



FP initiative

International initiative on x-ray fundamental
parameters

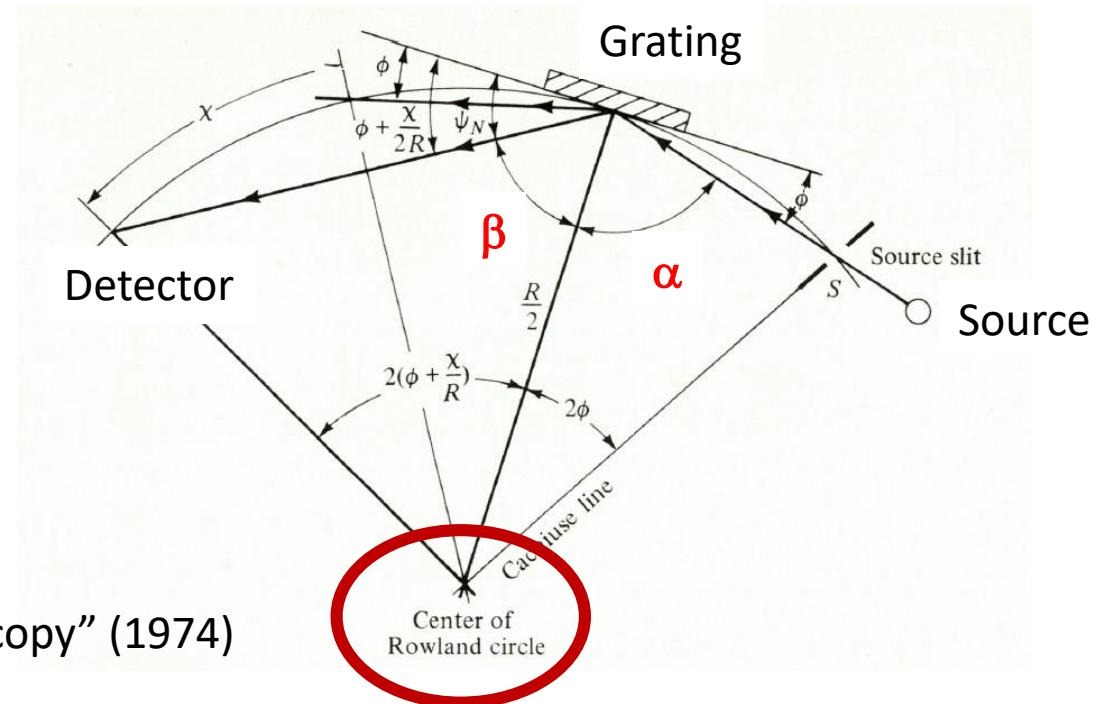
X-ray spectroscopy in the ultra-soft x-ray range with a reflection zone plate spectrometer

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WDS – RZP - Grating spectrometer

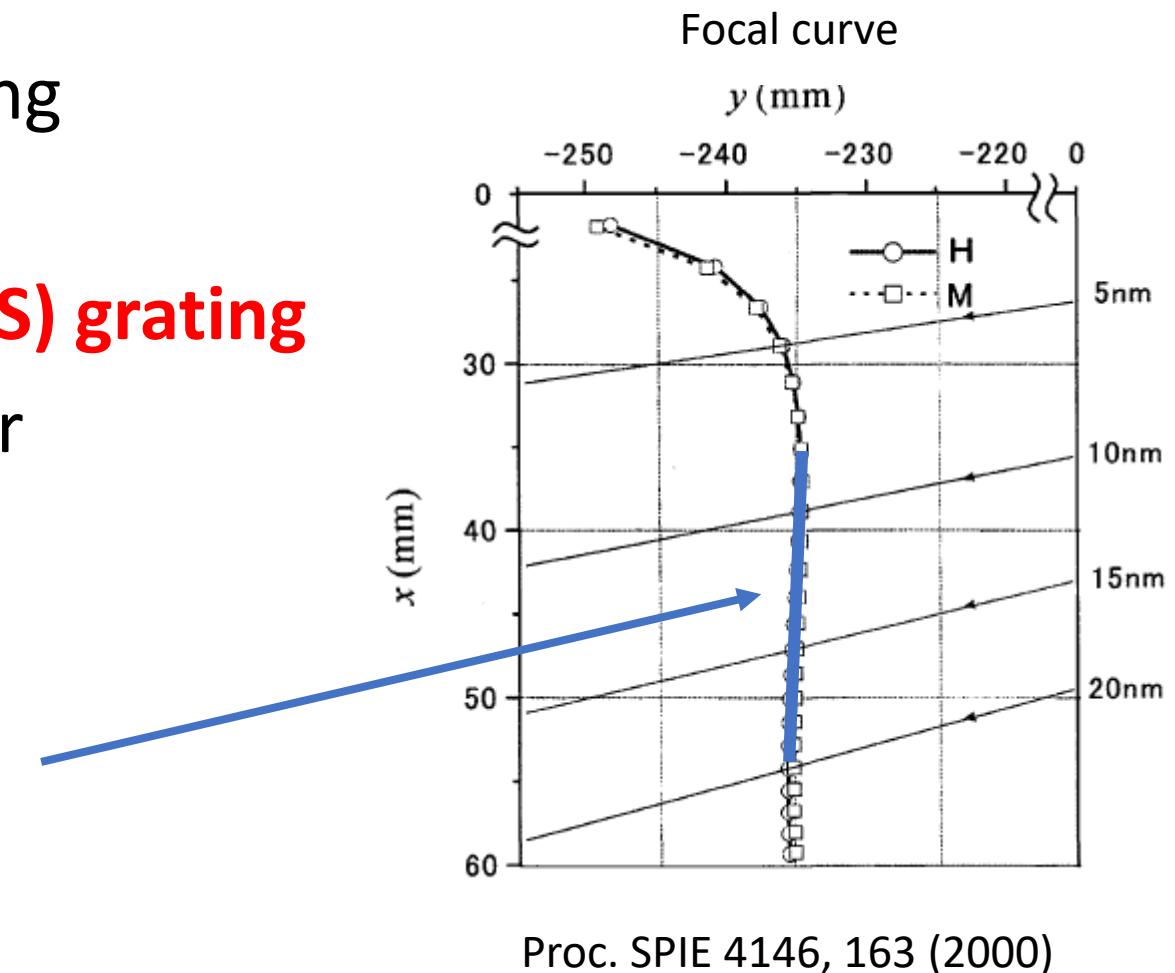
- Grating spectrometers are suited for the ultra-soft x-ray range
- Grating spectrometer works following the grating law
- $n \lambda = d (\sin\alpha - \sin\beta)$ d is the period of the grating
α and β are the incident and detection angles
(with respect to the normal of the grating)
- For example:
 $d = 10^{-6} \text{ m}$ (1000 lines/mm)
 $\alpha = 85^\circ$ $\beta = 80^\circ$
 $n = 1$
 $\lambda = 11 \text{ nm}$ (112 eV)



