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Efficient electron acceleration and pair production using the NIF-ARC laser[1]

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Relativistic plasmas play an important role in the morphology of energetic astrophysical phenomenon, particularly within the shock formation that results in gamma ray bursts. Developing a laboratory-based platform to study the microphysics of such shocks has been pursed for the past decade using high-energy intense short pulse lasers. Here, we report on bringing up a pair plasma experimental capability at the National Ignition Facility (NIF) using the Advanced Radiographic Capability (ARC) laser. ARC has the largest amount of available short pulse energy in the world (up to 4 kJ) but is delivered at sub-relativistic intensities ($I_L 10^{18}$ W/cm^2), below the established threshold to generate positron-electron pair plasmas. Through a series of experiments within a NIF Discovery Science campaign, this limitation was overcome using novel target-based plasma optics which produced a significant enhancement to the laser-to-target coupling efficiency [1] and resulted in a pair yield increase ¿10x [2]. Compound parabolic concentrator (CPC) targets have subsequently been used to enhance proton and high-energy x-ray production [3]. With this established platform, we will discuss a proposed experiment to test plasma collective effects inside a relativistic pair plasma that could be performed at the NIF.

References: [1] G. J. Williams et al., Production of Relativistic Electrons at Sub-Relativistic Laser Intensities. Phys. Rev. E, 101:031201, Mar 2020. [2] G. J. Williams et al., Increasing intense laser to target coupling efficiency using CPC targets [To be submitted, 2020]. [3] A. G. MacPhee et al., Enhanced laserplasma interactions using non-imaging optical concentrator targets. Optica, 7(2):129130, Feb 2020.

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