ZynAddSubFX
an open-source software synthesizer

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http://zynaddsubfx.sourceforge.net

Features:

- Realtime, poliphonic, multitimbral and microtonal

- 3 powerfull synth engines

- Many types of effects

- Full control of a large number of parameters

- The instruments generated by it has very high quality and "warmth"

- Everything is generated by the synth (eg. no external samples)

- Easy to use user interface

- Many others...

ZynAddSubFX Structure

- It is divided into several (music) parts.

- Midi channels can be assigned to parts

- The effects can be connected as System Effects, Insertion Effects or Part Effect

ZynAddSubFX Main Structure
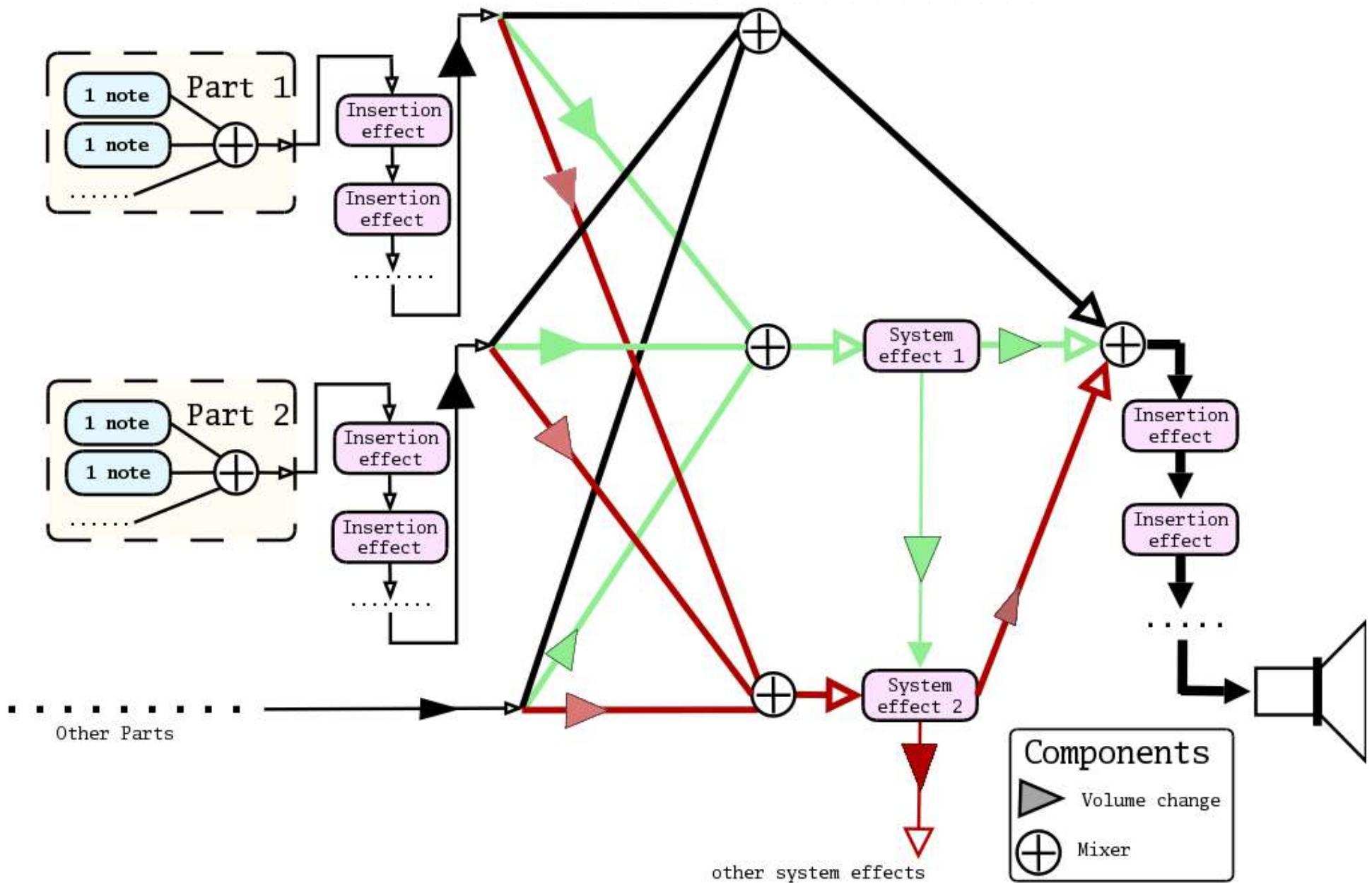
Part's structure

- One part contains a single instrument or an instrument kit

- Each part has it's own effects

- Each instrument's kit item has 3 synth engines: ADsynth, SUBsynth and PADsynth

Part's Structure

Synth engines

- **ADDsynth** – is a highly complex synthesis engine that has several oscilators that can generate any waveform. This engine has filters, LFOs, envelopes, resonances and supports FM, PM, RingModulation synthesis.
- **SUBsynth** – is a simpler synth that generates the sound by filtering the desired harmonics from white noise
- **PADsynth** – is a new synthesis method which will be described later

