HESEB Helmholtz-SESAME Soft X-Ray Beamline für SESAME

SESAME

DESY. JÜLICH FORSCHUNGSZENTRUM HZB Helmholtz Zentrum Berlin HZDR KIT

The HESEB Project

An overview

Frank Lehner / Wolfgang Eberhardt
(on behalf of the HESEB collaboration)
DESY

Presentation at the HESEB soft x-ray workshop
U Istanbul / Türkiye
8/9 September 2022

About us

- Professor Wolfgang Eberhardt
- synchrotron radiation pioneer
- world expert in soft x-ray science
- former director of BESSY, now at DESY
- Scientific Head of HESEB project
- engaged at SESAME for many years, acting as „observer“ for the German government at the SESAME Council

- (Particle) Physicists by training at DESY, FNAL and CERN
- > 20 years experience in research management
- Head of directorates division, chief of staff
- engaged at SESAME since 2011
  - OPEN SESAME, BEATS, HESEB

Both work at research center DESY in Germany

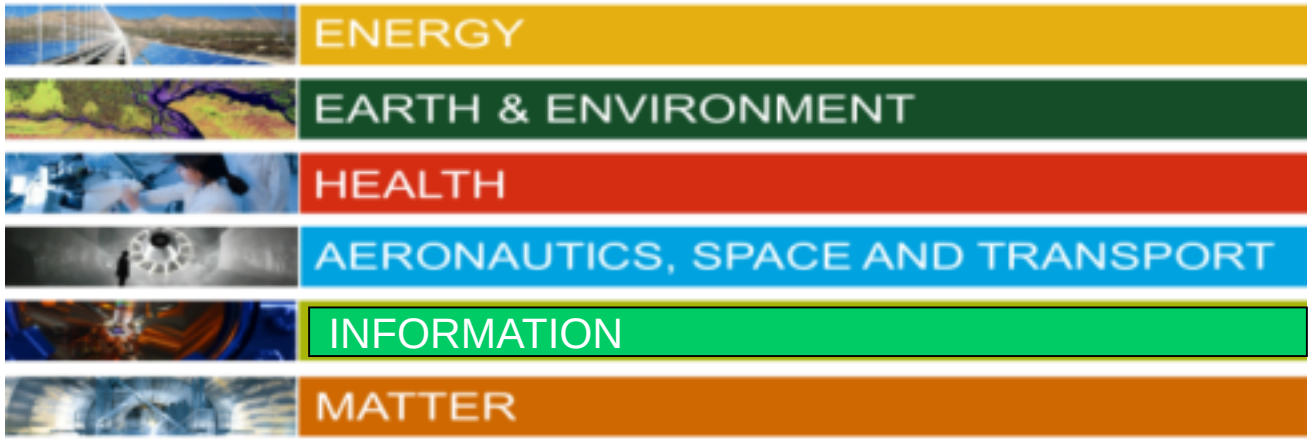
- National lab in Germany, ~2600 employees
- Design, build and operate large-scale Research Infrastructures in particle / astroparticle physics, photon science, lasers/plasma and data science
- New future project is PETRA IV, start campaigning now

Helmholtz Association

- Largest research organization in Germany
- 18 legally independent research centers with 43‘000 staff
- Budget: 5,2 billion €
- Cutting-edge research in six major fields:

Hermann von Helmholtz
(1821 – 1894)

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES



HESEB Beamline for Soft X-Rays

Overview

in ~2017 idea of a Helmholtz Beamline@SESAME as a prominent sign for a Helmholtz engage „Science Diplomacy“

- soft x-rays: complementing the existing first three SESAME beamlines & extending the scientific capabiities into soft x-rays
- soft x-rays were part of the long-term strategic plan of SESAME and fully endorsed by SESAME committees and user communities
- A strong research interest and committments by researchers from Türkiye was signalled from the beginning
- Strong support by Helmholtz centers (DESY, HZB, HZDR, FZJ, KIT)

HESEB consortium / project:

