SWISS LIGHT SOURCE SLS

PAUL SCHERRER INSTITUT

A users viewpoint: absorption spectroscopy at a synchrotron

Frithjof Nolting

Magnetic data storage and recording

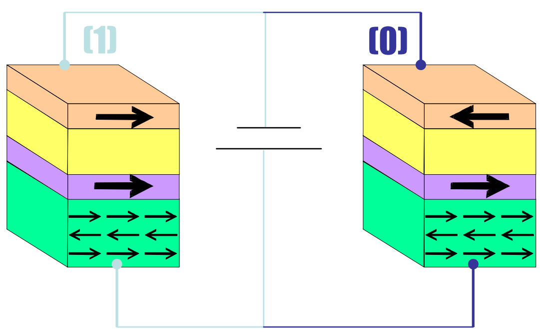
SWISS LIGHT SOURCE SLS

GMR Element

Ferromagnet

Ferromagnet

Antiferromagnet



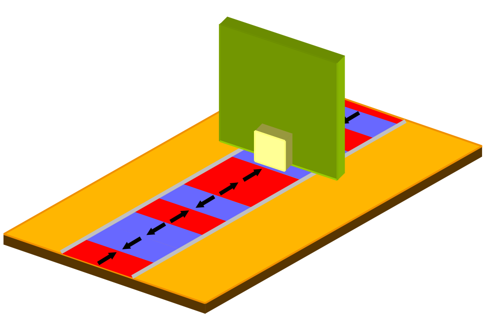
Top layer "free" can be switched

Bottom layer "pinned"
Hard layer or Exchange coupling

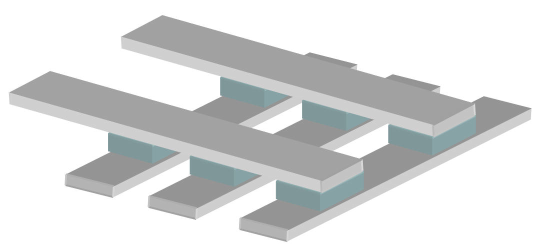
Low resistance

high resistance

Hard disk head



MRAM

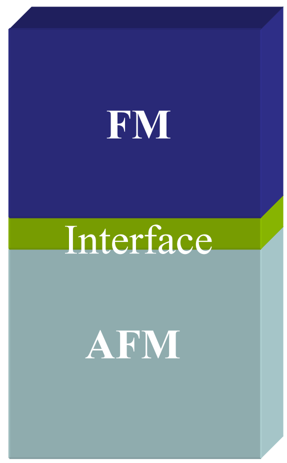


How?

- Different models for AFM/FM coupling exist.

- Different assumptions on AFM structure lead to complete different results.

- Spin arrangement at the interface is important

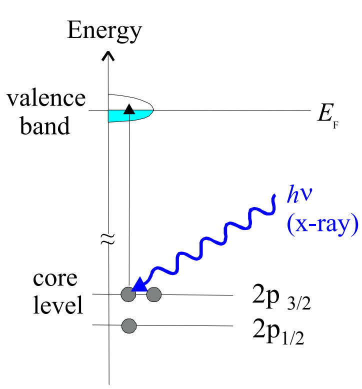


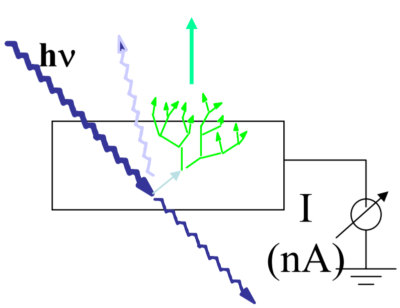
- **High Spatial Resolution**
- **Elemental Sensitivity**
- **Ferromagnetic Contrast**
- **Antiferromagnetic Contrast**
- **Surface/Interface Sensitivity**