Diagram for ZynAddSubFX synth engines
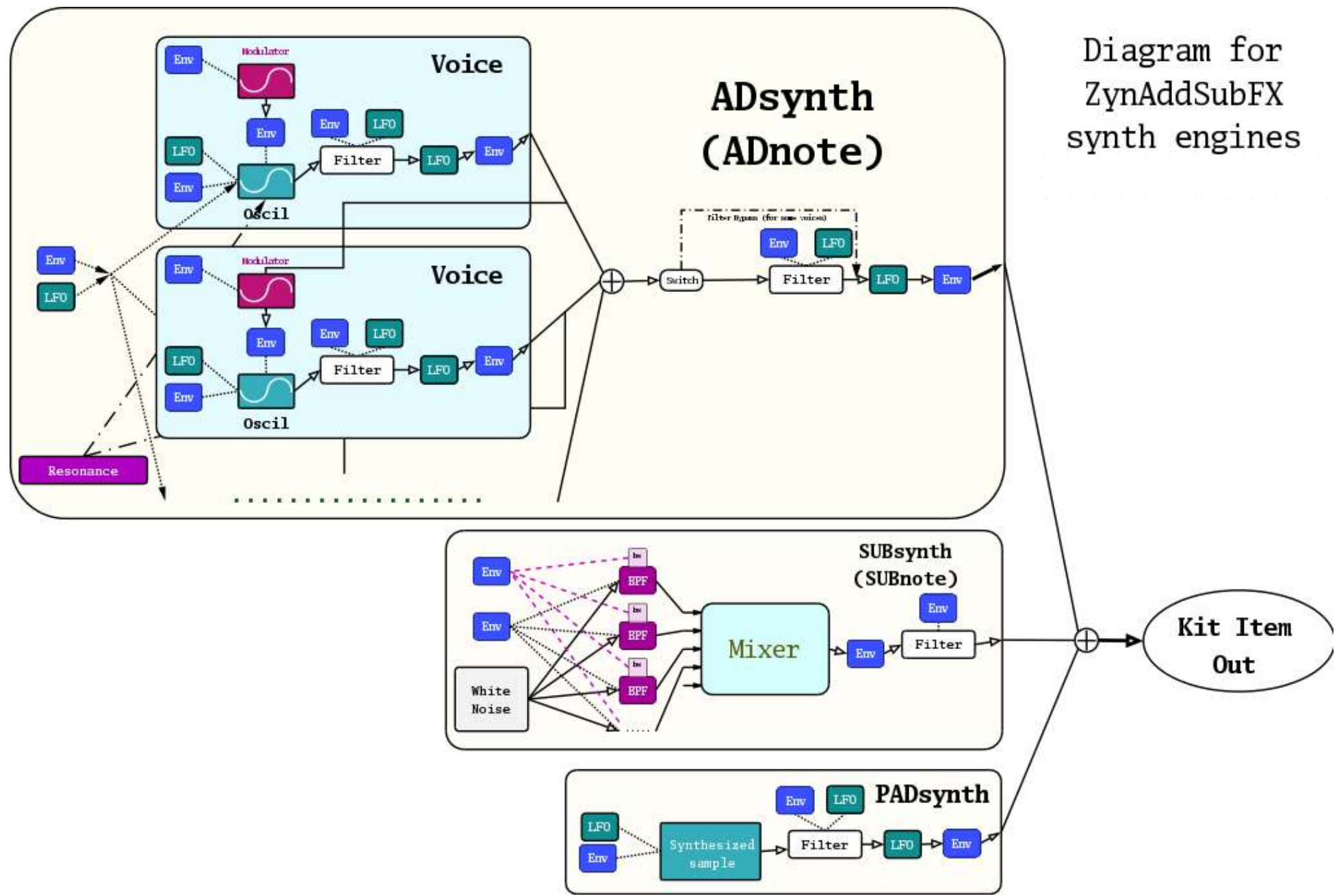
ADDsynth

- This engine is divided into several voices.

- Each voices has own oscillator, filter, envelopes and LFO's. The envelopes and LFO's controls the amplitude, frequency and the filter's frequency.