- Helmholtz research centers: DESY, FZJ, HZB, HZDR, KIT
- Project duration: 4 years 1/ 2019 – 12/2022 (+ one year extension)
- Funds: ~3.5 M€, Helmholtz manpower in-kind

HESEB Goals

- the **construction and commissioning** of the beamline at SESAME
  - 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)
  - Project should be driven by cost/performance effectiveness

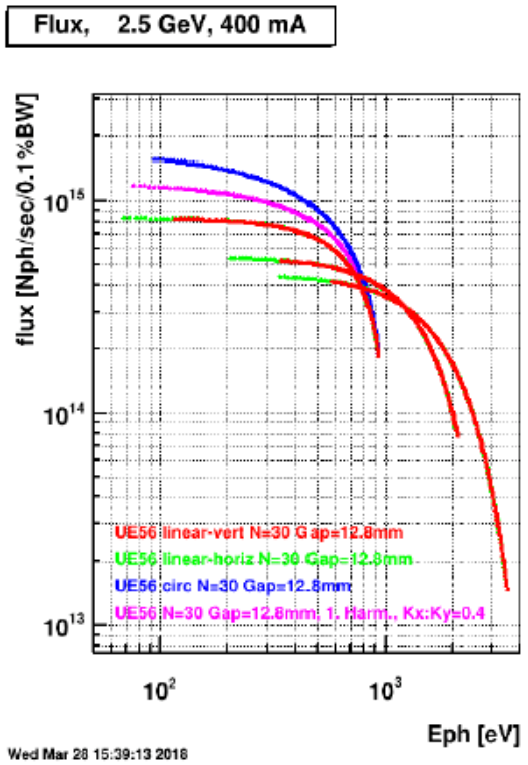
- the **training of SESAME staff** at participating Helmholtz centers to enable reliable operation of the beamline by local staff
- the fostering of the **establishment of a broad user community of HESEB** from the SESAME member states through training, workshops, and schools
- the **leveraging of additional 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
  - Project should act as an „anchor“ to seed cooperation between German research institutions/universities and SESAME member communities

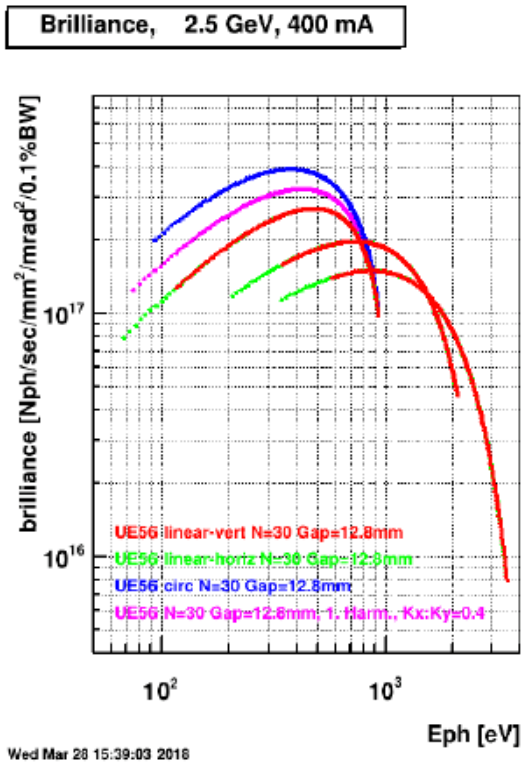
Soft X-rays ➔ High Resolution Spectroscopy

Soft x-rays in photon energy range ~100 eV – 1keV

Covers the core edges:

- C-, N-, O- K-edge
  Organics catalysis, crucial elements for bio, geo
- Si L-edge—semiconductors
- Transition metal L-edges magnetics
- Rare earth 3d edges magnetics
- Al- K-edge, Si-K-edge





