Hybrid plasma accelerators: towards high brightness beams

M. F. Gilljohann[1,7,8], D. Campbell[5,6], Y. Y. Chang[2], S. Corde[1] J. P. Couperus[2], A. Debus[2], A. Döpp[7,8], M. Foerster[7,8], T. Heinemann[4,5,6], B. Hidding[5,6], A. Irman[2], S. Karsch[7,8], A. Knetsch[1], A. Koehler[2], O. Kononenko[1], Y. Mankovska[1], A. Martinez de la Ossa[4], A. Matheron[1], A. Nutter[5,6,2], R. Pausch[2], P. San Miguel Claveria[1], S. Schoebel[2,3], U. Schramm[2,3], P. Ufer[2,3]

[1] *LOA, Palaiseau, France;* [2] *HZDR, Dresden, Germany;* [3] *TU Dresden, Dresden, Germany;* [4] *DESY, Hamburg, Germany;* [5] *The Cockcroft Institute, Warrington, UK;* [6] *University of Strathclyde, Glasgow, UK;* [7] *LMU München, Garching, Germany;* [8] *MPQ, Garching, Germany;* [9] *CASUS, Görlitz, Germany*

The unique properties of plasma with its ability to generate ultra-high electromagnetic fields makes it a promising candidate for novel types of particle accelerators and colliders. The basic mechanism of plasma-based accelerators is that an intense laser pulse or relativistic particle bunch drives an electron wave (wakefield) while traveling through plasma, and particles can be accelerated in the strong electric fields in its wake. The type of driver has a strong implication on the plasma dynamics and therefore the acceleration process. Our collaboration is developing a hybrid type of plasma accelerator that utilizes the synergy of both laser and electron drivers by using a laser-driven stage to generate the driver for a subsequent particle-driven stage [1]. This offers a path towards compact sources of electron beams of highest quality.

We would like to present experimental results from the combined effort of our collaboration during the last few years. The first milestone we achieved was the demonstration of laser-accelerated electron bunches driving plasma wakefields and its direct visualization using a few-cycle optical probe [2]. This allowed us to study the ion motion taking place in the acceleration process, which has implications for some types of large-scale plasma accelerators. The next milestone was the proof-of-concept controlled injection and acceleration of witness bunches [3, 4]. Most recently, we have shown experimentally that the hybrid scheme acts as a beam quality and stability transformer, where (comparably) low-quality laser-accelerated bunches are transformed into high-quality bunches with increased stability, a critical milestone demonstrating the very strong potential of the hybrid scheme.

References

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