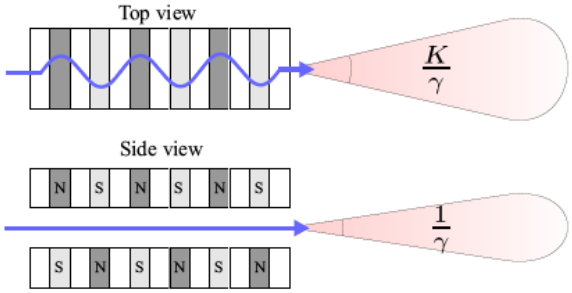
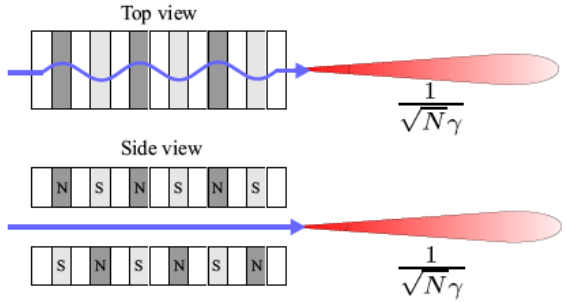
Insertion devices: more bends for more light

Wiggler:
large angular excursions,
essentially a series of bends

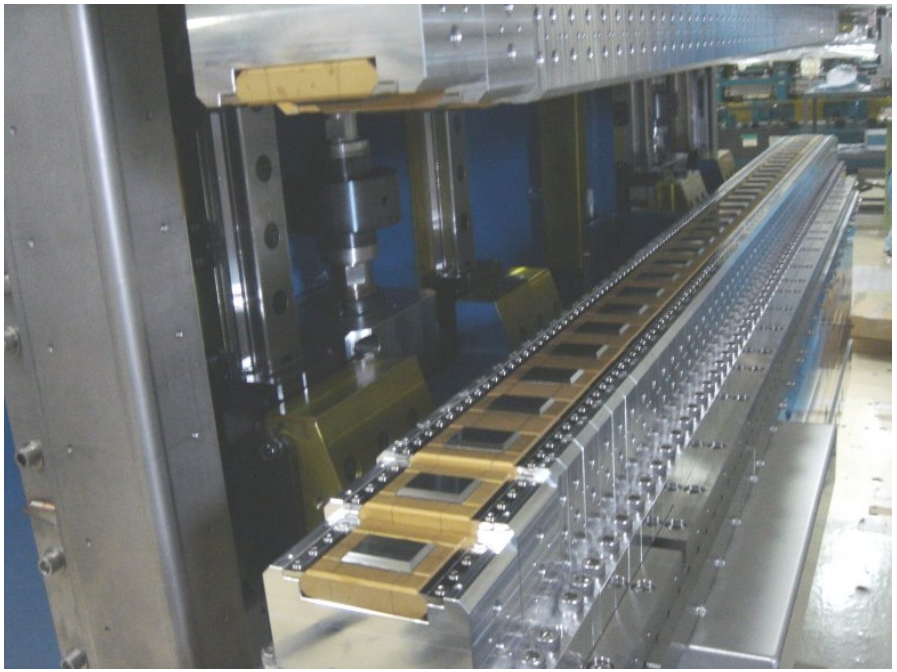


