Digital Images and Symbolic Encoding of Guatemalan Polyphonic Choirbooks

Enhancing Preservation and Access for Early Music Sources through Digitization and Music Information Retrieval

Martha E. M. Thomae Elías
Postdoctoral Research Fellow at NOVA University of Lisbon
PhD Music Technology (McGill University)

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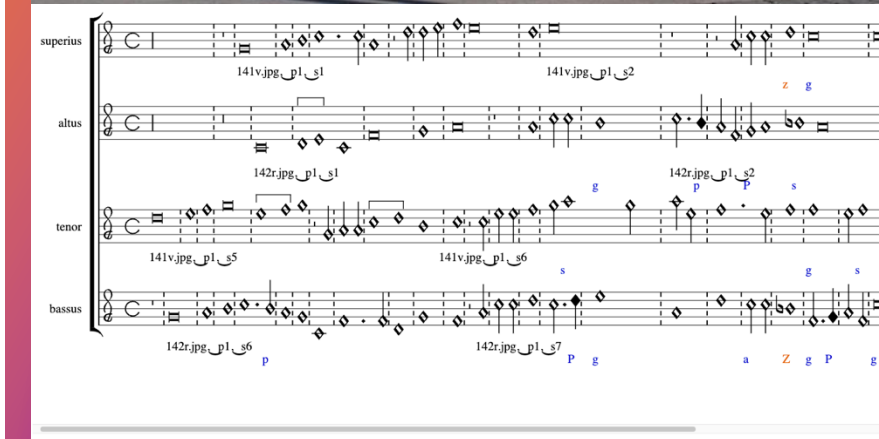
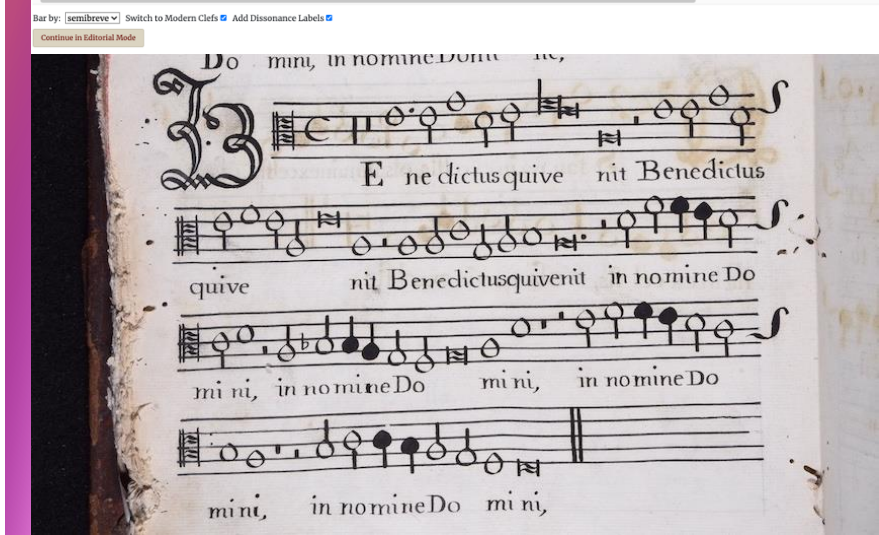
Universidad Federal de Rio de Janeiro, Brazil
December 11th, 2024





Some Background

I am from Guatemala

I was fortunate to do my Master's and PhD studies in *Music Technology* in Canada (at McGill University)

And what I wanted with this project was to **take all that music technology background** I got during my studies and **apply it to the musical heritage** of **my home country (Guatemala)** to help in its preservation

Introduction

Motivation and Corpus

Introduction: Motivation

- Digitization and encoding of music books from Guatemala
- Part of Guatemala's colonial past and an important part of its cultural heritage
- **Goal:** Preserve and enhance access to this music
- Through the digitization and music information retrieval (MIR) technologies

Introduction: Corpus

- Six choirbooks held at the Archivo Histórico Arquidiocesano de Guatemala (AHAG), an archive located next to the Metropolitan Cathedral in Guatemala City
- Manuscripts (handwritten music)
- Average page dimensions: 30 cm x 45 cm
- Material: Paper
- Copied in the 17th and 18th centuries
- Contain mostly Renaissance European polyphonic music (16th c.), which continued to be used in Guatemala until the 19th c.

Introduction: Corpus

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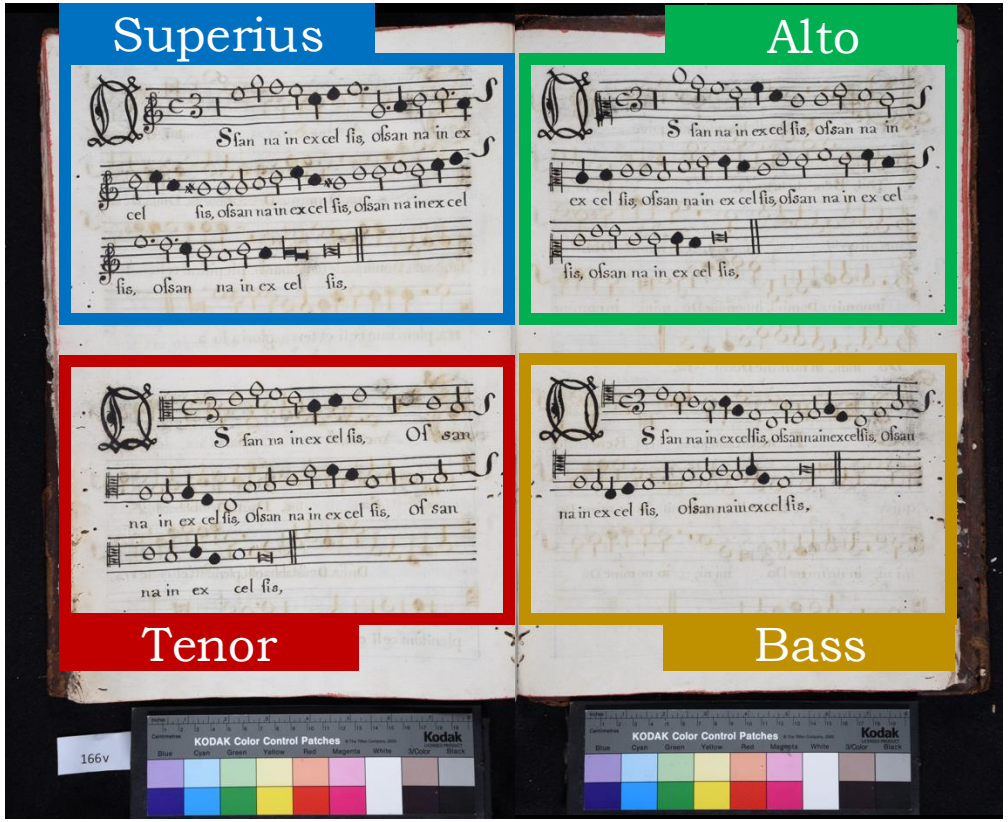
Introduction: Corpus

Contain mostly Renaissance European **polyphonic** music (16th c.)

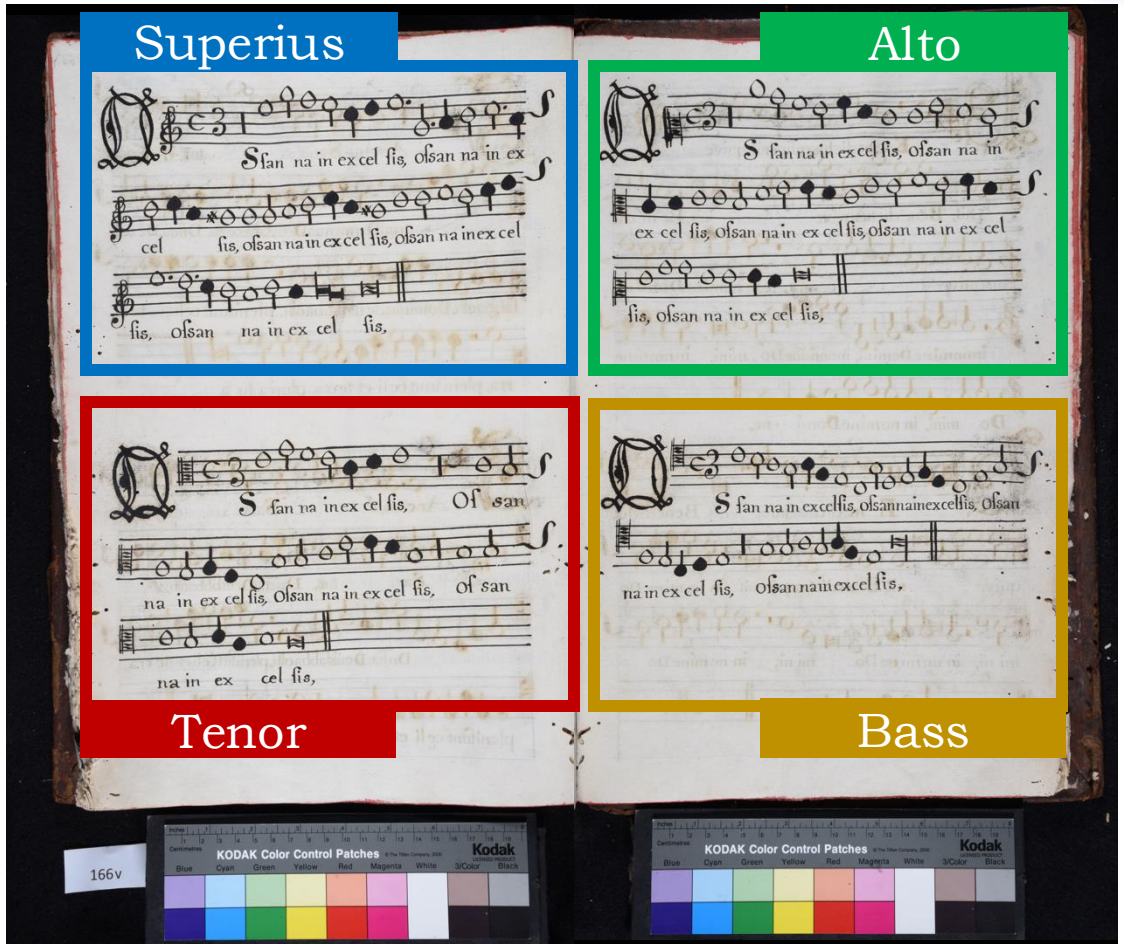
- Each of the different voices (soprano, alto, tenor, bass) sing their own melody
- Rather than the whole choir singing the same melody (**monophonic** music)
- Written in **mensural notation**
- Written in a **separate-parts layout** (**voices separated** rather than lined up in a **score layout**)

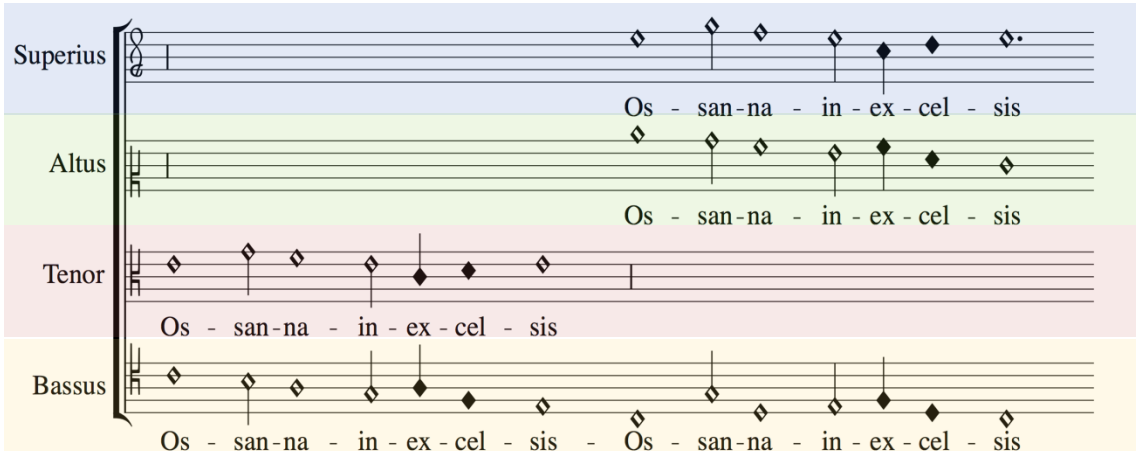


Introduction: Corpus (*Mensural Music Books*)

- Usually in some **separate-parts** layout

Score



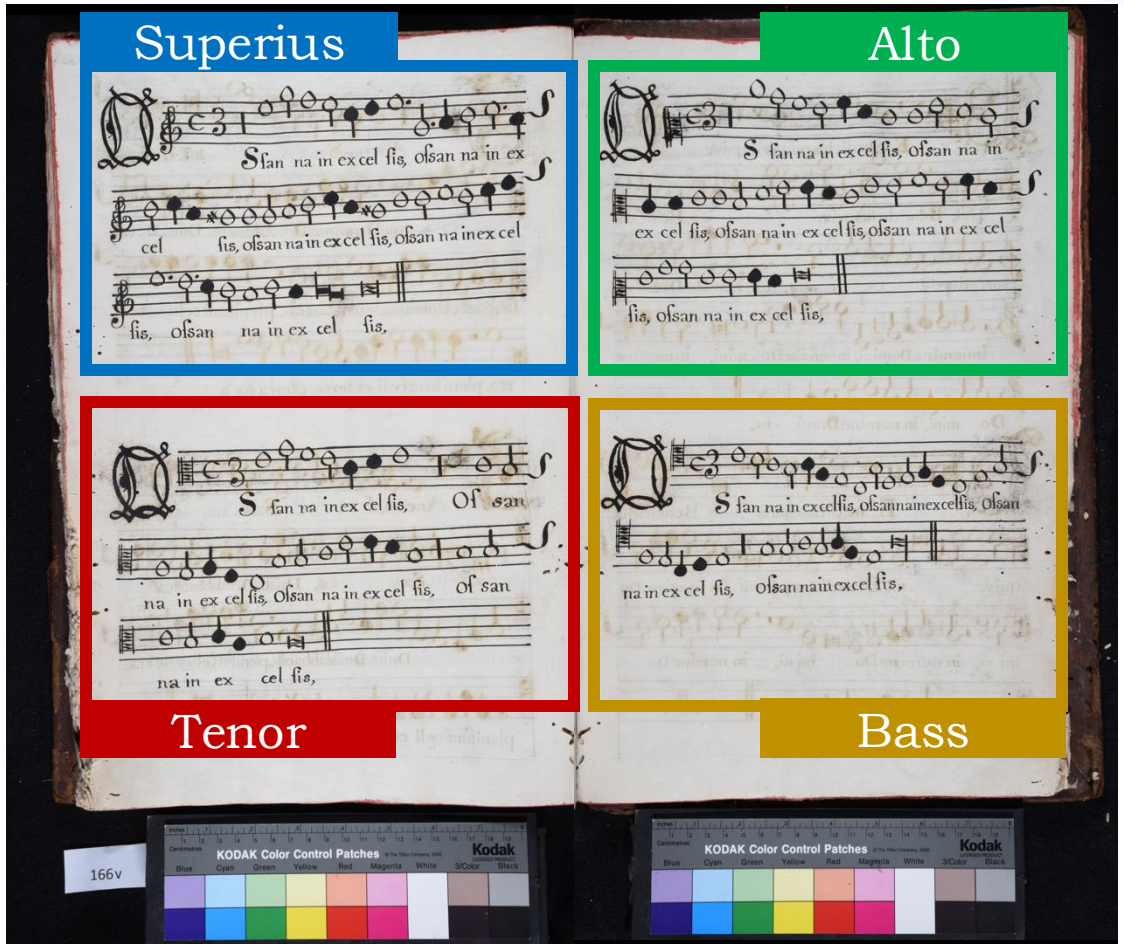


which implies dealing with the issue of this early music notation (the interpretation of the notes' duration)

You need an expert to interpret the duration of the notes in this notation

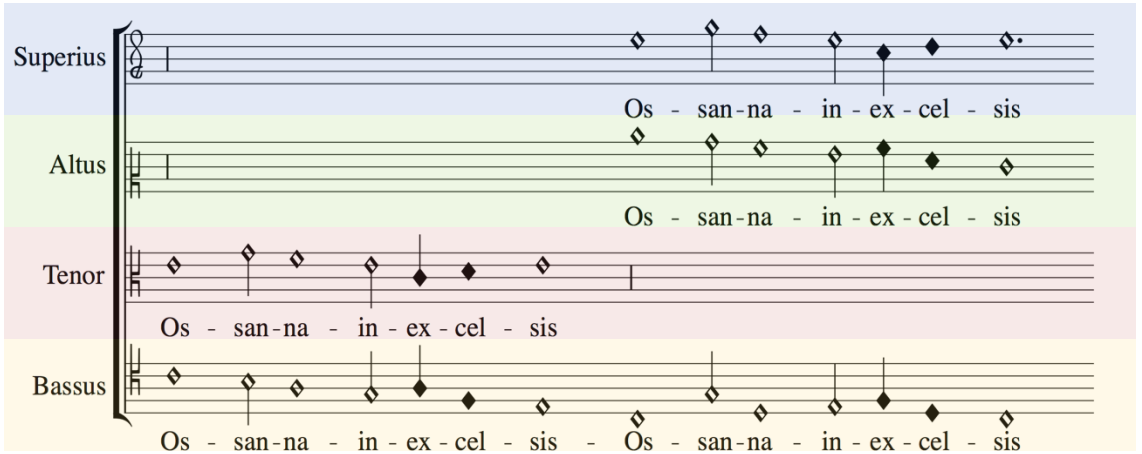
Introduction: Corpus (*Mensural Music Books*)

- Usually in some **separate-parts** layout



Symbolic Score

- A **score** encoded in a *symbolic* or ***machine-readable*** format



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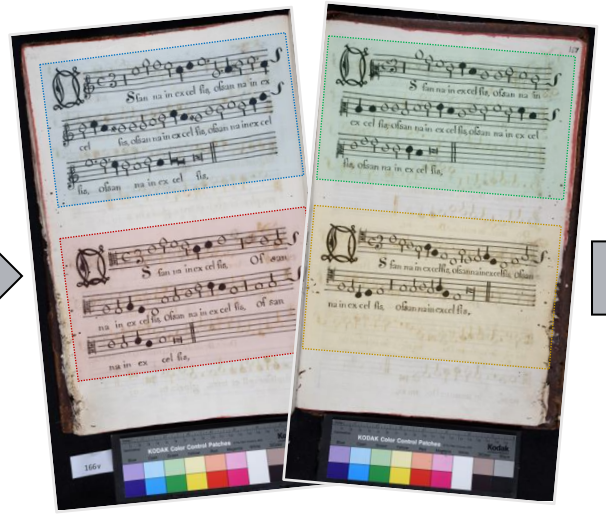
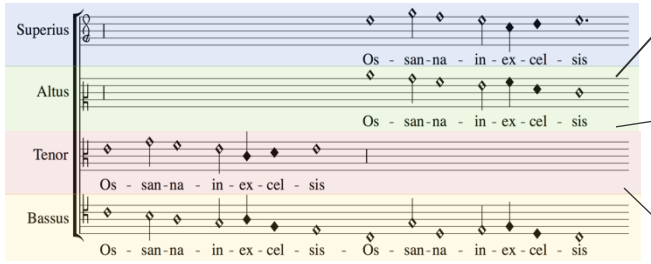
Introduction: Motivation

- **Goal:** Preserve and enhance access to this music
- Through the digitization and music information retrieval (MIR) technologies
- **Pilot project:** First book

Manuscript



Digital images
of the mensural pieces



Symbolic Score
interpreted durations,
an issue in mensural notation

playback

automatic transcription into modern values

comparison to concordant sources

Introduction: Motivation

- **Goal:** Preserve and enhance access to this music
- Through the **digitization** and **music information retrieval (MIR)** technologies:
  - A **do-it-yourself (DIY) book scanner** for high-resolution images
  - **Optical music recognition (OMR)** software trained for handwritten mensural notation
  - An **interpreter for mensural notation**
  - A **music-analysis tool** served as an **error checker**
- Present these tools and their integration into a **digitization and MIR pipeline** to create the digital images and symbolic scores

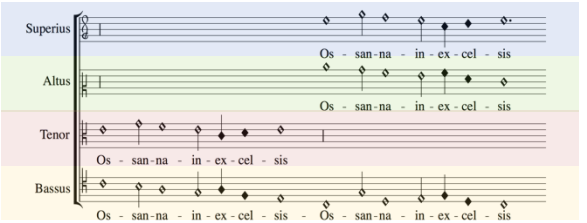
Work

The Digitization and Music Information Retrieval (MIR) Pipeline

Digitization & MIR Pipeline

Digitization → Optical music recognition (OMR) with human correction → Automatic scoring up & editorial correction

Manuscript

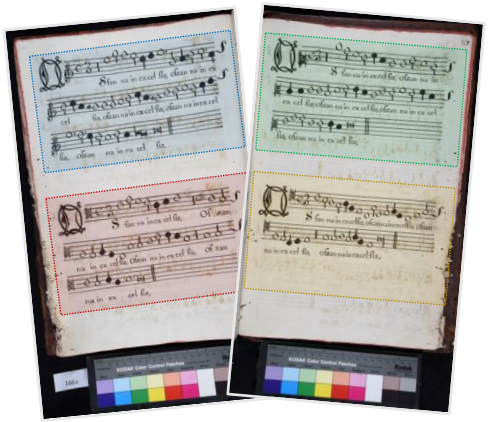


Score file
interpreted durations

Digitization & MIR Pipeline

Digitization → Optical music recognition (OMR) with human correction → Automatic scoring up & editorial correction

