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Affordable simulations of collider-relevant plasma-based accelerators (and more) with mesh refinement

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While simulations of plasma acceleration are becoming affordable, specific problems remain hard to model. This is the case for collider-relevant parameters (high energy, low emittance beam), long beams (as seen for example in the AWAKE experiment) or positron acceleration, where scale discrepancies call for impractical number of grid cells. In this work, we present numerical methods to reduce the cost of simulations by orders of magnitude. In particular, the implementation of mesh refinement and adaptive resolution in recent quasi-static codes HiPACE++ (3D quasi-static particle-in-cell on GPU) and Wake-T (axisymmetric reduced model for fast evaluations on a laptop) make challenging simulations very cost-effective. Integrated in a suite of open-source and documented tools, these improvements allow for multi-physics studies of the most demanding scenarios of plasma acceleration.

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