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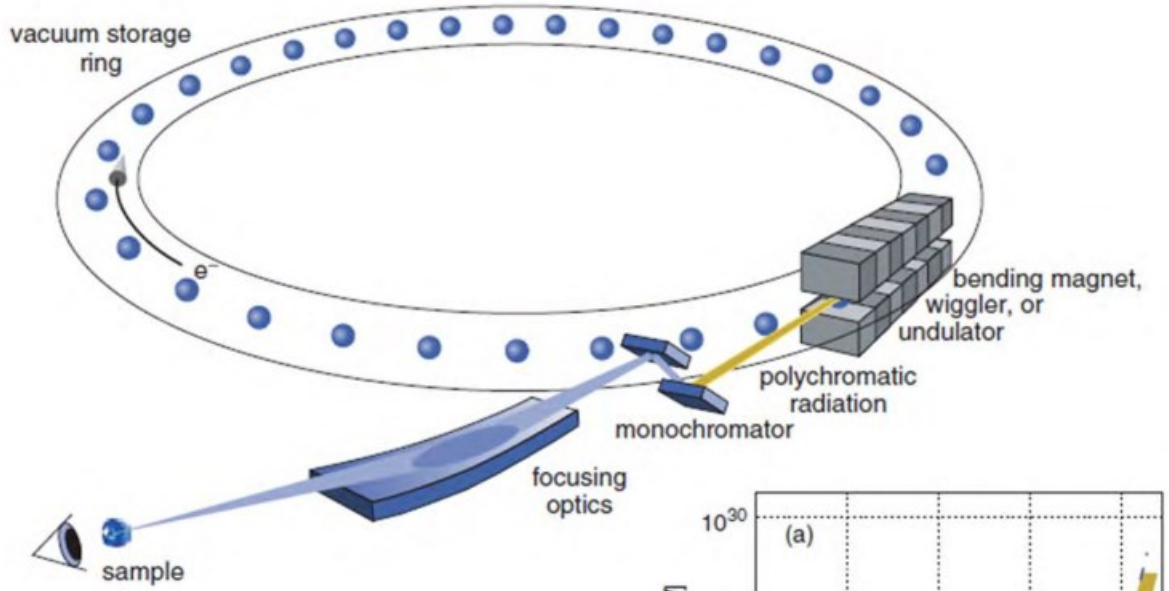
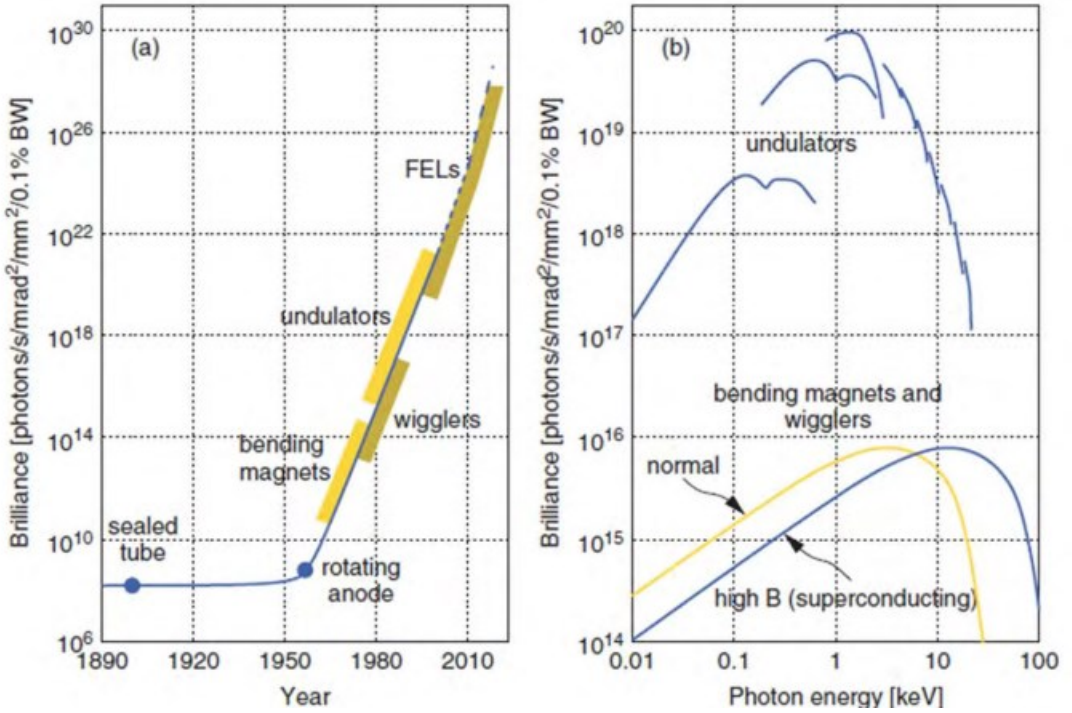
Orange pins on the map represent members of the lightsources.org collaboration.