Manuscript



Digital images

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   <dot/>
   <note dur="minima" pname="c" oct="5"/>
   <ligature form="recta">
    <note dur="semibrevis" pname="d" oct="5"/>
    <note dur="semibrevis" pname="g" oct="4"/>
   </ligature>
   <note dur="brevis" pname="b" oct="4"/>
  </staff>
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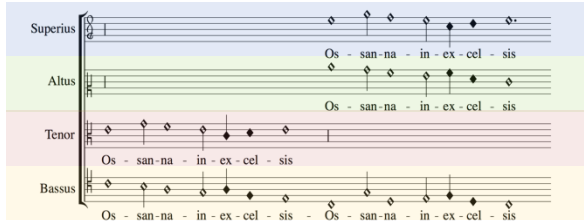
</mei>
```

Parts file

encodes the **symbols** in each **part/voice** of the images

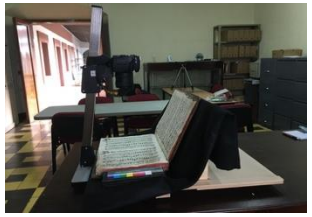


Score file

interpreted durations

Digitization & MIR Pipeline

Digitization

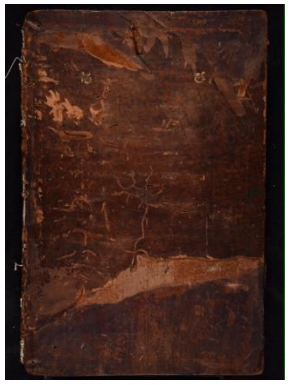


Optical music recognition (OMR)
with human correction

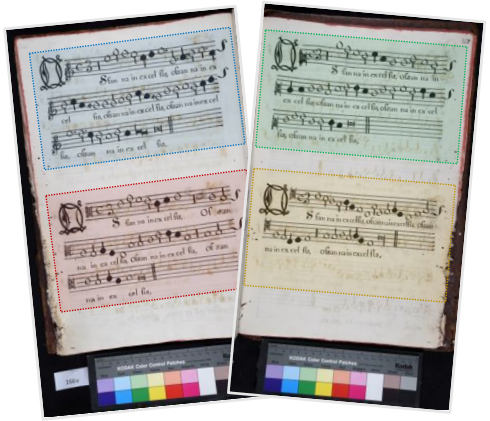
MUSCIMA++
Music Recognition, encoding, and transcription

Automatic scoring up
&
editorial correction

MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC



Manuscript



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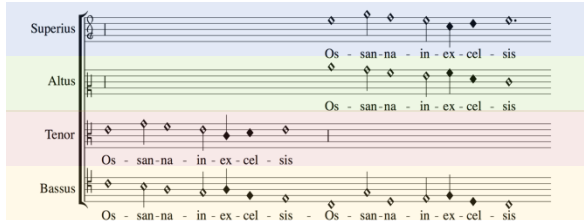

Score file
interpreted durations

Digitization & MIR Pipeline

Digitization

Optical music recognition (OMR)
with human correction

MURET
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Automatic scoring up
&
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MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

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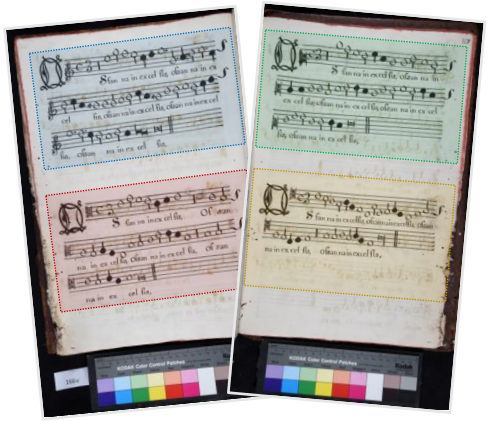

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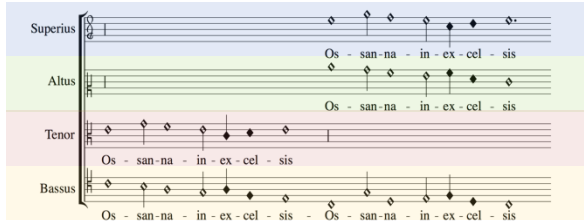

Score file
interpreted durations

1. Digitization

Obtaining digital images

Do-it-yourself book scanner

Digitization

Do-it-yourself (DIY) book scanner

Digitization

Optical music recognition (OMR)

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MEASURING POLYPHONY

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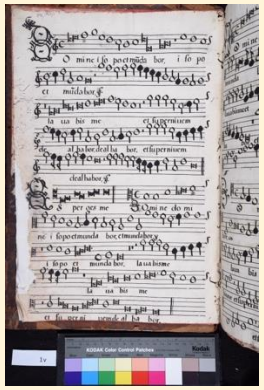
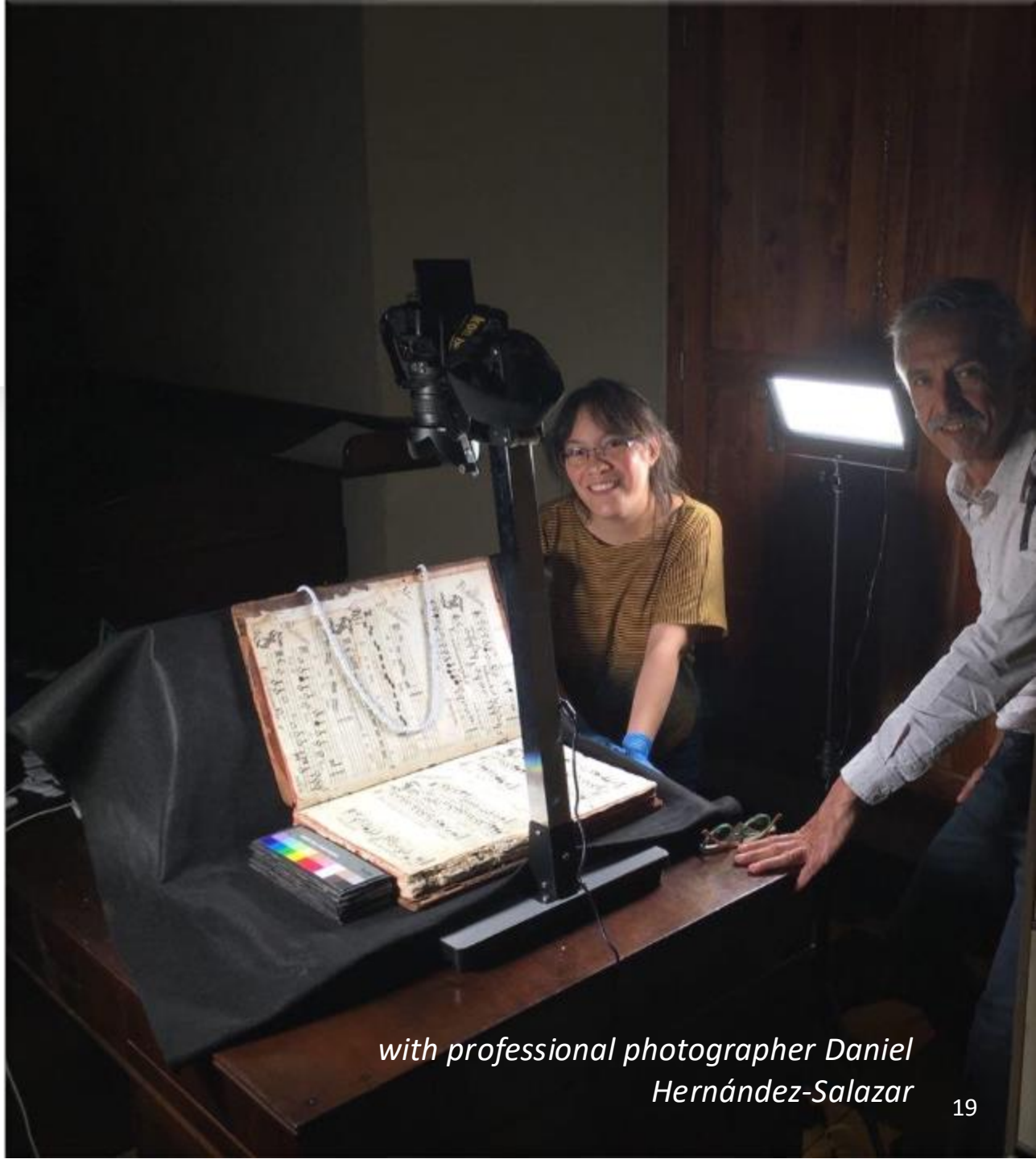


Digital image

Technology Used

DIY Book Scanner

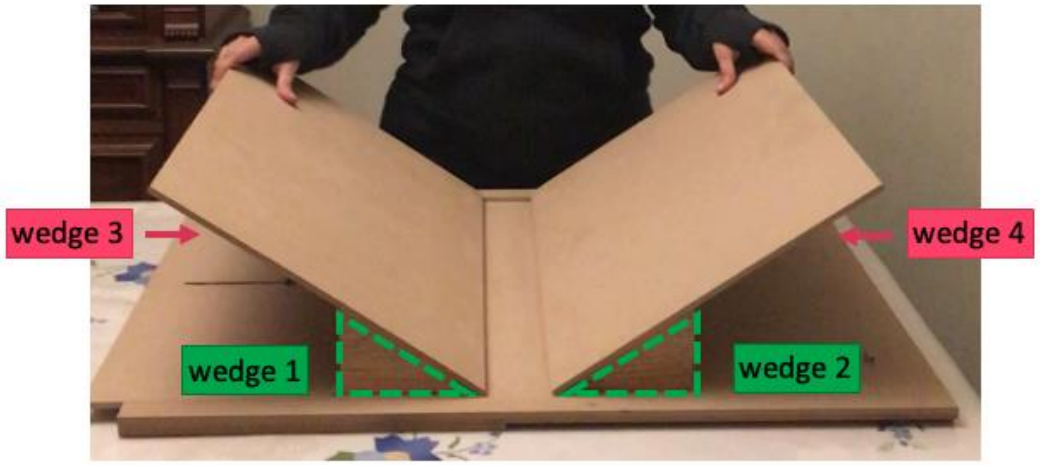
- With **borrowed** (camera & lights) and **built** parts (cradle)
- Advice from various institutions including the *Digital Image Archive of Medieval Music* (*DIAMM*)

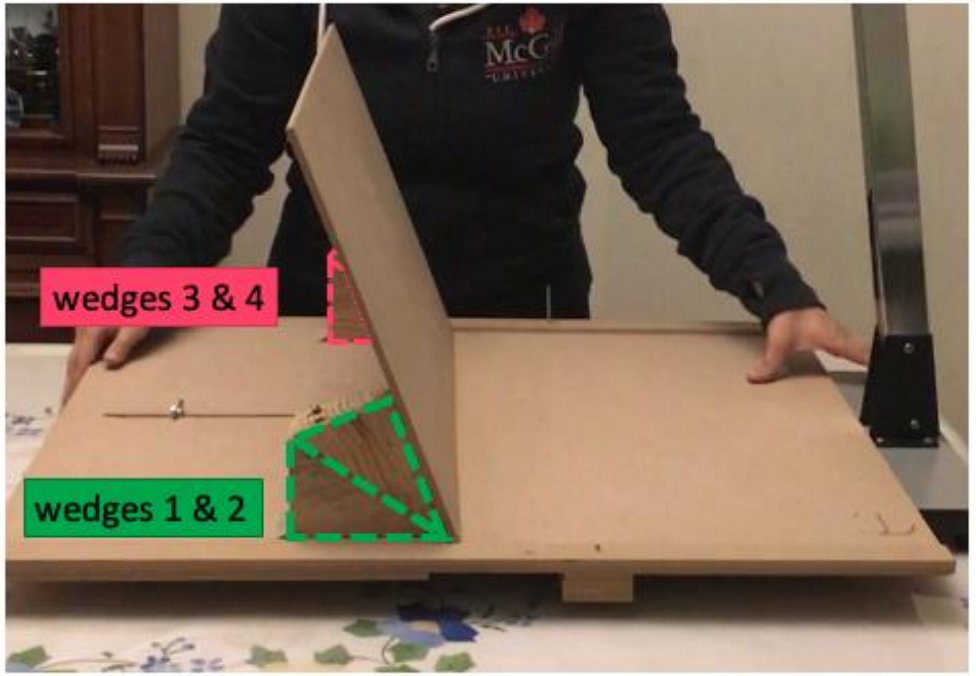


with professional photographer Daniel Hernández-Salazar

Book Cradle: Configurations

Hold the book opened at 110º angle
by using four wedges of 35º





German Thomae

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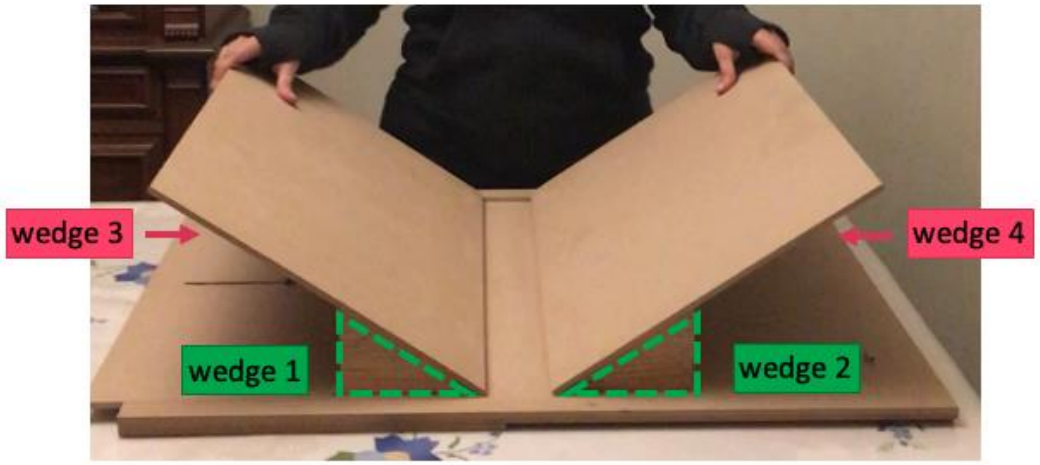


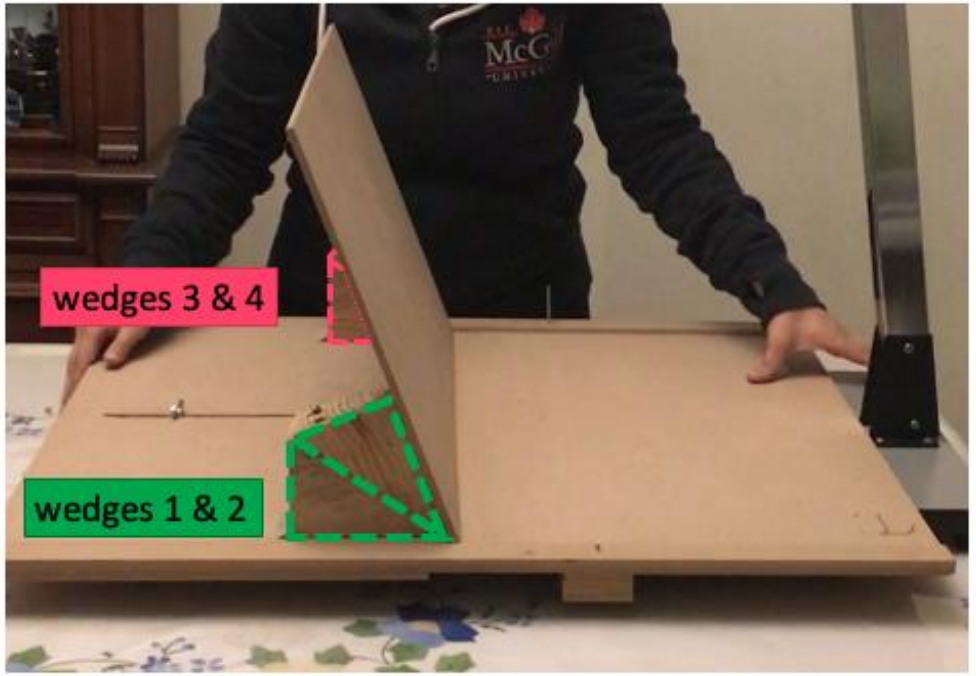
German Thomae

https://caso.com/services/document-scanning/book-scanning/

Book Cradle: Configurations

Hold the book opened at 110º angle
by using four wedges of 35º

https://www.telescopiomania.eu/9161-reproduction-table-bresser-br-cst-copy-stand-40x48-cm-4007922033389.html



German Thomae

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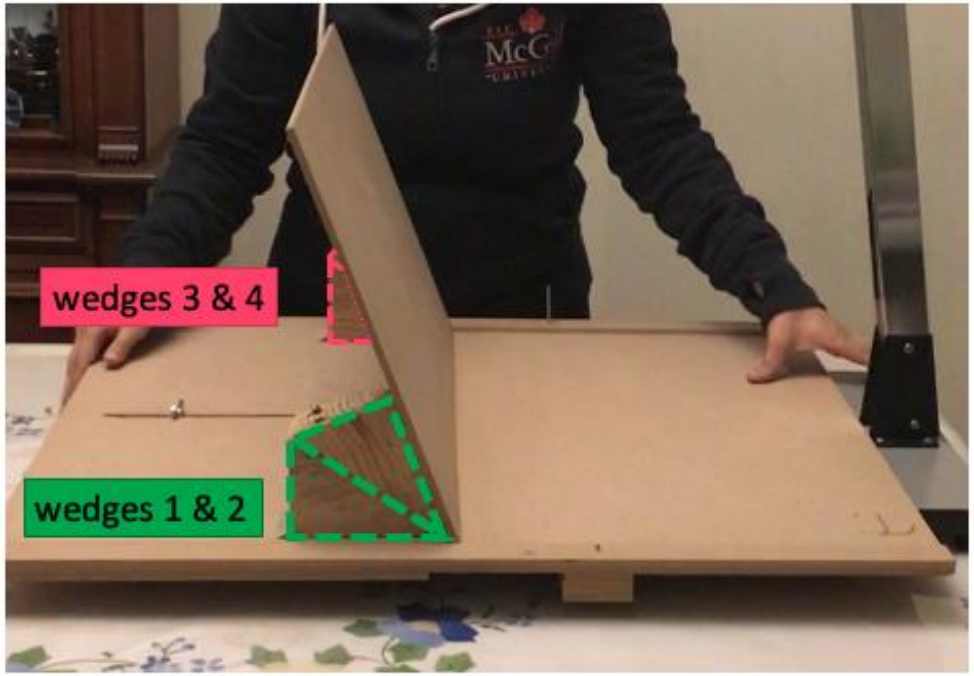
https://www.bsb-muenchen.de/einblicke/vom-buch-zum-byte-digitalisierung-an-der-bayerischen-staatsbibliothek

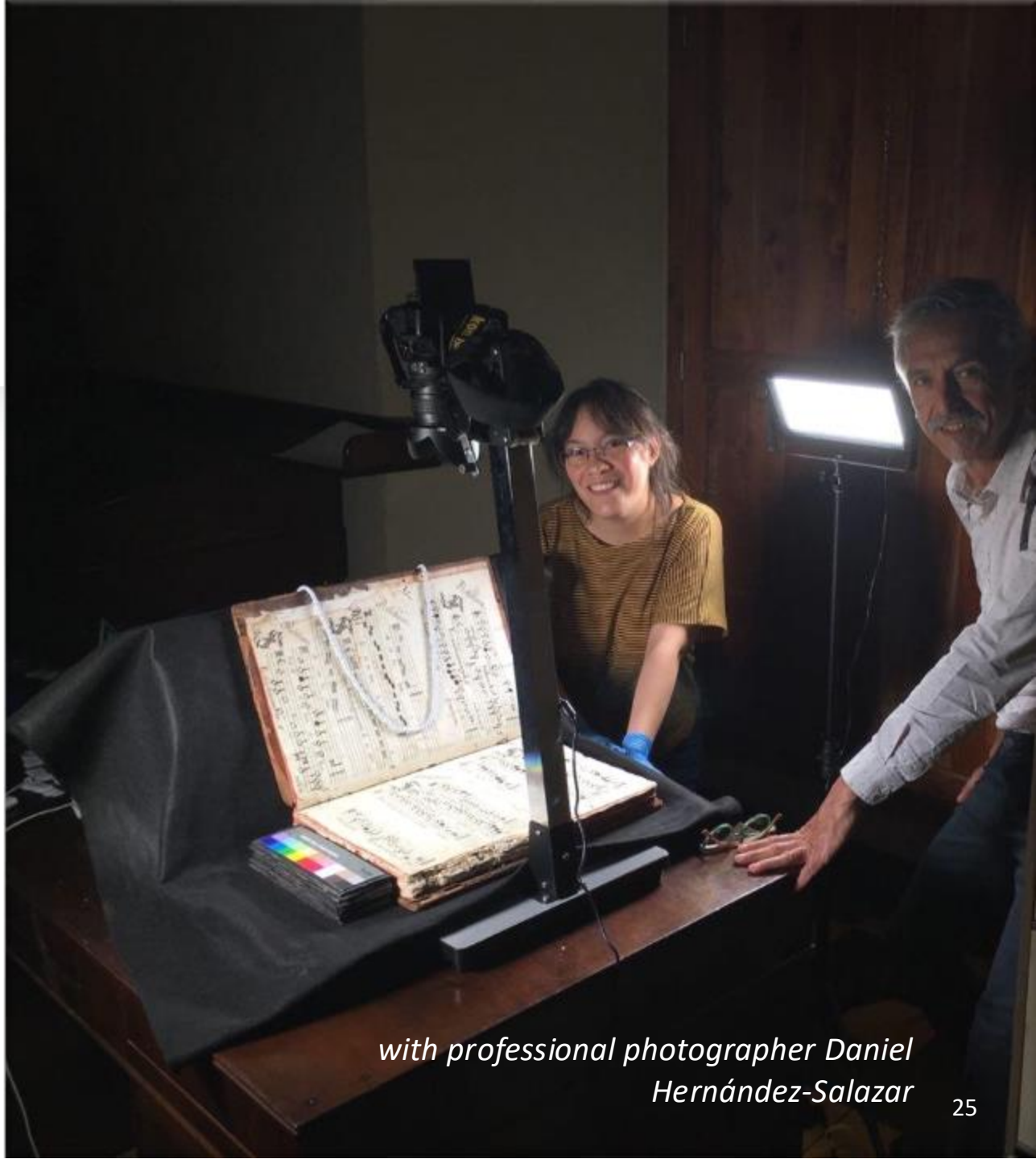


German Thomae

Digitization Stage

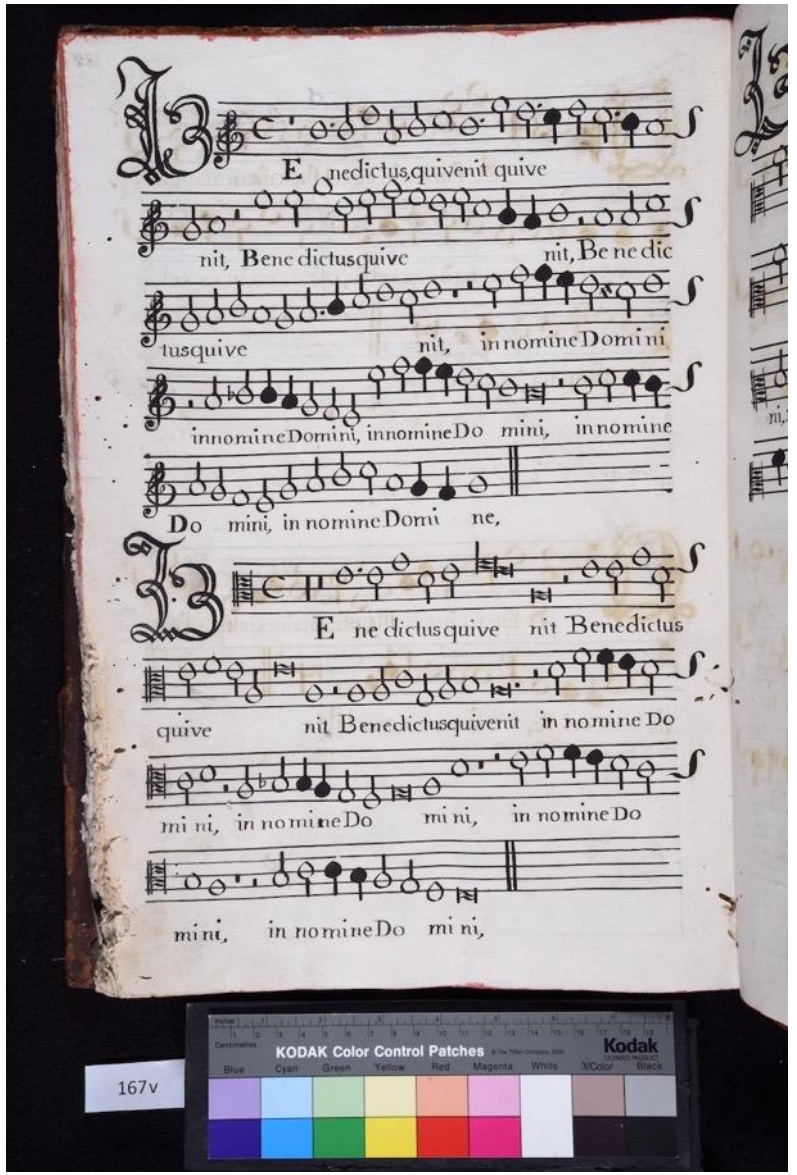
AFFORDABLE

- **Equipment:** Do-it-yourself (DIY) book scanner
- **Conservation task:** Outsourced to non-profit institution
- **Digitization task:** Conducted by me with a professional photographer hired for a few of sessions to set up the camera parameters



with professional photographer Daniel Hernández-Salazar

Results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KODAK Color Control Patches
Kodak
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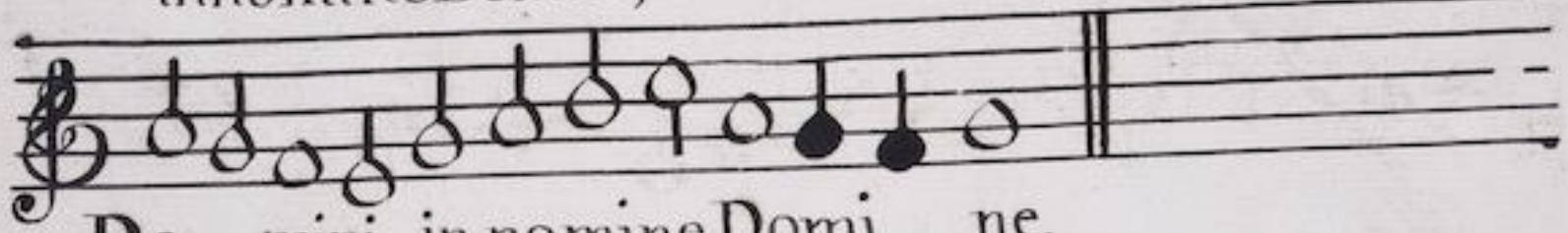
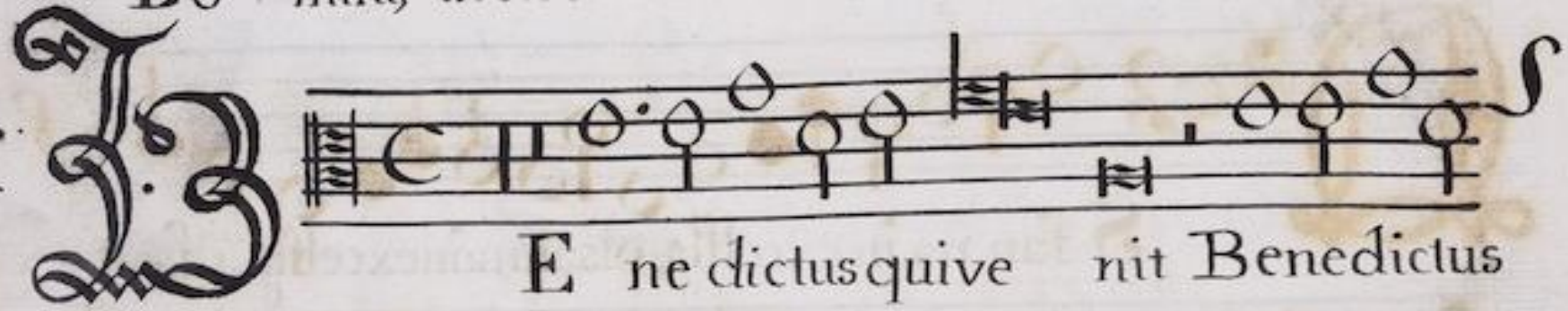
innomineDomini, innomineDo mini, innomine



Do mini, in nomineDomi ne,



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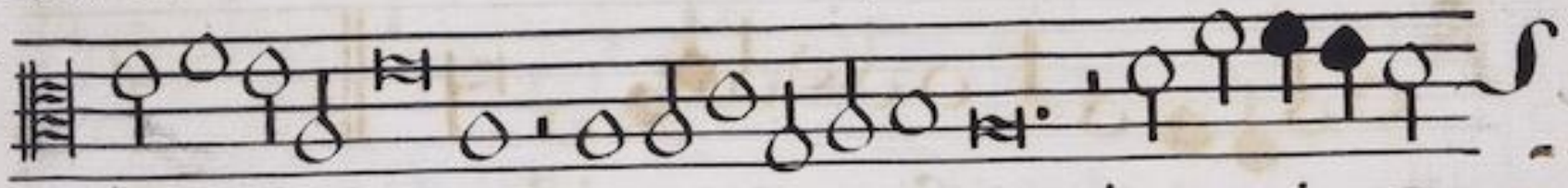
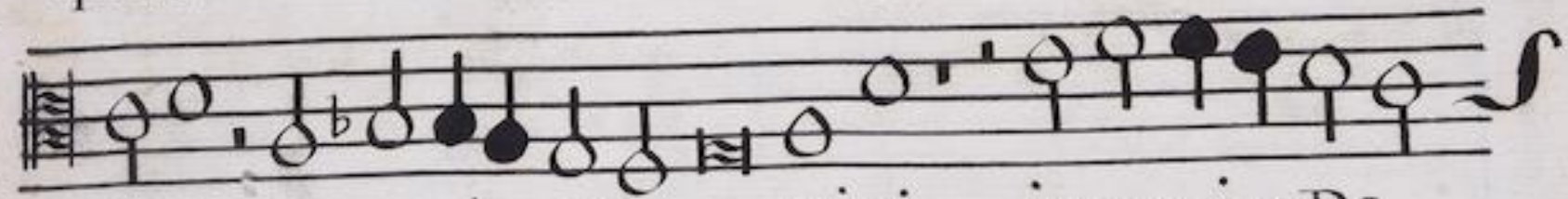
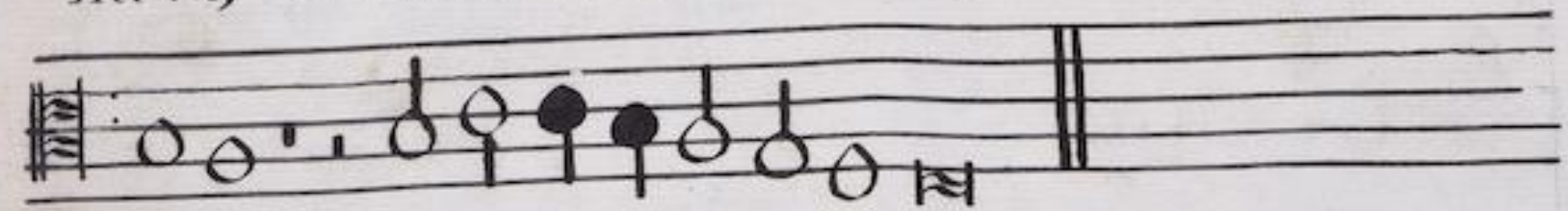


quive nit Benedictusquivenit in nomine Do



mi ni, in nomineDo mi ni, in nomineDo



2. MIR Technologies

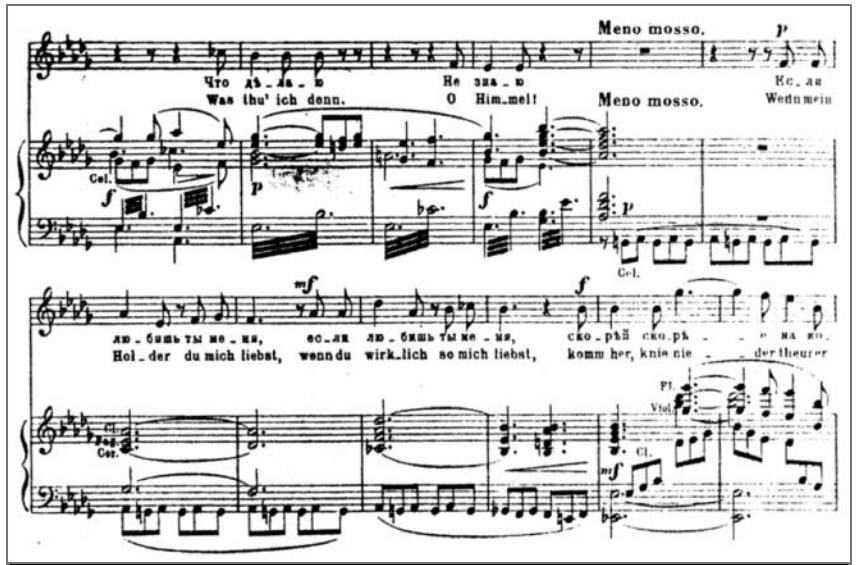
Obtaining symbolic files

Optical Music Recognition

