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

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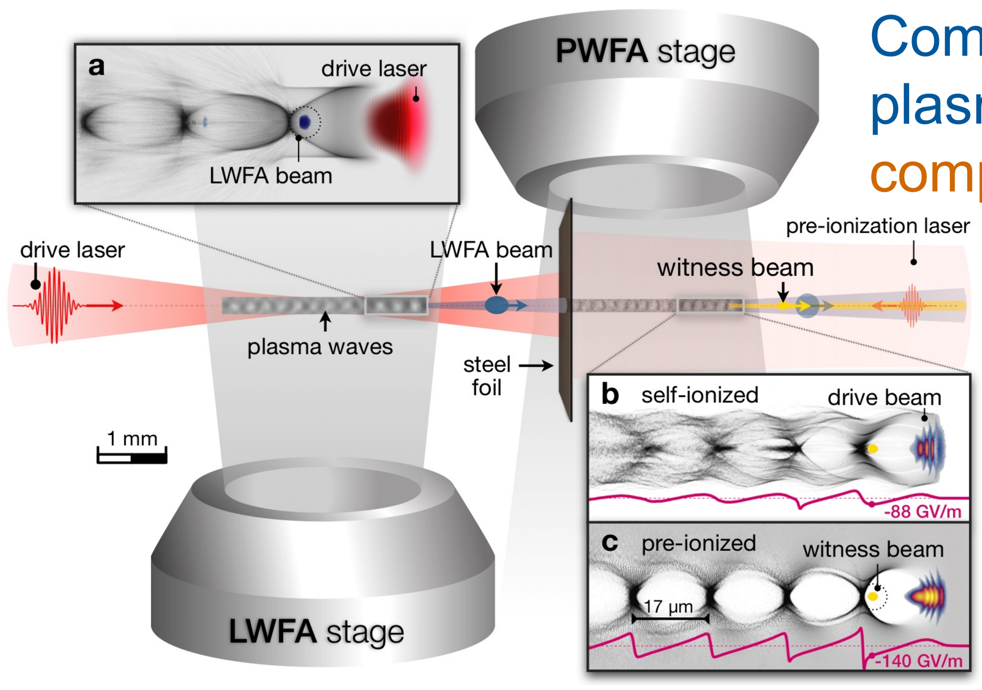
