Contribution ID: **40** Type: **Oral contribution**

Ultra-efficient proton acceleration from planar cryogenic hydrogen jets at 1 Hz repetition rate

Monday, 14 April 2025 15:20 (20 minutes)

Laser plasma-based ion accelerators have not yet reached their full potential in producing high radiation doses at high particle energies, mainly due to the lack of a suitable high-repetition-rate targets that also provide adequate control of the plasma conditions. Cryogenic, solid gas jet targets are being developed to fill this gap, as they combine many favourable properties for studying advanced laser ion acceleration regimes, such as low solid density, single ion species composition and ease of probing in experiments, with repetition-rated operation capability by being self-replenishing and completely debris-free.
In this talk, we present first results from an ongoing experiment using planar, sheet-like cryogenic hydrogen jet targets to accelerate proton bunches at 1 Hz repetition rate. Using the Draco PW laser at intrinsic contrast and significantly reduced laser energy, we report stable, continuous acceleration of ion beams over thousands of consecutive shots. Despite the low laser energy of only 1.6 J, maximum proton energies of up to 40 MeV are observed, indicating an extremely high acceleration efficiency. This combination of tens of MeV proton energies with very modest laser parameters marks a significant step forward towards developing laser driven ion sources for scientific and industrial applications.

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Session Classification: Parallel Session

Track Classification: Ion acceleration