WDS to the Rescue: Improving your SEM/EDS

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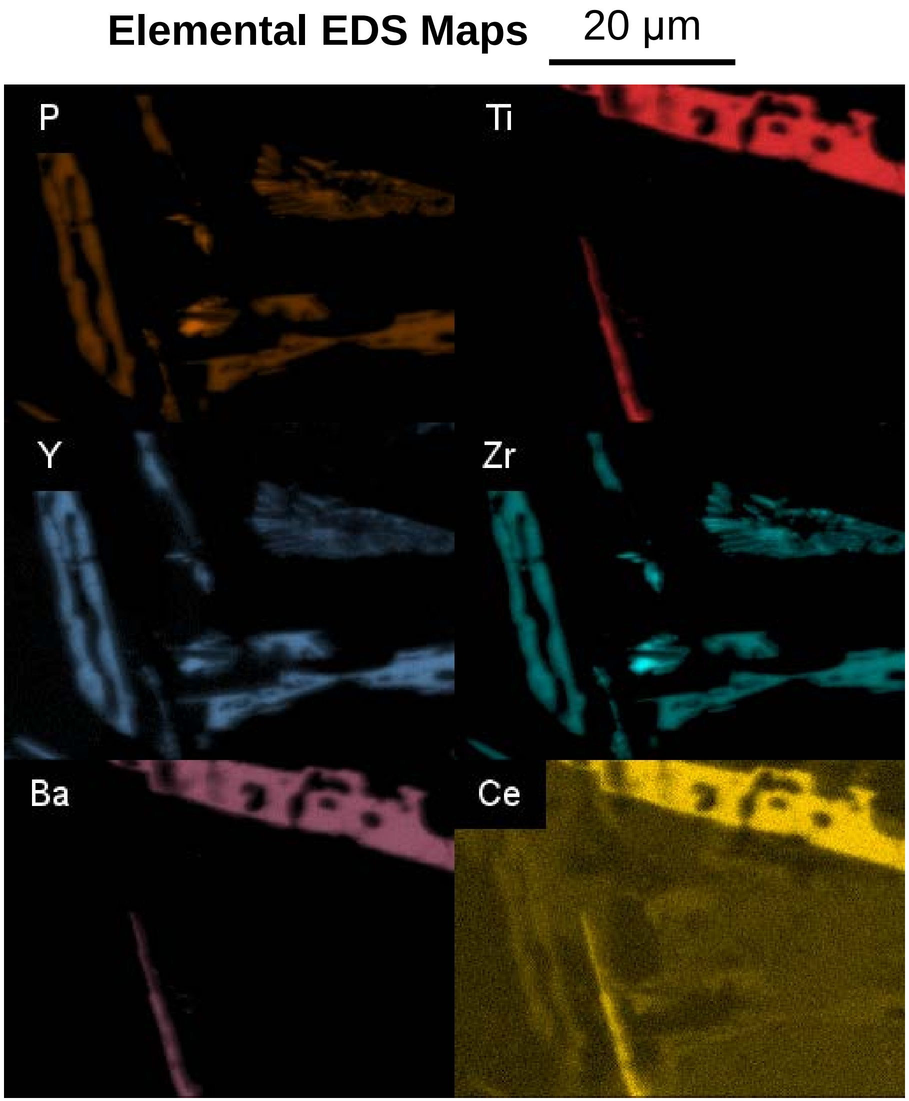
Introduction

- Everybody loves EDS
  - Super fast
  - Easy to use
  - Accurate results

- EDS has limitations
  - Energy resolution: the best is ~120 eV @ Mn Kα
    - Results in many peak overlaps (i.e., X-ray interferences)
    - Requires faith in peak deconvolution algorithms
  - Relatively poor peak-to-background ratio
    - Difficult to detect trace elements

