

# USING SYNCHROTRON TECHNIQUES TO UNDERSTAND PLANT DISEASES

Stripe Rust and Wheat

Alanna Orsak, 2017

# STRIPE RUST

- Disease of wheat caused by *Puccinia striiformis* f. sp. *tritici* (*Pst*)
- Causes yield loss of up to 65%
  - Reduces photosynthetic area of leaves, desiccates and steals sugars
- **Symptoms:**
  - Chlorosis (early)
  - Yellow pustules erupting in stripes along the veins of leaves (late)





# STRIPE RUST

- Becoming more prevalent in Western Canada
  - New races able to overwinter locally
  - Recently milder winters
- The best form of control is using a wheat variety with genetic resistance

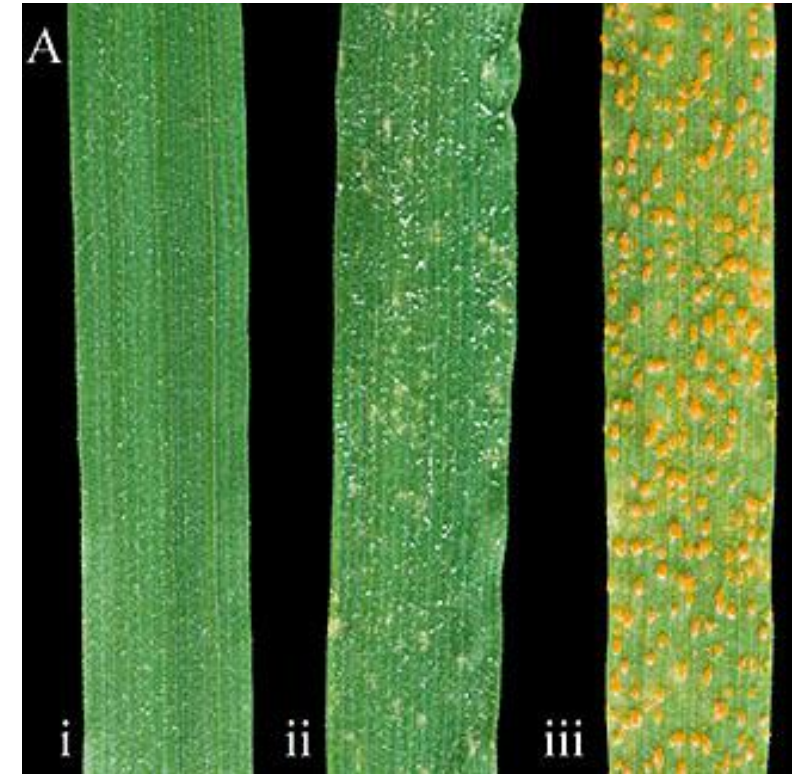
# STRIPE RUST RESISTANCE

- Race-specific resistance
- Wheat variety Avocet + *Yr10* is susceptible to *Pst* race W053, but resistant to W047

	W047	W053
Avocet S	Susceptible	Susceptible
Avocet Yr10	Resistant	Susceptible

- Resistant wheat varieties undergo a **hypersensitive response** when exposed to *Pst*
  - Programmed cell death

The Hypersensitive Response



[https://www.researchgate.net/profile/Graham\\_McGrann/publication/45582460/figure/fig7/AS:281822559785010@1444203142960/Figure-1-Puccinia-striiformis-f-sp-tritici-inoculations-Yellow-rust-infection.png](https://www.researchgate.net/profile/Graham_McGrann/publication/45582460/figure/fig7/AS:281822559785010@1444203142960/Figure-1-Puccinia-striiformis-f-sp-tritici-inoculations-Yellow-rust-infection.png)

