BOSTON UNIVERSITY

X-Ray Diffraction: Examining Crystal Structure

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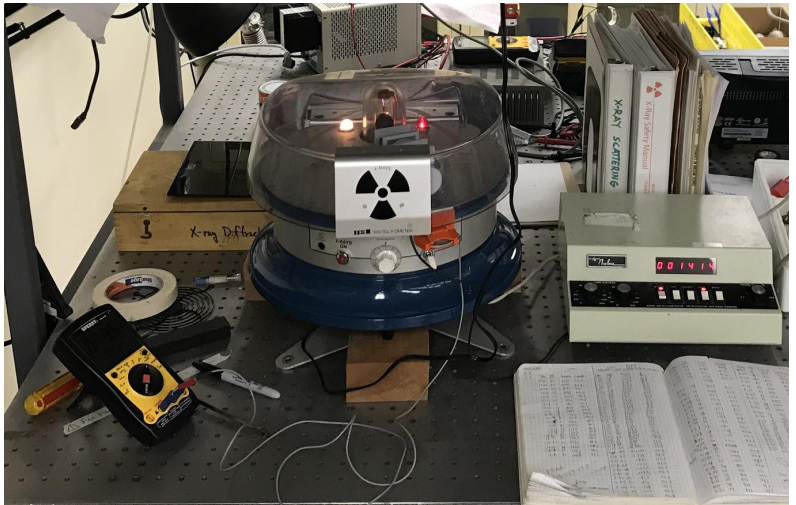
Overview

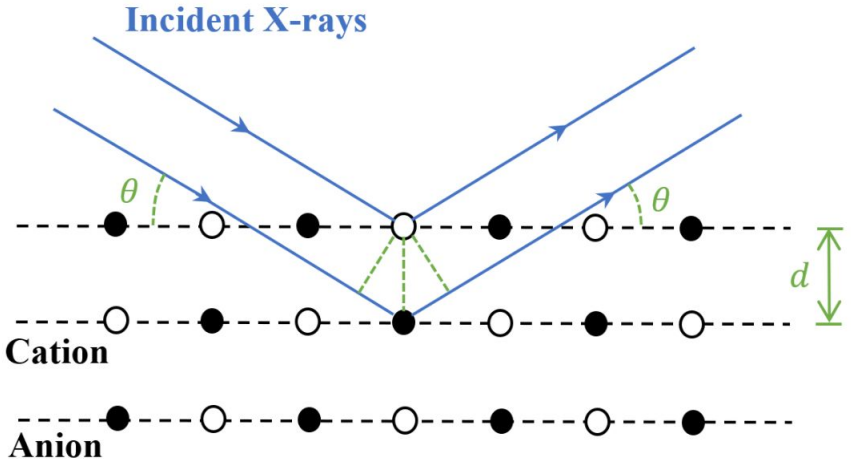
- Bragg diffraction
- Producing X-rays
- Apparatus: Tel-X-Ometer, Geiger-Muller Tube
- Procedure
- Results and Systematics
- Future Work and Improvements



Bragg Diffraction

- Bragg Diffraction: Diffraction of X-rays on crystal lattices

$$\lambda \sim d$$



- Bragg condition describes where diffracted waves constructively interfere:

