HESEB Helmholtz-SESAME Soft X-Ray Beamline für SESAME

HESEB Beamline

Introduction and Science

Wolfgang Eberhardt
DESY

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

SESAME

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

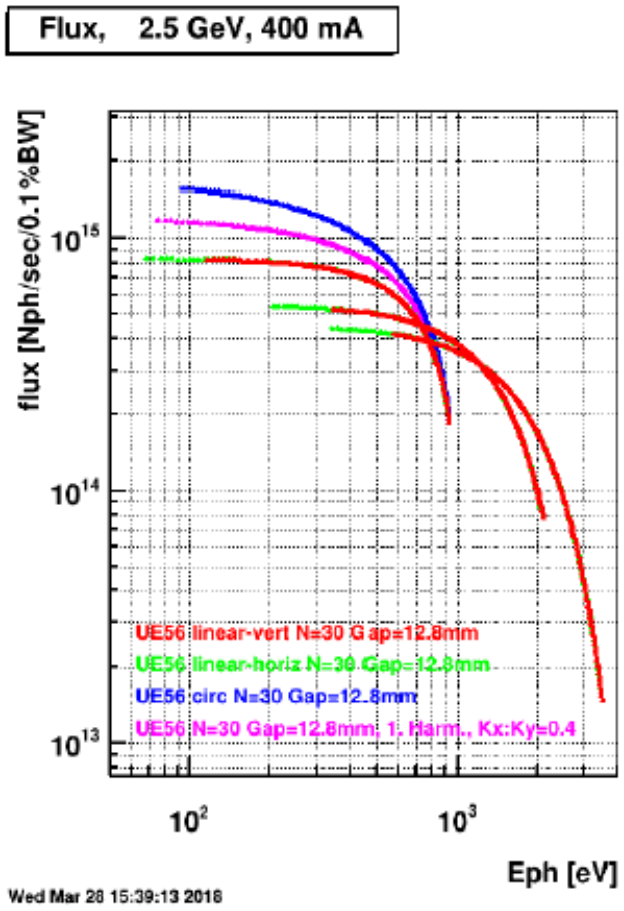
The HESEB Soft X-ray Beamline

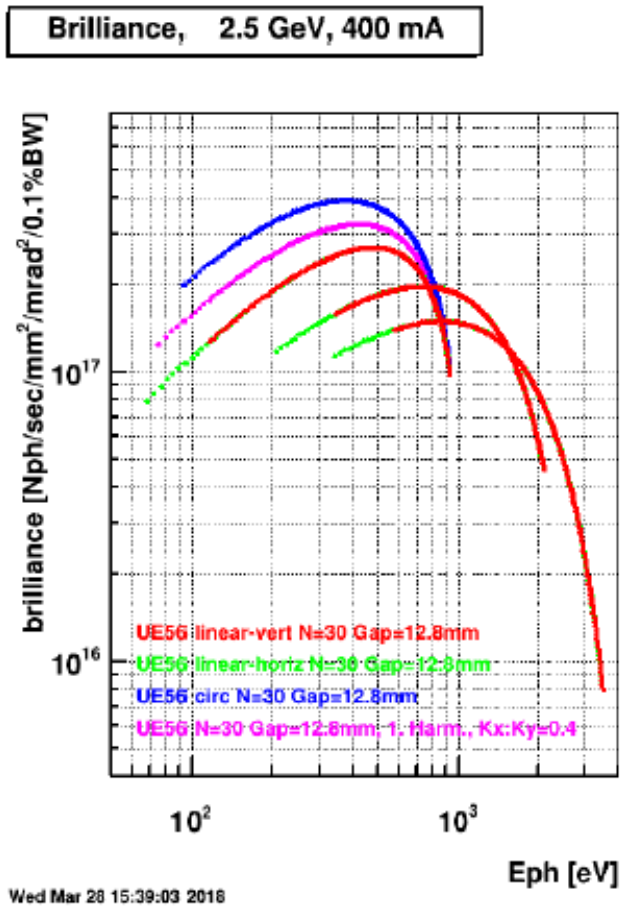
Funded by the Helmholtz Gemeinschaft : Start January 2019-----4 years duration----- 3.5 M €

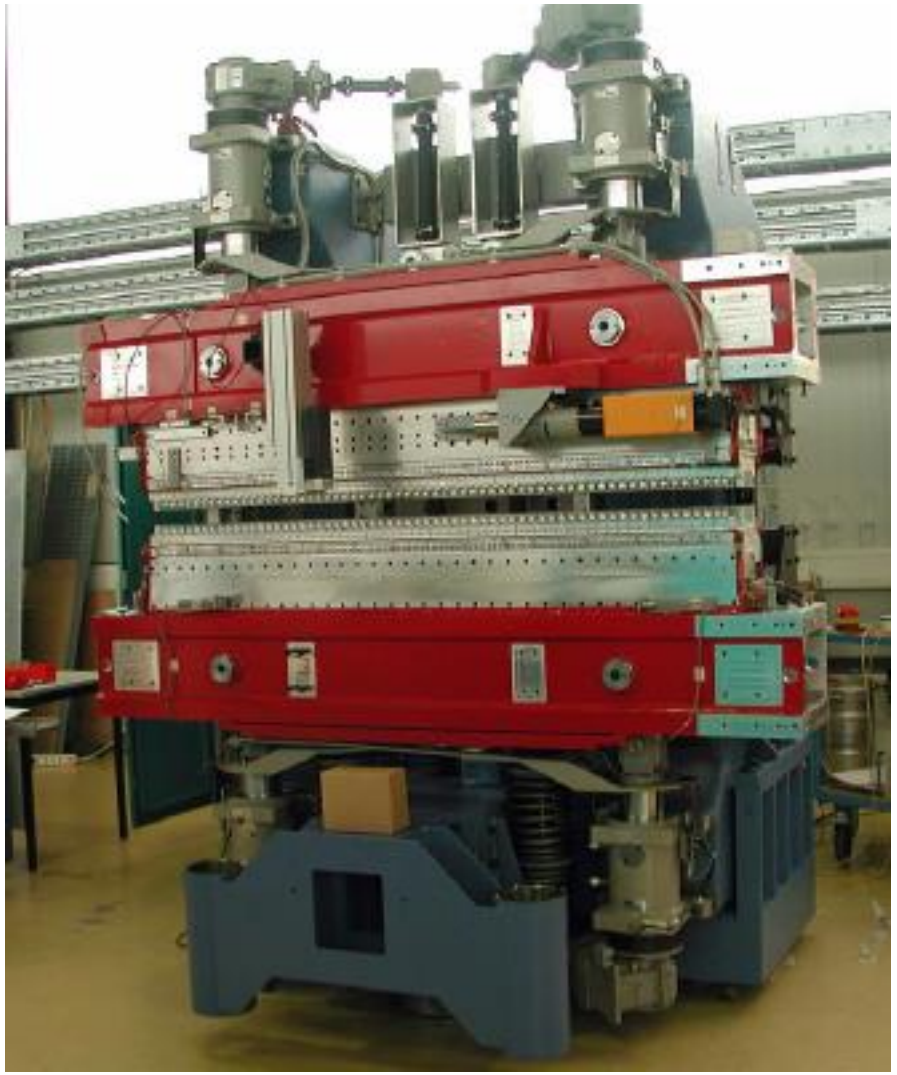
- **Variable polarization undulator based soft X-ray beamline dedicated to enable advanced photoemission/spectroscopy experiments**
- **Helmholtz consortium provides beamline in basic version: (absorption spectroscopy with polarized soft X-rays)**
  - Additional Instrumentation/endstations should come 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 (PGM)
  - ‚off-the-shelf‘ – procurement and installation through manufacturer: FMB (Berlin)

HESEB Beamline

Undulator UE56 with variable polarization







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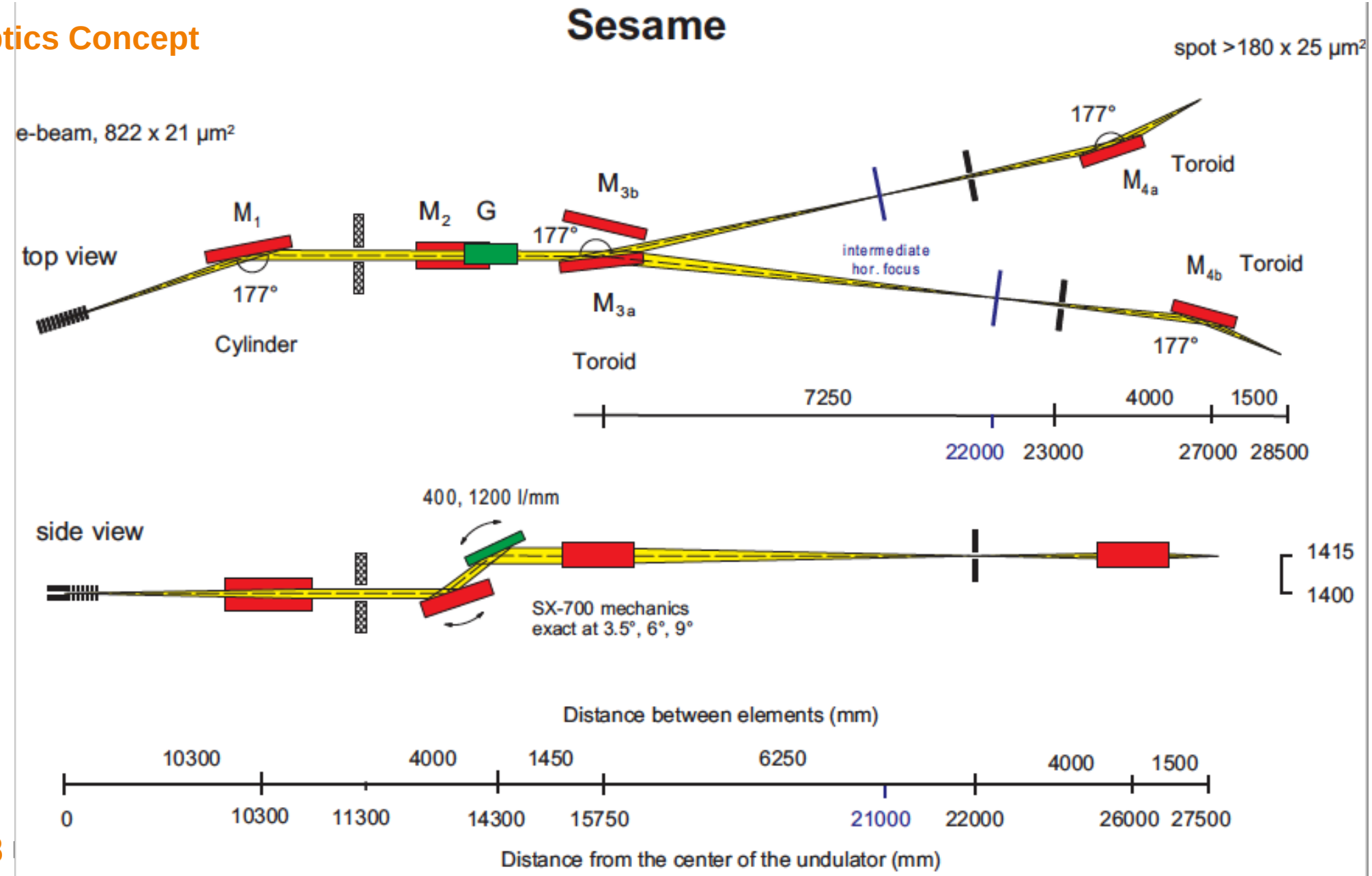
Optics Concept



