

# X-Ray Fluorescence Spectroscopy (XRF) and Mapping Capabilities for Agriculture

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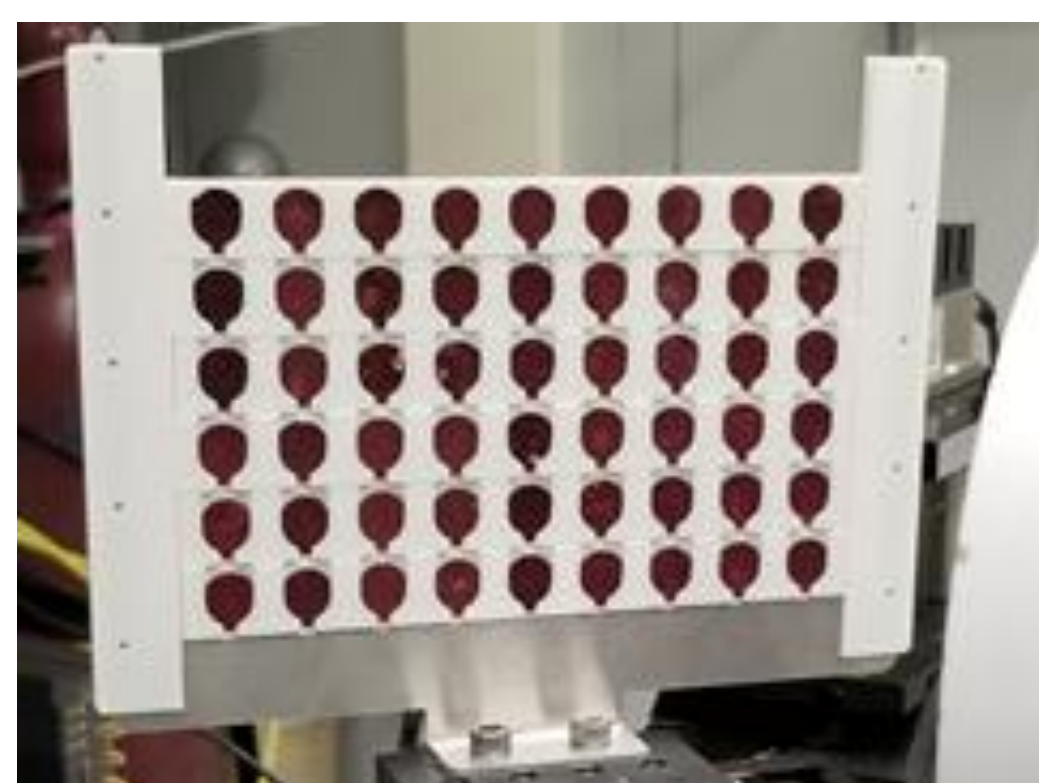
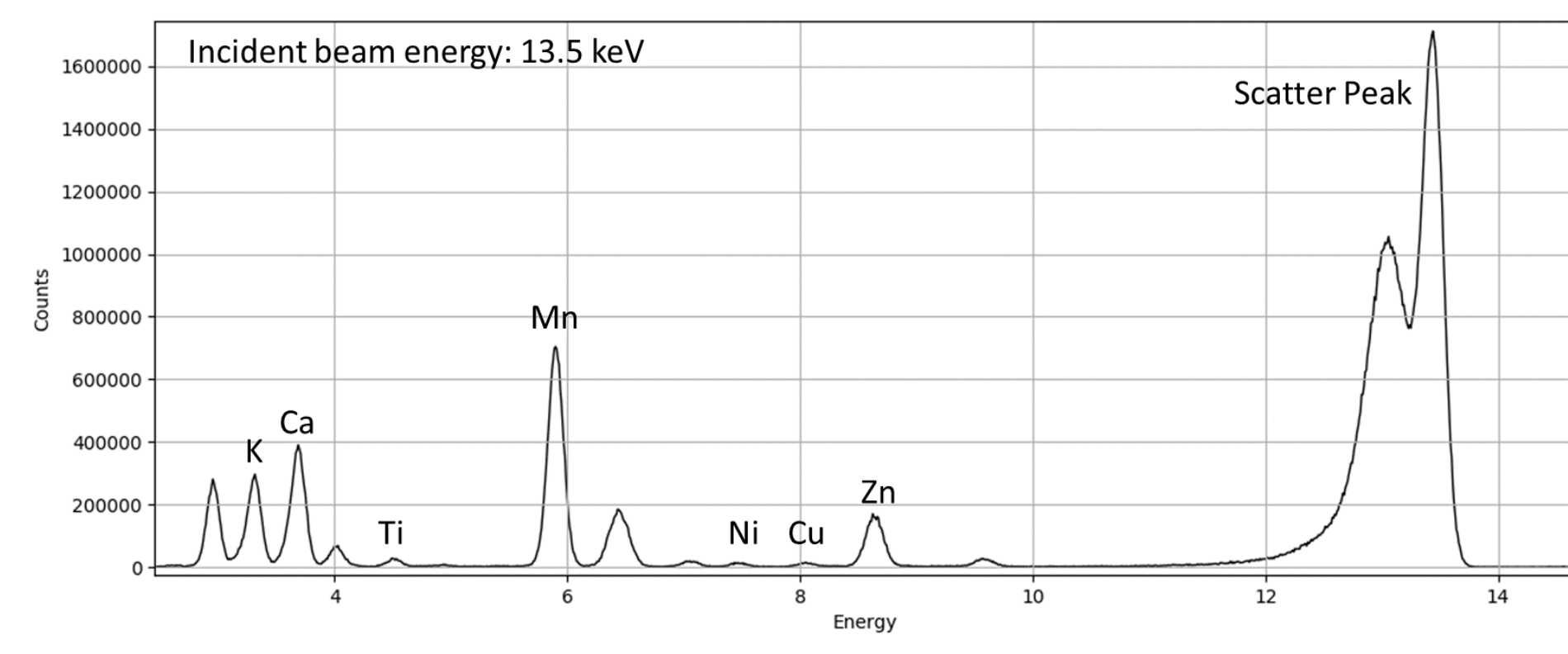
## Introduction

