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Towards high-repetition-rate, application-driven LPAs for radiotherapy

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The translation of laser-plasma accelerators (LPAs) from research facilities to clinical settings relies on both scalability and control. Bringing industrial, multi-kHz Yb lasers into the LPA landscape is a key step toward this goal, promising compact, tuneable electron sources for therapeutic applications, like FLASH radiotherapy.

Here, we present an integrated effort that combines the commissioning of a novel, kHz LPA with a machine learning-based simulation framework, designed to tailor the beam properties for optimised dose delivery. The optimisation routine navigates an hybrid workflow. It links computational fluid dynamics (CFD) for plasma source modelling, particle-in-cell (PIC) simulations for laser–plasma interaction and GEANT4 for dose deposition, to yield electron beams with specific spatial and temporal dose profiles. This simulation-led approach enables a precise plasma source design, assisting the experimental tuning and accelerating the system integration.

The simulation pipeline and the optimisation outcome are presented, alongside the first experimental results from the kHz Yb-laser-driven LPA under development. Together, these efforts represent a promising pathway toward application-driven, next-generation radiotherapy, enabled by industrial laser technology.

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