



CARMINE-EMANUELE CELLA

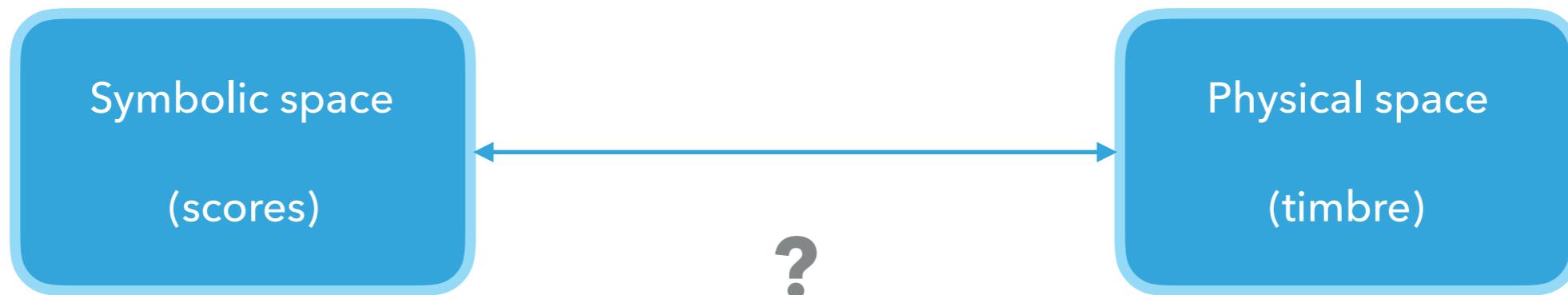
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# ON COMPUTER-ASSISTED ORCHESTRATION

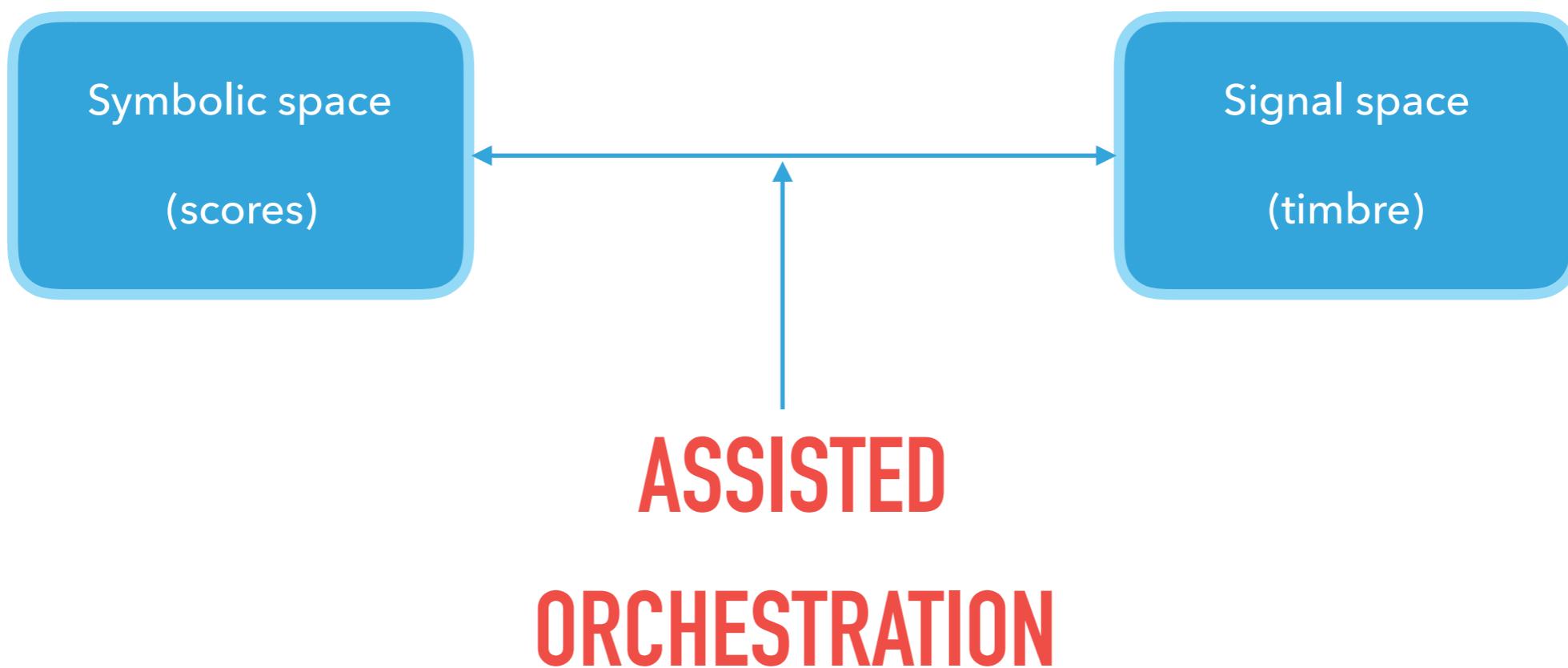
MUSIC 159

# THE OPEN PROBLEM (OBSESSION)

Which connections can we make between  
the symbolic space and the signal space?



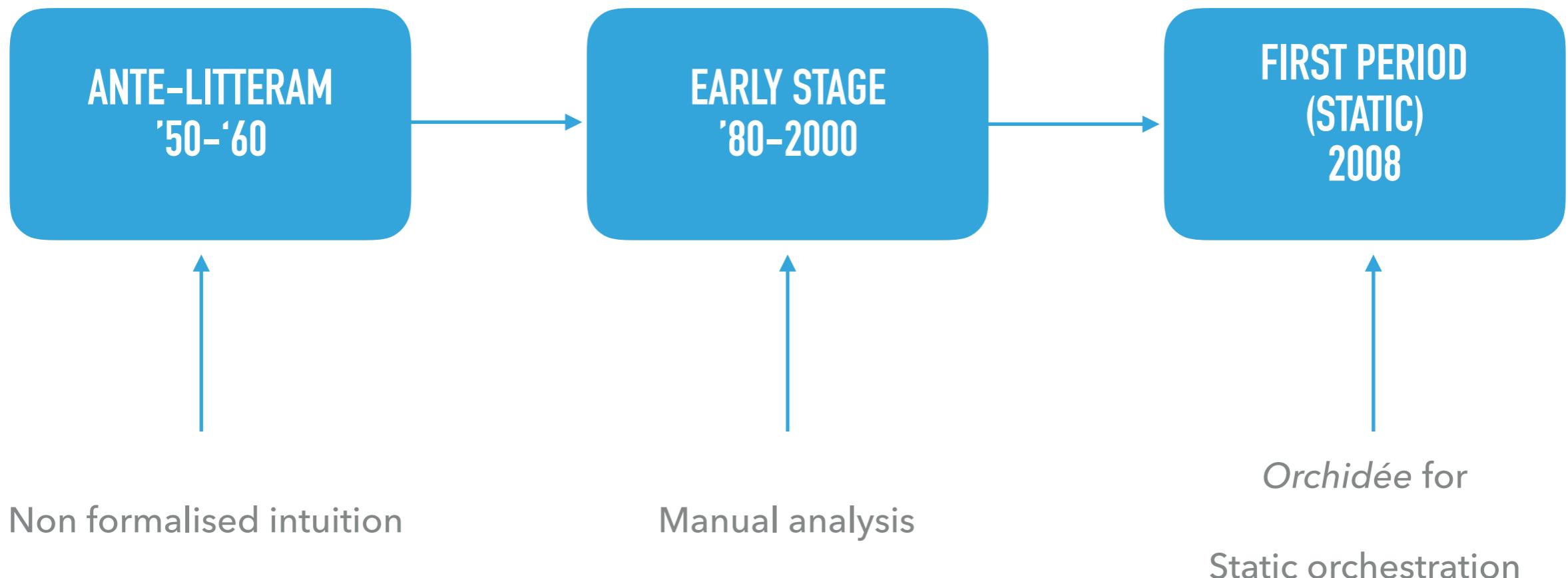
## BETWEEN SYMBOLS AND SIGNALS: A SECOND APPROACH



