

X-ray radiation in art

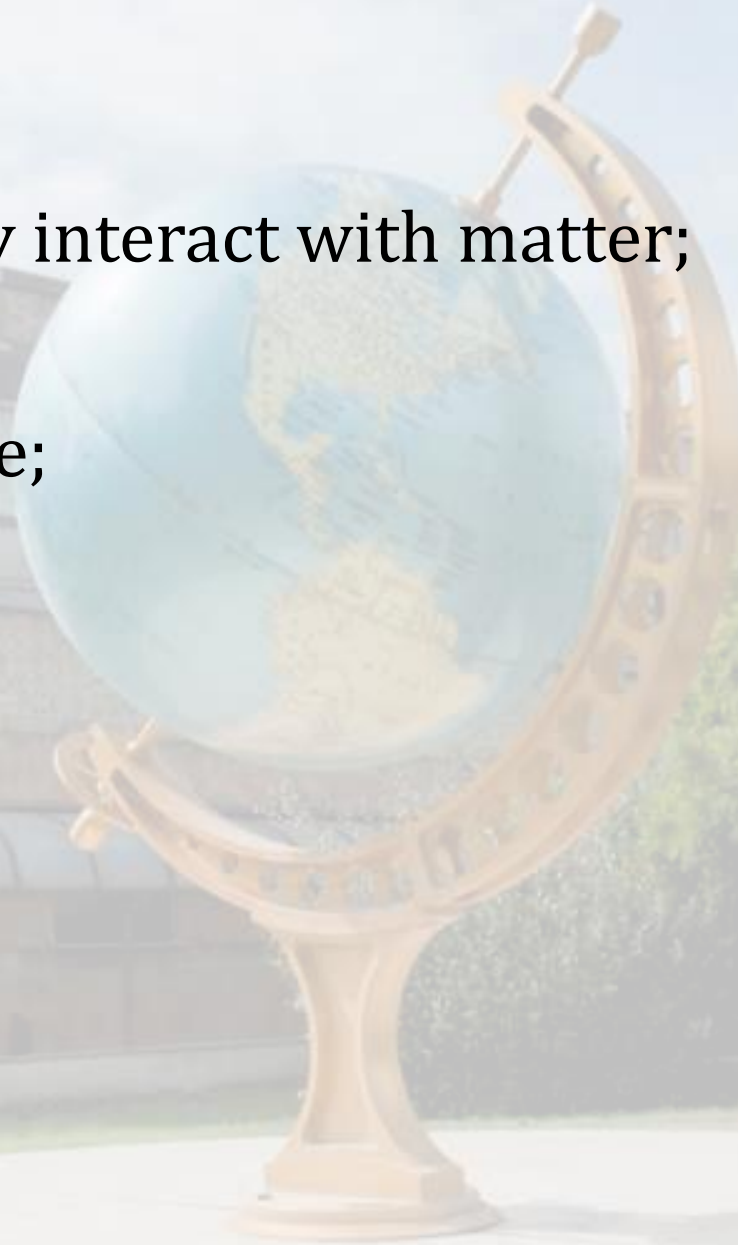
Application, use and limitations

Speaker: Sergio Augusto Barcellos Lins

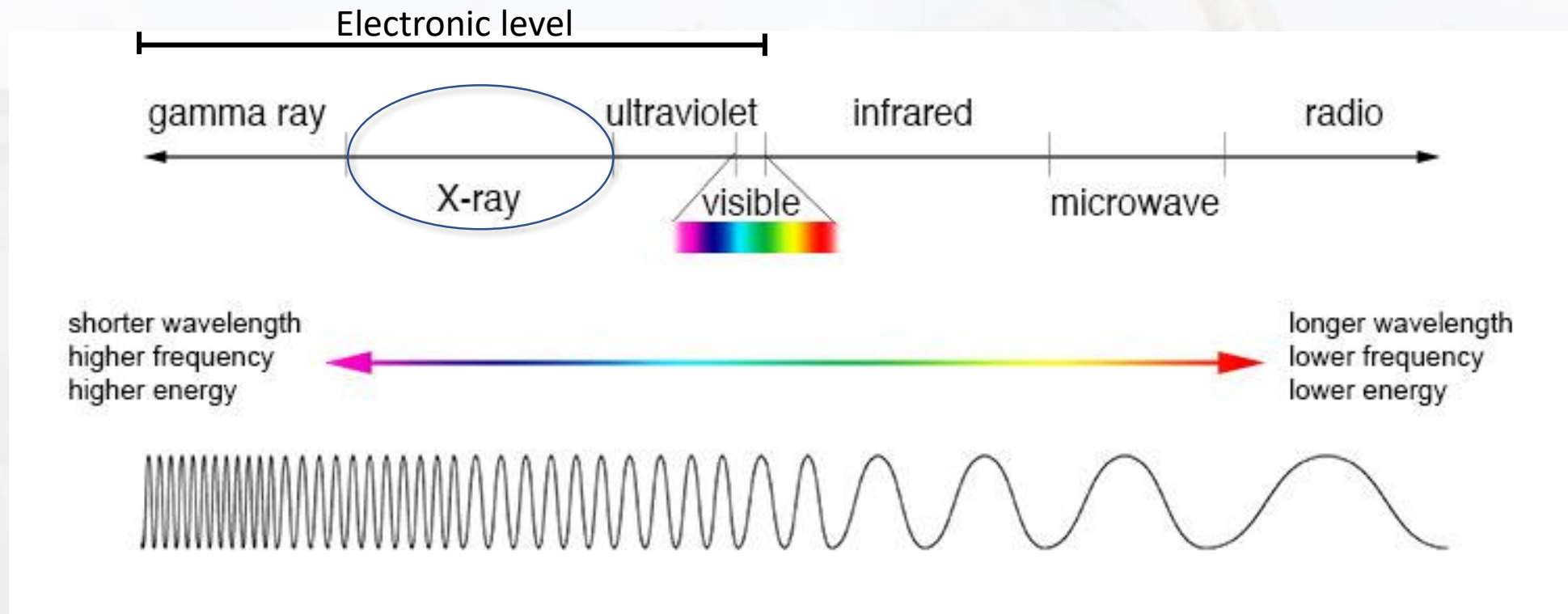
sergio.lins@roma3.infn.it

Overview

- What are X-rays and how they interact with matter;
- Transmittance vs fluorescence;
- Diagnostic;
- Dose;



Introduction



Visible light:

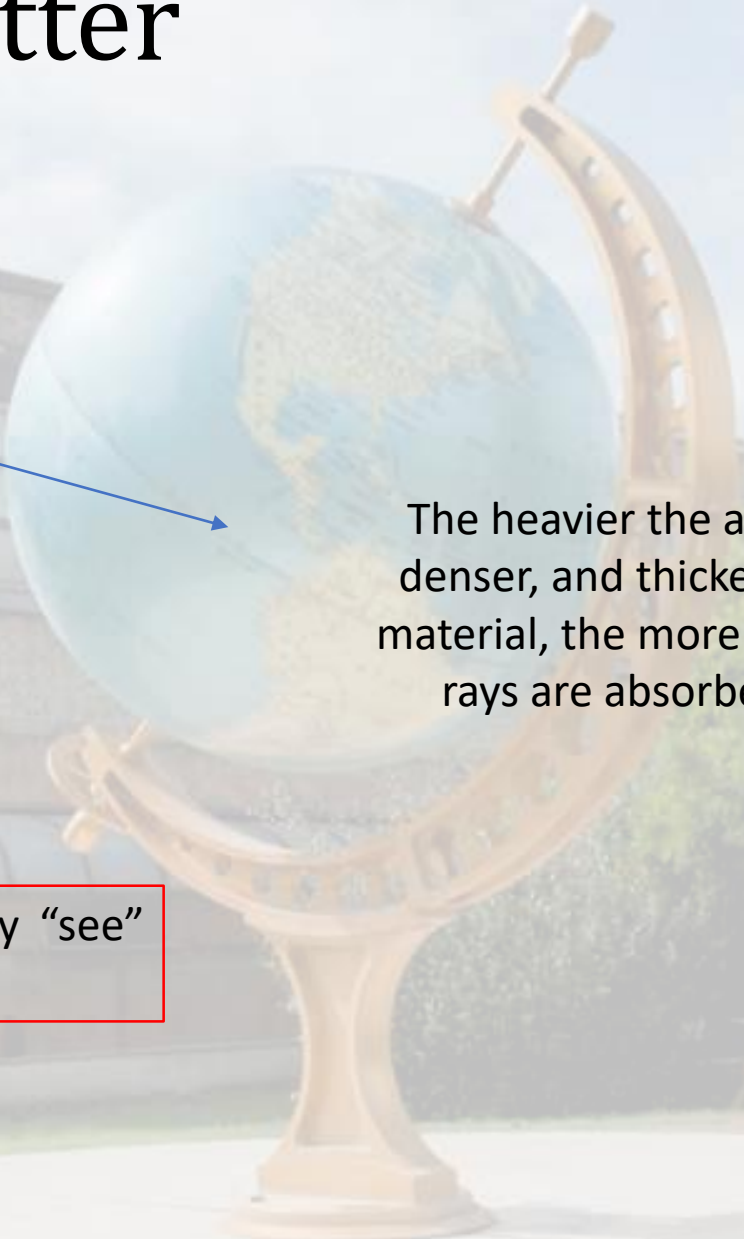
$\pm 700 - 400 \text{ nm}$

X-Rays:

$\pm 8.20 - 0,01 \text{ nm}$

Interaction with matter

- Atomic number
- Density
- Thickness

A globe on a stand is positioned in the center-right of the slide. A blue arrow points from the text block on the right towards the globe. The background is a faded image of a building and trees.

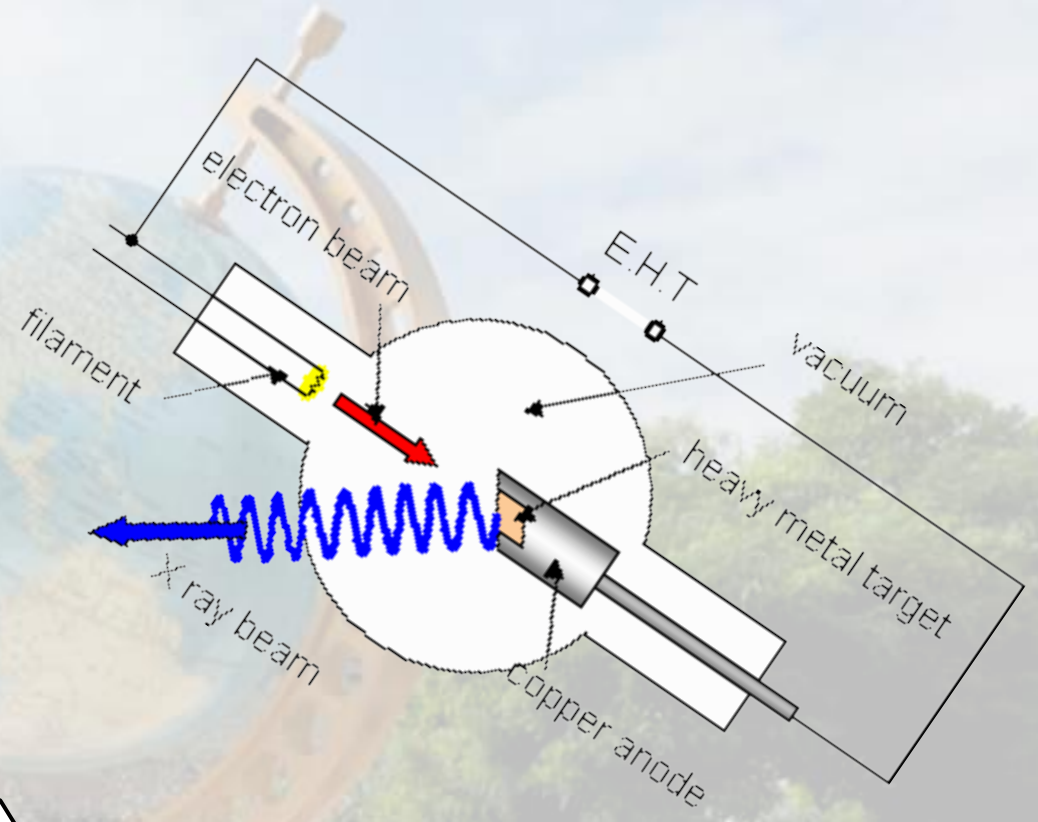
The heavier the atom, denser, and thicker the material, the more the X-rays are absorbed!

X-rays interact at an electronic level, what they “see” are the atoms that compose the material.

