

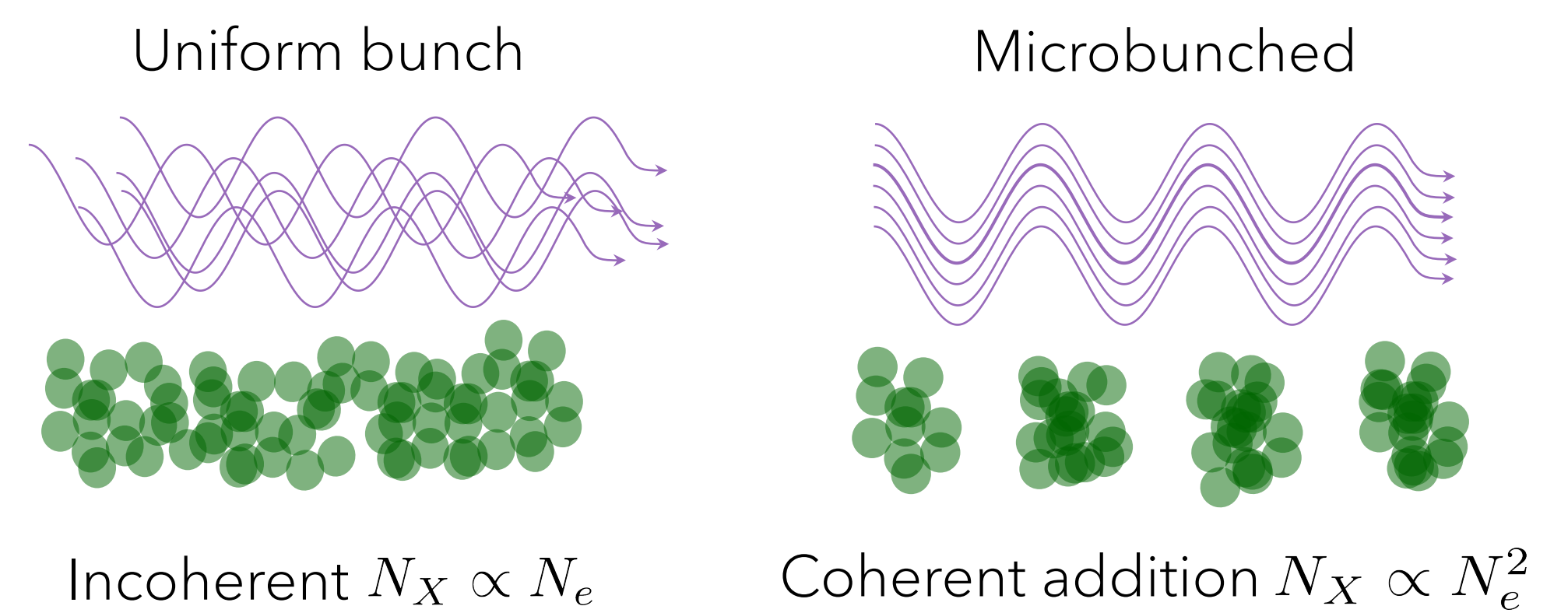
Smart*Light 2.0

Coherent soft x-rays from microbunched electrons

Coherent Compton Scattering

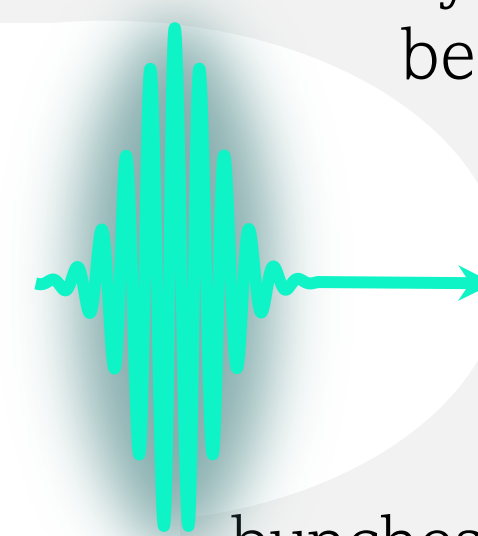
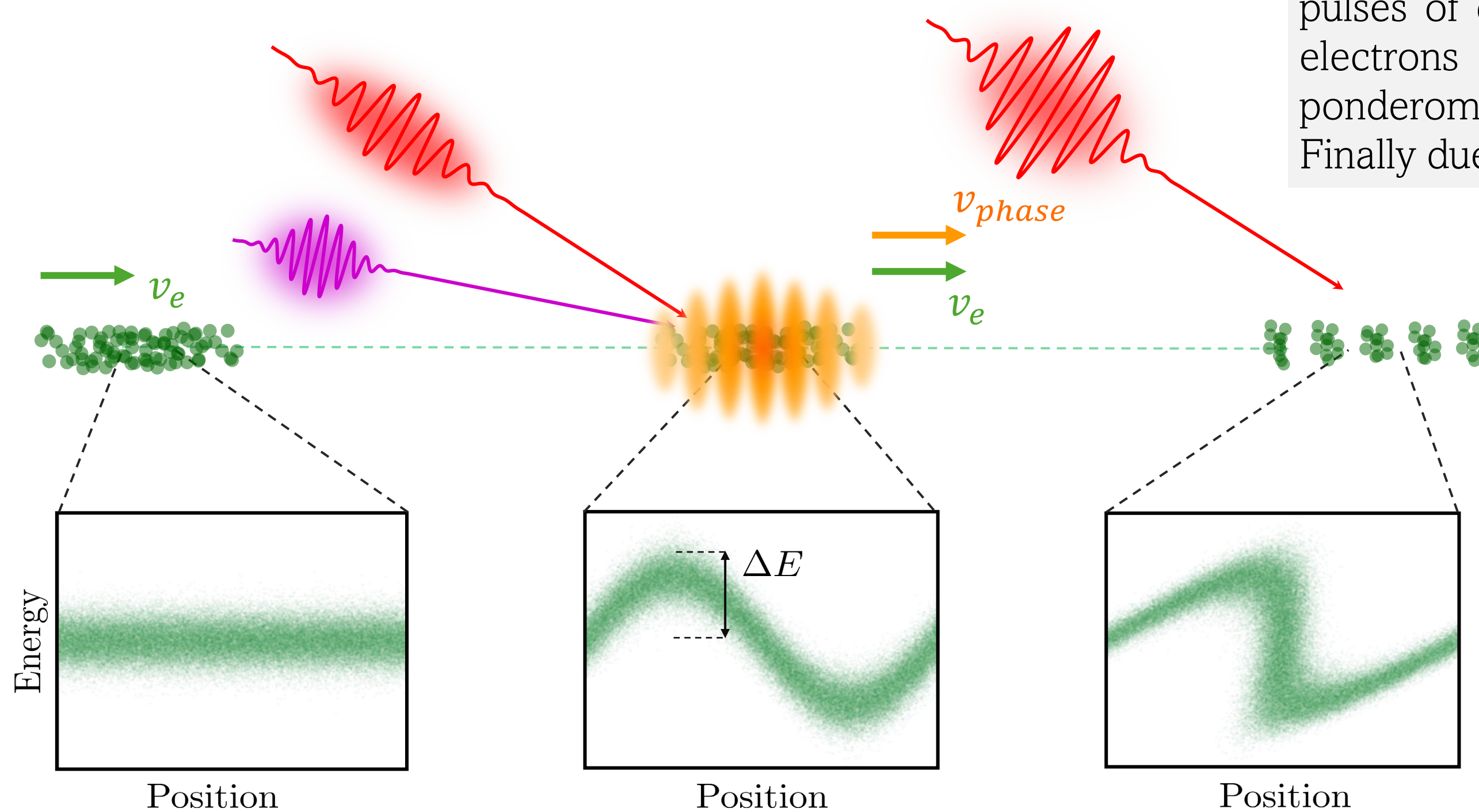
Compact sources offering high-brightness radiation in the EUV to x-ray regime are highly desired. Inverse Compton scattering (ICS), in which an electron beam colliding with a laser pulse produces radiation, is a source of x-rays of increasing prevalence in modern labs, complementing large scale facilities like synchrotrons and x-ray free electron lasers.

Due to the small Thomson cross-section, the efficiency of ICS sources is low. Especially in the EUV and soft x-ray regime. This efficiency can be enhanced by orders of magnitude via coherent emission [1]. However, microbunching at the beam energy relevant to ICS sources is a challenge that has yet to be met.



Ponderomotive Bunching

We propose to attain microbunching in the following two steps. First the electron beam interacts with two laser pulses of different frequency and interaction angles. Here electrons interact with the laser field via the ponderomotive force, resulting in an energy modulation. Finally due to the velocity difference within the electron beam, microbunching is formed.



This process has been described analytically for realistic lasers and electron bunches. For electron beams with low emittance and energy spread, mJ laser pulses are sufficient to attain microbunching in the extreme UV.

