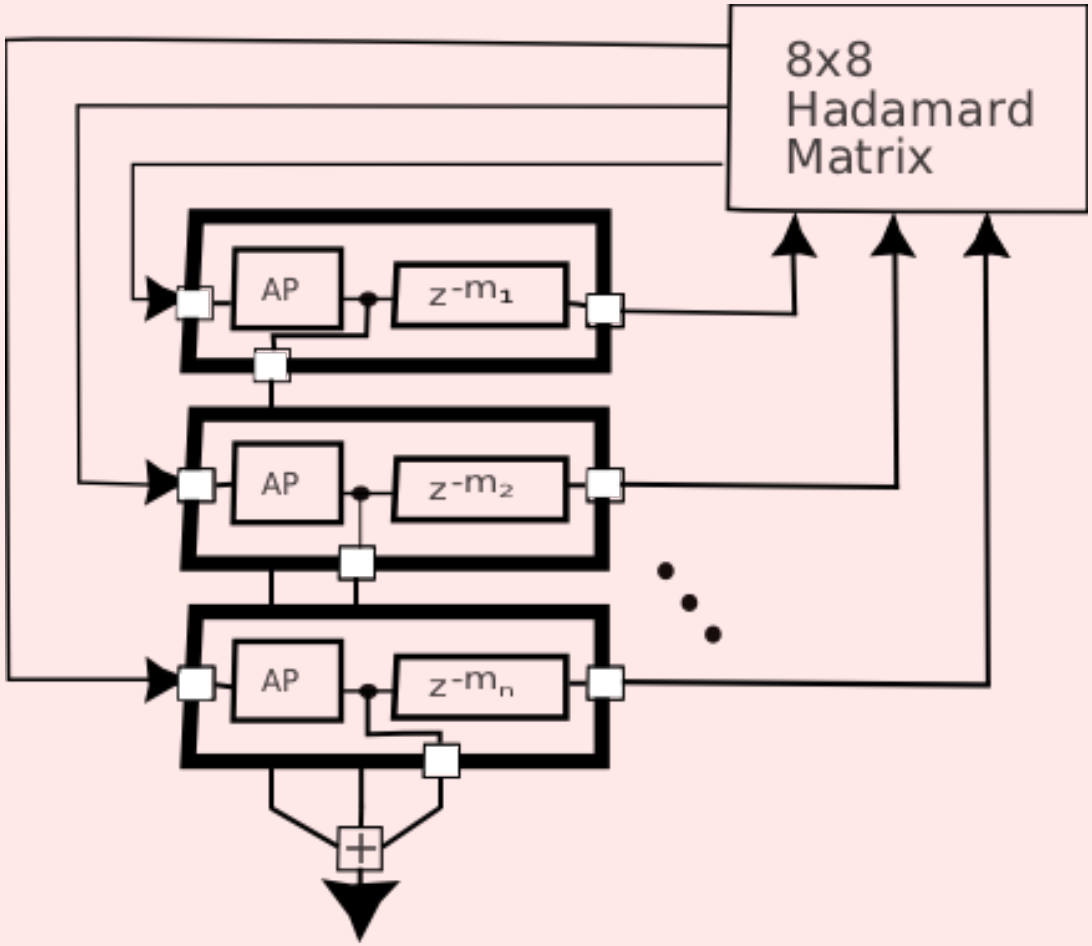
Evolution of algorithms: g2reverb

- Author: Fons Adriaensen. High quality reverb for large spaces.



Evolution of algorithms: zita reverb

- Author: Fons Adriaensen. High quality reverb developed for the church organ simulator "aeolus".