# HISTORY

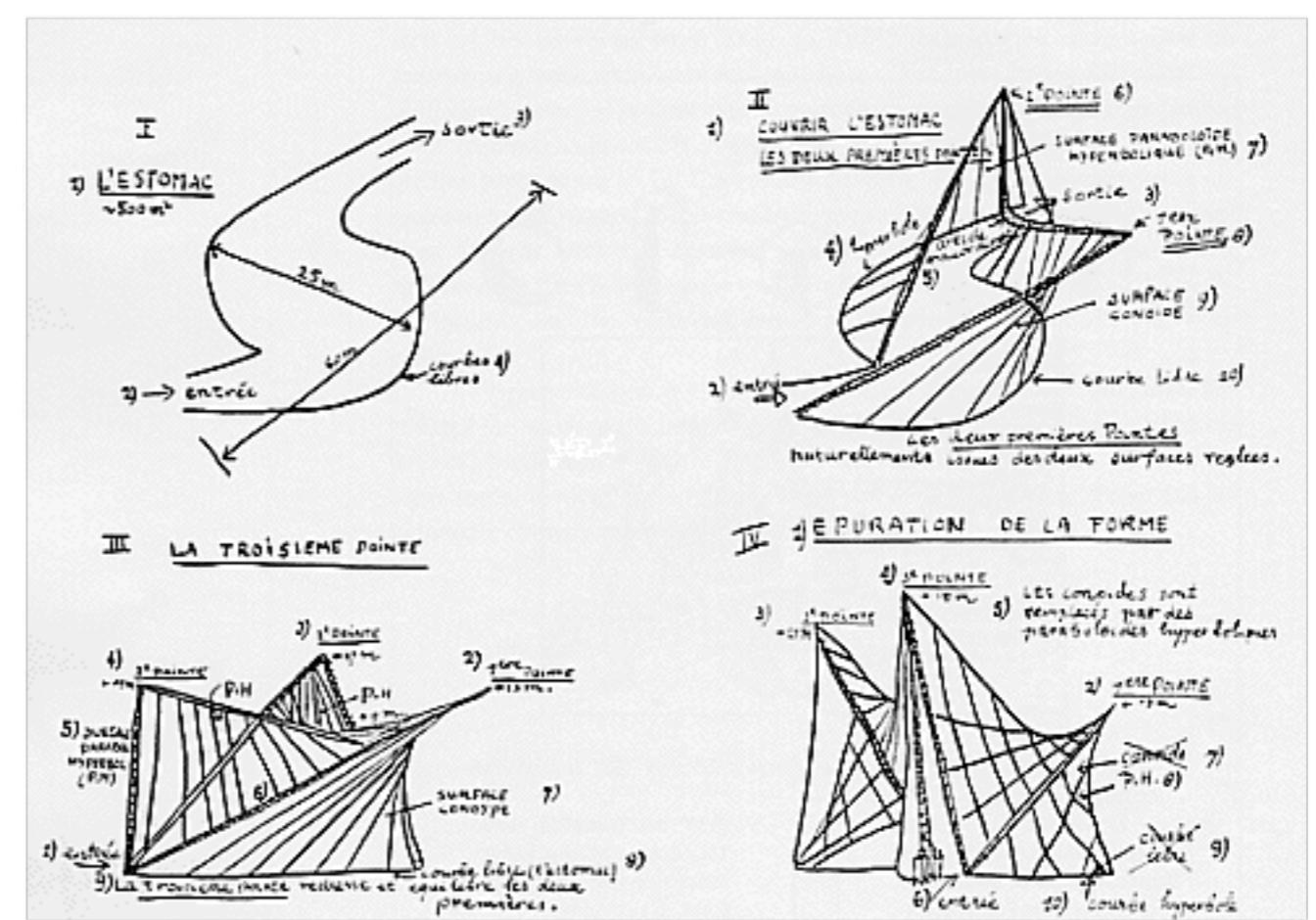
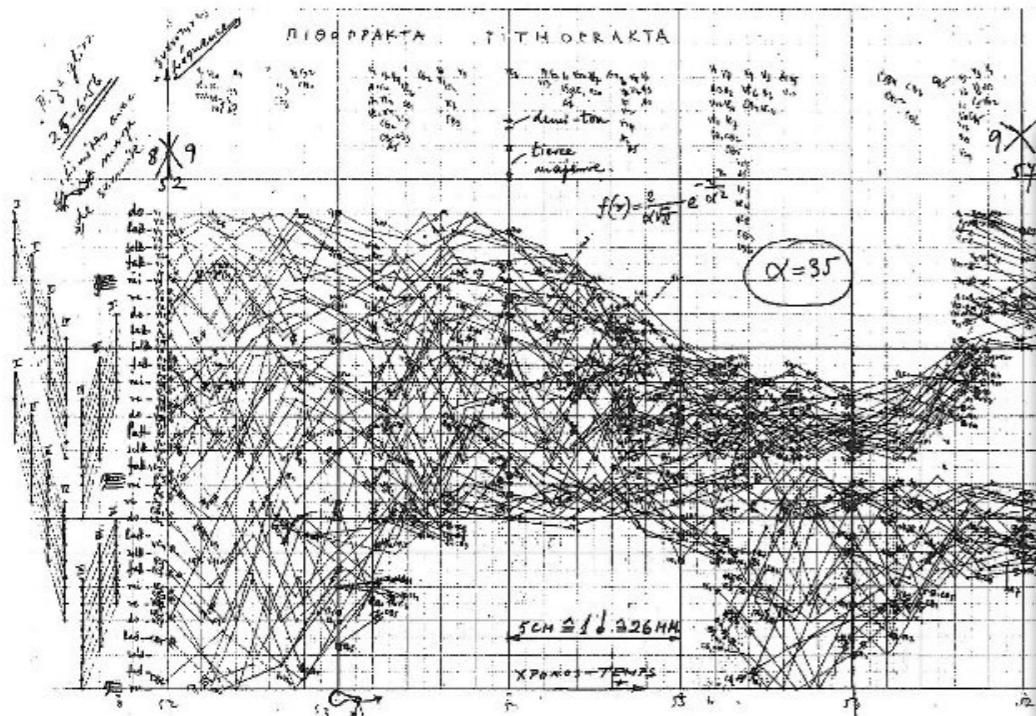
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## OVERVIEW



# I. XENAKIS - GEOMETRIC APPROACH

*Pithoprakta* (1955-56), mesures 52-59 : graphique de Xenakis  
 Source : Iannis Xenakis, *Musique. Architecture*, Tournai, Casterman, 1976, p. 167



# ANTE-LITTERAM

# I. XENAKIS, METASTASEIS (1953–1954)

- 1 -

# METASTASEIS

B METASTASEIS<sup>B</sup>

DUREE 7 MINUTES

JANNIS XENAKIS  
1953-54

NOTA: Dédies à Maurice Le Roux

UNE NOTE SURMONTÉE DU SIGNE ♯ EST SOUÉE  $\frac{1}{4}$  TON PLUS HAUT.

" " " " ♪ " " " BAS.

LES GLISSANDI, D'UN MOUVEMENT RIGOUREUSEMENT  
CONTINU.

LA PARTITION EST ENTIEREMENT ÉCRITE EN

J = 50 M.M.

NOTES RÉELLES.

COMPOSITION DE L'ORCHESTRE.

1 PETITE FLUTE	2 TROMPETTES	1 TAMBOUR	12 SEC. VIOLIN(E)
1 GRANDE FLUTE	2 TROMBONES	1 TIMBALE	8 ALTO(S) (A)
2 HAUT-BOIS	1 XYLOPHONE	1 CAISSE CL.	8 Y/CELES(Y)
1 CLAR. BASSE	1 TRIANGLE	1 GR. CAISSE	6 C/BASSES(B)
3 CORS	1 WOOD-BLOCK	12 PREH. VIOL(V)	

TOTAL: 61 EXECUTANTS

Wood-Block

f

VI. {

f

f

f

f

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B. & H. 19635

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# PENDERECKI, TRENODY FOR THE VICTIMS OF HIROSHIMA (1960)

A black and white photograph of a musical score for string quartet. The score consists of four staves, each with a treble clef and a key signature of one sharp (F#). The staves are labeled from top to bottom: 2d Violin, 1st Violin, 10 Violoncello, and 5 Cello Bassoon. The music is written in a cursive, handwritten style. The page number '11' is visible at the bottom right.

# G. LIGETI, ATMOSPHÉRES (1961)

C ⑩

Fl. 1  
2.  
3.  
4.

C. 1.  
2.  
3.  
4.

SUL PONTE, MOLTO VIBR.

