Towards a Free Electron Laser Using Laser Plasma Acceleration on COXINEL

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Since the laser invention, the advent of X-ray Free Electron Lasers (FEL) half a century later, has opened new areas for matter investigation with higher temporal resolution. In parallel, the spectacular development of laser plasma acceleration (LPA) [1] that delivers today several GeV beam acceleration [2] in an extremely short distance appears also very promising. The qualification of the LPA for FEL application can thus be viewed as an important challenge [3]. Nevertheless, present LPA electron beam parameters (e. g. energy spread and beam divergence) do not meet conventional accelerator state-of-the-art performance and FEL application required a specific beam handling. In such a prospect, the COXINEL beam manipulation line [4, 5] using variable permanent magnet quadrupoles for emittance growth mitigation and de-mixing chicane equipped for the energy spread handling developed at SOLEIL has been installed for using electrons produced with the 60 TW laser of Laboratoire d'Optique Appliquée. Strategies for controlling electron beam position and dispersion have been elaborated and demonstrated [6]. Finally, undulator spontaneous emission has been measured at the end of the line.

References

[1] T. Tajima, J. Dawson, Laser electron accelerator, Physical Review Letters **43**, 267–270 (1979).

[2] W. P. Leemans *et al.*, Multi-GeV electron beams from capillary-dischargeguided subpetawatt laser pulses in the self-trapping regime. Phys. Rev. Lett. **113**, 245002 (2014).

[3] M. E. Couprie, A. Loulergue, M. Labat, R. Léhé, V. Malka,"Towards Free Electron Laser with Laser Plasma Accelerators,"J. Physics B: At., Mol. Opt. Phys. **47**, 234001 (2014)

[4] A. Loulergue, M. Labat, C. Benabderrahmane, V. Malka, M. E. Couprie,"Beam manipulation for compact laser wakefield accelerator based free-electron lasers",New J. Phys. **17**, 023028 (2015)

[5] M. E. Couprie *et al.*,"An application of Laser Plasma Acceleration: Towards a Free Electron Laser amplification,"Plasma Physics and Controlled Fusion, Volume 58, Number 3 (2016)

[6] T. André *et al.*, Control of laser plasma accelerated electrons for light sources, to appear in Nature Comm.