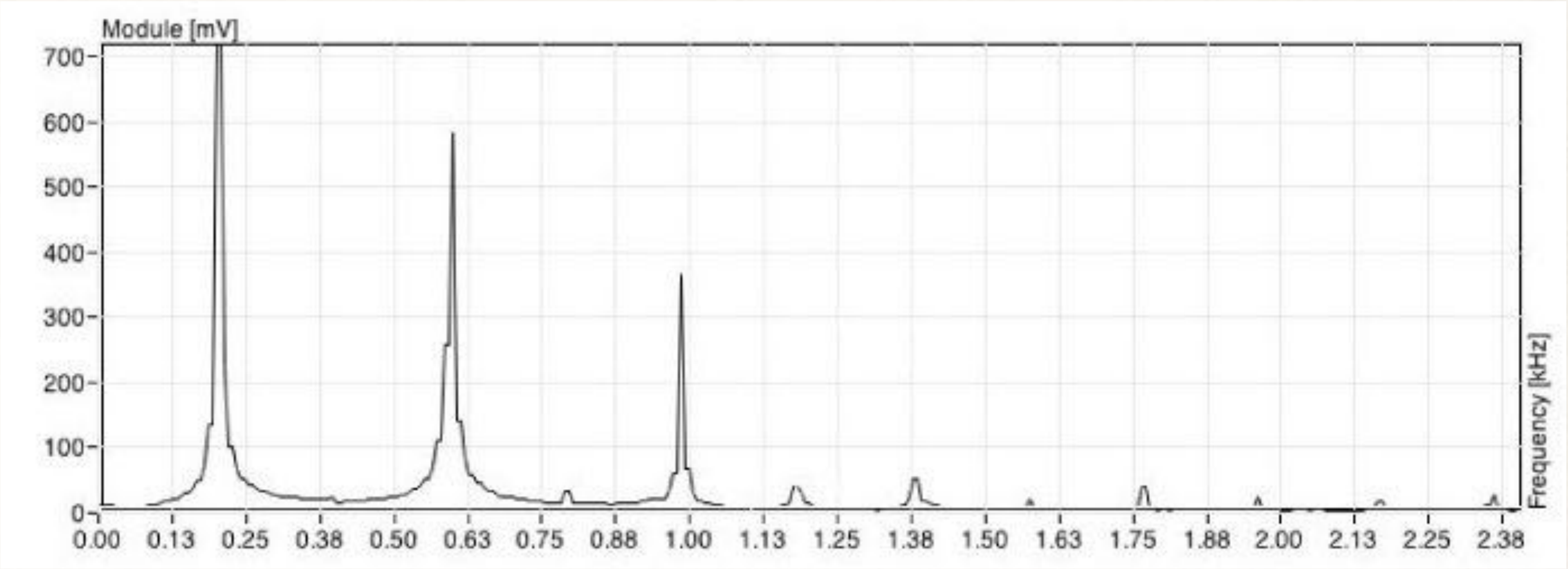
Software 2 WS 2016 #12

Chikashi Miyama

Additive Analysis/Resynthesis

Rekonstruktion eines Spektrum mit Additive Synthese

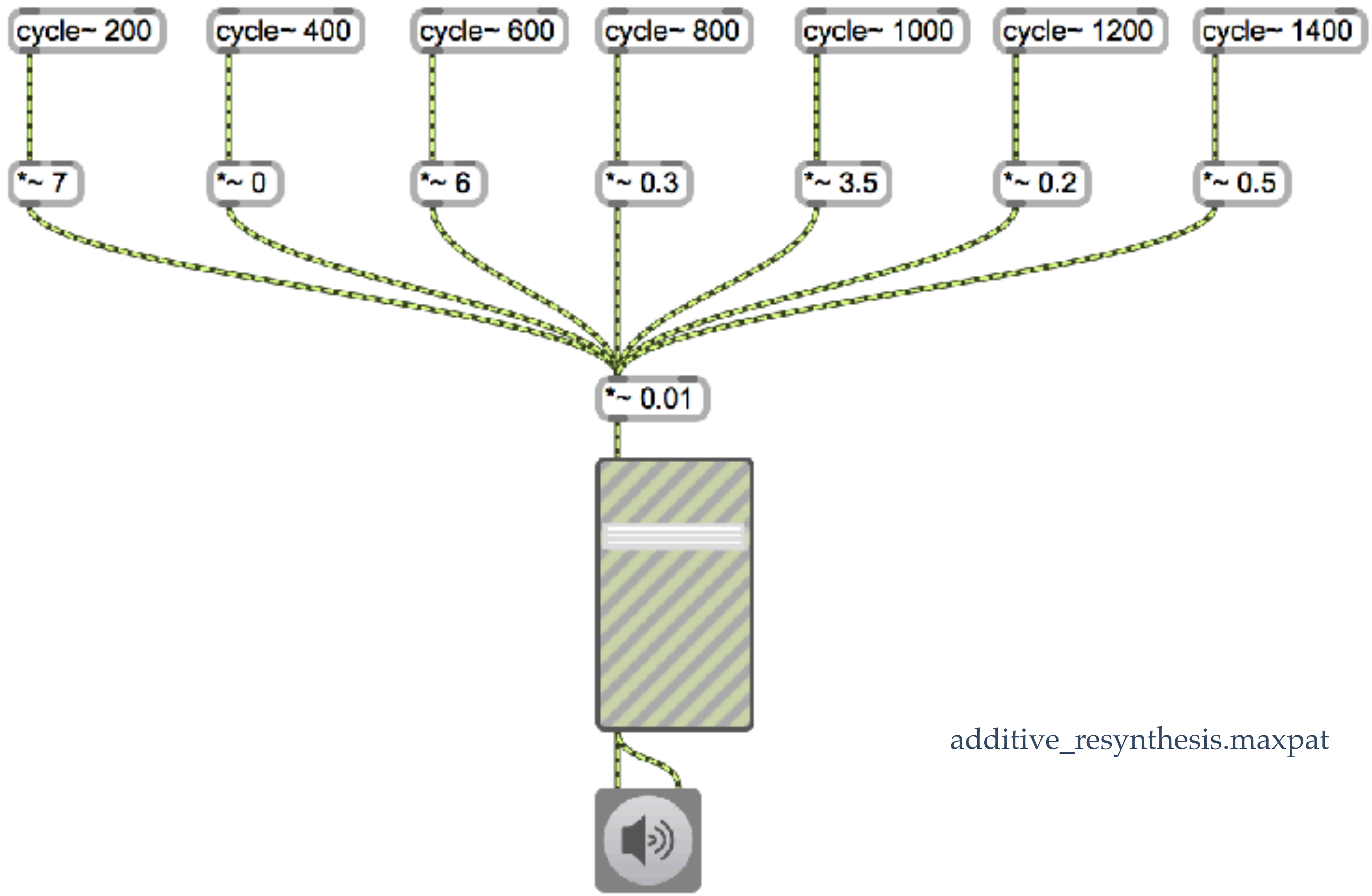


200 Hz Karinette

Rekonstruktion eines Spektrum mit Additive-Synthese

Oberton	Frequenz	Amplitude
Grund Ton	200	7
1	400	0
2	600	6
3	800	0.3
4	1000	3.5
5	1200	0.2
6	1400	0.5

Experiment mit Max



additive_resynthesis.maxpat

Analysis Resynthesis

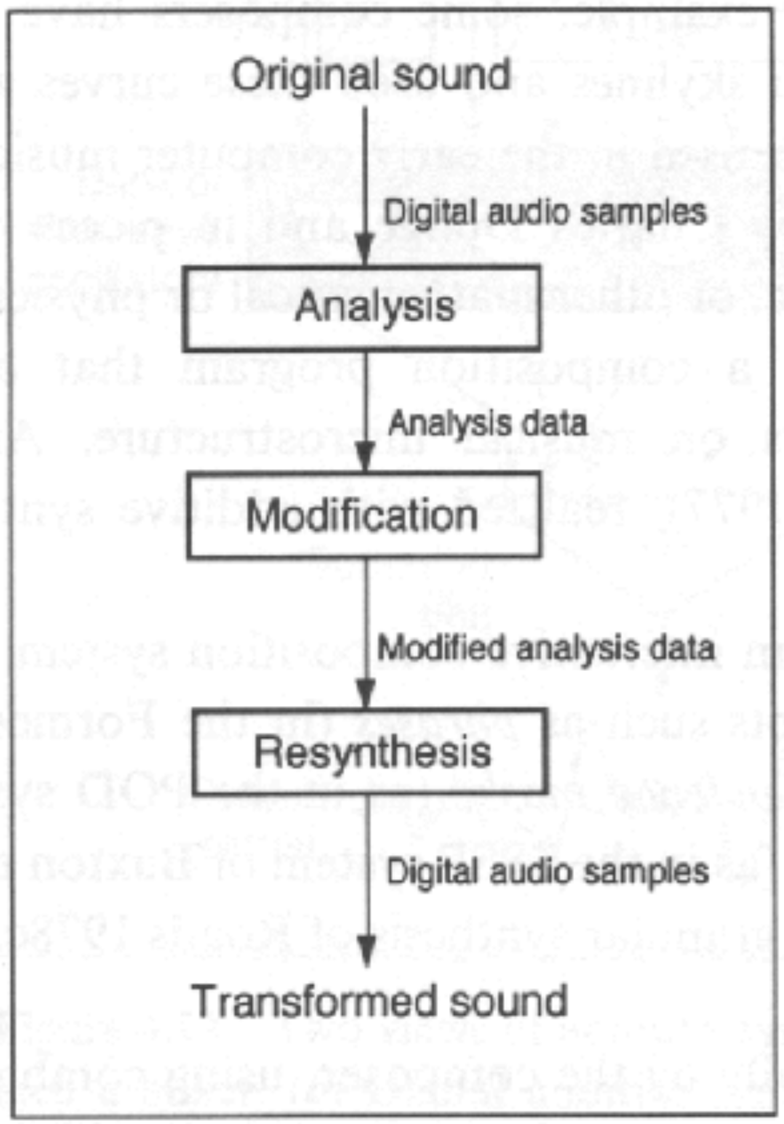
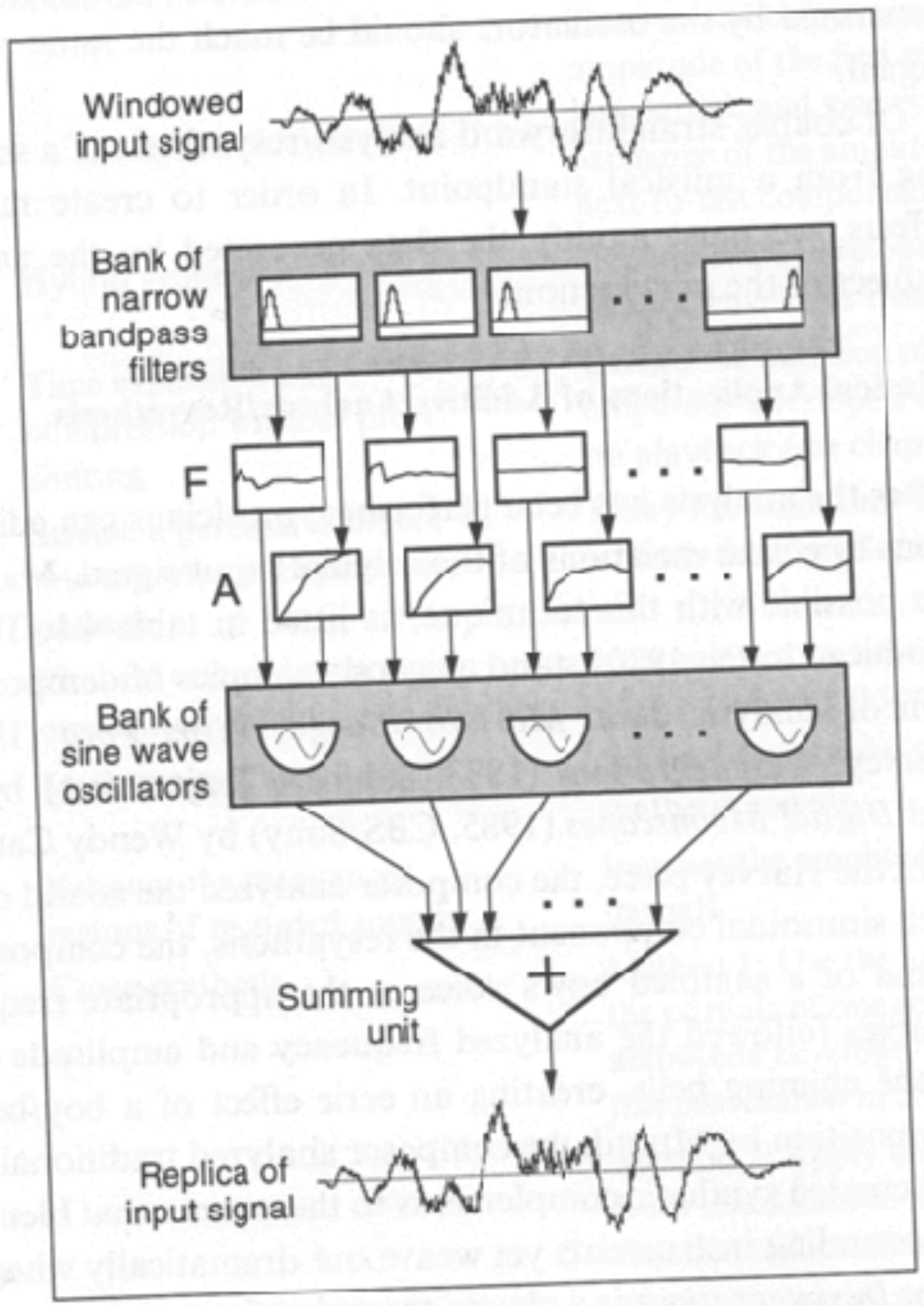
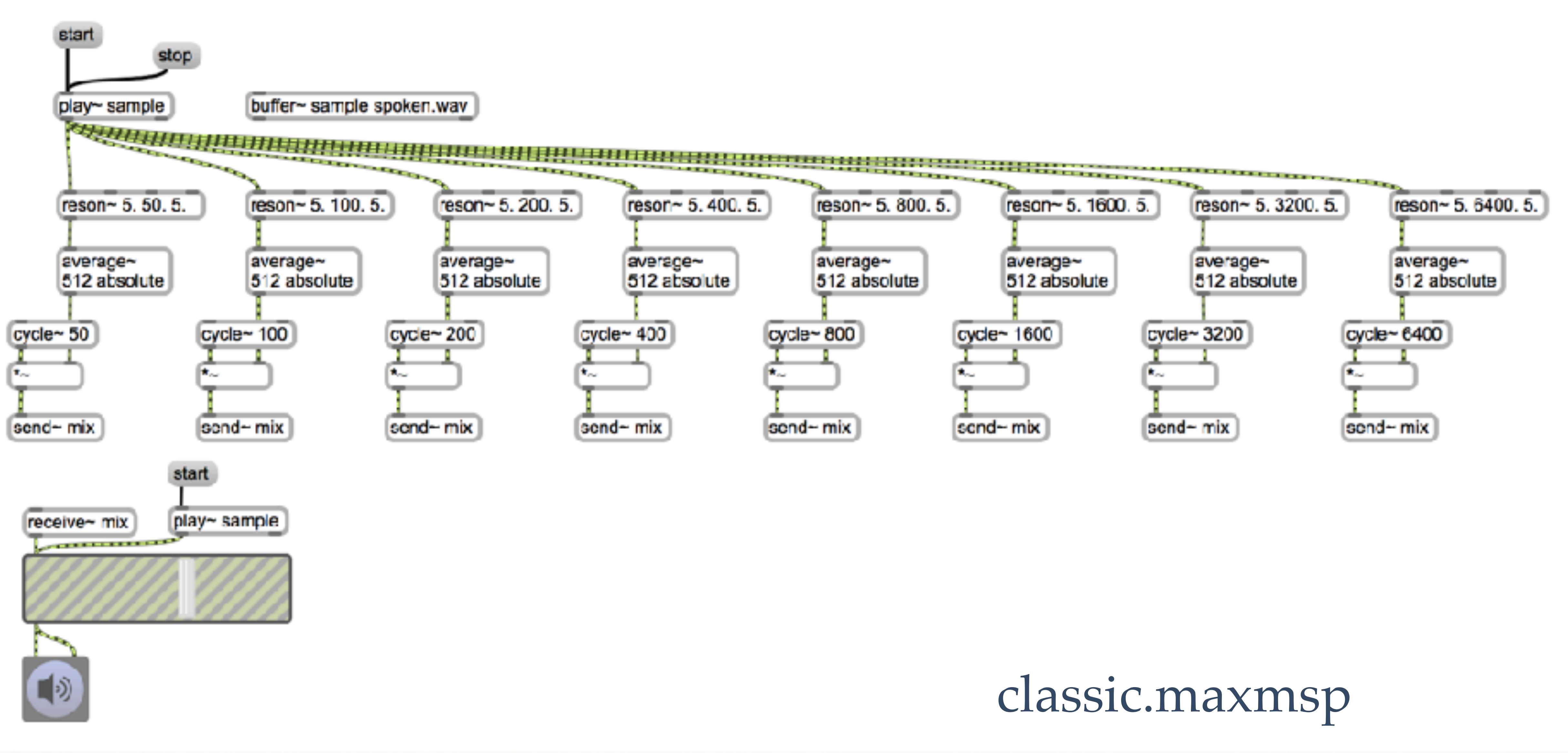


