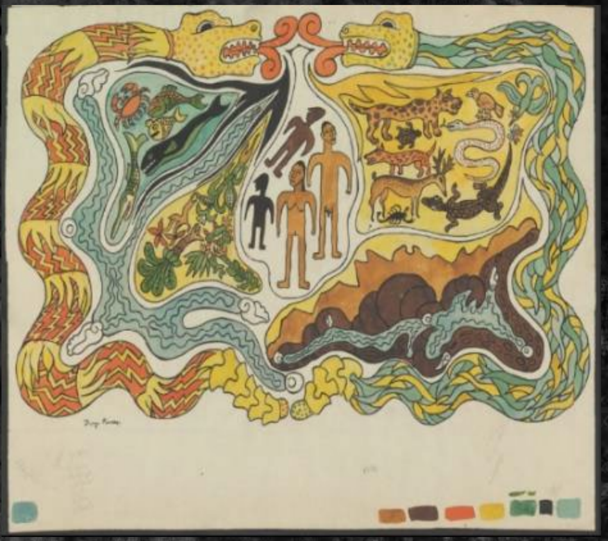
Fenella France, PhD, MBA

Library of Congress

Spectral Imaging

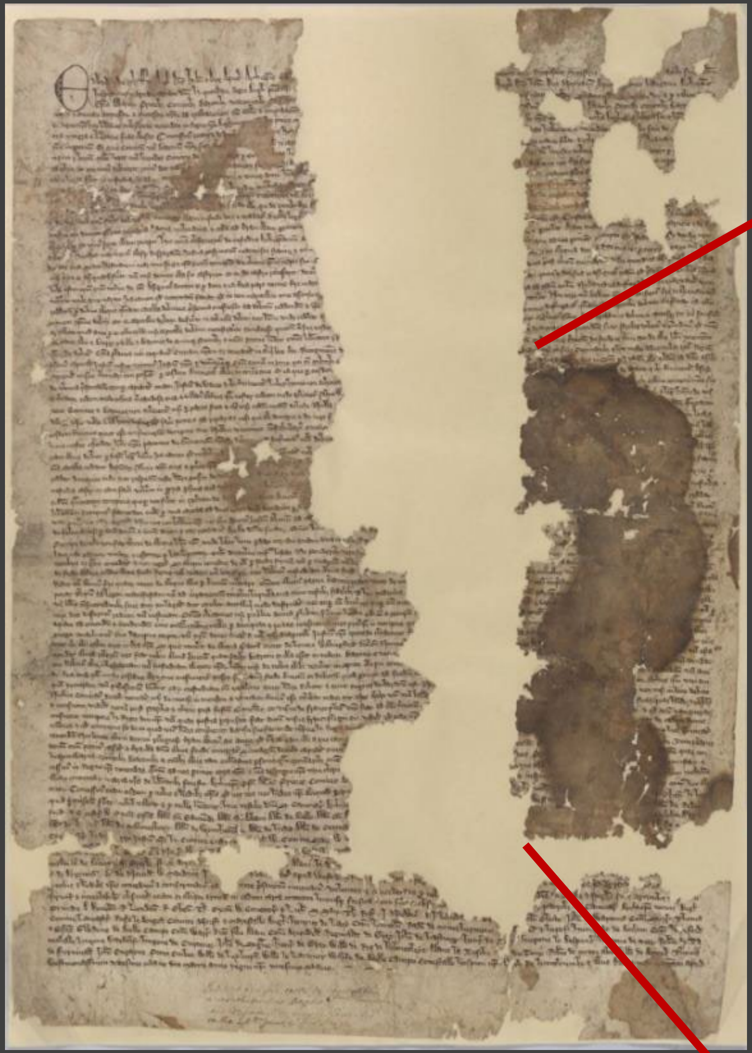


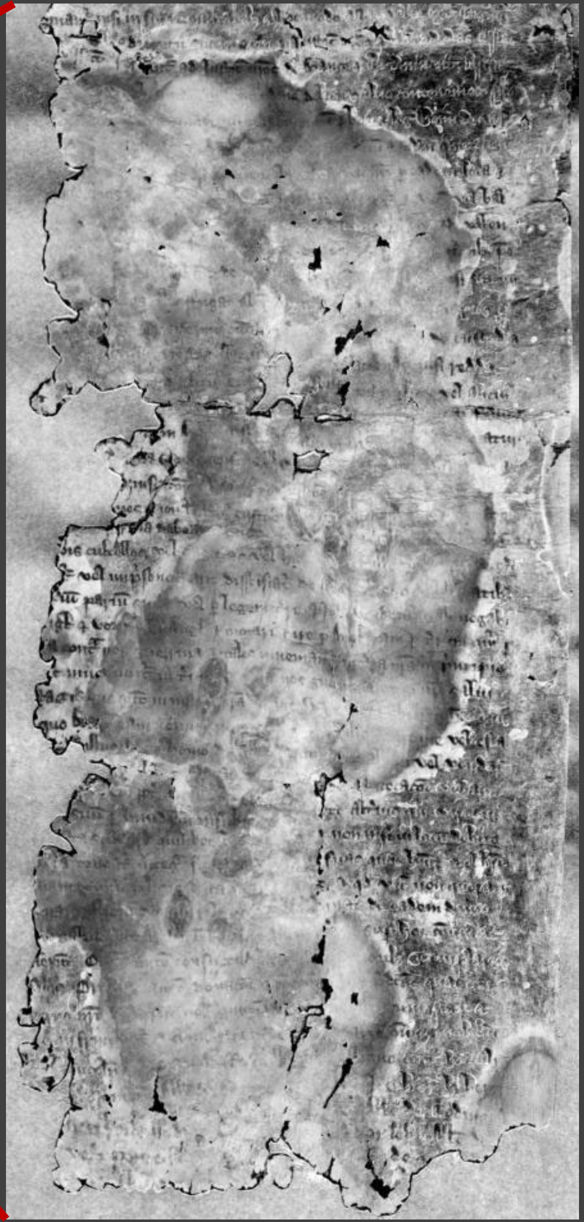
- Establish condition and assess preservation issues with multimodal imaging
  - *Determine current condition and preservation issues*
  - *Are pigments corrosive, contain harmful elements*
- Expand insights into collections with greater access to non-visible information; recovery of lost / obscured text and data
- Provenance of object for researchers / curators
  - *watermarks to accurately date paper of the document*
  - *identification of pigment, colorant*
  - *Recreate original object*