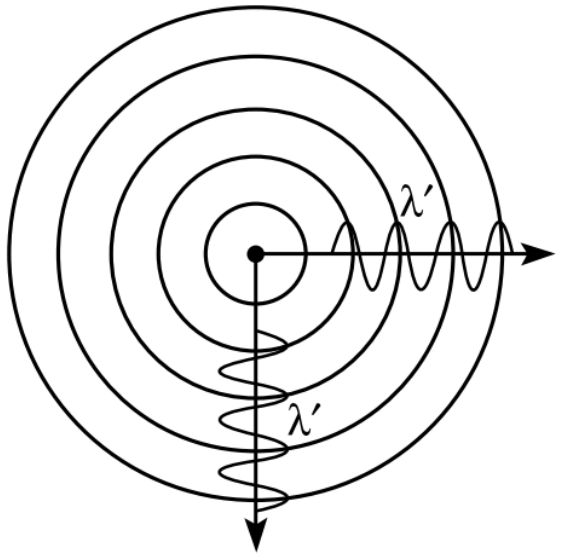




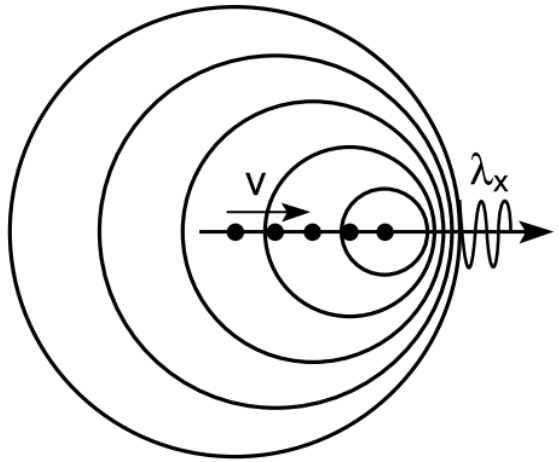
Luce di sincrotrone:

- Intensa
- Variabile (eV->50 keV)
- Polarizzata
- Brillante
- Risoluzione Temporale

$v \ll c$



$v \lesssim c$ Relativistico!



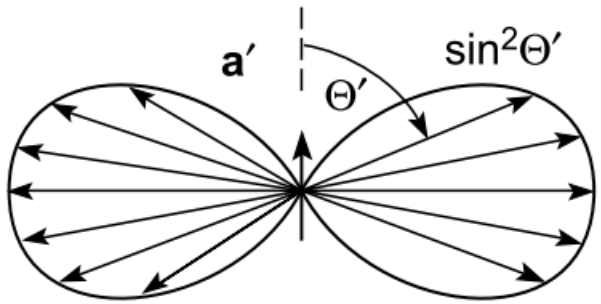
Note: Angle-dependent doppler shift

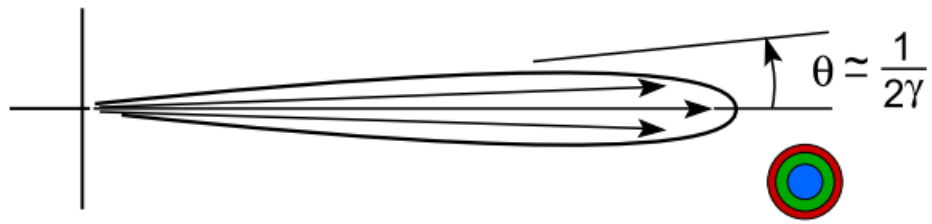
$$\lambda = \lambda' \left(1 - \frac{v}{c}\cos\theta\right)$$

$$\lambda = \lambda' \gamma \left(1 - \frac{v}{c}\cos\theta\right) \simeq \frac{\lambda'}{2\gamma}\left(1 + \gamma^2\theta^2\right)$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Frame moving with electron **Laboratory frame of reference**