Also “water window”, i.e. energy range between the Carbon K-edge
(290 eV) and oxygen K-edge (530 eV). Organic matter (i.e. carbon) is absorbing,
whereas water (i.e. oxygen) is relatively transparent,
=> providing a contrast mechanism that could permit microscopy of cells in their natural aqueous environment

Soft X-rays

Huge potential to probe magnetic structures through polarized soft x-rays / magnetic specificity

L-edges of transition metals

- dipole-permitted transition from 2*p* core level to the 3*d* valence level
- e.g. elemental ferromagnets Fe, Co, Ni

L-edge attractive to researchers studying new materials because of ability to probe the 3*d* valence electrons that are responsible for remarkable properties

Also cuprate high-temperature superconductors and manganate colossal magnetoresistance materials

see also talk by Sabreen Hammouda, FZJ

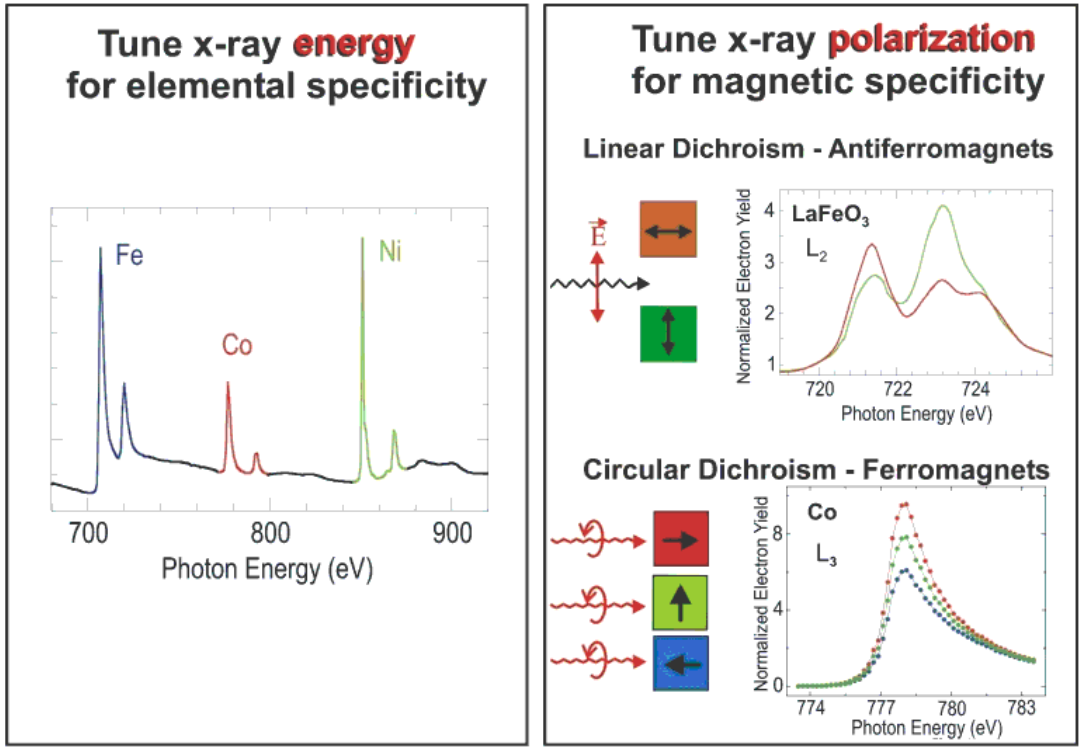
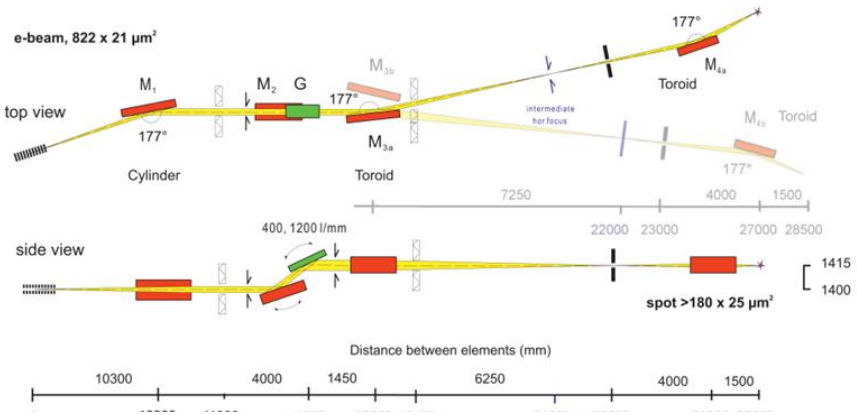