Using Multiple Imaging Modalities

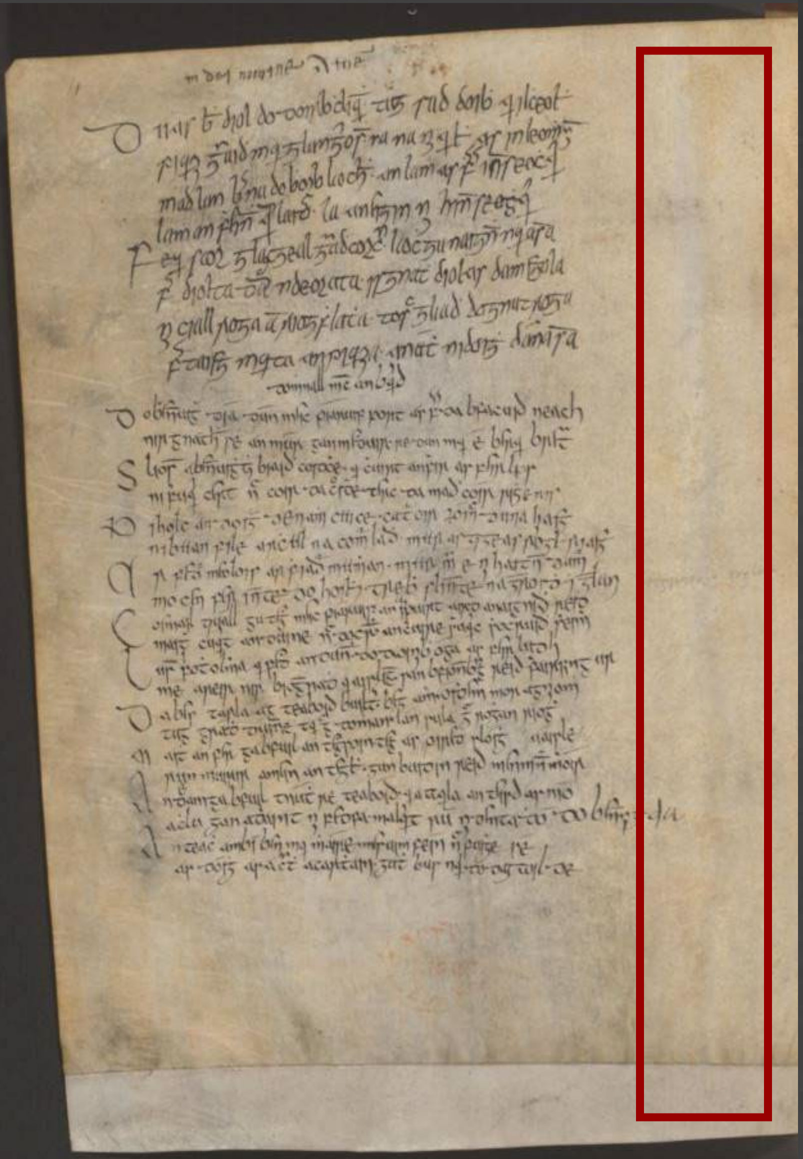
- Reflected illumination
  - Separate colors that look the same but are spectrally different; identify colorants, track changes in condition of objects
- Raking (side lighting)
  - Highlight construction techniques; indentations to recover faded text/images;
- Transmitted imaging
  - Identify treatments; capture watermarks; use with film or photographic materials; image through pages to pastedowns/rear of page
- Fluorescence
  - Characterize and separate similar organic colorants; enhance fluorescence response to assess conservation treatments
- CAPTURE ONCE, PROCESS OFTEN

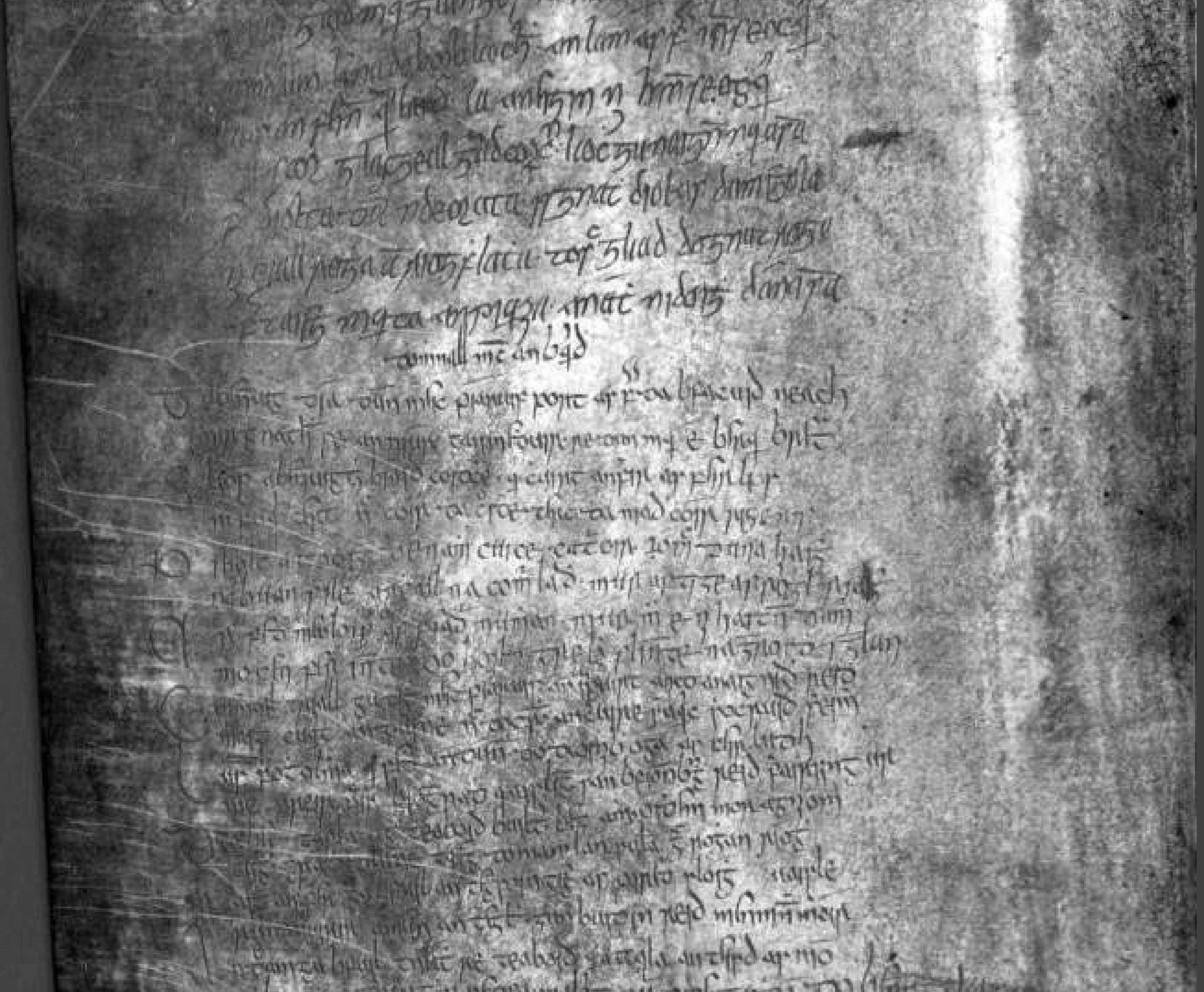
Image Processing – redactions and damage detection



