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Accompanying the hybrid LPWFA experiment campaign with a computer simulation campaign: What we model, what we learn, and where we need to become better

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The Hybrid Collaboration, a joint undertaking by HZDR, DESY, University of Strathclyde, LMU, and LOA, performed hybrid LPWFA experiments which utilize electron bunches from a laser wakefield accelerator (LWFA) as drivers of a plasma wakefield stage (PWFA) to demonstrate the feasibility of compact PWFAs serving as a test bed for the efficient investigation and optimization of PWFAs and their development into brightness boosters. 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 insights into the dynamics of the hybrid LPWFA that we gained from start-to-end simulations of the experimental setup at HZDR.

These regard electron injections due to hydrodynamic shocks, beam self-modulation and breakup, and cavity elongation - all backed-up by synthetic diagnostics that allow direct comparison with experimental measurements.

We discuss our approach to model these synthetic diagnostics directly within the PIconGPU simulation as well as modelling certain aspects of the experimental setup, such as the drive laser. Continuing this, the talk highlights a few recent technical advances in PIconGPU that enable better modelling of the micro-physics, experiment conditions, or signals of experiment diagnostics.

Acknowledgments

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