

HESEB

Helmholtz-SESAME
Soft X-Ray Beamline
für SESAME



HESEB Beamline TDR

Introduction and Science

Wolfgang Eberhardt
DESY



SESAME

Synchrotron-light for Experimental Science and Applications in the Middle East

Founded in 2004 as a UNESCO Project

- H. Winick, G. Voss, H. Schopper
- Donation of BESSY I as a jump start



Member States

Jordan
Cyprus
Egypt
Iran
Israel
Pakistan
Palestinian Authority
Turkey



SESAME

Synchrotron-light for Experimental Science and Applications in the Middle East

Inauguration in May 2017

- User operation has started on 2 beamlines
- Idea of a soft x-ray beamline at SESAME as a prominent sign for a Helmholtz engagement in „Science Diplomacy“

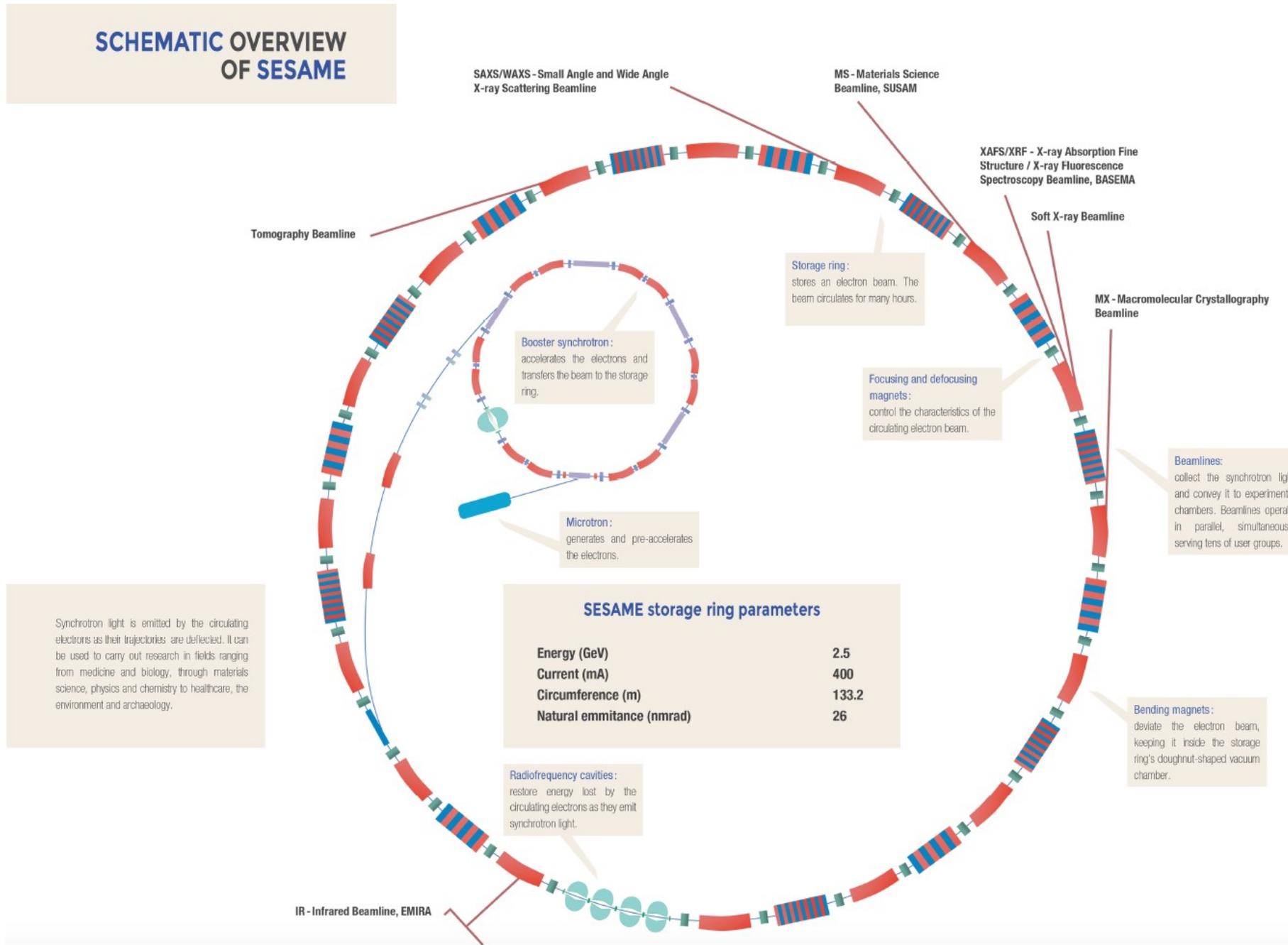


Inauguration Mai 2017

- Complementing the existing first three beamlines (that are funded and partially in operation: IR, XAFS and powder diffraction)
- Extending the scientific capabilities of SESAME
- soft x-ray beamline is part of the long-term strategic plan of SESAME and fully endorsed by SESAME committees and user communities
- Strong support and participation in initiative by Helmholtz centers (DESY, HZB, HZDR, FZJ, KIT)

SESAME Facility

SCHEMATIC OVERVIEW OF SESAME



Synchrotron light is emitted by the circulating electrons as their trajectories are deflected. It can be used to carry out research in fields ranging from medicine and biology, through materials science, physics and chemistry to healthcare, the environment and archaeology.

SESAME storage ring parameters

| | |
|---------------------------|-------|
| Energy (GeV) | 2.5 |
| Current (mA) | 400 |
| Circumference (m) | 133.2 |
| Natural emittance (nmrad) | 26 |

The HESEB Soft X-ray Beamline

Funded by the Helmholtz Gemeinschaft

Project Start January 2019

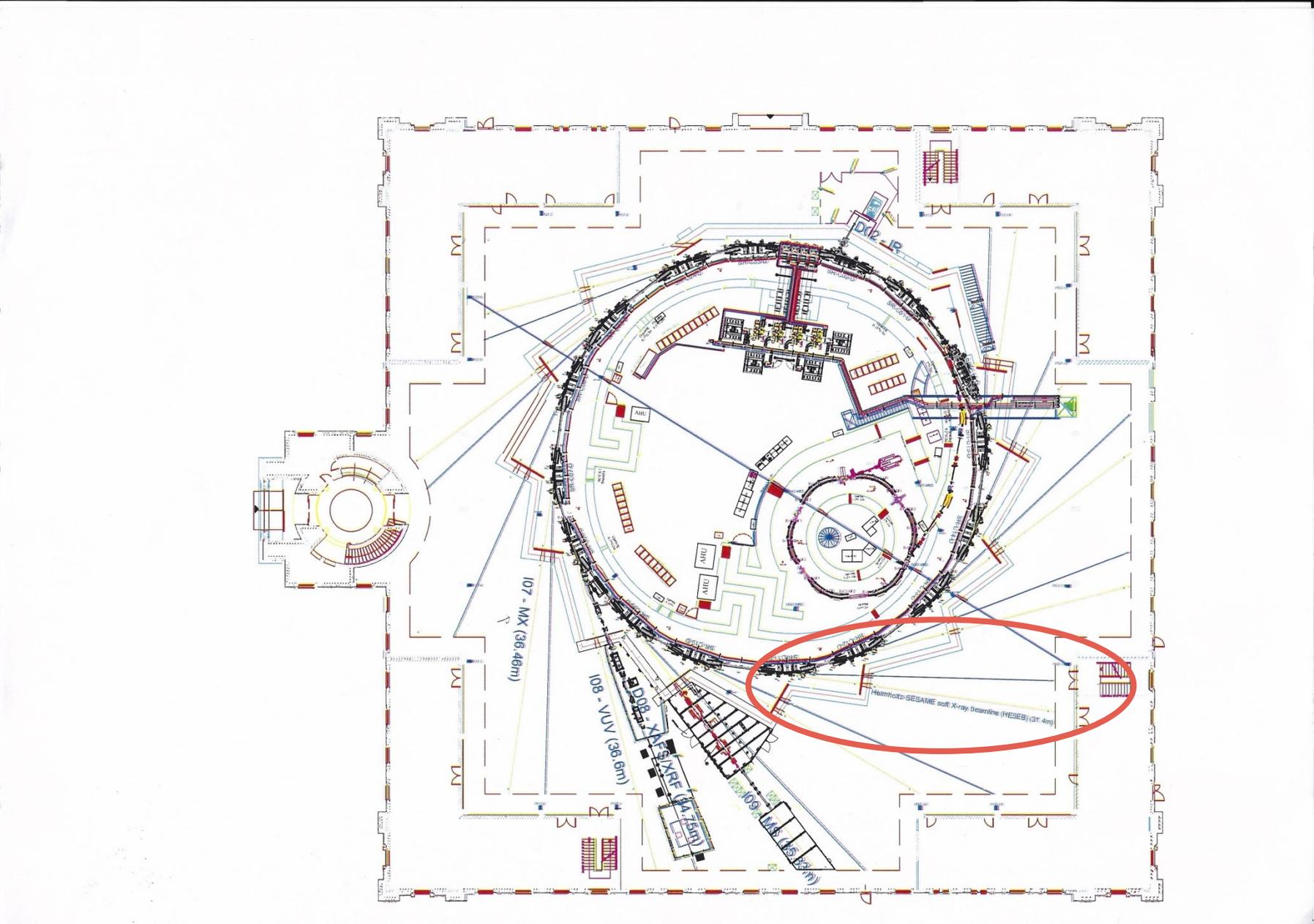
Four years duration

3.5 M €

- Variable polarization undulator based soft X-ray beamline dedicated to enable advanced photoemission/spectroscopy experiments
- Helmholtz consortium provides beamline in basic version (absorption spectroscopy with polarized soft X-rays)
 - Additional Instrumentation/endstations should come from SESAME members----State of the art photoemission (UPS/XPS) ---- RIXS ---- PEEM
 - Project should act as an „anchor“ to seed cooperation between German research institutions/universities and SESAME member communities
- Project should be driven by cost/performance effectiveness in design, installation and commissioning
 - build on available and successfully proven standard layout
 - base line is the well established PGM monochromator design
 - off-the-shelf – procurement and installation through manufacturer: e.g. FMB (Berlin)

