FASEM 2026 for Energy Materials

ESRF, 16 March 2026

Jean Daillant, ESRF Director General

32 YEARS OF SCIENCE AT THE HEART OF A SCIENCE AND INNOVATION EUROPEAN CAMPUS

ESRF · NEUTRONS FOR SOCIETY · EMBL · iram · LNCMI · cea · cnrs · ibs · UGA Université Grenoble Alpes · GRENOBLE INP UGA · GRENOBLE ECOLE DE MANAGEMENT · GIANT INNOVATION CAMPUS

- **3 European research institutes, members of EIROforum** and the Institute for Structural Biology, at the heart of GIANT, the campus of Innovation (*Grenoble Innovation for Advanced New Technologies)*
- Common research and training platforms

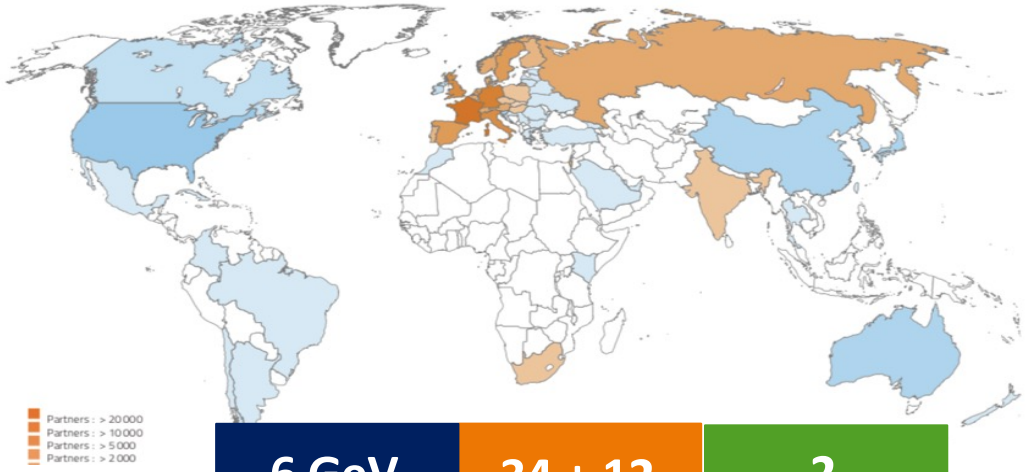
ESRF: AN INTERNATIONAL HUB TO PIONEER SCIENCE

19 PARTNER COUNTRIES

ESRF MISSIONS

- Bring nations together through science and advance knowledge
- Pioneer synchrotron technology to tackle global challenges
- Develop and operate state-of-the-art X-ray facilities and provide value to all partner countries
- Foster the use of x-rays for industry
- Train the next generations

FROM 2015 TO 2026
75 000 USER VISITS FROM 67 COUNTRIES
7 000 INDIVIDUAL LABS OR UNIVERSITIES



6 GeV Synchrotron

34 + 12 Beamlines (public + CRG)

2 CryoEMs

10 000 Scientific visitors each year

7 Nobel prizes to ESRF users

1600 Peer reviewed publications

11 ERC/EIC grants based on EBS

>300 Industrial clients

1994 - 2026: 32 YEARS OF SCIENCE, > 5 YEARS OF OPERATION WITH ESRF-EBS

Construction:1988-1994
Operation: 1994-2018

ESRF, the first 3rd-generation synchrotron: 11 European countries joining forces to open new vistas in synchrotron science

Upgrade Programme: 2009-2022

ESRF UPGRADE PROGRAMME (2009-2022) launched by the ESRF's 21 partner countries. UP PHASE-I delivered in 2015 on time and within the budget

Operation with ESRF-EBS: 25 AUGUST 2020

Delivery of **ESRF-Extremely Brilliant Source** (EBS), a game changer: the first of a new generation of high-brilliance X-ray sources

March 2026

32 years of operation
>5 years of operation of ESRF-EBS, a new kind of high-energy synchrotron

BRINGING NATIONS TOGETHER TO ENABLE SCIENTIFIC EXCELLENCE, INNOVATION AND TO ADDRESS GLOBAL CHALLENGES

A FACILITY IN HIGH DEMAND

PUBLIC BEAMTIME USER OPERATION AND STATISTICS

2 392
Submitted proposals in 2025
ESRF-EBS RECORD

1 018
Accepted proposals in 2025
ALL-TIME ESRF RECORD

16 770
Shifts delivered in 2024 (incl. Commercial beamtime)
ALL-TIME ESRF RECORD

1 257
Submitted proposals for 2026-I
(= 17 199 shifts)
NEW ESRF-EBS RECORD

USER VISITS & EXPERIMENTAL SESSIONS (2024)

