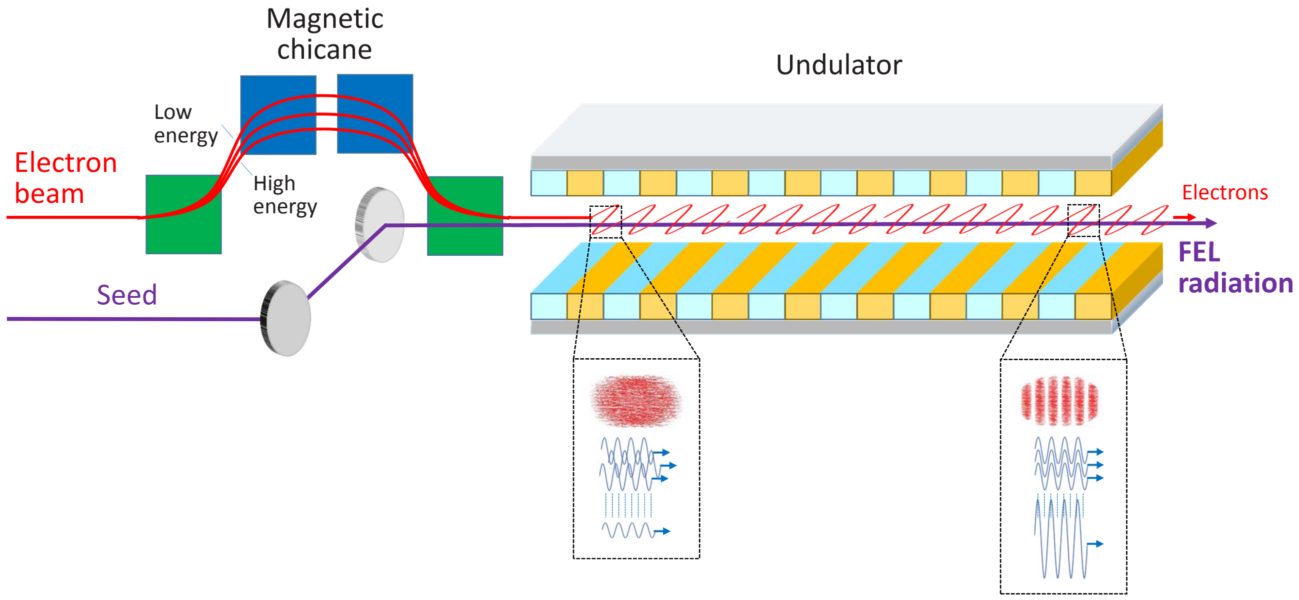
FREE-ELECTRON LASERS

Diagram: Scheme of a free-electron laser



Technology

A free-electron laser (FEL) is a source of coherent (i.e. laser-like) radiation. It works by sending a beam of high-energy electrons down a tube surrounded by a series of magnets with alternate polarities. This magnet array, called undulator, causes the electrons to undergo a sinusoidal motion and emit synchrotron radiation due to their acceleration in the transverse plane. The emitted radiation interferes constructively in the successive oscillations, creating a beam of coherent tunable high-intensity x-rays.

The periodic magnetic field of an undulator is created by either permanent magnets or electromagnets (superconducting or warm magnets). The FEL performance depends on the beam properties and undulator quality.

FELs driven by conventional electron accelerators are currently used in material sciences, nanotechnology, electronic materials processing, microfabrication, and biochemistry, to name but a few of their applications.

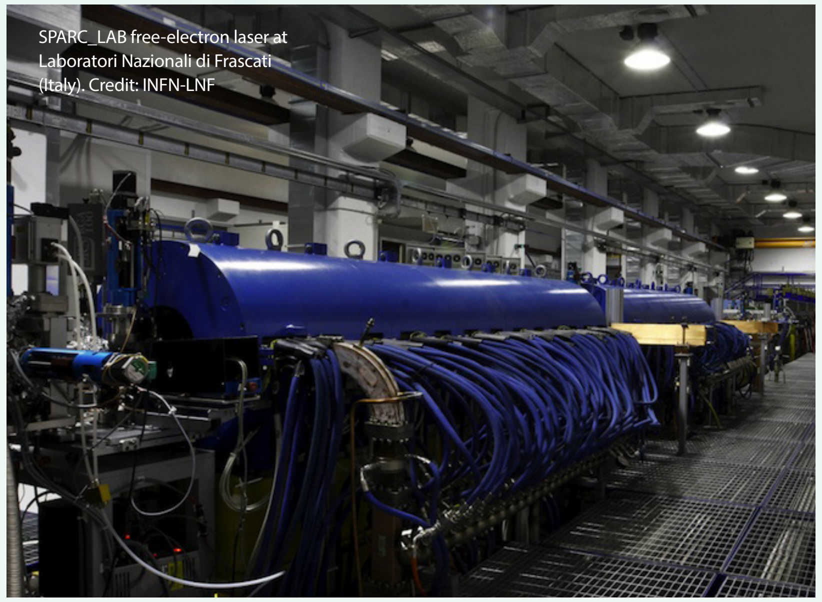
EuPRAXIA investigates the application of plasma accelerators as drivers for a FEL, paving the way towards FEL light sources of laboratory size for femtosecond time-resolved experiments.

Challenges & Innovation potential of EuPRAXIA

The development of an FEL for EuPRAXIA must overcome the intrinsic limitations of plasma-accelerated electrons, such as the large energy spread and divergence. At the same time, EuPRAXIA offers a unique opportunity for innovation in FEL technology.

Compact FELs

EuPRAXIA is developing strategies for short period undulators, such as in-vacuum cryogenic and superconducting undulators.



SPARC_LAB free-electron laser at Laboratori Nazionali di Frascati (Italy). Credit: INFN-LNF

Ultrafast science

The ultrashort x-ray pulses made available by the plasma accelerator-driven FEL open up a whole new range of possibilities to measure ultrafast processes in nature that can be analyzed at the electronic level without perturbation.

Magnetic undulator for a free-electron laser. © DESY, Heiner Müller-Elsner

Fast photon detection technology

The detector technology for ultrafast photon science has to be adapted to the plasma beam features.

FEL	Wavelength (nm)	Electron bunch duration (ps)	Energy (MeV)	Undulator periods	Undulator wavelength (cm)
SwissFEL (PSI, Switzerland)	70 – 800	0.5 – 3	100 – 220	265	1.5
SPARC (Frascati, Italy)	66 – 800	0.15 – 8	80 – 177	450	2.8
FERMI-2 (ELETTRA, Italy)	4 – 14.4	0.7 – 1.6	900 – 1500	396	3.5
FLASH2 (DESY, Germany)	4 – 80	0.05 – 0.5	500 – 1250	768	3.14
LCLS (SLAC, USA)	0.12	0.07	15400	3696	3
SACLA (SPring-8, Japan)	0.06 – 0.25	0.02 – 0.03	8300	6300	1.8

EuPRAXIA

www.eupraxia-project.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant no. 653782. The information herein reflects only the views of its authors and the Research Executive Agency is not responsible for any use that may be made of the information contained.