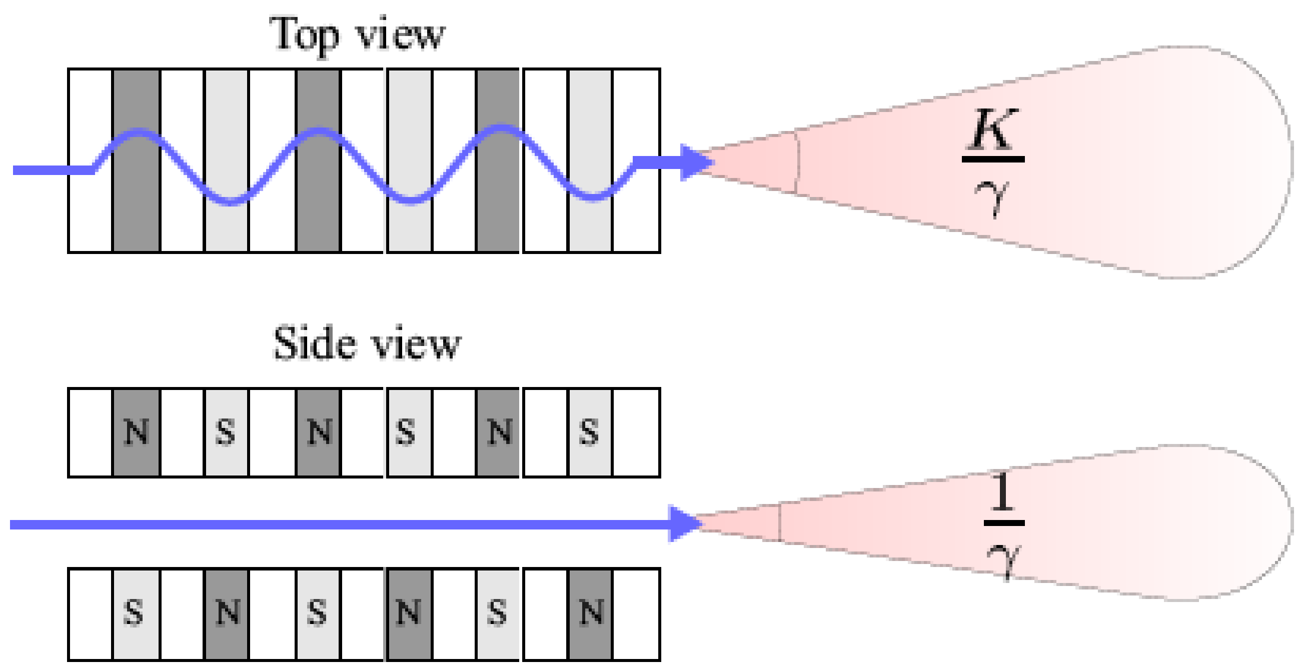
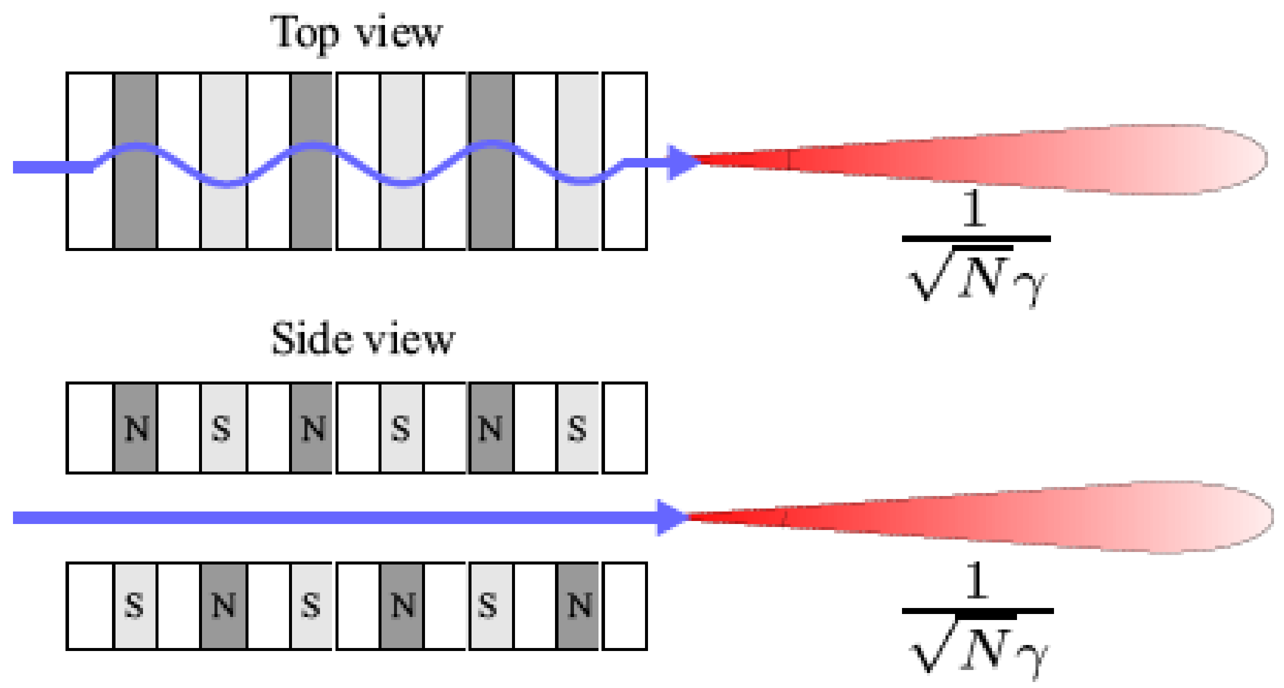
Undulator and Wigglers: Synchrotron based