2787
Experiment Sessions
ALL-TIME ESRF RECORD

~800
Commercial sessions

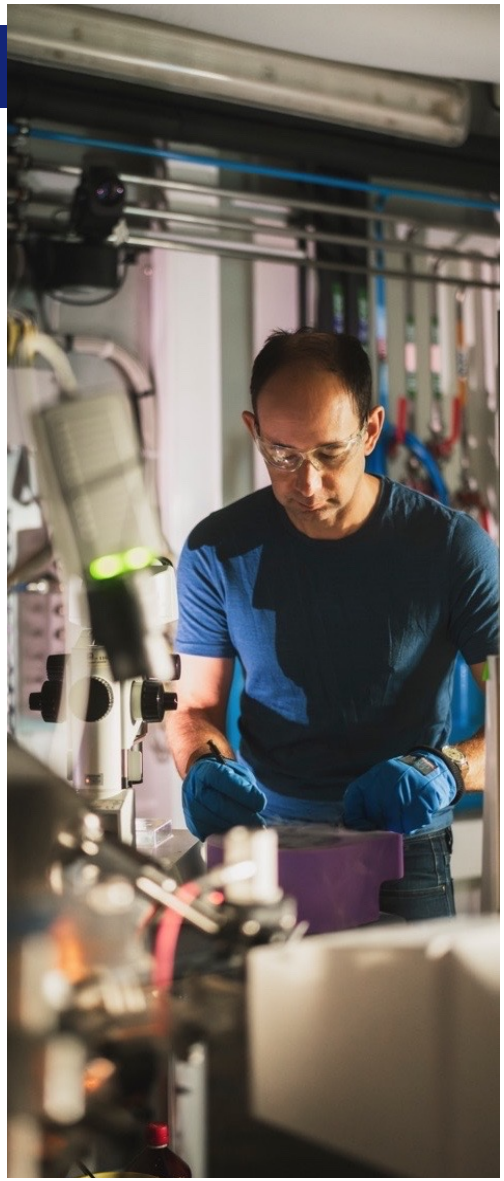
10432
User visits (34% remote)
ALL-TIME ESRF RECORD

7439
Public user visits
ALL-TIME ESRF RECORD

PUBLICATIONS

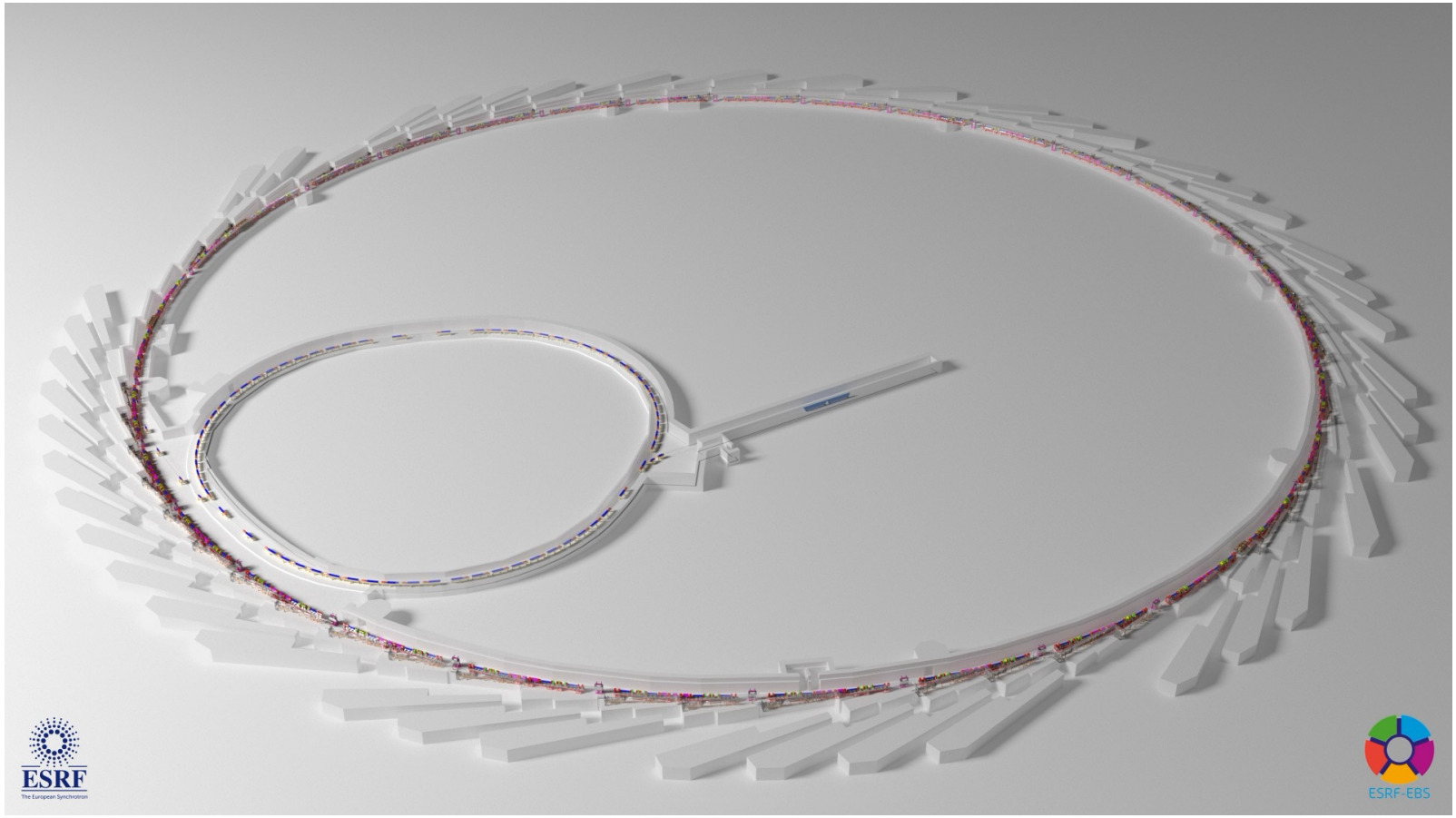
1600
Peer-reviewed publications in 2025 as of 09/01/2026
(40 % in journals with IF>7)

