HESEB Helmholtz-SESAME Soft X-Ray Beamline für SESAME

DESY. JÜLICH FORSCHUNGSZENTRUM HZB Helmholtz Zentrum Berlin HZDR KIT

# HESEB – The Helmholtz-SESAME soft X-ray beamline

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HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

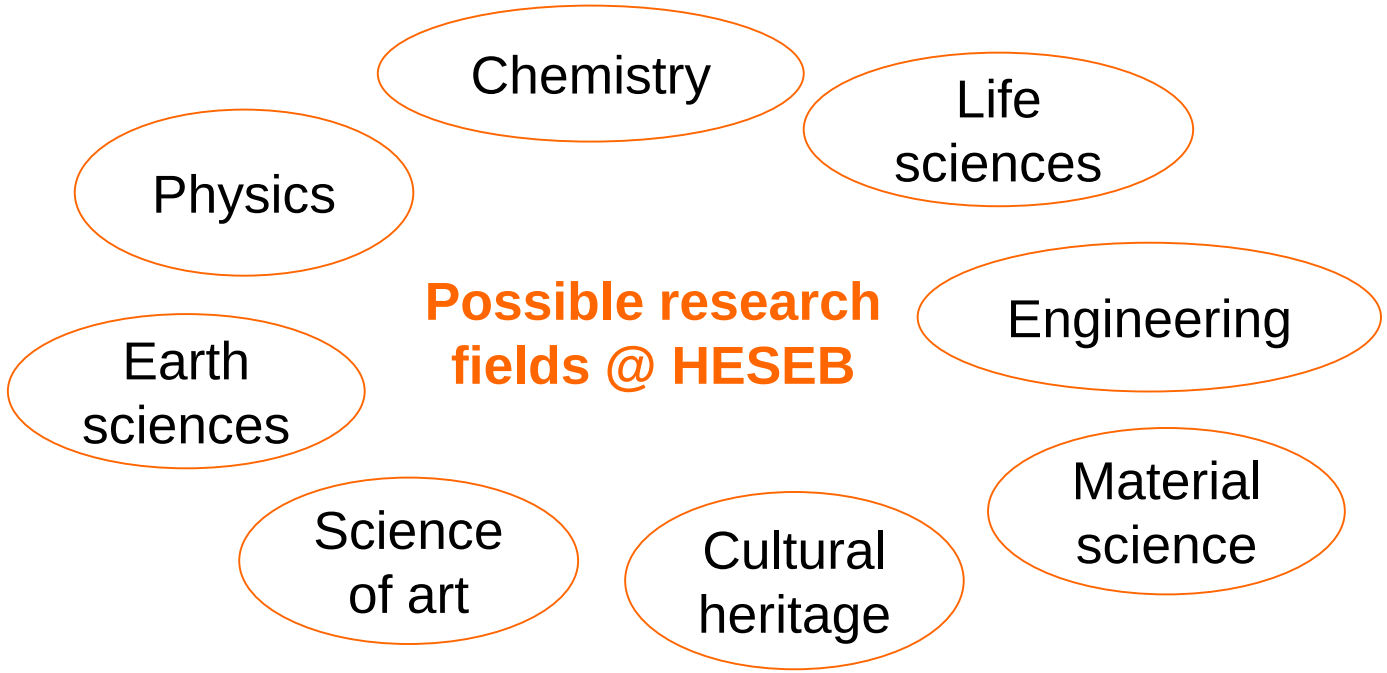
SESAME

# Outline

- HESEB project:
  - structure, goals, timeline, achievements and next steps -
- Beamline description
- Examples of possible experiments @HESEB

# HESEB initiative: a short introduction

- An initiative by the **Helmholtz Association of German Research Centers** to implement a **new beamline at SESAME** for scientific applications using **soft X-ray spectroscopic techniques**



# HESEB project: an international cooperation

- **Large number of top-class scientific applications**
- **New cooperation potentials** with German and international research groups

- **SESAME member states:**

  Jordan
  Cyprus
  Egypt
  Iran
  Israel
  Pakistan
  Palestinian authority
  Turkey

