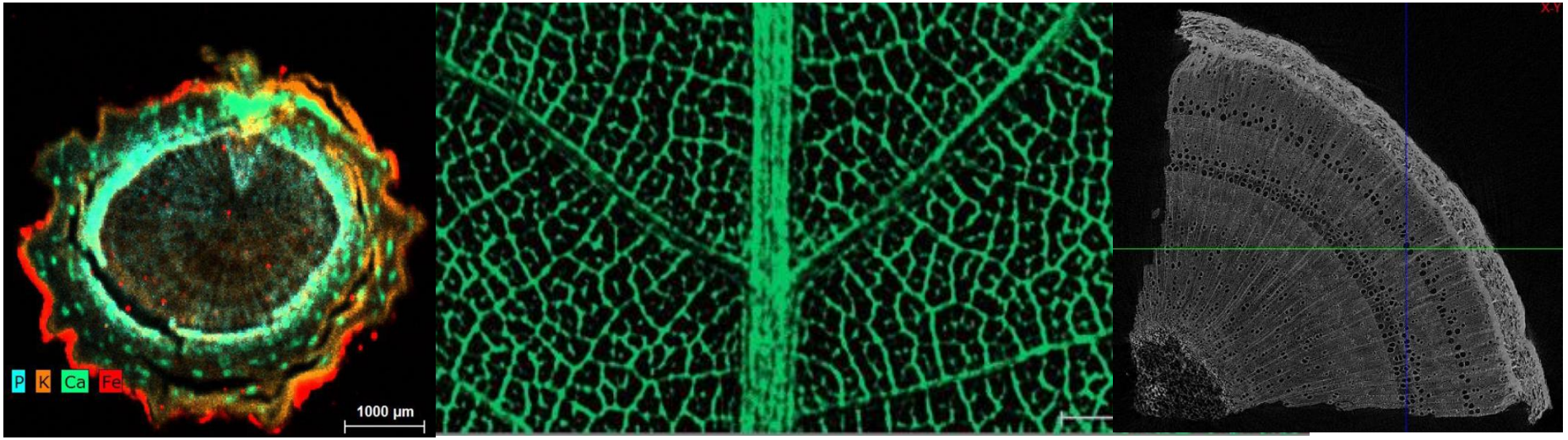
Workshop “H2I: Hyperspectral images for inspection applications» September 16, 2021



Wood analysis using tomographic and X-ray microfluorescence techniques

Roberto Terzano & Carlo Porfido

Department of Soil, Plant and Food Sciences

Micro X-ray Lab

University of Bari «Aldo Moro»

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Europäischer Fonds für regionale Entwicklung
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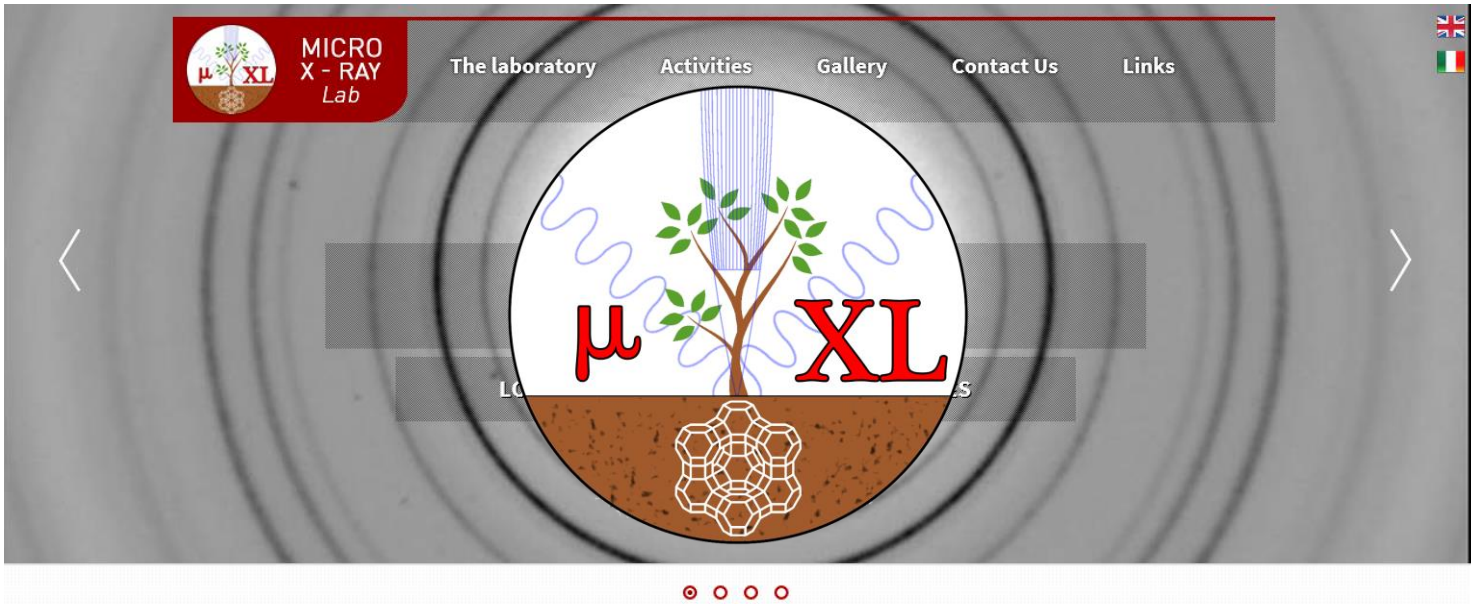
EUROPEAN UNION
AUTONOME PROVINZ BOZEN SÜDTIROL
PROVINCIA AUTONOMA DI BOLZANO ALTO ADIGE

Outline

- Presentation of Micro X-ray Lab and X-ray analytical techniques
- Introduction to micro X-ray tomography and micro X-ray fluorescence
- Applications to wood samples and results

Micro X-ray Lab

www.microxraylab.com



THE LAB

"Micro X-ray Lab" is a public research laboratory equipped with modern state-of-the art analytical instruments managed by highly qualified researchers of international reputation.

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SERVICES

We supply advanced scientific support to public and private eterprises in the development of new processes and technologies for environmental and agricultural applications.

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EQUIPMENT

X-ray fluorescence

Total reflection X-ray fluorescence

Powder X-ray diffraction

Micro X-ray fluorescence

HR micro X-ray tomography

FEG SEM and microanalysis

Read More »

Micro X-ray Lab

Team

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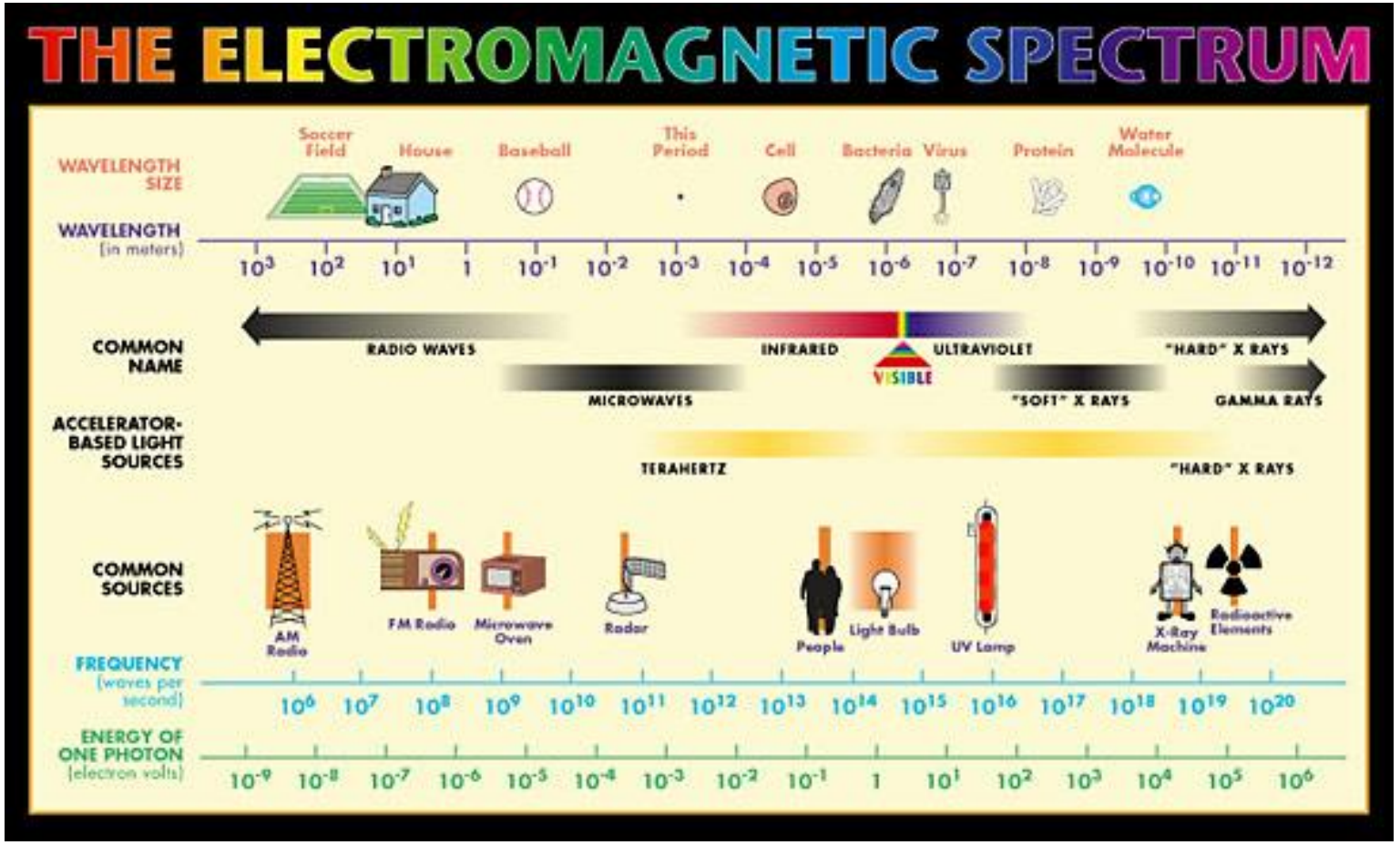
Ida Rascio
UniBA
Environmental Biologist

