PW-laser produced MeV proton beams stopped in WDM plasmas (H, He, Ar, N, Xe)

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Physical processes involved in the interaction of ion beams in Warm Dense Matter (WDM) (i.e. 1-100 eV. 0.01-100 g/cc) is fundamental to the understanding of condensed matter, solid-state physics, fusion sciences, and astrophysical phenomena. In particular, in the WDM regime the charge equilibrium and stopping power of ions differs significantly from that of both cold matter and ideal plasma due to free electron contributions, plasma correlation effects and electron degeneracy. Furthermore, experimental data is extremely scarce in this regie; the reason being that the creation a WDM state with a temporal duration consistent with the particles used to probe it has been extremely difficult to achieve experimentally. For the past couple of years, we have been developing an experimental platform using short pulse lasers that can produced relatively short bunches of protons (picosecond time scale) to study plasmas in the WDM regime. Earlier this year, using the Titan Laser at JLF, we used the CPA laser to create two identical proton beams in a gas jet. One was used as a reference, and the other beam was used to perform the stopping power measurement in a first evaluation of semi-empirical formulas that are being used to predict the stopping power of ions in numerical codes that are often used in ICF and astrophysics. The development of this short-pulse laser platform thus shows great promise to push further the investigation of ion interactions in the experimentally challenging conditions of WDM.