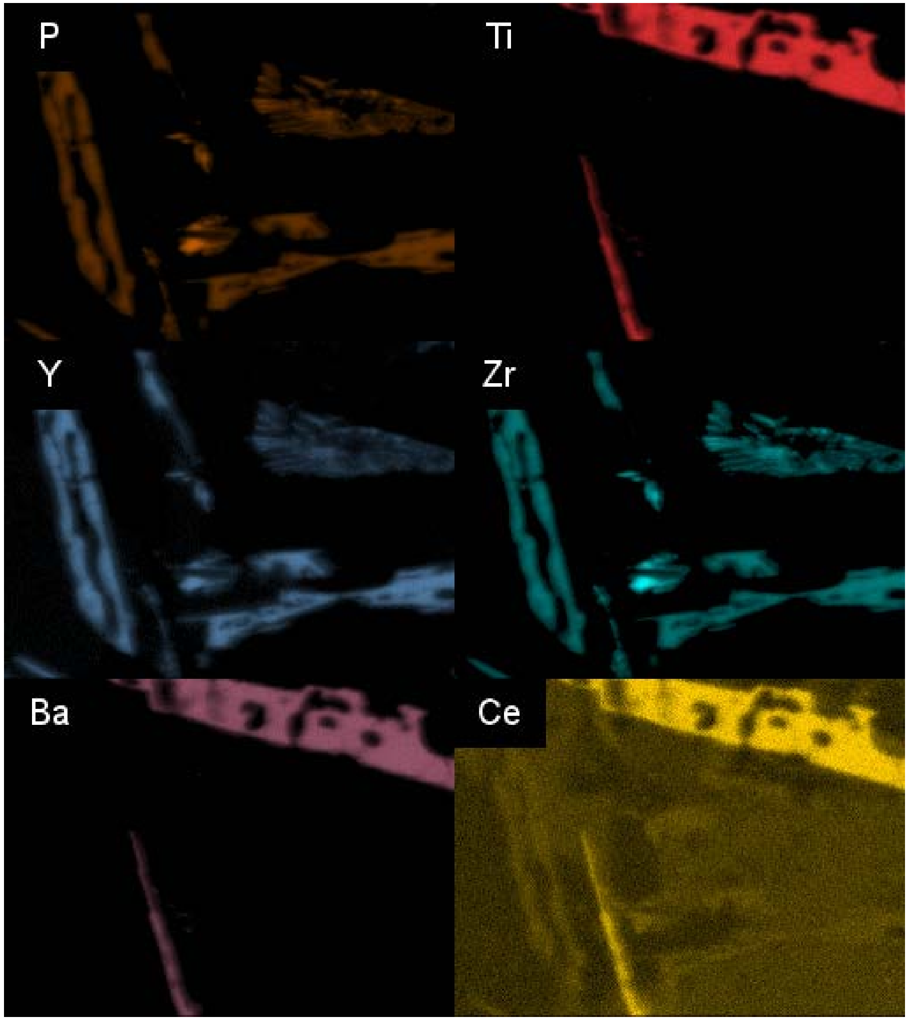
Introduction

Elemental EDS Maps



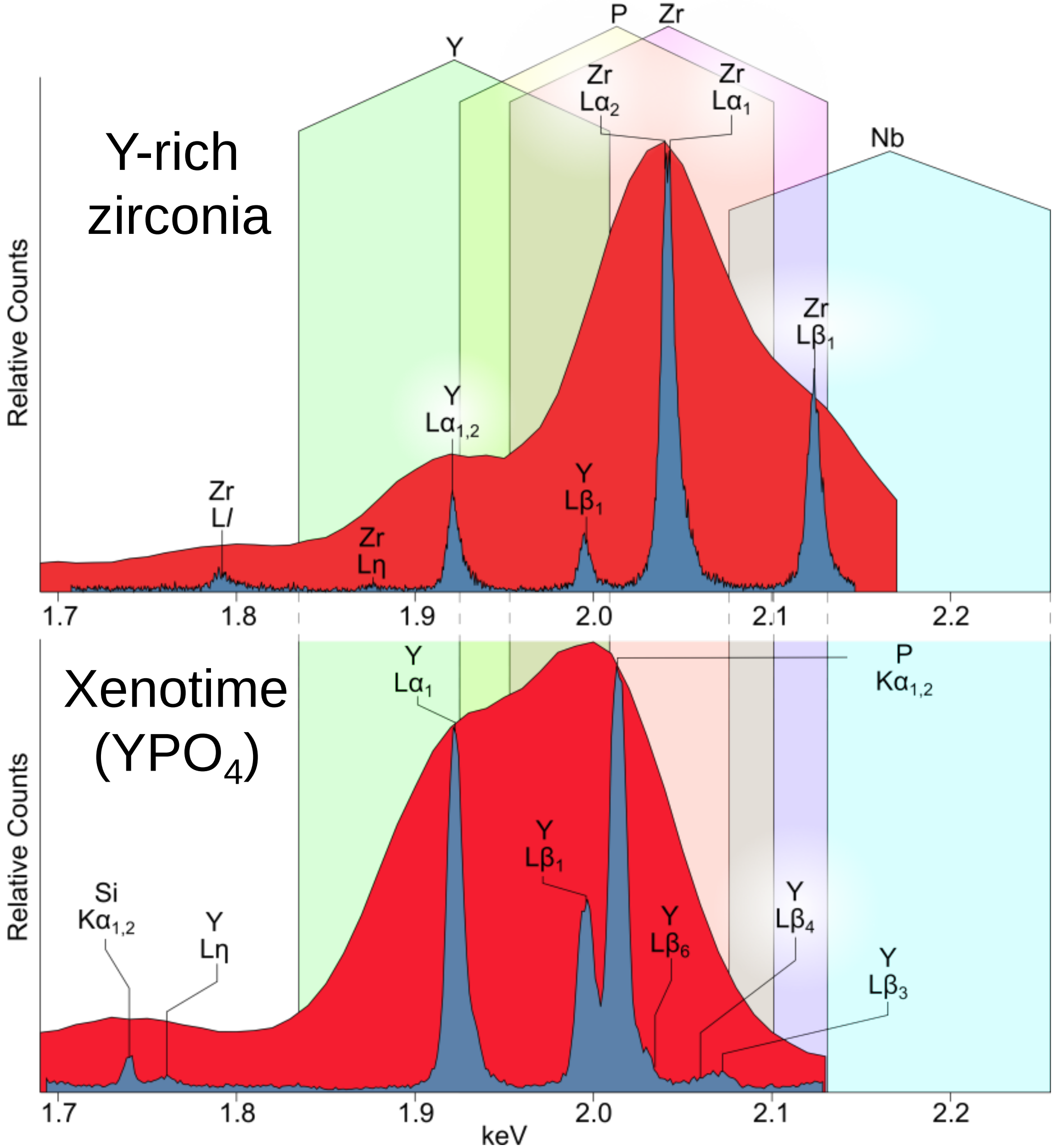
Introduction

Elemental EDS Maps 20 µm



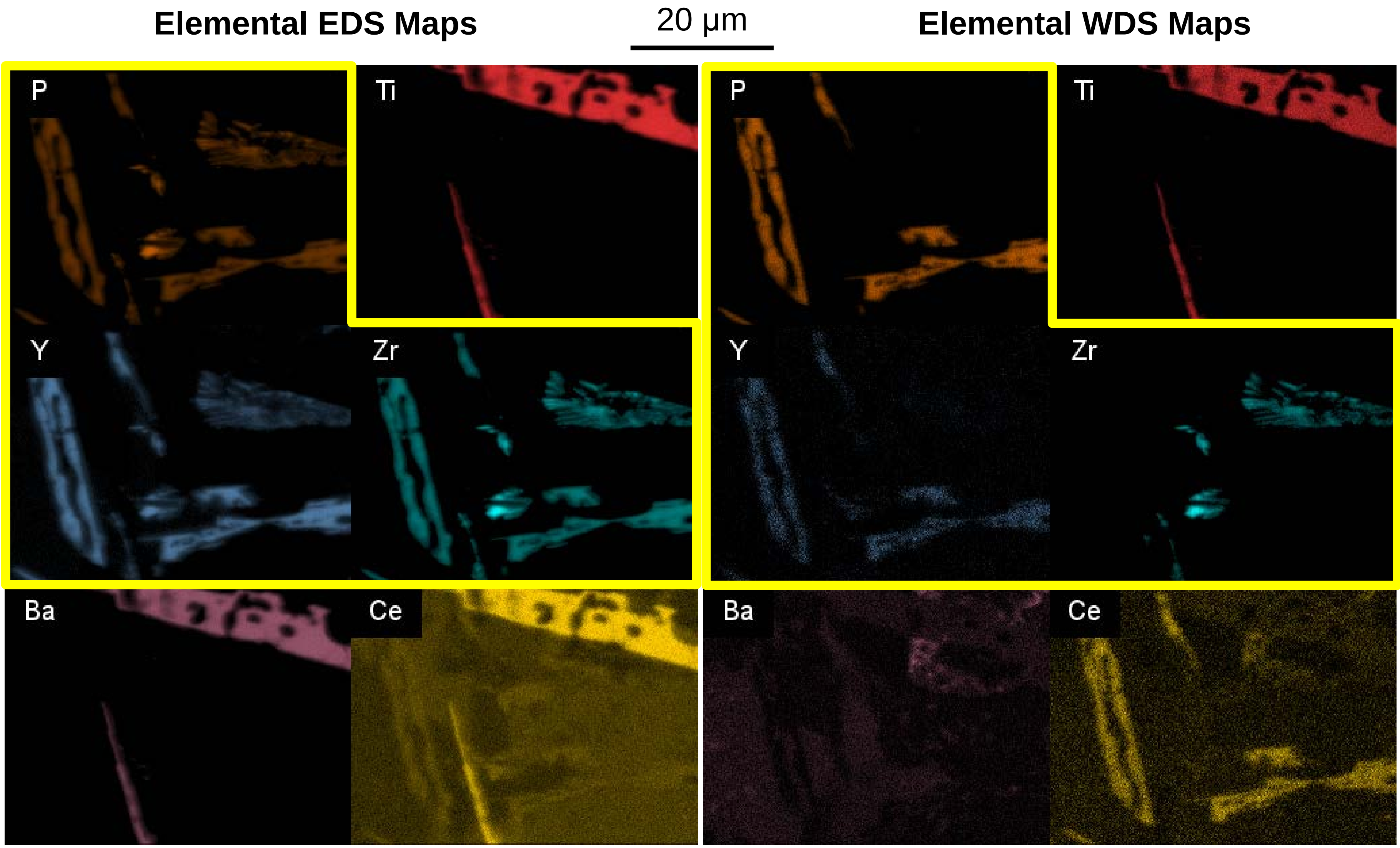
- Where EDS fails, WDS excels!
  - 10-20× better energy resolution compared to EDS
  - Cleanly resolves X-ray spectrum overlaps that EDS cannot
  - Greatly improved peak-to-background compared to EDS

The P-Y-Zr-Nb Interference

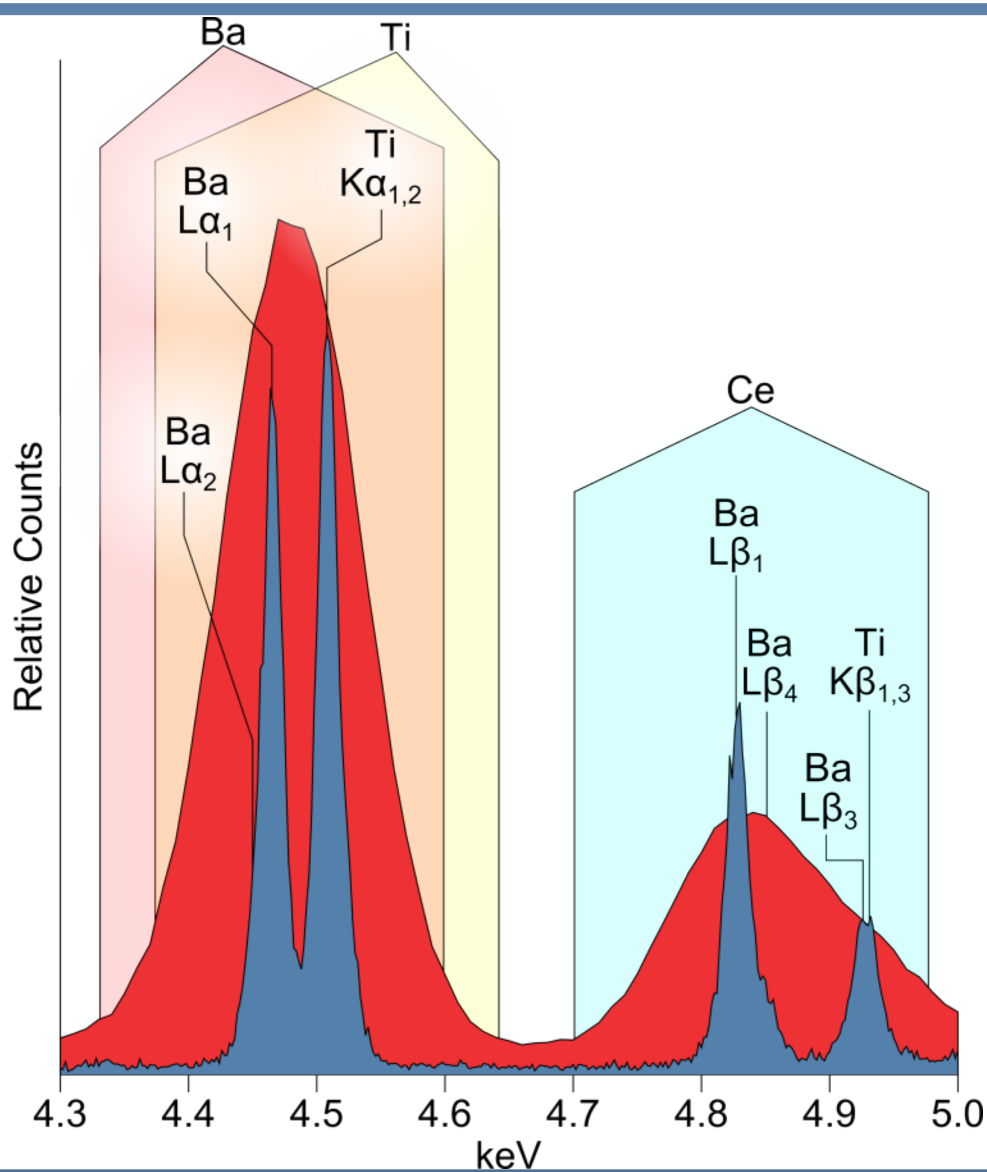


- P $K\alpha_{1,2}$ 2.013 kV
- Y $L\alpha_{1,2}$ 1.922 kV
- Y $L\beta_1$ 1.995 kV
- Zr $L\alpha_{1,2}$ 2.042 kV
- Zr $L\beta_1$ 2.124 kV
- Nb $L\alpha_1$ 2.166 kV
- Nb $L\alpha_2$ 2.163 kV
- Nb $L\eta$ 1.996 kV
- Nb Ll 1.902 kV