$$n\lambda = 2d\sin(\theta)$$

n = 1, 2, 3, …
d: interplanar spacing

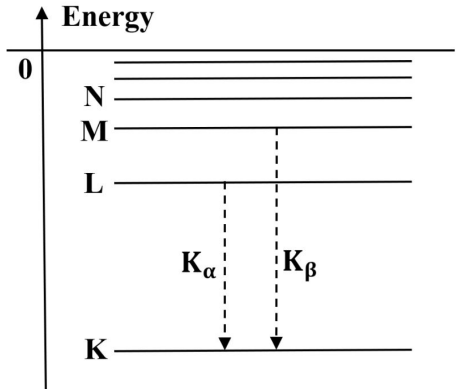
Producing X-Rays

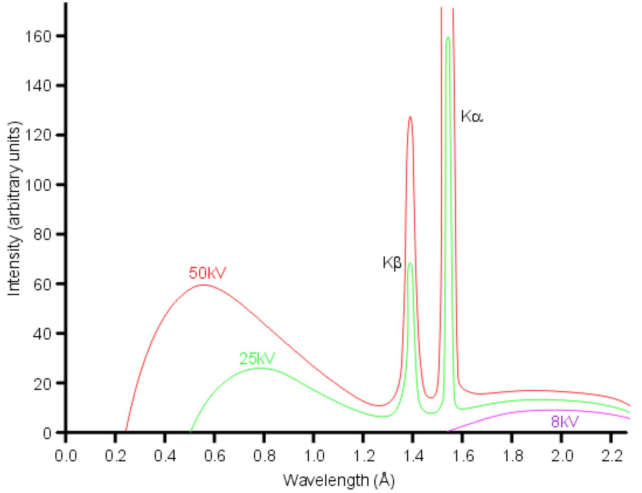
$$E = eV = \frac{hc}{\lambda}$$

- Higher potential creates shorter wavelength photons

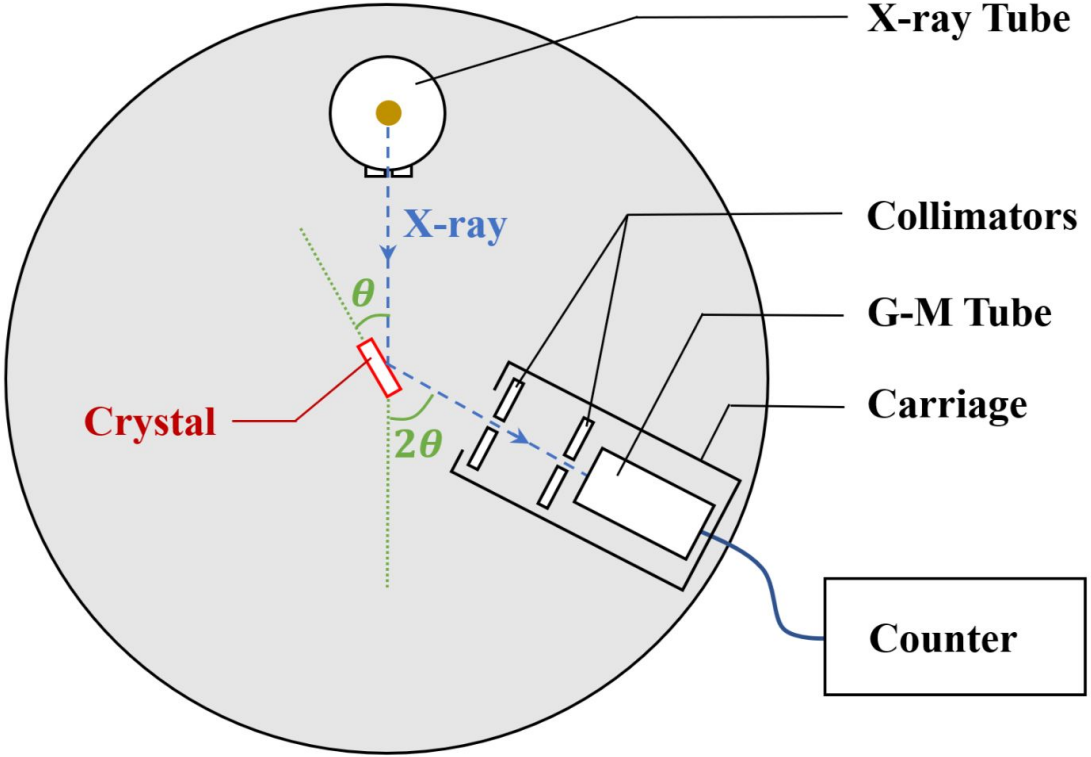
- Apparatus applies 30 kV to a copper source