Undulator:
small angular excursions,
inteference phenomena

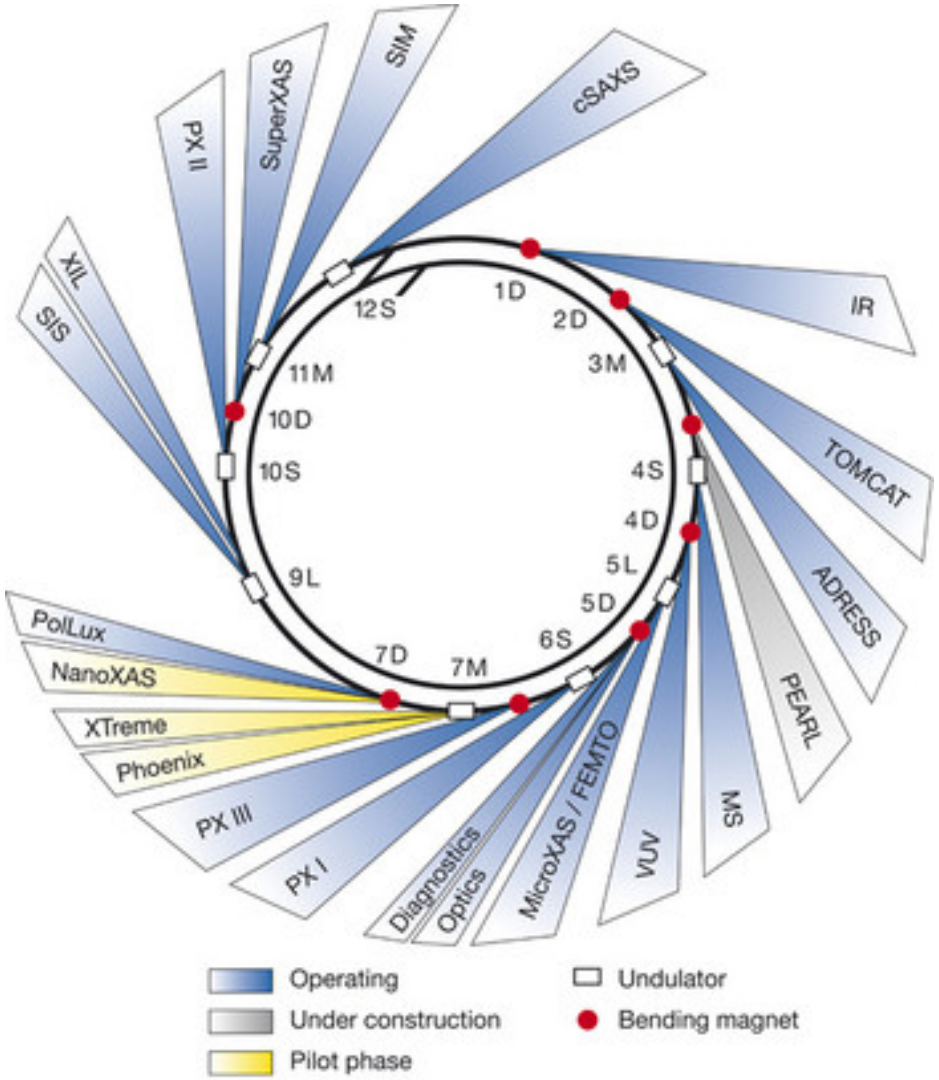


[Als-Nielsen & McMorrow, *Elements of Modern X-ray Physics*, John Wiley & Sons, Ltd, 2001]