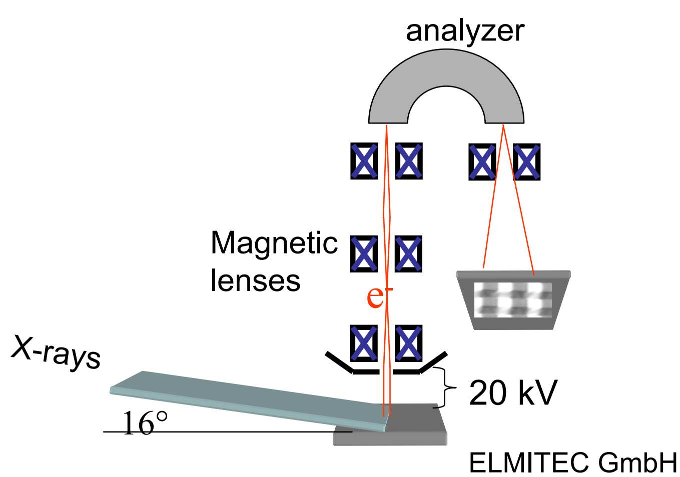
X-ray absorption spectroscopy (XAS) with spatial resolution

Photoemission Electron Microscope (PEEM)

Photoemission Electron Microscope



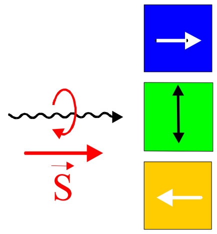


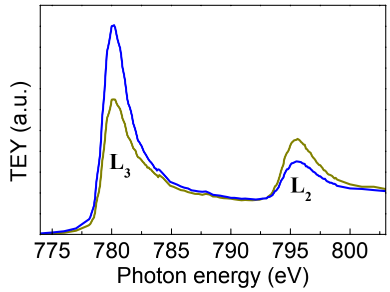


Sensitive to:
- elemental composition
- chemistry
- structural parameters
- electronic structure
- magnetic properties

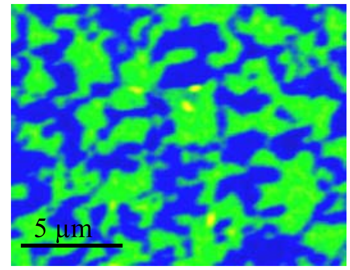
Magnetic microscopy

XMCD (**X**-ray **M**agnetic **C**ircular **D**ichroism)

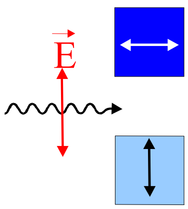


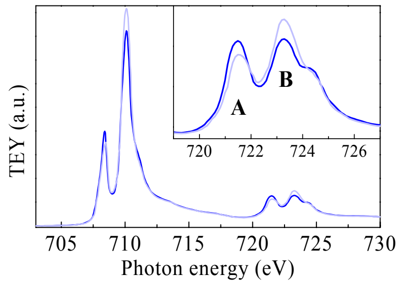


Co

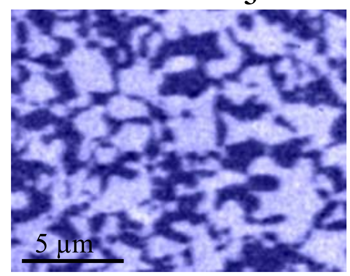


XMLD (**X**-ray **M**agnetic **L**inear **D**ichroism)



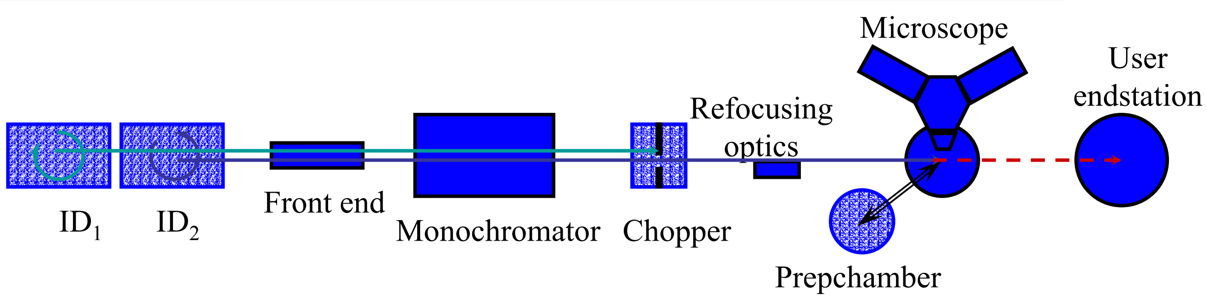


$LaFeO_3$



J. Stöhr et al. Science 1993   A. Scholl *et al.* Science 2000   F. Nolting *et al.* Nature 2000

SIM Beamline Layout



Undulator

T. Schmidt

- **2 Elliptical undulators**
- Pure permanent magnet
- **95eV < hν < 2000eV**
- $>10^{19}$ photons/s/mrad²/mm²/400mA
- 100 % circular polarization [125 - 900 eV] reduced on higher harmonics
- Hor. & vert. linear polar.