Detector (Transmission)
imaging



Detector (Fluorescence)



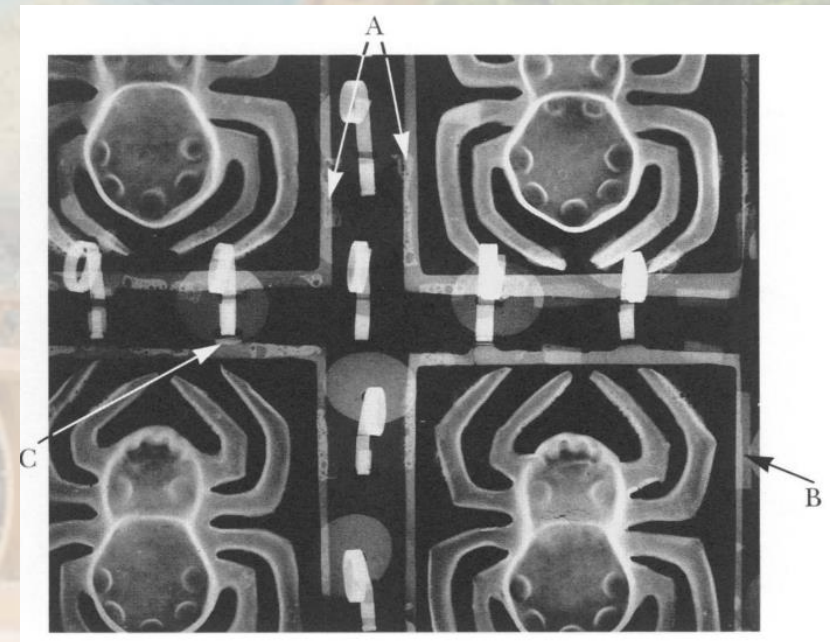
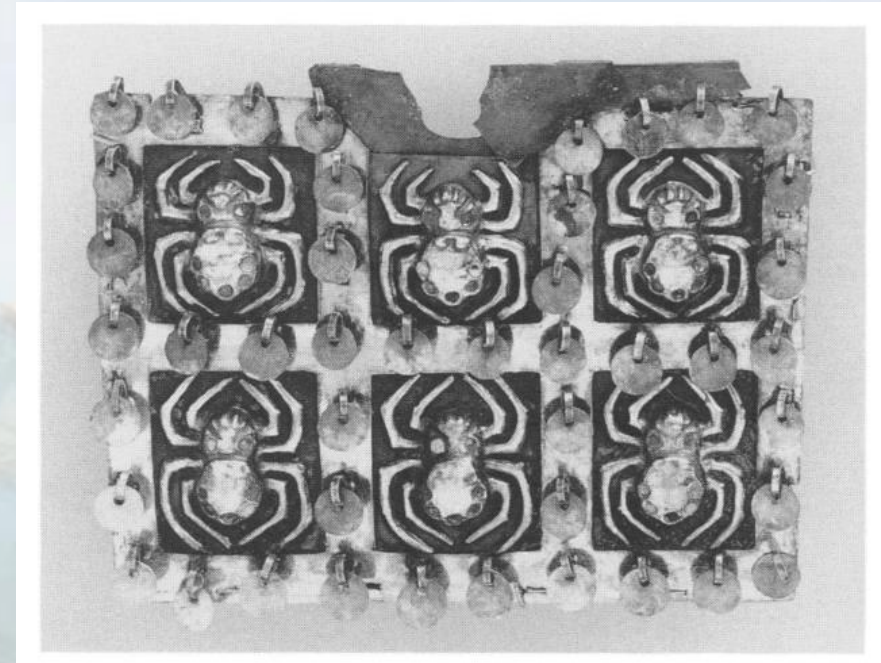
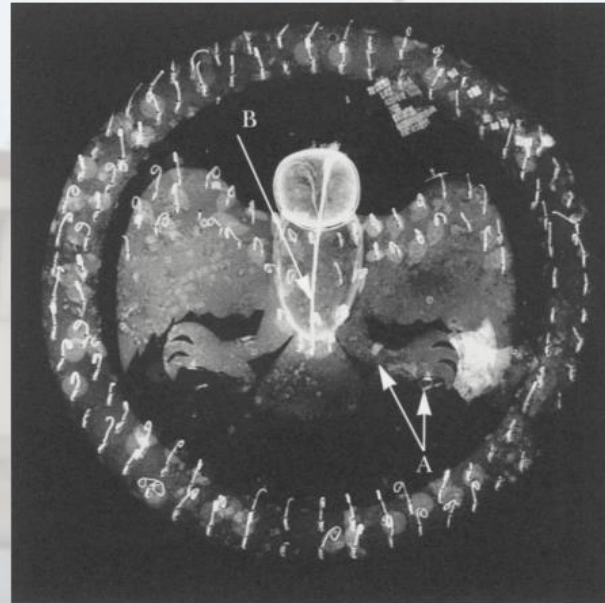
Radiographs



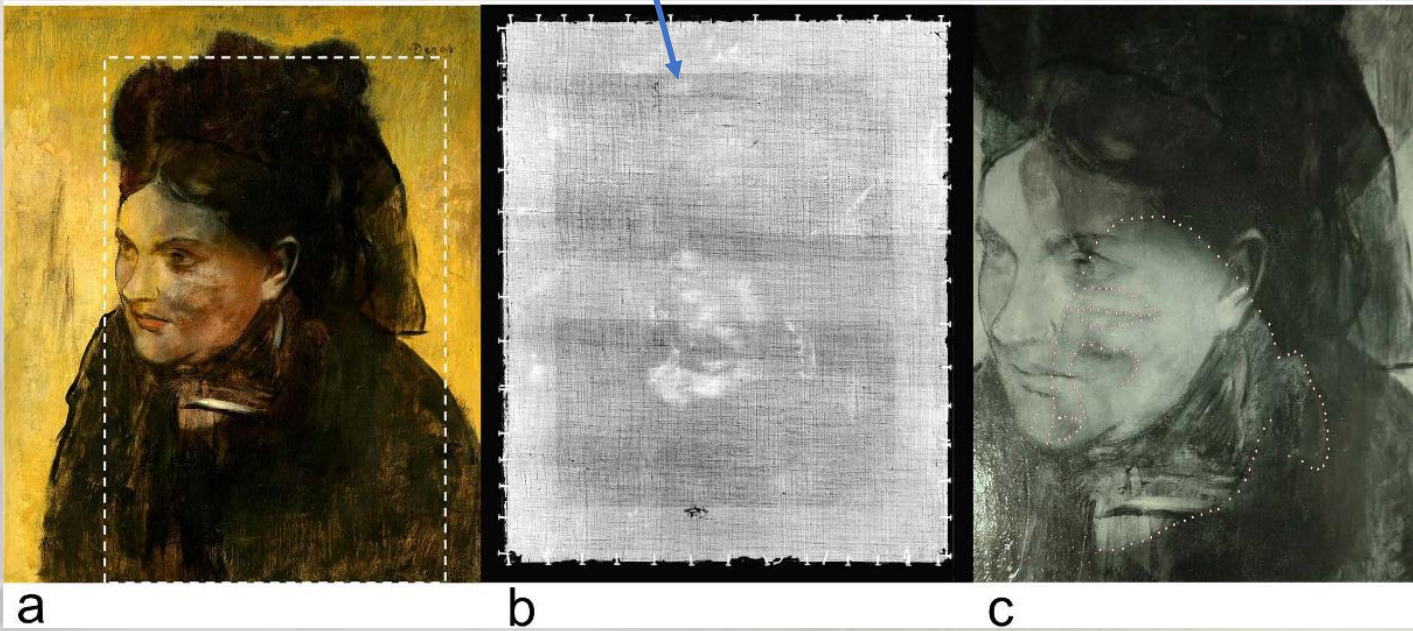
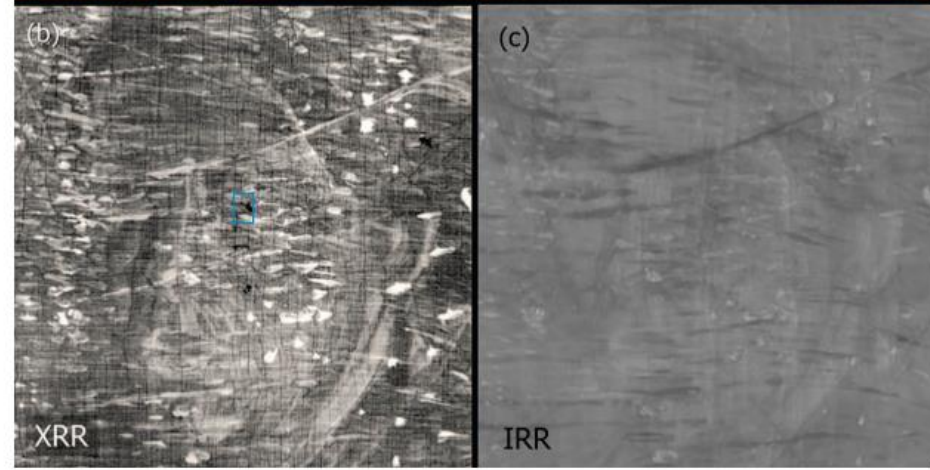
Vandivere, Abbie & van Loon, Annelies & Dooley, Kathryn & Haswell, Ralph & Erdmann, Robert & Leonhardt, Emilien & Delaney, John. (2019). Revealing the painterly technique beneath the surface of Vermeer's Girl with a Pearl Earring using macro- and microscale imaging. *Heritage Science*. 7. 10.1186/s40494-019-0308-4.



