Science Opportunities at SESAME

Andrea Lausi

SESAME

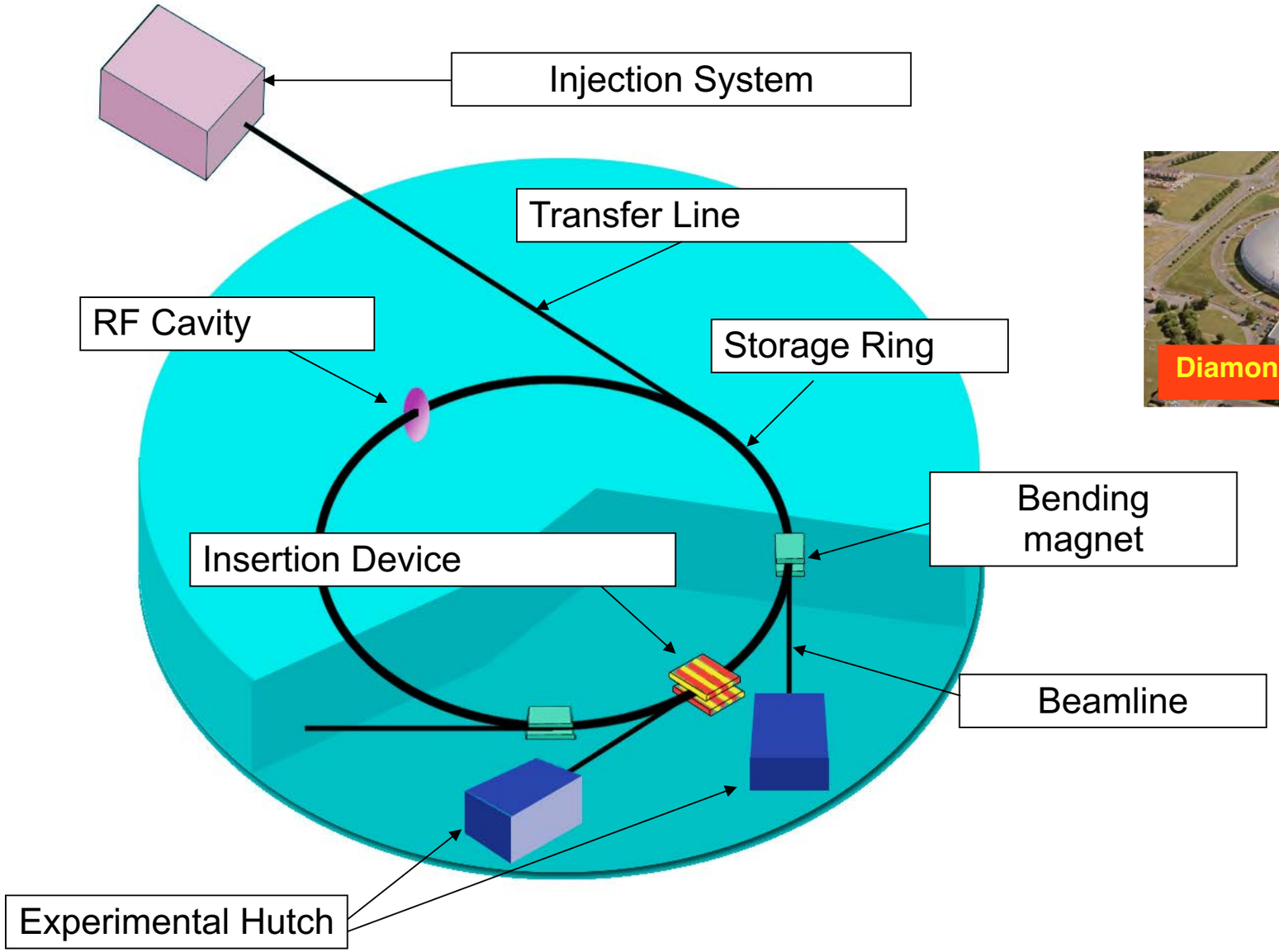
2022: 75 years SL

Synchrotron Light (SL), also referred to as Synchrotron Radiation (SR), was named after its discovery in a General Electric synchrotron accelerator built in 1946 and announced in May 1947 by Frank Elder, Anatole Gurewitsch, Robert Langmuir, and Herb Pollock in a letter entitled "Radiation from Electrons in a Synchrotron".

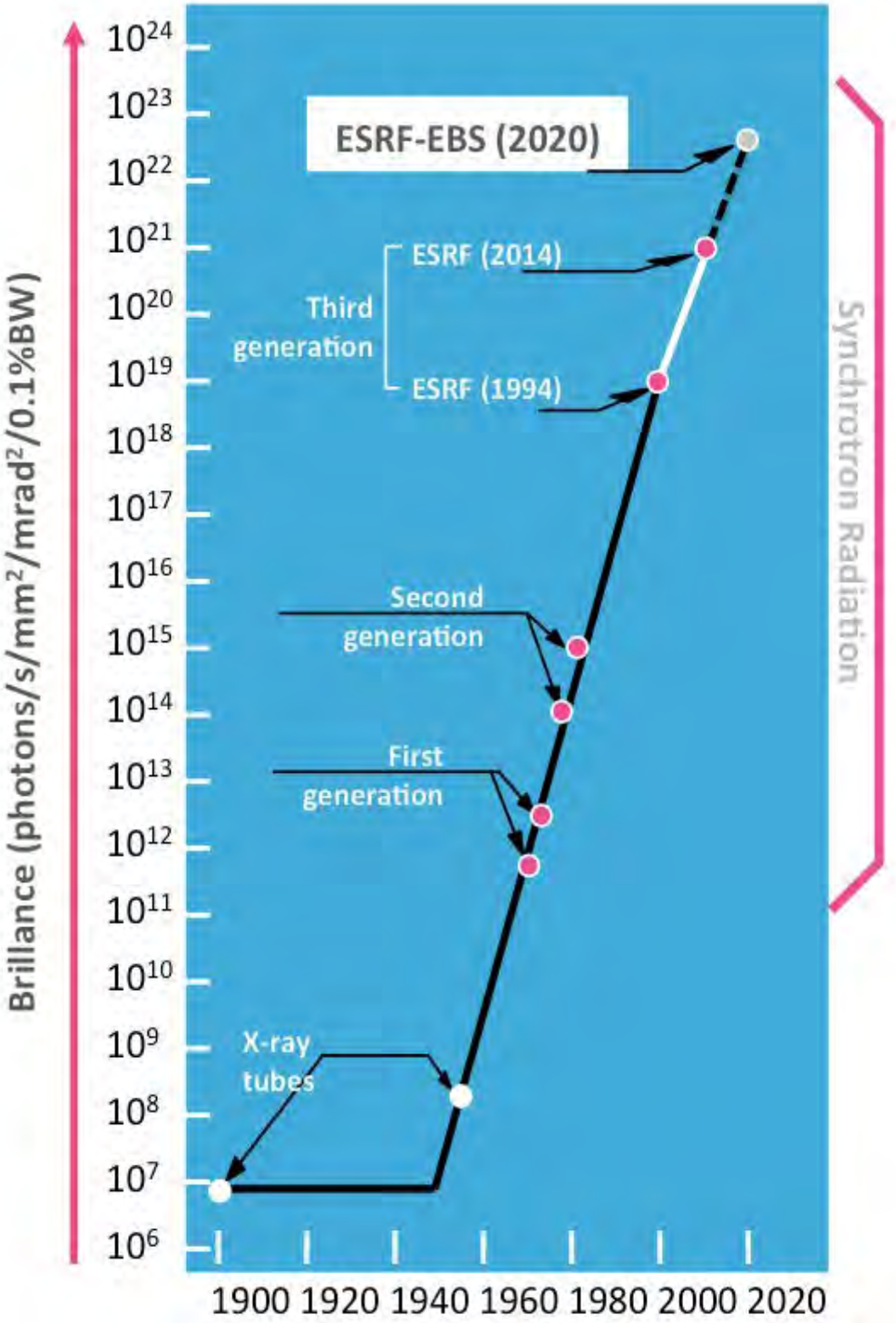
Picture taken from lightsources.org

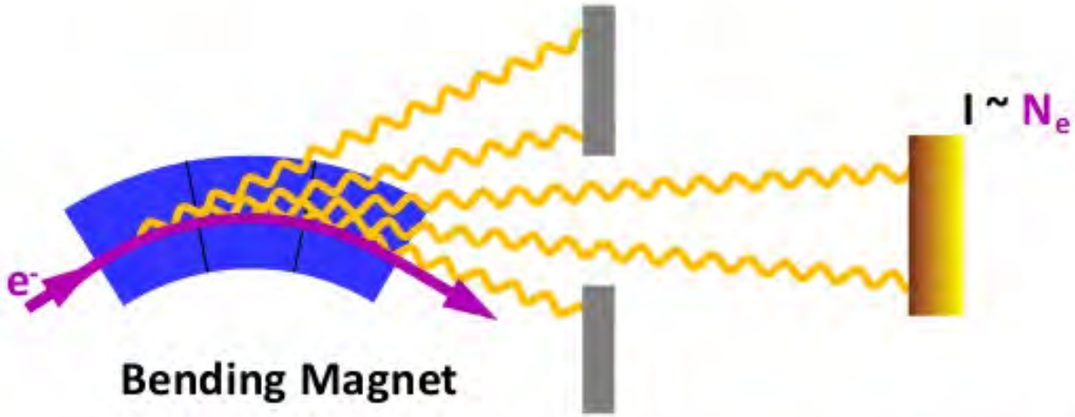
50,000 users, the largest scientific community in the world

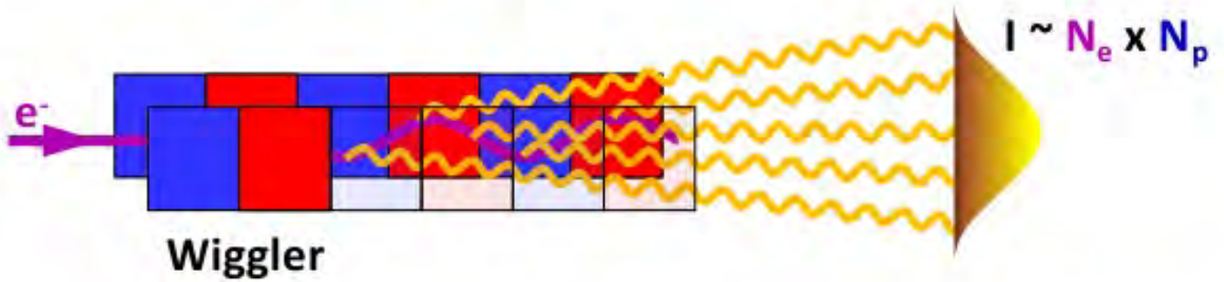
Scheme of a Synchrotron Light Source

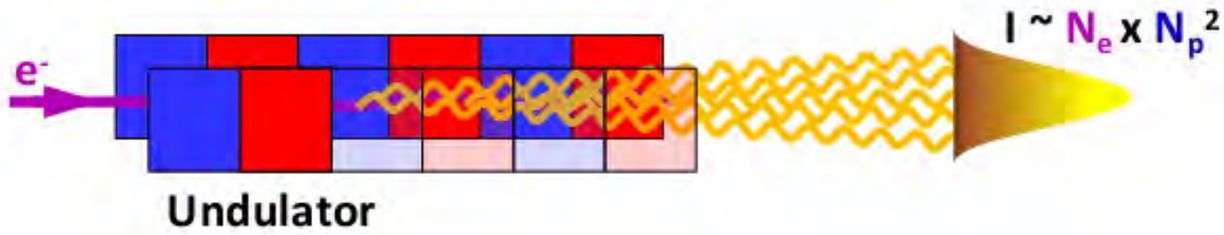


Toward Higher Brilliance

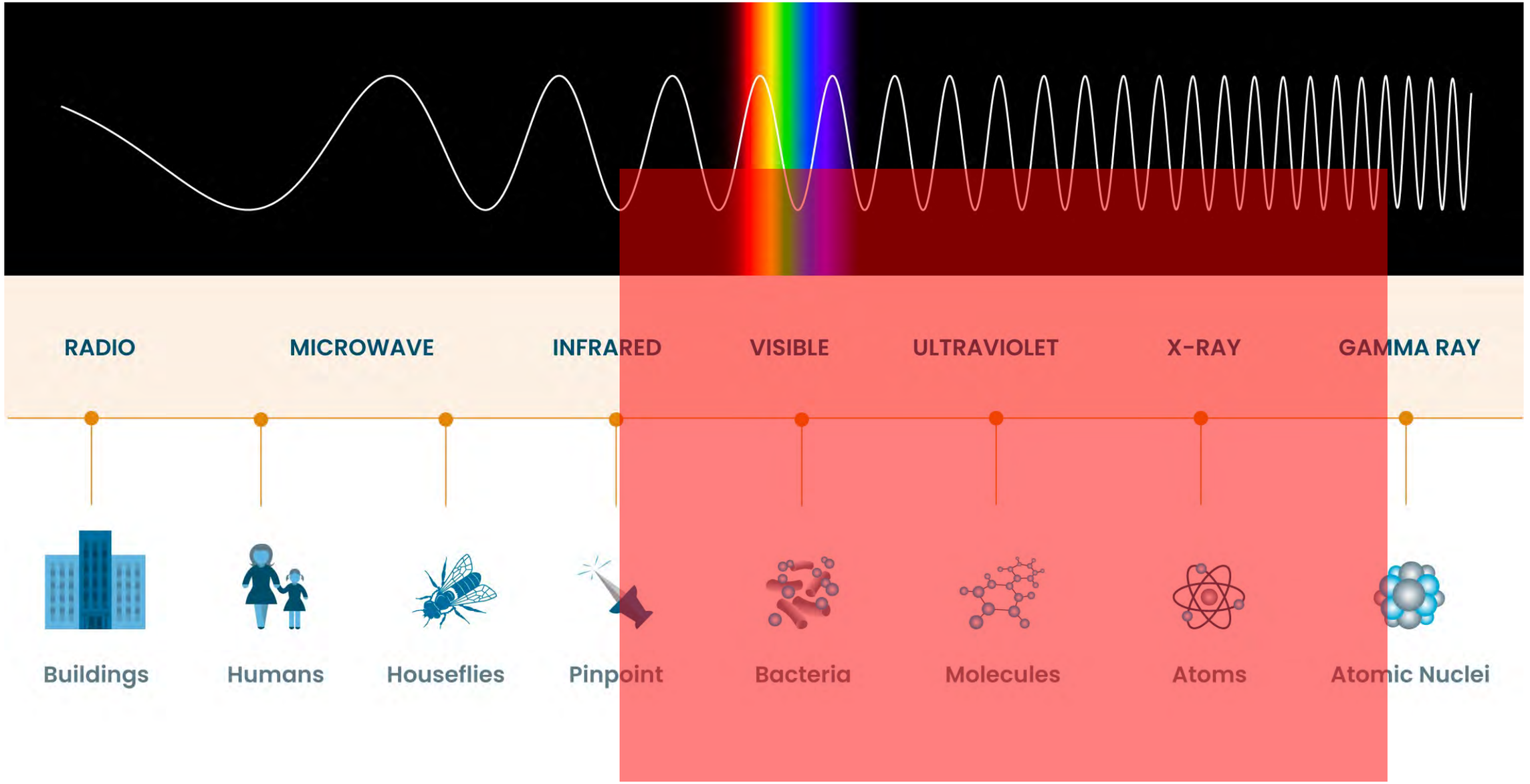




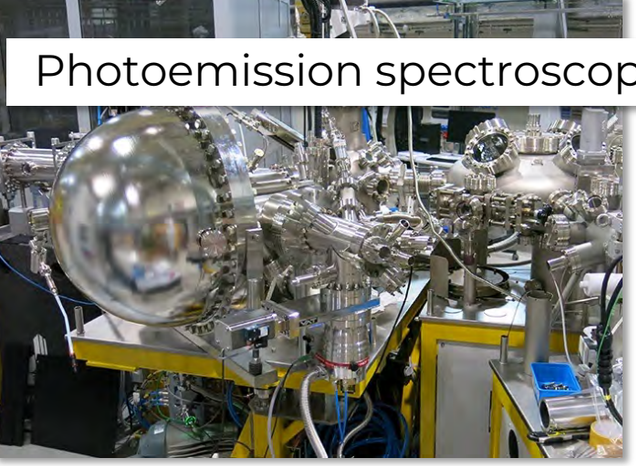




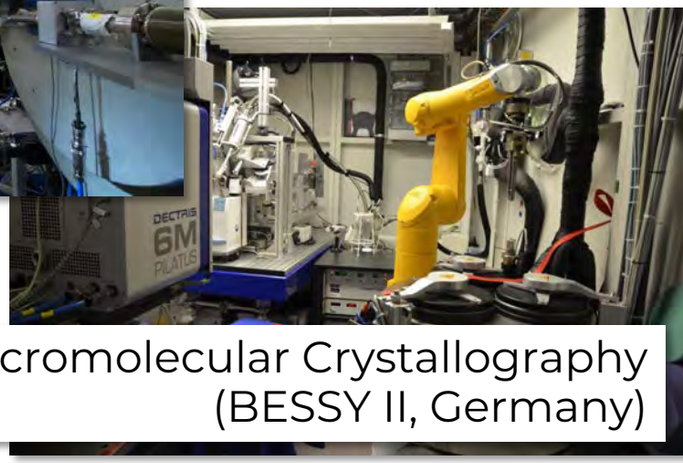
High Brilliance over a Wide Spectrum



Photoemission spectroscopy (SOLARIS, Poland)

