

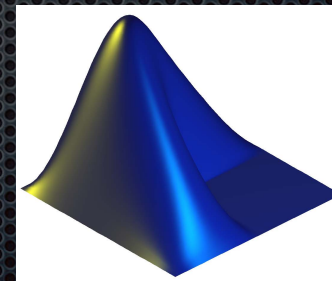
# A comprehensive framework for audio and music analysis

Olivier Lartillot

Aalborg University, Denmark



*MIRtoolbox*



*MiningSuite*



# Outline

- ✦ Audio and musical feature extraction from **recordings**
  - ✦ *MIRtoolbox*
- ✦ Music analysis from **symbolic** representation:
  - ✦ grouping, reduction, motivic patterns
- ✦ *MiningSuite*





# *MIRtoolbox*

- ✦ Comprehensive set of audio / musical features
- ✦ Modular syntactic layer on top of Matlab
  - ✦ both simple and powerful language
- ✦ Referential framework in Music Information Retrieval
  - ✦ 10000s of downloads, 500+ citations in papers





*MIRtoolbox*

Dynamics

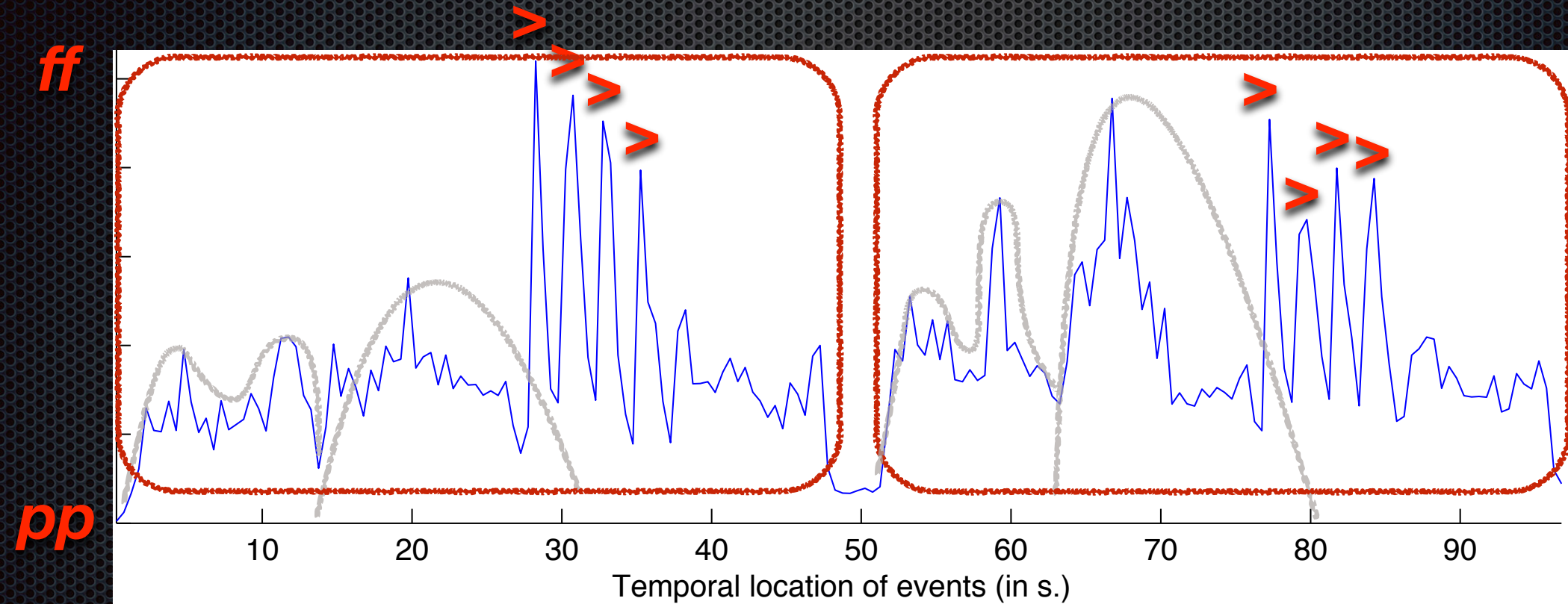


***Audio level***

**Sound**



# Dynamics: Global energy



Dvorak, Symphony 8 G major, *Allegretto grazioso - Molto vivace*





*MIRtoolbox*

Dynamics

Timbre



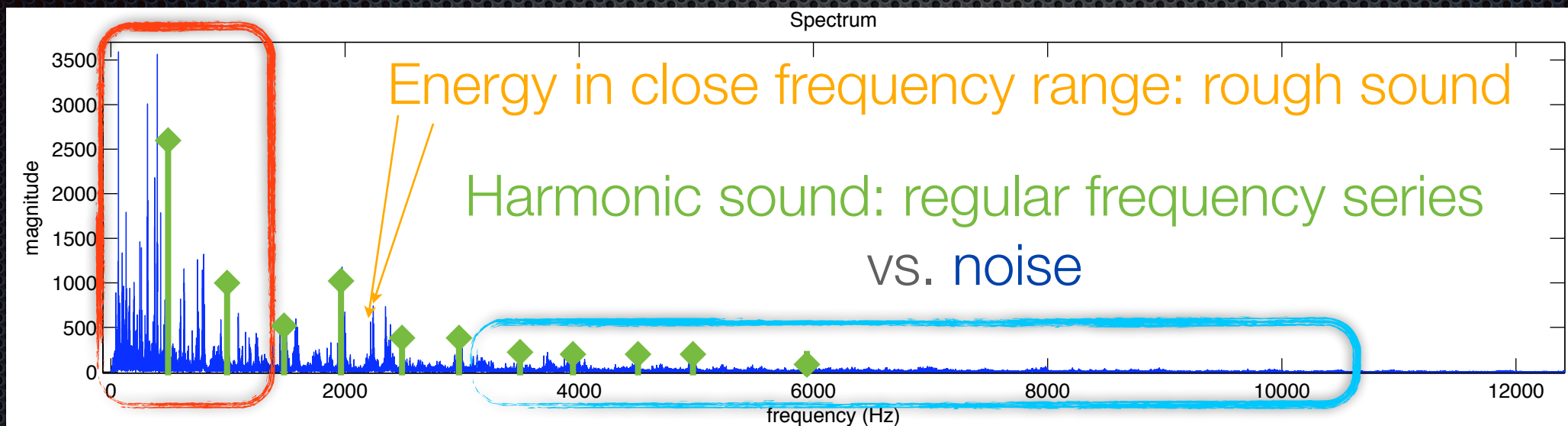
***Audio level***

**Sound**



# Timbre

- ✦ Energy decomposed into frequencies (**spectrum**)