What is Optical Music Recognition (OMR)?

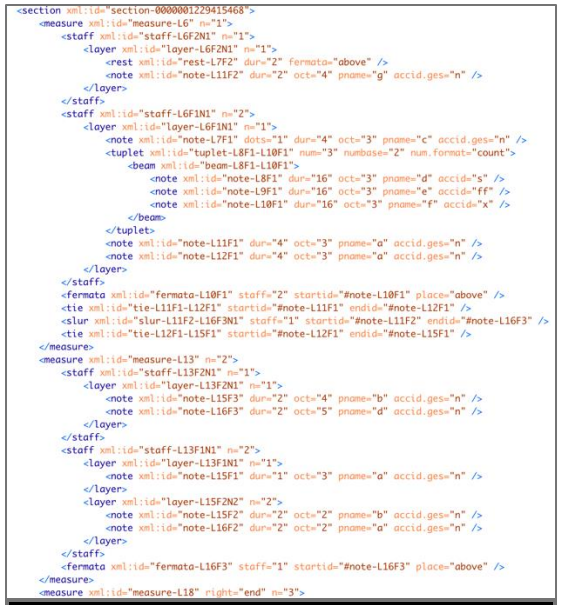
- Similar to Optical Character Recognition (OCR)
- OCR recognizes the characters in a digital text document and makes it searchable
- OMR recognizes the music characters in a digital music document and makes the images searchable by their music content

- **OMR is the process of converting images of music documents into symbolic computer representation**, such as MIDI, MusicXML, or MEI (Music Encoding Initiative)



Pixel Domain

OMR



Symbolic Domain

Optical Music Recognition (OMR)

MuRET (Music Recognition Encoding and Transcription)

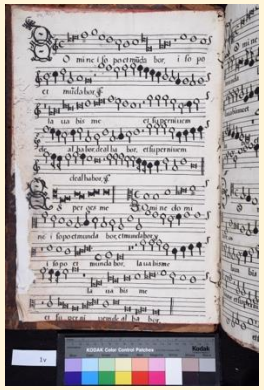
Digitization

Optical music recognition (OMR)
with human correction

MURET
Music Recognition, encoding, and transcription

Automatic scoring up
&
editorial correction

MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC



Digital image

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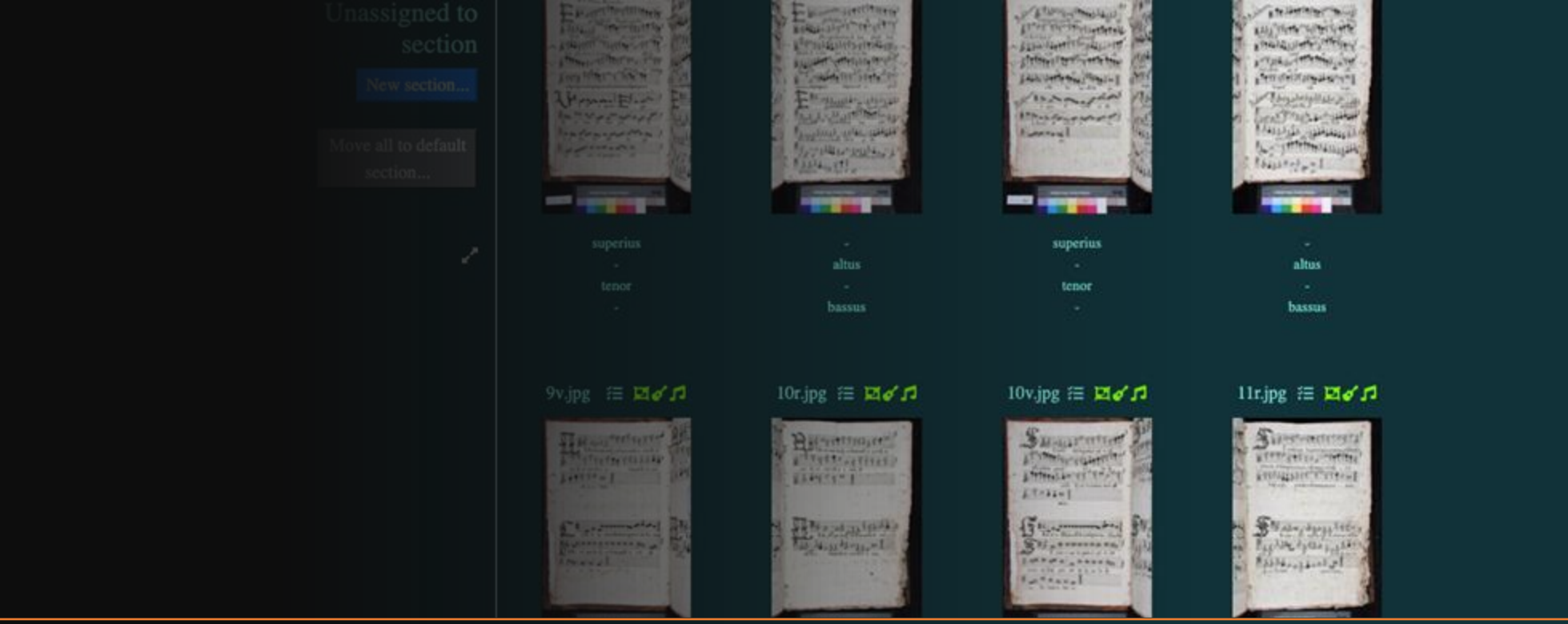
MEI Parts file
encodes the **symbols** in each **part/voice** of the images



MuRET

Optical music recognition framework that supports mensural notation

MURET

Music Recognition, encoding, and transcription

Developed by David Rizo, University of Alicante

MURET

Guatemala / 3 Vidi aquam

Logout as **martha**

Document overview

Right click on selected images for further exporting and part linking

Unassigned to section

New section...

Move all to default section...

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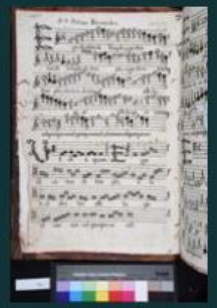

superius
-
tenor
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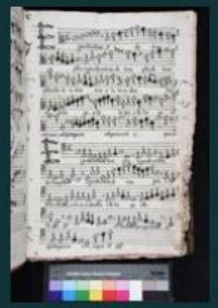
8r.jpg



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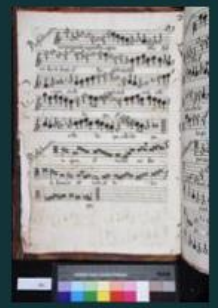
altus
-
bassus

8v.jpg



superius
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tenor
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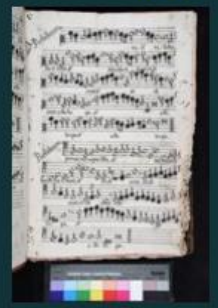
9r.jpg



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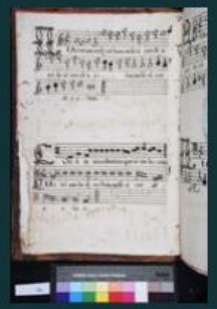

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tenor
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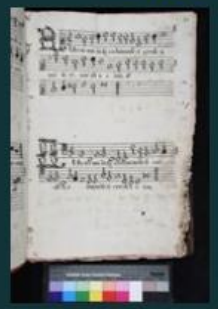
10r.jpg



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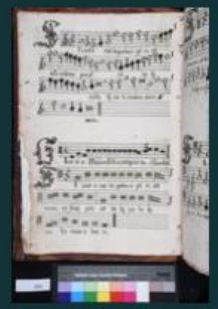
10v.jpg



superius
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tenor
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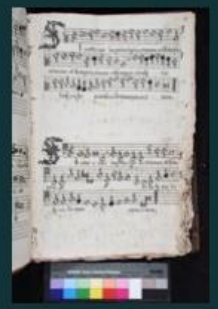
11r.jpg



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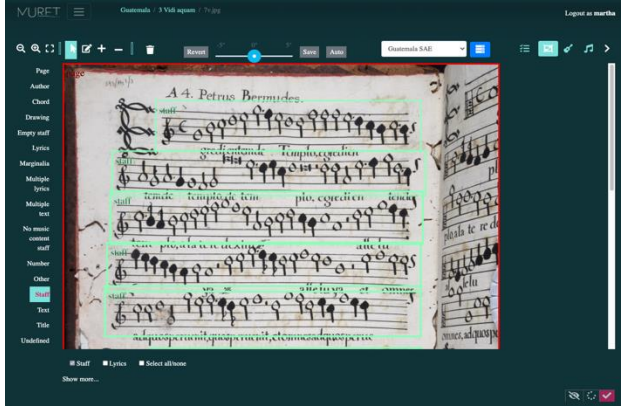
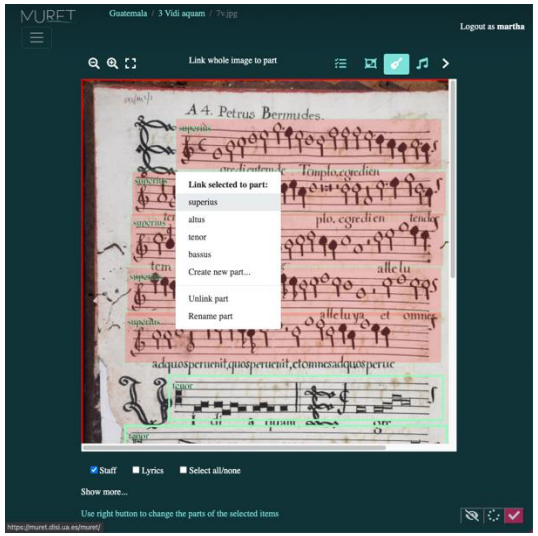
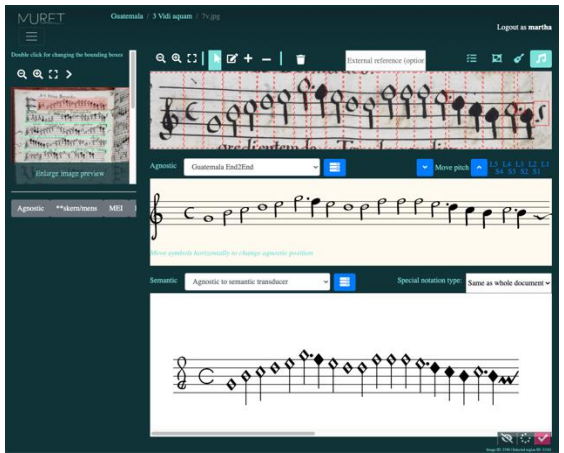
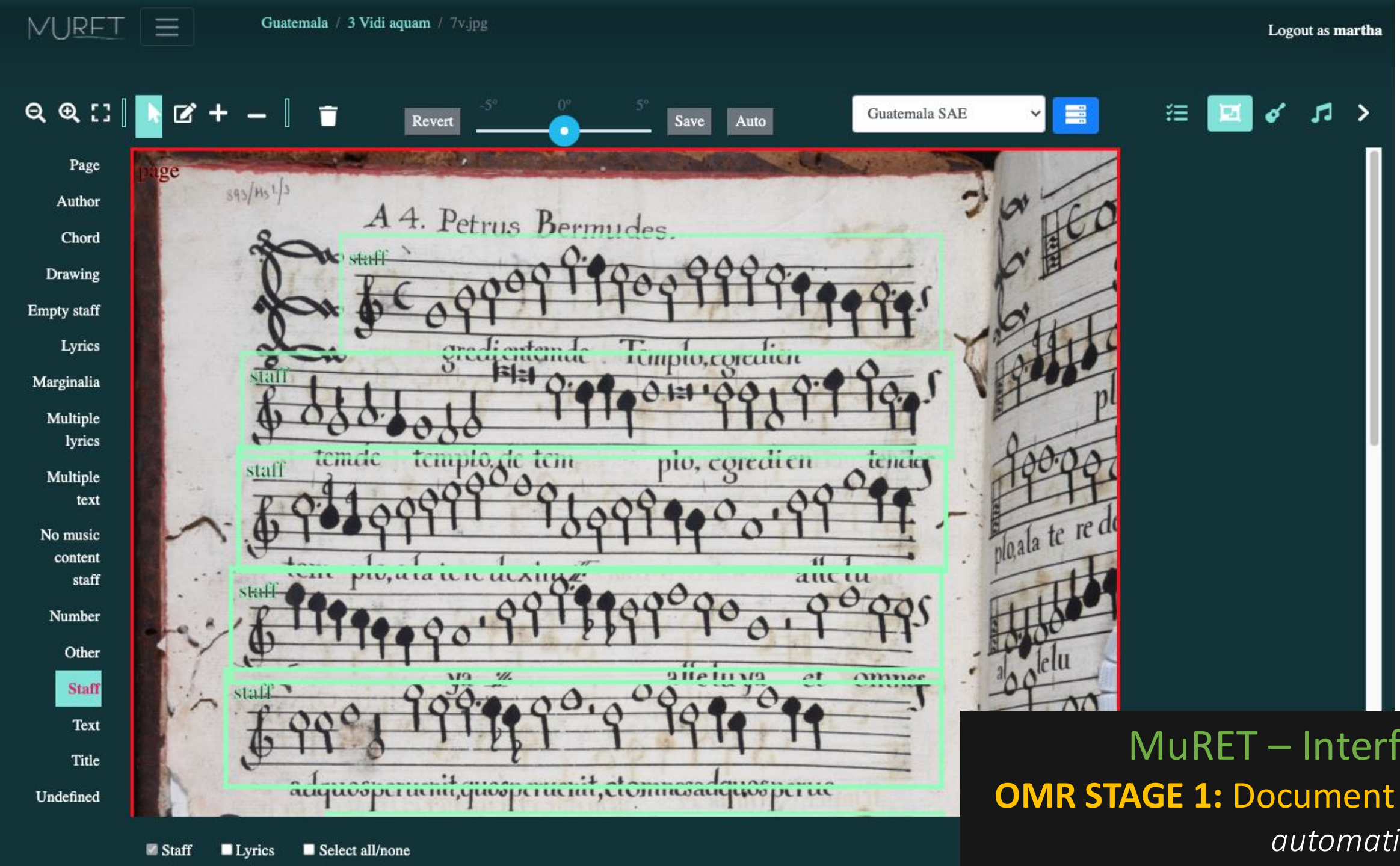
bassus





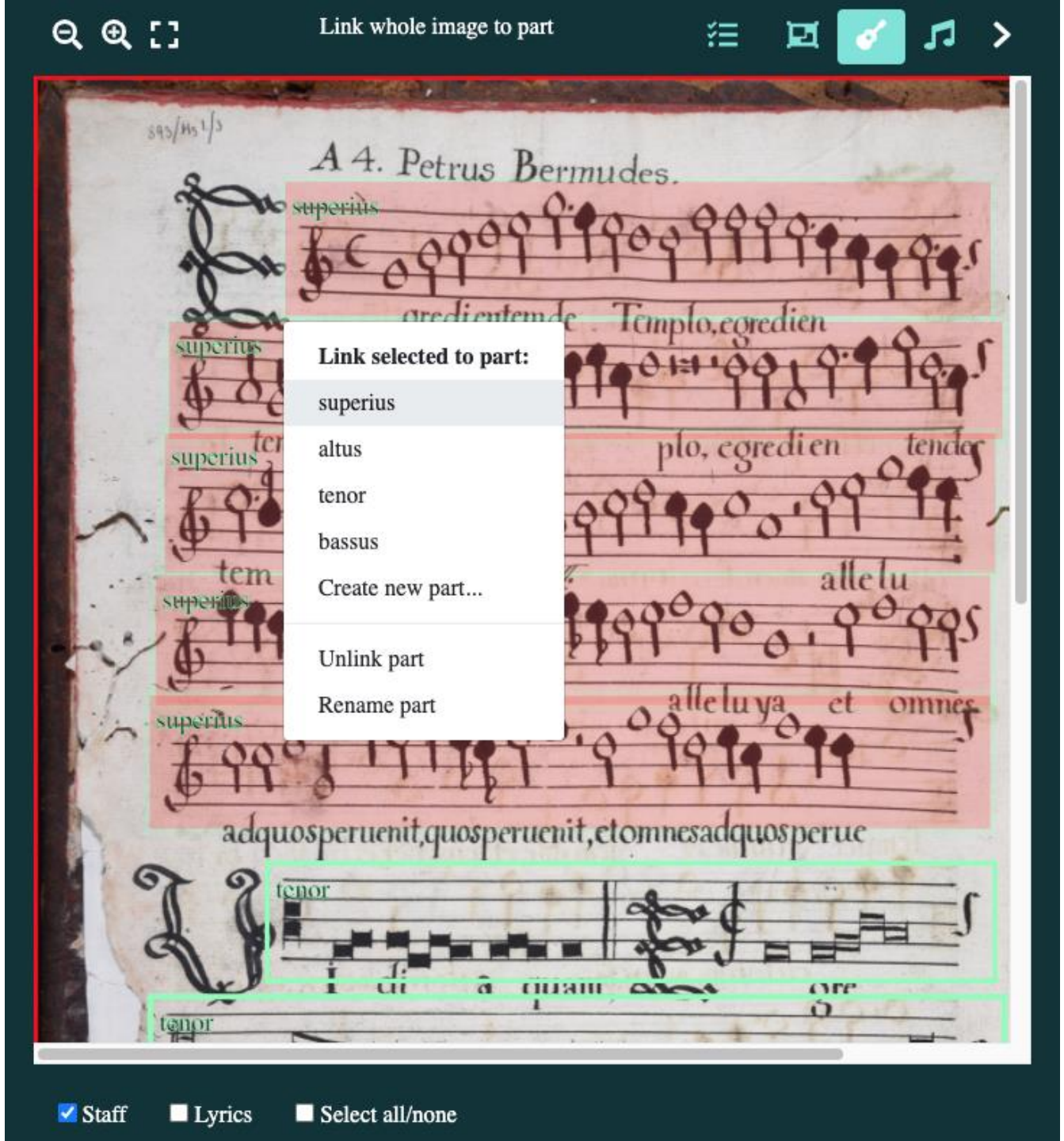




MuRET – Interface # 1

OMR STAGE 1: Document Analysis

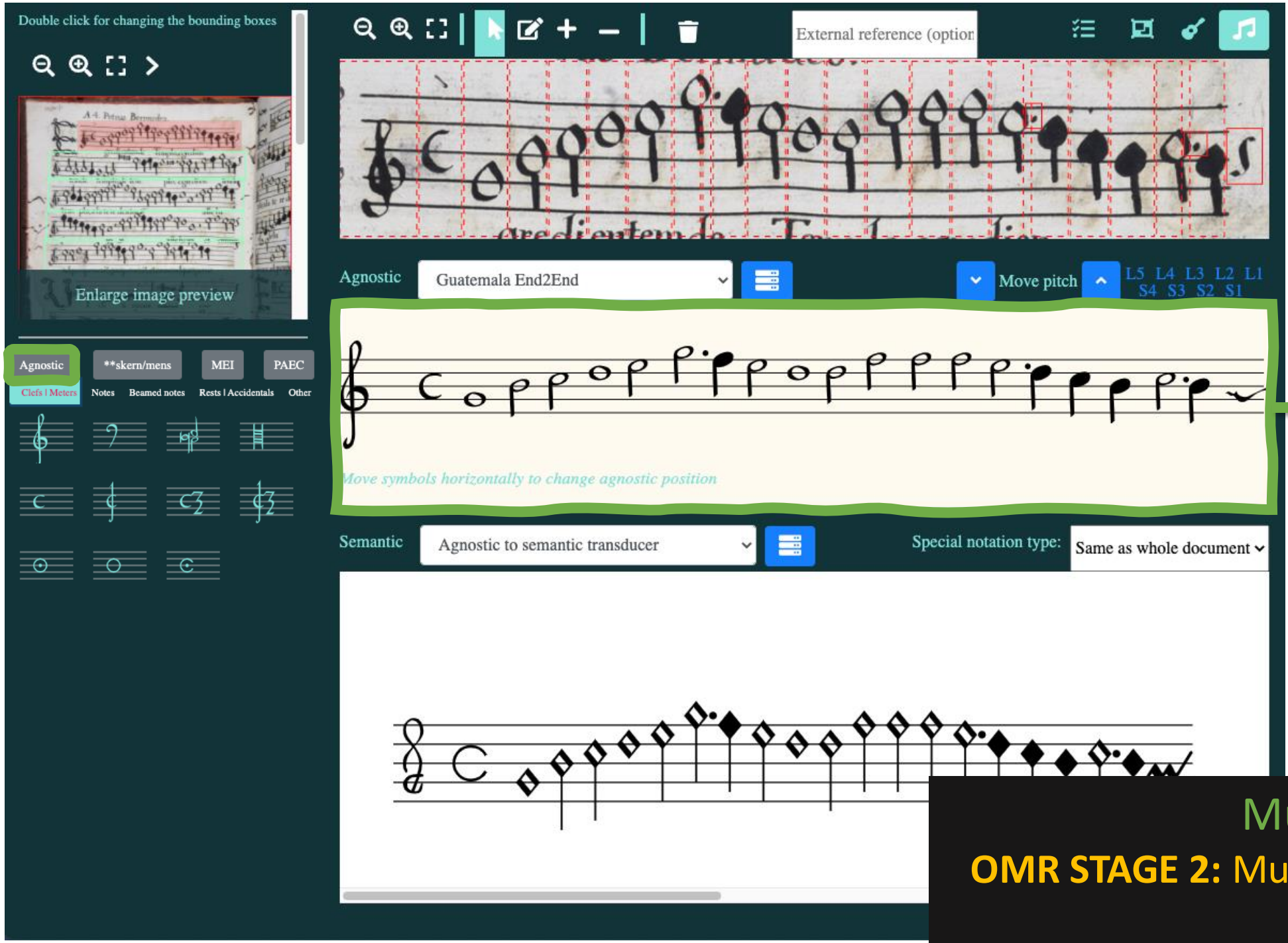
automatic process



MuRET – Interface # 2

Voice assignation

manual process

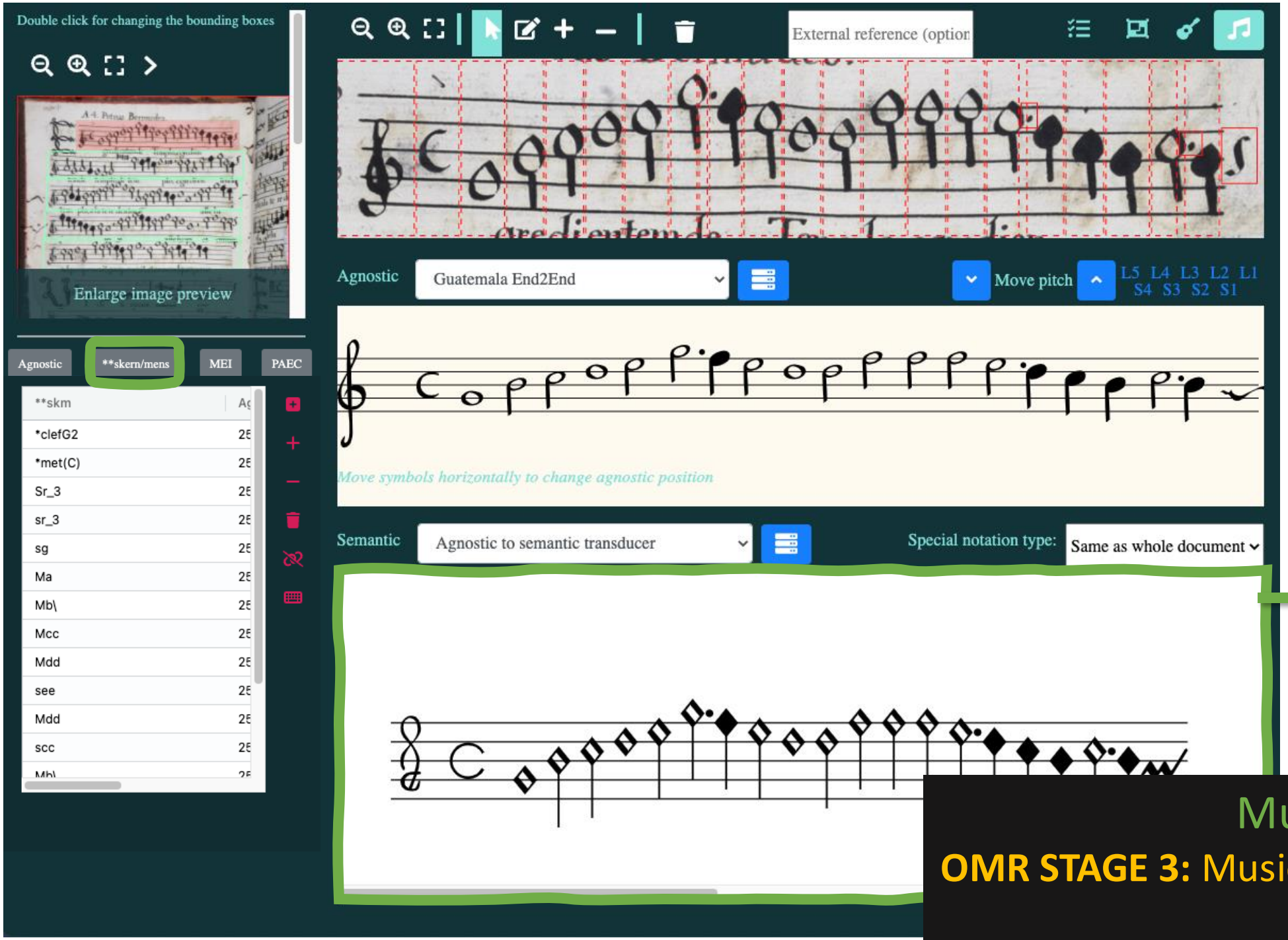


agnostic encoding

MuRET – Interface # 3

OMR STAGE 2: Music Symbol Recognition

automatic process



MuRET – Interface # 3

OMR STAGE 3: Music Notation Recognition

automatic process

MURET

Guatemala / 3 Vidi aquam

Logout as **martha**

Document overview

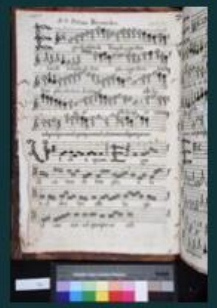
Right click on selected images for further exporting and part linking

Unassigned to section

New section...

Move all to default section...

7v.jpg



superius
-
tenor
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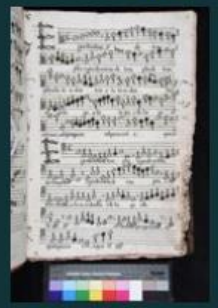
8r.jpg



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altus
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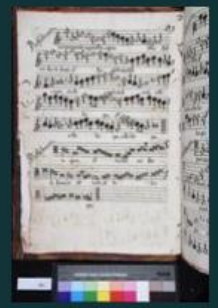
bassus

8v.jpg



superius
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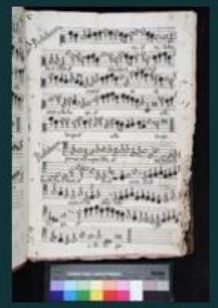
9r.jpg



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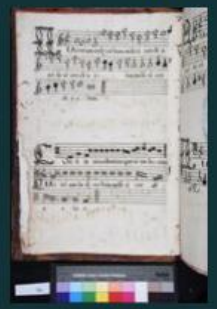
9v.jpg



superius
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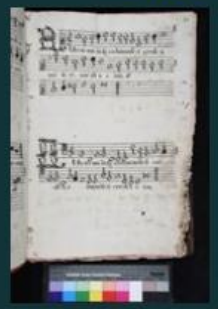
10r.jpg



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altus