SESAME

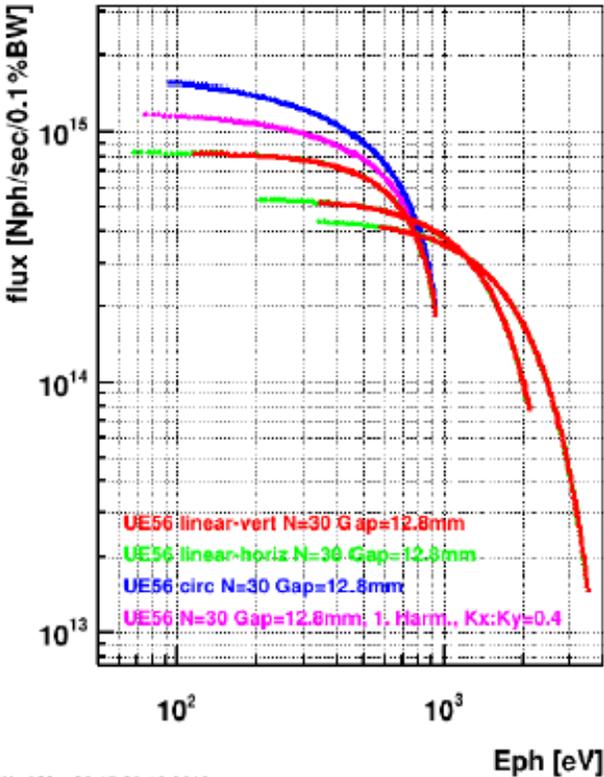
Floor Plan



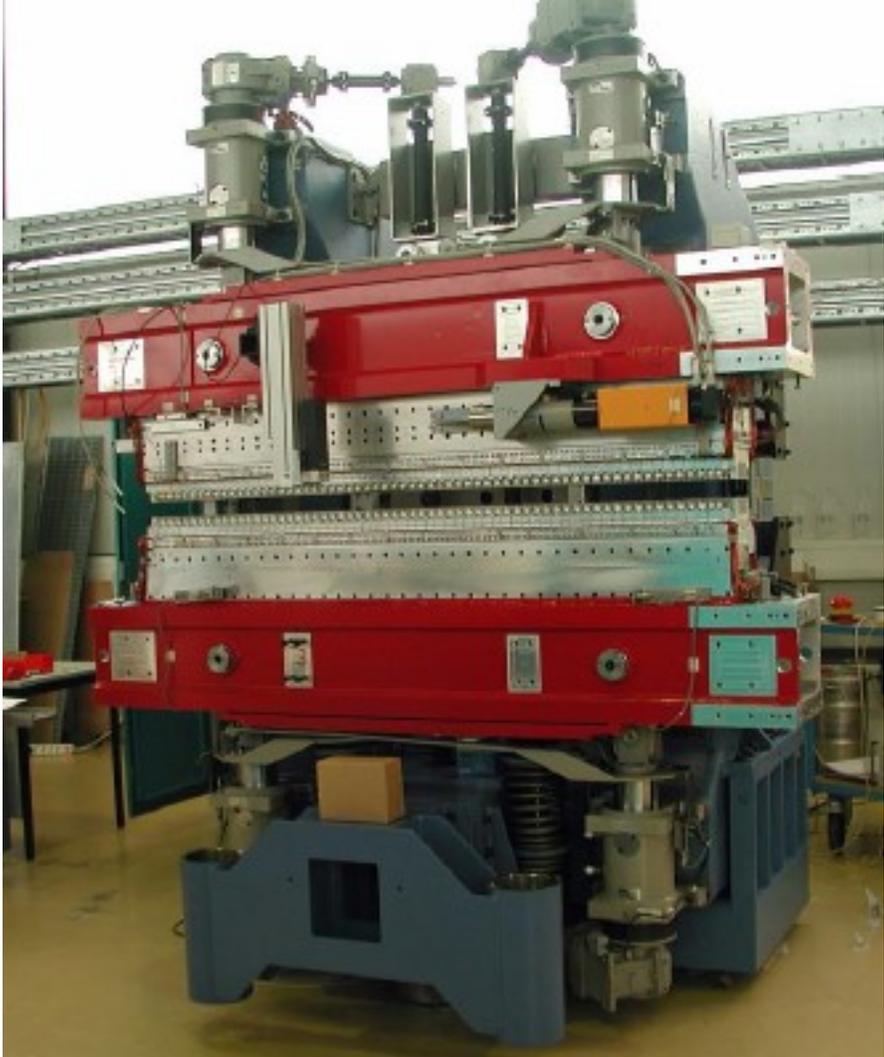
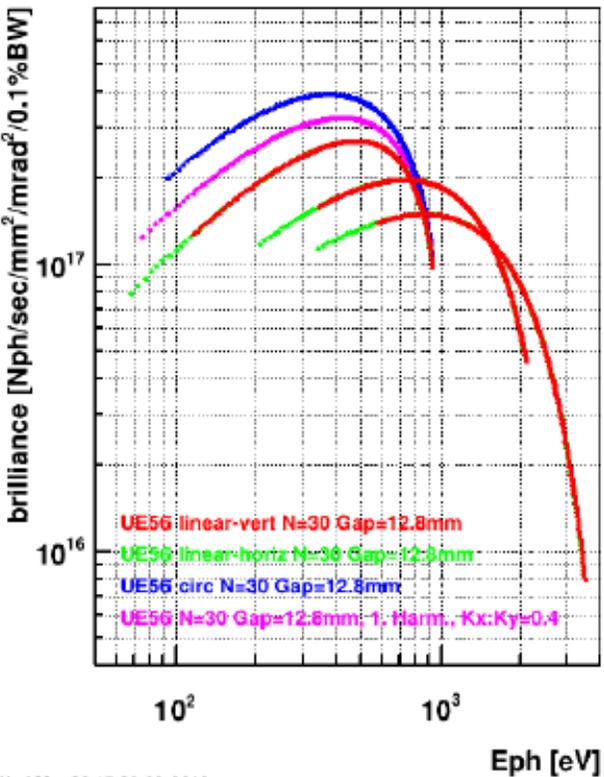
HESEB Beamline

Undulator UE56 with variable polarization

Flux, 2.5 GeV, 400 mA



Brilliance, 2.5 GeV, 400 mA

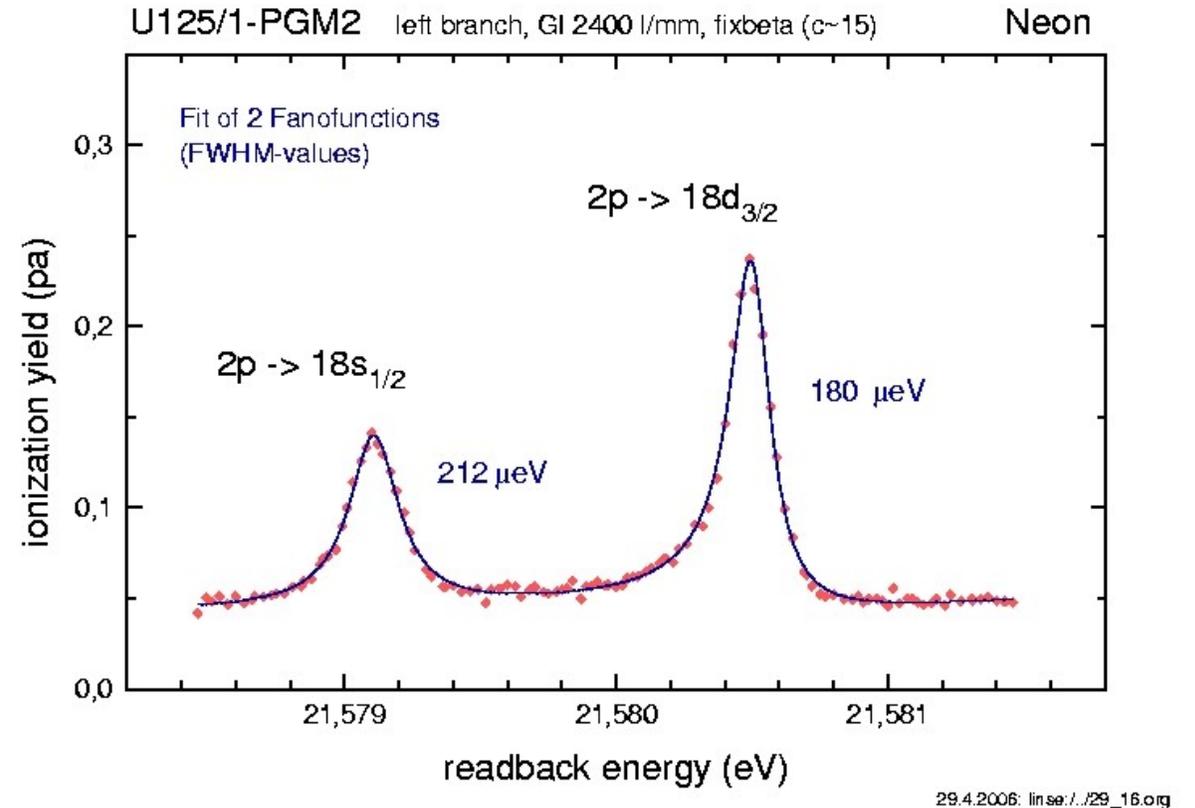
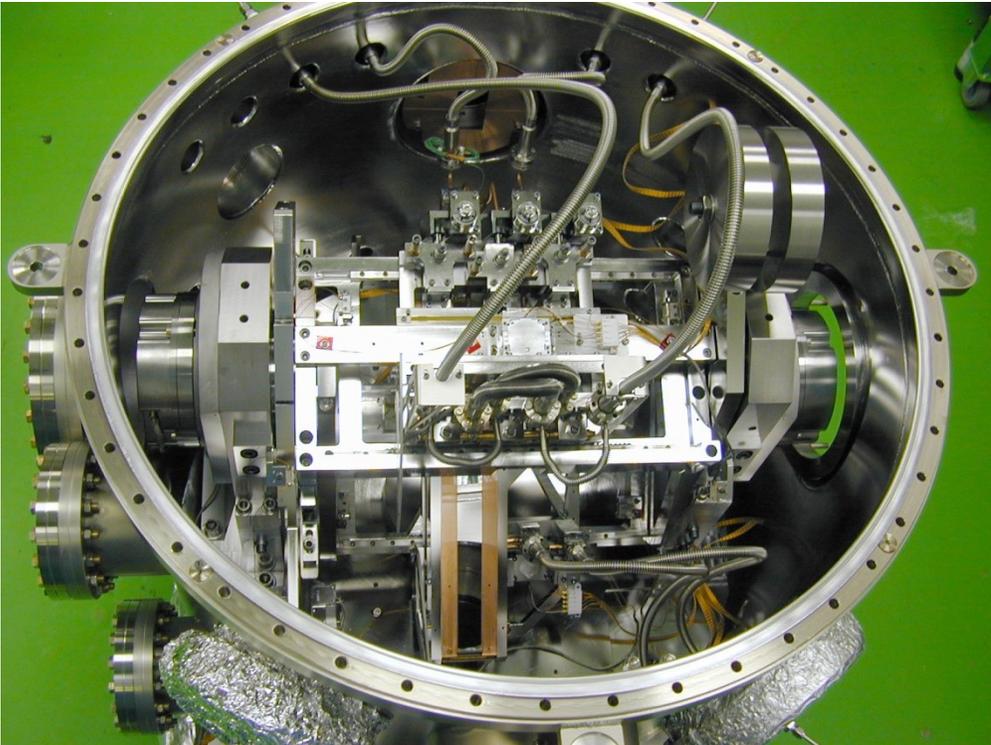


HESEB Beamline

PGM Monochromator

Optics Design by BESSY

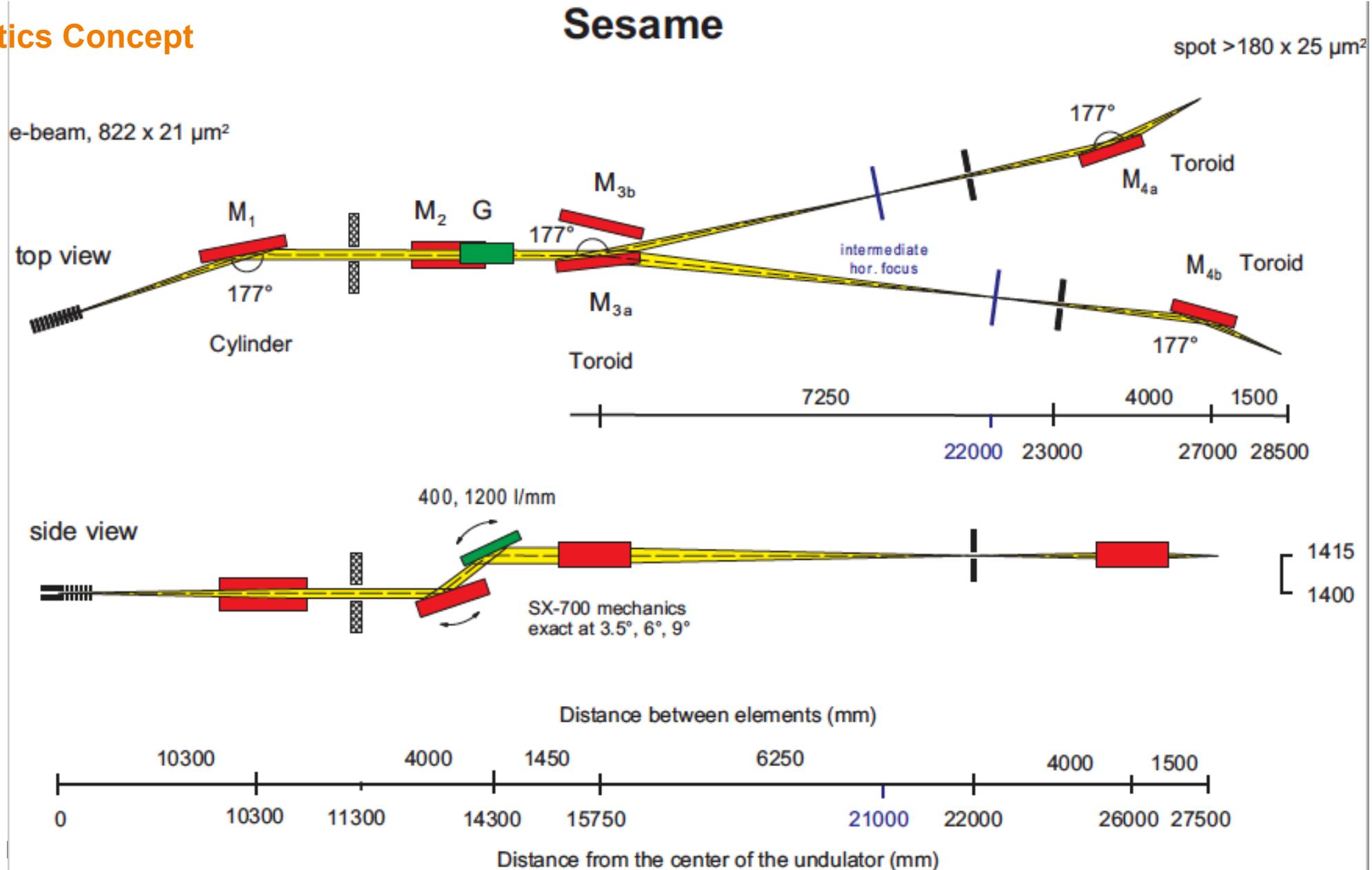
Manufactured by ZEISS, JENOPTIK, FMB
for a worldwide market