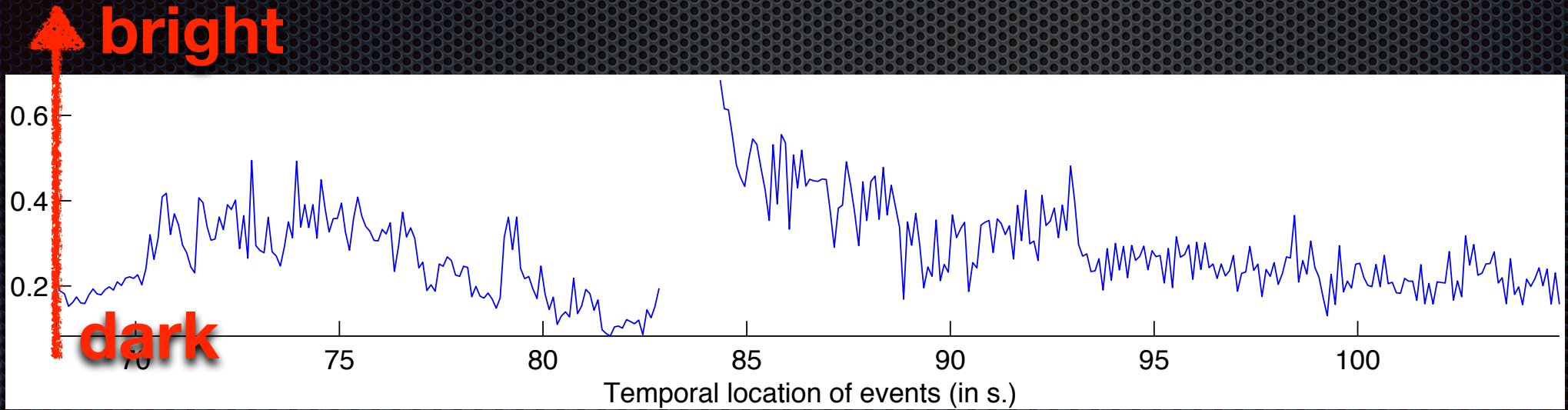


Low frequency  
energy: dark  
sound

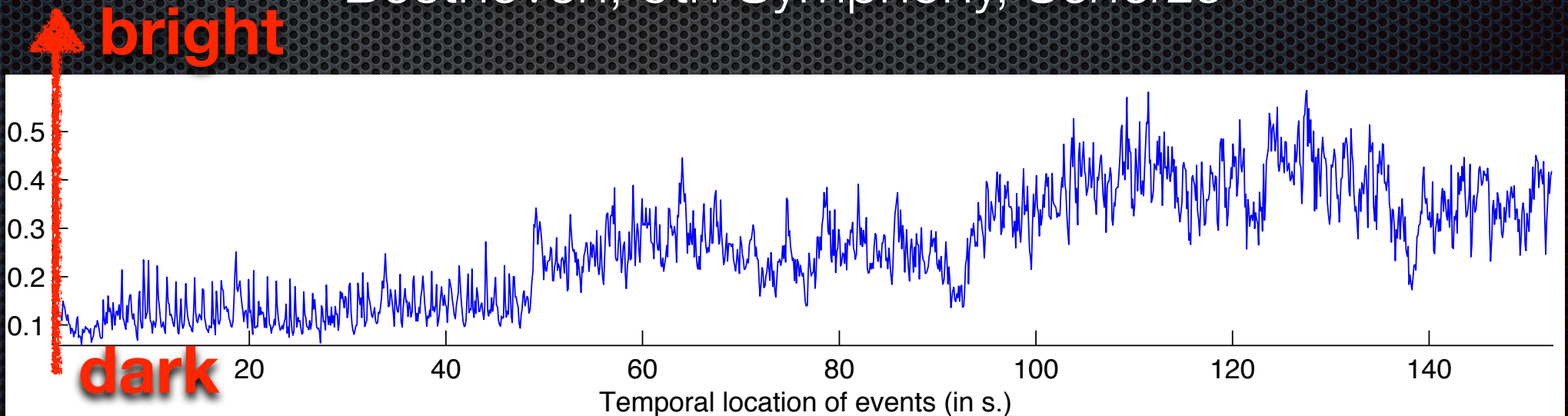
High frequency energy:  
bright sound



# Timbral gesture: brightness



Beethoven, 9th Symphony, *Scherzo*



Beethoven, 7th Symphony, *Allegretto*





*MIRtoolbox*

Dynamics

Timbre

Pitch

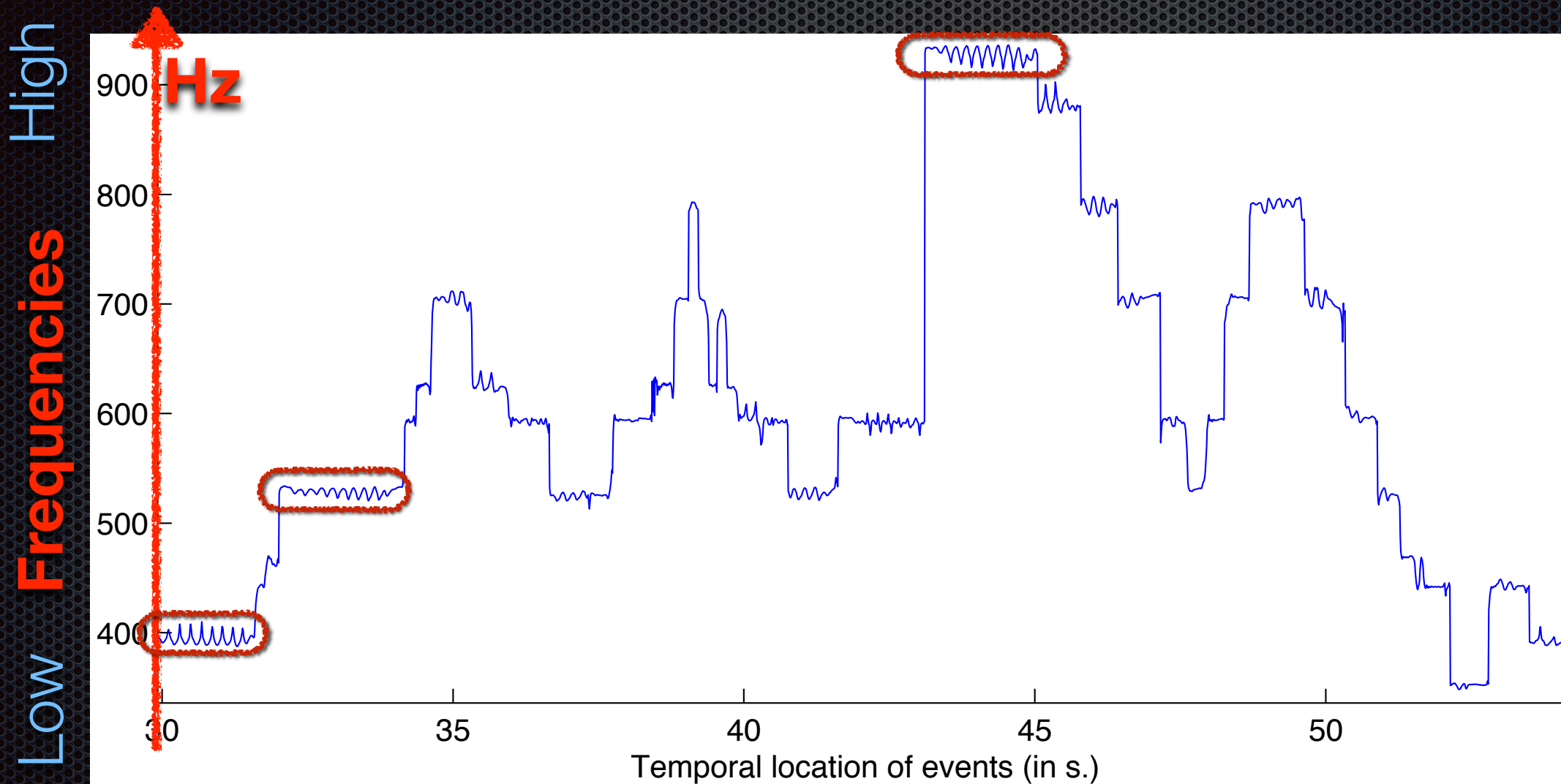
***Audio level***

**Sound**





# Pitch gesture



Harty, Miniature for oboe and piano, *Orientale*





*MIRtoolbox*

*“Symbolic” level*

Notes

Dynamics

Timbre

Pitch

***Audio level***

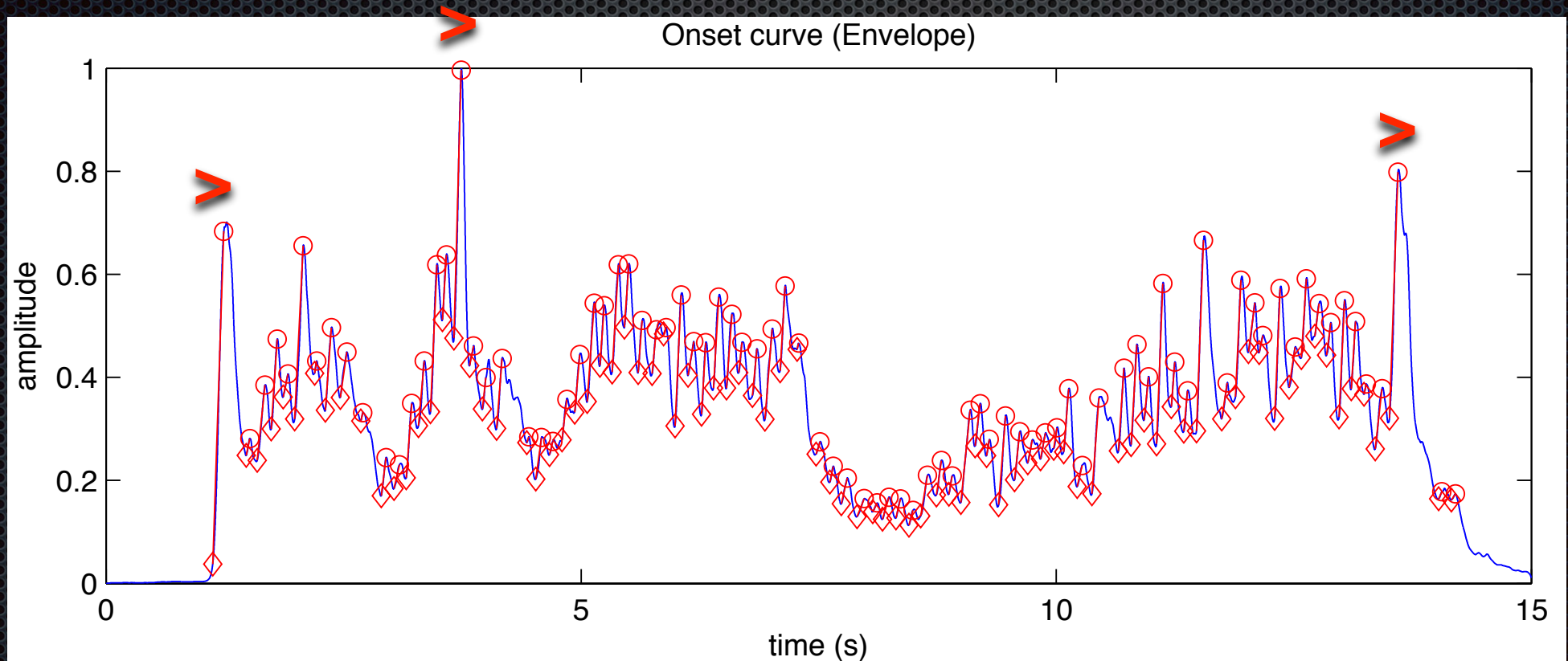