V. I. 1.  
2.  
3.  
4.  
5.  
6.  
7.  
8.  
9.  
10.  
11.  
12.  
13.  
14. *sempre ppp*  
*(SUL TASTO, NON VIBR.)*

V. II. 1.  
2.  
3.  
4.  
5.  
6.  
7.  
8.  
9.  
10.  
11.  
12.  
13.  
14. *sempre ppp*  
*(SUL TASTO, NON VIBR.)*

Vla. 1.  
2.  
3.  
4.  
5.  
6.  
7.  
8.  
9.  
10. *sempre ppp*  
*(SUL TASTO, NON VIBR.)*

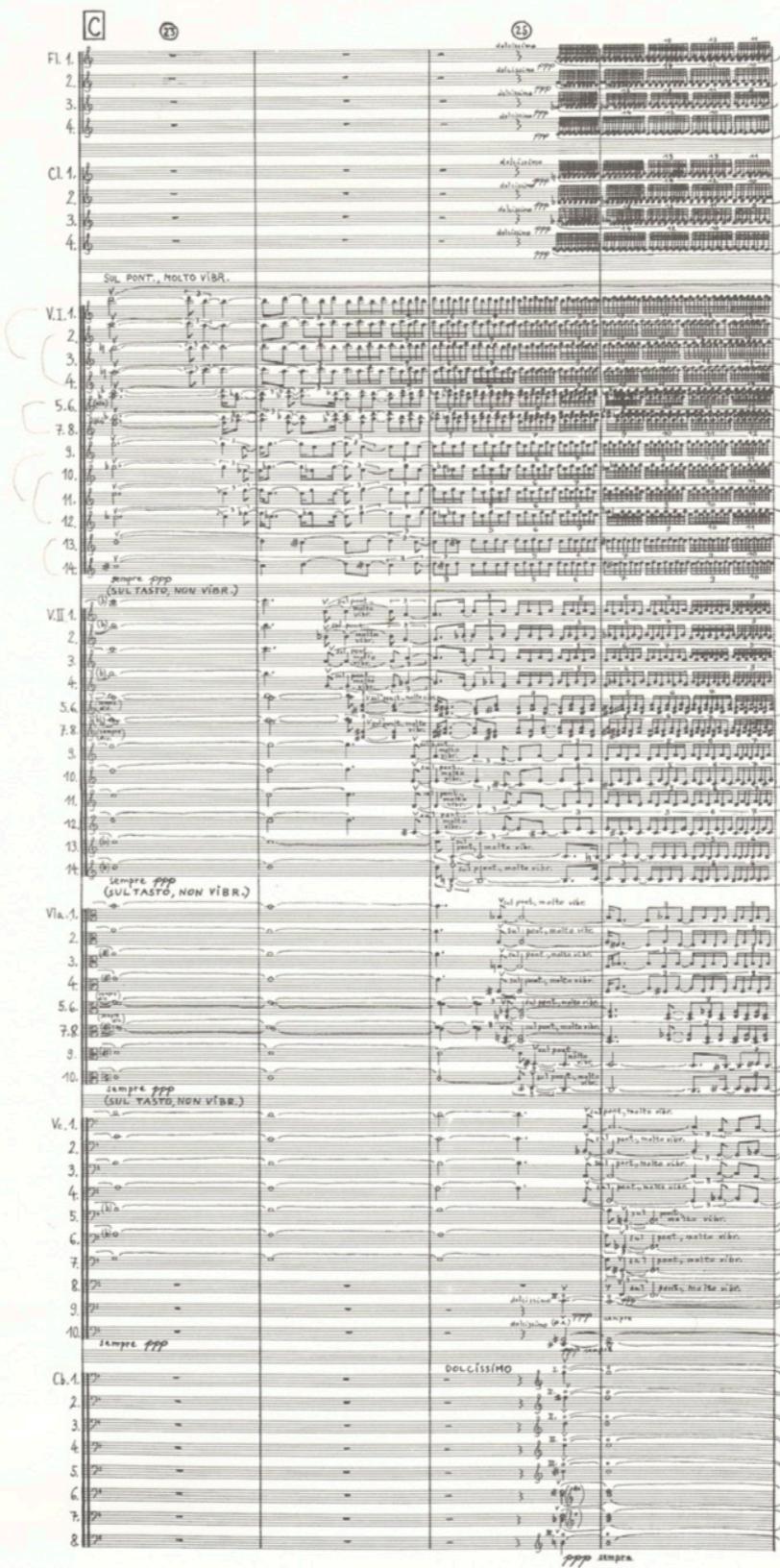
Vc. 1.  
2.  
3.  
4.  
5.  
6.  
7.  
8.  
9.  
10. *sempre ppp*

Cb. 1.  
2.  
3.  
4.  
5.  
6.  
7.  
8.

23

DOLCISSIMO

*ppp sempre*



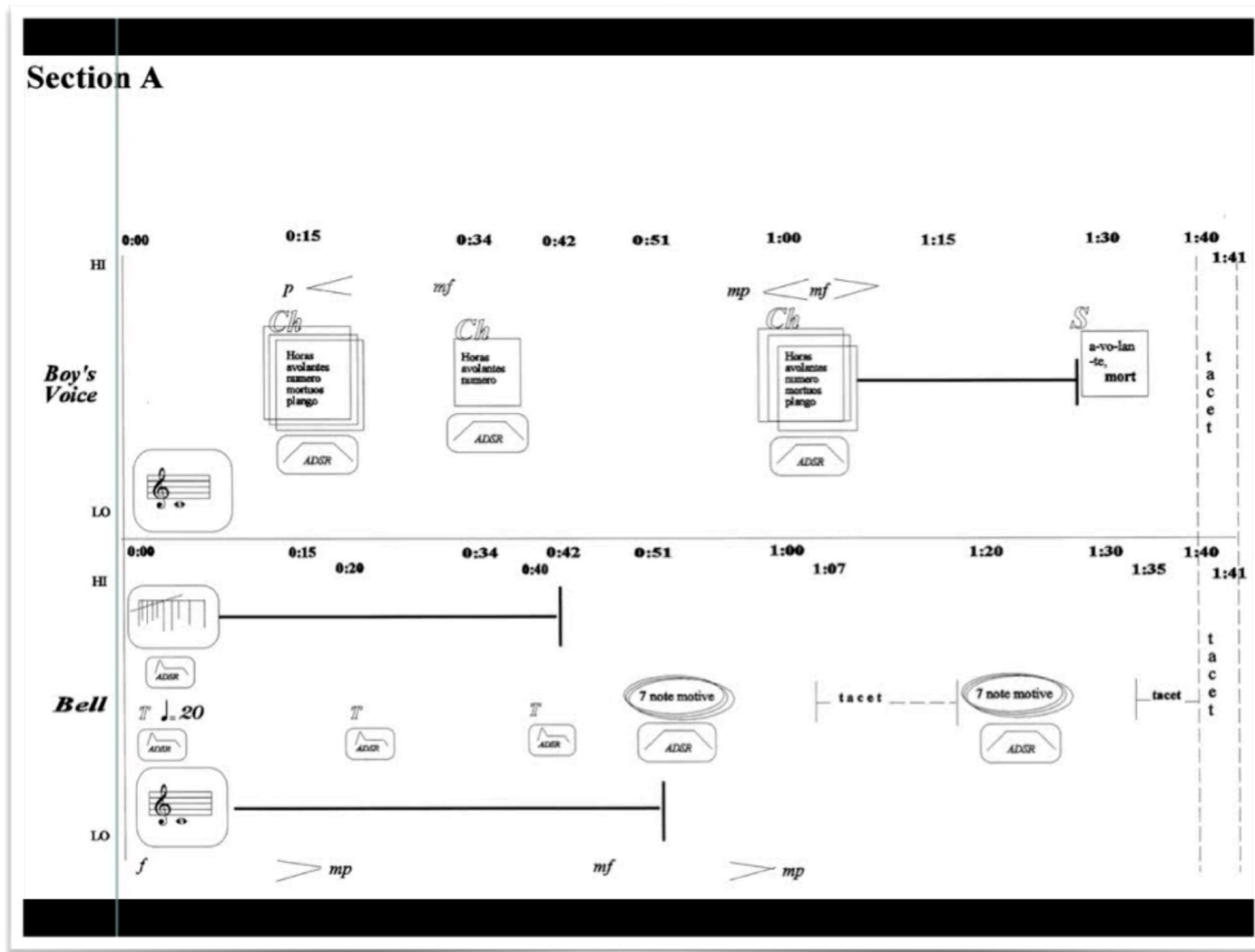
## HARVEY'S BELL

# Mortuos Plango, Vivos Voco (1981)

*Mortuos Plango, Vivos Voco* is notable both within and without Harvey's career: "it showed that IRCAM institute's apparently esoteric research programme could yield music capable of appealing to a wider audience"