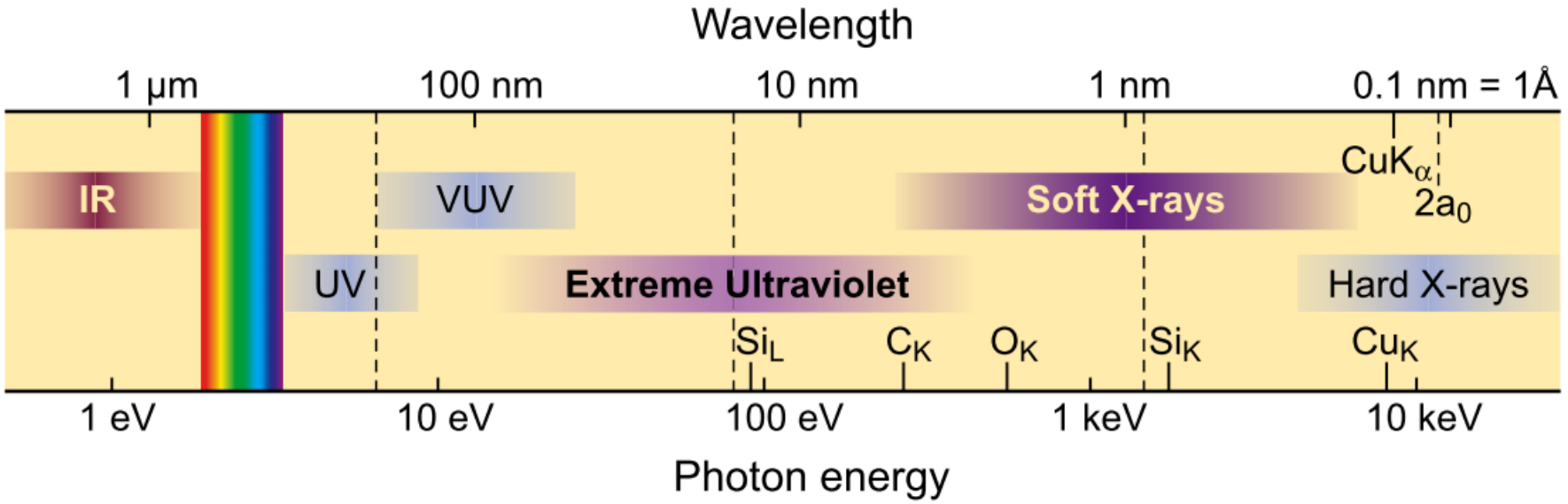




$$\tan\theta = \frac{\sin\theta'}{\gamma(\beta + \cos\theta')} \qquad (5.1)$$

$$\theta \simeq \frac{1}{2\gamma} \qquad (5.2)$$

Regione dello Spettro elettromagnetico



Ultra-Small

Nature

Technology

Flea

Human hair ~30 μm wide

Red blood cells & white cell ~ 5μm

Virus ~ 200 nm

DNA helix ~3 nm width

Water molecule

Atom

10^{-3} m — 1 mm

The Microworld

100 μm

10 μm

10^{-6} m — 1 μm

The Nanoworld

100 nm

10 nm

10^{-9} m — 1 nm

0.1 nm

Head of a pin ~ 1mm

