Contribution ID: **192** Type: **Poster**

Broadband Operation and Machine Protection in a Fiber Laser Driver for Wakefield Accelerators

Tuesday, 23 July 2024 18:00 (1h 30m)

Multi-kHz laser plasma accelerators (LPA) have the potential for high impact applications in scientific, medical, industrial and security fields. Today's >100MeV LPAs are limited to a few Hertz repetition rates since they are driven by Ti:Sapphire lasers that have limited power handling capability and wall-plug efficiency. To address this, we propose coherently combining short pulse fiber lasers temporally, spatially, and spectrally to achieve high energy ultrashort pulses at high repetition rates.

Multi-spectral band amplification and combining is key to achieving the tens-of-fs pulse duration requirements for current LPAs. Previously, we have demonstrated record-short 42fs spectrally combined pulses, but with single-stage amplification and small pulse stretching factor. We have recently built a three-spectral-channel, multi-stage fiber chirped pulse amplification (FCPA) laser system with a nanosecond stretched pulse duration and high gain, in which we aim to combine these spectral channels and achieve ~40fs combined and compressed pulses.

The many cascaded amplifier stages in an FCPA system requires machine protection to avoid system damage.We have designed an FPGA-based protection system that implements independent control loops at different points within the amplifier chain by rapidly sensing and stopping pulses with several different errors (amplitude, duration, timing).

This work was supported by the DOE under Contract No. DE-AC02-05CH11231, Gordon & Betty Moore Foundation under Grant ID 10631, and DARPA via the Northrop Grumman Corporation.

Working group

WG1 : Laser-driven plasma wakefield acceleration

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Session Classification: Poster [Atrium]