# PROJECT OBJECTIVES

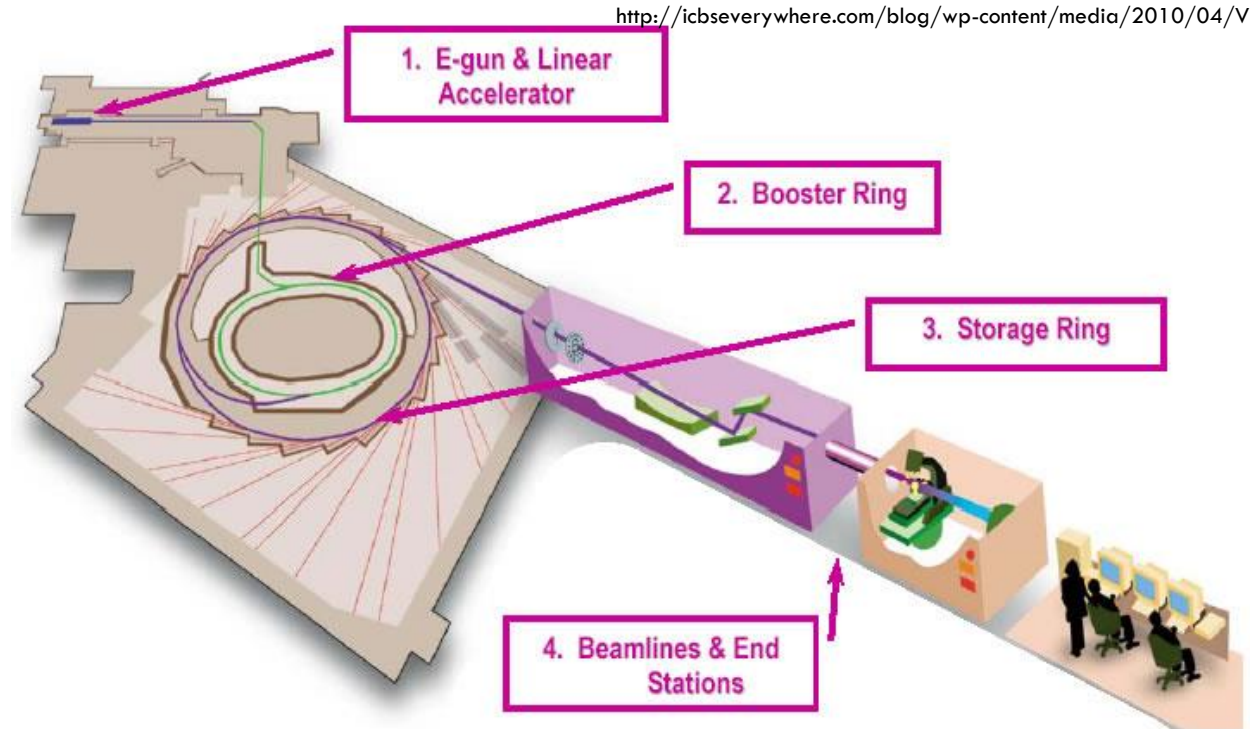
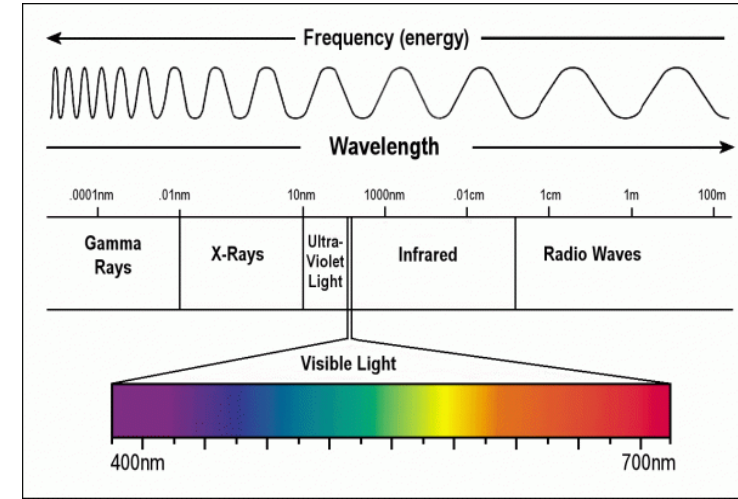
	W047	W053
Avocet S	Susceptible	Susceptible
Avocet Yr10	Resistant	Susceptible



- To understand how *Pst* and wheat interact
  - What changes occur in wheat during infection? During the HR?
  - e.g. Does lignin content increase in response to infection?
- How?
  - Infecting isogenic lines of Avocet *Yr10* and Avocet *S* with rust isolates to produce susceptible and resistant reactions.
  - Using synchrotron X-ray and Mid-infrared beams to measure cellular components.