Optics

U. Flechsig

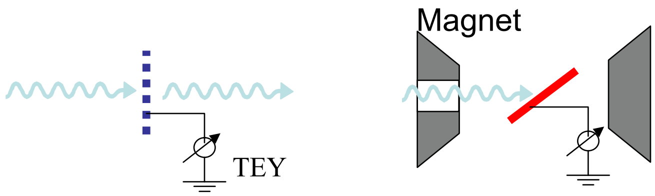
- Plane grating monochromator
- E/ΔE > 8000
- <5% 2nd order light
- **Switch helicity**
- Focus 30x100µm²

Endstation

C. Quitmann & F. Nolting

- SLS endstation:
  - **PEEM & LEEM**
    Δx~25 - 50nm spatial
    ΔE~150meV energy
  - Sample Prep chamber
  - **User endstation**

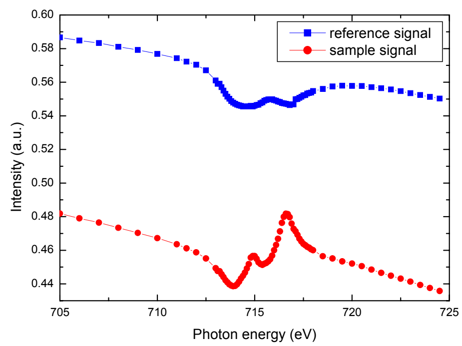
How do we measure

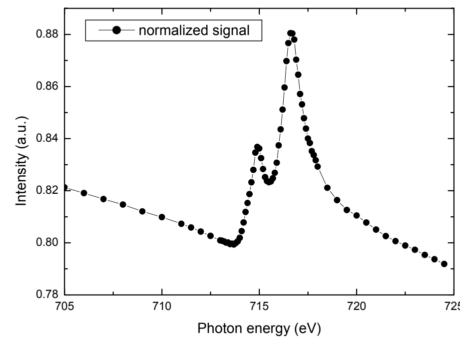


Reference signal

Sample signal

$$\frac{\color{blue}{\text{Sample}}}{\color{red}{\text{Reference}}} = \text{Norm}$$

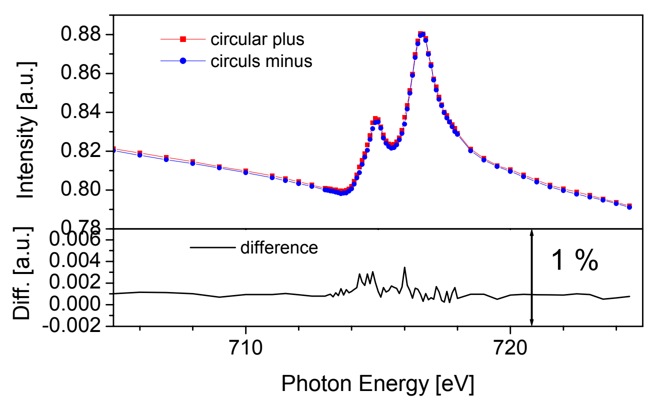




Moving gap and monochromator, stop, measure (1s – 1minute), moving …

How do we measure

- Change polarization and repeat
- Take difference of spectra



Absorption spectrum requires frequent moving of gap and shift

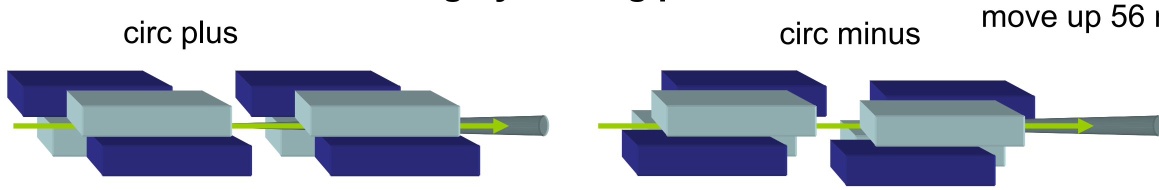
must not effect other beamlines

transparent!

