

Synchrotron Radiation Facilities

How to choose the right synchrotron for your experiment — and what Elettra 2.0 changes

G. Paolucci · Muggia School on Synchrotron Radiation · September 2026

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How should a young researcher choose a synchrotron?

The machine is important — but the decisive choice is usually the beamline and the experimental capability.

1 Start from the scientific question

2 Define the photons you need

3 Find the right beamline

- Technique: diffraction, spectroscopy, imaging, scattering, photoemission, tomography, etc.
- Photon requirements: energy range, flux, bandwidth, polarization, coherence.
- Sample requirements: size, environment, pressure/temperature, radiation sensitivity, in situ or operando conditions.
- Resolution and dynamics: spatial resolution, time resolution, detector speed.
- Practical factors: beamline maturity, user support, proposal access, remote measurements and sample logistics.

Do not ask: “Which synchrotron is the best?” Ask: “Which beamline can do my experiment best?”

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A good first proposal can be built in five questions

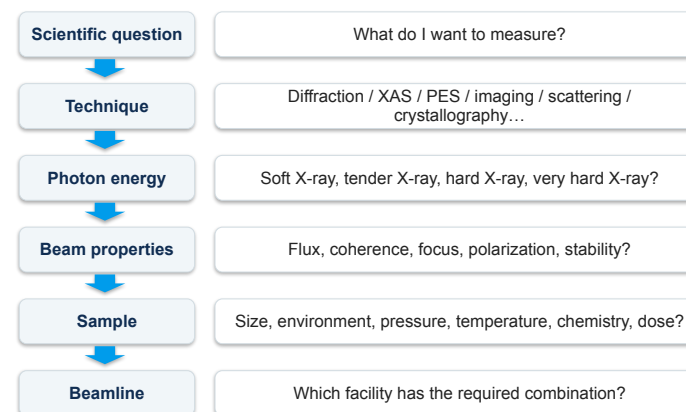
- 1** What is the scientific hypothesis?
- 2** What signal or structural information must be measured?
- 3** What photon energy / beam property is required?
- 4** What sample and environment are required?
- 5** Which beamline has the complete experimental chain?

The best facility choice is an experimental match, not a league table.

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A practical decision tree



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Match the experiment to the source properties

If you need...	Look first at...	Typical examples
Very hard X-rays	electron energy + high-field source	ESRF, PETRA III/IV, Elettra 2.0 superbends
Nano / coherent imaging	low emittance + coherent fraction + long beamline	Sirius, MAX IV, Elettra 2.0
Soft X-ray spectroscopy / ARPES	undulator energy range + polarization + resolution	MAX IV, SOLEIL, Elettra
Macromolecular crystallography	flux + focus + fast detector + sample automation	ESRF, PETRA, Sirius, Elettra 2.0
Fast / operando experiments	flux + detector speed + sample environment	Many facilities; compare beamline, not ring
Ultrafast dynamics	timing structure / pump-probe capability / FEL	FERMI and suitable storage-ring beamlines

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The major facilities are complementary, not interchangeable

ESRF-EBS 6 GeV · very high-energy X-rays large international portfolio	PETRA III / IV 6 GeV · hard-X-ray strength large-scale instruments	MAX IV 3 GeV + 1.5 GeV rings hard + soft X-rays
Sirius 3 GeV · SBA coherence / nano / advanced imaging	SOLEIL / SOLEIL II 2.75 GeV · broad soft-to-hard programme 4G upgrade	Elettra 2.0 2.4 GeV · 212 pm-rad coherence + broad user programme

- No box is a ranking: the relevant question is which beamline satisfies the experimental requirements.
- The same technique can be available at several facilities, but with different photon energy, coherence, sample environments, detectors and access models.

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How to compare two candidate beamlines

- 1 Photon energy: is the absorption edge / scattering geometry accessible?
- 2 Flux and brilliance: will the signal be strong enough?
- 3 Coherence: is phase information or coherent imaging required?
- 4 Focus: what beam size is really needed?
- 5 Detector: speed, dynamic range and energy resolution?
- 6 Sample environment: can it reproduce the real experiment?
- 7 Access and support: proposal timing, sample handling, remote options, local expertise?

