§16. Design Study on Electron Temperature Profile Measurement for RT-1

Nishiura, M., Yoshida, Z., Kawazura, Y., Yano, Y., Mushiake, T., Kashyap, A. (Univ. Tokyo),
Yamada, I., Funaba, H., Narihara, K.

The RT-1 device is a unique plasma system exploring the possibility of advanced fusion with high-beta, high-performance confinement. The basic concept is the simulation of the self-organizing process that creates magnetospheric plasma vortexes. Variety of interesting mechanisms are at function in the vicinity of magnetic dipole; inward diffusion that `creates' density gradients, spontaneous heating related to the generation of radiation belts, automatic adjustment of pressure profile that realizes stable high (~1) beta equilibrium, etc. The key issue of the experiment is the identification of the density and temperature profiles. For example, Fig. 1 shows the electron density profile, measured by three-cord interferometers, and fitted by a model function r^{-a} (r and a are the radial position and the fitting coefficient). The observed peaked density profile is, in principle, consistent with the theoretical prediction. By other measurements, such as visible light spectroscopies, soft X-ray spectrometer, etc., we have discovered various interesting phenomena; for example, anisotropic ion temperatures caused by the spontaneous betatron acceleration, E×B drift created by the two-fluid effect, etc.

In order to advance the physics understanding, as well as to give proofs of principles toward advanced fusion, we need more detailed measurements of the high-temperature electrons. We have started design study for a Thomson scattering (TS) system to measure the local electron temperature and density. In RT-1, the electron density and the temperature range from 10^{16} to 10^{18} m^{-3}, and <100 eV, respectively as a typical operation. The electron density of 10^{17}-10^{18} m^{-3} is considered to be low compared with that in LHD and other devices where TS systems are applied.

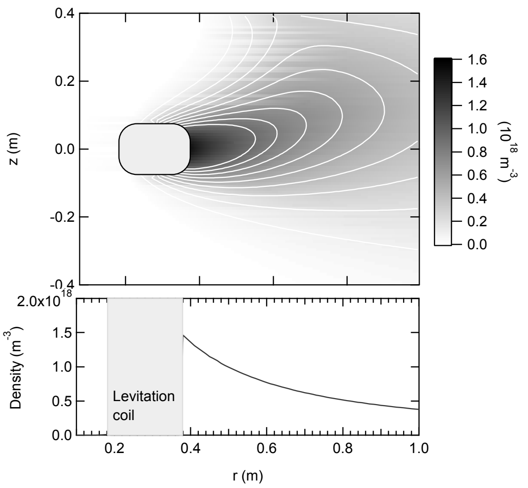

Fig.1 Typical example of electron density profile in RT-1 that is measured by three chord interferometers.

In TST-2 and Gamma 10, they reported that TS diagnostics under the low density conditions are possible to obtain the electron temperature. These results encouraged us to apply a TS system to RT-1 plasma diagnostic. For the collection optics of scattered photons the photon number was calculated in two cases for a TS system in RT-1 geometry shown in Fig. 2. With the scattering length of 60 mm, the collection lens of 100 mm in diameter, the leaser power of 0.8 J, and the electron density of 10^{17} m^{-3}, the 1.2×10^4 scattered photons could be collected at Z = –0.3 m. The other location from the upper port also collected the scattered photon of more than 10^4. The photon number more than 10^4 counts is considered to be a feasible level to obtain the adequate signal to noise ratio for a TS system.

From Fig. 3, the spectrum shape in Thomson scattering is shifted due to the relativistic effect of electrons. Based on this inspection, the energy filters of a polychromator will be designed to reconstruct the spectrum.

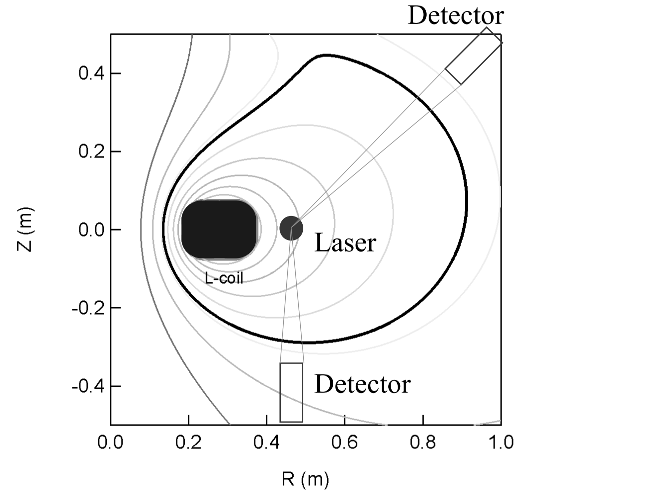

Fig.2 Geometry for TS system on the poloidal plane in RT-1. The photon detector is located near the plasma boundary to increase the solid angle.

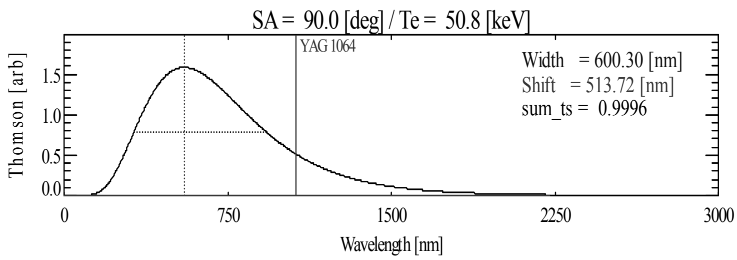

Fig.3 Thomson scattering spectrum with high temperature case.