**Curtis Roads**

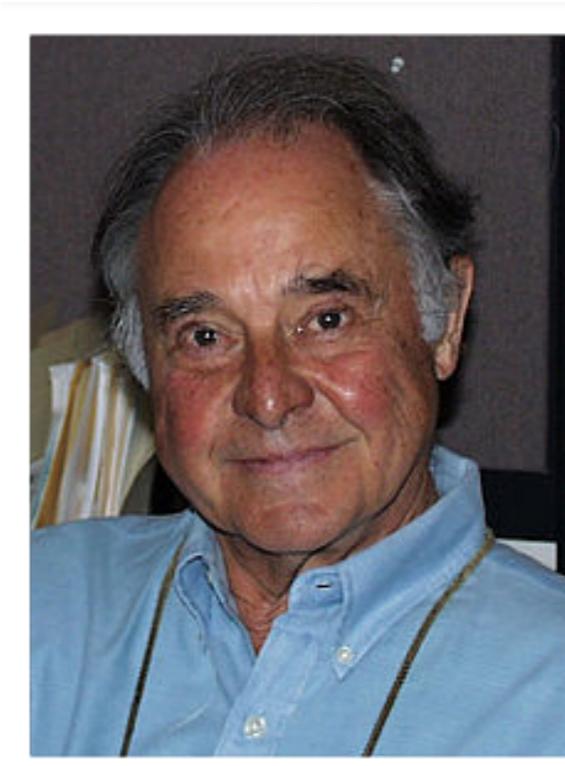
# J. HARVEY, MORTUOS PLANGO, VIVOS VOCHO (1981)



## ALTERNATIVE APPROACHES

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### J. CHOWNING, PHONE (1981)



# EARLY STAGES

## Y. MARESZ, METAL EXTENSIONS (2001)

*Metal Extensions* est une œuvre un peu particulière dans ma production car elle repose sur les fondations d'une pièce plus ancienne, *Metallics* (1995), pour trompette solo et dispositif électronique, dont j'avais toujours eu l'intention de faire une version élargie pour trompette et ensemble. C'est aussi ma première confrontation, face à ce qui est progressivement apparu comme un défi, celui de la transcription la plus fidèle possible d'un matériau électronique dans le monde instrumental.

The musical score for "Metal Extensions" is a complex arrangement for a brass quintet, two woodwind quintets, two brass ensembles, two woodwind ensembles, two percussion groups, and a large string orchestra. The score is divided into three systems, each starting with a tempo marking of ♩ = 76. The instruments listed on the left side of the score include Flute 1, Flute 2, Bassoon 1, Bassoon 2, Clarinet 1 in B♭, Clarinet 2 in B♭, Clarinet Bass in B♭, Bassoon 1, Bassoon 2, Cor 1 in F, Cor 2 in F, Trombone 1, Trombone 2, Tuba, Percussion 1, Percussion 2, Percussion 3, Piano, Bass, Trompette 1, Violin 1, Violin 2, Violin 3, Alto 1, Alto 2, Violoncello 1, Violoncello 2, and Cimbeline. The score features numerous dynamic markings such as ff, f, p, pp, and ff, along with specific performance instructions like "prendre la partie flûte", "petit filé", "petite cravate chinoise", "réaliser le plus vite possible", "acc. plos. sol. bbb.", and "acc. plos. sol. bbb.". The score is published by Éditions DURAND PARIS, France, and is identified by the code D. & F. 15449. The copyright notice at the bottom right indicates "Dépôt légal 2280 Paris. Tous droits réservés pour tous pays." The title "METAL EXTENSIONS" is prominently displayed in the center of the score, along with the subtitle "pour trompette solo et ensemble instrumental". The author's name, "Yan MARESZ", is also mentioned at the top right.

## BEGINNING OF ASSISTED ORCHESTRATION (ORCHIDÉE)

### J. HARVEY, SPEAKINGS (2008)

Dans *Speakings*, j'ai voulu réunir la musique orchestrale et la parole humaine. C'est comme si l'orchestre apprenait à parler, comme un bébé avec sa maman, comme le premier homme, ou comme entendre une langue très expressive que l'on ne comprend pas. [...]

Un « vocodeur de la forme spectrale » tire avantage des complexités fascinantes du langage : telle est l'idée principale de cette œuvre.



# SECOND PHASE OF ASSISTED ORCHESTRATION (ORCHIDEA)

## C. E. CELLA, STADES D'OMBRE, STADES DE LUMIÈRE (2018)

**FULL SCORE**

**Stades d'ombre,  
stades de lumière**

*For Eli*

Carmine-Emanuele Cella (2018)

**Flute** **C** **Grave**  $\text{quarter note} = 48$

**Oboe**

**Clarinet in B $\flat$**  **F#**

**Bassoon** **p senza crescere**

**Horn in F**

**Trumpet in B $\flat$**

**Trombone**

**Percussion** **TAM TAM** irregular movements with superball

**Piano**

**Violin I** **C** **Grave**  $\text{quarter note} = 48$

**Violin II**

**Viola** **on the bridge**

**Violoncello** **lead mute**

**Contrabass** **on the bridge**

**harmonic tremolo**

**mf senza crescere**

**pp**

**opening and closing with hand**

**ppp senza crescere**

**harmon mute**

**straight mute**

**ppp**

**p**

**l.v.**

**irregular movements with hands on the strings in the lower region**

**strike strings with hnds**

**ppp**

**p**

**ppp senza crescere**

**pizz.**

**mp**

**increasing vibrato speed**

**p espress.**

**on the bridge**

**ppp**

**mute**

**pp**

**ppp**

**lead mute**

**increasing vibrato speed**

**ppp**

**mp espress.**

Proprietà per tutti i Paesi della SUGARMUSIC S.p.A. - Milano, Galleria del Corso, 4.  
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S. 15732 Z.

## ASSISTED ORCHESTRATION: CONTEXT

*In 2003, I presented to Ircam a proposal for a long-term research project on the subject of computer-assisted orchestration. The results of this research project lead to the prototype softwares, ‘Orchidee’*

**Yan Maresz, On Computer-Assisted Orchestration, Contemporary Music Review, 2013**

Automatic orchestration is a long-standing problem researched at Ircam for about 15 years

Different parallel tools developed: a Matlab frameworks, Max/MSP interfaces, C++ standalone command line tools, etc.

Several PhD thesis including G. Carpentier, D. Tardieu and P. Esling and several journal papers

# MODELLING ORCHESTRATION

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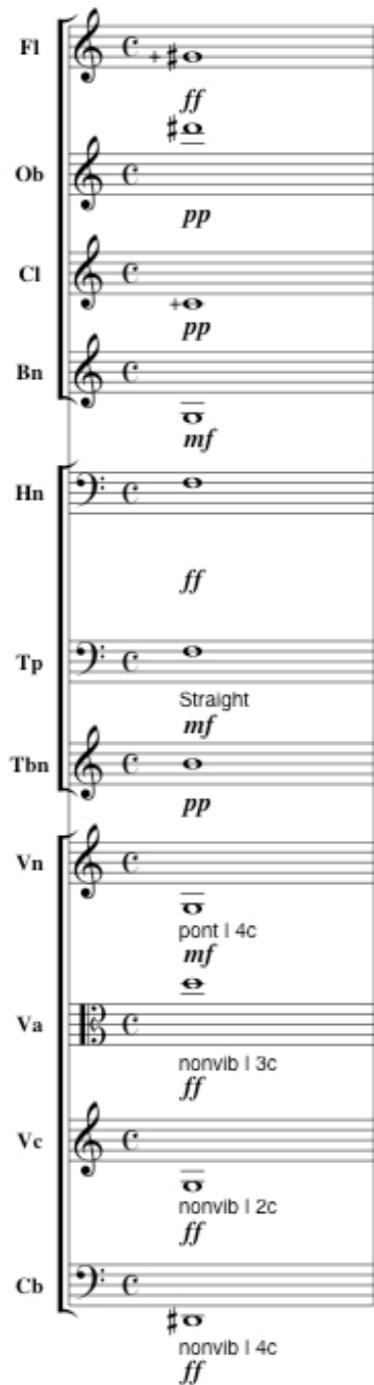
## ORCHESTRATION: PROJECTION

A musical score for orchestra, page 103, marked Muovendo  $\text{♩} = 78$ . The score includes parts for Picc., Fl., Ob., Eng. horn, Cl., B. Cl., and D. c. Various dynamic markings are present, such as *ff*, *sfff*, *simile*, *tr.*, *dim.*, and *3*.

PROJECTION

Signal space  
(timbre)

## ORCHESTRATION: INDUCTION?



?