The P-Y-Zr-Nb Interference

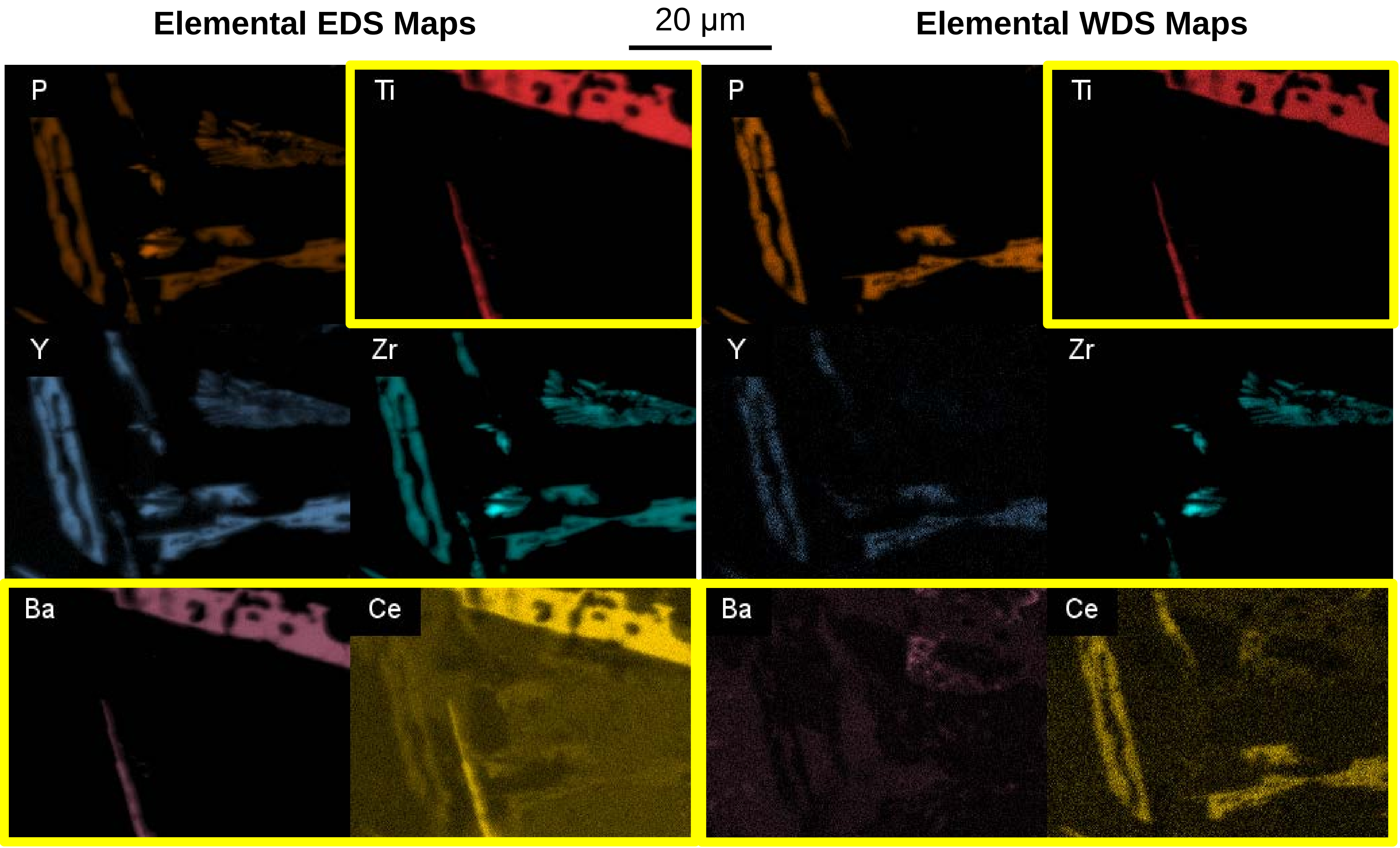


The Ti-Ba Interference



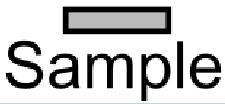
- Ti $K\alpha_{1,2}$ 4.508 kV
- Ti $K\beta_{1,3}$ 4.931 kV
- Ba $L\alpha_1$ 4.465 kV
- Ba $L\alpha_2$ 4.450 kV
- Ba $L\beta_1$ 4.827 kV
- Ba $L\beta_3$ 4.926 kV
- Ba $L\beta_4$ 4.851 kV

The Ti-Ba-Ce-La Interference



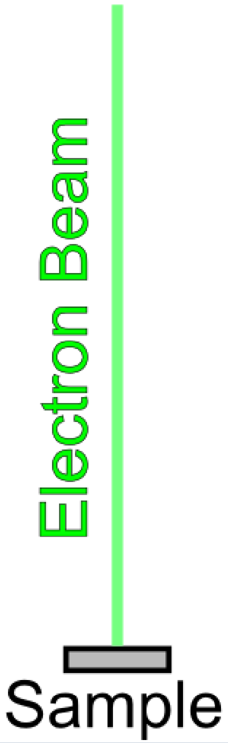
EDS and WDS: What's the difference?

- Hypothetical sample in an SEM



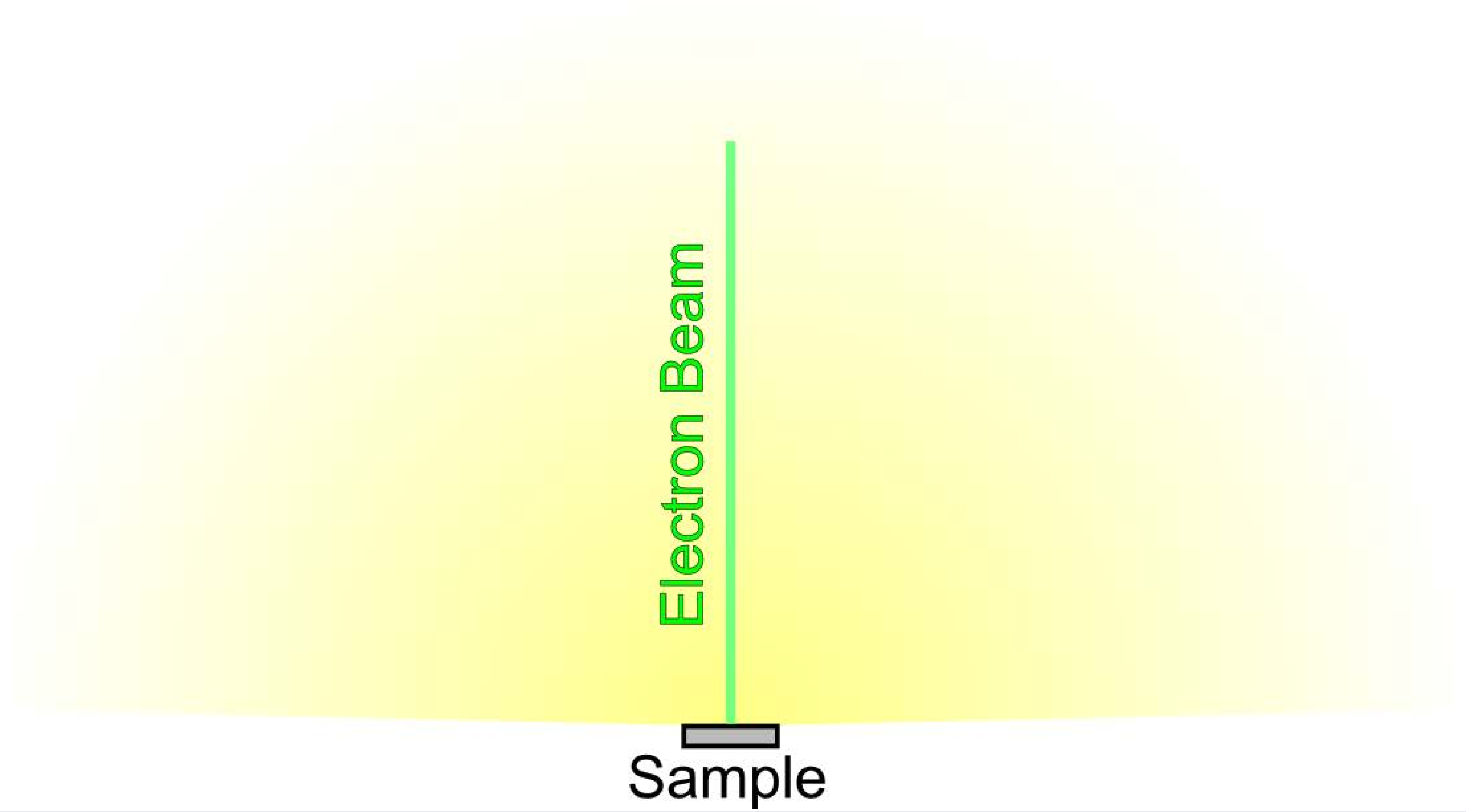
EDS and WDS: What's the difference?