Another Approach: nested series-allpasses

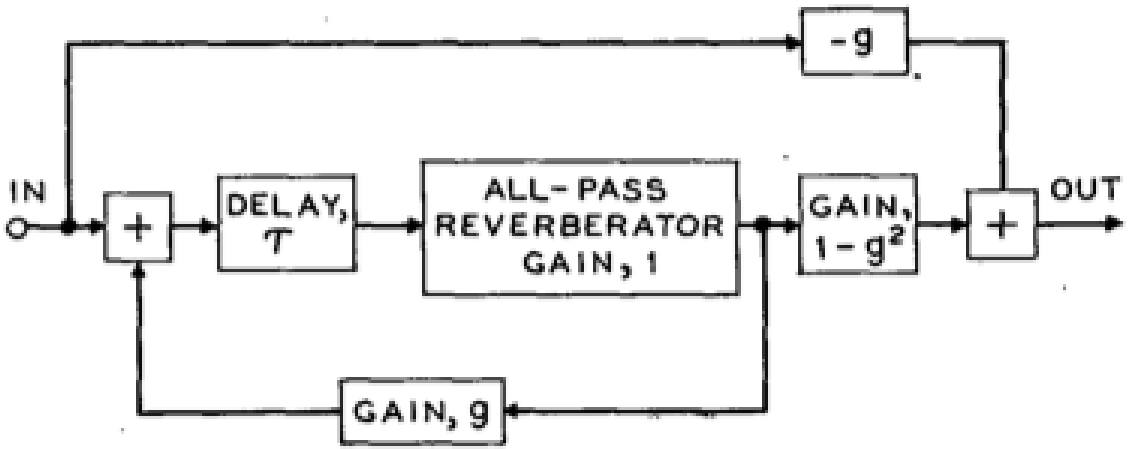
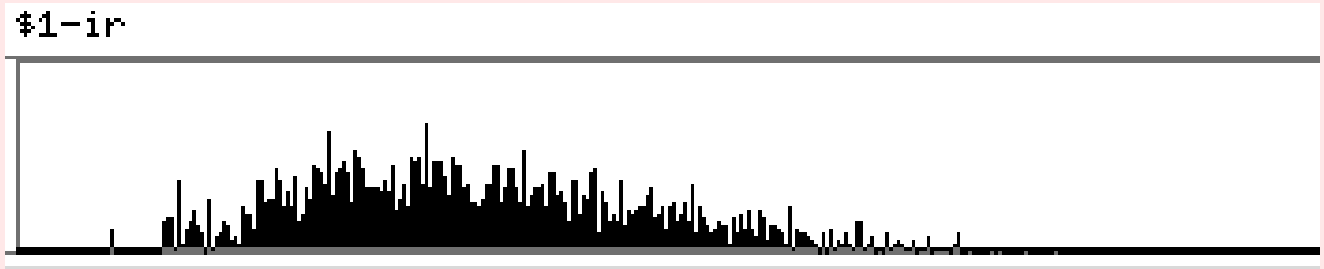


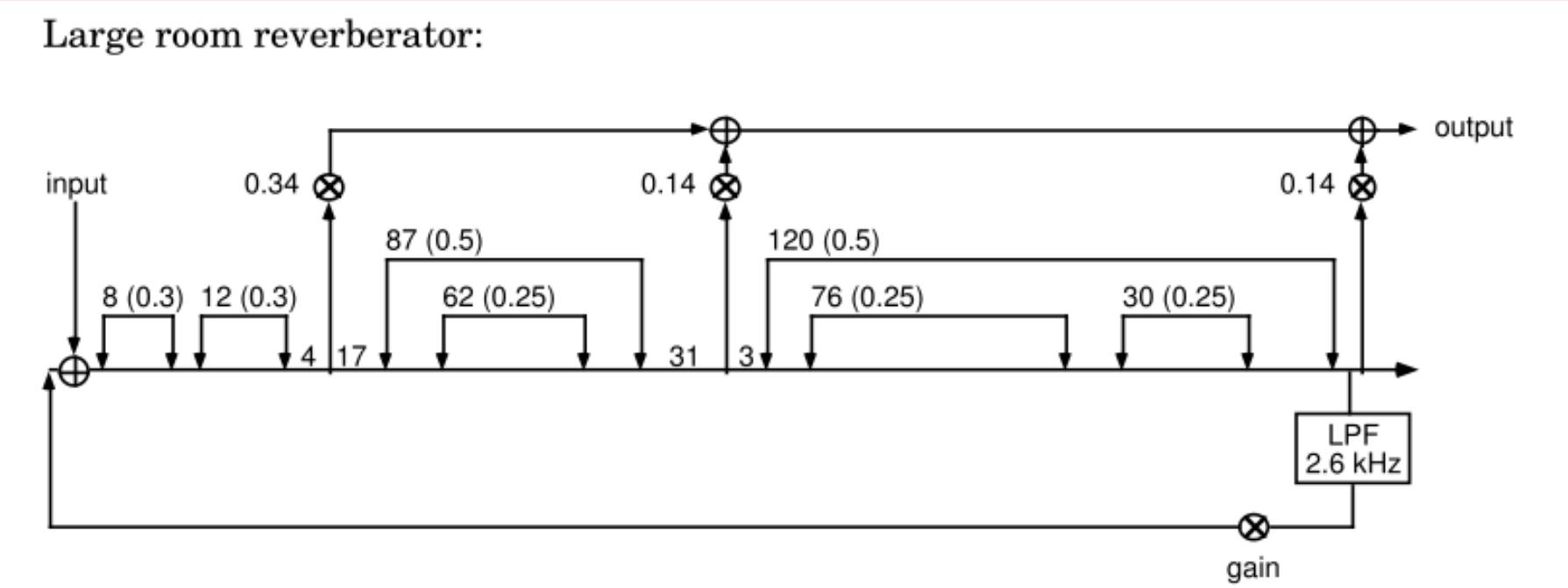
FIG. 5. All-pass reverberator with variable ratio of direct-to-reverberated sound. It produces a non-exponential decay of the reverberated sound.

