



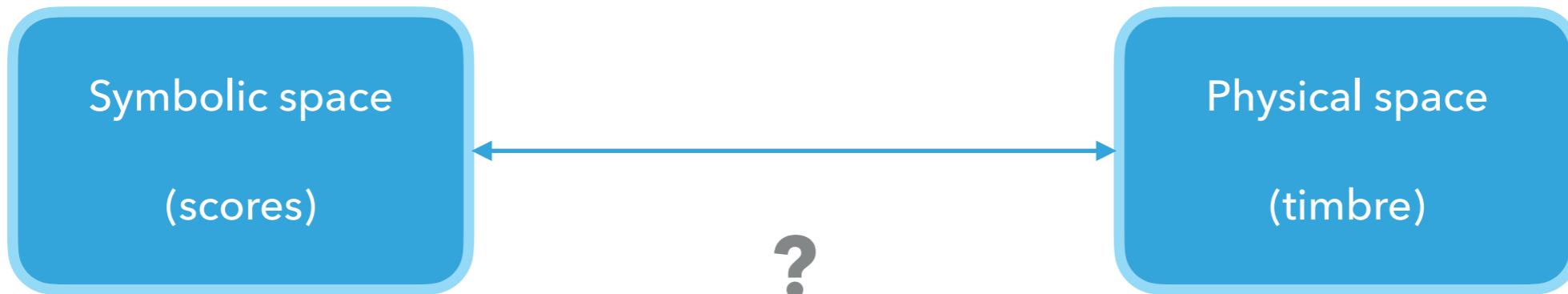
CARMINE-EMANUELE CELLA

ON COMPUTER-ASSISTED ORCHESTRATION

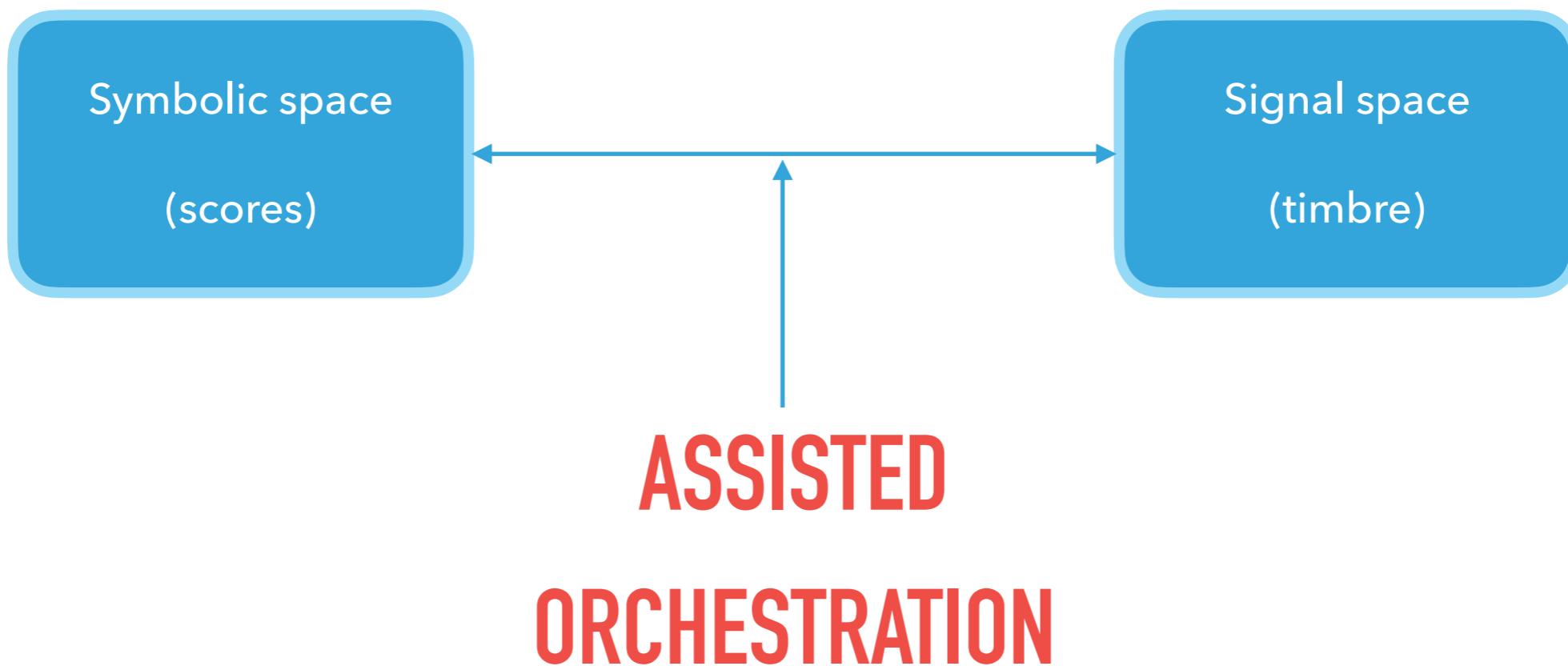
MUSIC 159

THE OPEN PROBLEM (OBSESSION)

