§3. Long-Pulse Sustainment of High Performance ITB Plasmas by Use of EC-Waves

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ECH system on LHD is improved year by year by applying new gyrotrons, improving operation procedures of the gyrotrons, and refurbishing the gyrotrons. In the 16th experimental campaign, a new high-power 154GHz gyrotron was started to be used for LHD experiment with pulse operation, but not used for long-pulse operation due to lack of conditioning operation for it. The transmission line for the 154GHz gyrotron was connected to a power injection antenna installed at LHD 2-O port (2-OL). Until the start of the 17th campaign, conditioning operation of the 154GHz gyrotron for long-pulse operation was completed.

Former three 77GHz gyrotrons suffered from increases in internal pressure during long-pulse power transmission to LHD. One of the 77GHz gyrotron was refurbished by adding sub-window to remove stray radiation power inside the gyrotron utilizing an occasion of fixing a problem on its collector. The stray power would come from reflection from the transmission line and cause local heating resulting in the pressure increase.

Using the EC-waves from the new 154GHz at 2-OL, the refurbished 77GHz at 5.5-U and existing 77GHz at 2-OR, long-pulse plasma sustainment was attempted in the 17th experimental campaign. The magnetic axis position R_{ax} and the toroidally averaged magnetic field on axis B_t were 3.647m and 2.715T, respectively. The working gas was helium. The injection powers from the gyrototns were 120kW, 110kW and 110kW, respectively and 340kW in total. The injection power of the 154GHz EC-wave was limited not due to the condition of the gyrotron but the insufficient cooling of power injection antenna mirrors. Figure 1 shows a discharge sustained for 325s. The line average electron density n_{e_ave} is 1.1×10^{19}m^{-3} and the central electron temperature T_{e0} is 3.5keV. Thus, the plasma parameters were much improved from the former discharges sustained with EC-waves: n_{e_ave} of 0.15×10^{19}m^{-3} and T_{e0} of 1.7keV for 65min. by 110kW and, n_{e_ave} of 0.7×10^{19}m^{-3} and T_{e0} of 1.7keV for 30min. by 260kW.

It should be noted that the electron temperature profile with internal transport barrier (ITB) was realized and sustained quite stationary during the discharge as seen in Fig. 2, due to the increase in the injection power by applying the 154GHz EC-wave.

The additional sub-window on the 5.5-U 77 GHz gyrotron worked well. The increase in the internal pressure was suppressed and almost saturated. However, by the improvement in the gyrotron, the next problem preventing the extension of pulse width became clear. The discharge was terminated due to a sudden increase in the radiation from iron. A plasma monitor using a CCD camera suggests that occurring sparks near the power injection port, 5.5-U port would be responsible to the increase in the radiation.

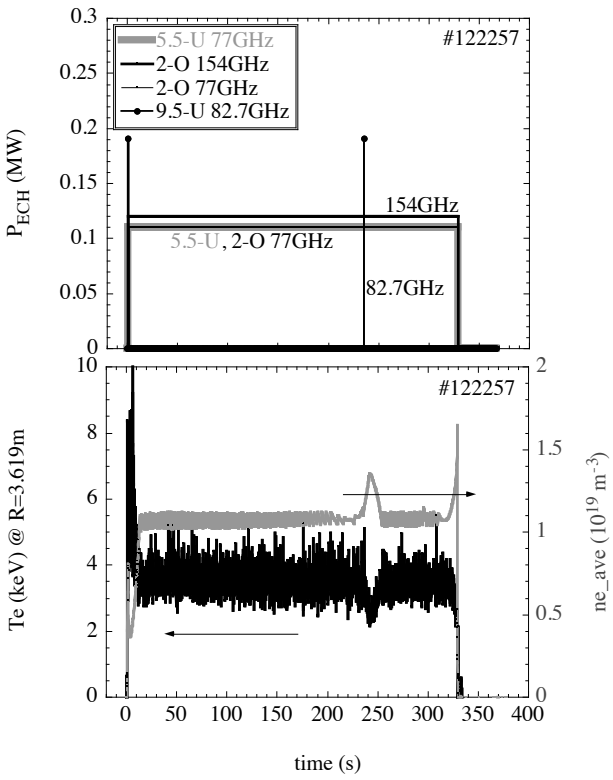

Fig. 1. Top: waveforms of EC-wave powers, and bottom: line average electron density and central electron temperature in the 325s discharge keeping ITB, #122257.

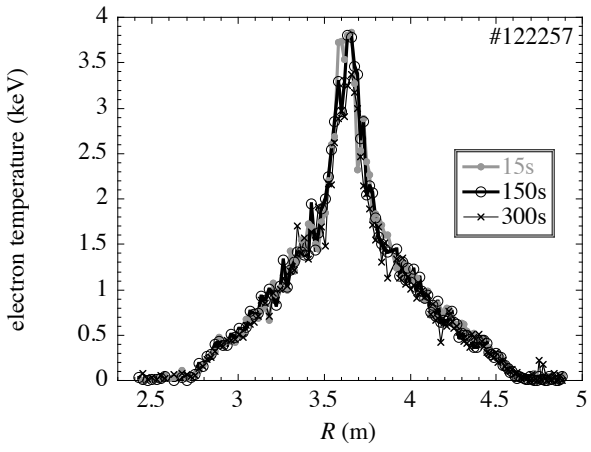

Fig. 2. Electron temperature profiles at 15, 150 and 300s in the 325s discharge #122257. Fine ITB profile was sustained quite stationary during the discharge.