Single-shot XES and XAS

Jakub Szlachetko & Maarten Nachtegaal

SuperXAS beamline, Paul Scherrer Institut

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Outline

x-ray spectroscopy at SuperXAS,SLS

von Hamos geometry

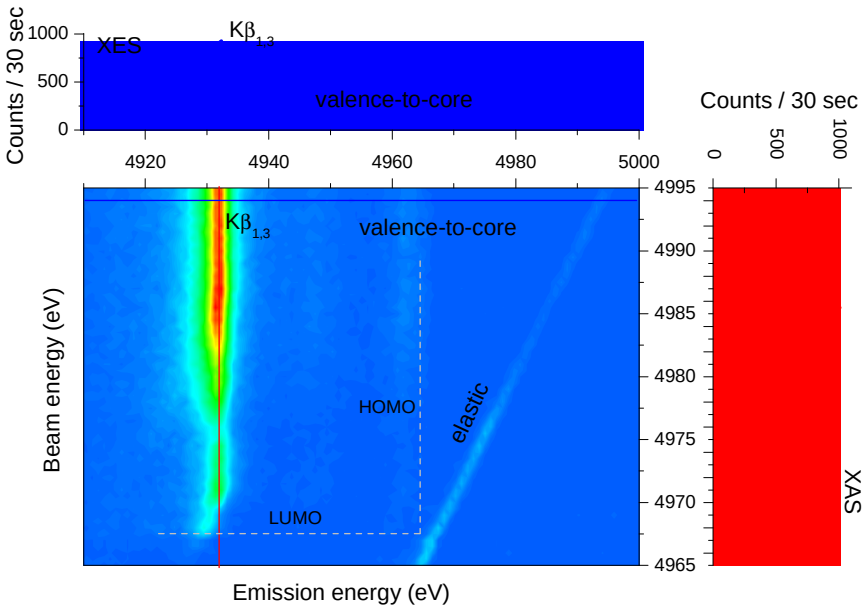
spectrometer performances, multi-segmented crystal arrangment

single-shot XES and XAS at XFEL

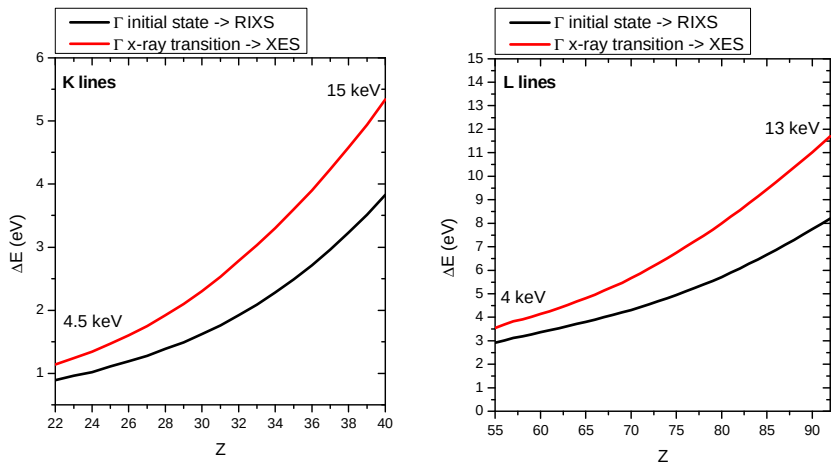
- beam requirements
- feasibility measurements

The von Hamos spectrometer for SuperXAS beamline

Application to resonant inelastic x-ray scattering (RIXS) and x-ray emission spectroscopy (XES)

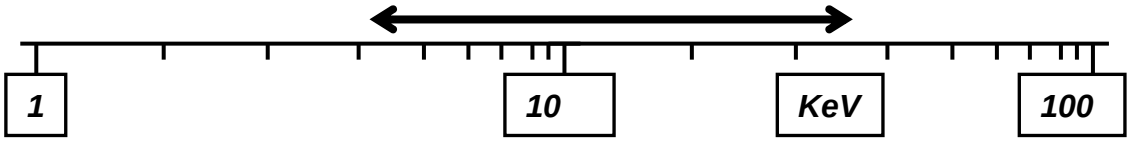


Needed energy resolution



In-situ X-ray absorption & X-ray emission spectroscopy

SuperXAS @ SLS

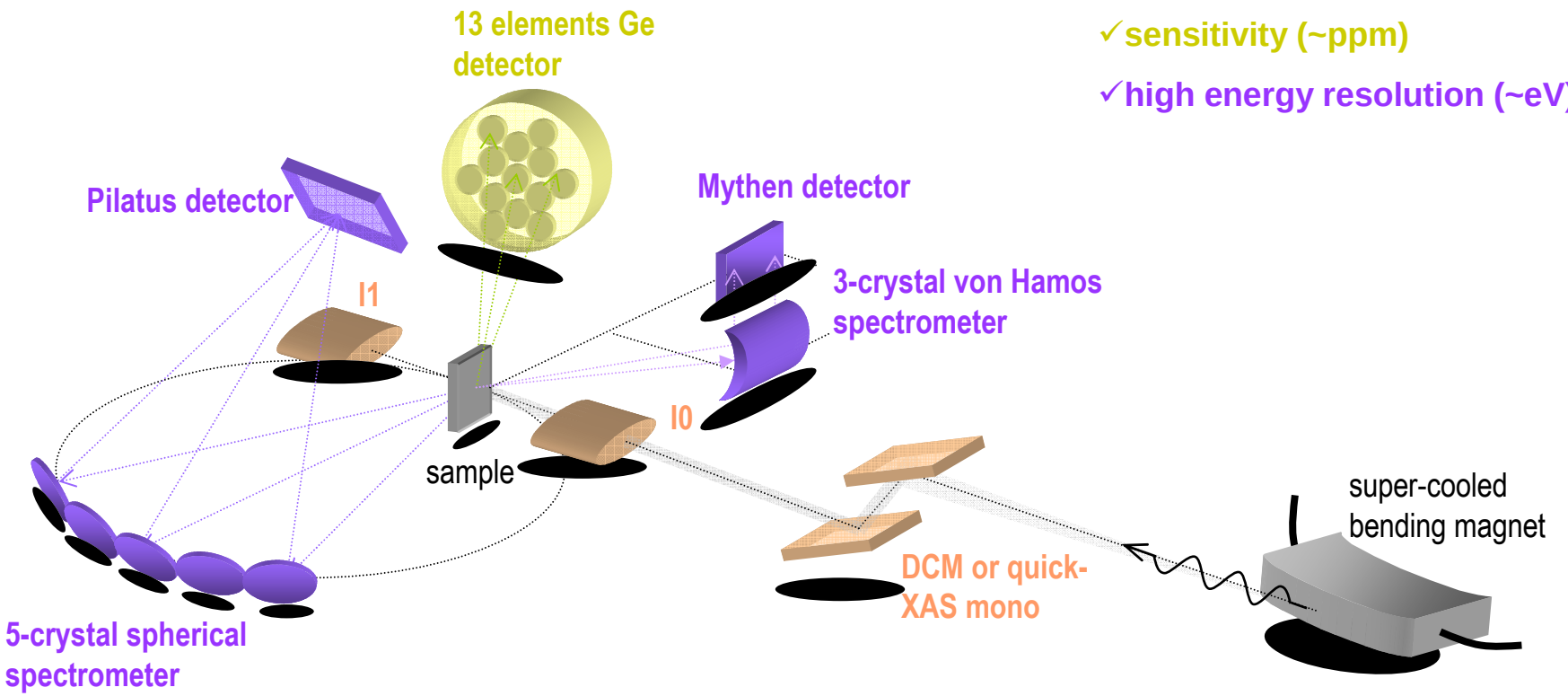


Key points:

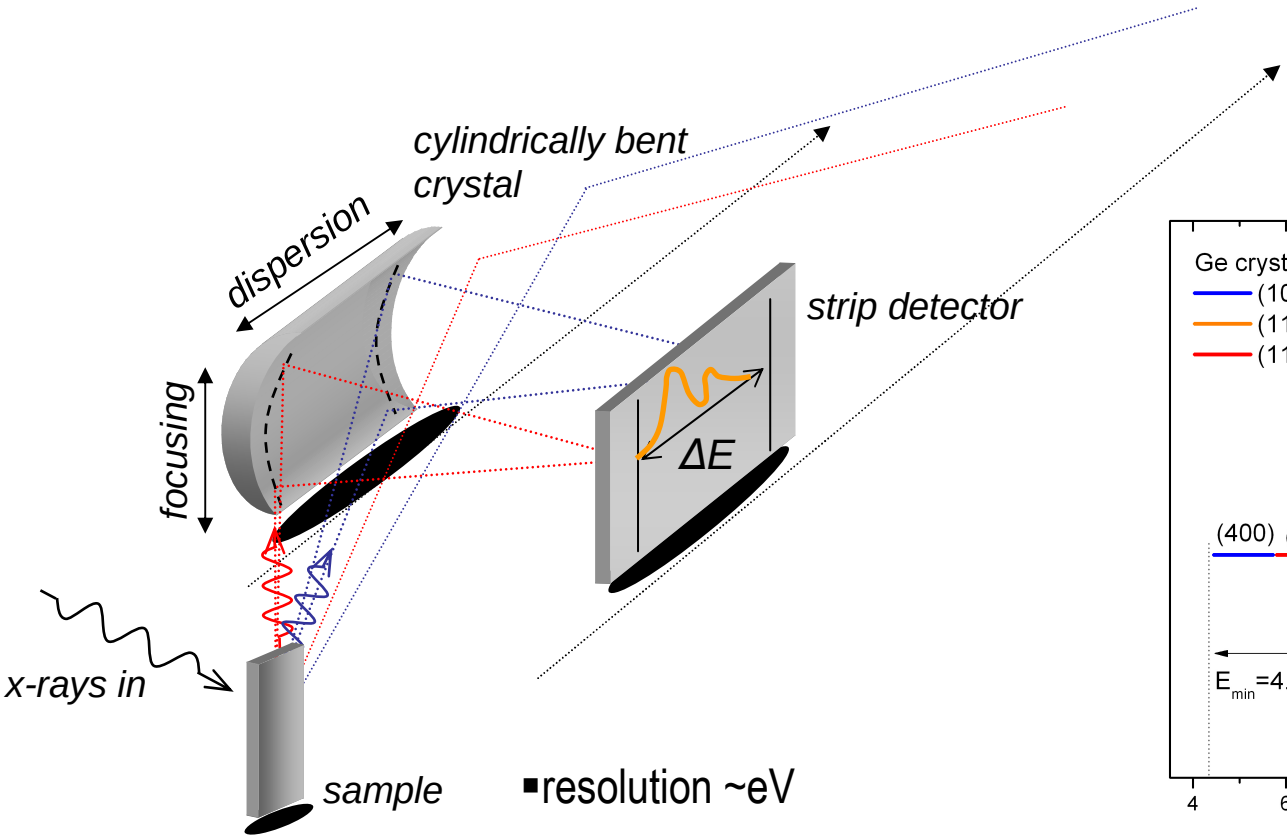
✓time resolution (~msec)

✓sensitivity (~ppm)

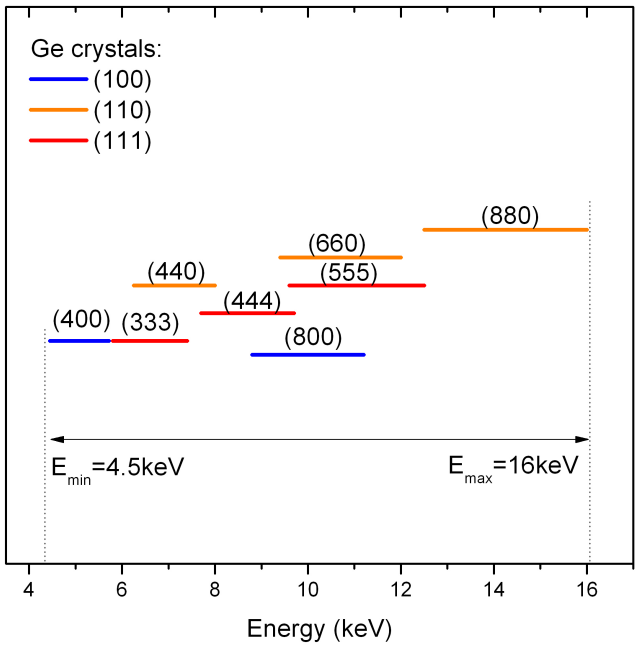
✓high energy resolution (~eV)