Figure 4.20 General overview of analysis/resynthesis. The modification stage may involve manual edits to the analysis data or modifications via *cross-synthesis* where the analysis data of one sound scale the analysis data from another sound.

Das klassische Modell

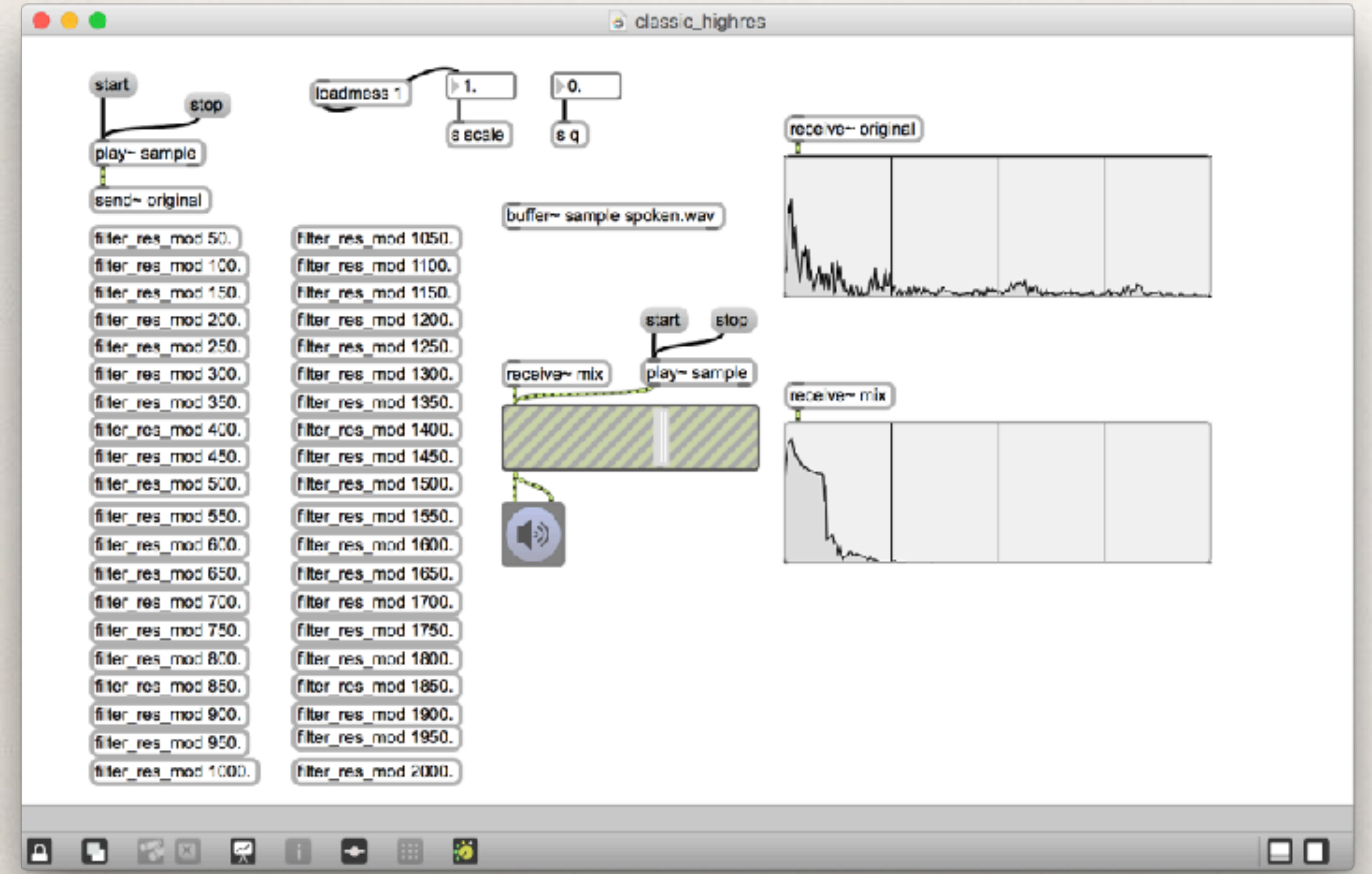


Experiment mit Max



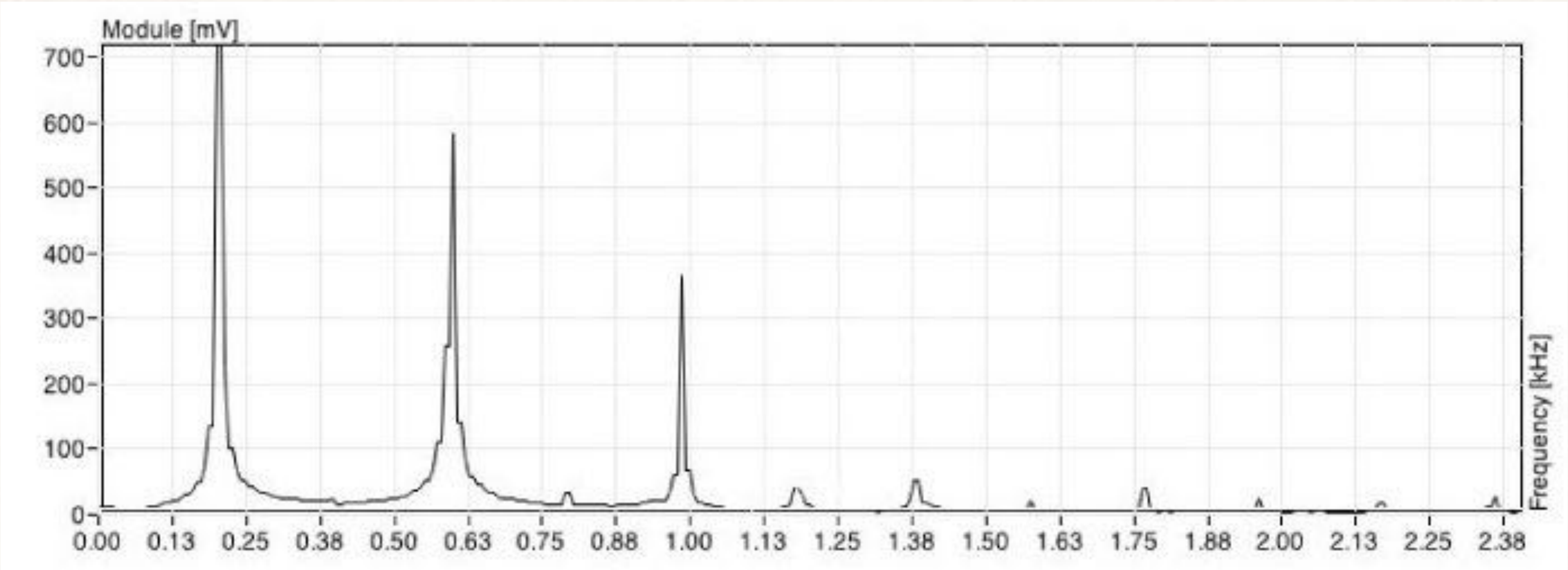
classic.maxmsp

Experiment mit Max



classic_highres.maxmsp

Sinusoidal Analysis



200 Hz
700 mV

600 Hz
590 mV

1000 Hz /
380

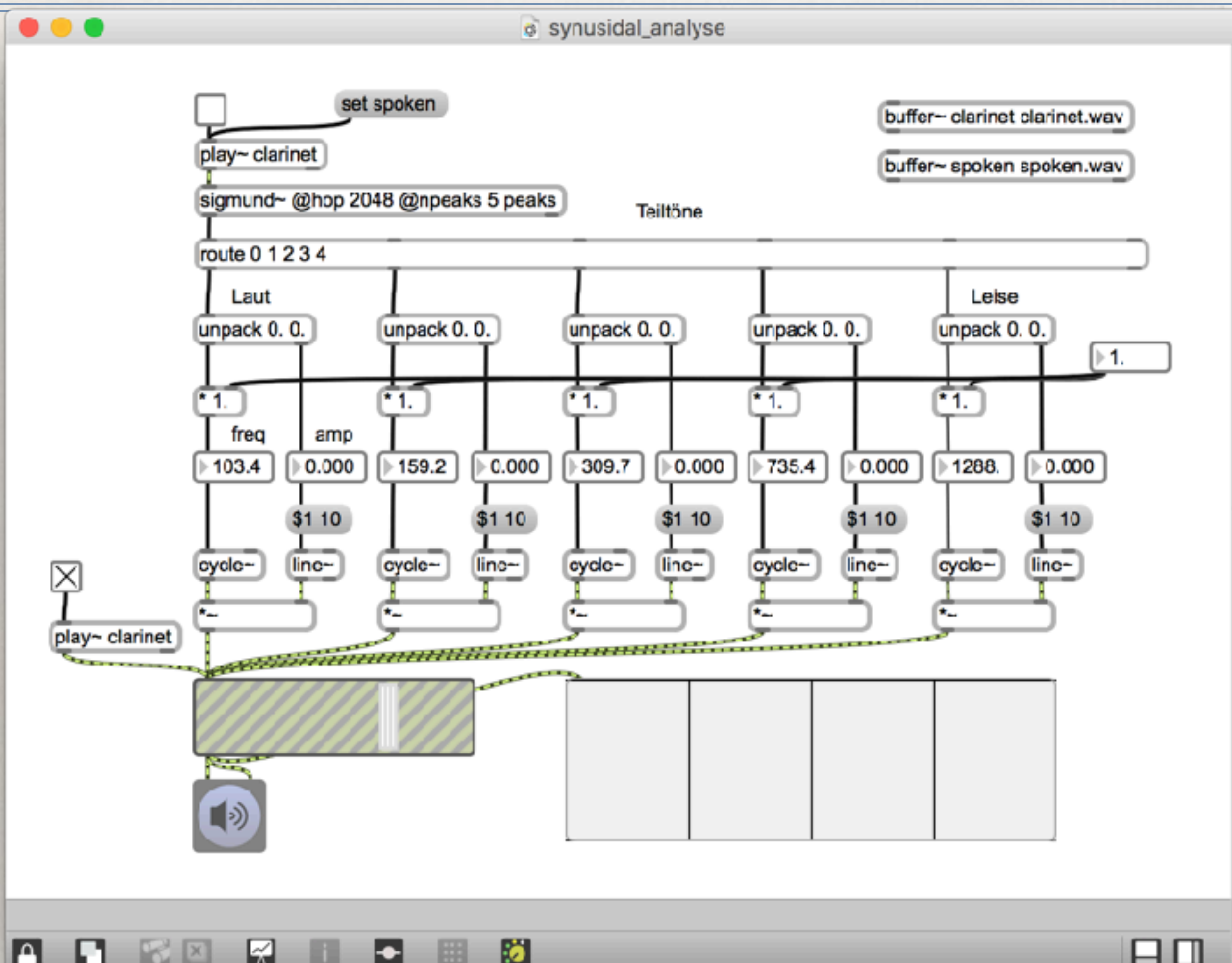
osc 1
200 Hz

osc 2
600 Hz

osc 3
1000 Hz

Resynth

Sinusoidal Analysis



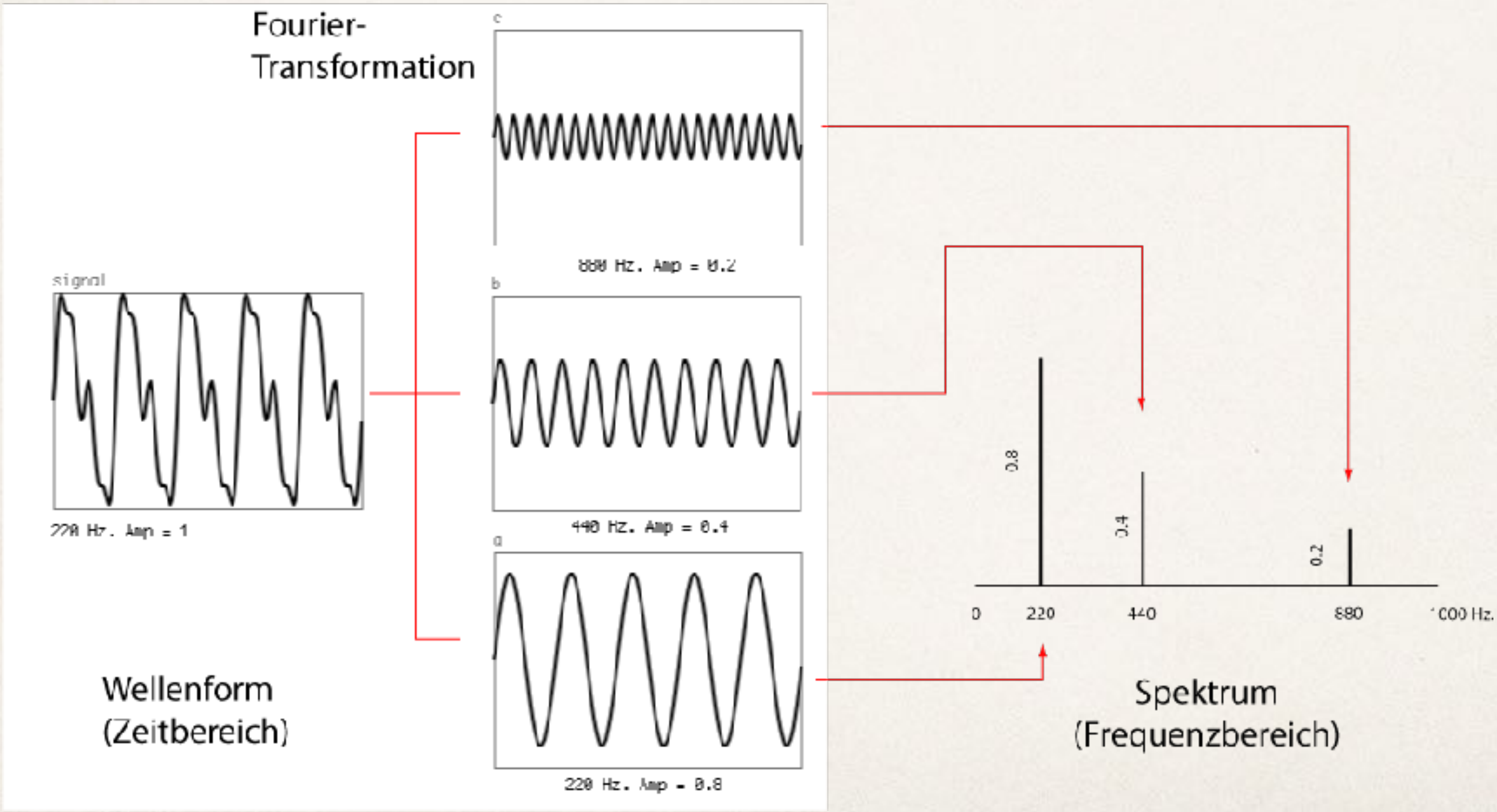