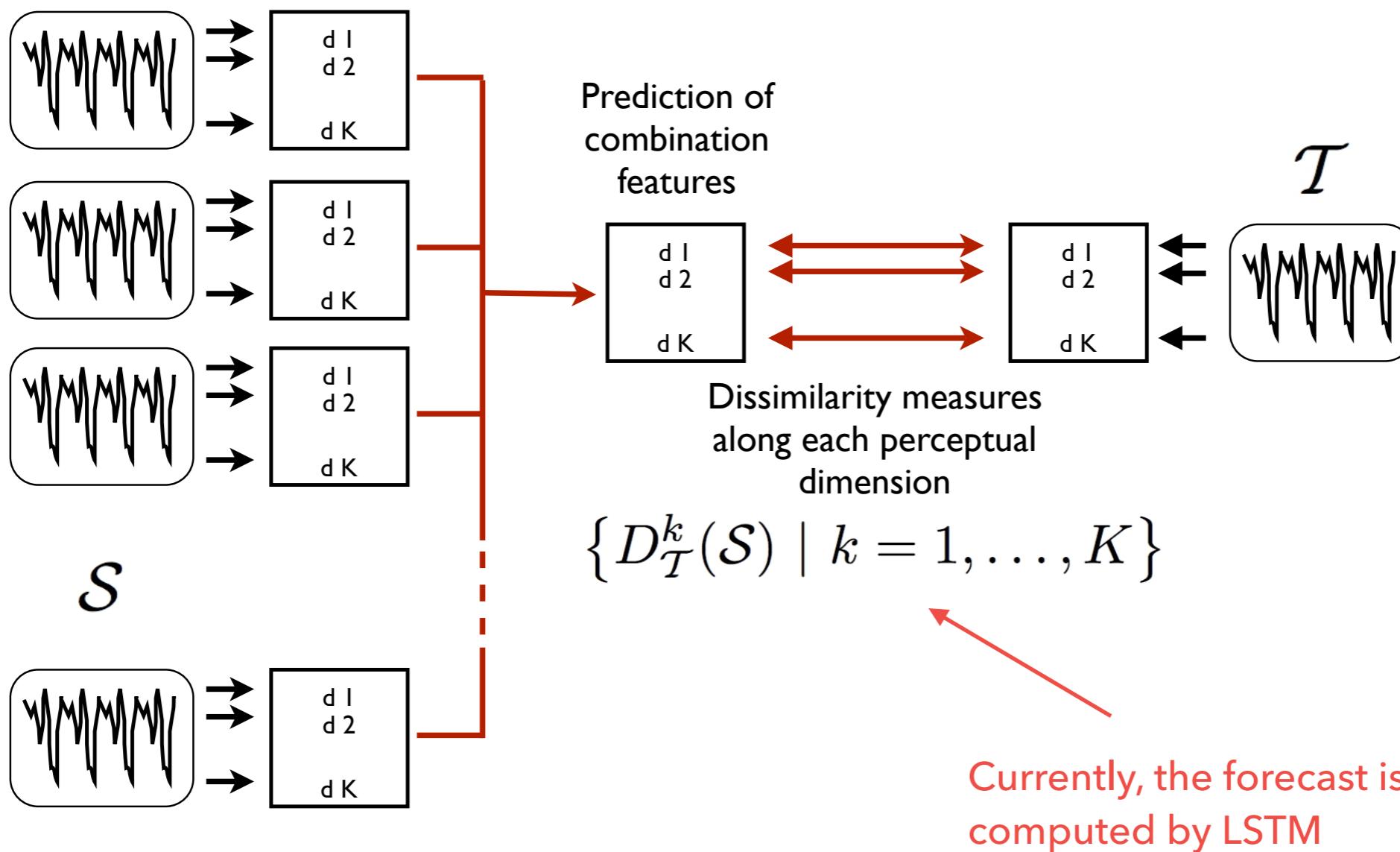
Signal space  
(timbre)

## PROBLEM STATEMENT

- How an orchestra can be used to reproduce a **target timbre** within a compositional context?
- How can we find a combination of instruments that:
  - ◆ Best matches a given target sound?
  - ◆ Fits writing constraints specified by the composer?
- More formally:
  - ◆ A combinatorial optimization problem defined on timbre description
  - ◆ A constraint solving problem on the variables of musical writing

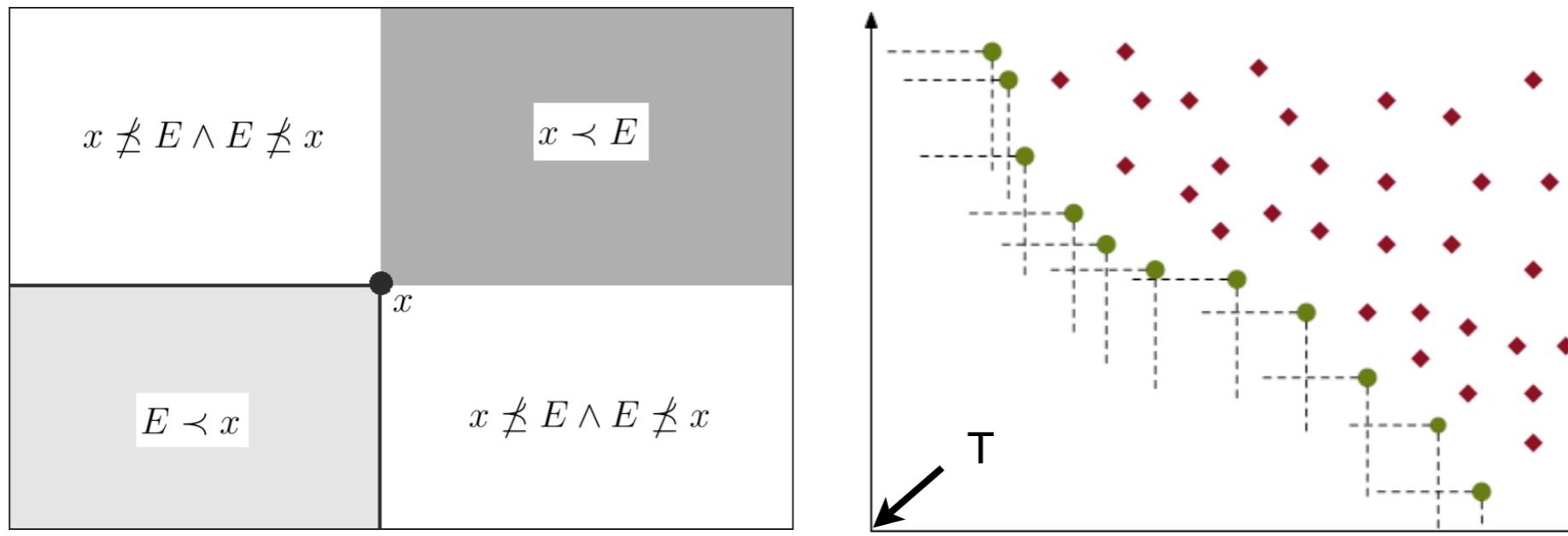
## HYPOTHESIS ON SIMILARITY

The features of a combination of sounds can be predicted from the values of individual features (forecast)



## MULTIOBJECTIVE HEURISTICS

- Relative importance of perceptual dimensions cannot be known without prior information on listening preferences
- Multiobjective optimization jointly minimizes:  $\{D_T^k(\mathcal{S}) \mid k = 1, \dots, K\}$
- Pareto dominance:  $\mathcal{S}_1 \preceq \mathcal{S}_2 \Leftrightarrow \forall k, D_T^k(\mathcal{S}_1) \leq D_T^k(\mathcal{S}_2)$



- Set of optimal solutions (implicitly corresponding to different listening preferences)

# COMPUTER ASSISTED ORCHESTRATION

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## HARVEY'S SPEAKINGS (2008)