Modes for switching the polarization

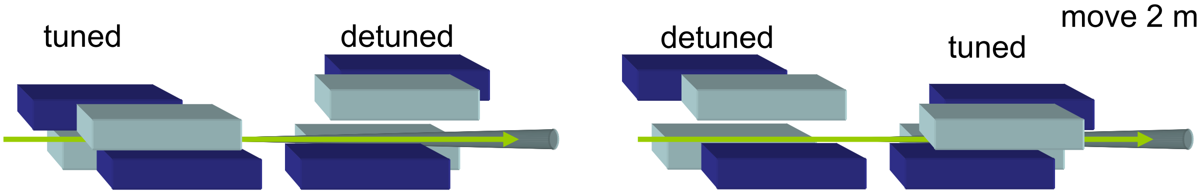
switching by moving phase

120 s
move up 56 mm



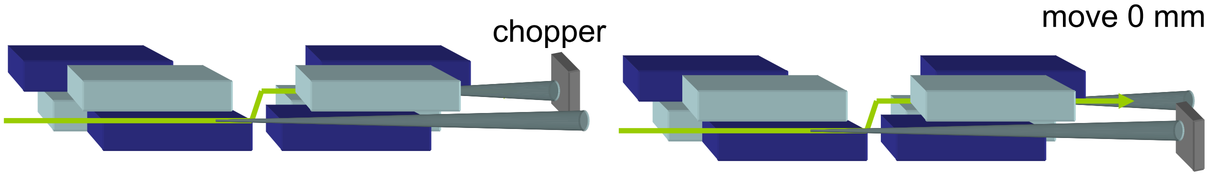
switching by moving the gap

1s - 8 s
move 2 mm



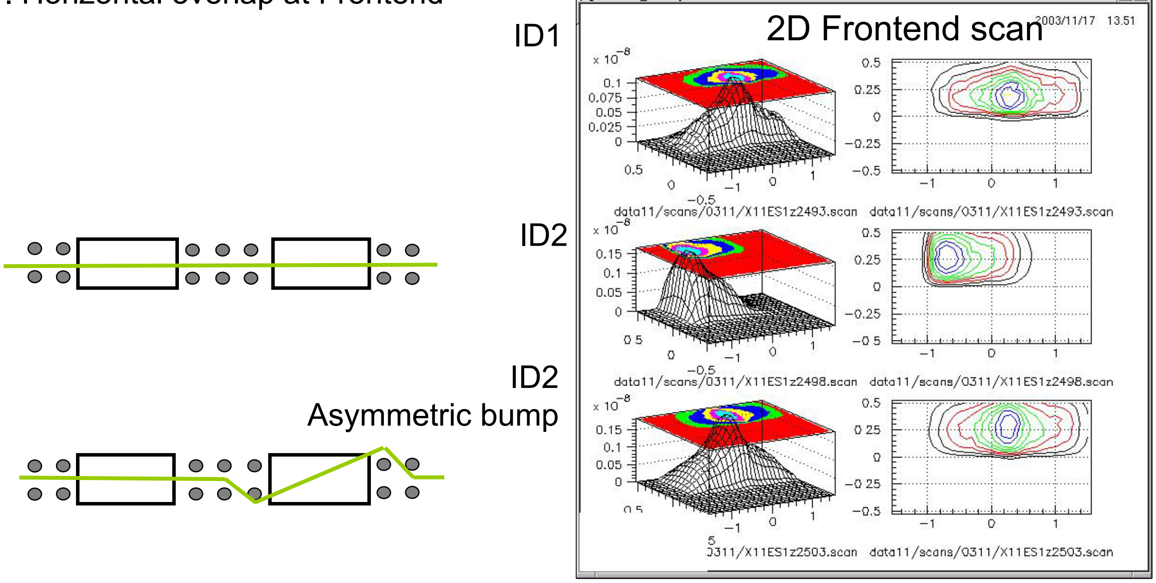
switching by using a chopper

100 Hz
move 0 mm

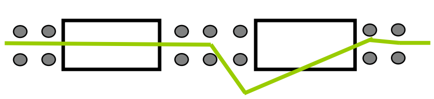


Alignment of IDs - Horizontal

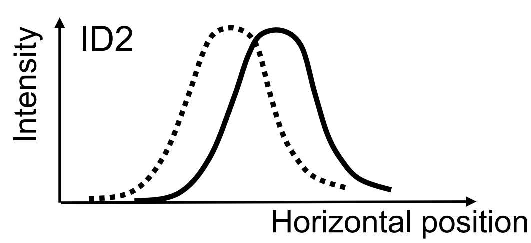
1. Horizontal overlap at Frontend