The von Hamos geometry



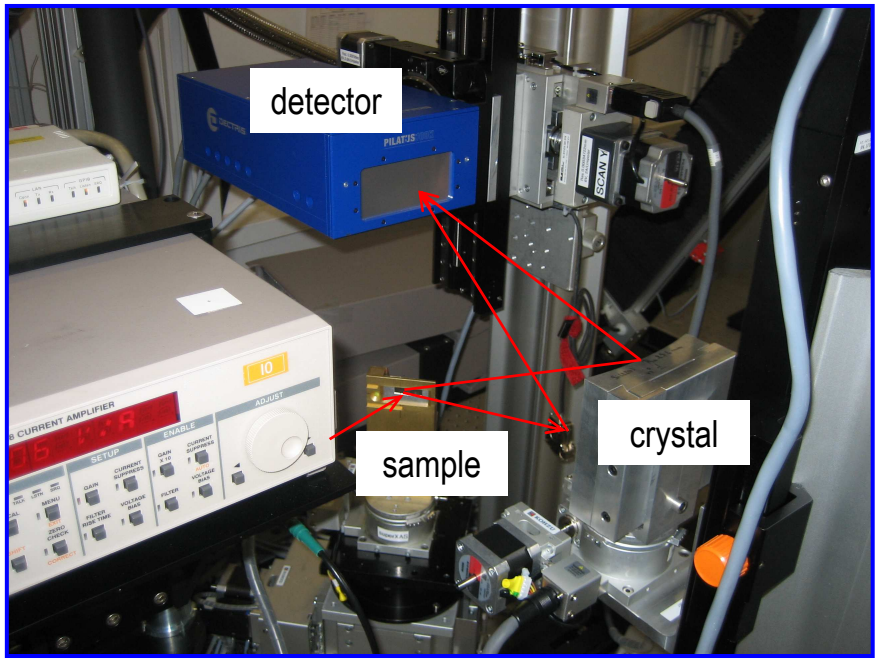
crystals for diffraction



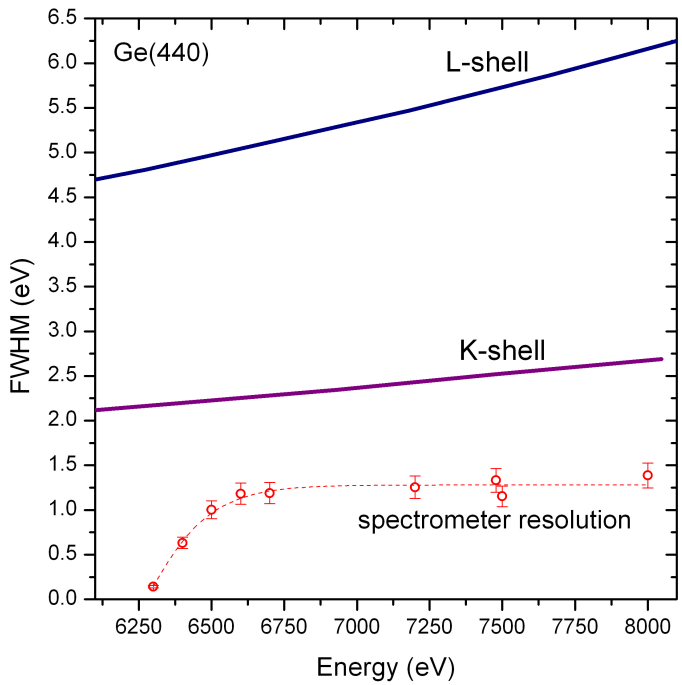
- resolution ~eV
- energy bandwidth for single-shot measurement: 100-500eV
- single-shot capability