+300
Compared to 2021, 2022, 2023



SYNCHROTRON AND ESRF-EBS

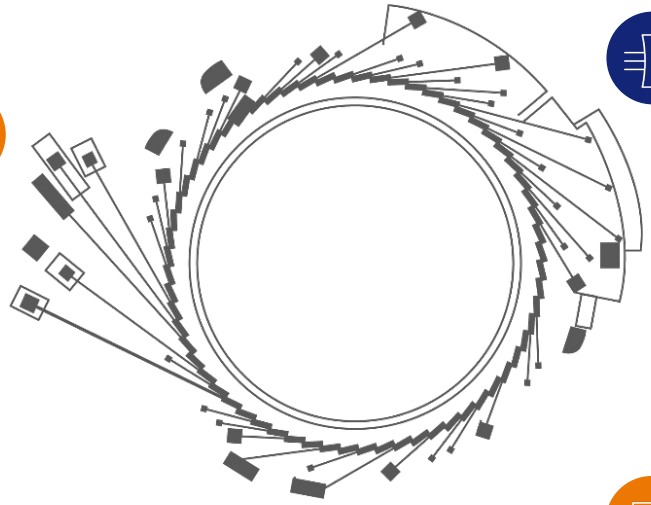
ESRF-EBS: HOW DOES IT WORK?



ESRF SYNCHROTRON TECHNIQUES

SCATTERING

- Small angle scattering
- Resonant X-ray scattering
- Inelastic scattering
- Powder diffraction
- Surface diffraction
- Protein crystallography



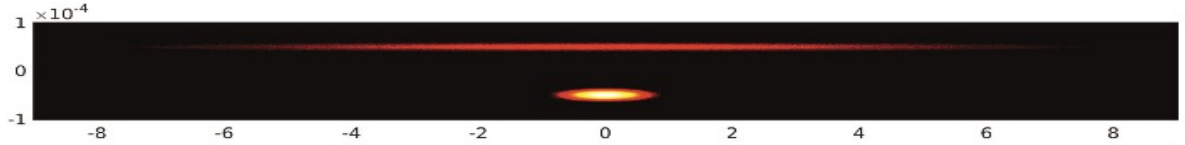
SPECTROSCOPY

- X-ray fluorescence
- X-ray absorption near-edge structure
- Extended X-ray absorption fine structure

IMAGING

- Nano/micro tomography
- Phase-contrast tomography
- Hierarchical tomography
- Laminography

ESRF-EBS LATTICE VS. PREVIOUS ESRF-DBA LATTICE: DBA → H7BA

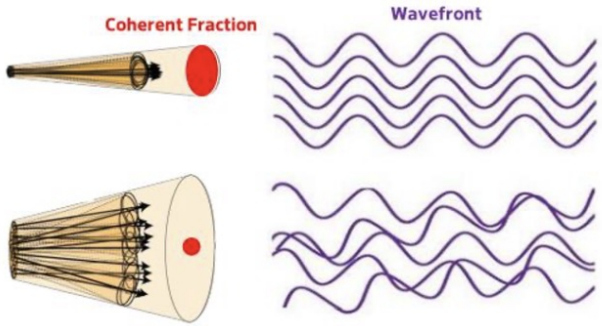


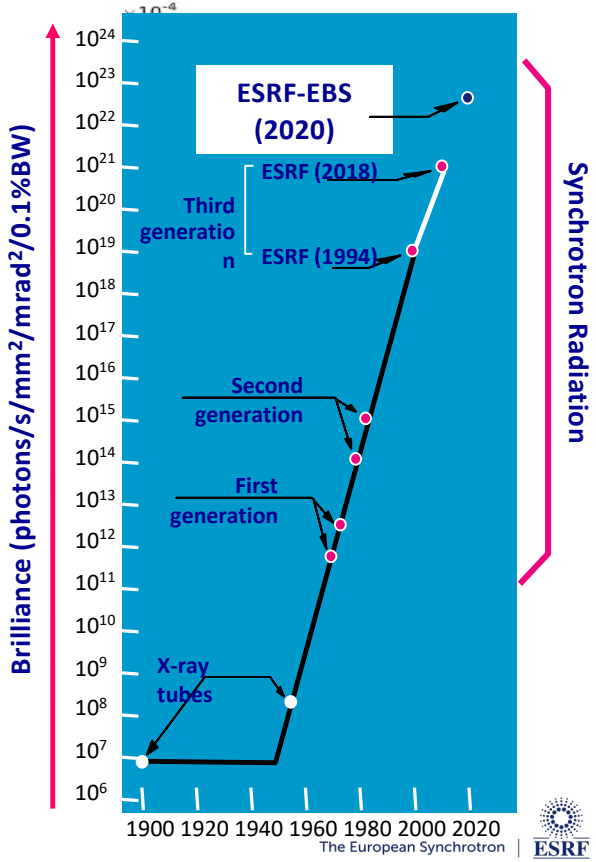
$$Brilliance = \frac{SpectralFlux}{4\pi^2\sigma_x\sigma'_x\sigma_y\sigma'_y} = \frac{SpectralFlux}{4\pi^2\epsilon_x\epsilon_y}\left[\frac{Photons/s}{mm^2mrad^20.1\%bandwidth}\right]$$