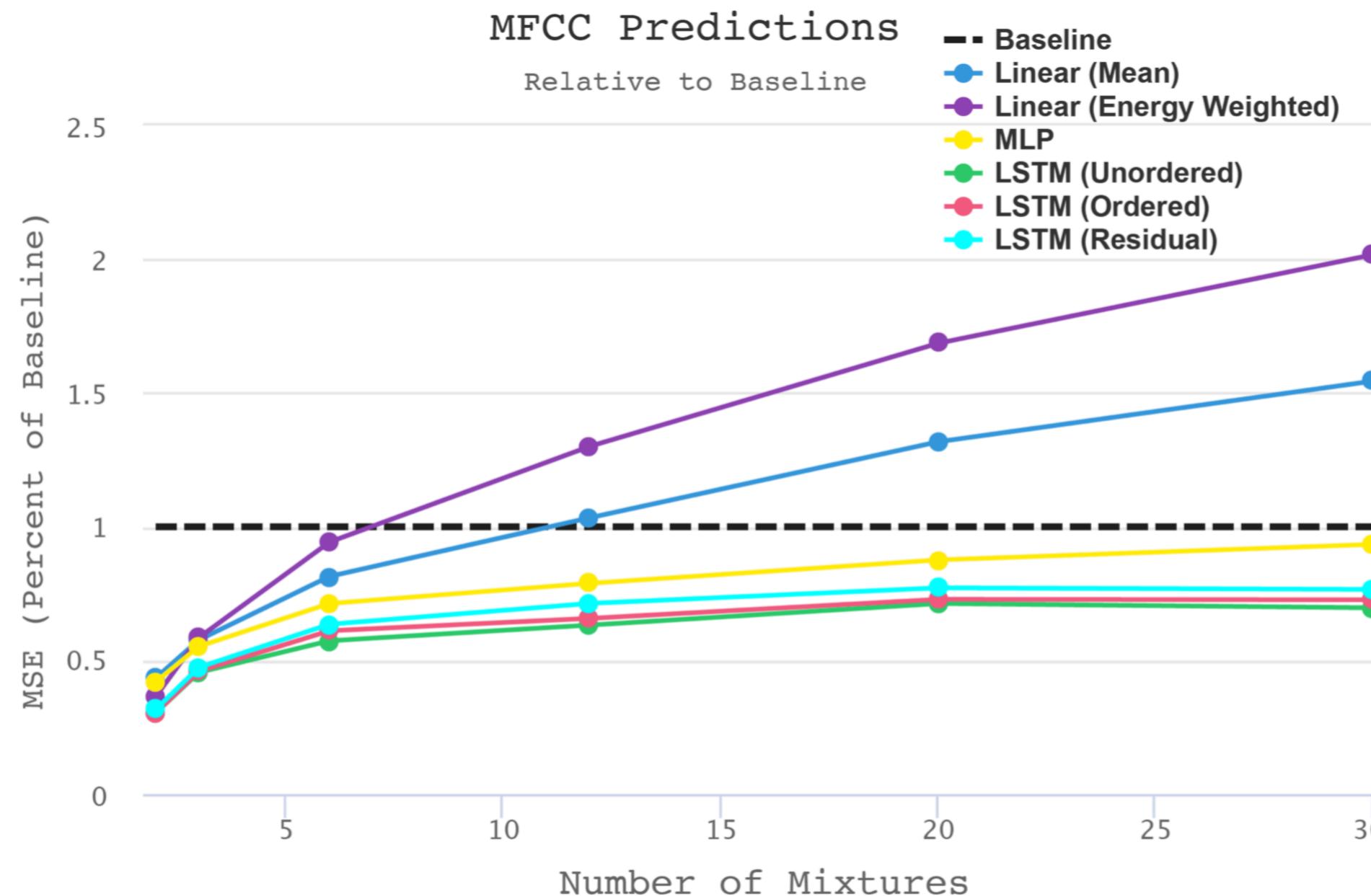


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## CURRENT APPROACH

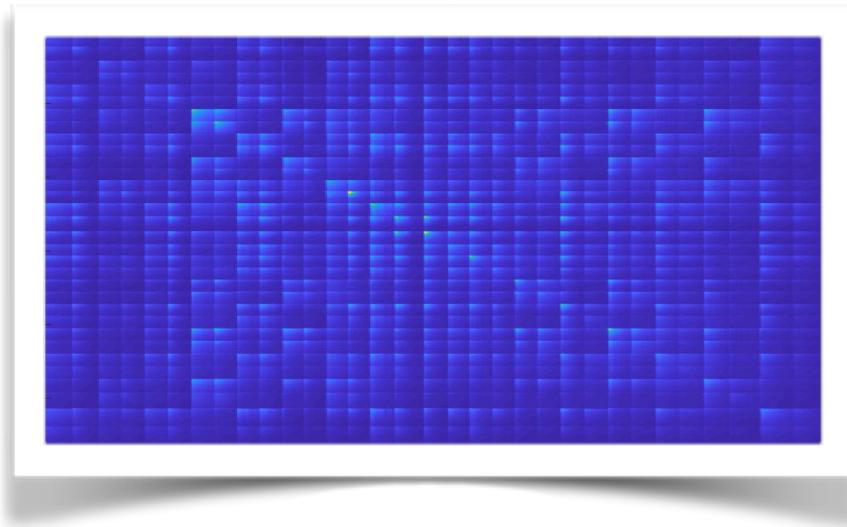
- Architecture: evolutionary optimization with dynamic symbolic constraints (forecast made by LSTM network)
- Relaxed pursuit strategy for initial population
- Asymmetric distance for timbre evaluation
- Temporal modelling: graph structure and continuity model

# FEATURE FORECAST (MFCC)

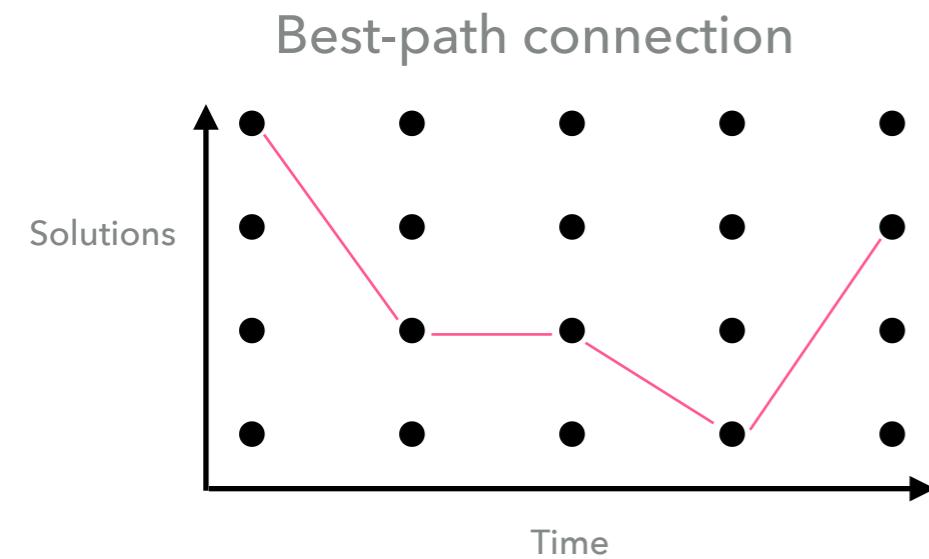
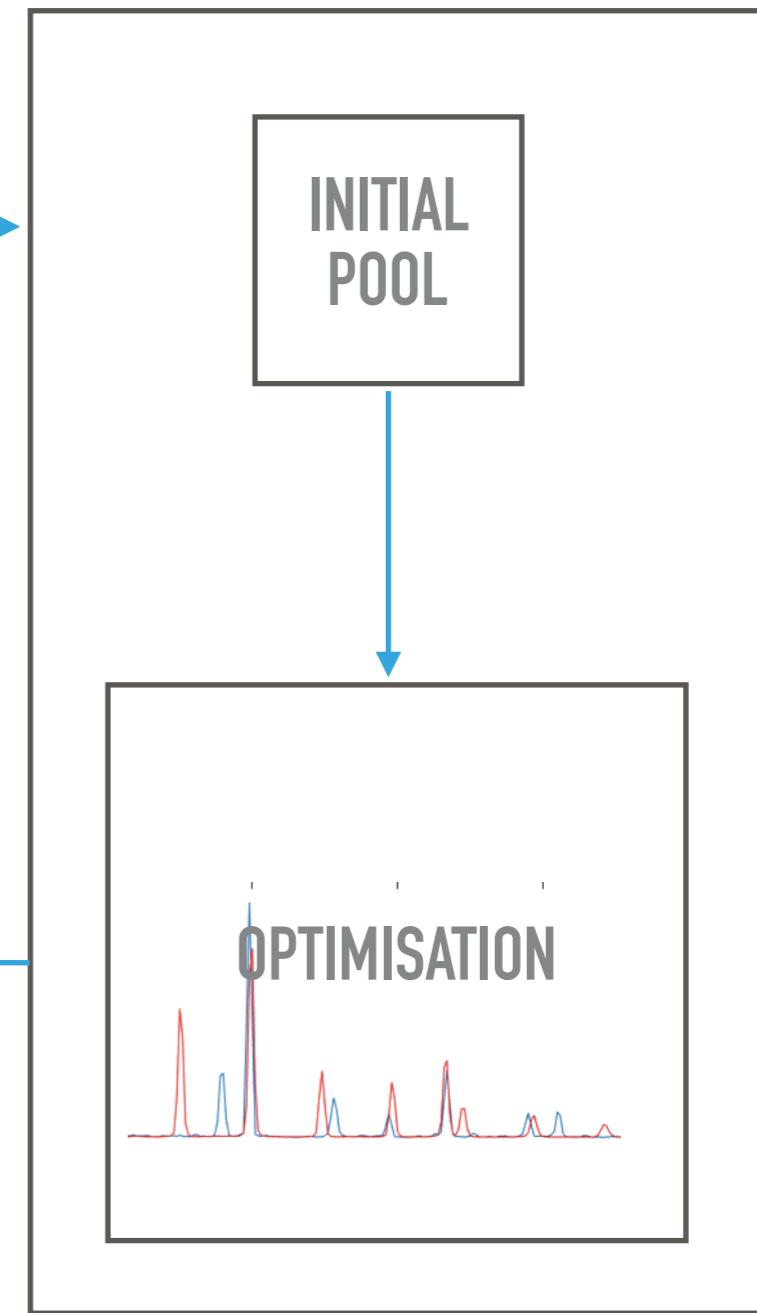


