§2. Extention of High T_e Regime in the Large Helical Device

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Enhancement of the output power per gyrotron has been planned in the Large Helical Device (LHD) and the replacement of the existing gyrotrons with higher-power tubes is in progress. An electron cycrotron resonance heating (ECRH) system with eight gyrotrons has been operated for preionization and plasma heating. Of these, high power 77-GHz gyrotrons with an output power of more than 1 MW each have been operated since the experimental campaign in 2007. At present, three 77-GHz gyrotrons are operational for plasma experiments. In addition, high power gyrotrons with the frequency of 154 GHz (1 MW/5 s, 0.5 MW/CW) have been installed since 2012. Figure 1 shows the history of the port-through ECRH power injected into the LHD. The heating capability of ECRH on the LHD has been upgraded year by year. The LHD now has 5.4 MW of a simultaneous-injection-ECRH power available for experiments. In the research, we tried the extension of the high electron temperature (T_e) regime of the LHD plasmas using the high power ECRH system.

Figure 2 shows the radial profiles of T_e and the electron density n_e in a typical high T_e plasma with the moderately high line-averaged electron density n_{e_fir} of $2x10^{19}$ m^{-3} produced using ECRH alone. In order to focus the high-power 77/154 GHz EC waves on the plasma center, the experiments were carried out under the magnetic configurations of R_{ax} = 3.60 m/ B_t = 2.705 T. Highly accurate T_e profiles were obtained by the accumulation of data of Thomson scattered light during 5 fixed-condition discharges with the two YAG laser beams injected together. A central electron temperature of 10 keV was successfully achieved using a center-focused ECRH of 5.4 MW. The values of T_{e0} significantly exceeded ~7 keV, obtained in previous experiments at n_{e_fir} ~$2x10^{19}$ m^{-3}.

Higher-density operations with n_{e_fir} of more than $4x10^{19}$ m^{-3} were also carried out using ECRH alone. The plasma stored energy of 690 kJ was realized in the discharge without a radiation collapse. The value is new record of W_p in ECRH plasma and is 1.3 times larger than the previous achievement. Figure 3 shows the map of simultaneously attained T_{e0} and n_{e_fir} for ECRH discharges. The plasma parameter regime with regard to the electron temperature was successfully extended in high density conditions.

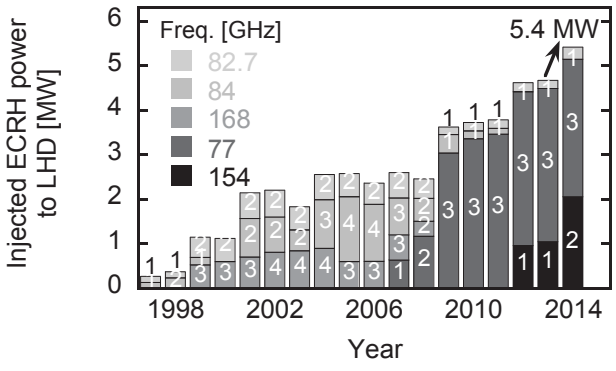

Figure 1. The history of the port-through ECRH power injected into the LHD.

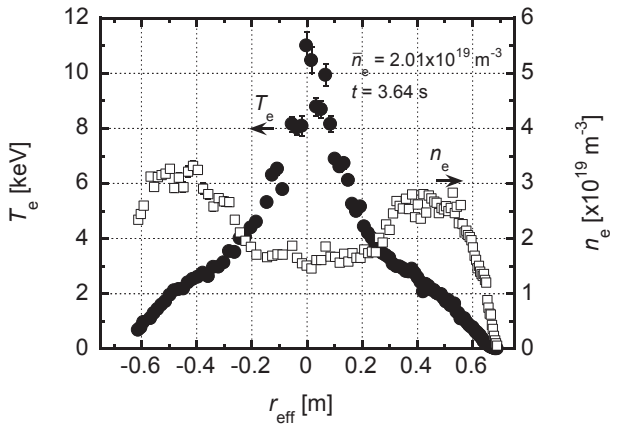

Figure 2. The radial profiles of T_e and n_e in a typical high T_e plasma with n_{e_fir} of $2x10^{19}$ m^{-3} produced using ECRH alone.

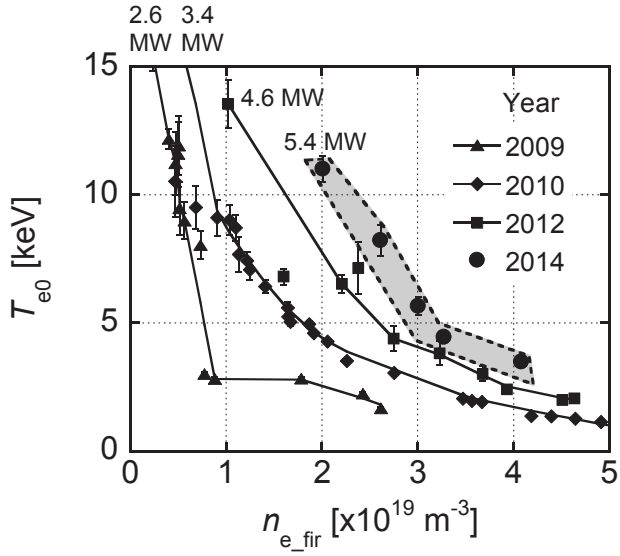

Figure 3. The map of simultaneously attained T_{e0} and n_{e_fir} for ECRH discharges.