sinusoidal analysis

Joseph Fourier

ein französischer Mathematiker und Physiker. Mit der Fourieranalyse legte er einen Grundstein für den Fortschritt der modernen Physik und Technik.

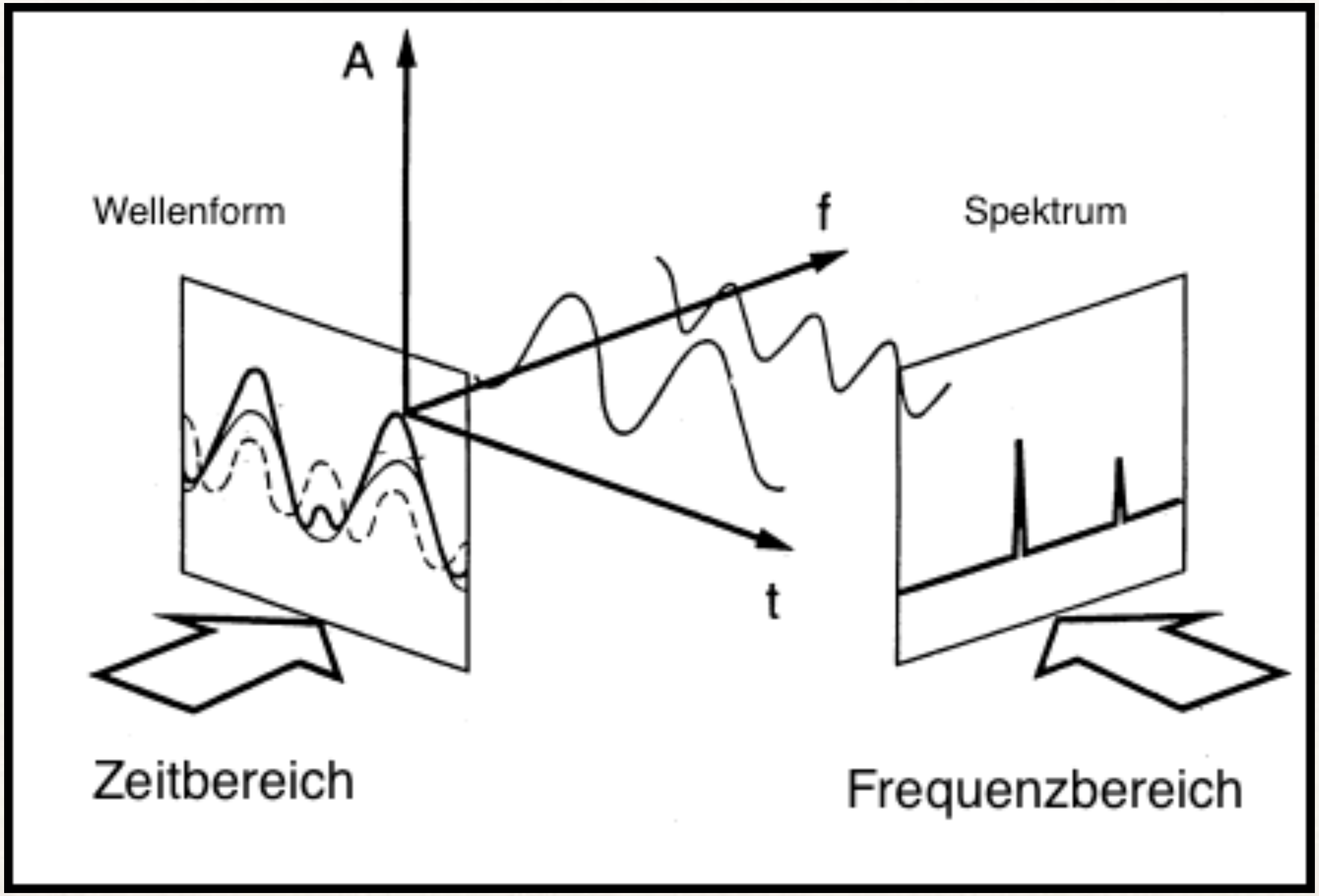
Er entdeckte: ein periodisches Signal lässt sich durch Überlagerung von sinus- bzw. kosinusförmigen Teilschwingungen unterschiedlicher Frequenz und Amplitude erzeugen.

FT

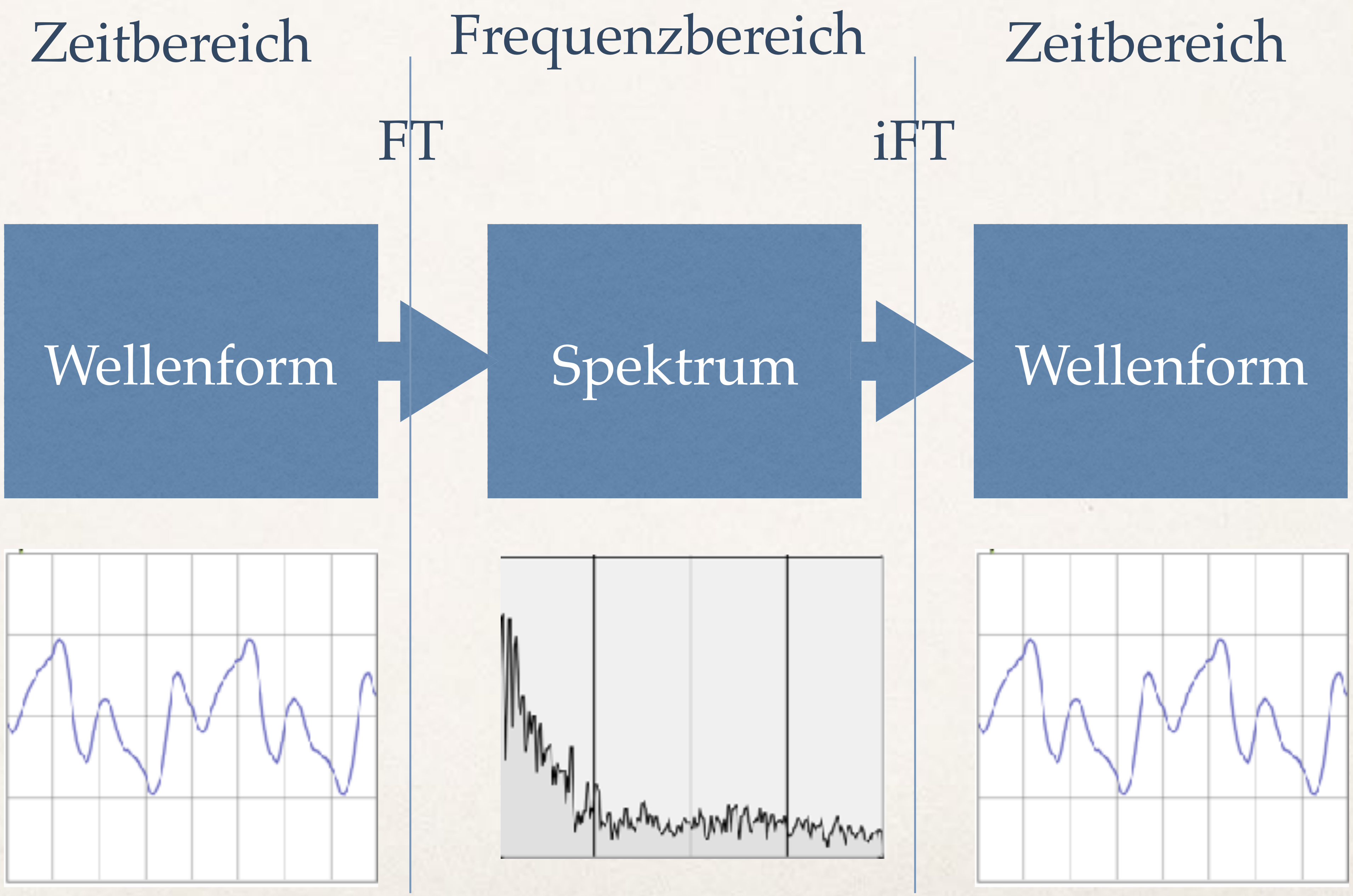


Fourier-
Transformation
signal
220 Hz. Amp = 1
880 Hz. Amp = 0.2
440 Hz. Amp = 0.4
220 Hz. Amp = 0.8
Wellenform
(Zeitbereich)
0.8
0.4
0.2
0
220
440
880
1000 Hz.
Spektrum
(Frequenzbereich)