$$Emittance: \epsilon_{x,y} = \sigma_{x,y}\sigma'_{x,y}$$

$$Coherentfraction: f_{coh} = \frac{(\lambda/4\pi)^2}{\epsilon_x\epsilon_y}$$

$$\epsilon_x = C_L\frac{E^2}{N_d^2}$$

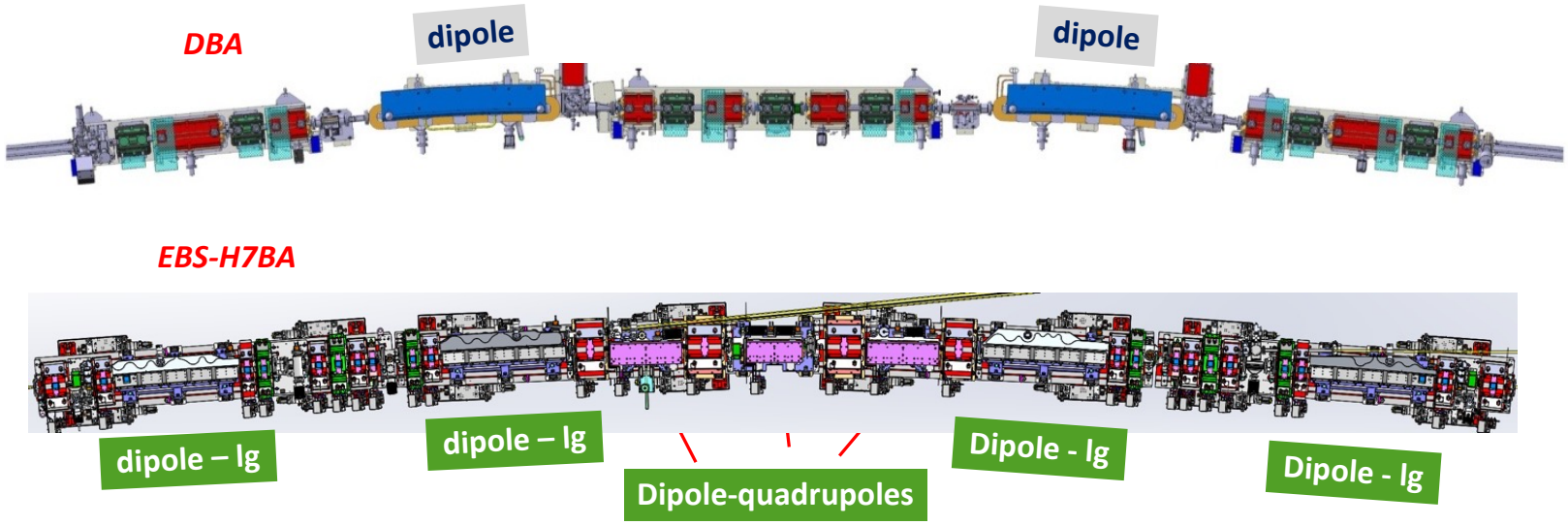




ESRF-EBS LATTICE VS. PREVIOUS ESRF-DBA LATTICE: DBA → H7BA

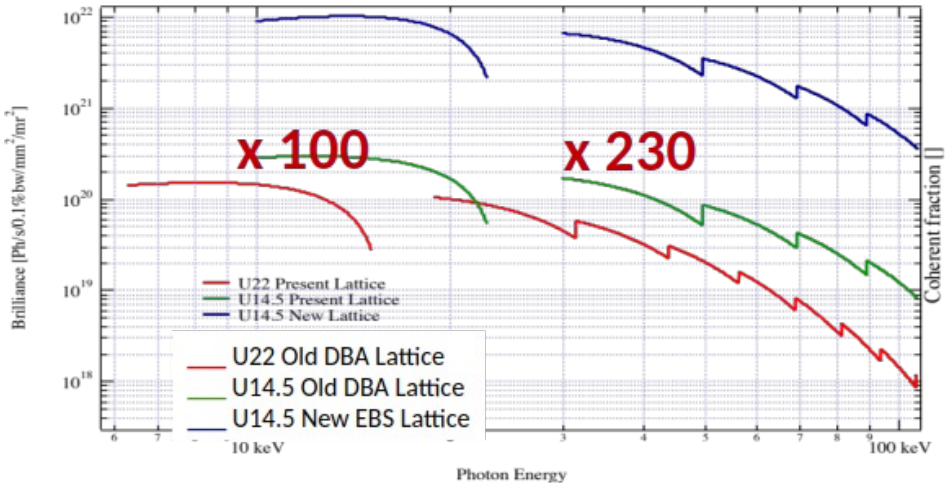
- **Previous ESRF lattice (cell)**
  Double Bend Achromat = **17 M** (2 dipoles + 8 quad. + 7 sext.) per cell
  ID length = 5 m (standard) / 6m / 7m
- **EBS lattice (cell)**
  Hybrid 7 Bend Achromat = **31 M** (4 dipoles-lg + 3 dipole-quad + 16 quad., 6 sext., 2 oct.)
  ID length = 5 m

31 magnets per cell instead of 17
32 cells (arcs) with 4 girders each
6 sextupoles instead of 7
Longer and weaker dipoles

