

**DDMAL**

DISTRIBUTED DIGITAL MUSIC  
ARCHIVES & LIBRARIES LAB



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# Plan

- ❖ OMR (optical music recognition)
- ❖ SIMSSA Project
- ❖ LinkedMusic Project

# Optical Music Recognition (OMR)

A process of converting images of music scores into a symbolic computer representation, such as MIDI, MusicXML, or MEI (Music Encoding Initiative).



OMR



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      </measure>
    </measure>
  </measure>
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# Steps Involved in OMR

Digitized Score



Image Preprocessing

Binarization

Noise Removal

Structural Analysis

Image Segmentation

Music Symbol Recognition

Staves Processing

Symbol Segmentation

Symbol Classification

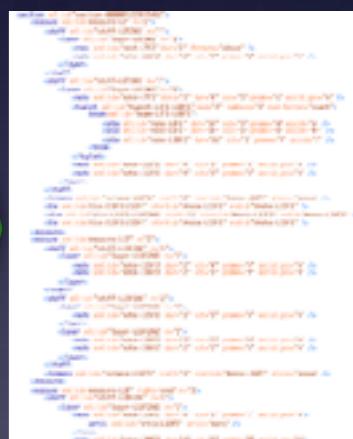
Music Notation Reconstruction

Symbol Combination

Semantic Assignment (pitch, value)

Musical Structure Reconstruction

Final Output

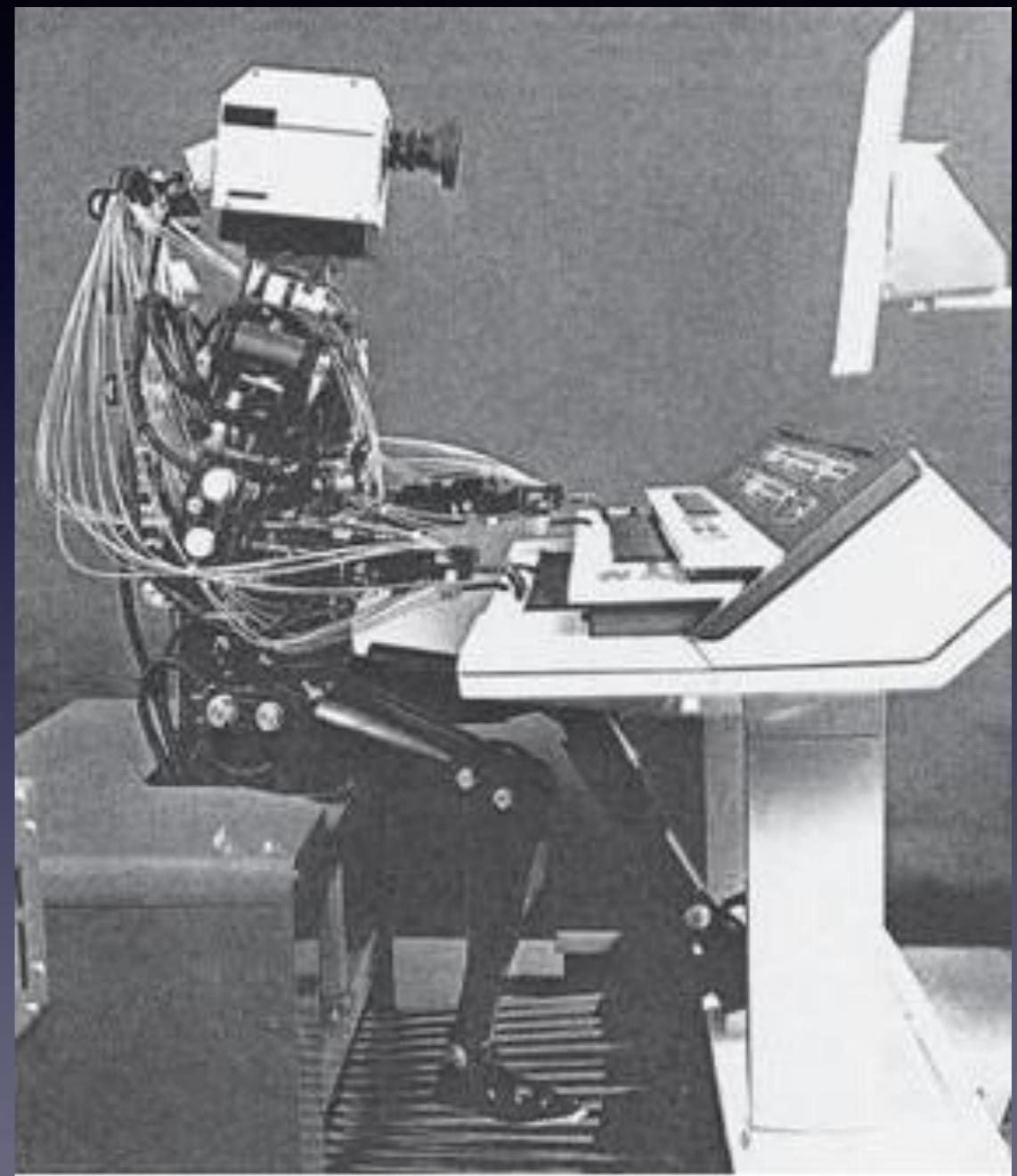


# Why is OMR important?

- ❖ Automatic playback
- ❖ Rearrangements
  - ❖ Transpositions
  - ❖ Change of mode (Major /Minor)
- ❖ Symbolic music analysis
  - ❖ Searching
  - ❖ Data mining
  - ❖ Distant reading
- ❖ Reprints (for publishers)
- ❖ Braille output
- ❖ Score following

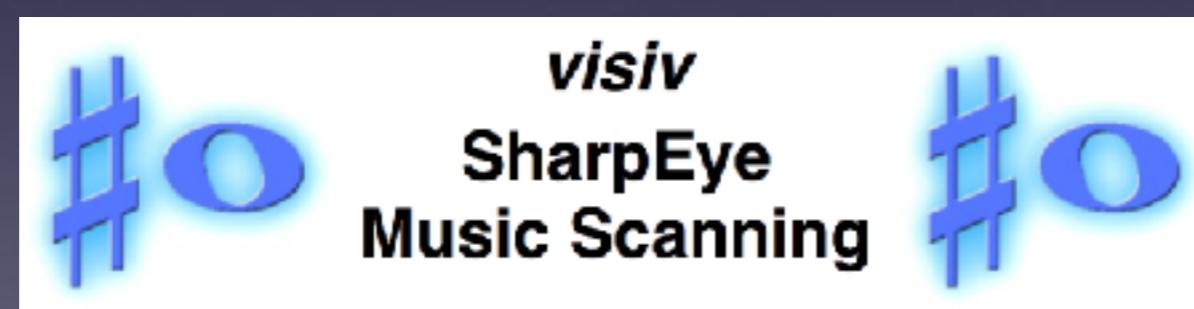
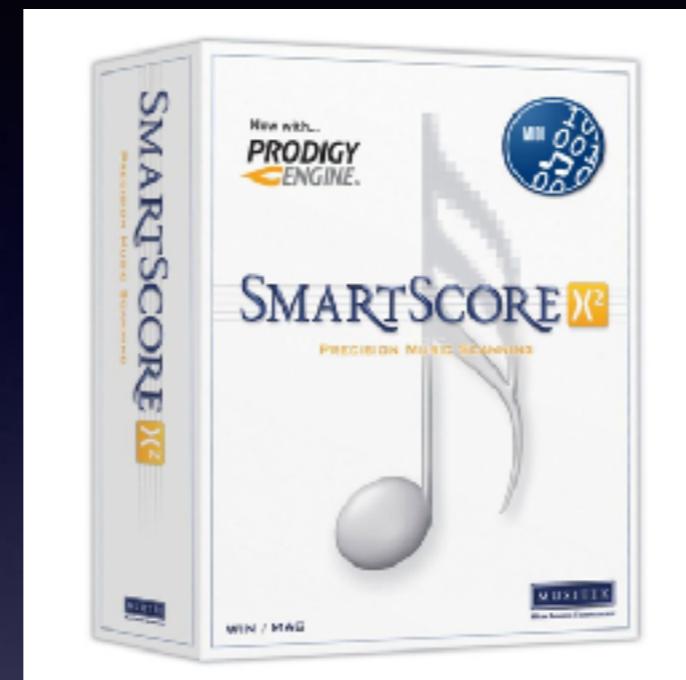
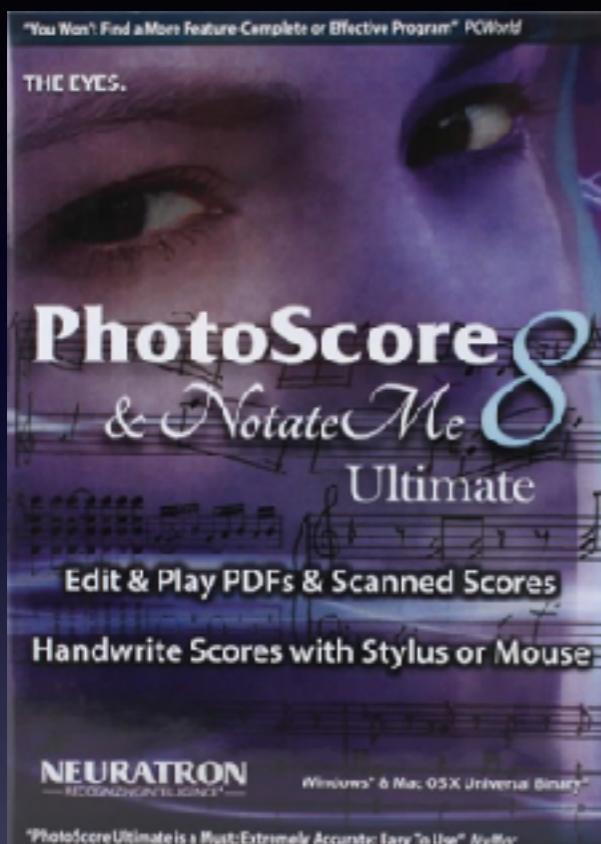
# A Brief History of Optical Music Recognition (OMR)

- ❖ 1966: First PhD dissertation on OMR
- ❖ 1970: First published digital scan of music
- ❖ 1984: First robot with OMR capabilities



<https://www.scaruffi.com/mind/ai/wabot.jpg>

# OMR Software



# Birth of Gamera (2001)

- ❖ Fra  
rec
  - ❖ De
  - ❖ Im
  - ❖ Do
  - ❖ Sy
  - ❖ Po
- 
- atch

Generalized Algorithms and Methods for Enhancement and Restoration of Archives

# SIMSSA

: Single Interface for Music  
: Score Searching and Analysis

- ❖ Think: “Google Scores”
- ❖ Similar to “Google Books” minus Google
  - ❖ OMR (optical music recognition) to enable full-text search
  - ❖ Sophisticated music analysis and query
- ❖ Access to digitized scores world-wide from a single website
- ❖ 12-year project: 2011–2022: \$4.4M

# The Vision: Global Music Library

The central monitor displays the **DIAMM** logo, which stands for the Digital Image Archive of Medieval Music. Below the logo, the text "Digital Image Archive of Medieval Music" is visible. The monitor is positioned in front of a dark background featuring several small, colorful 3D avatars of people's heads.

**Tools**

**diva<sup>js</sup>**

**Music Encoding Initiative**

**Humdrum**

**music21**

**Metadata & Text**

**F<sup>c</sup>antus**

**RISM**

**rim**

**Music Treasures Consortium**

**Early Music Online**

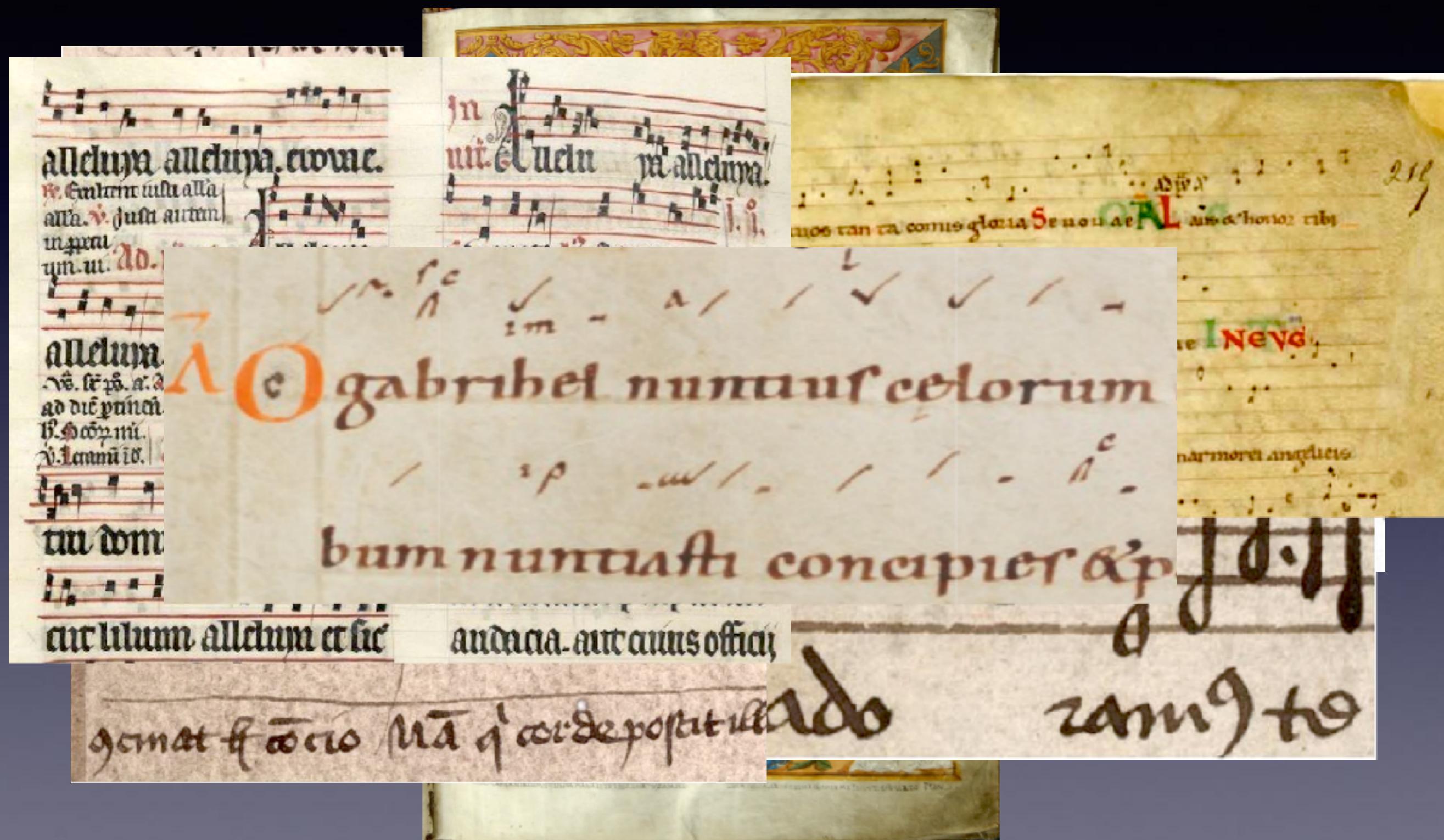
**MSLP**

# SIMSSA Team

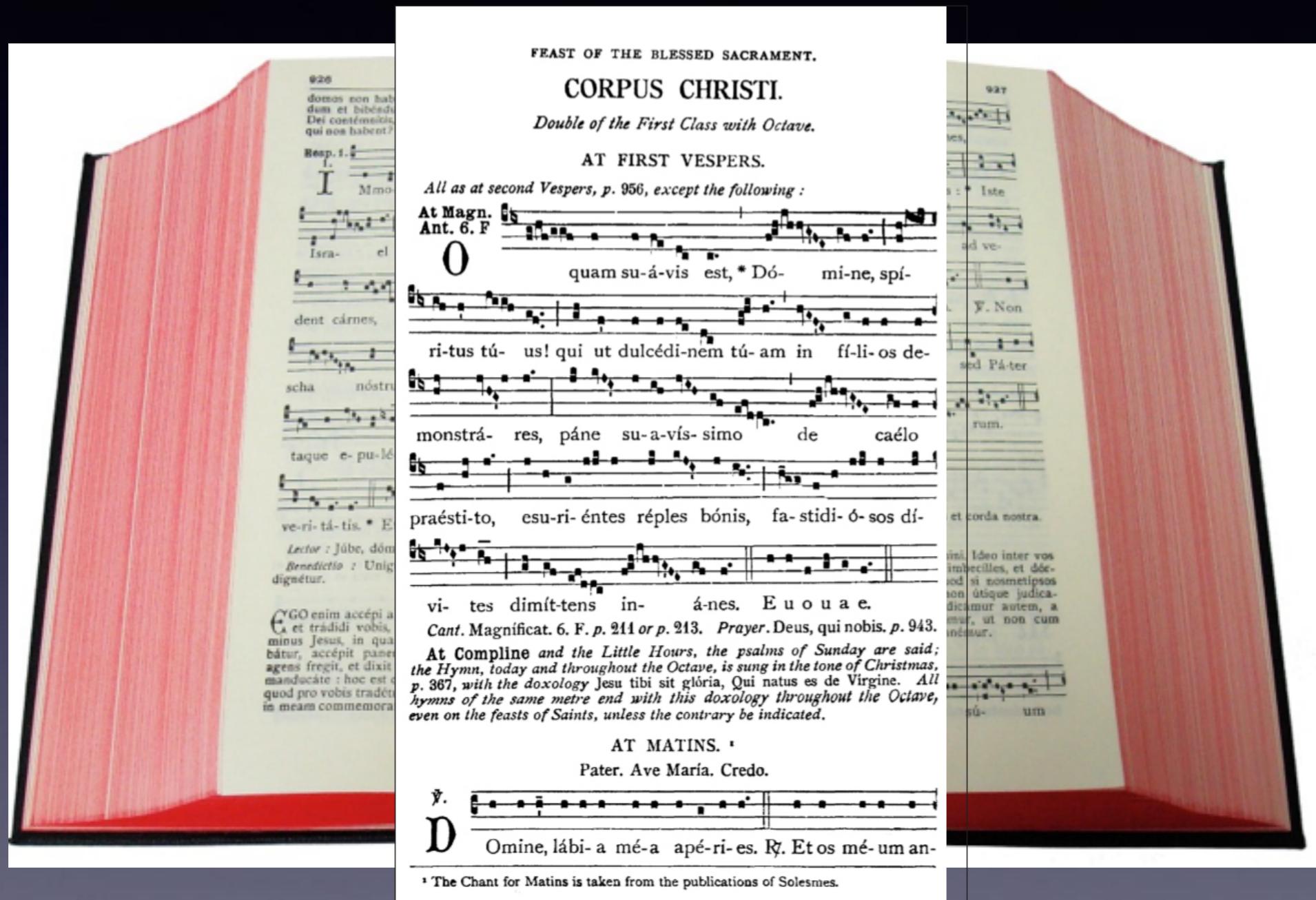
- ❖ Musicologists (20)
- ❖ Music Librarians (8)
- ❖ Music Technologists (11)
- ❖ Partners (23) including:
  - ❖ Bavarian State Library
  - ❖ Bibliothèque nationale de France
  - ❖ British Library
  - ❖ Harvard University Music Library
  - ❖ HathiTrust Research Center
  - ❖ New York Philharmonic Archives

# Neume Notation

## Early Western Music Notation System: 10th–16th Century



# 2011: *Liber Usualis Project*



FEAST OF THE BLESSED SACRAMENT.

## CORPUS CHRISTI.

*Double of the First Class with Octave.*

### AT FIRST VESPERS.

*All as at second Vespers, p. 956, except the following:*

**At Magn.**

**Ant. 6. F**

**O** quam su-á-vis est, \* Dó- mi-ne, spí-  
ri-tus tú- us! qui ut dulcédi-nem tú- am in fí-li- os de-  
monstrá- res, páne su-a-vís-simo de caélo  
praéstí-to, esu-ri- éntes réples bónis, fa-stidi- ó-sos dí-  
vi- tes dimít-tens in- ánes. Eu o u a e.

*Cant. Magnificat. 6. F. p. 244 or p. 213. Prayer. Deus, qui nobis. p. 943.*

*At Compline and the Little Hours, the psalms of Sunday are said; the Hymn, today and throughout the Octave, is sung in the tone of Christmas, p. 367, with the doxology Iesu tibi sit glória, Qui natus es de Virgine. All hymns of the same metre end with this doxology throughout the Octave, even on the feasts of Saints, unless the contrary be indicated.*

### AT MATINS.

Pater. Ave María. Credo.

**Y.**

**D**

Omine, lábi- a mé-a apé-ri- es. R. Et os mé- um an-

\* The Chant for Matins is taken from the publications of Solesmes.

Full-text search of 2,000 pages of Latin text and square notation

# Search the Liber Usualis

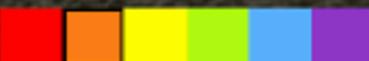
What is this? [Find out more about what we are trying to do.](#)

edcdeee

Strict pitch sequence

Search

Clear



previous

Result 1 of 40 for edcdeee

next

Go to page  Go

Current page: 157 of 2340

X. — For feasts of the Blessed Virgin. 2. 45

in gló- ri- a Dé- i Pá-tris. A- men.

**S** Anctus, \* Sánctus, Sánctus Dóminus Dé-us Sá-

ba- oth. Pléni sunt caéli et térra gló-ri-a tú- a. Hosánnna

in excél-sis. Benedíctus qui vé- nit in nómine Dómi-

ni. Hosánnna in excél-sis.

**A** -gnus Dé- i, \* qui tollis peccáta móndi : mi-se-ré-

re nóbis. Agnus Dé- i, \* qui tollis peccáta móndi : mi-

se-ré- re nóbis. Agnus Dé- i, \* qui tollis peccáta móndi :

# Preprocessing: Aruspix

**FEAST OF THE BLESSED SACRAMENT.**

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**Ant. 6. F**

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ri-tus tú- us! qui ut dulcédi-nem tú- am in fí-li- os de-  
monstrá- res, páne su-a-vís-simo de caélo  
praésti-to, esu-ri- éntes réples bónis, fa-stidi- ó-sos dí-  
vi- tes dimít-tens in- ánes. Eu ou a e.

*Cant. Magnificat. 6. F. p. 211 or p. 213. Prayer. Deus, qui nobis. p. 943.*

*At Compline and the Little Hours, the psalms of Sunday are said, the Hymn, today and throughout the Octave, is sung in the tone of Christmas, p. 367, with the doxology Jesu tibi sit glória, Qui natus es de Virgine. All hymns of the same metre end with this doxology throughout the Octave, even on the feasts of Saints, unless the contrary be indicated.*

**AT MATINS.**  
Pater. Ave María. Credo.

**D** Omine, lábi- a mé-a apé-ri- es. R. Et os mé- um an-

\* The Chant for Matins is taken from the publications of Solesmes.

**FEAST OF THE BLESSED SACRAMENT.**

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monstrá- res, páne su-a-vís-simo de caélo  
praésti-to, esu-ri- éntes réples bónis, fa-stidi- ó-sos dí-  
vi- tes dimít-tens in- ánes. Eu ou a e.

*Cant. Magnificat. 6. F. p. 211 or p. 213. Prayer. Deus, qui nobis. p. 943.*

*At Compline and the Little Hours, the psalms of Sunday are said, the Hymn, today and throughout the Octave, is sung in the tone of Christmas, p. 367, with the doxology Jesu tibi sit glória, Qui natus es de Virgine. All hymns of the same metre end with this doxology throughout the Octave, even on the feasts of Saints, unless the contrary be indicated.*

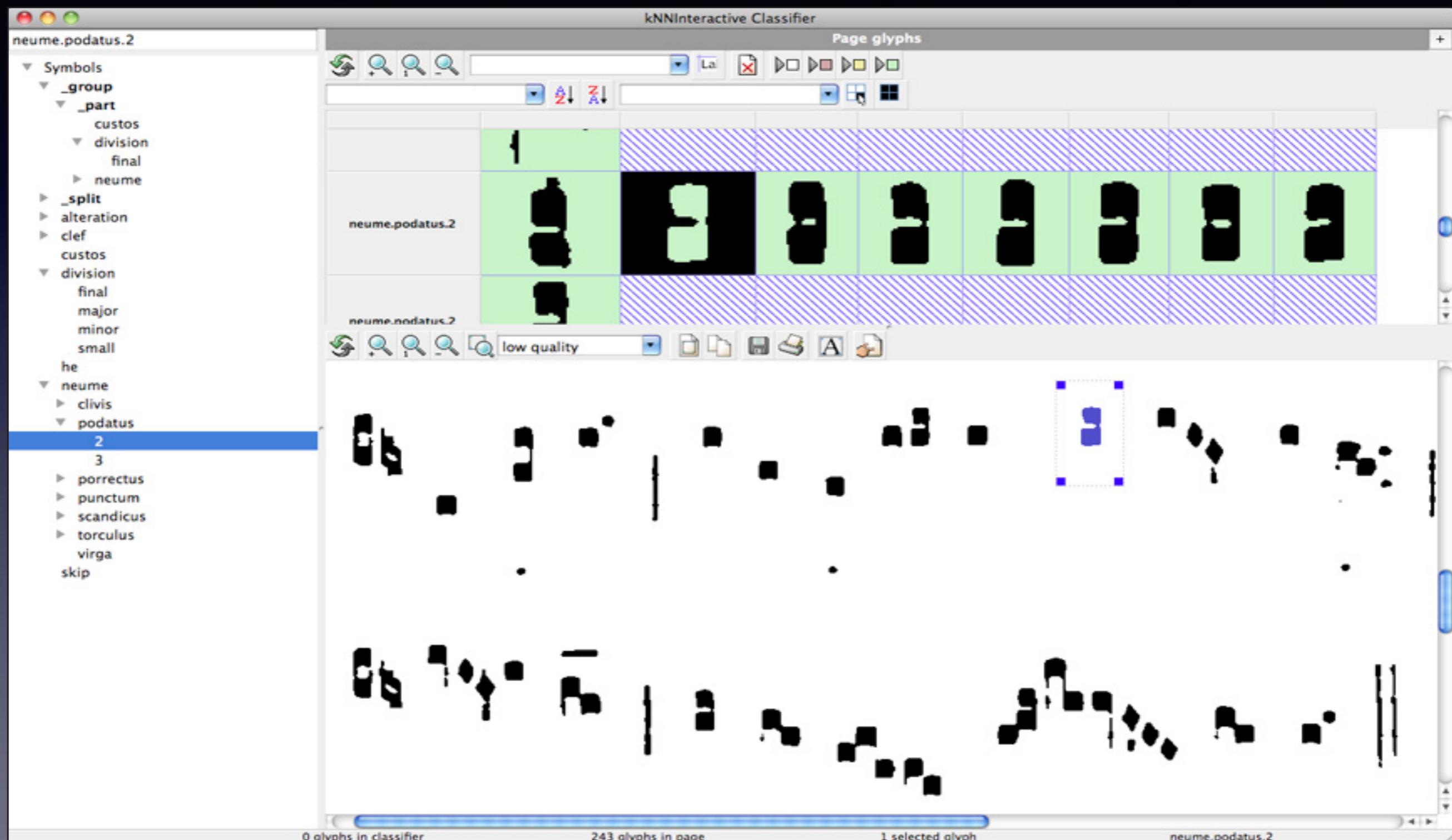
**AT MATINS.**  
Pater. Ave María. Credo.

**D** Omine, lábi- a mé-a apé-ri- es. R. Et os mé- um an-

\* The Chant for Matins is taken from the publications of Solesmes.

- In staff music symbols
- Title elements
- Lyrics or inter staves music symbols
- Ornate letter
- In staff text elements
- Blank

# Music recognition: *Gamera*



# Text recognition: *Ocropolis*

The image shows a desktop interface with two open windows. On the left is a GIMP image viewer window titled '1105.png' showing a scanned page of Latin liturgical text. On the right is a gedit text editor window titled '1105.html' displaying the same text in HTML format with added semantic annotations.

**FEAST OF THE BLESSED SACRAMENT.**  
**CORPUS CHRISTI.**  
*Double of the First Class with Octave.*  
**AT FIRST VESPERS.**  
*All as at second Vespers, p. 956, except the following:*

quam su-a-vis est, \* Dó-mi-ne, spi-

ri-tus tú- us! qui ut dulcidi-nem tú- am in filii-os de-

monstrá- res, páne su-a-vis-simo de caélo

praésti-to, esu-ri-éntes réples bónis, fa-stidi-ó-sos di-

vi- tes dimit-tens in- ánes. E u o u a e.

*Cant. Magnificat. 6. F. p. 911 or p. 913. Prayer. Deus, qui nobis. p. 943.*

*At Compline and the Little Hours, the psalms of Sunday are said; the Hymn, today and throughout the Octave, is sung in the tone of Christmas, p. 367, with the doxology Jesu tibi sit glória, Qui natus es de Virgine. All hymns of the same metre end with this doxology throughout the Octave, even on the feasts of Saints, unless the contrary be indicated.*

**AT MATINS.**  
*Pater. Ave Maria. Credo.*

Omine, lábi- a mé-a apé-ri-es. R. Et os mé- um an-

\* The Chant for Matins is taken from the publications of Solesmes.

**process.bash** **text.py** **\*genmei.py** **\*1105.html**

pan class="ocr\_line" title="bbox 401 2455 1182 2498">FEAST OF THE BLESSED SACRAMENT. </span>

pan class="ocr\_line" title="bbox 491 2350 1087 2413">CORPUS CHRISTI. </span>

pan class="ocr\_line" title="bbox 484 2261 1175 2311">Double of the First Class with Octave </span>

pan class="ocr\_line" title="bbox 536 2164 1037 2207">AT FIRST VESPERS. </span>

pan class="ocr\_line" title="bbox 184 2078 1140 2134">All as at second Vespers, p. 356, except the following: </span>

pan class="ocr\_line" title="bbox 499 1839 1435 1898">quam su-a-vis est, \* Do-mi-ne, spi-</span>

pan class="ocr\_line" title="bbox 114 1635 1484 1688">ri-tus ta-us! qui ut dulcidi-nem ta-am in filii-os de-</span>

pan class="ocr\_line" title="bbox 78 1486 1452 1498">monstra-res, pane su-a-vis-simo de caélo </span>

pan class="ocr\_line" title="bbox 57 1177 1464 1230">praésti-to, esu-ri-éntes réples bónis, fa-stidi-ó-sos di-</span>

pan class="ocr\_line" title="bbox 183 946 1317 989">vi- tes dimit-tens in- ánes. E u o u a e. </span>

pan class="ocr\_line" title="bbox 97 810 1503 854">At Compline and the Little Hours, the psalms of Sunday are said; </span>

pan class="ocr\_line" title="bbox 55 769 1500 810">the Hymn, today and throughout the Octave, is sung in the tone of Christmas. </span>

pan class="ocr\_line" title="bbox 53 727 1503 769">p. 367, with the doxology Jesu tibi sit glória, Qui natus es de Virgine. All </span>

pan class="ocr\_line" title="bbox 52 681 1499 727">hymns of the same metre end with this doxology throughout the Octave, </span>

pan class="ocr\_line" title="bbox 48 639 1188 681">even on the feasts of Saints, unless the contrary be indicated. </span>

pan class="ocr\_line" title="bbox 602 559 899 596">AT MATINS. </span>

pan class="ocr\_line" title="bbox 516 490 1031 530">Pater. Ave Maria. Credo. </span>

pan class="ocr\_line" title="bbox 256 266 1489 326">Omine, lábi- a mé-a apé-ri-es. D. Et os mé- um an- </span>

HTML Tab Width: 8 Ln 14, Col 50 INS

9 x 48 pixels 8.1 KB 78% 18 / 60

the Hymn, today and throughout the Octave, is sung in the tone of Christmas.

1447 x 43 pixels 7.7 KB 82% 12 / 60

p. 367, with the doxology Jesu tibi sit glória, Qui natus es de Virgine. All

1693 x 2747 pixels 213.9 KB 37% 1105 / 2340 2 x 44 pixels 7.1 KB 82% 15 / 60

# Pitch correction: *Aruspix*

The screenshot shows the Aruspix software interface with a musical score titled "Auspix - Recognition - untitled (91%)." The score consists of three staves of neumatic notation. Above the notation, the lyrics are written in Latin: "quam su-á-vis est, \* Dó- mi-ne, spí- ri-tus tú- us! qui ut dulcédi-ném tú- am in fí-li- os de-monstrá- res, páne su-a-vís- simo de caélo". Below the main score, there is a lower staff with blue and black notes, likely representing a reference or a different version of the pitch. The software has a standard menu bar with options like New, Open, Save, Cut, Copy, Paste, Undo, Redo, Zoom in, Zoom out, Fit, and Run.

# Web interface: *Diva.js*

FEAST OF THE BLESSED SACRAMENT.  
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ri-tus tú- us! qui ut dulcédi-ném tú- am in fí-li- os de-  
monstrá- res, páne su-a-vís- simo de caélo

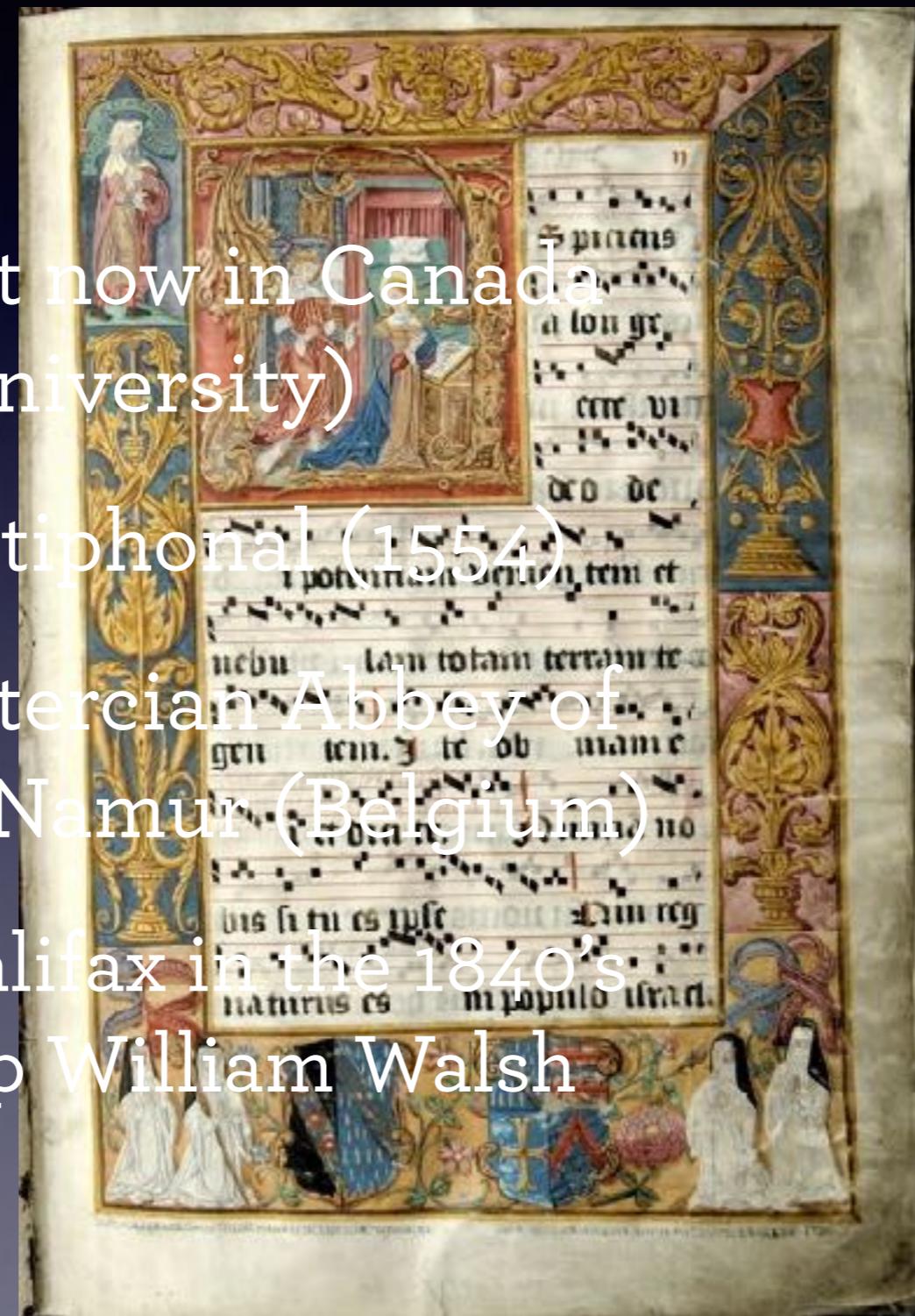


FGACA Strict pitch sequence Search Clear

previous Found 77 results for FGACA next

# 2012: *Salzinnes Project*

- ❖ A manuscript now in Canada (St. Mary's University)
- ❖ Salzinnes Antiphonal (1554)
- ❖ From the Cistercian Abbey of Salzinnes in Namur (Belgium)
- ❖ Brought to Halifax in the 1840's by Archbishop William Walsh



# 2013: Rodan

Andrew Hankinson

- ❖ Rodan: Remote Online Document Analysis Network

- ❖ Wo

rec





Greyscale

Binarization

Border Removal

Lyric Removal

Staff Removal

Shape Classification

Music Reconstruction

Shape/Image Alignment



# Layout Analysis

## Calvo's Method

Greyscale

Binarization

Border Removal

Lyric Removal

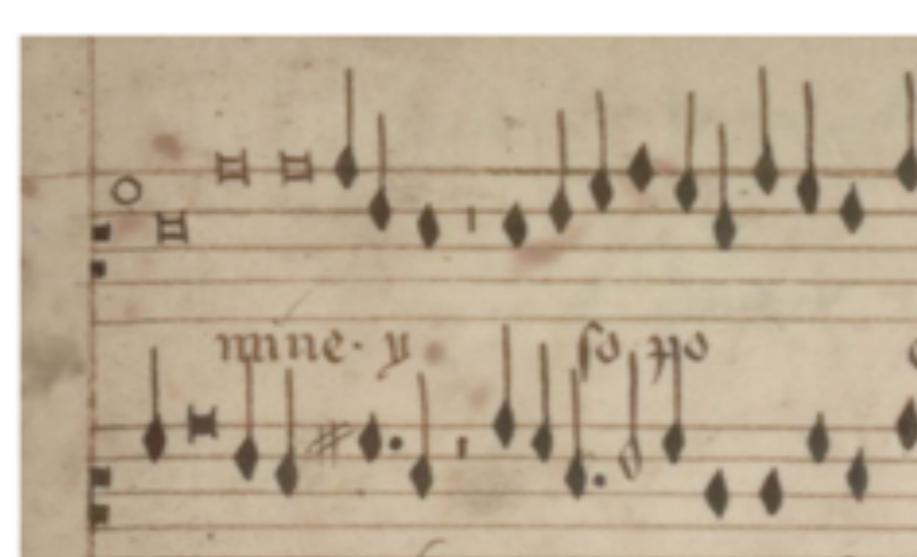
Staff Removal

Shape Classification

Music Reconstruction

Shape/Image Alignment

# Three Different Outputs in One Step! Using Deep Neural Networks



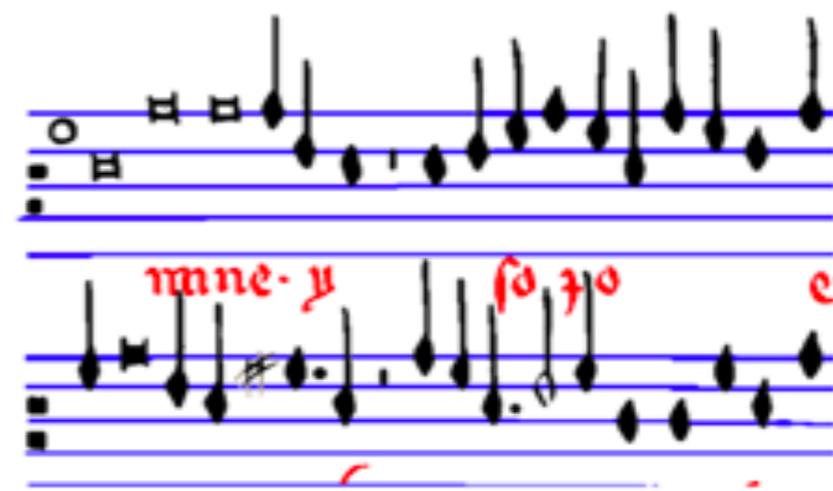
(a) Input image



(b) Binarization



(c) Text detection



(d) Staff-line detection

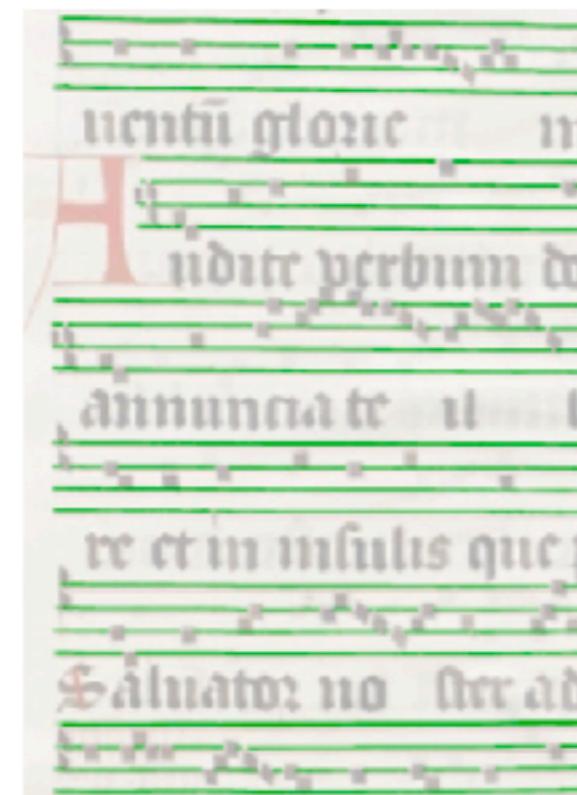
# Separation of Staves, Notes & Texts

Jorge Calvo Zaragoza • Paco Castellanos

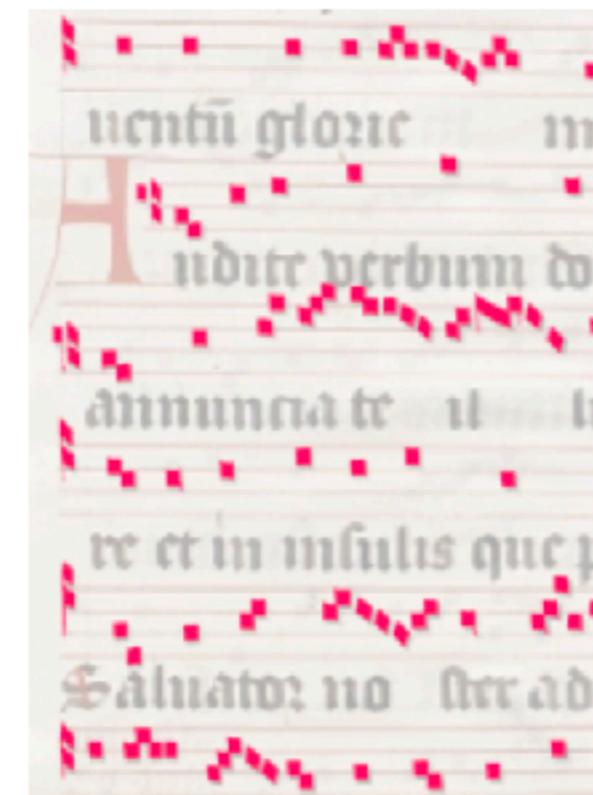
Actual



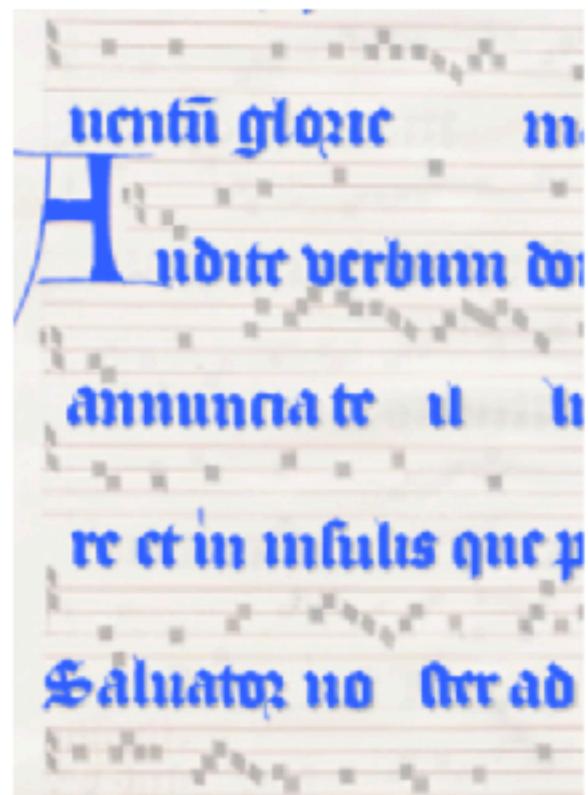
Staff



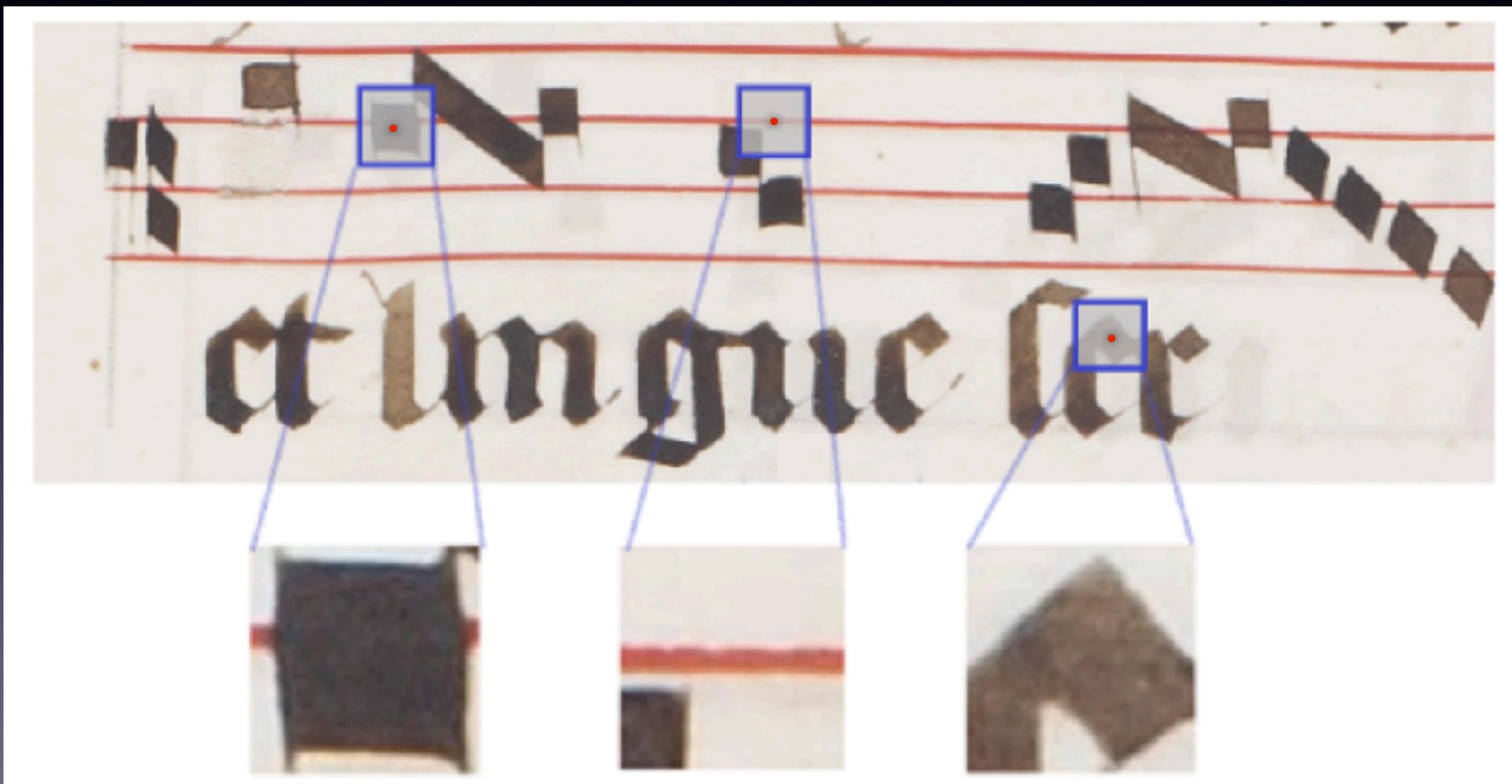
Note



Text

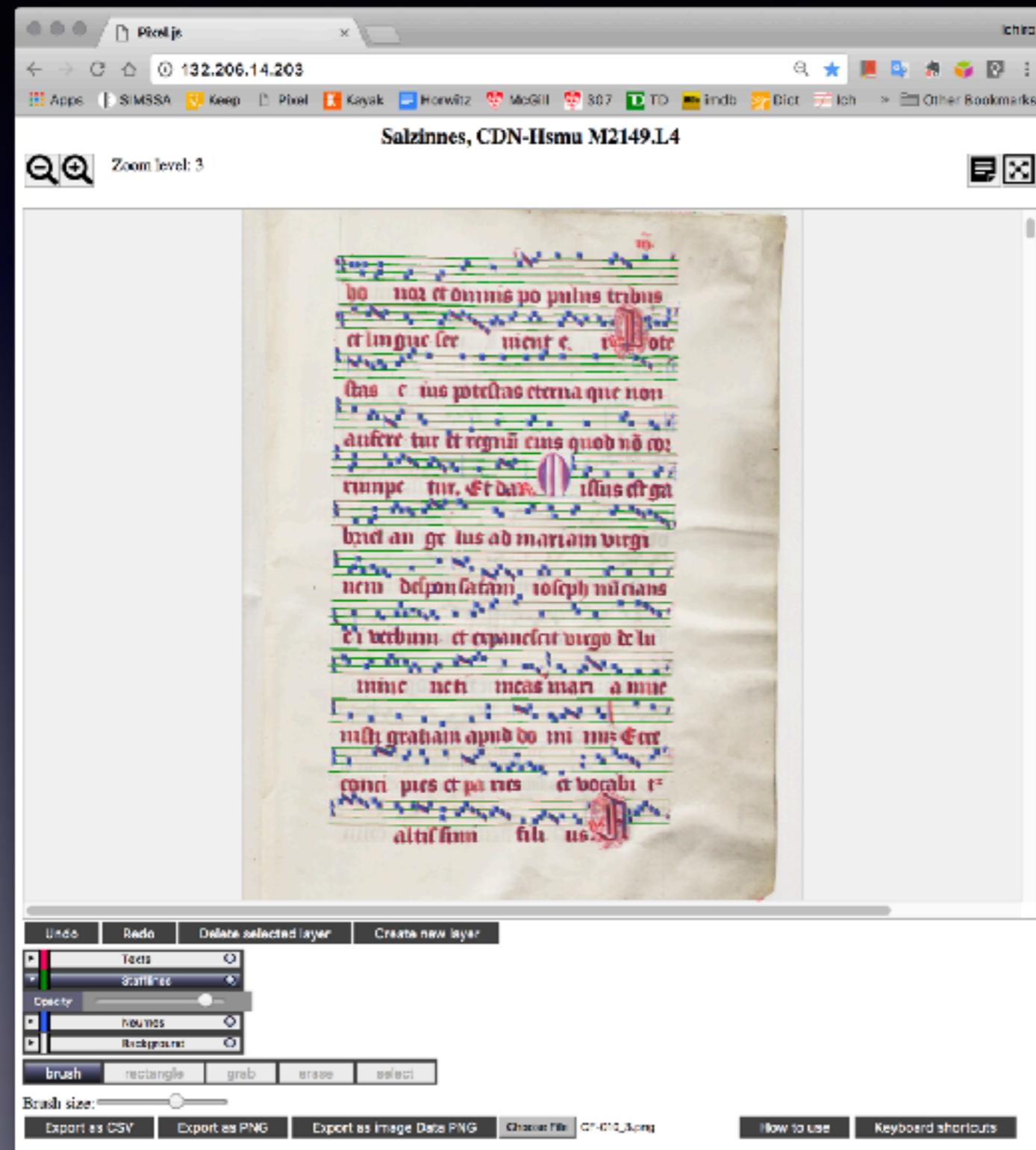


# Creating the Ground Truth

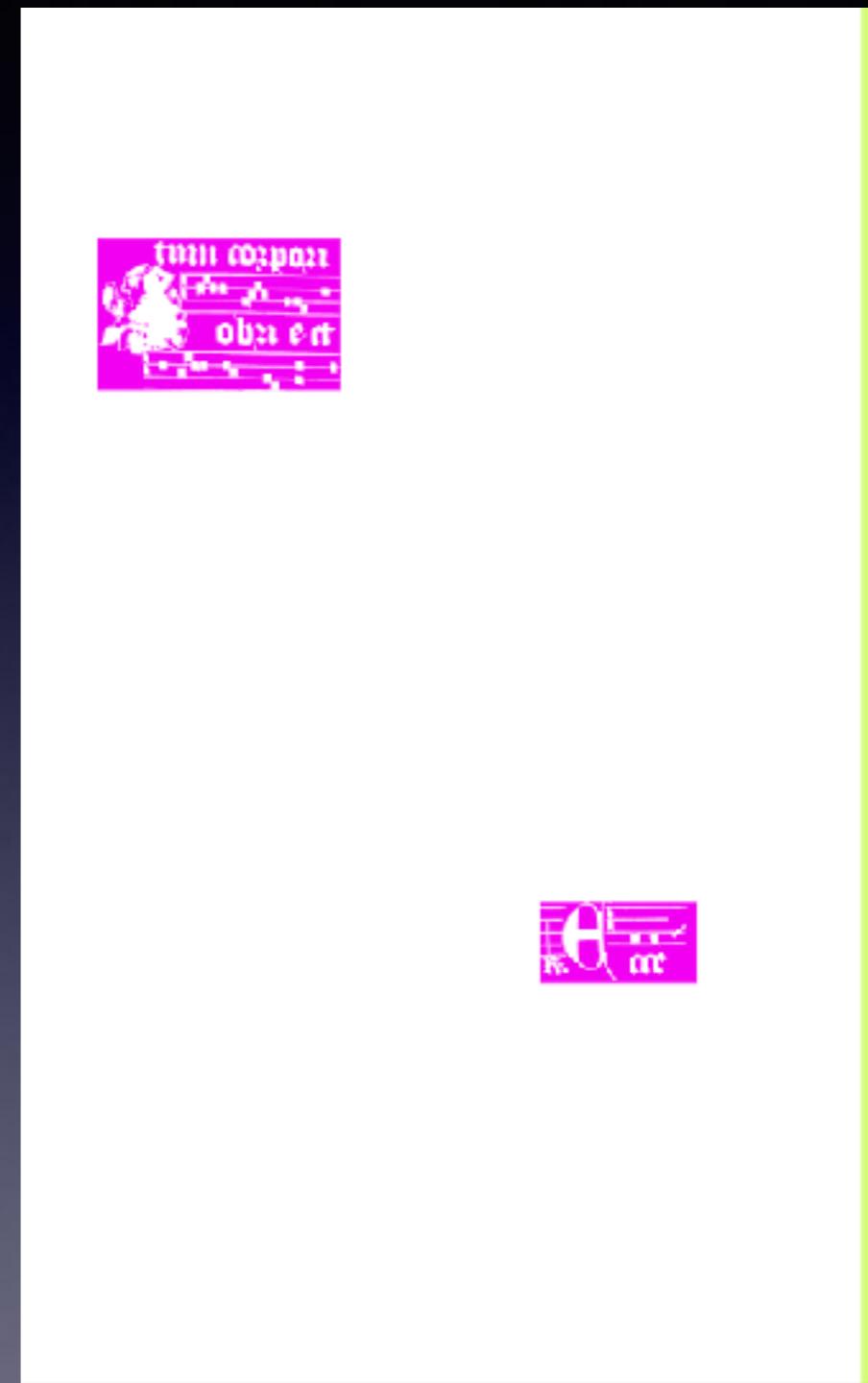
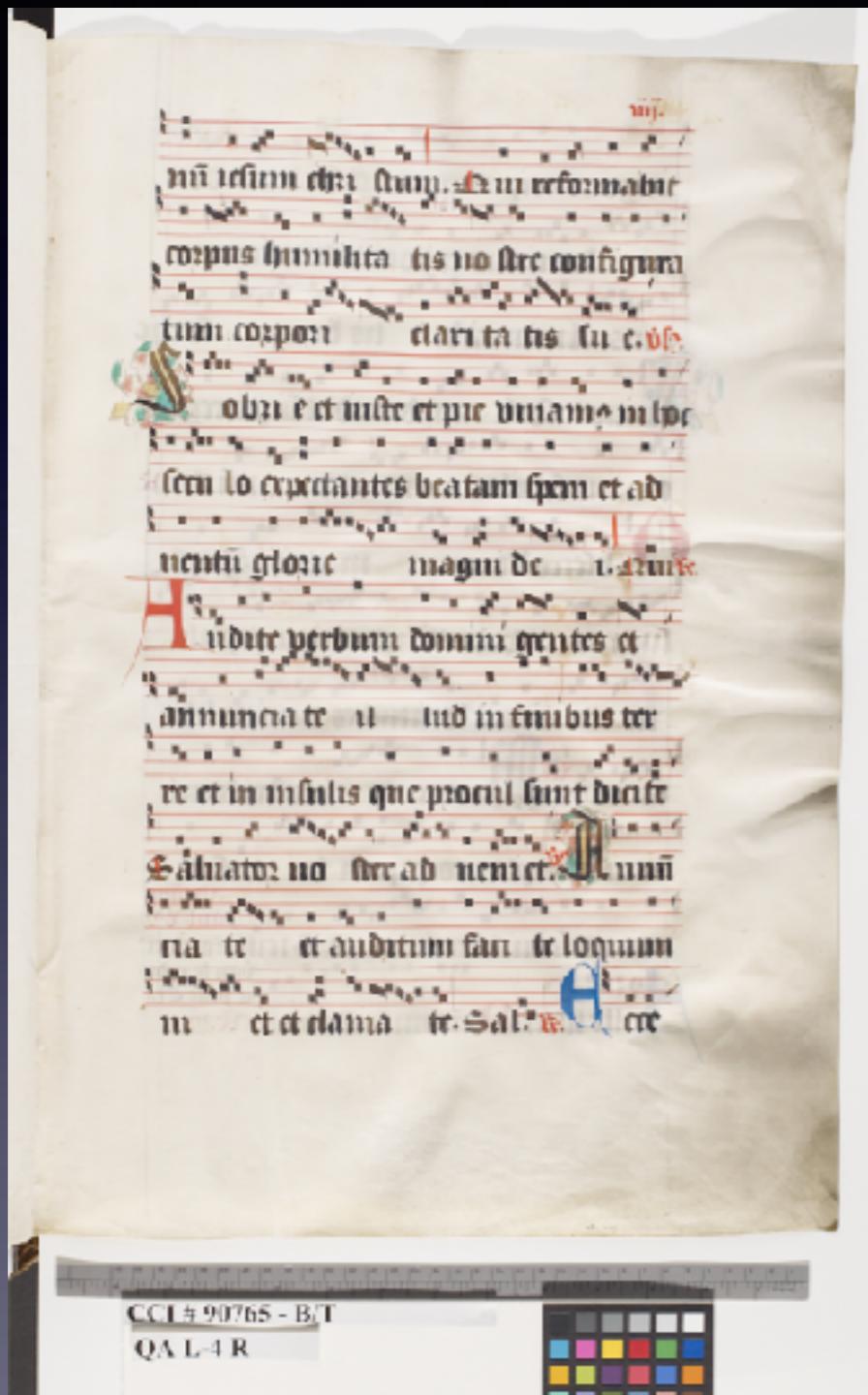