Research activities @ Micro X-ray Lab

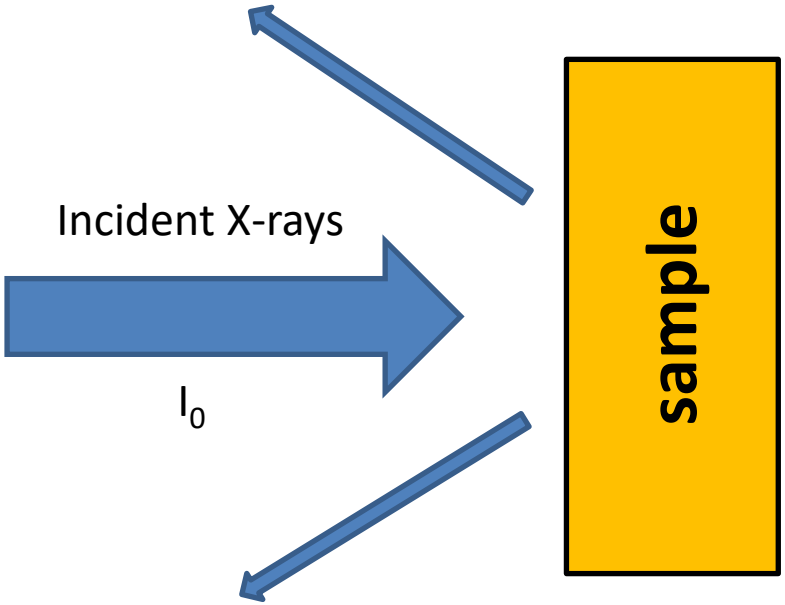
- Soil pollution and soil remediation
- Plant science
- Food science
- Material science
- Cultural heritage
- Geology and geochemistry

Hyperspectral images: X-rays



Interaction of X-rays with matter

Scattered (diffracted) X-rays
(structural information, mineral identification)



Transmitted X-rays

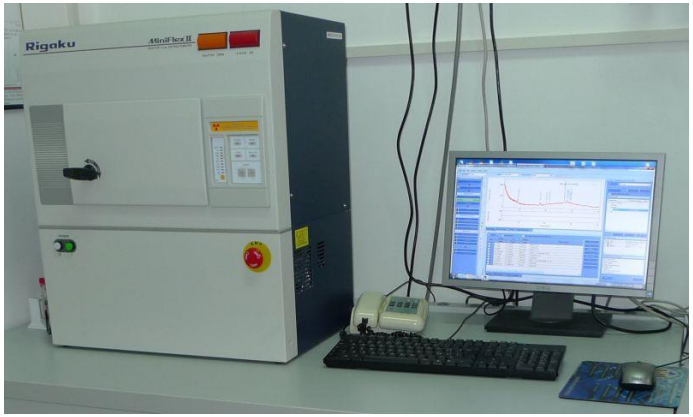
- Structural information (**μXCT**)
- Chemical speciation (XAS)

$I_t < I_0$

Fluorescence X-rays (XRF)
(chemical information, elemental analysis)

X-ray techniques at “Micro X-ray Lab”

