Interactive Performance Systems for Rock Music

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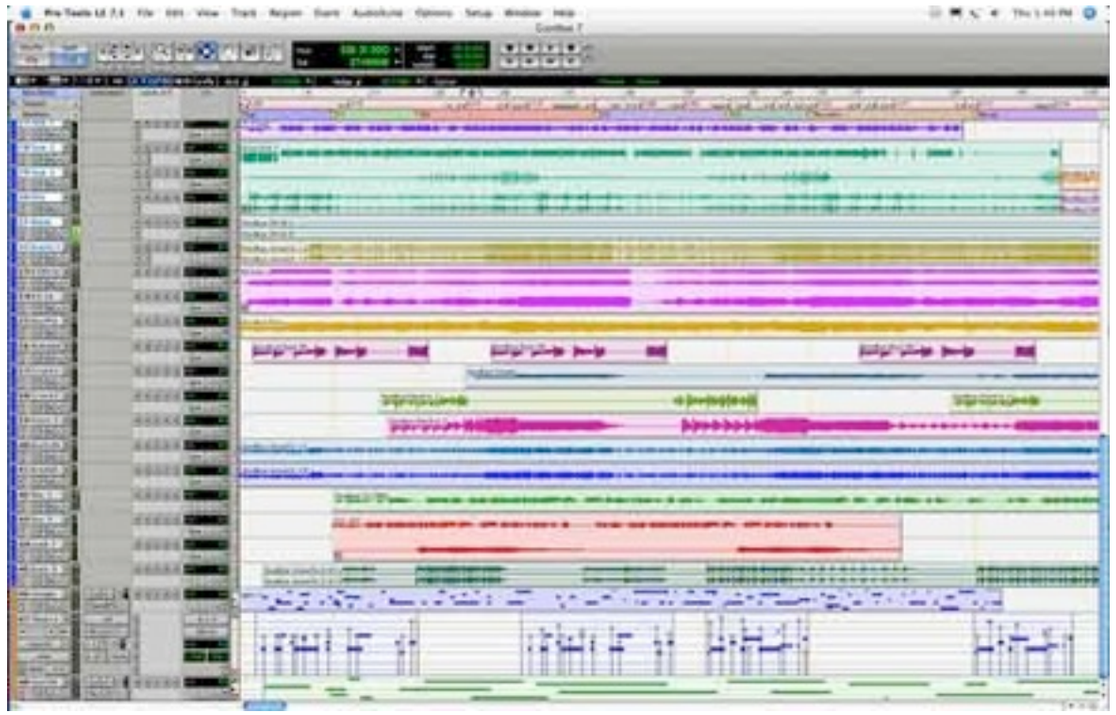
Motivation

- Current sequencing software (ProTools, Logic, Cubase) powerful tool for recording: overdubs, editing between takes, MIDI sequencing

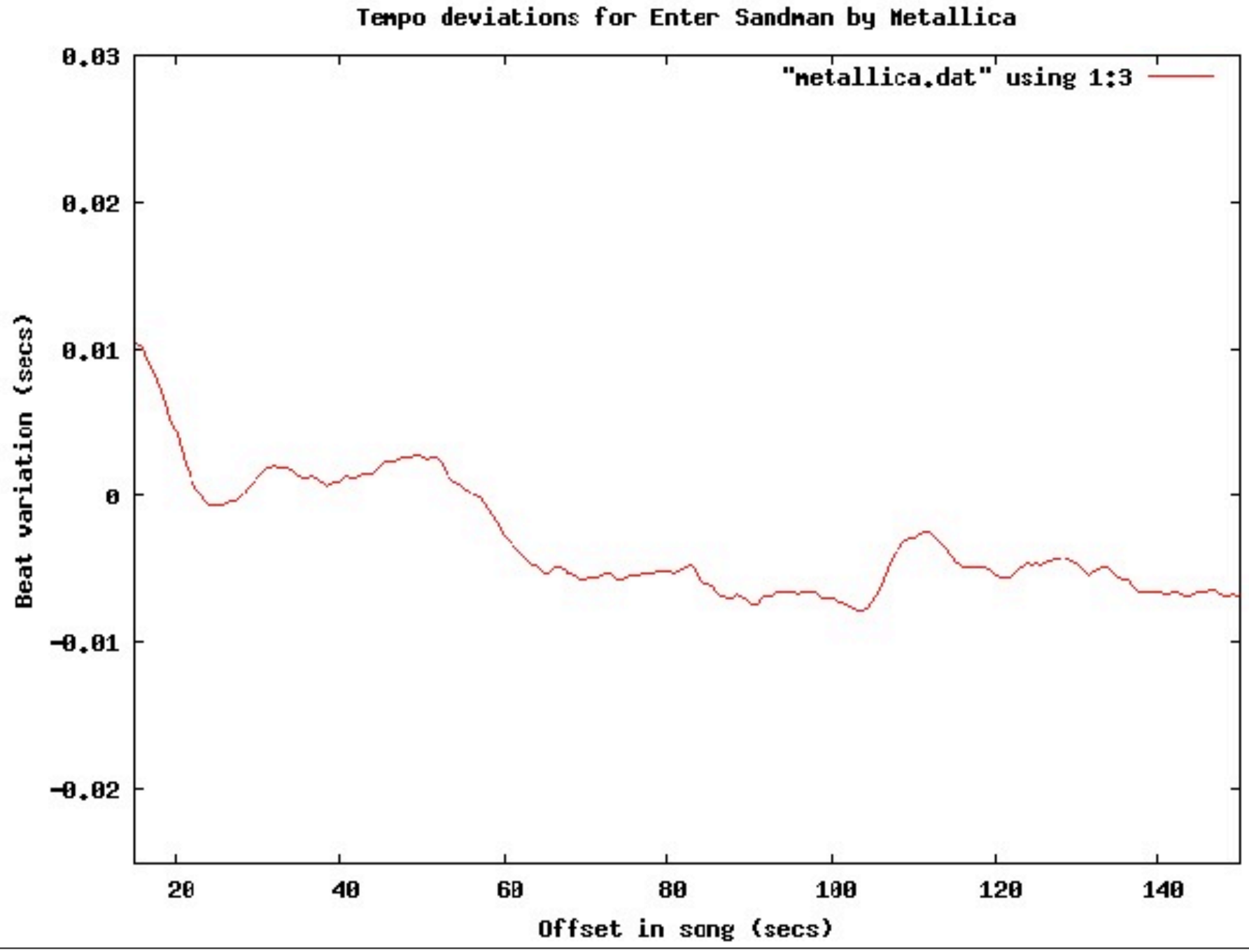
- Difficulty in integrating these parts when playing live

- Current ‘solution’ is the backing track: non-responsive. Click tracks means songs are at a constant tempo, the drummer is acoustically isolated and these parts are static.



Click track analysis

- ‘No click for Lars’ (http://musicmachinery.com/2009/03/02/in-search-of-the-click-track/ - Paul Lamere)



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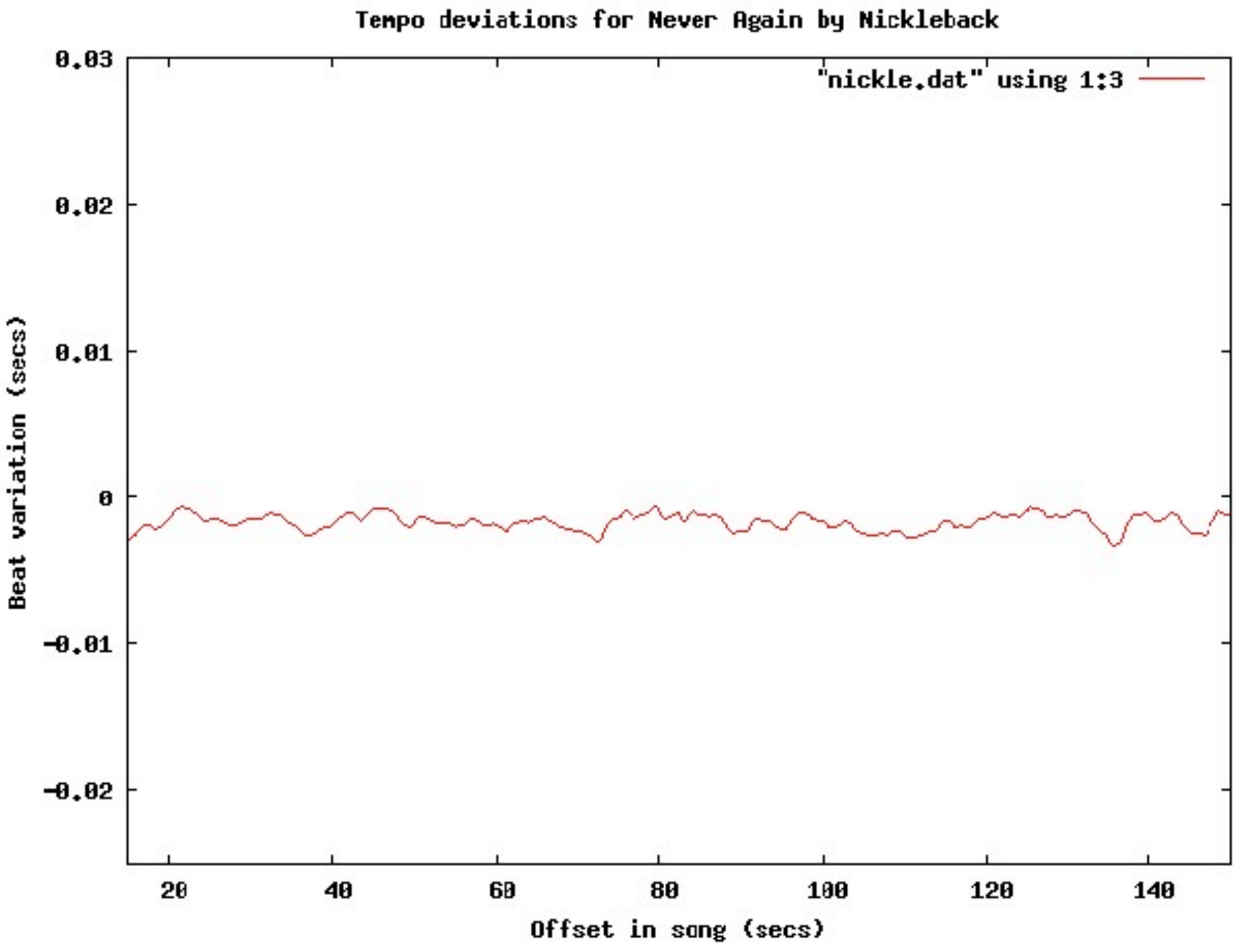
Click track analysis