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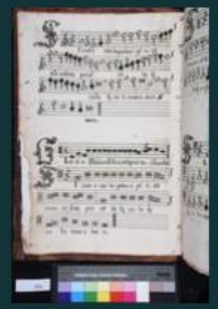
10v.jpg



superius
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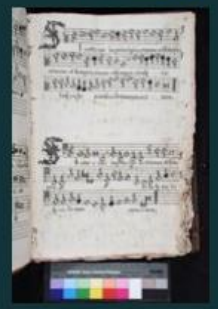
11r.jpg



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altus
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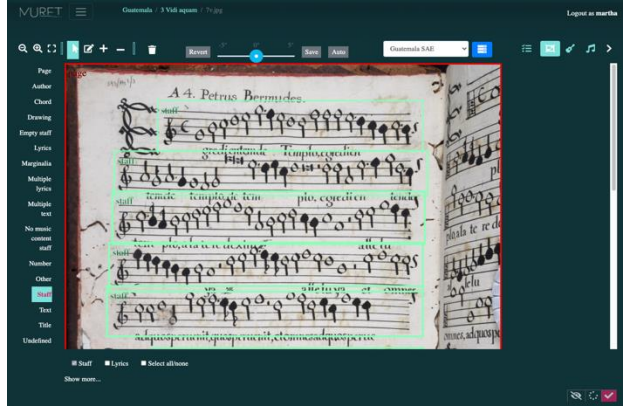
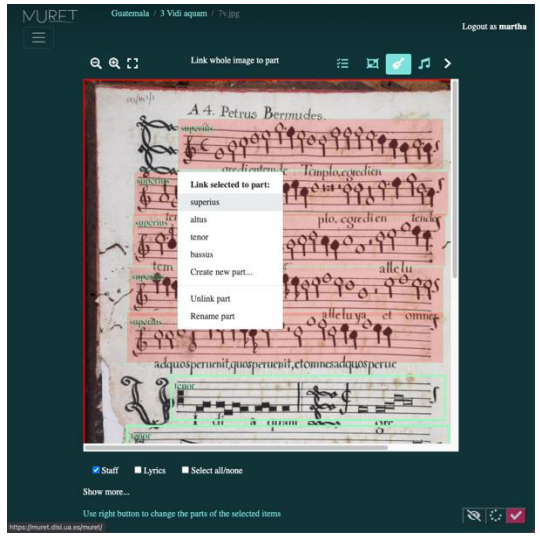
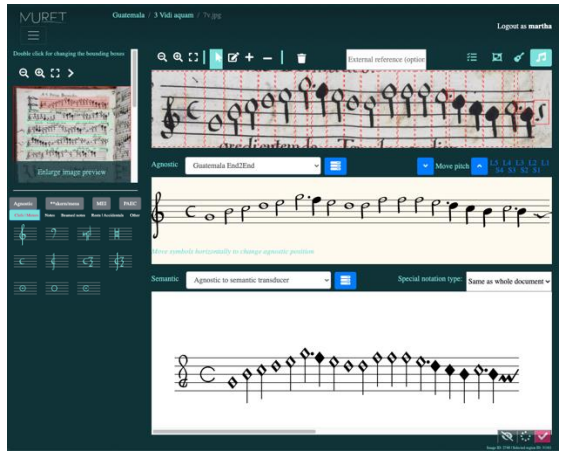
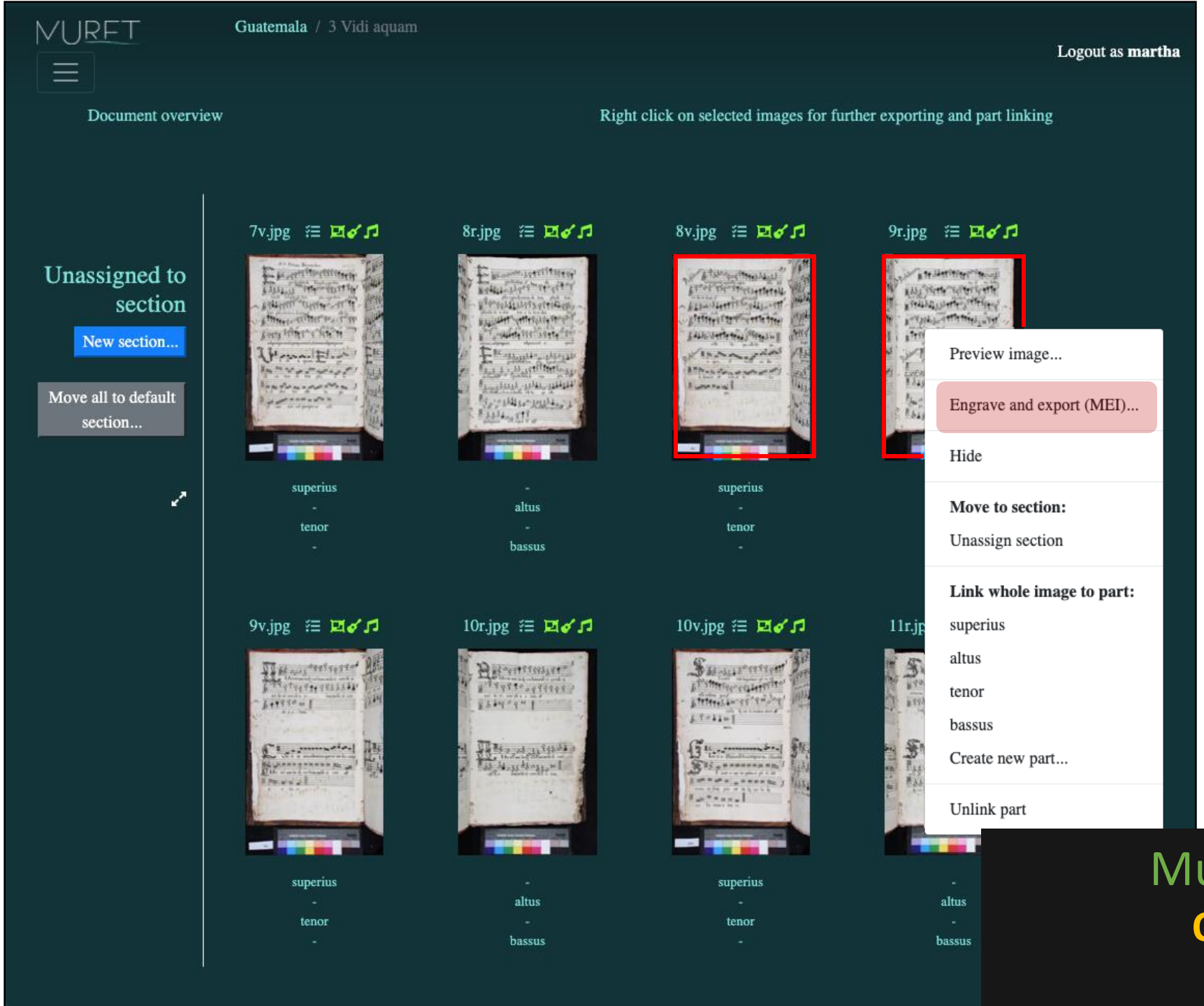
bassus









MuRET – Overview Interface

OMR STAGE 4: Music Encoding

automatic process

3. MIR Technologies

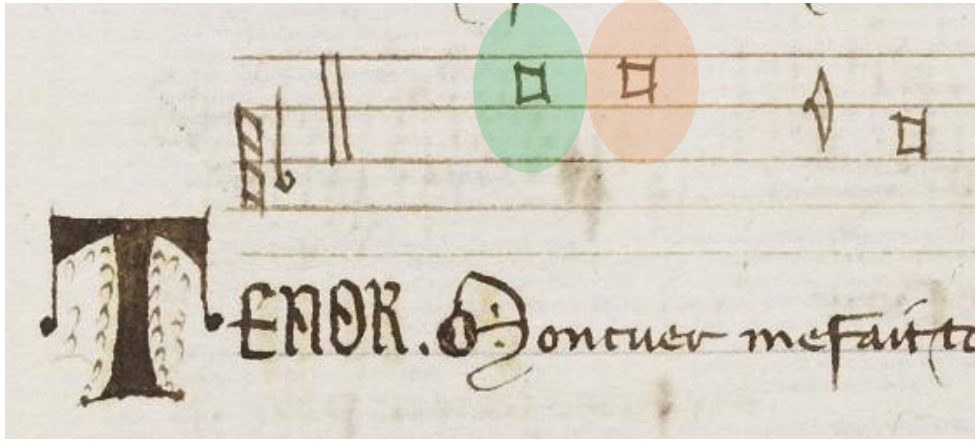
Obtaining symbolic files

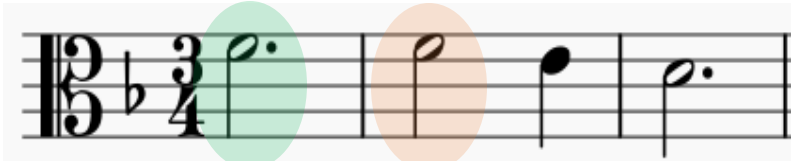
Interpreter of mensural notation

(automatic “scoring up” / “voice alignment”)

What is the Issue with Mensural Notation?

The note shape (the type of note) is not enough to convey the duration of a note.



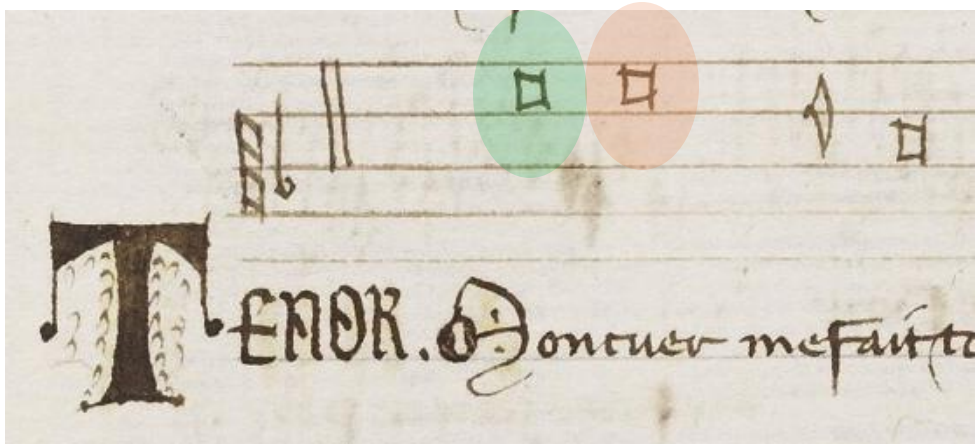


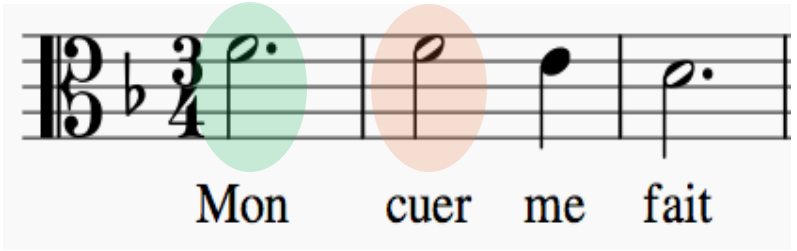
3 quarter notes

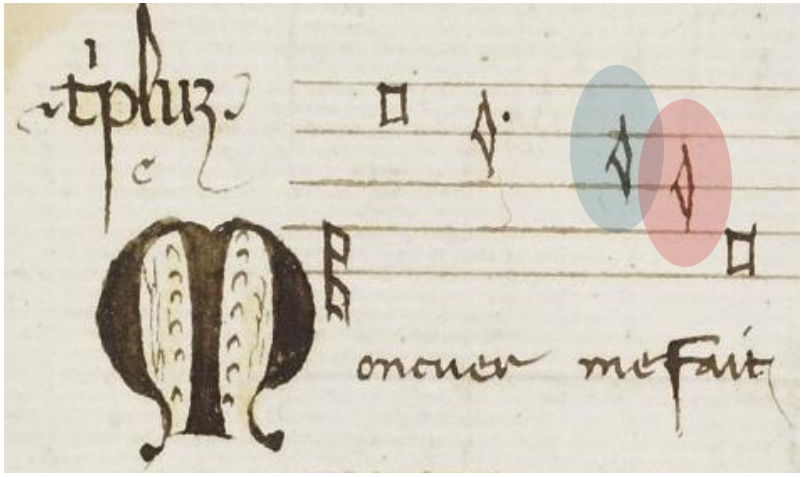
2 quarter notes

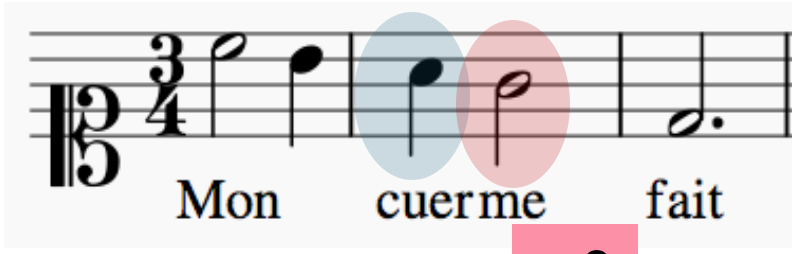
What is the Issue with Mensural Notation?

The note shape (the type of note) is not enough to convey the duration of a note.









x 2

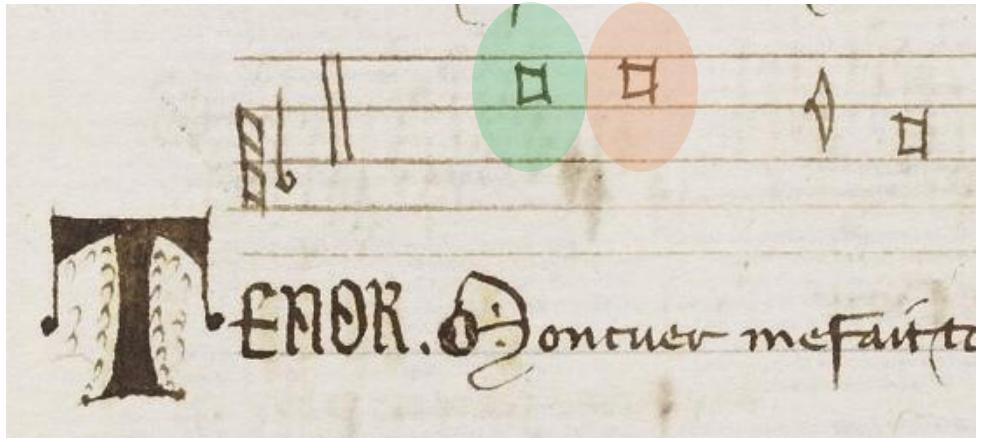
The duration of the individual note symbols in mensural notation depends on

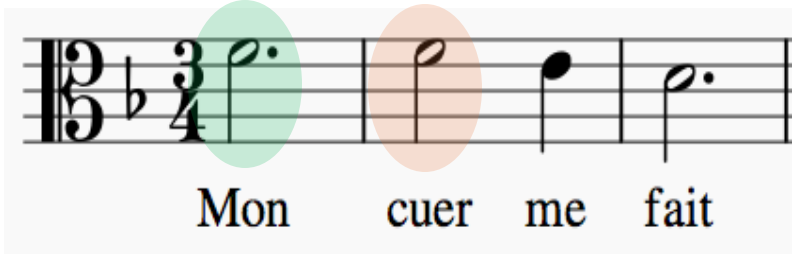
(1) the **"mensuration"**
or *meter* of the piece,
which can be *duple or triple meter*
(gives the value of the note by default)

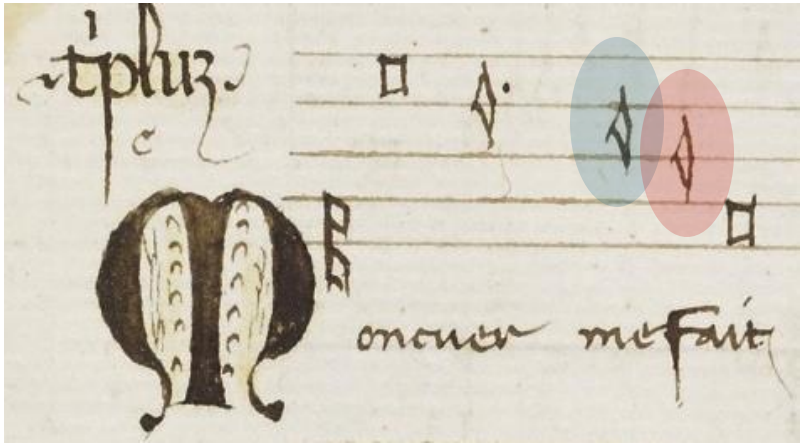
(2) In **triple meter**,
the **duration** of the individual
note symbols is not absolute, but
rather **depends on "context"**

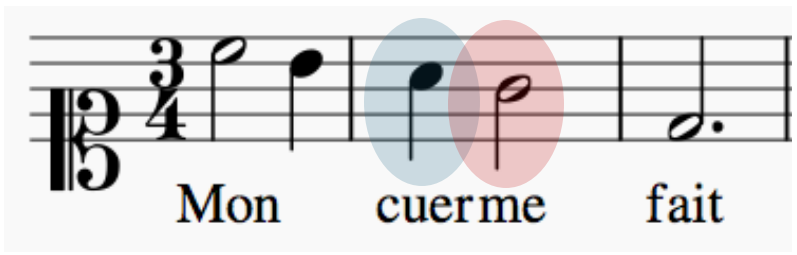
What is the Issue with Mensural Notation?

In **triple meter**, the note shape is not enough to convey the duration of a note. **The note's default duration can be modified by the context** (i.e., notes preceding or following)





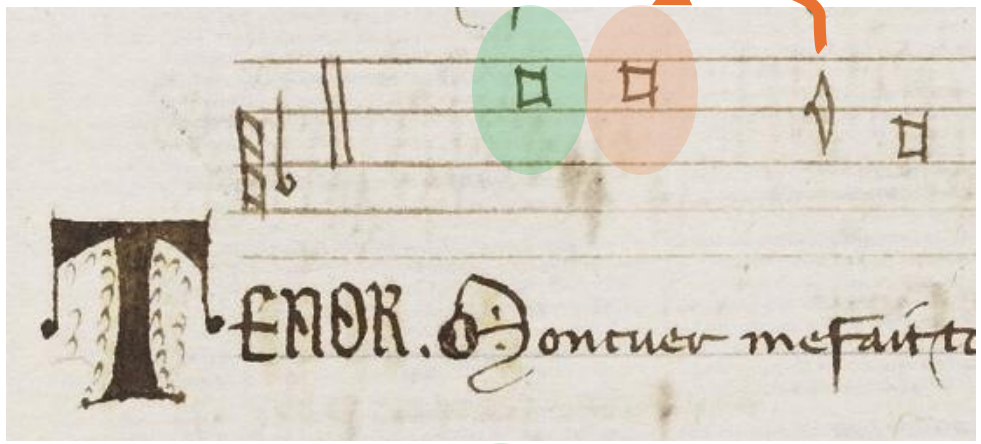




What is the Issue with Mensural Notation?

In **triple meter**, the note shape is not enough to convey the duration of a note. **The note's default duration can be modified by the context** (i.e., notes preceding or following)

IMPERFECTION



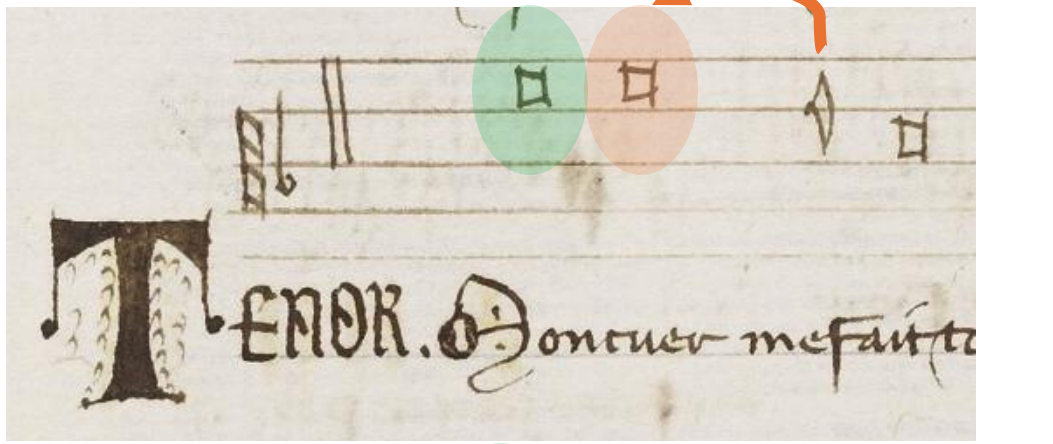
perfecta (ternary)

imperfecta (binary)

What is the Issue with Mensural Notation?

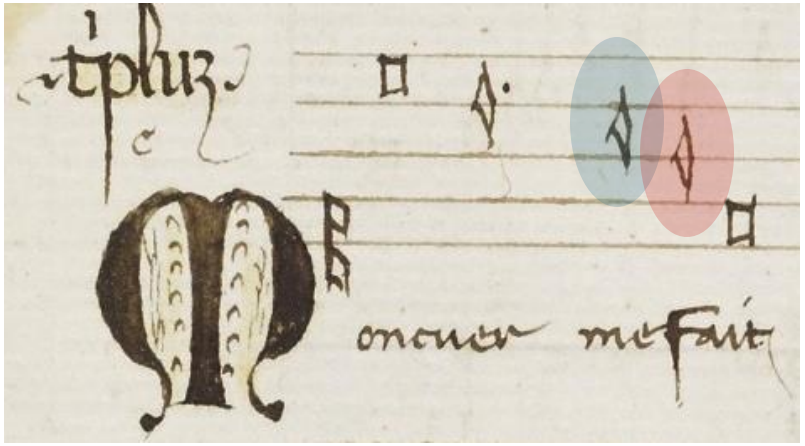
In **triple meter**, the note shape is not enough to convey the duration of a note. **The note's default duration can be modified by the context** (i.e., notes preceding or following)

IMPERFECTION



perfecta (ternary) **imperfecta** (binary)

ALTERATION

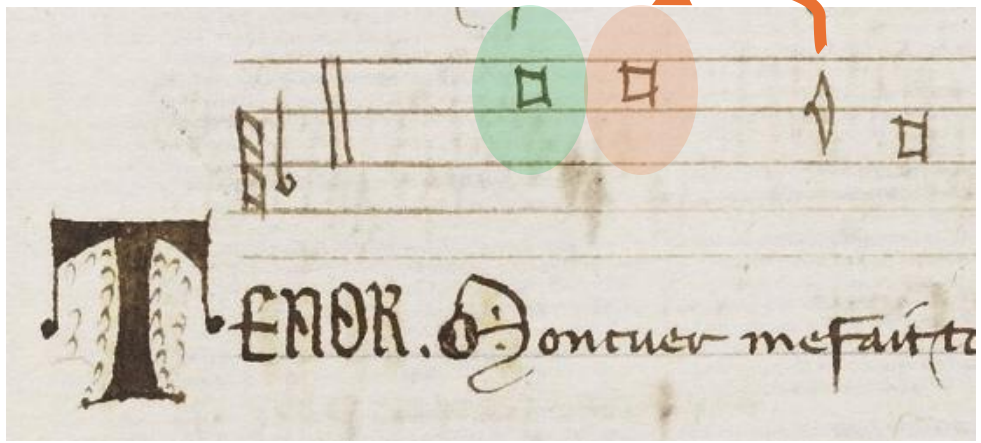


regular **altera** (*altered*, twice as long)

What is the Issue with Mensural Notation?

Principles of Imperfection and Alteration

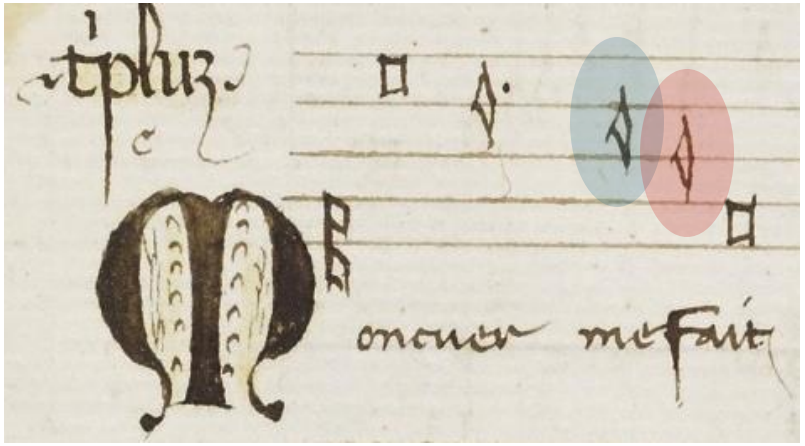
IMPERFECTION



perfecta (ternary)

imperfecta (binary)

ALTERATION



regular

altera (*altered*, twice as long)

3. MIR Technologies

Obtaining symbolic files

Interpreter of mensural notation
(automatic “scoring up” / “voice alignment”)

- Developed an expert system based on the “principles of imperfection and alteration”
- Implemented it into Python (Master’s degree)
- Re-implement it as a part of an online mensural notation editor, which is **the next tool used**

Automatic Voice Alignment & Editorial Correction

Measuring Polyphony Editor (MP-Editor)

Digitization

Optical music recognition (OMR)

with human correction

MURET

Automatic scoring up & editorial correction

MEASURING POLYPHONY

DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

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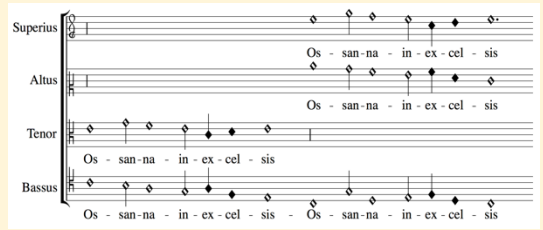
<mei>
 <music>
  <staff n="1">
   <clef line="2" shape="G"/>
   <note dur="semibrevis" pname="g" oct="5"/>
   <note dur="semibrevis" pname="d" oct="5"/>
   <dot/>
   <note dur="minima" pname="c" oct="5"/>
   <ligature form="recta">
    <note dur="semibrevis" pname="d" oct="5"/>
    <note dur="semibrevis" pname="g" oct="4"/>
   </ligature>
   <note dur="brevis" pname="b" oct="4"/>
  </staff>
 </music>
</mei>
```