Resolution of 180 μeV
 $E/\Delta E = 1.2 \cdot 10^5$

HESEB Beamline

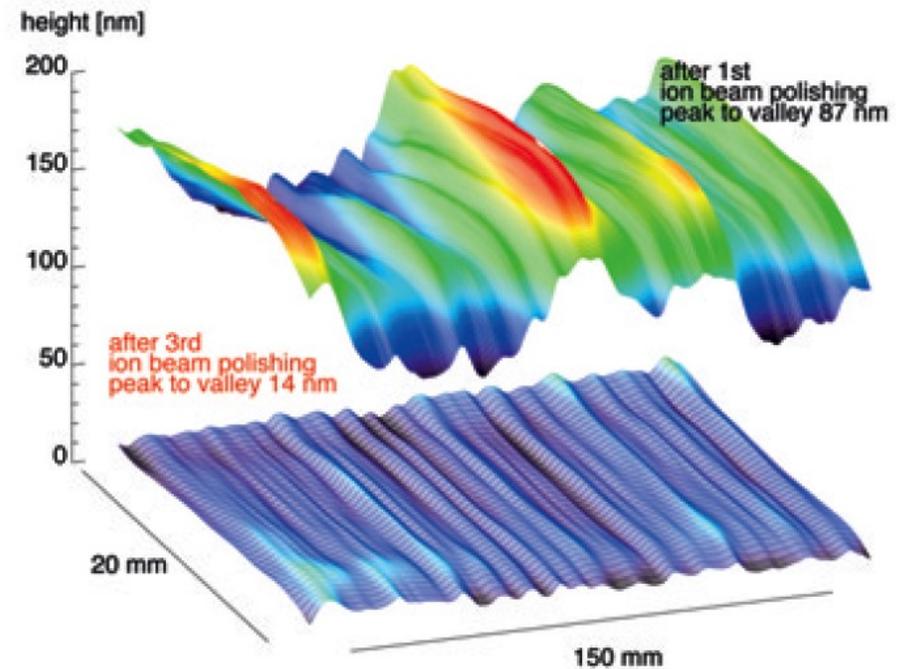
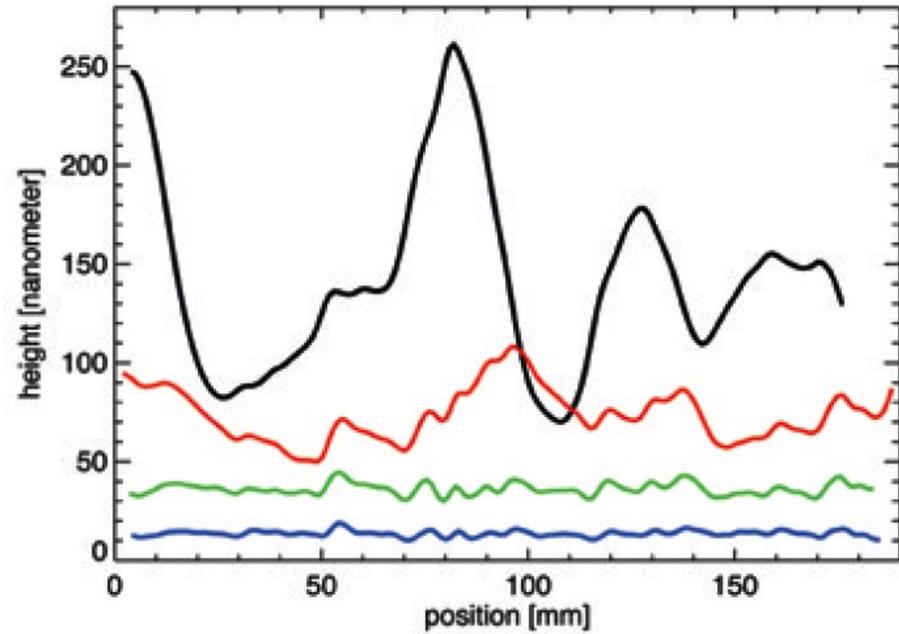
Optics Concept



HESEB Beamline

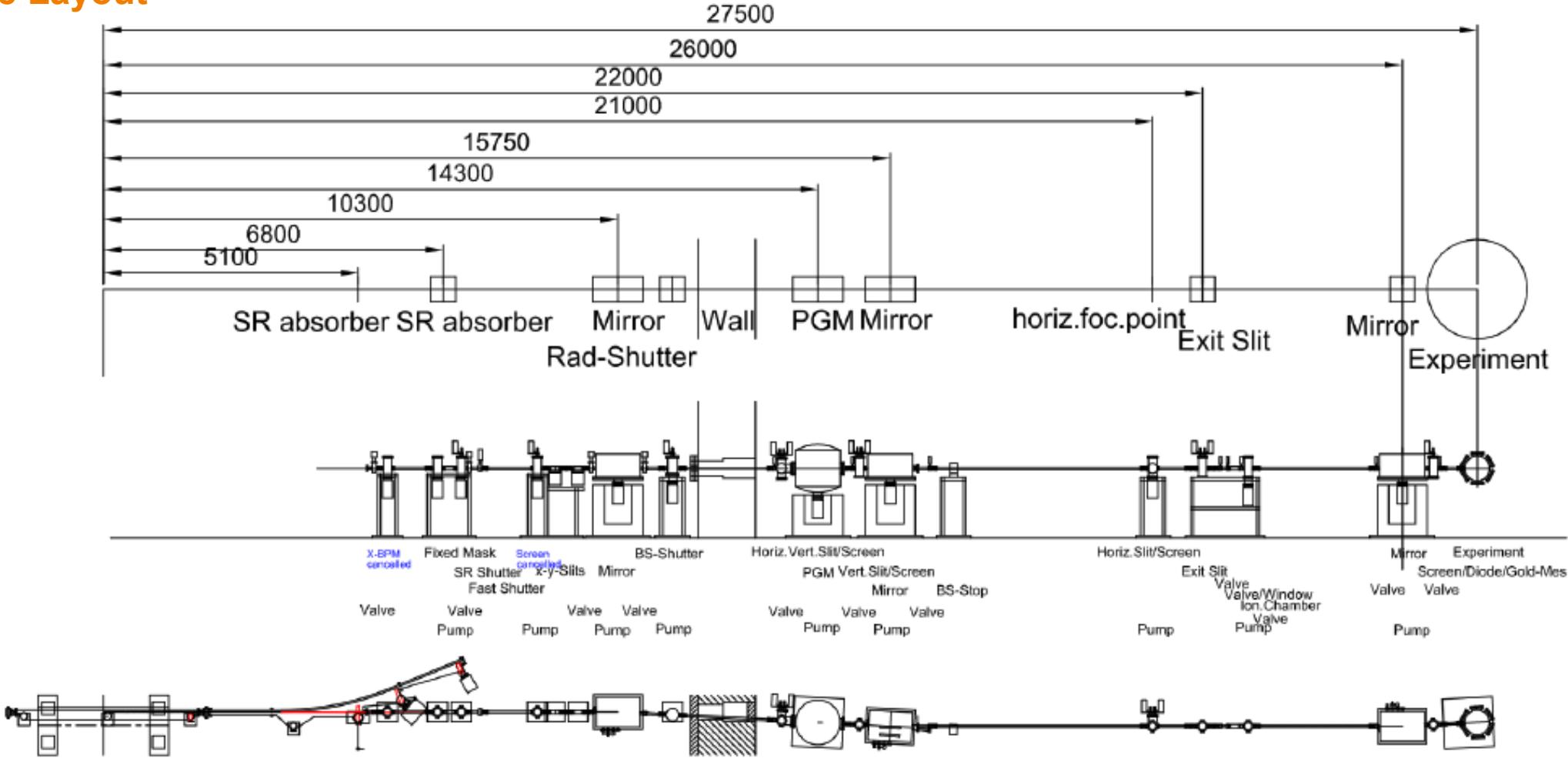
Nanometer Optics Metrology at HZB

2D profiling of optical surfaces
With a precision of an order of
magnitude better than
industry (ZEISS)



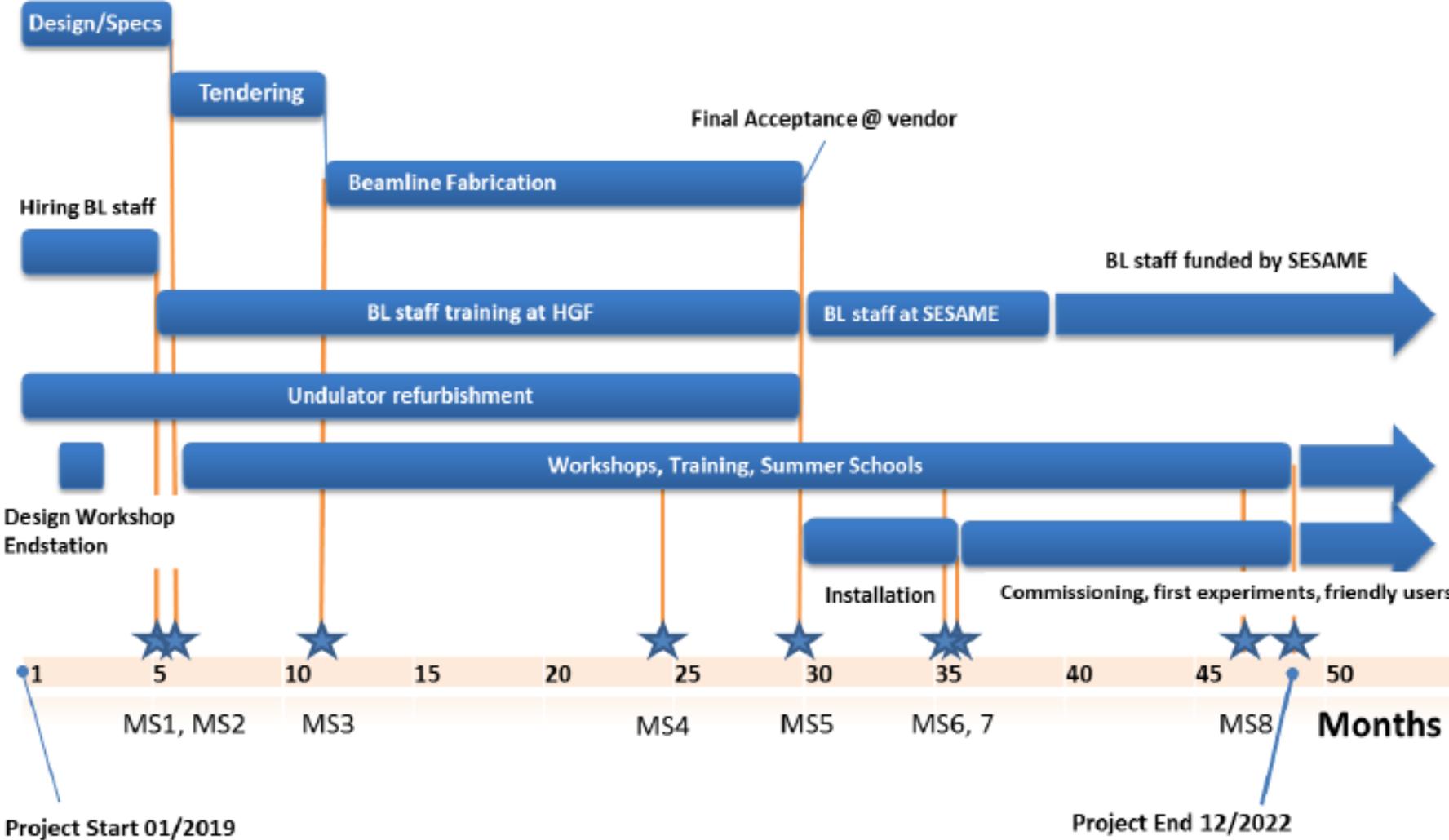
HESEB Beamline

Beamline Layout



HESEB Beamline

Project Time Plan



Soft X-ray Science Examples

Soft X-rays → High Resolution Spectroscopy

Covers the core edges:

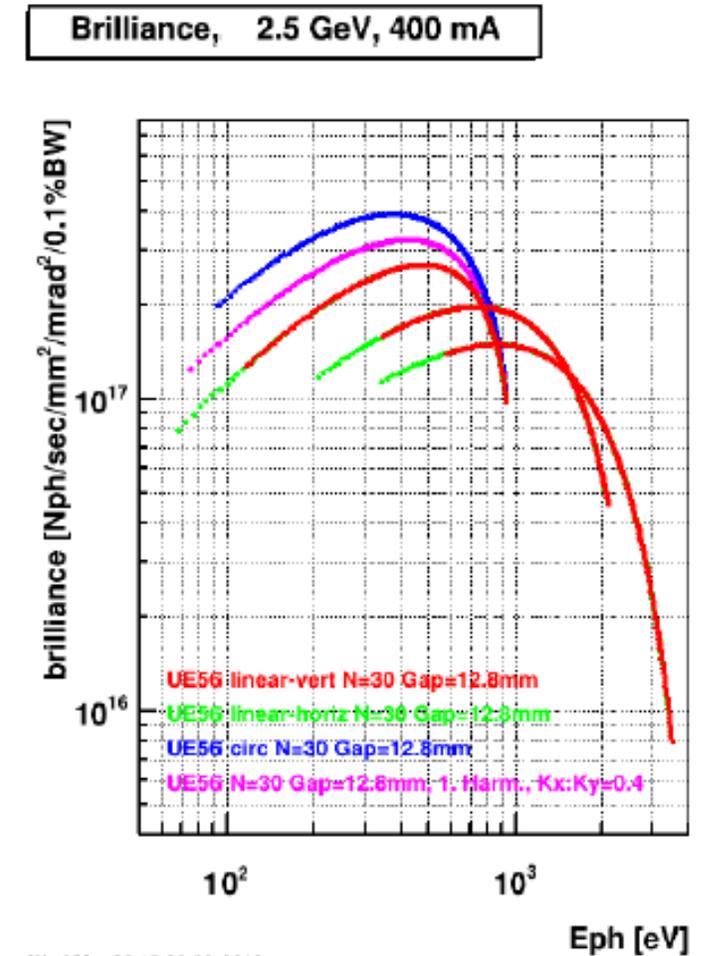
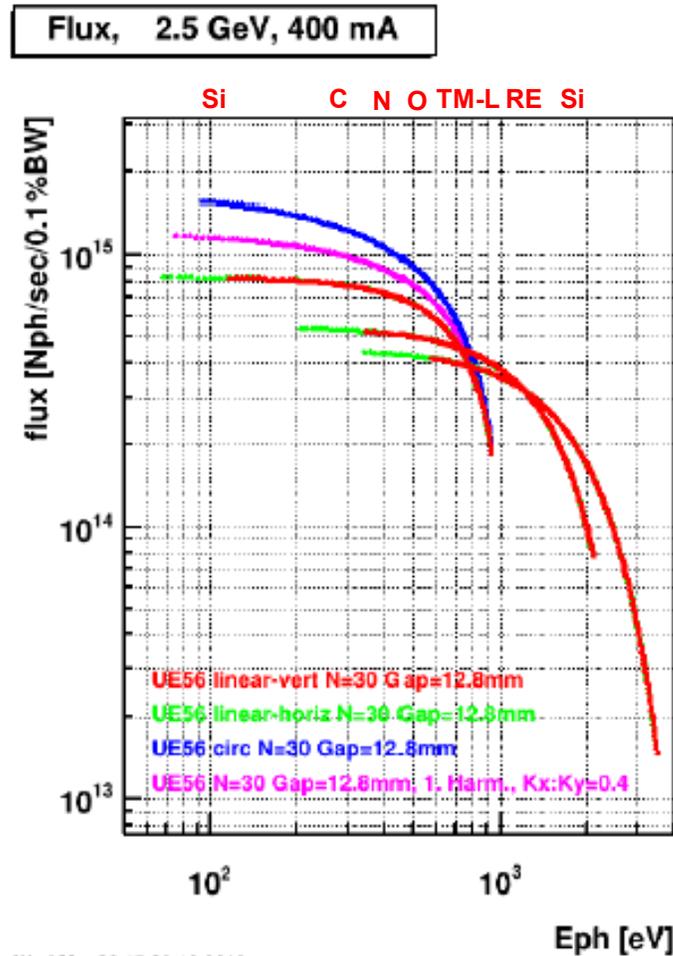
Si L-edge—**semiconductors**

C-, N-, O- Kedge
Organics catalysis

TM-L-edges **magnetics**

RE 3d edges **magnetics**

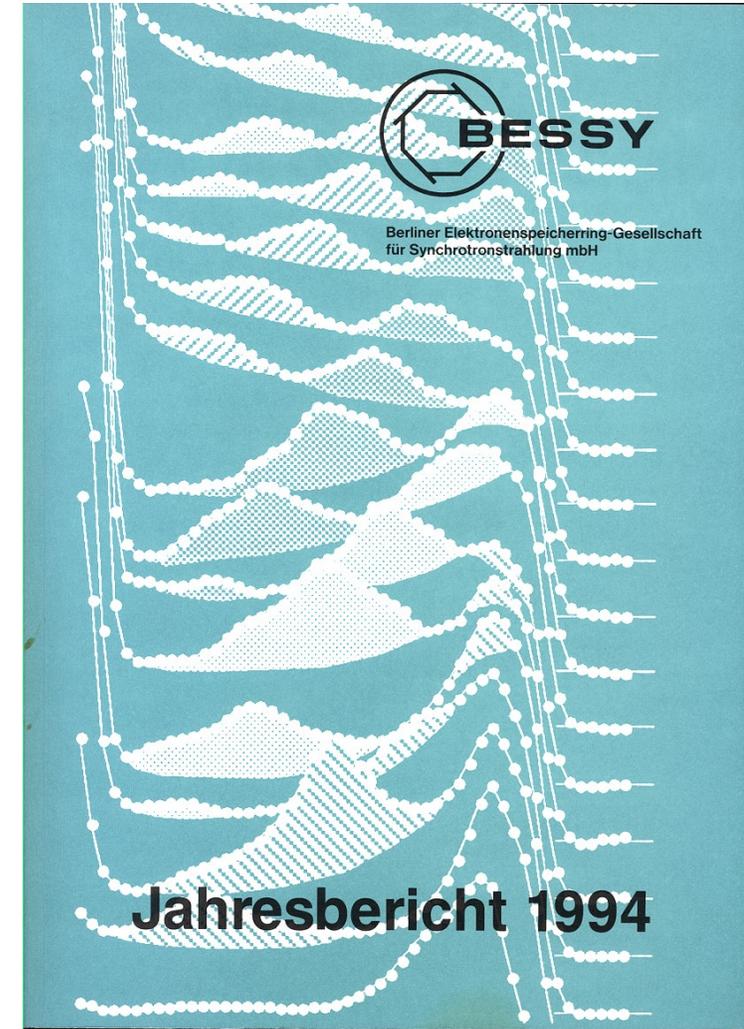
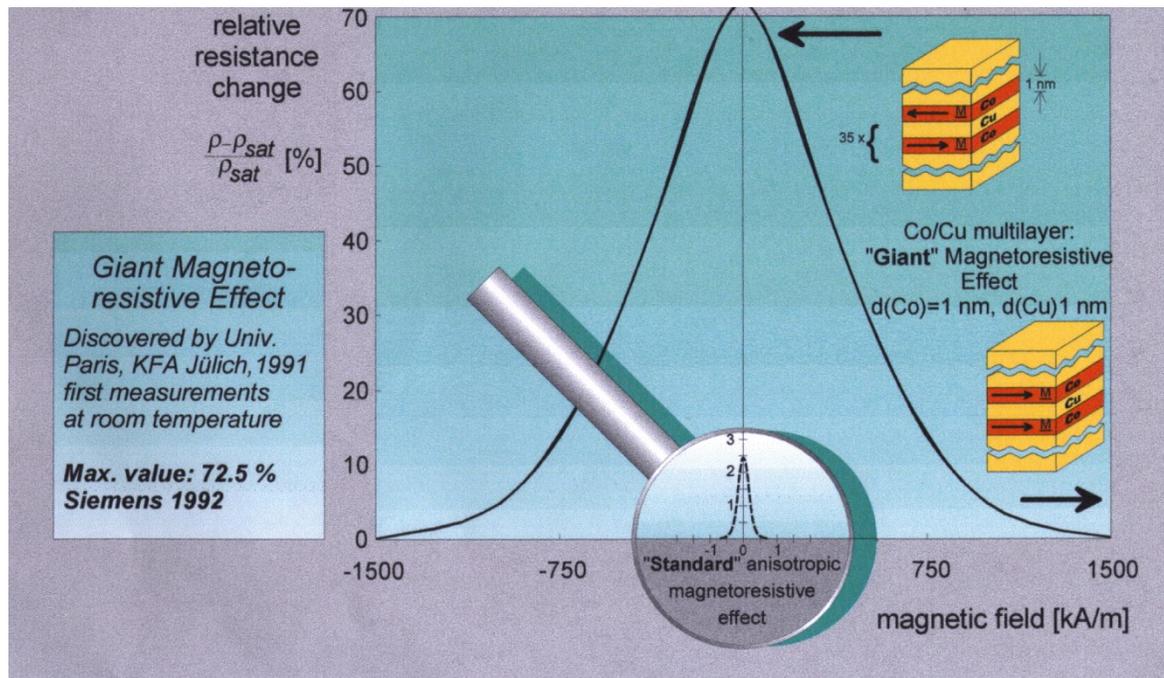
Al- K-edge, Si-K-edge



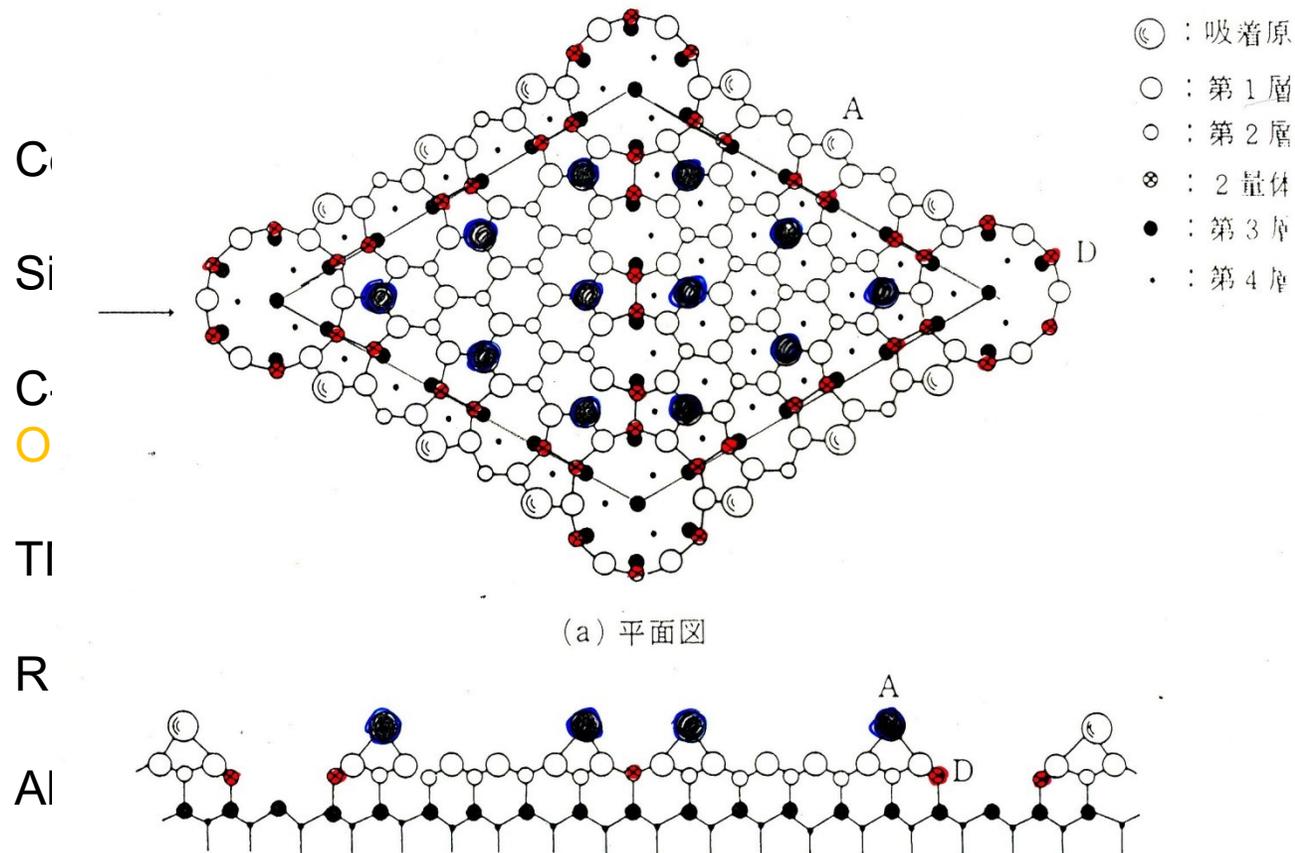
Soft X-rays → High Resolution Spectroscopy