**Sound**





# Dynamics: Note attacks

*sf*

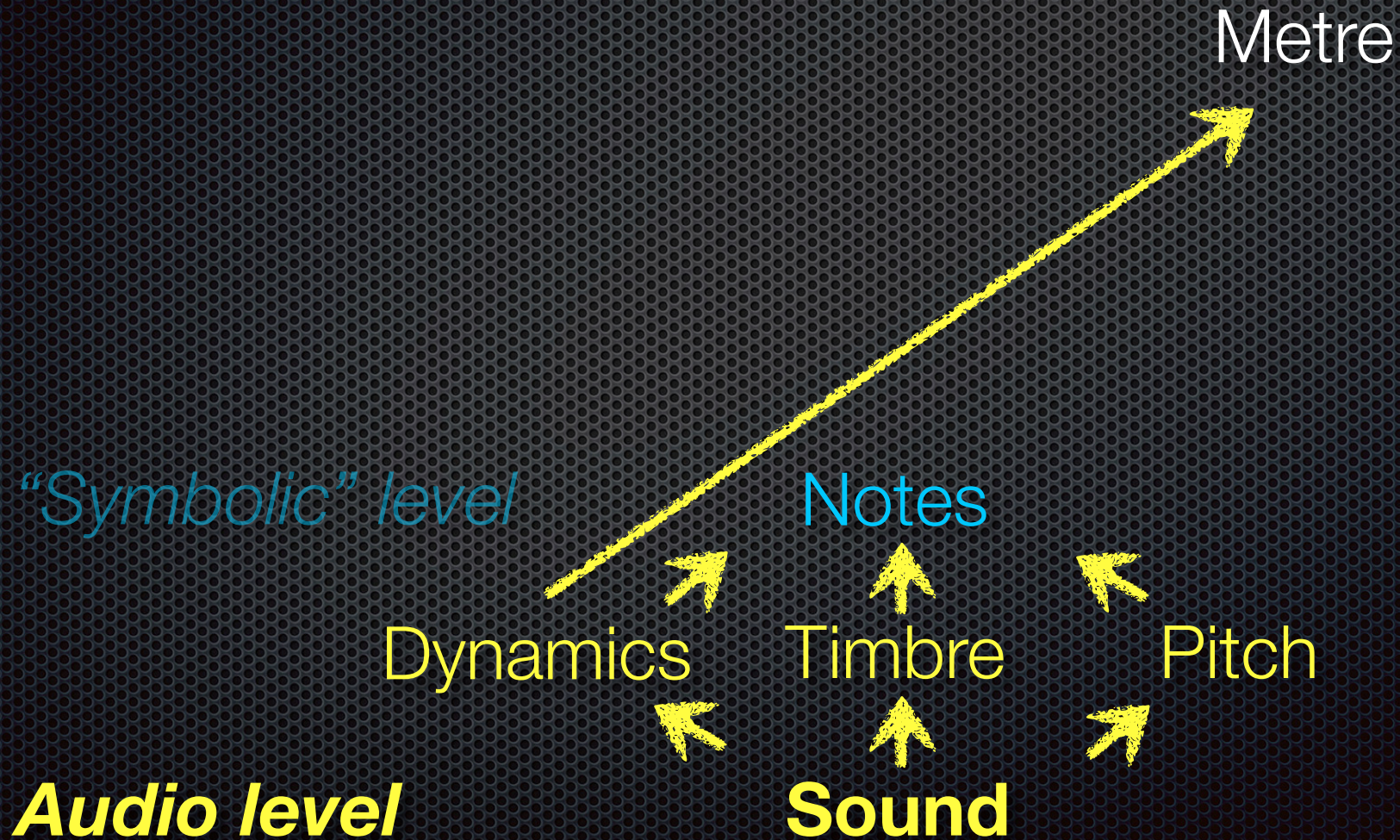


CPE Bach, Cello Concerto in A major, WQ172, 3rd movement





*MIRtoolbox*



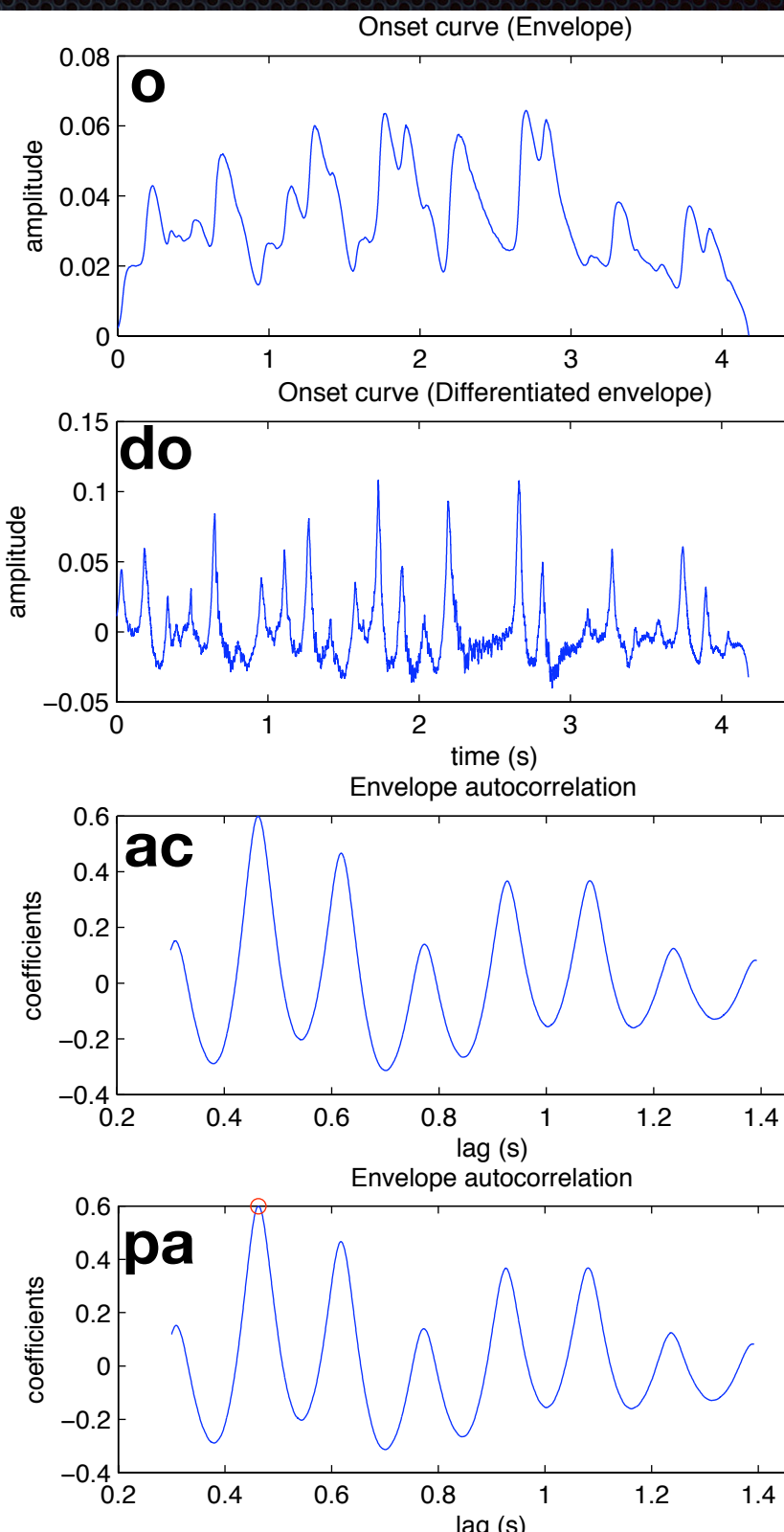


# Tempo estimation

- ✦ `o = mironsets('mysong', 'Detect', 'No')`
- ✦ `do = mironsets(o, 'Diff')`
- ✦ `ac = mirautocor(do)`
- ✦ `pa = mirpeaks(ac, 'Total', 1)`

In short:

- ✦ `[t, pa] = mirtempo('mysong')`  
**t = 129.6333 bpm**



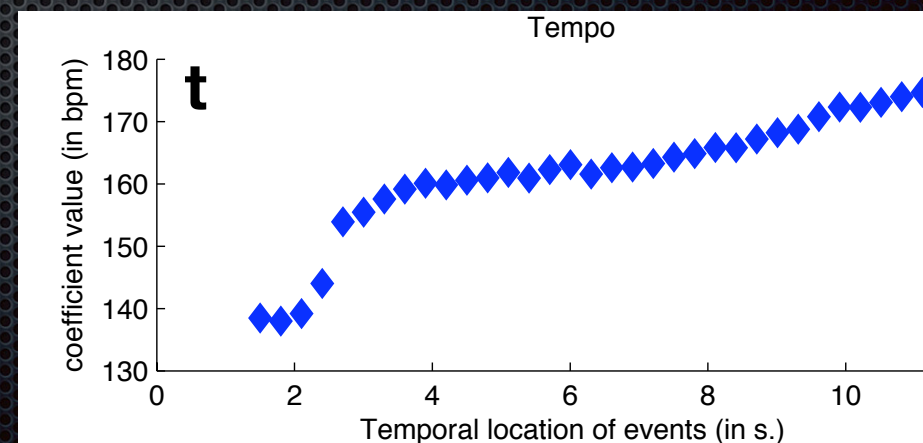
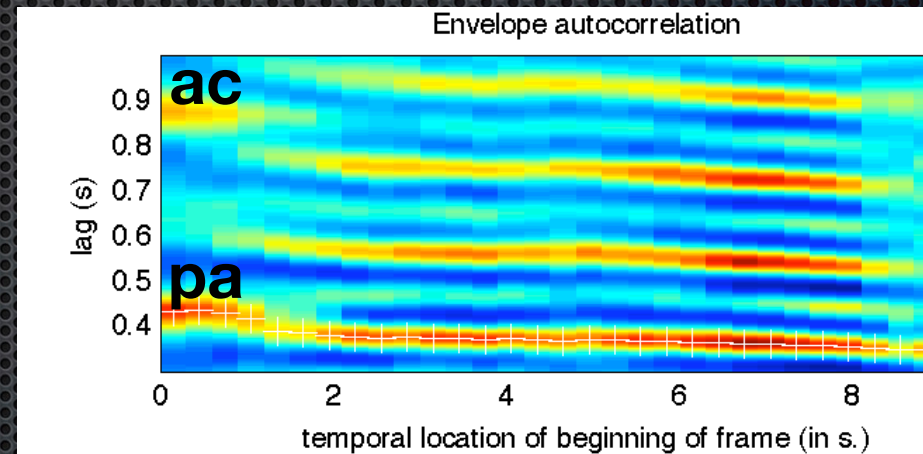
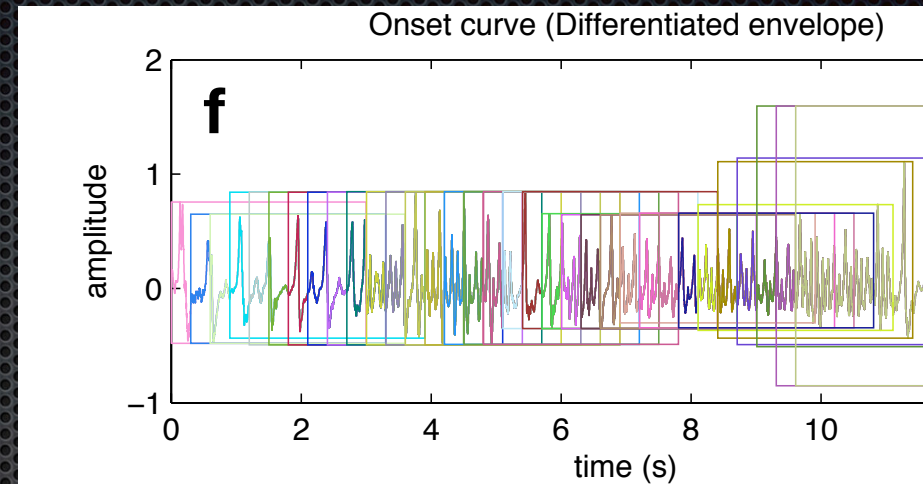