- Schroeder: Response can become quite "gaussian"



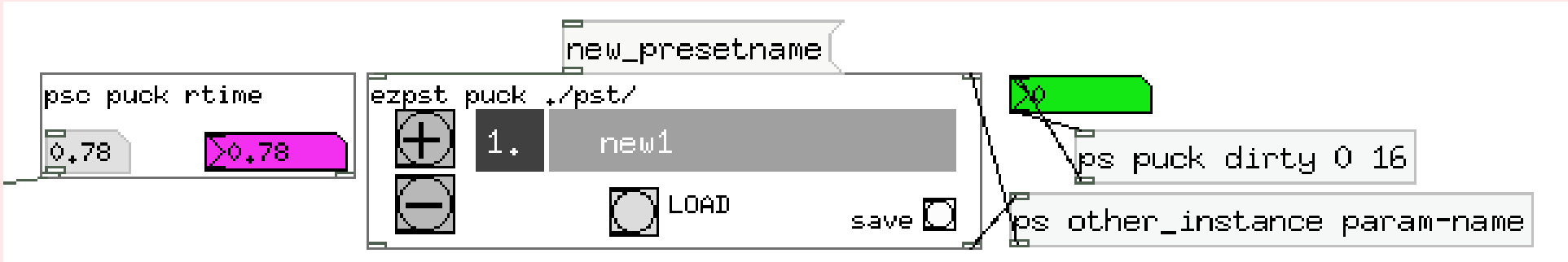
Shaping of late reverberation: A practical example

- W.G. Gardner: a virtual acoustic room with a decent character



- Jot and Dattorro proposed quite similar designs
- Griessinger mentiones the work of Gardner explicitly
- Cross-coupling of stereo channels is used for further improvement
- Pirilae et. al (DAFX98): non-exponential decays

Implementation in PD: preset management



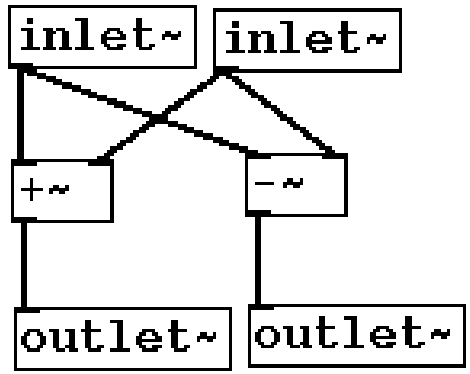
- jack integrates multi-track mixer software (Muse): fully usable reverb including total recall
- some externals adapted and developed in FAUST
- preset management: inspired by pp from Pluggo. Can manage instances of its own. Supports parameter scaling and modulation. Simple to use. Reliable.