Insertion devices: more bends for more light

Wiggler:
large angular excursions,
essentially a series of bends

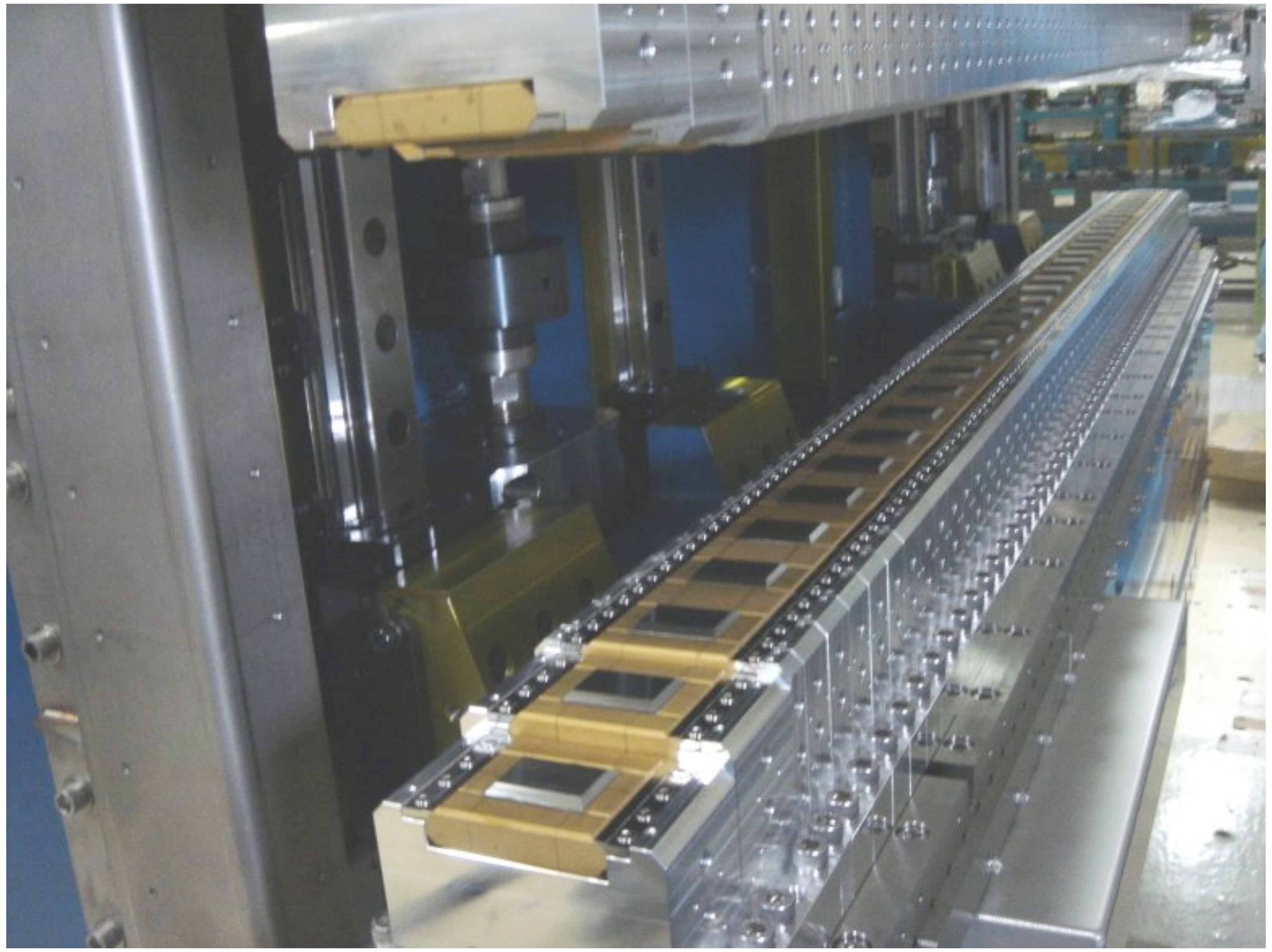


Undulator:
small angular excursions,
inteference phenomena

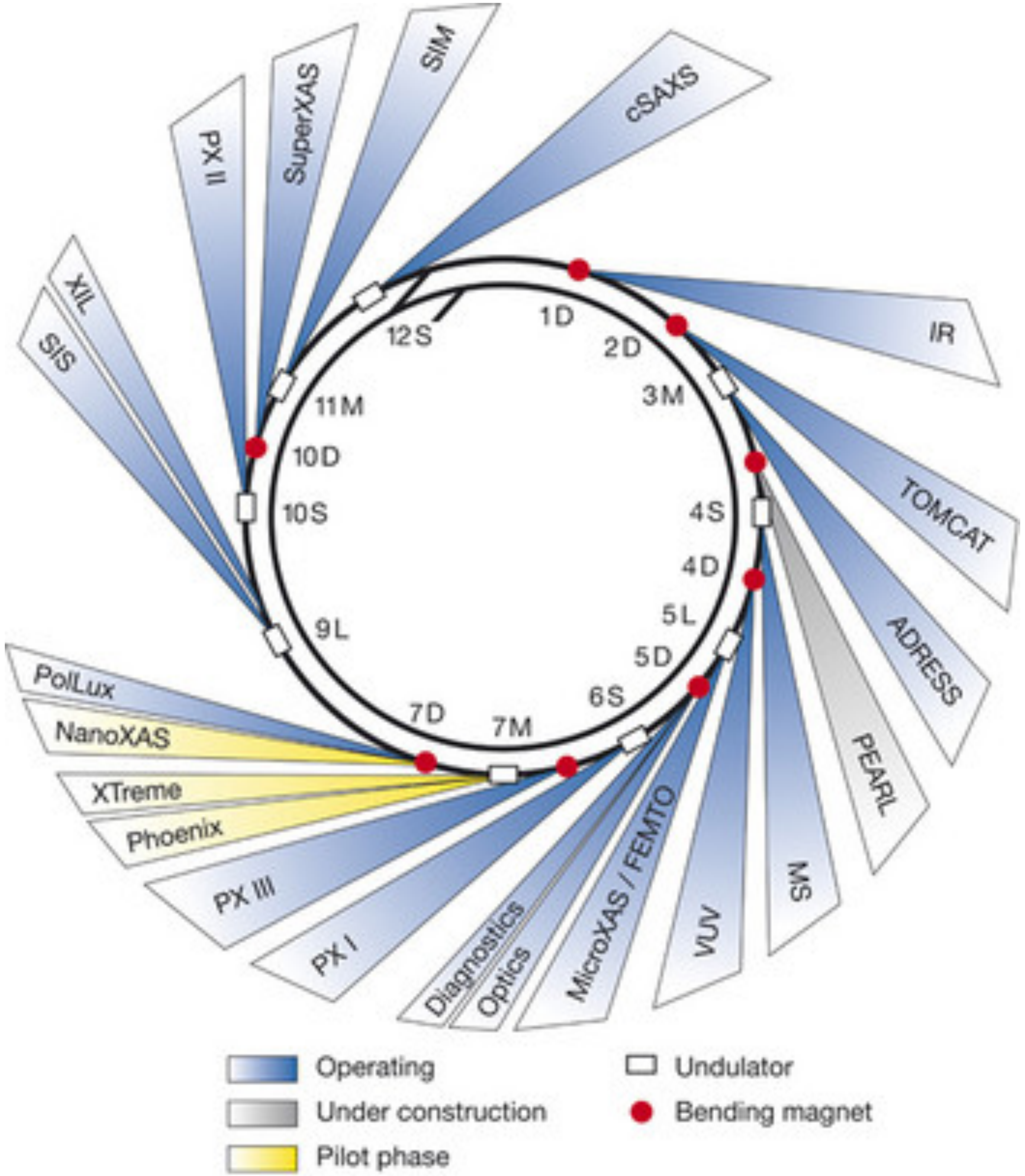


[Als-Nielsen & McMorrow, *Elements of Modern X-ray Physics*, John Wiley & Sons, Ltd, 2001]