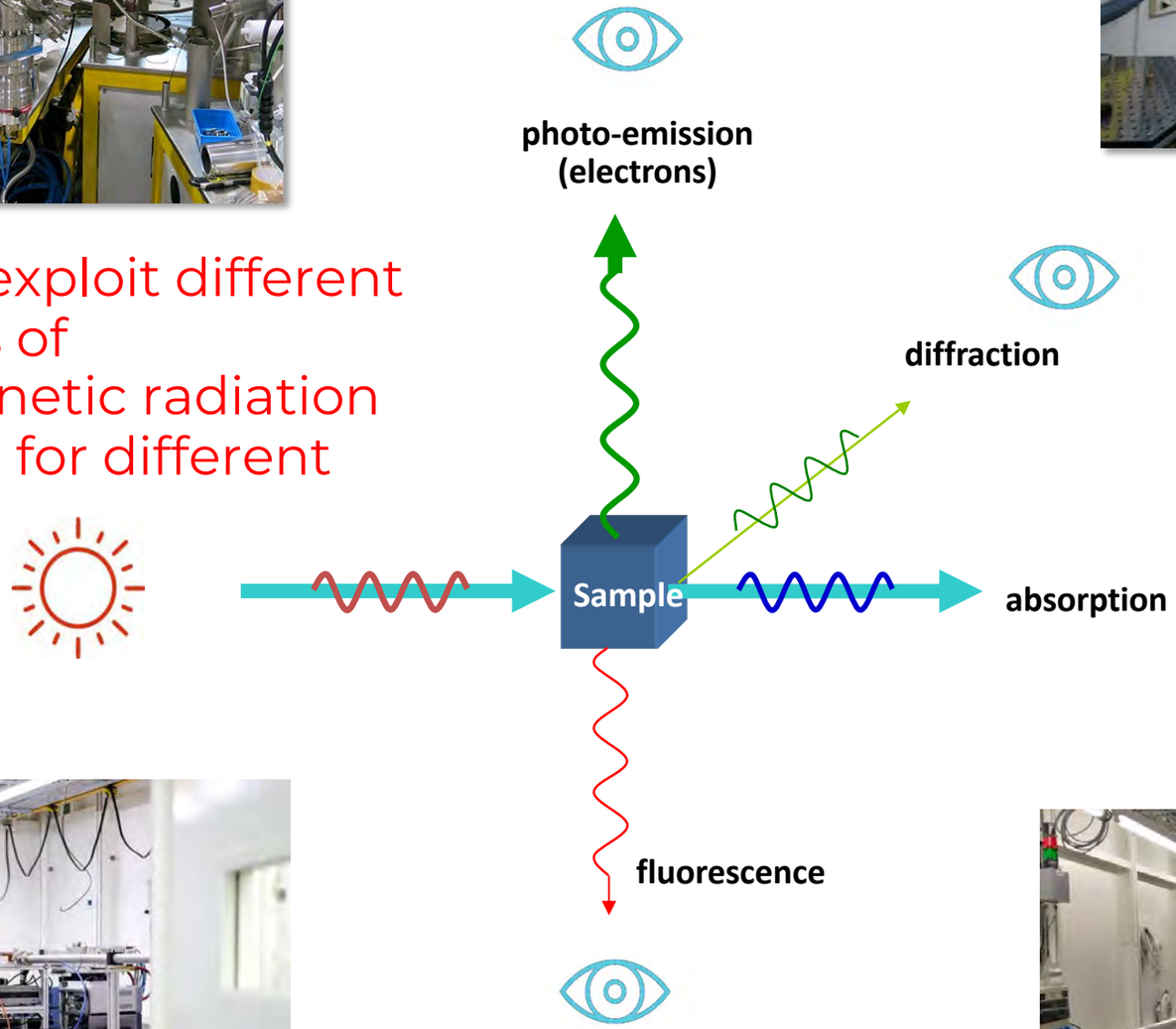


Powder diffraction (ESRF, France)



Macromolecular Crystallography (BESSY II, Germany)

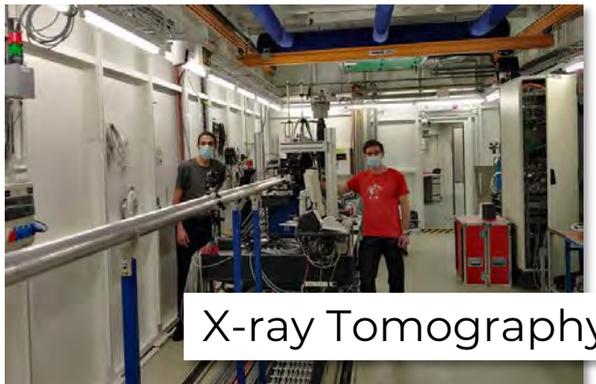
Beamlines exploit different interactions of electromagnetic radiation with matter for different analysis



Infrared Spectroscopy (ALBA, Spain)

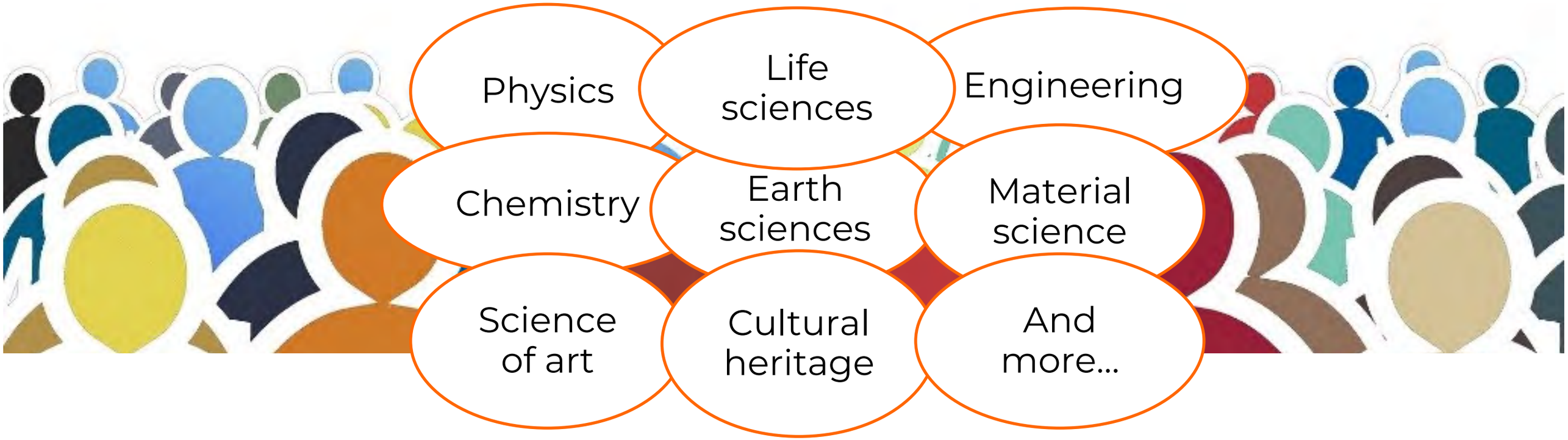
Photo © Ivan Lim

XAFS/XRF (SESAME, Jordan)



X-ray Tomography (SLS, Switzerland)

Synchrotron light sources are scientific cultural centers in continuous evolution



Access granted for proposals on peer review basis

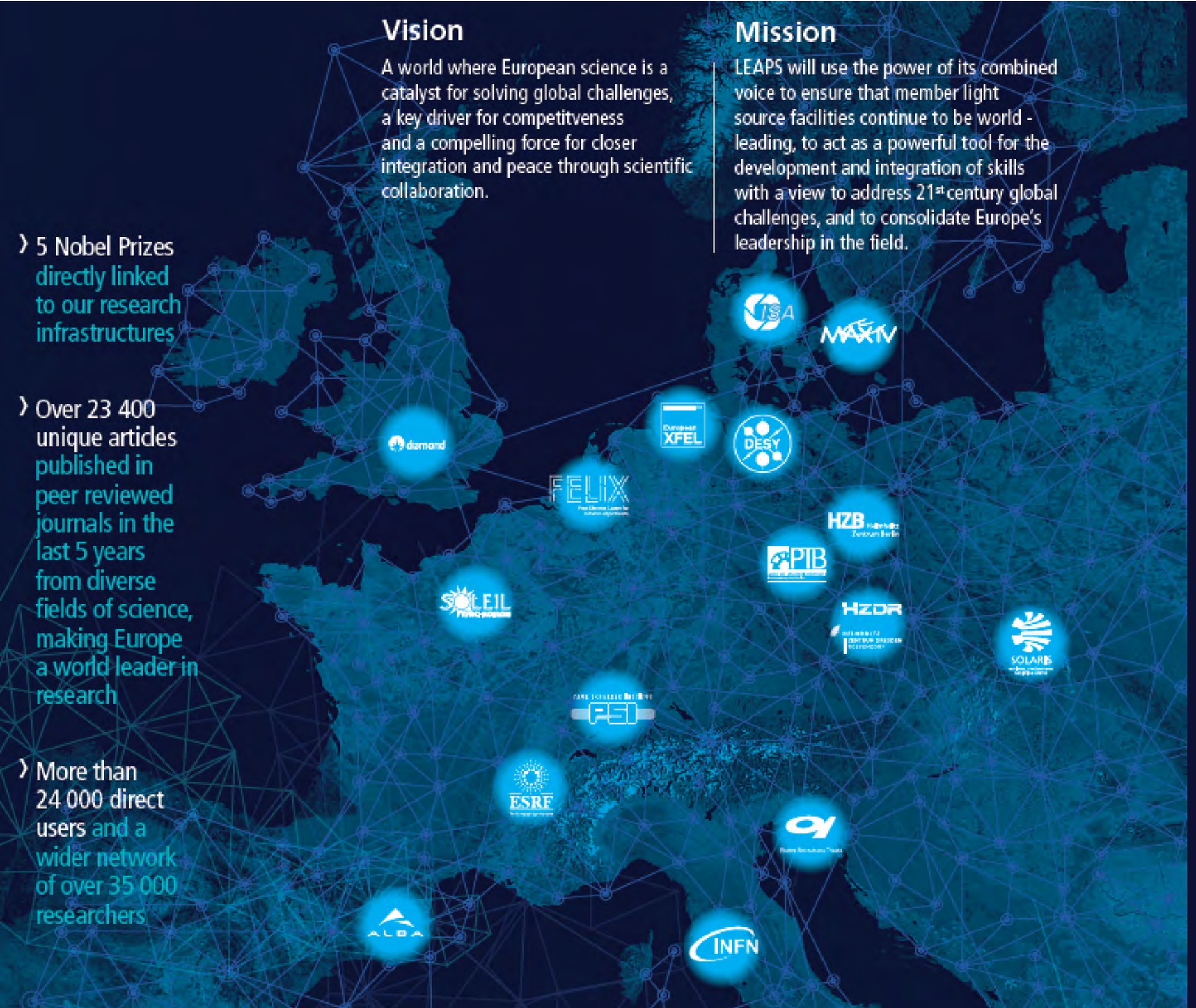
Vision

A world where European science is a catalyst for solving global challenges, a key driver for competitveness and a compelling force for closer integration and peace through scientific collaboration.

Mission

LEAPS will use the power of its combined voice to ensure that member light source facilities continue to be world - leading, to act as a powerful tool for the development and integration of skills with a view to address 21st century global challenges, and to consolidate Europe's leadership in the field.

- 5 Nobel Prizes directly linked to our research infrastructures
- Over 23 400 unique artides published in peer reviewed journals in the last 5 years from diverse fields of science, making Europe a world leader in research
- More than 24 000 direct users and a wider network of over 35 000 researchers



LEAPS:
the League of European Accelerator-based Photon Sources
groups
the major "Photon Factories"
in Europe

In November 2018, SESAME become the 1st Associate Member of LEAPS

Sergio Fubini

Eliezer Rabinovici

Gustav Voss

Herwig Schopper

Herman Winick

Pioneers of SESAME

United Nations Educational, Scientific and Cultural Organization

- SESAME is a cooperative venture by scientists and governments of the region set up on the model of CERN although it has very different scientific aims.

- It was established under the auspices of UNESCO (United Nations Educational, Scientific and Cultural Organization) following the formal approval given for this by the Organization's Executive Board (164th session, May 2002).

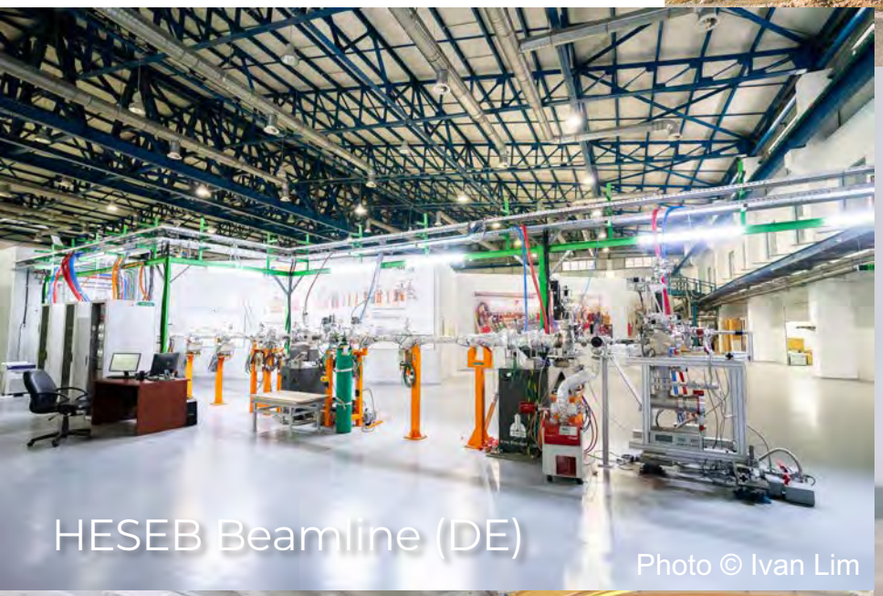
- SESAME is a User facility open to international academic and industrial communities.

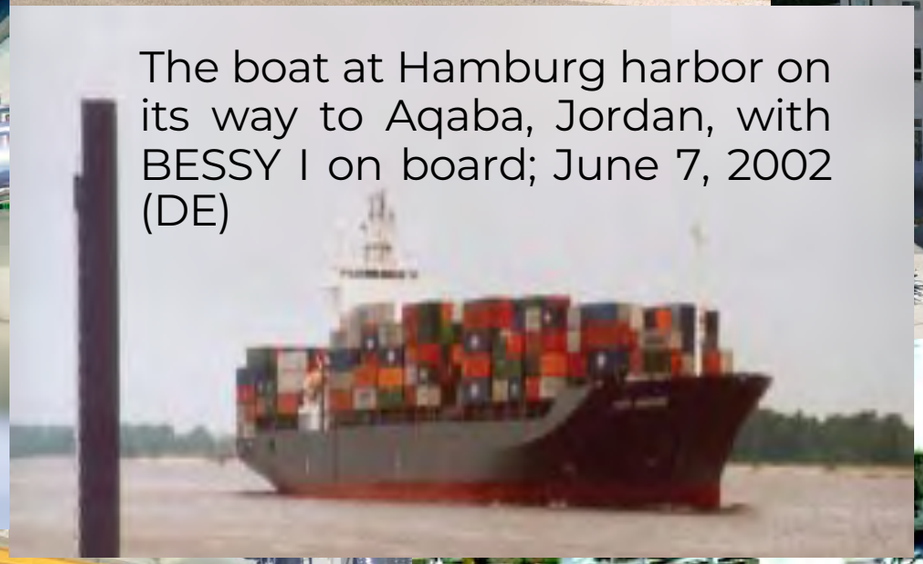
SESAME is composed of **Members** and Observers

SESAME is composed of Members and **Observers**

Brazil, Canada, CERN, China, the European Union, France, Germany, Greece, Italy, Japan, Kuwait, Portugal, Russian Federation, Spain, Sweden, Switzerland, the United Arab Emirates, the United Kingdom, and the United States of America

SESAME received much support from non-members. Examples are…





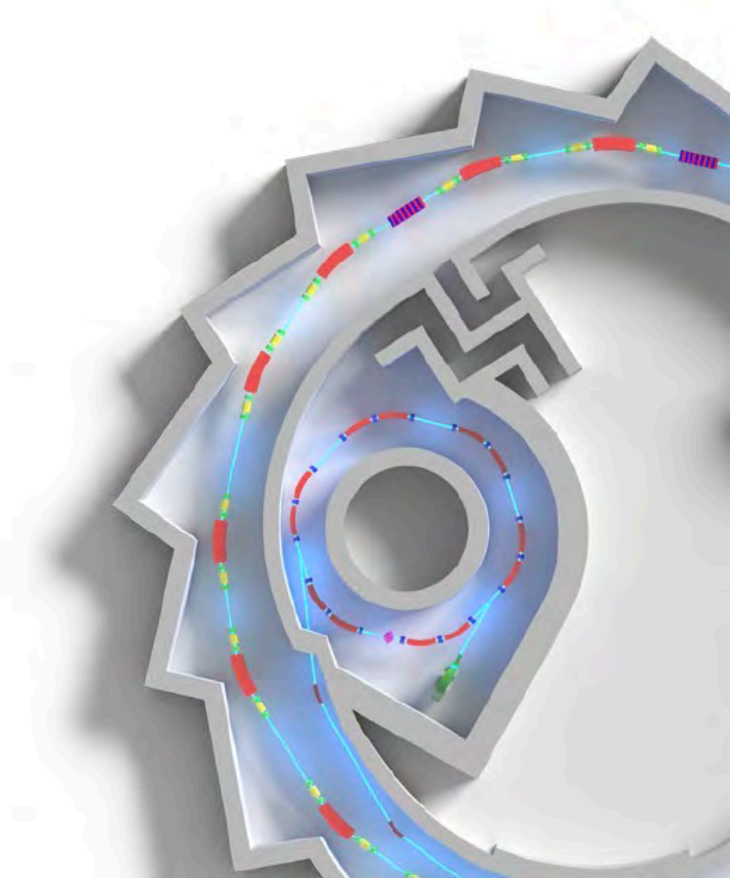
SESAME Energy Balance

6.5 MW Solar Power Plant
Financed by EU

Average Annual Production:
11.57 GWh
CO_2 Saved: -7,104 Ton

MAX Peak Load: 2.1MW
Average Annual Consumption: 9.7GWh
CO_2 Saved: - 5,955 Ton

- Cooling System: 542kWh
- Storage Ring Magnets: 521kWh
- Main RF System: 480kWh
- SESAME Main Building: 100kWh
- Injector (Microtron & Booster): 62.5kWh



Inaugurated December 4, 2019, the Sergio Fubini Guest House was funded by the Italian Ministry of Education, Universities and Research through INFN (total of 1.75 M Euro). The Guest House includes a canteen, meeting rooms and 48 guestrooms. 2 are accessible to disabled persons.