Then talk to the beamline scientist. A short discussion can save months of preparing the wrong experiment.

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Where does Elettra 2.0 fit?

- 2.4 GeV storage ring with 212 pm-rad design emittance: a low-emittance source aimed at high brilliance and coherence.
- Particularly relevant when the experiment benefits from small beams, coherent illumination, advanced spectroscopy or fast measurements.
- Superbends extend the hard-X-ray range; in-vacuum undulators and EPUs provide specialised photon beams.
- The beamline portfolio spans materials science, spectroscopy, imaging, crystallography, coherent methods and life-science applications.
- Elettra 2.0 should therefore be considered alongside ESRF, PETRA, MAX IV, Sirius and SOLEIL — according to the experiment, not as a generic “best source”.

For a young researcher: start with the experiment → identify the beamline → check the source → discuss the proposal.

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What is a synchrotron light source?

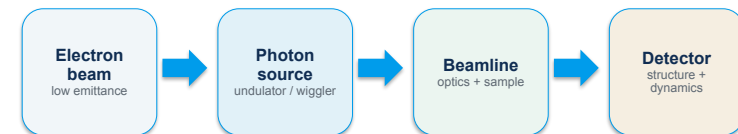
- Electrons are accelerated to relativistic energies and stored in a ring.
- Their trajectory is bent by magnetic fields; the acceleration produces synchrotron radiation.
- Beamlines select, condition and focus the photons for a specific experiment.
- The facility is therefore a combination of accelerator, photon sources, beamlines, detectors and scientific support.

electron beam → insertion device / bending magnet → optics → sample → detector

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Why storage rings are such powerful microscopes



The central accelerator quantity is emittance: smaller electron phase-space area → smaller, better collimated photon source.

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From first-generation rings to diffraction-limited storage rings

Third Generation sources

old (<1995)

HIS (>5 GeV) machines built for applications with hard x-rays (1<2Å)

medium energy rings optimized for soft (1~2 nm)

In early years of this century, 3 GeV rings were developed so that 1Å can be reached with undulators

More recently, multi-bend achromat rings allow higher brilliance as well as higher coherence

• First/second generation: high-energy physics rings adapted or purpose-built for photon production.

• Third generation: dedicated low-emittance storage rings with optimized insertion devices.

• Fourth generation (DLSR): multi-bend achromats reduce horizontal emittance by 1–2 orders of magnitude.

• The scientific payoff is not only brightness: coherence, nano-focusing and photon economy become central.

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The emittance (electron beam size * Electron beam divergence) is the key parameter



For Elettra 2.0: 212 pm-rad at 2.4 GeV

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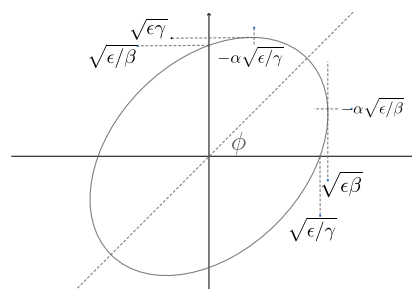
Emittance

$$\epsilon_x = \gamma x^2 + 2\alpha x x' + \beta x'^2$$

For a storage ring

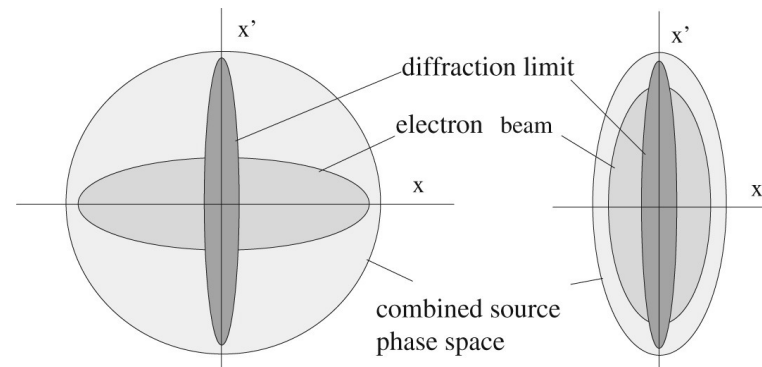
$$\epsilon_x = F \frac{\gamma^2}{J_x N_d^3}$$