Implementation of Feedback Matrixes in PD

$$H = 0.707 \begin{bmatrix} 0 & 1 & 1 & 0 \\ -1 & 0 & 0 & -1 \\ 1 & 0 & 0 & -1 \\ 0 & -1 & 1 & 0 \end{bmatrix}$$

$$A = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

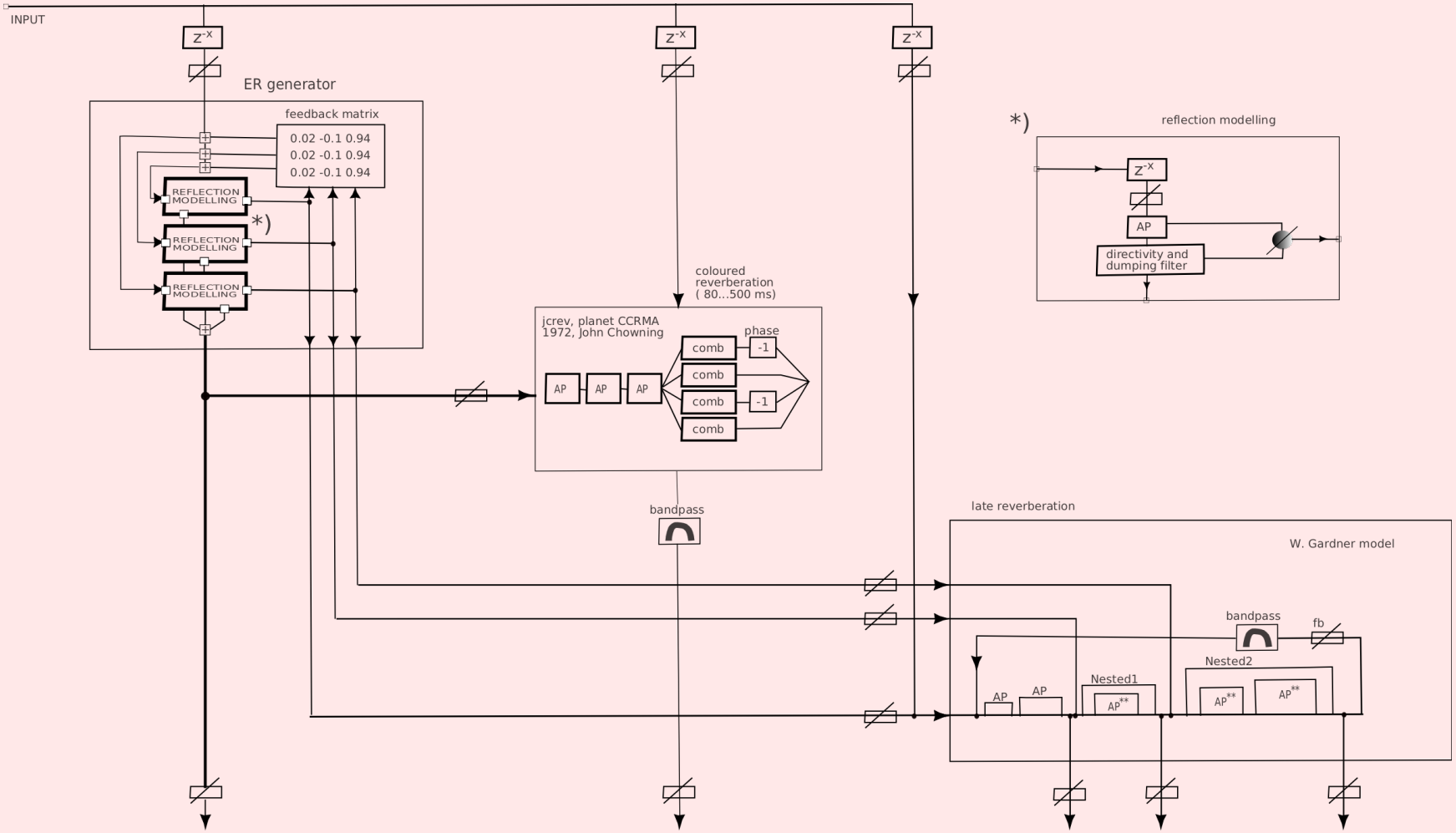
$$B = \frac{1}{3} \begin{bmatrix} 2 & -2 & 1 \\ 1 & 2 & 2 \\ 2 & 1 & -2 \end{bmatrix}$$



