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High-performance laser proton acceleration using cryogenic hydrogen jet targets with cylindrical and planar geometry

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We report on recent experimental results deploying a continuous cryogenic hydrogen jet as a debris-free, renewable laser-driven source of pure proton beams generated at the 150 TW ultrashort pulse laser Draco. Efficient proton acceleration reaching cut-off energies of up to 20 MeV with particle numbers exceeding 10^9 particles per MeV per steradian is demonstrated, showing for the first time that the acceleration performance is comparable to solid foil targets with thicknesses in the micrometer range. Two different target geometries are presented and their proton beam deliverance characterized: cylindrical (diameter = 5 µm) and planar (20 µm x 2 µm).

In both cases typical Target Normal Sheath Acceleration emission patterns with exponential proton energy spectra are detected.

Significantly higher proton numbers in laser-forward direction are observed when deploying the planar jet as compared to the cylindrical jet case. This is confirmed by two-dimensional Particle in Cell (2D3V PIC) simulations, which demonstrate that the planar jet proves favorable as its geometry leads to more optimized acceleration conditions.

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