SESAME

AN OPPORTUNITY FOR SCIENCE AND GROWTH

Andrea Lausi

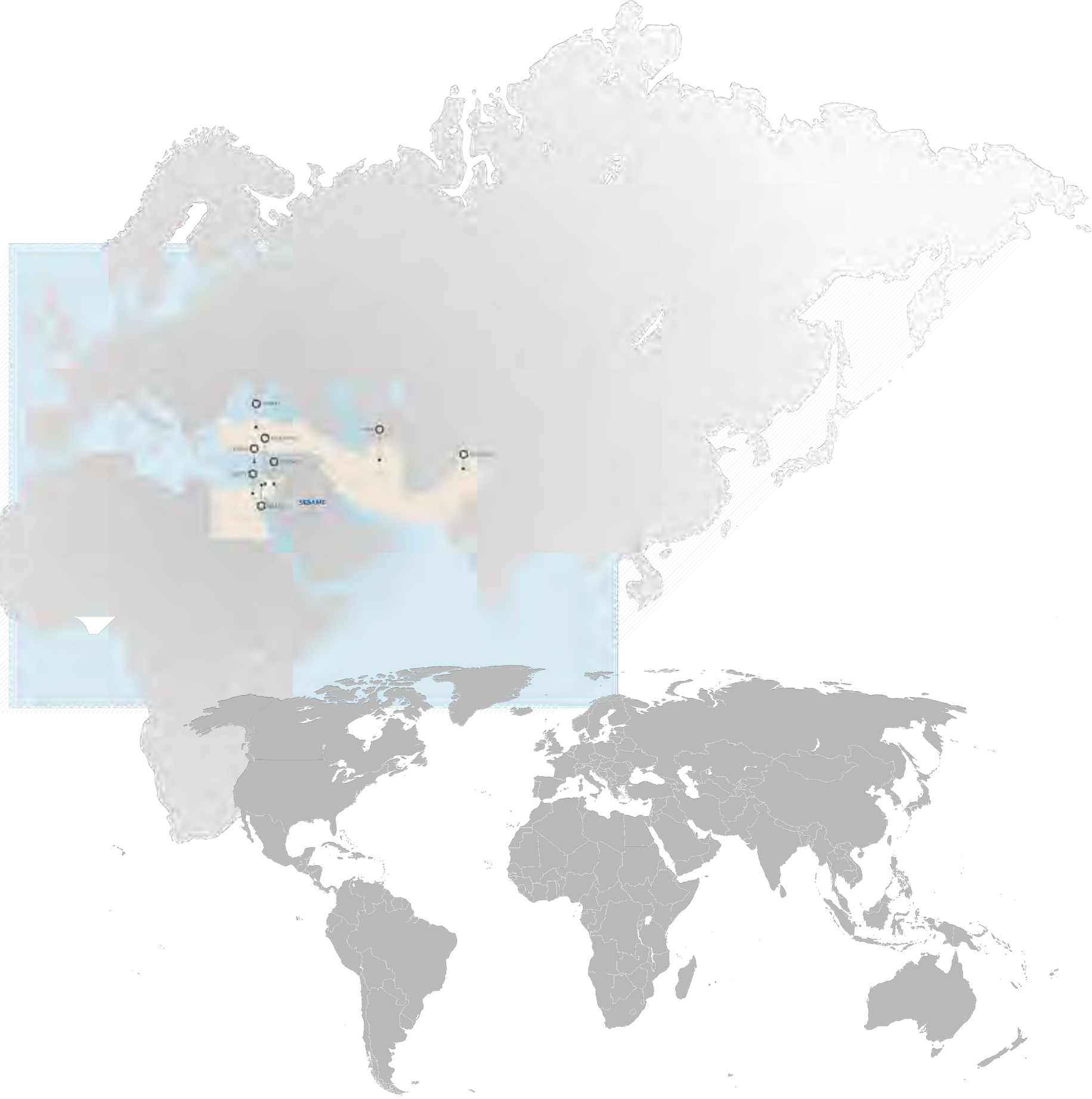
With contributions by
Gihan Kamel, Messaoud Harfouche,
Mahmoud Abdellatief,
Gianluca Iori, Mustafa Fatih Genişel

SESAME is located in Allan, NW of Amman, the capital of Jordan

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 (European Organization for Nuclear Research) although it has very different scientific aims.
- It was developed 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 composed of Members and Observers



SESAME is composed of **Members** and Observers

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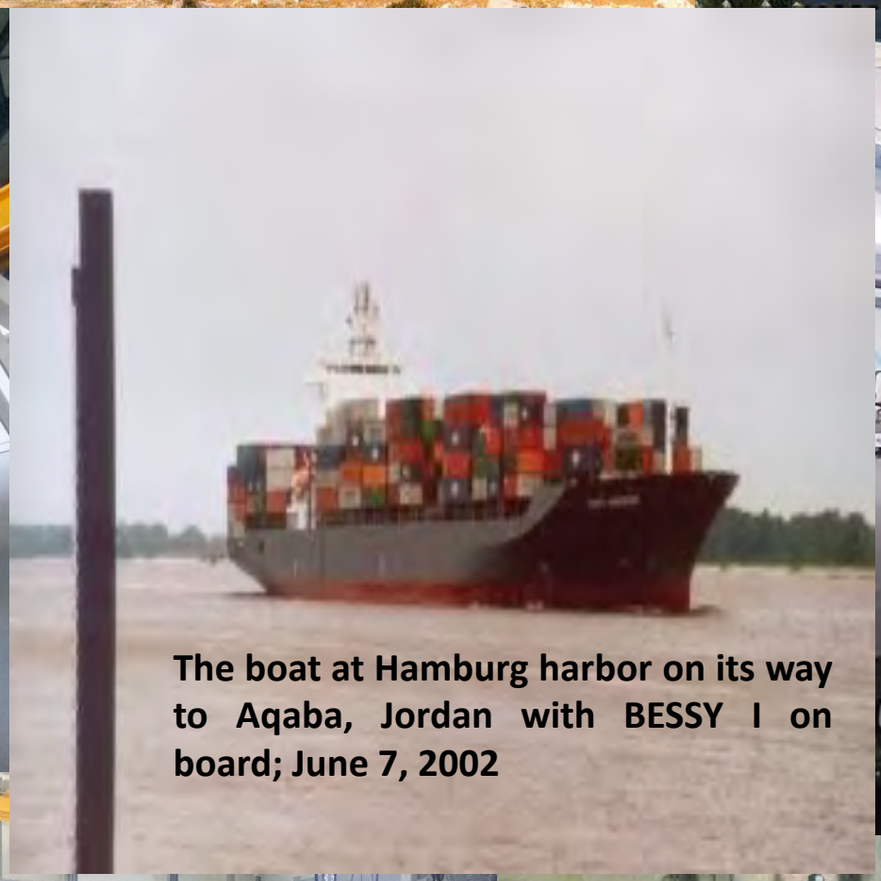
Brazil, Canada, CERN, China, the European Union, France, Germany, Greece, Italy, Japan, Kuwait, Portugal, Russian Federation, Spain, Sweden, Switzerland, the United Arab Emirates, the United Kingdom, and the United States of America.

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


Solar Power Plant (EU)


Sergio Fubini Guest-House (I)


Rossendorf Beamline (D)


The boat at Hamburg harbor on its way to Aqaba, Jordan with BESSY I on board; June 7, 2002


XAFS/XRF Monochromator (UK)

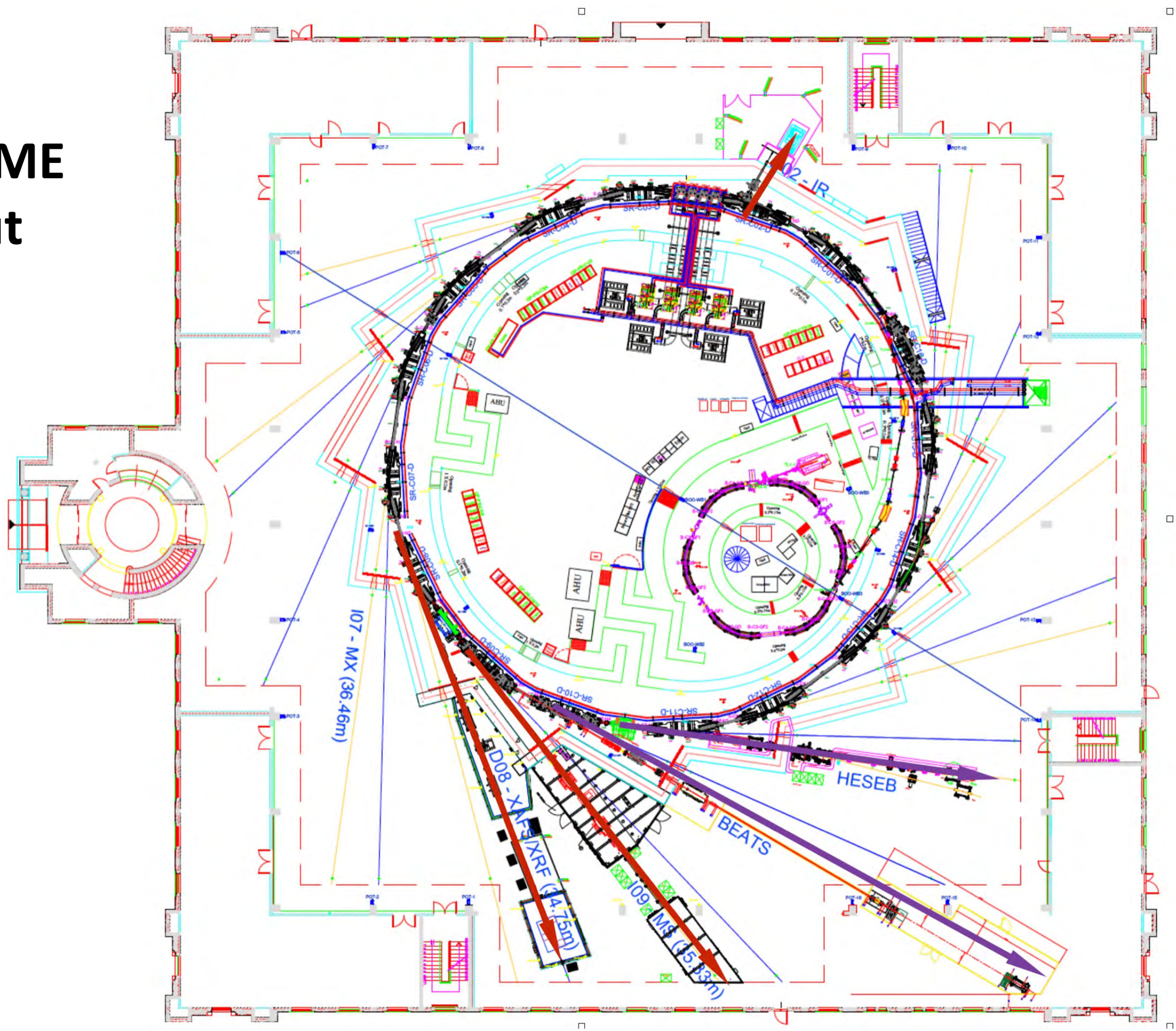

Material Science Beamline (CH)


The 4 RF Cavities (I)

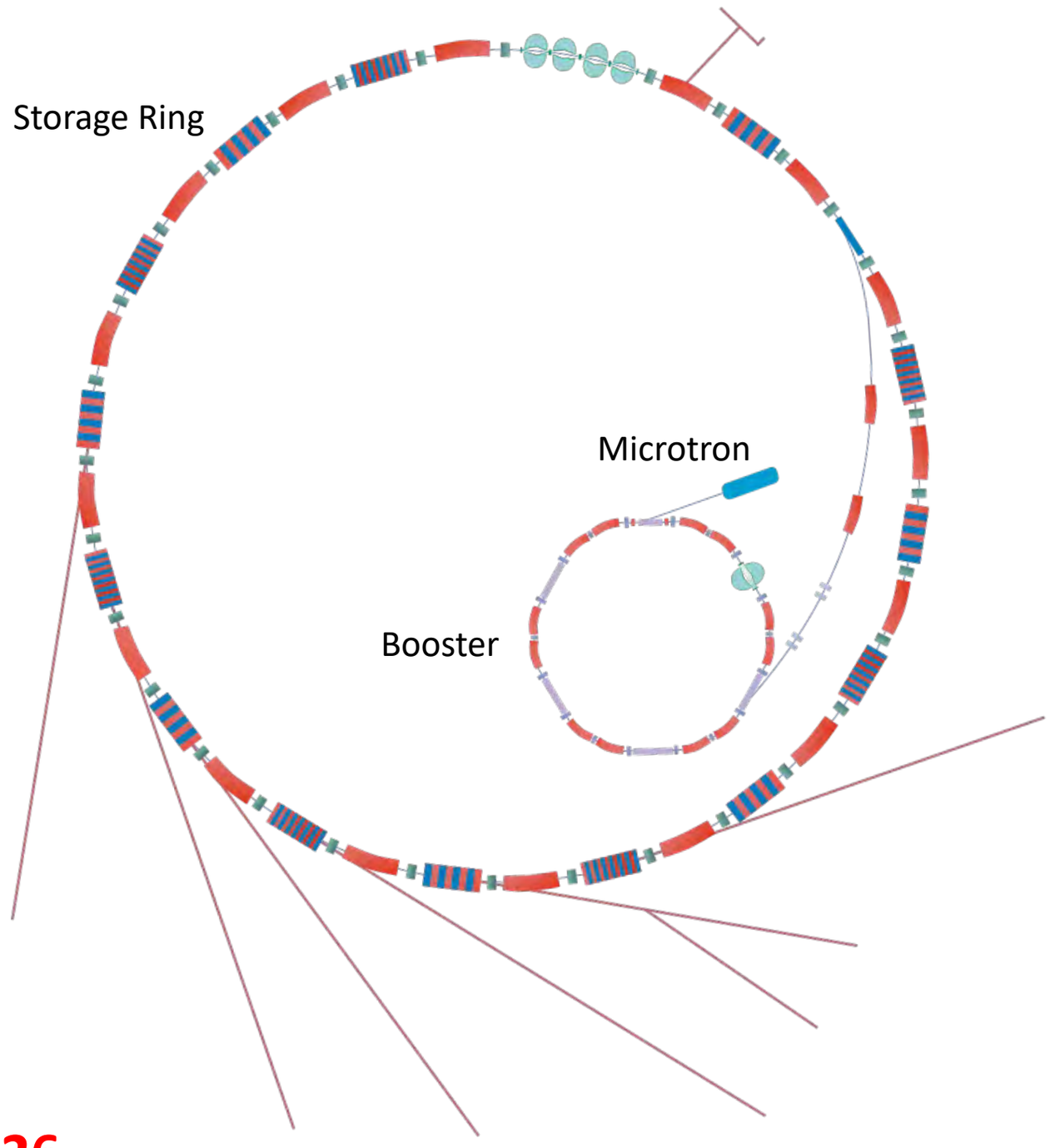
SESAME Opening Ceremony, May 16, 2017

His Majesty King Abdullah II following the opening of SESAME, flanked by Heads of the delegations of the SESAME Members and Directors of International Organisations that have supported SESAME. To the King's left, HRH Princess Sumaya of Jordan, who headed the Jordanian delegation, and Fabiola Gianotti, Director General of CERN; to the right, Irena Bokova, Director-General of UNESCO, and Carlos Moedas, European Commissioner for Research, Science and Innovation.

SESAME layout



SESAME layout



SESAME storage ring parameters

Energy (GeV) 2.5
Current (mA) 400
Circumference (m) 133.2
Natural emmitance (nmrad) 26

Three Beamlines in Operation

Number of proposals received for the IR (2018-2021), XAFS-XRF (2018-2021) and MS (2020-2021) beamlines:

Belgium	**1**
Colombia	**1**
Cyprus	**18**
Egypt	**75**
France	**1**
Germany	**2**
Iran	**55**
Israel	**8**
Italy	**8**
Jordan	**38**
Kenya	**3**
Malaysia	**1**
Malta	**1**
Mexico	**1**
Pakistan	**47**
Palestine	**12**
Qatar	**3**
South Africa	**1**
Sweden	**1**
Turkey	**45**
United Arab Emirates	**2**
United Kingdom	**1**
TOTAL	**325**

Three Beamlines under Construction

BEATS – BEAmline for Tomoghraphy at SESAME (2022)

HESEB – Helmholtz-SESAME Beamline (2022)

TXPES – Turkish X-ray PhotoEmission Spectroscopy Beamline (2023)

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 (Materials Science)	5-25 keV	MPW
ID10	BEATS: Beamline for Tomography at SESAME	8-50 keV	3-Pole Wiggler
ID11 L	HESEB: Helmholtz-SESAME Beamline	70-1800 eV	Undulator
ID11 R	TXPES: Turkish X-ray Photoemission Spectroscopy	70-1800 eV	Undulator
	MX Macromolecular Crystallography	~4 ~14 keV	In-Vacuum Undulator
	SAXS (Small Angle X-ray Scattering)	~8 keV	In-Vacuum Undulator

BM02 - Infrared Beamline, IR

Gihan Kamel

Ahmed Refaat

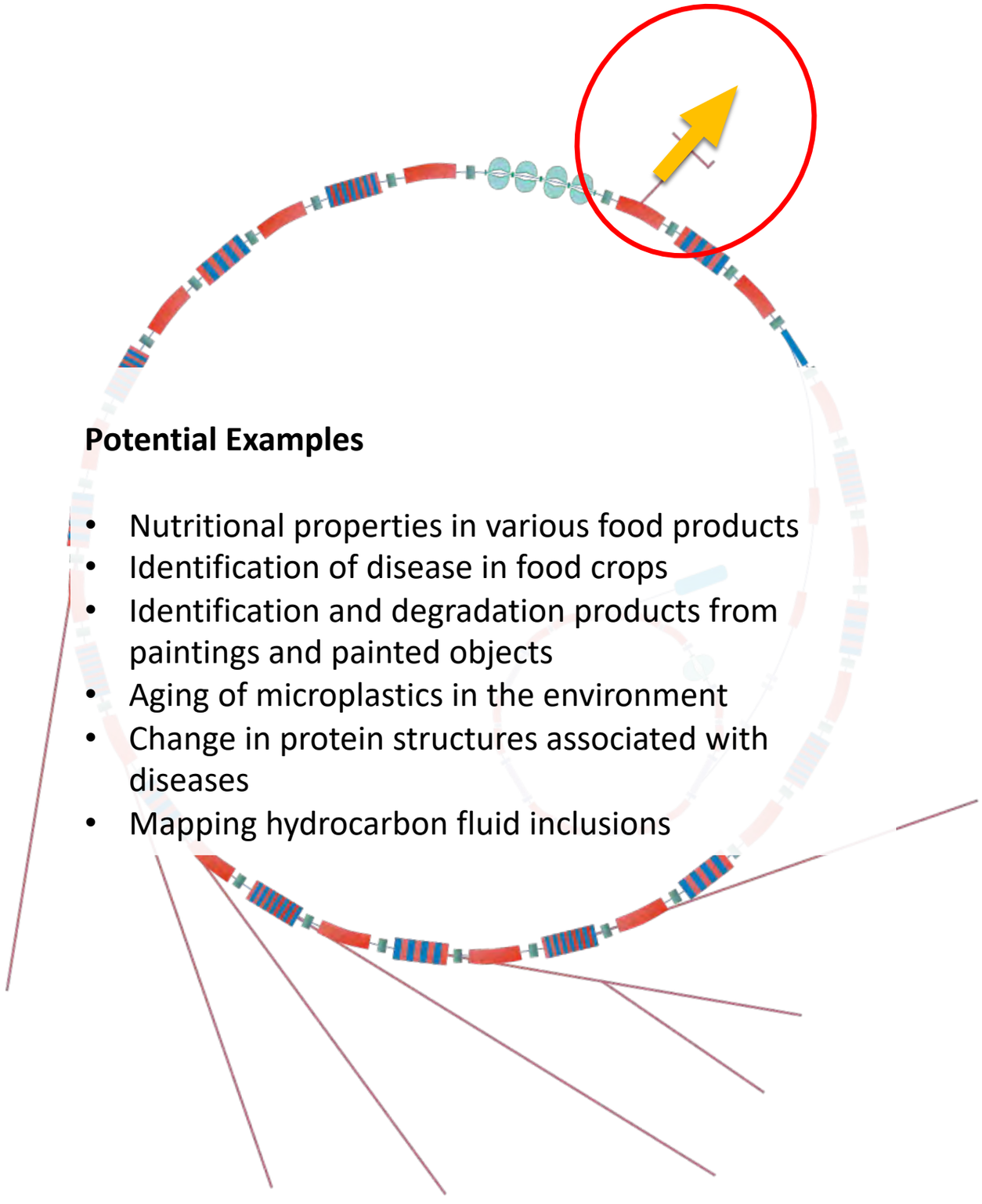
Operational since November 2018
infrared spectroscopy and microscopy

Source – Bending magnet

Experimental station – The SESAME IR beamline is currently equipped with a new endstation of the Bruker Vertex 70v FTIR spectrometer coupled to Hyperion 3000 IR-vis Microscope.