There are many opportunities for agriculture research using X-ray fluorescence spectroscopy (XRF) and imaging at CLS:

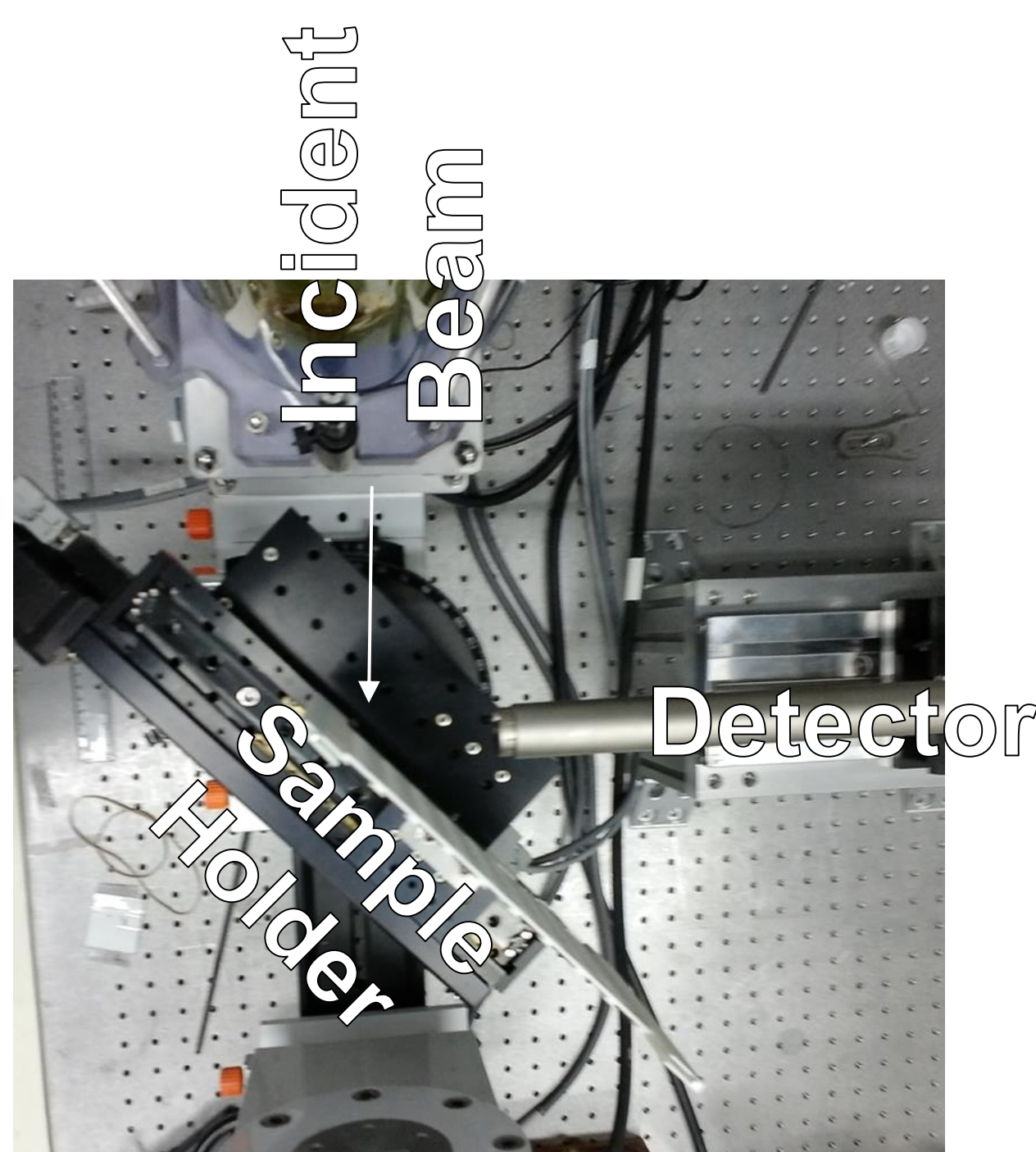
- Wide variety of samples (leaves, roots, berries, seeds, Lygus bugs, etc.)
- Many elements at once (K, Ca, Mn, Fe, Zn, Se, etc.)
- Bulk XRF – large numbers of samples analyzed quickly
- XRF mapping – location of elements within a sample
- Confocal XRF – location of elements within a sample in a stack of 2D maps (pseudo-volume)

## Bulk XRF

There are a few beamlines at CLS that are suitable for agricultural bulk XRF measurements. A few hard X-ray beamlines are IDEAS, BioXAS-side, and VESPERS. A couple of soft X-ray beamlines are SGM and SM.



IDEAS multi-pellet holder (up to 54 pellets).