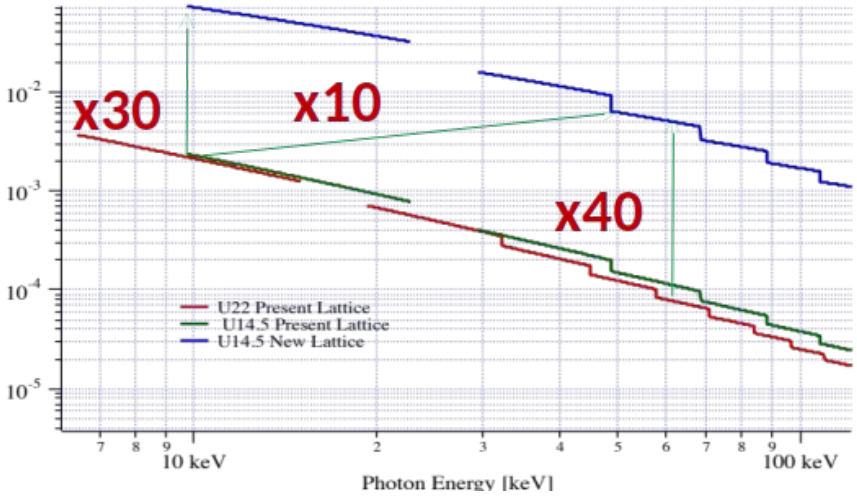


INCREASED BRILLANCE AND COHERENCE FLUX

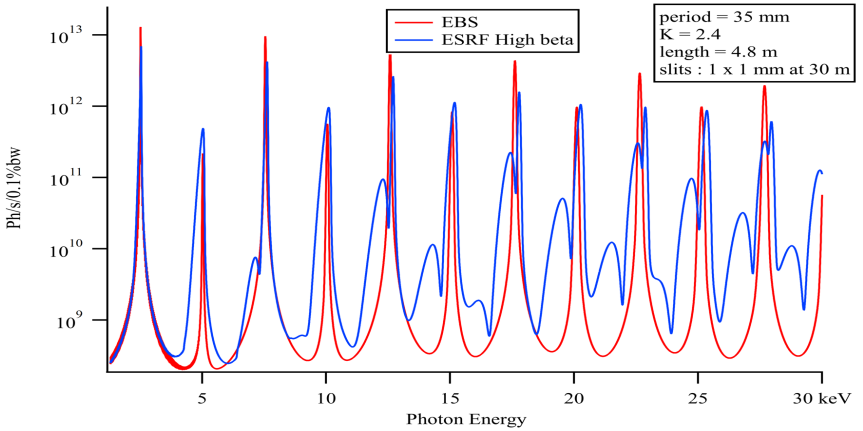
BRILLIANCE



COHERENT FLUX



SPECTRAL PURITY



NEW SCIENCE OPPORTUNITIES WITH EBS

ESRF-EBS: PUSHING THE FRONTIERS OF TECHNOLOGY TO ADVANCE SCIENCE

Spatial Resolution

- Nanotomography down to 30 nm (ID16A)
- 10 nm foreseen (ID18)
- 15+ beamlines with sub-µm resolution

Time Resolution

- 100 ps scattering & diffraction (ID01, ID09)
- 40 ps Nano-XEOL (ID16B)
- ns-µs dynamics (ID10, ID14, ID19, ID29)

Operando Science

- 20+ beamlines (catalysis, electrochemistry, biochemistry, mechanics, high pressure, magnetism, electronics)

High Throughput

- >1000 samples / 20min (ID31)

Multiscale Experiments

- Hierarchical multi-scale imaging for sub-µm to 2.5m @BM18

High Sensitivity

- ppb detection (ID16A/B, ID24)
- ~ 100 atoms in 40nm pixel – zg (ID16A).
- 10^{-5} dichroism (ID12)
- 10^{-6} strain (ID01)

Multi-Probe

- Powder diffraction + Fluo @ID22.
- XAS + mass spec, UV-Vis, Raman, FTIR @ID24, BM23

Extreme conditions

- T from 5 K to 5000K
- > 600 GPa (static)
- B = 17 T
- E = 1MV/cm

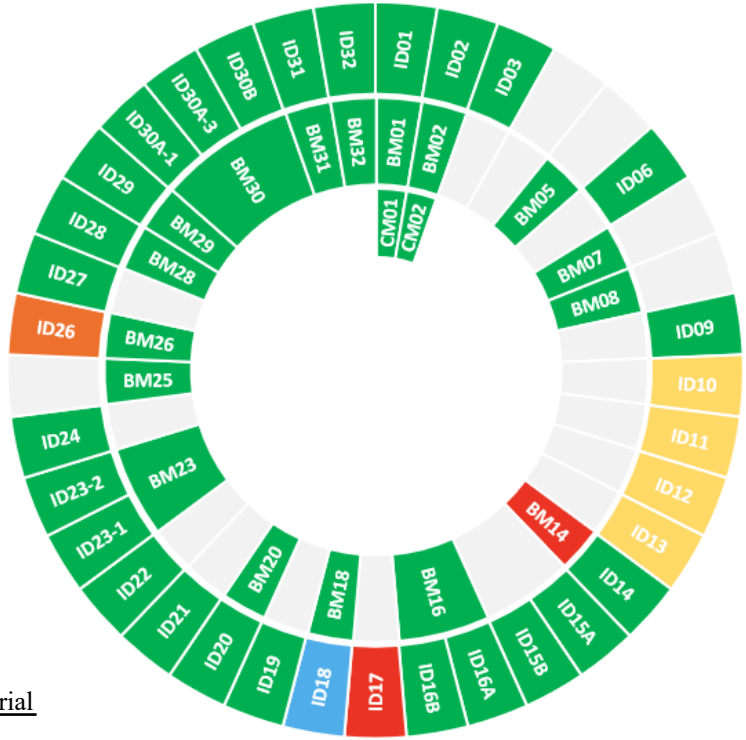
What EBS enables: Smaller – Faster – More sensitive – More realistic – More complex experiments