2. Horizontal overlap at focus of experiment

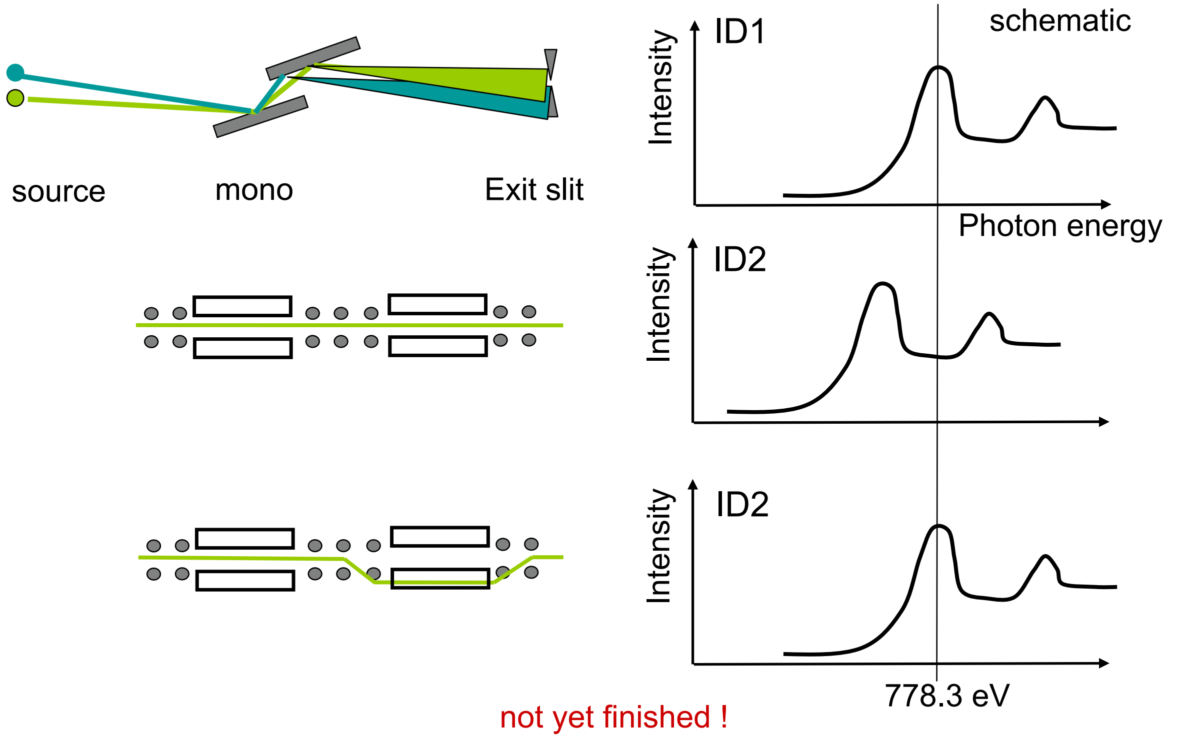


Closed bump using chicane magnets



Alignment of IDs - Vertical

3. Vertical (energy) overlap at focus of experiment



Beam variation - Noise

horizontal movement → intensity variation

XAS normalization reduces it by a factor of 10-100

PEEM no normalization

days	no problem
hours	no problem
sec - minutes	bad
mili seconds	ok

10 µm about 2%

vertical movement → energy variation

no normalization!