Fig. 2: Soft x-ray magnetic imaging using for example PEEM, STXM or TXM. A layer in the sample is selected by tuning the x-ray energy to the desired element. X-ray polarization contrast at an absorption peak is used for imaging contrast. The local electron yield from a sample region depends on the relative orientation of the magnetic direction or axis and the polarization, as illustrated on the right.

https://www-ssrl.slac.stanford.edu/dichroism/XDSM/Mic2_large.gif

HESEB Beamline

Optics concept /parameters / layout



Following collimated plane grating monochromator (PGM) concept

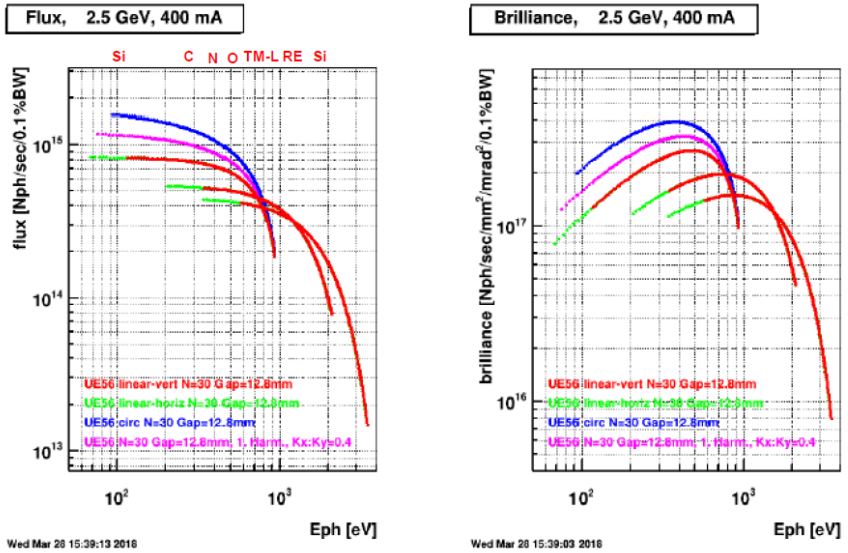
- HESEB in its base configuration will allow absorption spectroscopy with polarized soft X-rays using fluorescence or electron yield spectroscopy
- a unique feature will be the possibility to operate under ‚ambient pressure' conditions
- A second branch with additional Instrumentation/endstations will come from Türkiye ----State of the art photoemission ---- TXPES (see talk by Emrah Özensoy)

Parameter	Value
Undulator	UE56, APPLE II, Length: 1,7m, Period: 56mm
Polarization modes	Linear / circular
E_Photon range	~90 – 2000 eV
Photon flux on sample	1E12 1/s
Monochromator	Collimated plane-grating monochromator PGM (BESSY design)
Spot size on sample	180 (h) x 25 (v) um
Branches	Two: • Absorption chamber • TXPES

