



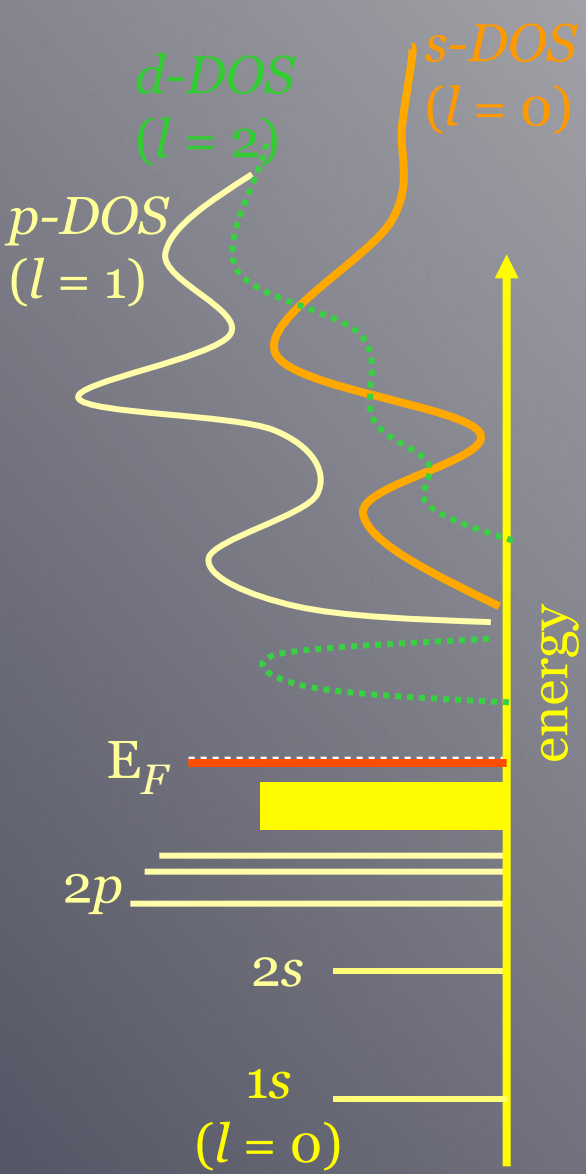
Tabletop X-Ray Spectroscopy of Battery Materials

Colleen Werkheiser

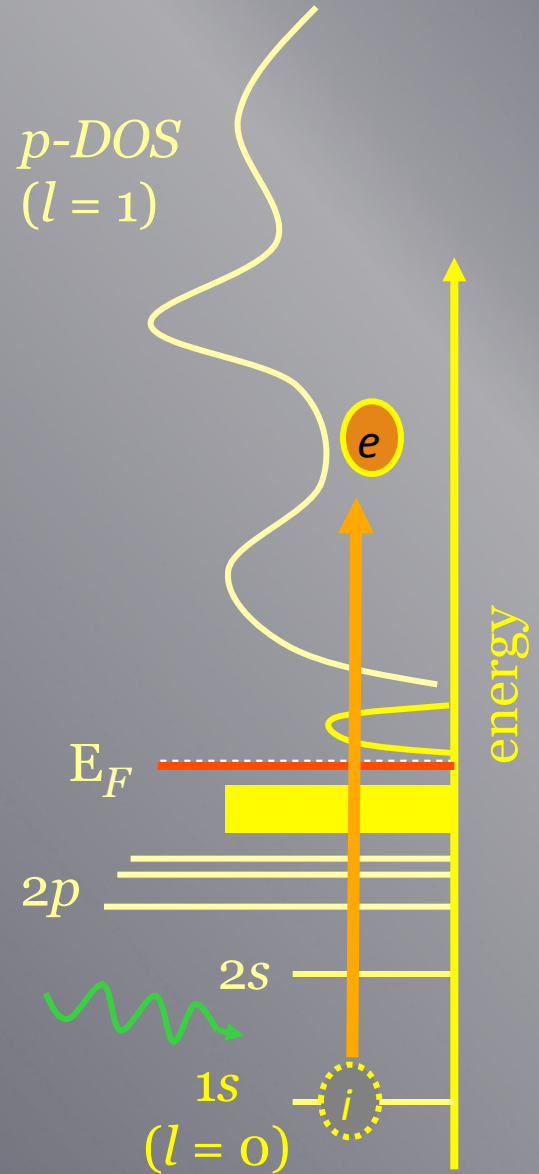
Seidler Group
University of Washington

August 20, 2015

Make an excitation ...