Radiographs



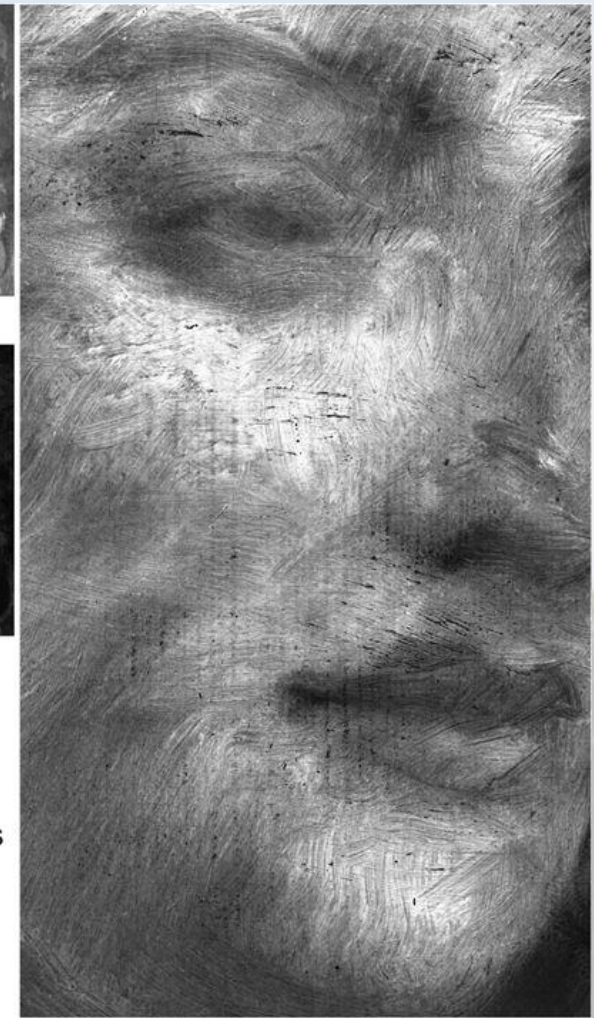
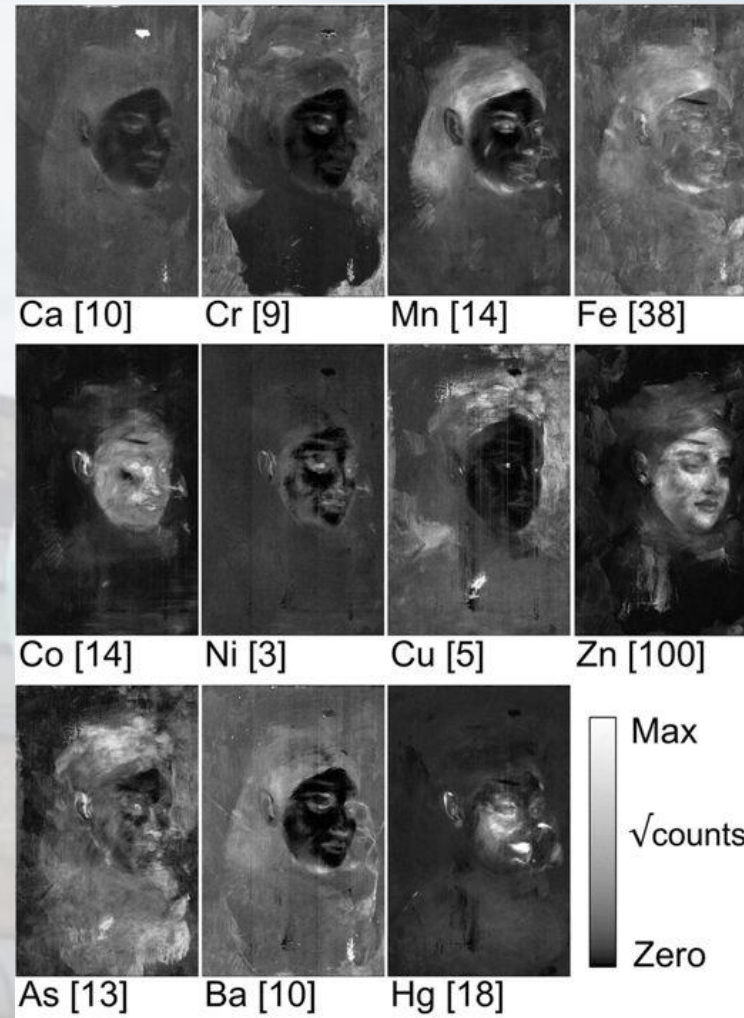
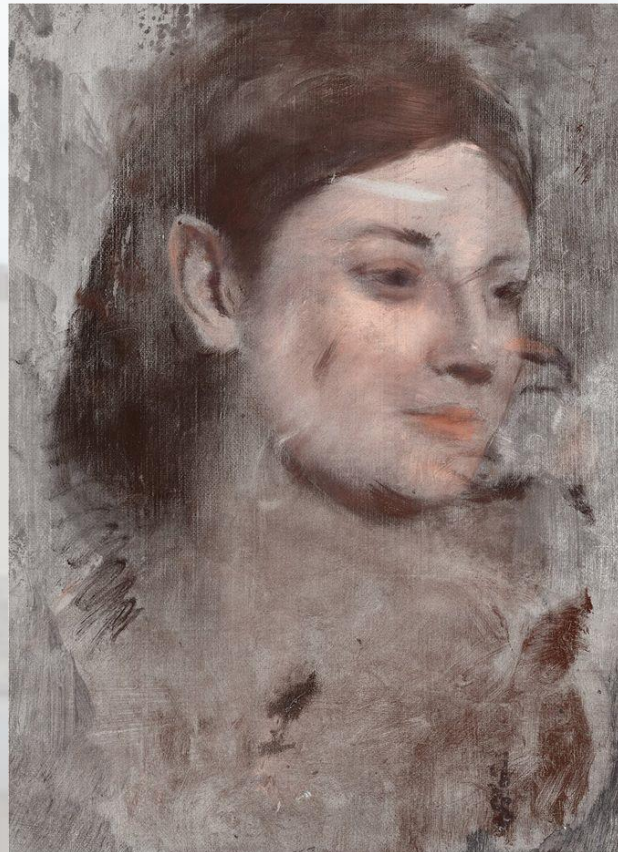
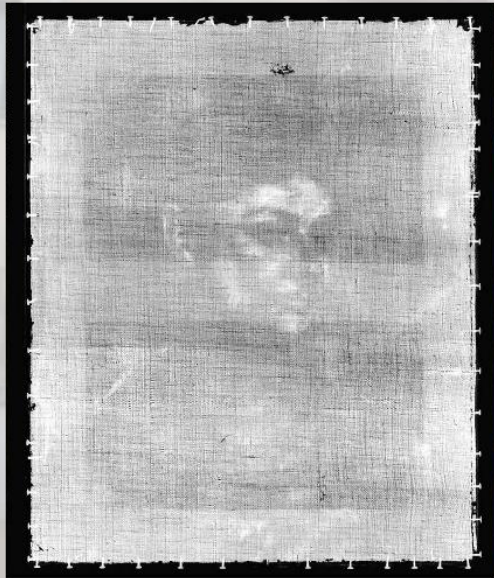
- Voids;
- Cracks;
- Past interventions;
- Hidden paintings!



Joris Dik, Koen Janssens, Geert Van Der Snickt, Luuk van der Loeff, Karen Rickers, and Marine Cotte *Analytical Chemistry* **2008** 80 (16), 6436-6442 doi: 10.1021/ac800965g

Thurrowgood, D., Paterson, D., de Jonge, M. *et al.* A Hidden Portrait by Edgar Degas. *Sci Rep* **6**, 29594 (2016) doi:10.1038/srep29594

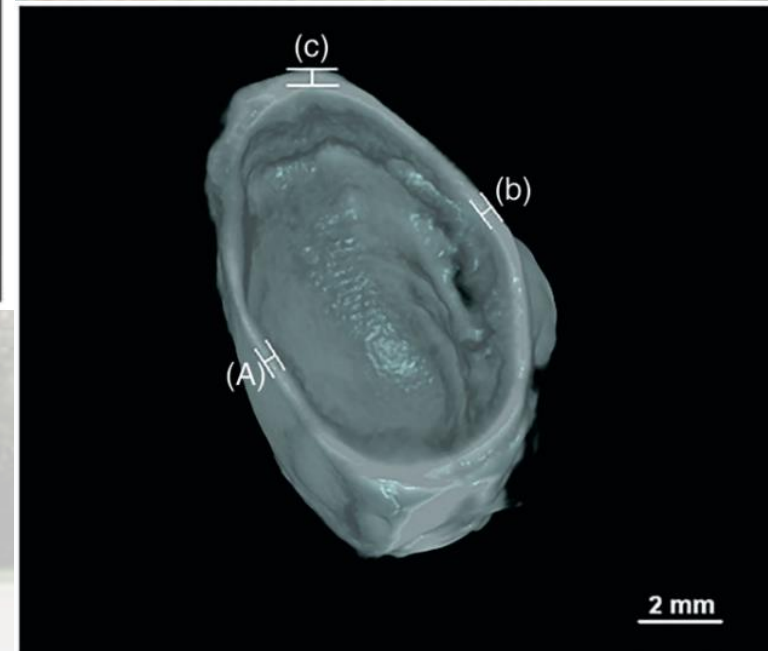
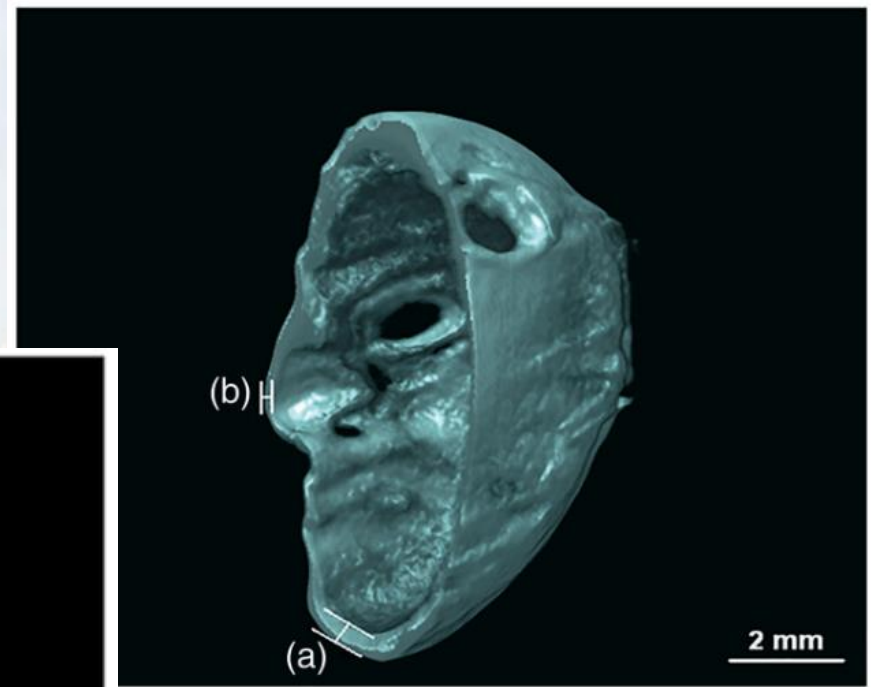
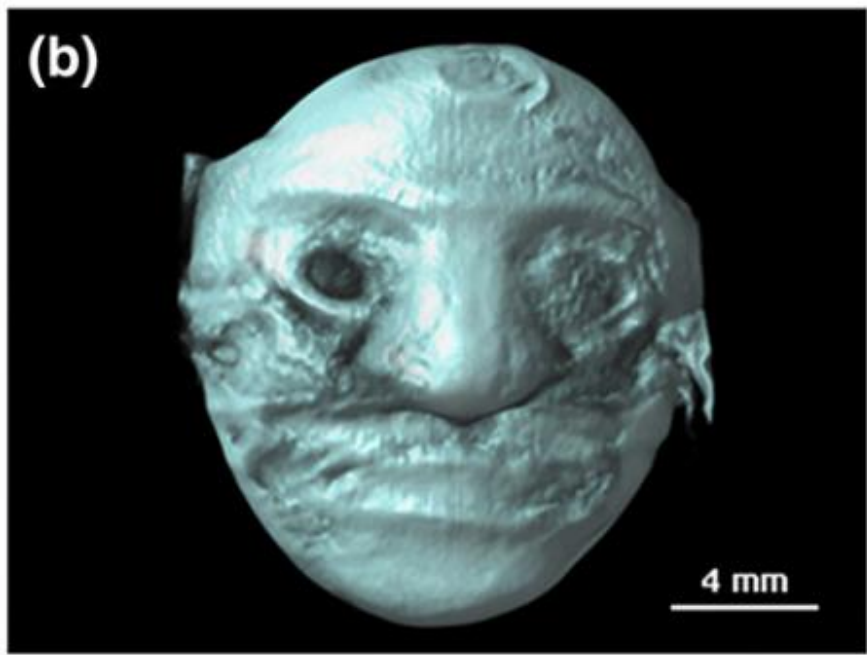
- Hidden paintings!