R. Follath and F. Senf ., Nucl . Instrum & Methods Phys Res A390 (1997) 388

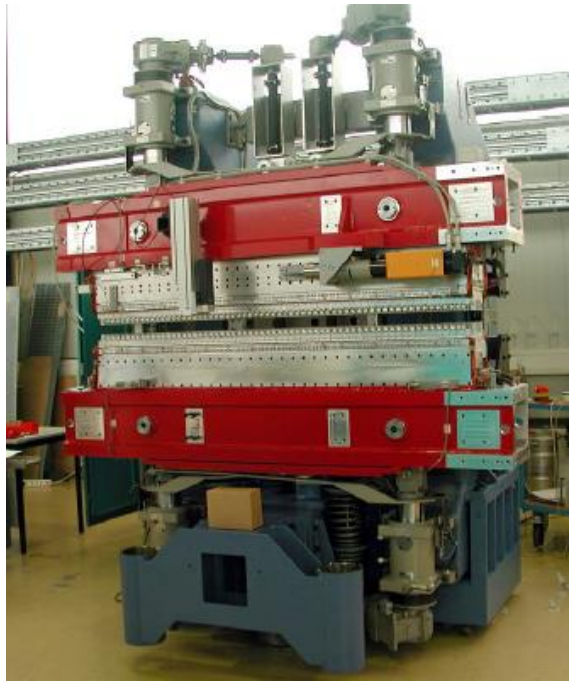
HESEB Beamline

Undulator UE56 (APPLE II) with variable polarization



Meseck, Bahrdt, Viefhaus, HZB Berlin

UE56

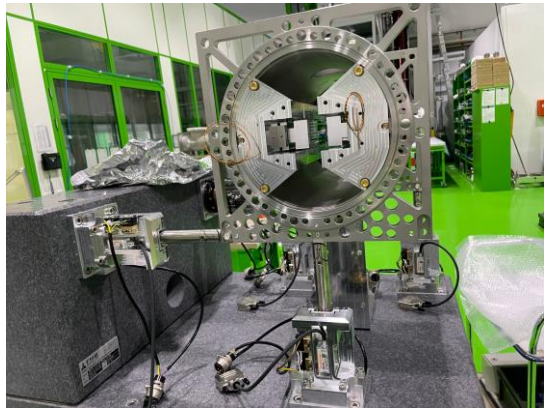


In a nutshell:

- UE56, APPLE II, Length: 1,7m, Period: 56 mm
- Circular / linear polarization
- Undulator from BESSY II, refurbished & upgraded, incl. new control
- training stay of 4 SESAME staff at HZB over summer / fall 2021
- Undulator shipped & installed to SESAME in April 2022

HESEB Beamline

- Optical / BL design finished in summer 2019 / international design review led by Z. Hussain / LBL
- EU-wide tendering over fall/winter 2019; contracted to FMB in Feb 2020
- Factory acceptance tests at FMB passed in Sept/Oct 2021, then delivery to SESAME in two larger shipments from Nov 2021 onwards
- Installation work starting from January 2022 & site acceptance tests



At FMB

PGM mechanics

Installed @ SESAME

See more details by Mustafa Genisel

HESEB Beamline

Installation at SESAME in Jan/Feb 2022

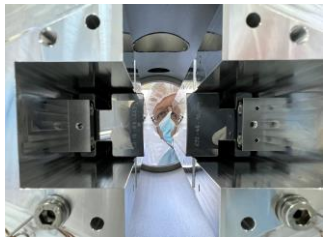
a big thank you to the fantastic SESAME crew !!!!

Mirrors / gratings

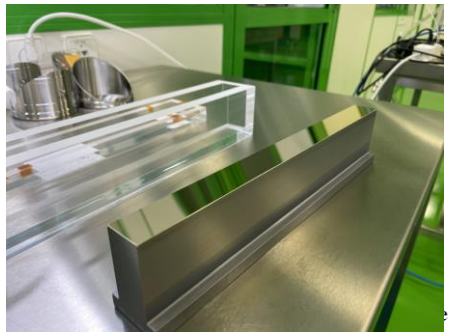
HESEB

- Mirrors M1, M2, M3a/b, M4a were ordered & delivered from ZEISS
  - Precision metrology done at HZB metrology lab (Frank Siewert)
  - All measured parameters in tangential and sagittal direction such as radius of curvature and slope error are within the specifications.
  - One mirror (M2) encountered coating difficulties (Au on Ta buinding layer) and was resent to ZEISS for refurbishment (and is now accepted)
- Gratings:

  two planar blaze gratings
  (400 l/mm; 1200 l/mm)
  were produced at HZB
  and delivered in November to FMB