December 14, 2013, winter storm **ALEXA**

Worst snowfall in 50 years in Amman and Jerusalem

2015: new roof in place

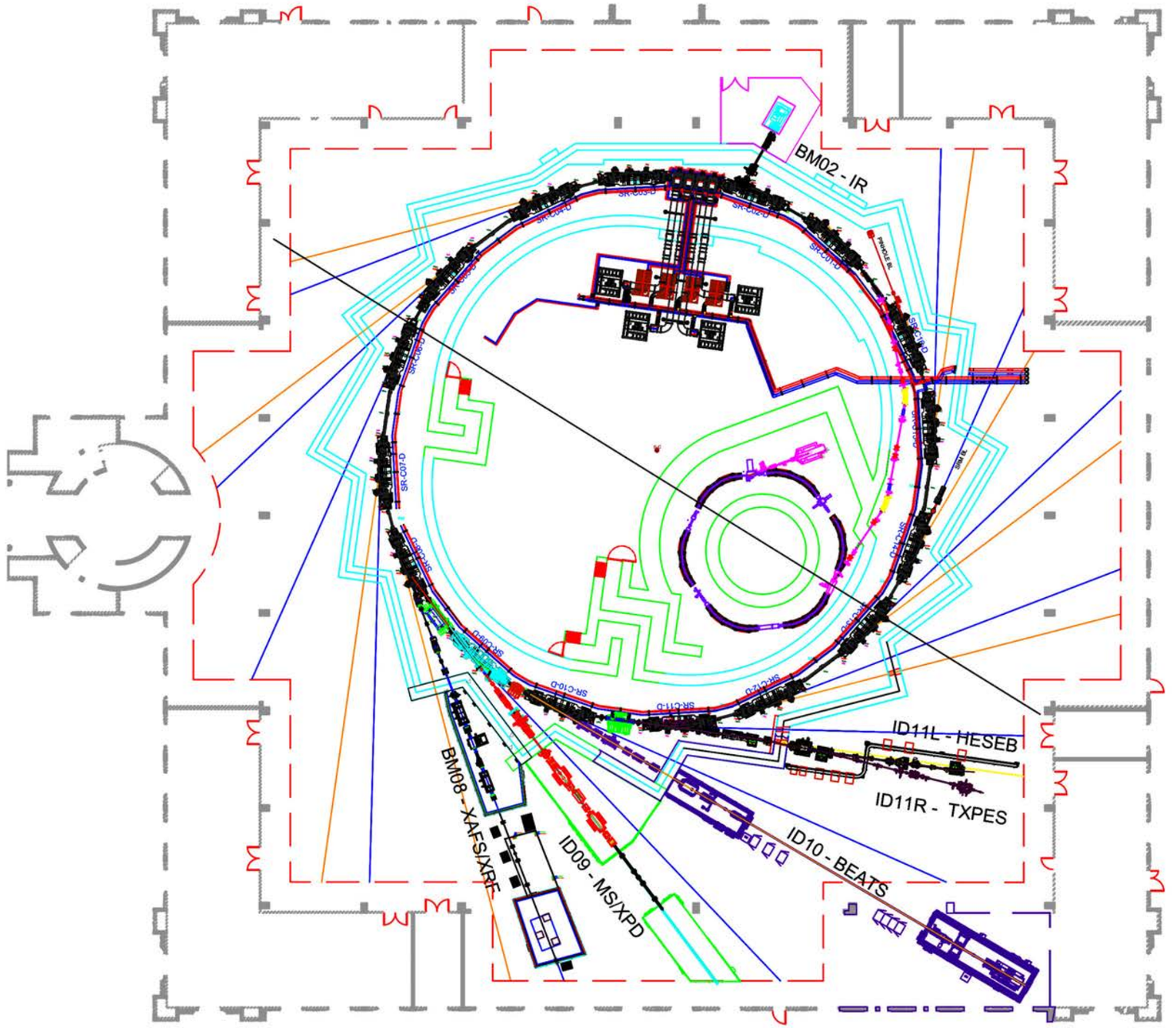
HM King Abdullah II at the opening of SESAME with Heads of the delegations of the SESAME Members, Directors-General of Intergovernmental Organizations, President SESAME Council and SESAME's Directorate. Left of the King, HRH Princess Sumaya, head of Jordan's delegation; and Fabiola Gianotti, Director General CERN; to his right, Irina Bokova, Director-General UNESCO; Carlos Moedas, EC Commissioner for Research, Science and Innovation; and Rolf Heuer, President-Elect SESAME Council. Directly behind the King, Chris Llewellyn Smith, President SESAME Council with on left Khaled Toukan, Director SESAME. Back far left Yukiya Amano, Director General IAEA

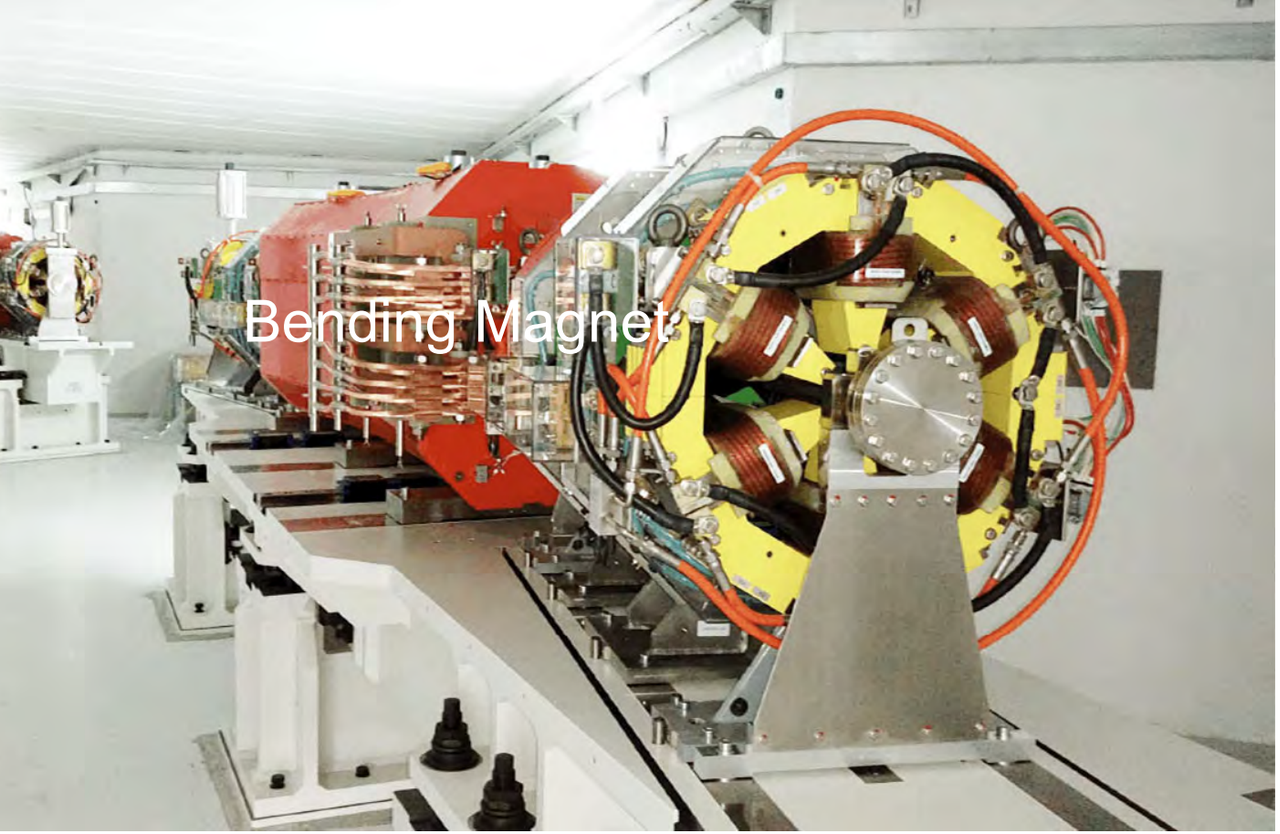
A 3rd generation light source
2.5 GeV electrons – 133 meters circumference

Shielding wall surrounding SESAME accelerator

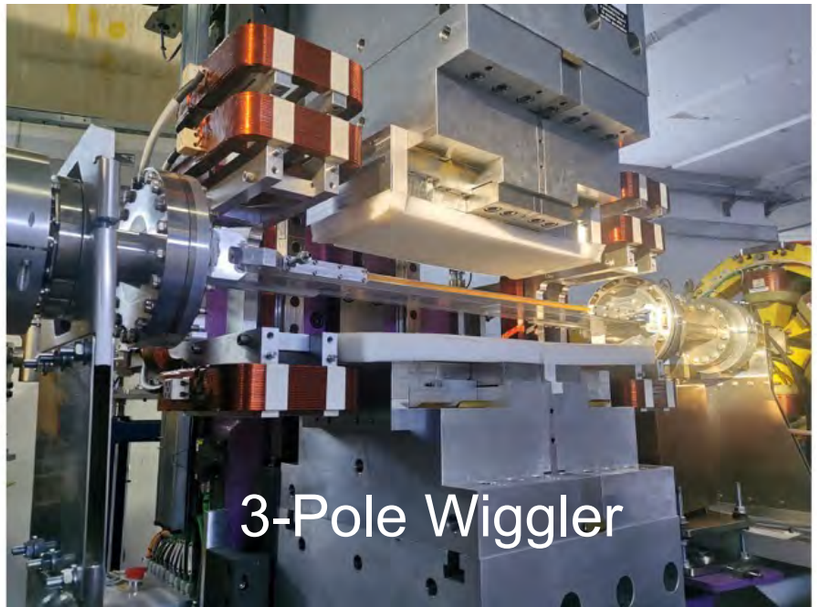
Photo © Ivan Lim

Dieter Einfeld, SESAME storage ring designer



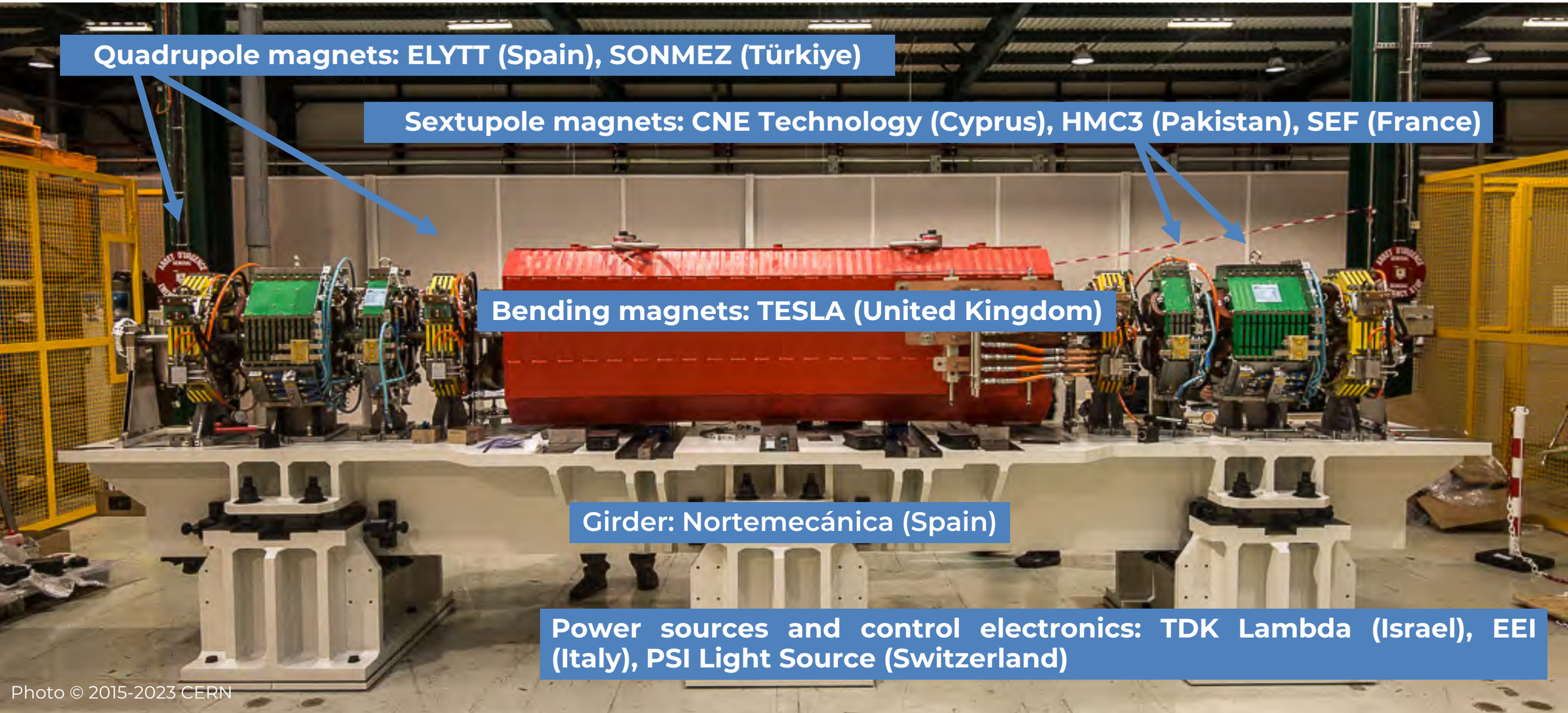


SR parameter	Value
Energy	2.5 GeV
Circumference	133 m
Emittance	26 nmrad
Current	300 mA
RF frequency	500 MHz
# cavities	4
Long straits	8 (4 m)
Short streights	8 (2 m)



CESSAMag

Magnets designed at SESAME,
procured by SESAME/CERN EC FP7 project CESSAMag
QA/QC at ALBA (Spain) and at CERN

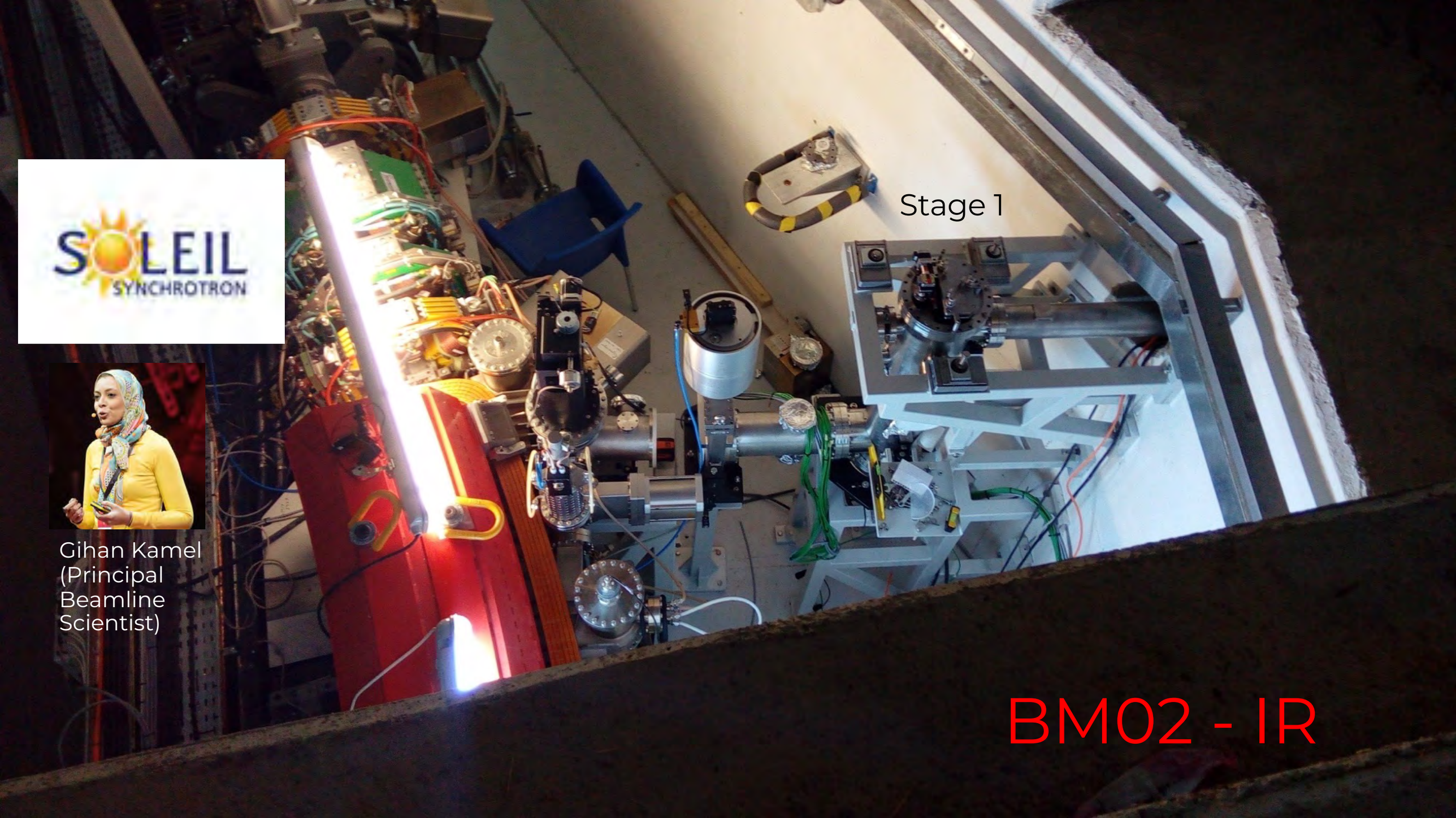


SESAME Phase 1 beamlines

No	Beamline	Energy Range	Source Type
BM02	IR (Infrared) spectromicroscopy	0.001-3 eV	Bending Magnet
BM08	XAFS/XRF (X-ray Absorption Fine Structure/X-ray Fluorescence) spectroscopy	4.5-30 keV	Bending Magnet
ID09	MS/XPD (Materials Science/X-ray Powder Diffraction)	5-25 keV	Multipole Wiggler
ID10	BEATS: Beamline for Tomography at SESAME	8-50 keV	3-Pole Wiggler
ID11L	HESEB: Helmholtz-SESAME Beamline	70-1800 eV	Undulator
ID11R	TXPES: Turkish X-ray Photoemission Spectroscopy	70-1800 eV	Undulator
	MX Macromolecular Crystallography	~12.4 keV	
	SAXS (Small Angle X-ray Scattering)	~8 keV	