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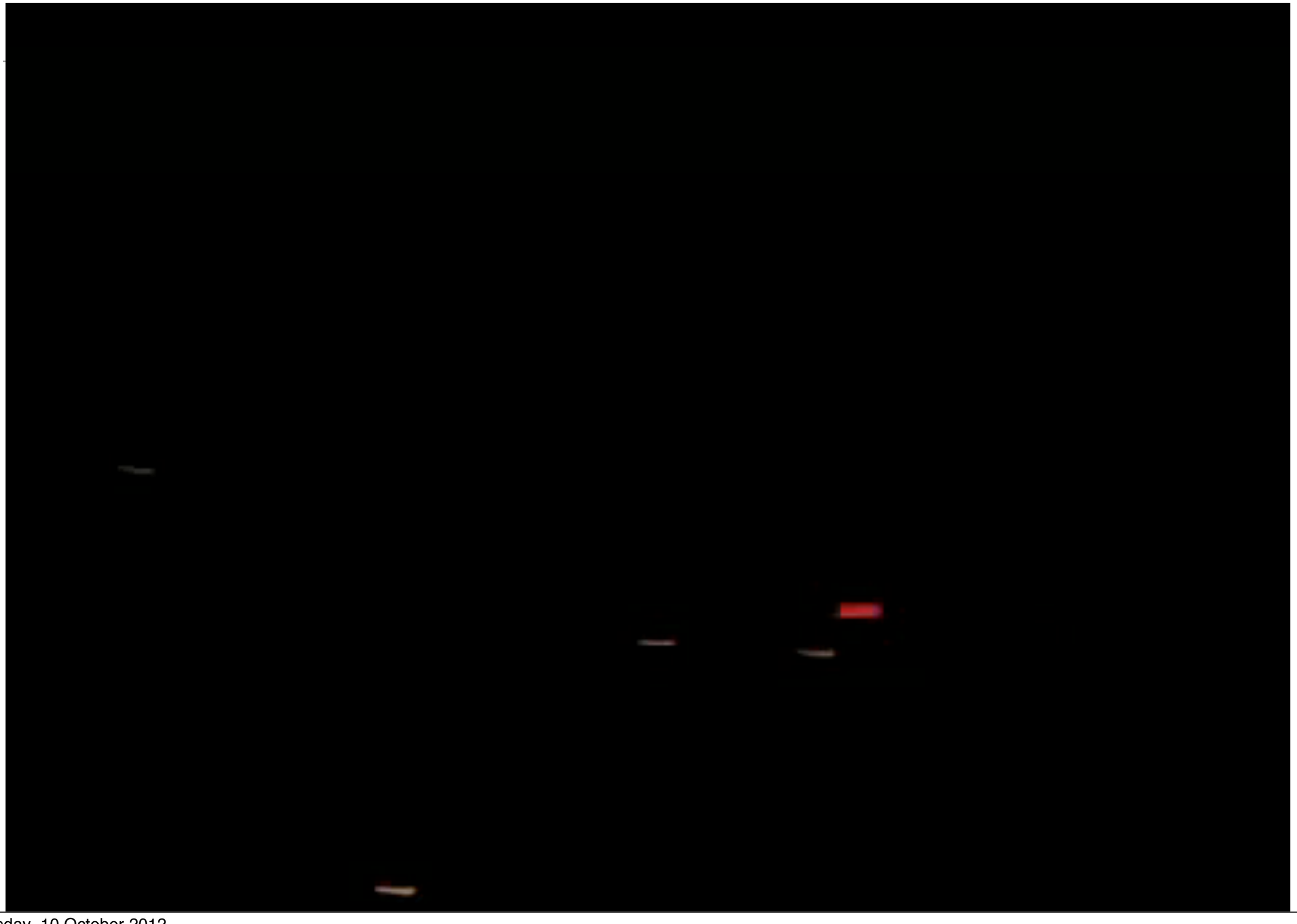
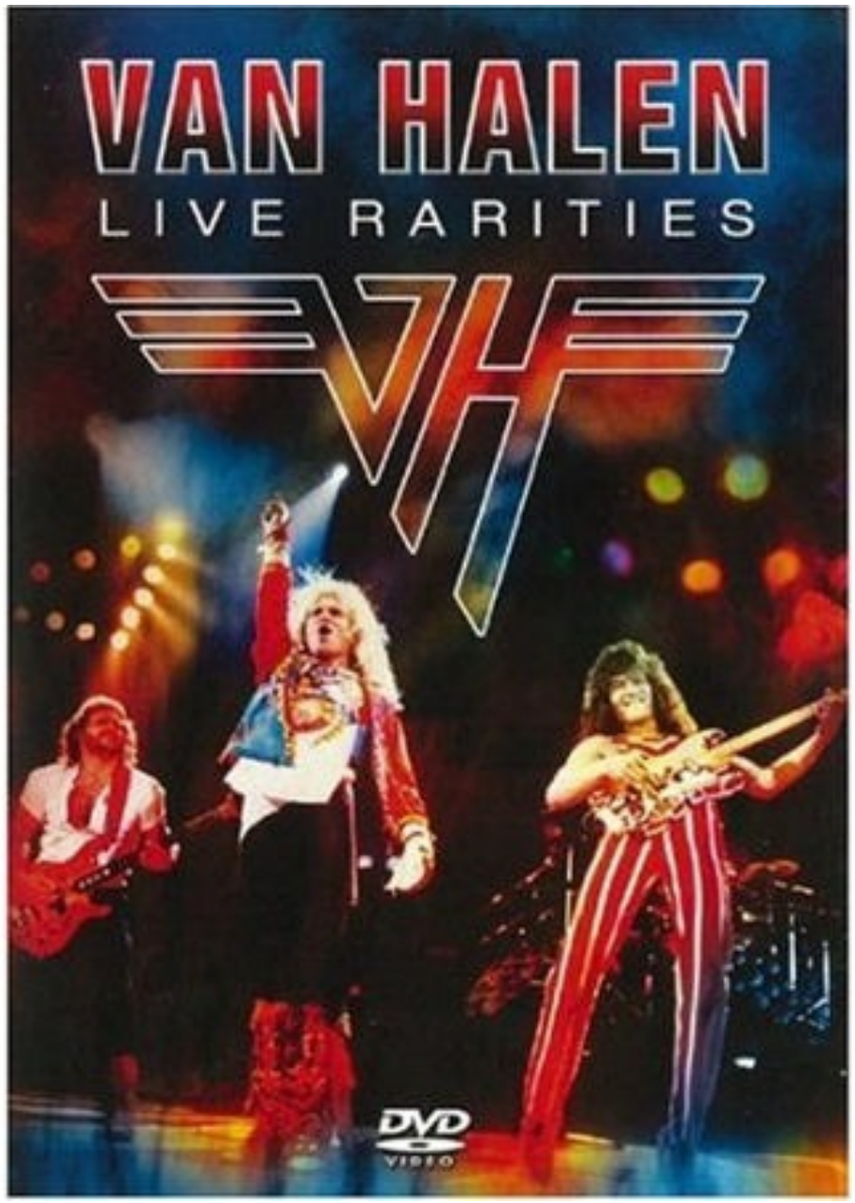
The Problem with Backing Tracks