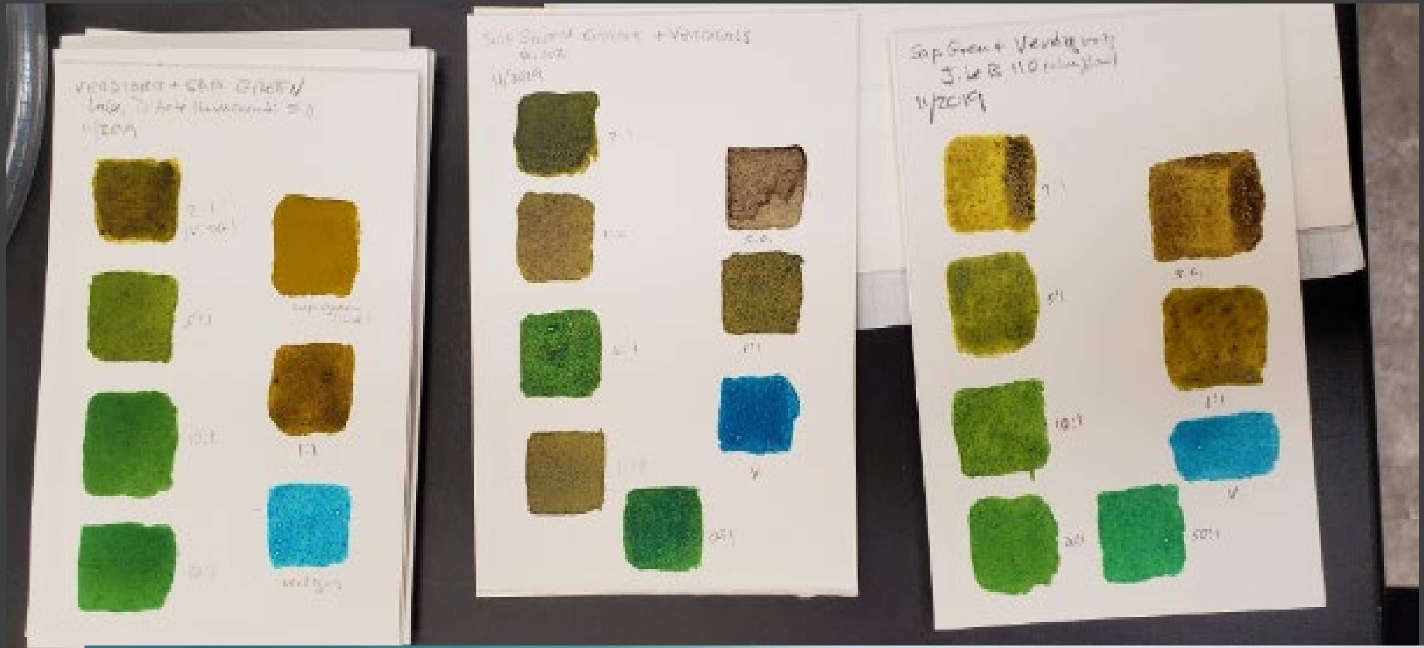


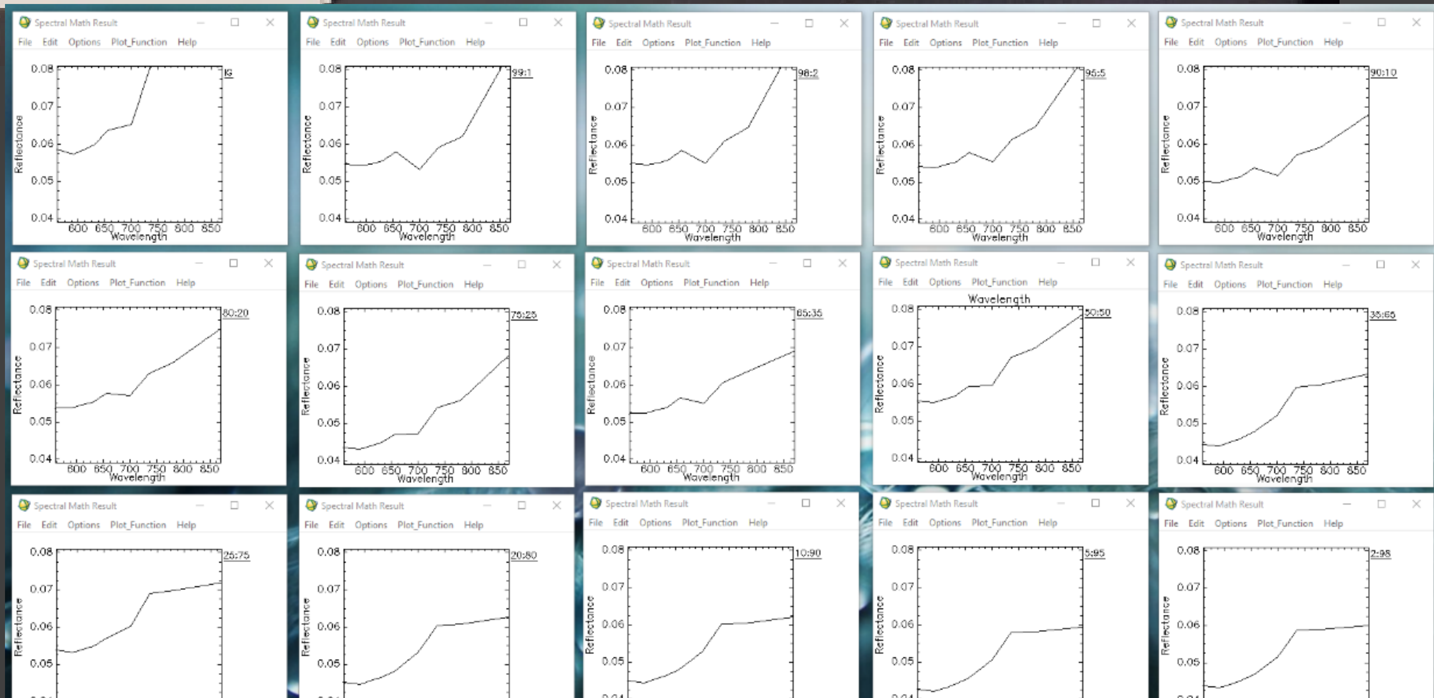
Creation Techniques





Spectral Library – Colorants, Inks, Substrates





Materials Analytical Approach & Data Fusion

Baseline imaging – mapping spectral response of a material across an entire object *(multispectral imaging)*

Range of complementary analytical techniques to build knowledge of the manuscripts

(organic/ inorganic components)

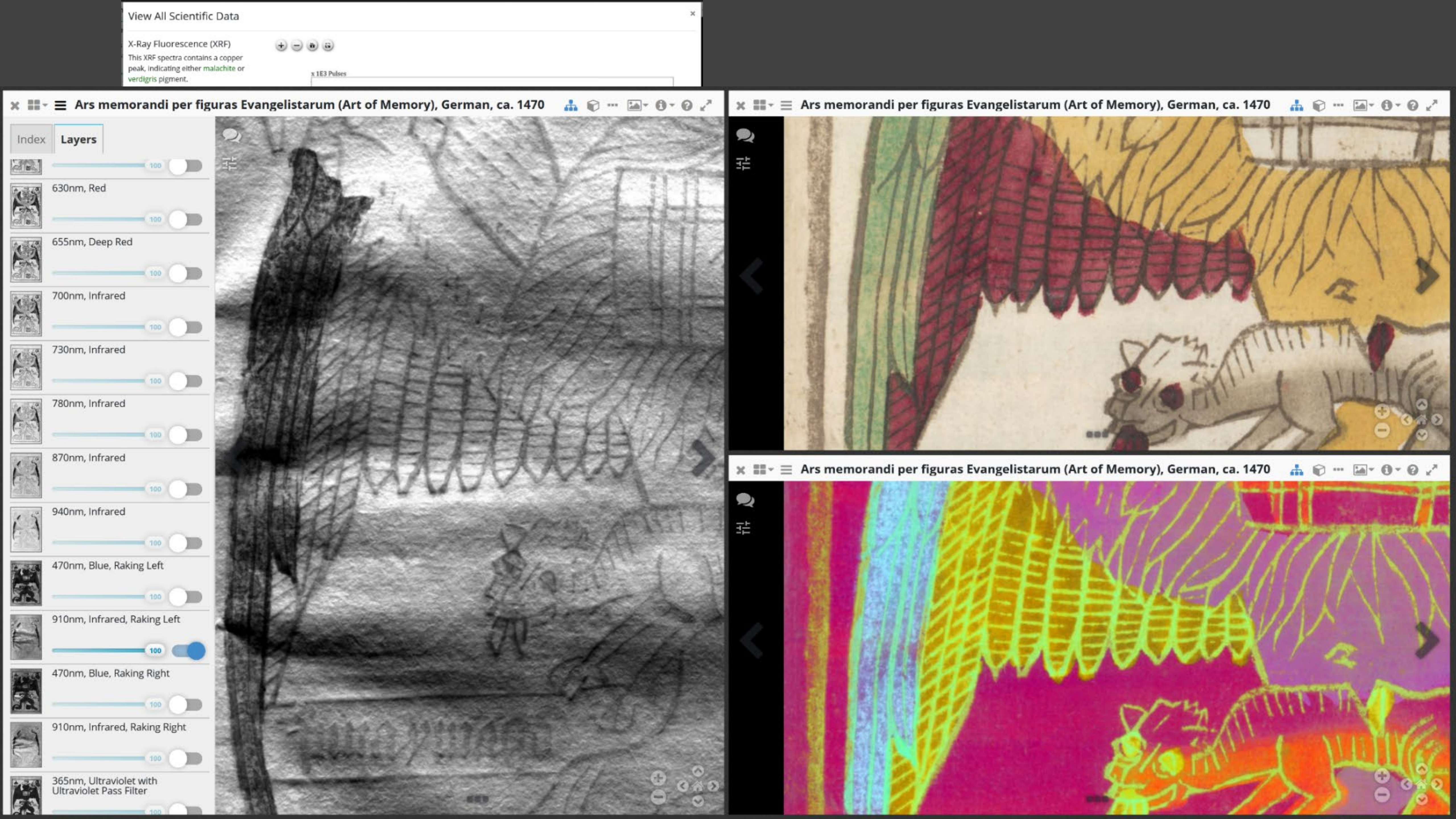
Techniques used included:

X-Ray Fluorescence (XRF), Fourier Transform Infrared Spectroscopy (FTIR), Fiber Optic Reflectance Spectroscopy (FORS), microscopy, volatiles profile of materials