Number of Dipole magnets



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Matching of the electron beam emittance to the diffraction limited emittance to gain maximum photon beam brightness



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What the MBA/DLSR transition changes

More photons where they matter

- higher brilliance and photon density
- smaller beam sizes and divergence
- shorter acquisition times
- access to photon-hungry experiments

More coherent light

- ptychography and CDI
- phase-contrast imaging
- XPCS and coherent scattering
- nano-spectroscopy and nano-ARPES

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Five reference facilities at a glance

Indicative machine parameters; emittance definitions can differ between sources.

Facility	Energy	Circumference	Emittance	Generation / role
ESRF-EBS	6 GeV	844 m	133 pm natural	4G high-energy X-rays
MAX IV	3 / 1.5 GeV	528 / 96 m	~500 / — pm	4G hard + soft X-rays
Sirius	3 GeV	518 m	250 pm bare lattice	4G, SBA
PETRA III	6 GeV	2304 m	1.3 nm H	3G high-energy hard X-rays
SOLEIL / II	2.75 GeV	354 m	~3.9 nm → 50 pm	3G → 4G upgrade

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ESRF-EBS: the high-energy reference

- Extremely Brilliant Source (EBS) uses a multi-bend achromat lattice.
- ESRF reports performance gains of about two orders of magnitude in brilliance/coherence compared with the previous ring.
- The upgrade illustrates how new accelerator optics can transform existing experimental programmes—not just add a few new techniques.

Lesson for Elettra 2.0: the ring upgrade and the beamline upgrade must be designed as one scientific programme.

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Diamond-II: another national facility in transition

- Diamond-II is designed around Double Triple Bend Achromats (DTBAs).
- Target: substantially higher brightness and coherence, with additional insertion-device opportunities.
- Construction and pre-series component assembly are underway; the planned dark period begins at the end of 2027.
- The project couples machine, beamline, data/computation and infrastructure upgrades.

A modern light source is increasingly a data and instrumentation infrastructure—not only an accelerator.

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Upgrade projects

- ESRF-EBS established the fourth-generation concept at high energy.
- Diamond-II is preparing a major next-generation upgrade in the UK.
- Sirius demonstrates what a purpose-built Brazilian fourth-generation facility can deliver.
- Many other national laboratories are upgrading existing rings rather than building completely new tunnels.
- Elettra 2.0 belongs to this same global transition—but with a particularly compact, reuse-the-existing-infrastructure strategy.

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Synchrotron facilities upgrade timeplan

Main facilities worldwide moving towards the 4th generation technology

<2025	2025	2026	2027	2029	2030	2032
 ESRF-EBS - France	 SLS 2.0 - Switzerland	 HEPS - China	 Elettra 2.0	 DLS - UK	 SOLEIL II - France	 Petra IV - Germany
 SIR - LNL S - Trieste	 APS - USA			 ALS-U - Advanced Light Source	 Bessy III - Germany	 ALBA SINCROTRONE - Torino
 MAX IV - Uppsala	 NanoTerasu - Japan			 Spring-8 II - Japan		 NLS-II - USA

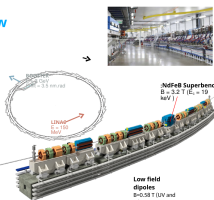
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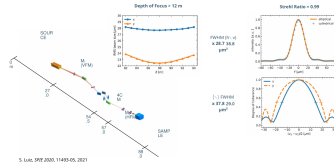
Sirius: fourth-generation performance at CNPEM

Sirius Overview

Storage Ring design parameters	
Beam energy	2.8 GeV
Circumference	518 m
Lattice	2D x SBA
Current, top-up	100 (100 nA, 100 nA)
Bunch length	8 ps
Energy spread	0.09 %
RF frequency	100 MHz
Hor. emittance (beam x 100)	250 x 150 μm^2
Vertical emittance (beam x 100)	25 x 15 μm^2
Straight section length (m)	1.5 m / 1.4 m



CATERET - SRW



Sirius shows how coherence can enable nanoscale imaging and ptychography/CDI.