The Problem with Backing Tracks

- Inflexible
- Unresponsive
- Isolates players through headphones
- Cannot recover from error



http://warmowski.wordpress.com/2007/10/19/whos-right-slap-fight/

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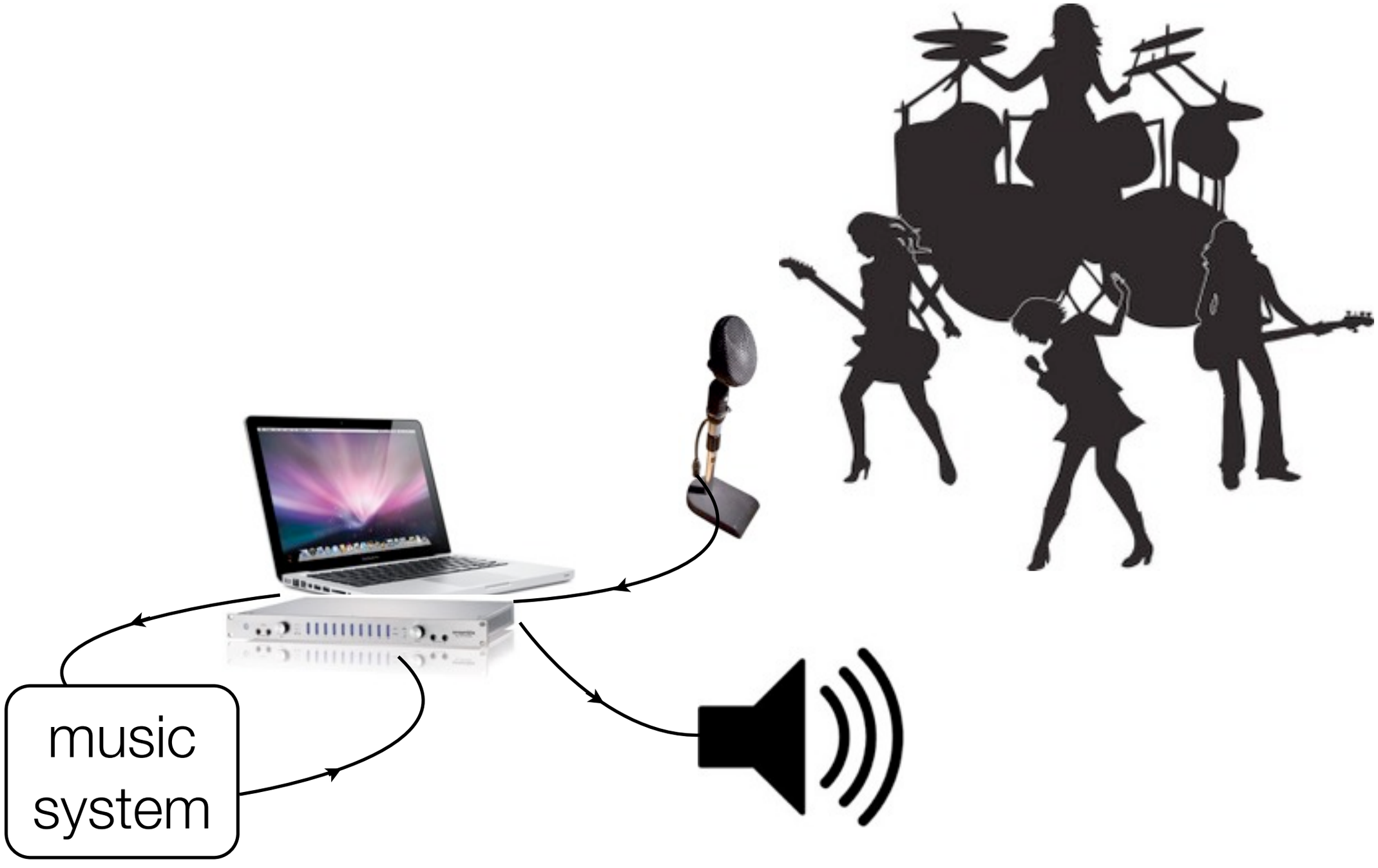
A model Performance System for a band



Key Features

- **Missing Musician**

- Ideally the system has a representation of musical structure

- Require processes for **Tempo** and **Phase** following - i.e. which beat and bars, and what speed?

- Balance between **Reliability** vs **Reactivity**

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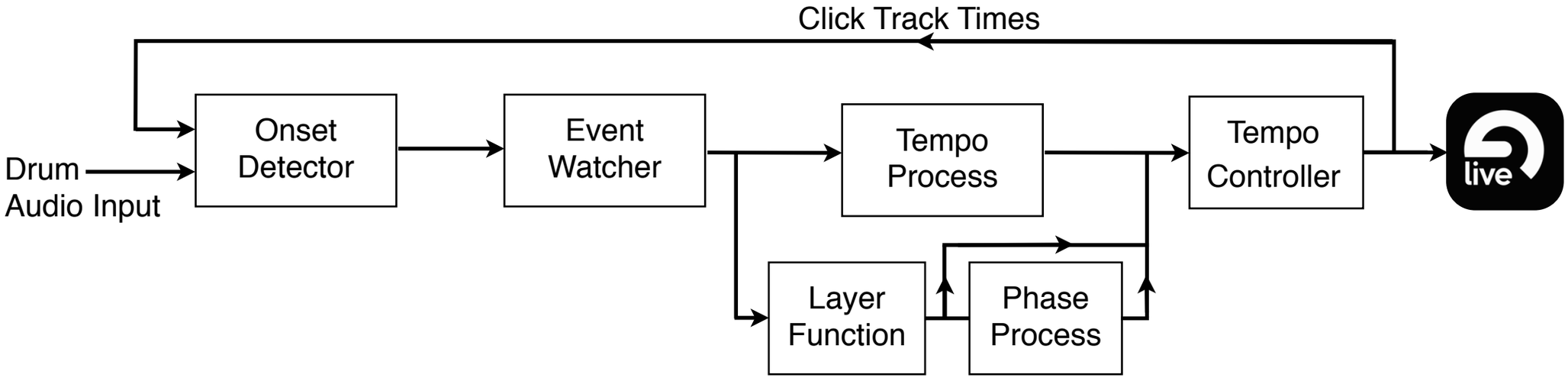
B-Keeper: Drum Tracker

- System designed solely around the drums
- Microphones on kick and snare giving onset times
- Initialise using count-in or known tempo.
- Assume known regular metre : e.g. 4/4, so can infer the metrical position of beats
- Approximately steady tempo so estimate is always known.
- Use of Ableton Live for sequencing time-stretched audio

Approach

- Event-based using kick and snare drum onsets
- Dual Processes for tempo and phase update. Slower rough tempo process and a fast phase process.
- Use of metrical information to interpret onsets
- Rule-based automatic adaptation of system parameters
- Phase process: Responsive windows around expected beats - similarity with oscillator models, e.g. Large and Kolen (1994)
- Tempo Process: look at IOI intervals, thresholding strategy

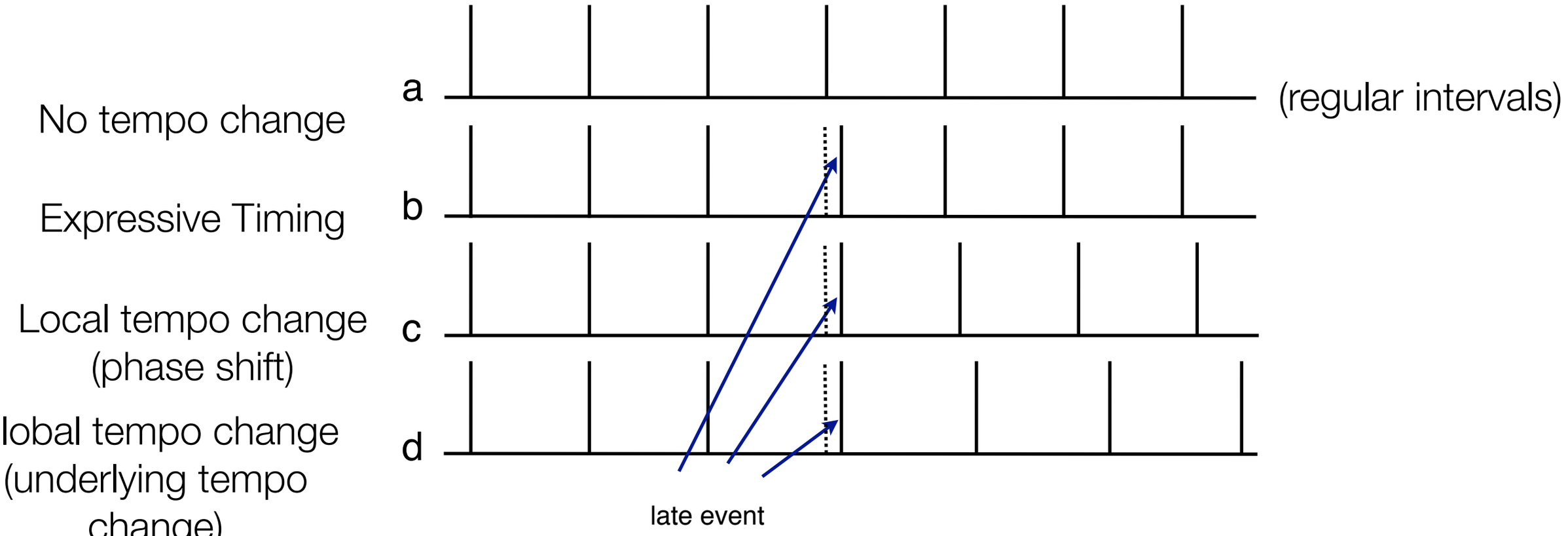
System Design



click track gives information about the beat times and bar position of the sequencer.

onset detector gives information about where drum events happen *relative* to this click track