a

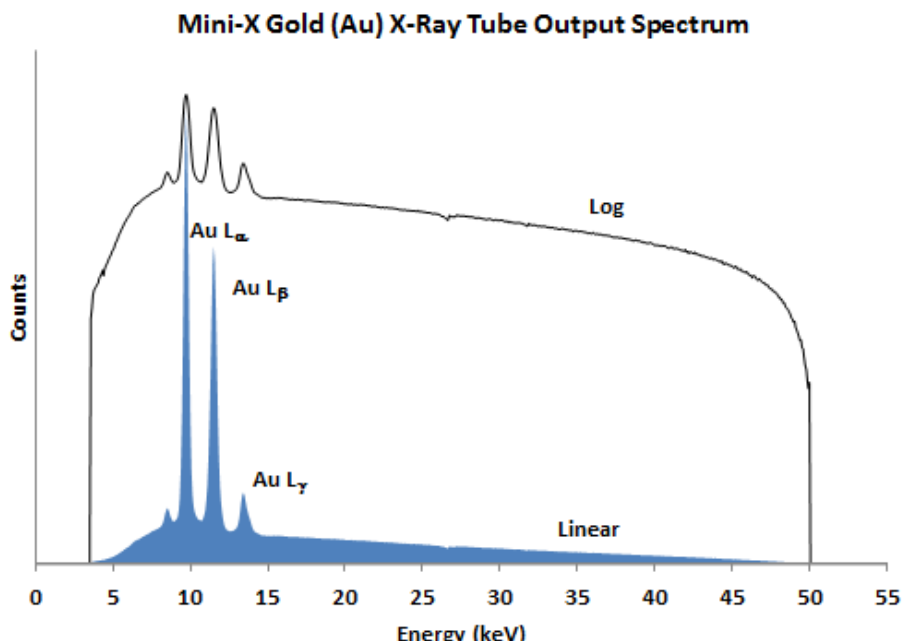
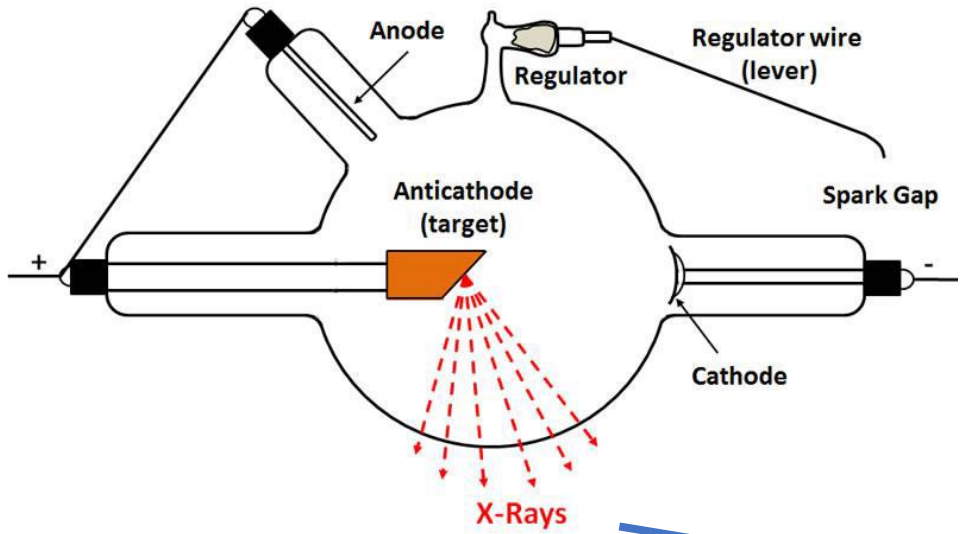
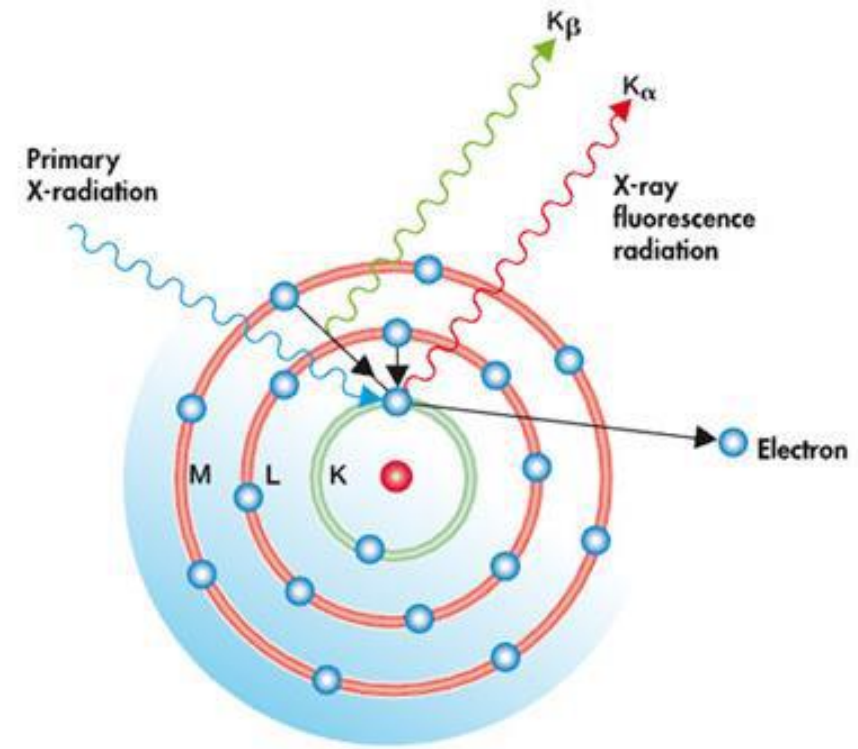
b

Tomography



Fluorescence

- What exactly is X-Ray fluorescence?

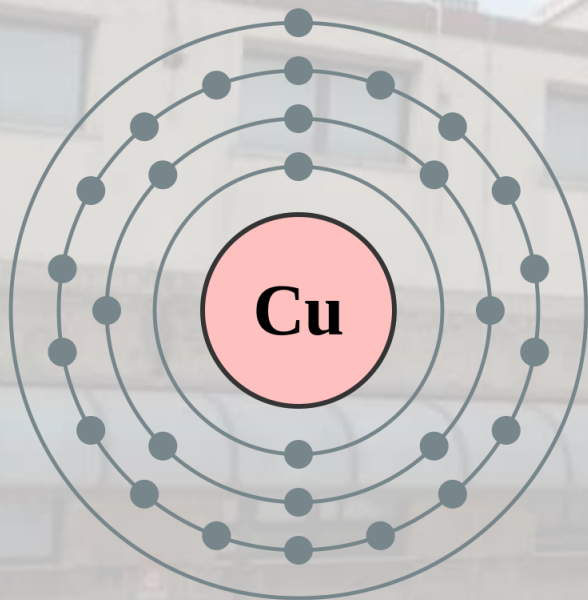


Continuum
Discrete energies

- Information on elements!

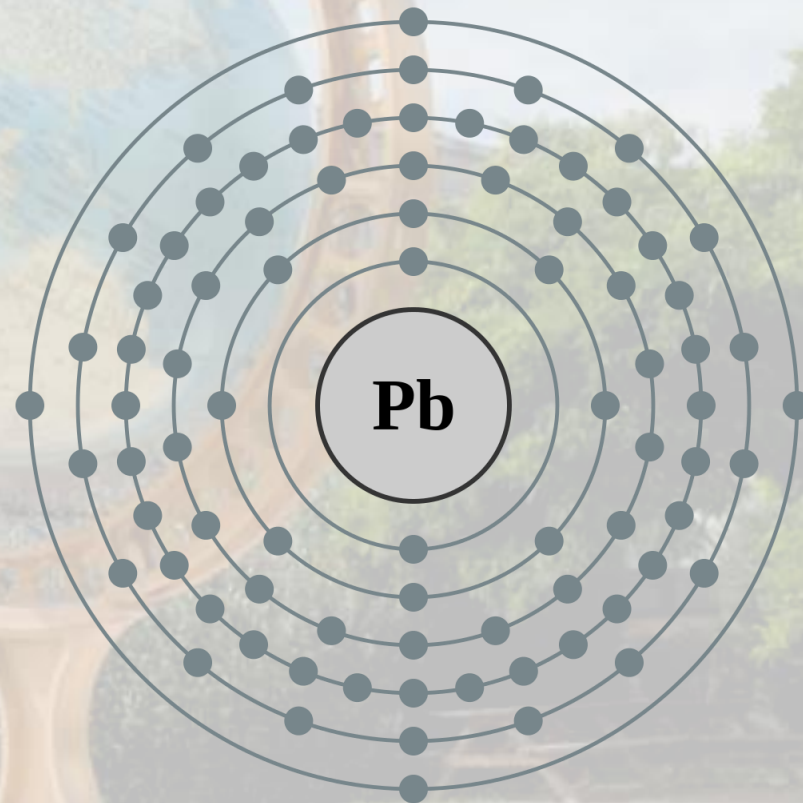
29: Copper

2,8,18,1

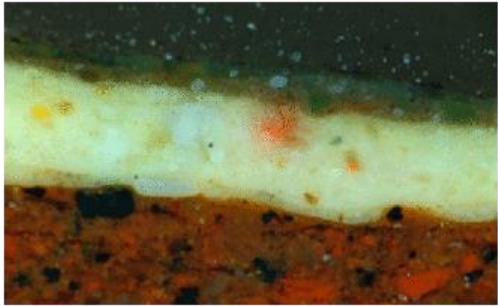


82: Lead

2,8,18,32,18,4



- Information on elements!

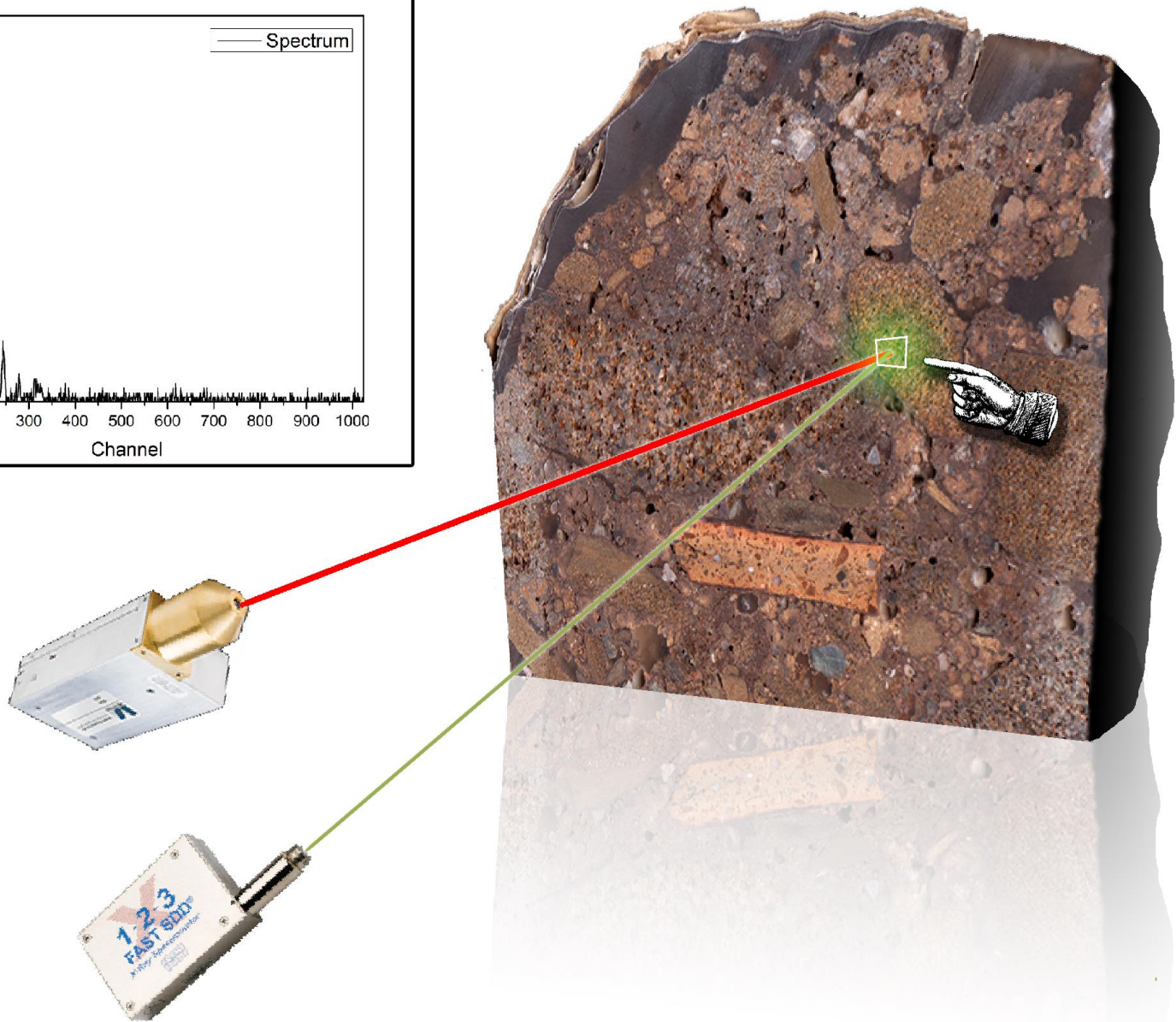
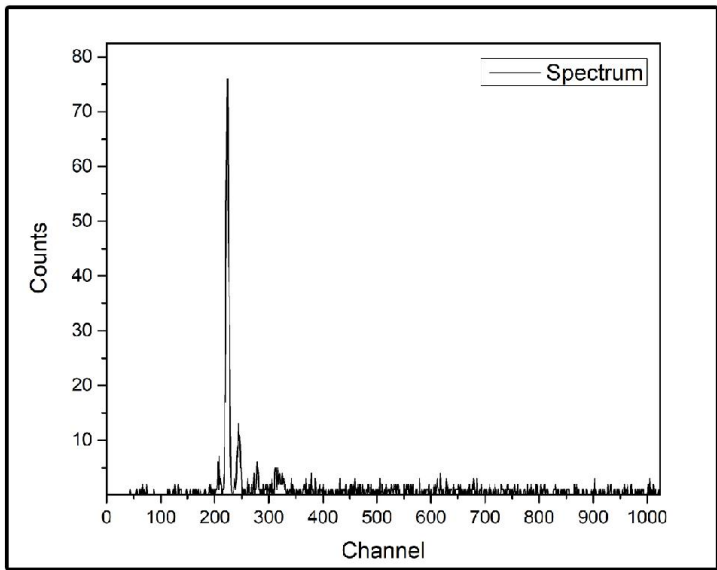


