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Design of a 5 GeV laser plasma accelerating module in the quasi-linear regime

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Multi-GeV-class laser-plasma accelerating modules are key-components of laser-plasma accelerators, being used either as a booster of an upstream plasma or conventional injector or as modular acceleration sections of a multi-staged high energy plasma linac. Such a plasma module, operating in the quasi-linear regime, has been especially designed for the 5 GeV acceleration stage of the EuPRAXIA project. The design was based on analytical expressions valid in this regime and simulations with the PIC code WARP were implemented to evaluate its performance. At low bunch charge, the 5 GeV energy gain was achieved with a 30 cm long plasma channel and a quasi-matched laser power around 140 TW, in good agreement with analytical expressions. At practical bunch charge (30 pC), the beam loading and accelerating field curvature effects were partially compensated to minimize the energy spread for Gaussian and triangular bunch shapes. Optimal energy spreads smaller than 4% and 1%, respectively, were obtained while the transverse emittances were preserved. In addition, preliminary studies on the matching of the beam at the entrance and exit of the plasma channel, and on the robustness of the plasma module against various errors have been carried out.

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