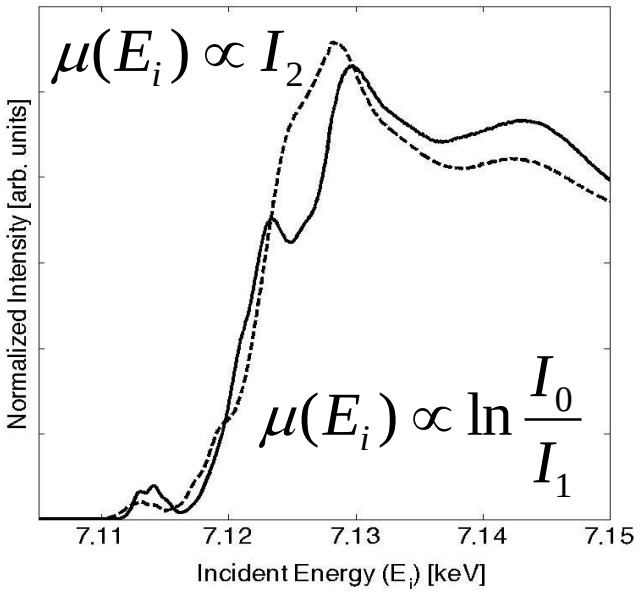
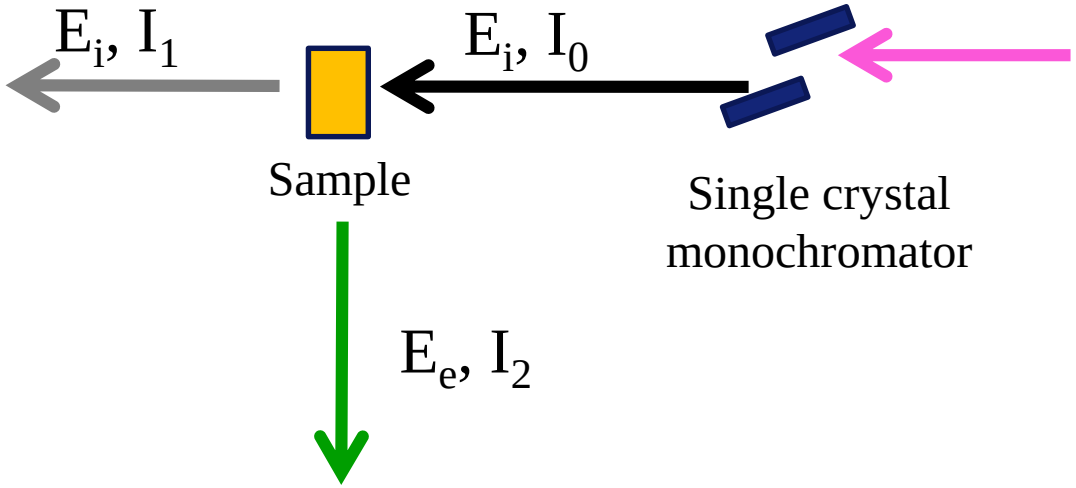
Radiation damage in X-ray spectroscopy

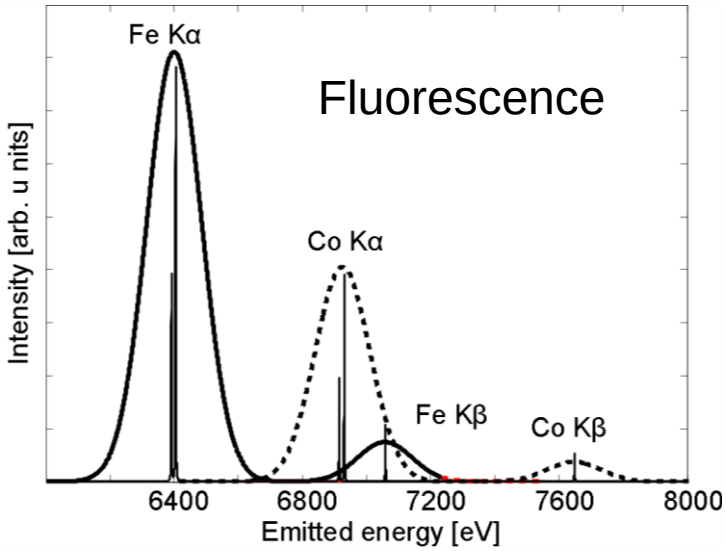
Pieter Glatzel

ESRF | The European Synchrotron

Photon-in/photon out spectroscopy





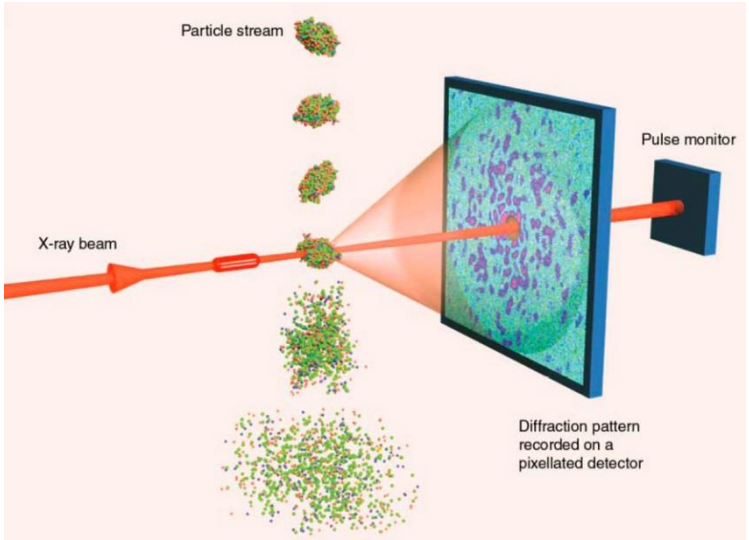


Biological samples are often measured in fluorescence detection.

Radiation damage in X-ray spectroscopy

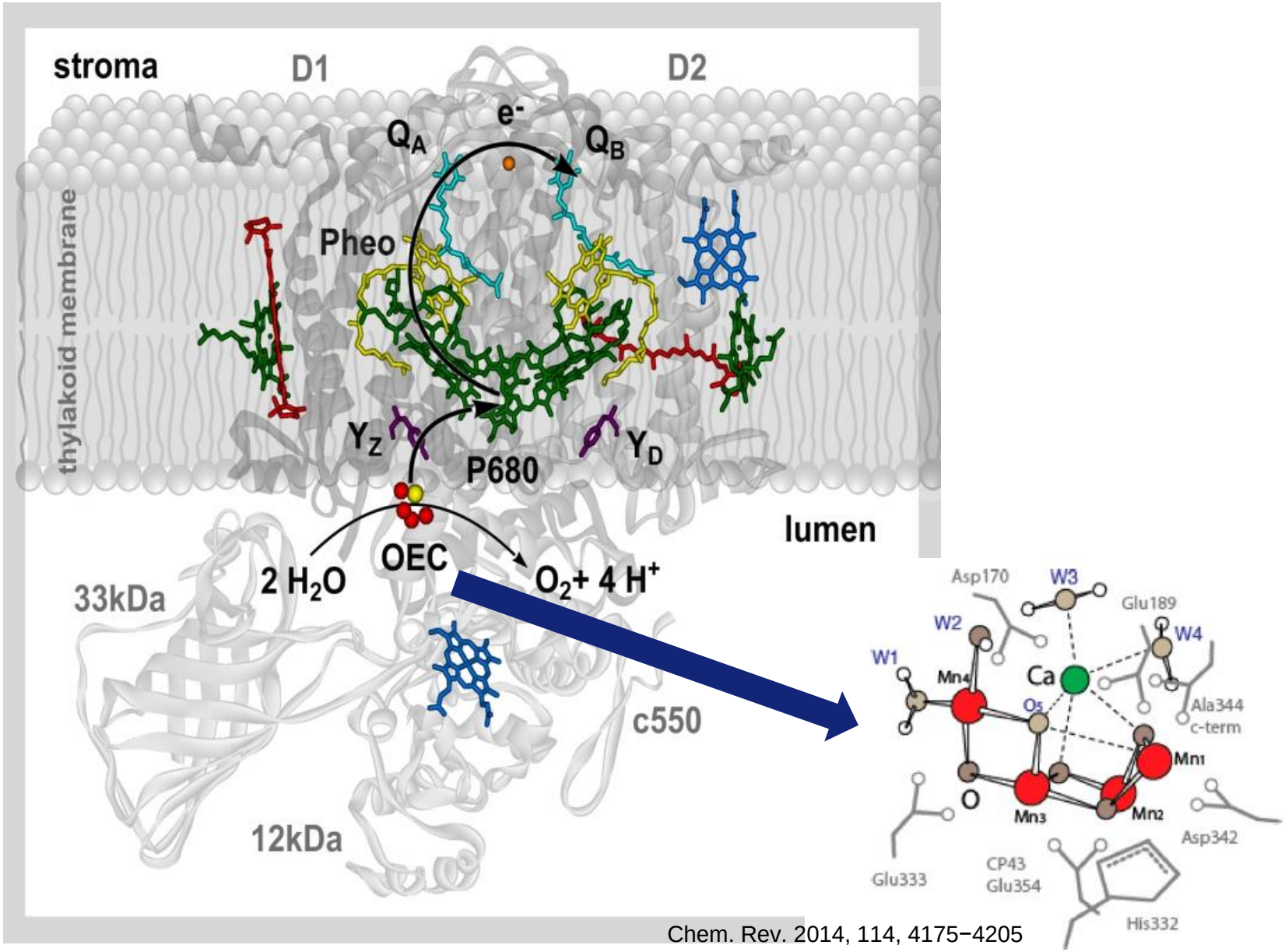
In case spectral changes are observed with increasing X-ray dose (radiation damage):