DVD track

10 μm

1 μm Electrodes connected with nanotubes

Carbon nanotube ~ 2nm diameter

Atomic corral ~ 14 nm diameter

Ultra-Fast

Nature

Technology

Hydrogen transfer time in molecules is ~ 1ns

Spin precesses in 1 Tesla field is 10 ps

H

S

Shock wave propagates by 1 atom in ~ 100 fs

Water dissociates in ~10 fs

Bohr period of valence electron is ~ 1 fs

10^{-9} s — 1 ns

Computing time per bit is ~ 1 ns

Magnetic recording time per bit is ~ 2 ns

100 ps

Optical network switching time per bit is ~ 100 ps

10 ps

10^{-12} s — 1 ps

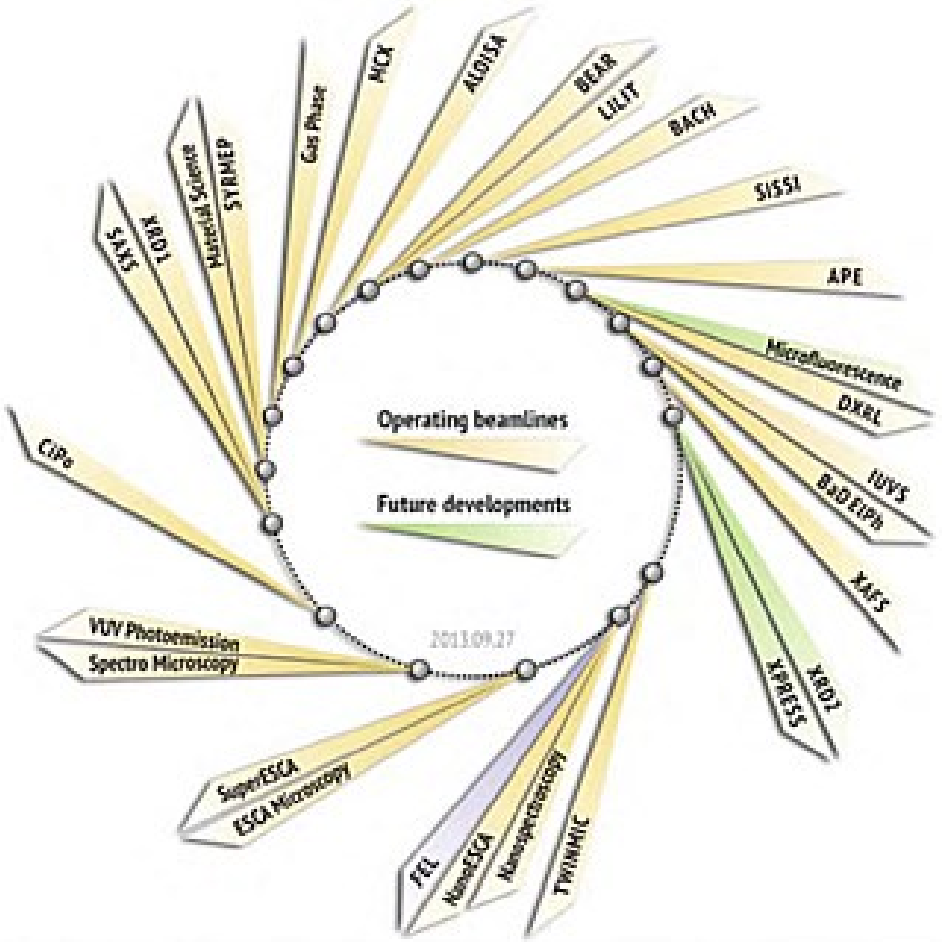
100 fs

10 fs

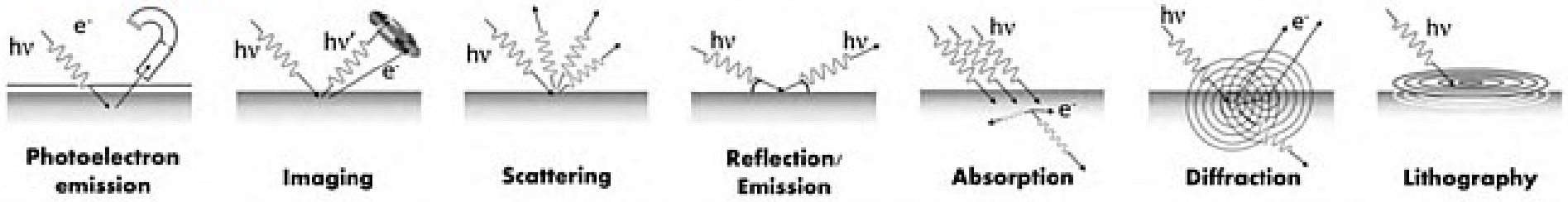
10^{-15} s — 1 fs

Sincrotrone Elettra e il FEL Fermi

Elettra



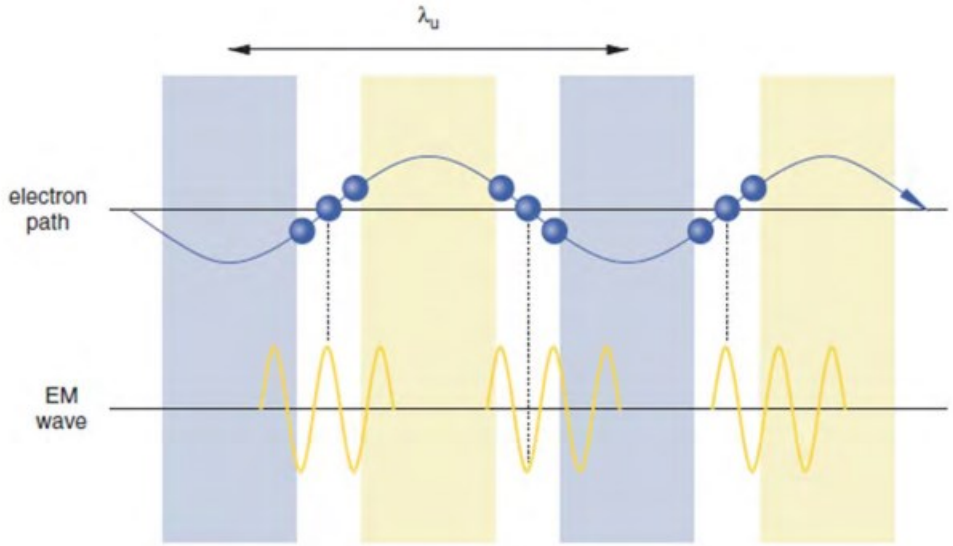
Beamlines by technique

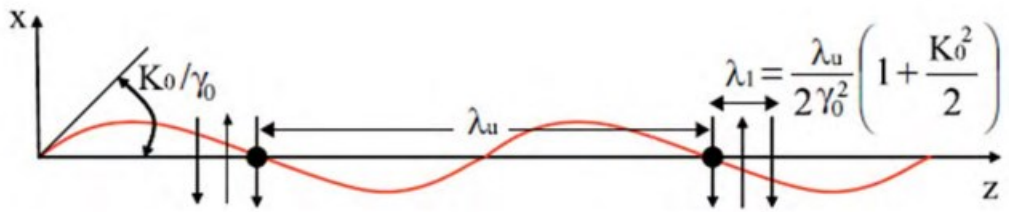


Applicazioni della luce di sincrotrone:

- Scienza delle superfici
- Materiali magnetici
- Chimica dei materiali
- Scienze ambientali
- Cristallografia
- Processi dinamici (FEL)
- Biologia
- ….

