§5. Development of the Multi-pass Thomson Scattering System in the GAMMA 10 Tandem Mirror

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A multi-pass (MP) Thomson scattering (TS) system modeled on the GAMMA 10-TS system was constructed for enhancing the Thomson scattered signals and obtaining the time resolved TS signals [1,2]. The MPTS system has a polarization-based configuration with an image relaying system. The former MPTS system in GAMMA 10 can measure only four passing signals. We changed the larger aperture polarization control device for improving the MP laser confinement and obtaining the over four passing MPTS signals. The integrated MPTS signals increased about 1.2 times larger than that in the former system.

A schematic diagram of the multi-pass method of the polarization based system is shown in the Fig. 1. This system is based on the GAMMA10 double-pass TS system. Horizontal polarized laser light from the YAG laser is focused onto the plasma center by the first convex lens from the down side port window after passing a short pass mirror, the two Faraday rotators for isolator, a half wave plate, mirrors, a polarizer, a pockels cell and iris. We changed this pockels cell (Gooch&Housego, QX1630) with a larger aperture of 15 mm. The Pockels cell switches the polarization of the laser beam from horizontal to vertical for reflected passes during the gate pulse (~500 ns) which is generated by using high speed and high voltage switching driver (Lasermetrics, 5046ER). After the interaction with plasma, the laser light emits from the upper side port window and collimated by the second convex lens. A pair of lenses is a key component of this optical system. It makes the image relaying optical system from iris to reflection mirror to maintain the laser beam quality during the multi-pass propagation. Laser light reflected by the reflection mirror for the second pass and focused again onto the plasma. The second passing laser beam polarization is changed from horizontal to vertical by the Pockels cell. The vertical polarized laser light is reflected by the mirror. Then the multi-pass configuration is constructed.

Figure 2 shows the typical polychromator output signals of multi-pass configurations in end divertor module experiments. We have successfully constructed the MPTS system. The integrated MPTS signals from passes 1-8 (integration time of Δt = 260 ns) in the MP configuration were about 3.6 times larger than that in the single-pass configuration (Δt = 65 ns). The electron temperatures obtained from the single-pass TS signal and from MPTS signals were about 77 ± 45 eV and 56 ± 6 eV, respectively. The resolution of the electron temperature measurement was improved by the MPTS system.

We successfully constructed the MPTS system and successfully obtained more than five passing MPTS signals.

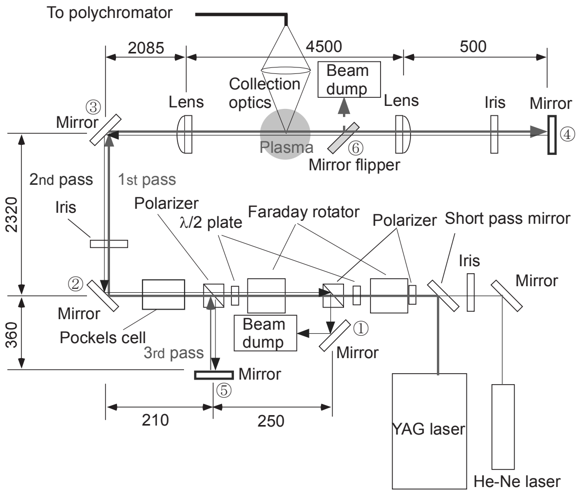

Fig. 1. Schematic of the MPTS system.

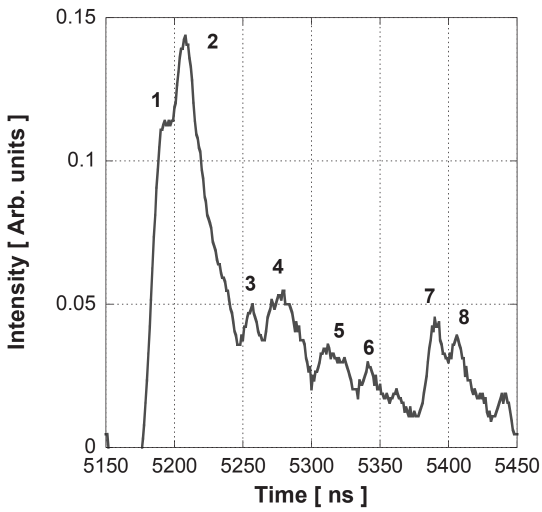

Fig. 2. Single and multi-pass TS signals.

The double-pass TS system have successfully observed double pass TS signals in LHD. In LHD, the backward and forward scattered TS signals can be measured for a higher temperature range and a temperature anisotropy. In LHD and Heliotron-J, they examine for installing the MPTS.

[1] M. Yoshikawa, et al., Plasma and Fusion Res. **9**, 1202126 (2014).

[2] M. Yoshikawa, et al., Rev. Sci. Instrum. **85**, 11D801 (2014).