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Latest Results from the FLASHForward Experiment

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The FLASHForward experiment at DESY uses high-quality electron bunches from the FLASH linac to perform fundamental plasma-wakefield-accelerator research. An overview of recent results will be provided in three areas: beam-quality preservation, energy efficient acceleration and repetition-rate limits. By precisely controlling the transverse properties of the witness bunch we demonstrate the preservation of the witness-bunch emittance ϵ_n during plasma acceleration for the first time. ϵ_n was preserved at 2.8 mm-mrad while maintaining $> 20\%$ instantaneous energy-transfer efficiency. To improve the overall energy-transfer efficiency, the acceleration distance must be increased. We will present the design and development of a new discharge plasma source which allowed us to accelerate a 1.2 GeV witness bunch by more than 0.5 GeV with per-cent-level energy spread. To further improve bunch quality, we have incorporated Bayesian optimisation techniques into our workflow and have demonstrated 0.25 GeV energy gain with $< 0.2\%$ energy spread. Finally, we further studied the ultimate repetition rate of plasma accelerators, which can be limited by secondary ionisation over tens or hundreds of nanoseconds driven by the hot plasma species left after the wakefield interaction.

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