# Pixel.js: Ground Truth Creator

Zeyad Saleh, Ké Zhang & Eric Liu

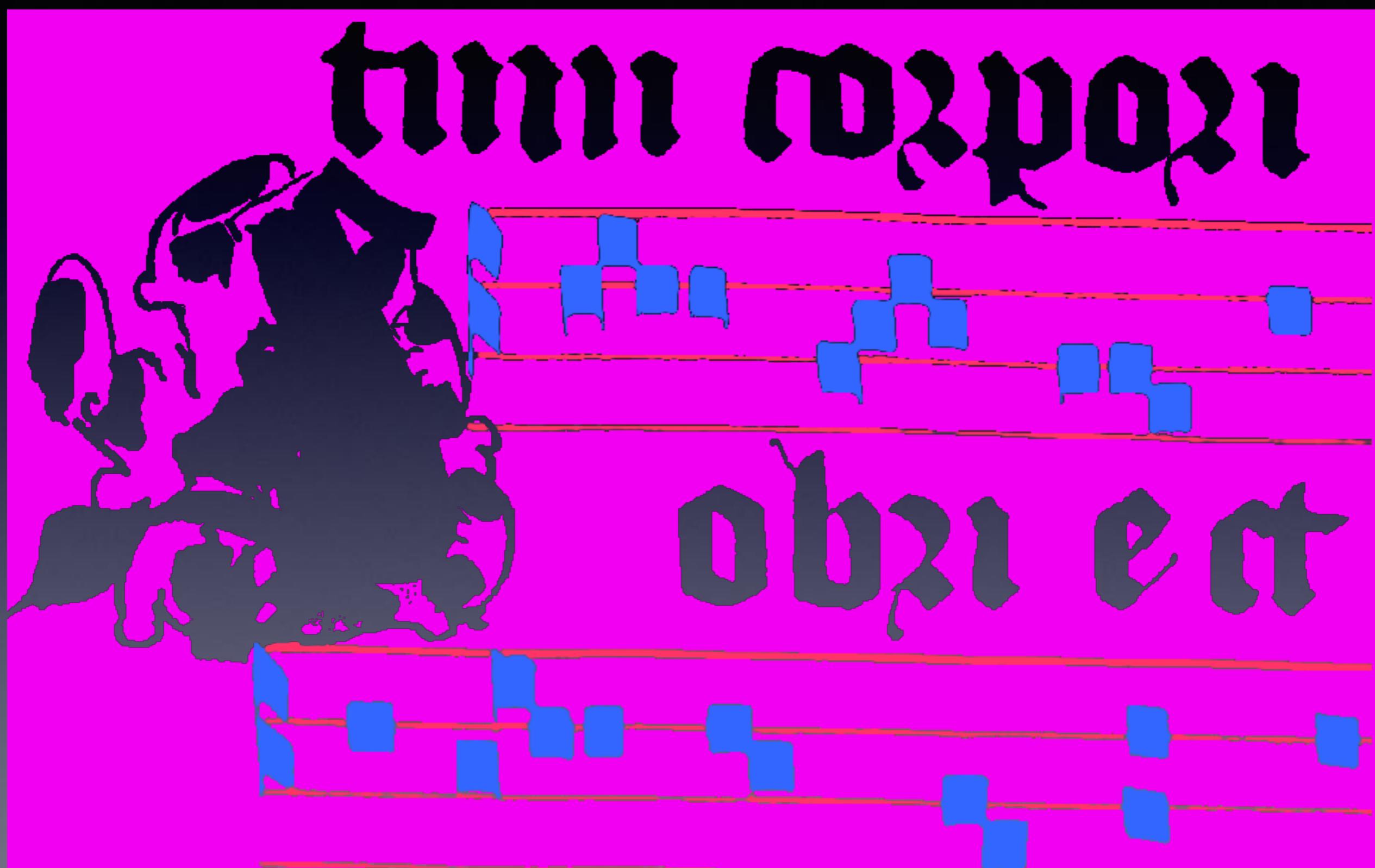


# Partial Creation of Ground Truth



To classify over 30 million pixels: 3 days (24 hours)!

# Ground Truth



# Original Image & Ground Truth

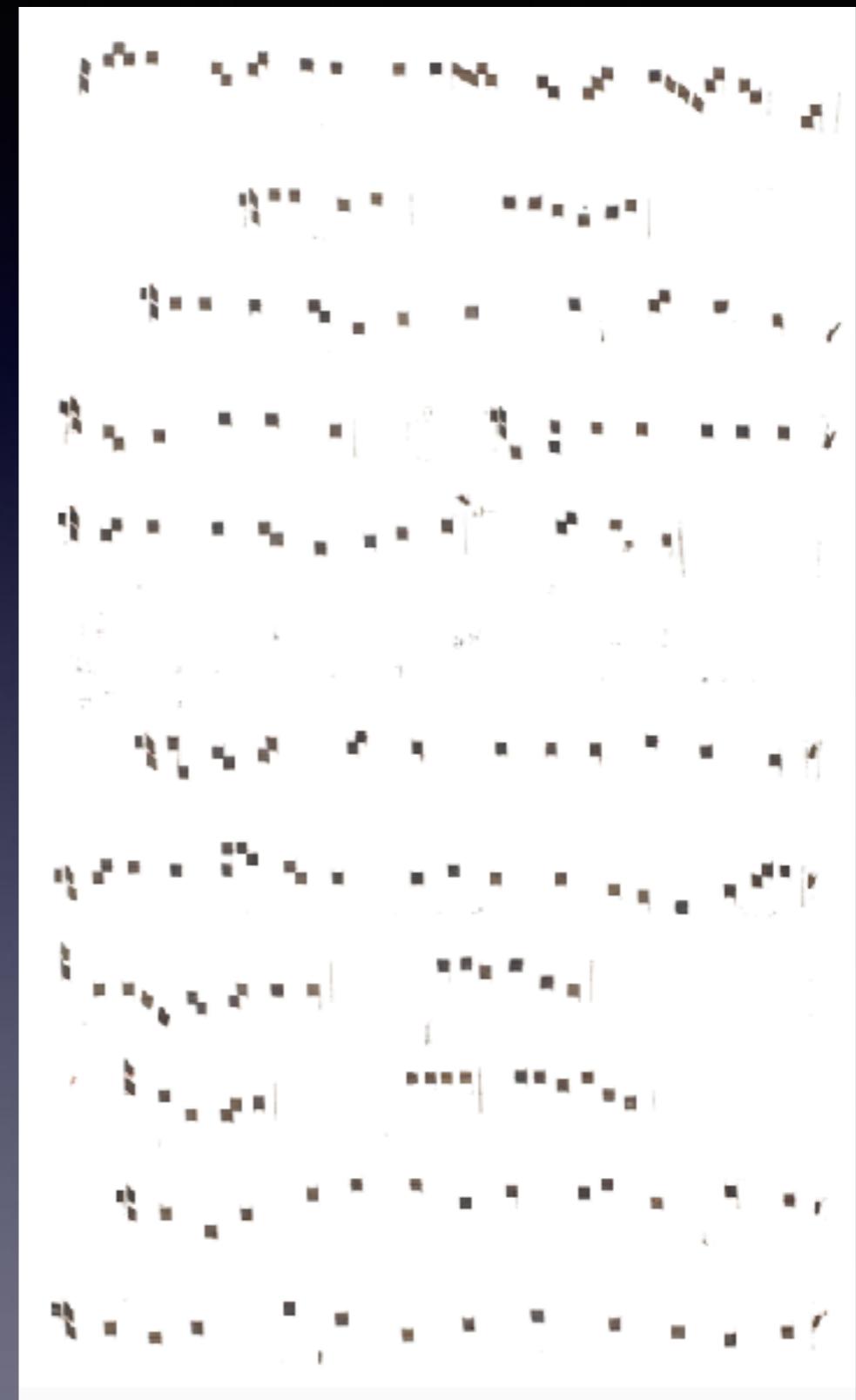
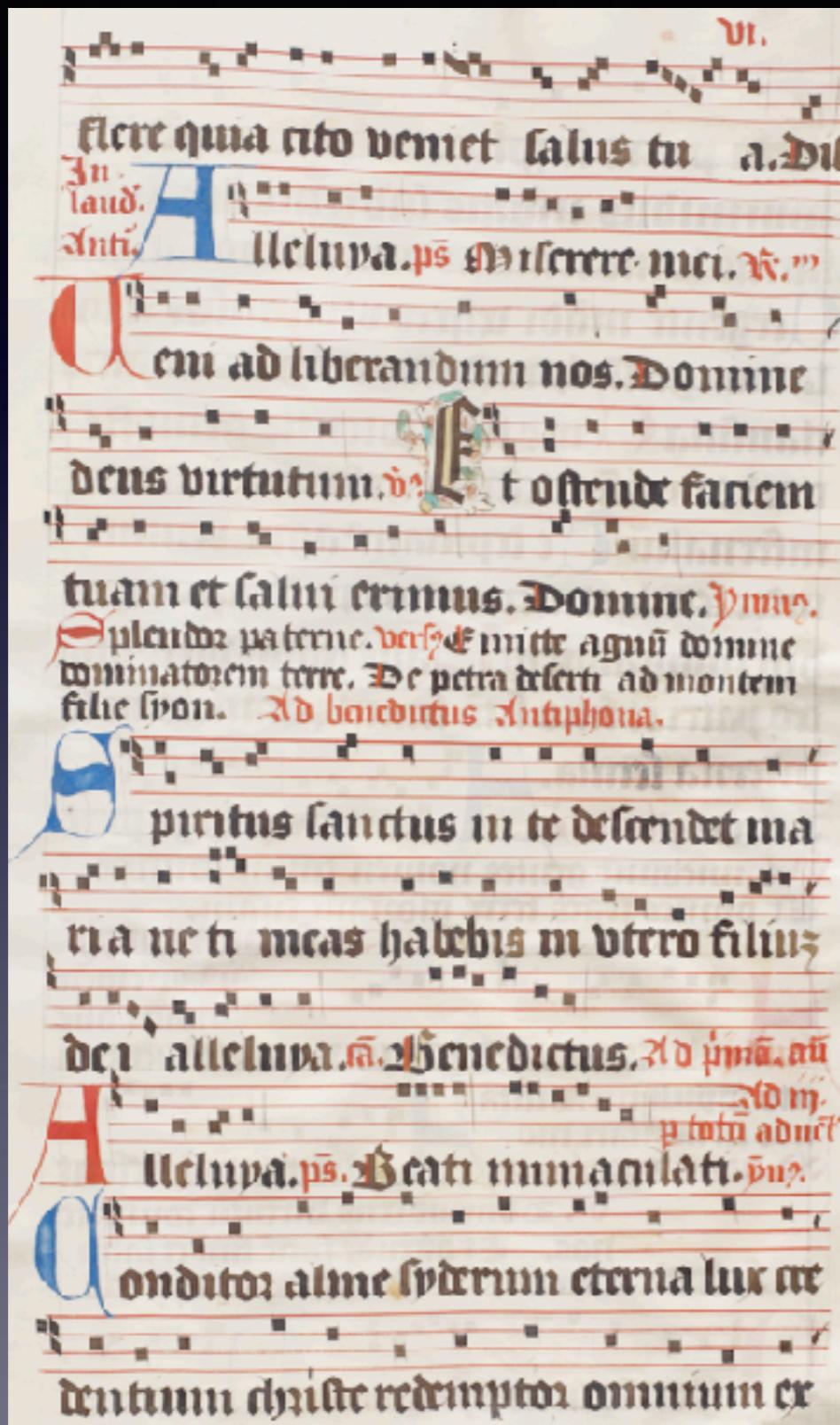


Original Image

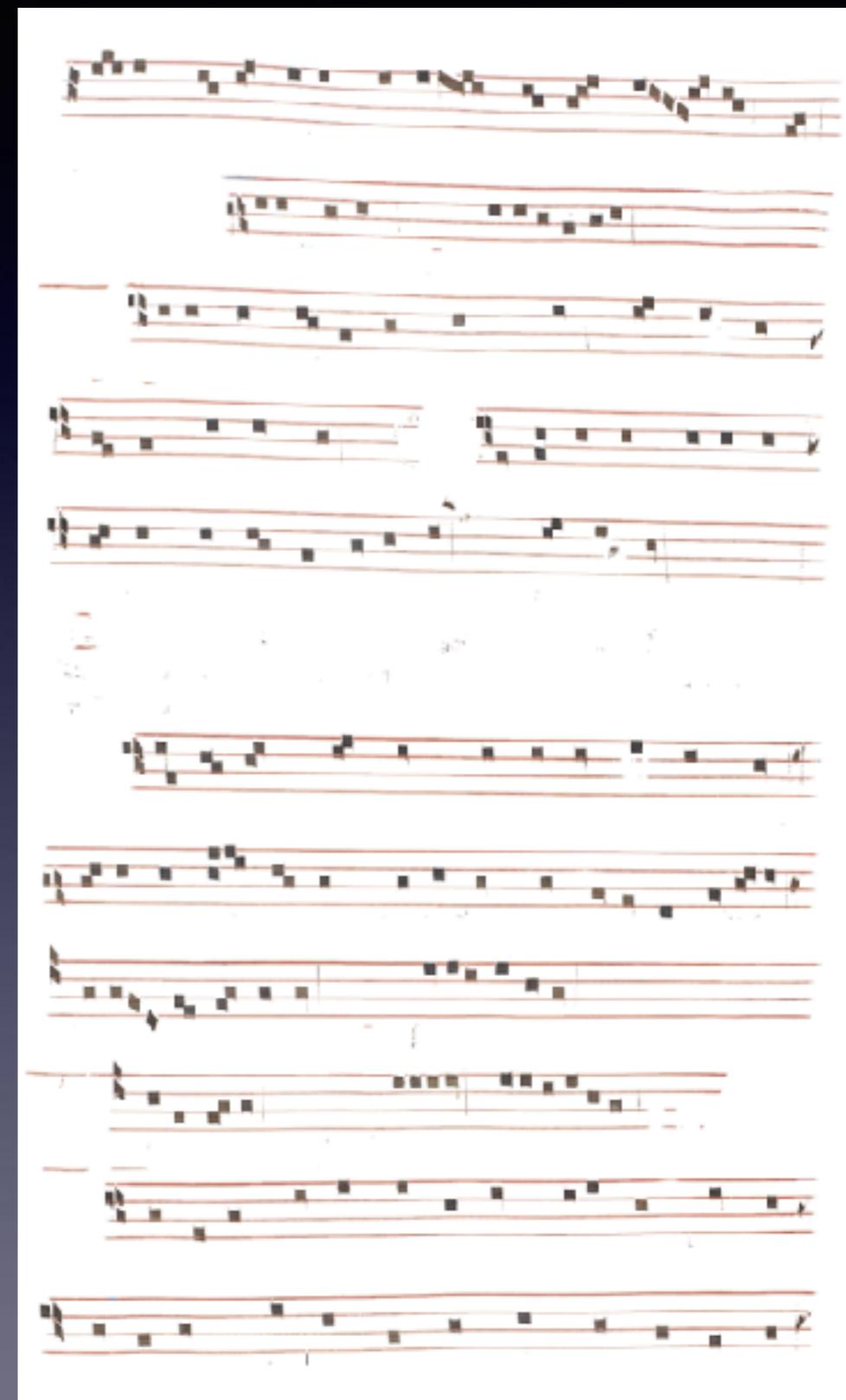
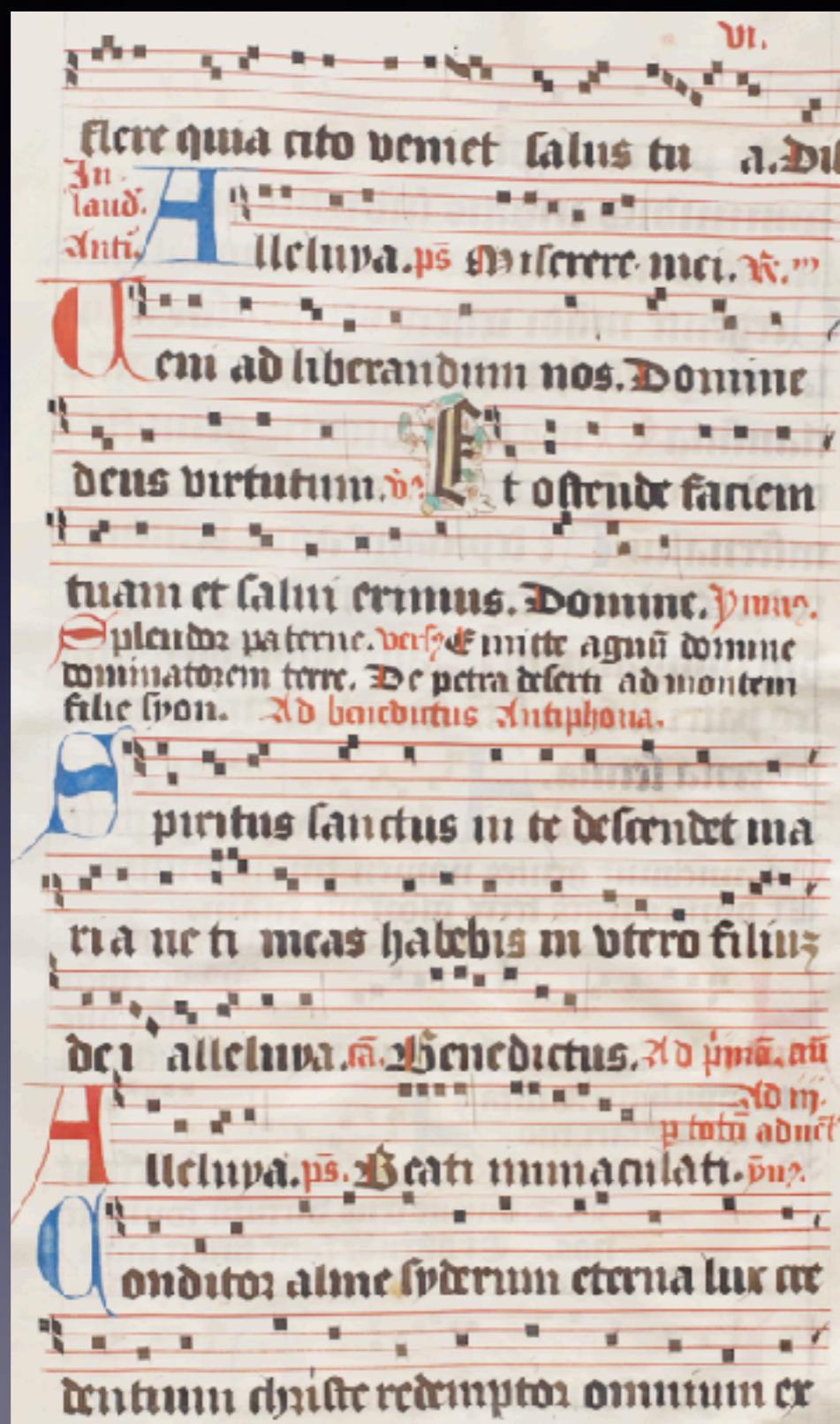


Ground Truth

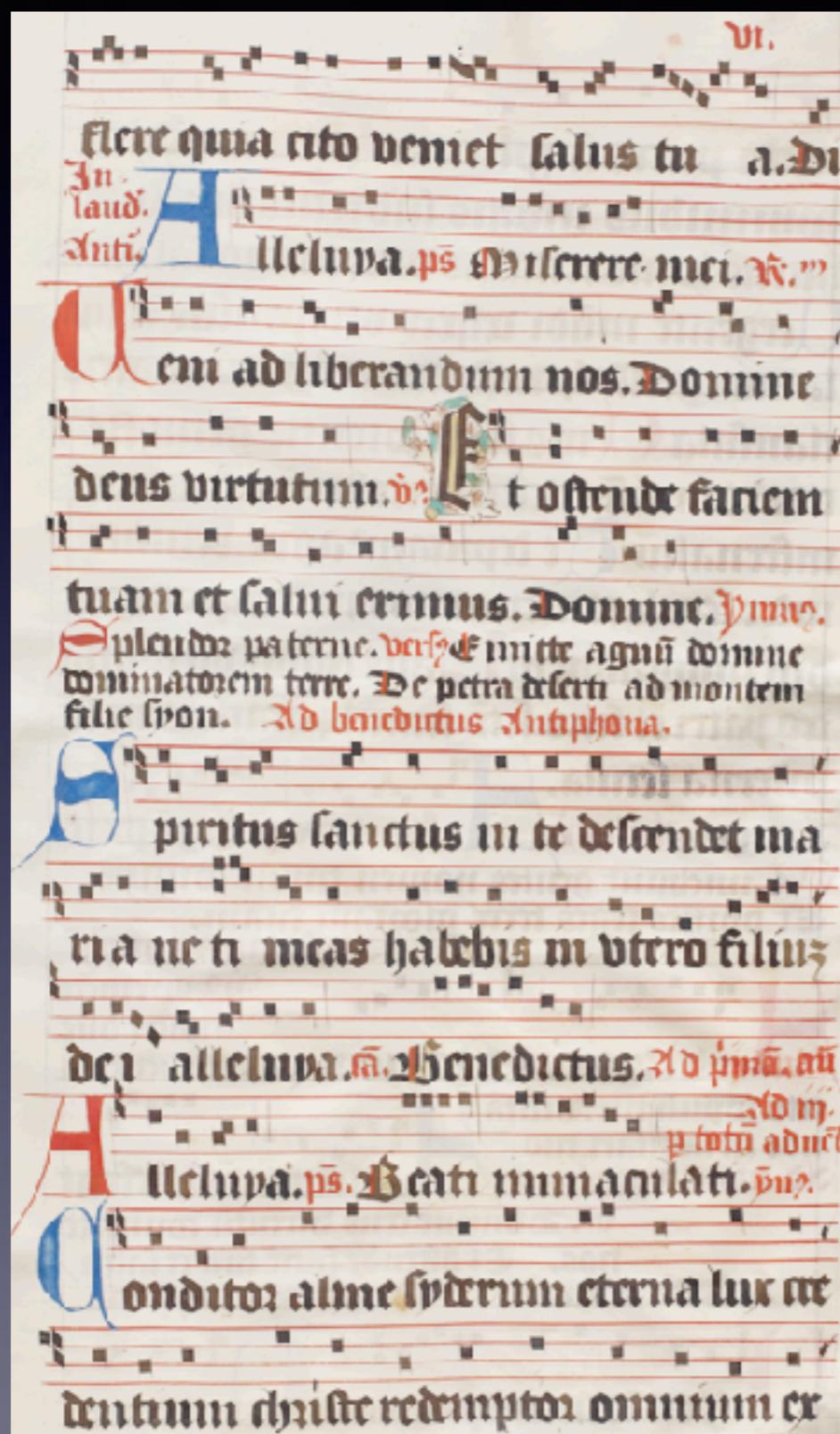
# Classification of a Page: Notes



# Classification of a Page: with Staves



# Classification of a Page



# InteractiveClassifier.js

Minh Anh Nguyen

Interactive Classifier   Submit Corrections and Re-Classify   Finalize Classification and Save GameraXML   Group Glyphs and Re-Classify

Classes

- clef
  - c
- neume
  - clirmacus
  - clivis
  - podatus
  - porrectus
  - punctum
  - torculus

neume.clirmacus

neume.clivis

neume.podatus

neume.porrectus

neume.punctum

neume.torculus

Edit

Connected Components

Class **neume.clirmacus**

Splitting **Split x** **Split**

Manual ID false

Confidence 0.8058486954409073

Position (1221, 1221)

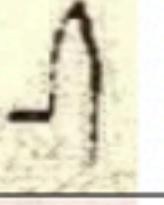
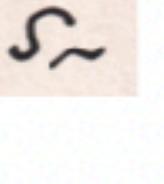
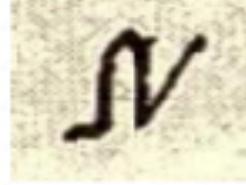
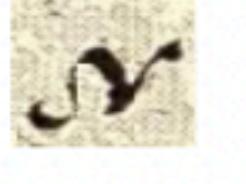
Dimensions (55, 54)

The screenshot shows the InteractiveClassifier.js application interface. On the left, there's a sidebar with a tree view of classes: 'clef' (with 'c') and 'neume' (with 'clirmacus', 'clivis', 'podatus', 'orrectus', 'punctum', 'torculus'). Below this is an 'Edit' section with a 'Connected Components' button and a 'Class' dropdown set to 'neume.clirmacus'. Under 'Splitting', there are buttons for 'Split x' and 'Split'. At the bottom of the sidebar are 'Manual ID', 'Confidence' (0.8058486954409073), 'Position' (1221, 1221), and 'Dimensions' (55, 54). The main area contains a grid of musical glyphs. A row of glyphs is highlighted with a red border. Below the grid is a horizontal bar with various musical symbols.



- ❖ The Music Encoding Initiative (MEI) is a community-driven effort to define a system for encoding musical documents in a machine-readable file format (XML).
- ❖ In development since 1999.
- ❖ MEI is based on Text Encoding Initiative (TEI).
- ❖ MEI is an alternative to MusicXML.

# Neume Mapping Table to MEI

		Torculus 3		
<b>3 pitches: n-h-l</b>				
	21,5 (10r) <b>plenitudine m</b>	<b>Torculus</b>	neame.torculus	<pre>&lt;neume&gt;   &lt;nc tilt= "e" /&gt;   &lt;nc angled= "true" tilt= "n" intm= "u" /&gt;   &lt;nc tilt= "se" intm= "d" /&gt; &lt;/neume&gt;</pre>
	21,5 (10r) <b>tua</b>	<b>Torculus</b>	neame.torculus	<pre>&lt;neume&gt;   &lt;nc curve= "a" /&gt;   &lt;nc tilt= "nw" intm= "u" /&gt;   &lt;nc curve= "c" intm= "d" /&gt; &lt;/neume&gt;</pre>
	21,5 (10r) <b>et</b>	<b>Torculus melodic</b>	neame.torculus	<pre>&lt;neume&gt;   &lt;nc tilt= "e" /&gt;   &lt;nc angled= "true" tilt= "n" intm= "u" /&gt;   &lt;nc tilt= "se" intm= "d" rel_len= "1" /&gt; &lt;/neume&gt;</pre>
		<b>Torculus</b>	neame.torculus	<pre>&lt;neume&gt;   &lt;nc curve= "a" /&gt;   &lt;nc tilt= "n" intm= "u" curve= "c" /&gt;   &lt;nc con= "g" tilt= "ne" angled= true" intm= "d" /&gt; &lt;/neume&gt;</pre>
		<b>Torculus resupinus 4</b>		
<b>4 pitches: n-h-l-h</b>				
	21,12 (10r) <b>nostrum</b>	<b>Torculus resupinus</b>	neame.torculus_resupinus	<pre>&lt;neume&gt;   &lt;nc tilt= "e" /&gt;   &lt;nc tilt= "n" angled= "true" intm= "u" /&gt;   &lt;nc tilt= "s" intm= "d" /&gt;   &lt;nc angled= "true" tilt= "ne" intm= "u" /&gt; &lt;/neume&gt;</pre>
	22,13 (10v) <b>tribuisti</b>	<b>Torculus resupinus</b>	neame.torculus_resupinus	<pre>&lt;neume&gt;   &lt;nc curve= "a" /&gt;   &lt;nc tilt= "n" intm= "u" /&gt;   &lt;nc tilt= "se" intm= "d" /&gt;   &lt;nc angled= "true" tilt= "ne" intm= "u" /&gt; &lt;/neume&gt;</pre>

# Neume Mapping Tool

## Imane Chafi

Home   New neume   About us   Contact   Help   Log-out   User1

### Punctum

Images:



Name:

Punctum

Classification:

neume.punctum

Mei Snippet:

```
1 //mei snippet for neume.punctum
2 <neume>
3 <nc>
4 </neume>
```

Folio:

1/r9

[Update](#)

[Delete](#)

Description:

Punctum

### Pes

Images:



Name:

Pes

Classification:

neume.pes.b.3

Mei Snippet:

```
1 //mei snippet for neume.pes.b.3
2 <neume>
3 <nc/>
4 <nc intm = "25"/>
5 </neume> |
6
```

element parse error: Error: invalid tagName:

Folio:

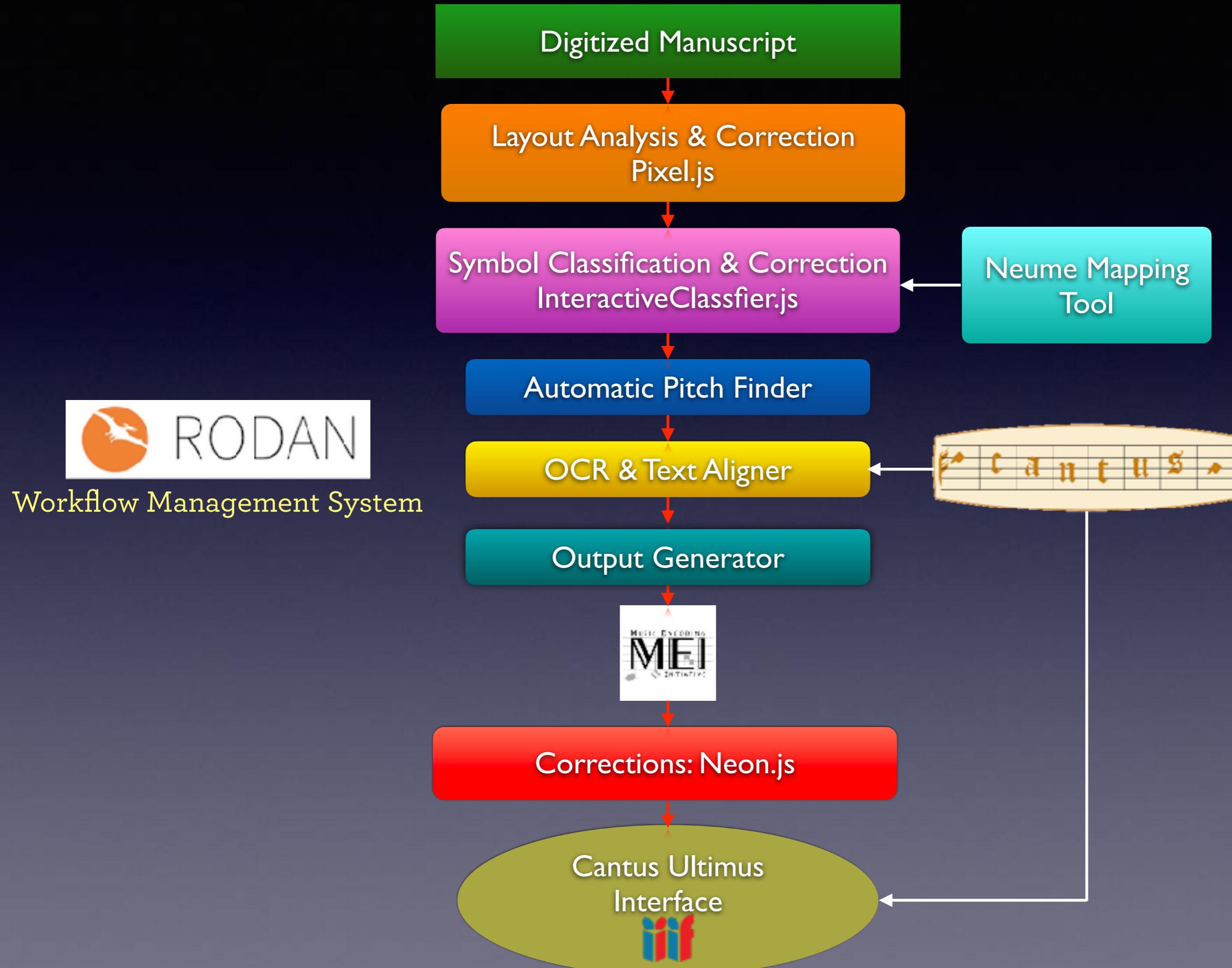
1n3, 1r5

[Update](#)

[Delete](#)

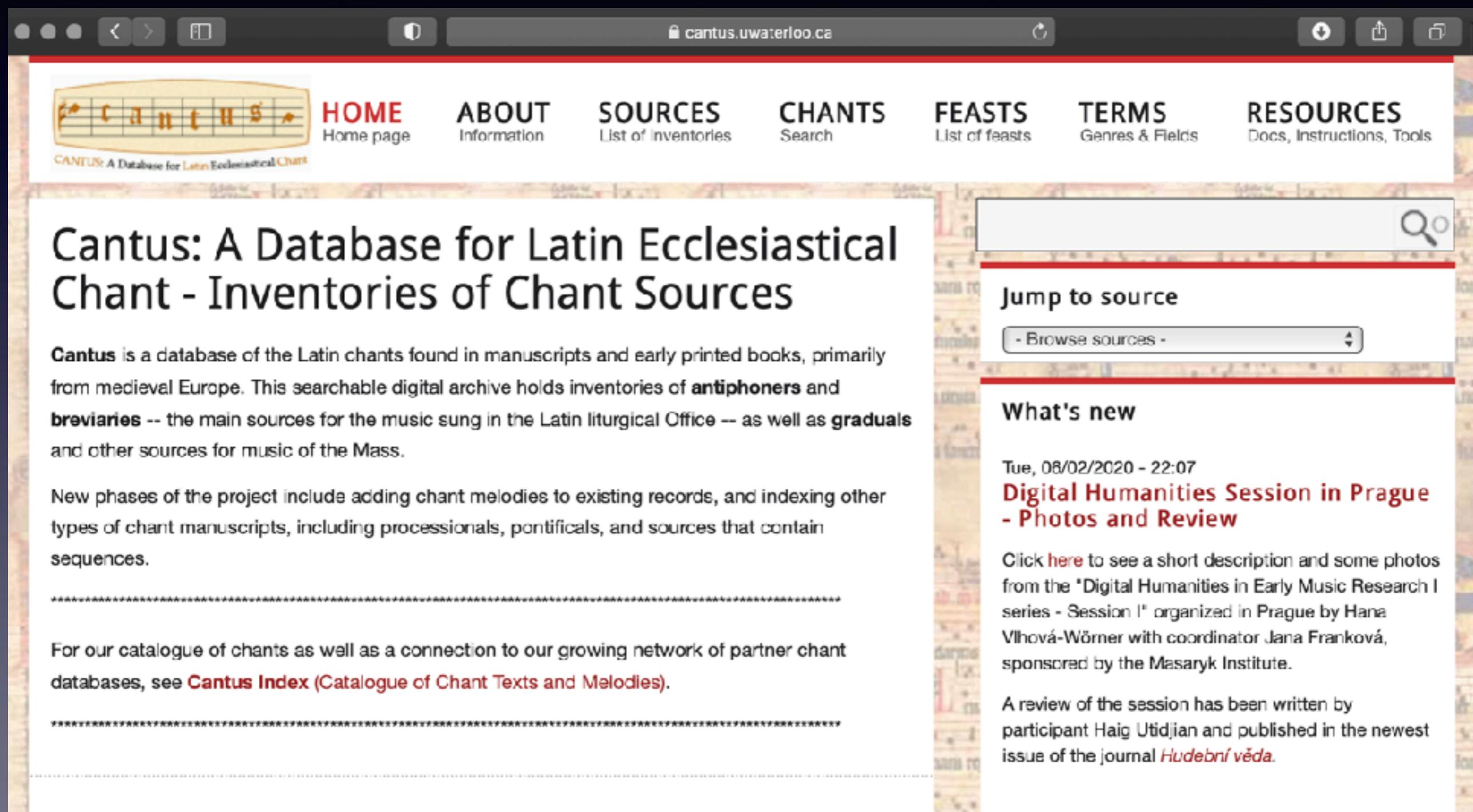
Description:

# SIMSSA Workflow for Neume Notation



# Cantus Database

Debra Lacoste • Jan Koláček • Jennifer Bain  
Junhao Wang • Jacob deGroot-Maggetti



The screenshot shows a web browser displaying the homepage of the Cantus Database at cantus.uwaterloo.ca. The page features a header with the project name in large orange letters, followed by the names of the team members in red. Below the header is a navigation bar with links for HOME, ABOUT, SOURCES, CHANTS, FEASTS, TERMS, and RESOURCES. The main content area has a background image of a medieval manuscript. It includes a search bar, a 'Jump to source' button, a 'What's new' section with a recent update about a digital humanities session in Prague, and a footer with links to SIMSSA, DDMAL, and LinkedMusic.

**CANTUS** A Database for Latin Ecclesiastical Chant

**HOME** Home page    **ABOUT** Information    **SOURCES** List of inventories    **CHANTS** Search    **FEASTS** List of feasts    **TERMS** Genres & Fields    **RESOURCES** Docs, Instructions, Tools

## Cantus: A Database for Latin Ecclesiastical Chant - Inventories of Chant Sources

**Cantus** is a database of the Latin chants found in manuscripts and early printed books, primarily from medieval Europe. This searchable digital archive holds inventories of **antiphoners** and **breviaries** -- the main sources for the music sung in the Latin liturgical Office -- as well as **graduals** and other sources for music of the Mass.

New phases of the project include adding chant melodies to existing records, and indexing other types of chant manuscripts, including processions, pontificals, and sources that contain sequences.

\*\*\*\*\*

For our catalogue of chants as well as a connection to our growing network of partner chant databases, see [Cantus Index \(Catalogue of Chant Texts and Melodies\)](#).

\*\*\*\*\*

Jump to source

- Browse sources -

### What's new

Tue, 08/02/2020 - 22:07

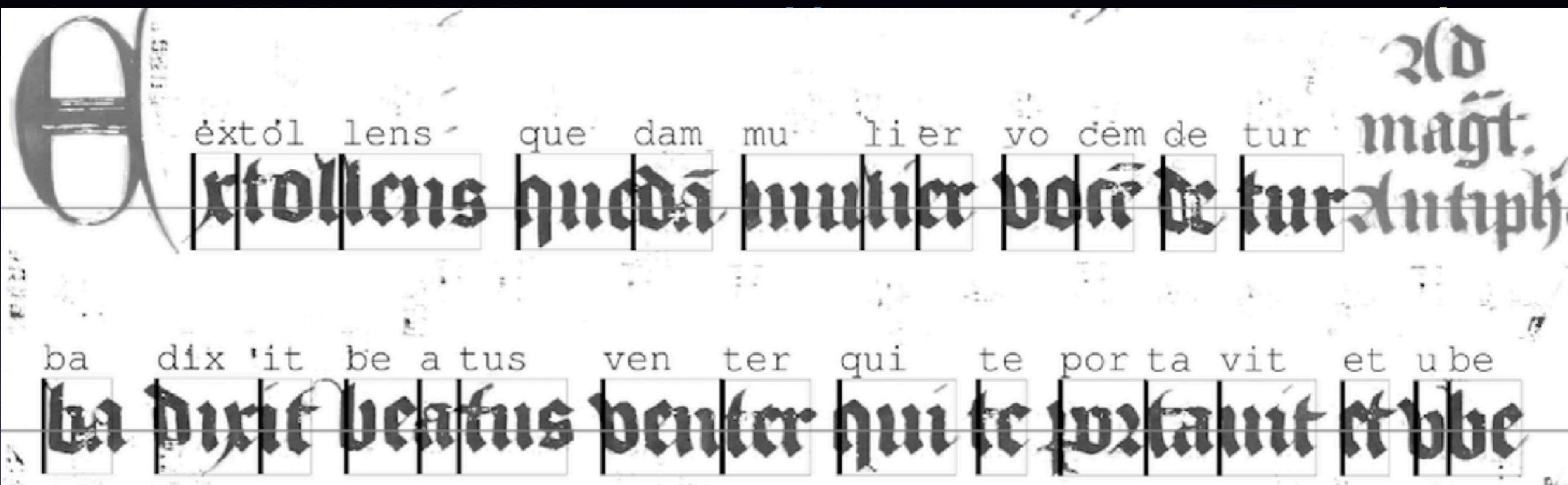
**Digital Humanities Session in Prague - Photos and Review**

Click [here](#) to see a short description and some photos from the "Digital Humanities in Early Music Research I series - Session I" organized in Prague by Hana Vlhová-Wörner with coordinator Jana Franková, sponsored by the Masaryk Institute.

A review of the session has been written by participant Haig Utidjan and published in the newest issue of the journal *Hudební věda*.

# OCR & Text Aligner

Timothy de Reuse



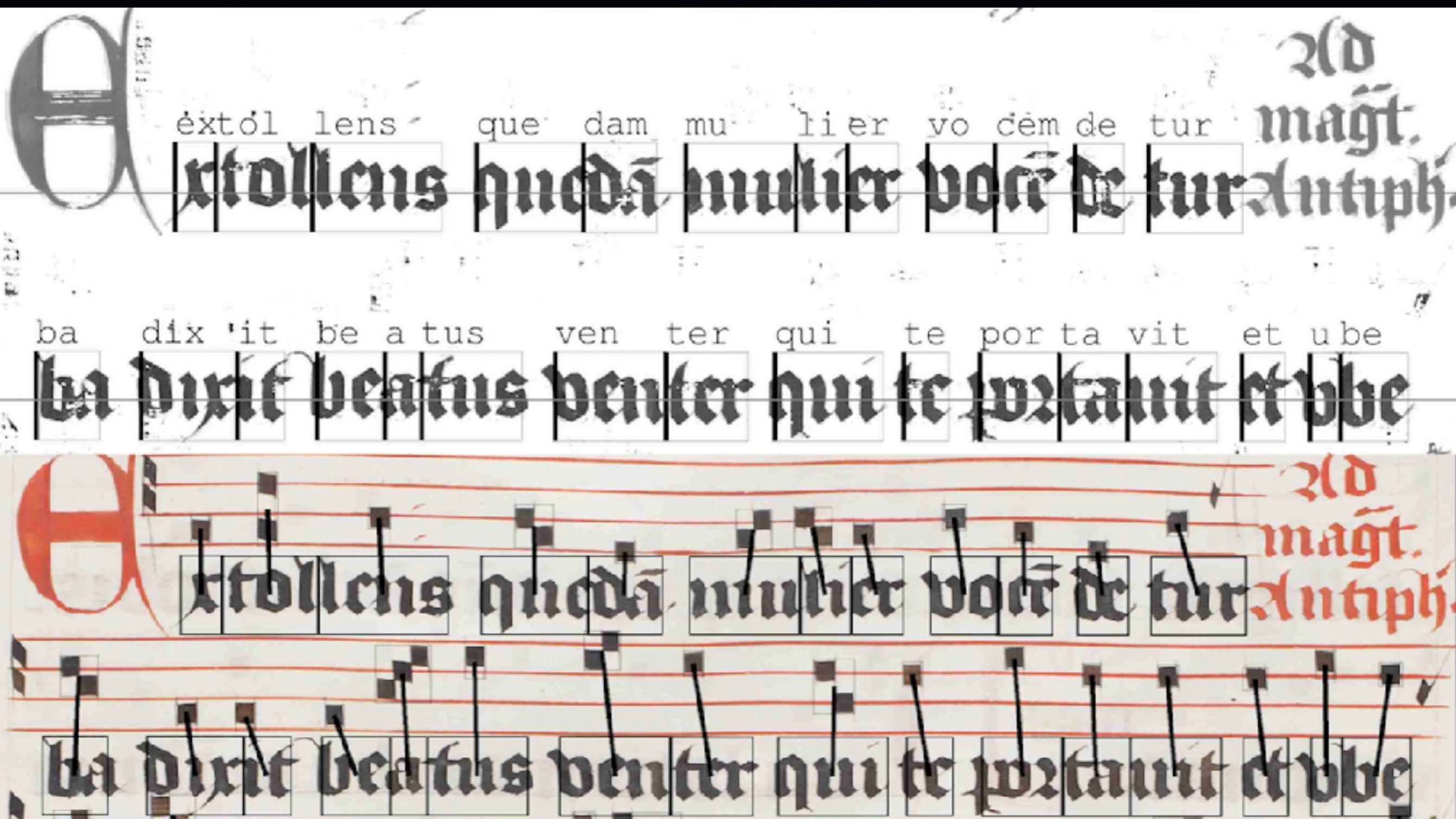
From Cantus Database

**Extollens quaedam mulier vocem de tur-  
ba dixit beatus venter qui te portavit et ube...**

- ❖ OCR used: OCropus (recurrent neural network: LSTM)
- ❖ Sequence alignment: Needleman-Wunsch algorithm

# OCR & Text Aligner

Timothy de Reuse



# Neume Editor ONline: Neon

Juliette Regimbal • Caitlin Hutnyk • Yinan Zhou

The screenshot shows a digital interface for editing neumes (ancient musical notation) over a manuscript page. The manuscript features four-line red staves with black neumes and Latin text in a Gothic script. The text includes "Iusti sancto. Be. Gloriantur illos", "Ex alto per frumentum.", and "Et de petra melle fa". The digital interface has a toolbar at the top with "File", "MEI Actions", and "Help" buttons, and status indicators for "076r-154", "MEI Version: 5.1", and "MEI Status: VALID". On the right, there's a "Debug Mode: OFF" button and a "Feedback Form" link. A sidebar titled "EDIT" contains "Selection Mode" buttons for "Syllable", "Neume", "Neume Component", "Staff", "Layer Element", and "Box" (which is selected). Below these are buttons for "Match Height for Entire Row" and "Delete", and "Undo" and "Redo" buttons. A "Syllables on this page" section lists the words from the manuscript: "mo De dit Gio ri a pa tri et ti li o et spi ri tu i sanc to Ci ba vil il los Ex ad i pe fru men li Et de pe tra mel le sa tu ra vit e os Gio ri a pa".

# Cantus Ultimus Interface

Néstor Nápoles • Dylan Hillerbrand

The image shows a screenshot of the Cantus Ultimus Interface. On the left, a medieval manuscript page from the Salzinnes, CDN-Hsmu M2149.L4 is displayed, featuring intricate gold and blue foliate decorations, a large initial 'R', and musical notation on four-line red staves. On the right, a digital interface provides metadata and a musical score for the chant. The header includes the URL 'cantus.ultra.csail.mit.edu/manuscript/133y?folio=002r&chant=1'. The interface has tabs for 'About', 'Activities', 'Team', 'Manuscripts', and 'Search'. Below the tabs, it shows 'Folio 002r (3 of 479)' with navigation buttons for 'Go', 'Previous Folio', and 'Next Folio'. A 'Manuscript Info' button is also present. The main content area is divided into sections: 'Chants' (listing 'Aspiciens a longe ecce video'), 'Cantus ID: 006129', 'Sequence: 1', 'Feast: Dom. 1 Adventus', 'Office: Matins', 'Genre: Responsory', and 'Mode: 7'. Below this is a 'Full Text' section with the Latin text: 'Aspiciens a longe ecce video dei potentiam venientem et nebulam totam terram tegentem. Ite obliam ei et dicite nuntia nobis si tu es ipse qui regnaturus es in populo Israel'. At the bottom is a musical score for 'Aspiciens a longe ecce video' with lyrics aligned under the notes.

# LinkedMusic

- ❖ Be able to search across various music databases from one website
  - ❖ Database integration using linked data
- ❖ Universal Musical Instrument Lexicon
  - ❖ Create a crowd-sourced website
  - ❖ Images and recordings of musical instruments
  - ❖ Name of the instrument in the local language
- ❖ Funded for 7 years (2022-2029): \$3.2M

# LinkedMusic: Co-applicants (7)

- ❖ Jennifer Bain  
(Dalhousie University)
- ❖ Houman Behzadi (McGill)
- ❖ Julie Cumming (McGill)
- ❖ Debra Lacoste  
(University of Waterloo)
- ❖ Audrey Laplante  
(Université de Montréal)
- ❖ Cory McKay  
(Marianopolis College)
- ❖ Laurent Pugin (RISM-Digital)

# LinkedMusic: Collaborators (18)

- ❖ Rachelle Chiasson-Taylor  
(Library and Archives Canada)
- ❖ Julia Craig-McFeely  
(Oxford University)
- ❖ Jürgen Diet  
(Bavarian State Library)
- ❖ Robin Desmeules (McGill)
- ❖ Simon Dixon  
(Queen Mary, University of London)
- ❖ Jon Dunn (Indiana University)
- ❖ Andrew Hankinson (RISM Digital)
- ❖ Johannes Kepper  
(University of Paderborn)
- ❖ Kevin Kishimoto  
(Stanford University)
- ❖ David Lewis  
(Goldsmiths, University of London)
- ❖ Jonathan Manton (Yale University)
- ❖ Kevin Page (University of Oxford)
- ❖ Alastair Porter (UPF / MetaBrainz)
- ❖ Jenn Riley (McGill)
- ❖ Patrick Savage (Keio University)
- ❖ David Weigl (University of Music and Performing Arts Vienna)
- ❖ Susan Weiss  
(Johns Hopkins University)
- ❖ Frans Wiering  
(University of Utrecht)

# LinkedMusic: Partners (9)

- ❖ Bavarian State Library (Jürgen Diet)
- ❖ British Library
- ❖ Calcul Québec
- ❖ Dalhousie University (Jennifer Bain)
- ❖ MetaBrainz Foundation (Alastair Porter)
- ❖ RISM Digital (Laurent Pugin)
- ❖ Université de Montréal (Audrey Laplante)
- ❖ University of Oxford (Julia Craig-McFeely)
- ❖ University of Waterloo (Debra Lacoste)

# Advisory Board Members

- ❖ Barbara Dobbs McKenzie (RILM: Répertoire International de Littérature Musicale)
- ❖ Perry Roland (University of Virginia)
- ❖ Rob Sanderson (Yale University)
- ❖ Xavier Serra (University of Pompeu Fabra)

# Staff & Graduate Students

## ❖ Project Manager

❖ Vi-An Tran

## ❖ Postdoctoral Fellow

❖ Anna de Bakker

## ❖ Graduate Students

❖ Kyrie Bouressa

❖ Hanwen Zhang

❖ Kun Fang

❖ Liam Pond

❖ Lucas March

❖ Yu-Chia Kuo

## ❖ Researchers

❖ Dylan Hillerbrand

❖ Geneviève Gates-Panneton

❖ Yinan Zhou

# Research Assistants

- ❖ Yueqiao Zhang
- ❖ Sichen Meng (intern?)
- ❖ Antoine Phan
- ❖ Caroline Guo (part time)
- ❖ Linnea Kirby
- ❖ Zhanna Klimanova (part time)
- ❖ Mai Lyn Puittinen
- ❖ Sebastien Chow
- ❖ Simon Ngassam

# LinkedMusic.ca

LinkedMusic    ABOUT    PARTICIPANTS    ACTIVITIES    REFERENCES    VIM    OPPORTUNITIES    CONTACT US

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# LinkedMusic

The goal of our new LinkedMusic Partnership is to link music databases through metadata schemas: structures for organizing information stored in a database. This will go a long way towards bringing online music search to the same level of sophistication currently possible for text-based resources, allowing us to answer fundamental questions about music and how it interacts with human creativity, society, culture, and history.