The beamline is also giving access to a second offline endstation (Globar IR source) equipped of 8700 Thermo Scientific FTIR spectrometer coupled with a Thermo Scientific Nicolet Continuum XL IR-microscope.

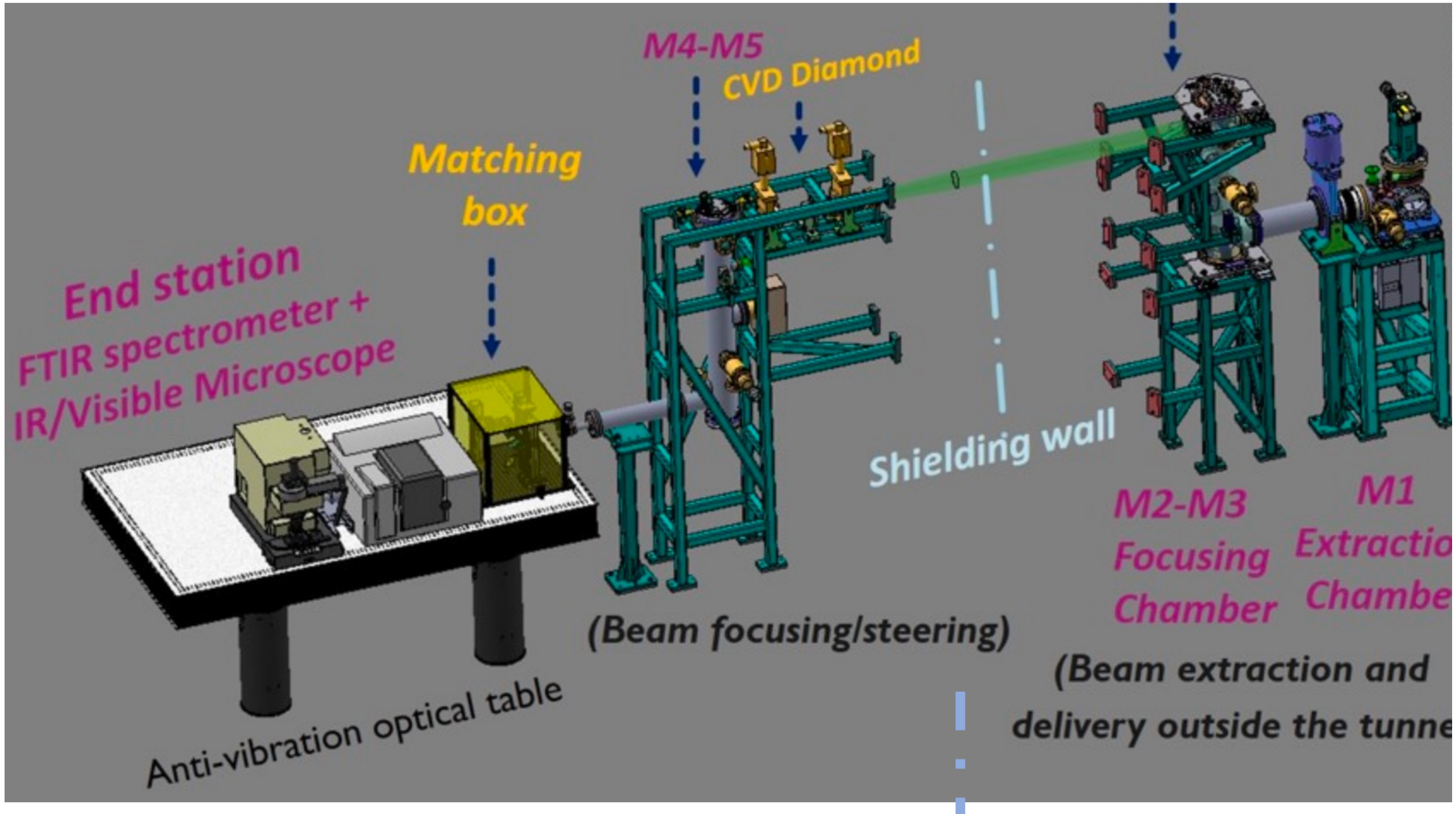
Sample Type – Fiber, Liquid, Powder, Solid.



Potential Examples

- Nutritional properties in various food products
- Identification of disease in food crops
- Identification and degradation products from paintings and painted objects
- Aging of microplastics in the environment
- Change in protein structures associated with diseases
- Mapping hydrocarbon fluid inclusions

IR beamline layout



Stage 2 and experimental setup

Stage 1

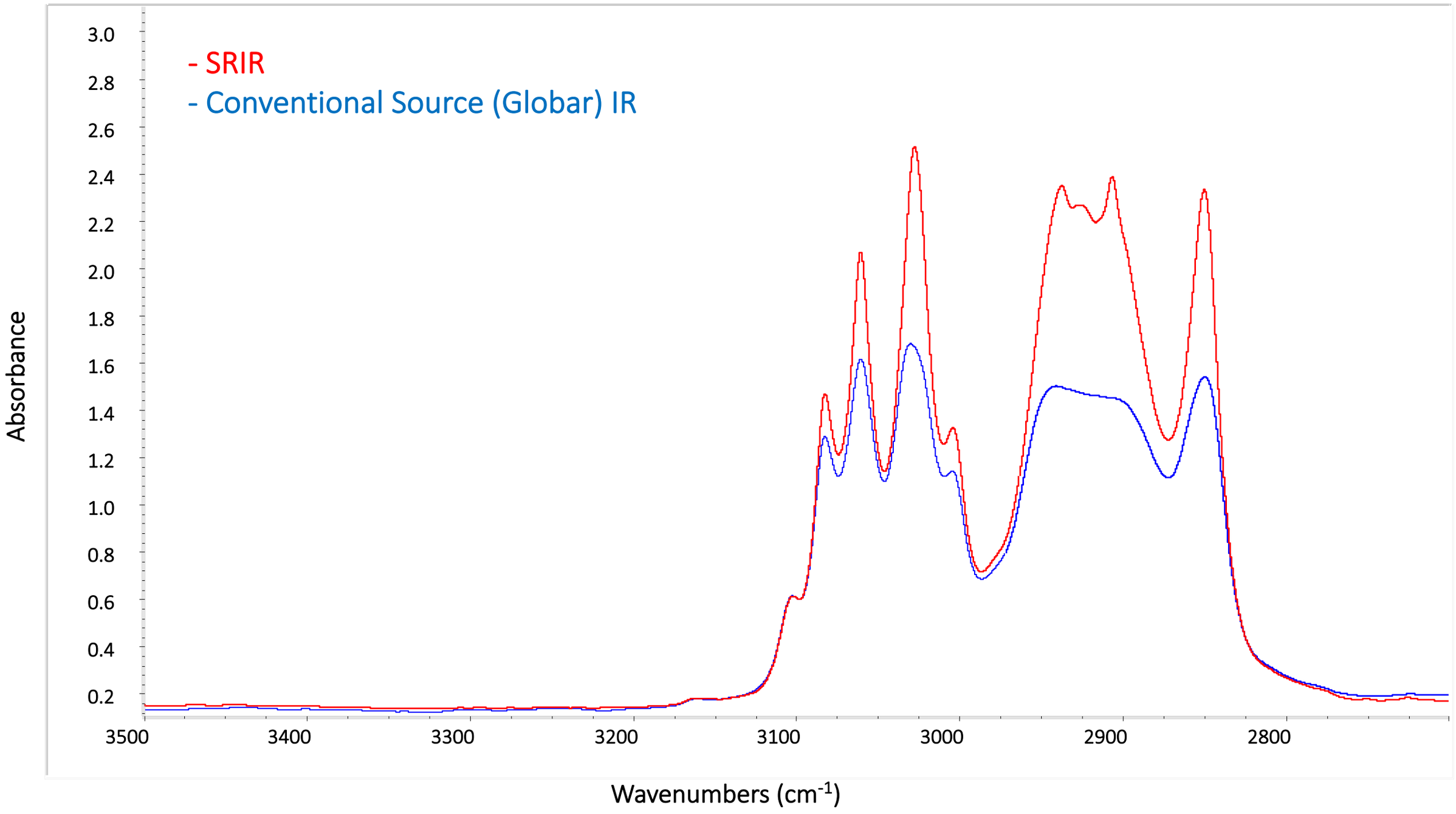
Top view of Stage I

September 2017:
IR Optical elements up to the shielding wall installed

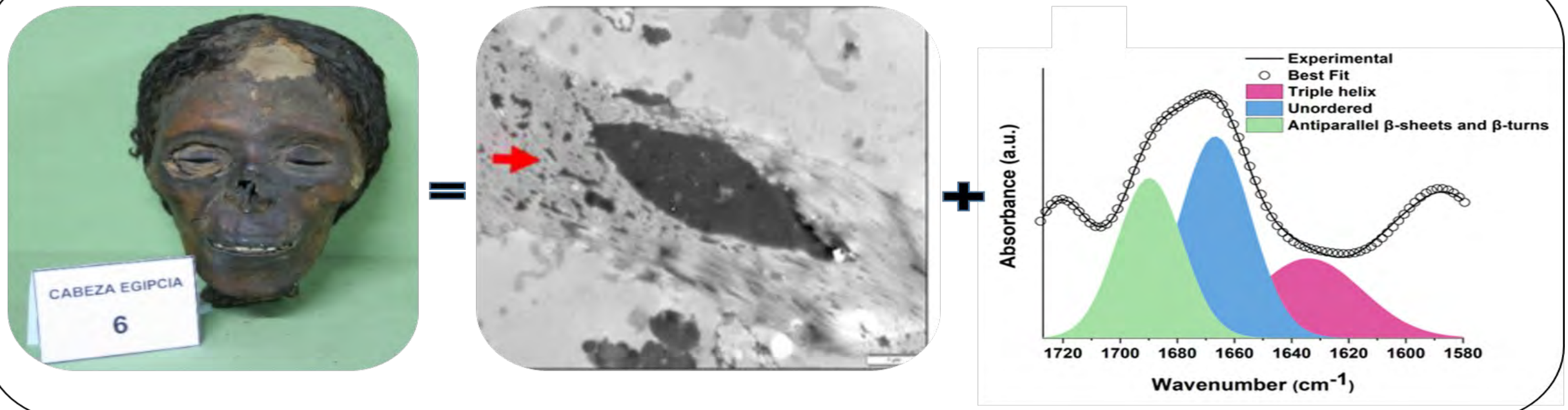
First IR beam observed in April 2018

Stage II and experimental setup

IR: Polystyrene 3 mil Standard Sample



Analysis of proteins from embalmed mummified human head skin using FTIR to confirm a possible skin disorder that appeared in histological examination



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

Ahmed Refaat

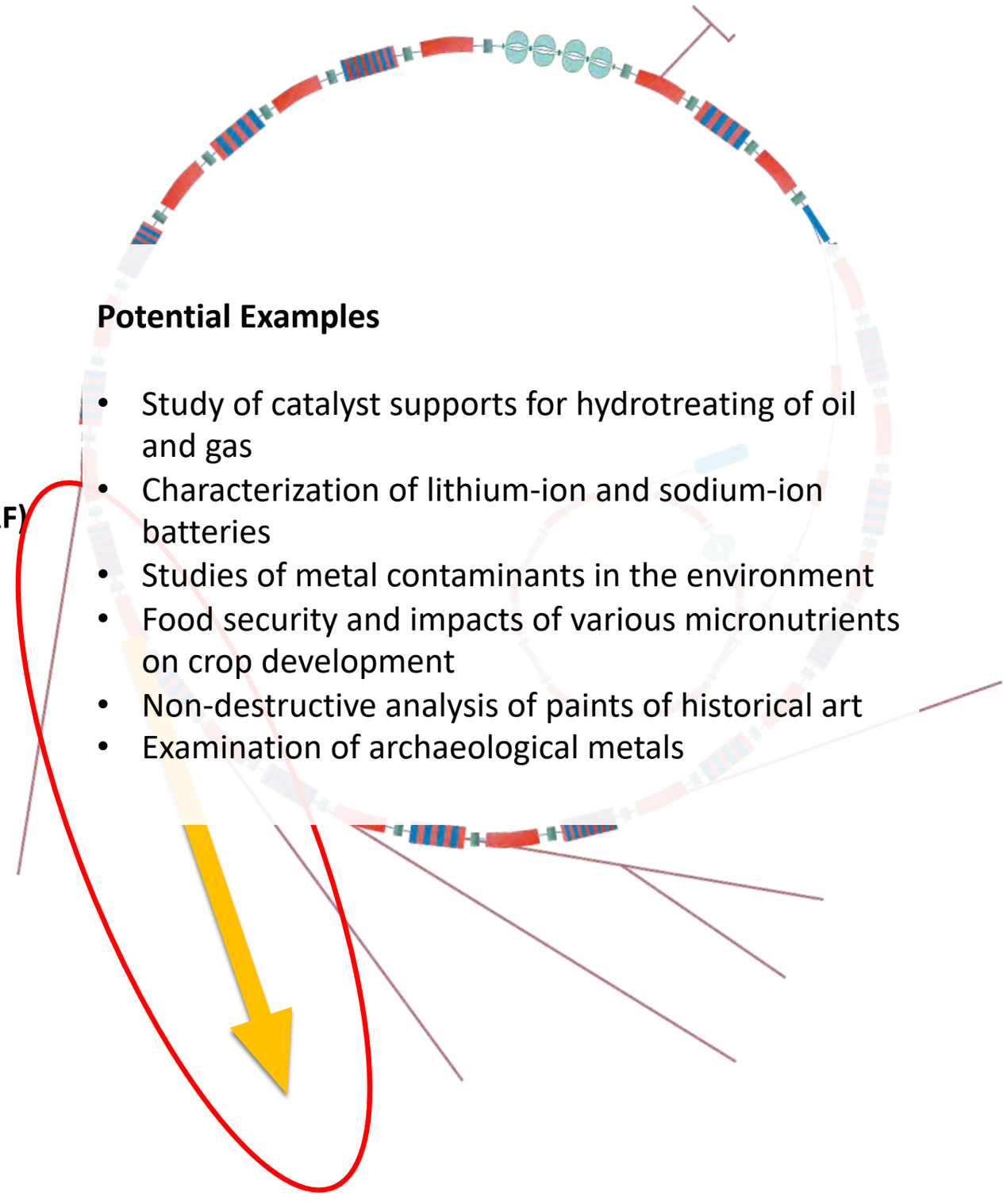
Operational since July 2018

X-ray Absorption Fine Structure/X-ray Fluorescence (XAFS/XRF)

Source – Bending magnet

Experimental station – optical table with 6 axis of freedom and used as support for different detectors as well as for the sample manipulator and other sample. Detectors comprise Ion Chambers and X-Ray Fluorescence detectors (KETEK single element silicon drift detector and INFN 64 element silicon drift detector)

Sample Type – Crystal, Amorphous, Powder, Gel, Liquid, Gas



Potential Examples

- Study of catalyst supports for hydrotreating of oil and gas
- Characterization of lithium-ion and sodium-ion batteries
- Studies of metal contaminants in the environment
- Food security and impacts of various micronutrients on crop development
- Non-destructive analysis of paints of historical art
- Examination of archaeological metals

XAFS/XRF Safety Hutches being installed in April 2016

XAFS/XRF Optical Components Installed during Hutch Installation

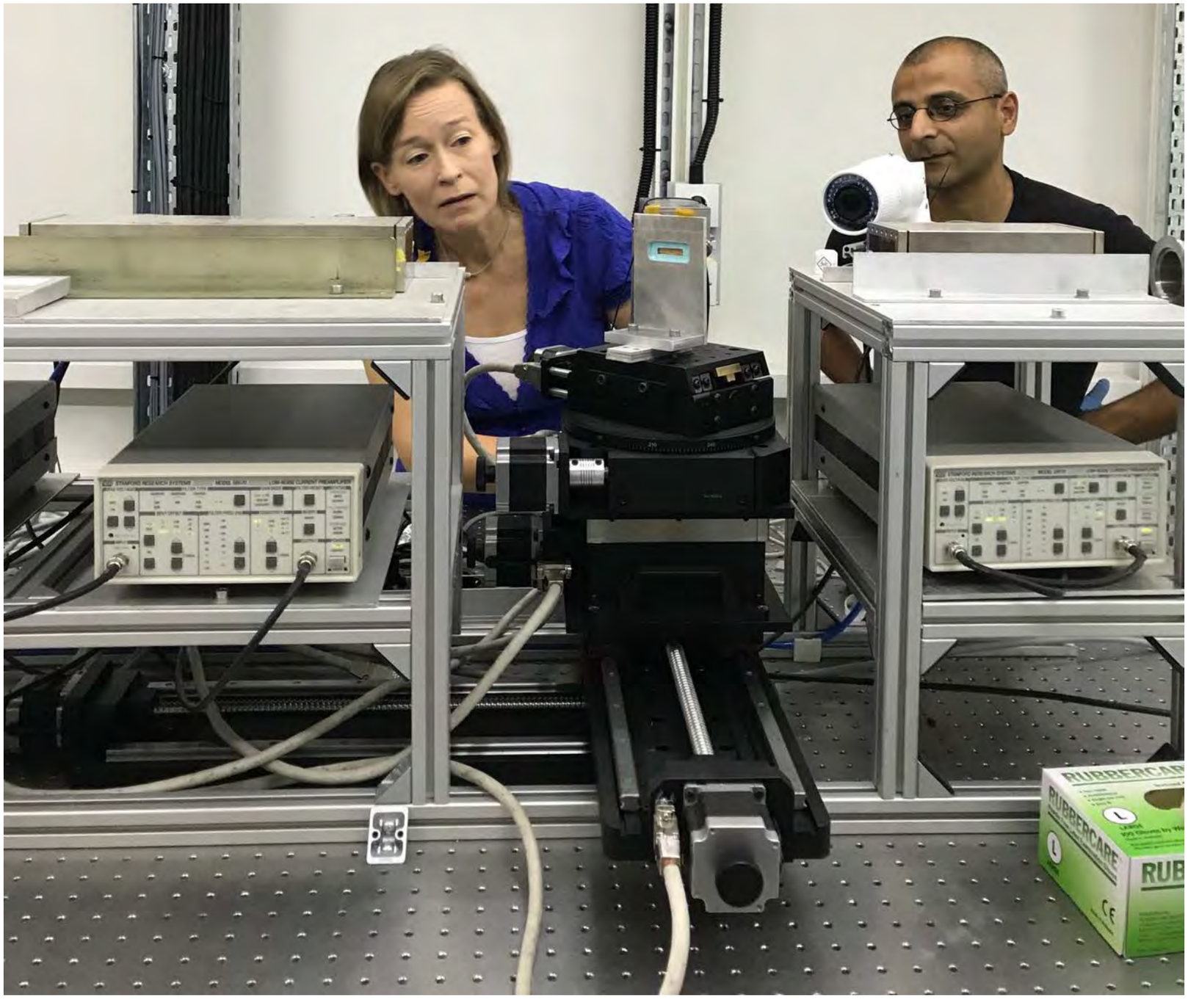
XAFS/XRF monochromator movement under test, with controller developed at SESAME

