§59. Electron Temperature Measurement on the QUEST Spherical Tokamak Device

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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.

The system consists of a laser, a spherical mirror, and a polychromator. The laser has a wavelength of 1064 nm, an energy of 1.65 J, a repetition rate of 10 Hz. The output beam is focused near the center of the plasma by a lens which has a focal length of 3 m. The scattered light is collected by a spherical mirror (ϕ:0.5 m, *f*:0.5 m) through a window (ϕ:0.38 m). The system was designed to measure six spatial points in the plasma (major radius: 340 - 1080 mm). The scattering angle is 162 - 171 degrees. The scattering length is 17 - 51 mm, and the solid angle is 0.03 - 0.05 sr. We used a large N.A. (= 0.37) optical fiber (ϕ:2 mm) to collect the reflected light from the spherical mirror. A fast response polychromator unit, which has six avalanche photodiodes (APDs) and interference filters, was developed. The signals are recorded by 6 fast oscilloscopes with a sampling rate of 1 Gs/s. Since the RF sustained plasmas have a very low electron density (e.g. $n_e \sim 2 \times 10^{17} m^{-3}$), we have to accumulate the signal over about 200 laser pulses (i.e., 5 sec x 4 shot). On the other hand, the electron density of inductively started-up plasma (Ohmic plasma) is much higher than the RF sustained plasmas, and we do not have to accumulate the signal.

We have measured various plasmas so far. Figure 1 shows the temperature profiles for RF (8.2 GHz) sustained inboard null plasmas with different toroidal field strengths. The electron temperature shows a peak near the fundamental resonance positions for the RF. Note that these positions are close to the null positions. We also measured RF sustained divertor plasmas, RF sustained limiter plasmas, Ohmic plasmas and RF sustained plasmas with CT injection.

Figure 2 shows a discharge initiated by Ohmic inductive current and sustained by the RF. Since the scattering signal is strong, we can measure the temperature and the density without accumulating the signals.

The system is calibrated by using Raman scattering signal from nitrogen gas (up to 50 Torr), and we can obtain relative electron density profile in arbitrary unit. In order to obtain the absolute electron density, we are planning to use the data of microwave interferometer.

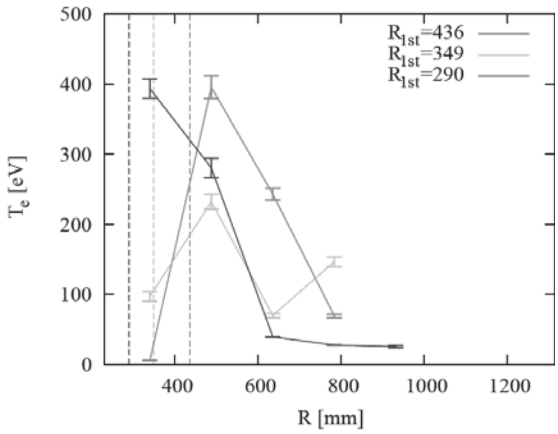

Fig. 1 Electron temperature profiles for inboard null discharges with 3 different toroidal field strengths. Fundamental electron cyclotron resonance positions are shown by dotted lines.

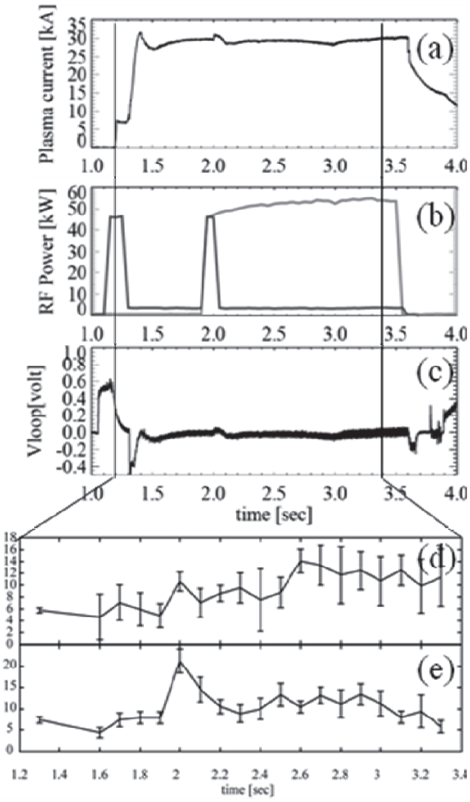

Fig. 2 Time evolution of the plasma current (a), RF injection power (b), loop voltage (c), electron temperature (d) and density (e) at *R*=0.488 m.

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