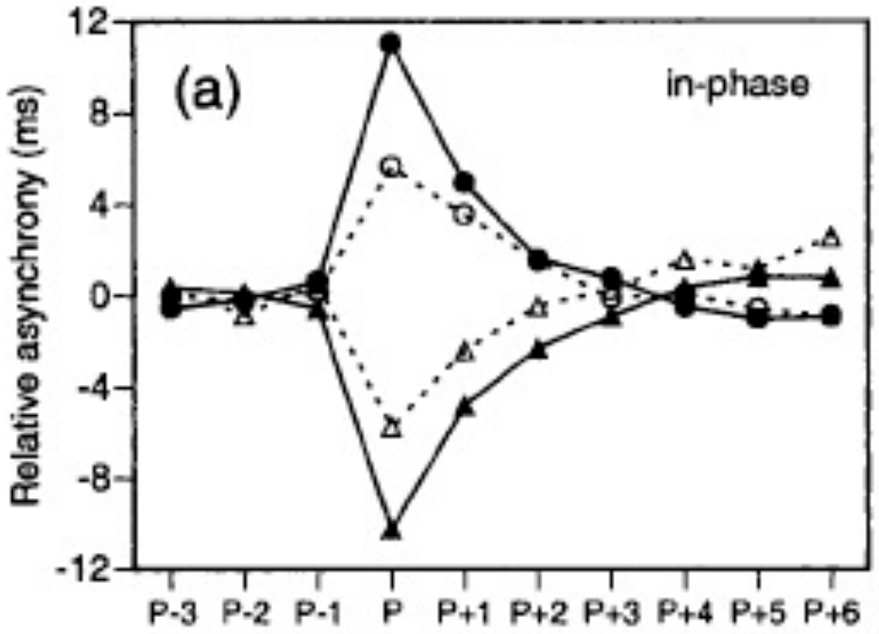
Event Interpretation:

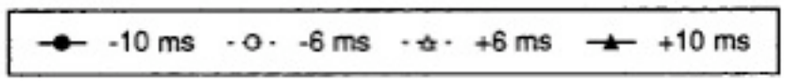


The problem facing real-time beat trackers is deciding:
what do you do when you observe the difference in the event?
It could be any of these three types of timing change. The correct interpretation depends on what happens next (which has not yet been observed).

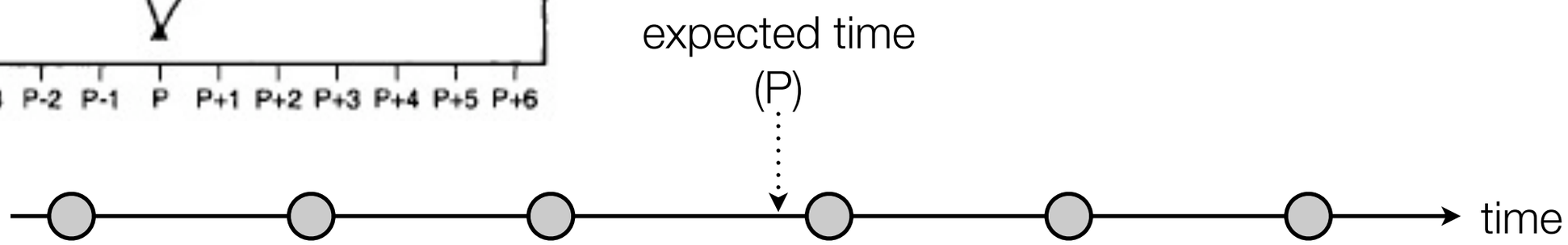
Illustration after Gouyon and Dixon, 2005

Sensorimotor Synchronisation



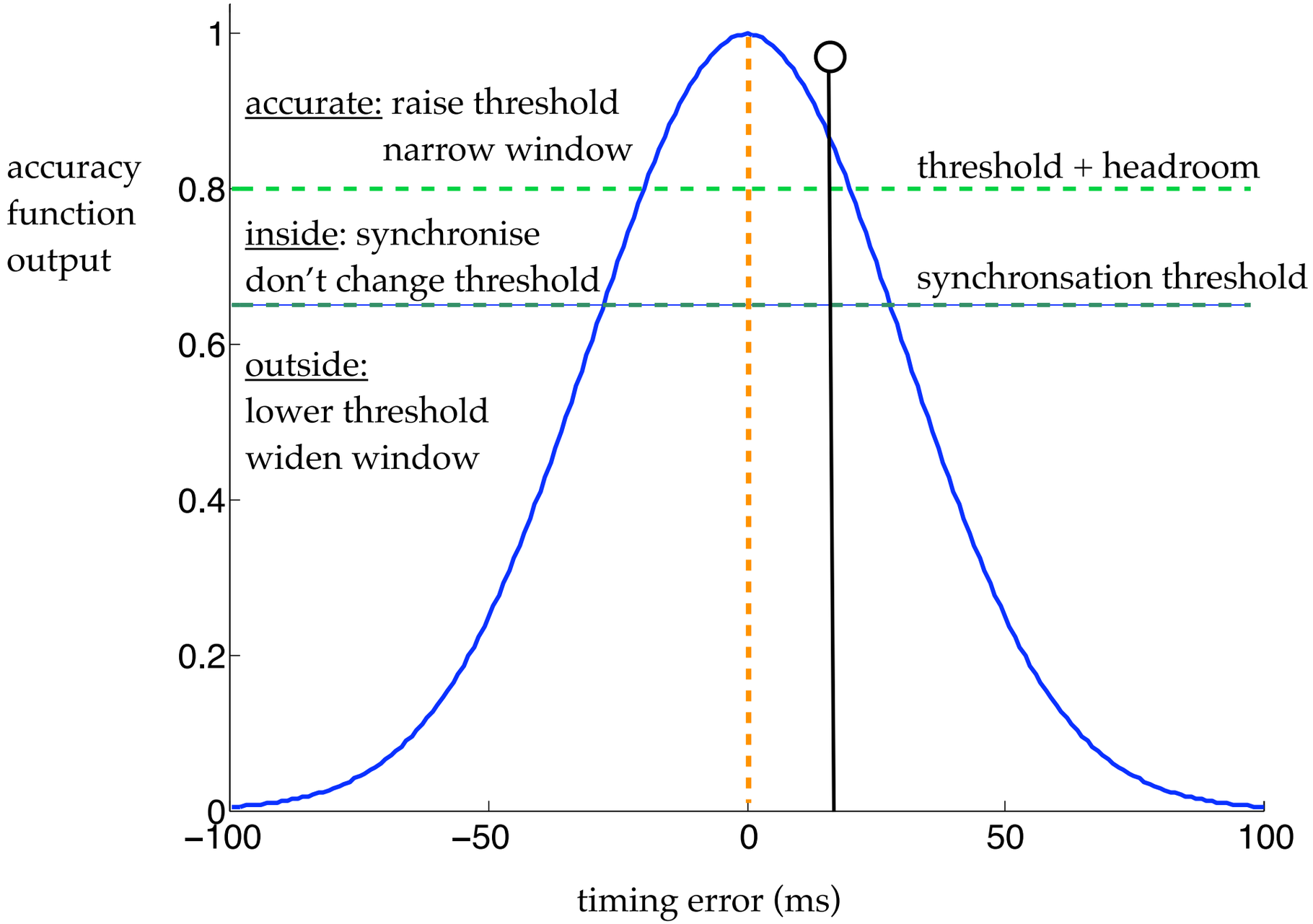


Phase correction adjustments made to four different changes of phase made to a sequence of isochronous (i.e. equally-spaced) pulses.



- Dual process model (Repp 2001): adjustments to both tempo and phase
- Fast phase response to re-align phase. In humans, 60% of the phase difference is adjusted within one beat.
- Slower response to underlying tempo change.