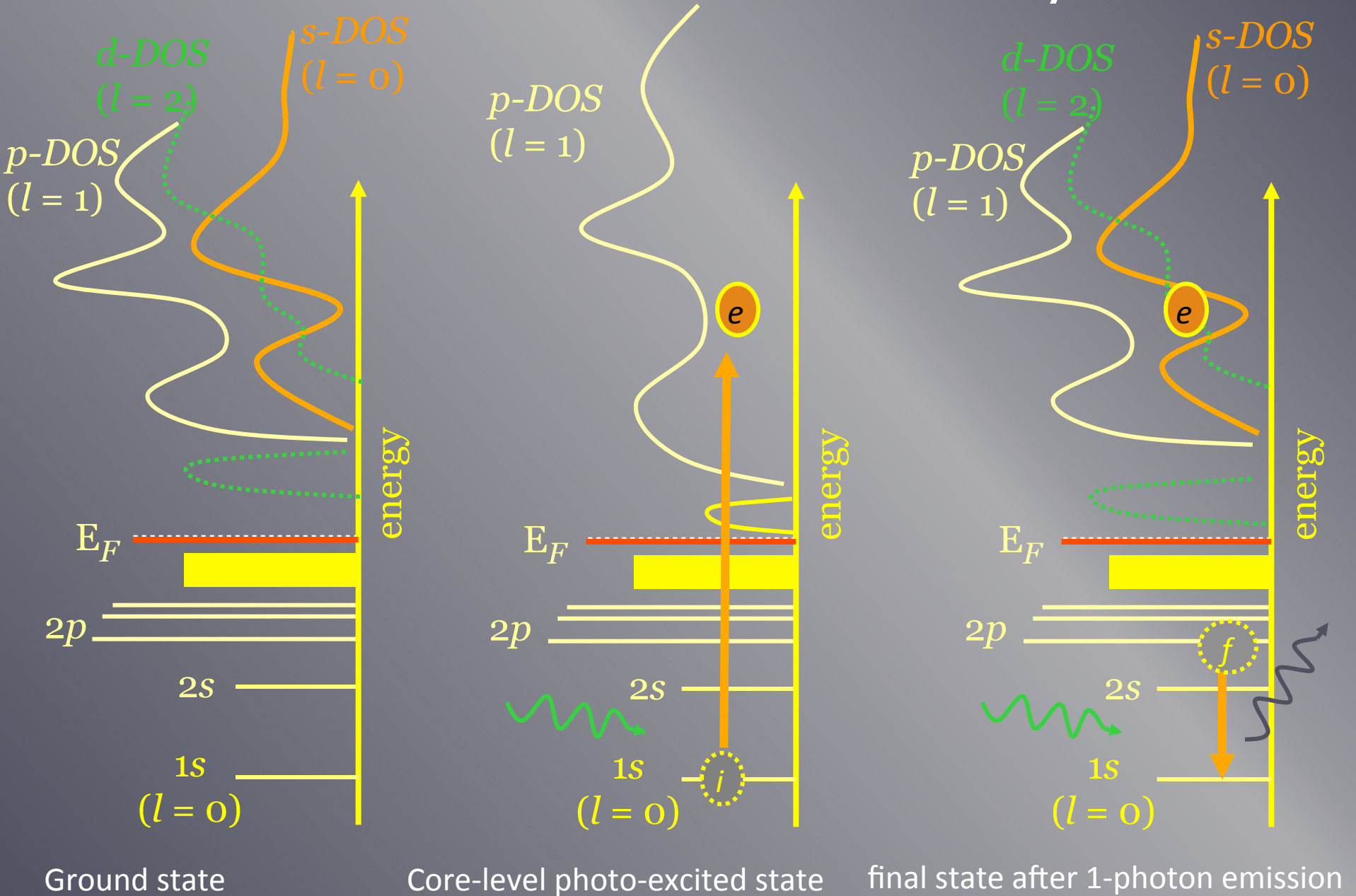


Ground state

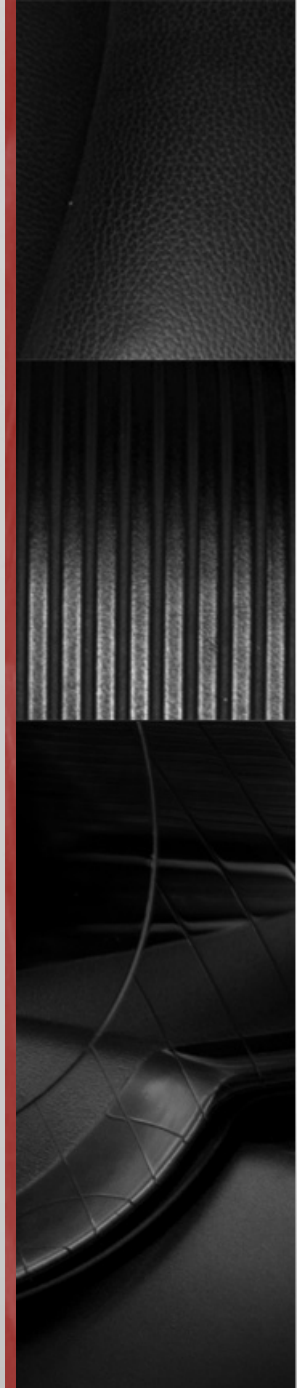
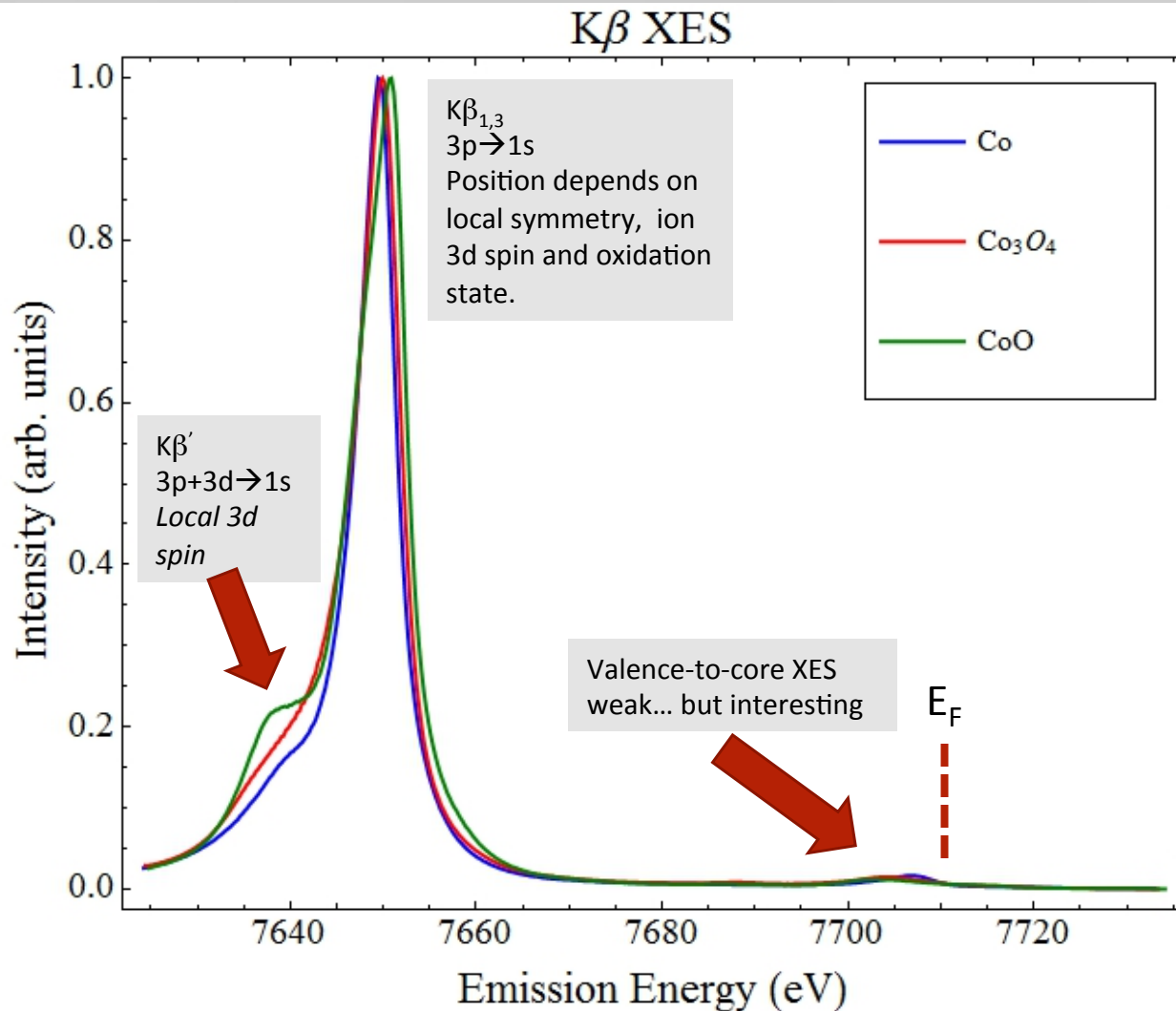


Core-level photo-excited state

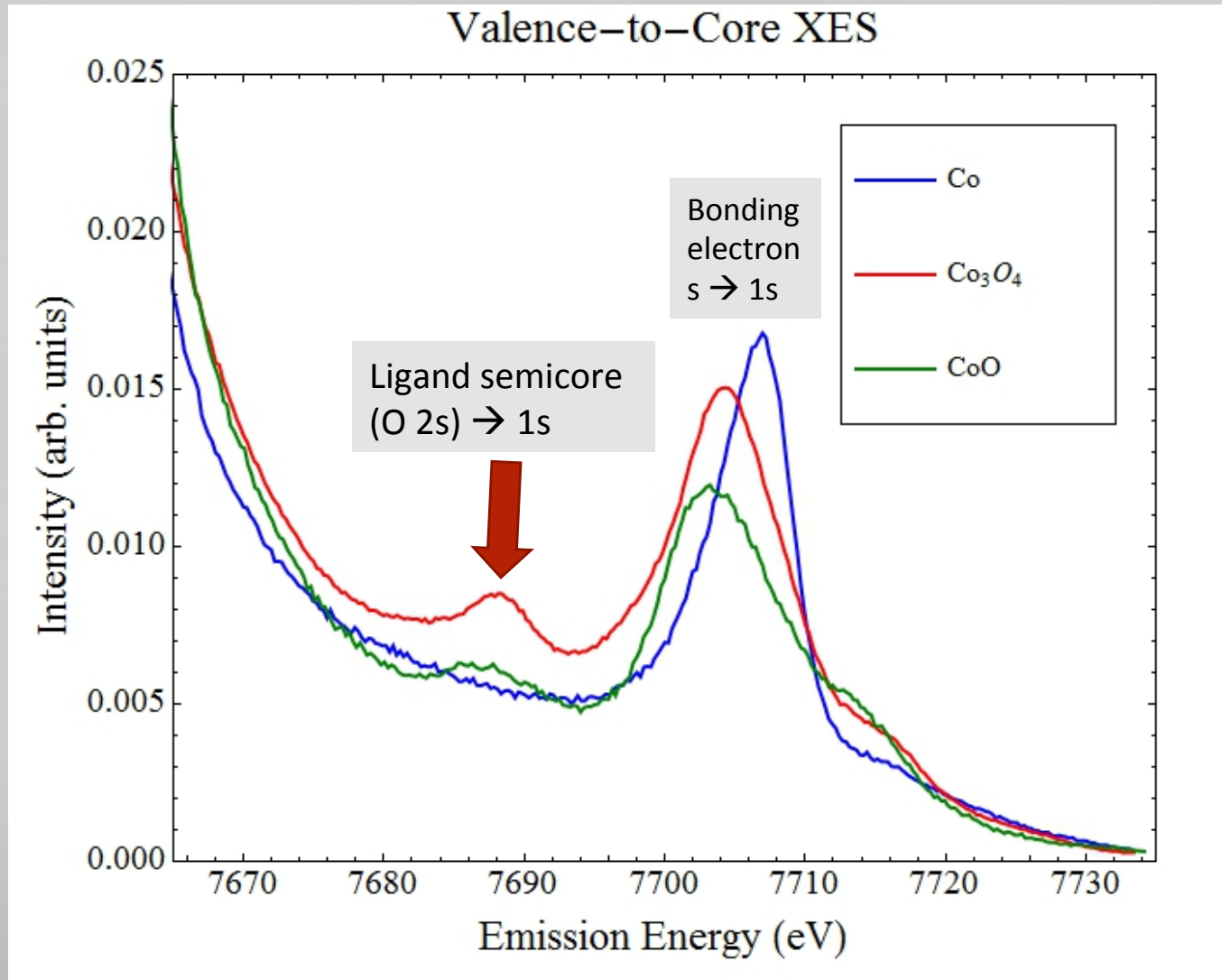
Make an excitation and decay...

