GDC MARCH 17-21, 2025
SAN FRANCISCO, CA

The Synthesizer Plugins of COCOON

Jakob Schmid
Geometric Interactive

GEOMETRIC INTERACTIVE

#GDC2025

Who am I?

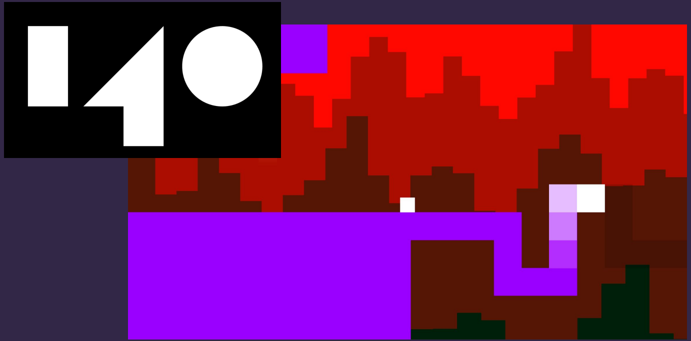
Computer scientist, Aalborg University, Denmark

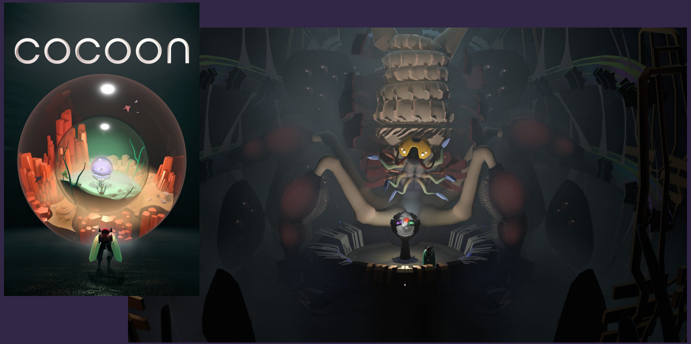
17 years game development experience

Audio programmer on INSIDE

Co-founder of Geometric Interactive

Created electronic music since late 1980s





What is COCOON?

A single-player puzzle adventure by

Geometric Interactive

Game director	Jeppe Carlsen
Art director	Erwin Kho

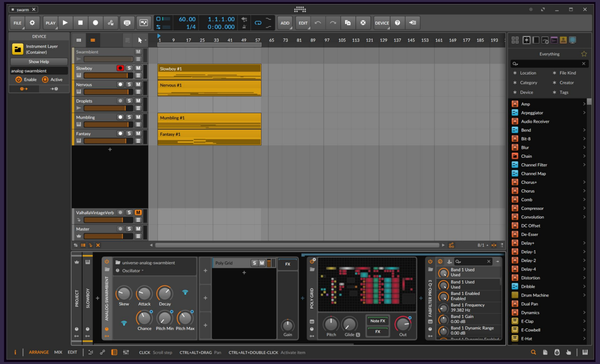
Production: 6.5 years, 1-13 people

Play time: ~ 5 hours

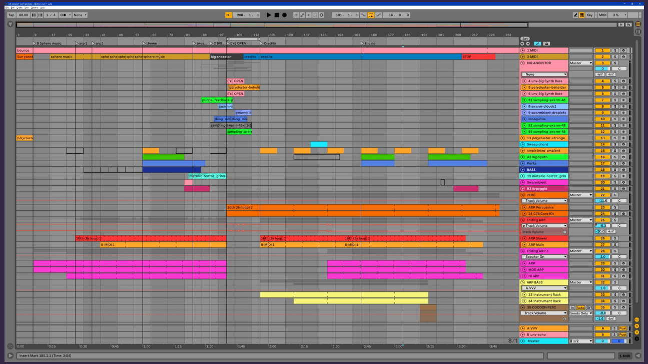
Game and Audio Engine

Music Software

Ableton Live	Ableton Live was used for sound design and music production
Bitwig Studio	Bitwig was used for music production and prototyping new synthesizers



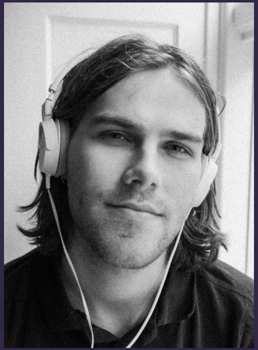
Bitwig Studio 5



Ableton Live 11

COCOON Audio Team

Audio direction and music	Jakob Schmid
Sound design	Julian Lentz Mikkel Anttila



Topics

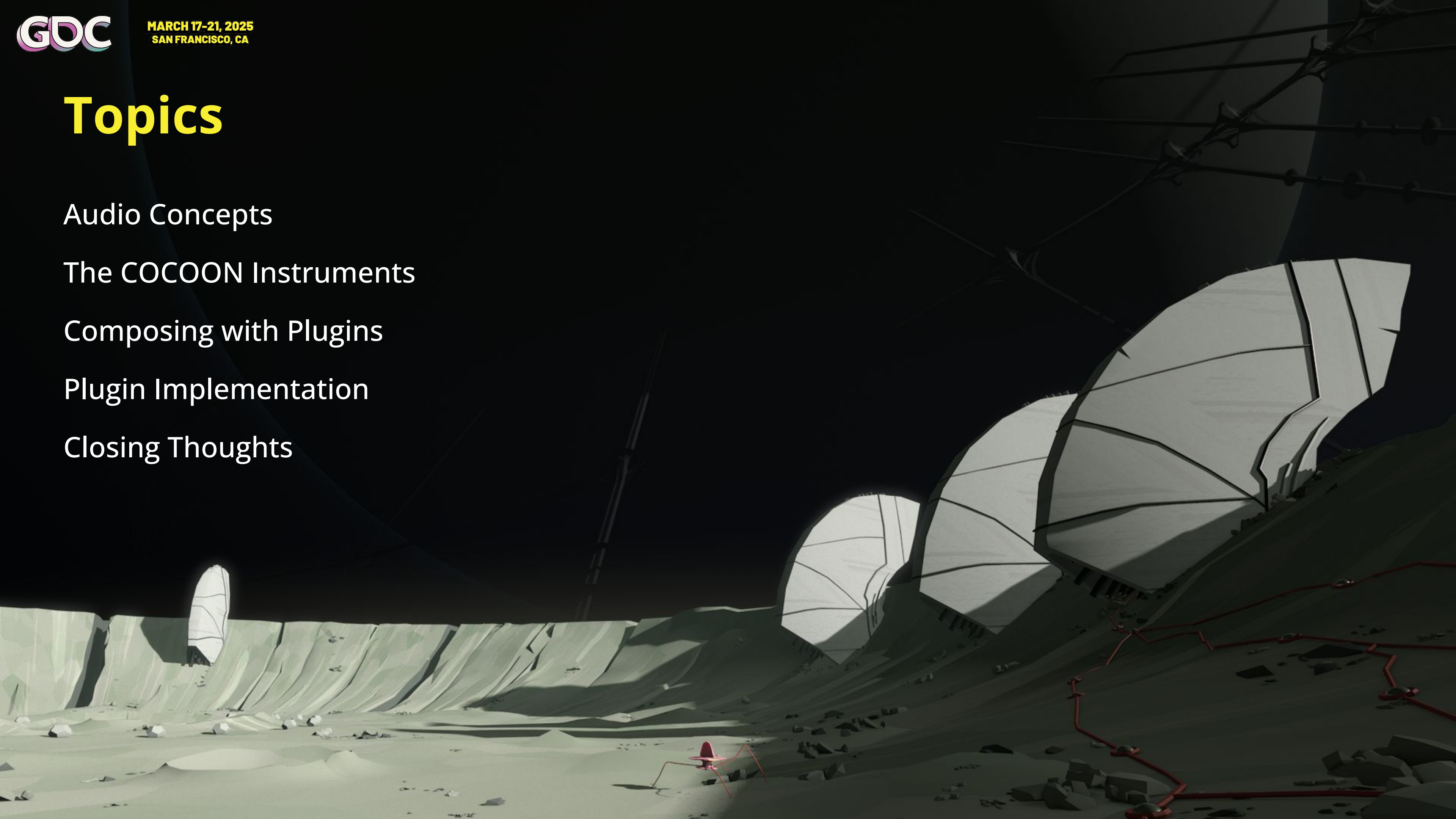
Audio Concepts

The COCOON Instruments

Composing with Plugins

Plugin Implementation

Closing Thoughts



Audio Concepts

Music Concept

Sound Design Concept

Artistic Framework

Music Concept

Vignettes | Pre-composed vignettes for big moments

Ambient music | Real-time synthesized ambient music for puzzle gameplay

Big moment: Vignette

Puzzle gameplay: synthesized ambient music

Why Real-time Synthesis?

Loop free — Ambient music doesn't loop during ‘thinking breaks’

Reactive — Music reacts to game events: notes, timbre, effects

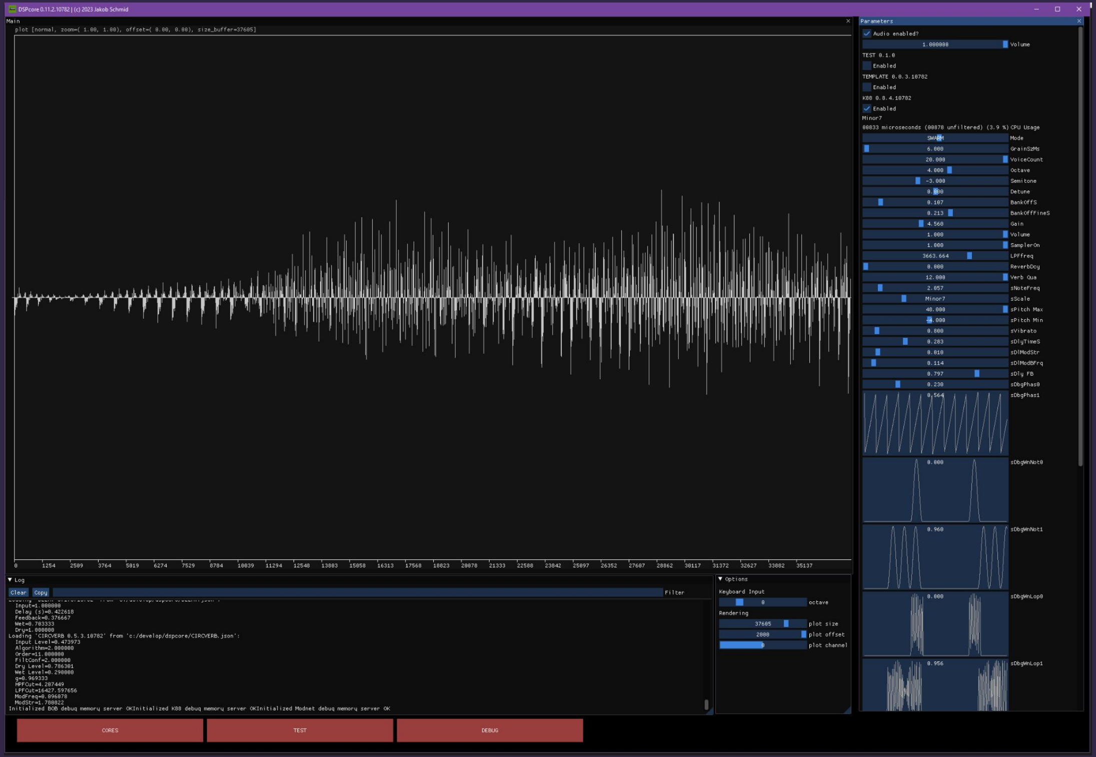
Unique soundtracks — Each player has a unique game soundtrack

Tiny — Ambient music for COCOON takes up 5 MB on disk in total

(for a 5 hour game)

Why Real-time Synthesis? The REAL reason!

I love creating music systems!


DSPcore 0.11.2.10782 | (c) 2023 Jakob Schmid

Main

```
plot [normal, zoom=( 1.00, 1.00), offset=( 0.00, 0.00), size_buffer=37605]
```

▼ Log

```
  Input=1.000000
  Delay (s)=0.422618
  Feedback=0.376667
  Wet=0.703333
  Dry=1.000000
Loading 'CIRCVERB 0.5.3.10782' from 'c:/develop/dspcore/CIRCVERB.json':
  Input Level=0.473973
  Algorithm=2.000000
  Order=11.000000
  FiltConf=2.000000
  Dry Level=0.786301
  Wet Level=0.290000
  g=0.969333
  HPFCut=4.207449
  LPFCut=16427.597656
  ModFreq=0.096078
  ModStr=1.780822
Initialized BOB debug memory server OKInitialized K88 debug memory server OKInitialized Modnet debug memory server OK
```

▼ Options

```
Keyboard Input
  0        octave
Rendering
  37605    plot size
  2000     plot offset
  0        plot channel
```

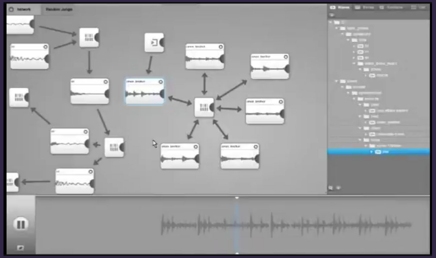
Parameters

```
☑ Audio enabled?
  1.000000   Volume
TEST 0.1.0
☐ Enabled
TEMPLATE 0.0.3.10782
☐ Enabled
K88 0.8.4.10782
☑ Enabled
Minor7
00833 microseconds (00878 unfiltered) (3.9 %) CPU Usage
  SWARM      Mode
  6.000      GrainSzMs
  20.000     VoiceCount
  4.000      Octave
  -3.000     Semitone
  0.000      Detune
  0.107      BankOffS
  0.213      BankOffFineS
  4.560      Gain
  1.000      Volume
  1.000      SamplerOn
  3663.664   LPFfreq
  0.000      ReverbDcy
  12.000     Verb Qua
  2.057      sNoteFreq
  Minor7     sScale
  48.000     sPitch Max
  -4.000     sPitch Min
  0.800      sVibrato
  0.283      sDlyTimeS
  0.010      sDlModStr
  0.114      sDlModBFrq
  0.797      sDly FB
  0.230      sDbgPhas0
  0.564      sDbgPhas1
  0.000      sDbgWnNot0
  0.960      sDbgWnNot1
  0.000      sDbgWnLop0
  0.956      sDbgWnLop1
```

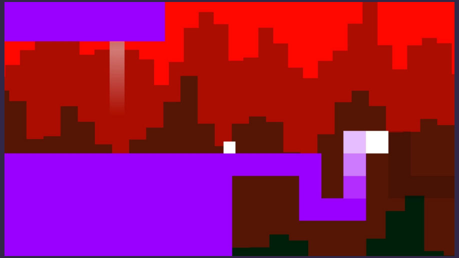
Professional Music Projects

Lost Empire: Immortals	Dynamic stem mixing system
Audioflow	Graph-based music middleware
140	Adaptive music systems for Jeppe Carlsen's music platformer
Rytmos	DSP plugins for Floppy Club's puzzle game

Lost Empire: Immortals (2008)



Audioflow (2010)



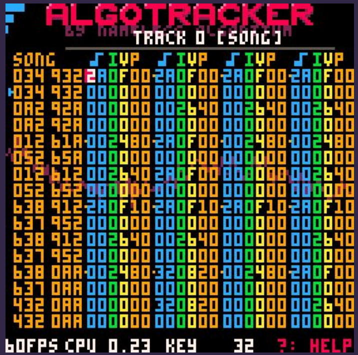
140 (2013)

Rytmos (2023)

Hobby Music Projects

Acorn Electron	(~BBC Micro) one-channel music player
Pico-8	AlgoTracker 3-track sample-/synthesis tracker
Sega MD/Genesis	AlgoTracker music replayer
Defender	Emulator of sound board for Eugene Jarvis' Defender (1981)

Acorn Electron

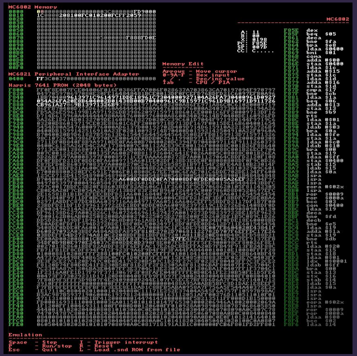


```
ALGOTRACKER
BY NAMELESS ALGORITHM
              TRACK 0 [SONG]
SONG      ♪IVP   ♪IVP   ♪IVP   ♪IVP
034 932 2A0F00-2A0F00-2A0F00-2A0F00
034 932 000000 000000 000000 000000
0A2 92A 000000 002640 002640 002640
0A2 92A 000000 000000 000000 000000
012 61A-002480-2A0F00-002480-002480
052 65A 000000 000000 000000 000000
012 612 002640 2A0F00 000000 002640
052 652 000000 000000 000000 000000
638 912-2A0F10-2A0F10-2A0F10-2A0F10
637 952 000000 000000 000000 000000
638 912 002640 002640 000000 002640
637 952 000000 000000 000000 000000
638 0AA-002480-320820-002480-2A0F00
637 0AA 000000 000000 000000 000000
432 0AA 000000 320820 000000 002640
432 0AA 000000 000000 000000 000000
60FPS CPU 0.23 KEY    32  ?: HELP
```

AlgoTracker (Pico-8)

```
GENESIS ALGOTRACKER 0.1
MEMORY $00E00100:
0100|01190000 00000000 00001734 00000000
0110|04020404 00000000 00000000 00000000
0120|05000013 23262D00 05000013 05000013
0130|00000000 00000000 00000000 00000000
```

AlgoTracker (Mega Drive)



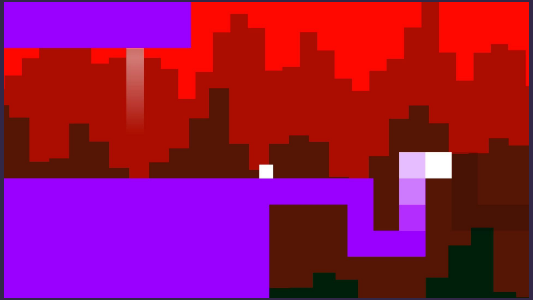
```
MC6802 Memory
0000    000000000000000003C000000FD9000
0010    1C0000208100FC010200FCFF20590000
0020    00000000000000000000000000000000
0030    00000000000000000000000000000000
0040    00000000000000000000000000000000
0050    00000000000000000000000000000000
0060    00000000000000000000000000000000
0070    0000000000000000050000F888FD0E
0080    00000000000000000000000000000000
0090    00000000000000000000000000000000
00A0    00000000000000000000000000000000
00B0    00000000000000000000000000000000
00C0    00000000000000000000000000000000
00D0    00000000000000000000000000000000
00E0    00000000000000000000000000000000
00F0    00000000000000000000000000000000
MC6821 Peripheral Interface Adapter
0400    FF3C0037000000000000000000000000
Harris 7641 PROM (2048 bytes)
F800    [illegible]
...
FFE0    [illegible]

                                   MC6802
                                   ----------------------------
             A:  11                F85E  dex
             B:  00                F85F  beq   $05
             X:  0198              F861  deca
            PC:  F85E              F862  bne   $fa
            SP:  007D              F864  bra   $e8
            CC:  C.....            F866  ldaa  $0400
                                   F869  bmi   $01
                                   F86B  coma
                                   F86C  adda  #$00
                                   F86E  staa  $0400
                                   F871  ldaa  $1c
                                   F873  adda  #$15
                                   F875  staa  $1c
                                   F877  ldaa  $1d
                                   F879  adda  #$16
                                   F87B  staa  $1d
                                   F87D  cmpa  $17
                                   F87F  bne   $cb
                                   F881  ldaa  $1a
                                   F883  beq   $06
                                   F885  adda  #$13
                                   F887  staa  $13
                                   F889  bne   $b9
                                   F88B  rts
                                   F88C  ldaa  #$01
                                   F88E  staa  $1a
                                   F890  ldab  #$03
                                   F892  bra   $0a
                                   F894  ldaa  #$fe
                                   F896  staa  $1a
                                   F898  ldaa  #$c0
                                   F89A  ldab  #$10
                                   F89C  bra   $00
                                   F89E  staa  $19
                                   F8A0  ldaa  #$ff
                                   F8A2  staa  $0400
                                   F8A5  stab  $15
                                   F8A7  ldab  $15
                                   F8A9  ldaa  $0a
                                   F8AB  lsra
                                   F8AC  lsra
                                   F8AD  lsra
                                   F8AE  eora  #$02x
                                   F8B0  lsra
                                   F8B1  ror   $0009
                                   F8B4  ror   $000a
                                   F8B7  bcc   $03
                                   F8B9  com   $0400
                                   F8BC  ldaa  $19
                                   F8BE  deca
                                   F8BF  bne   $fd
                                   F8C1  decb
                                   F8C2  bne   $e5
                                   F8C4  ldaa  $19
                                   F8C6  adda  #$1a
                                   F8C8  staa  $19
                                   F8CA  bne   $db
                                   F8CC  rts
                                   F8CD  ldaa  #$20
                                   F8CF  staa  $15
                                   F8D1  staa  $18
                                   F8D3  ldaa  #$01
                                   F8D5  ldx   #$0001
                                   F8D8  ldab  #$ff
                                   F8DA  bra   $00
                                   F8DC  staa  $13
                                   F8DE  stx   $16
                                   F8E0  stab  $14
                                   F8E2  ldab  $15
                                   F8E4  ldaa  $0a
                                   F8E6  lsra
                                   F8E7  lsra
                                   F8E8  lsra
                                   F8E9  eora  #$02x
                                   F8EB  lsra
                                   F8EC  ror   $0009
                                   F8EF  ror   $000a
                                   F8F2  ldaa  #$00
                                   F8F4  bcc   $02
                                   F8F6  ldaa  $14

Memory Edit
-----------
Arrows  - Move cursor
0-9A-F  - Hex input
+ / .   - Dec/inc value
Tab     - CPU / PIA

Emulation
--------------------------------
Space   - Step       I - Trigger interrupt
P       - Run/stop   R - Reset
Esc     - Quit       L - Load .snd ROM from file
```

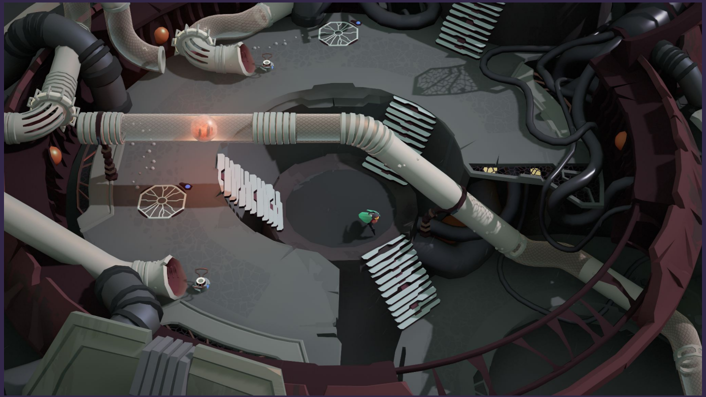
DefendEmu

Sound Design Concept

Synthetic sound design - no recorded sound!