L.V. Azaroff, "X-ray spectroscopy" (1974)

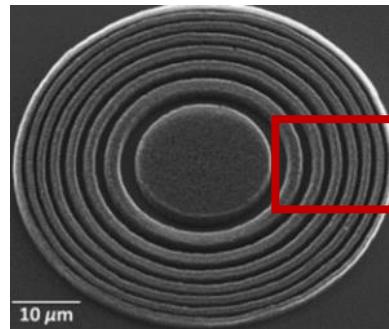
WDS – Grating spectrometer

- Periodic grating requires scanning
- **Use of variable line spacing (VLS) grating**
- Soft x-ray flat-field spectrometer
- Wavelengths focused on a line
- Linear detector or **CCD camera**
- No more scanning

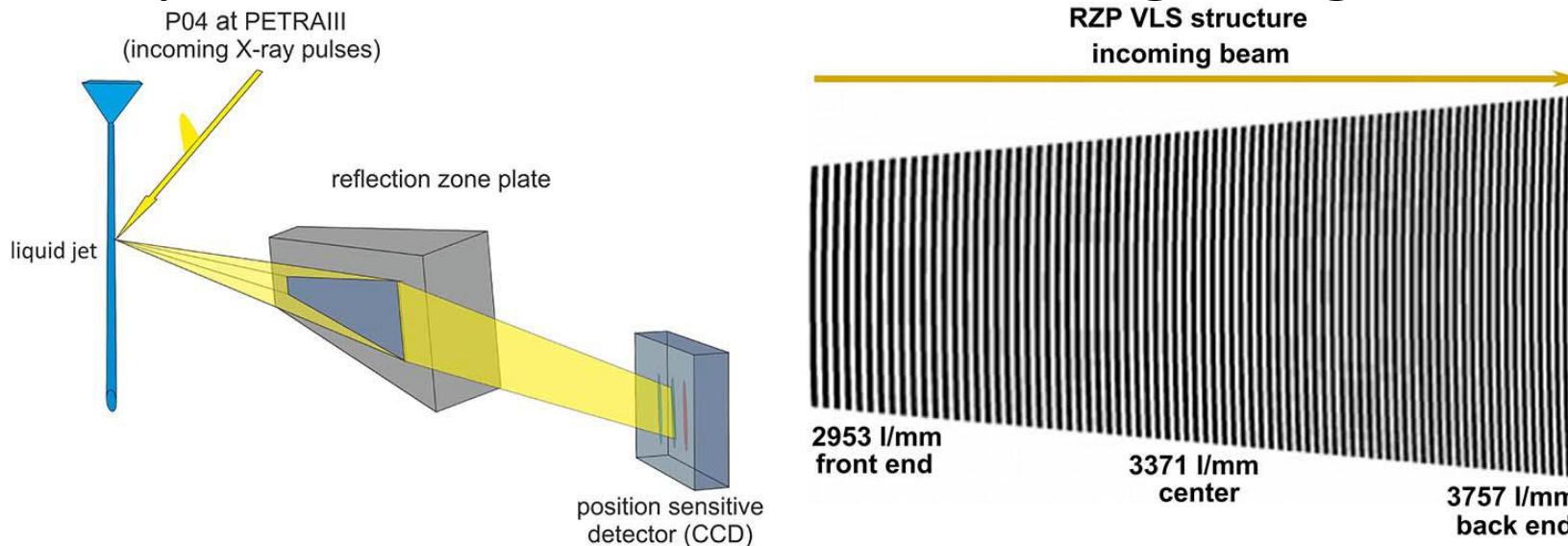