# Tempo estimation

- ❖ `o = mironsets('mysong', 'Detect', 'No')`
- ❖ `do = mironsets(o, 'Diff')`
- ❖ **`f = mirframe(do)`**
- ❖ `ac = mirautocor(do)`
- ❖ `pa = mirpeaks(ac, 'Total', 1)`

In short:

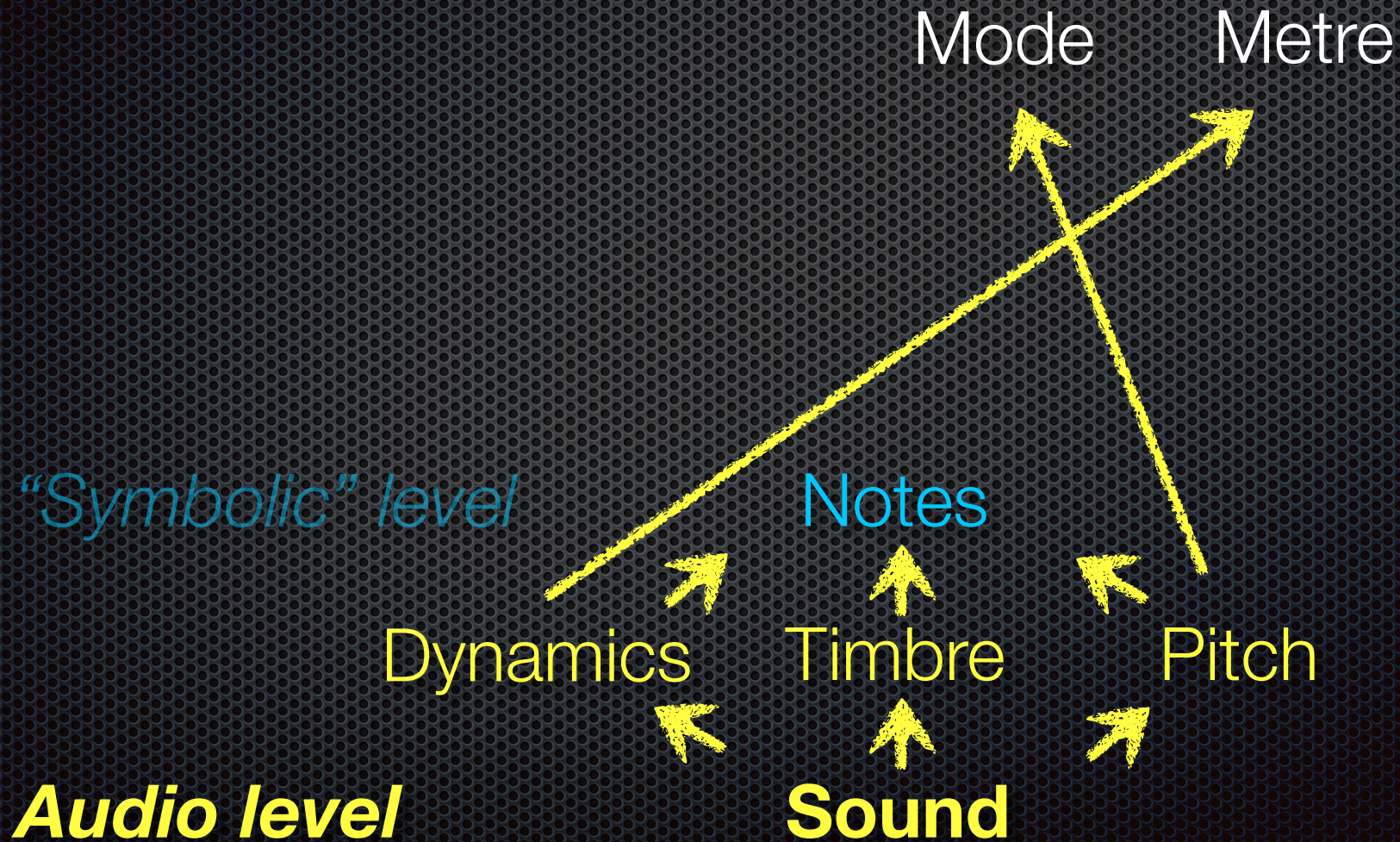
- ❖ `[t, pa] = mirtempo('mysong', 'Frame')`







# MIRtoolbox



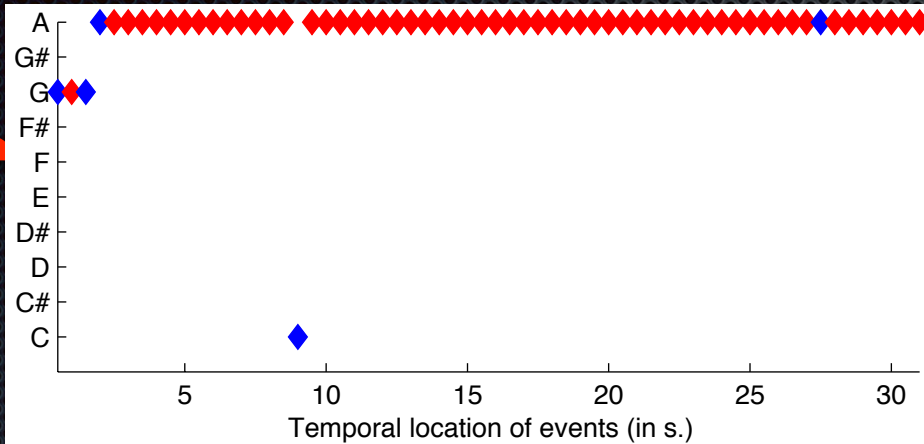


\* Sykes, Glowinski, Grandjean, Lartillot, Eliard. *Is a contemporary listener able to distinguish between the musical emotional figures created by Monteverdi? SysMus 2013*

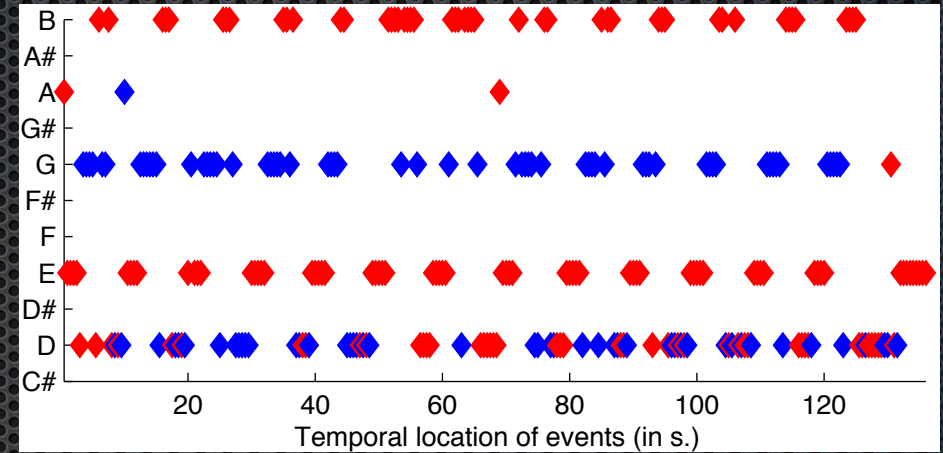
# Tonal gesture



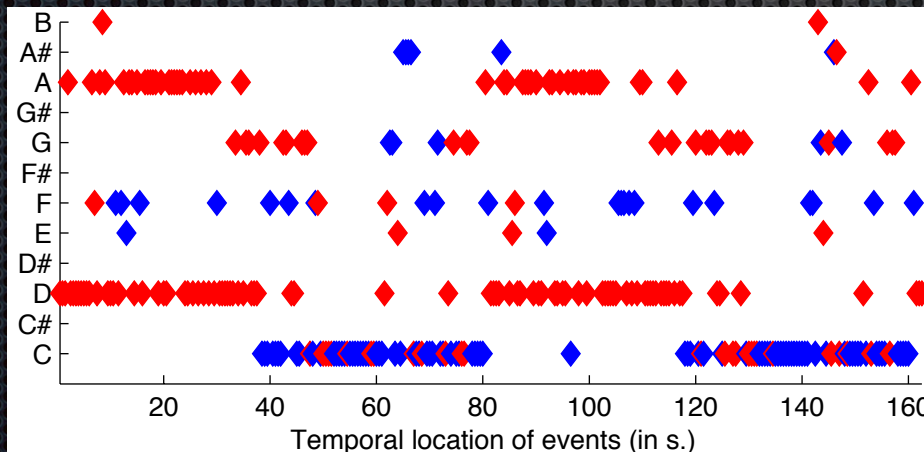
Keys



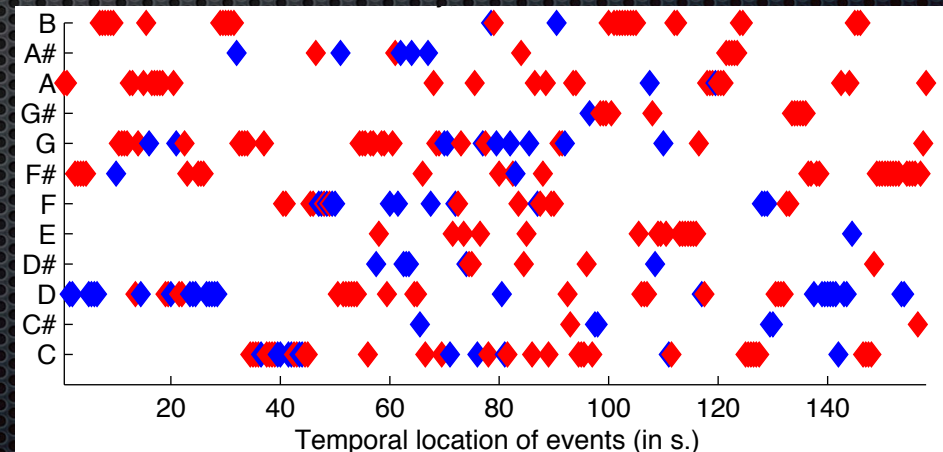
Monteverdi, *Hor che'l ciel e la terra*, 1st part \*