Utilizing the echo effect, similar to echo-enables harmonic generation [2], would allow for coherent Compton scattering at soft x-ray wavelengths

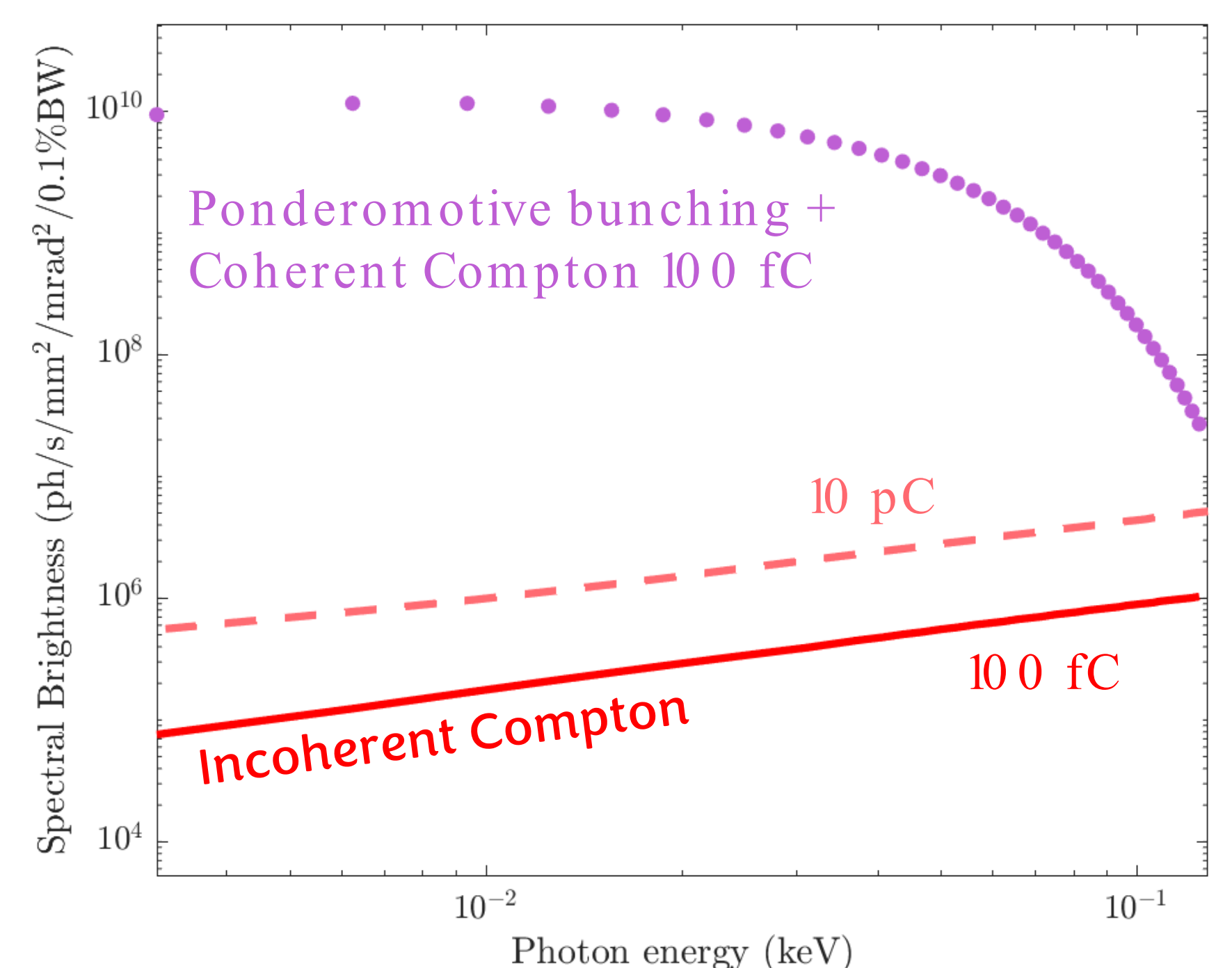
Coherent Compton source

From our analytical model and particle tracking simulations we propose a coherent ICS source. The electron and laser parameters are based on the current setup of Smart*Light at the TU/e [3].

Buncher		
Wavelength	800 nm	266 nm
Pulse energy	1 mJ	100 μJ
Interaction angle	5.7 deg	3.3 deg
Energy mod.	19 keV	
Drift length	8.2 cm	

Electron beam	
Beam energy	10 MeV
Bunch charge	100 fC
Energy spread	1 keV
Normalized emittance	15 nmrad
Repetition rate	1 kHz

Compton Laser	
Wavelength	800 nm
Pulse energy	10 mJ
Interaction angle	3-25 deg



References

- [1] Schaap, B. H., et al. "Ponderomotive bunching of a relativistic electron beam for a superradiant Thomson source." Phys. Rev. Accel. Beams 26, 074401
- [2] Stupakov, G. (2009). "Using the beam-echo effect for generation of short-wavelength radiation". Phys. Rev. Lett. 102, 074801
- [3] Nijhof, D. F. J. (2024). "Ultracold electron source development and X-band acceleration for a compact ICS-based x-ray source."