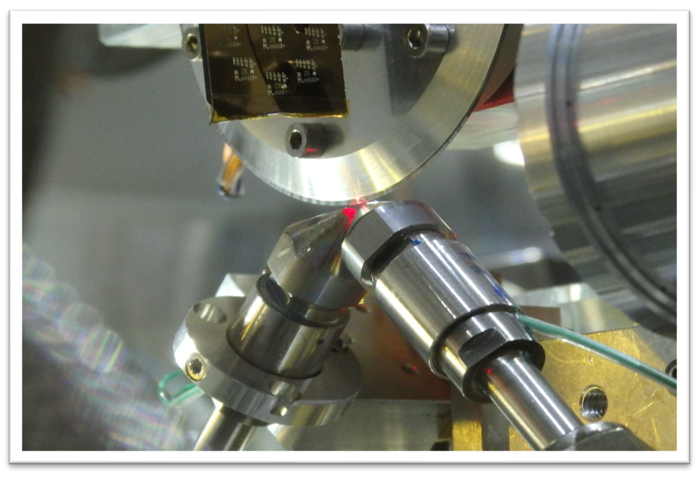
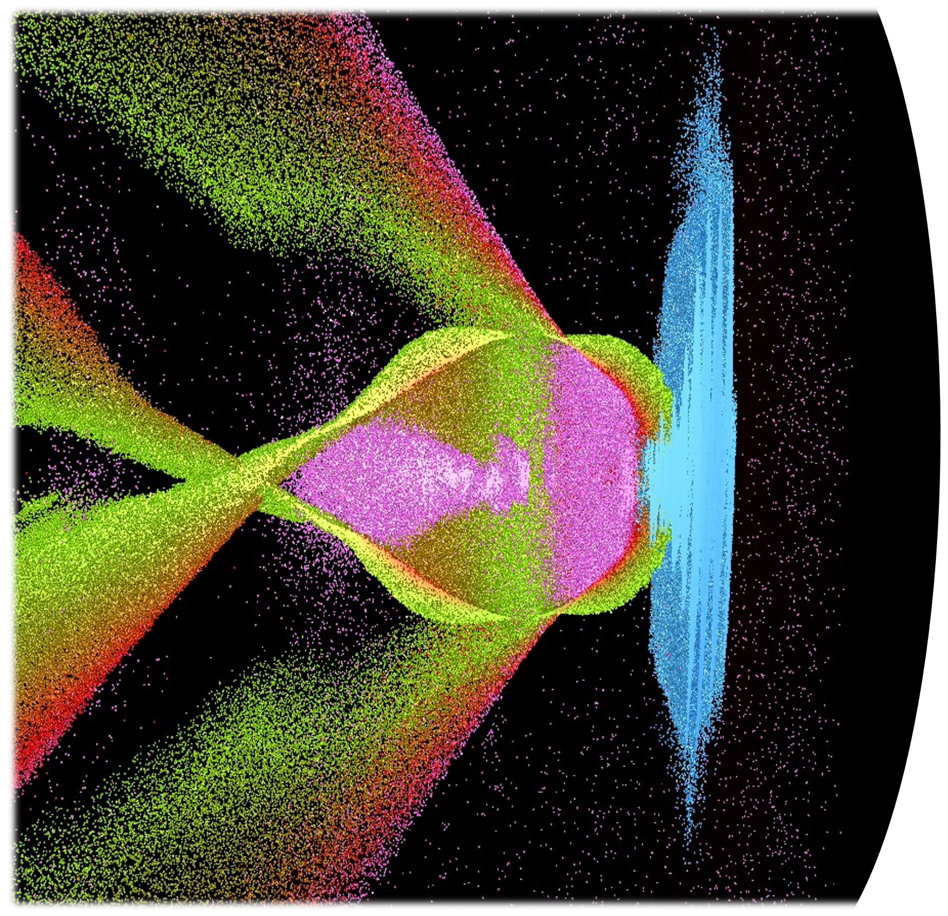
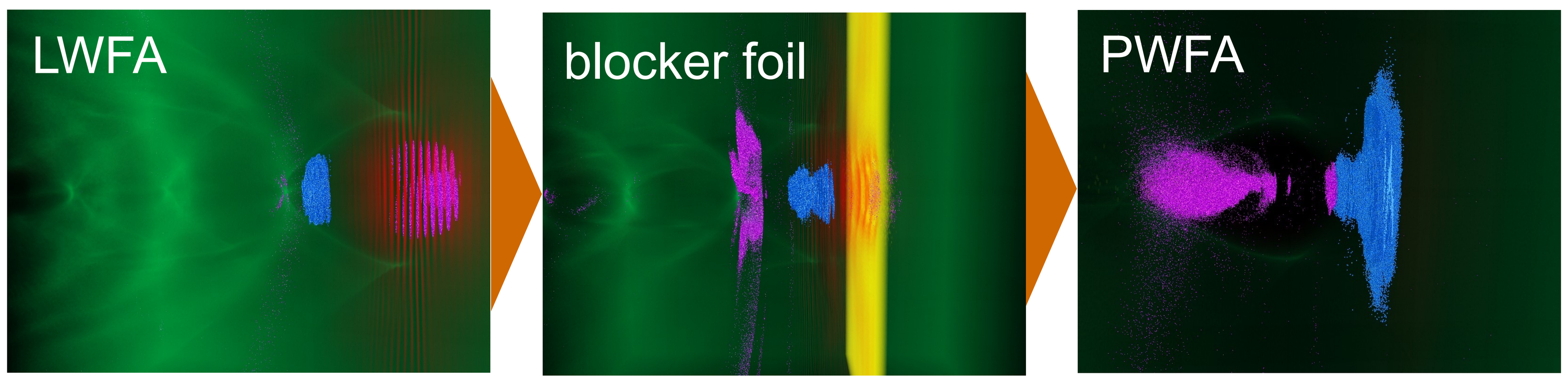
Fundamental concept of the L|PWFA hybrid acceleration scheme