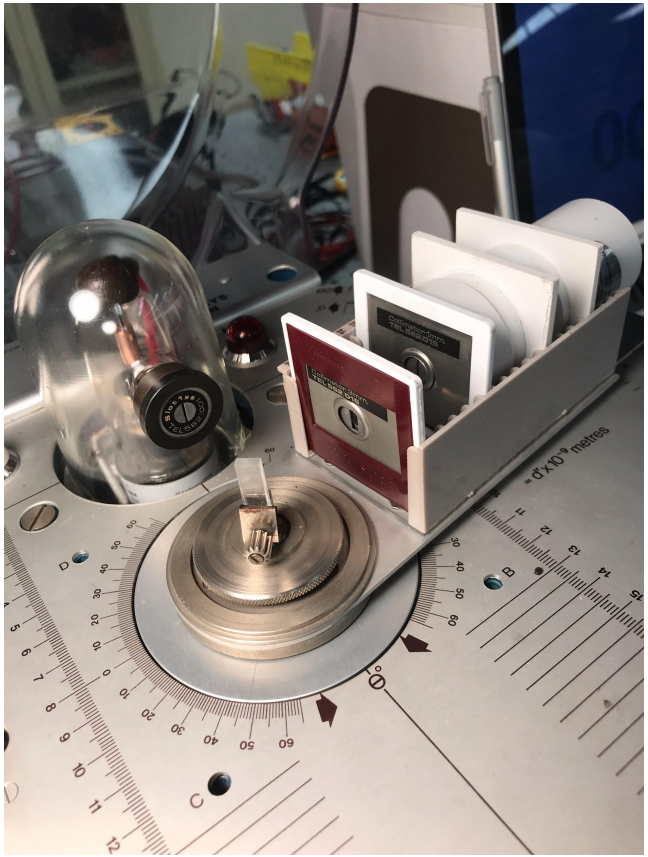
$$K_\alpha = 154 \pm 1.0 \text{ pm}$$
$$K_\beta = 138 \pm 1.0 \text{ pm}$$