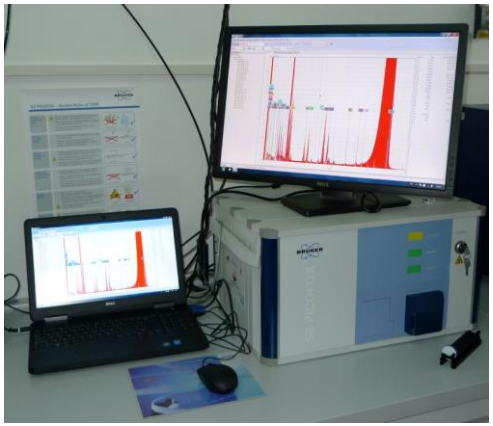
XRD



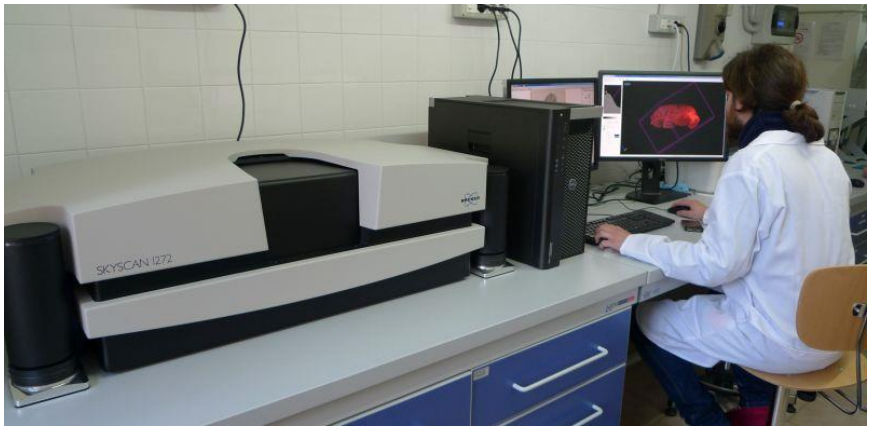
XRF

µXRF

TXRF

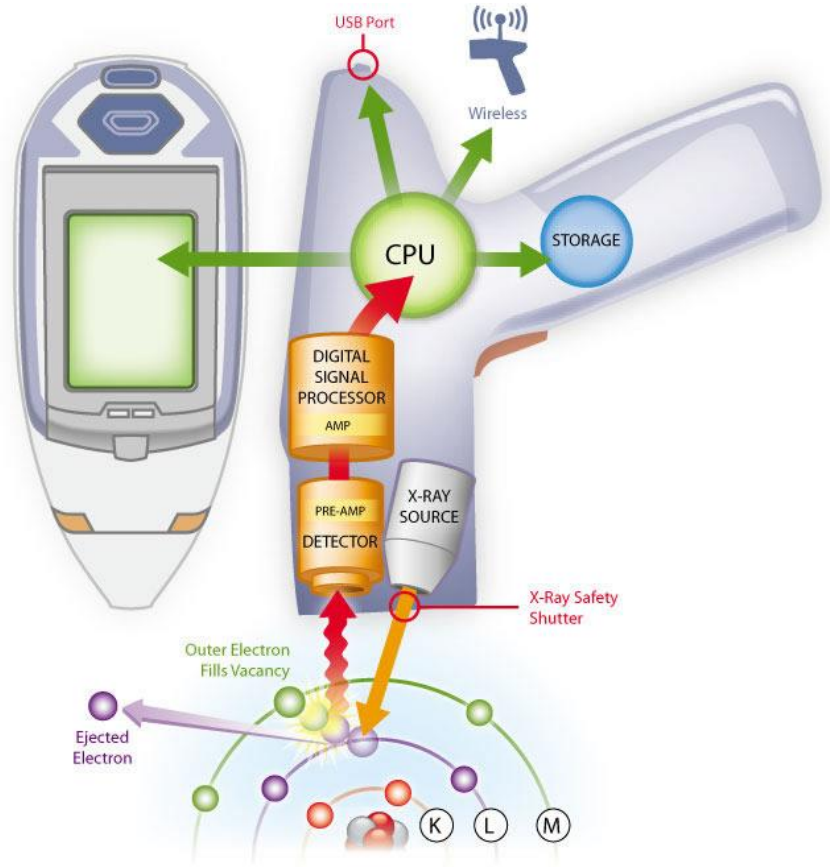


HR µCT



FESEM-EDX

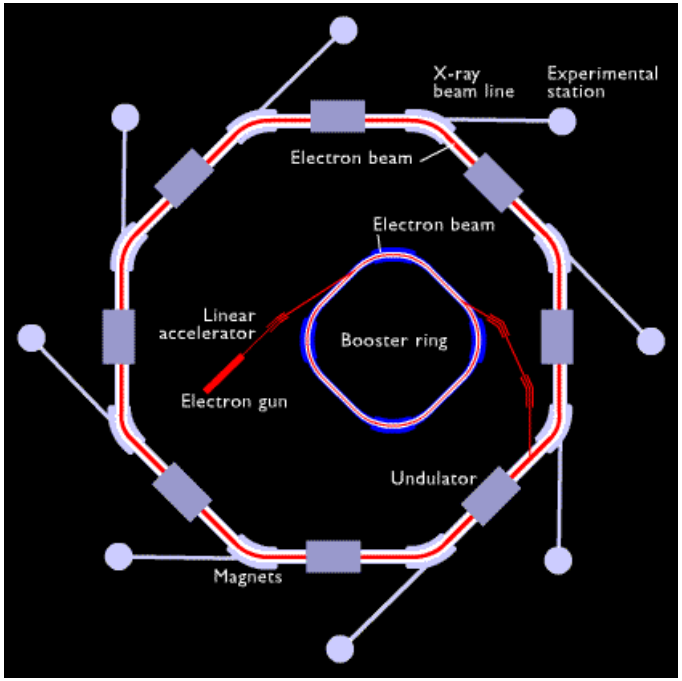
X-ray fluorescence spectroscopy: Portable Instrumentation

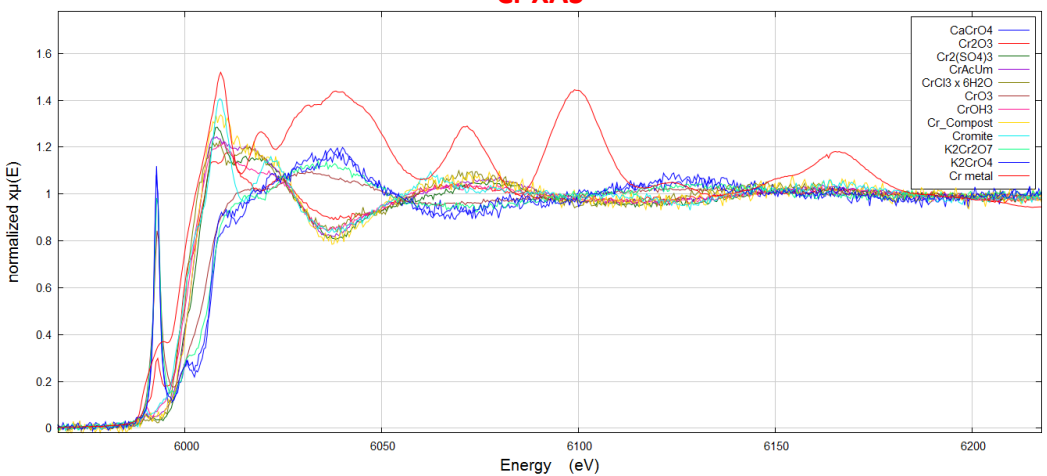


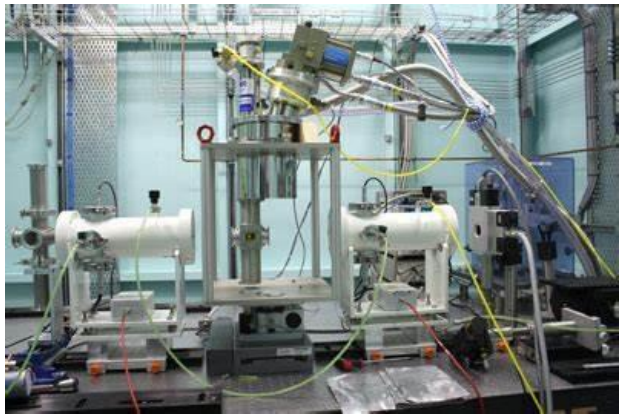
L.O.D.: 10-100 ppm→100%

K→U

X-ray analyses @ synchrotron facilities



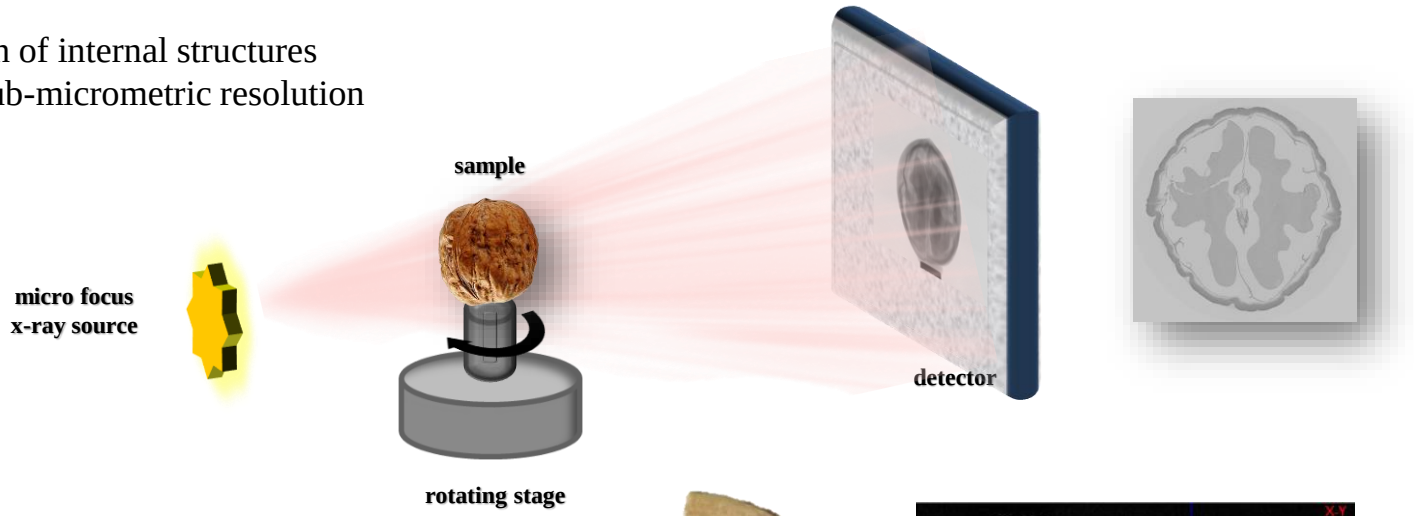




Computed X-ray microtomography

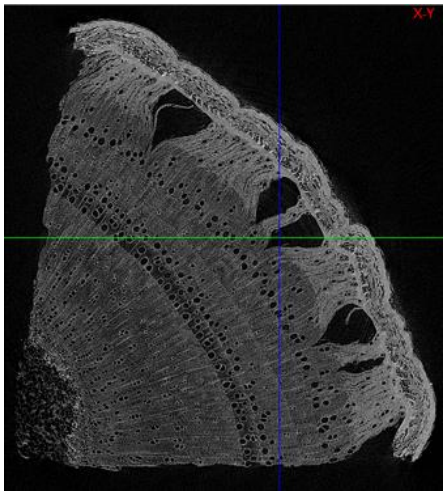
Basic principles of micro-CT

- ✓ non distructive
- ✓ datailed description of internal structures
- ✓ micrometric and sub-micrometric resolution