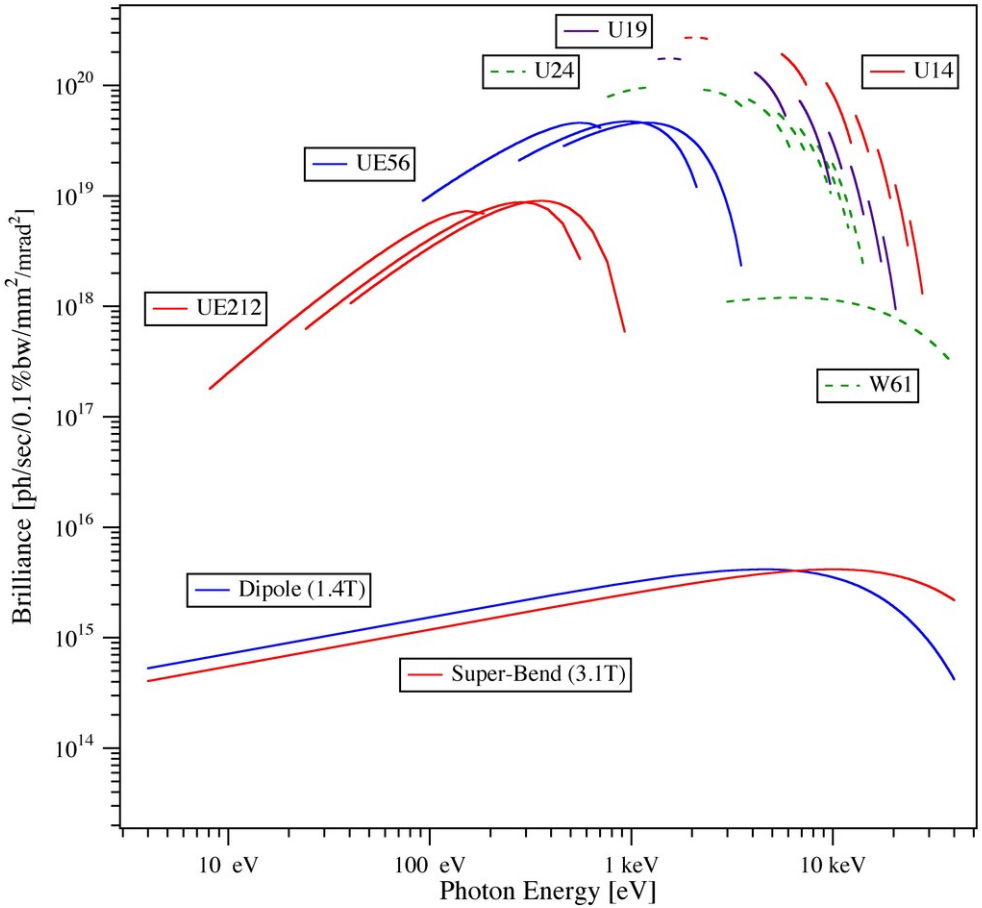
Insertion devices: more bends for more light