- For each voice there is an extra oscillator which is used as a modulator.
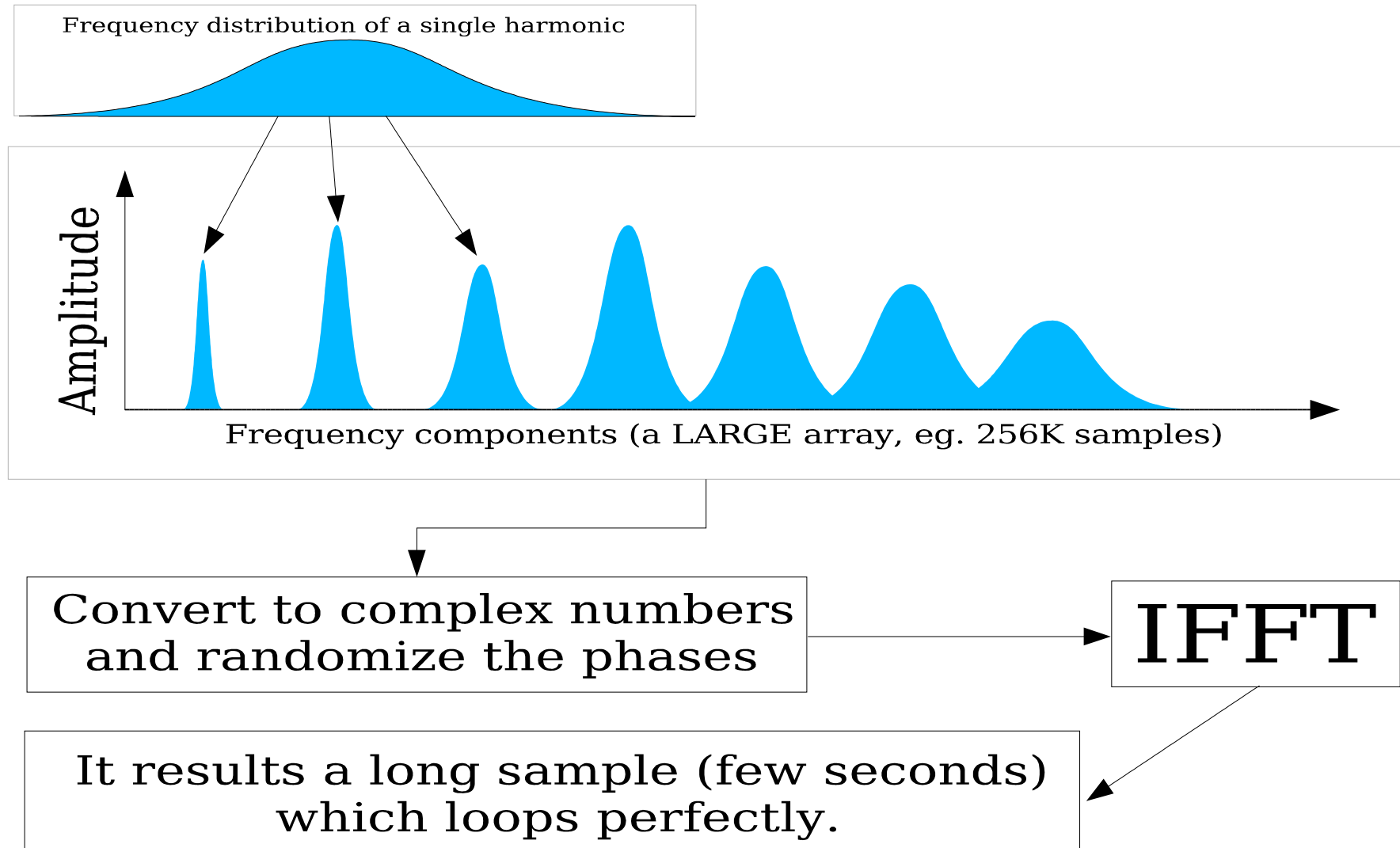
- Stacked FM possible

SUBsynth

- The SUBsynth generates a white noise which is filtered by band-pass filters

- This engine has amplitude,bandwidth and frequency envelopes and a filter

- Each harmonic has it's own bandwidth control

PADsynth

(**P**aul's**AD**ditive synth)

- This is the most innovative sound engine. It uses the ideea that every harmonics is not a single "sine" frequency, but is a frequency band

- It generates wavetables by doing IFFT's of a very long arrays. The sound is generated by playing these wavetables at different speeds. For one instrument there are more wavetables.

PADsynth synthesis steps

Frequency distribution of a single harmonic

Amplitude

Frequency components (a LARGE array, eg. 256K samples)

Convert to complex numbers and randomize the phases

IFFT

It results a long sample (few seconds) which loops perfectly.

Effects Types

- ZynAddSubFX supports 8 types of effects

  - Reverberation

  - Echo

  - Chorus/Flange

  - Phaser

  - AlienWah

  - Distortion

  - EQ

  - Dynamic filter (eg. Vocal Morpher, WahWah,etc.)

- The effects has many parameters

Basic Blocks of ZynAddSubFX

- Oscillators – are used by ADDsynth and PADsynth

- LFO's – low frequency oscillators

- Envelopes

- Filters

Oscillators

- They generate the sounds by processing some base-functions. There are many ways to make the desired harmonic structure.

- They can generate any waveform

- Offers a lot of advanced features like adaptive-harmonics, phase/amplitude randomness, etc.