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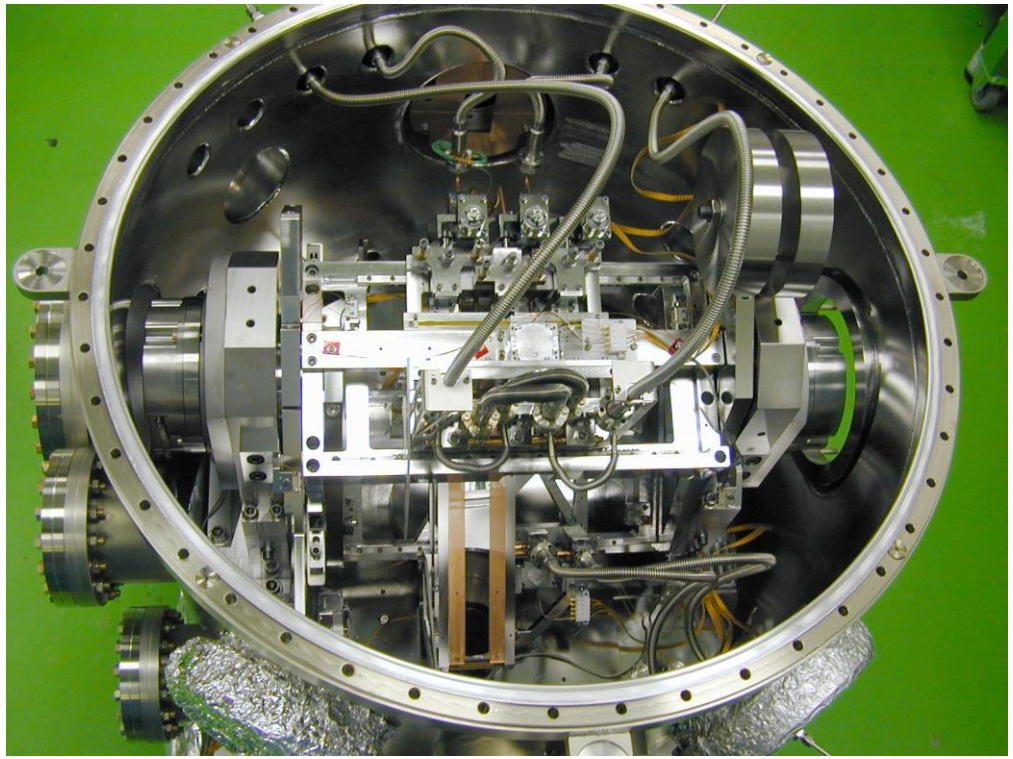
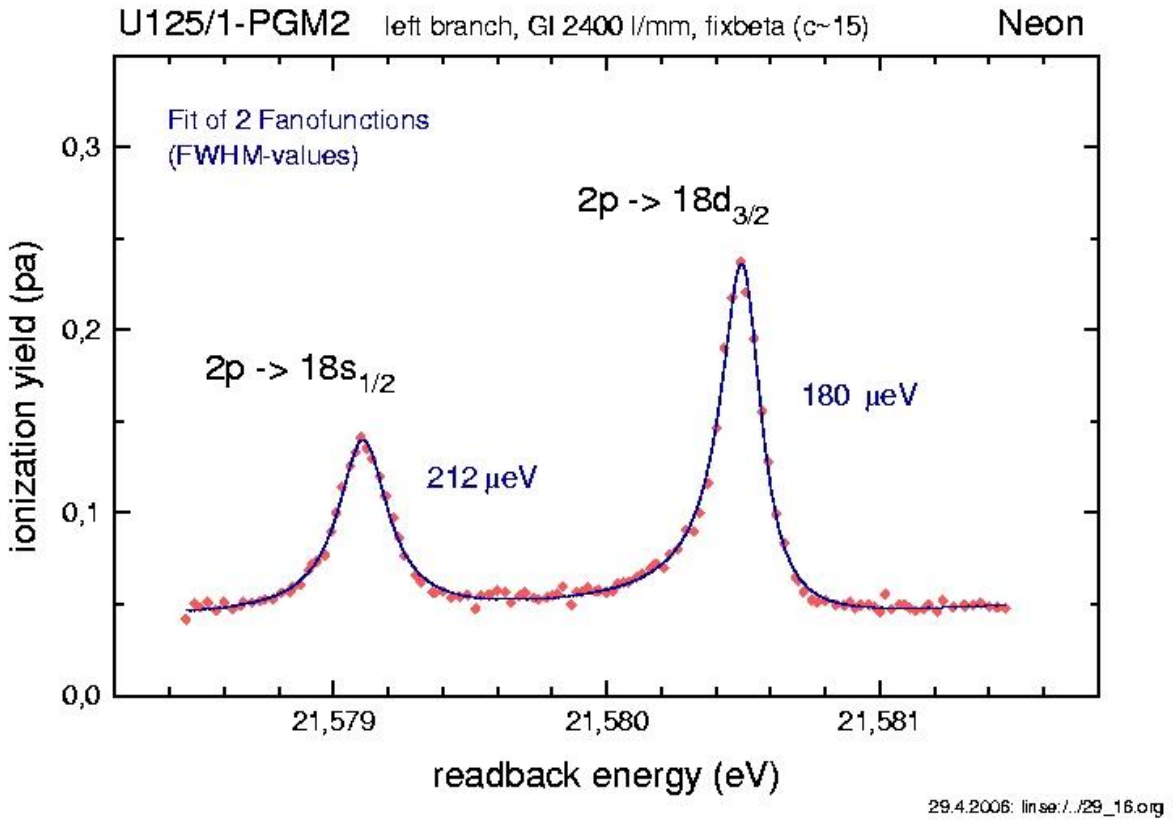
PGM Monochromator

Optics Design by BESSY
Manufactured by ZEISS, JENOPTIK, FMB
for a worldwide market





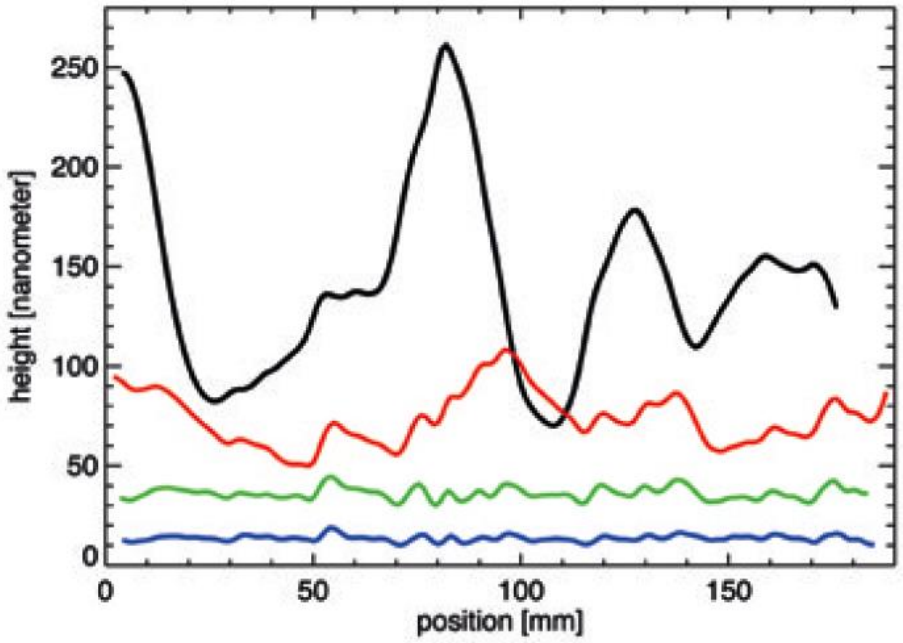
Resolution of 180 µeV
$E/\Delta E = 1.2 * 10^5$

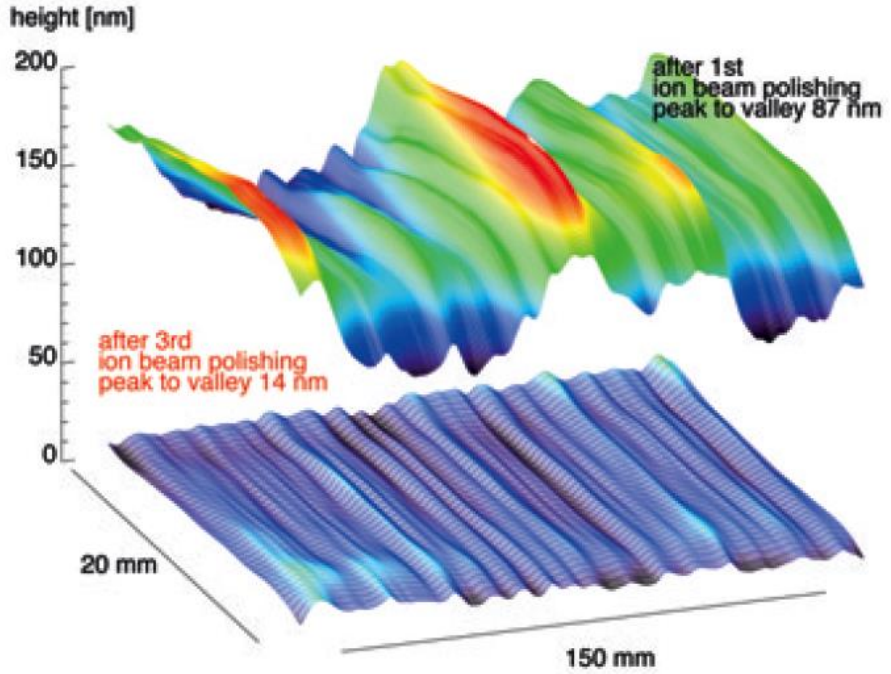
HESEB Beamline

Nanometer Optics Metrology at HZB

2D profiling of optical surfaces

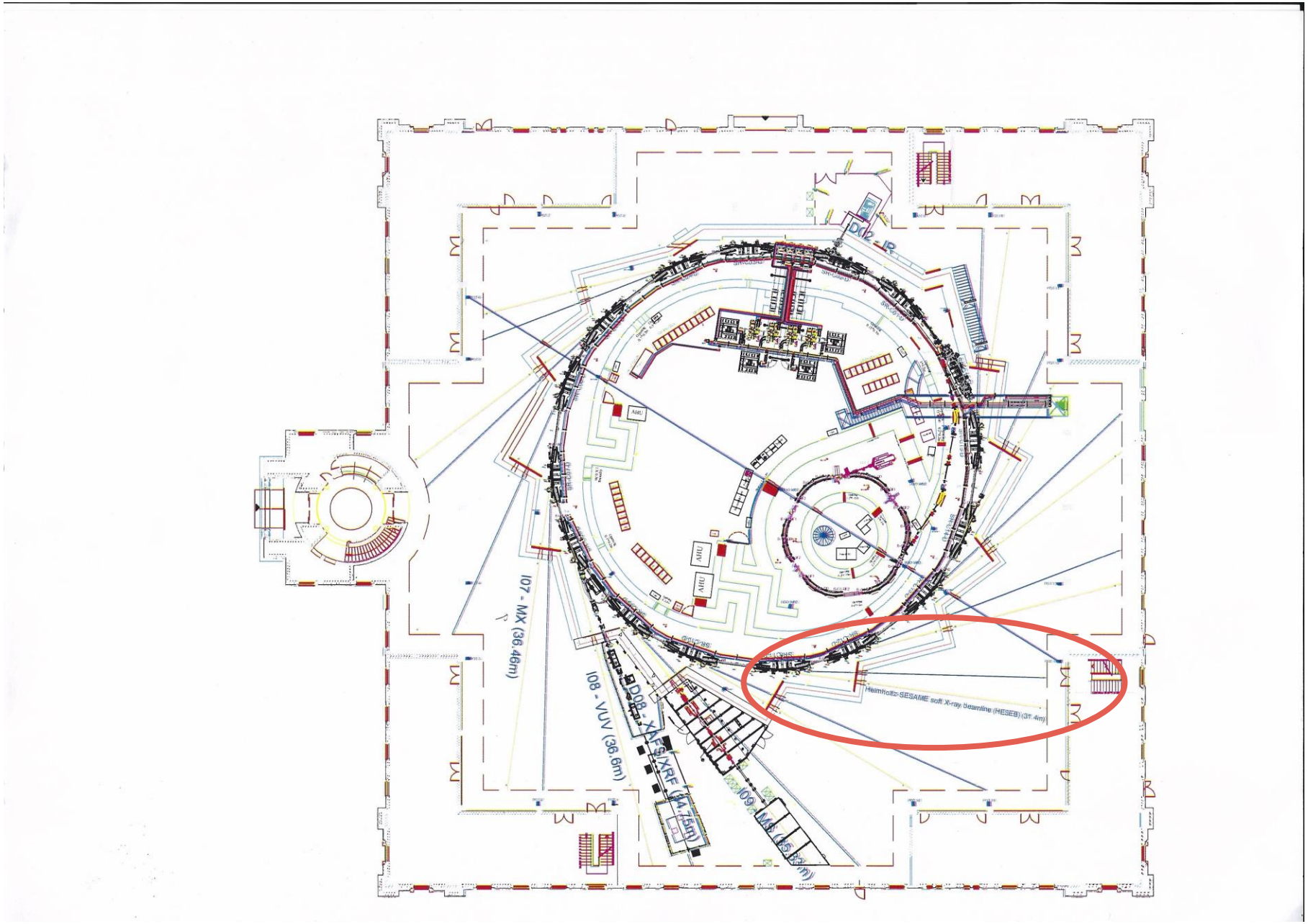
With a precision of an order of magnitude better than industry (ZEISS)





