THE EUROPEAN CLUSTER OF ADVANCED LASER LIGHT SOURCES

free-electron lasers

synchrotrons

optical lasers

EUCALL

COOPERATION

Synergy between Optical Laser- and Accelerator-Based Light Sources

Formation of EUCALL

The overlap between optical laser light sources and accelerator-based X-ray light sources has been limited for a long time, due to differences in light wavelength, their scientific application, and the character of the light source installations.

Optical lasers have become so powerful that they can now drive intense secondary sources of coherent and incoherent X-rays. This community has started to build and operate large Research Infrastructures (RIs), providing these secondary X-ray sources to users for their investigations.

Simultaneously, the development of accelerator-based X-ray free-electron lasers (FELs) opens access to X-ray laser radiation with unprecedented brightness and therefore enables employing techniques developed for optical lasers in the X-ray regime.

The emerging combination of powerful laser and X-ray light sources, paired with the huge amount of experience in laser and X-ray science that exist in their scientific communities, will lead to new regimes of scientific applications, with the potential to contribute to solving global challenges in healthcare, energy research, new materials, and more.

To explore this potential, leading radiation science RIs across Europe have formed the European Cluster of Advanced Laser Light Sources (EUCALL), with funding from the European Union for the period 2015–2018.

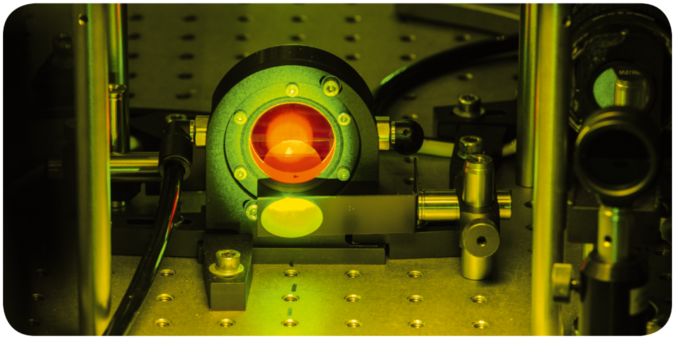
What EUCALL does

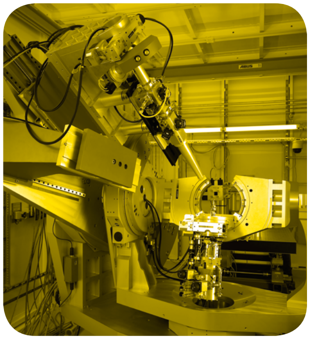
Around 100 scientists from EUCALL's facilities collaborate on EUCALL's objectives. A major part is the development of new standardised hardware and software for use at the photon science beamlines of EUCALL's RIs. Standardisation of these techniques at EUCALL facilities will provide easier access to users, who will be able to use the same systems at multiple facilities across Europe:

- new experiment simulation software
- ultrafast data acquisition software
- sample handling and positioning systems
- advanced beam diagnostic tools

EUCALL will also develop new strategies for Synergy of Advanced Light Sources, in which senior scientists from FEL and optical laser facilities will together identify novel research opportunities, methodologies, and technologies within EUCALL:

- analyse and promote the efficient use of its facilities
- identify and develop the combined research potential of its facilities
- analyse and promote the innovation potential offered by its facilities
- identify joint foresight topics in science and research policy, strengthening the portfolio of RIs within the European Research Area





