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Solid Hydrogen target for laser driven proton acceleration

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There is a great interest for fundamental research but also for applied research, in producing energetic protons. These protons can be used for example in the field of thermonuclear inertial confinement fusion research or in medical domains as proton therapy.
One mean to obtain a beam of energetic protons consists in focusing a high intensity laser on a target. Various physical mechanisms of laser-driven ion acceleration have been investigated to date. The mechanism most investigated experimentally is the Target Normal Sheath Acceleration (TNSA) when ions are accelerated at the rear side of thin target in a quasi- electrostatic sheath formed by fast electrons propagating from the target front side 3,4 .
A suitable target for this application is a thin ribbon of solid H2.
In this context, the low temperature laboratory of the CEA developed a cryostat able to produce a continuous film of solid H2 of some tens of microns in thickness and one millimeter in width. A new extrusion technique is used, without any mobile part. Thermodynamic properties of the fluid are used to achieve this goal. The principle is as follow: Once the experimental cell is totally filled with solid H2, the inlet valve is closed and the top of the cell is heated up. The pressure increases and pushes the solid H2 placed at the bottom of the cell through a calibrated hole.
The construction of new high power laser facilities (e.g. high repetition rate petawatt-class lasers at ELI-Beamlines5) will clearly enable numerous prospective applications based on secondary sources of energetic particles. In particular the use of the proposed solid hydrogen cryogenic target along with these emerging laser technologies will allow demonstrating future medical applications such as hadron therapy 6,7. In fact, in recent years pilot experiments of cancer cell irradiation have already been realized8. The possibility to use other gases than hydrogen (e.g. deuteron) suitable for different applications is also envisioned in the future.
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