# Sub-cycle pulse generation in laser-plasma interaction: from relativistic mirrors to laser wakefield driven amplification

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Electromagnetic pulses with duration less than an optical cycle can provide the ultimate temporal resolution for a given frequency range of interest. While a lot of recent progress has been achieved in the production of such sub-cycle pulses with conventional optical methods, scaling their energy faces limitations, such as material damage thresholds. Laser-plasma based methods could offer a way to overcome such limitations.

We recently proposed two schemes to generate energy-scalable sub-cycle pulses by employing amplification of a suitable seed-pulse at a sub-wavelength scale. In the first scheme, a electron bunch acts as a relativistic mirror interacting with an electromagnetic seed pulse of wavelength longer than the bunch duration [1]. In order to ensure sub-cycle amplification the electron bunch is injected into the seed pulse as the latter is reflected by foil. In the second scheme, we propose to produce sub-cycle pulses by utilizing the interaction of a low-intensity, long-wavelength seed pulse co-propagating with a wake driven by an intense pump laser pulse [2]. 3D PIC simulations show that a seed pulse with wavelength longer than the plasma skin depth can extract energy from the leading density spike of the wake. As a result of localized amplification, an intense, sub-cycle pulse is formed which is both frequency- and CEP-tunable.

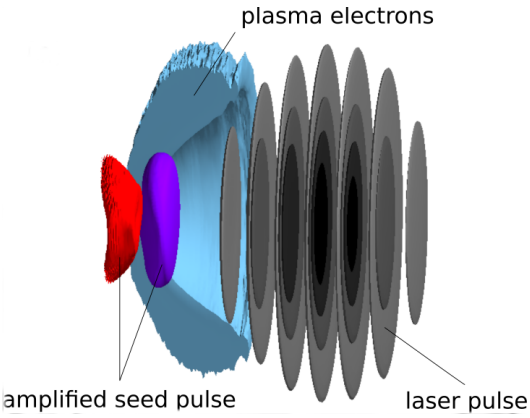


Figure 1: *Illustration of laser-wakefield-driven amplification [2].*

I will present simulations showing that sub-wavelength amplification can be implemented with laser drivers with energy of few tens of mJ, coupled to available or forthcoming mid-infrared sources. Moreover, both methods will be discussed under a common theoretical framework.

## References

[1] I. Thiele, E. Siminos, and T. Fülöp, Electron beam driven generation of frequency-tunable isolated relativistic sub-cycle pulses, Phys. Rev. Lett. 122, 104803 (2019)

[2] E. Siminos and I. Thiele, Laser wakefield driven generation of isolated CEP-tunable intense sub-cycle pulses, arXiv:1902.05014