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Investigations of fast electron generation and transport in dense plasma using the Vulcan PW laser

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Understanding the physics of the generation and transport of fast electrons in ultra-intense laser irradiation of solid targets is important for the fast ignition approach to inertial confinement fusion and plays a crucial role in the optimization of high power laser-driven ion and radiation sources and in warm dense matter physics. In this talk I will present an overview of fast electron generation and transport physics and report results from recent experimental investigations of fast electron transport in solid targets performed using the Vulcan laser at RAL, and simulations performed to aid the interpretation of the measurements. The following three topics will be discussed:

(1) The effects of preplasma expansion on laser energy coupling to fast electrons is diagnosed by measuring the properties of beams of protons accelerated from the target rear surface and $K\alpha$ emission from fluorescent layers buried within the targets. It will be shown that optimum preplasma expansion conditions exist for laser energy absorption and the effect of a potential barrier formed by the preplasma will be discussed;

(2) Measurement of the spatial-intensity distributions of protons accelerated from the rear surface of relatively thick solid targets is used to investigate the filamentation of laser-generated fast electron beams in different solid target materials. It is found that scattering produces no measurable effect in suppressing electron propagation instabilities and that the target resistivity at low temperatures (<20 eV) plays a significant role in defining the fast electron beam transport pattern. Simulation results, using a 3D hybrid PIC code further suggest that pinching of the beam by self-generated magnetic fields can contribute to filamentation suppression;

(3) Measurements of proton acceleration as a function of target thickness show evidence of a restriction of the lateral expansion of the fast electron propagation which is likely to result from self-generated magnetic fields. The role of self-generated magnetic fields in pinching the fast electron beam is discussed;