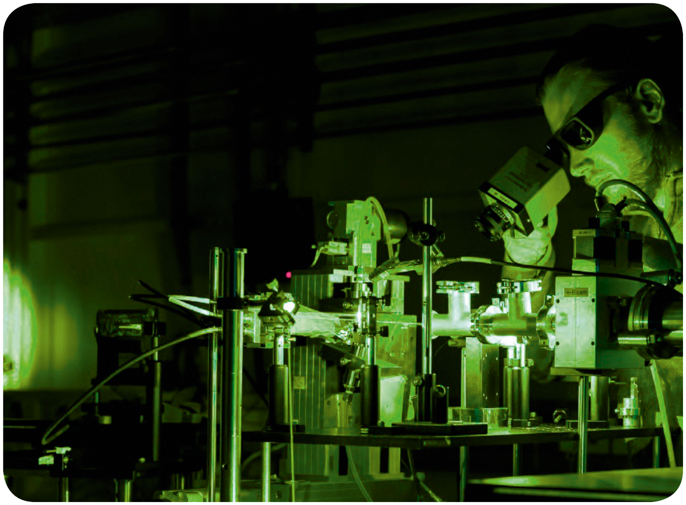
Advanced Laser Light Sources

EUCALL's Research Infrastructures, based on large optical laser systems or particle accelerators, advance science with intense X-ray and laser beams.

Optical Lasers

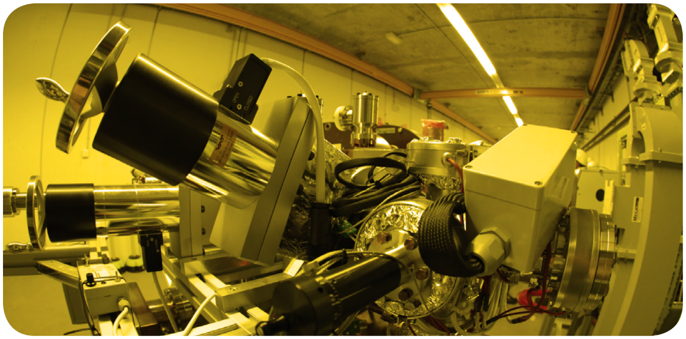
The laser's advantage over standard light sources in research and technology comes from its high coherence, ultrashort pulses, ultranarrow bandwidth, and unrivalled peak intensity.

Optical laser installations can be compact, and larger table-top devices can be operated by few people in-house. Modern powerful lasers can generate intense X-ray pulses to be used for scientific applications, which allow smaller facilities than accelerator-based sources, but at lower beam intensities.



Accelerator-Based X-ray Sources

Since the 1940s, the synchrotron facility, based on relativistic particle accelerators, has developed into an extremely high performance X-ray source. Every year, tens of thousands of researchers use synchrotron radiation to study problems in many science domains, including material science, structural biology, and energy research. Recently established FEL facilities provide laser radiation in the X-ray domain. Their unique combination of high coherence, extreme intensity and short pulses allows completely new experiments.