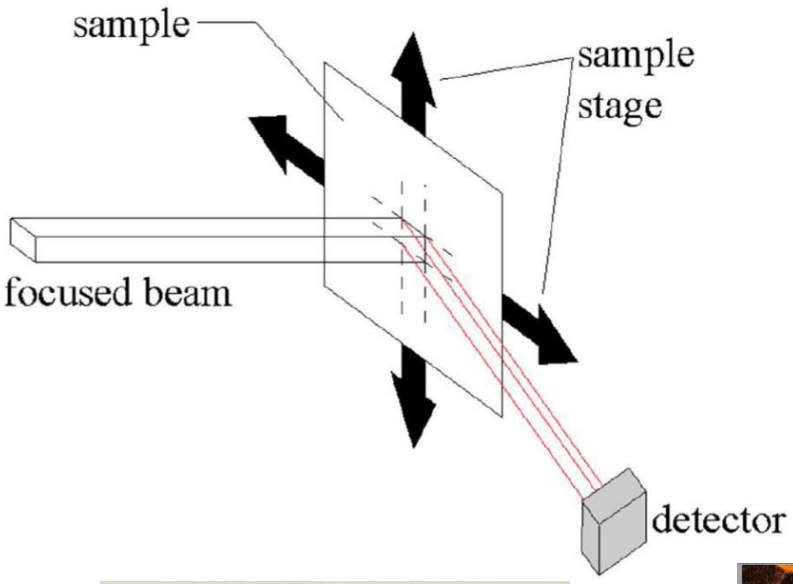


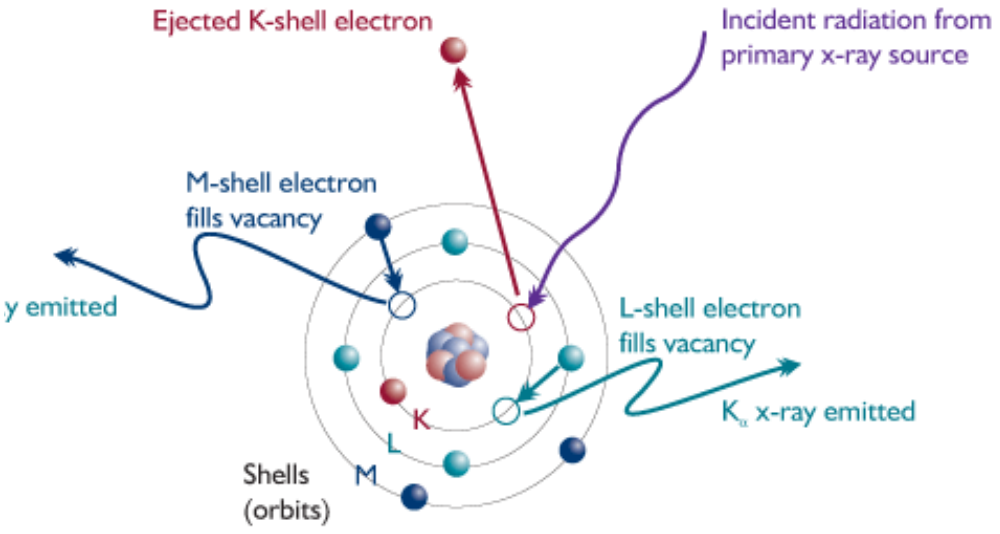
Photoelectric absorption of x-rays is very sensitively dependent on Z, the atomic number of the absorbing material

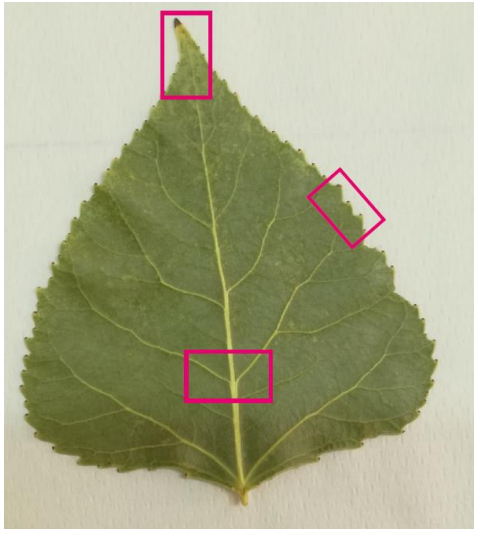
$$\tau \propto \frac{Z^4}{E^{3.5}}$$

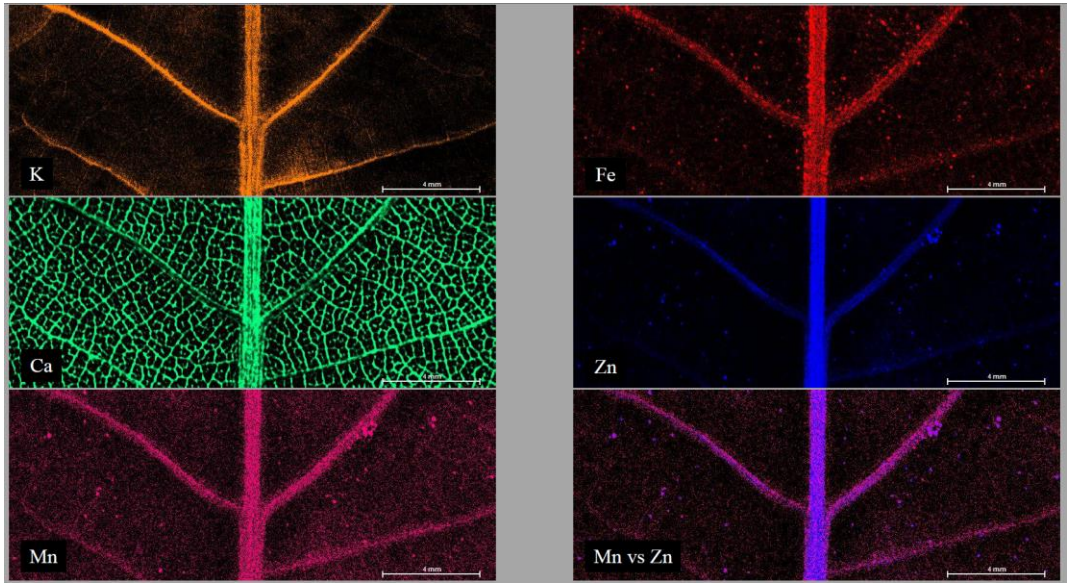


Micro X-ray Fluorescence



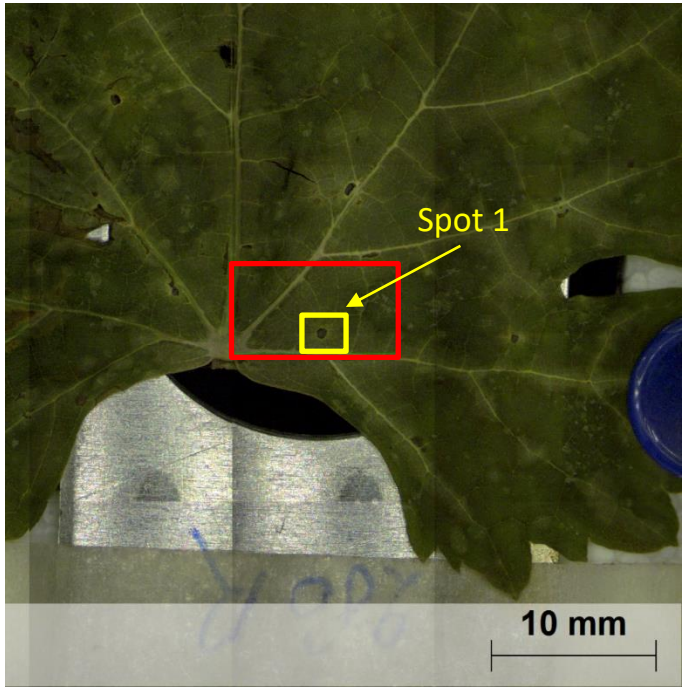


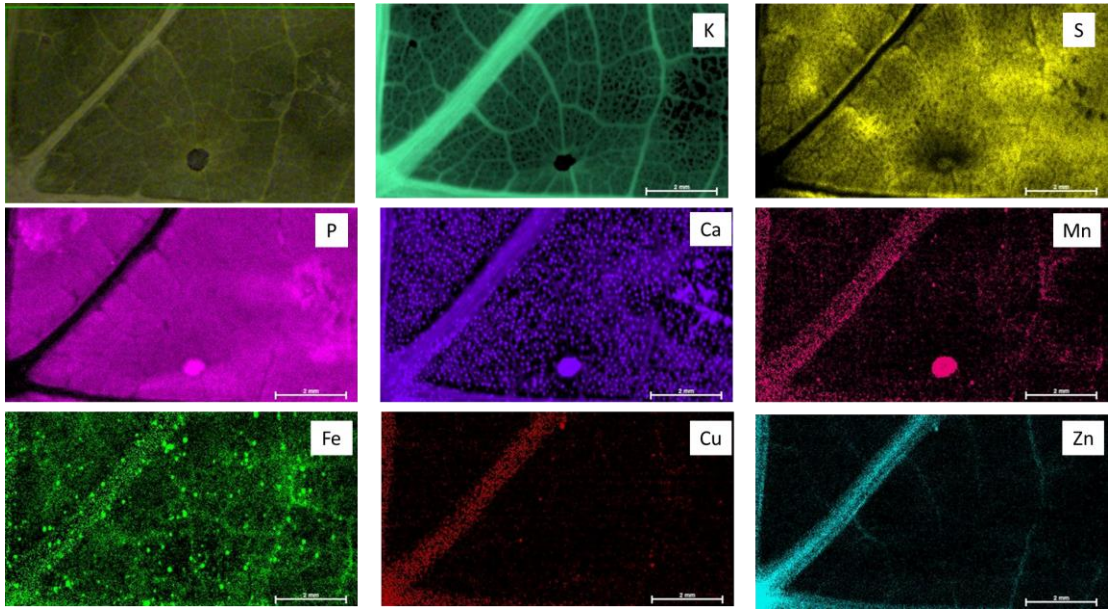




Micro X-ray fluorescence: Grapevine leaves

Plasmopara viticola infection affects mineral elements allocation and distribution in Vitis vinifera leaves