1) Increase detection efficiency
2) Use more sample
3) (Beat the radical diffusion time)



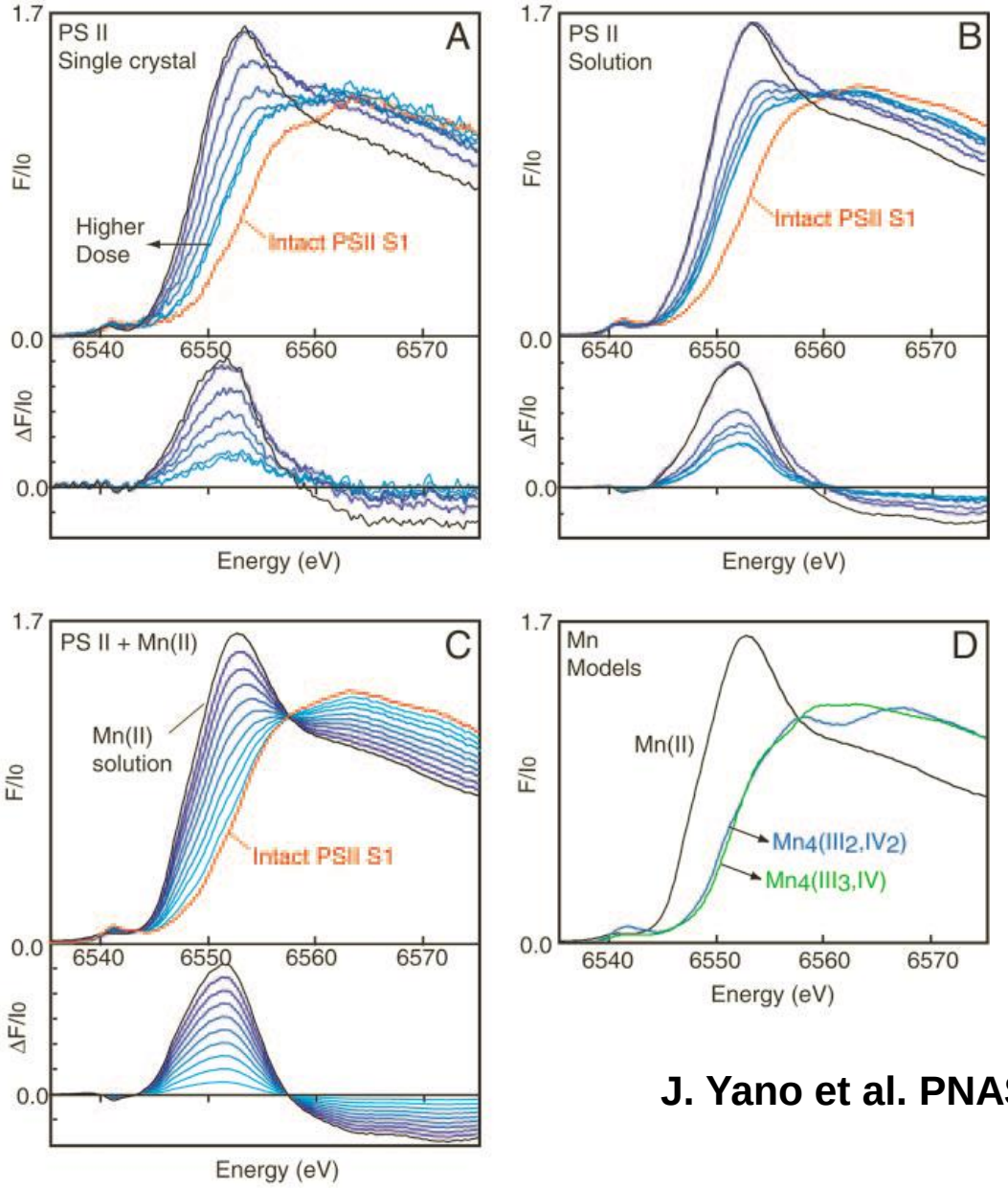
Science 316, 1444-1448 (2007); Nature 406, 752-757 (2000)

Photosystem II



Chem. Rev. 2014, 114, 4175−4205

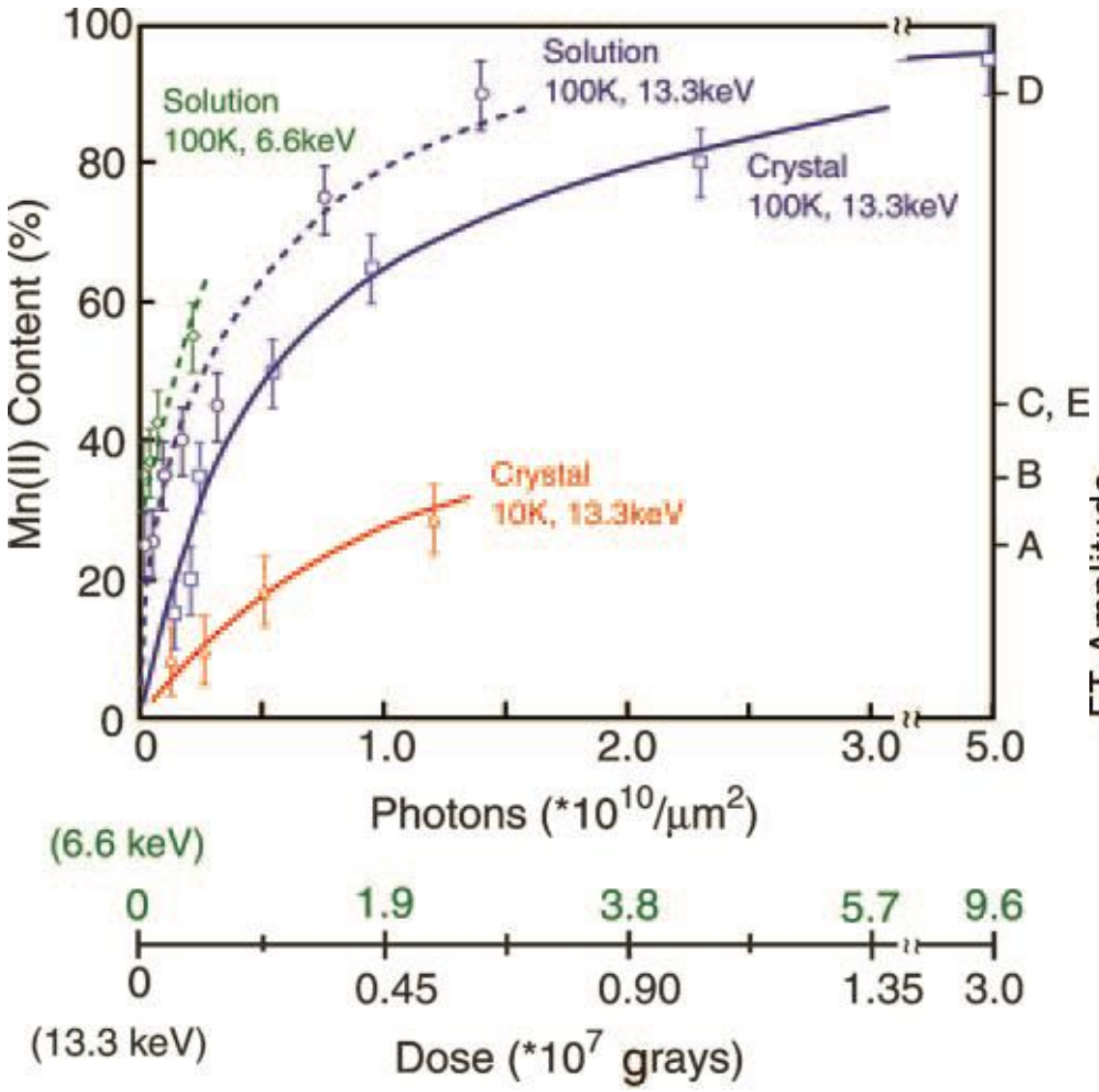
X-ray damage as a function of dose and temperature