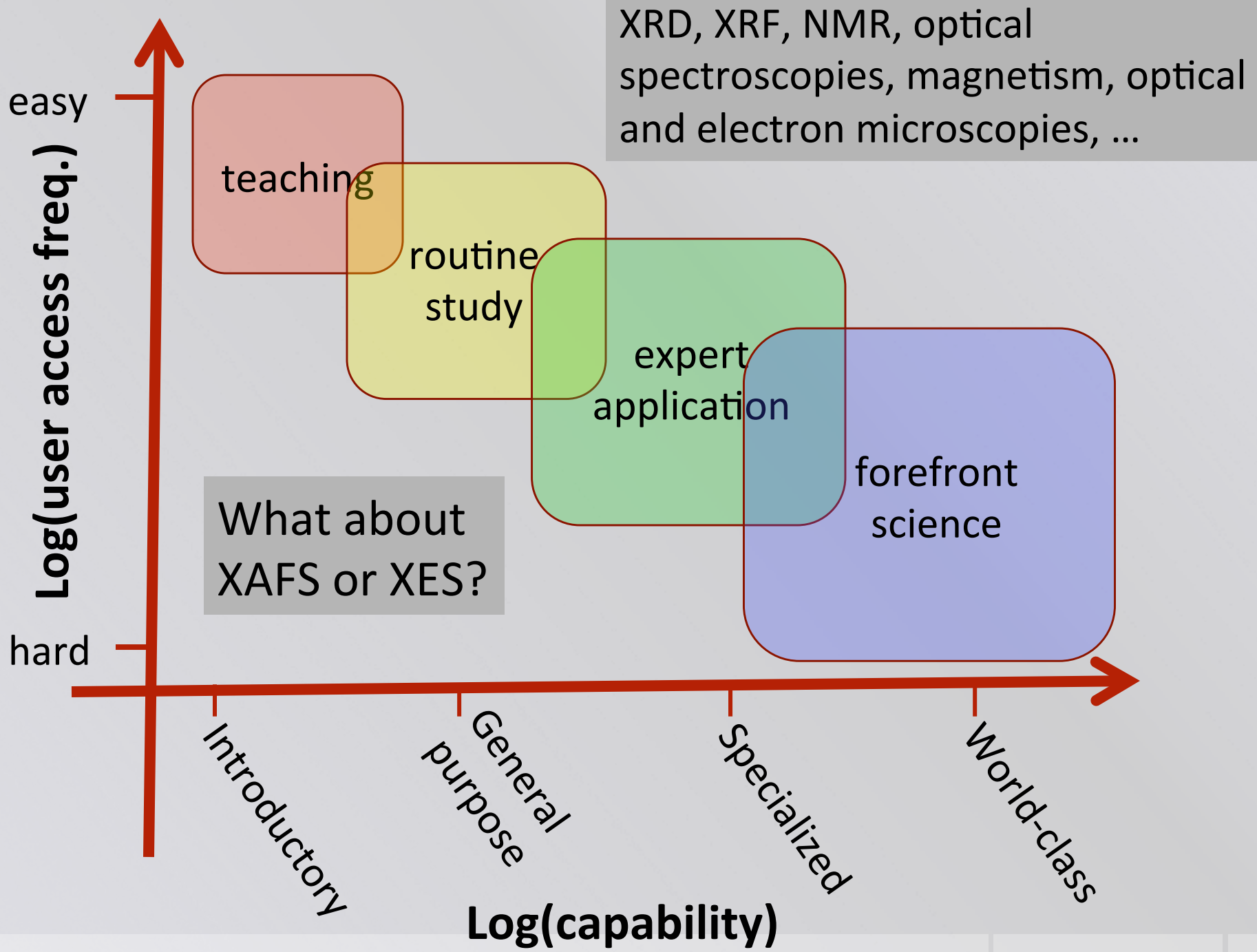


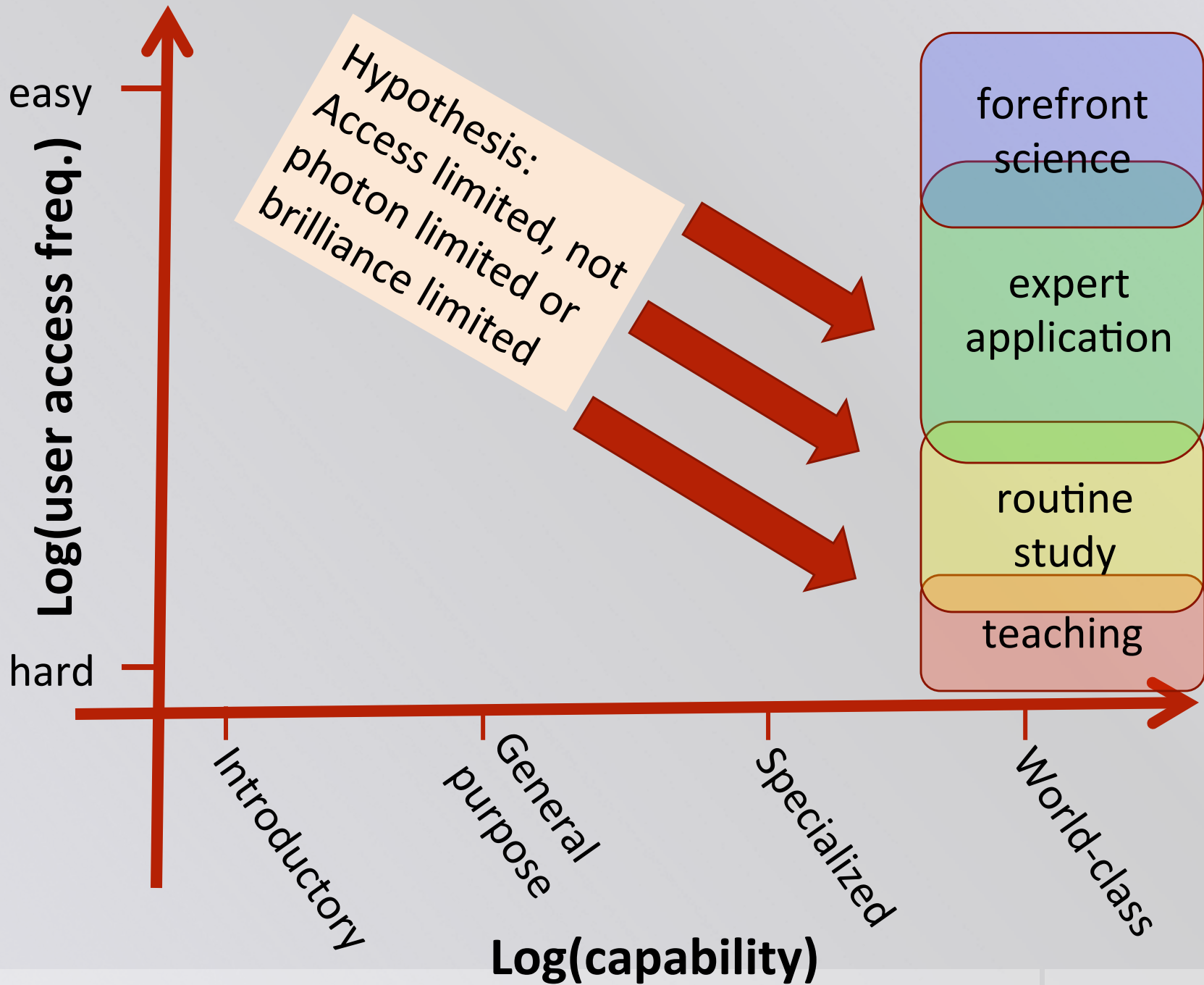
Some high-resolution x-ray emission spectroscopy (XES) measurements...



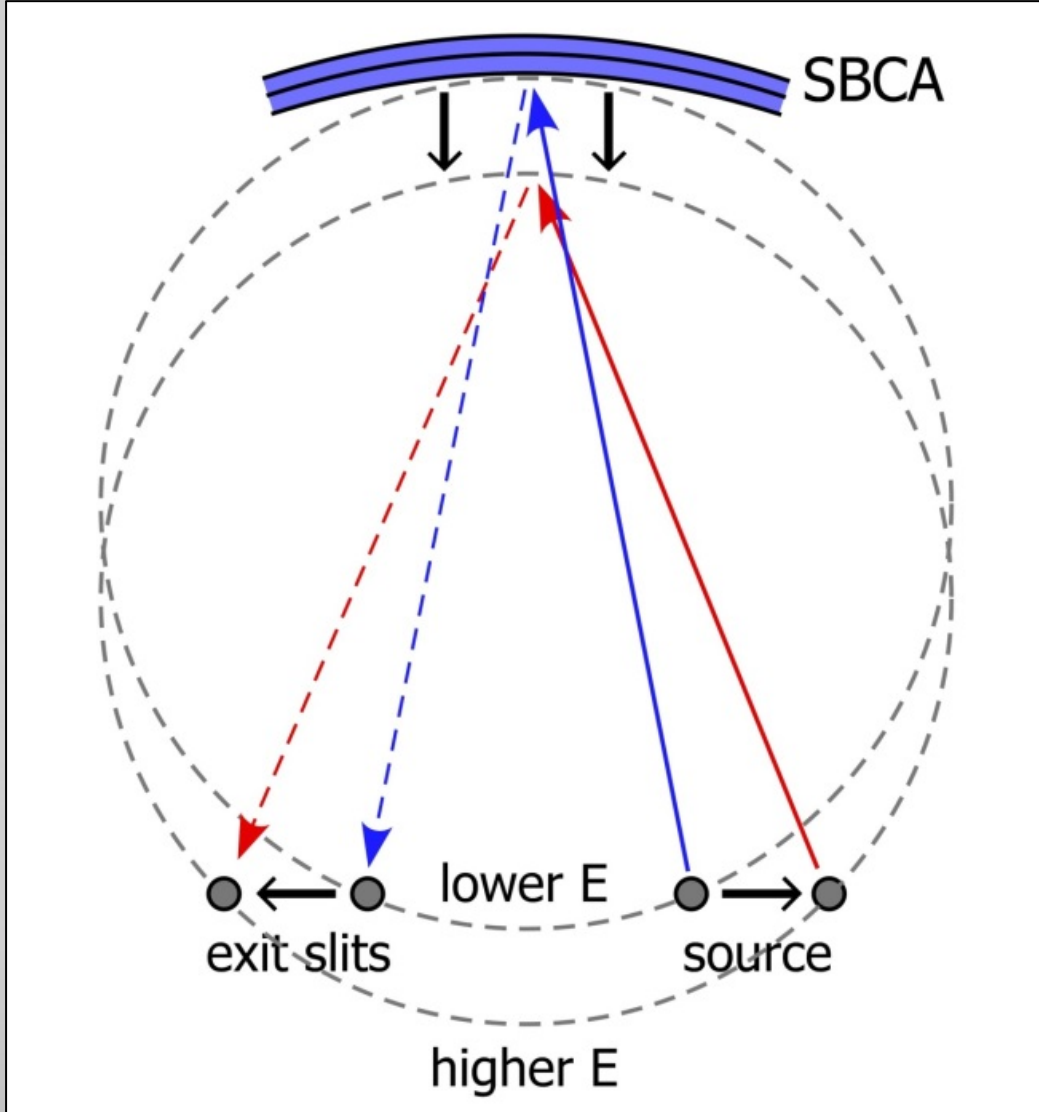
Some high-resolution x-ray emission spectroscopy (XES) measurements...