Spin Polarized Photoemission

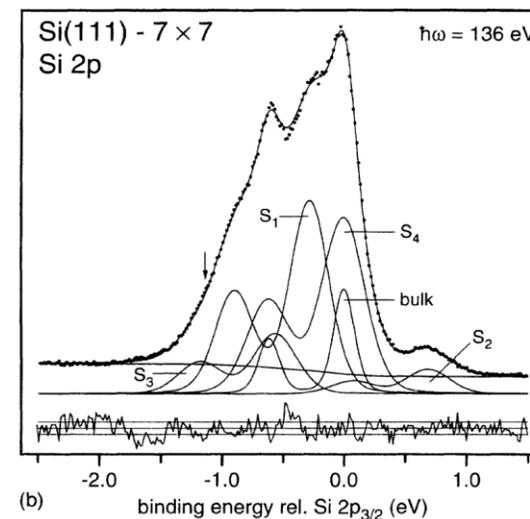
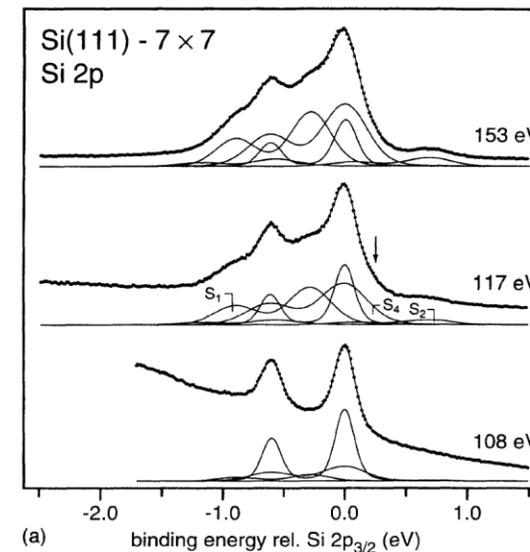
Magnetic Quantum Well States at the origin of the GMR effect



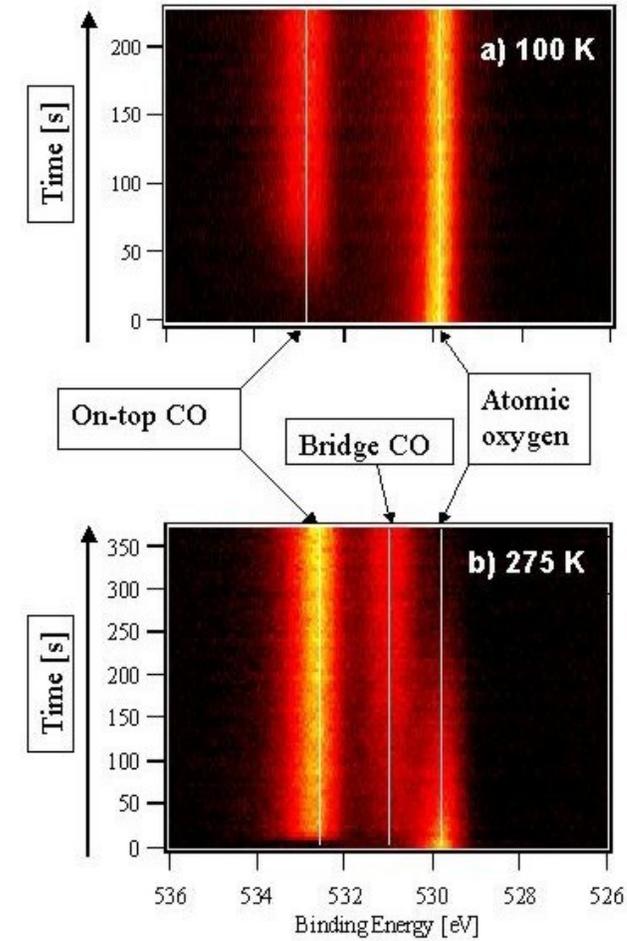
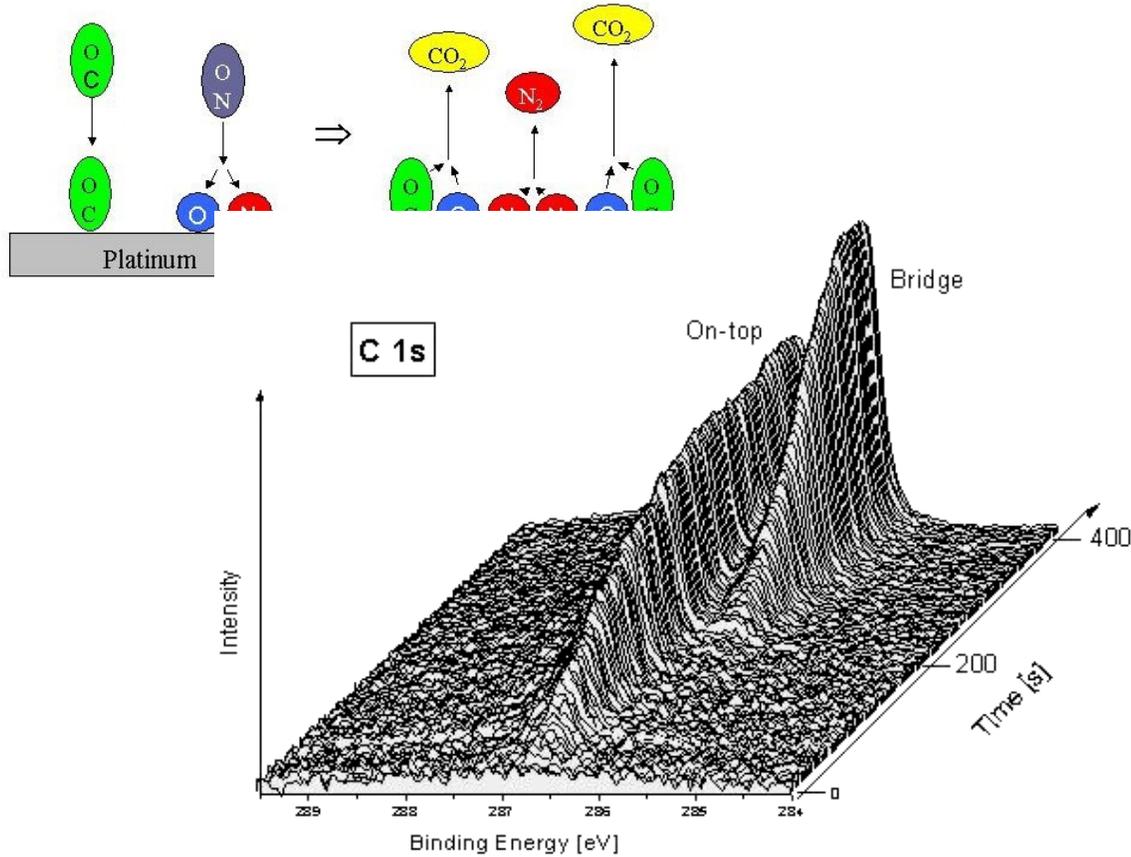
Soft X-rays → High Resolution XPS



K. Takayanagi, Y. Tanishiro, S. Takahashi, M. Takahashi
 Surf. Sci. 164, 367 (1985)

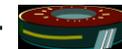


J.J. Paggel, W. Theis, K. Horn
 Ch. Jung, C. Hellwig, H. Petersen
 Phys. Rev B50, 18686 (1994)

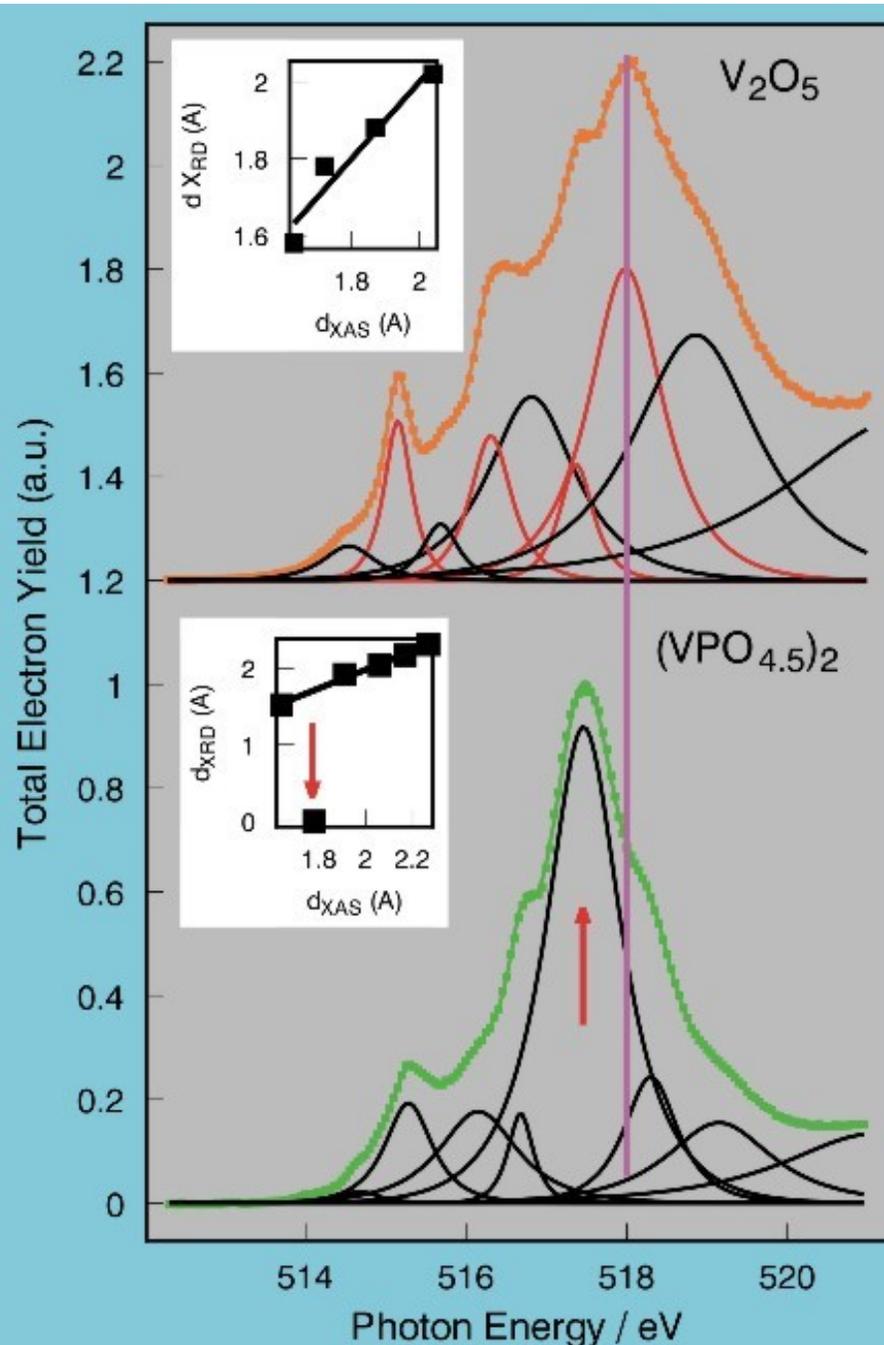


Binding sites of CO on a Pt surface identified by high resolution time resolved XPS

R. Denecke, M. Kinne, T. Fuhrmann, C. Whelan, J. Zhu, H.P. Steinrück (Univ. Erlangen)



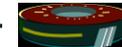
Spectroscopy of catalysts under process conditions