The von Hamos spectrometer

Prototype instrument – tests Feb2011

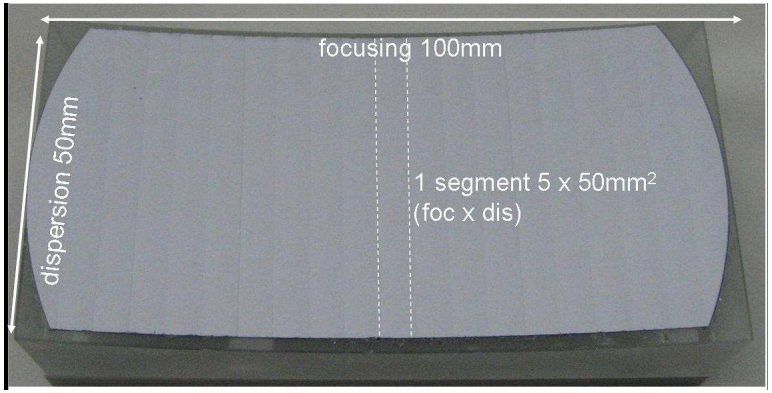


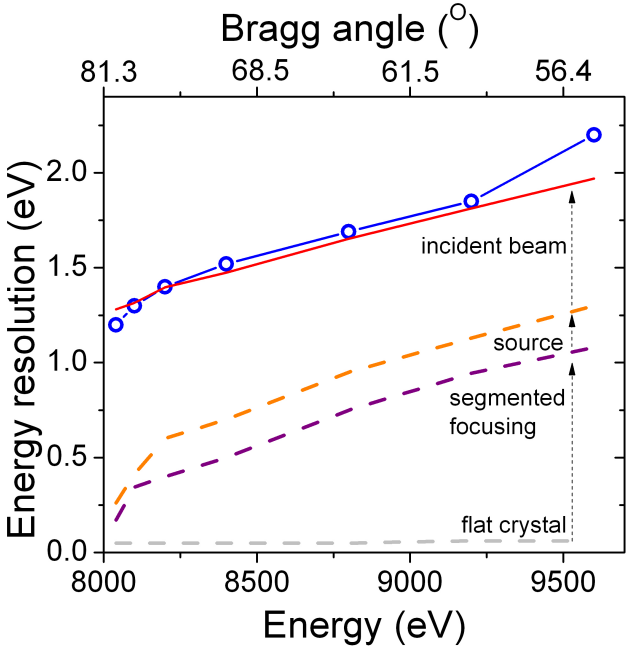
Energy resolution

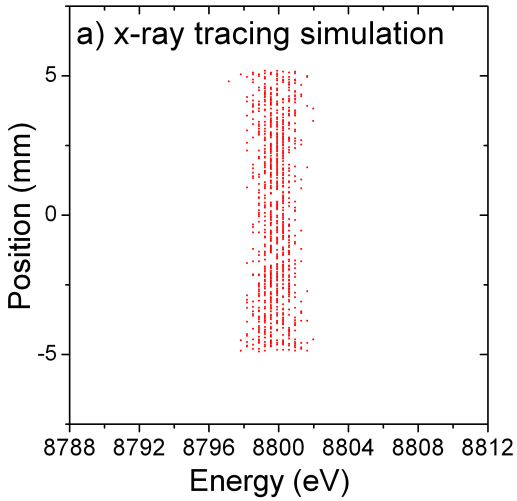


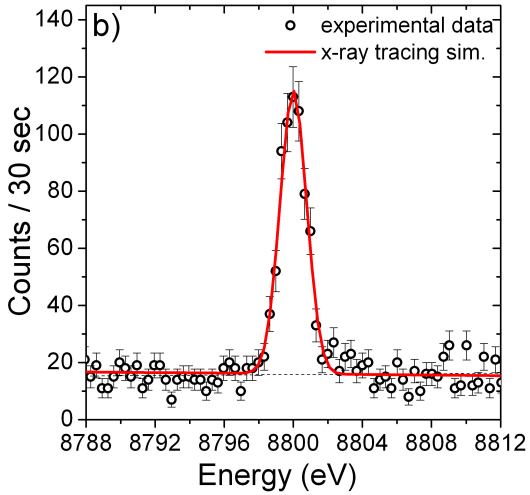
The von Hamos spectrometer

Segmented crystals





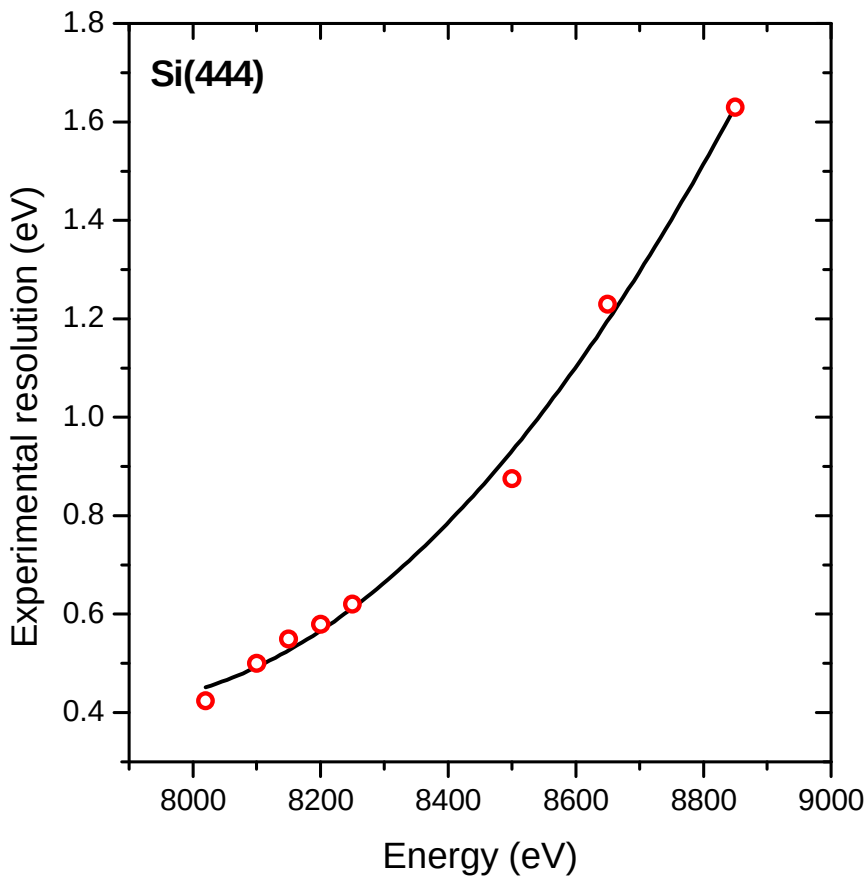




The von Hamos spectrometer

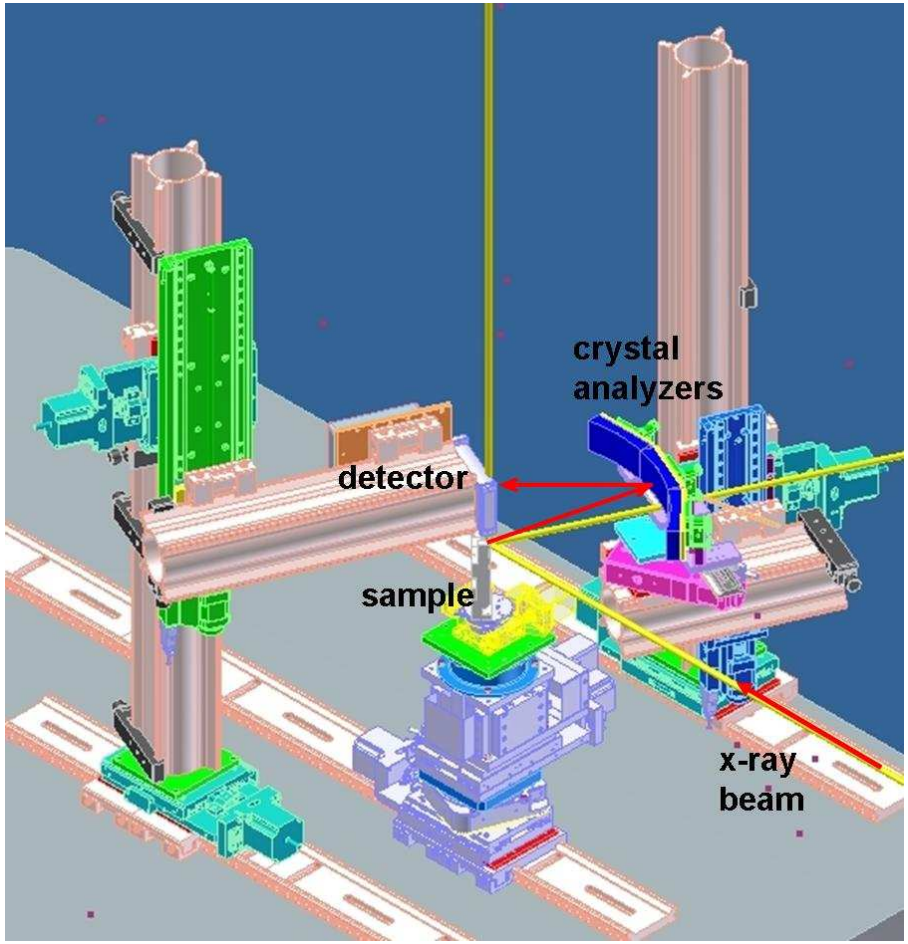
Segmented crystals - latest results

100 segments of 1mm x 50mm size



The von Hamos spectrometer

Multi-crystal arrangement