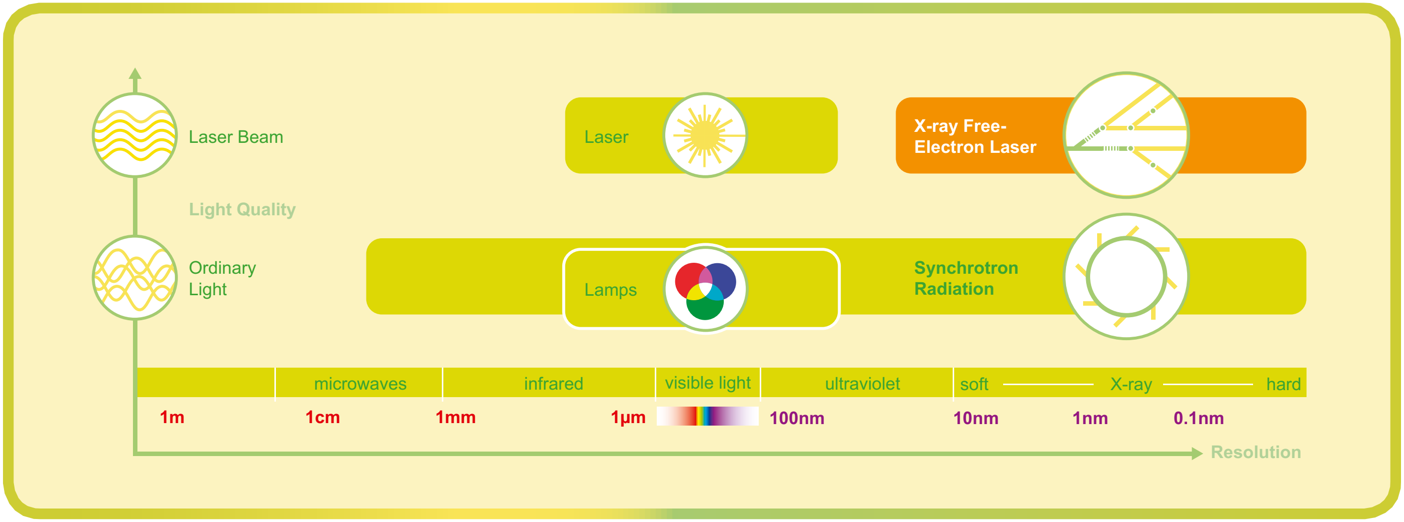
Impact of Laser Light Sources

Optical lasers have an annual market of billions of euro and have applications ranging from fundamental science to daily life, including global telecommunication, medicine, high precision metrology, and many more. As these lasers begin to drive secondary X-ray sources, their impact is expected to widen even further.

Applications of X-ray radiation by synchrotron and FEL light sources have also revolutionised science and technology. They enable us to understand the atomic and mesoscopic structure of even the most complex materials. We can follow dynamics on all time scales from hours to femtoseconds. Studying bacteria, proteins, batteries, solar panels, turbine blades, or even matter like existing in planetary interiors allows insight into all kind of relevant processes.

Research Infrastructures (RIs) – are facilities, resources and related services used by the scientific community to conduct top-level research in their respective fields, ranging from social sciences to astronomy, genomics and nanotechnologies.

X-ray beams generated by synchrotrons, FELs or optical lasers each have different characteristic – such as peak brightness, photon energy, pulse duration – from which potential users select the most appropriate for their experiments.



Light quality and wavelengths of different light sources. Laser beams (which are coherent) have a higher light quality than ordinary light (called incoherent, represented by lamps). Large light source facilities are shown to the right. X-ray FELs (orange) are capable of producing coherent light within the X-ray portion of the spectrum. Synchrotrons cover a broad spectrum of wavelengths but can only produce incoherent light. (Copyright European XFEL)

EUCALL's Partners

EUCALL's largest RIs are international facilities:

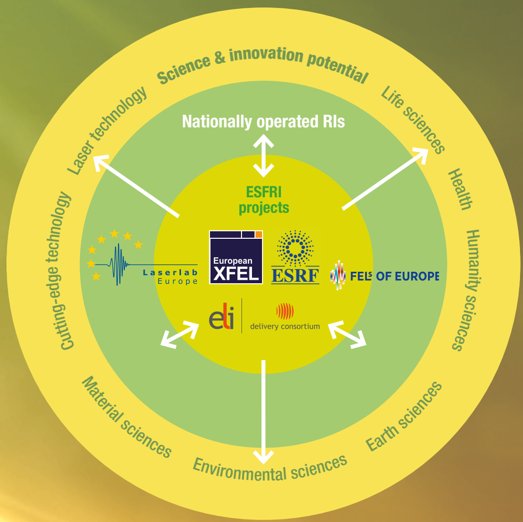
- The Extreme Light Infrastructure (ELI) will have three high-power optical laser installations, producing secondary light ranging from the THz to the gamma. It is currently under construction in the Czech Republic, Hungary, and Romania, and will provide first light for users in 2018.
- The European X-Ray Free-Electron Laser Facility (European XFEL) uses a superconducting linear accelerator to generate intense, ultrashort X-ray FEL pulses. It is currently under construction in Hamburg, Germany, and will provide first light for users in 2017.
- The European Synchrotron Radiation Facility (ESRF) in Grenoble, France provides X-ray synchrotron radiation and operates an increasing number of instruments combining high-power optical lasers with X-rays.