# The HESEB project in a nutshell

- **Project consortium:**

**5 centers of the Helmholtz Association of German Research Centers**

**DESY**: Deutsches Elektronen-Synchrotron (project coordinator)

**FZJ**: Forschungszentrum Jülich

**HZB**: Helmholtz Zentrum Berlin für Materialien und Energie GmbH

**HZDR**: Helmholtz-Zentrum Dresden-Rossendorf e.V.

**KIT**: Karlsruhe Institute of Technology

in collaboration with SESAME and SESAME member countries and beyond

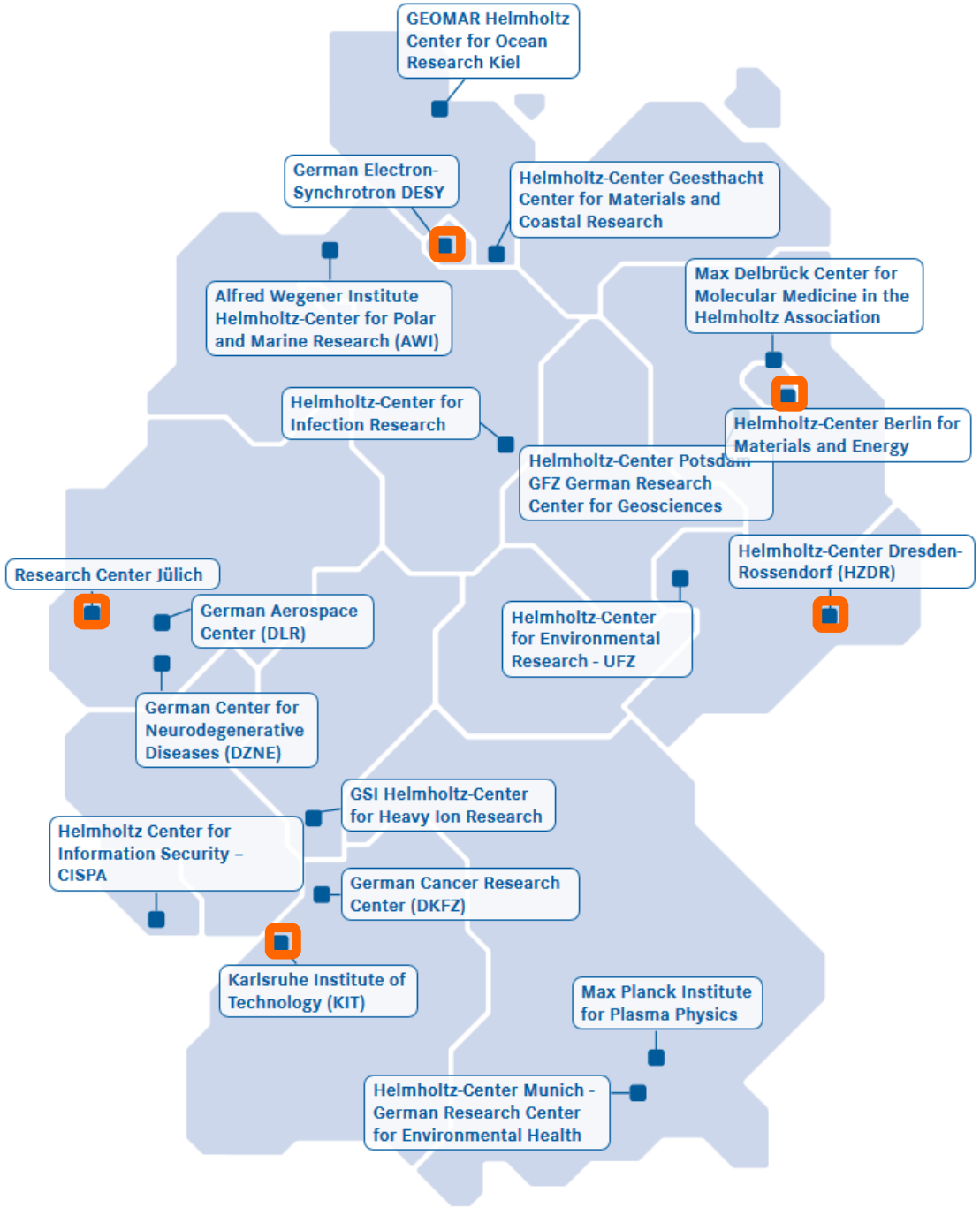
- **Project running time:**

Starting date: 1 January 2019

End date: 31 December 2022

- **Budget:**

3.5 Mio EUR from the Helmholtz Initiative & Networking Fund




https://heseb.desy.de/

# HESEB - Project goals

## Main goals to be achieved:

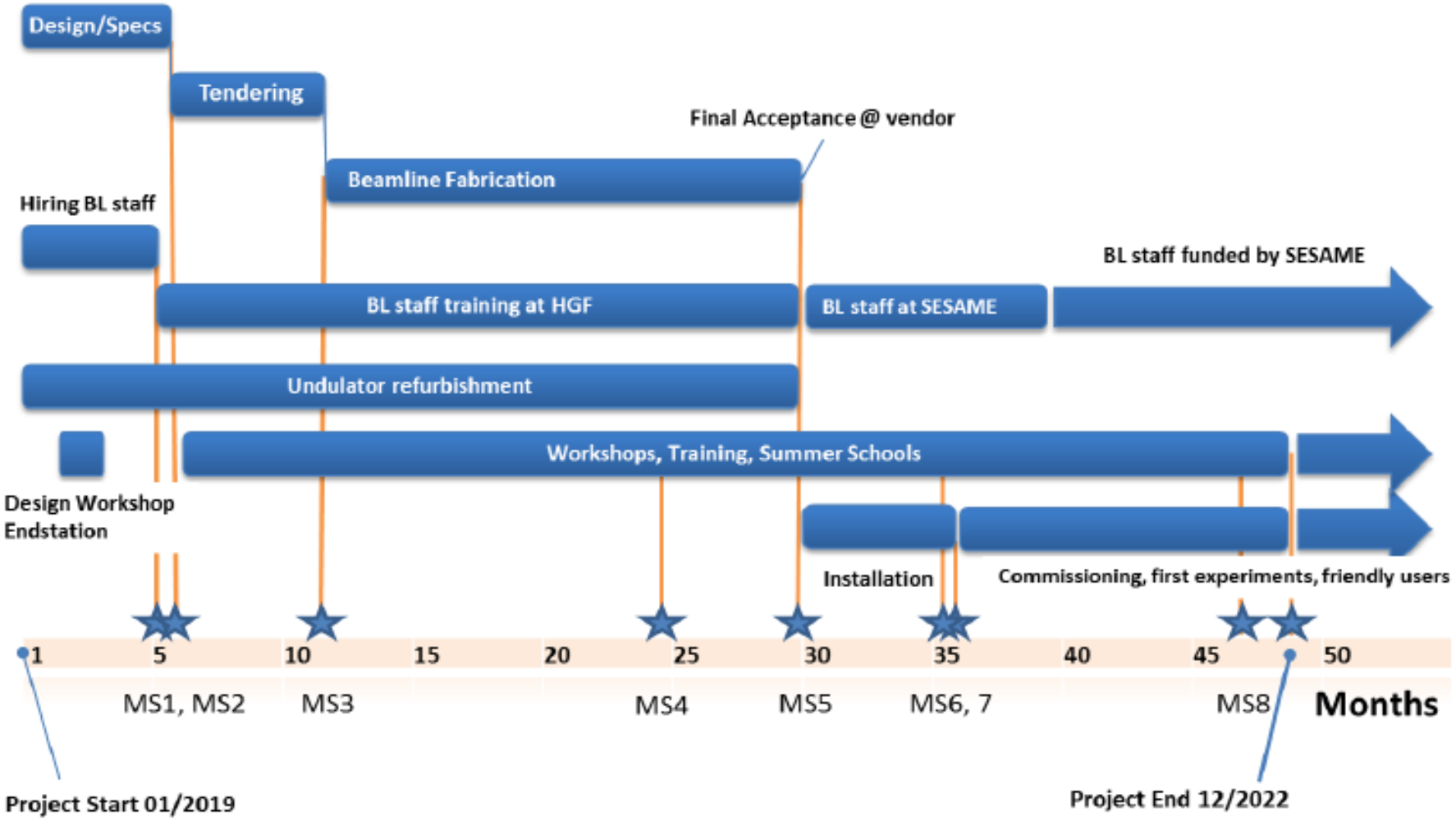
→ the **construction and commissioning of the beamline at SESAME**

→ the **leveraging of additional contributions from the SESAME member countries** to promote the build-up of international user consortia and to secure funding for experimental endstations and additional instrumentation

→ the **training of SESAME staff** at participating Helmholtz centers to enable reliable operation of the beamline by local staff

→ the fostering of the **establishment of a broad user community of HESEB** from the SESAME member states through training, workshops, and schools

# HESEB - Project timeline



# HESEB - Project structure

- **6 work packages:**

**WP1**: Beamline
**WP2**: Undulator
**WP3**: Commissioning
**WP4**: Beamline staff
**WP5**: User support
**WP6**: Project management

**WP1: Beamline**
- Design, specifications and procurement
- Lead Partner: DESY

**WP2: Undulator**
- Design and refurbishment
- Lead Partner: HZB

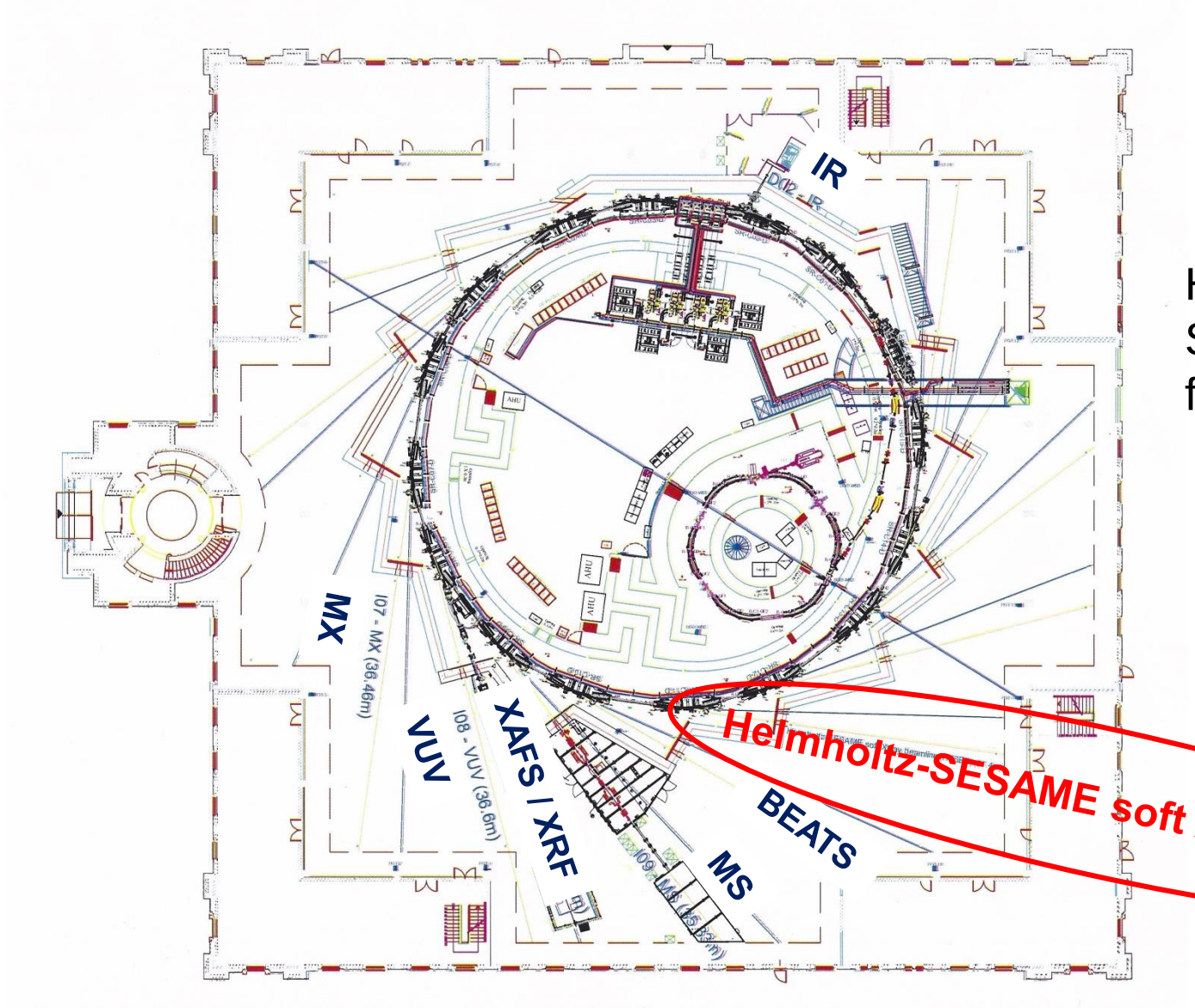
**WP3: Commissioning**
- Installation and commissionning
- Lead Partner: FZJ