Phase Synchronisation



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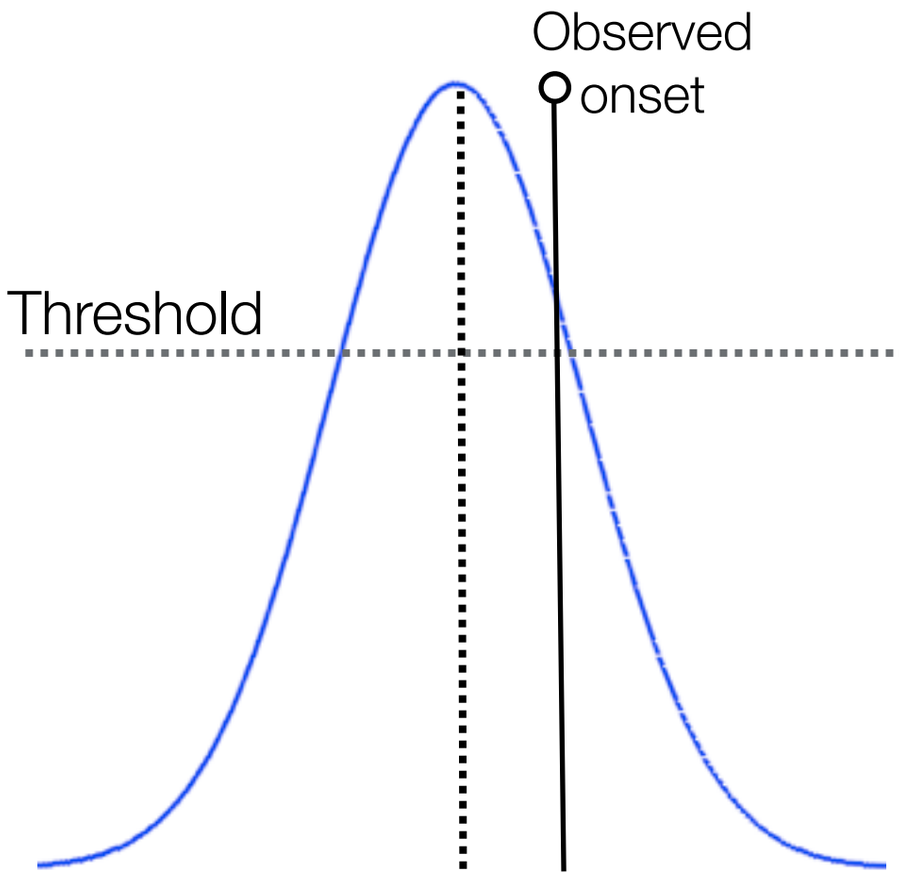
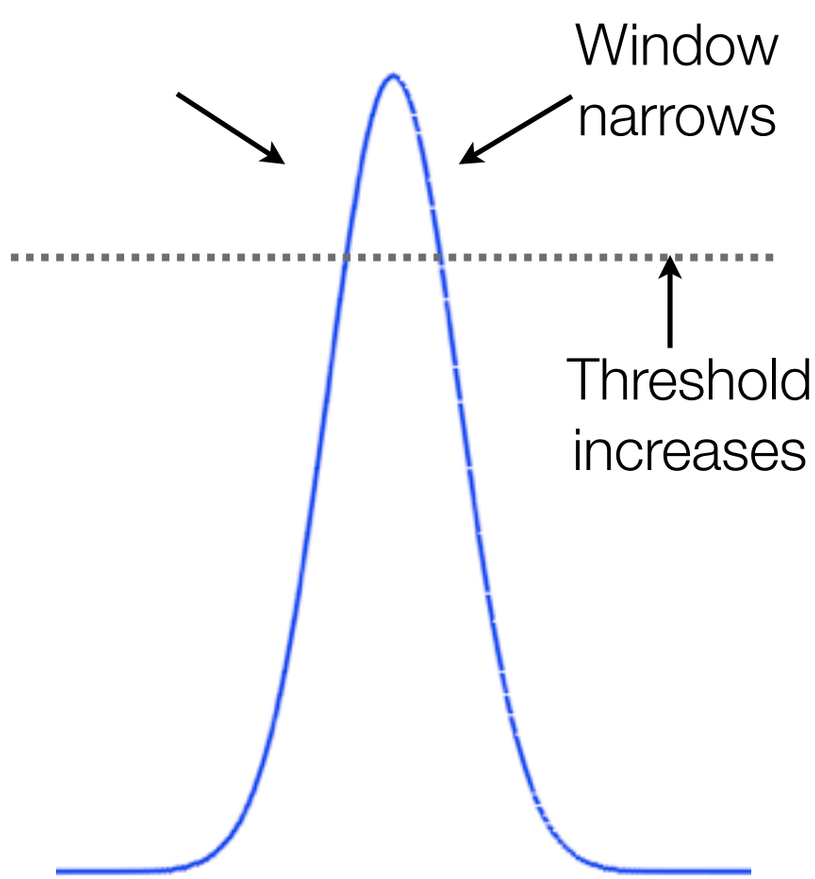
Phase Synchronisation





$$g(t) = e^{\frac{-(t - E[t])^2}{\sigma^2}}$$

Gaussian function

E[t] (expected)

σ parameterises the accuracy function: enables control of the algorithm's behaviour

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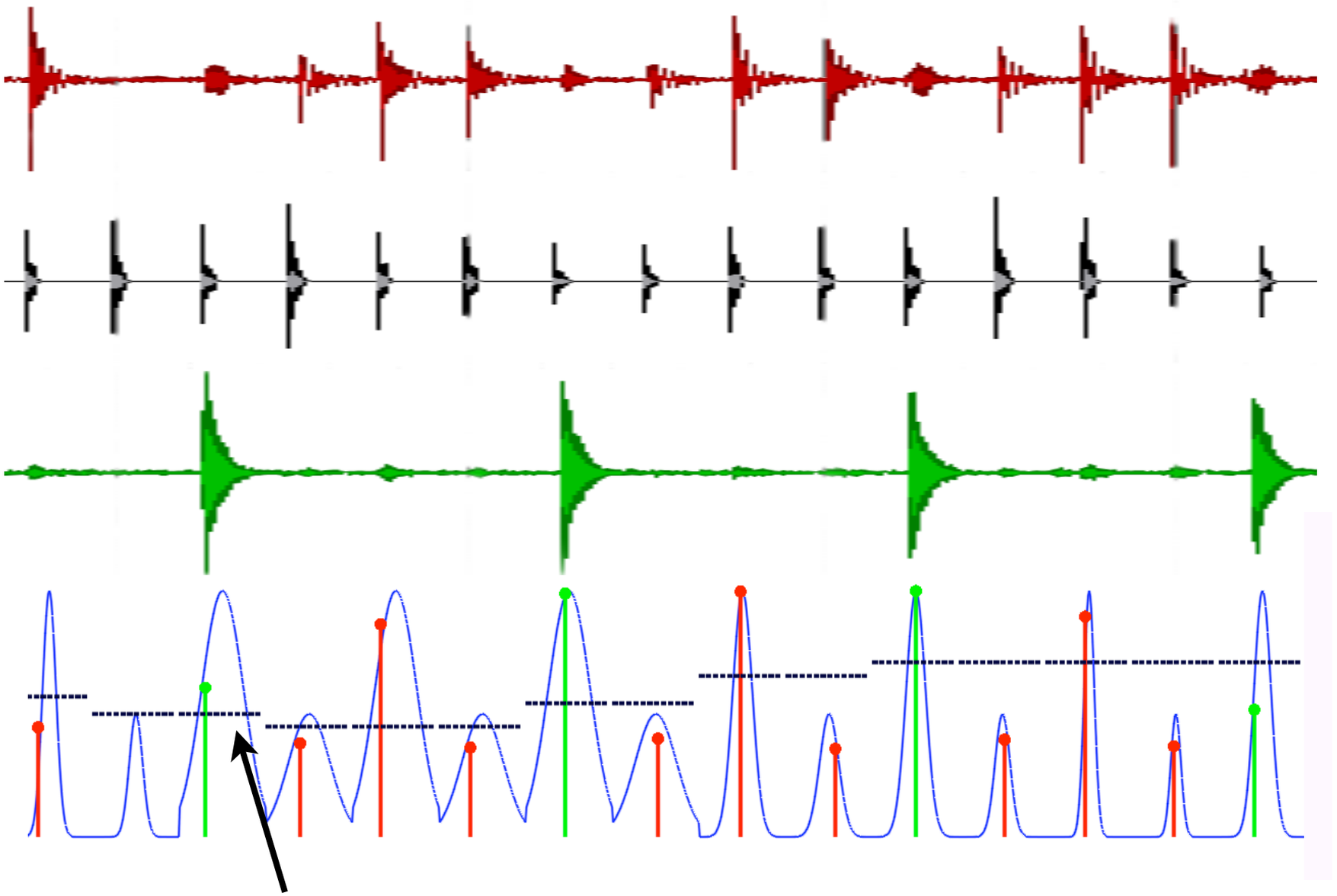
Inputs: Kick, Snare and Click Track