# TEMPORAL MODELING

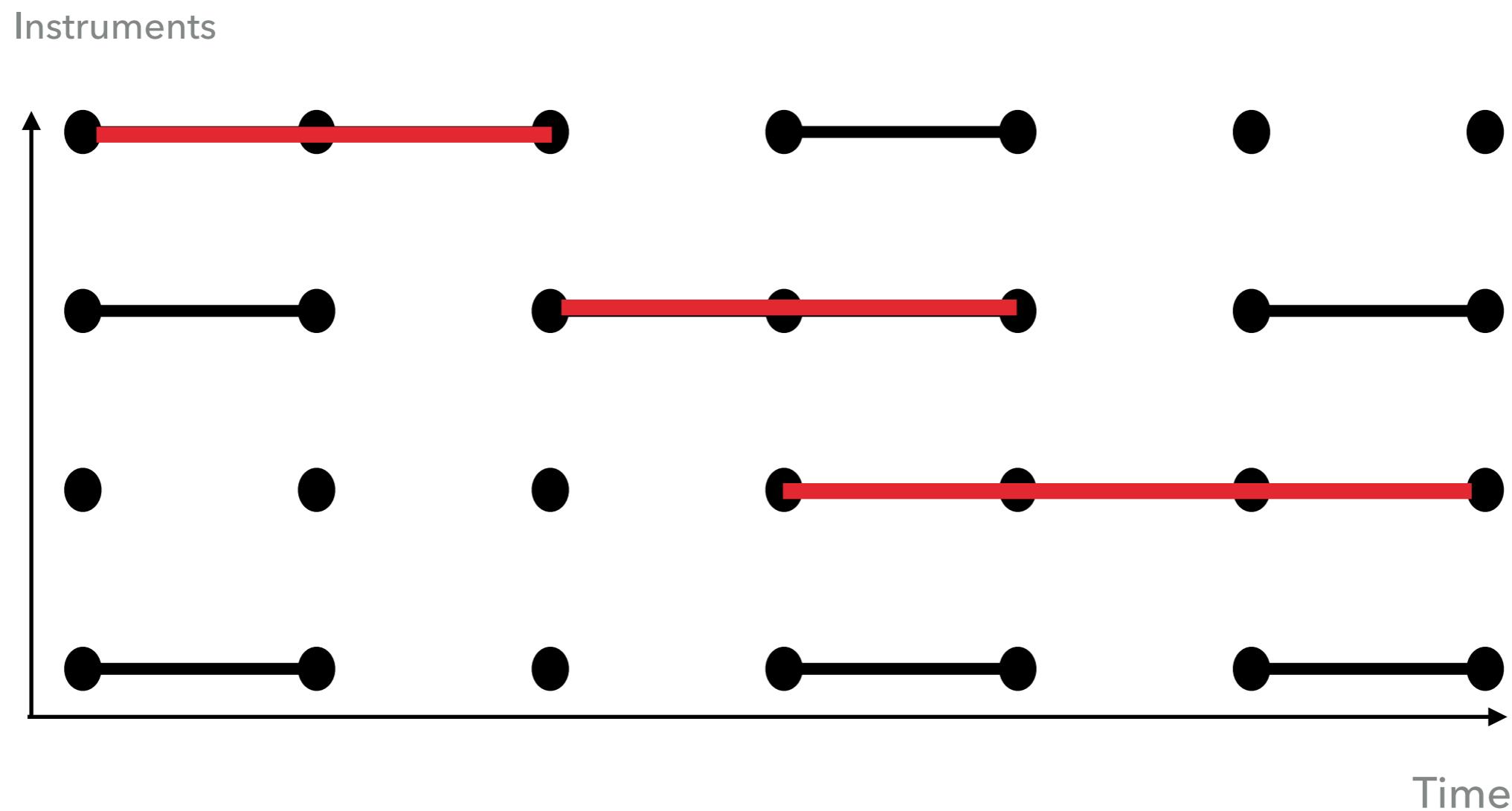
Novelty measure for segmentation



For each segment....



# CONTINUITY MODEL



# ORCHIDEA & FRIENDS (DEMO)

## orchidea.session

(c) 2017-2018 Ircam, HEM Geneve

These two final steps will permit you to orchestrate your target and examine/listen to solutions.

**5**

set harmonic filtering to reduce the search on harmonically related samples in the database

**X** Harmonic filtering

press here to orchestrate

Orchestrate

orchestrate  
t s b  
s parameters

**6**

after the orchestration has been computed, you can check the results by pressing here...