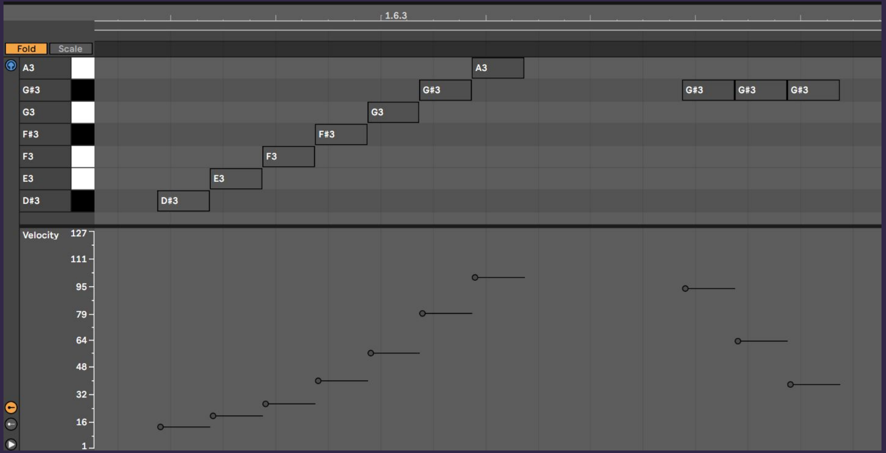
Music aesthetics	Fits synthesized ambient music
Art aesthetics	Fits aesthetics of living artificial worlds
Familiar process	Production process similar to ‘140’

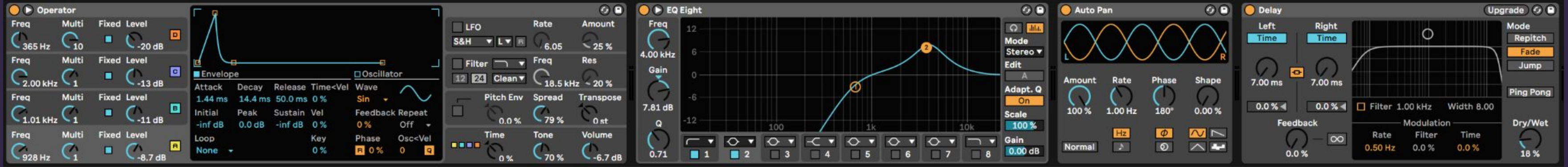




Synthetic Sound Design Experiments

Frogs, crickets, wind





Operator

Freq	Multi	Fixed	Level	
365 Hz	10	■	-20 dB	D
2.00 kHz	1	■	-13 dB	C
1.01 kHz	1	■	-11 dB	B
928 Hz	1	■	-8.7 dB	A

■ Envelope

Attack	Decay	Release	Time<Vel
1.44 ms	14.4 ms	50.0 ms	0 %
Initial	Peak	Sustain	Vel
-inf dB	0.0 dB	-inf dB	0 %
Loop			Key
None			0 %

□ Oscillator

Wave: Sin
Feedback: 0 %
Repeat: Off
Phase: R 0 %
Osc<Vel: 0 Q

□ LFO S&H L R
Rate: 6.05
Amount: 25 %

□ Filter
12 24 Clean
Freq: 18.5 kHz
Res: 20 %

□
Pitch Env: 0.0 %
Spread: 79 %
Transpose: 0 st

Time: 0 %
Tone: 70 %
Volume: -6.7 dB

EQ Eight

Freq: 4.00 kHz
Gain: 7.81 dB
Q: 0.71

Mode: Stereo
Edit: A
Adapt. Q: On
Scale: 100 %
Gain: 0.00 dB

■ 1 ■ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □ 8

Auto Pan

Amount	Rate	Phase	Shape
100 %	1.00 Hz	180°	0.00 %

Normal
Hz
♪

Delay
Upgrade

Left	Right
Time	Time
7.00 ms	7.00 ms
0.0 %	0.0 %

Feedback: 0.0 %
∞

□ Filter 1.00 kHz Width 8.00

Modulation

Rate	Filter	Time
0.50 Hz	0.0 %	0.0 %

Mode: Repitch [✓ Fade] Jump
Ping Pong
Dry/Wet: 18 %

▸ gdc-frog

Artistic Framework

Ambient music	Real-time synthesized ambient music for puzzle gameplay
Vignettes	Pre-rendered synthetic music vignettes for big moments
Sound design	Pre-rendered synthetic sounds for all sound design

Why the Constraints?

Creating an artistic framework with strict constraints is helpful

Avoid paralysis	Avoid paralysis from too many options
Focus	Focus work during the infancy of the project
Coherence	Coherence in final work
References	Assists in finding references - "synthesized music without sequencer" 1970s New Age music Tangerine Dream, Vangelis, Jean-Michel Jarre

Tangerine Dream (1975), photo by Geoffrey Tyrrell

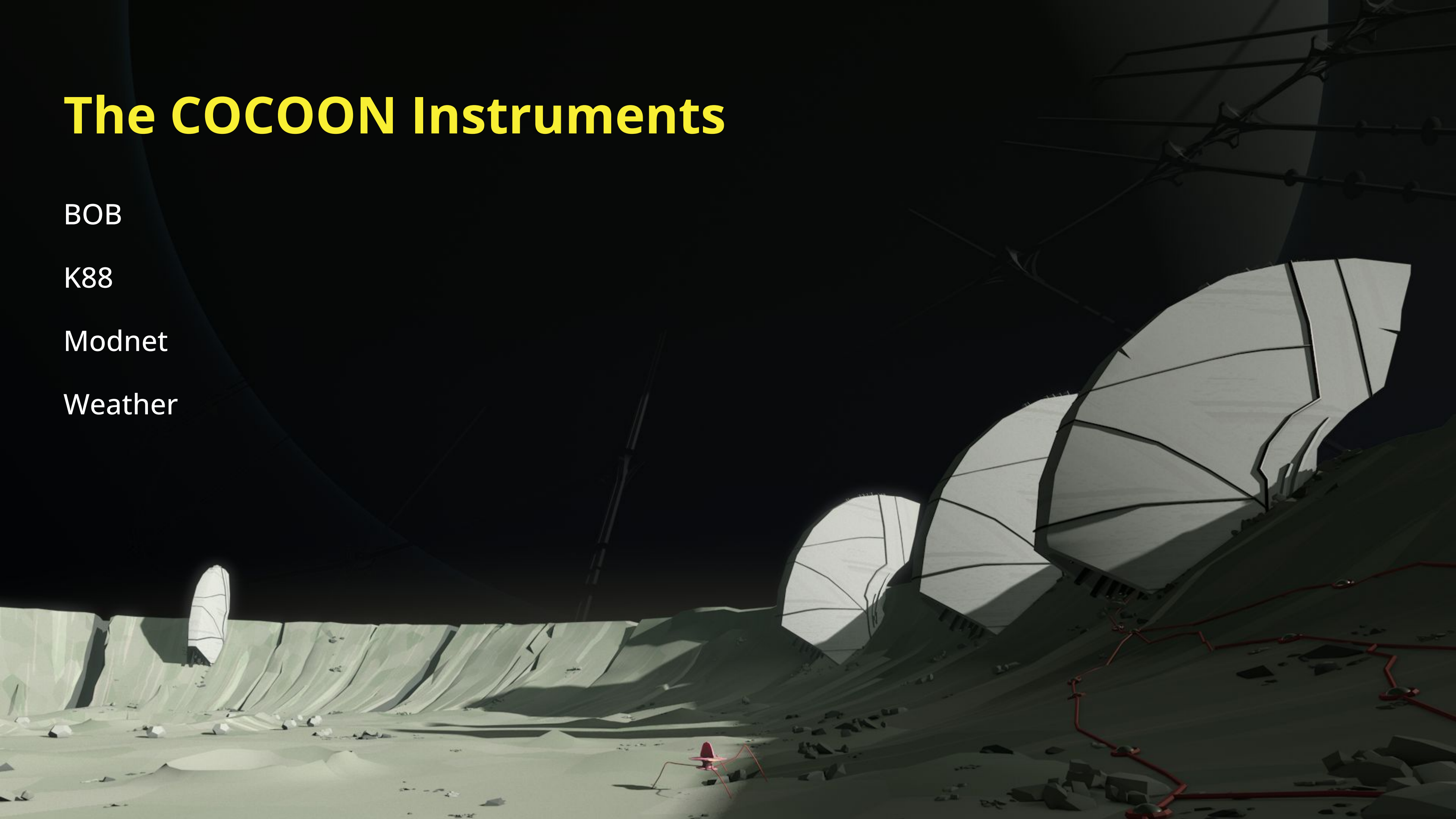
The COCOON Instruments

BOB

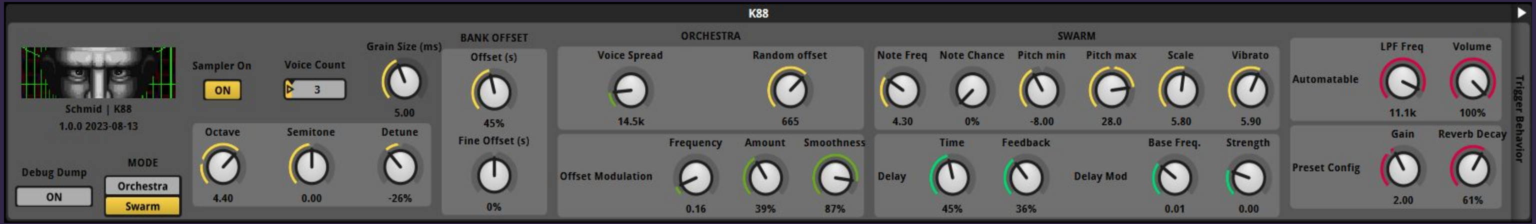
K88

Modnet

Weather



COCOON Instruments



K88

Schmid | K88
1.0.0 2023-08-13

Debug Dump ON

MODE Orchestra Swarm

Sampler On ON

Voice Count 3

Grain Size (ms) 5.00

Octave 4.40
Semitone 0.00
Detune -26%

BANK OFFSET
Offset (s) 45%
Fine Offset (s) 0%

ORCHESTRA
Voice Spread 14.5k
Random offset 665

Offset Modulation
Frequency 0.16
Amount 39%
Smoothness 87%

SWARM
Note Freq 4.30
Note Chance 0%
Pitch min -8.00
Pitch max 28.0
Scale 5.80
Vibrato 5.90

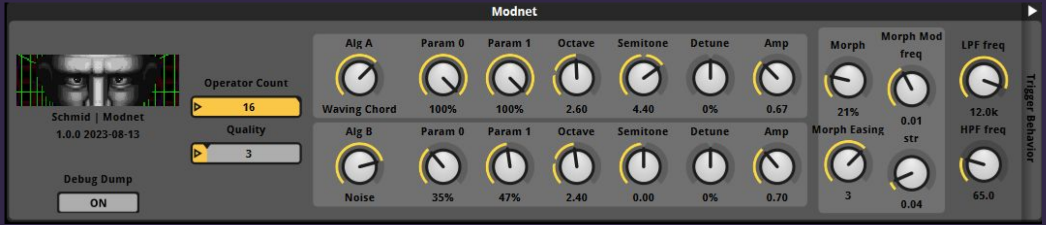
Delay
Time 45%
Feedback 36%

Delay Mod
Base Freq. 0.01
Strength 0.00

Automatable
LPF Freq 11.1k
Volume 100%

Preset Config
Gain 2.00
Reverb Decay 61%

Trigger Behavior



Modnet

Schmid | Modnet
1.0.0 2023-08-13

Debug Dump ON

Operator Count 16
Quality 3

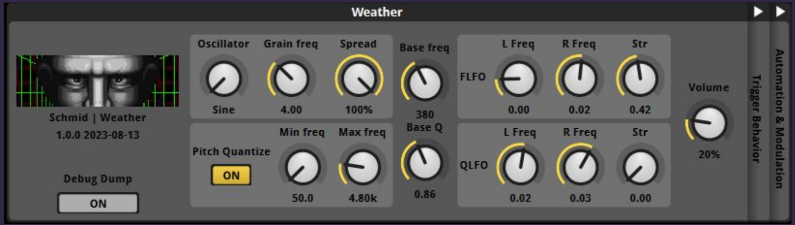
Alg A Waving Chord
Param 0 100%
Param 1 100%
Octave 2.60
Semitone 4.40
Detune 0%
Amp 0.67

Alg B Noise
Param 0 35%
Param 1 47%
Octave 2.40
Semitone 0.00
Detune 0%
Amp 0.70

Morph 21%
Morph Easing 3
Morph Mod freq 0.01
str 0.04

LPF freq 12.0k
HPF freq 65.0

Trigger Behavior



Weather

Schmid | Weather
1.0.0 2023-08-13

Debug Dump ON

Oscillator Sine
Grain freq 4.00
Spread 100%

Pitch Quantize ON
Min freq 50.0
Max freq 4.80k

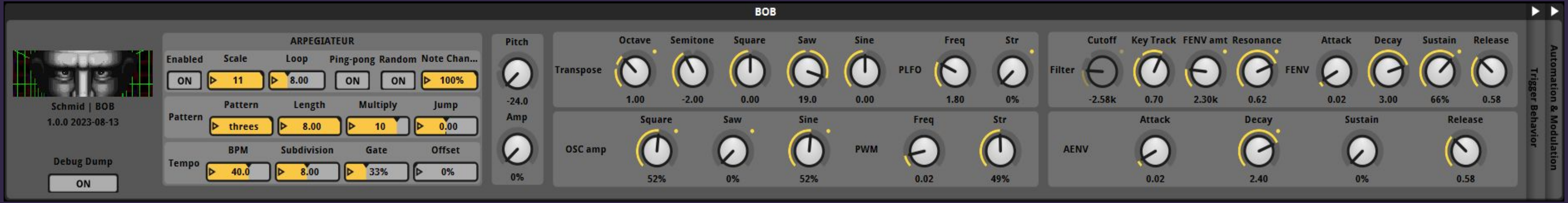
Base freq 380
Base Q 0.86

FLFO
L Freq 0.00
R Freq 0.02
Str 0.42

QLFO
L Freq 0.02
R Freq 0.03
Str 0.00

Volume 20%

Trigger Behavior
Automation & Modulation



BOB

Schmid | BOB
1.0.0 2023-08-13

Debug Dump ON

ARPEGIATEUR
Enabled ON
Scale 11
Loop 8.00
Ping-pong ON
Random ON
Note Chan... 100%

Pattern
Pattern threes
Length 8.00
Multiply 10
Jump 0.00

Tempo
BPM 40.0
Subdivision 8.00
Gate 33%
Offset 0%

Pitch -24.0
Amp 0%

Transpose
Octave 1.00
Semitone -2.00
Square 0.00
Saw 19.0
Sine 0.00

PLFO
Freq 1.80
Str 0%

OSC amp
Square 52%
Saw 0%
Sine 52%

PWM
Freq 0.02
Str 49%

Filter
Cutoff -2.58k
Key Track 0.70
FENV amt 2.30k
Resonance 0.62

FENV
Attack 0.02
Decay 3.00
Sustain 66%
Release 0.58

AENV
Attack 0.02
Decay 2.40
Sustain 0%
Release 0.58

Trigger Behavior
Automation & Modulation

BOB

Subtractive synthesizer

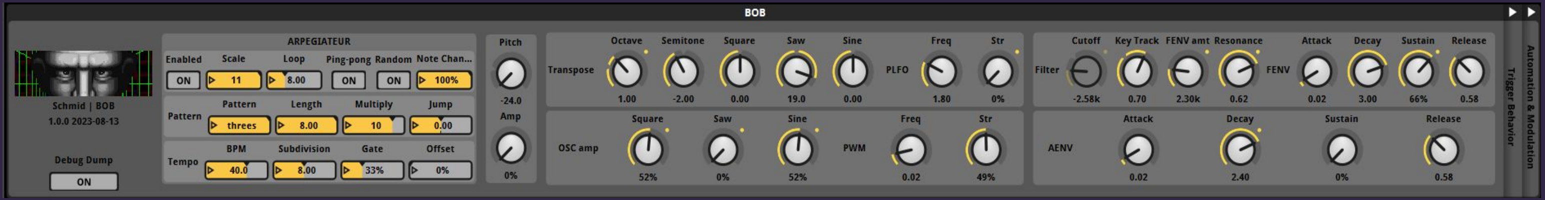
Arpeggiator | Monophonic arpeggiator generates notes

Three oscillators | Square, saw, sine oscillators with individual pitch and amplitude

PWM / vibrato | Pulse-width modulation of square wave and vibrato

Ladder filter | Ladder filter for resonant filtering

Envelopes | Amplitude and filter envelopes for shaping notes



BOB

Schmid | BOB
1.0.0 2023-08-13

Debug Dump
ON

ARPEGIATEUR

Enabled	Scale	Loop	Ping-pong	Random	Note Chan...
ON	11	8.00	ON	ON	100%

Pattern	Pattern	Length	Multiply	Jump
	threes	8.00	10	0.00

Tempo	BPM	Subdivision	Gate	Offset
	40.0	8.00	33%	0%

Pitch	Amp
-24.0	0%

Transpose	Octave	Semitone	Square	Saw	Sine	PLFO	Freq	Str
	1.00	-2.00	0.00	19.0	0.00		1.80	0%

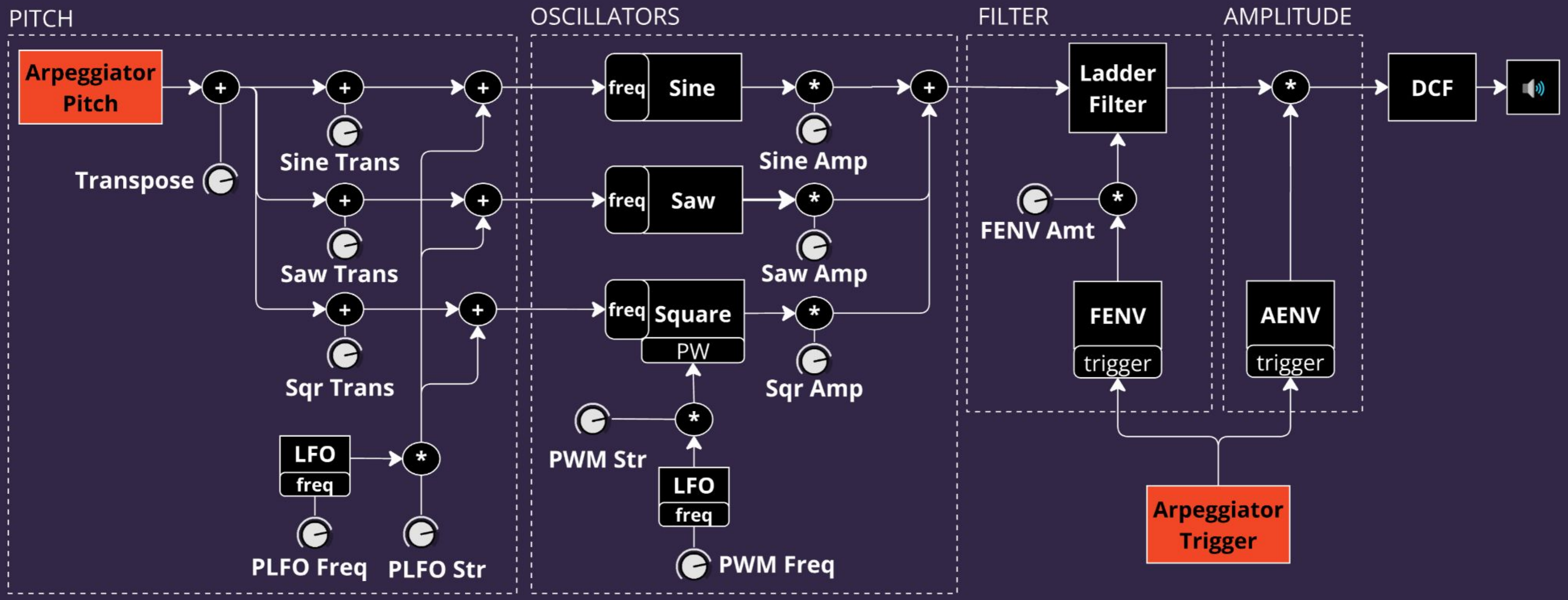
OSC amp	Square	Saw	Sine	PWM	Freq	Str
	52%	0%	52%		0.02	49%

Filter	Cutoff	Key Track	FENV amt	Resonance	FENV	Attack	Decay	Sustain	Release
	-2.58k	0.70	2.30k	0.62		0.02	3.00	66%	0.58

AENV	Attack	Decay	Sustain	Release
	0.02	2.40	0%	0.58

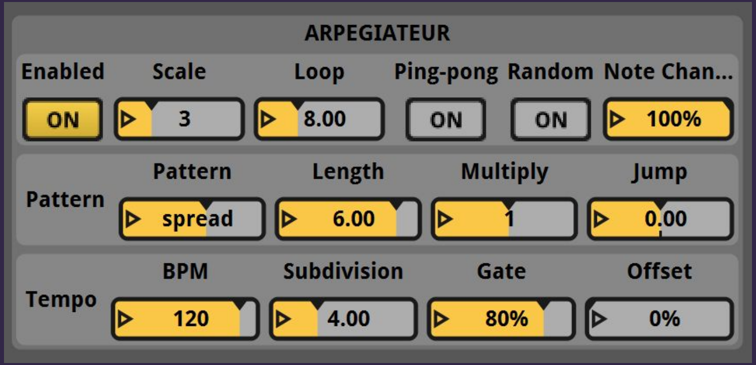
▸ gdc-bob

BOB Structure



BOB Arpeggiator

Arpeggiator	Arpeggiator is the only way that BOB can play anything in COCOON
Usability	More flexible than usable
Scale	Notes are picked from predefined scale