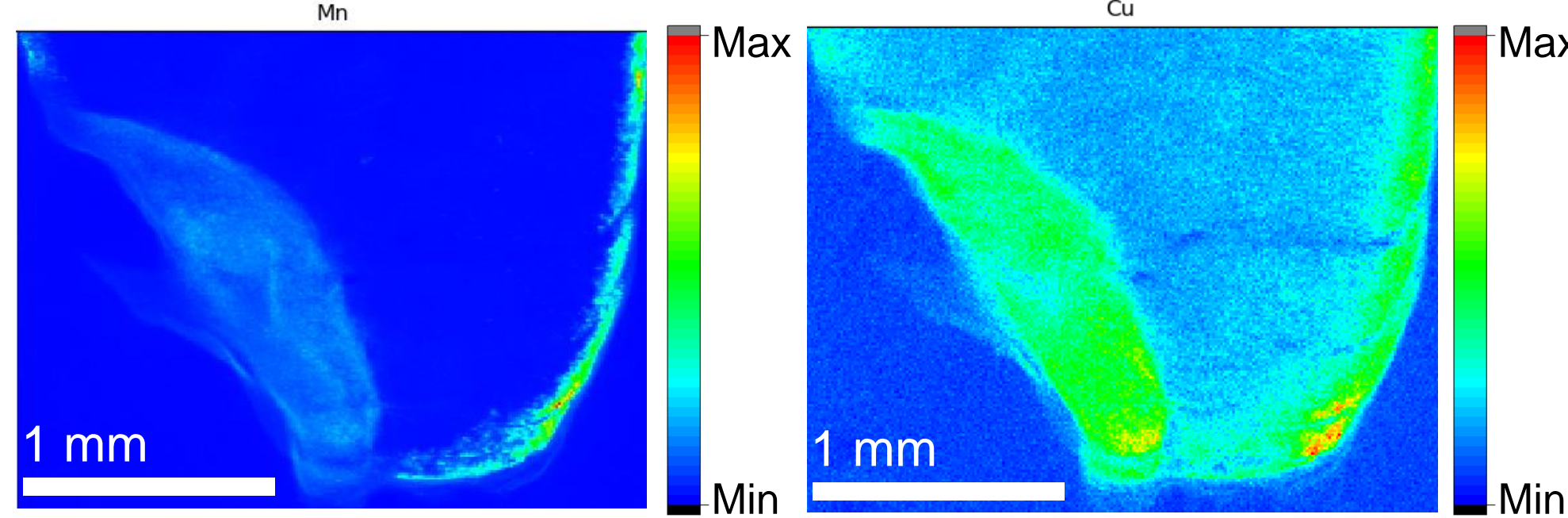
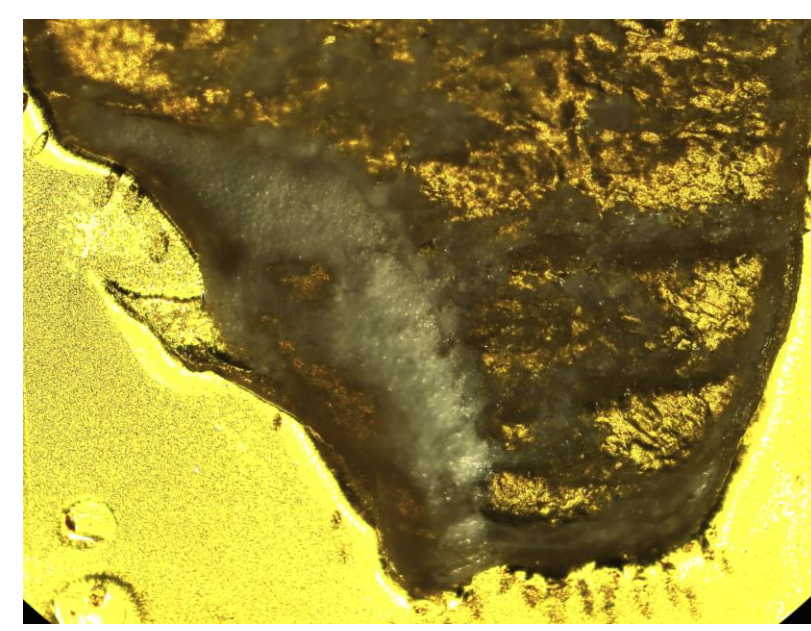
IDEAS bulk measurement set up.

