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Short-pulse methods in fiber chirped pulse amplification systems towards kHz plasma accelerator drivers

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The next-generation precision laser-plasma accelerators (LPA) require kHz repetition-rates and higher to enable feedback control, and to meet application rep-rate needs. Coherently combined fiber lasers, efficient and high-power, are considered one of the most promising laser technologies to drive kHz LPAs. Since LPAs need short laser pulse durations at tens-of-fs, the pulse stretcher, compressor, and pulse shaping in a fiber chirped-pulse amplification (FCPA) system need to be broadband, and the broad bandwidth needs to be maintained with high gain (~100dB).

We have designed and implemented novel short-pulse methods in a high-energy FCPA system, including specialty fiber based pulse stretching, programmable pulse shaping, distributed spectral filtering, and out-of-plane Littrow configuration grating compression. We have developed a FCPA system dispersion model and matched dispersion of different orders. Dispersive fiber based pulse stretcher has been fabricated and is broadband, polarization-maintaining, and compact. A pulse shaper is programmed with the capability to independently tune different orders of dispersion. Multiple spectral filters are distributed in the multi-stage FCPA system to optimally compensate for strong gain narrowing and saturation. An out-of-plane Littrow-configuration grating compressor is designed to accommodate broad bandwidth and high power with high throughput. This work shows a path to achieve tens-of-fs, high-average-power kHz pulses from FCPA systems for driving LPAs.

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Working group

WG1 : Laser-driven plasma wakefield acceleration

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