THE TWO BENDING MAGNET BEAMLINES

BM02-IR and BM08-XAFS/XRF

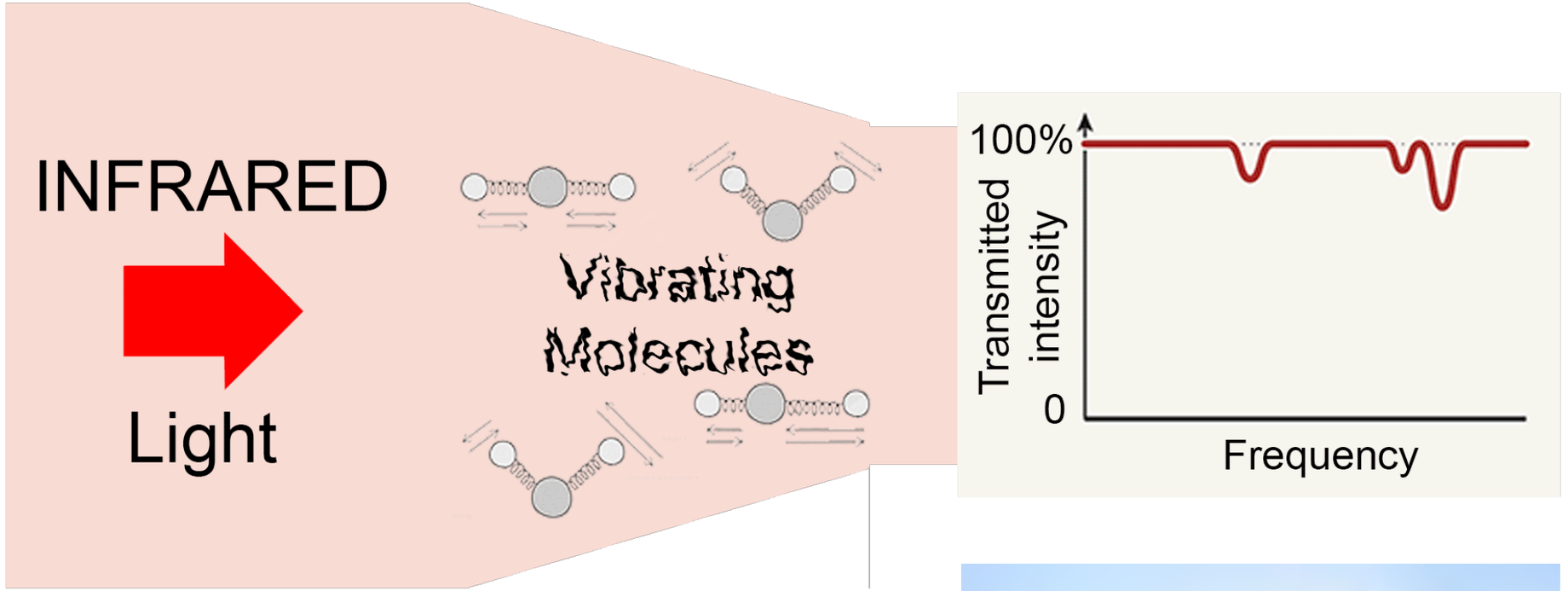


Gihan Kamel (Principal Beamline Scientist)

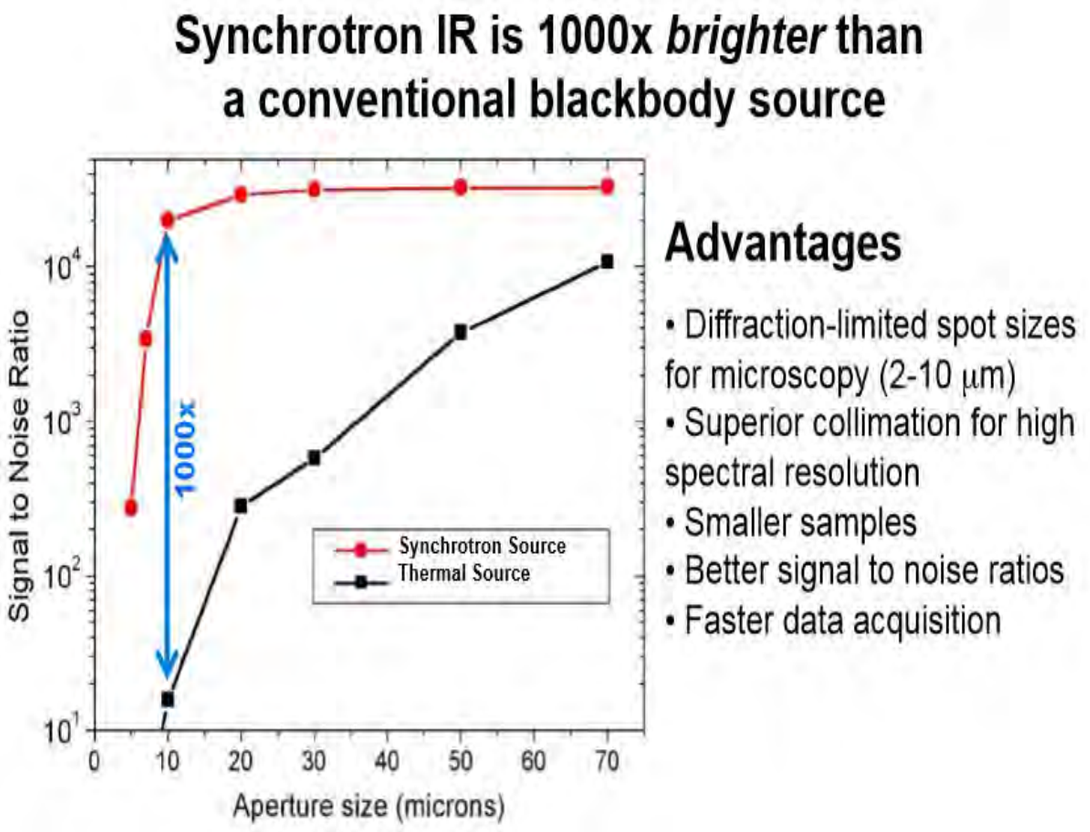
2022: New Microscope and Spectrometer installed in the Experimental Hutch as part of INFN-CHNet

INFN CHNet
Istituto Nazionale di Fisica Nucleare
Cultural Heritage Network

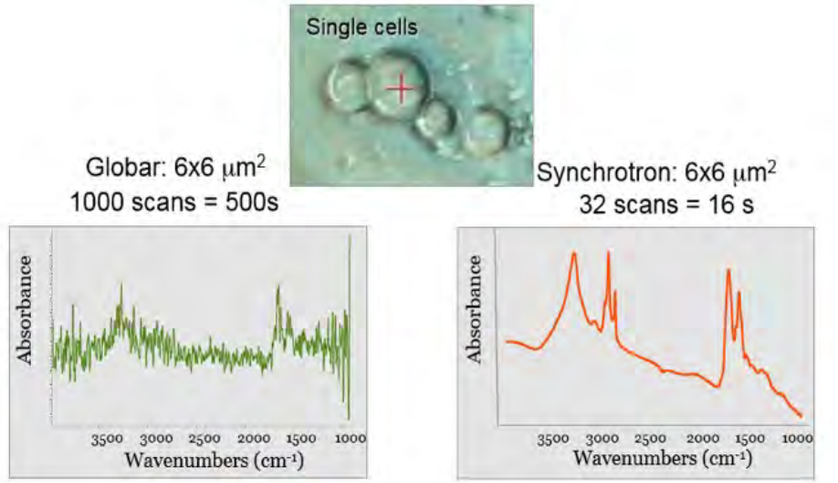
Infrared Spectroscopy



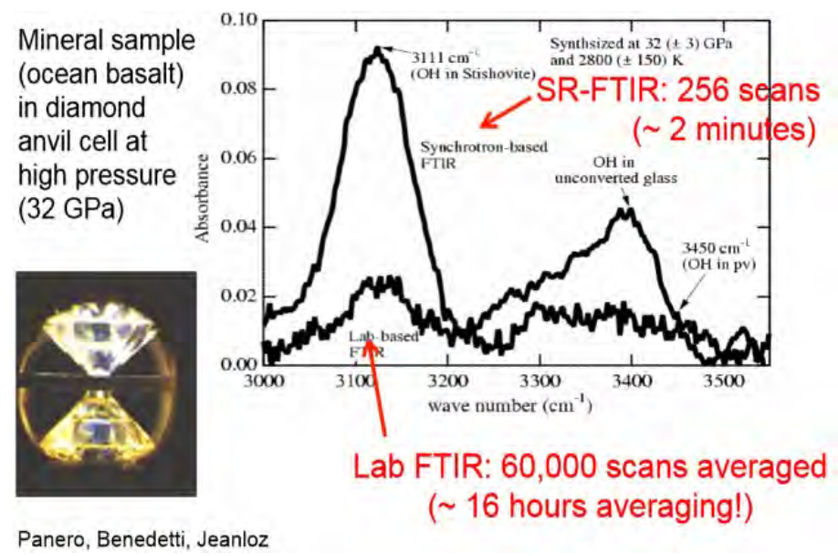
SR Advantages over thermal sources



Holman et al., Spectroscopy - An International Journal 17(2-3), 139-159 (2003).



From Paul Dumas, SOLEIL



Panero, Benedetti, Jeanloz

Jordan: Diagnostic Tools for Pre-Eclampsia

Journal of Pharmaceutical and Biomedical Analysis 184 (2020) 113186

Contents lists available at ScienceDirect

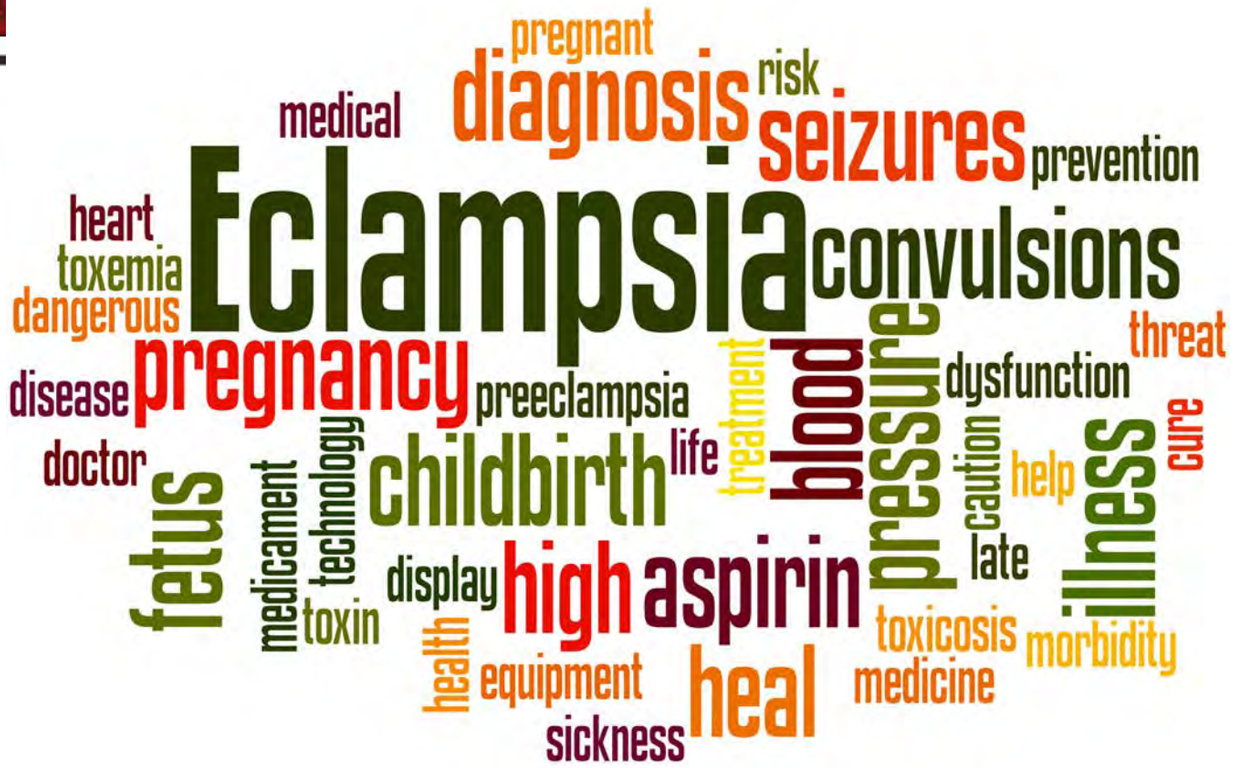
Journal of Pharmaceutical and Biomedical Analysis

journal homepage: www.elsevier.com/locate/jpba

Investigating the molecular structure of placenta and plasma in pre-eclampsia by infrared microspectroscopy

Lina A. Dahabiyeh[a,*], Randa S.H. Mansour[b], Shawqi S. Saleh[c], Gihan Kamel[d,e]

[a] Department of Pharmaceutical Sciences, School of Pharmacy, The University of Jordan, Queen Rania St, Amman, 11942, Jordan
[b] Faculty of Pharmacy, Philadelphia University, 19392, Amman, Jordan
[c] Department of Obstetrics and Gynaecology, School of Medicine, The University of Jordan, 11942, Amman, Jordan
[d] SESAME Synchrotron (Synchrotron-light for Experimental Science and Applications in the Middle East), 19252, Allan, Jordan
[e] Department of Physics, Faculty of Science, Helwan University, Cairo, Egypt



Malta and UK: Egyptian mummified embalmed head

Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 261 (2021) 120073

Contents lists available at ScienceDirect

Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy

journal homepage: www.elsevier.com/locate/saa

Mummified embalmed head skin: SR-FTIR microspectroscopic exploration

Despina Moissidou [a], Hayley Derricott [a], Gihan Kamel [b,c,*]

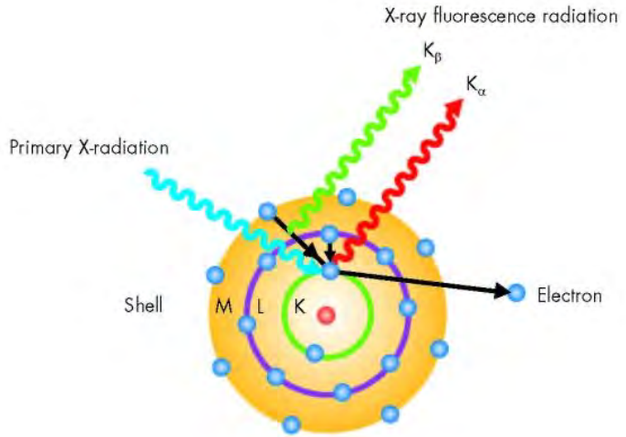
[a] Barts and the London School of Medicine and Dentistry, Queen Mary University of London, Malta Campus, Malta
[b] SESAME (Synchrotron-light for Experimental Science and Applications in the Middle East), Allan, Jordan
[c] Department of Physics, Faculty of Science, Helwan University, Cairo, Egypt

BM08 - XAFS/XRF

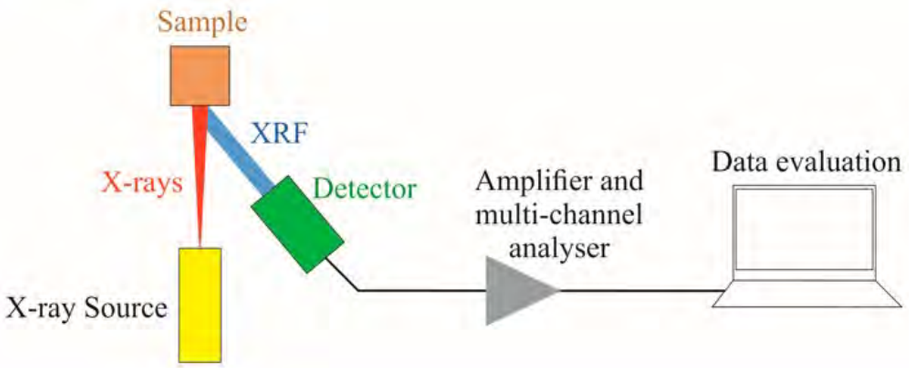
Messaoud Harfouche
(Principal Beamline Scientist)

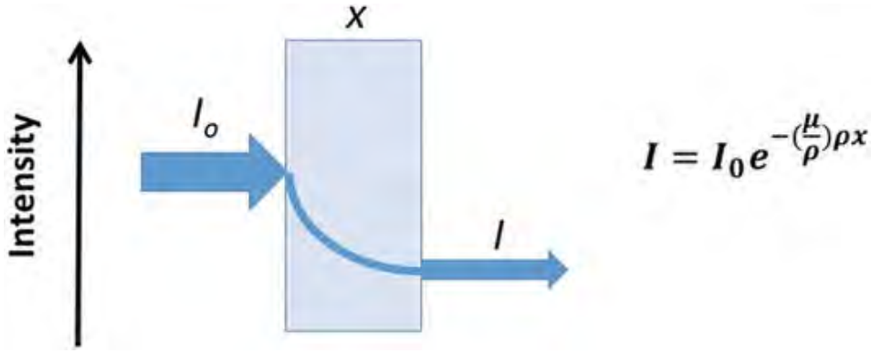
Latif Ullah Khan
(Beamline Scientist)

X-ray Absorption Spectroscopy



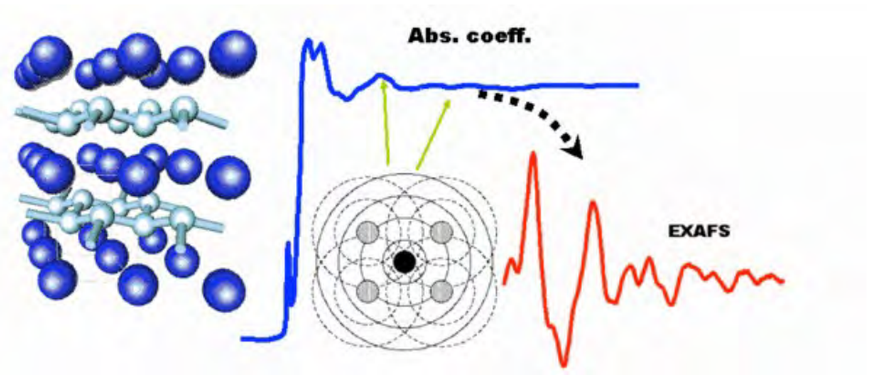
from: https://xrf-spectroscopy.com/





$$I = I_0 e^{-(\frac{\mu}{\rho})\rho x}$$

from DOI: 10.5772/66868



from: www.fis.unipr.it/phevix/exafs.html

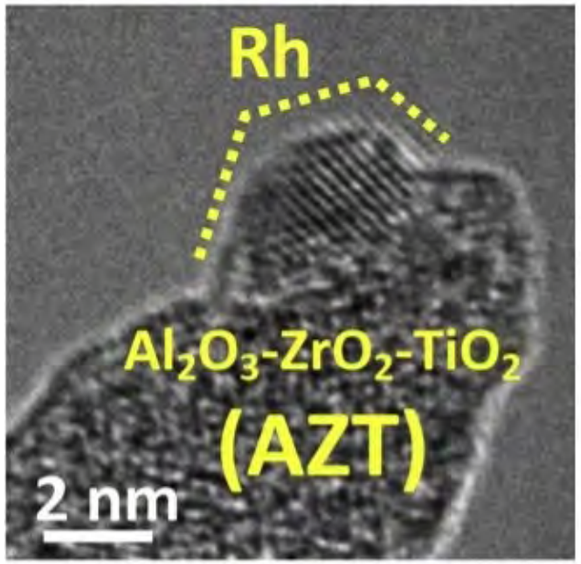
Istituto Nazionale di Fisica Nucleare

Elettra Sincrotrone Trieste

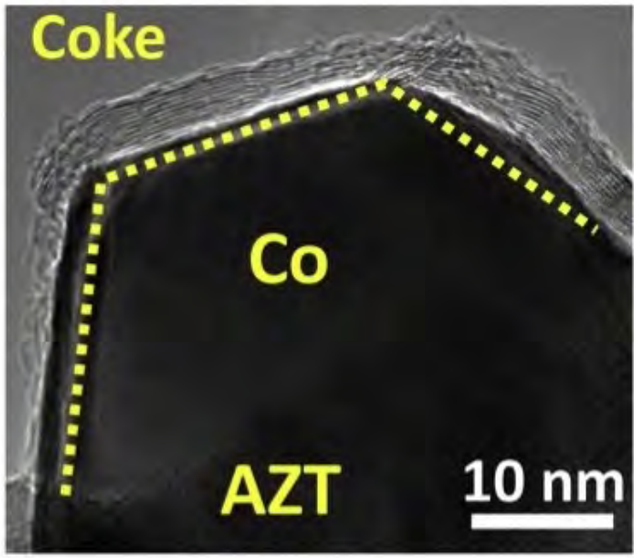
December 2019: installation of a new 64-elements X-ray Fluorescence Silicon Drift Detector (8 Modules x 8 SDDs with a total sentitive area of 499 mm^2)