1-m Rowland Circle Spectrometer

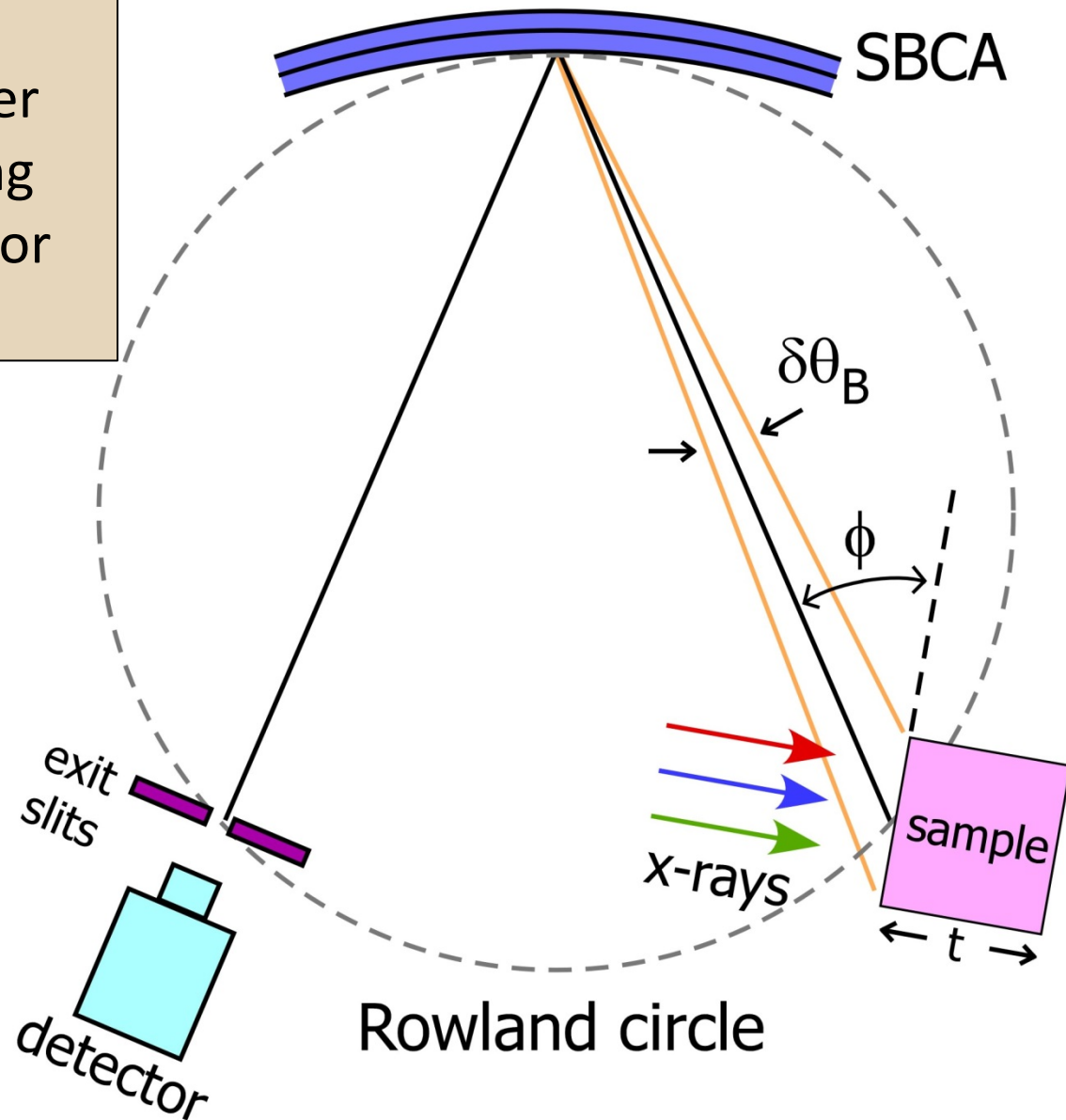


Exactly the 'standard' high-resolution spectrometer for inelastic scattering studies at synchrotrons.

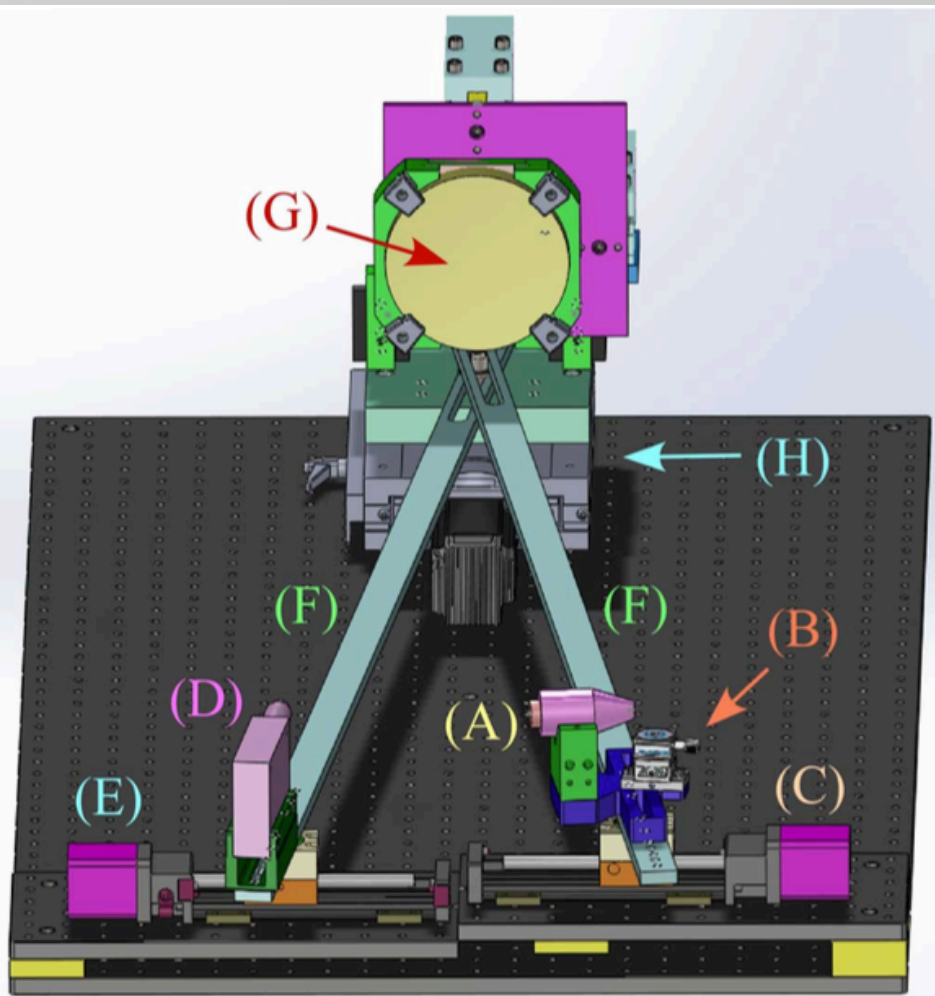
- Point-to-point focusing
- Energy selective via Bragg's law
- Scan energy by synchronously moving source and detector along circle

(Non-resonant) XES configuration

Use the Rowland-circle spectrometer to make a scanning monochromator for the emission.