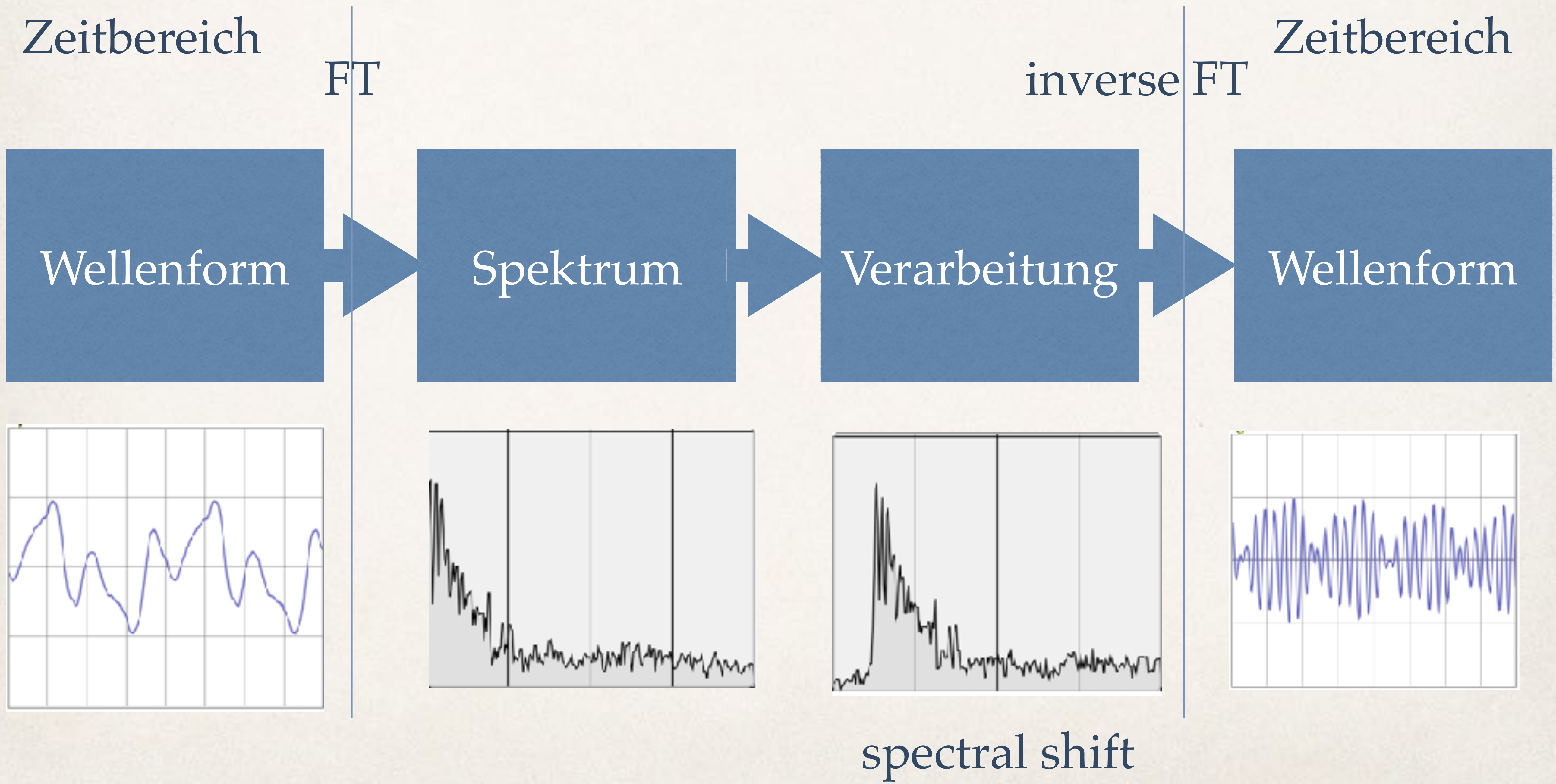
FT / iFT



FT / iFT


Zeitbereich
Frequenzbereich
Zeitbereich
FT
iFT
Wellenform
Spektrum
Wellenform

FFT Resynthesis



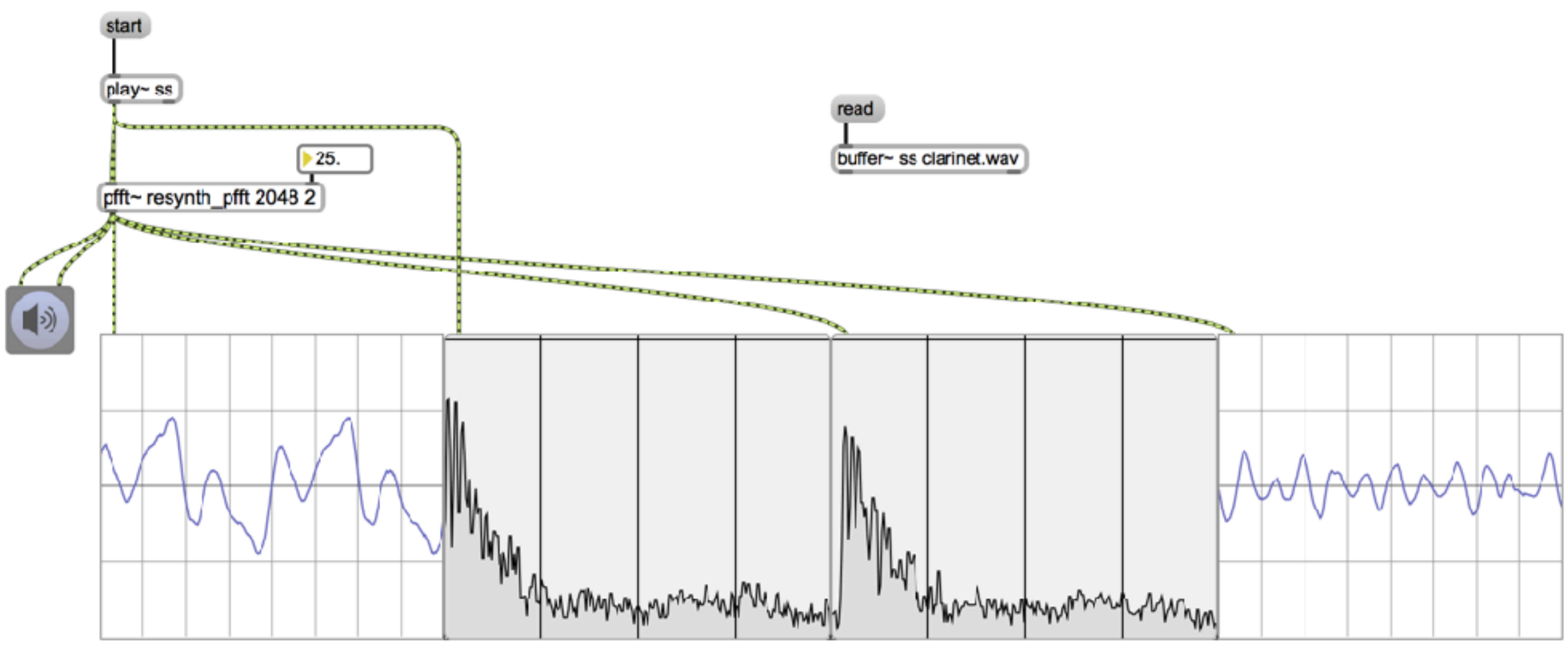
Anwendungen

Table 4.1 Musical transformations using additive analysis/resynthesis

Musical effect	Technique
Variations of recorded sounds	Change selected frequency or amplitude envelopes by editing or multiplications by arbitrary functions.
Spectrum scaling (without time scaling)	Multiply the frequency of all the partials (possibly excepting the fundamental) by a factor *n* or by arbitrary functions. Since multiplication does not preserve formant structures, vocal and instrumental sounds may lose their characteristic identity.
Spectrum shifting (without time scaling)	Add a factor *n* or an arbitrary function to all partials (possibly excepting the fundamental). For small values this preserves formant structures.
Spectrum inversion	Reversing the order of the frequency components before resynthesis, so that the amplitude of the first partial is assigned to the last partial, and vice versa, followed by exchange of the amplitudes of the second and next-to-last components, etc.
Hybrid timbres	Replace some envelopes from one sound with selected envelopes from another sound.
Time expansion and compression without pitch shifting	Extend the duration of the frequency and amplitude envelopes, or change the *hop size* on playback (see chapter 13).
Stretch a percussive timbre into a prolonged synthetic passage	Delay the onset time of each partial and smooth their envelopes.
Timbral interpolation from one instrumental tone to another	Interpolate over time between the envelopes of two instrument tones.
Mutating synthetic sounds	Interpolate between the envelopes of arbitrary synthetic sounds.
Enhance the resonance regions of recorded sounds	Increase the amplitude of selected frequency partials.
Cross-synthesis	Method 1: Use the amplitude envelopes for the partials of one sound to scale the amplitude envelopes of another sound (see *fast convolution* in chapter 10). Method 2: Apply the amplitude envelopes from one sound to the frequency (or phase) functions of another sound. Method 3: Apply the noise residual from one sound to the quasi-harmonic part of another sound (see, for example, the description of spectral modeling synthesis and the comb wavelet transform in chapter 13).

