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Beam Reproducibility in a Density Downramp Plasma Wakefield Accelerator

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Plasma wakefield accelerators offer exceptional gradients, enabling compact accelerators. Using a density downramp injection scheme, ultra-short electron bunches with sub-micron emittance and tens of pico-Coulombs of charge can be generated and promptly accelerated. While these beam parameters are of utmost interest for future compact X-ray sources and other imaging techniques, the viability of plasma accelerators for these demanding applications depends critically on controlling and reliably reproducing the electron beam parameters. In this work, we investigate the physics effects of system input variations and their impact on the performance of a gas-jet density downramp plasma accelerator. The HTU experiment of the BELLA center is accurately modeled using particle-in-cell simulations to determine jitter tolerances and provide guidance for optimal operation. The results presented will discuss the sensitivity analysis and its implications for achieving high-quality electron beams.

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