The “go-team”

Prioritizing and creating a structured approach to resources, time demands and complementary data to answer research questions

“active learning”


View All Scientific Data
X-Ray Fluorescence (XRF)
This XRF spectra contains a copper peak, indicating either malachite or verdigris pigment.
x 1E3 Pulses
Ars memorandi per figuras Evangelistarum (Art of Memory), German, ca. 1470
Index
Layers
630nm, Red
655nm, Deep Red
700nm, Infrared
730nm, Infrared
780nm, Infrared
870nm, Infrared
940nm, Infrared
470nm, Blue, Raking Left
910nm, Infrared, Raking Left
470nm, Blue, Raking Right
910nm, Infrared, Raking Right
365nm, Ultraviolet with Ultraviolet Pass Filter
Ars memorandi per figuras Evangelistarum (Art of Memory), German, ca. 1470
Ars memorandi per figuras Evangelistarum (Art of Memory), German, ca. 1470

Francesca Gabrieli, PhD

Rijksmuseum

Reflectance Imaging Spectroscopy at *The Night Watch*

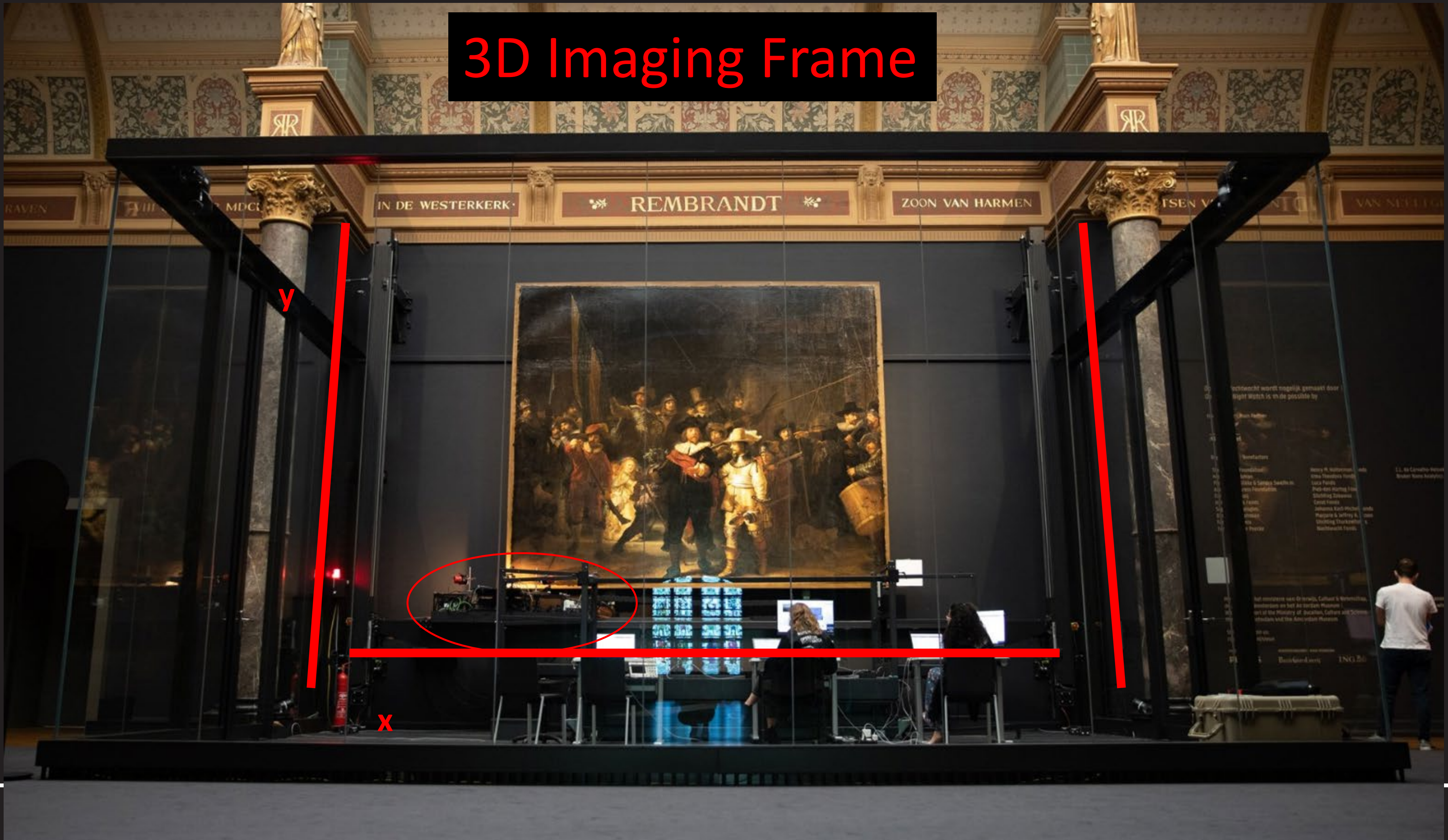
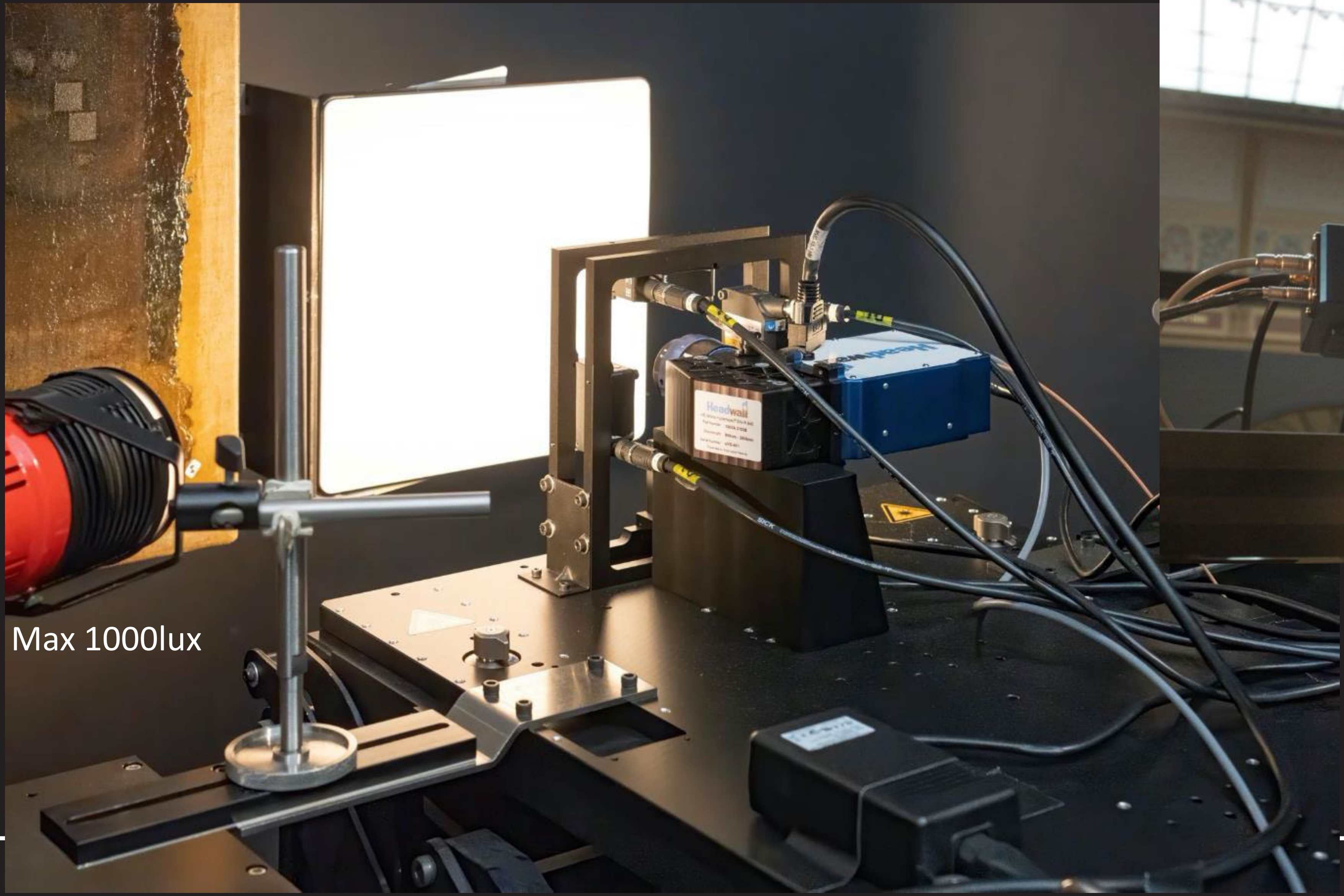
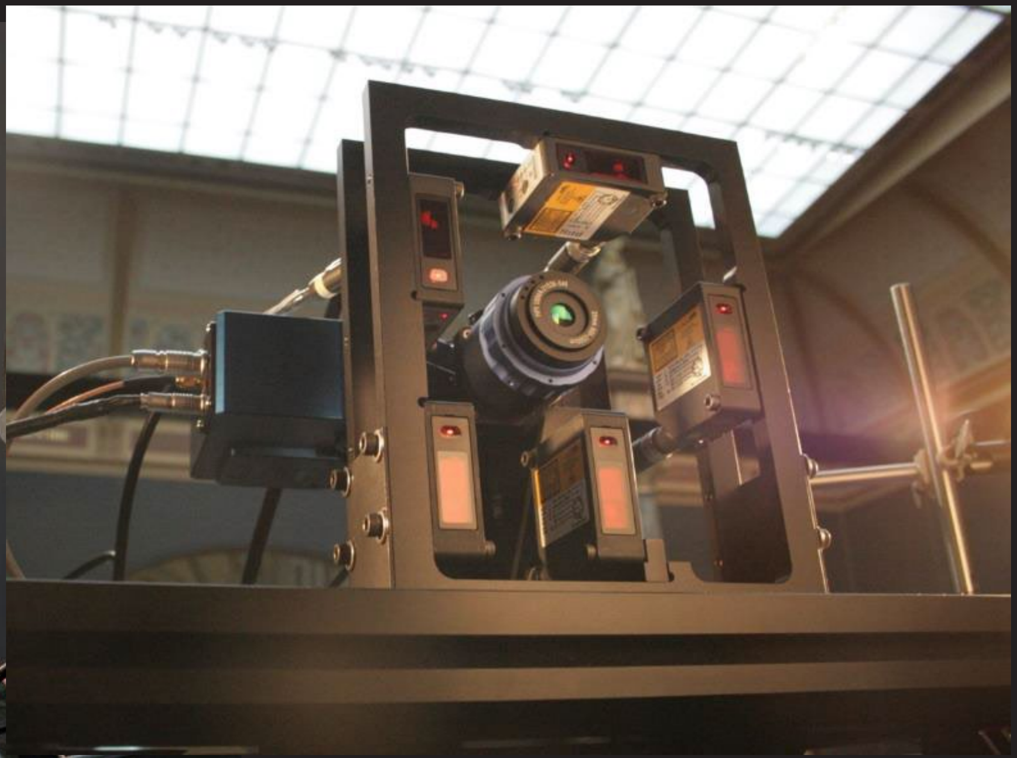


