§5. Present Operational Regime of 77 GHz-1 MW Gyrotron in the Large Helical Device

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A 77 GHz-gyrotron, which design value is 1 MW/ 5 s, 300 kW/ CW, was newly installed in the Large Helical Device (LHD) for not only the enhancement of the total heating property but also the increase of the control knob of the local plasma parameters. We have already done the arrangement of the peripheral components including the transmission line. Now we proceed the gyrotron conditioning and enlarge the operational regime day by day.

We set an operation roadmap of this gyrotron as follows. First we perform 1 MW output for short pulse, next is a few hundred kW for 5 s oscillation. After that we try 1 MW for 5 s operation and final aim is 300 kW continuous oscillation.

Figure 1 shows the progress of the extension of (a) power and (b) pulse width for the 77 GHz gyrotron, (c) the operational regime and its present boundary in power vs. pulse width. The solid circle and the solid square in fig 1 (a) represent the output power from the gyrotron and the injection power to LHD plasma, respectively. The injection power to LHD was evaluated by the dummy load of Teflon tube equipped in the LHD hall. We confirmed the power loss in the transmission line as ~22 %. We have already finished the short pulse test of 1 MW oscillation and 460 kW/ 5.0 s. In the present state, we are aiming for the gyrotron operation of 1 MW/ 5 s and we have been attained 810 kW/ 3.6 s until now. This means the millimetre power of ~630 kW can be injected to LHD.

We obtained preliminary results of the evaluation of the absorption power to the LHD plasma. In order to estimate the absorption efficiency, modulated millimeter wave of 39 Hz and ΔP = 630 kW was injected to NBI plasma under R_{ax} = 3.6 m, B_0 = 1.375 T (2nd harmonic heating). Absorption power was estimated from the change of the time derivative of the plasma stored energy W_p at ECRH on/ off. Figure 2 shows (a) the typical time evolution of ECRH power and W_p, the dependence of the absorption efficiency on (b) the focal point in the direction of the major radius R_{foc} at (α, β) = (-45°, 0°), (c) the polarization angle α at (R_{foc}, β) = (3.63 m, 0°). Here the polarization state of (α, β) = (-45°, 0°) corresponds to X mode injection. As can be seen from these figures, the absorption efficiency reached to 80 % in the case that R_{foc} was set at the plasma core region and peaked at α = -45°. However, it is highly possible that the absorption power was underestimated because the change of W_p after ECRH on/ off was sluggish, not exponential. Thus it is thought that the actual absorption efficiency is more than 80 %. These results denote the 2nd-harmonic X mode ECRH effectively contributes to plasma heating.

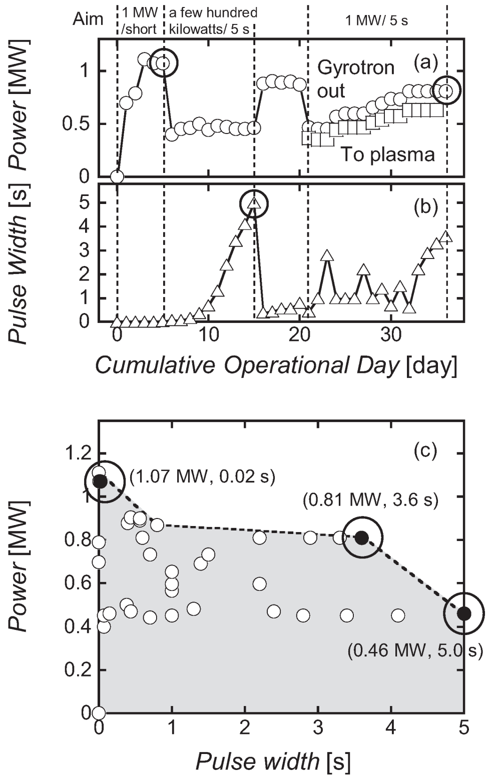

Fig. 1. The progress of the extension of (a) power and (b) pulse width for the 77 GHz gyrotron. (c) Operational regime and its present boundary in power vs. pulse width.

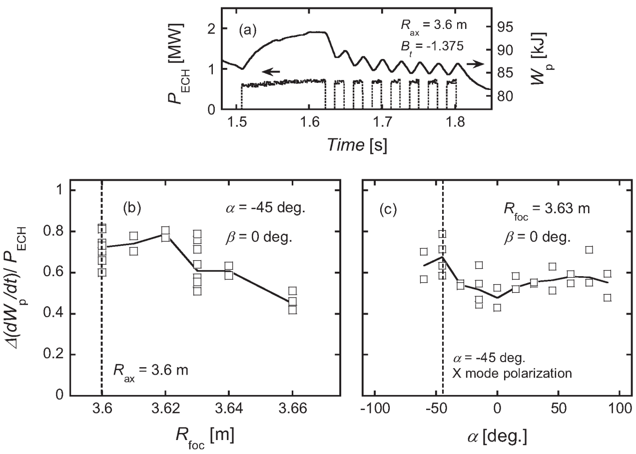

Fig. 2. The typical time evolution of ECRH power and the plasma stored energy W_p. The dependence of the absorption efficiency on (b) the focal point R_{foc} at (α, β) = (-45°, 0°) and (c) the polarization angle α at (R_{foc}, β) = (3.63 m, 0°). The absorption efficiency reached to 80 %.