ENHANCEMENT OF ULTRASHORT X-RAYS PULSES

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INTRODUCTION

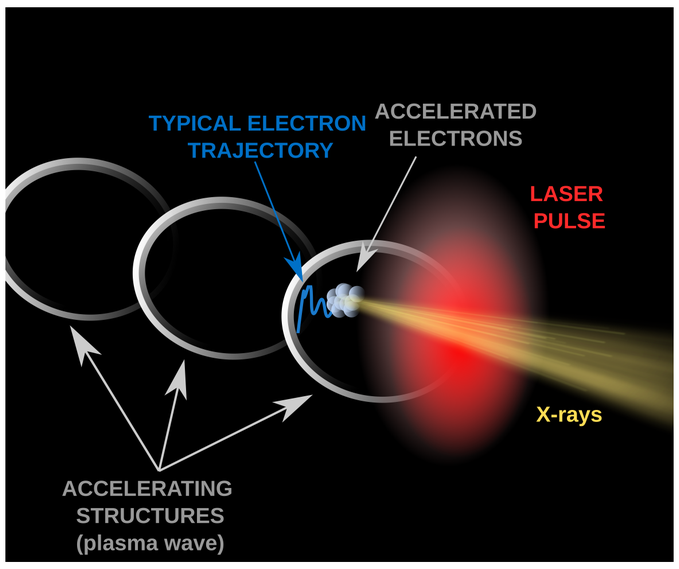
Short directional X-rays are interesting for many applications such as femtosecond chemistry, biology and medical imaging techniques.

They are produced by cyclic electron accelerators (synchrotrons) with large dimensions, due to the curved trajectories of electrons.

Plasma electron accelerators, still being in development, enable 1000x lower acceleration length $\Longrightarrow$ much more compact, lower price.

X-rays are produced during transverse oscillatory motion of electrons in accelerating plasma wave generated by a very intense ultrashort ($\sim$fs) laser pulse.

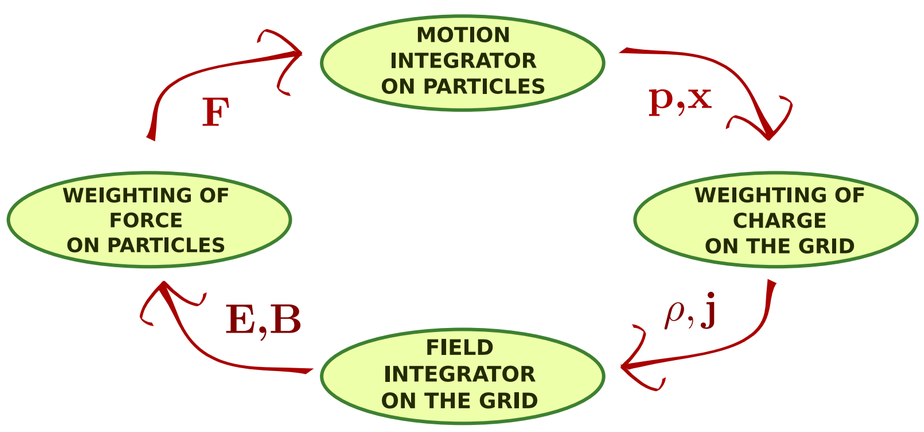
We show that the intensity of radiation can be increased by the manipulation with plasma density.

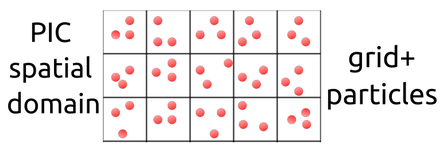


SIMULATION SET-UP

Calculation of electron trajectories: Particle-in-cell simulations (PIC) in the EPOCH Code; fields are calculated on a grid of cells filled with "macroparticles" (bunches of real particles). *Arber, T., PPCF 57 (11), 113001 (2015).*

Calculation of X-ray radiation: post-processing code based on calculation of Liénard-Wiechert potentials (radiation of moving charge). *Horný, V. et al. Physics of Plasmas 24 (6), 063107 (2017).*





2D PIC PARAMETERS

Laser wavelength λ	0.8 μm
Waist of the pulse	9.5 μm
Pulse duration	17.6 fs
Simulation time	5 ps
Simulation box size	85×30 μm^2
Cell size	0.027×0.04 μm^2
Particles per cell	4