Combining laser wakefield acceleration (LWFA) with beam-driven plasma wakefield acceleration (PWFA) allows to produce an extremely compact source for high brightness electrons.









In collaboration with:

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN · HZDR HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF · University of Strathclyde Glasgow · loa · DESY.

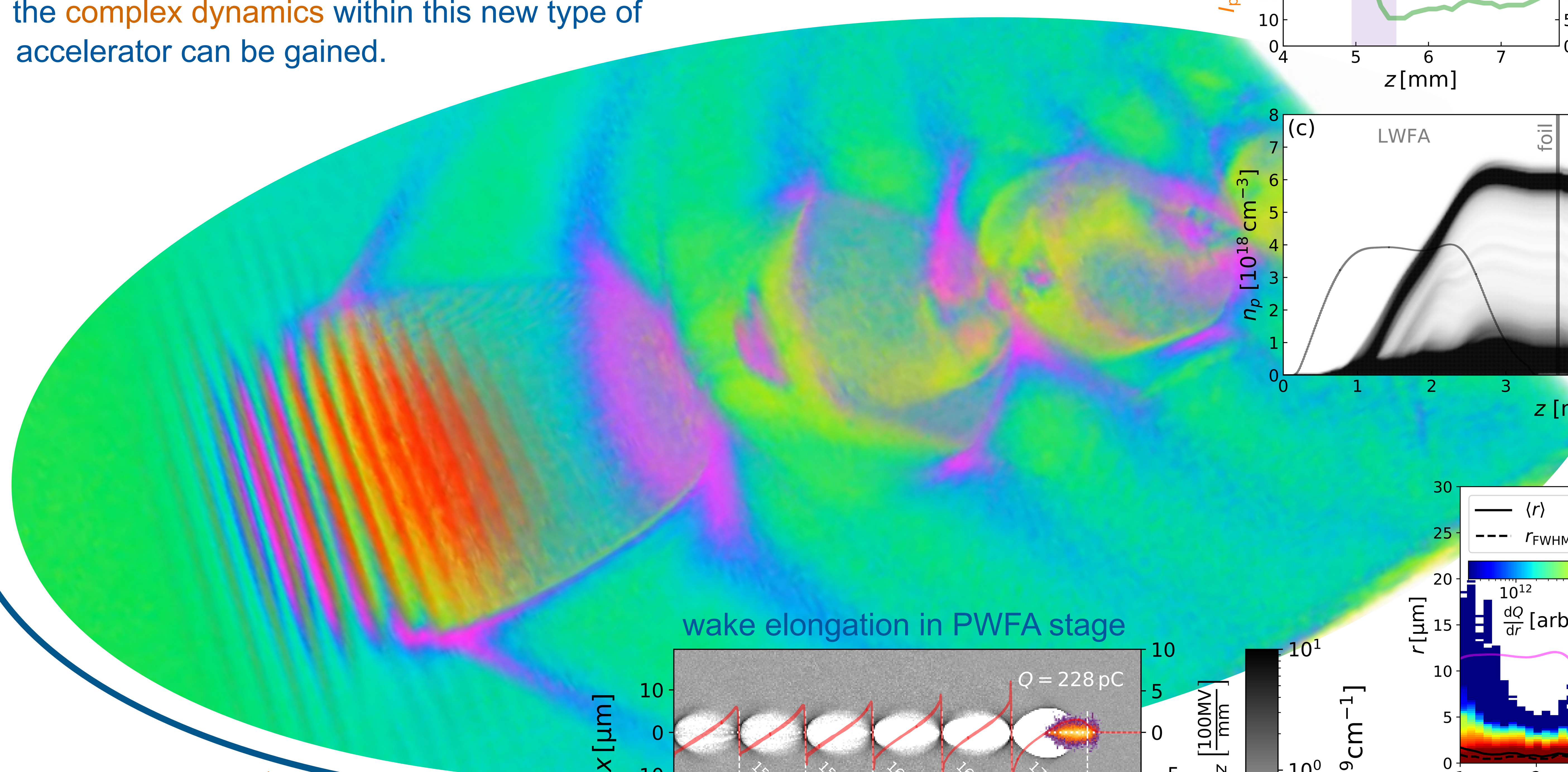
Kurz, T., Heinemann, T., et al. (2021)
Demonstration of a compact plasma accelerator powered by laser-accelerated electron beams
Nature Communications, 12(1), 2895

Couperus Cabadağ, J. P., Pausch, R., et al. (2021)
Gas-dynamic density downramp injection in a beam-driven plasma wakefield accelerator
Physical Review Research, 3(4), L042005