Kick

Click

Snare

Onsets



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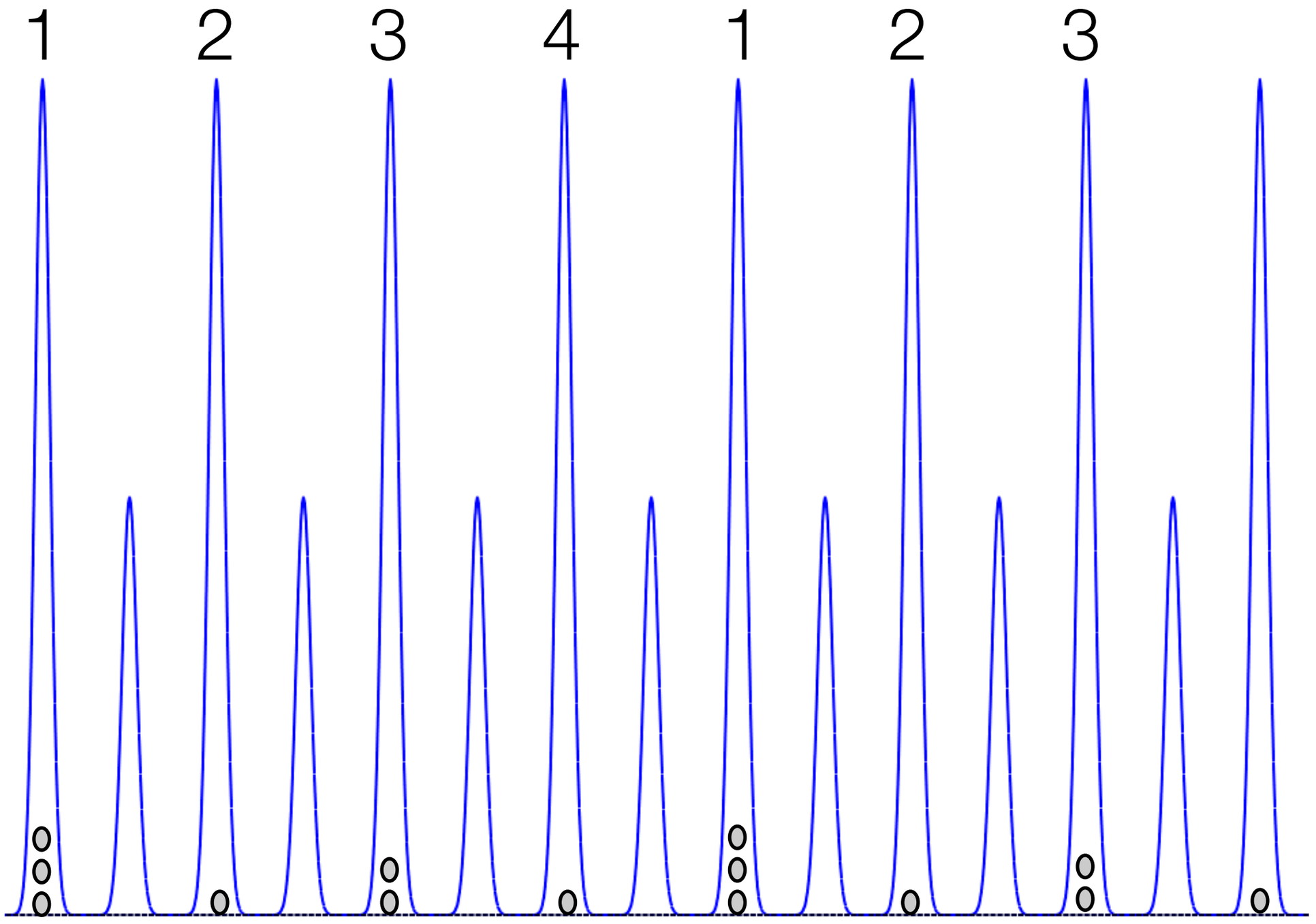
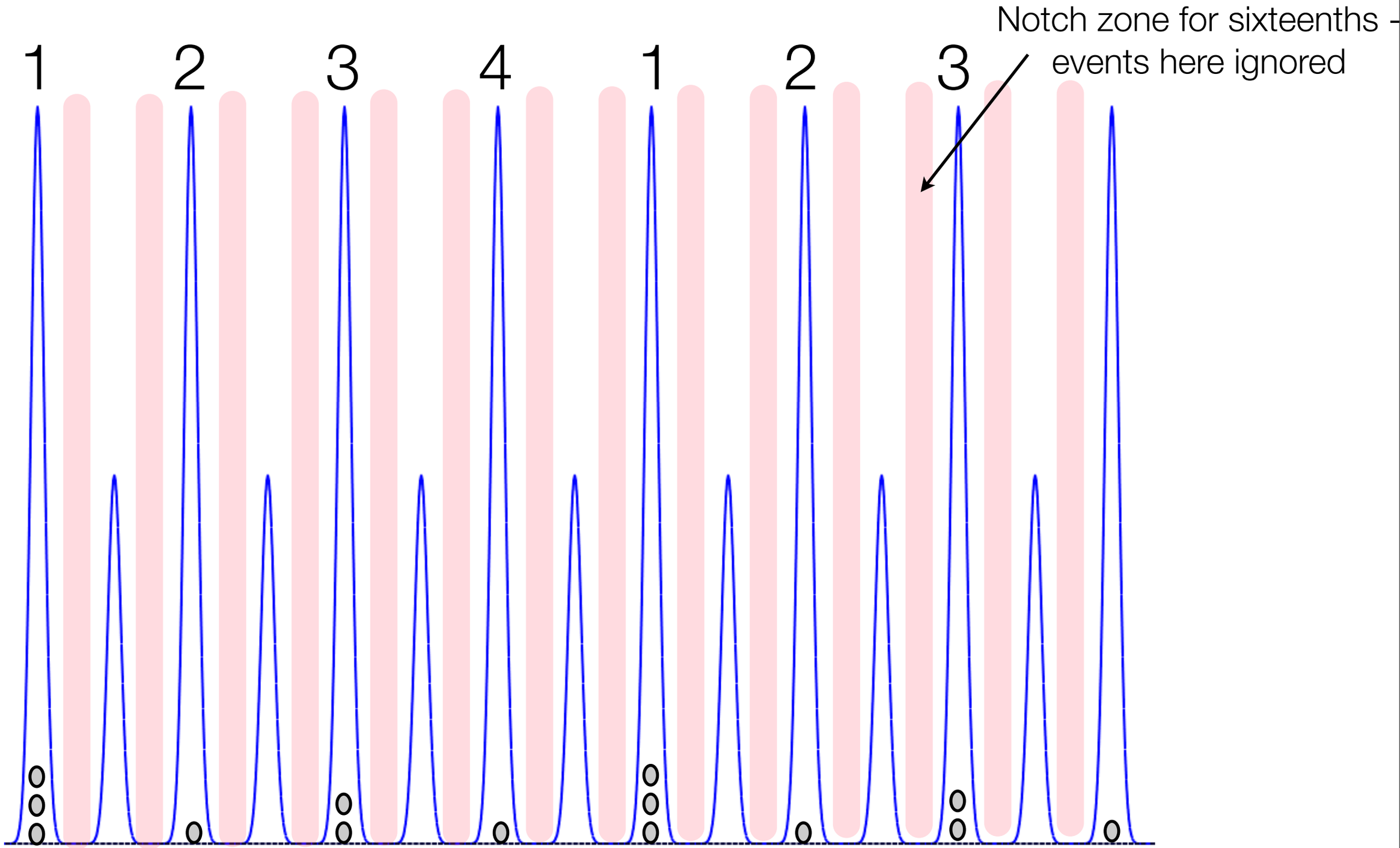
Layer Function

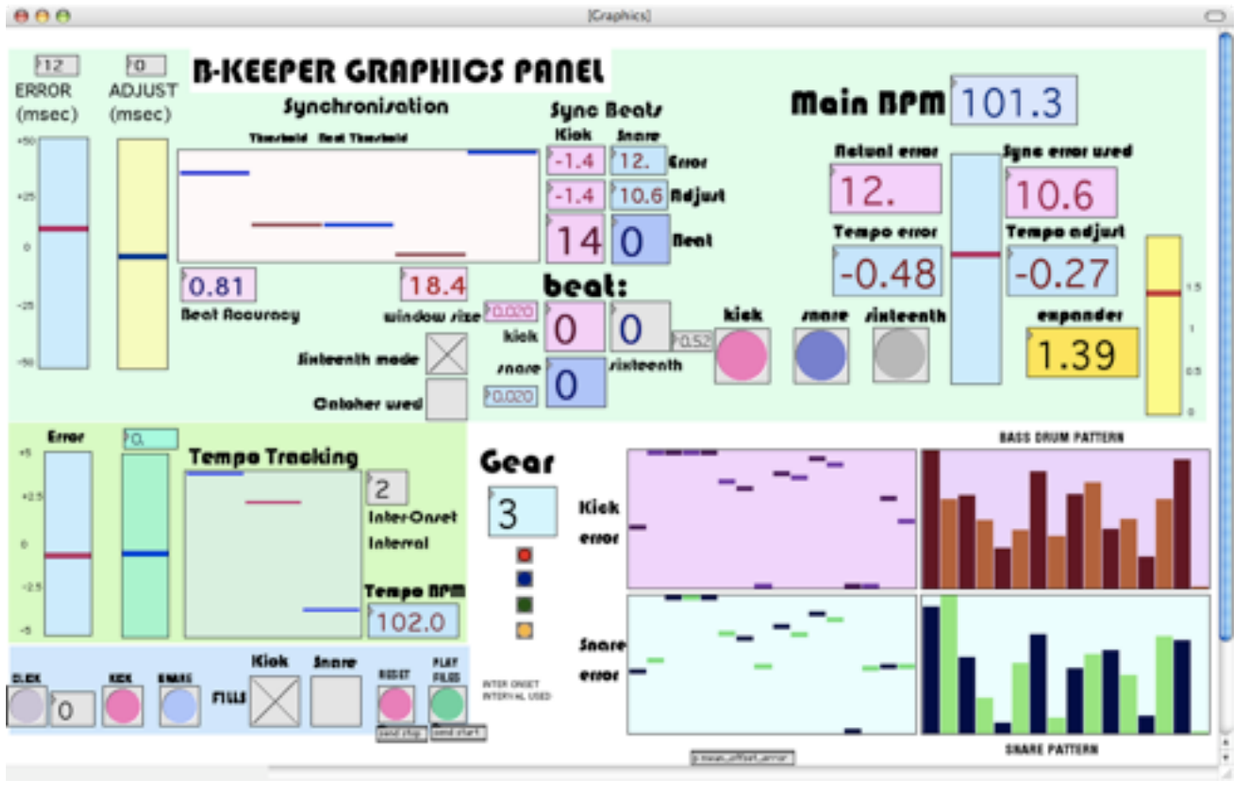


Layer Function



Max standalone version

Tempo Control via MIDI pitchbend message



B-Keeper Interface

Ableton Live Sequencer

Ableton Live provides expected beat locations via click track.

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Application

- Backing tracks synchronise automatically
- Live Looping
- Plugin for drum channel

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In practice: Higamos Hogamos

photo by Tom Medwell

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In practice: Live Looping

Students engaging with 'B-keeper', an intelligent computer system that helps bands keep the beat when playing live – The Royal Academy of Engineering Exhibition Zone, Big Bang Fair, 2009

ENGINEERING PUBLIC ENGAGEMENT

For some years, The Royal Academy of Engineering has been developing its public engagement activity. Dr Lesley Paterson, Head of Communications and Engagement, helped establish the Academy's public engagement grants scheme, *Ingenious*, in 2006. She writes for *Ingenia* about some of the projects that have been raising awareness of engineering.