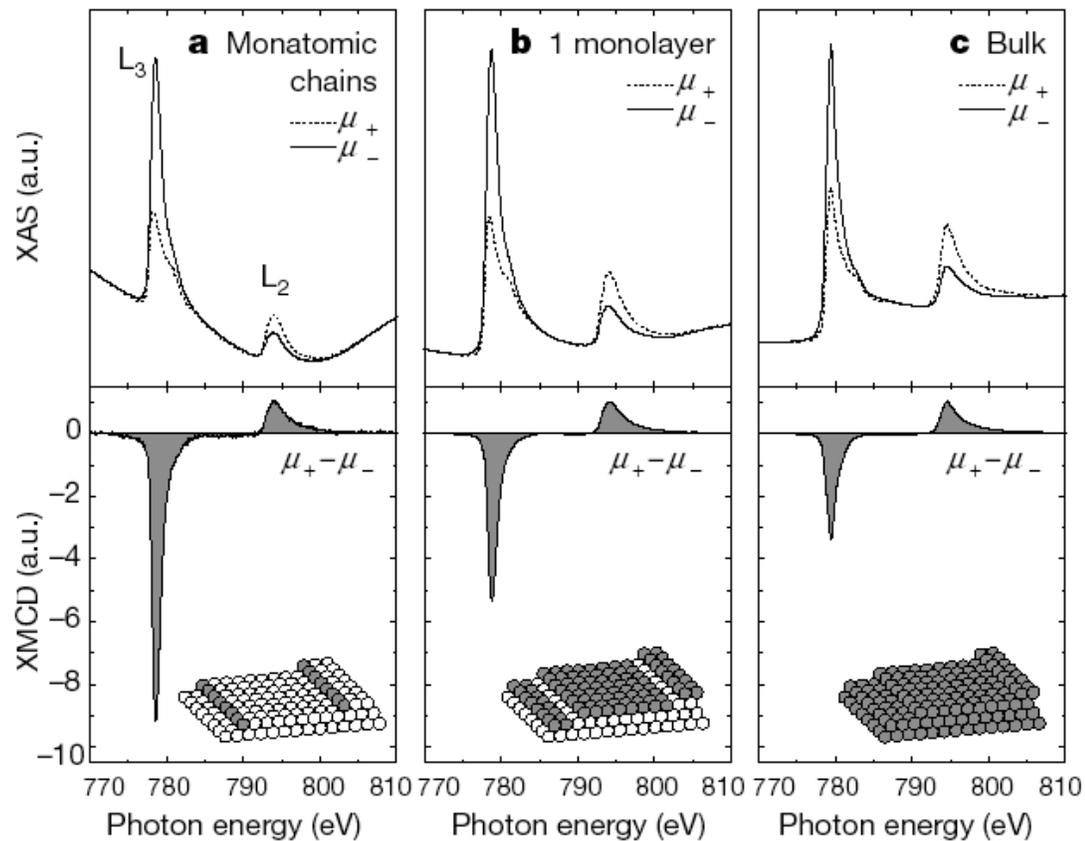
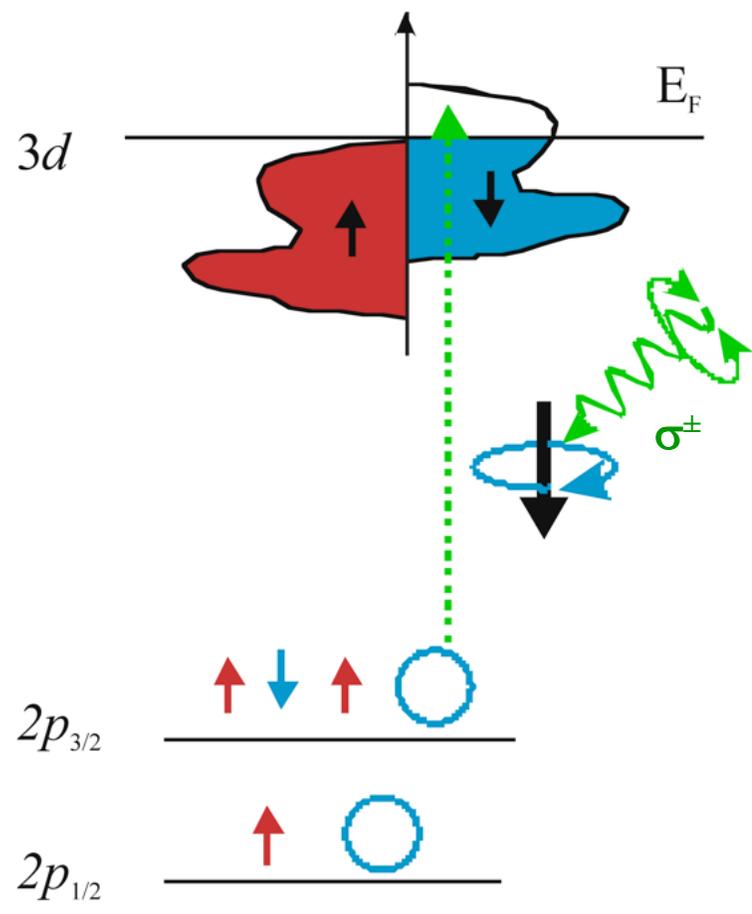
Methane oxidation using a vanadium oxide catalyst reveals an intermediate state which is only present under reaction conditions

NEXAFS spectra of catalysts during chemical reactions

M. Hävecker, R.W. Mayer, A. Knop-Gericke, R. Schlögl (FHI Berlin)

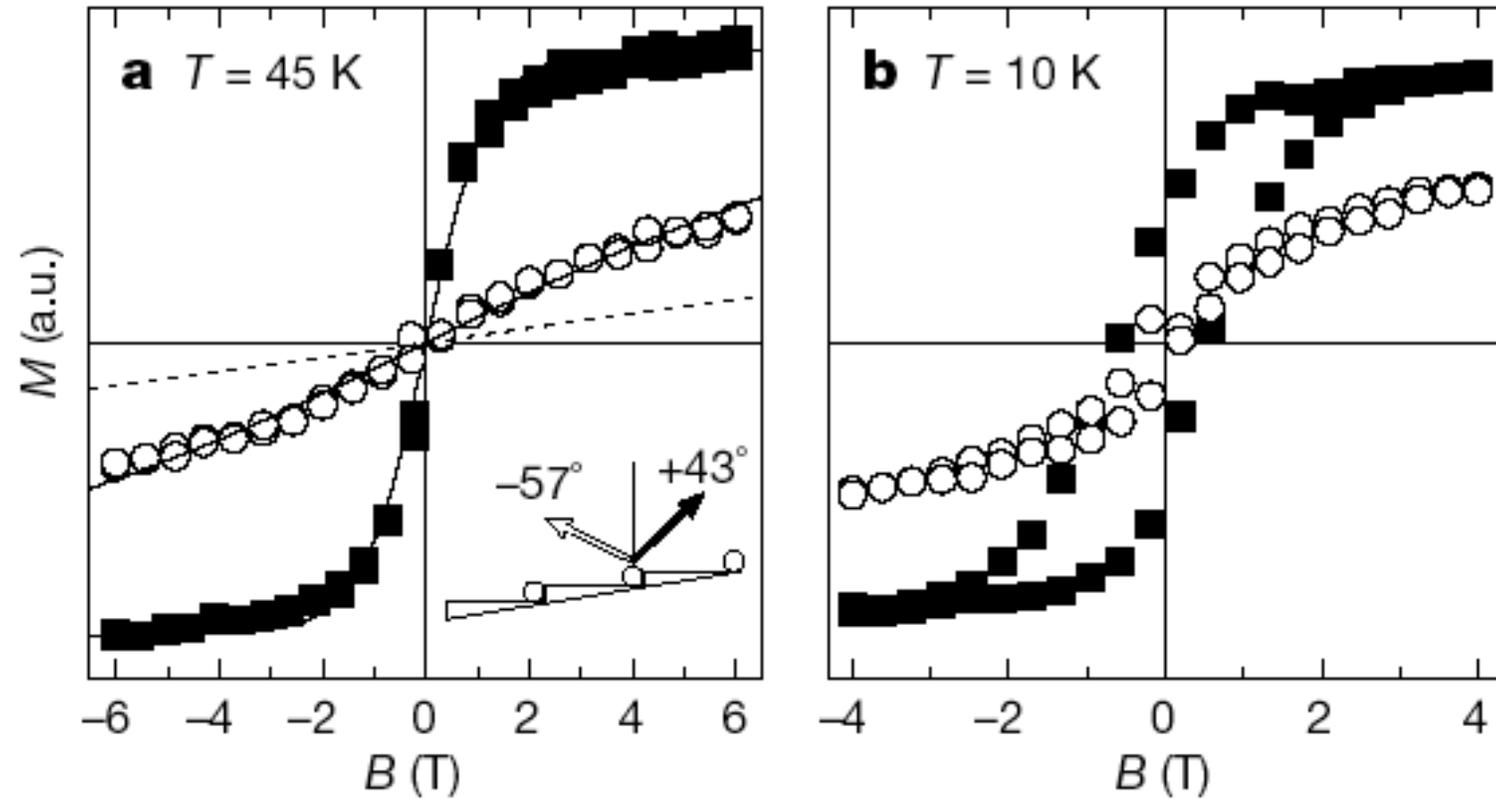
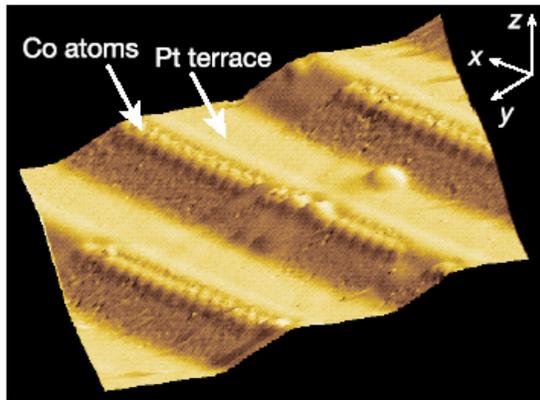
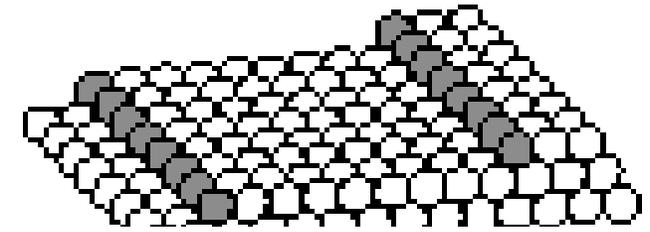
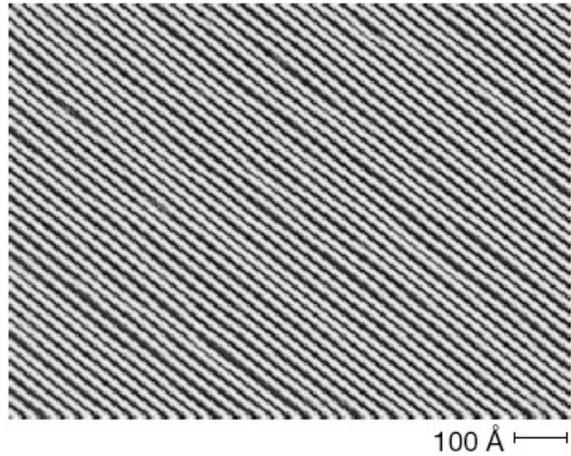


Magnetic Systems → CMXD



P. Gambardella, A. Dallmeyer, K. Maiti, M. C. Malagoli, W. Eberhardt, K. Kern, C. Carbone, **Nature** **416**, 301 (2002)

Magnetic Systems → Co mono-atomic chain on Pt

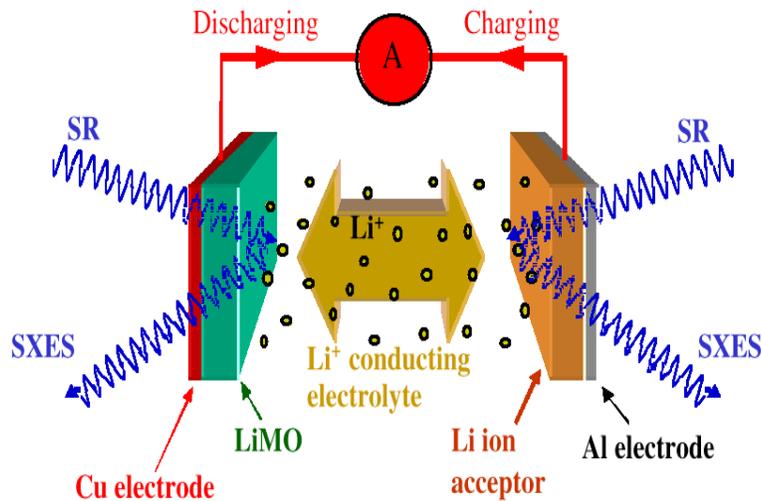


P. Gambardella, A. Dallmeyer, K. Maiti, M. C. Malagoli, W. Eberhardt, K. Kern, C. Carbone, **Nature** **416**, 301 (2002)

