Radiation imprint of ultra-intense laser heating of solids

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Laser-accelerated ions are increasingly recognized as a promising alternative to conventionally accelerated ion beams. Possible applications range from fast ignition in laser fusion to ion tumor therapy as well as studies of transient high-current and high-field phenomena in laboratory astrophysics and material science. A combination of ultra-short duration and very high charge density is the most sought-after characteristic of these beams which are produced in the violent interaction of an ultra-intense short pulse laser with a solid target.

We have performed the – to our knowledge – very first full 3D particle-in-cell simulations of this interaction that includes the picosecond time span prior to the arrival of the main laser pulse. This time period is thought to be decisive for the following main pulse interaction, yet it is poorly explored – partly due to the immense computational needs to resolve the plasma kinetically with full precision. Here, we bridge scales hitherto inaccessible, from attosecond plasma oscillations over few-femtosecond laser oscillations and transient, non-equilibrium plasma dynamics on the tens of femtosecond laser duration to picosecond pre-plasma development. We study the influence of pre-pulse laser conditions and material on the ion acceleration performance. Additionally, we aim to infer radiative signatures of the plasma dynamics and link them to isochoric heating, instability development, and other complex dynamics. Beyond gaining a fundamental understanding of the governing fundamental principle plasma dynamics, the results will be used in the ongoing development of novel diagnostics analyzing the bremsstrahlung and synchrotron radiation in order to experimentally probe the sub-ps interaction. The simulations have been performed at Piz Daint at CSCS, Switzerland, using the 3D particle-in-cell code PIConGPU developed at HZDR.

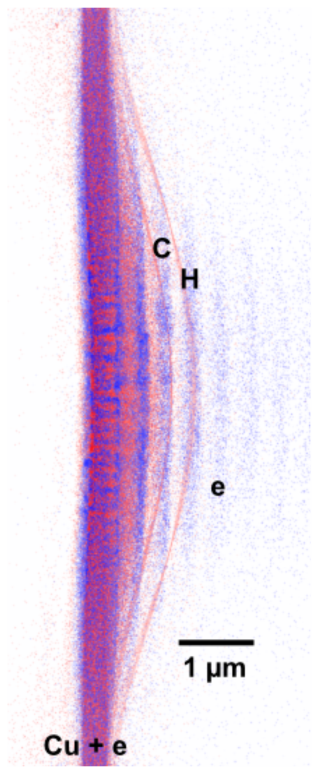

Figure 1: *Longitudinal current density component of a 300nm Cu target with organic contamination layer.*