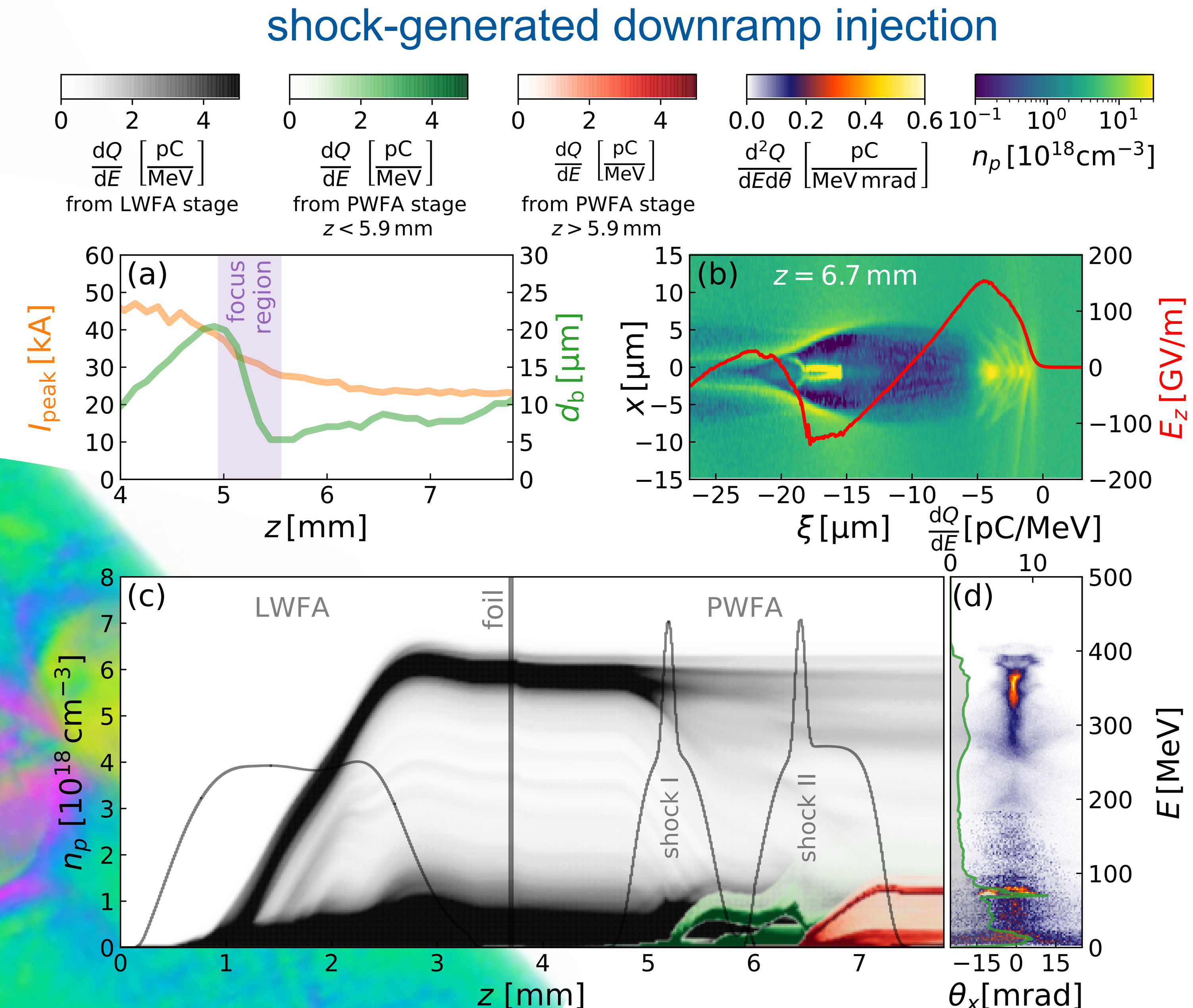
Schöbel, S., Pausch, R., et al. (2022)
Effect of driver charge on wakefield characteristics in a plasma accelerator probed by femtosecond shadowgraphy
New Journal of Physics, 24(8), 083034.