82: Lead

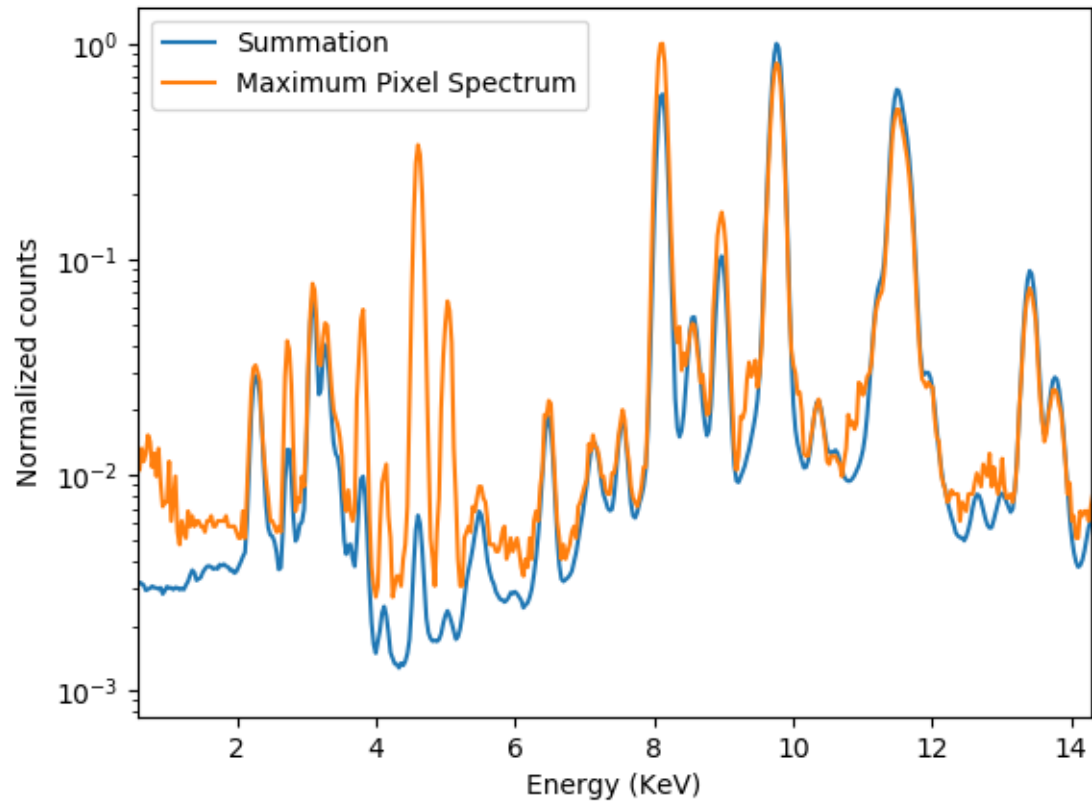
2,8,18,32,18,4

Pb





X-Ray Fluorescence (XRF)

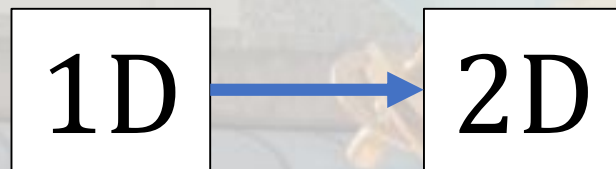


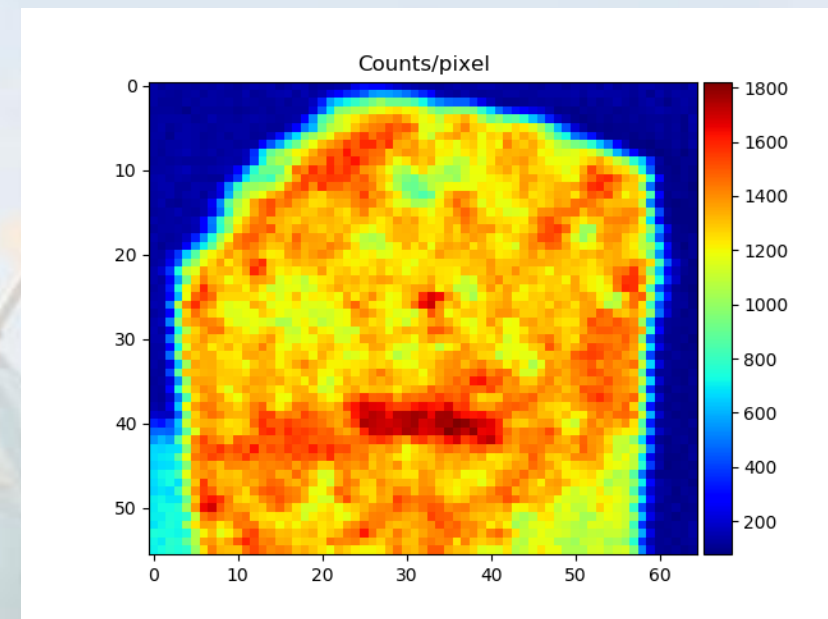
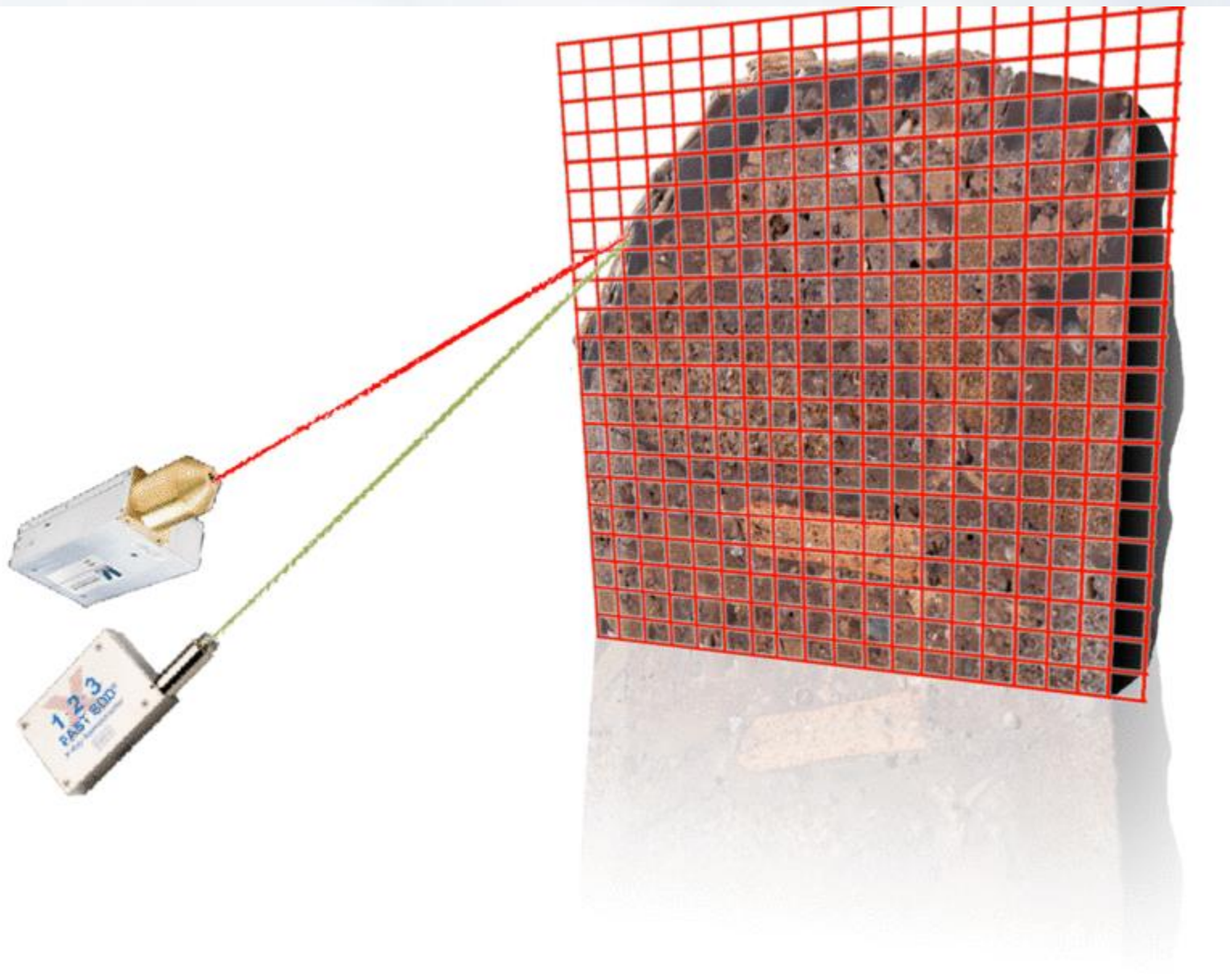
- ☞ Different materials
- ☞ Quantitative
- ☞ Qualitative
- ☞ Semi-Quantitative

Chemical composition!

X-Ray Fluorescence (XRF)

Still, it gives us some limited results.

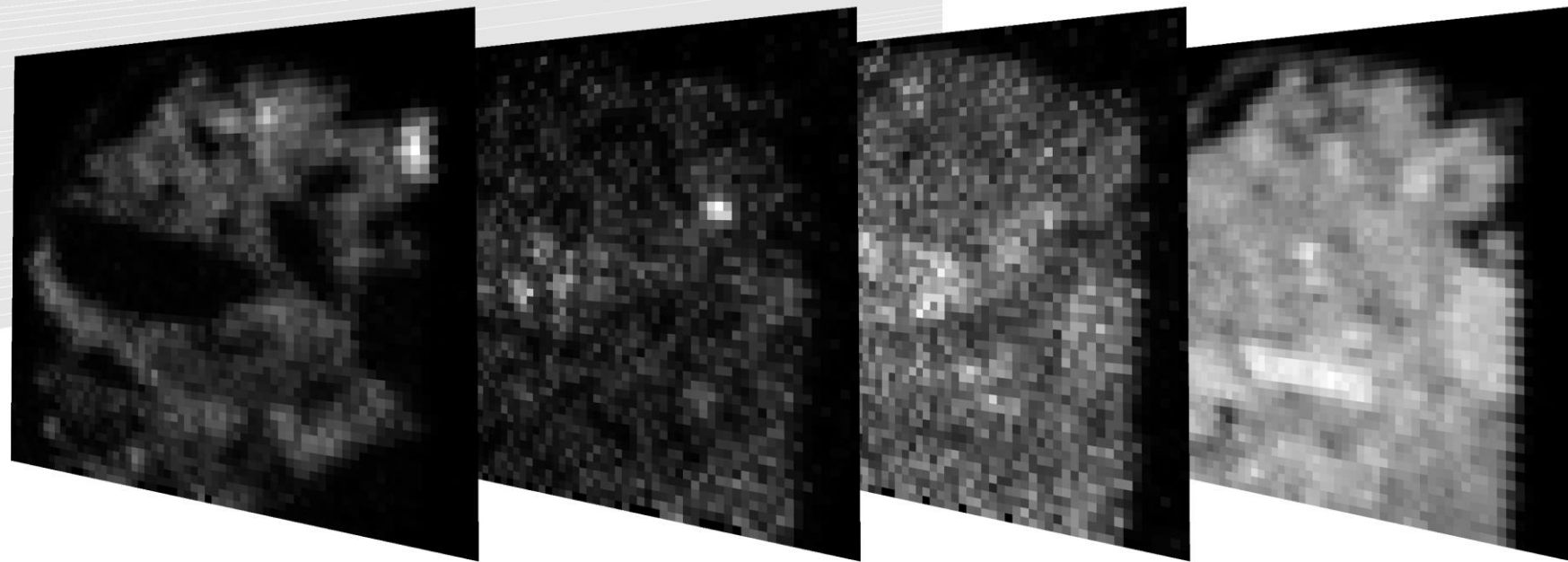
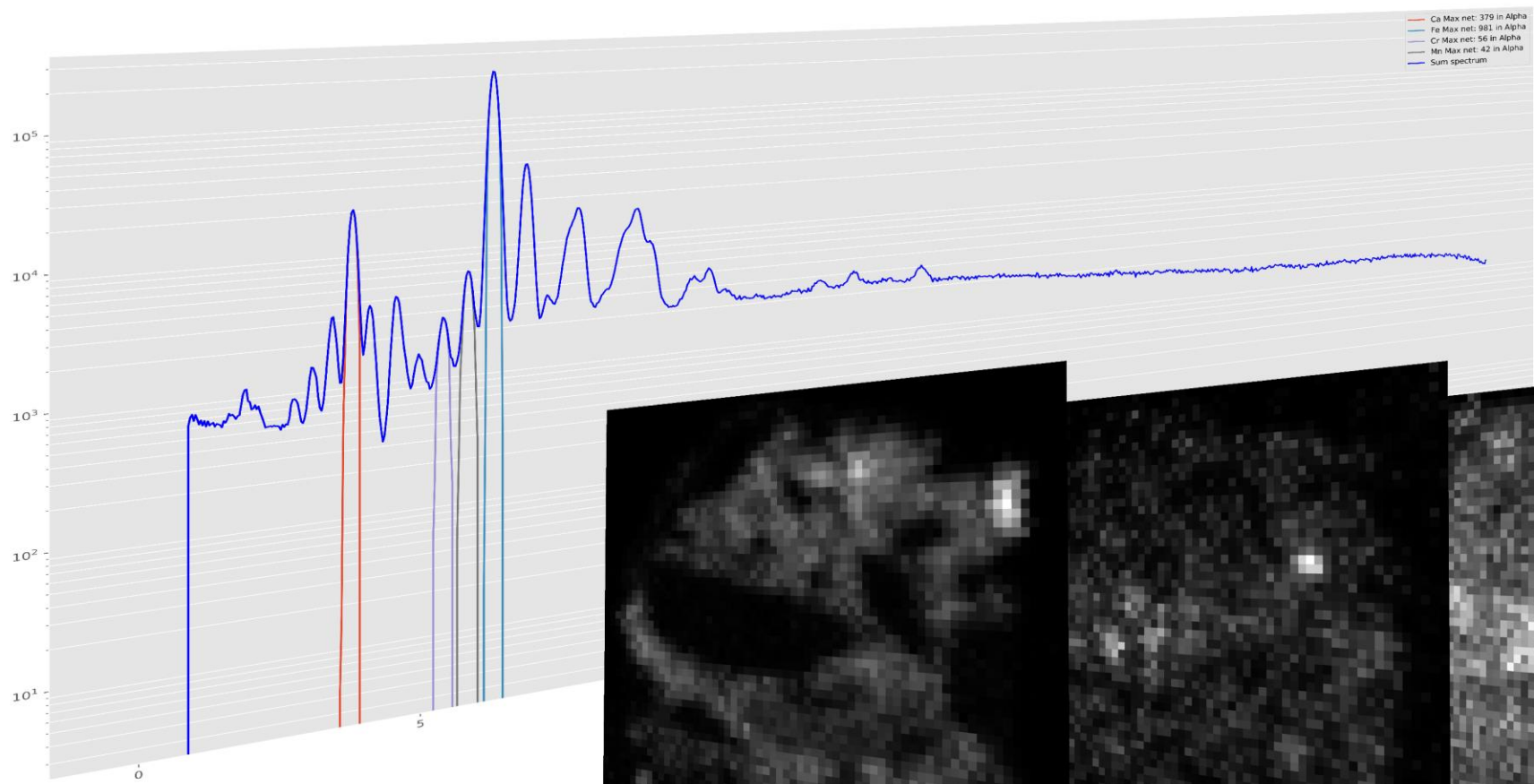