ARPEGIATEUR

Enabled	Scale	Loop	Ping-pong	Random	Note Chan...
ON	3	8.00	ON	ON	100%

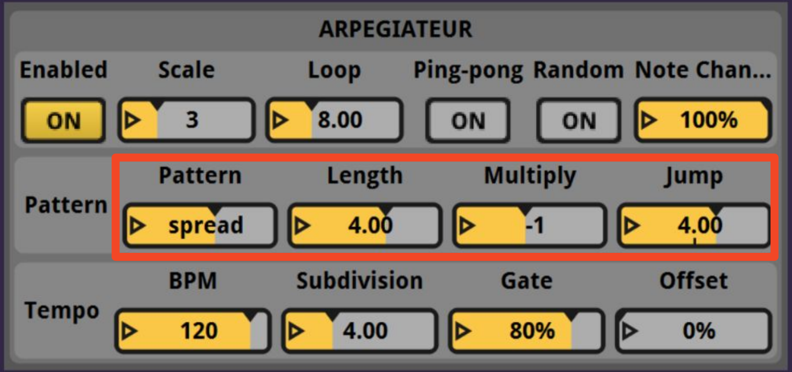
	Pattern	Length	Multiply	Jump
Pattern	spread	6.00	1	0.00

	BPM	Subdivision	Gate	Offset
Tempo	120	4.00	80%	0%

Named 'Arpegiateur' after Jean-Michel Jarre's 1982 track

BOB Arpeggiator: Parameters

Example parameters



ARPEGIATEUR

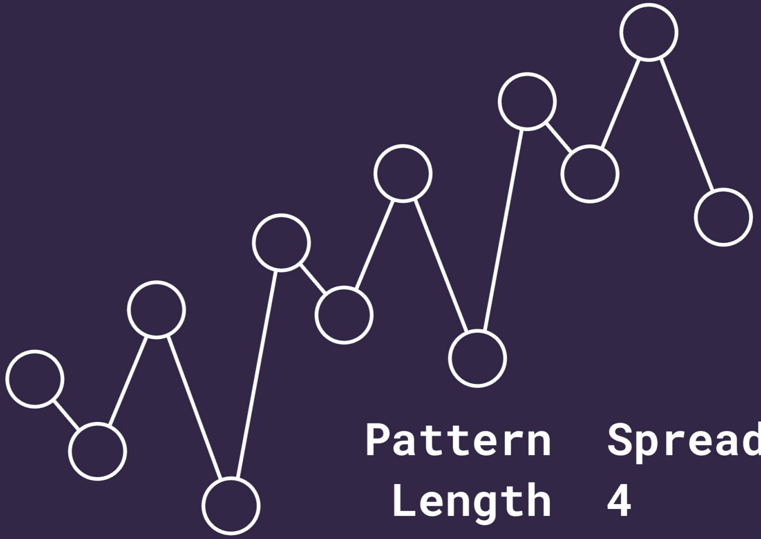
Enabled	Scale	Loop	Ping-pong	Random	Note Chan...
ON	▷ 3	▷ 8.00	ON	ON	▷ 100%

Pattern

Pattern	Length	Multiply	Jump
▷ spread	▷ 4.00	▷ -1	▷ 4.00

Tempo

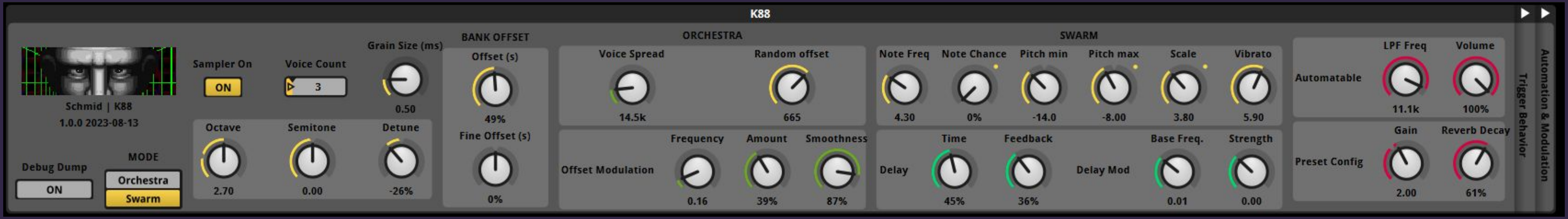
BPM	Subdivision	Gate	Offset
▷ 120	▷ 4.00	▷ 80%	▷ 0%



Pattern	Spread
Length	4
Multiply	-1
Jump	4

K88

Granular synthesis	Grains of sample data are extracted and windowed
Two modes	Orchestra and Swarm
Sample bank	4MB built-in sample bank recorded from classic synthesizer
Reverb	Series of 12 all-pass filters 'smears' the output to create soft pads



K88

Schmid | K88
1.0.0 2023-08-13

Debug Dump ON

MODE
Orchestra
Swarm

Sampler On ON

Voice Count 3

Grain Size (ms) 0.50

Octave 2.70

Semitone 0.00

Detune -26%

BANK OFFSET
Offset (s) 49%
Fine Offset (s) 0%

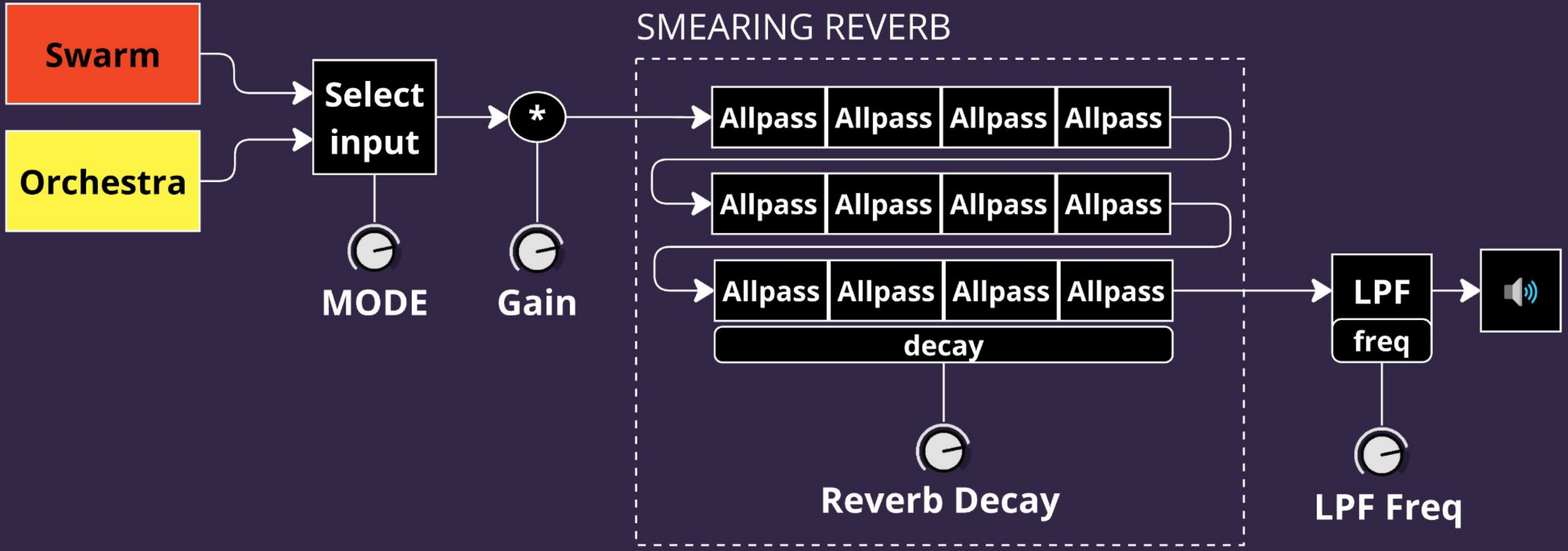
ORCHESTRA
Voice Spread 14.5k
Random offset 665
Offset Modulation: Frequency 0.16, Amount 39%, Smoothness 87%

SWARM
Note Freq 4.30
Note Chance 0%
Pitch min -14.0
Pitch max -8.00
Scale 3.80
Vibrato 5.90
Delay: Time 45%, Feedback 36%
Delay Mod: Base Freq. 0.01, Strength 0.00

Automatable: LPF Freq 11.1k, Volume 100%

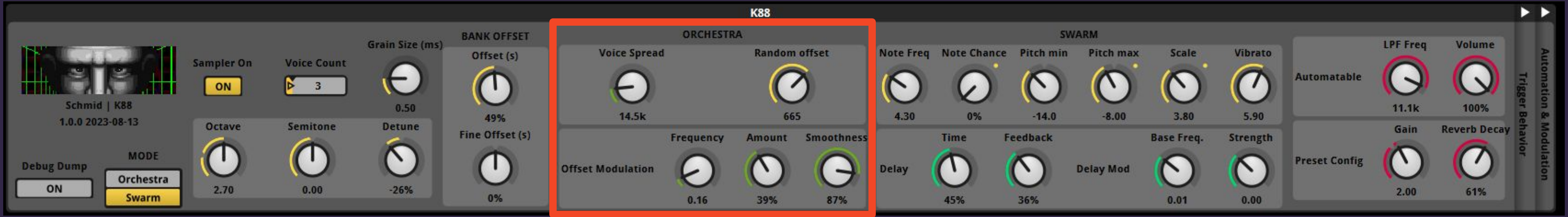
Preset Config: Gain 2.00, Reverb Decay 61%

K88 Common Output



K88 Orchestra Mode

Sliding playheads	Slides parallel playheads across sample bank
Grains	Grains are extracted from bank under playheads
S/H LFO	Sample/hold LFO controls playhead position
Horror music	Atonal orchestral sound - good for horror!



K88

Schmid | K88
1.0.0 2023-08-13

Sampler On ON
Voice Count 3
Grain Size (ms) 0.50
Octave 2.70
Semitone 0.00
Detune -26%
Debug Dump ON
MODE Orchestra [✓ Swarm]

BANK OFFSET
Offset (s) 49%
Fine Offset (s) 0%

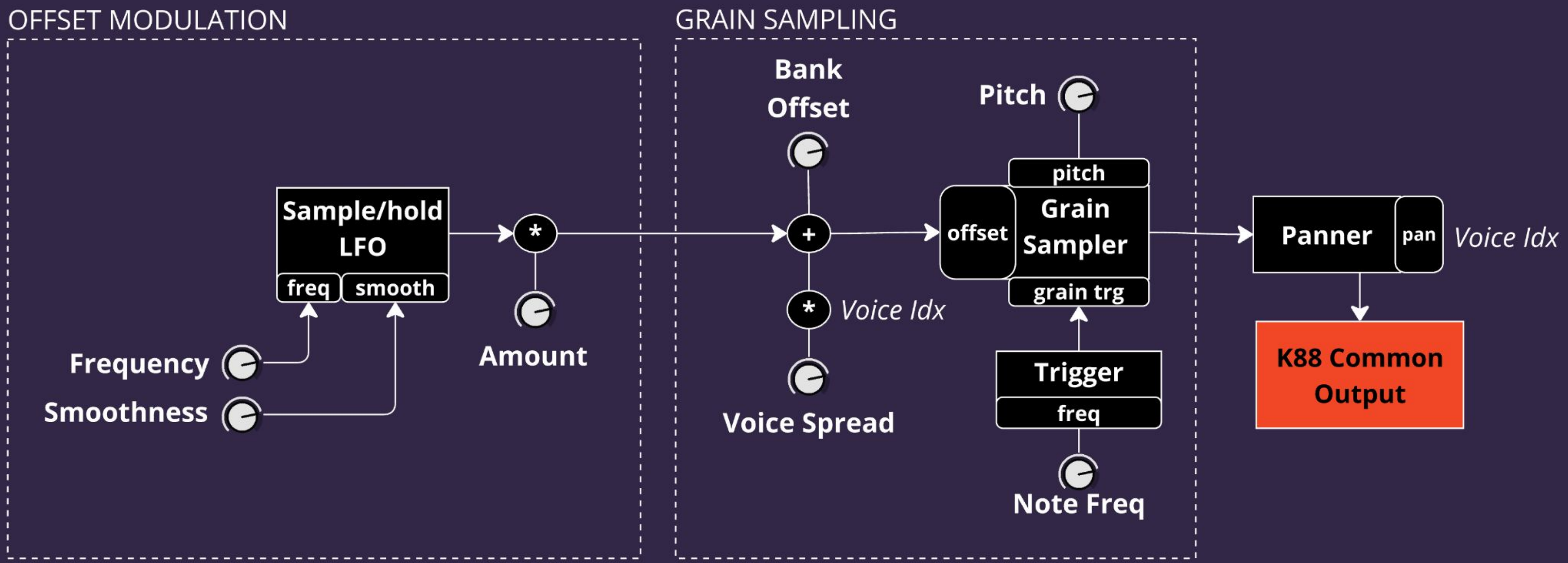
ORCHESTRA
Voice Spread 14.5k
Random offset 665
Offset Modulation: Frequency 0.16, Amount 39%, Smoothness 87%

SWARM
Note Freq 4.30
Note Chance 0%
Pitch min -14.0
Pitch max -8.00
Scale 3.80
Vibrato 5.90
Delay: Time 45%, Feedback 36%
Delay Mod: Base Freq. 0.01, Strength 0.00

Automatable: LPF Freq 11.1k, Volume 100%
Preset Config: Gain 2.00, Reverb Decay 61%

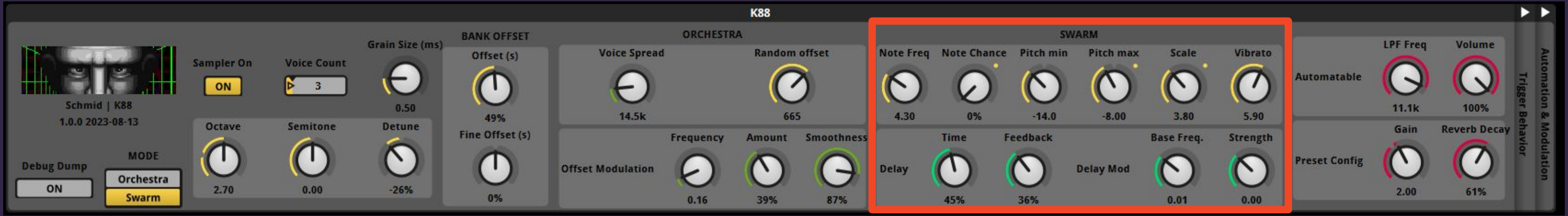
▸ gdc-k88-orchestra

K88 Orchestra Mode



K88 Swarm Mode

Extracts grains	Extracts grains from specified offset in sample bank
Scale and pitch	Grains are tuned to scale between pitch min and max
Vibrato and delay	Per-voice vibrato and modulated delay



K88

Schmid | K88
1.0.0 2023-08-13

Sampler On: ON
Voice Count: 3
Grain Size (ms): 0.50
Octave: 2.70
Semitone: 0.00
Detune: -26%
Debug Dump: ON
MODE: Orchestra / Swarm

BANK OFFSET
Offset (s): 49%
Fine Offset (s): 0%

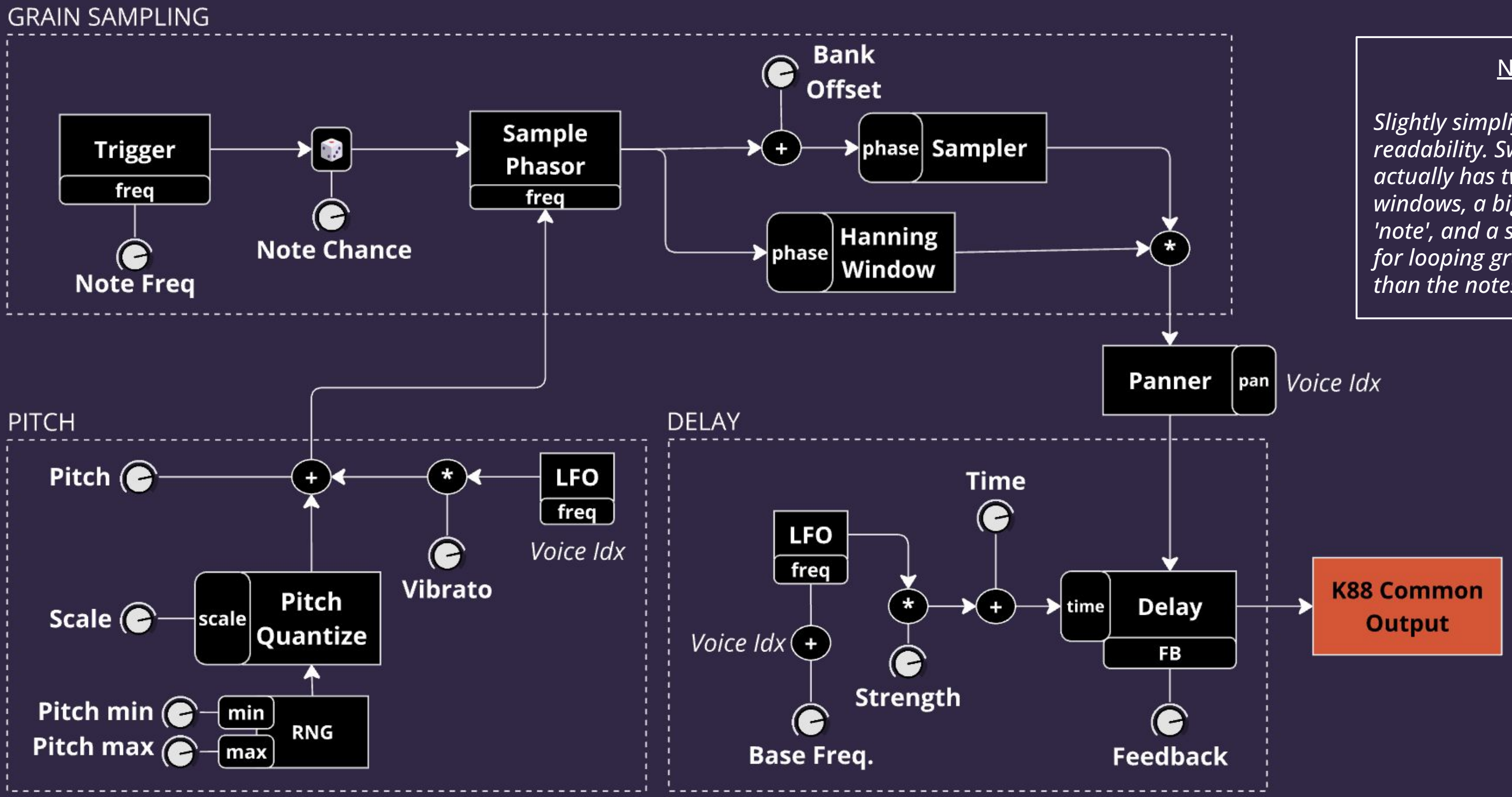
ORCHESTRA
Voice Spread: 14.5k
Random offset: 665
Offset Modulation
Frequency: 0.16
Amount: 39%
Smoothness: 87%

SWARM
Note Freq: 4.30
Note Chance: 0%
Pitch min: -14.0
Pitch max: -8.00
Scale: 3.80
Vibrato: 5.90
Delay
Time: 45%
Feedback: 36%
Delay Mod
Base Freq.: 0.01
Strength: 0.00

Automatable
LPF Freq: 11.1k
Volume: 100%
Preset Config
Gain: 2.00
Reverb Decay: 61%

▸ gdc-k88-swarm

K88 Swarm Mode



Note

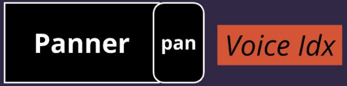
Slightly simplified for readability. Swarm mode actually has two separate windows, a big window per 'note', and a small window for looping grains shorter than the notes

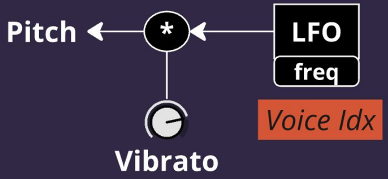
K88: A Sense of Multitude

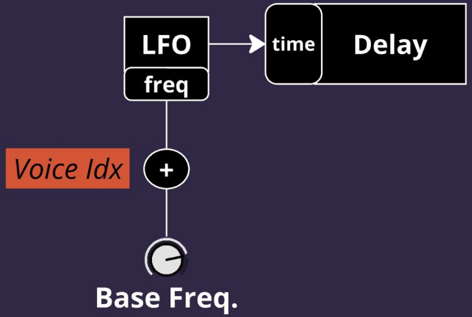
How to imply a multitude of sound sources?