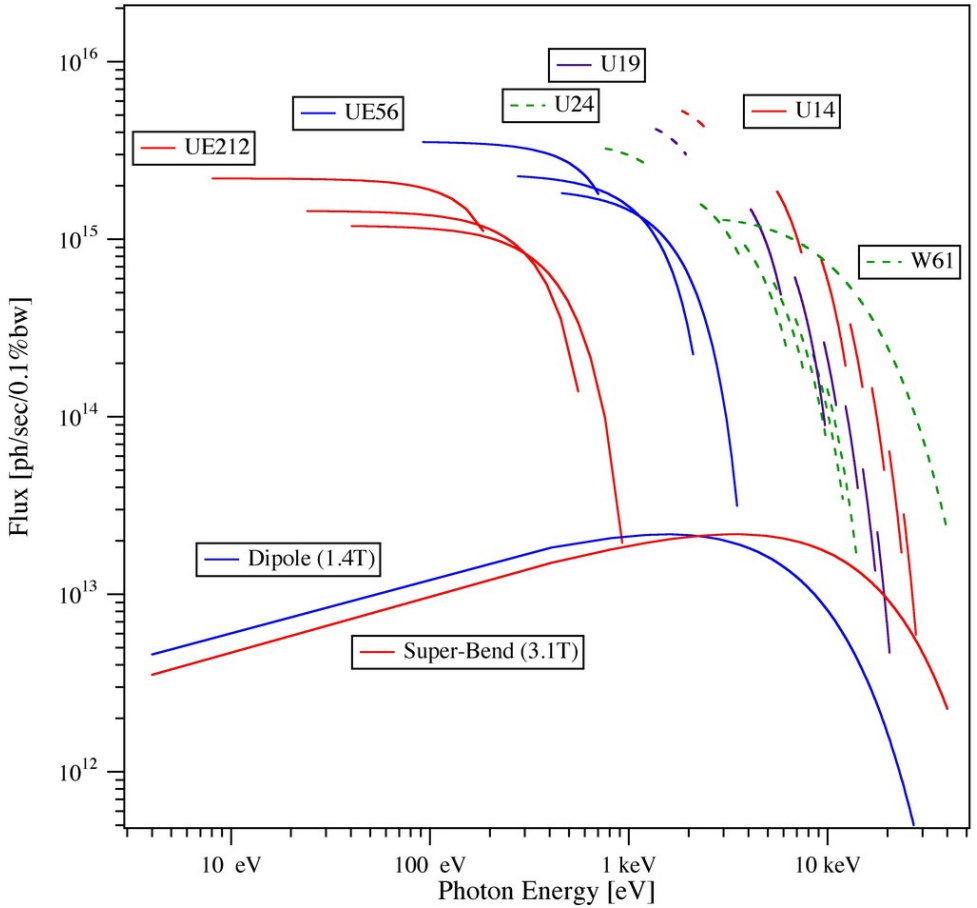


Swiss Light Source photon sources

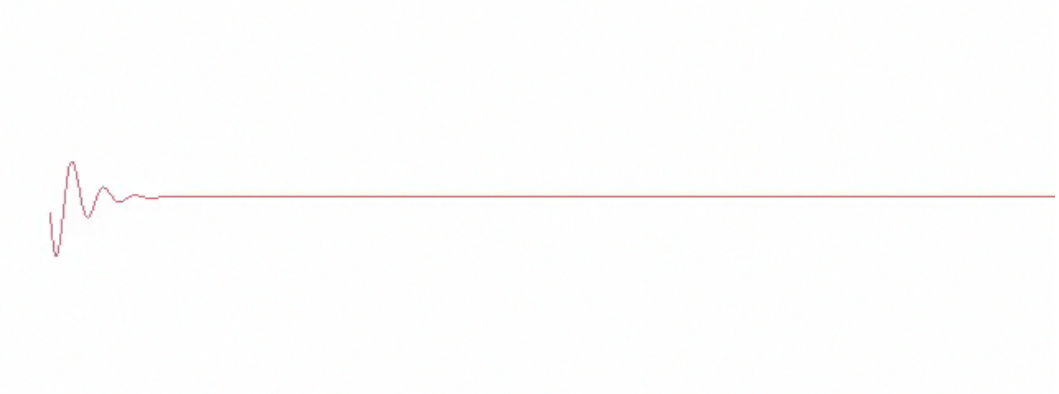


Swiss Light Source photon sources



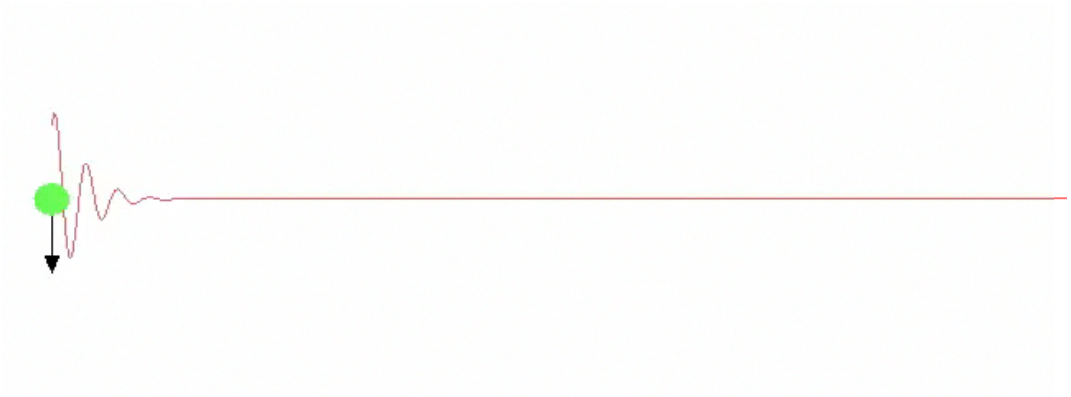


Energy exchange



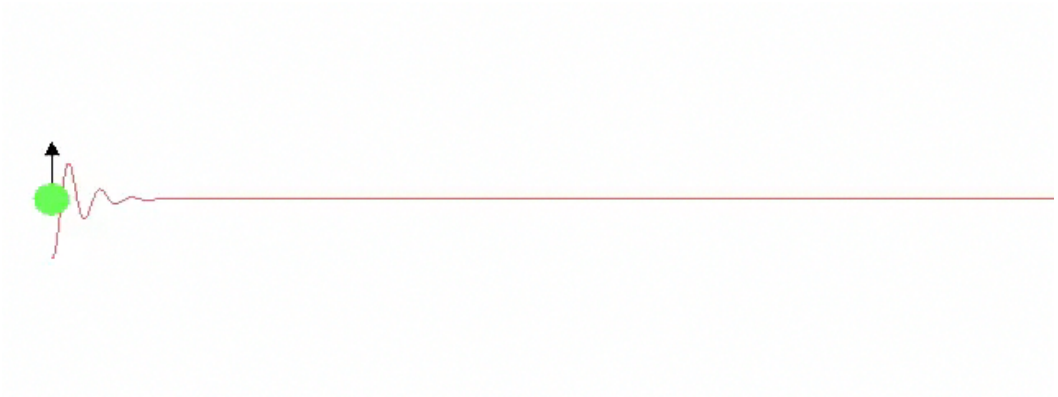
- E-field of light transverse to direction of propagation
- Can exchange energy with electrons with a transverse momentum component