- higher order matrixes are defined by recursive embedding, e.g:

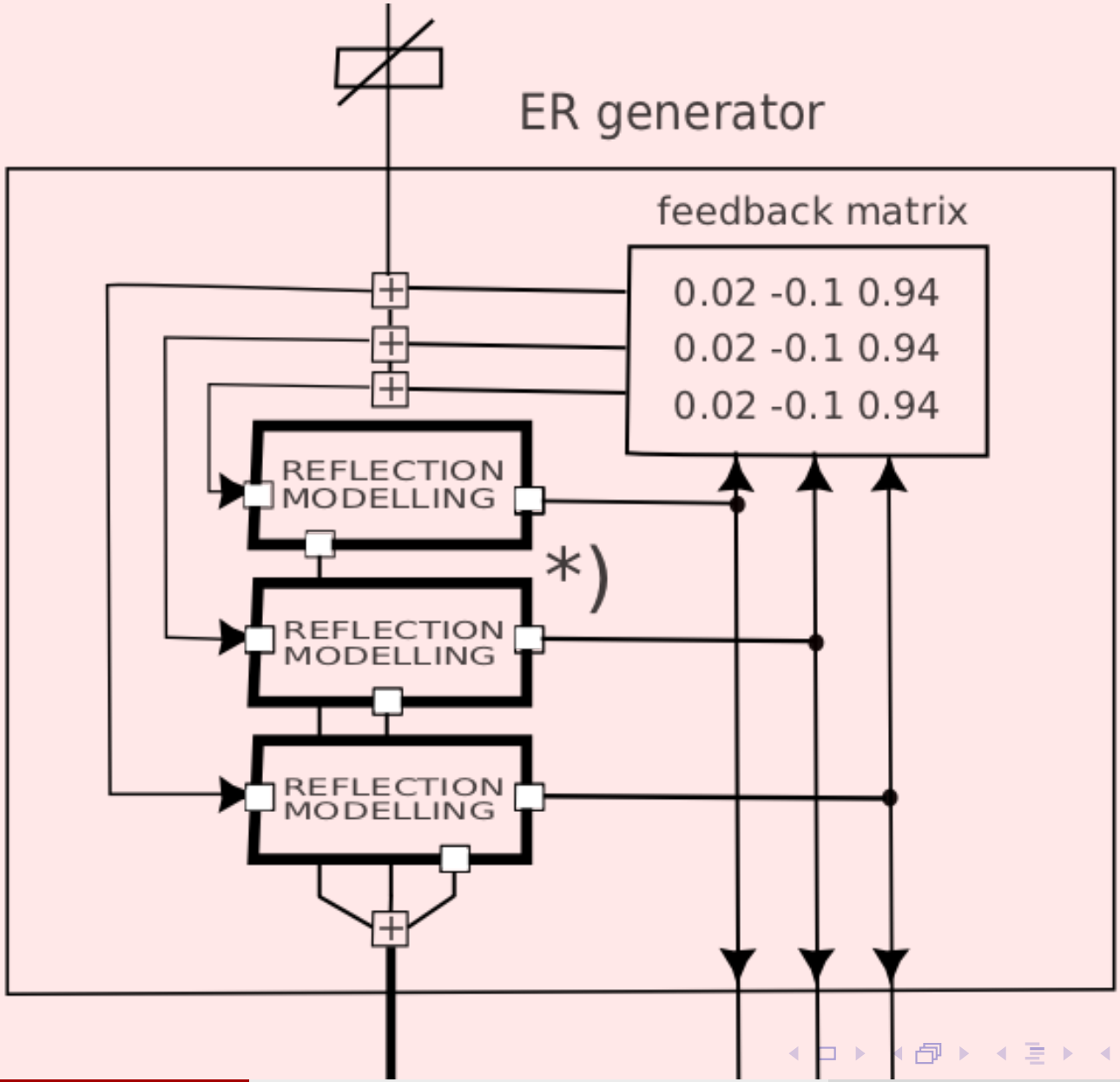
$$H = 0.707 \begin{bmatrix} A & A \\ -A & A \end{bmatrix}$$