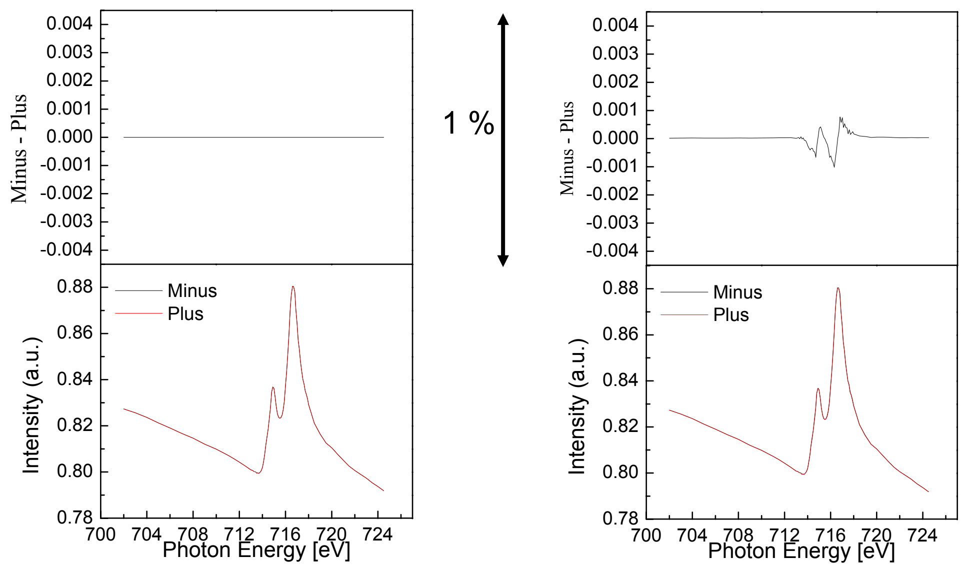
days	no problem
hours	bad
seconds	bad
mili seconds	ok