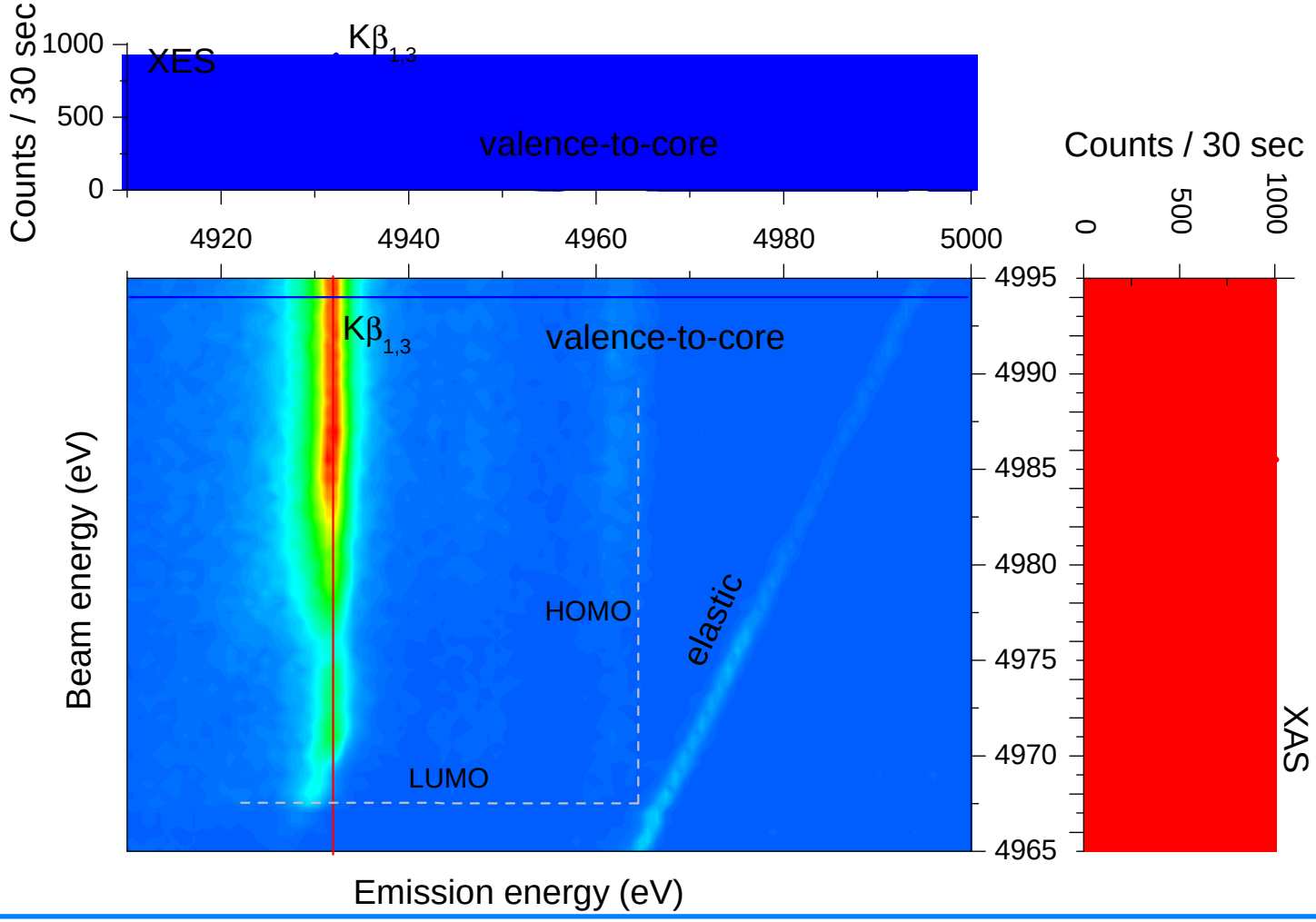


designed by Mathias Graf apprenticeship of Marcus Willimann

- in-air setup
- 3x3 crystals for x-ray diffraction (Ge(100), Ge(110),Ge(111))
- operation range 4.5keV – 15keV
- radius of curvature 25cm
- Bragg range between 80deg and 50deg
- MythenII 1280 x 50um strip detector

Applications

RIXS of valence-to-core transitions on semiconductors



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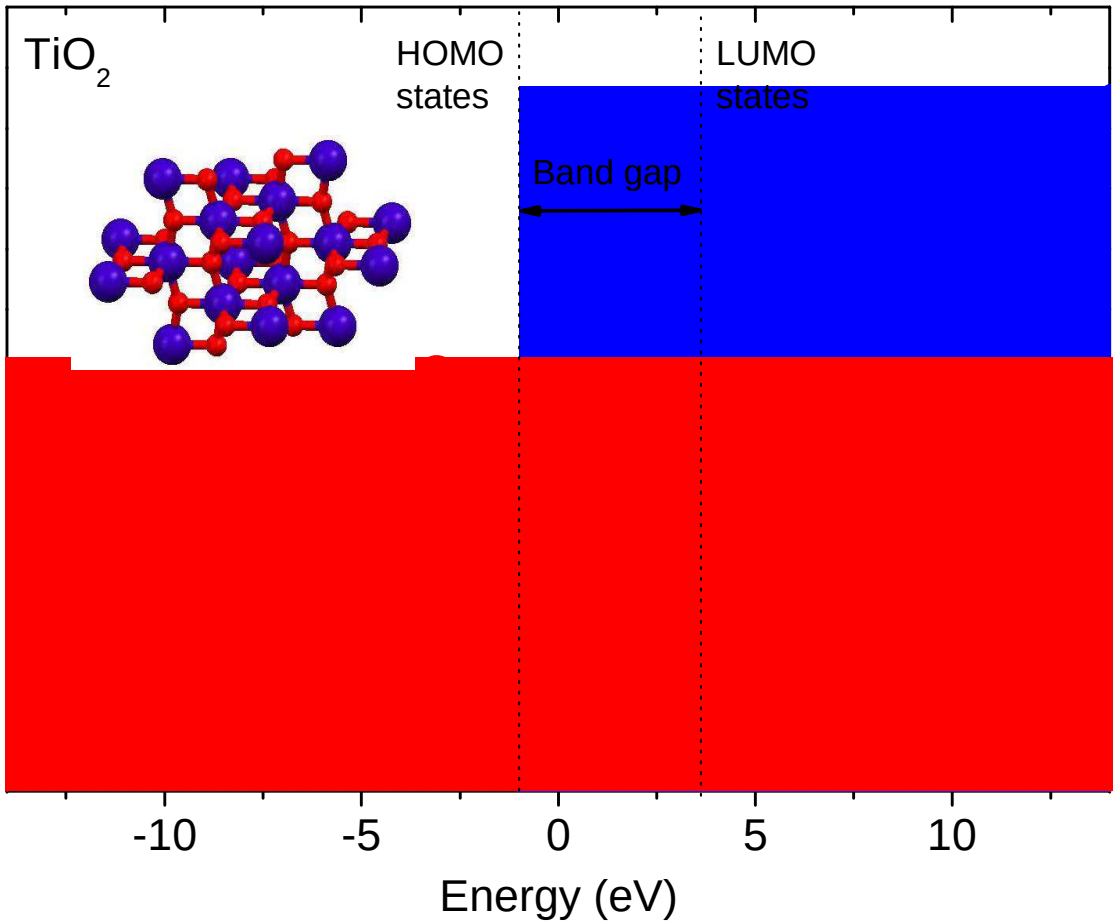
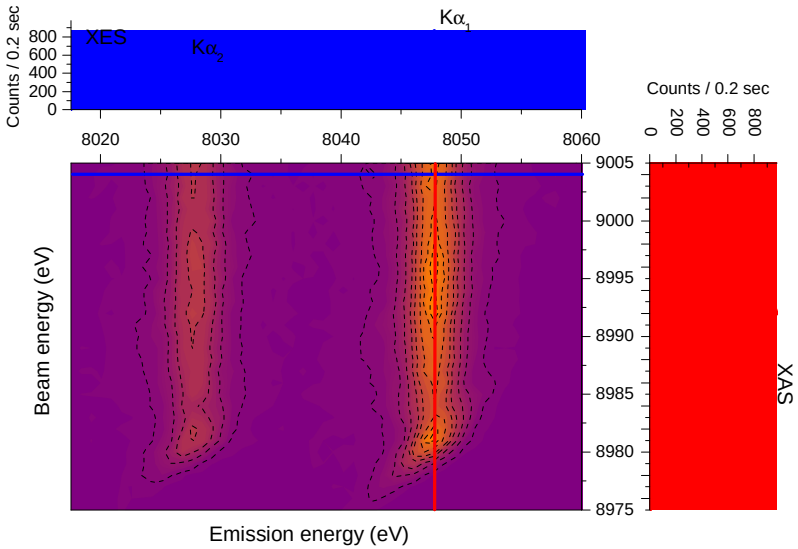