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What users actually gain

Sensitivity

detect weaker signals / smaller concentrations

Speed

collect the same information faster

Spatial resolution

focus to smaller dimensions

Coherence

measure phase, correlations and nanoscale structure

Energy range

reach new absorption edges and high-energy imaging

Flexibility

more techniques and more demanding sample environments

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Main scientific application families

Structural & materials science

- diffraction and total scattering
- surface and interface spectroscopy
- XAS / XANES / EXAFS
- nano- and micro-beam methods

Life & imaging

- macromolecular crystallography
- tomography and phase contrast
- fluorescence imaging
- medical and biological imaging

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Coherence changes the imaging paradigm

- Conventional absorption contrast measures how much X-ray intensity is lost.
- Phase-sensitive methods exploit the wave nature of the beam.
- High coherent fraction makes ptychography and coherent diffraction imaging practical at much higher performance.
- For tomography, coherence can improve contrast while preserving high spatial resolution.

Brightness →
more signal
Coherence →
new information

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Synchrotron sources and FELs are complementary

Storage ring

- high average flux
- many beamlines and techniques
- excellent stability
- broad user community

FERMI / seeded FEL

- ultrashort pulses
- high peak brightness
- longitudinal coherence
- time-resolved dynamics in the VUV–soft-X-ray range

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Why this is an engineering challenge

- Same ring circumference: 259.2 m.
- Same building and tunnel.
- Preserve the injection scheme and the positions of existing insertion-device beamlines.
- Fit a much denser magnet lattice into essentially the same footprint.
- Minimise the dark period while upgrading vacuum, RF, power supplies, diagnostics and beamlines.

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ESRF-EBS: the high-energy fourth-generation benchmark

- 6 GeV storage ring with 844 m circumference and 32 cells.
- The EBS lattice uses seven bending magnets per arc, replacing the previous two-bend structure.
- Natural horizontal emittance is 133 pm-rad; operational emittance is about 110 pm horizontally and 5 pm vertically.
- About 90% of the existing infrastructure was reused, while energy consumption was reduced by about 30%.
- Scientific strength: high-energy X-rays, nanofocusing, coherent imaging and demanding materials/structural studies.

ESRF-EBS shows that a major fourth-generation upgrade can transform an established high-energy facility without rebuilding the whole site.

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MAX IV: two rings, two photon-energy regimes

- The facility combines a 3 GeV storage ring (528 m) for hard X-rays with a 1.5 GeV ring (96 m) for soft X-rays and UV.
- The 3 GeV ring is a landmark multi-bend-achromat design and was conceived from the start as a low-emittance source.
- A full-energy 3 GeV linac injects both rings and also serves the Short Pulse Facility.
- The two-ring strategy provides complementary photon-energy coverage within one accelerator complex.
- MAX IV is therefore an instructive comparison with Elettra: compact DLSR technology can be combined with dedicated rings rather than one universal ring.

MAX IV = one site, two storage-ring energy scales

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Sirius: a purpose-built 4G source

- 3 GeV storage ring with 518 m circumference and a bare-lattice emittance of about 250 pm-rad.
- Twenty 5-bend achromat (5BA) cells provide 20 straight sections, 17 of them for insertion devices.
- The central dipole in each 5BA is a permanent-magnet superbend reaching about 3.2 T.
- The design is optimized for hard X-rays while preserving a high coherent fraction.
- Sirius is a useful comparison with Elettra 2.0 because both use strong multi-bend optics and compact superbend concepts, but in different lattice implementations.