Danish Radio Symphony Orchestra (2022)

Stereo spread	Spread voice panning
Random offset	Random grain offset avoids robotic quality
Per-voice vibrato	Each voice has unique pitch modulation
Per-voice delay	Each voice has separate modulated delay

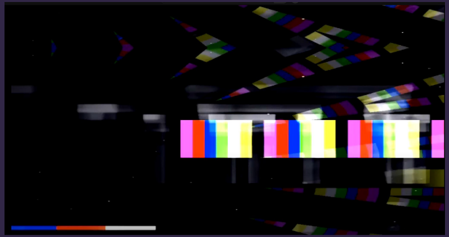


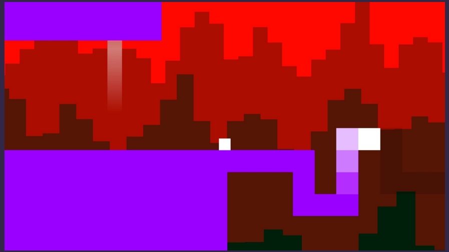


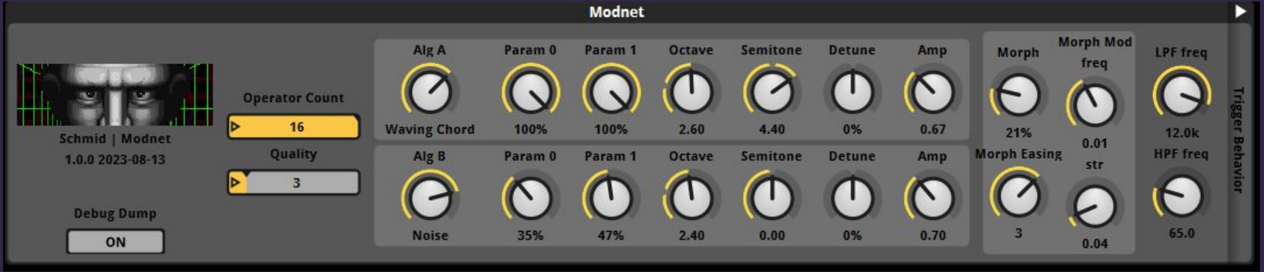


Modnet

FM/AM	FM/AM synthesizer with 16 operators
Brass-like	Brass-like sounds used to dramatic effect
Originally from 2013	Based on 50-operator non-realtime version developed in 2013 for a live performance
140	Also used on the '140' soundtrack







Modnet

Schmid | Modnet
1.0.0 2023-08-13

Debug Dump
ON

Operator Count
16

Quality
3

Alg A	Param 0	Param 1	Octave	Semitone	Detune	Amp
Waving Chord	100%	100%	2.60	4.40	0%	0.67
Alg B	Param 0	Param 1	Octave	Semitone	Detune	Amp
Noise	35%	47%	2.40	0.00	0%	0.70

Morph
21%

Morph Mod freq
0.01

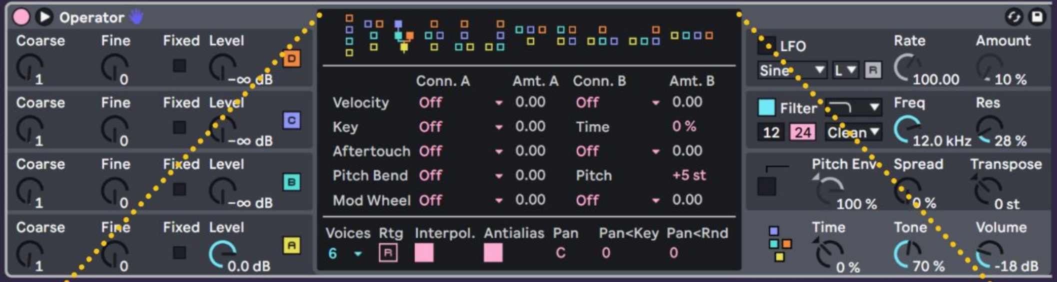
Morph Easing
3

str
0.04

LPF freq
12.0k

HPF freq
65.0

Ableton Operator Algorithm



Operator

Coarse	Fine	Fixed	Level	
1	0		-∞ dB	D
1	0		-∞ dB	C
1	0		-∞ dB	B
1	0		0.0 dB	A

	Conn. A	Amt. A	Conn. B	Amt. B
Velocity	Off	0.00	Off	0.00
Key	Off	0.00	Time	0 %
Aftertouch	Off	0.00	Off	0.00
Pitch Bend	Off	0.00	Pitch	+5 st
Mod Wheel	Off	0.00	Off	0.00

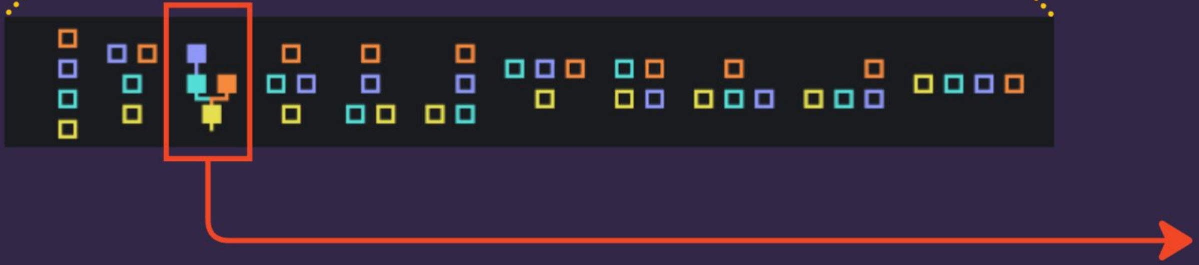
Voices	Rtg	Interpol.	Antialias	Pan	Pan<Key	Pan<Rnd
6	R			C	0	0

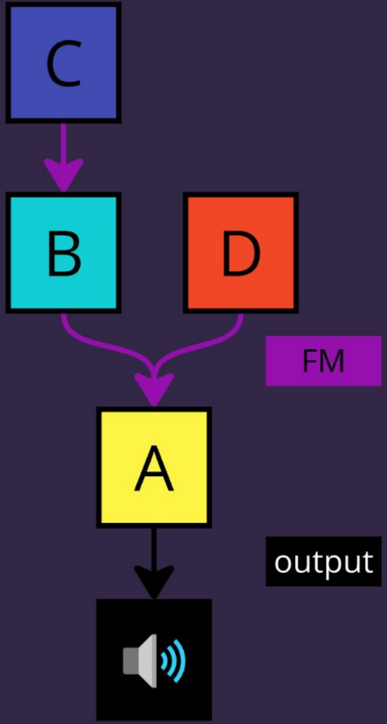
LFO Sine L R Rate 100.00 Amount 10 %

Filter 12 24 Clean Freq 12.0 kHz Res 28 %

Pitch Env 100 % Spread 0 % Transpose 0 st

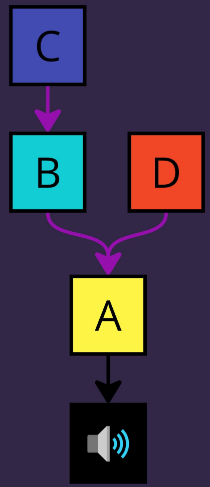
Time 0 % Tone 70 % Volume -18 dB



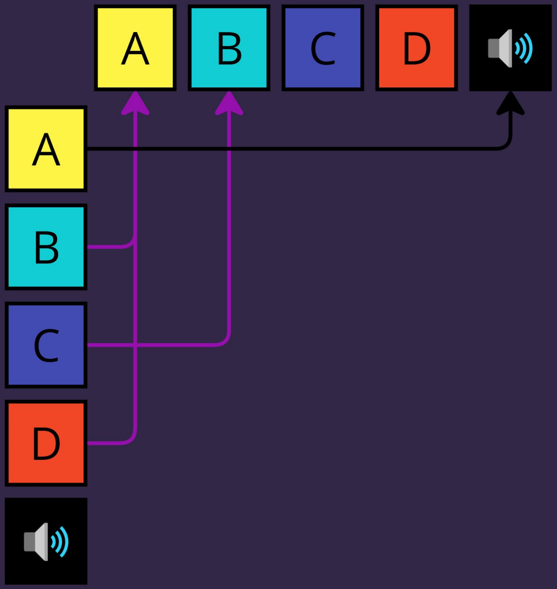


FM Algorithm Normalized Form

FM algorithm



Normalized form



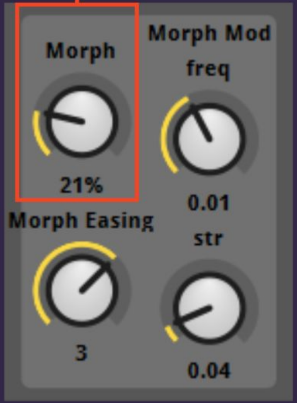
Modulation matrix

FM	A	B	C	D	🔊
A	0	0	0	0	0
B	1	0	0	0	0
C	0	1	0	0	0
D	1	0	0	0	0
🔊	0	0	0	0	0

Modnet Configuration Interpolation

Modulation Matrix 1

FM	A	B	C	D	🔊
A	0	0	0	0	0
B	1	0	0	0	0
C	0	1	0	0	0
D	1	0	0	0	0
🔊	0	0	0	0	0



Morph 21%

Morph Mod freq 0.01

Morph Easing 3

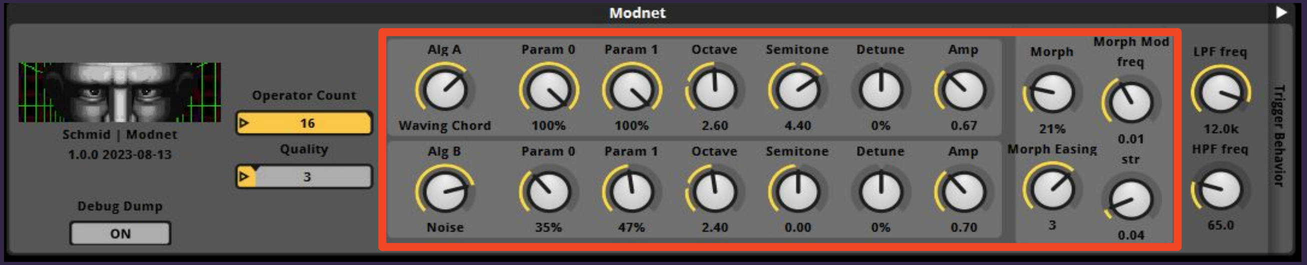
str 0.04

Modulation Matrix 2

FM	A	B	C	D	🔊
A	1	0	0	0	0
B	1	0	0	0	0
C	0	0.5	0	0	0
D	0	1	0	0	0
🔊	0	0	0	0	0

Modnet Configuration Interpolation

Meta-algorithms	Meta-algorithm generates patches
Two patches	Two patches are defined, A and B
Morph	Morph parameter interpolates between A and B LFO varies morph to add life to sound
Edge of morph	Interesting sounds are found in the interpolation space close to A and B



Modnet

Schmid | Modnet
1.0.0 2023-08-13

Operator Count: 16
Quality: 3
Debug Dump: ON

Alg A: Waving Chord
Param 0: 100%
Param 1: 100%
Octave: 2.60
Semitone: 4.40
Detune: 0%
Amp: 0.67

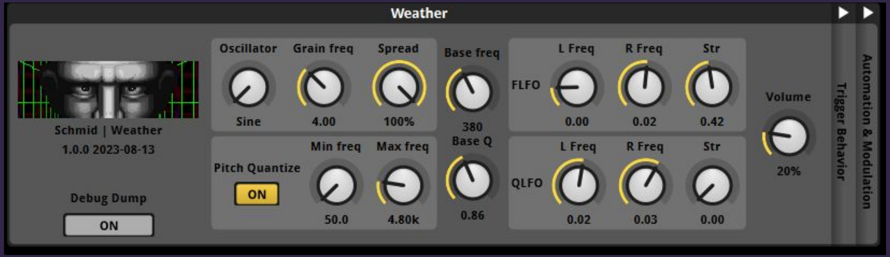
Alg B: Noise
Param 0: 35%
Param 1: 47%
Octave: 2.40
Semitone: 0.00
Detune: 0%
Amp: 0.70

Morph: 21%
Morph Easing: 3
Morph Mod freq: 0.01
str: 0.04

LPF freq: 12.0k
HPF freq: 65.0

Weather

Ambience	Wind / rain simulator designed for ambience
Grains	Generates up to 20.000 grains per second
Filters	Resonant filter for left and right channel
Movement	Four LFOs control filter cutoff and resonance



Weather

Schmid | Weather
1.0.0 2023-08-13

Debug Dump: ON

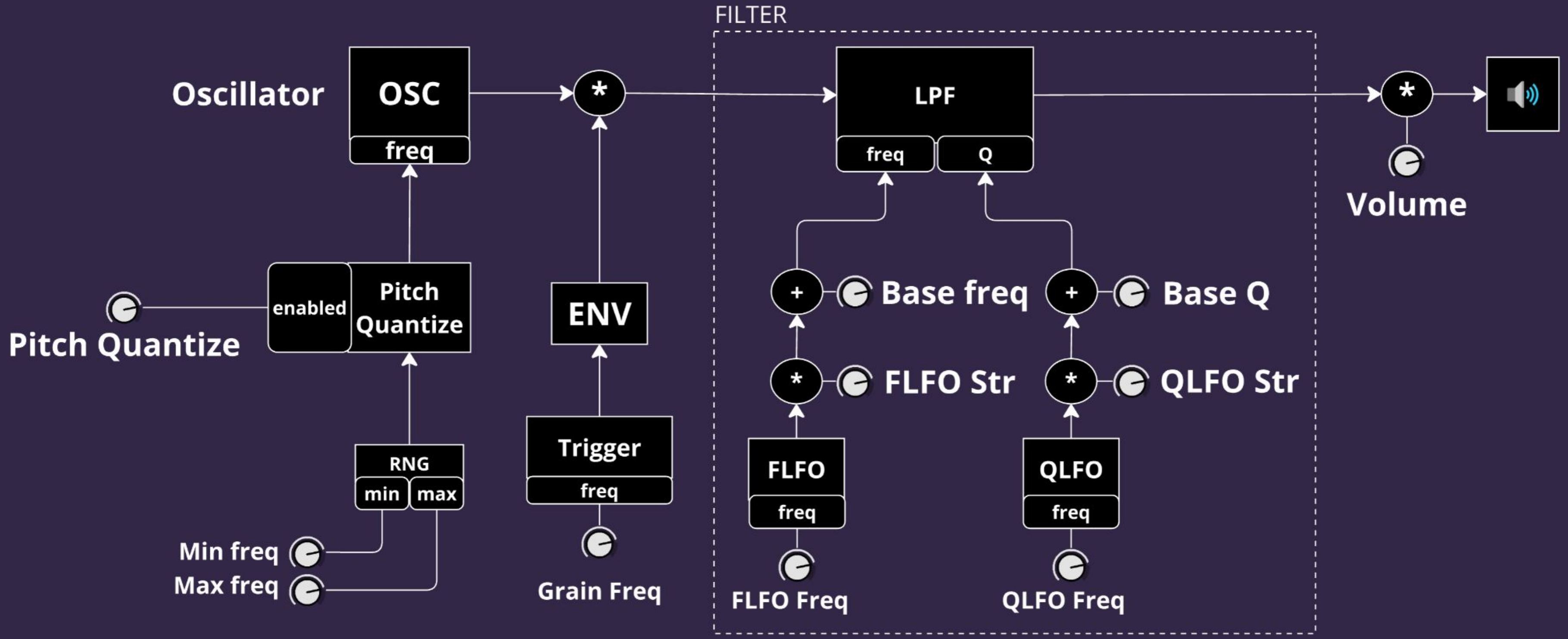
Oscillator: Sine
Grain freq: 4.00
Spread: 100%
Base freq: 380
Base Q: 0.86
Pitch Quantize: ON
Min freq: 50.0
Max freq: 4.80k

FLFO — L Freq: 0.00, R Freq: 0.02, Str: 0.42
QLFO — L Freq: 0.02, R Freq: 0.03, Str: 0.00

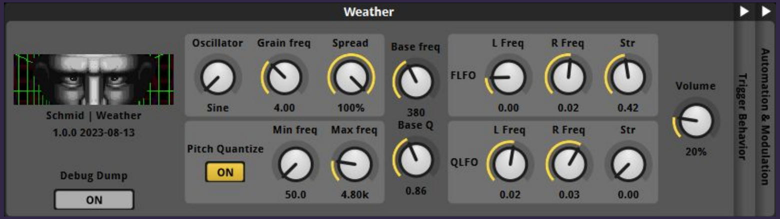
Volume: 20%

Weather Structure

Duplicated for each stereo channel



Ambience and Music



Weather

Schmid | Weather
1.0.0 2023-08-13

Debug Dump: ON

Oscillator: Sine
Grain freq: 4.00
Spread: 100%

Pitch Quantize: ON
Min freq: 50.0
Max freq: 4.80k

Base freq: 380
Base Q: 0.86

FLFO: L Freq 0.00, R Freq 0.02, Str 0.42
QLFO: L Freq 0.02, R Freq 0.03, Str 0.00

Volume: 20%

▸ gdc-weather1 , gdc-weather2

Composing with Plugins

Composing in FMOD Studio

Boss Fights

Mastering

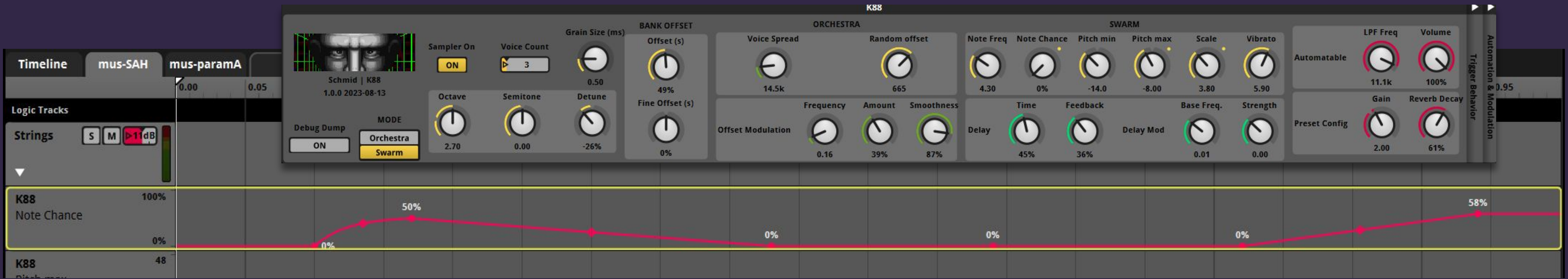
Composing in FMOD Studio

Constant output Instruments play constantly, phrases and form are exclusively generated from parameter changes

3 instruments Three instrument instances used for typical ambient music

FX buses Fixed reverb and delay busses

EQ EQ required, especially for Modnet



Sampler On ON

Voice Count 3

Grain Size (ms) 0.50

Octave 2.70

Semitone 0.00

Detune -26%

Debug Dump ON

MODE Orchestra / Swarm

Offset (s) 49%

Fine Offset (s) 0%

Voice Spread 14.5k

Random offset 665

Offset Modulation: Frequency 0.16, Amount 39%, Smoothness 87%

Note Freq 4.30

Note Chance 0%

Pitch min -14.0

Pitch max -8.00

Scale 3.80

Vibrato 5.90

Delay: Time 45%, Feedback 36%

Delay Mod: Base Freq. 0.01, Strength 0.00

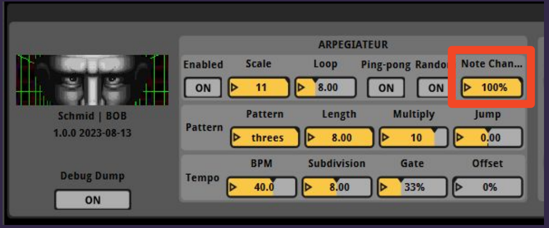
Automatable: LPF Freq 11.1k, Volume 100%

Preset Config: Gain 2.00, Reverb Decay 61%

Note Chance

Used for BOB arpeggiator notes and K88 grains

Play chance	Roll a dice for every note/grain triggered, determining if it should play
Note-based fading	Automation enables musical sounding note-based 'fades'
Note-based ducking	Duck track by setting note chance to 0 during stingers



Schmid | BOB
1.0.0 2023-08-13

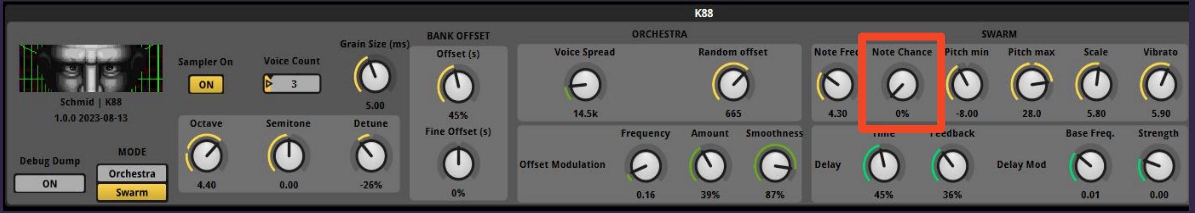
Debug Dump ON

ARPEGIATEUR

Enabled ON
Scale 11
Loop 8.00
Ping-pong ON
Rando ON
Note Chan... 100%

Pattern
Pattern threes
Length 8.00
Multiply 10
Jump 0.00

Tempo
BPM 40.0
Subdivision 8.00
Gate 33%
Offset 0%



K88

Schmid | K88
1.0.0 2023-08-13

Debug Dump ON

MODE Orchestra Swarm

Sampler On ON
Voice Count 3
Grain Size (ms) 5.00
Octave 4.40
Semitone 0.00
Detune -26%

BANK OFFSET
Offset (s) 45%
Fine Offset (s) 0%

ORCHESTRA
Voice Spread 14.5k
Random offset 665
Offset Modulation
Frequency 0.16
Amount 39%
Smoothness 87%

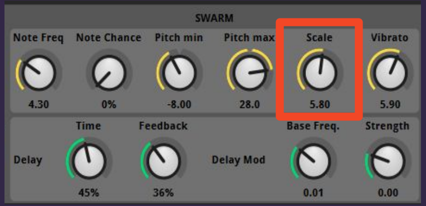
SWARM
Note Freq 4.30
Note Chance 0%
Pitch min -8.00
Pitch max 28.0
Scale 5.80
Vibrato 5.90
Delay
Time 45%
Feedback 36%
Delay Mod
Base Freq. 0.01
Strength 0.00

Incremental Scale Control

Used for BOB arpeggiator notes and K88 grains

Harmonic control | Scale control allows music to react harmonically to game state

Tension | Increase / decrease harmonic tension

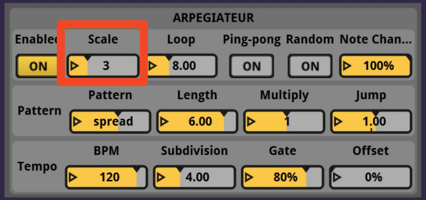


SWARM

Note Freq 4.30
Note Chance 0%
Pitch min -8.00
Pitch max 28.0
Scale 5.80
Vibrato 5.90