WDS – Grating spectrometer – RZP

- Fresnel lenses
- Reflection zone plates

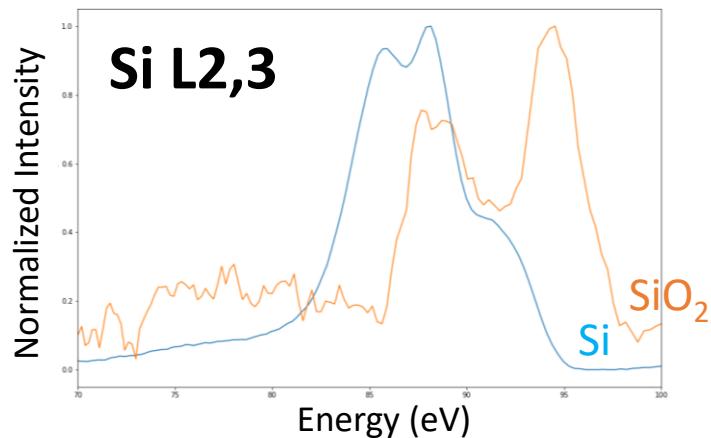
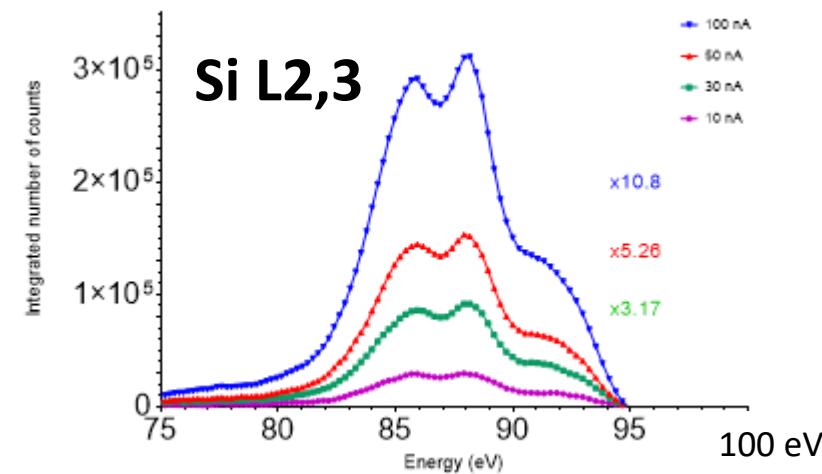
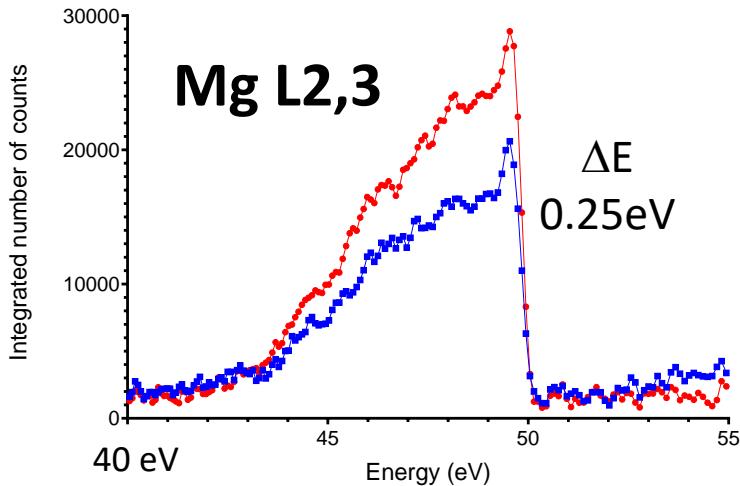


- **Reflection (Fresnel) zone plate (RZP) spectrometer**
- Only a part of the RZP is used as a VLS grating



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WDS – Grating spectrometer – RZP