I. Carlomagno et al., J. Synchrotron Rad. (2021). 28, 1811–1819

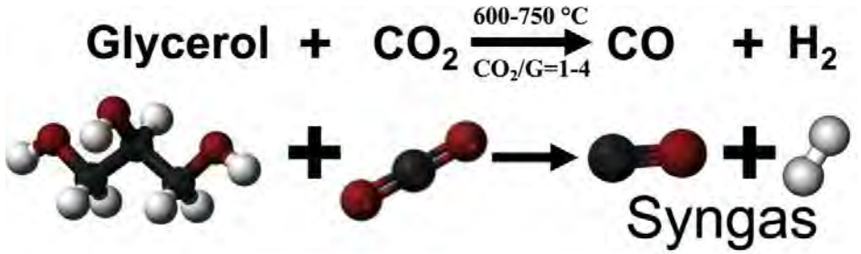
Türkiye: Syngas Production from Glycerol



Rh/AZT



Co/AZT



Applied Catalysis B: Environmental 256 (2019) 117808

Contents lists available at ScienceDirect

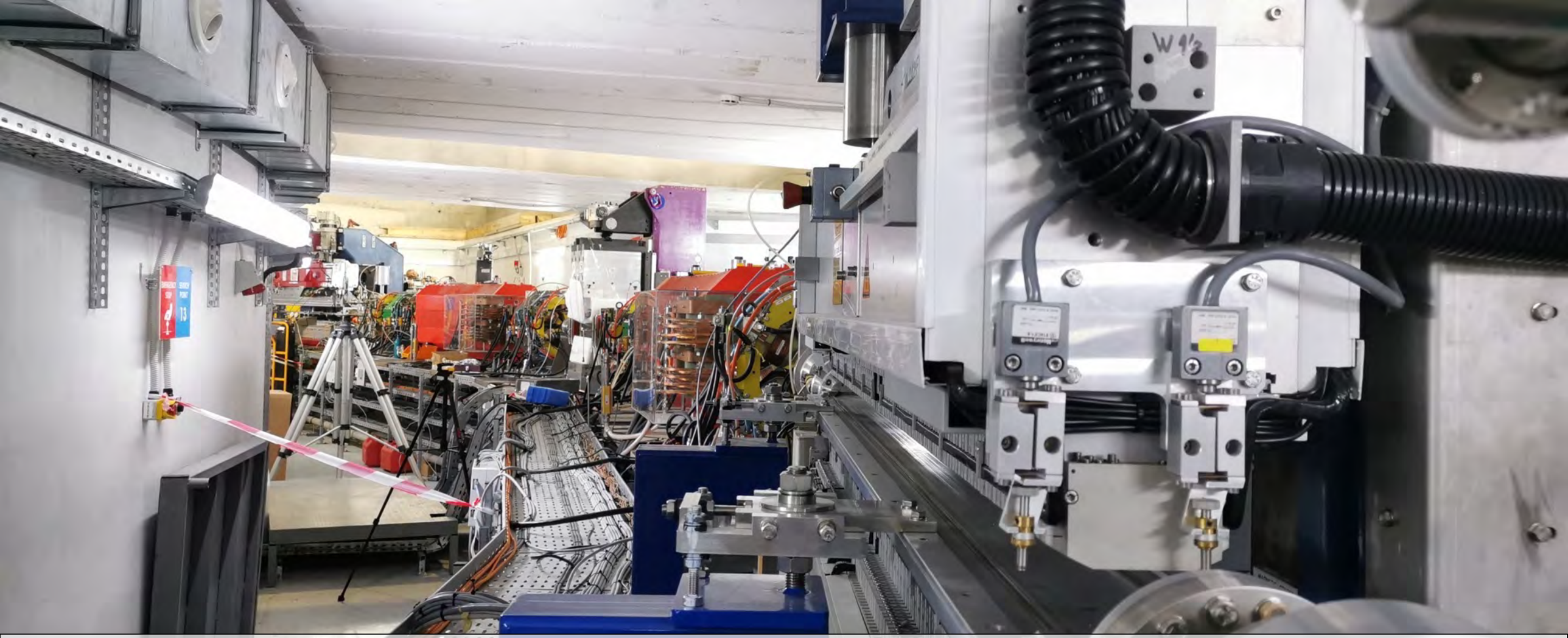
Applied Catalysis B: Environmental

journal homepage: www.elsevier.com/locate/apcatb

Exceptionally active and stable catalysts for CO_2 reforming of glycerol to syngas

Selin Bac[a], Zafer Say[b,c], Yusuf Kocak[b], Kerem E. Ercan[b], Messaoud Harfouche[d], Emrah Ozensoy[b,e,**], Ahmet K. Avci[a,*]

[a] Department of Chemical Engineering, Bogazici University, Bebek, 34342, Istanbul, Turkey
[b] Bilkent University, Department of Chemistry, 06800, Ankara, Turkey
[c] Department of Physics, Chalmers University of Technology, 412 96, Göteborg, Sweden
[d] Synchrotron-Light for Experimental Science and Applications in the Middle East (SESAME), 19252, Allan, Jordan
[e] UNAM-National Nanotechnology Center, Bilkent University, 06800, Ankara, Turkey



THE THREE ID BEAMLINES
ID09-MS/XPD, ID10-BEATS, ID11L-HESEB

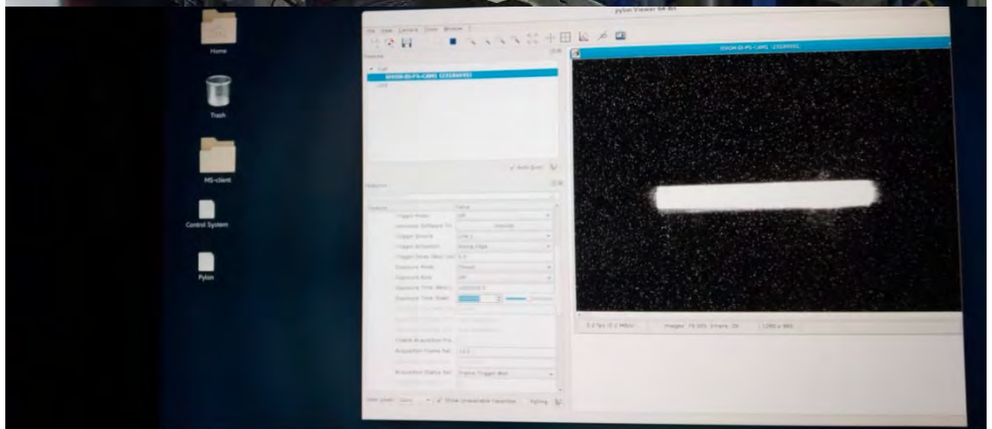
Mahmoud Abdellatief
(Principal Beamline Scientist)

Philipp Hans
(Beamline Scientist)

ID09 – MS/XPD

PAUL SCHERRER INSTITUT

PSI

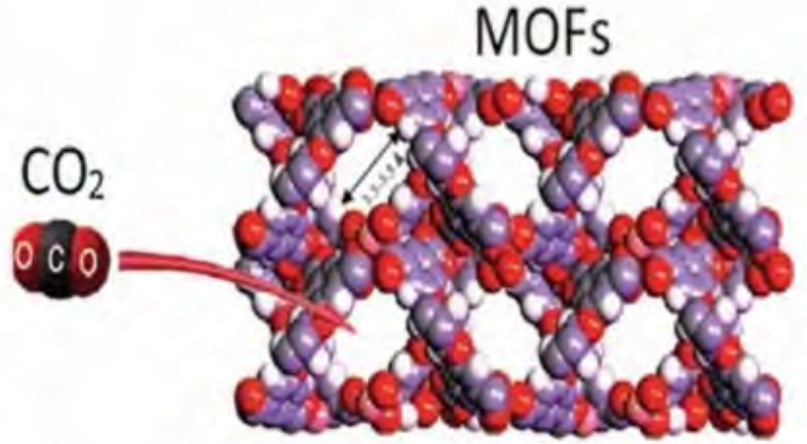


January 2019 - Wiggler source before installation and commissioning

December 2019 – First monochromatic beam in experimental hutch

January 2020: beginning installation of the Experimental Station

Jordan: Design of Metal-Organic Frameworks



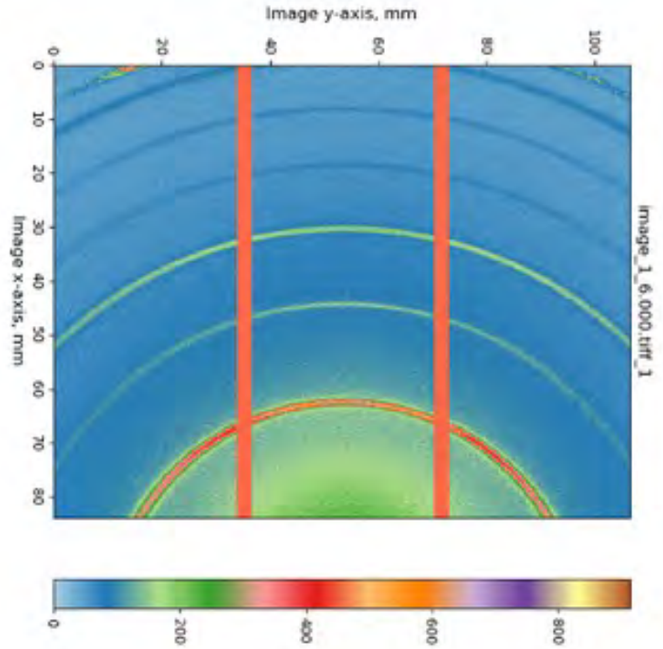
ACS MATERIALS LETTERS

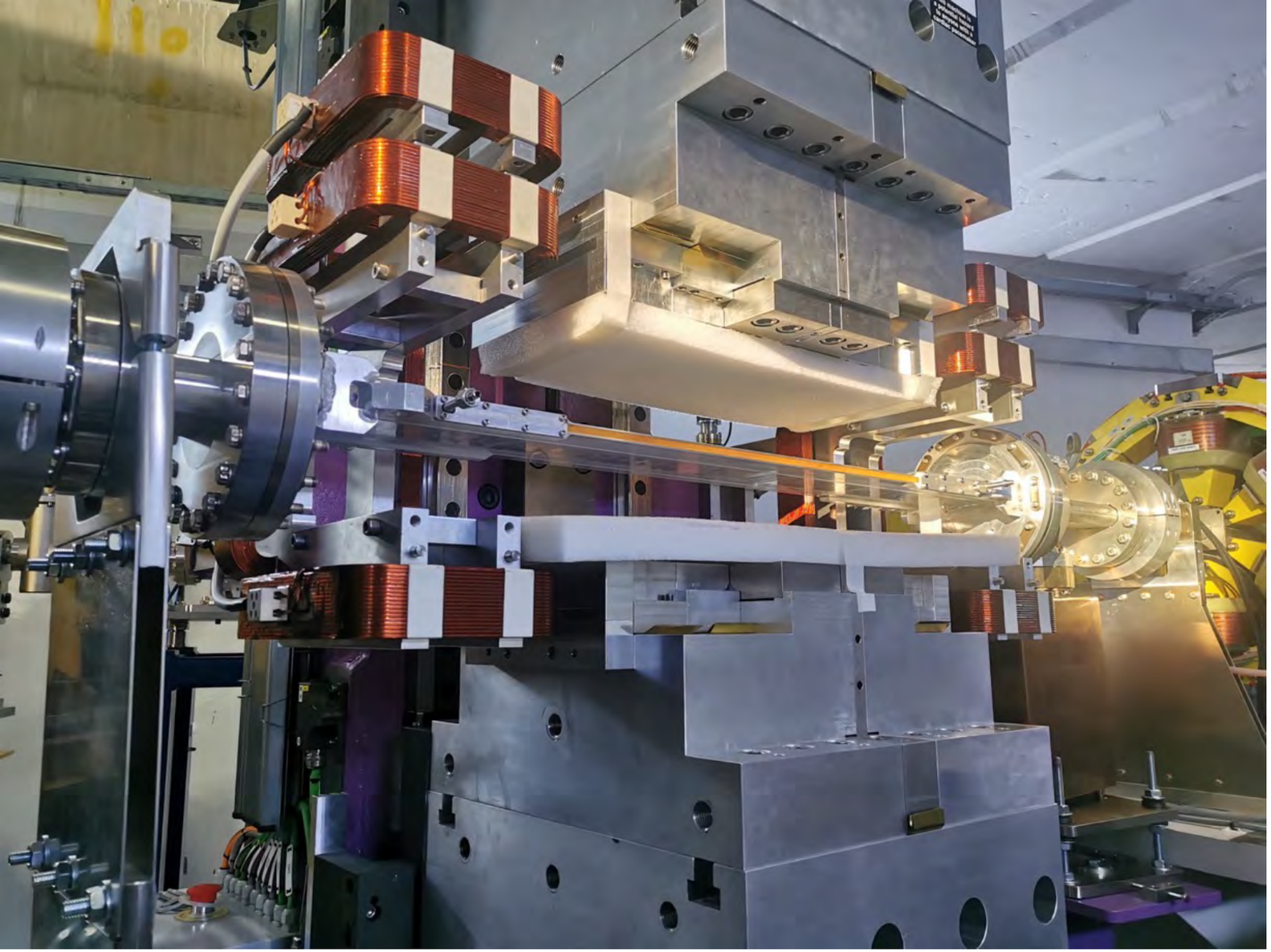
www.acsmaterialsletters.org

LETTER

Robust Barium Phosphonate Metal–Organic Frameworks Synthesized under Aqueous Conditions

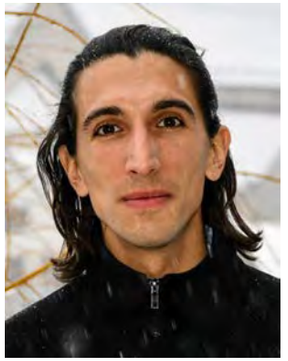
Khalifah A. Salmeia,* Simone Dolabella,‡ Dambarudhar Parida,‡ Terry J. Frankcombe, Akef T. Afaneh, Kyle E. Cordova, Bassem Al-Maythalony, Shanyu Zhao, Romain Civioc, Ali Marashdeh, Bernhard Spingler, Ruggero Frison, and Antonia Neels*





ID10 - BEATS BEAmline for Tomoghraphy at SESAME

Axel Kaprolat (ESRF), Project Coordinator



Gianluca Iori (Principal Beamline Scientist)

ALBA

The Cyprus Institute
Research·Technology·Innovation

DESY.