SESAME

Floor Plan



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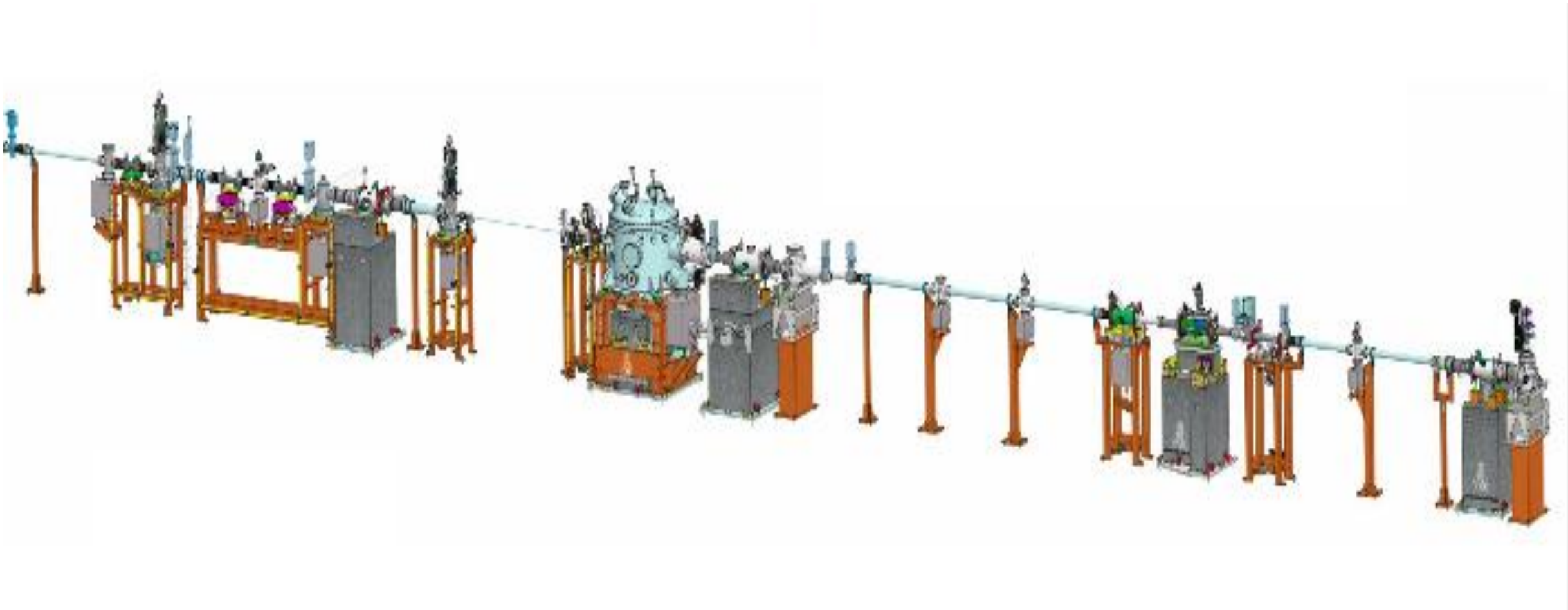
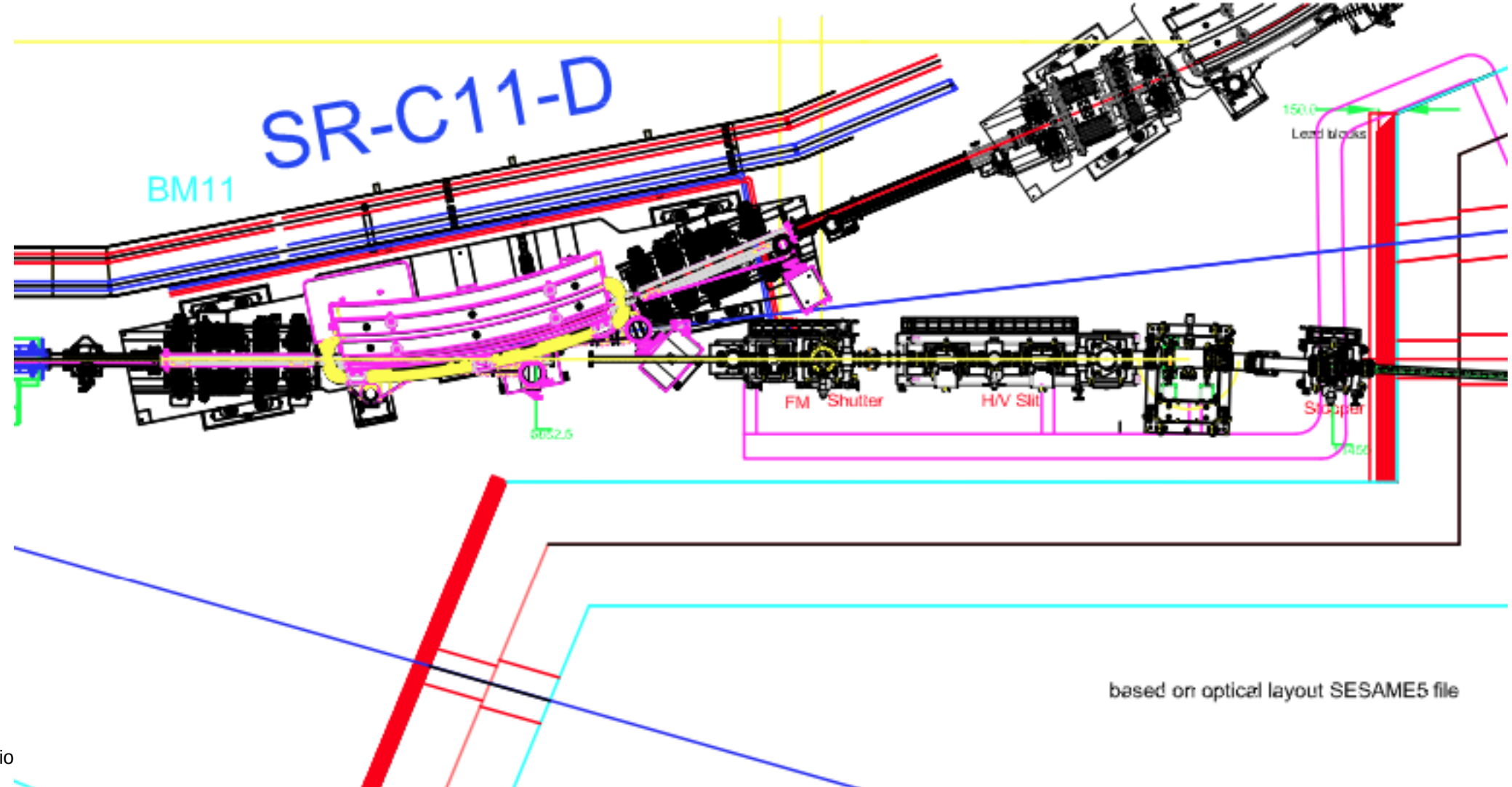
Beamline Final Design



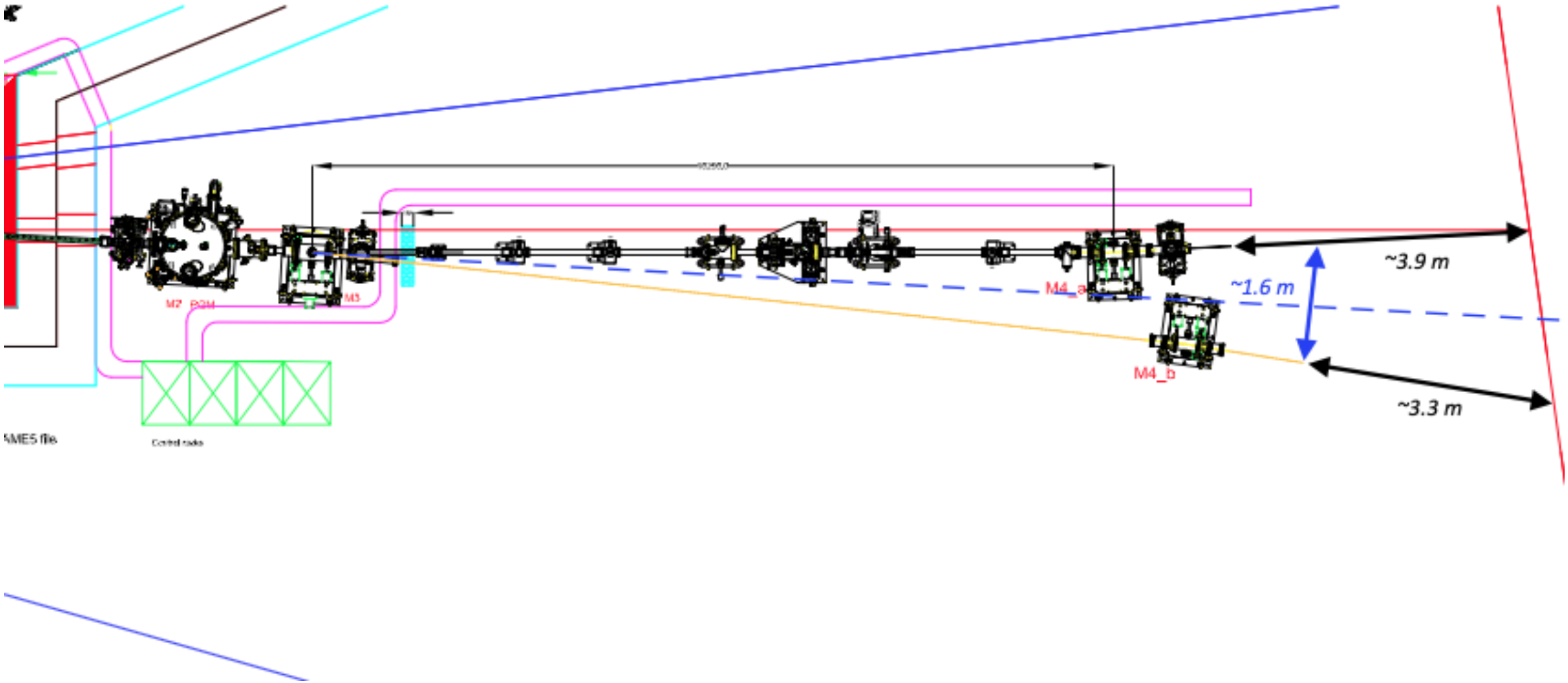
HESEB Beamline

Beamline Layout



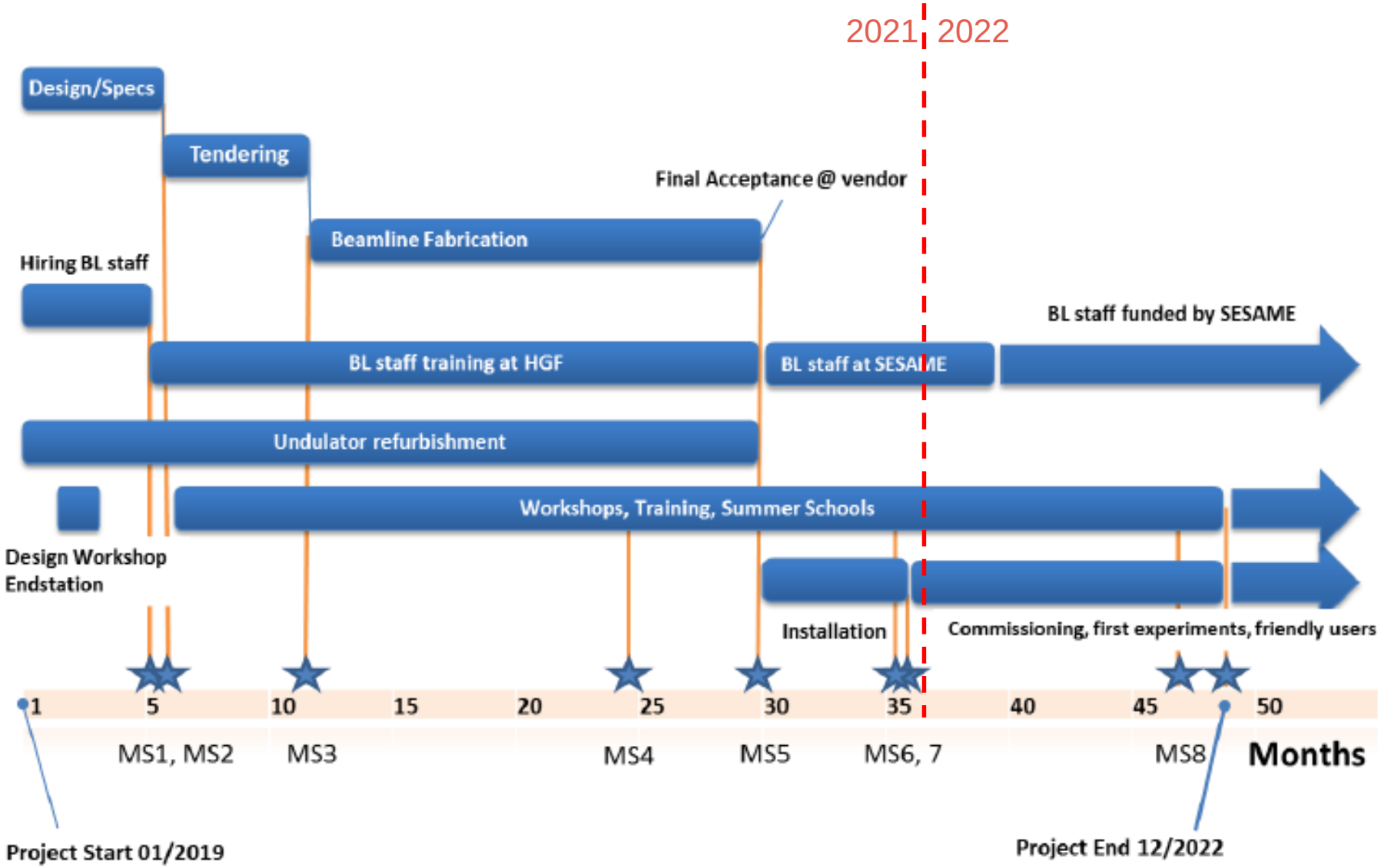
HESEB Beamline

Beamline Layout



HESEB Beamline

Project Time Plan



Soft X-ray Science Examples

Soft X-rays ➔ High Resolution Spectroscopy

Covers the core edges:

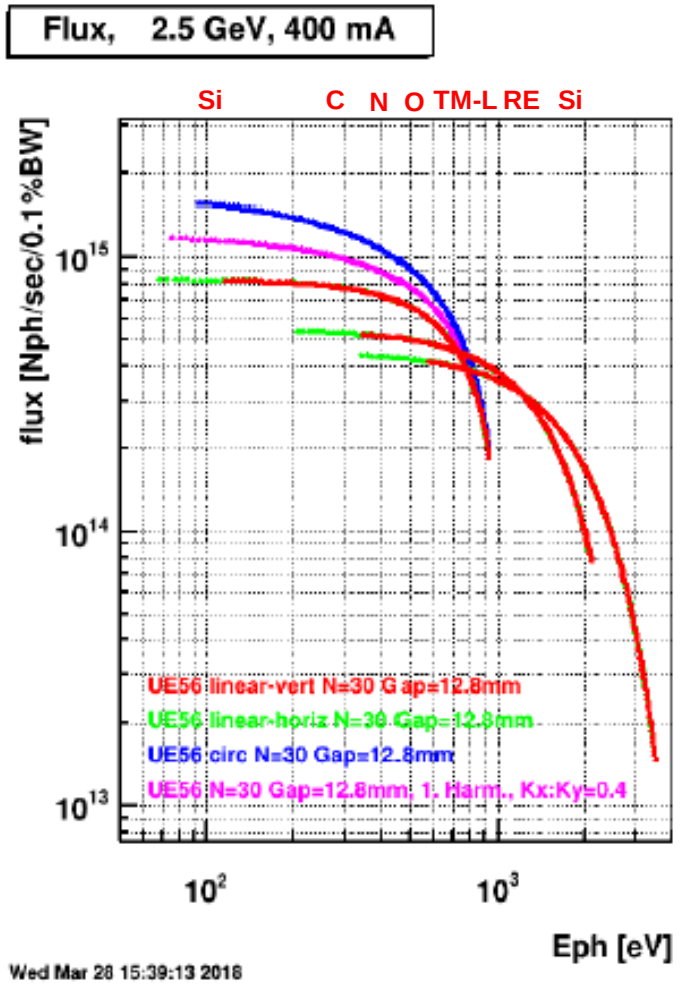
Si L-edge—semiconductors

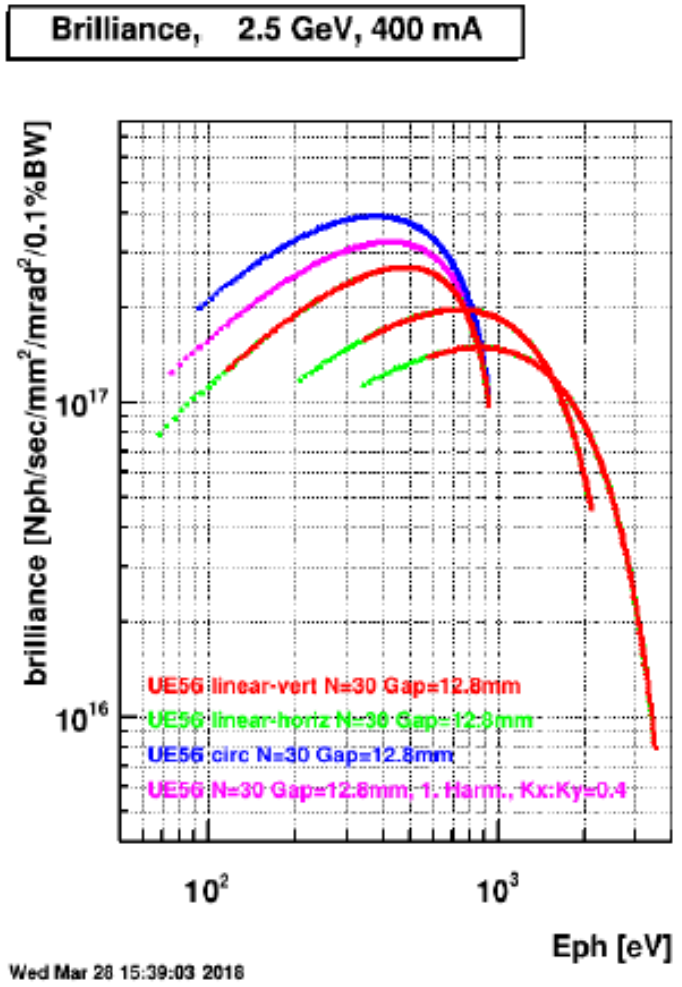
C-, N-, O- Kedge
Organics catalysis

TM-L-edges magnetics

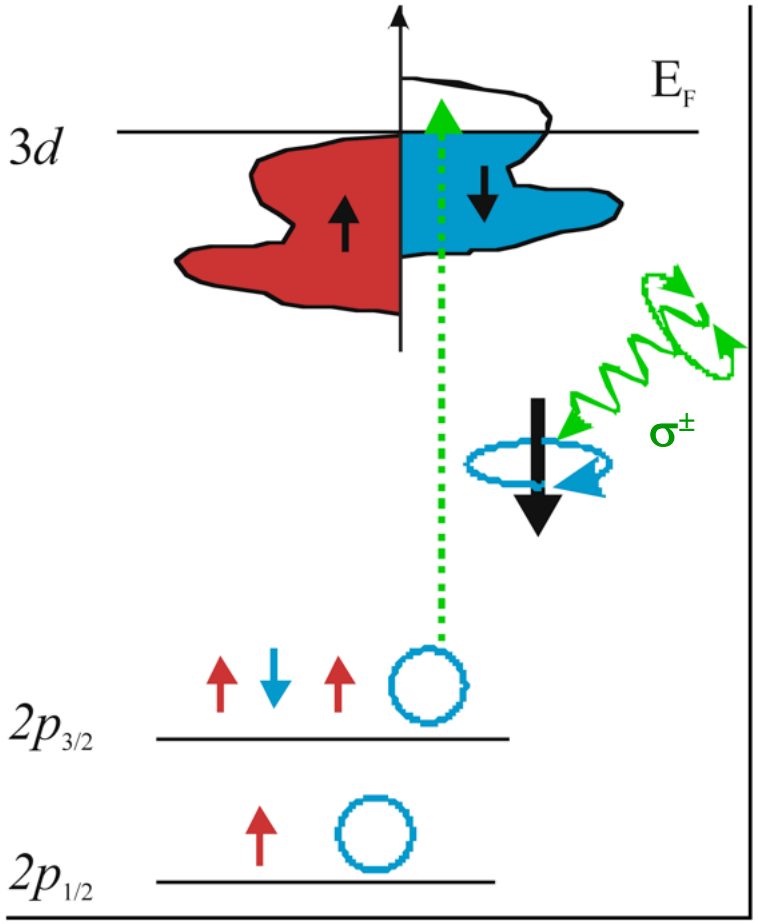
RE 3d edges magnetics

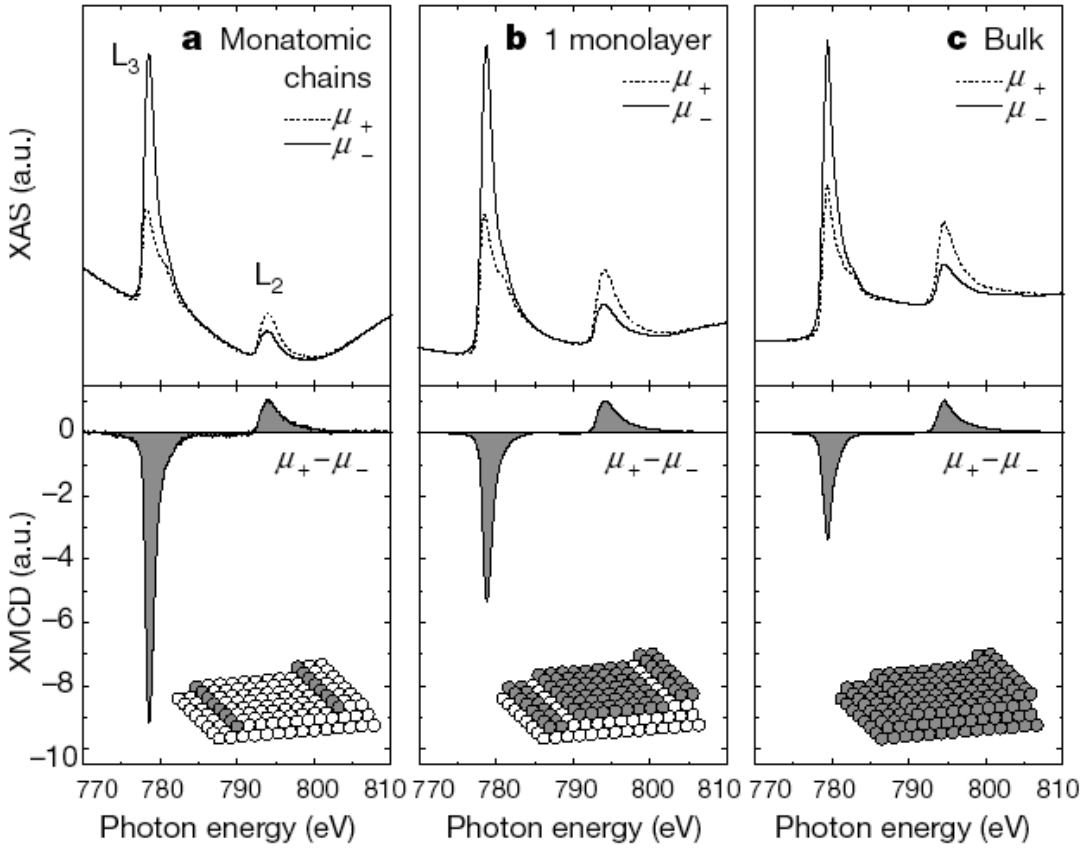
Al- K-edge, Si-K-edge





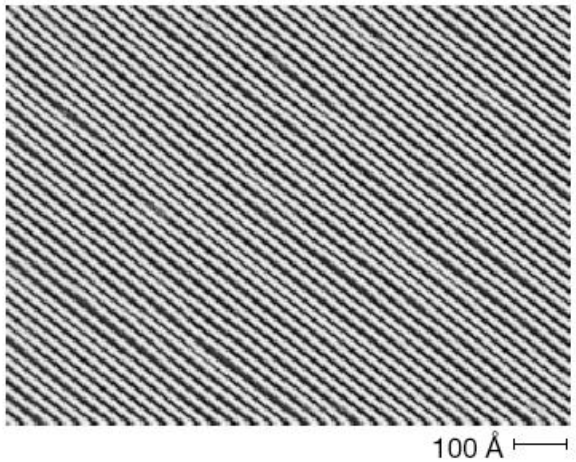
Magnetic Systems ➔ CMXD

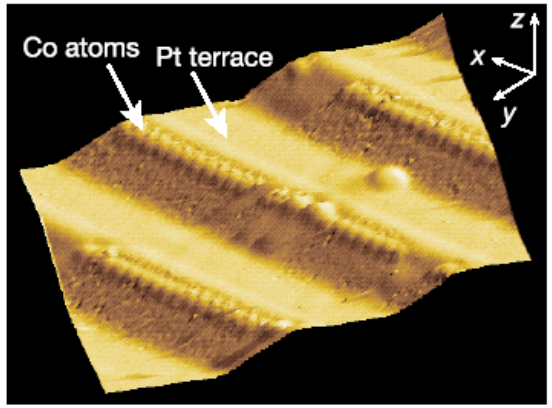


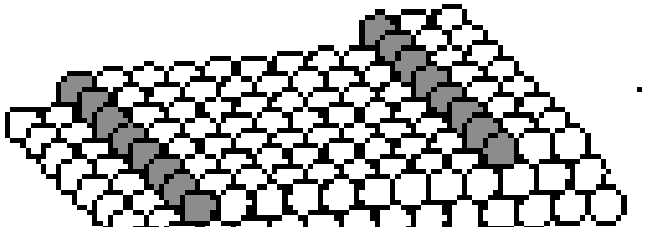


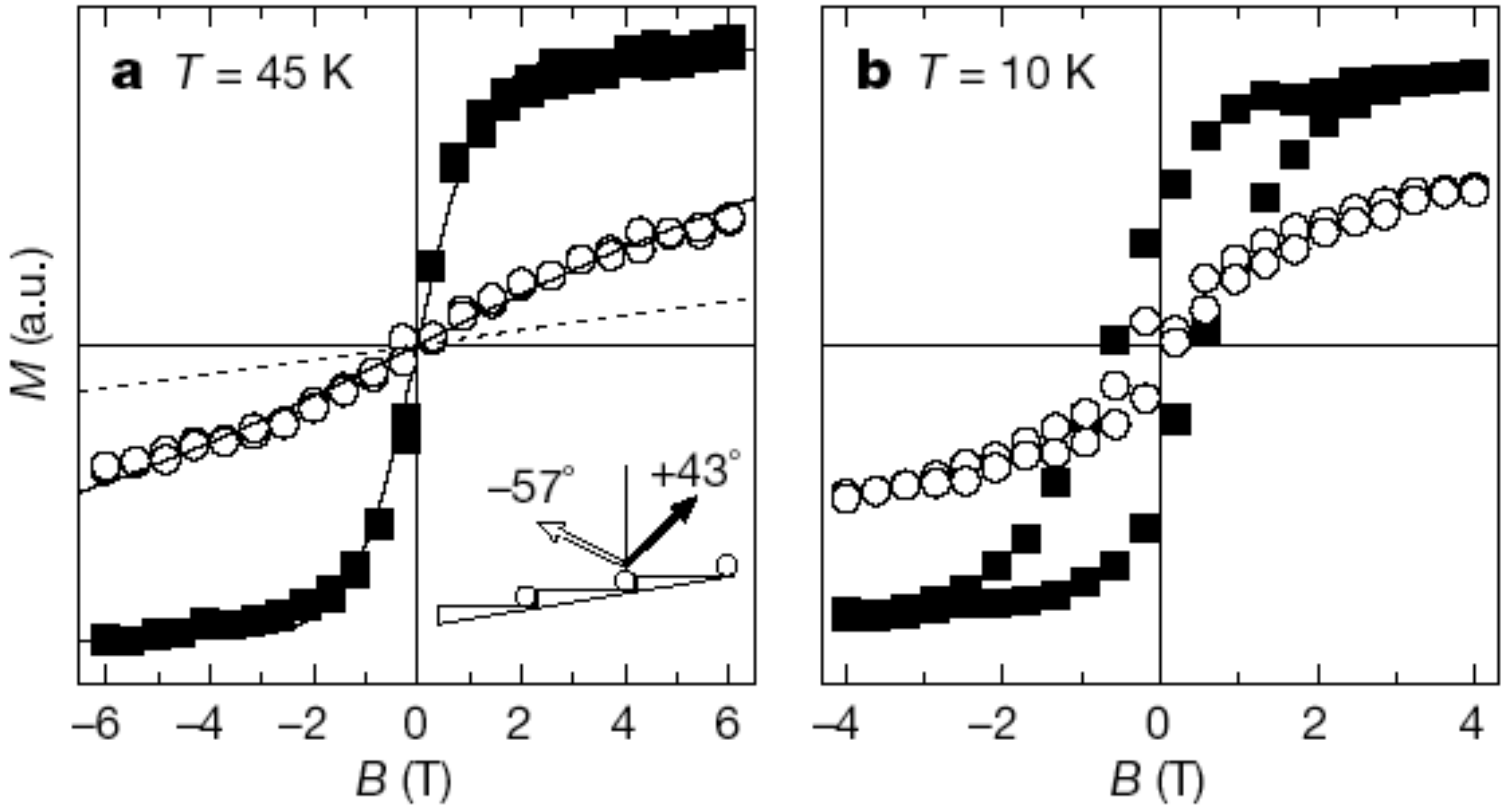
P. Gambardella, A. Dallmeyer, K. Maiti, M. C. Malagoli, W. Eberhardt, K. Kern, C. Carbone, **Nature 416**, 301 (2002)

