§71. Electron Temperature and Density Profile Measurement on the QUEST Spherical Tokamak Device

Ejiri, A., Yamaguchi, T., Hiratsuka, J., Togashi, H., Takase, Y., Nakamura, K. (Frontier Sci., Univ. Tokyo),
Nagashima, Y., Hasegawa, M. (RIAM, Kyushu Univ.),
Tojo, H. (JAEA),
Narihara, K.

QUEST is a spherical tokamak device aiming at steady state operation sustained by electron Bernstein wave. In order to obtain the electron temperature and electron density profiles of the QUEST plasmas, an efficient and compact Thomson scattering system has been developed[1]. These profiles are necessary to estimate the slowing down time of the high energy electrons, which are believed to be the carrier of plasma current in QUEST. They are also important to reconstruct the equilibrium. Furthermore, the electron density profile is necessary to study the RF wave propagation, mode conversion, current drive and heating.

In fiscal year 2013, various types of RF sustained plasmas were measured. These are (1) 28 GHz RF power sustained limiter configuration (Fig. 1), (2) 8.2 GHz RF power sustained inboard field null configuration, (3) 8.2 GHz RF power sustained divertor configuration, (4) 8.2 GHz RF power limiter configuration, (4) compact torus injection to 8.2 GHz RF power plasma, (5) additional 8.2 GHz RF pulse injection to 28 GHz RF power sustained plasma. Figure 1 shows the electron temperature and the density profiles during 28 GHz RF power (200 kW) injection. During the period of 2.2 – 2.6 s, a plasma current of 25 kA was sustained. These RF sustained plasmas often have asymmetric hollow temperature profiles, and shows a peak near the inboard EC resonance, while the density profiles have the maximum near the center or show flat profiles. The typical central electron density for 28 GHz RF sustained plasma was less than $2 \times 10^{18} m^{-3}$, while that for 8.2 GHz RF sustained plasma was less than $3 \times 10^{17} m^{-3}$. These values indicate that the density is limited by wave accessibility. The inboard field null configuration plasma is characterized by a high poloidal beta value (e.g., ~3). On the other hand, the poloidal beta value of the bulk electrons measured by the Thomson scattering system is very low (e.g., ~ 0.015). In addition, an estimation shows that the bootstrap current due to the bulk electrons was much lower than the observed plasma current. Theses analyses suggest that the plasma equilibrium and the plasma current are dominated by high energy electrons generated by RF power.

In order to adjust the fiber position precisely, the fiber holder and its stage have been modified. Using the stage, the spatial measurement points can be changed shot by shot. Figure 2 shows an example of 12 spatial point measurement of RF sustained plasma, where 8.2 GHz RF power (~ 80 kW) was injected and a plasma current of 10 kA was sustained.

In order to measure anisotropy of electron temperature and to increase the signal to noise ratio, a coaxial multi-pass scheme is under development. The scheme based on the optical cavity, where the laser injection and confinement are controlled by the combination of a fast Pockels cell and a polarizer. A test system was constructed, and the measured confinement efficiency of the optical cavity was about 73 % per one roundtrip[2]. The scheme was applied to the Thomson scattering system in TST-2 spherical tokamak, and the improvement in the signal to noise ratio was confirmed for Ohmic discharges.

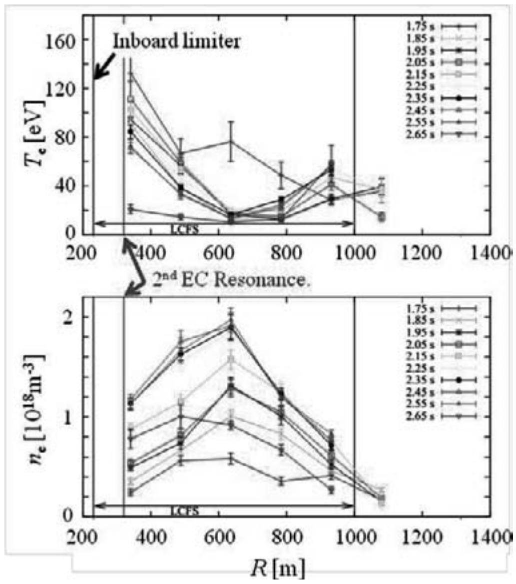

Fig. 1 Electron temperature and density profiles during 28 GHz RF power injection.

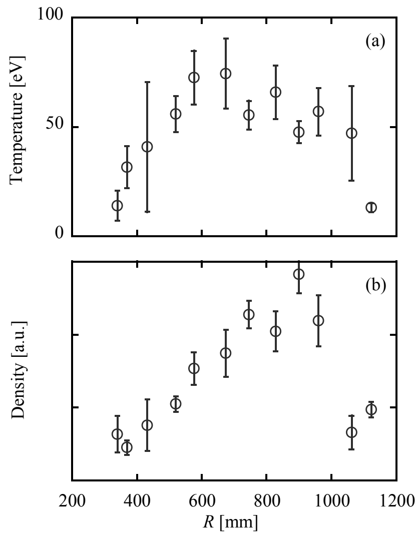

Fig. 2 Electron temperature and density profile for a 8.2 GHz sustained limiter configuration plasma.

1) T. Yamaguchi, et al.: Plasma Fusion Res. **8**, 1302001 (2013).

2) H. Togashi, et al.: Plasma Fusion Res. **9**, 1202005 (2014).