Deuterons and Neutrons from Cryogenic Deuterium Ribbons at Vulcan Petawatt

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The sustained interest in laser-driven neutron sources comes from their compactness and affordability while opening the possibilities for a wide range of applications, potentially complementing the research carried out at large-scale spallation facilities. An experiment was carried out at the Vulcan Petawatt facility (CLF, UK) to generate bright, ultra-short neutron bursts employing cryogenic ribbons of solid deuterium. This unique target can produce a single species, debris-free ion beam suitable for a wide range of applications (depending on the gas used, e.g. proton acceleration from hydrogen gas). In this case, deuterium ions up to 25 MeV/nucleon were detected in the forward direction, correspondingly with high energy neutrons in high fluxes being produced. Due to the low density of the target (~ 200 mg/cc) and the significant radiation pressure at the delivered laser intensities ($5 \times 10^{19} - 5 \times 10^{20}$W/cm^2), considerable compression of the deuterium plasma at the front surface is expected and accelerating bulk deuterium by the hole-boring mechanism. The neutrons are subsequently produced by the d(d,n)^{3}He fusion reaction in the target bulk driven by ions produced by the hole-boring front. The ion and neutron data is complemented by the back-reflected Doppler-shifted spectrum of the laser, providing measurements of the hole boring velocities at different intensities. Extensive full-scale, multi-dimensional Particle-In-Cell simulations support the experimental results to explain the complex underlying physics involving ps-class lasers at linear polarisation.