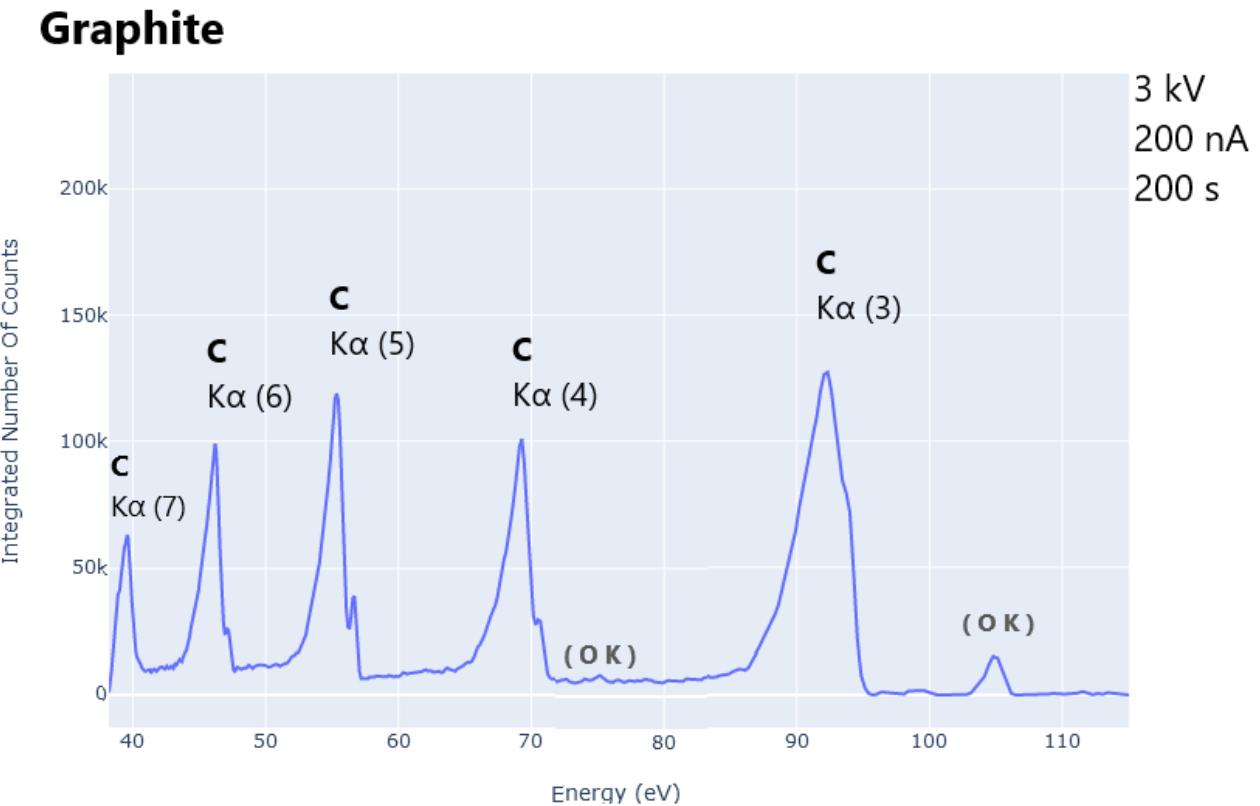
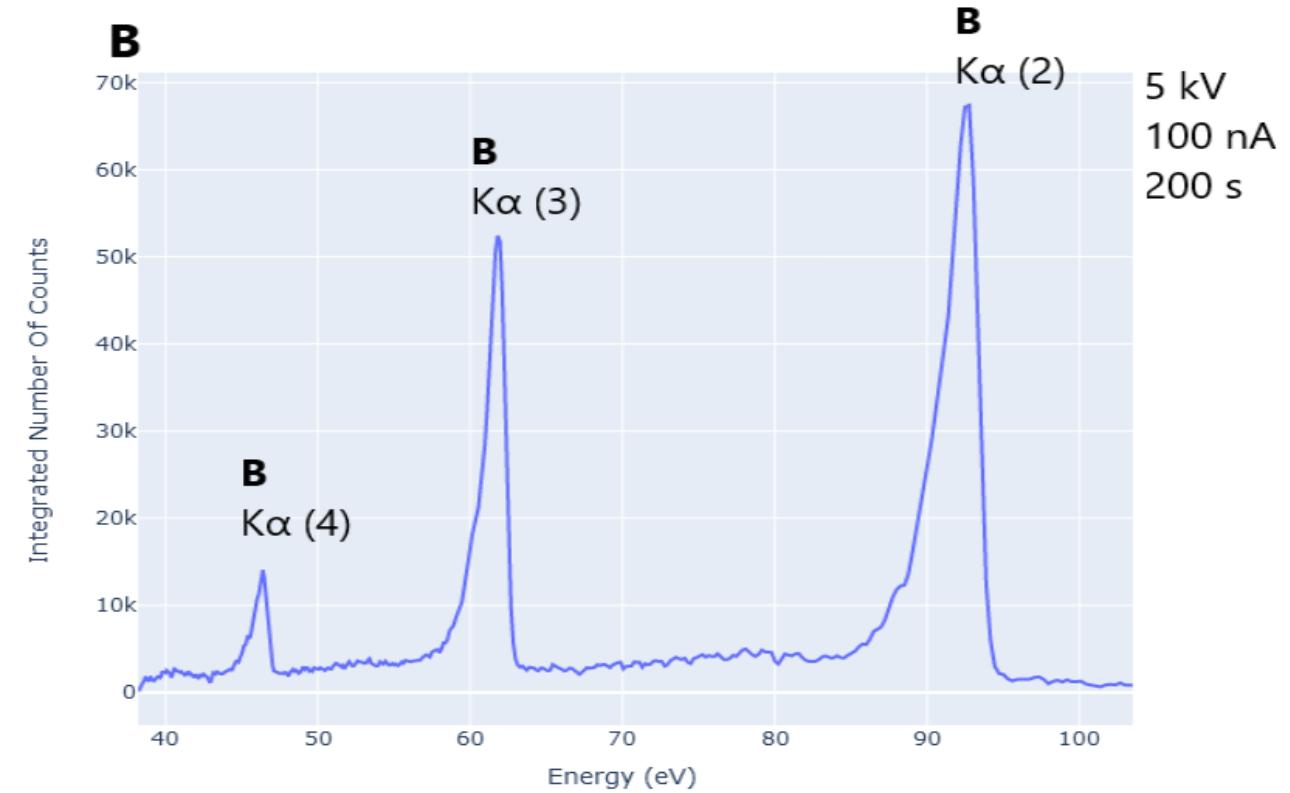