XAFS/XRF experimental station

BL opened to Storage ring on October 11, 2017

XAFS/XRF First monochromatic beam on November 22, 2017

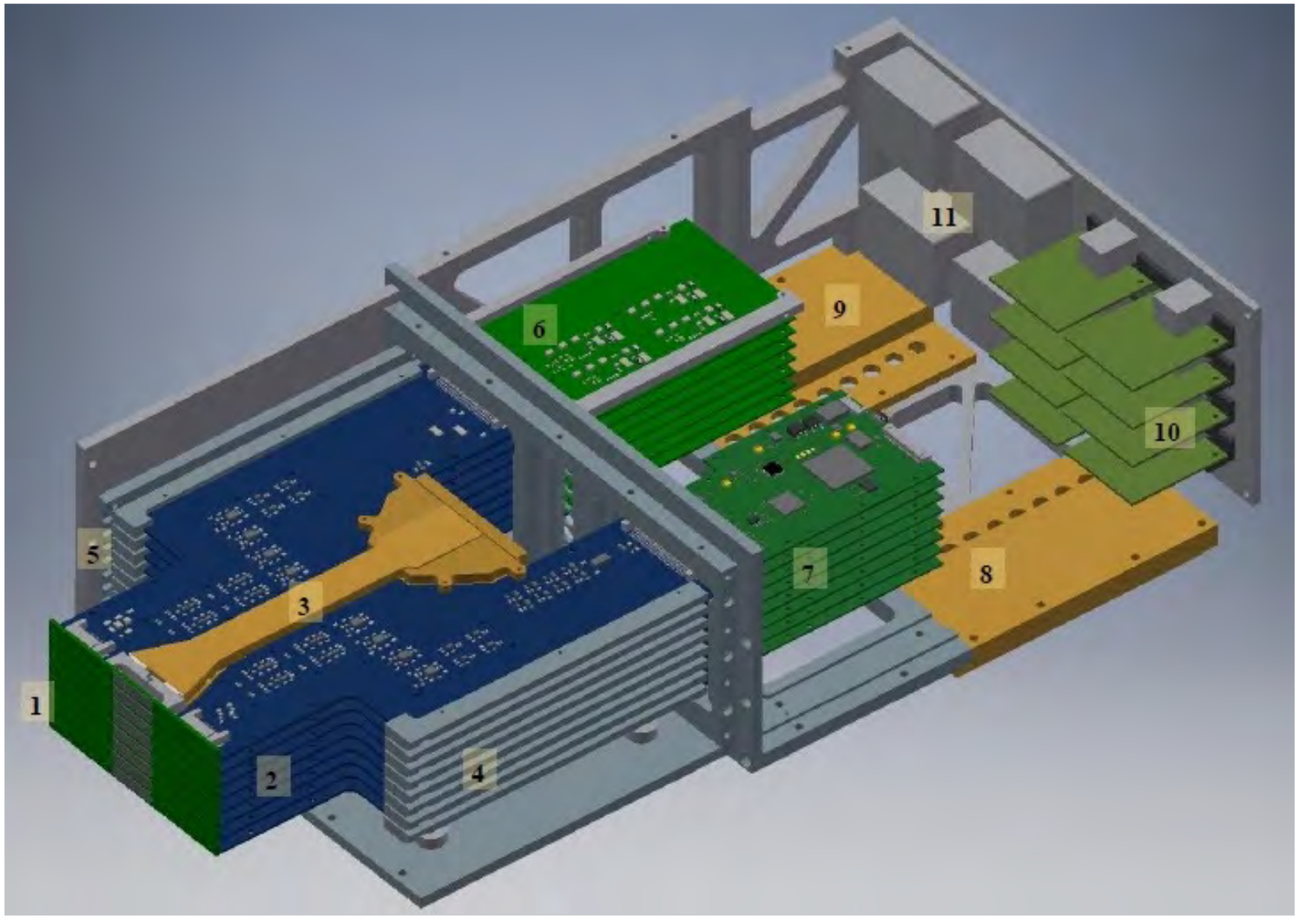
XAFS/XRF first users in July 2018



Kirsi Lorentz and Iosif Hafez from The Cyprus Institute positioning the detector and mounting a sample for study in the experimental hutch of the XAFS/XRF beamline during their measurement run at SESAME in July 2018

December 2019 : new X-ray Fluorescence 64-elements Silicon Drift Detector installed

8 Modules x 8 SDDs with a total sentitive area of 499 mm^2

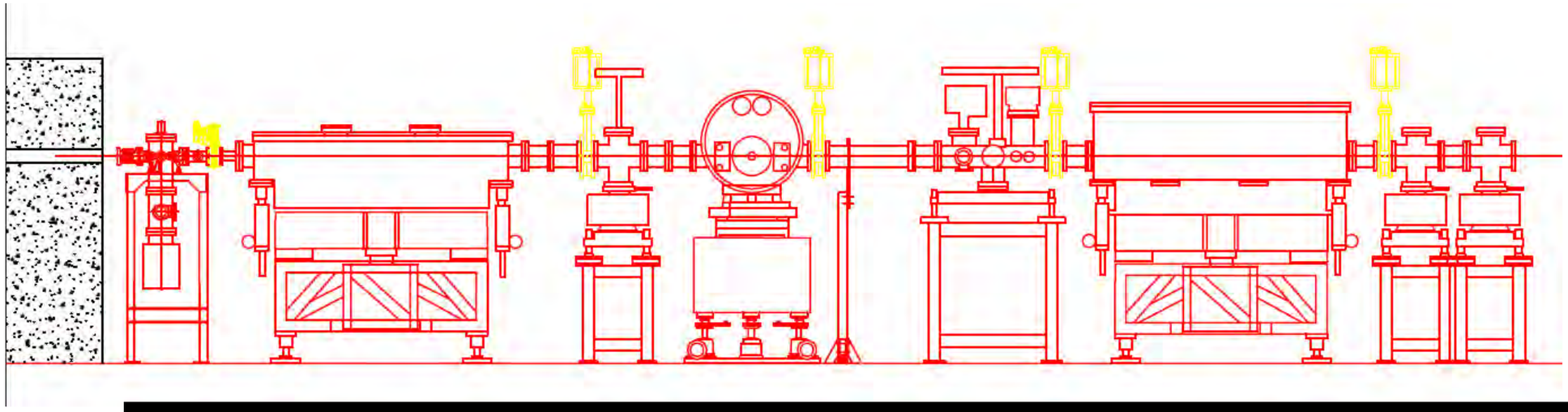


1. Front-end PCBs
2. Conditioning PCBs
3. Brass profile with cooling liquid flowing inside
4. Insertion guides at flanks of detecting heads
5. Rails for eight detection heads
6. Power supply and filters
7. Back-end PCBs
8. Inlet cooling distribution
9. Outlet cooling distribution
10. Ethernet PCBs
11. Power supply connectors