10 µm about 10 meV

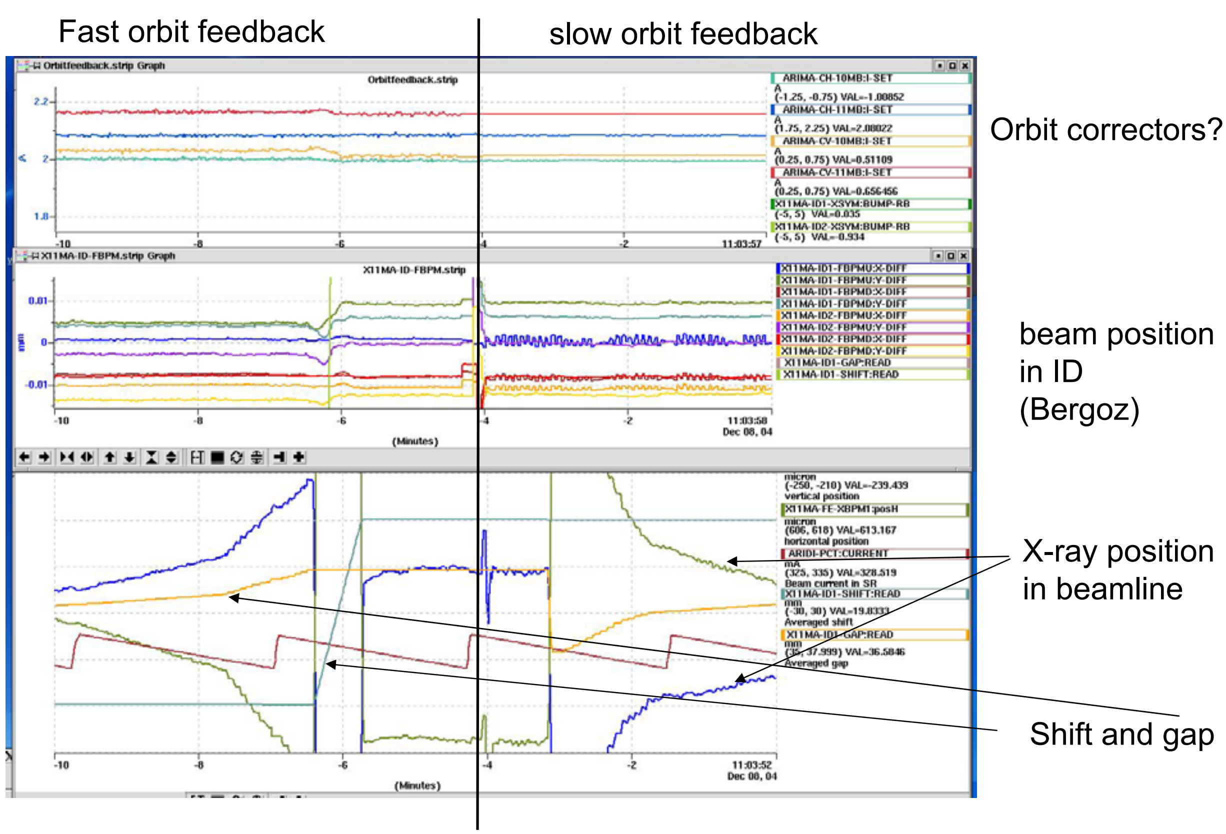
Energy shift

Identical spectra

Energy shift of 10 meV

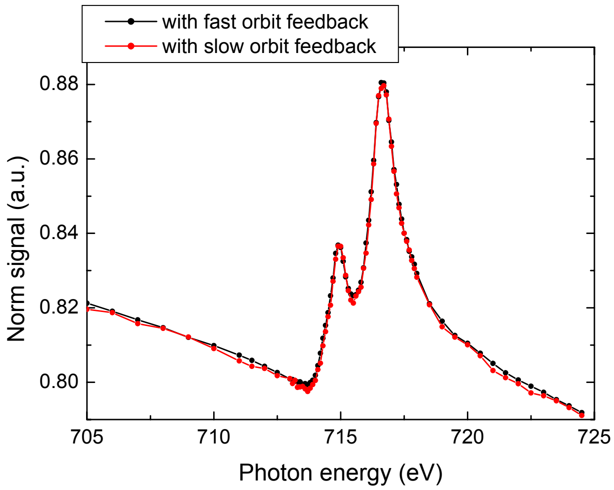


Orbit feedback

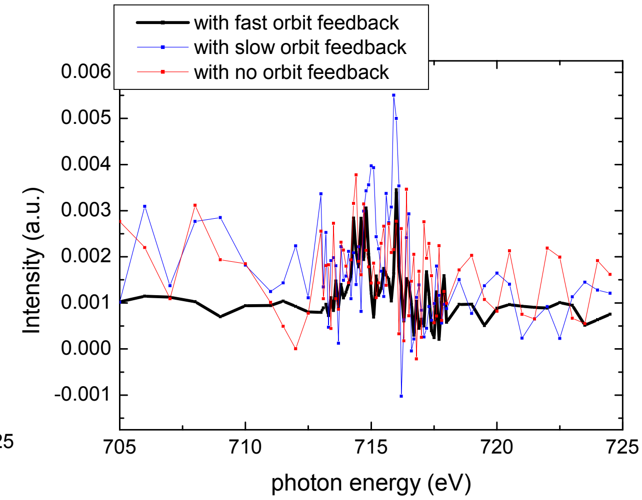


Orbit feedback – effect on measurement

Normalized signal, circular plus

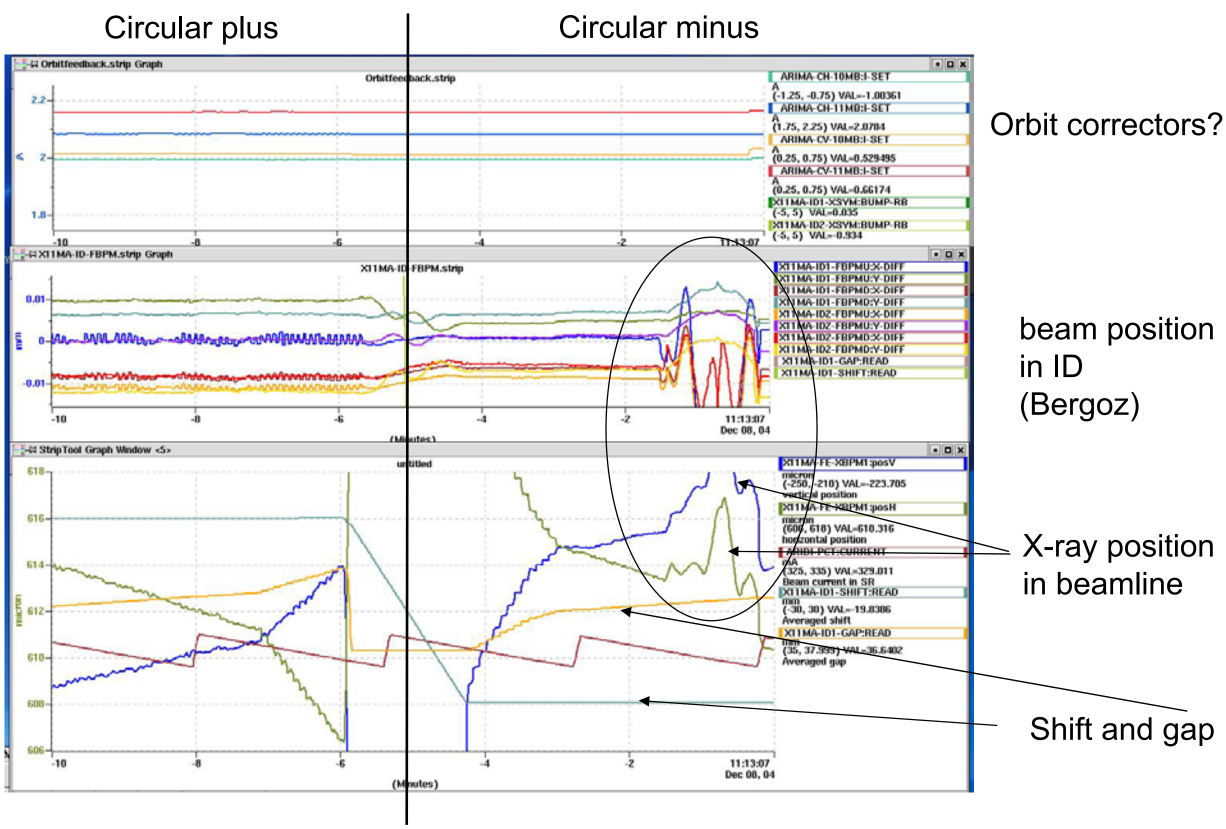


Difference circular plus and minus

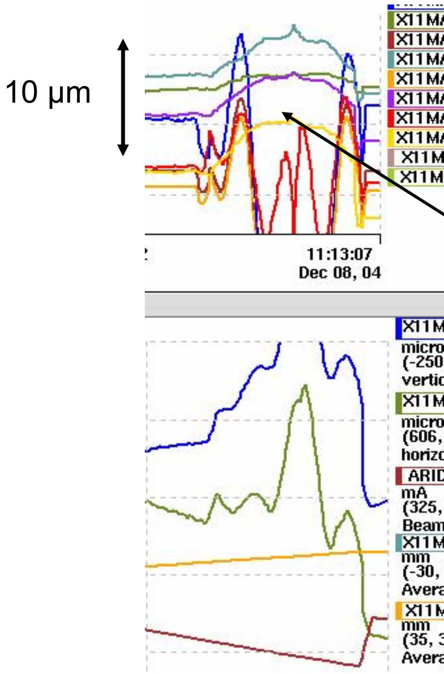


Increased noise!!!

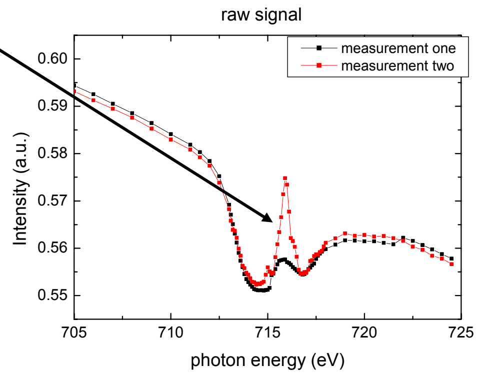
Slow Orbit feedback



Slow Orbit feedback

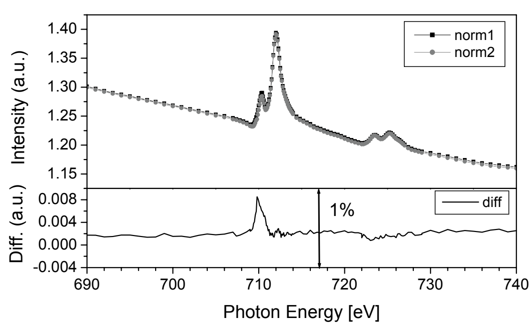


Not transparent !



Summary

We can do great measurements at SLS



- Transparent IDs are essential! Very difficult to make a double EPU system 100% transparent. Have to rely on Orbit feedback

- For the measurement “no” difference between slow and no Orbit feedback

- Critical time scale second – hour
  (10 Hz – 0.0001 Hz)
  Intensity variation 0.1% ≈ 0.5 µm
  energy variation 1meV ≈ 1 µm

- Slow Orbit feedback is not sufficient

Fast Orbit feedback is great