Multistream design & Modulation



- control of onset and amplitude response

Multistream design & Modulation



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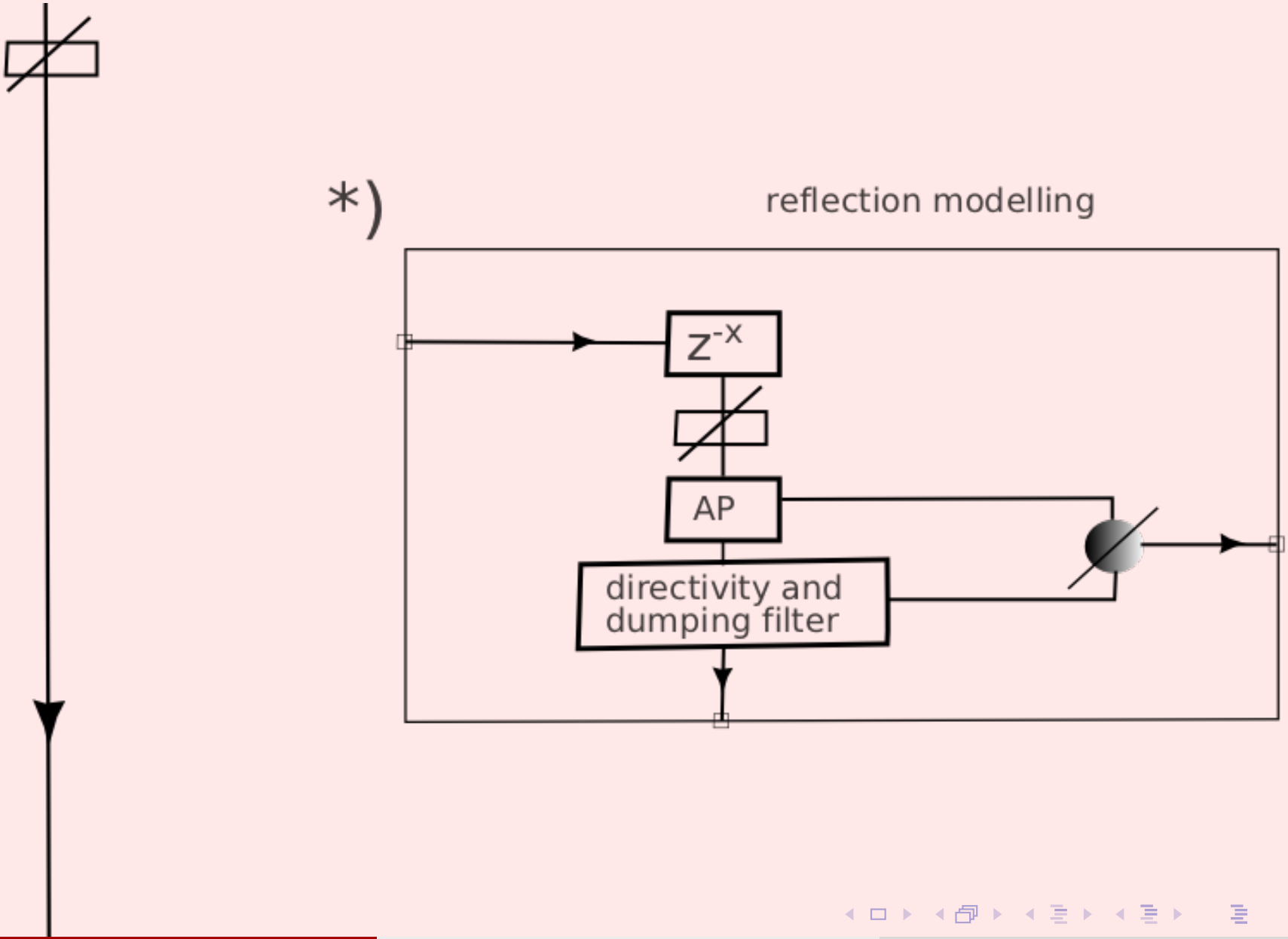
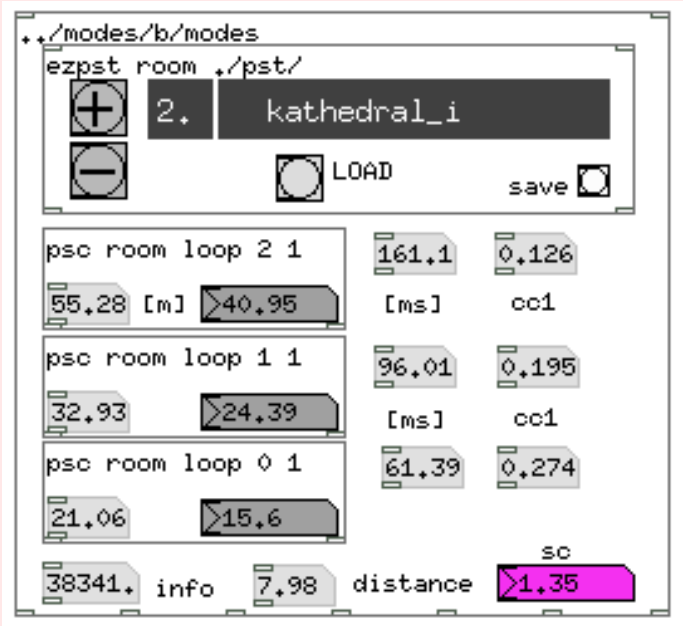
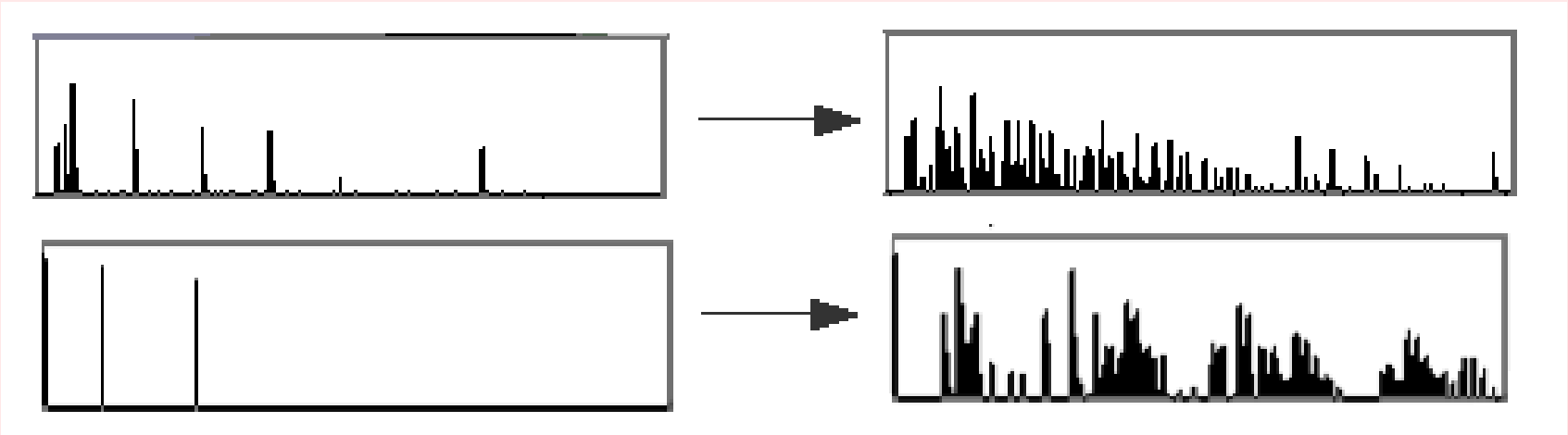