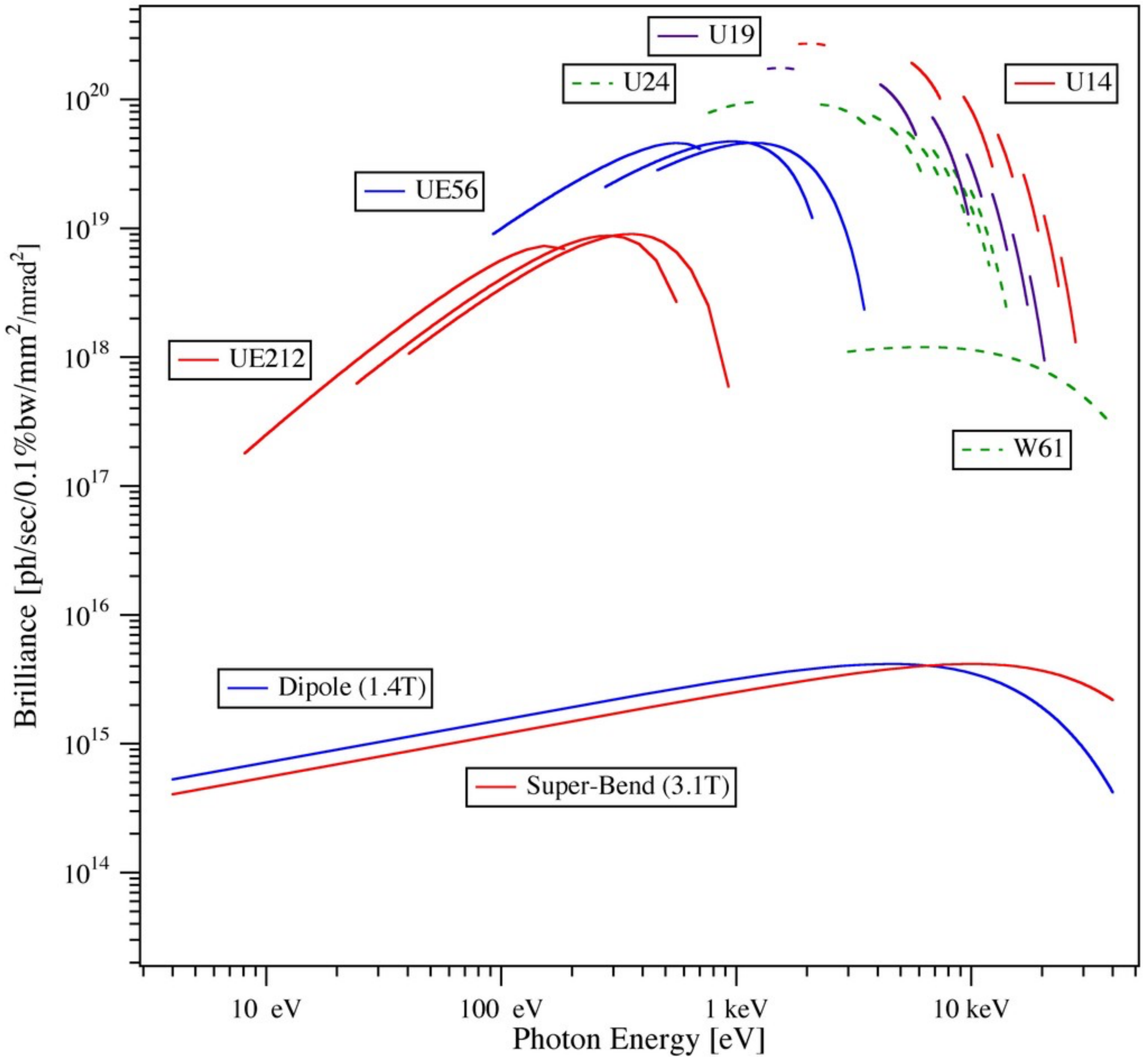
Insertion devices: more bends for more light