Energy exchange



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

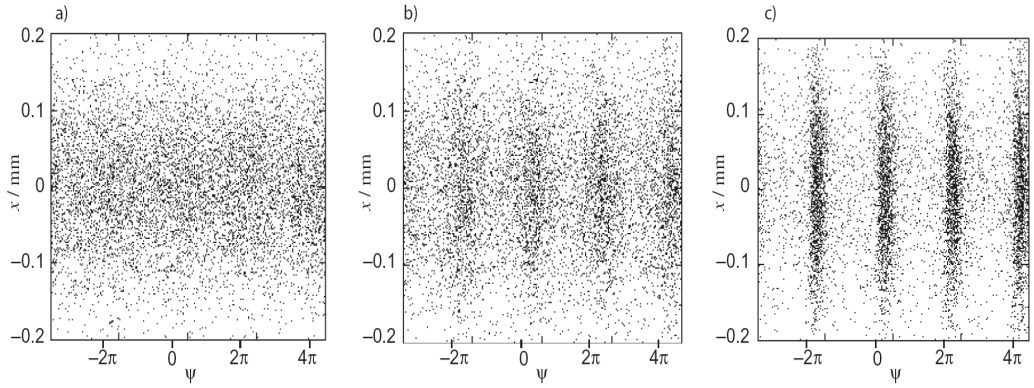
Energy exchange



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

Free electron laser

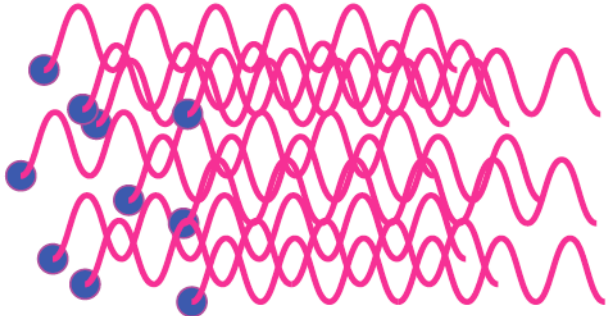
Microbunching: modulation of electron energy causes electrons to bunch with a periodicity…



Emission of bunched electrons adds coherently!