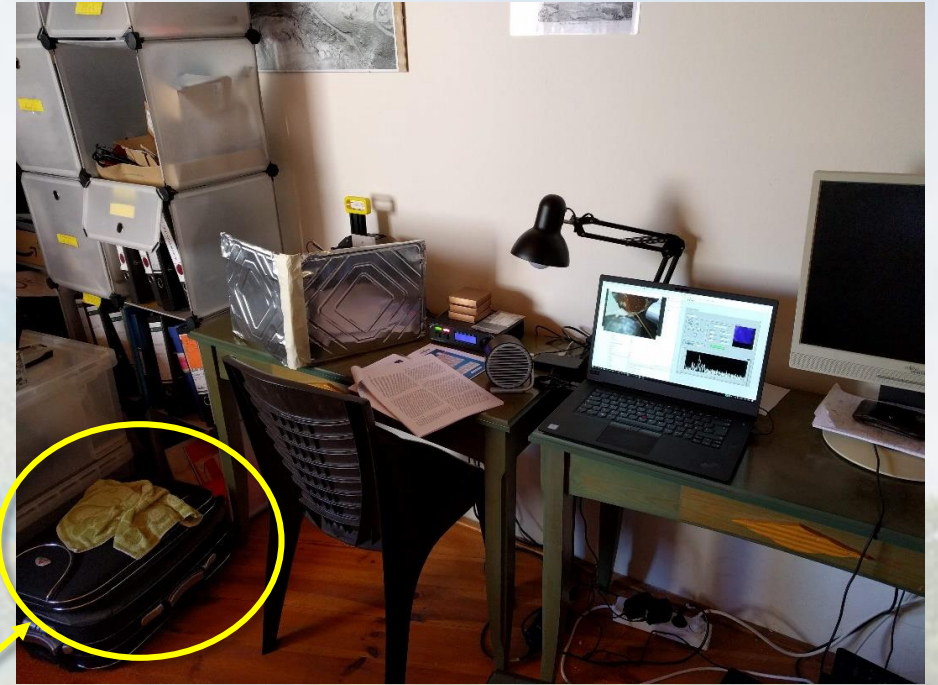
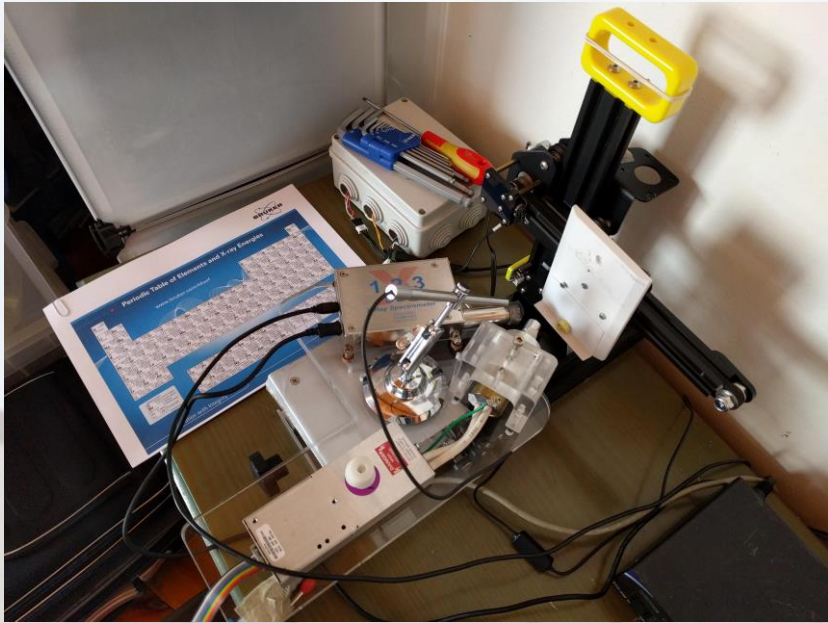