Our goals include:

- Develop a comprehensive international metadata schema for music
- Develop mapping tools to map extant metadata schemas onto our new schema
- Index aggregated metadata to enable simultaneous search of individual databases

For more information, please contact [Ichiro Fujinaga](#).

L'objectif de notre nouveau partenariat LinkedMusic est de lier des bases de données musicales par des schémas de métadonnées, des structures d'organisation de l'information stockées dans une base de données. Ce projet contribuera grandement à amener la recherche de musique en ligne au même niveau de sophistication que la recherche de ressources textuelles, nous permettant ainsi de répondre à des questions fondamentales sur la musique et comment elle interagit avec la créativité, la société, la culture et l'histoire humaines.

# Initial 14 Databases

1. RISM
2. DIAMM
3. Cantus Database
4. Cantus Index
5. Cantus Ultimus
6. SIMSSA DB
7. Canadian Chant Database
8. Global Jukebox
9. Dig That Lick
10. MusicBrainz
11. AcousticBrainz
12. CritiqueBrainz
13. ListenBrainz
14. Motet Database

# Summary

- ❖ Optical Music Recognition (OMR)
- ❖ SIMSSA (Single Interface for Music Score Searching and Analysis)
  - ❖ Neume notation
  - ❖ Gamera
  - ❖ Rodan
- ❖ LinkedMusic

# Dinner on Wednesday Night

- ❖ 6 pm Kim Fung (second floor, 1111 Rue Saint-Urbain)

# Acknowledgements

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Paco Castellanos  
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Remi Chiu  
Morgane Ciot  
Nat Condit-Schultz  
Kemal Conger  
Julie Cumming  
Alex Daigle  
Jacob deGroot-Maggetti  
Marie DeYoung  
Anna de Bakker  
Tim de Reuse  
  
Natasha Dillabough  
Daniel Donnelly  
Neda Eshraghi  
Meredith Evans  
Wei Gao  
David Garfinkel  
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Mahtab Ghamsari  
Arielle Goldman  
Marisa Goldman  
Ryan Groves  
Jamie Klassen  
Kemal Kongar  
Gaby Halpin  
Peter Henderson  
Dylan Hillerbrand  
Jason Hockman  
Emily Hopkinson  
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Sam Howes  
Catlin Hutnyk  
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Néstor Nápoles  
Clare Neil  
Khoi Nguyen  
Minh Anh Nguyen  
Chris Niven  
Rory O'Connor  
Laura Osterlund  
Phyllis Ouyang  
Jérôme Parent-Lévesque  
  
Alexandre Parmentier  
Gustavo Pedro  
Sacha Perry-Fagant  
David Peterman  
Hong Van Pham  
Alastair Porter  
Ravi Raina  
Juliette Regimbal  
Deepanjan Roy  
Zeyad Saleh  
Evan Savage  
Peter Schubert  
Harry Simmonds  
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Martha Thomae  
Andrew Tran  
Vi-An Tran  
Finn Upham  
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Tim Wilfong  
Mike Winters  
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Jinho Yoon  
Ké Zhang  
Max Zhang  
Yinan Zhou



# Funded by



Social Sciences and Humanities  
Research Council of Canada

Conseil de recherches en  
sciences humaines du Canada

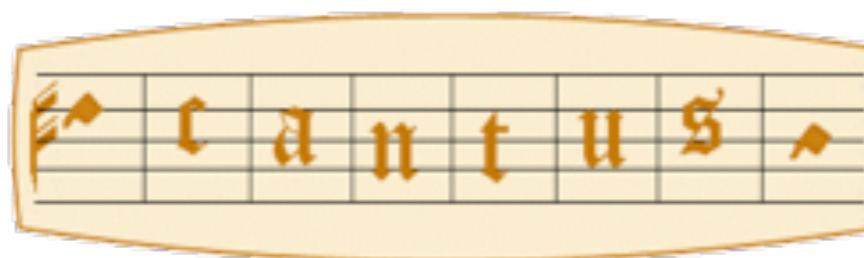
Canada<sup>1+</sup>



Schulich School of Music  
École de musique Schulich



Centre for Interdisciplinary Research  
in Music Media and Technology



**Fonds de recherche  
Société et culture**

Québec



Digital Research  
Alliance of Canada

Alliance de recherche  
numérique du Canada



Calcul Québec



# LinkedMusic Team @McGill: Summer 2024



---



# A Practical Guide to Frontend Dev

Yinan Zhou  
DDMAL, McGill University  
Training Week 2025 Summer

---

# Outline

- Formatting
- Linting
- Typing
- Testing

---

# Formatting



# What is a formatter?

A **formatter** is a tool that automatically rewrites your code to follow a consistent **style** and **formatting** rules.

- Indentation and spacing
- Semicolons
- Single/Double quotes
- Etc.



# EditorConfig

Maintains consistent **basic** editor behavior across different IDEs/editors and developers

- Indentation
- Line endings
- Final newline at end of file

# Prettier

Automatically formats code to follow a consistent style

- Wrapping
- Spacing
- Quotes
- Semicolons
- Bracket placement
- Etc.

---

# Linting

---

# What is linting?



<https://i.ytimg.com/vi/nE6u9Y2HqFE/maxresdefault.jpg>



# What is a linter?

A **linter** is a tool that analyzes your code for **errors**, **bad practices**, or style issues — and often suggests or enforces improvements.

- Syntax errors
- Undefined variables
- Dangerous patterns
- Etc.



# ESLint

Popular linter for JavaScript

- Customizable
- Supports TypeScript
- Works with Prettier

---

# Typing



# TypeScript

JavaScript + types = safer code

- Detects type mismatches
- Great for large codebases

---

# Testing

---

# Cypress E2E Testing

- Tests in a real browser
- Human-readable syntax
- Live debugger and time-travel



## Three Phases

1. Set up the application state
2. Take an action
3. Make an assertion about the resulting application state

# Introduction to Docker

DDMAL 2025 May

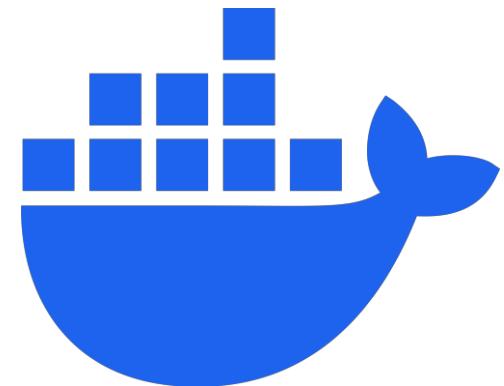
Hanwen Zhang

# Outline

- What is Docker?
- Key Docker concepts
- Docker architecture
- Basic Docker commands
- Docker compose, Docker swarm, and Kubernetes
- Docker for Rodan

# What is Docker?

- An open-source platform for developing, shipping, and running applications
- Uses containerization technology
- Packages software with all dependencies
- “Build once, run anywhere” philosophy



# The Problem Docker Solves

- **Old way:** “It works on my machine.”
- Different environments cause inconsistencies
- Dependency conflicts
- Setup complexity
- Scaling challenges

# Why Docker Matters

- **Consistency:** Same environment everywhere
- **Isolation:** Applications run independently
- **Efficiency:** Less resource-intensive than virtual machines
- **Portability:** Works across different platforms
- **Scalability:** Easy to scale applications

# Docker vs. Virtual Machines

Docker	Virtual Machines
Share host OS	Full OS per instance
Lightweight (MBs), fast startup	Heavy (GBs), slow boot
Ideal for microservices	Good for full OS isolation
Lower resource usage	Higher overhead

# Core Docker Concepts

**Image** – Snapshot or blueprint (e.g., python:3.11-alpine)

**Container** – Running instance of an image

**Dockerfile** – Script with instructions to build an image

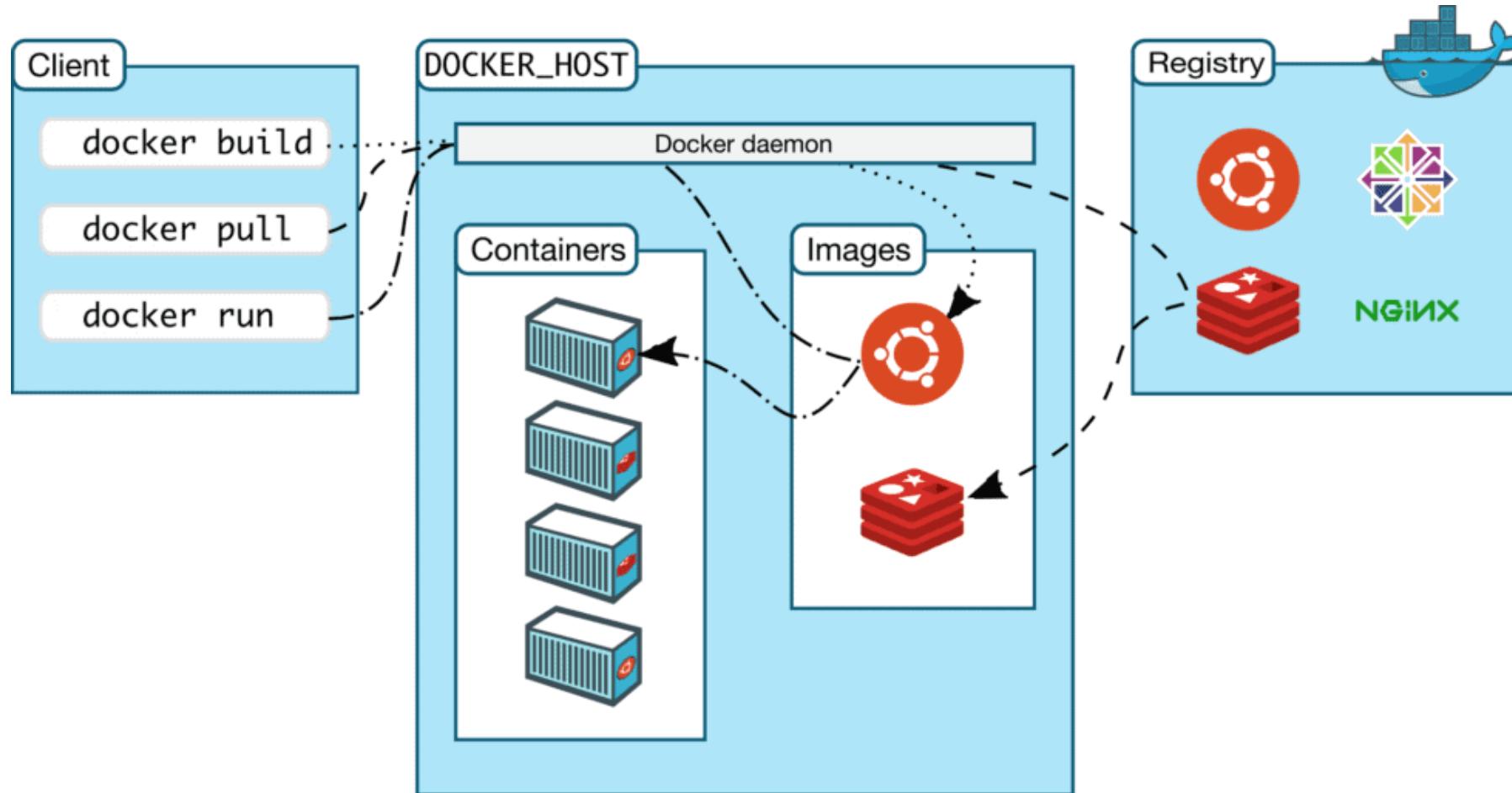
**Volume** – Store data outside the container (e.g., DB files)

**Docker Hub** – Public image registry (like GitHub)

# Docker Architecture

- Client-server architecture
- Docker client communicates with Docker daemon
- Docker daemon manages building, running containers
- Docker registry stores images
- Docker volumes provide persistent storage

# Docker Architecture



# Demo

## app.py

```
from flask import Flask
app = Flask(__name__)

@app.route("/")
def hello():
    return "Hello, Docker!"

if __name__ == "__main__":
    app.run(host="0.0.0.0", port=5000)
```

## Dockerfile

```
# Use a lightweight Python image
FROM python:3.11-slim

# Set working directory
WORKDIR /app

# Copy only what's needed
COPY app.py .

# Install Flask
RUN pip install flask

# Expose port
EXPOSE 5000

# Run the app
CMD ["python", "app.py"]
```

# Basic Docker Commands

```
● ● ●

# List all containers (including stopped)
docker ps -a

# Stop a container
docker stop [container_id_or_name]

# Open an interactive shell inside a running container
docker exec -it [container_id_or_name] bash

# View the logs from a container
docker logs [container_id_or_name]

# Show detailed info about the Docker system and swarm status
docker info

# List all running services in the swarm
docker service ls

# View detailed info about tasks (containers) for a service
docker service ps [service_id] --no-trunc
```

# Docker Compose

- **What is Docker Compose?**
  - Tool for defining and running multi-container Docker applications
- **Key benefits:**
  - Define the application stack in a single YAML file
  - Start all services with a single command
  - Share the same configuration across environments
  - Manage container dependencies and networking
- **Common usage:**
  - Development environments
  - Automated testing
  - CI/CD pipelines

# Docker Swarm

- **What is Docker Swarm?**
  - Native clustering and orchestration solution for Docker
- **Key concepts:**
  - **Swarm:** Cluster of Docker nodes
  - **Node:** Docker Engine instance (manager or worker)
  - **Service:** Definition of tasks to execute
  - **Task:** Container running on a node
- **Core features:**
  - Declarative service model
  - Built-in load balancing
  - Scaling services up/down
  - Desired state reconciliation
  - Multi-host networking
  - Rolling updates

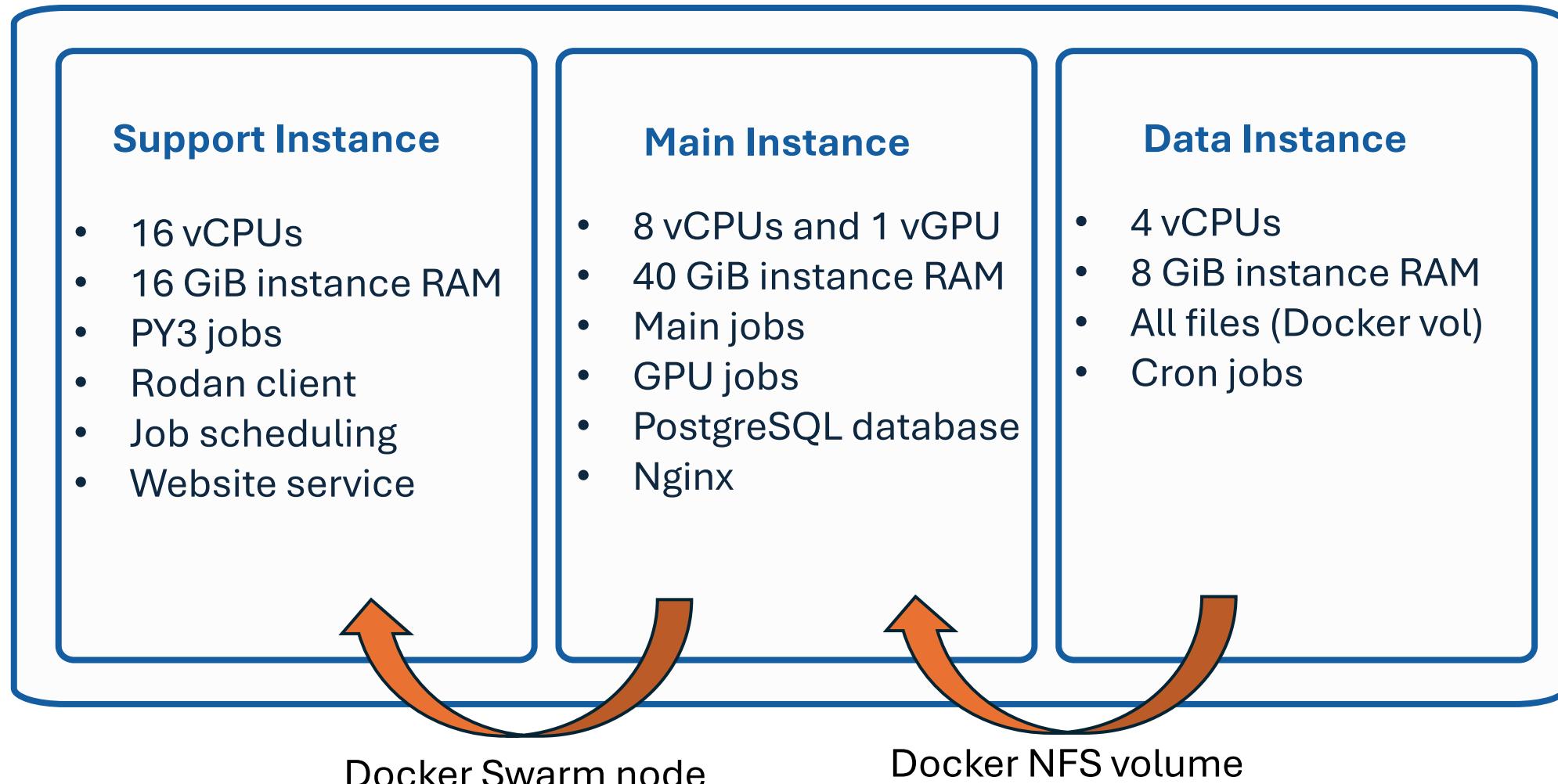
# Kubernetes

- **What is Kubernetes?**
  - Open-source platform for automating deployment, scaling, and management of containerized applications
- **Core advantages:**
  - Auto-scaling based on demand
  - Self-healing capabilities
  - Automated rollouts and rollbacks
  - Horizontal infrastructure scaling
  - Service discovery and load balancing
  - Storage orchestration
- **Key concepts:**
  - **Cluster:** Set of nodes running containerized applications
  - **Node:** Worker machine (VM or physical) in the cluster
  - **Pod:** Smallest deployable unit (one or more containers)
  - **Deployment:** Manages pods and replica sets
  - **Service:** Exposes an application running on pods

# Docker Compose vs. Swarm vs. Kubernetes

Feature	Docker Compose	Docker Swarm	Kubernetes
Purpose	Local dev (multi-container)	Lightweight orchestration	Full production orchestration
Setup complexity	Very low	Low	High
Scaling	Manual	Built-in (--replicas)	Automatic
Load balancing	No	Yes	Yes (via services/ingress)
Rolling updates	No	Yes	Yes
Production-ready	No	Limited use	Yes (industry standard)

# Rodan Server with Docker Swarm



# Best Practices

- Use official base images when possible
- Minimize layers to reduce image size
- Do not run as root inside containers
- Use `.dockerignore` file
- Tag images meaningfully
- Clean up unused images and containers
- Ask ChatGPT

Thank you.

# CantusDB: an introduction

Anna de Bakker  
DDMAL Training Week 2025

overview:

Historical overview:

What is CantusDB for?

How did it arise?

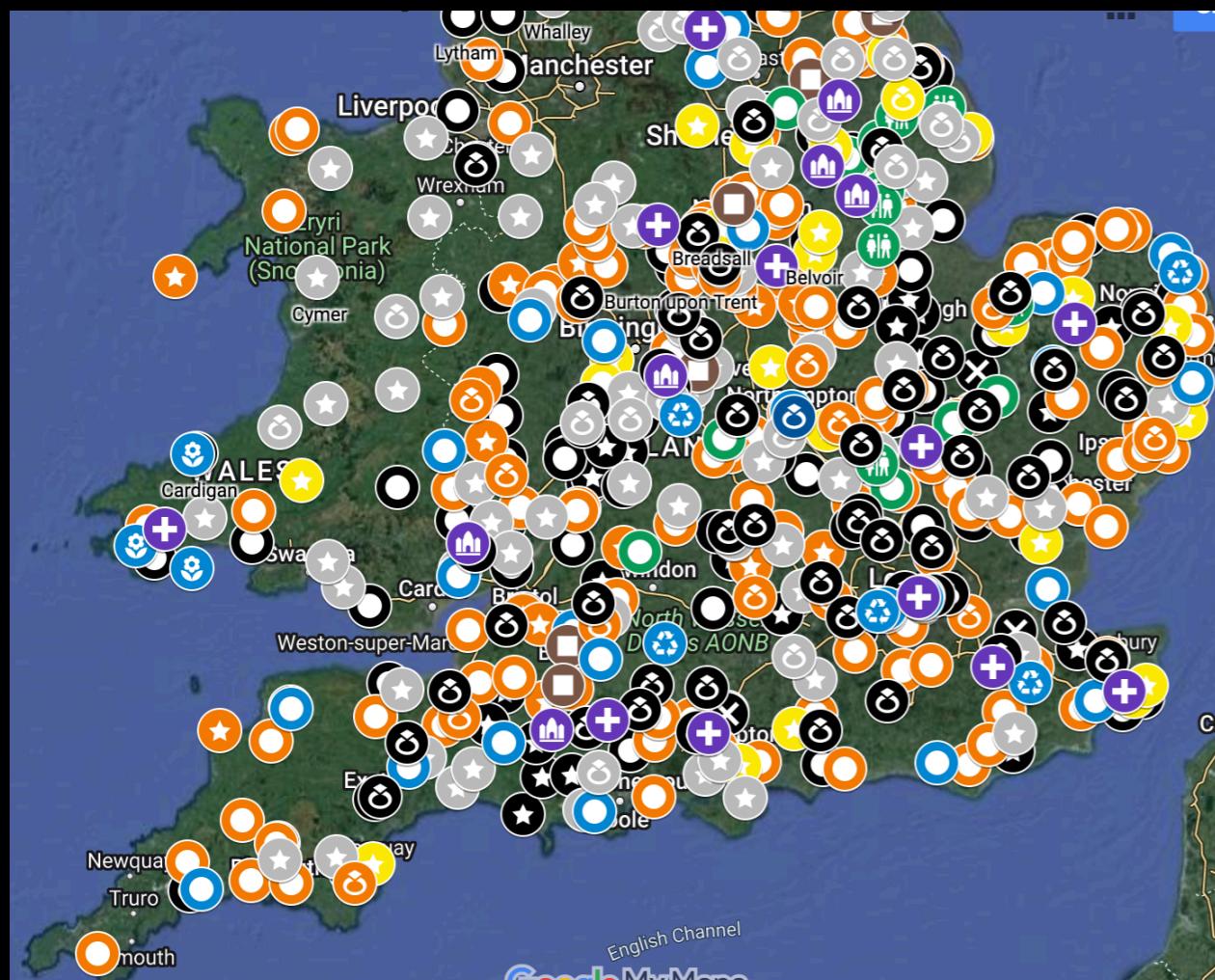
Who uses it and how?

What kinds of things does it record?

What's the relationship to LinkedMusic?

## some historical context

-Medieval Europe had *a lot* of churches  
[citation needed]



(that's  
a lot of chant!)

Every non-mendicant monastery in England and Wales dissolved 1536-1539 (map: J.A. Cameron)  
Colours denote different monastic orders (types of communities)

## some historical context

- Medieval Europe had *a lot* of churches  
[citation needed]
- Each of those might have 8-9 services a day
- Each service might have 5-40 things to sing



## some historical context



- What to sing varies depending on the feast (what's being celebrated)
- Feasts can vary from place to place
- order of items can differ

-most of this data is recorded in surprisingly durable form!

Knowledge of trends—> *what* a particular community sang about, *how* they chose to do it, *who else* they were connected to



# some historical context

- music is hard [citation needed]
- text is easy!
- initial efforts to catalog (on paper!) in 1960s

<p>1375 Amen amen<sup>1</sup> dico vobis, quia<sup>2</sup> plorabitis et flebitis<sup>3</sup> vos, mundus autem gaudebit; vos autem contristabimini, sed<sup>4</sup> tristitia vestra vertetur in gaudium, alleluia.<sup>5</sup></p> <p>1 - C: <i>un seul</i> amen. 2 - C: <i>quia manque</i>. 3 - S: <i>flevitis</i>. 4 - C: <i>vos autem contristabimini sed manque</i>. 5 - C: <i>deux</i> alleluia.</p>	<p><i>Dom. III post Pascha</i></p>	<p>84   C B E M V H R F S L</p>
<p>1376 Amen amen dico vobis: Si quid petieritis Patrem in nomine meo, dabit vobis, alleluia alleluia.</p>	<p><i>Dom. V post Pascha</i></p>	<p>86   L</p>
<p>1377 Amen amen dico vobis: Si quis sermonem meum servaverit, mortem non gustabit<sup>1</sup> in aeternum.</p> <p>1 - C: <i>videbit</i>.</p>	<p><i>Dom. de Passione</i></p>	<p>66   C D</p>

Hesbert, Corpus Antiphonalium Officii  
vol.3, 1968

# some historical context

- these text-centred efforts become the core of Cantus Index (not our topic today)
- basically a catalog of every known chant *text*, standardized and attached to an ID

The screenshot shows a detailed view of a chant entry on the Cantus Index website. The top navigation bar includes links for CANTUS INDEX, ABOUT, CHANTS, MELODIES, GENRES, FEASTS, and CONTACT. The main content area displays the following information for chant ID 200293:

**200293**

[View](#) [Edit](#)

**Genre:** A

**Full text:** Anna Christi thalamum intrans cum honore cinamomum balsamum superat odore

**Feast:** [Annae](#)

**Notes:** AH v.25 #19;

[Add new comment](#)

Below the main details are two buttons: » Suggest a change in full text and » Suggest a minor variant.

**Authoring information**

Chant added by: [Cantus Manuscript Database](#)  
Post date: 11/08/2012 - 09:31  
Last update: 01/06/2019 - 16:46

Proofread by: [Debra](#)

**Chants with similar words / phrases**

	Full text
a00328 A	Anna maris stella mater tu crimina pelle quae Jesu Christi thalamum mundo peperisti principium vite quo vivunt Ismaelitae ex te namque pia processit virgo Maria
ah50031.1 H	Inventor rutili dux bone luminis qui certis vicibus tempora dividis merso sole chaos ingruit horridum lucem redde tuis Christe fidelibus   Per Christum genitum summe pater tuum in quo visibilis stat...

**Chant Resources (Links)**

» [Search this chant in online resources](#)

**Melodies in sources**

» [Display the melodies connected with this chant](#)

## so...what's CantusDB?

- split from “Cantus Index” in 2012
- CantusDB records every chant in a manuscript : i.e. every instantiation of a chant in some place
- basically, a Table of Contents for many chant manuscripts, with standardized references
- maintained by DDMAL in cooperation with the Digital Analysis of Chant Transmission (DACT) project

## so...what's CantusDB?

- cantusindex.org : over 60,000 chant *texts*
- Cantus Database (<https://cantusdatabase.org>) : over 539,000 chant items
- There are several other “Cantus Network” databases using the same metadata fields
- Together these have metadata on over a million chants

# so...what's CantusDB?

- this data is entered by scholars and their minions
- cleaned up by admins before publication  
(N.b. scholars would probably do this work anyway!)



In sollempnitate famuli dei Arnulphi conuss.	Villariensis,	q.e.	ii	k.I. <sup>1</sup>
<b>First Vespers</b>				
<b>Chant type</b>	<b>Mode</b>	<b>Incipit</b>	<b>Source</b>	
Antiphon	1	Celebretur hodierna (with large capital)	None	
Antiphon	2	Hic fertur	<i>Vita</i> 1.1.1	
Antiphon	3	Cumque foret	<i>Vita</i> 1.1.4	
Antiphon	4	Hic Arnulfus	<i>Vita</i> 1.1.7	
[Chapter]		Dilectus a deo et hominibus.	Ecclesiasticus 45:1	
Responsory	1	O vere felicem puer Arnulphum	<i>Vita</i> 1.1.10	
Verse	1	Carnalem in eo	<i>Vita</i> 1.1.10	
Hymn	8	Gaude mater ecclesia (with incipit)	Various	
Versiculus		In die glorie	?	
Magnificat antiphon [Collect]	3	Magnificat nunc anima	None	
<b>Compline</b>				
Hymn	7	Arnulpho congratulemur (with incipit)	None	
<b>First Nocturn</b>				

# CantusDB is very useful for:

- finding chants and seeing where they occur
- finding images of a chant
- seeing what was done in some place
- or what was done on some day!

Search Chants

Displaying 1-9 of 9 chants.

» [Search lucas on CantusIndex.org](#)

Keyword search

Contains	lucas		
Service	Genre	Cantus ID	Mode
- Any -	- Any -		
Feast	Position	Melodies	- Any -

**Apply**

Siglum	Folio	Incipit/Full Text	Feast	Service	Genre	Position	Cantus ID	Mode	FT	Mel	Image
A-KN CCI 1012	026v	<b>Hanc vero quam Lucas peccatricem</b> Hanc vero quam Lucas peccatricem mulierem Joannes Mariam nominat illam esse Mariam credimus de qua Marcus septem daemonia ejecta fuisse testatur septem enim daemonia habuit quae universis viciis plena fuit sed ecce quia turpitudinis suae maculas aspergit lavanda ad fontem misericordiae cucurrit	Mariae Magdalene	M	R	14	601730	3	✓	♪	<a href="#">Image</a>
A-KN CCI 589	052r	<b>Hanc vero quam Lucas</b>	Mariae Magdalene	M	R	12	601730	*			<a href="#">Image</a>
D-FUI Aa 55	125r	<b>Hanc vero quam Lucas</b> Hanc vero quam Lucas	Mariae Magdalene	M	R	3.2	601730	3			<a href="#">Image</a>
D-Knd 215	197v	<b>Hanc vero quam lucas peccatricem</b> Hanc vero quam lucas peccatricem mulierem Joannes Mariam nominat illam esse Maria credimus de qua Marcus septem demonia ejecta fuisse testatur et septem enim demonia habitat quae universis vitiis plena fuit sed ecce quia turpitudinis suae maculas aspergit lavando ad fontem misericordie currit	Mariae Magdalene	M	R	1.3	601730	?	✓		<a href="#">Image</a>
F-Pn Latin 1112	298v	<b>Jucundare plebs fidelis cuius pater</b> Jucundare plebs fidelis cuius pater est in caelis recolens Ezechielis prophetae praeconia   Circa thronum majestatis cum spiritibus beatis quattuor diversitatis astant animalia   Est Joannes testis ipsi dicens in apocalypsi vere vidi vere scripsi vera testimonia   Formam primam aquilinam et secundam leoninam sed humanam et bovinam duo gerunt alia   Formae formant figuraram	Matthaei	MI	Sq		ah55007.1		✓		<a href="#">Image</a>

Also have a melody search based on Volpiano

## Anna Christi thalamum intrans cum

### Source

Karlsruhe, Badische Landesbibliothek - Musiksammlung, Aug. LX

### Folio

**Sequence**

a035r

14

### Feast

Annae

L

### Service

A

### Genre

A

### Position

1

### Cantus ID

200293

### Mode

\*

### Full text as in Source (standardized spelling)

Anna Christi thalamum intrans cum honore cinnamomum balsamum superat odore

### Full text as in Source (source spelling)

Anna xpisti thalamum intrans cum honore cinamomum balsamum superat odore

### Image link

<https://digital.blb-karlsruhe.de/blbhs/content/pageview/1253449>

### Image link (Cantus Ultimus)

<https://cantus.simssa.ca/manuscript/123612/?folio=a035r&chant=14>

## Concordances

### Summary

Cantus Database (CD)

7 concordances

### ▼ Hide concordance details

Source	Incipit	Office   Genre   Position	Feast	Mode	Database
D-KA Aug. LX, a035r	Anna Christi thalamum intrans cum	L   A   1	Annae	*	CD
DK-Kk 3449 8o [10] X, 069r	Anna Christi thalamum intrans	L   A   1	Annae	1	CD
F-CA Impr. XVI C 4, 149v	Anna Christi thalamum intrans	V2   A   1	Annae	1	CD

...an international reference point for all kinds of chant-related data!

CantusDB is also useful for comparing one example of chant to others

### Image link (Cantus Ultimus)

<https://cantus.simssa.ca/manuscript/123612/?folio=a035r&chant=14>

## Concordances

### Summary

Cantus Database (CD)

7 concordances

### ▼ Hide concordance details

Source	Incipit	Office   Genre   Position	Feast	Mode	Database
D-KA Aug. LX, a035r	Anna Christi thalamum intrans cum	L   A   1	Annae	*	CD
DK-Kk 3449 8o [10] X, 069r	Anna Christi thalamum intrans	L   A   1	Annae	1	CD
F-CA Impr. XVI C 4, 149v	Anna Christi thalamum intrans	V2   A   1	Annae	1	CD
MA Impr. 1537, 408r	Anna Christi thalamum intrans cum	L   A   1	Annae	1	CD
NZ-Wt MSR-03, 183r	Anna Christi thalamum intrans cum	L   A   1	Annae	1	CD
PL-Kkar 1 (Rkp 12), 105	Anna Christi thalamum intrans	L   A   1	Annae	1	CD
PL-Kkar 3 (Rkp 15), 121r	Anna Christi thalamum intrans	L   A   1	Annae	1	CD

## Melodies

Displaying 2 melodies from the following databases:

Chant	Melody
DK-Kk Gl. Kgl. S. 3449 8o [10] X 069r   L A 1 Annae Cantus ID: 200293	 M:1
NZ-Wt MSR-03 183r   L A 1 Annae Cantus ID: 200293	 M:1  Anna Christi thalamum intrans cum honore cinamomum balsamum superat odore

# Two main types of objects in CantusDB: *sources* and *chants*

**Browse sources**

Displaying 1 - 245 of 245 sources

Segment      General search (siglum, city, description ..)      Indexing notes

CANTUS Database       Enter any part of a word       Search for indexers, proofreaders, editors.

Provenance (origin / history)      Century      Full source / fragment

- Any -      - Any -      - Any -      **Apply**      **Reset**

Siglum	Summary	Date/Origin	Image link	Chants / Melodies
A-Gu 29	Fourteenth-century antiphoner in two volumes (with A-Gu 30) from the Abbey of Sankt Lambrecht (...)	14th century St-Lambrecht	Images	4291 / 5
A-Gu 30	Fourteenth-century antiphoner in two volumes (with A-Gu 29) from the Abbey of Sankt Lambrecht (...)	14th century St-Lambrecht	Images	5490
A-KN 1010	Twelfth-century antiphoner from Klosterneuburg, Austria. Four-line dry-point staves with D-, F-, A...	12th century Klosterneuburg	Images	2384 / 410
A-KN 1011	Fourteenth-century antiphoner from Klosterneuburg, Austria. Five-line	14th century Klosterneuburg	Images	2744 / 8

# Sources

- each represent a manuscript or fragment
- have information about type of book & current location
- paragraphs for longer form description
- some data about who worked on the inventory
- navigation to sections of manuscript (+external links)

Montréal, McGill University - Rare Books and Special Collections -  
Manuscript Collection, MS Medieval 0073

[View](#) | [Edit](#)

**Cantus Signum**

CDN-Mrb MS Medieval 0073

**Holding Institution**

Montréal, McGill University - Rare Books and Special Collections - Manuscript Collection (CDN-Mrb)

**Manuscript/Print**

Manuscript

**Summary**

Miscellaneous choirbook from Northern Italy, made of 10 independent codicological units produced in different periods for a total of 143 un-numbered folios, with several lacunae. Written in various Gothic hands on vellum; square notation on red, 4-line staves. The surface of the leaves measures from 465 x 335 mm to 455 x 320 mm; the writing surface varies more widely according to the fragment. According to Seymour De Ricci, MS 73 was written in the 15th century, yet with all probability most of the quires were produced much earlier, between the late 13th century and the early 14th. Obtained in Florence by Dr. Casey Wood on November 5th, 1930, MS 73 was added soon thereafter to the McGill Library collection, on 21 January 1931.

**Liturgical Occasions**

MS 73 restricts itself to selected liturgical occasions and, for some of them, it features the unusual combination of items for the office and the mass.

F. 1r, 11,000 Virgin Martyrs of Cologne (office, one sequence, and two alleluias); f. 23r, Thomas Aquinas (office and mass); f. 53v, Corpus Christi and its octave (office and mass); f. 87r, Moving of Thomas's relics (office); f. 101r, Corpus Christi and its octave (office); f. 116r, Conversion of Paul (office); f. 127r, Common of Saints (office); f. 131r, Sexagesima Sunday (office); f. 138v, Quinquagesima Sunday (office).

**Notes on the Inventory**

Incipit/CantusID

CDN-Mrb MS Medieval 0073

Select a folio:  Select a feast:

[» View all chants](#)  
[» View full inventory](#)  
[» View inventory with images](#)  
[» CSV export](#)  
[» Search chants in this source](#)  
[» Search melodies in this source](#)  
[» Analyse this source \(Cantus Analysis Tool\)](#)

CANTUS Database  
CDN-Mrb MS Medieval 0073

Provenance: [Dominican](#)  
Date: [14th century](#)  
Cursus: [Secular](#)  
Inventoried by:

- Alessandra Ignesti  
Schulich School of Music, McGill University

Proofreader:

- Brayden Olson

The inventory for CDN-Mrb MS Medieval 0073 was prepared by Alessandra Ignesti (McGill University), with proofreading by Brayden Olson (Dalhousie University).

Contributor: [Alessandra Ignesti](#)

# Sources

Typical source edit page

**Edit Source Montréal, McGill University - Rare Books and Special Collections - Manuscript Collection, MS Medieval 0073**

[View](#) | [Edit](#)

Holding Institution:  
Montréal, McGill University - Rare B...x ▾

Shelfmark:<sup>\*</sup> MS Medieval 0073  
Name: A colloquial or commonly-used name for the source

Segments:  
 Benedictamus Domino  
 Canadian Chant Database  
 Cantorales in the Americas  
 Chinese Catholic  
Plainchant  
 Sequence Database  
 CANTUS Database

Provenance (origin / history):  
Dominican  
If the origin is unknown, select a location where the source was used later in its lifetime and provide details in the "Provenance notes" field.

Provenance notes:  
More exact indication of the provenance (if necessary)

Complete Source/Fragmnet:  
Fragmented

Century:  
x 14th century

Manuscript/Print:  
Manuscript

Date:  
Date of the source, if known (e.g. "1541")

Cursus:  
Secular

Note: some information is fixed vocabulary; some fields reference external concepts

# Chants

[View](#) | [Edit](#)

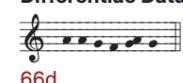
## Sponsus pulcher pree omnibus rex

### Source

Montréal, McGill University - Rare Books and Special Collections - Manuscript Collection, MS Medieval 0073

Folio	Sequence	Feast	Service	Genre	Position	Cantus ID	Mode
001v	3	XI milium	V	A	M	a02039	1
		Virginum					

### Differentiae Database



### Full text as in Source (standardized spelling)

Sponsus pulcher pree omnibus rex et sponsus virginum candidatis virginibus purpureis per gladium suum junxit conubium caeli iungendo civibus per passionis bravium super astris invexit

### Full text as in Source (source spelling)

Sponsus pulcher pre omnibus rex et sponsus virginum candidatis virginibus purpureis per gladium suum iunxit connubium celi iungendo civibus per passionis bravium super astris invexit | alleluya | ~Magnificat | Euouae

### Image link (Cantus Ultimus)

<https://cantus.simssa.ca/manuscript/680970/?folio=001v&chant=3>

Incipit/CantusID  
Source navigation  
CDN-Mrb MS Medieval 0073

001v < > 001r  
» Display facsimile (001v)

Display previous chants ▾  
Folio: 001v - Feast: XI milium Virginum

1 V R	Haec est dies*	a02055
2 V W	Adducentur regi virgines post eam	800008.1
3 V A M	Sponsus pulcher pree omnibus rex	a02039

Display next chants ▾

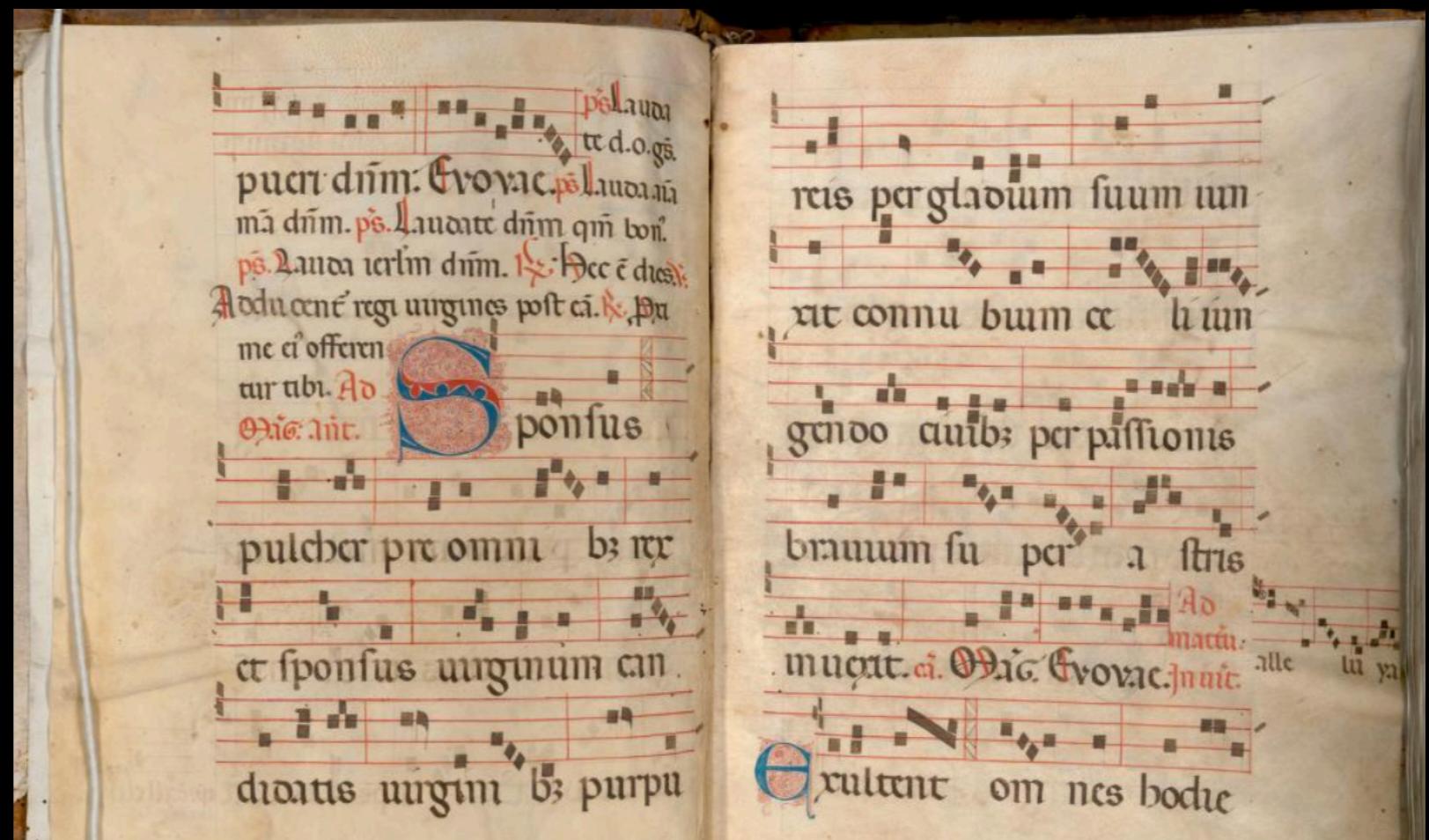
CANTUS Database  
CDN-Mrb MS Medieval 0073

Provenance: Dominican  
Cursus: Secular  
Inventoried by:  
• Alessandra Ignesti  
Schulich School of Music, McGill University

-some chants have no music

-other things on the page may be in the DB as metadata

Lots of information:  
-where they are in the book  
-when they were sung



# Chants

[View](#) | [Edit](#)

Marginalia: Folio: \* Sequence: \*

001v 3

Feast: XI milium Virginum

Service: [V] First Vespers

Genre: [A] Antiphon

Position: Cantus ID: Melody ID: Project:

M a02039 -----

Function: -----

Mode: Finalis: Differentia: Extra: Polyphony:

1 ----- -----

Differentiae Database: 66d

For a list of Differentia IDs, refer to the [Differentiae Database](#).

Addendum:

Full text as in Source (standardized spelling): \*

Sponsus pulcher p[re] omnibus rex et sponsus virginum conubium caeli jungendo civibus per passionis bravium s

Full text as in Source (standardized spelling) proofread:

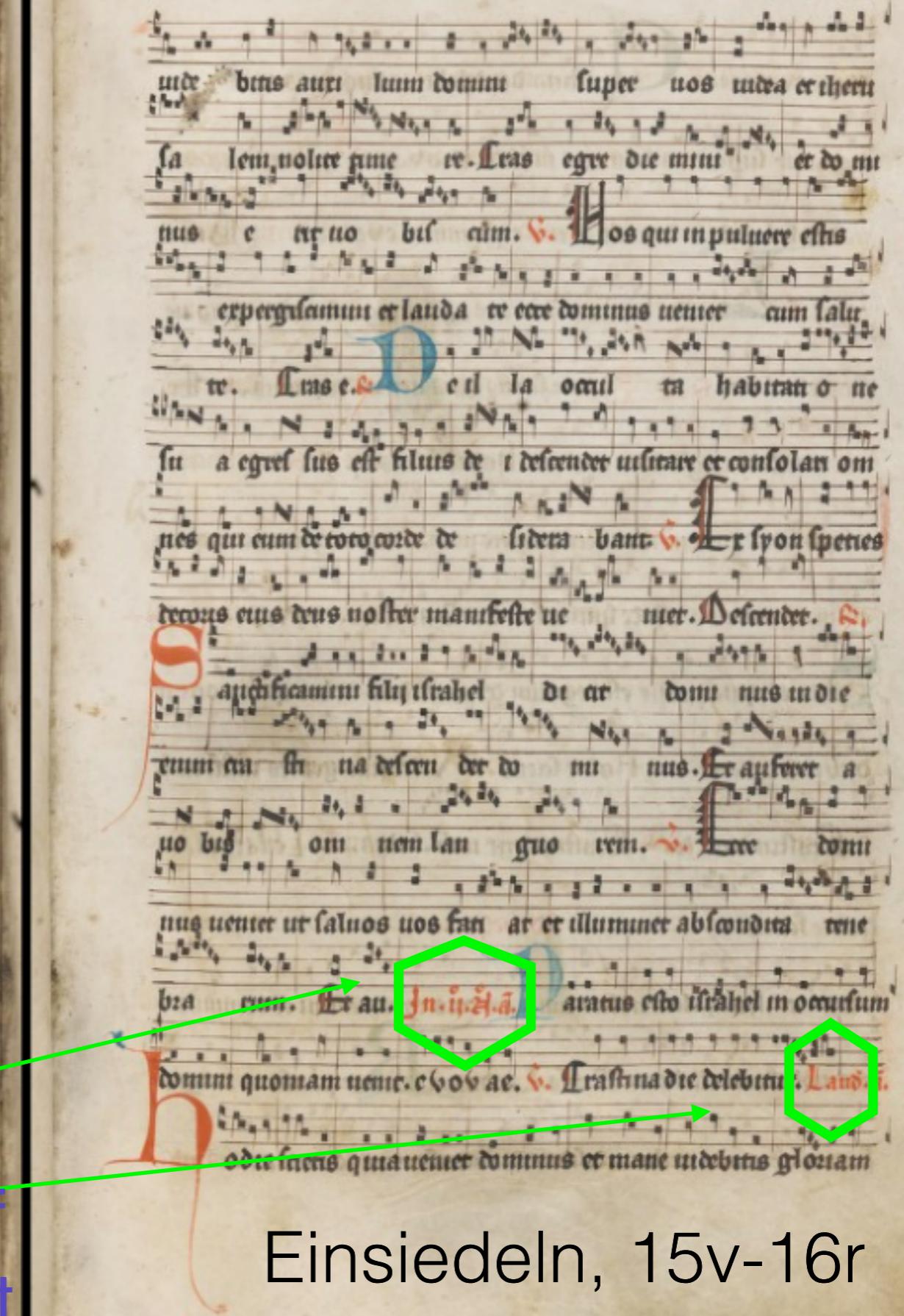
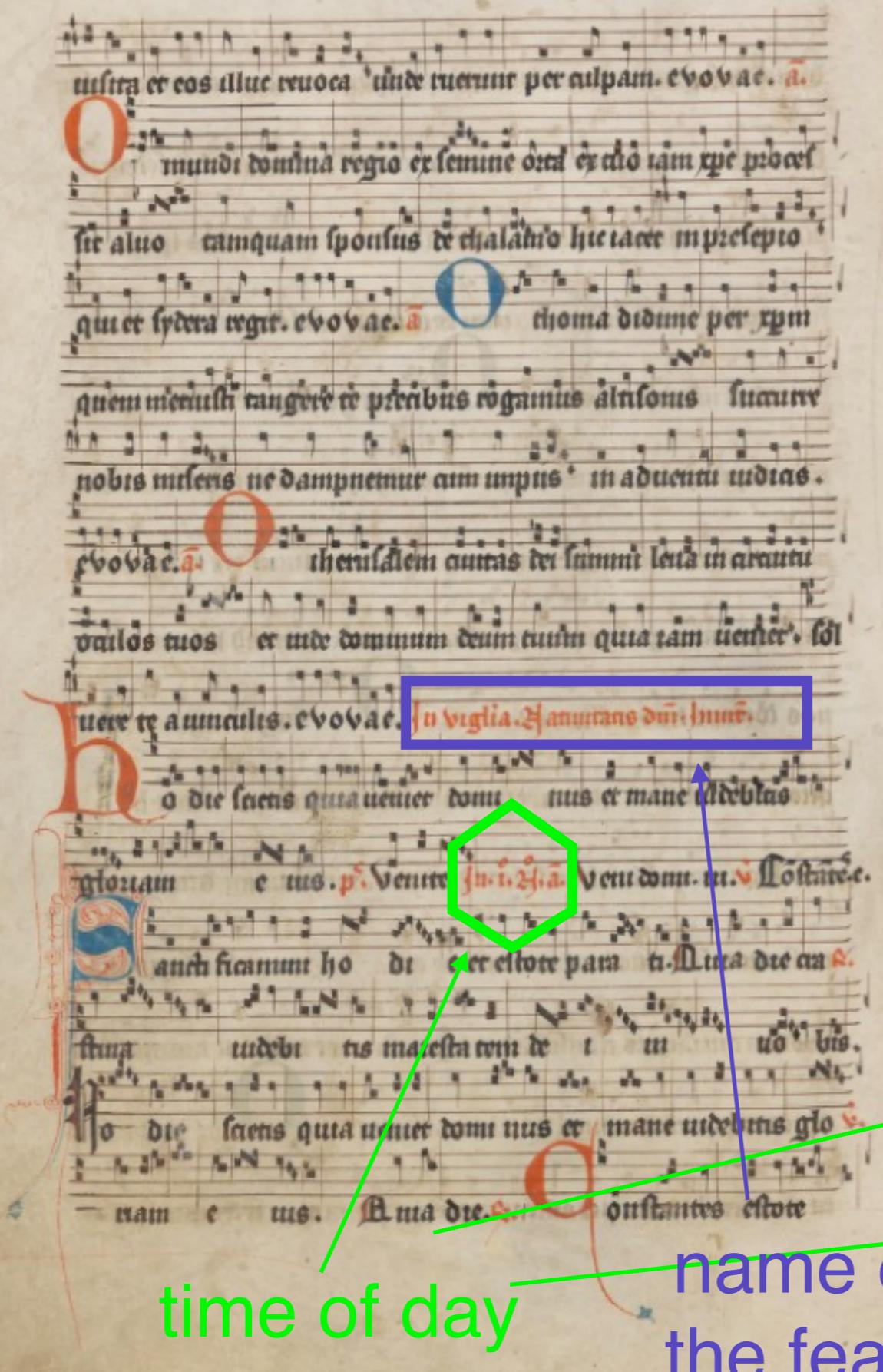
[Copy full text below](#)

## Typical chant edit page



## orienting yourself in a liturgical manuscript

- ‘folio numbers’ instead of page numbers
  - 50r= ‘recto’ (front) of the fiftieth leaf; 50v is the back
- rubrics (**‘red’**): give instructions/stage directions
  - feasts
  - time of day
  - types of chant
  - other information as needed