Delay — Time 45% — Feedback 36%

Delay Mod — Base Freq. 0.01 — Strength 0.00

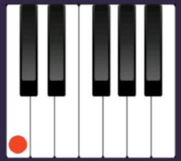


ARPEGIATEUR

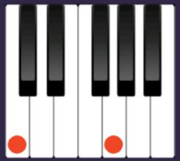
Enabled ON
Scale 3
Loop 8.00
Ping-pong ON
Random ON
Note Chan... 100%

Pattern — Pattern spread — Length 6.00 — Multiply 1 — Jump 1.00

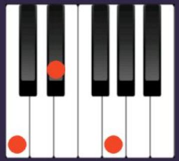
Tempo — BPM 120 — Subdivision 4.00 — Gate 80% — Offset 0%



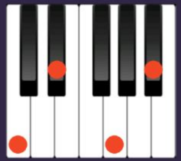
Scale 1
Prime



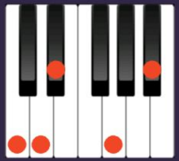
Scale 2
Fifth



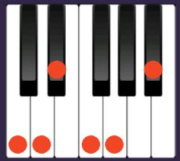
Scale 3
Minor



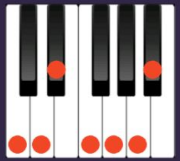
Scale 4
Minor 7



Scale 5
Minor 9



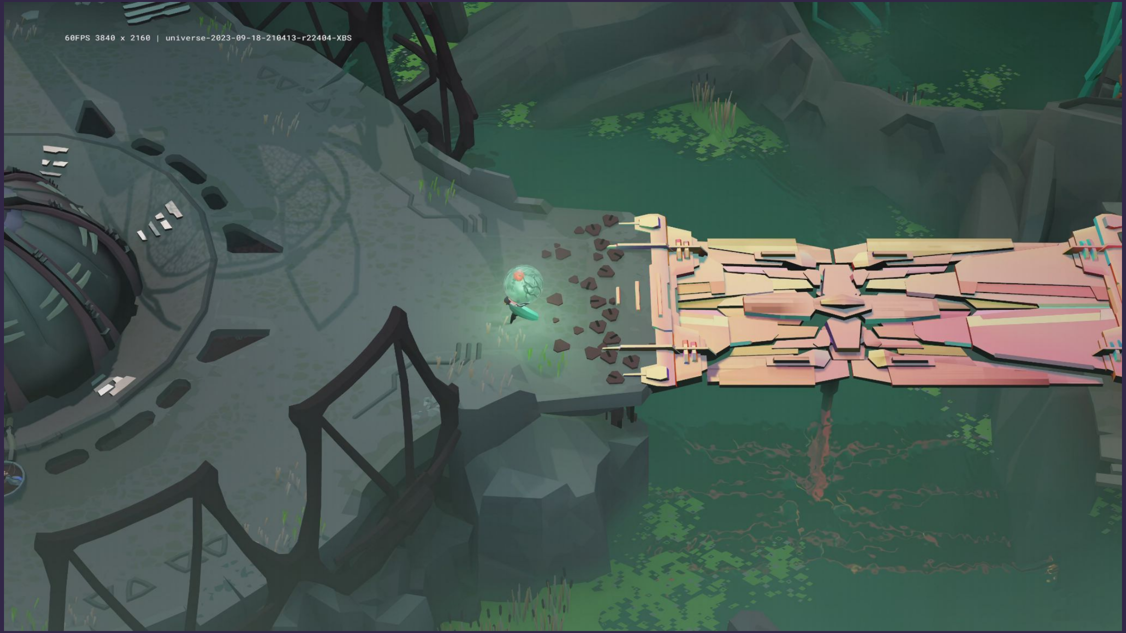
Scale 6
Minor 11



Scale 7
Minor 13

Green in Green

My favorite ambient music in the game.



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60FPS 3840 x 2160 | universe-2023-09-18-210413-r22404-XBS
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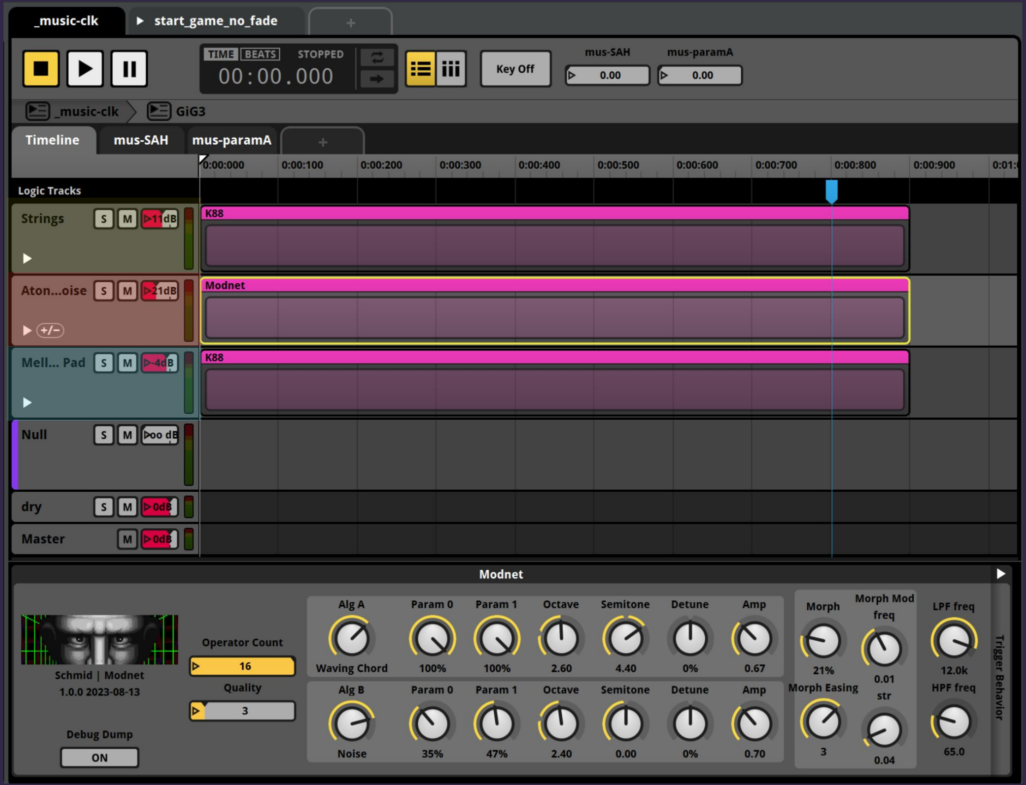
Green in Green: Plugins

Strings (K88)

Atonal noise (Modnet)

Mellow pad (K88)



mus-SAH 0.00

mus-paramA 0.00

Modnet

Schmid | Modnet
1.0.0 2023-08-13

Operator Count: 16

Quality: 3

Debug Dump: ON

Alg A	Param 0	Param 1	Octave	Semitone	Detune	Amp
Waving Chord	100%	100%	2.60	4.40	0%	0.67

Alg B	Param 0	Param 1	Octave	Semitone	Detune	Amp
Noise	35%	47%	2.40	0.00	0%	0.70

Morph: 21%

Morph Mod freq: 0.01

Morph Easing: 3

str: 0.04

LPF freq: 12.0k

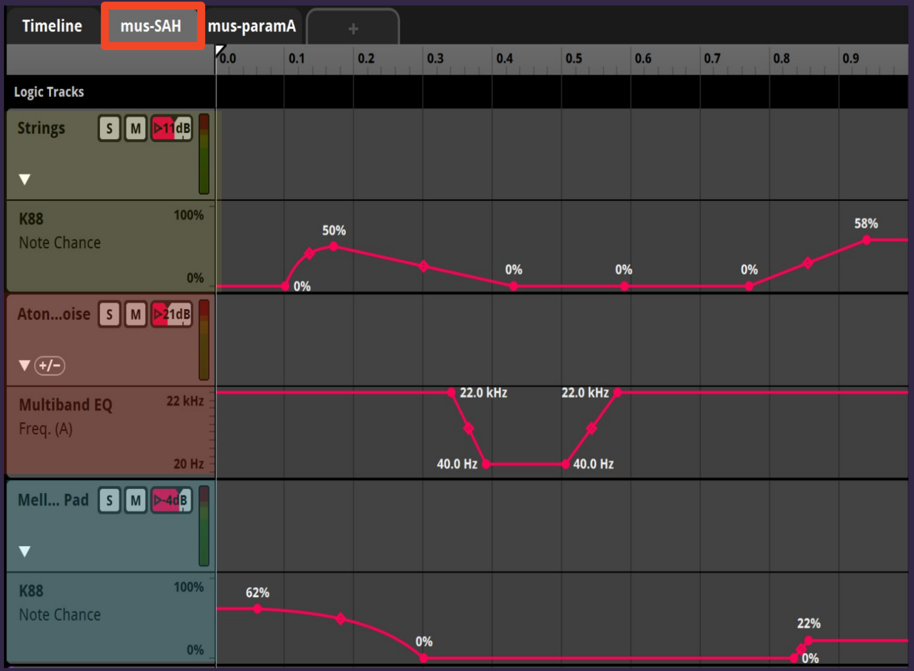
HPF freq: 65.0

Green in Green: Parameter-Controlled Form

Parameter-controlled Musical form controlled by single parameter

Non-linear 'Time' can move backwards and forwards

Testable Parameter sheet contains all desired instrument configurations



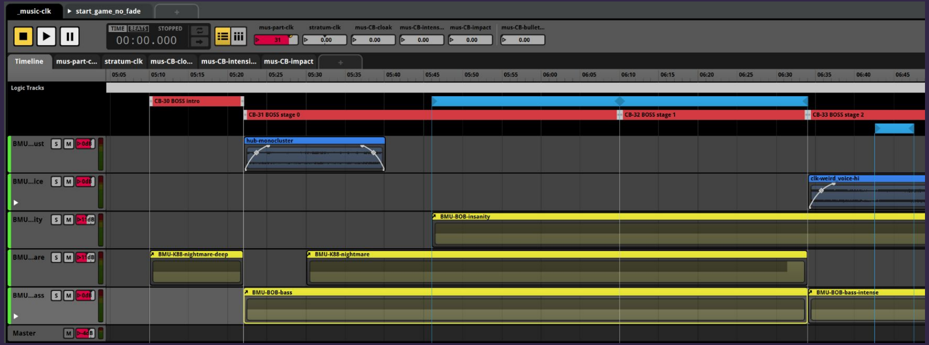
Boss Fights

Synthesis and stems	2-3 instruments, a few prerecorded stems
Adaptive	Real-time synthesized music reacts to boss actions: pitch, timbre, and filtering

Cloak Boss Tracks

3 instruments plus a few prerecorded stems

Bass	BOB bassline with FMOD Delay
Insanity	BOB creepy vibrato synth
Nightmare	K88 in Orchestra mode generates a chaotic orchestral background



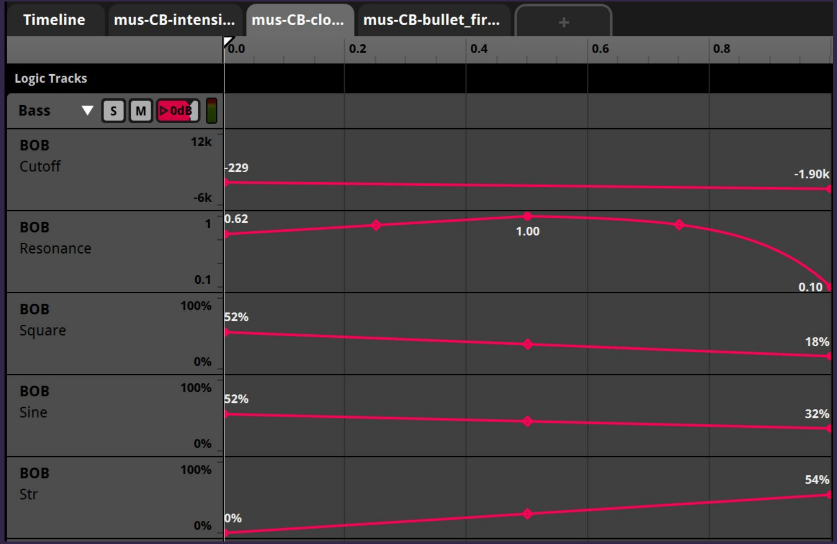
Cloak Boss Parameters

intensity	Boss movement speed
cloak	1 when cloaked, 0 when decloaked
bullet_fired	Set to 1 when boss fires bullets, returns to 0 over 3.5 seconds
impact	Music ducking, set to 1 during explosions and when catching player

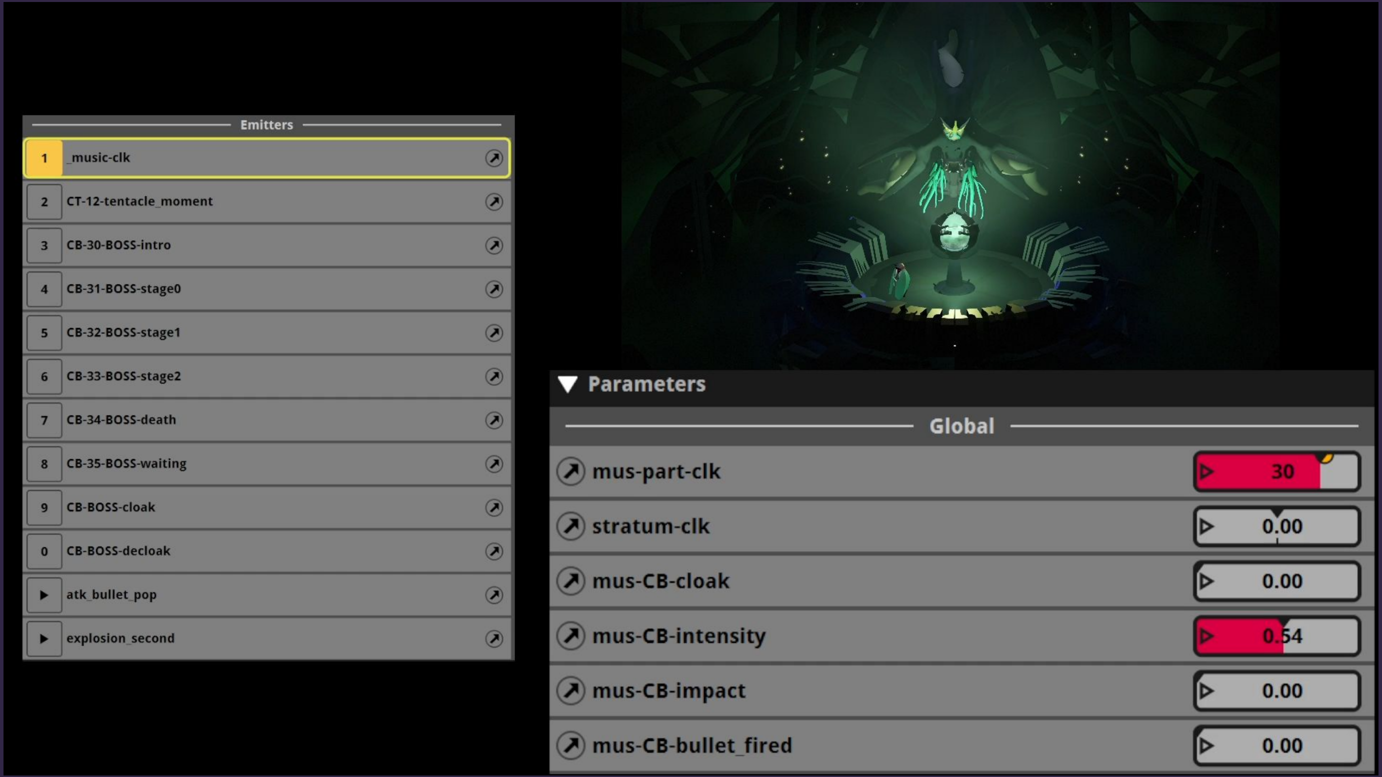
Cloak Boss Automation

Example parameter: cloak

Bass	Waveform mix, vibrato, filter frequency and resonance
Insanity	Octave, filter frequency
Nightmare	Octave, grain size, volume



Cloak Boss FMOD Demo



Emitters

1	_music-clk	↗
2	CT-12-tentacle_moment	↗
3	CB-30-BOSS-intro	↗
4	CB-31-BOSS-stage0	↗
5	CB-32-BOSS-stage1	↗
6	CB-33-BOSS-stage2	↗
7	CB-34-BOSS-death	↗
8	CB-35-BOSS-waiting	↗
9	CB-BOSS-cloak	↗
0	CB-BOSS-decloak	↗
▶	atk_bullet_pop	↗
▶	explosion_second	↗

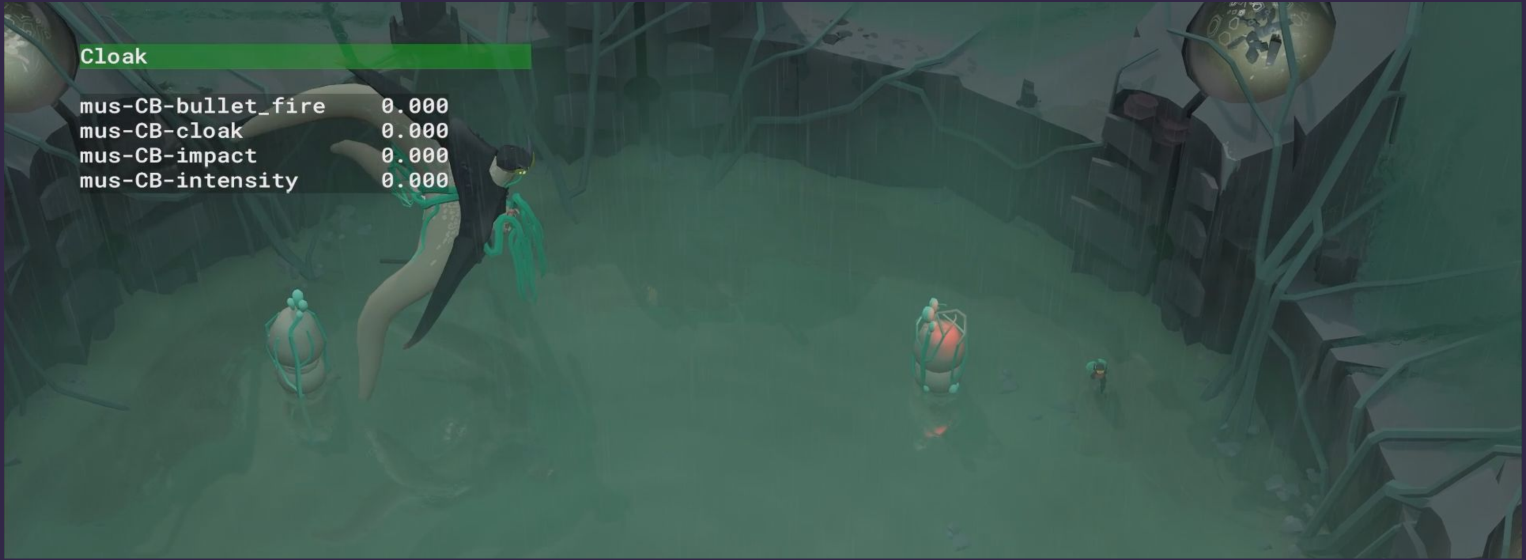
▼ Parameters

Global

↗ mus-part-clk	▷ 30
↗ stratum-clk	▷ 0.00
↗ mus-CB-cloak	▷ 0.00
↗ mus-CB-intensity	▷ 0.54
↗ mus-CB-impact	▷ 0.00
↗ mus-CB-bullet_fired	▷ 0.00

▸ gdc-fmod_studio

Cloak Boss Gameplay Demo



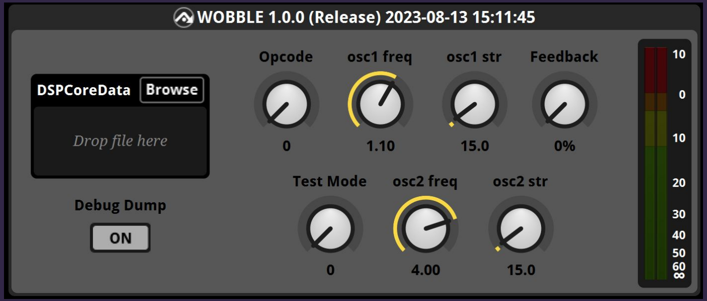
```
Cloak

mus-CB-bullet_fire     0.000
mus-CB-cloak           0.000
mus-CB-impact          0.000
mus-CB-intensity       0.000
```

▸ gdc-cloak_boss

Mastering

Coherence problem | Pre-rendered and real-time synthesized music have different production quality

Master plugin | Master plugin Wobble adds pitch instability to music bus, improving coherence