ESRF-EBS: PUSHING THE FRONTIERS OF TECHNOLOGY TO ADVANCE SCIENCE

SCIENTIFIC PROGRAMME

1. Health Innovation, and overcoming diseases
2. Materials of the future, circular economy, and sustainable industry
3. Clean energy transition and sustainable energy technologies
4. Geoscience; planetary research
5. Environmental research, climate challenges, and food safety
6. Human history and cultural heritage

https://www.esrf.fr/about/information-material



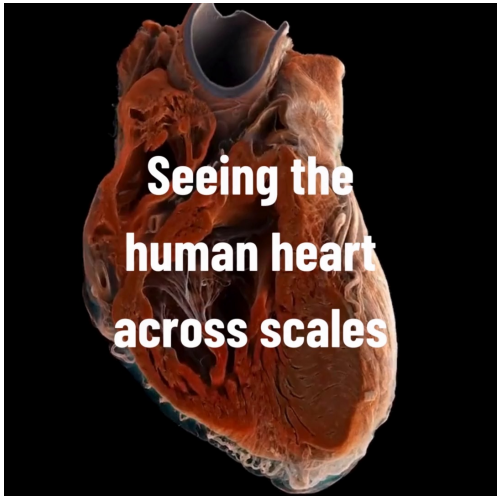
A renewed portfolio to advance science

4 new beamlines + 1 new under commissionning
Major beamline upgrades

5 YEARS OF ESRF-EBS: NEW SCIENCE

REVOLUTIONIZING BIOMEDICAL IMAGING

- **3D imaging of entire human organs down to the micron level, from full anatomy to individual cells**
- Bridge the imaging gap between radiology and pathology with an innovative technique, HiP-CT @BM18
- A breakthrough that led to the Human Organ Atlas, a global open-science atlas of healthy and diseased organs

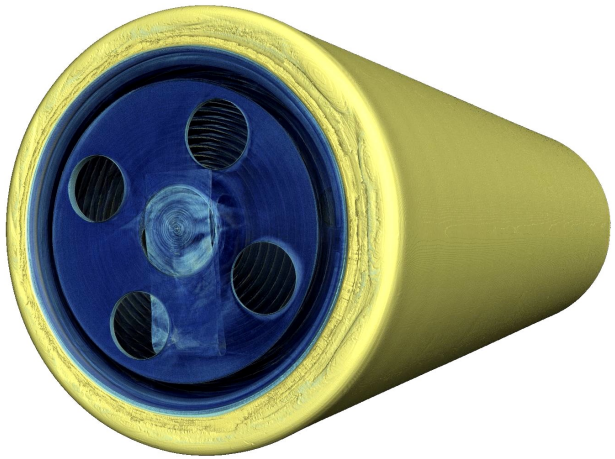


Multidimensional Analysis of the Adult Human Heart in Health and Disease Using Hierarchical Phase-Contrast Tomography, J. Brunet et al., *Radiology* (2024)

OBSERVING REAL DEVICES WORK

- **Structural, morphological, and chemical changes can be detected with unrivalled resolution and speed** across multiple length scales – from atoms to full devices – allowing processes to be observed **in real time, under true operating conditions.**

Tafforeau 2021 (ESRF)

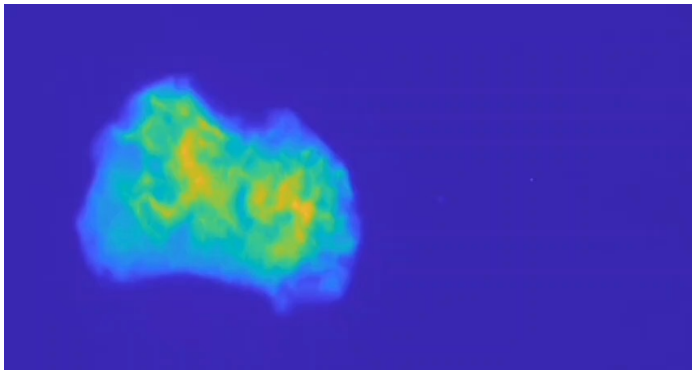


Quantifying Heterogeneous Degradation Pathways and Deformation fields in Solid-State Batteries, J.hu et al., Adv. Energy Mater. (2024)

5 YEARS OF ESRF-EBS: NEW SCIENCE

UNLOCKING MATERIALS AT THE NANOSCALE

- **Capturing the hidden nanoscale dynamics that governs material performance in real time, thanks to Pink beam DFXM @ID03**
- ~ 100 increase in incoming flux (10^{15} photons /s). 30-fold increase in diffracted intensity while maintaining a 100 nm spatial resolution.
- Gives access to timescales and details not accessible by any other technique.