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

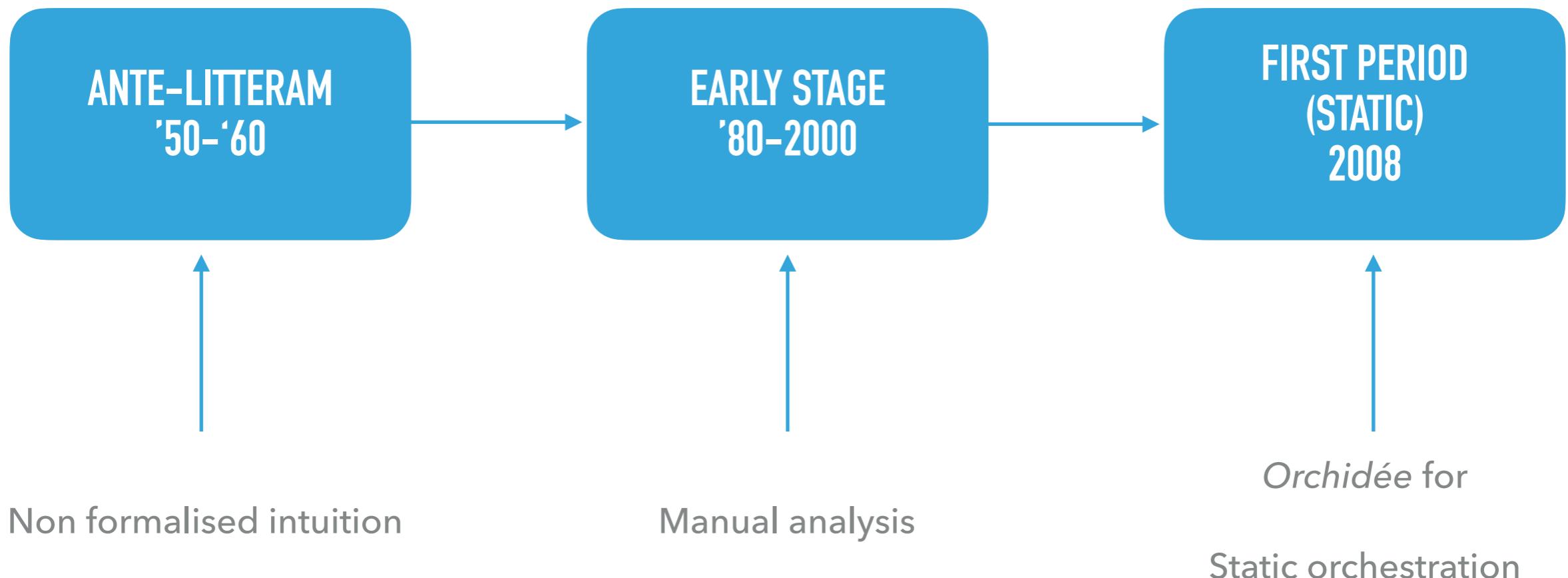


BETWEEN SYMBOLS AND SIGNALS: A SECOND APPROACH



HISTORY

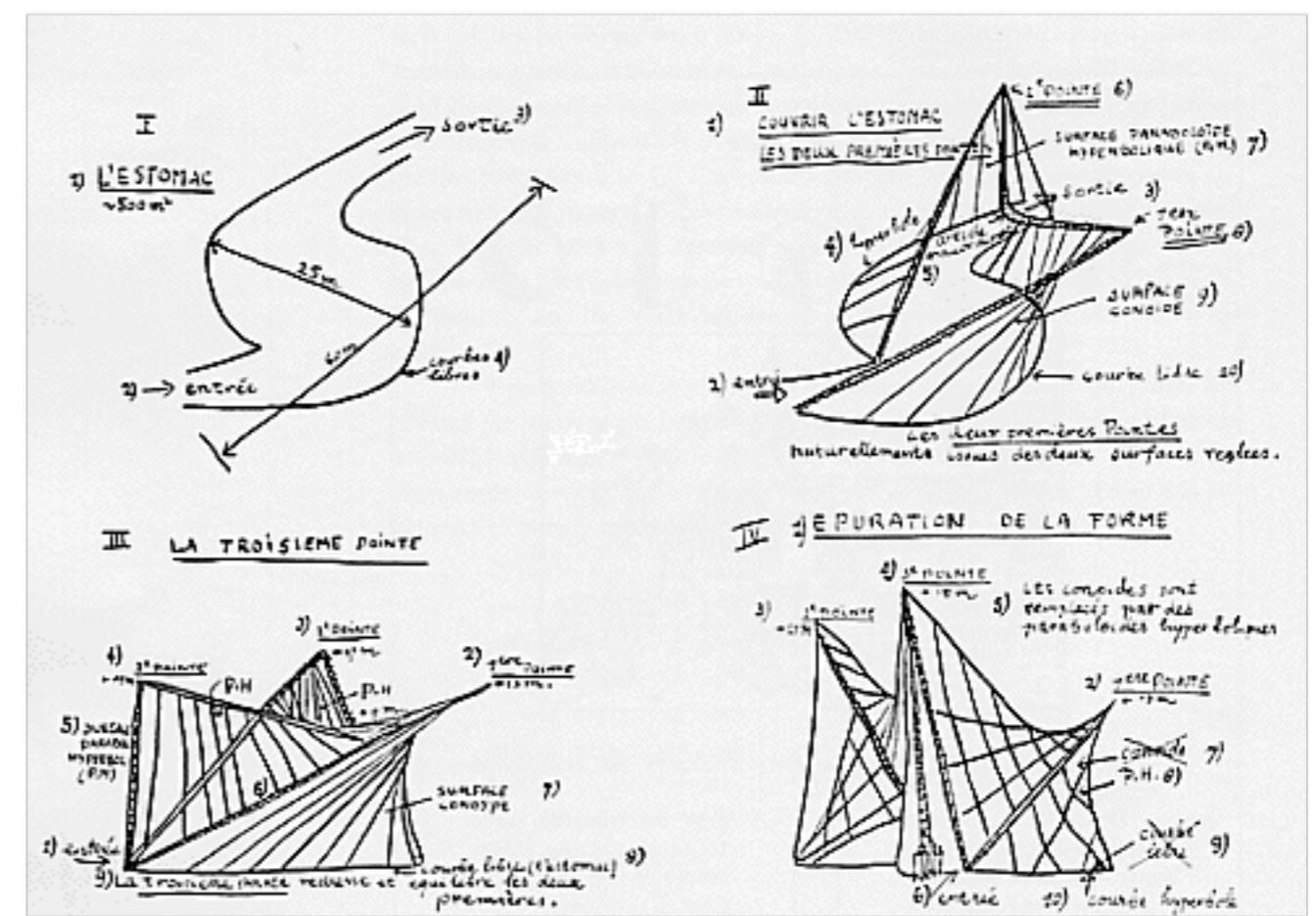
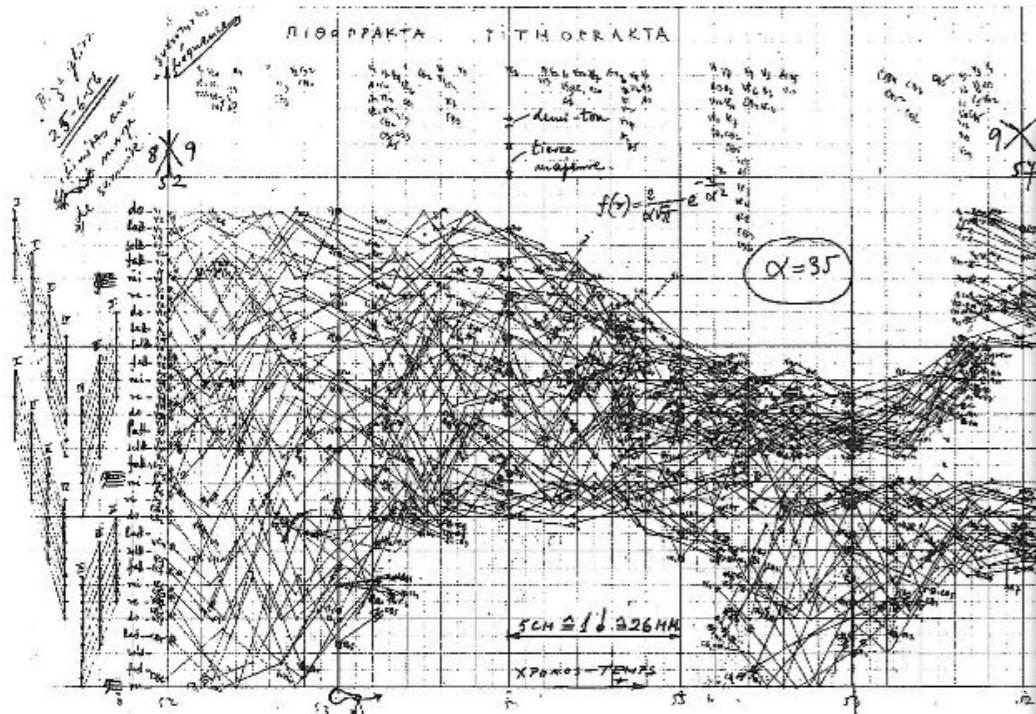
OVERVIEW



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
DUREE 7 MINUTES

JANNIS XENAKIS
1953-54

NOTA: Dédicés 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

$\text{J} = 50 \text{ M.M.}$

NOTES RÉELLES.

COMPOSITION DE L'ORCHESTRE.

1 PETITE FLUTE	2 TROMPETTES	1 TAMBOUR	12 SEC. VIOLIN(1)
1 GRANDE FLUTE	2 TROMBONES	1 TIMBALE	8 ALTO (A)
2 HAUT-BOIS	1 XYLOPHONE	1 CAISSE CL.	8 VI CELLE(VC)
1 CLAR. BASSE	1 TRIANGLE	1 GR. CAISSE	6 C/BASSES(B).
3 COR	1 WOOD-BLOCK	12 PREH. VIOLIN(2)	

TOTAL: 61 EXECUTANTS

Wood-Bl.