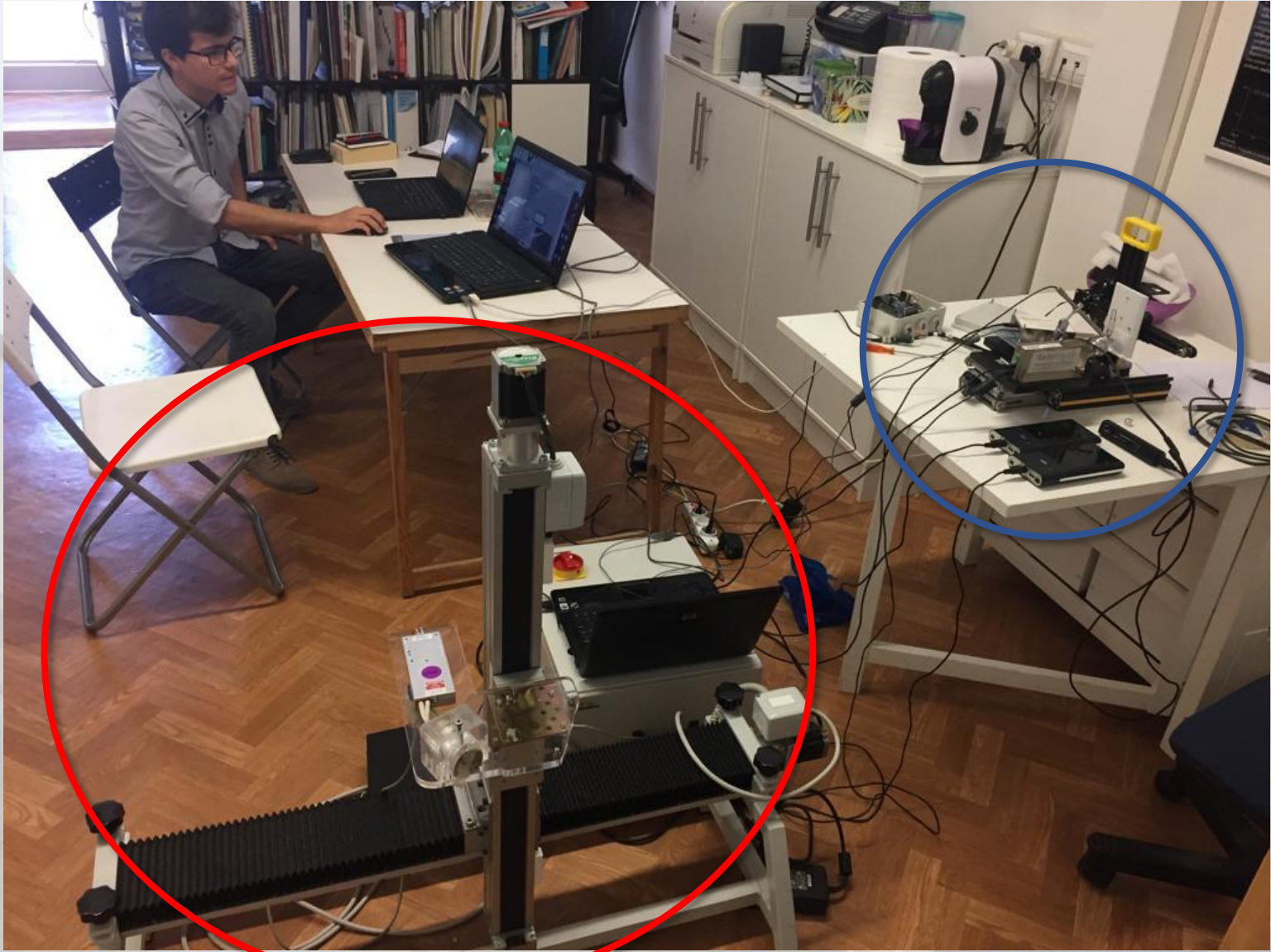
Dwell-time



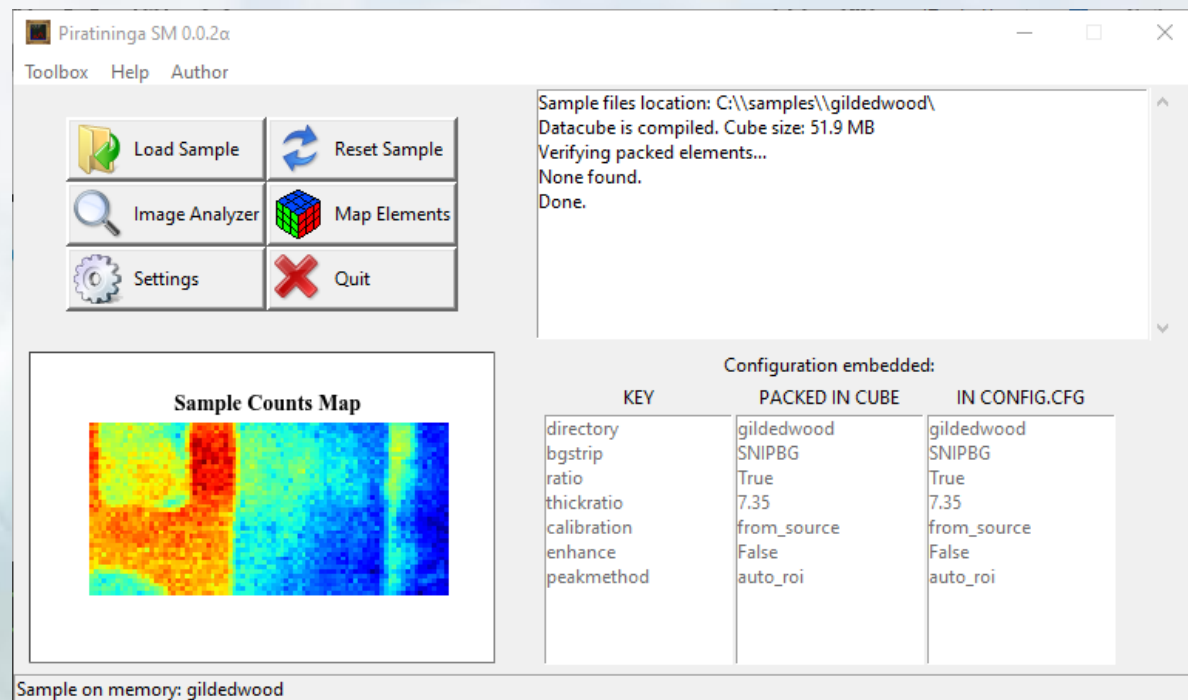
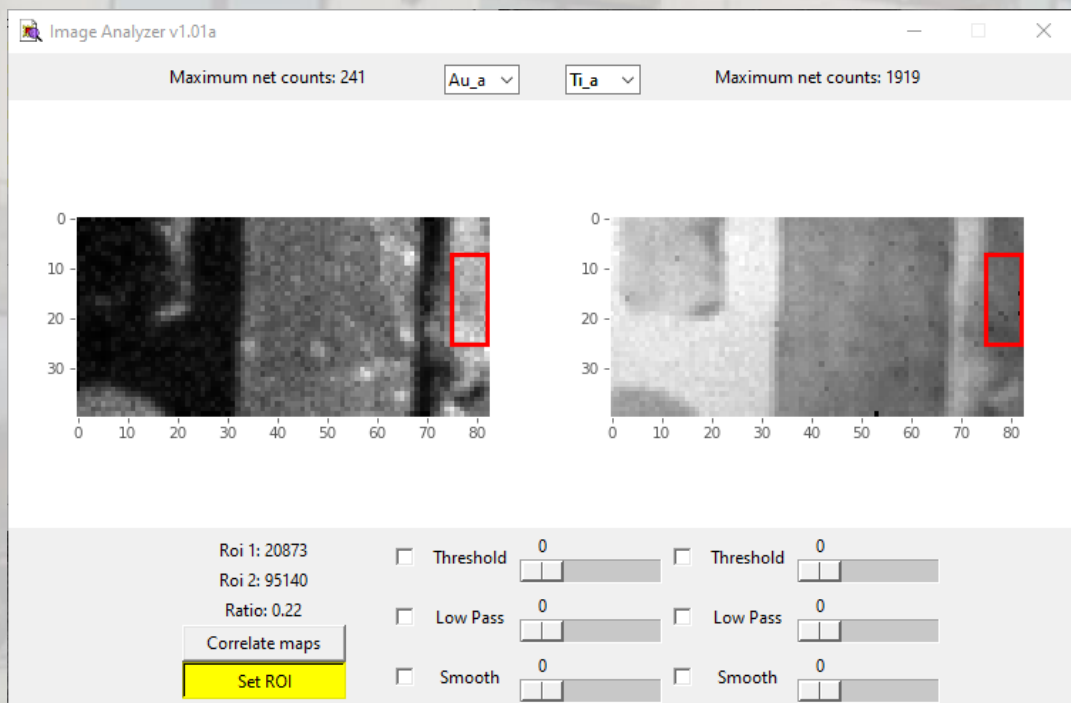
Resolution







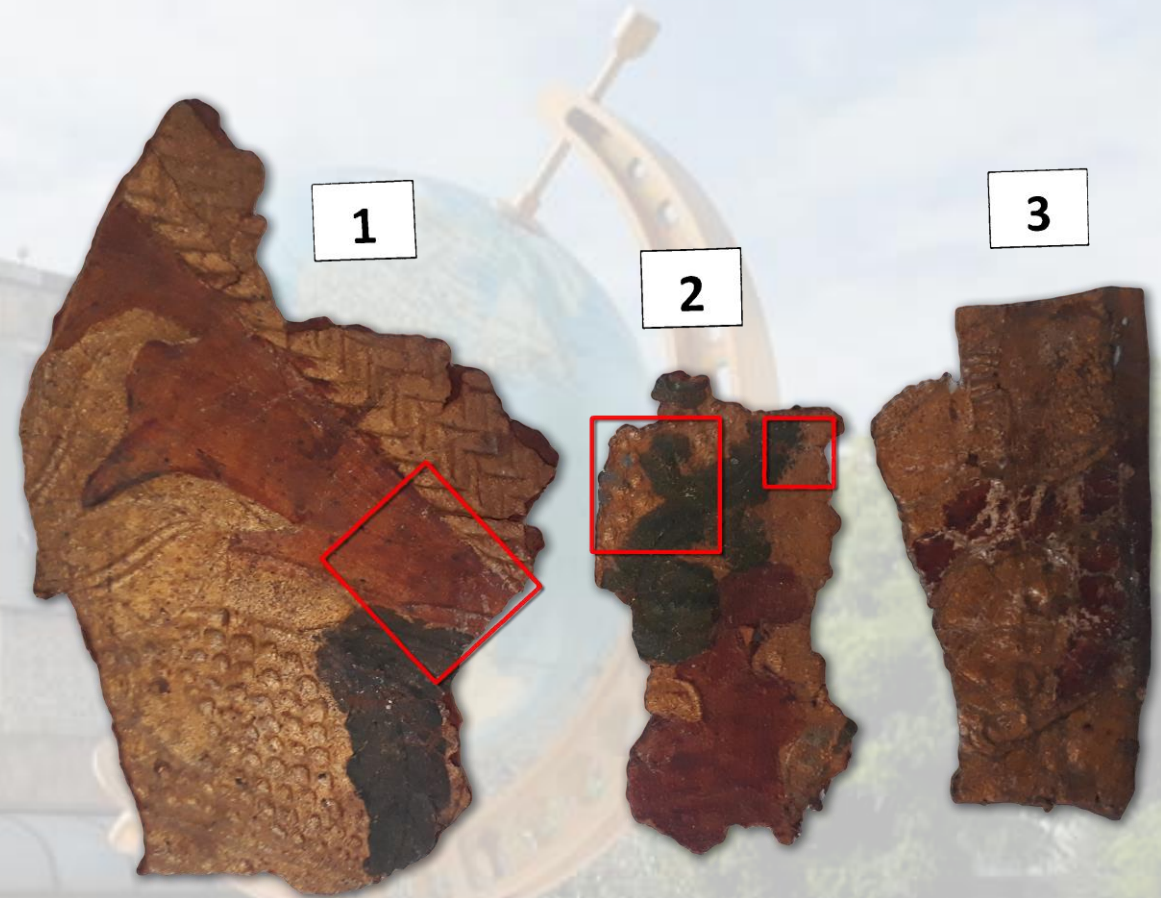
- Custom software tailored specifically for suiting cultural heritage needs



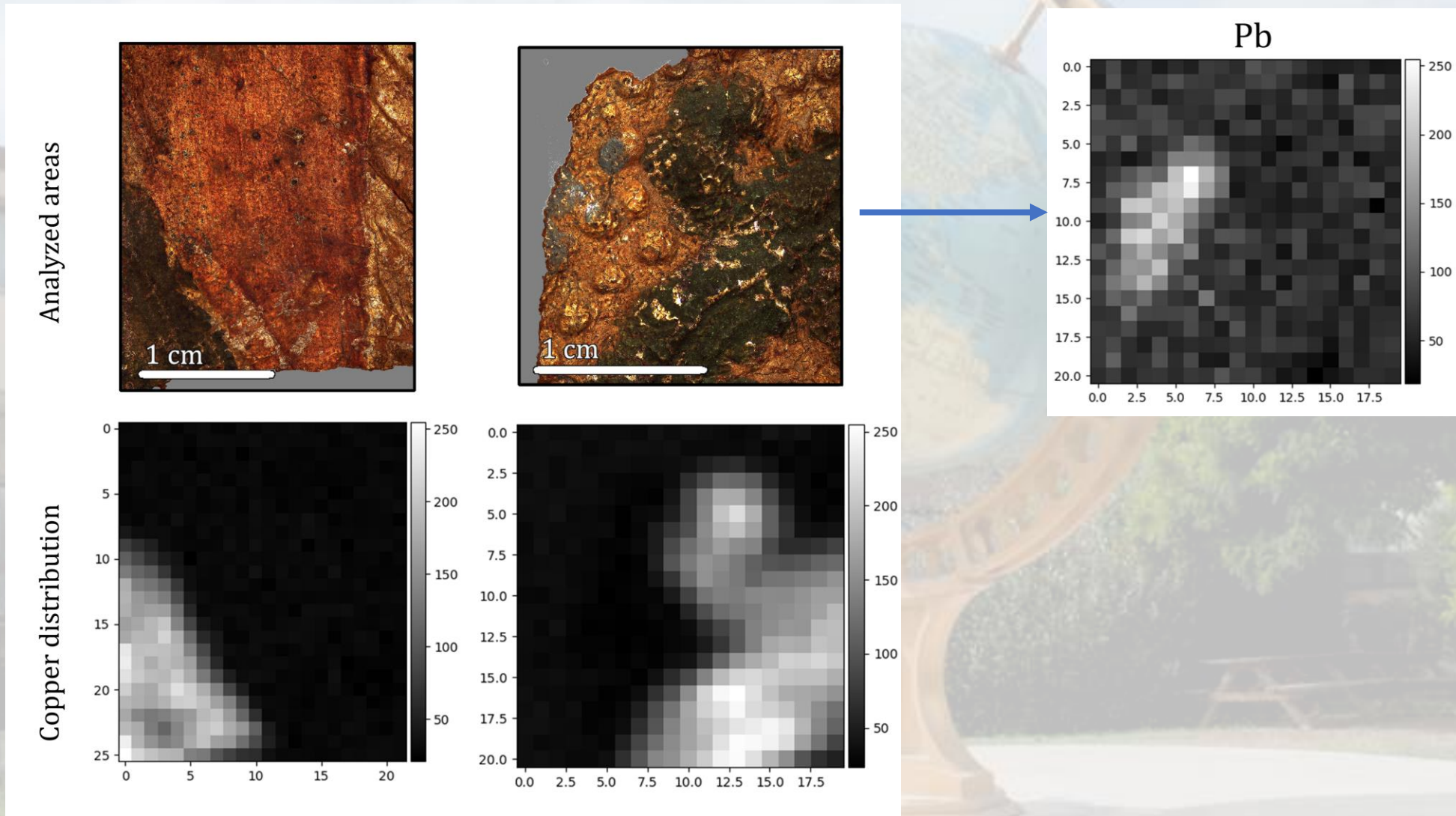
Case study

Questions:

- 👉 Pigments
- 👉 Pictorial technique
- 👉 Leather preparation

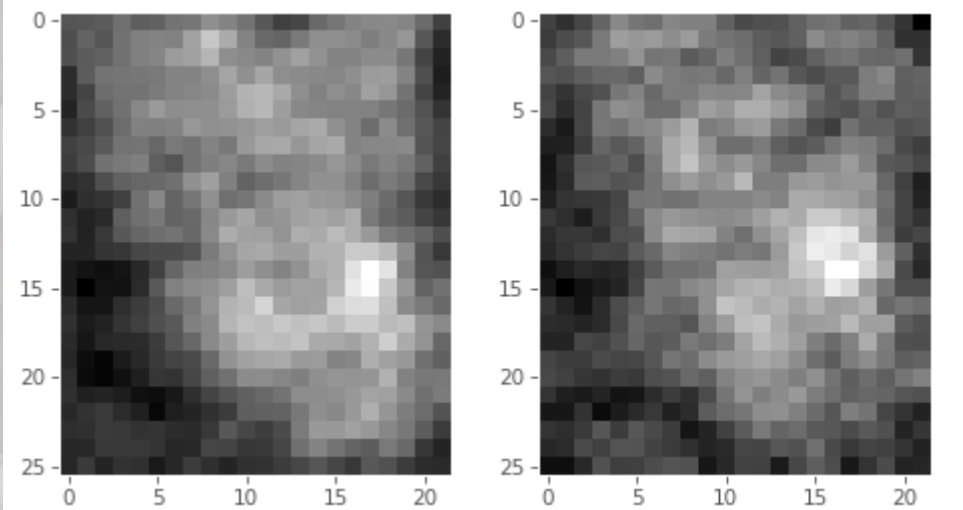


Case study

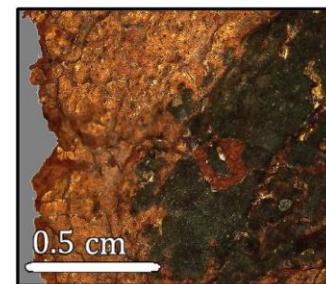
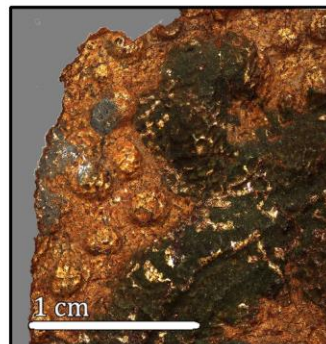