Elettra Sincrotrone Trieste

ESRF
The European Synchrotron

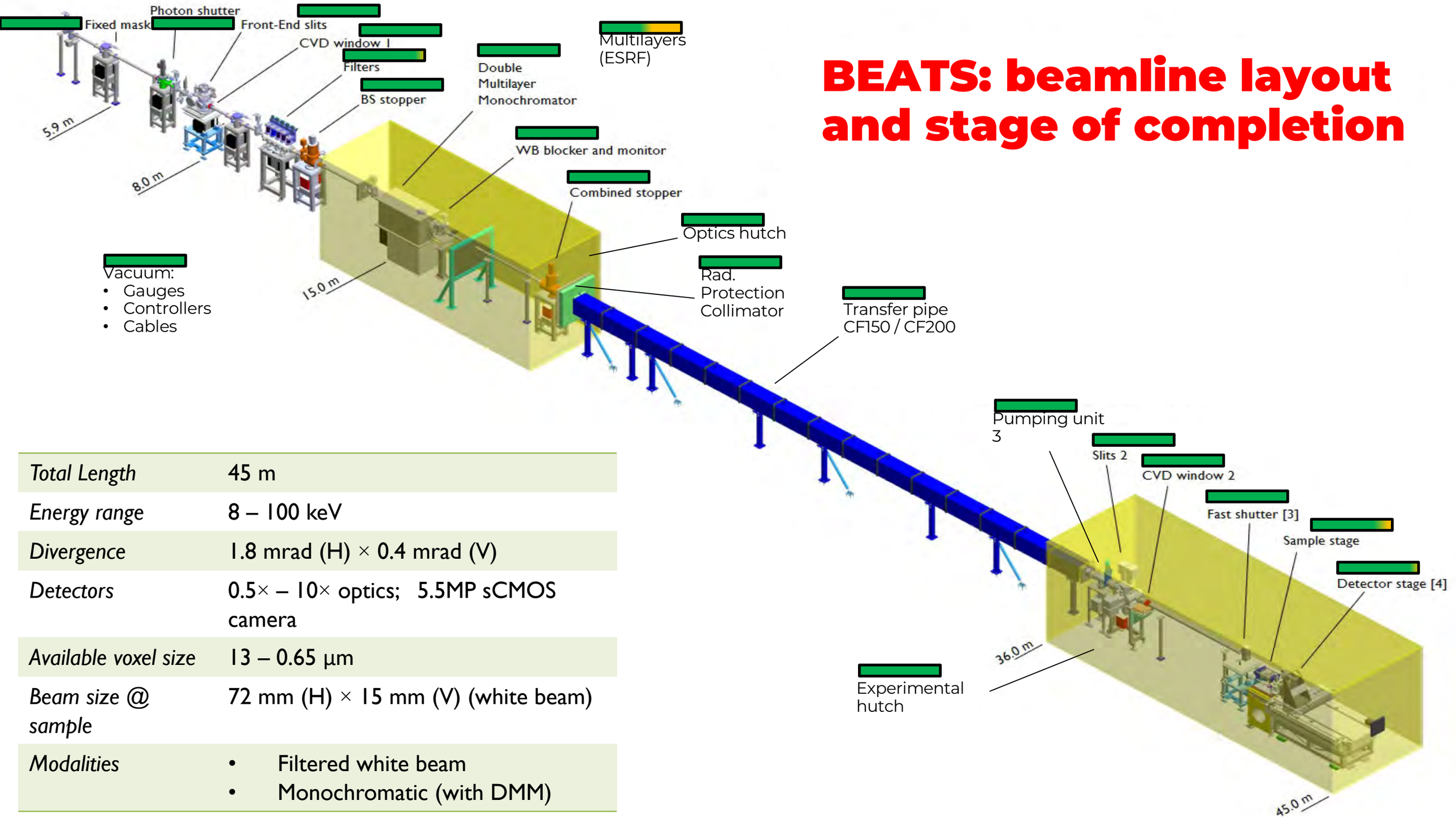
INFN
LNF

Paul Scherrer Institut
PSI

SESAME

SOLARIS
National Synchrotron Radiation Centre

BEATS: beamline layout and stage of completion

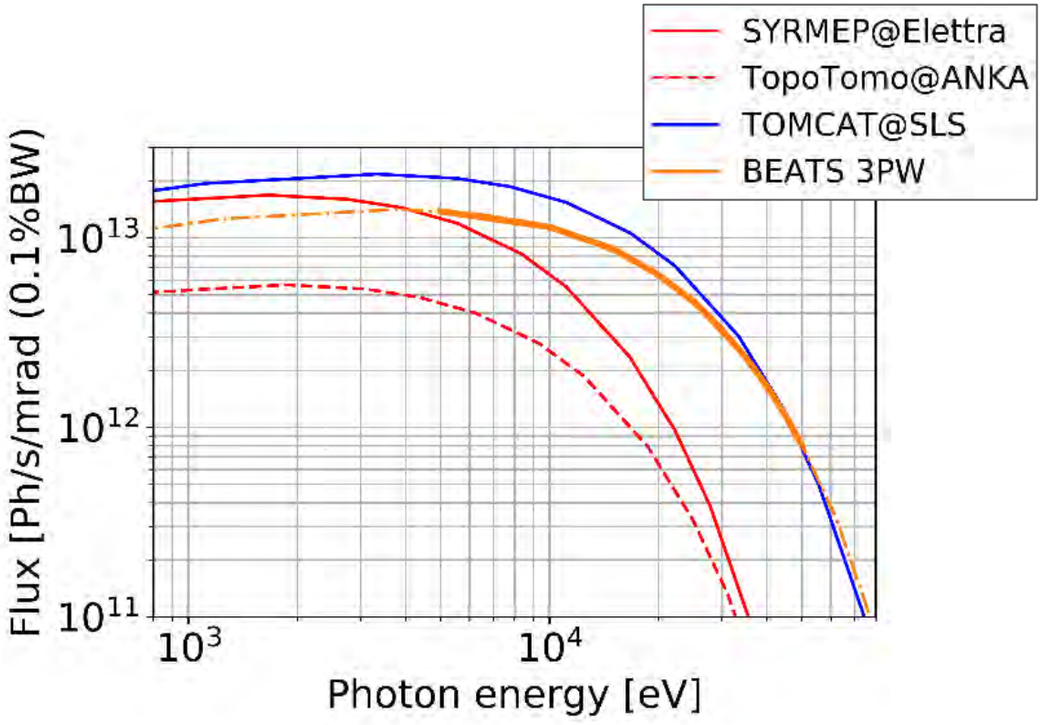


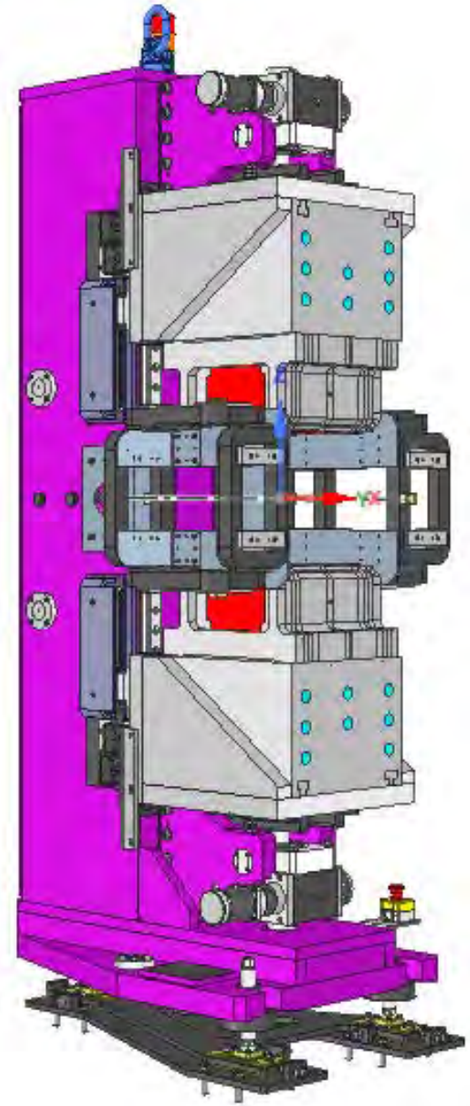
Total Length	45 m
Energy range	8 – 100 keV
Divergence	1.8 mrad (H) × 0.4 mrad (V)
Detectors	0.5× – 10× optics; 5.5MP sCMOS camera
Available voxel size	13 – 0.65 µm
Beam size @ sample	72 mm (H) × 15 mm (V) (white beam)
Modalities	• Filtered white beam • Monochromatic (with DMM)

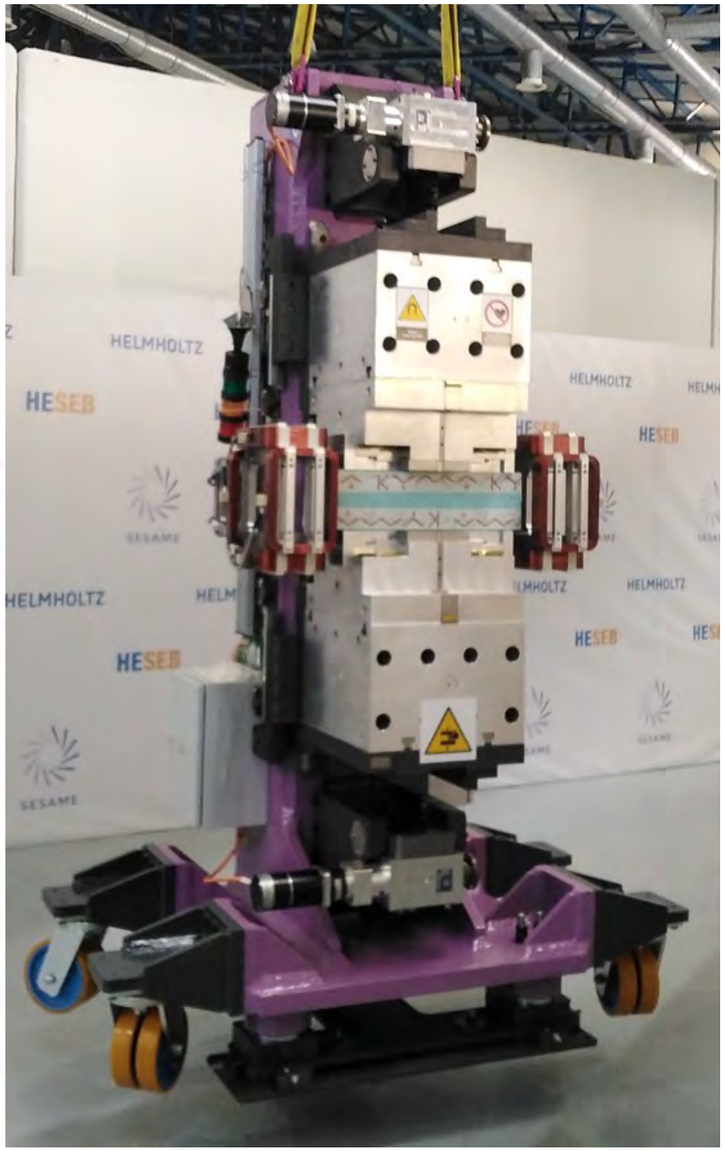
BEATS X-ray source

3-pole wiggler

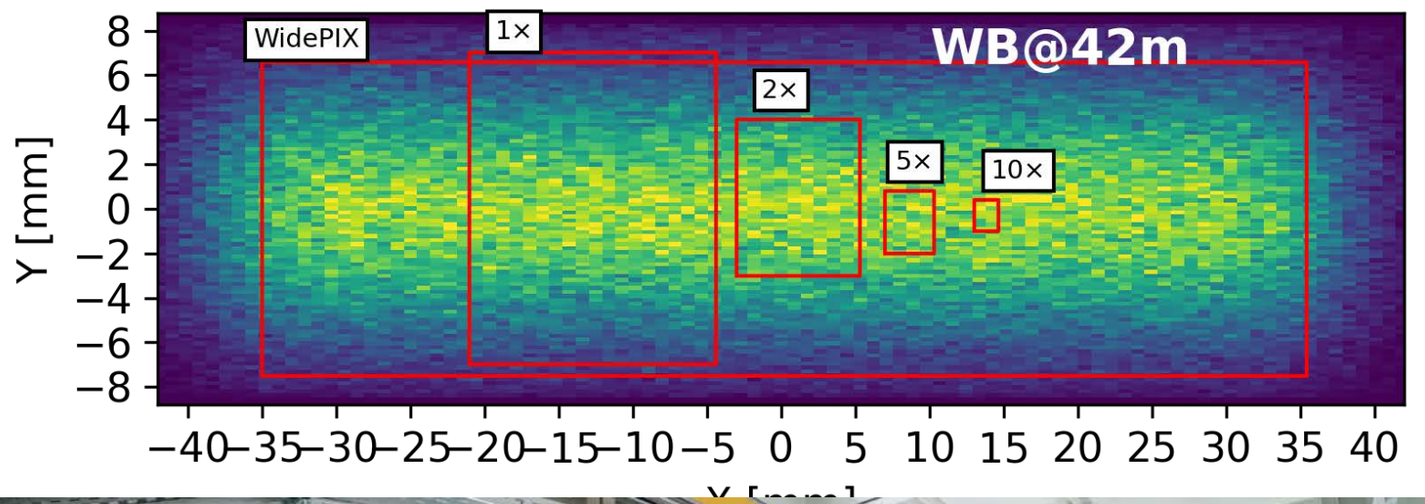
- Minimum gap: 11 mm
- Maximum field: 2.92 T
- Magnetic length: 0.41 m







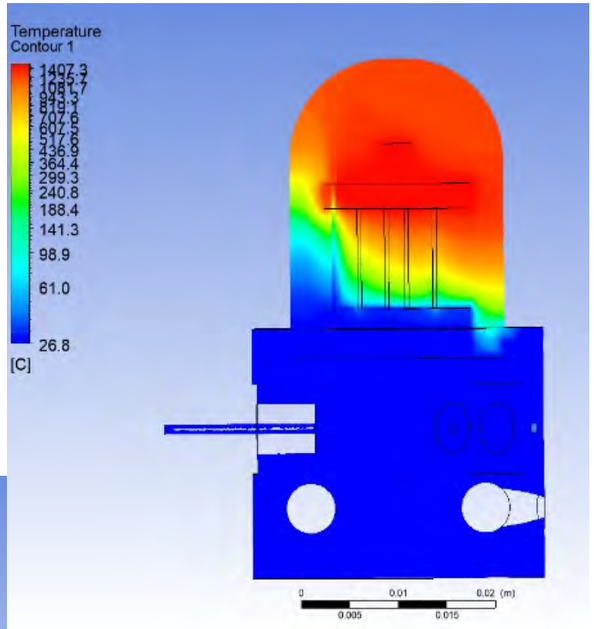
Magnif.	Field of view	Pixel size
0.5×	33.2 × 28.0 mm²	13.0 µm
1×	16.6 × 14.0 mm²	6.5 µm
2×	8.3 × 7.0 mm²	3.25 µm
5×	3.4 × 2.8 mm²	1.3 µm
10×	1.7 × 1.4 mm²	0.65 µm

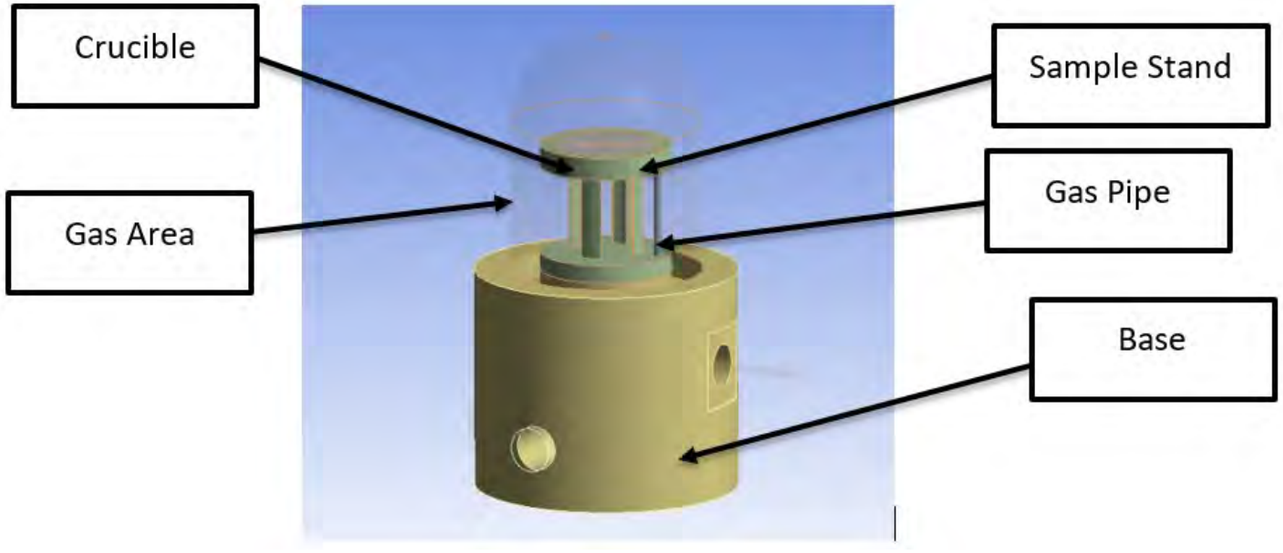


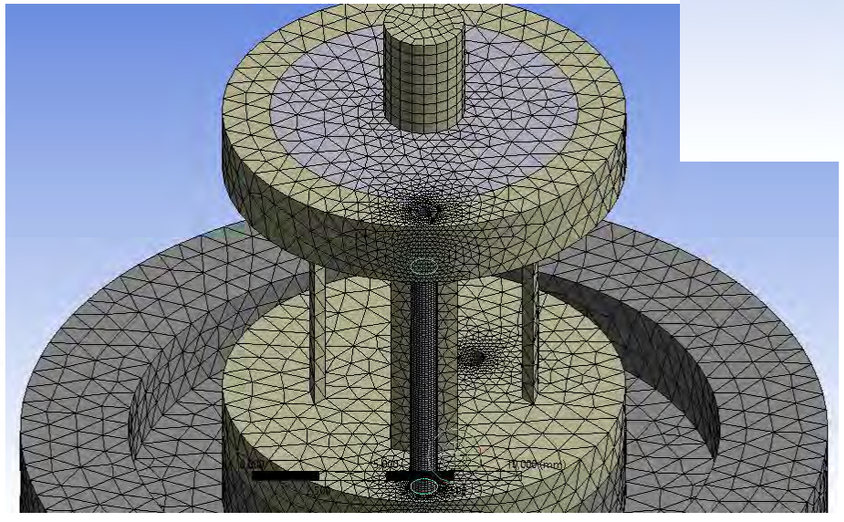
BEATS:
sample environments for in-situ studies

Fortune Mokoena

- Sample furnace – Induction heating:
  - Crucible architecture
  - Temperature control and convection regime around sample
  - Isolation of slip ring and sensitive equipment
  - Simulation of different sample materials and sizes
  - Prediction of cooling flow rate for experiments at the beamline





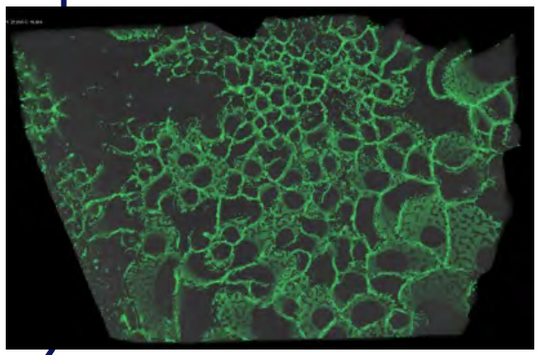


[F. Mokoena, M.Sc. thesis]

BEATS scientific case

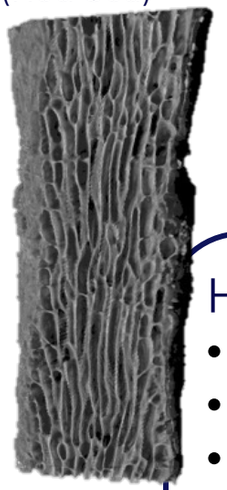
Archaeology and Cultural Heritage

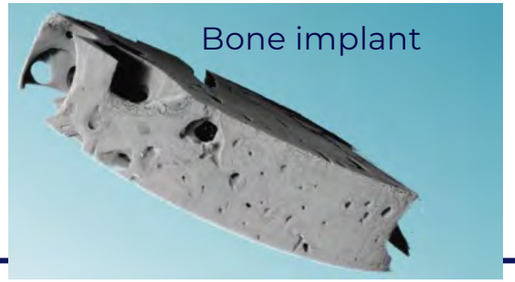
- Archaeological materials
- Human bioarchaeology
- Plant remains
- Animal remains and artefacts