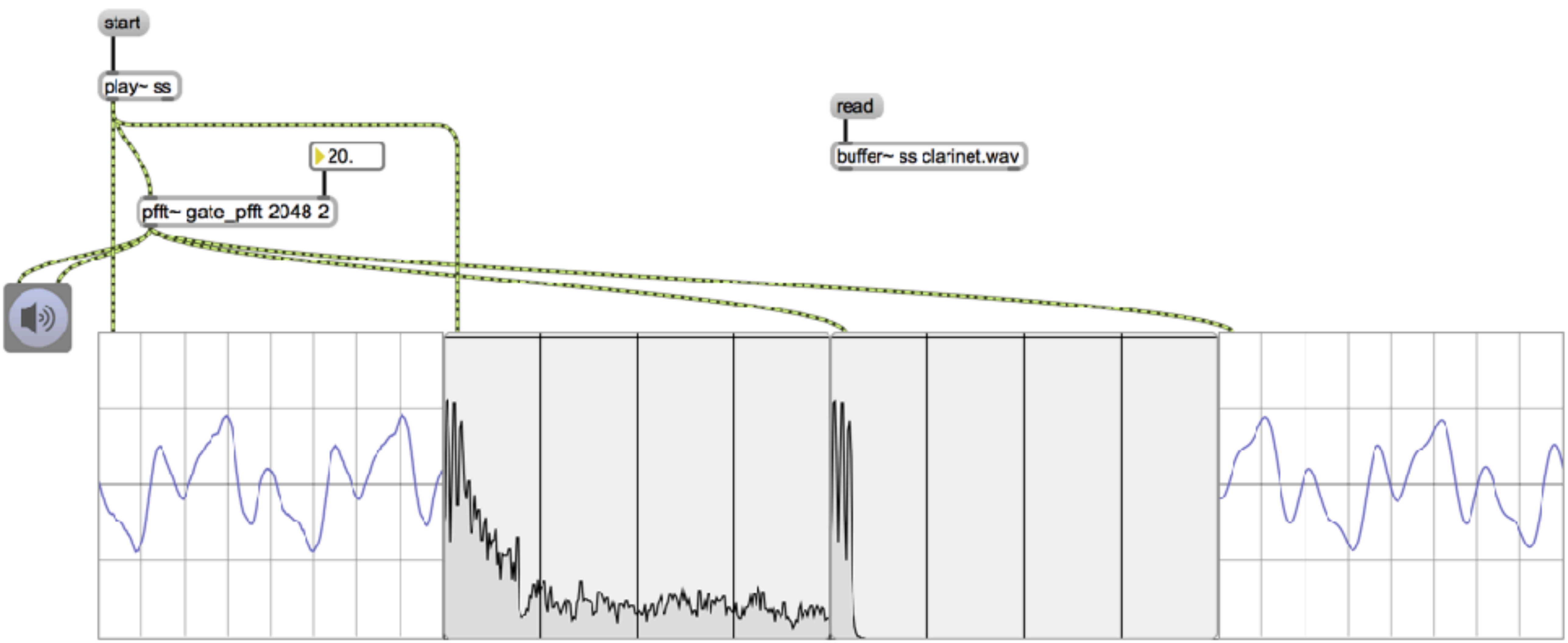
Experiment mit Max

Spectral Shift



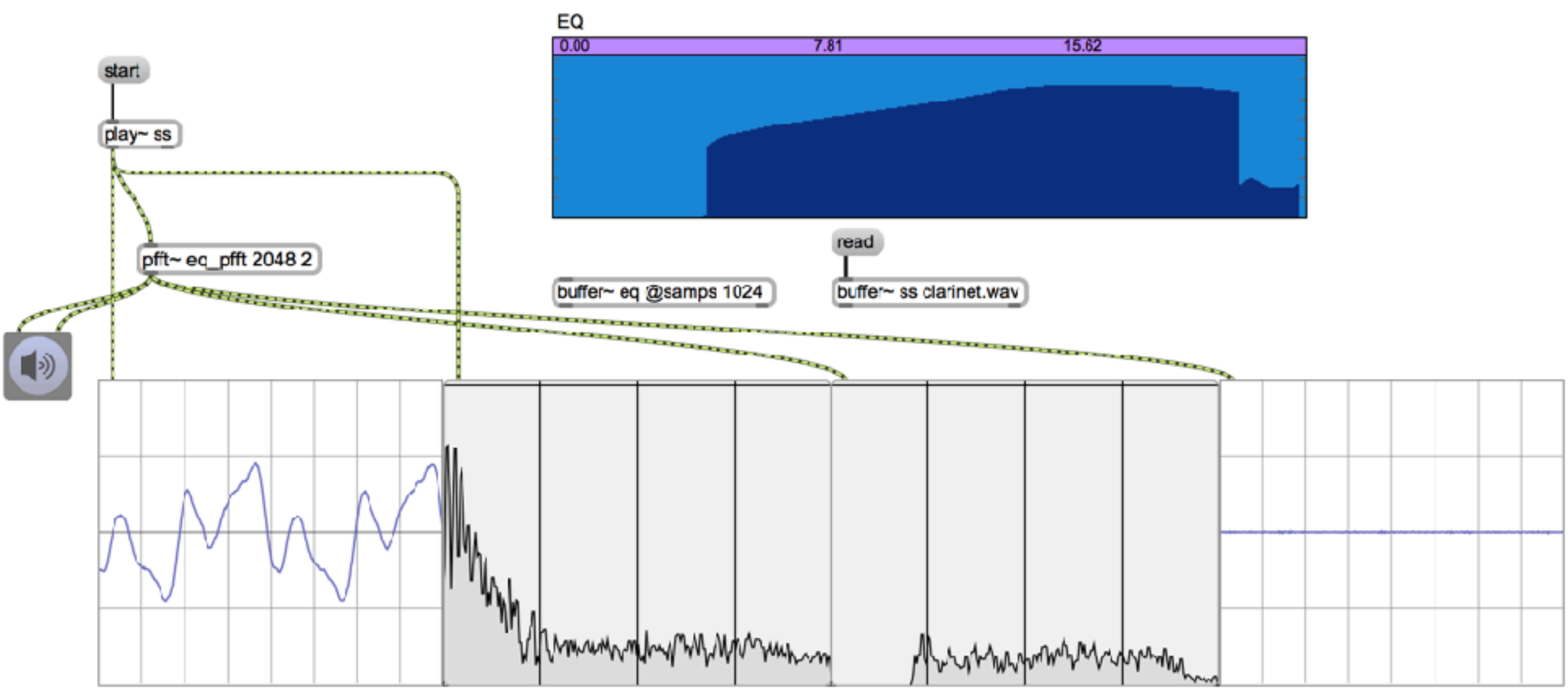
Experiment mit Max

Spectral gate



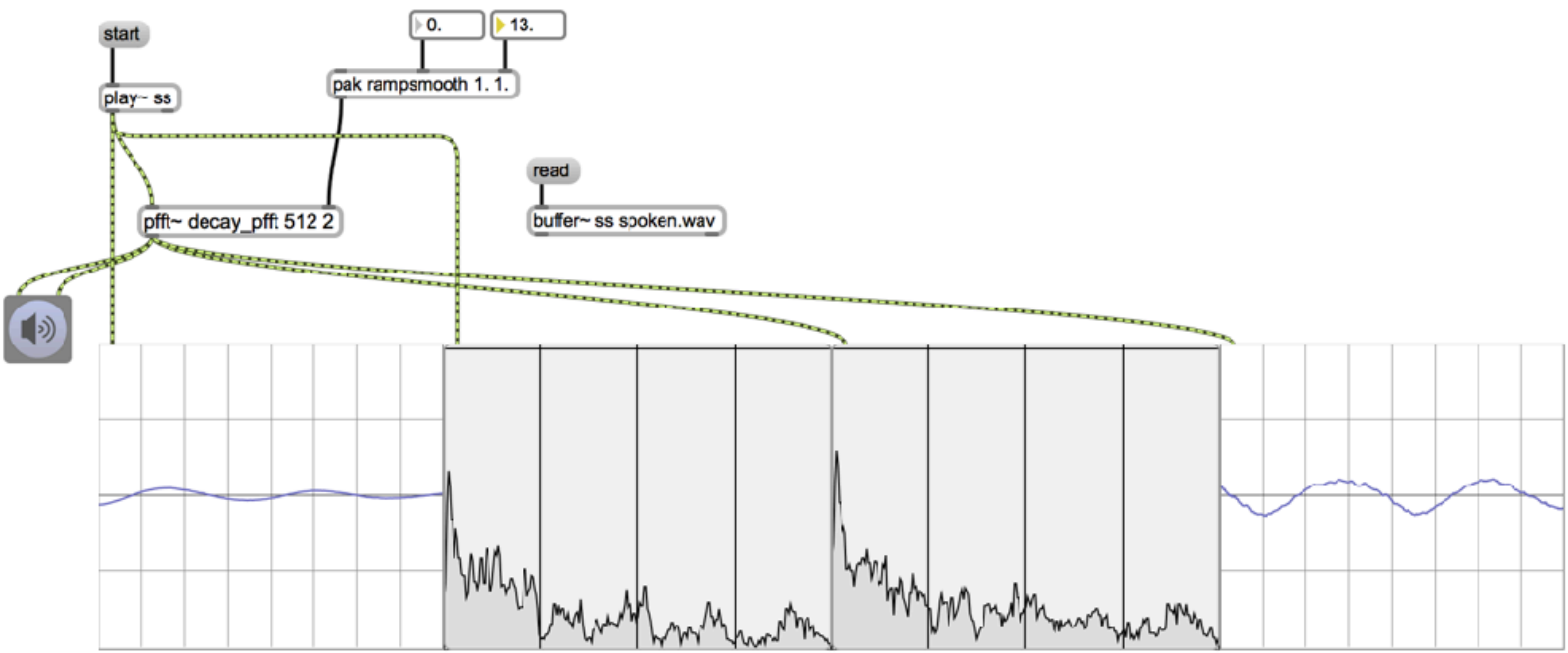
Experiment mit Max

Spectral EQ



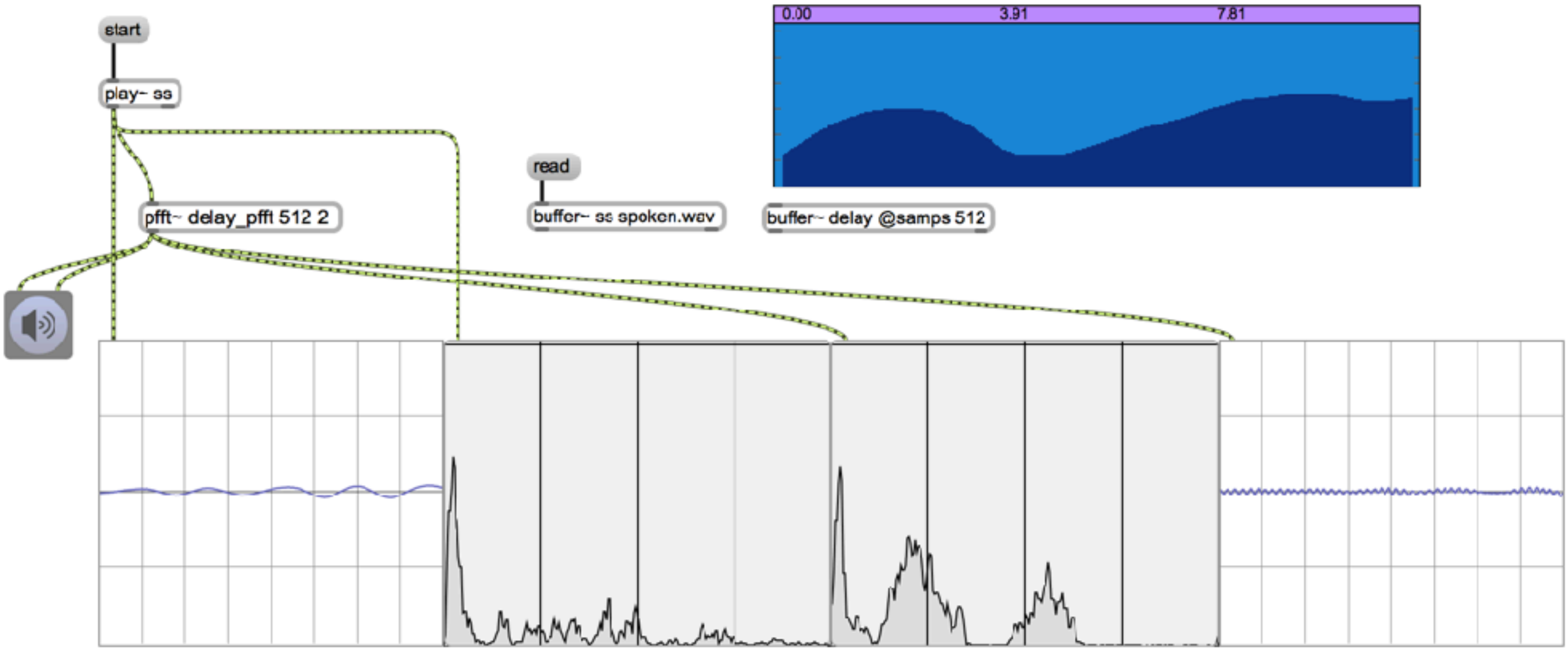
Experiment mit Max

Spectral Decay



Experiment mit Max

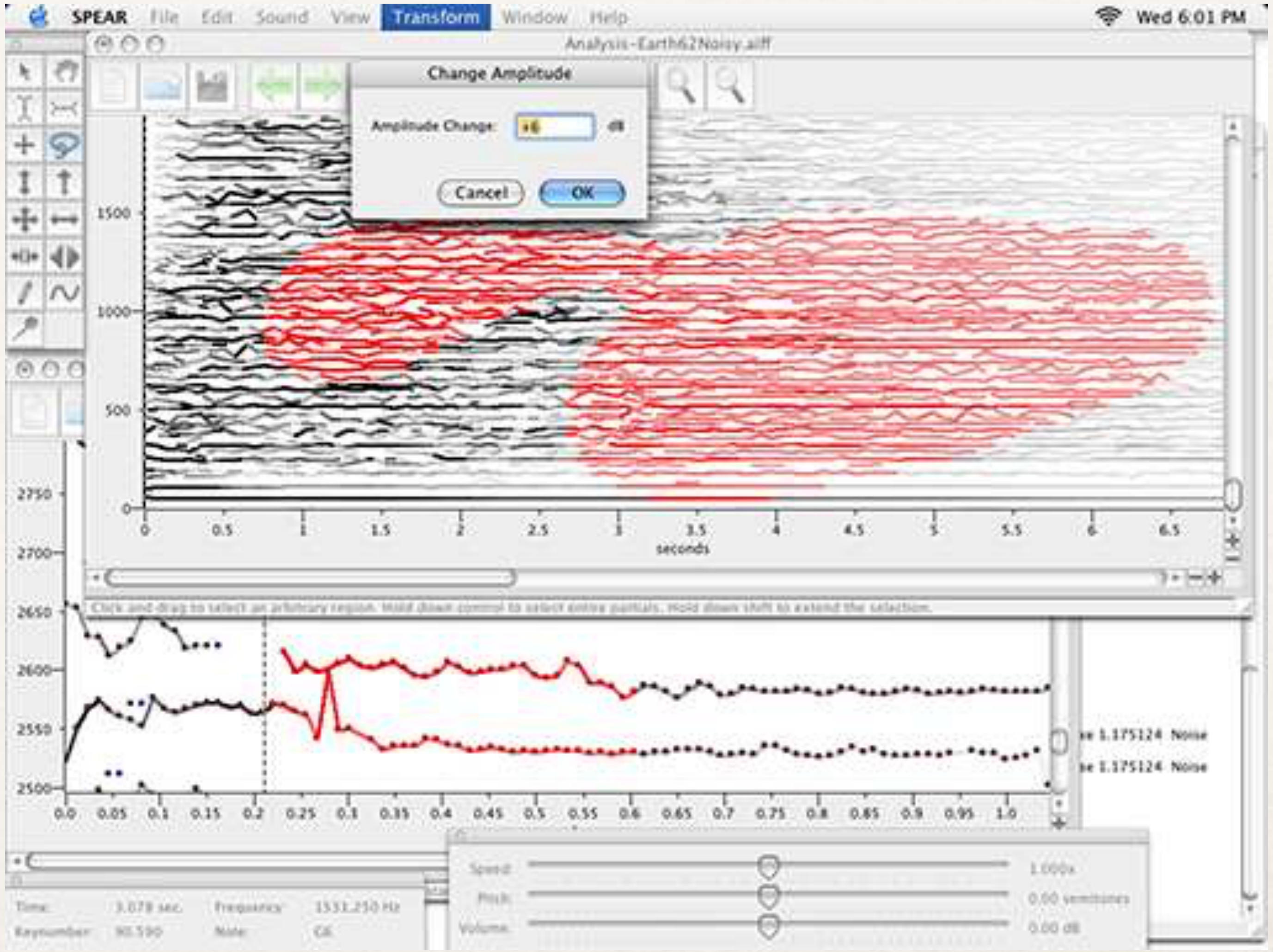
Spectral Delay



SPEAR

SPEAR

- Eine Software für *Resynthesis*



Demo - Spear

Musikalische Anwendungen

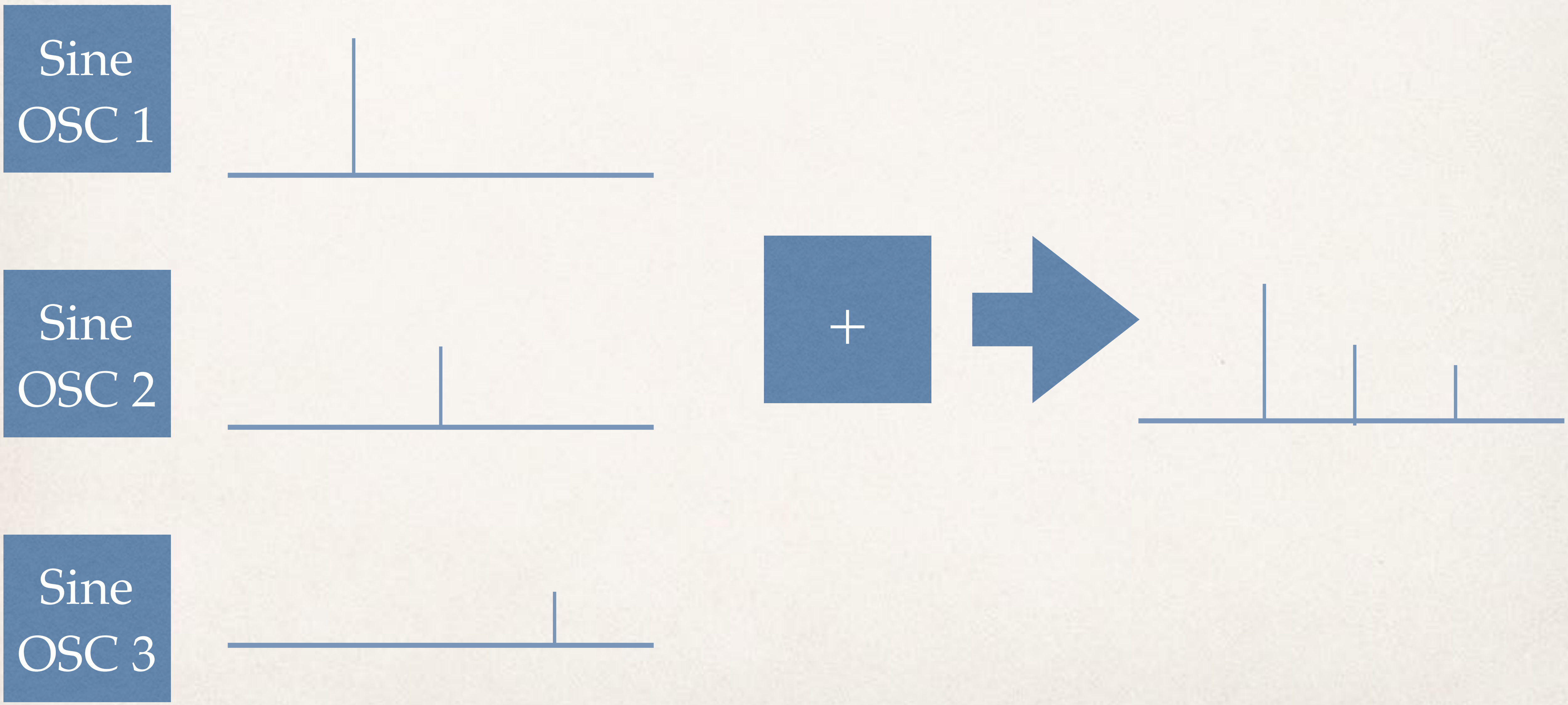
Cort Lippe

Music for piano

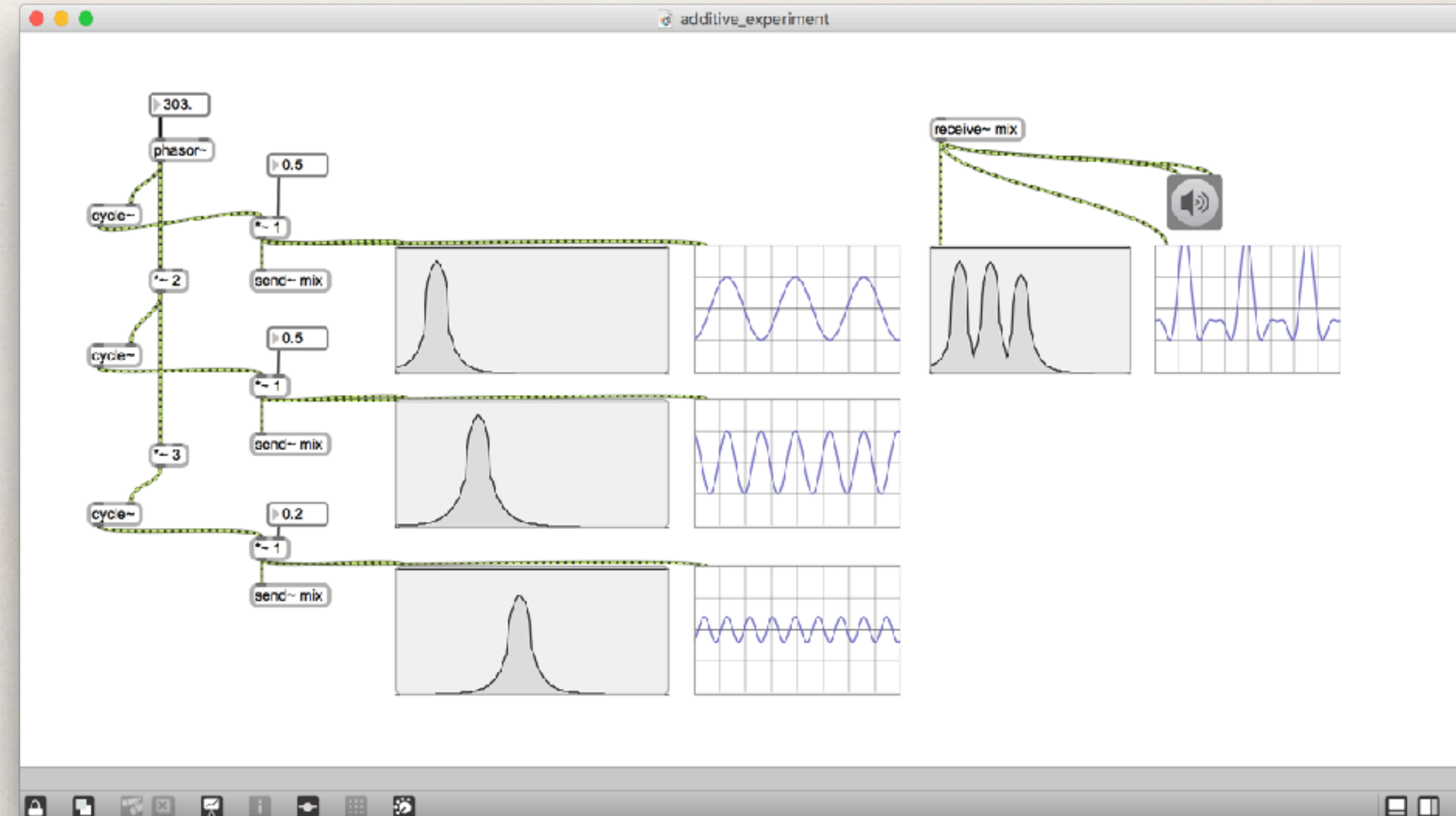
Walsh Synthese

Additive Synthese

Baustein eines Spektrums = Sinus



Experiment mit Max



Begrenzung der Additive Synthese

- Was ist die schwierigste Wellenform für die Additive Synthese?

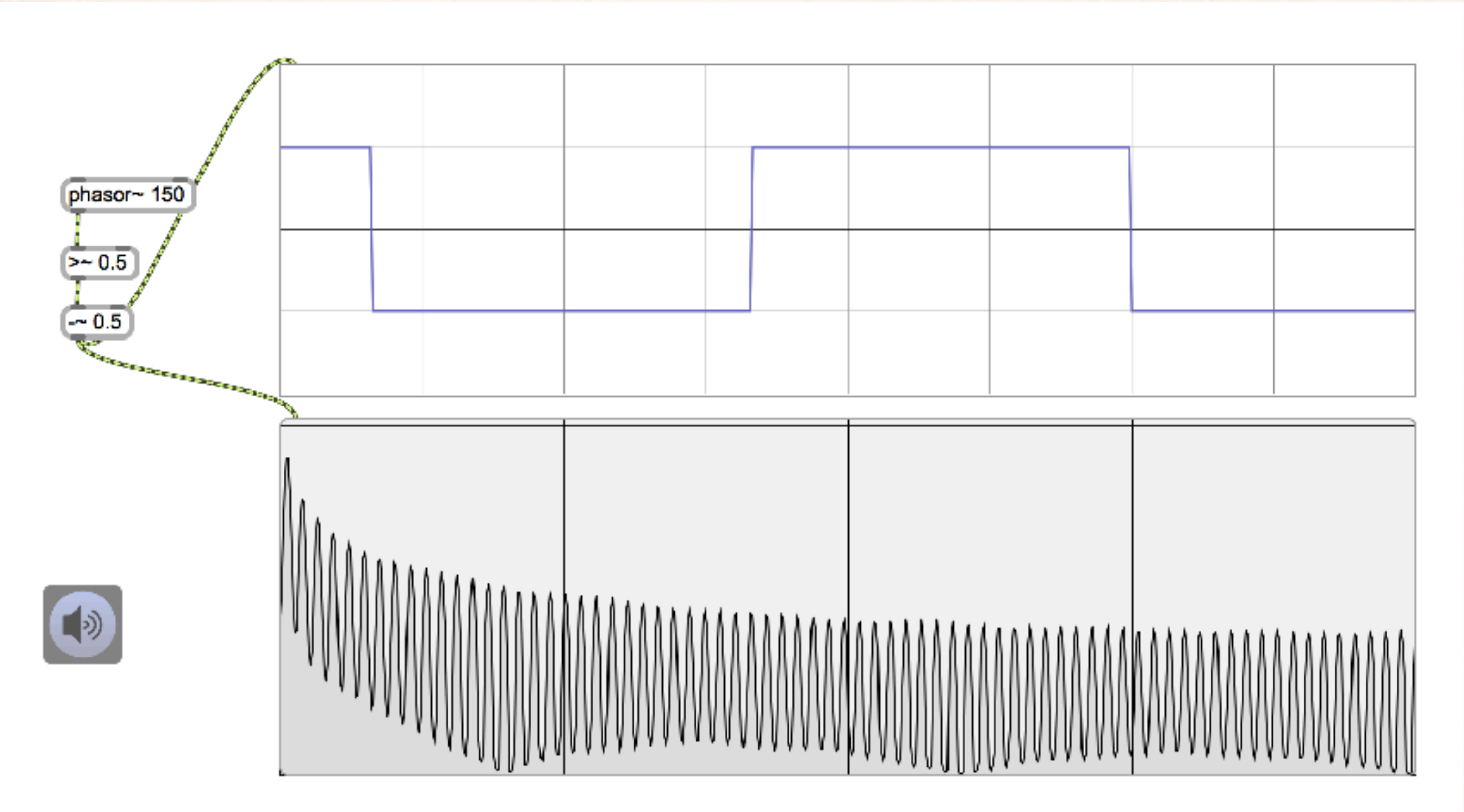