Case study

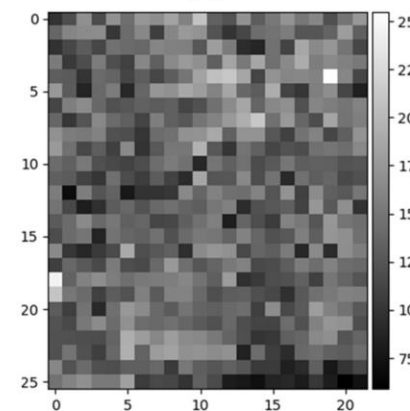
Pb-L α / Pb-L β



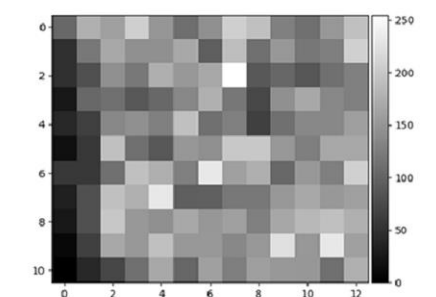
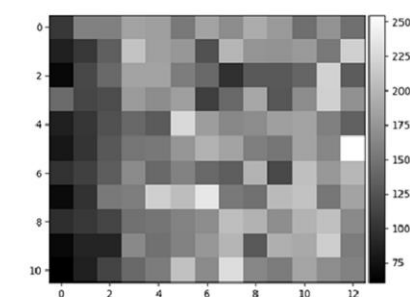
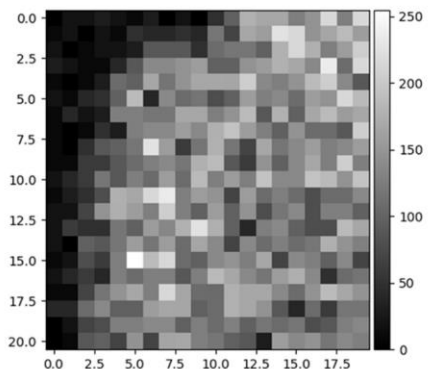
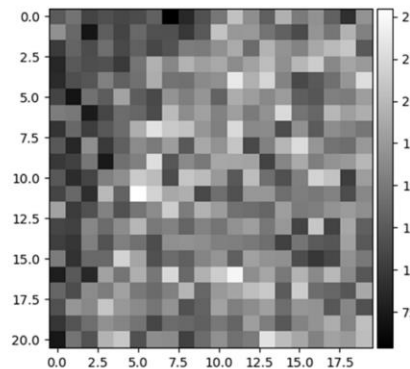
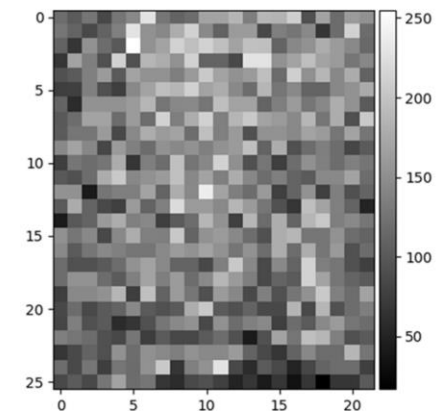
Analyzed areas



Fe

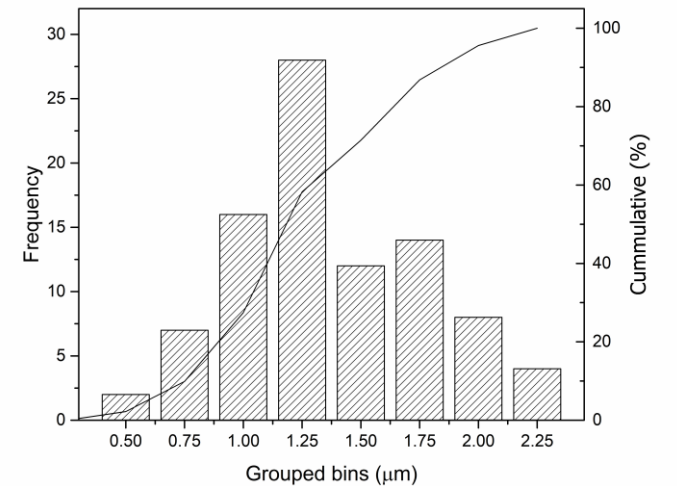
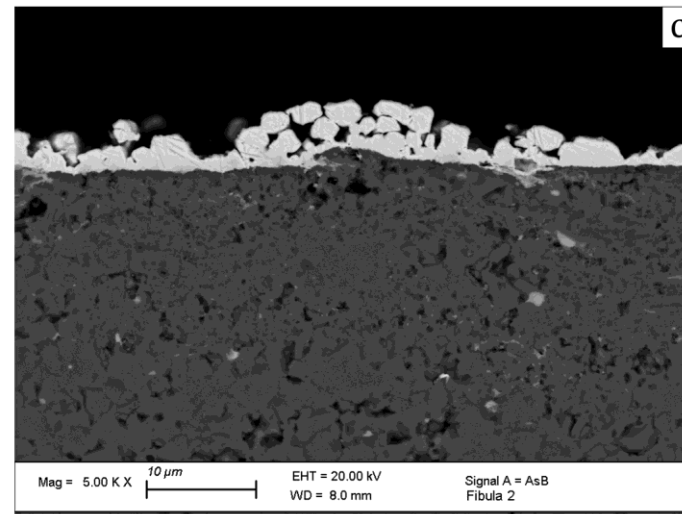
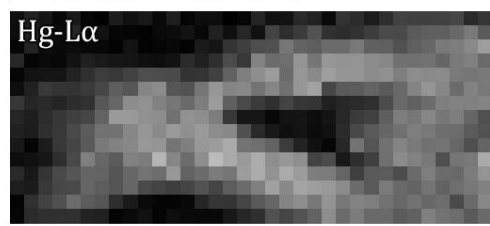
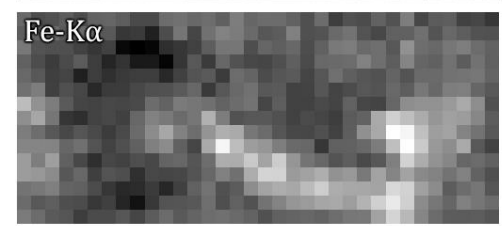
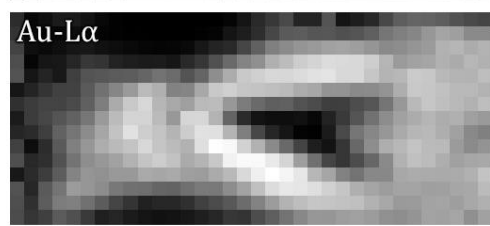
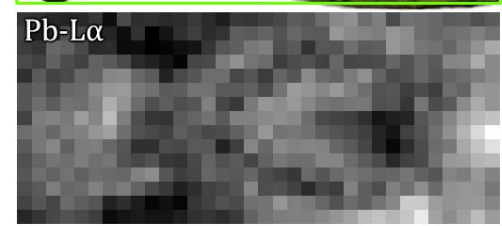
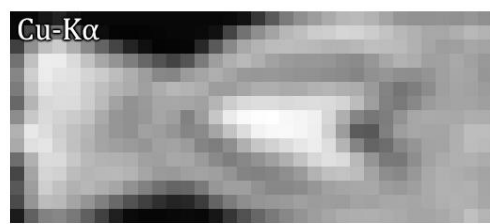
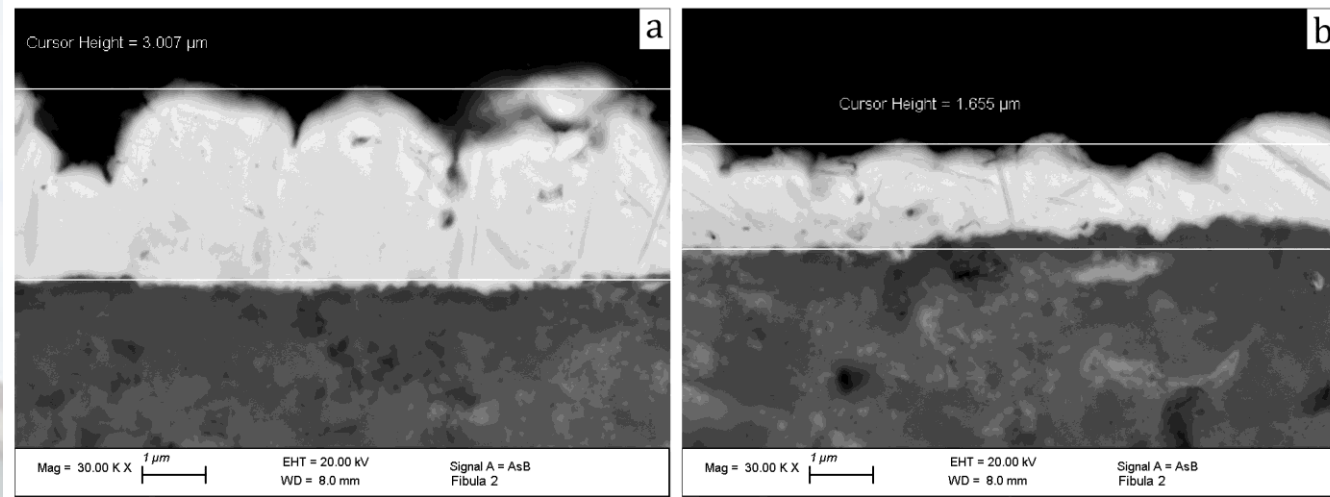


Ca



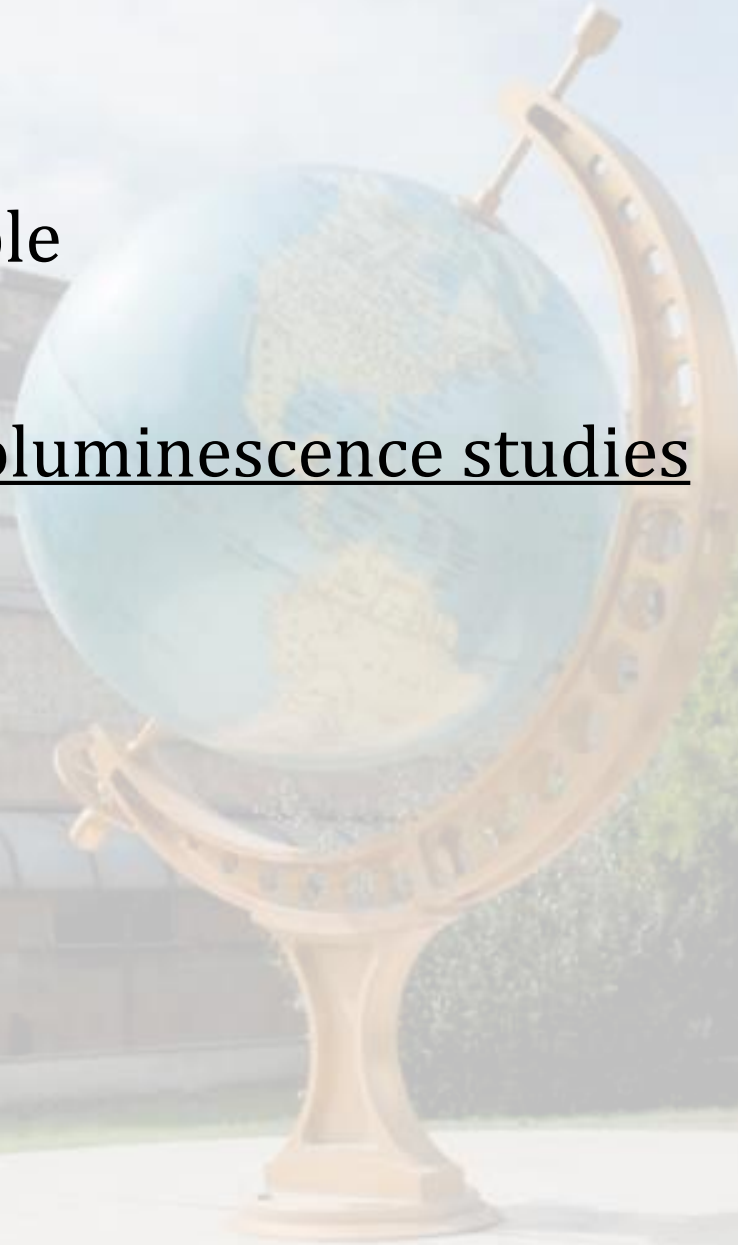
impure potash alum, soda ash/lime

Case study



Dosimetry

- Energy deposited in the sample
- X-ray analysis **hinders** thermoluminescence studies



Thank you for your attention!

DTC LAZIO
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BENI E ATTIVITÀ CULTURALI
CENTRO DI ECCELLENZA



Istituto Nazionale di Fisica Nucleare
SEZIONE DI ROMA TRE