© Copyright 1967 by Boosey & Hawkes Music Publishers Ltd.

B. & H. 19635

All rights reserved
Printed in England

PENDERECKI, TRENODY FOR THE VICTIMS OF HIROSHIMA (1960)

2 Violini
1 Viola
1 Violoncello
1 Cello/Bass

mf ff

www.youtube.com/gerubach

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

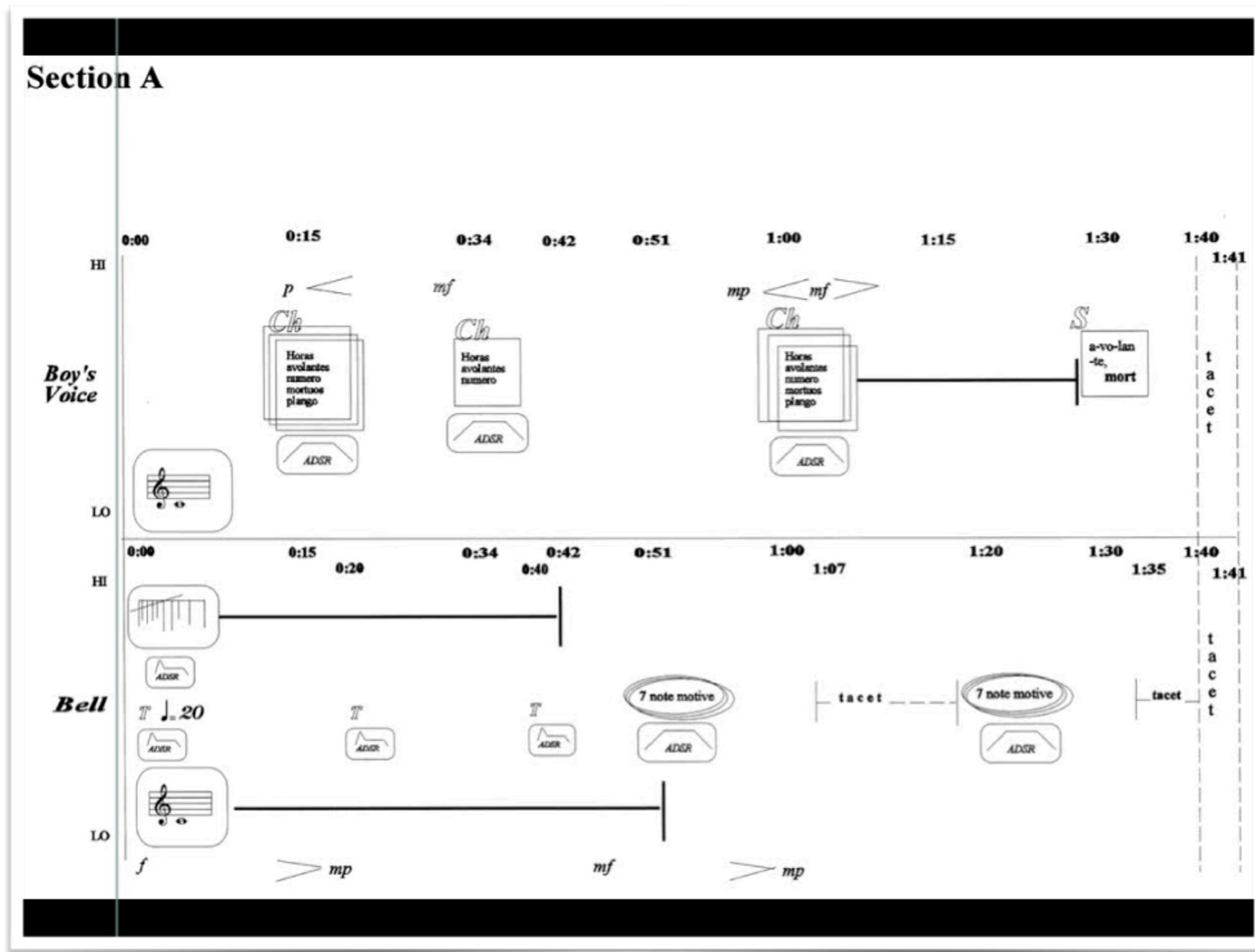
HARVEY'S BELL

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"

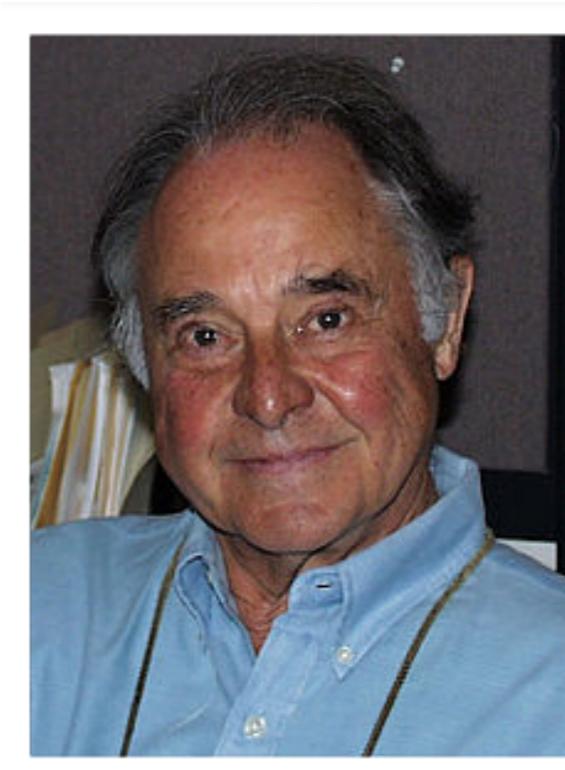
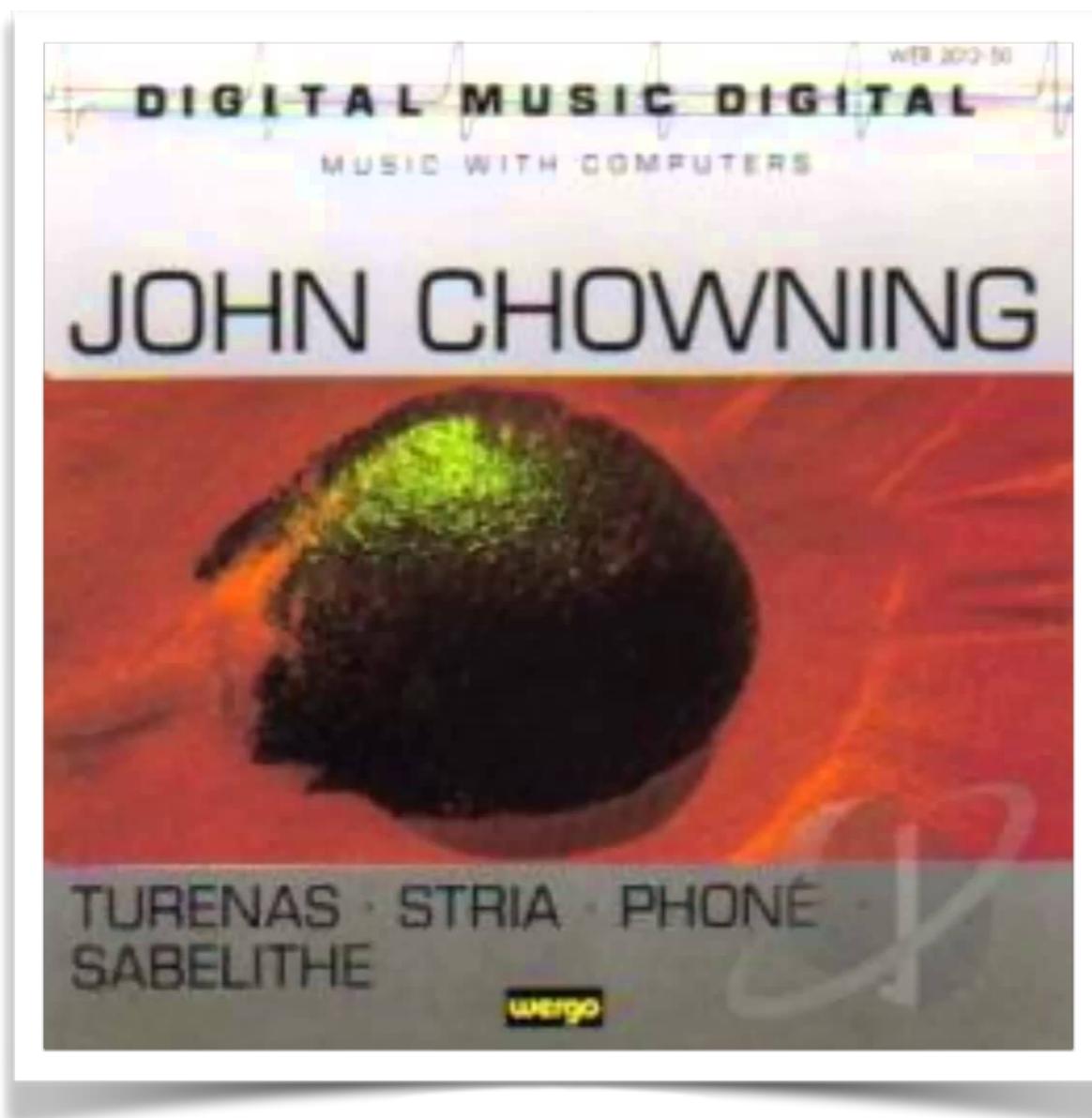
Curtis Roads