Soft X-rays →

In-situ process monitoring using all photon related spectroscopies

Electrochemistry
Corrosion
Lubrication
Catalysis

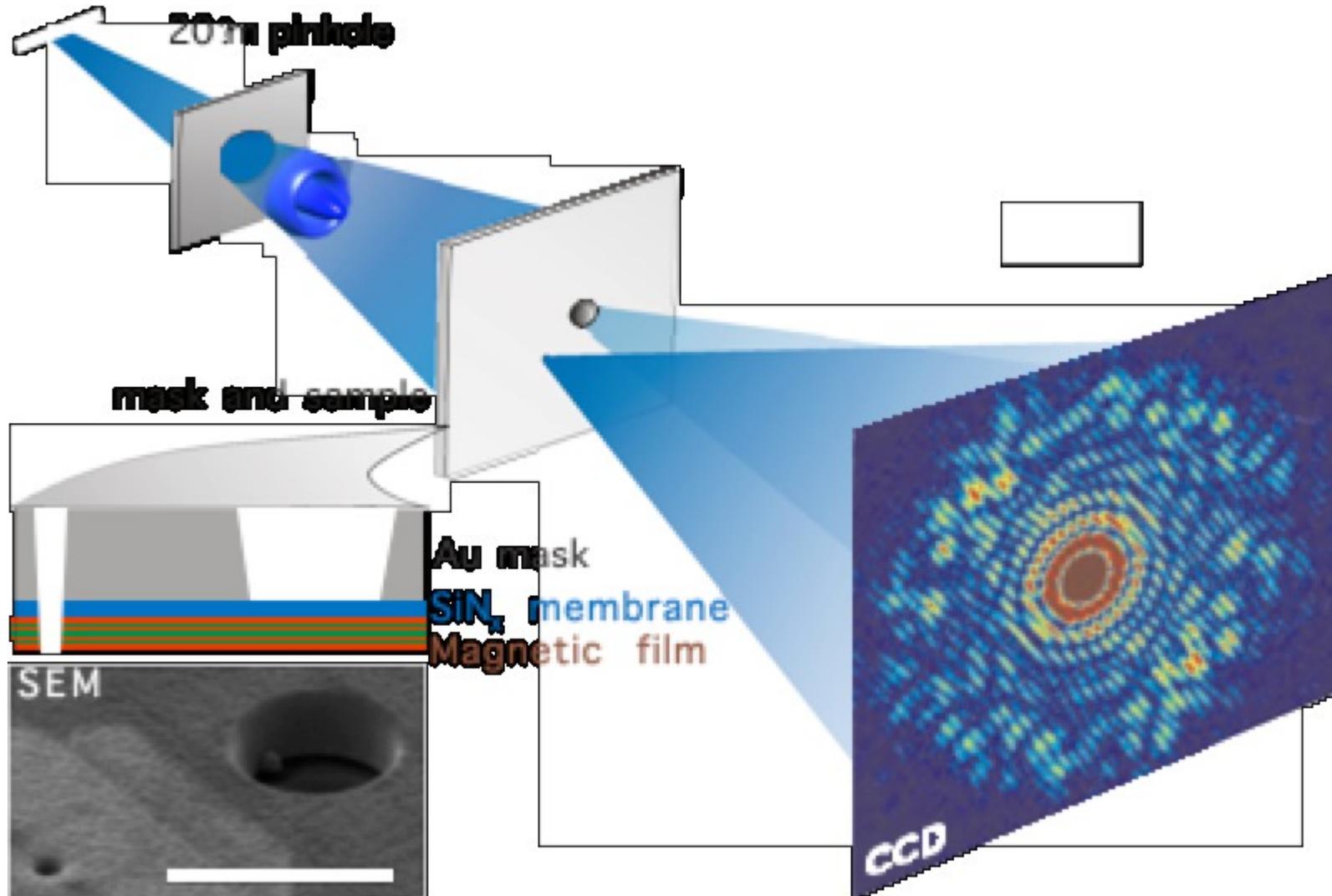


Spectroscopy of battery electrodes under operational conditions



Pattern formation during a chemical reaction
G. Ertl FHI Berlin

Soft X-rays → Holografy with coherent X-rays





16 December 2004

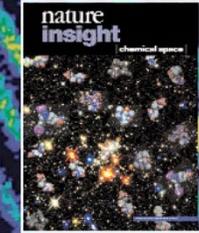
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nature

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www.nature.com/nature

Inside this week



X-ray holography

Lensless imaging at the nanoscale

The 'Halloween storm'
How the Sun plays its tricks

Protein transport
Escape from the nucleus

Duck-billed platypus
Curiouser and curiouser

Locusts over Africa
Time for biological control?

S. Eisebitt
J. Lüning
W.F. Schlotter
M. Lörger
O. Hellwig
W. Eberhardt
J. Stöhr

NATURE 432,
885 (2004)



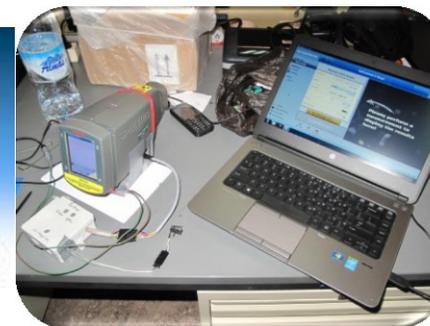
Birgit Kanngießer

**Characterisation and Conservation of Paintings on Walls and Sculpture from Nabataean Petra
June 2016 – June 2019**



1. Materials analysis and development

- Analytical Investigations of wall paintings and sculpture: in-situ and ex-situ; organic and inorganic, non-invasive & ND
- Development of experimental conservation material for gold: synthesis, characterisation, validation, evaluation

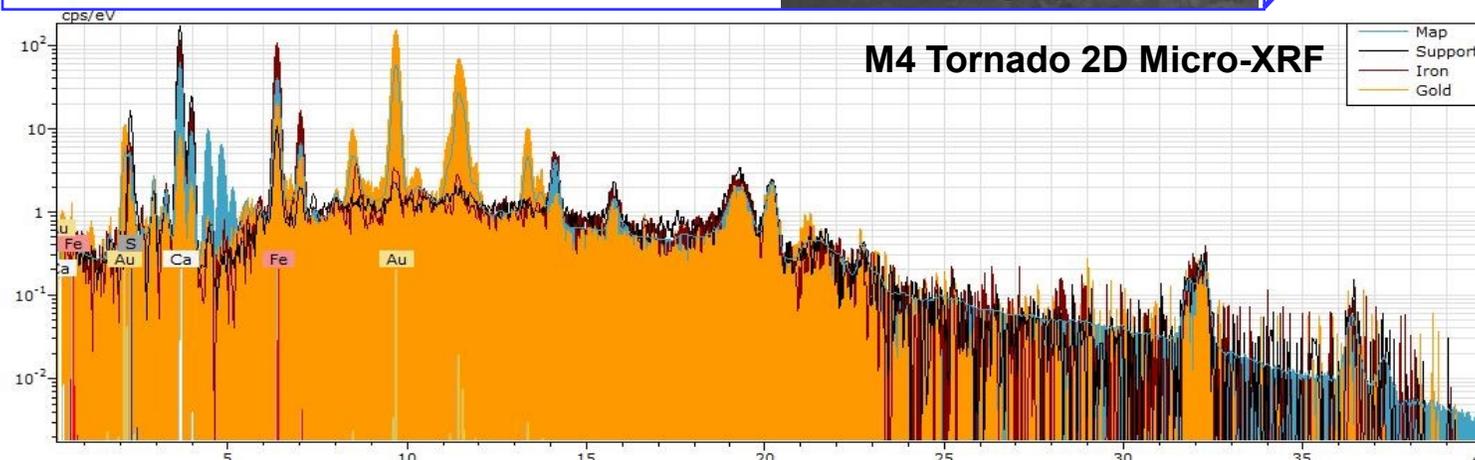
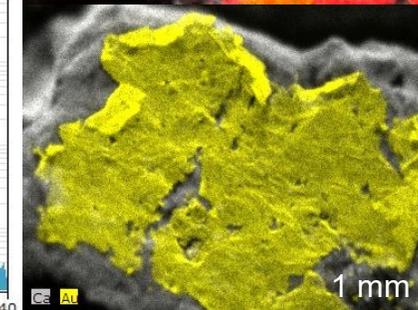
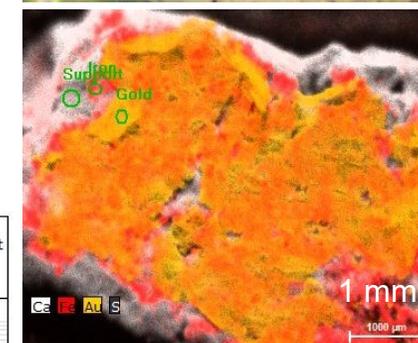
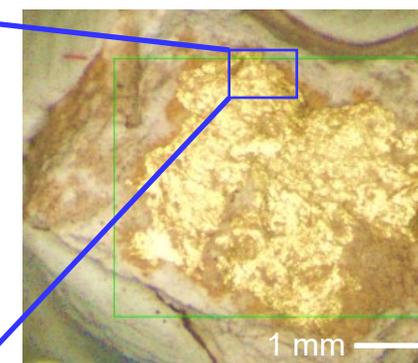
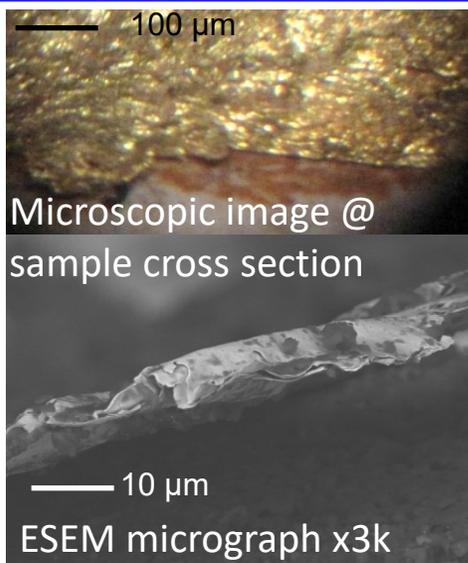
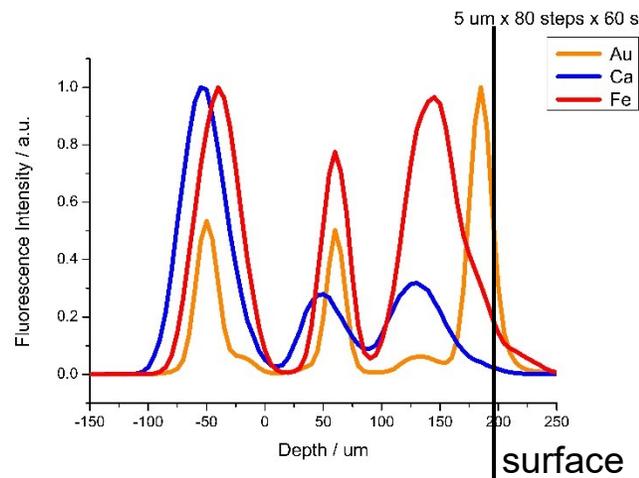


Elemental analysis

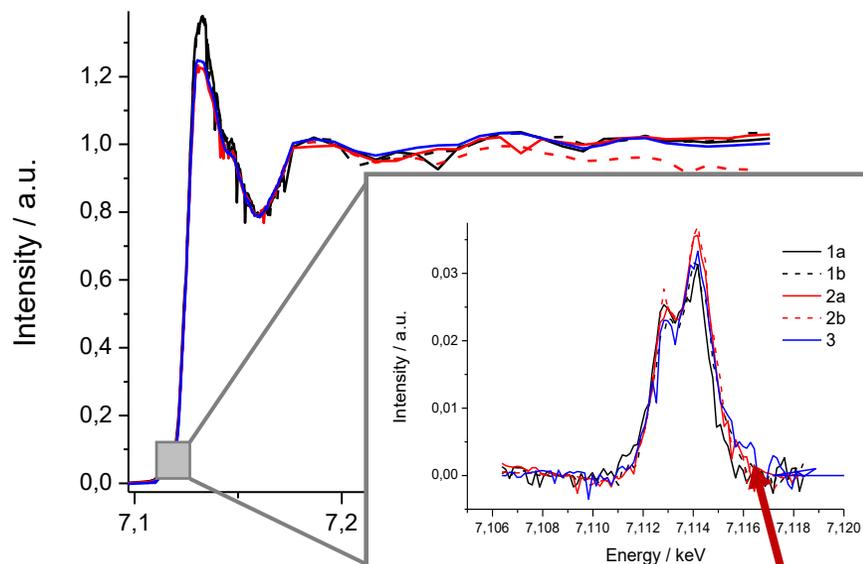
2D- μ XRF (Bruker Nano): Rh Tube, 50 KeV and 600 μ A. SDD Detector: <150 eV FWHM, resolution 25 μ m, 15°

3D- μ XRF (TU-Berlin): Mo Tube, 50 KeV and 600 μ A. SDD Detector: <145 eV, resolution 12,9 \pm 0,7 μ m; 45°