MEI Parts file

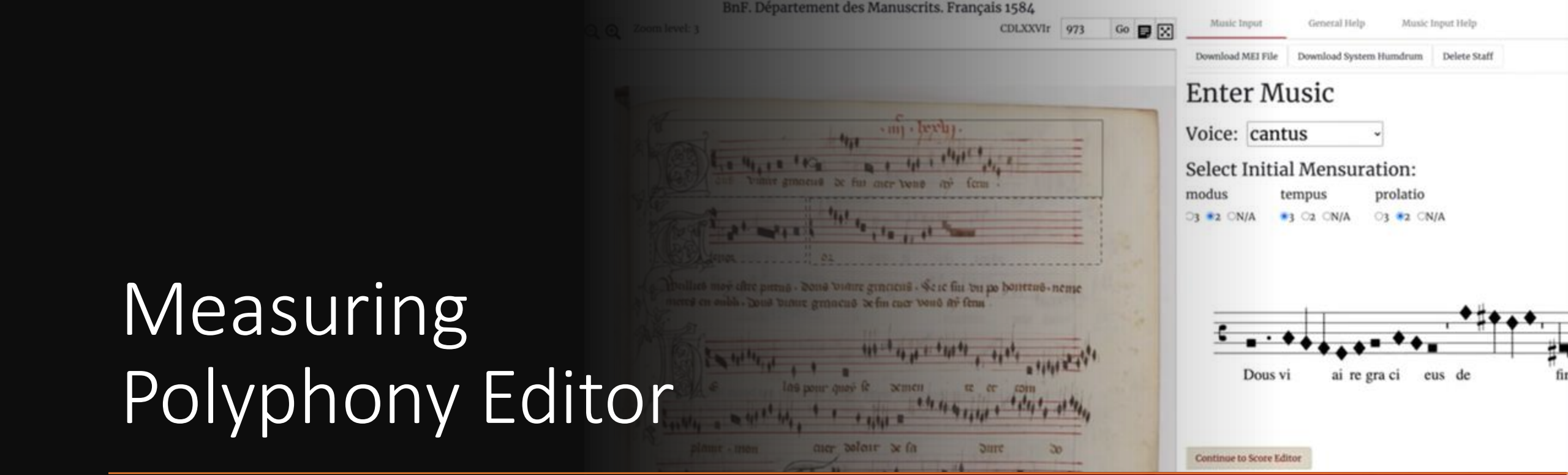
encodes the **symbols** in each **part/voice** of the images



MEI Score file

interpreted durations

(i.e., *alteration* & *imperfection*)



Measuring Polyphony Editor

Online editor for mensural notation

Karen Desmond (PI), Maynooth University

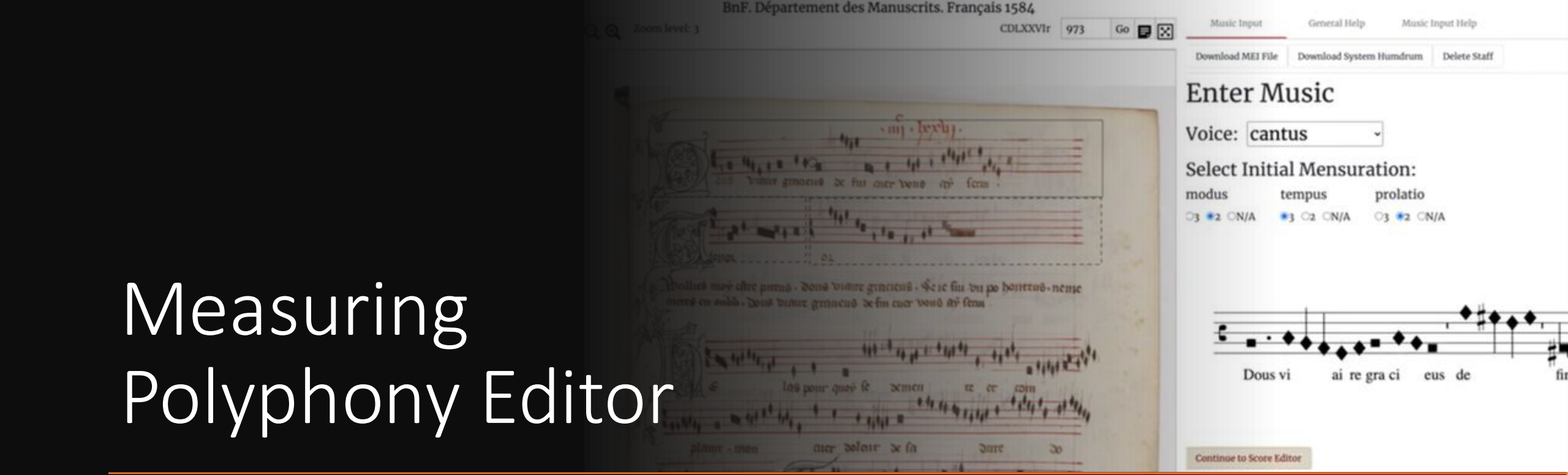
Mostly developed at McGill University:

- **Juliette Regimbal** (lead developer)
- **Martha E. Thomae** (automatic voice alignment function)

And with **Laurent Pugin** (Verovio), **Craig Sapp** (Humdrum), and **Andrew Hankinson** (IIIF)

MEASURING POLYPHONY

DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC



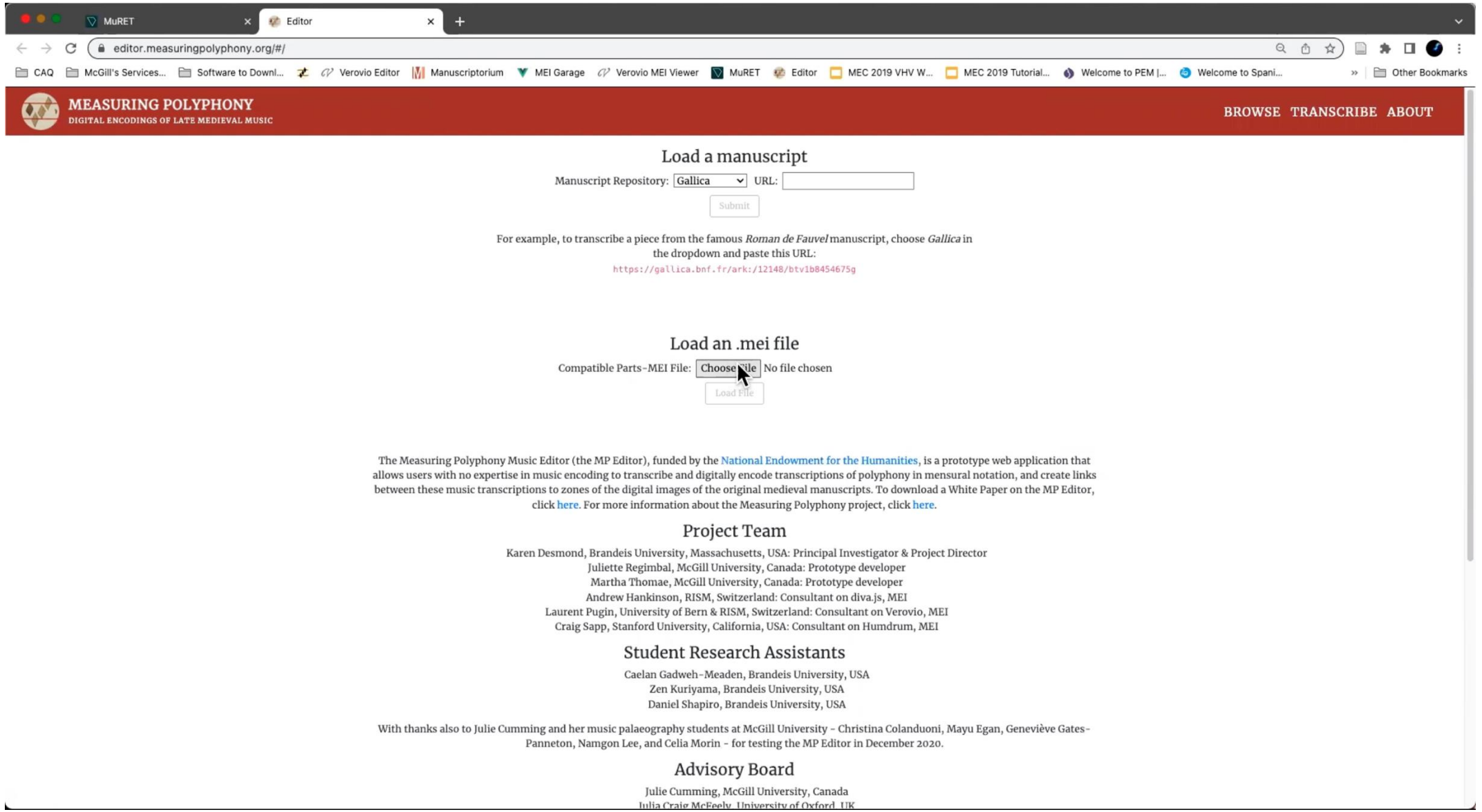
Measuring Polyphony Editor

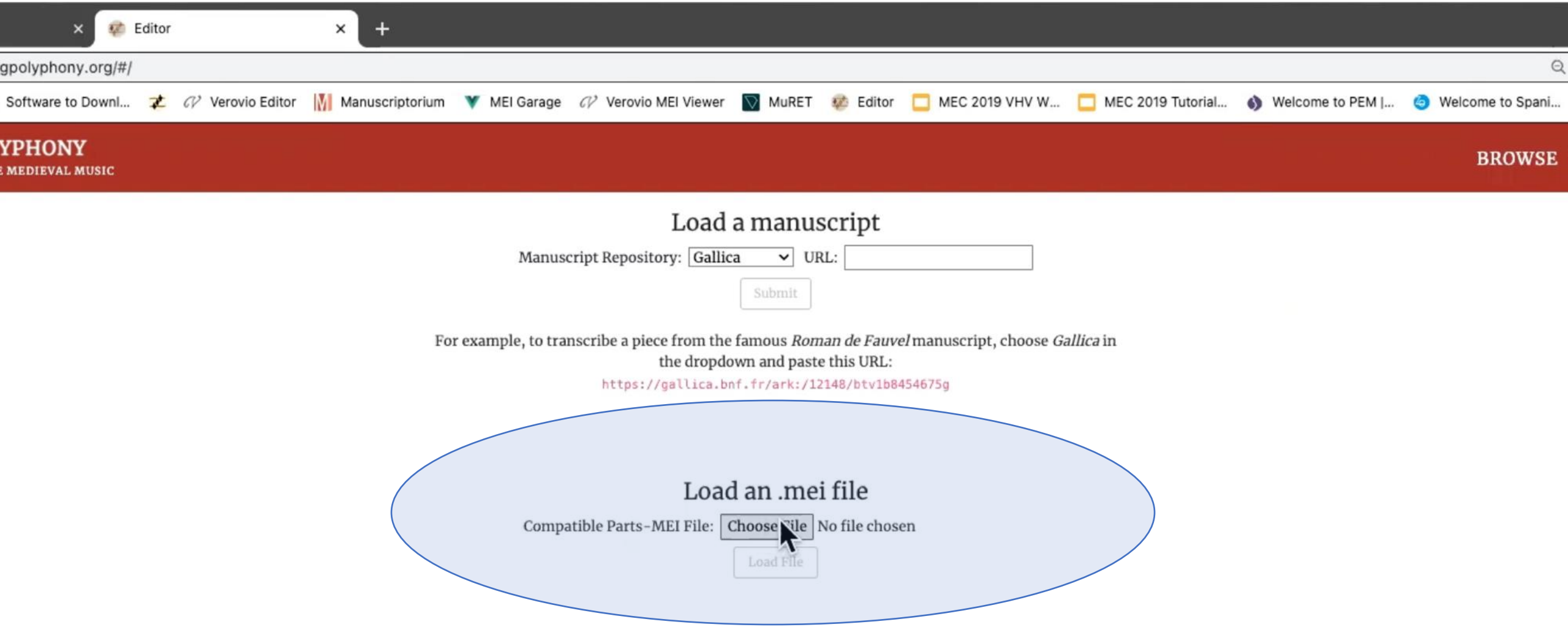
Online editor for mensural notation with **two parts:**

1. **Input Editor:** The user types in the notes using the computer keyboard
2. **Score Editor:** It processes the notes entered, computes their duration based on a system of rules, and lines up the piece in score layout

MEASURING POLYPHONY

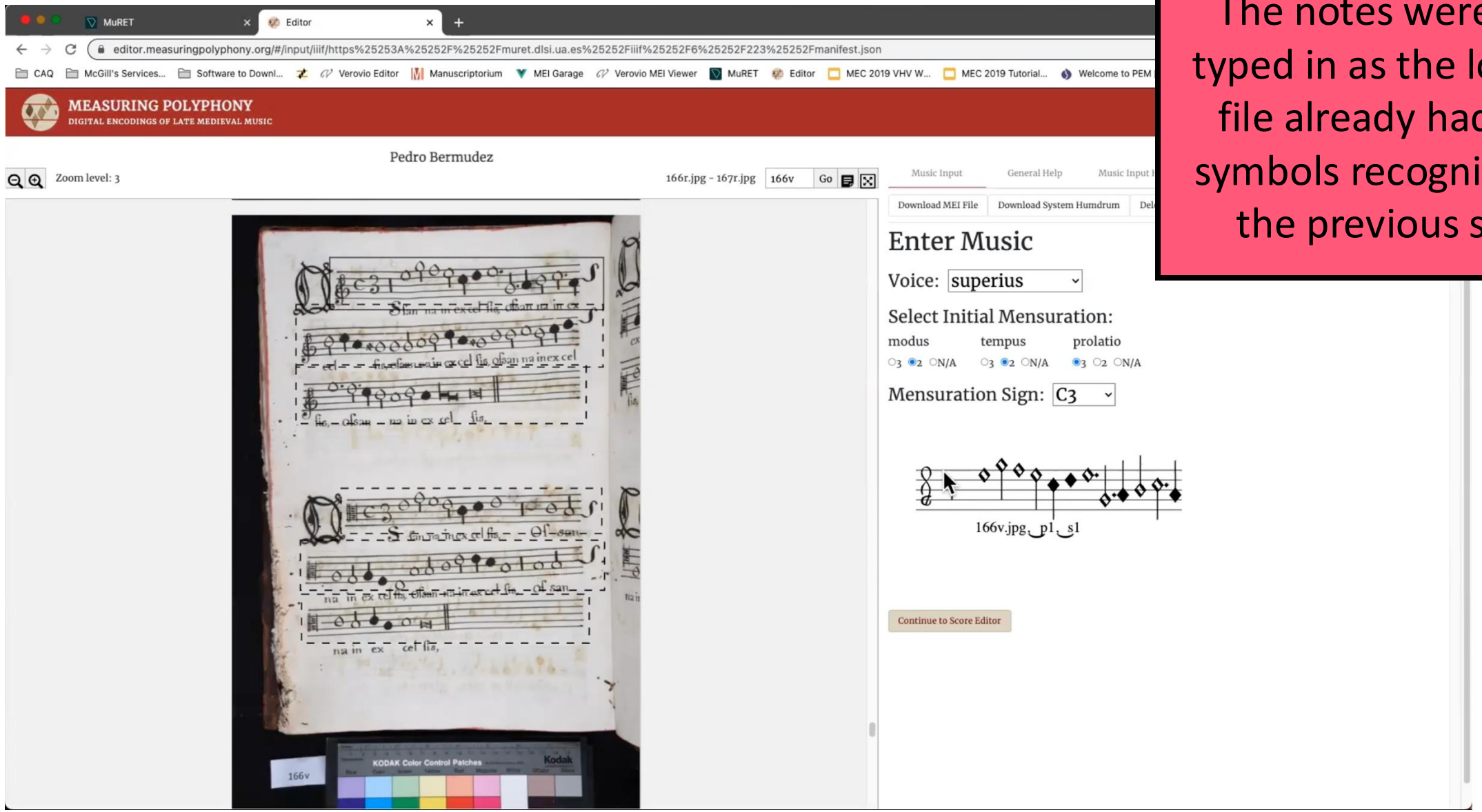
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

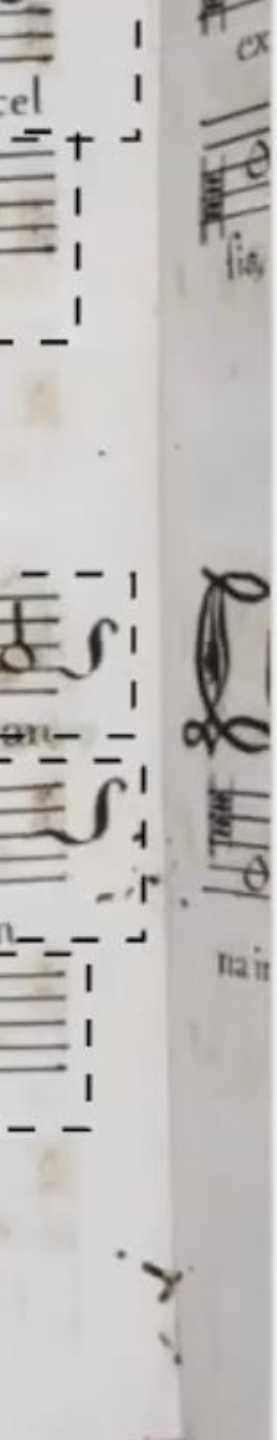

MuRET
Editor
editor.measuringpolyphony.org/#/
CAQ
McGill's Services...
Software to Downl...
Verovio Editor
Manuscriptorium
MEI Garage
Verovio MEI Viewer
MuRET
Editor
MEC 2019 VHV W...
MEC 2019 Tutorial...
Welcome to PEM |...
Welcome to Spani...
Other Bookmarks
MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC
BROWSE TRANSCRIBE ABOUT
Load a manuscript
Manuscript Repository: Gallica URL:
Submit
For example, to transcribe a piece from the famous Roman de Fauvel manuscript, choose Gallica in the dropdown and paste this URL:
https://gallica.bnf.fr/ark:/12148/btv1b8454675g
Load an .mei file
Compatible Parts-MEI File: Choose File No file chosen
Load File
The Measuring Polyphony Music Editor (the MP Editor), funded by the National Endowment for the Humanities, is a prototype web application that allows users with no expertise in music encoding to transcribe and digitally encode transcriptions of polyphony in mensural notation, and create links between these music transcriptions to zones of the digital images of the original medieval manuscripts. To download a White Paper on the MP Editor, click here. For more information about the Measuring Polyphony project, click here.
Project Team
Karen Desmond, Brandeis University, Massachusetts, USA: Principal Investigator & Project Director
Juliette Regimbal, McGill University, Canada: Prototype developer
Martha Thomae, McGill University, Canada: Prototype developer
Andrew Hankinson, RISM, Switzerland: Consultant on diva.js, MEI
Laurent Pugin, University of Bern & RISM, Switzerland: Consultant on Verovio, MEI
Craig Sapp, Stanford University, California, USA: Consultant on Humdrum, MEI
Student Research Assistants
Caelan Gadweh-Meaden, Brandeis University, USA
Zen Kuriyama, Brandeis University, USA
Daniel Shapiro, Brandeis University, USA
With thanks also to Julie Cumming and her music palaeography students at McGill University - Christina Colanduoni, Mayu Egan, Geneviève Gates-Panneton, Namgon Lee, and Celia Morin - for testing the MP Editor in December 2020.
Advisory Board
Julie Cumming, McGill University, Canada
Julia Craig McFeely, University of Oxford, UK


Editor
gpolyphony.org/#/
Software to Downl...
Verovio Editor
Manuscriptorium
MEI Garage
Verovio MEI Viewer
MuRET
Editor
MEC 2019 VHV W...
MEC 2019 Tutorial...
Welcome to PEM |...
Welcome to Spani...
YPHONY
E MEDIEVAL MUSIC
BROWSE
Load a manuscript
Manuscript Repository: Gallica URL:
Submit
For example, to transcribe a piece from the famous Roman de Fauvel manuscript, choose Gallica in the dropdown and paste this URL:
https://gallica.bnf.fr/ark:/12148/btv1b8454675g
Load an .mei file
Compatible Parts-MEI File: Choose File No file chosen
Load File
The Measuring Polyphony Music Editor (the MP Editor), funded by the National Endowment for the Humanities, is a prototype web application that allows users with no expertise in music encoding to transcribe and digitally encode transcriptions of polyphony in mensural notation, and create links between these music transcriptions to zones of the digital images of the original medieval manuscripts. To download a White Paper on the MP Editor, click here. For more information about the Measuring Polyphony project, click here.
Project Team
Karen Desmond, Brandeis University, Massachusetts, USA: Principal Investigator & Project Director