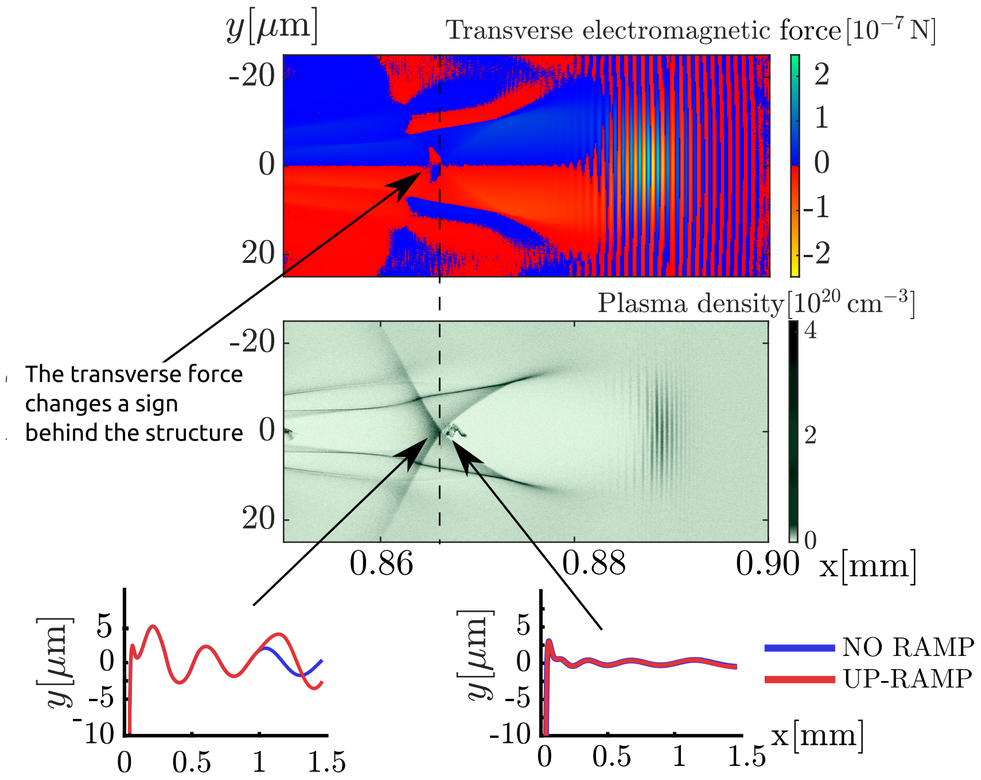
RESULTS

Electrons are focused into an axis during the acceleration in plasma.

The oscillations of electrons gradually attenuate. X-rays are suppressed.

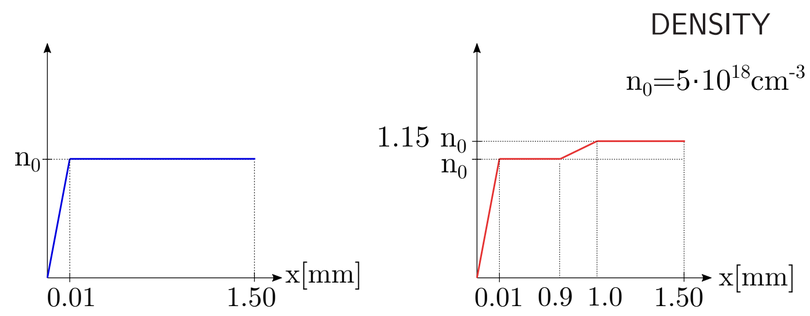
If the density is increased, electrons are pushed to the defocusing part of the plasma wave for few 10s of fs, it boosts the oscillation again.

The intensity of X-rays is increased, as shown by the simulations.



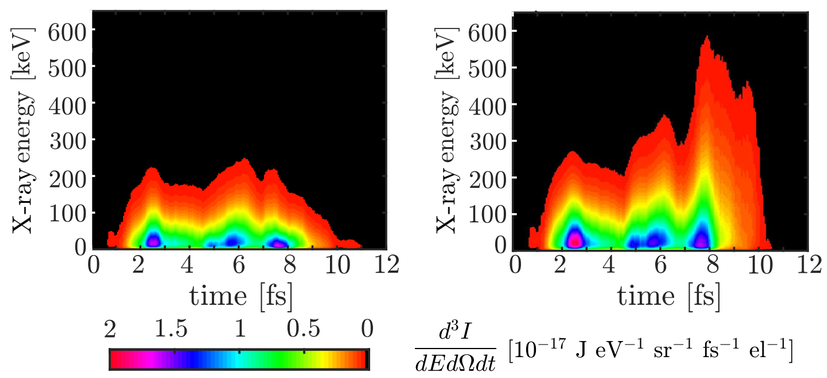
PLASMA DENSITY PROFILES

WITHOUT A RAMP **WITH AN UP-RAMP**



COMPARISON OF X-RAY SPECTRA

WITHOUT A RAMP **WITH AN UP-RAMP**



CONCLUSION

Plasma based electron accelerators introduce a new compact source of highly directional few-femtosecond X-ray beams. In this work, a new method that can increase the intensity of radiation in these accelerators is presented and verified by numerical simulations. It requires a slight plasma density modulation, which is nowadays experimentally achievable. Upcoming studies of the process in the 3D simulation geometry will help us understand and tune the process better for potential applications.

ACKNOWLEDGEMENT

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