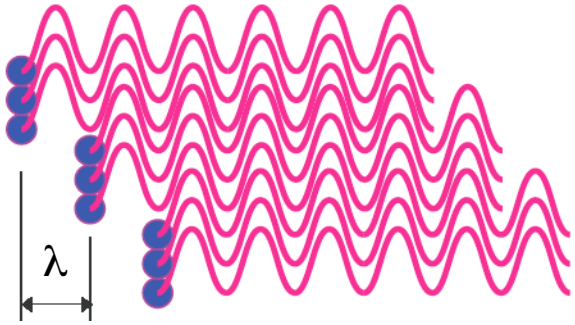
Microbunching enhancement

Spontaneous



$$P = N\ P_1$$

Superradiant

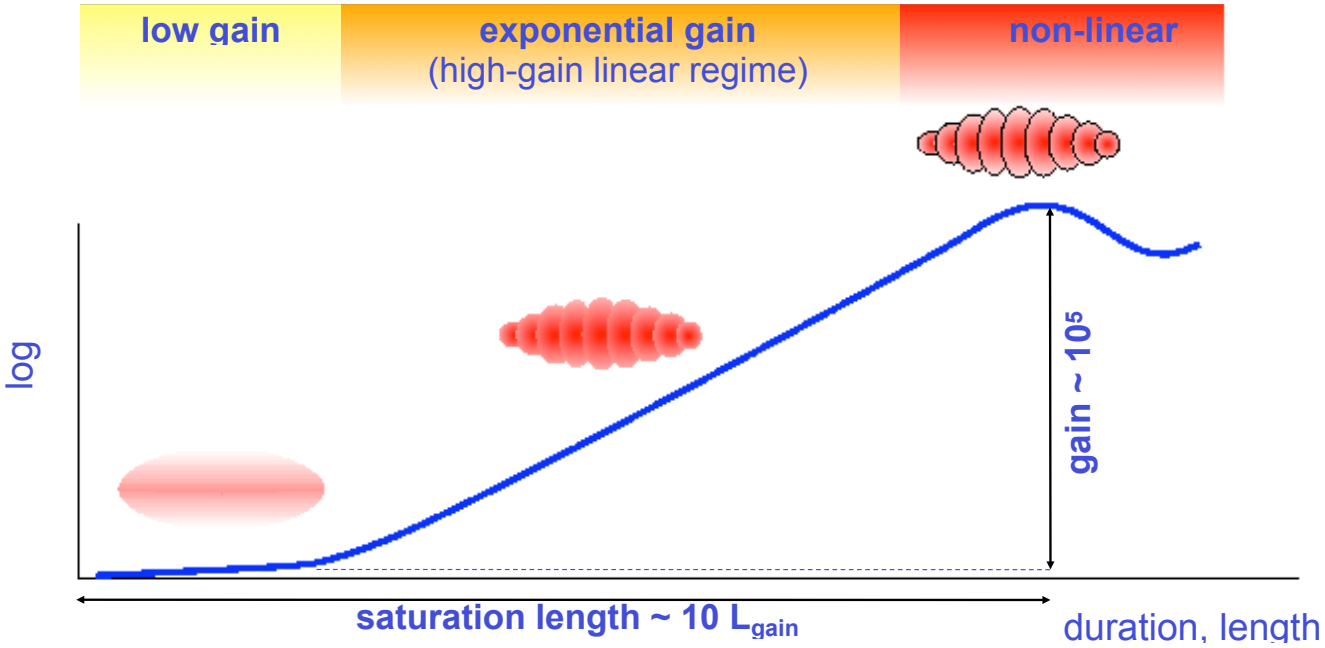


$$E = N\ E_1$$

$$P = N^2\ P_1$$

N ≈ 10⁹

Saturation



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