Public engagement in science and engineering has been encouraged and supported for many years, driven by the efforts of passionate individuals, specialist consultancies and large institutions. It is an important way of inspiring young people and helps the wider public to better understand scientific and technological issues that affect their lives.

One of the many ways that engineering engagement is happening is through The Royal Academy of Engineering's *Ingenious* programme. Set up in 2006, it is funded by the Department for Business, Innovation and Skills (BIS). From encouraging engineers to take to the stage at festivals and county shows, to giving hands-on demonstrations and guidance in the classroom, hosting debates or even making films and helping produce dramas, *Ingenious* engineers have the chance to inspire a wide range of people.

Ingenious grants are awarded to projects that put engineers at the heart of public engagement, giving engineers the training, encouragement and opportunity to develop their creative and presentation skills and share their expertise with young people, families and adult audiences.

Around 15 projects are funded through the *Ingenious* programme each year and to date 60 projects have received funding and a total of 1,000 engineers have been involved.

ENGINEERING ENGAGEMENT

Public engagement is a valuable tool for making young people aware of engineering and encouraging them to consider it as a viable career choice. However, it is also important to help the public, both young people and adults, to better recognise engineering and its place in society.

Engagement can enrich people's lives by giving them the latest news on novel technologies and provide inspirational tales of engineering challenges overcome. In addition, it offers engineers and the public an opportunity to communicate with each other. It facilitates an exchange of views and enables engineers to explain why they are approaching a challenge in a particular way and what the alternatives might be.

There are also plenty of benefits for the engineers as well as for the public. Public engagement is an excellent way for engineers to improve both their professional and personal development by helping to build communication skills. Furthermore, many engineers report that it gives them a chance to give 'something back' and get inspired by the enthusiasm shown by the public for their field of work.

The following case studies present a few of the projects that have been funded by the Academy over the last five years.

DRUM HERO

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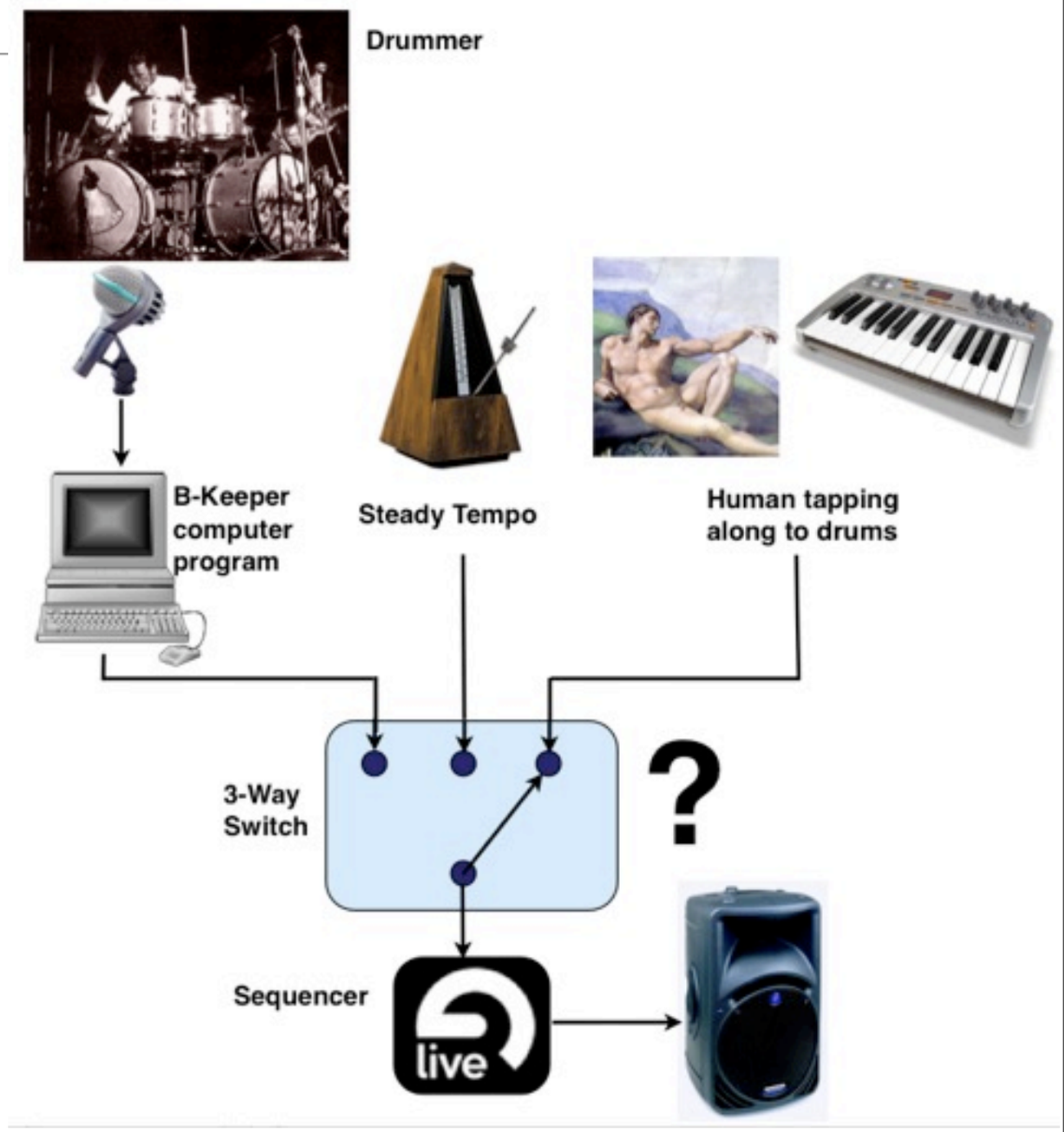
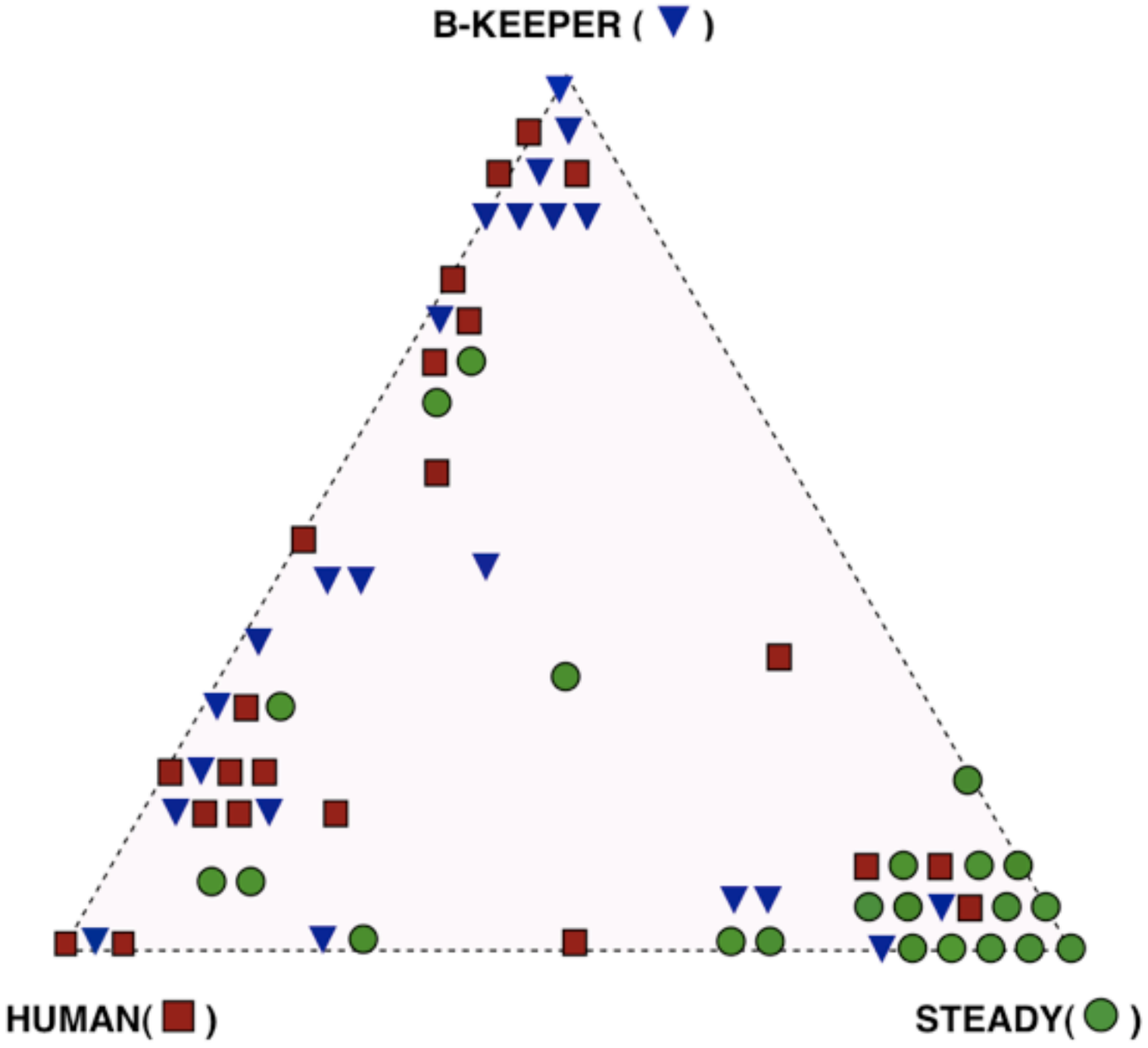
- Brings genuine musical interaction to game setting
- Enjoyable immersion in game and teaches timing and rhythmic skill at the same time
- Competitive - scores for correct patterns when played in time
- Modelled on human listeners, so a ‘realistic’ response of how a band would respond to your playing

Evaluation

- Musical Turing Test
- Three controllers: B-Keeper, a Human Tapper and a fixed-tempo Metronome
- Aim for drummers to distinguish between them
- Two pieces. Eleven professional drummers. Randomised order



Evaluation Results



As judged by the drummers.

