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The European XFEL photocathode laser

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We present the design, performance and long-term stability of the hybrid Yb:fiber, Nd:YVO4 laser used to generate electrons from the RF photocathode gun at the European XFEL facility. The laser provides deep UV output pulses in 600µs long bursts with variable internal repetition rate ranging from 564kHz to 1.1285MHz up to 4.5MHz. Due to its robust laser architecture, comprised of a mode-locked and synchronized fiber oscillator, Yb:fiber amplifiers and Nd:YVO4 gain blocks, the laser has operated with >99% uptime since January 2017. Using this laser, the XFEL reported landmark electron beam energies of 17.5 GeV in July 2018, and simultaneous multi-mJ lasing in its three SASE beamlines. The XFEL photocathode laser offers two parallel outputs (1064nm) with single pulse energies of >100µJ and 11ps width (FWHM). One output is converted to the deep UV (266nm) with conversion efficiencies > 25%. The second beam is sent to a laser heater to reduce microbunching instabilities, increasing the SASE efficiency. For efficient XFEL operation several state-of-art laser controls were implemented, such as: feed-forward algorithm to flatten electron charge along the bunch, active beam stabilization with
< +/-10µm beam pointing jitter at the photocathode, state machines for hands-off end-user operation, temporal pulse synchronization and drift compensation, which reduce the timing jigger of the electron bunches to less than 45fs.

Summary

We present the design, performance and long-term stability of the hybrid Yb:fiber, Nd:YVO4 laser used to generate electrons from the RF photocathode gun at the European XFEL facility.

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