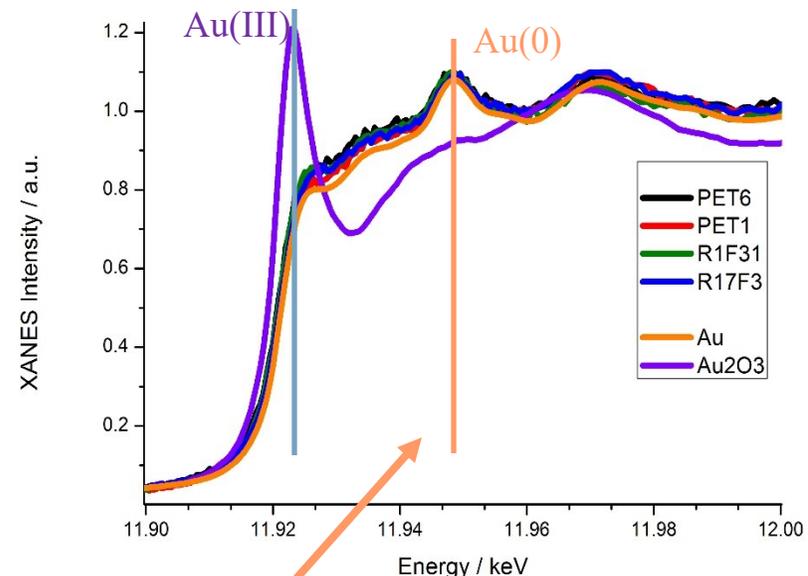
3D Micro-XRF



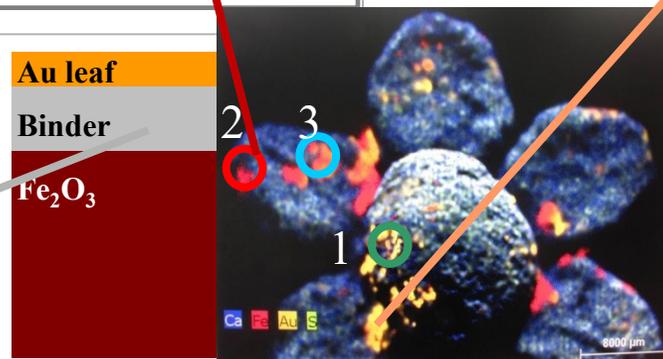
2D and 3D Micro-XANES @ Fe K α Edge



2D Micro-XANES @ Au L $_3$ Edge



- Centro-symmetric Fe:
- 6-coordinated Fe³⁺ → hematite Fe₂O₃
- Fe is unaffected by Au



Features of metallic Au are present as expected

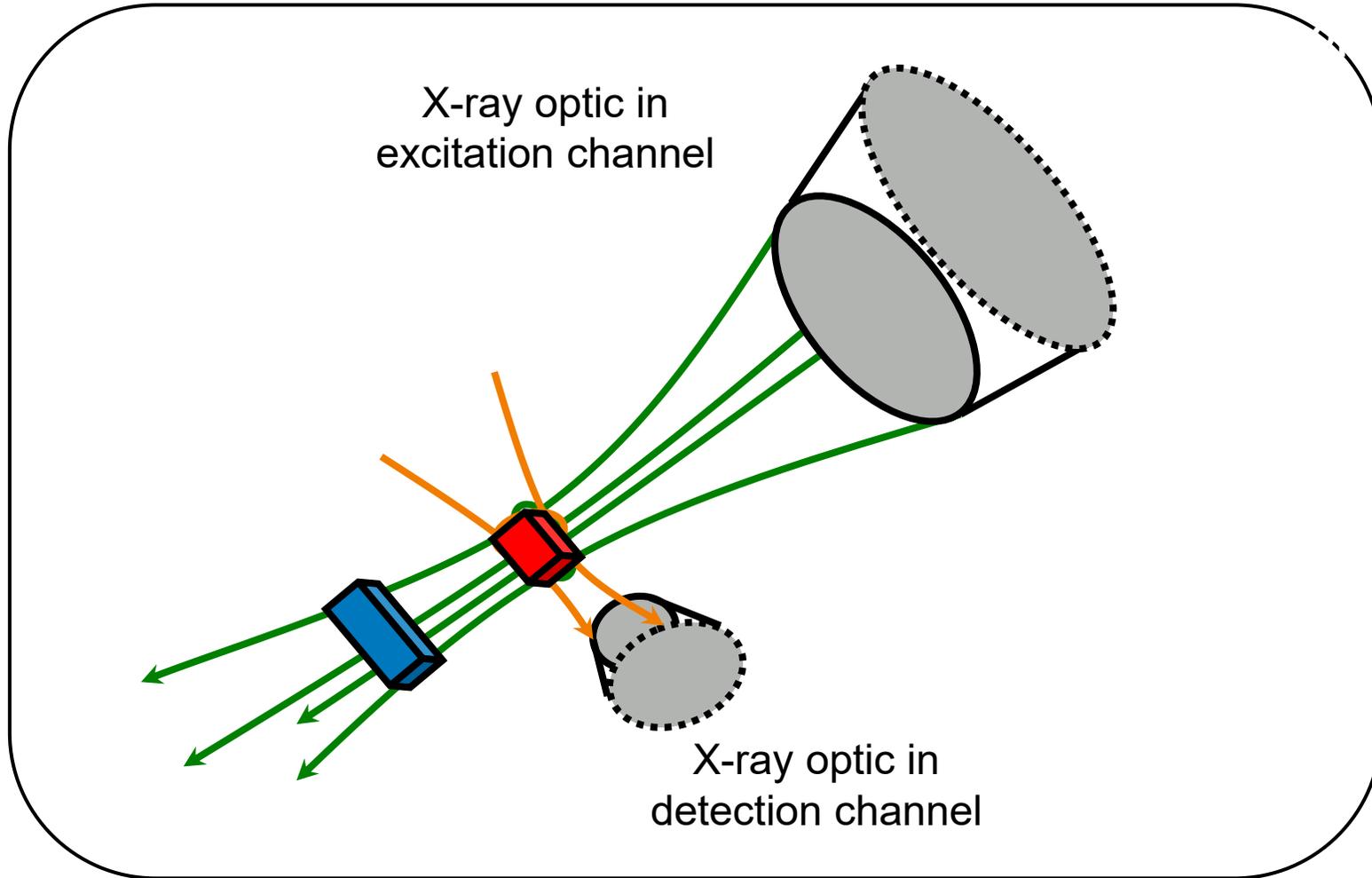
Protein based binder was reported as animal glue (collagen protein) (1;2)

●1a,1b: Fe+Au, center; ●2a,2b: Fe alone, leaf; ●3: Fe under Au, leaf

XANES measurements @ MySpot beamline, Bessy II →

7T-WLS-1 source; Si 311 monochromator; 7-element Si(Li) detector; E/ΔE >10,000

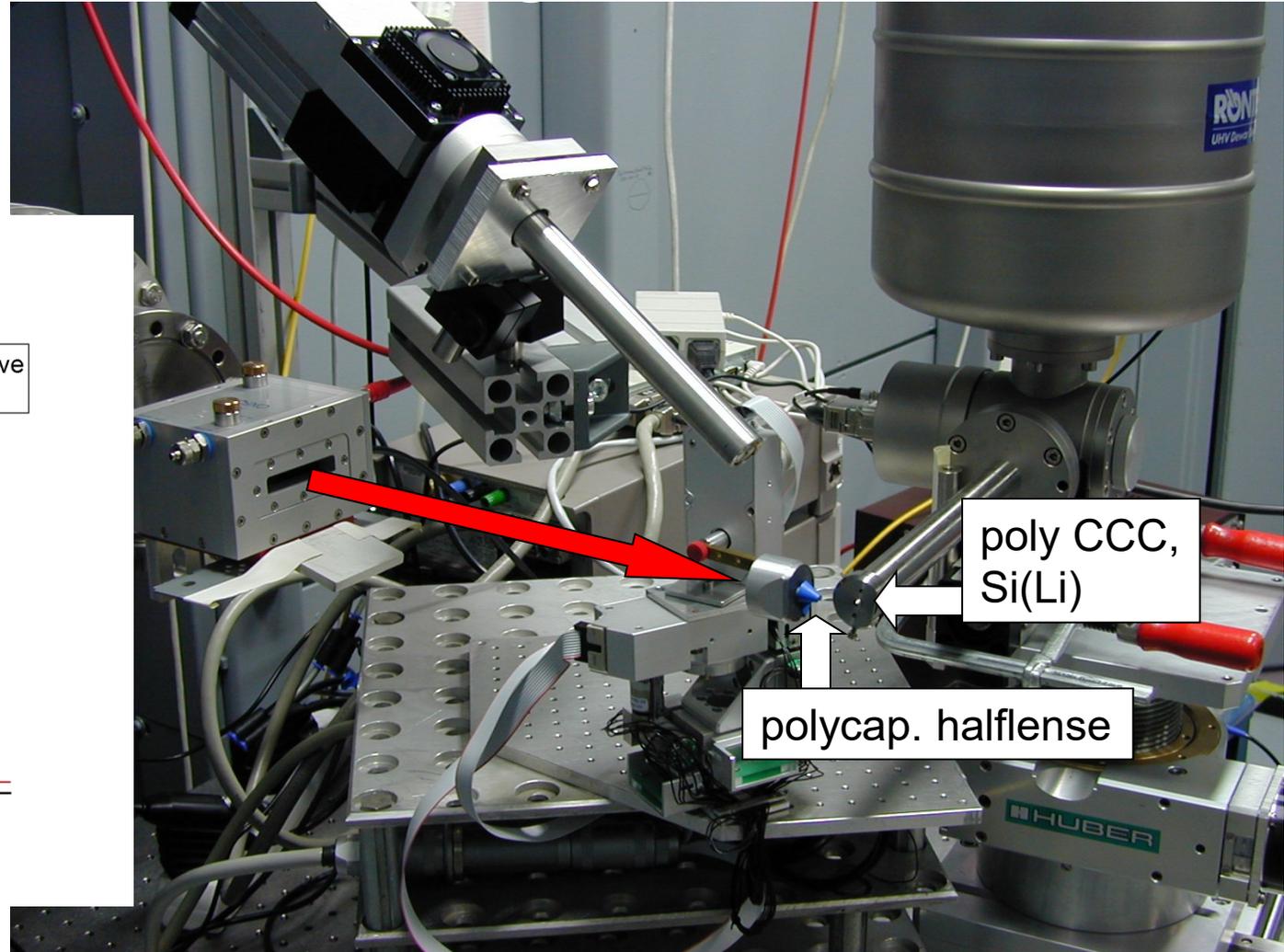
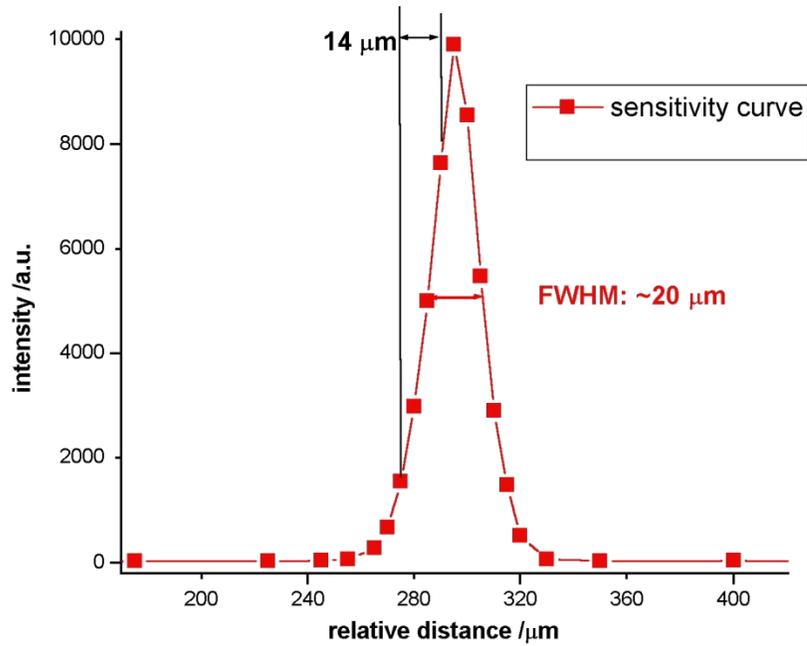
3D Micro XRS Spectrometer



B. Kanngießner at μ -spot BAM Line (BESSY)

3D Micro XRS Spectrometer

B. Kanngießner at μ -spot BAM Line (BESSY)



The HESEB Soft X-ray Beamline

- Soft x-ray beamline needs to become an integral part of SESAME's suite of beamlines / instruments, contributing successfully to the scientific output of the facility
- The operation of the basic beamline (soft X-ray absorption with variable polarization light) has to be completely funded by SESAME
- Form a CRG (collaborative research group) „business model“ at SESAME (cf. ESRF, ILL, ...) for expansion/additional capabilities
- A CRG would have certain amount of entitled access time, remaining part is given to public use (after peer review)
- Turkey as a SESAME Member together with collaborating partners can form a CRG to provide additional (XPS-)endstations and operational staff for instruments
- Science Partners from Jordan and TU Berlin

Thank you