§10. Electron Temperature Measurement by Using Thomson Scattering System in the Tandem Mirror GAMMA 10

Yoshikawa, M., Miyata, Y., Yaguchi, F., Imai, T.,
Ichimura, M., Nakashima, Y., Shima, Y. (Univ. Tsukuba),
Minami, T. (Kyoto Univ.),
Kawahata, K., Yamada, I., Yasuhara, R., Funaba, H.

Thomson scattering (TS) is the most reliable diagnostic to measure the electron temperature.[1-4] In GAMMA 10, the electron temperature is measured by a soft X-ray measurement. In these days, direct electron heating by electron cyclotron heating (ECH) experiments in the central cell have been carried out. Then we planned to install the neodymium-doped yttrium aluminium garnet laser (Nd:YAG) TS in order to measure electron temperature directly in the central cell of GAMMA 10. GAMMA 10 is the largest tandem mirror machine with plasma confinement achieved by not only a magnetic mirror configuration but also high potentials at both end regions. The main plasma is produced and heated by ion cyclotron range of frequency waves. The confinement potentials are produced by the plug- and barrier-ECH (P/B-ECH) at the plug/barrier region. The typical electron density, electron and ion temperatures are about 2×10^{12} cm^{-3}, 0.1 keV and 5 keV, respectively, during confinement potential formation. The newly installed TS was the same concept system as those installed in CHS and LHD in NIFS. We used the high power YAG laser (1064 nm, 2 J/pulse), a focusing lens (f = 2 m, ϕ 50 mm), collection mirror (ϕ 600 mm, R = 1200 mm), bundled optical fiber (input 2 × 7 mm, output ϕ 4.6 mm, length of 6.67 m) and the NIFS 5 channel polychromator with avalanche photodiode. We used the 90 degree TS. This system will be able to measure the electron temperature range from 0.02 to 10 keV with 0.01 keV resolution, and its measureable radial range is about ±200 mm with space resolution of about Δd ~ 20 mm. The sampling rate of the system is 10 Hz. We show the schematic view of the GAMMA 10 TS in Fig. 1. In this fund year, we measured the electron temperature by using this newly installed TS for the first time in the tandem mirror GAMMA 10.

The Raman and Rayleigh calibration experiments were carried out for setting of optical system and stray light in the evaluation of GAMMA 10 YAG-TS. The nitrogen gas was used, and the pressure in GAMMA 10 device was raised up to 200 Torr. In Fig. 2, signal intensities of Raman scattering measurement as a function of target pressure is shown. The measured scattering signal is proportional to the gas pressure. The linear component indicates the scattering light and the offset indicates the stray light. The stray light in this system is very small.

We applied the YAG-TS to measure the electron temperature of GAMMA 10 plasma. The signal to noise ratio is about 3. We can obtain the electron temperature of about 0.04 keV before applying P/B-ECH. With application of P/B-ECH, the electron temperature increased to about 0.08 keV. The error of the electron temperature measurement by the system is about 13 % by considering minimize chi-squared value analysis.

In summary, YAG-TS was installed to the tandem mirror GAMMA 10. This system can be operated to measure electron temperature in the very low plasma density region less than 2×10^{18} m^{-3}. We can successfully measure the electron temperature in the tandem mirror GAMMA 10 by using YAG-TS for the first time. The electron temperature is obtained at one position and one period.

1) Narihara, K. et al.: Fusion Eng. Design **34-35**, 67 (1997).
2) Narihara, K. et al.: Rev.Sci. Instrum. **72**, 1122 (2001).
3) Kainaga, S. et al.: Plasma Fusion Res. **3**, 027 (2008).
4) Lee, H. G. et al.: Rev. Sci. Instrum. **72**, 1118 (2001).

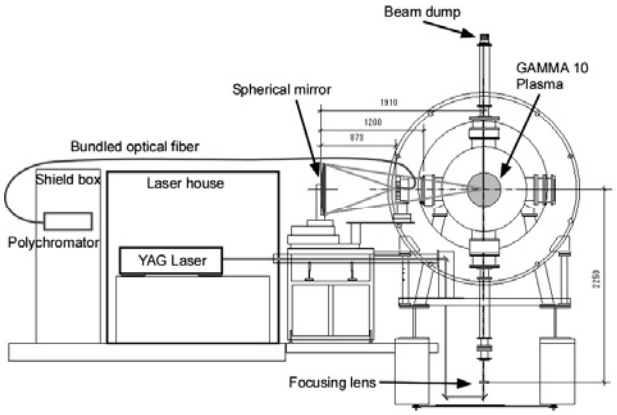

Fig. 1. The YAG-TS in GAMMA 10.

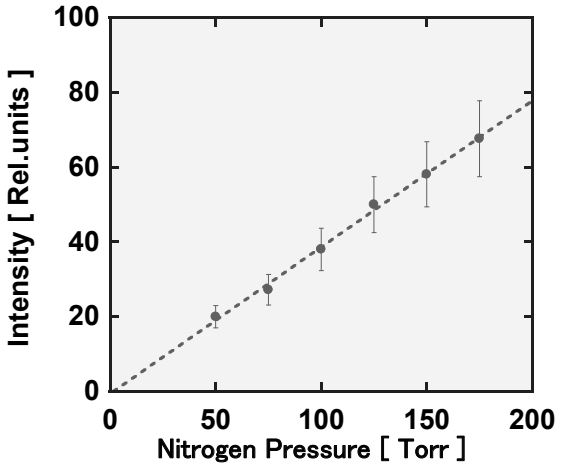

Fig. 2. Signal intensities of Raman scattering measurement as a function of target pressure.