CAMECA SX100
EPMA

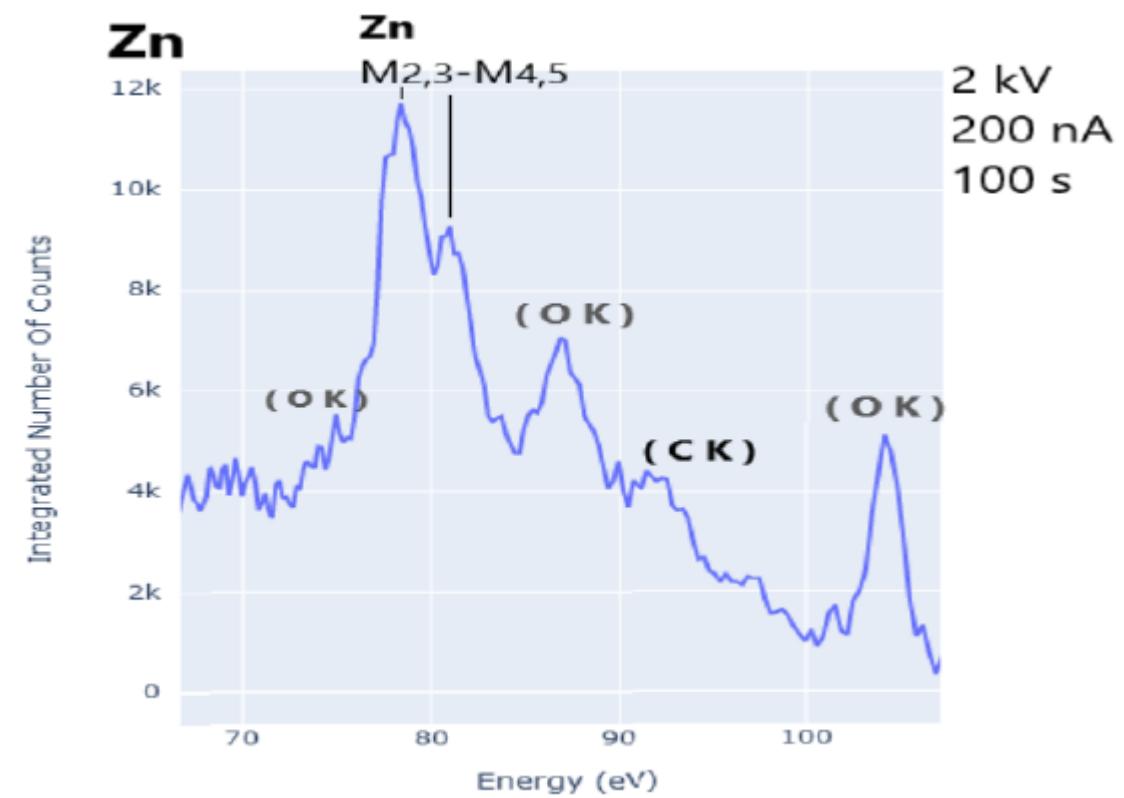
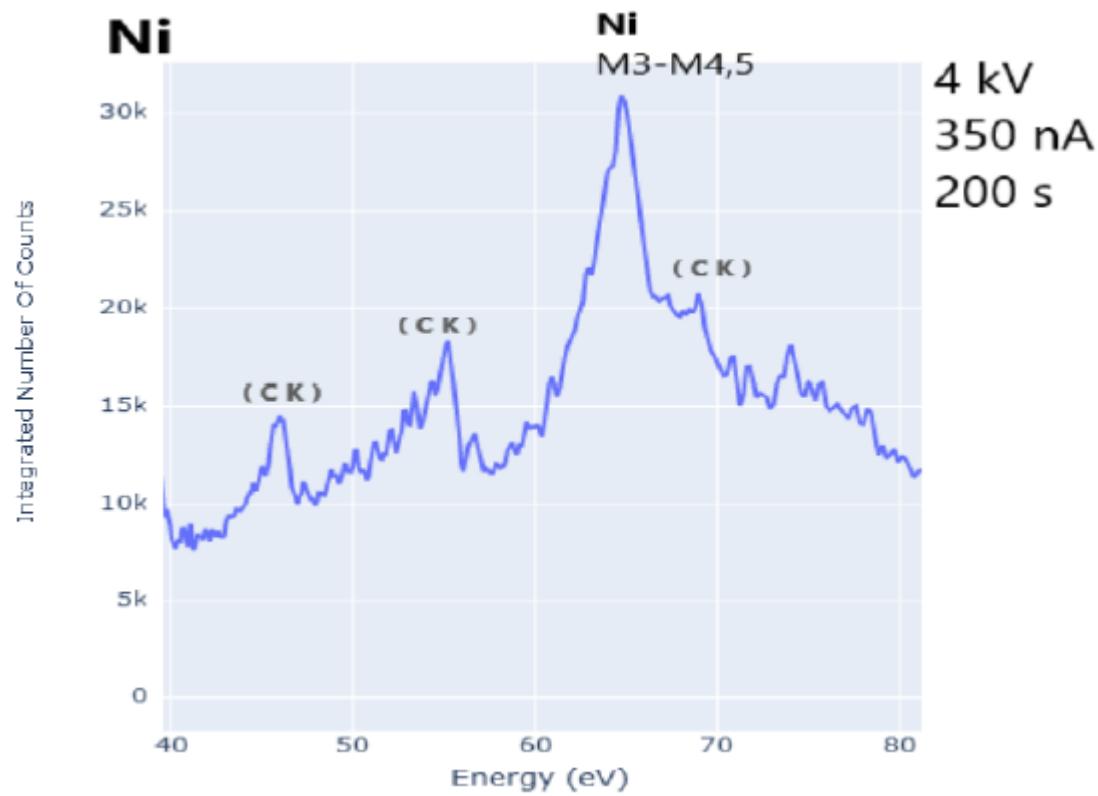
NOB spectro-
meter