The "coffin"





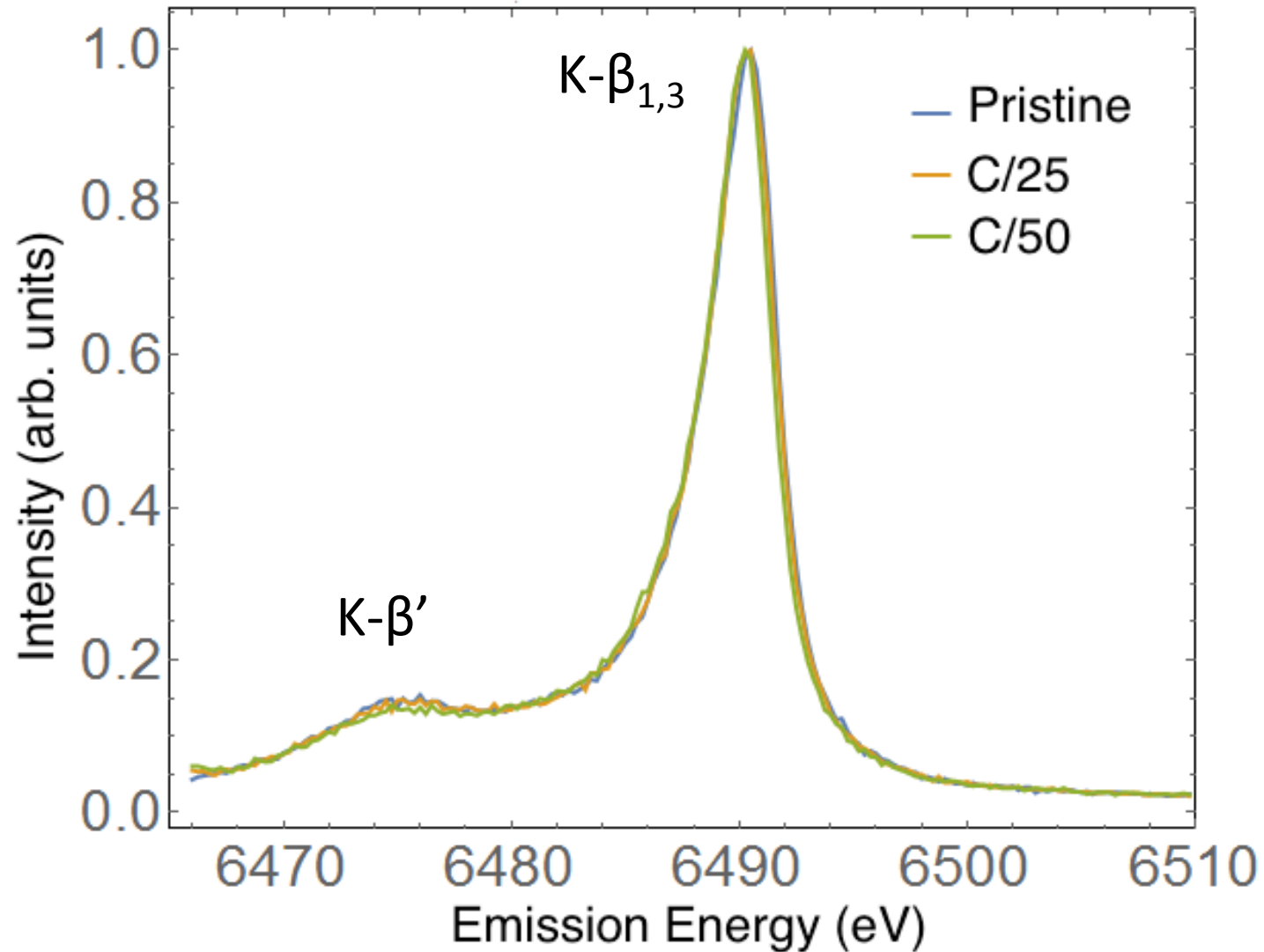
Why do we care about Li-ion batteries?

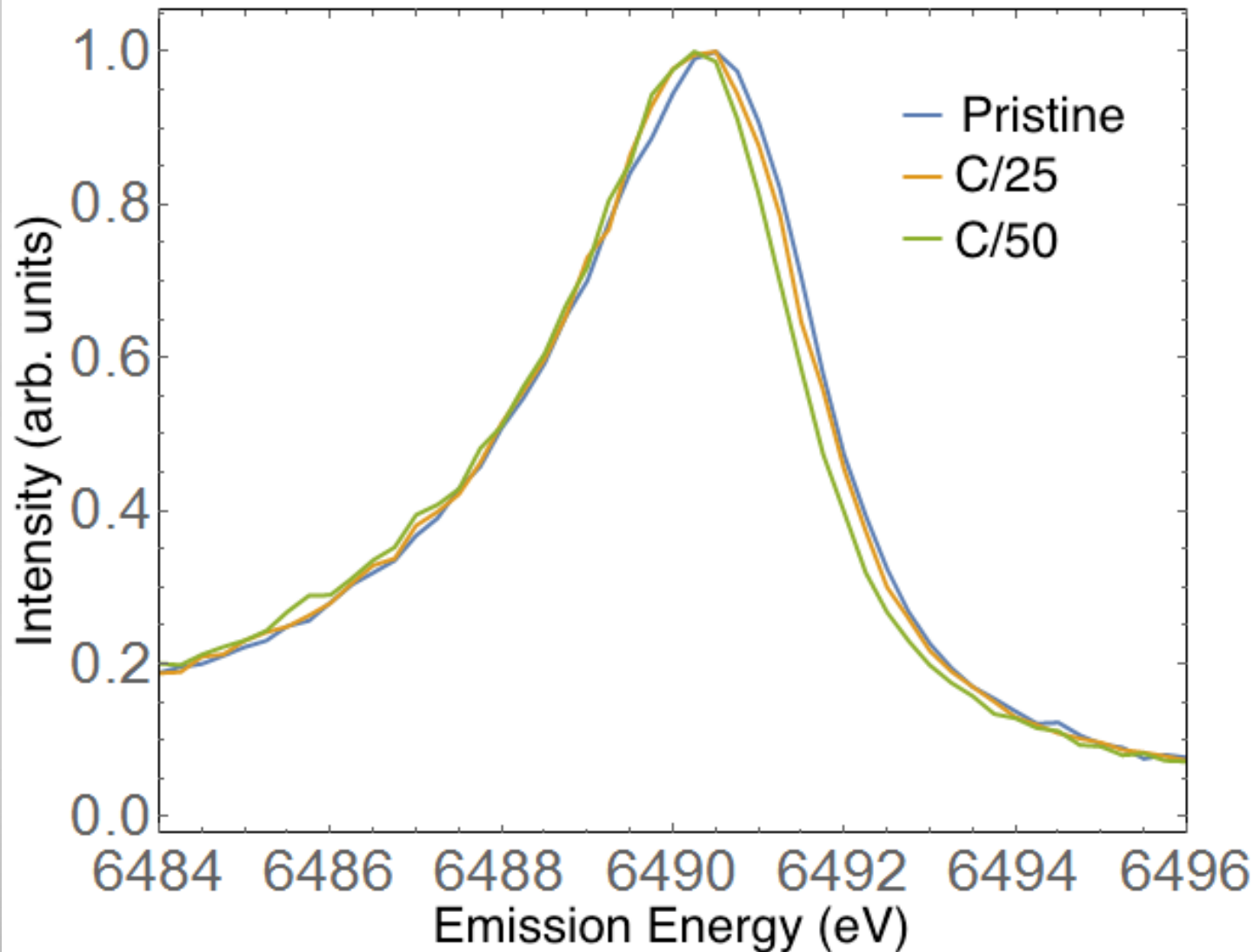
- There is a need to reduce dependence on fossil fuels (high costs and environmental impacts)
- Already in use (~10 year battery life)
- Good candidate for applications in hybrid cars

Still need improvements

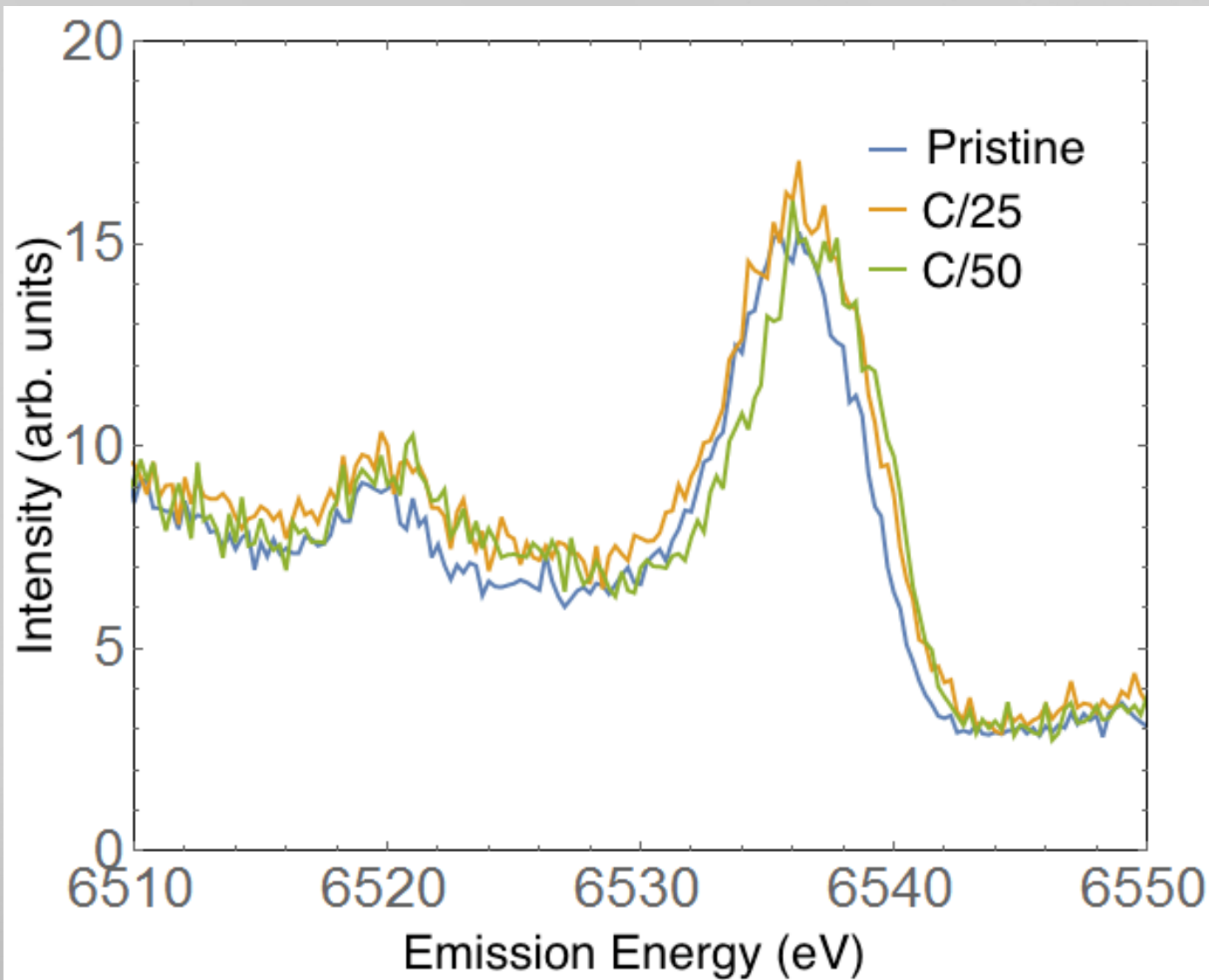
- Energy density
- Power capability
- Calendar-life performance
- Safety
- Cost