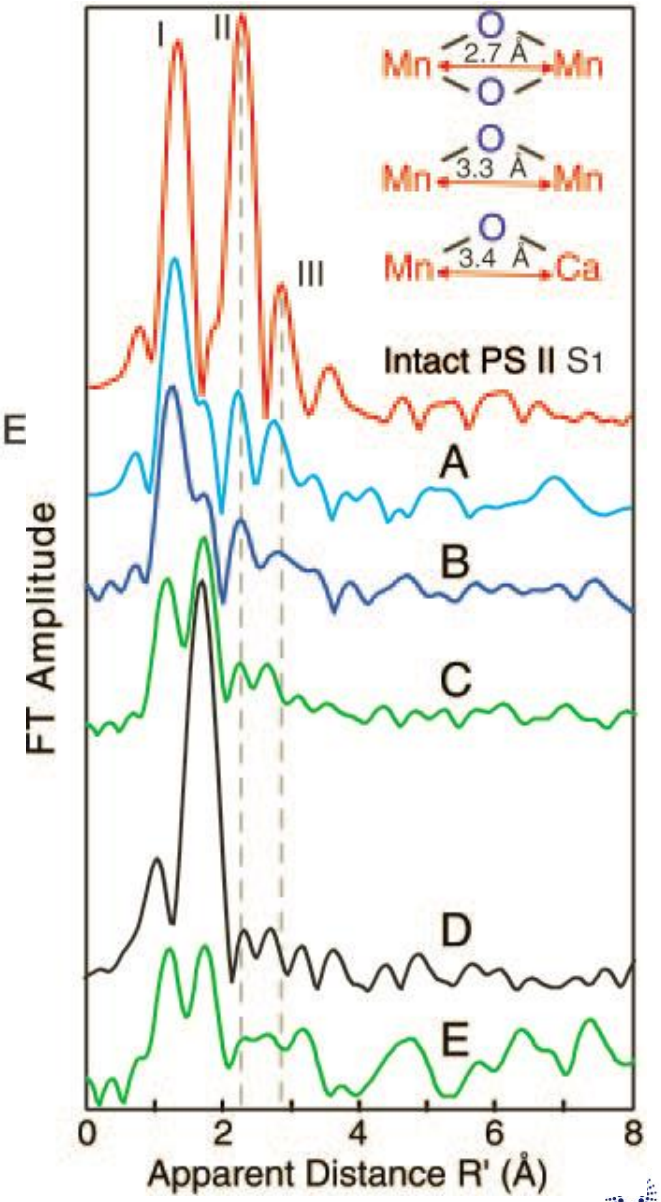


- Mn(III) and Mn(IV) are reduced to Mn(II) by X-rays
- Mn(II) resembles Mn in solution
- Spectroscopy sets an orders of magnitude lower dose limit than crystallography