Mirror M1 at FMB



HZB Helmholtz Zentrum Berlin

Optical Metrology at
Department Optics and Beamlines

Measurement Report
HESEB Helmholtz Beamline at SESAME

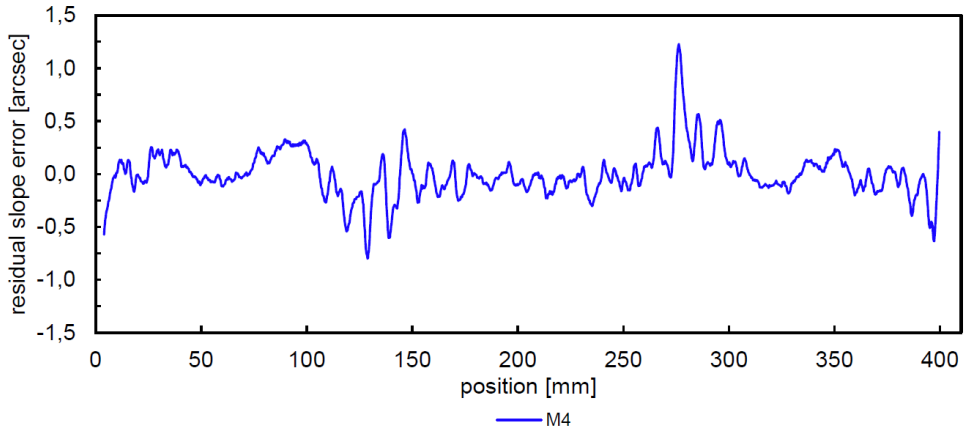
Grzegorz Gwalt, Frank Siewert
e-mail: frank.siewert@helmholtz-berlin.de

24th April 2021

Manufacturer:	**Carl Zeiss SMT GmbH**
Customer:	FMB Feinwerk- und Meßtechnik GmbH
Serial Number:	**"19-0208-M1"** **"19-0208-M2"** **"19-0208-M3a"** **"19-0208-M4a"**