Photo: Reinier Gerritsen

Auto Focus Using Lasers Sensor



Max 1000lux



The platform was programmed to move (in or out) when it was outside of a narrow range of distances around the depth of field, measured with lasers in order to keep a spatial resolution of 168um.

For VNIR: bottom laser
For SWIR: average of top and bottom laser

SWIR camera

RIS-VNIR scanning of *The Night Watch*: planning

2/10% overlap h/v

3 columns

26 rows

2/14% overlap h/v

3 columns

41 rows

78 swaths: 780GB (32bit) data acquired

123 swathas:765GB (32bit) data acquired

RIJKS MUSEUM

Spatial resolution at the painting: 0.168um

Challenges of data processing of *The Night Watch*

1) **Eliminating the glints of the laser** (anomaly detection algorithm ENVI)

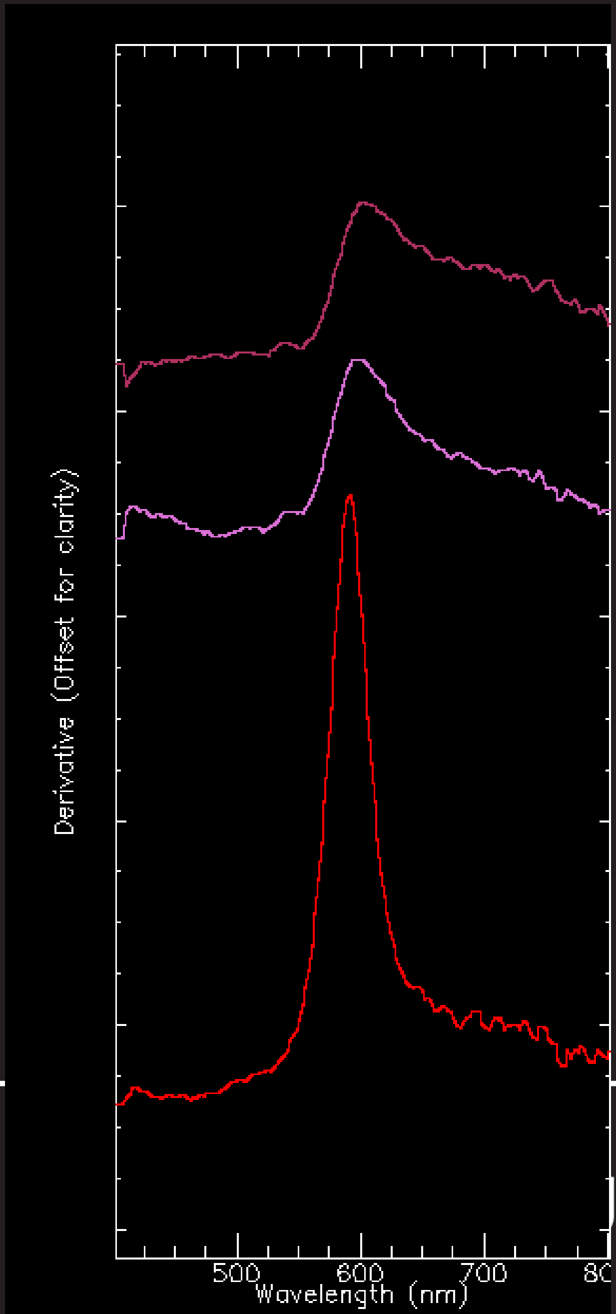
2) **Anomalies in dataset due to electricity instability** (DESTRIPE)

3) **Reduce random noise** (MNF)

4) **Finding endmembers for pigment in mixtures and degraded pigments** (linear unmixing)

5) **Using mapping tools for such a huge dataset** (powerful computers)

Mapping of organic pigments –m Red Lake



Organic Lake

Orgamic Lake
+ Vermillion

Vermillion

Roger Easton, PhD

Rochester Institute of Technology

Recent MSI Processing Example:

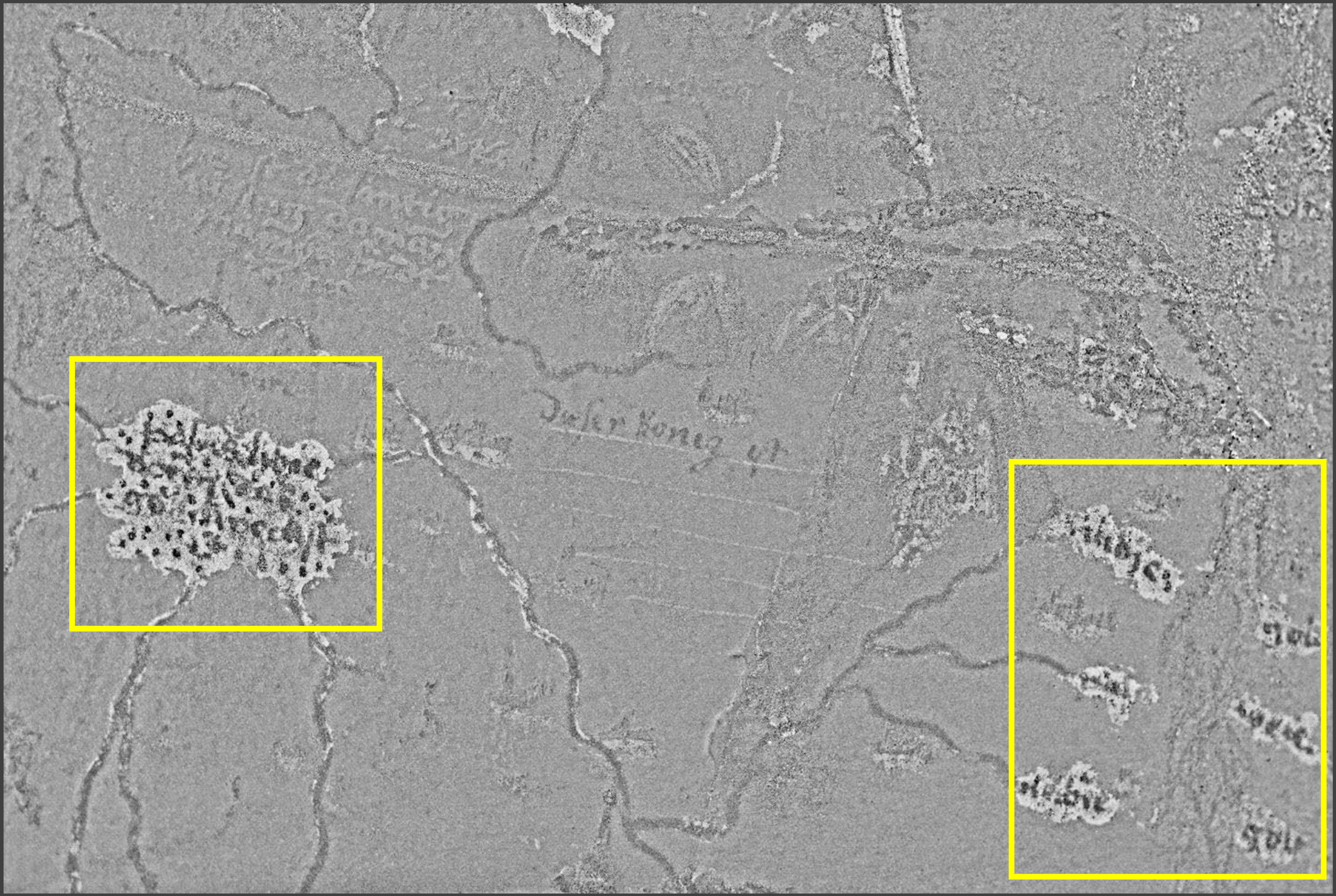
- *Erdapfel* (“Earth Apple”) Globe at *Germanisches Nationalmuseum*, Nürnberg
  - 51-cm diameter
  - fabricated circa 1490-1492
  - has been erased and overwritten in spots
- 2022 processing of 2017 test images of two tiles collected by Ken Boydston of *Megavision*

Roger L. Easton, Jr., Chester F. Carlson Center for Imaging Science
Rochester Institute of Technology, easton@cis.rit.edu, 1-585-475-5969