Begrenzung der Additive Synthese

- Additive Synthese
  - Was ist die schwierigste Wellenform zu imitieren?

Begrenzung der Additive Synthese

- Additive Synthese
  - Was ist die schwierigste Wellenform zu imitieren?
- **Rechteck**

Rechteck



ca 140 Oszillatoren sind nötig!

Rechteck

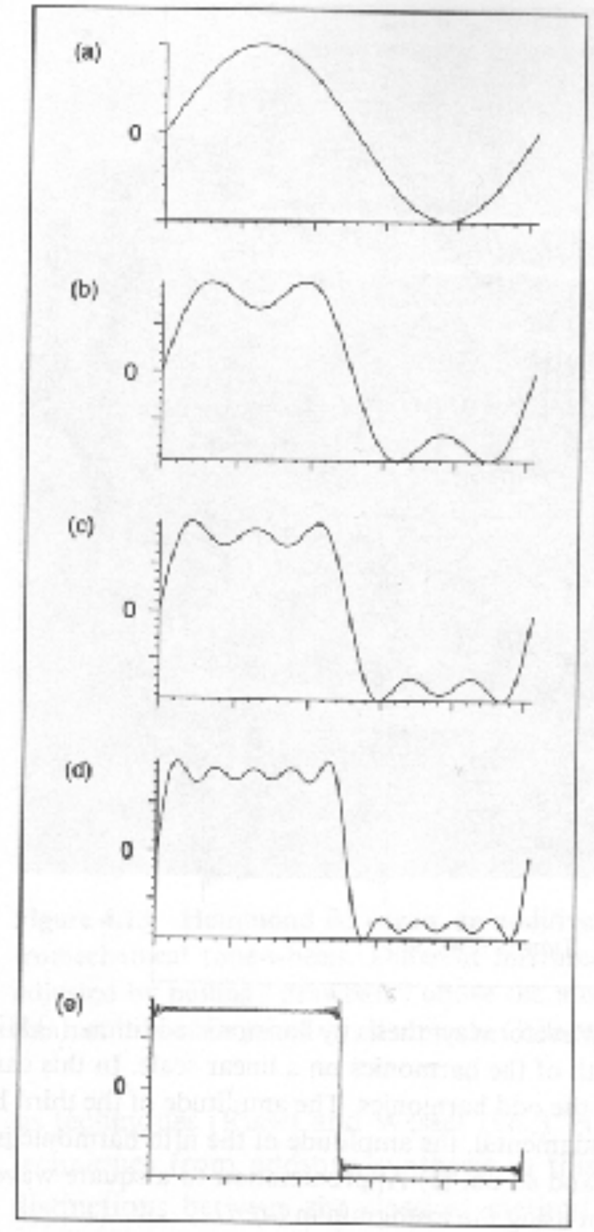


Figure 4.15 Stages of harmonic addition as seen in a series of time-domain waveforms. (*a*) Fundamental only. (*b*) First and third harmonics. (*c*) Sum of odd harmonics through the fifth. (*d*) Sum of odd harmonics through the ninth. (*e*) Quasi-square wave created by summing odd harmonics up to the 101st.

Walsh Synthese

Rechteck als Baustein

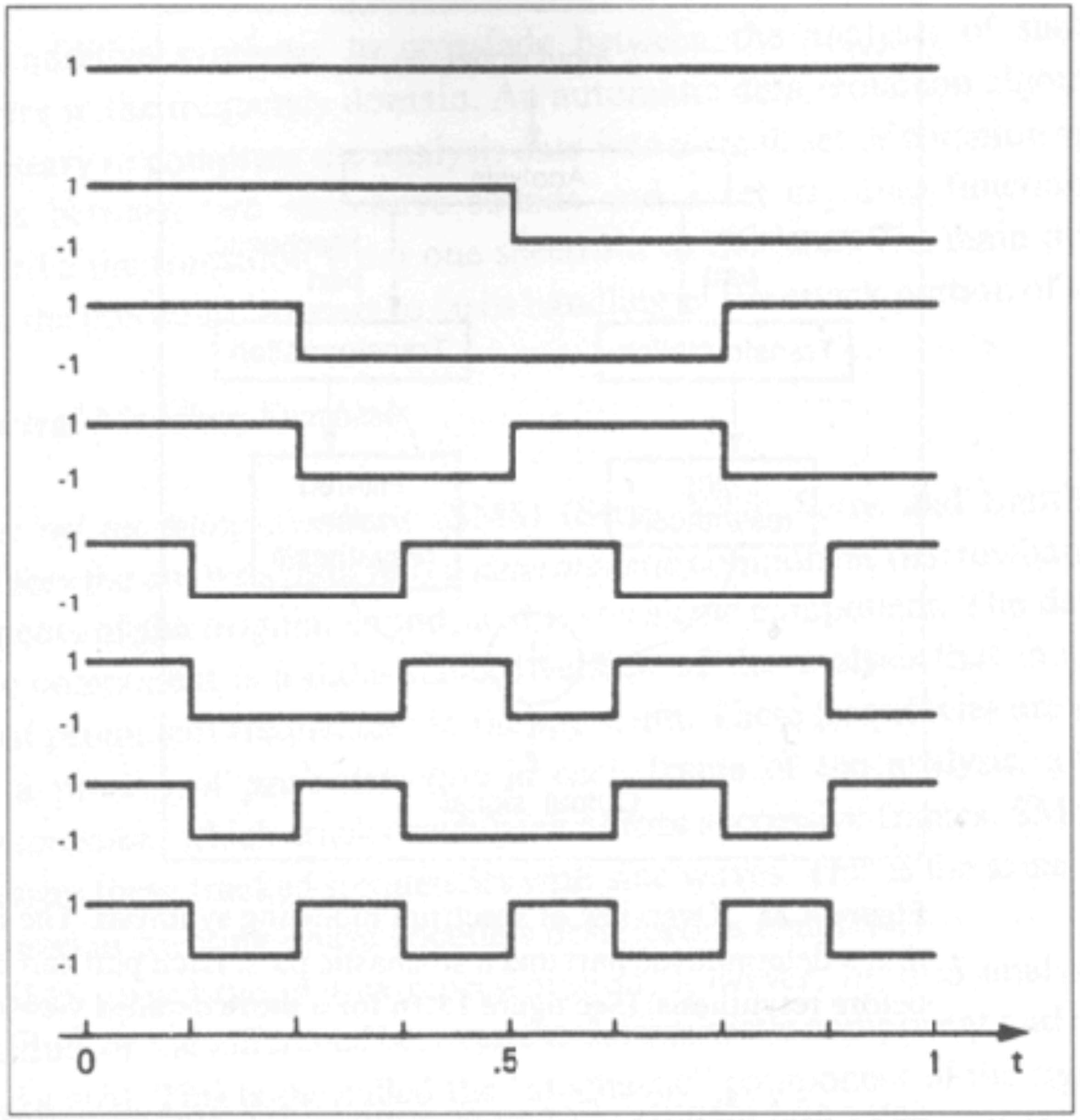


Figure 4.24 The first eight Walsh functions, 0 (top) to 7 (bottom).