INPUT EDITOR

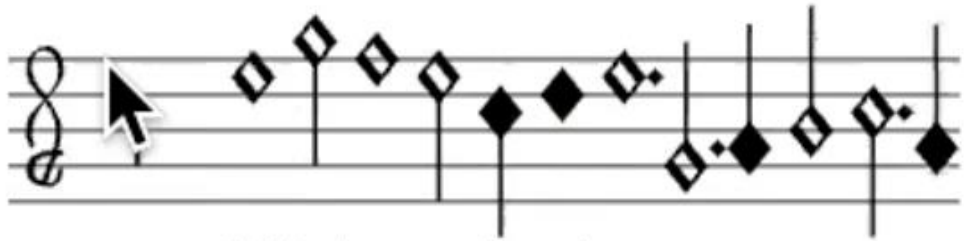
The notes were not typed in as the loaded file already had the symbols recognized in the previous step





modus	tempus	prolatio
○3 ◉2 ○N/A	○3 ◉2 ○N/A	◉3 ○2 ○N/A

Mensuration Sign: C3



166v.jpg, p1, s1

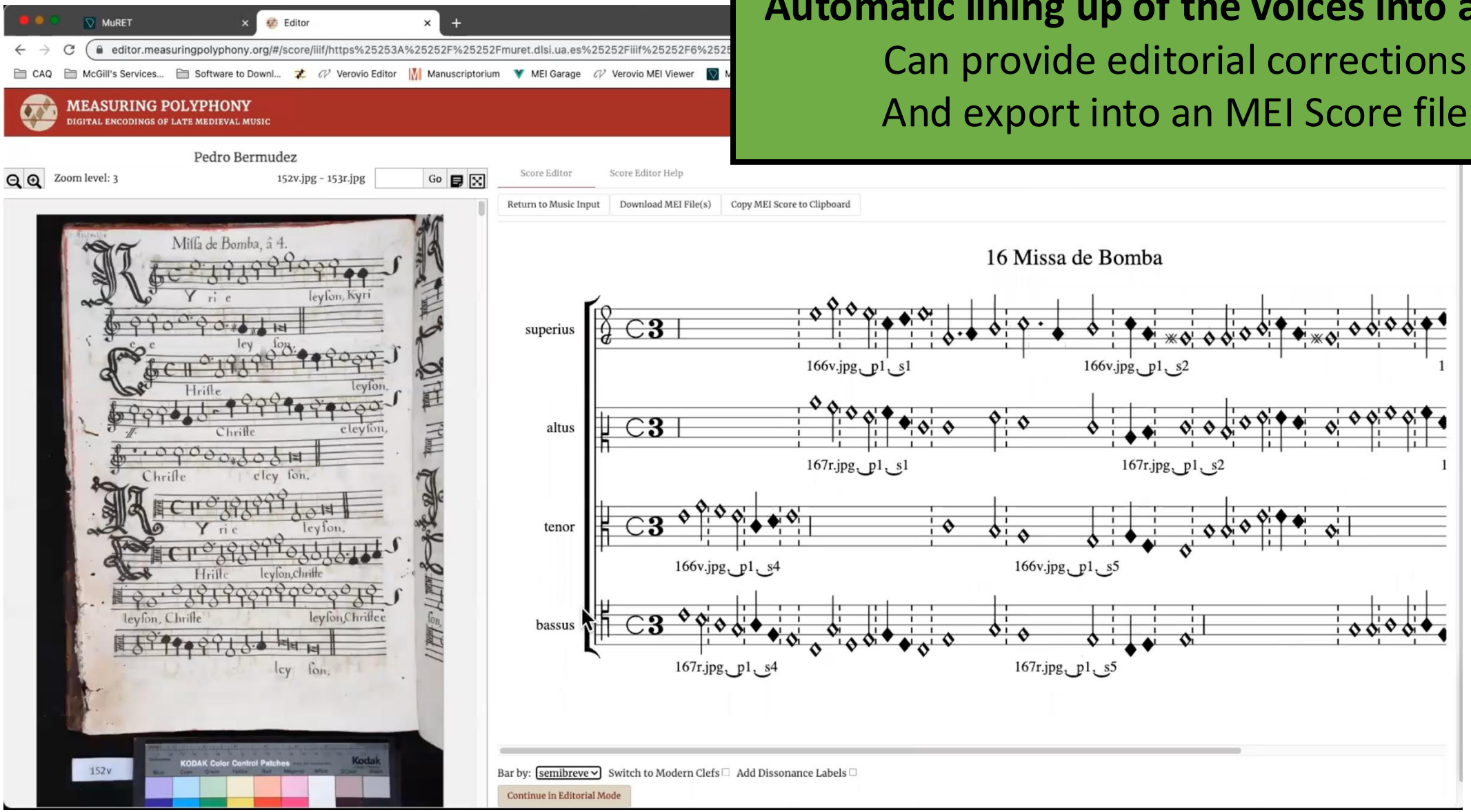
Continue to Score Editor

SCORE EDITOR

Automatic lining up of the voices into a score

Can provide editorial corrections

And export into an MEI Score file



SCORE EDITOR

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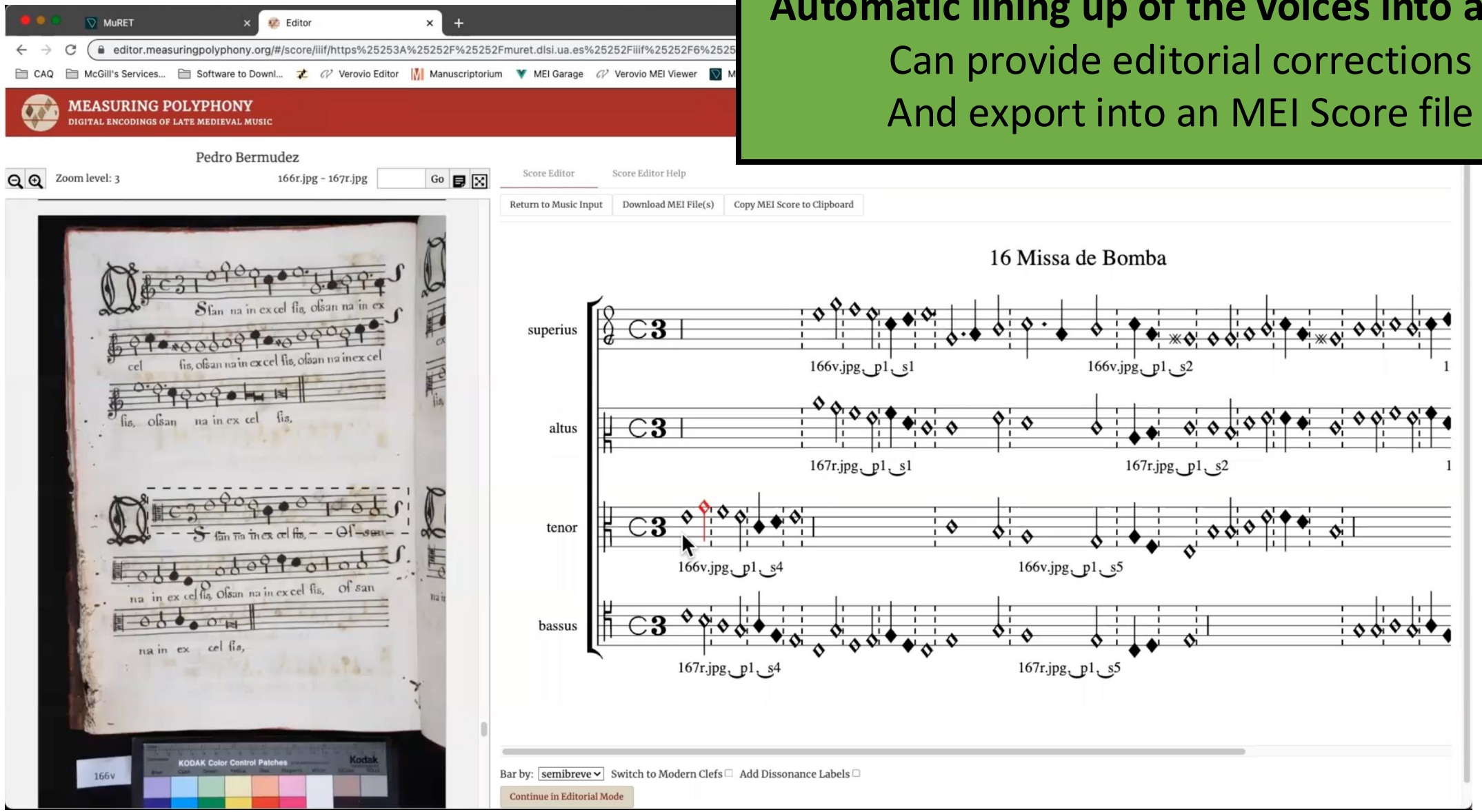

SCORE EDITOR

Automatic lining up of the voices into a score

Can provide editorial corrections

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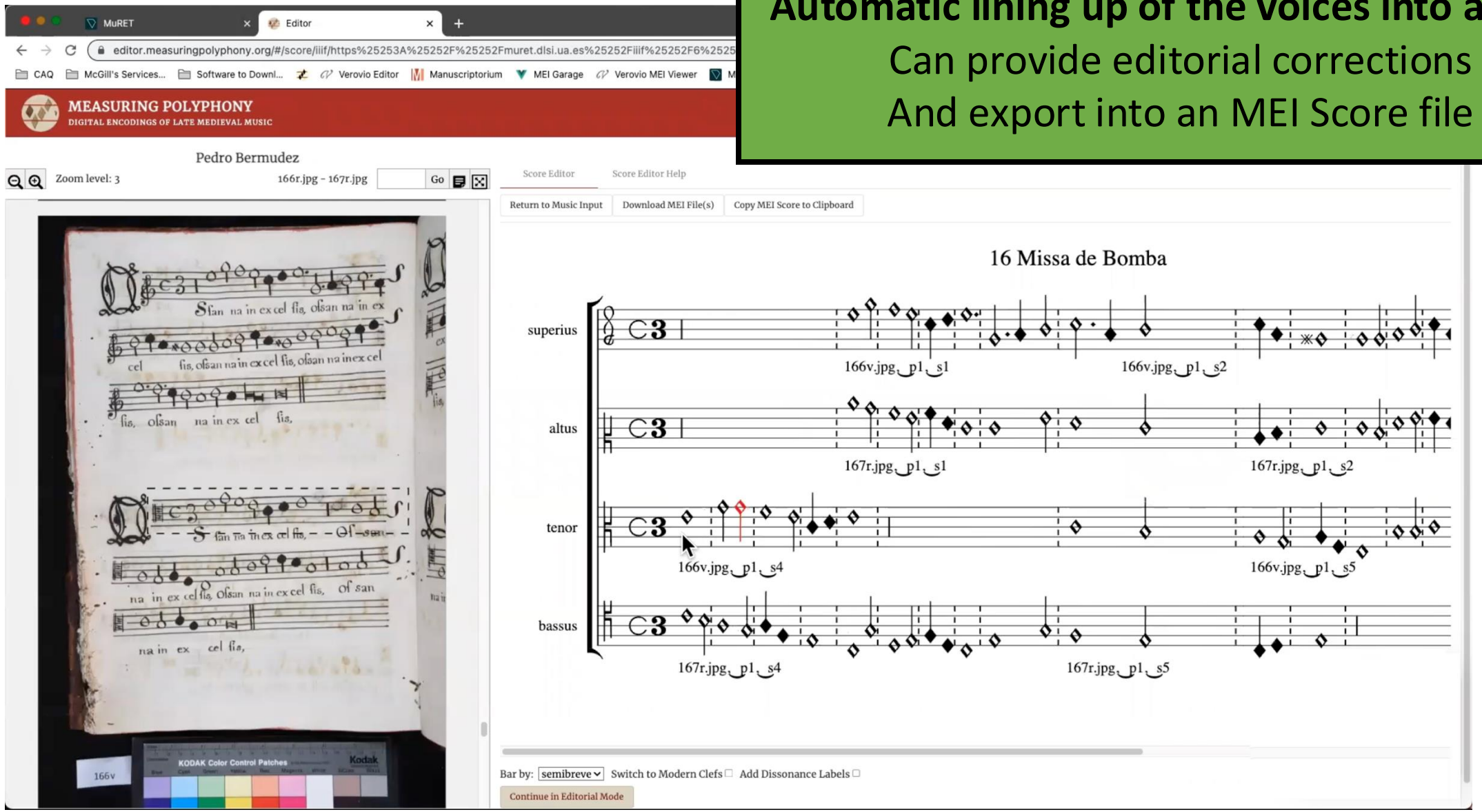
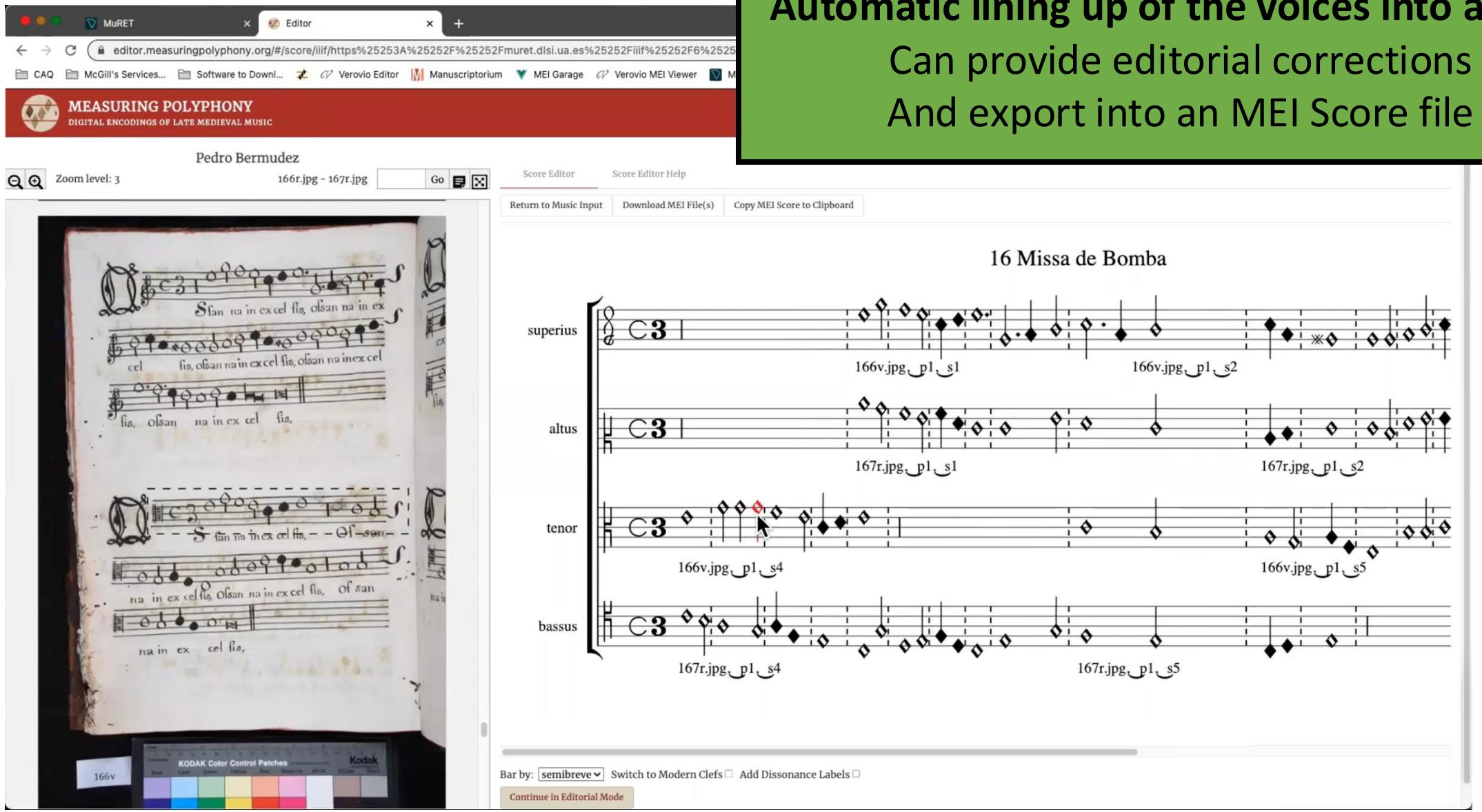


SCORE EDITOR

Automatic lining up of the voices into a score

Can provide editorial corrections

And export into an MEI Score file

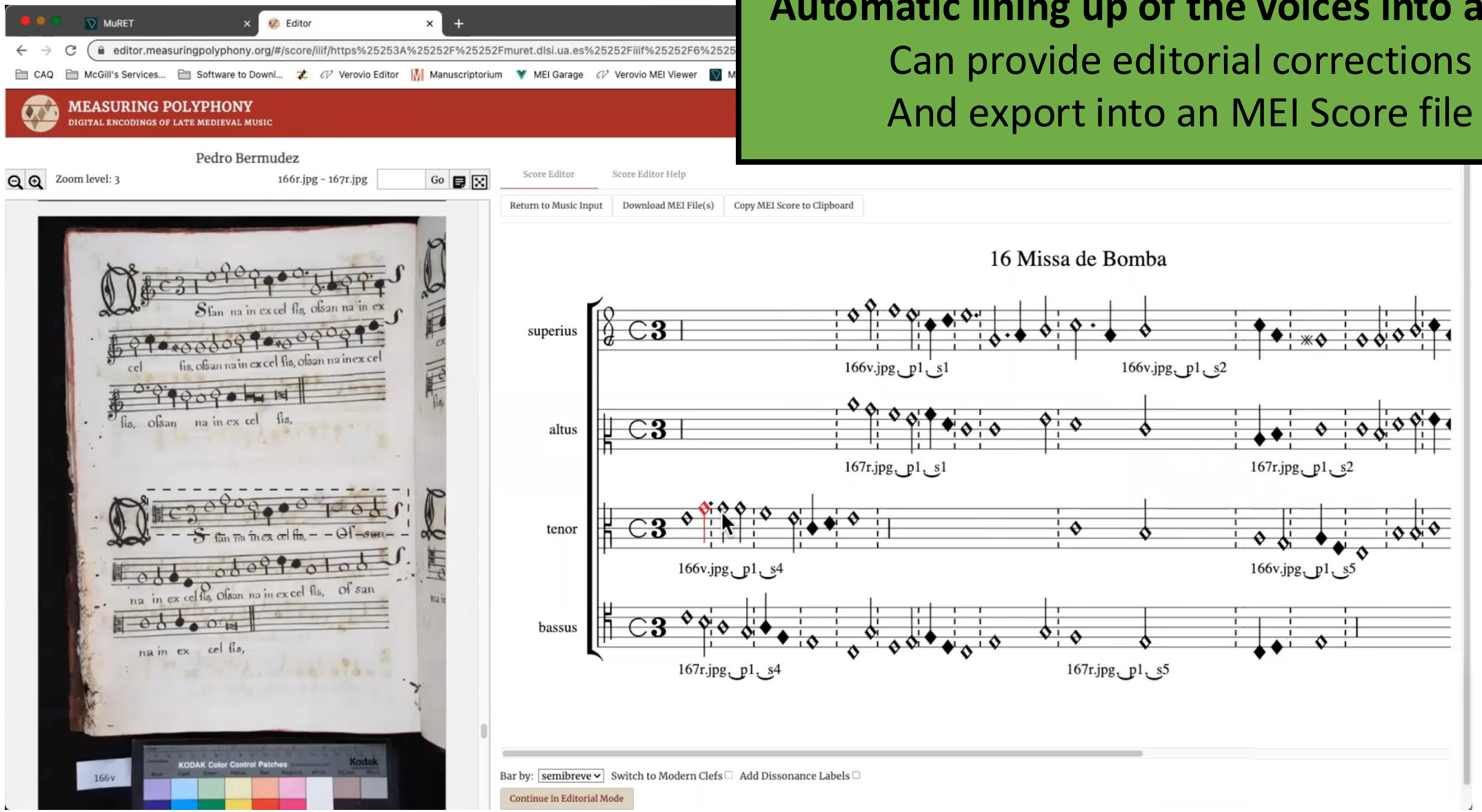


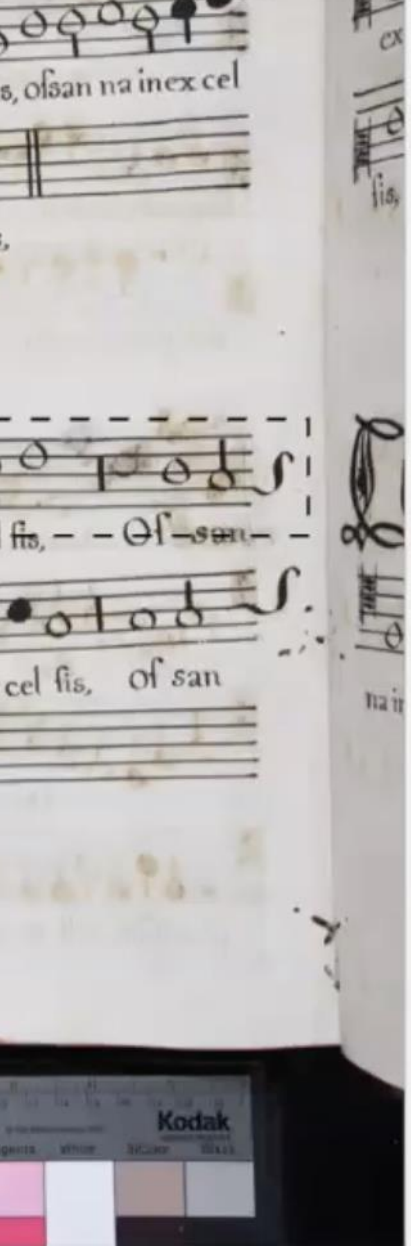
SCORE EDITOR

Automatic lining up of the voices into a score

Can provide editorial corrections

And export into an MEI Score file





SCORE EDITOR

Automatic lining up of the voices into a score

Can provide editorial corrections

And export into an MEI Score file

superius

altus

tenor

bassus

166v.jpg_p1_s4

166v.

167r.jpg_p1_s4

167r.jpg_p1_s5

Bar by: semibreve Switch to Modern Clefs Add Dissonance Labels

Continue in Editorial Mode

SCORE EDITOR

Automatic lining up of the voices into a score

Can provide editorial corrections

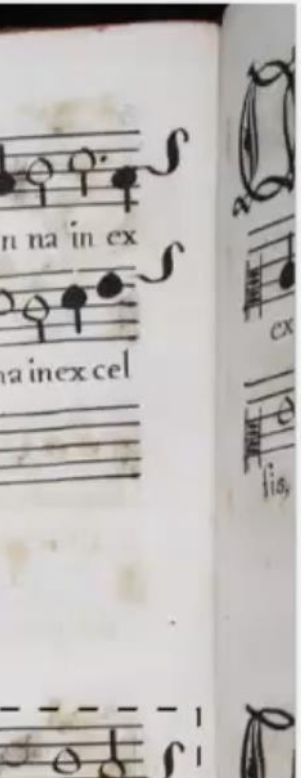
And export into an MEI Score file

https%25253A%25252F%25252Fmuret.dlsi.ua.es%25252Fiiif%25252F6%25252F223%25252Fm

Verovio Editor | Manuscriptorium | MEI Garage | Verovio MEI Viewer | MuRET | Editor

BROWSE TRAN

167r.jpg Go



Score Editor | Score Editor Help

Return to Music Input | Download MEI File(s) | Copy MEI Score to Clipboard

16 Missa de Bomba

superius

166v.jpg_p1_s1 166v.jpg_p1_s2

altus

167r.jpg_p1_s1 167r.jpg_p1

Digitization & MIR Pipeline

Digitization

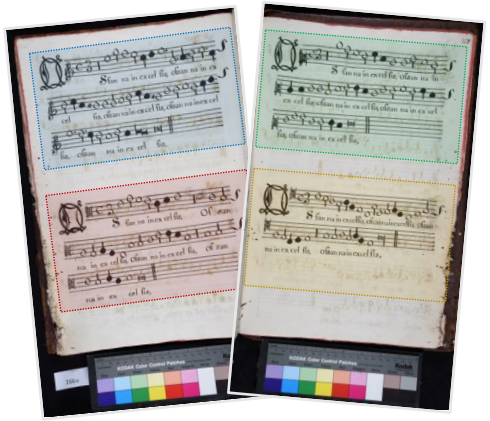
Optical music recognition (OMR)
with human correction

MURET
Music Recognition, encoding, and transcription

Automatic scoring up
&
editorial correction

MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

Manuscript



Digital images

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 <music>
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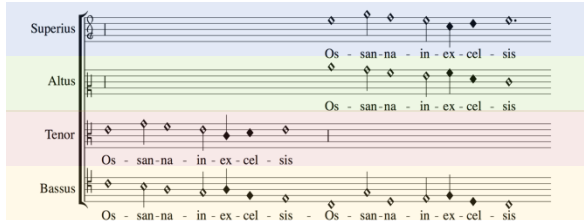
   <clef line="2" shape="G"/>
   <note dur="semibrevis" pname="g" oct="5"/>
   <note dur="semibrevis" pname="d" oct="5"/>
   <dot/>
   <note dur="minima" pname="c" oct="5"/>
   <ligature form="recta">
    <note dur="semibrevis" pname="d" oct="5"/>
    <note dur="semibrevis" pname="g" oct="4"/>
   </ligature>
   <note dur="brevis" pname="b" oct="4"/>
  </staff>
 </music>
</mei>
```

MEI Parts file
encodes the **symbols** in each **part/voice** of the images



MEI Score file
interpreted durations
(i.e., *alteration* & *imperfection*)

Get the Best of Both Tools!

Optical music recognition (OMR)
with human correction

MUSCRET
Music Recognition, encoding, and transcription

Automatic scoring up
&
editorial correction

MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