Studying the L|PWFA dynamics by modeling the experiment with PIConGPU

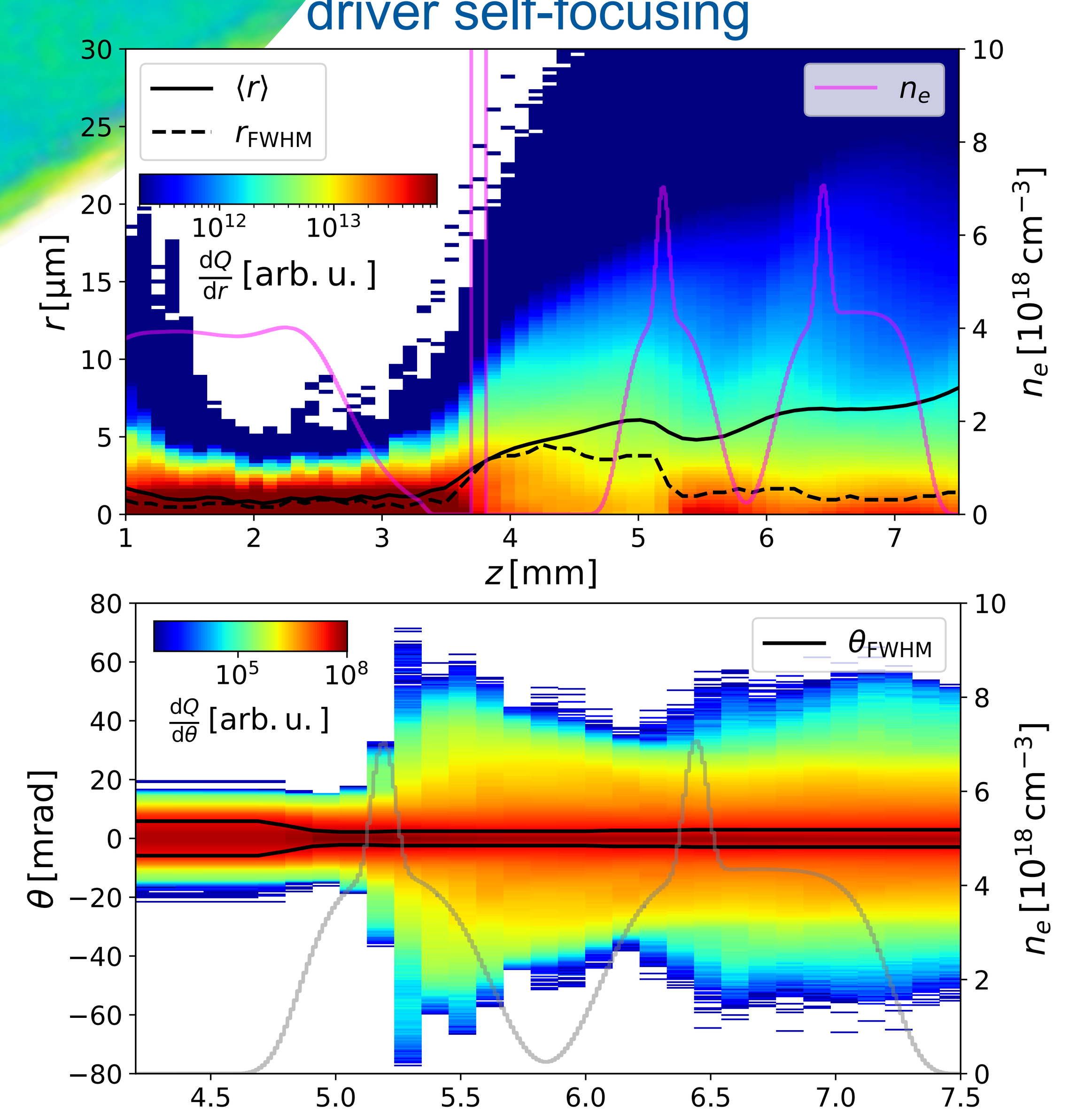
Gaining inside into laser plasma accelerators via simulations is an essential step in understanding and improving them. However, modeling the L|PWFA hybrid accelerator is a challenging task. Detailed input from the experiment like higher laser modes and exact density profiles need to be considered. Furthermore, particle-in-cell simulation are computationally expensive and require both a highly efficient and parallel simulation framework as well as sophisticated numerical algorithms like dispersion free or arbitrary order field solvers, efficient current depositing schemes and Liénard-Wiechert based initialization methods. Only with a constant feedback loop between experiment and theory, an understanding of the complex dynamics within this new type of accelerator can be gained.