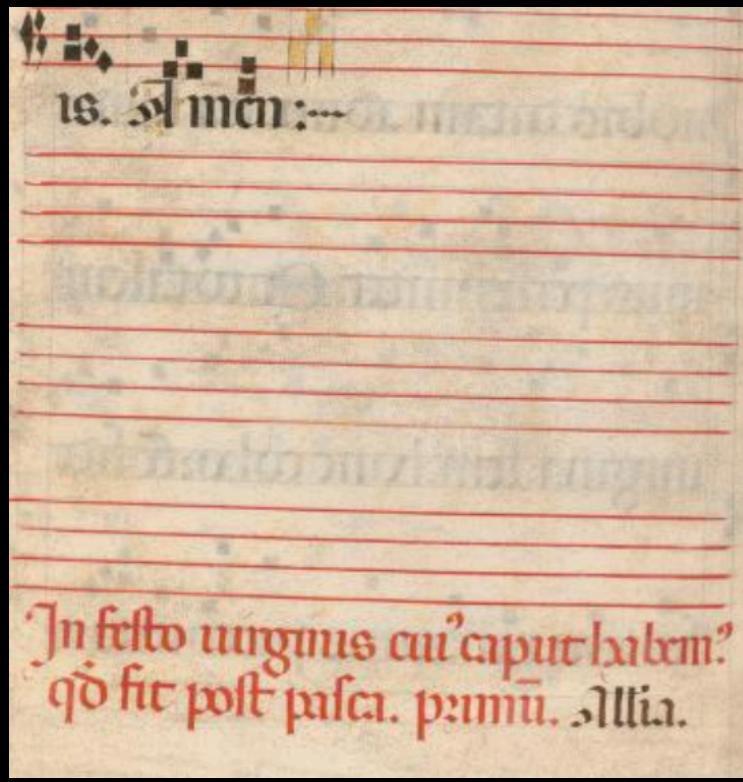


time of day

name of  
the feast

Einsiedeln, 15v-16r

# Some examples of rubrics



McGill Ms 0073

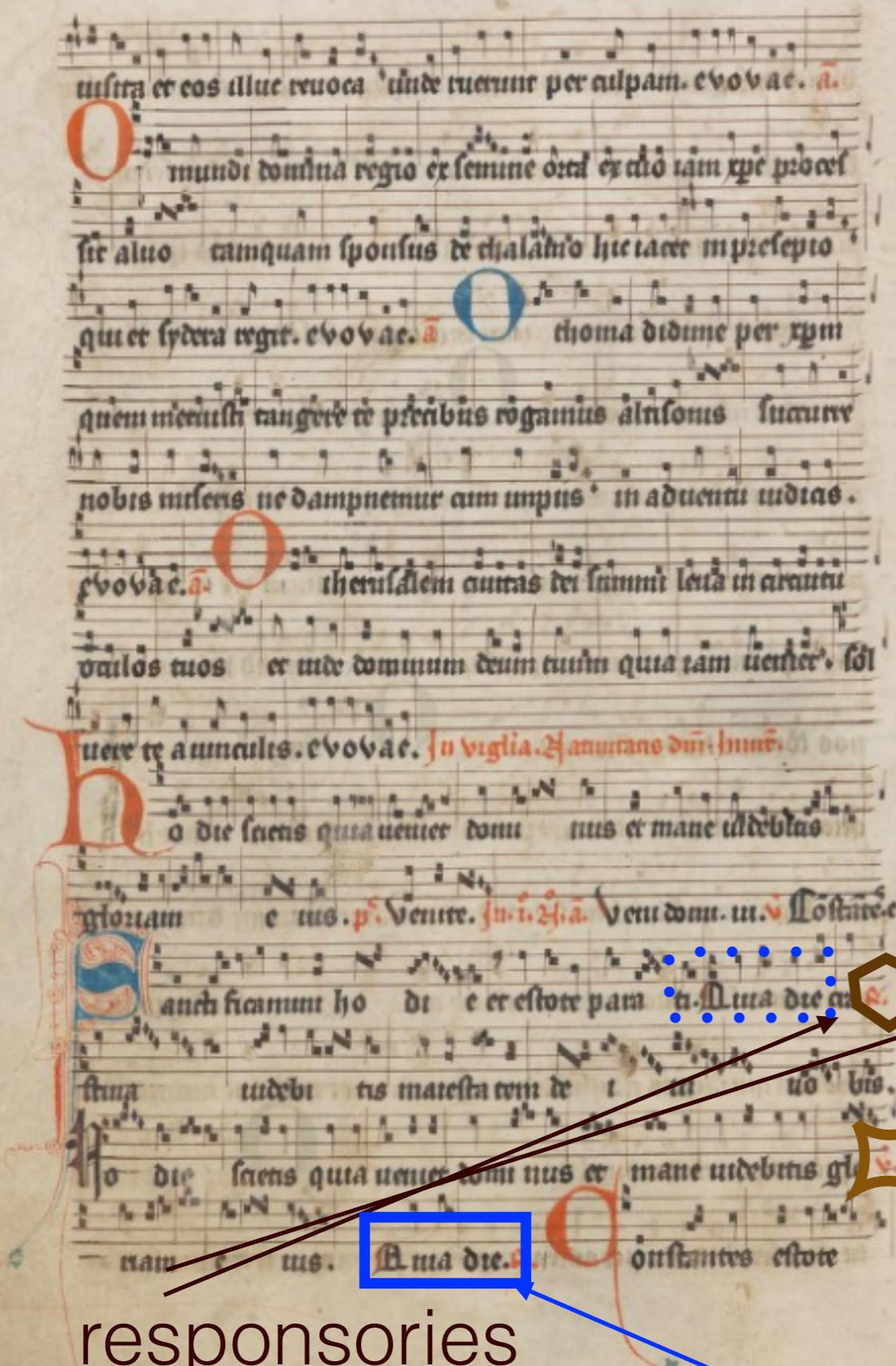


ad diuinū. lī. viii. Videntur mī. Ista lī legit ab uno p̄fō in  
supp̄lētū mīm p̄cedat q̄nq̄s p̄m de uestiario ordinatiū i  
supp̄ellūm s̄ cap̄r̄ oclātiō auit̄ alb̄is + c̄rēos ardēntes i ma  
nib̄ p̄stantes ad gra dū d̄si accidant.  
finita lī ūcipiārie. ludūm vocē simul. **H** udi in vocē  
de ce lo uenici tam ueni te om̄ n̄s uirgines sa pien  
bis fiduc̄. O leū reon dite m̄ ua l̄is uestris dū spon sus adue  
p̄fā dicāt ne rit. usū. q̄ media nocte damo: fās ē eate spon sus uānt. O leū

McGill MS 0018

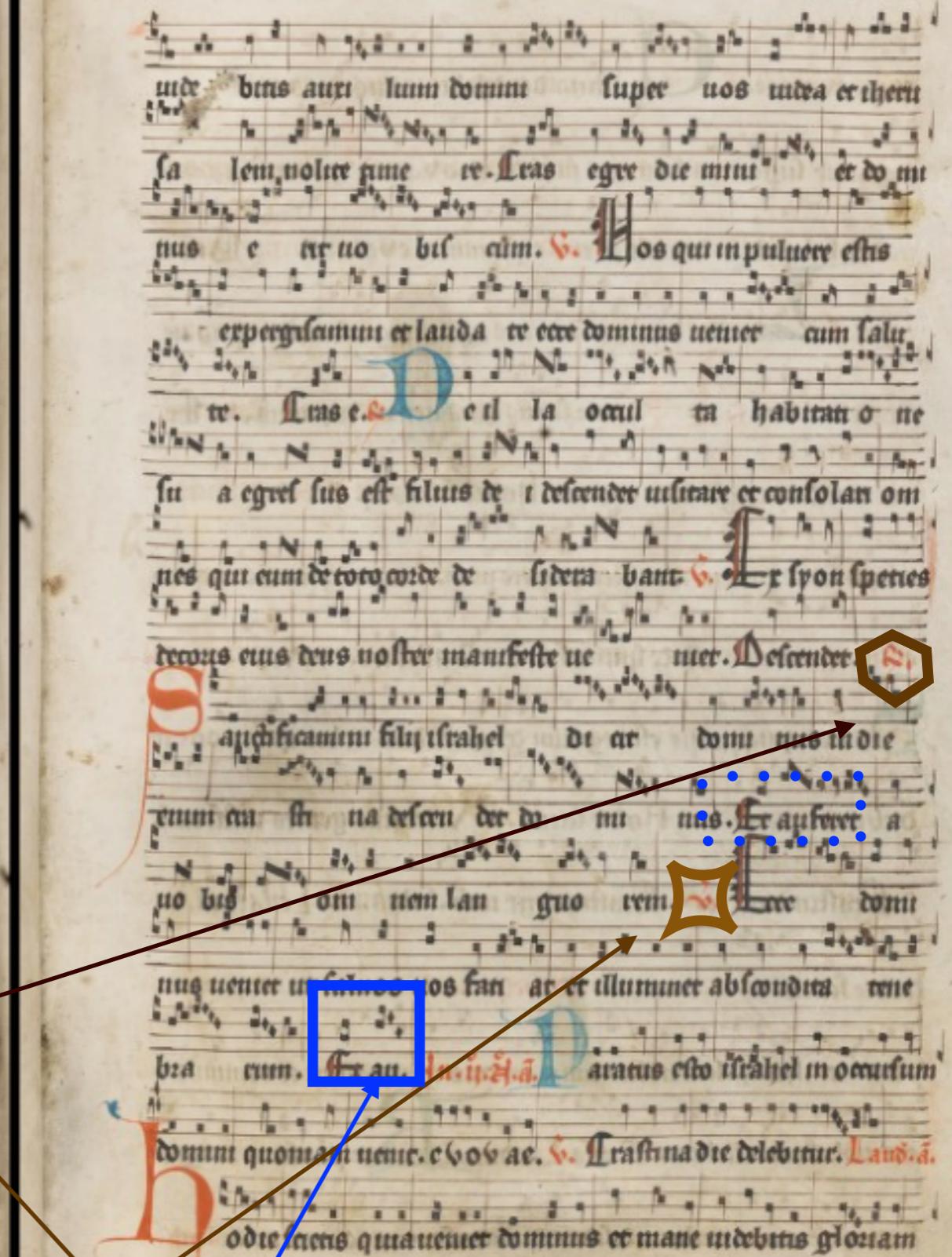
## some useful vocabulary

- types of chant (“Genre” in Cantus DB):
  - responsory (long, multipart structure)
  - antiphons (go with psalms)
- ‘incipits’ give the beginning of a chant you are expected to know/have somewhere else
- ‘differentiae’: shorthand for a formula to chant a psalm on.
  - text is usually ‘euouae’=seculorum amen



responsories

cues to repeat music



verses



antiphons

differentiae



# Chants

View | Edit

Marginalia: Folio: \* Sequence: \*

Feast: XI milium Virginum

Service: [V] First Vespers

Genre: [A] Antiphon

Position: Canticus ID: Melody ID: Project:

Function: -----

Mode: 1 Finalis: Differentia: Extra: Polyphony: -----

Differentiae Database: 66d  
For a list of Differentia IDs, refer to the [Differentiae Database](#).

Addendum:

Chant range:



## Typical chant edit page

-again note differences in fixed/free and internal/external metadata fields

# Some world domination data linking ideas



# Some world domination data linking ideas

- “institution” linked to RISM at source level (done!)
- “book type” could be linked to external authorities (currently not controlled vocabulary)
- “notation”, “provenance” likewise not controlled

*Edit Source Montréal, McGill University - Rare Books and Special Collections - Manuscript Collection, MS Medieval 0073*

[View](#) | [Edit](#)

Holding Institution:  
Montréal, McGill University - Rare B...x ▾

Shelfmark\*: MS Medieval 0073  
Name: A colloquial or commonly-used name for the source

Segments:  
 Benedictamus Domino  
 Canadian Chant Database  
 Cantorales in the Americas  
 Chinese Catholic  
Plainchant  
 Sequence Database  
 CANTUS Database

Provenance (origin / history):  
Dominican  
If the origin is unknown, select a location where the source was used later in its lifetime and provide details in the "Provenance notes" field.

Provenance notes:

Complete Source/Fragment:  
Fragmented

More exact indication of the provenance (if necessary):

# Some world domination data linking ideas

- text linked to Cantus Index at [chant level](#)
- “feast” being added to WikiData for external authority
- “differentia” linked to Differentia Database (but not other musical information)

View | Edit

Marginalia: Folio: \* Sequence: \*

Feast: XI milium Virginum

Service: [V] First Vespers

Genre: [A] Antiphon

Position: M Cantus ID: a02039 Melody ID:

Function: -----

Mode: 1 Finalis: Differentia: Extra: Polyphony: -----

Differentiae Database: 66d

For a list of Differentiae IDs refer to the [Differentiae Database](#).

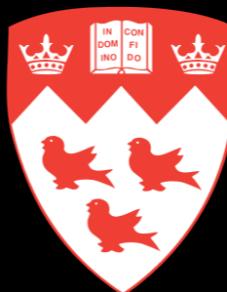
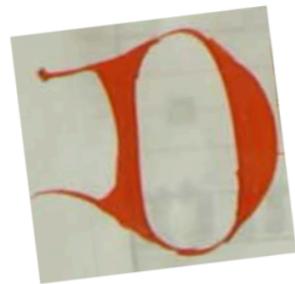
Add another chant

Chant search

# Thank you!

DDMAL

DISTRIBUTED DIGITAL MUSIC  
ARCHIVES & LIBRARIES LAB



# McGill



# DALHOUSIE UNIVERSITY



Social Sciences and Humanities  
Research Council of Canada

Conseil de recherches en  
sciences humaines du Canada

Canada

# LinkedMusic

## Introduction



Ichiro Fujinaga

Music Technology Area, Schulich School of Music  
McGill University

# LinkedMusic: Key Concepts

- ❖ Be able to search across various music databases from one website
- ❖ Universal Music Instrument Lexicon (formerly known as Virtual Instrument Museum)
  - ❖ Create a crowd-sourced website
  - ❖ Images and recordings of musical instruments
  - ❖ Name of the instrument in the local language
  - ❖ Basically a front-end for displaying and editing musical instrument data on Wikidata
- ❖ Funded for 7 years (2022–2029): \$3.2M
  - ❖ SSHRC Partnership Grant
  - ❖ FRQSC Research Team Support Grant
  - ❖ McGill University

# LinkedMusic Project Meeting II

21 October 2023: McGill University, Montreal



Lutz, Julie Cumming, Susan Forscher Weiss, Dylan Hillerbrand,  
David Lewis, Houman Behzadi, Kevin Kishimoto, Jon Manton,  
Robin Desmeules

# LinkedMusic Workshop IV

7 April 2024: Dalhousie University



- ❖ **Guest speaker:** Jan Hajič
- ❖ **Participants:** Jennifer Bain (host), Debra Lacoste, Andrew Hankinson, Anna de Bakker, Dylan Hillerbrand, Julia Craig-McFeely, Tim Expert, Houman Behzadi, Lucero Enríquez Rubio, Julie Cumming, Lionel Li-Xing Hong, Phoebe Durand-McConnell, Marcia Ostashewski

# LinkedMusic Workshop V

24 June 2024: Lisbon, Portugal



- ❖ Guest speaker: Ichiro Fujinaga
- ❖ Participants: Elsa de Luca, (host), Martha Thomae, Alessandra Ignesti, Craig Sapp, Debra Lacoste, Jennifer Bain, Manuel Pedro Ferreira, Francesco Orio, João Pedro d'Alvarenga, Antoine Pham, Hana Vlhová-Wörner

# LinkedMusic Project Meeting III

26 October 2024: McGill University, Montreal



Lutz, Julie Cunningham, Susan Fischer Weiss, Dylan Fincher-Strickland,  
David Lewis, Houman Behzadi, Kevin Kishimoto, Jon Manton,  
Robin Desmeules

# LinkedMusic.ca

Google ▾ Translated to: [Chinese \(Simplified\)](#) ▾ [Show original](#)

Options ▾

链接音乐

关于 參與者 活动 参考 密尔沃基大学 机会 联系我们

Powered by



Translate

# LinkedMusic

我们新成立的 LinkedMusic Partnership 的目标是通过元数据架构（用于组织数据库中存储的信息的结构）链接音乐数据库。这将大大有助于将在线音乐搜索提升到与当前基于文本的资源相同的复杂程度，使我们能够回答有关音乐以及音乐如何与人类创造力、社会、文化和历史互动的基本问题。

我们的目标包括：

- 制定全面的国际音乐元数据模式
- 开发映射工具，将现有的元数据模式映射到我们的新模式上
- 索引聚合元数据，以便同时搜索各个数据库

如需了解更多信息，请联系 [Ichiro Fujinaga](#)。

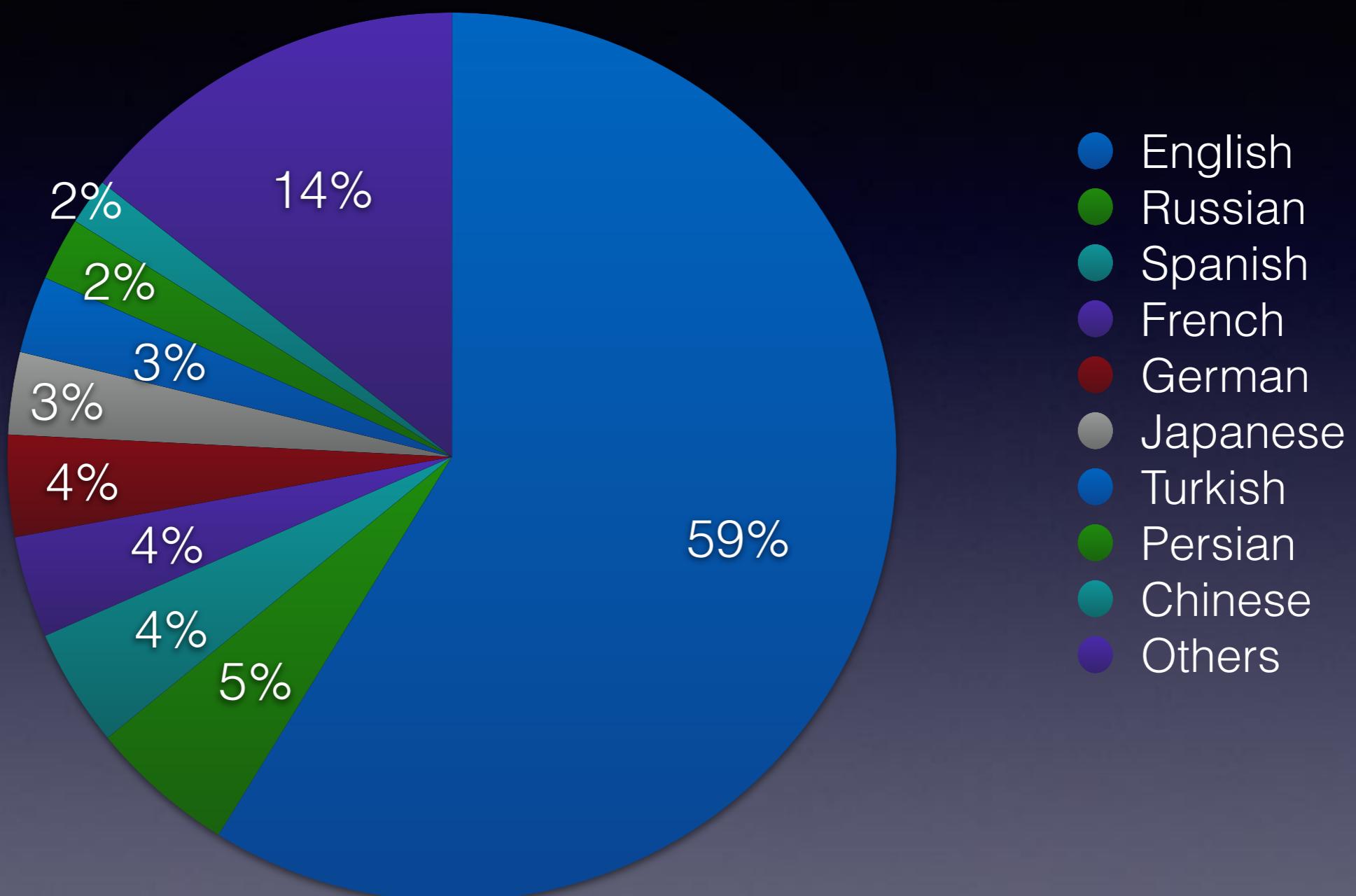
L'objectif de notre nouveau partenariat LinkedMusic est de lier des bases de données musicales par des schémas de métadonnées, des structures d'organisation de l'information stockées dans une base de données. Ce projet contribuera grandement à amener la recherche de musique en ligne au même niveau de sophistication que la recherche de ressources textuelles, nous permettant ainsi de répondre à des questions fondamentales sur la musique et comment elle interagit avec la créativité, la société, la culture et l'histoire humaines.

Nos objectifs incluent :

# Goals of LinkedMusic

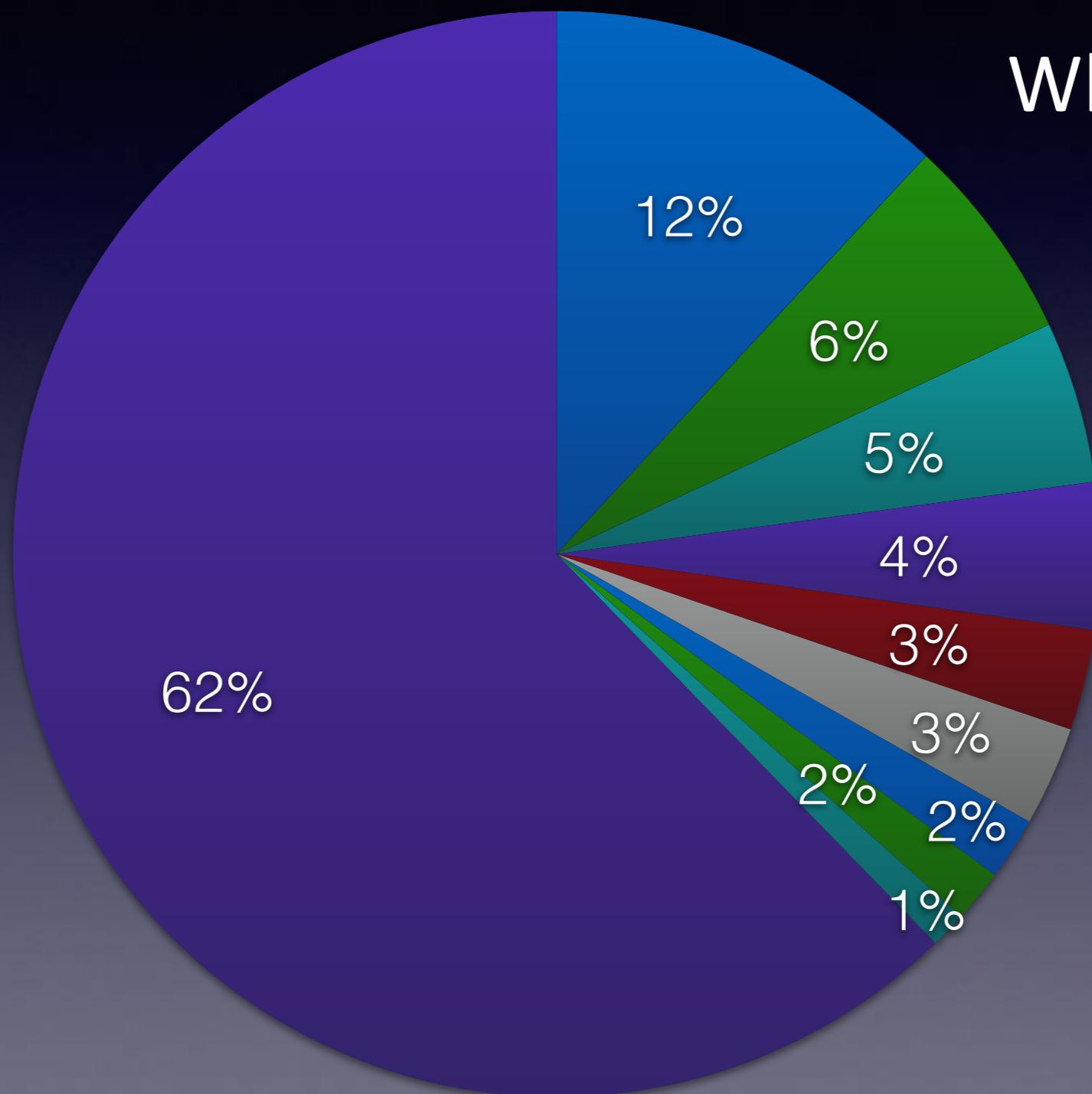
- ❖ Make musical information accessible to more people in the world
- ❖ Make musical queries available in languages other than English

Languages most frequently used for web content as of January 2023, by share of websites (statista.com)



# Languages spoken as a First Language

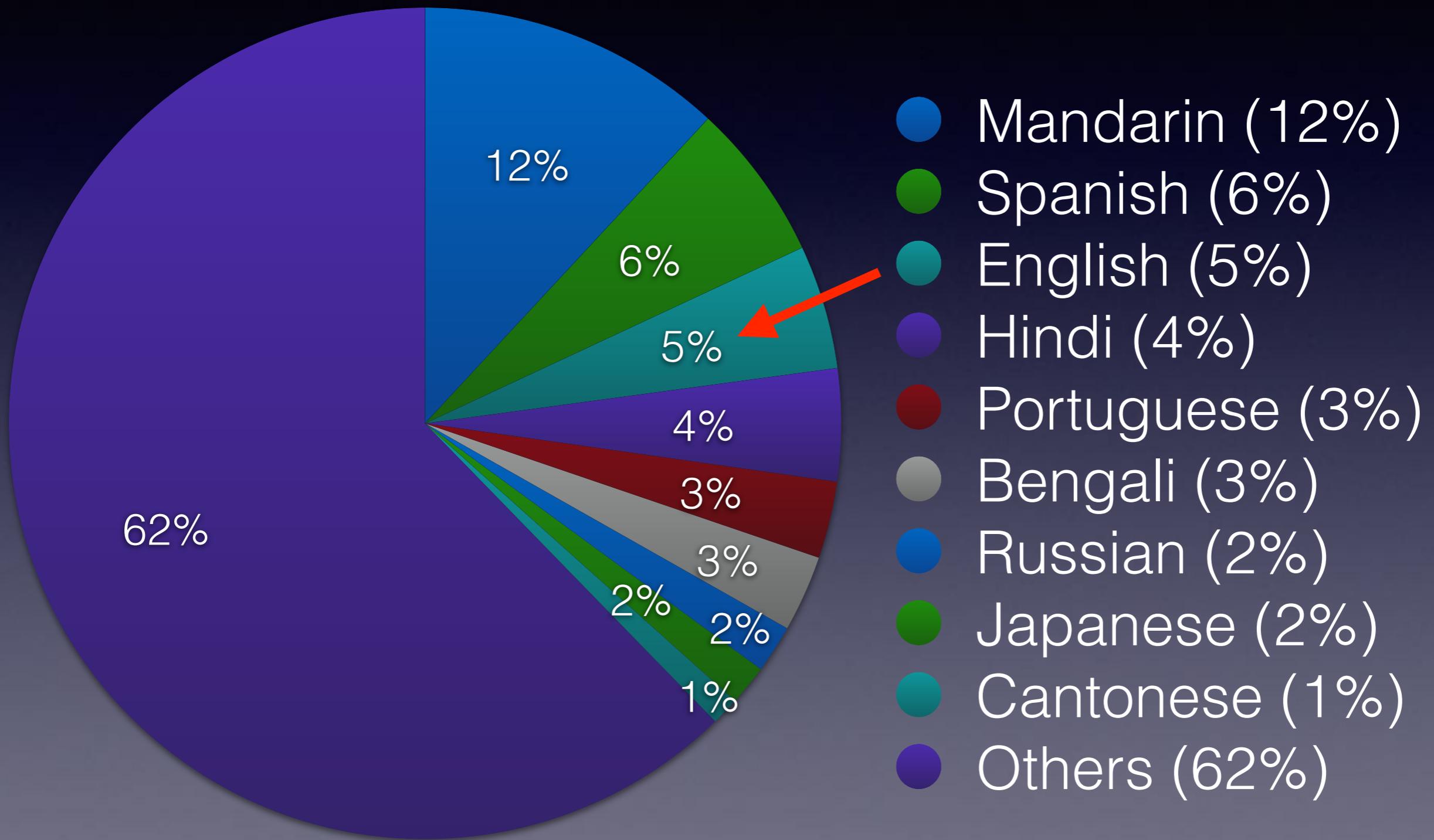
(Wikipedia: 2023)



Which slice is  
English?

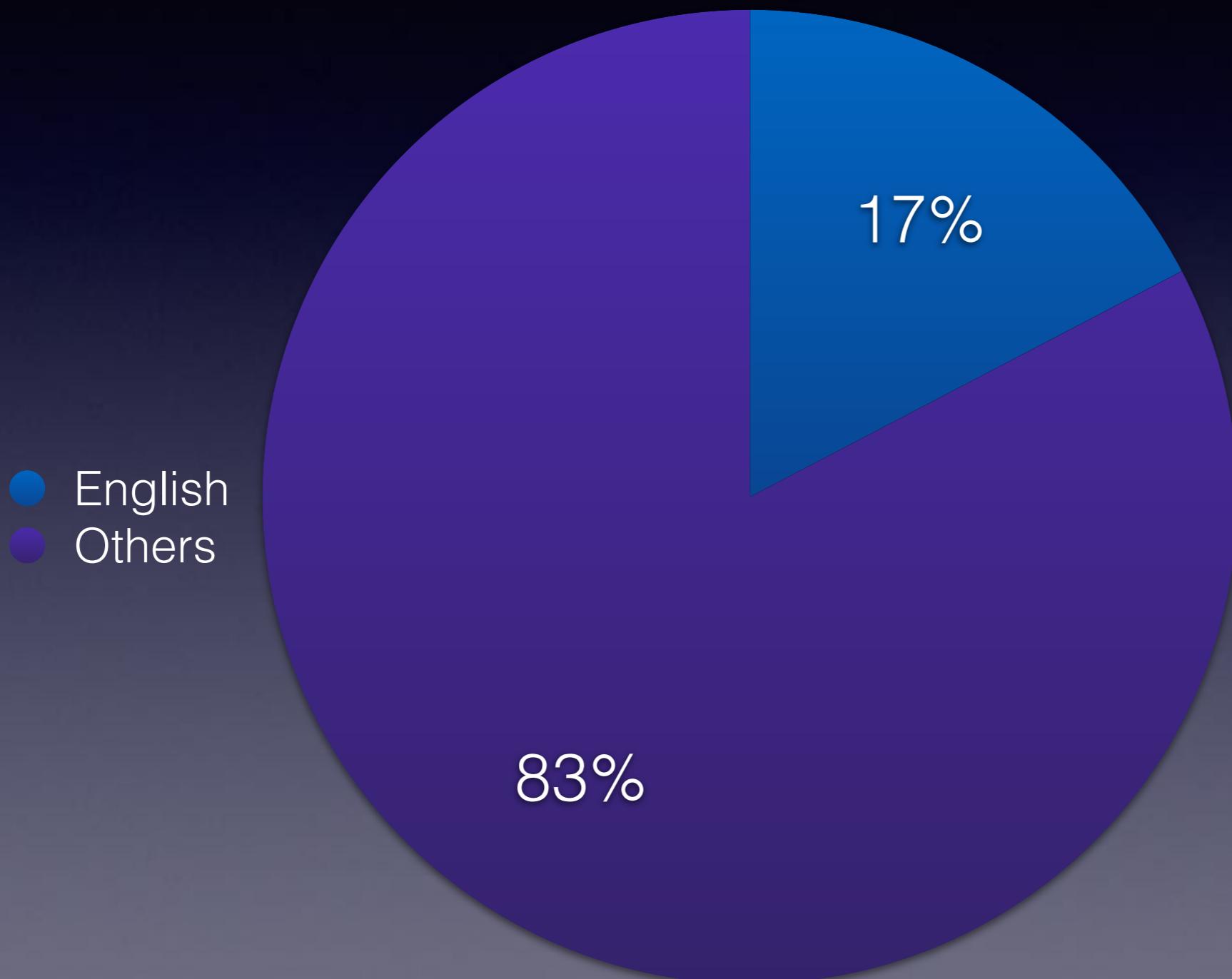
# Languages spoken as First Language

(Wikipedia: 2023)

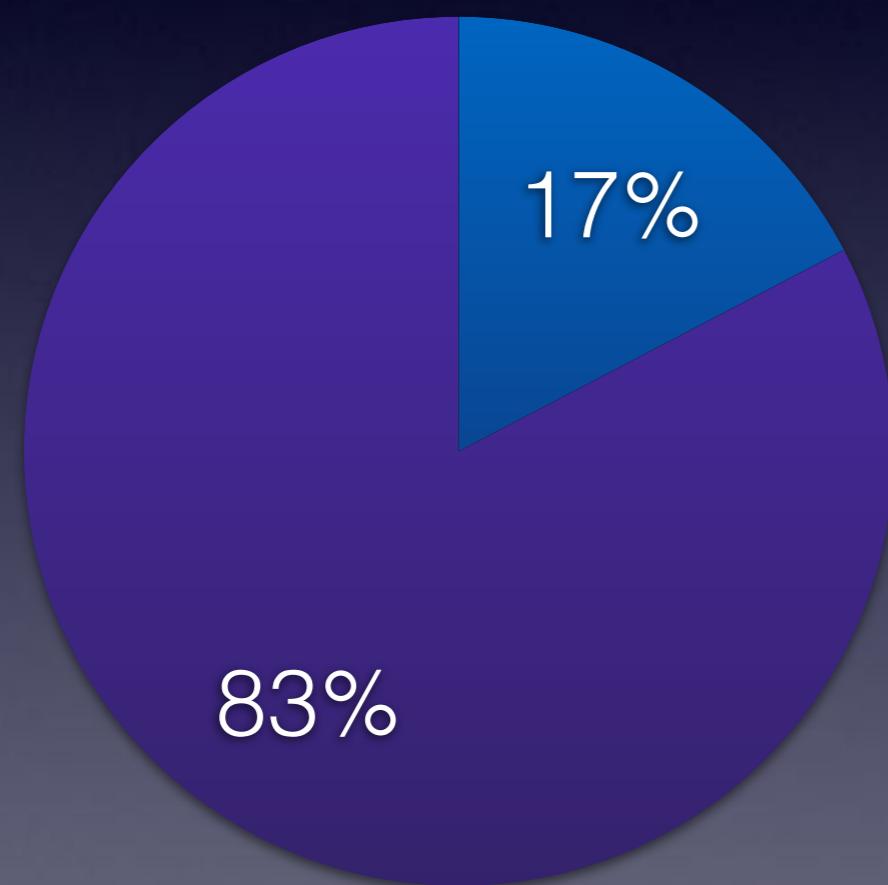


# Who can speak English?

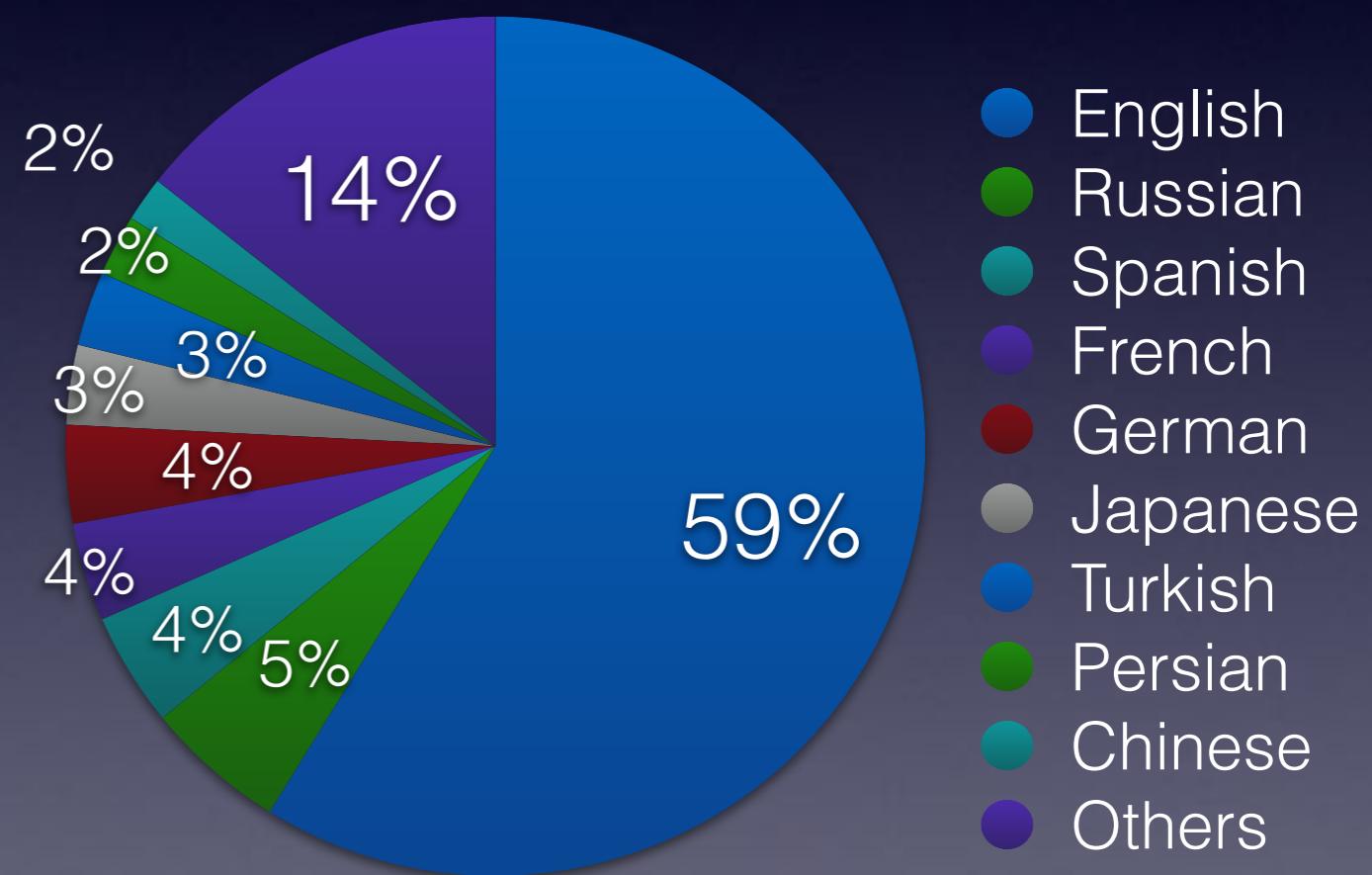
([www.babbel.com](http://www.babbel.com))



# Who can speak English? Compared to websites



Can speak English



Websites

# Initial 14 Databases

1. SIMSSA DB
2. Cantus Ultimus
3. Cantus Database
4. DIAMM
5. RISM
6. Cantus Index
7. Canadian Chant Database
8. Global Jukebox
9. DTL1000 (Dig That Lick)
10. MusicBrainz
11. AcousticBrainz
12. CritiqueBrainz
13. ListenBrainz
14. MOTET Database  
(Jennifer Thomas)
- + 15. TheSession.org

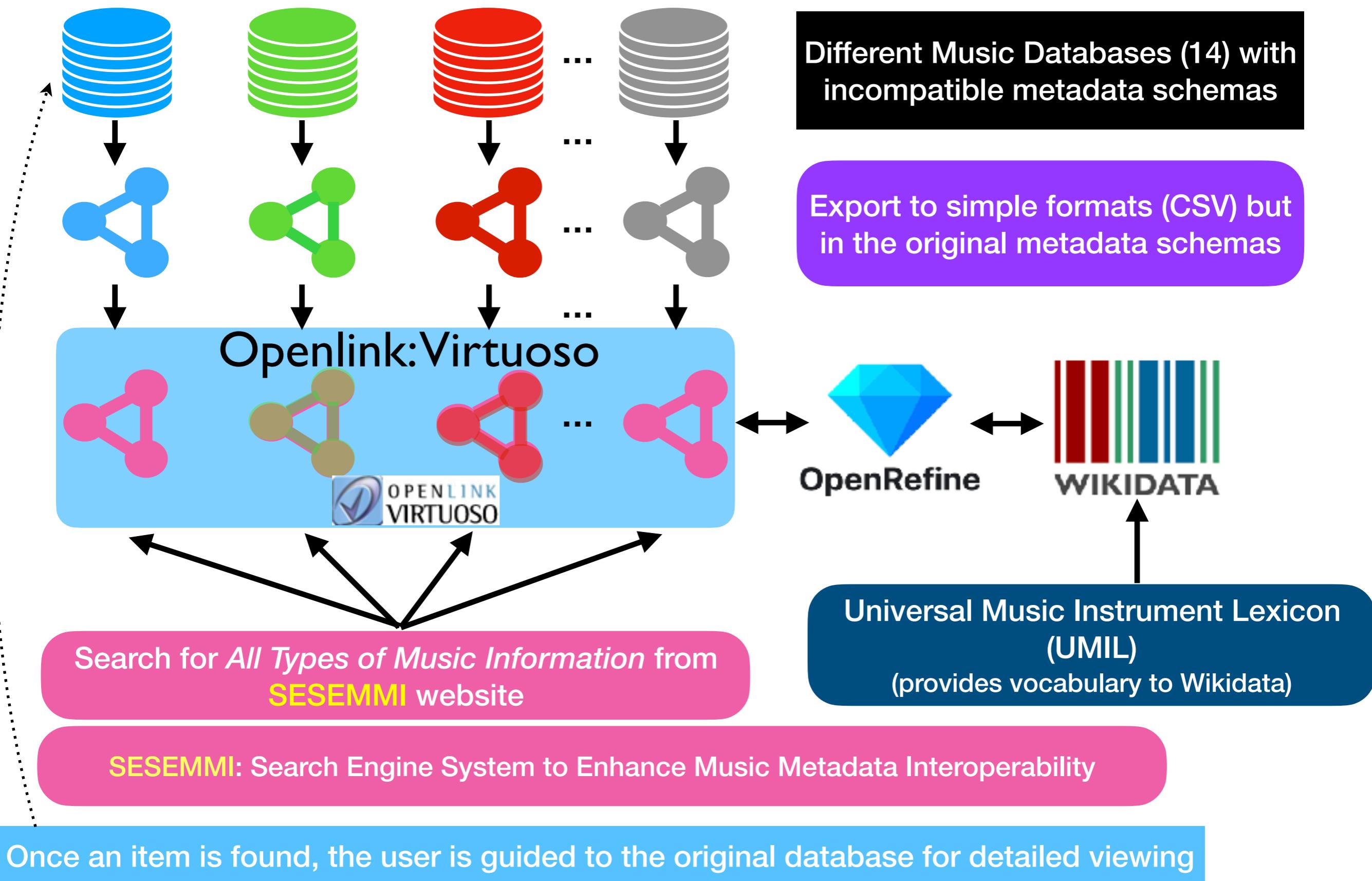
# “Lazy Searching”

- ❖ Lazy Learning vs Greedy Learning
  - ❖ Lazy learning: k-nearest neighbour
  - ❖ Greedy learning: artificial neural networks
- ❖ Harvesting vs Federated Search
  - ❖ Harvesting search: Google
    - ❖ Harvested data is indexed
  - ❖ Federated search: Kayak, Google Flights, Expedia
    - ❖ Needs APIs (Application Programming Interface) on the client side (e.g., airlines and hotels)
- ❖ Lazy searching: Harvesting without indexing

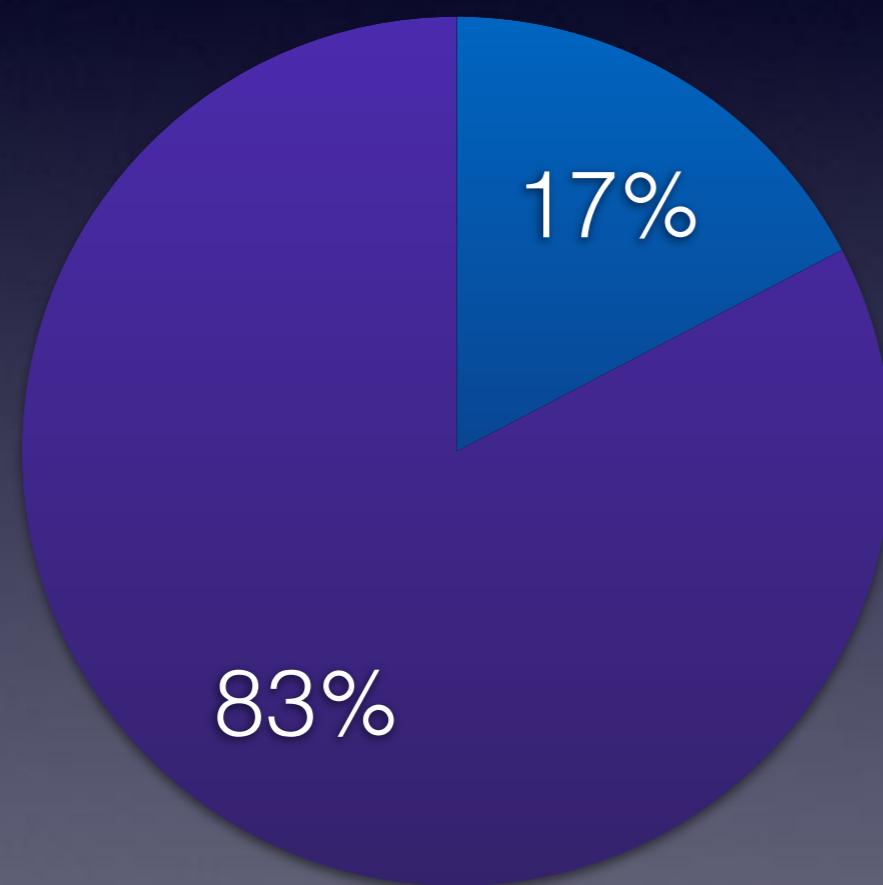
# Current Basic Process

- ❖ Combine various sources and dump them into our LinkedMusic Data Lake: OpenLink Virtuoso
- ❖ Reconcile schema (properties) and vocabularies to Wikidata using OpenRefine
- ❖ Use SPARQL and other search engines (e.g., Solr, ElasticSearch) for queries

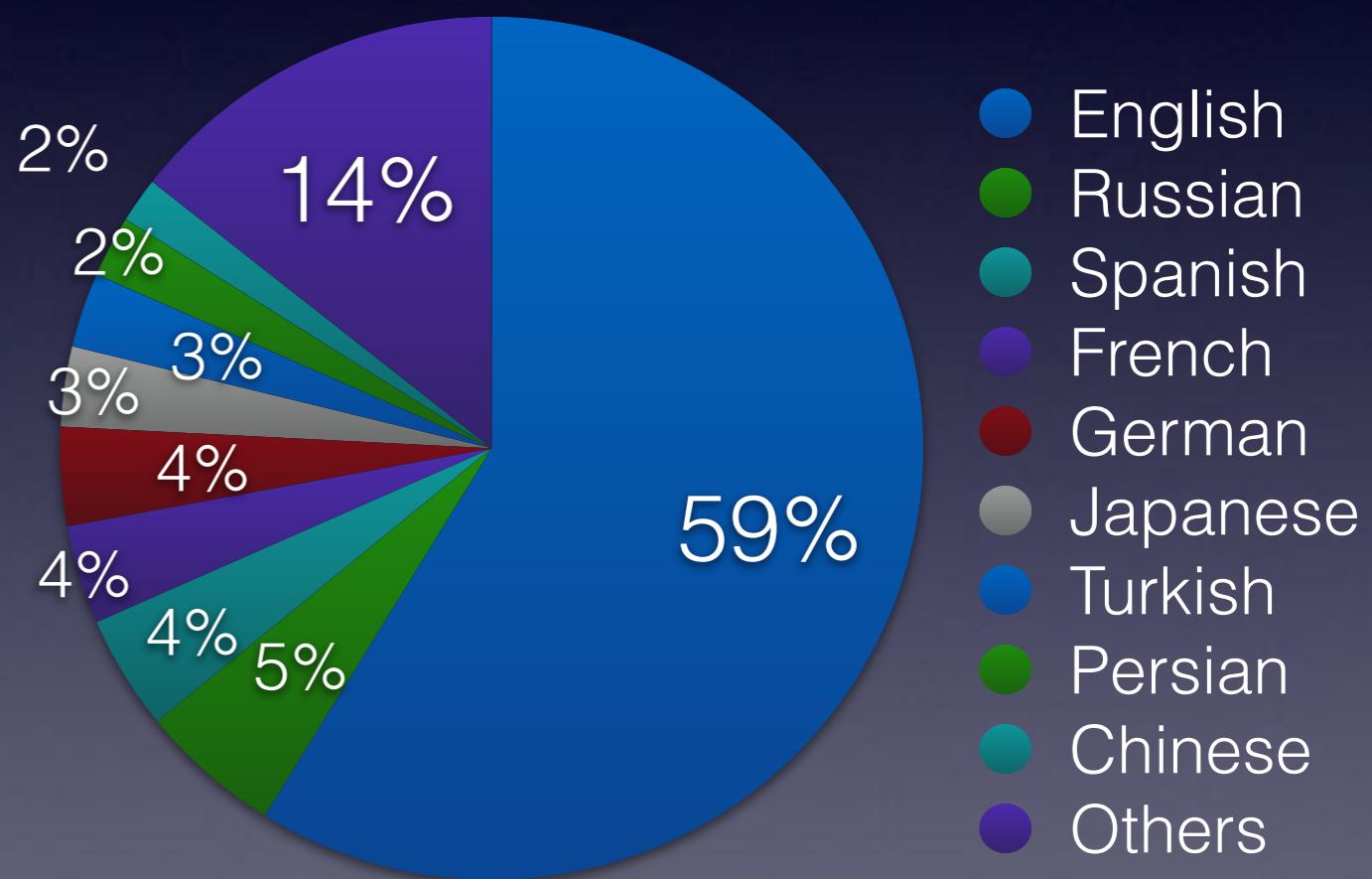
# LinkedMusic Overall Process: Virtuoso Version



# Who can speak English? Compared to websites



Can speak English



Websites

# UMIL (Universal Musical Instrument Lexicon)

Formerly known as VIM (Virtual Instrument Museum)

- ❖ Name of musical instruments may be needed for query
- ❖ Music instrument names varies across languages and cultures
- ❖ A way to translate musical instrument names in as many language as possible
- ❖ User-friendly interface to populate musical instruments in Wikidata

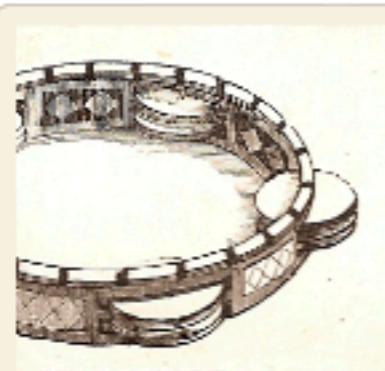
**Hornbostel-Sachs  
Classification**

1 - Idiophones	43
2 - Membranophones	9
3 - Chordophones	61
4 - Aerophones	61
5 - Electrophones	4
Unclassified	84

More facet search coming...

**INSTRUMENT LIST**

English

**Instrument name language**

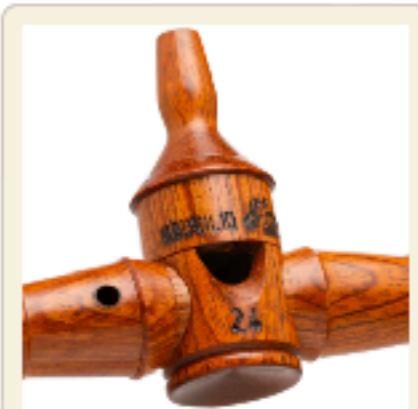
Tambourine



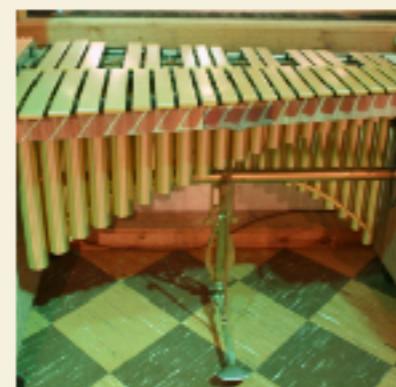
Triangle



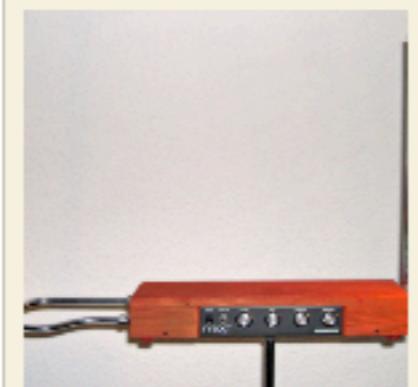
Zill



Whistle



Vibraphone



Theremin



Hurdy-Gurdy



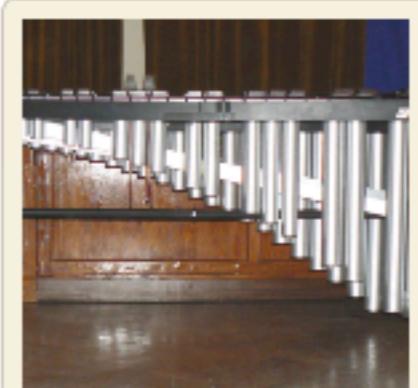
Snare Drum



Tabla

Transposing  
Instrument

Pan Flute



Marimba

# Overview of technologies used in LinkedMusic

- ❖ Linked Data
- ❖ Semantic Web
- ❖ Ontologies
- ❖ RDF
- ❖ SPARQL
- ❖ Wikidata
- ❖ OpenRefine

# What is Linked Data?

- ❖ Linked data is a method to create interlinked data sets that can be accessed by both humans and machines.
- ❖ It facilitates data integration and enhance the interoperability of diverse datasets.
  - ❖ RDF (Resource Description Framework)
  - ❖ URIs (Uniform Resource Identifiers)
  - ❖ JSON-LD (JavaScript Object Notation for Linked Data)

# What is the Semantic Web?

*The Semantic Web is an extension of the World Wide Web that enables data to be linked, shared, and used by computers.*

## Benefits

- ❖ Interoperability
- ❖ Linked Data
- ❖ Data Integration
- ❖ Knowledge Representation
- ❖ Machine Understanding
- ❖ Inference and Reasoning
- ❖ Search and Discovery

# Semantic Web: Interoperability

- ❖ The Semantic Web aims to enhance data interoperability by providing a common framework for representing and linking data across diverse sources, formats, and domains. This facilitates data integration and exchange between different systems and organizations.
- ❖ This is usually achieved through **Linked Data** using:
  - ❖ **RDF** (Resource Description Framework)
  - ❖ **URIs** (Uniform Resource Identifiers)

# Semantic Web: Data Integration

- ❖ Using standardized ontologies and vocabularies, the Semantic Web simplifies the process of integrating data from multiple sources.
- ❖ Particularly useful for applications that need to access and analyze diverse datasets.

# Semantic Web: Data Integration

- ❖ Using *standardized ontologies and vocabularies*, the Semantic Web simplifies the process of integrating data from multiple sources.
- ❖ Particularly useful for applications that need to access and analyze diverse datasets.