Walsh-Funktion

https://de.wikipedia.org/wiki/Walsh-Funktion

We define the sequence of Walsh functions $W_k : [0,1] \to \{-1,1\}$, $k \in \mathbb{N}_0$ as follows.

For any $k \in \mathbb{N}_0$, $x \in [0,1]$ let

$$k = \sum_{j=0}^{\infty} k_j 2^j, k_j \in \{0,1\}, \quad x = \sum_{j=1}^{\infty} x_j 2^{-j}, x_j \in \{0,1\}$$

such that there are only finitely many non-zero k_j and no trailing x_j all equal to 1, be the canonical binary representations of integer k and real number x, correspondingly. Then, by definition

$$W_k(x) = (-1)^{\sum_{j=0}^{\infty} k_j x_{j+1}}$$

In particular, $W_0(x) = 1$ everywhere on the interval.

Notice that W_{2^m} is precisely the Rademacher function r_m. Thus, the Rademacher system is a subsystem of the Walsh system. Moreover, every Walsh function is a product of Rademacher functions:

$$W_k(x) = \prod_{j=0}^{\infty} r_j(x)^{k_j}$$

Walsh Funktion

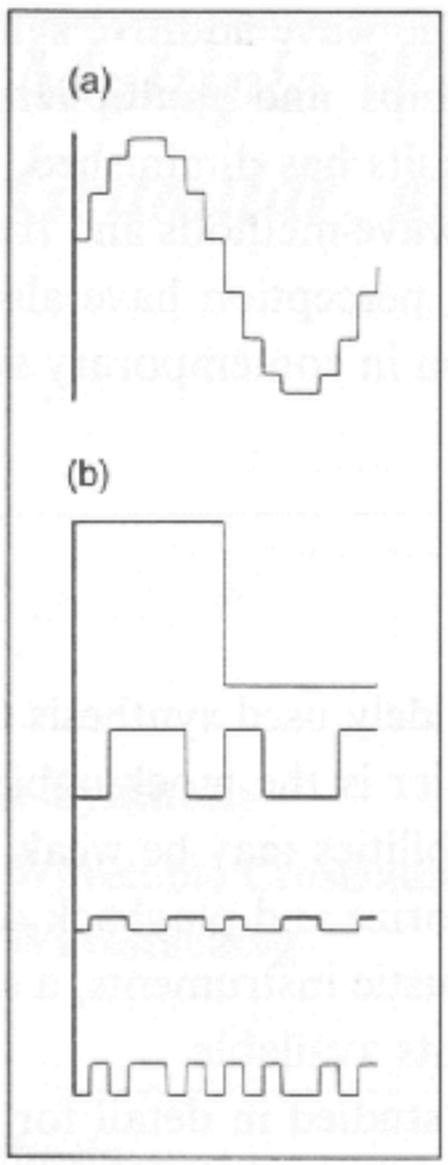
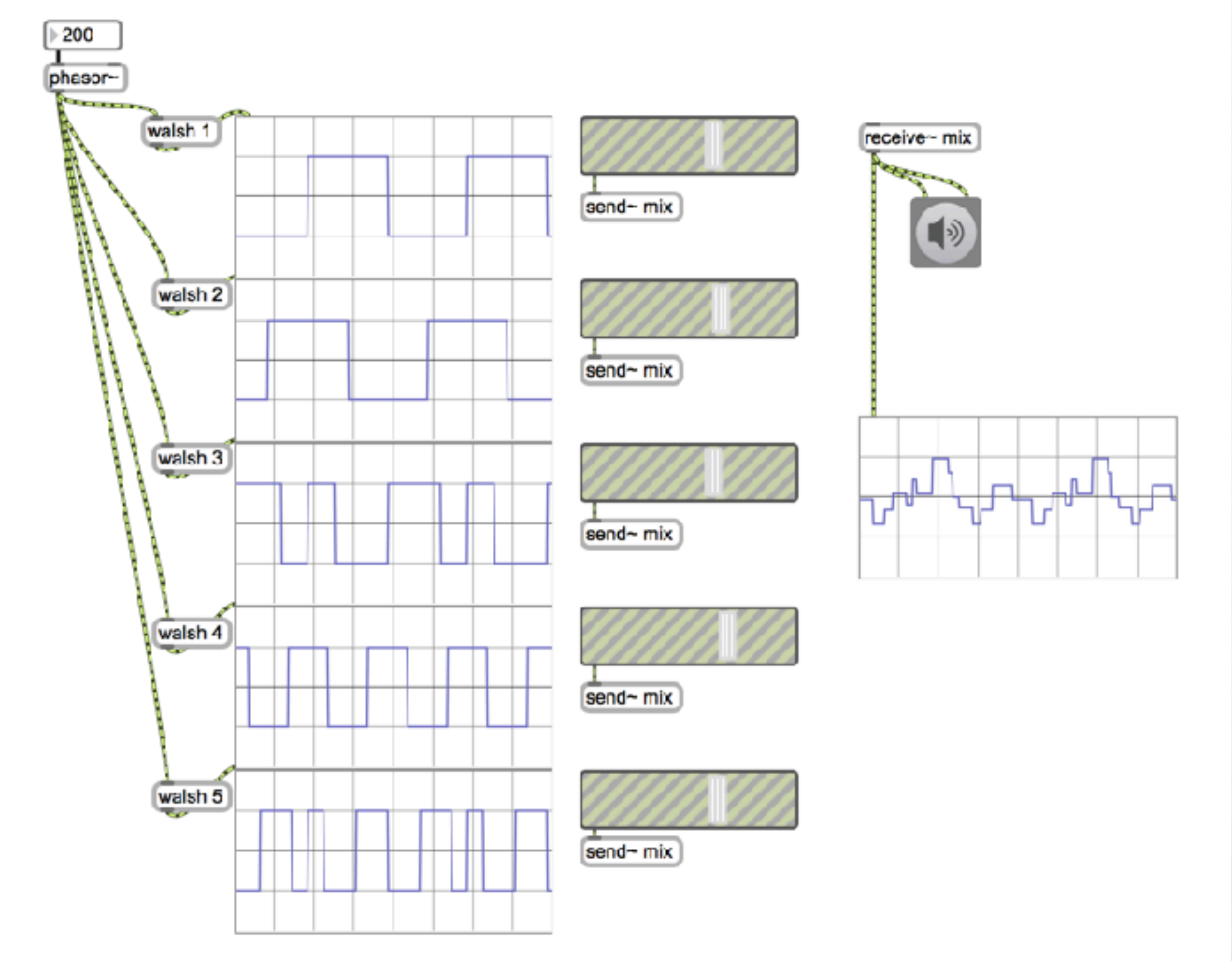


Figure 4.25 Demonstration of Walsh function summation. (*a*) A simple sine wave approximation built by adding the Walsh functions shown in (*b*). (After Tempelaars 1977.)

Experiment mit Max



Corpus-based Concatenative Synthesis

Corpus

Corpus … **Sammlung** ➡ **Datenbank**

Concatenation … **Verkettung**

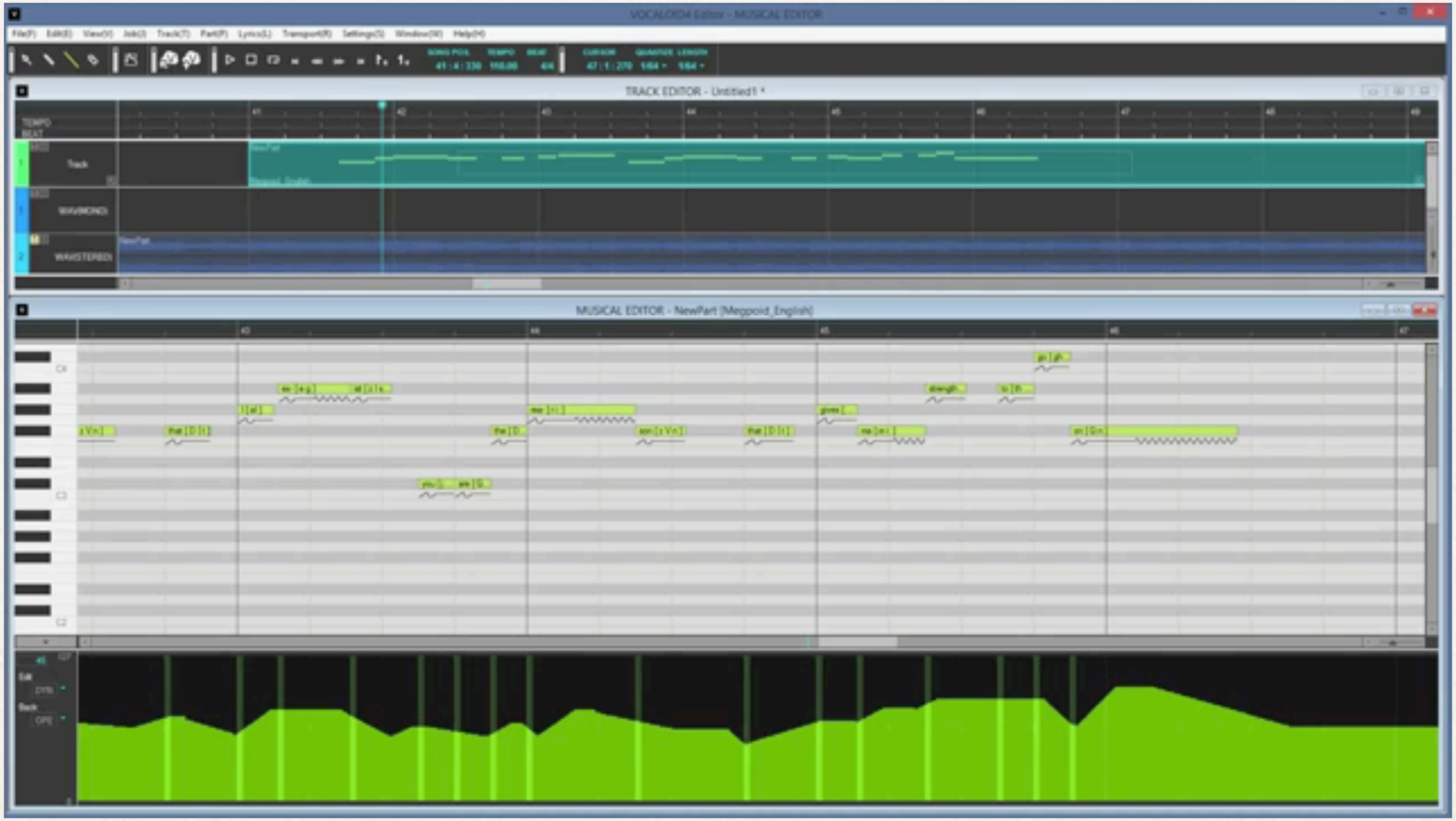
Datenbank und Klang

- https://www.freesound.org
- http://www.xeno-canto.org bird song
- http://theremin.music.uiowa.edu/MIS.html# instrument
- http://www.whosampled.com sampling
- http://mycity-mysounds.zkm.de soundscape