Roman glass

Mineralized algae (Red Sea)



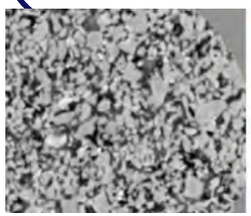


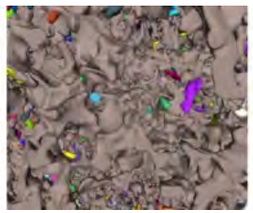
Health, Biology and Food

- Musculoskeletal research
- Bone and dental implants
- Soft tissue imaging
- Animal and plant characterization
- Food science

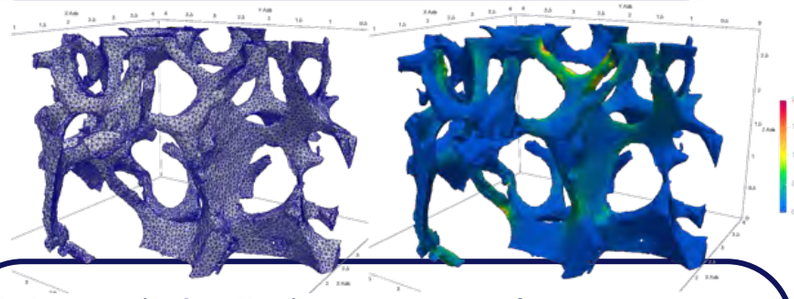
Agriculture and Environment

- Simulation of rock properties
- Soil characterization
- Sustainable agriculture





Sandstone core



Materials Science and Engineering

- Light materials and alloys
- Materials under mechanical stress
- Energy materials research

Services to industry and private sector

ID11 left – HESEB

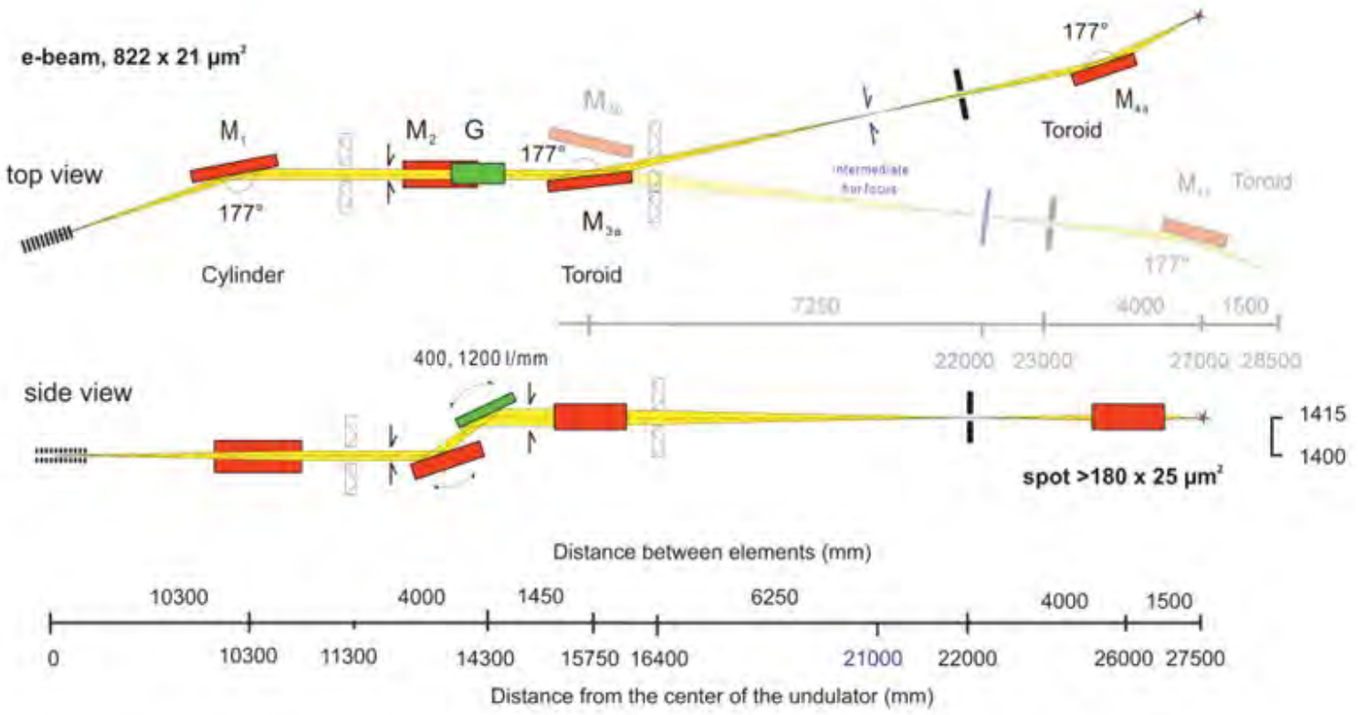
Photo © Ivan Lim

Wolfgang Eberharadt (DESY), Scientific Head

Mustafa Fatih Genişel (Principal Beamline Scientist)

HESEB Beamline

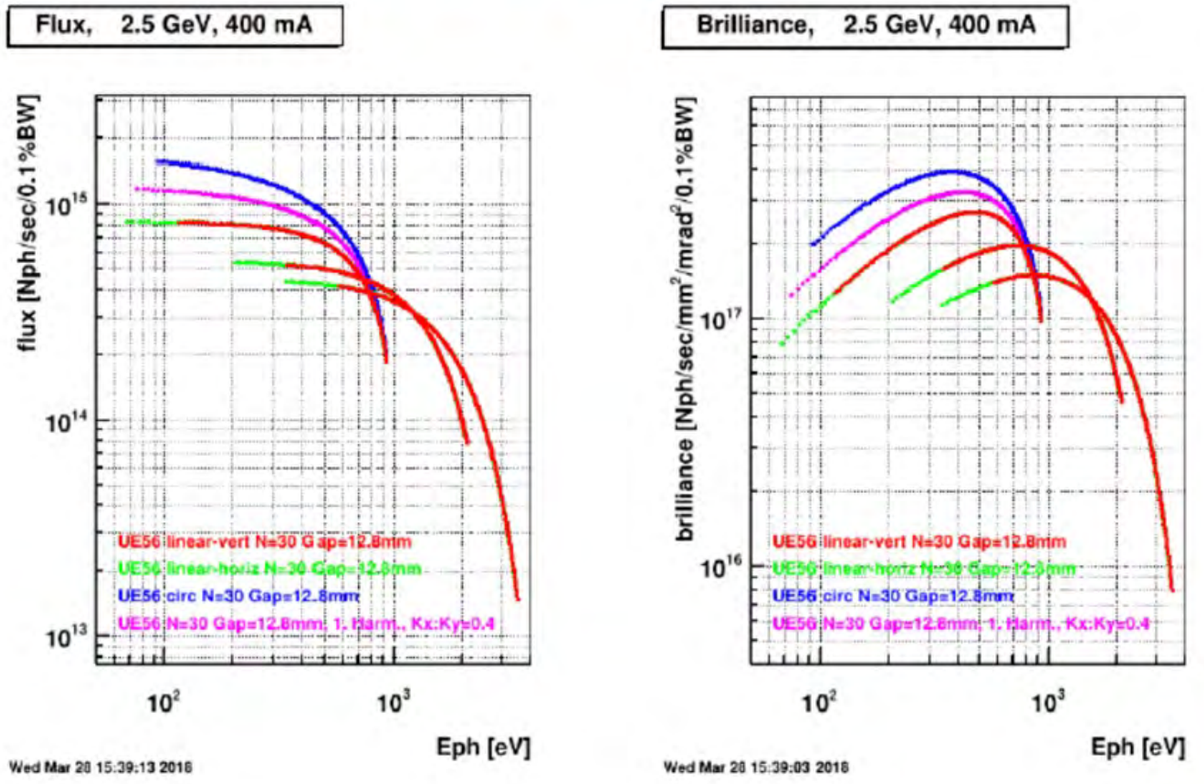
Optics concept /parameters



Parameter	Value
Undulator	UE56, APPLE II, Length: 1,7m, Period: 56mm
Polarization modes	Linear / circular
Photon range	~90 – 2000 eV
Photon flux on sample	10^{12} Photons/s
Monochromator	Collimated plane-grating monochromator PGM (BESSY design)
Spot size on sample	180 (h) x 25 (v) um
Branches	Two: • HESEB absorption chamber • TXPES

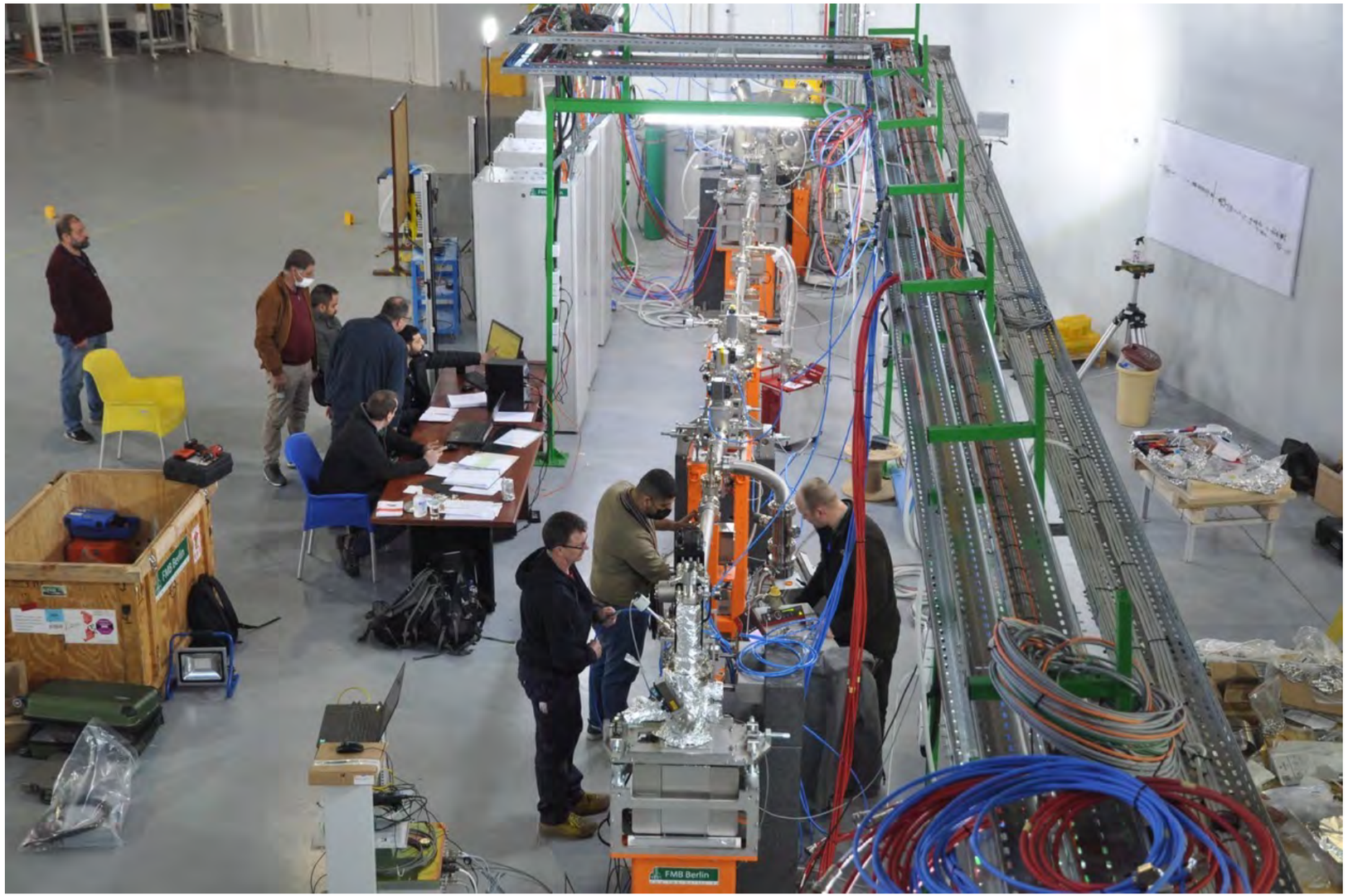
HESEB Beamline

Undulator UE56 with variable polarization



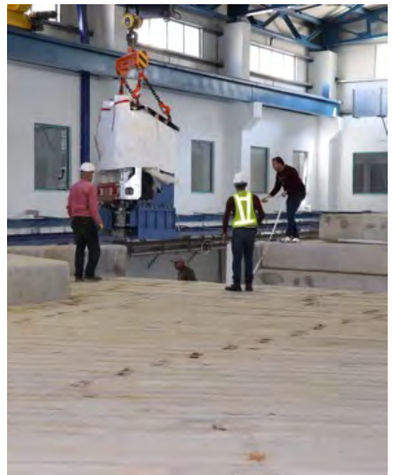
Covers the core edges:

- 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



Final vacuum test + controls tuning, January 2022

Installation of undulator, April 2022



Experimental Chamber

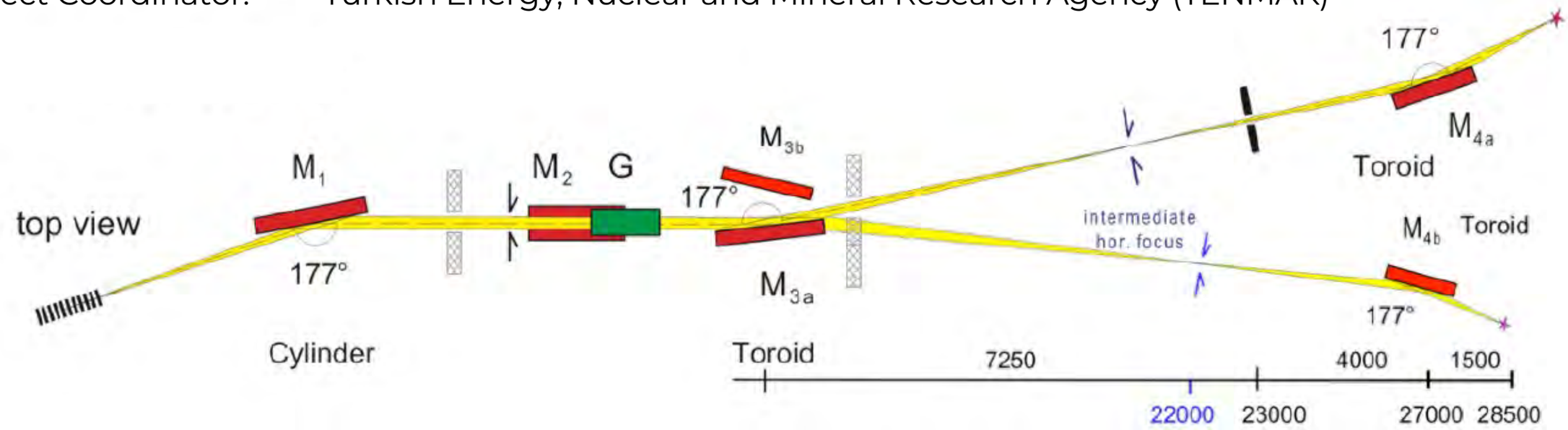
- Fluorescence Detector (XRF)
- Total Electron Yield measurement
- LN_2 Cooling
- Sample Heating (up to 800° C)
- Motorized Sample Holder for 2D imaging

Differential pumping allows for measurement at low vacuum and He atmosphere allows for measurments of cultural heritage specimens

ID11 right – TXPES

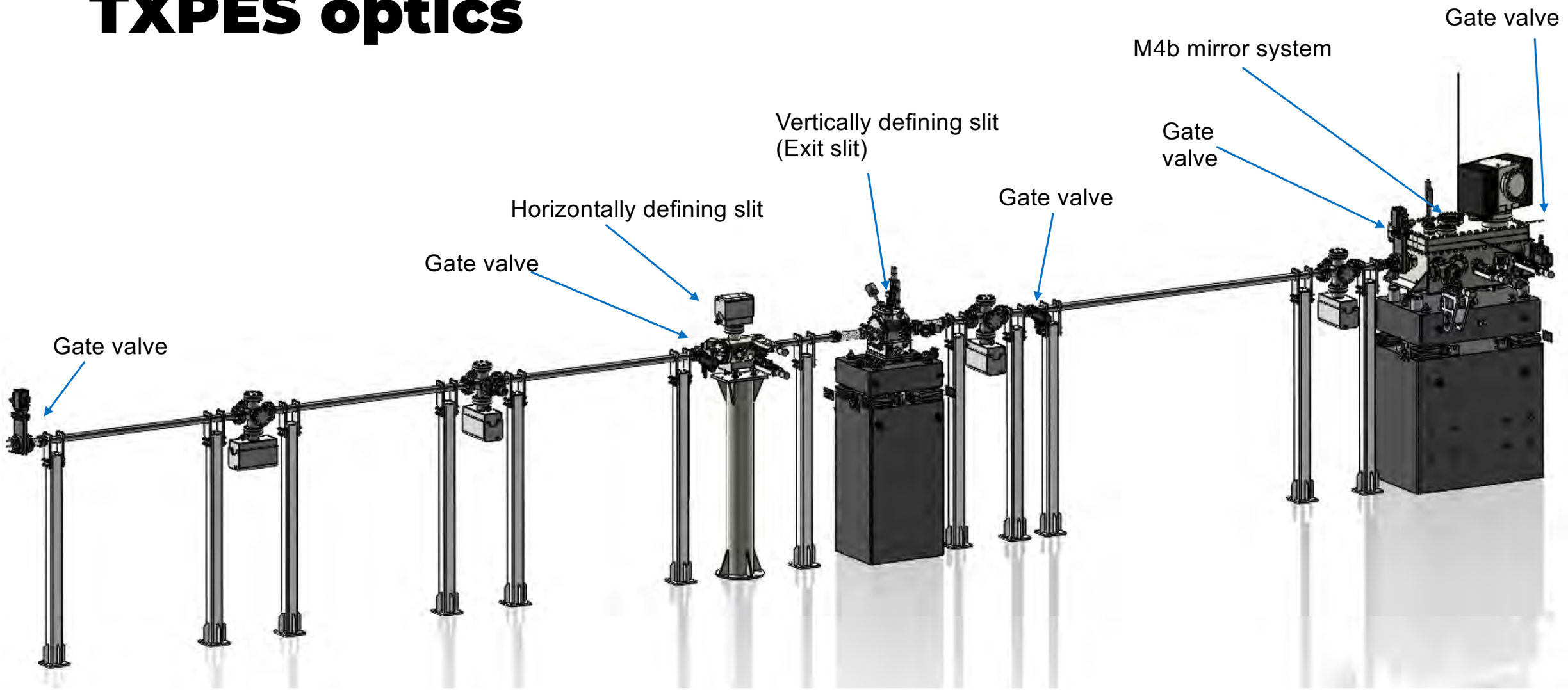
The Turkish soft X-ray PhotoElectron Spectroscopy beamline (TXPES) is a project for the design and construction of a Soft X-ray Photoelectron Spectroscopy beamline at SESAME as a complementary beamline to HESEB

