§70. Development of a Thomson Scattering System for 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 (EBW). One of the key factors in optimizing the EBW current drive is the electron density profile. Not only the mode conversion efficiency, but also the trajectory of rays depends on the density profile. Therefore, the measurements of electron density profile are quite important. We have developed a compact and efficient Thomson scattering (TS) system to measure the electron temperature and density profiles in QUEST.

Compact torus (CT) injection is one of the core fueling methods, and a system has been installed on QUEST. In FY 2015, we measured the fast time evolutions of temperature and density profiles during CT injection using an external laser control system. The time difference between the timings of CT injection and TS measurement was precisely adjusted, and scanned on a discharge by discharge basis. The target plasmas of CT injection were Ohmic plasmas with a plasma current of about 20 kA. The central electron temperature was about 10 eV. Figure 1 shows the time evolutions for the cases without (Figs. 1(a) and (b)) and with (Figs. 1(c) and (d)) CT injections. A CT was injected when the plasma current and the density are slowly increasing (see Fig. 1(a)). At 2 ms after the CT injection, densities in the whole region increased (compare the diamonds in Figs. 1(a) and 1(c)). In contrast, temperatures decreased in the whole region. We also measured the profiles at different timings. Analysis shows that the profiles start to vary at a timing between +0.1 ms and +0.5 ms. The order of this time delay is reasonable when we assume that the perturbation due to the CT injection, which is located at the opposite side of the torus from the TS measurement position, propagates toroidally with an ion sound speed. At +102 ms (squares in Figs. 1(a) and (c)), the densities with CT become more than twice higher than those without CT, and this increment is partly due to the slow influx of gas used to generate the CT. In the case shown in Fig. 1, the waveform of the plasma current was not distorted by the CT injection, but when the density enhancement factor just after the CT injection was more than twice, the plasma current shows a quick and significant drop. Therefore, we need to control the CT to avoid such a large distortion.

In FY 2015, a gyrotron (28 GHz) was reinstalled on QUEST with a new focusing optics, and the density and temperature profiles were measured by the TS system. The plasmas were initiated by two wave powers (8.2 GHz/17 kW and 28 GHz/140 kW), and a cylinder like plasma (I_p ~ 7 kA) was sustained. After that one of the wave powers

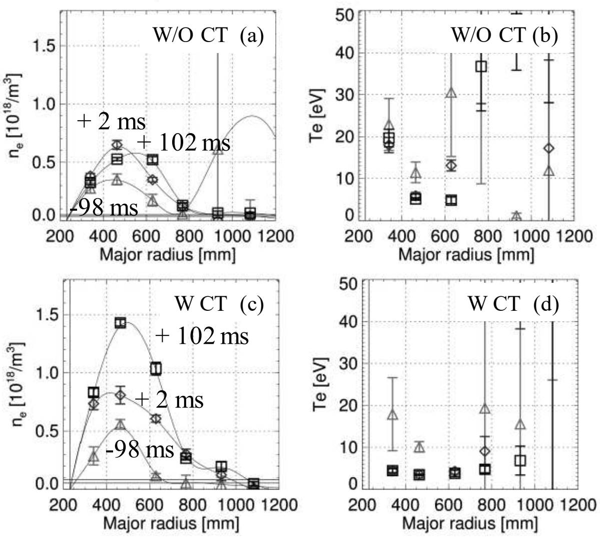

Fig. 1 Electron density (a), (c), and temperature (b), (d) profiles for the cases without and with CT injection. Triangles, diamonds and squares represent the profiles at -98, +2 and +102 ms from the CT injection timings, respectively.

(8.2 GHz/17 kW) was switched off. Then a spherical tokamak configuration was formed (I_p ~ 15 kA) and sustained by the remaining wave power (28 GHz/140 kW) alone. Figure 2 shows the profiles at those two sustained phases. At the first phase, when a cylindrical plasma was sustained by the two wave powers, a double peak density profile can be seen (Fig. 2(a)) These peaks probably represent plasma production at the two resonance layers. On the other hand, at the second phase, one of the two peaks disappeared (Fig. 2(c)). The temperature profile was flat and the temperatures were nearly 100 eV at the first phase, while the profile becomes hollow and low at the second phase.

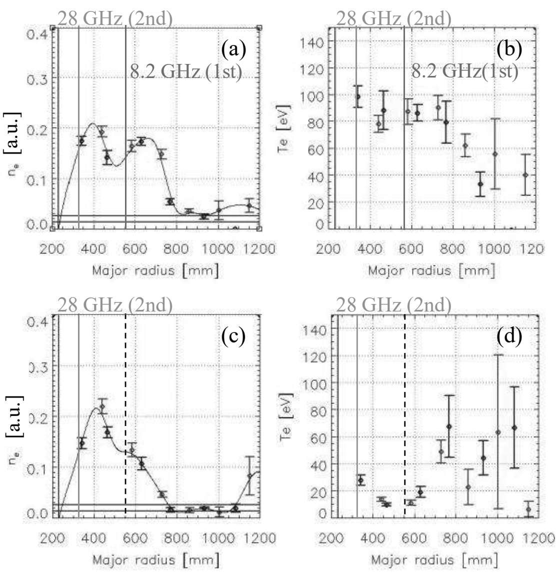

Fig. 2 Electron density (a), (c), and temperature (b), (d) profiles for the initial phase (Figs. (a) and (b) and the second phase (Figs. (c) and (d)).