Generation of Highly Stable Electron Beam in LWFA via Shock Injection

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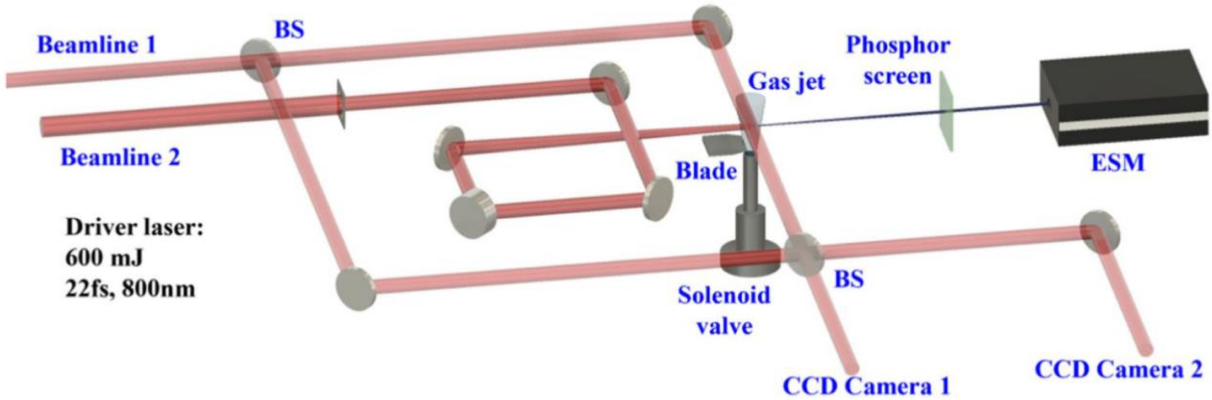

The laser wake-field acceleration (LWFA) provides energetic electron beams with higher acceleration gradient and more compact facility compared with the conventional accelerator. Significant developments have been achieved in the past decades and various mechanisms have been proposed for injection controlling, laser guiding, and beam quality improving. However, all the LWFA applications require high stability and reproducibility of the ejected beam which are still far away from the current laser driven plasma accelerator.

To maintain the reproducibility of the accelerated electron beam, it requires a stable gas target in the vacuum chamber with precise density distribution profile. It guarantees that the laser-plasma interacts in a proper density region and the relative laser focal position doesn't shift too much from shot to shot. In this work, we focus on the instability originating from the gas jet due to the nonlinear fluid dynamics in the supersonic nozzle. The role of the stilling chamber in a modified Converging-Diverging nozzle is investigated. According to the fluid dynamics simulations, the chamber dissipates the turbulence and stabilizes the gas jets. Via both the numerical simulations and the Mach-Zehnder interferometric measurements, the instability originated from the nonlinear turbulence and the mechanism to suppress the instability are studied.

By ensuring the precise electron injection control and optimizing the stability of the gas jet, highly stable and highly reproducible quasi-monoenergetic electron beams have been generated with an energy spread of less than 1%, energies approaching 400 MeV, pointing stability of less than 0.5 mrad, and energy stability of less than 6% (rms).

References

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