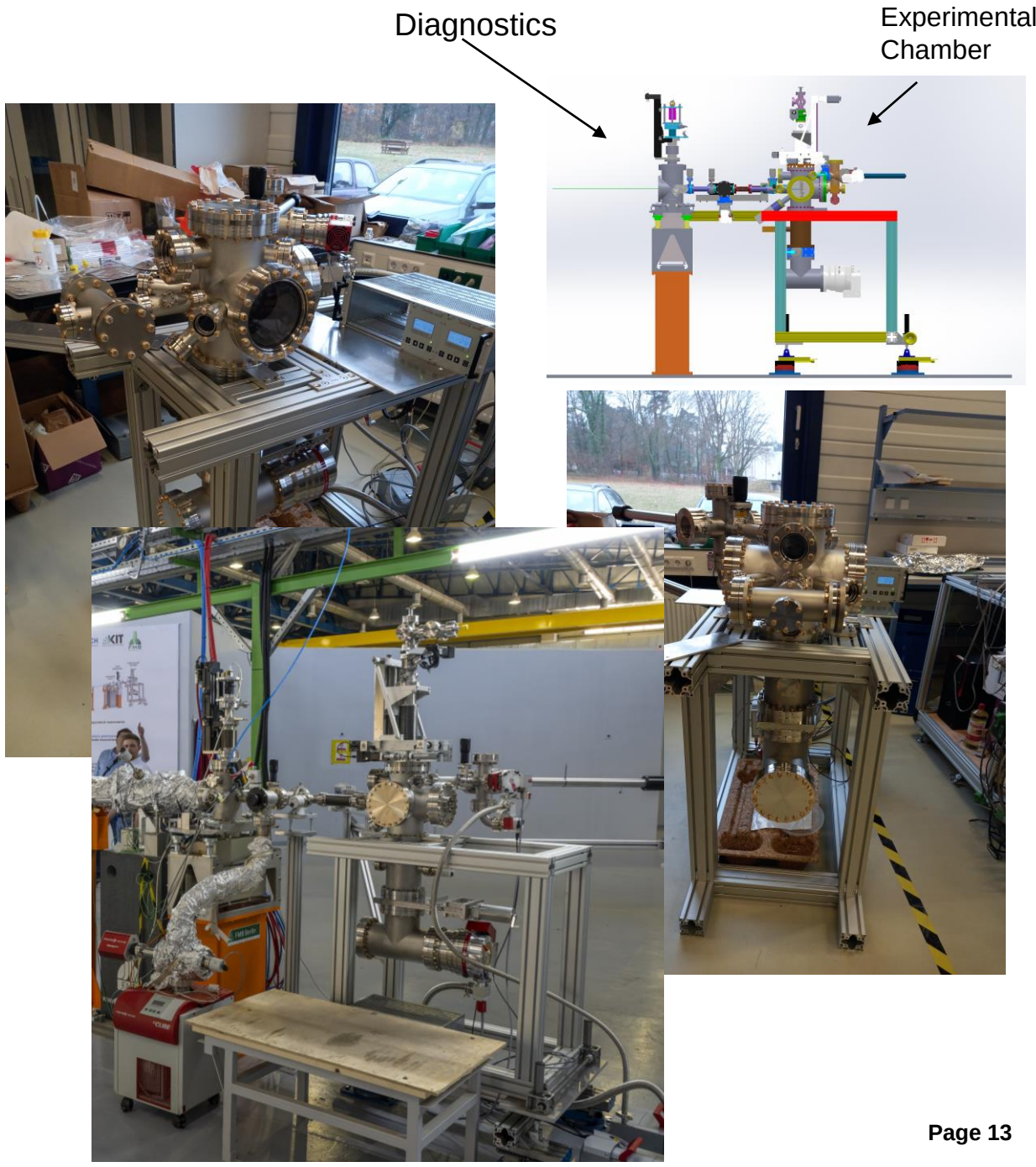
Mirror: M4a

F. Siewert, Metrology Lab HZB



HESEB Experimental Chamber

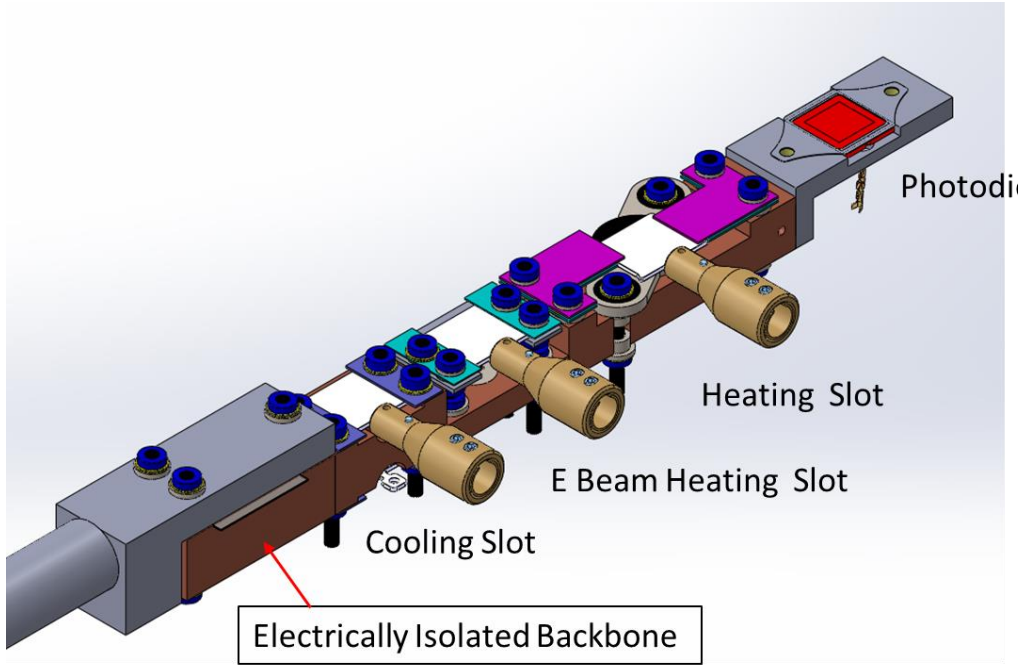
- HESEB project will include experimental chamber on day one
  - Design led by W. Eberhardt / M. Genisel
  - Absorption, CMXD and fluorescence yield studies
  - 2D-mapping of surfaces with 20 μm spatial resolution UHV---up to pressures of 1 atmosphere (He)
  - Set up at KIT tested
  - Adjustments for focussing capillary (TU-Berlin) have been designed and built
  - Manipulator arm with sample transfer heating/cooling
  - built at FZ Jülich