WOBBLE 1.0.0 (Release) 2023-08-13 15:11:45

DSPCoreData Browse

Drop file here

Debug Dump: ON

Opcode: 0

osc1 freq: 1.10

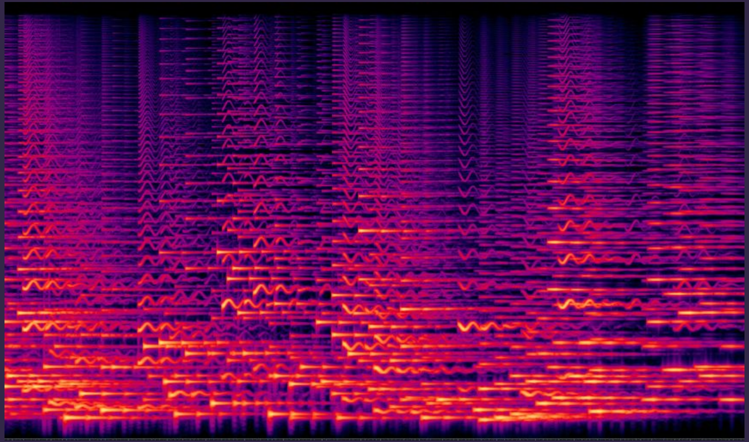
osc1 str: 15.0

Feedback: 0%

Test Mode: 0

osc2 freq: 4.00

osc2 str: 15.0

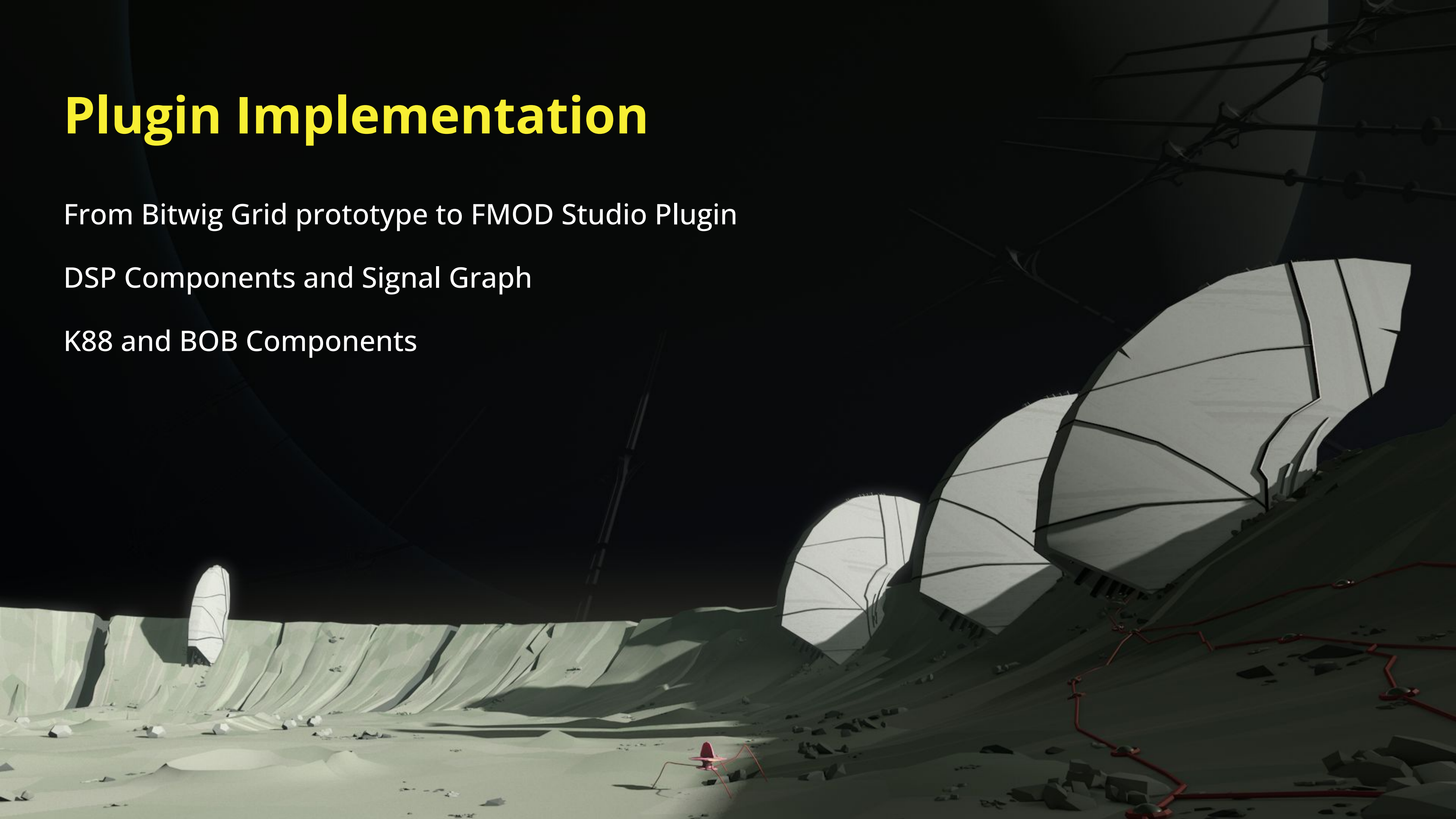


Plugin Implementation

From Bitwig Grid prototype to FMOD Studio Plugin

DSP Components and Signal Graph

K88 and BOB Components



Disclaimer

Self-taught DSP programmer

I'm probably saying things wrong

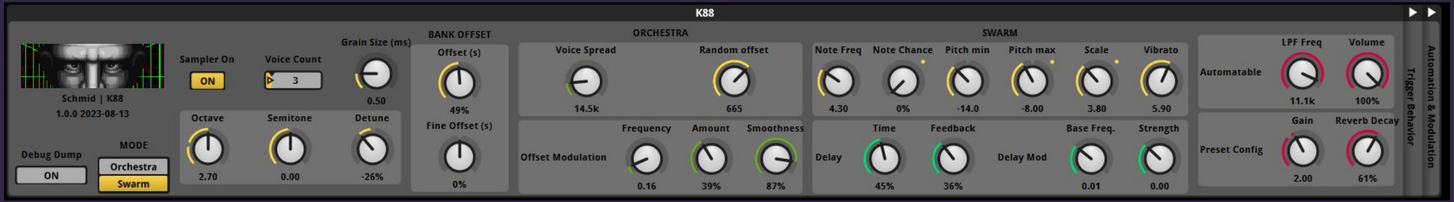
Bear with me

How to write an FMOD Studio Plugin

FMOD Studio plugin API is open

Plugins are normally written in C++

Start with example project and modify



K88

Schmid | K88
1.0.0 2023-08-13

Sampler On: ON
Voice Count: 3
Grain Size (ms): 0.50
Debug Dump: ON
MODE: Orchestra / Swarm
Octave: 2.70
Semitone: 0.00
Detune: -26%

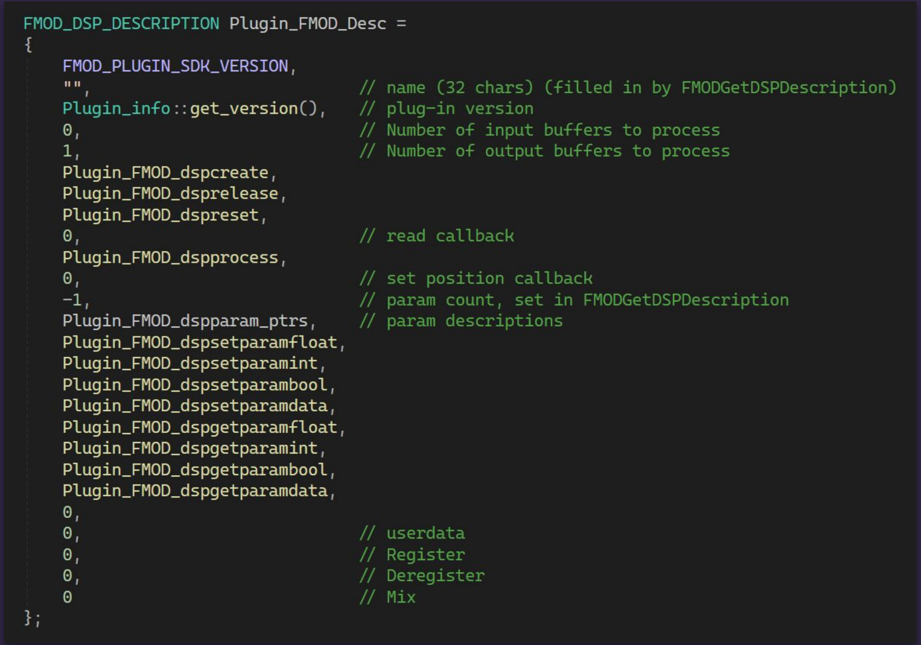
BANK OFFSET
Offset (s): 49%
Fine Offset (s): 0%

ORCHESTRA
Voice Spread: 14.5k
Random offset: 665
Offset Modulation
Frequency: 0.16
Amount: 39%
Smoothness: 87%

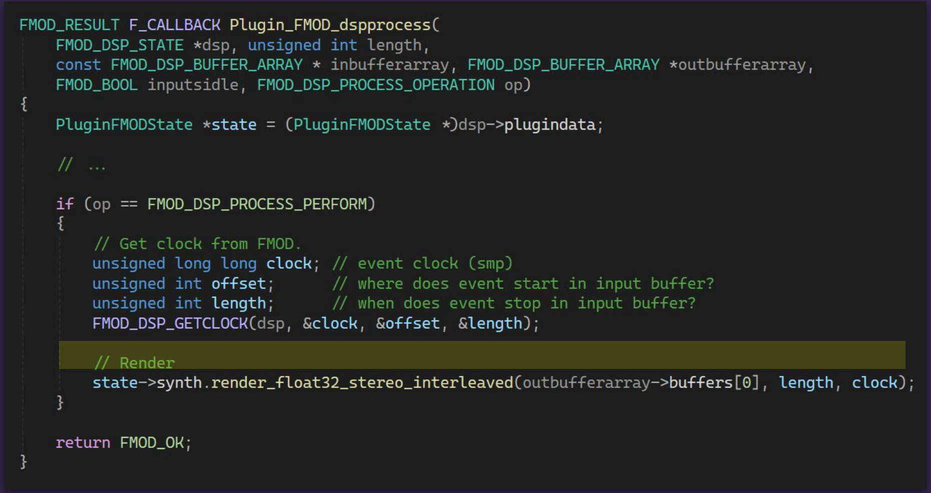
SWARM
Note Freq: 4.30
Note Chance: 0%
Pitch min: -14.0
Pitch max: -8.00
Scale: 3.80
Vibrato: 5.90
Delay
Time: 45%
Feedback: 36%
Delay Mod
Base Freq.: 0.01
Strength: 0.00

Automatable
LPF Freq: 11.1k
Volume: 100%
Preset Config
Gain: 2.00
Reverb Decay: 61%

FMOD Plugin API

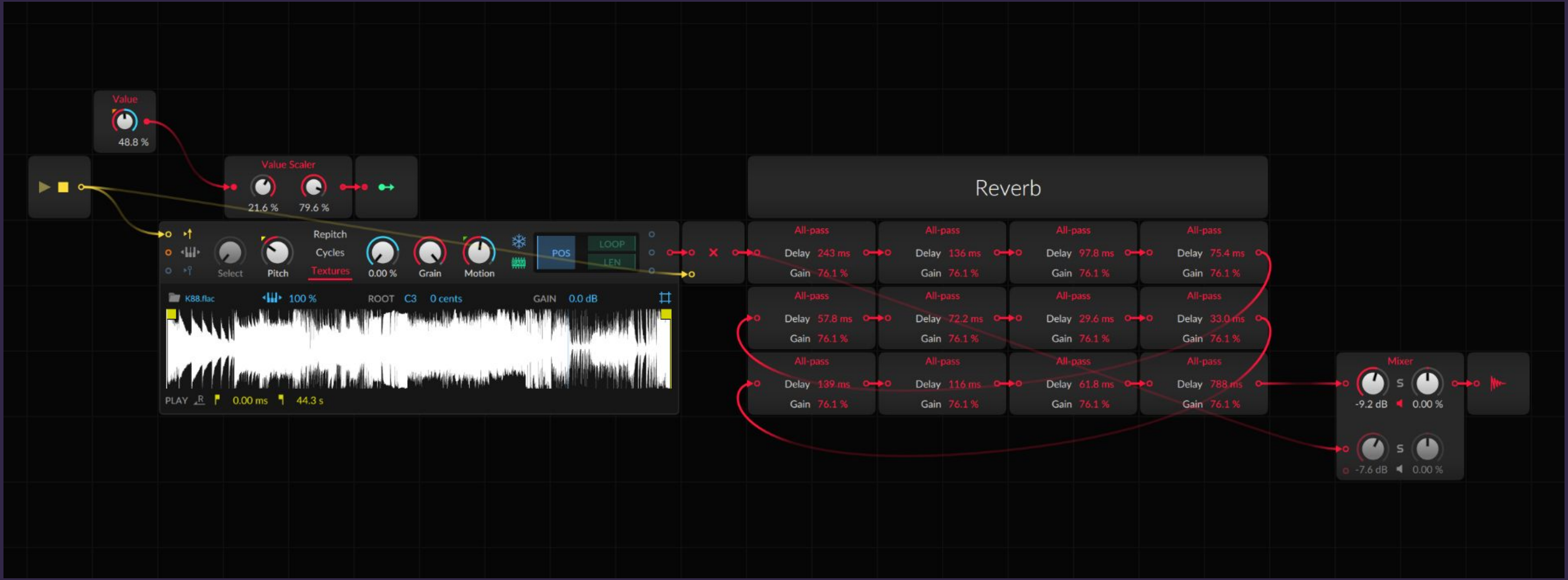


```
FMOD_DSP_DESCRIPTION Plugin_FMOD_Desc =
{
    FMOD_PLUGIN_SDK_VERSION,
    "",                           // name (32 chars) (filled in by FMODGetDSPDescription)
    Plugin_info::get_version(),   // plug-in version
    0,                            // Number of input buffers to process
    1,                            // Number of output buffers to process
    Plugin_FMOD_dspcreate,
    Plugin_FMOD_dsprelease,
    Plugin_FMOD_dspreset,
    0,                            // read callback
    Plugin_FMOD_dspprocess,
    0,                            // set position callback
    -1,                           // param count, set in FMODGetDSPDescription
    Plugin_FMOD_dspparam_ptrs,    // param descriptions
    Plugin_FMOD_dspsetparamfloat,
    Plugin_FMOD_dspsetparamint,
    Plugin_FMOD_dspsetparambool,
    Plugin_FMOD_dspsetparamdata,
    Plugin_FMOD_dspgetparamfloat,
    Plugin_FMOD_dspgetparamint,
    Plugin_FMOD_dspgetparambool,
    Plugin_FMOD_dspgetparamdata,
    0,
    0,                            // userdata
    0,                            // Register
    0,                            // Deregister
    0                             // Mix
};
```



```
FMOD_RESULT F_CALLBACK Plugin_FMOD_dspprocess(
    FMOD_DSP_STATE *dsp, unsigned int length,
    const FMOD_DSP_BUFFER_ARRAY * inbufferarray, FMOD_DSP_BUFFER_ARRAY *outbufferarray,
    FMOD_BOOL inputsidle, FMOD_DSP_PROCESS_OPERATION op)
{
    PluginFMODState *state = (PluginFMODState *)dsp->plugindata;

    // ...

    if (op == FMOD_DSP_PROCESS_PERFORM)
    {
        // Get clock from FMOD.
        unsigned long long clock; // event clock (smp)
        unsigned int offset;        // where does event start in input buffer?
        unsigned int length;        // when does event stop in input buffer?
        FMOD_DSP_GETCLOCK(dsp, &clock, &offset, &length);

        // Render
        state->synth.render_float32_stereo_interleaved(outbufferarray->buffers[0], length, clock);
    }

    return FMOD_OK;
}
```

K88 Orchestra Mode Bitwig Prototype



Value 48.8 %

Value Scaler 21.6 % 79.6 %

Select · Pitch · Repitch · Cycles · Textures · 0.00 % · Grain · Motion · POS · LOOP · LEN

K88.flac 100 % ROOT C3 0 cents GAIN 0.0 dB

PLAY 0.00 ms 44.3 s

Reverb

All-pass Delay 243 ms Gain 76.1 %

All-pass Delay 136 ms Gain 76.1 %

All-pass Delay 97.8 ms Gain 76.1 %

All-pass Delay 75.4 ms Gain 76.1 %

All-pass Delay 57.8 ms Gain 76.1 %

All-pass Delay 72.2 ms Gain 76.1 %

All-pass Delay 29.6 ms Gain 76.1 %

All-pass Delay 33.0 ms Gain 76.1 %

All-pass Delay 139 ms Gain 76.1 %

All-pass Delay 116 ms Gain 76.1 %

All-pass Delay 61.8 ms Gain 76.1 %

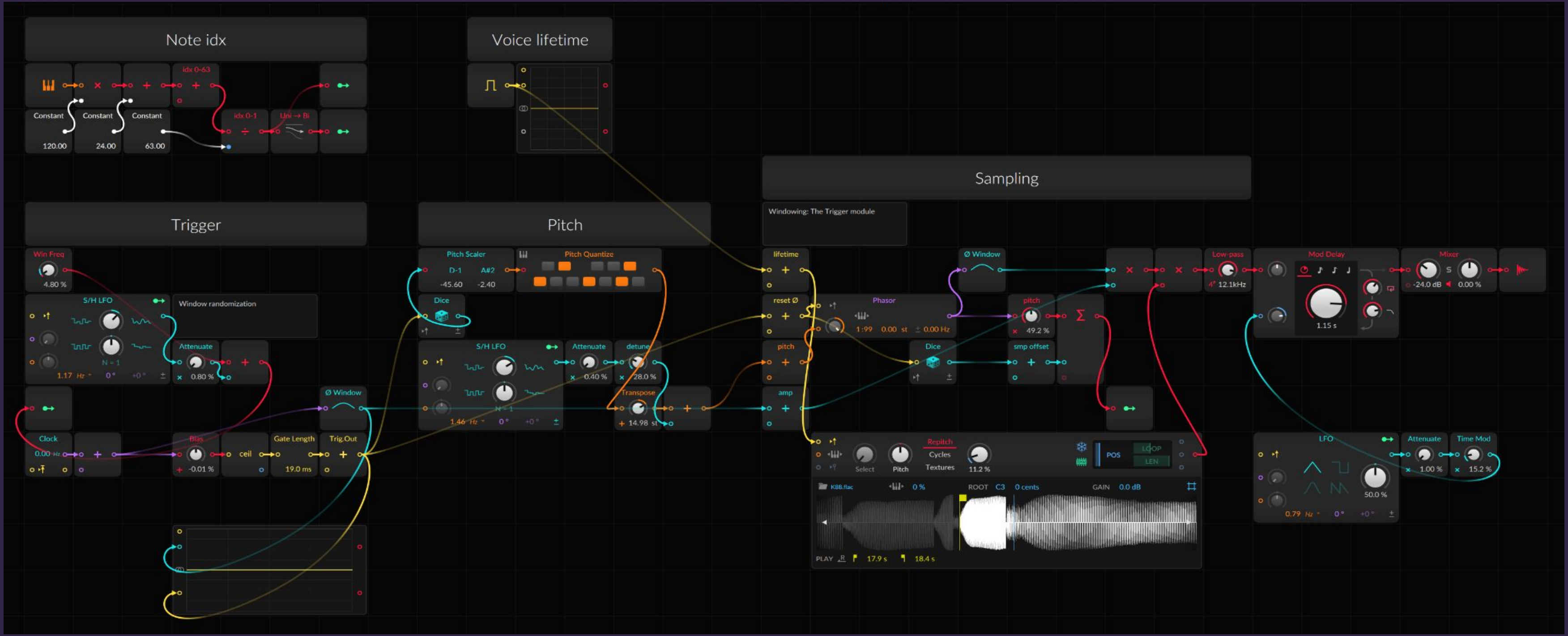
All-pass Delay 788 ms Gain 76.1 %

Mixer -9.2 dB S 0.00 %

-7.6 dB S 0.00 %

The K88 Orchestra mode started as a Bitwig Grid patch

K88 Swarm Mode Bitwig Prototype

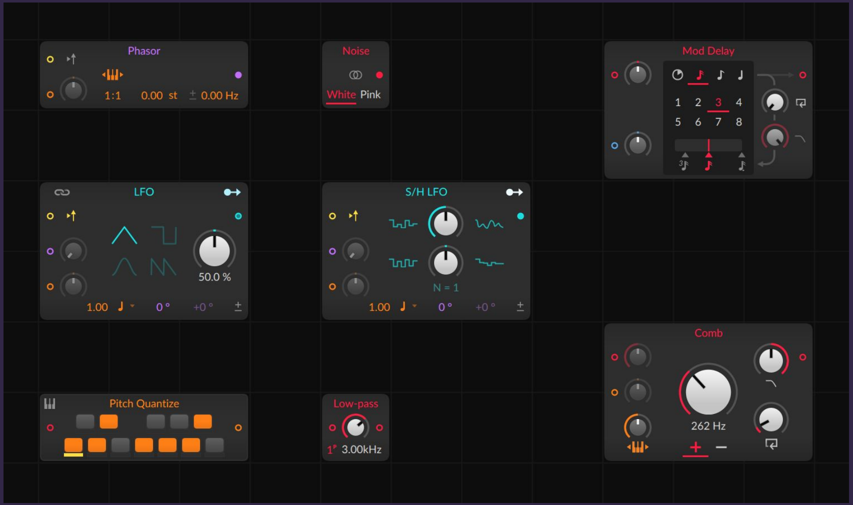


The K88 Swarm mode started as a Bitwig Grid patch

DSP Components

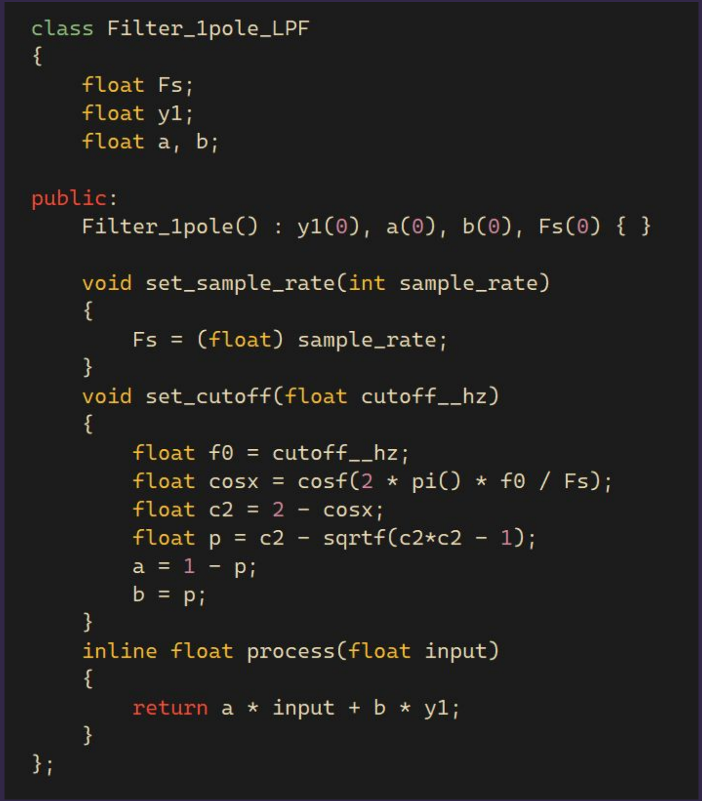
A Bitwig Grid patch can be expressed as a graph of DSP nodes.

