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Optimization of Laser Wakefield Acceleration for High-Quality Electron Beams

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Laser Wakefield Acceleration (LWFA) enables the acceleration of electrons to very-high energies over a few millimeters of plasma. High-intensity laser beams generate plasma waves with accelerating gradients up to 100 GV/m—far exceeding those of conventional accelerators. Current research focuses on optimizing electron beam quality, including charge, energy spread, and divergence. Achieving a high-quality electron beam is critical for advancing LWFA toward applications such as medical therapy, free-electron lasers, and compact future accelerators.
LWFA experiments are performed by the LPGP team at Helmholtz-Zentrum Dresden-Rossendorf (HZDR). We develop a high-quality electron source in gas cells using a tailored plasma density profile. This profile employs the ionization injection scheme to trap and accelerate electrons efficiently. Alongside experimental studies, we conduct Numerical Particle-in-Cell (PIC) simulations to investigate the influence of key input parameters, such as gas pressure, laser focal position, and laser energy. This poster illustrates the role of key mechanisms through the comparison of experimental results and numerical simulations with SMILEI.

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