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Research opportunities at Brookhaven's Accelerator Test Facility supported by multi-wavelength lasers combined with an electron beam

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Brookhaven's Accelerator Test Facility (ATF) offers users access to a broad array of advanced research capabilities, including an RF photocathode electron LINAC, a femtosecond Ti:Sapphire laser, and a high-peak-power long-wave infrared (LWIR) laser. These systems can be synchronized for integrated experiments or operated independently, supporting R&D in next-generation accelerator and laser technologies, and exploration of diverse regimes of laser/e-beam/plasma interactions.

The ATF's pioneering work in developing sub-picosecond, multi-terawatt LWIR laser systems is opening new frontiers in strong-field physics, particularly in low-density regimes of laser-plasma interactions.

In our talk, we will present short-term plans for the development of a 20-TW, 500 fs, 9-μm laser system. This laser is ideally suited for driving plasma bubbles at electron densities of approximately 10^{16} cm-3. Such conditions are optimal for investigating precision external electron injection into plasma cavities, a key step toward generating low-emittance electron beams for compact laser wakefield accelerators with wide-ranging scientific and industrial applications.

Additionally, we will explore the prospects of high-repetition-rate lasers with the same pulse format and of LWIR laser systems exceeding 100 TW. Through its ponderomotive effect, such laser could rival the performance of multi-petawatt near-infrared lasers, opening the door to a new class of strong-field experiments and applications.

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