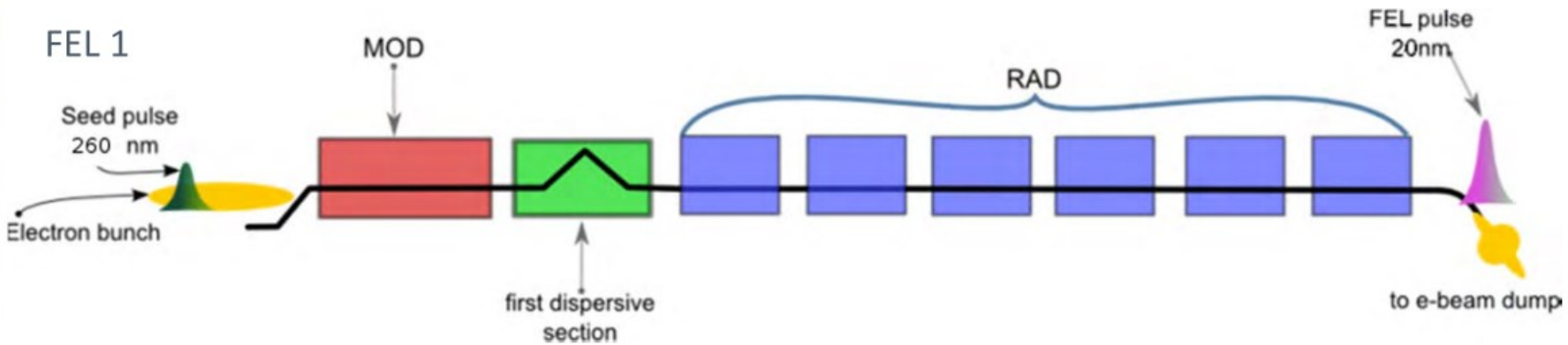
FEL principles: intro

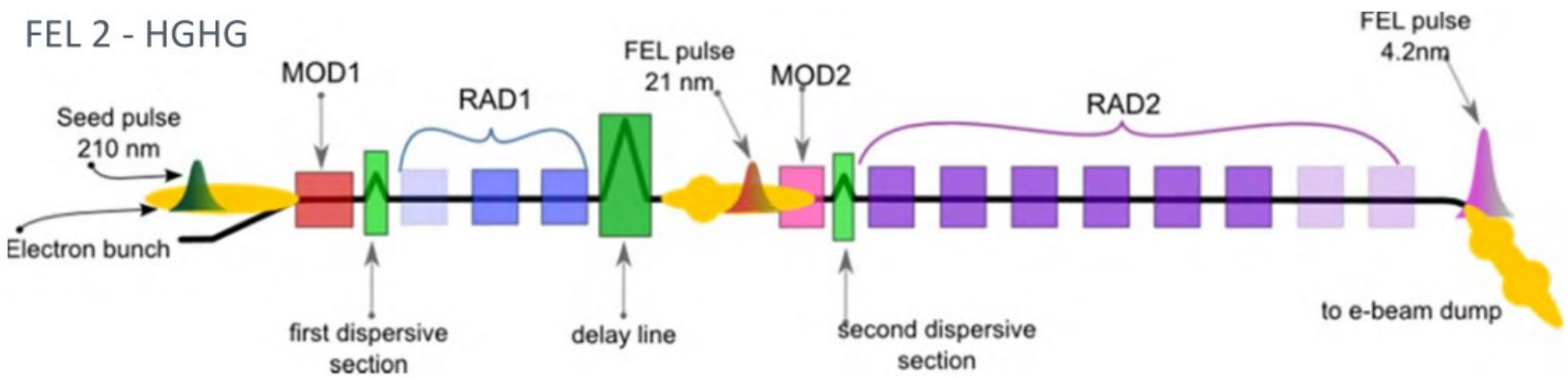




or) After an electron (black dot) travels one undulator period λ_u of the sinusoidal trajectory (in red), a plane wave (represented by alternating vertical arrows) overtakes the electron by one resonant wavelength λ_1. Thus, the undulator radiation carrying this resonant wavelength can exchange energy with the electron over many undulator periods.