Image credit: https://globemakers.com/facsimile/globe_behaim.html

1. African Interior

Image credit: Kenneth Boydston, *MegaVision*

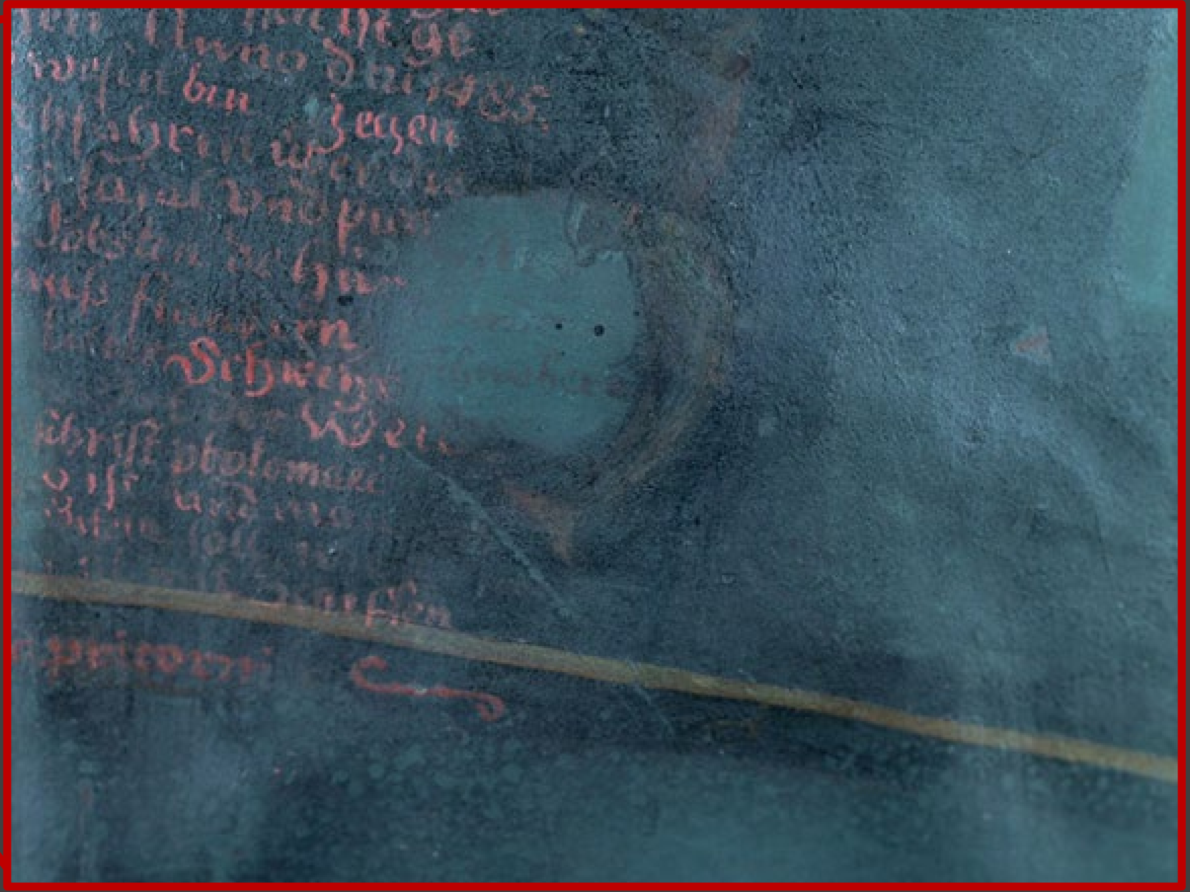


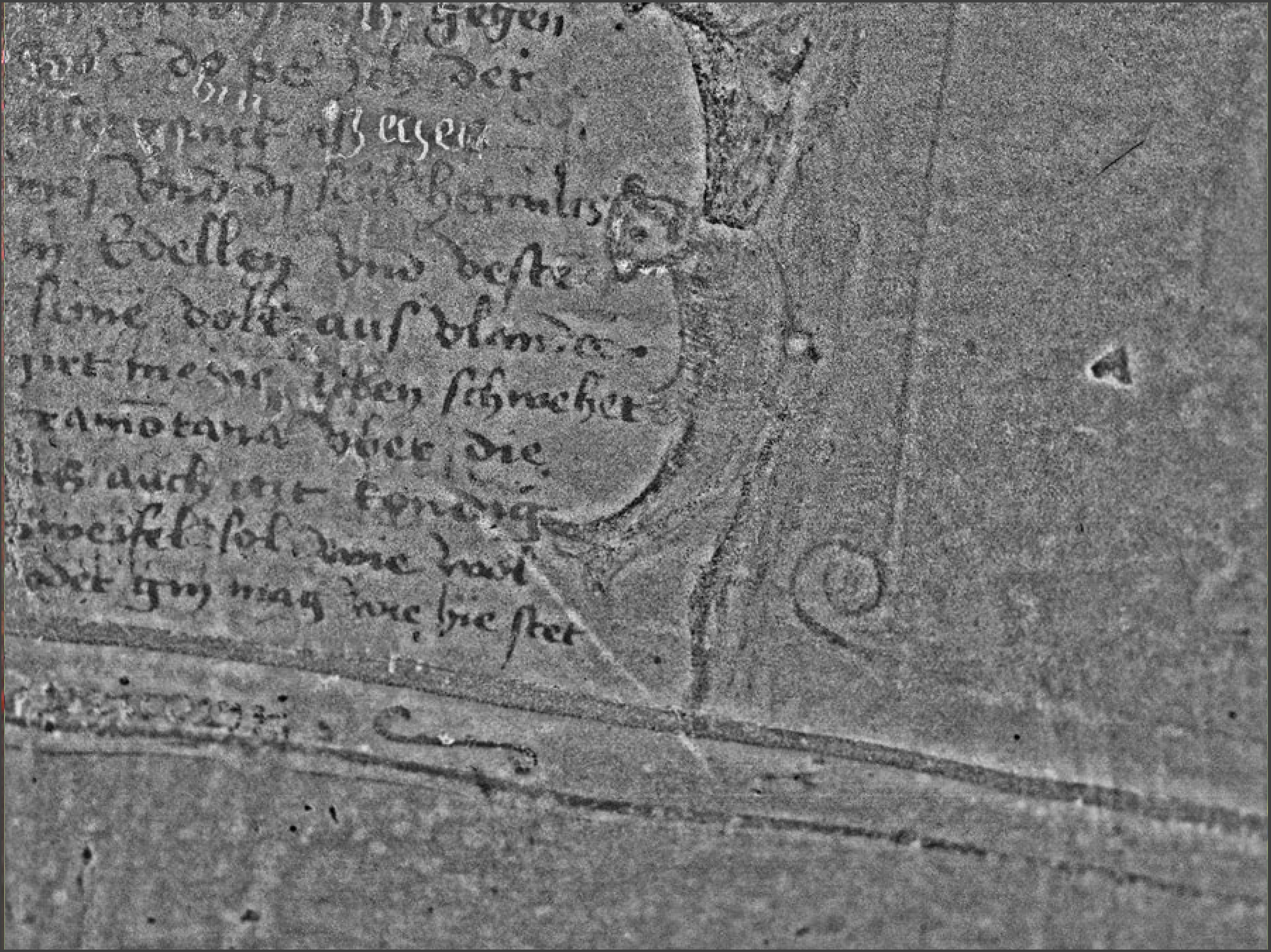
Visual Appearance

Previously unsuspected texts in water bodies

24 bands, “blur and divide” (51 × 51 box × 5), statistics from lake, Minimum Noise Fraction Band 24

2. South Atlantic





13 reflective bands
local statistics, MNF

Different undertext
6 infrared reflective bands
statistics from entire scene
MNF+4, Gaussian rendering

John K Delaney, PhD

National Gallery of Art

Imaging Spectroscopy at
The National Gallery of Art, Washington

National Gallery of Art

Macro-XRF Scanner (XRF-IS)

- XG labs detector with $50 mm^2$ area
- 0 to 26 keV, 0.0137 keV sampling
- 40 msec integration
- 750 μA, 50 kV Rhodium (XOS)
- 0.10 mm to 1 mm x-ray spot size (spatial)
- Scan area 1.5 by 1.5 m
- Single pixel scanner
- Scan time: $1 m^2$ at $1 mm^2$ sampling in 12 hr

VNIR & SWIR Hyperspectral Camera (RIS, FIS)

- EMCCD & InSb Focal Plane Arrays
- 380 to 950 nm, 2.5 nm sampling
- 1000 to 2500 nm, 2.8 nm sampling
- 100 to 150 msec integration
- 0.18 mm spatial sampling size
- TH Lamps at 1000 lux
- Line scanner (1024 pixels along slit)
- Scan time: $1 m^2$ at $1 mm^2$ sampling in 5 min

The Feast of the Gods

Giovanni Bellini and Titian, 1514/1529

National Gallery of Art, Washington, Widener Collection

National Gallery of Art

False color SWIR RIS

Simulation constructed from SWIR Transmitted Images, SWIR RIS by Ms. Becca Goodman

Appendix in “Giovanni Bellini The Last Works”, by David. A. Brown, Publisher Skira Editore, 2019

Truth Data Sets Exist

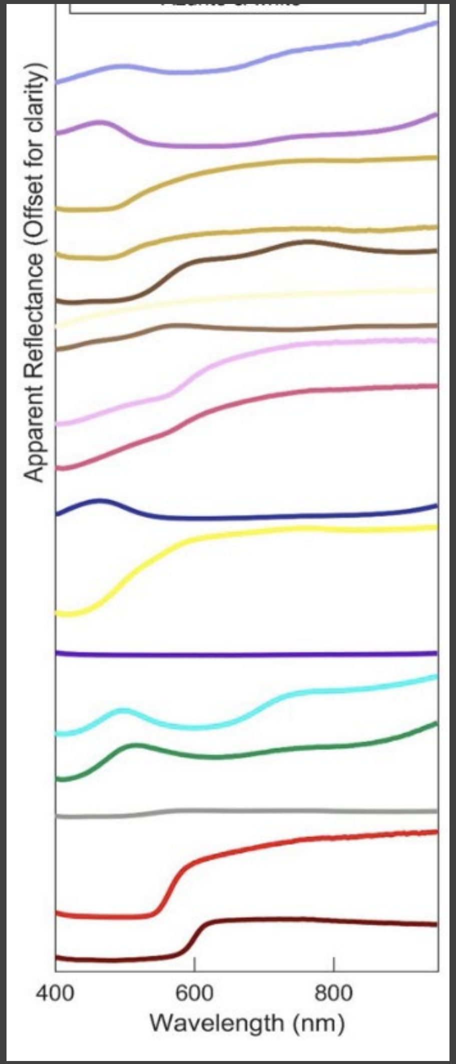
- Classified using ENVI-SHW
- Pigments have been identified

Christ and the Virgin Enthroned with Forty Saints

Master of the Dominican Effigies c. 1340

From the Laudario of Sant’ Agnese

RIS classification (400-950 nm), pigment identification using results from spot XRF and reflectance spectroscopy 350 to 2500 nm



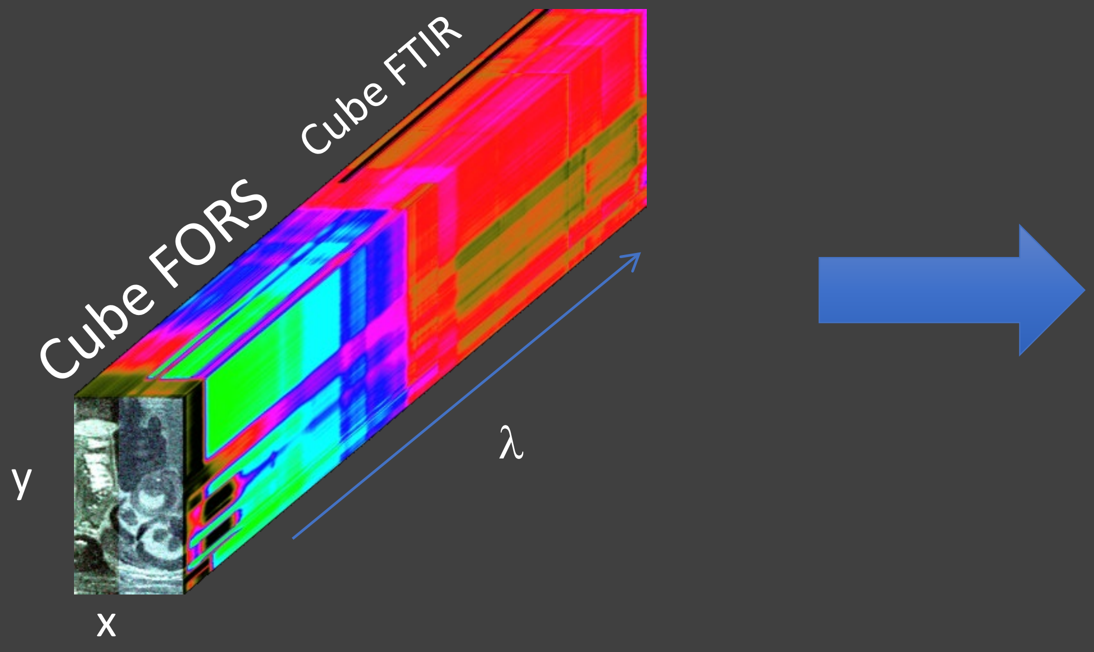
Rosenwald Collection, National Gallery of Art, 1959.16.2

