§3. HIBP Measurements of Density Ramp-up Phase of CHS Plasma

Nakano, H., Fujisawa, A., Shimizu, A., Ohshima, S., Iguchi, H., Yoshimura, Y., Minami, T.,

The confinement property of high-density region or density limit in toroidal plasmas is one of the important physics issues for magnetic fusion researches. In density ramp-up experiment, the changes of plasma characteristics including fluctuations have been studied in ECR heated CHS plasma using heavy ion beam probes (HIBP). It is well known that the HIBP is capable to measure electrostatic potential and density simultaneously.

Figure 1 shows a typical waveform of the plasma parameters in the density ramp-up experiment. In this experiment, the density increases monotonically until ~92 ms, then the plasma collapse happens. After the collapse, the electron temperature drops below the lower limit of the measurable value of Thomson scattering, although the density value does not show a drastic change. The HIBP beam from r = 4 cm also shows a significant drop after the collapse, corresponding to the rapid decrease in temperature due to the extremely low ionization rate below the electron temperature of ~ 10 eV.

The fixed-point measurement with the HIBP was performed shot-by-shot basis to investigate how the plasma profile and fluctuations change during the density ramp-up. One of the findings in the measurement is that the electron temperature decreases with the density increase, and that the cooling should start from the plasma edge, and the cooling propagates toward the core in a comparable time scale of confinement (~1 ms). This result is obtained by comparing the detected beam current at each observation point.

In addition, we have also obtained how the fluctuations behave during the density ramp-up. One of the obvious results is that the density fluctuations decrease with an increase in density until n_e ~10 x 10^{18} m^{-3} for all frequencies measured with the HIBP. The density fluctuation amplitudes at 20 kHz and 140 kHz decrease to about 1/10 from n_e ~5 x 10^{18} m^{-3} (t ~ 60 ms) to n_e ~10 x 10^{18} m^{-3} (t ~ 80 ms). This tendency could be consistent with the better confinement time in higher density regime, which has been confirmed in ISS95 scaling. However, just (~1 ms) before the collapse, density fluctuations are found to increase, particularly in low frequency range (~ 50 kHz). Figure 2 shows the examples of density fluctuation changes at three frequencies (20 kHz, 70 kHz, and 140 kHz). It is also found that the change of potential fluctuation is almost similar to that of density fluctuations.

Finally, it is a future work to evaluate the changes of the turbulence driven particle flux from these measurements during the density ramp-up, and to investigate the role of the low frequency fluctuations appearing just before the collapse.

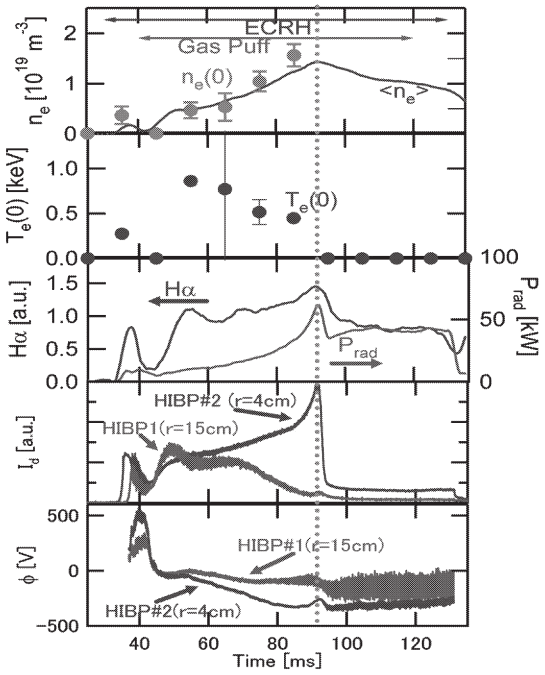

Fig. 1 The waveform of line-average-density, the central density and electron temperature, H-alpha signal, radiation power, detected beam currents of HIBP, and potential measured with HIBP in the density ramp-up experiment. The plasma collapses at 92 ms.

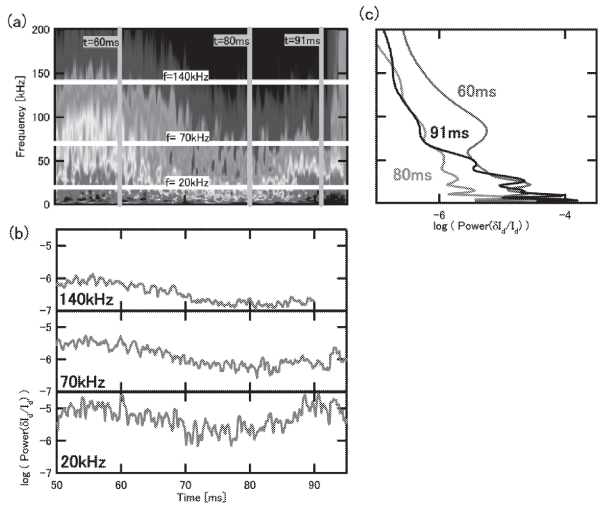

Fig. 2 (a) The fluctuation time evolution map of the detected beam current, which reflects density, through ionization point at r = 12 cm with (b) three waveforms of the fluctuation amplitudes at 20, 70 and 140 kHz, and (c) three fluctuation spectra at 60, 80 and 91 ms.