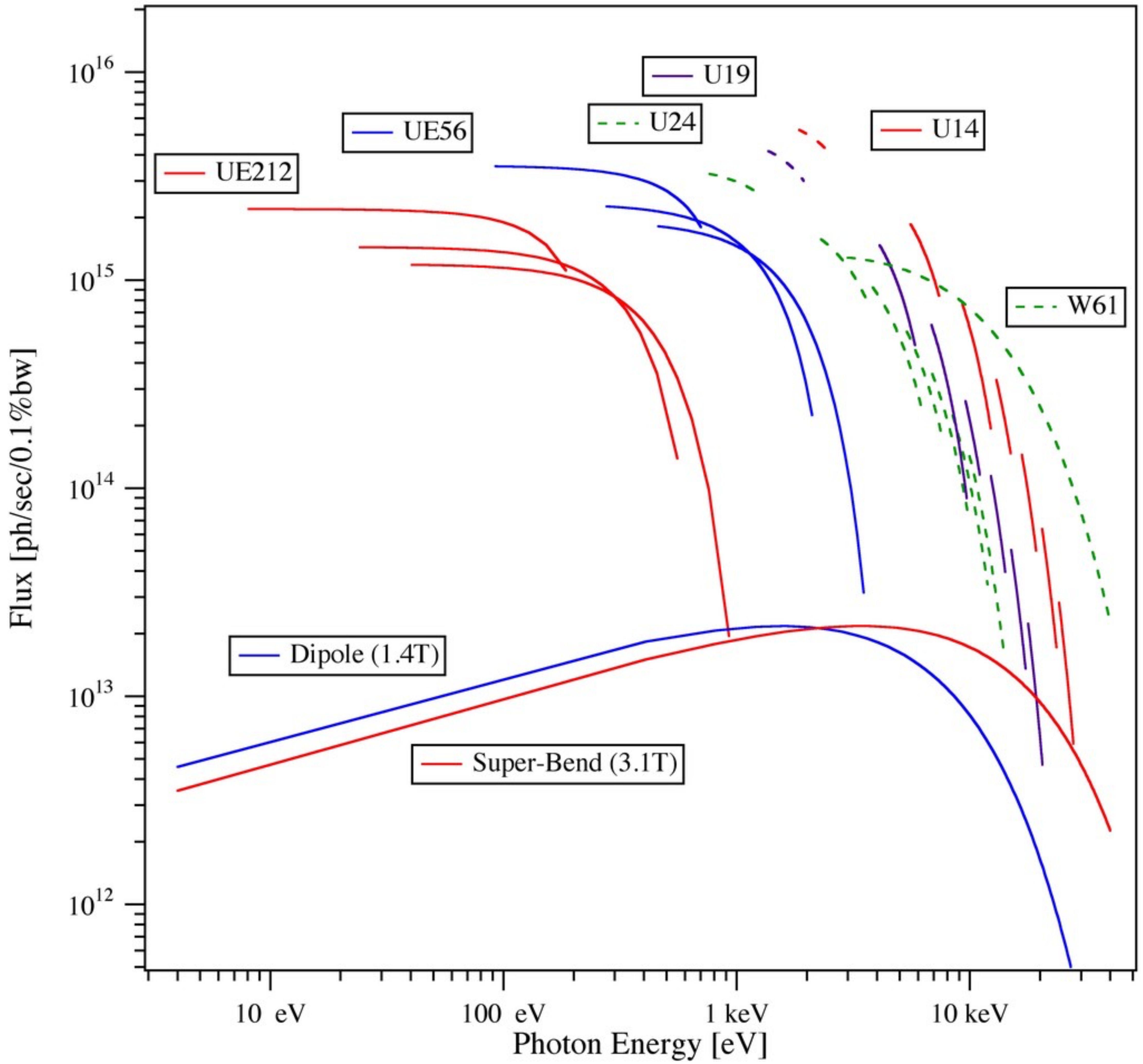


Swiss Light Source photon sources



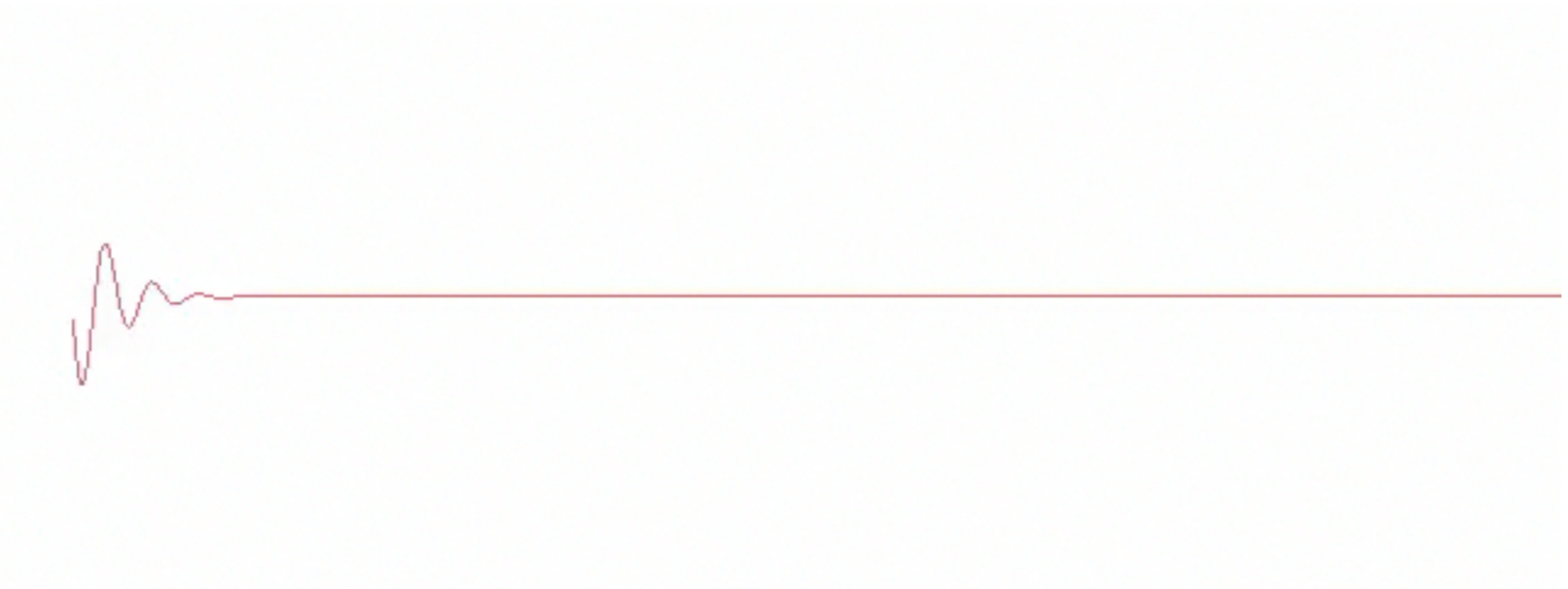
Swiss Light Source photon sources





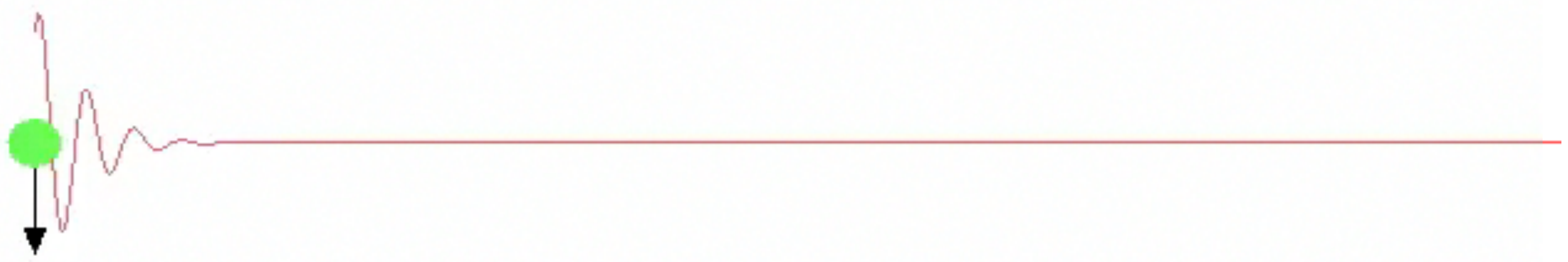
FELs “SASE” action

Energy exchange



- E-field of light transverse to direction of propagation
- Can exchange energy with electrons with a transverse momentum component

Energy exchange



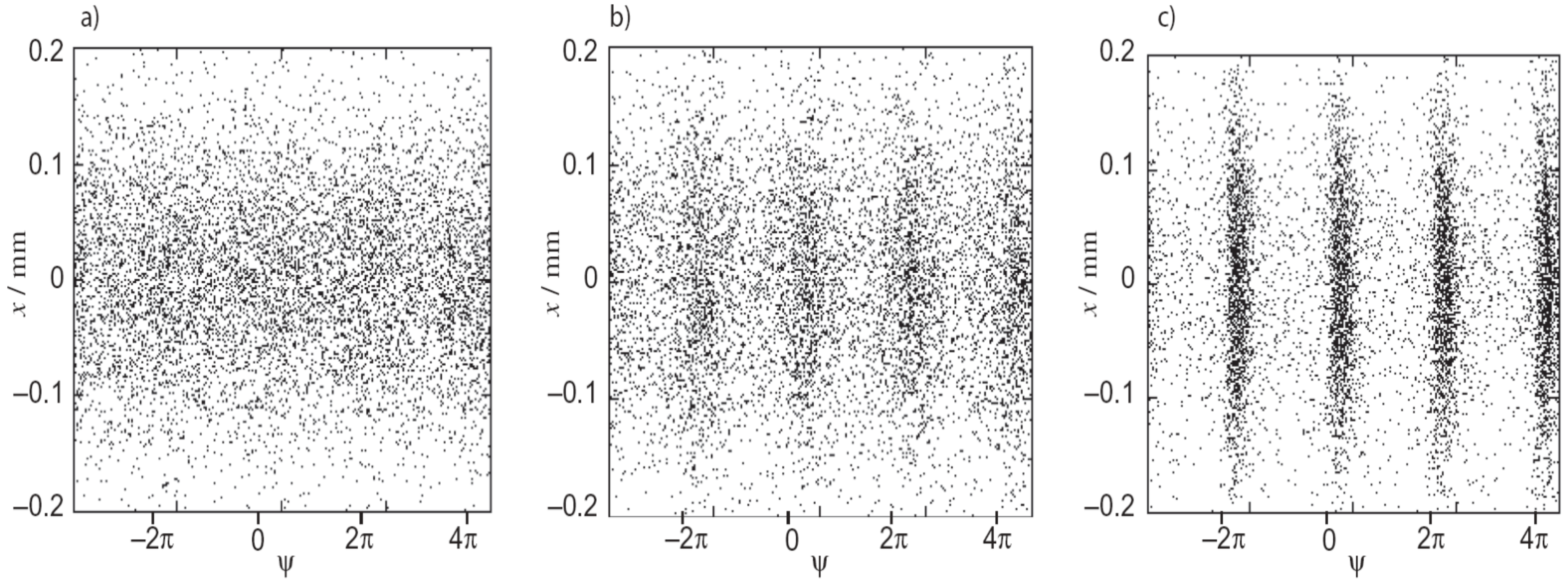
$$dE/dt = \mathbf{F} \cdot \mathbf{v} \geq 0$$