LFO

- ZynAddSubFX has many LFO types
- They changes the amplitude, frequency of the signal or frequency of the filters
- LFO parameters are:
  - Basic parameters: frequency, amplitude, delay
  - Advanced paramters: type, frequency stretch, continous-mode, frequency and amplitude randomness.

Envelopes

- Envelopes has 2 modes: parametric (ADSR, ASR, etc.) or free

  - Parametric mode offers easy access to Attack, Decay, Sustain or Release parameters

  - Free mode means that the envelope can have any shape

Filters

- Filter types
  - Analog Filters (low-pass, high-pass, band-pass, notch, peak, and shelf filters)
  - Arbitrary format filters
    - They can be used, for example, to make vowels
  - State variable filters
- There is a special kind of filters: the resonances (used by oscillators). These has an arbitrary frequency response.

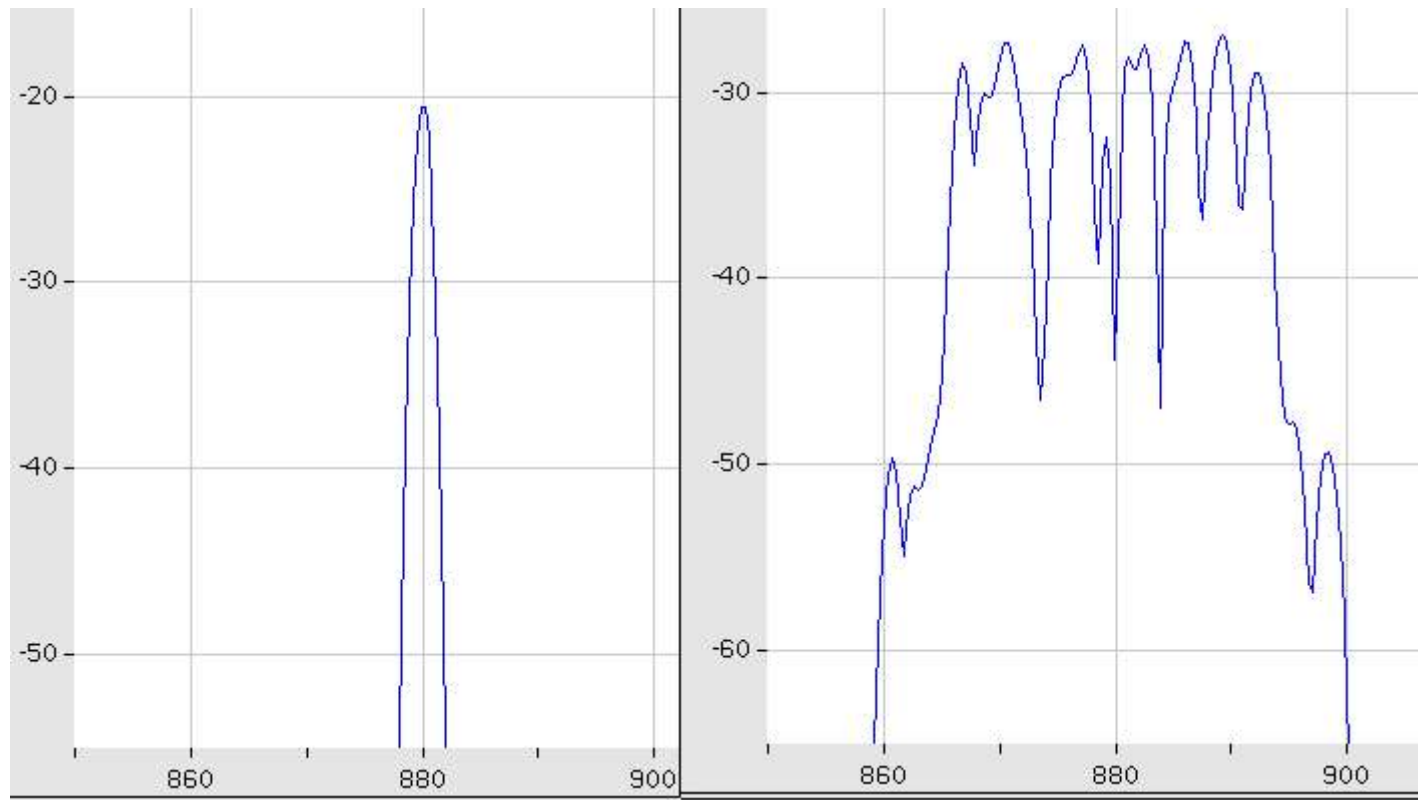# ZynAddSubFX design principles

- To be sure that this synthesizer can produce beautifull sounds, several principles was used by the author

  - Bandwidth of every harmonic

  - Randomness

  - Amplitude decrease of higher harmonics on lower velocities

  - Resonance

The bandwidth of each harmonic

- This considers the harmonics as frequency bands. Also, instead of considering the time-domain changes of the sounds, is much simpler to consider only frequency-domain parameters of these harmonics (frequency spread and phases)

- Even if is well-known the fact that the vibratto or detune cause frequency spread, there are interesting facts about the harmonics which are ignored by DSP/music literature.