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



ALTERNATIVE APPROACHES

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.

DÉPARTEMENT PROFESSIONNEL
PHOTOGRAPHIE INTÉGRAL
Sous le 11 Mars 1927
Même partiture
composée par Yan MAREZ
(Code Pénal, Art. 42)

à Sara
Commande de l'Ensemble Intercontemporain
METAL EXTENSIONS
pour trompette solo et ensemble instrumental

Yan MAREZ
2001

© 2001 by Éditions DURAND
PARIS, France

D. & F. 15449

Dépôt légal 22280
Tous droits réservés
pour tous pays.

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.

5

1.2. red

2. blue

1. green

1.2. yellow

Tpt.

Tpt.

Tpt.

Tpt.

Tpt.

Tpt.

Tpt.

Pno. 2

Pno. 1

M. 18
Extr.)

Vcl.

Vcl.

String
Vcl.

String
Vcl.

Vcl.

Vcl.

Vcl.

Fl.

Sax.

Clar.

Th.

Pno.

Hp.

Pf.

Vcl.

Vcl.

Vcl.

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)

The musical score consists of two systems of musical notation. The top system, labeled 'Grave ♩ = 48', includes parts for Flute, Oboe, Clarinet in B♭, Bassoon, Horn in F, Trumpet in B♭, Trombone, Percussion, Piano, Violin I, Violin II, Viola, Violoncello, and Contrabass. The bottom system, also labeled 'Grave ♩ = 48', includes parts for Flute, Oboe, Clarinet in B♭, Bassoon, Horn in F, Trumpet in B♭, Trombone, Percussion, Piano, Violin I, Violin II, Viola, Violoncello, and Contrabass. The score features complex rhythmic patterns, dynamic markings like *ppp*, *mf*, and *p*, and various performance techniques such as harmonic tremolo, irregular movements with superball, and hand strikes on strings.

Top System (Measures 1-2):

- Flute:** harmonic tremolo, *pp*, *mf senza crescere*, *p*.
- Oboe:** *p senza crescere*.
- Clarinet in B♭:** *ppp*.
- Bassoon:** *ppp*.
- Horn in F:** opening and closing with hand, *ppp senza crescere*, harmon mute, straight mute.
- Trumpet in B♭:** *ppp*.
- Trombone:** *ppp*.
- Percussion:** TAM TAM, irregular movements with superball, *ppp*, *mp*.
- Piano:** irregular movements with hands on the strings in the lower region, *ppp*, *p*.

Bottom System (Measures 1-2):

- Violin I:** *p* espress., on the bridge.
- Violin II:** *ppp*.
- Viola:** mute, *ppp*, *pp*, *ppp*.
- Violoncello:** lead mute, increasing vibrato speed.
- Contrabass:** *ppp*.

Top System (Measures 3-4):

- Flute:** *ppp senza crescere*.
- Oboe:** strike strings with hnds, *ppp*, *p*.

Bottom System (Measures 3-4):

- Violin I:** increasing vibrato speed.
- Violin II:** *pizz.*
- Viola:** *pizz.*
- Violoncello:** *mp* espress.
- Contrabass:** *mp*.

Proprietà per tutti i Paesi della SUGARMUSIC S.p.A. - Milano, Galleria del Corso, 4.
© Copyright 2018 by SUGARMUSIC S.p.A. - Milano.
Tutti i diritti riservati a termini di legge - All rights reserved. International Copyright secured.

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

COMPUTER ASSISTED ORCHESTRATION

ORCHESTRATION: PROJECTION

7 Muovendo $\text{♩} = 78$

103 **8**

Picc.

Fl.

Ob.

Eng. horn

Cl.

B. Cl.

PROJECTION

Signal space (timbre)

ORCHESTRATION: INDUCTION?

A musical score for ten orchestra instruments. From top to bottom, the instruments are: Flute (Fl), Oboe (Ob), Clarinet (Cl), Bassoon (Bn), Horn (Hn), Trombone (Tp), Bass Trombone (Tbn), Violin (Vn), Viola (Va), and Cello/Bass (Cb). Each instrument has a staff with specific dynamic markings: Fl (ff, #o), Ob (pp), Cl (eo, pp), Bn (mf), Hn (eo), Tp (ff), Tbn (Straight, mf), Vn (mf, pont 4c, eo), Va (nonvib 3c, ff), Vc (nonvib 2c, ff), and Cb (eo, nonvib 4c, ff).

?