Energy exchange

$$dE/dt = \mathbf{F} \cdot \mathbf{v} \leq 0$$

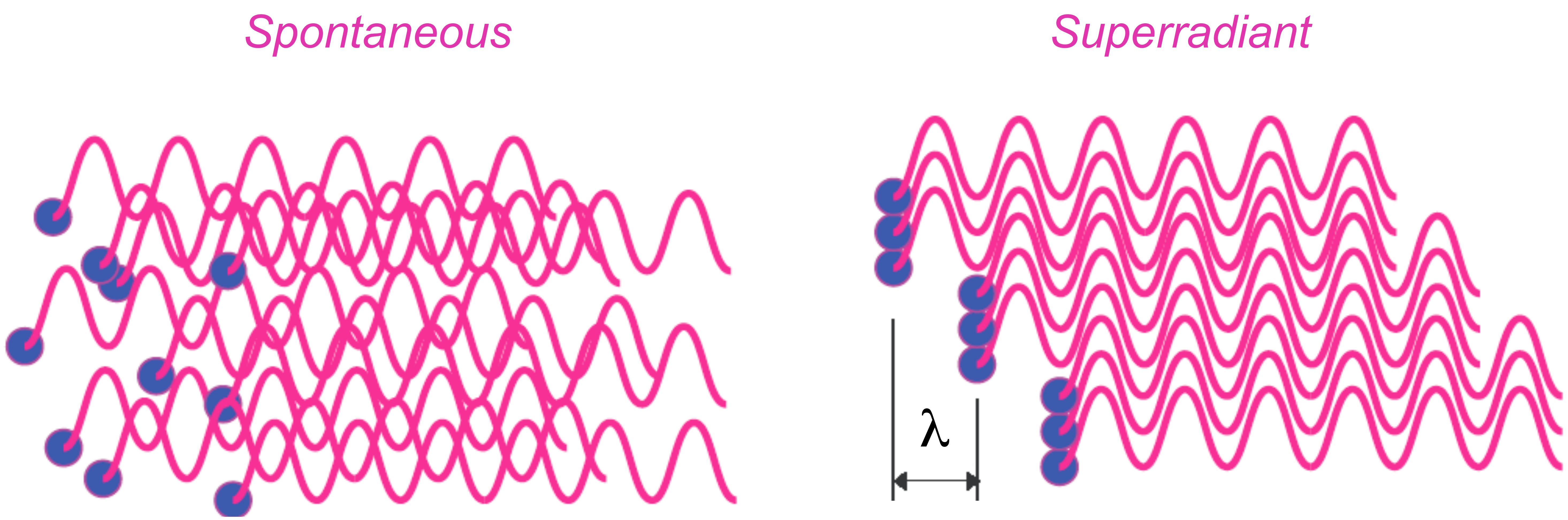
Free electron laser

Microbunching: modulation of electron energy causes electrons to bunch with a periodicity…



Emission of bunched electrons adds coherently!