View all solutions

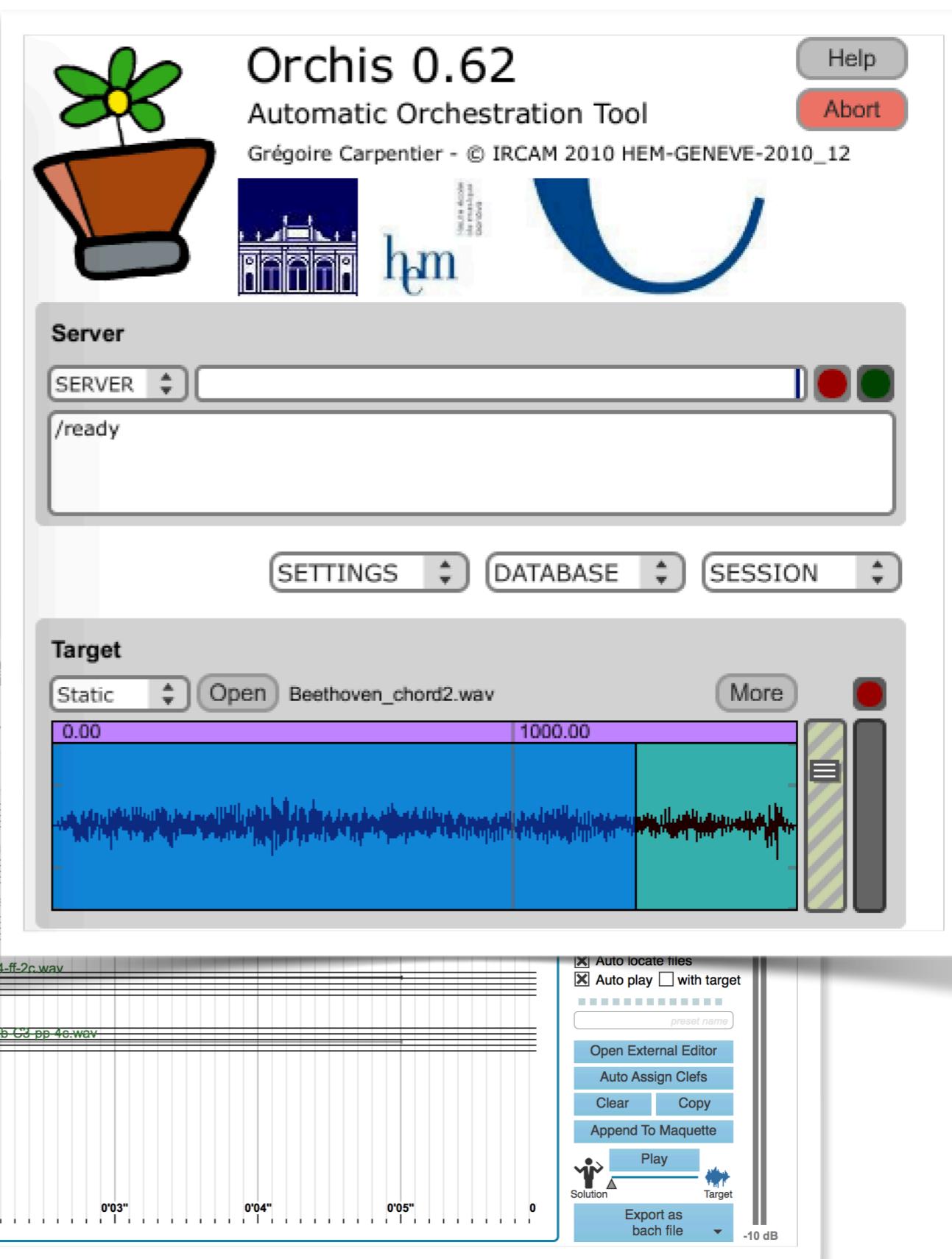
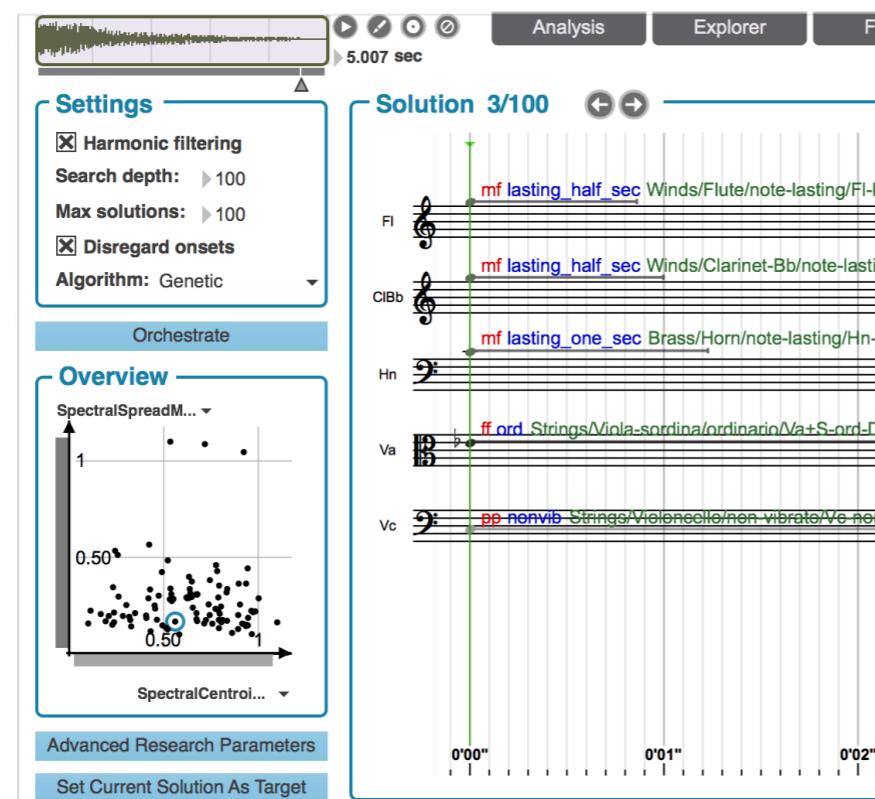
...or you can examine/listen each solution individually

r nb\_solutions

0

6

- 0 Fl ord C#6 mf - - - 0 Bn ord C4 mf 0 Bn ord C4 pp 0 Hn ord D#4 mf 0 Hn ord G4 mf - - 0 Tbn ord C3 mf 0 Tbn ord G4 pp - - - 0 Vn ord A5 pp - 0 Va ord C#6 ff 0 Va nonvib C6 pp - 0 Vc ord C4 pp -



## PANE, SALE, SABBIA (2017)

- **Instrumentation:** opera for four voices, chamber orchestra and electronics
- **Commission:** Ukho ensemble, Kiev
- **First performance:** June 2017, National Opera, Kiev,  
Ukho ensemble, Luigi Gaggero
- **Duration:** 1 hour, 3 scenes in a single act
- **Production:** January-June 2017
- **Subject:** a true story happened in Italy in May 1944

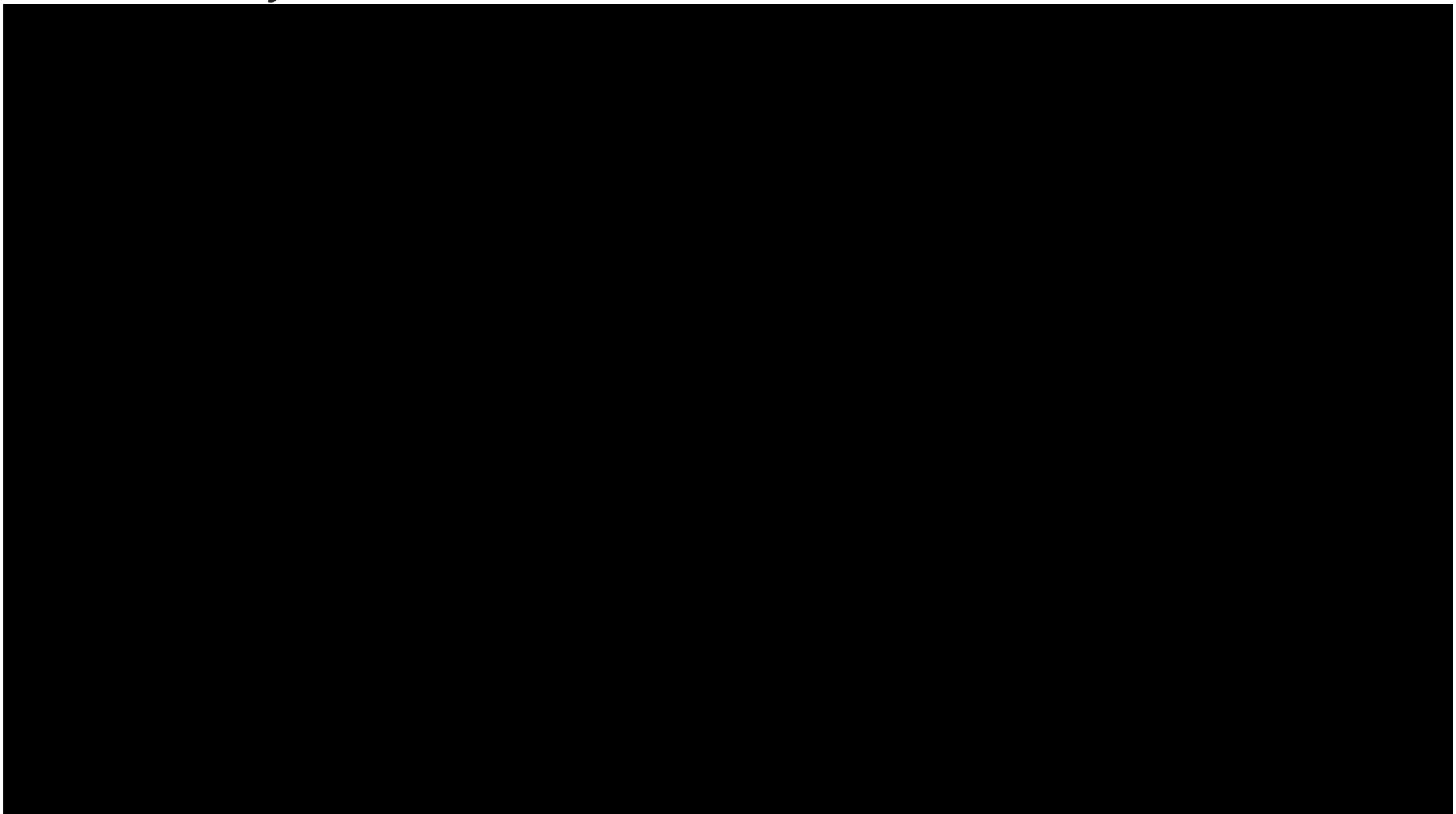
PANE, SALE, SABBIA

## PRODUCTION IN KIEV



## ASSISTED ORCHESTRATION (EXCERPTS)

Third scene is a sort of *marche funébre* where the orchestra plays orchestrations of bells created by the Orchidea toolbox



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# THANK YOU!

**Suggested exercise: download Orchidea and try it!**