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OPPORTUNITIES FOR ADVANCED ACCELERATOR RESEARCH WITH FEMTOSECOND LONG-WAVELENGTH LASERS

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Ultra-intense lasers are the driving force of the advanced accelerator research (AAR). Extension of their spectral reach from the presently achievable near-IR into the long-wave IR (LWIR) domain opens opportunities to explore new regimes of particle acceleration, gaining deeper insight into laser-plasma interactions, and improve laser accelerator parameters. Longer laser wavelength facilitates low density regimes of laser plasma accelerators where bigger plasma bubbles are created for laser wake field electron acceleration or gas jets can be used for monoenergetic shock-wave ion acceleration.
BNL Accelerator Test Facility (ATF) traditionally offers users an access to a terawatt class picosecond CO2 laser operating at 9 μm. The present-day ATF's state-of-art laser system features the most advanced configuration that includes a solid-state, femtosecond, optical parametric amplifier front end, a chirped pulse amplification (CPA), and the use of multiple CO2 isotopes in a chain of laser amplifiers. This laser is capable to deliver 5 TW peak power in a single 2 ps pulse. However, realization of the LWFA bubble regime requires reduction in the laser pulse duration down to 500 fs or shorter and an increase in peak power over the present ATF laser system. Such upgrade is the target of the ATF's two-year modernization program that includes two parallel approaches: The first thrust is the nonlinear post-compression where spectrum of the laser pulse is broadened by a self-phase modulation in a nonlinear optical material. The resulting chirped pulse can be compressed to 500 fs at 10 TW by a dispersive optical element. Another approach includes developing a source for the 500 fs, 10 mJ, 9 μm seed pulse that should allow to reach 20 TW in the CPA regime. A combination of these two approaches holds the promise of achieving 100 TW at 100 fs. The combination of such LWIR laser with also available at ATF electron linac and near-IR lasers will empower a unique state-of-the-art science program at the forefront of AAR.

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