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Collider-quality electron bunches from an all-optical plasma photoinjector

Wednesday 13 August 2025 16:00 (2 hours)

In recent years, plasma accelerators have advanced significantly toward producing beams suitable for colliders, aiming to replace conventional MV/m RF fields with GV/m fields of nonlinear plasma waves. Realizing a plasma-based collider requires electron bunches with high charge (hundreds of pC), low normalized emittance (~ 100 nm), and energy spread below 1%. Minimizing energy spread during acceleration involves flattening the accelerating field, which is achievable with a trapezoidal charge distribution.

We present a plasma photoinjector concept that enables collider-quality electron bunch generation using two-color ionization injection. The spatiotemporal control over the ionizing laser creates a moving ionization front inside a nonlinear plasma wave, generating an electron bunch with a current profile that flattens the accelerating field. Particle-in-cell (PIC) simulations of the ionization stage show the formation of an electron bunch with 220 pC charge and low emittance ($\epsilon_x = 171$ nm-rad, $\epsilon_y = 76$ nm-rad). Quasistatic PIC simulations of the acceleration stage show that this bunch is efficiently accelerated to 20 GeV over 2-meters with an energy spread below 1% and emittances of $\epsilon_x = 177$ nm-rad and $\epsilon_y = 82$ nm-rad. This high-quality electron bunch meets Snowmass collider requirements and establishes the feasibility of plasma photoinjectors for future collider applications.

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Yes

Would you like to submit this poster in student poster session on Sunday (August 10th)

No

Footnotes

- Jain, Arohi, et al. "Collider-quality electron bunches from an all-optical plasma photoinjector." arXiv preprint arXiv:2503.09557 (2025).

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Yes

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