Tiersen, *Comptine d'un autre été : L'après-midi*



Beethoven, 9th Symphony, *Scherzo*

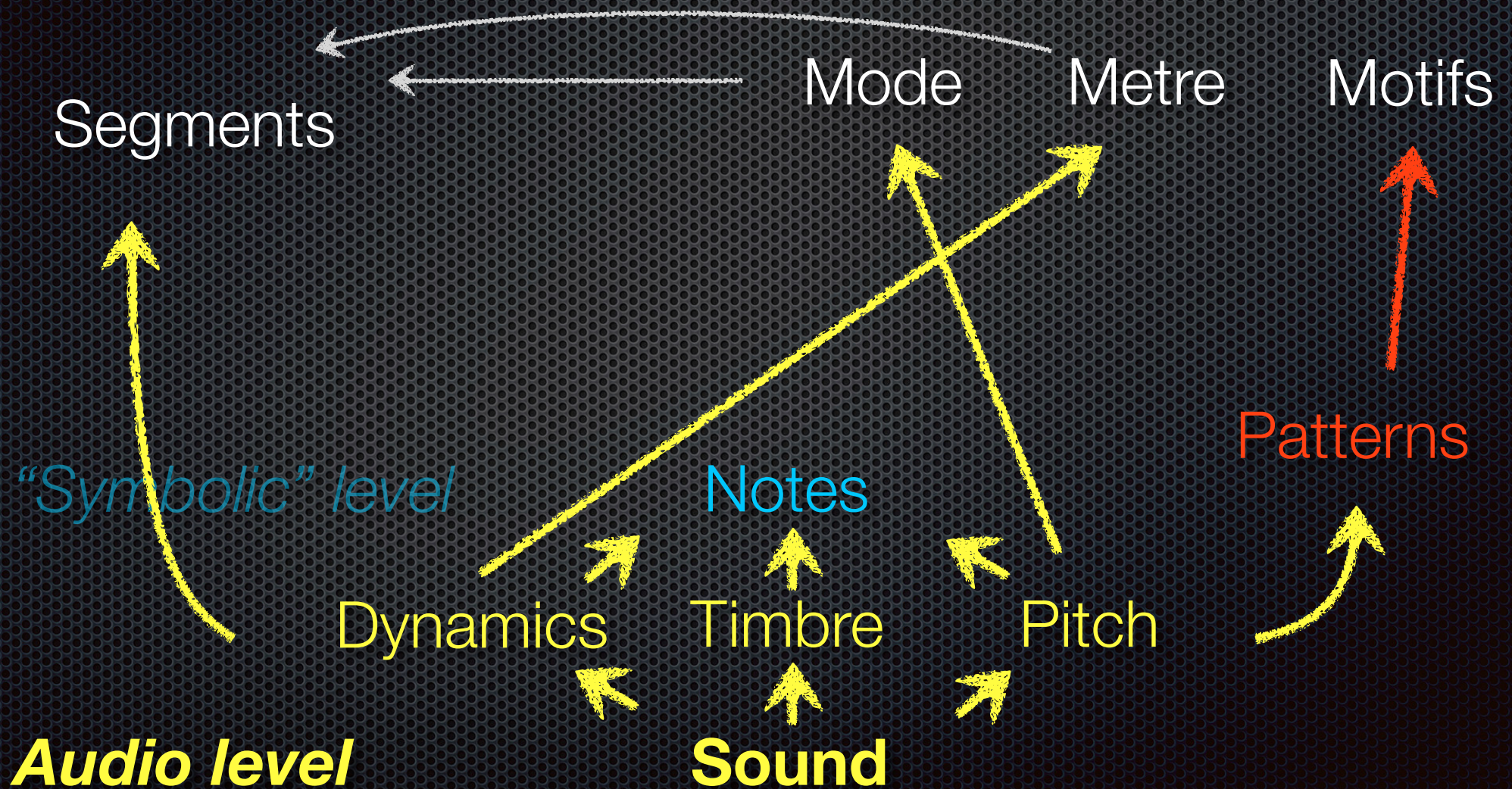


Schönberg, *Verklärte Nacht, Sehr Ruhig*





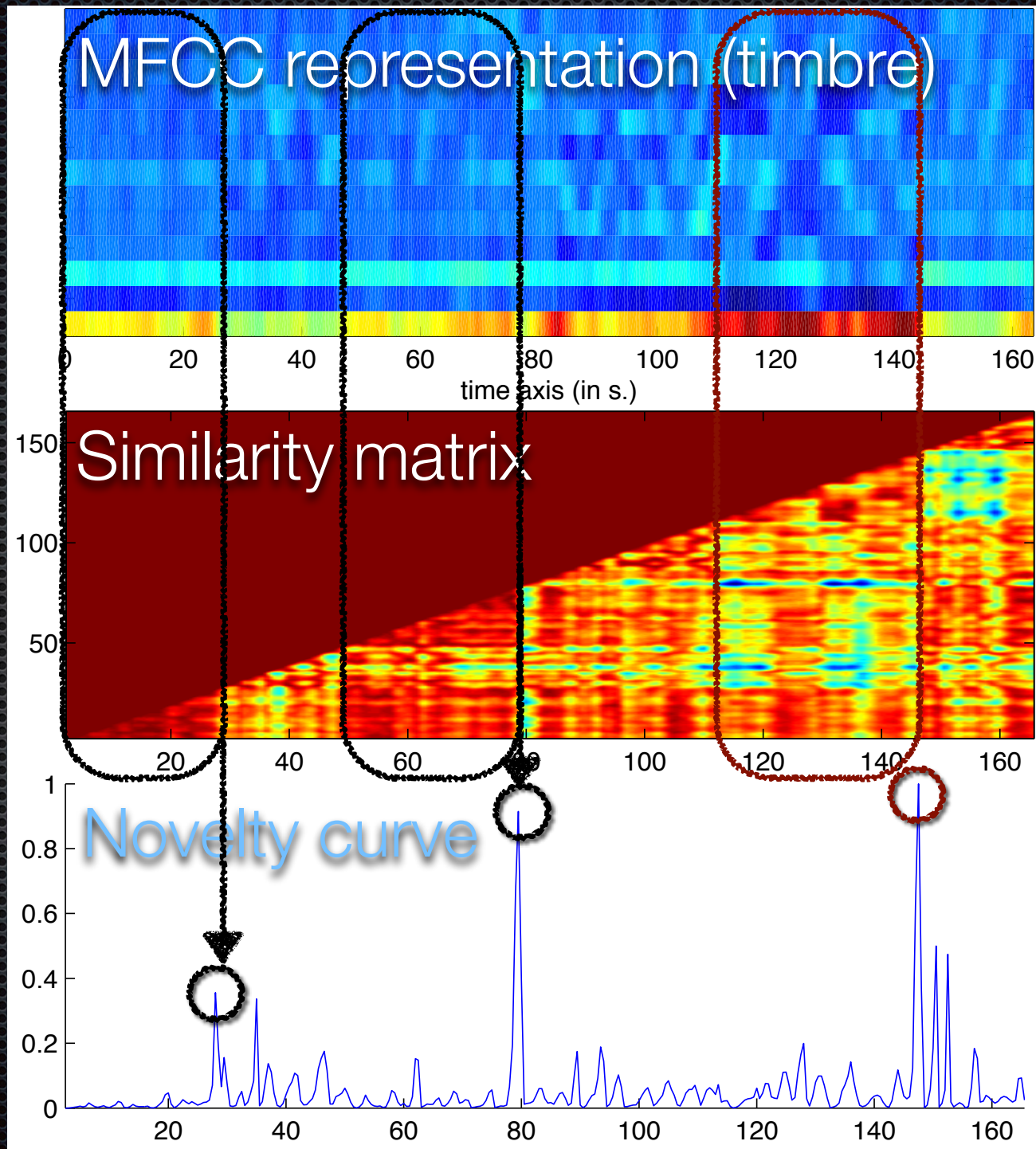
# MIRtoolbox





# Timbral structure

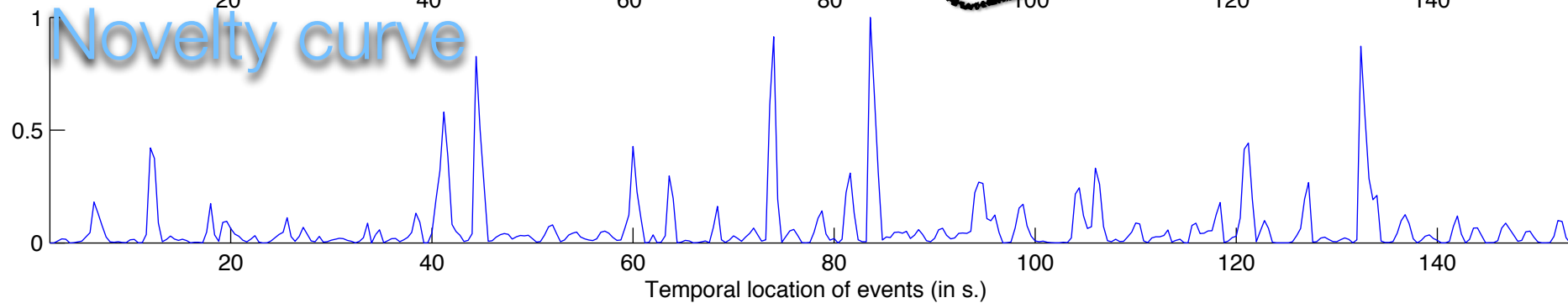
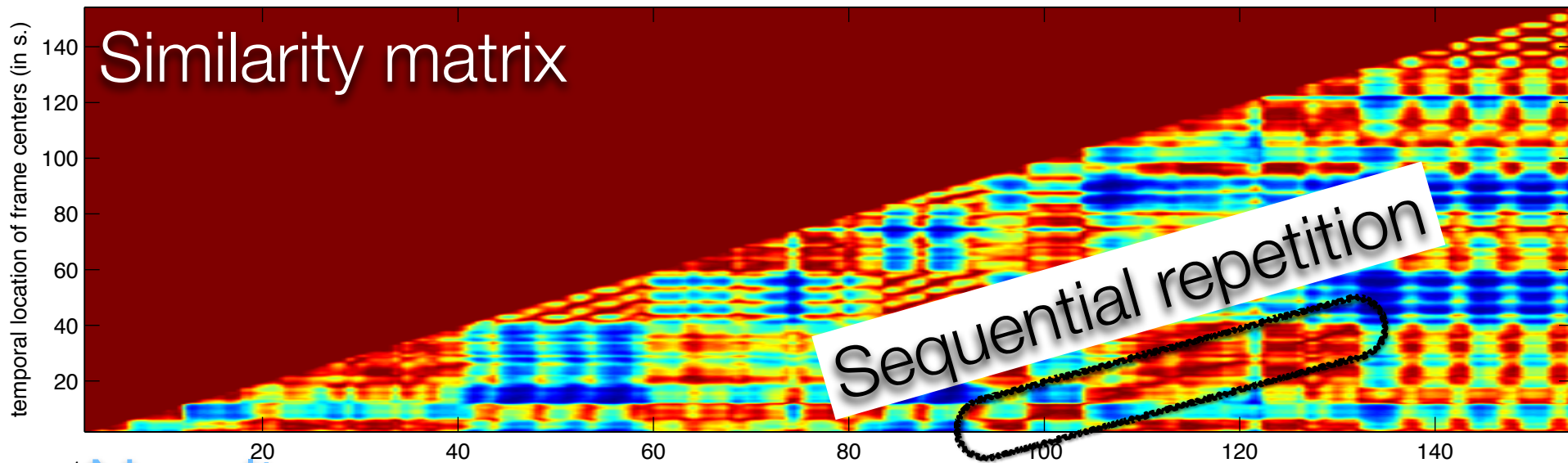
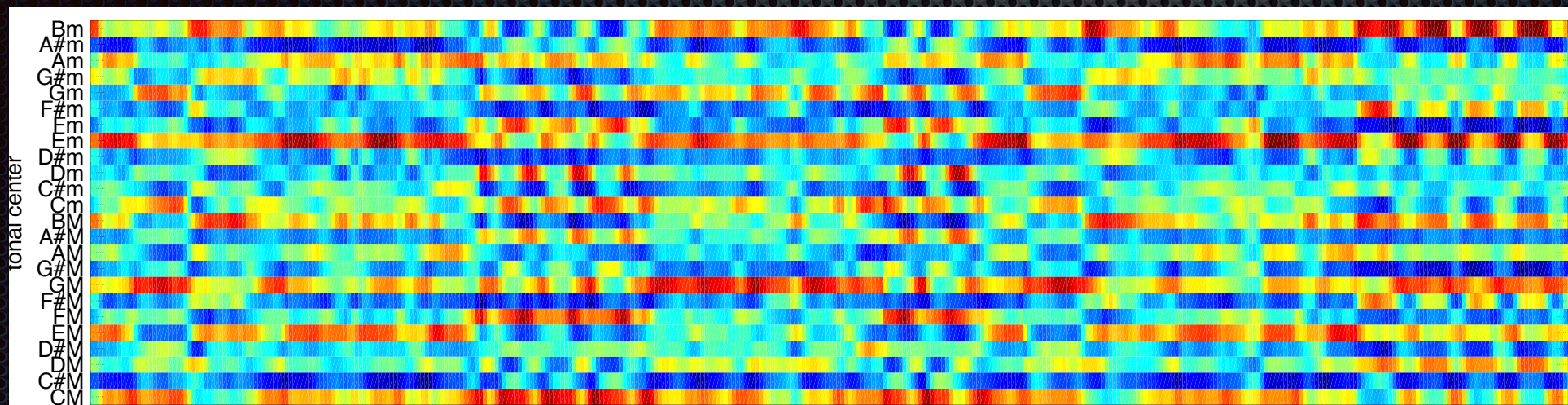
Brahms,  
Symphony No.3  
in F major,  
*Poco Allegretto*