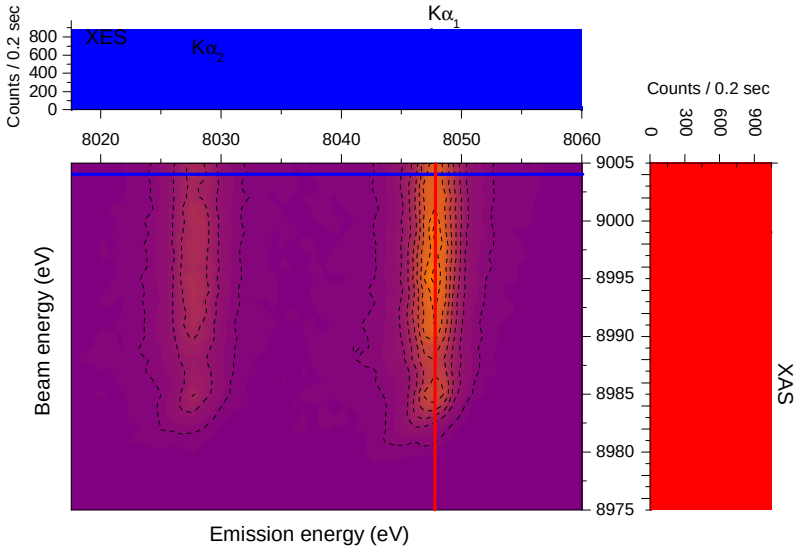
Applications

Quick-RIXS measurements

Cu_2O



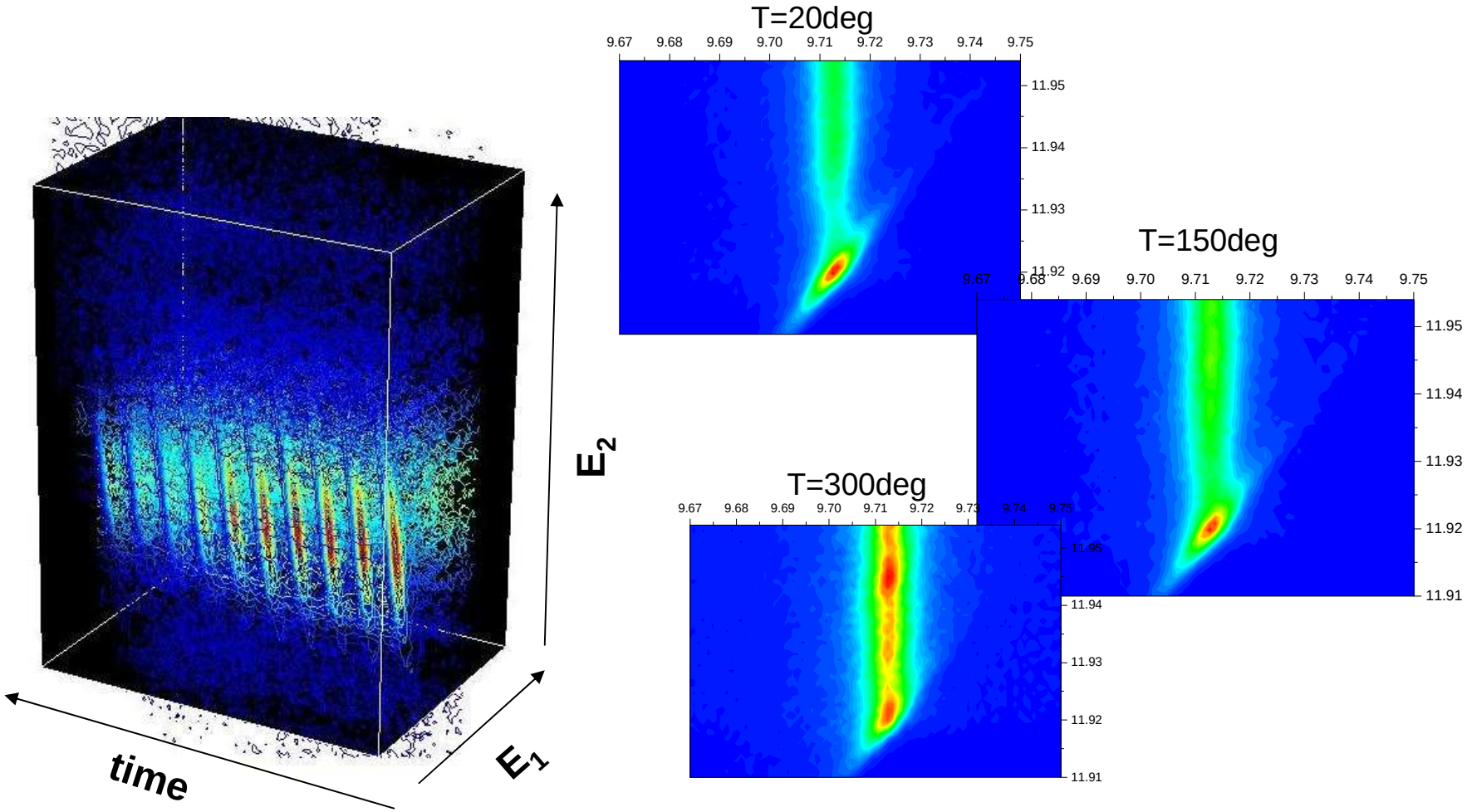
CuO



total acquisition time for full RIXS map ~7sec

Applications

Time-resolved RIXS – TPR of Au



Single shot XES and XAS spectroscopy

X-ray beam requirements:

XES

- no need for monochromaticity (ΔE < few hundreds of eV)
- for far above edge excitations independent on shot-to-shot mean beam energy

high-resolution XAS/RIXS

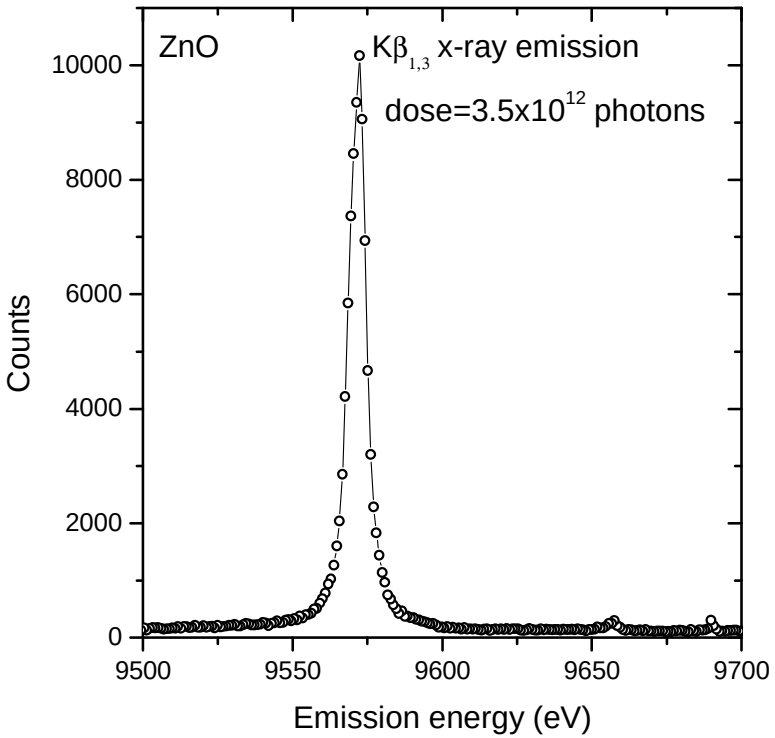
- monochromatic beam requested
- beam energy well controlled over few hundreds eV
- I0 information crucial