Pairwise comparison

	Judged as:	
Controller	Human Tapper	Steady Tempo
Human Tapper	**12**	**4**
Steady Tempo	**5**	**14**

	Judged as:	
Controller	Human Tapper	B-Keeper
Human Tapper	**9**	**8**
B-Keeper	**8**	**8**

Feedback

"Put simply, it is a system which throws a virtual harness over our computer and forces it to keep time with Marcus' drums - so off with his headphones and on with a new era of liberated playing with no need for click tracks and count-ins."
Tom Havelock (Hook and the Twin).

"It feels like playing with another human. You can get a vibe going."
Steve Webster (Higamos Hogamos, DC Recordings)

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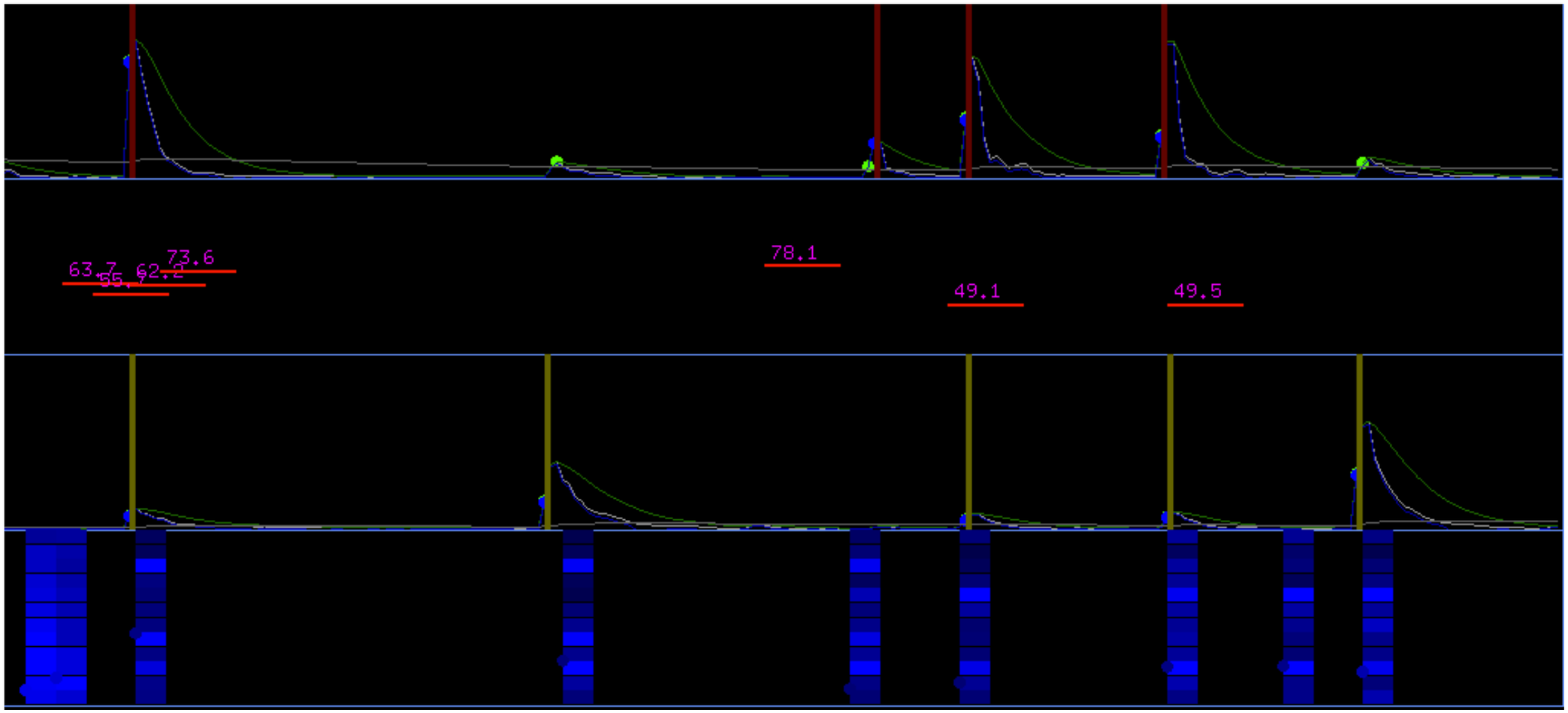
Multitrack Matching

kick

bass

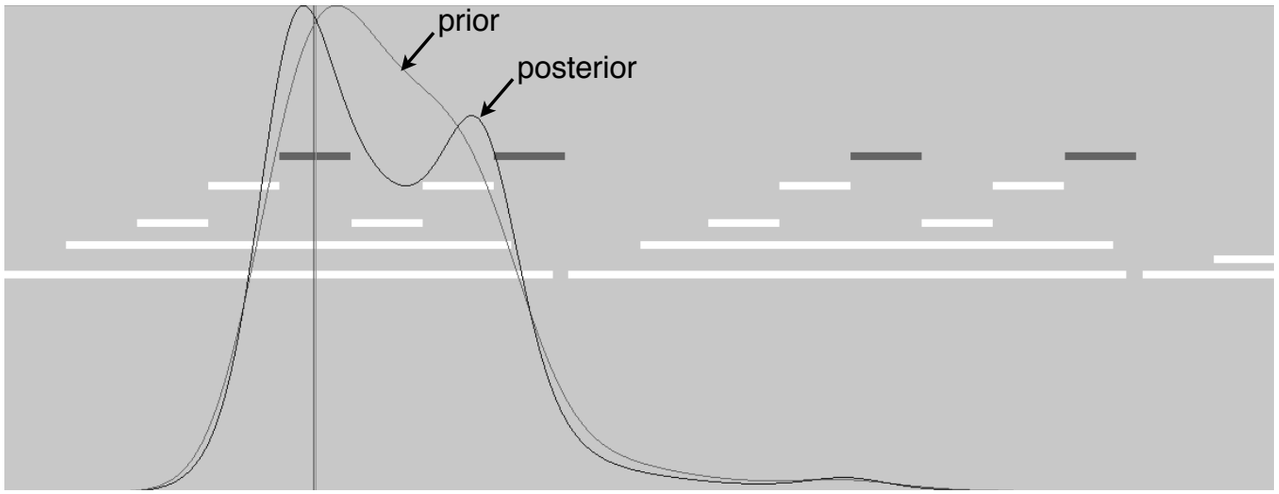
snare

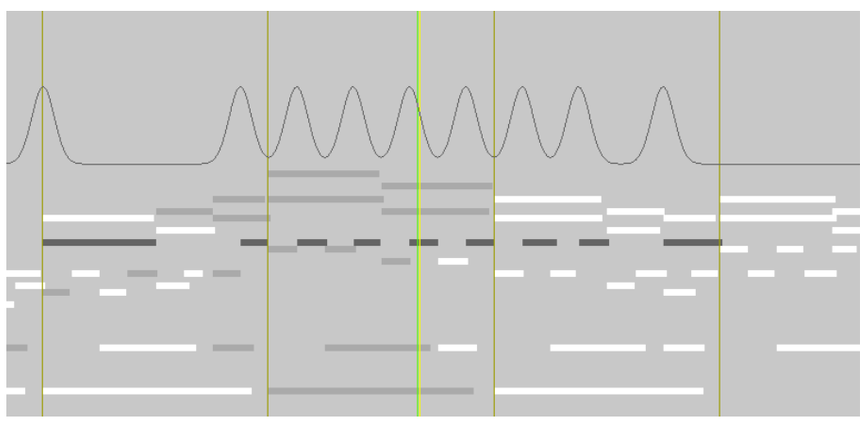
electric guitar



Probabilistic Event Based Matching

- Expectation, prediction - incorporate new information
- Quantifies uncertainty about where we are
- Likelihood function for where we are in the score given the observation





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References

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B. H. Repp. Phase correction, phase resetting, and phase shifts after subliminal timing perturbations in sensorimotor synchronization. Journal of Experimental Psychology: Human Perception and Performance, vol. 27, no.3, pages 600 - 621, 2001.

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Conclusion

- Strategies to simplify the problem - use what you know
- Make use of mutual aspect to interaction: listening *to* the system as well as the system listening to you
- Interpretation is critical - what to ignore, what to use
- Future: musical structure, pattern representation, models of time

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- B-Keeper: Available for download from: http://www.b-keeper.org
- www.eecs.qmul.ac.uk/~andrewr
- email: andrew.robertson@eecs.qmul.ac.uk

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The Royal Academy of Engineering

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Pioneering research and skills