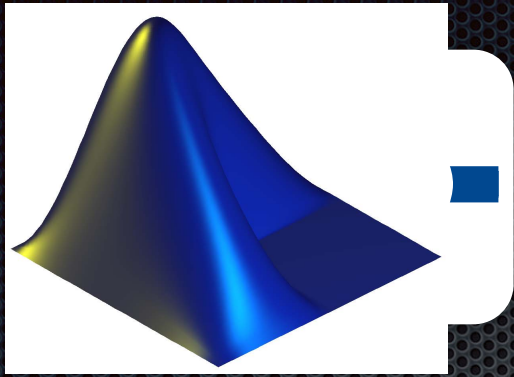


# Tonal structure

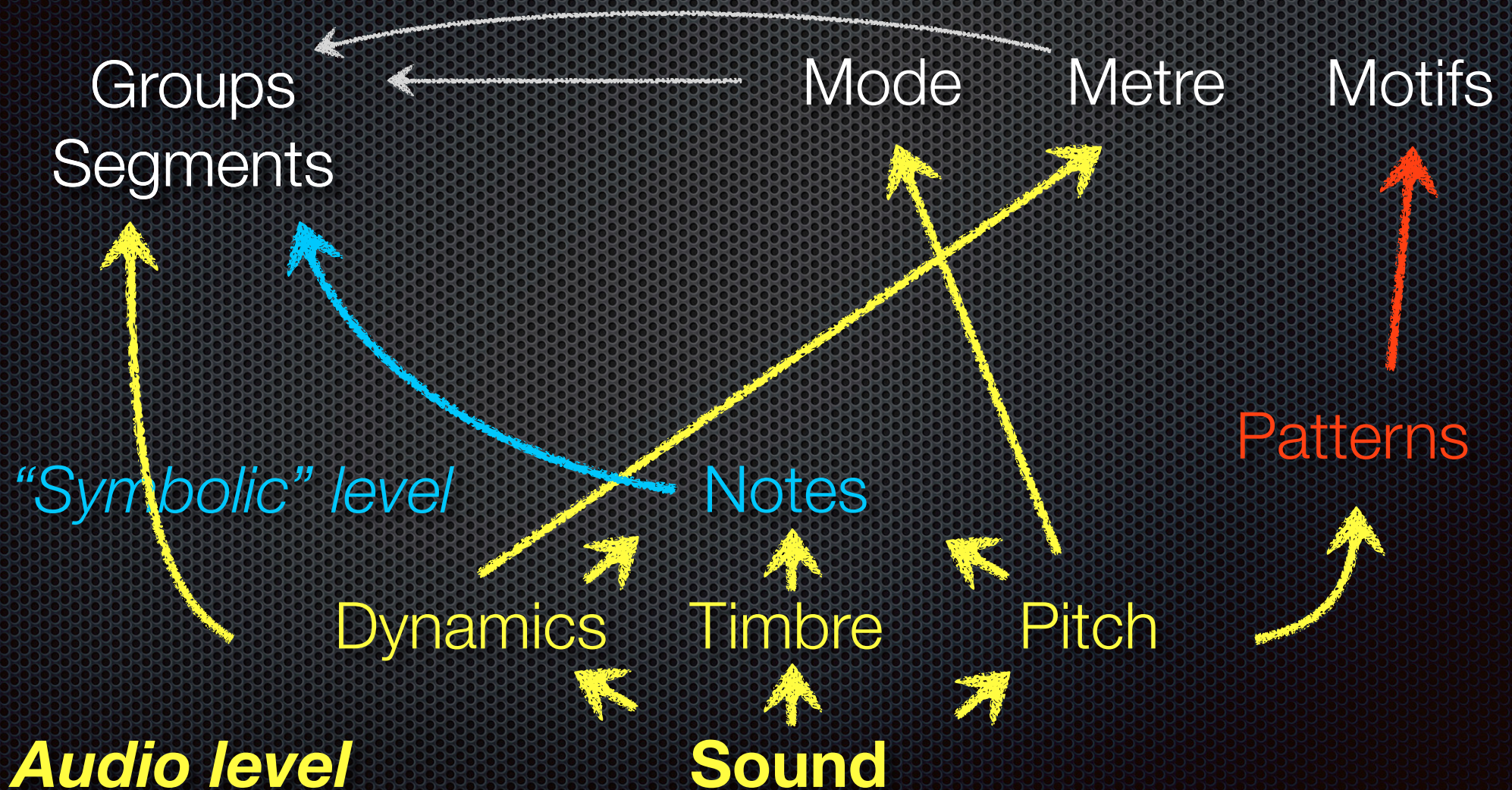
Bazzini, *Dance of the Goblins*





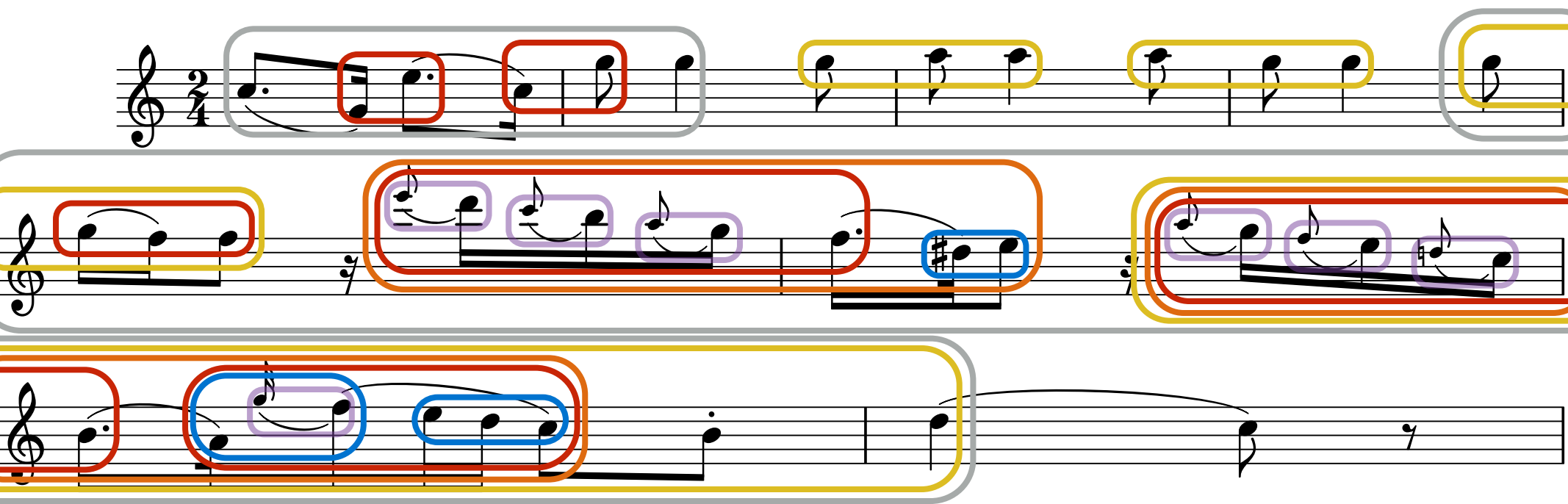


# Minimalistex



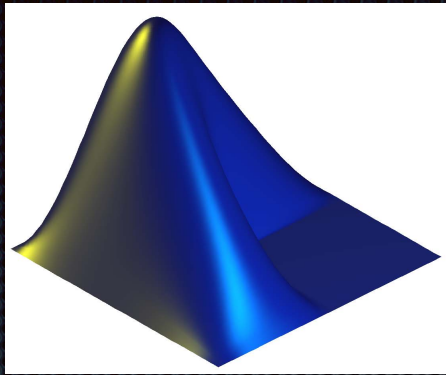


# Local grouping

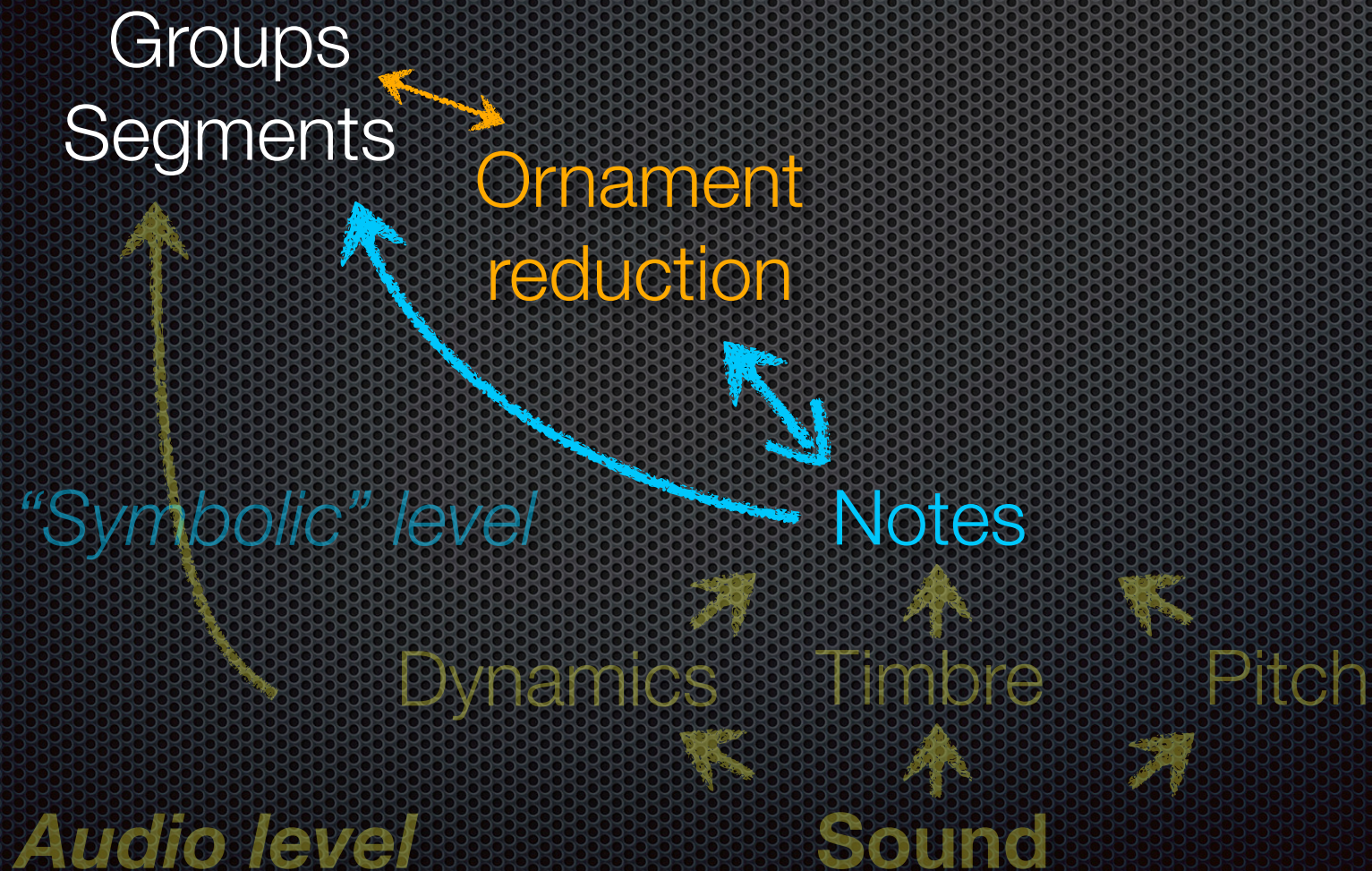


Mozart, Variation XI on “*Ah, vous dirai-je maman*”, K.265/300e





# *MiningSuite*





# Ornamentation reduction

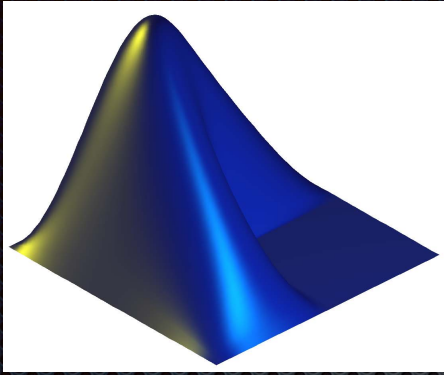
head

The image displays three staves of musical notation in 2/4 time, illustrating the concept of ornamentation reduction. The notation is annotated with a syntagmatic network, represented by colored boxes and arrows. The first staff shows a sequence of notes with red boxes