- Using this idea can result very simple synthesis algorithms which produces very beautifull sounds

- The base of the ZynAddSubFX synth engines comes directly from this ideea
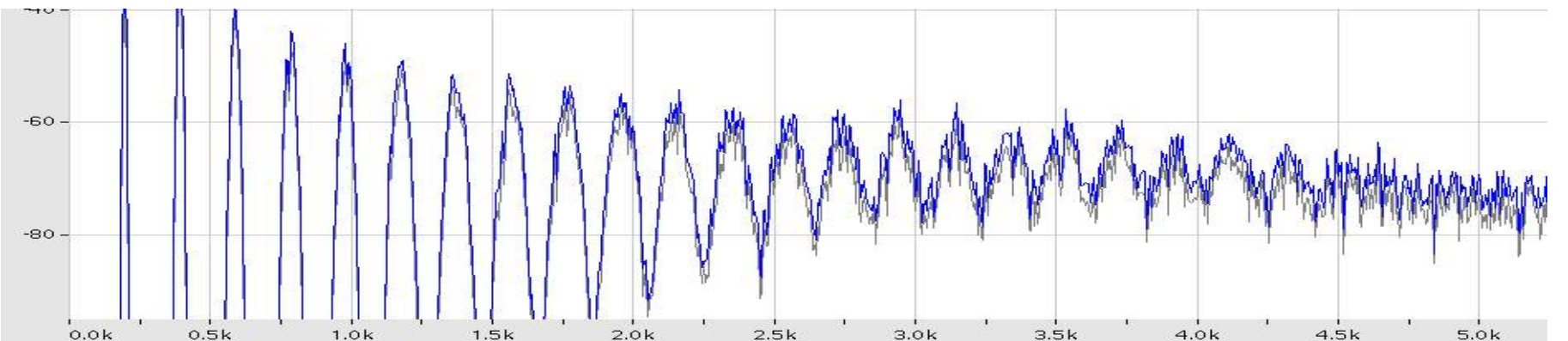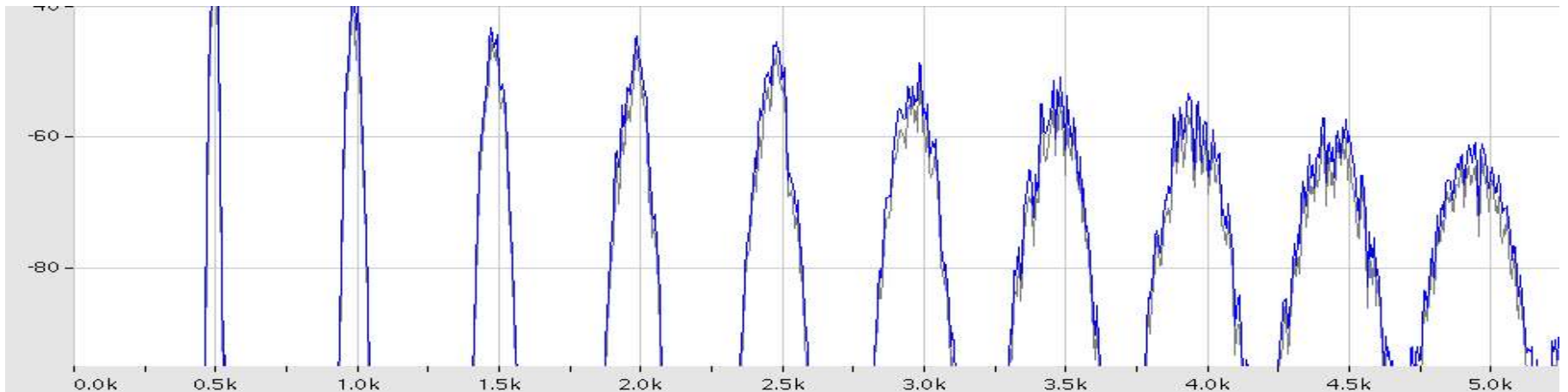
Narrow harmonic vs wide harmonic

Narrow

Wide (½ semitones)