INFN
Istituto Nazionale di Fisica Nucleare

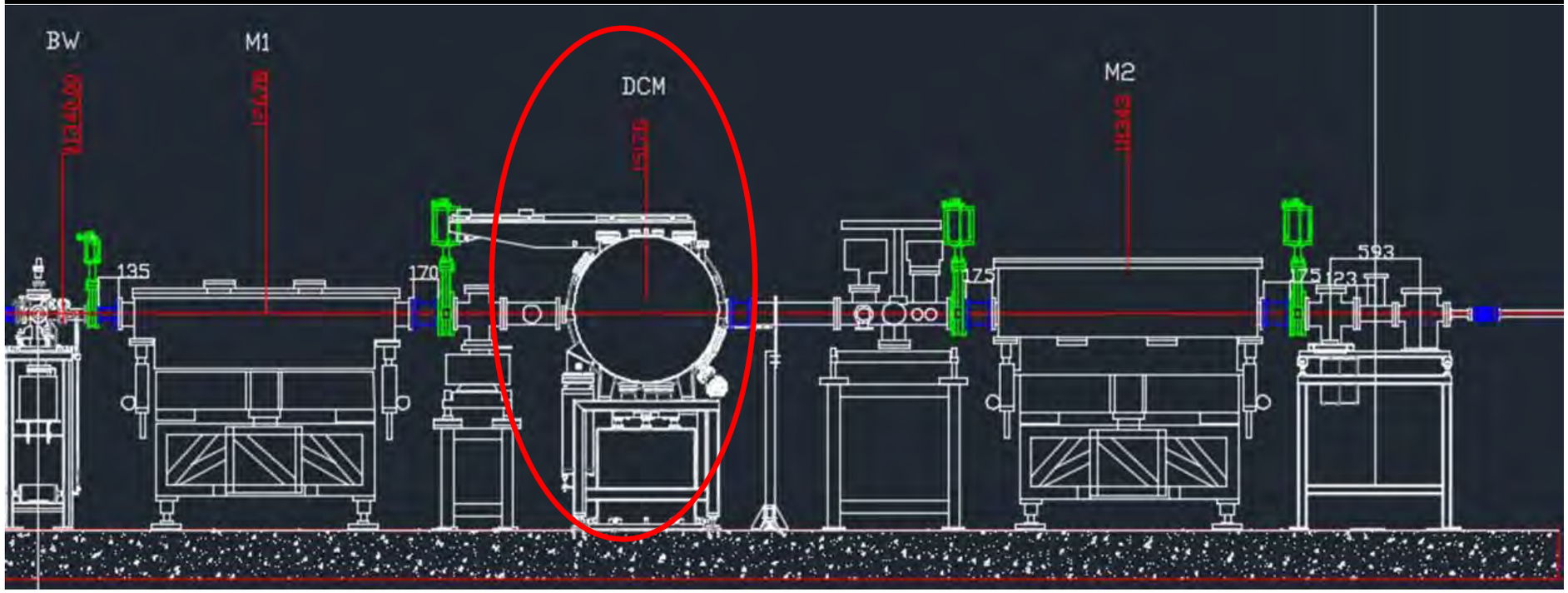
Elettra Sincrotrone Trieste

2020: New Double Crystal Monochromator



2016

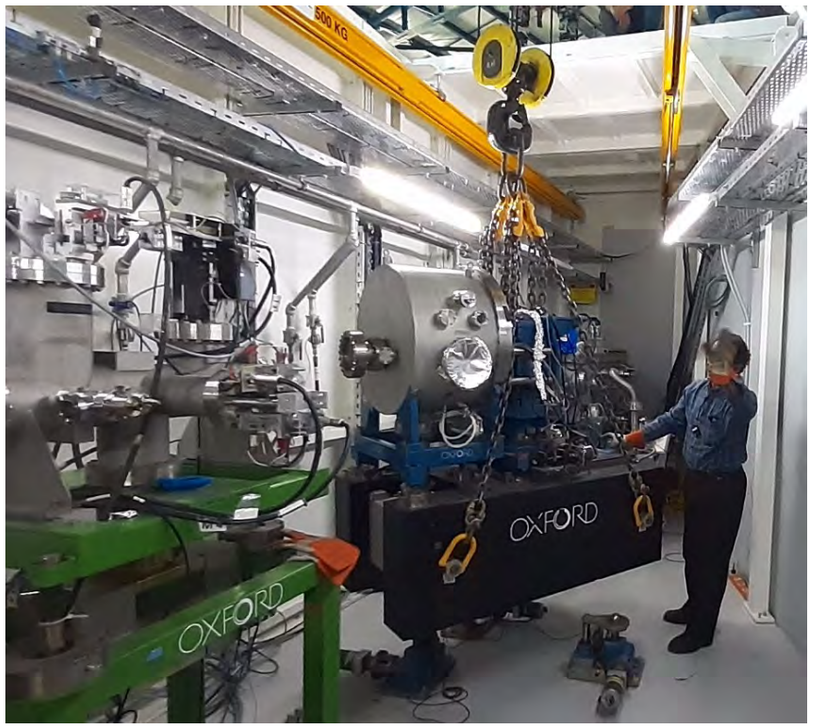
Fits perfectly into the beamline layout



2020

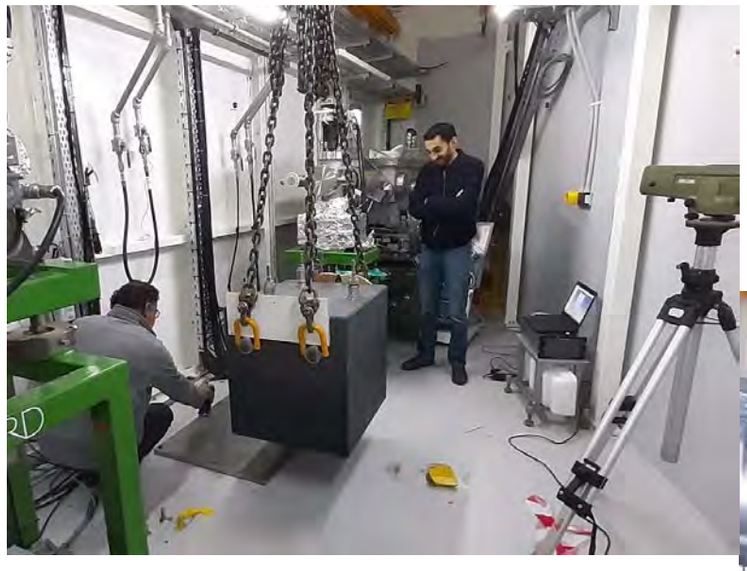
Installing New DCM

Removing old DCM



February 6, 2020

Fixing Granite Table

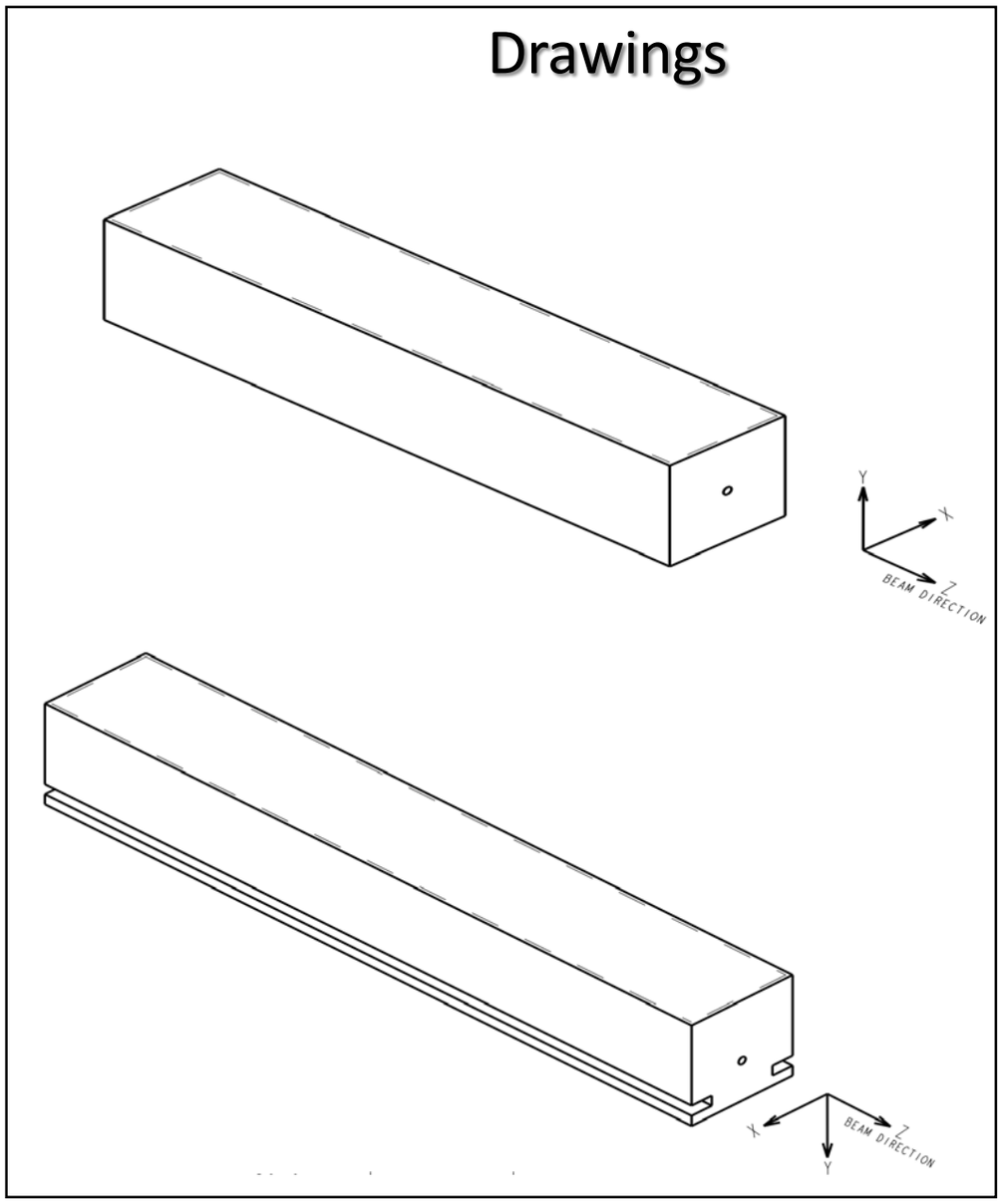


February 11, 2020

Installing the DCM Chamber

February 12, 2020

Si (311) pair of crystals installed beginning of 2021



Argonne NATIONAL LABORATORY

Ercan Alp
XianRong Huang
Elina Kasman
Lahsen Assoufid

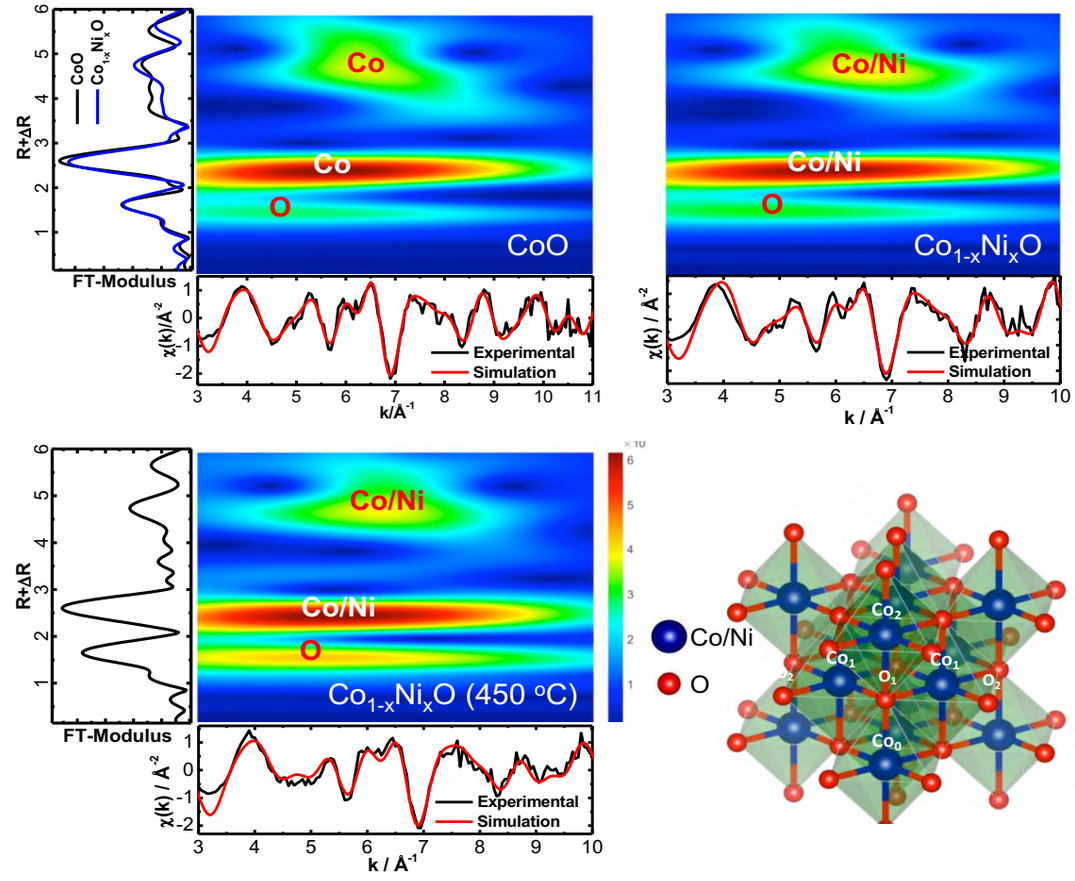
Si(311) crystals to be polished

Energy Conversion and Storage Devices

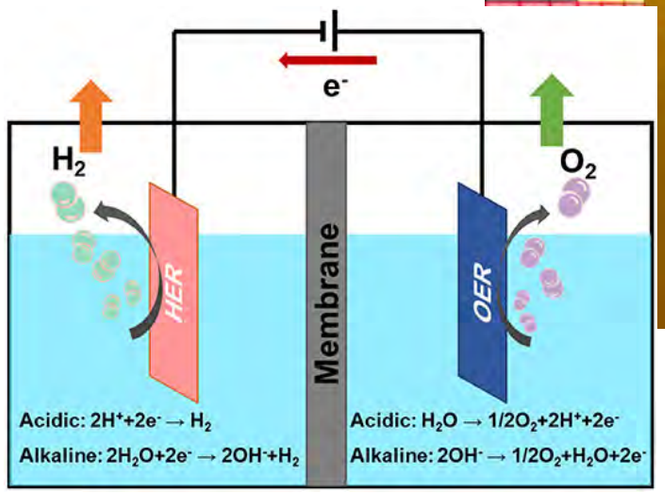
Samples: Nickel ion-implanted Coblat (II) Oxides thin films deposited on the Fluorine-doped Tin Oxide (FTO) glass, using Pelletron Tandem Accelerator (E: 700 KeV).

Experiment: Exploring defects/oxygen vacancies in these samples *via* **XAFS** to enhance their efficiencies for application as electrocatalysts in Hydrogen Evolution Reaction - HER (Fuel Cells).

Results: EXAFS Simulation by Evolutionary Algorithm Implemented in Reverse Monte Carlo method (EA-RMC)



Water Electrolysis System



Research Group from National Center of Physics Pakistan

Publication: Latif Ullah Khan, Naila Jabeen, Messaoud Harfouche et al. Investigating Local Structure of Ion-Implanted (Ni^{2+}) and Thermally Annealed Rocksalt CoO film by EXAFS Simulation Using Evolutionary Algorithm. ACS Applied Energy Materials (ACS) 2021. DOI: https://doi.org/10.1021/acsaem.0c02676

ID09 – Powder diffraction Beamline (Materials Science), MS

Mahmoud Abdellatief

Operational since December 2020

Powder diffraction

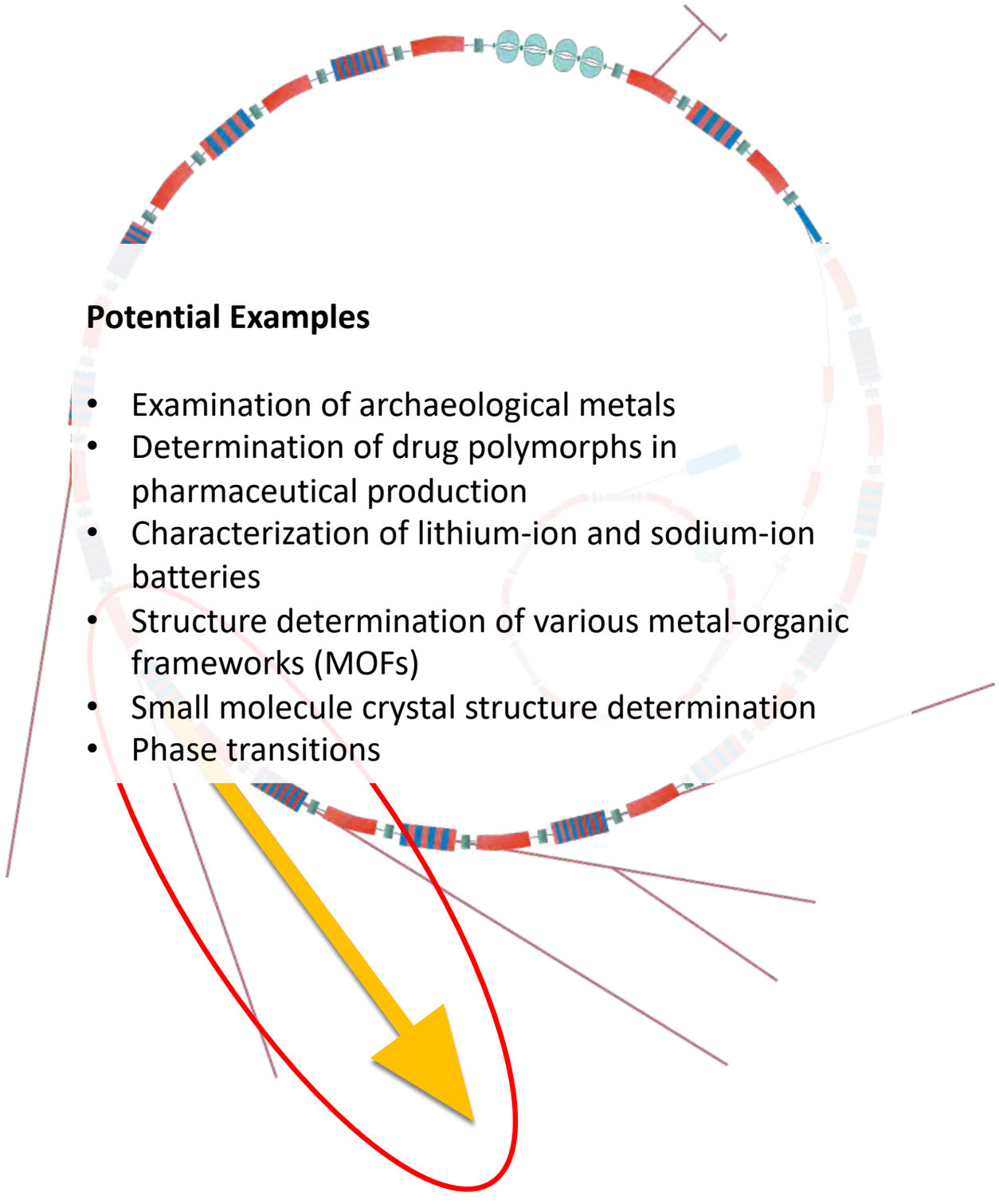
Source – Multipole wiggler

Experimental station – 2-circle diffractometer, with motorised translation stage to align the capillary to the spinner.

Sample environment – Hot Blower (RT to 1300 K) and Cryo Stream (100 K to RT)

Detector – Dectris Pilatus 300K

Sample Type –Powder in Capillary and Flat Plate



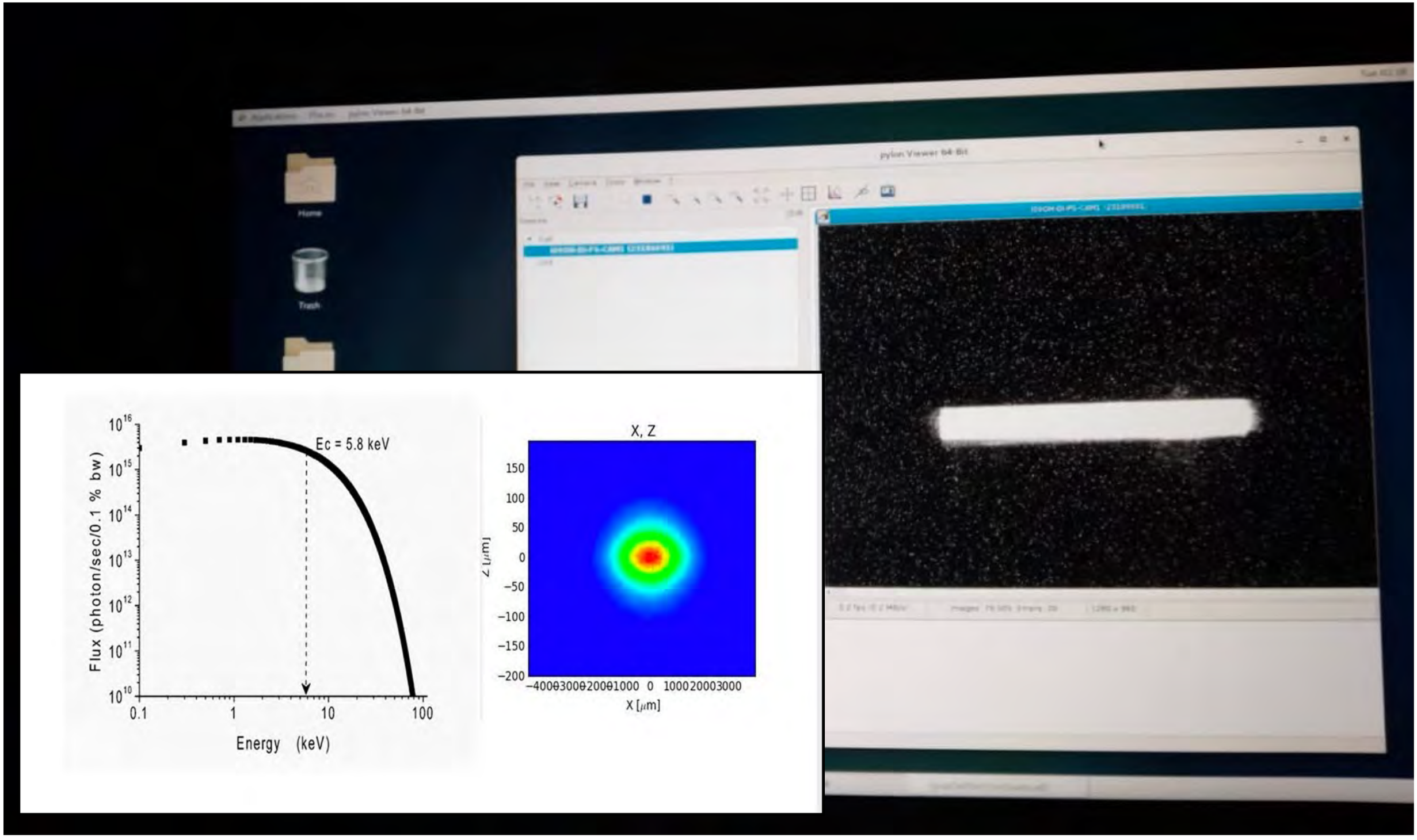
Potential Examples

- Examination of archaeological metals
- Determination of drug polymorphs in pharmaceutical production
- Characterization of lithium-ion and sodium-ion batteries
- Structure determination of various metal-organic frameworks (MOFs)
- Small molecule crystal structure determination
- Phase transitions

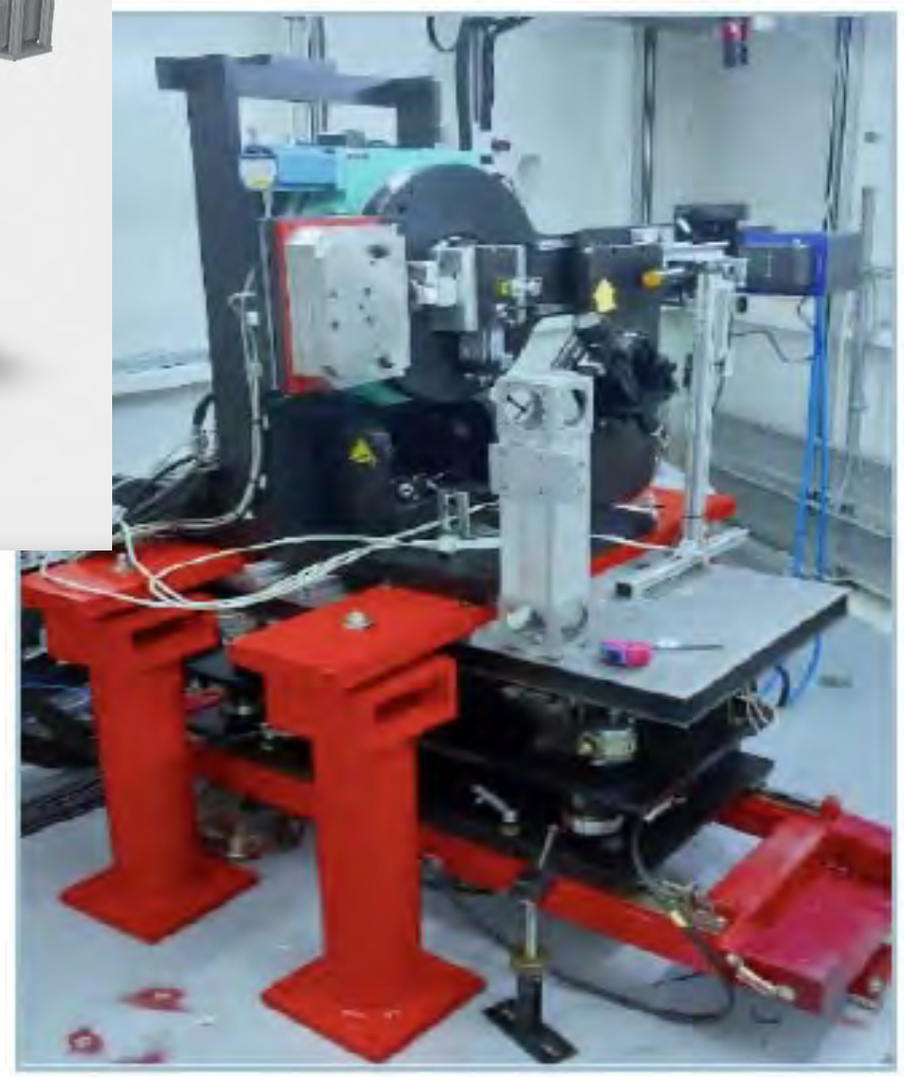
Materials Science Beamline
Wiggler final motion control tests before operation

Materials Science Beamline
November 24, 2019: all MS components installed and under vacuum

Materials Science Beamline
Commissioning started on December 1, 2019
First monochromatic beam on December 3, 2019



Materials Science Beamline
January 2020 beginning installation of the Experimental Station

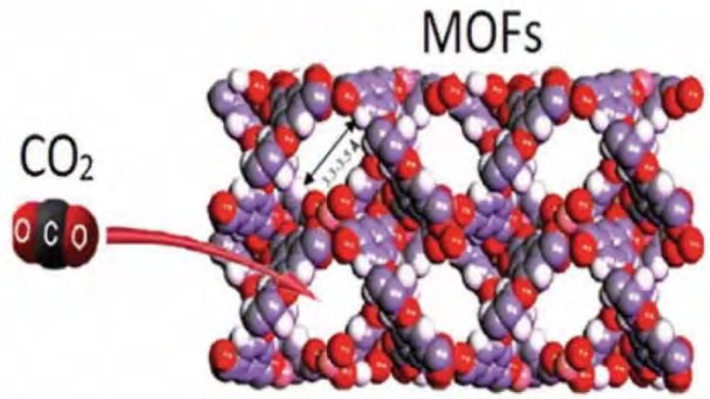


In 2019, Diamond donated a Kappa diffractometer to SESAME for its MS (Materials Science) beamline. After modification from Kappa to two-circle geometry the diffractometer was installed in the beamline utilising a support table from the 2008 Daresbury loan.

Materials Science Beamline
December 2020 first user group

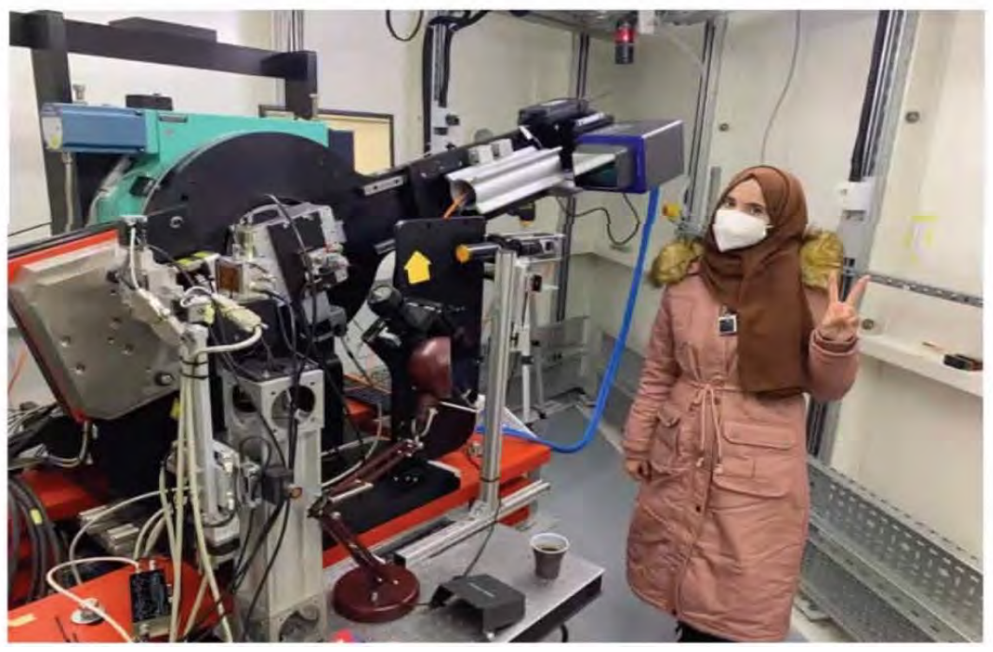
Crystallographic Analysis of Porous Metal Oxide Frameworks (MOFs) for C02 sorption applications.