Microbunching enhancement



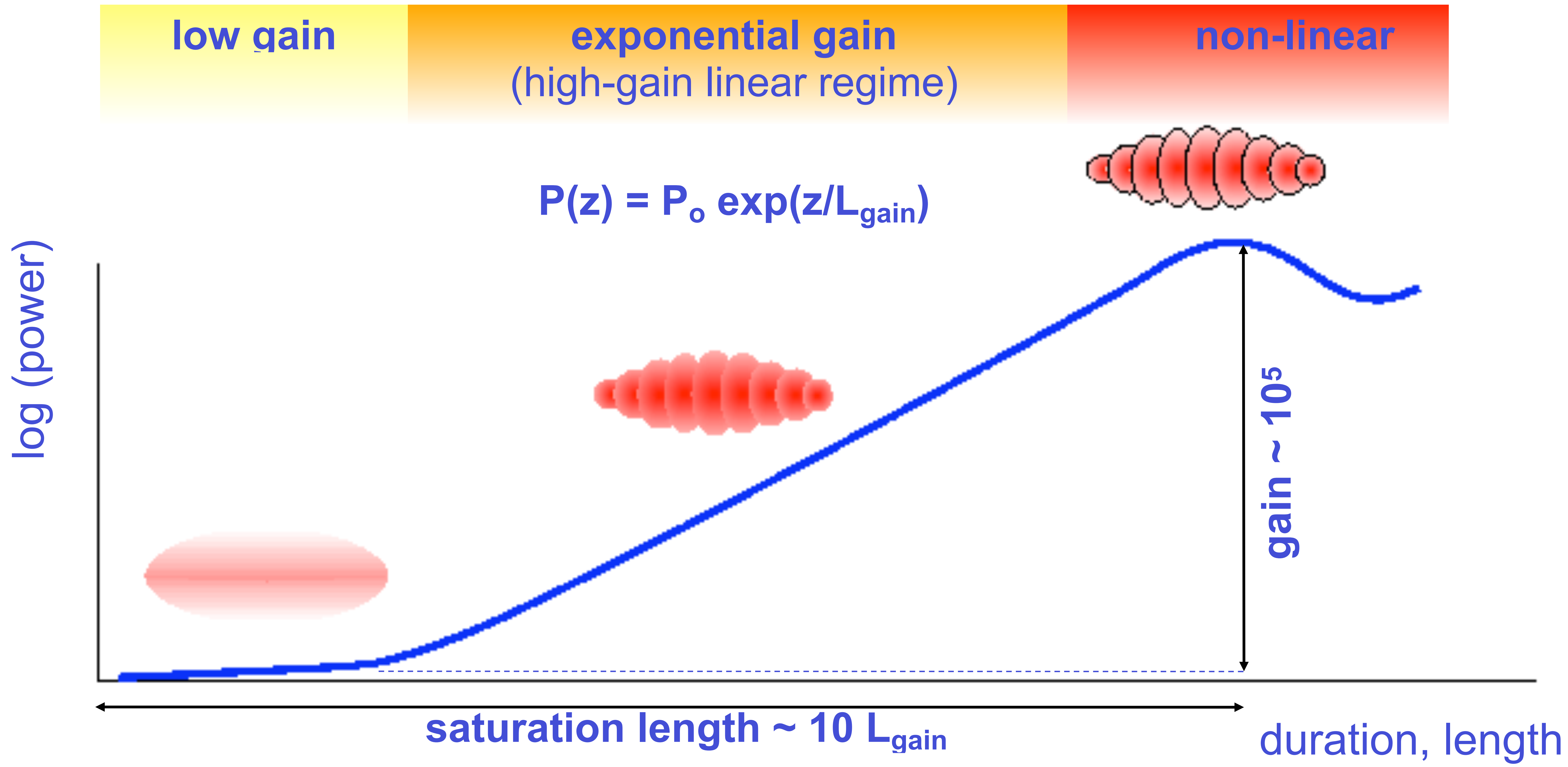
$$P = N\ P_1$$

$$E = N\ E_1$$

$$P = N^2\ P_1$$

$$N \approx 10^9$$

Saturation



Result: coherent, bright, short (< 10 fs) x-ray pulses

Electron generation/acceleration

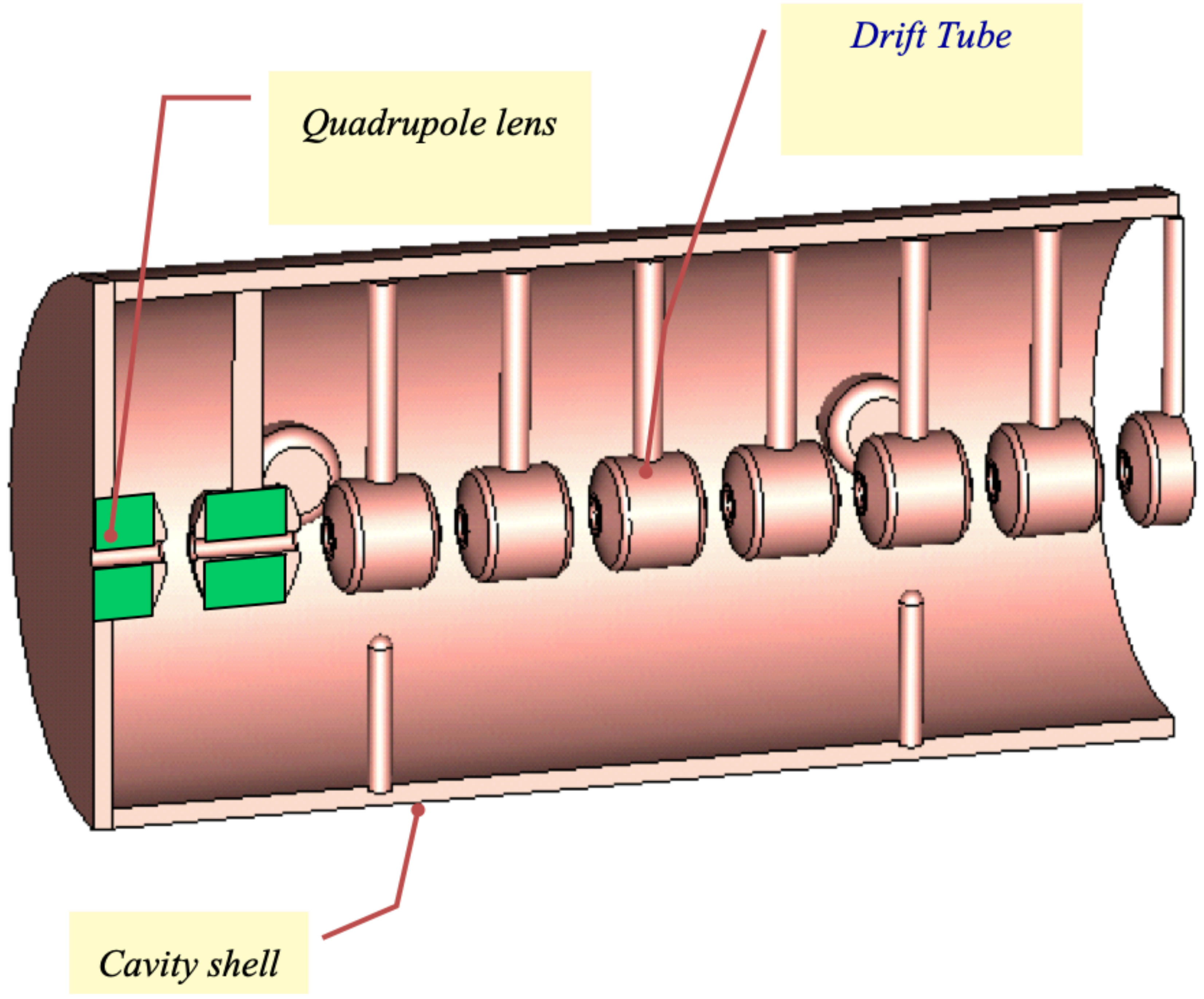


Fig. 8: Sketch of the DTL

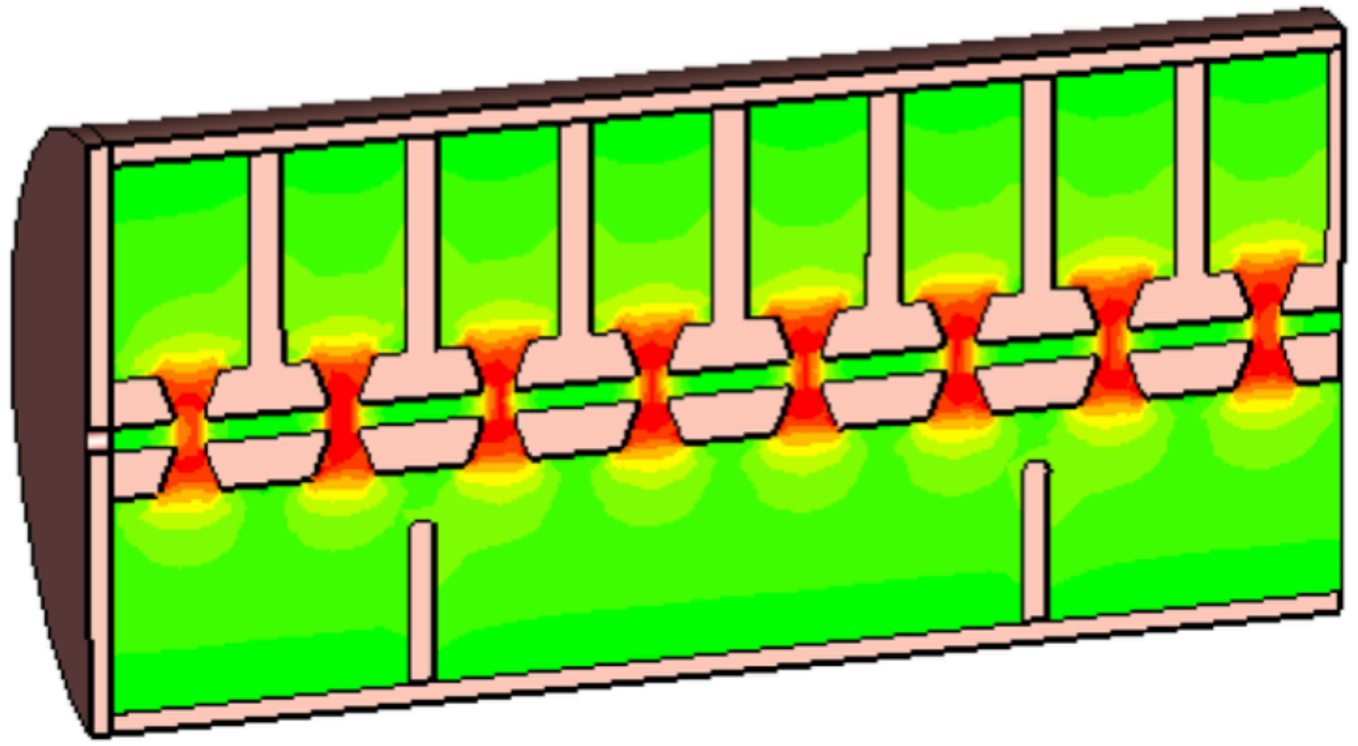
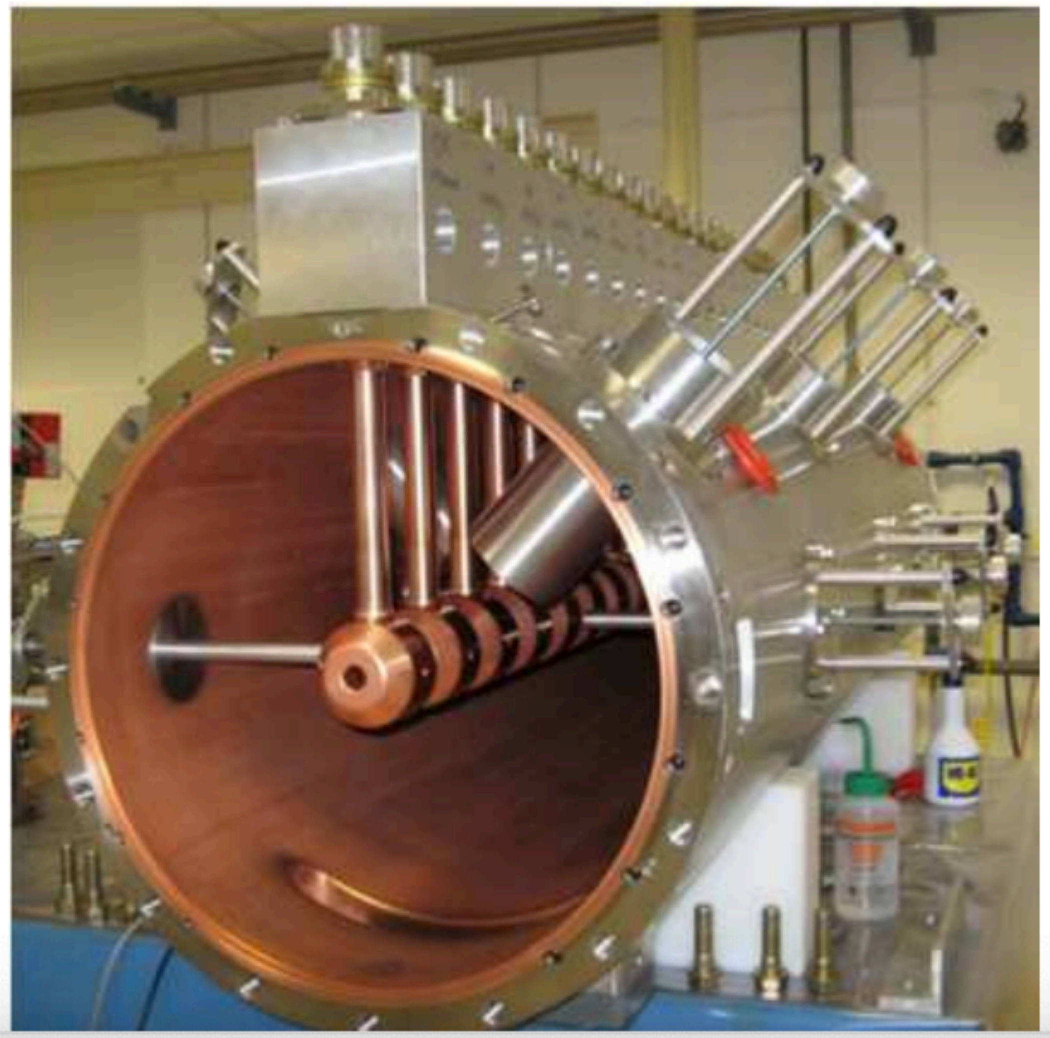