J. Yano et al. PNAS, 102, 12047 (2005)

X-ray damage as a function of dose and temperature

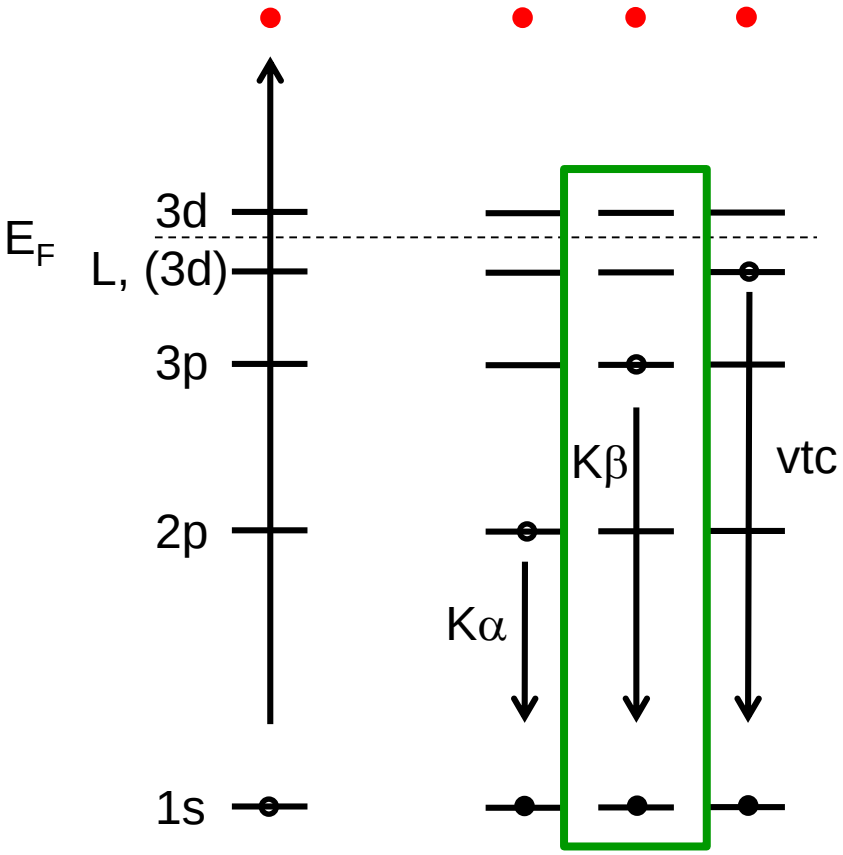


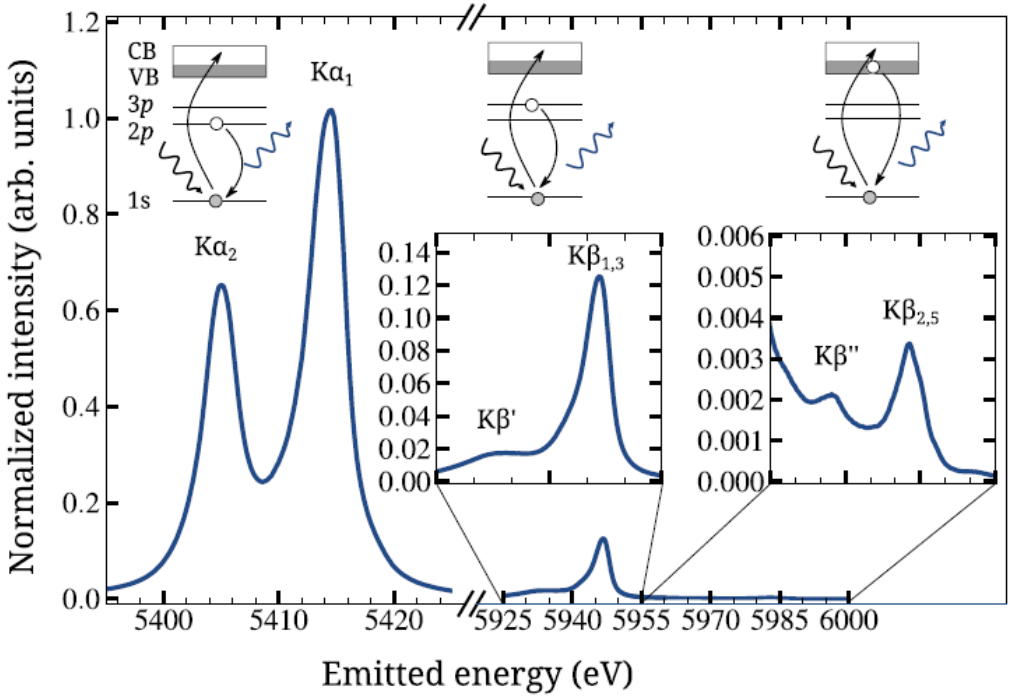


J. Yano et al. PNAS, 102, 12047 (2005)

Photon-in/photon-out spectroscopic techniques

Non-resonant

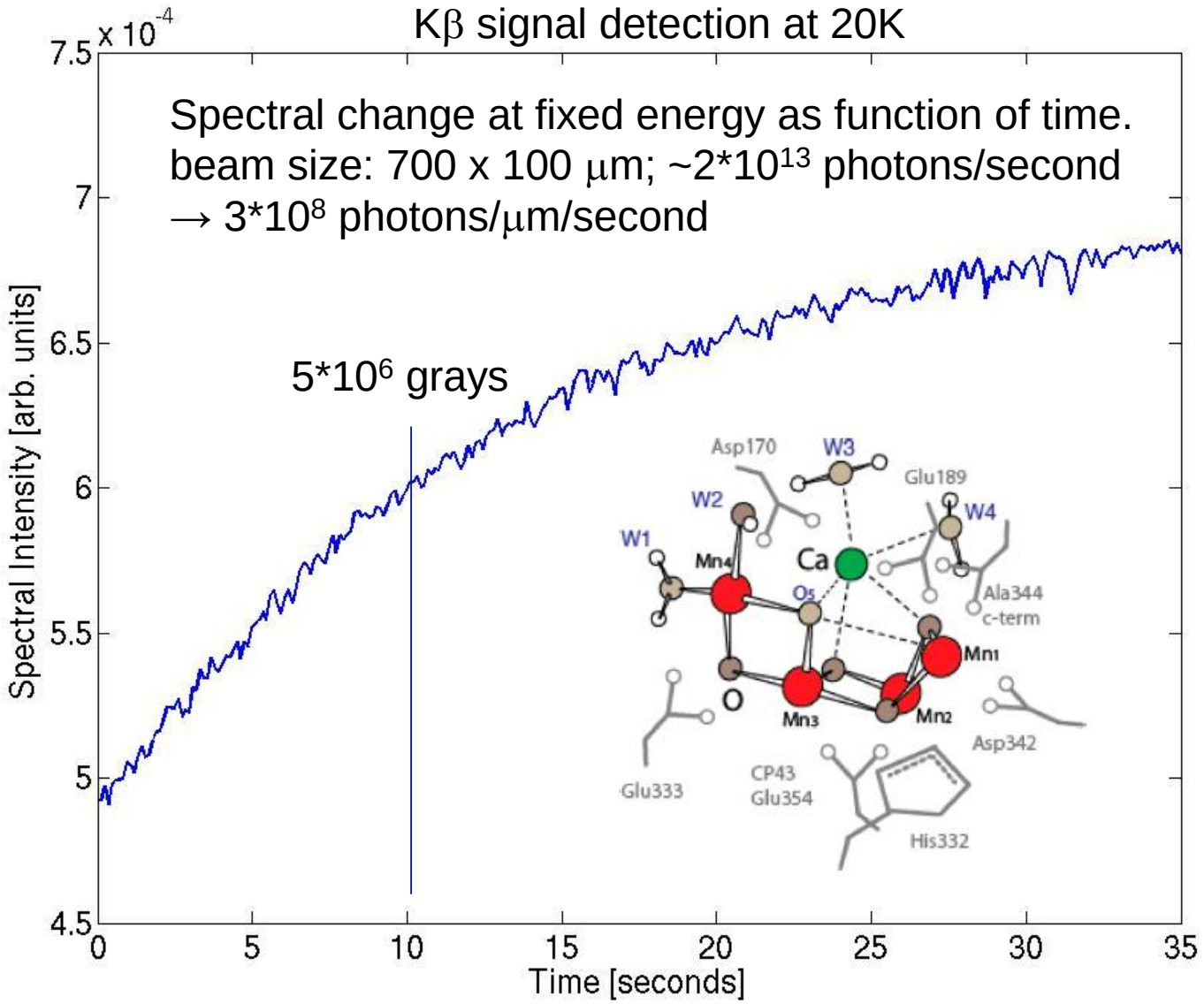




P. Glatzel and U. Bergmann, Cord. Chem. Rev. (2004)

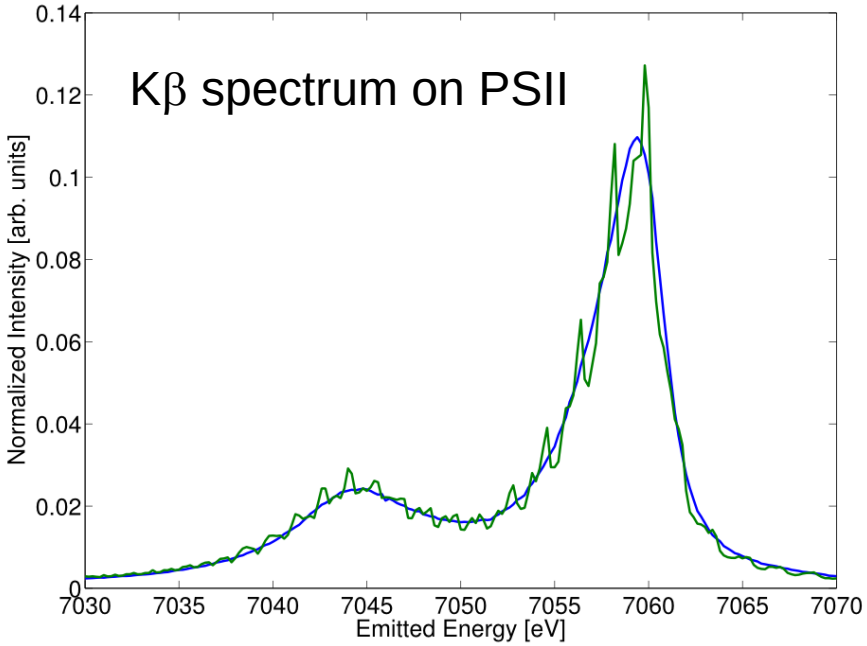
M. Rovezzi and P. Glatzel Semicond. Sci. Technol. **29** 023002 (2014)

Dealing with radiation sensitive samples on ID26



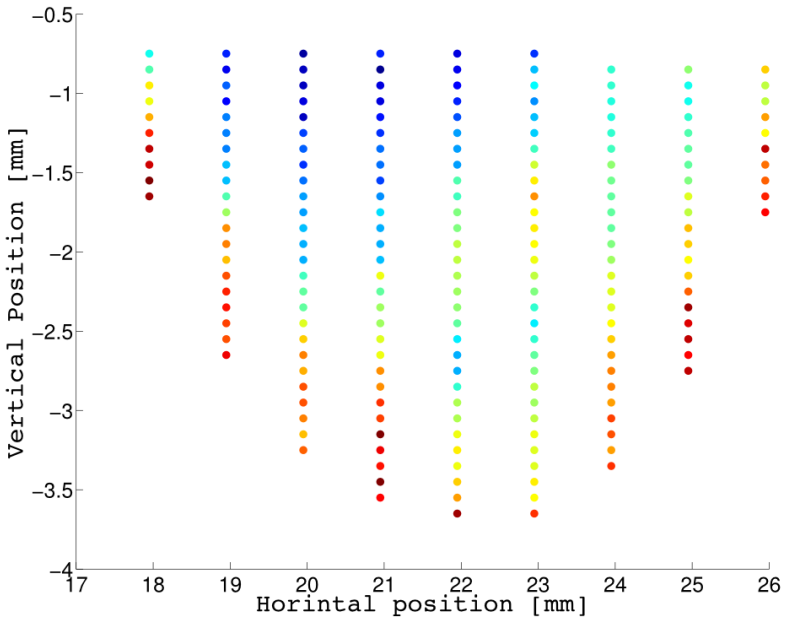
With J. Yano, V. Yachandra, R. Chatterjee, LBNL