**WP4: Beamline staff**
- Recruitment, training and education of staff
- Lead Partner: KIT

**WP5: User support**
- Training and user community build-up
- Lead Partner: HZDR

**WP6: Project Management**
- Management of project, communication, outreach
- Lead Partner: DESY

# SESAME layout and position of HESEB



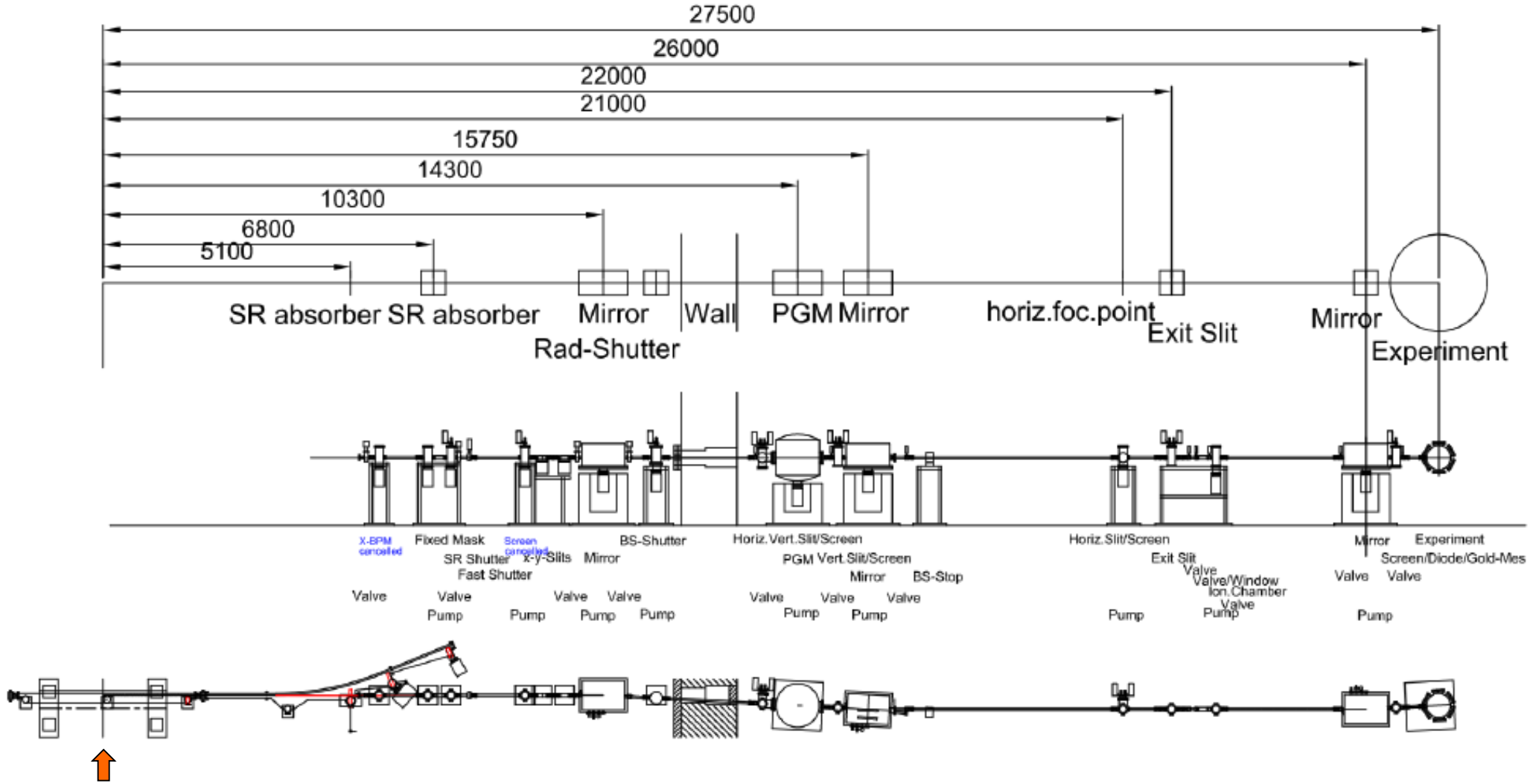

HESEB will become available for the SESAME user community within the four-year HESEB project duration.

**1st light @ HESEB expected in summer 2021**

# HESEB Beamline

## Beamline Layout

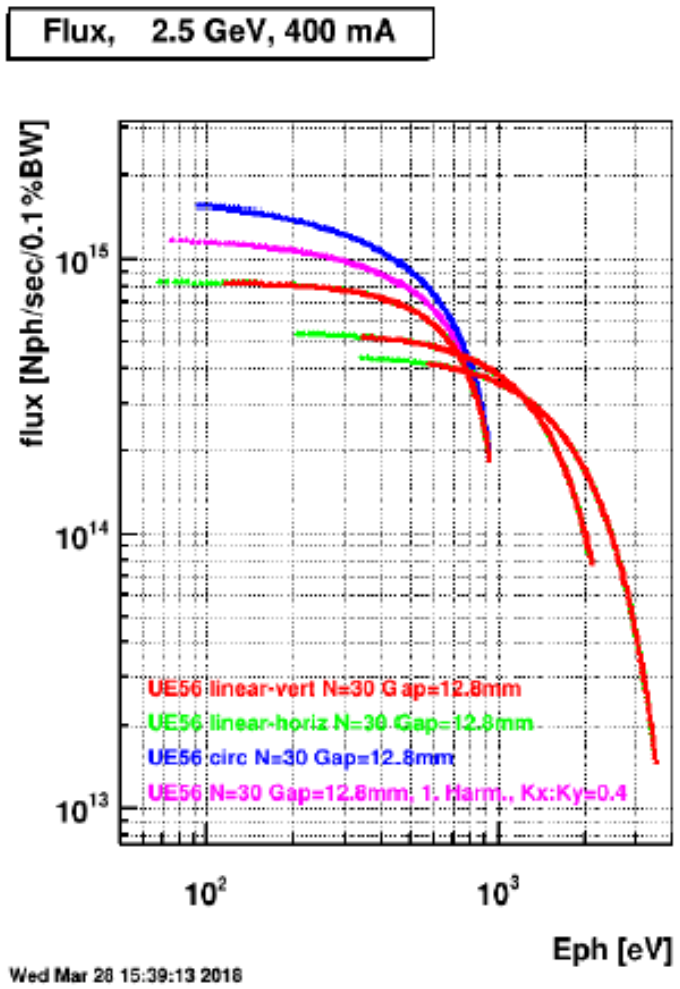
**Distances (in mm) from undulator center to beamline components**