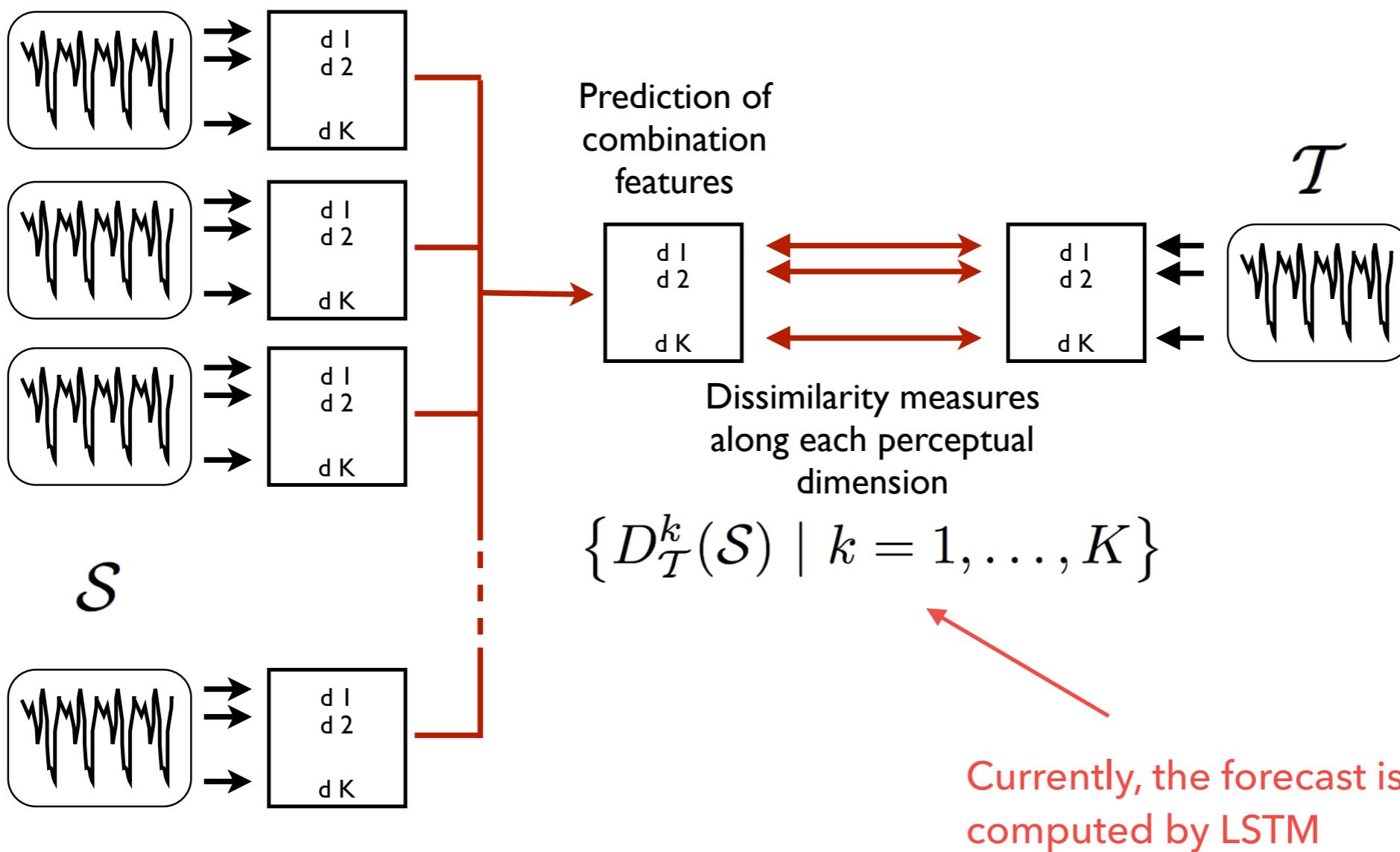
Signal space
(timbre)