Magnetic Systems ➔ Co mono-atomic chain on Pt



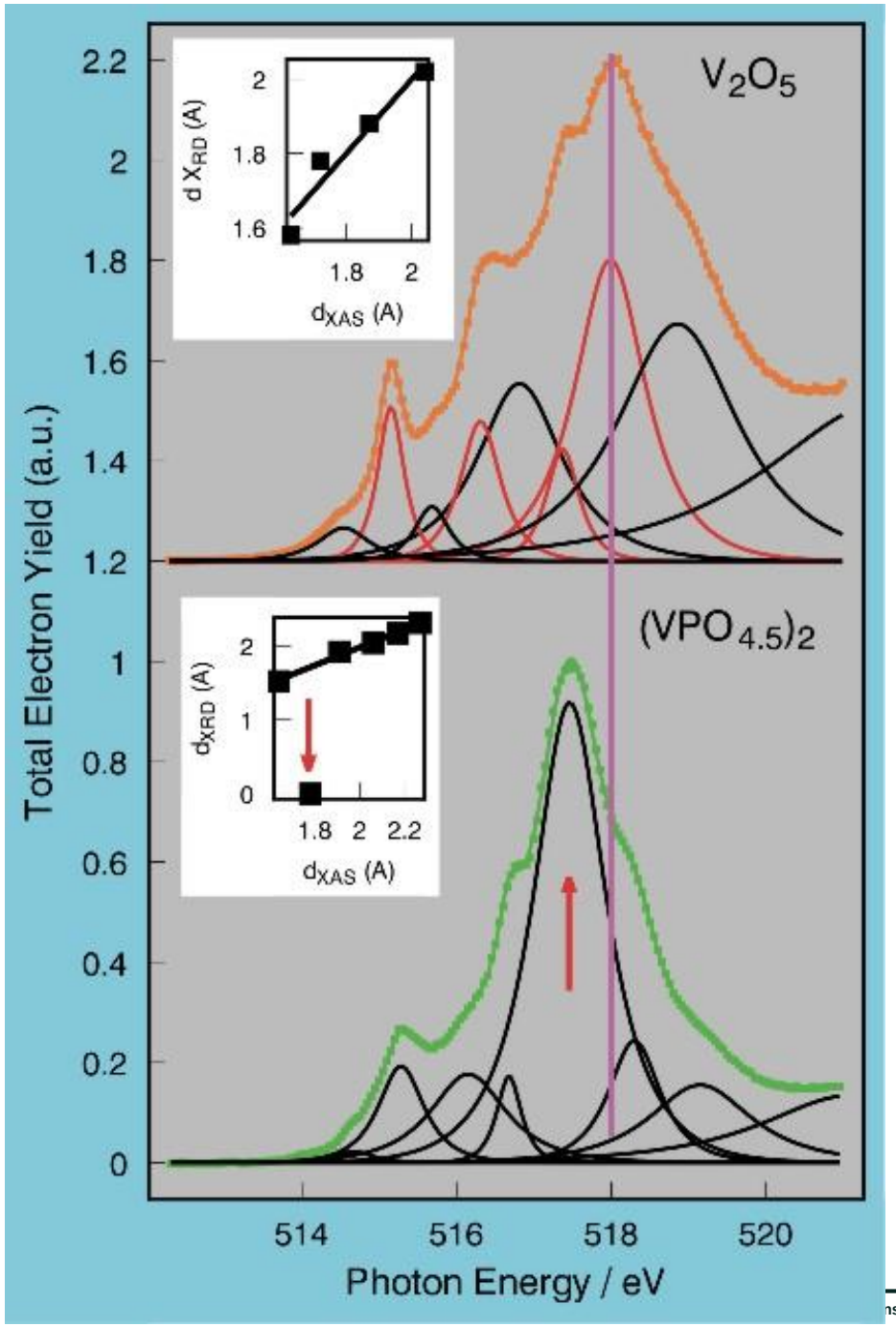






P. Gambardella, A. Dallmeyer, K. Maiti, M. C. Malagoli, W. Eberhardt, K. Kern, C. Carbone, **Nature 416**, 301 (2002)

Spectroscopy of catalysts under process conditions

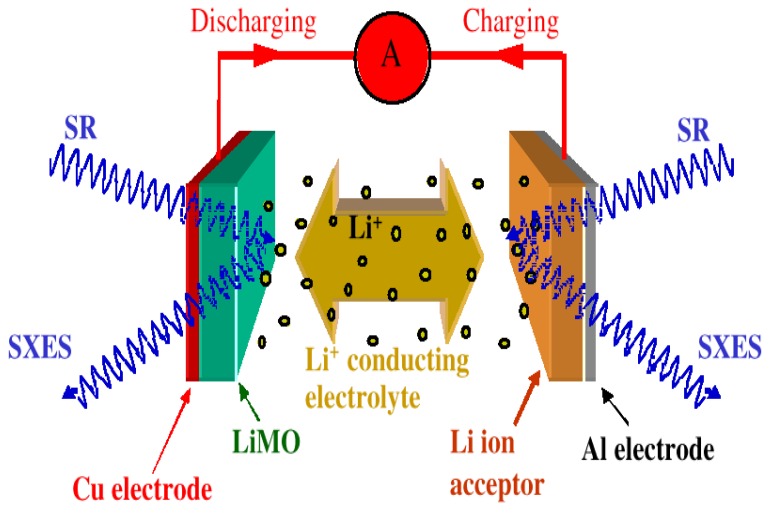


Methane oxidation using a vanadium oxide catalyst reveals an intermediate state which is only present under reaction conditions

NEXAFS spectra of catalysts during chemical reactions

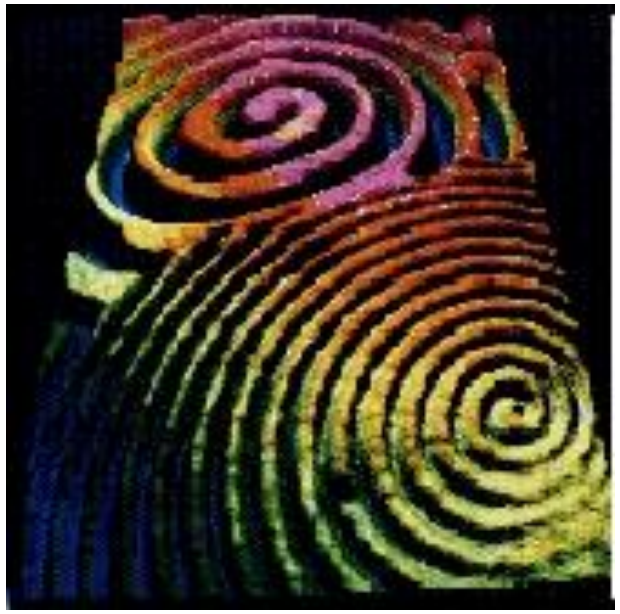
M. Hävecker, R.W. Mayer, A. Knop-Gericke, R. Schlögl (FHI Berlin)

Soft X-rays ➔
In-situ process monitoring using all photon related spectroscopies



Spectroscopy of battery electrodes under operational conditions

Electrochemistry
Corrosion
Lubrication
Catalysis



Pattern formation during a chemical reaction
G. Ertl FHI Berlin

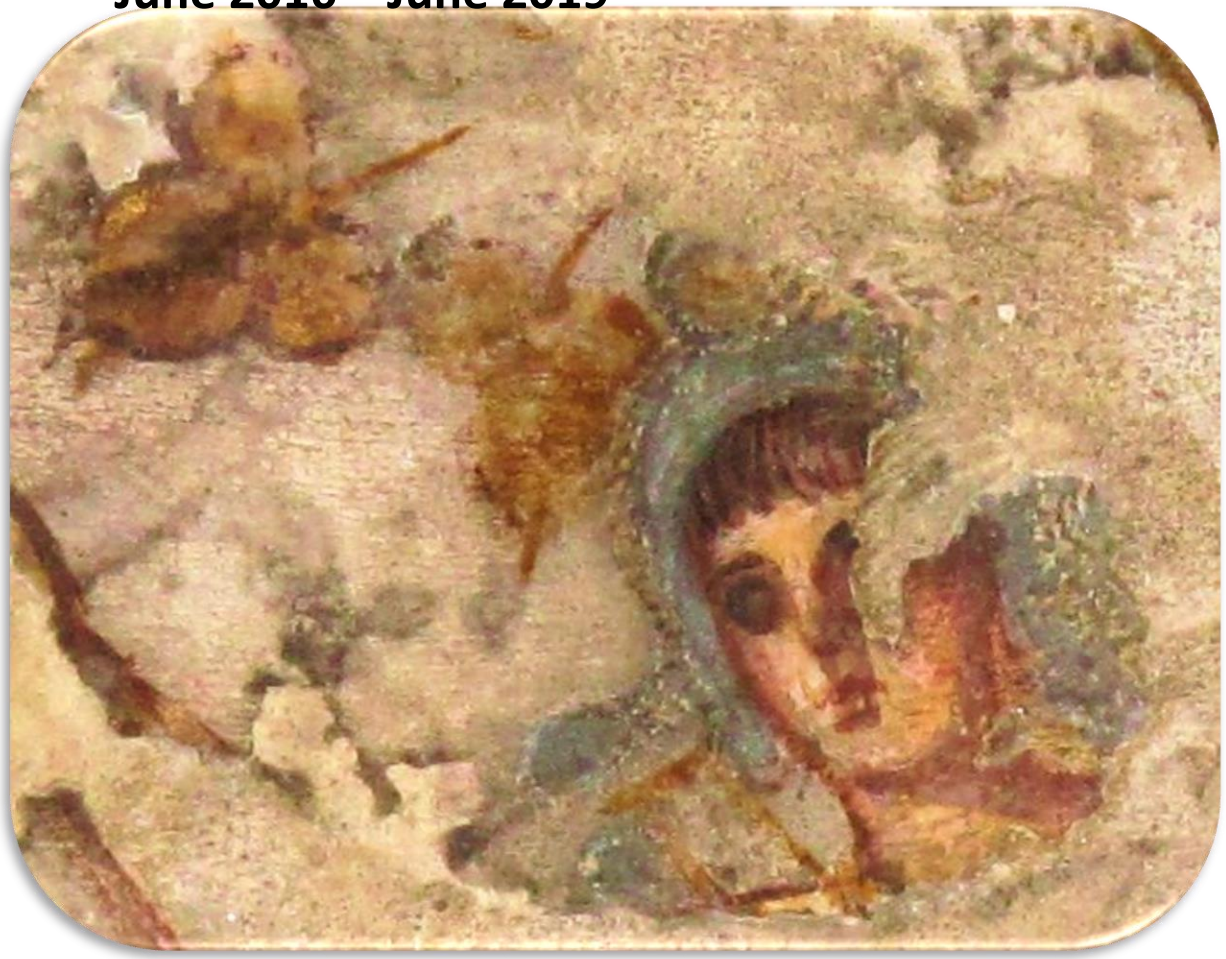
Petra Painting Conservation Project (PPCP)

Birgit Kanngießer

BLiX Berlin Laboratory for innovative X-ray Technologies

Characterisation and Conservation of Paintings on Walls and Sculpture from Nabataean Petra