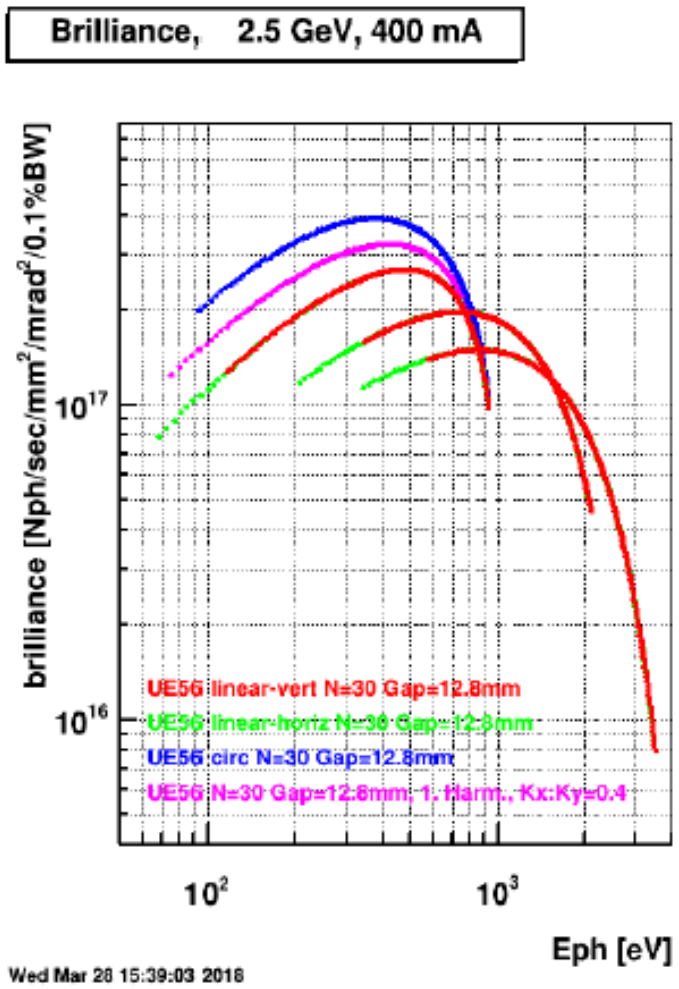


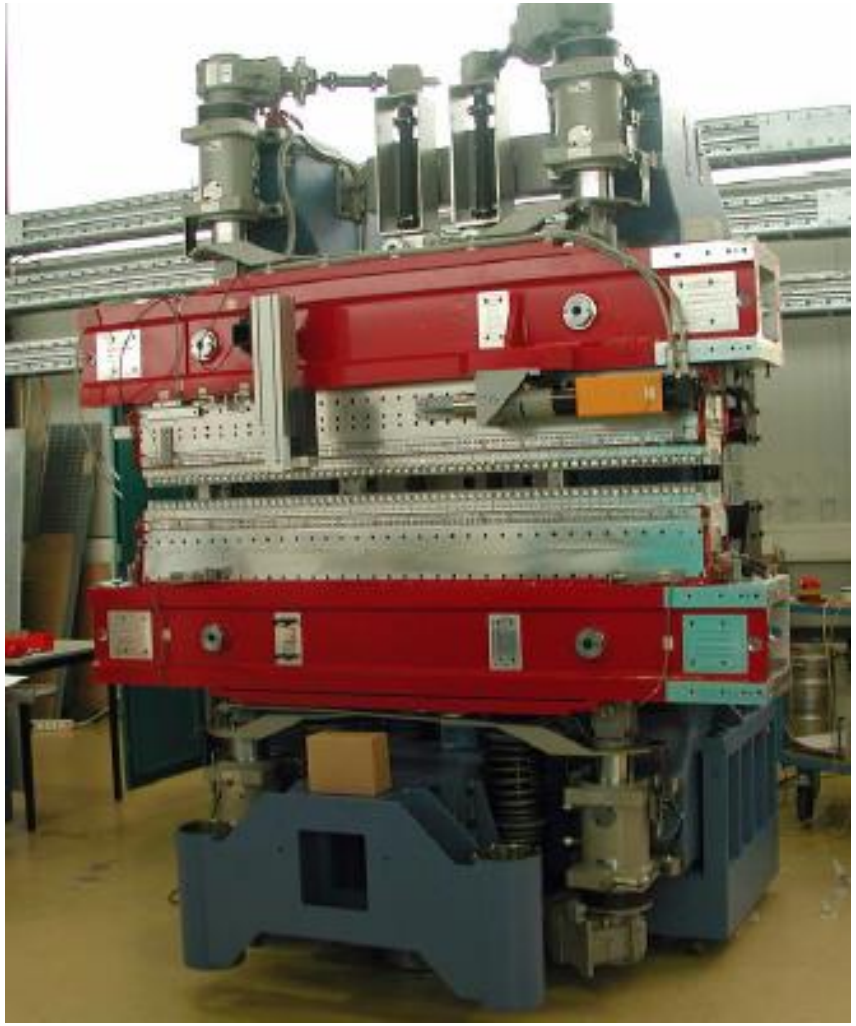
# HESEB Beamline

## Undulator UE56 with variable polarization

**Spectral properties of UE56 undulator for a Gap of 12.8 mm:**



A photograph of an UE56 undulator (HZB)

# HESEB - Activities within WP1

## **Design**, **specification** and **procurement** of a beamline in the soft X-ray range

**Design:**

✓ **June 2019: Technical design review** of the HESEB beamline by three international experts

| Beamline component | Value |
|---|---|
| Undulator<br><br>Length / Period<br>Polarization modes | UE56 APPLE II type device<br>– donation of BESSY II, being refurbished) –<br>1.7 m / 56 mm<br>circular, linear |
| $E_{photon}$ range | from ~ 90 eV to 1.8 keV |
| Photon flux (on sample) | $10^{12}$/s |
| Monochromator | collimated plane-grating monochromator (BESSY design)* |
| Beamline layout / endstations | (i) NEXAFS, XMCD, RIXS<br>(ii) ARPES<br>(iii) PEEM (optional) |

*R. Follath and F. Senf., Nucl. Instrum & Methods Phys Res A, **390**, 388 (1997).

# HESEB - Activities within WP4

## Training and Education of future beamline staff

- **Position of beamline scientist @HESEB**
  - **Hiring of Mustafa Genişel**

    Dicle University, Turkey

    Surface and Material Advanced Research and Technology Lab (SMART Lab)

  - **Official start: February 1st, 2020**

  - **Beamline training at KIT @WERA beamline** with Stefan Schuppler and co-workers

# I. HESEB - Activities within WP5

## User support, cooperation development, Seed Projects / Teaming

**Activities during the project phase aiming at building a strong HESEB User Community:**

- **Focused workshops**
- **Summer schools** adopting the format of the renowned HERCULES specialized courses
- **Research stays** of several weeks at suitable facilities of Helmholtz centers or collaborating European partners
- **Twinning program** with experienced soft X-ray users acting as mentors for new HESEB users and offering support for experiment set up, during beamtime and for data analysis

# II. HESEB - Activities within WP5

## User support, cooperation development, Seed Projects / Teaming


**Preliminary agenda and registration:**

**https://www.hzdr.de/db/Cms?pOid=58977**

### Workshop programme:

- → Day 1: Selected expert lectures on soft X-ray applications
- → Day 2: teaming-day adopting the world café format with several thematic roundtable discussions
- → Day 3: future perspectives, e.g. additional experiments, further upgrades

# HESEB: a versatile state-of-the-art instrument

## Offered soft X-ray experimental techniques

→ **photon-in photon-out spectroscopy**

→ **photon-in electron-out spectroscopy**

- **Initial planned experimental station:**

**= a sample scanning stage and a solid-state detector** allowing photon-in photon-out spectroscopy, and energy dependent x-ray absorption spectroscopy

→ probing of the **elemental structure of matter**, with a focus on the study of archeology artifacts of regional cultural heritage (XRF)

→ probing the **elemental and chemical composition of materials** (NEXAFS)

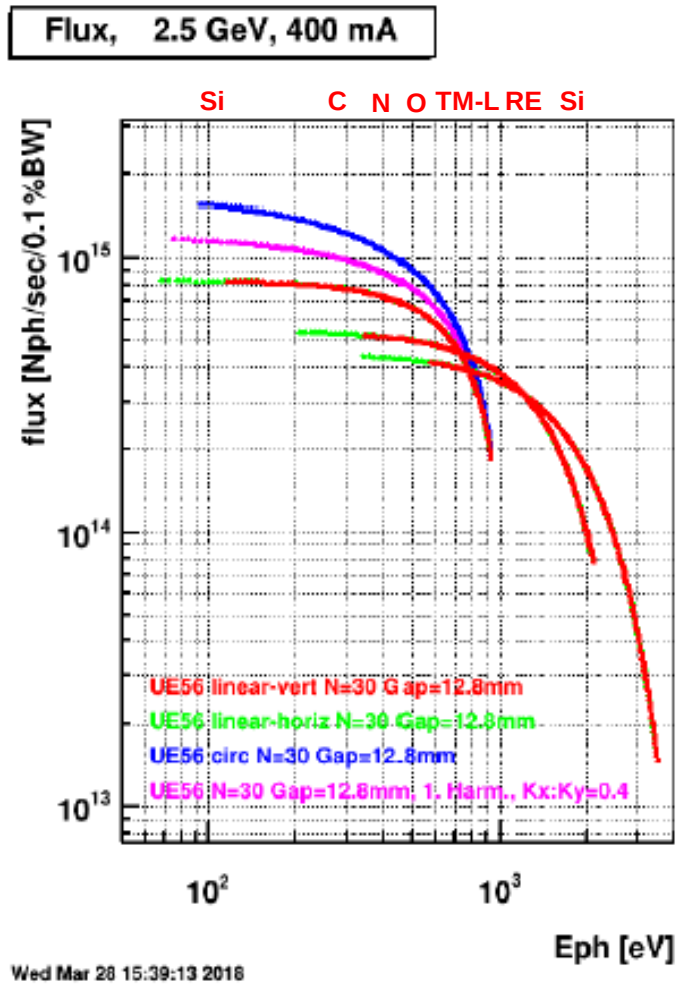
→ studying **elemental specific magnetic properties of materials** (XMCD) by using circular polarization

