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Plasma-Based Solutions for Beam Handling and Driver Extraction

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Plasma wakefield acceleration (PWFA) has achieved significant energy gains of gigaelectronvolts over centimeter-scale distances while maintaining high beam quality essential for high-brilliance applications. However, key challenges persist, particularly in managing the transverse handling of beams and removing the depleted high-charge driver without compromising the accelerated witness bunch.
We propose plasma-based solutions to address these challenges. Active-plasma lenses can be utilized for focusing, matching, and extracting the witness bunch, thereby reducing divergence and maintaining beam quality. Also, an innovative system of beam collimators and discharge capillaries enables the removal of the high-charge driver while preserving the emittance and peak current of the witness bunch.
These solutions are validated through numerical simulations, detailed particle-collimator interaction studies, and supported by experimental results.
This approach aims to enhance the practical implementation of PWFA, paving the way for compact, high-performance accelerators suitable for next-generation scientific and technological applications.

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