



Present States and Future Prospect of Fast Ignition Realization Experiment (FIREX) with Gekko and LFEX Lasers at ILE

Mayuko Koga,

Y. Arikawa, H. Azechi, Y. Fujimoto, S. Fujioka, H. Habara, Y. Hironaka, H. Homma, H. Hosoda, T. Jitsuno, T. Johzaki, J. Kawanaka, R. Kodama, K. Mima, N. Miyanaga, M. Murakami, H. Nagatomo, M. Nakai, Y. Nakata, H. Nakamura, H. Nishimura, T. Norimatsu, Y. Sakawa, N. Sarukura, K. Shigemori, H. Shiraga, T. Shimizu, H. Takabe, M. Tanabe, K. A. Tanaka, T. Tanimoto, T. Tsubakimoto, T. Watari, A. Sunahara², M. Isobe³, A. Iwamoto³, T. Mito³, O. Motojima³, T. Ozaki³, H. Sakagami³, T. Taguchi⁴, Y. Nakao⁵, H. Cai⁶, M. Key⁷, P. Norreys⁸, J. Pasley⁹

Osaka University, Japan, ²Institute for Laser Technology, Japan, ³National Institute for Fusion Science, Japan, ⁴Setsuman University, Japan, ⁵Kyushu University, Japan, ⁶Institute of Applied Physics and Computational Mathematics, China, ⁷Lawrence Livermore National Laboratory, USA, ⁸Central Laser Facility, STFC Rutherford Appleton Laboratory, UK, ⁹University of York, UK

2-6 Yamada-Oka, Suita, Osaka 565-0871 JAPAN

koga-m@ile.osaka-u.ac.jp

Fast ignition is one of the proposed ways to achieve high fusion energy gain in inertial fusion research. It has a potential to achieve ignition and burn with about one tenth of laser energy required for the central ignition scheme. High density compression (estimated to be six hundred times liquid density [1]) and the fast heating of the compressed core to 0.9 keV temperature [2] have previously been demonstrated at Osaka university. Now, we are working on the fast ignition realization experiment (FIREX) project. The goal of FIREX-I is to demonstrate fast heating of fusion fuel up to the ignition temperature of 5keV by a high energy short pulse laser pulse.

The new short pulse laser system, LFEX laser, has been completely assembled and one of four beamlets is now in operation. The wavelength of the laser is 1.05 μm and the pulse duration is adjustable from 1 to 20 ps. The maximum output energy is 10 kJ, and will be delivered when the system is completed and the four beamlets are combined. The fast-ignition experiment was performed by using this single short pulse combined with the Gekko XII implosion laser. The targets were deuterated plastic shells with gold cones. The diameter of shells are $\sim 500 \mu\text{m}$. We used cones with two different opening angles and tip sizes ($30^\circ / 10\mu\text{m}\phi$ and $45^\circ / 30\mu\text{m}\phi$). The energy of GXII implosion laser was about 2 kJ and the pulse width was 1.5 ns. The energy of LFEX laser was increased up to 800 J and two pulse durations were compared, 5 ps and 1ps. In the experiment, X-ray images were obtained by filtered pinhole cameras, X-ray streak cameras, and X-ray framing cameras. Fusion neutron yields from the 2.45 MeV $d(d,n)^3\text{He}$ reaction were measured using neutron scintillators. The energetic electron spectra were measured using calibrated electron spectrometers.

It was found that the neutron yield was increased by a factor of thirty as a result of the fast electron-induced heating. The estimated coupling efficiency between LFEX laser pulse and the compressed fuel was low (less than 5%). The measured fast electron temperature was higher (4~10 MeV) than previous short pulse laser (PW laser) experiments (2~6MeV). A streaked X-ray image obtained in a separate gold plate target experiment showed that pre-formed plasma was generated by the pre-pulse of the LFEX laser before the arrival of the high intensity portion of the pulse injection. The data suggests that the bulk of the laser energy was used to heat electrons in the cone tip and pre-formed plasma. Certainly, the generated high energy electrons were coupled less efficiently to the core than previous experiments. Further investigations and attempts to overcome these problems are now in progress.

Hard X-rays above 100 keV were found to be generated by energetic electrons. These X-rays caused much noise in diagnostics. Techniques for making improved measurements in such a harsh environment are being investigated.