Fermi@Elettra





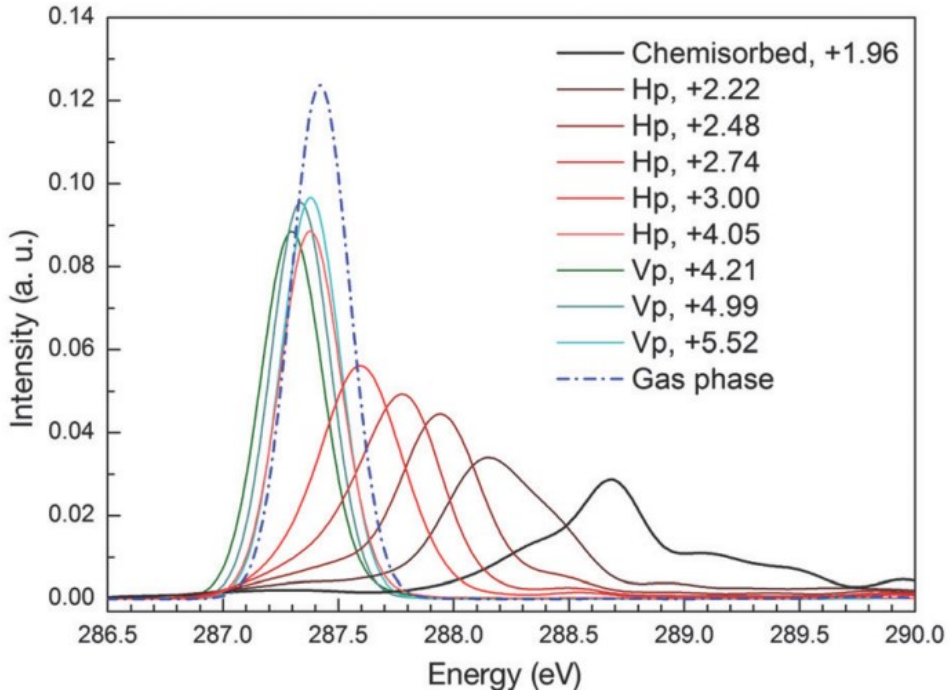
Fermi@Elettra

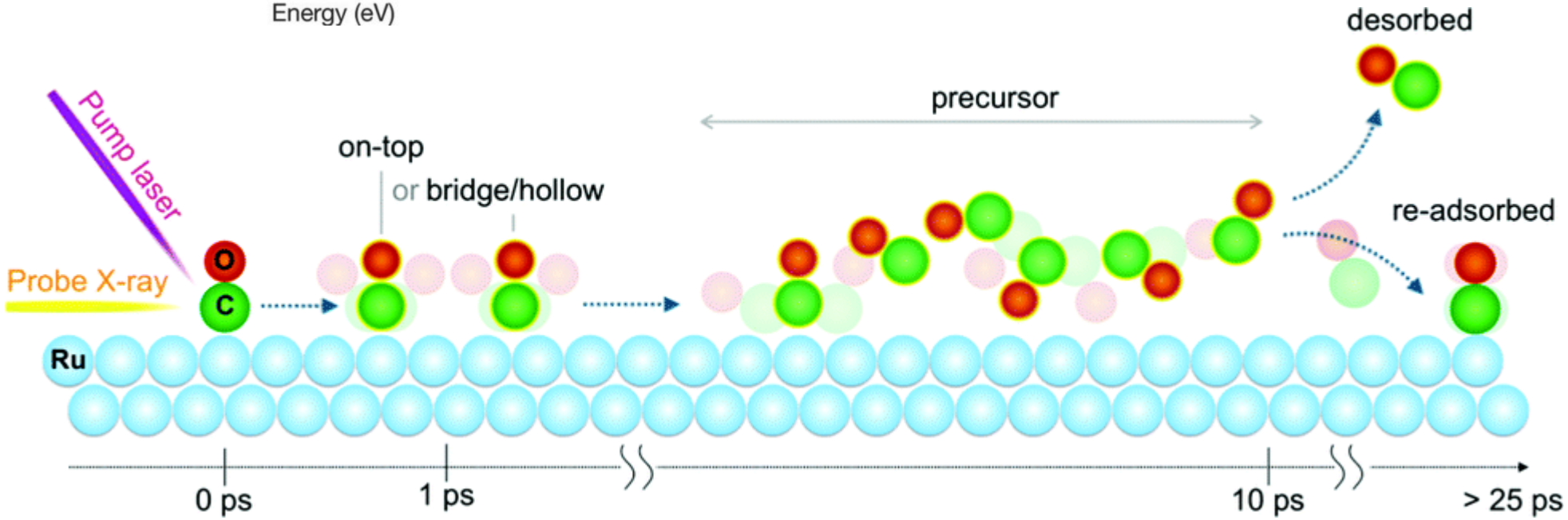
lists some of the basic parameters of the electron beam and of the FEL radiation at 40 nm (FEL-1) and 10 nm (FEL-2).

Table 2.3.1: Nominal electron beam and FEL parameters.

Parameters	*Value at 40 nm*	*Value at 10 nm (fresh bunch)*	*Units*
Electron beam energy	1.2	1.2	GeV
Peak current	800	500	A
Emittance (slice)	1.5	1.5	μm, rms
Energy spread (slice)	150	150	keV
Bunch duration	700	1400	fs, FWHM
Repetition rate	10	10	Hz
FEL peak power	1 ÷ 5	0.5 ÷ 1	GW
FEL pulse duration	50 ÷ 100	100 ÷ 200	fs, FWHM
# of photons/pulse	10^{14}	10^{12}	
Bandwidth	~ 20	5	meV

40 nm = 31 eV ; 10 nm = 124 eV





H. Wang et al., Phys.Chem.Chem.Phys., 2020, 22, 2677