## XRF Mapping

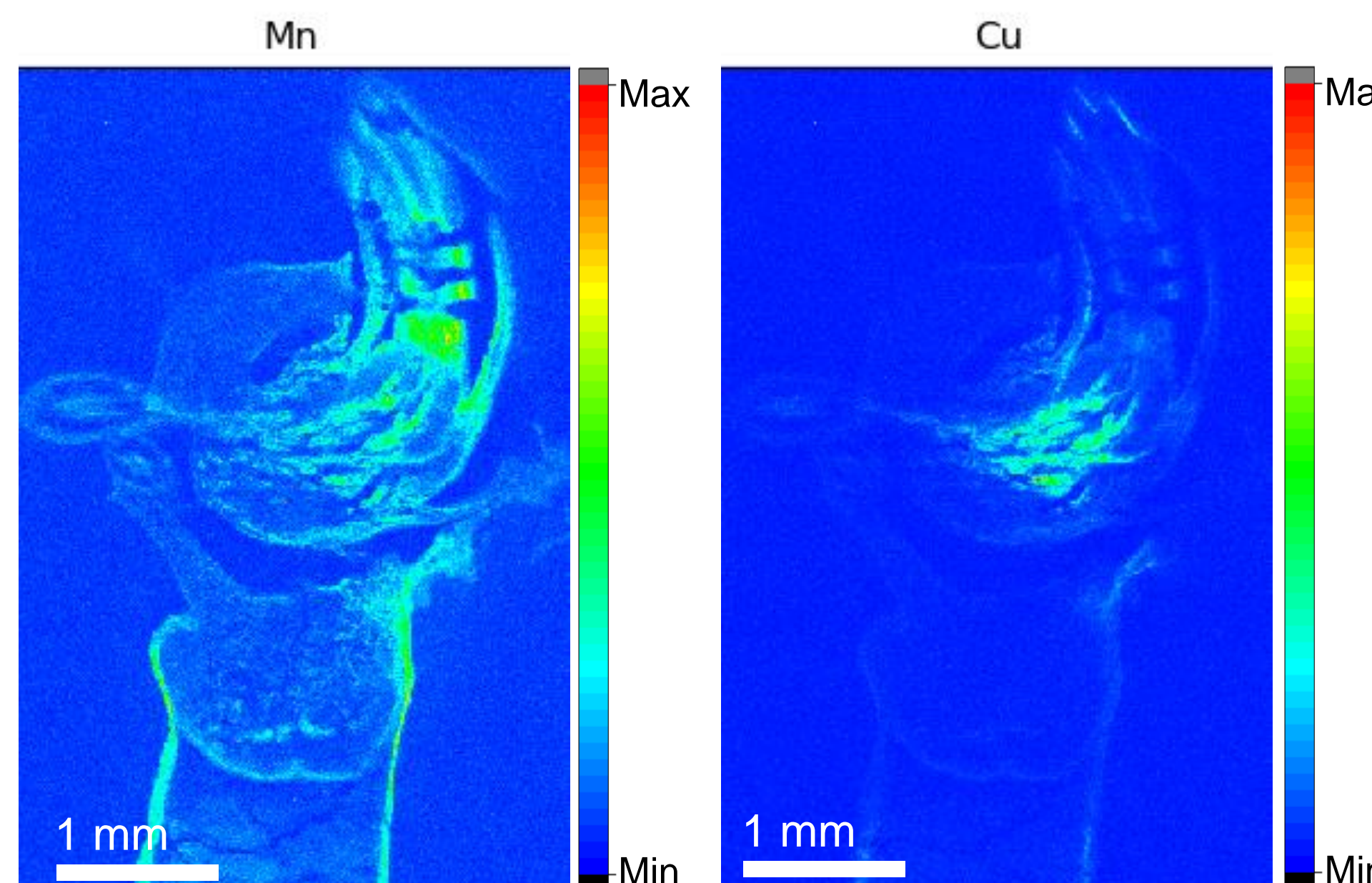
Several beamlines at CLS are suitable for agricultural XRF mapping: IDEAS, BioXAS-Imaging, and VESPERS. Localization of elements within samples from micron to nano scales.



