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Kilohertz laser wakefield accelerator using near critical density plasmas and millijoule-level drive pulses[1]

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Laser wakefield accelerators operating in the so-called bubble or blowout regime are typically driven by Joule-class femtosecond laser systems driving plasma waves in highly underdense plasmas ($10^{17} - 10^{19} cm^{-3}$). While these accelerators are very promising for accelerating GeV scale, low emittance electron beams, the large energy requirements of the laser systems have so far limited them to repetition rates below 10 Hz. However, there are a variety of applications, such as ultrafast electron diffraction or high repetition rate gamma ray sources for materials characterization or medical radiography, which would benefit from lower energy (1-10 MeV) but higher repetition rate (~1 kHz) sources of relativistic electrons. This talk will describe relativistic wakefield acceleration of electron bunches in the range 1-10 MeV, driven by a 1 kHz, 30 fs, 1-12 mJ laser system. Our results are made possible by the use of very high density cryogenic H_2 and He gas jet targets yielding electron densities $> 10^{21} cm^{-3}$ in thin ~100 μm gas flows. At these high densities the critical power for relativistic self-focusing and the plasma wave phase velocity are greatly reduced, leading to pulse collapse and self-injection even with ~1 mJ drive laser pulses. Applications of this source to ultrafast electron diffraction and gamma ray radiography will be discussed.

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