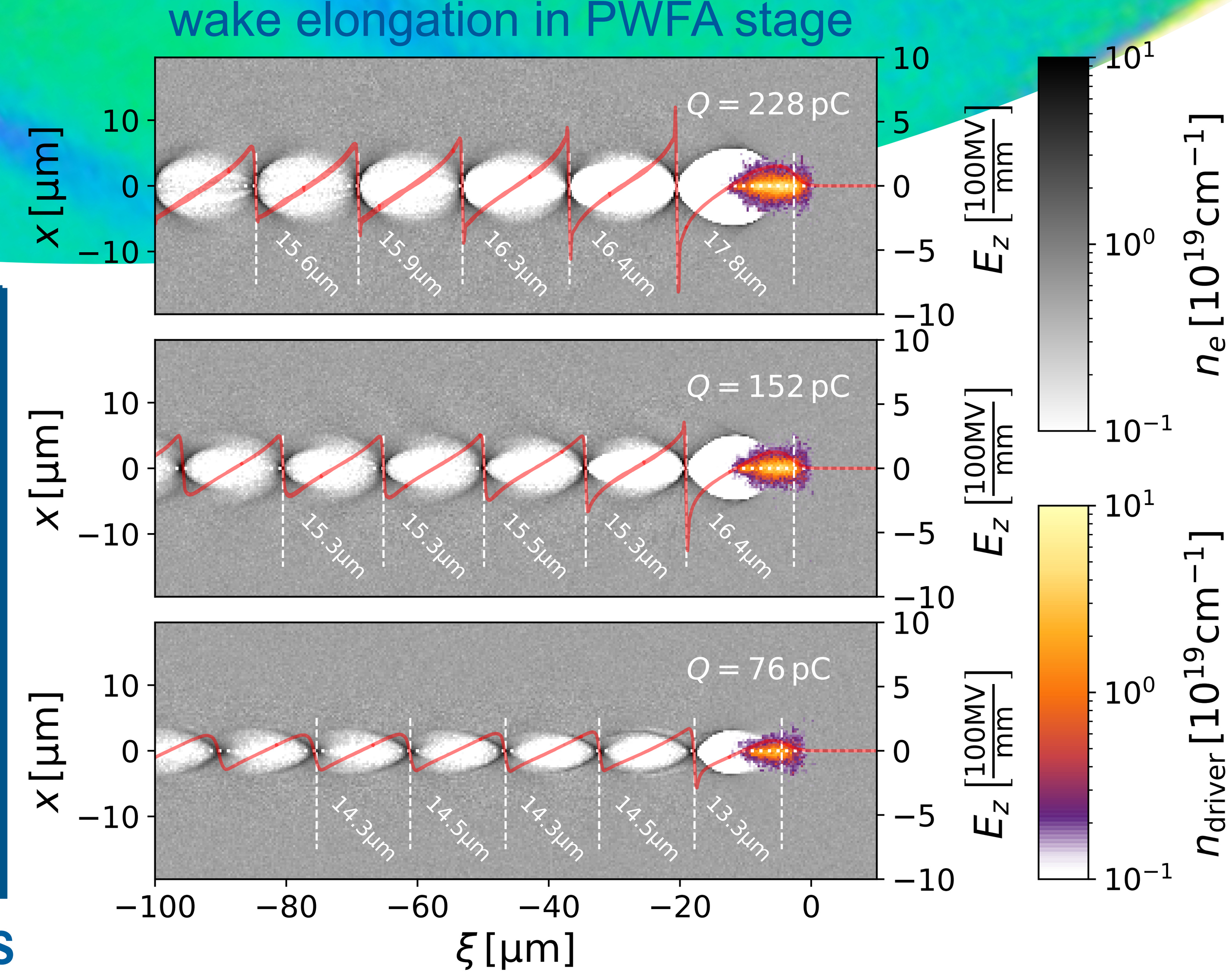
start-to-end L|PWFA hybrid accelerator with shock-generated downramp injection



driver self-focusing



wake elongation in PWFA stage



PIConGPU

for more details on PIConGPU, please see poster 101 by A. Debus

openPMD

PIConGPU uses alpaka and can run on any architecture from GPU to CPU

POWER8 · NVIDIA TESLA · SPARC64 · ARM · intel · intel Xeon Phi · AMD

PIConGPU is open source

try it yourself
http://picongpu.hzdr.de

Visualized with: ISAAC

Simulation performed at: ZIH · TECHNISCHE UNIVERSITÄT DRESDEN

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