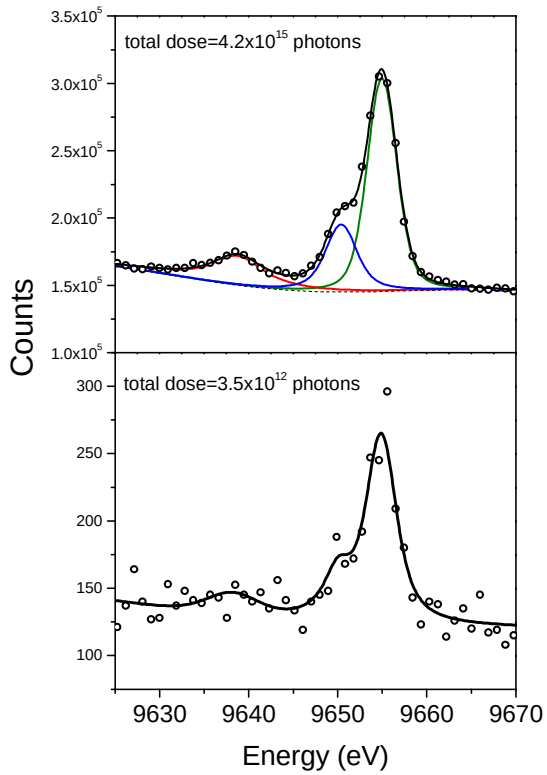
Spectrometer requirements

- beam size < 100um
- beam position stability <50um
- spatial resolution for detector<=50um, expected rates ~ max few hundreds/shot/strip