MOFs materials have attractive structures due to the presence of well-defined nanosized pore channels that lead to intrinsically high internal surface areas, which allow for the physical adsorption of a wide range of guest molecules



(Climate change control)

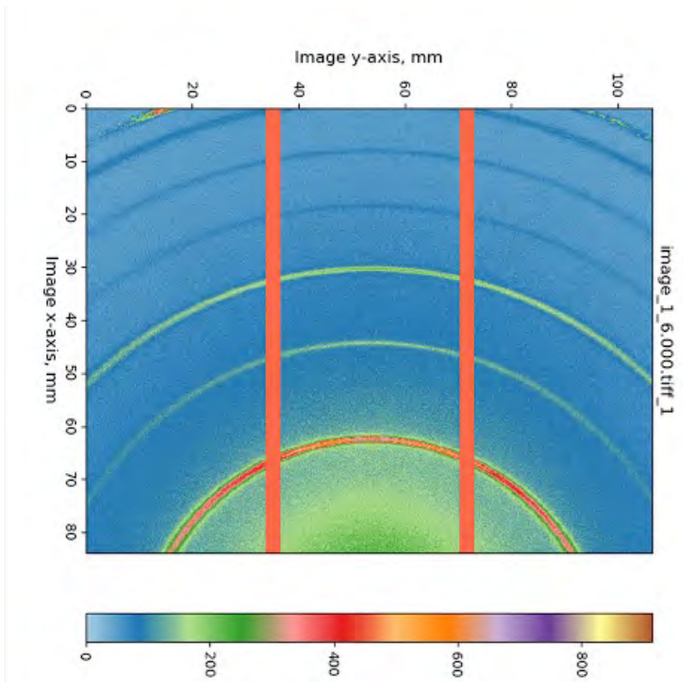
XRD is used to investigate and understand the correlation between MOFs crystal structures and their gas storage and sorption properties (mainly CO2 is of interest). The experiments should provide the needed knowledge required to tune these materials for better sorption efficiency.

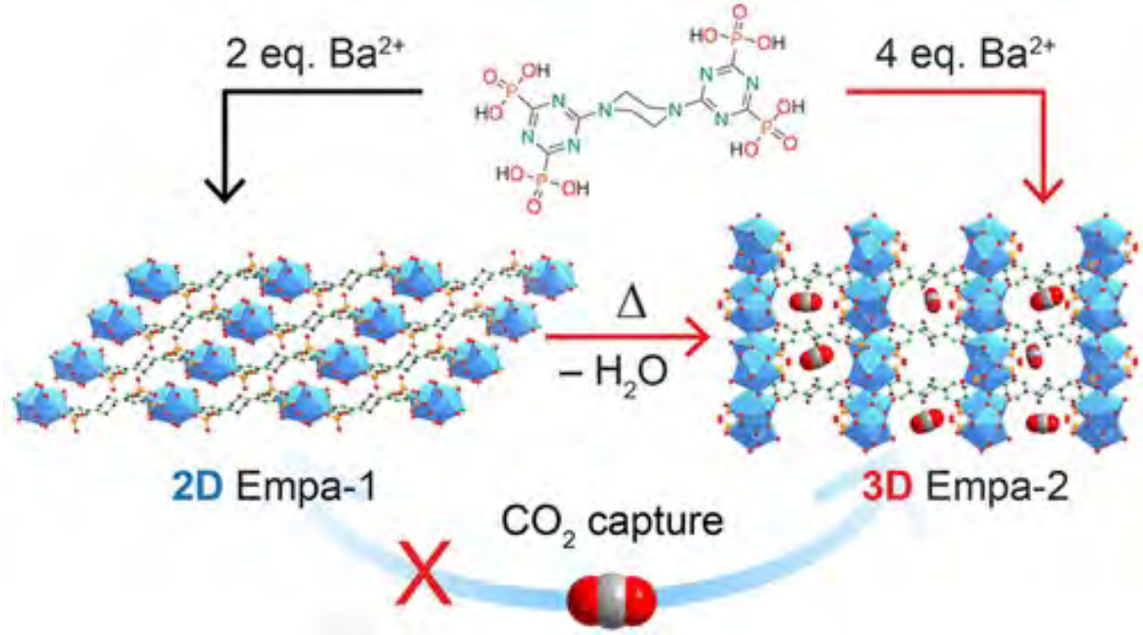


Materials Science Beamline
June 2020 first article
Novel Materials for CO_2 Binding

First users (from RSS of Jordan)

Crystallographic Analysis of Porous Frameworks
for Strong and Re-generable Binding of CO_2





ACS Materials Lett. 2021, 3, 7, 1010–1015
Publication date: June 15, 2021 https://doi.org/10.1021/acsmaterialslett.1c00275
(First user data taken at MS, and also first publication of the beamline, that was open in Dec 2020)

ID10 – BEAmline for Tomography at SESAME, BEATS

Axel Kaprolat, ESRF

Gianluca Iori, SESAME

Operational 2022

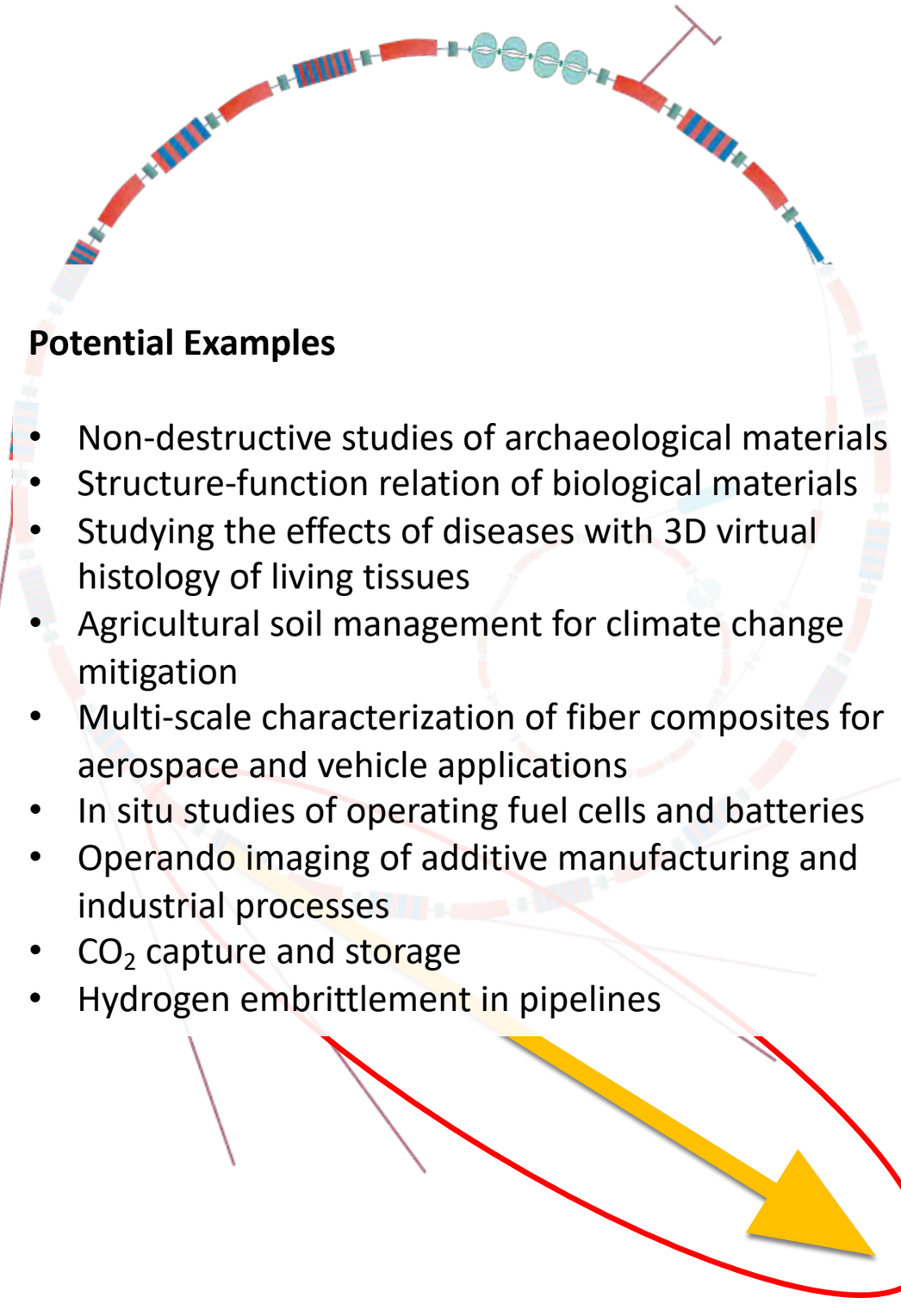
A new beamline for TOMOGRAPHY

6 M Euro funding (EU)

X-ray source: 3-pole wiggler, 3T, E_c= 12.4 keV

User community build-up workshops

Funded by the EU's H2020 framework programme under grant agreement n°822535



Potential Examples

- Non-destructive studies of archaeological materials
- Structure-function relation of biological materials
- Studying the effects of diseases with 3D virtual histology of living tissues
- Agricultural soil management for climate change mitigation
- Multi-scale characterization of fiber composites for aerospace and vehicle applications
- In situ studies of operating fuel cells and batteries
- Operando imaging of additive manufacturing and industrial processes
- CO_2 capture and storage
- Hydrogen embrittlement in pipelines

BEATS Project Structure

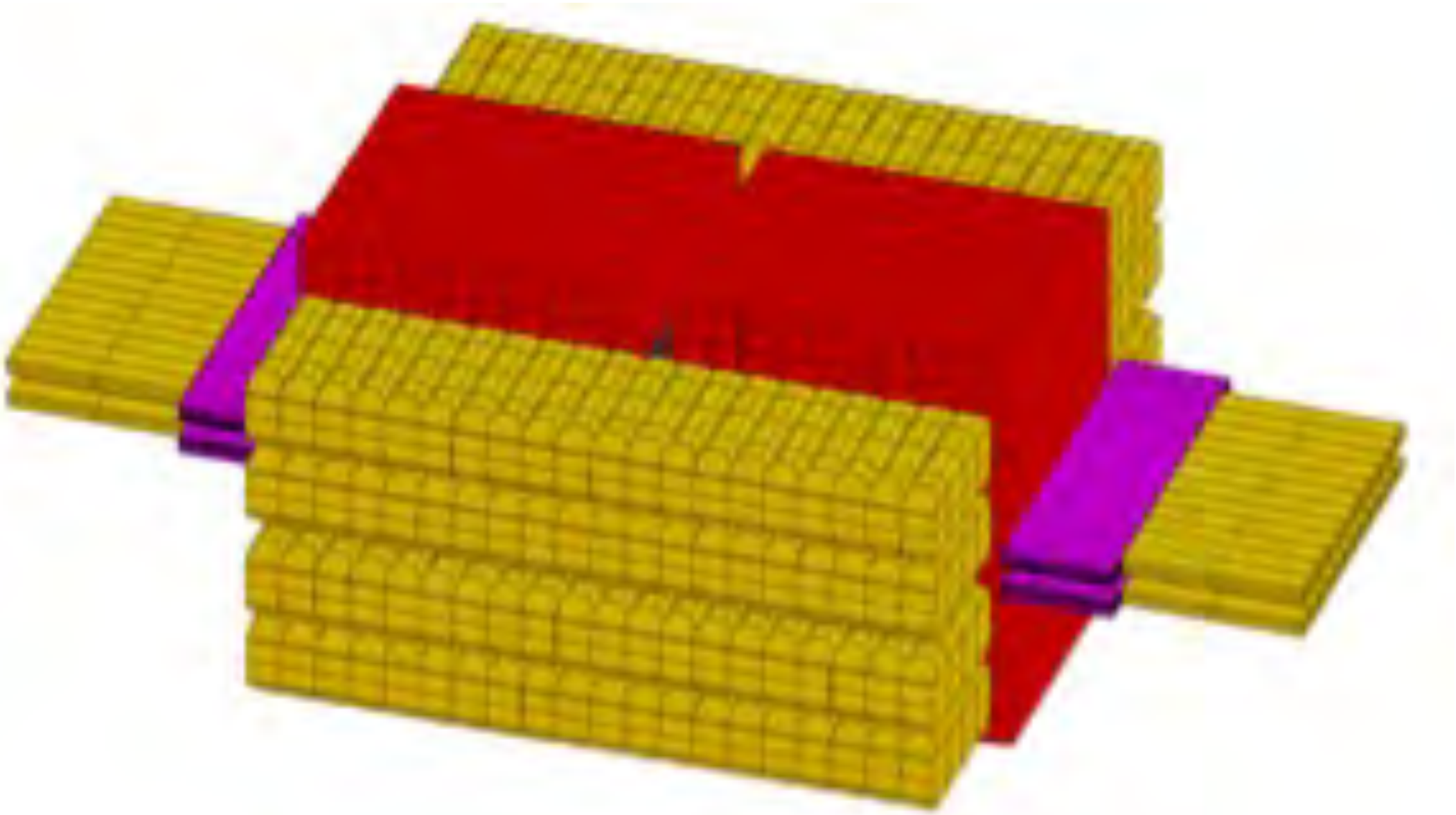
ALBA-CELLS:	Source, Radiation Protection
CvI:	Sustainability, Data Analysis
DESY:	Sustainability
ELETTRA:	Technical Design, Assembly
ESRF:	Management, Technical Design, Commissioning
INFN:	Source, Technical Design
PSI:	Training, Sustainability
SESAME:	ALL
SOLARIS:	ALL

Funded by the EU's H2020 framework programme under grant agreement n°822535

BEATS: the source

Increase the critical energy (now at 6.04 keV – 1.45 T – 2.5 GeV)

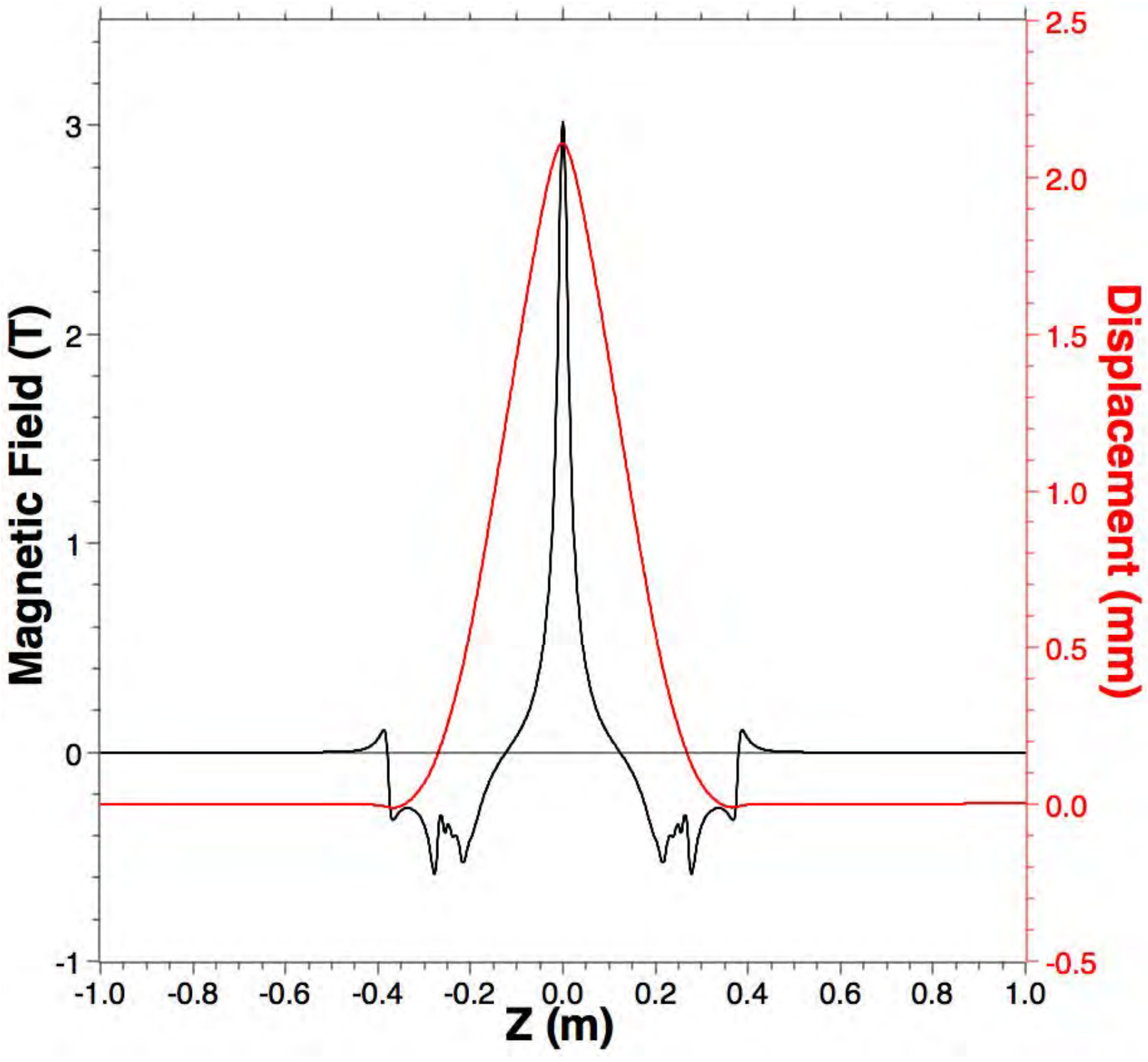
WP3 source:
led by INFN + ALBA + SESAME
3PW (Courtesy of Josep Campmany)



Funded by the EU's H2020 framework programme under grant agreement n°822535

BEATS: the source

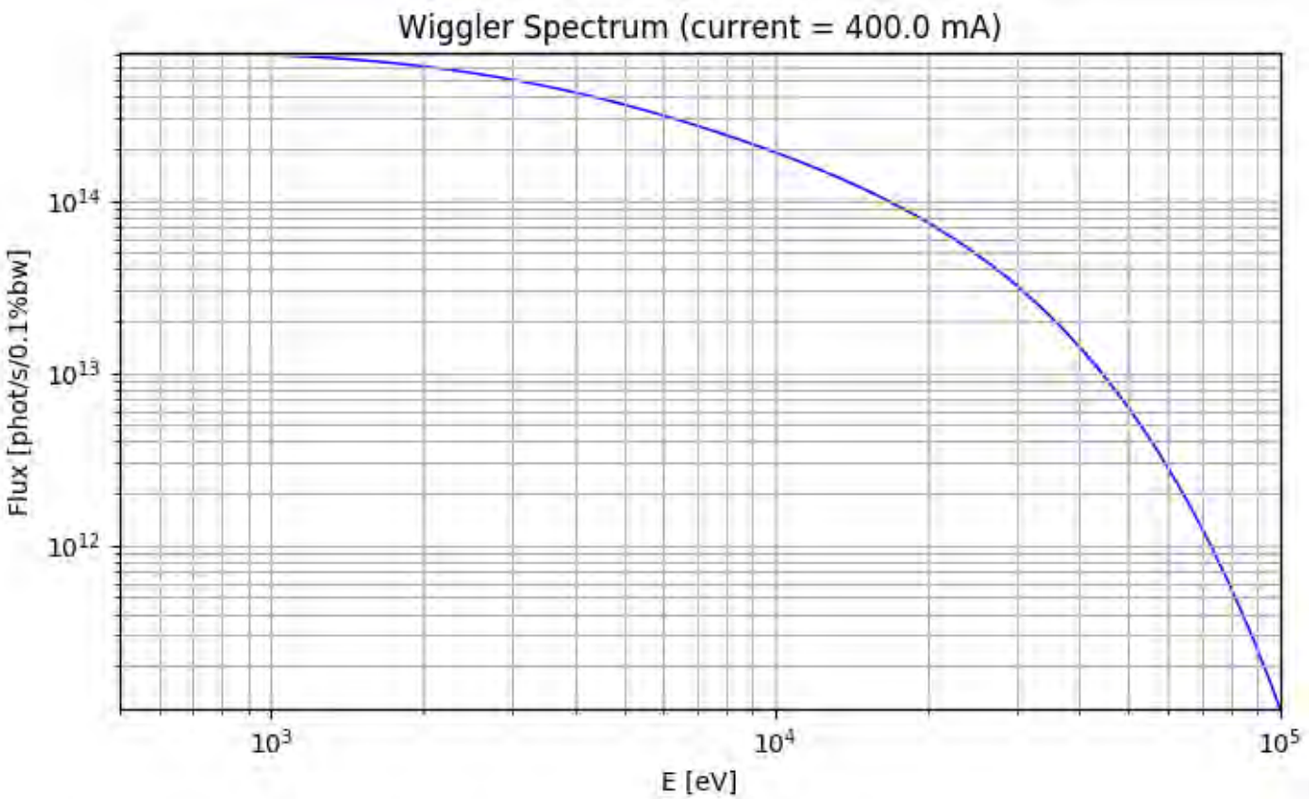
Increase the critical energy (now at 6.04 keV – 1.45 T – 2.5 GeV)