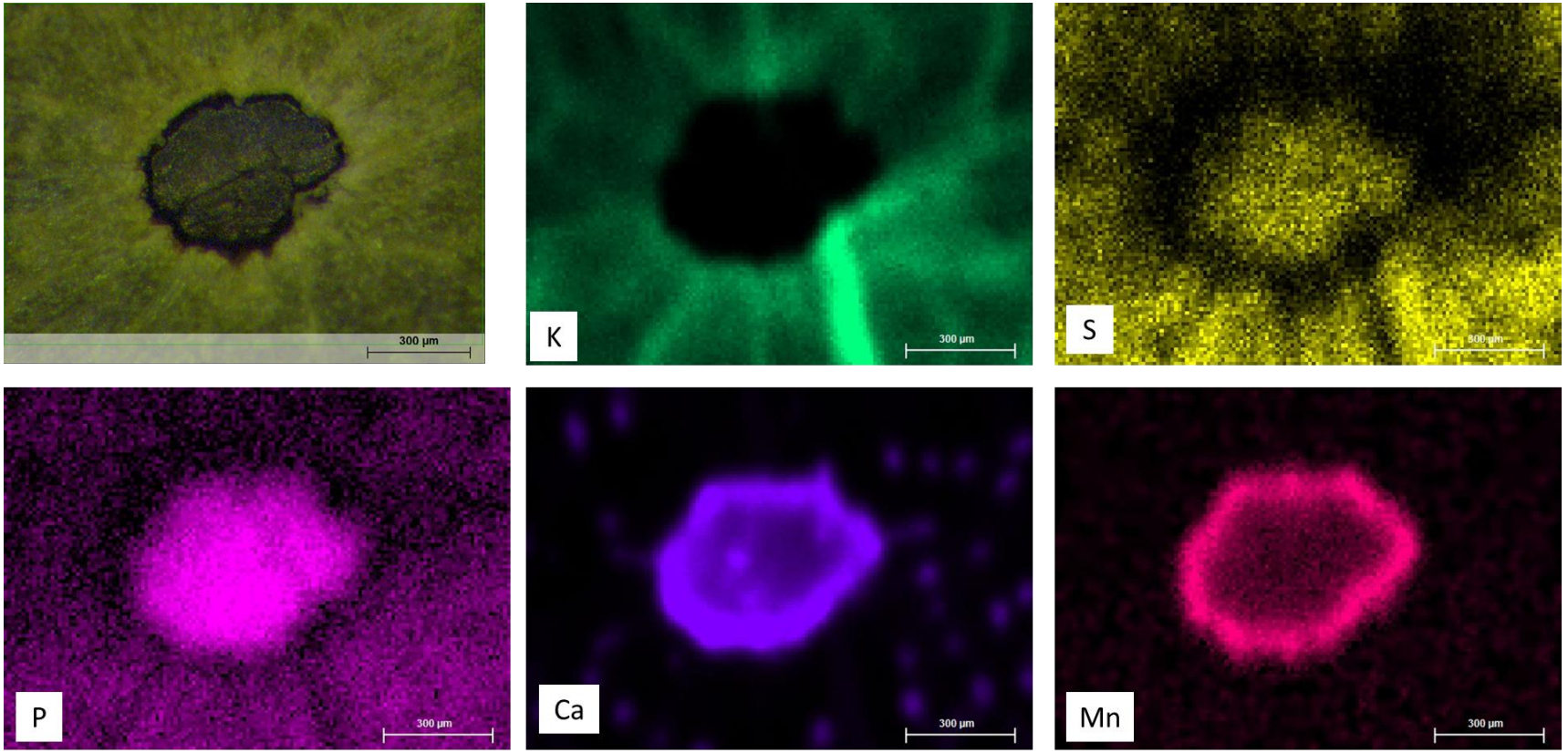


Cesco et al., 2020, Scientific Reports

Reserach activities @ Micro X-ray Lab

«Battle for nutrients» between plants and pathogens

(Naim et al., 2021, J. Exp. Bot.)