These international RIs are based on the developments and experience of many national RIs, either operating, under construction, or planned. These national RIs participate in EUCALL through two international networks:

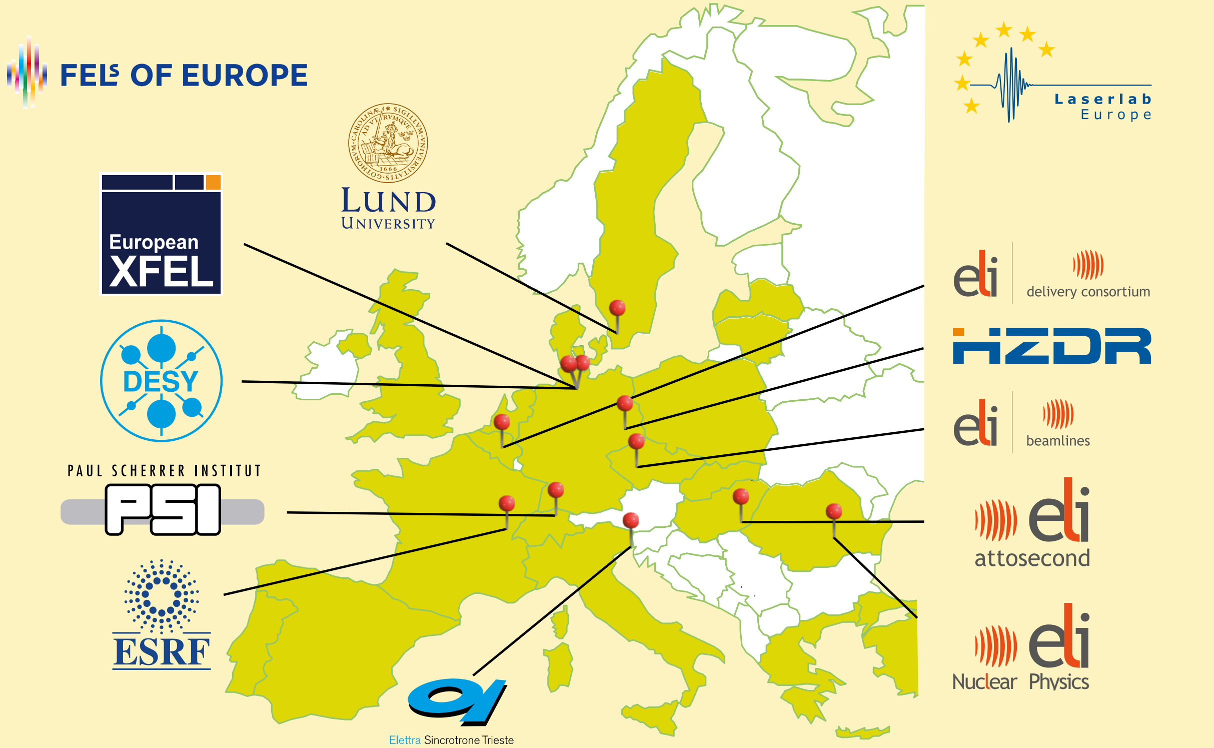
- Laserlab-Europe links 33 institutions doing laser-based interdisciplinary research in 16 countries. The network provides transnational access to users, and is the central infrastructure in Europe where new developments in optical laser research take place.
- FELs of Europe is a collaboration of all European FEL facilities, comprising 14 organizations in nine countries. The network provides a pan-European infrastructure that realises the full scientific potential of these unique accelerator-based light sources.

Five of the national RIs are specifically involved in EUCALL as project partners – DESY and HZDR in Germany, Elettra Synchrotron in Italy, Lund University/MAX IV in Sweden, and PSI in Switzerland.

The interaction of the EUCALL partners, both international and national RIs, and their embedding into science and innovation.



The EUCALL Cluster



EUCALL's six FEL and synchrotron sources and five optical light facilities (red pins). Countries involved in the European clusters FELs of Europe and Laserlab-Europe are coloured.

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