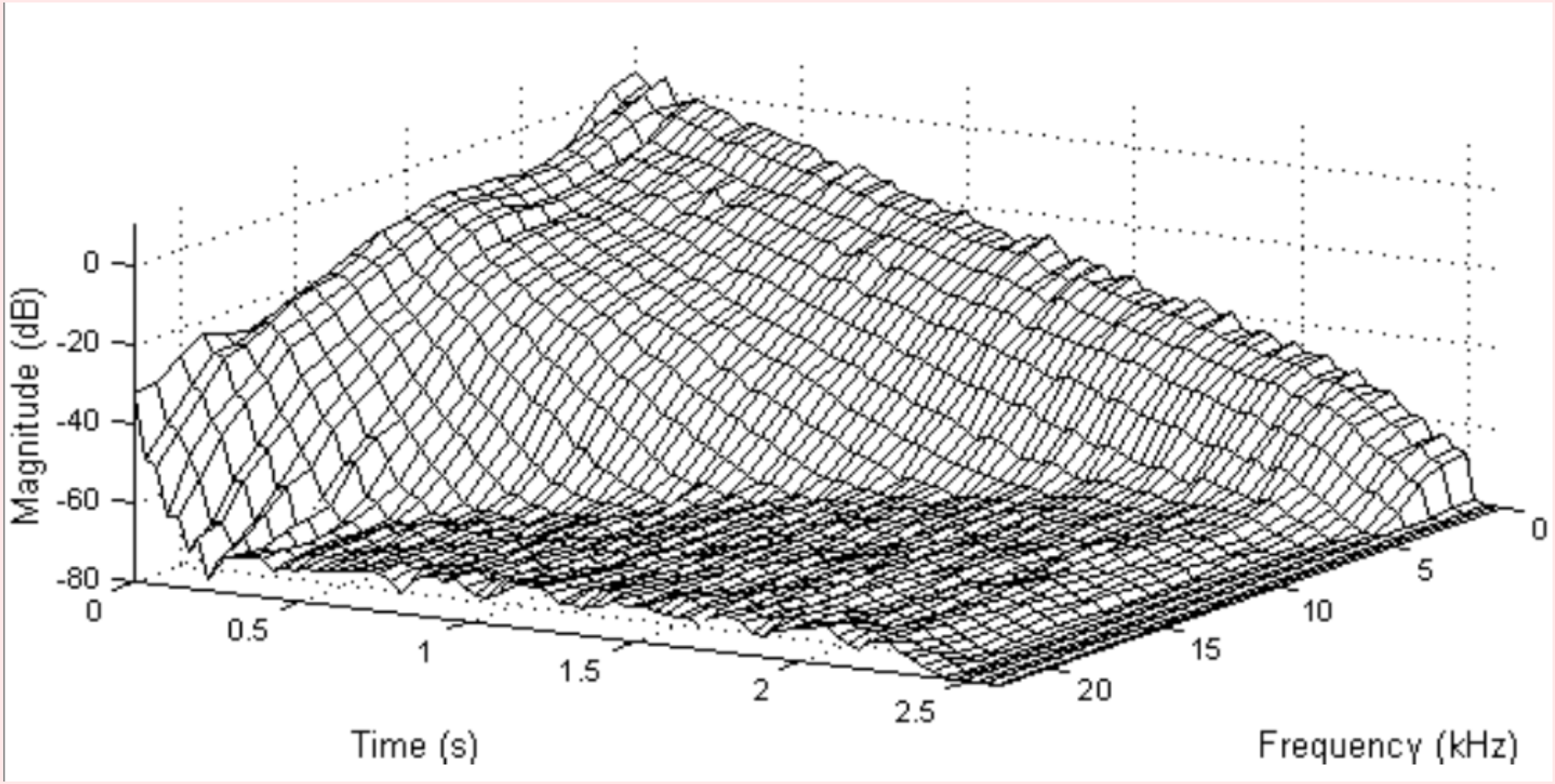
Early reflection generation





Ways to introduce losses

- Use of phase cancelations, as opposed to loss-filters



Pittfalls, Tipps & Tricks

- Intensitiy-pan of ER between speakers?
- ... exeption: fast moving sources
- random chorus for additional diffusivity
- good sounding and bad sounding spots
- spacing of delays: mutually prime, algorithmic or "real" proportions?
- aligning delay length and feedback: the distance cue

Future Work

- optimize CPU usage
- build a USB controller for the device (prob. NXP-LPC176x based)
- build analogue circuitry for filters and phase shifters
- embed into hardware