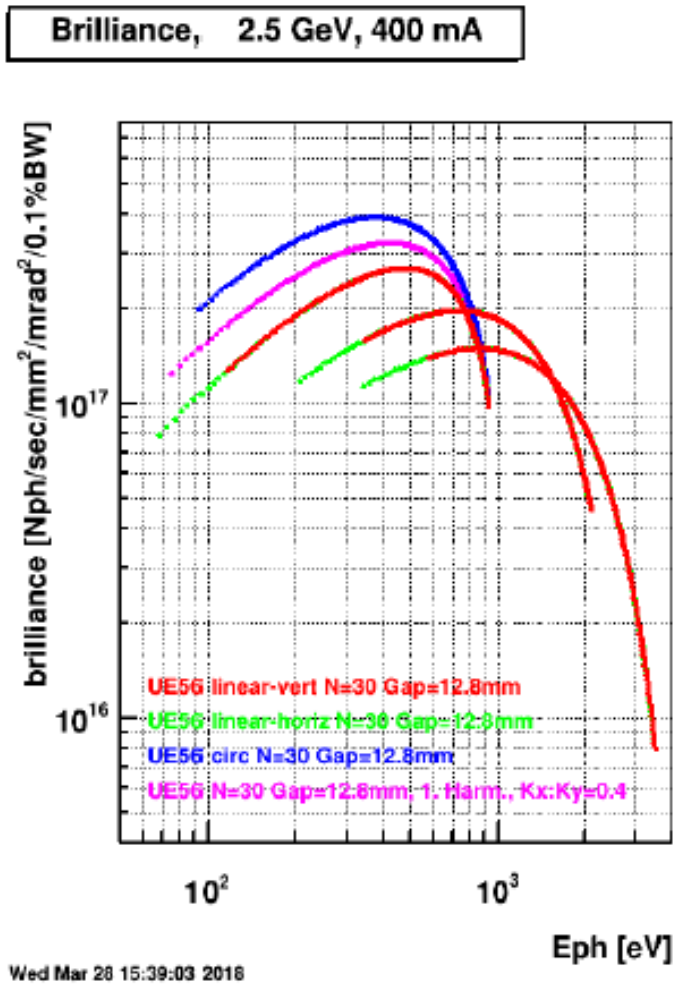
- **A large range of possible experiments offered to the users**

# Soft X-ray science possible @HESEB

## Soft X-rays ➔ High Resolution Spectroscopy

- **Covers a wide range of core absorption edges:**
  - Si L-edge **Semiconductors**
  - C-, N-, O- K-edge **Organics catalysis**
  - TM- L-edges **magnetics**
  - RE 3d edges **magnetics**
  - Al- K-edge, Si-K-edge

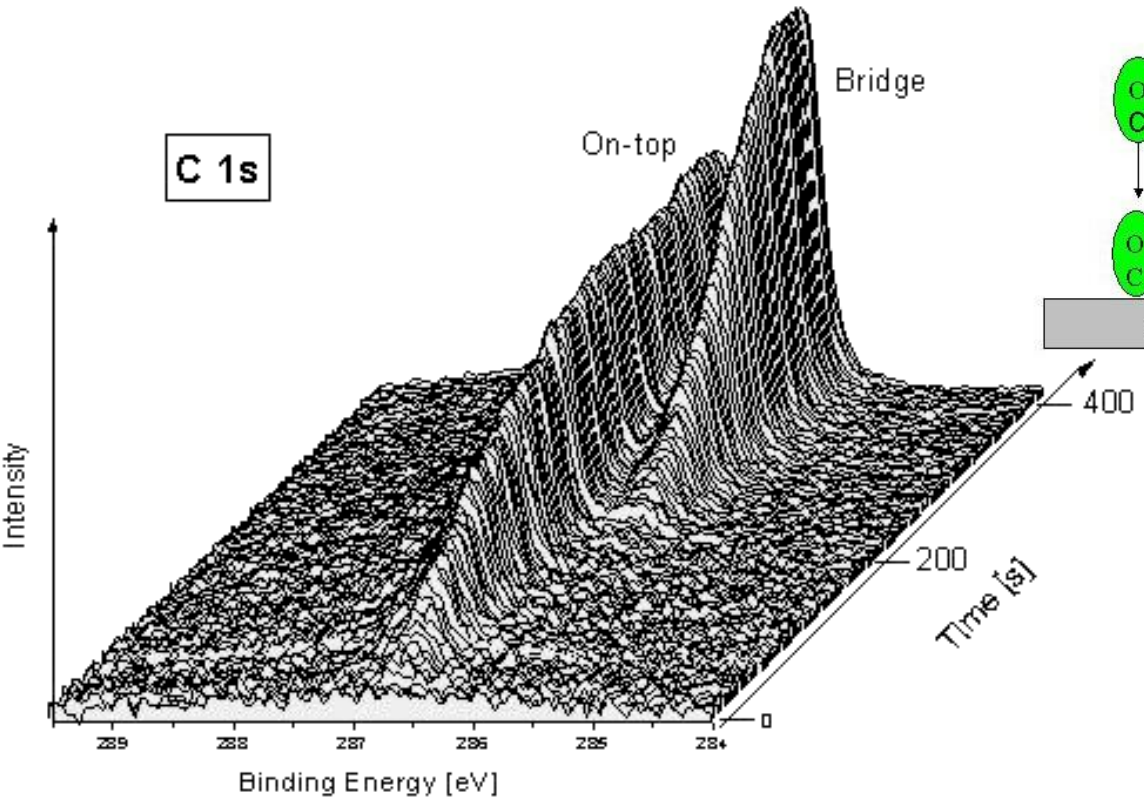


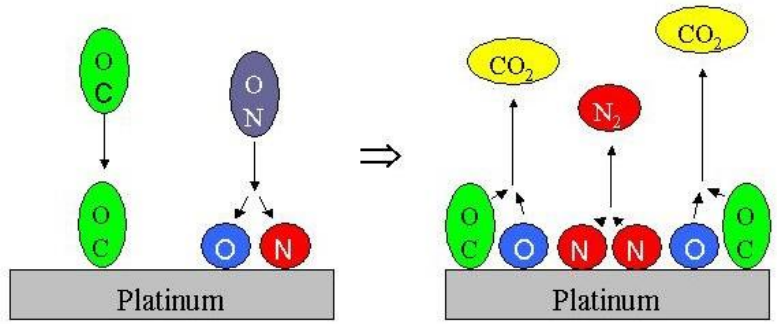



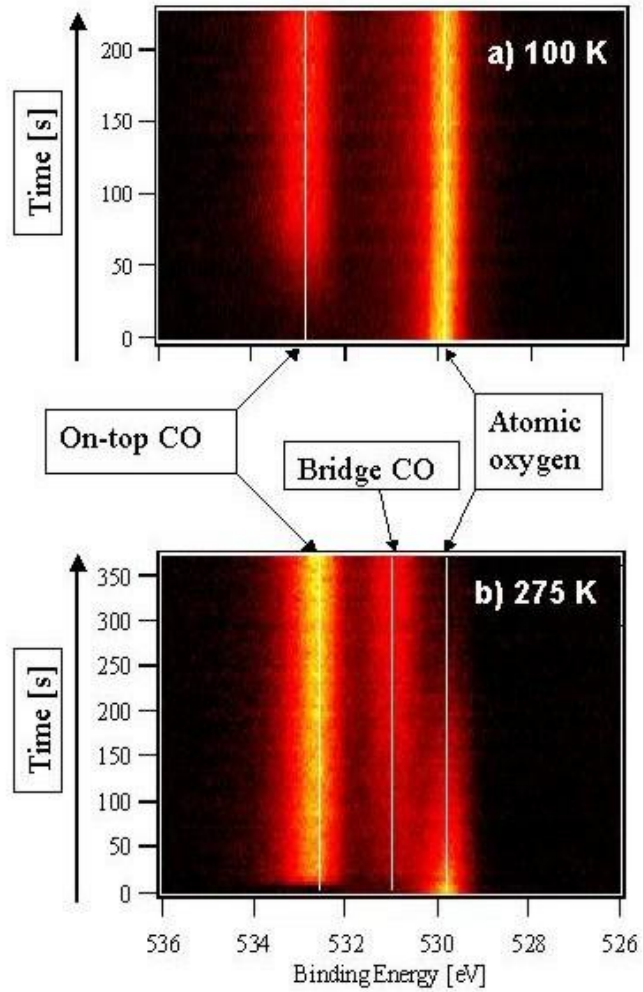
# Chemical reaction dynamics on surfaces

