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Development of Bright MeV X-ray Sources with Compound Parabolic Concentrator Targets on Petawatt Class Lasers[1]

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The peak on-target laser intensity is a key parameter for High Energy Density applications such as laser driven particle acceleration and x-ray sources. In most Petawatt class laser systems, high intensities are achieved using low F/ (F/2-F/3) optics. This puts steep requirements on laser beam quality, which leads to increased facility cost and complexity. As an alternative approach, we have implemented miniature Compound Parabolic Concentrator (CPC) targets which act as a non-imaging focusing optic [1], which relax focusing requirements while achieving target performance consistent with high intensity. A series of experiments have been performed on a range of facilities - the Texas Petawatt, Titan, and NIF Advanced Radiographic Capability (ARC) - to characterize and understand the performance of CPC targets. Laser conditions varied from pulse durations of 0.1 40 ps, energies from 100 2600 J, and F/s of 10 60. In these experiments the production of MeV electrons and x-rays was measured, and a large enhancement of mean electron energy (4-5x higher) and x-ray brightness (¿10x higher for photons ¿ 100keV) was observed with CPC compared to flat targets. These experiments were modeled with 1, 2 and 3D particle in cell simulations, giving results consistent with a hypothesis that the CPC acts as an in-situ focusing plasma mirror that increases the laser intensity at the tip. These simulations further suggest that plasma confinement at the cone tip enhances the efficiency of energetic electron production. This talk will discuss the experimental and simulation results, and their implications for the development of bright MeV x-ray and particle sources on Petawatt class laser systems.
[1] MacPhee et al., Enhanced laser-plasma interactions using non-imaging optical concentrator targets, Optica, vol. 7 issue 1 (2020).

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