It can be implemented as a set of simple components and a graph rendering algorithm.



A selection of useful Bitwig Grid nodes

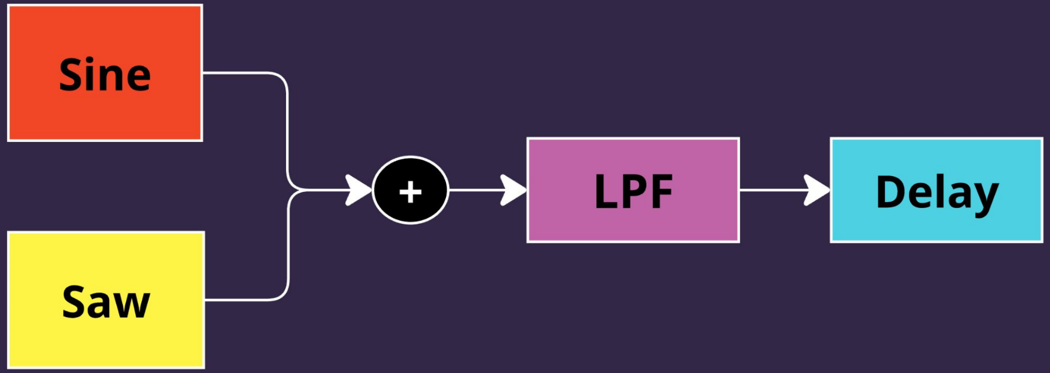
Component: 1-pole LPF



```
class Filter_1pole_LPF
{
    float Fs;
    float y1;
    float a, b;

public:
    Filter_1pole() : y1(0), a(0), b(0), Fs(0) { }

    void set_sample_rate(int sample_rate)
    {
        Fs = (float) sample_rate;
    }
    void set_cutoff(float cutoff__hz)
    {
        float f0 = cutoff__hz;
        float cosx = cosf(2 * pi() * f0 / Fs);
        float c2 = 2 - cosx;
        float p = c2 - sqrtf(c2*c2 - 1);
        a = 1 - p;
        b = p;
    }
    inline float process(float input)
    {
        return a * input + b * y1;
    }
};
```

Signal Graph

The signal graph can be implemented in code as a fixed sequence of component updates.



```
sin_out      = osc_sin.get_output()
saw_out      = osc_saw.get_output()
out_filtered = lpf.process(sin_out + saw_out)
out          = delay.render(out_filtered)
```

K88 Example Components

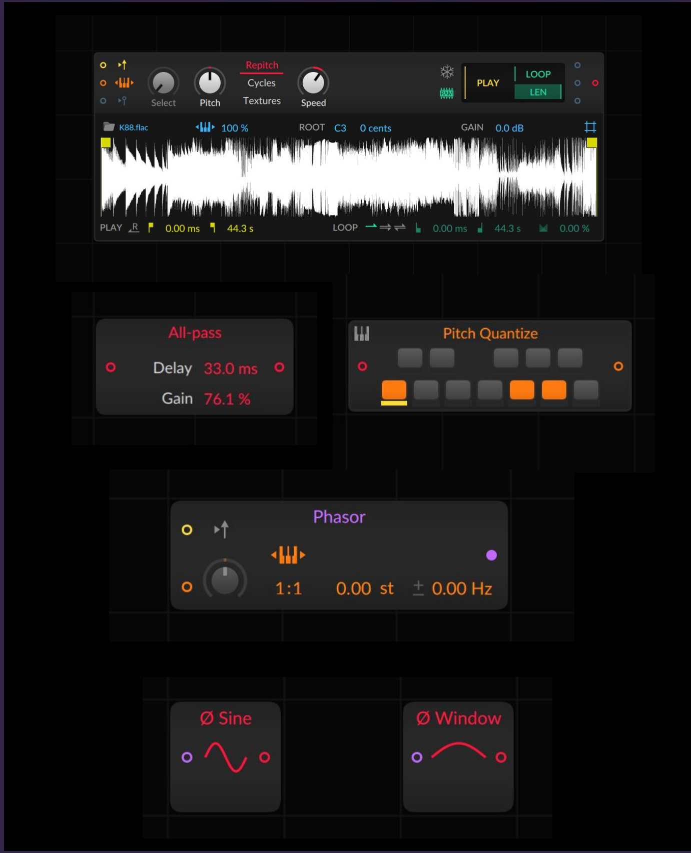
Sampler Sampler with linear interpolation

All-pass filter All-pass filter based on circular buffer

Pitch quantizer Quantizes arbitrary frequencies to selected scale

Phasor Phase generator component, generates a control signal 0..1

LUT Lookup table combines with phase generator to make oscillators or grain windows

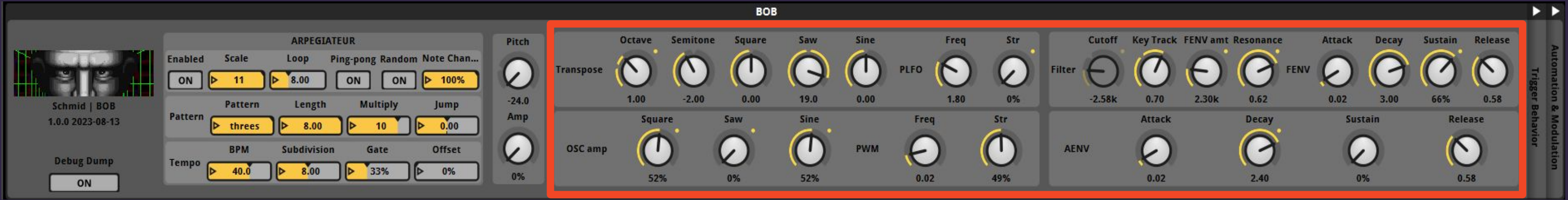


BOB Components

Band-limited oscillators Band-limited oscillators avoids aliasing of sawtooth and square waves

Ladder filter Moog-style resonant filter

DC filter DC filter removes DC offset that can be introduced in signal chains



BOB

Schmid | BOB
1.0.0 2023-08-13

Debug Dump: ON

ARPEGIATEUR
Enabled: ON
Scale: 11
Loop: 8.00
Ping-pong: ON
Random: ON
Note Chan...: 100%

Pattern
Pattern: threes
Length: 8.00
Multiply: 10
Jump: 0.00

Tempo
BPM: 40.0
Subdivision: 8.00
Gate: 33%
Offset: 0%

Pitch: -24.0
Amp: 0%

Transpose
Octave: 1.00
Semitone: -2.00
Square: 0.00
Saw: 19.0
Sine: 0.00

PLFO
Freq: 1.80
Str: 0%

OSC amp
Square: 52%
Saw: 0%
Sine: 52%

PWM
Freq: 0.02
Str: 49%

Filter
Cutoff: -2.58k
Key Track: 0.70
FENV amt: 2.30k
Resonance: 0.62

FENV
Attack: 0.02
Decay: 3.00
Sustain: 66%
Release: 0.58

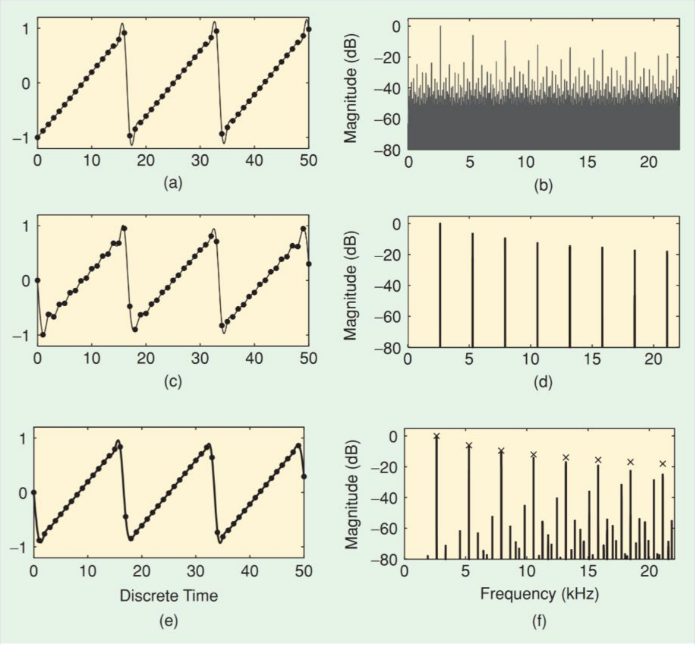
AENV
Attack: 0.02
Decay: 2.40
Sustain: 0%
Release: 0.58

BOB: Band-limited Oscillators

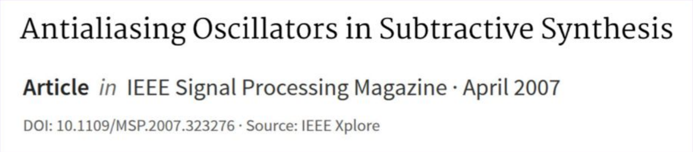
Trivial sawtooth

Ideal band-limited sawtooth: sum of sines

PolyBLEP approximation



$$p_{\mathrm{PolyBLEP}}(t) = \begin{cases} \frac{t^2}{2} + t + \frac{1}{2}, & \text{when } -1 \leq t \leq 0 \\ t - \frac{t^2}{2} - \frac{1}{2}, & \text{when } 0 < t \leq 1. \end{cases} \qquad (7)$$



Antialiasing Oscillators in Subtractive Synthesis

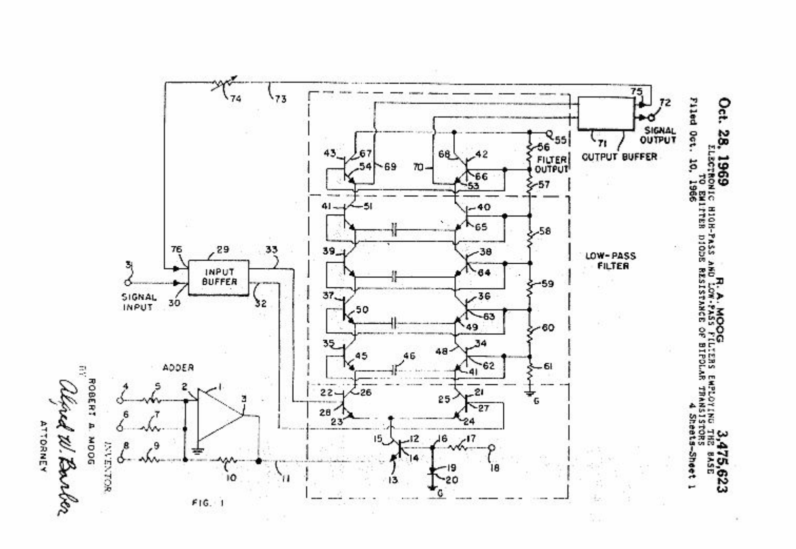
Article *in* IEEE Signal Processing Magazine · April 2007

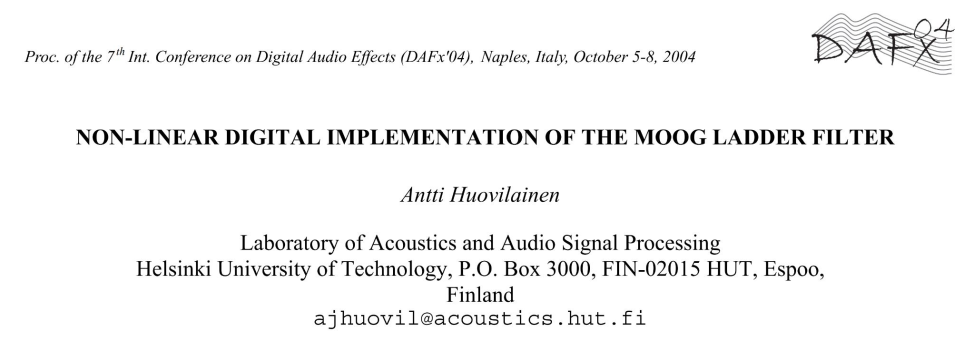
DOI: 10.1109/MSP.2007.323276 · Source: IEEE Xplore

https://ieeexplore.ieee.org/document/4117934

BOB: Ladder Filter

https://dafx.de/paper-archive/2004/P_061.PDF





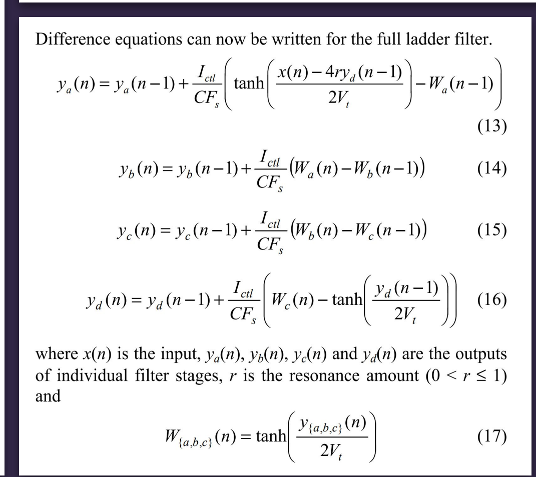
Proc. of the 7th Int. Conference on Digital Audio Effects (DAFx'04), Naples, Italy, October 5-8, 2004

DAFx04

NON-LINEAR DIGITAL IMPLEMENTATION OF THE MOOG LADDER FILTER

Antti Huovilainen

Laboratory of Acoustics and Audio Signal Processing
Helsinki University of Technology, P.O. Box 3000, FIN-02015 HUT, Espoo, Finland
ajhuovil@acoustics.hut.fi



Difference equations can now be written for the full ladder filter.

$$y_a(n) = y_a(n-1) + \frac{I_{ctl}}{CF_s}\left(\tanh\left(\frac{x(n)-4ry_d(n-1)}{2V_t}\right) - W_a(n-1)\right) \quad (13)$$

$$y_b(n) = y_b(n-1) + \frac{I_{ctl}}{CF_s}\left(W_a(n) - W_b(n-1)\right) \quad (14)$$

$$y_c(n) = y_c(n-1) + \frac{I_{ctl}}{CF_s}\left(W_b(n) - W_c(n-1)\right) \quad (15)$$

$$y_d(n) = y_d(n-1) + \frac{I_{ctl}}{CF_s}\left(W_c(n) - \tanh\left(\frac{y_d(n-1)}{2V_t}\right)\right) \quad (16)$$

where $x(n)$ is the input, $y_a(n)$, $y_b(n)$, $y_c(n)$ and $y_d(n)$ are the outputs of individual filter stages, r is the resonance amount ($0 < r \leq 1$) and

$$W_{\{a,b,c\}}(n) = \tanh\left(\frac{y_{\{a,b,c\}}(n)}{2V_t}\right) \quad (17)$$

Closing Thoughts

Platforms

Testing and Debugging

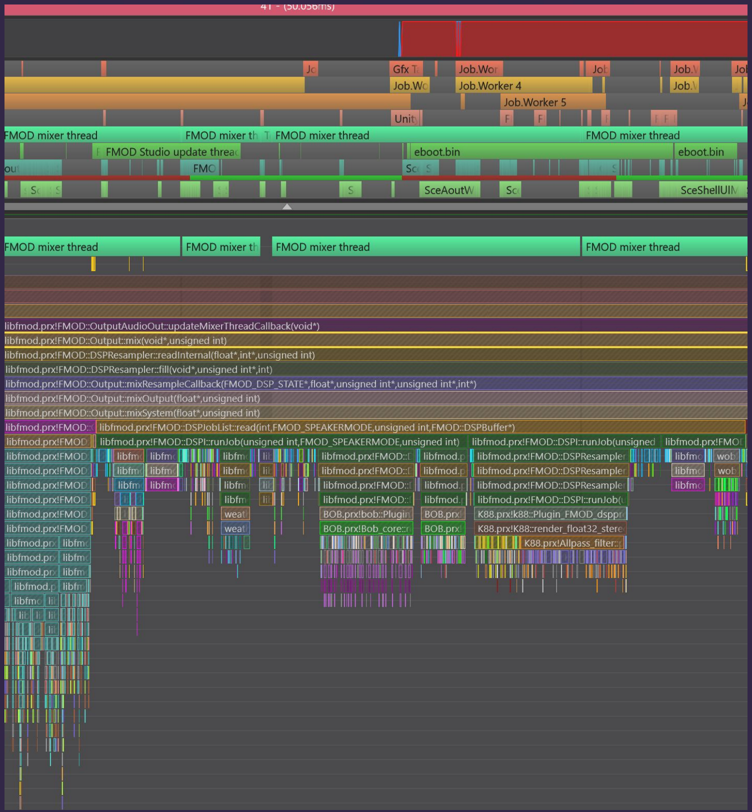
Other APIs

Questions

Platforms

COCOON plugins run on

> Windows
> Xbox Series S|X, Xbox One
> PlayStation 5, PlayStation 4
> Nintendo Switch



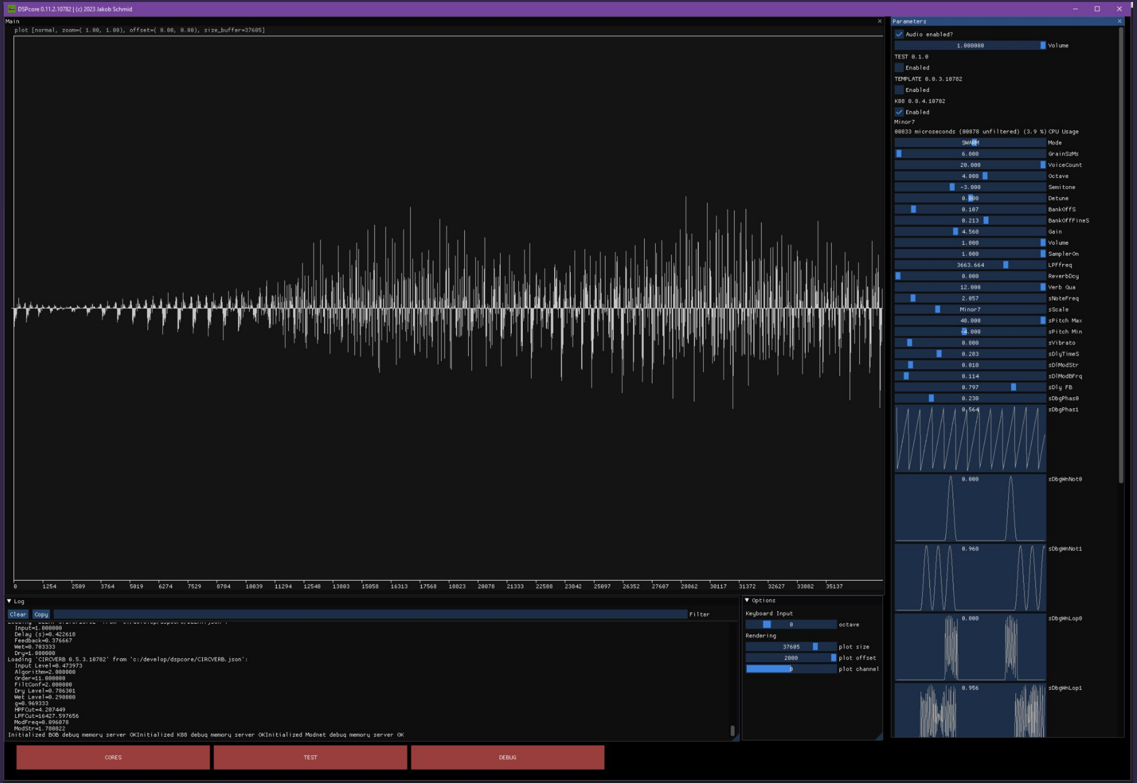
libfmod.prx!FMOD::OutputAudioOut::updateMixerThreadCallback(void*)
libfmod.prx!FMOD::Output::mix(void*,unsigned int)
libfmod.prx!FMOD::DSPResampler::readInternal(float*,int*,unsigned int)
libfmod.prx!FMOD::DSPResampler::fill(void*,unsigned int*,int)
libfmod.prx!FMOD::Output::mixResampleCallback(FMOD_DSP_STATE*,float*,unsigned int*,unsigned int*,int*)
libfmod.prx!FMOD::Output::mixOutput(float*,unsigned int)
libfmod.prx!FMOD::Output::mixSystem(float*,unsigned int)
libfmod.prx!FMOD::DSPJobList::read(int,FMOD_SPEAKERMODE,unsigned int,FMOD::DSPBuffer*)
libfmod.prx!FMOD::DSPI::runJob(unsigned int,FMOD_SPEAKERMODE,unsigned int)

libfmod.prx!FMOD::DSPResampler
libfmod.prx!FMOD::DSPI::runJob(
BOB.prx!bob::Plugin
BOB.prx!Bob_core::
K88.prx!k88::Plugin_FMOD_dsppr
K88.prx!K88::render_float32_stere
K88.prx!Allpass_filter::

DSPcore.exe: Test Interface

Visualizes output waveform

Easy to step debug



DSPcore 0.11.2.10782 | (c) 2023 Jakob Schmid

Main

```
plot [normal, zoom=( 1.00, 1.00), offset=( 0.00, 0.00), size_buffer=37605]
```

▼ Log

```
  Input=1.000000
  Delay (s)=0.422618
  Feedback=0.376667
  Wet=0.703333
  Dry=1.000000
Loading 'CIRCVERB 0.5.3.10782' from 'c:/develop/dspcore/CIRCVERB.json':
  Input Level=0.473973
  Algorithm=2.000000
  Order=11.000000
  FiltConf=2.000000
  Dry Level=0.786301
  Wet Level=0.290000
  g=0.969333
  HPFCut=4.207449
  LPFCut=16427.597656
  ModFreq=0.096078
  ModStr=1.780822
Initialized BOB debug memory server OKInitialized K88 debug memory server OKInitialized Modnet debug memory server OK
```

▼ Options

```
Keyboard Input
0          octave
Rendering
37605      plot size
2000       plot offset
0          plot channel
```