June 2016 – June 2019



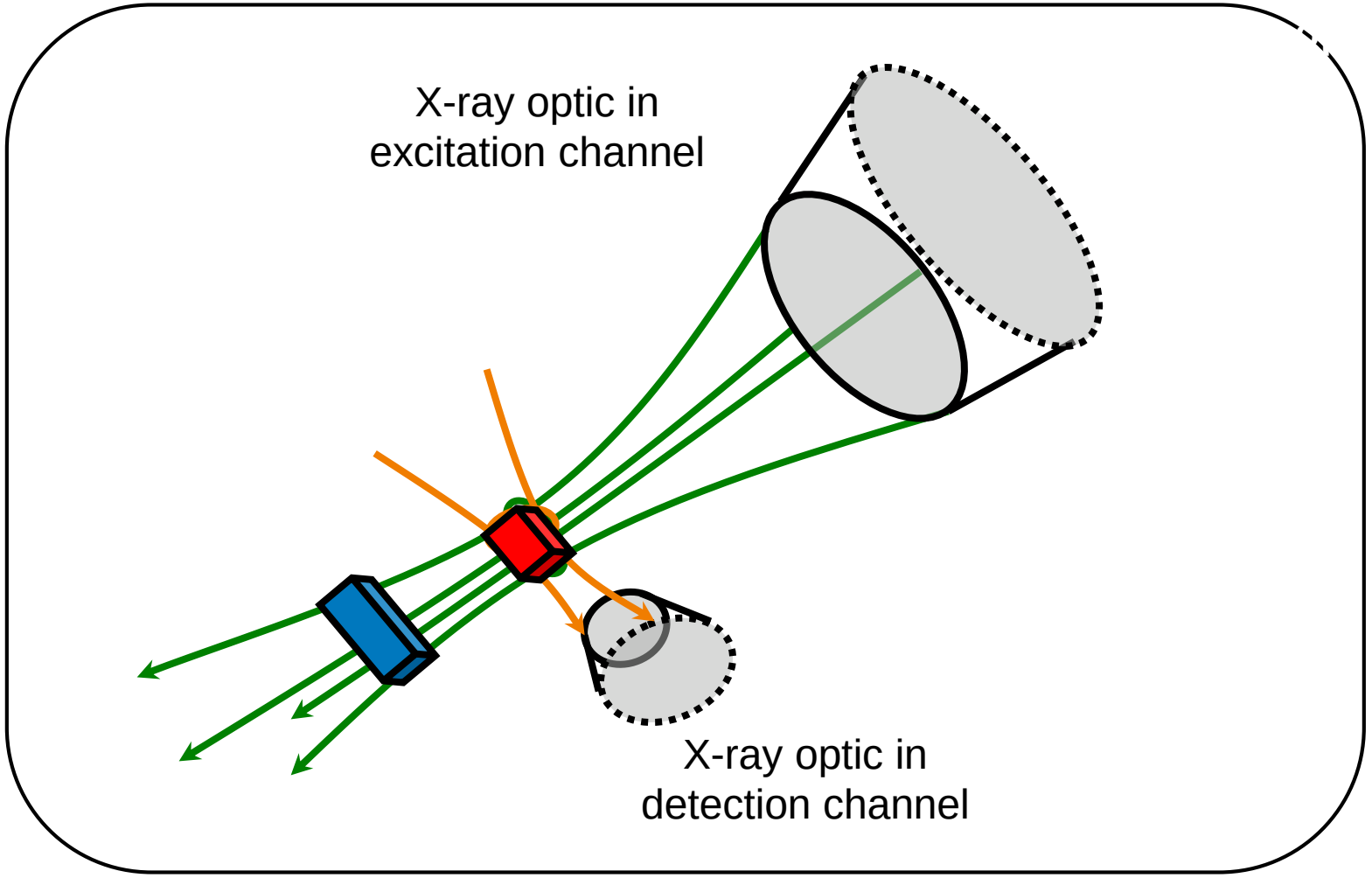
HESEB

DFG Deutsche Forschungsgemeinschaft

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

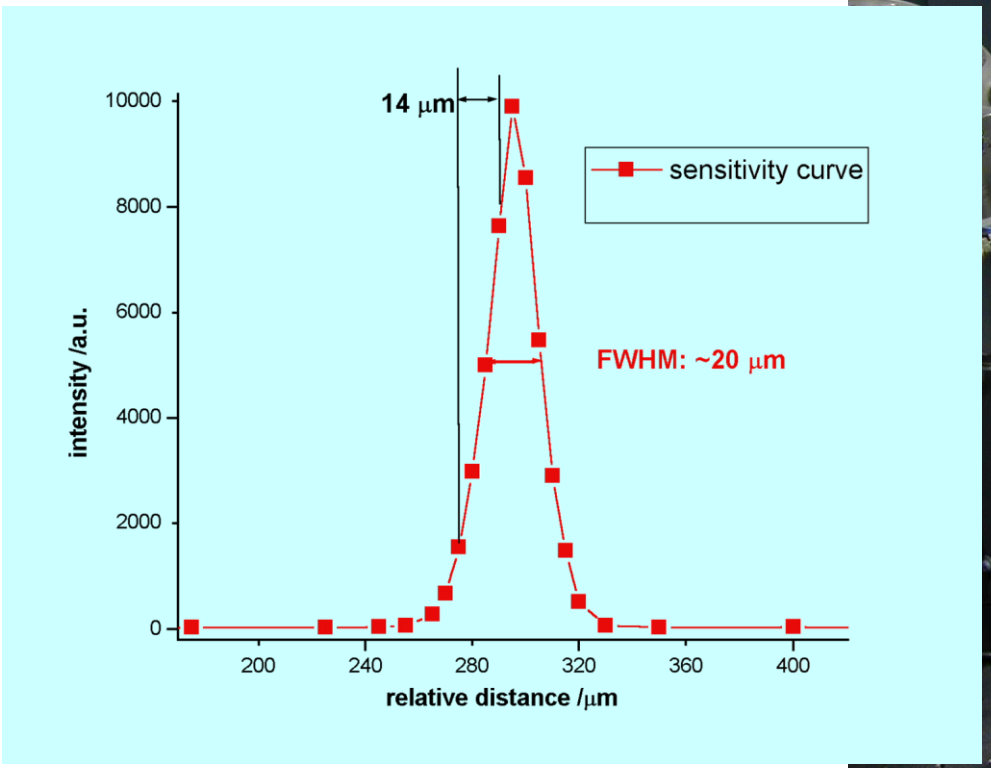
3D Micro XRS Spectrometer

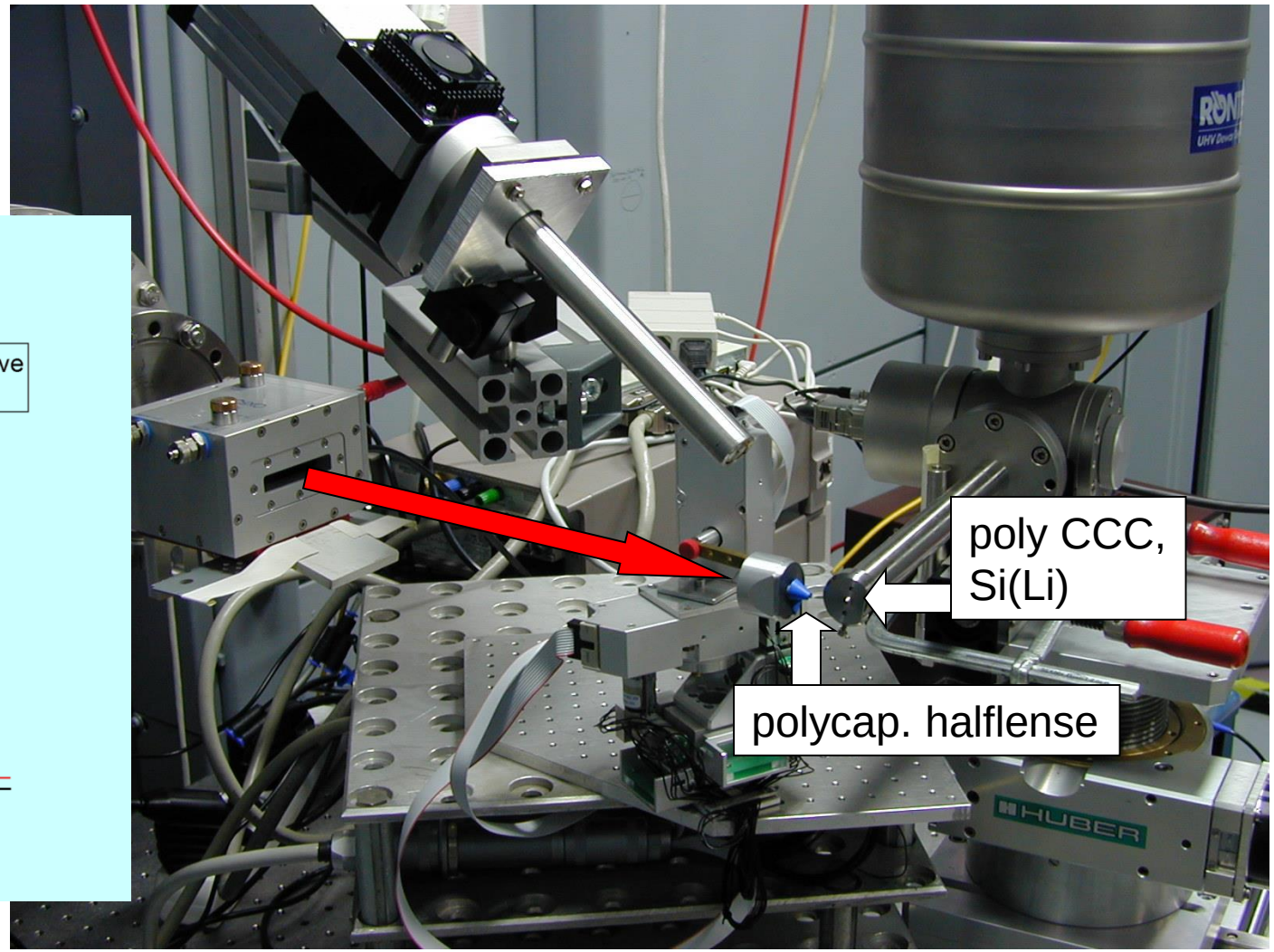


B. Kanngießer at μ-spot BAM Line (BESSY)

3D Micro XRS Spectrometer

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



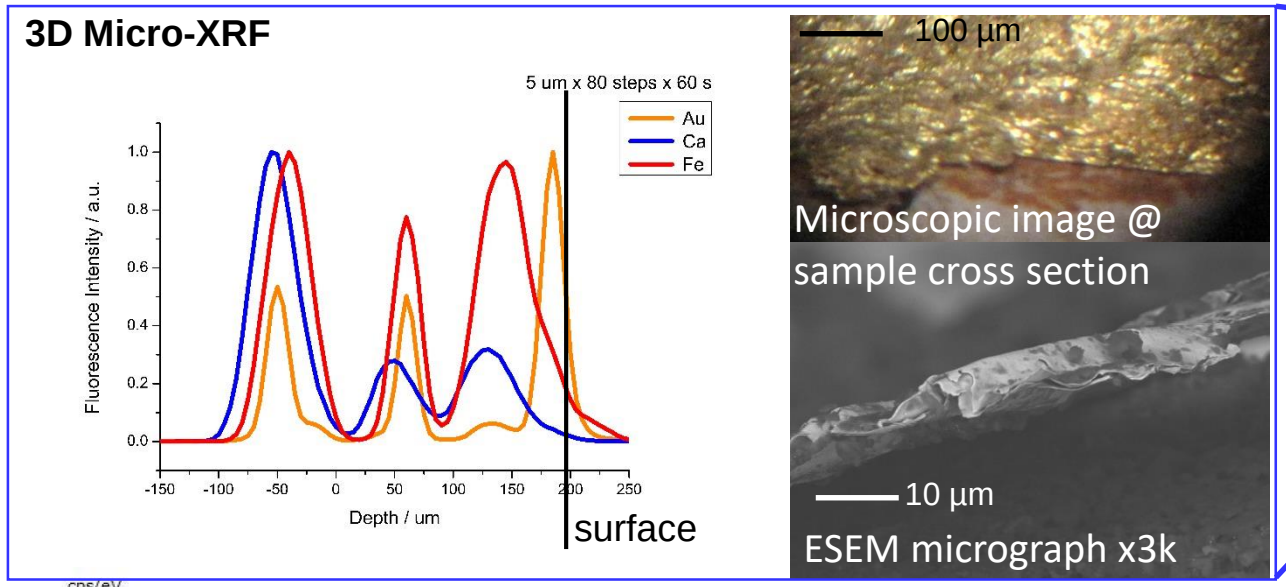


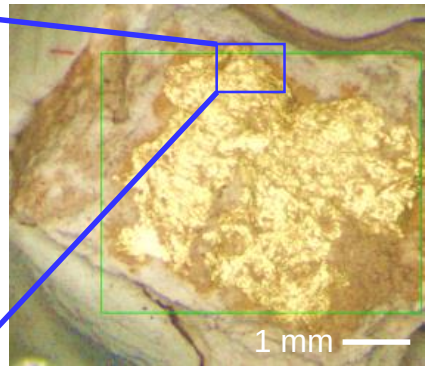
Understanding the problem

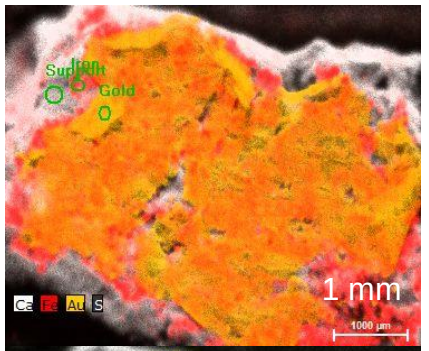
Elemental analysis

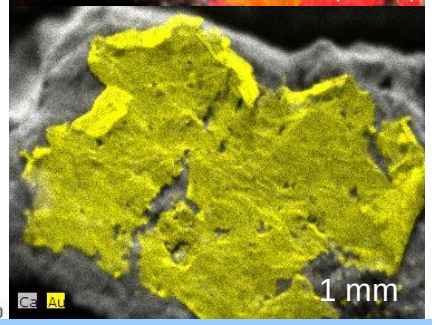
2D-µXRF (Bruker Nano): Rh Tube, 50 KeV and 600 µA. SDD Detector: <150 eV FWHM, resolution 25 µm; 45°

