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Development of gas targets for various laser-plasma experiments

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Various laser-plasma experiments, including those in laboratory astrophysics, particle acceleration, plasma physics, and X-ray generation, require advanced gas target technology—a system capable of delivering gas with a precisely defined density profile within a high-vacuum environment. The performance of particle beams and radiation in these experiments is highly sensitive to the optimal density profile established in the gas target. In this work, we present the development of supersonic gas jet targets designed for high-intensity, ultra-short laser pulses operating at high repetition rates (3.3 Hz at GeV, 1 kHz at 10s MeV)[1]. Hydrodynamic simulations of neutral gas flow were employed to build the design of these targets. The density profiles were characterized through tomography[2] before the experiment and ultra-fast post-compressed probe diagnostics during the experiment[3]. We explore conical and slit supersonic nozzles, along with multi-stage target configurations, tailored for specific experimental needs. Additionally, we introduce a novel supersonic gas jet catcher, developed for differential pumping in laser-plasma interaction experiments. To enhance the stability and reproducibility of the laser-plasma interactions, the targets are optimized for continuous-flow operation.

[1] Lazzarini et al., Phys Plasmas 2024, https://doi.org/10.1063/5.0189051
[2] Karatodorov et al., Sci Rep 2021, https://doi.org/10.1038/s41598-021-94436-6
[3] Lorenz et al., HPLSE 2024, https://doi.org/10.1017/hpl.2024.29

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