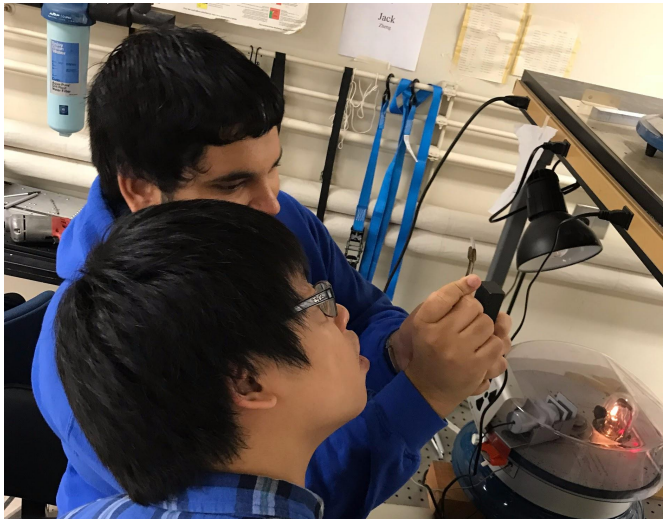
Tel-X-Ometer Setup





Procedure

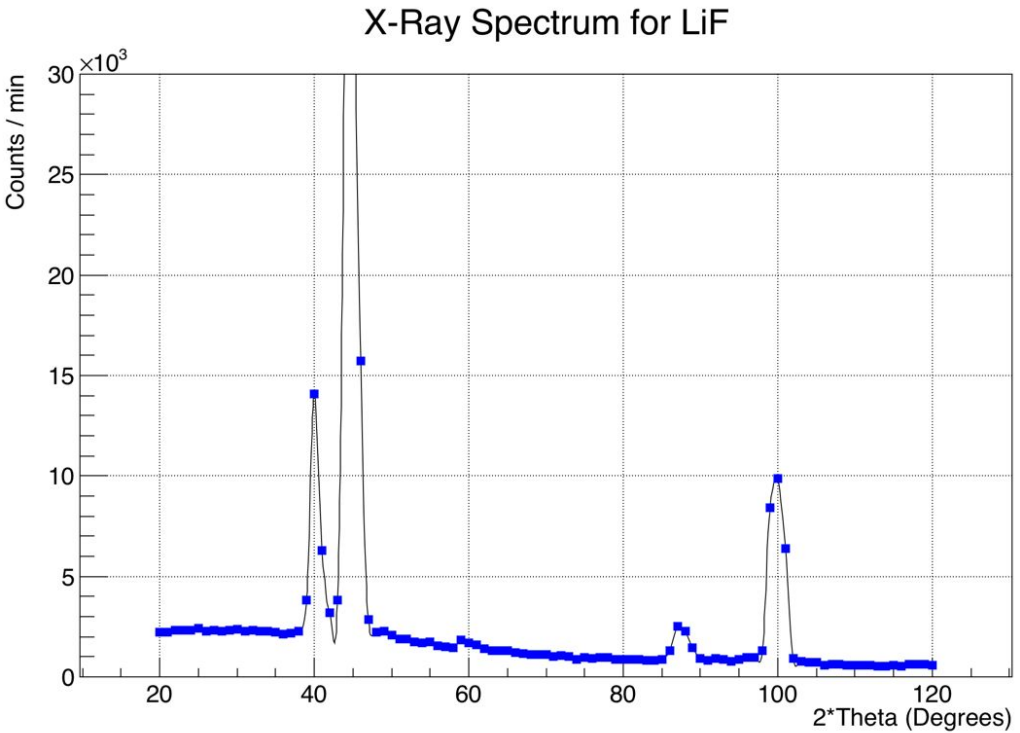
- Use a *clean* crystal: surface should be smooth and clear
- Count x-rays for 1 minute at each degree of 2θ
- Check that Tel-X-Ometer does not overheat



Results: Lithium Fluoride (LiF)

- Each peak gives value for *d* using Bragg equation
- n = 1, 2 peaks are observed
- Averaging over all values:

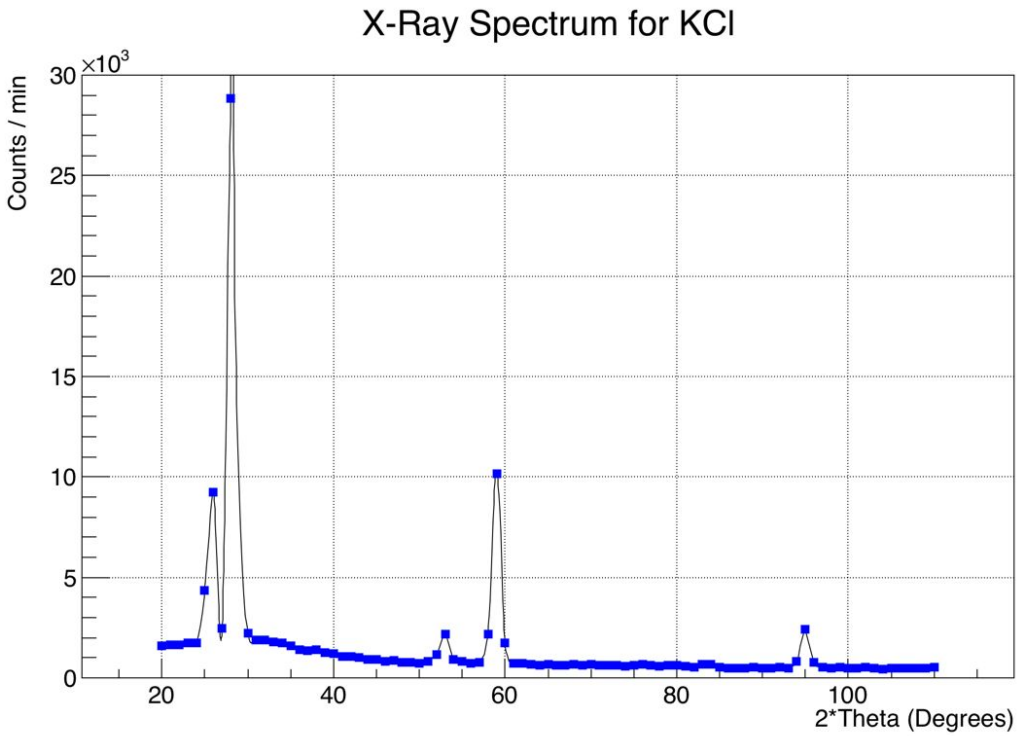
$$d_{LiF} = 201 \pm 2.9\ pm$$



Results: Potassium Chloride (KCl)

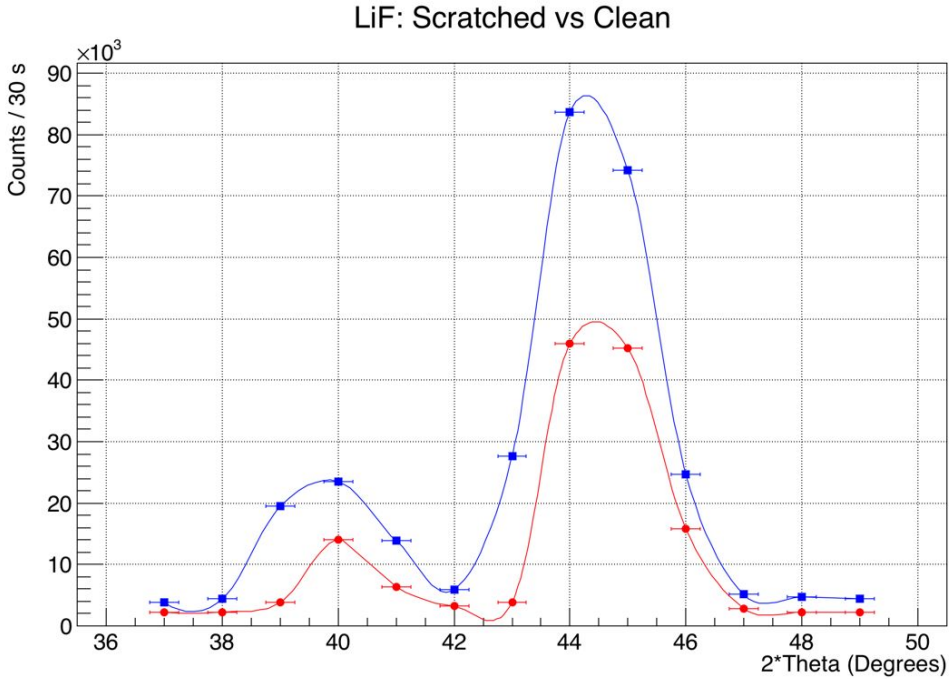
- Each peak gives value for *d* using Bragg equation
- n = 1, 2, and 3 peaks are observed
- Averaging over all values:

$$d_{KCl} = 311 \pm 6.4\ pm$$



Systematics

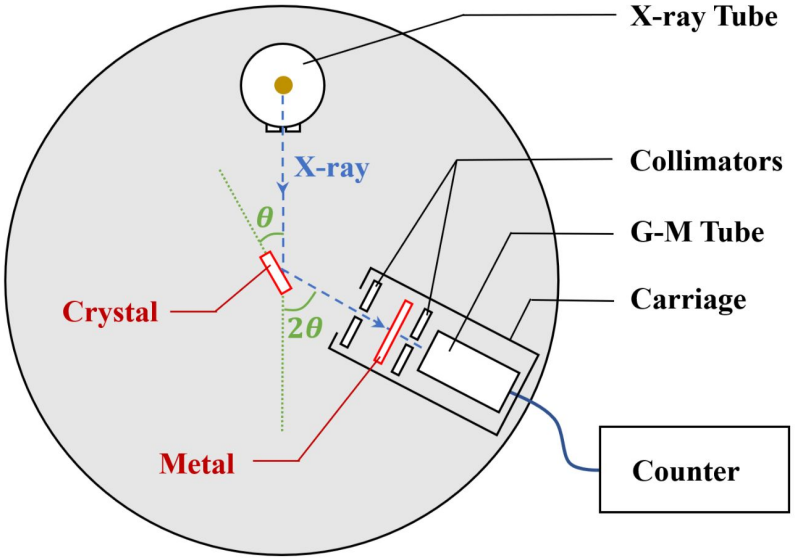
- Scratched (dirty) crystal
  - Peaks are smeared
- Operating voltage of Tel-X-Ometer and GM Tube
  - No noticeable effect
- Alignment of crystal
  - Shift of peak
- Fluctuations of counts day to day
  - Affected width of peak
  - Cause unknown: Temperature fluctuations?