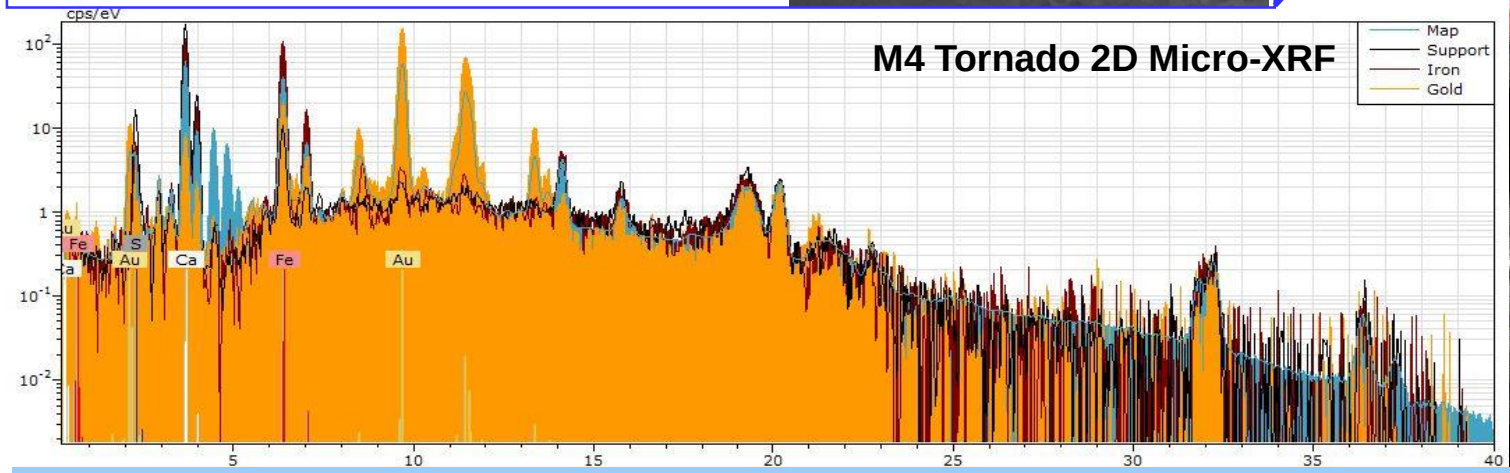
3D-µXRF (TU-Berlin): Mo Tube, 50 KeV and 600 µA. SDD Detector: <145 eV, resolution 12,9 ± 0,7µm; 45°







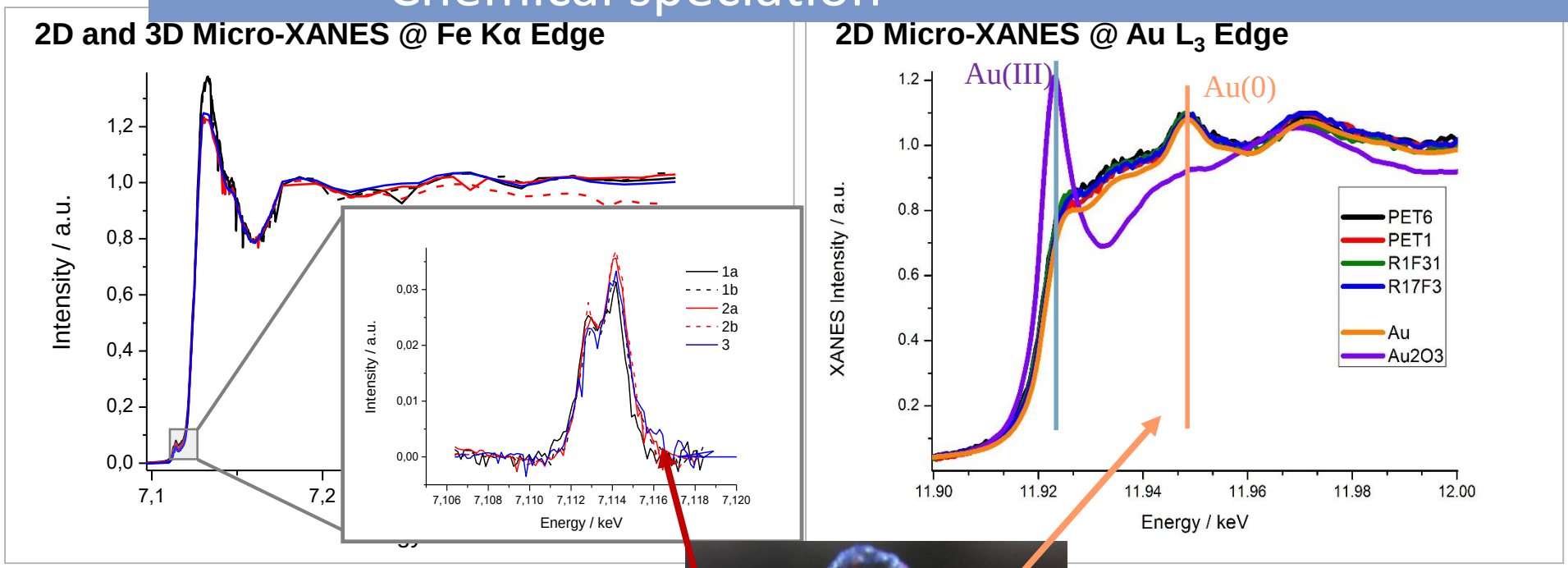




Maram Na'es, Lars Lühl, Ioanna Mantouvalo, Birgit Kanngießer

Understanding the problem

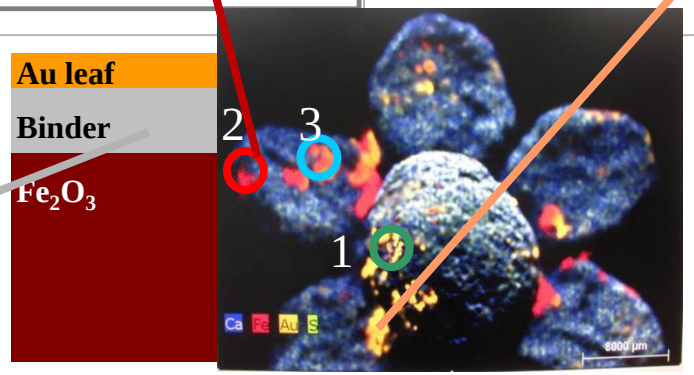
Chemical speciation



- Centro-symmetric Fe:

6-coordinated Fe^{3+} → hematite Fe_2O_3

- Fe is unaffected by Au



Features of metallic Au are present as expected

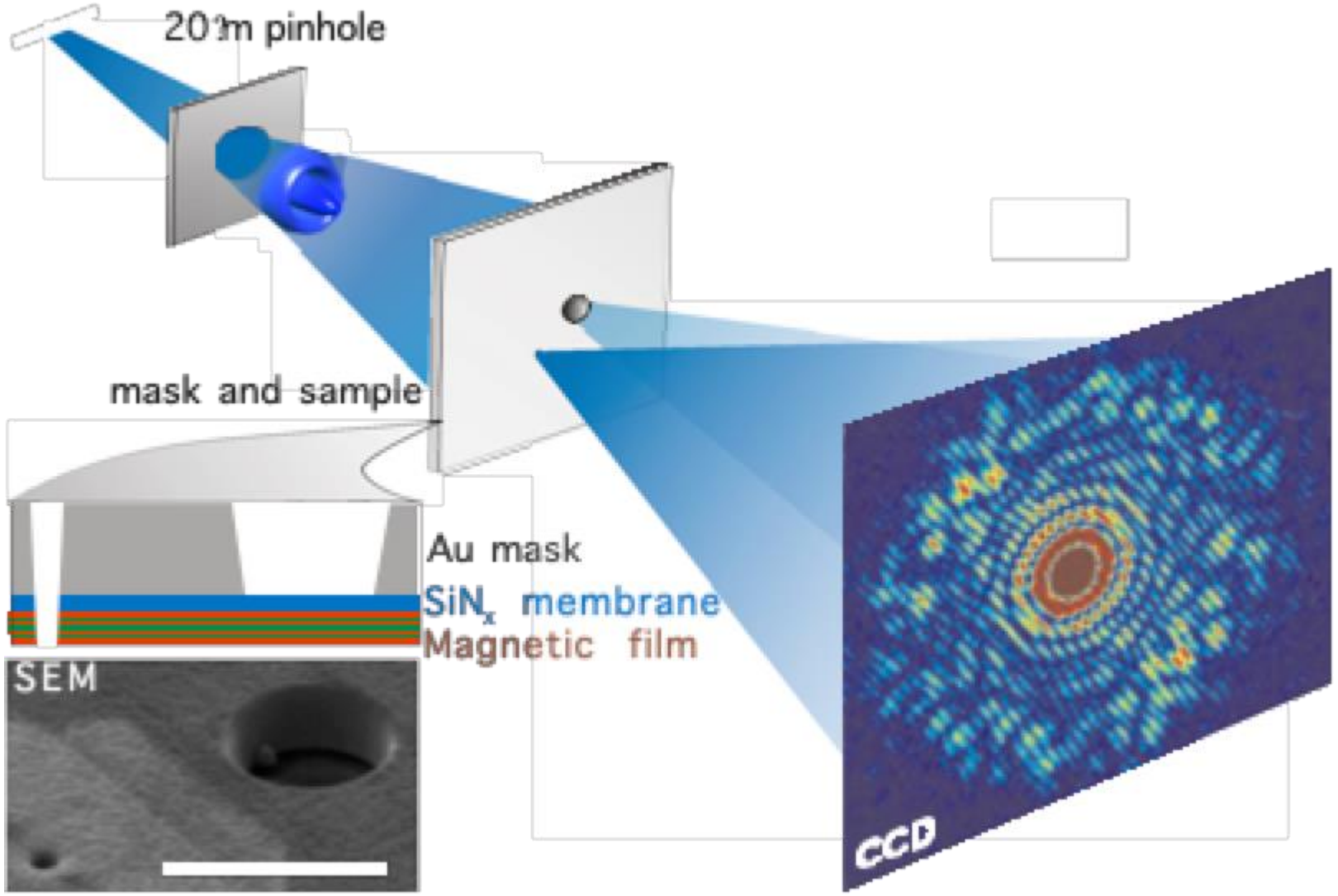
Protein based binder was reported as animal glue (collagen protein) (1;2)

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

Maram Na'es, Lars Lühl, Ioanna Mantouvalo, Birgit Kanngießer

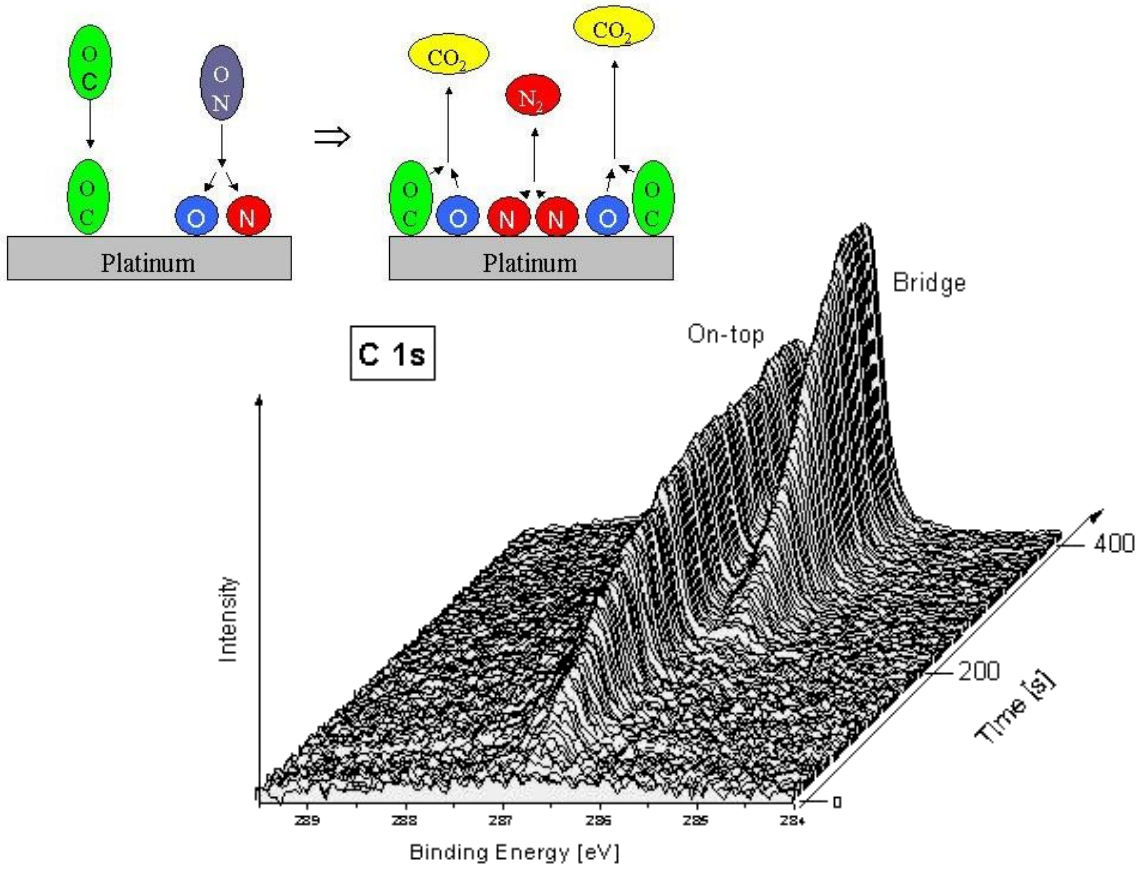
Soft X-rays ➔ Holografy with coherent X-rays