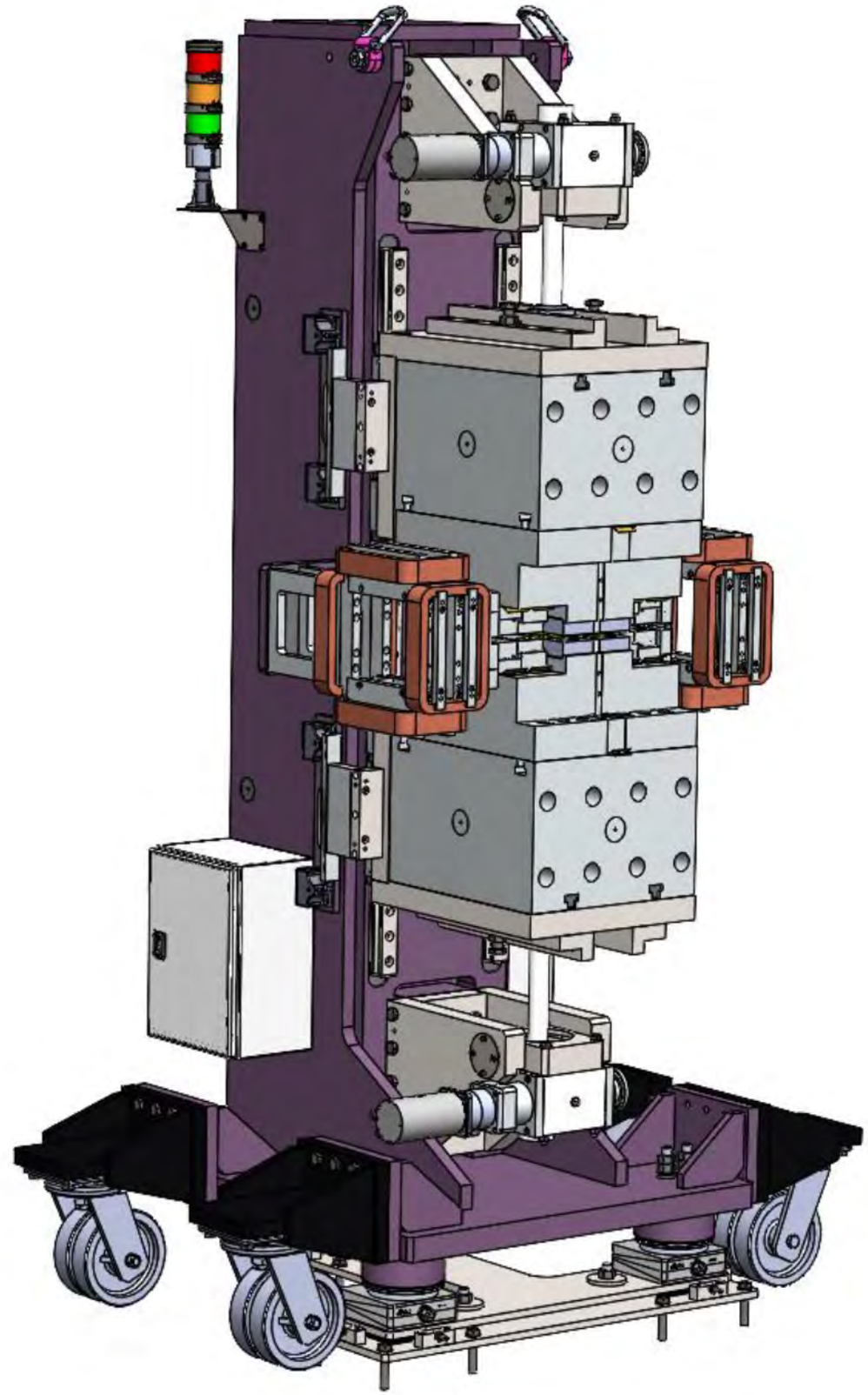


Funded by the EU's H2020 framework programme under grant agreement n°822535

BEATS: the source

Total estimated emitted power ~0.9 kW



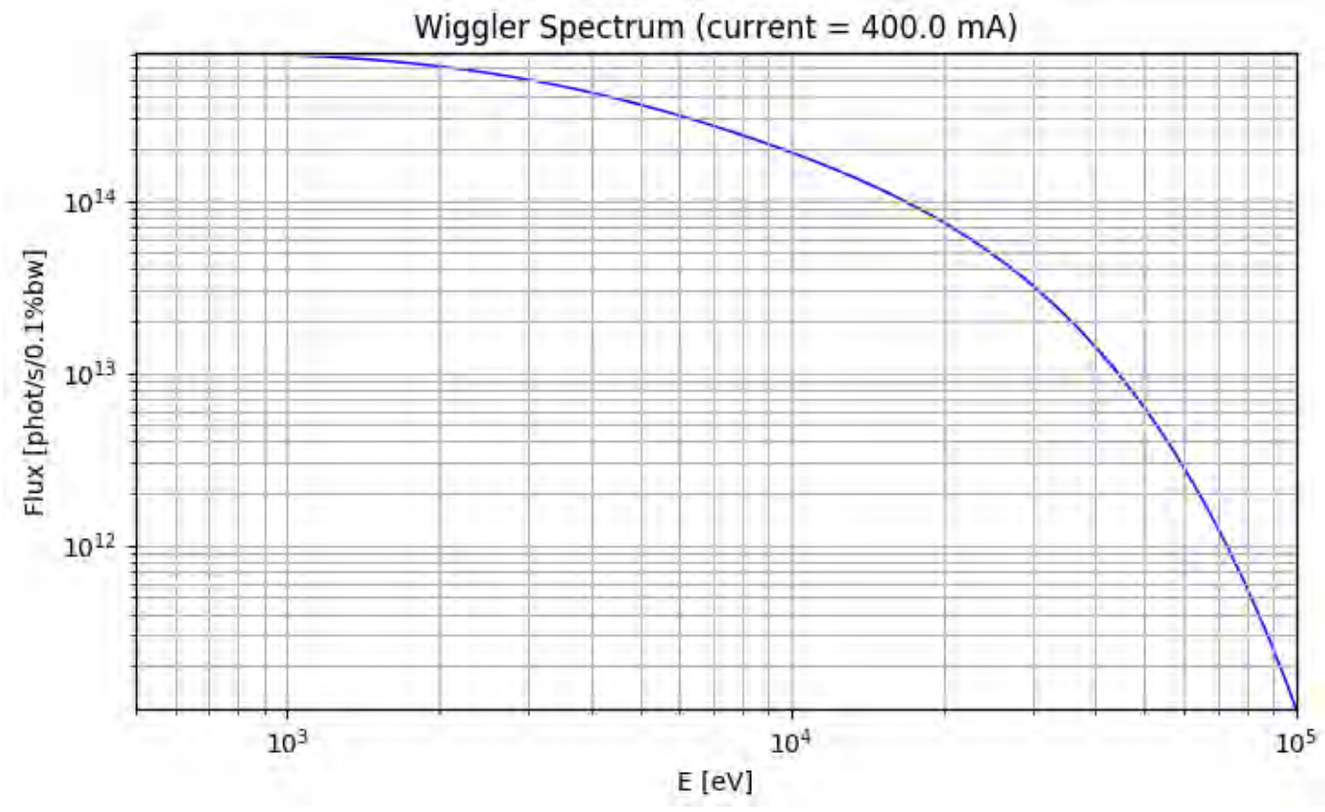


Source (INFN + ALBA + SESAME)
Delivery January 2022

Funded by the EU's H2020 framework programme under grant agreement n°822535

BEATS: the source

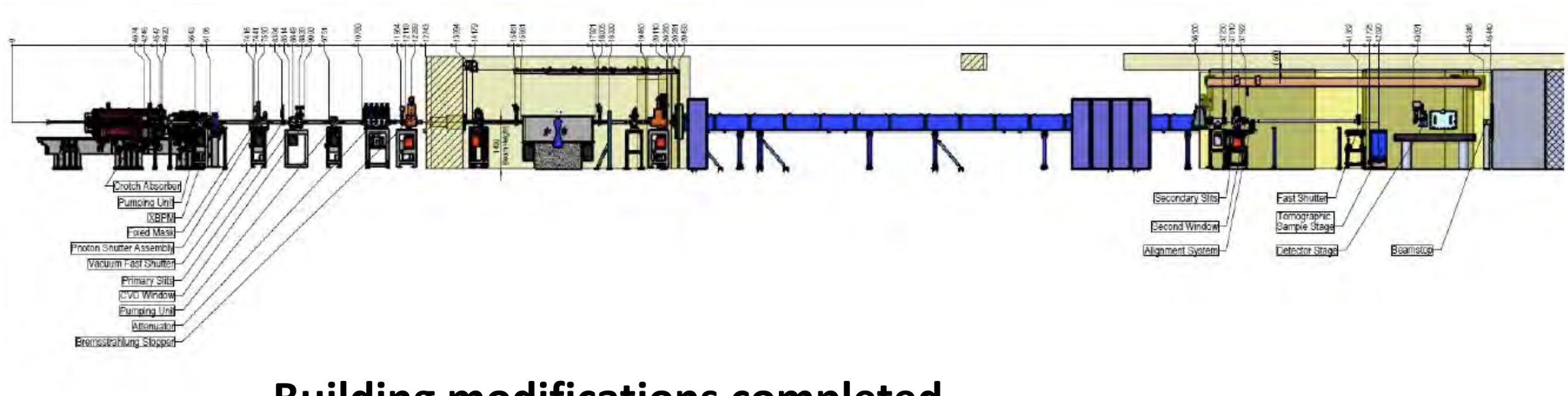
Total estimated emitted power ~0.9 kW



Source (INFN + ALBA + SESAME)
Delivery January 2022

Funded by the EU's H2020 framework programme under grant agreement n°822535

BEATS

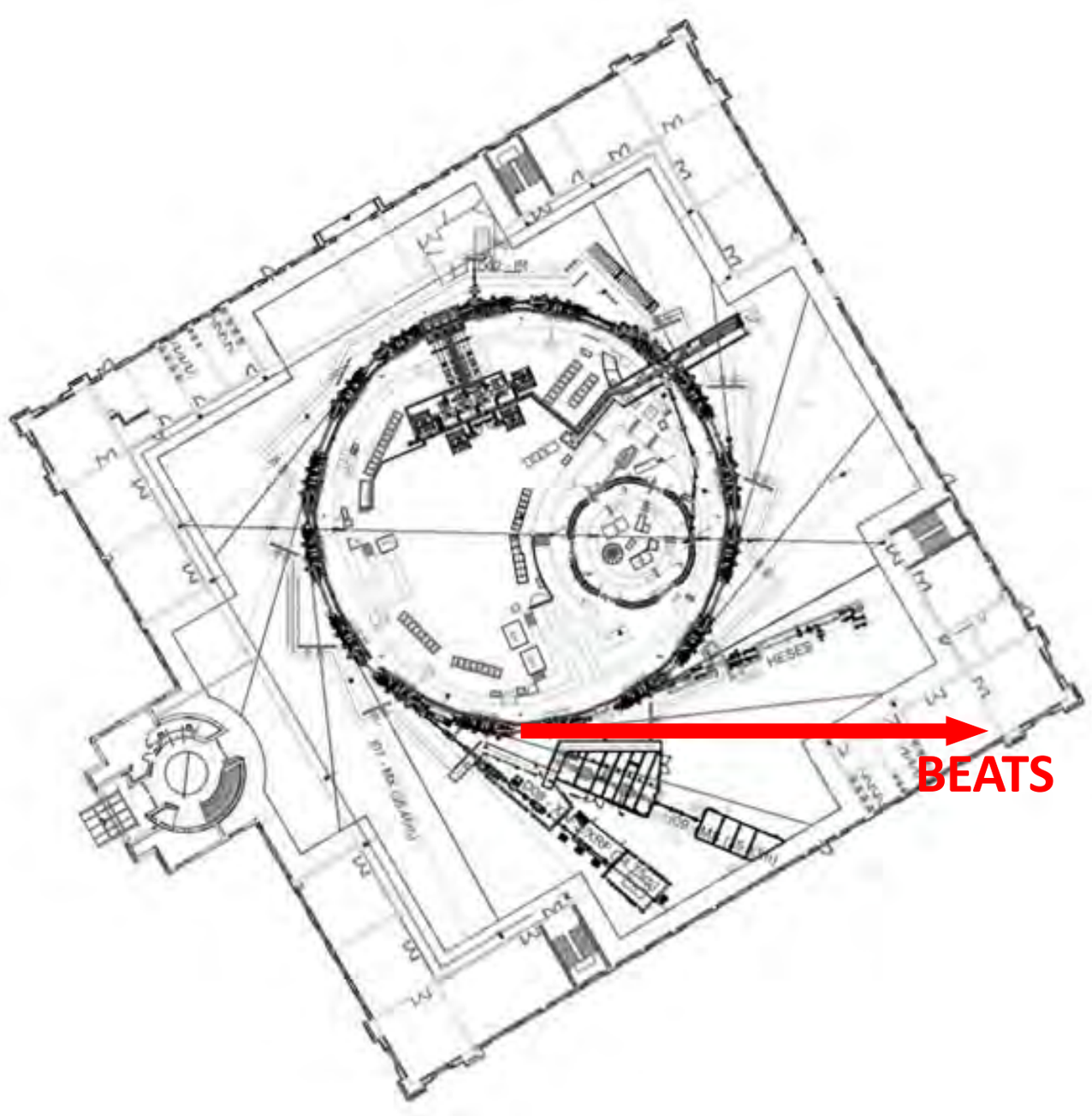


Building modifications completed
Hutches delivery December 2021
Source delivery January 2022
Front-end delivery March 2022
Monochromator delivery June 2022

Funded by the EU's H2020 framework programme under grant agreement n°822535

Enlargement of the Experimental Area to accommodate BEATS

- ✓ **Construction works** (experimental area floor reinforcement) **completed in February 2021**
- ✓ **Infrastructure orders placed**, works ongoing



Funded by the EU's H2020 framework programme under grant agreement n°822535

ID11 – Helmholtz-SESAME Beamline, HESEB

Wolfgang Eberhard

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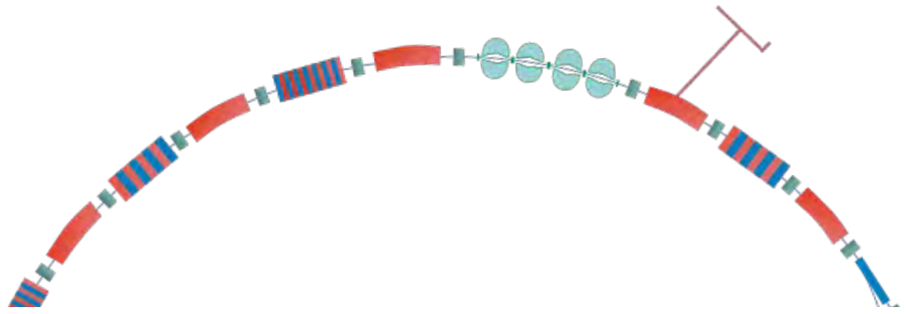
Operational 2022

A new soft X-ray beamline dedicated to enable advanced photoemission/spectroscopy experiments

Based on a variable polarization undulator

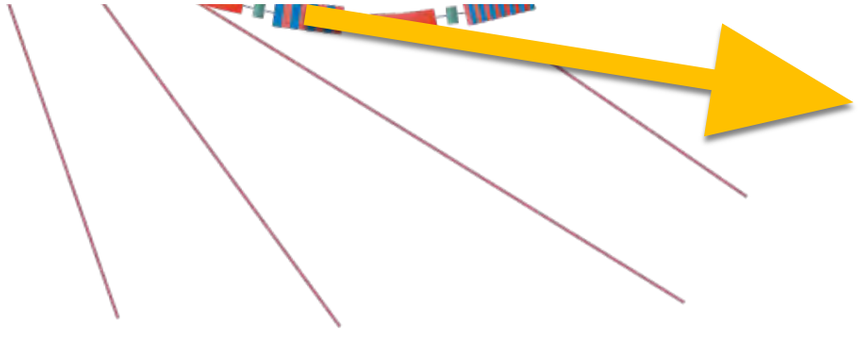
Kick-off meeting in January 2019 at DESY

