§3. The Results of the Electron Spectrometer on FG02 Experimental Series of the FIREX-I Project

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The high energetic electron measurement is one of the most important issues to research the ignition mechanism in the Fast Ignition Realization Experiment (FIREX) Project. We prepare an Electron SpectroMeter (ESM)[1)], which was calibrated using L-band LINAC in the Institute of Scientific and Industrial Research, Osaka University. The integrated experiments, in which a spherical shell with a guided cone is used, have been performed on the Gekko XII and LFEX laser facilities.

The fast ignition can be expected higher pellet gain by heating the imploded core auxiliary using the heating laser (LFEX). Here it is important to keep high flux and low tail temperature (Te) of the hot electron in order to obtain the high coupling efficiency between the imploded core and the electron beam. The tail temperature increases when the scale length of the pre-formed plasma becomes thicker. The pre-plasma is mainly formed by the pre-pulse of LFEX.

We compare the electron tail temperatures for various targets (plain, cone and integrated target) irradiated by LFEX laser with 1.5 ps. The electron flux observed by ESM is less than one hundreds of total generated amount due to the strong self-electric field. Therefore the total amount of electron is roughly estimated from X-ray intensity. Hard X-ray with several MeV range can be measured using the imaging plate located behind several cm thick lead. At the integrated experiments, usually 9 beams of imploding lasers are used in order to minimize the irradiation of imploding laser to the cone, although the implosion symmetry is worse. Therefore we also try the implosion with 12 beams of imploding lasers.

The results of Te and X-ray are Te(plane)<Te(cone)<Te(Integrated,9beams)~Te(Integrated,12beams) and X(plane)<X(cone)<X(Integrated,9beams)<X(Integrated, 12beams), respectively. The difference of Te and X-ray between at the plain and at the cone, can be explained by the difference of geometrical shapes of the pre-plasmas. The cone shape forms long plasma with the jet-like on the LFEX laser axis. The implosion and the relevant physical phenomena may affect Te at the integrated target. Ideally the ignition should be independent on the implosion in the fast ignition scheme. However the Te and X-ray at the integrated target are higher than those at the cone. The difference of Te between at 9 and at 12 beams may not be clear. However X-ray amount at 12 beams is obviously higher than that at 9 beams.

We assume that the reasons are as follows;

(1) the pre-plasma formation by the radiation from the imploded core,
(2) the damage of the cone tip by the imploded core,
(3) the instability of the hot electron due to the existence of the ablation plasma,
(4) the pre-plasma formation irregularly irradiated by the GXII laser.

About (1), the X-ray energy from the imploded core is only several keV and the cone is made of the 7 μm-thick gold with 1 μm-thick parylene. Therefore the pre-plasma by the radiation from the imploded core may not be essential. The motion of the imploded core during the compression phase is observed by using the X-ray streak camera. At 9 beams, the core moves toward the cone tip due to the irradiation asymmetry of the imploding laser. The possibility of the cone tip break by the core at 9 beams should be higher than that at 12 beams. However Te and X-ray at 9 beams is not higher than those at 12 beams. This means the effect of (2) may not be essential.

In the integrated targets, there is the ablation plasma around the cone, which enhances the electron emission due to the return current. The instability between the return current and the hot electron causes high Te as mentioned in (3).

The neutron yield is plotted against the delay time of the LFEX injection timing from the maximum compression time. The neutron yield becomes maximum when the timing of the LFEX laser injection corresponds the timing of the maximum compression. The time window is about 50 ps. Instead of the neutron, we can plot Te in the same graph. There is also the peak around the small delay as shown in Fig. 1. The imploding laser has the pulse duration of 1 ns before the maximum compression. If the pre-plasma is also formed by the imploding laser as mentioned in (4), Te should increase near the implosion timing. The results suggest that the assumption of (4) seems true, because the implosion lasers of 12 beams has more possibility of cone irradiation than those of 9 beams.

According to the results on FG02 experimental series, the reason of the higher Te and X-ray on the integrated target, especially at 12 beams may be due to (3) and (4). In order to confirm those assumptions, we are preparing the mask for avoiding the irradiation of the imploding laser to the cone. We also have a plan to measure the pre-plasma formed by the imploded core.

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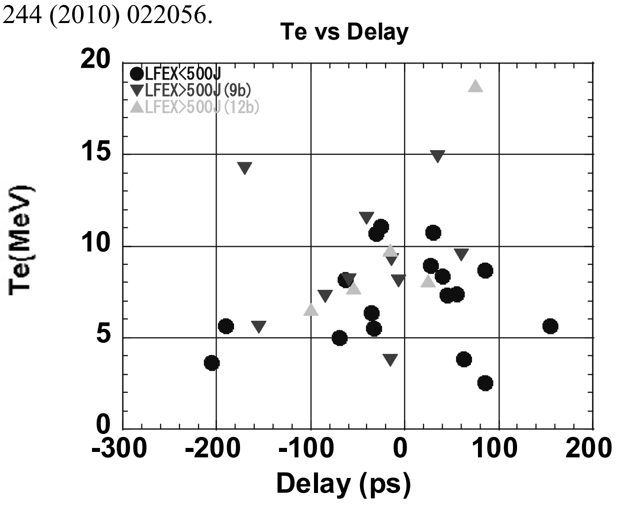

Figure 1. The electron tail temperature vs. the delay time of the LFEX injection timing from the maximum compression time.