Important rule #1

• In beautiful sounds, higher harmonics have bigger bandwidths
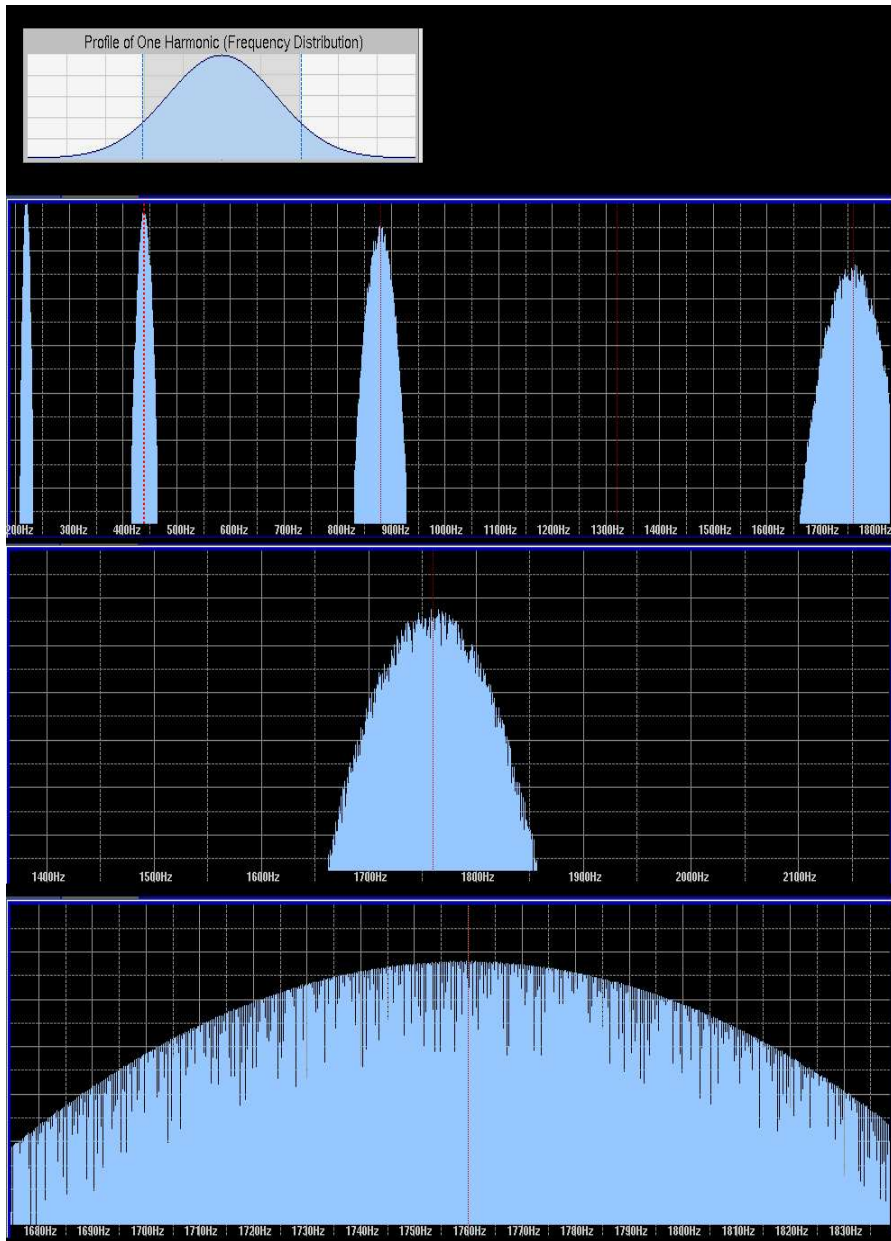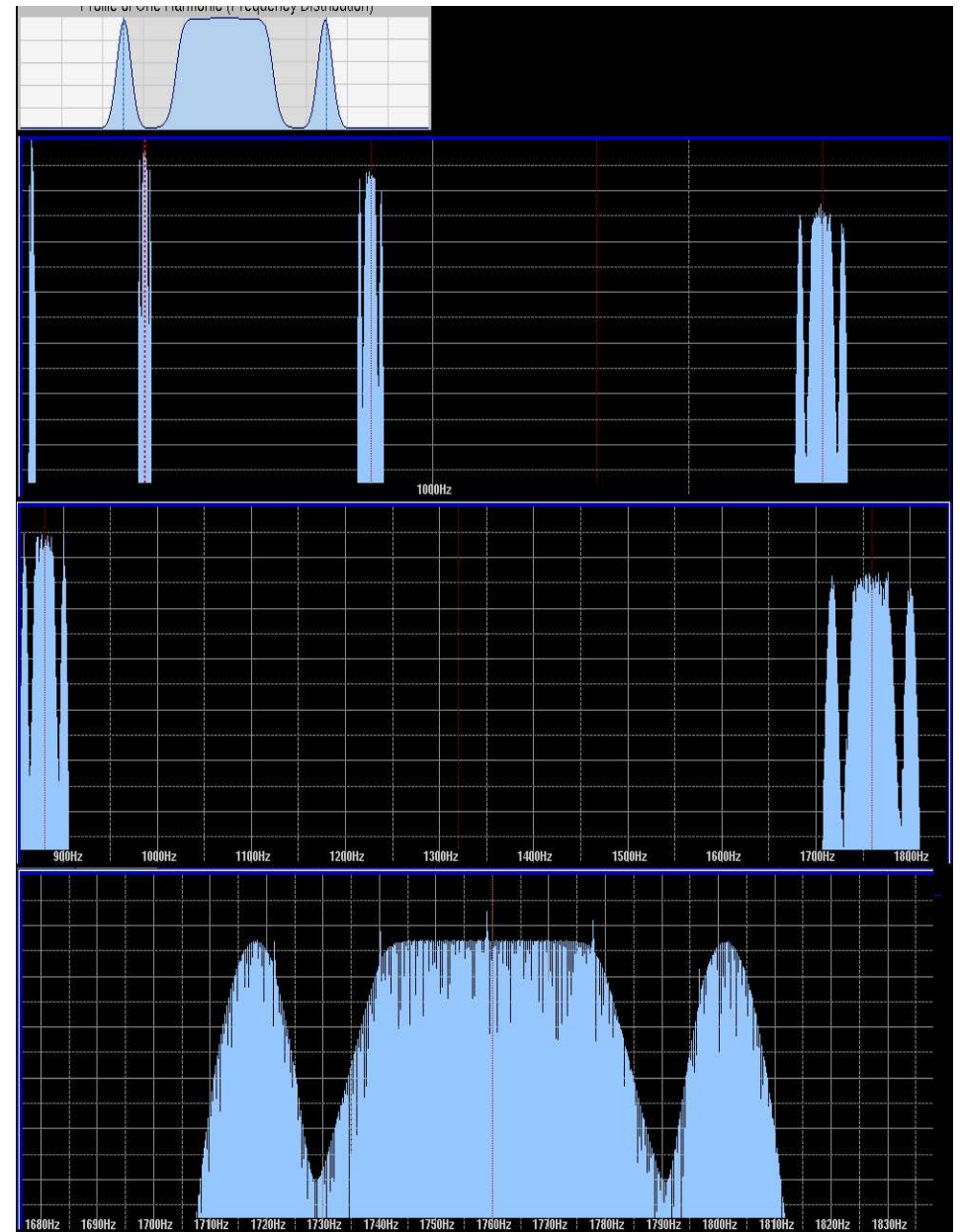