Some spectra

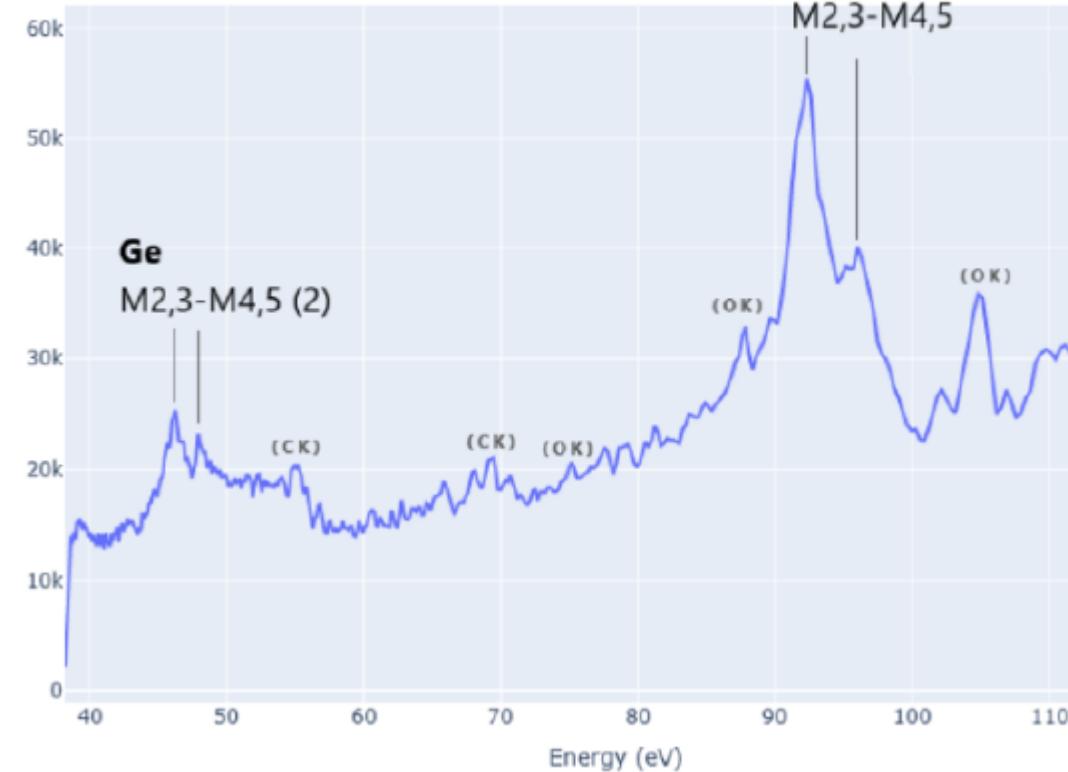


Some spectra



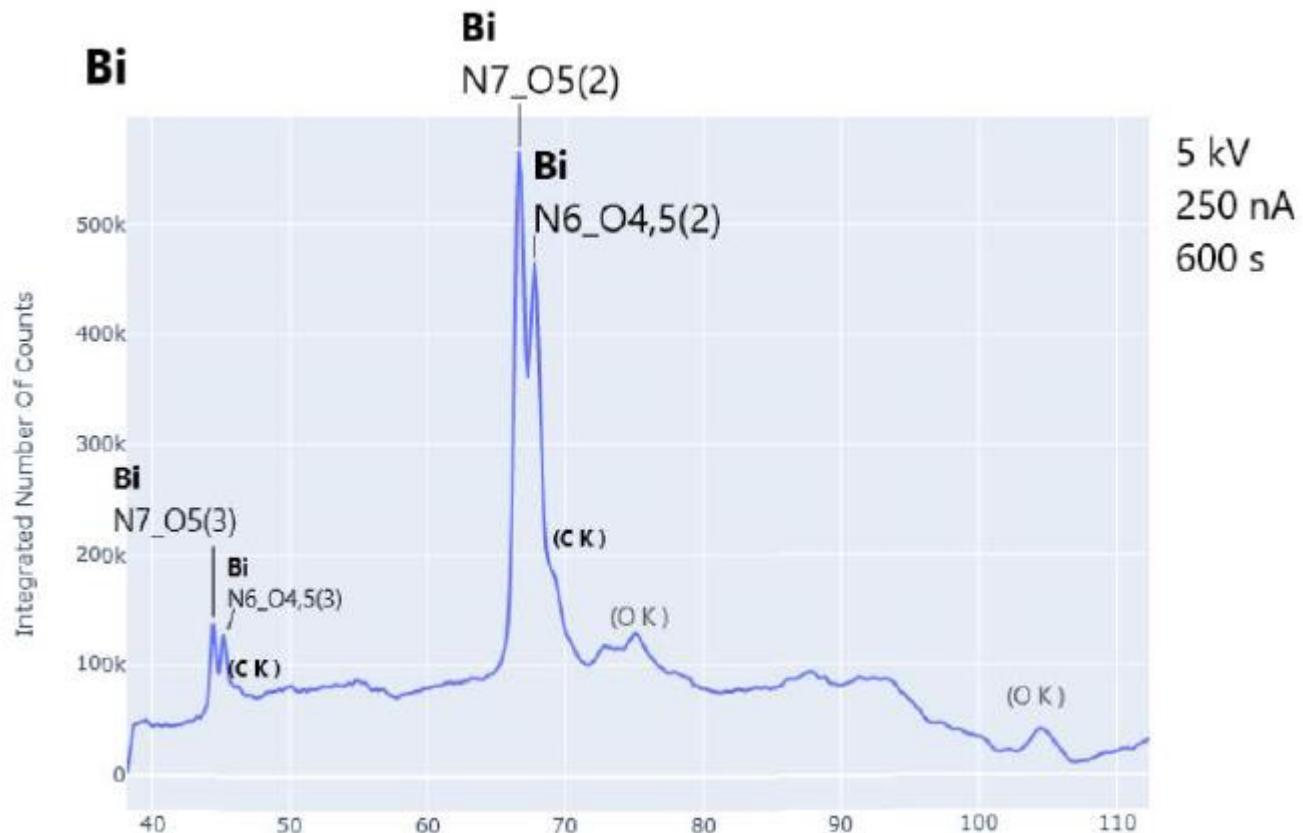
Some spectra

Ge

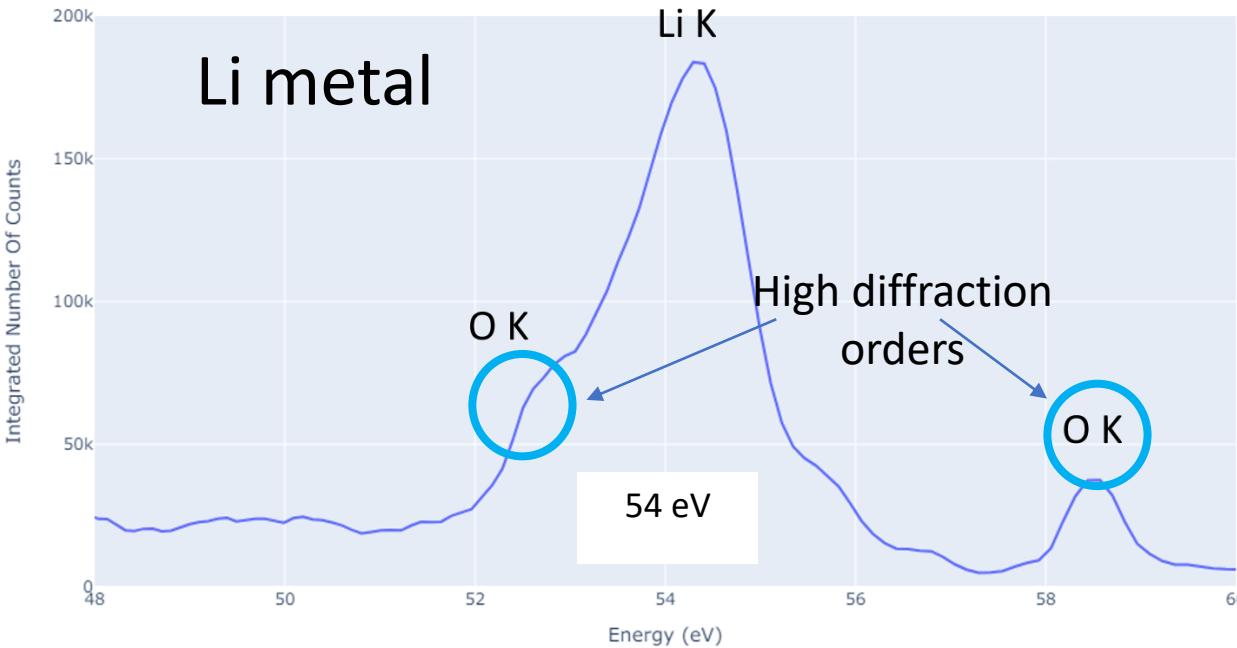


3 kV
150 nA
400 s

Bi

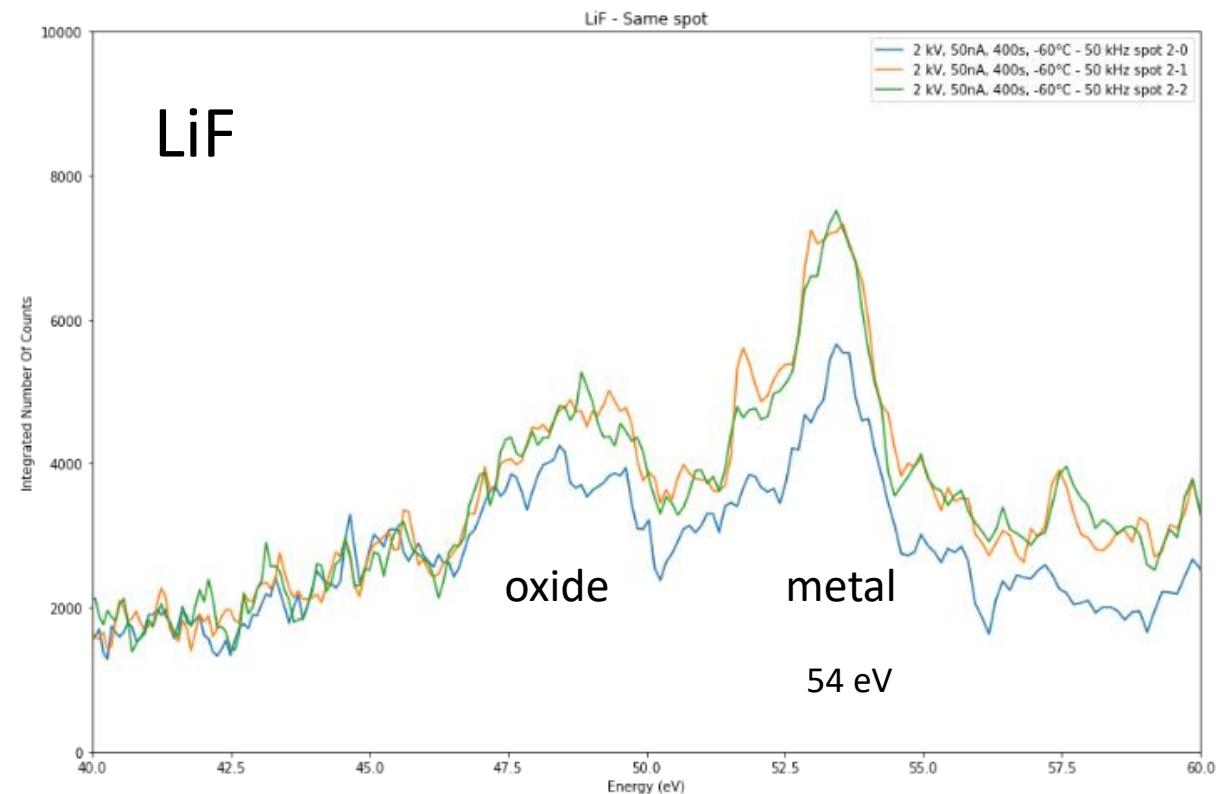


Li K range

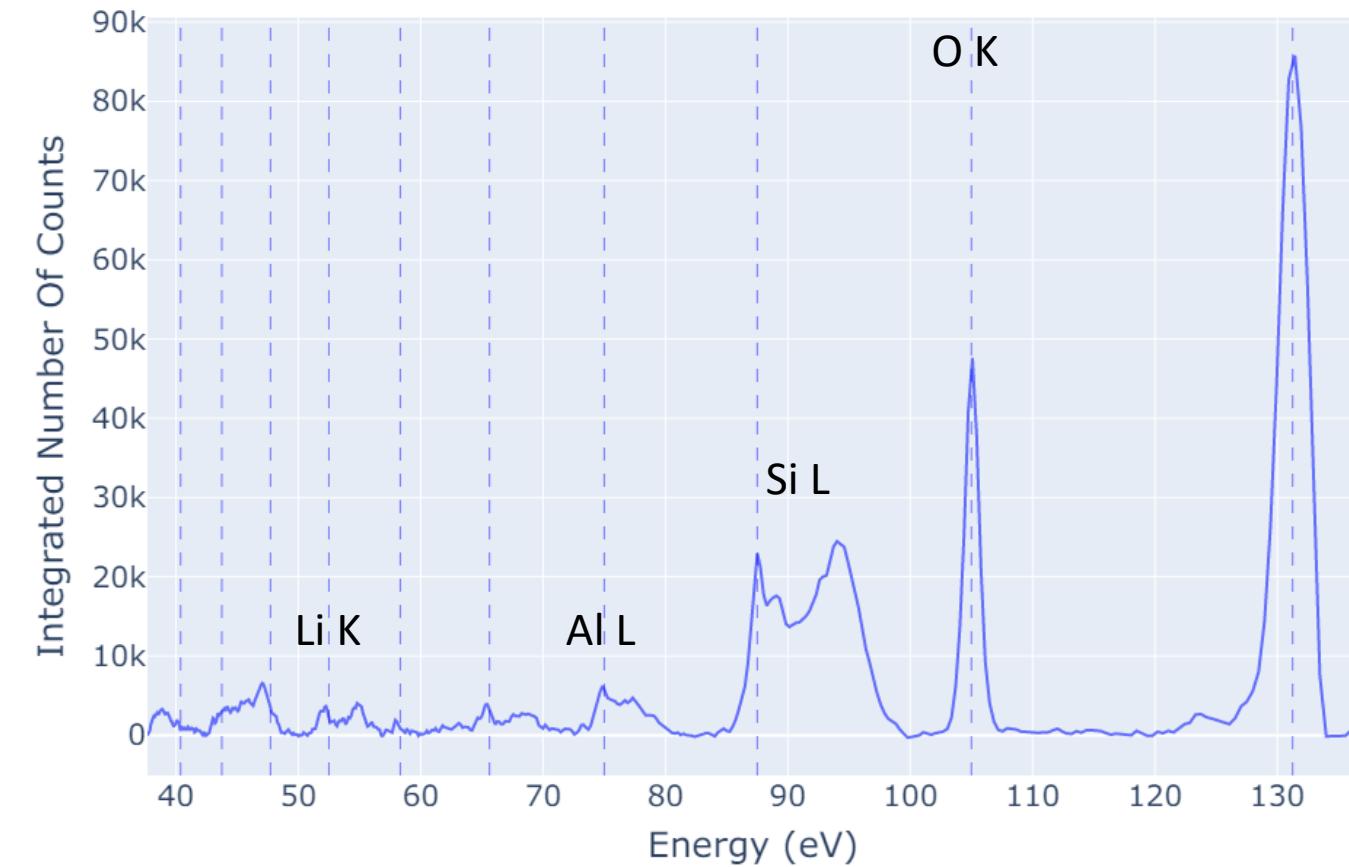


Interference with O Ka emission
diffraction at high orders

Damaging of the sample
by the electron beam



Li K range – Lepidolite – $K(Li,Al)_3(Si,Al)_4O_{10}(F,OH)_2$



Conclusion

- RZP spectrometer setup on a “standard” electron microprobe
- Standard = W filament; HT min 2 kV; no preparation chamber; no cryo-holder; ...
- Spectral range 40-120 eV
- Spectral resolution: 0.25 eV @ 40 eV 0.75 eV @ 120 eV
- Thanks to ANR SQLX project (ANR-20-CE29-0022; <https://anr.fr/Projet-ANR-20-CE29-0022>) and particularly to K. Hassebi, W. Aid, N. Rividi, K. Le Guen, V. Ilakovac, M.-C. Lépy
- Thanks to NanoOptics Berlin, <https://www.nanooptics-berlin.com/>