# WHAT IS A SYNCHROTRON?

- “Giant Microscope”
- Only 47 facilities exist worldwide
  - Canadian Light Source, Saskatoon, SK
- Accelerates electrons to the speed of light
- Different beamlines generated by passing the electrons through magnets
  - X-Rays, Infrared



<http://icbseverywhere.com/blog/wp-content/media/2010/04/VLS2-600x391.gif>

<http://agni.phys.iit.edu/~vpa/images/synchpic1.jpg>

# ADVANTAGES

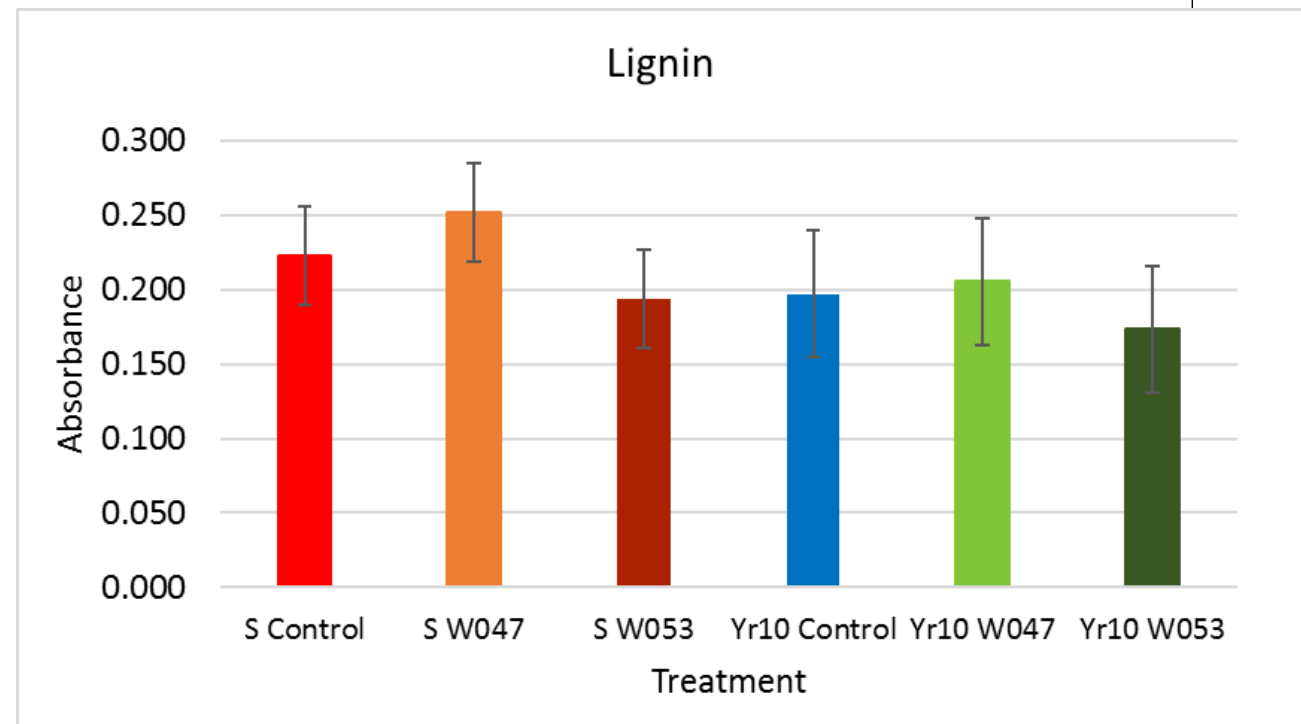
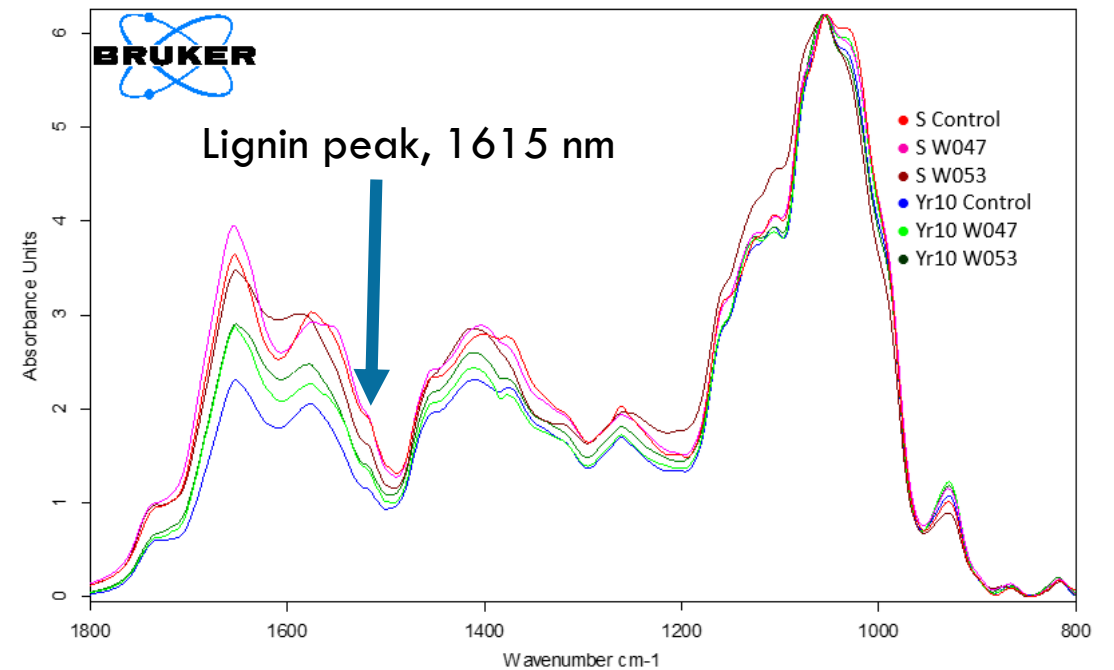
- Can measure a wide range of elements and molecules
- Faster and more accurate than spectrophotometry or other microscopy techniques
- Extremely high resolution and precise
  - Better than conventional sources of radiation
- Can locate, identify and measure elements at tissue, cellular and subcellular levels