# What is an ontology?

- ❖ Ontology is a structured and formal representation of knowledge that defines concepts, their attributes, and the relationships between them in a specific domain or subject area.
- ❖ Ontologies are used to establish **a common understanding and shared vocabulary** for a particular field of knowledge.
- ❖ Examples: FOAF, DBpedia, and CIDOC-CRM

# What is RDF?

- ❖ Resource Description Framework (RDF) is designed to be a universal data representation format.
- ❖ It promotes data interoperability by providing a common framework for expressing data and its relationships, making it easier to integrate data from various sources and domains.
- ❖ RDF Statement (Triples):
  - ❖ Subject - Predicate - Object
  - ❖ Kaija Saariaho - Born - 1952

# What is SPARQL?

- ❖ SPARQL (SPARQL Protocol and RDF Query Language)
- ❖ An RDF query language
- ❖ Allows users to query databases that can be mapped to RDF

# An example of SPARQL query

*Who was the mother of Clara Schumann?*

```
SELECT *
```

```
WHERE {
```

```
?person_of_interest rdfs:label "Clara Schumann"@en.  
?person_of_interest dbp:mother ?mom.
```

```
}
```

SPARQL query @DBpedia

# Why Wikidata?

## Why I like it

- ❖ Totally free: Public Domain (CC0)
- ❖ Flexible ontology and schema
- ❖ URI (Unique Resource Identifiers) are numeric
  - ❖ Language-agnostic
    - ❖ MARC fields: 100 (authors), 245 (title), 260 (publisher), etc.
- ❖ Loose crowd-sourced editing
  - ❖ Entities / items (QID) can easily be added
  - ❖ Properties (PID) need some group consent
- ❖ *OpenRefine* knows about Wikidata
- ❖ Very large, growing source of information

# Wikidata Triples

- ❖ Wikidata triples: Item - Property - Value
  - ❖ Equivalent to RDF: Subject - Predicate - Object
- ❖ Example: Maria Anna Mozart - Sibling of - W. A. Mozart

Q157928 - P3373 - Q254

# Very large, growing source of information

- ❖ 107,267,269 data items (as of 2023-10-14)
- ❖ 117,353,950 data items (as of 2025-05-06)
- ❖ Wikidata is only 13 years old (from ~2012)
- ❖ Acting as a consolidator of URIs. Becoming a central hub of information on the Internet
  - ❖ VIAF (Virtual International Authority File) (from ~2003)
    - ❖ Fanny Mendelssohn: <https://viaf.org/viaf/2535006>
    - ❖ Wikidata: <https://www.wikidata.org/wiki/Q57286>

# What's wrong with Wikidata?

- ❖ Disorganized
  - ❖ Anyone can add or modify anything
  - ❖ For example, musical instruments
- ❖ No authority
  - ❖ Looser than Wikipedia

# Ontologies in Wikidata

- ❖ Wikidata has the concepts of “Instance of” (P31) and “Subclass of” (P279)
- ❖ Its ontology and schema can be extended and modified by the Wikidata community, which makes it a dynamic and ever-evolving knowledge base
- ❖ Users can add new classes and properties, leading to a more flexible and adaptable structure

# OpenRefine

- ❖ A tool for data hygiene (data cleaning)
- ❖ Helps convert databases to RDF format
  - ❖ Mostly with table-like data format (e.g., spreadsheets)
- ❖ Knows about Wikidata
  - ❖ Finds Wikidata IDs for Items, Properties, and Values
  - ❖ The process is called “reconciliation”
    - ❖ Row headings → Item (subject)
    - ❖ Column headings → Property (predicate)
    - ❖ Cell values → Value (object)

# An example of how OpenRefine works

Courtesy of Julie Cumming (Motet Database)

Source name	Abbreviation	Dates	Provenance	Type of source	Size (cm)
Motetti C. Venice, Petrucci, 1504.	1504/1	1504	Italy, Venice	Motets	16 x 23
Fragmenta missarum, Venice, Petrucci, 1505	1505/1	1505	Italy, Venice	Masses	16 x 23
Attaingnant, Treze motetz musicaulz Paris: Attaingnant, 1531	1531/5	1531	France	Tablature, keyboard	
Der ander theil des Lautenbuchs. Nuremberg, Petreius, 1536	1536/13	1536	Germany, Nuremberg	Tablature, lute	
Bologna, Civico Museo Bibliografico Musicale, MS Q18.	Bologna Q18	1502-6	Italy, Bologna	Textless, chansons, laude and frottole	17 x 24

## Automatic Reconciliation using Wikidata + Manual Reconciliation

<a href="https://rism.online/sources/993103780">https://rism.online/sources/993103780</a>	1504/1	Q6148	Q641	Q188285	16 x 23
<a href="https://rism.online/sources/993103788">https://rism.online/sources/993103788</a>	1505/1	Q6153	Q641	Masses	16 x 23
<a href="https://rism.online/sources/993104054">https://rism.online/sources/993104054</a>	1531/5	Q6431	France	Q17126140	
<a href="https://rism.online/sources/993104150">https://rism.online/sources/993104150</a>	1536/13	Q6457	Q2090	Q119855423	
<a href="https://www.diamm.ac.uk/sources/1389">https://www.diamm.ac.uk/sources/1389</a>	Bologna Q18	1502-6	Q1891	Textless, chansons, laude and frottole	17 x 24

# A new task for LinkedMusic Project

- ❖ Improve the quality of musical information in Wikidata
  - ❖ Provide interfaces for editing, e.g., UMIL, Saints' Days
  - ❖ Provide visualization interfaces to identify missing or erroneous data (e.g., “[Transposing Instrument](#)”)

# Current Basic Process of Making LinkedMusic Data Lake

- ❖ Combine various data sources and dump them into our LinkedMusic Data Lake
- ❖ Use SPARQL and other search engines (e.g., Solr, ElasticSearch) for queries

# NLQ2SPARQL

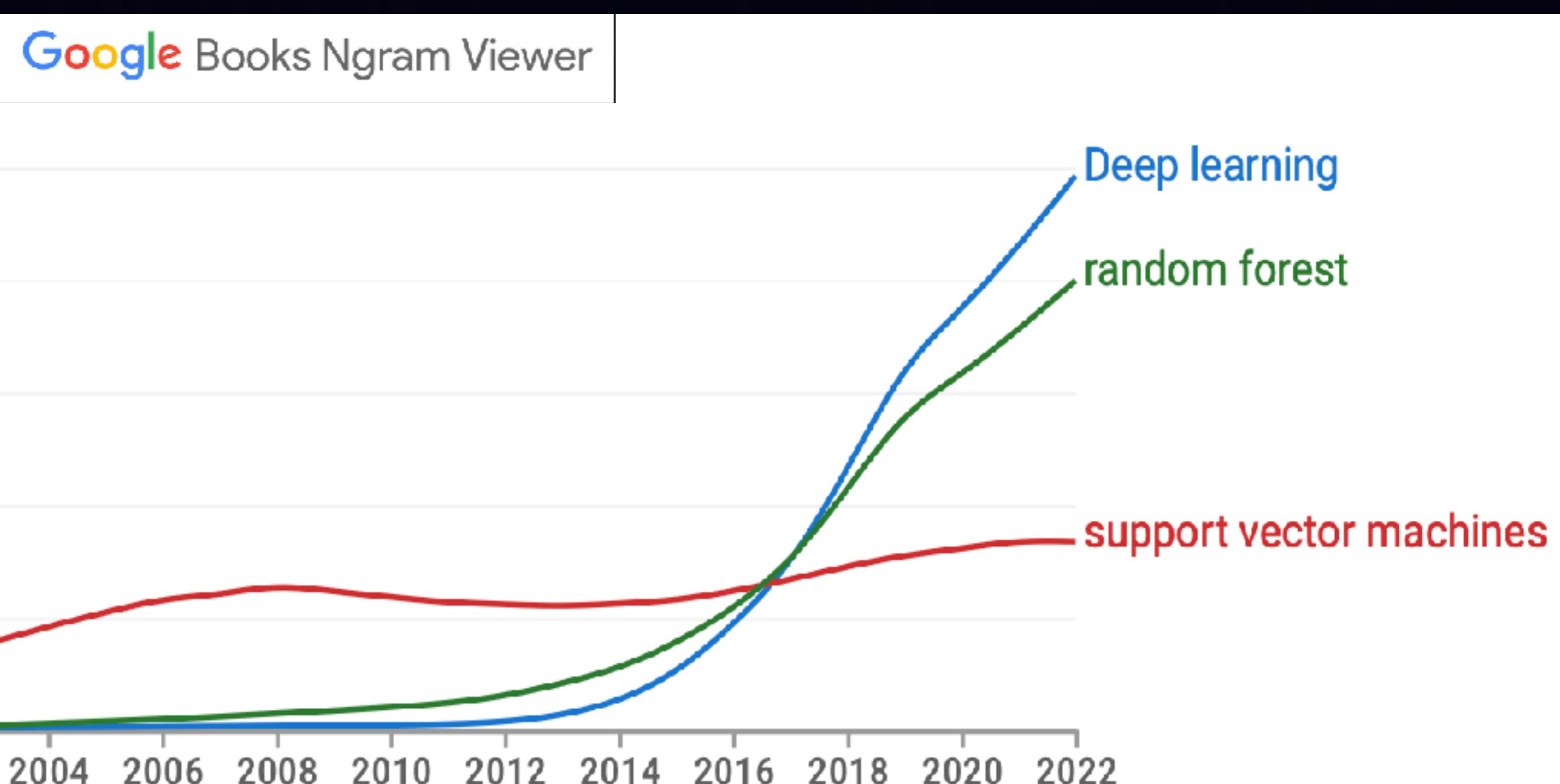
- ❖ Natural Language Query to SPARQL query conversion
- ❖ SPARQL: SPARQL Protocol and RDF Query Language

# How to Train Your Computer

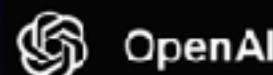
- ❖ Ground up
- ❖ Fine Tuning
- ❖ In-Context Learning (“In-Context Education”)
- ❖ RAGs retrieval augmented generation

# How to Train Your Computer

## A Brief History of Machine Learning



# On November 30, 2022 OpenAI announces ChatGPT !



Research

Products

Safety

Company



Andrew Hankinson <[andrew.hankinson@rism.digital](mailto:andrew.hankinson@rism.digital)>

andrew

December 6, 2022 at 5:06 AM

AH

Whoa.

To: Ichiro Fujinaga <[ichiro.fujinaga@mcgill.ca](mailto:ichiro.fujinaga@mcgill.ca)>,

Cc: Laurent Pugin <[laurent.pugin@rism.digital](mailto:laurent.pugin@rism.digital)>

Hide

Hi Ich, Laurent,

Further to the question of LinkedMusic and doing user interfaces for finding music materials...

Have you seen ChatGPT? It's incredibly cool.

We've trained a model called ChatGPT which interacts in a conversational way. The dialogue format makes it possible for ChatGPT to answer followup questions, admit its mistakes, challenge incorrect premises, and reject inappropriate requests.

# What is ChatGPT?

- ❖ ChatGPT is a type of Large Language Model (LLM)
- ❖ Designed specifically for conversation by OpenAI

# What is a Large Language Model (LLM)?

- ❖ A type of artificial neural networks called *transformers*
- ❖ Initially trained for language understanding using deep learning techniques
- ❖ LLMs are pre-trained on massive datasets: text, images, music
- ❖ They have generative capabilities: text, images, music
- ❖ GPT stands for Generative Pre-trained Transformer

# History of Large Language Models (LLM)

Date	Google	Date	Facebook	Anthropic
2017	Transformer paper	2023-02	LLaMA	
2018	BERT	2023-03	T	Claude
2019	T5	2023-07	LaMA 2	Claude 2
2020		2024-03	-3	Claude 3
2021	LaMDA	2024-04	LLaMA 3	
2022	PaLM	2024-06	(Nov)	Claude 3.5
2023	Bard (Mar)	2024-06	May)	Sonnet
2024	Gemini (Feb)	2024-07	LLaMA 3.2 (May)	
		2024-09	LLaMA 3.3	

# Issues in training an LLM

## ❖ Size

- ❖ Training data
- ❖ Model size

## ❖ Time

- ❖ Training time

## ❖ Cost

- ❖ Computing time

- ❖ Environment impact

LLMs	Size	Training time	Cost
ChatGPT	175B	34 days	\$4.6M
LLaMA 3	8B/70B	3/21 Days	
LLaMA 3.1	405B	2 Months	
GPT-4	1,760B	3–4 Months	~\$500M
Gemini	1,560B		~\$1–2B

# How to Train Your Computer

- ❖ ~~Ground up~~
- ❖ Fine Tuning
- ❖ In-Context Learning (“In-Context Education”)
- ❖ RAGs retrieval augmented generation

# How to Train Your Computer: Fine-tuning

- ❖ A type of transfer learning
  - ❖ Start with a pre-trained model
  - ❖ Retrain with new dataset by adjusting parameters
- ❖ “Catastrophic forgetting”
- ❖ Still requires some computing resources

# How to Train Your Computer

- ❖ ~~Ground up~~
- ❖ ~~Fine Tuning~~
- ❖ In-Context Learning (“In-Context Education”)
- ❖ RAGs retrieval augmented generation

# How to Train Your Computer: In-Context Learning

- ❖ Prompt engineering
- ❖ Provide the context before the prompt

*I'm preparing a slide presentation for academics.*

*Please make some slides for explaining In-Context Learning.*

- ❖ No training necessary! 😊
- ❖ Has no memory, however 😔 “In-Context Education”
- ❖ Restrictions on size of the context window (token limits)
  - ❖ ChatGPT: 2,000 words
  - ❖ ChatGPT 4o: 96,000 words
  - ❖ Claude 3.1 Sonnet: 150,000 words
  - ❖ Google Gemini: 750,000 words

# How to Train Your Computer

- ❖ ~~Ground up~~
- ❖ ~~Fine Tuning~~
- ❖ In-Context Learning (“In-Context Education”) 
- ❖ RAGs retrieval augmented generation

# How to Train Your Computer: **RAG (Retrieval Augmented Generation)**

- ❖ Combine dynamic search with LLM
- ❖ Documents or other data, including databases, are retrieved then used as an additional context for LLM prompt
- ❖ User preferences can also be retrieved for personalized response
- ❖ Future research avenue (e.g., Knowledge Graph Embeddings)

# LLMs and LinkedMusic

- ❖ LLM (ChatGPT) is used for NLQ2PARQL (Natural Language Query to SPARQL) with in-context learning
  - ❖ More about queries on Thursday
- ❖ LinkedMusic may become unnecessary as LLMs improve over the next few years

# Comparing queries: Google vs SPARQL

- ❖ Google: “17th-century German composers who died in London”
- ❖ SPARQL: “17th-century German composers who died in London”
- ❖ ChatGPT3: 17th-century German composers who died in London
- ❖ ChatGPT: “Generate SPARQL for Wikidata: 17th-century German composers who died in London”
- ❖ With Handel: Wikidata (2023-10-21)
- ❖ With Handel: Wikidata (2024-06-29)
- ❖ ChatGPT4o: 17th-century German composers who died in London
- ❖ Claude: 17th-century German composers who died in London

# Screenshot 2024-10-01

## Claude 3.5 Sonnet

Claude Q 17th-Century German Composers in London ▾ ☆ ≡

IF • 17th-century German composers who died in London

Here are some notable 17th-century German composers who died in London:

1. Johann Christoph Pepusch (1667-1752)
  - Born in Berlin, died in London
  - Known for arranging music for The Beggar's Opera
2. George Frideric Handel (1685-1759)
  - Born in Halle, died in London
  - One of the most famous Baroque composers
  - Wrote many operas, oratorios including Messiah
3. Johann Christian Bach (1735-1782)
  - Born in Leipzig, died in London
  - Youngest son of Johann Sebastian Bach
  - Known as the "London Bach"

Reply to Claude... edit camera

□ Claude 3.5 Sonnet

# Screenshot 2025-05-06

## Claude 3.7 Sonnet



17th-century German composers who died in London

Here are several 17th-century German composers who died in London:

1. Johann Christoph Pepusch (1667-1752) - Born in Berlin, he moved to England around 1700 and became an influential figure in London's musical life. Although he died in 1752 (slightly outside the 17th century), he was born in the 17th century and spent his later years in London.
2. Jakob Greber (c. 1673-1731) - A German baroque composer who worked in London and died there.
3. Georg Frideric Handel (1685-1759) - Though born in Halle, Germany in the late 17th century, Handel moved to London in 1712 and became naturalized as a British subject in 1727. He died in London in 1759. While his death occurred in the 18th century, he was born in the 17th century and is perhaps the most famous German composer to have died in London.

The list of German composers who were both born in the 17th century AND died in London

Reply to Claude...



Claude 3.7 Sonnet



# Future projects

- ❖ Public UMIL: Crowd sourcing
- ❖ NLQ2SQL for Cantus Database (Lucas March)
- ❖ Continuous Integration for NLQ2SPARQL
  - ❖ Integrate database reconciliation as part of the in-context learning
- ❖ Investigate the use of RAG (Retrieval-Augmented Generation) for queries
- ❖ Use LLMs to generate frontend (e.g., sortable table)
- ❖ Continue to update Wikidata: e.g., Saints and Feasts
- ❖ How to keep Wikidata updated and correct

# Future Meetings

- ❖ LinkedMusic Workshops:
  - ❖ Music Encoding Conference in London, UK
    - ❖ Monday 2 June 2025: 2 pm
  - ❖ IAML in Salzburg
    - ❖ Sunday 6 July 2025: 3 pm

# Possible Future Workshop Sites

- ❖ 2026 / 05: MEC (Tokyo, Japan)
- ❖ 2026 / 06: IAML (Thessaloniki, Greece)
- ❖ 2027 / 03: MLA (TBA)
- ❖ 2027 / 08: IMS Congress (University of Stavanger, Norway)

# Acknowledgements



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DDMAL

DISTRIBUTED DIGITAL MUSIC  
ARCHIVES & LIBRARIES LAB



Centre for Interdisciplinary Research  
in Music Media and Technology

*Fonds  
de recherche*

Québec



Digital Research  
Alliance of Canada

Alliance de recherche  
numérique du Canada



Calcul Québec

These slides were created with the assistants from ChatGPT, Claude, and Gemini.



# SIMSSA / LinkedMusic Team @McGill

## Summer 2024



Hanwen Zhang

Lucas March

Kyrie Bouressa

Anna de Bakker

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Yueqiao Zhang

Dylan Hillerbrand

Yinan Zhou

Junjun Cao

Kun Fang

Geneviève Gates-Panneton (MIA)

# Comparing queries: Google vs SPARQL

- ❖ Google: “17th-century German composers who died in London”
- ❖ SPARQL: “17th-century German composers who died in London”
- ❖ ChatGPT: “Generate SPARQL for Wikidata: 17th-century German composers who died in London”
- ❖ With Handel: [Wikidata](#)

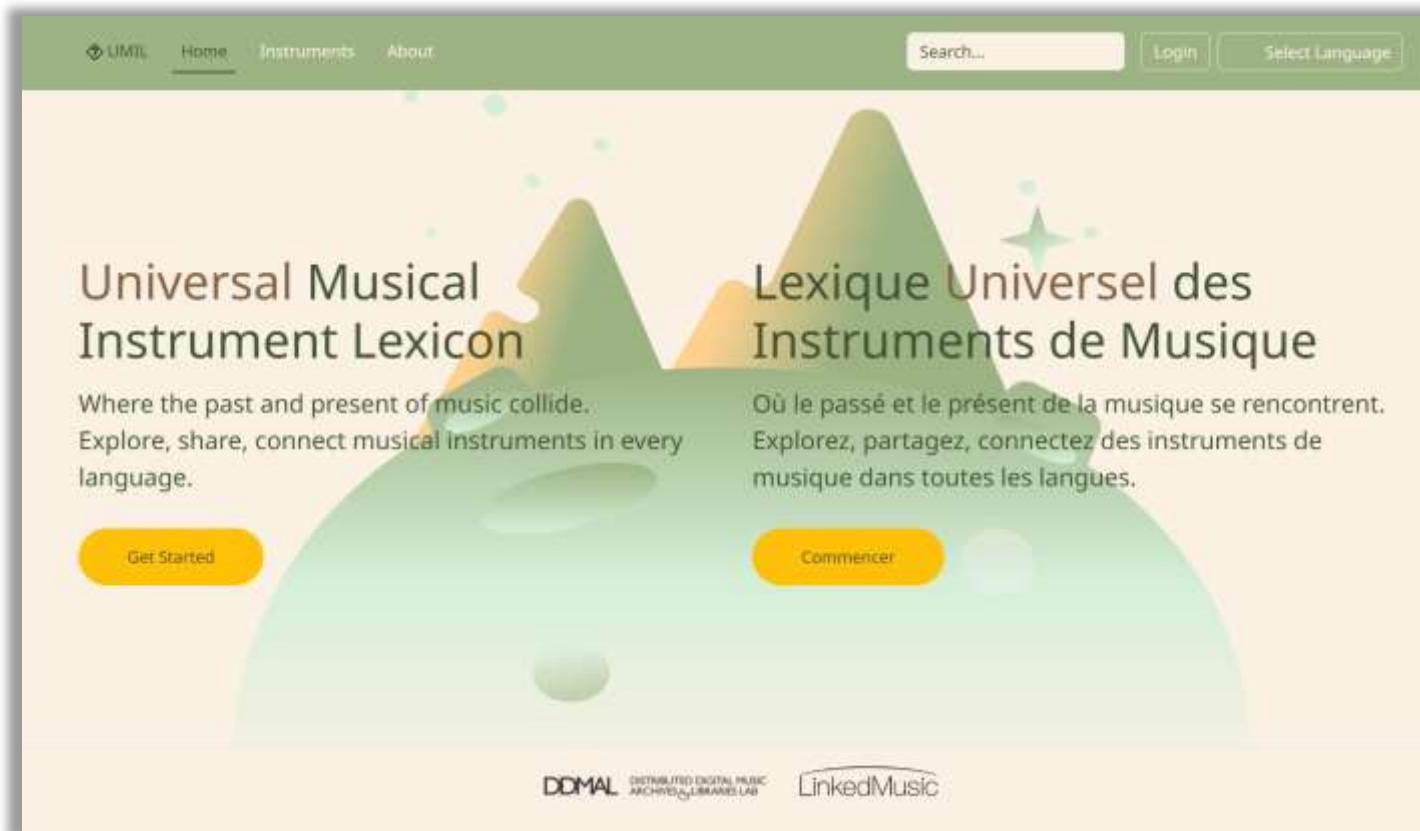
# Universal Musical Instrument Lexicon

DDMAL Training Week  
2025-05-06

*Presented by Kun Fang*

# Overview

- **Crowdsources names and images of instruments**
- **Multilingual interface for easy contribution**
- **Simplifies editing and publishing to Wikidata**



# Why do we need UMIL?

- **Addressing Issues with Wikidata**
  - **Data Quality:** Incomplete or inaccurate instrument data
    - *UMIL ensures cleaner, well-organized data through community contributions.*
  - **Convenience:** lacks a user-friendly way to view/edit all instrument information at once
    - *UMIL offers a centralized platform where users can easily view, edit, and submit instrument data.*

# Why do we need UMIL?

- **UMIL's Key Functions**
  - **Crowdsourcing platform** where users can...
    - Contribute new instruments
    - Submit instrument names in different languages
    - Upload instrument images
  - **Interacts with Wikidata**
    - Get information **from** Wikidata
    - Publish information **to** Wikidata

# How to Get Started?

- Visit UMIL: <https://vim.simssa.ca/>
- UMIL's **Github Repo**: <https://github.com/DDMAL/VIM>
- UMIL is a **Django**-based project.
- Please follow the **README** file to get familiar with:
  1. Installation for Local Development
    - Requirements: Docker Engine with Compose V2
    - Initial Set-Up Instructions
    - Debugging: **django-debug-toolbar** and **django-extensions**
  2. Installation for Deployment
  3. Managing Database Migrations
  4. Loading Data
  5. Additional Tools for Python Development: **Poetry**

# Current Progress

- 1. Display & Search Instruments**
- 2. View & Edit Mode for Instrument**

# Module 1: Display & Search Instruments

800+ Musical Instruments

**Hornbostel-Sachs Classification**

- 1 - Idiophones (131)
- 2 - Membranophones (62)
- 3 - Chordophones (275)
- 4 - Aerophones (278)
- 5 - Electrophones (29)
- Unclassified

More facet search coming...

**INSTRUMENT LIST**

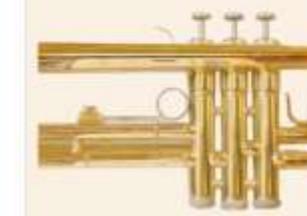
English ▾

Showing 1 to 20 of 801

English | Français

View 20 | 50 | 100 per page

**Multi-languages**

 Guitar	 Trumpet	 Clarinet	 Bass Clarinet
 Bagpipes	 Trombone	 Violin	 Cello

**Hornbostel-Sachs  
Classification  
Faceted Search**

2025/05

7

# Module 2: View & Edit Mode for Instrument

- **View Mode**

INSTRUMENT LIST English ▾

Showing 1 to 20 of 881 entries

Guitar

View on Wikidata

True

WIKIDATA

Main page Community portal Project chat Create a new Item Recent changes Random Item Query Service Nearby Help Donate Lexicographical data Create a new Lexeme Recent changes Random Lexeme Tools What links here Related changes Special pages

Item Discussion

guitar (Q6607)

fretted string instrument

In more languages Configure

Language	Label	Description
English	guitar	fretted string instrument
Chinese	吉他	撥弦樂器
Chinese (Taiwan)	吉他	撥弦樂器
Chinese (China)	吉他	乐器

All entered languages

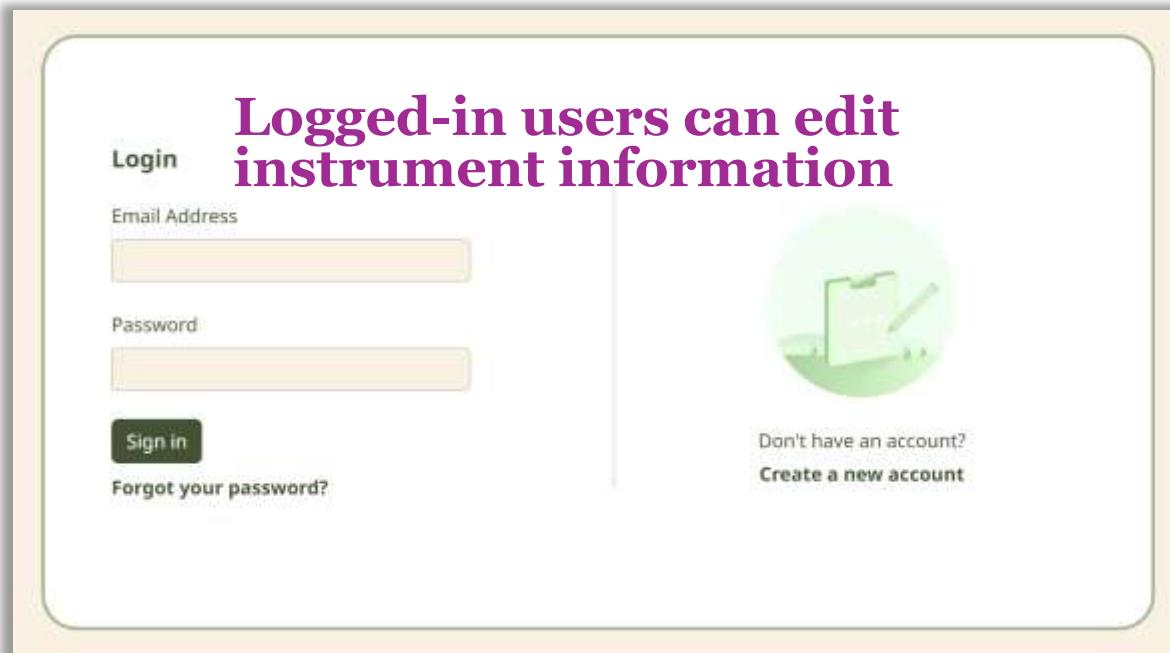
Statements

instance of type of musical instrument

e

# Module 2: View & Edit Mode for Instrument

- **Edit Mode**



- Add instrument names
- Add images
- Create new instruments

The screenshot shows a list of instruments with a "Guitar" entry highlighted. A pink arrow points from the "Add instrument names" and "Upload new images" buttons in the edit mode section of the guitar card to the corresponding items in the list. The list header says "INSTRUMENT LIST English ▾" and "Showing 1 to 20 of 881 entries". The guitar card also includes a "View on Wikidata" button.

# Module 2: View & Edit Mode for Instrument

- **Edit Mode: Add Instrument Names**

**Input fields: Language\*, Name\*, Source\*, Description, Alias**

The screenshot shows a modal dialog titled "Add New Name for **Guitar** (wikidata ID:Q6607)". The dialog has a header with "INSTRUMENT LIST" and "English". It contains two rows of input fields for adding new names. Each row includes fields for Language (with a dropdown placeholder "Type to search"), Name (placeholder "Enter name"), Source (placeholder "Enter source"), Description (placeholder "Enter description"), and Also known as (placeholder "Enter alias"). There are "Remove" buttons next to each row. Below the rows is a button "Add another row". At the bottom, there is a checkbox "Do you want to publish also to Wikidata?" and a "Publish" button. The background of the dialog shows a blurred image of various musical instruments.

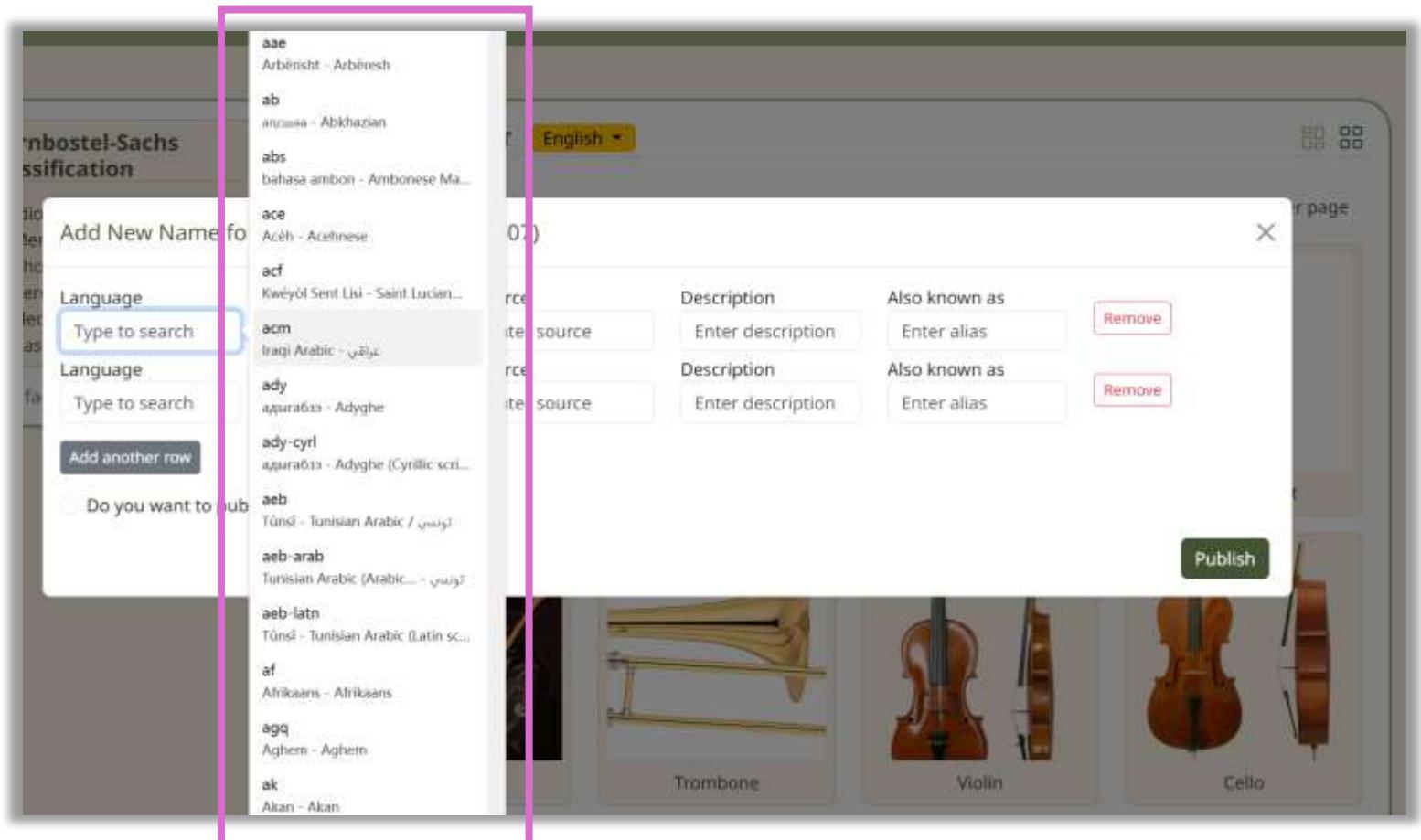
Add more names at once

Check this box to publish to Wikidata

# Module 2: View & Edit Mode for Instrument

- **Edit Mode: Multi-language Support**

- Choose a language in the list (**600+ languages**)
- Identified by **Wikidata's language code** (e.g., "en", "fr")
- Get the language list by calling **Wikidata API**



# What's Next?

**Call for Contributions!**

# 1. Interact with Wikidata: Add New Names

- **Where do we use the Wikidata API when adding new names?**
  - Get Wikidata's latest language list
  - Get/Set instrument information
    - Name
    - Description
    - Alias
    - ...

## 2. Interact with Wikidata: Add New Images

- **Objective:** Uploaded images will appear directly on **the instrument's Wikidata page**.
- **How it works:**
  - **Step 1:** Upload image to **Wikimedia Commons**
    - *Wikimedia Commons is a free media repository where images, videos, and audio are stored and shared.*
  - **Step 2:** Retrieve the **name of the uploaded image**.
  - **Step 3:** Link the image name to the instrument's **“image” property (P18)**.



# 3. Interact with Wikidata: Create New Instruments

- **Expected result**

- Calling Wikidata API to create non-existing instruments to Wikidata.
- Design a user-friendly way to publish new instruments to Wikidata.
- The process is similar to “Add new names”.

# Challenges: Interacting with Wikidata

# Challenge 1: Make Edits to Wikidata

- Requires a Wikidata account of a specific type: **Auto-confirmed user** to publish content.
- **Solution**
  - Create a DDMAL account; Contributions made through UMIL will be published using this account.

**New users** [ edit ]

Any logged-in user may maintain a watchlist at [Special:Watchlist](#), and may email any other user (unless blocked from doing so) by using [Special:EmailUser](#). While they no longer have the editing rate limit, they must still answer a CAPTCHA prompt when adding new external links until they become autoconfirmed or confirmed.

**Autoconfirmed users** [ edit ]

An account with at least 4 days of age and at least 50 edits (90 days and 100 edits for editors from Tor nodes; abuse filter can potentially delay or revert automatic promotion) is said to be **autoconfirmed**. Any user account which does not meet these requirements can be granted the [confirmed](#) permission and receive the same permissions. Autoconfirmed users no longer need to respond to CAPTCHAs for most actions, [can edit semi-protected pages](#), and can move most pages (except items and properties, which are simply renamed by changing the appropriate labels instead).

# Challenge 2: Upload Images to Wikimedia

- Copyright issues for uploading images.
- **Solution**
  - Follow [Wikimedia's copyright policy](#) by asking users to complete a [questionnaire](#)
  - Review content before publishing
    - **Human review:** Conducted by the UMIL team
    - **Automatic check tools:** Further investigate existing mechanisms for checking/filtering inappropriate content



**Call for better solutions!**

# Other Challenges

1. **User-Friendliness** When Interacting with Wikidata
2. Ensuring **Accuracy** of Submitted Information
3. Encouraging Contributions in **Multiple Languages**  
(Especially Native Language for That Instrument)

# Summary: To-Do List

- Interaction with Wikidata (high priority)
  - Upload instrument names to Wikidata
  - Upload images to Wikidata
  - Create non-existing instruments to Wikidata
- Multi-language support (medium priority)
  - Re-design the website language and instrument language
- Frontend adjustment (low priority)
  - Make UMIL looks reasonable on mobile phones

# Thank you!

# Linked Music Data Lake



Yueqiao Zhang  
2025 May 7 Training Session

# Outline

**01**

Intro

---

**02**

Motivations & Goals

---

**03**

RDF

---

**04**

Supported Sources

---

**05**

Workflow & Methods

---

**06**

Future

---

# PROJECT *GOALS*

---

Music metadata lives in many silos. Our goal was to:

- Aggregate all of these into one place.
- Reconcile entities against a common vocabulary (Wikidata).
- Expose the result as RDF, so researchers and applications can query across collections seamlessly.

## 01 Siloed Metadata

- Different communities, different databases
  - Little or no cross-walk between them
- 

## 02 Heterogeneous Formats

- CSV, JSON-Lines, RDF, XML, proprietary dumps
  - Varying schemas for the same core concepts
- 

## 03 Divergent Identifiers

- Each source rolls its own IDs for works, performers, editions
  - No “global authority” to bind them together
-



# REPO Guide

<https://github.com/DDMAL/linkedmusic-datalake>

## **code**

Cantus DB

MusicBrainz

RISM

The Session

*Contains scripts used for fetching, converting, and some database-specific functions.*

## **data**

Cantus DB

MusicBrainz

RISM

The Session

Simssa DB

*Contains raw, converted, and reconciled dataset files. Some are not there, but will be created by the scripts.*

## **doc**

Cantus DB

MusicBrainz

RISM

The Session

Simssa DB

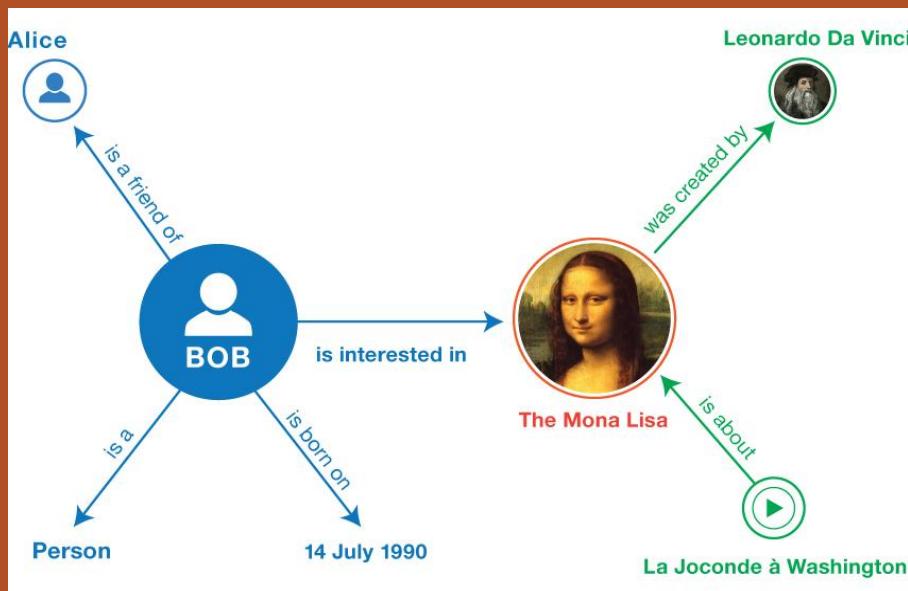
OpenRefine tips

etc...

*Contains documents for our past decisions, records, and work logs and operational manuals.*

# RDF

What is RDF?



## Resource Description Framework

Triple-based model: Subject → Predicate → Object

URIs as identifiers for things and relationships

Graph structure: Easily joins data across domains

Serialization formats: Turtle, RDF/XML, JSON-LD

```
<Bob> <is a> <person>.  
<Bob> <is a friend of> <Alice>.  
<Bob> <is born on> <the 4th of July 1990>.  
<Bob> <is interested in> <the Mona Lisa>.  
<the Mona Lisa> <was created by>  
    <Leonardo da Vinci>.  
<the video 'La Joconde à Washington'>  
    <is about> <the Mona Lisa>
```

# SUPPORTED SOURCES

A brief overview of the databases I went through for the past year

## Cantus DB

## MusicBrainz

## RISM

## The Session

## Simssa DB

A scholarly repository of Latin chant melodies drawn from medieval manuscripts and early printed books, provided in **CSV format** for easy integration and analysis.

An open music encyclopedia that curates extensive metadata on artists, releases, and recordings; its public **JSON-Lines** dumps are parsed into our data lake via **RDFLib**.

The Répertoire International des Sources Musicales is an international catalogue of historical musical sources—manuscripts, prints, and related documents—offered as **RDF** datasets for deep musicological research.

A community-driven archive of Irish traditional tunes, whose public **CSV** datasets we reconcile against Wikidata to link folk-music heritage across sources.

A discovery platform for symbolic music files (including MEI, Kern, MusicXML, and MIDI) evolved from the Digging into Data project, currently under active development.

# HOW IT WORKS

End-to-End Pipeline

## STEP 01 - Preprocessing

Fetch raw data dumps in various formats (RDF, JSONL, CSV) from each source.

## STEP 02 - Schema

Convert the database into RDF. Understand, extract the schema.

### TOOLS INVOLVED

→ Fetch python scripts

### TOOLS INVOLVED

→ Various conversion scripts  
→ OpenRefine RDF plugin

## STEP 03 - Reconcile

Reconcile RDF table rows against Wikidata using OpenRefine (plus an "archive" of manual fixes).

### TOOLS INVOLVED

→ OpenRefine Reconciliation  
→ Wikidata  
→ A LOT of Research

## STEP 04 - Transform

Transform reconciled raw RDF into RDF Turtle and load into our Virtuoso staging endpoint.

### TOOLS INVOLVED

→ RDF Transform Plugin  
→ OpenRefine  
→ Virtuoso Staging

# FETCHING & *PREPROCESSING*

See more detailed explanations for how to use scripts in the doc folder.

## STEP 01 - fetching

We fetch raw data from various sources, usually by python scripts.

### Example

The `fetch.py` script in MusicBrainz code folder retrieves the latest version data and downloads them.

## STEP 02 - converting

We parse the downloaded raw files into CSV or RDF by customized scripts.

### Example

MusicBrainz provides archived files. We unzip them and convert them into RDF.

## STEP 03 - extra works

For specific sources, we need some additional work.

### Example

MusicBrainz does not provide the full genre export. We need to retrieve it independently.

## STEP 04 - schema

In OpenRefine, we need to specify the schema of the RDF graph for the export in RDF.

### Example

RISM provides raw RDF that requires reconciliation. We can edit the RDF Transform in OpenRefine.

OpenRefine part 1 ttl Permalink

Facet / Filter Undo / Redo 1 / 1 Extract... Apply...

Filter 0. Create project 1. Save RDF Transform

17896 records

RDF Transform

The RDF template below specifies how the RDF data is generated from your tabular data. The cells in each record of your data will get placed into nodes within the transform. Configure the transform by using column names and values, computed strings, or specified IRI as a subject, property, and object resources or literals. Compute strings using GREL. See the docs.

Base IRI: http://127.0.0.1:3333/ Edit

Transform Preview

Available Namespaces: rdf rdfs owl xsd vcard foaf + Add Manage

\* R: subject > http://www.w3.org/#type > R: http://www.w3.org...syntax- Add property...  
Add type...  
\* > http://www.w3.org/#label > L: http://www.w3.org...df-schema#label Add object...  
\* > http://www.wikidata...rop/direct/P195 Add type...  
\* > http://www.wikidata...rop/direct/P361 Add type...  
\* > http://www.wikidata...prop/direct/P50 Add type...  
Add Root Node Import Template Export Template Save 1

2 OK Cancel

Extensions RDF Transform RDF Wikibase

first < previous 1 next > last »

http://www.w3.org/2000/01/rdf-schema#label http://www.wikidata.org/entity/17896  
n, Wolfenbüttel; Celle; ...@none  
https://rism.online/i/17896  
Manuscript copy; SK-BRm MUS XVIII

František (1786-1858)@none  
none

@en  
@en  
; Manuscript copy; E-SE 18/42@en

# ENTITY RECONCILIATION

**01****LOAD**

- Load into OpenRefine
- Configure Wikidata Reconciliation Service
- Customize Auto-Match properties

**02****AUTO MATCH**

- Transform cells (e.g. dates)
- Set Auto-Match thresholds
- Auto-Match results

**03****EDGE CASE**

- Resolve homonyms by context (e.g. names, birth/death dates)
- Split or merge entries for compound works

**04****REVIEW**

- Flag low confidence or no-match rows
- Edit or discard reconciliation judgements

**05****ARCHIVE**

- Keep decisions in /ArchiveForReconciledEntries folder for future reference and reducing manual works

# RDF EXPORT

After carefully reconciling entities...

---

## Re-Examine RDF Transform

We might add some rows after reconciliation. We re-examine the RDF Transform according to our updated RDF graph.

## RDF Export

We are now ready to export the RDF graph. The RDF Transform plugin also provides us with various RDF serialization format, which we can adapt to our purpose.

**Upload**

In many cases, we should repeat the entire procedure again on another dataset file for the same database, then we should merge all the exported RDF graph into a complete full graph (e.g. RISM).

## Repeating

In many cases, we should repeat the entire procedure again on another dataset file for the same database, then we should merge all the exported RDF graph into a complete full graph (e.g. RISM).

# ROADS AHEAD



## 01

Improving Reconciliation: leverage automated entity linking models to reduce manual work.

## 02

Updating and Importing New Sources: keep all the existing ones updated and add more archives in the future.

## 03

Public Endpoint: integrate the Natural Language Query to SPARQL and move from staging to production with documentation and examples.

## 04

Community Contributions: welcome pull requests for new mappings, scripts, and ontology extensions

# QUESTIONS?

# LinkedMusic

## Querying



Ichiro Fujinaga

Music Technology Area, Schulich School of Music  
McGill University

# Current Basic Process of Making LinkedMusic Data Lake

- ❖ Combine various data sources and dump them into our LinkedMusic Data Lake
- ❖ Use SPARQL and other search engines (e.g., Solr, ElasticSearch) for queries

# NLQ2SPARQL

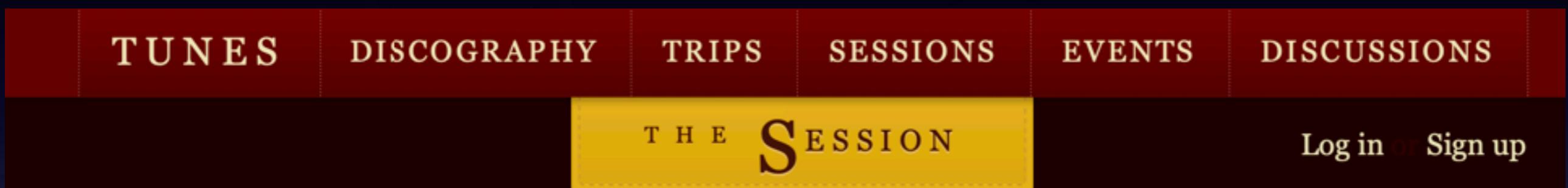
- ❖ Natural Language Query to SPARQL query conversion
- ❖ SPARQL: SPARQL Protocol and RDF Query Language

# Our Solution

1. Export the database to text files
2. Convert to RDF (Resource Description Framework / linked data)
3. Store as text files (archive)
4. Import into an RDF graph database
5. Query using natural languages with ChatGPT

# Example: Sessions Database

## Database of Traditional Irish Music sessions



Fáilte

Search  for

The Session is a community website dedicated to Irish traditional music.

You can **find tunes** to play, **find sessions** to play them in, and **join in discussions** about the music. You can also **find events** (like concerts and festivals), or **explore the track listings of recordings**.

You can contribute too. If you're already a member, you can **log in**. If you're not yet a member, membership is free and it only takes a moment to **sign up**.

You can also **install The Session app** on your phone or computer.

# 1. Export the database to text files

A sample of CSV file of events in Sessions Database

events_id	event	dtstart	dtend	venue	address	town	area	country
<a href="https://thesession.org/events/3310">https://thesession.org/events/3310</a>	-	1900-01-01 00:00:00	1900-01-01 00:00:00	-		Ober-Kainsbach	Hessen	Germany
<a href="https://thesession.org/events/11">https://thesession.org/events/11</a>	Colm Gannon, Sean McKeon And John Blake	2006-06-07 09:30:00	2006-06-07 12:00:00	The Goalpost	226 Water Street	Quincy	Massachusetts	USA
<a href="https://thesession.org/events/5">https://thesession.org/events/5</a>	Brid O'Donohue	2006-06-09 08:00:00	2006-06-09 00:00:00	Glór	Causeway Link	Ennis	Clare	Ireland
<a href="https://thesession.org/events/6">https://thesession.org/events/6</a>	National Celtic Festival	2006-06-09 19:00:00	2006-06-12 15:00:00	Various Venues		Portarlington	Victoria	Australia
<a href="https://thesession.org/events/7">https://thesession.org/events/7</a>	The Irish Connections Festival	2006-06-09 19:00:00	2006-06-11 00:00:00	Irish Cultural Centre	200 New Boston Drive	Canton	Massachusetts	USA
<a href="https://thesession.org/events/19">https://thesession.org/events/19</a>	Louisville Irish Fest	2006-06-10 11:00:00	2006-06-11 06:00:00	Belvedere/River Front Plaza		Louisville	Kentucky	USA
<a href="https://thesession.org/events/4">https://thesession.org/events/4</a>	élan Concert (feat Damien Mullane And Sam Proctor)	2006-06-10 20:00:00	2006-06-10 23:30:00	Irish Cultural Centre	5 Black's Road	Hammersmith	London	England
<a href="https://thesession.org/events/2">https://thesession.org/events/2</a>	Edel Fox And Rogan O'Flaherty	2006-06-10 21:30:00	2006-06-10	The Crosses Of Annagh		Miltown Malbay	Clare	Ireland

## 2. Convert to RDF (linked data)

Assign each item to an URI (Universal Resource Identifier)  
using OpenRefine and Wikidata

town	area	country
Ober-Kainsbach	Hessen	Germany



town	town_wiki	area	area_wiki	country	country_wiki
Ober-Kainsbach Choose new match	<a href="https://www.wikidata.org/wiki/Q2008827">https://www.wikidata.org/wiki/Q2008827</a>	Hesse Choose new match	<a href="https://www.wikidata.org/wiki/Q1199">https://www.wikidata.org/wiki/Q1199</a>	Germany Choose new match	<a href="https://www.wikidata.org/wiki/Q183">https://www.wikidata.org/wiki/Q183</a>

### 3. Store as **text files (archive)**

- ❖ Convert the CSV file with URI to flattened RDF (Resource Description Framework),  
e.g.:
  - ❖ Turtle
  - ❖ JSON-LD
  - ❖ N-Quads
- ❖ Also known as RDF serialization
- ❖ To be stored in a long-term archive

## 4. Import into an RDF graph database

We use an open-source software called Virtuoso



Other open-source examples include:



# 5. Query using natural languages (1)

Usually RDF database is queried using SPARQL (SPARQL Protocol and RDF Query Language)

The screenshot shows the SPARQL Query Editor interface. At the top, there is a navigation bar with links for 'SPARQL Query Editor', 'About', 'Tables', 'Conductor', 'Facet Browser', and 'Permalink'. Below the navigation bar, there is a section for 'Default Data Set Name (Graph IRI)' with an empty input field. Underneath this is a large 'Query Text' area with a blue border, containing a single vertical line character '|'. At the bottom of the interface, there is a 'Results Format' dropdown set to 'HTML', and two buttons: 'Execute Query' (in blue) and 'Reset'.

# 5. Query using natural languages (2)

Example query: “Find sessions that took place in Greece”

TUNES    DISCOGRAPHY    TRIPS    SESSIONS    EVENTS    DISCUSSIONS

## Sessions

Search for sessions on  in

### Searching for sessions in “Greece”

The map displays the Mediterranean Sea and surrounding landmasses. Two specific locations are highlighted with blue pins: one near the city of Athens in Greece and another near the city of Thessaloniki in Greece. The map also shows the coastlines of Italy, Sicily, and the Balkan Peninsula. Various cities and regions are labeled in multiple languages, reflecting the international nature of the sessions.

**1. The Lucky Sparrow Irish Pub**, Athens, Athens, Greece  
Added by [Athens Irish Festival](#) 9 months ago.

**2. The Dubliner**, Thessaloniki, Makedonia, Greece  
Added by [lukegarry](#) 3 years ago. Updated 2 months ago.

## 5. Query using natural languages (3)

Example query: “**Find sessions that took place in Greece**”

**Equivalent SPARQL code:**

```
PREFIX wd: <http://www.wikidata.org/entity/>
```

```
PREFIX wdt: <http://www.wikidata.org/prop/direct/>
```

```
SELECT ?session
WHERE {
    ?session rdf:type thesession:sessions .
    ?session wdt:P17 wd:Q41 .
}
```

**Comment:** P17 is the country property and Q41 is Greece in Wikidata

# 5. Query using natural languages (4)

## Inserting the SPARQL query in Virtuoso

SPARQL Query Editor    About    Tables ▾    Conductor    Facet Browser    Permalink

Default Data Set Name (Graph IRI)  
`http://sample/thesession/reconciled`

Extensions: cxml save to dav sponge User: SPARQL

Query Text

```
PREFIX wd: <http://www.wikidata.org/entity/>
PREFIX wdt: <http://www.wikidata.org/prop/direct/>

SELECT ?session
WHERE {
    ?session rdf:type thesession:sessions .
    ?session wdt:P17 wd:Q41 .
}
```

Results Format `HTML` ▾

**Execute Query** **Reset**

# 5. Query using natural languages (5)

Executing the SPARQL query in Virtuoso

SPARQL | HTML5 table

session

<https://thesession.org/sessions/7243>

<https://thesession.org/sessions/8020>

7243	The Dubliner	Katouni 16	Thessaloniki
8020	The Lucky Sparrow Irish Pub	Triptolemou 44	Athens

But we cannot ask general users to create SPARQL queries!

## 5. Query using natural languages (6)

ChatGPT to rescue!

I have an RDF database reconciled with Wikidata.

It contains  
country it \

Create a c }  
in Greece.

```
PREFIX wd: <http://www.wikidata.org/entity/>
PREFIX wdt: <http://www.wikidata.org/prop/direct/>

SELECT ?session
WHERE {
    ?session rdf:type thesession:sessions .
    ?session wdt:P17 wd:Q41 .
```

This prompt produces the correct SPARQL code!  
(most of the time)

# Demo 1

- ❖ Enter in ChatGPT:
- ❖ In my database reconciled with Wikidata, sessions are of type <https://thesession.org/sessions>, and the name of each session is stored in property P2561. Generate a complete SPARQL code to:  
Find all sessions that took place in Greece.
- ❖ ChatGPT
- ❖ Virtuoso

# Demo 1b

## Query in different languages

- ❖ Enter in ChatGPT:
- ❖ In my database reconciled with Wikidata, sessions are of type <https://thesession.org/sessions>, and the name of each session is stored in property P2561. Generate a complete SPARQL code to:  
找到喺希臘嘅演奏會  
("Find all sessions that took place in Greece").
- ❖ ChatGPT
- ❖ Virtuoso

# Demo 2 (1)

The screenshot shows a web browser window with the URL [thesession.org](https://thesession.org) in the address bar. The page has a dark header with a navigation bar containing links for Log in or Sign up, TUNES, DISCOGRAPHY, TRIPS, SESSIONS, EVENTS, and DISCUSSIONS. A yellow sidebar on the left is labeled "THE SESSION". The main content area is titled "Tunes" and features a search bar with the query "Search jigs in Dmajor for Malcolm". Below the search bar, the text "Searching jigs in Dmajor for ‘Malcolm’" is displayed. Two results are listed: 1. [Malcolm’s New Fiddle \(Jerry Holland’s\) JIG](#) and 2. [Malcolm Johnstone JIG](#).

