§7. Expansion of High-T_e Regime in 15th Experimental Campaign on the LHD

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In the LHD, an ECRH system with seven gyrotrons, whose frequencies are 77, 82.7, 84 and 168 GHz, has been operated for plasma generation and heating. Of these, the high power 77-GHz gyrotrons with the output power of more than 1 MW have been operated since the 2007 experimental campaign.[1, 2] In the present state, three 77 GHz gyrotrons are operational for plasma experiments. The total injection power of ECRH to the plasma significantly increased due to the installation of the 77 GHz tubes and reached a value of 3.7 MW. In the research, we tried the expansion of the high electron temperature regime of the LHD plasmas using the high power ECRH system. In particular, a new heating scenario with ICRH was applied for the first time.

In order to focus the high-power 77 GHz EC wave on the plasma centre, the experiments were carried out under the magnetic configurations of R_{ax} = 3.53 m/ B_t = 2.705 T and R_{ax} = 3.75 m/ B_t = 2.736 T. Figure 1 shows the typical time evolution of (a) the RF heating power, (b) line-averaged electron density n_{e_fir}, (c) the ion temperature T_i and (d) the central electron temperature T_{e0} for the discharge with and without ICRH. The target plasmas were sustained by ECRH with the injection power of 3.45 MW and SSGP of He was injected at 3.9 s in order to decrease H/(H+He) and realize the better condition for the fundamental ICR heating. In the discharge of #108950 ICRH with 1.3 MW was superposed from 4.0 s to 4.3 s. As can be seen from fig. 1, rapid increase of n_e was observed just after the He injection by SSGP. In the case with ICRH superposition the sustainment of the higher density and both increase of T_i and T_{e0} were attained. Quasi-steady-state operations with higher density more than 4x10^{19} m^{-3} were also carried out using ECRH alone. The plasma with n_e~5x10^{19}, W_p ~300 kJ and τ_E ~100 ms could be sustained for 2.3 s without radiation collapse.

Figure 2 shows the map of simultaneously attained T_{e0} and n_{e_fir} for ECRH discharges in several magnetic configurations. The open and the solid symbols represent the data obtained previous and 2011 experimental campaign, respectively. The plasma parameter regime with regard to the electron was successfully expanded in high density conditions.

1) Takahashi, H. et al.: Fusion Sci. Technol. **57** (2010) 19.
2) Shimozuma, T. *et al.*: Fusion Sci. Technol. **58** (2010) 530.

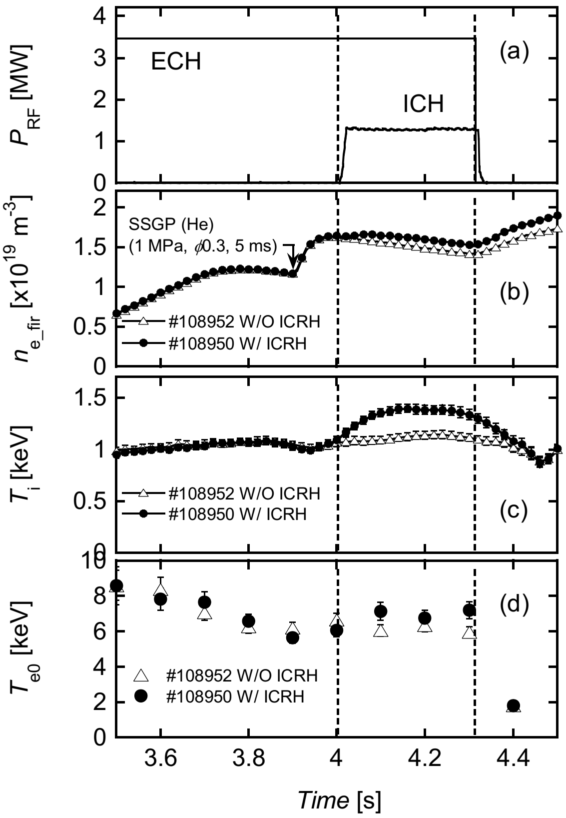

Fig. 1. The typical time evolution of (a) the RF heating power, (b) line-averaged electron density n_{e_fir}, (c) the ion temperature T_i and (d) the central electron temperature T_{e0} for the discharge with and without ICRH.

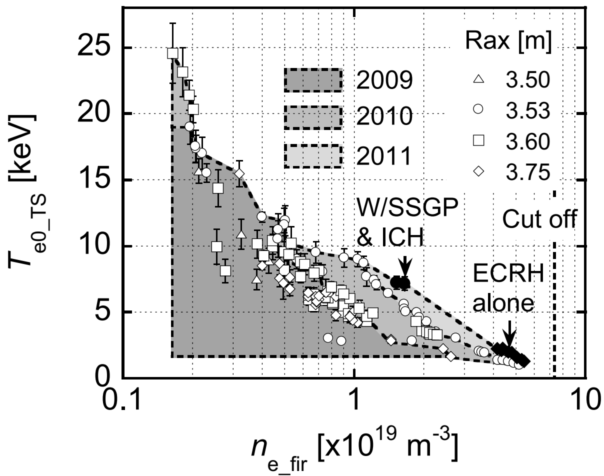

Fig. 2. The map of simultaneously attained T_{e0} and n_{e_fir} for ECRH discharges in several magnetic configurations.