Blue: Scratched Crystal
Red: Clean Crystal

Future Work and Improvements

- Increase resolution by reducing angular spacing
- Why do number of counts changes from day to day?
- Test metal absorption over a range of 2θ with peaks



Acknowledgements

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References

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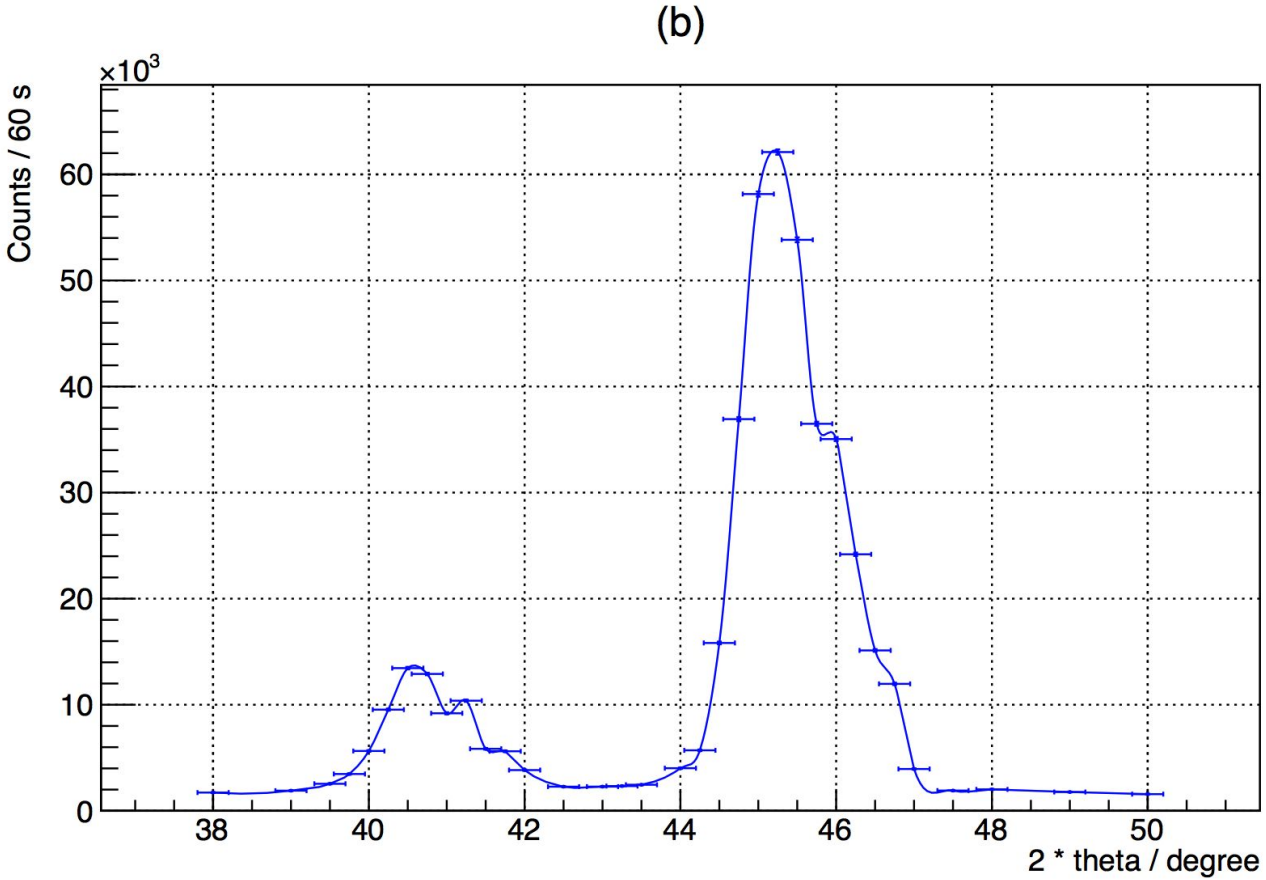
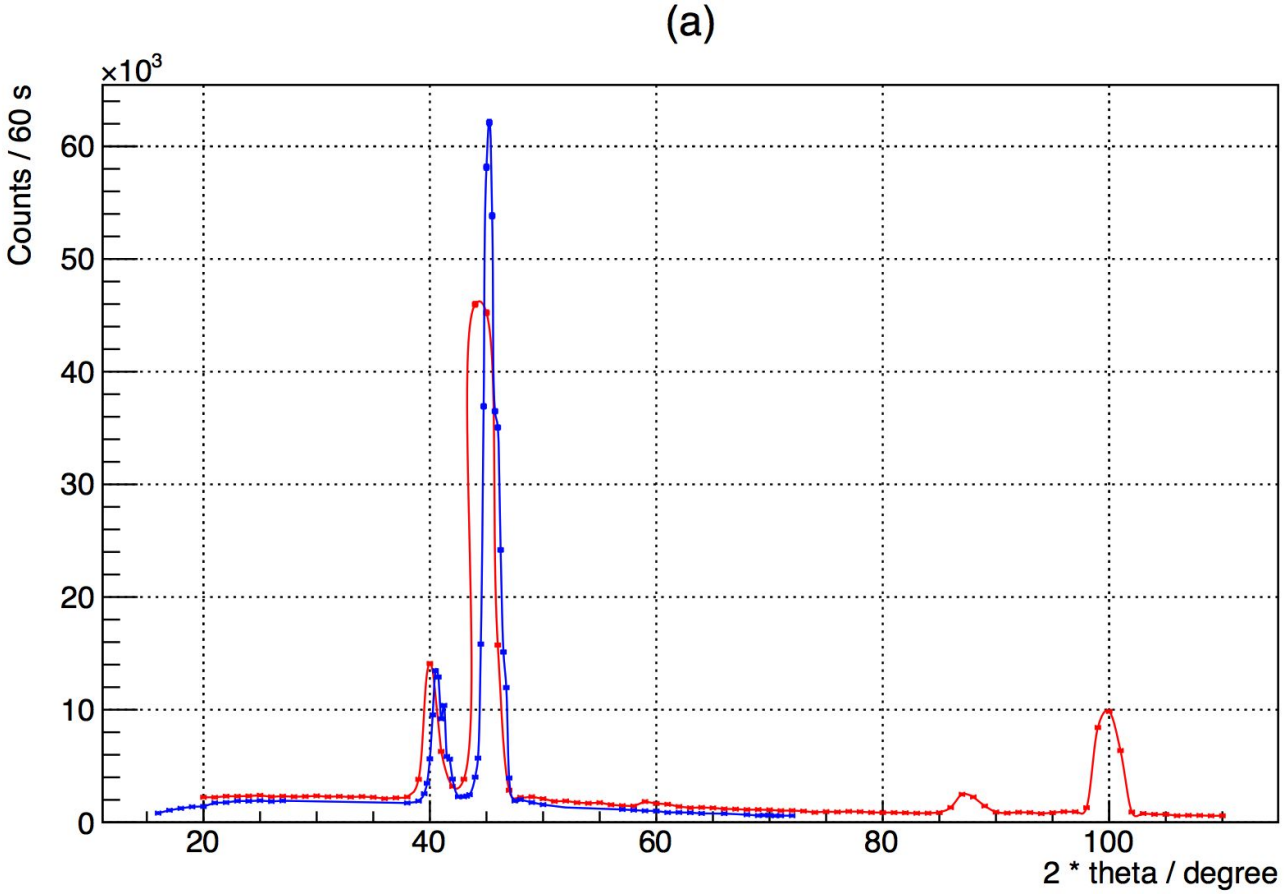
http://pd.chem.ucl.ac.uk/pdnn/inst1/xrays.htm