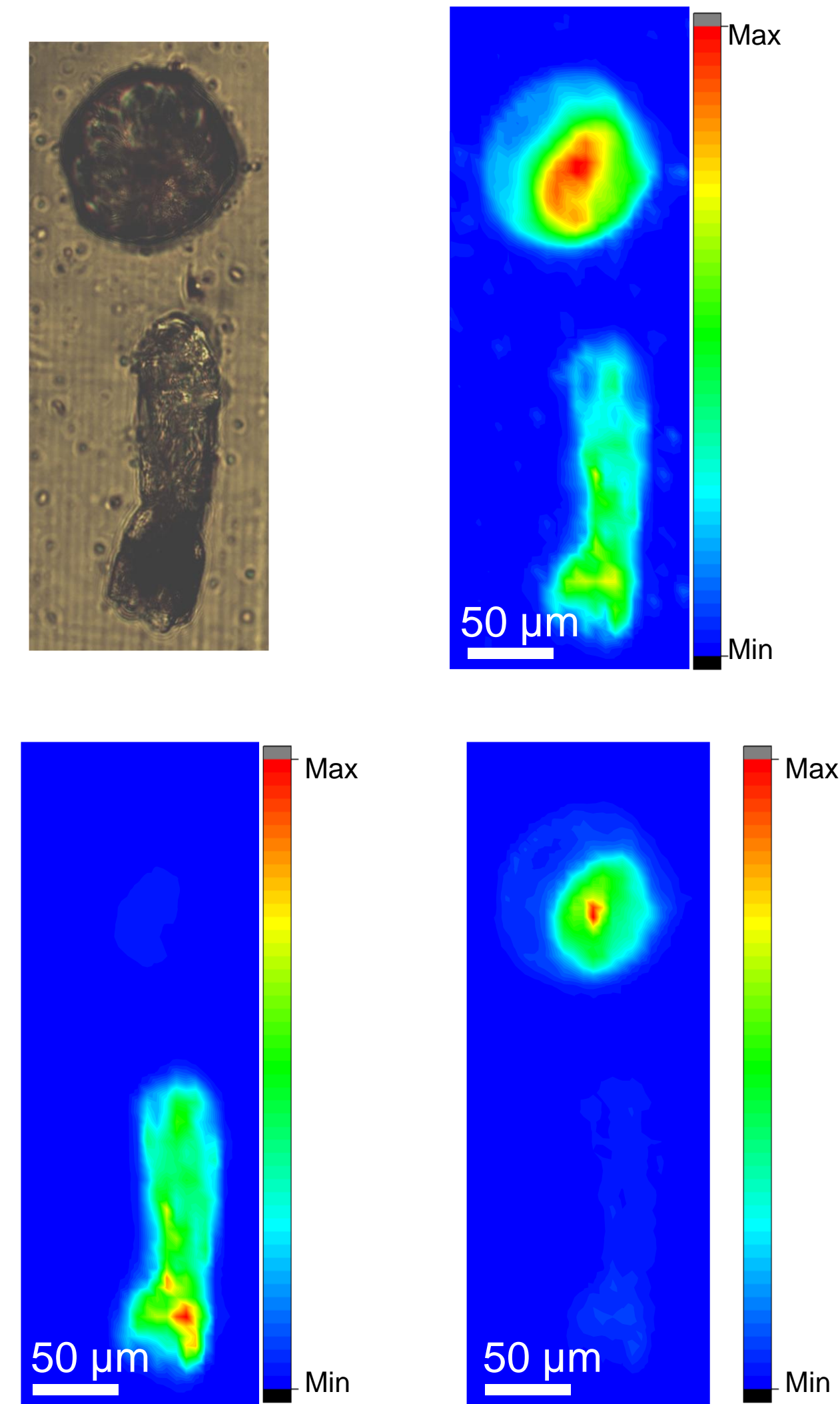
IDEAS mapping set up



Microscope image and XRF maps (Mn and Cu) collected at the BioXAS-Imaging beamline of a thin-sectioned rice grain.