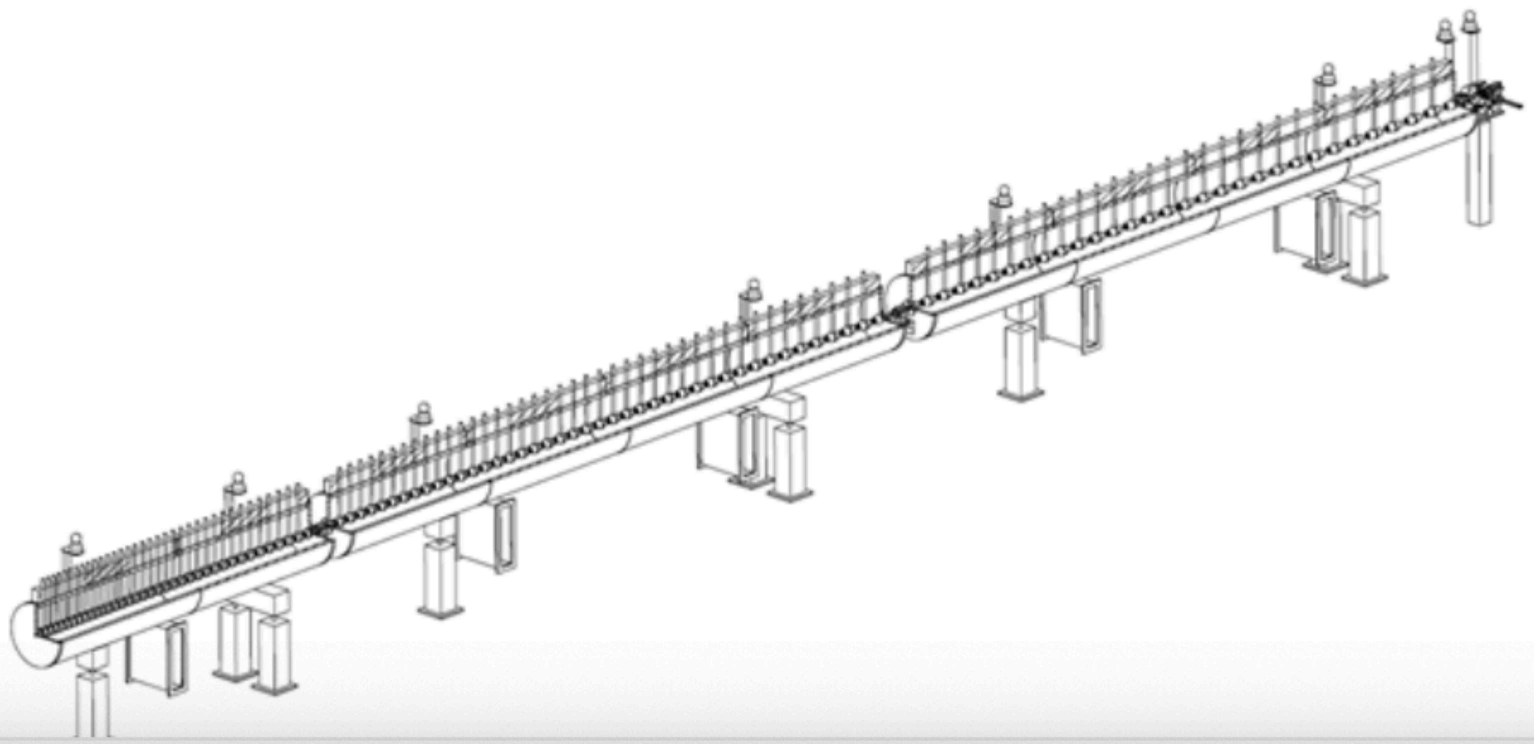
Fig. 9: Field distribution in a DTL

ALVAREZ STRUCTURES: EXAMPLES

CERN LINAC 2 tank 1:
200 MHz 7 m x 3 tanks, 1 m diameter, final energy 50 MeV.



CERN LINAC 4: 352 MHz frequency, Tank diameter 500 mm, 3 resonators (tanks), Length 19 m, 120 Drift Tubes, Energy: 3 MeV to 50 MeV, β=0.08 to 0.31 $\rightarrow$ cell length from 68mm to 264mm.