# RESULTS: MID-IR

- Mid-IR measures carbohydrates, lipids and proteins
- No significant difference found among treatments for lignin, cellulose, hemicellulose, pectins or proteins
  - Any differences are due to basal resistance.



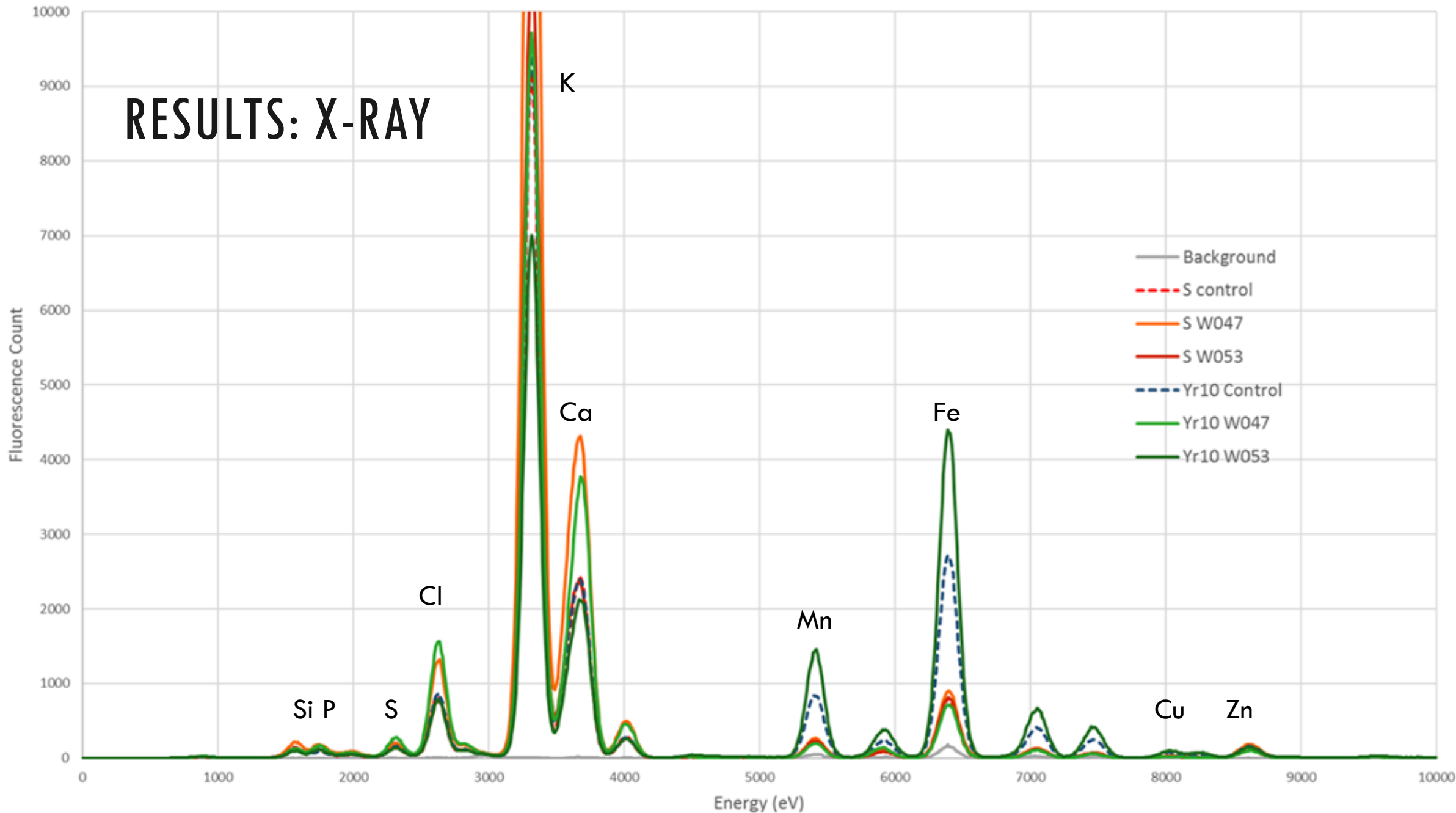
# MID-IR INTERPRETATION AND ERROR



- Error:
  - Poor/uneven infection of leaf samples
  - Disproportionate sample measurements
  - Cracked pellets
- Conclusion:
  - Any differences in samples due to basal resistance. Not related to HR.
  - Alanna is bad at making pellets