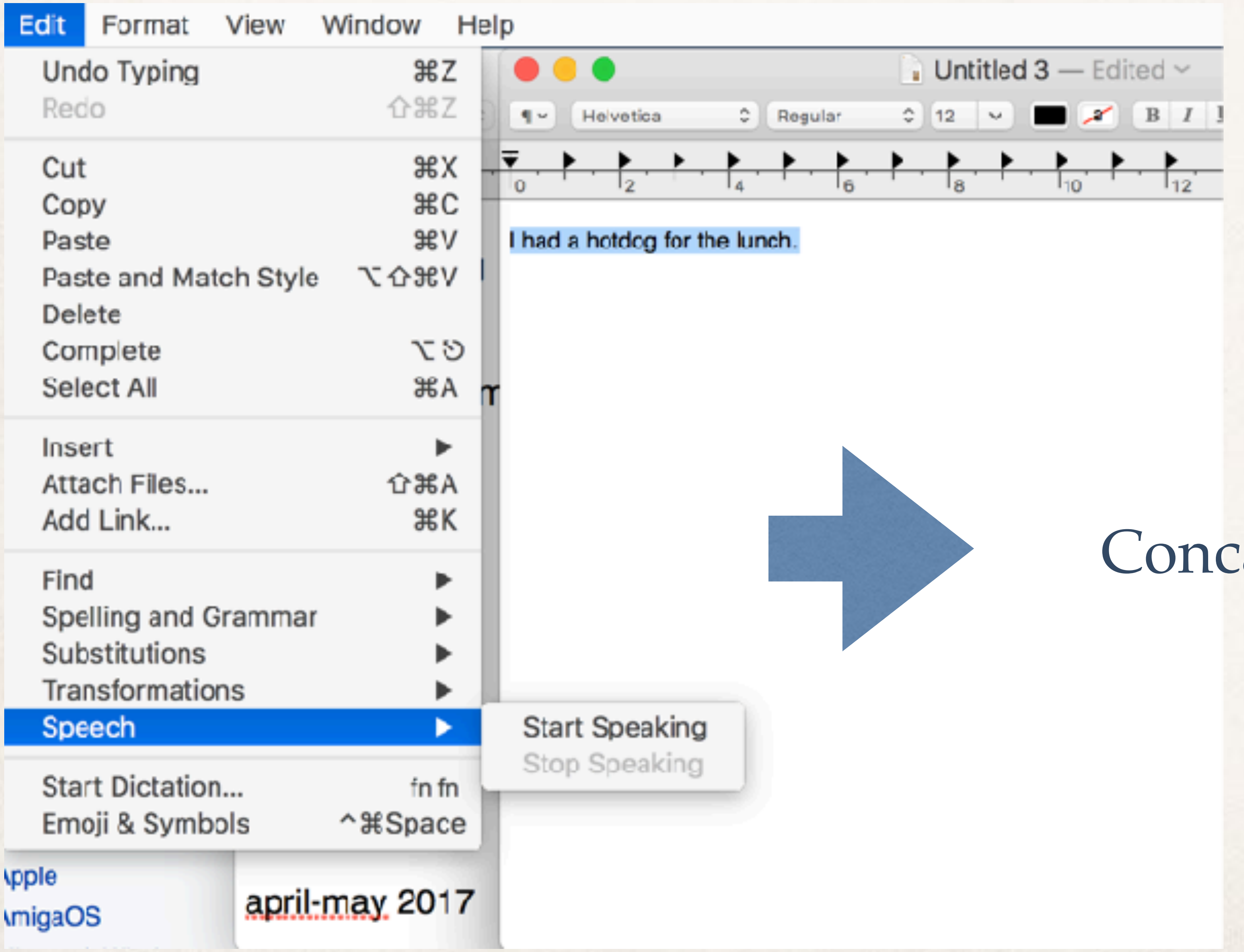
Speech Synthesis

Dr. Stephen Hawking

Vocaloid

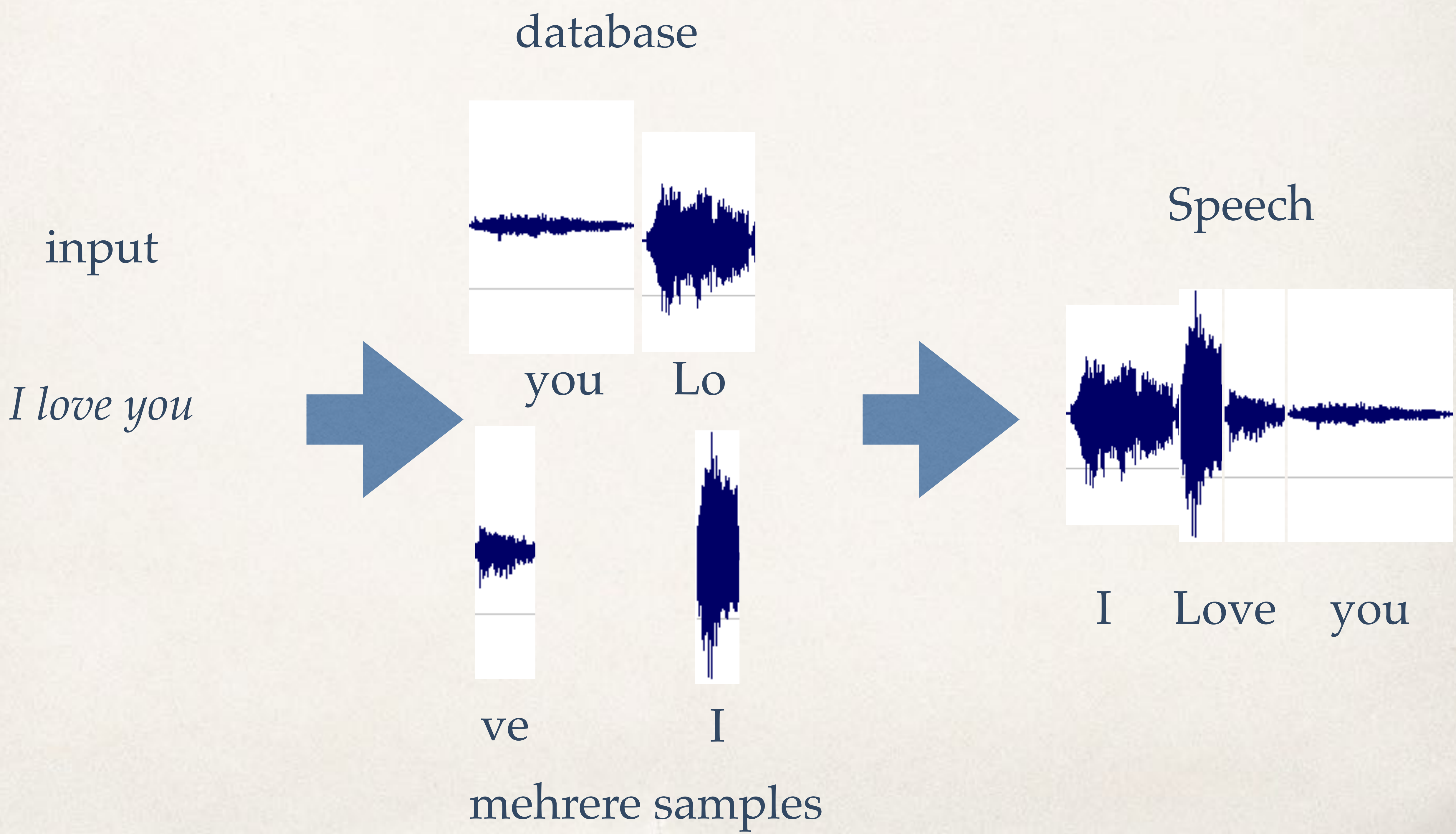

TRACK EDITOR - Untitled1 *
MUSICAL EDITOR - NewPart [Megpoid_English]

Speech Synthesis



Concatenative Synthesis

Speech Synthesis



Granular Synthesis vs Concatenative Synthesis

*In contrast to granular synthesis, concatenative synthesis is driven by an **analysis of the source sound**, in order to identify the units that best match the specified criterion.*

Sprachsynthese

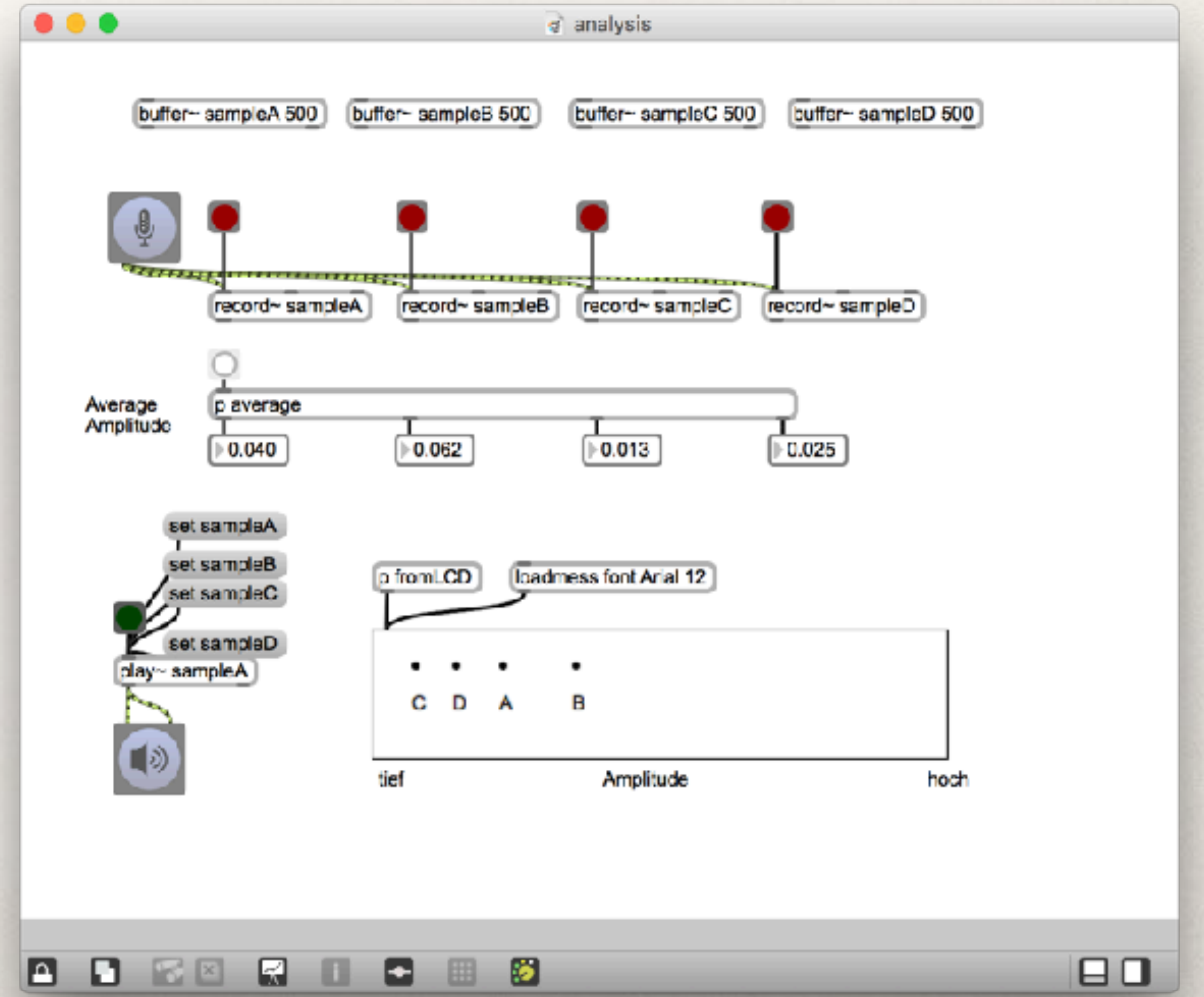
Klangsynthese

Concatenative ⟷ Granular

Analyse

Experiment mit Sound Source

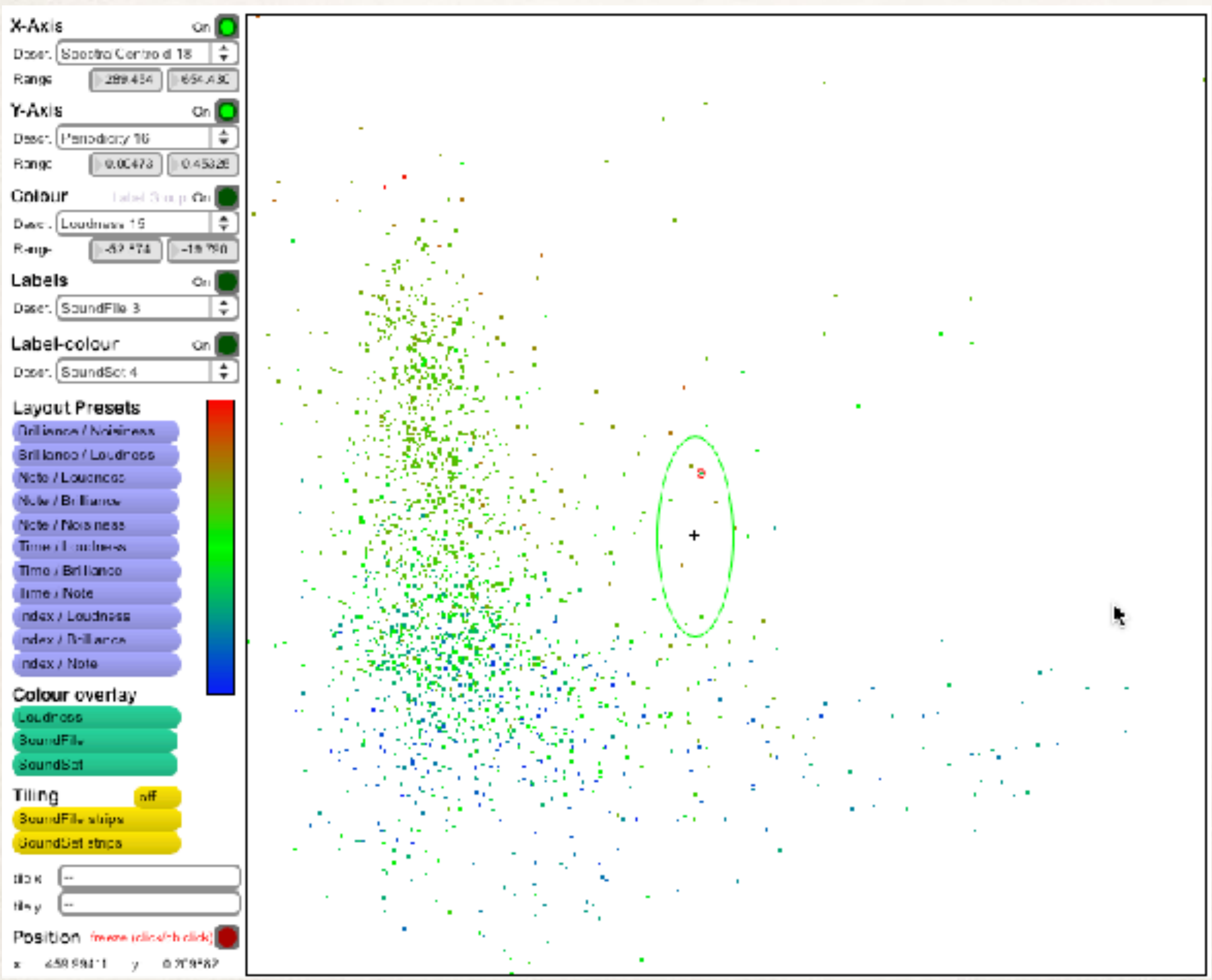
Analysis of Sound Source



Cata -RT (IRCAM)

CataRT

http://imtr.ircam.fr/imtr/CataRT



Klangbeispiel

Diemo Schwarz Cata-RT