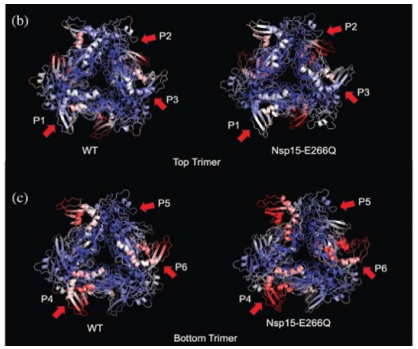


3D/4D imaging of complex and deformed microstructures with pink-beam dark field X-ray microscopy, C. Yildirim et al., Commun. Mater. 6, 198 (2025)

European Research Council
Established by the European Commission

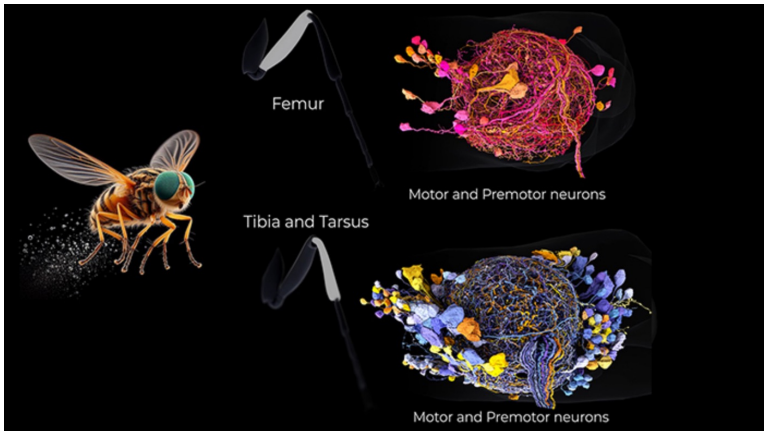
CAPTURING PROTEINS IN MOTION WITH SERIAL CRYSTALLOGRAPHY

- **New capabilities @ID29 for time-resolved studies of protein dynamics at room temperature**
- The recent JSBIG-developed SµX sample changer robot → a step towards high-throughput SµX at a synchrotron
- **Next step: a fully integrated drug discovery pipeline** with virtual screening, high-throughput crystallisation, automated crystal harvesting, and automated structure determination



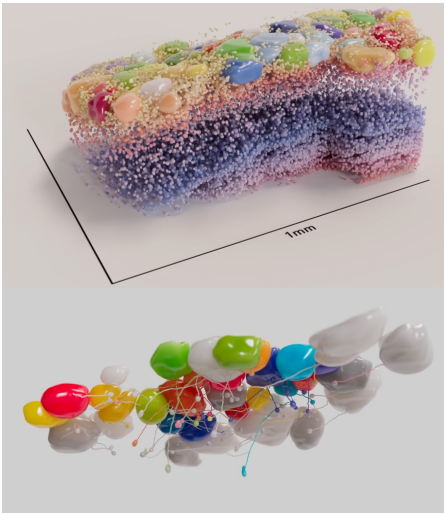
Functional implications of hexameric dynamics in SARS-CoV-2 Nsp15, M. Sonowal et al., Protein Sci. 34(6), e70115 (2025)

ID16A: NANOIMAGING BEAMLINE FOR LIFE SCIENCES AND BIOMEDICAL RESEARCH



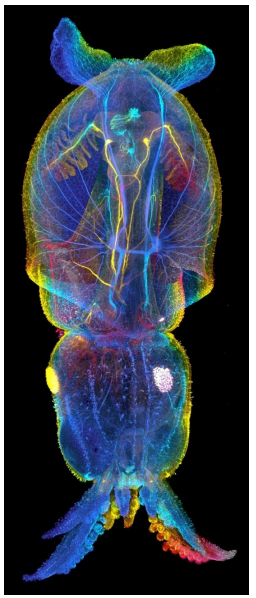
Neural networks controlling fly wing & leg movement

Azevedo et al. Nature 2024
Mamiya et al. Neuron 2023
U. Washington, Harvard Medical School



Structure-function mapping of mouse olfactory bulb circuits, combining functional and x-ray imaging.

Francis Crick Institute



Complete neural wiring in a squid

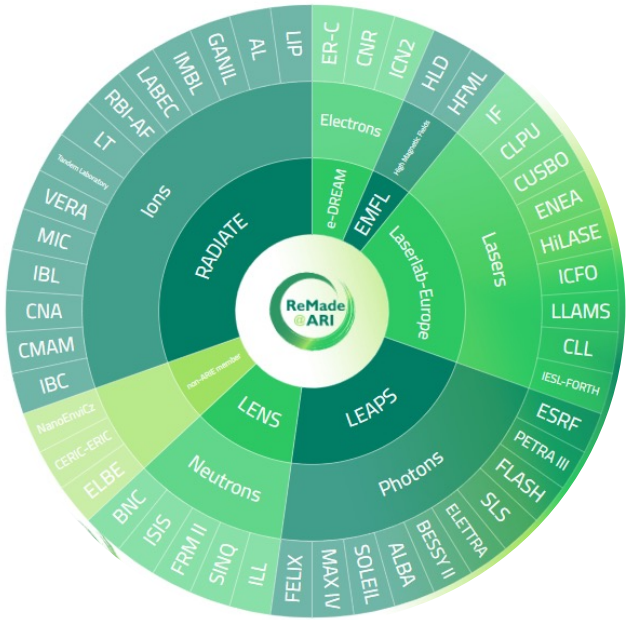
Cardona Lab , MRC Cambridge

➢ **New technique, X-ray Nano-Holotomography,** ~30nm isotropic resolution across large tissue volumes, imaging neuronal circuits 100x faster than traditional methods.

Challenge: Higher speed (300x), resolving power (10-20 nm voxel) & larger sample volume (at least 1 mm^3) with equal/better quality !