See more details by Mustafa Genisel

Experimental Chamber cont‘d

- HESEB chamber and detector
  - Design of manipulator receptor part finished, produced at FZJ
  - Advanced Si drift detector (Bruker) for fluorescence signal
  - use capillary optics for creating a 20μ spot size
  - (cooperation with TU Berlin / Prof B. Kanngiesser) => interesting science case within Petra painting conversation project



See talk by Maram Na‘es

Surface Analysis of Thin Films for Cultural Heritage

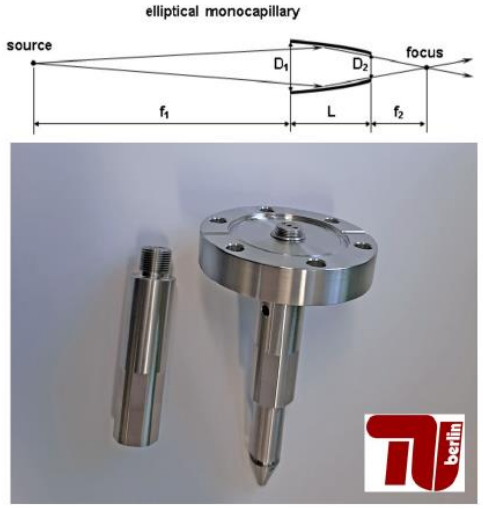


Fig. 5 Elliptical monocapillary and holder for focussing and differential pumping

HESEB User community building

https://www.hzdr.de/db/Cms?pOid=58977&pNid=0

Activities and plans

- In the original proposal we prepared/planned various teaming/twinning actions for 2020, incl. a major workshop in March 2020 in Turkey
  - However, had to cancel all this due to SARS-CoV2
- In 2020/2021 several HESEB online seminars/ workshops were organized
- We also made use of synergies with BEATS, i.e. close coordination for joint SESAME/HESEB/BEATS events:
  - workshop on archaeology / cultural heritage in Feb 2022
  - workshop on cooperation with Africa in July 2022
  - dedicated event to target Palestinian research communites in Nov 2021
- HESEB research stay program
  - Two-month research stay at a European SR lab, full integration into BL team
  - research interests / proposals matched to beamline
  - ample opportunities to establish new contacts, networks

Inauguration of HESEB Beamline

SESAME, 12 June 2022

Conclusions

HESEB Helmholtz-SESAME Soft X-Ray Beamline for SESAME

HESEB soft x-ray beamline

- HESEB project is a strong and visible effort of Helmholtz to contribute to international cooperation, to the science diplomacy goals at SESAME, and to capacity building in the region
- The beamline has been designed, delivered, installed and is currently in the commissioning phase
- We are preparing the „friendly user phase“ with first experiments at HESEB before the beamline will become part of open call proposal system at SESAME in 2023
- User community building efforts will continue in 2023

- A big thank you goes to all HESEB project members, collaborators and to the fantastic SESAME staff