Sirius: 5BA + superbends + dedicated 4G infrastructure

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PETRA III: the hard-X-ray specialist

- 6 GeV storage ring with a 2.304 km circumference.
- PETRA was originally a particle-physics collider; PETRA III was created by rebuilding one-eighth of the ring with optimized insertion-device sections.
- PETRA III provides very high-brilliance hard X-rays, especially valuable for tiny samples, nanocrystals and high-energy diffraction.
- DESY currently operates 25 beamlines with almost 60 instruments at PETRA III.
- The planned PETRA IV project will move this high-energy source into the fourth-generation regime.

PETRA III illustrates the power of high energy + very long circumference; Elettra 2.0 takes a very different compact-ring route.

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SOLEIL II: a very close European comparison

- SOLEIL operates at 2.75 GeV in a 354 m ring—very close in energy and scale to Elettra.
- SOLEIL II replaces the present storage ring while preserving the existing infrastructure and beamline extraction geometry.
- The upgrade targets a 50 pm-rad round-beam emittance using an atypical 7BA–4BA lattice.
- About 100× coherent-flux gain is targeted, with 29 beamlines and three laboratories upgraded.
- Construction is underway; current planning targets commissioning in the early 2030s.

SOLEIL II and Elettra 2.0 are especially useful to compare: similar ring scale, different lattice and project choices.

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What these facilities teach us

- ESRF-EBS: high-energy fourth-generation performance can be achieved through a deep rebuild of an established ring.
- MAX IV: different electron energies can be optimized for different photon-energy communities.
- Sirius: a purpose-built 4G machine can integrate multi-bend optics and superbends from the start.
- PETRA III: very high energy and a large circumference remain powerful for hard-X-ray science.
- SOLEIL II: an upgrade at Elettra-like energy and scale can pursue a fourth-generation source while preserving much of the existing site.
- Elettra 2.0 sits in this international landscape as a compact, high-performance 2.4 GeV DLSR upgrade.

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ELETTRA 2.0

A new fourth-generation synchrotron source for the next decades

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The strategic question for Elettra

Why replace a successful machine?

- The present Elettra ring has been a highly productive third-generation source for more than three decades.
- Modern experiments increasingly require smaller beams, higher coherent fraction, higher photon density and faster detectors.
- These demands cannot be met indefinitely by incremental beamline improvements alone.
- Elettra 2.0 therefore replaces the storage ring while reusing the tunnel, building, injection complex and much of the existing beamline geography.

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Elettra 2.0 in one slide

2.4 GeV

212 pm-rad

259.2 m

up to 32 beamlines

- 12-fold symmetric S6BA-E lattice
- Horizontal emittance reduced by roughly 1–2 orders of magnitude, depending on the comparison basis
- Brilliance and coherent fraction increase by more than two orders of magnitude in the design case
- Two 6 T superconducting superbends extend high-energy X-ray capabilities
- User operation begins progressively from 2027

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Project history: 2012 → 2029



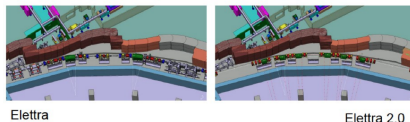
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The lattice: S6BA-E

Elettra 2.0 Lattice

Exploiting multi-bend technology to approach the theoretical brightness limit - the third European upgrade project. Going from the Elettra double bend achromat lattice (left) to the Elettra 2.0 symmetric six-bend enhanced achromat lattice (right).



- 12 identical achromats provide a 12-fold symmetric ring.
- Each achromat contains six bending elements with combined focusing functions.
- Reverse bends and compact optics reduce equilibrium emittance.
- Short straight sections create additional opportunities for insertion devices.
- The lattice is designed around the constraint of the existing 259.2 m circumference.

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The emittance leap

- Current Elettra: natural horizontal emittance ≈ 10 nm-rad at 2.4 GeV.
- Elettra 2.0: 212 pm-rad at 2.4 GeV.
- That is roughly a factor 47–50 reduction on this parameter basis.
- The resulting photon source approaches the diffraction limit in both transverse planes.