Bandwidth of each harmonic

Important rule #2

• In beautiful sounds, phases of sine components of the harmonics are random
• This happens, usually, in ensembles and choirs
• The reverberation randomizes the phases of the sine components of the harmonics

Bandwidth of each harmonic

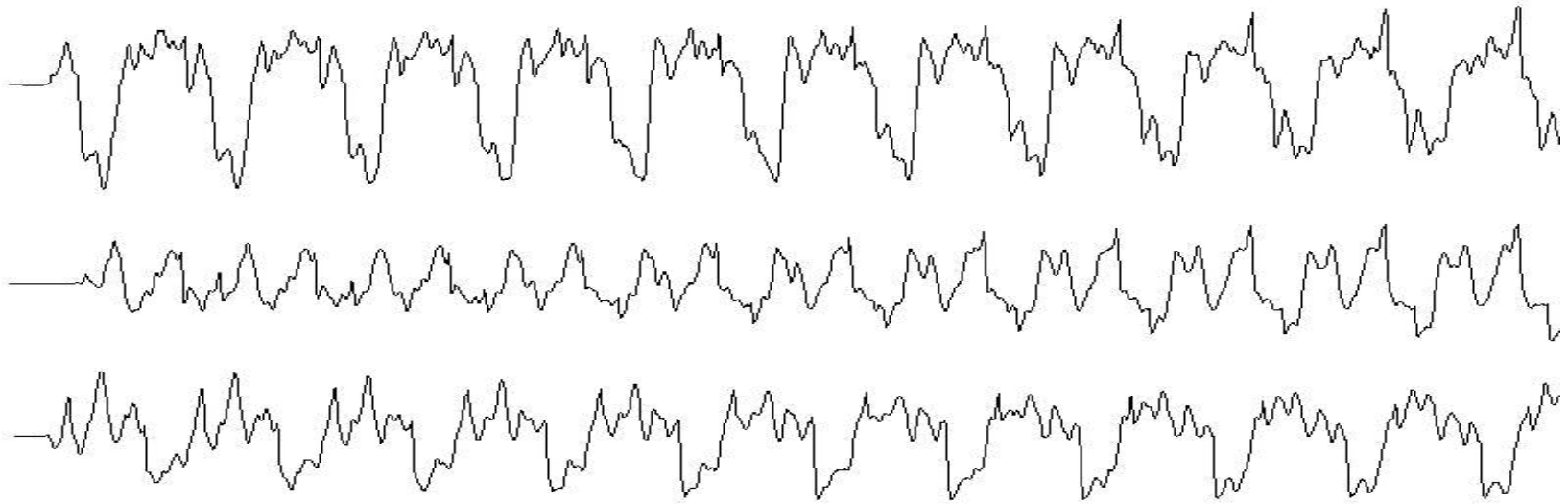# PADsynth and meaning of the "Harmonic Profile"

Zoom In

Bandwidth of each harmonic

Randomness

- Digital synthesis sounds "cold" because the same recorded sample is played over and over at each keypress

- To make sound "warm", ZynAddSubFX has many parameters that adds randomness


Few keystrokes at the same pitch/strength with same instrument

Resonance

- ZynAddSubFX offers many ways to make resonance: by using filters (formant or resonance) , adaptive-harmonics, etc.