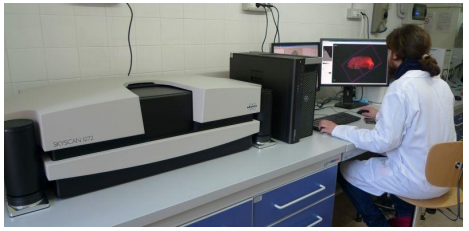
Cesco et al., 2020, Scientific Reports

Applications to wood samples and results

Infected regions of the wood appear darker and crumbled

Healthy regions are lighter in colour and more compact

➢ **HR µCT**

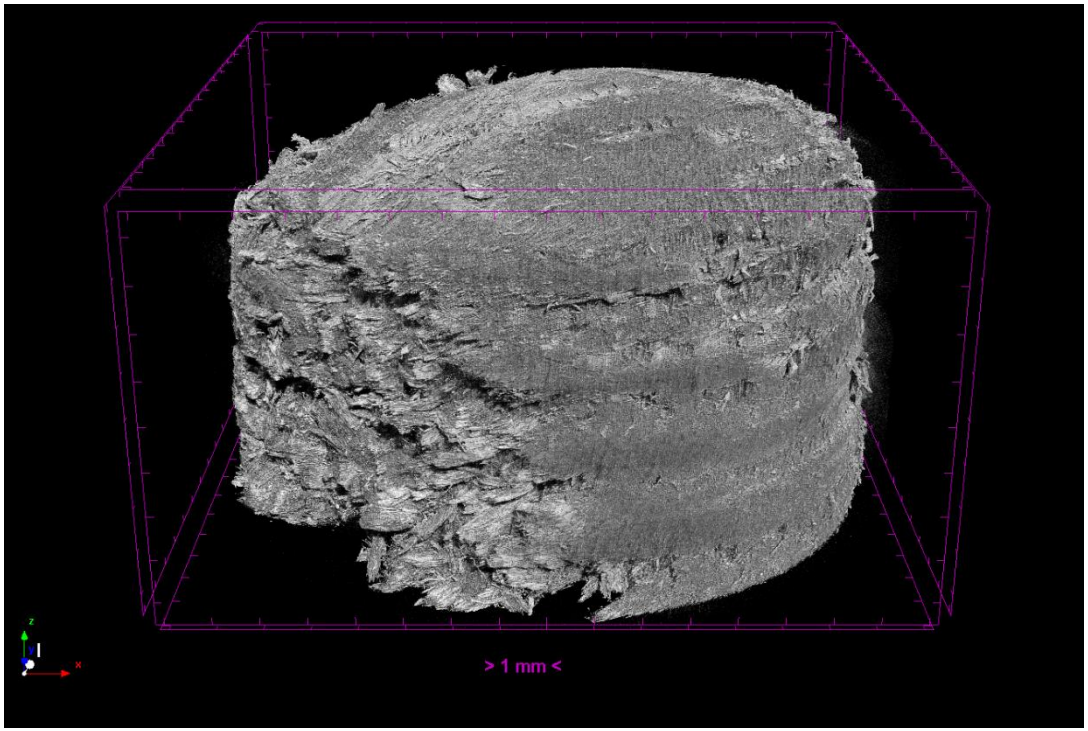


Evaluate structural differences between healty and infected wood

➢ **µXRF**

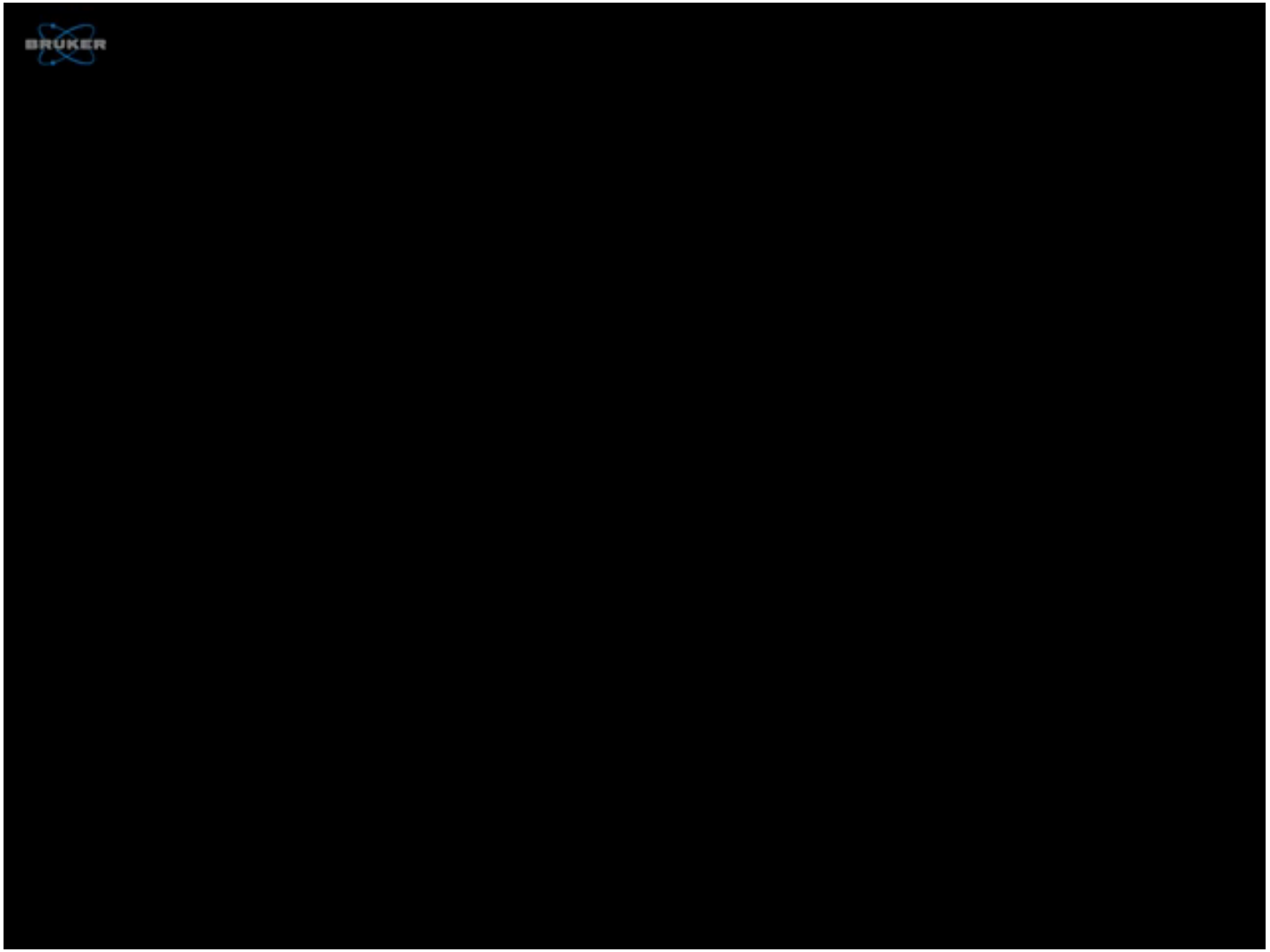
Investigate the distribution of elements within healthy and infected wood regions

Investigating wood defects through X-rays: HR µCT



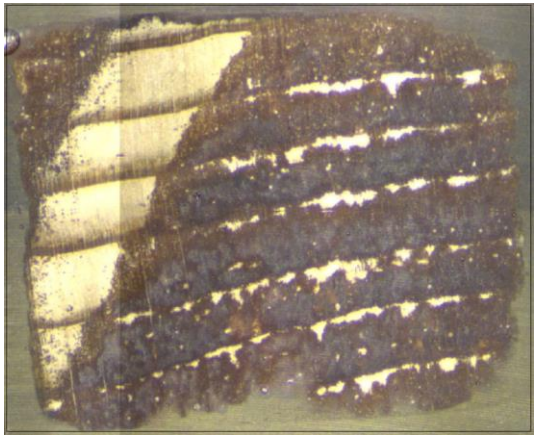
density

Investigating wood defects through X-rays: HR µCT



Investigating wood defects through X-rays: µXRF

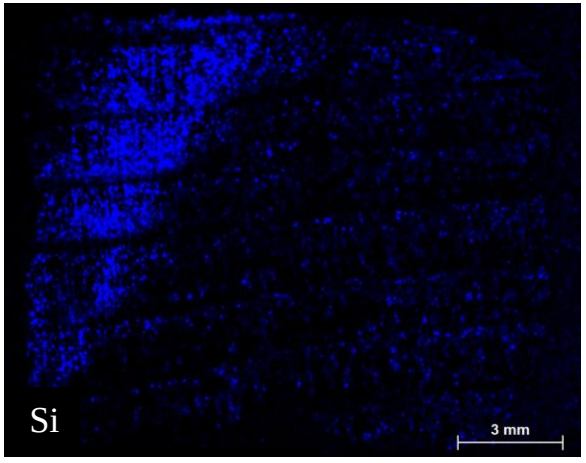
After µCT analysis, the wood cilinder was embedded in epoxy resin, then cut to prepare a thin section of wood for µXRF analysis (the red line in the upper figure indicates the cutting plane, passing through both infected and healthy wood tissues.

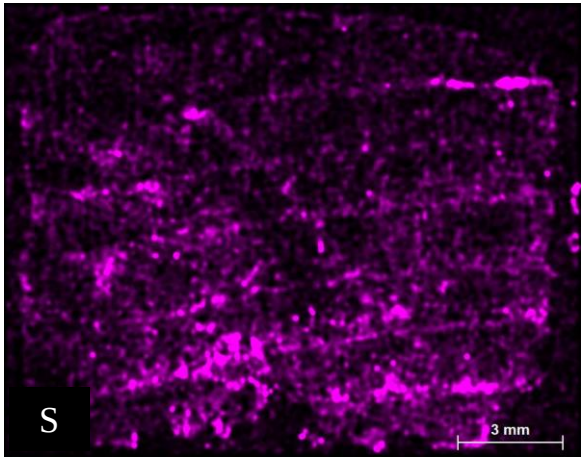


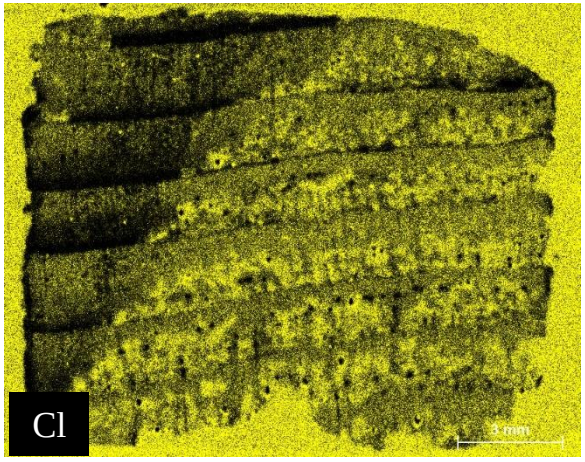
Embedded wood slice

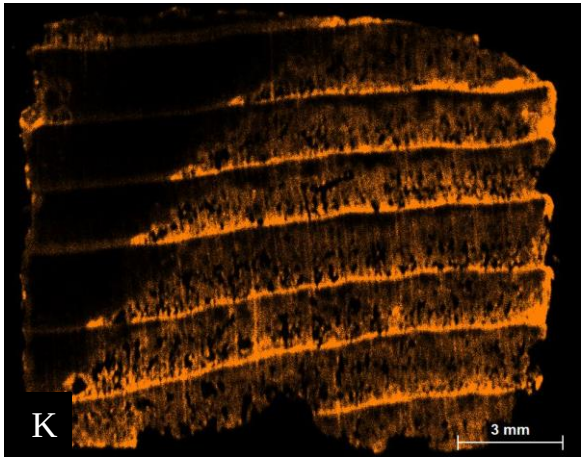
Embedded wood thin section (≈ 200 µm)

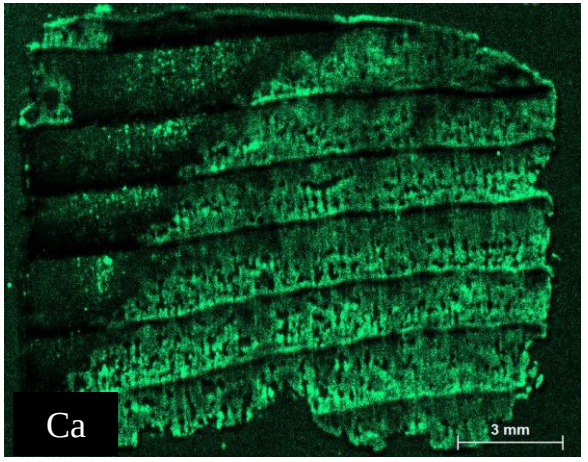
Investigating wood defects through X-rays: μXRF