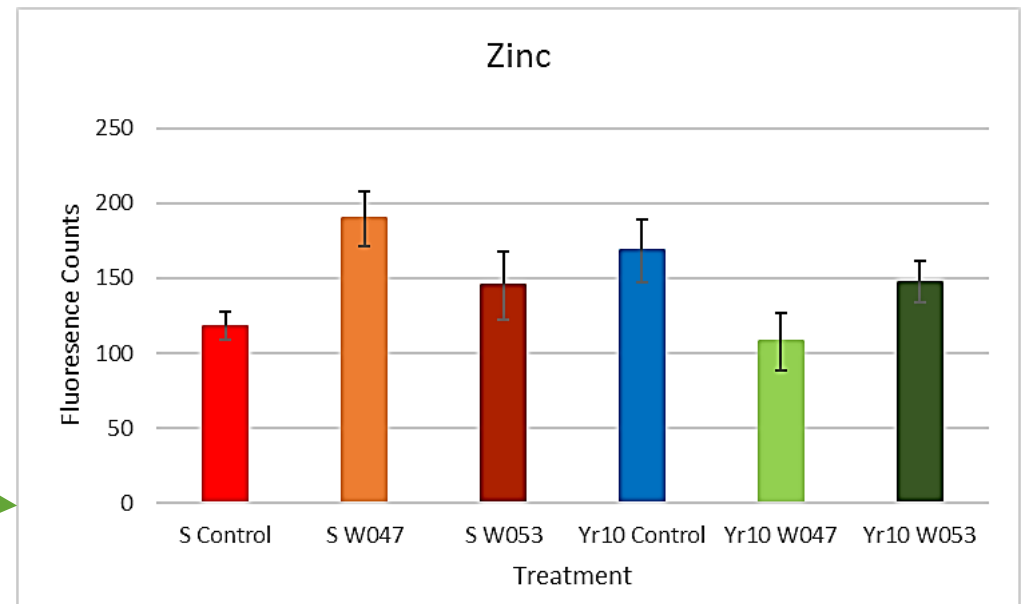
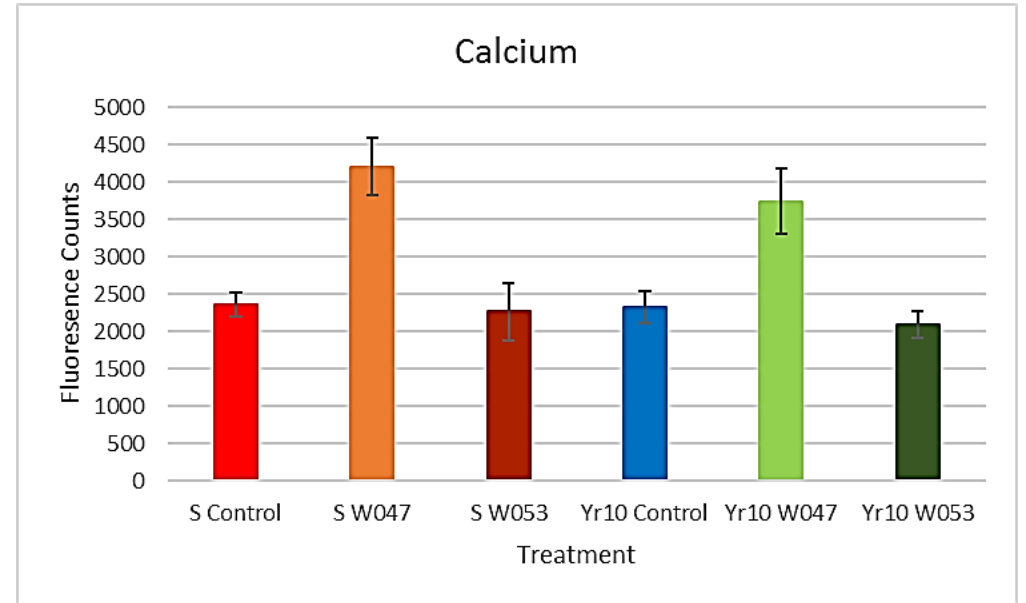
# X-Ray Fluorescence Spectra of Wheat Leaves

## RESULTS: X-RAY



# RESULTS: X-RAY

- X-ray measures elements:
  - Si, P, S, Cl, K, Ca, Mn, Fe, Cu, Zn
- Two trends/speculations:
  - W047 infected lines appear to have higher content of P, S, Cl, Ca
    - Upregulation upon infection
    - Important elements in cell walls and membranes
  - In the resistant reaction (Yr10 W047) Mn, Fe, Cu, Zn content is comparatively reduced
    - Relation to HR



# X-RAY INTERPRETATION A ERROR

- Error:
  - Poor/uneven infection of leaf samples
  - Improper data collection procedure used
- Conclusion:
  - A general trend may be apparent
  - BUT experiment must be redone



# APPLICATIONS OF SYNCHROTRONS IN PLANT SCIENCE

- Highly underutilized tool
- Functional genotyping/phenotyping
- Understanding how plants respond to stresses
  - Disease resistance
  - Abiotic stress (frost, heat, drought, etc.)

Thank you:

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- Dr. Randy Kutcher, U of S
- Luisa Paulina Cholango Martinez, U of S



QUESTIONS?