~10 nm

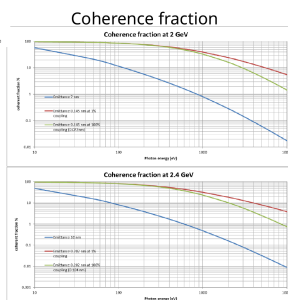
0.212 nm

~50× lower horizontal emittance

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Brilliance and coherence



- The new source increases the coherent fraction dramatically, especially at soft and tender X-ray energies.
- Brilliance is expected to increase by more than two orders of magnitude.
- These gains are the enabling technology behind nano-beams, faster spectroscopy and coherent imaging.

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Photon sources @Elettra 2.0: more than just the storage ring

- Two superconducting superbends with peak field around 6 T.
- High-energy photons up to about 130 keV for selected beamlines.
- New short-period in-vacuum undulators for hard X-ray microspot applications.
- New EPU's for coherent diffraction imaging and polarization control.
- Several existing insertion devices are being reused or upgraded for the first operational phase.

Source technology is being matched to the scientific case beamline by beamline.

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 Elettra Sincrotrone Trieste Magnets

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Life sciences and imaging

- Smaller, more coherent beams improve phase-contrast imaging and tomography.
- Micro- and nanocrystal protein diffraction becomes more accessible because the beam can be focused while retaining high collimation.
- SYRMEP-Life Science is designed to extend the medical imaging programme, including lung and breast applications.
- High-energy superbend radiation opens new possibilities for thick samples and high-resolution morphology.

From materials microscopy to patient-scale imaging: the same source upgrade supports very different spatial scales.

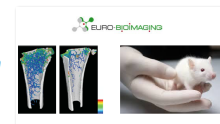
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The SYRMEP – Life Science beamline Higher energies for multiscale and multi resolution tomography and imaging applications

- "In vitro" imaging: high resolution morphological studies (es. micro-CT studies of tissues, organs, biomaterials - virtual histology)
High resolution required, main limitation is radiation damage, typical pixel size: 0.9-3 μm
- Imaging of small animals ('Pre-clinical'): applied for different purposes in the development of *animal models*
Research protocols, pixel size: 9 μm (for ex-vivo) up to 100 μm (in-vivo).
- Clinical: applications to patients
Need to **limit** radiation dose. Strict research protocol for selected patients. Find best compromise between dose and image quality, pixel sizes : 50 – 100 μm



breast CT **Lung CT**

Medical Advisory Board
list members for the SYRMEP-LS

- Prof. Hans-Ulrich Kauczor, Heidelberg University Hospital, Radiologist
- Prof. Sam Bygal, University Grenoble Alpes - Functional pulmonary imaging
- Prof. Renato Sergio Alfonsi, University of Milano - Pneumologist
- Prof. Marco Chiodini, University of Verona - Pathologist
- Prof. Stefan Andreas, Univ. Goettingen - Cardiologist and pneumologist
- Dr. Azzurra Landi, Università Cattolica di Roma - Radiologist
- Dr. Giuseppe Cicchetti, Policlinico Gemelli (Roma) - Radiologist
- Prof. Helmut Prosch - Medical University Vienna - Radiologist

Lung CT on living patients

In collaboration with Christian Dullin and Claudia Benke

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New beamlines higher priority: SYRMEP-LS projects status

Safety hatch

- Self-supporting structure. Removable and walkable floor area.
- Area covered: ~130m². Two sections with different height
- Wall Pb thickness: 15-35 mm (roof 12 mm)



ventilation

Door to medical facility

fluids

Electrical pipes

Expected installation: January 2026

Reference hatch used for standards definition

- Hutch walls – ring wall connection
- PSS hardware/procedures
- Labyrinths safety rules

Ricorrendo al piano alveare al tubo

Schematizzazione interna a giunzione

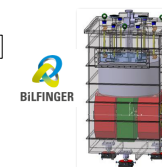
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SYRMEP-LS