Dealing with radiation sensitive samples



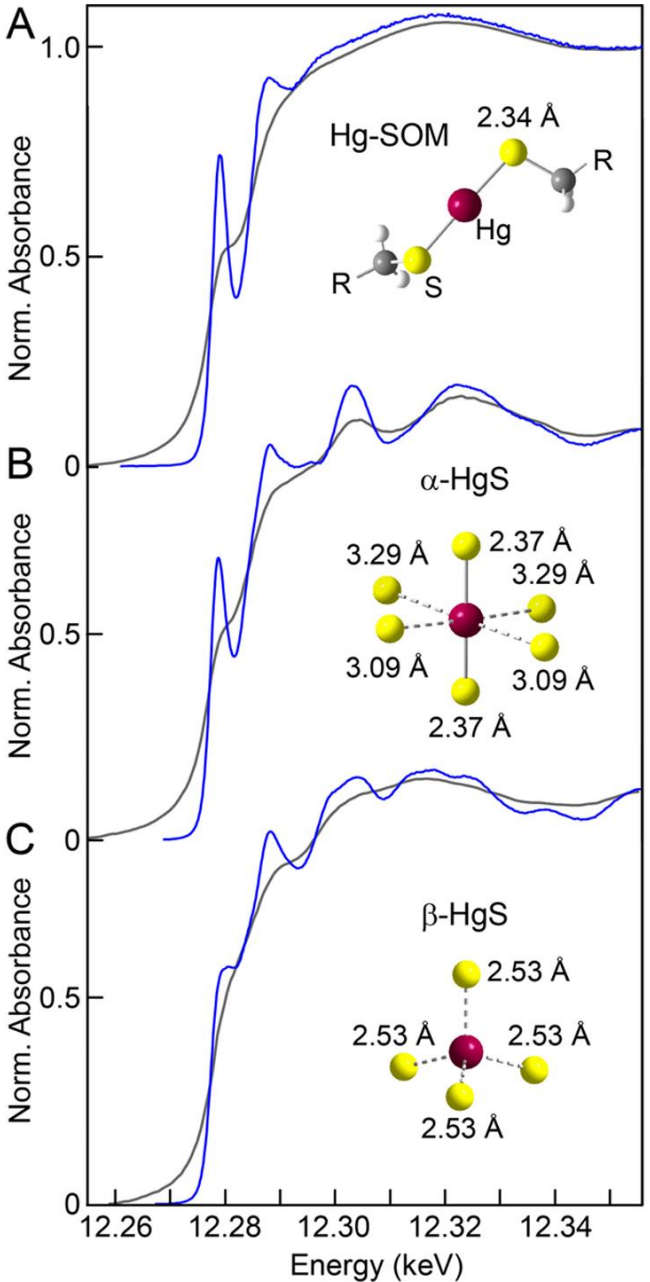
Each energy point measured in different position of beam on sample.

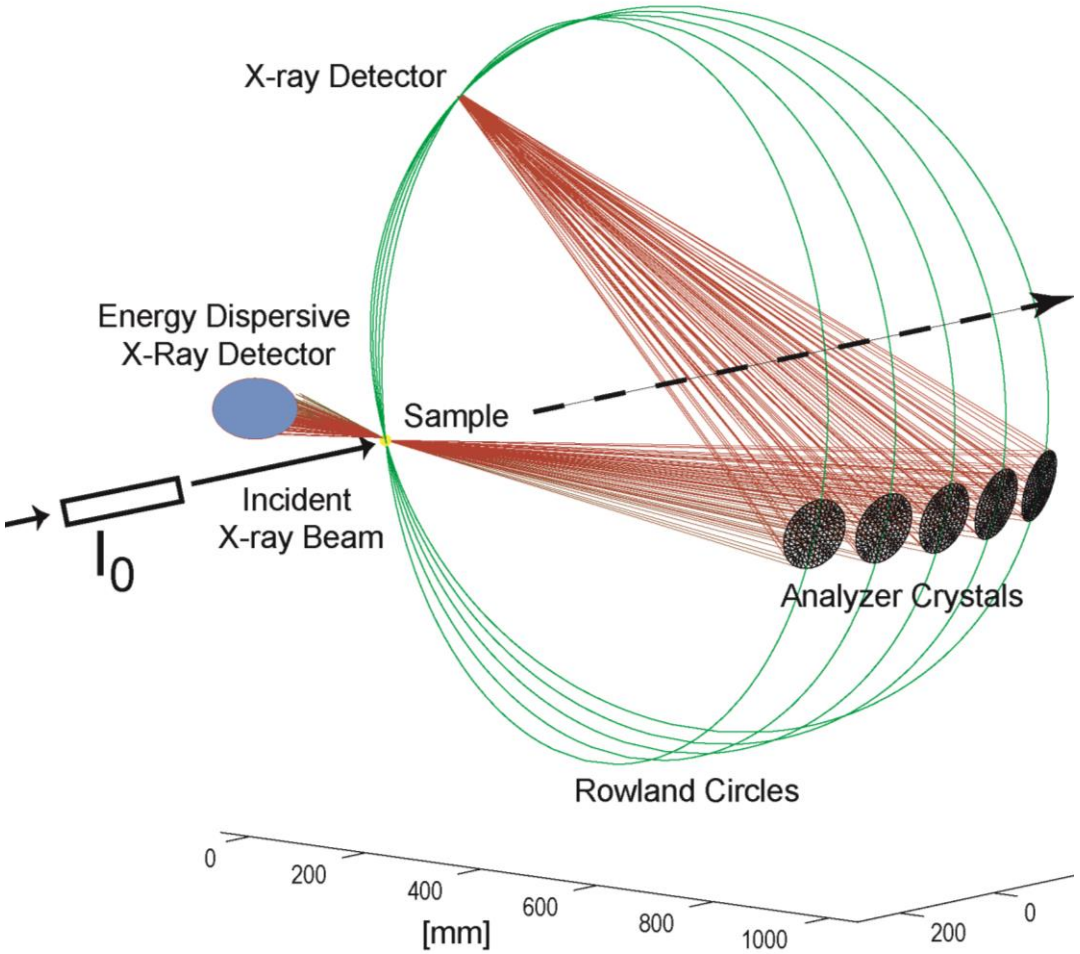
Take map of metal fluorescence response.