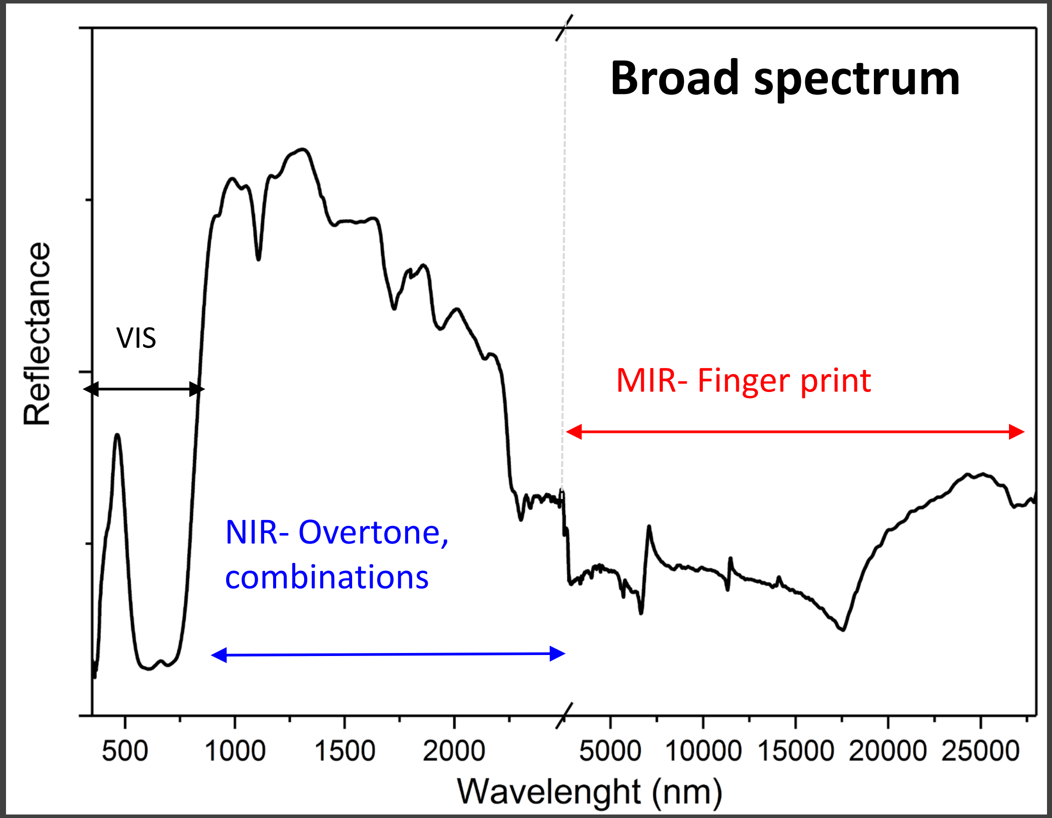
Kleynhans et al., Microchemical Journal, March 2020

BR-RIS Proof of Concept – Image Cube Formation

1. Convert mid-IR data to Reflectance and nm
2. Combine nUV-Vis-NIR spectra with mid-IR (concatenated at 2500 nm & Scale only)

   (Since spectra are collected with the same spatial sampling and since easel moves the painting using positional information)
3. Final cubes spatial x by y pixels and z bands!





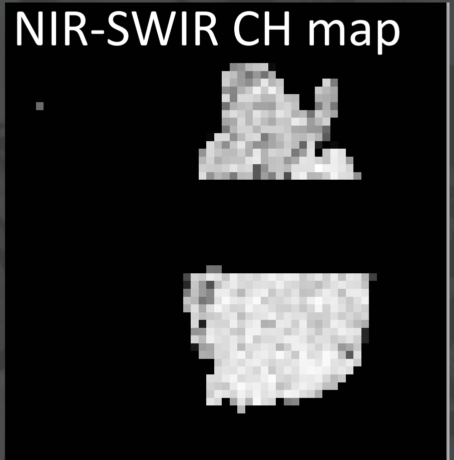
350 to 28,000 nm (or 28,000 to 350 cm^{-1})

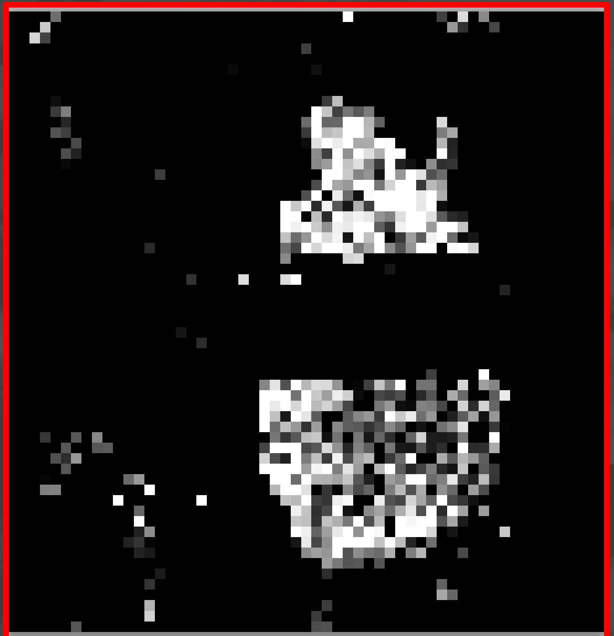
Gabrieli et al. *Science Advances, vol 5 #8*, 2019

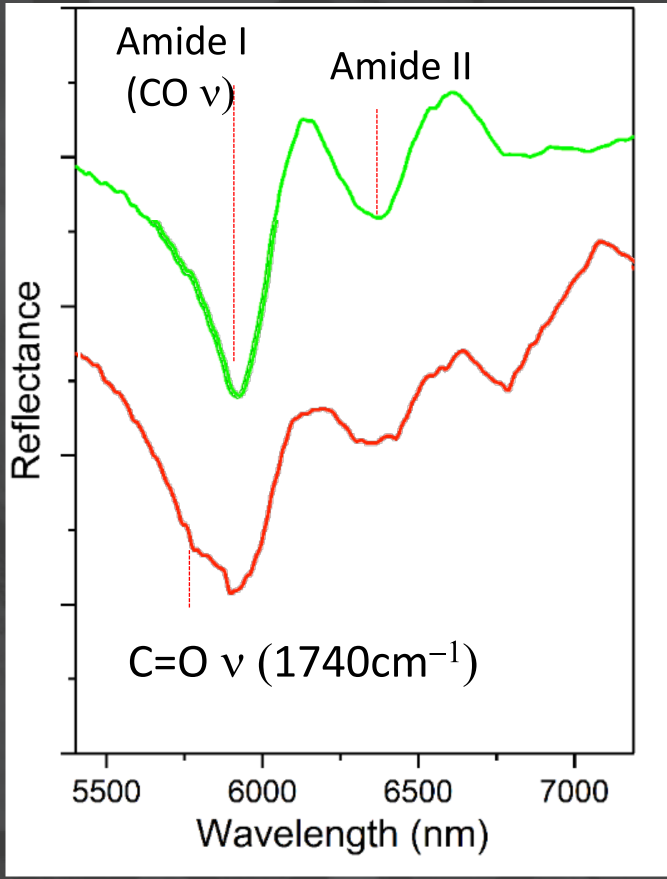
National Gallery of Art

BR-RIS on manuscript: Binders mapping

Color image of scanned detail:
Praying Prophet, **Lorenzo Monaco**, 1410/1413-Rosenwald Collection NGA







Green = proteic component due to the presence of Amide I and II

Red = proteic component + lipidic component (C=O stretching at ~5700nm or 1740 cm^{-1})

Confirmation of the presence of egg yolk binding media