Photon transport installation

- ☐ **Source** Order signed on March 27th 2026, delivery on February 28th, 2028
- ☐ **Safety hatch** **innospec** Installation completed
- ☐ **Services** Installation completed on May 15th
- ☐ **Photon transport** **CINEL** Installation period on June 15th – August 15th



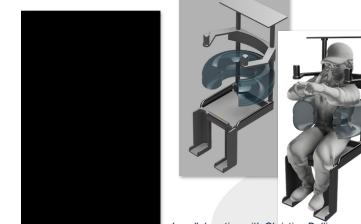
Medical imaging program

- Visit of a delegation of doctors from local hospitals to start defining cooperation programs ✓
- In collaboration with Medical Advisory Board definition of the clinical protocol for patient tomography ✓
- Realization of a chair testing design to help defining the technical specification of the patient chair ✓

Patient stage technical specifications

- Mechanical part (stages, motion, etc.) ready ✓
- Working on the safety/certification issues in collaboration with **MedTech Projects** Ongoing

Expected tender publication: Sept 2026



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Coherent science: CDI, ptychography and XPCS

- CDI: recover structure from coherent diffraction without a conventional imaging lens.
- Ptychography: scan a coherent beam and reconstruct both object and illumination.
- XPCS: follow slow dynamics through temporal correlations of coherent speckle.
- Elettra 2.0 increases the coherent fraction sufficiently to move these methods from specialised demonstrations toward routine user capability.

Coherence is not simply 'more brightness': it is a new experimental degree of freedom.

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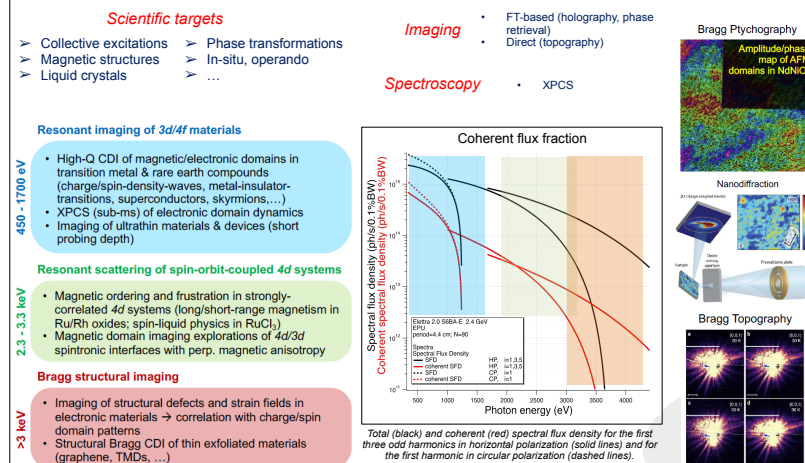
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The CDI beamline

In collaboration with C. Mazzoli (NSLS-II) and R. Comin (MIT)

A new soft and tender X-ray coherent scattering and imaging beamline



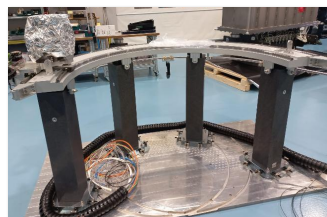
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Other updates - CDI



- Delivery of the pre-analysis chamber (14/04)
- X-ray diagnostic & fast shutter
- SAT in progress



- External arm, 18/03/2026 @ CINEL
- Motion of external CMOS detector
- Assembly in progress, delivery expected in Oct/Nov along with the entire system

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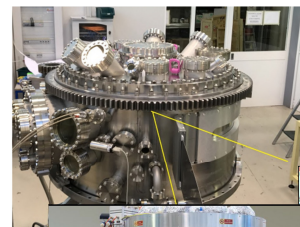
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New beamlines high priority: projects status and timeplan: **CDI**

End station DREAmS

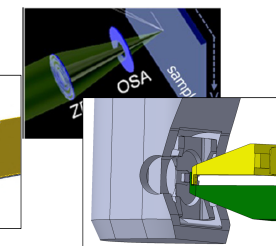
Commission assigned to:
(December 2023)