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

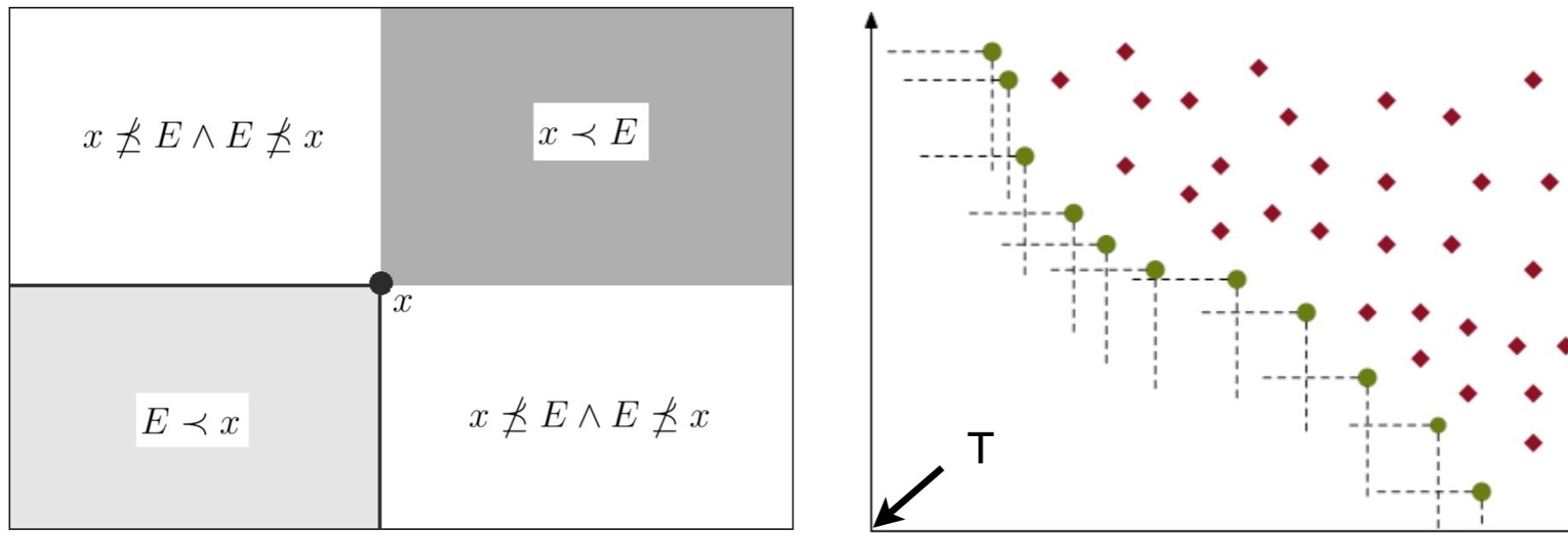
HYPOTHESIS ON SIMILARITY

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

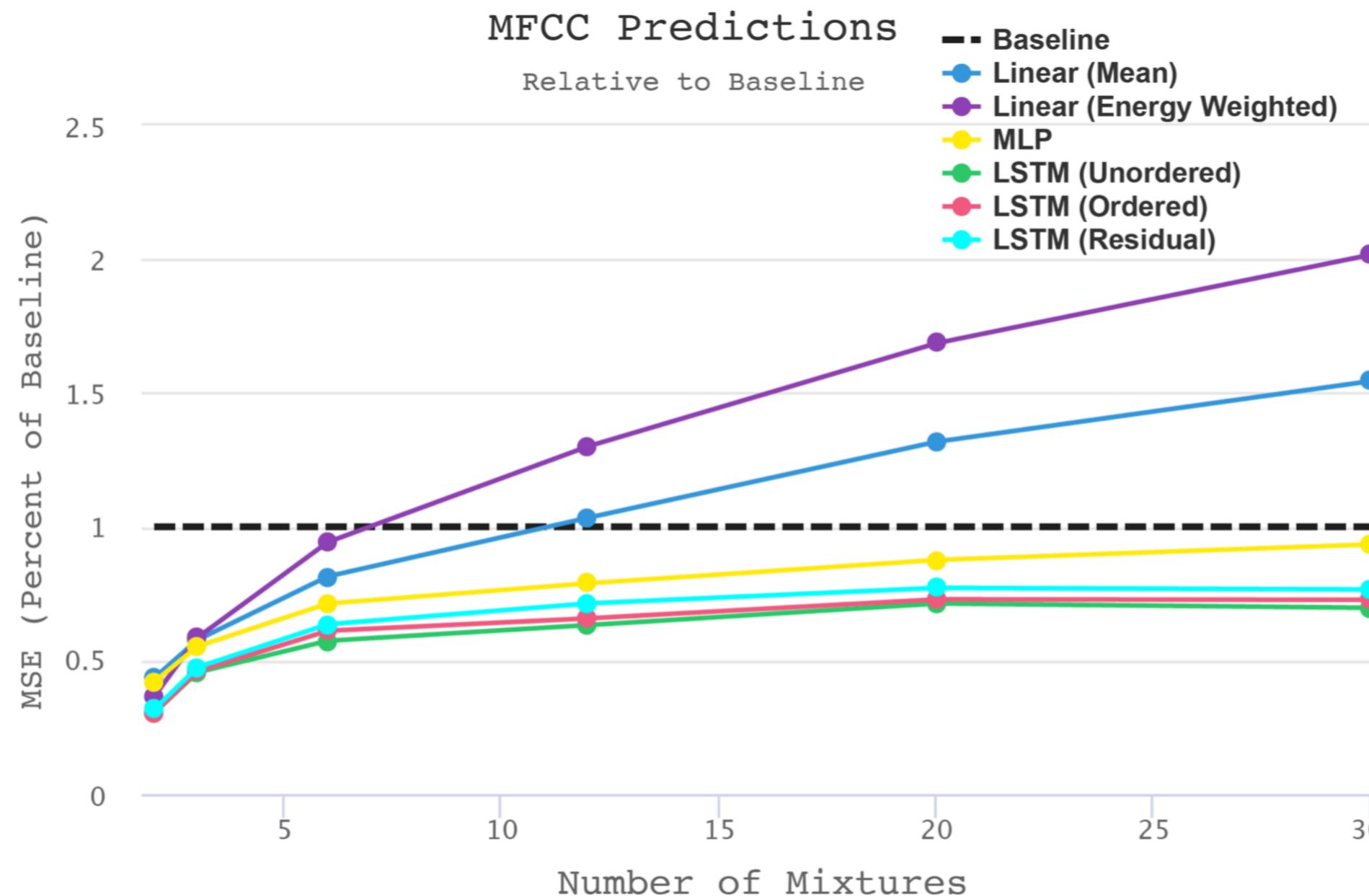
HARVEY'S SPEAKINGS (2008)



CURRENT APPROACH

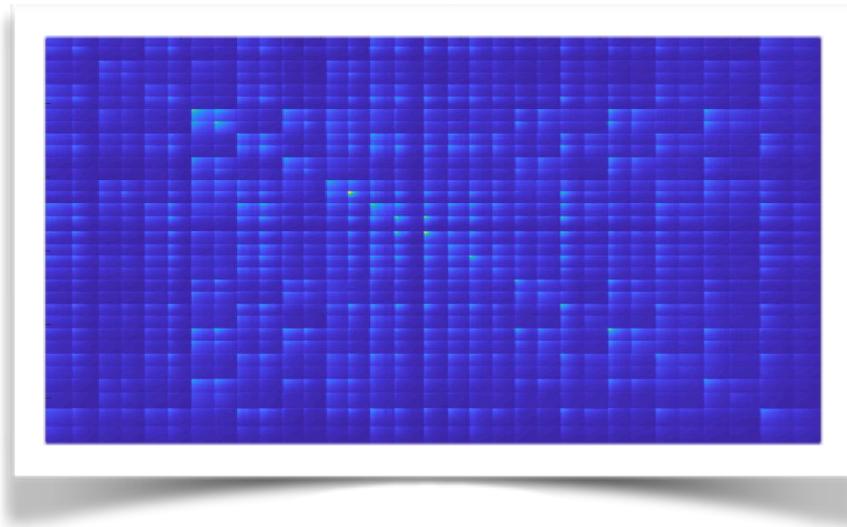
- Architecture: evolutionary optimization with dynamic symbolic constraints (forecast made by LSTM network)
- Relaxed pursuit strategy for initial population
- Asymmetric distance for timbre evaluation
- Temporal modelling: graph structure and continuity model

FEATURE FORECAST (MFCC)

