## §24. Short Interval Measurement of the Thomson Scattering System at the Pellet Injection

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synchronized Pellet injection Thomson scattering measurement has been demonstrated using an event triggering system in LHD. The multi-laser configuration has enabled us to observe time-revolved density and temperature profiles during a pellet ablation in short interval within 1 ms. This measurement technique is one of advantageous method to investigate the mechanism of the pellet deposition and the transient phenomena<sup>1)</sup>. 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 system<sup>2)</sup> 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 lasers<sup>3)</sup>. By using multi-laser system with the coaxial beam combining shot by shot TS measurement is available at the transient plasma phenomena in LHD.

TTL triggers from the transient plasma phenomena such as the pellet injection or the LHD timing system are used as master triggers of this system. Logic OR of this 2 line is the master trigger of the triggering system. Triggers for the three laser outputs are distributed by the DG645 which is the commercial pulse generator based on the FPGA system. The accuracy of trigger timing is less than 1 ns. It can generate the arbitrary timing trigger for the flash lamp and the Q-switch of three lasers. Then, the trigger timing duration between the Q-switch and the flash lamp should be fixed due to maintain the laser extraction efficiency. The shortest time interval of the multi-laser output for TS measurement is about a few micro second. This is depending on the data acquisition system of the LHD TS system.

Figure 1 shows the Timings of the lasers for the Thomson scattering system relative to H $\alpha$  emission light signal from the pellet ablation at the #113431 (16th experiment campaign). In this measurement, a pellet light gate signal with about 3.5 ms delay was used for the trigger of laser triggering sequences. A duration of two laser pulses after pellet injection was 200 µs. We have demonstrated the burst mode TS measurements within 1 ms after pellet ablation. Figure 2 shows  $T_e$  and  $n_e$  profiles from Thomson scattering measurements before and after pellet injection. Laser 2 put into the plasma before pellet injection (3.73358)

s, filled circle). After that, Laser 1 was injected after pellet injection (3.751974 s, filled square, Timing of the laser input can be seen from Fig. 1.). After 200  $\mu$ 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, open square). From the Fig. 3, we can see  $T_e$  and  $n_e$  profiles were dramatically changed after pellet injection with shot-by-shot TS measurements.

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 Timings of the lasers for the Thomson scattering system relative to  $H\alpha$  emission light signal from the pellet ablation.



Fig.2  $T_{\rm e}$  and  $n_{\rm e}$  profiles from Thomson scattering measurements before and after pellet ablation.

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- 2) Naylor, G. Rev. Sci. Instrum. 81, 10E110 (2010).
- 3) Yasuhara, R. et al.: Plasma and Fusion Research 7, 2402030 (2012).