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Spatial and spectral x-ray characterization of the Target Normal Sheath Acceleration regime

H.F.Lowe[1], M. Nishiuchi[1], N.P. Dover[1], K. Kondo[1], H.Sakaki[1], E.J. Ditter[2], O. Ettlinger[2], G. Hicks[2], Z. Najmudin[2], H. Kiriyama[1], M. Kando[1], K. Kondo[1].
[1] Kansai Photon Science Institute, National Institutes for Quantum and Radiological Science and Technology, [2] Department of Physics, Imperial College London
lowe.hazelfrances@qst.go.jp

A core aim of the high-power laser program at the Kansai Photon Science Institute (KPSI) is the production of ions with a high specific charge (Q/M) and high peak current per shot via laser irradiation of a solid target. Medical uses of laser driven ion sources are of great interest for making treatments such as proton or hadron therapy [1][2] for treatment of cancer available at lower cost and requiring significantly smaller facilities. This is made possible by the exceptionally high electric field strength (~10TV/m) [3] achieved at laser intensities of 10^{21}W/cm2 and the highly charged ions produced, both of which lead to very efficient ion acceleration over much shorter length scales than can be achieved in traditional accelerators. These ion beam properties also make laser driven ion beams advantageous for replacing the existing front end of a conventional accelerator system [3][4].

In the high energy, high density plasmas formed by the interaction of an ultra-short pulse laser with a ~100nm-1µm target foil, ions are generated by Target Normal Sheath Acceleration (TNSA). In TNSA, the majority of the electrons ejected from the rear surface of the target (where the front surface is the irradiated side) by the laser field are pulled back towards the interaction region by the ions, creating a strong sheath field at the rear of the target with a field strength of ~1V/m. This sheath field accelerates ions out of the target with a typical proton source size of ~10µm [5][6].

TNSA and specifically the formation of the sheath field on the rear surface of the target needs to be better understood in order to optimize laser driven ion beams for the applications mentioned above. An understanding of the electron dynamics that control formation of the sheath field in the target is essential and studying x-ray emission from the interaction region provides valuable information about the electron population. For this purpose, preliminary measurements of the spatial and spectral characteristics of the interaction region generated by the irradiation of ultra-thin foil targets by the 10^{22}W/cm^2 J-KAREN-P laser have been made via penumbral imaging of the x-ray source and continuum x-ray spectroscopy.

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