

(3) High Beta and MHD Physics

§1. Short Interval Measurement of the Thomson Scattering Signals at the Pellet Injection

Yasuhara, R., Sakamoto, R., Motojima, G., Yamada, I., Hayashi, H. (National Institute for Fusion Science)

Thomson scattering (TS) measurements of a short interval less than 1 ms are strongly desired for a research on transient plasma events such as a pellet injection¹⁾. One of the practical solutions to realize a short time interval measurement is the burst mode operation with a multi laser configuration. Each laser in a multi-laser configuration can adjust the laser output timing independently. It allows a short interval burst mode measurement within the number of laser systems. MAST TS system has demonstrated such burst mode measurement of TS system²⁾ by using 8 probe lasers with the FPGA triggering system. They have obtained the electron temperature (T_e) and the electron density (n_e) values from the transient plasma phenomena. In LHD, we have three lasers for the probe laser of the TS. Three burst pulses can use for a short time interval measurement. In addition, we have developed the coaxial beam combining technique to improve the spatial uncertainty of T_e and n_e values measured by each probe lasers³⁾. By using a multi-laser system with coaxial beam combining, shot-by-shot TS measurements of the transient plasma phenomena in the LHD can be obtained. From this experiment, we report the details of this burst-mode measurement system and the results of the demonstration of this system for a pellet injection experiment. Our diagnostic method will aid in the cross-validation of simulations and experiments concerning transient plasma events.

TTL triggers from a tangential event such as the pellet injector signal or the LHD timing system are used as the master triggers of this system. Triggers for the three laser outputs are distributed by the DG645 system, which is a commercial pulse generator based on the FPGA system. The accuracy of the trigger timing is less than 1 ns. The DG645 can generate an arbitrary timing trigger for the flash lamp and the Q-switch of three lasers. The trigger timing duration between the Q-switch and the flash lamp is subsequently fixed to maintain the laser extraction efficiency.

Figure 1 shows n_e profiles from Thomson scattering measurements before and after pellet injection from the pellet ablation at the #113431. Laser 2 put into the plasma before pellet injection (3.73358 s, square). After that, Laser 1 was injected after pellet injection (3.751974 s, diamond). After 200 μ s of Laser 1, Laser 3 was worked for the measurement of T_e and n_e profiles (3.752175 s, open circle). Finally, Laser 2 put into the plasma again (3.766912 s, filled circle). From the Fig. 1, we can see n_e profiles were dramatically changed after pellet injection with shot-by-shot TS measurements.

At pellet injection, strong $H\alpha$ emission is observed from the evaporation of the pellet. This $H\alpha$ spectrum is broadened from 630 nm to 680 nm due to the Stark effect⁴⁾. To confirm the effect of this broadened $H\alpha$ light for the Thomson scattering measurement, we measured the back

grand signals during the pellet evaporation. Figure 2 shows the result of the back grand signal measurement. We have obtained eight back grand signals from 20 μ s to 160 μ s after the TS signal measurements at each laser shots. The horizontal axis represents the laser shot number. 187 show the 3.751974 s which is the after pellet injection. Filled bars show the TS signal and open bars show the back grand signals. From this figure, there are no significant signals in the back grand measurement. This result shows the effect of the $H\alpha$ emission is negligible in this pellet measurement.

We have demonstrated TS measurements of a short interval less than 1 ms by using the event triggering system with a multi-laser configuration. We have tried to measure this system at the pellet injection and obtained T_e and n_e profiles before and just after pellet injection. This measurement technique will contribute understanding the mechanism of the pellet deposition and the transient phenomena of the LHD plasmas.

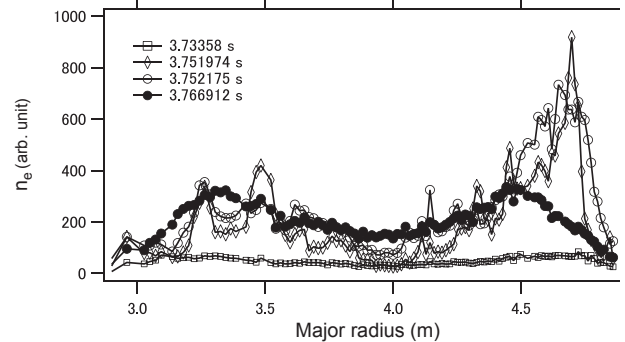


Fig. 1 n_e profiles from Thomson scattering measurements before and after pellet ablation. Square plots show the plasma before pellet injection (3.73358 s). Diamond plots show after pellet injection (3.751974 s). Open circle plots show n_e profile after 200 μ s (3.752175 s). Filled circle plot shows the laser timing of 3.766912 s.

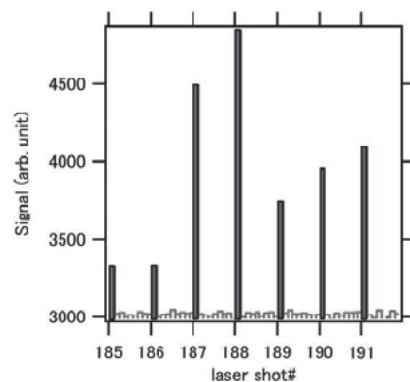


Fig. 2. Signal level of the polychromator at 4.5 m.

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- 3) Yasuhara, R. et al.: Plasma and Fusion Research 7, 2402030 (2012).
- 4) Goto M., et al., Plasma Phys. Control. Fusion 49 1163–1176 (2007).