Preliminary tests: $\text{Li}_x\text{Mn}_2\text{O}_4$



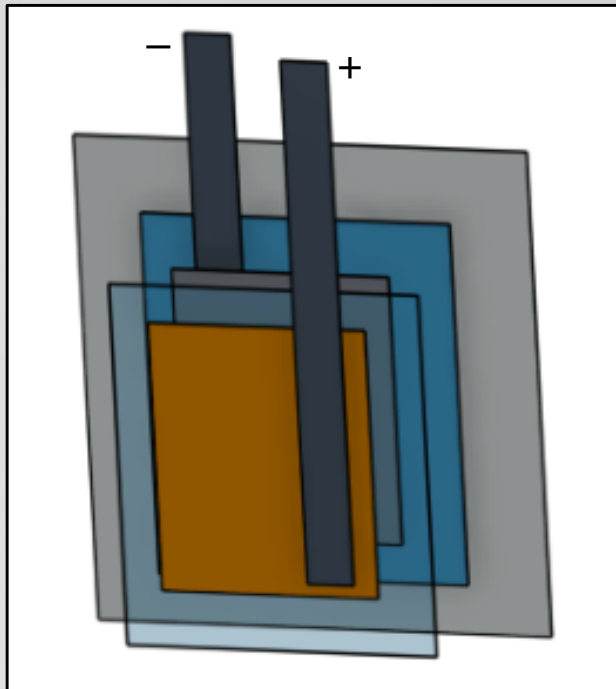


$\text{Li}_x\text{Mn}_2\text{O}_4$: valence

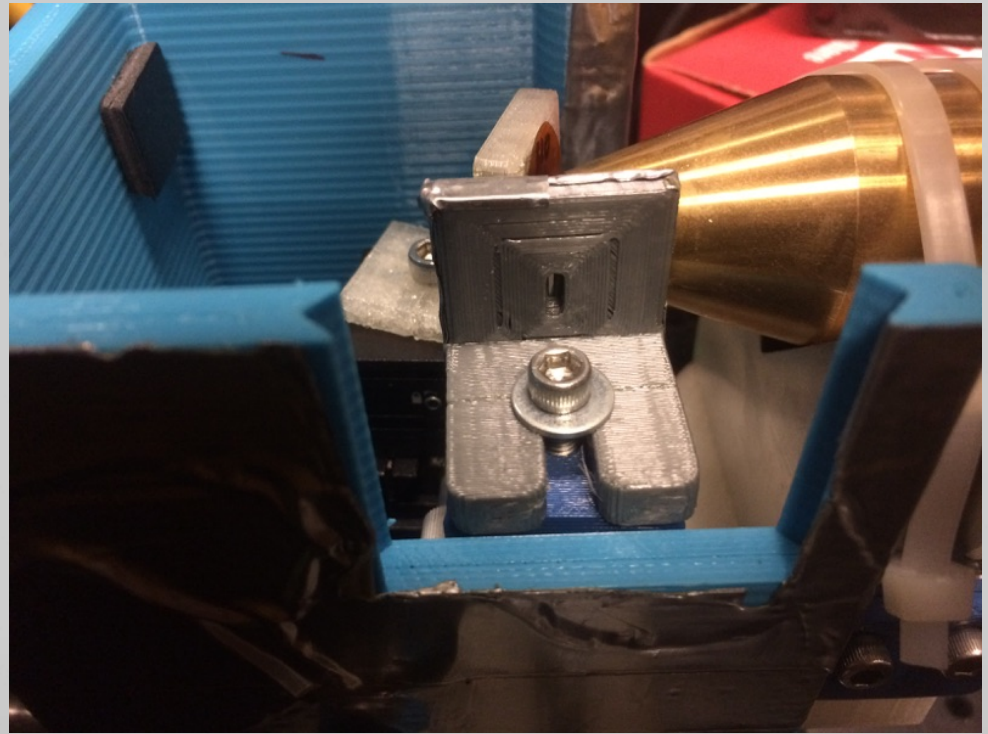
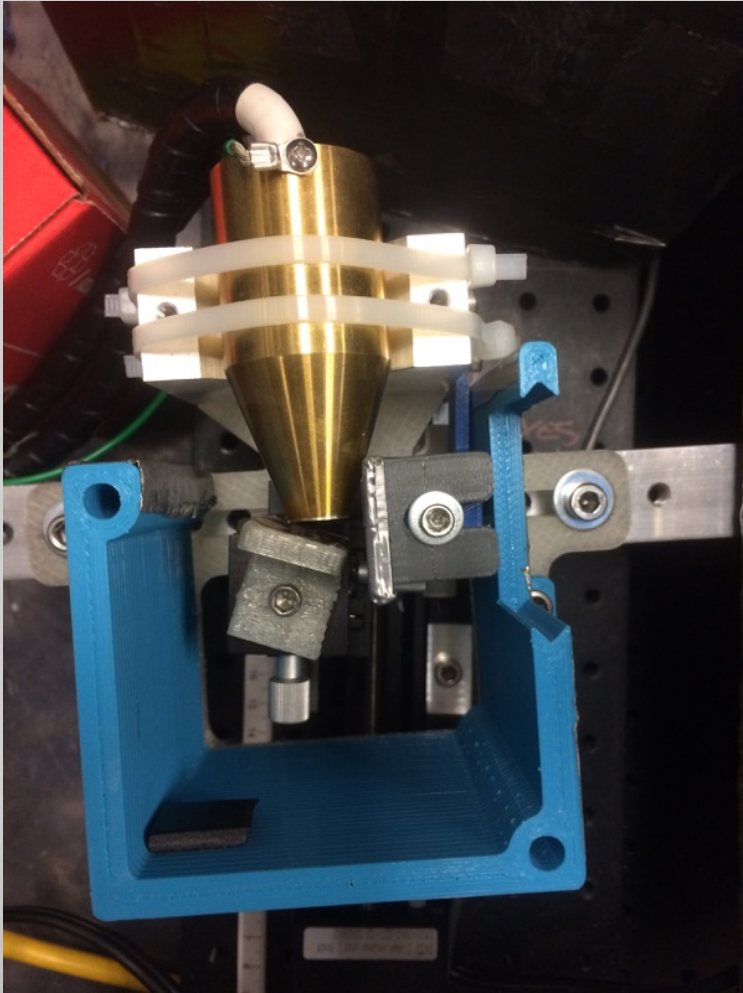