Increasing the efficiency

HERFD-XANES in Hg

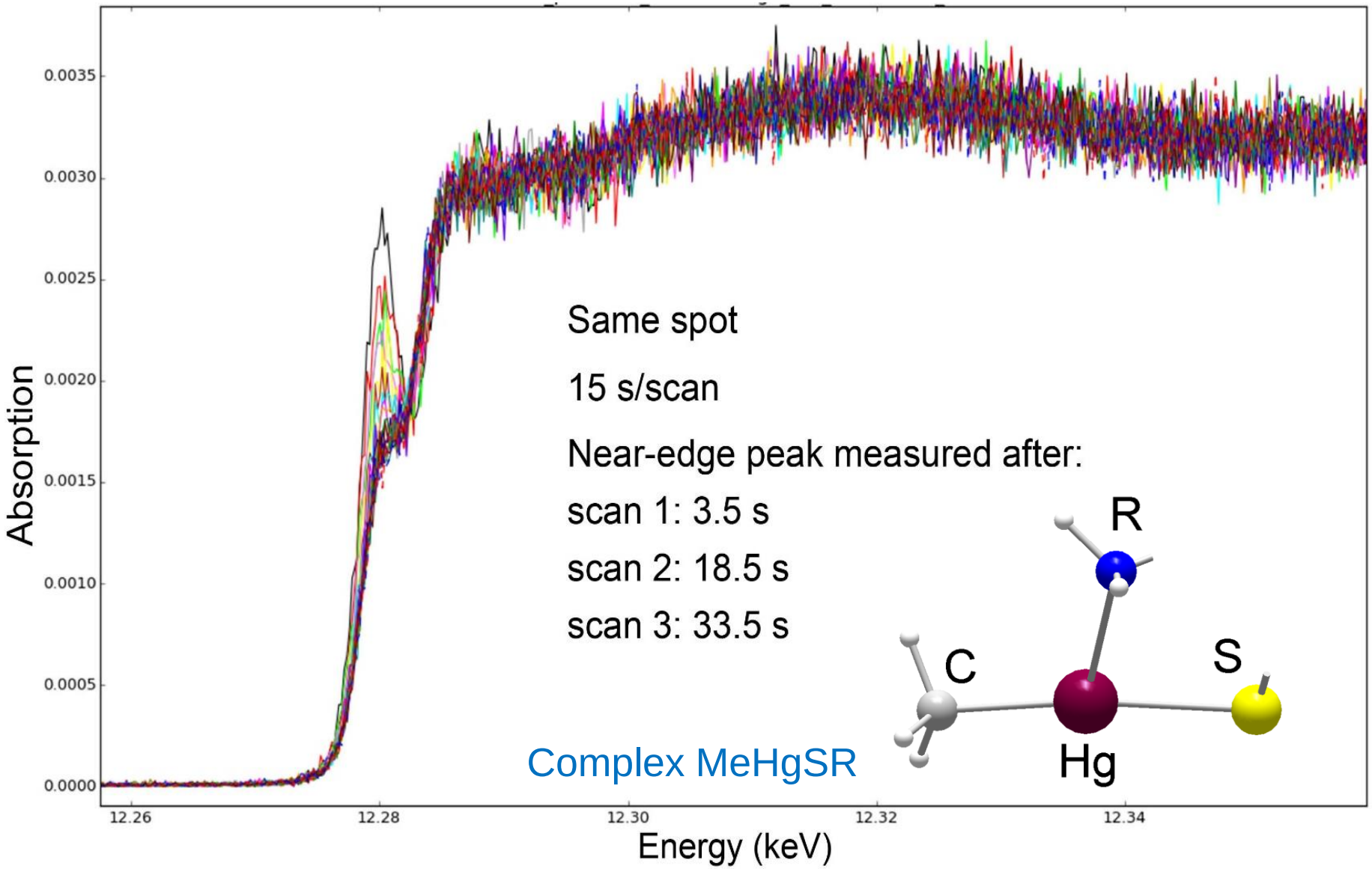




A. Manceau et al., Env. Sci. & Techn (2015)

A. Manceau et al., Inorg. Chem. (2015)

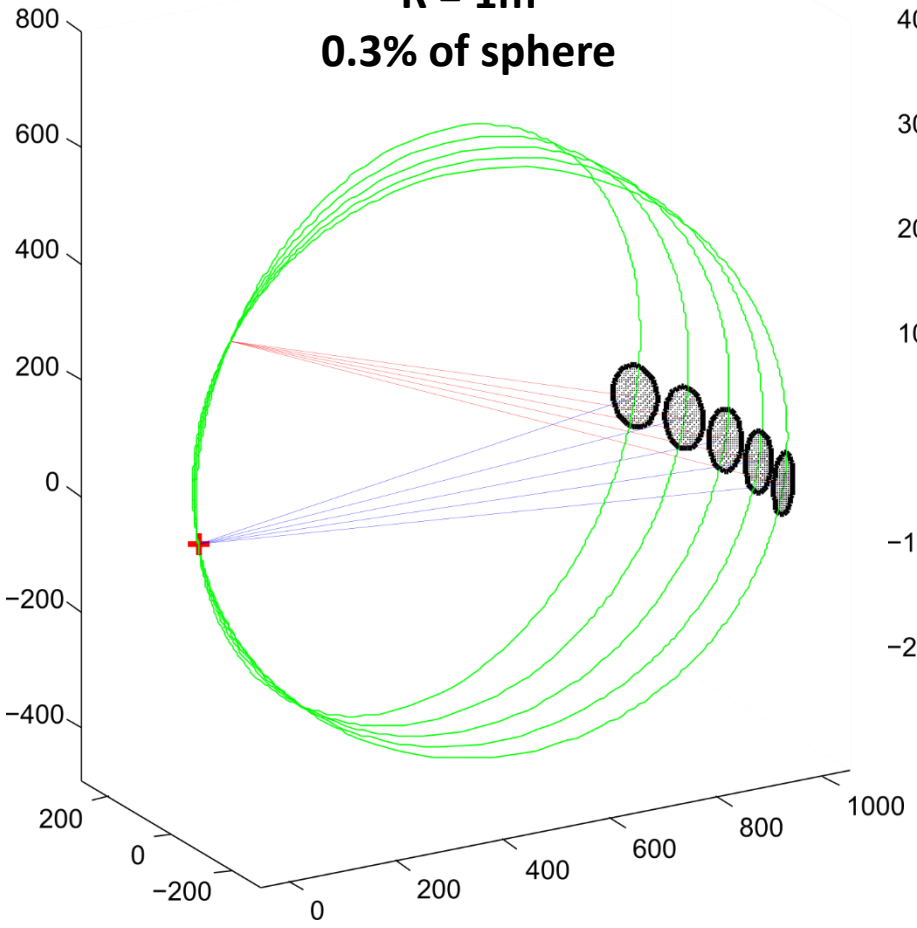
Radiation damage in Hg coordination complex