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

Study of the kinetics of the adsorption system CO/NO/Pt(111) by time-resolved high-resolution XPS



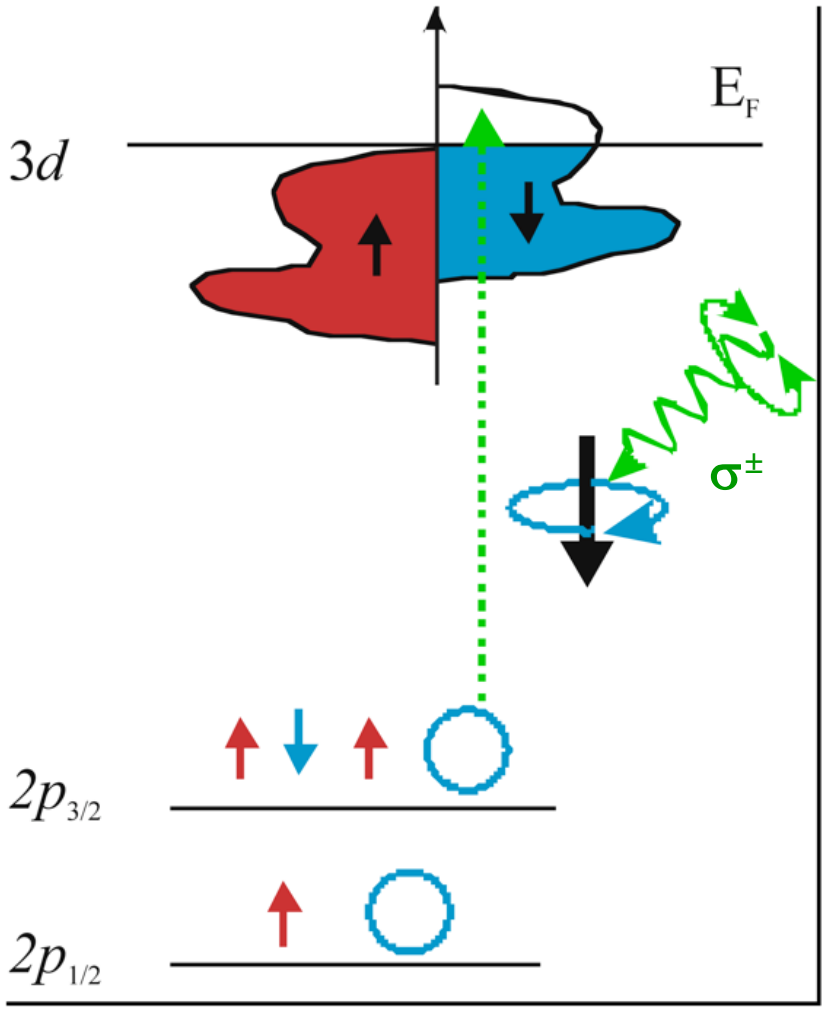



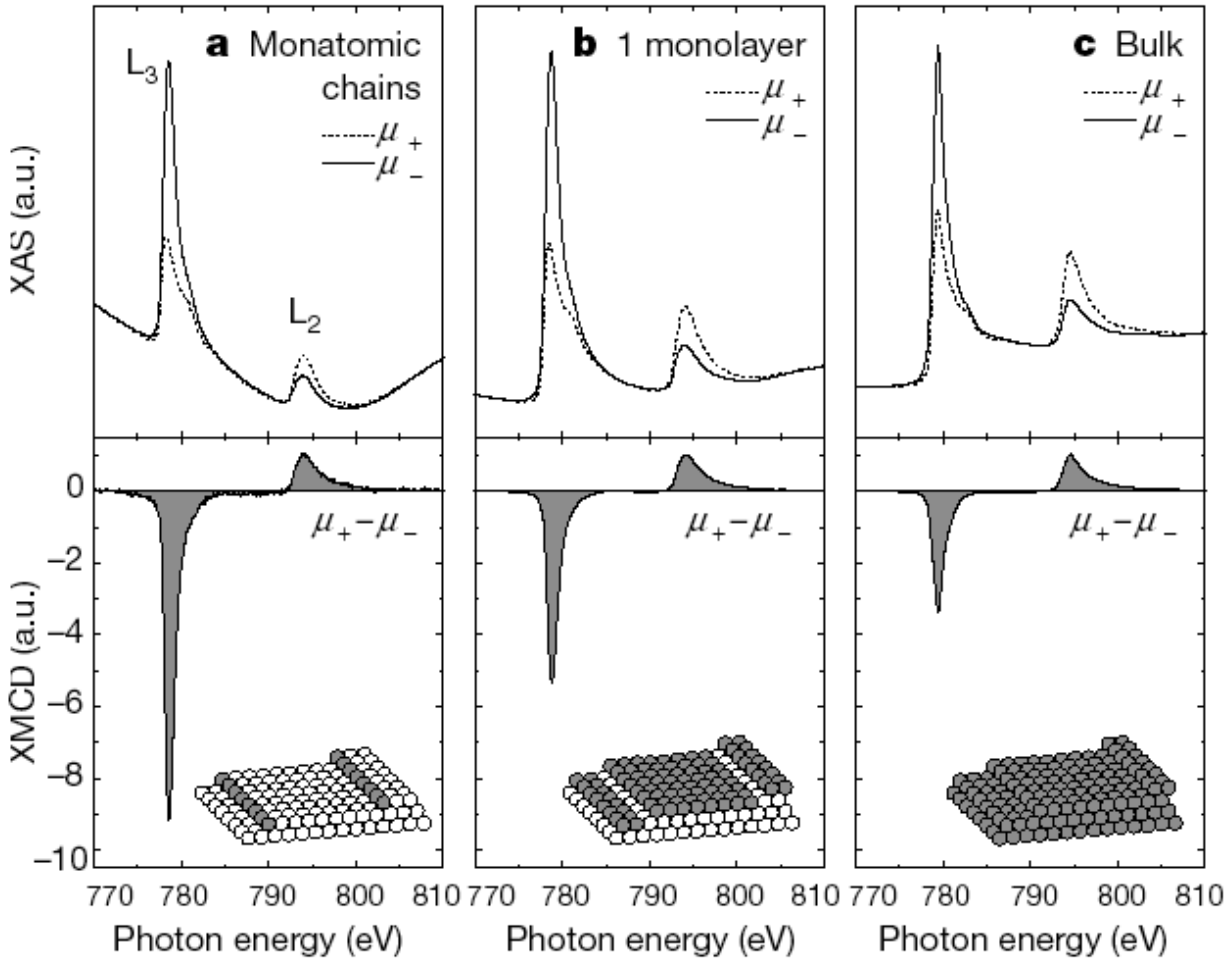




**Binding sites of CO on a Pt surface identified by high resolution time-resolved XPS**

M. Kinne et al., J. Chem. Phys. 117, 10853 (2002)

# Magnetic Systems ➔ CMXD




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

# Conclusions

- The HESEB soft X-ray beamline is:

- an integral part of SESAME‘s suite of beamlines / instruments, contributing successfully to the scientific output of the facility

- planned as a versatile instrument offered to the user community

- Technical design completed

- Call for tender procedure ongoing

- First light expected in summer 2021

- User support: fostering of the establishment of a broad user community of HESEB from the SESAME member states through training, workshops, and schools

# Acknowledgements

Thank you for your attention.