3.9 M Euro funding secured (Helmholtz Institute)



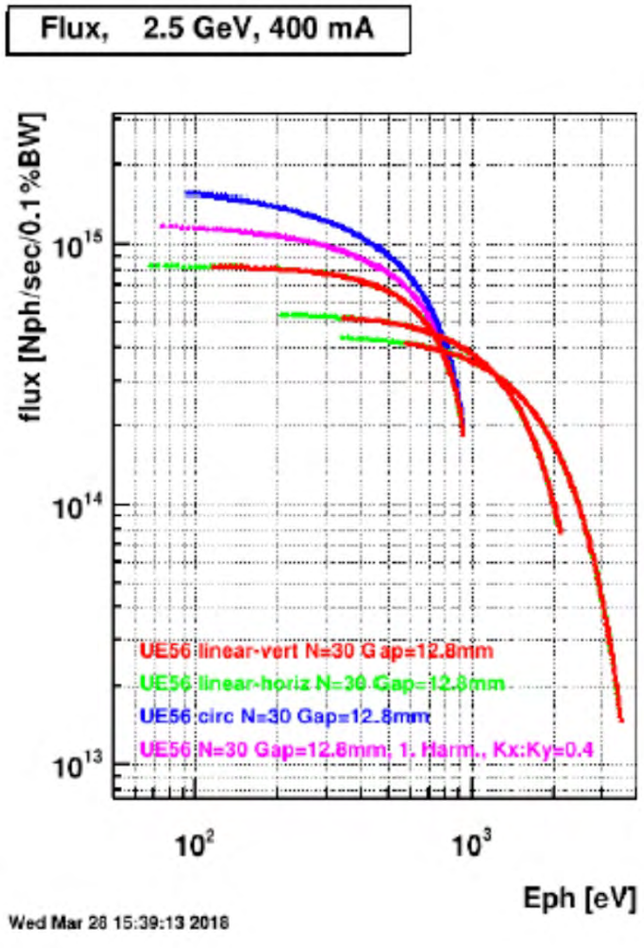
Potential Examples

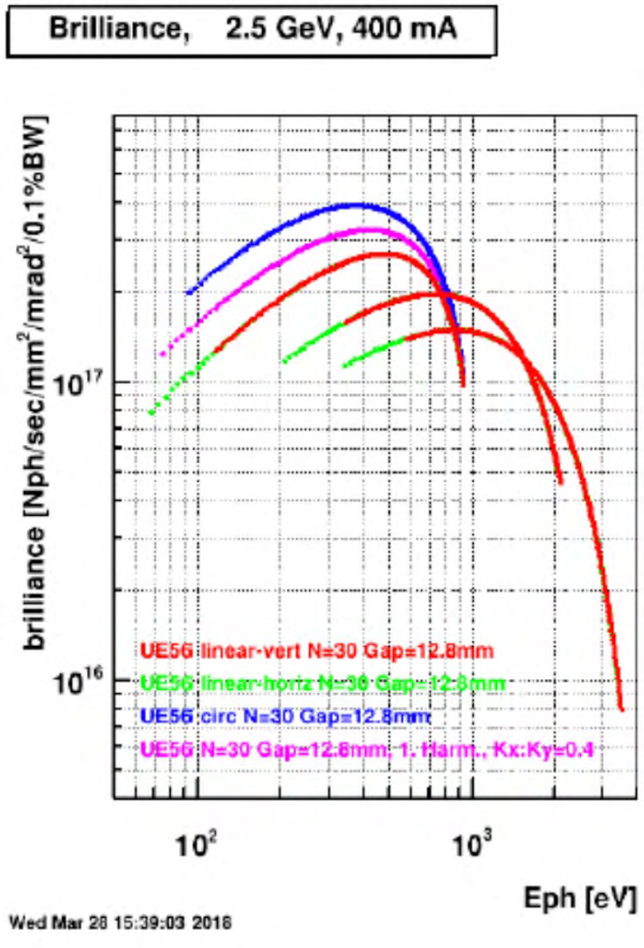
- Absorption spectroscopy with polarized soft X-rays
- Magnetic dichroism in the X-ray region (CMXD)
- Spectroscopy of catalysts under process conditions
- Spectroscopy of battery electrodes under operational conditions
- Non-destructive studies of archaeological materials (e.g. Characterisation and Conservation of Paintings on Walls and Sculpture from Nabataean Petra)

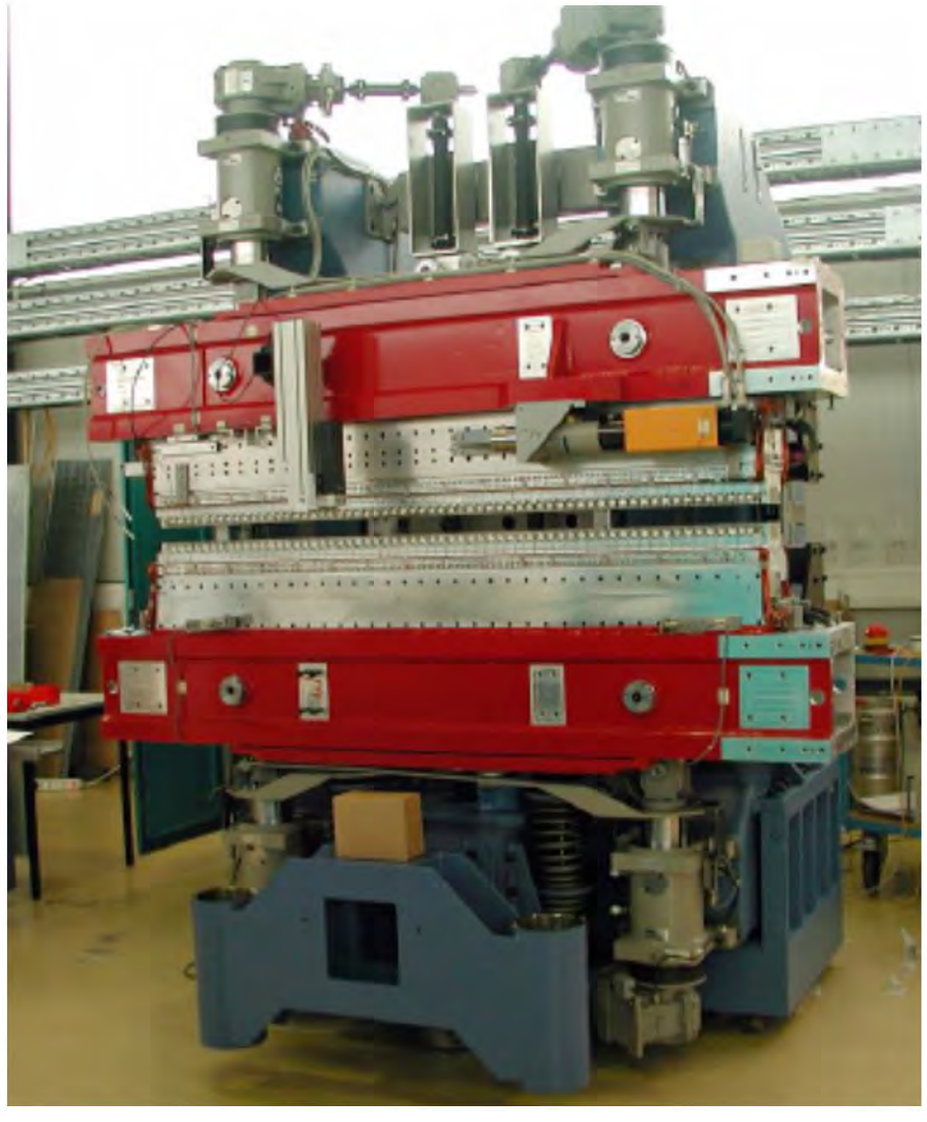


HESEB Beamline

Undulator UE56 with variable polarization





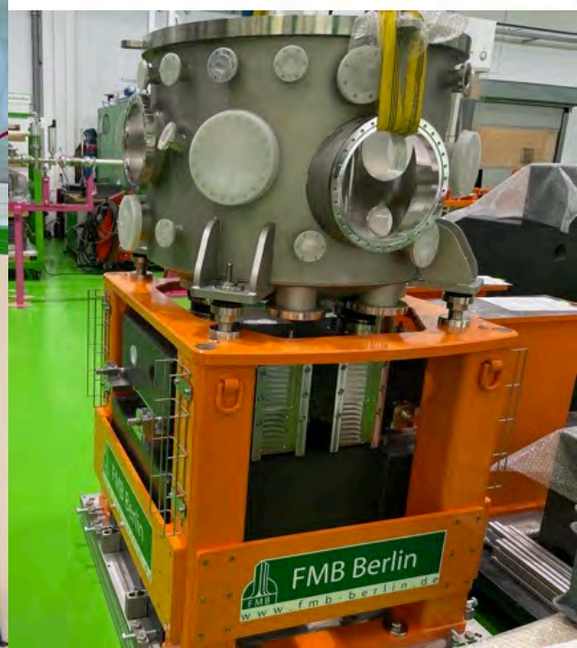


Source refurbished
Delivery September 2021

HESEB

DESY. JÜLICH FORSCHUNGSZENTRUM HZB Helmholtz Zentrum Berlin HZDR KIT

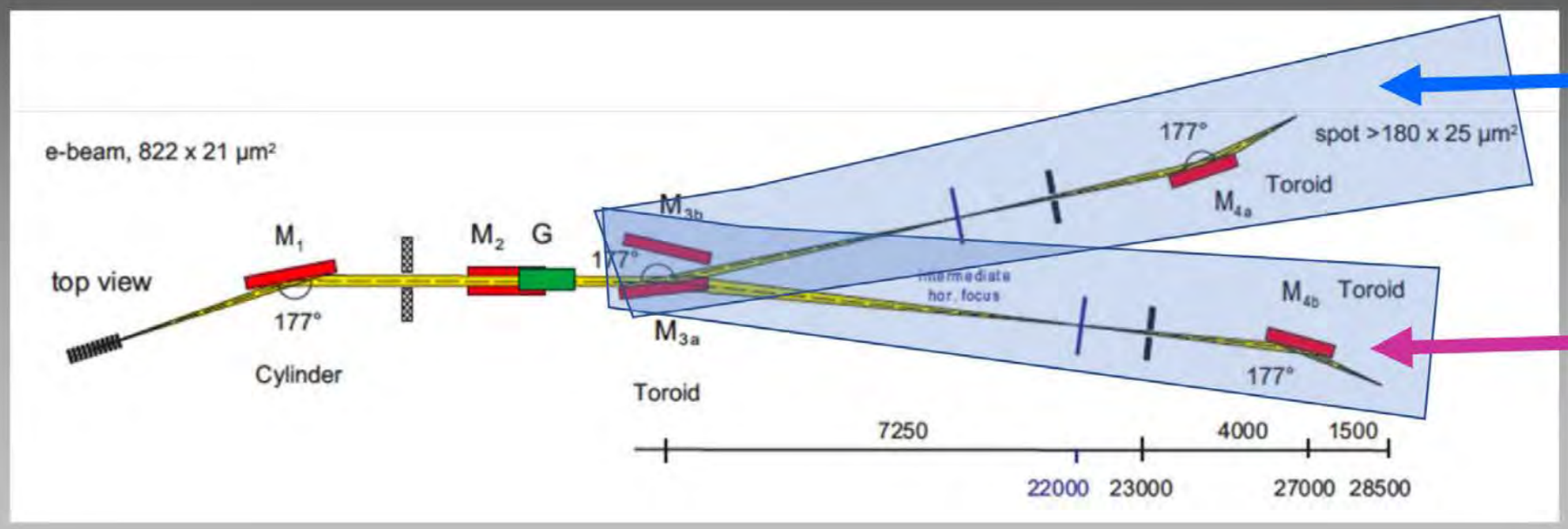
Beamline and front-end under construction
Delivery November 2021



New beamline initiatives, III

TXPES

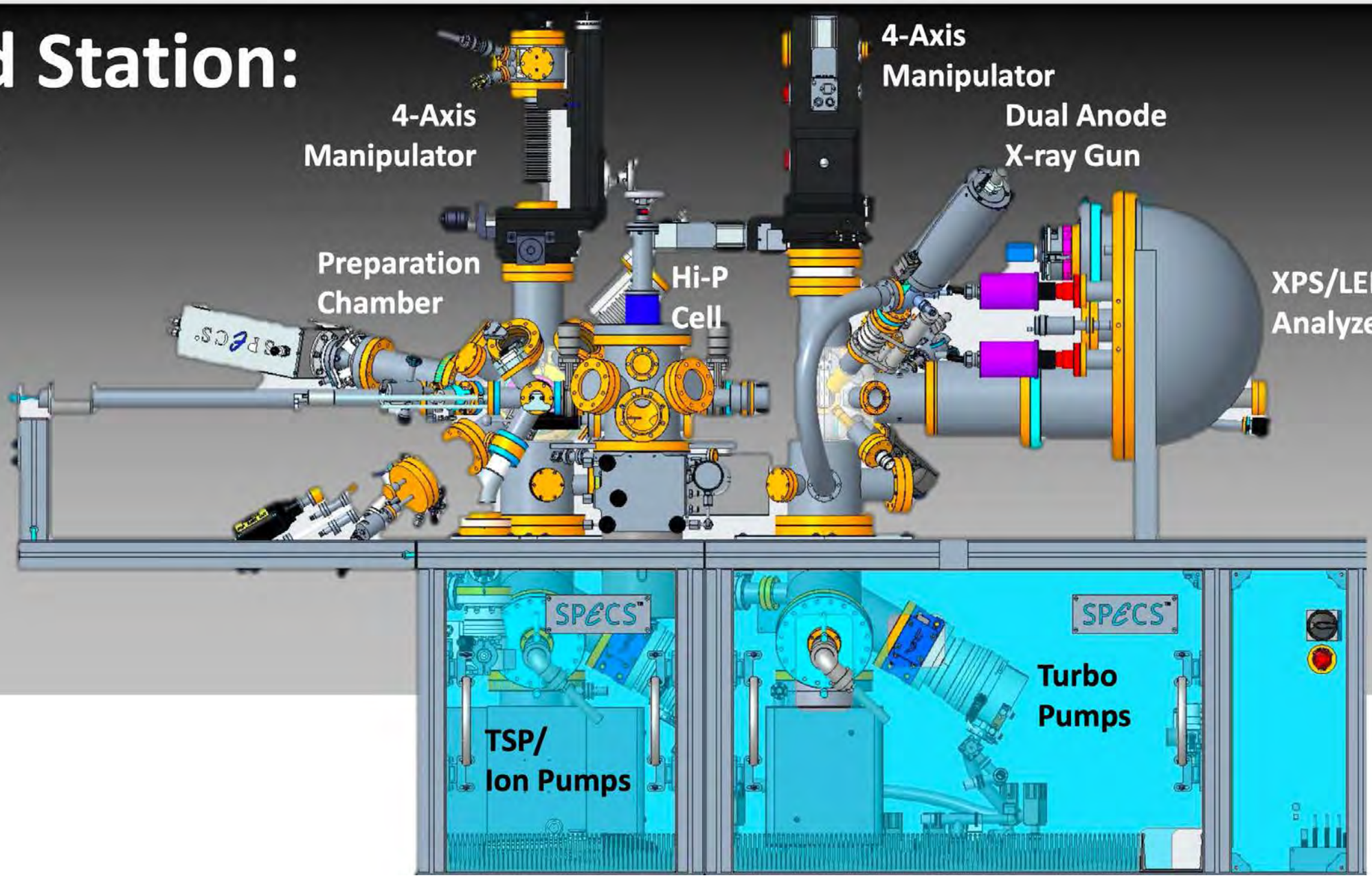
Complementarity of TXPES & HESEB Beamlines