around the first two notes, a grey box around the first three notes, and yellow boxes around subsequent notes. Red arrows point from the word 'head' to the first two notes. The second staff shows a sequence of notes with purple boxes around the first three notes, a blue box around the fourth note, and yellow boxes around the last three notes. The third staff shows a sequence of notes with red boxes around the first two notes, a purple box around the third note, a blue box around the fourth note, and a yellow box around the fifth note. The notation includes treble clefs, a 2/4 time signature, and various note values and rests.

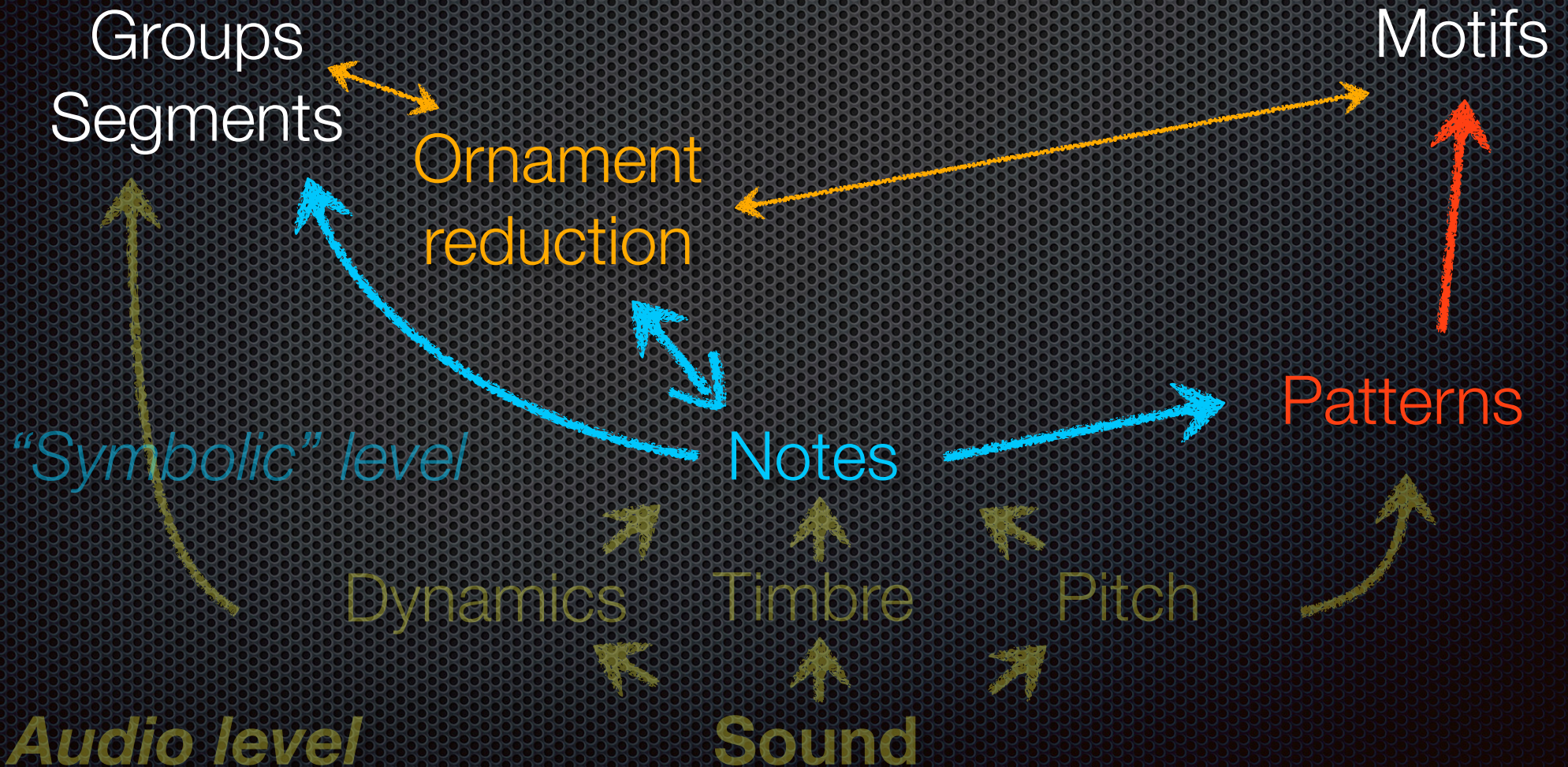
Mozart, Variation XI on “*Ah, vous dirai-je maman*”, K.265/300e