Single shot XES

Electronic structure of ZnO

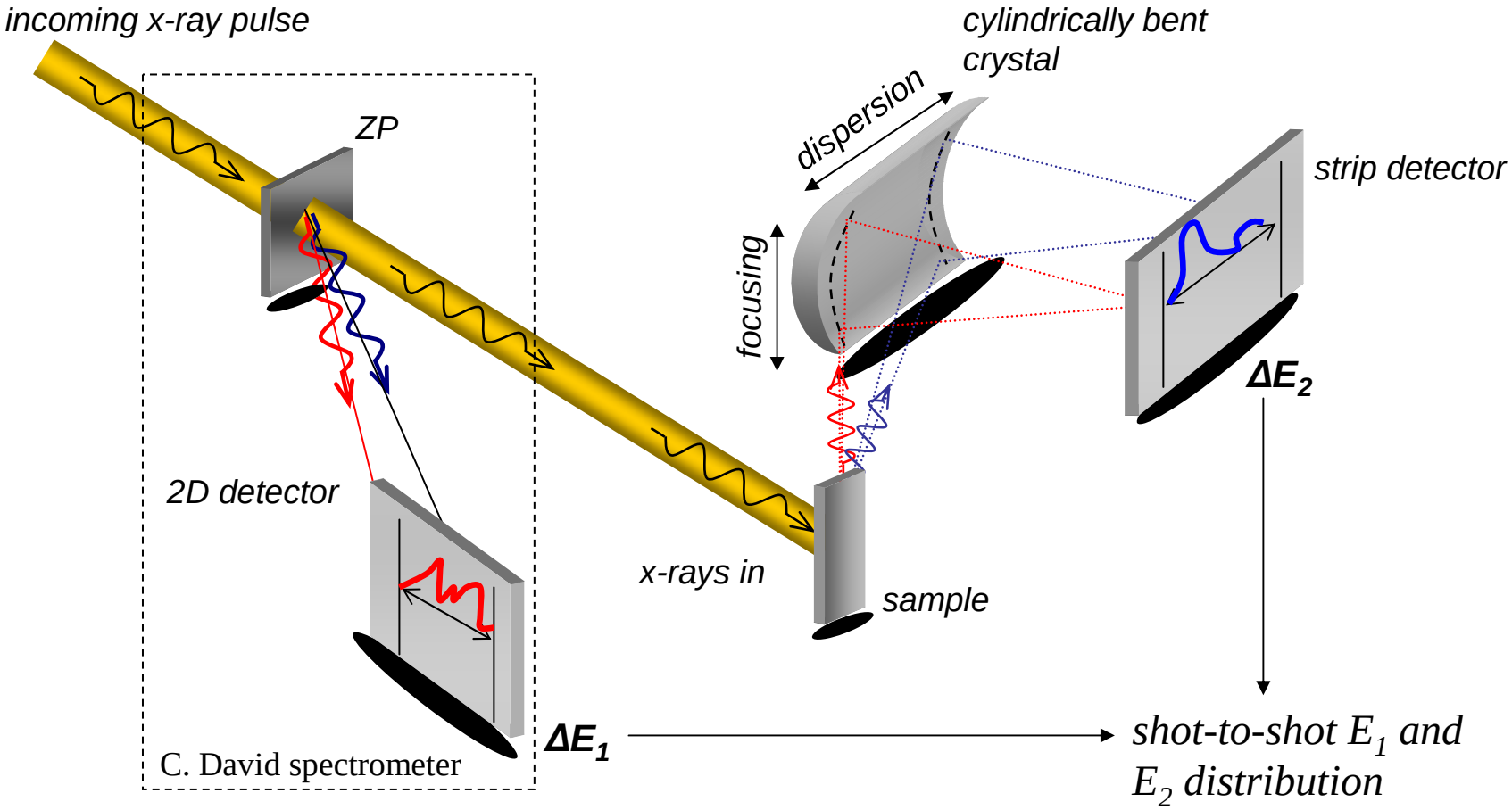




occupied electronic states in single-shot

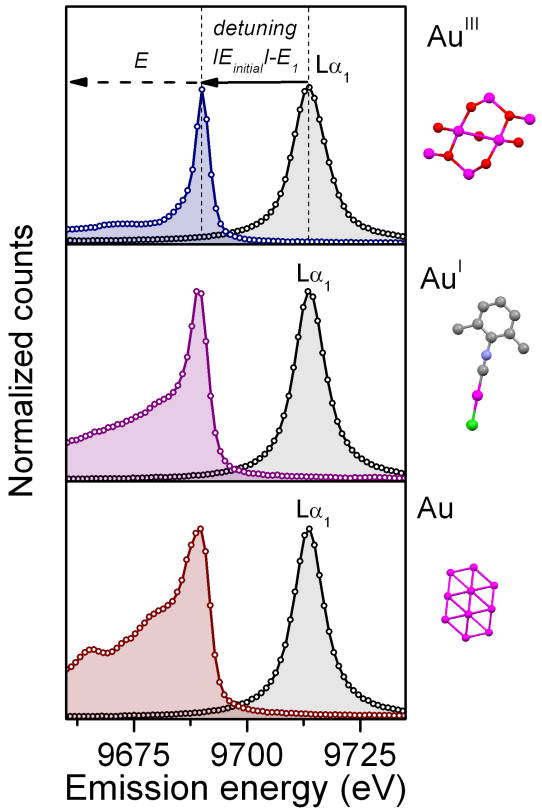
Single shot XAS

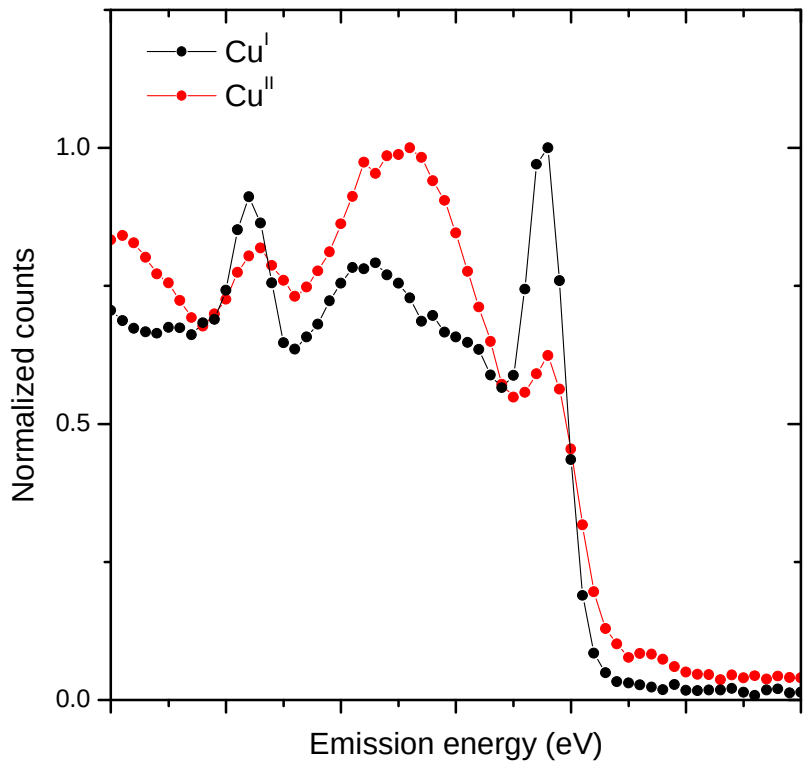
Experimental configuration



Single shot XAS

Off-resonant excitations





unoccupied electronic states in single-shot

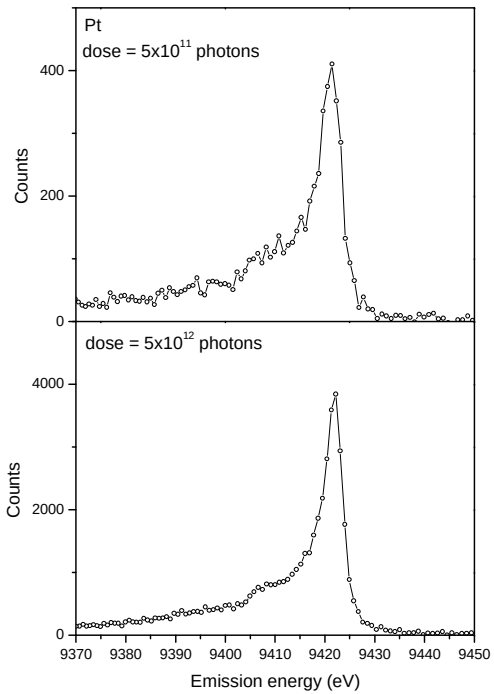
Single shot XAS

Off-resonant excitations

Exp resolution ~ ΔE_1

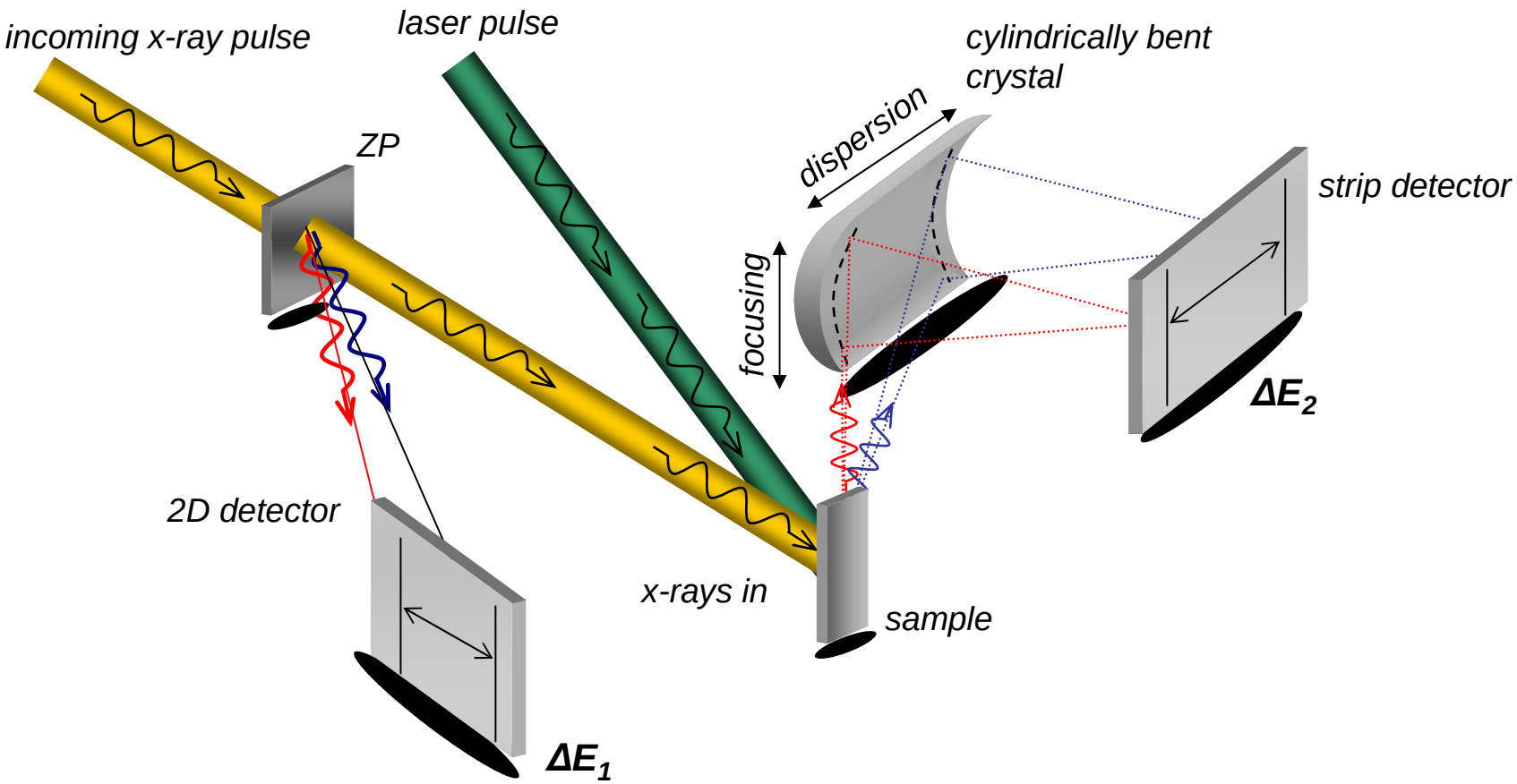
if ΔE_1 >>1-3 eV→ deconvolution on I_0 necessery

Feasibility :



Single shot XES and XAS in pump-probe scheme

Experimental configuration



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Thank you for your attention