EBS SCIENCE TO CONTRIBUTE TO CIRCULAR ECONOMY

A EUROPEAN PROJECT FOR CIRCULAR ECONOMY (2022-2026) BASED on PHOTONS & NEUTRONS



Supporting research into circular materials by offering academic and industrial researchers transnational access to over 50 EU infrastructures

8 beamlines at the ESRF: ID01, BM05, ID11, ID13, ID15A, ID19, ID22, ID31

X-ray tomography, X-ray diffraction, X-ray imaging

ESRF
The European Synchrotron

ESRF DATA STRATEGY: TOWARDS A FULLY DATA-CENTRIC APPROACH

50 Petabytes
of data archived since 2015 at ESRF

1.5 PB
produced in a single experiment

ONGOING UPDATE OF THE DATA STRATEGY

More efficient tools for data processing and data analysis

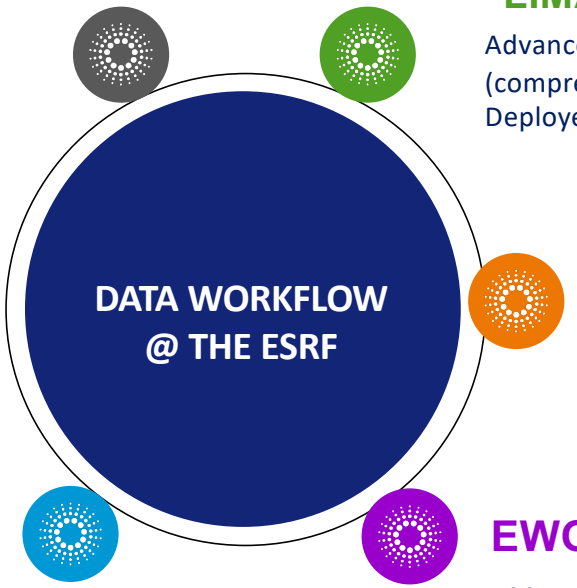
Development of metadata together with improved automation workflows and AI exploitation of data

Increased data FAIRness

eosc

panosc
photon and neutron open science cloud

SOFTWARE DEVELOPMENTS



BLISS
Beamline control – data collection.
Deployed at 40 beamlines.

LIMA2
Advanced features (compression, data triage).
Deployed at 3 beamlines.

DRAC
Advanced data catalog for Open Science for all techniques (including MX) based on ICAT metadata catalogue

e-LOGBOOK
Allows data integration in data catalog. Used at 25 beamlines.

VISA
Web platform for remote data analysis online and offline

EWOKS
Metaworkflow system deployed at 35 beamlines.

ESRF OPEN DATA PORTALS: ACCELERATING OPEN SCIENCE

Launch of a new open-access 3D Atlas of Human Organs announced in *Science Advances*

https://human-organ-atlas.esrf.eu/

- More than 8500 unique visitors and 1000+ downloads per day since 11 March (date of publication in *Science Advances*)
- A strong international press coverage

BBC SCIENCE FOCUS

This stunning 3D map lets anyone explore real human organs down to a single cell

EL PAÍS

INVESTIGACION CIENTIFICA >

Un nuevo atlas interactivo permite ver el cuerpo humano como nunca antes

Rai News

Dalle cellule agli organi e viceversa: è lo Human Organ Atlas, atlante online del corpo umano in 3d

Frankreich

"Google Earth des menschlichen Körpers": Neuer 3D-Atlas zeigt Organe und Zellen wie nie zuvor

TRAINING THE NEXT GENERATION

ACTIONS WITH SCHOOLS

Synchrotron@School,
A pedagogical programme towards high-schools -1 500 students/year
'Girls in Science' actions
Partnership with engineering schools - CentraleSupelec- and **universities** –UGA

ESRF-ILL INITIATIVES

HERCULES, a European school for "Neutron & Synchrotron Radiation Science" with lectures and practical work
ESRF-ILL International Undergraduate Student Summer Programme
(150 applications, 22 students)

PhD PROGRAMMES

Inhouse programme: ~30 PhD positions/year
COFUND EU programmes:

Around 1/3 of ESRF PhD/Postdoc go on to industry after being trained at the ESRF

NEXTSTEP from Sept.2025 (36 PhDs ESRF-ILL-eDREAM)

KEY MILESTONES IN 32 YEARS OF ESRF'S HISTORY

ESRF convention signed

First electron beam in the storage ring

First ESRF Highlights

1988 **1989** **1992** **1994** **1995**

First Users Meeting

User operations begin with 15 beamlines

First ESRF News magazine

Number of Beamlines: 40

Phase I Upgrade Programme (UP)

Nobel Prize in Chemistry for ESRF User: Brian Kobilka (G-protein–coupled receptors)

1996 **1998** **2009** **2012** **2015** **2017** **2018**

Number of beamlines: 44 (CM01)

SR current: 200mA; 4000 pmrad
B: 10^{20} ph/mm^2/mrad^2/0.1%bw

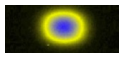
Nobel Prizes in Chemistry for ESRF Users: Ada Yonath Venkatraman Ramakrishnan (Ribosome)

The ESRF designs a revolutionary storage ring (H7BA Lattice)

Phase II UP: EBS project launched

20-month EBS shutdown

Restart User operations with EBS



Remote experiments

Number of Beamlines: 45

2020 **2021** **2024** **2025**

Horizontal emittance: 134 pmrad
B: 10^{22} ph/mm^2/mrad^2/0.1%bw
Coherent flux: x 30- x 40

Nobel Prizes **in Chemistry** for ESRF collaborators: David Baker & John Jumper (protein design)

Nobel Prize **in Chemistry** for ESRF collaborator Omar Yaghi (for metal-organic–frameworks)

Shaping the future of the ESRF Science & Innovation Programme 2026 - 2035


ESRF
The European Synchrotron
THANK YOU FOR YOUR ATTENTION