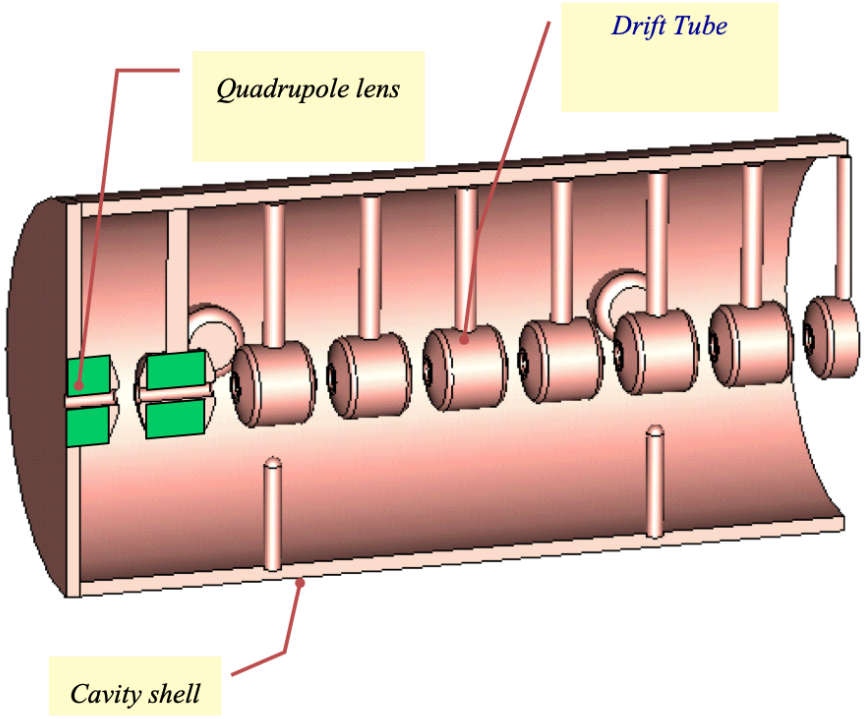


Fig. 8: Sketch of the DTL

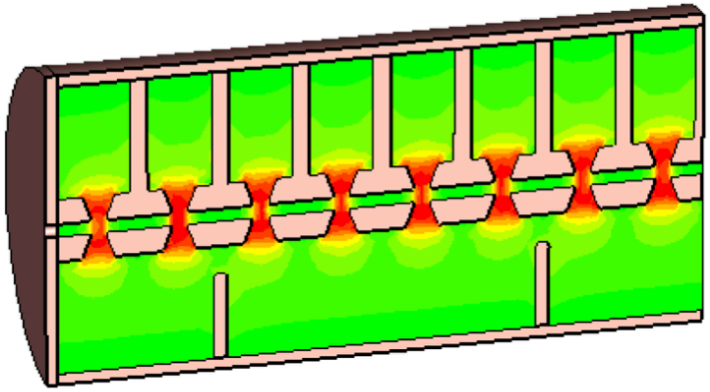


Fig. 9: Field distribution in a DTL

X-ray Cerenkov

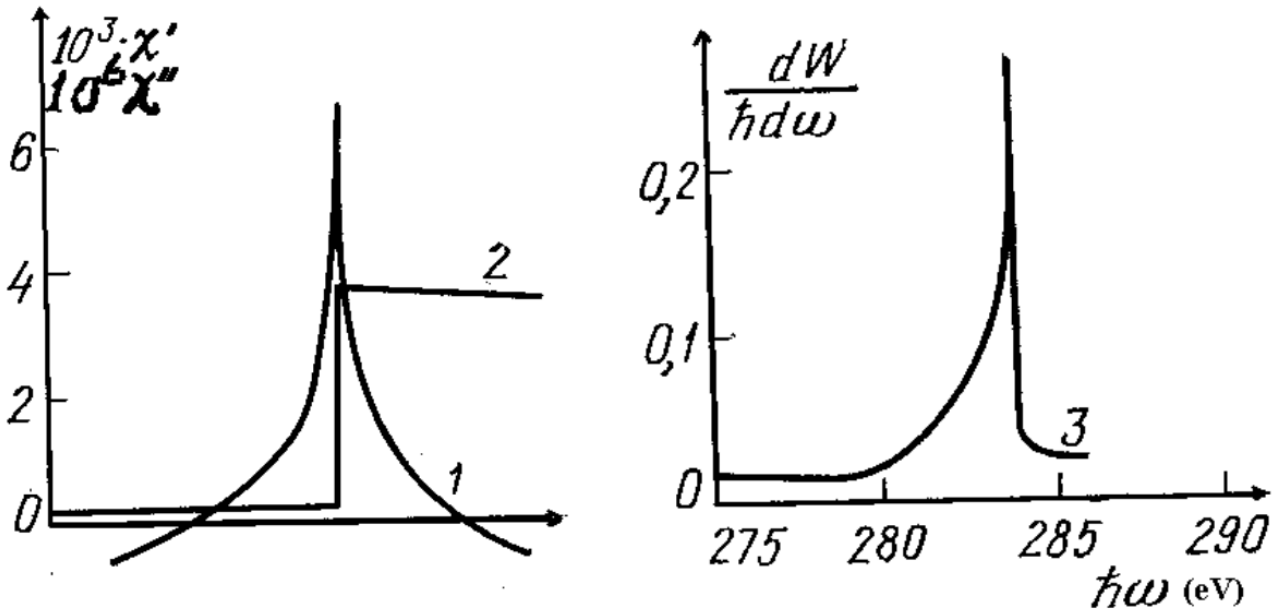
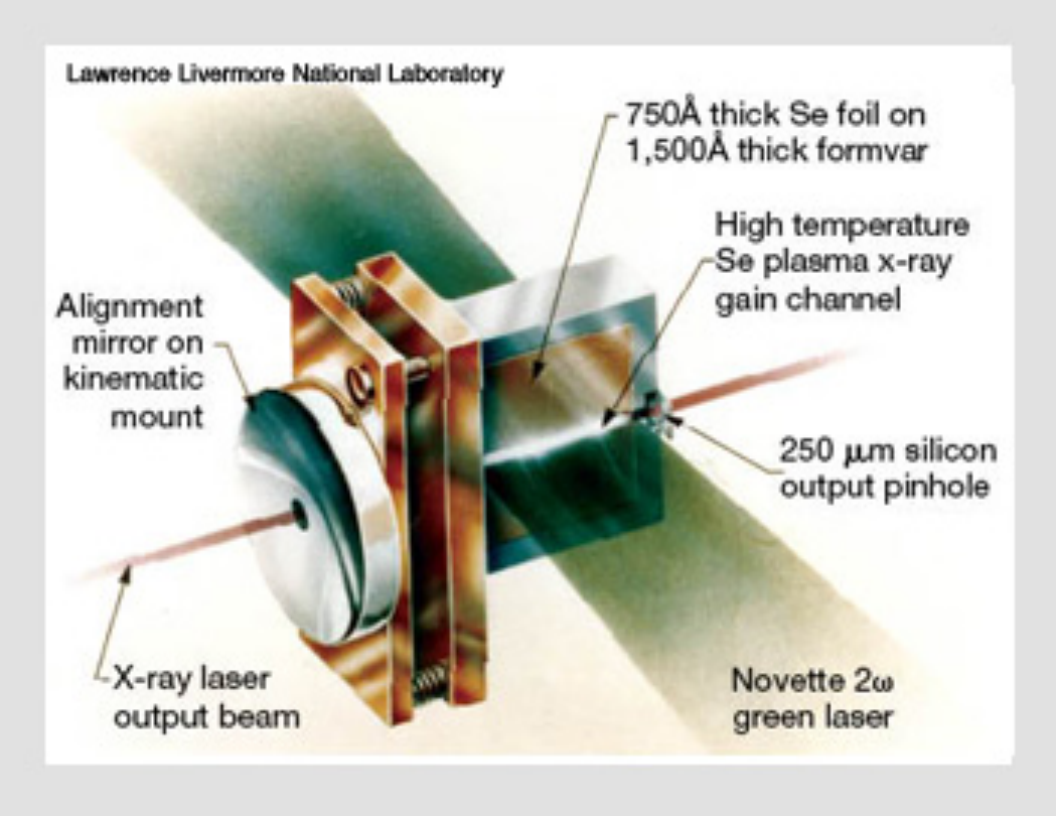


Figure 1. Dependence of χ' and χ'' a) and of XCR intensity b) produced by 1 GeV electrons in carbon with ρ =1.5 g/cm^3 upon photon energy [15].

https://link.springer.com/chapter/10.1007/1-4020-3450-4_17

Atomic transition x-ray laser



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