# Supporting slides

# SESAME

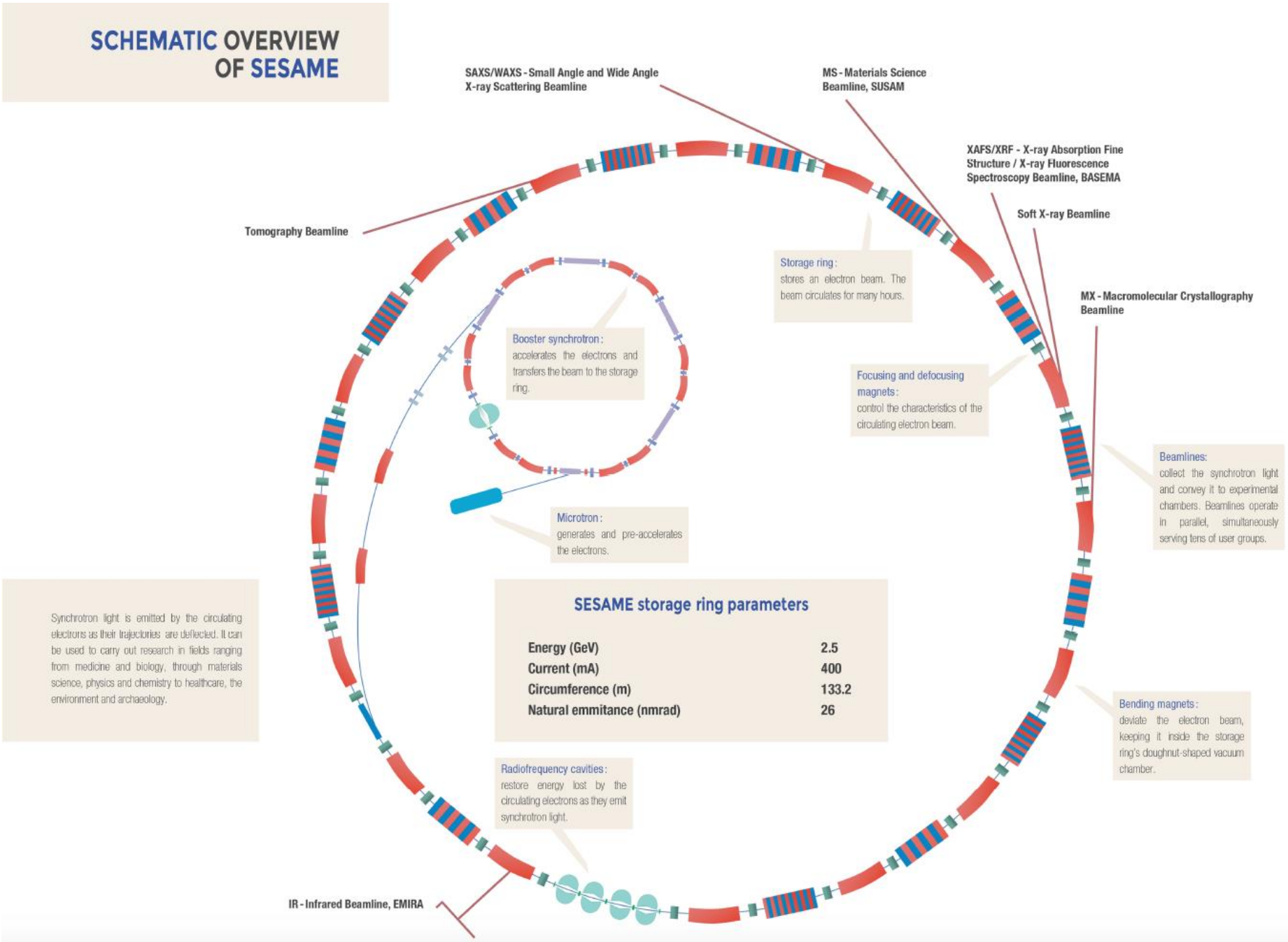
## Synchrotron-light for Experimental Science and Applications in the Middle East

**Inauguration in May 2017**

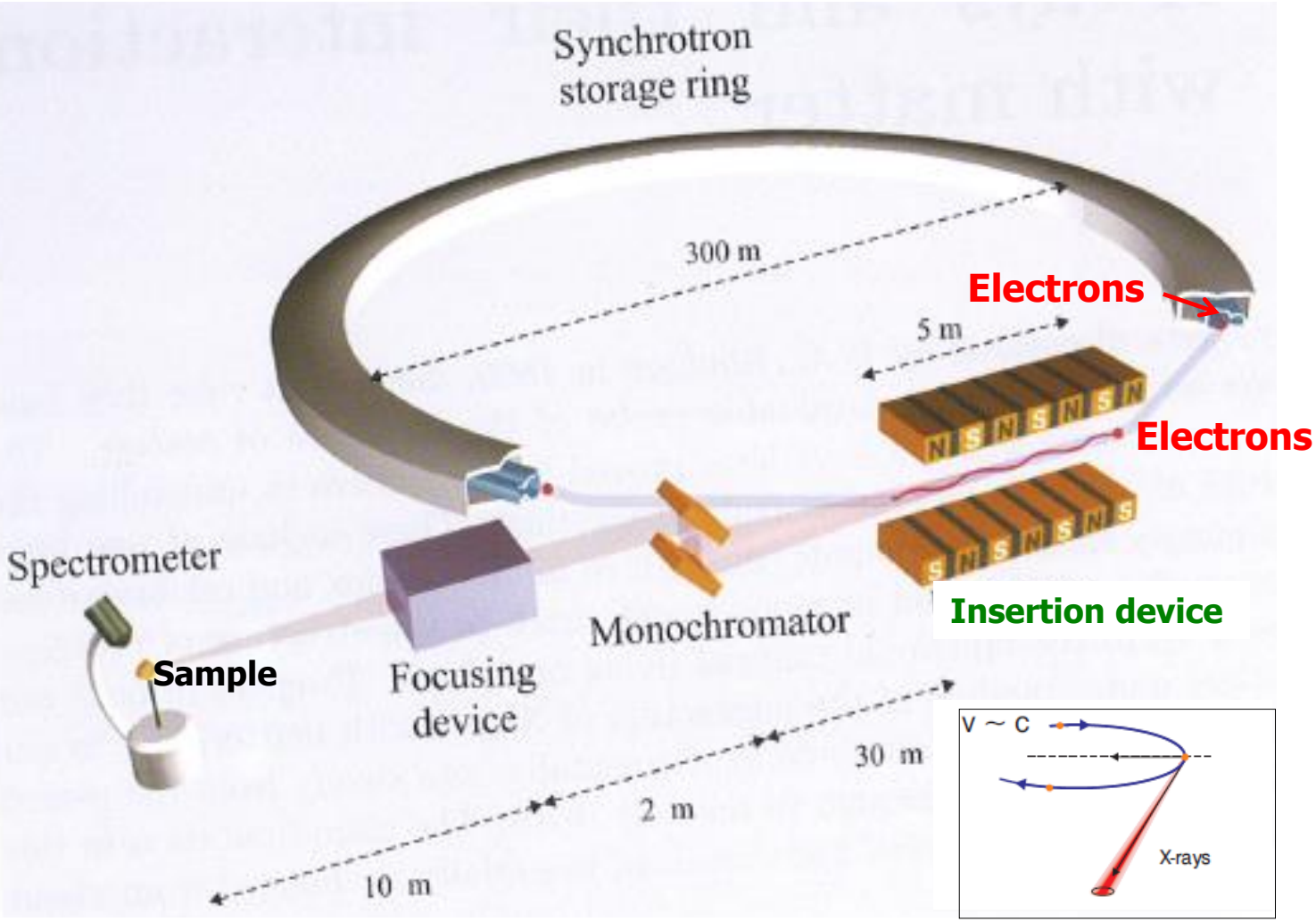
- **User operation has started on 2 beamlines**
  - **Idea of a soft x-ray beamline at SESAME as a prominent sign for a Helmholtz engagement in „Science Diplomacy“**


- Complementing the existing first three beamlines (that are funded and partially in operation: IR, XAFS and powder diffraction)
- Extending the scientific capabiities 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 of a beamline @ a synchrotron light source




A synchrotron facility =

- an evacuated *storage ring* in which high-energy (2.4 GeV) ***electrons*** circulate at highly relativistic velocities

- the *synchrotron radiation*:

 - is emitted by the electrons as their direction is changed by ***insertion devices***.