Log in or Sign up    TUNES    DISCOGRAPHY    TRIPS    SESSIONS    EVENTS    DISCUSSIONS

THE SESSION

Tunes

Search jigs in Dmajor for Malcolm

SEARCH

THE SESSION

Searching jigs in Dmajor for “Malcolm”

1. [Malcolm’s New Fiddle \(Jerry Holland’s\) JIG](#)
2. [Malcolm Johnstone JIG](#)

# Demo 2 (2)

- ❖ Enter in ChatGPT:

Given an RDF database reconciled with Wikidata, and

...

```
wd:Q170412 rdf:type owl:Class ; rdfs:label "tune".
```

```
wdt:P136 rdfs:type owl:DatatypeProperty ; rdfs:label "genre".
```

```
wdt:P826 rdfs:type owl:DatatypeProperty ; rdfs:comment "This property is also used about the tonality of a tune etc".
```

```
wdt:P2561 rdfs:label "name".
```

...

Generate SPARQL for the following [Note: SPARQL be syntactically correct such as `filter[contains[lcase[str(?x)]]`]:

Find the tunes of genre “jig”, of “D major”, having “Malcolm” in its name.

- ❖ ChatGPT
- ❖ Virtuoso

# Demo 3

## Queries not available on TheSession

- ❖ Enter in ChatGPT:

Given an RDF database with properties(wdt:P2561) reconciled with Wikidata, and

...

<<https://thesession.org/sessions>> a owl:Class .

...

Generate complete and correct SPARQL for the following:

Find a session named “Hurley's Irish Pub”

- ❖ ChatGPT
- ❖ Virtuoso

## Demo 4

# Queries with TheSession and Wikidata

### ❖ Enter in ChatGPT:

Given an RDF graph <<http://sample/thesession/reconciled>>, the properties and classes of instances are reconciled with Wikidata as much as possible, so regarding SPARQL queries across different databases, we use `graph <...>` and `service <...>`. and Given:

```
@prefix thesession: <https://thesession.org/>. thesession:sessions a owl:Class.
```

```
wdt:P17 rdfs:domain <https://thesession.org/sessions>.
```

```
wdt:P2561 rdfs:domain <https://thesession.org/sessions>.
```

```
--for graph <http://sample/thesession/reconciled>
```

```
    wdt:P361 rdfs:domain <ex:country>. wd:Q27468 rdfs:label "Eastern Europe".
```

```
--for service <https://query.wikidata.org/sparql>
```

Make sure to generate a correct SPARQL for the following question (Note: Use the properties or classes as above primarily; traverse wikidata before local graph):

Which sessions took place in Eastern Europe?

### ❖ [ChatGPT](#)

### ❖ [Virtuoso](#)

# Conclusions

- ❖ By converting a database to an RDF graph database, we can search the database with natural language queries
- ❖ Because we use ChatGPT, we can make queries in many different natural languages: “找到喺希臘嘅演奏會”
- ❖ We can even make queries that were not possible with the original web interface
- ❖ Furthermore, because we reconciled with Wikidata, we can query with concepts that were not defined in the original database: “Find sessions in Eastern Europe”
- ❖ Because RDF graphs can be stored as text files, we can easily archive them for long-term preservations

# Future Directions

- ❖ We are improving our prompts so that ChatGPT makes fewer errors
  - ❖ Prompt Engineering
  - ❖ In-context Learning
- ❖ We can even ask ChatGPT to create a web interface with sorting capabilities in real time (e.g., Val Town)

# Acknowledgements



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sciences humaines du Canada

Canada



Schulich School of Music  
École de musique Schulich

DDMAL

DISTRIBUTED DIGITAL MUSIC  
ARCHIVES & LIBRARIES LAB



Centre for Interdisciplinary Research  
in Music Media and Technology

*Fonds  
de recherche*

Québec



Digital Research  
Alliance of Canada

Alliance de recherche  
numérique du Canada



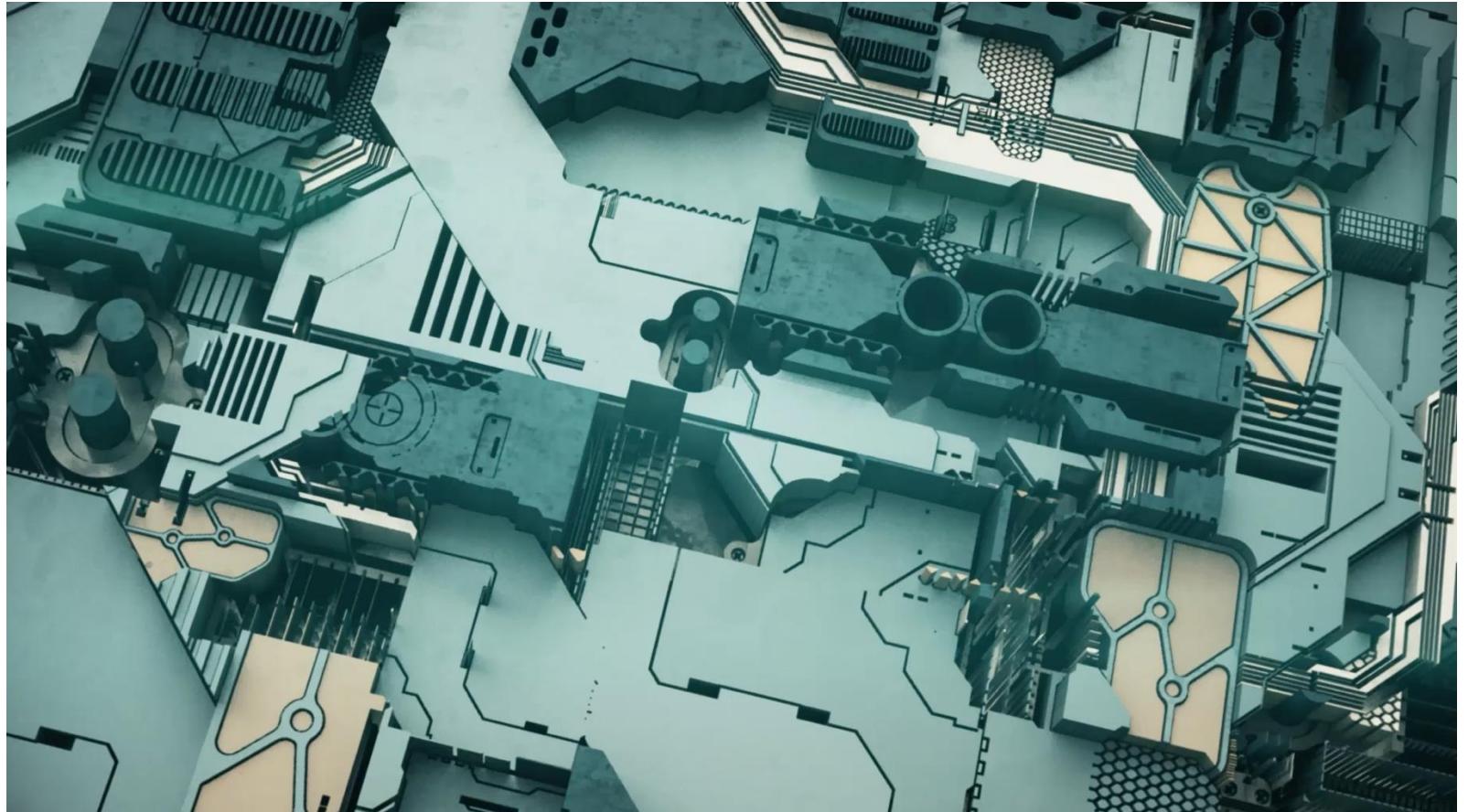
Calcul Québec

These slides were created with the assistants from ChatGPT, Claude, and Gemini.

# End-to-end OMR: what is it, and how do we do it?

DDMAL Training Week  
2025

Kyrie Bouressa

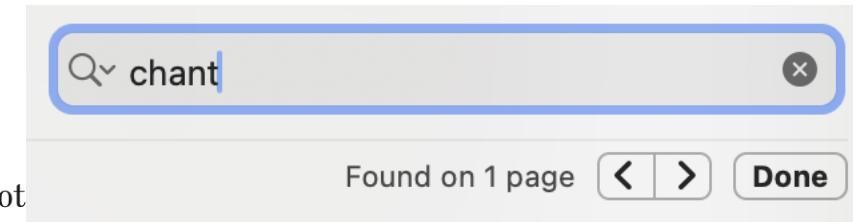


# Optical Music Recognition (OMR)

Optical Music Recognition (OMR) is the process of converting scanned images of pages of music into computer readable and manipulable symbols. We [DDMAL] focus on creating music recognition tools for libraries, archives and musicologists, and specialize in working with early music notation.

# Searching for letters, words, and phrases

- You're probably familiar with OCR (optical character recognition):
  - Allows for the searching of a word or a phrase in a digital document
- OCR relies on internal knowledge of type/script
  - “standard” OCR
  - Historical/handwritten
    - Requires training
    - Requires a LOT of samples



1968.  
LØW, *Liturgica Islandica* (Bibliot

inger, *A Comparative Study of Chant Melodies from Fragments of the lost Nidaros* 1999; Lori Kruckenberg and Andreas Haug, *The Sequences of Nidaros. A Nordic European Context*, Trondheim, 2006.

A screenshot of the Transkribus software interface. At the top, the word "Transkribus" is visible. Below it is a photograph of a handwritten manuscript page. The text on the page is written in cursive and includes the following lines:

Adress to dear Isabella on the  
Authors recovery  
Oh Isa pain did visit me  
I was at the last extremity  
How often did I think of you  
I wished your graceful form to view

To the right of the image, the same text is shown in a clean, modern font, representing the transcribed version of the handwritten lyrics. The word "Isabella" is underlined in green, indicating it was identified by the OCR process.

# Searching for notes, intervals, and phrases

- OMR allows us to search a piece of music for specific notes, intervals, phrases, or contours.
  - “How many times does a descending fall of a fourth happen in this piece?”
  - “How many times does this melody show up?”
  - “Where are these intervals?”
- OMR also relies on internal knowledge of type/script
  - “modern” OMR
  - Historical/handwritten OMR
    - Requires training
    - Requires a LOT of samples

ccba

Strict pitch sequence

Search

Clear

previous

Result 1 of 1479 for ccba

h mágna ópe-ra Dómi-ni

Full page

Show zone boxes

Edit zones

img/Baumann-Ludwig\_Mondnacht-am-Meer/01.jpg

# How do we get there?

- Meet *MEI*! A way we can encode *symbolic* musical notation to it can be represented and translated in the same (or another) symbolic format.
  - (*Yinan will talk more about this in a bit!*)
  - Music Encoding Initiative
  - Symbolic: represents a thing you need training to learn

```
</staffGrp>
</staffGrp>
</scoreDef>
<section xml:id="s1">
<pb xml:id="plndmm31" facs="#surface_01J46HF9ZHFCAXXRKM4J"
<measure xml:id="mx6ol8t" facs="#zone_01J46HF9ZJRHWGJ7WCN
<staff xml:id="m1s1" n="1">
<layer xml:id="m1s1l1" n="1">
<mRest xml:id="mh3e7dd"/>
</layer>
</staff>
<staff xml:id="m1s2" n="2">
<layer xml:id="m1s2l1" n="1">
<beam xml:id="b0aj44f">
<note xml:id="n1rjzmja" dur="8" facs="#zn58tx
<accid xml:id="aummy1r1" accid.ges="s"/>
</note>
<note xml:id="n1dnbrb8" dur="8" oct="4" pname=
<note xml:id="n5wq0db" dur="8" oct="4" pname=
<accid xml:id="ak9pbxx1" accid.ges="s"/>
</note>
</beam>
<note xml:id="nc35f0i" dur="4" oct="4" pname="e"
<note xml:id="n1yr73h0" dur="8" oct="3" pname="b
<note xml:id="ng791c8" dur="4" oct="4" pname="e"
<note xml:id="n1d6f7mf" dur="8" oct="4" pname="f
<accid xml:id="aa7jy6k2" accid.ges="s"/>
```

Drawback: manually  
doing this is a pain

# Machine Learning and OMR

Seeking to train models to recognize music, staves, and text:

automate the image → digital transcription pipeline

The image shows a page from a medieval manuscript. At the top, there is a decorative initial letter. Below it, a red horizontal bar spans across the page with the text "Music Layer" written on it. The page contains five staves of musical notation, each with a treble clef. Below the staves, there is a line of Latin text written in a Gothic script. The text is as follows:

As- pi- ci- ens a lon- ge ec- ce vi- de o de- i  
po- ten- ti- am ve- ni- en- tem et ne- bu- lam to- tam ter- ram te-  
gen- tem I- te ob- vi- am e- i et di- ci-  
te Nunc- a no- bis si tu es ip- se Qui reg- na-  
tu- rus es in po- pu- lo is- rael

# SIMSSA and the *Liber Usualis*

*How can we search for:*

- Specific notes
- Strict pitch sequences
- Transposed pitch sequences
- Contour
- Intervals
- Text?

Search the Liber Usualis

What is this? Find out more about what we are trying to do.

Neumes

Strict pitch sequence

Transposed pitch sequence

Contour

Intervals

Text

Search | Clear | Go to page | Go | Current page: 26 of 2340

previous | next

**xxvj.** Rules for Interpretation.

Example:

Kyrie VII

Ký- ri- e e- lé- i- son.  
Ký- ri- e e- lé- i- son.

which must be rendered in this way:

no breath      breath  
Ký- ri- e e- lé- i- son.

4. Finally the close of a whole period is marked either by a full bar, or by a double bar at the end of the piece, or at the end of an important division of the piece. Here breath must be taken and a longer pause made. In the modern notation this pause is indicated by a quaver rest which is placed before or after the bar line, in accordance with the rhythm of the phrase following.

In pieces normally sung by alternating choirs (as in the *Kyrie*, *Gloria*, *Credo* etc), the double bar indicates a change of Choir. In such cases the pause will vary according to its importance in the melody and the text.

5. *The Comma* allows only a rapid breath without break in the movement, hence during the value of the preceding note:

6. Though breath need not necessarily be taken at every bar-line, yet, on the other hand, in the more elaborate pieces (graduals, alleluia, offertories) it is sometimes necessary and indeed excellent to breathe between the bars marked in the book. It is impossible to give minute rules for doing this correctly. All that need be said here is that breath must be taken in such cases a) without

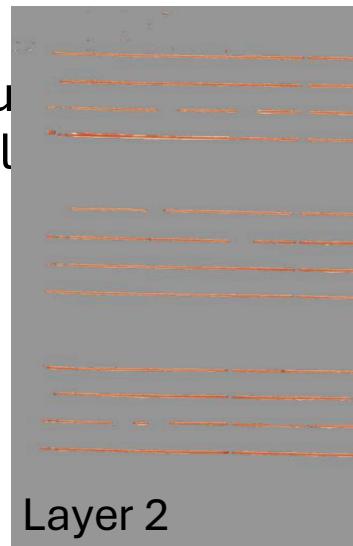
Hosted by the Distributed Digital Music Archives & Libraries Lab of McGill University. Contact us with questions or comments



# Rodan Phase 1

- Input an image
- Annotate sections of the image

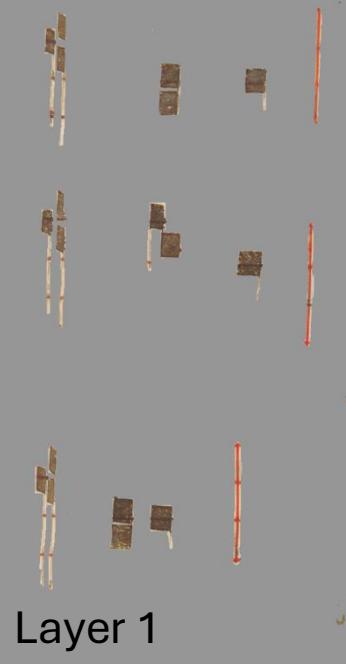
- Teach the machine: a student needs a lot of examples!
- I'll talk about depth shortly



Layer 2



Layer 3



Layer 1

patri et filio et spiritui  
Alle. sus uenit ex te obuiam a.  
regnans regnat do  
minus mundo factus co  
minus carnis perma te  
riam quā traxit de uirgi

MS73 fol.63

## Music Layer



## Rock

- Train a model to identify images

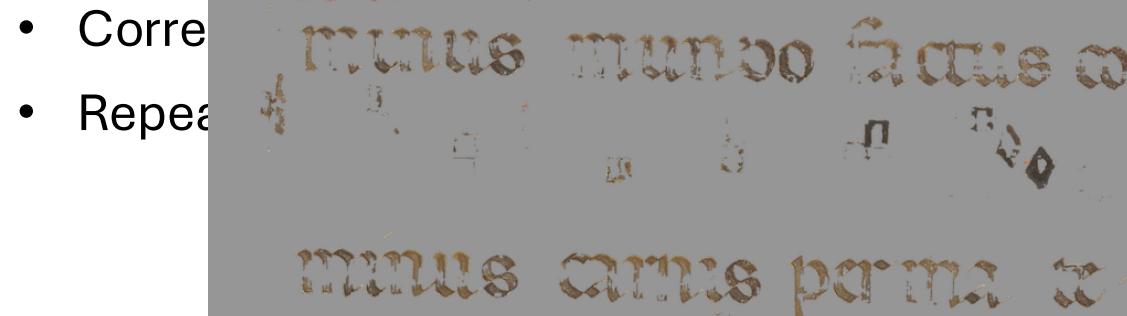
- The Staff Layer



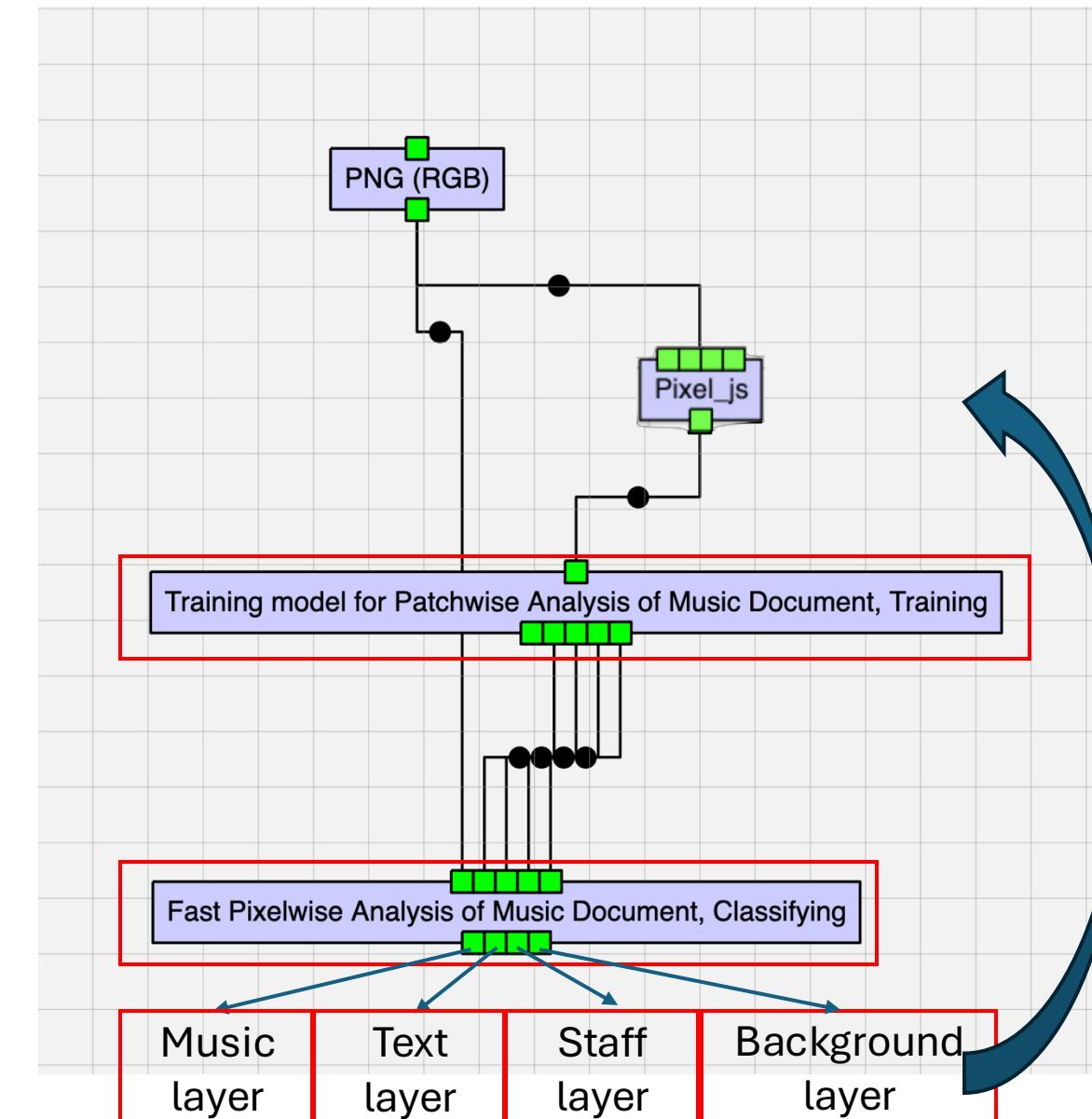
- Classify text layers tries to

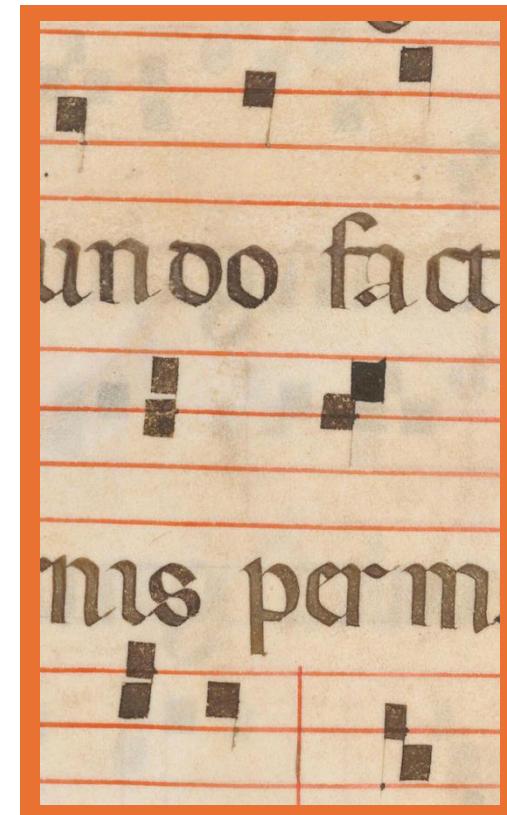
## Text

## Text Layer

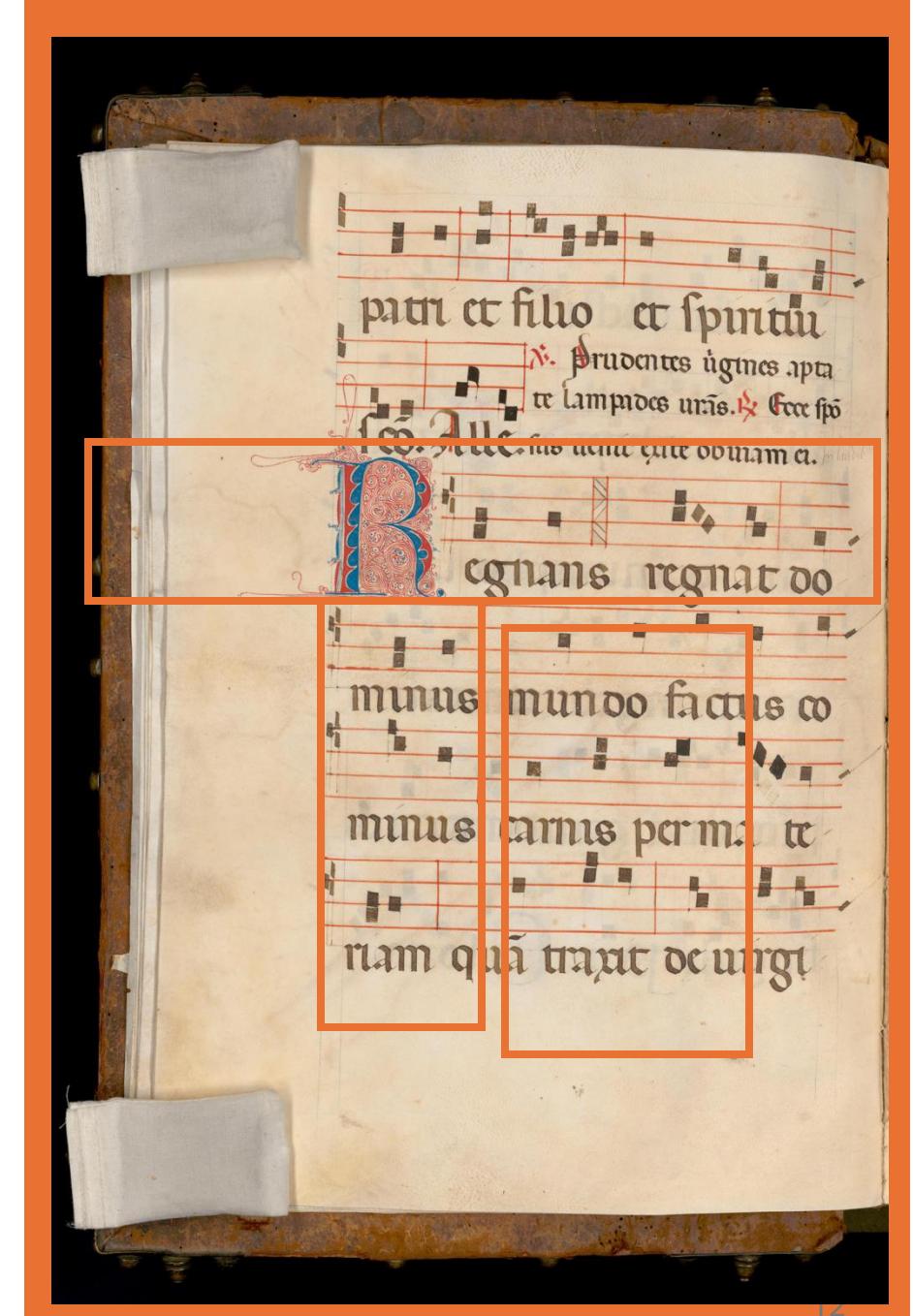


- Correct
- Repeat

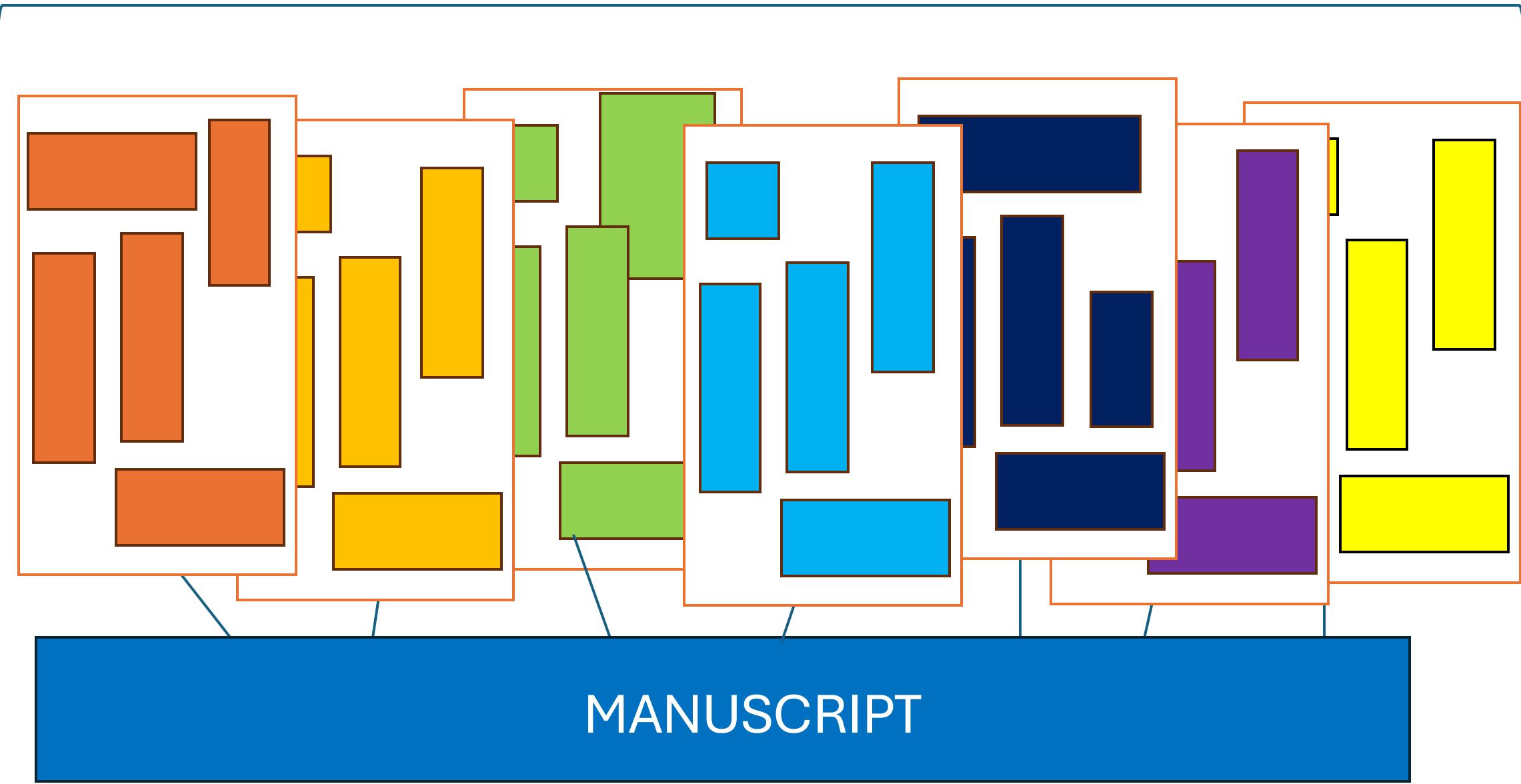




MS73 fol. 63



# “Whole” Model



# Phase 2: Note-level Classifying

Stage 1: Interactive (Manual) Classifying

Music layers can now be separated from text and staff—now what?

- Learning types of neumes
- Recognizing different versions of the same neumes, clefs, custodes

We do this manually to train the classifier, until it begins sorting neumes accurately.

Gen will talk about this more in a bit!



neume.virga  
neume.podatus2b  
neume.clivis  
clef.c

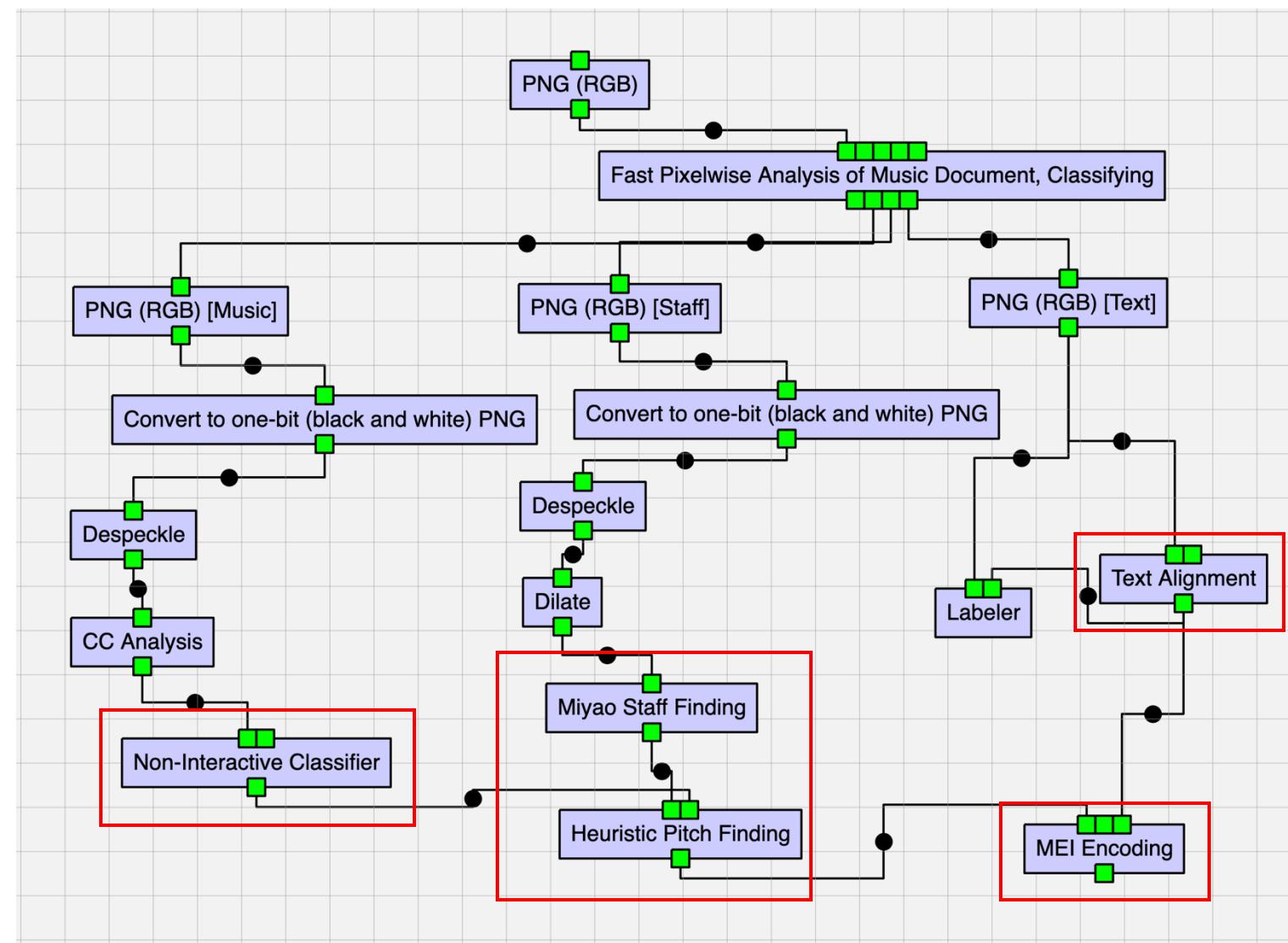
*Etc.*

# Phase 2: Note-level Classifying

## Stage 2: Non-Interactive (automatic) Classifying

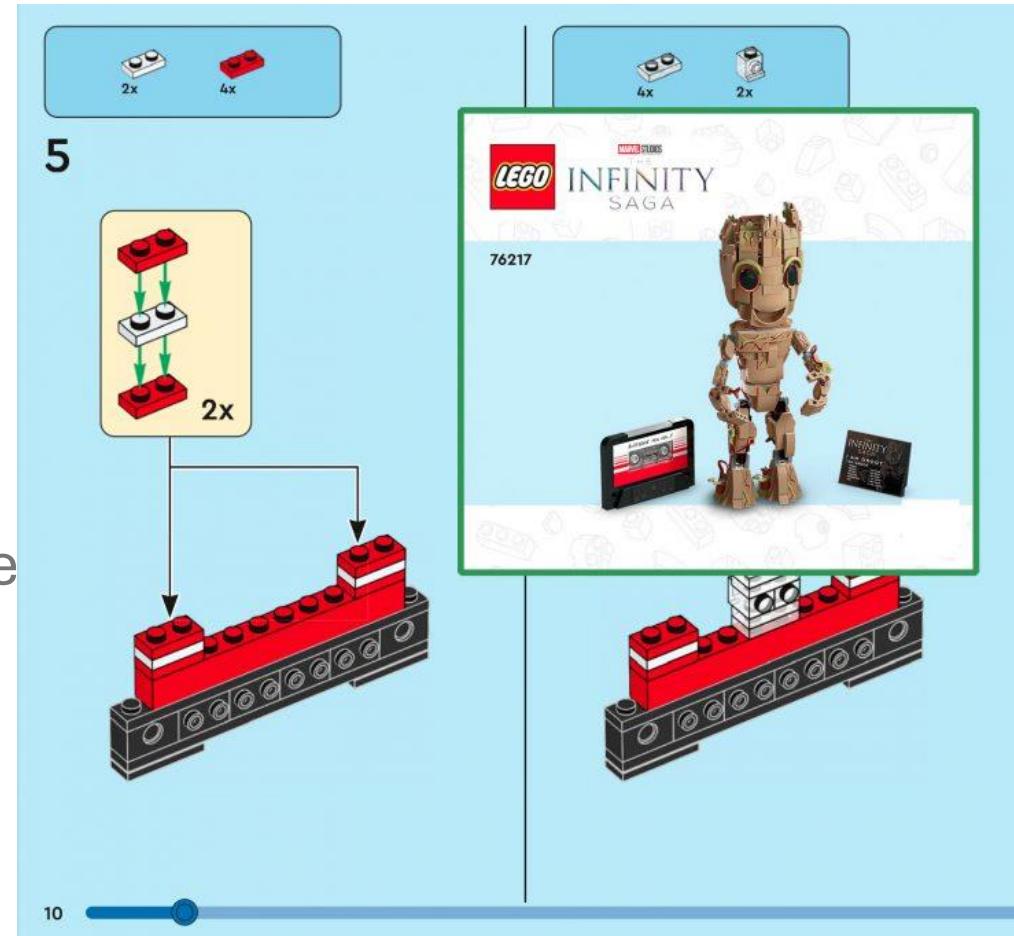
Rodan can now sort neume types even if they look a little different from one another

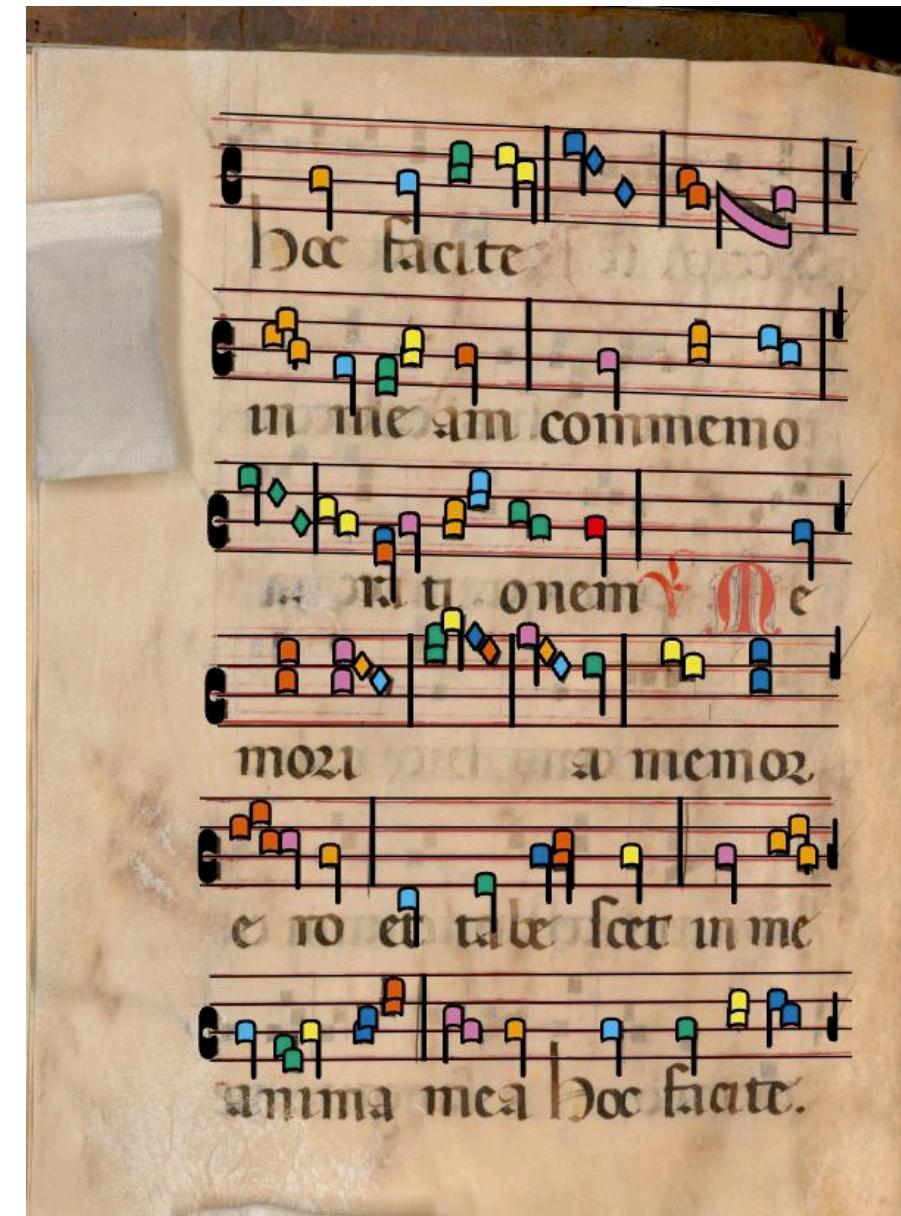
- Neumes are identified in an MEI format
  - Neume.virga
- Staff layer gets analysed
- Text transcript is applied to the text layer
- An MEI file is produced



# Remember: MEI is an instruction manual!

Machine readable language to symbolic representation





Okay, it's encoded  
and corrected—now  
what?

# Cantus Ultimus

## Welcome to Cantus Ultimus

The main objective of this research is to incorporate the latest optical music recognition (OMR) technologies with plainchant manuscripts in order to transform the existing [CANTUS](#) database into a state-of-the-art research environment in which both music and text are fully searchable.

You can view currently available manuscripts on the [Manuscripts page](#).

This research is part of the [SIMSSA project](#).

For more information, please contact [Ichiro Fujinaga](#).

## SIMSSA | Single Interface for Music Score Searching and Analysis



Social Sciences and Humanities  
Research Council of Canada

Conseil de recherches en  
sciences humaines du Canada



McGill



Schulich School of Music  
École de musique Schulich

DDMAL

DISTRIBUTED DIGITAL MUSIC  
ARCHIVES & LIBRARIES LAB



Centre for Interdisciplinary Research  
in Music Media and Technology

Fonds de recherche  
Société et culture

Québec





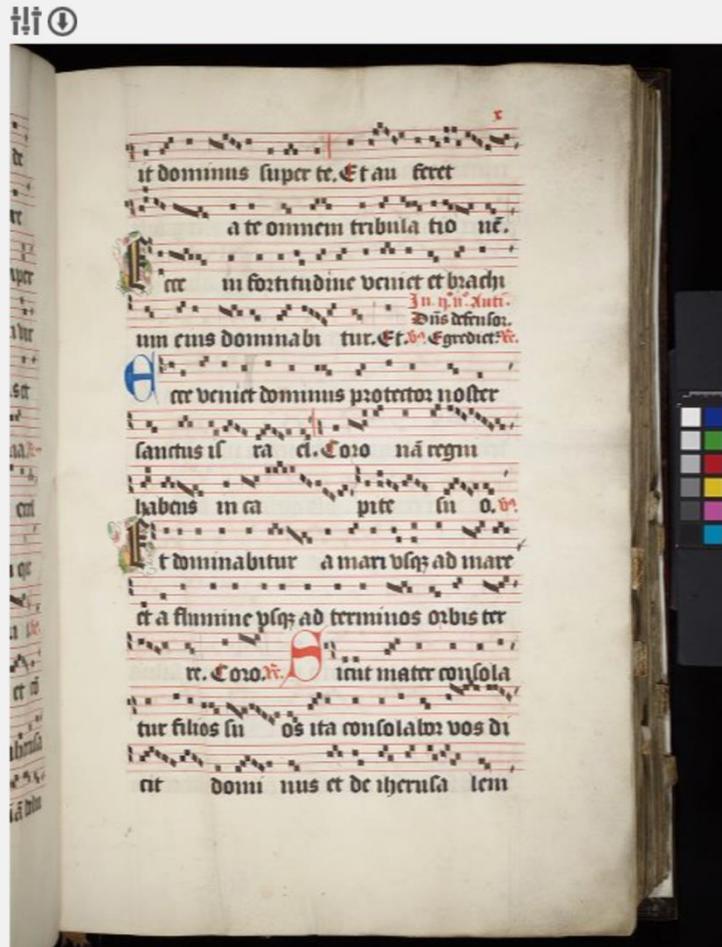
Zoom level: 1.00

Folio 010r (27 of 497)

Go



Manuscript info



Go to first chant

Previous Folio

Next Folio

Folio 010r

Search Manuscript

## Chants

Ecce in fortitudine veniet et

**Cantus ID:** 006290b ([Visit record in Cantus Database](#))**Sequence:** 1**Feast:** Dom. 2 Adventus**Office:** Matins**Genre:** Responsory verse**Mode:** 1

## Full Text

Ecce in fortitudine veniet et bracchium ejus dominabitur

Ec- ce in for- ti- tu- di- ne ve- ni- et et bra- chи- um e- ius do- mi- na-  
bi- tur Et

**Play Audio** **Stop Audio**

Dominus defensor

013v

Dicite pusillanimes  
confortamini ecce dominus

1

Fer. 6 Hebd. 2  
Antiphon  
Adv.Second  
Vespers

Bringing it back—Getting Started

Input Port: Image x

**Available Resources**

TABLE FILTERS

**Creator**

**Created** mm / dd / yyyy , -- :-- :--

**Name**

**Uploaded or generated:**

Uploaded

**Name** **Create**

Salzinnes_012r	kyrieb
Salzinnes_131v	kyrieb

05 16:42:43

rgb+pn

α

```
graph TD; A[PNG (RGB)] --> B[Pixel_js]; B --> C["Training model for Patchwise Analysis of Music Document, Training"]; C --> D["Fast Pixelwise Analysis of Music Document, Classifying"]
```

**Training model for Patchwise Analysis of Music Document, Training**

**Fast Pixelwise Analysis of Music Document, Classifying**

document, Training

sifying

**Edit Name/Description**

**Add Job**

**Import Workflow**

**Clear Assigned Resources**

**Run**

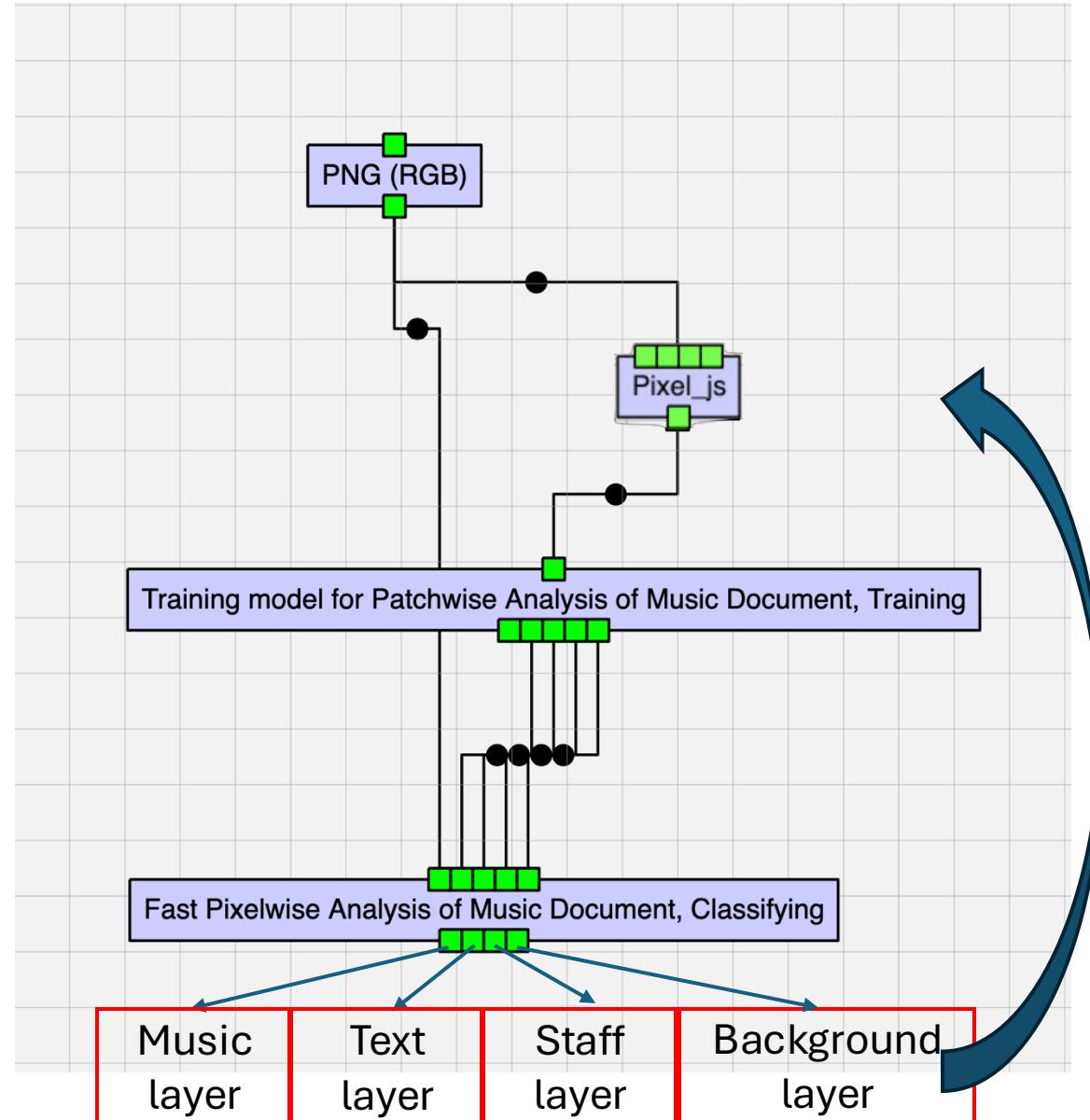
rodan2.simssa.ca

Submission successful! Click OK to exit Pixel.js.

OK

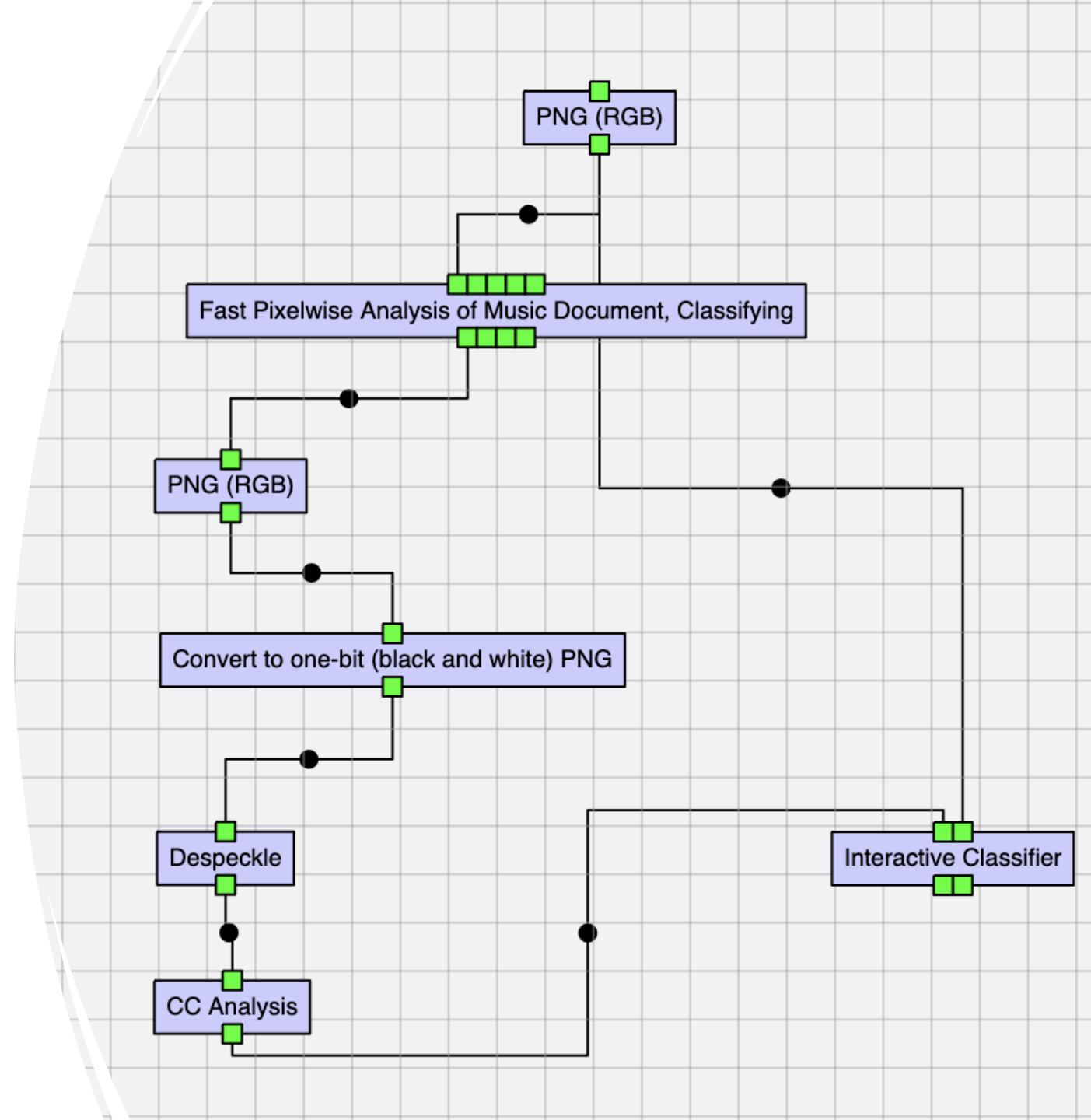
# Phase 2: Train, Classify, Correct

- Pixel sample used as training input
- Models used to separate image into four layers
- Input those layers into pixel and correct them
- Change images per iteration as needed; want models to generalize!