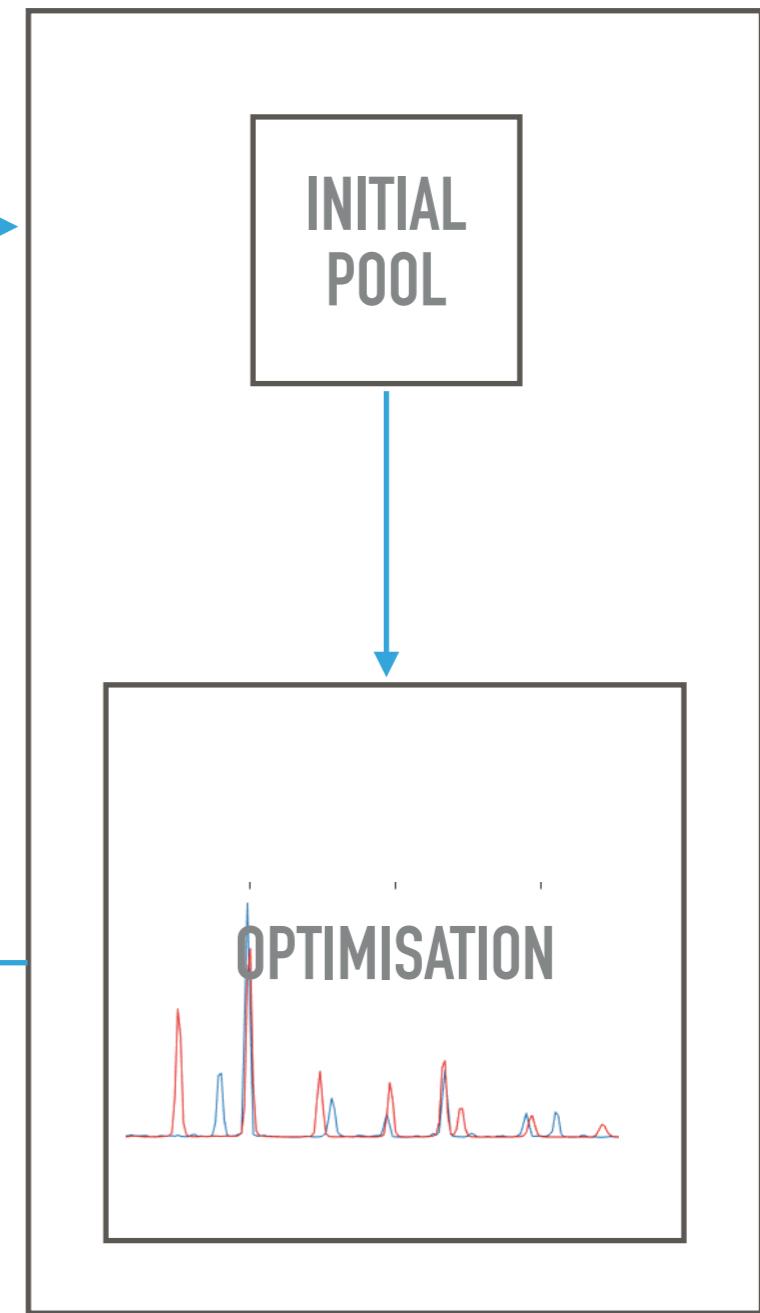


TEMPORAL MODELING

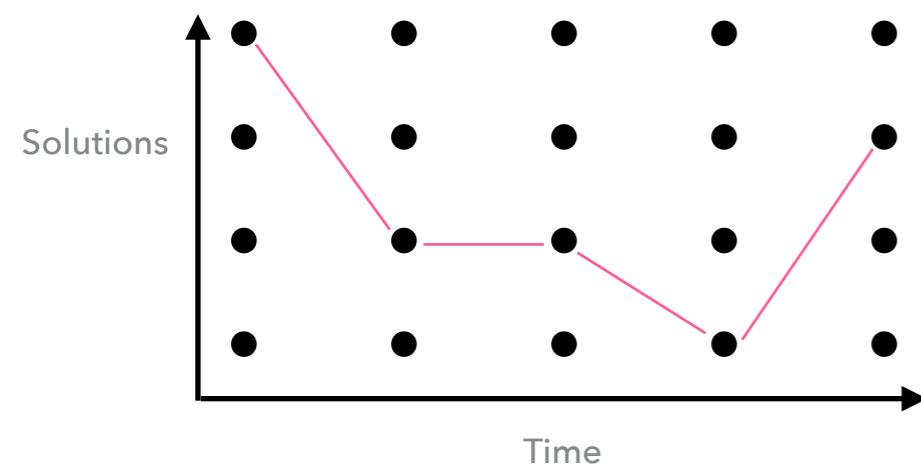
Novelty measure for segmentation



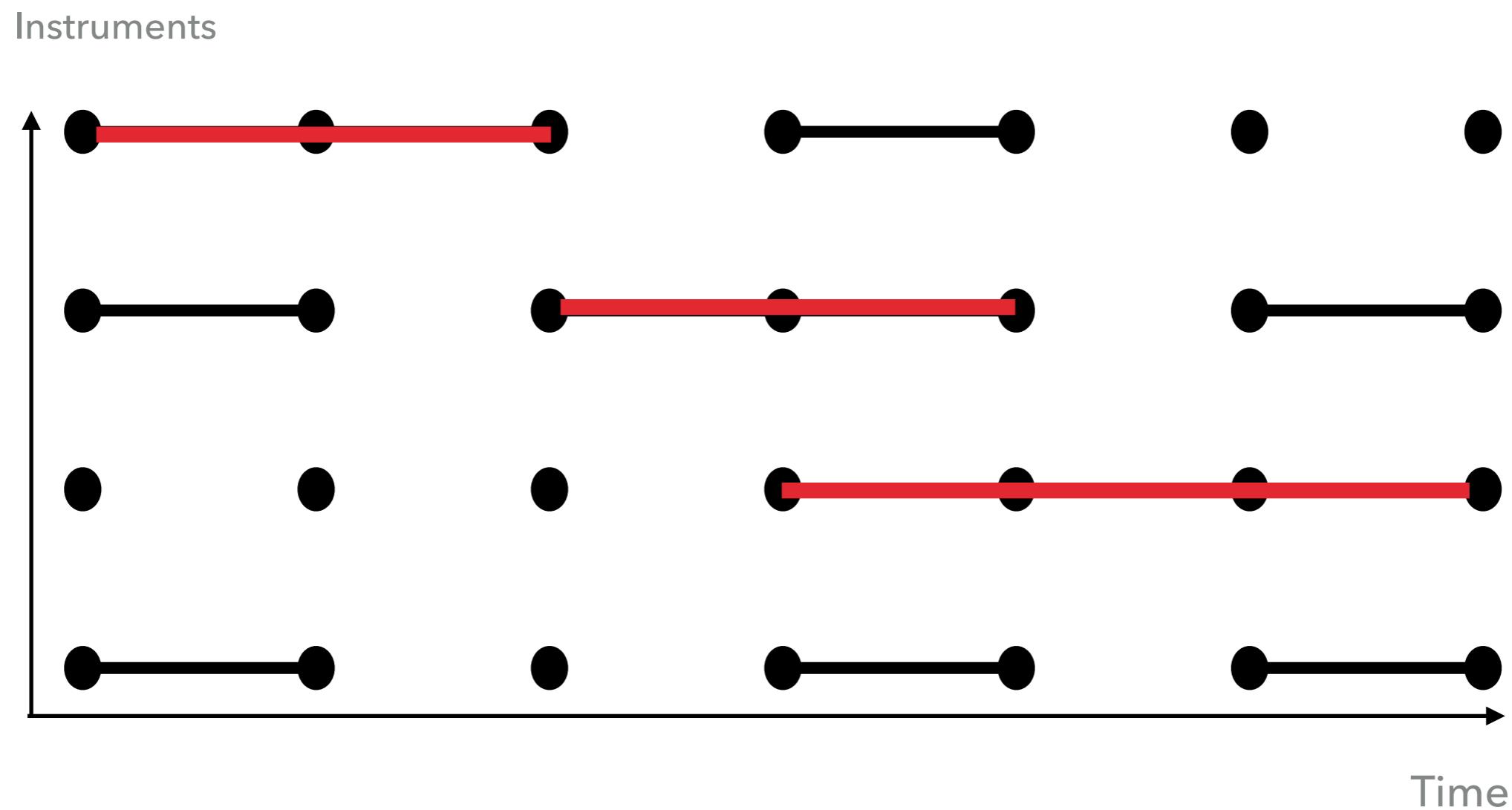
For each segment....