- Project Approval Date: February 2020
- Project Duration: 36 Months (02/2020 - 02/2023)
- Project Budget: ₺27 M
- Project Coordinator: Turkish Energy, Nuclear and Mineral Research Agency (TENMAK)



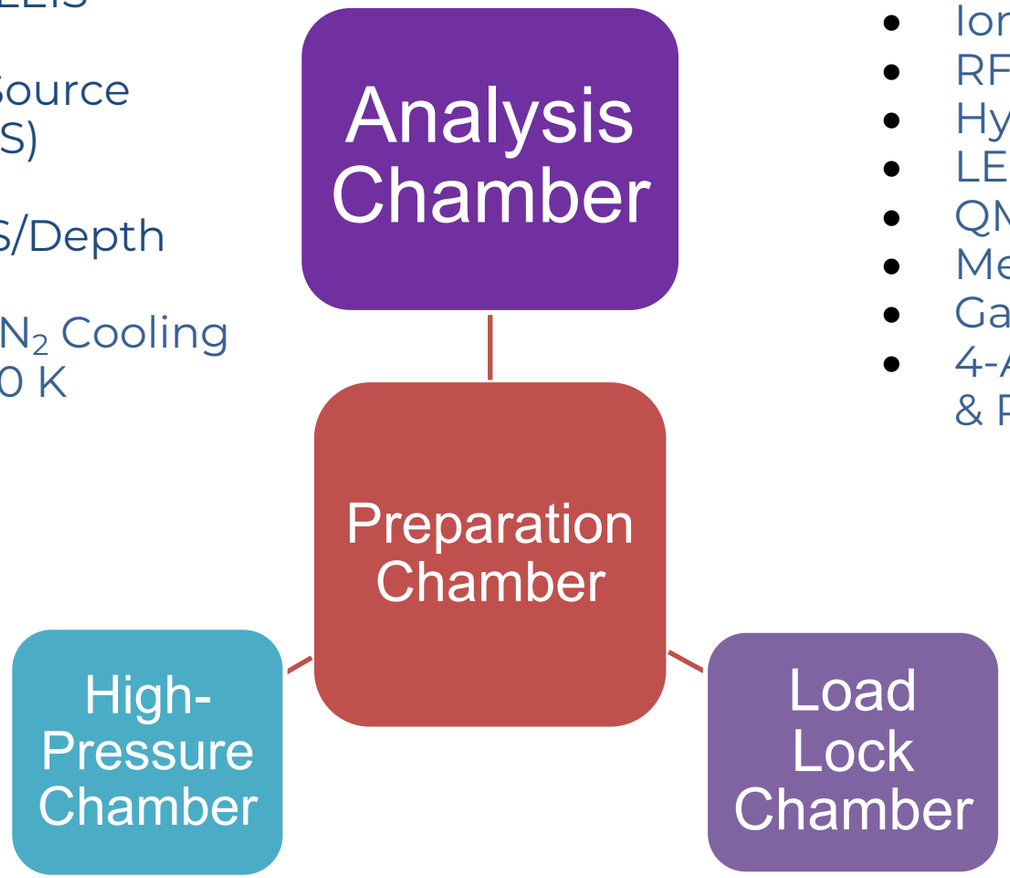
Emrah Ozensoy, Bilkent University Chemistry Department, Ankara, Turkey

TXPES optics



TXPES End Station Components

- PHOIBOS 150 CMOS XPS/LEIS Analyzer
- XR 50: Dual Anode X-ray Source
- UVS 10: UV Source (for UPS)
- Electron Flood Gun
- Rastering Ion Gun for LEIS/Depth Profiling
- 4-Axis Manipulator with LN_2 Cooling & Resistive Heating to 1200 K



- Ion Gun for Sputtering
- RF-Plasma Source
- Hydrogen Cracker
- LEED
- QMS
- Metal/Metal Oxide Evaporators
- Gas Dosers
- 4-Axis Manipulator with LN_2 Cooling & Resistive Heating to 1200 K

- HPC-20 High-Pressure Cell for Reactive Sample Pretreatment

- Sample Loading/Removal

Proposals for beamtime received (2017-2023)	
CYPRUS	28
EGYPT	130
IRAN	77
ISRAEL	11
JORDAN	78
PAKISTAN	64
PALESTINE	18
TÜRKIYE	86
FRANCE, GERMANY, ITALY, RUSSIAN FEDERATION, UAE, UK (SESAME Observers)	34
ALGERIA, MOROCCO, OMAN, QATAR	16
OTHERS (BELGIUM, COLOMBIA, INDIA, KENYA, MALAYSIA, MALTA, MEXICO, NETHERLANDS, SOUTH AFRICA, SWEDEN)	30
Total	**572**
Total Accepted	**294**

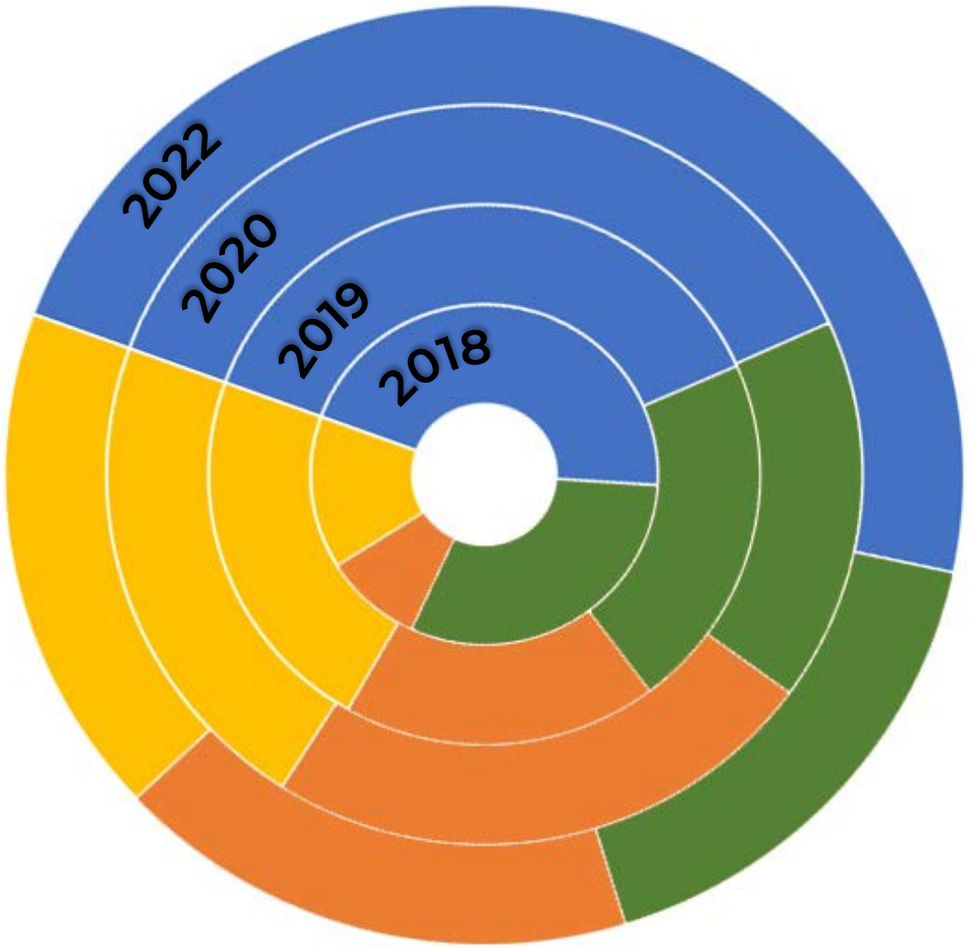
SESAME PRC
Proposal Review Committee
Samar HASNAIN (Chair) University of Liverpool, UK

Archaeological and Heritage Sciences	
Mariangela CESTELLI GUIDI (coordinator)	INFN, Italy
Francois FAUTH	ALBA Synchrotron, Spain
Caroline JACKSON	University of Sheffield, UK
Costanza MILIANI	CNR, Italy

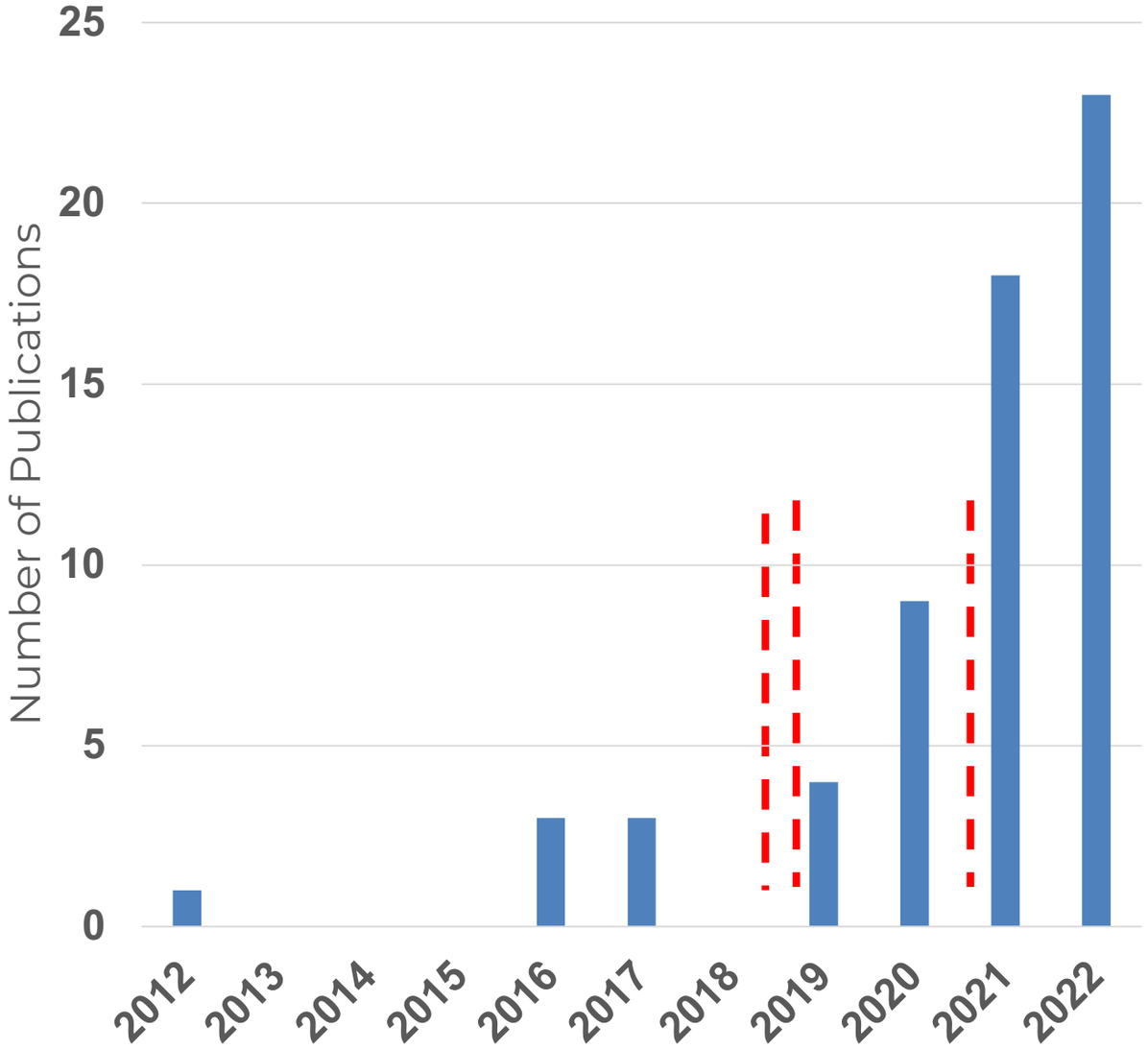
Life Sciences	
Michel HOUGH	Diamond Light Source, UK
Christophe SANDT	Synchrotron SOLEIL, France
Zehra SAYERS	Sabancı University, Türkiye
Lisa VACCARI (coordinator)	Elettra Sincrotrone Trieste, Italy

Chemical Sciences	
Sofia DIAZ-MORENO (coordinator)	Diamond Light Source, UK
Thomas ELLIS	University of Saskatchewan, Canada
Antonella GLISENTI	Univertity of Padova, Italy
Sarp KAYA	Koç University, Türkiye

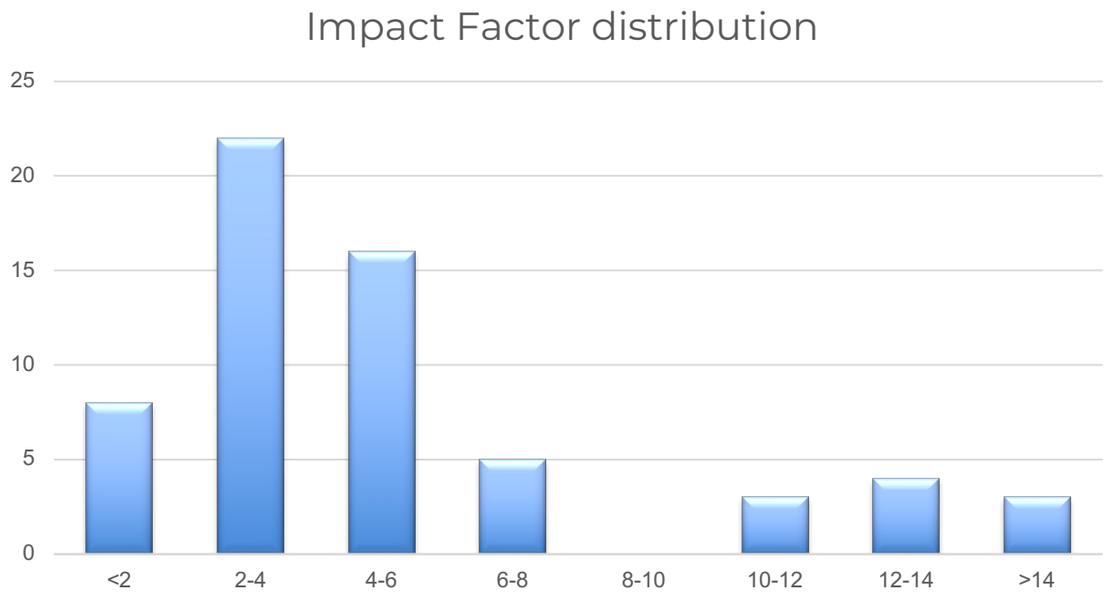
Materials and Physical Sciences	
Muhammad Javed AKHTAR	PINSTECH, Pakistan
Andrew FITCH (coordinator)	ESRF, France
Bruce RAVEL	NIST and NSLS II, USA
Brian ROSEN	Tel Aviv University, Israel



Publications



Feb 2023:
65 peer-review publications
Average scientific impact factor 5.4
20% of publications have IF > 10



Training and Other Events at SESAME

© Ivan Lim: 2022 Regional Study Tour on NST Contribution to the UN SDGs following the 2021 Secondary NST Education Competition, 16-20 October 2022

https://indico.ictp.it/event/10057/

Directors: **A. LAUSI**, SESAME; **E. MITCHELL**, ESRF (France); **G. KAMEL**, SESAME; **I. SWAINSON**, IAEA; **K. LORENTZ**, Cyprus Institute (Cyprus); **M. ZEMA**, University of Bari (Italy); **Ö. ÖZTÜRK**, University of Siegen (Germany); **S. MTINGWA**, TriSEED Consultants LLC (USA); **S. CONNELL**, University of Johannesburg and AfLS (South Africa)

ENGAGE

Enabling the next generation of computational physicists and engineers

Marie Sklodowska-Curie PhD fellowships in Computational Physics and Engineering

https://engage.cyi.ac.cy/

Degree Awarding Institutions:
The Cyprus Institute, Humboldt University of Berlin, Georg-August-Universität Göttingen, Rheinisch-Westfälische Technische Hochschule Aachen, University of Padova, Technical University of Delft

ENGAGE Research Facilities
ESRF, DESY, Max Planck Institute for Polymer Research, Foundation for Research & Technology Hellas, SESAME

Project 14: Deep learning for the derivation of finite element models from 3D synchrotron X-ray tomography data – M. Nicolaou, The Cyprus Institute/SESAME

Project 15: Automated interpretation of SR-based XRF and IR spectroscopic data using machine learning approach in archaeological sciences – C. Chrysostomou, The Cyprus Institute/SESAME

SESAME's 18th Users' Meeting

4th & 5th May 2023 on SESAME premises

https://www.sesame.org.jo/events/18th-sesame-users-meeting-4th-5th-may-2023

Photo © Ivan Lim

HESEB School (in presence + hybrid)

- Date and place of the school: 8-9 May 2023
- In presence: 8 students
- Virtual participants (limited to 8 May): unlimited number
- Scope: lectures and hands-on sessions on synchrotron soft X-ray techniques

BEATS School (in presence + hybrid)

- Date and place of the school: 6-7 June 2023 connected with the inauguration of BEATS on SESAME premises
- In presence: 10 students
- Virtual participants (limited to 6 June): unlimited number
- Scope: lectures and hands-on sessions on synchrotron X-ray tomography

https://indico.sesame.org.jo/event/3/

INFN - SESAME International School on Efficient Scientific Computing

May 27, 2023 to June 2, 2023
on SESAME premises

The school is organized as a small class of at most 30 students and focuses on trends in hardware architectures and parallel programming, with more in-depth lessons on modern C++, effective memory usage, floating-point computation and programming in a heterogeneous environment combining multi-threading, GPUs and clusters.

SESAME Today

SESAME is open and produces world-class science

SESAME is an internationally well-connected facility

SESAME continues to increase its beamlines' portfolio and research and training opportunities

andrea.lausi@sesame.org.jo