HESEB Beamline

TXPES Beamline

TXPES End Station: Side View



TXPES

TENMAK

İhsan Doğramacı Bilkent University

TARLA
Turkish Accelerator and Radiation Laboratory in Ankara

KOÇ UNIVERSITY

MX beamline

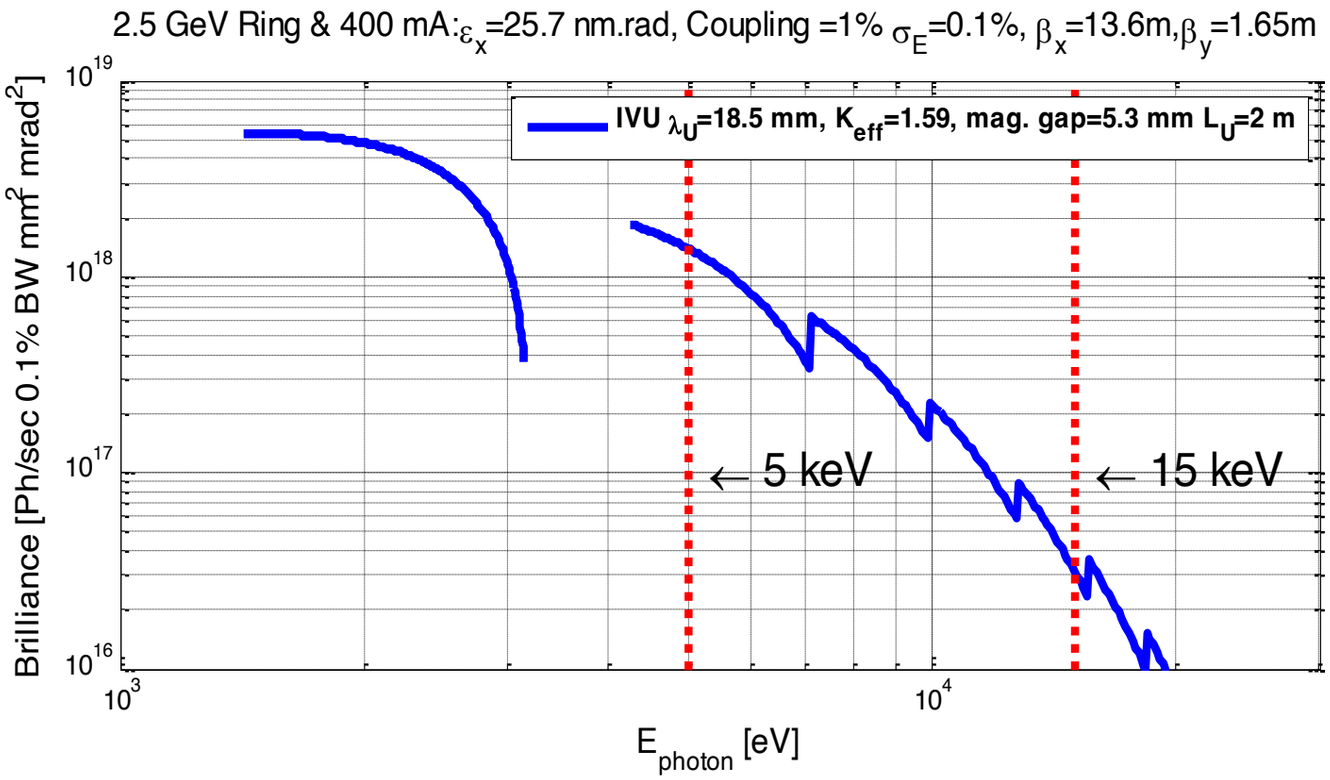
In-vacuum undulator

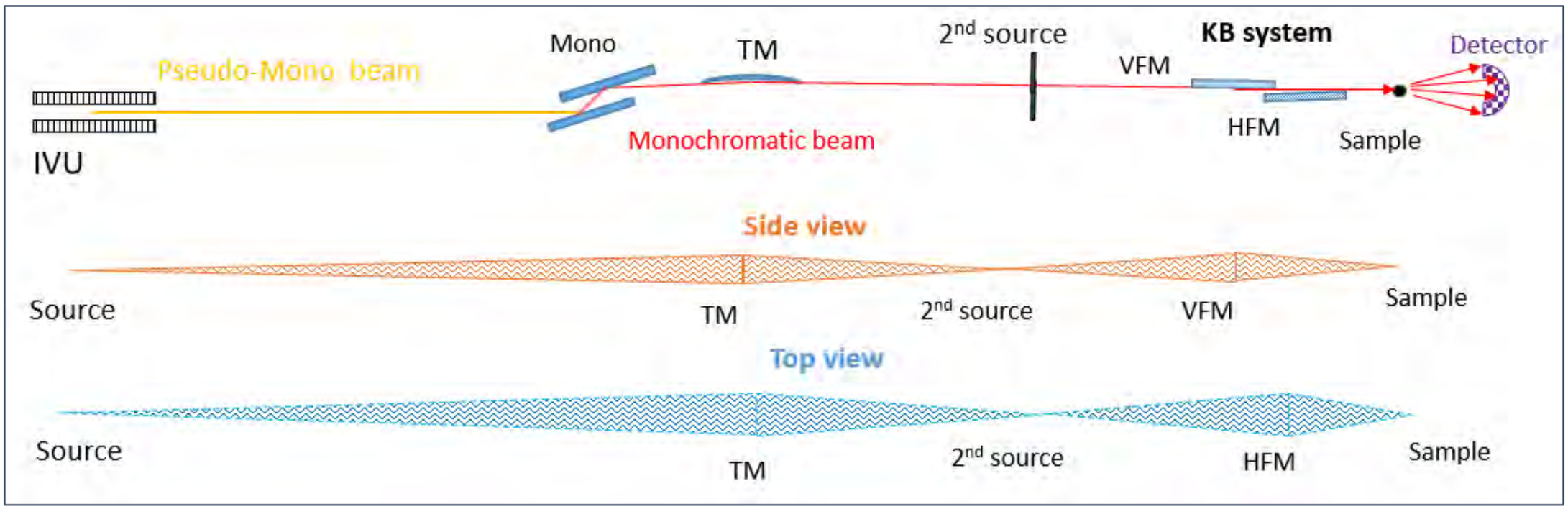
DCM

Toroidal mirror + KB system

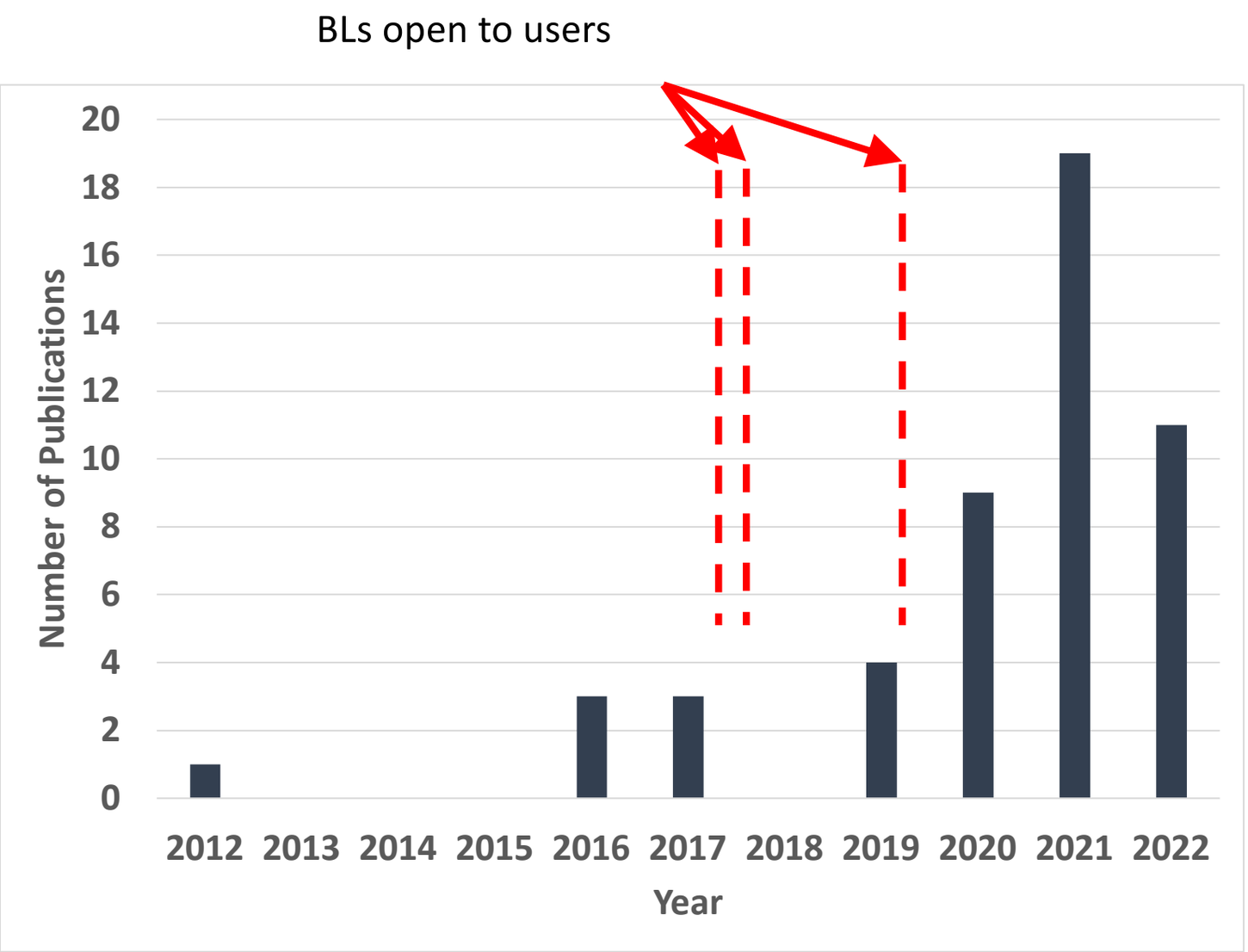
Automated Experimental Station

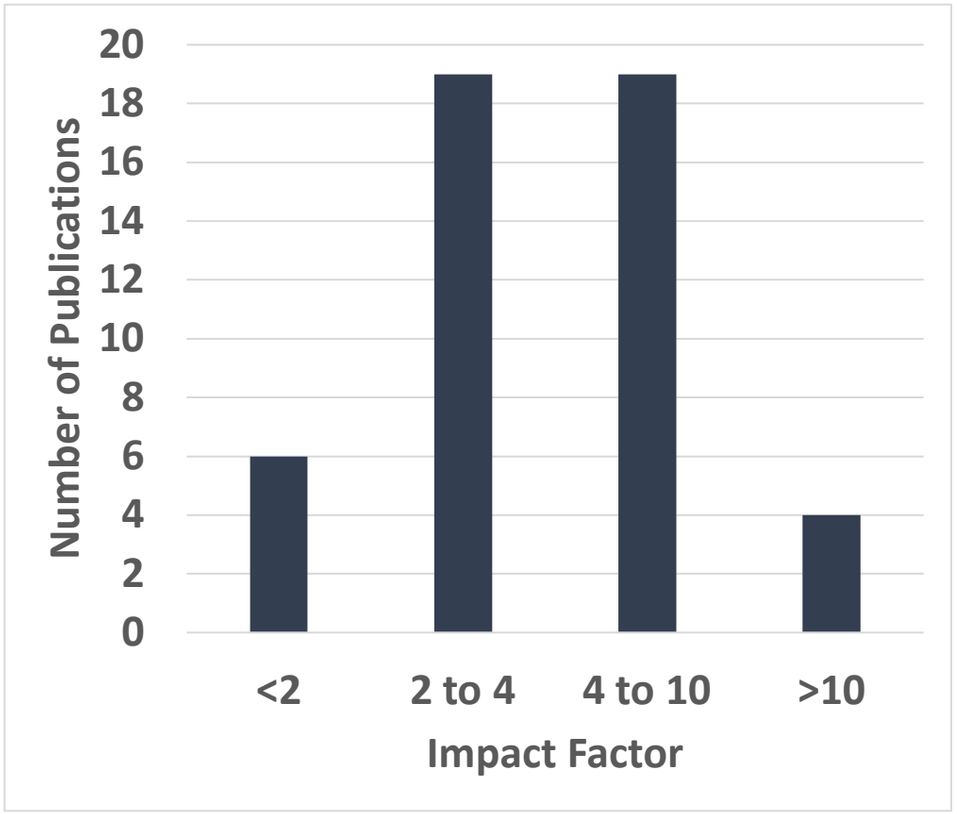
Large Detector





SESAME is continuing to grow with 151 requests for beamtime received in 2020 including all its Members. Scientific work has led to 50 peer-review publications with an average scientific impact factor of 4.4 and the work is typically published in the top 40% of journals in their respective fields.





In-progress at SESAME : Case Studies from Cyprus, Iran, Jordan, Palestine and Turkey

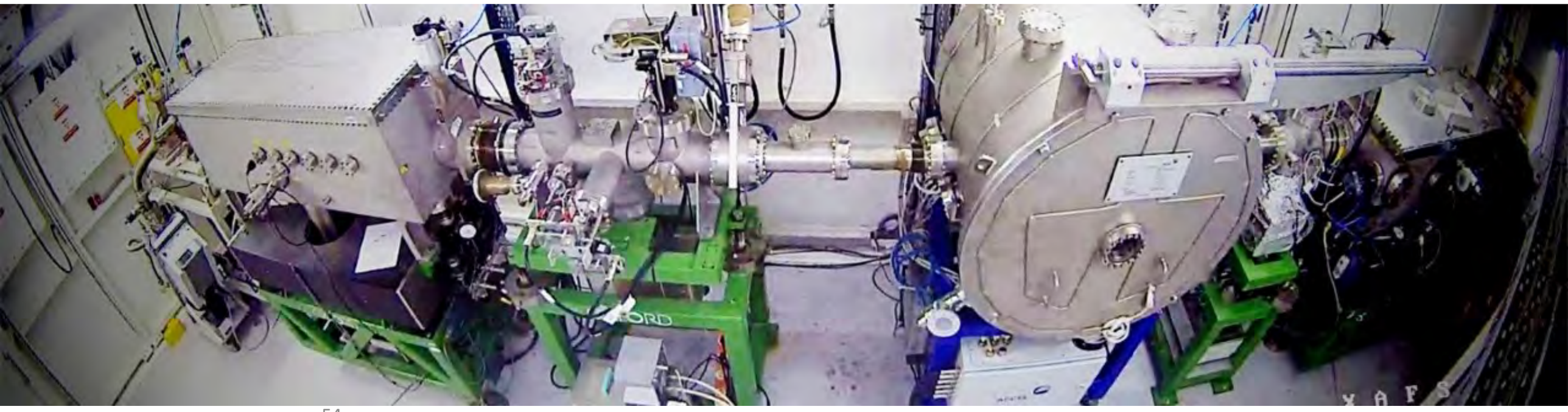
IR Micro-spectroscopy characterization of soil (ICTP Master students fellowship –West Bank, Palestine).

IR Micro-spectroscopy and Powder Diffraction investigation of novel materials that capture CO_2 from the surrounding environment.

IR determination of the presence of specific emerging pollutants in groundwaters.

IR and XAFS/XRF studies of heavy metal contamination, in soil and in cultivations.

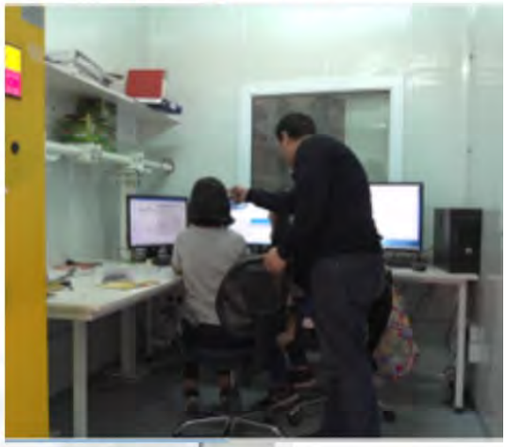
XAFS studies of oil shale ash contaminants.



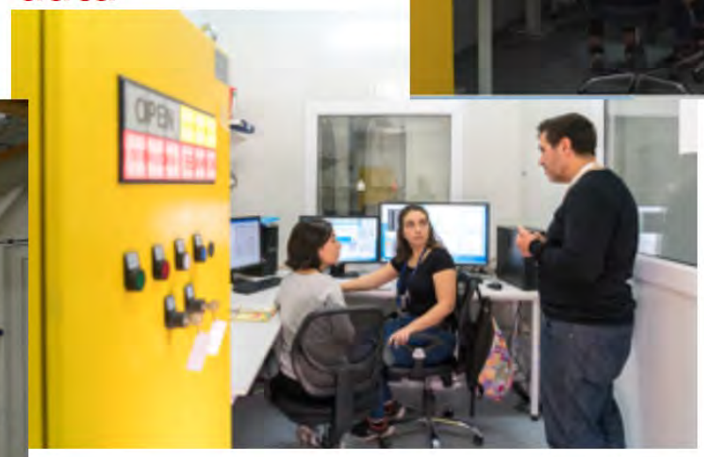
Step-by-Step Assistance to Users

- ➢ Most of the Users are new to the XAFS techniques
- ➢ Users Need Assistance in all the Experimental Process

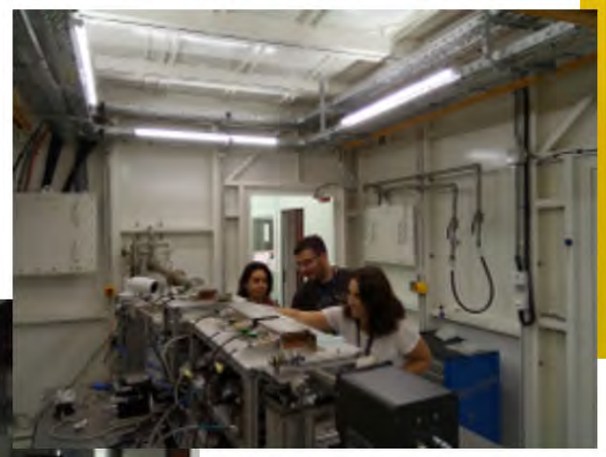
Analyzing data



Making plans & collecting good data



Mounting samples



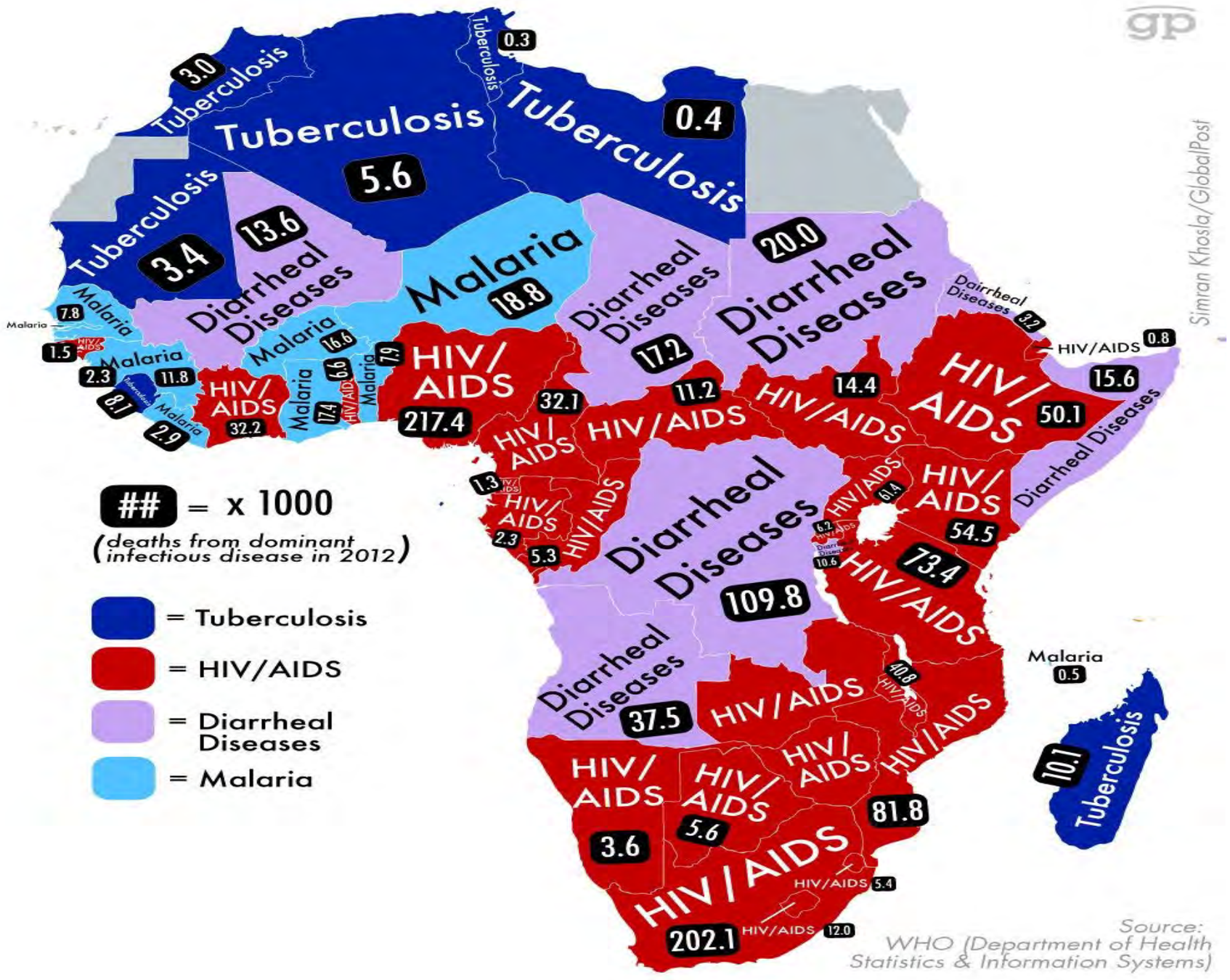
Preparing Samples

Collect less data but good √

Collect many and useless X

SESAME: Fubini Guest House

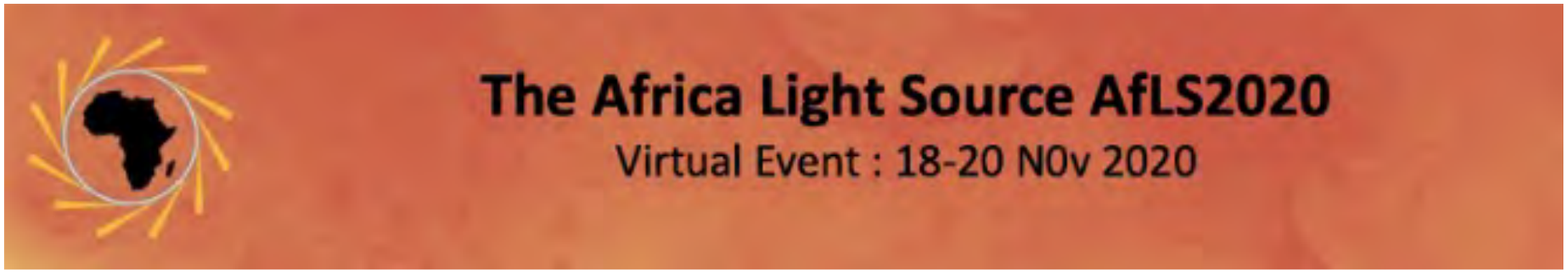
SESAME: a role model?



Towards an AfLS

African Light Source (AfLS) Foundation

On November 15, 2020 SESAME was the first light source to sign an MoU with AfLS.
The MoU was announced at the AfLS2020 Virtual Event.



The President of the Council of SESAME, Rolf Heuer, is a member of the International Advisory Committee of AfLS.

SESAME IR beamline principal scientist, Gihan Kamel, is a member of the AfLS Board of Trustees, a member of the AfLS Steering Executive Committee, and the deputy chair of the AfLS Strategy Committee. In addition, she is a co-convener of the Light Sources Group of the African Strategy for Fundamental and Applied Physics (ASFAP).

SESAME Scientific Director, Andrea Lausi, is a member of the Steering Committee of the LAAAMP project, partnering with IUPAP and IUCr to enhance Light Sources and crystallographic sciences in Africa, the Americas, Asia, Middle East and the Pacific.

Together with The Cyprus Institute and the IAEA, and with AfLS representatives from the University of Johannesburg, LAAMP and ESRF, SESAME is organising a School on Synchrotron Light Sources and their Applications, to be hosted online by ICTP in December 2021.

2019: thanks to EU support, SESAME became the World's FIRST large accelerator complex to be fully powered by renewable energy, and signed the UN’s Climate Neutral Now pledge

It takes a village to build a synchrotron source….

SESAME story is a special situation in history where a single facility received so much support from sister organizations and observer countries over an extended period.

High level cooperation ensures scientific output, high visibility and productivity.

Thank you!