Best-path connection



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

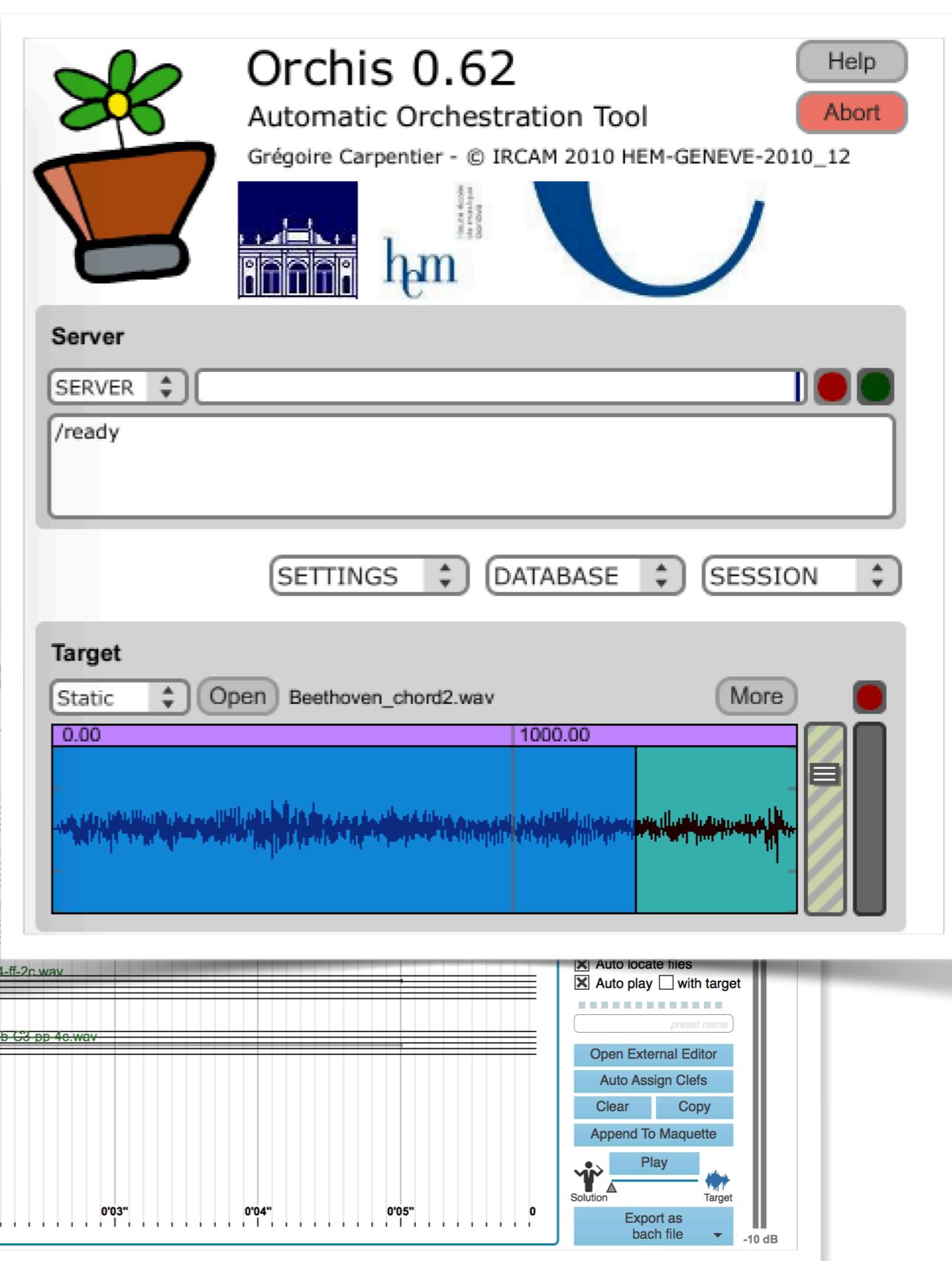
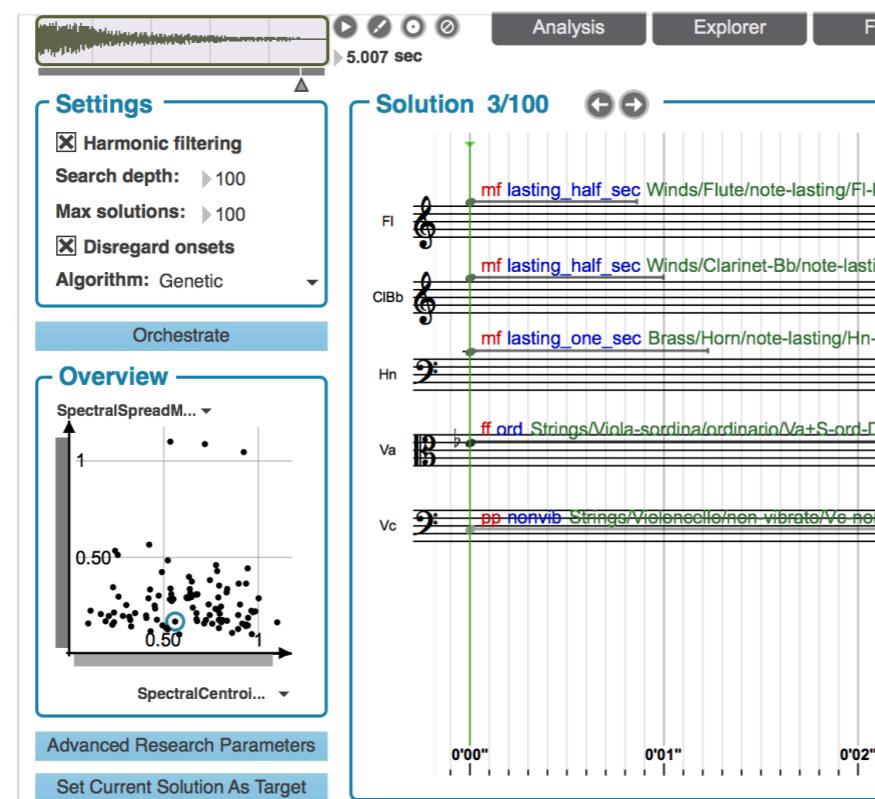
...or you can examine/listen each solution individually

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

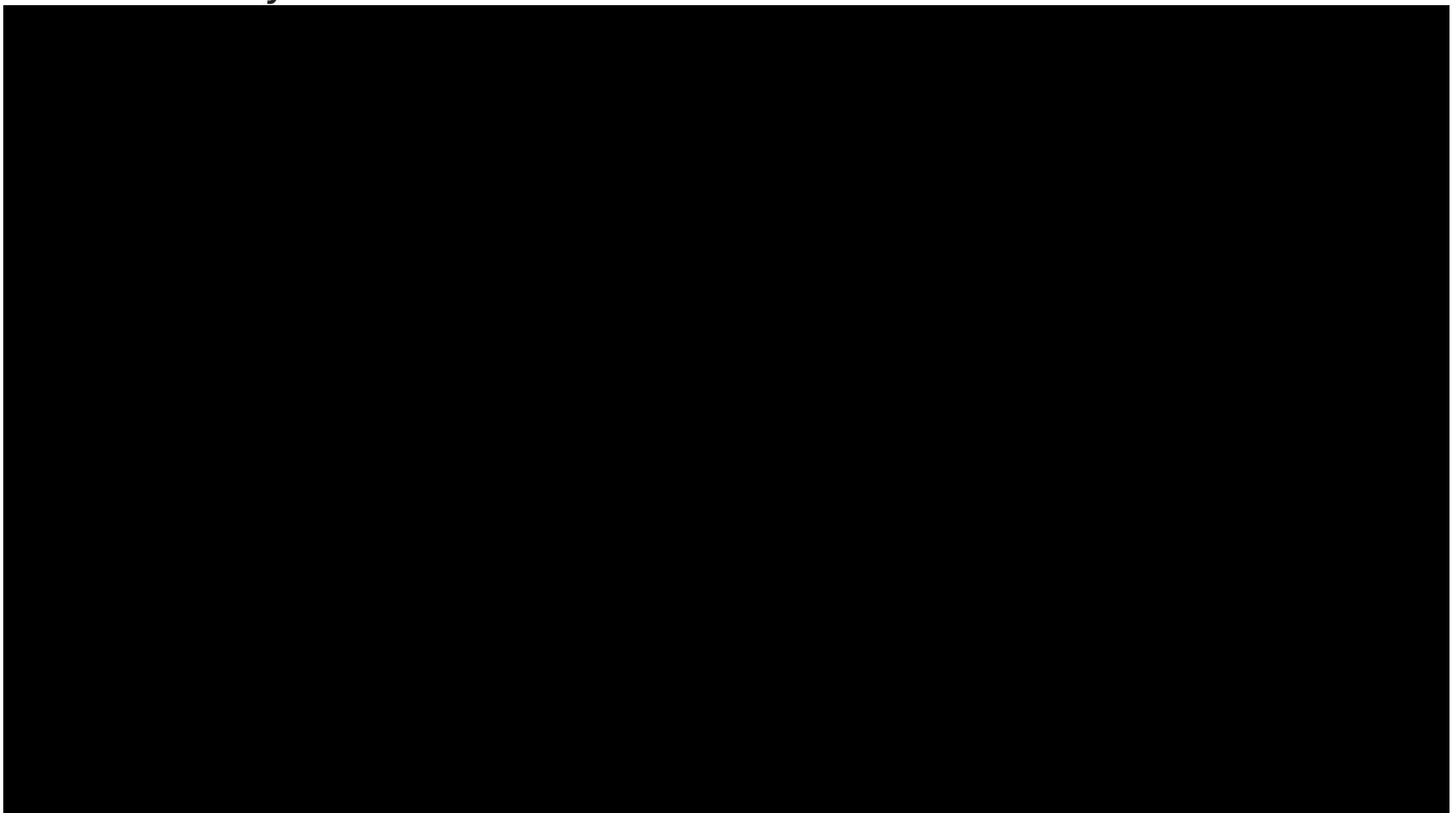
PANE, SALE, SABBIA

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



THANK YOU!

Suggested exercise: download Orchidea and try it!