§28. Third Harmonic ECH Experiments

Shimozuma, T., Idei, H., Kubo, S., Sato, M.

High harmonic heating of the electron cyclotron (EC) resonance is an attractive method to extend a heating regime of plasma parameters by reducing the density limitation due to some cutoffs of the EC wave propagation. The second harmonic heating by an extraordinary (X) mode injection from low field side antenna has been used for a plasma production and heating in Large Helical Device (LHD). For the third harmonic heating the linear theory predicts good absorption over a wide density range [1]. For the confinement magnetic field less then 3Tesla in LHD an ECH system which consists of two frequency range gyrotrons of 82.6GHz/84GHz and 168GHz has been developed. From the third experimental campaign of LHD two 82.6GHz/one 84GHz gyrotrons and three 168GHz gyrotrons can be operated to inject over 1 MW power into the LHD vacuum vessel.

Several experiments are performed for the different frequency heatings at the different strength of the confinement magnetic field, for example, the second harmonic heating by 84GHz power injection at 1.5T and 168GHz injection at 2.9T. The target plasma is produced by an EC fundamental or second harmonic resonance heating. The most attractive trials are the third harmonic heatings by both 82.6GHz/84GHz and 168GHz power injection into a plasma with the center field of 1T and 2T, respectively. This could be realized by a successful target plasma production by only neutral beam injection (NBI). Figure 1 shows a time evolution of some plasma parameters When a 168GHz power of 340kW are launched into the NBI produced plasma (electron temperature and average density are 1.5keV and $1.5 \times 10^{19} m^{-3}$, respectively) at about 2T on the magnetic axis (3.6m), noticeable increases of the plasma stored energy (several percent) is observed, while the electron density is kept constant. The temperature measured by Thomson scattering between R=3.55m and 3.65m is also plotted. Temperature profiles at t=1.8sec (just before RF turn-on) and t=2.1sec (just before RF turn-off) are plotted in Fig. 2. Increment of the electron temperature achieved about 200eV around central region. Absorption rate P_{abs}/P_{in}, that is estimated by a difference of dW_p/dt between before and after RF turn-on time, reaches 30%. This result is fairly good agreement with calculation results basing on the linear theory.

Reference
1) U. Gasparino, H. Idei, S. Kubo, et al., Nuclear Fusion, 38(1998)pp223-235.

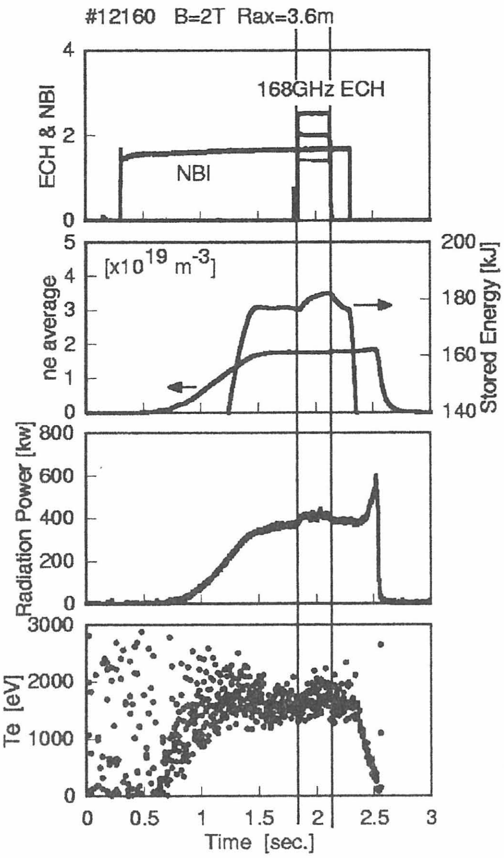

Fig. 1: The time evolution of plasma parameters at 3rd harmonic ECH.

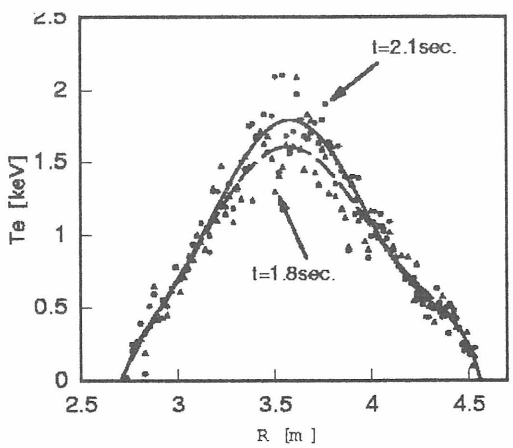

Fig. 2: Radial profile of electron temperature measured by Thomson scattering at t=1.8sec (before RF turn-on) and 2.1sec (before RF turn-off).