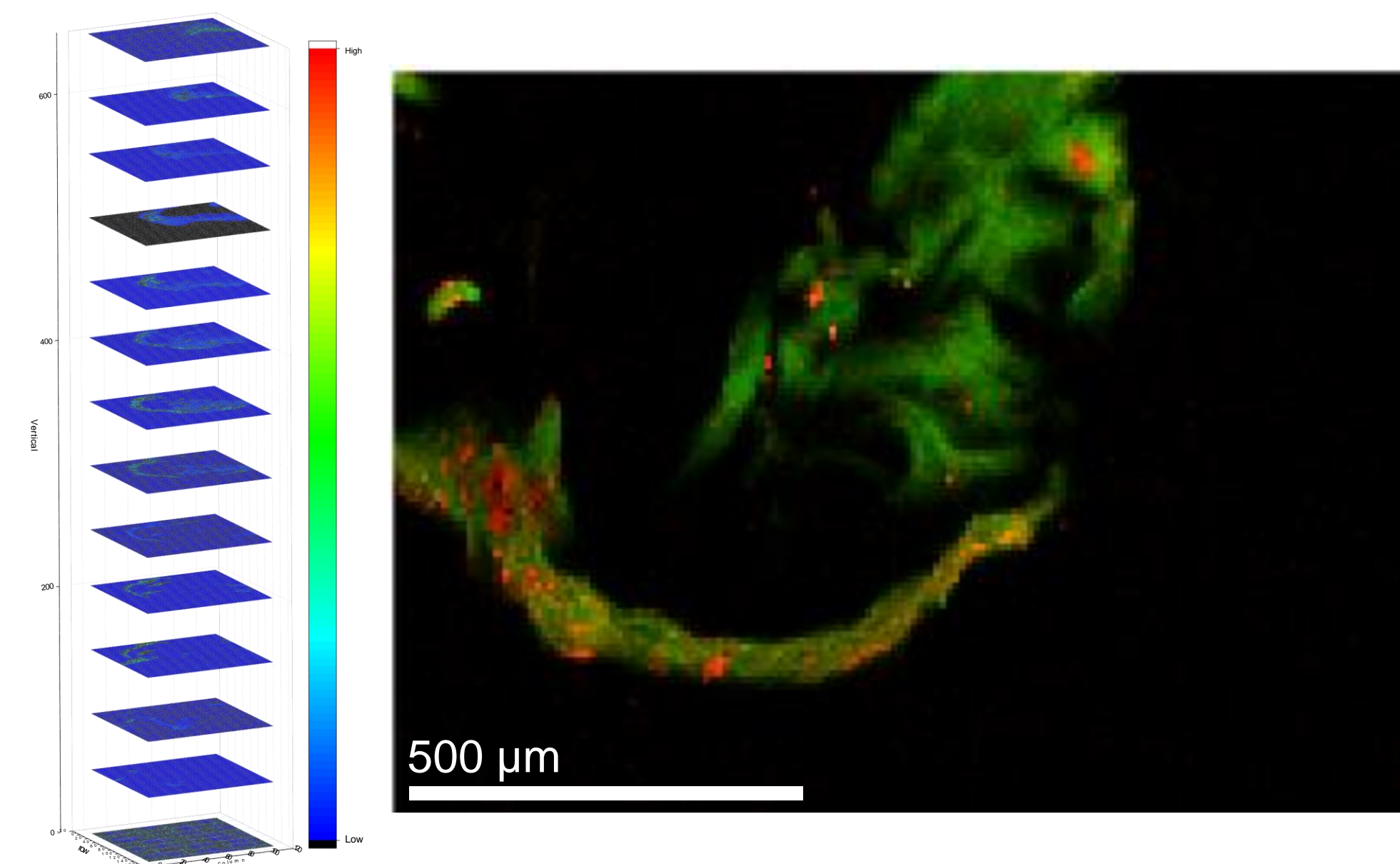
Microscope image and XRF maps (Mn and Cu) collected at the BioXAS-Imaging beamline of a thin-sectioned sprouted rice grain.



Microscope image and XRF maps (left to right: Ca, K, Mn) of a cannabis trichome. Ca is found in the stalk and glandular head, K is found mostly in the stalk, and Mn is found mostly in the glandular head.

## Confocal XRF

The CLS@APS beamline has a polycapillary optic that allows for confocal XRF microscopy.



Confocal images of Se in a Lygus bug treated with toxic nanoparticles. Left image shows the stack of 14 2D images and right image shows a correlation map of one of the 2D images showing Se (red) and Zn (green).

## Benefits of Synchrotron XRF Experiments for Agriculture

- High flux
  - faster experiments
  - see deeper into samples
- High resolution
- Wide variety of samples and experiment types



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