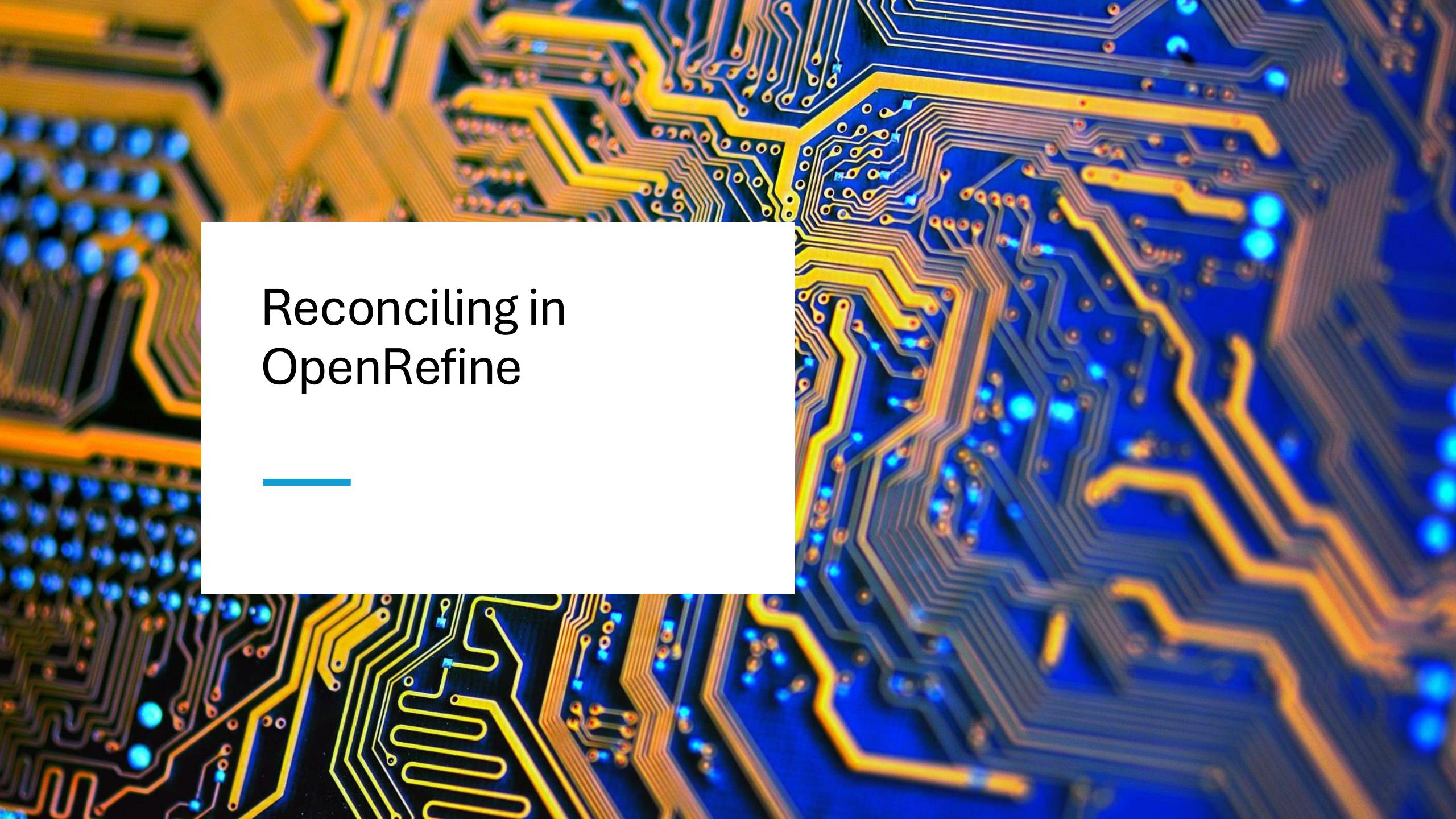


# Phase 2: Into the IC

- Input image
- Assign best models
- Begin training for individual neume recognition
- Gen!



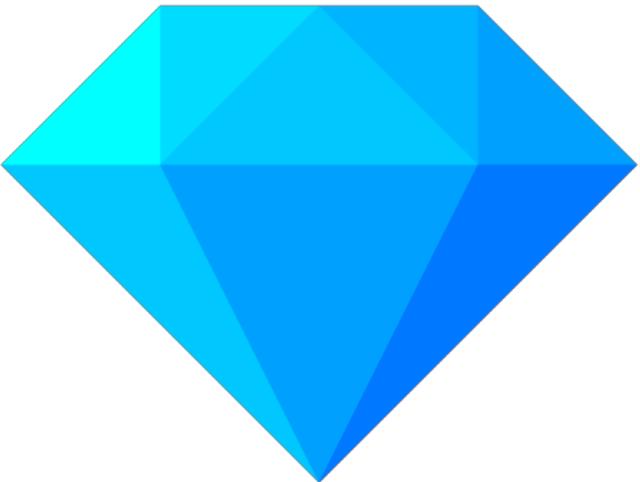




# Reconciling in OpenRefine

---

# What is OpenRefine?

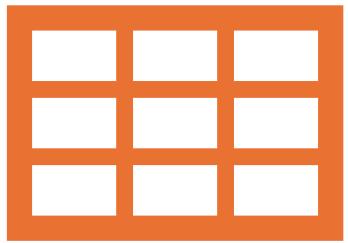


## **OpenRefine**

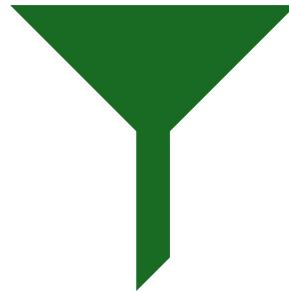
OpenRefine is a powerful free, open source tool for working with messy data: cleaning it; transforming it from one format into another; and extending it with web services and external data.

Our goal is to empower everyone to meaningfully engage with data by providing an accessible open source tool and nurturing a diverse, supportive community.

# What is Reconciliation?



**Reconciliation** in OpenRefine is the process of matching plain text data in your dataset to unique identifiers (like Wikidata Q-codes).



This allows for: **enriched, linked data** that can be used for research, visualization, or further transformation.

# Getting started: what you'll need

---

A dataset with  
names, places, or  
entities to reconcile

OpenRefine  
installed (free!)

Internet access

A CSV file,  
usually

Wikidata  
reconciliation  
utilizes a web  
API

# Big concept takeaways

Reconcile

Facet

Cluster

# Step 1: Into OpenRefine

- Upload dataset to OpenRefine
- Click “create project” -> Upload CSV (or TSV, Excel, etc.!)
- Review preview, hit “create”

*Sample dataset:*

**Person**

Johann Sebastian Bach

Marie Curie

Plato

**Role**

Composer

Scientist

Philosopher



A power tool for working with messy data.

Create project

Open project

Import project

Language settings

Extensions

« start over Configure parsing options

Project name OpenRefine Sample 1.xlsx

Tags

Create project »

Person	Profession
1. Johann Sebastian Bach	Composer
2. Marie Curie	Chemist
3. Plato	Philosopher



### Parse data as

Update preview

Disable auto  
preview

#### Excel files

JSON files

Line-based text files

CSV / TSV / separator-based files

Fixed-width field text files

PC-Axis text files

MARC files

JSON-LD files

RDF/N3 files

ODS/ODSXL files

#### Worksheets to Import

Select all Deselect all

OpenRefine Sample 1.xlsx#Sheet1

4 rows

Ignore first

0  line(s) at beginning of file

Parse next

1  line(s) as column headers

Discard initial

0  row(s) of data

Load at most

0  row(s) of data

Store blank rows

Store blank columns

Store blank cells as nulls

Store file source

Store archive file

Import all cells as text



Version 3.9.3 [TRUNK]

Preferences

Help

About

# 3 rows

Show as: **rows** records

Show: 5 10 25 50 100 500 1000 rows

Open... Export Help

Extensions Wikibase

it < previous 1 ▲ -3 next > last »

All	Person	Profession
1.	Facet ►	Composer
2.	Text filter	Chemist
3.	Edit cells ►	Philosopher

1. Facet ►

2. Text filter

3. Edit cells ►

Edit column ►

Transpose ►

Sort...

View ►

Reconcile ►

## Reconcile column Person

Reconcile each cell to an entity of one of these types:

- human  
Q5
- impact crater  
Q55818
- charitable organization  
Q708676
- television film  
Q506240
- comic strip  
Q838795
- asteroid  
Q3863
- entity  
Q35120

Also use relevant details from other columns:

Column As property

Profession

Reconcile against type:

Reconcile against no particular type

Auto-match candidates with high confidence

Maximum number of candidates to return

Back

Start reconciling...

Cancel

## 3 rows

Show as: **rows** records

Show: 5 10 25 50 100 500 1000 rows

	All	Person	Profession
1.	Johann Sebastian Bach	<input type="button" value="edit"/> Composer	
	<input checked="" type="checkbox"/> Johann Sebastian Bach (100)		
	<input checked="" type="checkbox"/> Johann Sebastian Bach (100)		
	<input checked="" type="checkbox"/> Johann Sebastian Bach discography (78)		
	<input checked="" type="checkbox"/> Create new item		
	Search for match		
2.	Marie Curie		
	Choose new match		
3.	Plato		
	<input checked="" type="checkbox"/> Plato (100)		
	<input checked="" type="checkbox"/> Plato the Comic (100)		
	<input checked="" type="checkbox"/> Plato (100)		
	<input checked="" type="checkbox"/> Create new item		
	See more   Search for match		

Match this cell

Match all identical cells

Cancel



Johann Sebastian Bach (Q638391)

German painter, grandson of the composer

## 3 rows

Show as: **rows** records

Show: 5 10 25 50 100 500 1000 rows

All	Person	Profession
	1. <a href="#">Johann Sebastian Bach</a> <a href="#">Choose new match</a>	Composer
	2. <a href="#">Marie Curie</a> <a href="#">Choose new match</a>	Chemist
	3. <a href="#">Plato</a> <a href="#">Choose new match</a>	Philosopher

# Nov

- Onc
- Wiki
- T
- W
- B
- fo

# date"

Add columns from reconciled column Person

Add property Preview Reset

Person	occupation <a href="#">remove</a> <a href="#">configure</a>	place of birth <a href="#">remove</a> <a href="#">configure</a>
Johann Sebastian Bach	composer organist harpsichordist violinist conductor choir director concertmaster musicologist music educator virtuoso school teacher	Eisenach
Marie Curie	physicist chemist university teacher	Warsaw
Plato	philosopher epigrammatist poet writer	Athens

Suggested properties

- [award received](#)
- [child](#)
- [country of citizenship](#)
- [educated at](#)
- [employer](#)
- [ethnic group](#)
- [father](#)
- [field of work](#)
- [image](#)
- [member of political party](#)
- [mother](#)
- [native language](#)
- [occupation](#)
- [place of birth](#)
- [place of burial](#)

OK Cancel

## 19 rows

Show as: [rows](#) [records](#)Show: [5](#) [10](#) [25](#) [50](#) [100](#) [500](#) [1000](#) rows

<a href="#">▼ All</a>	<a href="#">▼ Person</a>	<a href="#">▼ occupation</a>	<a href="#">▼ place of birth</a>	<a href="#">▼ date of birth</a>	<a href="#">▼ Profession</a>
		1. Johann Sebastian Bach Choose new match	composer Choose new match	Eisenach Choose new match	1685-03-21T00:00:00Z Composer
		2.	organist Choose new match		
		3.	harpsichordist Choose new match		
		4.	violinist Choose new match		
		5.	conductor Choose new match		
		6.	choir director Choose new match		
		7.	concertmaster Choose new match		
		8.	musicologist Choose new match		
		9.	music educator Choose new match		
		10.	virtuoso Choose new match		
		11.	school teacher Choose new match		
		12. Marie Curie Choose new match	physicist Choose new match	Warsaw Choose new match	1867-11-07T00:00:00Z Chemist
		13.	chemist Choose new match		
		14.	university teacher Choose new match		
		15. Plato Choose new match	philosopher Choose new match	Athens Choose new match	0428-01-01T00:00:00Z Philosopher
		16.	epigrammatist Choose new match		
		17.	poet Choose new match		
		18.	writer Choose new match		
		19.	philosopher of law Choose new match		

# Common Issues

---

Multiple spellings or names for one item/person/entity

**6 rows**

Show as: **rows** records      Show: 5 10 25 50 100 500 1000 rows

All	Location Name	Notes
☆ ❌	1. Reykjavik	Standard spelling
☆ ❌	2. Reykyavik	Common typo
☆ ❌	3. New York City	Official name
☆ ❌	4. NYC	Common abbreviation
☆ ❌	5. München	Native German spelling
☆ ❌	6. Munich	Anglicized spelling

- Select type: `human settlement (Q486972)`
  - OR! Leave blank for broader matches
- Start reconciliation
  - Match correct items

**6 rows**

Show as: **rows** records Show: 5 10 25 50 100 500 1000 rows

All	Location Name	Notes
☆ ❌	1. Reykjavík <input checked="" type="checkbox"/> Reykjavík (100) <input checked="" type="checkbox"/> Reykjavík (100) <input checked="" type="checkbox"/> Create new item <a href="#">Search for match</a>	Standard spelling
☆ ❌	2. Reykjavík <a href="#">Choose new match</a>	Common typo
☆ ❌	3. New York City <a href="#">Choose new match</a>	Official name
☆ ❌	4. New York City <a href="#">Choose new match</a>	Common abbreviation
☆ ❌	5. München <input checked="" type="checkbox"/> Munich (100) <input checked="" type="checkbox"/> München (100) <input checked="" type="checkbox"/> München (100) <input checked="" type="checkbox"/> Create new item <a href="#">See more</a>   <a href="#">Search for match</a>	Native German spelling
☆ ❌	6. Munich <input checked="" type="checkbox"/> Munich (100) <input checked="" type="checkbox"/> Munich (100) <input checked="" type="checkbox"/> Munich (100) <input checked="" type="checkbox"/> Create new item <a href="#">See more</a>   <a href="#">Search for match</a>	Anglicized spelling

## Add column based on column Location Name

New column name

On error  set to blank  store error  copy value from original column

Expression

Language

General Refine Expression Language (GREL) ▾

`cell.recon.match.id`

No syntax error.

OpenRefine uses this;  
GPT etc. are quite good with it

Preview

History

Starred

Help

row	value	cell.recon.match.id
1.	Reykjavik	Q1764
2.	Rekyavik	Q1764
3.	New York City	Q60
4.	NYC	Q60
5.	München	Q1958863
6.	Munich	Q1726

OK

Cancel

## 6 rows

Show as: **rows** records

Show: 5 10 25 50 100 500 1000 rows

<input type="checkbox"/> All	<input type="checkbox"/> Location Name	<input type="checkbox"/> Wikidata Q-ID	<input type="checkbox"/> country	<input type="checkbox"/> Notes
		1. <a href="#">Reykjavík</a> Choose new match	Q1764	Iceland Choose new match
		2. <a href="#">Reykjavík</a> Choose new match	Q1764	Iceland Choose new match
		3. <a href="#">New York City</a> Choose new match	Q60	United States Choose new match
		4. <a href="#">New York City</a> Choose new match	Q60	United States Choose new match
		5. <a href="#">München</a> Choose new match	Q1726	Germany Choose new match
		6. <a href="#">Munich</a> Choose new match	Q1726	Germany Choose new match

# Duplicate entries

- Cool, everything shows as it should and will group where it needs to go, but there are still duplicates—now what?
  - Can do this from either the corrected column, or from the “country” column
- You can do this by row or by table
  - I like to play it safe and add a “safety column” like the Q-ids to check my work before I bulk merge duplicates in an entire table

# 6 rows

## OpenRefine OpenRefine Sample 1.xlsx Permalink

Facet / Filter    Undo / Redo 15 / 15

Refresh    Reset all    Remove all

**Wikidata Q-ID** change  
3 choices Sort by: name count Cluster

	All	Location Name	Wikidata Q-ID	country	Notes
1.	Reykjavík	Q1764	Iceland	Standard spelling	
2.	Reykjavík	Q1764	Iceland	Common typo	
3.	New York City	Q60	United States	Official name	
4.	New York City	Q60	United States	Common abbreviation	
5.	München	Q1726	Germany	Native German spelling	
6.	Munich	Q1726	Germany	Anglicized spelling	

Reconcile

Facet / Filter   Undo / Redo 15 / 15   [!\[\]\(a2b1844a63be28a9aeead76312d2ed5f\_img.jpg\)](#) **2 matching rows** (6 total)

[Refresh](#)

 Wikidata  
3 choices Sort by

Q1726 2  
Q1764 2  
Q60 2  
Facet by choice

**Remove duplicate rows**

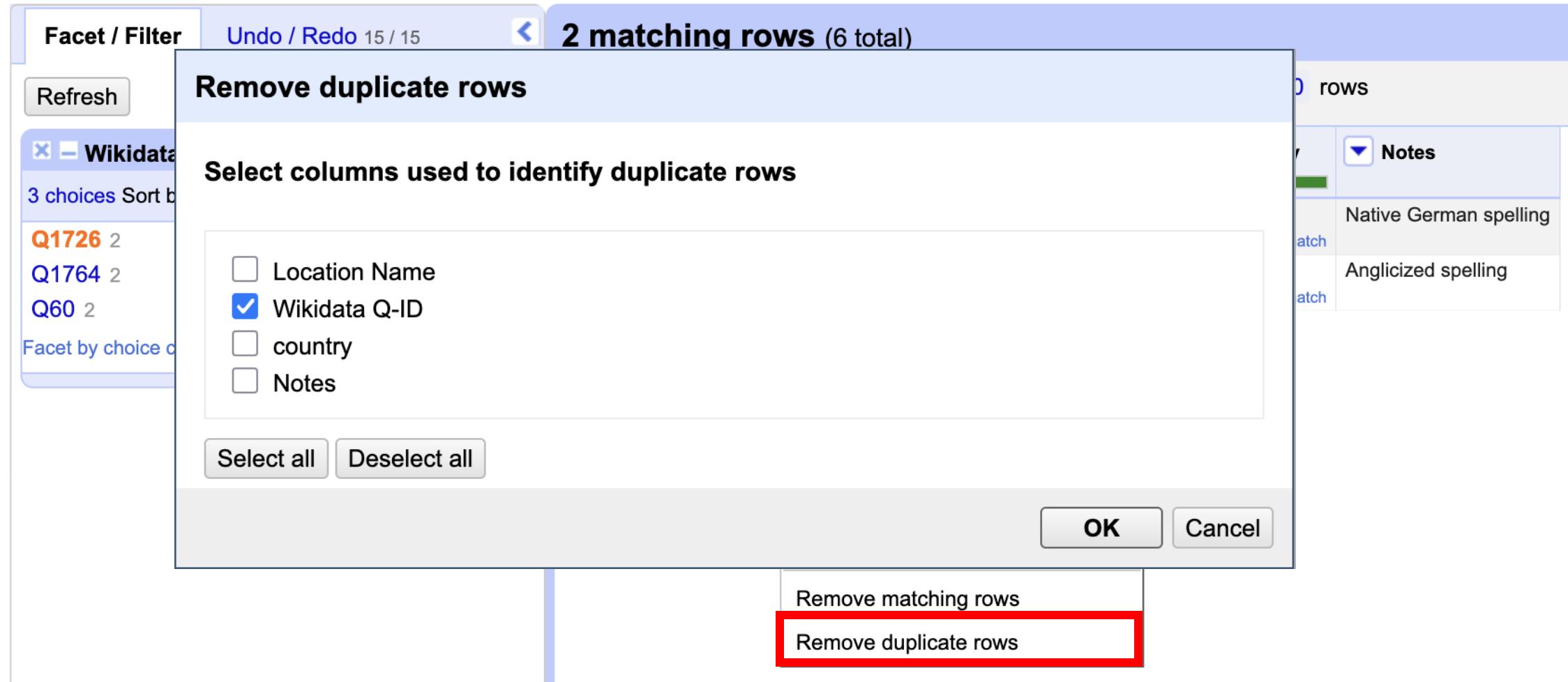
Select columns used to identify duplicate rows

Location Name  
 Wikidata Q-ID  
 country  
 Notes

[Select all](#) [Deselect all](#)

[OK](#) [Cancel](#)

[Remove matching rows](#)  
**Remove duplicate rows**



## 3 rows

Show as: **rows** records

Show: 5 10 25 50 100 500 1000 rows

<input type="checkbox"/> All	<input type="checkbox"/> Location Name	<input type="checkbox"/> Wikidata Q-ID	<input type="checkbox"/> country	<input type="checkbox"/> Notes
		1. <a href="#">Reykjavík</a> Choose new match	Q1764	Iceland Choose new match
		2. <a href="#">New York City</a> Choose new match	Q60	United States Choose new match
		3. <a href="#">München</a> Choose new match	Q1726	Germany Choose new match

# Fuzzy Matching with Clustering in OpenRefine

- Go to the column you want to clean
  - E.g., “Location name”
- Click column drop-down
  - Edit cells
  - Cluster and edit
- Suggested clusters
  - Choose your clustering method

## ***Keying Function***

fingerprint

metaphone3

n-gram-fingerprint

## ***Distance Function***

levenshtein

levenshtein

levenshtein or PPM

## ***Use Case***

Good for basic typos

Good for phonetic variants

Good for messy text / OCR errors

## Cluster and edit column "City"

Find groups of different cell values that might be other representations of the same thing. For example, "New York" and "new york" likely refer to the same concept and just differ by capitalization.

### Cluster and edit column "City"

Find groups of different cell values that might be other representations of the same thing. For example, "New York" and "new york" likely refer to the same concept and just differ by capitalization, and "Gödel" and "Godel" probably refer to the same person. [Find out more...](#)

Method Key collision  
 Auto-update

Merge? Values in cluster

Method Key collision

Auto-update

Keying function Metaphone3

Manage clustering fuctions

3 clusters found

Merge?	Values in cluster	New cell value	Cluster size	Row count	# Rows in cluster
<input type="checkbox"/>	<input type="checkbox"/> Texas (2 rows) <input type="checkbox"/> teksas	Texas	2	3	 <p>2 — 3</p>
<input type="checkbox"/>	<input type="checkbox"/> Reykavik <input type="checkbox"/> Reykyavik	Reykavik	2	2	 <p>Average length of choices 5.5 — 8.5</p>
<input type="checkbox"/>	<input type="checkbox"/> London (2 rows) <input type="checkbox"/> Lindon	London	2	3	 <p>Length variance of choices 0 — 0.5</p>

14 rows

Show as: rows records Show: 5 10

	All	City
1.	Reykjavík	Choose new match
2.	Reykjavík	Choose new match
3.	Reykjavík	Choose new match
4.	Reykjavík	Choose new match
5.	Reykjavík	Choose new match
6.	Reykjavík	Choose new match
7.	Reykjavík	Choose new match
8.	London	Choose new match
9.	London	Choose new match
10.	London	Choose new match
11.	London	Choose new match
12.	Texas City	Choose new match
13.	Texas City	Choose new match
14.	Texas City	Choose new match

Facet / Filter

Undo / Redo 10 / 10

Refresh

Reset all Remove all

x City

change

4 choices Sort by: name count

Cluster

London 3

lonfon 1

Reykjavík 7

Texas 3

Facet by choice counts

14 rows

Show as: rows records Show: 5 10 25 50 100 500

All

City

Facet

Text filter

Edit cells

Edit column

Transpose

Sort...

View

Reconcile

Text facet

Numeric facet

Timeline facet

Scatterplot facet...

Custom text facet...

Custom numeric facet...

Customized facets

	All	City
1.	Reykjavík	Choose new match
2.	Reykjavík	Choose new match
3.	Reykjavík	Choose new match
4.	Reykjavík	Choose new match
5.	Reykjavík	Choose new match
6.	Reykjavík	Choose new match
7.	Reykjavík	Choose new match
8.	London	Choose new match
9.	London	Choose new match
10.	London	Choose new match
11.	London	Choose new match
12.	Texas City	Choose new match
13.	Texas City	Choose new match
14.	Texas City	Choose new match

All

City

Facet

Text filter

Edit cells

Edit column

Transpose

Sort...

View

Reconcile

Text facet

Numeric facet

Timeline facet

Scatterplot facet...

Custom text facet...

Custom numeric facet...

Customized facets

## 14 rows

14 rows

Show as: rows records Show: 5 10

All		City
1.	Reykjavík	Choose new match
2.	Reykjavík	Choose new match
3.	Reykjavík	Choose new match
4.	Reykjavík	Choose new match
5.	Reykjavík	Choose new match
6.	Reykjavík	Choose new match
7.	Reykjavík	Choose new match
8.	London	Choose new match
9.	London	Choose new match
10.	London	Choose new match
11.	London	Choose new match
12.	Texas City	Choose new match
13.	Texas City	Choose new match
14.	Texas City	Choose new match

Show as: rows records Show: 5 10 25 50 100 500 1000 rows

<input type="button" value="▼ All"/>	All	<input type="button" value="▼ City"/>
	Transform...	
	Edit all columns	▶
	Facet	▶
	Add blank rows	▶
	<b>Edit rows</b>	▶
	Star rows	
	Edit columns	▶
	Unstar rows	
	View	▶
	Flag rows	
	Unflag rows	
	Remove matching rows	
	<b>Remove duplicate rows</b>	

## 3 rows

Show as: rows records Show: 5 10 25

All		City
1.	Reykjavík	Choose new match
2.	London	Choose new match
3.	Texas City	Choose new match

You've made it!

# Intro to OMR

## Part 2

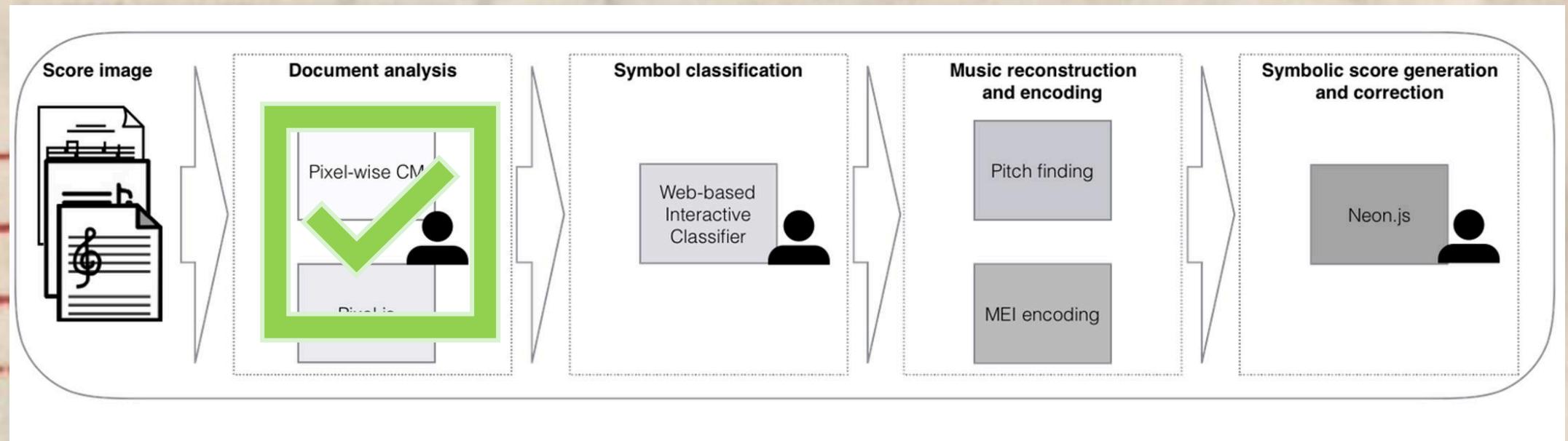
Geneviève Gates-Panneton

Rodan and Neon tester

# OMR Continued

- Symbol classification – Interactive Classifier
- End-to-End Optical Music Recognition – e2e OMR
- Neon
- Cantus Ultimus

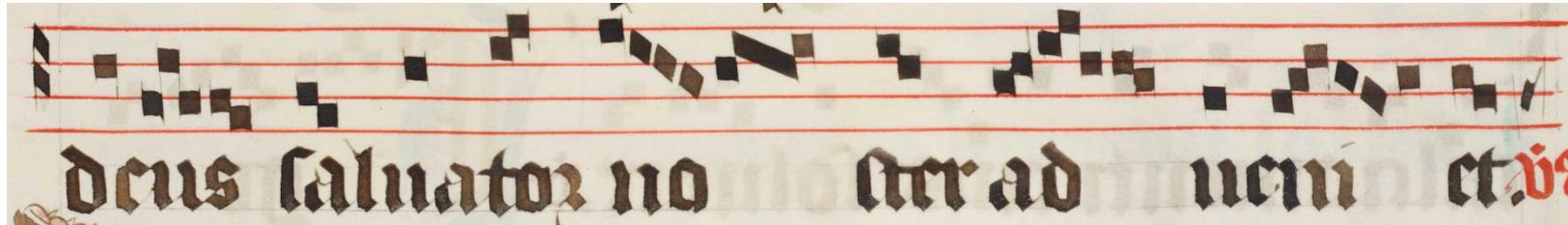
# Symbol classification in the IC



Teaching the computer to separate a folio image into layers containing staff lines, glyphs, etc.

Teaching the computer to tell musical symbols apart and identify them correctly

# Intro to square neume notation



Salzinnes

CDN-Hsmu M2149.L4



Einsiedeln

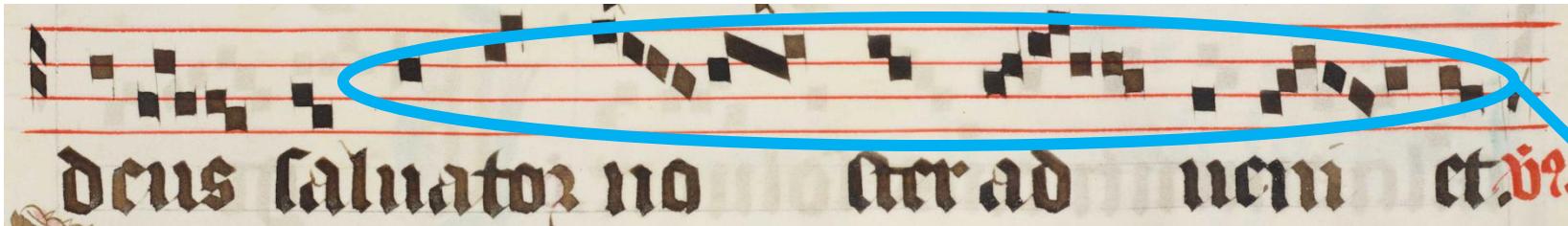
CH-E 611



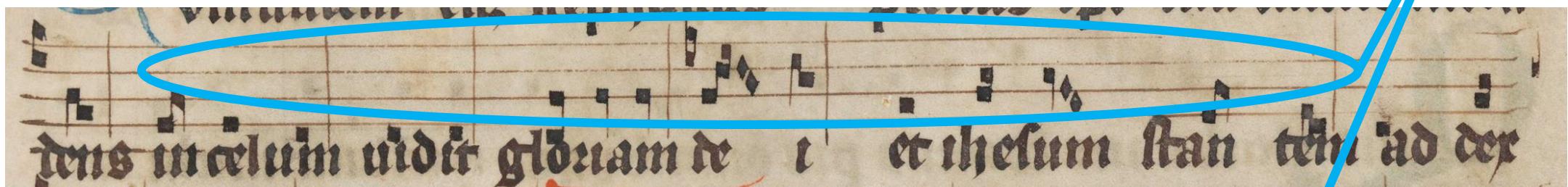
MS73

CDN-Mlr\_MS73

4 lines of staff



Things that are notes



deus in celum vidi gloriam de i et ihesum stan tem ad dex

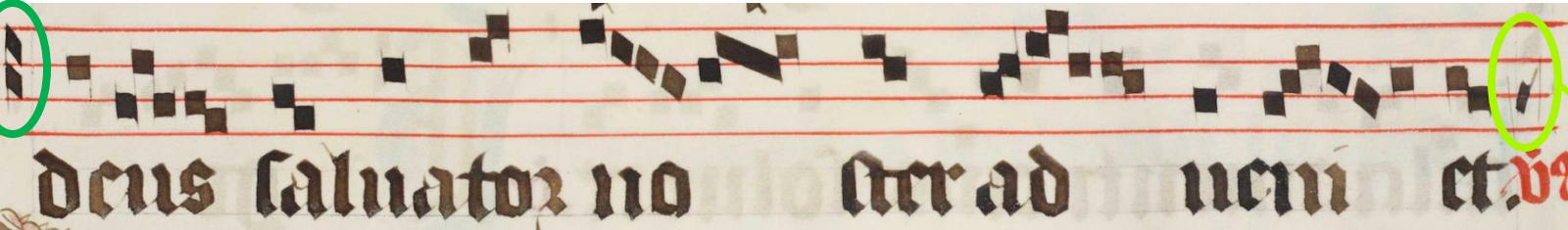
Latin text



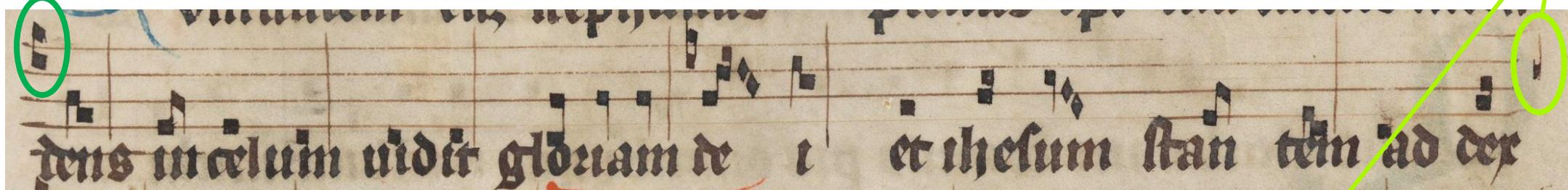
perduceret

ie rusa lem.

C clef



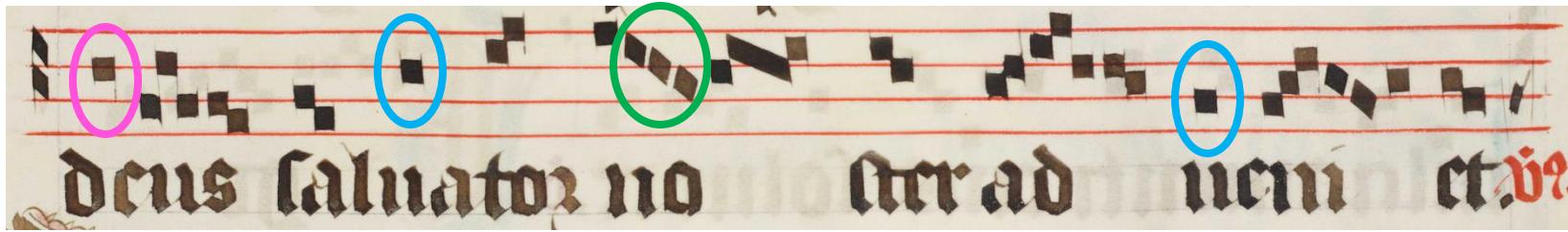
Custos –  
Indicates  
starting pitch  
of next staff



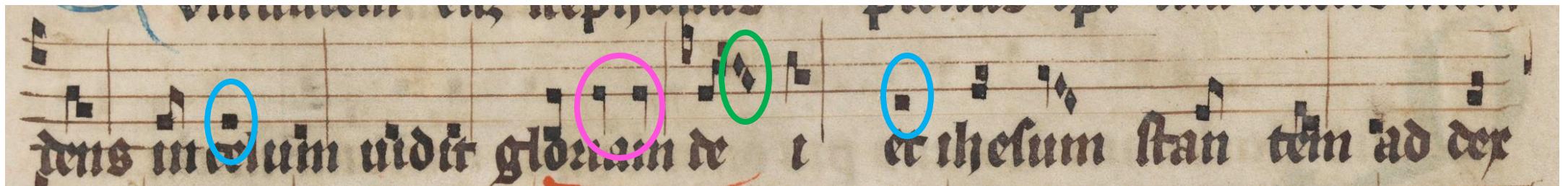
F clef



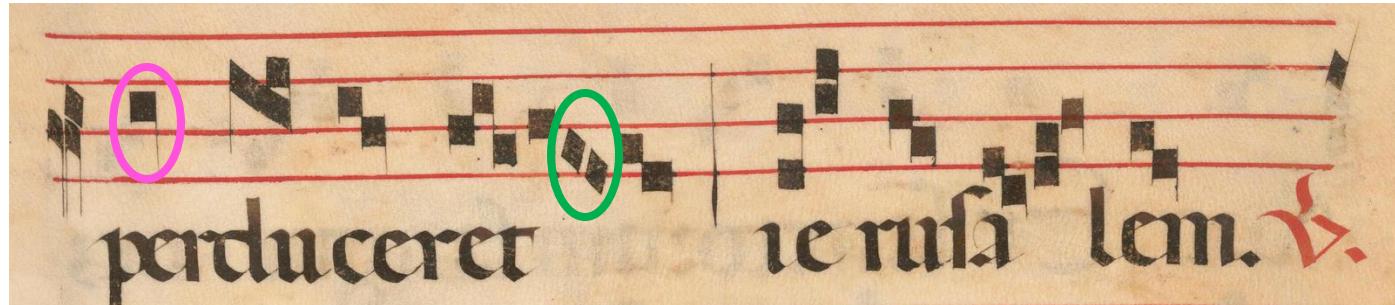
Punctum  
=  
Dot



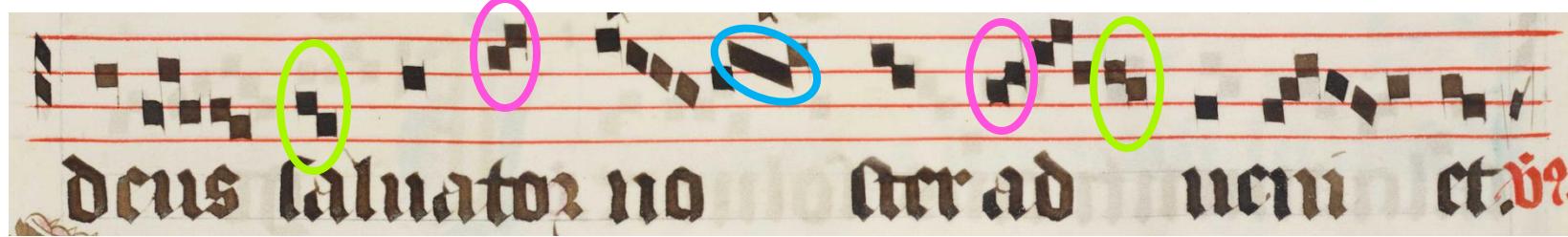
Virga  
=  
Dot with a tail



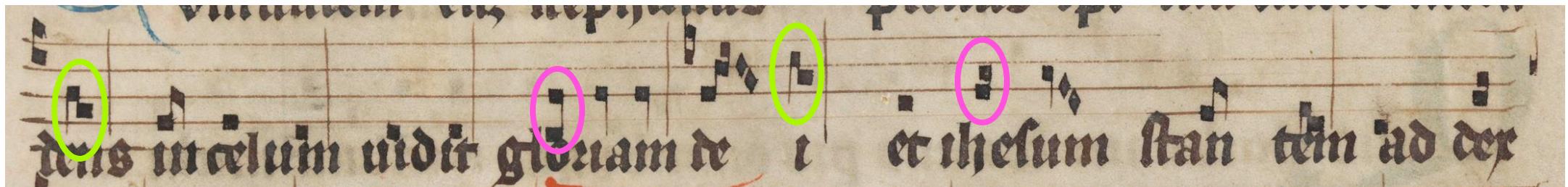
Inclinatum  
=  
Dot on an angle



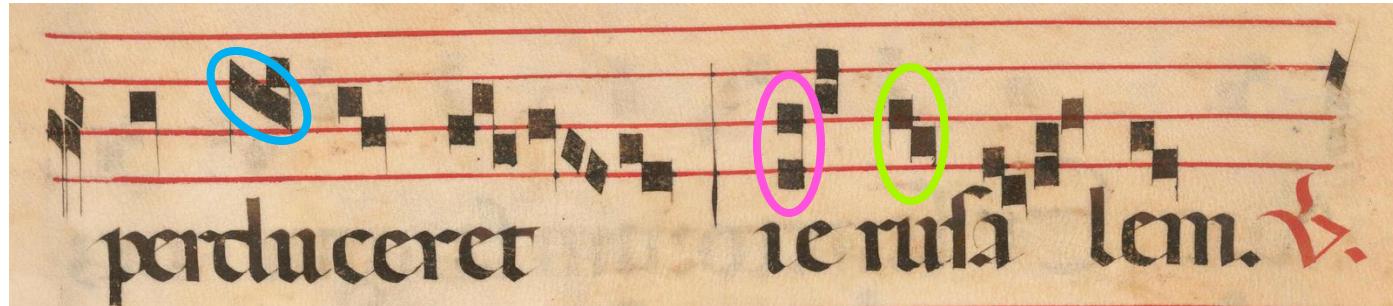
Podatus  
= Two-note ascending neume



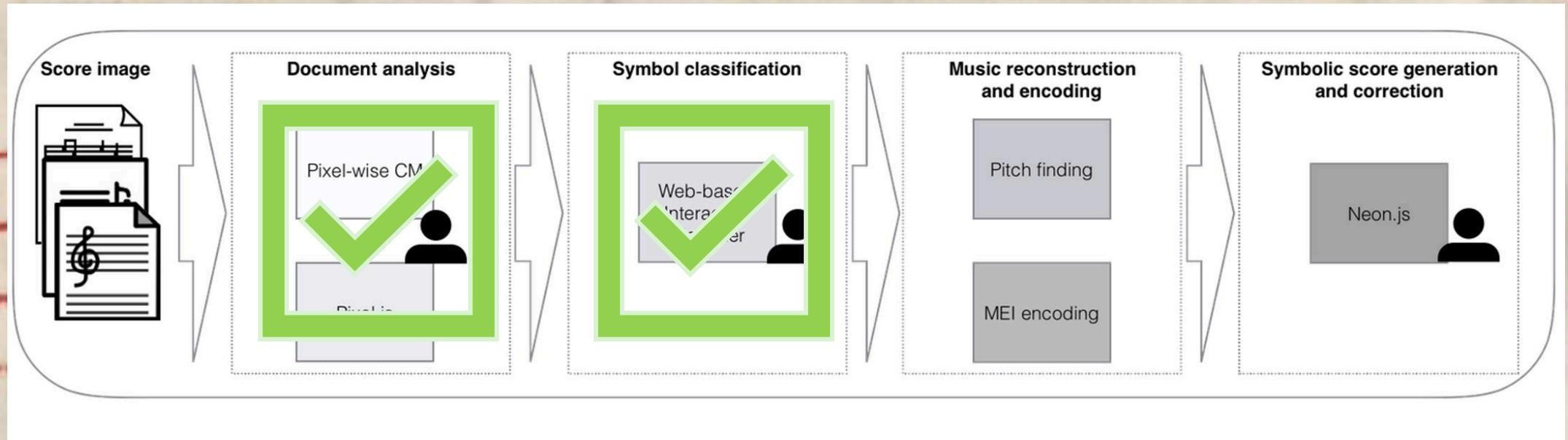
Clivis  
= Two-note descending neume



Oblique  
= Two-note descending neume



# Back to business

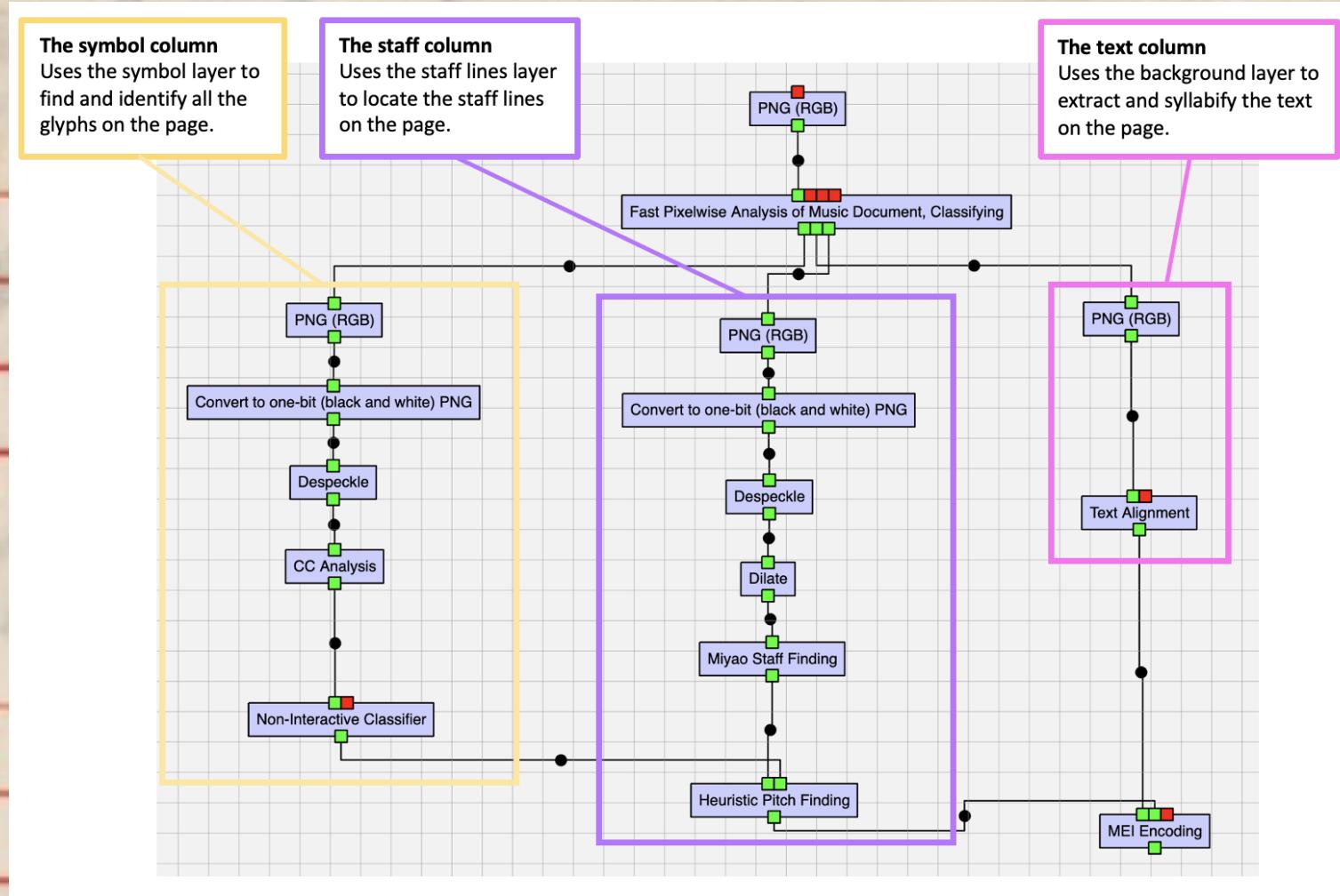


Teaching the computer to separate a folio image into layers containing staff lines, glyphs, etc.

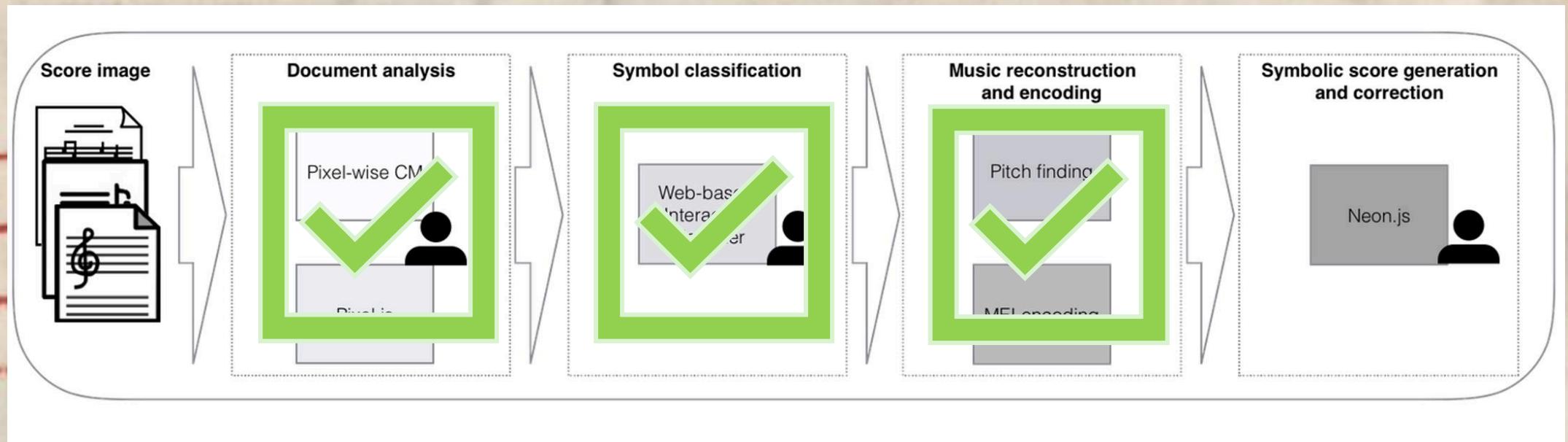
Teaching the computer to tell musical symbols apart and identify them correctly

End-to-end OMR!

# End-to-end OMR



# Neon



Teaching the computer to separate a folio image into layers containing staff lines, glyphs, etc.

Teaching the computer to tell musical symbols apart and identify them correctly

End-to-end OMR!

# Neon

<https://ddmal.music.mcgill.ca/Neon/>



Zoom level: 3.00

Folio 001v (4 of 573)

Go



Manuscript info

potentiam ueniens tem et nebu lam to tam terram te  
gen tem. te ob uiam e ter dicate. Nuntia  
nobis situ es ipse. Qui regnaturus es in popu  
lo israhel. Qui q[uo]d terrigena et filii hominum.  
simul in unum di ues et pau per. Te. Qui re  
gis israhel intende qui deducas uelud ouem ioseph qui sedes su  
ner die mi bvn. Nuntia. Sol lite portas principes

[Go to first chant](#)[Previous Folio](#)[Next Folio](#)

Folio 001v

Search Manuscript

Neume ▾

Notation

Search

## Available neumes



punctum



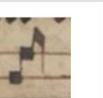
pes



distropha



clivis



scandicus



torcul

## Neume search

Searching...