Pouch Cell Batteries

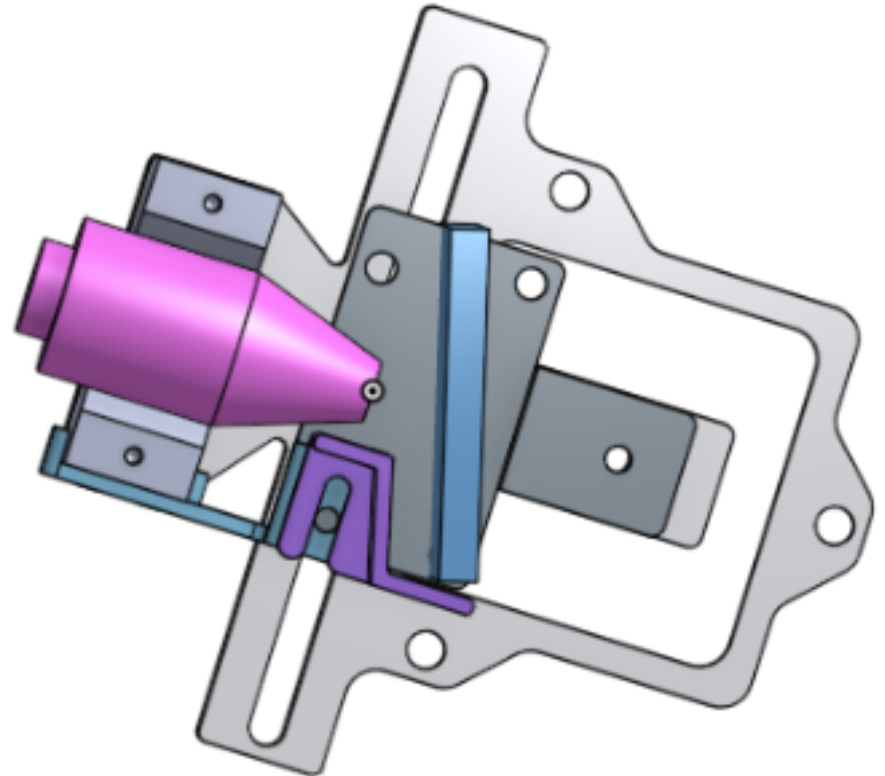
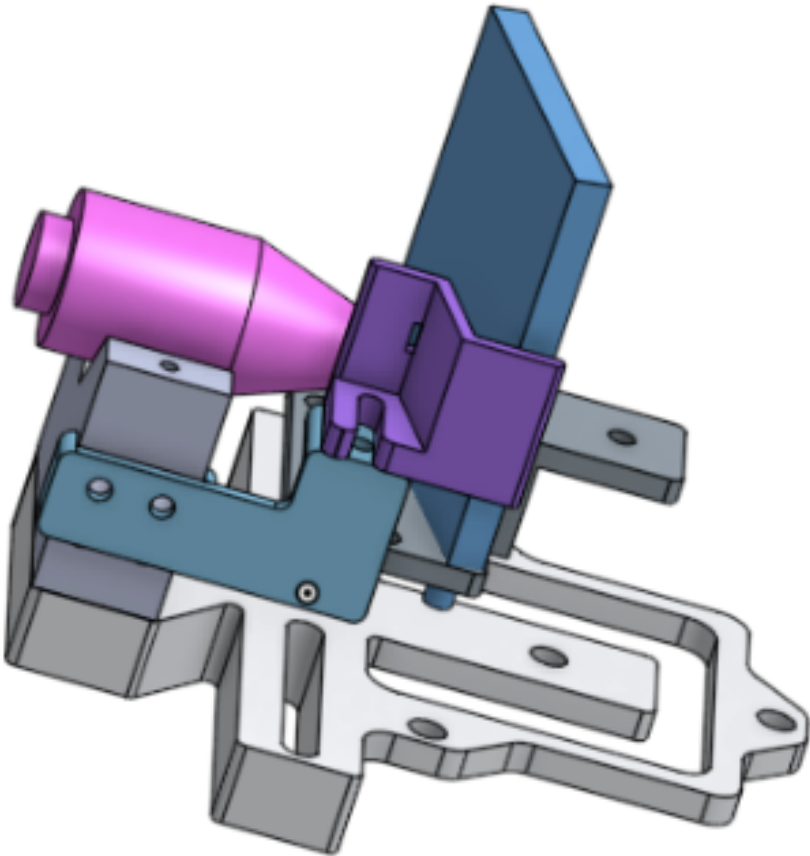
- Conductive foil tabs welded to current collectors
- Vacuum sealed
- 90-95% packaging efficiency
- Main limitation: lifespan shortened by humidity and high temperatures



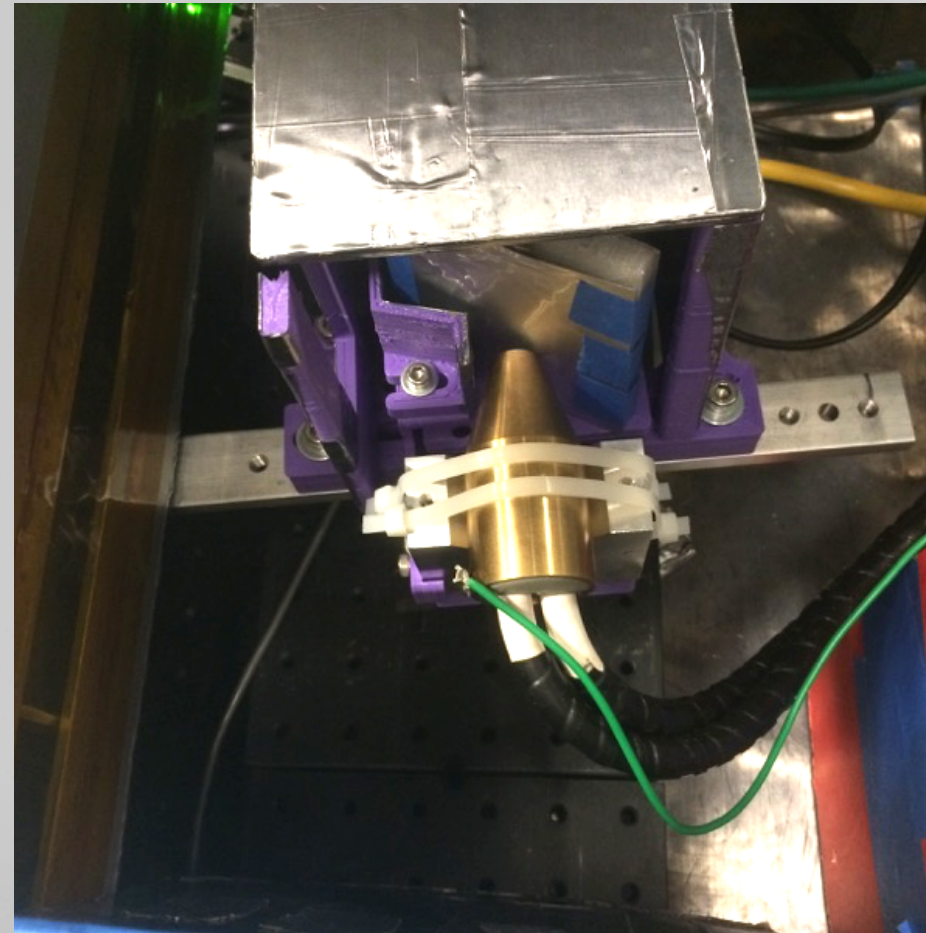
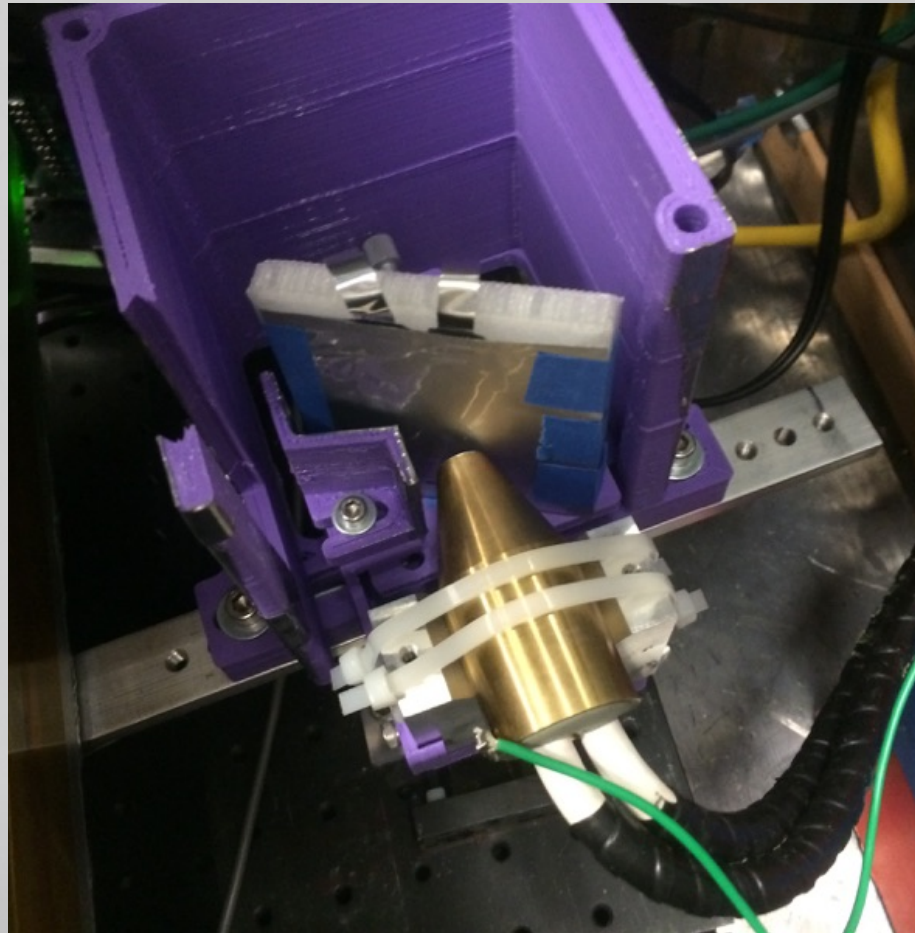
Original Geometry