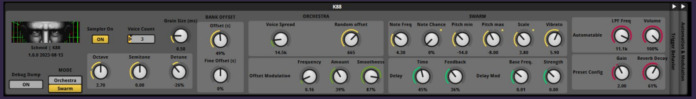
Parameters

```
☑ Audio enabled?
1.000000   Volume
TEST 0.1.0
☐ Enabled
TEMPLATE 0.0.3.10782
☐ Enabled
K88 0.8.4.10782
☑ Enabled
Minor7
00833 microseconds (00878 unfiltered) (3.9 %) CPU Usage
SWARM      Mode
6.000      GrainSzMs
20.000     VoiceCount
4.000      Octave
-3.000     Semitone
0.000      Detune
0.107      BankOffS
0.213      BankOffFineS
4.560      Gain
1.000      Volume
1.000      SamplerOn
3663.664   LPFfreq
0.000      ReverbDcy
12.000     Verb Qua
2.057      sNoteFreq
Minor7     sScale
48.000     sPitch Max
-4.000     sPitch Min
0.800      sVibrato
0.283      sDlyTimeS
0.010      sDlModStr
0.114      sDlModBFrq
0.797      sDly FB
0.230      sDbgPhas0
0.564      sDbgPhas1
0.000      sDbgWnNot0
0.960      sDbgWnNot1
0.000      sDbgWnLop0
0.956      sDbgWnLop1
```

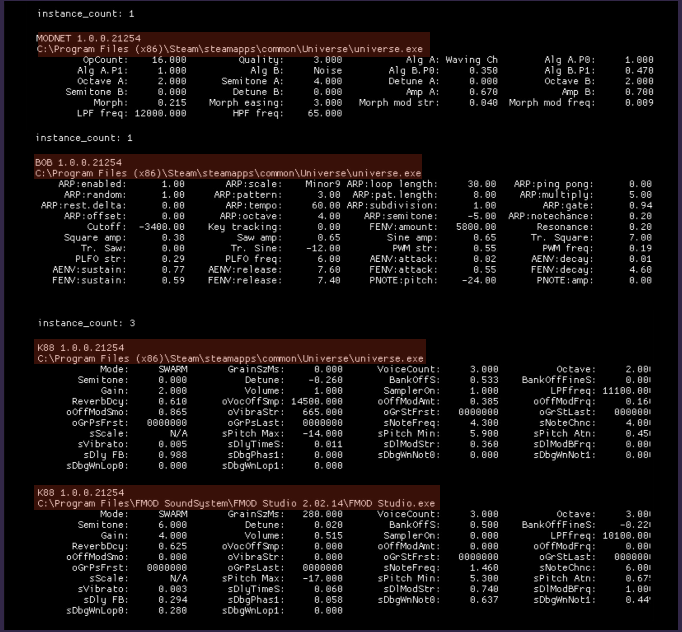
Debugging in DSPcore.exe

Internal plugin state can be inspected

Implemented Based on Shared memory using Windows FileMappings



Debug Dump: ON
MODE: Swarm
Sampler On: ON
Voice Count: 3
Grain Size (ms): 0.50
Octave: 2.70
Semitone: 0.00
Detune: -26%
Offset (s): 49%
Fine Offset (s): 0%
Voice Spread: 14.5k
Random offset: 665
Frequency: 0.16
Amount: 39%
Smoothness: 87%
Note Freq: 4.30
Note Chance: 0%
Pitch min: -14.0
Pitch max: -8.00
Scale: 3.80
Vibrato: 5.90
Time: 45%
Feedback: 36%
Base Freq.: 0.01
Strength: 0.00
LPF Freq: 11.1k
Volume: 100%
Gain: 2.00
Reverb Decay: 61%

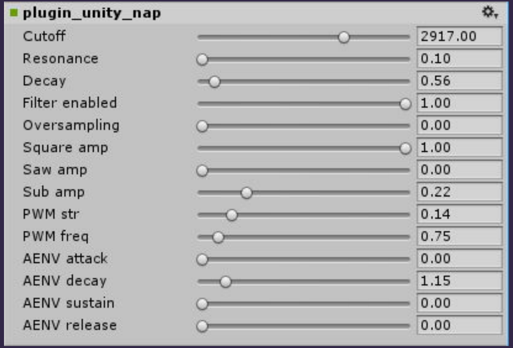


```
instance_count: 1

MODNET 1.0.0.21254
C:\Program Files (x86)\Steam\steamapps\common\Universe\universe.exe
     OpCount:    16.000         Quality:     3.000          Alg A: Waving Ch        Alg A.P0:     1.000
    Alg A.P1:     1.000           Alg B:     Noise        Alg B.P0:     0.350       Alg B.P1:     0.470
    Octave A:     2.000      Semitone A:     4.000        Detune A:     0.000       Octave B:     2.000
  Semitone B:     0.000        Detune B:     0.000           Amp A:     0.670          Amp B:     0.700
       Morph:     0.215    Morph easing:     3.000   Morph mod str:     0.040 Morph mod freq:     0.009
    LPF freq: 12000.000        HPF freq:    65.000

instance_count: 1

BOB 1.0.0.21254
C:\Program Files (x86)\Steam\steamapps\common\Universe\universe.exe
    ARP:enabled:      1.00        ARP:scale:    Minor9 ARP:loop length:     30.00    ARP:ping pong:      0.00
     ARP:random:      1.00      ARP:pattern:      3.00  ARP:pat.length:      8.00     ARP:multiply:      5.00
 ARP:rest.delta:      0.00        ARP:tempo:     60.00 ARP:subdivision:      1.00         ARP:gate:      0.94
     ARP:offset:      0.00       ARP:octave:      4.00    ARP:semitone:     -5.00   ARP:notechance:      0.20
         Cutoff:  -3400.00     Key tracking:      0.00     FENV:amount:   5800.00        Resonance:      0.20
     Square amp:      0.38         Saw amp:       0.65        Sine amp:      0.65       Tr. Square:      7.00
        Tr. Saw:      0.00         Tr. Sine:    -12.00         PWM str:      0.55         PWM freq:      0.19
       PLFO str:      0.29        PLFO freq:      6.00     AENV:attack:      0.02       AENV:decay:      0.01
   AENV:sustain:      0.77     AENV:release:      7.60     FENV:attack:      0.55       FENV:decay:      4.60
   FENV:sustain:      0.59     FENV:release:      7.40     PNOTE:pitch:    -24.00        PNOTE:amp:      0.00


instance_count: 3

K88 1.0.0.21254
C:\Program Files (x86)\Steam\steamapps\common\Universe\universe.exe
          Mode:      SWARM       GrainSzMs:      0.000      VoiceCount:      3.000          Octave:      2.00
      Semitone:      0.000          Detune:     -0.260       BankOffS:      0.533    BankOffFineS:      0.00
          Gain:      2.000          Volume:      1.000       SamplerOn:      1.000         LPFfreq:  11100.00
     ReverbDcy:      0.610     oVocOffSmp:  14500.000     oOffModAmt:      0.385      oOffModFrq:      0.16
    oOffModSmo:      0.865       oVibraStr:    665.000      oGrStFrst:    0000000       oGrStLast:    000000
     oGrPsFrst:    0000000       oGrPsLast:    0000000       sNoteFreq:      4.300       sNoteChnc:      4.00
        sScale:        N/A      sPitch Max:    -14.000      sPitch Min:      5.900      sPitch Atn:      0.45
      sVibrato:      0.005       sDlyTimeS:      0.011       sDlModStr:      0.360      sDlModBFrq:      0.00
       sDly FB:      0.988       sDbgPhas1:      0.000     sDbgWnNot0:      0.000      sDbgWnNot1:      0.00
    sDbgWnLop0:      0.000      sDbgWnLop1:      0.000

K88 1.0.0.21254
C:\Program Files\FMOD SoundSystem\FMOD Studio 2.02.14\FMOD Studio.exe
          Mode:      SWARM       GrainSzMs:    280.000      VoiceCount:      3.000          Octave:      3.00
      Semitone:      6.000          Detune:      0.020       BankOffS:      0.500    BankOffFineS:     -0.22
          Gain:      4.000          Volume:      0.515       SamplerOn:      0.000         LPFfreq:  10100.00
     ReverbDcy:      0.625     oVocOffSmp:      0.000      oOffModAmt:      0.000      oOffModFrq:      0.00
    oOffModSmo:      0.000       oVibraStr:      0.000       oGrStFrst:    0000000       oGrStLast:    000000
     oGrPsFrst:    0000000       oGrPsLast:    0000000       sNoteFreq:      1.460       sNoteChnc:      6.00
        sScale:        N/A      sPitch Max:    -17.000      sPitch Min:      5.300      sPitch Atn:      0.67
      sVibrato:      0.003       sDlyTimeS:      0.060       sDlModStr:      0.740      sDlModBFrq:      1.00
       sDly FB:      0.294       sDbgPhas1:      0.058      sDbgWnNot0:      0.637      sDbgWnNot1:      0.44
    sDbgWnLop0:      0.280      sDbgWnLop1:      0.000
```

Other APIs

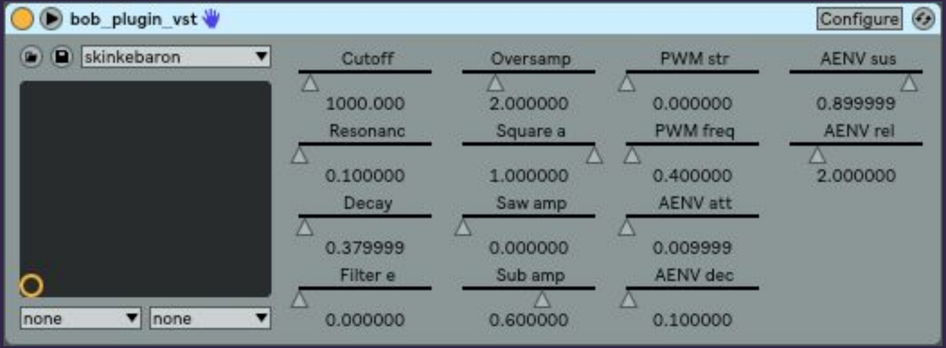
Steinberg VST	VST plugins for music software
Unity Native Audio Plugin	Unity audio system plugins
Audiokinetic Wwise	Wwise plugins

All DSP code is reused, only plugin interface is different



plugin_unity_nap

Cutoff	2917.00
Resonance	0.10
Decay	0.56
Filter enabled	1.00
Oversampling	0.00
Square amp	1.00
Saw amp	0.00
Sub amp	0.22
PWM str	0.14
PWM freq	0.75
AENV attack	0.00
AENV decay	1.15
AENV sustain	0.00
AENV release	0.00



bob_plugin_vst

skinkebaron

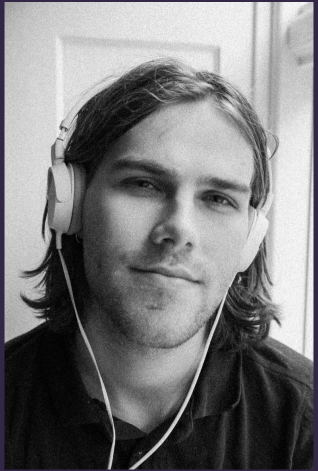
none

none

Cutoff	1000.000
Resonanc	0.100000
Decay	0.379999
Filter e	0.000000
Oversamp	2.000000
Square a	1.000000
Saw amp	0.000000
Sub amp	0.600000
PWM str	0.000000
PWM freq	0.400000
AENV att	0.009999
AENV dec	0.100000
AENV sus	0.899999
AENV rel	2.000000

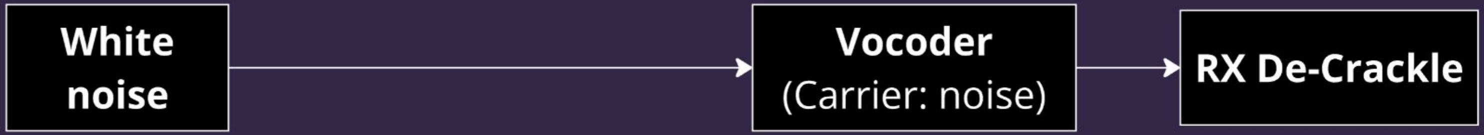
Guest Slides

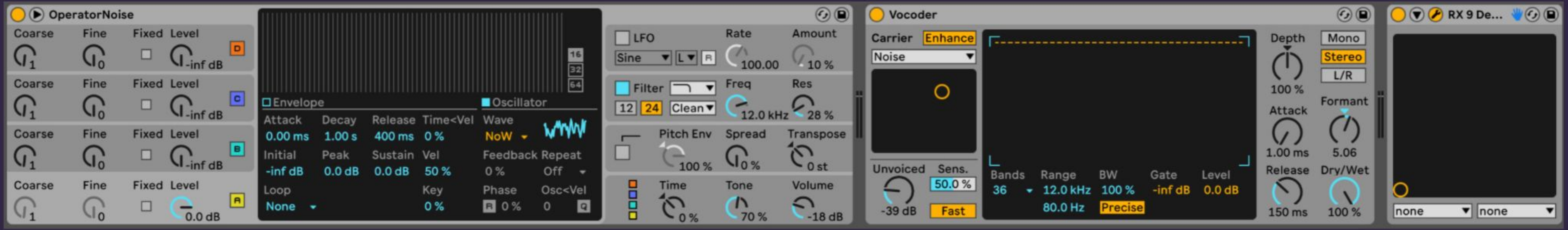
From sound designer Julian Lentz



Synthesizing Organic Material (slime)

Synthesize slimy and organic friction sounds in the game
- without ever getting your hands wet!


White noise → Vocoder (Carrier: noise) → RX De-Crackle


OperatorNoise

Coarse	Fine	Fixed	Level	
1	0	□	-inf dB	D
1	0	□	-inf dB	C
1	0	□	-inf dB	B
1	0	□	0.0 dB	A

Envelope
Attack 0.00 ms, Decay 1.00 s, Release 400 ms, Time<Vel 0 %
Initial -inf dB, Peak 0.0 dB, Sustain 0.0 dB, Vel 50 %
Loop None, Key 0 %

Oscillator
Wave NoW
Feedback 0 %, Repeat Off
Phase R 0 %, Osc<Vel 0 Q

LFO Sine L R, Rate 100.00, Amount 10 %
Filter 12 24 Clean, Freq 12.0 kHz, Res 28 %
Pitch Env 100 %, Spread 0 %, Transpose 0 st
Time 0 %, Tone 70 %, Volume -18 dB

Vocoder
Carrier Enhance Noise
Unvoiced -39 dB, Sens. 50.0 %, Fast
Bands 36, Range 12.0 kHz 80.0 Hz, BW 100 % Precise, Gate -inf dB, Level 0.0 dB
Depth 100 %, Mono Stereo L/R
Attack 1.00 ms, Formant 5.06
Release 150 ms, Dry/Wet 100 %

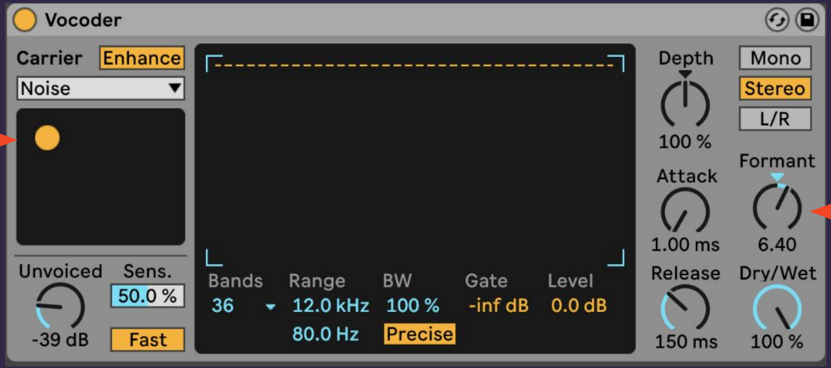
RX 9 De...
none none

Guest slide by sound designer Julian Lentz

Synthesizing Organic Material (slime)

Noise XY pad

Controls surface hardness.
From plastic to softer organic surfaces.



Vocoder

Carrier Enhance

Noise

Unvoiced -39 dB

Sens. 50.0 %

Fast

Bands 36

Range 12.0 kHz 80.0 Hz

BW 100 % Precise

Gate -inf dB

Level 0.0 dB

Depth 100 %

Attack 1.00 ms

Release 150 ms

Mono Stereo L/R

Formant 6.40

Dry/Wet 100 %

Formant

Controls overall tone. Modulating the parameter can simulate the sensation of a cocoon opening in all its slimy glory.

Guest slide by sound designer Julian Lentz

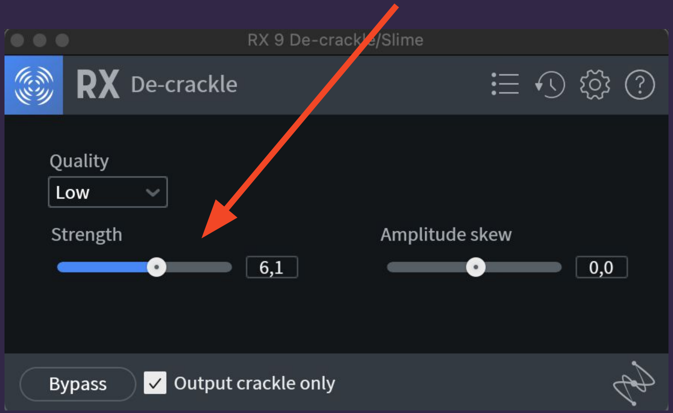
Synthesizing Organic Material (slime)

Strength

Control the audible frequency of transients with the strength slider.
Mimics the friction force.

iZotope RX De-crackle

Plug-in for removing unwanted crackling.
'Output crackle only' option to get crackling artifacts produced by vocoder.
This outputs very short sounds reminiscent of organic / wet friction.



RX 9 De-crackle/Slime

RX De-crackle

Quality: Low

Strength: 6,1

Amplitude skew: 0,0

Bypass

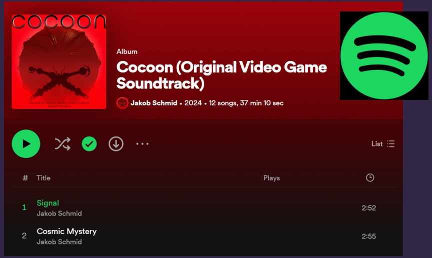
☑ Output crackle only

Guest slide by sound designer Julian Lentz

Questions?

Please rate my session!

Web	cocoongame.com
E-mail	jakob@schmid.dk
Bluesky	@schmid.dk
x.com	@jakobschmid
Slides here	schmid.dk/talks


Album

Cocoon (Original Video Game Soundtrack)

Jakob Schmid • 2024 • 12 songs, 37 min 10 sec

List

#	Title	Plays	
1	Signal Jakob Schmid		2:52
2	Cosmic Mystery Jakob Schmid		2:55

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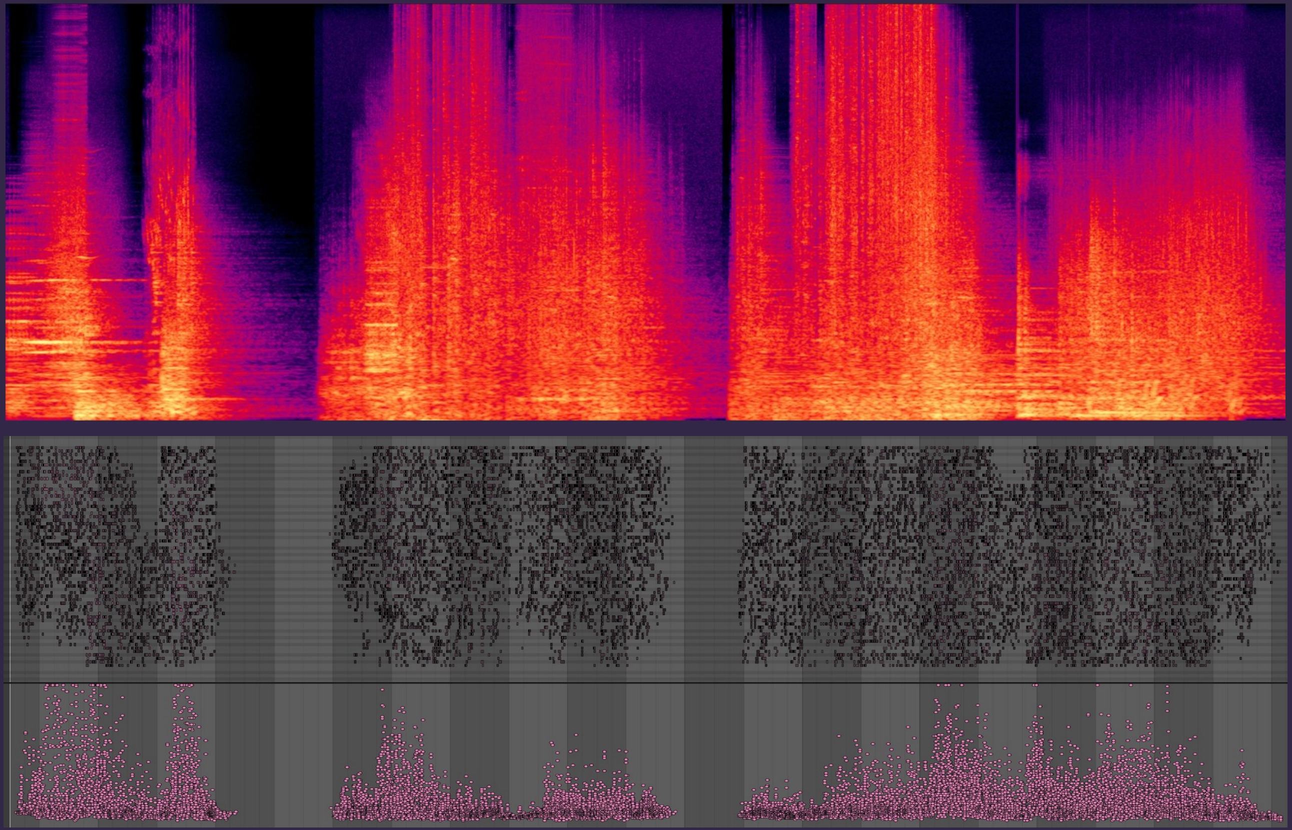
STEAM XBOX NINTENDO SWITCH PS5 | PS4

End of Slides

Thank you.



schmid-cocoon-gdc-2025-03-25-1548.pdf