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Improvement of electron beam properties for Few-TW LWFA conducted in a sub-mm gas cell filled with a helium-nitrogen mixture

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Developing a laser wakefield acceleration (LWFA) scheme by focusing few-TW laser pulses into a thin, dense gas target paves the way for generating high-average-current electron beams driven by a modern high-repetition-rate laser. Our previous study demonstrated that using a sub-mm nitrogen (N_2) gas cell facilitates the routine generation of 10-MeV-scale electron beams from few-TW LWFA with ionization-induced injection. *However, excessive ionization-induced defocusing of the pump laser pulse tends to occur in an N_2 target, motivating the use of a helium (He) –nitrogen (N_2) mixture as the gas target to mitigate pump pulse defocusing in few-TW LWFA*.* In this study, the effect of nitrogen doping ratio ranging from 0.5% to 5% was investigated using 40-fs, 1-TW pulses with a 0.4-mm-long gas cell. We found that a manifest peak repeatedly appears around 10 MeV in the energy spectra with the 99.5% He - 0.5% N_2 gas mixture - a result never observed with the pure N_2 cell. Using the He-N_2 mixture also leads to a noticeable increase in the charge of high-energy electrons (>5 MeV) and a reduction in the pointing fluctuation of the output beams compared to the pure N_2 target.

Footnotes

*P. -W. Lai et al., Phys. Plasmas, 30, 010703 (2023).**M. -W. Lin et al., Phys. Plasmas, 27, 013102 (2020).

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Author: LAI, Po Wei (National Tsing-Hua University (NTHU))

Co-authors: HUANG, Chen-Kang (National Central University); PAI, Chih-Hao (National Central University); CHU, Hsu-hsin (National Central University); TRAN, Khoa (National Tsing-Hua University (NTHU)); LIN, Ming-wei (National Tsing-Hua University (NTHU)); CHEN, Shih-Hung (National Central Univeristy); LIU, Yao-Li (National Central University)

Presenter: LAI, Po Wei (National Tsing-Hua University (NTHU))

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