Extra Slides

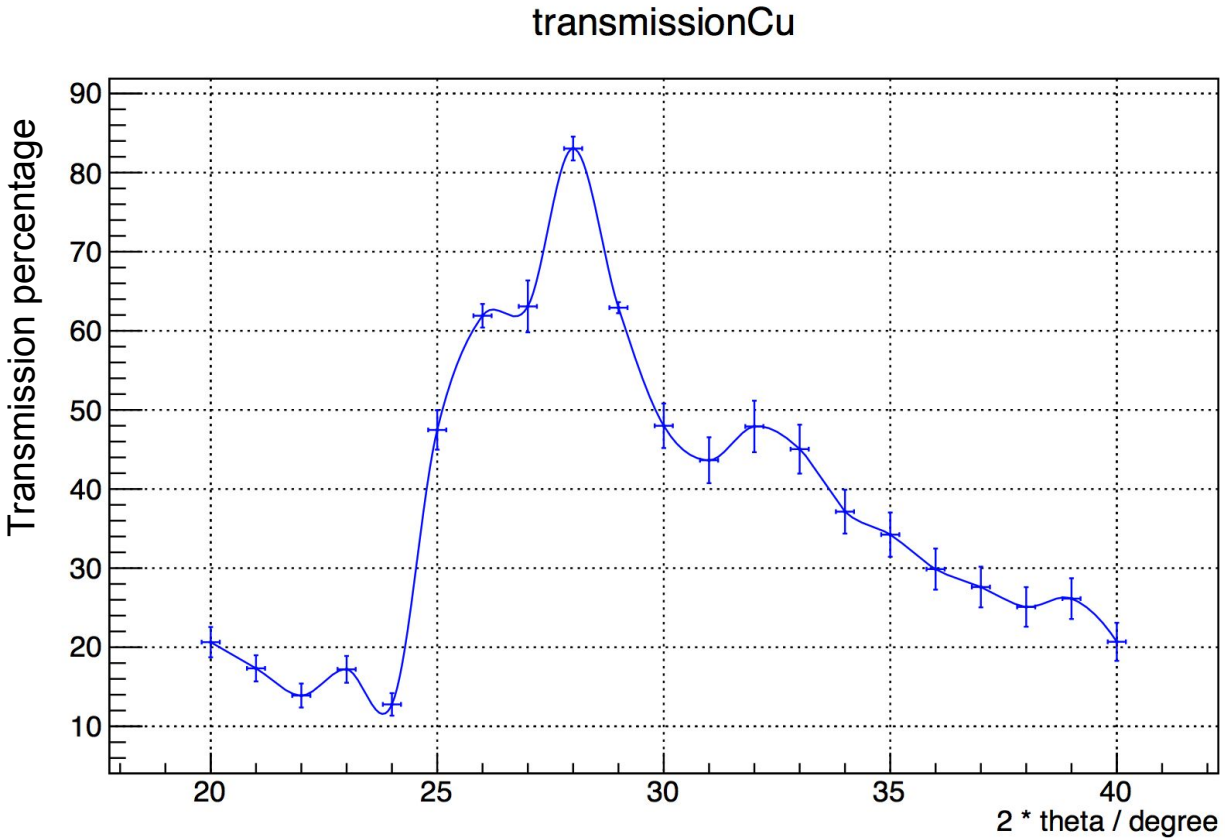
Increasing the resolution



Analyzing Increased Resolution



Transmission/Absorption of Copper



Transmission/Absorption of Nickel