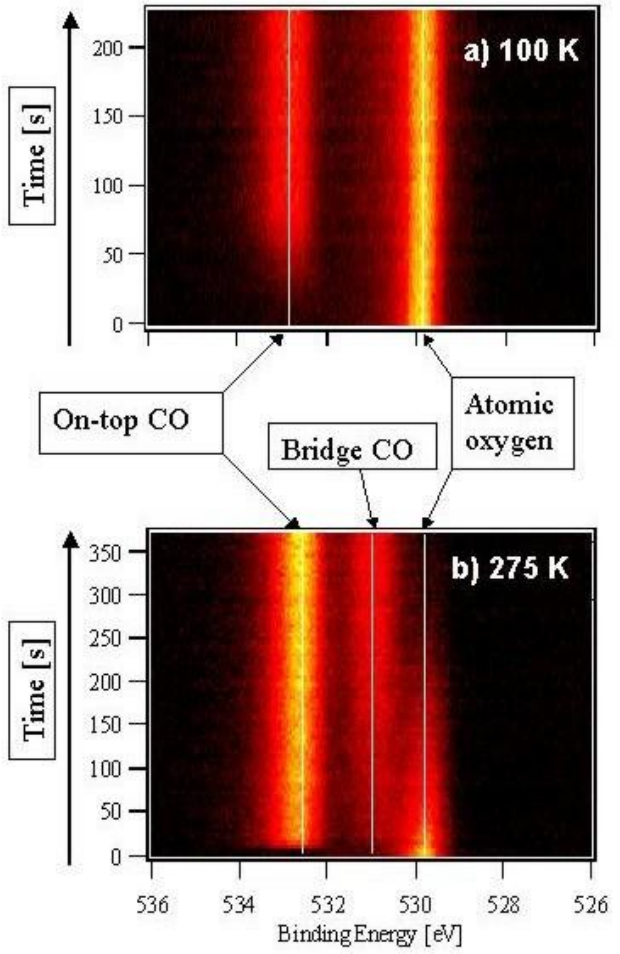


S. Eisebitt
J. Lüning
W.F. Schlotter
M. Lörgen
O. Hellwig
W. Eberhardt
J. Stöhr

NATURE **432,** 885 (2004)

Chemical reaction dynamics on surfaces



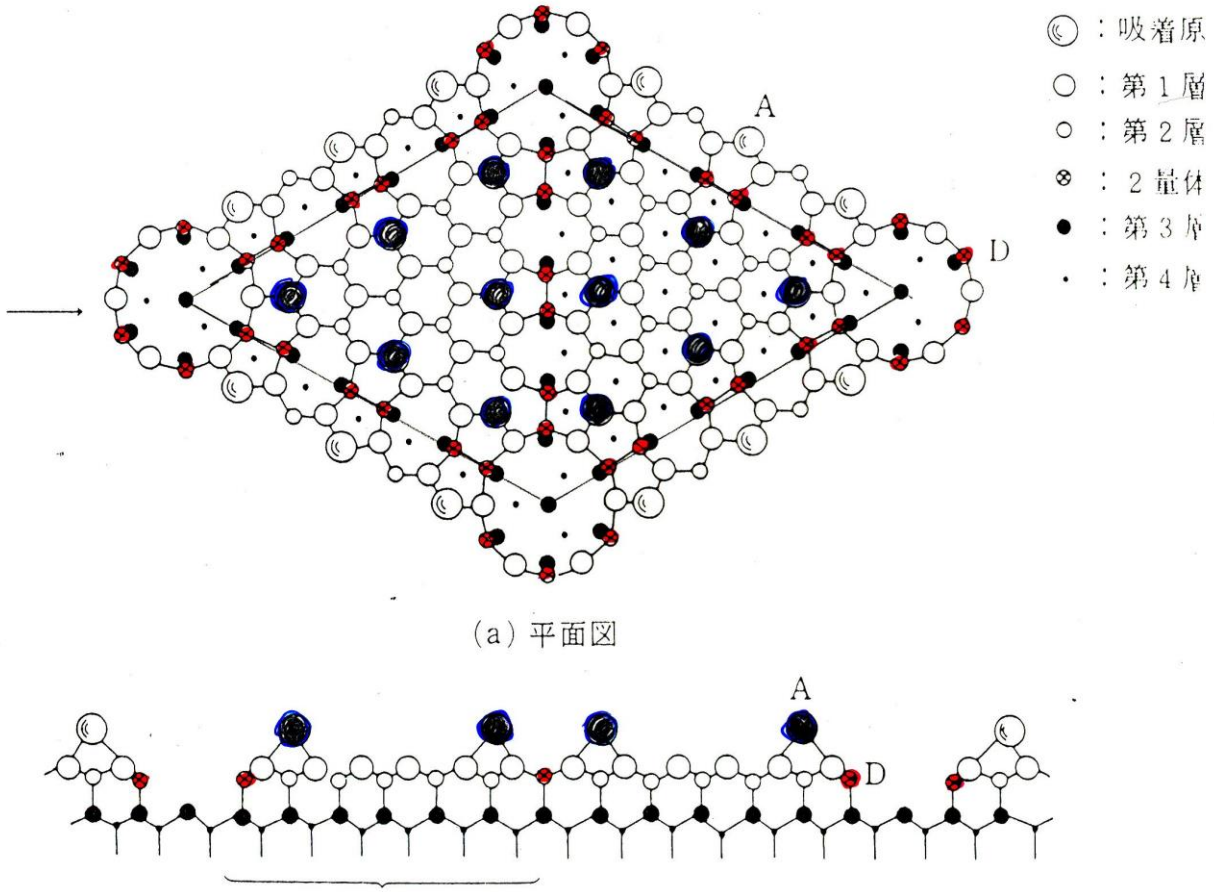


Binding sites of CO on a Pt surface identified by high resolution time resolved XPS

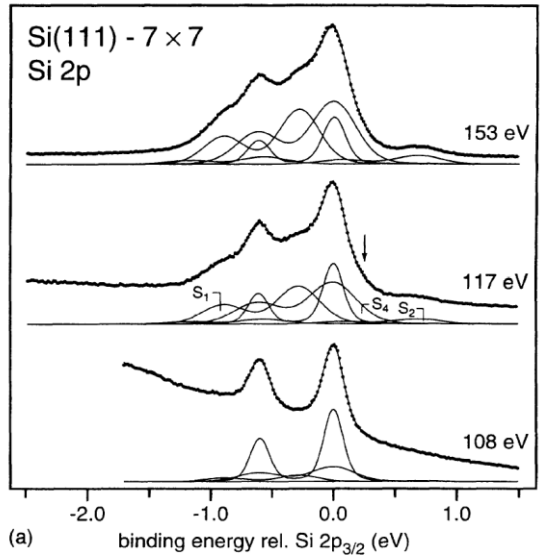
R. Denecke, M. Kinne, T. Fuhrmann, C. Whelan, J. Zhu, H.P. Steinrück (Univ. Erlangen)

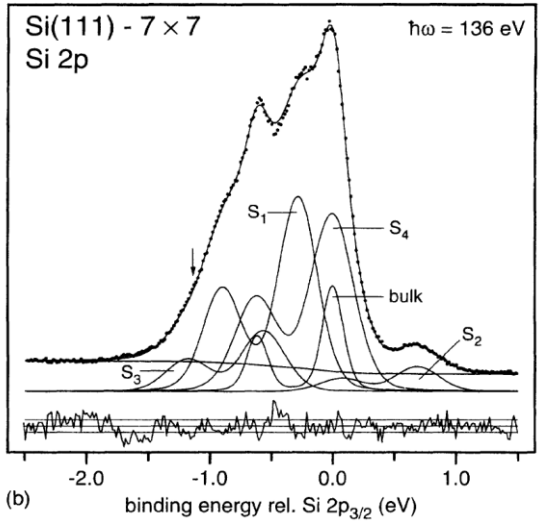
Soft X-rays ➔ High Resolution XPS

C
Si
C
O
Tl
R
Al



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



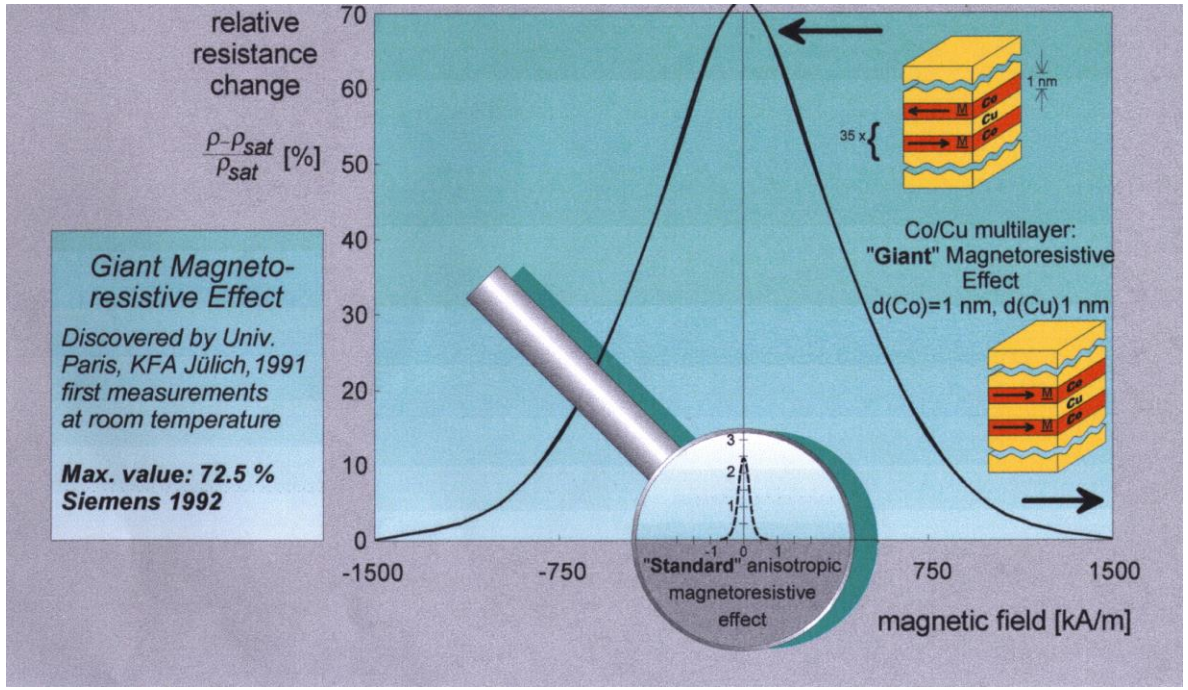


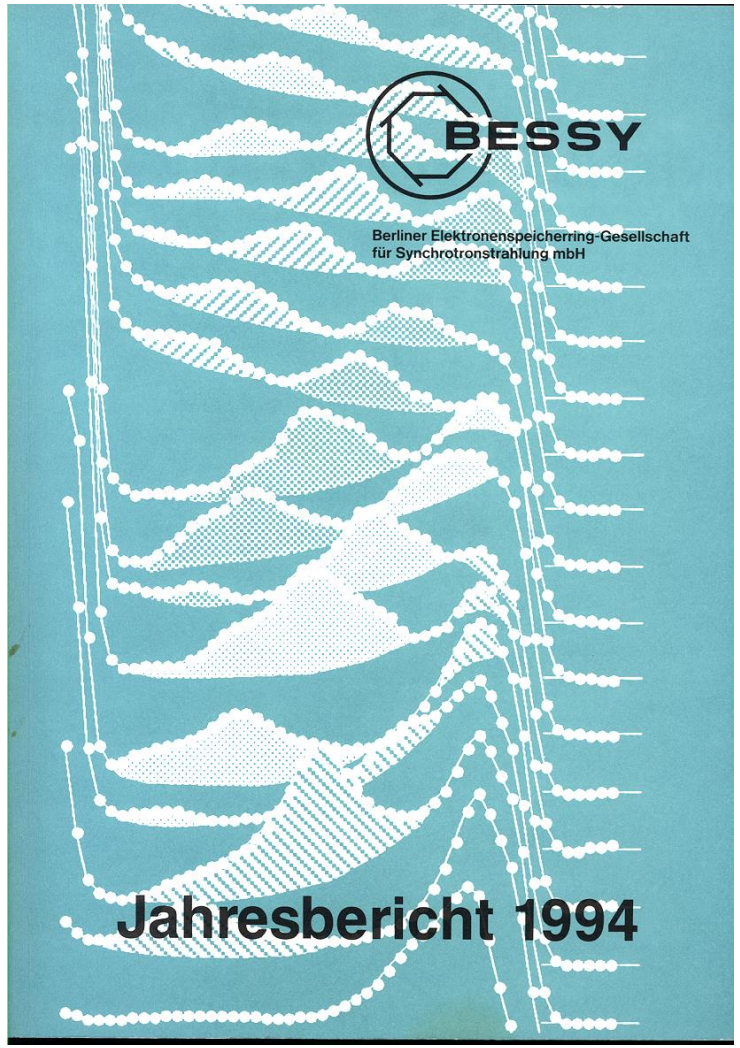
J.J. Paggel, W. Theis, K. Horn
Ch. Jung, C. Hellwig, H. Petersen
Phys. Rev B50, 18686 (1994)

Soft X-rays ➔ High Resolution Spectroscopy

Spin Polarized Photoemission

Magnetic Quantum Well States at the origin of the GMR effect





The HESEB Soft X-ray Beamline

- Soft x-ray beamline will be 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) will be completely funded by SESAME
- A CRG (collaborative research group) „business model“ at SESAME (cf. ESRF, ILL, …) is offered for expansion/additional capabilites
- A CRG would have certain amount of entitled access time, remaining part is given to public use (after peer review)
- Several instutes from Turkey (SESAME Member) are in the process of forming a CRG that provides an (XPS-)endstation and operational staff
- Science Partners from Jordan and TU Berlin

Thank you