- syntagmatic network





# MiningSuite





MINUETTO

Allergretto

First system of the Minuetto score. Treble clef, bass clef, 3/4 time signature. Dynamics include *p*. Fingerings are indicated with numbers 1-5. A red box highlights the first two measures, and a blue box highlights the last two measures.

Second system of the Minuetto score. Dynamics include *f*, *p*, and *sf*. Fingerings are indicated with numbers 1-5. A red box highlights the first two measures, and a blue box highlights the last two measures.

Third system of the Minuetto score. Dynamics include *p*, *sf*, *pp*, and *ff*. Fingerings are indicated with numbers 1-5.

Fourth system of the Minuetto score. Dynamics include *f*, *sf*, and *sf*. Fingerings are indicated with numbers 1-5.

Fifth system of the Minuetto score. Dynamics include *sf*, *f*, *sf*, *p*, *pp*, and *pp*. The system ends with *Fin*. Fingerings are indicated with numbers 1-5.

Sixth system of the Minuetto score. Dynamics include *p*. Fingerings are indicated with numbers 1-5. A blue dashed box highlights the first two measures.

Seventh system of the Minuetto score. Dynamics include *p*. Fingerings are indicated with numbers 1-5. A blue dashed box highlights the first two measures.



Barlow & Morgerstern A  
Barlow & Morgerstern B

Eighth system of the Minuetto score. Dynamics include *ff*, *p*, and *pp*. Fingerings are indicated with numbers 1-5.

Ninth system of the Minuetto score. Dynamics include *p*. Fingerings are indicated with numbers 1-5. A blue dashed box highlights the first two measures.

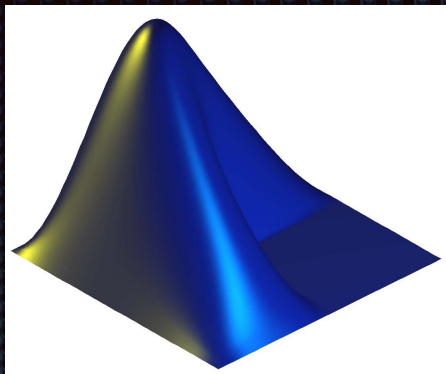


The image displays a musical score for J.S. Bach's *Well-Tempered Clavier, Book II, Fugue XX*. The score is presented in a system of eight staves, each labeled with a subject entry: L1, M1, U1, L2, U2, M2, U3, and L3. The notation is in common time (C) and features a variety of rhythmic values, including quarter, eighth, and sixteenth notes, as well as rests and accidentals. The staves are arranged in a vertical sequence, with L1 and L2 in the bass clef, and M1, U1, U2, M2, U3, and L3 in the treble clef. The music is characterized by its intricate counterpoint and the recurring motif of the subject entries.

J.S. Bach, *Well-Tempered Clavier*,  
Book II, Fugue XX  
Detected subject entries

Lartillot, ISMIR 2014

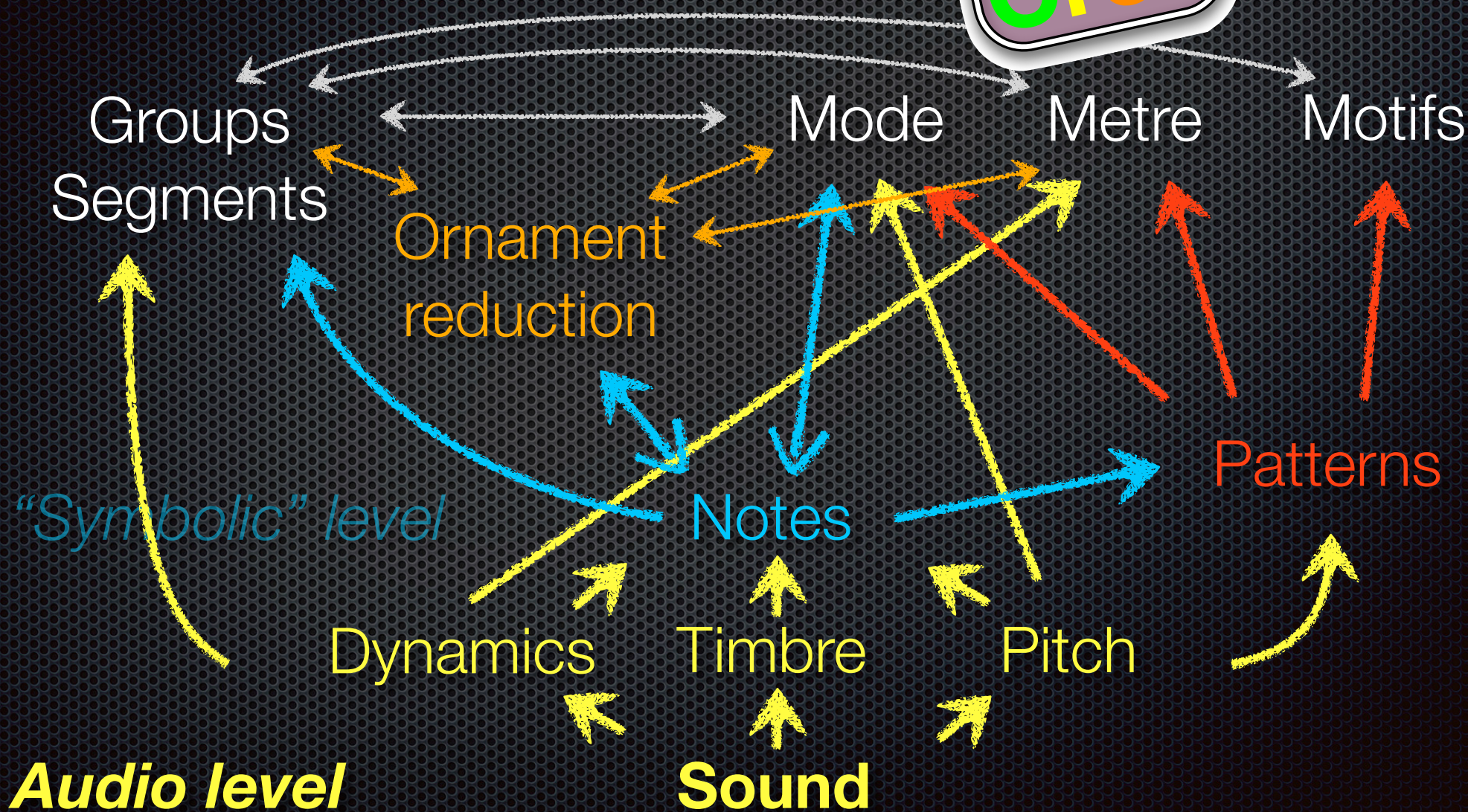




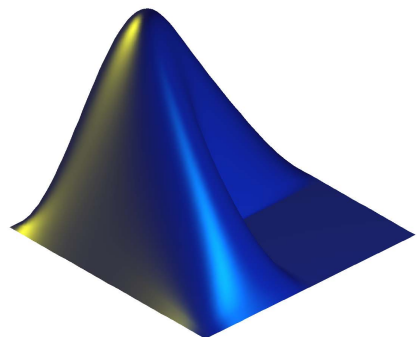
Mining



Emotion  
Style  
Form







# MiningSuite

*[code.google.com/p/miningsuite](http://code.google.com/p/miningsuite)*

## SIGMINR

signal processing

## SEQMINR

sequence processing

## AUDMINR

auditory modelling

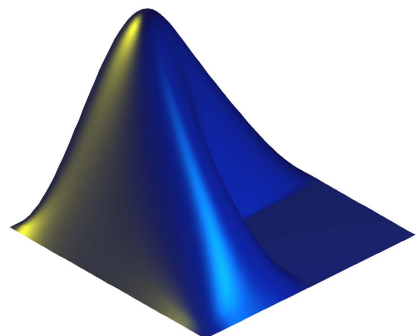
## PATMINR

pattern mining

## MUSMINR

music analysis





# MiningSuite

*code.google.com/p/miningsuite*

- New syntactic layer in the source code itself
  - Matlab optimisation & code readability
- Significantly optimised (in speed and memory)  
Fully rewritten using recent Matlab object-oriented programming capabilities
- Open source. Developers' community
- Tutorial at ISMIR 2014 conference