```
<mei>
 <music>
  <staff n="1">
   <clef line="2" shape="G"/>
   <note dur="semibrevis" pname="g" oct="5"/>
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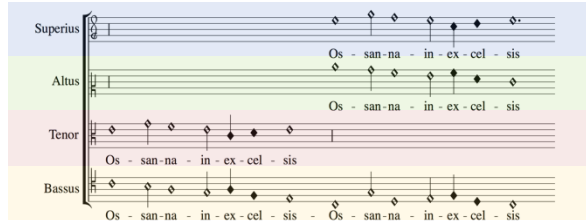
   <dot/>
   <note dur="minima" pname="c" oct="5"/>
   <ligature form="recta">
    <note dur="semibrevis" pname="d" oct="5"/>
    <note dur="semibrevis" pname="g" oct="4"/>
   </ligature>
   <note dur="brevis" pname="b" oct="4"/>
  </staff>
 </music>
</mei>
```

MEI Parts file
encodes the **symbols**
in each **part/voice**

Interoperability between MuRET & MP Editor

David Rizo, Juliette Regimbal, and Martha Thomae

	MuRET	MP Editor
Note shapes (and other symbols)	**Automatic** recognition	**Manual entry** (in input editor by computer keyboard)
Note duration	**Manual entry** (in semantic encoding, stage 3)	**Automatic** computation

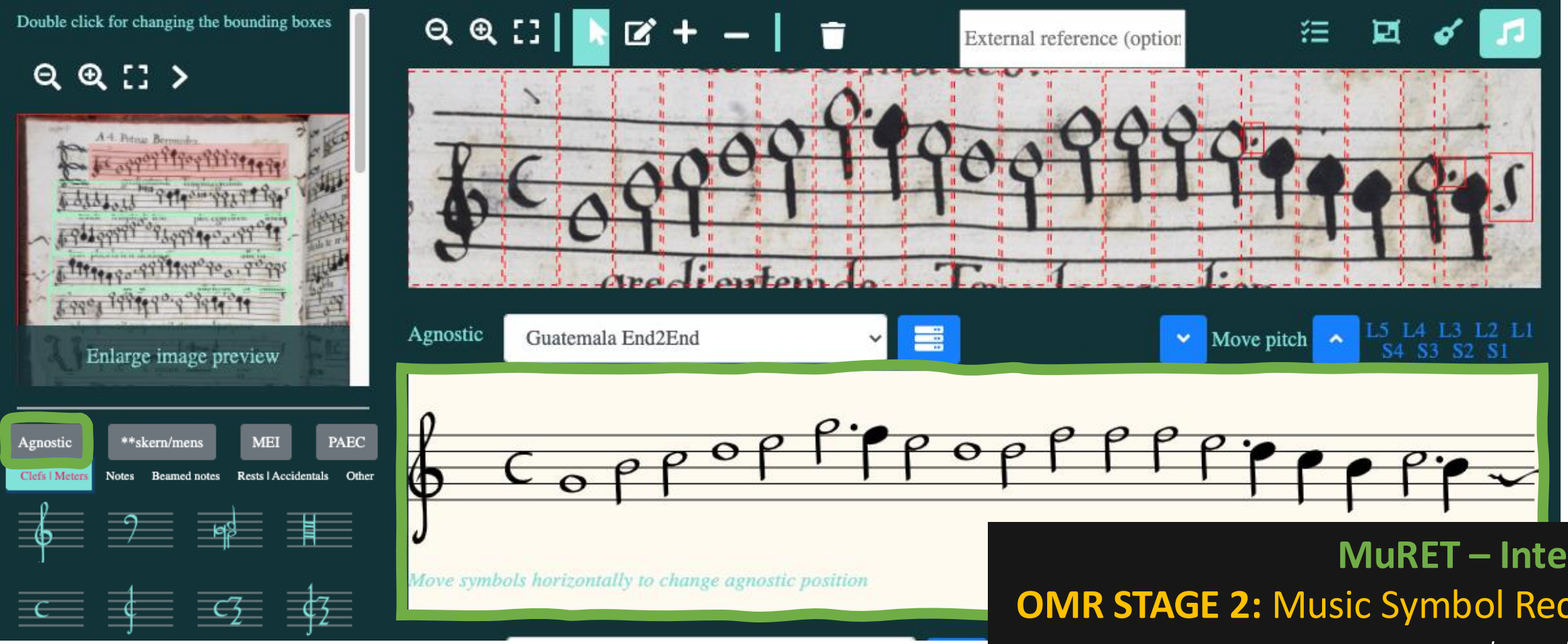


MEI Score file
interpreted durations
(i.e., *alteration* & *imperfection*)

Human Correction After Each Automatic Processes

"Symbol recognition" in *MuRET*
& "Scoring up" in *MP Editor*

How to facilitate this?



MuRET – Interface # 3

OMR STAGE 2: Music Symbol Recognition

automatic process

MuRET already has an interface that facilitates spotting and correcting errors in the "symbol recognition" process

The recognized symbols are lined up with the image

& The user can add/delete/modify the symbols

What about the MP Editor?

How can we facilitate human correction here?

The corrections done here are **editorial** in nature, we correct **errors made by the scribe**

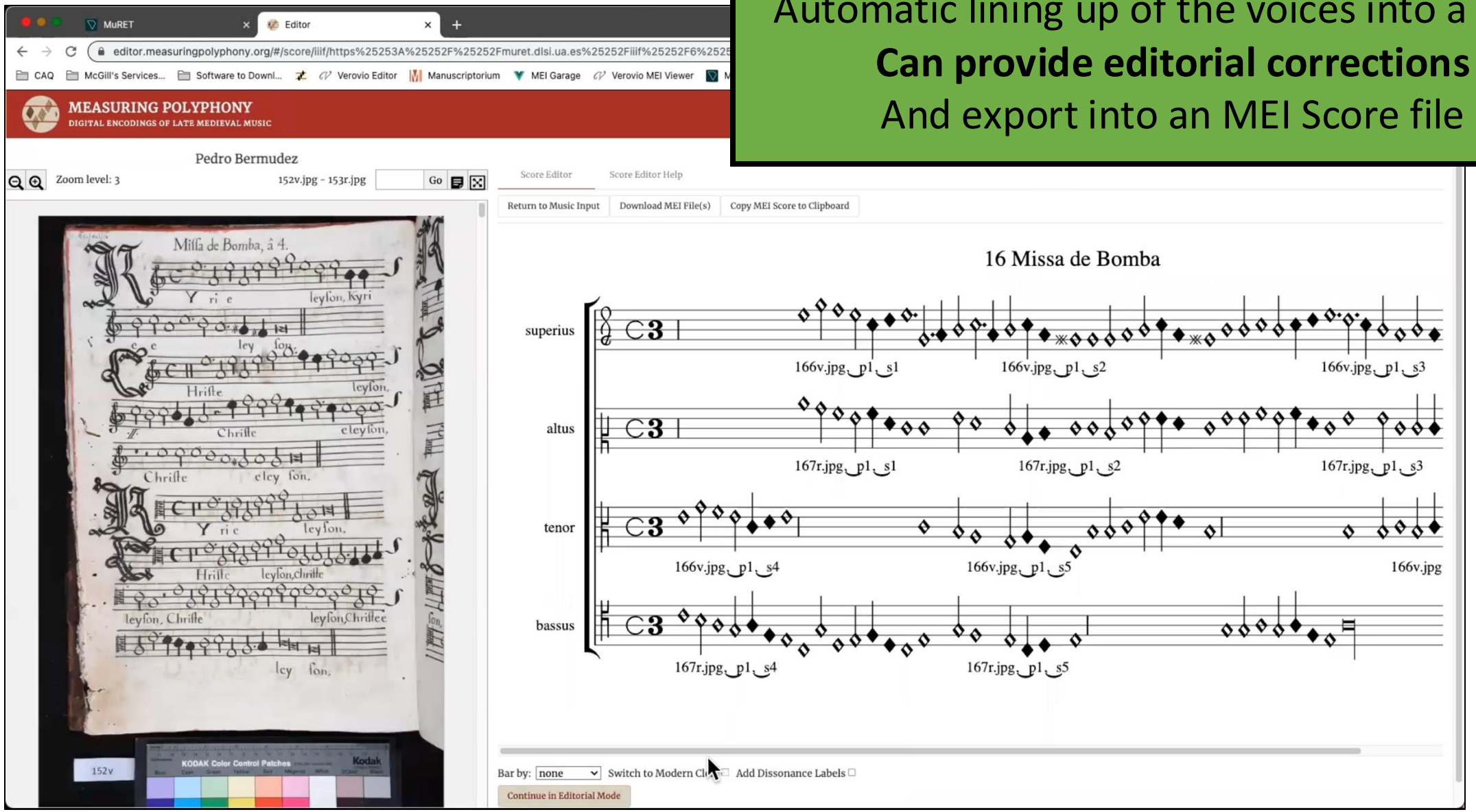
How can we make it easier to spot these errors?

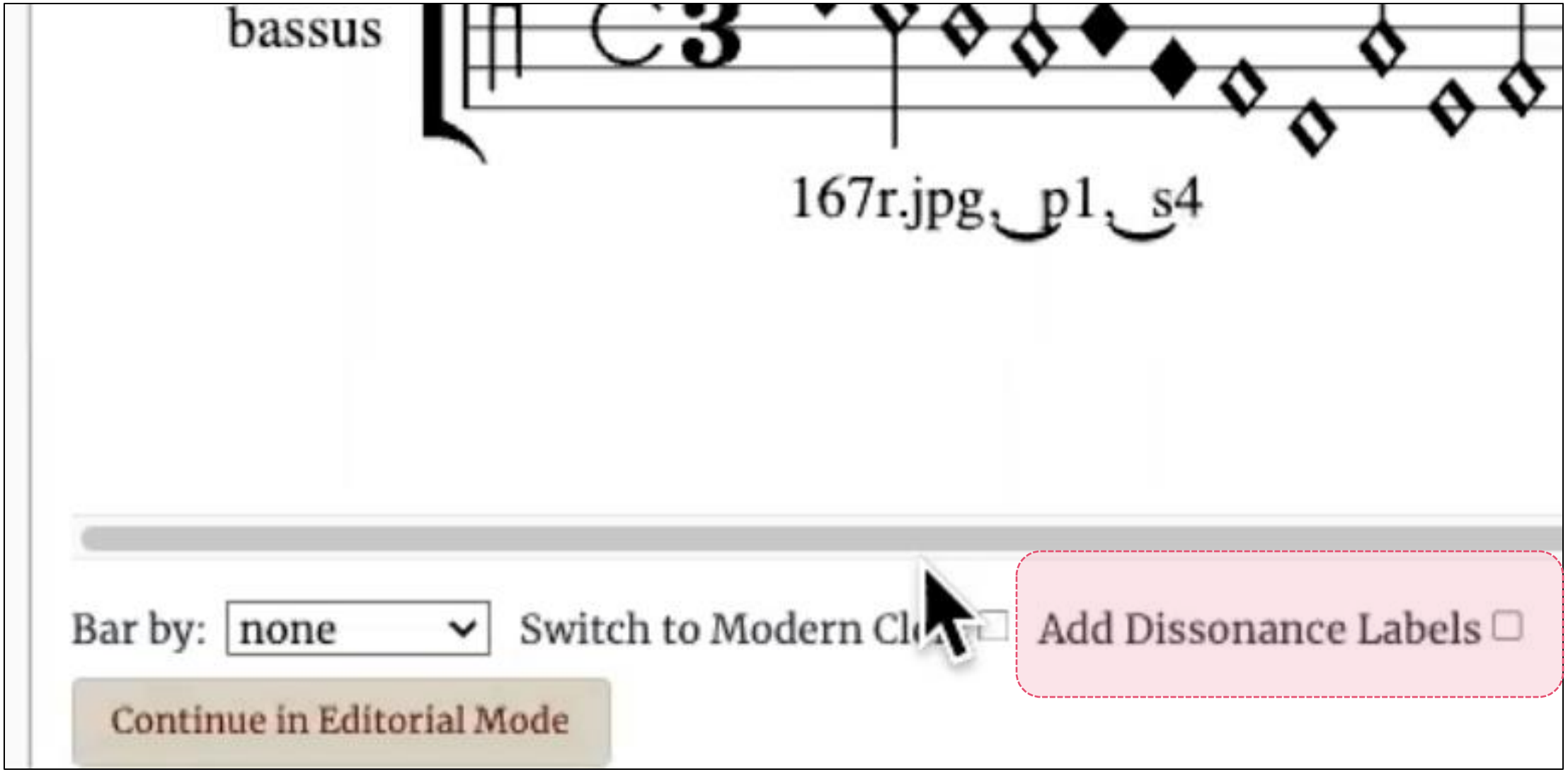
SCORE EDITOR

Automatic lining up of the voices into a score

Can provide editorial corrections

And export into an MEI Score file




bassus
167r.jpg_p1_s4
Bar by:
none
Switch to Modern Cl
Add Dissonance Labels
Continue in Editorial Mode

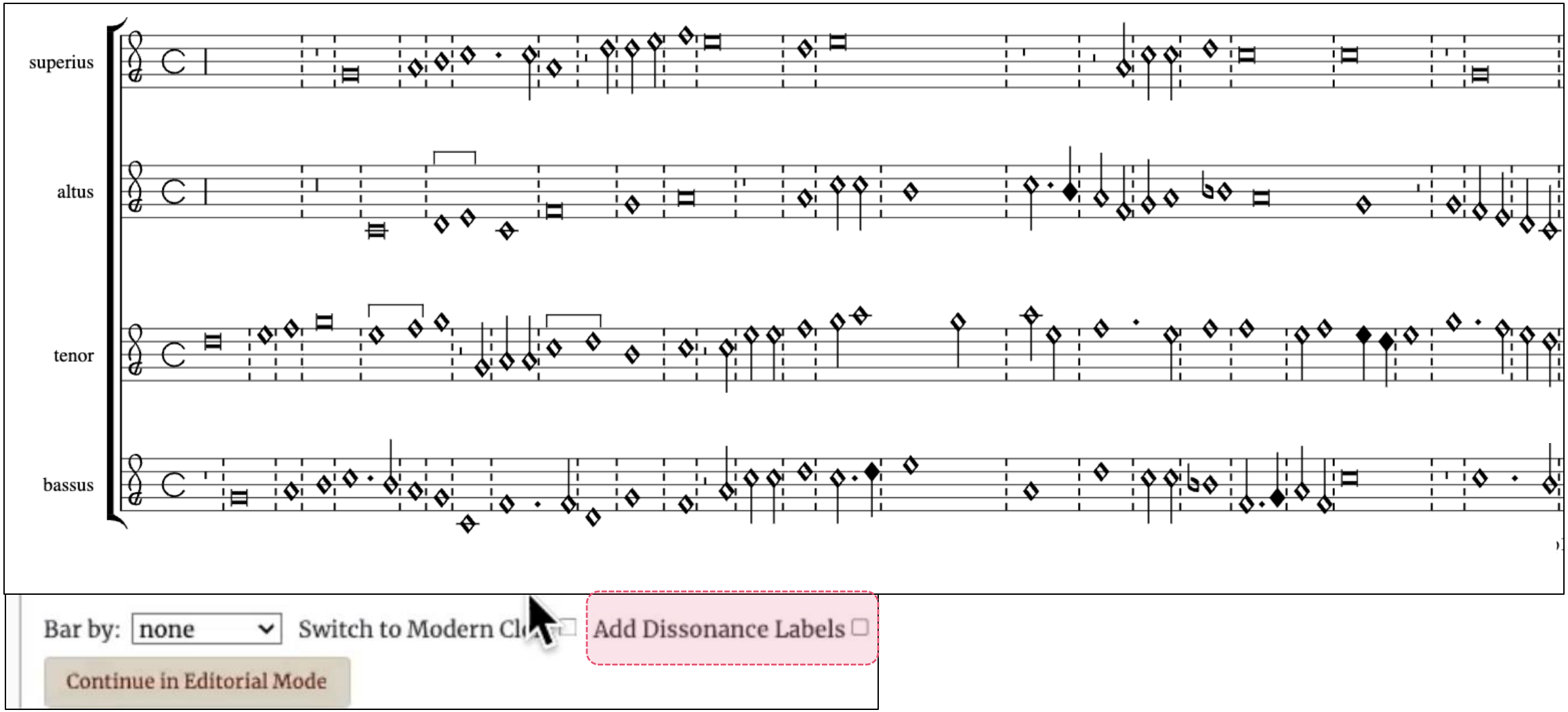
“Add Dissonance Labels” Filter

Labels the different types of dissonances according to their functions

Dissonances that function as passing tones (P/p), neighbour tones (N/n), suspensions (s), etc.

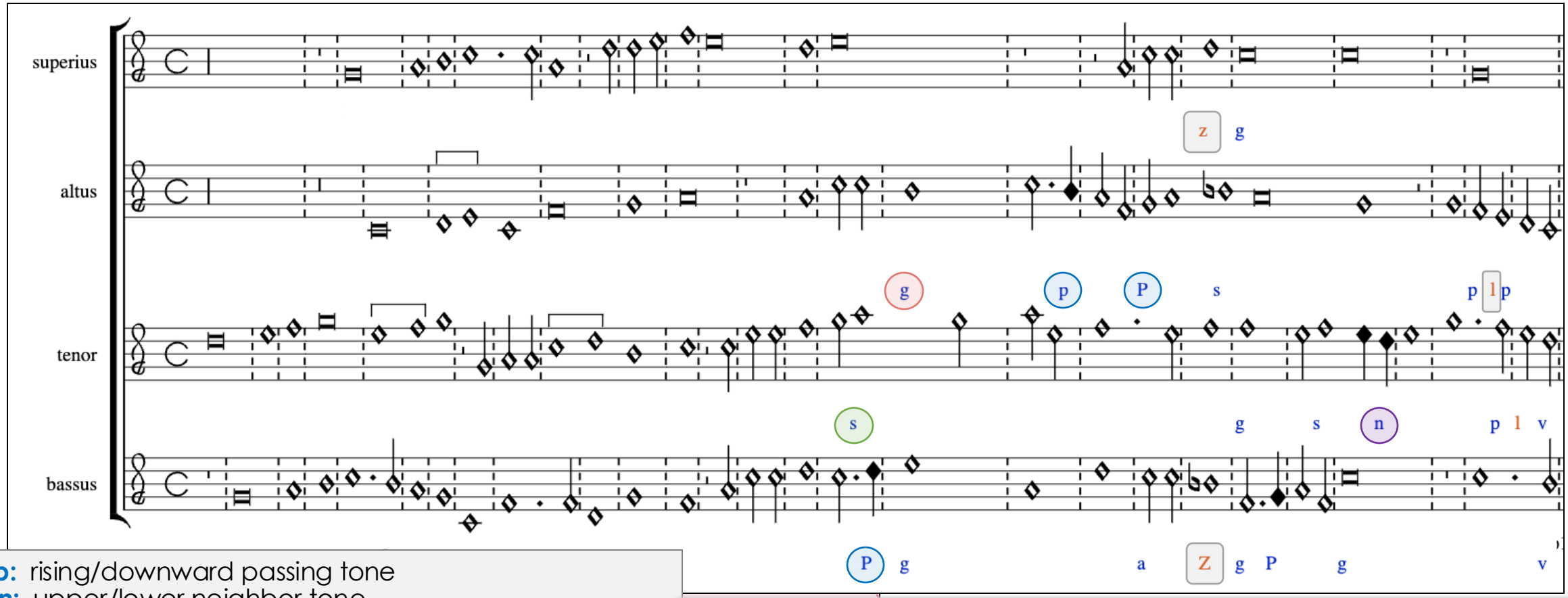
& dissonances whose functionality is not known

→ possible scribal errors?


superius
altus
tenor
bassus
Bar by:
none
Switch to Modern Cl
Add Dissonance Labels
Continue in Editorial Mode

Interoperability between MP Editor & Dissonance Filter (Humlib)

Craig Sapp, Juliette Regimbal, and Martha Thomae

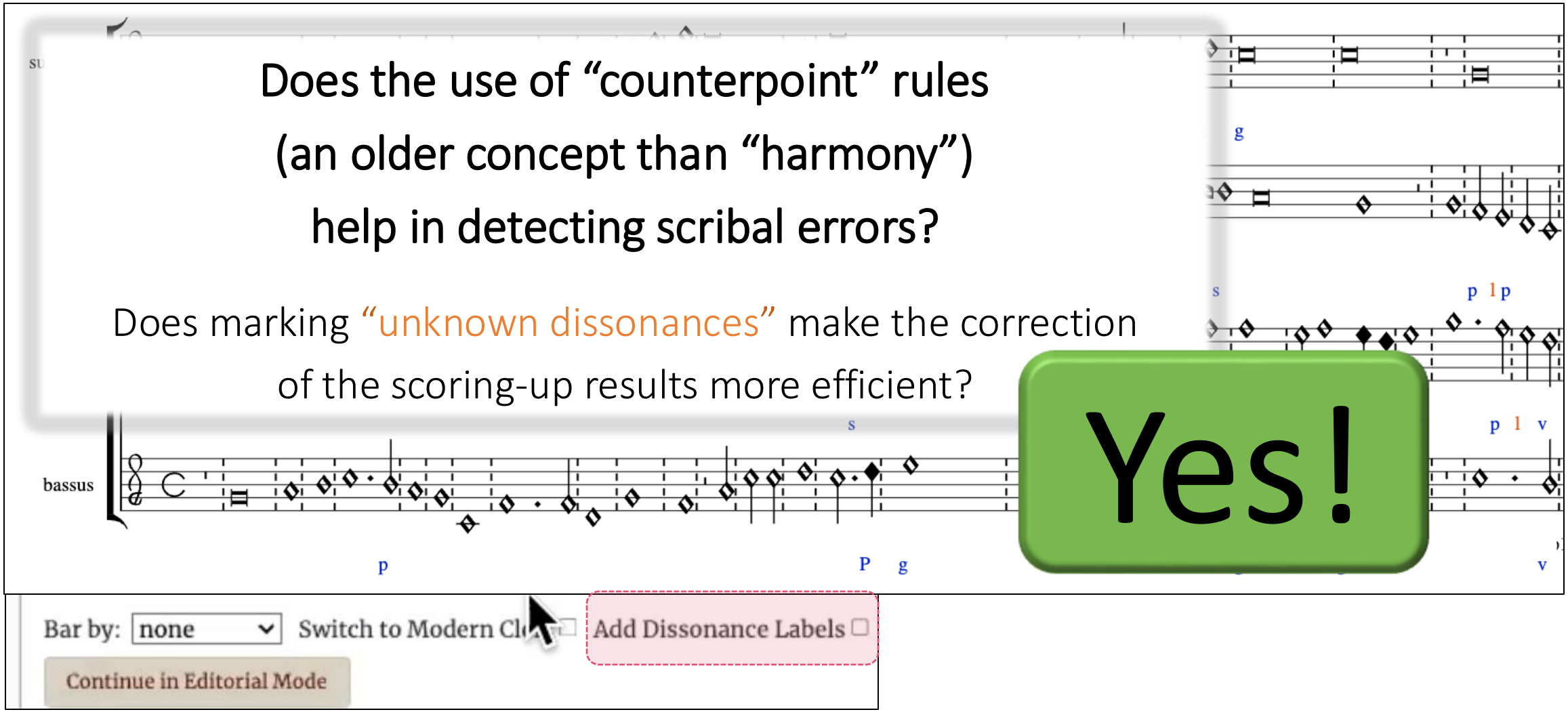


P/p: rising/downward passing tone
N/n: upper/lower neighbor tone
s: suspension
g: agent
Z/z: unclassified dissonance (2^{nd} or 7^{th} / 4^{th})
l: unclassified dissonance in parallel accompaniment

MP Editor with "known" and "unknown" dissonances
(labels come from *humlib's dissonant filter*,
developed by Alex Morgan and Craig Sapp for the Josquin Research Project)

Interoperability between MP Editor & Dissonance Filter (Humlib)

Craig Sapp, Juliette Regimbal, and Martha Thomae



Digitization & MIR Pipeline

Digitization

Optical music recognition (OMR)
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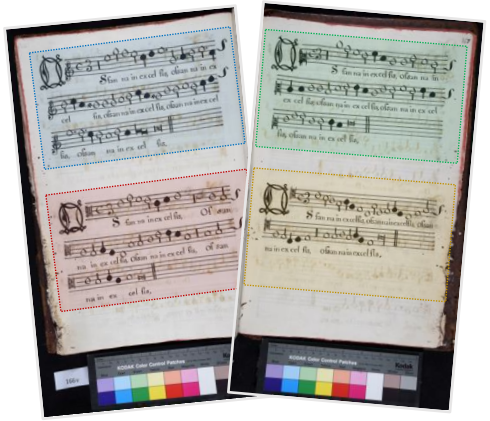
MEASURING POLYPHONY
DIGITAL ENCODINGS OF LATE MEDIEVAL MUSIC

Manuscript



Digital images

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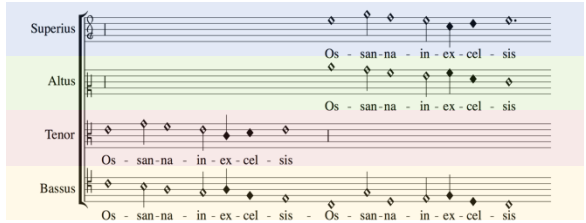
   <clef line="2" shape="G"/>
   <note dur="semibrevis" pname="g" oct="5"/>
   <note dur="semibrevis" pname="d" oct="5"/>
   <dot/>
   <note dur="minima" pname="c" oct="5"/>
   <ligature form="recta">
    <note dur="semibrevis" pname="d" oct="5"/>
    <note dur="semibrevis" pname="g" oct="4"/>
   </ligature>
   <note dur="brevis" pname="b" oct="4"/>
  </staff>
 </music>
</mei>
```

MEI Parts file
encodes the **symbols** in each **part/voice** of the images



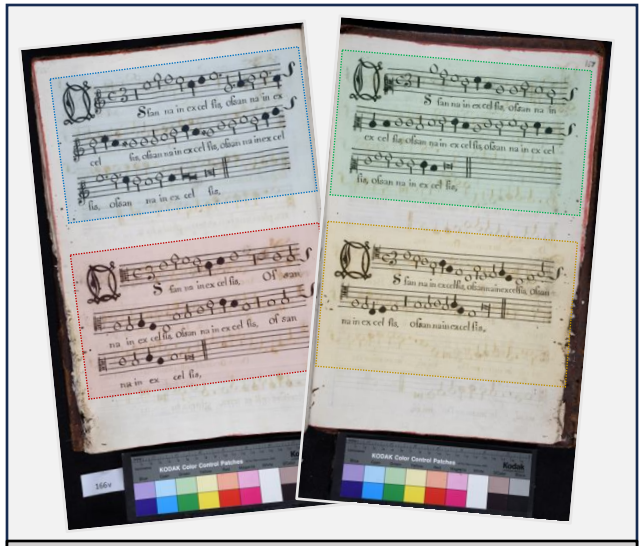
MEI Score file
interpreted durations
(i.e., *alteration* & *imperfection*)

& Humlib's Dissonant Filter (DF)

Outcomes

Preservation and enhanced access of Guatemala's historical music heritage through:

- Digital images
- Mensural MEI files encoding the separate parts and the scores



Digital images

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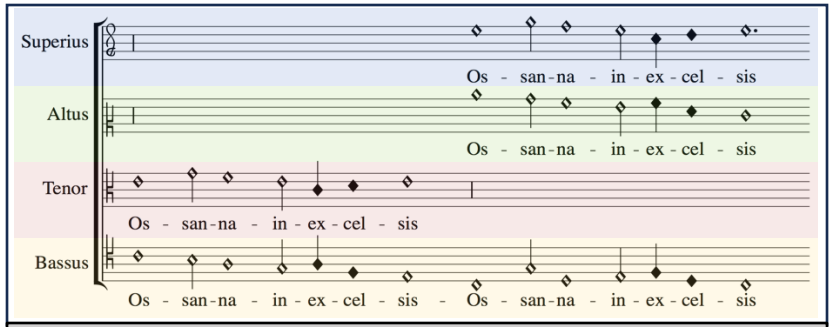
   </ligature>
   <note dur="brevis" pname="b" oct="4"/>
  </staff>
 </music>
</mei>
```

MEI Parts file
encodes the **symbols** in each **part/voice** of the images



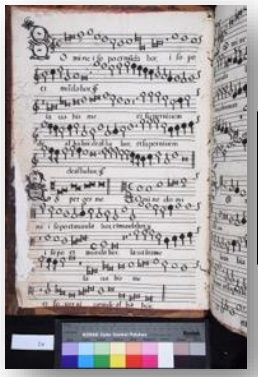
MEI Score file
interpreted durations
(i.e., *alteration* & *imperfection*)

Methodology: the digitization and MIR pipeline

- Allows for the semi-automatic transcription of mensural music from digital images of manuscripts in mensural notation
- Applicable to other mensural music sources
- It considers the use of DIY tools and free, online, and open software to be as accessible as possible to institutions with limited resources

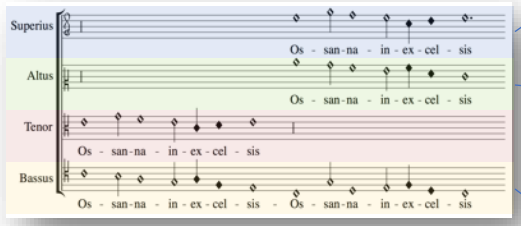
Manuscript

DIY book scanner



Digital image

MuRET & MP-Editor



Digital scores
Encoded in machine-readable files (MEI)

- playback
- automatic transcription into modern values
- comparison to concordant sources

Final Remarks

- Following the idea of “preservation and dissemination”
- Focused on using existing software rather than building another tool
- While the main goal of the project was related to preserving cultural heritage (i.e., preserving historical music works)
- Strived to preserve the previous work from people who put the effort and resources into building these MIR tools

Final Remarks

- Idea of “collaboration”
- Collaborating to preserve a heritage that can be lost
- Or collaborating on preserving these MIR technologies by acknowledging their existence and the specialized tasks they were built for, improving them, and bringing them together for a larger task using their individual advantages
- A lot of work can be done by collaborating instead of working in silos

Acknowledgements

This collaborative project would not have been possible without the support from:

- **Archivo Histórico Arquidiocesano de Guatemala (AHAG)** for granting permission for the project
- **Omar Morales Abril**, Guatemalan musicologist that provided me with advice and information about the choirbooks
- **Alejandro Conde**, AHAG's archivist that supported and facilitated the project
- **José German Thomae Villela** for constructing the cradle
- **Darryl Cameron** for lending the copystand
- **Daniel Hernández-Salazar** for setting the camera parameters
- **Distributed Digital Music Archives and Libraries (DDMAL) Lab at McGill University** for lending the lights and other parts of the equipment
- **Marvin Duchow Music Library at McGill University** for lending the camera
- **Centro de Rescate, Estudio y Análisis Científico del Arte (CREA)** for the conservation assessment of the collection and the conservation treatment of the choirbook

Acknowledgements

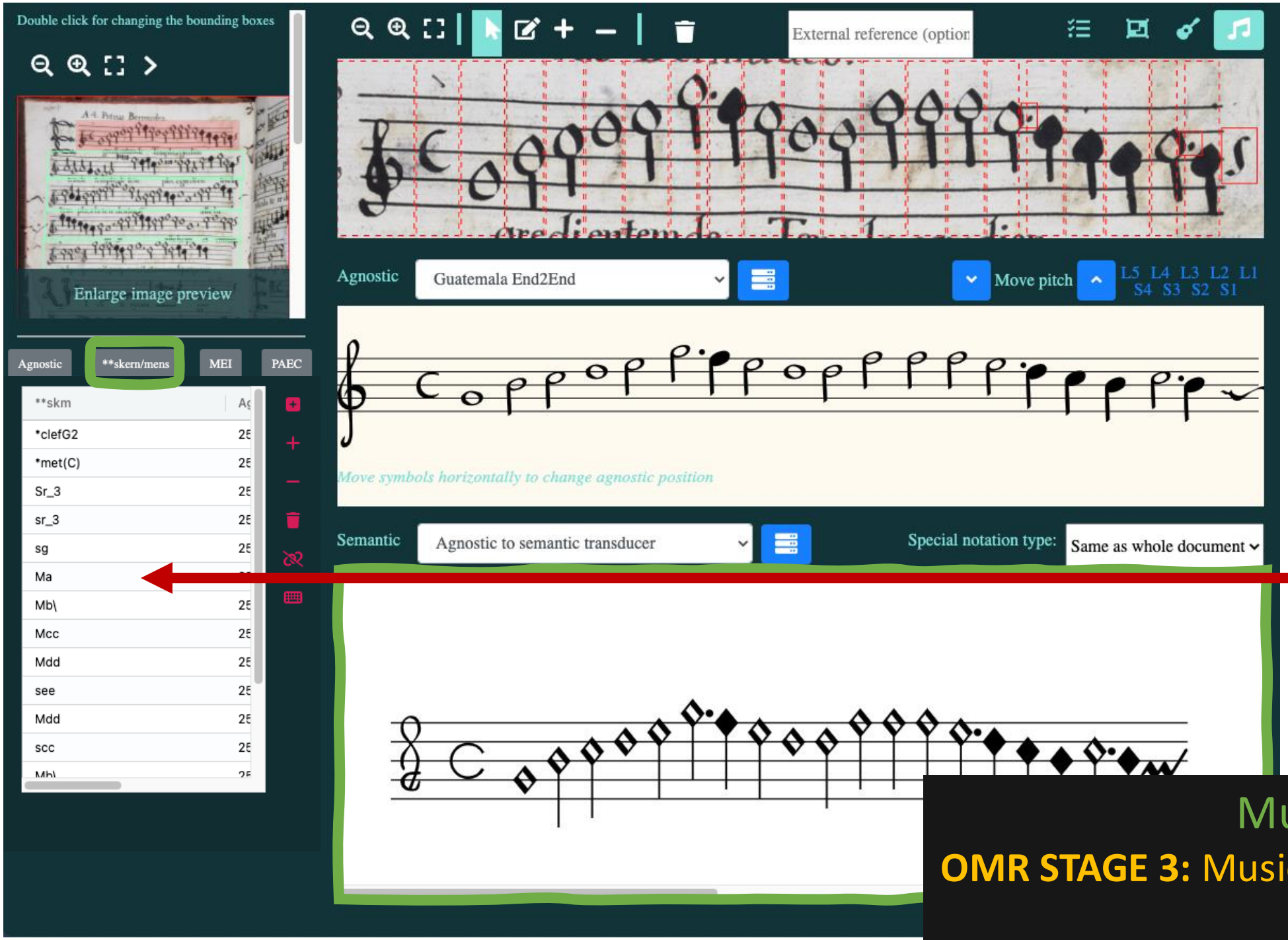
- **Julia Craig-McFeely** and **Lynda Sayce** (DIAMM), **Jessica Régimbald**, **Marie-Chantal Anctil**, and **Michel Legendre** (BAnQ), and **Gregory Houston** (McGill Library) for their advice regarding digitization and conservation of special collections
- **David Rizo**, **Karen Desmond**, and **Juliette Regimbal**
  who made possible for MuRET and the MP-Editor to communicate with one another
- **Craig Stuart Sapp** whose work allowed for the dissonance labels to be displayed in the MP-Editor
- **Jorge Calvo-Zaragoza**, **Francisco Castellanos**, **Antonio Ríos Vila**, **and José Manuel Iñesta** who developed the models used in MuRET
- **Laurent Pugin** for his work on Verovio
- **Alexander Morgan** for his Renaissance dissonance labeler script
- **Peter Schubert** for his expert advice in counterpoint matters
- **Geneviève Gates-Panneton** for her work in the experiment
- My **supervisors**: **Julie Cumming** and **Ichiro Fujinaga**

Thank you!

marthathomae@fcsh.unl.pt

https://martha-thomae.github.io/projects/guatemala.html

Extra Slides



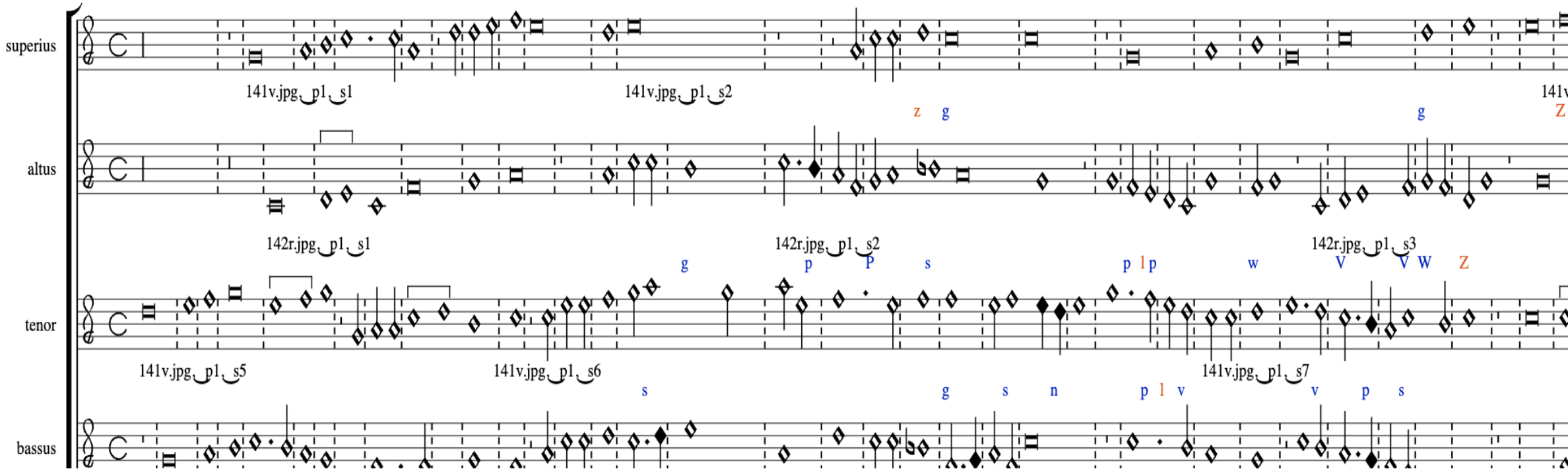
Inserting the note durational quality (perfecta, imperfecta, or altera) requires manual endoding

MuRET – Interface # 3

OMR STAGE 3: Music Notation Recognition

automatic process

1. Marking unknown dissonances reduces the correction time (at least to a half)
   → allows for a focused search for errors



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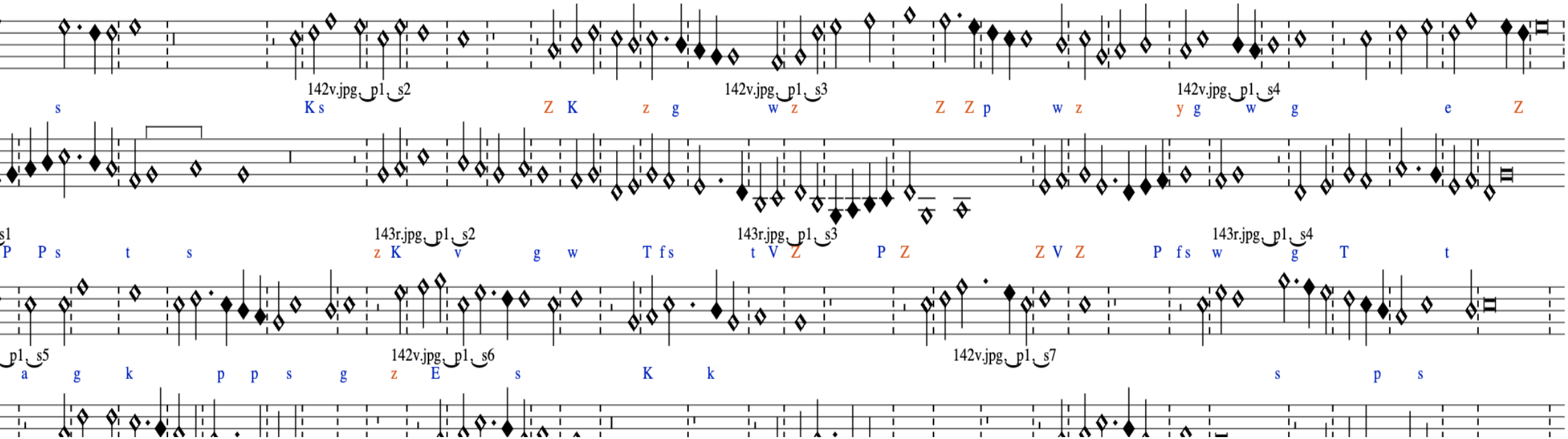

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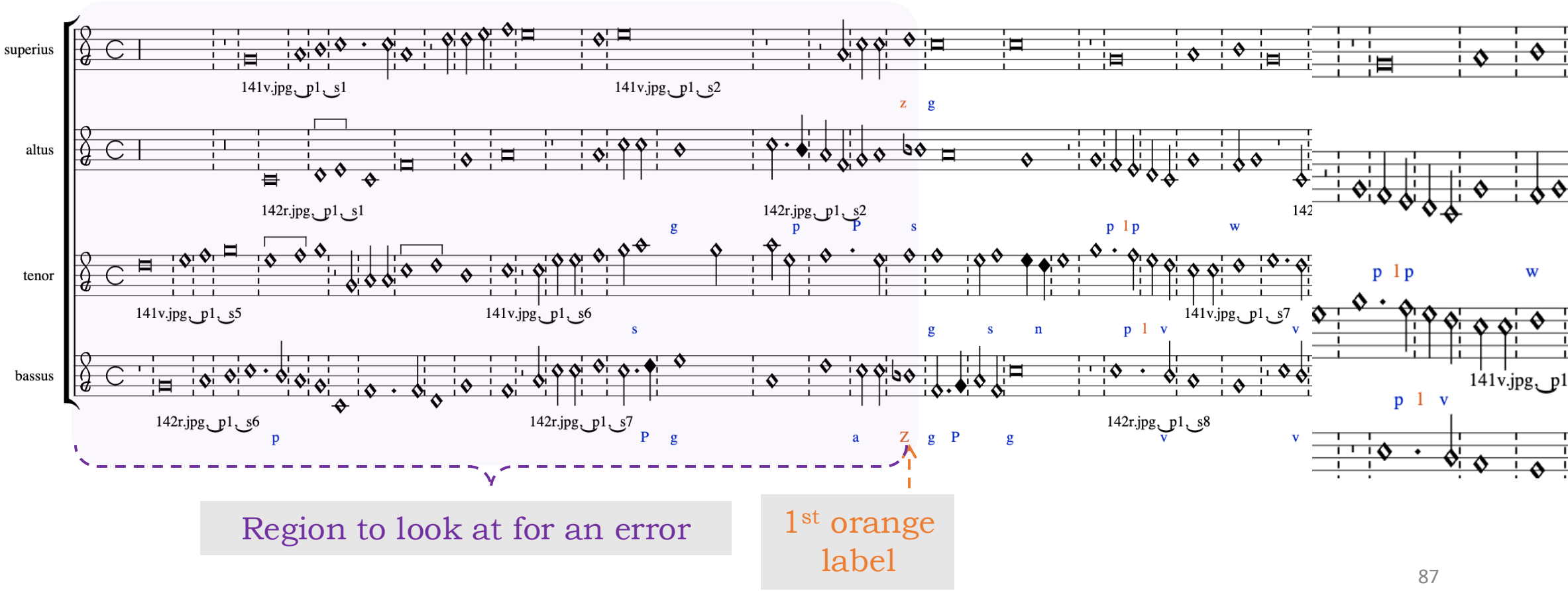
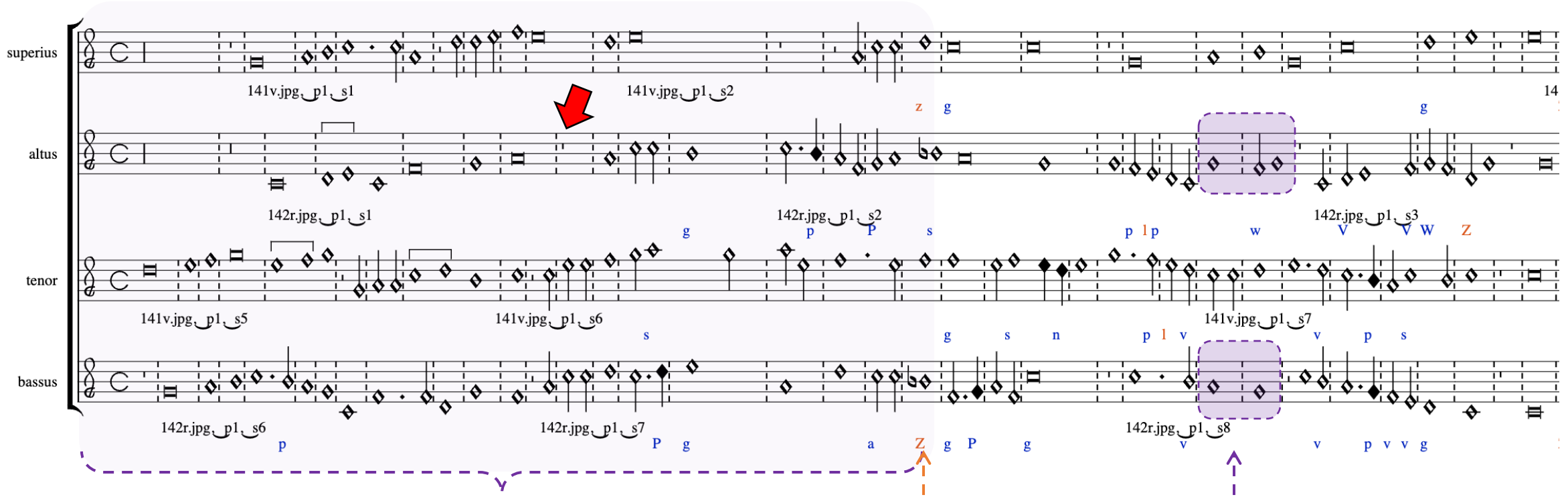
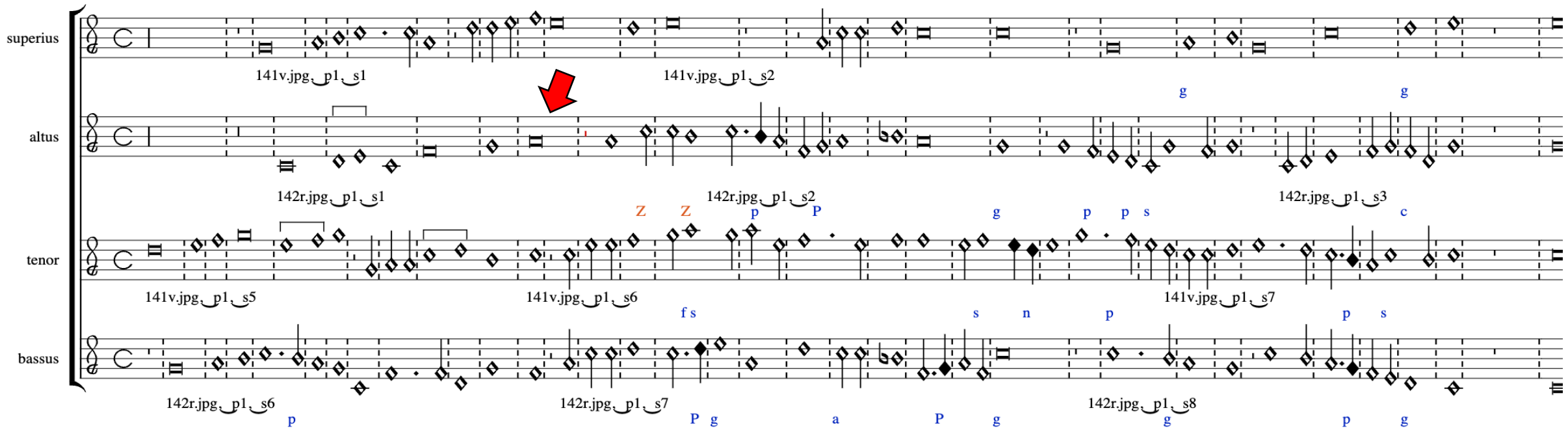
→ allows for a focused search for errors



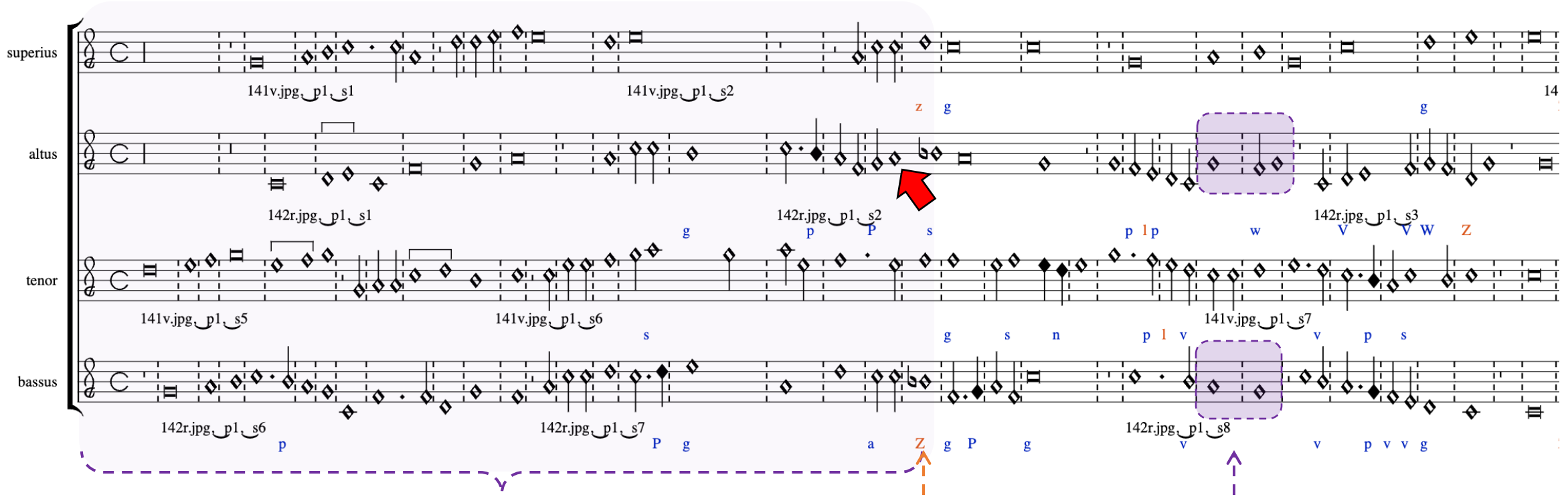
2. Marking unknown dissonances increases accuracy of corrections



2. Marking unknown dissonances increases accuracy of corrections



2. Marking unknown dissonances increases accuracy of corrections

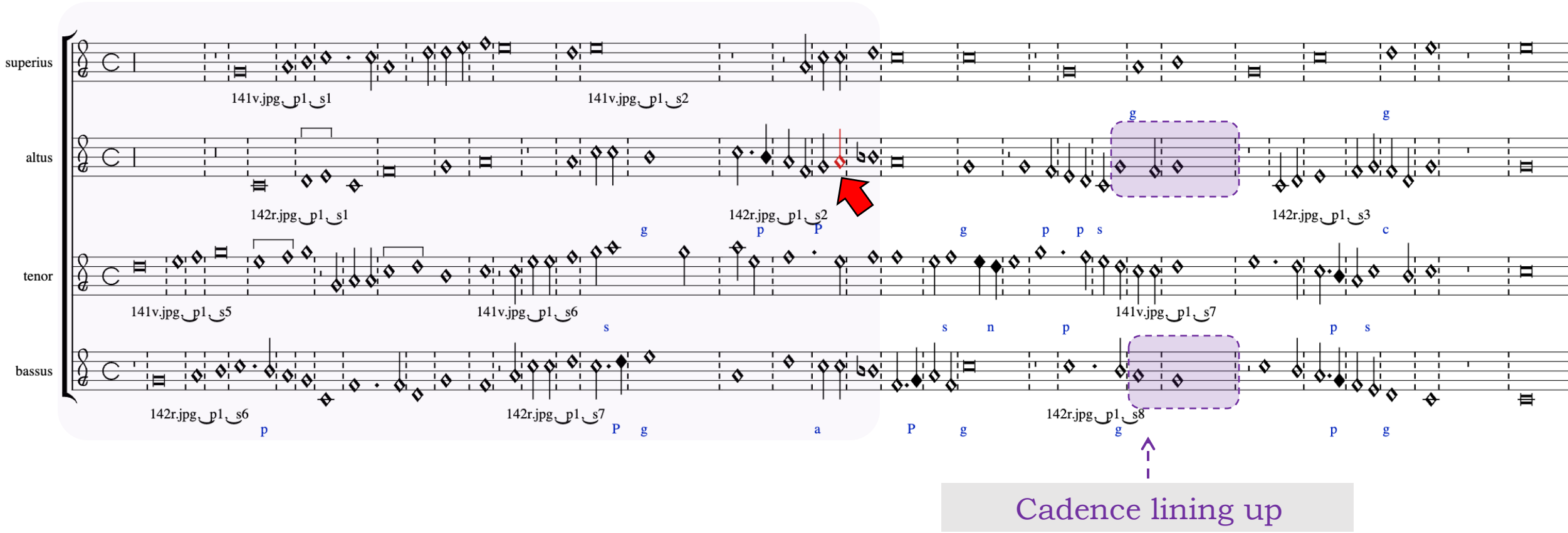


Region to look at for an error

1st orange label

Cadence does not line up; alto is a minim too long

2. Marking unknown dissonances increases accuracy of corrections



3. Marking unknown dissonances even helped detecting OMR errors that went unnoticed on the previous stage of the pipeline