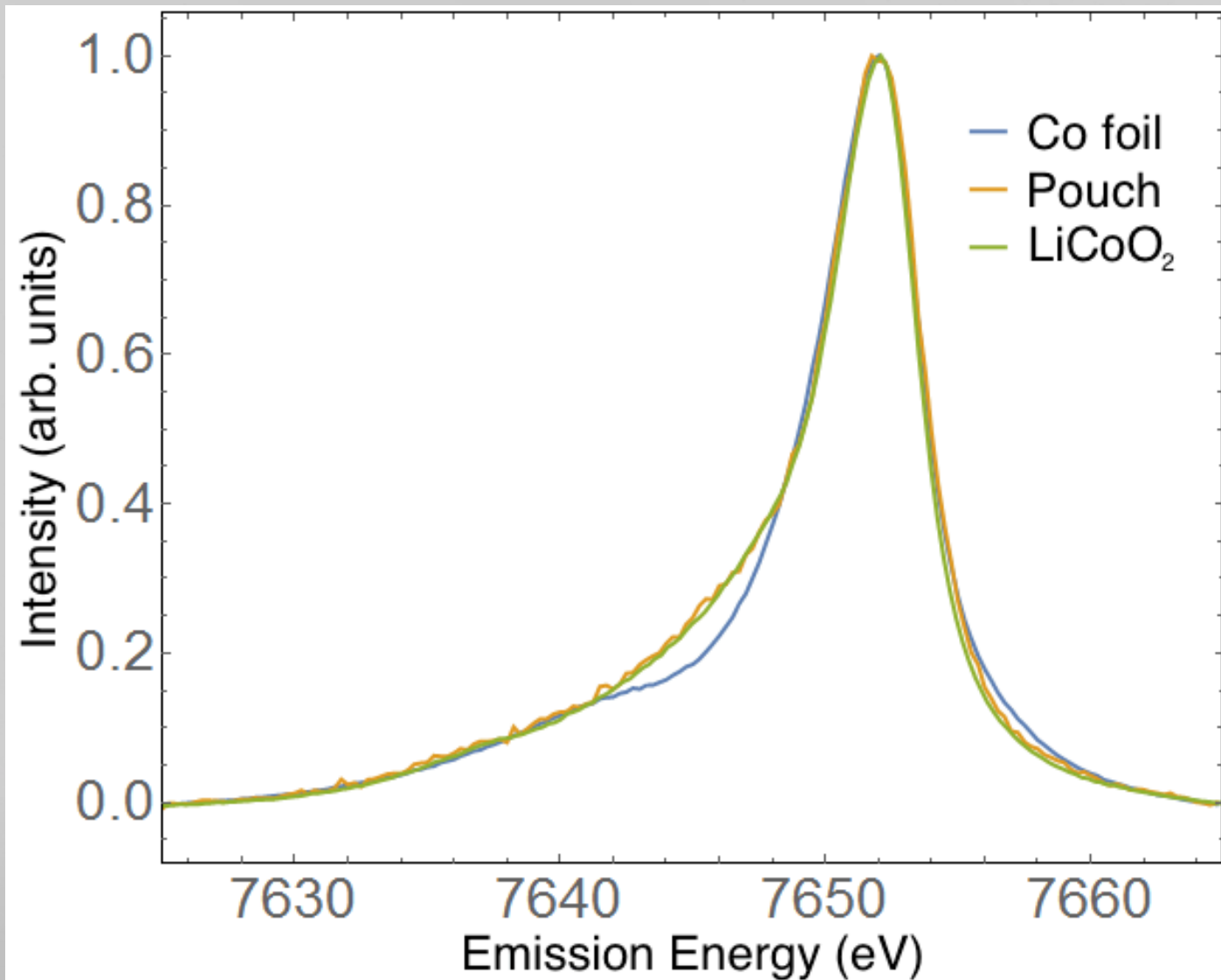
Pouch Cell Geometry



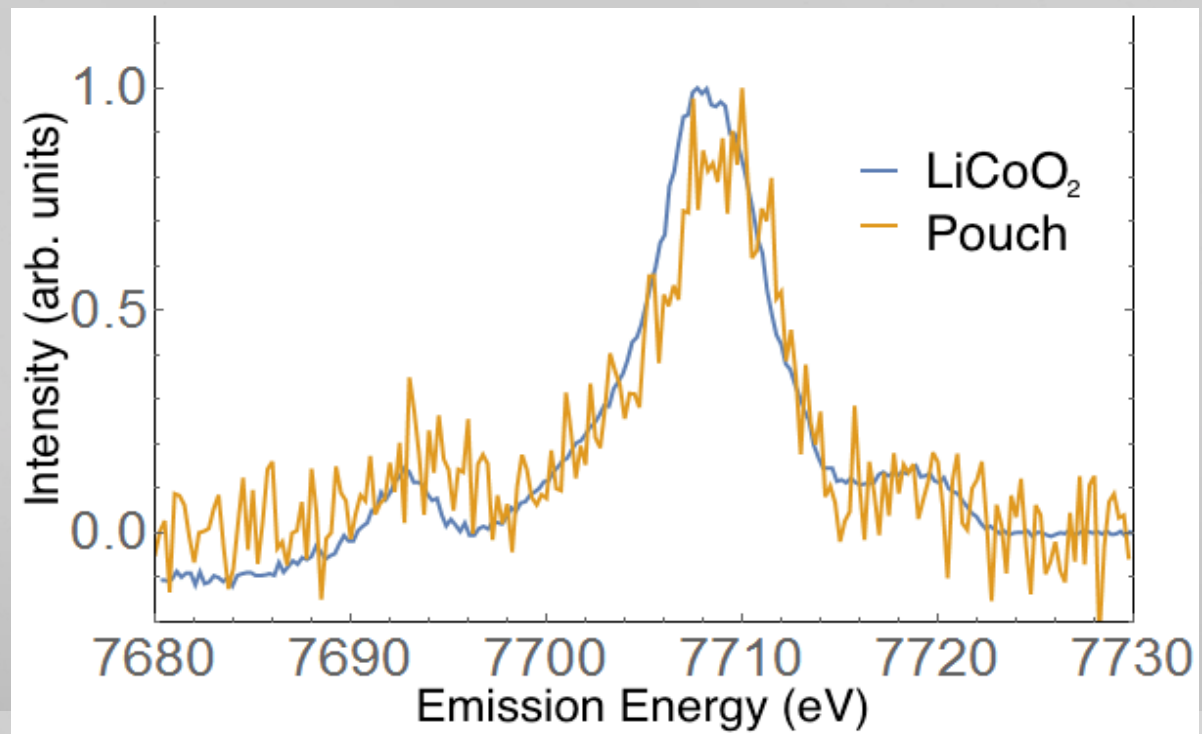
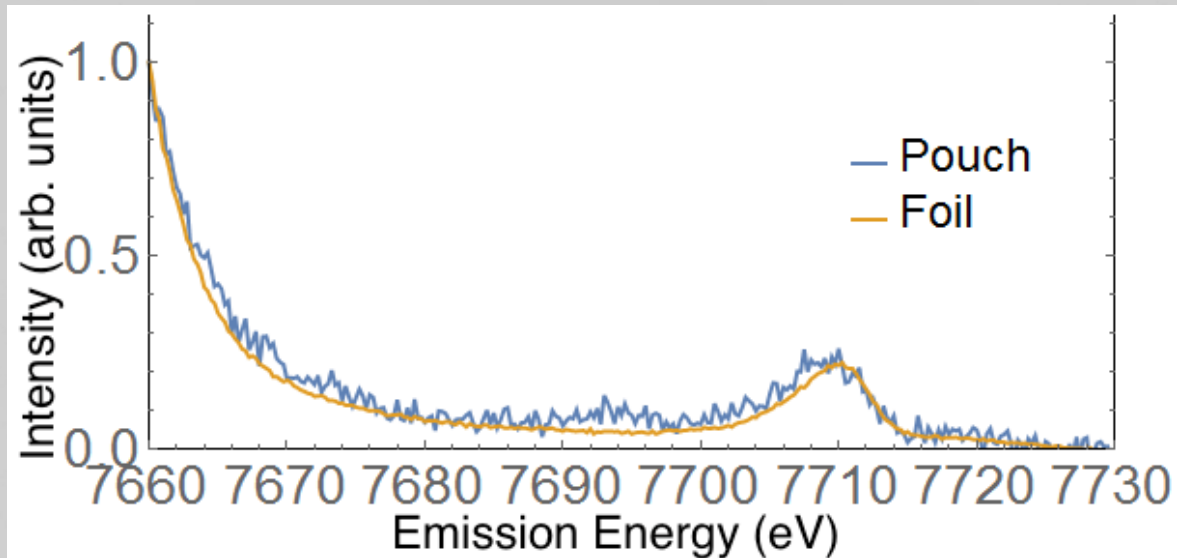
Pouch Cell Geometry



Pouch Cell Cobalt: $K\text{-}\beta_{1,3}$ and $K\text{-}\beta'$



Pouch Cell Cobalt: valence





Conclusions

- Proof of concept
- We have the resolution to do analysis
- This apparatus is a viable option for studying battery materials



Future and ongoing studies

- $K\text{-}\beta_{1,3}$ and $K\text{-}\beta'$ for Ni
- Valence for Ni
- Quantitative analysis of Mn samples
- Pouch cell measurements at different charge states



Acknowledgements

- Jerry Seidler, Evan, Devon, Alex, and the rest of the Seidler group
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