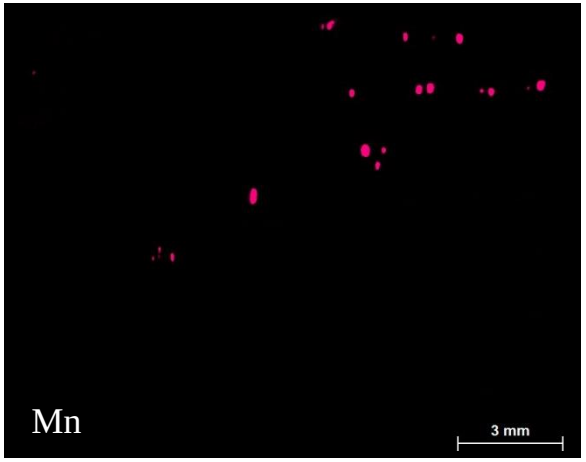


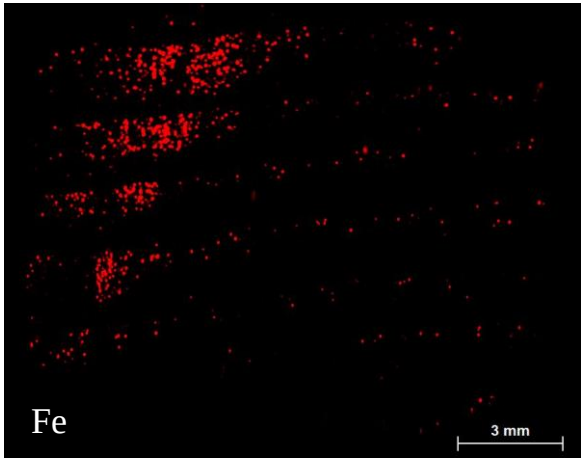


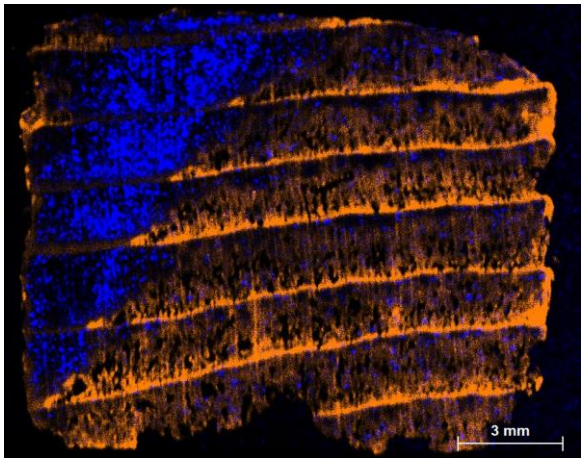




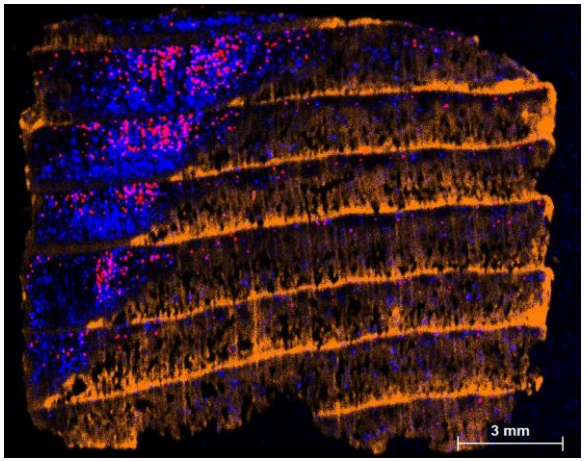
Investigating wood defects through X-rays: μXRF



