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## Coherently-combined fiber lasers for driving plasma accelerators at kHz repetition rates

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Laser-plasma accelerators (LPAs) have great potential to be compact and economic, and can enable many applications in science, industry, and medicine, from wakefield colliders (e.g. 10TeV) and precision LPA facilities (e.g. kBELLA) to photon and particle sources. These applications need new kHz rep-rate laser driver technologies producing Joules of pulse energy, up to 100's kW average power, and tens-of-percent wall-plug efficiency.

We developed a novel, energy/power scalable laser driver approach based on multidimensional coherent combining of ultrashort pulses from fiber lasers. Fiber lasers are the most efficient high power laser technology to date. Spatial beam combining enables average power and pulse energy scaling, and temporal pulse combining (stacking many amplified pulses into a single pulse) reduces fiber amplifier arrays needed for high energy to a practical size.

We have demonstrated close-to-full energy extraction (~10mJ) from 85 $\mu$ m-core Yb-doped fiber amplifiers and temporal combining of 81 amplified pulses. 4-channel spatial-temporal combining has achieved ~30mJ pulses at kHz rep-rates. We have shown diffractive combining of 2-D ultrashort-pulse beam arrays, and robust control of combining 81 beams. We also demonstrated record-short pulses (42fs) from fiber combination systems using spectral combining. Ongoing efforts are developing integrated fiber amplifier modules, and building scaled-up fiber systems (100-200mJ, 30-100fs, 1kW). Past and ongoing development has established a path to meet the needs of precision LPAs like kBELLA, their applications, and future colliders.

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### Working group

invited speaker

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