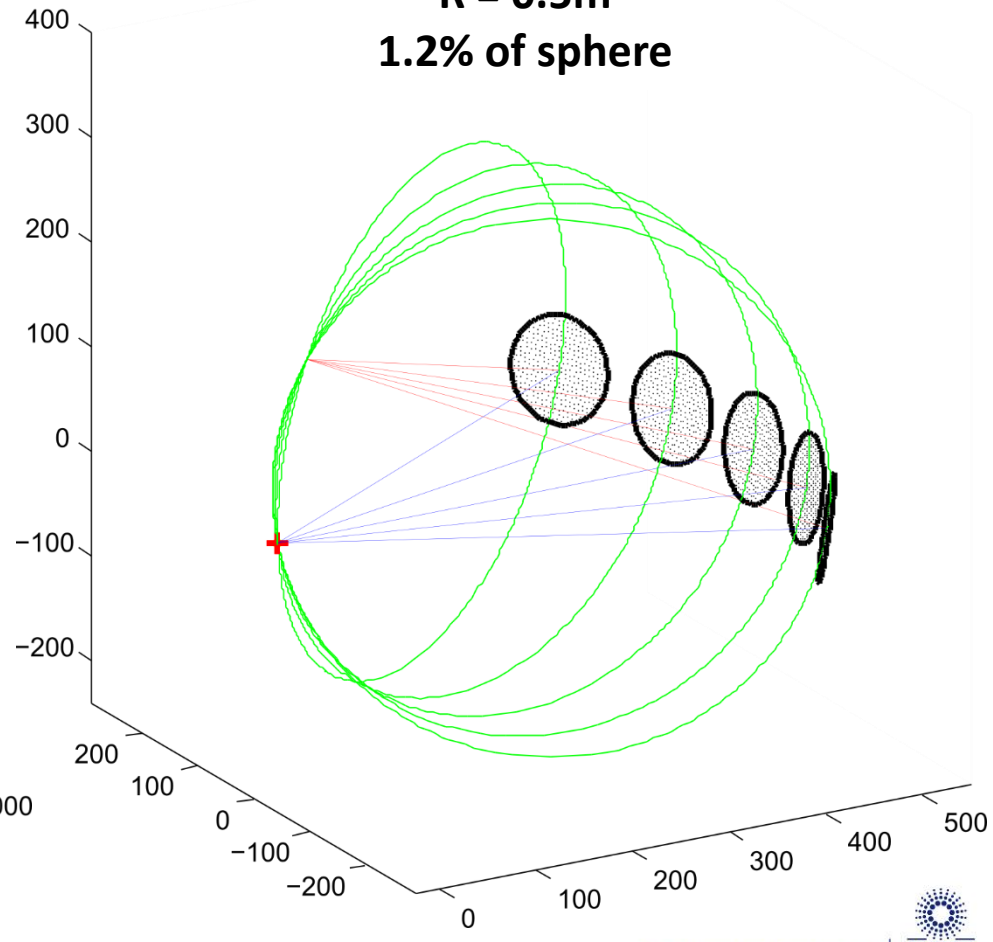


Courtesy A. Manceau

Improving the detection efficiency

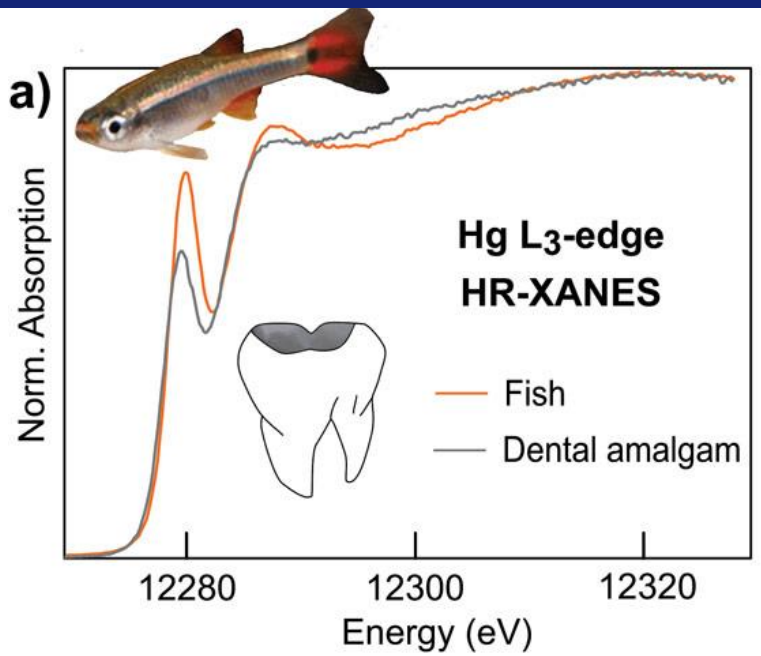
Increase solid angle by reducing the analyzer crystal bending radius.

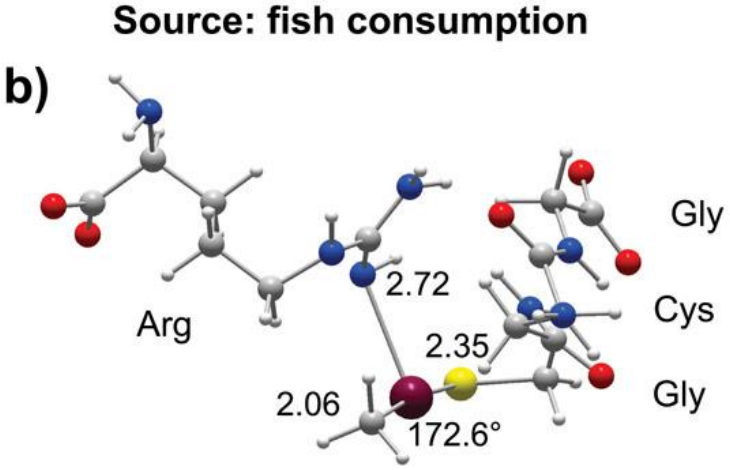


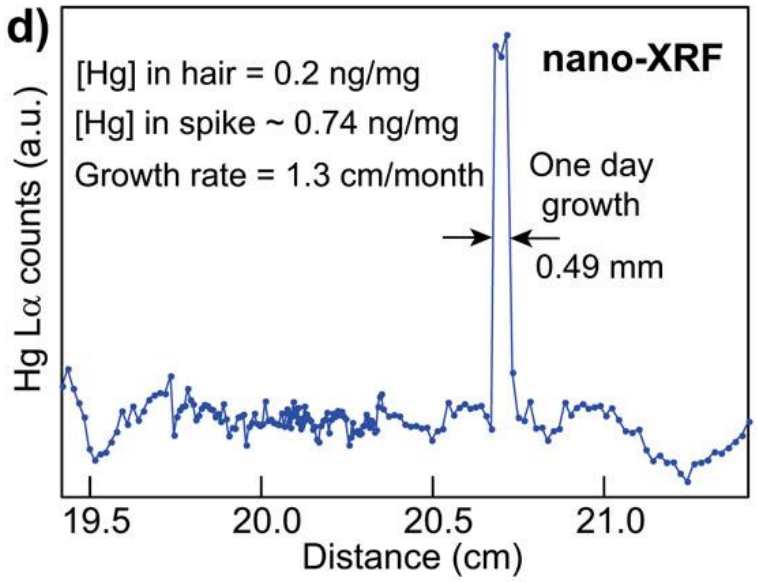


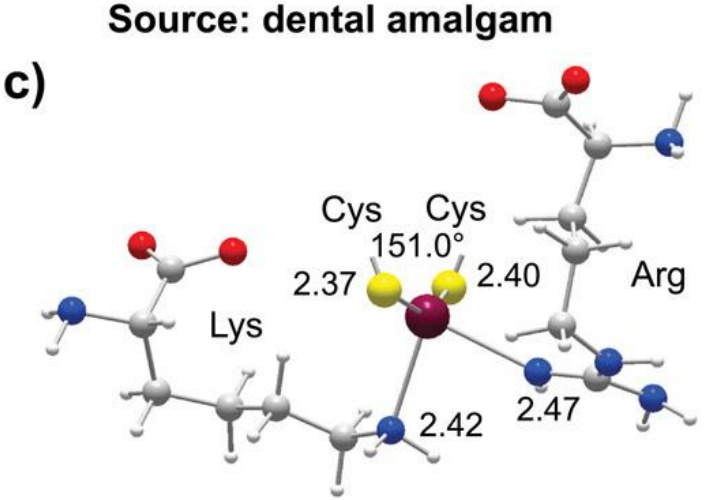
M. Rovezzi, P. Glatzel, R. Verbeni et al. RSI 2017