- For microanalysis, sample is normal to the electron beam



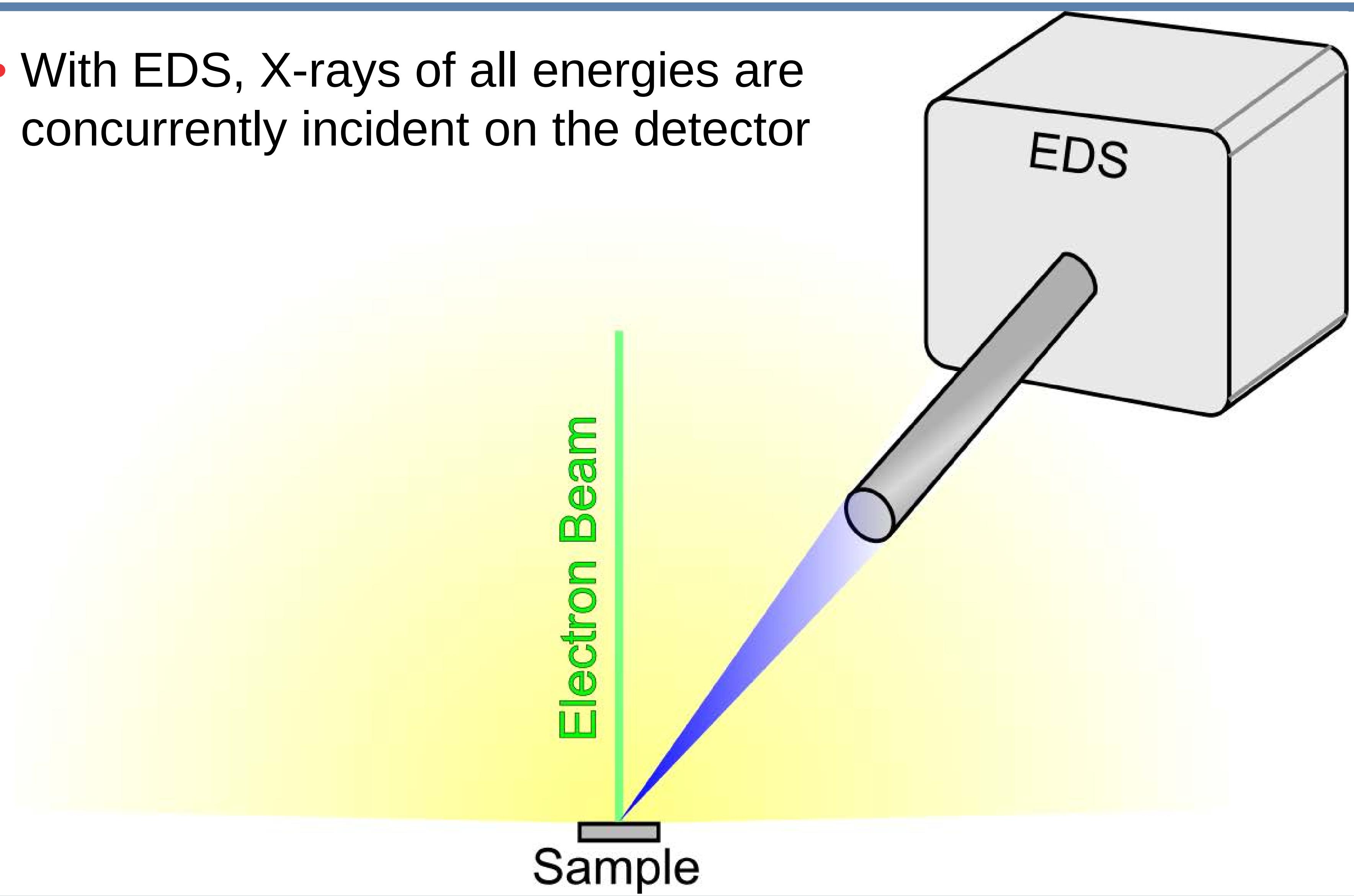
EDS and WDS: What's the difference?

- X-rays are emitted from the excitation volume in a 3-dimensional hemispherical wavefront



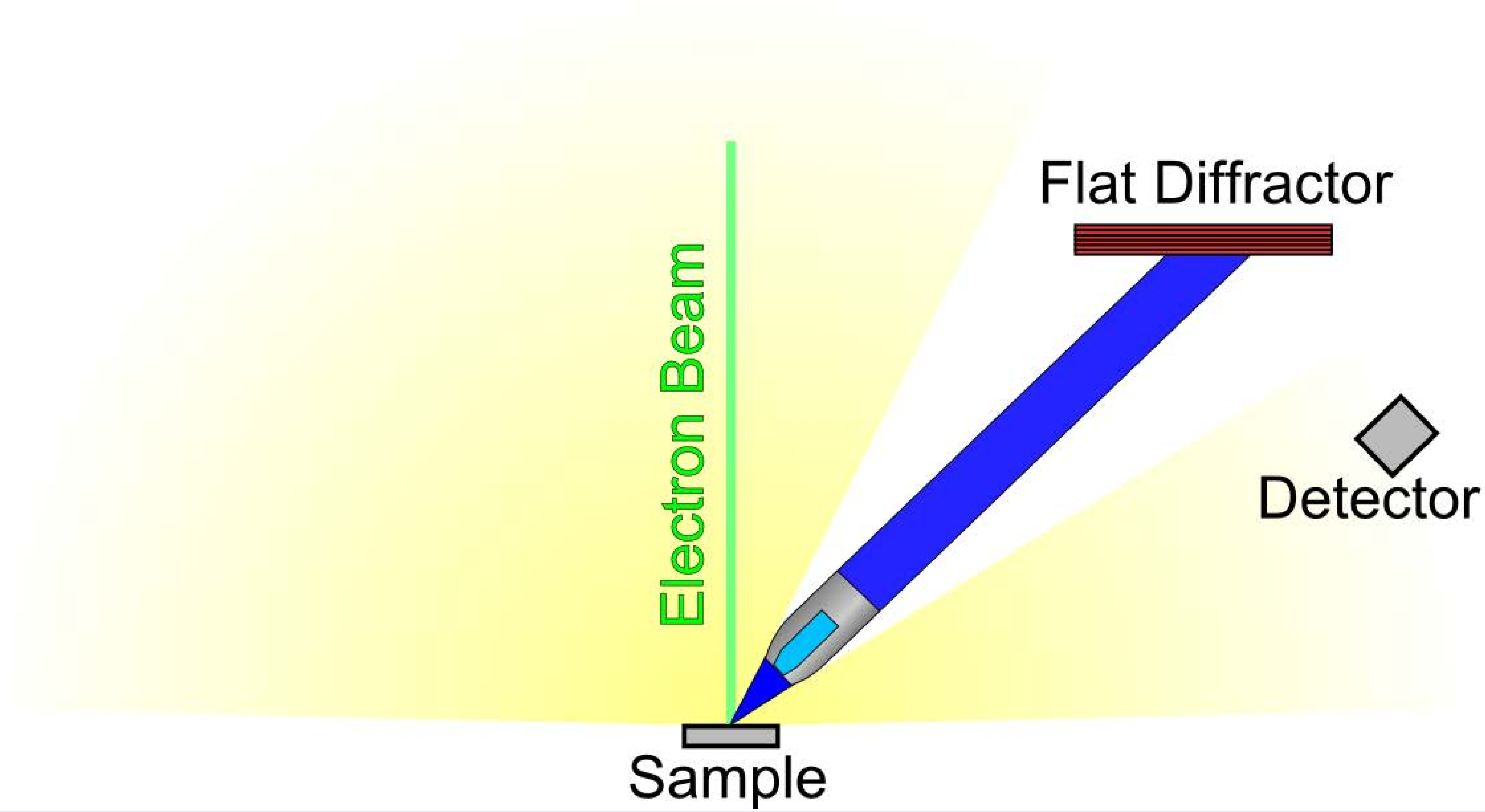
EDS and WDS: What's the difference?