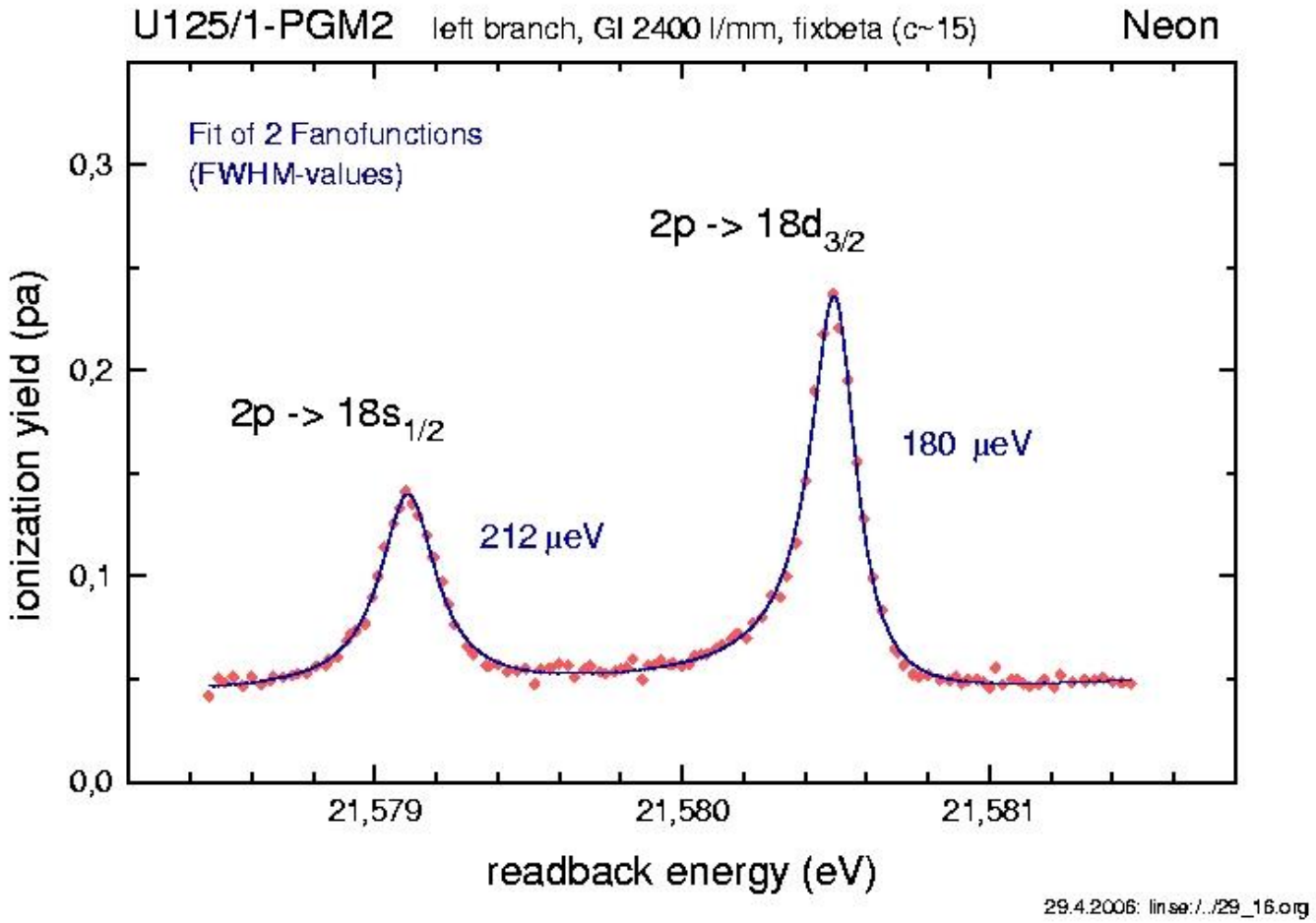
- is created at the *beamline*, i.e. *tangential* to the electron path in the storage ring.

- The synchrotron radiation is then passed through a number of ***optical elements*** (monochromator, focusing device) and is delivered to a sample.

Adapted from "Elements of modern X-ray physics", ISBN 978-0471-49858-2

# HESEB Beamline

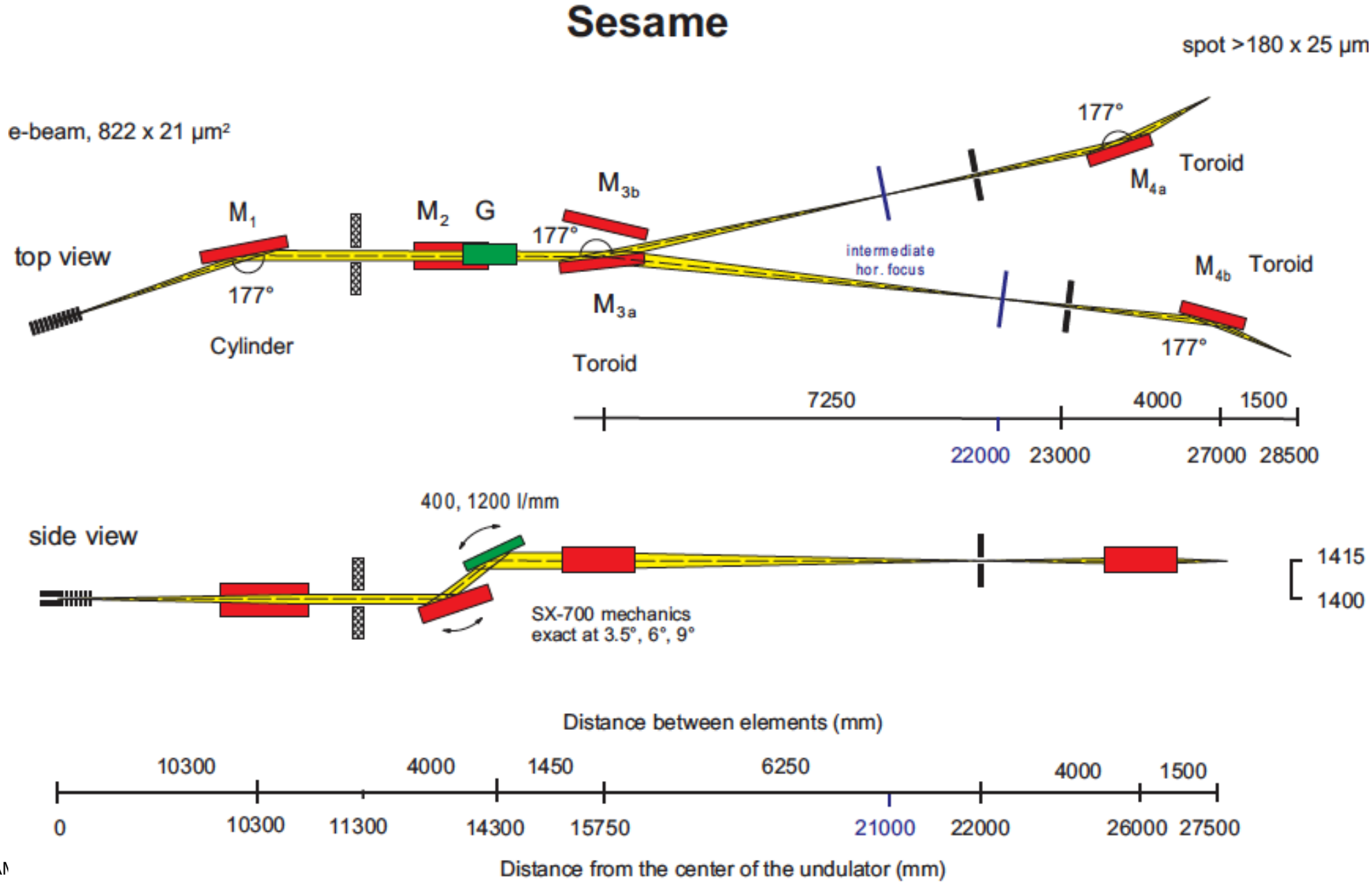
## Plane-grating monochromator




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

# 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)**