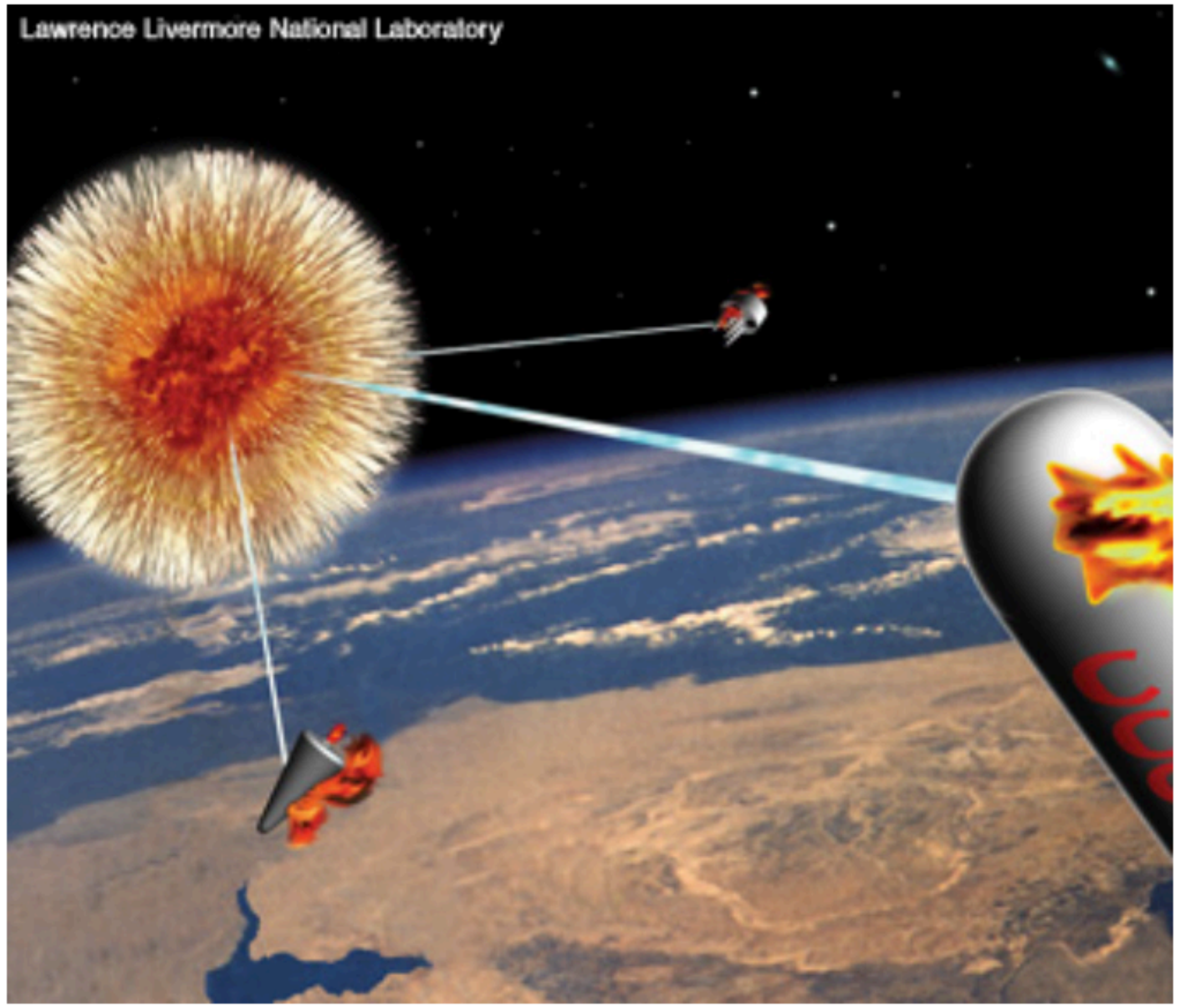


https://indico.cern.ch/event/532397/contributions/2170633/attachments/1343755/2025070/Alesini_LINEAR_ACCELERATOR_handouts.pdf

The History of the X-ray Laser

Jeff Hecht

The long and curious history of the X-ray laser began in an effort to expand the frontier of knowledge and culminated in one of the wildest schemes ever pursued by the United States government—the “Star Wars” missile defense initiative in the 1980s.



This artist’s concept shows beams from three X-ray rods destroying Cold War targets after detonation of the bomb powering the X-ray rods. If deployed in space, each of the thin rods of the X-ray laser weapon would be aimed at an enemy missile. From Joseph Nilsen, "Legacy of the X-ray Laser Program," Lawrence Livermore National Laboratory report.

https://www.optica-opn.org/home/articles/volume_19/issue_5/features/the_history_of_the_x-ray_laser/

Towards FEL based x-ray attosecond spectroscopy

PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS **8**, 040701 (2005)

Method of an enhanced self-amplified spontaneous emission for x-ray free electron lasers

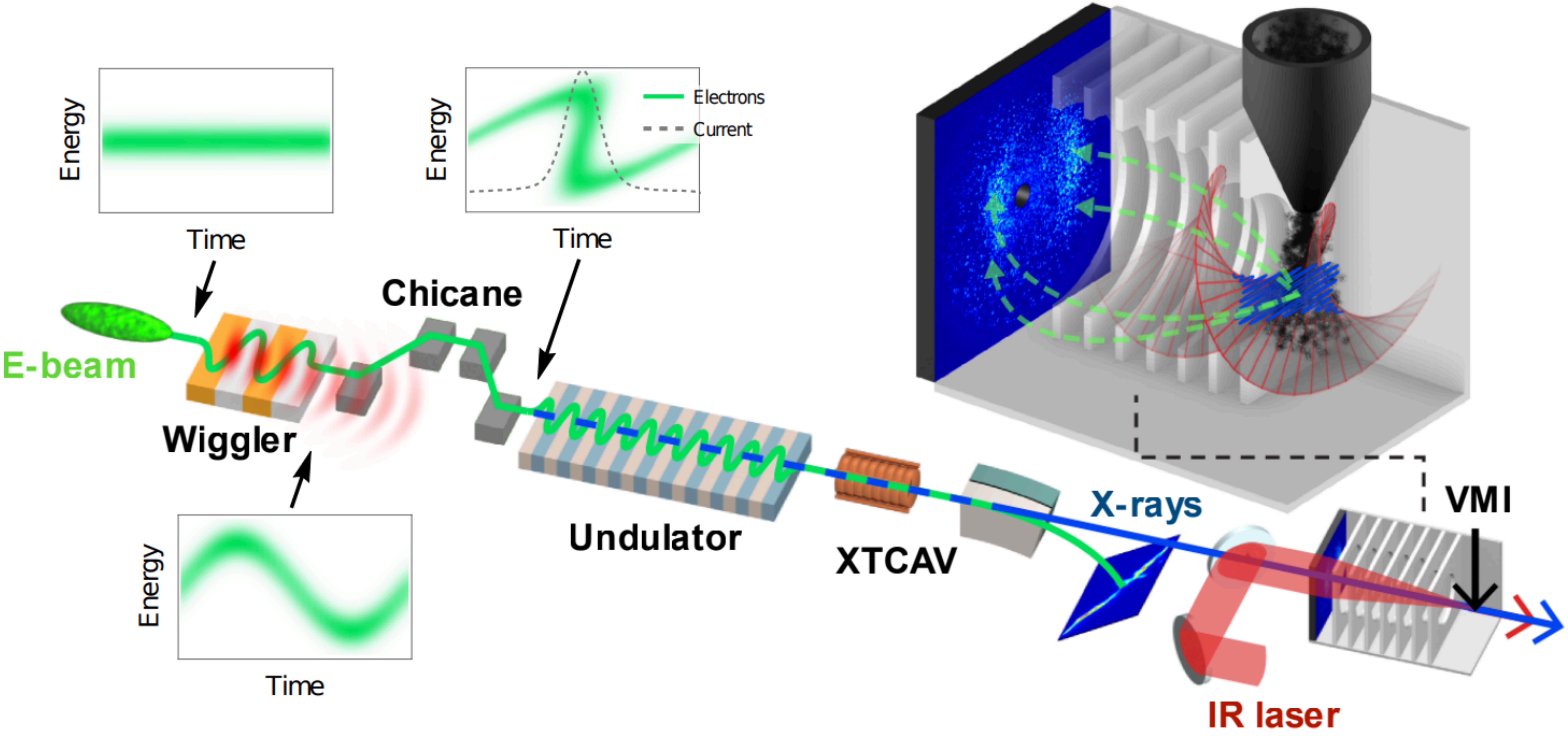
Alexander A. Zholents
Lawrence Berkeley National Laboratory, University of California, Berkeley, California 94720, USA
(Received 21 May 2004; published 12 April 2005)

Tunable isolated attosecond X-ray pulses with gigawatt peak power from a free-electron laser

Joseph Duris, Siqi Li, Taran Driver, Elio G. Champenois, James P. MacArthur, Alberto A. Lutman, Zhen Zhang, Philipp Rosenberger, Jeff W. Aldrich, Ryan Coffee, Giacomo Coslovich, Franz-Josef Decker, James M. Glownia, Gregor Hartmann, Wolfram Helml, Andrei Kamalov, Jonas Knurr, Jacek Krzywinski, Ming-Fu Lin, Jon P. Marangos, Megan Nantel, Adi Natan, Jordan T. O'Neal, Niranjan Shivaram, ... Agostino Marinelli

+ Show authors

Nature Photonics **14**, 30–36 (2020) | Cite this article



Energy
Time
Energy
Time
Electrons
Current
Chicane
E-beam
Wiggler
Energy
Time
Undulator
XTCAV
X-rays
VMI
IR laser