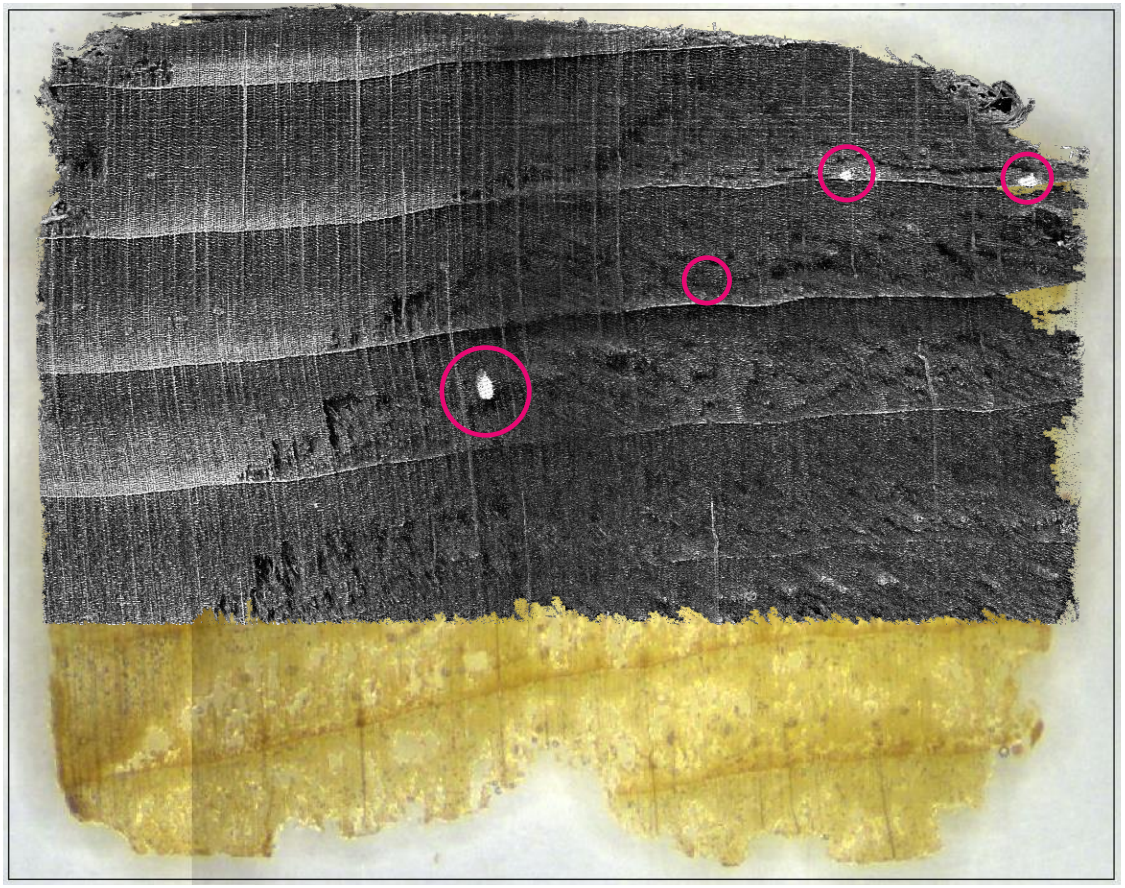




Si K Fe

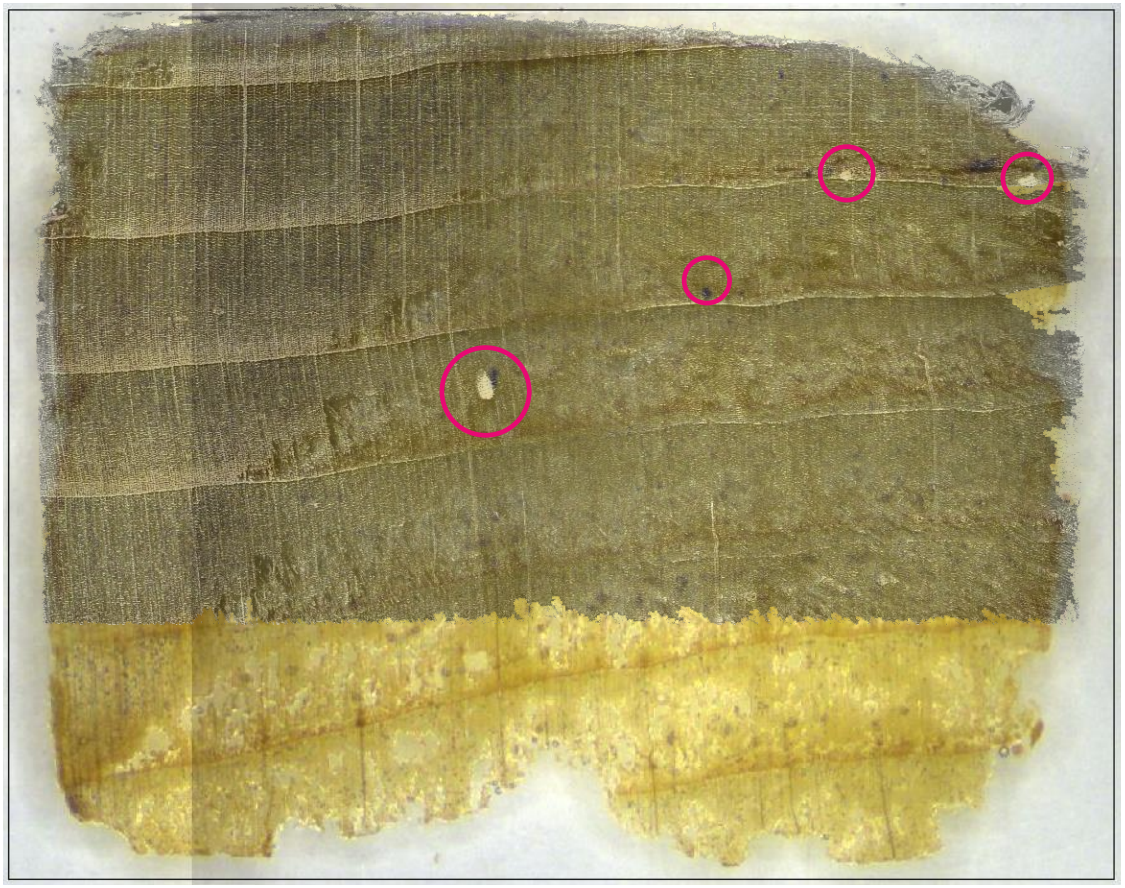


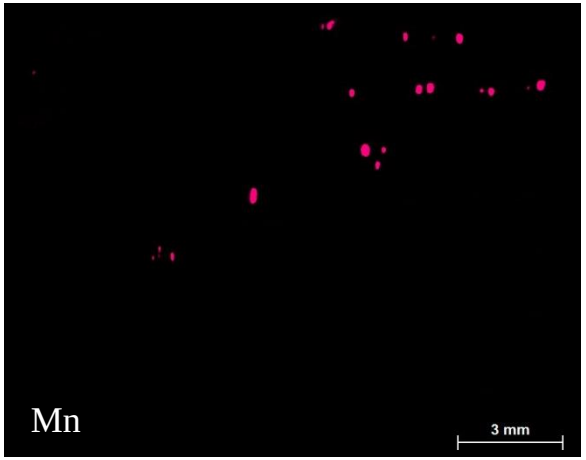
Investigating wood defects through X-rays: combined μXRF and HR μCT



Comparison between the wood thin section used for μXRF and the same section obtained through the HR μCT rendering.

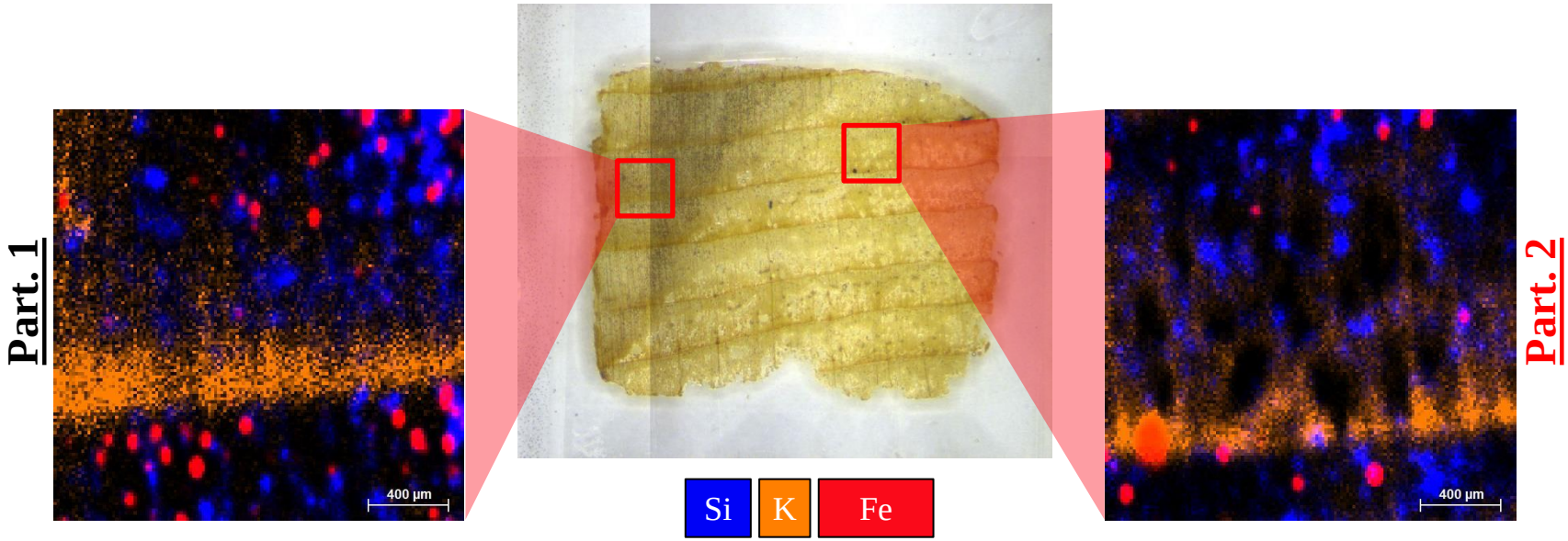
Investigating wood's defects through x-rays

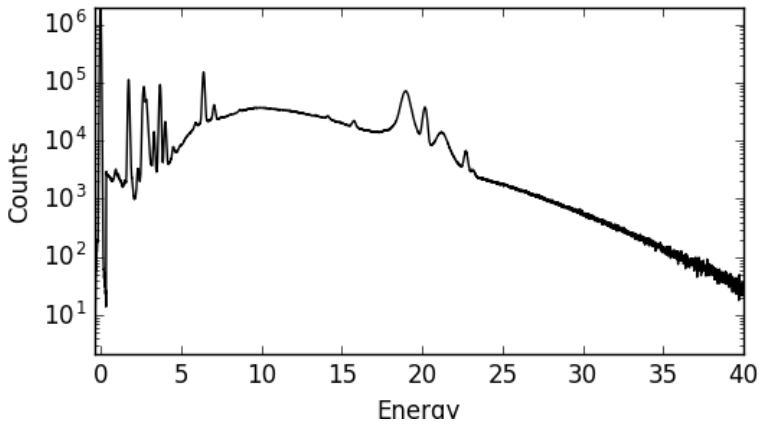


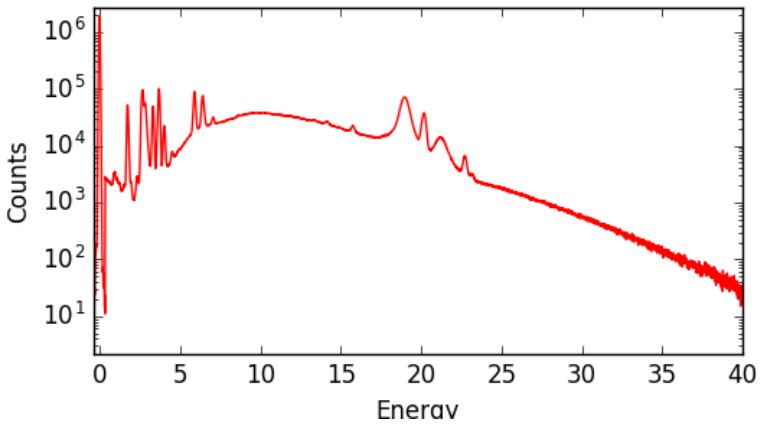


Denser iclusions, which appear as dark spots in the wood slice and as white spots in the µCT rendering, correrspond to localized Mn enrichment (µXRF).

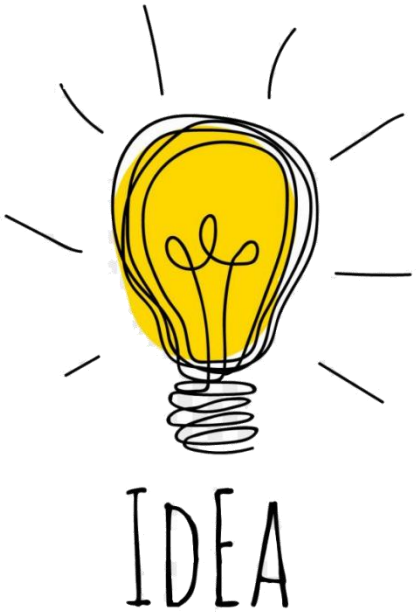
Investigating wood defects through X-rays: μXRF







Investigating wood defects through X-rays: pXRF



Could Mn be used as a marker to rapidly diagnose (fungi) infected wood?

Conclusions

Manganese can be used as a «tracer» to early detect fungi infection, likely in combination with other hyperspectral information

X-ray fluorescence can be an effective, fast and non destructive technique to quantify Mn in wood samples

Wood analysis using tomographic and X-ray microfluorescence techniques

Thank you for your attention!

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