- With EDS, X-rays of all energies are concurrently incident on the detector



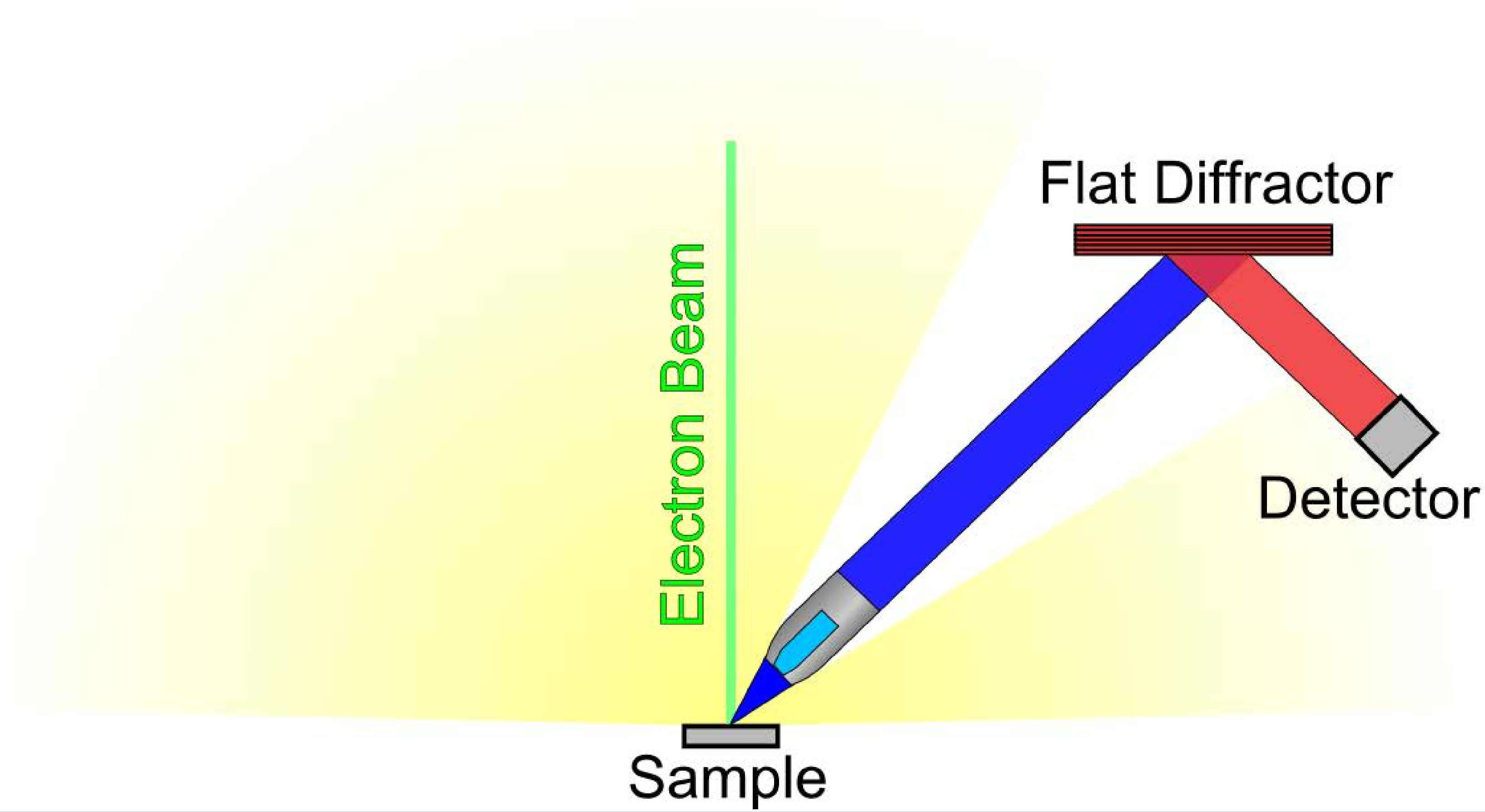
EDS and WDS: What's the difference?

- With WDS, the full X-ray continuum is incident on a diffractor

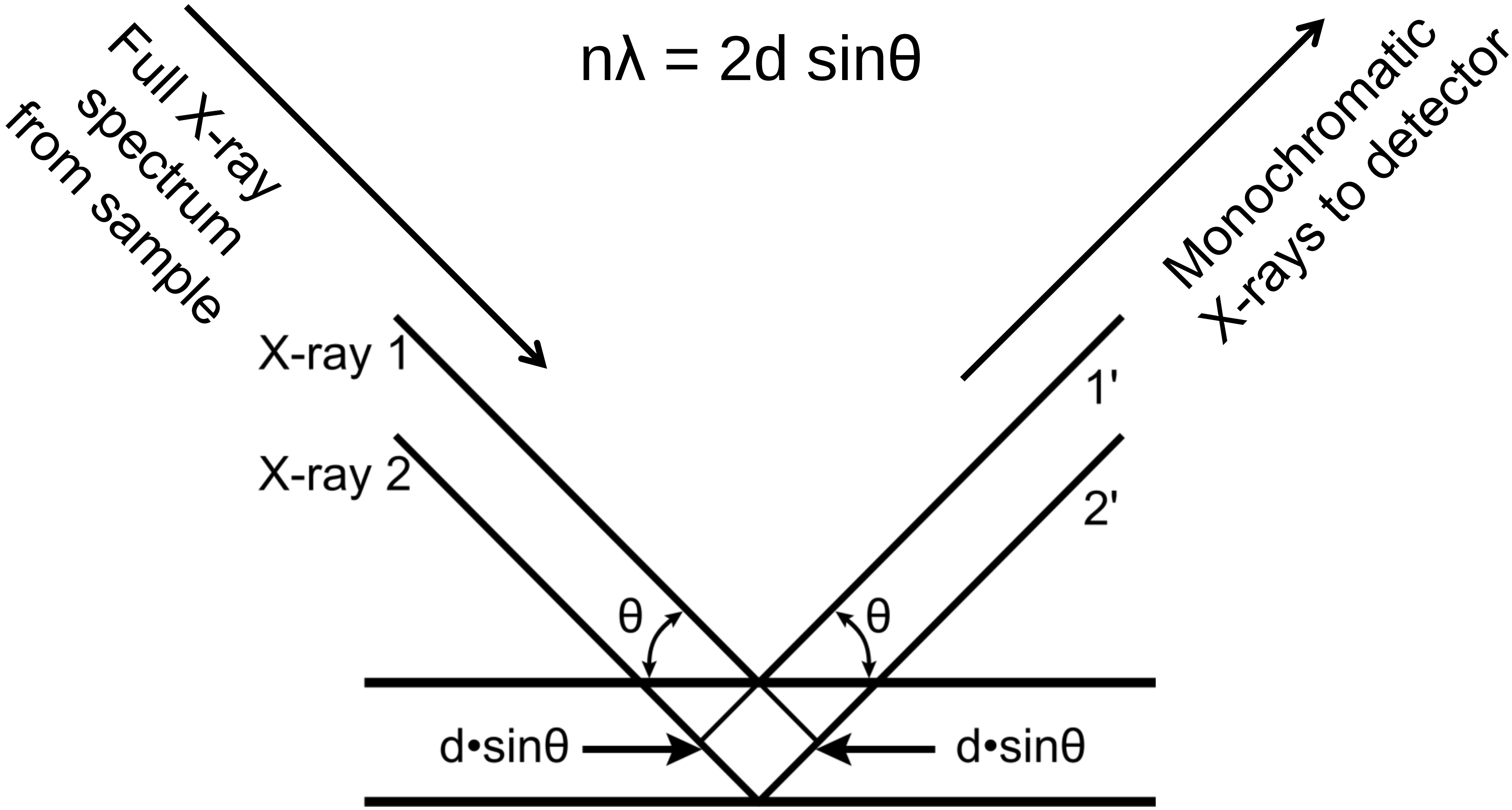


EDS and WDS: What's the difference?

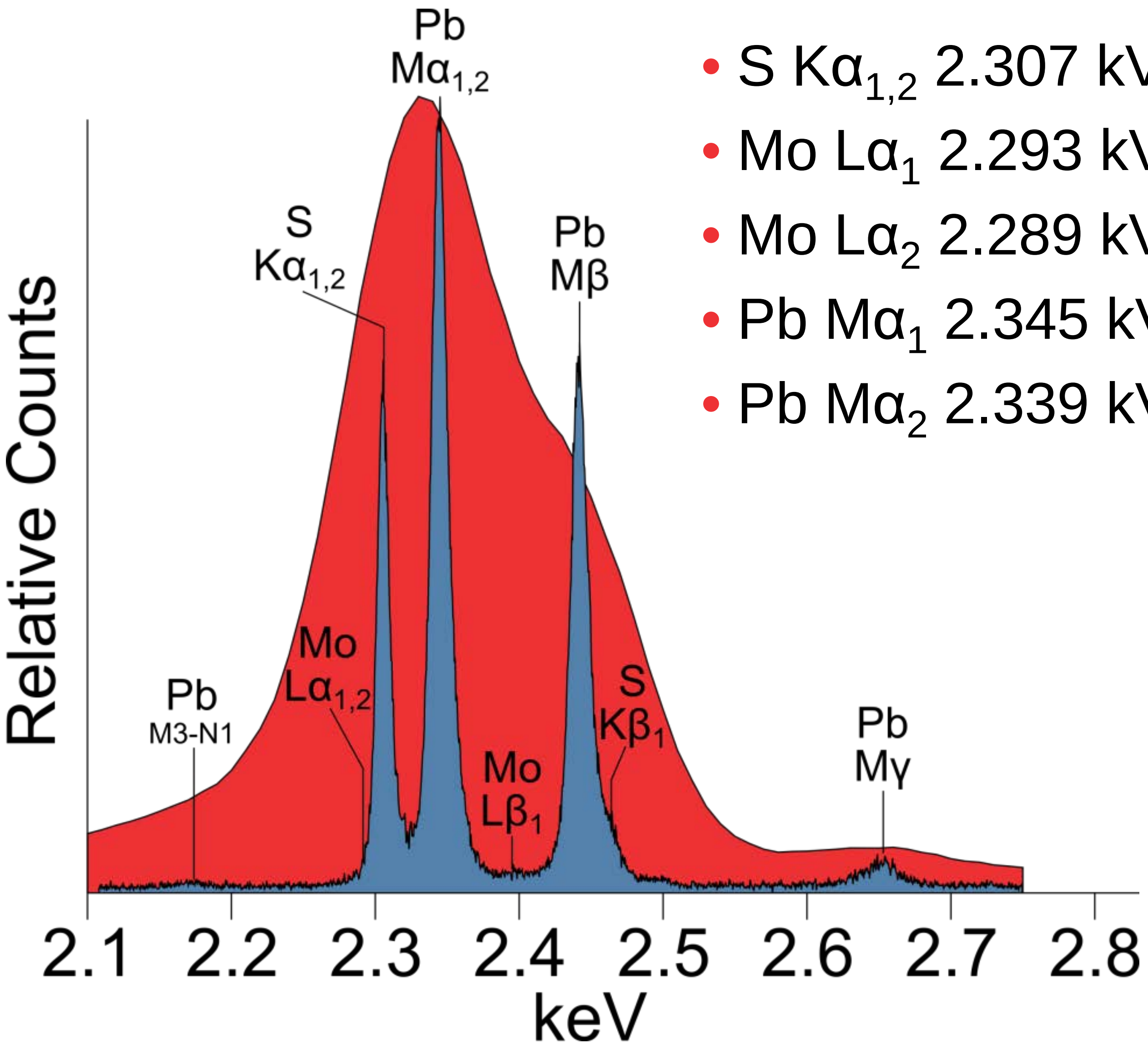
- Following Bragg's law, monochromatic X-rays are reflected to a detector