Adaptive harmonics

• It is a simple, but very effective way to produce natural-like sounds (e.g. A listener cannot realize that the sounds comes from a synthesizer and s/he thinks that is produced by real (natural) instrument)
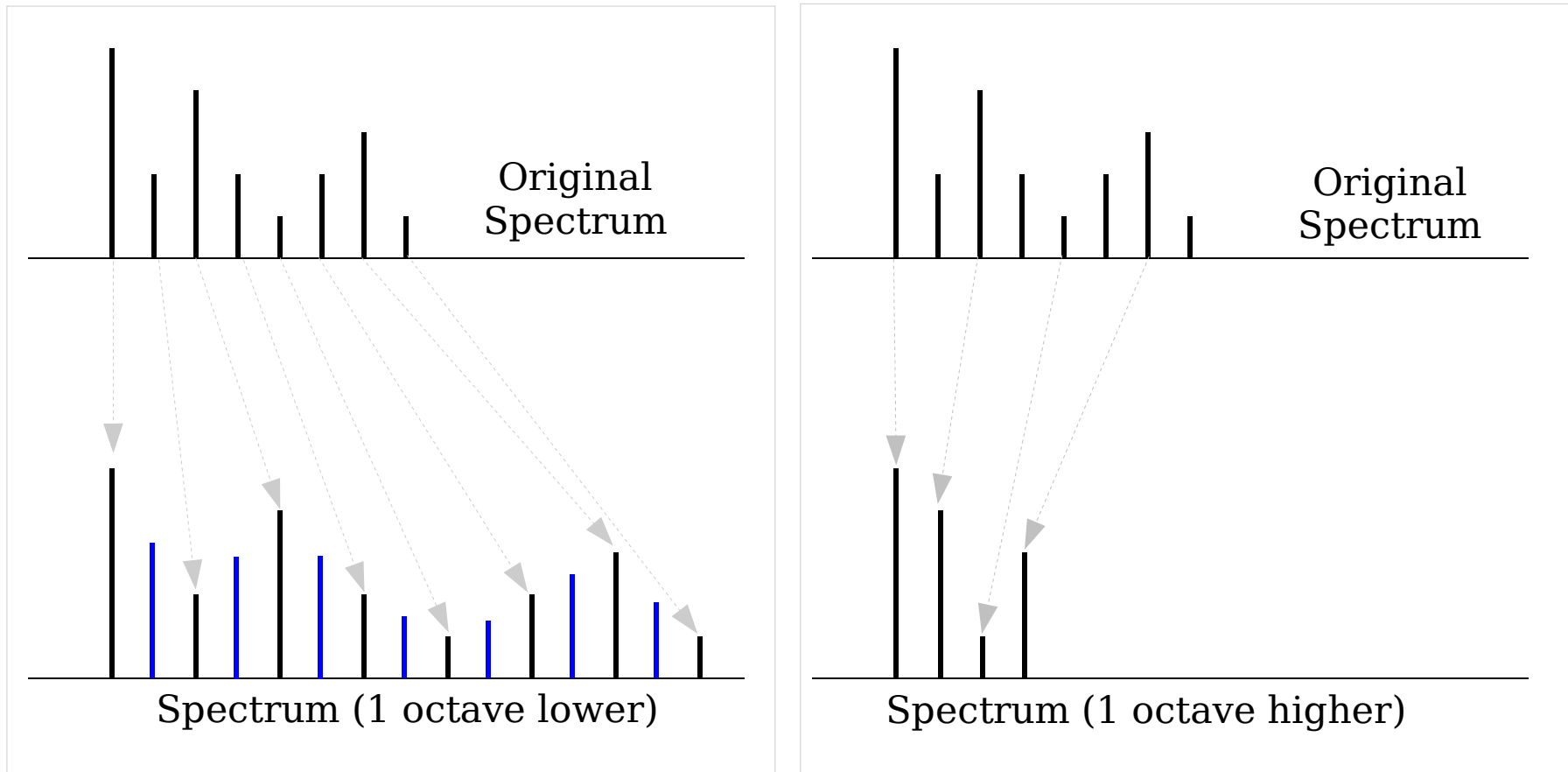
The Spectrum data is resampled according to the division between a fixed base frequency and the note's frequency.

Microtonal

- The most western music is tuned in the Equal Temperate scale with 12 notes/octave

- ZynAddSubFX supports any tunning with any number of notes/octave

- It can import tunnings in Scala formats and keyboard mappings

Todo list

- Manual and documentation

- Add the posibility to export instruments as wav (or sfz)

- On the long term:

  - Realtime-safe

  - Solve VST issues

  - Other synthesis engines

Audio Demos

- Play many instruments as possible
- JACK demo

Questions