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Verification of fast electrons convergence effect by controlling the plasma density distribution

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Fast ignition is an approach to inertial confinement fusion which has possibility to get a higher gain. In fast ignition scheme, fast electrons, generated by an ultra-intense laser, heat the highly compressed core plasma and trigger ignition. However, in a previous experimental study [1], an imploded core was irradiated directly by high intensity laser, and fast electrons characteristic was observed. According to this result, electrons divergence angle was about 100˚ at the time of peak compression which caused low heating efficiency but was 30˚-40˚ when irradiated 2.6 ns later from maximum compression.

To improve heating efficiency, this study examines the principle behind the generation of collimated fast electron beams in steep density gradients near the critical density. Previous studies [2,3] insist that strong magnetic fields caused by Weibel instability and transverse component of ponderomotive force scatter electrons in longer scale length. In other word, if we can obtain a small density scale at the front of low-density plasma channel in the imploded plasma, where the additional heating laser pulse create the fast electrons, we can expect relatively low divergence electron beam.

For this purpose, we performed a 2D-PIC simulation using a collective code FISCOF2-OH [4]. In order to evaluate the role of density scale, the density gradient near the critical density was varied by changing the scale length of preformed plasmas, and the characteristics of fast electrons produced by ultra-intense lasers were compared. The fast electron characteristic was measured by fitting the fast electron number (>0.5 MeV) path through $x = 5, 10, 15$ μm lines as shown in Figure 1, and the divergence angles were determined by the slope of their FWHM length. However, the divergence angle of the high-energy electrons showed a tendency slightly different from those in previous studies above, we also focus on the electric fields generated near the tips of plasma channel.

We calculated electron energy density, and electromagnetic fields. Fast electrons generation points and flow can be seen from electron energy density, and the principle of fast electrons divergence principal was verified by comparing the structures of electromagnetic fields.

In addition, we will also demonstrate the electron divergence inside the plasma channel using a double-pulse laser injection. Using a double-pulse laser, we investigated the conditions under which a steep density gradient is generated in the plasma channel and will report the results of comparing the divergence angles at those times.

References
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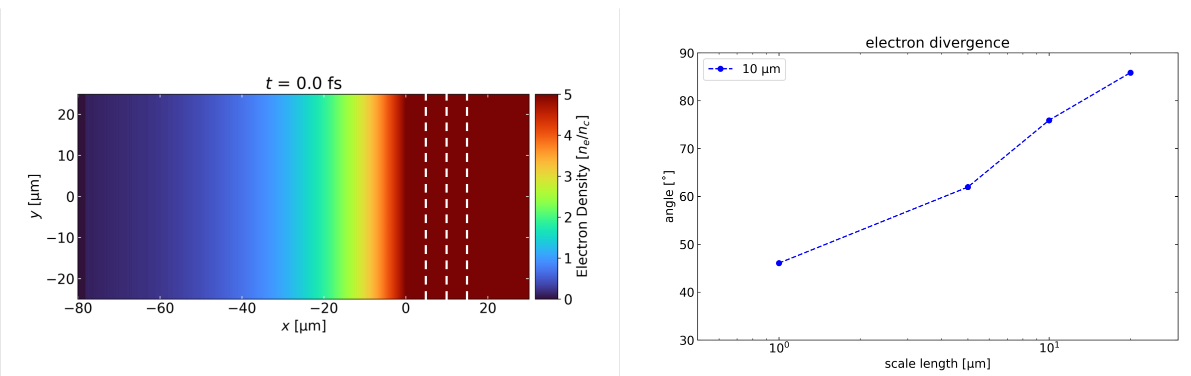

Figure 1. simulation box and electron divergence angle.