Bragg’s Law – at the core of WDS

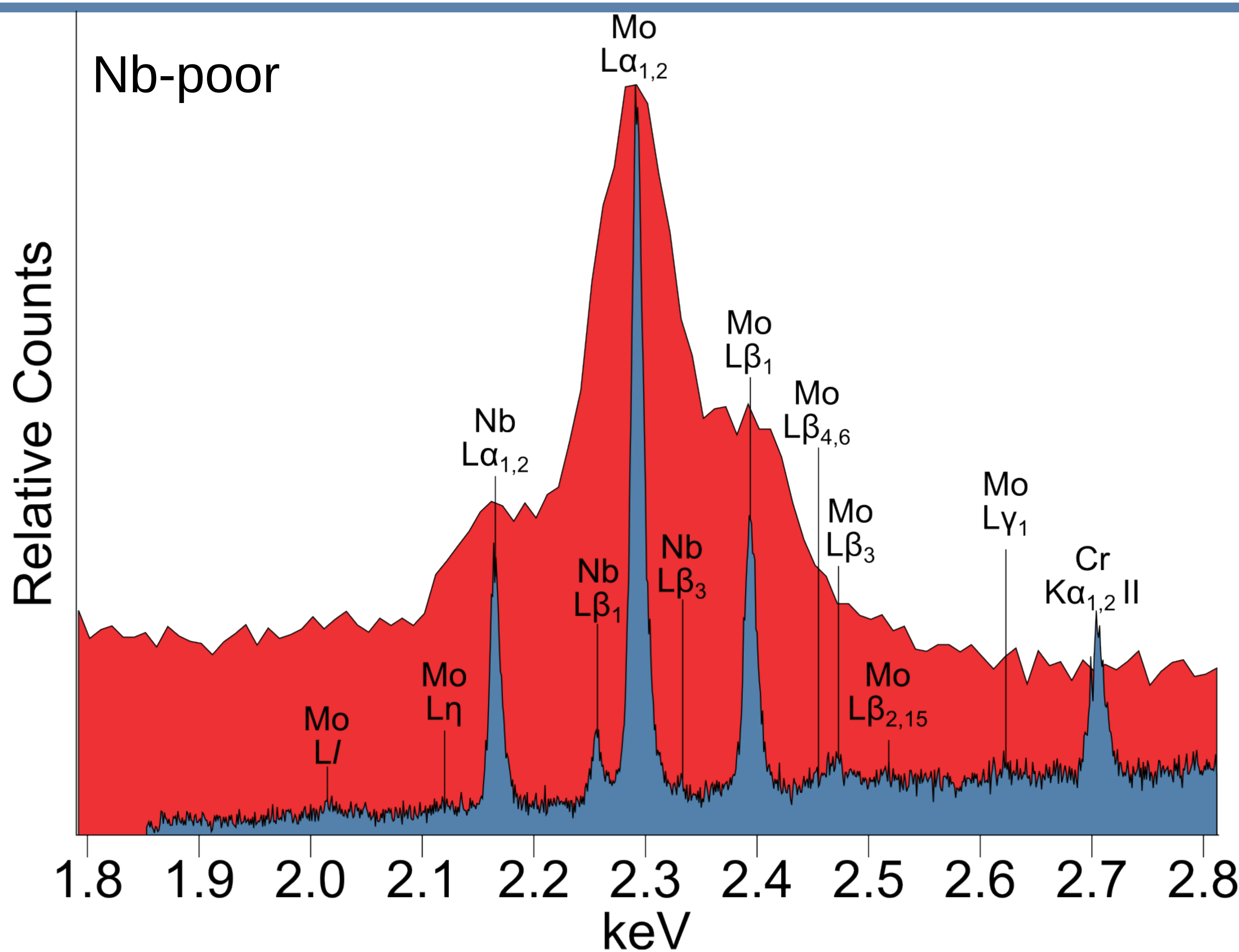


The Pb-Mo-S Interference



- S $K\alpha_{1,2}$ 2.307 kV
- Mo $L\alpha_1$ 2.293 kV
- Mo $L\alpha_2$ 2.289 kV
- Pb $M\alpha_1$ 2.345 kV
- Pb $M\alpha_2$ 2.339 kV

Alloys with Nb and Mo



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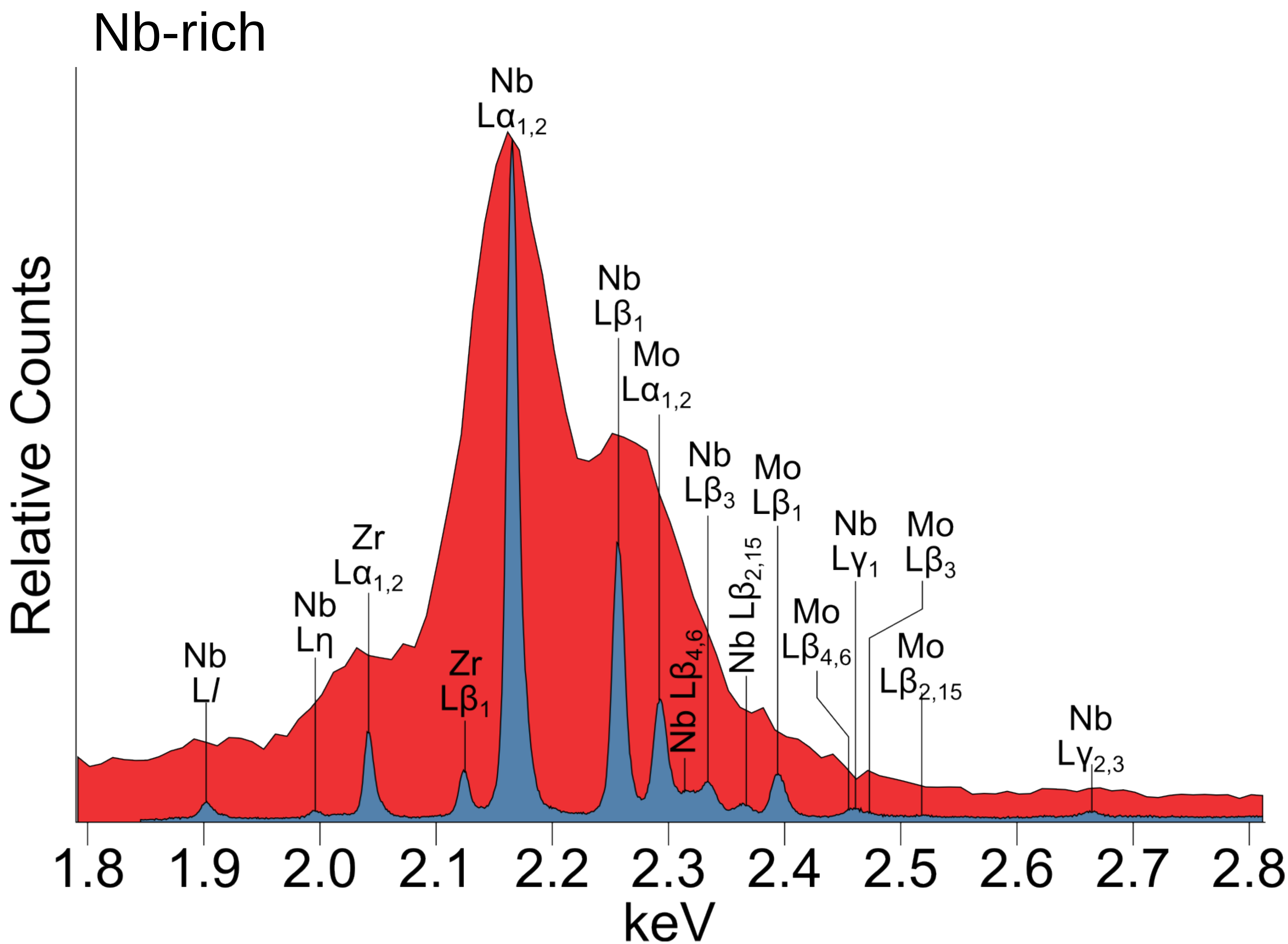
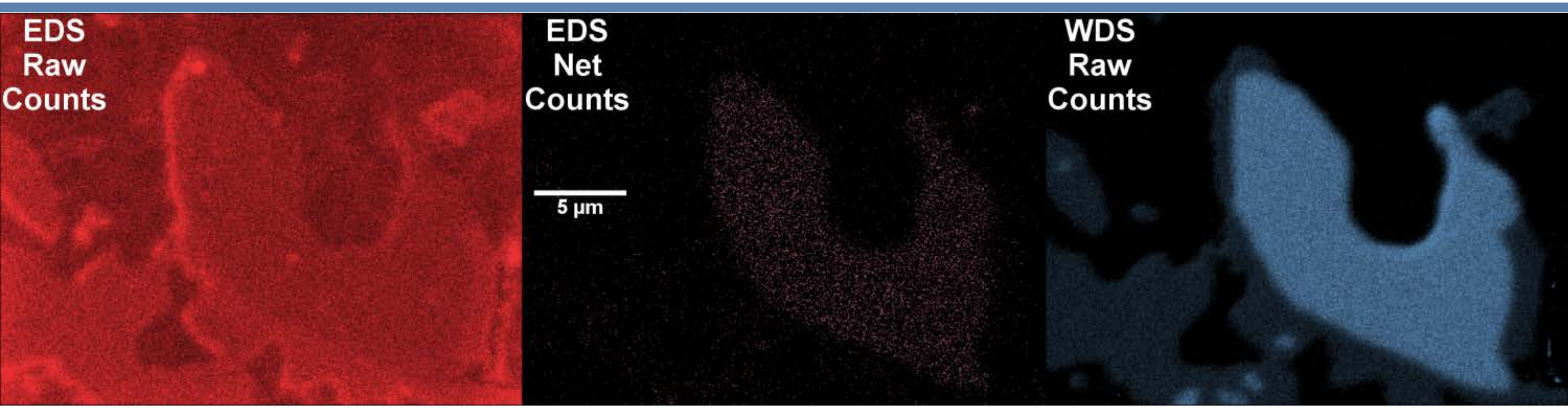
Alloys with Nb and Mo