Zoom level: 3.00



Folio 001v (4 of 573)

Go



Manuscript info

[Go to first chant](#)[Previous Folio](#)[Next Folio](#)

Folio 001v

Search Manuscript

Neume ▾

torculus

Search

## Available neumes



punctum



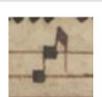
pes



distropha



clivis



scandicus



tor

3834 results for query: **torculus**

Folio	Neumes	Pitches	Contour
001v		d f e	
001v		e f e	
001v		d e c	
001v		e f e	

---



# Music Encoding Initiative (MEI)

Yinan Zhou  
DDMAL, McGill University  
Training Week 2025 Summer

---

# What is MEI?

---

# MEI

- Encodes music scores, metadata, and editorial work
- Built using eXtensible Markup Language (XML)
  - ◆ HTML: for web pages
  - ◆ TEI: for text
  - ◆ MEI: for music

---

# What does MEI look like?

```
1 <?xml version="1.0" encoding="UTF-8"?>
2 <?xml-model href="https://music-encoding.org/schema/5.0/mei-all.rng" type="application/xml" schematypens="http://relaxng.org/ns/structure/1.0"?>
3 <?xml-model href="https://music-encoding.org/schema/5.0/mei-all.rng" type="application/xml" schematypens="http://purl.oclc.org/dsdl/schematron"?>
4 <mei
5   xmlns="http://www.music-encoding.org/ns/mei" meiversion="5.0">
6     <meiHead xml:id="m-cc2cc34c-56cb-40fe-97b9-4f4b7ae83faf">
7       <fileDesc xml:id="m-0f28ed12-54a6-40bd-be31-d16ca7d137c7">
8         <titleStmt xml:id="m-4d9eeabe-75f6-439e-97f9-bb40a7909f1b">
9           <title xml:id="m-c85131ff-cf24-40f9-adaf-67c5be91bfcd">MEI Encoding Output (1.0.0)</title>
10        </titleStmt>
11        <pubStmt xml:id="m-74de0afe-1811-4536-831c-06c49919ead2"/>
12      </fileDesc>
13    </meiHead>
14    <music>
15      <facsimile xml:id="m-5a58254a-8580-49cd-9bad-23381501407f">
16        <surface xml:id="m-07936488-2a37-4829-b18b-b44bd091a94b" lrx="4872" lry="6496"> ...
17        </surface>
18      </facsimile>
19    </body>
20    <mdiv xml:id="m-0b6a5779-e528-4467-bad0-822bb7f82a38">
21      <score xml:id="m-a349a683-99e3-4fff-af3e-53de8a7b040c">
22        <scoreDef xml:id="m-17a8363d-e4bc-4dc3-a05c-bc1ff8c2612c"> ...
23        </scoreDef>
24        <section xml:id="m-48a24564-40a2-47d2-b96e-8f255d0d9bb3">
25          <staff n="1">
26            <layer n="1">
27              <pb xml:id="m-030a7c4d-21ad-4e1e-8d4a-2ec11d4346a8" facs="#m-07936488-2a37-4829-b18b-b44bd091a94b" />
28              <sb n="1" facs="#m-1c9e019c-05df-4aa2-ab71-8ee5d031cdcc" xml:id="m-c4015cca-0784-4e9a-86f6-ac646b1ecab2" />
29              <clef xml:id="m-d891b1f8-d9a6-4286-8a5b-3272e5c6e7e8" facs="#m-ce74aa6e-471f-487e-9b94-9ce7289af7f2" shape="C" line="4" />
30              <syllable xml:id="m-e93d9626-a102-4982-b8eb-fa64068801b4"> ...
31            </syllable>
32            <divLine xml:id="m-16d4e772-9c62-41fe-af3a-0fe90f0975d0" facs="#m-35d490b5-e192-4aea-91e1-4b4a96d44e47" form="maxima" />
33            <divLine xml:id="m-6bb7aa35-2b78-49aa-a28c-c39bc61eee4" facs="#m-4a26ea6d-57c5-4abe-a044-e19218e496f7" form="maxima" />
34            <accid xml:id="accid-0000001858106490" facs="#zone-0000000341653099" accid="f" />
35            <divLine xml:id="m-5a9680dc-2912-41c8-a837-631b48d56f35" facs="#m-b102226b-2e68-43e7-baf2-f0872e47b145" form="maxima" />
36            <syllable xml:id="m-d56c2ef3-297d-41ec-84b6-fbcccd8ce6b0f">
37              <syl xml:id="m-7fe96bca-0f15-4171-b883-8a5856ed5c9b" facs="#m-6ff3caed-62b0-4350-8db9-36eebceb3a4f">in</syl>
38            </syllable>
39          </staff>
40        </section>
41      </score>
42    </mdiv>
43  </music>
44</mei>
```

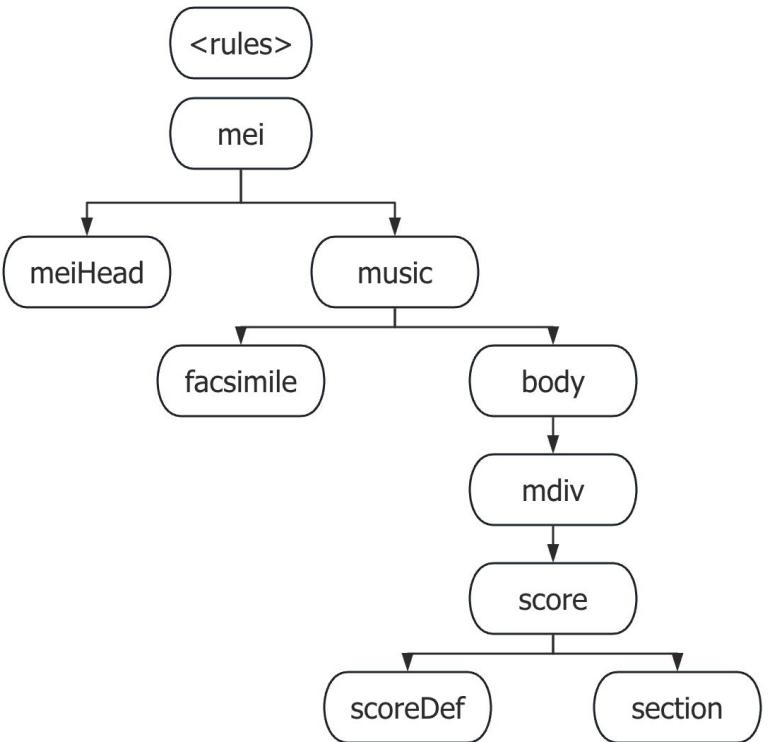
# It looks like code

- Uses nested tags
  - Human-readable
  - Machine-readable

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="https://music-encoding.org/schema/5.0/mei-all.rng" type="app
<?xml-model href="https://music-encoding.org/schema/5.0/mei-all.rng" type="app
<mei
    xmlns="http://www.music-encoding.org/ns/mei" meiversion="5.0">
        <meiHead xml:id="m-cc2cc34c-56cb-40fe-97b9-4f4b7ae83faf">
            <fileDesc xml:id="m-0f28ed12-54a6-40bd-be31-d16ca7d137c7">
                <titleStmt xml:id="m-4d9eeabe-75f6-439e-97f9-bb40a7909f1b">
                    <title xml:id="m-c85131ff-cf24-40f9-adaf-67c5be91bfcd">MEI Enc
                </titleStmt>
                <pubStmt xml:id="m-74de0afe-1811-4536-831c-06c49919ead2" />
            </fileDesc>
        </meiHead>
        <music>
            <facsimile xml:id="m-5a58254a-8580-49cd-9bad-23381501407f">
                <surface xml:id="m-07936488-2a37-4829-b18b-b44bd091a94b" lrx="4872
                </surface>
            </facsimile>
            <body>
                <mdiv xml:id="m-0b6a5779-e528-4467-bad0-822bb7f82a38">
                    <score xml:id="m-a349a683-99e3-4ff6-af3e-53de8a7b040c">
                        <scoreDef xml:id="m-17a8363d-e4bc-4dc3-a05c-bc1ff8c2612c">
                            </scoreDef>
                        <section xml:id="m-48a24564-40a2-47d2-b96e-8f255d0d9bb3">
                            <staff n="1">
                                <layer n="1">
                                    <pb xml:id="m-030a7c4d-21ad-4e1e-8d4a-2ec11d43
                                    <sb n="1" facs="#m-1c9e019c-05df-4aa2-ab71-8ee
                                    <clef xml:id="m-d891b1f8-d9a6-4286-8a5b-3272e5
                                    <syllable xml:id="m-e93d9626-a102-4982-b8eb-fa
                                    </syllable>
                                    <divLine xml:id="m-16d4e772-9c62-41fe-af3a-0fe
                                    <divLine xml:id="m-6bb7aa35-2b78-49aa-a28c-c39
                                    <accid xml:id="accid-0000001858106490" facs="#
                                    <divLine xml:id="m-5a9680dc-2912-41c8-a837-631
                                    <syllable xml:id="m-d56c2ef3-297d-41ec-84b6-fb
                                    <syl xml:id="m-7fe96bca-0f15-4171-b883-8a5
```

---

# MEI Structure



```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="https://music-encoding.org/schema/5.0/mei-all.rng" type="app
<?xml-model href="https://music-encoding.org/schema/5.0/mei-all.rng" type="app
mei
  xmlns="http://www.music-encoding.org/ns/mei" meiversion="5.0">
  <meiHead xml:id="m-cc2cc34c-56cb-40fe-97b9-4f4b7ae83faf">
    <fileDesc xml:id="m-0f28ed12-54a6-40bd-be31-d16ca7d137c7">
      <titleStmt xml:id="m-4d9eeabe-75f6-439e-97f9-bb40a7909f1b">
        <title xml:id="m-c85131ff-cf24-40f9-adaf-67c5be91bfcd">MEI Enc
      </titleStmt>
      <pubStmt xml:id="m-74de0afe-1811-4536-831c-06c49919ead2" />
    </fileDesc>
  </meiHead>
  <music>
    <facsimile xml:id="m-5a58254a-8580-49cd-9bad-23381501407f">
      <surface xml:id="m-07936488-2a37-4829-b18b-b44bd091a94b" lrx="4872
      </surface>
    </facsimile>
    <body>
      <mdiv xml:id="m-0b6a5779-e528-4467-bad0-822bb7f82a38">
        <score xml:id="m-a349a683-99e3-4ff6-af3e-53de8a7b040c">
          <scoreDef xml:id="m-17a8363d-e4bc-4dc3-a05c-bc1ff8c2612c">
            </scoreDef>
          <section xml:id="m-48a24564-40a2-47d2-b96e-8f255d0d9bb3">
            <staff n="1">
              <layer n="1">
                <pb xml:id="m-030a7c4d-21ad-4e1e-8d4a-2ec11d43
                <sb n="1" facs="#m-1c9e019c-05df-4aa2-ab71-8ee
                <clef xml:id="m-d891b1f8-d9a6-4286-8a5b-3272e5
                <syllable xml:id="m-e93d9626-a102-4982-b8eb-fa
                </syllable>
                <divLine xml:id="m-16d4e772-9c62-41fe-af3a-0fe
                <divLine xml:id="m-6bb7aa35-2b78-49aa-a28c-c39
                <accid xml:id="accid-0000001858106490" facs="#
                <divLine xml:id="m-5a9680dc-2912-41c8-a837-633
                <syllable xml:id="m-d56c2ef3-297d-41ec-84b6-fb
                <syl xml:id="m-7fe96bca-0f15-4171-b883-8a5
              </layer>
            </staff>
          </section>
        </score>
      </mdiv>
    </body>
  </music>

```

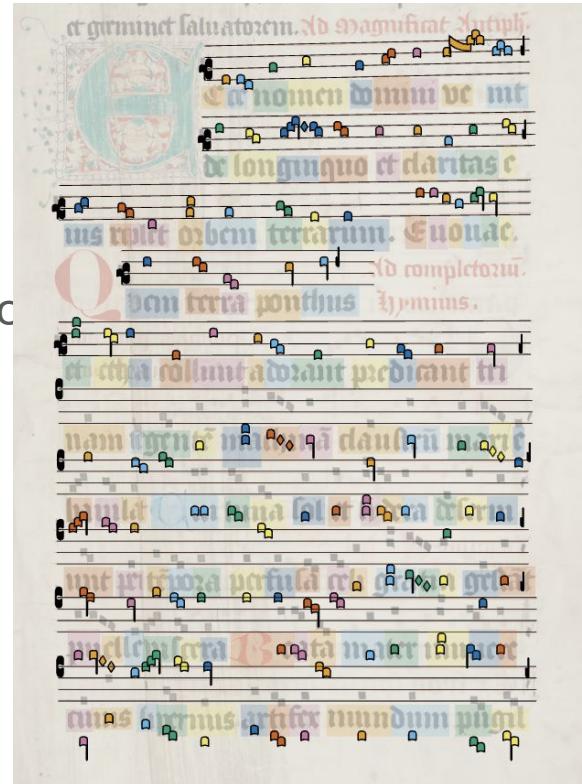
---

# Facsimile Module

---

# Why do we need facsimile?

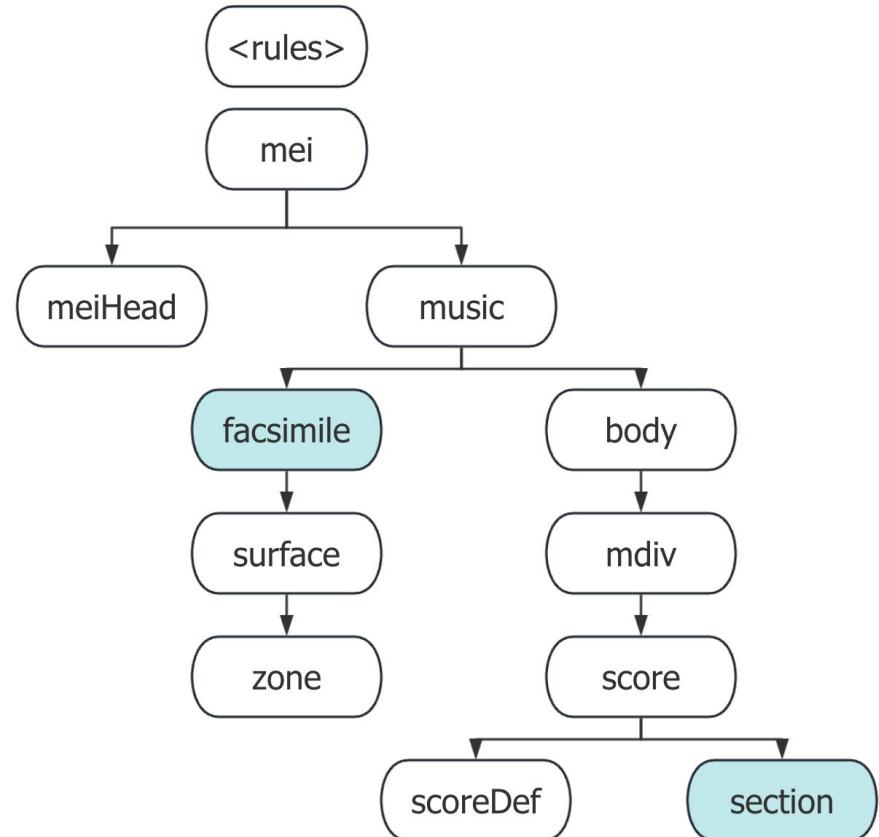
- Regular MEI doesn't show information about position
- Positioning matters for OMR



---

# Facsimiles

- Connect an MEI file with an external image source



```
4 <mei
5
6
7
8
9
10
11
12
13
14     <music>
15         <facsimile xml:id="m-5a58254a-8580-49cd-9bad-23381501407f">
16             <surface xml:id="m-07936488-2a37-4829-b18b-b44bd091a94b" lrx="4872" lry="6496">
17                 <zone xml:id="zone-000001663683811" lrx="1315" lry="2928" ulx="1115" uly="2728"/>
18                 <zone xml:id="zone-000000510676243" lrx="3986" lry="2622" ulx="3786" uly="2422"/>
19                 <zone xml:id="zone-0000001123102393" lrx="4019" lry="2579" ulx="3819" uly="2379"/>
20
21             </surface>
22         </facsimile>
23     <body>
24         <mdiv xml:id="m-0b6a5779-e528-4467-bad0-822bb7f82a38">
25             <score xml:id="m-a349a683-99e3-4ff6-af3e-53de8a7b040c">
26                 <scoreDef xml:id="m-17a8363d-e4bc-4dc3-a05c-bc1ff8c2612c">...
27             </scoreDef>
28             <section xml:id="m-48a24564-40a2-47d2-b96e-8f255d0d9bb3">
29                 <staff n="1">
30                     <layer n="1">
31                         <pb xml:id="m-030a7c4d-21ad-4e1e-8d4a-2ec11d4346a8" facs="#m-07936488-2a37-4829-b18b-b44bd091a94b"/>
32                         <sb n="1" facs="#m-1c9e019c-05df-4aa2-ab71-8ee5d031cdcc" xml:id="m-c4015cca-0784-4e9a-86f6-ac646b1ecab2"/>
33                         <clef xml:id="m-d891b1f8-d9a6-4286-8a5b-3272e5c6e7e8" facs="#m-ce74aa6e-471f-487e-9b94-9ce7289af7f2" shape="C" line="4" />
34                         <syllable xml:id="m-e93d9626-a102-4982-b8eb-fa64068801b4">...
35                     </syllable>
36                     <divLine xml:id="m-16d4e772-9c62-41fe-af3a-0fe90f0975d0" facs="#m-35d490b5-e192-4aea-91e1-4b4a96d44e47" form="maxima"/>
37                     <divLine xml:id="m-6bb7aa35-2b78-49aa-a28c-c39bc61eee4" facs="#m-4a26ea6d-57c5-4abe-a044-e19218e496f7" form="maxima"/>
38                     <accid xml:id="accid-0000001858106490" facs="#zone-000000341653099" accid="f"/>
39                     <divLine xml:id="m-5a9680dc-2912-41c8-a837-631b48d56f35" facs="#m-b102226b-2e68-43e7-baf2-f0872e47b145" form="maxima"/>
40                     <syllable xml:id="m-d56c2ef3-297d-41ec-84b6-fbccd8ce6b0f">
41                         <syl xml:id="m-7fe96bca-0f15-4171-b883-8a5856ed5c9b" facs="#m-6ff3caed-62b0-4350-8db9-36eebceb3a4f">in</syl>
42                         <neume xml:id="m-215f9505-9ffc-4486-be3a-d4fce75dab1d">
43                             <nc xml:id="m-5c7d33d2-59d2-4d8f-854f-0c9bb4e72dfa" facs="#m-30cb5bce-a524-4b73-ad6b-460771fc2b07" oct="2" pname="a"/>
44                             <nc xml:id="m-ccb98825-399a-462f-9790-4a514bdf894b" facs="#m-5a2d7859-e709-4849-b4cf-f855bc4bbfe7" oct="2" pname="b"/>
45                             <nc xml:id="m-0fa6d73c-2a57-47bc-855f-4aa4c23b0aa2" facs="#m-fcfc9293-3e83-4bcf-a0e4-15b17ff48f79" oct="2" pname="a"/>
46                         </neume>
47                     </syllable>
48                     <custos facs="#m-f5f5415f-365f-4669-9865-a07beb0e90c" oct="2" pname="f" xml:id="m-e247912b-91b1-40dd-b320-878c864e82cc"/>
49                     <sb n="2" facs="#m-5ffcb1da-a98c-47fc-93b4-eb2f6bbd59c6" xml:id="m-9ff34715-9c51-4ae8-b4e8-5151c053adce"/>
50                     <clef xml:id="m-03697ea8-f975-48f6-abb7-57e20732b696" facs="#m-48b35456-4c19-4ccd-8682-1d0441902392" shape="C" line="4" />
```

---

# Attributes

---

# Attributes

- Describe details of musical elements

```
<nc xml:id="m-10c4dc04" facs="#m-4f016e77" oct="2" pname="f" tilt="n"/>
```

nc	nc@tilt="n"	nc@tilt="s"	clef@shape="C"	clef@shape="F"
Punctum	Reversed virga	Virga	C clef	F clef
				

# MEI and Neon

Comparing MEI code with its rendering  
in Neon to better understand both  
(hopefully)

Geneviève Gates-Panneton

# Neumes



```
<syllable xml:id="syllable-0000002095556033">
    <syl xml:id="syl-000001757536115" facs="#zone-000001167758960">gra</syl>
    <neume xml:id="m-4e516f1b-ee78-4e51-b67a-4ba2c4f040e9">
        <nc xml:id="m-12c1d644-e6c7-4646-93e6-0bf59b430a54" facs="#m-5e27f28b-d756-49a0-89b6-52f2eb04f19d" oct="4" pname="c" tilt="s"/>
    </neume>
</syllable>
<syllable xml:id="syllable-000000172473945">
    <neume xml:id="neume-000001621958538">
        <nc xml:id="m-ac679338-d98a-4e14-8a71-5a8c3bcc21e7" facs="#m-e4a5bf30-b383-4d66-a65c-ce50854a16f5" oct="3" pname="b" tilt="s"/>
        <nc xml:id="nc-000001164240622" facs="#zone-000001281785955" oct="3" pname="a" tilt="se"/>
        <nc xml:id="nc-000000252947805" facs="#zone-000000392411552" oct="3" pname="g" tilt="se"/>
    </neume>
    <syl xml:id="syl-000001400462352" facs="#zone-000000285061853">ti</syl>
</syllable>
<syllable xml:id="m-13e7ea03-2ba7-4ef3-b42c-5e92d64f1b4e">
    <syl xml:id="m-688436ea-77ba-4116-857c-31e5ab092756" facs="#m-53b65492-8bcd-4355-8fb8-51c0b5668d45">a</syl>
    <neume xml:id="m-c051cd9e-ae92-4054-94c2-93264c160cd3">
        <nc xml:id="m-91014e80-806e-4036-9f5b-2d20da86ab25" facs="#m-45aa348e-5854-4ee6-8abf-4b26c2ec20c4" oct="3" pname="f"/>
        <nc xml:id="m-a497db31-6159-413c-b599-e70088b00889" facs="#m-342a14fb-33f8-4256-b161-8f769a2f8a07" oct="3" pname="g"/>
        <nc xml:id="m-1b8b5366-c8ae-41f1-823e-0b4d6c36c230" facs="#m-5d53a733-d0a1-47e9-ae70-8109019052d0" oct="3" pname="a"/>
    </neume>
</syllable>
```

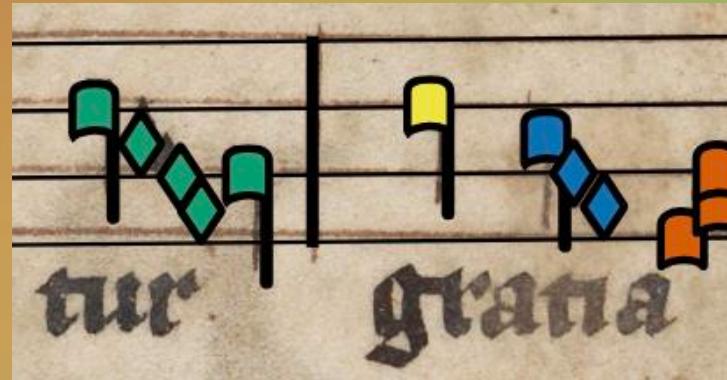
```
<syllable xml:id="a12pcd5f">
    <neume xml:id="m-4e516f1b-ee78-4e51-b67a-4ba2c4f040e9">
        <nc xml:id="m-12c1d644-e6c7-4646-93e6-0bf59b430a54" facs="#m-5e27f28b-d756-49a0-89b6-52f2eb04f19d" oct="4" pname="c" tilt="s"/>
    </neume>
    <syl xml:id="vs8lo5g" facs="#a18rz267"/>
</syllable>
<syllable xml:id="m1k0kmkt">
    <neume xml:id="l1s55u2x">
        <nc xml:id="m-ac679338-d98a-4e14-8a71-5a8c3bcc21e7" facs="#m-e4a5bf30-b383-4d66-a65c-ce50854a16f5" oct="3" pname="b" tilt="s"/>
    </neume>
    <neume xml:id="w1exw8r5">
        <nc xml:id="luzjmfg" facs="#t13mj1vg" oct="3" pname="a" tilt="se"/>
        <nc xml:id="o5u3248" facs="#x1ov7o3d" oct="3" pname="g" tilt="se"/>
    </neume>
    <syl xml:id="d1r74r9u" facs="#gveclh4">ti</syl>
</syllable>
<syllable xml:id="m-13e7ea03-2ba7-4ef3-b42c-5e92d64f1b4e">
    <syl xml:id="m-688436ea-77ba-4116-857c-31e5ab092756" facs="#m-53b65492-8bcd-4355-8fb8-51c0b5668d45">a</syl>
    <neume xml:id="m-c051cd9e-ae92-4054-94c2-93264c160cd3">
        <nc xml:id="m-91014e80-806e-4036-9f5b-2d20da86ab25" facs="#m-45aa348e-5854-4ee6-8abf-4b26c2ec20c4" oct="3" pname="f"/>
    </neume>
    <neume xml:id="drdd1ie">
        <nc xml:id="m-a497db31-6159-413c-b599-e70088b00889" facs="#m-342a14fb-33f8-4256-b161-8f769a2f8a07" oct="3" pname="g"/>
        <nc xml:id="m-1b8b5366-c8ae-41f1-823e-0b4d6c36c230" facs="#m-5d53a733-d0a1-47e9-ae70-8109019052d0" oct="3" pname="a"/>
    </neume>
</syllable>
```

# Syllables



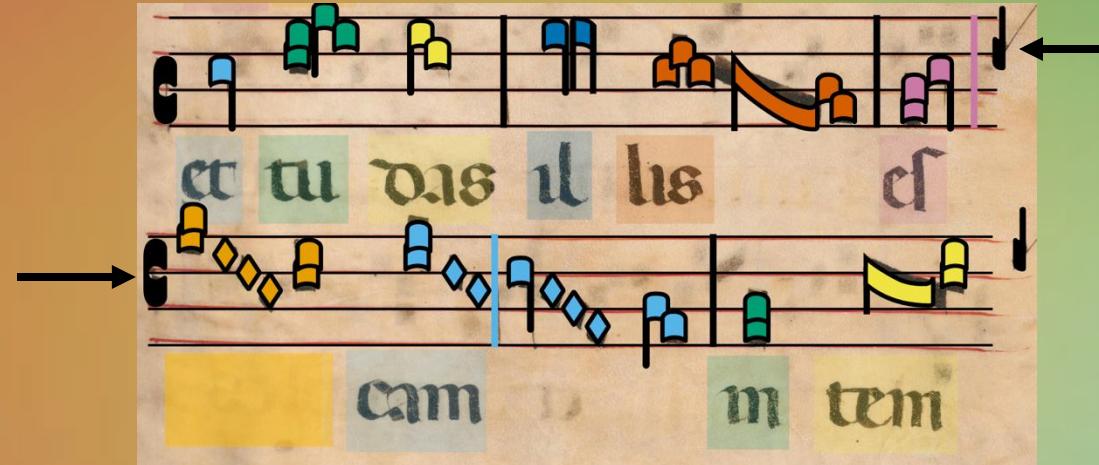
```
<syllable xml:id="ltuf5iw">
    <syl xml:id="m9h8ido" facs="#i1ft356f">tur</syl>
    <neume xml:id="j1r82lsk">
        <nc xml:id="m-9893a203-16e8-468f-aee9-5e9819e9d555" facs="#m-ec4d97b1-9a83-4635-b778-d0571bed4561" oct="4" pname="c" tilt="s"/>
        <nc xml:id="m-ce1e6232-7958-4011-83a5-7468a430c329" facs="#m-f50c5d37-abd3-43c5-8982-793a7e89a248" oct="3" pname="b" tilt="se"/>
        <nc xml:id="m-687f2cb3-5e73-425f-a373-7d8fab709b3a" facs="#m-e3255850-a5f0-408e-93cd-c4d014f0340a" oct="3" pname="a" tilt="se"/>
        <nc xml:id="u9ddu2v" facs="#qz2pgqb" oct="3" pname="g" tilt="se"/>
    </neume>
    <neume xml:id="mec7ouv">
        <nc xml:id="m-e9ce575b-3049-46d4-8272-f909adaf4c4d" facs="#m-8f3fd650-017d-4e35-a846-9478ad34c6fa" oct="3" pname="a" tilt="s"/>
    </neume>
    <neume xml:id="m-4e516f1b-ee78-4e51-b67a-4ba2c4f040e9">
        <nc xml:id="m-12c1d644-e6c7-4646-93e6-0bf59b430a54" facs="#m-5e27f28b-d756-49a0-89b6-52f2eb04f19d" oct="4" pname="c" tilt="s"/>
    </neume>
</syllable>
<syllable xml:id="m-f2041173-674d-4504-b480-3196f17ff554">
    <neume xml:id="l1s55u2x">
        <nc xml:id="m-ac679338-d98a-4e14-8a71-5a8c3bcc21e7" facs="#m-e4a5bf30-b383-4d66-a65c-ce50854a16f5" oct="3" pname="b" tilt="s"/>
        <nc xml:id="m-828b2d18-a8fc-4bf2-b61d-cc1d2009069e" facs="#m-b64a7581-8286-477e-91af-ecae90d305f0" oct="3" pname="a" ligated="false" tilt="se"/>
        <nc xml:id="m-96daae06-ffc8-44e5-8c3e-b5c36484a811" facs="#m-027aa70e-7b79-4603-b8dc-e70f6fc783d3" oct="3" pname="g" ligated="false" tilt="se"/>
    </neume>
    <syl xml:id="m-ef2ffd5f-0fa8-43f2-a16b-4f1598d40733" facs="#m-269659ab-4a40-4ec6-aaab-1cba0795812a">ti</syl>
</syllable>
<syllable xml:id="m-13e7ea03-2ba7-4ef3-b42c-5e92d64f1b4e">
    <syl xml:id="m-688436ea-77ba-4116-857c-31e5ab092756" facs="#m-53b65492-8bcd-4355-8fb8-51c0b5668d45">a</syl>
    <neume xml:id="m-c051cd9e-ae92-4054-94c2-93264c160cd3">
        <nc xml:id="m-91014e80-806e-4036-9f5b-2d20da86ab25" facs="#m-45aa348e-5854-4ee6-8abf-4b26c2ec20c4" oct="3" pname="f"/>
        <nc xml:id="m-a497db31-6159-413c-b599-e70088b00889" facs="#m-342a14fb-33f8-4256-b161-8f769a2f8a07" oct="3" pname="g"/>
        <nc xml:id="m-1b8b5366-c8ae-41f1-823e-0b4d6c36c230" facs="#m-5d53a733-d0a1-47e9-ae70-8109019052d0" oct="3" pname="a"/>
    </neume>
</syllable>
```

# Syllables



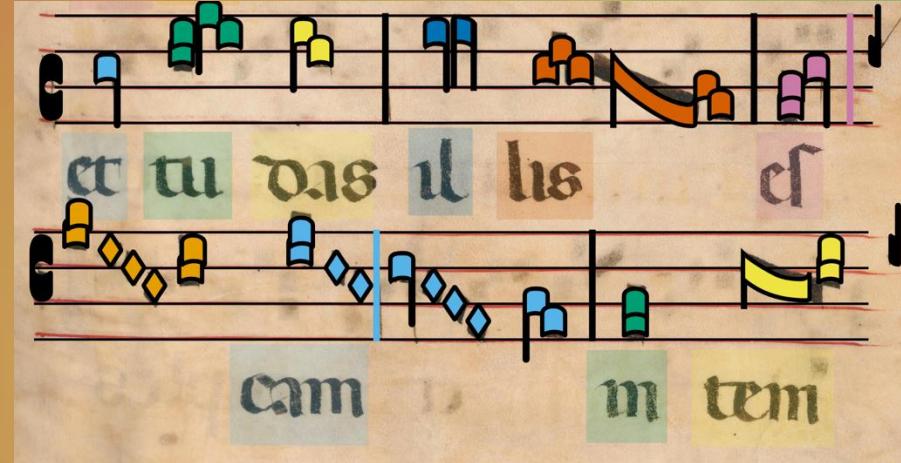
```
<syllable xml:id="syllable-0000001424531883">
    <syl xml:id="syl-0000002083193614" facs="#zone-000000448771436">tur</syl>
    <neume xml:id="neume-0000000269140093">
        <nc xml:id="m-9893a203-16e8-468f-aee9-5e9819e9d555" facs="#m-ec4d97b1-9a83-4635-b778-d0571bed4561" oct="4" pname="c" tilt="s"/>
        <nc xml:id="nc-000000398872946" facs="#zone-000001937024034" oct="3" pname="b" tilt="se"/>
        <nc xml:id="m-ce1e6232-7958-4011-83a5-7468a430c329" facs="#m-f50c5d37-abd3-43c5-8982-793a7e89a248" oct="3" pname="a" tilt="se"/>
        <nc xml:id="m-687f2cb3-5e73-425f-a373-7d8fab709b3a" facs="#m-e3255850-a5f0-408e-93cd-c4d014f0340a" oct="3" pname="g" tilt="se"/>
    </neume>
    <neume xml:id="neume-000001001348582">
        <nc xml:id="m-e9ce575b-3049-46d4-8272-f909adaf4c4d" facs="#m-8f3fd650-017d-4e35-a846-9478ad34c6fa" oct="3" pname="a" tilt="s"/>
    </neume>
</syllable>
<divLine xml:id="m-af154c10-89af-476c-a349-f7fff6e9302c" facs="#m-e1a4aca8-60ca-4f9a-bc07-7e1dc745b944" form="maxima"/>
<syllable xml:id="syllable-0000002095556033">
    <syl xml:id="syl-000001757536115" facs="#zone-000001167758960">gra</syl>
    <neume xml:id="m-4e516f1b-ee78-4e51-b67a-4ba2c4f040e9">
        <nc xml:id="m-12c1d644-e6c7-4646-93e6-0bf59b430a54" facs="#m-5e27f28b-d756-49a0-89b6-52f2eb04f19d" oct="4" pname="c" tilt="s"/>
    </neume>
</syllable>
<syllable xml:id="syllable-000000172473945">
    <neume xml:id="neume-000001621958538">
        <nc xml:id="m-ac679338-d98a-4e14-8a71-5a8c3bcc21e7" facs="#m-e4a5bf30-b383-4d66-a65c-ce50854a16f5" oct="3" pname="b" tilt="s"/>
        <nc xml:id="nc-000001164240622" facs="#zone-000001281785955" oct="3" pname="a" tilt="se"/>
        <nc xml:id="nc-000000252947805" facs="#zone-000000392411552" oct="3" pname="g" tilt="se"/>
    </neume>
    <syl xml:id="syl-000001400462352" facs="#zone-000000285061853">ti</syl>
</syllable>
<syllable xml:id="m-13e7ea03-2ba7-4ef3-b42c-5e92d64f1b4e">
    <syl xml:id="m-688436ea-77ba-4116-857c-31e5ab092756" facs="#m-53b65492-8bcd-4355-8fb8-51c0b5668d45">a</syl>
    <neume xml:id="m-c051cd9e-ae92-4054-94c2-93264c160cd3">
        <nc xml:id="m-91014e80-806e-4036-9f5b-2d20da86ab25" facs="#m-45aa348e-5854-4ee6-8abf-4b26c2ec20c4" oct="3" pname="f"/>
        <nc xml:id="m-a497db31-6159-413c-b599-e70088b00889" facs="#m-342a14fb-33f8-4256-b161-8f769a2f8a07" oct="3" pname="g"/>
        <nc xml:id="m-1b8b5366-c8ae-41f1-823e-0b4d6c36c230" facs="#m-5d53a733-d0a1-47e9-ae70-8109019052d0" oct="3" pname="a"/>
    </neume>
</syllable>
```

# Toggled syllables



```
<syllable xml:id="r1yqcr4d">
    <syl xml:id="m1h2tgyw" facs="#h1iud6yz">es</syl>
    <neume xml:id="p16hc89l">
        <nc xml:id="m-923c3ad4-3922-4a02-a051-c91d43c9eec5" facs="#m-39bba908-67ef-4d34-93ee-ab9a147482aa" oct="3" pname="b"/>
        <nc xml:id="m-8bc3fe96-e065-4ff6-ad91-bac29c53d621" facs="#m-6b87083c-0529-45d3-adec-c4e5189c8e59" oct="4" pname="c"/>
        <nc xml:id="m-c637a4b4-274c-4dd2-9f2a-954d12275e65" facs="#m-d88d9e7c-acde-4594-8f98-6ce2d8baf1e2" oct="4" pname="d" tilt="s"/>
    </neume>
    <divLine xml:id="idgcrjw" facs="#q18g0z2l" form="maxima"/>
</syllable>
=><custos oct="4" pname="e" xml:id="m-13f4706d-7806-476d-a694-99af314c1187" facs="#m-79ebe216-639e-4c9d-a16e-6f0634c5ae80"/>
=><sb n="6" facs="#m-e03a3b98-3cbd-4caa-9988-18a0e7f50fa3" xml:id="m-b84c1d1e-831a-4948-a699-a09dd6b81e1e"/>
=><clef xml:id="m-ca2ddb2b-7eb5-4b5b-8fe5-138fc126fbea" facs="#m-f6eddd2a-ce70-4e0c-8578-7d96c14d6204" shape="C" line="3"/>
<syllable xml:id="ogw830">
    <syl xml:id="h1gaw57t" facs="#w1m9z052"/>
    <neume xml:id="gz2v36k">
        <nc xml:id="m-5af8bc1b-5e0a-409c-b7d6-88930ee9c616" facs="#m-702c7002-f52a-49d1-a993-e727298d750d" oct="4" pname="e"/>
        <nc xml:id="m-524b845b-9f6e-4192-9258-f9f551e77c56" facs="#m-10e32a75-1fdc-4f66-94eb-4062bdf3d609" oct="4" pname="f"/>
        <nc xml:id="m-9612f563-4d02-427b-aff2-389992afaf68" facs="#m-00349e98-8f2f-47f4-ad00-54fc1b984bc3" oct="4" pname="d" tilt="se"/>
        <nc xml:id="m-83ef43dd-1add-4a15-9a62-fe1707cd1179" facs="#m-b54d46fe-d1b9-4482-9816-4f41f57fc6ae" oct="4" pname="c" tilt="se"/>
        <nc xml:id="m-8585b8d0-5826-43ea-b383-dc9240b51849" facs="#m-25cabd8f-5092-4771-bb72-ebdda2645a23" oct="3" pname="b" tilt="se"/>
    </neume>
    <neume xml:id="h1q2xlyr">
        <nc xml:id="i1q8x73" facs="#z12q1ycm" oct="4" pname="c"/>
        <nc xml:id="l174xt79" facs="#b1n4xm45" oct="4" pname="d"/>
    </neume>
</syllable>
```

# Toggled syllables



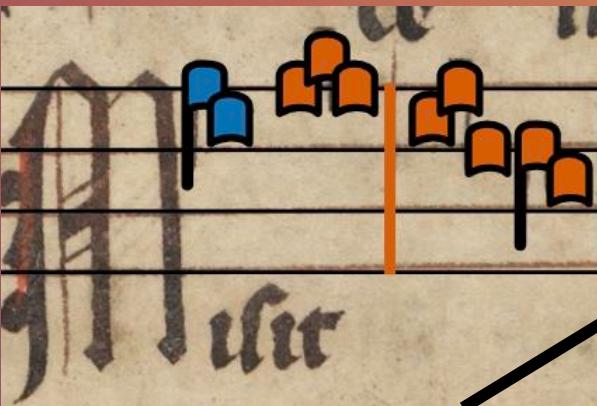
```
<syllable xml:id="r1yqcr4d" precedes="#ogw830">
    <syl xml:id="m1h2tgyw" facs="#h1iud6yz">es</syl>
    <neume xml:id="p16hc89l">
        <nc xml:id="m-923c3ad4-3922-4a02-a051-c91d43c9eec5" facs="#m-39bba908-67ef-4d34-93ee-ab9a147482aa" oct="3" pname="b"/>
        <nc xml:id="m-8bc3fe96-e065-4ff6-ad91-bac29c53d621" facs="#m-6b87083c-0529-45d3-adec-c4e5189c8e59" oct="4" pname="c"/>
        <nc xml:id="m-c637a4b4-274c-4dd2-9f2a-954d12275e65" facs="#m-d88d9e7c-acde-4594-8f98-6ce2d8baf1e2" oct="4" pname="d" tilt="s"/>
    </neume>
    <divLine xml:id="idgcrjw" facs="#q18g0z2l" form="maxima"/>
</syllable>
<custos oct="4" pname="e" xml:id="m-13f4706d-7806-476d-a694-99af314c1187" facs="#m-79ebe216-639e-4c9d-a16e-6f0634c5ae80"/>
<sb n="6" facs="#m-e03a3b98-3cbd-4caa-9988-18a0e7f50fa3" xml:id="m-b84c1d1e-831a-4948-a699-a09dd6b81e1e"/>
<clef xml:id="m-ca2ddb2b-7eb5-4b5b-8fe5-138fc126fbea" facs="#m-f6eddd2a-ce70-4e0c-8578-7d96c14d6204" shape="C" line="3"/>
<syllable xml:id="ogw830" follows="#r1yqcr4d">
    <neume xml:id="gz2v36k"> [red box]
        <nc xml:id="m-5af8bc1b-5e0a-409c-b7d6-88930ee9c616" facs="#m-702c7002-f52a-49d1-a993-e727298d750d" oct="4" pname="e"/>
        <nc xml:id="m-524b845b-9f6e-4192-9258-f9f551e77c56" facs="#m-10e32a75-1fdc-4f66-94eb-4062bdf3d609" oct="4" pname="f"/>
        <nc xml:id="m-9612f563-4d02-427b-aff2-389992afaf68" facs="#m-00349e98-8f2f-47f4-ad00-54fc1b984bc3" oct="4" pname="d" tilt="se"/>
        <nc xml:id="m-83ef43dd-1add-4a15-9a62-fe1707cd1179" facs="#m-b54d46fe-d1b9-4482-9816-4f41f57fc6ae" oct="4" pname="c" tilt="se"/>
        <nc xml:id="m-8585b8d0-5826-43ea-b383-dc9240b51849" facs="#m-25cabd8f-5092-4771-bb72-ebdda2645a23" oct="3" pname="b" tilt="se"/>
    </neume>
    <neume xml:id="h1q2xlyr">
        <nc xml:id="i1q8x73" facs="#z12q1ycm" oct="4" pname="c"/>
        <nc xml:id="l174xt79" facs="#b1n4xm45" oct="4" pname="d"/>
    </neume>
</syllable>
```

# Divisiones



```

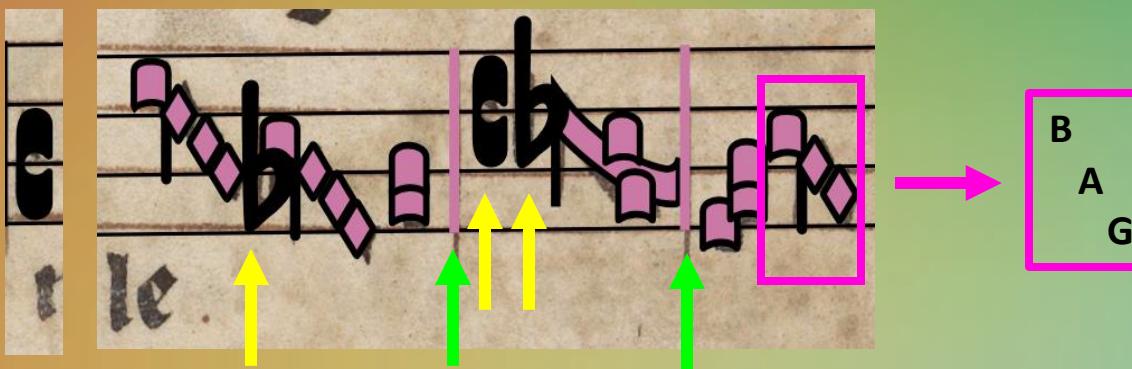
<syllable xml:id="m-e34dca3f-c631-491a-8cf1-e7388013ec3f">
    <syl xml:id="m-d513b4f7-1462-45eb-8c0e-8534ddb19492" facs="#m-f7b8c748-b19f-4b11-9905-a0ce1a3ab020">Mi</syl>
    <neume xml:id="m-303dd367-5395-43ec-9b96-588afb9038c8">
        <nc xml:id="m-61756a4d-9644-439e-b6cb-764ec7bf516f" facs="#m-86ff6d26-4e38-4f61-89ad-44ea43c3076e" oct="4" pname="c" tilt="n"/>
        <nc xml:id="m-85241867-484b-4e31-80f5-44bbec4ec9ab" facs="#m-93ffa2c2-3053-4cd2-adc7-e575627077ab" oct="3" pname="b"/>
    </neume>
</syllable>
<syllable xml:id="m-553679c3-54d3-487b-be4c-b1ebd4144e74">
    <syl xml:id="m-e10b9887-435e-4b1d-93fc-5e5d49d03ce2" facs="#m-8d9da152-c363-453f-9a9e-85a4ea2c500f">sit</syl>
    <neume xml:id="m-d109f9dc-8c2d-416b-b8d6-2c7f05c1e803">
        <nc xml:id="m-7a83aed8-0e29-4860-98c4-7e92c0d9d53e" facs="#m-0b51234b-c7f9-43ff-9825-1b6fb6d8829d" oct="4" pname="c"/>
        <nc xml:id="m-dbcbbf67-8ba1-4543-bc31-1eb0ec5cf4d8" facs="#m-5a39e866-98f9-402c-8c3b-016871c0afcb" oct="4" pname="d"/>
        <nc xml:id="m-187c36d0-2860-4a81-b3ca-517a54b9059b" facs="#m-4a9aba8d-6aa9-4aa0-842f-67d643f7b4b6" oct="4" pname="c"/>
        <nc xml:id="m-b306a4c2-be6e-4f52-a8a7-838de46ff7fa" facs="#m-bc721958-405e-4803-8d79-fbf86b2f2477" oct="3" pname="b"/>
        <nc xml:id="m-d33f4a58-dca8-4576-92c1-80a4c097f70b" facs="#m-7b38f835-1a99-4992-956b-7d1bbc5fcf81" oct="4" pname="c"/>
        <nc xml:id="m-819c014c-82ab-4d58-8696-2d77bcbb5ac8" facs="#m-d1eec9bf-7899-47bc-aea2-10453e8df38b" oct="3" pname="a"/>
        <nc xml:id="m-57693432-ed02-4348-905c-61539f5cad8a" facs="#m-5a643093-0b27-4331-969a-1907e3809db0" oct="3" pname="a" tilt="n"/>
        <nc xml:id="m-4e5cd325-c805-4c62-b541-9b6bbf80b954" facs="#m-9f86a9da-92ed-4408-a92b-64a96a483a4b" oct="3" pname="g"/>
    </neume>
</syllable>
<divLine xml:id="uxivaq1" facs="#q1q187r3" form="maxima"/>
```



```

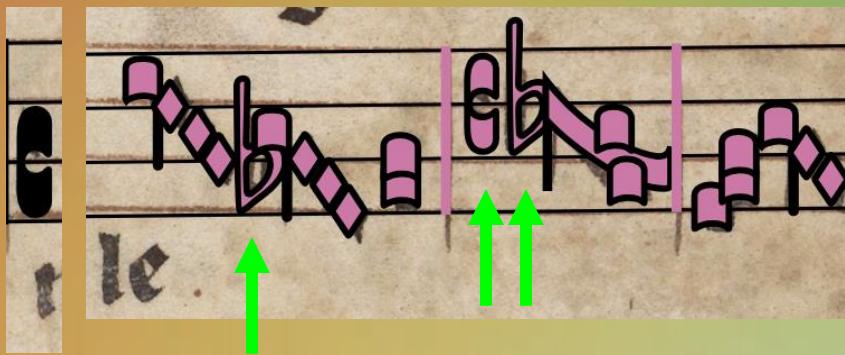
<syllable xml:id="m-e34dca3f-c631-491a-8cf1-e7388013ec3f">
    <syl xml:id="m-d513b4f7-1462-45eb-8c0e-8534ddb19492" facs="#m-f7b8c748-b19f-4b11-9905-a0ce1a3ab020">Mi</syl>
    <neume xml:id="m-303dd367-5395-43ec-9b96-588afb9038c8">
        <nc xml:id="m-61756a4d-9644-439e-b6cb-764ec7bf516f" facs="#m-86ff6d26-4e38-4f61-89ad-44ea43c3076e" oct="4" pname="c" tilt="n"/>
        <nc xml:id="m-85241867-484b-4e31-80f5-44bbec4ec9ab" facs="#m-93ffa2c2-3053-4cd2-adc7-e575627077ab" oct="3" pname="b"/>
    </neume>
</syllable>
<syllable xml:id="m-553679c3-54d3-487b-be4c-b1ebd4144e74">
    <syl xml:id="m-e10b9887-435e-4b1d-93fc-5e5d49d03ce2" facs="#m-8d9da152-c363-453f-9a9e-85a4ea2c500f">sit</syl>
    <neume xml:id="m-d109f9dc-8c2d-416b-b8d6-2c7f05c1e803">
        <nc xml:id="m-7a83aed8-0e29-4860-98c4-7e92c0d9d53e" facs="#m-0b51234b-c7f9-43ff-9825-1b6fb6d8829d" oct="4" pname="c"/>
        <nc xml:id="m-dbcbbf67-8ba1-4543-bc31-1eb0ec5cf4d8" facs="#m-5a39e866-98f9-402c-8c3b-016871c0afcb" oct="4" pname="d"/>
        <nc xml:id="m-187c36d0-2860-4a81-b3ca-517a54b9059b" facs="#m-4a9aba8d-6aa9-4aa0-842f-67d643f7b4b6" oct="4" pname="c"/>
    </neume>
    <divLine xml:id="dline-0000001328159453" facs="#zone-000000649568576" form="maxima"/>
    <neume xml:id="neume-000000459266755">
        <nc xml:id="m-b306a4c2-be6e-4f52-a8a7-838de46ff7fa" facs="#m-bc721958-405e-4803-8d79-fbf86b2f2477" oct="3" pname="b"/>
        <nc xml:id="m-d33f4a58-dca8-4576-92c1-80a4c097f70b" facs="#m-7b38f835-1a99-4992-956b-7d1bbc5fcf81" oct="4" pname="c"/>
        <nc xml:id="m-819c014c-82ab-4d58-8696-2d77bcbb5ac8" facs="#m-d1eec9bf-7899-47bc-aea2-10453e8df38b" oct="3" pname="a"/>
    </neume>
    <neume xml:id="neume-0000001915701874">
        <nc xml:id="m-57693432-ed02-4348-905c-61539f5cad8a" facs="#m-5a643093-0b27-4331-969a-1907e3809db0" oct="3" pname="a" tilt="n"/>
        <nc xml:id="m-4e5cd325-c805-4c62-b541-9b6bbf80b954" facs="#m-9f86a9da-92ed-4408-a92b-64a96a483a4b" oct="3" pname="g"/>
    </neume>
</syllable>
```

# Clefs and accidentals



```
<syllable xml:id="syllable-000000107081360">
    <syl xml:id="m-a82d9779-18b6-453b-bb1d-c4cfdb920b2" facs="#m-289055a3-d5b1-4bbf-8e4a-57edefd3b7cc">le</syl>
    <neume xml:id="m-556f16d6-3b32-4627-8c26-ea08599e7c55">
        <nc xml:id="m-912a7615-6f1f-4faa-b3bc-2f9e6a3006e0" facs="#m-c71f2bc1-9501-4d4f-a748-6e1b3797cbc4" oct="4" pname="f" tilt="s"/>
        <nc xml:id="m-54839914-0d3d-4b2a-b349-1c1768f1ea2f" facs="#m-4be7d4b4-18f4-460f-b4ae-4d2ba1c922d9" oct="4" pname="e" tilt="se"/>
        <nc xml:id="m-788e20fa-58c9-4034-8225-1e4e9febbd82" facs="#m-631ac04f-6fa0-4b4c-84b3-c8e2ca619631" oct="4" pname="d" tilt="se"/>
        <nc xml:id="m-752le637-ffca-4270-b02f-48360e7dd9c4" facs="#m-23df0447-3b35-4e1e-bbac-0b0cf3c67e84" oct="4" pname="c" tilt="se"/>
    </neume>
    <neume xml:id="neume-0000001686106881">
        <nc xml:id="m-69445f1c-b9ab-4deb-bfff-d01056c4da6d" facs="#m-adfbf0d6-51ca-4eaa-98d9-948f64aef372" oct="4" pname="d" tilt="s"/>
        <nc xml:id="m-65a36dc8-741d-4fa3-9819-82d525cd75b1" facs="#m-dab90c1a-4171-4a0e-9156-36134e1c9433" oct="4" pname="c" tilt="se"/>
        <nc xml:id="m-94714093-81af-4a87-9ea5-e7e88fb19ed6" facs="#m-80966836-e7b4-42f9-933d-6b148cf42ffd" oct="3" pname="b" tilt="se"/>
        <nc xml:id="m-7f1b8bd5-7aec-4332-b0da-3f8da3bae572" facs="#m-56e747d3-8570-4c27-8496-ad3a0376dbc" oct="3" pname="a" tilt="se"/>
    </neume>
    <neume xml:id="neume-0000000088519460">
        <nc xml:id="m-40f38c70-23c9-43a9-8e8d-00ae783a02f7" facs="#m-ad0b5AAF-6ca5-46cb-a5dd-0b71883e9a14" oct="3" pname="b"/>
        <nc xml:id="m-2583661f-8768-4c07-98a9-cff9aaec4ece" facs="#m-3e34d45b-8265-451e-aa98-9a1c3d3e6d65" oct="4" pname="c"/>
    </neume>
    <divLine xml:id="m-607f3bad-ca71-4a98-a2af-627194ede655" facs="#m-0a60c6c5-2491-4e7a-b942-e1fc3c2f565b" form="maxima"/>
    <neume xml:id="neume-0000001002334329">
        <nc xml:id="m-02ce6c5-845f-40dd-9d06-76fb18f35d20" facs="#m-d3a008e3-9be0-4721-8775-858ad48b1623" oct="4" pname="e" ligated="true"/>
        <nc xml:id="m-3cdf851f-d588-443e-b014-08860d9ca250" facs="#zone-0000002040041643" oct="4" pname="c" ligated="true"/>
        <nc xml:id="nc-0000002111254339" facs="#zone-0000002061531143" oct="4" pname="d"/>
        <nc xml:id="nc-0000000943535767" facs="#zone-0000001339987311" oct="3" pname="b"/>
    </neume>
    <divLine xml:id="m-8dbc33e8-c072-48d4-adaa-33f7c62dd922" facs="#m-8dc58fa7-a83e-4371-982f-2da03dc44e7d" form="maxima"/>
    <neume xml:id="m-28beb8a5-dada-496e-bd7d-e74fd1ada589">
        <nc xml:id="m-68d4df1e-c9d1-4992-a552-7478dad28468" facs="#m-f4282e55-8d71-4926-82a1-7996263fdc9e" oct="3" pname="a"/>
        <nc xml:id="m-97bf977f-a9b2-497b-9aa5-f1ba9fd17828" facs="#m-f798d035-4da1-453c-ad12-fe248c287f8d" oct="3" pname="b"/>
        <nc xml:id="m-b8a3cf9-7773-44ec-91a2-475f71cccd54a" facs="#m-163e26df-2178-4a9f-b380-23cb8893c52f" oct="4" pname="c"/>
    </neume>
    <neume xml:id="neume-000000275735372">
        <nc xml:id="m-60a8c942-ac1a-438c-bc38-0be45a7a39ed" facs="#m-9e03f514-6c5f-422b-90f4-d4636f944e32" oct="4" pname="d" tilt="s"/>
        <nc xml:id="m-5ed995e9-a175-4660-8f53-eb9903e81850" facs="#m-d2f252b3-f6b0-4554-bccf-ec344c0067f1" oct="4" pname="c" tilt="se"/>
        <nc xml:id="m-99e1fe79-fb0d-44ae-9982-b61ed63506ca" facs="#m-ae8a862c-fb0c-4a10-bdef-eea069841ff" oct="3" pname="b" tilt="se"/>
    </neume>
</syllable>
<accid xml:id="accid-000001800857329" facs="#zone-000001734069650" accid="f"/>
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```

# Clefs and accidentals



```
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    <neume xml:id="m-556f16d6-3b32-4627-8c26-ea08599e7c55">
        <nc xml:id="m-912a7615-6f1f-4faa-b3bc-2f9e6a3006e0" facs="#m-c71f2bc1-9501-4d4f-a748-6e1b3797cbc4" oct="4" pname="f" tilt="s"/>
        <nc xml:id="m-54839914-0d3d-4b2a-b349-1c1768f1ea2f" facs="#m-4be7d4b4-18f4-460f-b4ae-4d2ba1c922d9" oct="4" pname="e" tilt="se"/>
        <nc xml:id="m-788e20fa-58c9-4034-8225-1e4e9febbd82" facs="#m-631ac04f-6fa0-4b4c-84b3-c8e2ca619631" oct="4" pname="d" tilt="se"/>
        <nc xml:id="m-7521e637-ffca-4270-b02f-48360e7dd9c4" facs="#m-23df0447-3b35-4e1e-bbac-0b0cf3c67e84" oct="4" pname="c" tilt="se"/>
    </neume>
    <accid xml:id="accid-0000001800857329" facs="#zone-0000001734069650" accid="f"/>
    <neume xml:id="neume-0000001686106881">
        <nc xml:id="m-69445f1c-b9ab-4deb-bfff-d01056c4da6d" facs="#m-adfbf0d6-51ca-4eaa-98d9-948f64aef372" oct="4" pname="d" tilt="s"/>
        <nc xml:id="m-65a36dc8-741d-4fa3-9819-82d525cd75b1" facs="#m-dab90c1a-4171-4a0e-9156-36134e1c9433" oct="4" pname="c" tilt="se"/>
        <nc xml:id="m-94714093-81af-4a87-9ea5-e7e88fb19ed6" facs="#m-80966836-e7b4-42f9-933d-6b148cf42ffd" oct="3" pname="b" tilt="se"/>
        <nc xml:id="m-7f1b8bd5-7aec-4332-b0da-3f8da3bae572" facs="#m-56e747d3-8570-4c27-8496-ad3a0376dbcc" oct="3" pname="a" tilt="se"/>
    </neume>
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        <nc xml:id="m-40f38c70-23c9-43a9-8e8d-00ae783a02f7" facs="#m-ad0b5aa-f6ca5-46cb-a5dd-0b71883e9a14" oct="3" pname="b"/>
        <nc xml:id="m-2583661f-8768-4c07-98a9-cff9aaec4ece" facs="#m-3e34d45b-8265-451e-aa98-9a1c3d3e6d65" oct="4" pname="c"/>
    </neume>
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    <clef xml:id="m-e2d7a885-315f-4f19-991b-12381690e218" facs="#m-a553f082-a7f1-437b-99f4-15a701d082b3" shape="C" line="3"/>
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    <neume xml:id="neume-0000001002334329">
        <nc xml:id="m-02cee6c5-845f-40dd-9d06-76fb18f35d20" facs="#m-d3a008e3-9be0-4721-8775-858ad48b1623" oct="4" pname="c" ligated="true"/>
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        <nc xml:id="nc-0000000943535767" facs="#zone-0000001339987311" oct="3" pname="g"/>
    </neume>
    <divLine xml:id="m-8dbc33e8-c072-48d4-adaa-33f7c62dd922" facs="#m-8dc58fa7-a83e-4371-982f-2da03dc44e7d" form="maxima"/>
    <neume xml:id="m-28beb8a5-dada-496e-bd7d-e74fd1ada589">
        <nc xml:id="m-68d4df1e-c9d1-4992-a552-7478dad28468" facs="#m-f4282e55-8d71-4926-82a1-7996263fdc9e" oct="3" pname="f"/>
        <nc xml:id="m-97bf977f-a9b2-497b-9aa5-f1ba9fd17828" facs="#m-f798d035-4da1-453c-ad12-fe248c287f8d" oct="3" pname="g"/>
        <nc xml:id="m-b8a3cfc9-7773-44ec-91a2-475f71cccd54a" facs="#m-163e26df-2178-4a9f-b380-23cb8893c52f" oct="3" pname="a"/>
    </neume>
    <neume xml:id="neume-0000000275735372">
        <nc xml:id="m-60a8c942-ac1a-438c-bc38-0be45a7a39ed" facs="#m-9e03f514-6c5f-422b-90f4-d4636f944e32" oct="3" pname="b" tilt="s"/>
        <nc xml:id="m-5ed995e9-a175-4660-8f53-eb9903e81850" facs="#m-d2f252b3-f6b0-4554-bccf-ec344c0067f1" oct="3" pname="a" tilt="se"/>
        <nc xml:id="m-99e1fe79-fb0d-44ae-9982-b61ed63506ca" facs="#m-ae8a862c-fb0c-4a10-bdef-eea0698411ff" oct="3" pname="g" tilt="se"/>
    </neume>
</syllable>
```

# Thank you!

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