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Investigating novel hybrid LPWFA accelerators using start-to-end PIConGPU simulations

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The use of accelerated electrons from a laser wakefield accelerator (LWFA) as drivers of a plasma wakefield stage (PWFA) provides compact PWFAs that can serve as a test bed for the efficient investigation and optimization of PWFAs and their development into brightness boosters. Such hybrid accelerators have been experimentally realized at HZDR and LMU to study novel injection schemes. To better understand the microscopic, nonlinear dynamic of these accelerators, the experiments were accompanied by 3D3V particle-in-cell simulations using PIConGPU.

Here, we present the latest results from these numerical studies, covering injections due to hydrodynamic shocks, beam self-modulation and breakup, and cavity elongation - all accompanied by synthetic diagnostic methods that allow direct comparison with experimental measurements.
Challenges such as parasitic injections, shock injections, and non-ideal driver beam dynamics will be discussed. Recent technical advances in PIConGPU that enabled the execution of these large-scale simulation campaigns are briefly covered, as well as new synthetic in situ shadowgraph and radiation diagnostics.

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