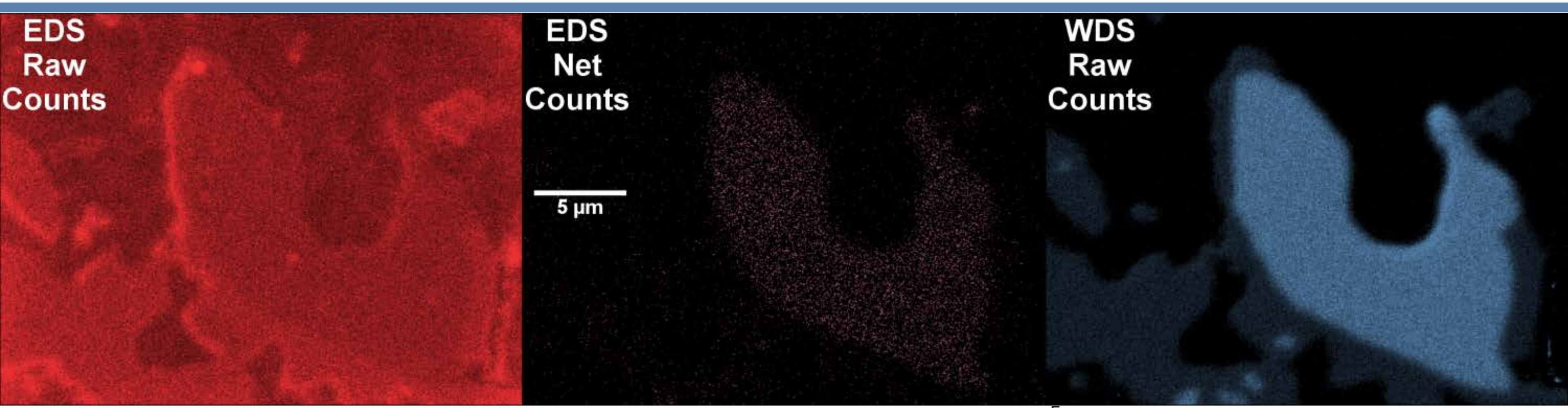


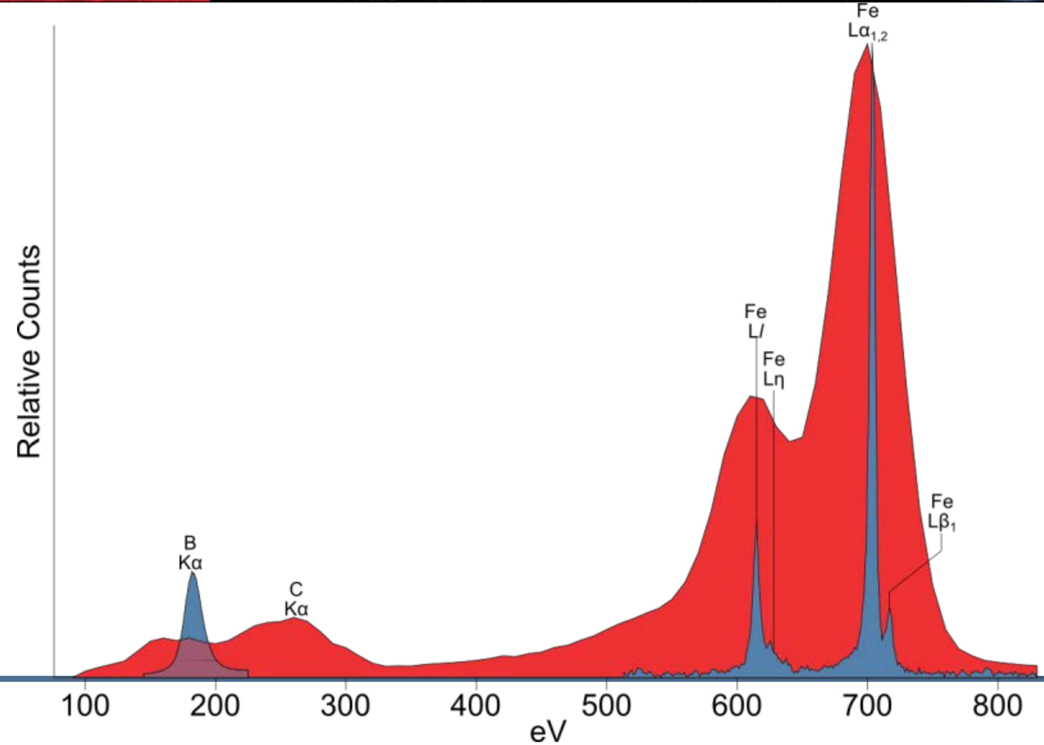
Trace B in Steel



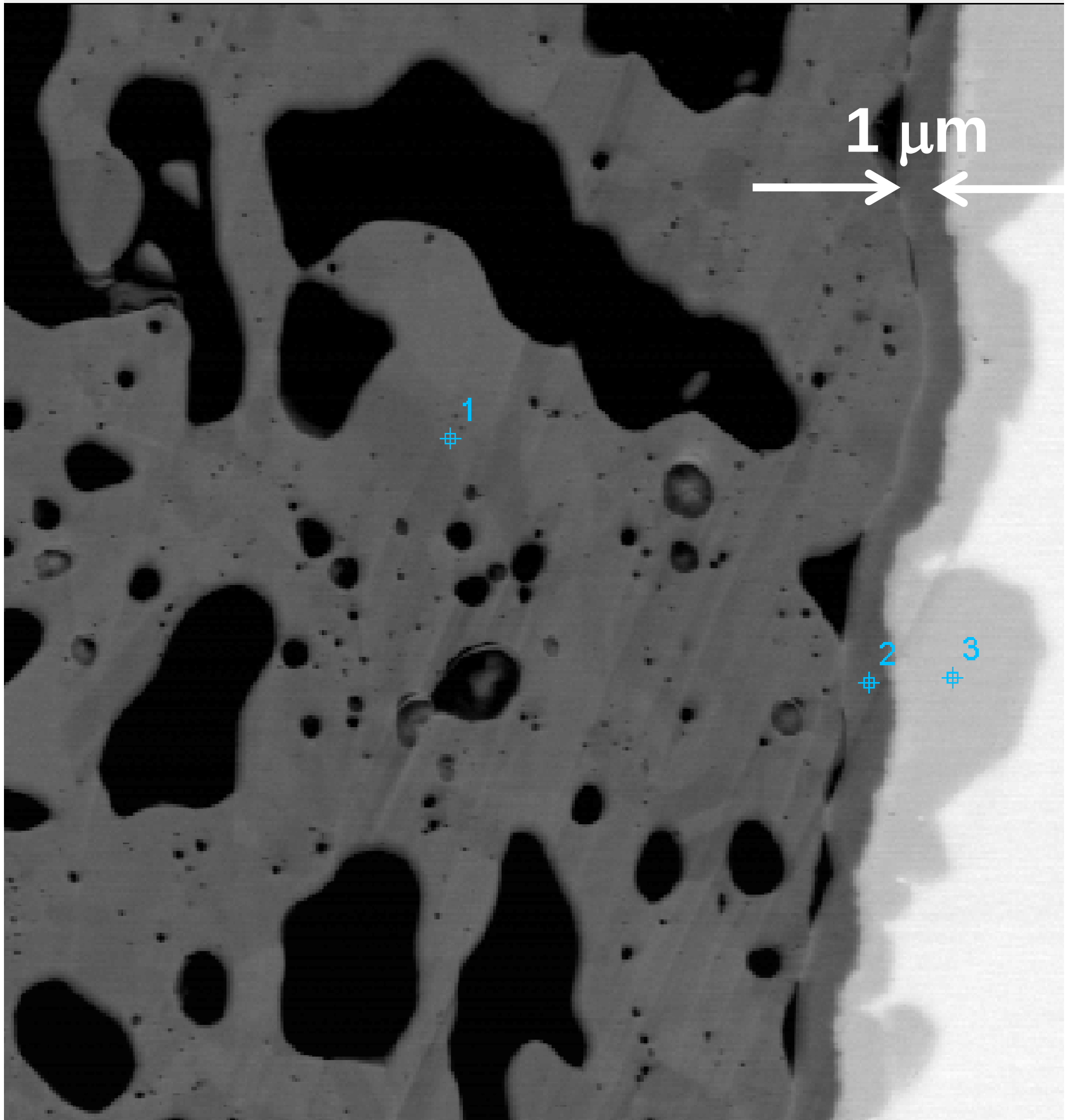
- EDS and WDS mapping of B in steel
- Only WDS can reveal 3 phases with different B concentrations

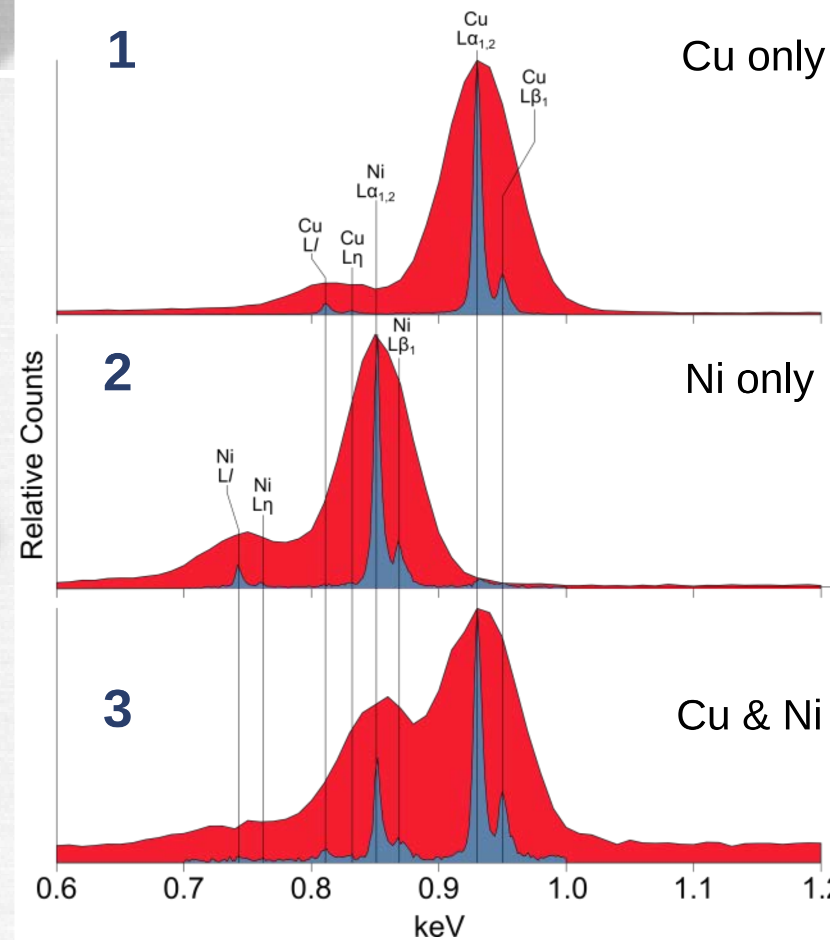
Trace B in Steel



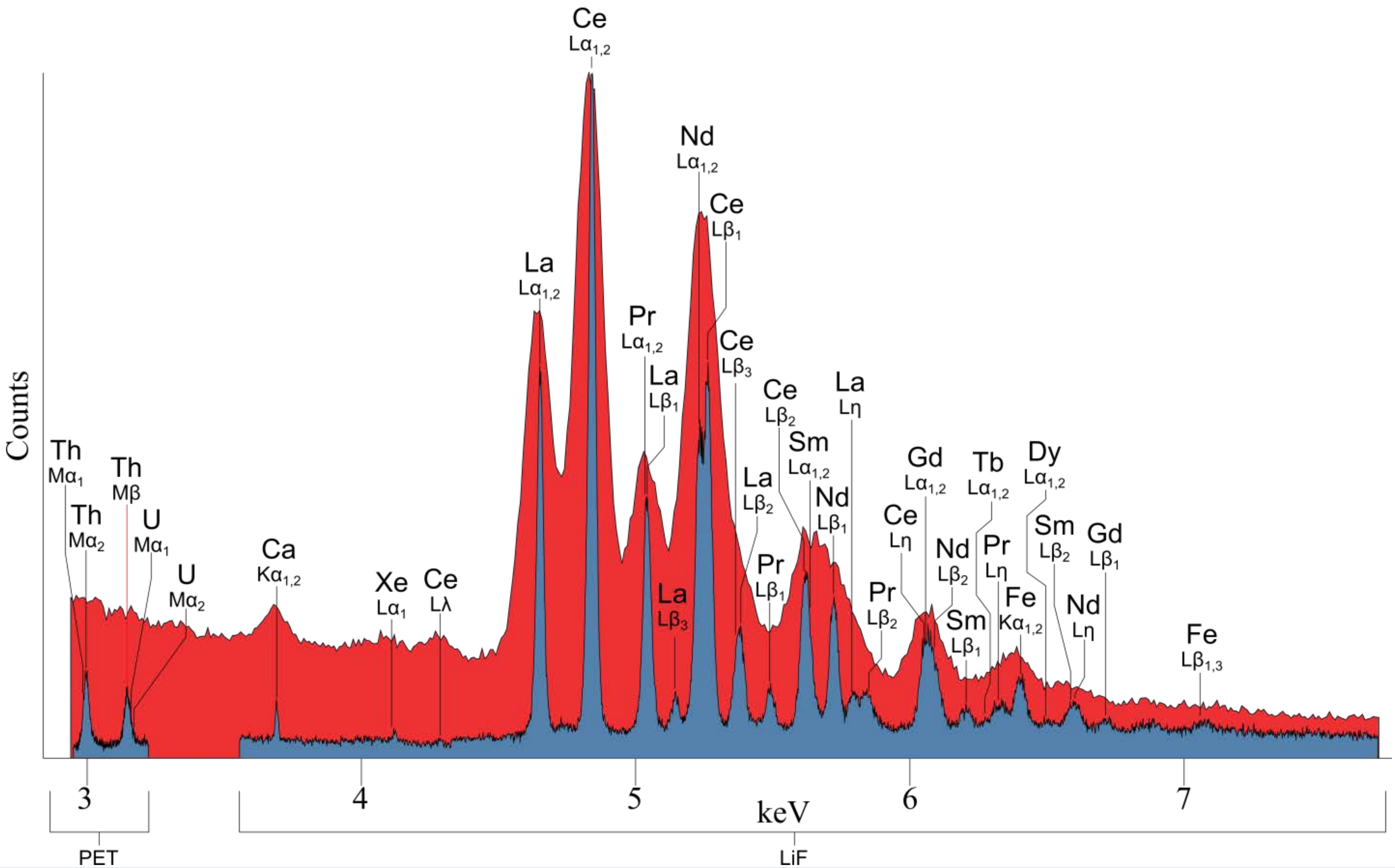


Spectrum analysis: WDS vs. EDS Ni-Cu intermetallic





Monazite: Rare earth elements, Th, and U



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Conclusions

- WDS: for when you know that you need to know

- Resolves X-ray interferences that are not resolvable with EDS
  - For example:
    - P-Y-Zr-Nb
    - Ba-Ti-Ce
    - Pb-S-Mo
    - REEs
    - Nb-Mo
- Greatly improved intensity
  - Especially for low-energy X-rays