HERFD-XANES in low concentration: Hg speciation in human hair







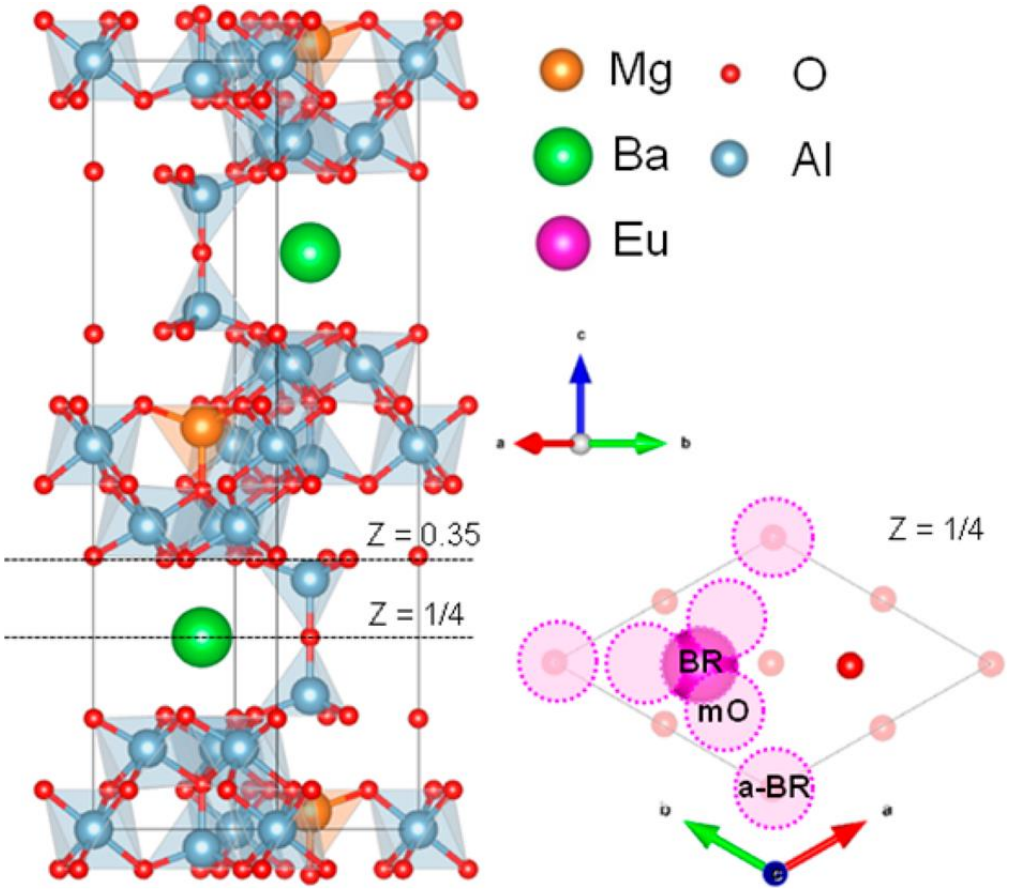


A. Manceau et al., Env. Science Tech. (2016)

Combining techniques

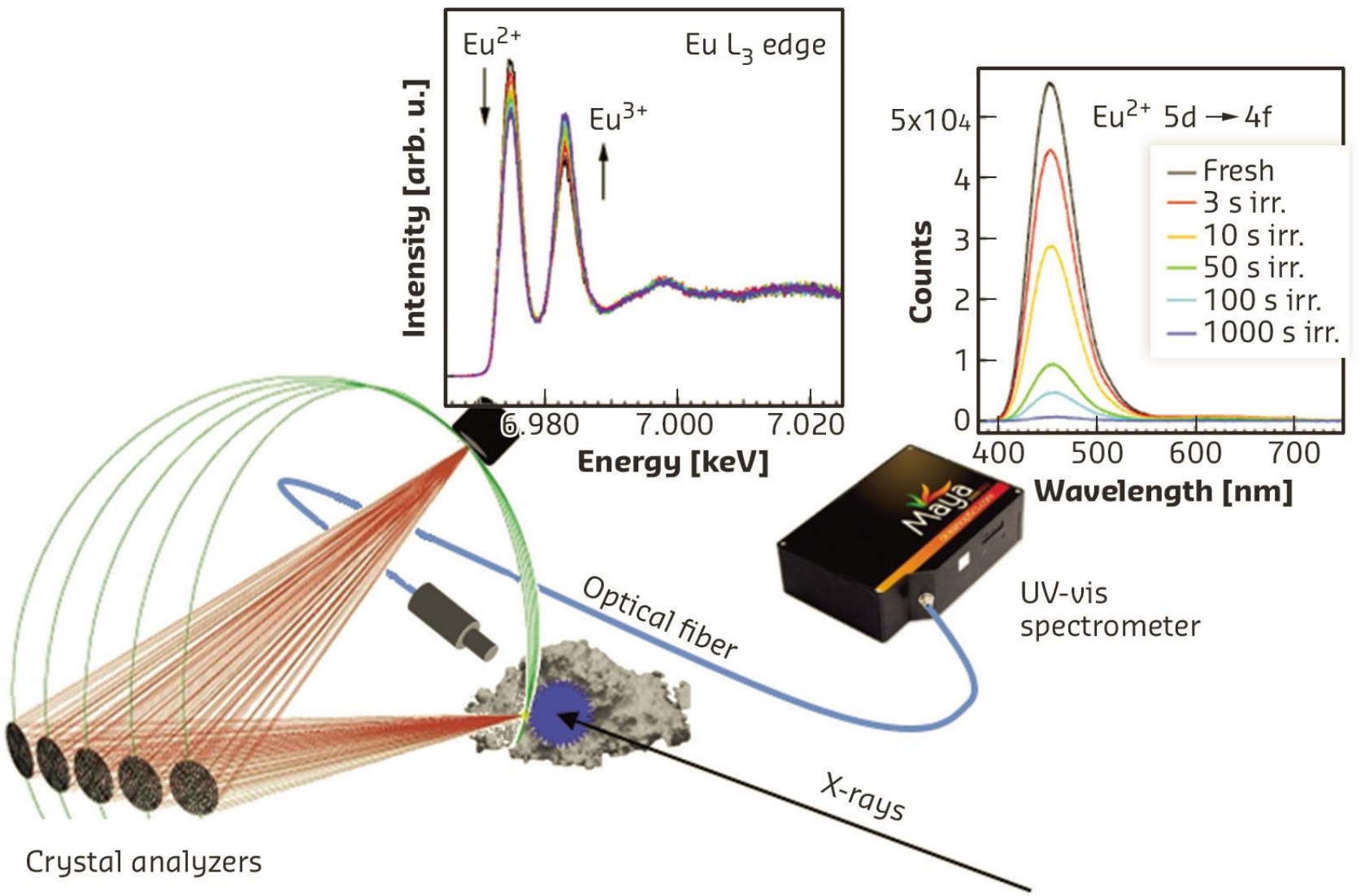
Oxidation and Luminescence Quenching of Europium in Blue Phosphors

$BaMgAl_{10}O_{17}$



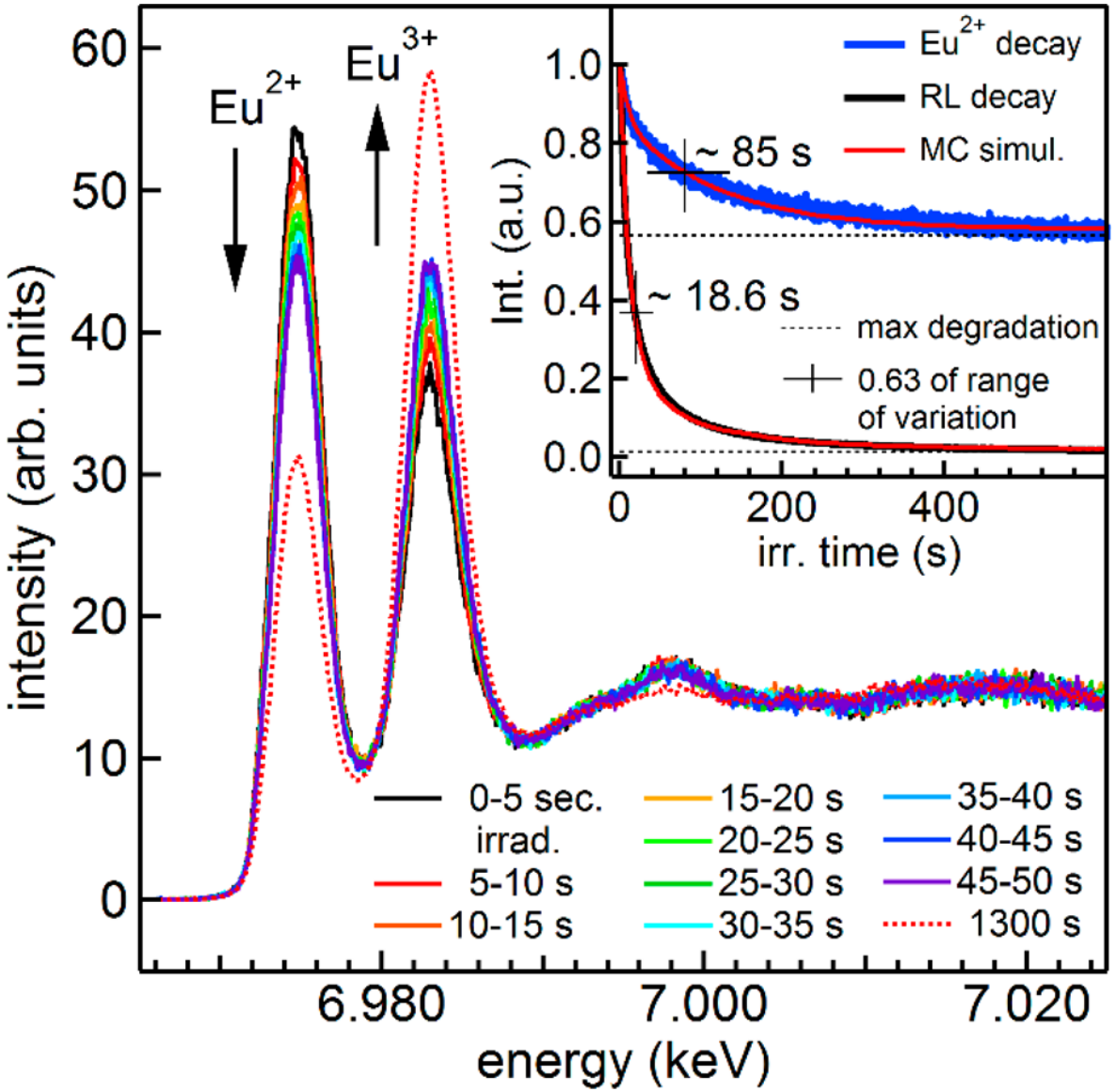
L. Amidani et al., Chem. Mater. 2017, 29, 10122−10129

Combine X-ray with UV-vis probe



L. Amidani et al., Chem. Mater. 2017, 29, 10122−10129

X-rays and luminescence



The luminescence decay is faster and complete.
→ "killer" centres suppress electron transfer

L. Amidani et al., Chem. Mater. 2017, 29, 10122−10129

Thank you.