Expected delivery: December 2025

Main features of the Dynamic Resonant Elastic X-ray Imaging and Scattering

- Wide-angle diffraction geometry with two detector arms for soft and tender X-rays
- Goniometer/manipulator with series of nested rototranslations (2T+1R+3T+2R)
- Low temperature (10 K base), to span the electronic phase transitions of most QMs
- Spatial resolution. Beam-forming optics (zone plates) with nanopositioning stages for <100 nm resolution
- Designed to work on an extended energy range (400-4000 eV) (resonant + Bragg diffraction)



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The construction phase: 2025–2026

- User operation of the old Elettra ring ended in 2025.
- Existing accelerator components were dismantled to make room for the new ring.
- New foundations, girders, magnets, vacuum systems, RF, power converters and diagnostics are being installed.
- By September 2026, the project is moving from installation toward beam commissioning.

This is the difficult transition: no new tunnel, but essentially a new accelerator inside the existing infrastructure.

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Time-resolved experiments: the future option

- The lattice is compatible with transverse deflecting (crab) cavities.
- Future implementation can generate fully coherent pulses of order 1 ps FWHM.
- This targets experiments requiring high repetition rate and moderate pulse intensity.
- The storage ring can therefore complement FERMI: high average flux and stability from Elettra 2.0, ultrashort high-peak-power pulses from the FEL.

Elettra 2.0 + FERMI = complementary time scales and photon-source regimes

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Commissioning and return to users

March 2027

beam commissioning planned to start

April 2027

beamline commissioning begins in parallel

June 2027

new ring + initial beamline set operational

Jul 2027

“friendly” user access begins

2027–29

progressive expansion toward full portfolio

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Day 1 versus full Elettra 2.0

Initial operation

- initial set of ~15 beamlines
- commissioning of the ring and beamlines in parallel
- re-use of selected existing insertion devices
- progressive opening to users

Full project

- up to 32 operating beamlines
- new coherent-imaging capability
- expanded hard-X-ray and microspot programme
- additional high-energy and soft/tender X-ray capabilities

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Elettra 2.0 and the user community

- The source upgrade is valuable only if beamlines, detectors, sample environments and data analysis evolve with it.
- Many experiments will become faster; some will become more precise; others will become possible for the first time.
- Proposal planning becomes increasingly important because the scientific question must be matched to the new source characteristics.
- The facility is designed as an open-access user infrastructure, with peer-reviewed access and selected proprietary access.

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A useful way to think about the upgrade



- lower electron emittance
- smaller and more coherent photon beams
- higher signal and faster measurements
- new sources: superbends, IVUs, EPUs
- new and upgraded beamlines
- new scientific communities and applications

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Elettra 2.0 in the context of FERMI

Elettra 2.0	FERMI
• storage-ring source • high average flux • many simultaneous beamlines • high stability • coherence + nano-beams • broad user programme	• seeded FEL • ultrashort pulses • high peak brightness • VUV–soft X-rays • time-resolved and nonlinear science • longitudinal coherence

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What I would emphasise to a new user

- Do not choose the beamline only from its name: discuss the experiment with the beamline team.
- At Elettra 2.0, photon energy, coherence, focus size, polarization and detector speed will all matter.
- Think about the whole experiment: source → optics → sample environment → detector → data analysis.
- The most interesting opportunities often arise when the new source capability is combined with a demanding scientific question.

The machine is the enabling technology; the scientific question remains the starting point.

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Conclusions

- The right synchrotron is the one whose beamline matches the scientific question.
- Compare photon energy, flux, coherence, focus, polarization, detector and sample environment.
- ESRF, PETRA, MAX IV, Sirius, SOLEIL and Elettra 2.0 offer complementary capabilities.
- Elettra 2.0 adds a low-emittance, high-coherence source with new photon-source options and an expanding beamline portfolio.
- The practical next step is to contact the relevant beamline scientist before writing the proposal.

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